

First studies with the high-resolution coupled wave current model CWAM and other aspects of the project Sea State Monitor

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Structure of the presentation:

- Motivation and intention of the project "Sea State Monitor"
- Model development
→ CWAM
- Model validation
→ using in-situ measurements
→ using TerraSAR-X
- The influence of currents and water depth on sea state
- Summary, conclusions, and outlook

Motivation and intention:

DWD: operational sea state forecast
using global and regional wave forecast models
(e.g. GWAM, EWAM).

BSH: operational sea current and water level prediction
using ocean circulation models (e.g. BSH CMOD, HBM).

Users of forecasts:

e.g. commercial shipping, recreational craft, coastal protection, offshore industry

Motivation and intention:

Offshore industry is very active
in German coastal waters.



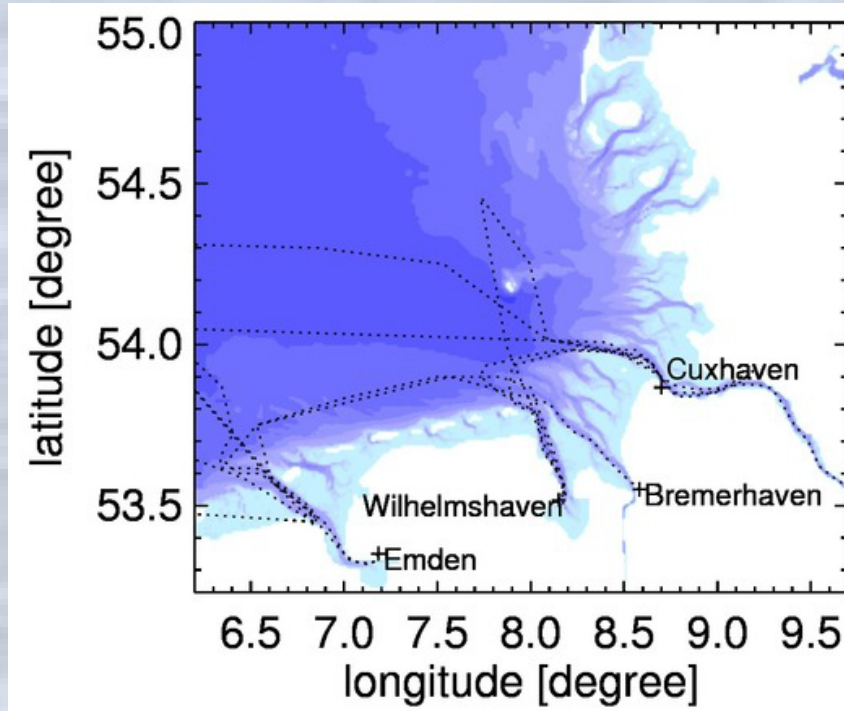
Photos from Global Tech | Offshore Wind GmbH

They need very exact forecast
in the range of low and
moderate wave heights.

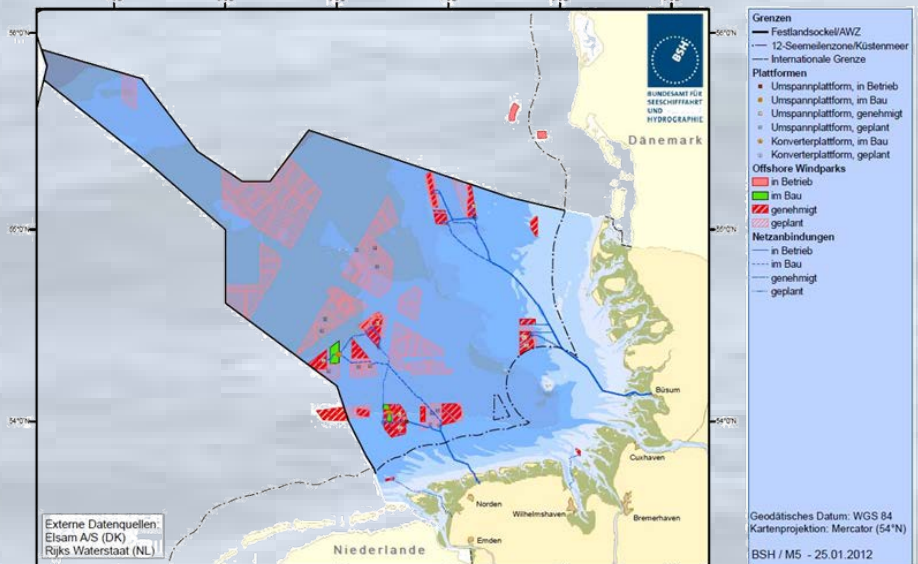
Motivation and intention:

Offshore industry operates in sea areas with complex topography and strong currents, where conventional prediction exhibits significant uncertainties.

Planned or existing wind farms within the German Bight



Typical shipping routes of the offshore industry within the German Bight



Motivation and intention:

improvement of the operational sea state, sea current, and sea height forecast for the German coastal waters

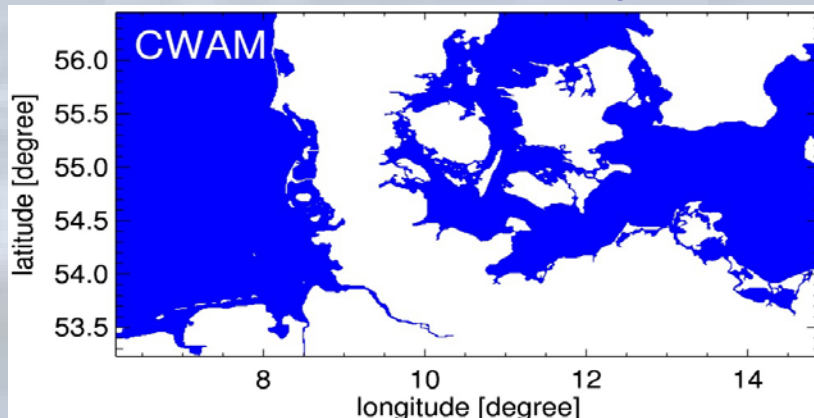
Main parts of the project:

- development of the high-resolution, coupled wave current model CWAM for the German Bight and the western Baltic Sea
- development of algorithms in order to derive meteo-marine parameters from radar satellite observations
- creation of new forecast products combining model and satellite data

Coastal Wave Model (CWAM)

NEW!

