



History of Remote Sensing

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In this lecture:

Meteorological satellites: Features

History of meteorological satellites

Current state of the meteorological satellite system

A satellite image of Earth from space, showing a large, well-defined cyclone or hurricane over the ocean. The Earth's curvature is visible at the top. A semi-transparent grey text box is overlaid on the lower half of the image.

Meteorological satellites

Are primarily intended to provide imagery and environmental data for

- Weather analysis**
- Weather prediction**
- Climate change studies**

Meteorological Satellites Should Provide

- Global or at least continental-scale coverage
 - Weather processes have a typical size of several thousand km
- Continuous coverage
 - Observations should be available everywhere, important for model applications
- High temporal frequency, near-real time availability
 - Critical when monitoring fast-developing atmospheric processes
 - Needed to issue timely warnings



Interest to Meteorological Satellites Data, Why ?

- Global view at the world's weather processes
- Many other practical applications besides weather
- Imagery available from multiple sources
- Imagery is easy to understand
- Data are free (mostly)

But you need to know what to get, where, and how to process.



A Little of History....

1950s – 1960s:

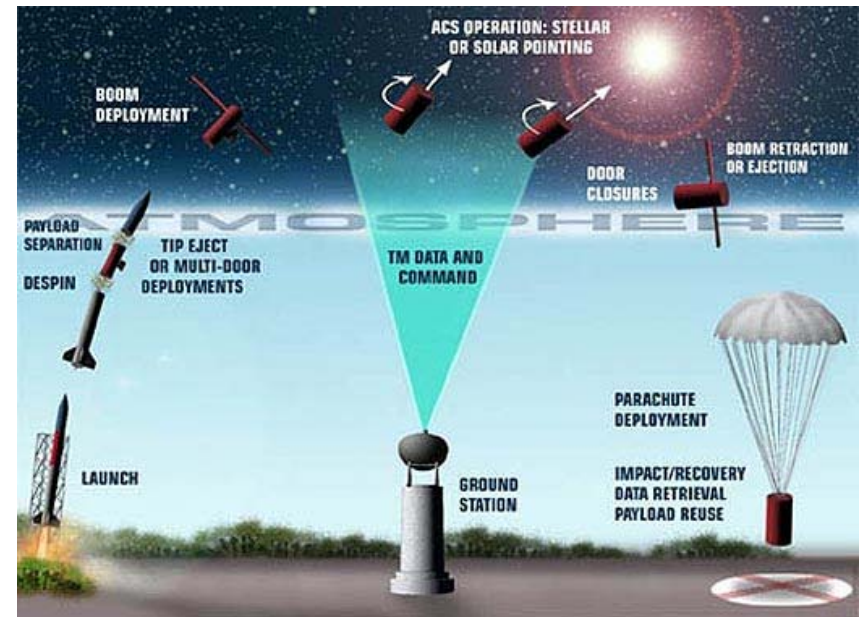
Beginning of satellite era

First weather satellites

US and USSR compete

1950s: Sounding rockets

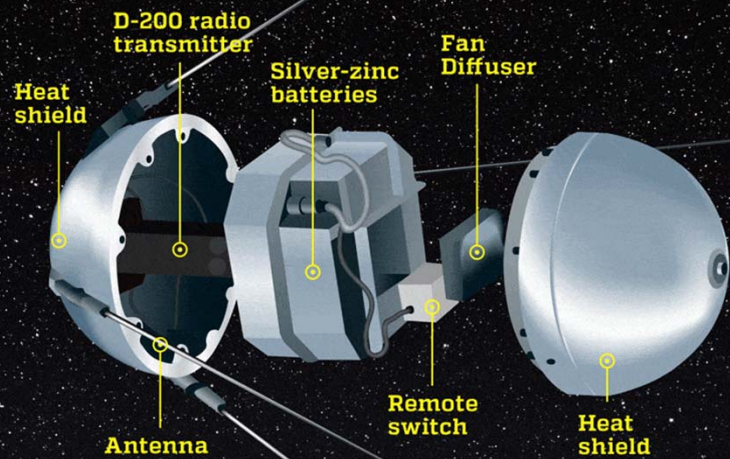
- Launched in 1957
- Contained internal temperature and pressure sensors
- Stimulated Space Race



Pictures taken with cameras onboard sounding rockets were the first images of the Earth received from space

1957: Sputnik-1

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- Contained internal temperature and pressure sensors
- Stimulated Space Race



