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Supplement of

Storm Anatol over Europe in December 1999: impacts on societal and energy infrastructure

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SECTION I. Wind measurements across the period of the storm and trajectory

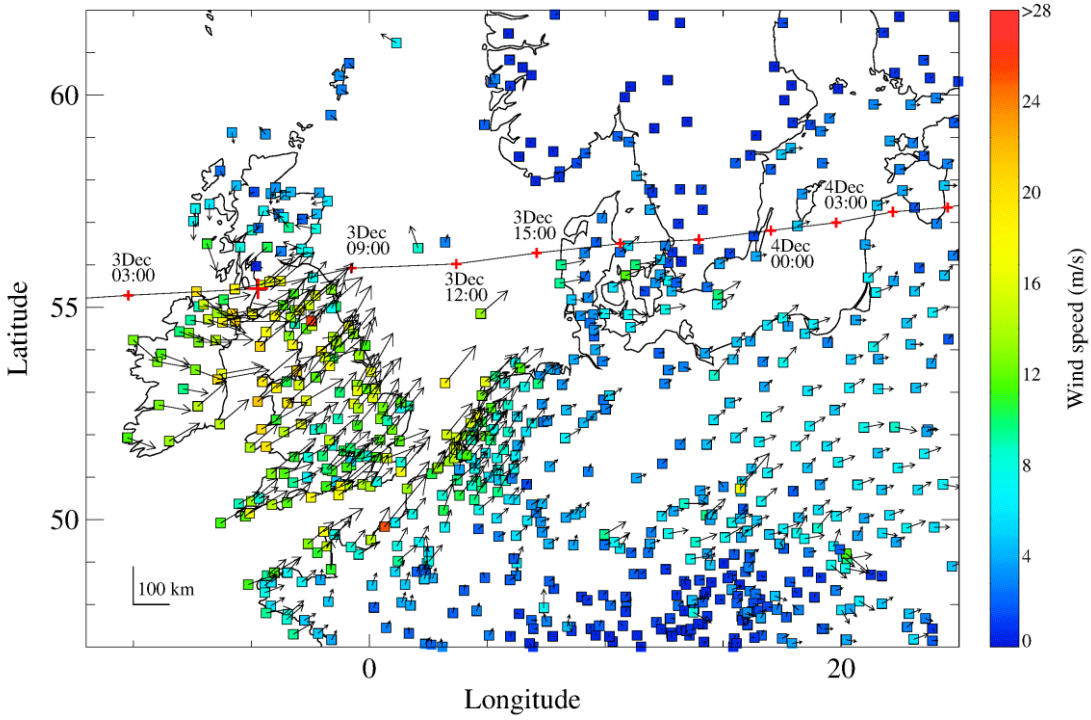

Figure S1a. Wind speed and direction at 06:00 GMT 3 December 1999 from selected stations of the USAF data set. The trajectory of low pressure centre is indicated by the black line with red crosses at 3 hour intervals (Roberts et al, 2014; XWS, 2020). The location of the pressure centre at the time of wind field is shown by a larger cross.

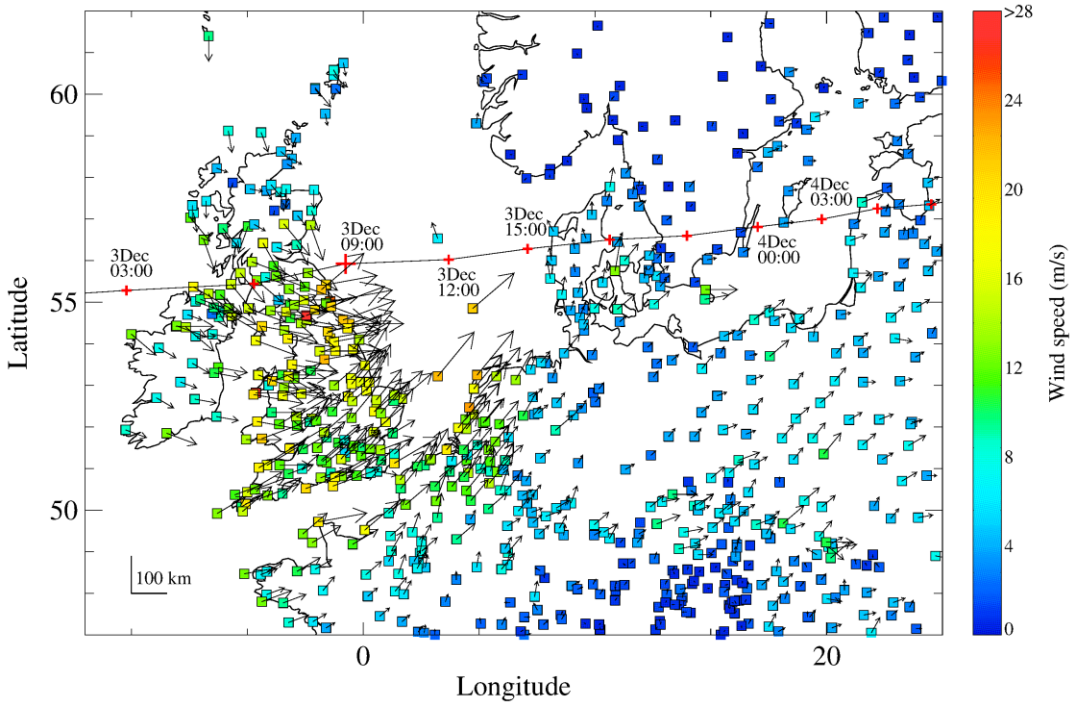

Figure S1b. Wind speed and direction at 09:00 GMT 3 December 1999 from selected stations of the USAF data set.

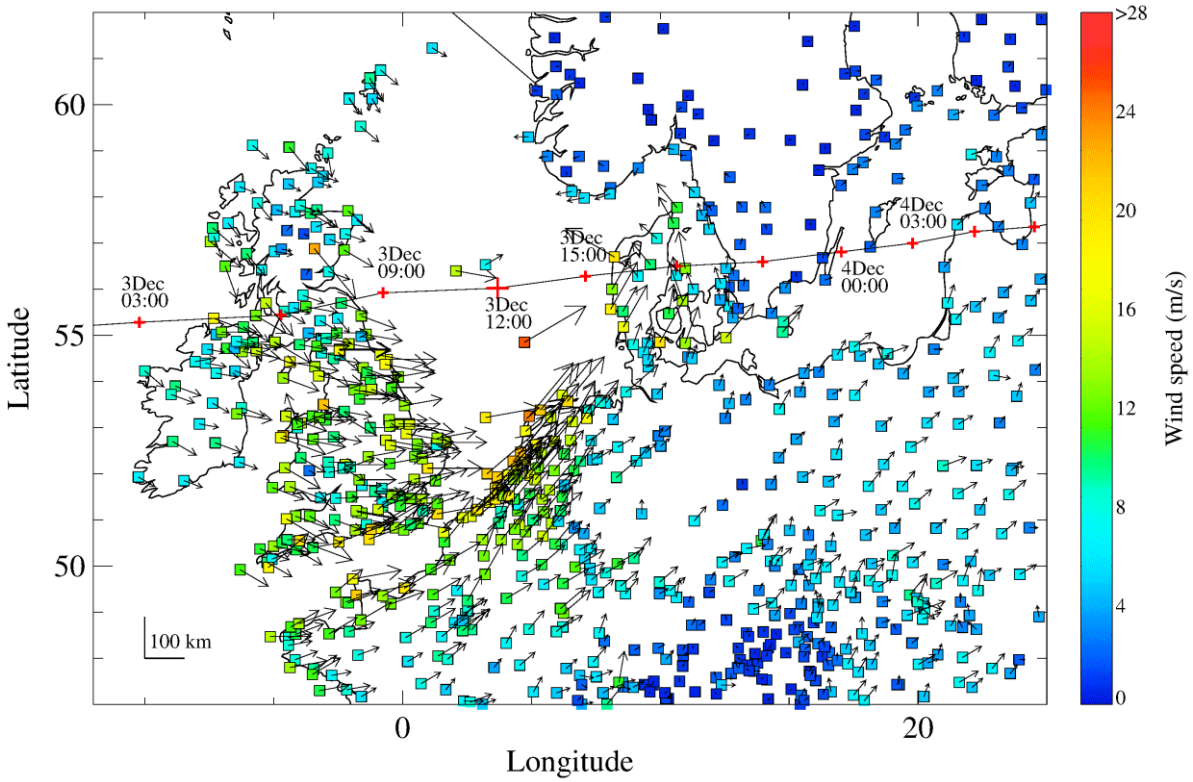

Figure S1c. Wind speed and direction at 12:00 GMT 3 December 1999 from selected stations of the USAF data set.

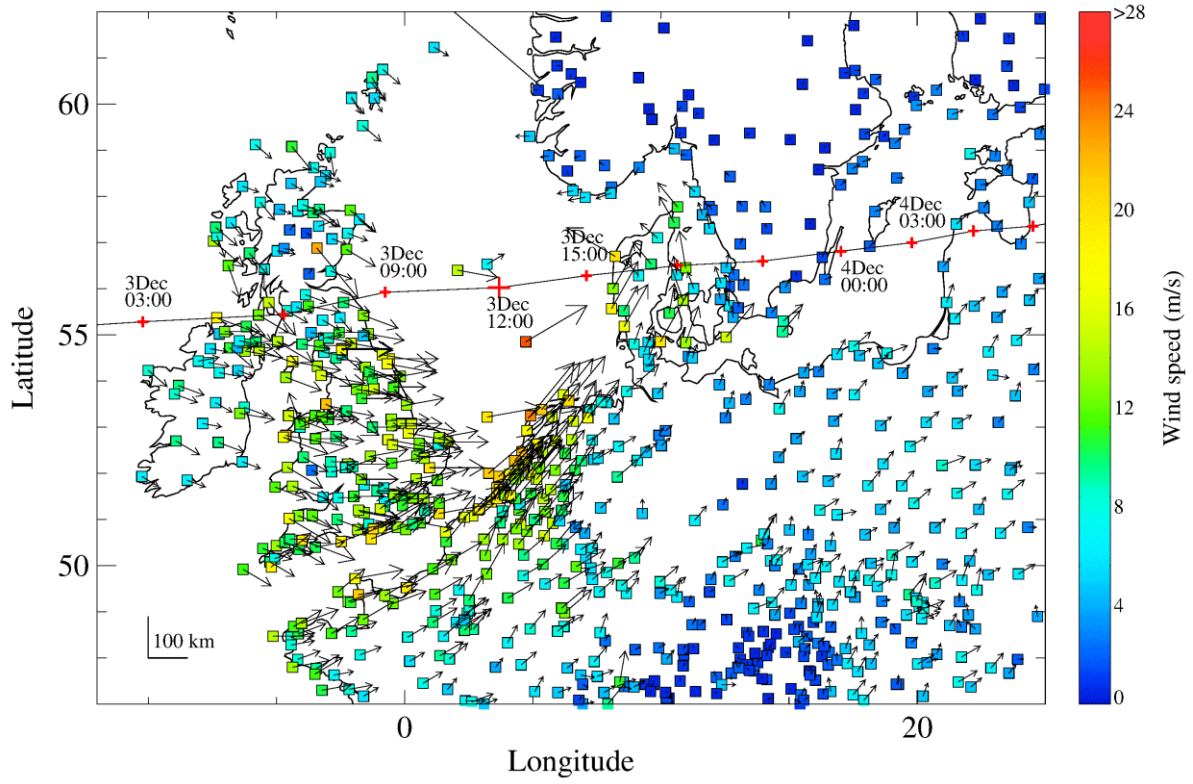

Figure S1d. Wind speed and direction at 15:00 GMT 3 December 1999 from selected stations of the USAF data set.

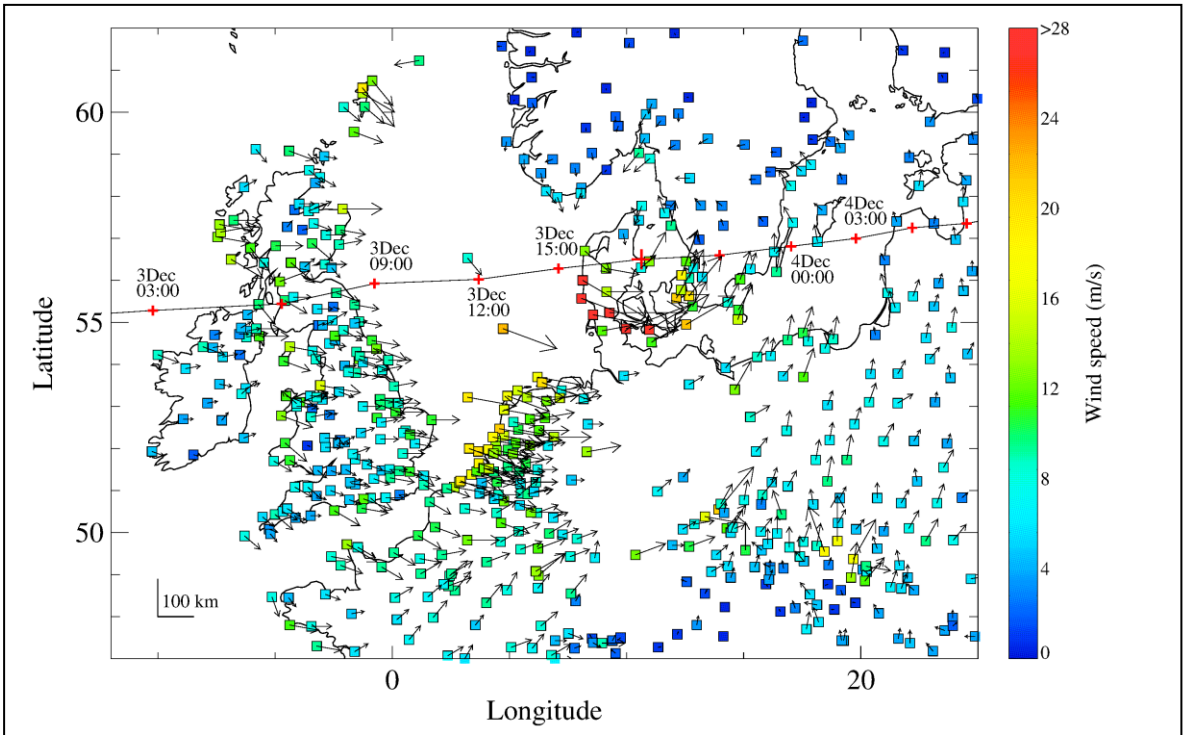

Figure S1e. Wind speed and direction at 18:00 GMT 3 December 1999 from selected stations of the USAF data set.

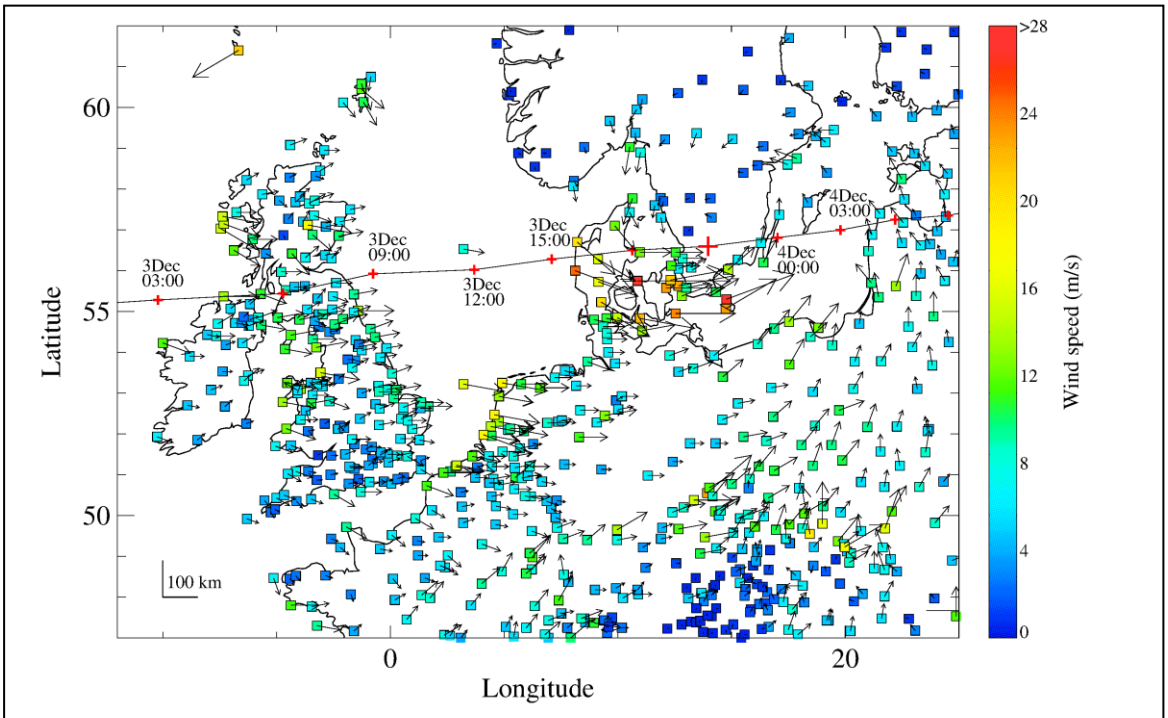

Figure S1f. Wind speed and direction at 21:00 GMT 3 December 1999 from selected stations of the USAF data set.

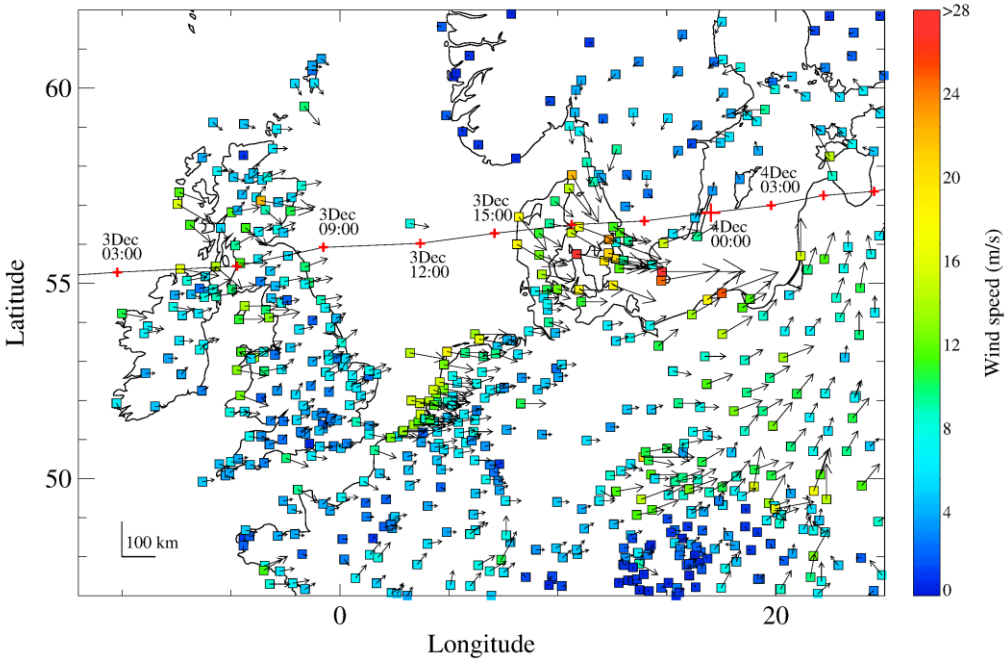

Figure S1g. Wind speed and direction at 00:00 GMT 4 December 1999 from selected stations of the USAF data set.

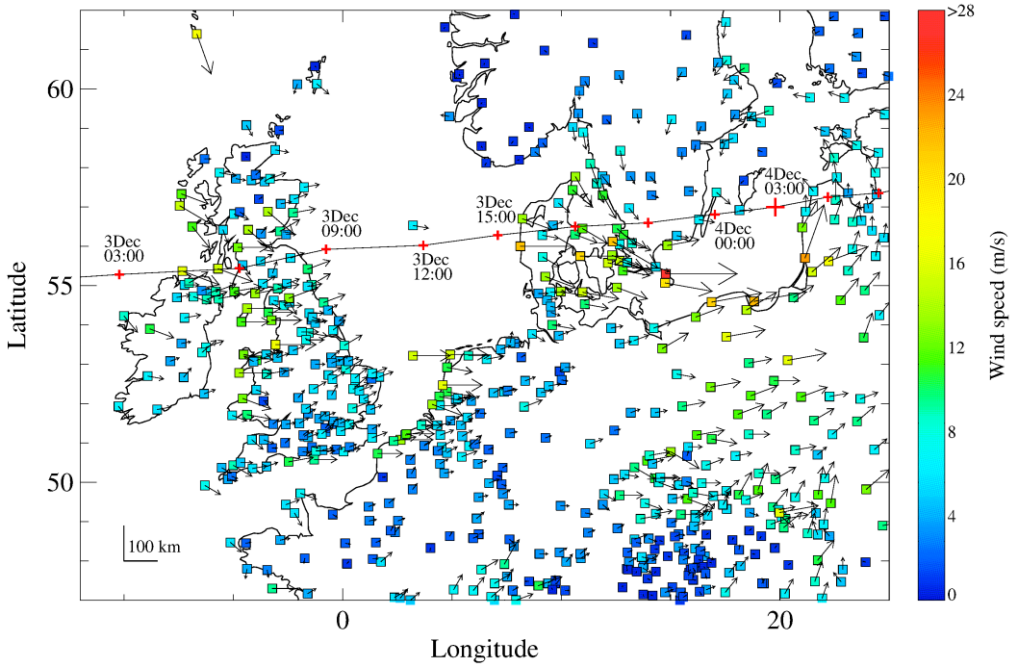

Figure S1h. Wind speed and direction at 03:00 GMT 4 December 1999 from selected stations of the USAF data set.

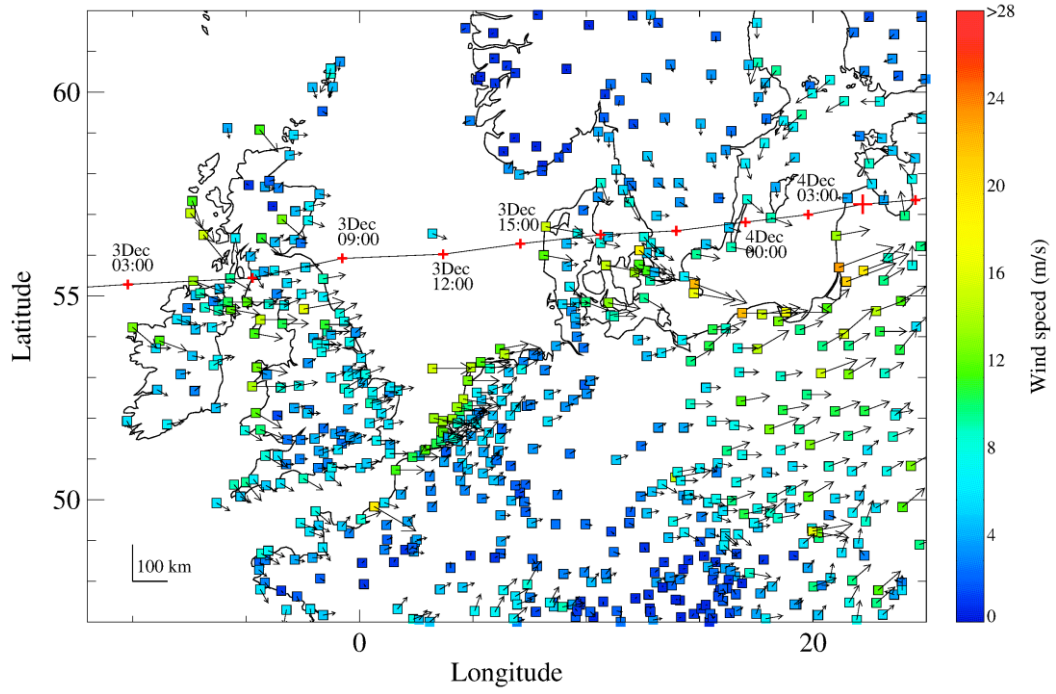

Figure S1i. Wind speed and direction at 06:00 GMT 4 December 1999 from selected stations of the USAF data set.

SECTION II. Wave measurements in the North Sea and Norwegian Sea

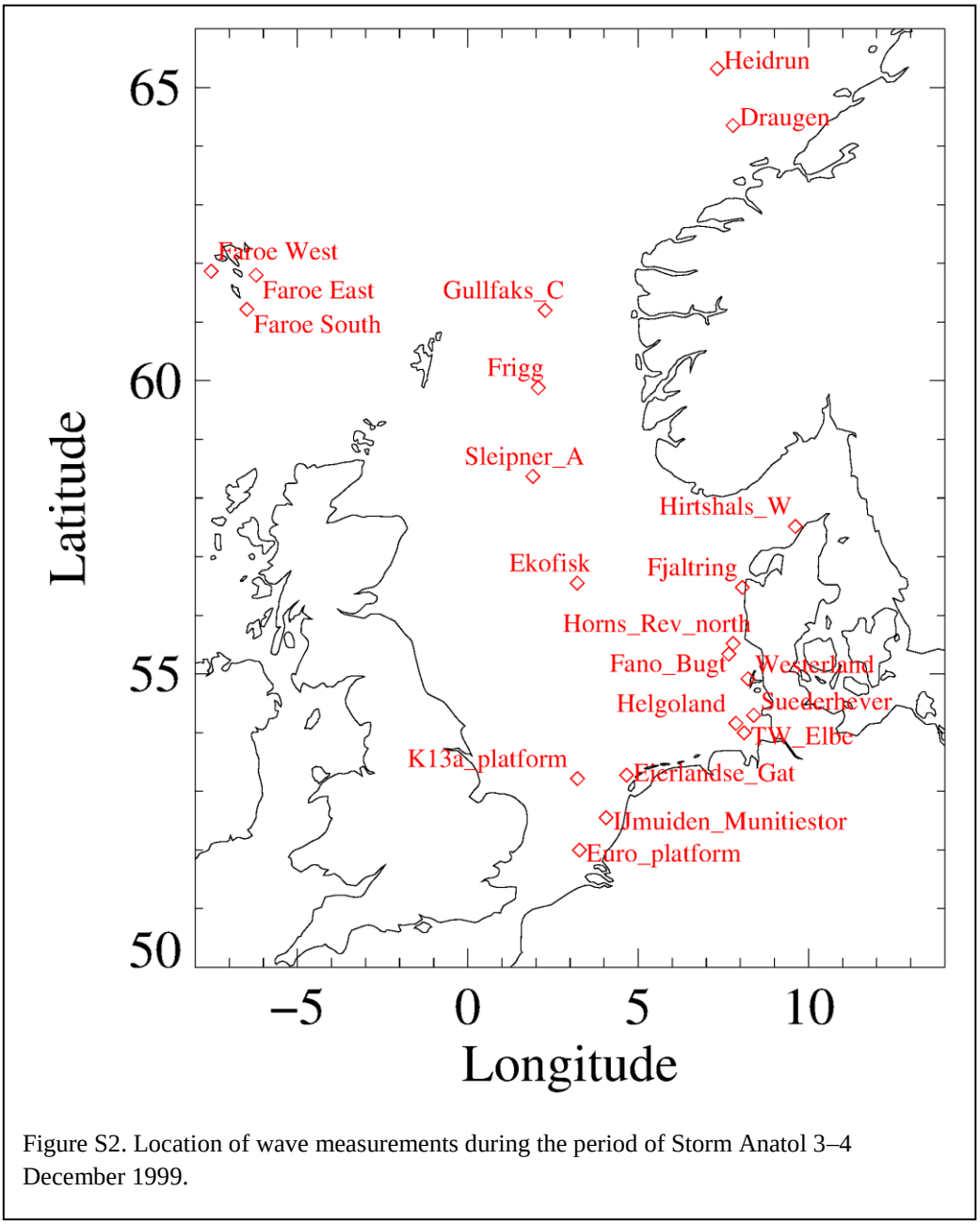

Figure S2. Location of wave measurements during the period of Storm Anatol 3–4 December 1999.

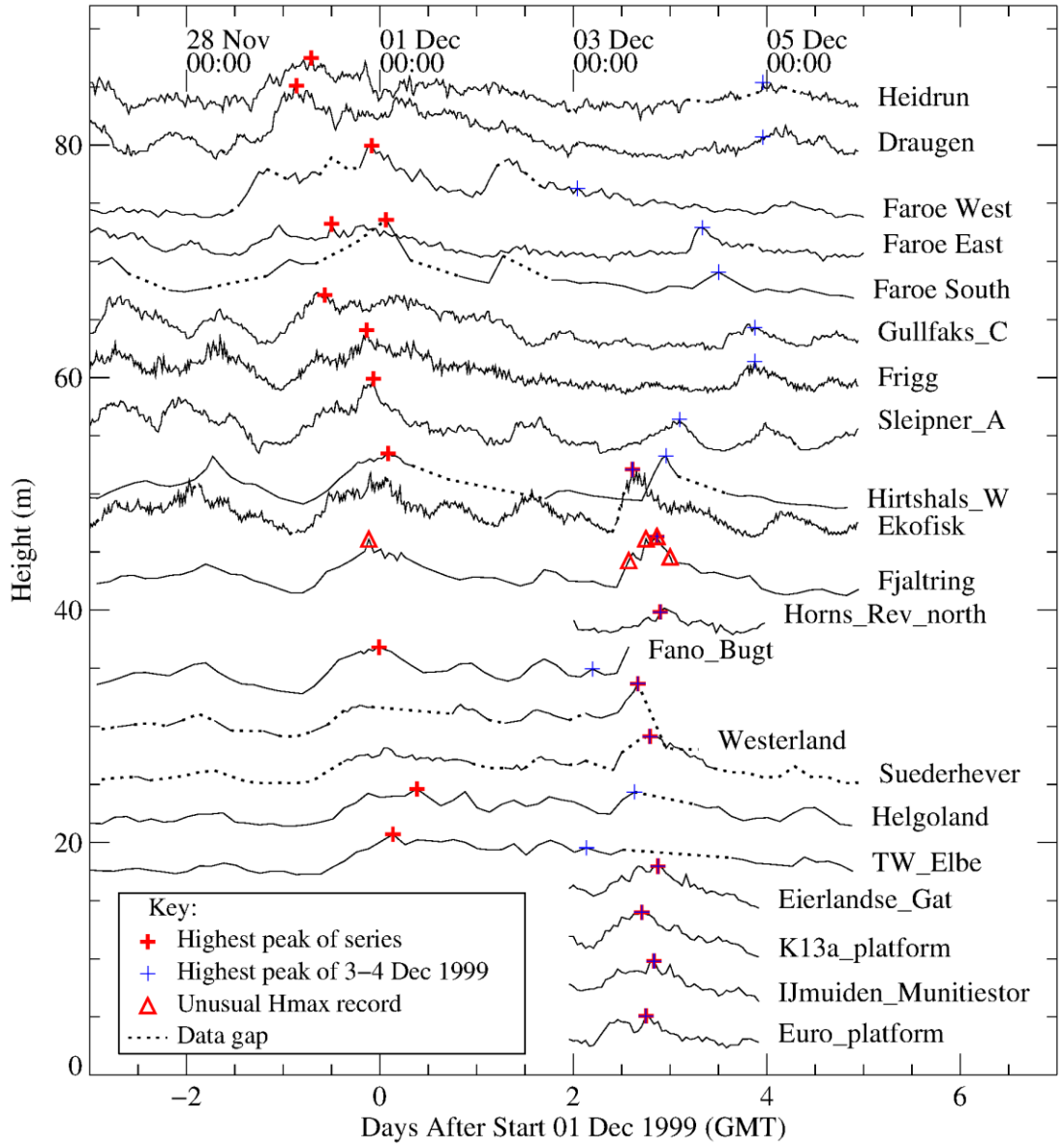

Figure S3. Time series of significant wave height for wave instruments in the North Sea and Norwegian Sea. The time series for each station have been vertically offset for presentation clarity. Note that data gaps occur in some stations when Storm Anatol was at its most intense. The Fjaltring wave buoy registered unusual maximum wave heights at the times shown by triangles. Prior to Storm Anatol there had been a serious storm on 30 November 1999. The following people provided the wave information for this plot: M. Bluemel (Landesbetrieb fuer Kuestenschutz, Nationalpark, und Meereschutz Schleswig-Holstein), L. Mueller (Bundesamt für Seeschifffahrt und Hydrographie), B. Niclasen (University of the Faroe Islands), R.G. Skaland (met.no), A. Zijderfeld (Rijkswaterstaat). Data for Horns Rev was digitized from Sommer (2002), and data from the Danish wave buoys was downloaded from the Kystdirektoratet website.

Table S1. Wave information from the North Sea and Norwegian Sea area for the period 28 November 1999 to 5 December 1999. Information is presented for the highest significant wave height over the full period and for the two day period of the storm 3–4 December 1999.

Wave information

Station name [1]	Land [2]	NNN [3]	Date & time series start [4]	Date & time series end [5]	Median Δt (min) [6]	Date/time peak full series [7]	Peak (m) [8]	Date/time peak 3–4Dec1999 [9]	Peak (m) [10]
Eierlandse_Gat	NE	48	02/12/1999 23:00	04/12/1999 22:00	60.0	03/12/1999 21:00	6.0	03/12/1999 21:00	6.0
Euro_platform	NE	48	02/12/1999 23:00	04/12/1999 22:00	60.0	03/12/1999 18:00	5.1	03/12/1999 18:00	5.1
IJmuiden_Munitiestor	NE	48	02/12/1999 23:00	04/12/1999 22:00	60.0	03/12/1999 20:00	5.8	03/12/1999 20:00	5.8
K13a_platform	NE	48	02/12/1999 23:00	04/12/1999 22:00	60.0	03/12/1999 17:00	6.0	03/12/1999 17:00	6.0
Helgoland	DE	59	28/11/1999 00:07	05/12/1999 21:06	182.0	01/12/1999 09:10	4.6	03/12/1999 15:09	4.3
TW_Elbe	DE	56	28/11/1999 00:11	05/12/1999 21:19	180.0	01/12/1999 03:14	4.7	03/12/1999 03:16	3.5
Fano_Bugt	DK	50	28/11/1999 01:45	03/12/1999 13:45	180.0	30/11/1999 23:45	4.8	03/12/1999 04:45	2.9
Fjaltring	DK	79	28/11/1999 01:45	05/12/1999 22:45	180.0	03/12/1999 20:45	6.3	03/12/1999 20:45	6.3
Hirtshals_W	DK	64	27/11/1999 23:00	05/12/1999 20:00	180.0	01/12/1999 02:00	5.5	03/12/1999 23:00	5.3
Horns_Rev_north	DK	48	03/12/1999 00:07	04/12/1999 23:26	58.5	03/12/1999 21:35	3.8	03/12/1999 21:35	3.8
Ekofisk	NO	562	27/11/1999 23:00	05/12/1999 22:40	20.0	03/12/1999 14:40	8.1	03/12/1999 14:40	8.1
Draugen	NO	573	27/11/1999 23:00	05/12/1999 22:40	20.0	30/11/1999 03:20	9.1	05/12/1999 00:00	4.8
Frigg	NO	576	27/11/1999 23:00	05/12/1999 22:40	20.0	30/11/1999 20:40	8.1	04/12/1999 21:00	5.4
Gullfaks_C	NO	576	27/11/1999 23:00	05/12/1999 22:40	20.0	30/11/1999 10:20	7.1	04/12/1999 21:00	4.3
Heidrun	NO	529	27/11/1999 23:00	05/12/1999 22:40	20.0	30/11/1999 07:00	7.5	04/12/1999 23:00	5.4
Sleipner_A	NO	574	27/11/1999 23:00	05/12/1999 22:40	20.0	30/11/1999 22:20	7.9	04/12/1999 02:20	4.4
Suederhever	DE	92	28/11/1999 03:00	05/12/1999 23:00	60.0	03/12/1999 19:00	5.1	03/12/1999 19:00	5.1
Westerland	DE	54	28/11/1999 03:00	04/12/1999 07:00	120.0	03/12/1999 16:00	5.7	03/12/1999 16:00	5.7
Faroe East	FA	192	28/11/1999 00:00	06/12/1999 00:00	60.0	30/11/1999 12:00	5.2	04/12/1999 08:00	4.9
Faroe South	FA	40	28/11/1999 02:01	05/12/1999 21:31	210.0	01/12/1999 01:32	9.6	04/12/1999 12:02	5.1
Faroe West	FA	172	28/11/1999 00:00	06/12/1999 00:00	60.0	30/11/1999 22:00	8.0	03/12/1999 01:00	4.3

Notes:
[1] Wave measuring station name
[2] Operating country
[3] Number of data points in time series
[4] Start date and time of time series (GMT)
[5] End date and time of time series (GMT)
[6] Median time interval
[7] Date and time of peak of full time series (GMT)
[8] Peak significant wave height of full time series.
[9] Date and time of peak of 2 d time series during Storm Anatol 3–4 December 1999.
[10] Peak significant wave height of 2 d time series during Storm Anatol 3–4 December 1999.

SECTION III. Quikscat image during the storm period.

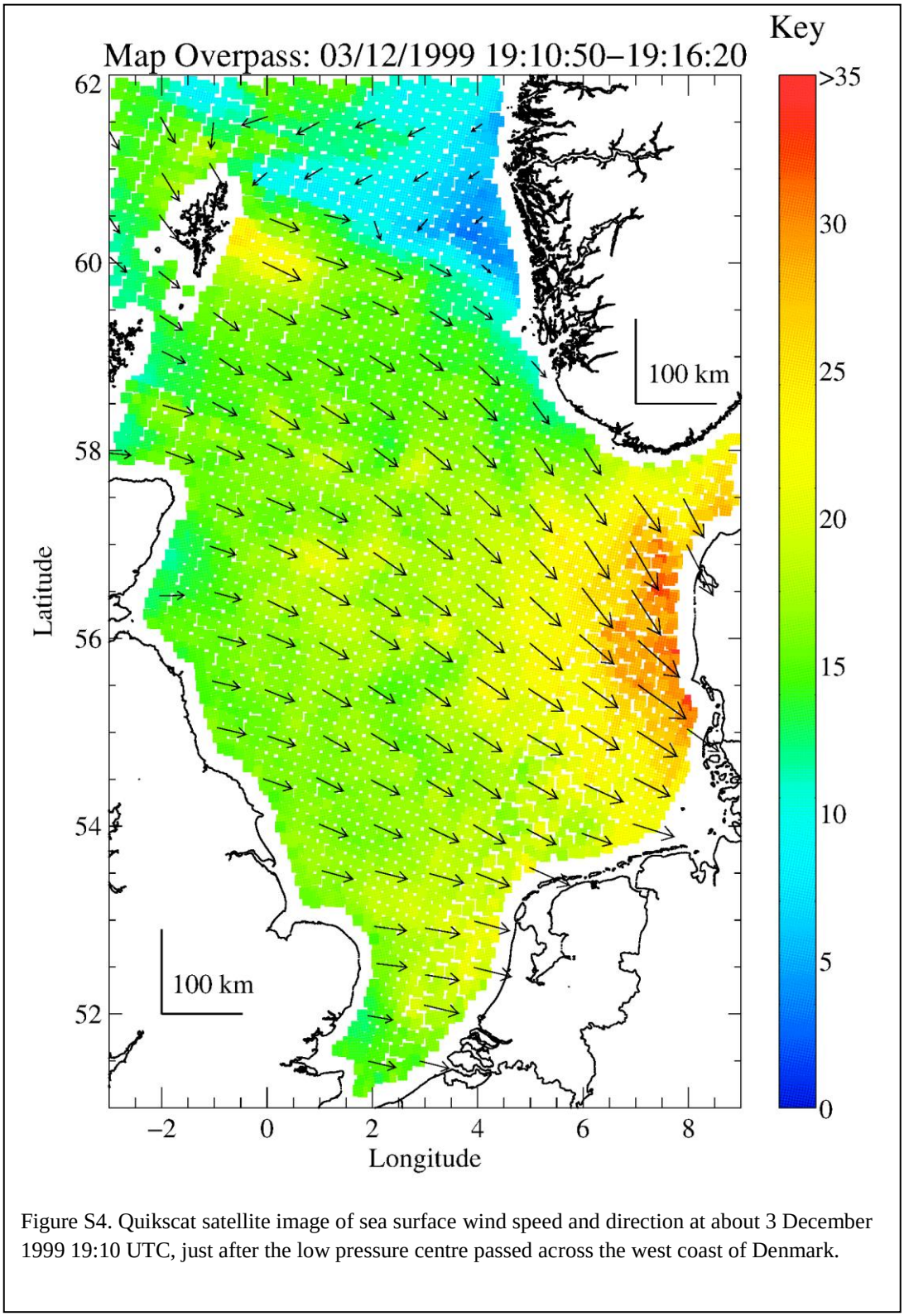

Figure S4. Quikscat satellite image of sea surface wind speed and direction at about 3 December 1999 19:10 UTC, just after the low pressure centre passed across the west coast of Denmark.