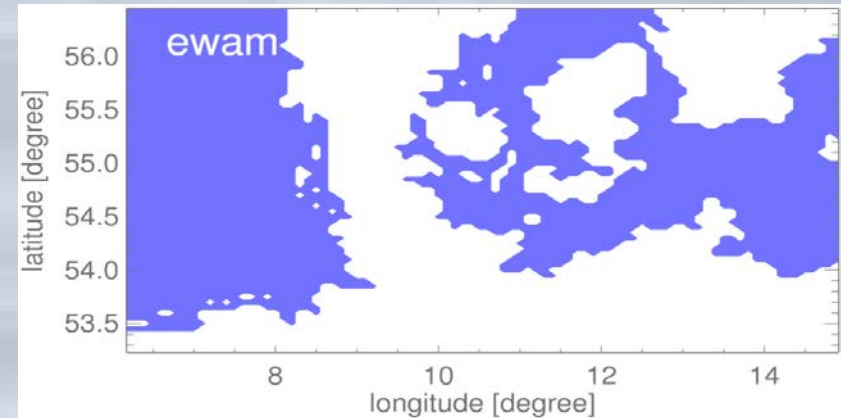
- wind input from COSMO-EU,
- spectral resolution: 36 directions, 30 frequencies
- increment longitude: 0.01389°
- increment latitude: 0.00833°
- coupled with the ocean circulation model (HBM) that provides current and water depth



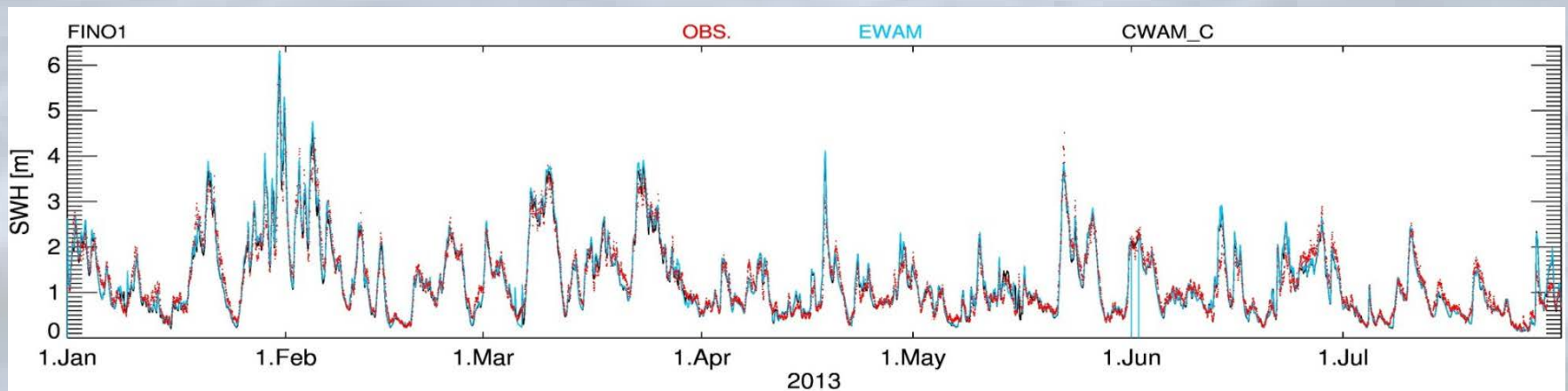
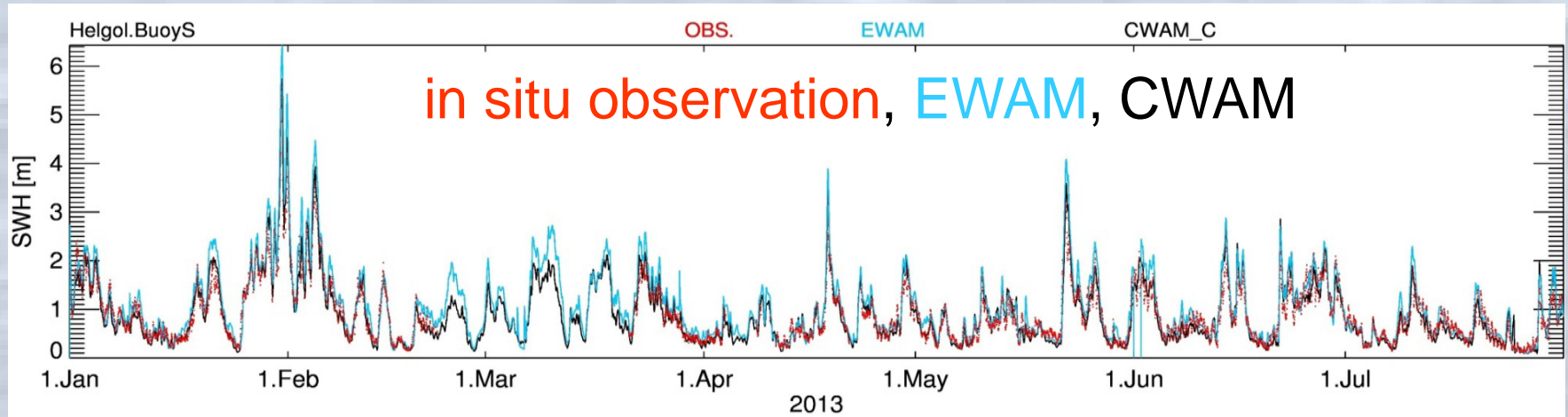
European Wave Model (EWAM)

