TIROS-1 Established the Foundation for Today's Remarkable JPSS and GOES-R Satellite Systems

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Presented at the 16th Annual Symposium on New Generation Operational Environmental Satellite Systems, 100th American Meteorological Society Annual Meeting, Boston, MA, January 13, 2020


TIROS


JPSS

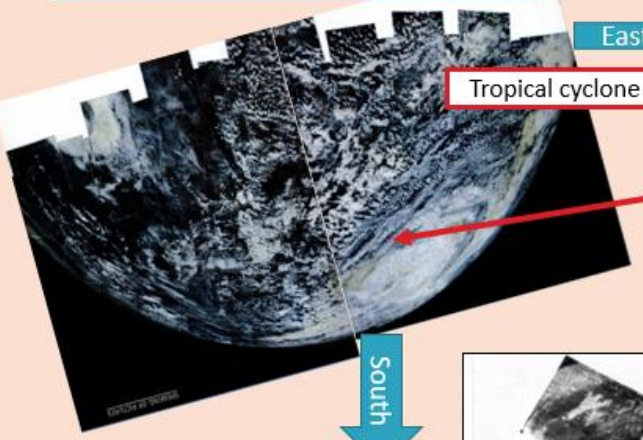
Outline

- The Path to Polar and Geostationary Systems
- Celebrate the 60th anniversary of TIROS-1
  - The first operational weather satellite (1 Apr 1960)
- Satellites and Instruments
- Milestones
- Meteorology: Early initiatives for ***Operational*** Applications

First Color Image from Space - Aerobee Rocket (1954)

First tropical cyclone observed from space (1954)

Color mosaic from Life Magazine (1955)



East

South

Tropical cyclone over Gulf of Mexico

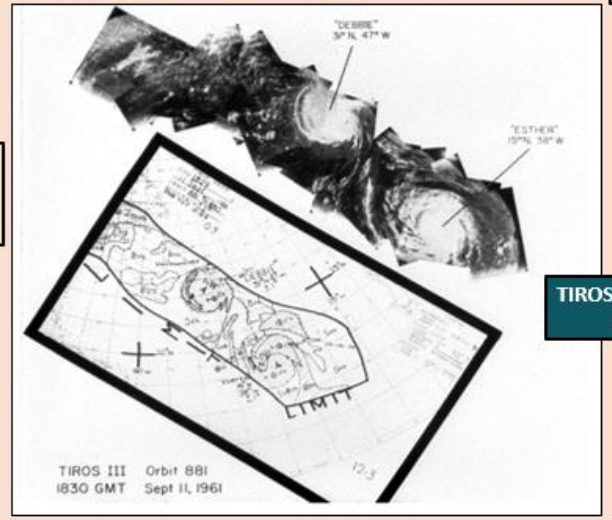
Aerobee Sounding Rocket Launched October 5, 1954 at 1815 GMT from White Sands.

Reached 100 miles altitude

Carried 35 mm color camera

Color Mosaic from ~ 90 images

"Vast regions of the Earth [were] still meteorologically unexplored territory." (Hubert and Berg, 1955)



TIROS-3 detects two Atlantic hurricanes (1961)

Source: Hubert and Berg, 1944


TIROS

Diverse Collaborators Initiated Weather Satellites


JPSS

IGY Satellites

1955 - 1958

National Academies Coordinate Planning:

- Army Signal Corps Rsrch Lab (Payload)
- Naval Rsrch Lab (Vanguard Team)
- Army Corps of Engineers
- Army Ballistic Missile Agency (Explorer)
- Industries (esp. RCA)
- Universities (esp. Univ Iowa)
- ARPA*

Office of Naval Research*
National Science Foundation*

TIROS Satellites

1958+

NASA* Designated to Sponsor & Coordinate Execution

- US Weather Bureau (Data Handling)
- Army Signal Corps Rsrch Lab (Payload)
- Naval Rsrch Lab (Vanguard Team)
- Industries (esp. RCA)
- Universities (Univ Iowa esp)
- WWW (International Cooperation)

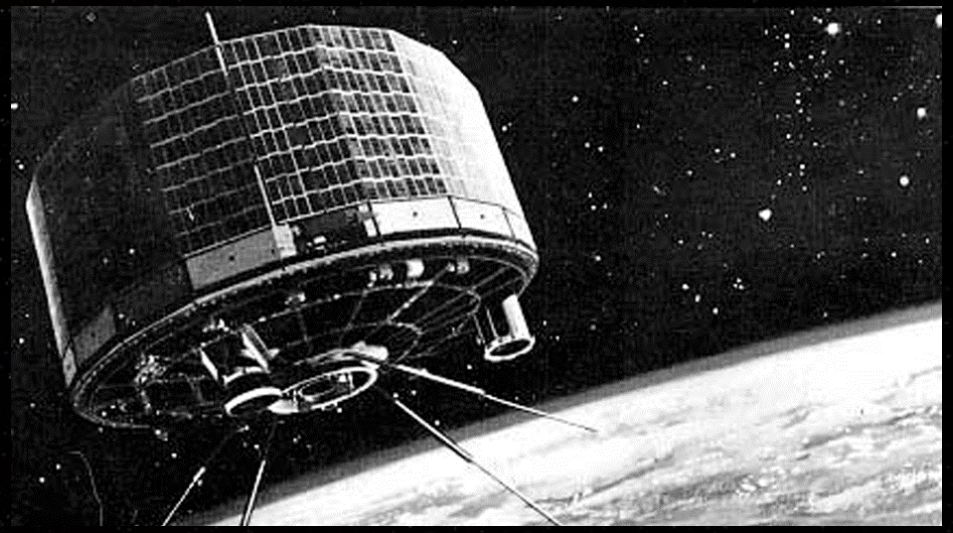
*sponsor transferring from ONR and NSF during IGY

Source: A. Callahan, 2013

TIROS-1

TIROS

JPSS



First Day Cover

Courtesy: D. Hillger

Equipped with two TV cameras and two video recorders, the spacecraft orbited 450 miles above Earth, relaying nearly 20,000 images of clouds and storm systems moving across our planet.

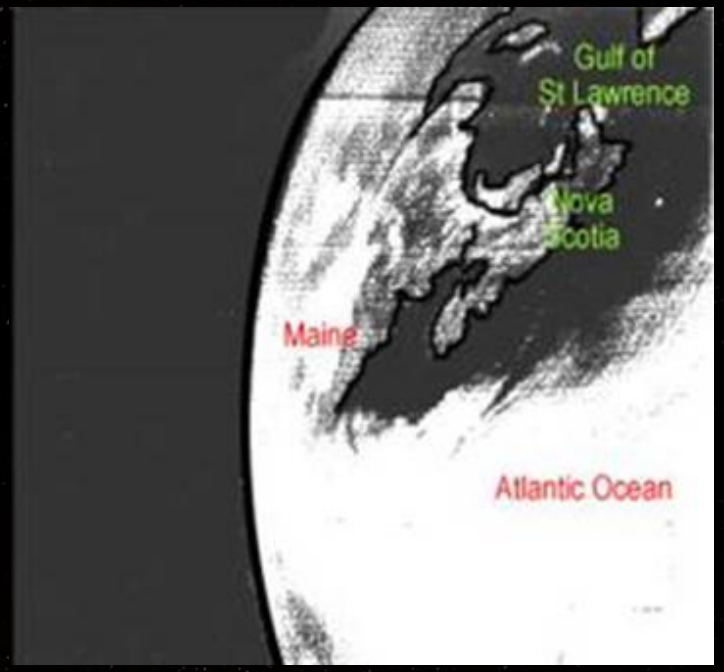
Though TIROS-1 was operational for only 78 days, the images it transmitted underscored the ***importance of monitoring global weather conditions from space*** - still a novel concept in the early 1960s. The success of TIROS-1 fueled demand for additional, more technologically advanced weather observation satellites that could gather more data and provide higher-resolution imagery.