SECTION IV. Radiosonde analysis across the period of Storm Anatol 3–4 December 1999

Explanation: Radiosonde data for Europe were downloaded from the University of Wyoming archival website at http://weather.uwyo.edu/upperair/sounding.html. The locations of the stations are shown in Fig. S5a. The data for the time period 20 November 1999–10 December 1999 were selected for analysis. Most of the stations had radiosonde ascents at 12 h intervals, although some had data at 6 h intervals. The original data sets included primary profile measurements (pressure, height, temperature, dew point temperature, wind speed, and wind direction), derived profile measurements (relative humidity, mixing ratio, and potential temperature) and a number of diagnostic values including convective available potential energy (CAPE) and lifted condensation level. Of these, height and wind speed data are presented here. Time series of vertical profiles of wind speed are shown in Fig. S5b–d for three stations showing the highest upper tropospheric wind speeds at the time of Storm Anatol on 3–4 December 1999 (Nottingham, Bergen in northern Germany, and Koebenhavn). Of these, the unusually high wind speed features of Bergen and Koebenhavn have been previously pointed out by DWD (2000), and these stations are near the path greatest gust damage along central and southern Denmark. The upper tropospheric wind speeds of ~80 m/s would have marked this storm as a category 5 hurricane if the wind speeds had been registered as a 10 minute sustained average at 10 m height above the ground surface. Latitude-height profiles of wind speed are shown for stations in central and western Europe at 3 December 1999 at 12:00 UTC (Fig. 5e) and 4 December 1999 at 00:00 UTC (Fig. 5f). The figures emphasize the presence of high wind speed jets over Denmark and northern Germany at the time of the storm.

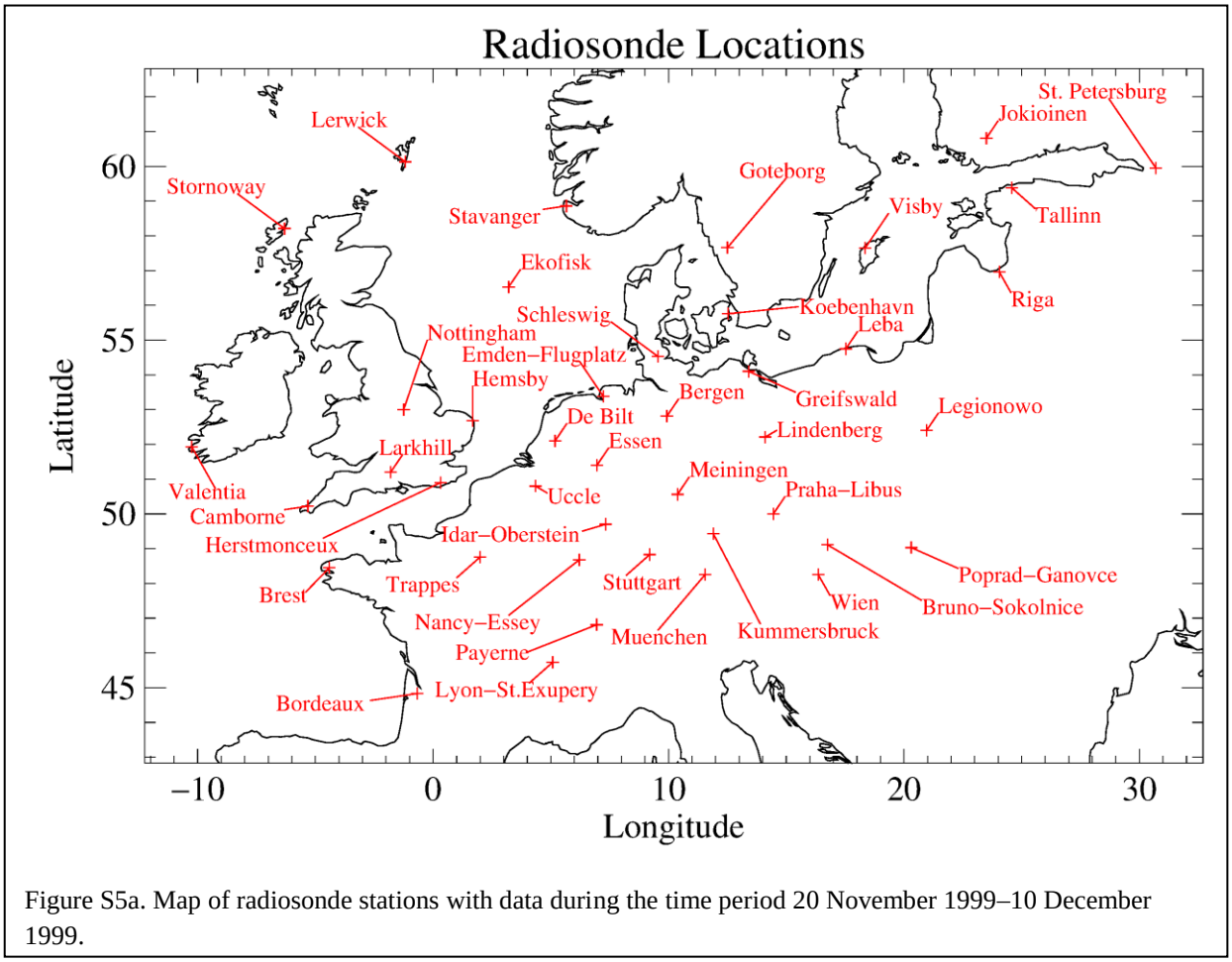

Figure S5a. Map of radiosonde stations with data during the time period 20 November 1999–10 December 1999.

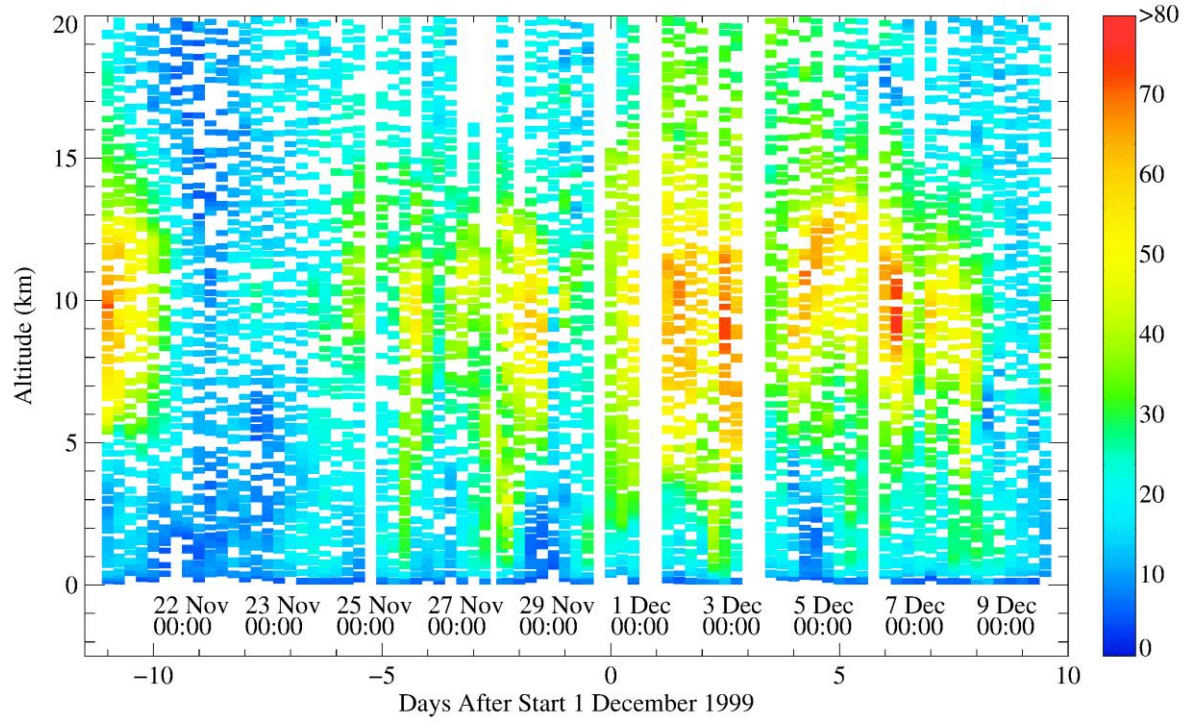

Figure S5b. Time series of vertical profiles of wind speed for the radiosonde station at Nottingham for the period 20 November 1999–10 December 1999.

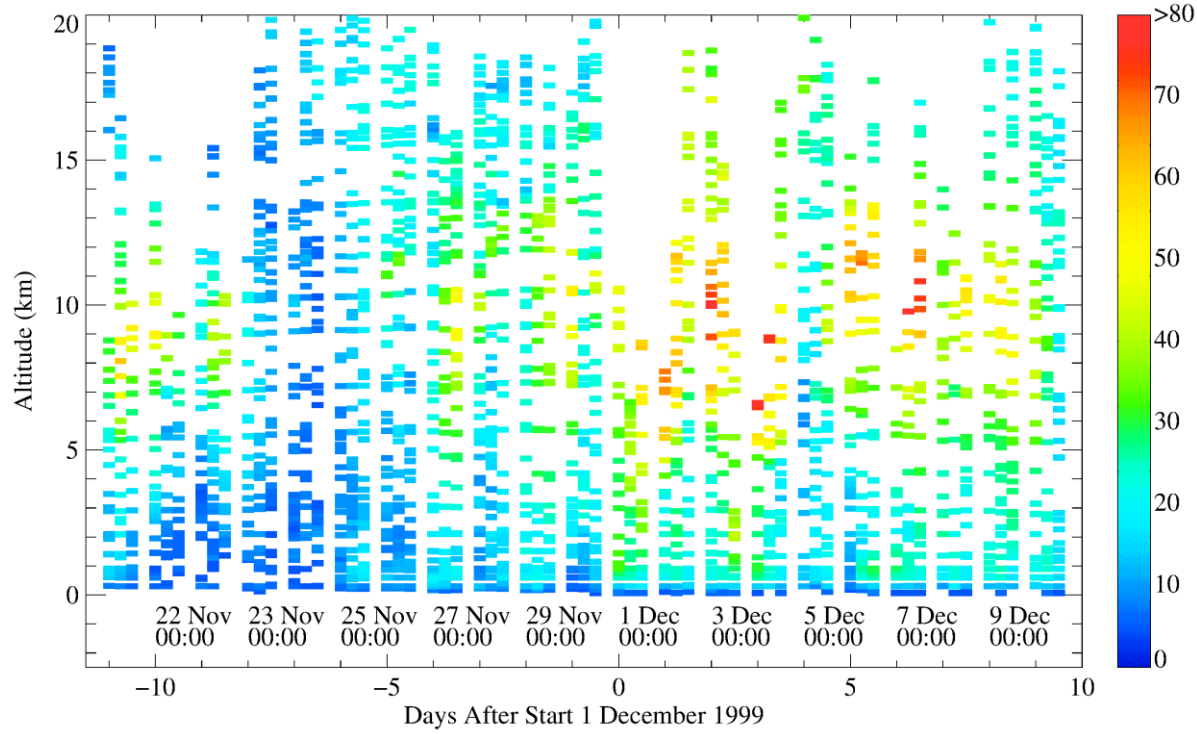

Figure S5c. Time series of vertical profiles of wind speed for the radiosonde station at Bergen in northern Germany for the period 20 November 1999–10 December 1999.

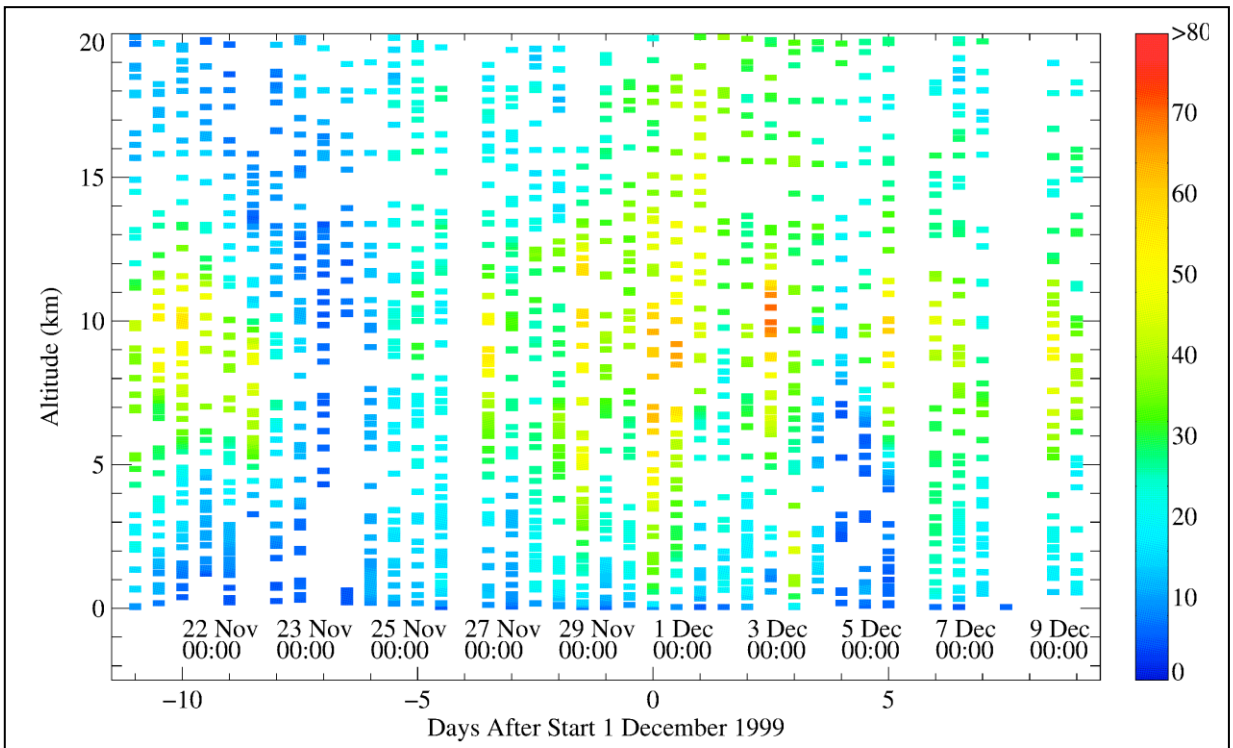

Figure S5d. Time series of vertical profiles of wind speed for the radiosonde station at Koebenhavn for the period 20 November 1999–10 December 1999.

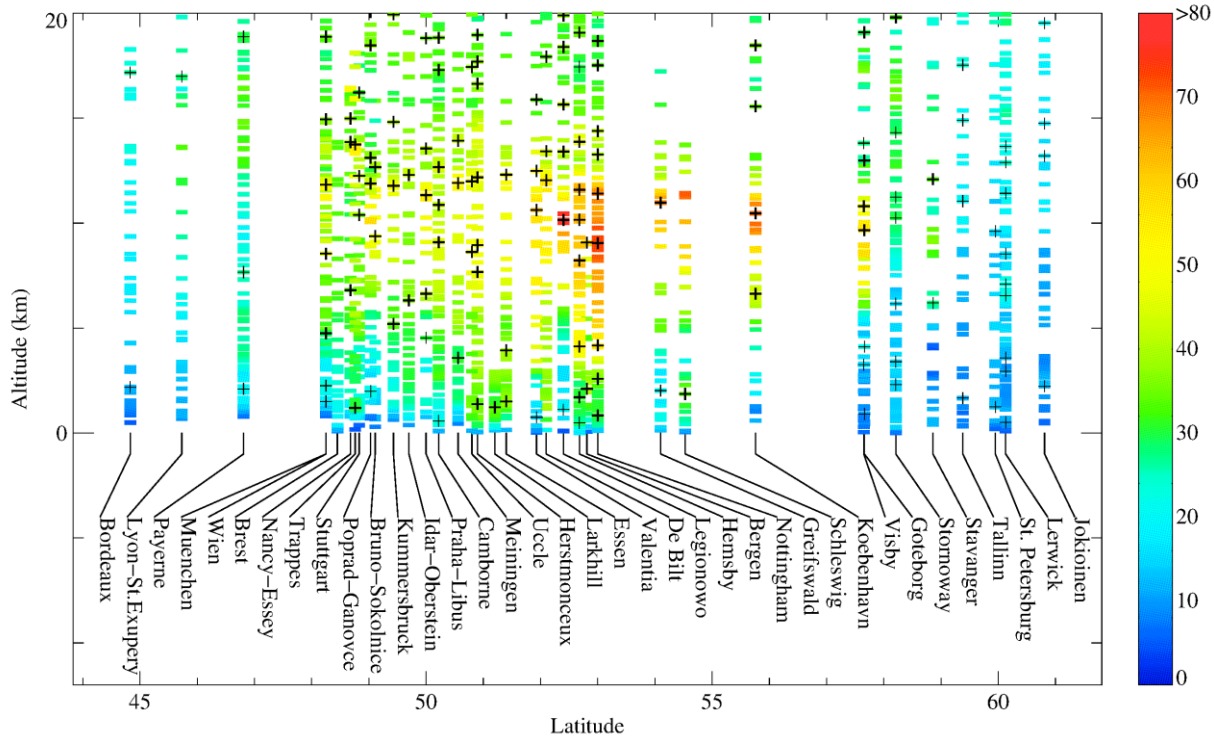

Figure S5e. Latitude-height section of radiosonde wind speeds for stations in central and western Europe on 3 December 1999 at 12:00 UTC. Crosses mark local maxima in the wind speed profiles, and bold crosses indicate local maximum wind speeds exceeding 32 m/s.

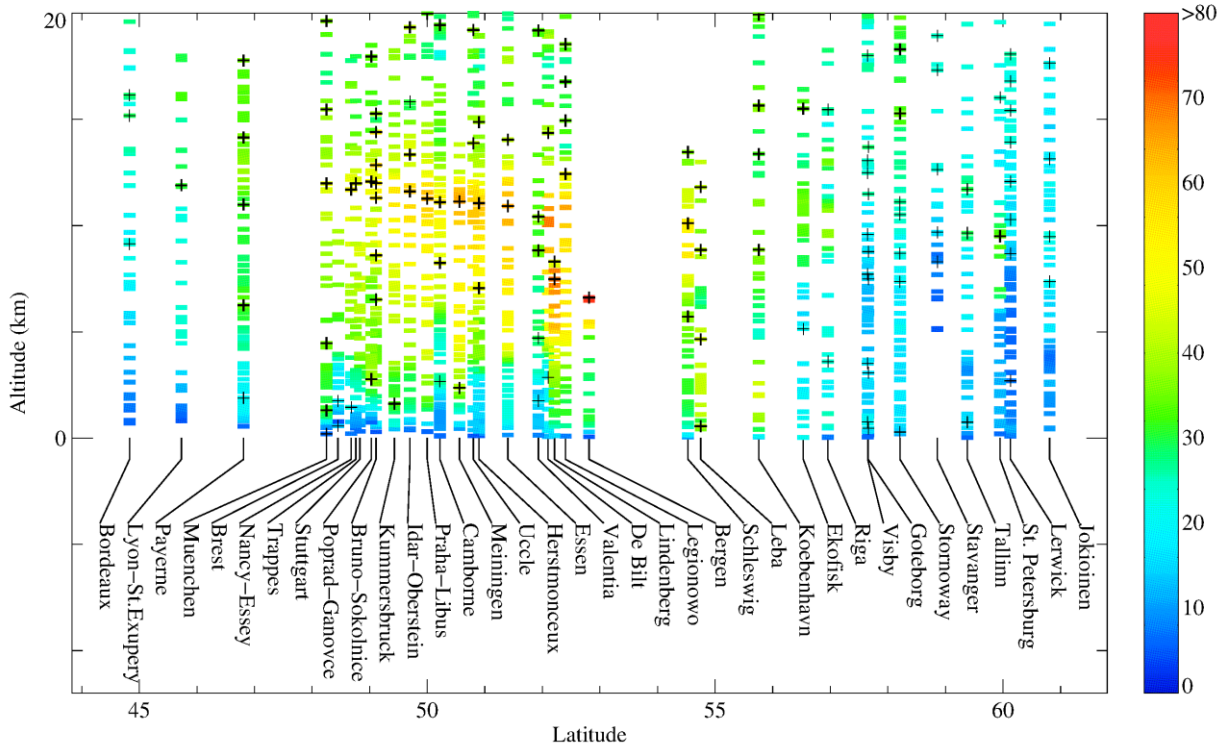

Figure S5f. Latitude-height section of radiosonde wind speeds for stations in central and western Europe on 4 December 1999 at 00:00 UTC. Crosses mark local maxima in the wind speed profiles, and bold crosses indicate local maximum wind speeds exceeding 32 m/s.

SECTION V. Thematic maps of storm impacts during Storm Anatol 3–4 December 1999

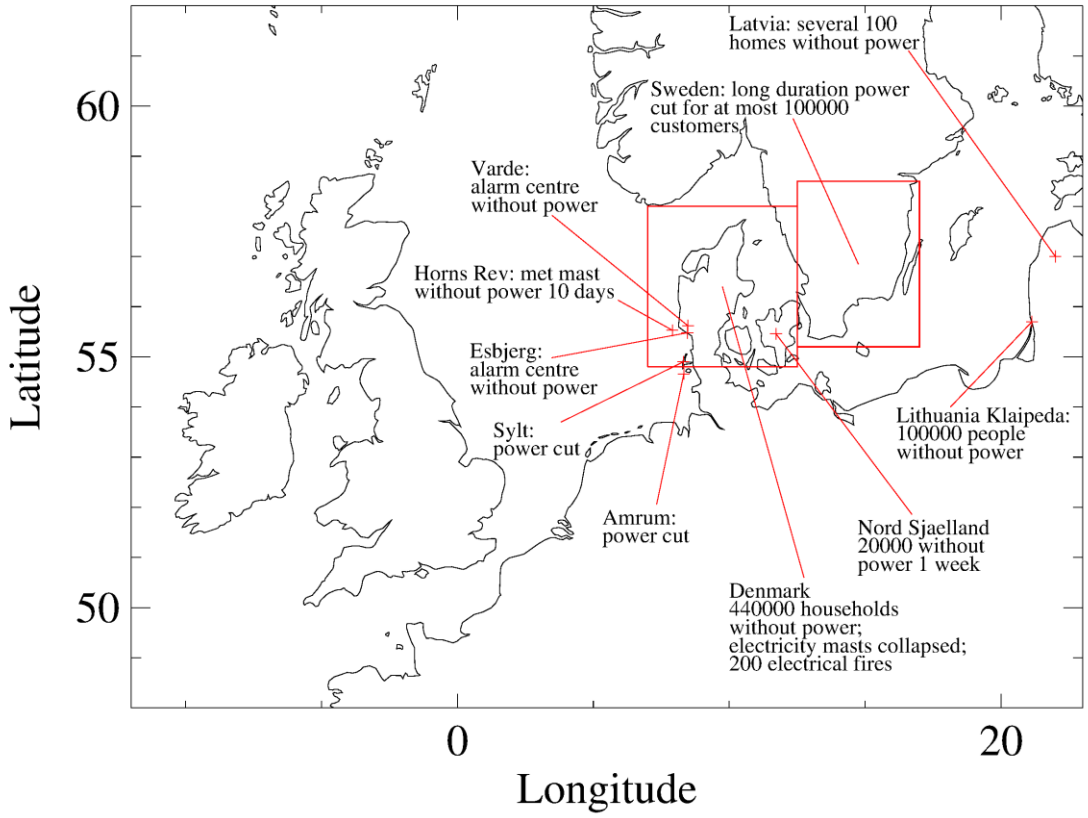

Figure S6. Thematic map of power outages reported in the literature during Storm Anatol 3–4 December 1999.

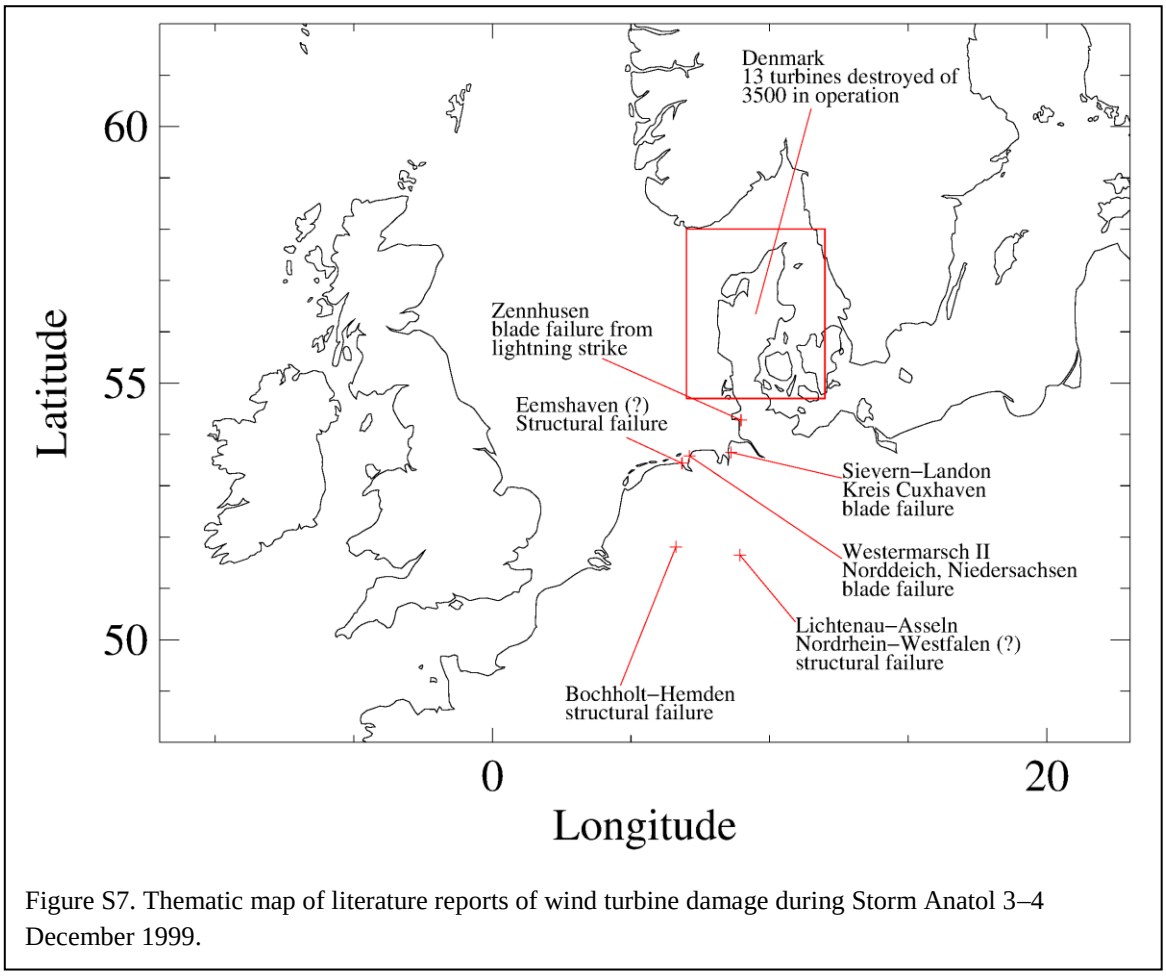

Figure S7. Thematic map of literature reports of wind turbine damage during Storm Anatol 3–4 December 1999.

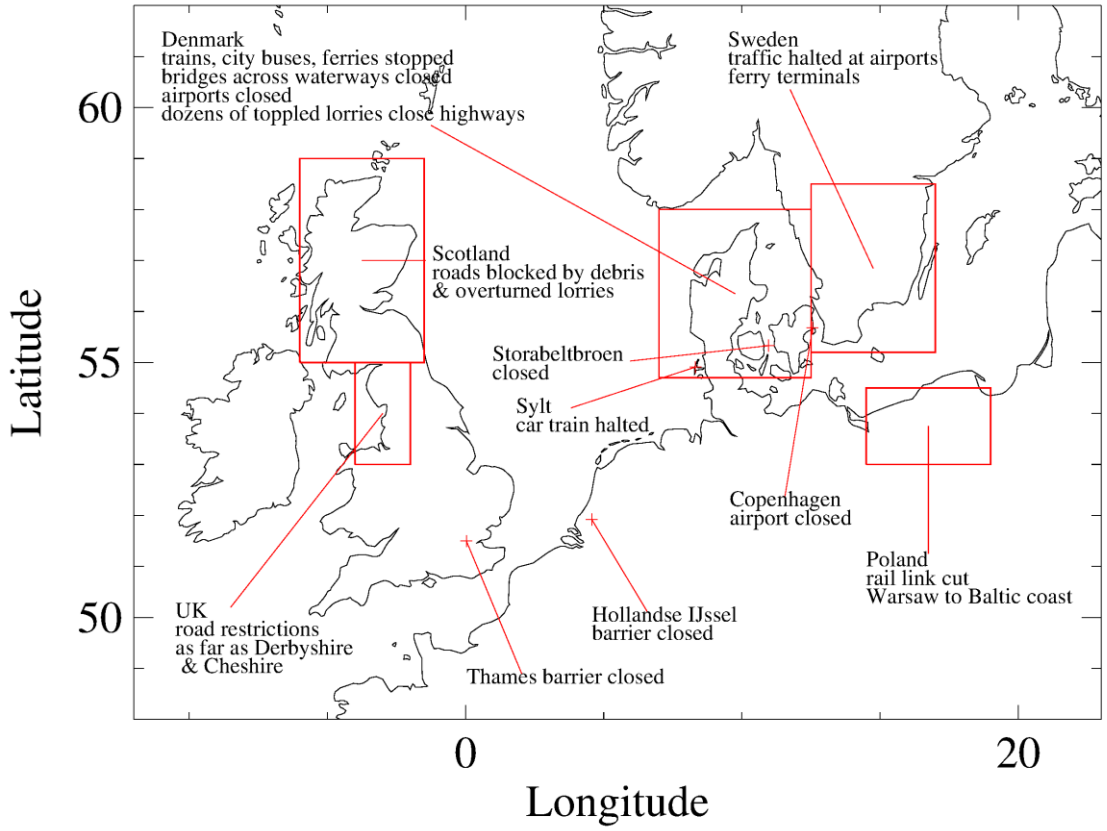

Figure S8. Thematic map of travel and transport interruptions during Storm Anatol 3–4 December 1999.

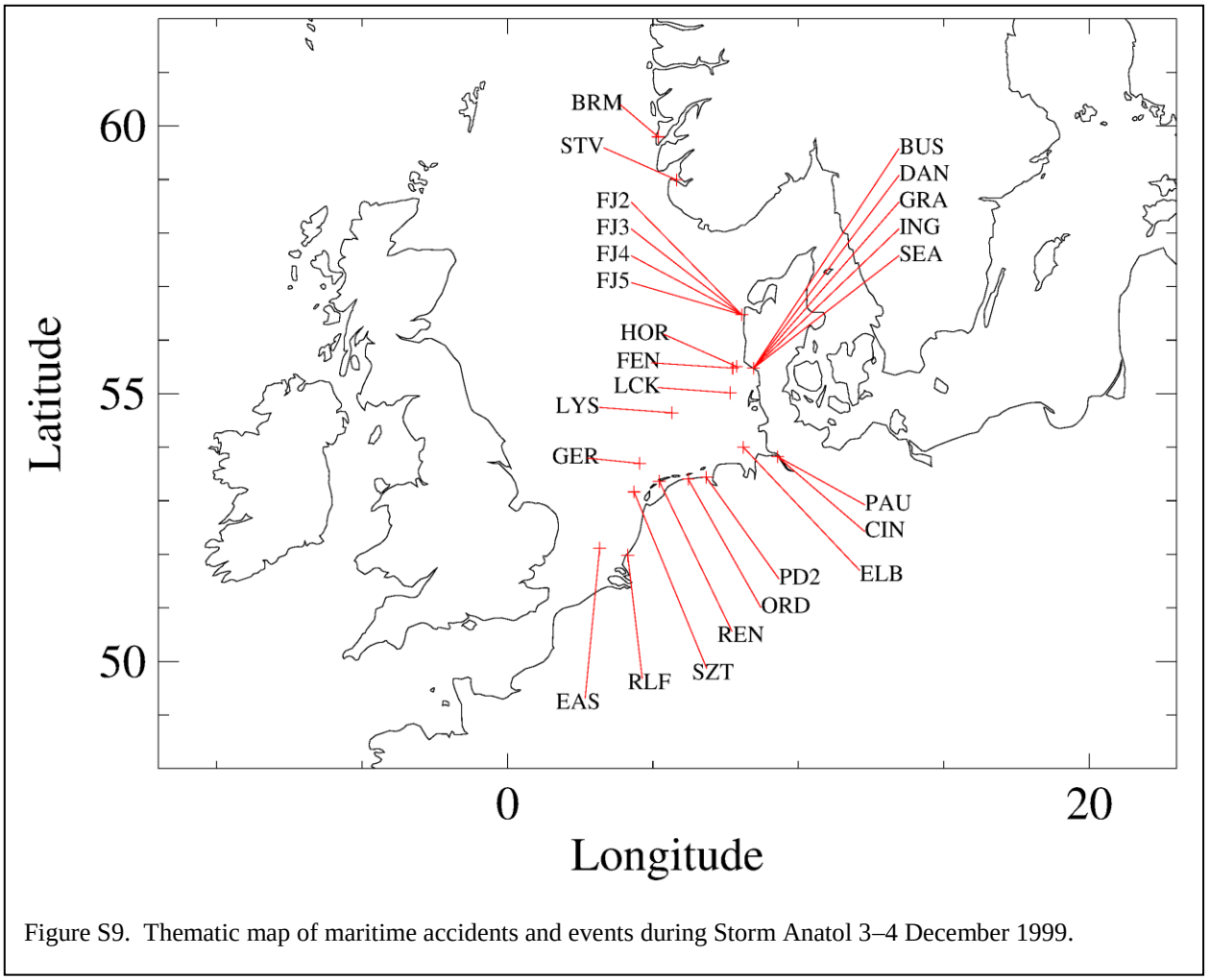

Figure S9. Thematic map of maritime accidents and events during Storm Anatol 3–4 December 1999.

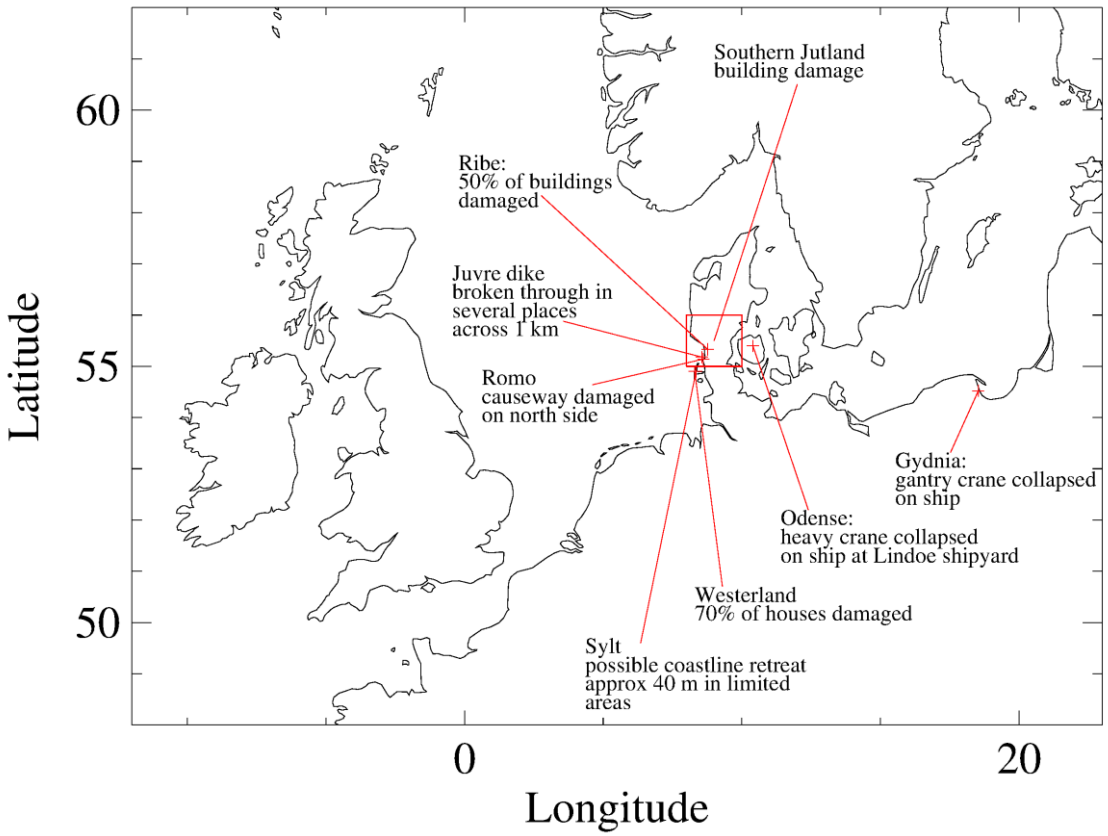

Figure S10. Thematic map of infrastructure and coastal dike damage during Storm Anatol 3–4 December 1999.

