Dr. A.K Mitra

The original distribution of satellite as agreed by CGMS (Coordination group of Meteorological satellite.

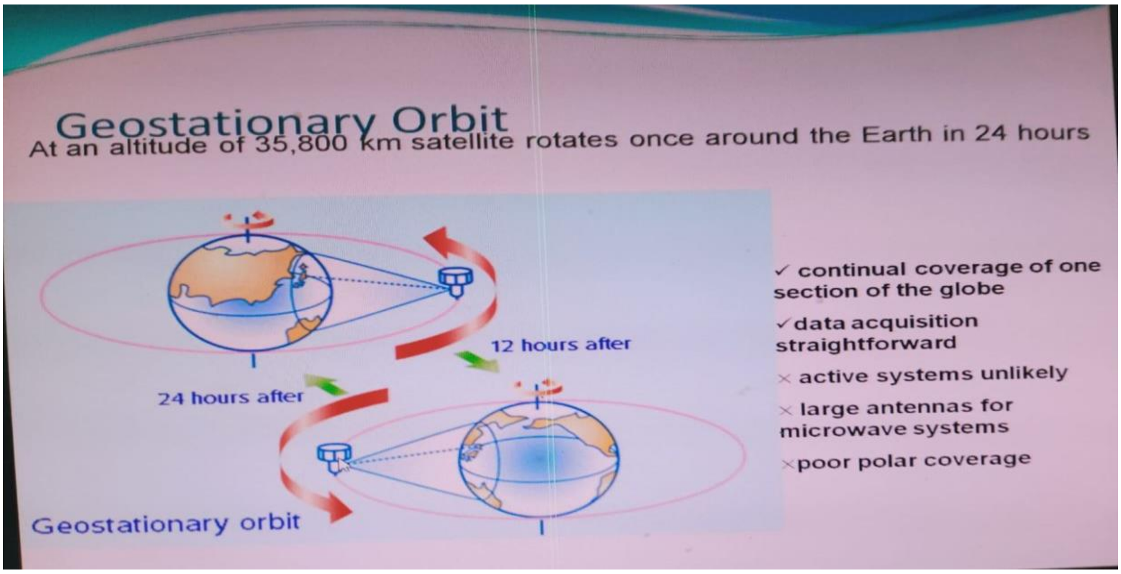
The space based global observing system:-

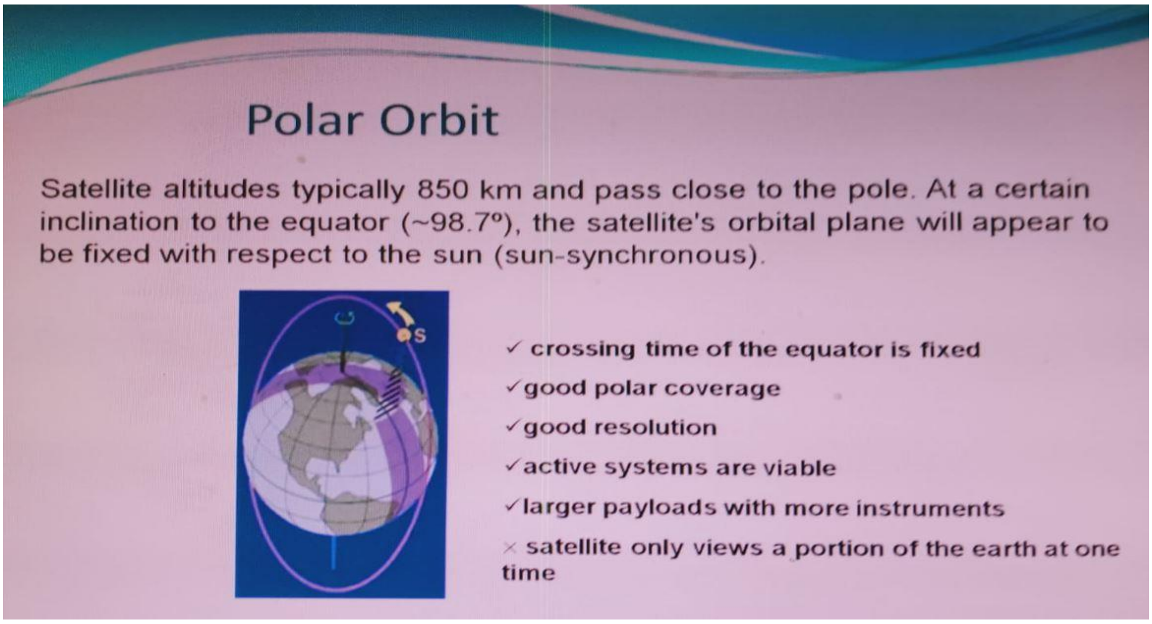
The space based sub- system of the WMO Global observing system includes three components :-