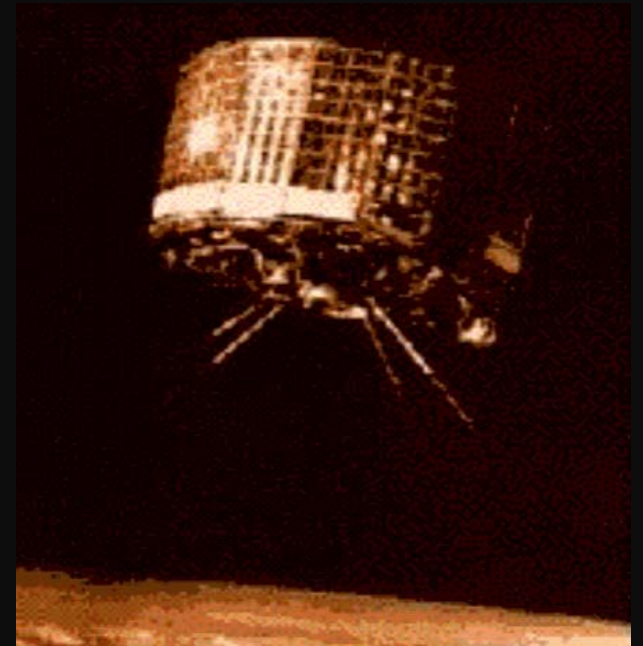
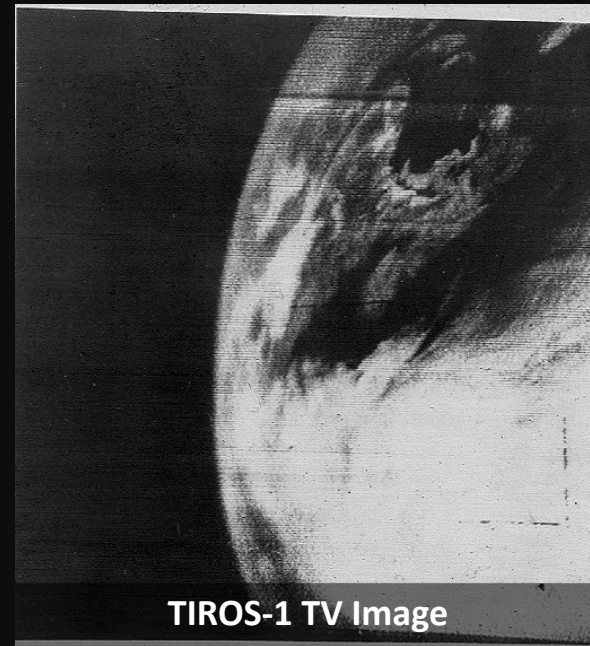
1959: First meteorological experiment

- The United States' earliest attempts to see Earth's weather from space began in the 1950s.
- Several experimental programs were developed and, by 1959, the first successful meteorological experiment made its way to space onboard the Explorer VII satellite.
- The satellite weighed 41.5 kg, was 75 cm high and 75 cm wide. Powered by solar cells, it also carried 15 nickel-cadmium batteries around its equator.
- It transmitted data continuously through to February 1961 and went dead on August 24, 1961.
- **It is still in orbit.**

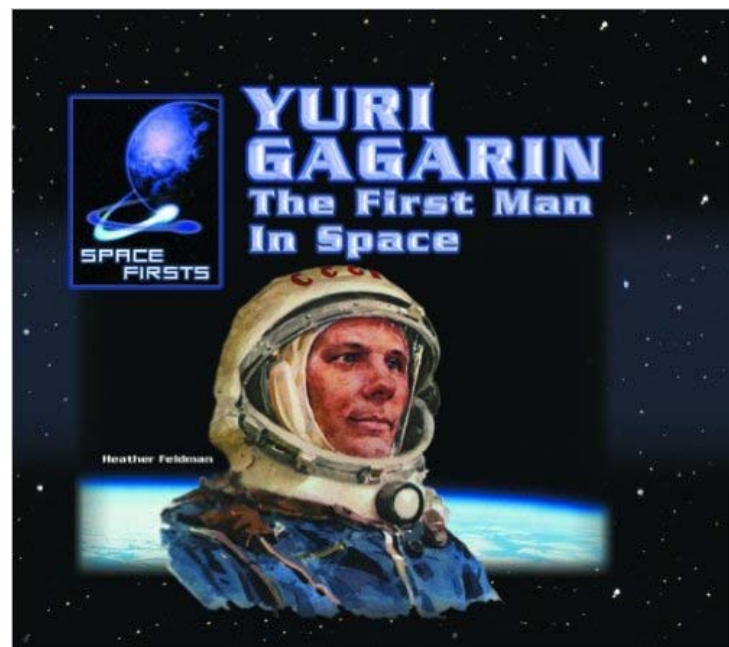


1960: First Weather Satellite TIROS-1

- **TIROS** Program (Television Infrared Observation Satellite):
- NASA early program to determine if satellites could be used to study the Earth.
- Weighing approximately 270 pounds and carrying two TV cameras and two video recorders, the satellite provided weather forecasters their first ever view of cloud formations as they developed around the globe.
- Operated 78 days



1961: First Man in Space



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The Huntsville Times

Where Progress...



Covers The Valley!

Man Enters Space

'So Close, Yet So Far,' Sighs Cape U.S. Had Hoped For Own Launch

SEVERAL Fla. (AP) — The Redstone rocket the United States had hoped would launch the first man into space stands on a launching pad in Florida but the Union beat the firing date by at least 15 minutes.

"So far," commented a technician who works on the Redstone to send one of America's astronauts on a short sub-orbital flight, hopefully late this month or early in May.

"If we hadn't had these troubles last fall and on the Cape and Latta (see there this year), we might have made it," the technician said.



Soviet Officer Orbits Globe In 5-Ton Ship Maximum Height Reached Reported As 188 Miles

MOSCOW (AP)—A Soviet astronaut has orbited the globe for more than an hour and returned safely to receive the plaudits of scientists and political leaders alike. Soviet announcement of the feat brought praise from President Kennedy and U. S. space experts left behind in the contest to put the first man into successful space flight.

By the Soviet account, Maj. Yuri Alekseyevich Gagarin, rode a five-ton spaceship once around the earth in an orbit taking an hour and 20 minutes. He was in the air a total of an hour and 48 minutes.

The whole sequence of events and the announcements relating to it raised a number of questions. The Soviet announcement said the flight took place today.