(J. Leslie, NOAA Press Release)

April 1, 1960: TIROS-1 Takes the First Weather Satellite Picture

TIROS

JPSS



First picture from TIROS-1
April 1, 1960

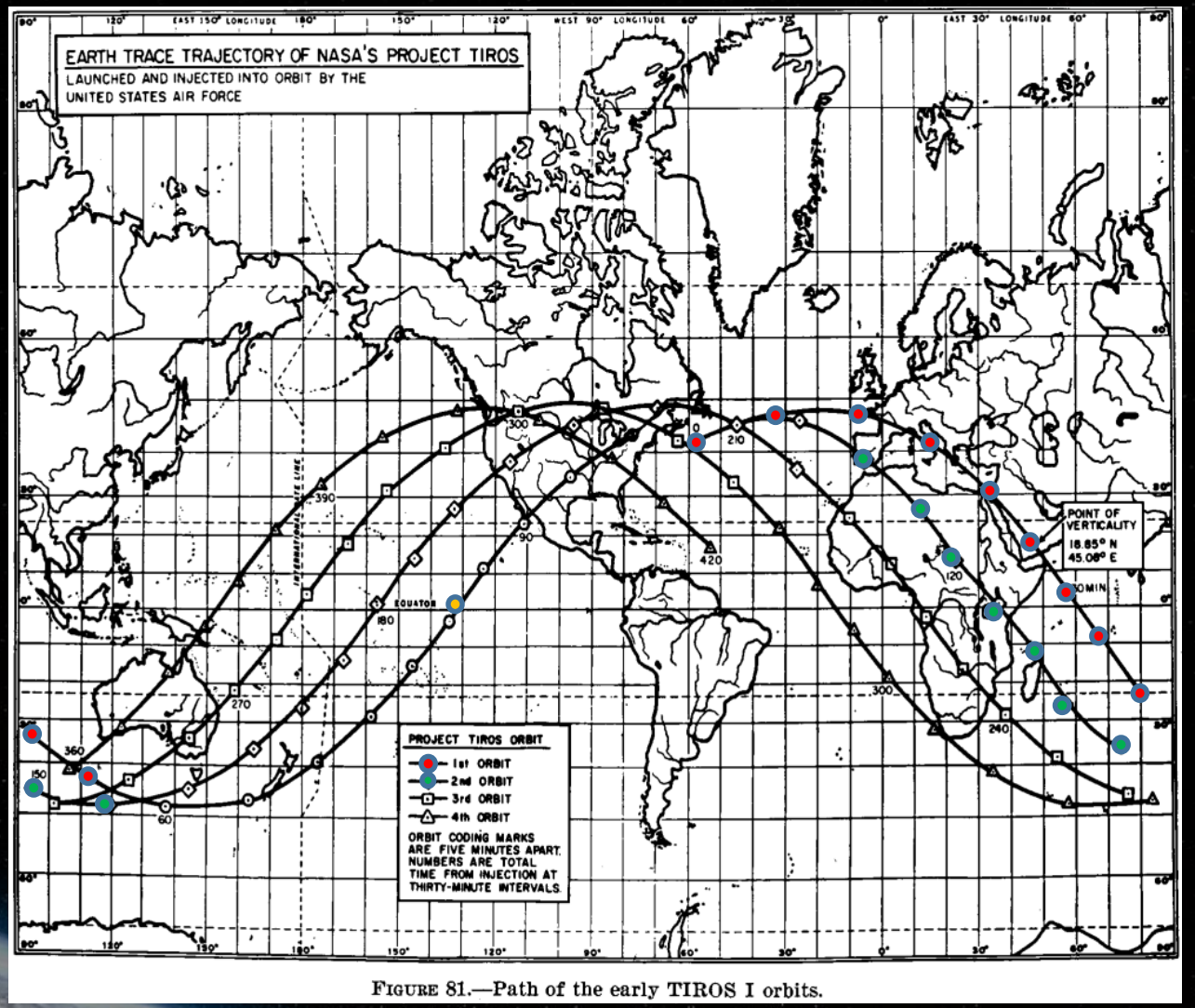


FIGURE 81.—Path of the early TIROS I orbits.

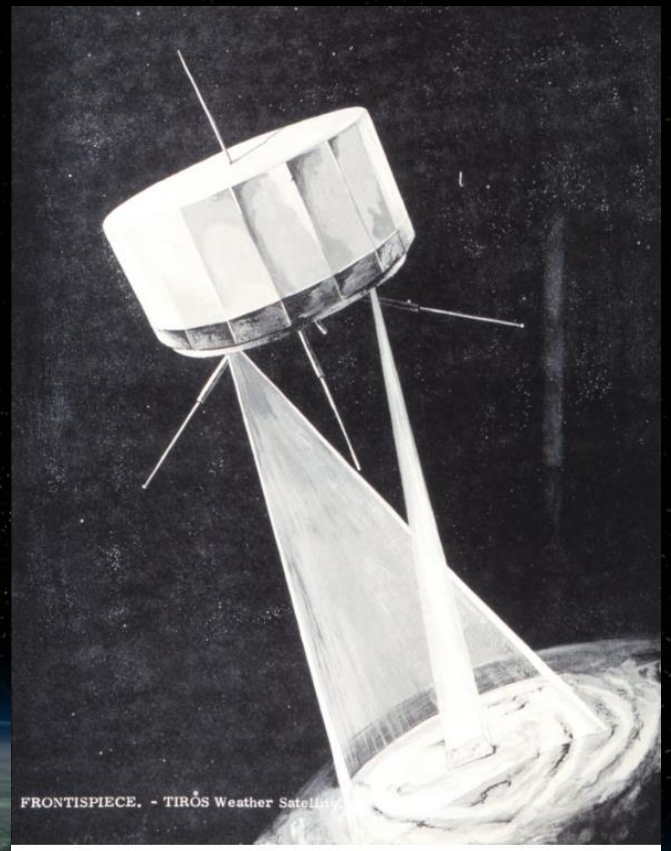
Map: Stroud, NASA TR-131, 1961


TIROS

Instrument Pointing Geometry was a Challenge


JPSS

Field of View for the wide-angle and narrow-angle cameras



Artist's conception of TIROS meteorological satellite system showing field of view of wide-angle and narrow-angle cameras on Earth's surface. Graphic in: "Operational Use of Weather Satellites", U. S. Navy Research Facility, Norfolk, Virginia, March 1960. Drawn prior to launch of TIROS I.

NOAA Central Library

Diagram of Earth pointing coverage

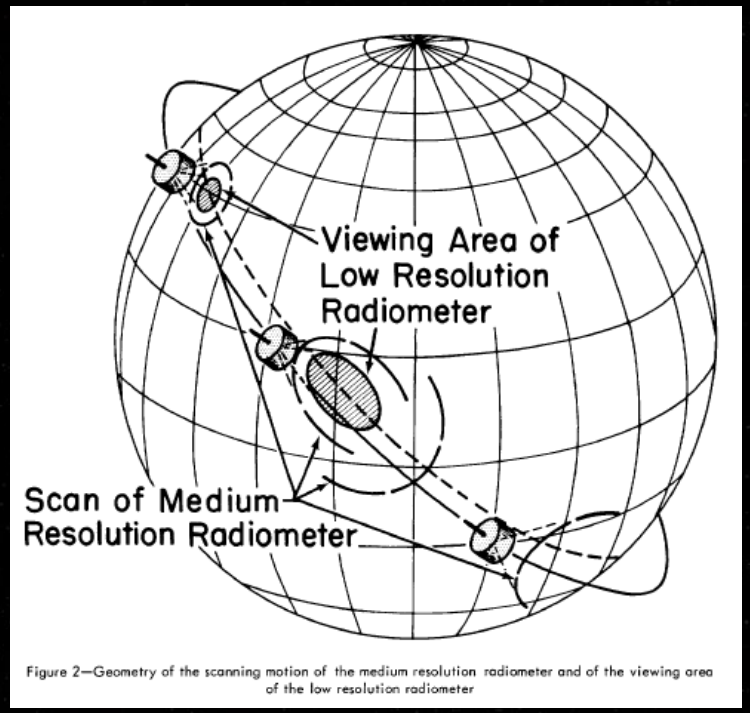


Figure 2—Geometry of the scanning motion of the medium resolution radiometer and of the viewing area of the low resolution radiometer

Sun illuminated pictures were possible for about one- fourth to one-third of an orbit

(Bandeen, NASA Tech Note D-1096, 1961)