Operational Geostationary (Geo Satellite) (25 total : 19 operational, 3 stand by one commissioning, 2 warning

Operational Low earth orbit (LEO) satellite(17 total:13+ operational 7+ warning, 1 commissioning)

Environmental research & development(R & D) 55+ total, currently)





Geostationary satellite= 35,800 km altitude

Sounding of temperature and humidity

- Which satellites/instruments do we use?
- What information is available in microwave data?
- What can we gain from the new generation of infra-red instruments?
- Radio occultation

Why Use Microwave Frequencies?

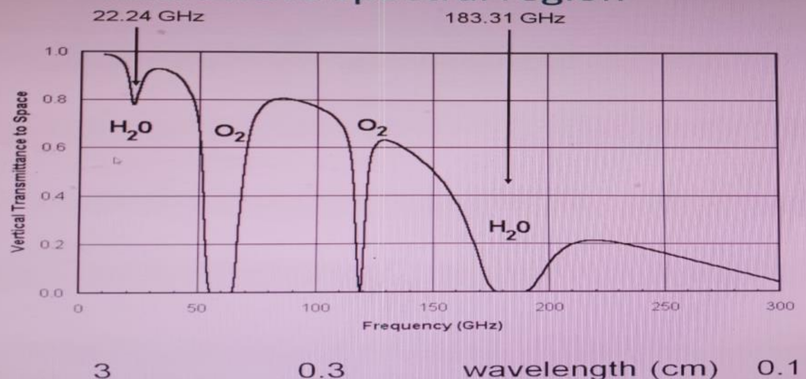
- Frequency range of 20 – 200 GHz (1cm – 1mm)
- Effect of clouds in field of view can generally be neglected
- Main absorbers are oxygen and water
- Rain in the field of view causes scattering and absorption
  - Data screening required
- More data usage:

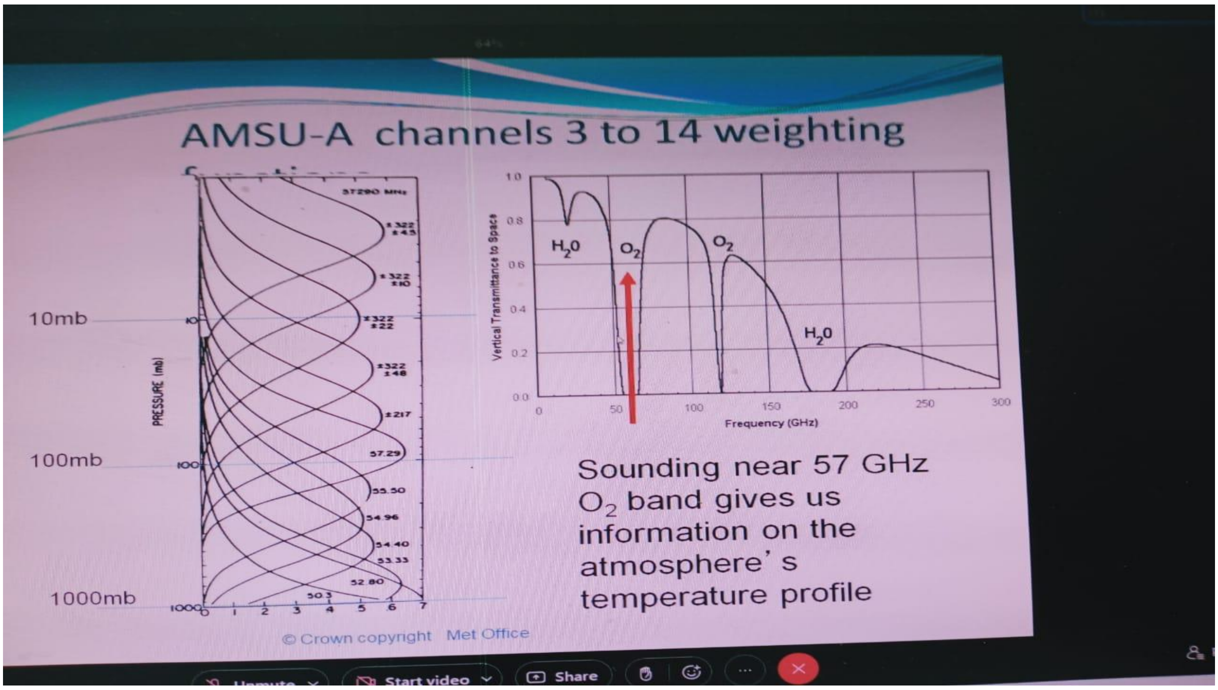
  Infra-red: cloud-free cases ~20% data

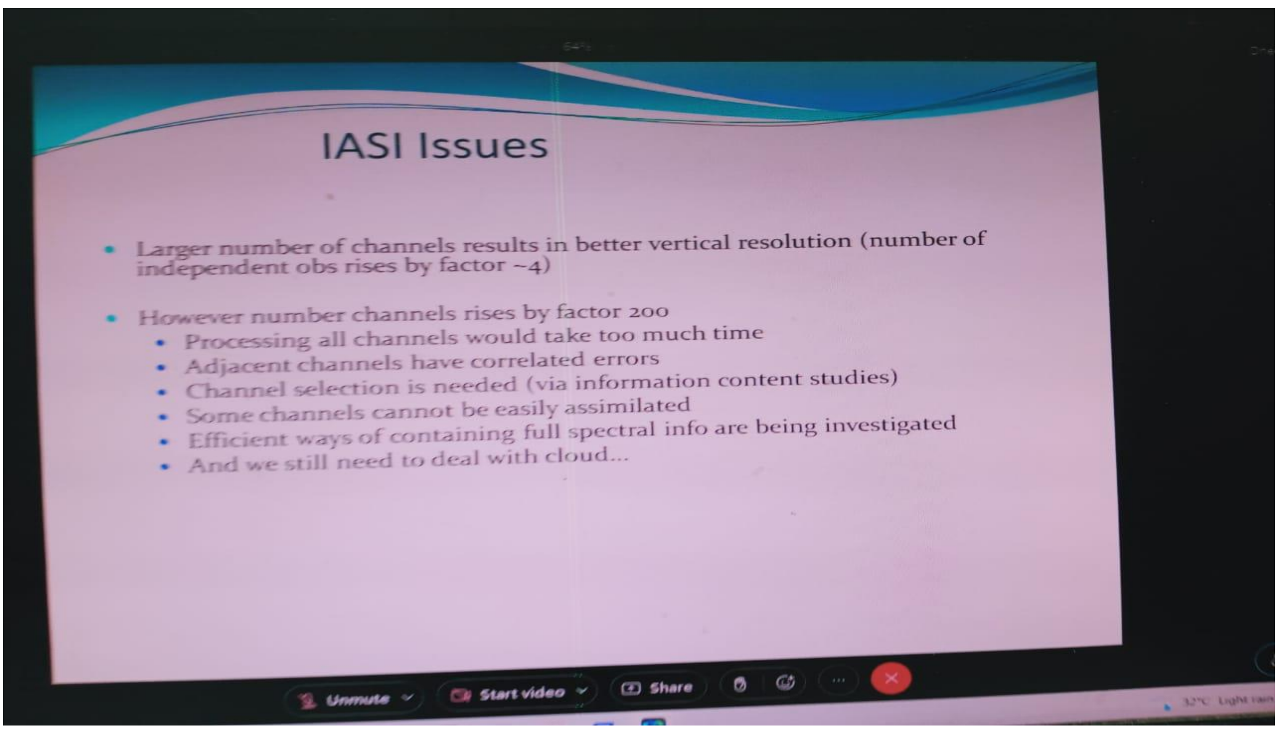
  Microwave: use ~90% data

Main microwave sounding instrument is *AMSU (Advanced Microwave Sounding Unit)*, a 20 Channel radiometer on the NOAA and MetOp satellite series

Key absorbing gases in the microwave spectral region




AMSU-A channels 3 to 14 weighting functions
10mb
100mb
1000mb
PRESSURE (mb)
57290 MHz
±322 ±4.5
±322 ±10
±322 ±22
±322 ±48
±217
57.29
55.50
54.96
54.40
53.33
52.80
50.3
Vertical Transmittance to Space
H_2O
O_2
O_2
H_2O
Frequency (GHz)
Sounding near 57 GHz
O_2 band gives us
information on the
atmosphere's
temperature profile
© Crown copyright Met Office

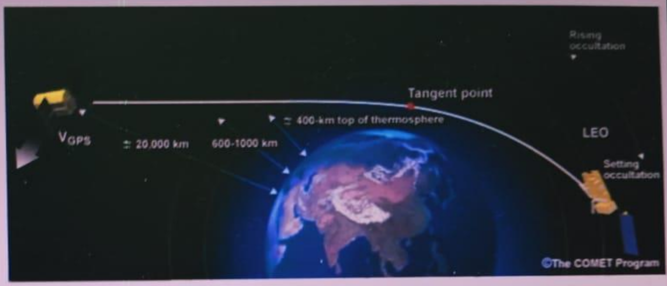

IASI Issues