VON BRAUN'S REACTION:

'To Keep Up, U. S. A. Must Run Like Hell'



1965: First Global View with TIROS-9

- **450 photo images were combined to** provide a complete view of the worlds weather
- Infrared imagery has become routinely available.
- This made possible getting pictures of clouds day and night

1966-1967: First Image from Geostationary Satellite

36,000 km above the ground

Orbital speed = Earth rotation speed

Satellite remains over the same spot

- 1966 First full disk image of the Earth (ATS-1)
- 1967 First color image of the Earth with red, blue and green cameras (ATS-3)



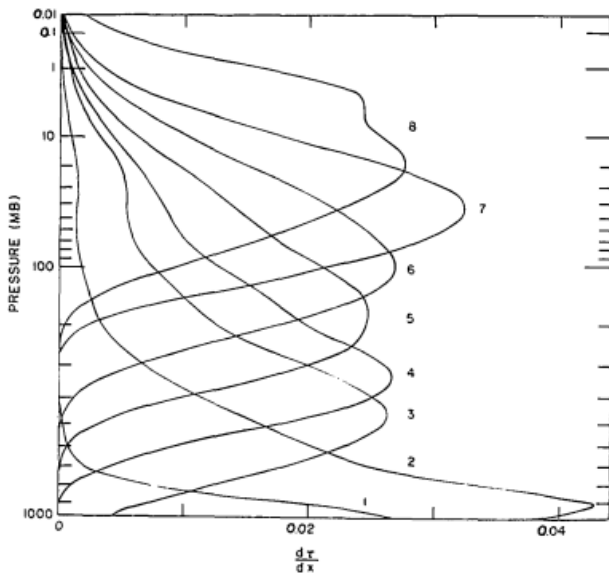
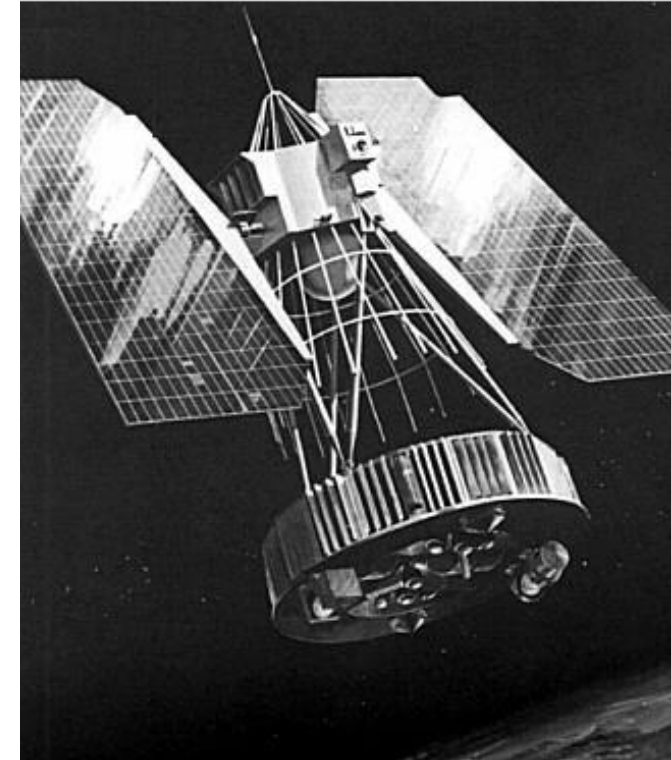
First color image of ATS-3

1969: First Sounding Instrument

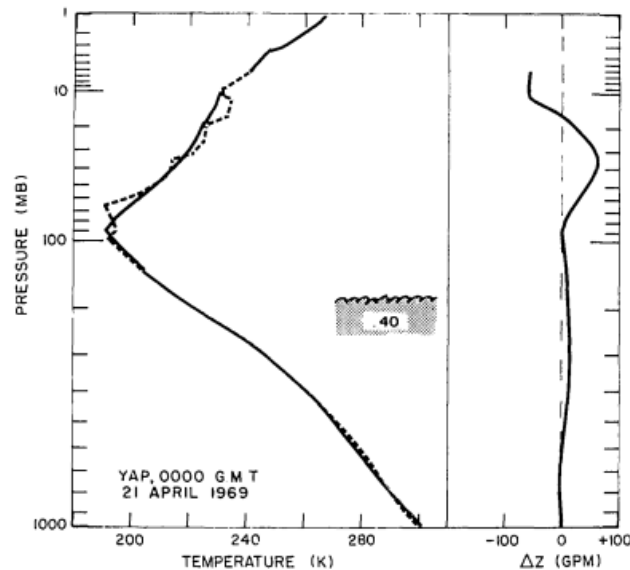
Infra-Red Spectrometer (SIRS) onboard
Nimbus-3 (NASA, USA)