TIROS 1 Photo Mosaics

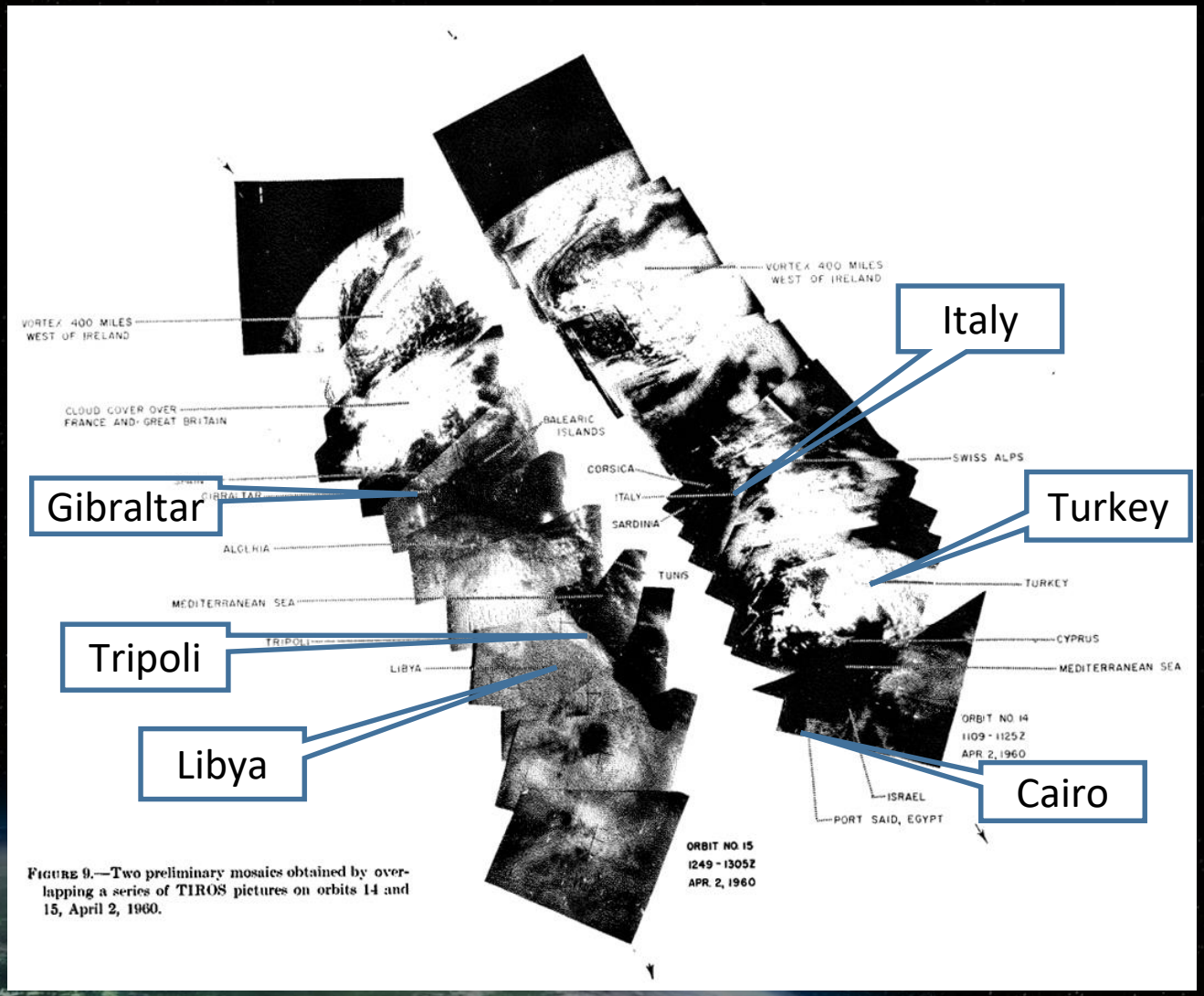


FIGURE 9.—Two preliminary mosaics obtained by overlapping a series of TIROS pictures on orbits 14 and 15, April 2, 1960.

- TIROS-1
- Orbits 14 and 15
- April 2, 1960

Pictures from individual orbits were arranged by hand to make nephanalyses.

Eventually (1966), software was written for grid overlays.

Fritz & Wexler, 1960: Mon. Wea. Rev.


TIROS

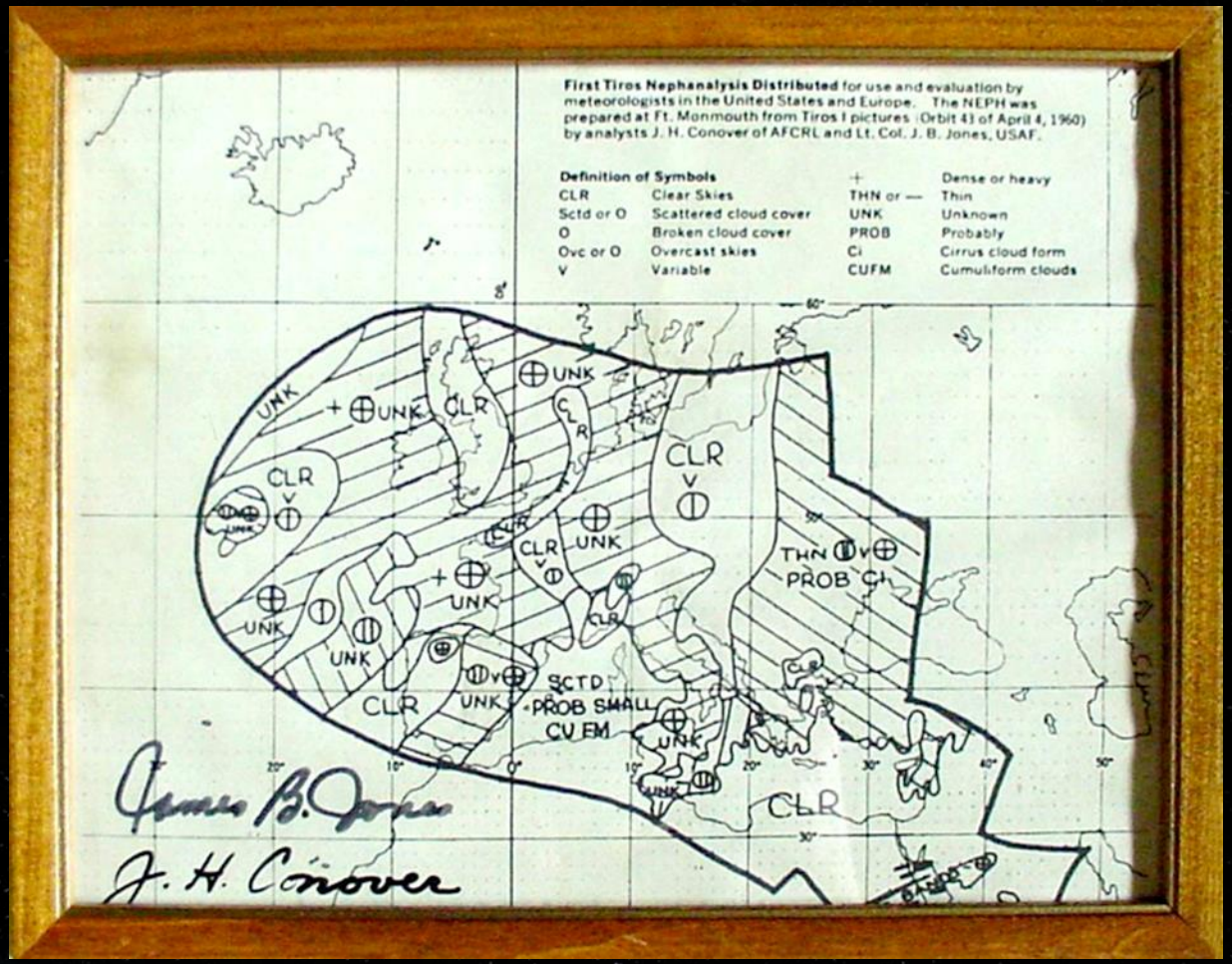
First Operational Nephanalysis


JPSS

Film was processed immediately to make 35 mm transparencies for projection and for prints. Geographic reference grids were overlaid on these pictures to determine the location where the pictures were taken. Analyses show the cloud types, amount and the extent of coverage.

This map by USAF Col. (then Major) James B. Jones and others distributed this nephanalysis by facsimile to weather stations around the globe for immediate use.

