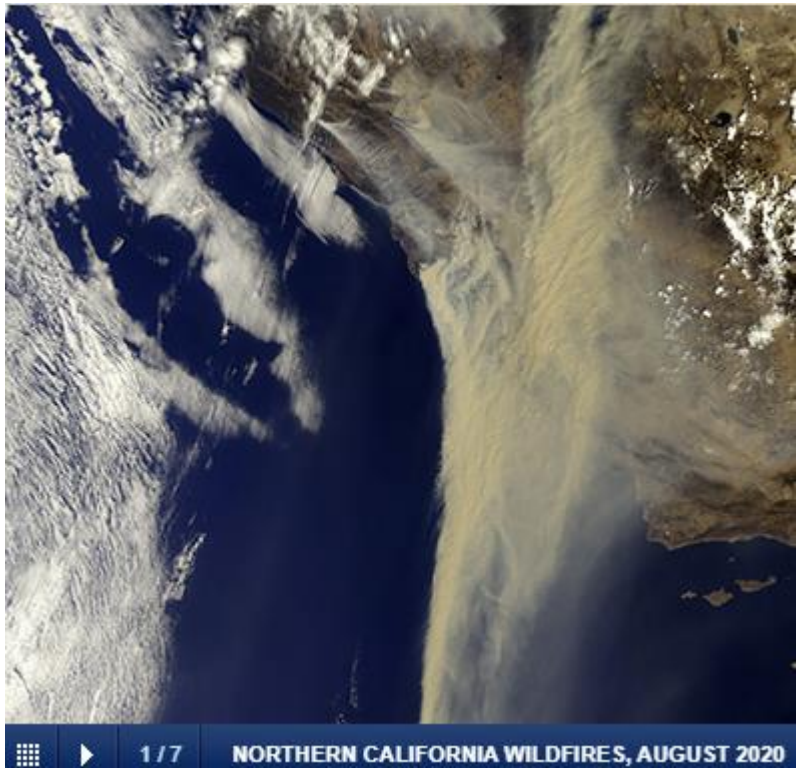


2020-08-19 Sentinel-3

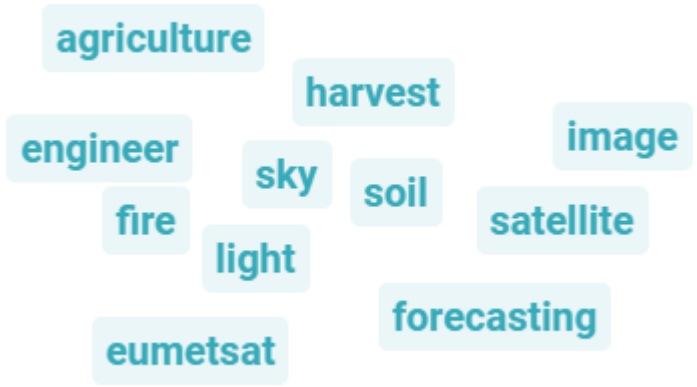
A light on heat

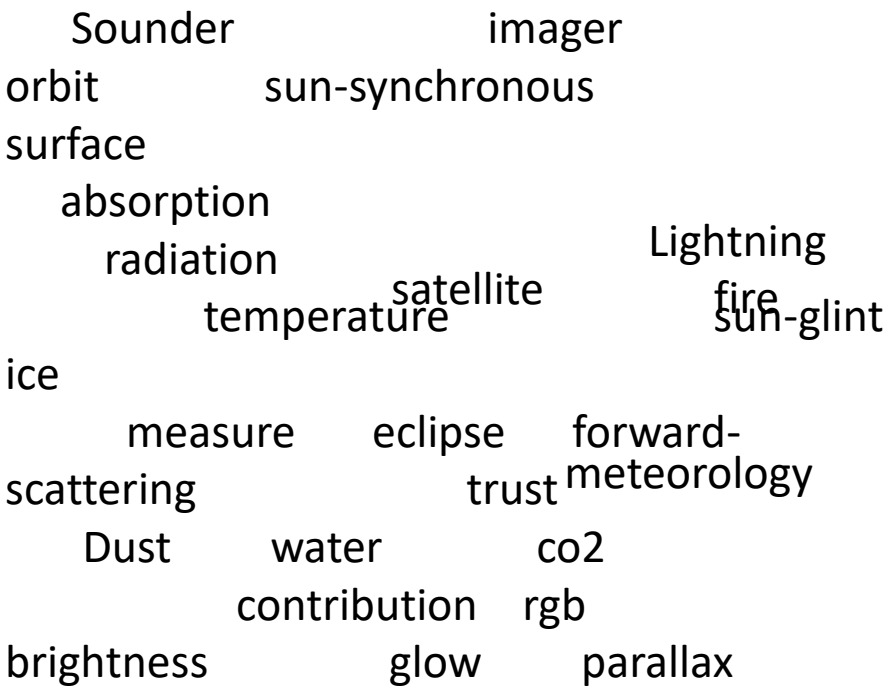
What radiation tells about air, soil, fire and water