Larger number of channels results in better vertical resolution (number of independent obs rises by factor ~4)
However number channels rises by factor 200
Processing all channels would take too much time
Adjacent channels have correlated errors
Channel selection is needed (via information content studies)
Some channels cannot be easily assimilated
Efficient ways of containing full spectral info are being investigated
And we still need to deal with cloud...

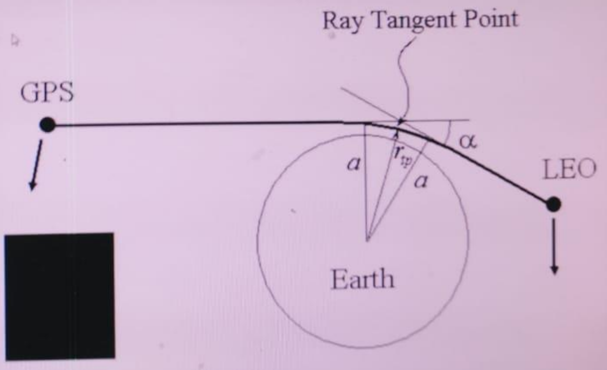
GPS (Global Positioning System)

- 24+ satellites in 6 circular orbital planes
- ~ 20200 km altitude
- ~ 12 hr period
- continuously transmit signals at two frequencies:
  - L1 at 1.57542 GHz (~19 cm)
  - L2 at 1.227 GHz (~ 24.4 cm)
  - (the dual frequency is used to eliminate the large contribution due to the ionosphere)
- Primarily used for navigation