Observations in several infrared bands

Vertical temperature profiles derived



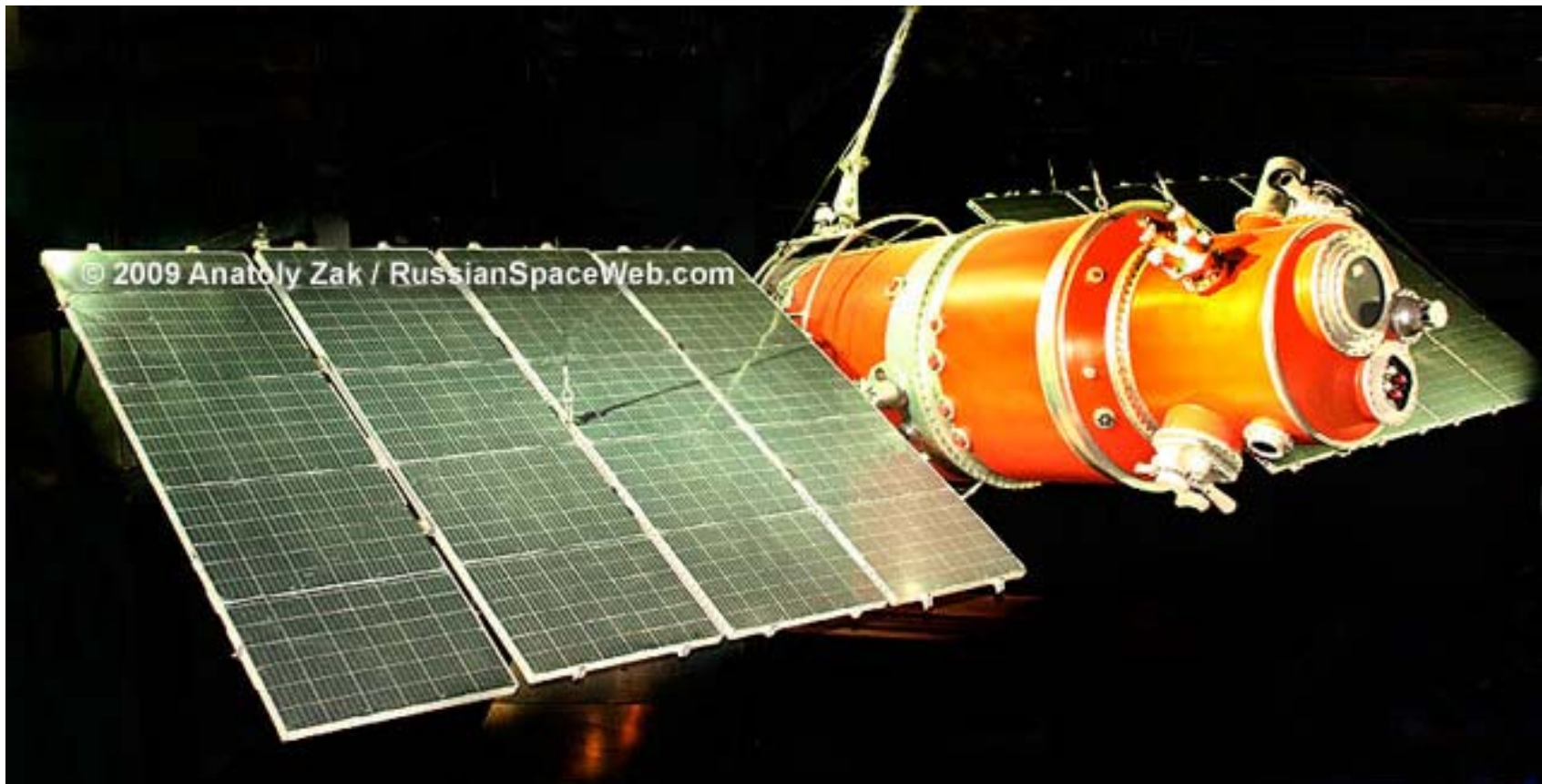
Maximum sensitivity of SIRS
spectral bands



Example of derived
temperature profile

1969: Russia Launches Meteor Program

- First Russian meteorological satellite in space
- Preceded by three years of flight testing of experimental satellites
- Provides gray-scale pictures of clouds



1970s:

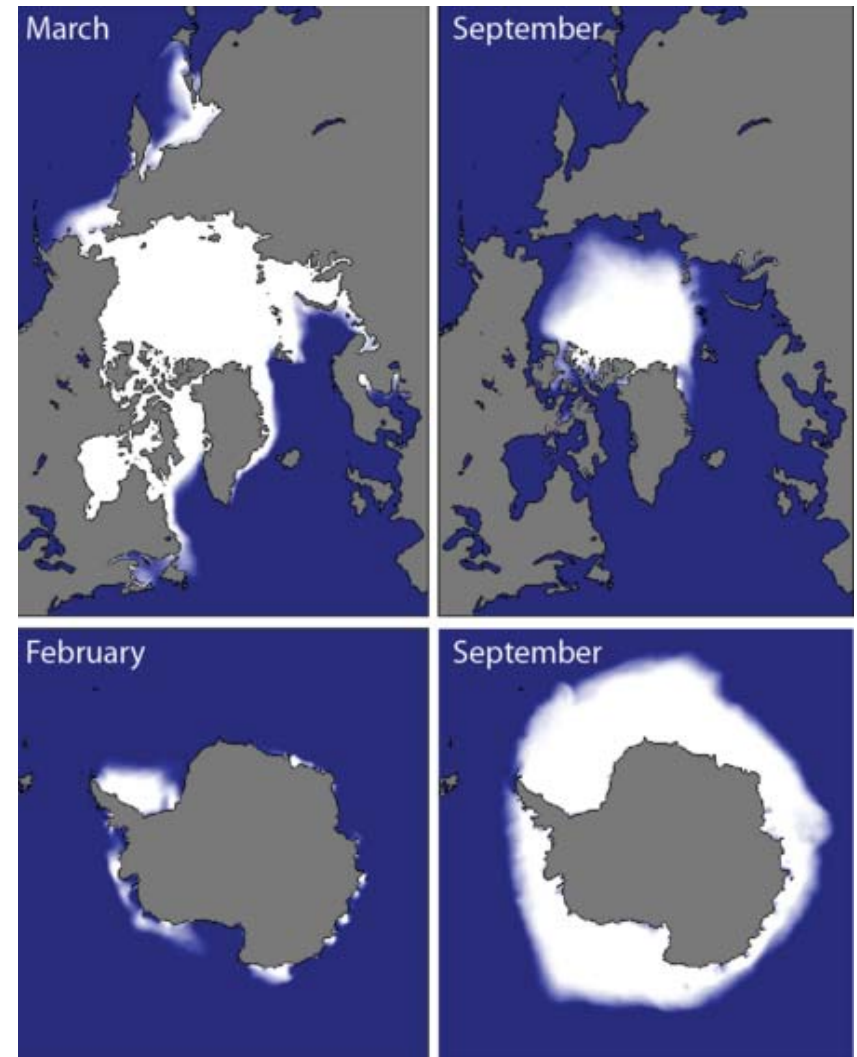
- **Operational use of satellite images**
- **New Sensors**
- **Europe and Japan join the “club”**