Within 48 hours of the TIROS-1 launch, the pictures and nephanalyses were made available to USWB meteorologists, US Air Weather Service, US Naval Weather Service, and International Users.



First operationally used TIROS nephanalysis (USAF)

Signatures: Lt Col Jones & J. Conover (AFCRL)

Rao, P. K., 2001: NOAA Technical Report NESDIS 101; Nat Air & Space Museum; and Widger, 1996

IR Systems: Bolometers for Vanguard TV-3

Fig. 1 Professors Suomi and Parent pose with the Vanguard Program's SLV-6 satellite. The Black ball is one of two black and two white spheres as part of their heat budget experiment.

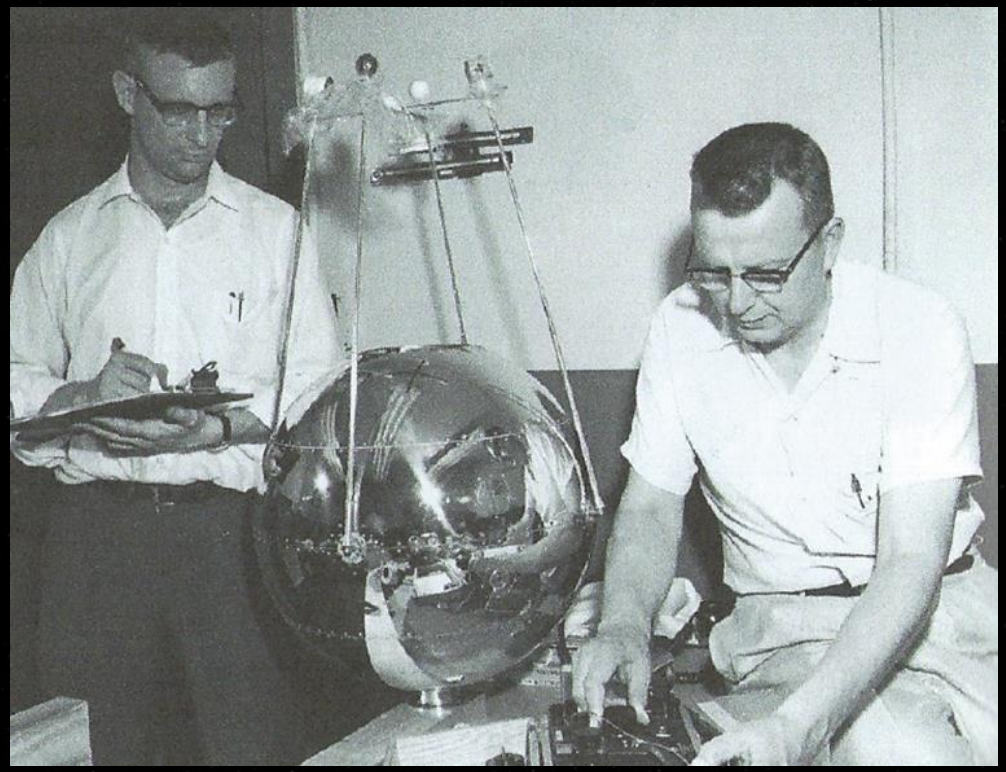


Fig. 2 Charles Stearns and Verner Suomi with the SLV-6 satellite carrying Suomi's early heat balance experiment in 1959. This launch (Jun 22, 1959) was unsuccessful (Courtesy UW-Madison Archives).

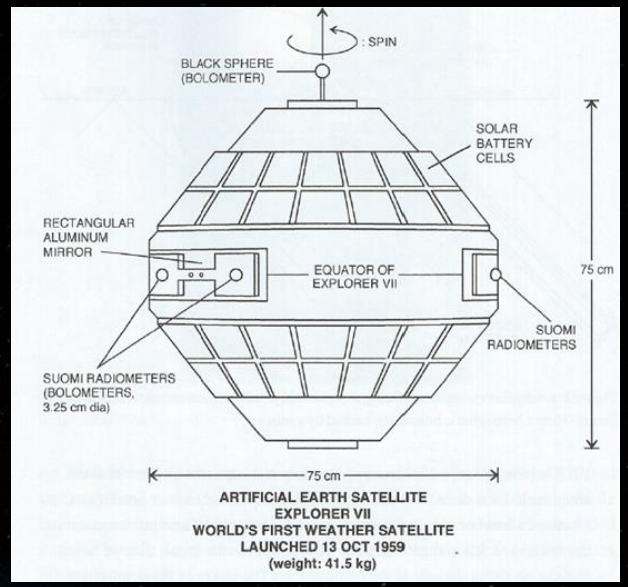
Lewis, 2018 AMS Book "Verner Suomi"

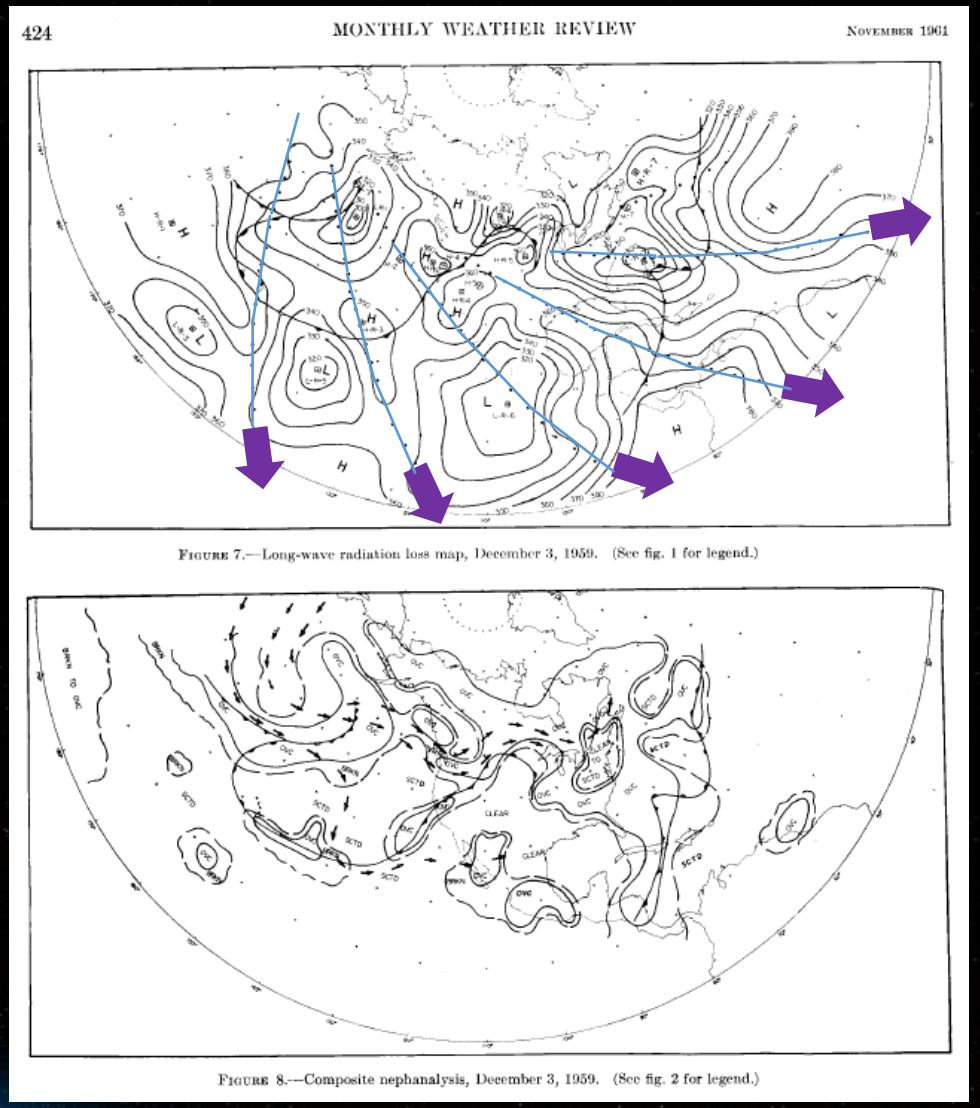
TIROS

Suomi's Mirror-Backed Radiometers for Explorer 7

JPSS

Weinstein and Suomi showed that the simple mirror-backed bolometer data could show **synoptic features** for situation awareness, analysis and forecasting. Launched Oct 13, 1959).