The GPSRO technique

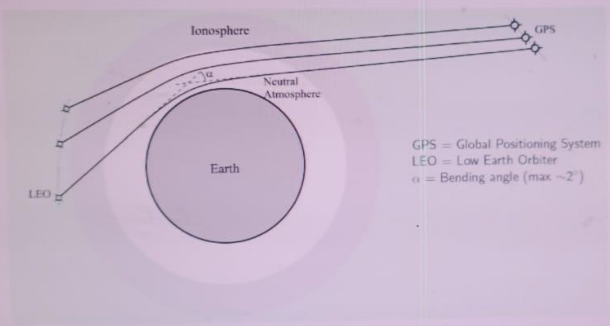
Viewed from the LEO (~800 km) the GPS satellite (~20000 km) is constantly rising or setting behind the Earth's horizon – "radio occultations." GPS signals are slightly delayed and their path slightly bent as they pass through the ionosphere and atmosphere. Measurement of this time delay, together with precise computations of the position and velocity of the satellites allows the "bending angle" to be calculated.





What can we extract from the signal?

$$N = \kappa_1 \frac{p}{T} + \kappa_2 \frac{e}{T^2}$$

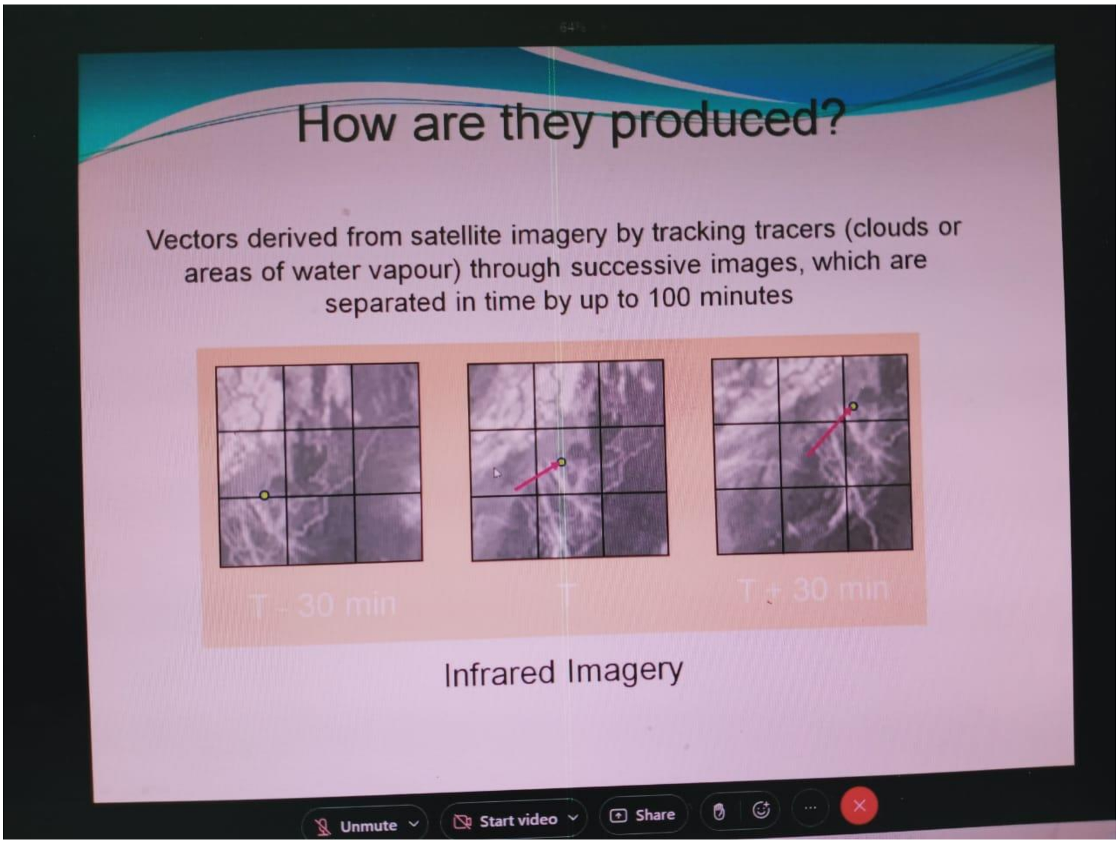


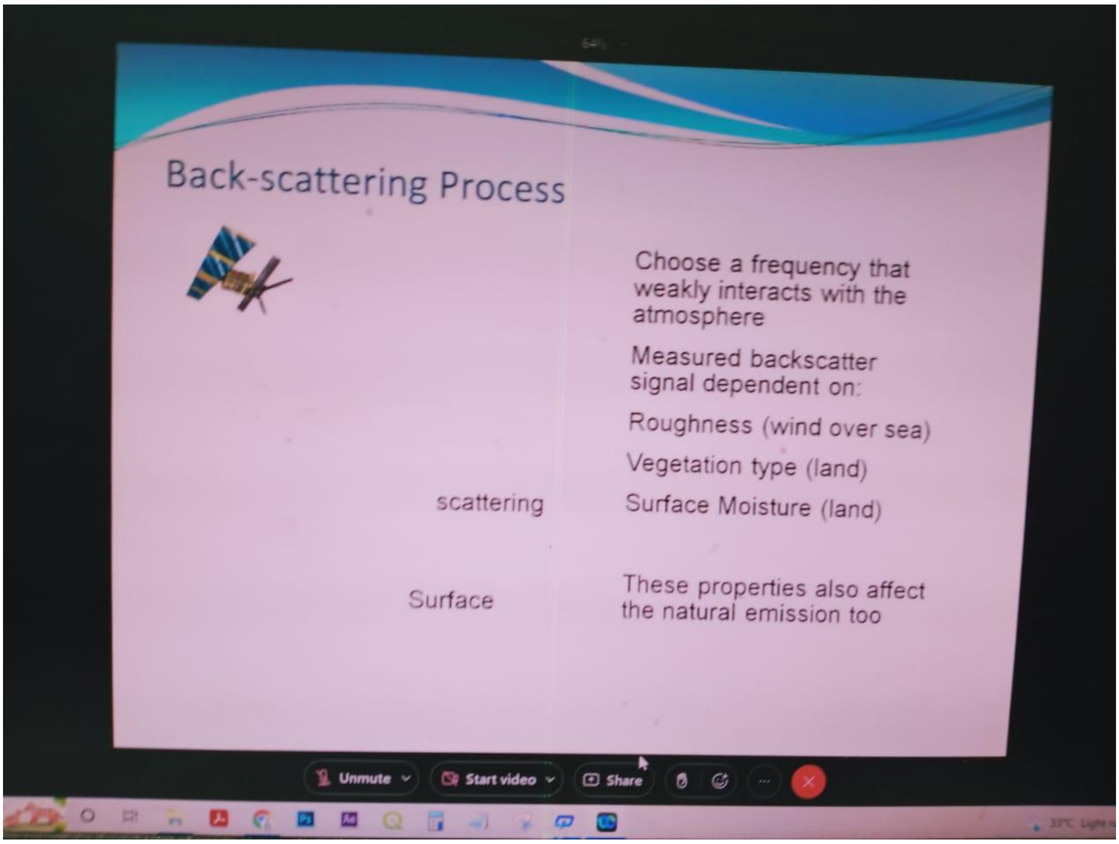
GPS = Global Positioning System
LEO = Low Earth Orbiter
α = Bending angle (max ~2°)