1972: Scanning radiometers replace video cameras (VHRR onboard NOAA-2)

- Equivalent of moving from film to digital photography
- Era of quantitative satellite observations begins

1972-1976: First microwave imaging instruments on board

- Microwave sensors can “see” through clouds: all-weather applications
- Proved very useful for ice mapping in the polar regions
- Can be used to derive temperature profile in the atmosphere
- SMMR onboard Nimbus-7: 1976-1989

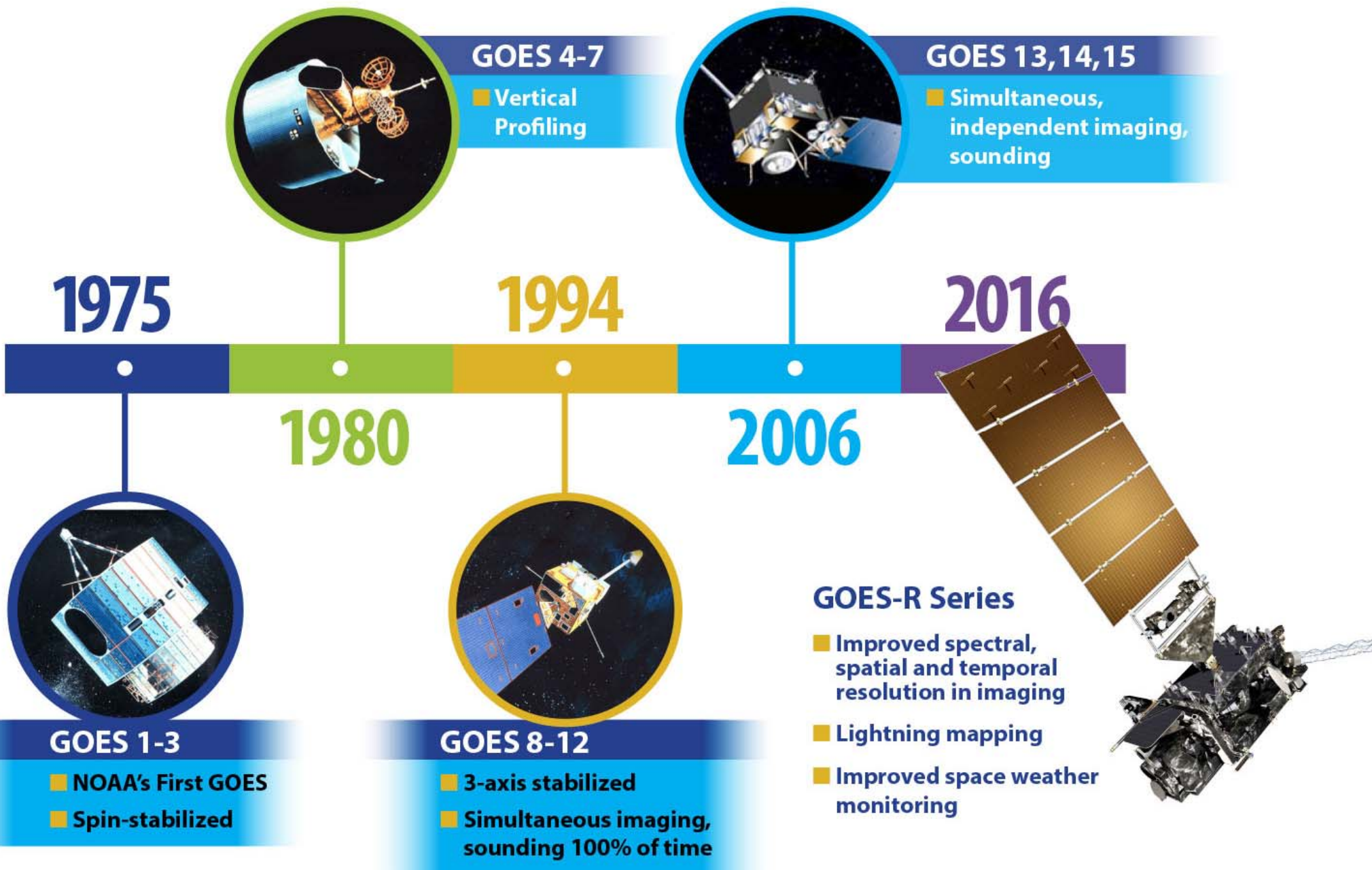


1975: US launches GOES satellite series

- GOES: Geostationary Operational Environmental Satellite
- Continuous observations of the Western Hemisphere
- 1 hour interval
- 5 spectral bands
- Found very useful for tracking hurricanes and tropical storms in Atlantic and Pacific Oceans



GOES-1 was launched 40 years ago today, on October 16, 1975



1977: Europe and Japan launch weather satellites



METEOSAT-1

FIRST IMAGE: 9 DEC 1977
COPYRIGHT ESA



Geostationary meteorological satellites launched over Europe (Meteosat-1) and over Far East (GMS)

Also in
1970s:
Satellite
images
used in TV
weather
forecasts



1980s :