jose.prieto@eumetsat.int

EUMETSAT

Expectation meets plan



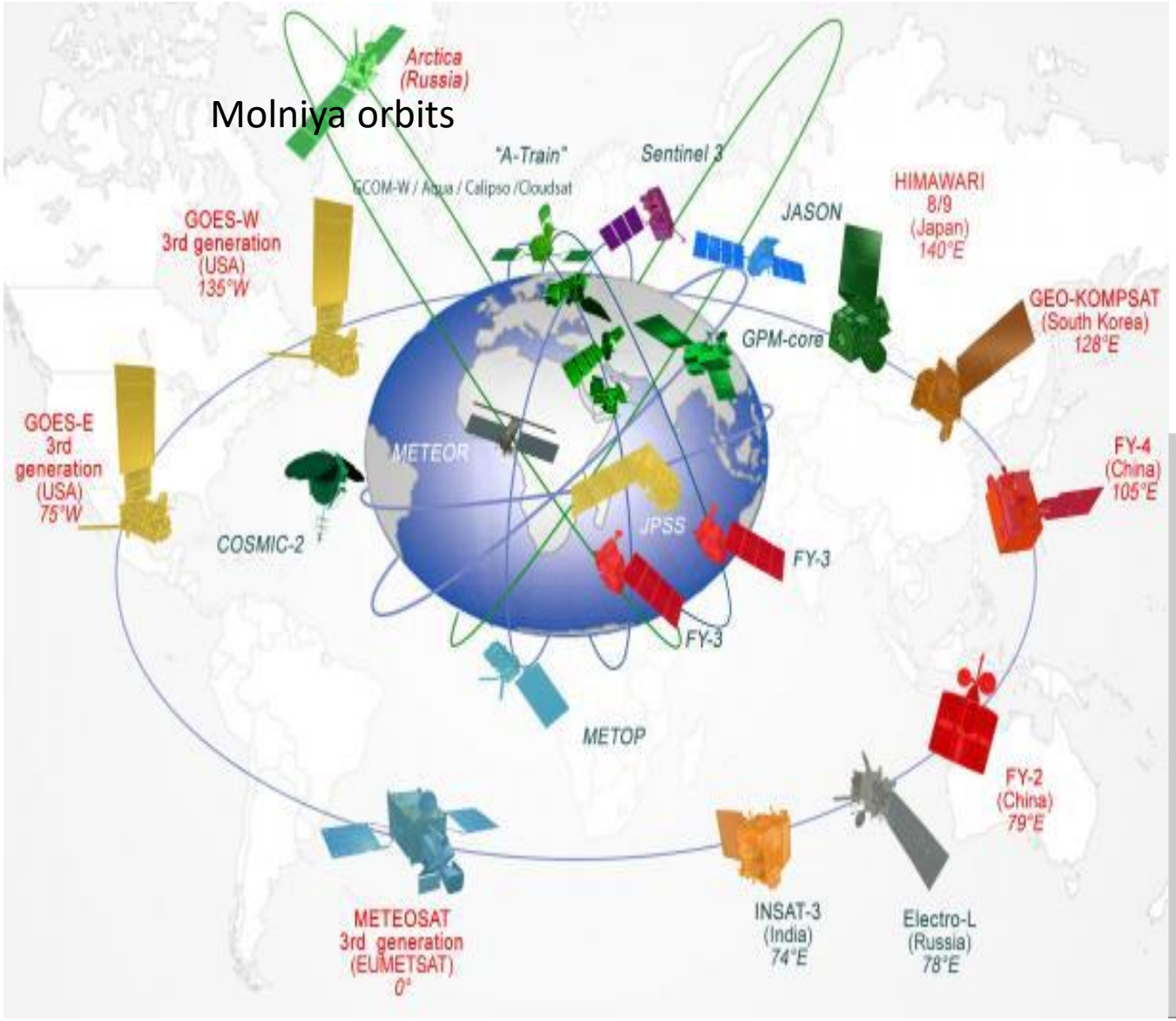


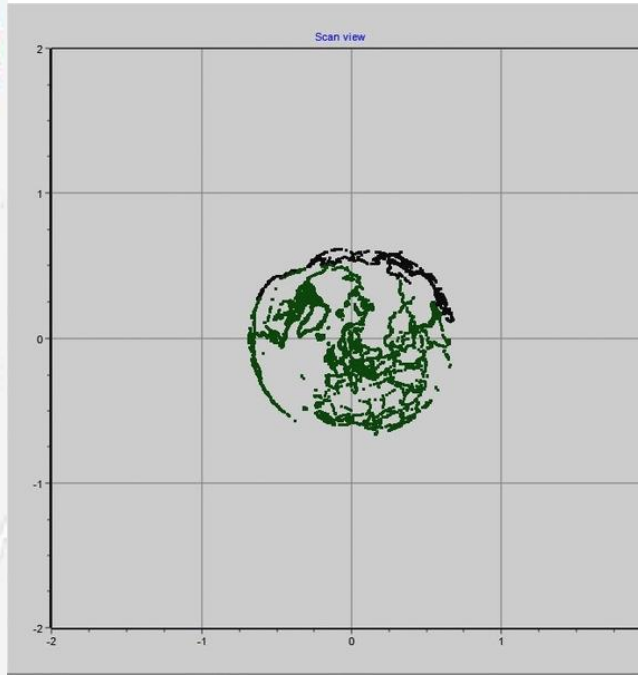
A history of radiation

- *2500 years ago:* Anaxagoras of Jonia
  „The **sun** is a mass of blazing metal,
  larger than the Peloponnese“
- *300 years ago:* Kepler sets laws of **planetary** movement, force of light. Fahrenheit builds a mercury thermometer.
- *265 years ago:* a **tsunami** and fires destroy Lisbon. First meteorological **series**. Franklin survives his invention of the **lightning** rod.
- *45 years ago:* **Geostationary** satellites usher in an era of monitoring the Earth from above the Equator.

The ruins of St. Paul's Church following the quake. Credit: Jacques-Philippe Le Bas.