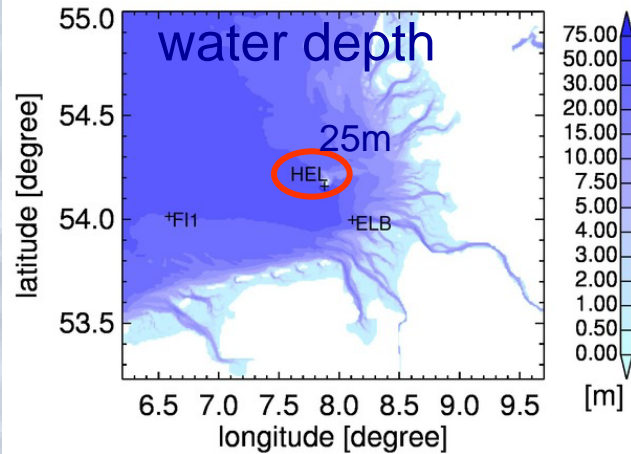
CONVENTIONAL

- increment longitude: 0.1°
- increment latitude: 0.05°

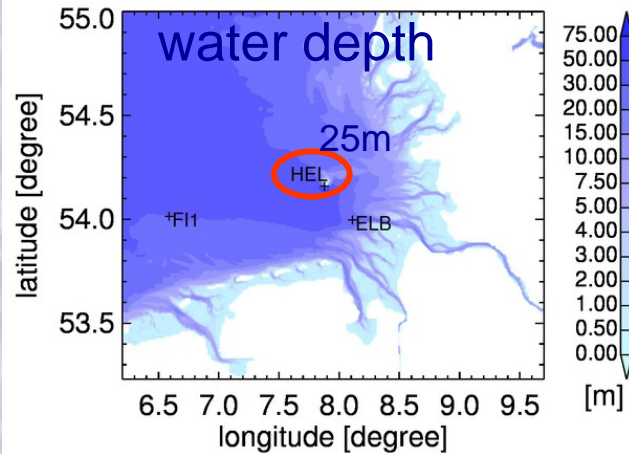


Comparison between CWAM, EWAM, and in situ measurements at two positions within the German Bight significant wave height





comparison model vs in situ measurements:

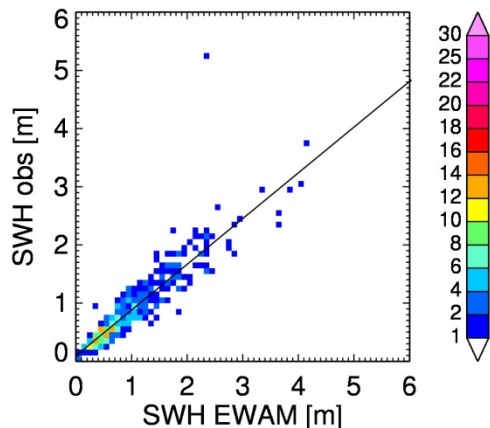


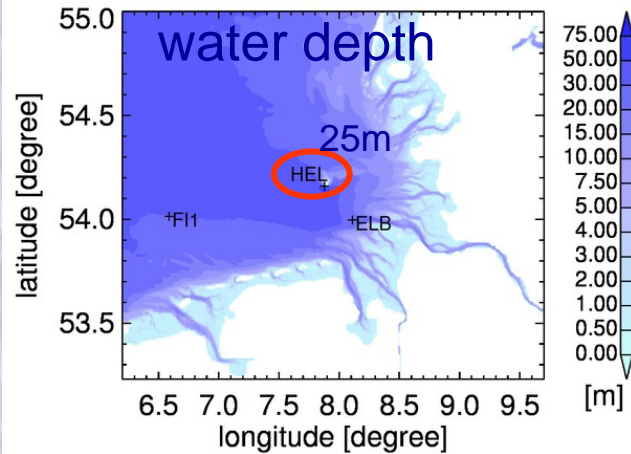
comparison model vs in situ measurements:

significant wave height at buoy position
close south of the island Helgoland

EWAM: European Wave Model

Helgol.BuoyS correlation coeff=0.951608
scatter index=0.313087



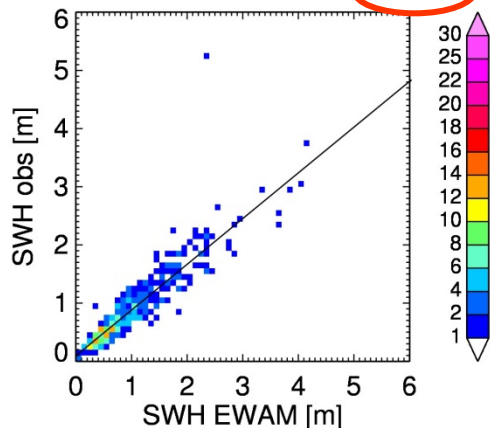


comparison model vs in situ measurements:

significant wave height at buoy position
close south of the island Helgoland

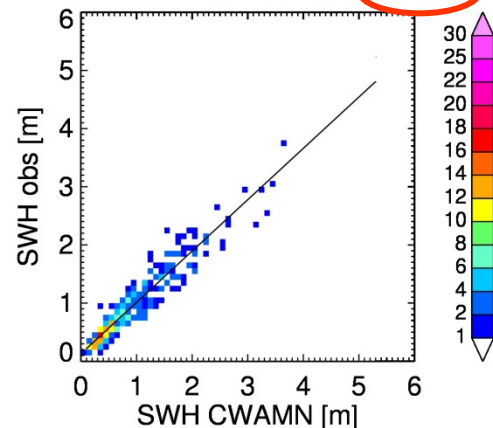
EWAM: European Wave Model

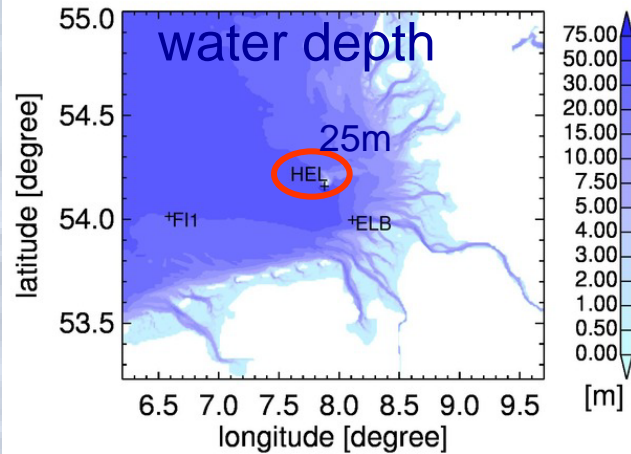
Helgol.BuoyS correlation coeff: 0.951608
scatter index: 0.313087



CWAMN: fixed depth, no current

Helgol.BuoyS correlation coeff: 0.957344
scatter index: 0.218326





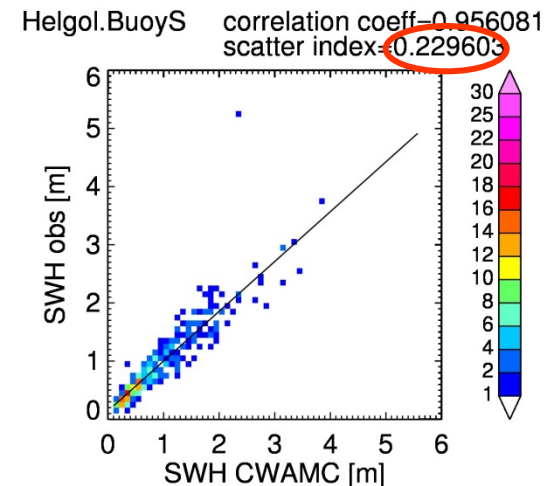
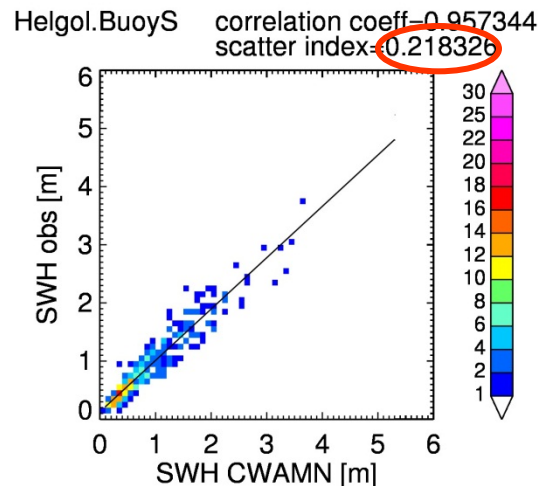
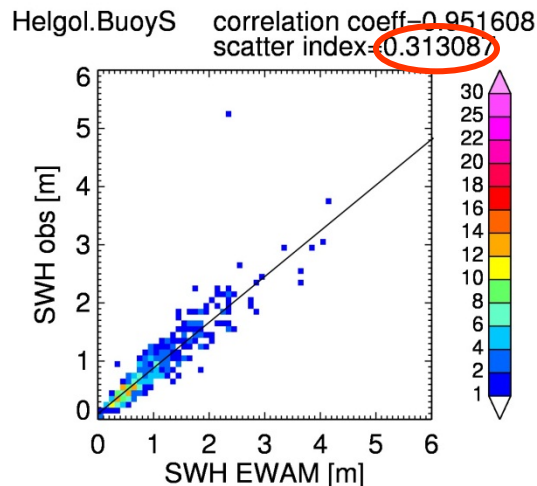
comparison model vs in situ measurements:

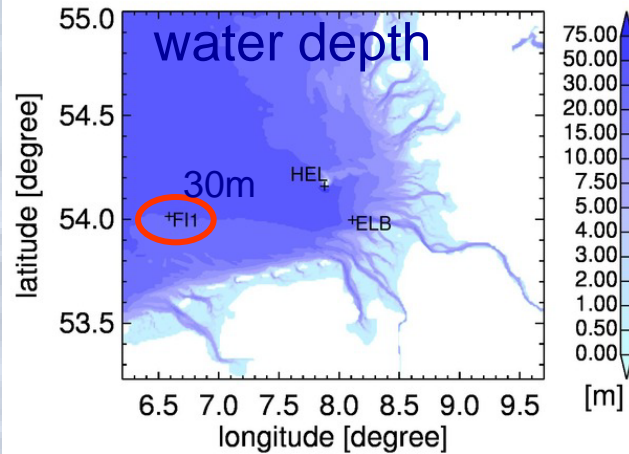
significant wave height at buoy position
close south of the island Helgoland

EWAM: European Wave Model

CWAMN: fixed depth, no current

CWAMC: variable depth, current



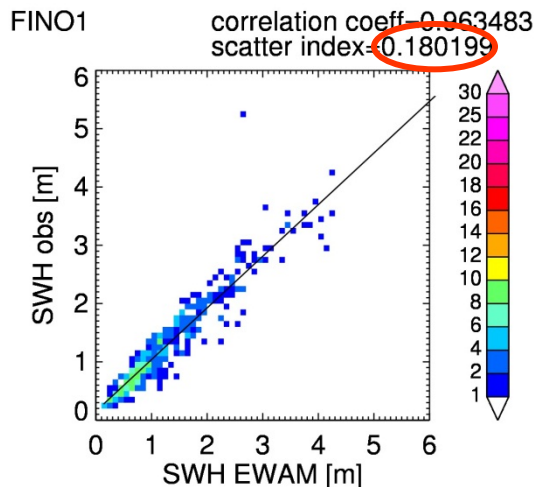


comparison model vs in situ measurements:

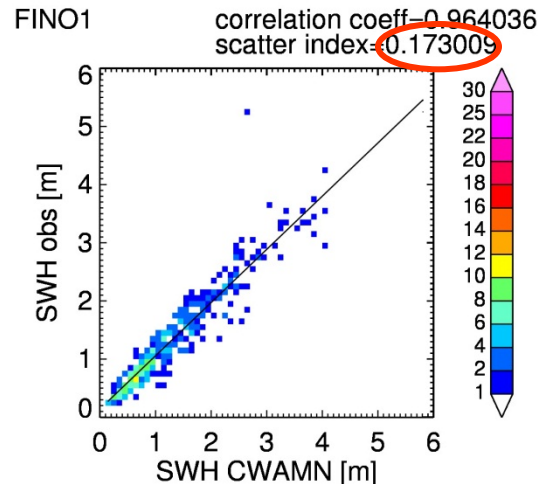
significant wave height at offshore research platform FINO 1*

(* The FINO project is promoted by the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety and by the Projektträger Jülich.)

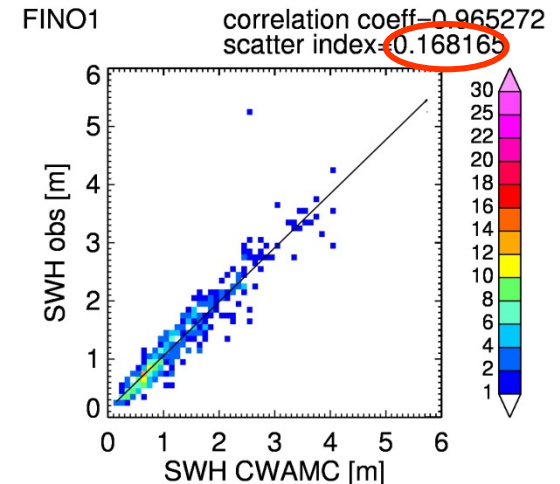
EWAM: European Wave Model



CWAMN: fixed depth, no current

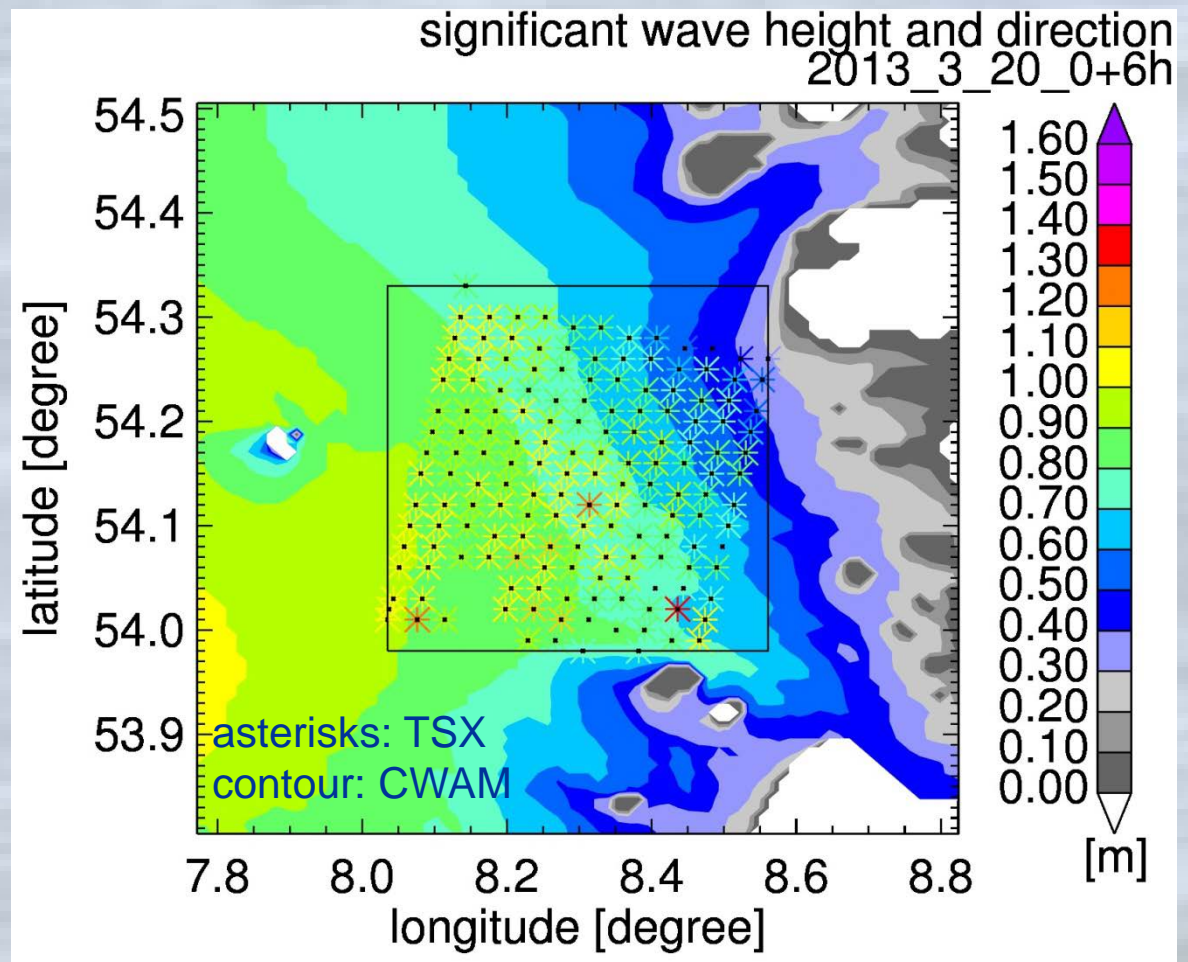


CWAMC: variable depth, current

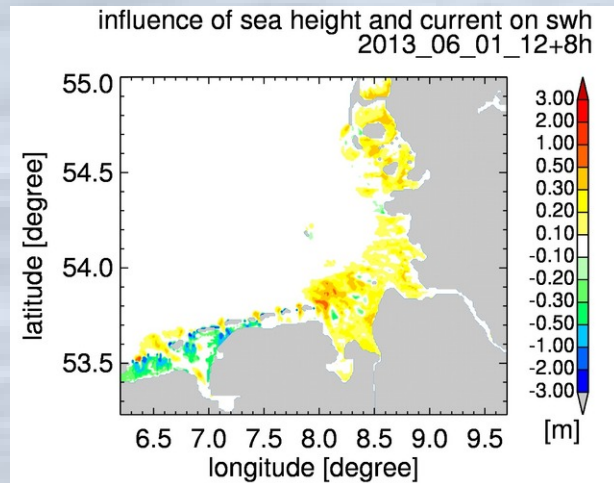


Comparison of TerraSAR-X (satellite) observations with CWAM results:

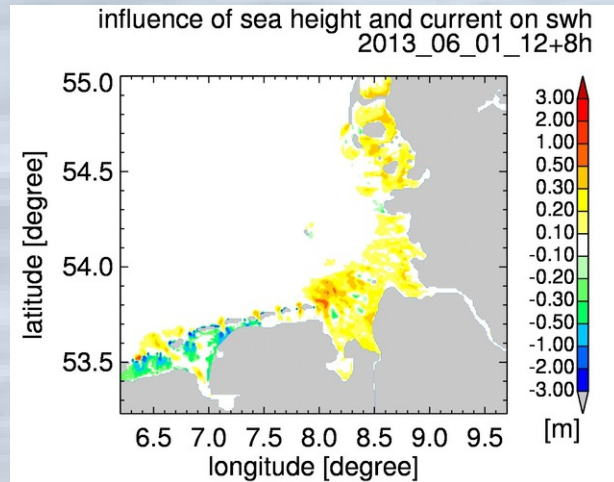