Multiple sensors on board
Broader application of data
India and China get in

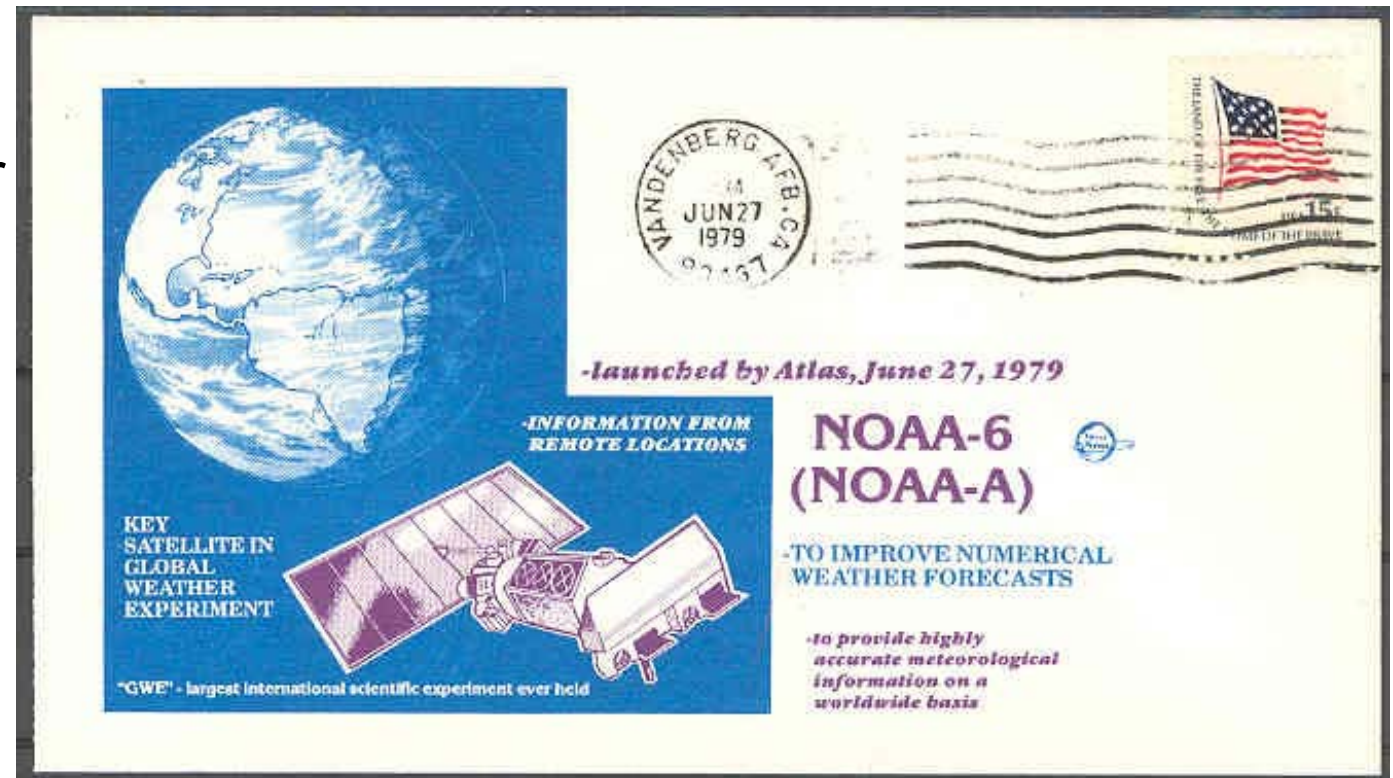
1979: NOAA-6: first satellite with multiple weather monitoring instruments onboard

Visible and infrared Imager

Infrared Sounder:

Microwave Sounder

Stratospheric Sounder



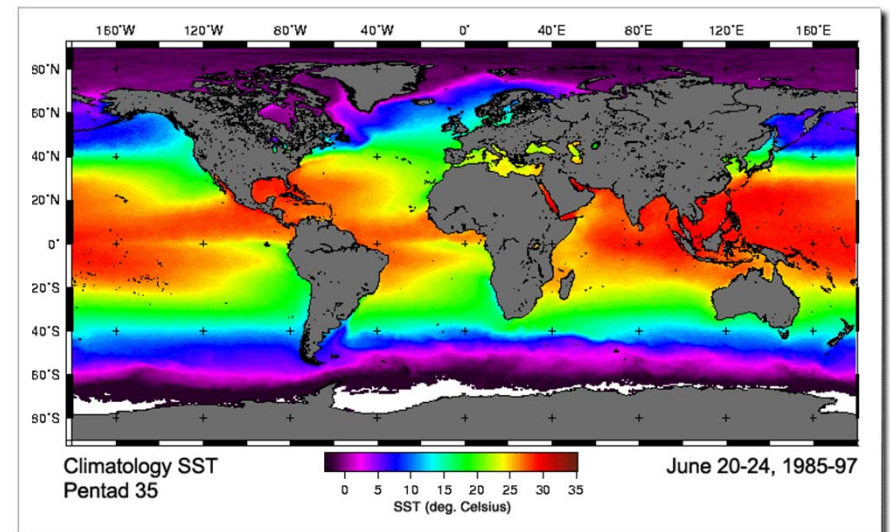
Observations in both visible, infrared and microwave bands allow for all-weather monitoring of atmosphere and land surface.

1981 - : AVHRR

AVHRR/2: Advanced Very High-Resolution Radiometer

- Deployed onboard NOAA (USA) and METOP (EUMETSAT)
- Twice a day (day and night) global observations
- 1 km spatial resolution (local), 4 km global
- Five spectral bands, visible to infrared
 - Snow, ice, surface temperature, vegetation , fires, oceans
- Used in climate studies

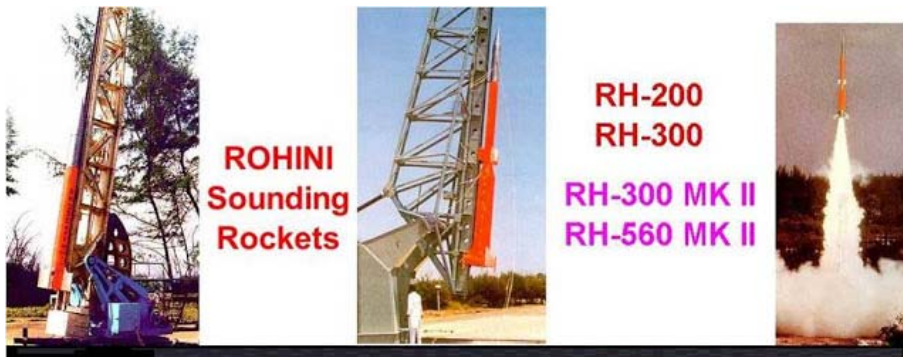
**Local data can be received
anywhere in the world**



AVHRR sensors continue to operate: Over 30 years of data !