WMO space programme





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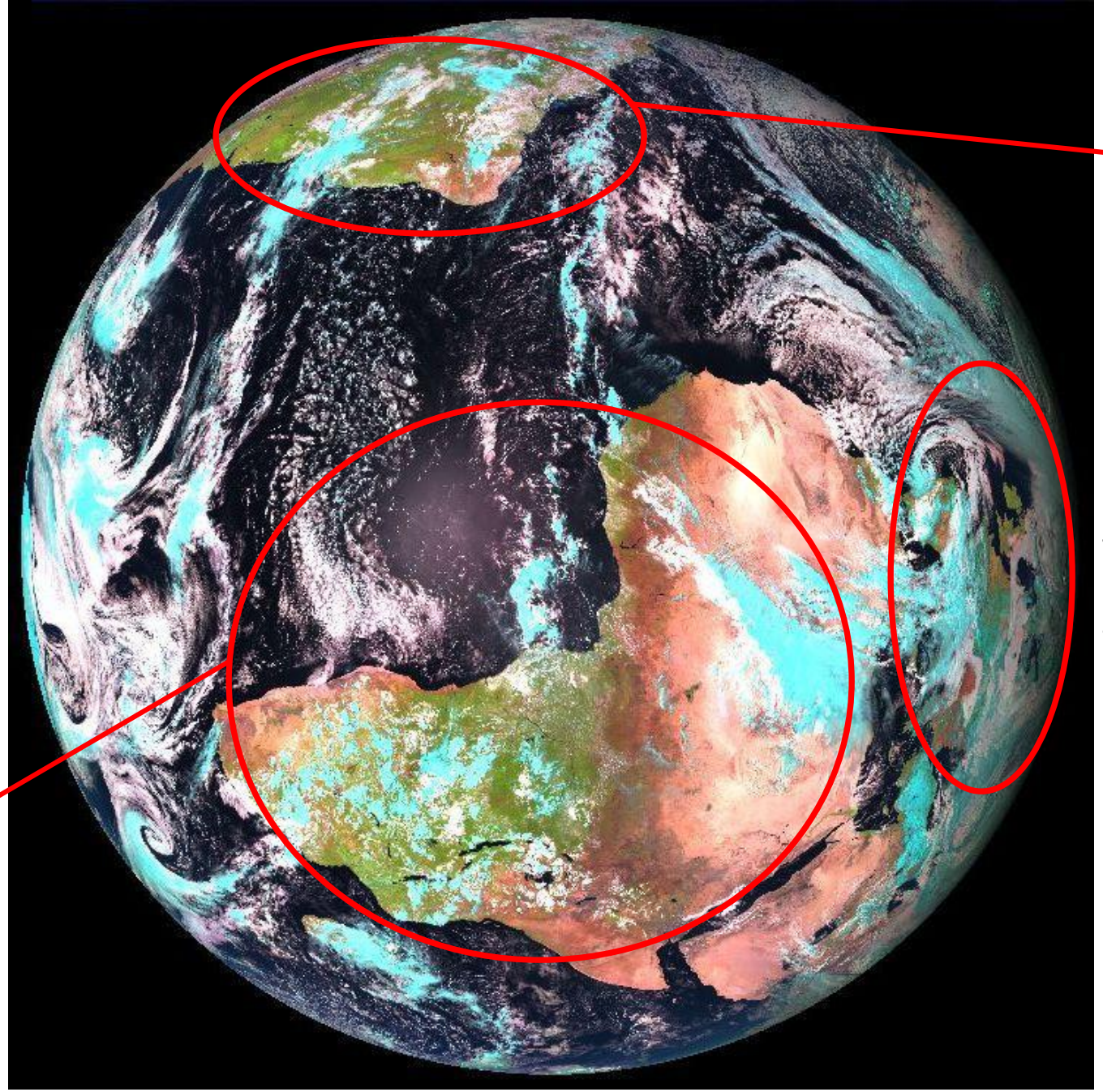

Meteosat, optimal for application in Africa, is still very useful in Europe and South America