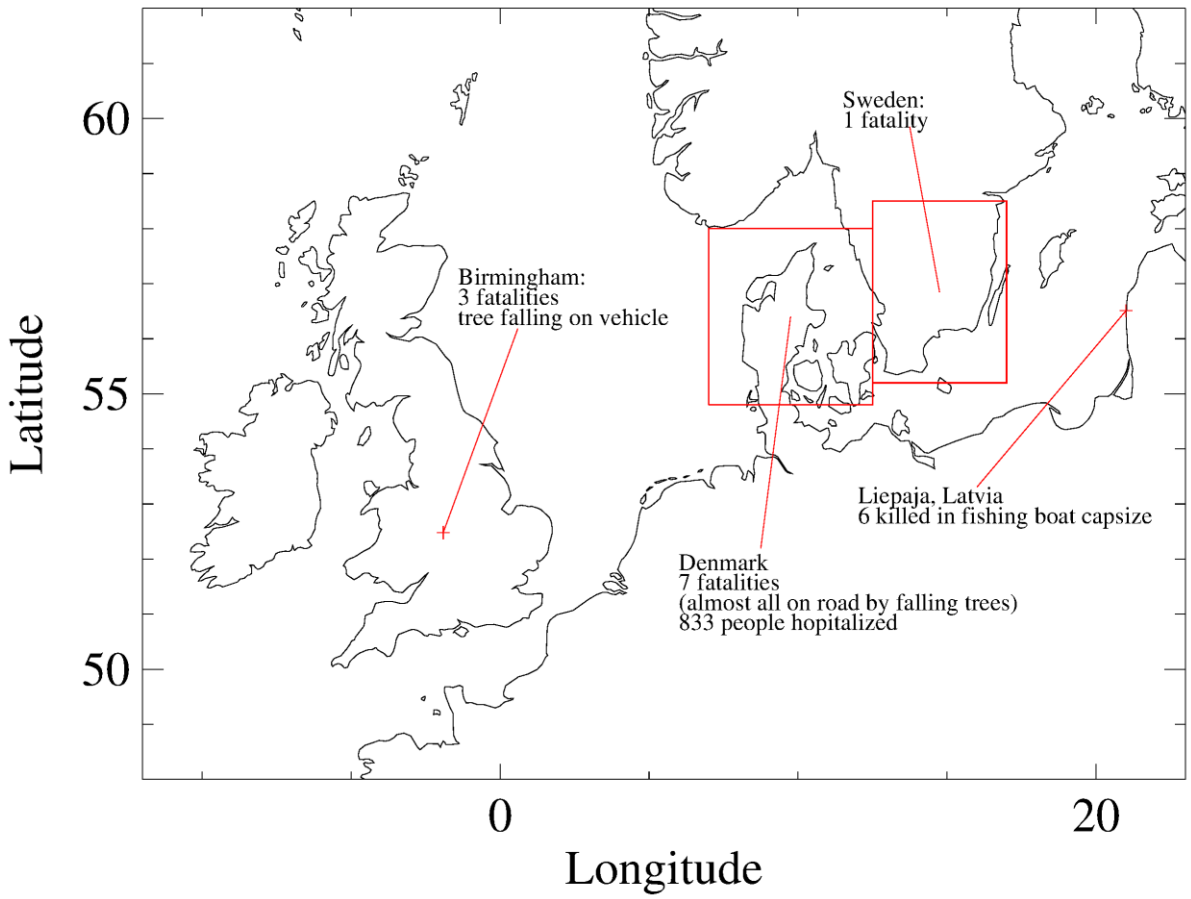

Figure S11. Thematic map of fatalities and injuries during Storm Anatol 3–4 December 1999.

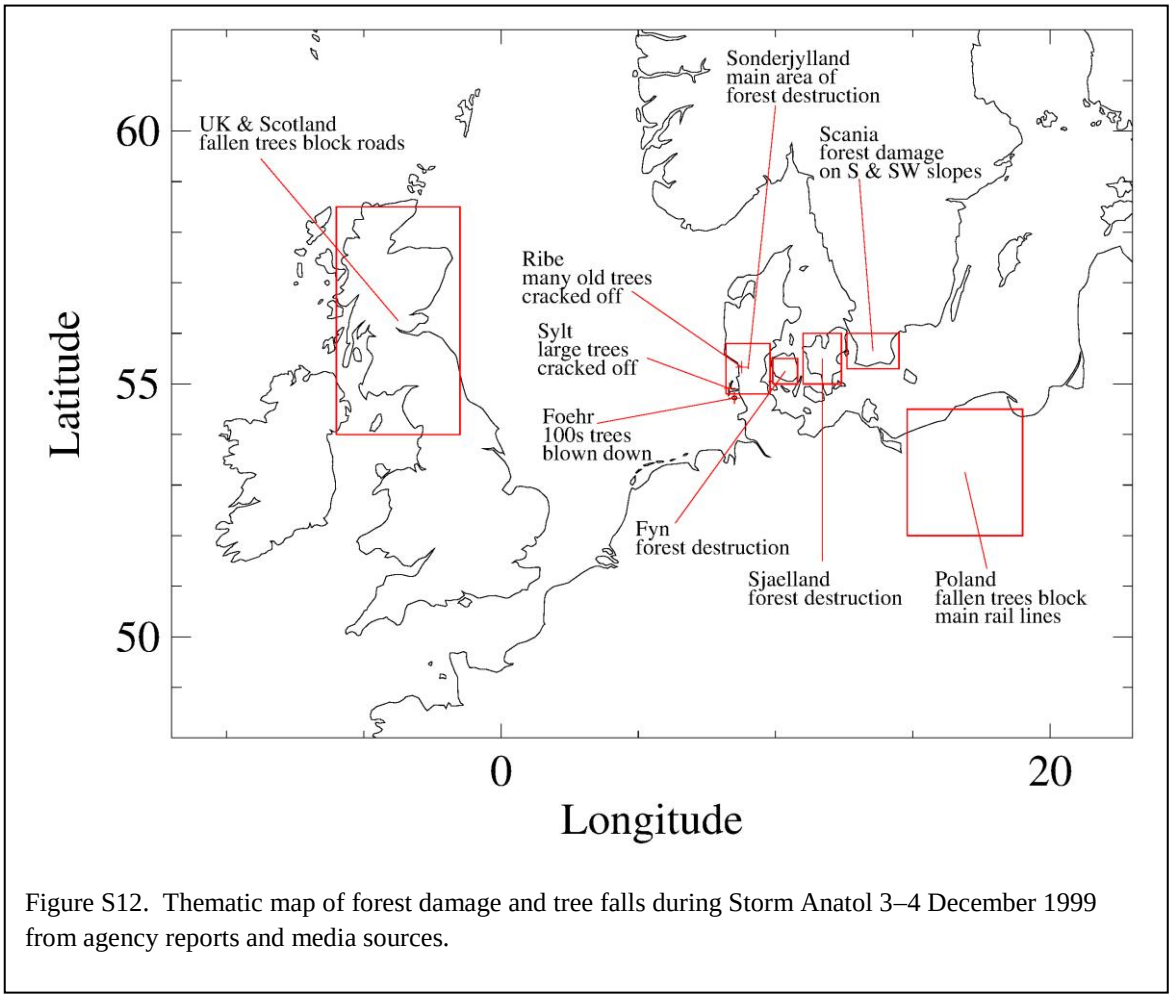

Figure S12. Thematic map of forest damage and tree falls during Storm Anatol 3–4 December 1999 from agency reports and media sources.

SECTION VI. Coastline modification on the west side of the German island of Sylt

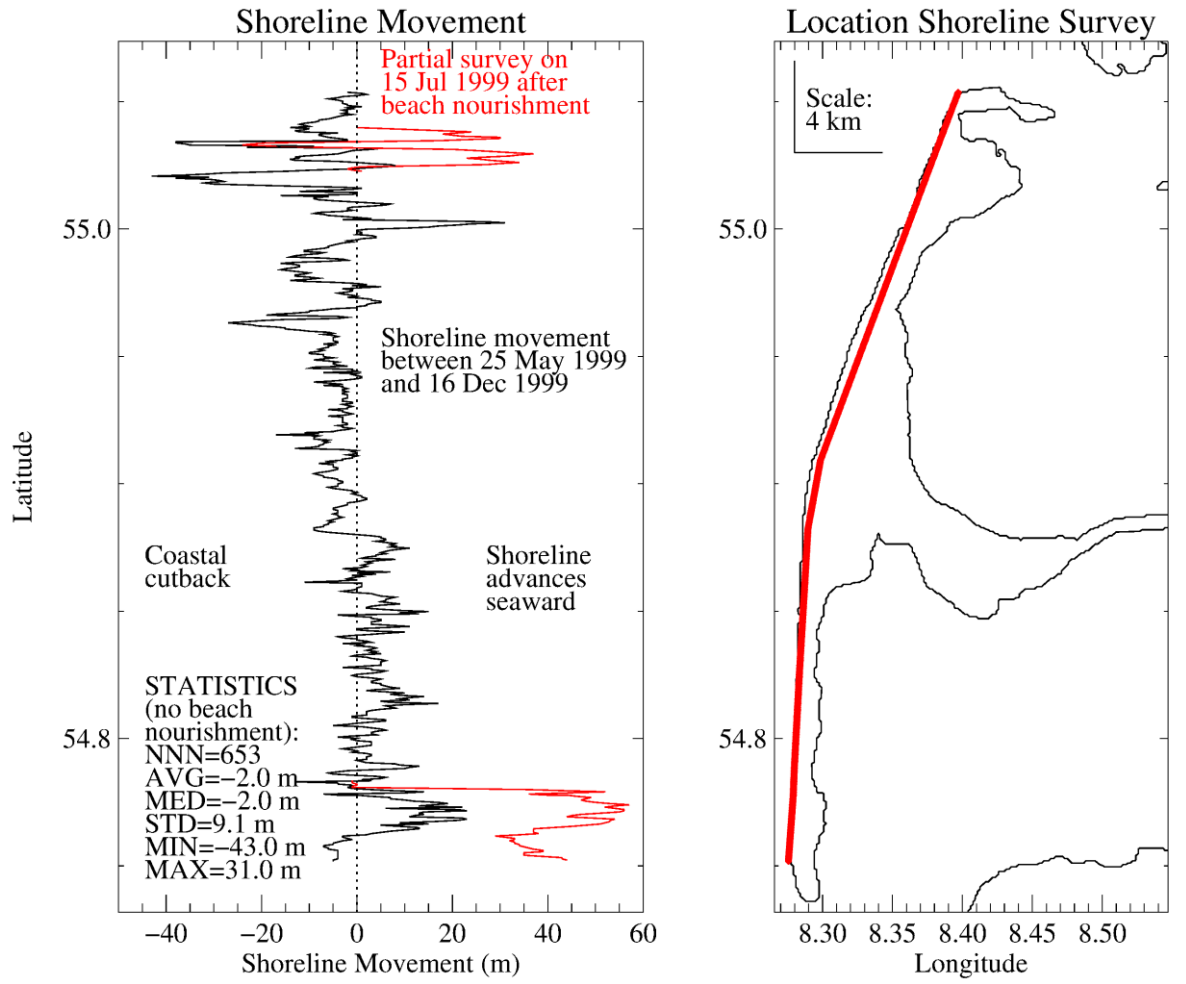

Figure S13. (a) Shoreline change at 3.75 m above sea level on 16 December 1999 with respect to a baseline measurement on 25 May 1999 (black line) and a partial shoreline change from a partial survey on 15 July 1999 with respect to 25 May 1999 (red line), focussing on beach nourishment areas at the northern and southern ends of Sylt that had been carried out inthe summer of 1999. Statistics for the sections not affected by beach nourishment indicate an average shoreline retreat of ~2 m and a maximum retreat of >40 m. Storm Anatol was the worst storm within the survey period. (b) Map showing the approximate locations of the survey profiles. Data for these graphs was sent by Arfst Hinrichsen (Landesbetrieb fuer Kuestenschutz, Nationalpark, und Meereschutz Schleswig-Holstein).

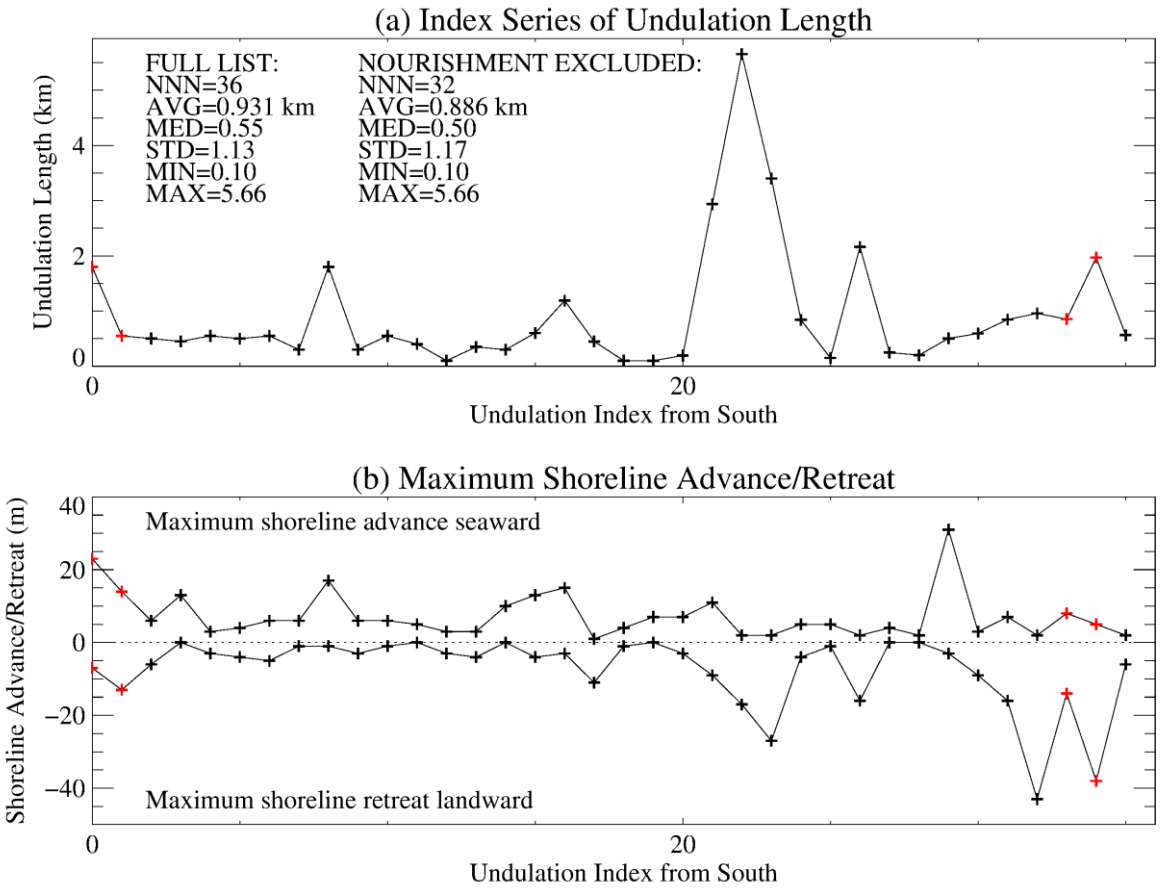

Figure S14. (a) Length of the shoreline modification undulations on the west coast of Sylt based on surveys carried out on 25 May 1999, 15 July 1999, and 16 December 1999. The median undulation 'wavelength' or repeat pattern is ~500 m. (b) Maximum shoreline advance and retreat for each undulation along the length of the west coast of Sylt. Areas of beach nourishment during the summer of 1999 have been marked with red crosses.

SECTION VII. Power spectra of water level data from UK east coast tide gauge stations

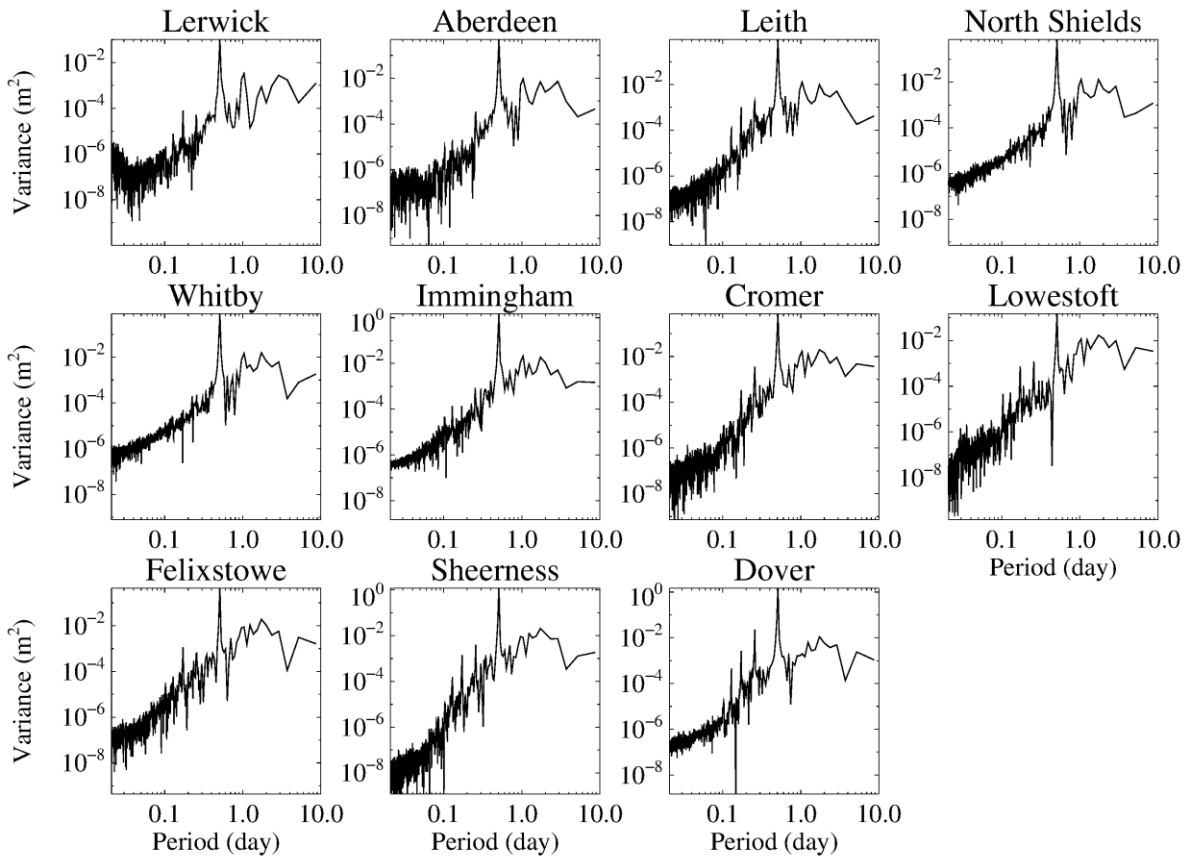

Figure S15. Spectra of water level time series measurements for tide gauge stations along the east coast of the UK for the 13 day period from 24 November 1999 to 6 December 1999 inclusive. The stations have been ordered from north to south.

SECTION VIII. Table of tide gauge stations used in the investigation

Table S2. Tide gauge information for 89 sites in the United Kingdom, France, the Netherlands, Germany, Denmark, and Norway.

N	Station Name	Abb	Country	Latitude (degree)	Longitude (degree)	Δt orig (min)	Δt use (min)	Source
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
1	North_Shields	NS	UK	55.01	−1.44	15	15	BODC
2	Lerwick	LW	UK	60.15	−1.14	15	15	BODC
3	Aberdeen	AB	UK	57.14	−2.07	15	15	BODC
4	Leith	LE	UK	55.99	−3.18	15	15	BODC
5	Whitby	WH	UK	54.49	−0.61	15	15	BODC
6	Immingham	IM	UK	53.63	−0.19	15	15	BODC
7	Cromer	CR	UK	52.93	1.30	15	15	BODC
8	Lowestoft	LT	UK	52.47	1.75	15	15	BODC
9	Felixstowe	FE	UK	51.96	1.35	15	15	BODC
10	Sheerness	SH	UK	51.44	0.74	15	15	BODC
11	Dover	DV	UK	51.12	1.32	15	15	BODC
12	Calais	CA	FR	50.97	1.87	60	60	GESLA
13	Dunkerque	DK	FR	51.05	2.37	60	60	GESLA
14	K13a platform	KP	NE	53.22	3.22	10	10	RWS
15	Lichteiland Goeree	LG	NE	51.92	3.67	10	10	RWS
16	Cadzand	CZ	NE	51.38	3.38	10	10	RWS
17	Terneuzen	TE	NE	51.34	3.82	10	10	RWS
18	Hansweert	HW	NE	51.45	4.01	10	10	RWS
19	Bath	BA	NE	51.40	4.21	10	10	RWS
20	Bergse Diepsluis west	BD	NE	51.51	4.17	10	10	RWS
21	Stavenisse	SE	NE	51.60	4.01	10	10	RWS
22	Krammersluizen west	KM	NE	51.66	4.14	10	10	RWS
23	Haringvliet 10	HT	NE	51.86	3.86	10	10	RWS
24	Spijkenisse	SJ	NE	51.86	4.33	10	10	RWS
25	Goidschalxoord	GX	NE	51.83	4.45	10	10	RWS
26	Vlaardingen	VD	NE	51.90	4.35	10	10	RWS
27	Hoek van Holland	HH	NE	51.98	4.12	10	10	RWS
28	Dordrecht	DD	NE	51.82	4.67	10	10	RWS
29	Rotterdam	RD	NE	51.92	4.50	10	10	RWS
30	Krimpen a/d Lek	KL	NE	51.89	4.63	10	10	RWS
31	Scheveningen	SC	NE	52.10	4.26	10	10	RWS
32	Schoonhoven	SO	NE	51.94	4.85	10	10	RWS
33	IJmuiden buitenhaven	IJ	NE	52.46	4.55	10	10	RWS
34	Den Helder	DH	NE	52.96	4.74	10	10	RWS
35	Den Oever buiten	DO	NE	52.93	5.05	10	10	RWS
36	Oudeschild	OS	NE	53.04	4.85	10	10	RWS
37	Texel Noordzee	TX	NE	53.12	4.73	10	10	RWS
38	Kornwerderzand buiten	KW	NE	53.07	5.34	10	10	RWS
39	Vlieland haven	VH	NE	53.30	5.09	10	10	RWS
40	Harlingen	HL	NE	53.18	5.41	10	10	RWS

Table S2 (continued).

N [1]	Station Name [2]	Abb [3]	Country [4]	Latitude (degree) [5]	Longitude (degree) [6]	Δt orig (min) [7]	Δt use (min) [8]	Source [9]
41	West−Terschelling	TL	NE	53.36	5.22	10	10	RWS
42	Terschelling Noordzee	TN	NE	53.44	5.33	10	10	RWS
43	Nes	NE	NE	53.43	5.76	10	10	RWS
44	Wierumergronden	WG	NE	53.52	5.96	10	10	RWS
45	Lauwersoog	LR	NE	53.41	6.20	10	10	RWS
46	Schiermonnikoog	SM	NE	53.47	6.20	10	10	RWS
47	Huibertgat	HG	NE	53.57	6.40	10	10	RWS
48	Eemshaven	EE	NE	53.45	6.83	10	10	RWS
49	Delfzijl	DF	NE	53.33	6.93	10	10	RWS
50	Knock	KN	DE	53.33	7.04	1	10	BAFG
51	Emden−Neue−Seeschleuse	EM	DE	53.34	7.20	1	10	BAFG
52	Borkum−Fischerbalje	BF	DE	53.56	6.75	1	10	BAFG
53	Bremen−Grosse−Weserbruecke	BW	DE	53.07	8.80	1	10	BAFG
54	Norderney−Riffgat	ND	DE	53.70	7.16	1	10	BAFG
55	Zollenspieker	ZO	DE	53.40	10.19	1	10	BAFG
56	Hamburg−St−Pauli	HB	DE	53.55	9.97	1	10	BAFG
57	Pinnau−Sperrwerk−AP	PS	DE	53.67	9.56	1	10	BAFG
58	Kollmar	KO	DE	53.73	9.46	1	10	BAFG
59	Glueckstadt	GL	DE	53.78	9.41	1	10	BAFG
60	LT−Alte−Weser	AW	DE	53.86	8.13	1	10	BAFG
61	Stoer−Sperrwerk−AP	SS	DE	53.83	9.40	1	10	BAFG
62	Cuxhaven−Steubenhoeft	CU	DE	53.87	8.72	1	10	BAFG
63	Brunsbuettel−Mole4	BR	DE	53.89	9.14	1	10	BAFG
64	Mittelgrund	MG	DE	53.94	8.63	1	10	BAFG
65	Zehnerloch	ZE	DE	53.95	8.66	1	10	BAFG
66	Scharhoern	SN	DE	53.97	8.46	1	10	BAFG
67	Bake−Z	BZ	DE	54.01	8.32	1	10	BAFG
68	Buesum	BU	DE	54.12	8.86	1	10	BAFG
69	Helgoland−Binnenhafen	HE	DE	54.18	7.90	1	10	BAFG
70	Helgoland−Suedhafen	HS	DE	54.18	7.90	1	10	BAFG
71	Eidersperrwerk−AP	EI	DE	54.26	8.84	1	10	BAFG
72	Husum	HU	DE	54.47	9.02	1	10	BAFG
73	Pellworm	PW	DE	54.50	8.70	1	10	BAFG
74	Wittduen	WI	DE	54.63	8.39	1	10	BAFG
75	Dagebuell	DA	DE	54.73	8.69	1	10	BAFG
76	Hoernum	HR	DE	54.76	8.31	1	10	BAFG
77	List	LS	DE	55.02	8.45	1	10	BAFG
78	Hojer	HO	DK	54.96	8.66	15	15	KDI
79	Havneby	HY	DK	55.09	8.57	15	15	KDI
80	Ballum	BM	DK	55.13	8.69	15	15	KDI

Table S2 (continued).

N	Station Name	Abb	Country	Latitude (degree)	Longitude (degree)	Δt orig (min)	Δt use (min)	Source
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
81	Esbjerg	EJ	DK	55.47	8.42	15	15	KDI
82	Hvide Sande (Havet)	HV	DK	56.00	8.11	15	15	KDI
83	Thorsminde (Havet)	TO	DK	56.37	8.11	15	15	KDI
84	Ferring	FR	DK	56.52	8.12	15	15	KDI
85	Thyboron (Havet hofde 58)	TY	DK	56.71	8.21	15	15	KDI
86	Tregde	TG	NO	58.01	7.56	10	10	Kartv
87	Stavanger	SV	NO	58.97	5.73	10	10	Kartv
88	Bergen	BG	NO	60.39	5.32	10	10	Kartv
89	Maloy	MY	NO	61.94	5.11	10	10	Kartv

Notes:
[1] Station running index
[2] Station name
[3] Station abbreviation used in figures of the main manuscript
[4] Country
[5] Latitude
[6] Longitude
[7] Data reporting interval in minutes
[8] Data time interval used in analysis; data for the Germany stations was averaged onto a 10 minute grid.
[9] Source:
BODC: (British Oceanographic Data Centre)
https://bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/
GESLA: (Global Extreme Sea Level Analysis) https://www.gesla.org
RWS: (Rijkswatersaat Waterinfo) https://waterinfo.rws.nl/#!/nav/expert/alle-groepen/
BAFG: (Bundesanstalt fuer Gewaesserkunde) email communication with Wilfried Wiechmann at Datenstelle-M1@bafg.de
KDI: (Kystdirektoratet) https://kystatlas.kyst.dk/public2/data/vandstand/vandstand.html
Kartv: (Kartverket) api.sehavniva.no/tideapi_en.html

SECTION IX. Table of maritime accidents and incidents 3–4 December 1999

Table S3. Information for the maritime accidents and offshore events for 3–4 December 1999.

N [1]	Ship/Platform Name or Incident [2]	Abb [3]	Lati–tude (deg) [4]	Longi–tude (deg) [5]	Date (GMT) dd/mm/yyyy [6]	Time GMT hh:mm [7]	Source [8]
1	Bremnes	BRM	59.79	5.18	03/12/1999	01:30	LCW_SR19991217
2	Bussard	BUS	55.48	8.46	03/12/1999	18:00	LCW_SR19991217
3	Cincobulk	CIN	53.82	9.29	03/12/1999	18:00	LCW_SR19991217
4	Dana Hafnia	DAN	55.48	8.46	03/12/1999	18:00	LCW_SR19991217
5	Eastfern	EAS	52.11	3.17	03/12/1999	16:20	LCW_SR19991217,KNRM
6	Fensfjord	FEN	55.48	7.74	04/12/1999	06:45	LCW_SR19991217
7	Gerarda	GER	53.70	4.54	04/12/1999	12:35	LCW_SR19991217,KNRM
8	G.Graadyb	GRA	55.48	8.46	03/12/1999	18:00	LCW_SR19991217
9	Ingrid P	ING	55.48	8.46	03/12/1999	18:00	LCW_SR19991217
10	Lucky Fortune	LCK	55.01	7.66	03/12/1999	17:10	LCW_SR19991217
11	Lys Ranger	LYS	54.64	5.65	03/12/1999	03:00	LCW_SR19991217
12	Oerd	ORD	53.40	6.21	03/12/1999	13:05	LCW_SR19991217,KNRM
13	Paula Ahrens	PAU	53.82	9.29	03/12/1999	12:00	LCW_SR19991217
14	Rolf Buck	RLF	51.98	4.13	03/12/1999	13:05	LCW_SR19991217
15	Sea Explorer	SEA	55.48	8.46	03/12/1999	18:00	LCW_SR19991217
16	Stavanger	STV	58.99	5.81	03/12/1999	11:30	LCW_SR19991217
17	Sztorm–2	SZT	53.17	4.35	03/12/1999	13:05	LCW_SR19991217,KNRM
18	Renasa	REN	53.36	5.22	03/12/1999	17:15	KNRM
19	PD_236	PD2	53.44	6.84	03/12/1999	09:30	KNRM
20	Feuerschiff Elbe	ELB	54.00	8.11	03/12/1999	12:00	JM2008
21	Horns Rev mast	HOR	55.51	7.88	03/12/1999	22:50	S2002
22	Fjaltring wave 2	FJ2	56.47	8.06	03/12/1999	20:45	KDI
23	Fjaltring wave 3	FJ3	56.47	8.06	03/12/1999	18:00	KDI
24	Fjaltring wave 4	FJ4	56.47	8.06	04/12/1999	00:00	KDI
25	Fjaltring wave 5	FJ5	56.47	8.06	03/12/1999	13:45	KDI

Notes:
[1] Running index of event
[2] Ship/platform name or wave measuring instrument with incident number
[3] Abbreviation used in figures of main manuscript
[4] Latitude
[5] Longitude
[6] Date of incident
[7] Time of incident
[8] Source
LCW_SR19991217: Lloyd's Casualty Week: vol. 318, No. 12, 17 December 1999.
KNRM: Koninklijke Nederlandse Redding Maatschappij; list of Dutch coastal rescues emailed by Gerda van Vliet.
JM2008: Jensen J, SH Mueller-Navarra, Storm surges on the German coast, Die Kueste, 74 ICCE (2008), 92-124.
S2002: Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.
KDI: Kystdirektoratet; unusual maximum wave heights registered by the Fjaltring waverider buoy and from online time series data.

SECTION X. Tide gauge levelling differences and corrections to literature surge values

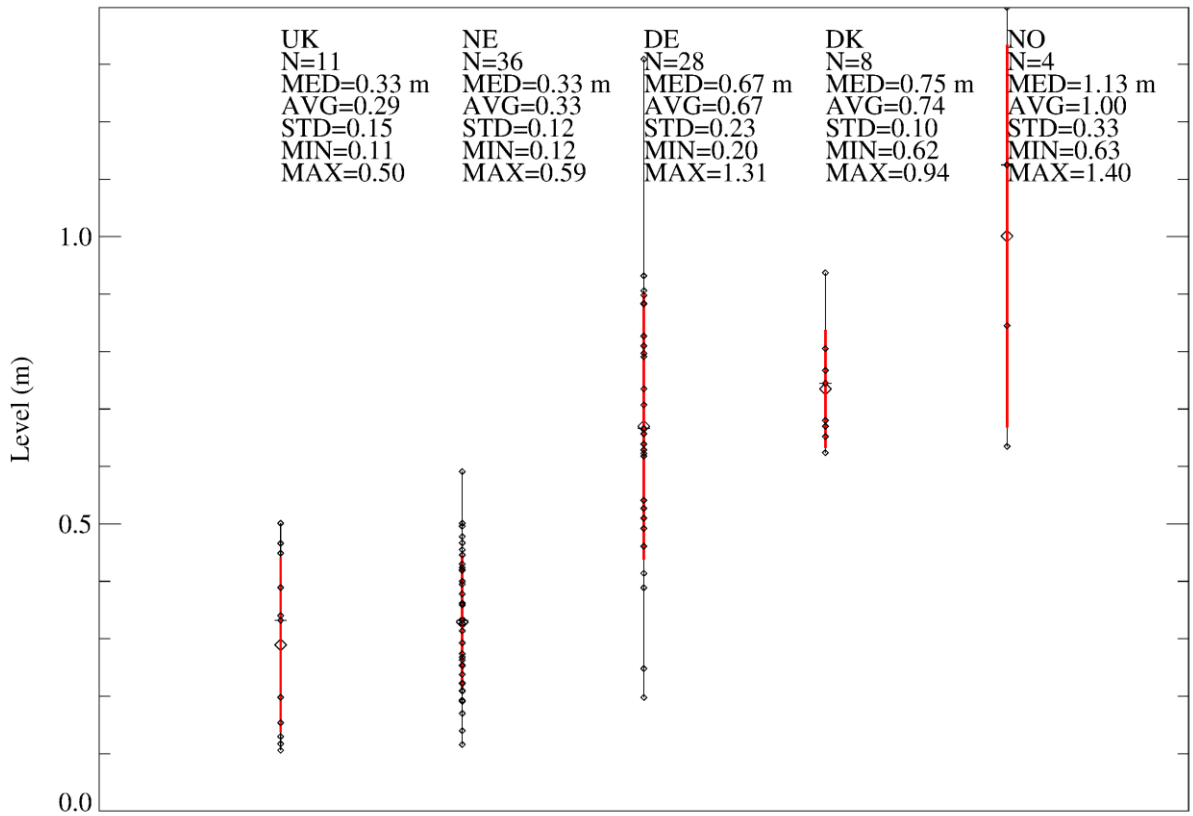

Figure S16. Difference of the reported mean sea level and the 13-day median level calculated from the tide gauge data. The station differences have been separated by country, and statistics from the country collections have been calculated. Norwegian stations show the largest apparent bias of ~1 m. The reason for the apparent bias is unknown.

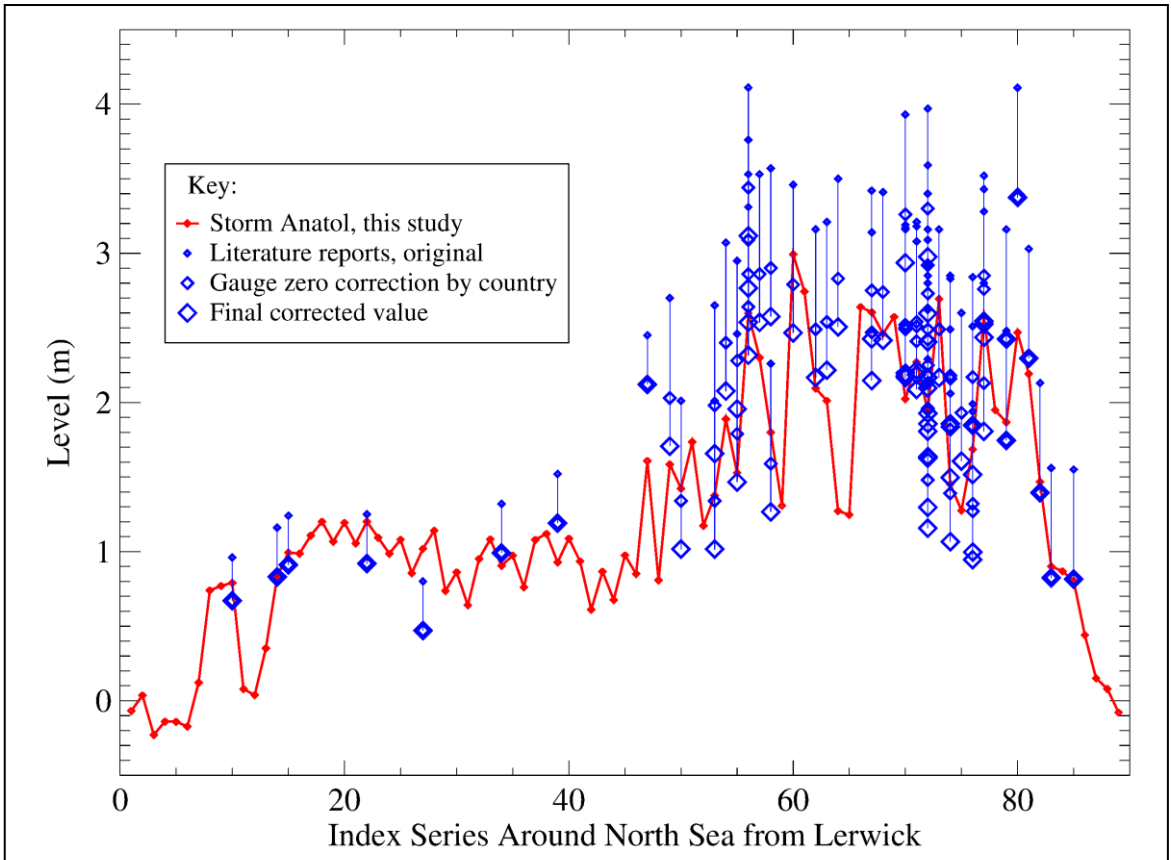

Figure S17. Storm Anatol skew surge for tide gauge stations with index arrangement around the North Sea coast starting from Lerwick in Scotland. The blue symbols give the original literature reports and with corrections applied to compare with the present analysis. The correction relates to the difference between official mean sea level for a station and 13-day mean calculated from the tide gauge data. Corrections to the literature values are made on a country basis using the average of the national collection of stations. An additional correction has been applied to the German literature values to convert from the country convention of measured maximum water level above mean high water to skew surge.