India

- 1982: INSAT
- India's first successfully launched communication satellite
- Meteorological applications
- Geostationary orbit, at 74° E
- Imagery in visible and infrared



The first sounding rocket was launched 1967



1988: FY1 (China)

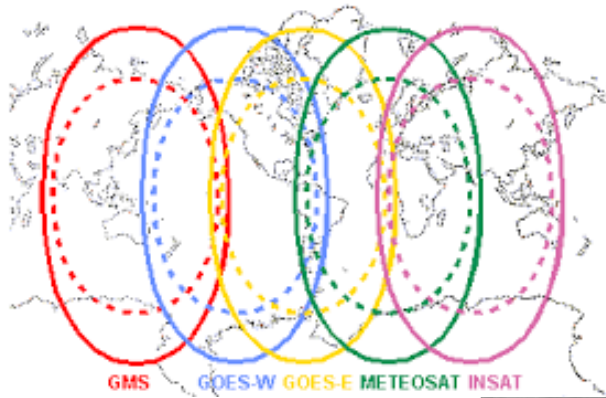
China's first successfully launched meteorological satellite

Polar-orbiting satellite

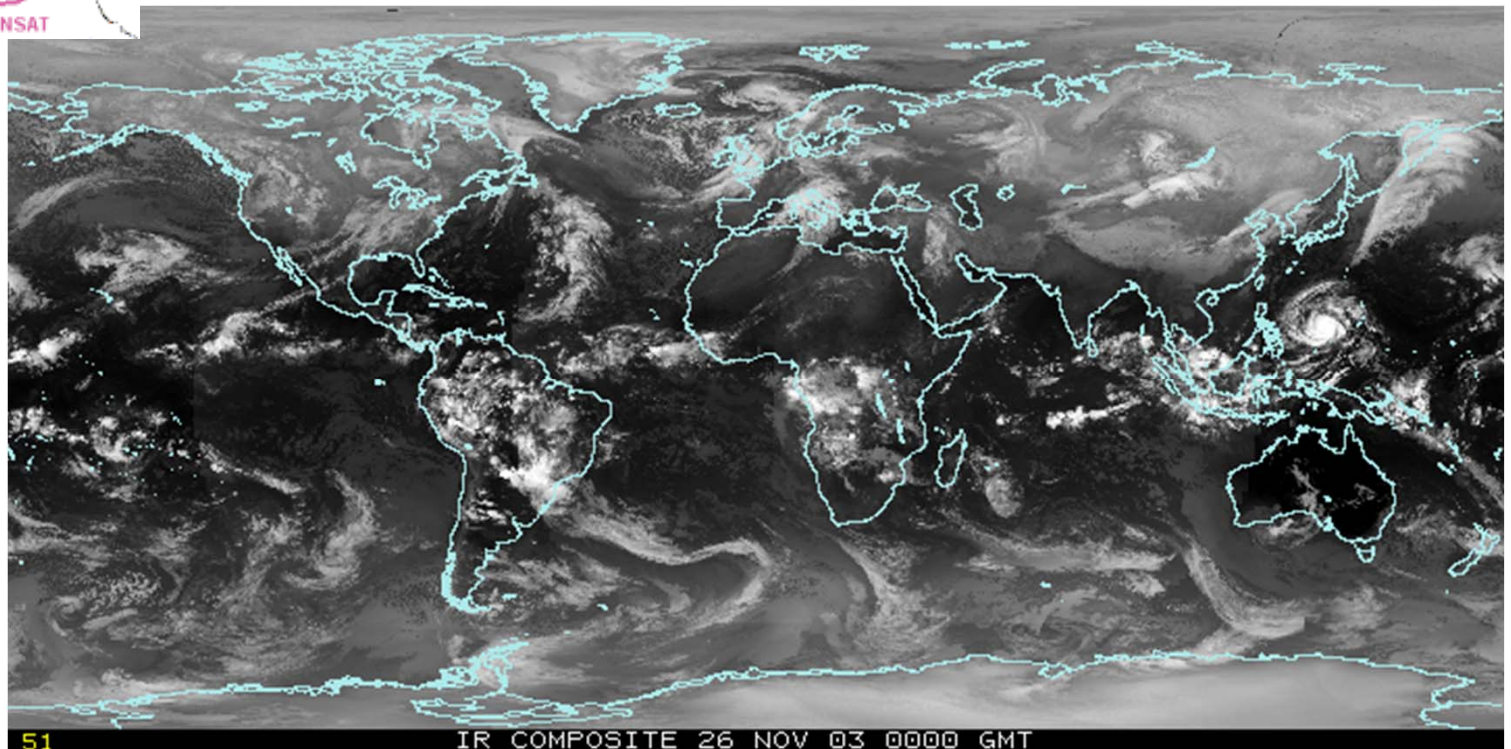
AVHRR-type 5-band scanning radiometer



1990s: Global coverage with geostationary satellite data



With five geostationary satellites of USA, Europe, India and Japan full global image is available every three hours



2000s: MODIS Era



Moderate Resolution Imaging Spectroradiometer (**MODIS**) , NASA

- Launched onboard Terra (1999) and Aqua (2002) satellites.
- 36 spectral bands covering visible to infrared spectral range
- Up to 250 m spatial resolution, twice a day global observations
- Over 30 land, atmosphere and ocean parameters derived routinely
- Both instruments are still operational (~15 year of data)