Top:
Dec 3, 1959
Outgoing
Long-wave
radiation
sensed by
Explorer 7

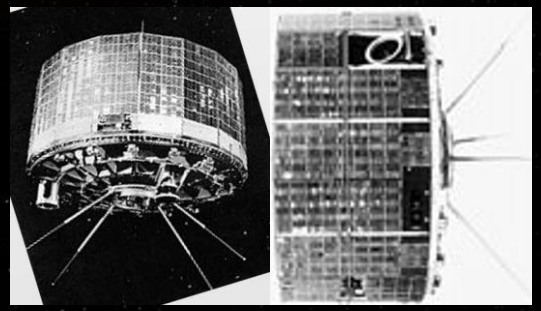
Bottom:
Composite
nephanalysis
from Surface
maps

Weinstein (USAF Lt Col) and Suomi, 1961 MWR

NOAA Polar Satellite Series History

TIROS

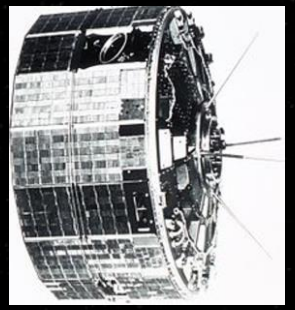
JPSS



TIROS 1-10
1960-1967

Two Camera System
(Visible)

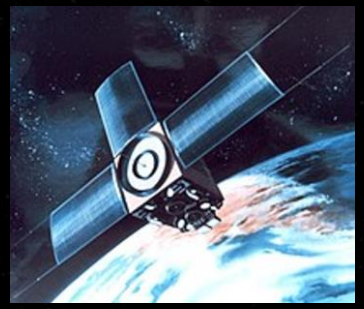
IR Hemispheric
Bolometers



ESSA 1-9
1966-1973

AVCS/APT

IR Flat Plate
Radiometers



ITOS-1, NOAA 1-5
1970-1979

VHRR
(2 Channels)

VHRR
(2 Channels)

VTPR, +

TIROS-N, NOAA-6-19
1978-Today

AVHRR
(4, 5, 6 Channels)

AVHRR
(4, 5, 6 Channels)

SNPP, NOAA-20
(JPSS-1)
2011-Today

VIIRS
(Vis, IR, DNB)

VIIRS
(Vis, IR, DNB)

CrIS,
ATMS, +

TIROS

Geostationary Chronology

GOES-R

ATS 1-3
SMS 1-2

1975

1980

1994

2006

2016

GOES 1-3
- NOAA's First GOES
- Spin-stabilized

GOES 4-7
- Vertical Profiling

GOES 8-12
- 3-axis stabilized
- Simultaneous imaging, sounding 100% of time

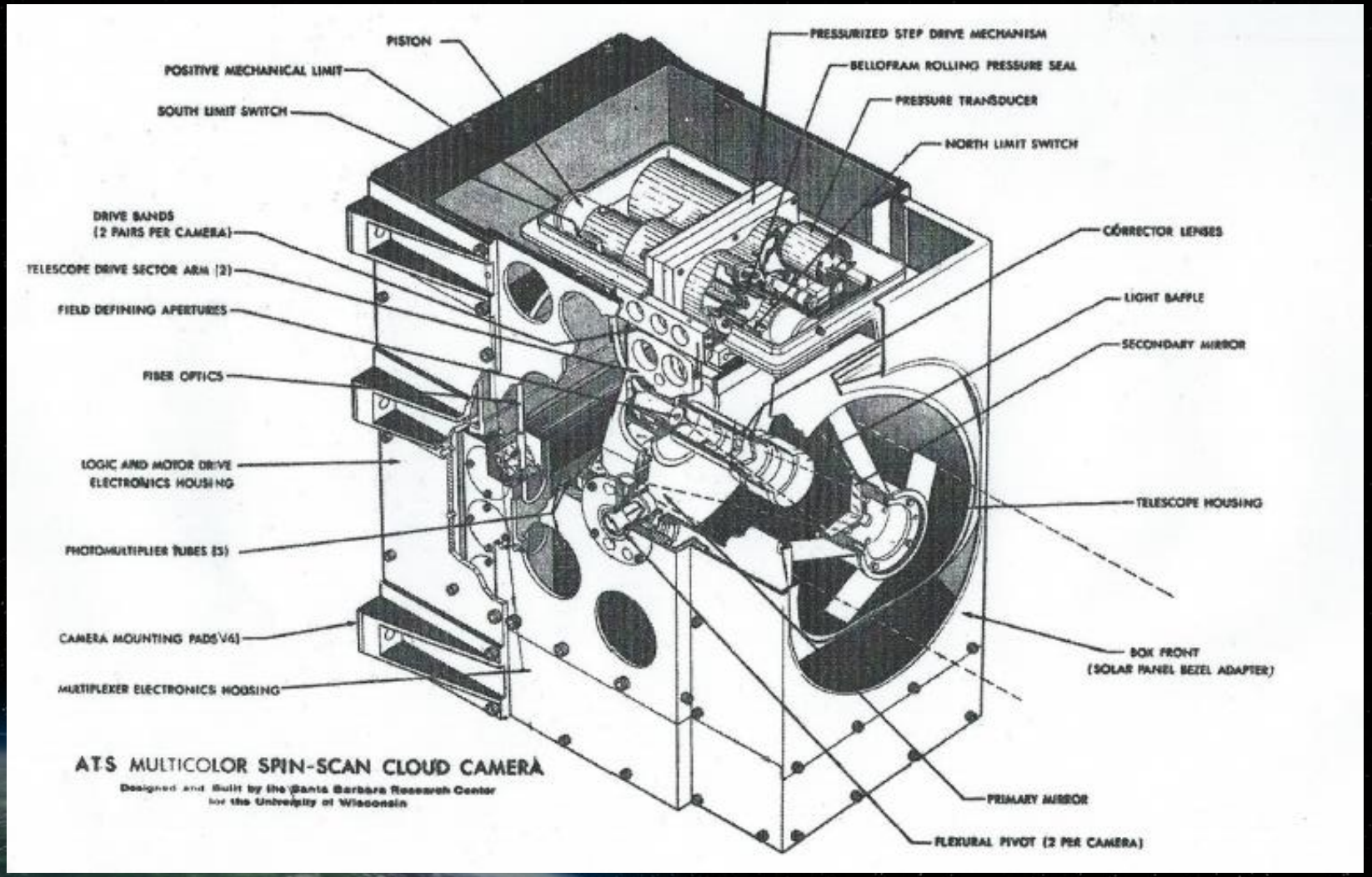
GOES 13,14,15
- Simultaneous, independent imaging, sounding

GOES-R Series
- Improved spectral, spatial and temporal resolution in imaging
- Lightning mapping
- Improved space weather monitoring

TIROS

ATS-3 Spin-Scan Imager (MSSCC)