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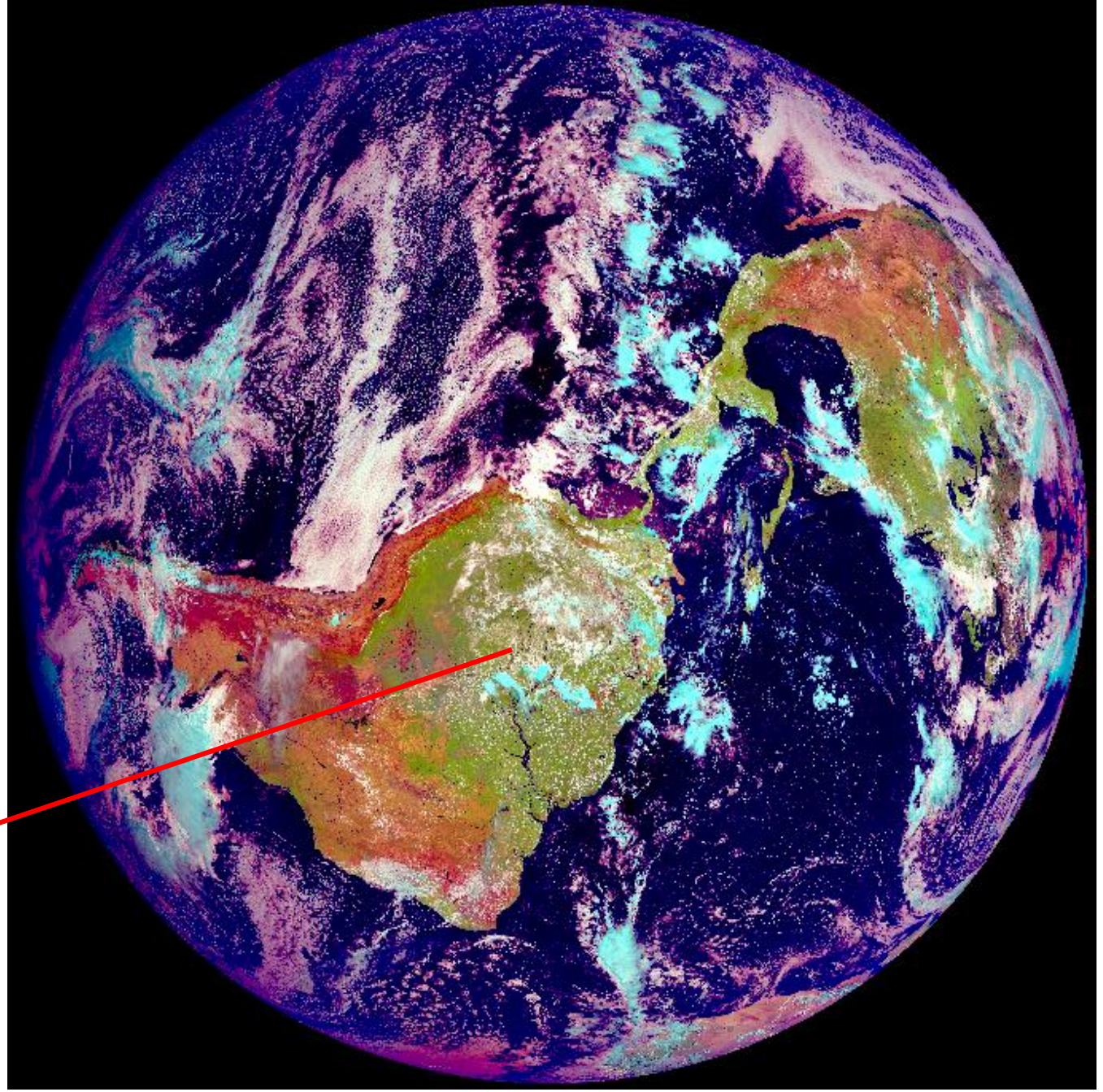


2 km

440 W/m^2

3 km

240 W/m^2

GOES-75W is optimal for the Americas, at higher resolution and richer in solar information