SECTION XI. Maximum amplitude of short period oscillations

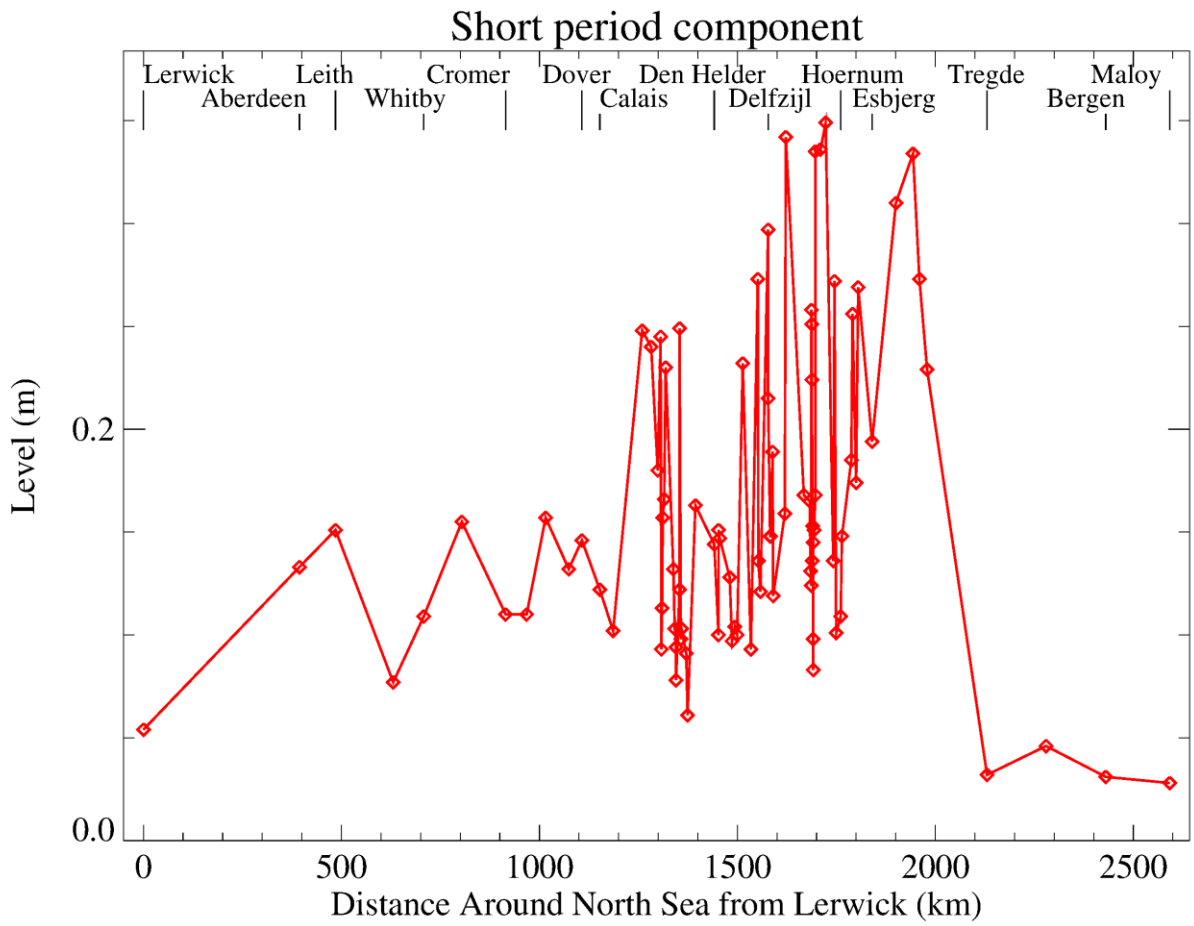

Figure S18. Maximum amplitude of highest short period oscillation during Storm Anatol 3–4 December 1999 versus coastal distance around the North Sea starting from Lerwick in Scotland.

Table S4. List of maximum range (in descending order) of down-crossing oscillations derived from the short period time series reconstructions for each North Sea tide gauge station.

N	Station Name	Range (cm)	Midpoint of Oscillation (h after start 3 Dec 1999)	Duration of Oscillation (h)
1	Bremen−Grosse−Weserbruecke	66.1	43.42	3.33
2	Hvide Sande (Havet)	62.8	11.88	2.75
3	Eidersperrwerk−AP	62.1	16.33	3.17
4	Thorsminde (Havet)	61.7	12.12	2.25
5	Stoer−Sperrwerk−AP	59.7	18.25	3.67
6	Ferring	59.7	12.50	3.00
7	Buesum	59.5	16.92	3.33
8	Bake−Z	52.8	19.67	1.50
9	Pinnau−Sperrwerk−AP	50.8	18.83	3.83
10	Ballum	50.5	16.25	2.50
11	Bath	48.5	9.83	3.67
12	Husum	48.2	22.00	3.83
13	Delfzijl	44.5	19.58	0.83
14	Thyboron (Havet hofde 58)	44.4	12.62	2.75
15	Krammersluizen west	42.4	43.67	2.00
16	Emden−Neue−Seeschleuse	41.6	40.42	3.67
17	Terneuzen	41.5	8.67	3.33
18	Cadzand	41.5	7.83	3.33
19	List	41.1	17.75	3.33
20	Hamburg−St−Pauli	39.8	32.33	3.17
21	Hansweert	38.6	9.25	3.50
22	Brunsbuettel−Mole4	36.3	17.75	3.67
23	Wierumergronden	35.4	13.75	3.50
24	Esbjerg	35.1	12.88	3.75
25	Terschelling Noordzee	34.2	13.83	1.67
26	Kollmar	33.6	18.50	3.83
27	Scheveningen	33.5	13.50	1.67
28	Huibertgat	33.5	14.17	3.33
29	Hojer	33.4	22.00	4.00
30	Zollenspieker	32.2	29.92	4.00
31	Zehnerloch	32.0	16.00	2.83
32	LT−Alte−Weser	31.3	15.25	3.33
33	IJmuiden buitenhaven	30.9	35.25	3.17
34	Bergse Diepsluis west	30.7	35.17	4.00
35	Texel Noordzee	30.7	36.08	3.83
36	Glueckstadt	30.6	18.42	4.00
37	Knock	30.4	40.17	3.83
38	Haringvliet 10	29.7	37.42	3.83
39	Dagebuell	28.1	29.08	3.33
40	Aberdeen	27.8	18.37	2.25
41	Scharhoern	26.6	15.58	3.00
42	Dover	26.6	30.50	4.00
43	Mittelgrund	26.4	4.33	3.83
44	Felixstowe	25.9	19.38	3.25
45	Eemshaven	25.5	38.75	2.83

Table 4 (continued).

N	Station Name	Range (cm)	Midpoint of Oscillation (h after start 3 Dec 1999)	Duration of Oscillation (h)
46	Den Helder	25.2	35.67	3.33
47	Den Oever buiten	25.0	36.83	3.33
48	Cromer	24.5	11.63	2.75
49	Cuxhaven–Steubenhoeft	24.2	4.67	3.83
50	Sheerness	23.4	45.75	4.00
51	Leith	23.3	20.00	3.50
52	Vlieland haven	23.1	20.67	1.67
53	Pellworm	23.0	42.08	3.67
54	Norderney–Riffgat	22.9	25.25	1.00
55	Lauwersoog	22.5	38.50	3.67
56	Havneby	22.1	22.50	4.00
57	Hoek van Holland	21.9	37.83	4.33
58	Immingham	21.6	16.50	3.00
59	Kornwerderzand buiten	21.4	38.17	4.00
60	Lichteiland Goeree	21.0	37.25	3.83
61	Schiermonnikoog	20.7	15.83	3.67
62	Dunkerque	20.2	44.50	3.00
63	Calais	20.2	31.00	4.00
64	Nes	19.9	15.42	3.50
65	Wittduen	19.8	17.83	1.83
66	Hoernum	19.5	27.17	2.50
67	Lowestoft	18.6	38.75	3.50
68	West–Terschelling	18.6	40.92	3.83
69	Rotterdam	18.4	35.25	3.50
70	Oudeschild	18.0	36.17	3.33
71	Krimpen a/d Lek	17.8	35.92	3.50
72	Borkum–Fischerbalje	17.7	38.75	3.00
73	K13a platform	16.9	18.00	3.00
74	Stavenisse	16.3	16.83	3.00
75	Spijkenisse	16.1	34.67	3.67
76	Vlaardingen	15.9	38.75	4.17
77	Dordrecht	15.7	36.00	3.00
78	Harlingen	15.4	25.42	4.17
79	Helgoland–Suedhafen	15.1	15.17	3.50
80	North_Shields	14.6	19.50	3.00
81	Helgoland–Binnenhafen	14.1	25.58	0.67
82	Whitby	13.4	9.00	1.00
83	Goidschalxoord	12.1	35.17	3.33
84	Lerwick	12.0	36.12	3.75
85	Schoonhoven	11.1	14.75	3.83
86	Stavanger	9.2	16.58	3.50
87	Tregde	6.1	24.83	3.33
88	Bergen	5.4	9.25	3.83
89	Maloy	5.4	33.08	1.50

SECTION XII. Range of water level variations across 10 minute intervals for the Germany data set

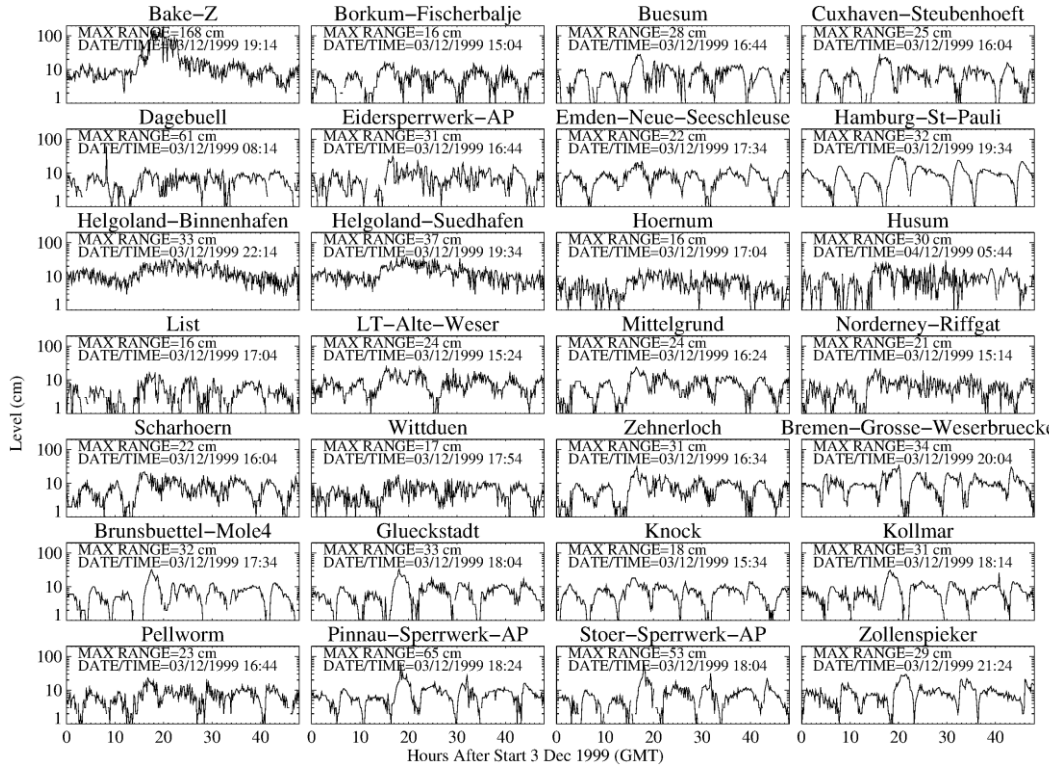

Figure S19. Range of water levels across 10-minute intervals, calculated from the original 1-minute time series data for Germany. The height data have been plotted on a log scale for presentation clarity. The high values for the Bake-Z station are probably erroneous. However, the capsize of a lightship nearby suggests that there were extreme sea state conditions at the site. The data for this graph was sent by Wilfried Wiechmann (Bundesanstalt für Gewasserkunde).

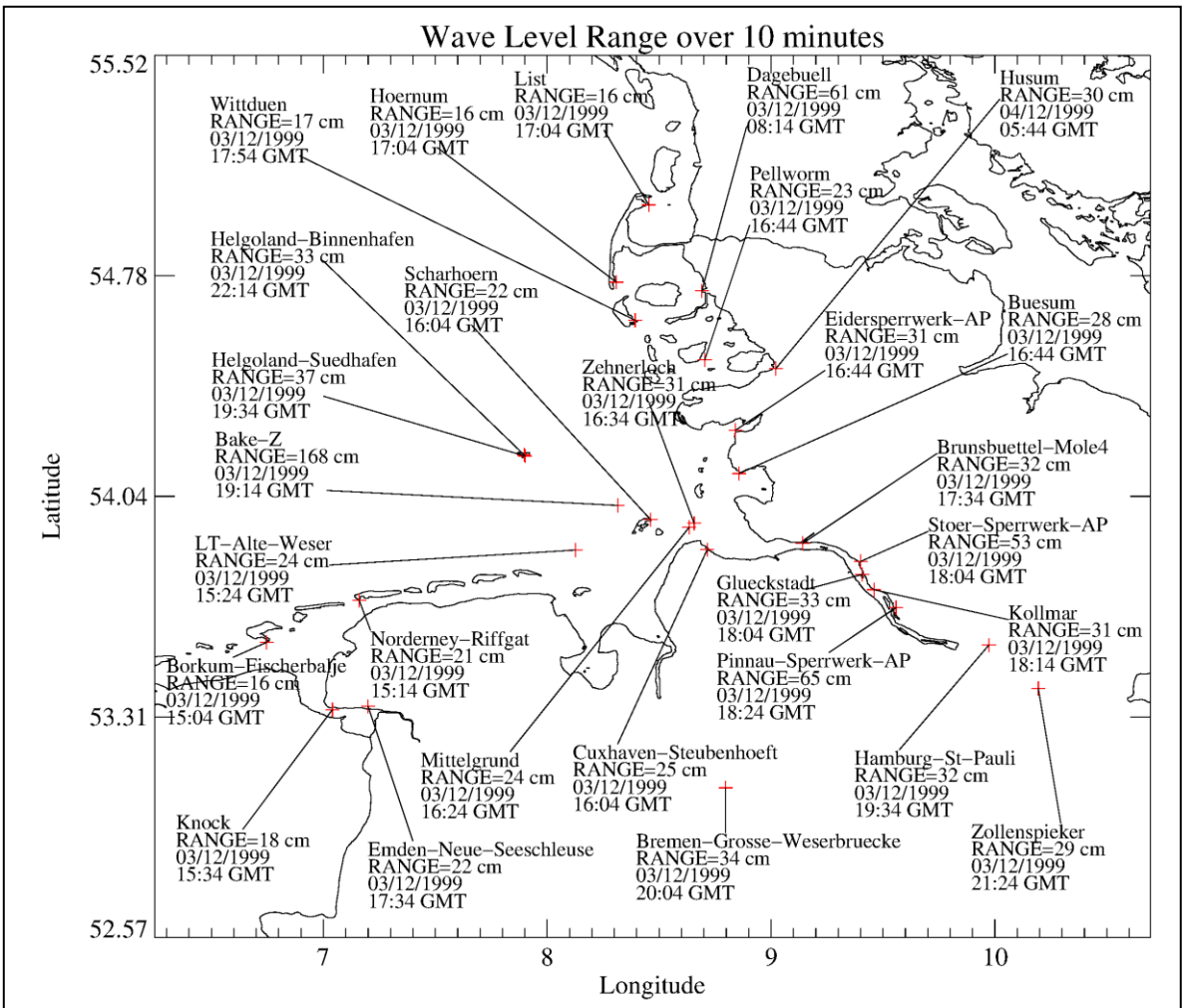

Figure S20. Map showing locations of the German tide gauge stations where the maximum range of water levels in 10-minute intervals were assessed.

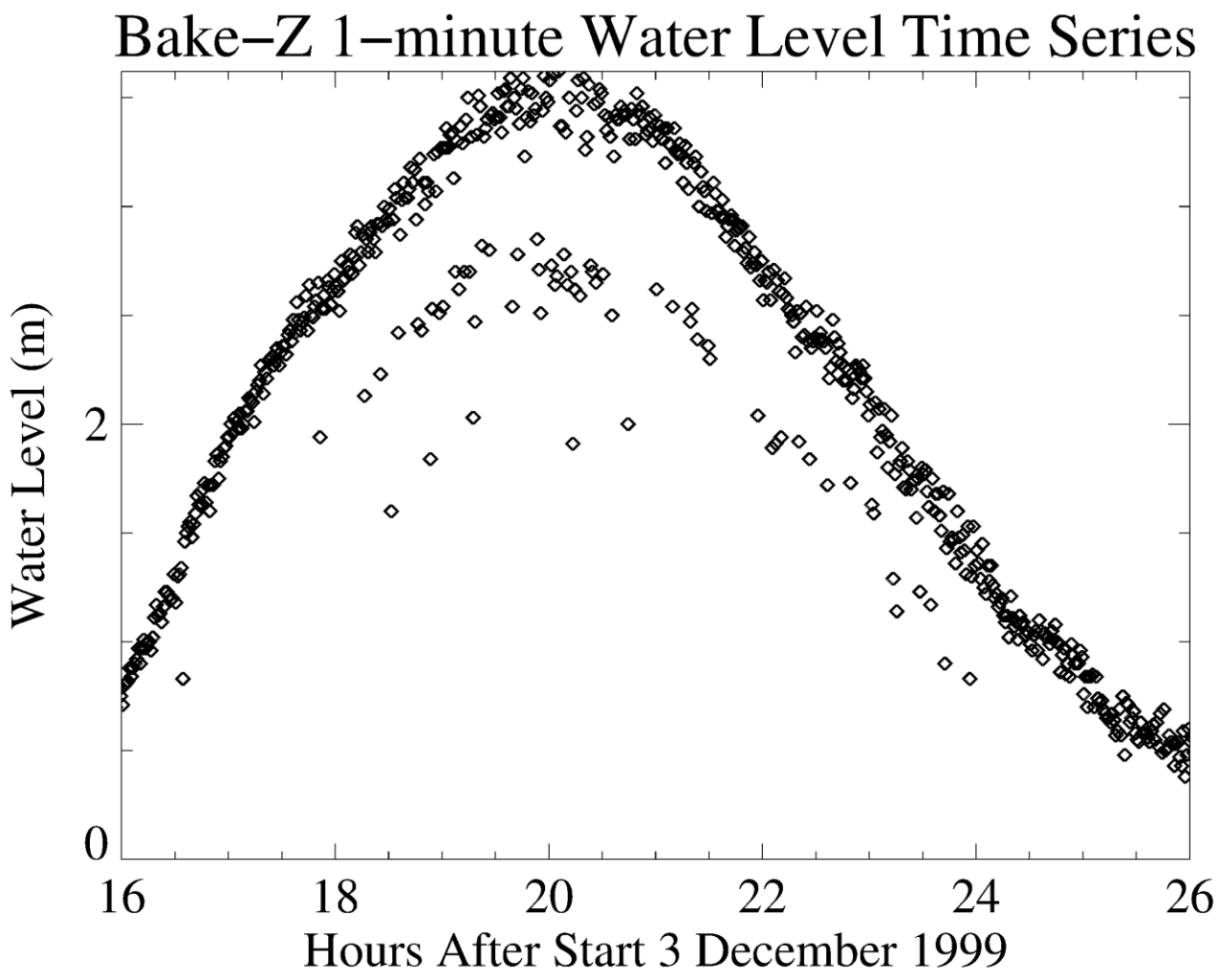

Figure S21. Water level at the Bake-Z tide gauge station at 1-minute intervals. The time series shows outliers with offsets in two clusters away from the likely true water level.

SECTION XIII. Return period of water level heights reported and inferred from literature reports

Table S5. Sorted list of return periods of highest water levels during Storm Anatol 3–4 December 1999.

N	Location	Country	Latitude (degree)	Longitude (degree)	Return Period (year)	Case
[1]	[2]	[3]	[4]	[5]	[6]	[7]
1	Ribe	DK	55.30	8.70	196	1:RP
2	Ribe	DK	55.30	8.70	183	3:RANK
3	Bork Havn	DK	55.80	8.30	140	5:kdi18
4	Ribe Kammersluse Flyder	DK	55.30	8.70	131	5:kdi18
5	Gradyb Barre	DK	55.40	8.30	84	5:kdi18
6	Havneby Havn	DK	55.10	8.60	53	5:kdi18
7	Husum	DE	54.47	9.02	53	4:JEA06
8	Esbjerg	DK	55.50	8.40	50	1:RP
9	Vidaa/Hojer	DK	55.00	8.70	43	1:RP
10	Vidaslusen–Hojer I	DK	55.00	8.70	35	5:kdi18
11	Esbjerg	DK	55.50	8.40	27	5:kdi18
12	Ballum	DK	55.10	8.70	25	1:RP
13	Ballum Sluse	DK	55.10	8.70	23	5:kdi18
14	Cuxhaven	DE	53.87	8.72	14	4:JEA06
15	Buesum	DE	54.12	8.87	13	4:JEA06
16	List auf Sylt	DE	55.02	8.44	11	4:JEA06
17	Hvide Sand	DK	56.00	8.10	9.0	1:RP
18	Skagen	DK	57.70	10.60	5.9	5:kdi18
19	Kloster Havn	DK	56.30	8.30	5.4	5:kdi18
20	Havneby	DK	55.10	8.60	5.0	1:RP
21	Hvide Sande Havet	DK	56.00	8.10	4.3	5:kdi18
22	Hals	DK	57.00	10.30	3.5	5:kdi18
23	Delfzijl	NE	53.33	6.93	3.0	2:FREQ
24	Thorsminde	DK	56.37	8.12	3.0	1:RP
25	Bremerhaven	DE	53.55	8.57	2.9	4:JEA06
26	Norderney	DE	53.70	7.15	2.4	3:RANK
27	Thyboren	DK	56.70	8.22	2.0	1:RP
28	Hvide Sande Havn	DK	56.00	8.10	1.7	5:kdi18
29	Ringkobing Havn	DK	56.10	8.20	1.5	5:kdi18
30	Dagebuell	DE	54.73	8.68	1.5	4:JEA06
31	Den Helder	NE	52.97	4.75	1.3	2:FREQ
32	Harlingen	NE	53.17	5.42	1.2	2:FREQ
33	Randers Havn	DK	56.50	10.00	1.2	5:kdi18
34	Hirtshals	DK	57.60	10.00	0.98	5:kdi18
35	Norderney	DE	53.70	7.15	0.96	4:JEA06

Table S5 (continued).

N [1]	Location [2]	Country [3]	Latitude (degree) [4]	Longitude (degree) [5]	Return Period (year) [6]	Case [7]
36	Hoek van Holland	NE	51.98	4.12	0.91	2:FREQ
37	Helgoland Binnenhafen	DE	54.18	7.88	0.70	4:JEA06
38	Roompot buiten	NE	51.62	3.67	0.59	2:FREQ
39	Hanstholm	DK	57.10	8.60	0.53	5:kdi18
40	Nr. Sundby	DK	57.10	9.90	0.42	5:kdi18
41	Vlissingen	NE	51.45	3.60	0.32	2:FREQ
42	Emden	DE	53.33	7.18	0.25	4:JEA06
43	Dordrecht	NE	51.82	4.67	0.24	2:FREQ
44	Ferring	DK	56.50	8.10	0.19	5:kdi18
45	Skive Havn	DK	56.60	9.10	0.16	5:kdi18
46	Juelsminde Havn	DK	55.70	10.00	0.08	5:kdi18
47	Hvalpsund	DK	56.70	9.20	0.07	5:kdi18
48	Attrup	DK	57.00	9.50	0.03	5:kdi18

Notes:
[1] Running index of data
[2] Station name
[3] Country
[4] Latitude
[5] Longitude
[6] Calculated return period in years
[7] Description of calculation:
1: RP: return period presented in source
2: FREQ: source presents number of exceedances within a time interval; return period is taken as reciprocal
3:RANK: source presents rank of water level across a date range; return period is calculated as the number of years represented divided by the rank.
4:JEA06: Jensen et al (2006) present the maximum water levels during Storm Anatol and tabulated values of standardized return periods versus water level that were interpolated to derive the return periods for the Storm Anatol case [Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006.]
5:kdi18: Ditlevsen et al (2018) present the maximum water levels during Storm Anatol and tabulated values of standardized return periods versus water level that were interpolated to derive the return periods for the Storm Anatol case [Ditlevsen C, MM Ramos, C Sorensen, UR Ciocan, T Pionkowitz, Hojvandsstatistikker 2017, Miljo- og Foedevaremnisteriet, Kystdirektoratet Lemvig, Februar, 2018]

SECTION XIV. Timing of the tide, surge, extreme oscillations, and maritime incidents around the North Sea coast

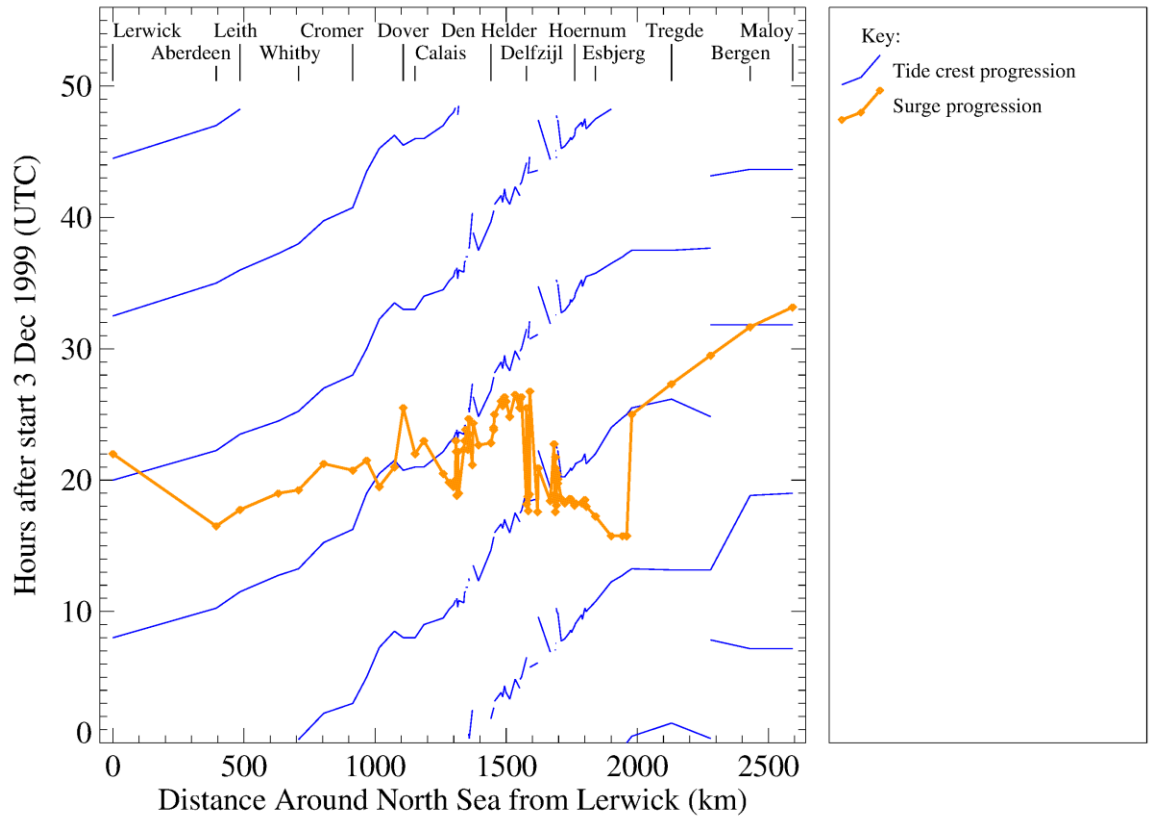

Figure S22. Summary of the progression of the tidal crests and storm surge peak around the North Sea on 3–4 December 1999. The data are plotted on axes of time versus counter-clockwise distance around the North Sea starting from Lerwick in Scotland.

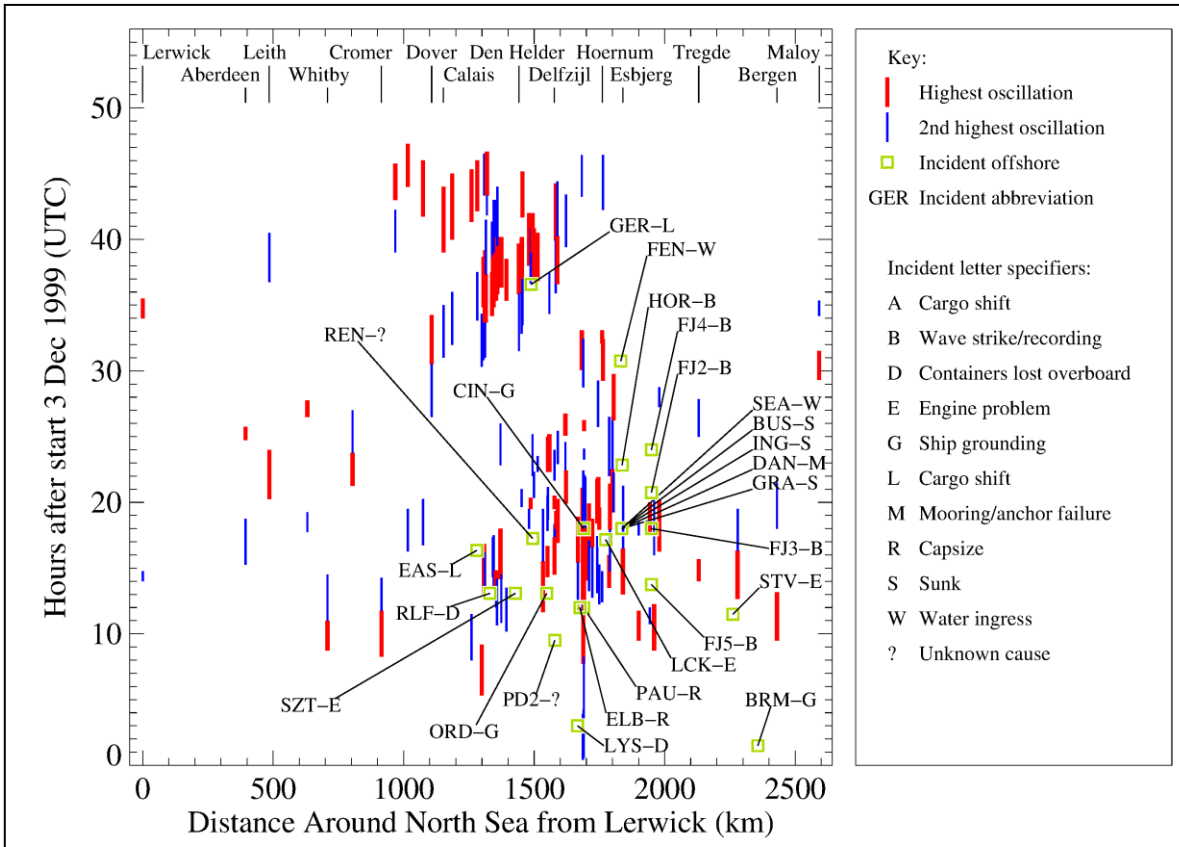

Figure S23. Summary of the spatial-temporal relationship of peak-to-trough range of the highest up-crossing short period oscillations in the tide gauge record and maritime incidents/accidents. The data are plotted on axes of time versus counter-clockwise distance around the North Sea starting from Lerwick in Scotland.

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Table SL1. List of sources reviewed for project (arranged by year and then alphabetically)

Source	Type[1]	Full Reference and Notes
Rossiter (1958)	4	Rossiter JR, Storm surges in the North Sea, 11 to 30 December 1954, Philosophical Transactions of the Royal Society of London, Series A, 251, No. 991, 139-160, 1958.
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Air Worldwide (20191219)	3	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019.
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Cappelen (2019)	1	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020)
World Energy Council (2019)	3	World Energy Council, Case Study Series, Extreme Weather, Windstorms France December 1999, https://www.worldenergy.org/assets/downloads/Windstorms_France_-Extreme_weather_conditions_SEP_2019.pdf, pdf date stamp: 11Oct2019
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XWS (20200906)	3	XWS, Extreme Wind Storms Catalogue, http://www.europeanwindstorms.org/cgi-bin/storms/storms.cgi, accessed 06Sep2020
Wikipedia (20210418)	1	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021

Notes:
[1] Type: 1=storm is main focus (or used as key example in general discussion); 2=1-4 case studies including the storm; 3=the storm is one of many case studies or mentioned only; 4=storm not mentioned; reference is included for background information

Table SL2. List of sources that could not be obtained (alphabetically)

Source	Full Reference and Notes
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Goennert (2000)	Goennert, G., Simulation der Sturmflut von .12.1999 und Veraenderung der Zugbahn des Sturmtiefs Anatol. Ergebnis einer Arbeitsgruppe in Zusammenarbeit mit dem DWD, BAW-AK, BSH und Strom- und Hafenbau, 2000
Hjorteland et al (1999)	Hjorteland K, MJ Mes, AK Magnusson, Ekofisk Observed Weather Compared with Weather Predictions, Offshore Technology Conference, 3-6May, Houston, Texas, 1999, OTC-10768-MS
Lonseth (2006)	Lonseth, L, Ekofisk Reference Data Set 1980-2005, Fugro Oceanor Report No C55060/4026/R2, 2006.
Magnusson (1993)	Magnusson AK, Ekofisk Extreme Wave Analysis, Preliminary Report, Tech Rep Nr 103, DNMI, Feb 1993
Munich Re (1973)	Munich Re, Sturmschaeden in Europa, 1973.
Standing (1997)	RG Standing, Green sea damage on FPSOs and FSUs, HSE Report OTH 486, London, 1997

Table SL3. List of normal photos of event (arranged by year and then alphabetically)

Source	Full Reference and Notes
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -photos of storm damage in Europe in December 1999 but Storm Anatol and locations not explicitly identified
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -FIG1. [PHOTOS] Damage from Storm Anatol in Denmark; roof, collapsed wall, collapsed barn (Source: AIR)
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -FIG. [PHOTO] Storm falls in Danish mixed forest after December hurricane 1999
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -FIG1. [PHOTO] damage from Anatol in Denmark; roof damage, collapsed wall, destroyed barn

Table SL4. Ranking of storm among events; assessing importance of storm (arranged by year and then alphabetically)

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 -75mph gust at Leeds was December record
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -Hurricane Anatol assessed as 100-year event
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -DMI watch chief Niels Thyge Rasmussen says Anatol was some of the worst storm weather Denmark has ever experienced
Lloyd's Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -storm is identified as the storm of the century for Denmark
Met Eireann (199912)	Met Eireann, Monthly Weather Bulletin, no. 164, Dec, 1999 -Anatol not ranked very dangerous for Ireland

	-some locations measured highest 10min wind speed and gust of month in pre-dawn 03Dec1999 -winds described as very strong and gusty -wave conditions around Ireland low on 3Dec (5m) but up to 9.5m on 8Dec (highest of month)
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -storm surge 3-4Dec1999 not exceptional for Netherlands -across entire Dutch coast return period ranking was 4X/year to 1 per 3year. -hurricane-strength storm caused problems Denmark & N Germany -German/Denmark: one of the 4 most powerful storms of 20th century -Denmark: only 3 comparable storms with wspd>125km/h: kerststorm 26Nov1902, surge 18Oct1967, surge 24Nov1981
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -how do these storms compare with previous storms? -last time hurricane strength winds at coast 26Feb1990 with 38m/s at Kullen -last time similar or higher winds Masekar and Orskar during 10Jan1991 and 7Dec1989 -last time comparable winds Hano 20Jan1986 and 24Nov1981 with 34m/s -last time comparable wind Falsterbo 17Oct1967 with 38m/s and 6 deaths
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -Denmark hit by most powerful hurricane of 20C
Bresch et al (2000)	Bresch DN, M Bisping, G Lemcke, Storm over Europe. An underestimated risk, Swiss Re (Swiss Reinsurance Company), 27pp, 2000. -Anatol rank 6/10 European winter storm insurance losses in list starting 1976; return period <5y
Kristensen et al (2000)	Kristensen L, O Rathmann, SO Hansen, Extreme wind in Denmark, Journal of Wind Engineering and Industrial Aerodynamics, 87, 147-166, 2000. -Anatol was worst storm on record for Denmark
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -only defining storm mentioned in the context of the revisions of Danish construction standards
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -"With wind speeds recorded of this magnitude the hurricane was the fiercest in Denmark for more than a 100 years."
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -rank 4 storm surge water level Esbjerg; rank 1 event in 1981 -all-time low water level record in western Baltic; 2m below normal; many gauges left dry
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -described as century storm -highest ever recorded 10min wind speed and gust in Videhavs areas
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm - FIG3.1.1. Windstorm damage in European forests, 1950-1999 NOTE: DEC1999 rank1 event; 1990 storm sequence rank 2 (source: Mr. Mart-Jan Schelhaas, Altera, Netherlands, 2000) -windthrow volumes largest on record; markets expected to be skewed for 2-3 years -Denmark: Anatol wind throw 159.1 percent of annual removal
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -storm identified as Danmark-Arhundrets orkan
Ulblich et al (2001)	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 -storm severity comparable to worst since 1980's: storm 23Nov1981, storm 15-16Oct1987, storm late Feb-1Mar1990, storm Lothar 26Dec1999, storm Martin 27Dec1999
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -Denmark: strongest hurricane of the 20th century -Germany: strongest hurricane of last decades -wind gust records in Denmark and extreme northern German stations -rank 4 storm surge Hamburg
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -Anatol strongest gale to hit Denmark in 20C -Anatol Sylt wind speed records at 184km/; exceeeded previous record from 1976 by 10% -Anatol wind speed record at Romo with the185km/s -Anatol Hamburg surge water level rank 4 of recent decades -Anatol insured losses many times higher than any other storm for 1990+1999 -for all Europe, Anatol after Lothar and Martin for insured losses; high losses Germany and France -TAB_p13: Comparison of insured losses from windstorm series 1990 & 1999: Daria, Herta, Vivian, Wiebke, Anatol, Lothar, Martin
Sommer (2002)	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.