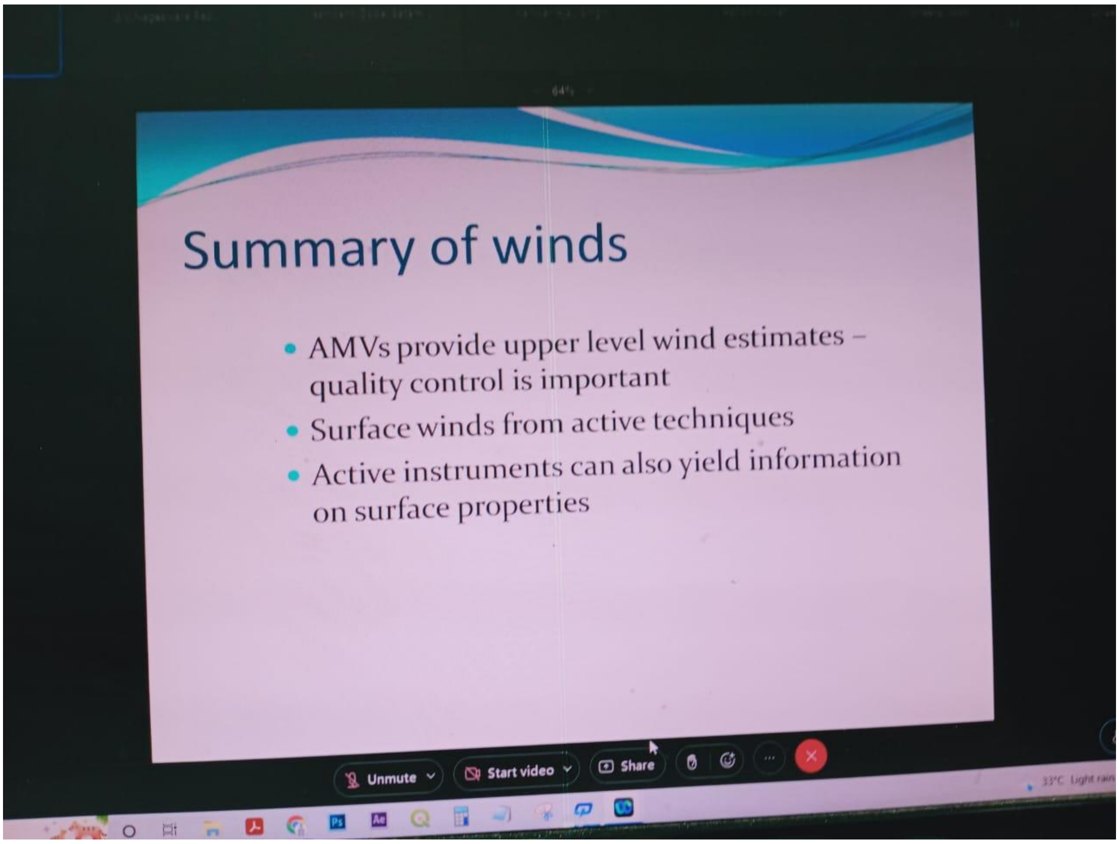
- In the (dry) stratosphere and polar troposphere: essentially temperature (via hydrostatic relation from density) with high vertical resolution
- In the (moist) troposphere: humidity & temperature ambiguity
- Measurements also have small systematic errors – useful for climate monitoring & investigating biases in the NWP system