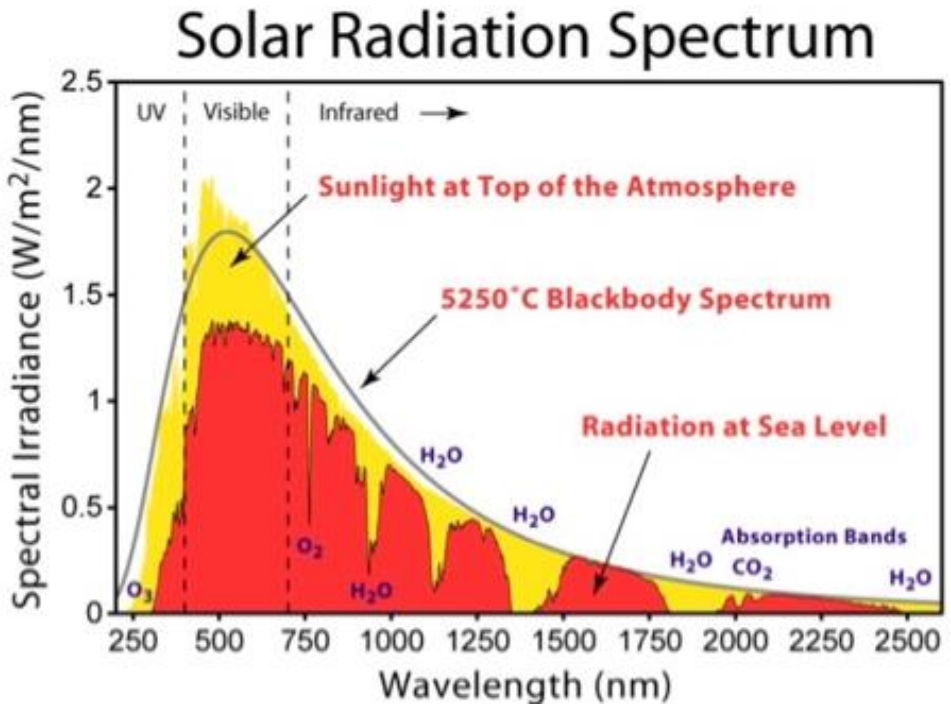
EUMETSAT

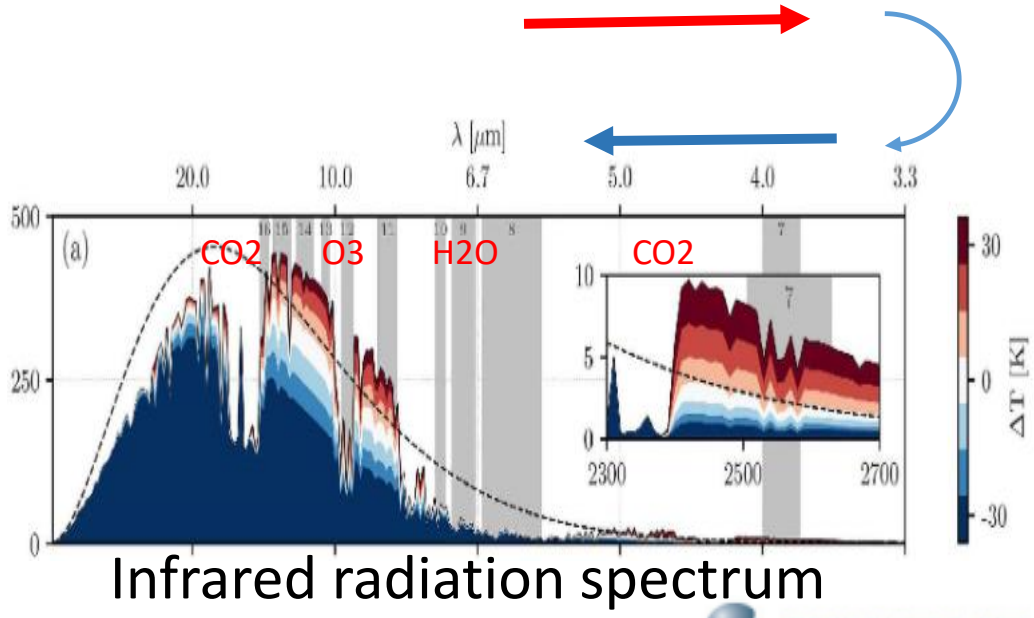
ABI channels

SOLAR

Thermal INFRARED

0.47µm	Blue, Rayleigh	*Fine aerosol*	1km
0.64	Red, high resolution	*Soil*	0.5
0.86	Near infrared	*Vegetation*	1
1.37	H2O absorption	*High cloud*	2
1.6	window	*Icy tops*	1
2.2	No absorption	*Particle size*	2
3.9	Shortwave window	*Fire, convection*	2
6.2	Upper-level water vapour	*Jets, ascents*	2
6.9	Midlevel water vapour	*Wind, turbulence*	2
7.3	Lower-level water vapour	*SO2*	2
8.4	Infrared window	*Phase, dust*	2
9.6	Ozone	*Stratosphere*	2
10.3	Cleanest window	*Cloud temperature*	2
11.2	Split window	*Low level humidity*	2
12.3	or triple window	*Sea surface*	2
13.3	CO_2	*Air temperature*	2