2010s: SNPP, VIIRS

SNPP: Suomi National Polar-orbiting Partnership satellite (launched in 2011)

- NOAA and NASA joint program
- Multiple remote sensing instruments including 22-bands VIIRS

VIIRS : Visible and Infrared Imaging Radiometer Suite,

- 22 bands visible to infrared, including day and night band
- 375 m spatial resolution, global twice a day observations
- Over 40 environmental products derived operationally



2010s: Geostationary Satellite System: Second Generation Finalized

Meteosat Second Generation (MSG), Eumetsat, (2002)

Himawari-8, Japan (2014)

GOES-R, USA (2016)

Constitute the second generation system of geostationary satellites

- Full disk images every 15 minutes (up to 1 min with GOES-R)
- 1-4 km spatial resolution.
- 12-14 spectral bands, visible to infrared.
- Multiple environmental product derived routinely

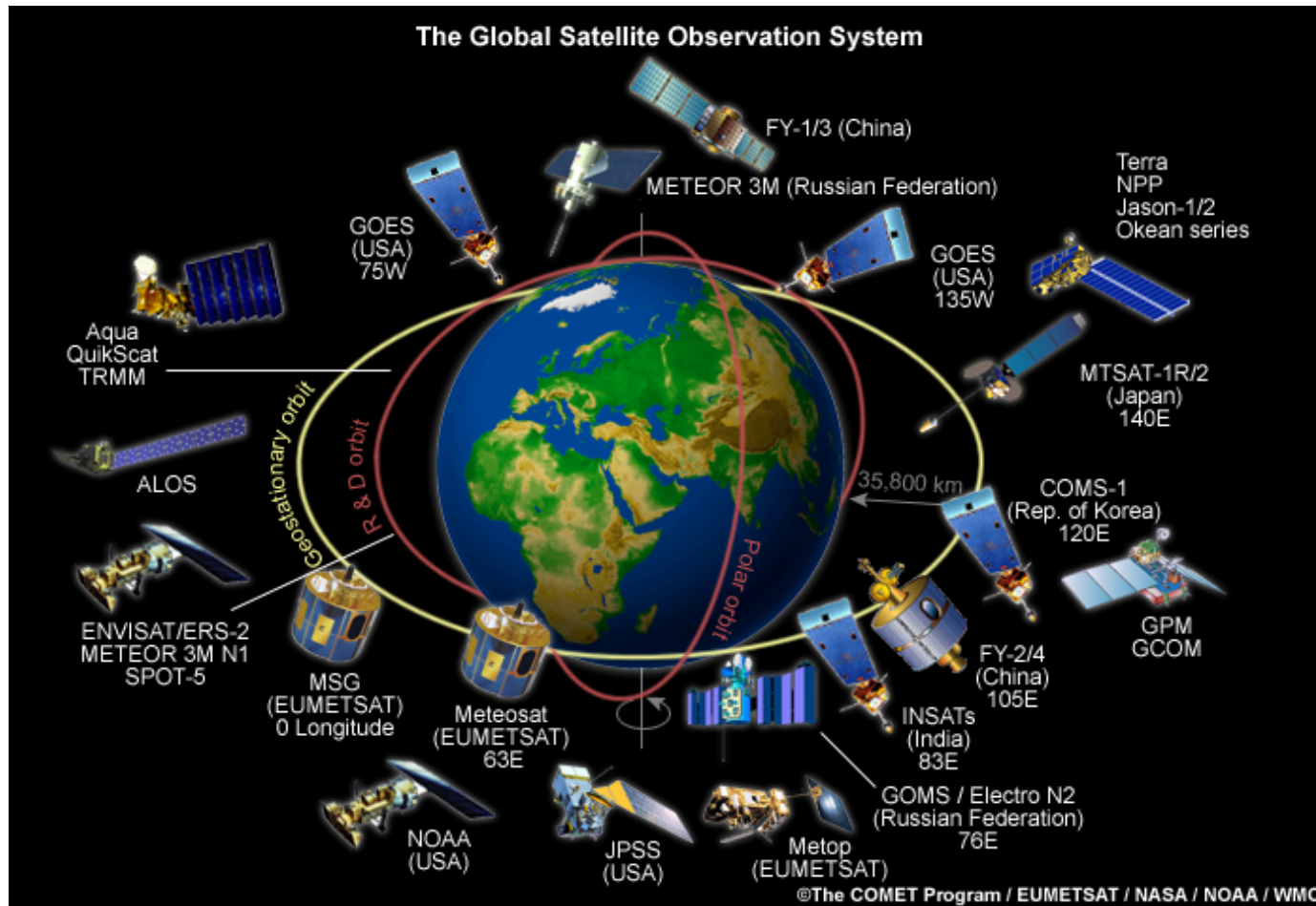
2010: South Korea's Weather satellite

COMMS – geostationary weather and communication satellite

- Images in 5 bands up to every 8 min over South Korea
- Early detection of severe phenomena
- Monitoring of climate change and atmospheric environment



Current weather satellite observing system



- 7-8 geostationary satellites
- Over 20 operational polar orbiting satellites
- Data and many derived products are available for free

The system is the result of cooperative efforts of multiple nations

SUMMARY

- Meteorological satellites have been serving people for more than 50 years
- Observations are performed from polar and geostationary orbits
- Over time instrumentation on weather satellites has undergone gradual improvement
- Capabilities of current satellites allow to extend their application far beyond weather
- Many countries contribute to the global system of meteorological satellites and observations by launching satellites and developing instrumentation

Reading

- **Remote Sensing Applications with Meteorological Satellites** by W. Paul Menzel,
<https://cimss.ssec.wisc.edu/rss/benevento/source/AppMetSat06.pdf>,
Chapter 1.