Significant wave height computed by CWAM and derived from high-resolution TerraSAR-X observation using XWAVE algorithm (Bruck and Lehner 2012)



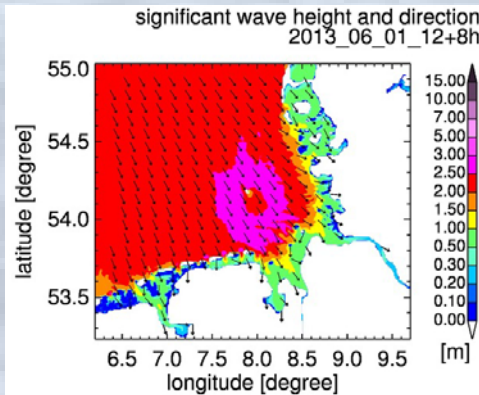
influence of water depth and current on the wave height:



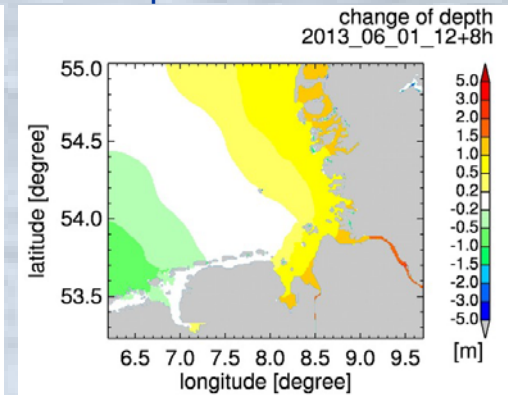
influence of water depth and current on the wave height:



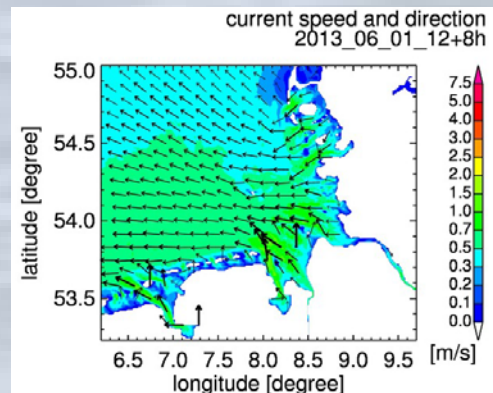
significant wave height



water depth relative to reference depth

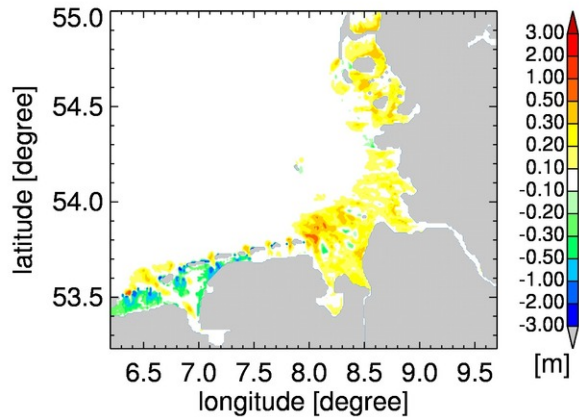


current

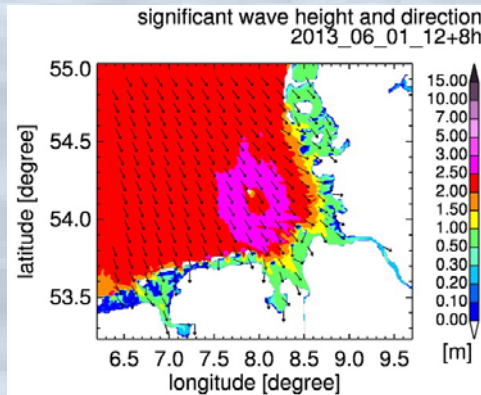


influence of water depth and current on the wave height:

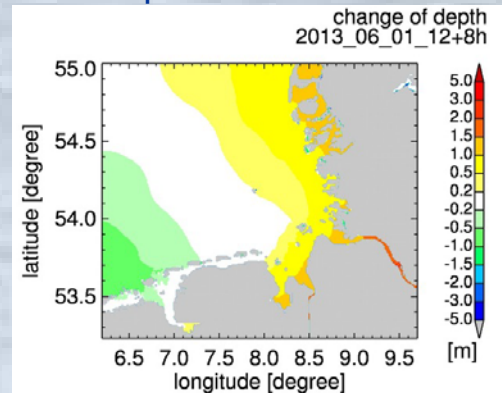
influence of sea height and current on swh
2013_06_01_12+8h



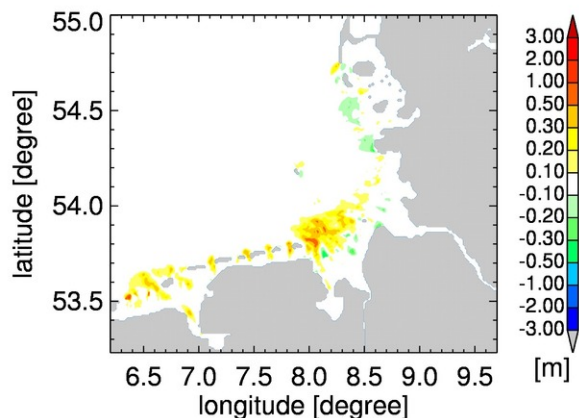
significant wave height



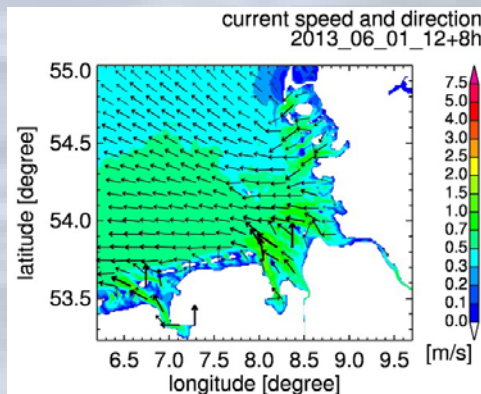
water depth relative to reference depth



influence of current on swh
2013_06_01_12+8h

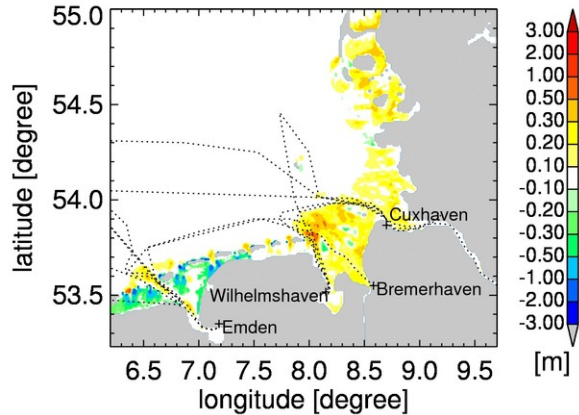


current

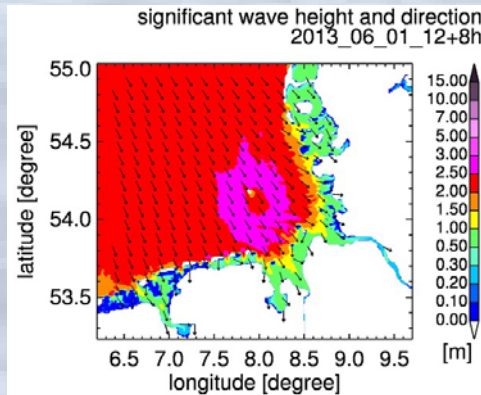


influence of water depth and current on the wave height:

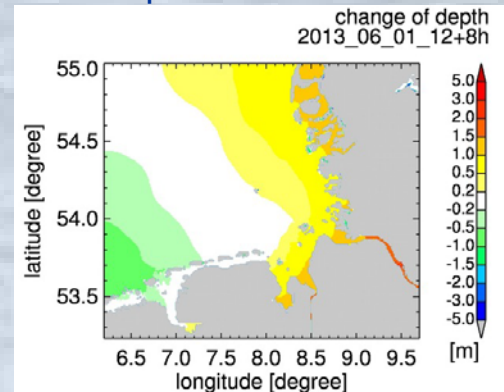
influence of sea height and current on swh
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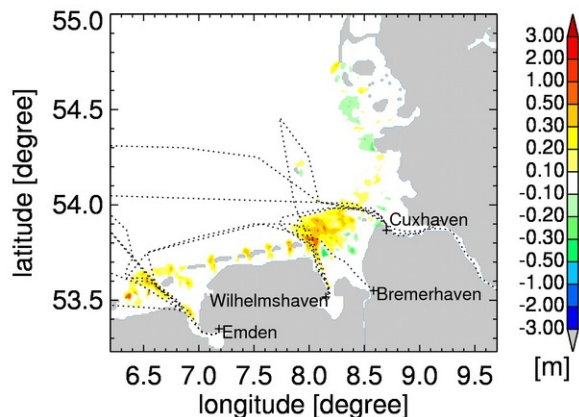
significant wave height