	-Anatol was century storm in Denmark
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 -strongest hurricane of the 20th century for Denmark
Woetmann Nielsen and Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -storm damage was considered >100y event -Dec1999 Europe unusual weather with 3 very severe cyclones 3,26,27 Dec
Nilsson et al (2004)	Nilsson C, I Stjernquist, L Barring, P Schlyter, AM Jonsson, H Samuelsson, Recorded storm damage in Swedish forests 1901-2000, Forest Ecology and Management 1999, 163-173, 2004 -Anatol 1999 was a rank 5 storm for forest destruction over 100 year period
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -rank 2 water levels at Hamburg and Husum in storm list 16-17Feb1962, Capella, Daria, Anatol -most German Bight stations otherwise showed rank 4
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -for measured 10m winds at Norderney, Anatol rank 6 of 22 storms 1962-2002 -strongest storm observed in Denmark
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -Anatol rank 2 event at Husum (1: 1976) and Borkum (1:1962) -Anatol rank 3 event at Wilhelmshaven, Bremerhaven, Cuxhaven, Busum, List
Mueller-Westermeier (2007)	Gerhard Mueller-Westermeier, Beschreibung un klimatologische Bewertung des Orkantiefs "Kyrill", pdf properties: Title: Deutscher Wetterdienst - Nationale Klimauberwachung, Author: Gerhard Mueller-Westermeier, Subjet: Orkan Kyrill, datestamp: 26Jan2007 -Anatol rank 7/25 for wind gust in period 1990-2007 with 51.00 m/s measured on List/Sylt
Nilsson et al. (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -several stations in Denmark registered highest ever wind speeds -Sweden Falsterbo station registered most violent storm since 1967 -Storm Gudrun Jan 2005 was worse storm for tree damage
Fink et al (2009)	Fink AH, T Brucher, V Ermert, A Kruger, JG Pinto, The European storm Kyrill in Jan 2007: synoptic evolution, meteorological impacts and some considerations with respect to climate change, Natural Hazards and Earth System Sciences, 9, 405-423, 2009. -Anatol rank 6/10 storms since 1990 in damage parameter -Anatol rank 3/10 storms since 1990 in minimum central pressure (Daria, Wiebke lower)
Goennert and Buss (2009)	Goennert, Gabriele & Thomas Buss, Sturmfluten zur Bemessung von Hochwasserschutzanlagen, Berichte des Landesbetriebes Strassen, Bruecken und Gewaesser Nr.2/2009, Freie und Hansestadt Hamburg, Landesbetrieb Strassen, Bruecken und Gewaesser, Hamburg ISSN 1867-7959. -Anatol rank 4 storm in time series 1900-2008: 03-04/01/1976 H=1011 S=423 16-17/02/1962 H=995 S=387 20-22/01/1976 H=970 S=289
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -Anatol: strongest winds in Denmark for acentury
Fehrmann and Fackler (2010)	Fehrmann,A. and A. Fackler, Offshore wind farms: risk and initial loss experience, Temple Insurance, a member of the Munich Re Group, 2010 [PDF timestamp: 09Mar2010] (last date reference 2001; last incident reference 2003) -Anatol 1999 was one of three defining storms important for defining insurance loss; others were Gujarat 1998 cyclone and unidentified storm on Spanish Atlantic island (Canary Islands?, Storm Delta 2005?)
Gardiner (2010)	Gardiner, Barry, Appendix 3: Background information on 11 storms selected for detailed analysis, European Forest Institute, Atlantic European Regional Office - EFIAtlantic, 161 pp. [PDF properties: datestamp 23Jul2010] -Storm Gudrun Jan 2005 had more damage in northern part of Denmark compared with Storm Anatol. -Storm Anatol Dec11999 had more damage in southern part of country
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -water levels during Anatol were lower than Britta, Tilo or 1906 surge
Schwierz et al (2010)	Schwierz C, P Koellnet-Heck, E Zenklusen Mutter, DN Bresch, P-L Vidale, M Wild, C Schaer, Modelling European winter wind storm losses in current and future climate, Climatic Change, 101, 485-514, 2010. -for insurance losses in Anatol-Lothar-Martin, Anatol was rank 3
Rosenthal et al (2011)	Rosenthal W, AL Pleskachevsky, S Lehner, S Brusch, Observation and modeling of high individual ocean waves and wave groups caused by a variable wind field, 12th International Workshop on Wave Hindcasting and Forecasting, Kohala Coast, Hawai'i, HI, 2011. -Anatol 3Dec1999 described as a heavy, fast-developing storm like Britta 2006 -Britta had an unsual rogue wave event at FINO1 north of Borkum -Anatol not described as serious rogue wave event similar to 1995 Draupner wave, Britta 2006, or Tilo 2007
SMHI (20111013)	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) -wind gusts in southern Skania at the 50y return period level or higher

Gardiner et al (2012)	Gardiner B, K Blennow, J-M Carnus, P Fleischer, F Ingemarson, G Landmann, M Lindner, M Marzano, B Nicoll, C Orazio, J-L Peyron, M-P Reviron, M-J Schelhaas, A Schuck, M Spielmann, T Usbeck, Destructive storm in European Forests: Past and Forthcoming Impacts, European Forest Institute, Atlantic European Regional Office - EFIAtlantic [pdf document properties: author=Barry Gardiner, datestamp=09Mar2012] -forest damage: for Denmark Anatol was rank3 event since 1950 after 1967 & 1981; low rank for Sweden storm sequence 1999 rank1 event for Europe with 1990 storms rank2
AON Benfield (2013)	AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013 -worst hurricane of 20C for Denmark -rank 15 insurance loss for Germany among storms reviewed 1703-2013 -new wind speed record set on Syt
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -rank2 storm surge level at Ribe after 11Oct1634 Burchardi flood; same water level as 27Nov1825
Fruergaard et al (2013)	Fruergaard M, TJ Andersen, PN Johannessen, LH Nielsen, M Pejrup, Major coastal impact induced by a 1000-year storm event, Nature, Scientific Reports, 3:1051, DOI: 101038/srep01051, 2013. -Anatol was rank 2 surge, 1m lower than 6.1m marked on Ribe Cathedral for surge 11-12Oct1634
Humbling (2013)	Humbling David, Weatherwatch: Our severe gales are not hurricanes, but they can be as deadly, The Guardian, 13Dec2013 -review of hurricane Anatol 1999 and damage to Denmark and Germany; defining event to compare with storm Xaver
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -Anatol one of 18 serious insurance storms between 1976-2010
Haeseler and Lefebvre (2013)	Haeseler S, C Lefebvre, Heavy storm Christian on 28 October 2013, DWD, 13Nov2013 -Anatol had rank1 gust for List/Sylt in Germany; record still stood after Storm Christian in Oct2012 -Anatol gust did not rank in top ten of any other coast station in Germany -for Denmark, Anatol held record gust (51.4 m/s or 185 km/h) until storm Christian Oct2013 when Kegnaes Fyr registered gust 53.5m/s or 193km/h
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -all 3 December storms achieved hurricane strength -Anatol was the most powerful of the 3 December storms (with Lothar and Martin) -there is broad concensus that Anatol was the most powerful storm to have hit Denmark during the instrumental period -Anatol air pressure fell to 952.4hPa; it was a country-wide category 4 storm -Storm Allan Oct 2013 had higher record winds but was shorter duration and limited area
Kristandt et al (2014)	Kristandt, J, B Brecht, H Frank, H Knaack, Optimization of empirical storm surge forecast – modelling of high resolution wind fields, Die Kuste, 18, 301-308, 2014 -Storm Anatol had rank 21 storm surge of 39 surges 1962-2011 -1962 was rank1 as Norderney; Capella 1976 was highest water level for any station on North Sea coast
Roberts et al (2014)	Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014 -report opened with Anatol/Lothar/Martin Dec 1999 inflicted 2012USD 13.5billion & 150 fatalities -Anatol rank 9 of 23 top insurance loss storms in period 1979-2013 -Anatol had higher wind speeds over a greater area but Lothar/Martin had higher insurance losses
Danish Energy Agency (2015)	Danish Energy Agency, Security of Electricity Supply in Denmark, 1st edition 2015, translated 2016, Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, ISBN 978-87-93180-15-4 -Storm Anatol was worst storm of century -storms Dec1999, Jan2005, Oct2013, Dec2013 were equal strength
Thejorunal.ie (20151214)	thejournal.ie, The deadliest storms to evr hit Europe, 14Dec2015 0610AM, https://www.thejournal.ie/europe-storms-2497164-Dec2015/, accessed 10Dec2020 -Storm Anatol rank 10 for monetary losses and rank 8 for fatalities (20) -worst storm Lothar 1999 with 10.6b EUR damage and 110 fatalities
Capellen (2018)	Cappelen, J., Storm og ekstrem vind i Danmark - opgorelser og analyser til og med 2017, DMI rapport 18-07, Copenhagen 2018 -Anatol one of the four country-wide hurricanes of 20th century: 1902 Christmas storm, 17-18Oct1967, 25Nov1981, 03Dec1999 -described as most powerful storm in Danish area since start systematic measurement 1870s -Surge coincided with low tide. If it had coincided with high water, water levels would have been as high as 1634, where water level was 612cm
Ditlevsen (2018)	Ditlevsen C, MM Ramos, C Sorensen, UR Ciocan, T Pionkowitz, Hojvandsstatistikker 2017, Miljo- og Foedevaremnisteriet, Kystdirektoratet Lemvig, Februar, 2018 -Denmark storm surge water levels at rank 1 for some Denmark west coast stations
Cappelen et al (2018b)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/ -if surge had come at astron high water (6h earlier or later) water levels 1-1.5m higher -we would have had a surge of same level as 'manddrukningen i 1634'; worst ever Waddensee flood
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] -most serious recent Denmark windthrow storms: Anatol 1999, Gudrun 2005, Allan 2013, Bodil (2013) -Anatol most serious storm as a country-wide categrory 4; Gudrun was a country-wide category 3
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -Anatol was Denmark's largest insured loss ever

	-Denmark: Anatol completely exhausted many reinsurance covers
Astleitner (2019)	Astleitner, Thomas, 3. December 1999: Orkantief Anatol fegt ueber de Nordsee, https://uwr.de/de/a/3-dezember-1999-orkan-tief-anatol-trifft-deutschland, published 3Dec2019, accessed 20Sep2020 -new wind speed records for northern Germany during Anatol
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) *-3Dec1999 Denmark impacted by most powerful hurricane ever -record stood until hurricane Allan Oct 2013 /w highest avg=39.5m/s, gust 53.5m/s
World Energy Council (2019)	World Energy Council, Case Study Series, Extreme Weather, Windstorms France December 1999, https://www.worldenergy.org/assets/downloads/Windstorms_France_-Extreme_weather_conditions_SEP_2019.pdf, pdf date stamp: 11Oct2019 -Anatol storm Denmark insurance record 2bill EUR; insurers blieved such a loss impossible -Anatol/Lothar/Martin were 100y events
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -Ribe rank2 surge after Burchardi 1634 surge; equal in height to 1825 surge

Table SL5. Severe forecast (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -hurricane passage over Denmark predicted at early point -first indication of hurricane was in DMI 7d forecast broadcast Thu 02Dec 1030 -followed up Thu evening by DR TV meteorologist & weather presentation TV2 from DMI warning -no doubt that there would be unusual and serious weather phenomenon
Lloyd's Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -Sniegs fishing boat capsize and fatalities in Latvia due to severe storm forecast issued only previous day.
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -word of hurricane at DMI Thursday 2Dec1999 1030MEZ in connection with 7d advance forecast -earlier hurricane weather forecast on key sites was critized
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -DMI Mike21 surge model gave predicted water levels up to 2.5m below observed -correct surge warning not sent out
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -numerical model gave indications of severe Denmark storm on 3Dec from Tuesday 30Nov -not possible to see how violet it would become; trajectory uncertain -confirmation of numerical forecasts not until 0000UTC 3Dec1999 when stations NW Ireland had 10mb pressure drop in 3h
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -Denmark 3 Dec storm first appeared in advance forecasts from 28Nov of the experimental DMI hemispheric model -storm forecast 2 days in advance in the normal DMI operational model (as good as physically possible)
Buizza and Hollingsworth (2001)	Buizza, Roberto and Anthony Hollingsworth, Severe weather prediction using the ECMWF EPS - The European Storms of December 1999, ECMWF Newsletter, No. 89, Winter 2000/01. -EPS gave some indication of severe storm from 28Nov -steady improvement in EPS predictions from one dayd to next -EPS consensus of storm with >50% of members only took place 24-30h before event -high resolution HEPS gave better predictions with >50% member onverging on storm 55h before event -normal operation forecast model gave different forecasts from one day to next
Buizza and Hollingsworth (2002)	Buizza, Roberto and Anthony Hollingsworth, Storm predicton over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002 -EPS gave some indication of severe storm from 28Nov -steady improvement in EPS predictions from one dayd to next -EPS consensus of storm with >50% of members only took place 24-30h before event -high resolution HEPS gave better predictions with >50% member onverging on storm 55h before event -normal operation forecast model gave different forecasts from one day to next
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 -extraordinary storm event forecast from midday 02Dec1999 -precise storm surge forecasts can only be given 18h in advance
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -DMI HIRLAM made a fair prediction of the Denmark storm 48h in advance
Cappelen et al (2018a)	Cappelen J, S Olufsen, MH Ribegaard, JW Nielsen, T Schmith, N Hansen, Det traekker op til orkan, updated 25Jun2018a, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/det-traekker-op-til-orkan/ -already on 30Nov1999 model prognosis of violent storm in development -02Dec1999 model prognosis showed very power low pressure under steady development could give wind of hurricane strength -first indication of hurricane appeared in DMI 7day forecast sent on Thursday 02Dec1999 10:30M?

	-early Friday 3Dec ... the low pressure was deepening explosively -within 12h central pressure fell from 996hPa to 958hPa on way west from Hebrides to central Nsea
Cappelen et al (2018g)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Bringer fremtiden flerer decemberorkaner? 25Jun2018f, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/bringer-fremtiden-flere-decemberorkaner/ -DMI forecast the Anatol hurricane the day before -one of the problems with the hurricane was that many did not know how violent it can be

Table SL6. Storm not as bad as expected; not as bad as it could have been (arranged by year and then alphabetically)

Source	Full Reference and Notes
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -surge max occurred at low water -if surge max at high water, water levels would have been 1m higher; catastrophe
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -no major damage to dykes in Germany
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -water levels during Anatol were low because wind from southwest during peak tide
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -Ribe did not have sea flooding because water level 0.3m below dike crest of 7.0m -50% of houses damaged by strong winds; mostly roof damage -if surge had arrived during high tide, water levels would have been 1-1.5m higher; Ribe would have been flooded
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -Anatol storm impact relatively mild in Sweden
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -Ribe water level reached 5.12m; instrument malfunction *-surge occurred at low water; could have been 1-1.5m higher if at astronomical high water

Table SL7. Storm worse than expected (arranged by year and then alphabetically)

Source	Full Reference and Notes
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -interrupted car train service at Hindenburg; people sitting in cars on train for 6h at height of storm -wind destroyed mobile homes; hundreds of roofs damaged -70% of houses damaged at beach front
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -DMI watch chief Niels Thyge Rasmussen says Anatol was some of the worst storm weather Denmark has ever experienced
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -forecast water levels Delfzijl 0.36m higher than expected
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -worst Denmark hurricane of 20th C (time scale longer than 1 generation; outside living memory) -hurricane forecast on key internet sites critisized -call centers for emergency services overwhelmed
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -increasing estimates of insurance losses followign the storm -roof and cladding damage should have been within thresholds Danish construction guideline thresholds -10min wind speed and 1s gust at top of Horns Rev highest ever recorded in Denmark
Neckelsen and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -waves hit Horns Rev mast junction box shed at 6.2m above sea level; forced out power cables & caused 10 day power outage
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -storm described as century event -numerical model gave indications of severe Denmark storm on 3Dec from Tuesday 30Nov -not possible to see how violent it would become; trajectory uncertain
Sommer (2002)	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002. -primary measurement instrument system went down for 10d when Anatol wave strikes instrument cabin pushed power plugs out of sockets
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-

	martin-ten-years-later/ -insurance industry did not assess severe storm event like 1990 to be frequent enough to justify re-insurance cover for scale of Anatol damage -for Denmark; Anatol storm damage was an order of magnitude more than the next most severe storm winter 1981
Cappelen et al (2018)	Cappelen J, S Olufsen, MH Ribegaard, JW Nielsen, T Schmith, N Hansen, Det traekker op til orkan, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/det-traekker-op-til-orkan/ -no doubt that we will be standing over an unusual and serious weather phenomenon

Table SL8. Storm duration; extended period bad weather (arranged by year and then alphabetically)

Source	Full Reference and Notes
Bancroft (1999)	George P. Bancroft, Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. -weather map with North European storm 30Nov1999
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -hurricane strength winds over extended period -1st observations of storm strength 25m/s 15:00 MET; lasted until 2300 Jyllands W coast -hurricane strength or greater 17:00-19:00
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -car train service at Hindenburg interrupted for 6h at height of storm
Lloyd's Casualty Week (19991210)	Lloyd's Casualty Week, vol.318, No.11, Dec10, 1999 -severe winter storms Scandinavia 30Nov1999 (Finland and Sweden) -ship accidents Bay of Biscay, eastern Atlantic in week before Storm Xaver
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -Storm Anatol was short duration storm for Dutch storm surge service -preceding surge warning 27Nov1999 Schelde and West Holland -preceding surge warning 01Dec1999 Delfzijl
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -four southern Sweden storms from end November to mid-December -first storm passed 29Nov -highest wind speed 29m/s at Masekar outside Orust -winds to 27m/s at Harstena at Ostgotakusten in spite of west wind from land -1.5d later wind blew not quite so hard -highest wind night 30Nov-1Dec at 25m/s at Masekar on Orskar in N Uppland; wind from west -third and last storm passed during night to 4Dec and was clearly the worst -started in Atlantic W of Ireland in evening of 2Dec -moved NNE via Scotland and Nsea to Jylland where it culminated 19MET 3Dec at 953hPa central pressure -during following night passed over Gotland -Sweden winds blew at 33m/s at Hano (hurricane strength); 30m/s at Falsterbo -wind direction approx SW; highest winds Skane and Blekinge -later another storm on 17-18Dec with 17m/s Hano & 25m/s at Nidingen and Harstena
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -Denmark storm on 17Dec1999
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -1999 storm shorter duration compared with 1981 but more powerful
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -Dec2000 reported as particularly stormy with 2 Denmark storms and 2 France storms; additional storm end Jan2000
Sommer (2002)	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002. -maximum wind period lasted 2.5h
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -rapid development of storm
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -Storm Anatol belonged to Circulation type of surge for low pressure centre mving quickly over British Isles adn intensifying over the North Sea -Cuxhaven water levels 1.5m above normal at low tide and reached 4.53m NN in 6 hours
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -Anatol very fast storm crossing North Sea in 12 h
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -preceding storm in early Dec 1999 may have weakened tree root systems in southern Sweden
Von Storch and Woth (2008)	von Storch, Hans and Katja Woth, Storm surges: perspectrives and options, Sustain Sci, 3, 33-43, 2008 -Anatol was a rather small fast moving storm with a fetch 100-200km in 1999 in the North Sea area

	-Anatol was unusually small for extratropical cyclone and similar to tropical storm in size
SMHI (20111013)	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) -3 storms in succession starting on 29Nov1999 and ending with Anatol
Ge et al. (2014)	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. -approximate 1m storm surge started already on 1Dec1999
Roberts et al (2014)	Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014 -Anatol was fast-moving storm
Cappelen et al (2018b)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/ -in Waddensee surge water levels fell quickly after maximum -high water levels lasted longer on Danish west coast -second high water shortly after midnight that lasted until morning 04Dec
Cappelen et al (2018e)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018e, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/ -winds storm force or higher 1500-2300MET 3Dec1999 in Denmark
Surgewatch (20201013)	Surgewatch, Storm event 28th November 1999, https://www.surgewatch.org/events/1999_11_28/, accessed 13Oct2020 -surge and overtopping in Solent area 28Nov1999
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -rapid development of storm center between 2Dec and 3Dec1999

Table SL9. Names of the storm (arranged by year and then alphabetically)

Name	Full Reference and Notes
Adam	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020)
Anatol	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. Fink AH, T Brucher, V Ermert, A Kruger, JG Pinto, The European storm Kyrill in Jan 2007: synoptic evolution, meteorological impacts and some considerations with respect to climate change, Natural Hazards and Earth System Sciences, 9, 405-423, 2009. Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 Gatey, DA, The analysis of extreme synoptic winds, Ph.D. Thesis, University of Western Ontario, 2011. University of Western Ontario - Electronic Thesis and Dissertation Repository. Paper 268. Sieber, Jeanette, Impacts of extreme hydro-meteorological events on electricity generation and possible adaptation measures. A GIS-based approach for corporate risk management and enhanced climate mitigation concepts in Germany. Ph.D. thesis, Julius-Maximilians-Universitaet Wuerzburg - Institut fuer Geographie, Karlsruhe, November 2012 AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013 Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014

	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020)
Storm Carola	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021
Danish storm	Buizza, Roberto and Anthony Hollingsworth, Severe weather prediction using the ECMWF EPS - The European Storms of December 1999, ECMWF Newsletter, No. 89, Winter 2000/01. Buizza, Roberto and Anthony Hollingsworth, Storm prediction over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002
Danmark-Arhundrets orkan	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000
Decemberorkanen	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 Cappelen J, S Olufsen, MH Ribegaard, JW Nielsen, T Schmith, N Hansen, Det traekker op til orkan, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/det-traekker-op-til-orkan/
Decemberstormen 1999	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000
Denmark storm	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003.
Orkanen den 3.december 1999	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000.
SR79	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.
Unnamed (hurricane)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 Lloyds Casualty Week, vol318, No12, 17Dec1999 Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002. Sommer, A., Offshore measurements of wind and waves at Horns Rev & Laeso, Denmark. European Seminar OWEMES 2003, Apr 10-12, 2003, Naples, Campania, Italy. SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) Danish Energy Agency, Security of Electricity Supply in Denmark, 1st edition 2015, translated 2016, Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, ISBN 978-87-93180-15-4

Table SL10. Satellite pictures (arranged by year and then alphabetically)

Source	Full Reference and Notes
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. FIG. [SATELLITE] visible? satellite image of storm over NW Europe
Aakjaer (2000)	Aakjaer AF, Orkanen i Nordsoen den 30. oktober 2000, Vejret, 85, 1-7, 2000 -FIG5a.[SATELLITE] Infrared image from American NOAA satellite 3Dec1999 1725MET
Beredskapsstyrelsen (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -cover picture is satellite image of storm Anatol from DMI; unknown satellite
Forestry Commission (2000)	Forestry Commission, Naar skoven blaeser omkuld, Vejret, 85, pp.8-9, Dec, 2000 -FIG. Satellite picture 3Dec1999 1115. from DMI (Infrared?); Anatol over NW Denmark
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -video clips of METEOSAT infrared images covering 2-4Dec1999
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -FIG11.NOAA infrared satellite images at (a) 05:36UTC 3Dec, (b) 13:52UTC 3Dec, and (c) 17L49UTC 3Dec. In (c) the dashed curve with arrows indicates the position and flow direction of the low-level jet BBJ.
Astleitner (2019)	Astleitner, Thomas, 3. December 1999: Orkantief Anatol fegt ueber de Nordsee, https://uwr.de/de/a/3-dezember-1999-orkan-tief-anatol-trifft-deutschland, published 3Dec2019, accessed 20Sep2020 -FIG [MAP] MET IR 03Dec1999 18:00URC FU-Berlin (oppen cell convection pattern)
Capellen (2018)	Cappelen, J., Storm og ekstrem vind i Danmark - opgorelser og analyser til og med 2017, DMI rapport 18-07, Copenhagen 2018 FIG. [SATELLITE] Friday 03Dec1999 Denmark hit by the most powerful hurricane ever registered. NOAA satellite picture 1749UTC NOTE: band of open cell convective clouds NNW-SSE from Shetland to Dutch coast
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -FIG2. visible satellite image 03Dec1999 1900
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -FIG: IR satellite picture Anatol taken 03Dec1999 17:25MET

Table SL11. Meteorological maps or surface analysis (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -FIG1. [MAP] Observations 3Dec1999 1900MET. Low pressure trajectory indicated with times UTC and air pressure at centre. Symbol information in FIG5 and FIG6
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -FIG. [MAP] Surface pressure field on the 4Dec2020 1300MET. Trajectory with minimum pressure marked at 12h intervals
UKMO (1999)	UKMO, Daily Weather Summary, 26Nov1999 to 05Dec1999
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 - FIG1. [MAP] Map of lowest surface pressures during passage of low pressure. Arrow shows trajectory of low pressure center with times marked. 10min avg & gusts shown
Bancroft (2000)	Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. -FIG10. MPC Atlantic Part 1 surface analysis charts valid 12UTC 02Dec1999 and 03Dec1999; 500mb chart (actually 6h computer model forecast) valid 00UTC 03Dec1999 or halfway between the valid times of surface analysis charts
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. *-FIG1. [MAP] Maximum reduced wind speeds over the southern Denmark 3Dec1999. Wind speeds from Elsam projekt (bold), Riso (normal), DMI (italics)
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -Denmark map showing maximum wind speed and low pressure trajectory
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -FIG1. [MAP] Low pressure center position from 3Dec 0000UTC to 4Dec 0300UTC -FIG2a.[MAP] Average wind and wind gust 3Dec 1500UTC. Flags give wind speed and direction while the number gives the most powerful wind gust over the last 3h. All values in knots -FIG2b.[MAP] Wind measurements on 3Dec 1800UTC. Number for windgusts covers the latest 6h -FIG2c.[MAP] Wind measurements on 3Dec 2100UTC. info same as FIG2a -FIG2d.[MAP] Wind measurements on 4Dec 0000UTC. Number for wind gust covers last 6h
Woetman Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -FIG2. Synoptic observations of wind, weather, and sea level pressure 17UTC 3Dec1999
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -FIG2. (a) 42h forecast of sea level pressure and wind velocity (WMO standard) at 10m height valid for 1800UTC 3Dec1999. (b) Verifying observations on 1800UTC 3Dec1999 of sea level pressure and 10m wind velocity (WMO standard). Dashed lines are subjectively analyzed isobars at 956, 964, 984hPa. Vertical arrow shows position of Horns Rev
SMHI (20111013)	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) -map of Scania with wind speeds and gusts for selections stations where the 10min avg wind speed is at least 21m/s
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -FIG2-4. Maximum sustained and peak gust wind speed interpolations for the Anatol (a,b), Lothar (c,d), and Martin (e,f) wind storms; all from 1999
Roberts et al (2014)	Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014 -Map of station measurements of maximum wind speed
Capellen (2018)	Cappelen, J., Storm og ekstrem vind i Danmark - opgorelser og analyser til og med 2017, DMI rapport 18-07, Copenhagen 2018 -FIG. [MAP] Highest avg wind during Dec hurricane 1999 based on reanalysis of data from 3-4Dec1999 -FIG. [MAP] Highest wind gusts during Dec hurricane 1999 based on reanalysis of data from 3-4Dec1999
Astleitner (2019)	Astleitner, Thomas, 3. December 1999: Orkantief Anatol fegt ueber de Nordsee, https://uwr.de/de/a/3-dezember-1999-orkan-tief-anatol-trifft-deutschland, published 3Dec2019, accessed 20Sep2020 -weather map and surface pressure for NW Europe but unknown time

Table SL12. Model fields (arranged by year and then alphabetically)

Source	Full Reference and Notes
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -FIG. [MAP] Maps of NW Europe showing surface wind and sea level pressure at 03Dec1999: 0600Z, 0900Z, 1200Z, 1500Z, 1800Z, 2100Z, 04Dec1999: 0000Z

Bell et al (2000)	Bell GD, MS Halpert, RS Schnell, RW Higgins, J Lawrimore, VE Kousky, R Tinker, W Thlaw, M Chelliah, A Arthusa, Climate Assessment for 1999, Bulletin of the American Meteorological Society, 81, S1-S50, 2000 -FIG61. (a) [MAP] mean 300hPa heights and wind speeds during Dec1999
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -FIG1. [MAP] Hirlam analysis of wind & pressure for 03Dec1999 18:00UTC. Shown in the way that DMI's storm surge model sees it. Only wind over ocean has meaning. THe highest wind speeds are about 34-35m/s
Woetman Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -FIG1. 17h operational HIRLAM-E prognosis from 00UTC 3Dec1999. The shown fields are sea level pressure (full lines, 2hPa contour) and wind at 10m height (V10m) contour interval 4m/s with smallest contour at 18m/s -FIG3. 17h genkort (see text) HIRLAM-G prognosis from 00UTC 3Dec1999. The shown fields are sea level pressure (stipled, contour interval 2hPa) and 10m wind speed (full contours at 24,26,28,29 m/s) -FIG4. Same as Fig3 but for HIRLAM-E. -FIG5. 17h genkort (see text) HIRLAN-D prognosis from 00UTC 3Dec1999. The shown fields are sea level pressure (stippled, 2hPa contour interval) and V10m (full contours 24,26,28,29,30,31 and 32m/s) -FIG6. 23h HIRLAM-D prognosis from 00UTC 3Dec1999. The shown fields are sea level pressure (stippled, 2hPa intervals) and calculated maximum value of V10m at every grid point in prognosis period from +18 to +23 hour (full contours at 28, 30, 32, 34, 36m/s) -FIG7. as for FIG5, but on a larger DMI-HIRLAM-D area.
Ulblich et al (2001)	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 -FIG1. [MAP] ECMWF sea level pressure analsysi for (a) Anatol, (b) Lothar, (c) Martin. at the time of the most violent gusts. Contours are every 5mb. Black dots indicate points where max gales within the period exceeded 63 or 80kt. The 6-h positions are also indicated. (d) German Weather Service (DWD) operational manual surface analysis. The location of the fronts is taken from the DWD analysis. -FIG2. [MAP] Large scale conditions associated witht he storms: (a), (d), and (g) Anatol; (b), (e), and (h) Lothar; (c), (f), and (i) Martin. The left-hand column shows the 500mb geopotential height (solid lines, contour interval 8dam) and temperature fields (broken lines, contour interval 5degC), the middle column equivalent potential temperature (contour interval 5K) at 850mb, and the right hand column the 3day avg upper level 300-500mb maximum Eady growth rate (per day). Dates and associated cyclone locations (arrows) are indicated along with the cyclone track from 6h positions. Grid points where local values exceed the 85th and 99th percentile shaded -FIG6. [MAP] Fields of maximum Eady growth rate (per day) and equivalent potential temperature (contour interval 5K) at 850mb for three historic European storm events
Buizza and Hollingsworth (2001)	Buizza, Roberto and Anthony Hollingsworth, Severe weather prediction using the ECMWF EPS - The European Storms of December 1999, ECMWF Newsletter, No. 89, Winter 2000/01. -mean sea level pressure field around North Sea and NW Europe for 04Dec1999
Buizza and Hollingsworth (2002)	Buizza, Roberto and Anthony Hollingsworth, Storm prediction over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002 -mean sea level pressure field around North Sea and NW Europe for 04Dec1999
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 Kriging grid map of peak gust Anatol
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 FIG6. [MAP] forecast North Sea surge water level for 03Dec1999 22:00 based on a model run with data up to 02Dec1999 22:00.
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -FIG2. (a) 42h forecast of sea level pressure and wind velocity (WMO standard) at 10m height valid for 1800UTC 3Dec1999. -FIG5. [MAP] Relative vorticity at 950hPa, sea level pressure, and 300hPa wind speed. (a) is a 12h forecast valid at 12UTC 2Dec, (b) is a 30h forecast valid 06UTC 3Dec and (c) is a 36h forecast valid 12UTC 3Dec -FIG6. Vertical cross section with distribution of relative humidity RH, theta_e, and V_n normal to section. The thick dashed curve is 1.5PVU contour -FIG7. Potential vorticity at 315K, theta_e at 950hPa. (a) is a 12h forecast valid at 12UTC 2Dec, (b) is a 30h forecast valid 06UTC 3Dec and (c) is a 36h forecast valid 12UTC 3Dec -FIG9. Vertical cross-section with relative humidity RH and wind speed V_n normal to cross section -FIG10.Distribution of theta_e in C at 600hPa. Surface fronts are shown with conventional symbols, the center of the surface low is marked by L and the jet core at 300hPa is shown by thick

	dashed curve.
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -FIG7. Maps of 10m wind speed and sea level pressure at 0000UTC 03Dec1999
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -modelled storm surge field in German Bight
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -FIG2. [MAP] Mean sea level pressure field and 1000hPa wind vectors of 3Dec1999 1800UTC computed from NCEP-NCAR reanalysis. Units are hPa with isobars every 5hPa. Wind speed vectors in m/s. Superimposed on this field is the track of the low pressure system that produced the storm Anatol from 2Dec 1200UTC to 5Dec 1200UTC with P in hPa every 6h. -FIG3. [MAP] Map showing the track of the low pressure centre across southern Sweden on 3-4Dec1999. The lines show the lowest pressure during the passage, and the Ltt show the low pressure centre at time tt.
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -FIG5. Comparison of max wind velocities (m/s) and directions in the modelled wind fields of storms (a) Anatol 03Dec1999, (b) Britta 01Nov2006, (c) Tilo 09Nov2007 (DWD)
Gatey (2011)	Gatey, DA, The analysis of extreme synoptic winds, Ph.D. Thesis, University of Western Ontario, 2011. University of Western Ontario - Electronic Thesis and Dissertation Repository. Paper 268. -FIG5.2. MSLP field Storm Anatol 03Dec1999 18:00h -FIG5.4. Geostrophic wind field: Storm Anatol 03Dec1999 18:00 -FIG5.6. Quasi-Geostrophic wind field: Storm Anatol 03Dec1999 18:00 -FIG5.8. Semi-Geostrophic wind field: Storm Anatol 03Dec1999 18:00 -FIG5.12.Wind field at 1000m: Anatol 3Dec1999 18:00
AON Benfield (2013)	AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013 -FIG_p31. map of max wind gust for Anatol 03Dec1999
Roberts et al (2014)	Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014 -MetUM model of maximum wind speed; model initialized with ERA-Interim -model had problems simulating depth the sea level pressure in Denmark
Cappelen et al (2018)	Cappelen J, S Olufsen, MH Ribegaard, JW Nielsen, T Schmith, N Hansen, Det traekker op til orkan, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/det-traekker-op-til-orkan/ FIG. [MAP] average wind speed (and surface atmospheric pressure?) at 15:00 03Dec1999. Average wind speed of storm strength is registered for the first time in W Denmark, NOTE high winds on RHS of low pressure center
Cappelen et al (2018e)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/ -FIG. [MAP] highest avg wind during December hurricane based on reanalysis of data 3-4Dec1999 [Michael Scharling] -FIG. [MAP] highest wind gust during December hurricane based on reanalysis of data 3-4Dec1999 [Michael Scharling]

Table SL13. Satellite altimeter strip maps (arranged by year and then alphabetically)

Source	Full Reference and Notes
Toffoli et al (2005)	A.Toffoli, J.M. Lefevre, E. Bitner-Gregersen, J. Monbaliu, Towards the identification of warning criteria: Analysis of a ship accident database, Applied Ocean Research, 27, 281-291, 2005 -there was data extraction for Topex-Poseidon, ERS1, ERS2 for Hs for ship accidents in the period 1995-1999. -Storm Anatol ship accidents not mentioned specifically, but likely

Table SL14. List meteorological data (arranged by year and then alphabetically)

Data type	Location	Time Interval	Full Reference and Notes
[TEXT] maximum gust	Prestwick, Humber Bridge, Crosby, Leeds	3Dec1999	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299
[FIG] Time series of weather symbols showing wind speed, gust, temperature, humidity, weather conditions	Romo/Juvre, Blaavandshuk, List/Sylt	3-4Dec1999	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999.
[TEXT] maximum gust	Esbjerg	3Dec1999	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00
[TABLE] maximum 10 min wind speed and gust of month	Shannon, Kilkenny, Connaught airport, Clones, Birr, Mullingar	3Dec1999	Met Eireann, Monthly Weather Bulletin, no. 164, Dec, 1999
[FIG] Time series wind	Europlatform, Hoek van	3-4 Dec 1999	RWS, Verslag van de Stormvloed can 3 en 4 december 1999

speed and direction	Holland, IJmuiden, platform K13a		(SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.
[TEXT] Single ship report from Walter Hertwig 3	North Sea ship report 55N 2E	3Dec1999	Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38.
[TABLE] maximum 10 minute wind speeds from original measurements and reduced to 10m height with times	Horns Rev, Tobol, Omo, Rodsand, Gedser Rev, Gedser Odde, Vindeby, Middelgrunden, Riso, Tystofte, Borglum, Skjern, Kegnaes, Bastrup, Beldringe, Tystofte, Abed, Gedser Odde, Sjaelsmark, Kastrup, Klemensker Ost	3 Dec 1999	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000.
[FIGURE] Time series air pressure, 5s avg gust, and 10min sustained wind speed	Horns Rev 62m mast	3Dec1999	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000
[TABLE] maximum wind speed at 4 measurement heights	Horns Rev 62m mast	3 Dec 1999	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000
[MAP] map labelled with maximum sustained wind speeds	Denmark stations	3-4 Dec 1999	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000
[MAP] map with wind flags	Denmark, northernmost Germany, south Sweden	3Dec1999 1500 UTC	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000.
[MAP] map with wind flags	Denmark, northernmost Germany, south Sweden	3Dec1999 1800 UTC	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000.
[MAP] map with wind flags	Denmark, northernmost Germany, south Sweden	3Dec1999 2100 UTC	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000.
[MAP] map with wind flags	Denmark, northernmost Germany, south Sweden	4Dec1999 0000 UTC	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000.
[MAP] synoptic map with wind, weather, surface pressure printed	Denmark, southernmost Sweden, northernmost Germany	3 Dec 1999 1700 MET	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000.
[TABLE] maximum gust	Sylt (WMO 10020), Kap Arkona (WMO 10091), Hel (WMO 12135)	3-4Dec1999	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001
[TEXT] maximum gust	North Sea platform, Romo, Sylt, Fehmarn, Kap Arkon Rugen, Bornholm, Hela Peninsula, Gdansk (Danzig), Kaliningrad (Konigsburg)	3-4Dec1999	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[FIGURE] Time series annual maximum gust	List auf Sylt	3-4Dec1999	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[FIGURE] Time series sea level pressure	List auf Sylt, Torup Sweden	3-4Dec1999	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[FIGURE] Time series 10 minute average wind speed	Unnamed North Sea platform 55.5N 5.00E	3-4Dec1999	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[FIGURE] Time series of gust and 10min average wind speed	List auf Sylt, Westermarkelsdorf	3-4Dec1999	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[TABLE] maximum wind speed of radiosonde profile	Radiosonde stations in central and western Europe	3-4Dec1999	DWD, Klimatologische Bewertung der juensten Stark-Windereignisse (Anatol und Lothar) aus der Sicht der Klimatologie der freien Atmosphaere, [pdf document properties: 28/05/2002]
[TABLE] maximum wind speeds	Romo, Copenhagen, Sylt, Cape Arcona (Ruegen)	3-4Dec1999	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002
[FIG] Time series of the wind speed (10min, 5s, 1s) and air pressure at 62m	Horns Rev	3-4Dec1999	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.
[TEXT] maximum 1s gust at 62m height 58.5m/s	Horns Rev M2 Mast	3Dec1999 18:00MET?	Sommer, A., Offshore measurements of wind and waves at Horns Rev & Laeso, Denmark. European Seminar OWEMES

			2003, Apr 10-12, 2003, Naples, Campania, Italy.
[FIGURE] time series of Horns Rev wind speed at 30m (height corrected)	Horns Rev mast	3 Dec 1999 0600-2330UTC	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003.
[TABLE] Maximum wind speed	Norderney	03Dec1999	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21.
[TABLE] highest wind gust in Germany during storm	List/Sylt	3-4Dec1999	Gerhard Mueller-Westermeier, Beschreibung un klimatologische Bewertung des Orkantiefs "Kyrill", pdf properties: Title: Deutscher Wetterdienst - Nationale Klimauberwachung, Author: Gerhard Mueller-Westermeier, Subjet: Orkan Kyrill, datestamp: 26Jan2007
[FIGURE] time series of gust wind speed	Malmo, Horby, Skillinge, Helsingborg, Hano	3-4Dec1999	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007.
[FIGURE] Map with text for 10 min average wind speed and gust	8 stations in southern Sweden	3-4Dec1999	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762)
[TEXT] 10 minute average wind speed	Hano, Falsterbo	3-4Dec1999	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762)
[TEXT] maximum wind gusts	Fehmarn, Hiddensee, Mecklenburg-Vorpommern	3Dec1999	AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013
[TEXT] maximum wind and gust	Romo	3Dec1999	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/
[TEXT] Lowest measured air pressure	Anholt	3Dec1999	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/
[TEXT] Maximum average wind and gust	Sylt	3Dec1999	Astleitner, Thomas, 3. December 1999: Orkantief Anatol fegt ueber de Nordsee, https://uwr.de/de/a/3-dezember-1999-orkan-tief-anatol-trifft-deutschland, published 3Dec2019, accessed 20Sep2020

Table SL15. Significant wave height and sea state (arranged by year and then alphabetically)

Data type	Location	Time Interval	Full Reference and Notes
[FIG] Time series of wave height	Europlatform, IJmuiden, K13a, Eierlandse Gat	3-4 Dec 1999	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.
[TABLE] maximum wave height and maximum significant wave height	Horns Rev, 2 waverider locations north and soth of shoal	3Dec1999	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000
[FIG] Time seris of significant wave height and maximum wave hieght	Horns Rev, waverider buoys, north and south	3-4Dec1999	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.
[TABLE] maximum wave height and maximum significant wave height	Horns Rev, 2 waverider locations north and soth of shoal	3Dec1999	Sommer, A., Offshore measurements of wind and waves at Horns Rev & Laeso, Denmark. European Seminar OWEMES 2003, Apr 10-12, 2003, Naples, Campania, Italy.

Table SL16. Wave period and other wave data (arranged by year and then alphabetically)

Data type	Location	Time Interval	Full Reference and Notes
[FIG] Time series of wave direction	Europlatform, IJmuiden, K13a, Eierlandse Gat	3-4 Dec 1999	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.