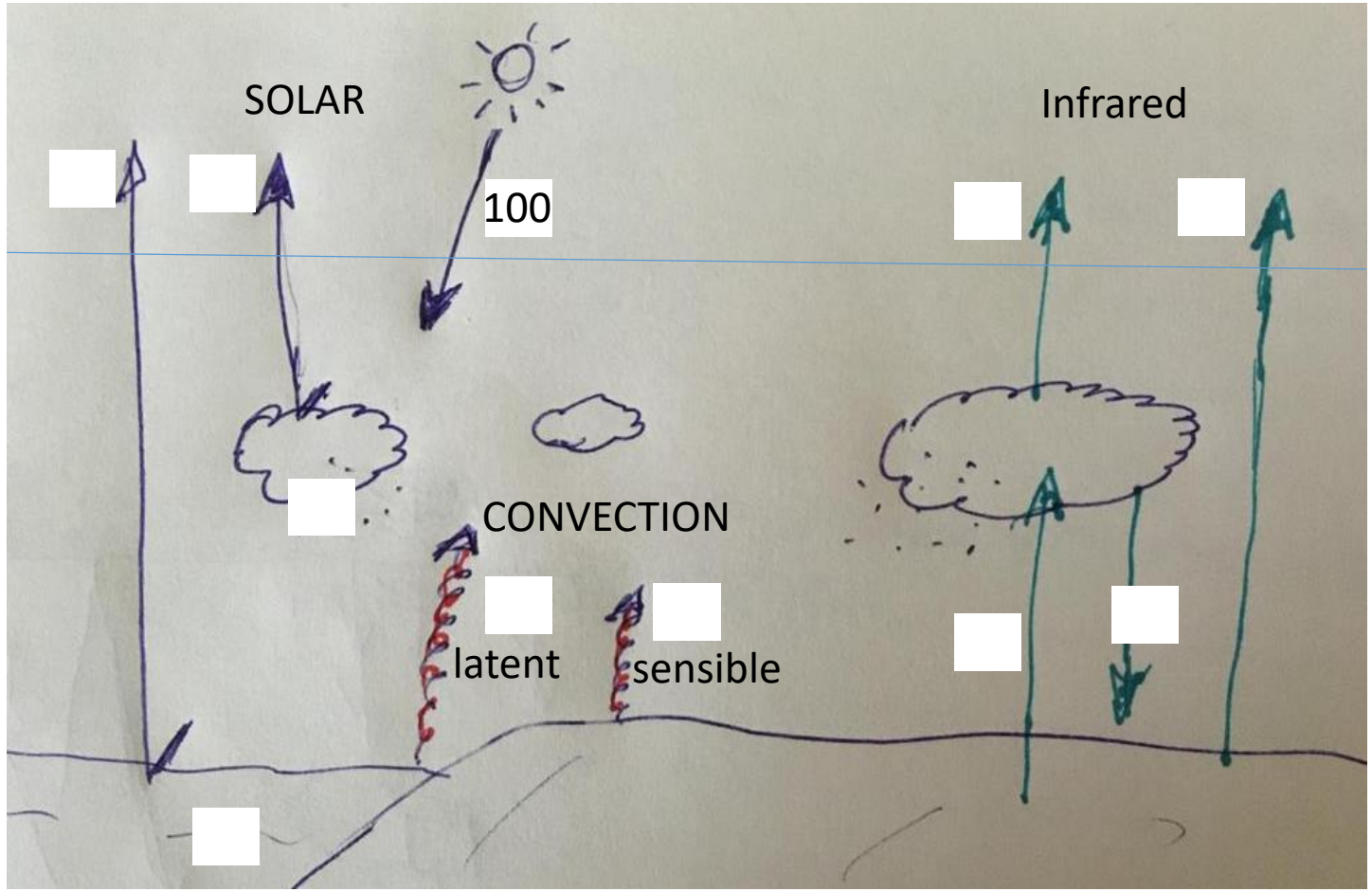




Infrared radiation spectrum

EUMETSAT

Earth radiative-convective balance



105

100

59

48

25

23

23

12

6

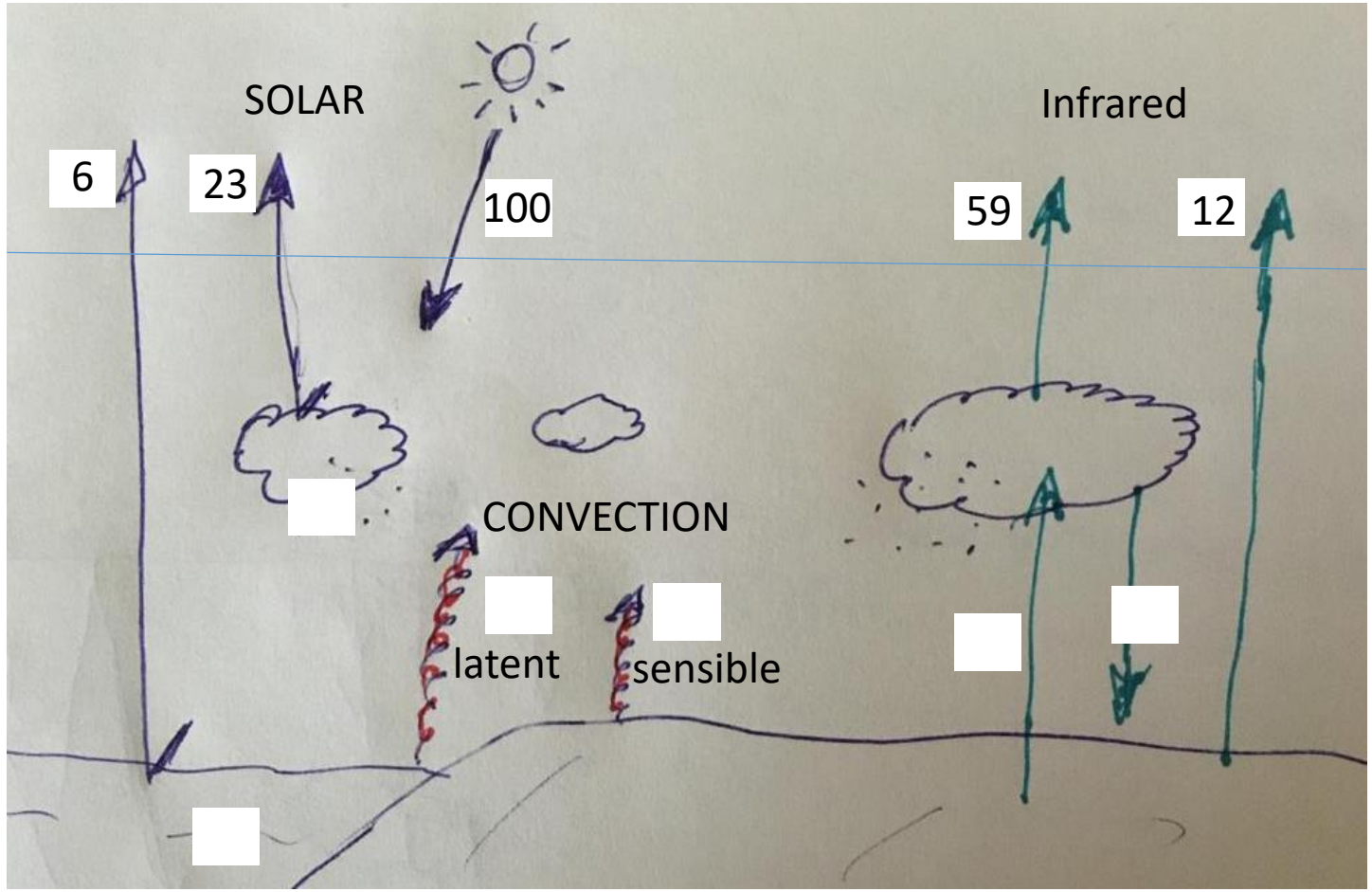
6

Figures are AVERAGES: day-night land-sea cloudy-clear seasonal

"100"= 342 Wm-2 (SOLAR CONSTANT/4)