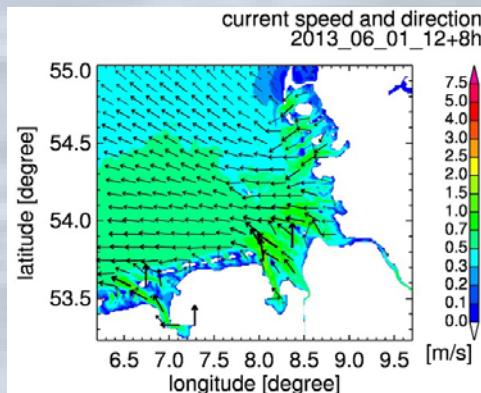
water depth relative to reference depth



influence of current on swh
2013_06_01_12+8h

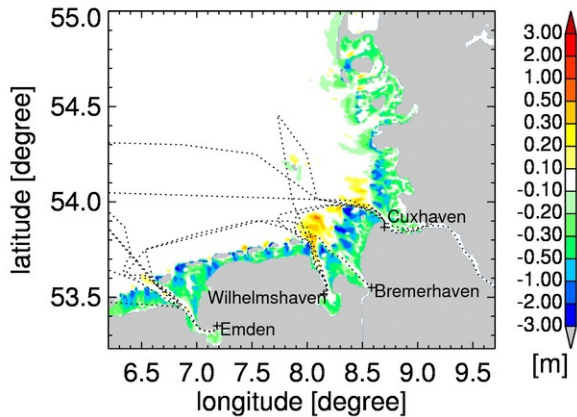


current

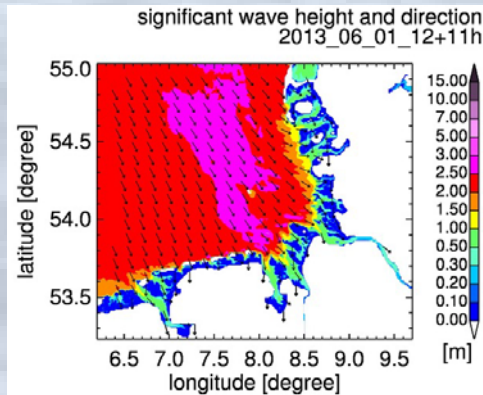


influence of water depth and current on the wave height:

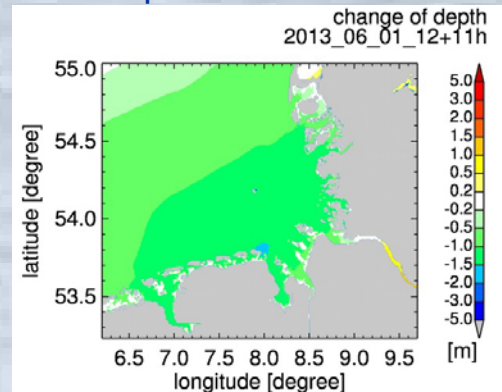
influence of sea height and current on swh
2013_06_01_12+11h



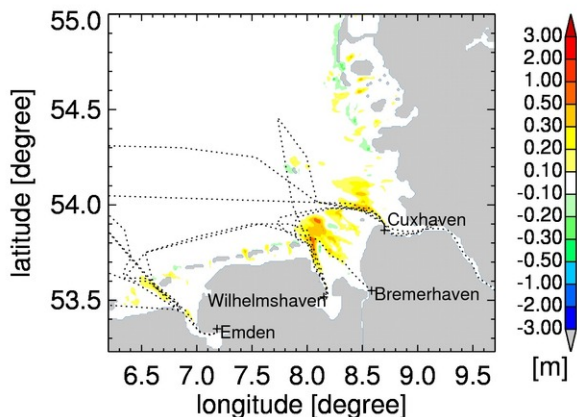
significant wave height



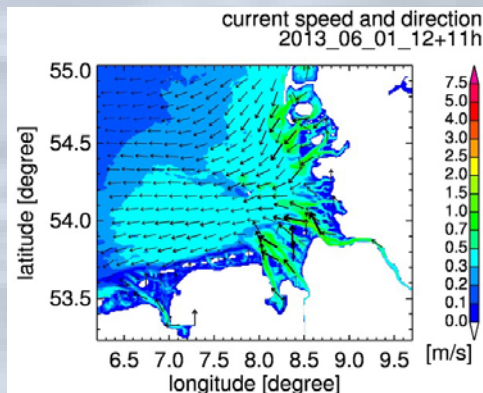
water depth relative to reference depth



influence of current on swh
2013_06_01_12+11h



current



Summary and conclusions:

- CWAM has been developed
- Comparison with buoy measurements shows:
 - general improvement of wave height prediction due to higher model resolution and more detailed representation of topography
- First studies indicate:
 - potential improvements in near shore areas when time varying water depth and currents are taken into account
 - effects of currents are highly localized, but affected areas are highly frequented by offshore industry (main beneficiary of improved forecasts)

Outlook:

- Interactive coupling of CWAM and the ocean circulation model HBM
- Extension of the operational forecast time range to 48 or 72 hours
- Refinement of algorithms to derive meteo-marine parameters from TerraSAR-X satellite measurements
- Validation of model results with space-borne SAR data covering large areas



THANK YOU

Scatter Index as used by Ris et al. 1999:

$$SI = \text{rms}_{\text{error}} / \bar{X}$$

$$\text{rms}_{\text{error}} = \sqrt{\frac{1}{N} \cdot \sum (X_n - Y_n)^2}$$

X_n : observed values

Y_n : computed values

N: number of observations

\bar{X} : averaged observed value