GOES-R

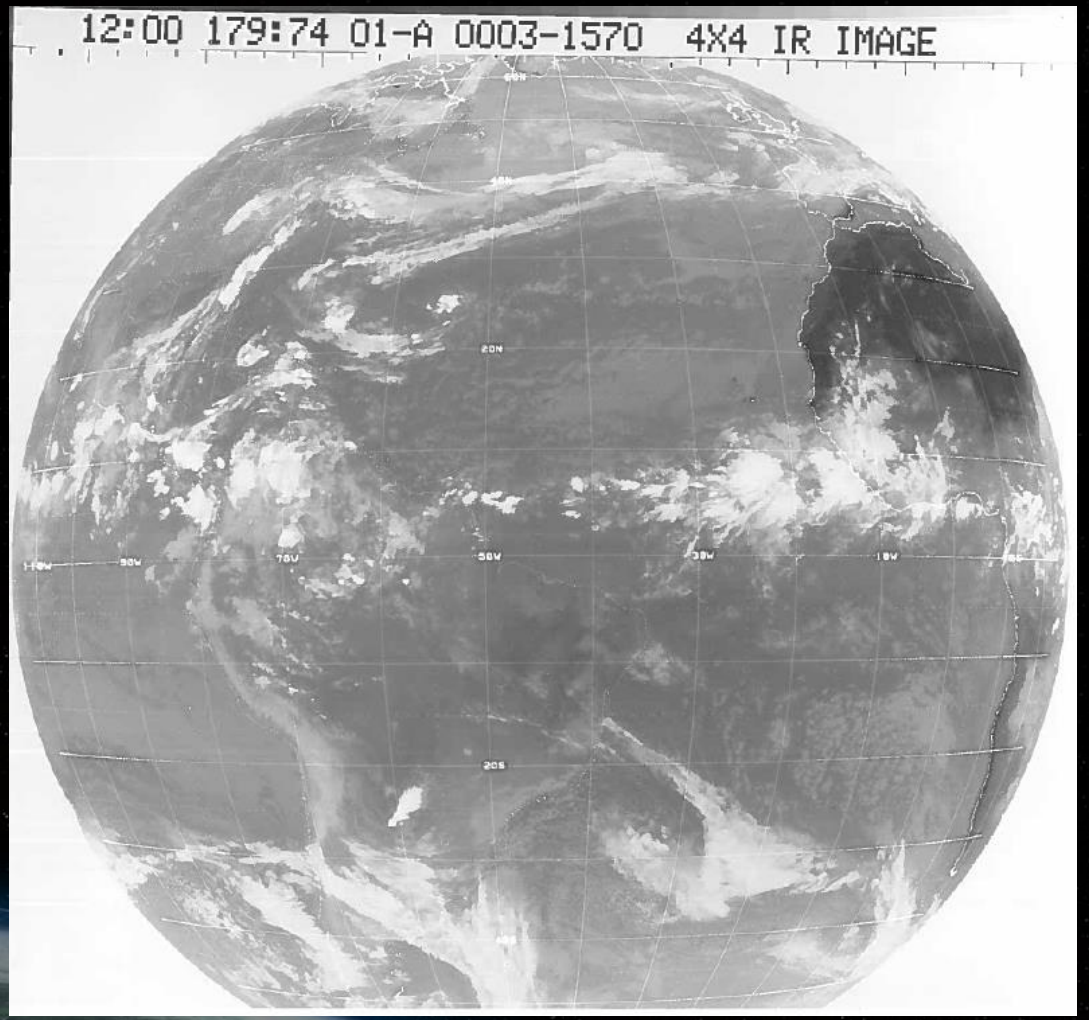


ATS-3 MSSCC: Multicolor Spin-Scan Cloudcover Camera

TIROS

SMS-1 – the First Infrared Image from a GEO

GOES-R



SMS-1 from NASA/NOAA. Launched in 1974.

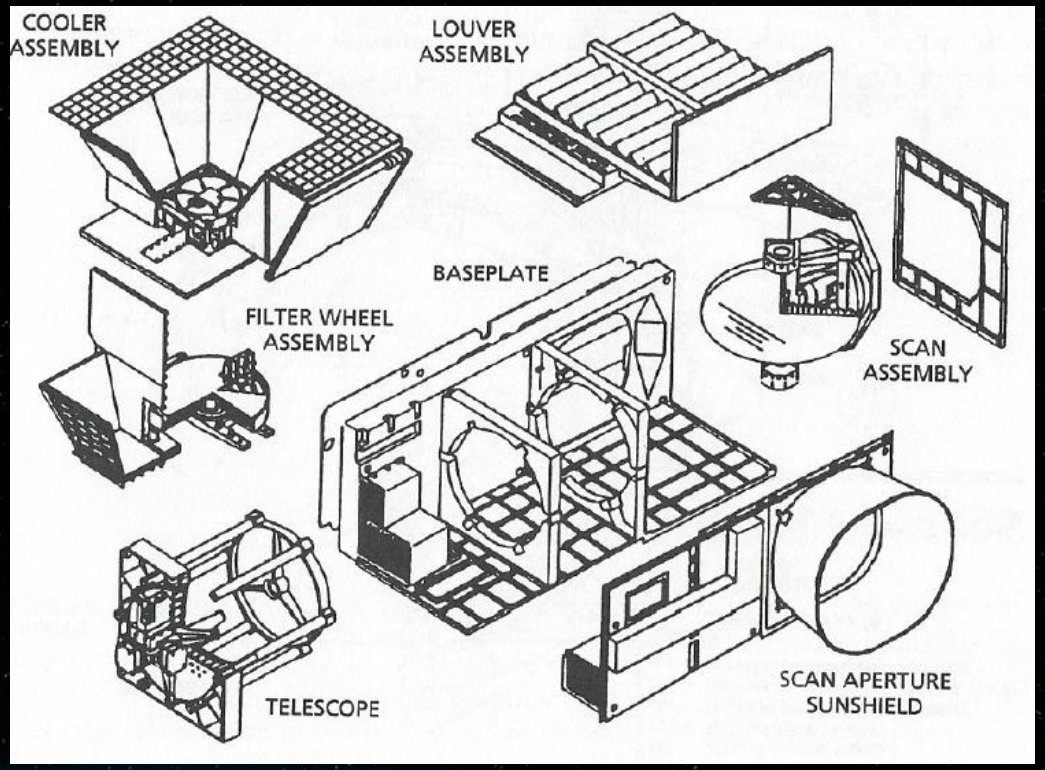
SSP 45°W

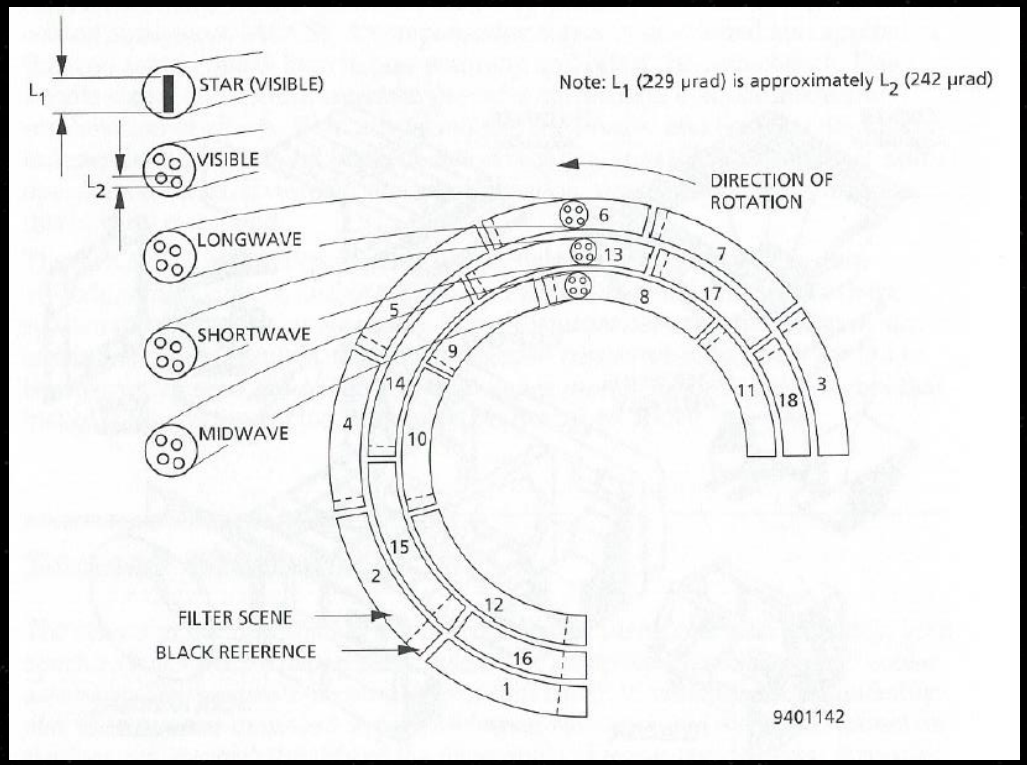
Sensor: VISSR

TIROS

GOES 8 – 15 Sounder Sensor Diagrams

GOES-R





GOES-8 Launch Apr 13, 1994)

I-M Data Book (42-45)