Table SL17. Surge reports and quantitative water levels (arranged by year and then alphabetically)

Data type	Location	Time Interval	Full Reference and Notes
[TABLE] Maximum water levels	Esbjerg, Vidaa(Hojer), Torsminde	3 Dec 1999 afternoon	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100,

			DK-2100 Kobenhaven 0, 9Dec1999.
[TEXT] skew surge statement that water level 3.2m over normal	Esbjerg	3 Dec 1999 afternoon	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00
[TABLE] Highest water levels and skew surge references to mean high tide (1986-1995)	Stations in Schleswig-Holstein and Niedersachsen	3-4 Dec 1999	Land Schleswig-Holstein, Sturmflutereignis am 03.12.1999 (Wasserstaende an Pegelmessstellen), Amt fuer laendliche Raeume, Husum, Az.: 5621, document sent by Maria Bluemel 09Sep2020
[TEXT] maximum water level 5.86m	Hamburg	3 Dec 1999 23:15?	Lloyds Casualty Week, vol318, No12, 17Dec1999
[TEXT] maximum skew surge 4.10m	Esbjerg	3-4 Dec 1999	Lloyds Casualty Week, vol318, No12, 17Dec1999
[TABLE] Maximum values of water level, true surge, and skew surge with times	Delfzijl, Vlissingen, Roompot buiten, Hoek van Holland, Dordrecht, Den Helder, Harlingen	3-4 Dec 1999	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.
[FIG] Time series of measured water level, model astronomical tide, surge residual	Delfzijl, Vlissingen, Roompot buiten, Hoek van Holland, Dordrecht, Den Helder, Harlingen	3-4 Dec 1999	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.
[TABLE] maximum water level across storm period 2.80 m but with power outage?	Horns Rev Mast	(3 Dec 1999)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000
[TABLE] maximum water level, astronomical tides, maximum residual	Thyboron, Ferring, Tosminde, Hvide Sande, Esbjerg, Ribe, Havneby, Ballum, Vidaa/Hojer	3-4 Dec 1999	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000
[TEXT] Maximum surge 5.82m	Hamburg	3 Dec 1999 23:15MEZ	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002]
[TEXT] Maximum surge water level at 5.86m	Hamburg	3 Dec1999	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002
[FIG] Time series of water level from ADCP? showing maximum of 2.75 m	Horns Rev	3-4Dec1999	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.
[TABLE] MHW for 1999, astronomical departure from MHW, surge residual, departure from MHW, max water level for PN reference, time of maximum water level, PN reference level, maximum water level for NN reference level	Helgoland, Borkum, Emden, Wilhelmshaven, Alte Weser, Bremerhaven, Bremen, Grosser Vogelsand, Cuxhaven, Hamburg, Buesum, Bildesperrwerk, Husum, Ribe, Esbjerg.	3 Dec 1999	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003
[TABLE] Maximum water level 2.80m; expected high tide about 0.49m	Horns Rev	3 Dec 1999	Sommer, A., Offshore measurements of wind and waves at Horns Rev & Laeso, Denmark. European Seminar OWEMES 2003, Apr 10-12, 2003, Naples, Campania, Italy.
[TABLE] Maximum water levels relative normal null	Borkum, Emden, Norderney, Helgoland, Wilhelmshaven, Bremerhaven, Bremen, Cuxhaven, Hamburg, Buesum, Husum, Dagebuell, Wittduen, List	3Dec1999	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005
[TABLE] Measured highest water levels	Borkum, Emden, Norderney, Helgoland, Wilhelmshaven, Bremerhaven, Cuxhaven, Buesum, Husum, Dagebuell, Wittduen, List, Esbjerg	3-4Dec1999	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006.
[FIG] Measured water level, astronomical tide, surge residual	Cuxhaven	3-4Dec1999	Goennert, Gabriele & Thomas Buss, Sturmfluten zur Bemessung von Hochwasserschutzanlagen, Berichte des Landesbetriebes Strassen, Bruecken und Gewaesser Nr.2/2009, Freie und Hansestadt Hamburg, Landesbetrieb Strassen, Bruecken und Gewaesser, Hamburg ISSN 1867-7959.
[FIG] Measured highest water levels during Anatol	Brokum, Eemshaven, Eemshoern, Delfzijl Knock, Emden, Pogum barrier	3-4 Dec 1999	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier,

			32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010
[TEXT] Maximum water level 3.43 m ODN?, skew surge 0.96 m, true surge 1.39 m	Southend on Sea, UK	3 Dec 1999	Environment Agency, Thames Barrier Prject Pack 2012, time stamp Nov. 24, 2011 Environment Agency, Thames Barrier Project Pack, January, 2018
[TEXT] Maximum water level	Hamburg	3 Dec1999	AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013
[TEXT] Highest water levels	Ribe	3 Dec 1999	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021
[FIG, TEXT] maximum measured water levels	Hamburg, Harburg	3 Dec 1999	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014.
[TABLE] 'wind surge' 201cm	Norderney	1999	Kristandt, J, B Brecht, H Frank, H Knaack, Optimization of empirical storm surge forecast – modelling of high resolution wind fields, Die Kuste, 18, 301-308, 2014
[FIGURE] Highest water levels labelled on map	Hanstholm, Thyboron, Ferring, Thorsminde, Hvide Sand, Esbjerg, Ribe, Havneby, Ballum, Vidaa/Hojer	3 Dec 1999	Cappelen, J., Storm og ekstrem vind i Danmark - opgorelser og analyser til og med 2017, DMI rapport 18-07, Copenhagen 2018
[FIGURE] Highest water levels labelled on map	Hanstholm, Thyboron, Ferring, Thorsminde, Hvide Sand, Esbjerg, Ribe, Havneby, Ballum, Vidaa/Hojer	3 Dec 1999	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/
[TABLE] Detrended highest measured water level	~20 stations on Danish west coast and Kattegat	3-4 Dec 1999	Ditlevsen C, MM Ramos, C Sorensen, UR Ciocan, T Pionkowitz, Hojvandsstatistikker 2017, Miljo- og Foedevaremnisteriet, Kystdirektoratet Lemvig, Februar, 2018
[TEXT] Maximum water level before instrument malfunction	Ribe	3 Dec 1999	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020)
[TEXT] Maximum water level	Ribe, Hamburg	3 Dec 1999	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021

Table SL18. Water current information (arranged by year and then alphabetically)

Data type	Location	Time Interval	Full Reference and Notes
[FIG] Time series of water current speed at Baltic Sea outflow	Vestbroen i Storesbaelt	4 Dec 1999	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000
[FIG] Time series of water current at 3 levels showing maximum value 0.98m/s on afternoon 04Dec1999	Horns Rev	3-4Dec1999	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002.

Table SL19. Return period of water level; ranking of water level

Source	Full Reference and Notes
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -water levels expressed as return period frequencies for Delfzijl, Vlissingen, Roompot buiten, Hoek van Holland, Dordrecht, Den Helder, Harlingen
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -Thyboron: 2y -Torsminde: 3y -Hvide Sand: 9y -Esbjerg: 50y (rank 4 after 1981 storm) -Ribe: >196y -Havneby: 5y -Ballum: 25y -Vidaa/Hojer: 43y
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -rank 4 storm surge water level Hamburg
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002

	-water level Hamburg rank 4 of recent decades
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -ranking of water level for storms in period 1962-1999
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -tabulated information to calculate return period levels for Emden, Norderney, Bremerhaven, Cuxhaven, Helgoland, Buesum, Husum, Dagebuell, List
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -previous comparable water leve before Anatol 27Nov1825 and then 11Oct1634
Ditlevesen et al (2018)	Ditlevsen C, MM Ramos, C Sorensen, UR Ciocan, T Pionkowitz, Hojvandsstatistikker 2017, Miljo- og Foedevaremnisteriet, Kystdirektoratet Lemvig, Februar, 2018 -information to calculate return period of water level for Storm Anatol
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -rank 2 water level in Ribe after Buchardi 1634 flood; equal in height to 1825 surge -rank 4 storm surge Hamburg

Table SL20. Return period of wind speed; ranking of wind speed

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 -75mph gust at Leeds was December records
Met Eireann (199912)	Met Eireann, Monthly Weather Bulletin, no. 164, Dec, 1999 -mean wind speeds for the mnth were above normal everywhere -mean wind speeds for Belmullet and Malin Head were highest for December for 5-16 years.
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -previous comparable storms from Sweden from 1967, 1981 and after
Kristensen et al (2000)	Kristensen L, O Rathmann, SO Hansen, Extreme wind in Denmark, Journal of Wind Engineering and Industrial Aerodynamics, 87, 147-166, 2000. -return period maximum wind speed Skjern (47y), Kegnaes (27y), Tystofte (204y) -low value for Kegnaes may be due to WASP corrections to standard conditions
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -return period graph and reduced wind speed for Horns Rev indicate that Anatol was a 400year event
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -description as Danmark-Arhundrets orkan
IEA (2001)	IEA, Wind Energy Annual Report 2000, International Energy Agency, National Renewable Energy Laboratory, May, 2001. (Author Ian Fletcher) pdf document properties: datestamp: 08Jul2005; -Database on wind energy chracteristics 1996-1998 -Toboel wind field data (3000h, Denmark with 400y wind event; storm 03Dec1999)
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -wind speed record for station in Denmark and some stations in nothernmost Germany
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -rank 1 wind speed Sylt; previous record 1976 -rank 1 record wind speed Romo Denmark
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -Sweden Falsterbo stations register most violetn wind speed since 1967 -several stations in Denmark registered highest wind speeds up to that time
Della-Marta et al (2009)	Della-Marta PM, H Mathis, C Frei, MA Liniger, J Kleinn, C Appenzeller, The return period of wind storms over Europe, International Journal of Climatology, 29, 437-459, 2009. -return period WS10: 4.31y (2.82-6.72y) -return period FG10: 2.93 (2.09-4.17)
SMHI (20111013)	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) -map of gust return periods for Sweden showing values of 50 years in southernmost Scania
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] -for 100y series 5y interval between major windthrow; 10y interval between 250000m3 throw
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -Anatol very high wind speeds registered avg 38.1m/s, gust 51.4m/s -record stood until hurricane Allan Oct 2013 /w highest avg=39.5m/s, gust 53.5m/s

Table SL21. Storm trajectory map (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej

	100, DK-2100 Kobenhaven 0, 9Dec1999. -map showing trajectory and central pressures at 3h intervals between 3Dec1999 1200-2100UTC
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -FIG2. [MAP] Trajectory of the low pressure centre and surface pressure at 4Dec1999 1300MET
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -FIG1. [MAP] Map of lowest surface pressures during passage of low pressure. Arrow shows trajectory of low pressure center with times marked. 10min avg & gusts shown
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -Denmark map with low pressure trajectory indicated
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -trajectory map with min low pressure marked 3Dec1999 0000UTC to 4Dec1999 0300UTC
Ulblich et al (2001)	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 -minimum pressure trajectory at 6h intervals
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -[MAP] storm trajectory in 3h station on rectilinear axes
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -Anatol trajectory map given: 02Dec1999 2100UTC to 09Dec1999 0900UTC
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -FIG2. [MAP] Mean sea level pressure field and 1000hPa wind vectors of 3Dec1999 1800UTC computed from NCEP-NCAR reanalysis. Units are hPa with isobars every 5hPa. Wind speed vectors in m/s. Superimposed on this field is the track of the low pressure system that produced the storm Anatol from 2Dec 1200UTC to 5Dec 1200UTC with P in hPa every 6h. -FIG3. [MAP] Map showing the track of the low pressure centre across southern Sweden on 3-4Dec1999. The lines show the lowest pressure during the passage, and the Ltt show the low pressure centre at time tt.
Fink et al (2009)	Fink AH, T Brucher, V Ermert, A Kruger, JG Pinto, The European storm Kyrill in Jan 2007: synoptic evolution, meteorological impacts and some considerations with respect to climate change, Natural Hazards and Earth System Sciences, 9, 405-423, 2009. -map with storm trajectory from NCEP-1 reanalyssis field
Gardiner (2010)	Gardiner, Barry, Appendix 3: Background information on 11 storms selected for detailed analysis, European Forest Institute, Atlantic European Regional Office - EFIAtlantic, 161 pp. [PDF properties: datestamp 23Jul2010] -map with schematic trajectories of storms Anatol, Lothar, Martin in Dec 1999
SMHI (20111013)	SMHI_20111013, Hosten 1999 - Arhundradets storm? 13Oct2011 (https://www.smhi.se/kunskapsbanken/meteorologi/hosten-1999-arhundradets-storm-1.5762) -map showing trajectory of the Anatol low pressure center across Scania
XWS (20200906)	XWS, Extreme Wind Storms Catalogue, http://www.europeanwindstorms.org/cgi-bin/storms/storms.cgi, accessed 06Sep2020

Table SL22. Unusual pressure drop; time series central pressure; explosive characteristics; bomb (arranged by year and then alphabetically)

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 -Dun Laoghaire had 9mb fall in pressure over 3h period to 3Dec1999 0000UTC
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -comment that explosively deepening low pressure centres near Denmark are difficult to forecast
UKMO (1999)	UKMO, Daily Weather Summary, 26Nov1999 to 05Dec1999 -Storm Anatol pressure drop given in series of maps of Daily Weather Summary
Aakjaer (2000)	Aakjaer AF, Orkanen i Nordsoen den 30. oktober 2000, Vejret, 85, 1-7, 2000 -time series of central drop; comparison of hurricanes 30Oct2000, 3-4Dec1999, and Faeroe hurricane from 1993. -hurricanes 1999 and 2000 were similar to each other; Faraoe 1993 hurricane much deeper -reference to atmospheric bomb used by US meteorologists to describe their east coast storms.
Bancroft (2000)	Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. -966mb in North Sea at 1200UTC 03Dec -remarkable 49mb drop in central pressure in 24h; 14mb in last 6h -500mb analysis valid 00UTC 03Dec shows short wave trough that amplified with upper low east of Iceland
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -measured time series of atmospheric pressure at 55m height on 62m mast
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -hurricane with explosive development
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -storm forecast initially confirmed with stations in NW Ireland with P drops of 10mb in 3h. -map shows rapid development 995 to 958hPa drop in 12h from W of Hebrides to Nsea

Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -difficult to simulate all details of explosive cyclogenesis in DMI Hirlam
Ulblich et al (2001)	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 -rapid intensification of central pressure after it approached British Isles from 990 mb 0000GMT 03Dec1999 to 957 mb 1200GMT 03Dec1999 over central North Sea (note bomb criterion met) -minimum pressure 953mb near east coast of Jutland
Buizza and Hollingsworth (2001)	Buizza, Roberto and Anthony Hollingsworth, Severe weather prediction using the ECMWF EPS - The European Storms of December 1999, ECMWF Newsletter, No. 89, Winter 2000/01. -storm central pressure dropped from 996 to 961hPa in 12h from 0000Z to 1200Z on 3Dec1999
Buizza and Hollingsworth (2002)	Buizza, Roberto and Anthony Hollingsworth, Storm prediction over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002 -storm central pressure dropped from 996 to 961hPa in 12h from 0000Z to 1200Z on 3Dec1999
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -unusual presure drop of 40hPa in 12h -[FIG] Time series showing fast pressure drop and increase at List auf Sylt and Torup Sweden
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -maximum deepening rate 80hPa/day as low pressure center passed under jet stream -atmospheric bomb of Sanders and Gyakum (1980)
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -max deepening rate 13hPa/6h when it crossed northern Scotland -deepened further when it crossed North Sea night to Dec3 -crossed S Scandinavia night 3-4Dec1999 -sfc P=952hPa over Jylland Denmark 1900UTC 3Dec
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -mention of unsual pressure drop and bomb characteristics for Braer storm 8-11Jan1993 & Oct 1967 storm but not Anatol
Cappelen et al (2018)	Cappelen J, S Olufsen, MH Ribegaard, JW Nielsen, T Schmith, N Hansen, Det traekker op til orkan, updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/det-traekker-op-til-orkan/ -early Friday 3Dec ... the low pressure was deepening explosively -within 12h central pressure fell from 996hPa to 958hPa on way west from Hebrides to central Nsea -low P center achieved min of 952.4hPa (lowest ever was 943.9hPa) from Skive to Anholt
Worls Energy Council (2019)	World Energy Council, Case Study Series, Extreme Weather, Windstorms France December 1999, https://www.worldenergy.org/assets/downloads/Windstorms_France_-Extreme_weather_conditions_SEP_2019.pdf, pdf date stamp: 11Oct2019 -explosive deepening for Lothar; meteorological bomb

Table SL23. Low level jet

Source	Full Reference and Notes
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -low level jet seen in model simulations
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -atmospheric sounding theta_v increasing from 900-500hPa; low level jet at 1500-2000m
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -mention of low level jet for most severe storms -starts in NE quadrant and spirals counterclockwise

Table SL24. Sting Jet

Source	Full Reference and Notes
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -mention of sting jet for some of most sever storms: Allan 28Oct2013, Great Storm 15-16Oct1987

Table SL25. Radiosonde analysis

Source	Full Reference and Notes
DWD (20020528)	DWD, Klimatologische Bewertung der juensten Stark-Windereignisse (Anatol und Lothar) aus der Sicht der Klimatologie der freien Atmosphaere, [pdf document properties: 28/05/2002] -maximum wind speed in the radiosondes for stations in central and western Europe -unusual number of cases of high wind speeds >60m/s and >80m/s during winter 1995/6, 1996/7, 1997/8 -Radiosonde wind speeds during Anatol reached >60 and 80m/s -north-south gradient in maximum wind speeds
University of Wyoming (20210914)	University of Wyoming, http://weather.uwyo.edu/upperair/sounding.html, last access 14Sep2021 -global database radiosonde measurements, including the period of Storm Anatol.

Table SL26. Stable atmospheric boundary layer

Source	Full Reference and Notes
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -atmospheric sounding theta_v increasing from 900-500hPa; low level jet at 1500-2000m

Table SL27. Strong jet stream

Source	Full Reference and Notes
Bancroft (2000)	Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. -p30. Dec was very active with strong W of SW flow aloft leading to a series of strong low P systems moving into W Europe beginning 3Dec
Bell et al (2000)	Bell GD, MS Halpert, RS Schnell, RW Higgins, J Lawrimore, VE Kousky, R Tinker, W Thlaw, M Chelliah, A Arthusa, Climate Assessment for 1999, Bulletin of the American Meteorological Society, 81, S1-S50, 2000 -strong jet stream displaced to low altitude during Dec 1999
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -problems simulating jet stream in ECMWF because of different spatial resolution the in zonal and meridional directions
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm -bizarre meteorological combination combined 3 factors for 26-28Dec storms a. blast of strong polar air b. jet stream oscillating 350-400km/h compared to normal 100kph c. series of zones of extremely low pressure at low altitudes
DWD (20020528b)	DWD, Klimatologische Bewertung der juensten Stark-Windereignisse (Anatol und Lothar) aus der Sicht der Klimatologie der freien Atmosphaere, [pdf document properties: 28/05/2002] -high radiosonde wind speeds during Storms Anatol and Lothar -highest radiosonde wind speeds typically reached at tropopause (summer) or stratosphere
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -maximum deepening rate 80hPa/day as low pressure center passed under jet stream
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -powerful Atlantic jet stream with wind speed 60-72m/s
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -stronger than normal upper level jet for Storm Lothar

Table SL28. Squall line, convective thunderstorms, tornadoes (arranged by year and then alphabetically)

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 -low dragged cold front across all S areas of British Isles -rain clearing in S England in evening -snow showers as far S as N Wales and Shropshire, blocking roads in N & causing accidents *-thunder reported in the showers from the Northern Isles to Cheshire

Table SL29. Lightning (arranged by year and then alphabetically)

Source	Full Reference and Notes
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -reference to lightning strike in Oct 1999 that severely damaged top anemometer
Caithness Windfarm (20180730)	CaithnessWindfarm, craigdr, Detailed accidents to 19 June 2018. Document time stamp 30/07/2018, 177pp Wind turbine accident compilation (start 30Nov1980) [Storm Anatol 1999 reports] -lightning strike damages blades of turbines at Zennhausen Germany 3Dec1999 -lightning strike damages turbine blade at Westermarsch II, Norddeich, Niedersachsen

Table SL30. Meso-vortex (arranged by year and then alphabetically)

Source	Full Reference and Notes

Table SL31. Meteotsunami and unusual surges (arranged by year and then alphabetically)

Source	Full Reference and Notes
Aakjaer (2000)	Aakjaer AF, Orkanen i Nordsoen den 30. oktober 2000, Vejret, 85, 1-7, 2000 -storm surge at Hvide Sande without strong storm winds on 30Oct2000 -dynamical effect shift of low P trajectory to north, releasing water as wave to flow north at long wave speed

Table SL32. Hurricane gusts only on south (right) side of pressure center (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999.

	-weather map 3Dec1999 1800UTC shows highest wind speeds only on right hand side of trajectory
Aakjaer (2000)	Aakjaer AF, Orkanen i Nordsoen den 30. oktober 2000, Vejret, 85, 1-7, 2000 -surface weather map shows strongest winds on right hand side of storm center 30 Oct 2000
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -highest water levels in Vadehavet
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -hurricane gust were only S of the low P trajectory -in north Jylland only few places with storm gusts to 25m/s both in front of and behind L
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -map of modelled maximum wind speeds in a strip across southern Denmark
Frank and Majewki (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -model fields show strongest winds in cold sector to S and SW of low pressure center
Fink et al (2009)	Fink AH, T Brucher, V Ermert, A Kruger, JG Pinto, The European storm Kyrill in Jan 2007: synoptic evolution, meteorological impacts and some considerations with respect to climate change, Natural Hazards and Earth System Sciences, 9, 405-423, 2009. -map of wind speed exceedance at the 98th percentile for Daria, Anatol, Kyrill show damaging winds almost entirely on right hand side of storm track
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -maximum in wind speed to south of low pressure (right) -low level jet LLJ; poison breath -jet starts normally in NE quadrant; spreads south spiraling counterclockwise
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -little tree-fall loss in north Jylland on left hand side of trajectory
Cappelen et al (2018e)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018e, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/ -only S of hurricane eye that winds achieved hurricane strength
Cappelen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -almost entire country impacted -except N Jylland wind gusts in most places reached 40-50m/s or 150-175km/h -worst impacts in S Jylland, especially Waddensee

Table SL33. Culmination time and location determines damage properties of storm

Source	Full Reference and Notes
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -moved NNE via Scotland and Nsea to Jylland where it culminated 19MET 3Dec at 953hPa central pressure
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -reference the deepening and mature phase
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -storms are most dangerous when they are intensifying
RMS (2014)	RMS, 2013-2014 Winter Storms in Europe. An Insurance and Catastrophe Modeling Perspective. RMS White Paper. [PDF TIMESTAMP 11Mar2014] -presentation of storm tracks for early winter 1990 and winter 2013-2014 showing atmospheric pressure nadir points -storm considered less serious if pressure nadir points to west of British Isles.

Table SL34. Infragravity wave, rogue wave, green water incidents (arranged by year and then alphabetically)

Source	Full Reference and Notes
Leonhardsen et al (2001)	Leonhardsen RL, G Ersdal, A Kvitrud, Experience and risk assessment of FPSOs in use on the Norwegian Continental Shelf. Description of Events, The Eleventh International Offshore and Polar Engeineering Conference, International Society of Offshore and Polar Engineerings, 2001. 6pp. Paper No. 2001-IL-05 [pdf document datastamp=08Apr2001] -green water incidents on 30Nov1999 to Asgard A and Petrojarl Varg

Table SL35. Wave dynamics and dike breaches; wave runup studies (arranged by year and then alphabetically)

Source	Full Reference and Notes
Schrovers et al (2007)	Schroevers M, J Dekker, R Groenendaal, H Peters, Inventory wave data for model calibration, Rijksinstituut voor Kust en Zee, Rijkswaterstaat, July, 2007 [pdf timestamp 07Jan2016] * -'the dike breached in 1999. Hereafter, wave locations in the tidal basin between the islands of Romo and Mando (including the location closest a dike, 3013) were set-up especially to check wave propagation in this inlet' -'During the 1999 event there were high water levels at the mainland dykes, which was one of the causes for failure. It is believed that the back flow after this initial setup was one of the causes for the dike on the lee side of Romo to fail. DCA would very much like input on how and where to measure this back flow effect including the waves'

Table SL36. Precipitation, river level dike breaches (arranged by year and then alphabetically)

Source	Full Reference and Notes

Table SL37. Unusual peak of significant wave height in northern North Sea (arranged by year and then alphabetically)

Source	Full Reference and Notes

Table SL38. Double surge peak from wind and travelling wave (arranged by year and then alphabetically)

Source	Full Reference and Notes
Neckmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -double peak in wind speed across 2.5h period of hurricane maximum
Capellen et al (2018b)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/ -second high water after midnight lasting until morning

Table SL39. Very low water levels (arranged by year and then alphabetically)

Source	Full Reference and Notes
Capellen et al (2018b)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/ -in indre dansk farvand, east facing coasts dry; harbours had yachts luying on ground -water levels fell to 2m below normal; lowest ever registered -lost water sent into Baltic and turned back in course of Friday as high water S of Baelthavet

Table SL40. Modelled turbulence kinetic energy in ocean wave model (arranged by year and then alphabetically)

Source	Full Reference and Notes

Table SL41. Classification of storm surges (arranged by year and then alphabetically)

Source	Full Reference and Notes
Keers (1966)	Keers, JF, The meteorological conditions leading to storm surges in the North Sea, Meteorological Magazine, London, 95, (1130), 261-272, Sept. 1966 -Four types of storm surges for England east coast
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -Windstau type versus Circulation Type -Anatol belonged to Circulation type; rapid passage over British Isles and intensification over North Sea
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -comment that trajectory of storm between Scotland and Jutland, similar to summer storm Aug 1990
Von Storch and Woth (2008)	von Storch, Hans and Katja Woth, Storm surges: perspectrives and options, Sustain Sci, 3, 33-43, 2008 -tropical versus extratropical storms and surges
Kristandt et al (2014)	Kristandt, J, B Brecht, H Frank, H Knaack, Optimization of empirical storm surge forecast – modelling of high resolution wind fields, Die Kuste, 18, 301-308, 2014 -Surge storm types: Scandinavia type, Skaggerak type, Jutland type (Petersen and Rodhe, 1991) -Anatol belonged to Jutlan d type like Capella 1976 -Jutland type: develop at Nfld coast; cross 8E at 55-57N; short duration, very strong storms; affect mostly W coast Schleswig Holstein & Elbe; example Capella 1976
RMS (2014)	RMS, 2013-2014 Winter Storms in Europe. An Insurance and Catastrophe Modeling Perspective. RMS White Paper. [PDF TIMESTAMP 11Mar2014] -classification of serious European winter storms by location of where central pressure reaches minimum

Table SL42. Fatalities & injuries

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999 www.met.reading.ac.uk/~brugge/diary1999.html#1299 *-3 people killed as tree blown down in Kings Heath, Birmingham
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -tree toppled onto electricity mast that fell on man
Lloyds Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -6 fishermen killed when Sniegs fishing boat overturned by large wave -2 woman and man killed in 3 separate car accidents in Denmark -another woman killed by debris from roof Denmark -3 people in Birmingham killed by tree falling on vehicles -hospitals Denmark treated many injuries -6 people killed and many injured in country's most severe storm of century during yesterday afternoon to early hours Dec 4 -weekend storms left at least 17 dead and scores injured across N Europe -7 people killed Denmark - cargo aircraft Ilyushin-114 crashed on takeoff at Domodedomo airport in SE Moscow at around 0200UTC (0500local); 5/7 crew killed; Itar-Tass said it was due to engine fire or HIGH WINDS
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999.

	-30 fatalities across Europe
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -one fatality Sweden
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -7 fatalities during hurricane; almost all fatalities on roads, most associated with fallen trees -833 injuries requiring hospitalization
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm -100 fatalities from 3 storms; 19 fatalities in Germany recovering fallen timber
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -' Das Orkantief ‚Anatol' war in Dänemark, wo besonders hohe Schäden und zahlreiche Menschenopfer zu beklagen waren'
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 ->20 fatalities
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -20 people killed; 160 people killed in Anatol+Lothar+Martin
Humbling (2013)	Humbling David, Weatherwatch: Our severe gales are not hurricanes, but they can be as deadly, The Guardian, 13Dec2013 ->100 deaths during 3 storm sequence of Dec2013
Thejournal.ie (20151214)	thejournal.ie, The deadliest storms to evr hit Europe, 14Dec2015 0610AM, https://www.thejournal.ie/europe-storms-2497164-Dec2015/, accessed 10Dec2020 -20 fatalities give for storm Anatol
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -7 deaths Denmark; >800 injured requiring doctor attention
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -across country 7killed, 800 injured & hospitalized

Table SL43. Coastal flooding, dike breaks, and evacuations (arranged by year and then alphabetically)

Source	Full Reference and Notes
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -Esbjerg harbour area flooded
Lloyds Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -on Denmark west coast, people in many low-lying areas evacuated as coast water levels rose > 5m above normal levels -Esbjerg offices and warehouses flooded
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -400-500 surge damage cases -people evacuated in Sonderjylland because of damage to 4 dykes
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -Mando evacuated -Esbjerg main destruction flooding of harbour area -Juvre dyke north of Romo broke through in several places over a km stretch -significant numbers of animals drowned -newly restored route on the dam from mainland to Romo partly destroyed on north side
Schroevers et al (2007)	Schroevers M, J Dekker, R Groenendaal, H Peters, Inventory wave data for model calibration, Rijksinstituut voor Kust en Zee, Rijkswaterstaat, July, 2007 [pdf timestamp 07Jan2016] -mainland dike break between Mano and Romo islands -dike break on lee side of Romo island from back flow effect
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -dike breaks at Resby and Juvredeich
Ge et al (2014)	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. -parts of HafenCity not behind 7.5m Elbe Dyke and flooded
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -flooding at Romo

Table SL44. Coastal dike heights and protection levels (arranged by year and then alphabetically)

Source	Full Reference and Notes
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -Hamburg dike heights at 5.4-5.8mNN in 1962 during surge disaster.
Von Storch (2008)	von Storch, Hans and Katja Woth, Storm surges: perspectrives and options, Sustain Sci, 3, 33-43, 2008 -history of Hamburg dike heights and surges -before 1825 dyke failure at NN+5.20m -after 1825 dyke heights rainsed to NN+5.70m -after 1962 dyke heights raised to NN+7.20m -after 1976 dyke heights raised to NN+8.0m and then NN+9.30m -since 1962 several storm surges to the NN+5.50m to NN+6.00m
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -Design water levels Emden revised upward to 6.39 mNN in Lower Saxon Dike act -FIG10. Determination of the highest expected high water level at Emden with an open storm surge barrier by Single value method (Luders & Leis 1964) & in compliance with Lower Saxon Dyke Act. -based on highest known surge setup from 1906 event; 50cm sea level rise added
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -Ribe dike 7.0m during storm Anatol and was almost overtopped when water level+waves reached 6.70m -dike heights at Ballum are 4.0m; lowest along coast -description of dike structure with sand core for drainage & shallow angle front to dissipate wave energy
Ge et al (2014)	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. -Elbe dike is 7.5m high in Hamburg and prevents flooding of hinterlands

Table SL45. Surge barrier closures (arranged by year and then alphabetically)

Source	Full Reference and Notes
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. *-during storm passage storm surge barrier in the Hollandse IJssel closed
Environment Agency (2012)	Environment Agency, Thames Barrier Prject Pack 2012, time stamp Nov. 24, 2011 -Thames Barrier closed hydraulically at 2200 GMT -vigorous depression across North Sea with strong northerly winds -measured tide running well above forecast -maximum level at Southend 3.43m (ODN?) with a surge at high water of 0.96m (skew surge) and a maximum surge of 1.39 m (true surge) -Thames Barrier main gates reopened at 2315GMT
Environment Agency (2018)	Environment Agency, Thames Barrier Project Pack, January, 2018 -as for Environment Agency (2012)

Table SL46. Beach damage and coastal issues; salt water contamination of groundwater; sewer systems (arranged by year and then alphabetically)

Source	Full Reference and Notes
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -in only one night Sylt lost 1.4 million m3 of sand; more than in full year -ocean took all sand laid down in beach protection scheme the for 9.5 million DM -also on south point of island near Hoernum and Lister Ellenbogen beach scraped away
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -broken dykes in Sonder-Jylland
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -Juvre dyke north of Romo broke through in several places over a km stretch -newly restored route on the dam from mainland to Romo partly destroyed on north side -building debris from Mando scattered over dyke by waves

Table SL47. Power interruptions (arranged by year and then alphabetically)

Source	Full Reference and Notes
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -cases of electricity masts blown down -Esbjerg & Varde alarm center out of action because of power outage
Lloyds Casualty Week	Lloyds Casualty Week, vol318, No12, 17Dec1999

(19991217)	-Lithuania Klaipeda 100,000 people left without power after strong winds damaged transmission lines -Latvia: several hundred homes without power in western areas -power blackouts and flooding in many parts of Denmark -power blackouts reported in many parts of Denmark -electricity blackouts occurred in many areas of Denmark; torn power lines set off 400 fires -power cut: parts of Schleswig-Holstein & North Sea islands of Sylt and Amrum
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -long duration power cuts for at most 100000 customers (Sweden)
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -400,000 households without electricity
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -10 day power outage for most instruments at Horns Rev because waves hit junction box shed and forced out power cables
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -Romo and Ribe met stations had a power cut of several hours so highest gusts not known
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -165000 households without power due to major damage of overhead line network (Denmark, Sweden)
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -large scale power interruptions specfically mentioned for Martin but not Anatol or Lothar -Lothar+Martin: electricity: 1/4 France high tension transmission lines lost & 300 high voltage pylons toppled -one of greatest energy disruptions ever experienced by a modern developed country -10 mill people across France & Germany without power at height of winter
Sieber (2012)	Sieber, Jeanette, Impacts of extreme hydro-meteorological events on electricity generation and possible adaptation measures. A GIS-based approach for corporate risk management and enhanced climate mitigation concepts in Germany. Ph.D. thesis, Julius-Maximilians-Universitaet Wuerzburg - Institut fuer Geographie, Karlsruhe, November 2012 -electricity supply to 165000 households failed -summary of storm 1999-2010 with important energy impacts Europe
Humbling (2013)	Humbling David, Weatherwatch: Our severe gales are not hurricanes, but they can be as deadly, The Guardian, 13Dec2013 -3 million people without electricity during 3 storms of Dec1999
Danish Energy Agency (2015)	Danish Energy Agency, Security of Electricity Supply in Denmark, 1st edition 2015, translated 2016, Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, ISBN 978-87-93180-15-4 -approx 440000 households lost electricity in worst hurricane of century.
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -electricity masts suffered during the storm -fallen power cables caused 200 fires across the country -several thousand customers had experience the December hurricane & days afterward without power -20000 people in nordsjaelland spent week in winter darkness
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -France 25% high tension lines lost; 300 transmission pylons toppled -one of greatest energy disruptions for modern developed country
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -fallen electricity cables caused >200 fires -Nordsjaelland 20000 people without electricity for entire week -train traffic partly stopped for several days

Table SL48. List bridge closures, cancelled ferry crossings, port closures, airport cancel, rail interruptions, traffic accidents (arranged by year and then alphabetically)

Source	Full Reference and Notes
Brugge (1999)	Brugge, Roger, Weather Diary, Dec 1999, www.met.reading.ac.uk/~brugge/diary1999.html#1299 -strong gusts led to many blocked roads with fallen debris and overturned lorries Scotland -road restrictions imposed in exposed areas as far S as Cheshire and Derbyshire -A65 flooded at Settle
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -Sylt car train service interrupted for 6h at Hindenburgdamm
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -early in the afternoon Storebaeltsbroen was closed -most ferry routes stopped, flights grounded
Lloyd's Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -storm forced closure of Latvia's Ventspils port and Lithuania Klaipeda port -storm forced closure of Latvia's 3 main ports, which re-opened early today -Denmark: trains, city buses, ferries stopped running; road auth closed bridges

	-Denmark: lorries toppled by strong winds blocking some highways -Denmark: airports including Copenhagen international closed -rain, snow and high winds caused serious travel problems Scotland -Denmark: trains, city buses, ferries ceased running -Denmark: road authorities closed bridges across major waterways -Denmark: dozens of lorries toppled & blocked highways -Denmark: airports and Copenhagen international closed -Denmark: air, ferry, rail and road traffic resumed gradually this morning & bridges over major waterway re-opened -Denmark: thousands of people stranded as airports closed and train/bus services suspended -Denmark: winds: DMI meas up to 180km/h toppled dozens of lorries, closing highways -Denmark: thousands of fallen trees hampered traffic across country *-no major damage to port or vessels in Hamburg -Poland: rail service between Warsaw and Baltic cities of Szczezin and Gdansk cut by falling trees -Sweden: storms halted traffic at airports and ferry terminals -Moscow, Dec5: Reuters: cargo aircraft Ilyushin-114 crashed on takeoff at Domodedomo airport in SE Moscow at around 0200UTC (0500local); 5/7 crew killed; Itar-Tass said it was due to engine fire or HIGH WINDS
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -train traffic partly stopped for several days
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -fallen trees paralyze rail network dor several days -trees block secondary roads

Table SL49. Structural damage to wind farms and wind energy impacts (arranged by year and then alphabetically)

Source	Full Reference and Notes
Sommer (2002)	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002. -wave strike during Anatol disabled Horns Rev primary measurement system for 10days
Fehrmann and Fackler (2010)	Fehrmann,A. and A. Fackler, Offshore wind farms: risk and initial loss experience, Temple Insurance, a member of the Munich Re Group, 2010 [PDF timestamp: 09Mar2010] (last date reference 2001; last incident reference 2003) -13 older wind turbines destroyed in Denmark out of 3500 onshore turbines in operation at time of storm.
Caithness Windfarm (20180730)	CaithnessWindfarm, craigdr, Detailed accidents to 19 June 2018. Document time stamp 30/07/2018, 177pp Wind turbine accident compilation (start 30Nov1980) [Storm Anatol 1999 reports] -blade failure, Sievern-Langdon, Kreis Cuxhaven, 3Dec1999 -structural failure, Bochholt-Hemden, 3Dec1999 -structural failure Jutland, 3Dec1999 -blade failure, Zennhusen, 3 Dec 1999 (lightning) -blade failure, Westermarsch II, Norddeich, Niedersachsen (4Dec1999) -structural failure, Eemshaven 9Dec1999 -structural failure, Lichtenau-Asseln, Nordrhein-Westfalen
Buchana and McSharry (2019)	Buchana P, PR McSharry, Windstorm risk assessment for offshore wind farms in the North Sea, Wind Energy, 22, 1219-1229, 2019 -no mention of offshore or onshore wind turbine damage during storm Anatol -Anatol-Lothar-Martin mentioned as defining destructive storms in Europe as late as 2019

Table SL50. Hydropower impacts (arranged by year and then alphabetically)

Source	Full Reference and Notes

Table SL51. Structural damage to buildings, piers, and cultural monuments (arranged by year and then alphabetically)