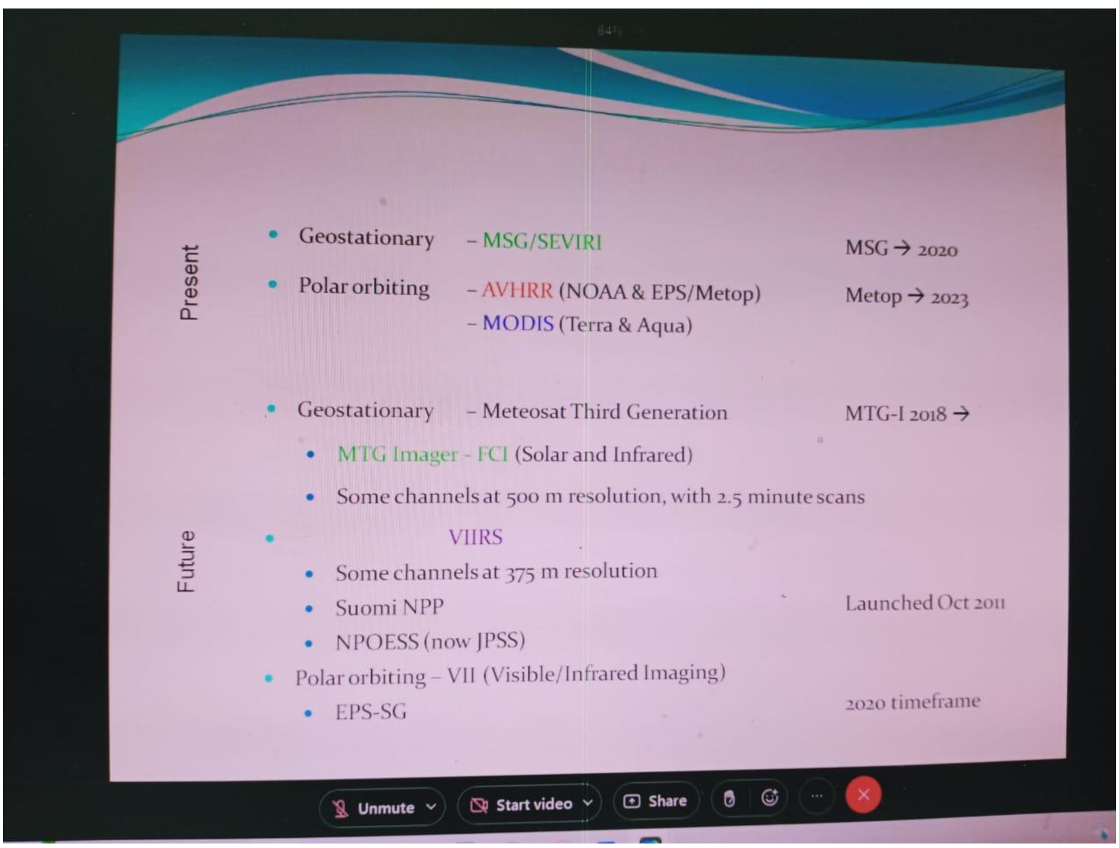
Summary of sounding data

- **Microwave sounding data has become a key part of the Global Observing System, probably the most important satellite component in terms of NWP impact.**
- **Use is still however not complete**
  - More use of near-surface channels over land surfaces
  - Better treatment of the effects of cloud and rain on radiance data
  - More use of channels with humidity information particularly in the boundary layer
- **Infrared: IASI provides greater vertical resolution**
  - Increase usage of information
  - Use more data in cloudy fields of view
- **GPS RO provides complementary observations with high vertical resolution.**


How are they produced?
Vectors derived from satellite imagery by tracking tracers (clouds or areas of water vapour) through successive images, which are separated in time by up to 100 minutes
T - 30 min
T
T + 30 min
Infrared Imagery
Unmute
Start video
Share


Back-scattering Process
Choose a frequency that weakly interacts with the atmosphere
Measured backscatter signal dependent on:
Roughness (wind over sea)
Vegetation type (land)
Surface Moisture (land)
These properties also affect the natural emission too
scattering
Surface
Unmute
Start video
Share


Summary of winds
AMVs provide upper level wind estimates – quality control is important
Surface winds from active techniques
Active instruments can also yield information on surface properties
Unmute
Start video
Share


Present
Geostationary – MSG/SEVIRI
MSG → 2020
Polar orbiting – AVHRR (NOAA & EPS/Metop)
– MODIS (Terra & Aqua)
Metop → 2023
Future
Geostationary – Meteosat Third Generation
MTG-I 2018 →
MTG Imager - FCI (Solar and Infrared)
Some channels at 500 m resolution, with 2.5 minute scans
VIIRS
Some channels at 375 m resolution
Suomi NPP
Launched Oct 2011
NPOESS (now JPSS)
Polar orbiting – VII (Visible/Infrared Imaging)
EPS-SG
2020 timeframe
Unmute
Start video
Share