TIROS

GEO First Sensor Milestones

GOES-R

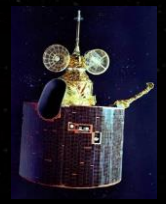
ATS-1	Dec 7, 1966	SSCC	1st Spin-scan Imager (Suomi)
ATS-3	Nov 5, 1967	MSSCC	1st Full Color Disc (RBG)
SMS-1	May 17, 1974	VISSR	1st Vis & IR Full disk images
GOES-4	Sep 9, 1980	VISSR/VAS	1st Geo Sounder (shared)
GOES-8	Apr 13, 1994	Imager/Sounder	1st Geo Sounder (simultaneous)
GOES-12	Jul 23, 2001	SXI	1st Solar X-ray imager
GOES-16	Nov 19, 2016	ABI, GLM	1st 16 Chan Imager & 1st Lightning

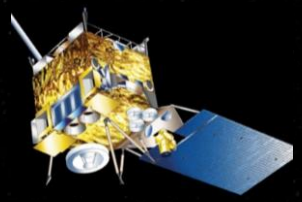
Sensor Acronyms

- SSCC Spin-Scan Cloudcover Camera
- MSSCC Multicolor Spin-Scan Cloudcover Camera
- VISSR Visible Spin-Scan Radiometer
- VAS VISSR Atmosphere Sounder
- SXI Solar X-ray Imager
- ABI Advanced Baseline Imager
- GLM Global Lightning Mapper

Geostationary Satellite Series History

TIROS





GOES-R

ATS 1- 3	SMS 1-2 GOES 1-3	GOES-4-7	GOES 8-12	GOES 13-15	GOES-16-U
1966-1975	1974-1981	1980-1996	1994-2013	2006-Today	2016-Today
1- SSCC* WEFAX 2- AVCS 3- MSSCC* WEFAX	S-1 VISSR S-2 VISSR G-1 VISSR SEM G-2 Same G-3 Same	VISSR (VAS) 12 Chan WEFAX SEM DCS	Imager (5 Chan) Sounder (19 Chan) DCS WEFAX SEM	Imager (5 Chan) Sounder (19 Chan) DCS WEFAX SEM XRS	ABI (16 Chan) GLM SEISS EXIS SUVI Magnetometer
ATS-3 1st Color Disk, ATS-3 BOMEX images, 1969	G-3 GARP images, 1979	GOES-G failed launch	G-12 1st SXI 1st 3 axis stability 1st flexible scans	G-13 transferring to USAF	

* from V. Suomi

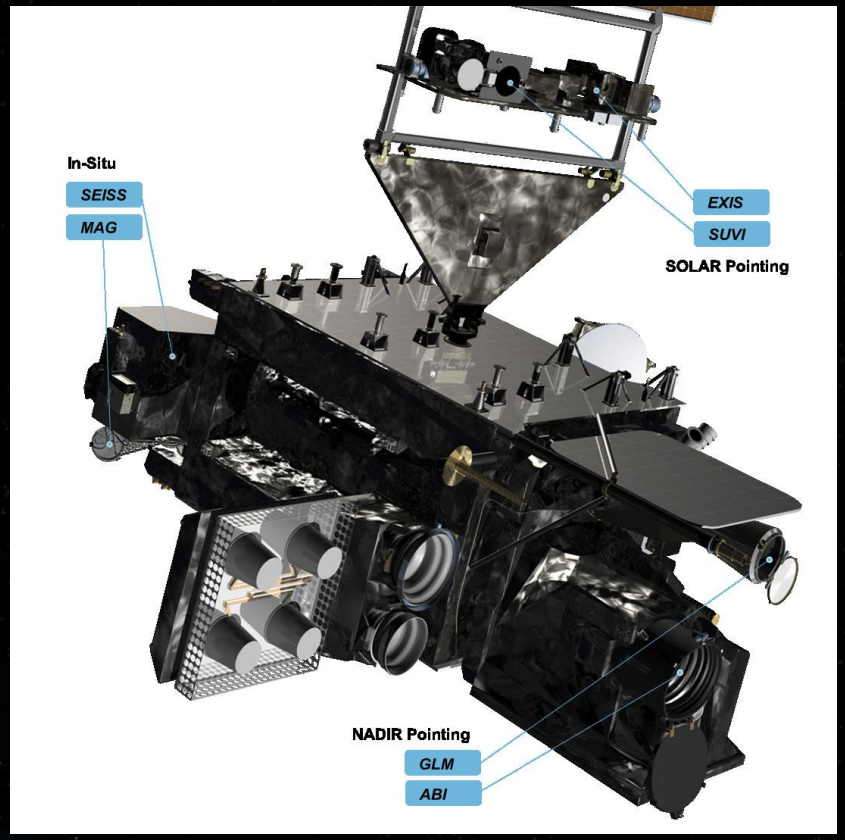
TIROS

GOES-R Instruments

GOES-R

<u>In-Situ</u>

SEISS	Space Environment In-Situ Suite
MAG	Magnetometer



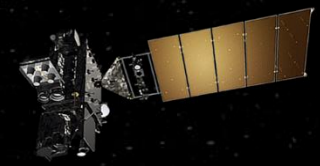
<u>SOLAR Pointing</u>

EXIS	Extreme Ultraviolet and X-ray Irradiance Sensors
SUVI	Solar Ultraviolet Imager

<u>NADIR Pointing</u>

GLM	Geostationary Lightning Mapper
ABI	Advanced Baseline Imager

TIROS



GOES-R

Summary

- Celebrate TIROS-1 the 1st Weather Satellite – basis leading to Polar and Geostationary Systems
- Lessons Learned
  - Multi-Organization Collaboration
  - Importance of IGY
- Early Visible and IR sensors for nephanalysis and synoptic awareness
- Growth: From Visible and IR sensors to scanners (SAP and OLS)

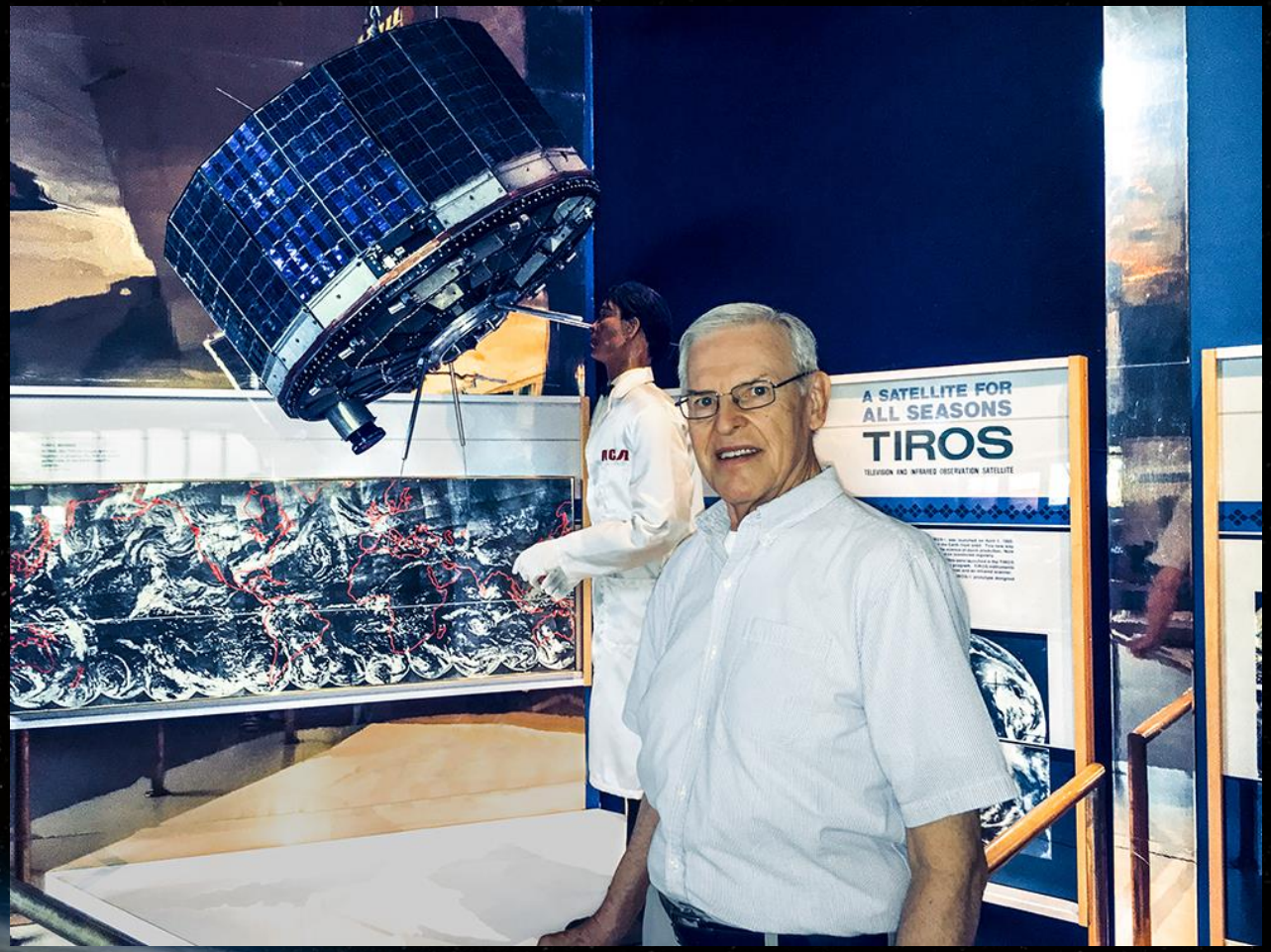
Questions?