Source	Full Reference and Notes
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -70% of houses damaged at Westerland -mobile homes destroyed -hundreds of roofs damaged
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -deroofed houses -Tonder: police station de-roofed
Lloyds Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -Denmark: storm uprooted trees and ripped roofs off many buildings -Denmark: material damage from heavy rains and gale winds estimate to exceed 1bill kronur (Danish Insurance Information Service) -Danish rescue officials logged >4000 reports of damage to buildings, mainly shattered windows and torn off roofs -Poland: 105m crane capable of lifting 900t toppled into sea at Gydnia shipyard -Poland: strong winds in Baltic region toppled one of world's largest gantry cranes, the 900tonne Kone crane at Gydnia Shipyard in Poland early hours of Dec4 -Poland: winds gusting up to 170km/h too strong for heavy steel hawsers to secure crane for gales; collapse caused damage to Drydock no 2; crane spanned 70m wide drydock -Odense shipyard: 3000ton crane toppled over vessel being built (Friday evening Dec3); 2000 workers sent home -heavy crane at Lindoe shipyard fell onto new building YARD No.170 (Danish container vessel 91560gt) in dry

	dock; crane seriously damaged; ship with minor damage -hurricane did considerable damage to constructions, roofs, forests, etc -Lindoe shipyard Odense, heavy crane collapsed on newbuilding Yard No.170; damage estimated at 2 million DKK
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -roof tile and side cladding damage during Storm Anatol should have been within Danish construction standards.
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -main damage: roofs, facades, vehicles, boats, scaffolding
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 -damage to buildings in southern Jutland
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -photos of Anatol damage in Denmark -Lothar+Martin: building: 60% of roofs damaged in the area of Paris; state of emergency in city
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -50% of buildings in Ribe damaged; mostly roofs and lost roof tiles
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -much roof and house damage

Table SL52. Forest damage and tree falls (arranged by year and then alphabetically)

Source	Full Reference and Notes
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -large trees snapped off on Sylt
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -large numbers of toppled trees
Lloyds Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -Denmark: storm uprooted trees and ripped roofs off many buildings -3 people killed in 2 vehicles at Kings Heath Birmingham 0940UTC when large tree fell onto traffic -Denmark: thousands of fallen trees hampered traffic across country -Poland: rail service between Warsaw and Baltic cities of Szczezin and Gdansk cut by falling trees -hurricane did considerable damage to constructions, roofs, forests, etc
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -Nationale Deene Meteo: 6 million toppled trees 3Dec1999
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -over 5 million m3 fallen timber; of which 3 million in N Gotland & S Svealand by storm 29Nov -last time of such windthrow in Sweden was during snowstorm 17Nov1995 when 5 million m3 toppled
Forestry Commission (2000)	Forestry Commission, Naar skoven blaeser omkuld, Vejret, 85, pp.8-9, Dec, 2000 -3Dec1999 southern part of country hit by 100y storms -15000 ha forest destroyed by storm; 3.5 mill m3 tree lay on ground -Dansk Skovforening dedicate January issue of magazine Skoven to the storm
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm -FIG3.1.1. Windstorm damage in European forests, 1950-1999 NOTE: DEC1999 rank1 event (source: Mr. Mart-Jan Schelhaas, Altera, Netherlands, 2000) -fallen timber in Europe storm worst case on record back to 1950; 1999 storm sequence rank2 -fatalities in harvesting fallen timber -Anatol: worst impact Denmark, Sweden secondary -Lothar/Martin: heavy preceding rain weakened soil; worst damage France, Germany, Switzerland -part of windthrow loss in France due to changing silviculture practices
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -significant forest damage in Denmark (100-150% of annual harvest) and Sweden (<10% annual harvest)
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 -damage to forests in southern Jutland
Nilsson et al (2004)	Nilsson C, I Stjernquist, L Barring, P Schlyter, AM Jonsson, H Samuelsson, Recorded storm damage in Swedish forests 1901-2000, Forest Ecology and Management 1999, 163-173, 2004 -*-FIG2. Annual total damaged volume expressed as cubic meter over bark Mm3 and the annual total number of forest damaging storms; note break at 7.5mm3 in upper y-axis storms 1999, 1995, 1981

	-Anatol was most recent severe storm event; previous severe storms 1995, 1981
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -forest damage in Scania; mostly on S and SW facing slopes -forest management practices
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -Lothar+Martin: forests devastated: area level several times average annual yield in France, Germany, Switzerland combined
Gardiner et al (2012)	Gardiner B, K Blennow, J-M Carnus, P Fleischer, F Ingemarson, G Landmann, M Lindner, M Marzano, B Nicoll, C Orazio, J-L Peyron, M-P Reviron, M-J Schelhaas, A Schuck, M Spielmann, T Usbeck, Destructive storm in European Forests: Past and Forthcoming Impacts, European Forest Institute, Atlantic European Regional Office - EFIAtlantic [pdf document properties: author=Barry Gardiner, datestamp=09Mar2012] *FIG7. Damage as percentage of growing stock for different countries NOTE: for Denmark Anatol was rank3 event since 1950 after 1967 & 1981; low rank for Sweden storm sequence 1999 rank1 event for Europe with 1990 storms rank2; NOTE: 6.5% value for Denmark considered very high; highest values 7% for 1967,1981 storm. -FIG4. Envelope of threshold of damage versus gust wind speed.
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -many old trees cracked off around Ribe
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -in days after hurricane assessment of stormfalls carrried out (trees blown down) -stormfalls amounted to 3.4million m3; later better estimates 4 million m3 -TAB. Tabulated tree fall by tree type (coniferous, deciduous) and region (Sydjylland, upper Jylland ,Fyn. Sjaelland)
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] -Lindet state forest district Denmark; Anatol damage to different tree species: European beech, sessile oak, cypress unharmed; spruce & pine blown over (Jorgensen and Nielsen 2001) -FIG6.2.[MAP] Maximum wind speed (gusts) during storm Anatol on 3Dec1999. Orange marks forests experiencing wind throw. Red dotted line is trajectory. * -recommendations from windthrow act Act 349 17May2000
Cappelen (2019)	Cappelen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webpage downloaded 12Oct2020) -massive storm fall of 4 million m3 wood & other vegetation especially Sonderjylland
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -100s trees blown down on island of Foehr

Table SL53. General ship/rig emergency reports/offshore incidents/platform evacuations (arranged by year and then alphabetically)

Source	Full Reference and Notes
Kristeligt Dagblad (1999)	Kristeligt Dagblad, Orkan haergede landet over. Paa vestkysten naede vindstyrken op pa 47 sekundmeter, 4Dec1999 00:00 -Sovaernets Operative Kommando: sea traffic okay
Lloyd's Casualty Week (19991210)	Lloyd's Casualty Week, vol.318, No.11, Dec10, 1999 Bajorai, Baltica, Candourity, Corona, De Kaper, Dole America, Esmeralda, Framnes; Friedrich Russ, Friendship, Gerda Maria, Grampion Venture, Havsoki Jan V, Knighton, Kvinnherad, Larita, Monagas II, Nordhav, Palatin, Risvaer, Sirius, Sjard, Sleipner, Snorre B, Sociality, unidentified, Vana Tallinn, Viking Victor, Volharding,
Lloyds Casualty Week (19991217)	Lloyd's Casualty Week, vol318, No12, 17Dec1999 -fishing boat Sniegs capsizes in Latvia before dawn with 6 fatalities -Bremnes, Grampion Venture, Paula Ahrens, Cincobulk, Seines, Stavanger, Sniegs, -Rolf Buck, Oerd, Sztorm-2, Eastfern, -Fensfjord, Lys Ranger, Lucky Fortune, Gerarda, Dana Hafnia, Ek-sky, Sea Explorer, Bussard, Ingrid P, GL. Graady,
DGZRS (2000)	DGZRS, "Fischkutter brennt" Eiswette bringt die "Jente" und drei Mann in Sicherheit, Jahrbuch 2000, Deutsche Gesellschaft zur Rettung Schiffbruechiger, Hamburg, pp6-7, 2000. -rescue of fish cutter Jente by German rescue cruiser Eiswette near Amrum
Leonhardsen et al (2001)	Leonhardsen RL, G Ersdal, A Kvitrud, Experience and risk assessment of FPSOs in use on the Norwegian Continental Shelf. Description of Events, The Eleventh International Offshore and Polar Engeineering Conference, International Society of Offshore and Polar Engineerings, 2001. 6pp. Paper No. 2001-IL-05 [pdf document datastamp=08Apr2001] -green water incidents at Asgard A and Petrojarl Varg
HSE (2002c)	HSE, An investigation of storm incidents in UK waters, Prepared by the Met Office for the Health and Safety Executive, Offshore Technology Report 2001/078, 2002c. -listing of 'wave' event on a 'ship'; it may be a rague wave strike on a ship or a greenwater incident on an FPSO
Bitner-Gregersen and	Bitner-Gregersen EM, AK Magnusson, Extreme events in field data and in a second order wave model, Proc. of the

Magnusson (2004)	Rogue Waves 2004 workshop, Oct 20-22, 2004, Brest, France -Varg B greenwater incident on 30Nov1999; Ekofisk wave data analysis
Jensen and Mueller-Navarra (2008)	Jensen J, SH Mueller-Navarra, Storm surges on the German coast, Die Kueste, 74 ICCE (2008), 92-124. -Anatol: Elbe lightship capsized in heavy seas and suffered heavy damage unmanned lightship Elbe considered unnecessary as navigation aid; removed from service
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -shipwreck Feuerschiff FS2 at position of Elbe 1

Table SL54. Instrument failures during storm (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -most powerful wind 38m/s measured at Romo 18:00MET; gust to more than 50m/s -anemometer Romo broken by hurricane 1900MET
Land Schleswig-Holstein (1999)	Land Schleswig-Holstein, Sturmflutereignis am 03.12.1999 (Wasserstaende an Pegelmessstellen), Amt fuer laendliche Raeume, Husum, Az.: 5621, document sent by Maria Bluemel 09Sep2020 - gauge power cut: Suedwesthoern, Schluettsiel (power off during storm), S.N kood-Siel
Kristensen et al (2000)	Kristensen L, O Rathmann, SO Hansen, Extreme wind in Denmark, Journal of Wind Engineering and Industrial Aerodynamics, 87, 147-166, 2000. -comment on missing data in wind speed time series in the calculation of 50 year extreme winds for 4 stations in Denmark
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -wave strike causes several day data gap in main meteorological measurement system
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -DMI tide gauge Esbjerg and Vidaa/Hojer stopped when storm at highest -KDI tide Ribe stopped during storm
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -Romo and Ribe met stations had a power cut of several hours so highest gusts are not known
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -1800UTC Romo reports gust of almost 50m/s; anemometer broke after
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -instrument malfunction for List auf Sylt so that strongest wind gust probably not recorded
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -power loss to Sylt met station; stronger gusts could not be ruled out
Nilsson et al (2002)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -time series data for Sweden Hano and Skillinge have gaps because of temporary instrument or data transfer failure
Sommer (2002)	Sommer A, Wind Resources at Horns Rev, Eltra PSO-2000 Proj nr. EG-05 3248, Tech-wise, 2002. -wave strike on instrument cabin at 6.2m height at Horns Rev mast pushed power plugs out of sockets and switched off primary measurement system for 10days.
Goennert and Buss (2009)	Goennert, Gabriele & Thomas Buss, Sturmfluten zur Bemessung von Hochwasserschutzanlagen, Berichte des Landesbetriebes Strassen, Bruecken und Gewaesser Nr.2/2009, Freie und Hansestadt Hamburg, Landesbetrieb Strassen, Bruecken und Gewaesser, Hamburg ISSN 1867-7959. -Cuxhaven tide gauge fails 04Dec2013 15:30
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -Ribe Kammersleuse tide gauge failed when water level reached 5.13m -dike surveys 1 day later showed water level+wave runup reached 6.7m or 0.3m below dike crest 7.0m
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -Romo anemometer broke at height of storm so wind speeds higher than avg 38.1 gust 51.4m/s possible
Cappelen et al (2018e)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018e, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/ -after 1900, winds decreased slowly but anemometer connection at Romo broken
Astleitner (2019)	Astleitner, Thomas, 3. December 1999: Orkantief Anatol fegt ueber de Nordsee, https://uwr.de/de/a/3-dezember-1999-orkan-tief-anatol-trifft-deutschland, published 3Dec2019, accessed 20Sep2020 *-Sylt had unbelievable 185km/h wind gust *-station had power loss for several hours; possible that wind gusts were higher
Cappelen (2019)	Cappelen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -Ribe water level reached 5.12m; instrument malfunction
Wikipedia (20210418)	Wikipedia, Orkan Anatol, https://de.wikipedia.org/wiki/Orkan_Anatol, accessed 18Apr2021 -highest gust Sylt 180km/h before power failed

Table SL55. Nonhomogeneous data sets (arranged by year and then alphabetically)

Source	Full Reference and Notes
Vedin and Alexandersson (1999)	Vedin, Haldo and Hans Alexandersson, Aarhunderadets storm? Vaader och Vatten, p.18, Dec, 1999 -storm 3-4Dec was worst in Sweden farvand region since start of 1990s -Falsterbo had worst wind since 1967

	-significant gusts: Hano to 43m/s, Malmo to 36m/s * -not possible to compare gusts with previous times; before 1995, gust meas only at airports
Kristensen et al (2000)	Kristensen L, O Rathmann, SO Hansen, Extreme wind in Denmark, Journal of Wind Engineering and Industrial Aerodynamics, 87, 147-166, 2000. -Sprogo mast wind speed time series discontinued in 1999 before storm Anatol -wind speed time series relatively short; Sprogo longest record & extends back to 1977.
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -modern anemometers in use only over past 20-30 years -difficult to assess wind conditions for 1902 storm
Schmidt (2001)	Schmidt H, Die Entwicklung der Sturmhaufigkeit in der Deutschen Bucht zwischen 1878 und 2000. Klimastatusbericht 2001, DWD. pp199-205. -no homogeneous data sets for German Bight longer than 30 years -geostrophic wind speeds more homogeneous but deviations between 2 independent data sets in 1950s.
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -Change of instrumentation for List auf Sylt 1995 so that higher gusts could be registered -before 1995 highest values bounded at 160km/h
Von Storch and Woth (2008)	von Storch, Hans and Katja Woth, Storm surges: perspectrives and options, Sustain Sci, 3, 33-43, 2008 -problems with quantifying historic sea level rise; near-lying German stations in east Waddensee disagree
Gatey (2011)	Gatey, DA, The analysis of extreme synoptic winds, Ph.D. Thesis, University of Western Ontario, 2011. University of Western Ontario - Electronic Thesis and Dissertation Repository. Paper 268. -jumps and discontinuities in 50y wind speed across national boundaries
Pelt (2013)	Pelt, S., Kraftige storme med oprindelse i Nordatlanten, Vejret, 137, 44-47, 2013 -few wind speed data from early 20C and quality lower; difficult to compare with modern measurements

Table SL56. Climatological background of storm; unusual preceding weather events (arranged by year and then alphabetically)

Source	Full Reference and Notes
Met Eireann (199912)	Met Eireann, Monthly Weather Bulletin, no. 164, Dec, 1999 -annual temperature Ireland 1C above normal -6th consecutive year with mean annual temperatures above normal for Ireland -annual temperature Ireland not as high as the record year of 1997.
Bell et al (1999)	Bell GD, MS Halpert, RS Schnell, RW Higgins, J Lawrimore, VE Kousky, R Tinker, W Thlaw, M Chelliah, A Arthusa, Climate Assessment for 1999, Bulletin of the American Meteorological Society, 81, S1-S50, 2000 -1999 had rank 5 high surface temperatures and rank2 extratropical surface temperature since record start 1880 * -anomalous 1999 warmth continues trend that began 1977 -1998 was rank 1 temperature year.
Bresch et al (2000)	Bresch DN, M Bisping, G Lemcke, Storm over Europe. An underestimated risk, Swiss Re (Swiss Reinsurance Company), 27pp, 2000. -storm series phenomenon in 1990 & 1999 -stationary Icelandic low
Rosenorn (2000b)	Rosenorn, Af Stig, Efteraarsvejret 1999, Vejret, 82, No1., 22 Aargang, pp. 24-27, Februar, 2000b. -record warm temperatures during September 1999 at 16.2C; 3.5C over 1961-1990 climate normal -previous record Sept 1949 with 16.0C -October and November with normal temperatures; overall SON temperatures much higher than average
DWD (20020528b)	DWD, Klimatologische Bewertung der juensten Stark-Windereignisse (Anatol und Lothar) aus der Sicht der Klimatologie der freien Atmosphaere, [pdf document properties: 28/05/2002] -unusually high radiosonde wind speeds during the winters 1995/6, 1996/7, and 1997/8 (winter 1998/9 normal) -radiosonde time series record from 1974
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -1999 & 1990 rank3 warmest year central Europe after 1934 & 1994 -Germany 1.3C higher than climate normal 1961-1990 -meteorological precursor situation 1990 & 1999 similar
Humbling (2013)	Humbling David, Weatherwatch: Our severe gales are not hurricanes, but they can be as deadly, The Guardian, 13Dec2013 -distribution of 20 most damaging European storms by month: Oct=2, Dec=5, Jan=9, Feb=4
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -Lothar stronger because: 1. stronger than normal upper level jet; 2. rapid intensification; 3. higher than normal Atlantic temperatures

Table SL57. Storm timing compared with spring tide; phase of surge and tide (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -maximum winds were at astronomical low water -if wind field had been 3-6h earlier then water levels would have been 1-1.5m higher
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -maximum surge 3h before high water
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000

	-surge max at low water; catastrophe would have occurred with higher water levels by 1m if surge and tide max coincided
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -comment that water levels 1.5m above normal low tide and 6 h later water levels reached 4.53mNN
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -Ribe storm surge arrived during low tide -if surge had come at high tide, water would have been 1-1.5m higher; levels would have been comparable to 1634 Burchardi flood and Ribe would have been flooded.
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) *-surge occurred at low water; could have been 1-1.5m higher if at astron high water -surge would have been at same level as 11Oct1634 (worst Waddensee surge ever 6.12m)

Table SL58. Tide analysis (arranged by year and then alphabetically)

Source	Full Reference and Notes
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -tide analysis for 6 Dutch basis stations
Larsen (2020)	Data files sent by X. Larsen in 2020 of tide model analysis of water level measured at Horn's Rev and Esberg

Table SL59. Data filtering and discretization issues (arranged by year and then alphabetically)

Source	Full Reference and Notes
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -comment that Torup met data available only every 3h
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -5s gust defined as average of 5 1Hz measurements of cup anemometer
Krogstad et al (2008)	Krogstad, HE., S.F. Barstow, J.P. Mathisen, L. Lonseth, A.K. Magnusson, M.A. Donelan, Extreme waves in the long-term wave measurements at Ekofisk, in Proc. Rogue Waves 2008 Workshop, ed. by M Olagnon and M. Prevosto, 13-15Oct2008, Brest France, 23-33, 2008 -special cleaning procedures applied to Ekofisk Reference Data Set to remove spikes: -'check compared the raw data to a band-pass filtered version (0.03-0.5Hz), and all records with a significant difference around the maximum crest (indicative of a spike or an irregularity were discarded from further analysis' -'check compared the raw data to a band-pass filtered version (0.03-0.5Hz), and all records with a significant difference around the maximum crest (indicative of a spike or an irregularity were discarded from further analysis'

Table SL60. Difficulties in meteorological model of storm (arranged by year and then alphabetically)

Source	Full Reference and Notes
Bancroft (2000)	Bancroft, George P., Marine Weather Review - North Atlantic Area September through December 1999, Mariners Weather Log, Vol.44, No.1, April 2000. pp.23-38. -surface analysis charts show low pressure center appearing and deepening after 12UTC 02Dec1999
Buizza and Hollingsworth (2001)	Buizza, Roberto and Anthony Hollingsworth, Severe weather prediction using the ECMWF EPS - The European Storms of December 1999, ECMWF Newsletter, No. 89, Winter 2000/01. -ECMWF standard operational model able to predict intensity and position of storm accurately 132h in advance; not stable model result and subsequent forecasts much poorer. -low resolution ensemble bad at advance forecast of storm over Denmark; a few of the members captured the storm at the 132h forecast; most members did not capture storm until 24h before event -High resolution ensemble performed better and half of members captured storm accurately at 55h before event -model simulations for Lothar and Martin even worse (small, fast-moving storms)
Buizza and Hollingsworth (2002)	Buizza, Roberto and Anthony Hollingsworth, Storm prediction over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002 -ECMWF standard operational model able to predict intensity and position of storm accurately 132h in advance; not stable model result and subsequent forecasts much poorer. -low resolution ensemble bad at advance forecast of storm over Denmark; a few of the members captured the storm at the 132h forecast; most members did not capture storm until 24h before event -High resolution ensemble performed better and half of members captured storm accurately at 55h before event -model simulations for Lothar and Martin even worse (small, fast-moving storms)
Woetmann Nielsen and Hansen Sass (2003)	Woetnamm Nielsen N and B Hansen Sass, A numerical, high-resolution study of the life cycle of the severe storm over Denmark on 3Dec1999, Tellus, 55A, 338-351, 2003. -DMI HIRLAM model operational forecast not good enough for surge prediction -post-storm analysis with HIRLAM model gave better storm simulation for track, phase of storm, and intensity of low level jet -model improved by higher horizontal and vertical resolution (0.15deg and 50levels) and extending domain to central Atlantic
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -small storm can not captured well with ERA-40 resolution

	-Anatol investigated using ECMWF's Ensemble Prediction System (EPS) -Buizza and Hollingsworth (2001): high res EPS T255 predicted storm much better than operational EPS T159 with same resolution as ERA-40 analysis * -strongest winds in cold sector S & SW of centre -3 submodels predict approximately same mas wspd -ERS-40 much weaker because pressure gradient weaker -LMK best for capturing short backing of wind at 2300Z 2Dec and 1800Z 4Dec -small scale convective structures beginning to emerge in highest resolution LMK model

Table SL61. Difficulties in modelling water levels and surge (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -forecast water levels in Waddensee were 1-1.5m lower than measured due to error in wind field model that made an incorrect prediction of the storm trajectory
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -observed water levels at Delfzijl 0.36m higher than forecast
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -DMI model water levels up to 2.5m lower than observations -correct surge warning not sent out -problem with met wind field prediction from deficient access to meas network on 2Dec -with best available wind field field, Mike21 surge model still deficient -actions at DMI to improve surge model -0.2m error for good surge prediction
Voldberg (2000)	Voldberg Henrik, Vredens julemaaned, Vejret, 82, no.1, 1-7, Feb, 2000. -high water levels on jyske west coast that was less well forecast -poor water forecast from E15 Hirlam based on 03Dec 00UTC predicted low P traj -predictions from 12h earlier were better.
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -problems in forecasting Denmark west coast storm surge originated in poor meteorological forecast
Mueller-Navarra et al (2003)	Mueller-Navarra SH, W Lang, S Dick, KC Soetje, Ueber de Verfahren der Wasserstands- und Stormflutvorhersage. Hydrodynamisch-numerische Modelle der Nord- und Ostsee und ein empirisch-statistisches Verfahren fuer die Deutsche Bucht, promet. Jahrg. 29, Nr 1-4, 117-124, June 2003 -difficulty in predicting surge water levels more than 18h ahead. -TAB4. Wind forecast of the Seewetterdienstes Hamburg, times in MEZ (widely varying Cuxhaven water level estimates on evening of 3Dec1999 based on sucessive wind speed and direction forecasts; all water level predictions lower than actual event but the earliest forecast was most accurate)
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -maximum envelope of highest water levels from 50 member model ensemble versus measured Anatol water levels in German Bight -role of drag coefficient parameterization
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -model water level predictions 15-20cm below observations because of low resolution wind fields
Environment Agency (2012)	Environment Agency, Thames Barrier Prject Pack 2012, time stamp Nov. 24, 2011 -measured tide much higher than forecast and Thames Barrier was closed
Ge et al (2014)	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. -unstructured grid model performed well in simulating the Hamburg surge

Table SL62. Future sea level rise and flooding effects; future climate and storm return period (arranged by year and then alphabetically)

Source	Full Reference and Notes
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -0.6C global warming in 20C; this rould lead to more intense storms; not all water level extremes have been realized -large uncertainty in future sea level rise; minimum estimate 10cm by end 21st century; several researchers believe it could be as high as several metres.
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -Cuxhaven water levels rising at 0.26cm/y; time series adjusted to 2004 before calculating return periods
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010

	-Design water level for Emden revised upward to 6.39m including 50cm increase to account for the sea level rise next century -Niedersachsen state government changes 100 year sea level rise from 25cm to 50cm
Danhostel-Ribe (2013)	Danhostel-Ribe, Sturmfluten, https://web.archive.org/web/20131215125955/http://www.danhostel-ribe.dk/de/sturmfluten, accessed 25Apr2021 -storm flooding levels becoming more frequent in last 50y -sea level has increased by 11cm in last 100y -UN climate scientists expect flobal water levels to increase 18-59cm -one group of experts expect water level increase 1m
Ge et al (2014)	Ge J, D Much, J Kappenberg, O Nino, P Ding, Z Chen, Simulating storm flooding maps over Hafencity under present and sea level rise scenarios, Journal of Flood Risk Management, 7, 319-331, 2014. -predictions of Hamburg flood level to 2100 -sea level rise antificipated to be between 0.18-0.59m
Cappelen et al (2018f)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Bringer fremtiden flerer decemberorkaner? 25Jun2018f, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/bringer-fremtiden-flere-decemberorkaner/ -models predict shift in North Atlantic storm track in 2100 -storms in North Sea will become more frequent and stronger -high average wind speed for Denmark to increase by 10% at 2100 -wind climate of Denmark will become more like Scotland today -more research is needed to assess if the decemberorkanen of 1999 will be a 30,10,5 year event at 2100.
Buchana and McSharry (2019)	Buchana P, PR McSharry, Windstorm risk assessment for offshore wind farms in the North Sea, Wind Energy, 22, 1219-1229, 2019 -mention of increased storminess and offshore wind farm risk with climate change

Table SL63. Storm event as manifestation of climate change (arranged by year and then alphabetically)

Source	Full Reference and Notes
Bresch et al (2000)	Bresch DN, M Bisping, G Lemcke, Storm over Europe. An underestimated risk, Swiss Re (Swiss Reinsurance Company), 27pp, 2000. -discussion global temperature increase 20C; acceleration since 1976; uncertain temperatures at 2100 -'computer simulations and meteorological records indicate that although the frequency and intensity of storms over the Atlantic have increased slightly during recent decades, the storm paths tend to be further to the north' -'at present, a direct correlation between storm losses and climate change cannot be substantiated on the basis of reliable data'
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm * -insufficient evidence to demonstrate storms becoming more frequent or severe -enormous storm damage occurred regularly
Ulblich et al (2001)	Ulblich U, AH Fink, M Klawa, JG Pinto, Three extreme storms over Europe in December 1999, Weather 56, 70-80, 2001 -'With respect to the scientific and public discussion on anthropogenic climate change one should emphasise that the occurrence of the storms cannot be taken as evidence for an enhanced greenhouse gas effect. Firstly, such an attempt would be inappropriate from a statistical point of view. Secondly, only the first of the three storms, Anatol, seems to fit the greenhouse gas signal recently described by Knippertz et al (2000)' ...ie. more storm events in northern Europe
DWD (20020528b)	DWD, Klimatologische Bewertung der juensten Stark-Windereignisse (Anatol und Lothar) aus der Sicht der Klimatologie der freien Atmosphaere, [pdf document properties: 28/05/2002] -unsually high radiosonde wind speeds during Storm Anatol similar to unusually high values in winters 1995/6, 1996/7, 1997/8
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -effects of climate change on wind storm events ... matter of controversial discussion * -blocking high central Europe; loss of snow cover permits storm entry
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -severe winter storm events had previously been perceied as very rare; 1990 event meant that another would not occur soon. -emergent phenomenon of storm clustering
Schwierz et al (2010)	Schwierz C, P Koellnet-Heck, E Zenklusen Mutter, DN Bresch, P-L Vidale, M Wild, C Schaer, Modelling European winter wind storm losses in current and future climate, Climatic Change, 101, 485-514, 2010. -'it is widely accepted that the world's climate is changing which results in significant alterations of regional weather and climatic conditions'
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -'these patterns, along with other forcing mechanisms and climatic conditions, are in a constant state of flux with changes potentially attributable to anthropogenic climate change, which has led many to suggest that changes in climate are at least partly to blame for recent increases in catastrophes'
Capellen et al (2018c)	Cappelen J, S Olufsen, MH ribergaard, JW Nielsen, T Schmith, N Hansen, Var klimaaendringer skyld i decemberorkan? updated 25Jun2018c, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-

	1999/var-klimaaendringer-skyld-i-decemberorkanen/ -first and foremost: not possible to link single weather events with global warming -only statistical changes of weather phenomenon over long time period can be linked to climate change -Decemberorkan could have taken place at the beginning or end of 20C even without increased Greenhouse effect and global warming -not possible to say if Decemberorkanen caused by global warming -if one asks if global temperature increase in 20C increases the risk of powerful Danish hurricanes in period 1990-1999, answer is clearly no
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -Dec 1999 storms were a departure from the expected trend so insurance companies were caught out.

Table SL64. Baltic Sea events (arranged by year and then alphabetically)

Source	Full Reference and Notes
Lloyd's Casualty Week (19991210)	Lloyd's Casualty Week, vol.318, No.11, Dec10, 1999 -Baltica -Friedrich Russ -unidentified ship lost timber Finnish coast -Vana Tallinn tug assistance to reach Helsinki
Lloyd's Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -Latvia, Liepaja: overturned fishing boat fatalities -Latvia and Lithuania: power cuts -Poland: Gydnia collapsed crane; blocked rail from Warsaw northward -air crash Moscow
RWS (1999)	RWS, Verslag van de Stormvloed can 3 en 4 december 1999 (SR79), Ministerie van VerKeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee, Stormvloedwaarschuwingsdienst, Postbus 20907, 2500EX 's-Gravenhage, 's-Gravenhage, december 1999. -emergency services fully engaged in N Germany, Denmark, S Sweden -storm trajectory northward in Baltic Sea into Gulf of Bothnia
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -record low water levels in western Baltic over 120y measurement record. -many tide gauges left dry -Baltic seiching
UN/ECE (2000)	UN/ECE Timber Committee, Chapter 3. Effects of the December 1999 storms on European timber markets, ECE/FAO Forest Products Annual Market Review, 1999-2000, 15pp, 2000, Timber Bulletin, Vol LIII, ECE/TIM/BULL/53/3 [pdf document properties: title=3stormdamageFIN.PDF; author=najera; datestamp=15/08/2000] https://www.unece/org/fileadmin/DAM/timber/docs/rev-00/rev00.htm -reports forest damage Sweden, Poland, Lithuania
DWD (20020528)	DWD, Orkantief 'Anatol' von 3./4. Dezember 1999 (5pp), https://www.dwd.de/DE/leistungen/besondereereignisse/stuerme/19991204_orkantief_anatol.pdf [pdf document properties: datestamp: 28May2002] -strong wind gusts in southern and central Baltic
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -gust field strong in Baltic Sea area on 4Dec2003
Nilsson et al (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -low pressure filled in as it crossed Baltic Sea
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -Sweden, Poland, Latvia, Lithuania, Russia affected by storm
Cappelen et al (2018b)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Stormfloden under decemberorkanen, updated 25Jun2018b, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/stormfloden-under-decemberorkanen/ -in indre dansk farvand, east facing coasts dry; harbours had yachts luying on ground -water levels fell to 2m below normal; lowest ever registered -lost water sent into Baltic and turned back in course of Friday as high water S of Baelthavet
Cappelen et al (2018e)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, N Hansen, Orkan passerer, updated 25Jun2018e, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/orkanen-passerer/ -hurricane force winds reach Kastrup 2100MET 3Dec1999; at this time Bornholm also has increase of wind

Table SL65. Aftermath: new defenses; new design criteria; assessment of climate change; model problems (arranged by year and then alphabetically)

Source	Full Reference and Notes
DMI (19991209)	DMI, Rapport. Orkanen over Danmark den 3.-4. december 1999, Denmarks Meteorologiske Institut, Lyngbyvej 100, DK-2100 Kobenhaven 0, 9Dec1999. -investigation of error in weather model -tests to see if weather and water level models would be improved by more advanced models and finer resolution -DMI to work more closely with emegency services
Focus (1999)	Focus, Strandfresser Anatol, Nr.50, 1999 (correspondent Birte Siedenburg), https://www.focus.de/politik/deutschland/sylt-strandfresser-anatol_aid_178994.html -Land Schleswig-Holstein government to spent 12 million DM for beach nourishment; Hartmut Mueller

	burgereister of Gemeinde Hoernum feels that 25 million DM should be committed to safeguard island
Aakjaer (2000)	Aakjaer AF, Orkanen i Nordsoen den 30. oktober 2000, Vejret, 85, 1-7, 2000 -discussion of Denmark storm surge 30Oct2000 and comparison with previous events including 3Dec1999
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -more effective forecast of 17Dec1999 storm as result of forecast deficiencies during Anatol
Kristensen et al (1999)	Kristensen L, O Rathmann, SO Hansen, Extreme wind in Denmark, Journal of Wind Engineering and Industrial Aerodynamics, 87, 147-166, 2000. -recommendation that the WASP correction method for Kegnaes wind speed should be reviewed; standard wind speed for Storm Anatol was too low considering the damage that occurred.
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -revision of Danish construction standards started 1995; dated 1998 -shorter time period for gust definition; emphasis on short period turbulence -higher thresholds for wind pressure -recommendation for revision of construction standards to address roof tile and cladding damage
Bresch et al (2000)	Bresch DN, M Bisping, G Lemcke, Storm over Europe. An underestimated risk, Swiss Re (Swiss Reinsurance Company), 27pp, 2000. -premiums for re-insurance should be increased by 2 times
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -DMI to improve surge prediction system
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -model investigation to assess reasons for DMI met model forecast of storm -ECMWF model zonal/meridional data discretization problem; 1h vs 6h time steps for data assimilimation, HIRLAM grid disretization, spatial extension of HIRLAM grid.
Buizza and Hollingsworth (2002)	Buizza, Roberto and Anthony Hollingsworth, Storm prediction over Europe using the ECMWF ensemble prediction system, Meteorol. Appl., 9, 2002 -ECMWF has a program of continuous model improvement -Dec1999 European storm s were a test of ensemble prediction system -between Dec1992 and Dec1996 ECMWF ran EPS with 33 members with T63L19 -Dec1996 EPS resolution enhanced to TL159l31 with 51 ensemble members -Oct1999 vertical levels increased to 40 -21Nov2000 EPS resolution increased to Tl255L40 with initial conditions from hires analysis Tl511L60
Munich Re (2002)	Munich Re, Winter Storms in Europe (II), Analysis of 1999 losses and loss potentials, Muenchener Rueck, Munich Re Group, 76pp, 2002 -effects of climate change on wind storm events ... matter of controversial discussion -ACACIA report 2000: assessment of potential effects & adaptations for climate change EUR -precautionary principle -IPCC2001: temperature increases 1.4-5.8C by end of century -probably climate change effects -N-S temperature gradient increase; circ of atmos accell; intensification wind storm (greenhouse effect incr energy input to atmos heat engine; switch in top gear) * -blocking high central Europe; loss of snow cover permits storm entry -convection processes increase; Germany lightning strokes incr exponentially with temp -prolonged heat & drought in S & central Europe in summer; heat wave; storms at end of heat waves cause damage: 3-4Jul2000: hailstorm Austria 6-7Jul2001: svere storm Germany 3Aug2001: hailstorm Germany * -clear signs of climate change; exagerrating to develop horror scenarios for Europe
Nilsson et al (2004)	Nilsson C, I Stjernquist, L Barring, P Schlyter, AM Jonsson, H Samuelsson, Recorded storm damage in Swedish forests 1901-2000, Forest Ecology and Management 1999, 163-173, 2004 -Sweden storm forest study motivated by recent storm events (eg 1999) -recent severe windstorms caused large damage & substantial economic loss in Europe regions -viewed from climate change aspect small incr wind intensity can damage forests several orders magnitude -storm damage in Swedish forests increased during the last century with peak 1980s; 1954 & 1969 worst years
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -2005 project MUSE Modelluntersuchungen zu Sturmfluten met sehr geringen
Frank and Majewski (2006)	Frank, H, and D Majewski, Hindcasts of historic storms with the DWD models GME, LMQ and LMK using ERA-40 reanalysis, ECMWF Newsletter No. 109, autumn 2006, pp.16-21. -NLWKN contracts DWD to simulate 22 Norderney storm1962-2002, probably in period 2002-2005
Schroevers et al (2007)	Schroevers M, J Dekker, R Groenendaal, H Peters, Inventory wave data for model calibration, Rijksinstituut voor Kust en Zee, Rijkswaterstaat, July, 2007 [pdf timestamp 07Jan2016] -North Sea Coastal zone Managers Group (NSCMG) 21Apr2005 data exchange proposal -organizations that cooperated during this inventory gather data for safety coastal defences, waterways, ecosystems -focus on shallow water wave effects, especially leeside of islands.
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/

	-aftermath: in 2000 most Scandinavian insurance companies significantly increased reinsurance coverage -new research on storm clustering (new phenomenon) -CRESTAplus initiative 2000: failed to gain wide acceptance -ACORD Association for Cooperative Operations Research and Development 2002 -identified short-comings in Eur insurance insdustry: a. ability to estimate sufficient coverage b. capacity to process large volumes of claims c. quality of data -after event AIR released new generation extratropical cyclone model; incorporated NWP -first time catastrophe model incorporated physical modelling of met peril
Fehrmann and Fackler (2010)	Fehrmann,A. and A. Fackler, Offshore wind farms: risk and initial loss experience, Temple Insurance, a member of the Munich Re Group, 2010 [PDF timestamp: 09Mar2010] (last date reference 2001; last incident reference 2003) -review of offshore wind energy industry by re-insurance company notes 3 cases of severe storm damage (Canary Islands, Gujarat 1998, Anatol 1999). -Anatol 1999 storm track through area of proposed offshore wind farm concentration in southern North Sea; statement such a storm would be 100 year event.
Herrling et al (2010)	Herrling Gerald, Heiko Knaack, Ralf Kaiser, Hanz D. Niemayer, Evaluation of design water levels at the Ems-Dollard estuary considering the effect of a storm surge barrier, 32nd Conference on Coastal Engineering 2010, Shanghai, China, 30Jun-05Jul2020. ed by JM Smith and P Lynett, pp. 3899-3917, [pdf document properties: title=ICCE2020_Ems_final, datestamp=15Sep2010 -Gandersum surge barrier in operation from 2001; construction start 1998 -Niedersachsen state government changes estimate of 100y sea level rise from 25cm to 50cm
Gatey (2011)	Gatey, DA, The analysis of extreme synoptic winds, Ph.D. Thesis, University of Western Ontario, 2011. University of Western Ontario - Electronic Thesis and Dissertation Repository. Paper 268. -calculation of 50y return wind speeds for wind engineering design -Storm Anatol 1999 and Burn's Day storm Jan 1990 as case studies to test maximum wind predictions
Humbling (2013)	Humbling David, Weatherwatch: Our severe gales are not hurricanes, but they can be as deadly, The Guardian, 13Dec2013 -Xaver had damaging storm surge but effective defences meant that insurance claims would be low
Joyner (2013)	Joyner, T.A., Optimizing peak gust and maximum sustained wind speed estimates from mid-latitude wave cyclones, Louisiana State University Doctoral Dissertations, 421, 2013 -developement of better wind speed mappng methods for the insurance industry
Danish Energy Agency (2015)	Danish Energy Agency, Security of Electricity Supply in Denmark, 1st edition 2015, translated 2016, Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, ISBN 978-87-93180-15-4 -Denmark power lines placed underground -green energy transition -energy grid links with surrounding countries
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] * -recommendations from windthrow act Act 349 17May2000 6.4. Norway spruce -important tree species introduced to many sites beyond native range -hot dry conditions from climate change creates suboptimal environments -expected to cease as productive species in England, S Finland and Sweden
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -using historical losses for risk assessment not sufficient -AIR Extratropical Cyclone Model gives comprehensive view of year-round risk for 22 European countries -model captures storm frequency and clustering that define hazard, and interannual variability
Cappelen et al (2019g)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Blev DMI klogere af decemberorkanen? updated 25Jun2018, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/blev-dmi-klogere-af-decemberorkanen/ -DMI make contact with preparation authorities, and there was procedure in place for the next storm 14d later for authorities to receive information direction from DMI -one of the problems with the hurricane was that many did not know how violent it can be -this was followed up the following year, where DMI sent out special warnings to the public and authorities -blinking lamp on DMI website whenever violent weather expected -at the same time, work carried out by weather modellers to the find out whether the hurricane could be forecast perfectly -it was shown that a very good prognosis could be achieved even with a 15km model grid mesh when the model is driven on a large geographic area with good atmospheric data -today several prognoses can be carried out with short time between runs, eg every hour -prognoses are slightly different because they take account of uncertainties in the model and in atmospheric state -best forecast by considering an ensemble -ensemble permits assessment of uncertainty of prognosis
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -Danish storm naming convention starts 2013 with Storm Allan as first storm