TIROS


JPSS


GOES-R

Q: Where was this picture taken?



A: National Air and Space Museum, Washington, DC July 2018

TIROS

JPSS

Backup Charts

TI

AMS100
AMERICAN METEOROLOGICAL SOCIETY
100TH ANNUAL MEETING | BOSTON | 2020

For More Information

JPSS

- AMS 100th Annual Meeting –Boston Jan 12-17, 2020 (Boston)

Monday, January 13, 2020 02:00 PM - 04:00 PM

Boston Convention and Exhibition Center - 253B

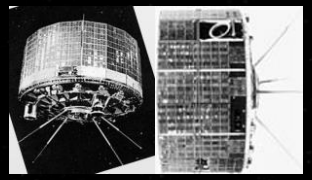
02:00 PM	16th Annual Symposium on New Generation Operational Environmental Satellite Systems **3.1A** TIROS Origins: How Military and Civilian Organizations Contributed to the First Weather Satellite System ***Angelina L. Callahan**, NRL, Washington, DC; and G. Dittberner and T. Vonder Haar*
02:15 PM	16th Annual Symposium on New Generation Operational Environmental Satellite Systems **3.2** *TIROS-1* Established the Foundation for Today's Remarkable JPSS and GOES-R Satellite Systems ***G. Dittberner**, CIRA, Springfield, VA; and T. Vonder Haar*
02:30 PM	16th Annual Symposium on New Generation Operational Environmental Satellite Systems **3.3A** Early Weather Satellite Observations Energized the History of Science Discoveries and Weather Forecasting ***Thomas Vonder Haar**, Colorado State Univ., Fort Collins, CO; and G. Dittberner*

TIROS

JPSS

DMSP Satellite Series History

F-19



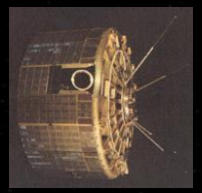
TIROS 1-10
1960-1967
(10 Sats)

1960-1967

2 Cameras

IR Hemispheric Bolometers
(4 Sats)

T-11 in Smithsonian Museum



DMSP
B1, B2, B3
(15 Sats)

1962-1966

1 Camera

IR – Flat Plate Radiometers
(5 Sats)

Cuba 1962

1st Tactical Sat
1965

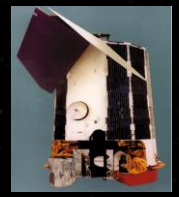
DMSP
4A/4B
(8 Sats)

1966-1969

2 Cameras

IR "C" System
Eight Crosstrack Radiometers

Last B4 – in Chicago Museum
(B4-4)



DMSP
5A/5B/ 5C
(11 Sats)

1970-1977

SAP*

HR, IR,
VHR,
WHR (IR)

HR able to control gain (thru Terminator)

DMSP
5D1/5 D2/5D3
(F-1 to F-19)

1976-Today

OLS

LS, TS, LF, TF
Smooth,
Fine

Nearly the Same Resolution

SNPP, JPSS
(NOAA-20)
(2 Sats to Date)

2011-Today

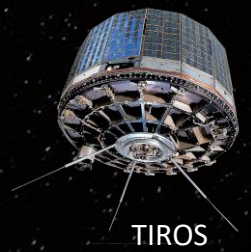
VIIRS

22 Channels
Day Night Band
(DNB)

Supplementary Sensors

* Sensor Aerospace Package

ATS-3 Provided Satellite data for BOMEX



TIROS

GOES-R

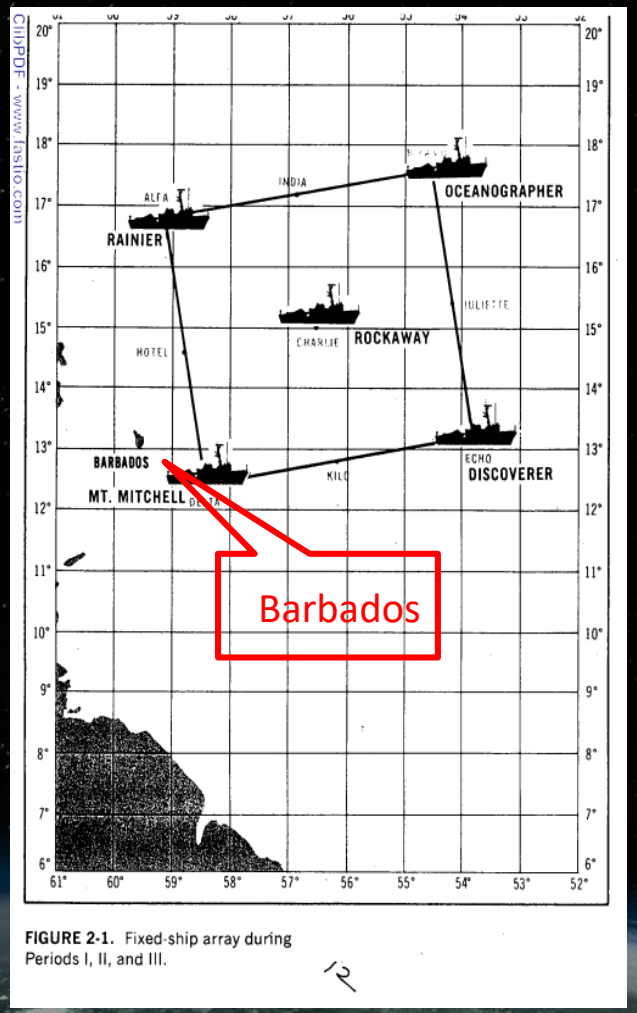
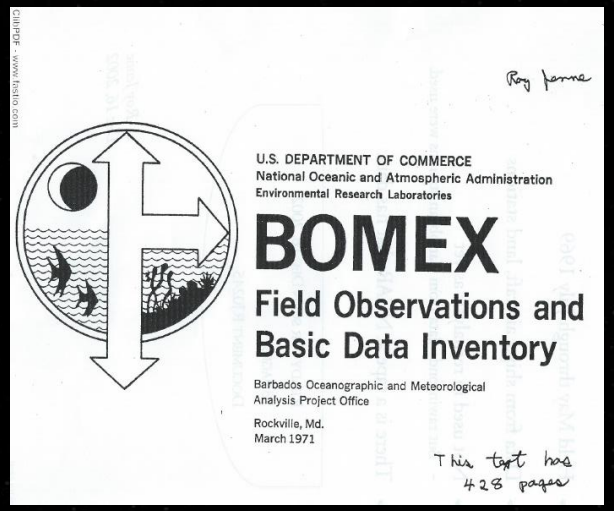


FIGURE 2-1. Fixed-ship array during Periods I, II, and III.



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

BOMEX

Field Observations and Basic Data Inventory

Barbados Oceanographic and Meteorological Analysis Project Office

Rockville, Md.
March 1971

This text has 428 pages

ATS-3 - the First Color disk (Menzel, 2001)

Barbados Oceanic and Meteorological Experiment (BOMEX)
- Field data gathering ran from May through Aug of 1969
- A 500 km square east of Barbados

ATS-3, plus ESSA-3 and Nimbus-3, were formidable satellite data sources for BOMEX.

Separate teams ran coordinating experiments selecting data such as collecting research aircraft to measure solar radiation with and without clouds. (from Vonder Haar)