Table SL66. Worst case storm surge situation (arranged by year and then alphabetically)

Source	Full Reference and Notes
Nielsen and Nielsen (2000)	Nielsen, Jacob Woge and Nielsen, Mads Hvid, Stormfloden foraarsaget af orkanen den 3. december 1999, Vejret, 82, 8-14, Februar 2000 -worst Esbjerg storm surge had been 1981
Rosenorn (2000)	Rosenorn, Af Stig, De kraftigste storme i det tyvende aarhundrede in Denmark, Vejret, 82, 15-18, Februar 2000 -review of 4 worst Denmark storms and Anatol assessed to be most powerful
Mueller-Navarra (2005)	Mueller-Navarra, Sylvin, Sturmfluten. Land under an Nord- und Ostsee, in: Entfesselte Elemente-Der Mensch und die Kraefte der Natur, 5, 92-99, Guetersloh. Wissen-Media-Verl., 2005 -2005 project MUSE Modelluntersuchungen zu Sturmfluten met sehr geringen -already in present climate conditions significantly greater storm & surges possible -predicted water levels 1-1.5m higher than previous measurements -western Baltic: only single well documented surge 12-13Nov1872; never reached since -new research project to be initiated for Baltic
Jensen et al (2006)	Jensen J, C Mudersbach, SH Mueller-Navarra, I Bork, C Koziar, V Renner, Modellgestuetzte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten an der deutschen Nordseekueste, Die Kueste, 71, 123-167, 2006. -from 50 member model ensemble, water levels could have been 1.4m higher during 1976 storm. -'Ausgeloest durch das Sturmtief Anatol im Dezember 1999 und den katastrophalen Sturmfluten in den vergangenen Jahrzehnten (z.B. in den Jahren 1962 un 1976) sind aktuell wieder Fragen nach moeglichen Hoehen von Sturmfluten laut geworden' -Gumbel type III distribution and asymptotic maximum water level at Cuxhaven
Schwierz et al (2010)	Schwierz C, P Koellnet-Heck, E Zenklusen Mutter, DN Bresch, P-L Vidale, M Wild, C Schaer, Modelling European winter wind storm losses in current and future climate, Climatic Change, 101, 485-514, 2010. -assessment of 100y insurance loss storm
Capellen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -surge would have been at same level as 11Oct1634 (worst Waddensee surge ever 6.12m)

Table SL67. Damage costs; insurance losses (arranged by year and then alphabetically)

Source	Full Reference and Notes
Lloyds Casualty Week (19991217)	Lloyds Casualty Week, vol318, No12, 17Dec1999 -Danish Insurance Information Service: cost could be 1 billion kronur; previous record storm damage 1981 827 million kronur
Beredskapsstyrelsen Udviklingsenheden (2000)	Beredskapsstyrelsen Udviklingsenheden, Den Samlede redningsbredskabssektors opgavelosning i forbindelse med orkanen d. 3.-4. december og stormen d. 17 december 1999 - En Tvaergaende evaluering og erfaringsopsamling. Februar 2000, Beredskabsstyrelsen, Beredskabsudviklingsenheden, Datavej 16, 3460 Birkerød, Telefon: 4590 6000, Telefax: 4590 6060, E-mail: bue@brs.dk, Internet: www.brs.dk -350,000 damage cases with value of 8 billion DKK
Bresch et al (2000)	Bresch DN, M Bisping, G Lemcke, Storm over Europe. An underestimated risk, Swiss Re (Swiss Reinsurance Company), 27pp, 2000. -listing of winter storm insurance losses from 1976; Anatol at rank 6/10 -Lothar/Martin caused solvency problems for French insurance companies -French companies overwhelms by large numbers of small claims (3 million) -importance of deductables to prevent swamping of processing procedure; should be 1% of total cover -Lothar damaged 60% roofs in Paris area; 80% of buildings outside.
Lemcke and Schibli (2000)	Lemcke G and F Schibli, Storm over Europe - an underestimated risk, 10Oct2000CET press release. [pdf document properties: 19Jul2007] -problems with insurance priemium assessment after Dec 1999 storms
Mann and Hansen (2000)	Mann AJ, SO Hansen, En storm gor ingen norm, Vejret, no1. 22.Argang, 82, pp.28-34, Februar 2000. -increasing estimates of insurance loss in months after storm starting from 1-2 billion DKR to 8 billion DKR in Feb 2000
Tatge (2009)	Tatge, Yoern, Looking back, looking forward: Anatol, Lothar and Martin ten years later, 09Dec2009. https://www.air-worldwide.com/publications/air-currents/looking-back-looking-forward-anatol-lothar-and-martin-ten-years-later/ -600000 individual insured losses; >2 billion EUR (1999) -most destructive impact on Denmark -before Anatol, largest Denmark insured loss from a storm was about 120 mill EUR in 1981 -Anatol insured loss 2 bill EUR (1999) order of magnitude larger -claims adjusters overwhelmed by number of claims to service; as much as 1/10 of population of country -to facilitate processing: agents sent payments up to threshold without review -this probably artificially increased Anatol's actual insured loss in Denmark
Schwierz et al (2010)	Schwierz C, P Koellnet-Heck, E Zenklusen Mutter, DN Bresch, P-L Vidale, M Wild, C Schaer, Modelling European winter wind storm losses in current and future climate, Climatic Change, 101, 485-514, 2010. -1970s mean yearly insured loss 2-3billion UDS2006; 2001-2006 yearly is 30 bill USD 2006 -contributing factors: increasing assets as risk, larger concent in exposed areas -Europe: volatility of losses exacerbated by clustering of severe storms: -4 in 1990: 14.6bn USD2006 from Herta (1.3), Vivian (4.9), Wiebke (1.2), Daria (7.2) -3 in 1999: 12.2bn USD2006 from Anatol (2.3), Lothar (7.0), Martin (2.9)
Gardiner et al. (2012)	Gardiner B, K Blennow, J-M Carnus, P Fleischer, F Ingemarson, G Landmann, M Lindner, M Marzano, B Nicoll, C Orazio, J-L Peyron, M-P Reviron, M-J Schelhaas, A Schuck, M Spielmann, T Usbeck, Destructive storm in European Forests: Past and Forthcoming Impacts, European Forest Institute, Atlantic European Regional Office - EFIAtlantic [pdf document properties: author=Barry Gardiner, datestamp=09Mar2012] -cost of Anatol forest damage for Sweden
AON Benfield (2013)	AON Benfield, Historie von 1703 bis 2012: Winterstuerme in Europea, Stand: Januar 2013

	-insured damage in Germany 290 mill EUR indexed to year 2012
Roberts et al (2014)	Roberts JF, AJ Champion, LC Dawkins, KI Hodes, LC Shaffrey, DB Stephenson, MA Stringer, HE Thornton, DB Youngman, The XWS open access catalogue of extreme European windstorms from 1979 to 2012, Nat. Hazards Earth Syst. Sci, 14, 2487-2501, 2014 -list of 23 top insurance storms in period 1979-2013; Anatol is rank 9
RMS (2014)	RMS, 2013-2014 Winter Storms in Europe. An Insurance and Catastrophe Modeling Perspective. RMS White Paper. [PDF TIMESTAMP 11Mar2014] -insurance losses for winter 2013-2014 not likely to reach levels of Anatol/Lothar/Martin in 1999 (13.9 billion USD), Kyrill in 2007 (6.8 billion USD), Xynthia in 2010 (2.9 billion USD) or summer UK flooding 2007 (6 billion USD)
Thejournal.ie (20151214)	thejournal.ie, The deadliest storms to ever hit Europe, 14Dec2015 0610AM, https://www.thejournal.ie/europe-storms-2497164-Dec2015/, accessed 10Dec2020 -Anatol monetory loss rank10 at 2.9b EUR; Lothar rank 1 at 10.6b EUR
Cappelen et al (2018d)	Cappelen J, S Olufsen, MH Ribergaard, JW Nielsen, T Schmith, H Hansen, Dagen derpa, updated 25Jun2018d, https://www.dmi.dk/vejr-og-atmosfare/temaforside-decemberorkanen-1999/dagen-derpaa/ -insurance campanies assess damage at 13 billion DKR -Saturday afternoon on 4Dec Falck 6000-7000 calls on storm damage
Air Worldwide (20191219)	Air Worldwide, Three severe storms together were a wake-up call, 19Dec2019. -large volume of small claims for European extretropical storm can be equivalent to tropical hurricane -extratropical cyclones last longer and impact larger area -Anatol had most destructive impact on Denmark; country's largest insured loss ever -French insurance market overwhelmed with >3 million claims, mostly from residential sector -impact on reinsurance market -Denmark: Anatol completely exhausted many reinsurance covers -from low probability of Daria-Vivian-Wiebke 1990 event, many insur companies decided reinsurance unnec -solvency problems -France: reinsurance based on 1990 event but wind speeds of Lathar & Martin 30% higher -most reinsurance programs exhausted by Lothar alone
Buchana and McSharry (2019)	Buchana P, PR McSharry, Windstorm risk assessment for offshore wind farms in the North Sea, Wind Energy, 22, 1219-1229, 2019 -US hurricane losses vary exponentially with wind speed at 5% per m/s (Murnane and Elsner) -power law relationship between losses and maximum wind speed: 4 to 10 -small changes wind speed can have devastating impacts
Cappelen (2019)	Capellen, John, Orkaner paa vore breddegrader, updated 8Jan2019 https://www.dmi.dk/vejr-og-atmosfare/temaforside-vind/orkaner-paa-vore-breddegrader/, (webapage downloaded 12Oct2020) -damage at ~13 billion DKK
World Energy Council (2019)	World Energy Council, Case Study Series, Extreme Weather, Windstorms France December 1999, https://www.worldenergy.org/assets/downloads/Windstorms_France_-Extreme_weather_conditions_SEP_2019.pdf, pdf date stamp: 11Oct2019 -2 bill EUR insurance loss for Denmark; insurers believed such a loss was impossible.

Table SL68. Online data sets (arranged by year and then alphabetically)

Source	Full Reference and Notes
Nilsson et al. (2007)	Nilsson C, S Goyette, L Barring, Relating forest damage data to the wind field from high-resolution RCM simulations: case study of Anatol striking Sweden in December 1999, Global and Planetary Change, 57, 161-176, 2007. -NCEP-NCAR reanalysis fields -Sweden station data -Copenhagen radiosonde profiles from University of Wyoming
Buchana and McSharry (2019)	Buchana P, PR McSharry, Windstorm risk assessment for offshore wind farms in the North Sea, Wind Energy, 22, 1219-1229, 2019 -extreme wind storm XWS catalog

Table SL69. Onshore/offshore wind energy policy and historical development

Source	Full Reference and Notes
Neckelmann and Petersen (2000)	Neckelmann, S. and J. Petersen, Evaluation of the stand-alone wind and wave measurement systems for Horns Rev 150MW offshore wind farm in Denmark, OWEMES 2000, ATENA, Rome, Sicily, pp.17-27, 2000 -feasibility study of offshore wind energy in Danish water 1995 -onshore wind turbines in Denmark reached limit and 1500 MW onshore goal reached in 1999 -Danish government resolution in 1998 for 5 offshore wind farms to be constructed during 2002-2008 with 150MW capacity each to operate for 20y period -Horns Rev met program started May1999, marine program started June 1999.
IEA (2001)	IEA, Wind Energy Annual Report 2000, International Energy Agency, National Renewable Energy Laboratory, May, 2001. (Author Ian Fletcher) pdf document properties: datestamp: 08Jul2005; -IEA founded in 1974 within framework of OECD Organization for Economic Cooperation and Development -2000 another good year for wind energy; wind supplies enough for 75% Denmark needs -advantages: rapid capacity building, removes fuel cost uncertainties; incr diversity energy supp -Germany & Spain had very high rate turbine installation; Denmark with exceptional year -offshore wind energy increased again in 2000. -projects developed in UK (4MW), Denmark (40MW), Sweden (10MW) -Denmark: strategy based on government action plan Energy 21 & setting ceilings on CO2 emissions -Denmark: renewable energy quotas announced 1999 -Denmark: 20% of electricity consumption covered by renewables end 2003 -Denmark: land turbine will form signif part of expansion; first 350MW of offshore wind energy

	-Denmark: long term goal to reach 5500MW by 2030 of which 4000MW expected to be offshore -Denmark: wind energy targets 500MW in 2010 and 2000 in 2025. -6143 turbines Denmark 2000
Sommer (2003)	Sommer, A., Offshore measurements of wind and waves at Horns Rev & Laeso, Denmark. European Seminar OWEMES 2003, Apr 10-12, 2003, Naples, Campania, Italy. -Danish government energy plan Energy21 installed capacity 5500MW by 2030, 4000MW offshore, 1500MW onshore -density onshore almost reached limit /w 1500MW in 1999 -utilization offshore only way to reach energy goals in Energy21 -feasibility study 1995; sites for 8000MW identified -large scale demonstration wind farms technically and economically feasible -Elsam/Eltra (W) & Elkraft (E) ordered by Danish goverment 1998 to construct 5 farms 2002-2008 for 20y operation
Sahin (2004)	Sahin, AD, Progress and recent trends in wind energy, Progress in Energy and Combustion Science, 30, 501-543, 2004. -historical development of wind energy -motivated by energy crises, pollution reduction, greenhouse gas reduction.
Modern Power Systems (2004)	Modern Power Systems, Horns Rev reveals the real hazards of offshore wind, https://www.modernpowersystems.com/features/featurehorns-rev-reveals-the-real-hazards-of-offshore-wind-720/, 01Oct2004 -Horns Rev started 2002; salt corrosion and other problems started Aug2003; turbines to shore summer 2004 -Vestas turbines at Kentish Flats, Scroby Sands, Frederikshavn Denmark. -advantages/disadvantages offshore wind farms.
DEA (2005)	DEA, Offshore Wind Power. Danish Experiences and Solutions. Danish Energy Authority, October, 2005. [pdf properties: datestamp: 24Oct2005] -Denmark 1980s most energy from coal; acidification of forest & lakes -2005: renewable energy 28% Danish electricity; 19% from wind power -wind power increasingly competitive wrt other energy with higher oil prices & CO2 tax -amount of renewable energy Denmark could reach 80% by 2025 -significant part of expansion large offshore wind farms -FIG2.2. Total installed capacity and number of wind turbines 1980-2004, calced on basis of Danish Energy Authority's basic data registry. NOTE: 6200 turbines in operation in 1999 with 2100MW installed capacity -FIG_p3. Vindeby west of Lolland was the world's first offshore wind farm. It has 11X450kW wind turbines. It provided Danish energy companies with experience *-TAB_p4. Existing Danish wind farms - status as of autumn 2005 First offshore windfarm Vindeby Falster 1991 Second offshore windfarm Tuno Knob Odder 1995 -wind power employs 20000 people directly & indirectly -3billion EUR turnover -wind power accounts for 4% Danish industrial production 8.3. 40% global market share
Elsam (2005)	Elsam, Horns Rev - daenisches Windkraftwerk in der Nordsee, Stahlbau, 451, 73, 2005, pdf datestamp: 02Jun2005 -significant contribution to Danish goal to reduce CO2 emissions; 2% of Danish energy use
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] -FIG6.1. Wind resource map of Denmark at 45m height above ground, mean windspeed meas. Data from EMD2001. Orange points mark forest with wind throw. Map drawn for wind energy
Buchana and McSharry (2019)	Buchana P, PR McSharry, Windstorm risk assessment for offshore wind farms in the North Sea, Wind Energy, 22, 1219-1229, 2019 -first offshore wind farm Denmark 1991 -2017: 84% of all offshore wind turbines located off coast of 10 European countries -2017: 18814MW offshore wind energy installed globally -offshore wind energy advantages: higher resources, NIMBY opposition weaker -Caithness wind farm reference: 370 blade failures, 299 fire cases, 189 structural instances

Table SL70. Context and background information where storm not mentioned (arranged by year and then alphabetically)

Source	Full Reference and Notes
Rossiter (1958)	Rossiter JR, Storm surges in the North Sea, 11 to 30 December 1954, Philosophical Transactions of the Royal Society of London, Series A, 251, No. 991, 139-160, 1958. -return surge proposed by Corkan (1958) to explain 36h oscillation of low frequency component -positive surge heavily dampled; negative surge with strong tendency to oscillations -longitudinal seiche period 30-40h; transverse seiche period 12h -ad hoc procedure for placing tide gauge data on common reference level.
Keers (1966)	Keers, JF, The meteorological conditions leading to storm surges in the North Sea, Meteorological Magazine, London, 95, (1130), 261-272, Sept. 1966 -classification of North Sea storm surge -North Sea positive surge often preceded by negative surge; reconance effect
Whitehouse (1977)	Whitehouse, P., Wave Phenomenon in the North Sea, The Marine Observer, XLVII, No. 257, pp.128-129, July 1977 (Met.O. 904) -freak wave kill zone in northern North Sea

	-big wave conditions: -SE gale from depression to W with front moving ENE across North Sea -wind conditions unremarkable: Bf6-9; v low cloud, visibility 1-2nm, falling pressure -3h before passage of fronthigh waves out of all proportion to fetch: 'like an of boiling water' -wave heights change from 5-7m to 15-17m; regular pattern becomes irregular -sea coming from up to 90deg of wind direction; imposs to distinguish sea from swell -not particularly shallow water & well away from Fisher banks -on 2 occasions major damage to ship; several occasions of minor damage
Neu (1984)	Neu HJA, Interannual variations and longer-term changes in sea state of the North Atlantic from 1970 to 1982, JGR, 89, 6397-6402, 1984. -changes in North Atlantic storminess; secular trend and 3- to 7-year fluctuation
Carter and Draper (1988)	Carter DJT and L Draper, Has the north-east Atlantic become rougher? Nature, 332, p.494. 1988. -increase in Hs from 1960s to 1985 at Sevenstones Light Vessel Land's End -50y Hs increased from 12 m 1960 to 18m 1990
Logue (1989)	Logue JJ, The estimation of extreme wind speeds over standard terrain in Ireland, Technical Note No. 51, Meteorological Service, Dublin, May 1989 -highest wind speeds in Ireland associated with extratropical cyclones -highest wind speeds within few 100km of low pressure center across a swath of width 100-200km on right hand side of track
Gram-Jensen (1991)	Gram-Jensen, Ib, Stormfloder, Danish Meteorological Institute, Scientific Report 91-1, Copenhagen, 1991 -history of Danish storm surges to 1991
Schmidt and von Storch (1993)	Schmidt H and H von Storch, German Bight storms analyzed, Nature, 343,791, 1993 -debate climate change and intensification of the extratropical storms -IPCC no stand because of lack of evidence -2 workshops Reykjavik 29-30March 1993 & Bergen Nov30-Dec1, 1992 Climate trends and future offshore Design and Operation Criteria hosted by DNMI; representatives from oil industry, cert agencies, scientists *-stationary time series over 100y
Hogben (1994)	Hogben, N, Increases in wave heights over the North Atlantic: A review of the evidence and some implications for the naval architect, Transacations of The Royal Institution of Naval Architects, W5, 93-101, 1994. -increases in North Atlantic wave height in recent decades; observed wave height & instruments -evidence for increase in extreme waves unclear (50 year wave) -no corresponding increase in wind speed. -naval architects doubt wave atlases and wave spectral models forced by winds.
Alexandersson et al (1998)	Alexandersson H, T Schmith, K Iden, H Tuomenvirta, Long-term variations of the storm climate over NW Europe, The Global Atmosphere and Ocean System, 6, 97-120, 1998 -geostrophic wind from pressure triangle analysis in northeast Altantic -clear increases in highest wind speedsfor many triangles northeast Atlantic -caution that recent trends may be broken
Schmith et al (1998)	Schmith T, E Kaas, TS Li, Northeast Atlantic winter storminess 1875-1995 re-analyzed, Climate Dynamics, 14, 529-536, 1998. -ongoing world debate climate change & human influence -flagged by insurance (Berz and Conrad 1994) & offshore industry * -climate change reports problematic: based on rumours & inhomog quant (insur losses) -wind data unusable because of changing observation procedures & instruments -importance of climate record length -analysis of new pressure data set from NE Atlantic stations; first difference pressure tendency
Hjorteland et al (1999)	Hjorteland K, MJ Mes, AK Magnusson, Ekofisk Observed Weather Compared with Weather Predictions, Offshore Technology Confernce, 3-6May, Houston, Texas, 1999, OTC-10768-MS -Ekofisk field came on stream 1971; subsidence was confirmed 1984 -Ekofisk Extreme Wave Warning EXWW -DNMI wave forecasts at 12, 24, 48h & 2,4,5,6 days advance weather and oceanography forecasts
Lloyd's Casualty Week (19991210)	Lloyd's Casualty Week, vol.318, No.11, Dec10, 1999 -storms and ship accidents in week before Anatol
Norwegian Petroleum Directory (1999)	Norwegian Petroleum Directorate, Offshore Norway 1999, Norwegian Petroleum Directorate, Prof. Olav Hanssens vei 10, P.O. Box 600, 4003 Stavanger, Norway [pdf document properties: datestamp: 24Jan2019] -overview of green water damage issues to the Norwegian FPSOs -FPSOs not designed accoriding to marine standards of tankers -traditional platform installations designed to clear highest waves -measures imposed to protect against green water damage -Norwegian CO2 tax from 1Jan1991
Winther-Jensen and Jorgensen (1999)	Winther-Jensen, M and ER Jorgensen, When real life wind speed exceeds design wind assumptions, 1999 European Wind Energy Conference, 1-5 March 1999, Nice, France pp220-223. -first case of large scale wind turbine collapse during a hurricane, -proposal to address accidental limit state case of 10000 year wind speed -expert team from DTU visits Porbandar sites in 1999.
Ersdal and Kvitrud (2000)	Ersdal G and A Kvitrud, Green water on Norwegian production ships, Proceedings of the tenth (2000) International Offshore and Polar Engineering Conference, Seattle, USA, May 28- June 2, 2000, The International Society of Offshore and Polar Engineers, 2000 -damage to FPSOs and FSUs in Norwegian and North Sea in period 1998-2000 from green water events -design criterion to take a 100y wave without any damage; 10000y without destruction
Lemcke and Schibli (2000)	Lemcke G and F Schibli, Storm over Europe - an underestimated risk, 10Oct2000CET press release. [pdf document properties: 19Jul2007]

	-return periods of severe winter storms in Europe -problems of over-optimistic insurance pricing based on most recent damage experience.
BOMEL (2001)	BOMEL Limited, Analysis of green water susceptibility of FPSO/FSUs on the UKCS, HSE Health and Safety Executive, Offshore Technology Report 2001/005, 38pp -background info on green water incidents at UK/Norway FPSOs 1995-2000
Magnusson and Donelan (2001)	Magnusson AK and MA Donelan, Extremes from evolved waves using measurements from a waverider buoy and vertical lasers, M Olagnon, GA Athanasoulis (ed), (2001) Rogue waves 2000: Proceedings of a Workshop in Brest, France, 29-30 November 2000. Actes de Colloues - IFREMER, 32. Editions IFREMER: Plouzane, ISBN 2-84433-063-0.X, 395pp, pp.141-150, 2001. -bad storm on Ekofisk field 12Dec1990 causing alot of damage to platforms -Ekofisk infrastructure subsiding due to oil extraction -Ekofisk Extreme Wave Warning introduced as mitigation measure of storm effects on subsiding platforms -case study of 4 storms: 25Oct1998, 27Oct1998, 4-5Feb1999, 17Feb1999. -DNMI efforts to forecast extreme crest heights in addition to significant wave height.
Schmidt (2001)	Schmidt H, Die Entwicklung der Sturmhaufigkeit in der Deutschen Bucht zwischen 1878 und 2000. Klimastatusbericht 2001, DWD. pp199-205. -geostrophic wind calculation from triangles of stations in the German Bight -mercury barometer readings more homogeneous than wind speed measurements -long trend of increasing wind speeds broken by low geostrophic wind speeds starting in 1996 -periods of increasing wind speeds 1880-1910 and 1930-1960
Faulkner (2002)	Faulkner, D., Shipping safety. A matter of concern, Ingenia, Royal Academy of Engineering, London (August/September), 13, 13-20, 2002 *-1991 peak loss bulk carriers over 10ktons; 22 ships & 200 people -main causes bulk carrier loss over 2 decades: 60% operational & 40% water ingress *-attributable ship loss: 30% bad weather, 25% unexplained *-ships not designed to survive extreme weather *-Oct1998: N Pacific storms sweep 700 containers from the 4 large containers ships * -first European Parliamentary Symposium on Marine Safety, 24Jan2002 (new procedures) -max pressure hatch covers; increase strength 2-3.5 * -ship rules order of magnitude inadequate -Maxwave projec run from Dec 1999 for 3 years; 4.65 million Euros, 6 partner countries -Faulkner & Maxwave leaders to meet with the IMO Oct 2002 to emphasize Maxwave & survival design
HSE (2002b)	HSE Health and Safety Executive, Floating Installations, Offshore Technology Report 2001/048, 2002 -HSE's Offshore installations: Guidance on Design, Construction and Certification (1990 plus amendments) -guidance originally published in support of certification regime un SI289 Offshore installations regulatiions 1974 -SI289 revoked by Offshore Installations Regulations 1974 -Guidance was formally withdrawn entirely 30June1998 -'the withdrawal of the Guidance was not a reflection of the soundness (or otherwise) of the technical information it contained'
Buchner (2003)	Buchner, Bas, Floaters challenged by waves, Offshore, 01Jun2003, https://www.offshore-mag.com/rigs-vessels/article/16755452/floaters-challenged-by-waves
Jung et al. (2003)	Jung T, E Klinker, S Uppala, 10. Reanalysis and reforecast of three major European storms of the 20th century using the ECMWF forecasting system, ERA-40 Project Report Series, 33pp, November, 2003. -ERA40 reanalysis project enables historic storm hindcasts for the first time at ECMWF -special data extraction from NCEP for the 1953 storm -ECMWF ensemble forecasts from the early 1990s grew from need to assess reliability and sensitivity of medium range weather forecasts. -previously forecast robustness assessed by comparing forecasts from different weather centers
Toffoli et al (2003)	Toffoli J.M., J.M. Lefevre, J. Montbaliu, H. Savina, E. Bitner-Gregersen, Freak waves: Clues for prediction in ship accidents? Proceedings of the Thirteenth (2003) International Offshore and Polar Engineering Conf. Honolulu, Hawaii, USA, May 25-30,2003, The International Society of Offshore and Polar Engineers -investigation of key met-ocean parameters for freak wave accidents from Lloyds ship accident database -no single met-ocean parameter good predictor of freak wave strikes -many freak wave ship accidents during low Hs -ECMWF ERA wave information pulled for accidents.
Bitner-Gregersen and Magnusson (2004)	Bitner-Gregersen EM, AK Magnusson, Extreme events in field data and in a second order wave model, Proc. of the Rogue Waves 2004 workshop, Oct 20-22, 2004, Brest, France -Varg B greenwater incident on 30Nov1999; Ekofisk wave data analysis
Sahin (2004)	Sahin, AD, Progress and recent trends in wind energy, Progress in Energy and Combustion Science, 30, 501-543, 2004. -historical development of wind energy -motivated by energy crises, pollution reduction, greenhouse gas reduction.
DEA (2005)	DEA, Offshore Wind Power. Danish Experiences and Solutions. Danish Energy Authority, October, 2005. [pdf properties: datestamp: 24Oct2005] -1997 Denmark Action Plan -Denmark wind farm shut down during storm Gudrun 08Jan2005 -Table of Denmark offshore wind farms with Horns Rev demonstration farm start 2002 -14% of Denmark energy production by wind energy in 2004 -wind energy construction 4% of total Denmark undustry production; 20000 people employed -Denmark turbines and ancillary infrastructure represents 40% of market share -map of Denmark energy grid -synergy with offshore oil industry
Elsam (2005)	Elsam, Horns Rev - daenisches Windkraftwerk in der Nordsee, Stahlbau, 451, 73, 2005, pdf datestamp:

	02Jun2005 -significant contribution to Danish goal to reduce CO2 emissions; 2% of Danish energy use
Liu et al (2005)	Liu WT, X Xie, H Hu, W Tang, Wind convergence observed by Quikscat, 2005 -Quikscat provides surface wind at 12.5km resolution -surface wind convergence and rain bands in Hurricane Floyd Sep1999.
Rosenthal (2005)	Rosenthal, W., Results of the Maxwave project, in Mueller P and D Henderson (ed), 2005, Rogue Waves. Proc. 14th 'Aha Huliko' Hawaii, Winter workshop, Univ. Hawaii, Manoa, Honolulu: School of Ocaen Earth Sci Technoll, Spec Publ, 193 pp., http://www.soest.hawaii,edu/PubServices/AhaHulikoa.html. -visual classification of 3 types of rogue waves: a.singular wave tower, b.three sisters, c.white wall -case studies: Draupner (01/01/95), Stenfjell (26/10/98), Schiehallion (09/11/1998) *-Accident Limit State: takes account of 10000 year wave -critical Maxwave parameters: maximum crest, wave steepness, wave asymmetry, dir wave spectrum
Sterl and Caires (2005)	Sterl, Andreas and Sofia Caires, Climatology, variability and extrema of ocean waves: The web-based KNMI/ERA-40 Wave Atlas, International Journal of Climatology, 25, 963-977, 2005. -ERA40 model can not support tropical cyclones
Williams (2005)	Williams, M.O., Wave mapping in UK waters, Prepared by PhysE for the Health and Safety Executive 2005, Research Report 392 -updated atlas of 100y extreme Hs for North Sea and northeastern Atlantic Ocean -special analysis for Magnus field in northern North Sea where NEXTRA model bias appeared
Bork et al (2007)	Bork I, S Dick, E Kleine, S Mueller-Navarra, Tsunami - a study regarding the North Sea coast, Berichte des Bundesamtes fuer Seeschifffaahrt und Hydrographie, Nr.41/2007, Hamburg and Rostock 2007 -high dissipation of the tsunami wave energy in North Sea model study -5m line tsunami introducted at N North Sea give 50cm residual in German Bight -area ofwave focussing in the Wash behind the Dogger Bank -area of wave focussing North Shields -high amplitude secondary waves in southern North Sea -coherence of initial tsunami wave lost in S North Sea except in constant depth model
Gorbatchev et al (2008)	Gorbatchev A, JM Mattei, V Rebour, E Vial, Report on flooding of Le Blayais power plant on 27 december 1999, internet 2008 -outline of Le Blayaispower plant incident in the Gironde during Storm Martin 27Dec1999
Krogstad et al (2008)	Krogstad, HE., S.F. Barstow, J.P. Mathisen, L. Lonseth, A.K. Magnusson, M.A. Donelan, Extreme waves in the long-term wave measurements at Ekofisk, in Proc. Rogue Waves 2008 Workshop, ed. by M Olagnon and M. Prevosto, 13-15Oct2008, Brest France, 23-33, 2008 -Ekofisk Reference Data Set from 1980
Wagenaar and Eecen (2009)	Wagenaar JW, PJ Eecen, Measurements of wind, wave and currents, OWEZ_R_122_Wave_20050701_200812131, ECN-E--09-015, December 2009 -Netherlands OWEZ wind farm project starts met-ocean monitoring from summer 2005 -subsidy of Ministry of Economic Affairs under CO2 reduction scheme Netherlands
Bilgili et al (2011)	Bilgili M, A. Yasar, E. Simsek, Offshore wind power development in Europe and its comparison with onshore counterpart, Renewable and Sustainable Energy Reviews, 15, 905-915, 2011 -history and development of onshore/offshore wind energy -pollution reduction, first commercial wind farms California 1980s, -first floating wind turbine Nogersund Sweden 1990, -UK exceeds Denmark installed offshore wind capacity 2008,
Rosenthal et al (2011)	Rosenthal W, AL Pleskachevsky, S Lehner, S Brusch, Observation and modeling of high individual ocean waves and wave groups caused by a variable wind field, 12th International Workshop on Wave Hindcasting and Forecasting, Kohala Coast, Hawai'i, HI, 2011. -introduction of a new type of wave model to simulate resonant growth between gust field and moving waves. -discussion that return period of extreme waves much shorter than originally thought from emipirical model.
Foster (2013)	Foster R, Signature of large aspect ratio roll vorticies in synthetic aperture radar images of tropical cyclones, Oceanography, 26, 58-67, 2013. -Synthetic aperture radar SAR images to retrieve wind divergence and curl at 1km resolutions -boundary layer rolls appear with space scales of 8-19km (about same resolution of as Quikscat) -cloud streets may or may not form in association with boundary layer rolls.
Fruergaard et al (2013)	Fruergaard M, TJ Andersen, PN Johannessen, LH Nielsen, M Pejrup, Major coastal impact induced by a 1000-year storm event, Nature, Scientific Reports, 3:1051, DOI: 101038/srep01051, 2013. -worst storm surge in Danish Waddensee 11-12Oct1634 -water level 6.1m from mark on Ribe Cathedral; 1 m higher than rank 2 surge
Feser et al (2015)	Feser F, M Barcikowska, O. Krueger, F. Schenk, R. Weiss, L. Xia, Review Article: Storminess over the North Atlantic and northwestern Europe - a review, QJR Meteorol. Soc, 141, 350-382, 2015. -studies from mid-1980s-1990s showing increading trend in sea state climate -subsequently found to be part of interannual variability
Larsen et al (2015)	Larsen XG, C Kalogeri, G Galanis, G Kallos, A statistical methodology for the estimation of extreme wave conditions for offshore renewable applications, Renewable Energy, 80, 205-218, 2015. -50y return period for signficant wave height at the Horns Rev site -reference to missing peak problem in wave models (Cavaleri et al, 2009)
Larsen et al (2017)	Larsen XG, J Du, R Bolanos, S Larsen, On the impact of wind on the development of wave field during storm Britta, Ocean Dynamics, 67, 1407-1427, 2017. -Anatol 1999 and Xaver (2013) mentioned as serious storms outside of main investigation period 2005-2013 -purpose to introduce new high resolution atmosphere-wave model to simulate Britta
Ravnsdal and Abrahamsen (2017)	Ravndal, Oda Roaldsdotter and Trine Abrahamsen, The Norwegian tide gauge network: National report of Norway, Kartverket, June 2017. -historical and present status of Norwegian tide gauge network
Halsne et al (2020)	Halsne M, N Oma, G Ersdal, A Kvitrud, RL Leonhardsen, M Langoy, T Andersen, LG Bjorheim, In service

	experiences with ship-shaped floating production units, Proceedings of the ASMI 2020 39th International Conference on Ocean, Offshore and Arctic Engineering, OMAE 2020, June 28-July 3, 2020, Fort Lauderdale, FL, USA, OMAE2020-19287 -North Sea FPSO green water incidents restart 2016 for first time since 2001 -fatigue cracks in FPSOs
Surgewatch (20201013)	Surgewatch, Storm event 28th November 1999, https://www.surgewatch.org/events/1999_11_28/, accessed 13Oct2020 -surge and overtopping in Solent area 28Nov1999

Table SL71. Errors/typos in source reports for storm (arranged by year and then alphabetically)

Source	Full Reference and Notes
Woetmann Nielsen (2000)	Woetmann Nielsen, AN, DMI-HIRLAM's forudsigelse af orkanen den 3.december 1999. Vejret, 82, pp. 19-23, februar 2000. -caution when reading sea level pressures printed on synoptic chart in FIG2; they are 400mb too low or else presented in an abbreviated format: P_map=(P_meas-900.0)*10.0
Decker (2018)	Decker, Lauge, Windthrow risk assessment of Douglas-fir stands in Denmark. A comparison study of Douglas-fir (Pseudotsuga menziesii) and Norway spruce (Picea abies), M.Sc. thesis, University of Copenhagen, submitted 6Aug2018 [pdf properties: title=Notatbog; author=Lauge Decker, Subject=SKOG303 - Silviculture and forest growth yield] -FIG6.2.[MAP] Maximum wind speed (gusts) during storm Anatol on 3Dec1999. Orange marks forests experiencing wind throw. Red dotted line is trajectory. ERROR IN TRAJECTORY MAP

Table SL72. Abbreviations used in manuscript (arranged by year and then alphabetically)

Abbreviation	Full name
DMI	Danmarks Meteorologiske Institut
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium Range Weather Forecasts
FINO1	Forschungsplattformen in Nord- und Ostsee Nr. 1
GESLA	Global Extreme Sea Level Analysis
HSE	Health and Safety Executive
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KNRM	Koninklijke Nederlandse Redding Maatschappij
RMS	Risk Managment Models, Analytics, Software & Services
RWS	Rijkswaterstaat
UKMO	UK Met Office
UN/ECE	United Nations Economic Commission for Europe
UTC	Coordinated Universal Time
WASA Group	Waves and Storms in the North Atlantic
XWS	Extreme Wind Storms

Table SL73. People contacted for information about storm (arranged by year and then alphabetically)

Name	Affilation
Berz, Gerhard	Munich Re (retired)
Beswick, Mark	UK Met Office National Meteorological Archive
Bluemel, Maria	Landesbetrieb fuer Kuestenschutz, Nationalpark, und Meereschutz Schleswig-Holstein
Ersdal, Gerhard	Petroleum Tilsynet (PTIL)
Frederiksen, Bjørn	Kystdirektoratet
Granneman, Edwin	Kustwacht
Hinrichsen, Arfst	Landesbetrieb fuer Kuestenschutz, Nationalpark, und Meereschutz Schleswig-Holstein
Machoczek, Pamela	Bundesamt für Seeschifffahrt und Hydrographie (BSH) library
Mueller, Larissa	Bundesamt für Seeschifffahrt und Hydrographie (BSH)
Niclasen, Bárður	University of the Faroe Islands
Reemts, Antke	Seenotretter
Ross, Catherine	UK Met Office National Meteorological Archive
Skaland, Reidun Gangsto	Met.no
Tainamo, Susanne	Swedish Meteorological and Hydrological Institute (SMHI)
Van Vliet, Gerda	Koninklijke Nederlandse Redding Maatschappij (KNRM)
Wiechmann, Wilfried	Bundesanstalt für Gewasserkunde (BAFG)
Zijderfeld, Annette	Rikswaterstaat (RWS)

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