EUMETSAT

Earth radiative-convective balance



105

100

48

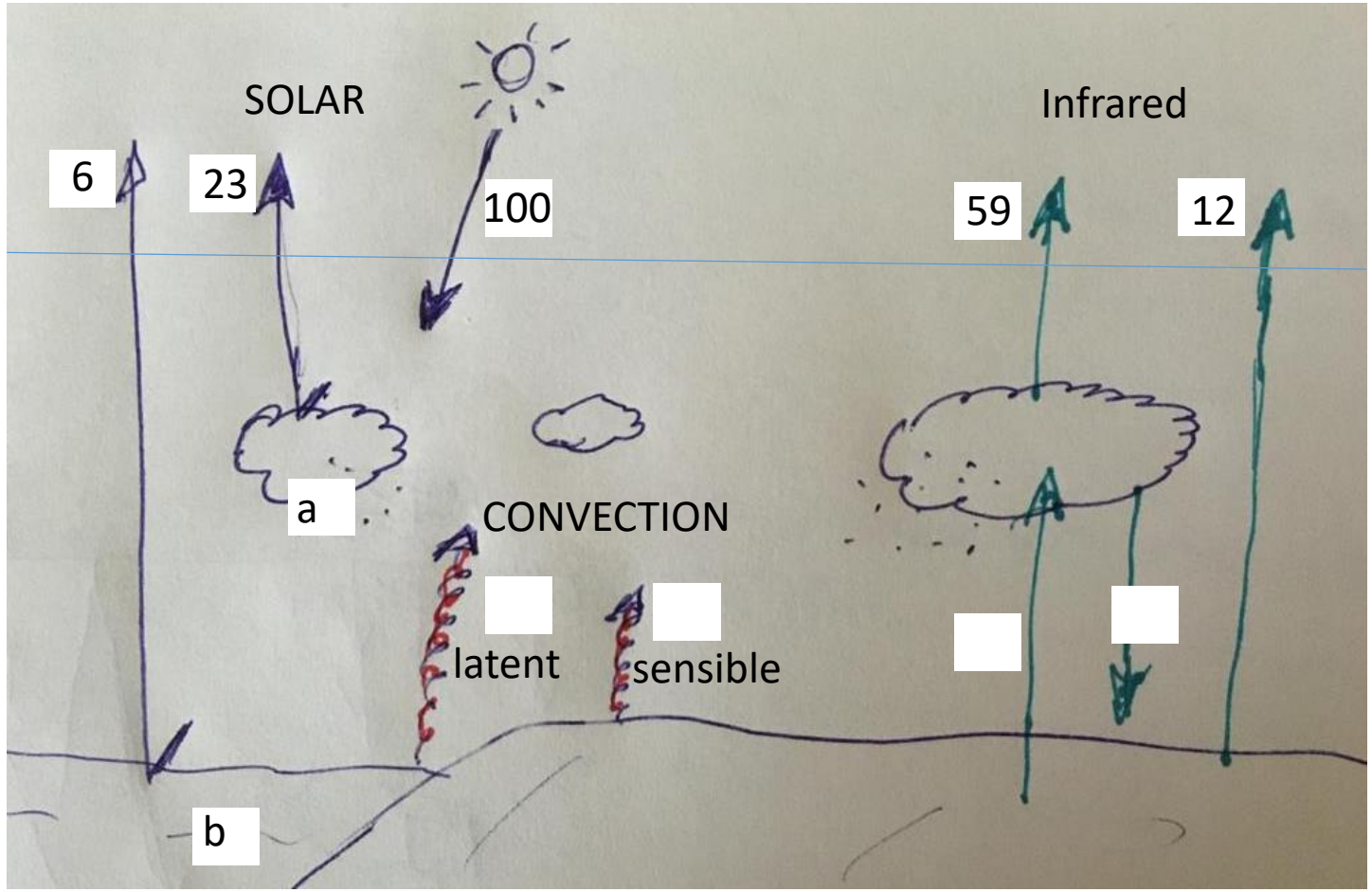
25

23

6

Earth radiative-convective balance

(sli.do #EUMSC2) A



105

100

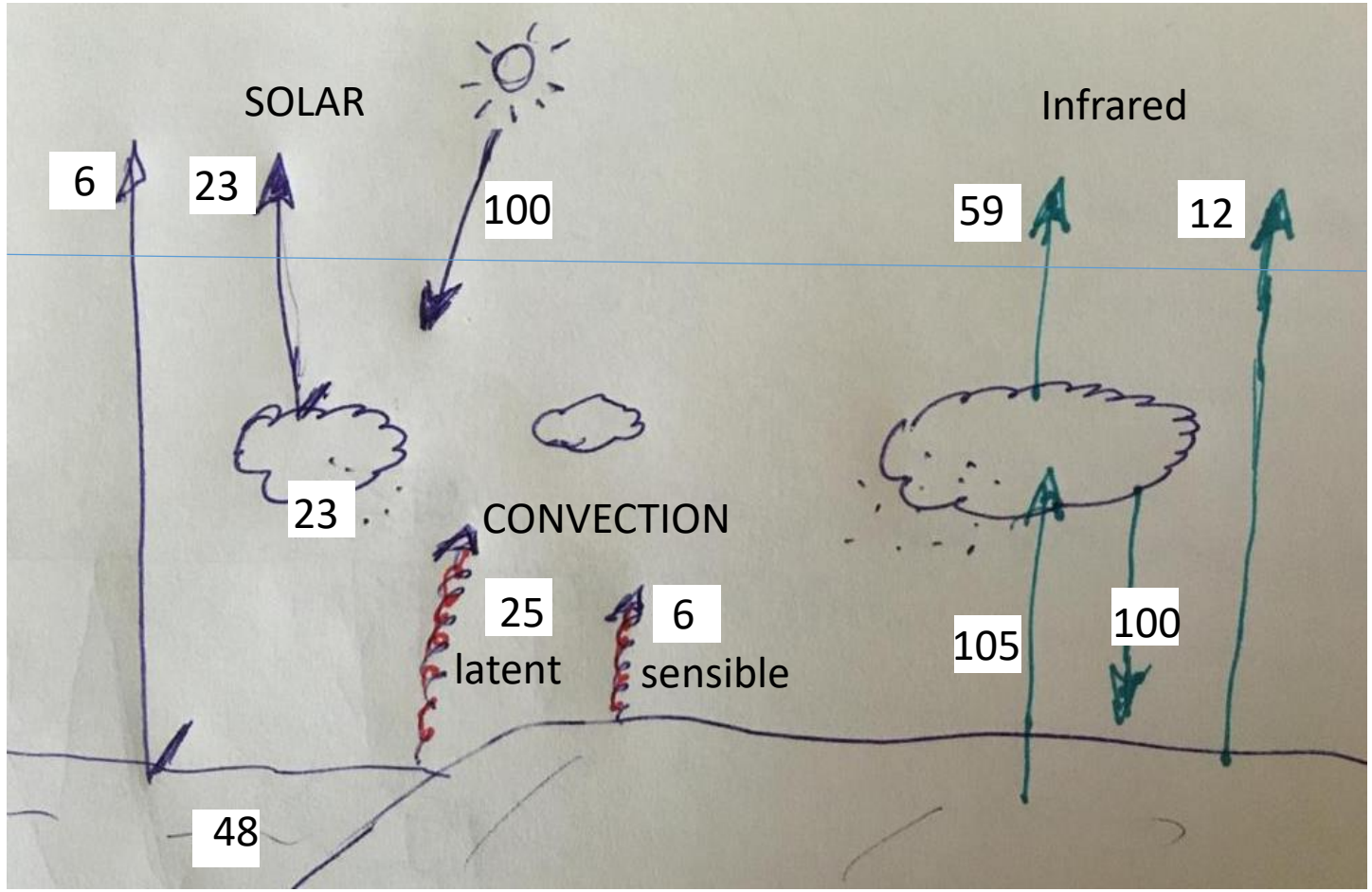
48

25

23

6

Earth radiative-convective balance



Earth **surface** sends 20% of the solar radiation **reflected back** to space.

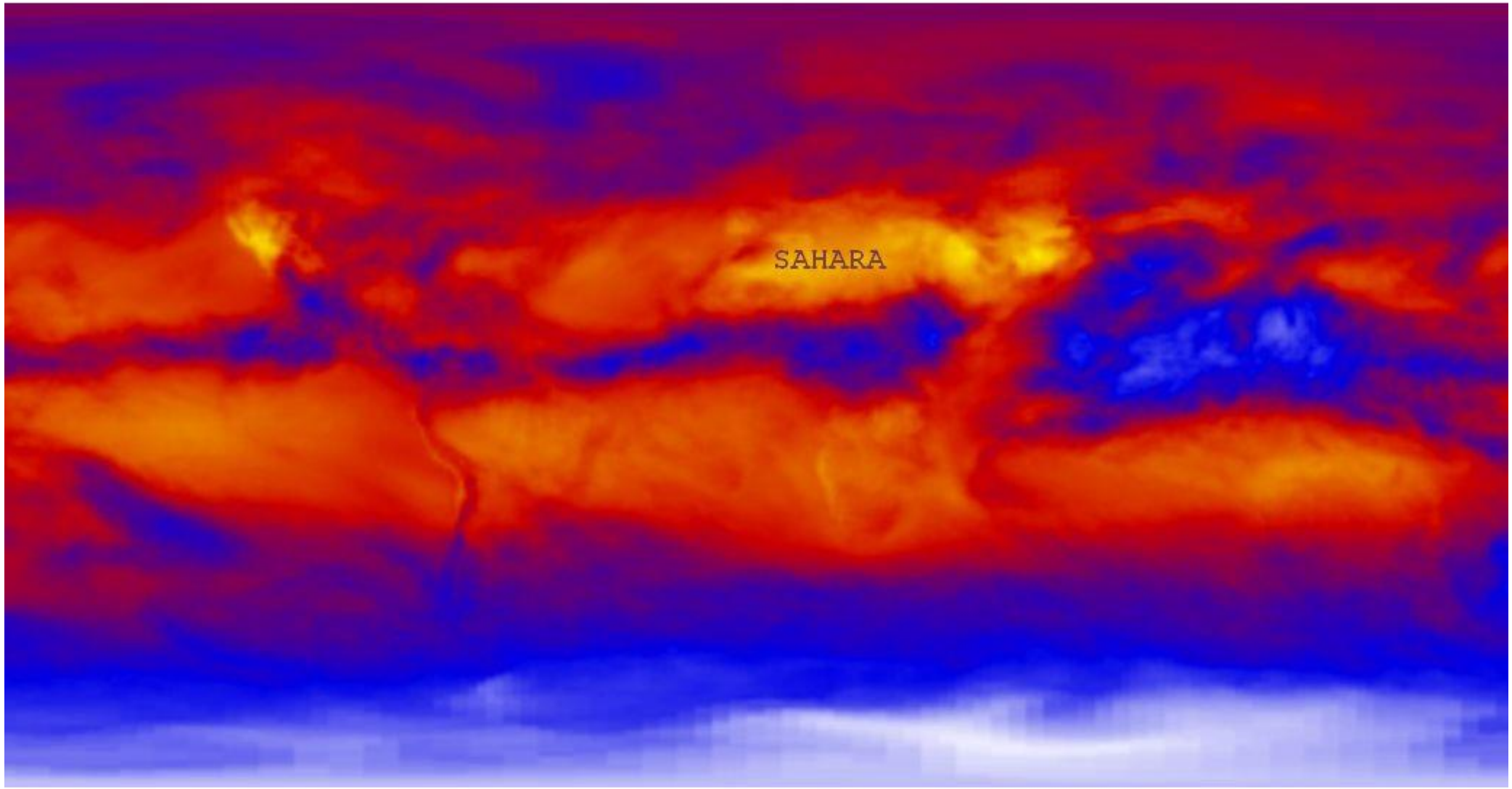
Earth **surface** makes 17% of the energy at the **infrared** channels.

Window channels use spectral gaps with more presence of **surface**.

Soils cool rather by **convection** than by radiation.

On the surface a **person** gets less solar radiation than infrared radiation from the ground + air.

OUTGOING LONGWAVE RADIATION (8 DAY)



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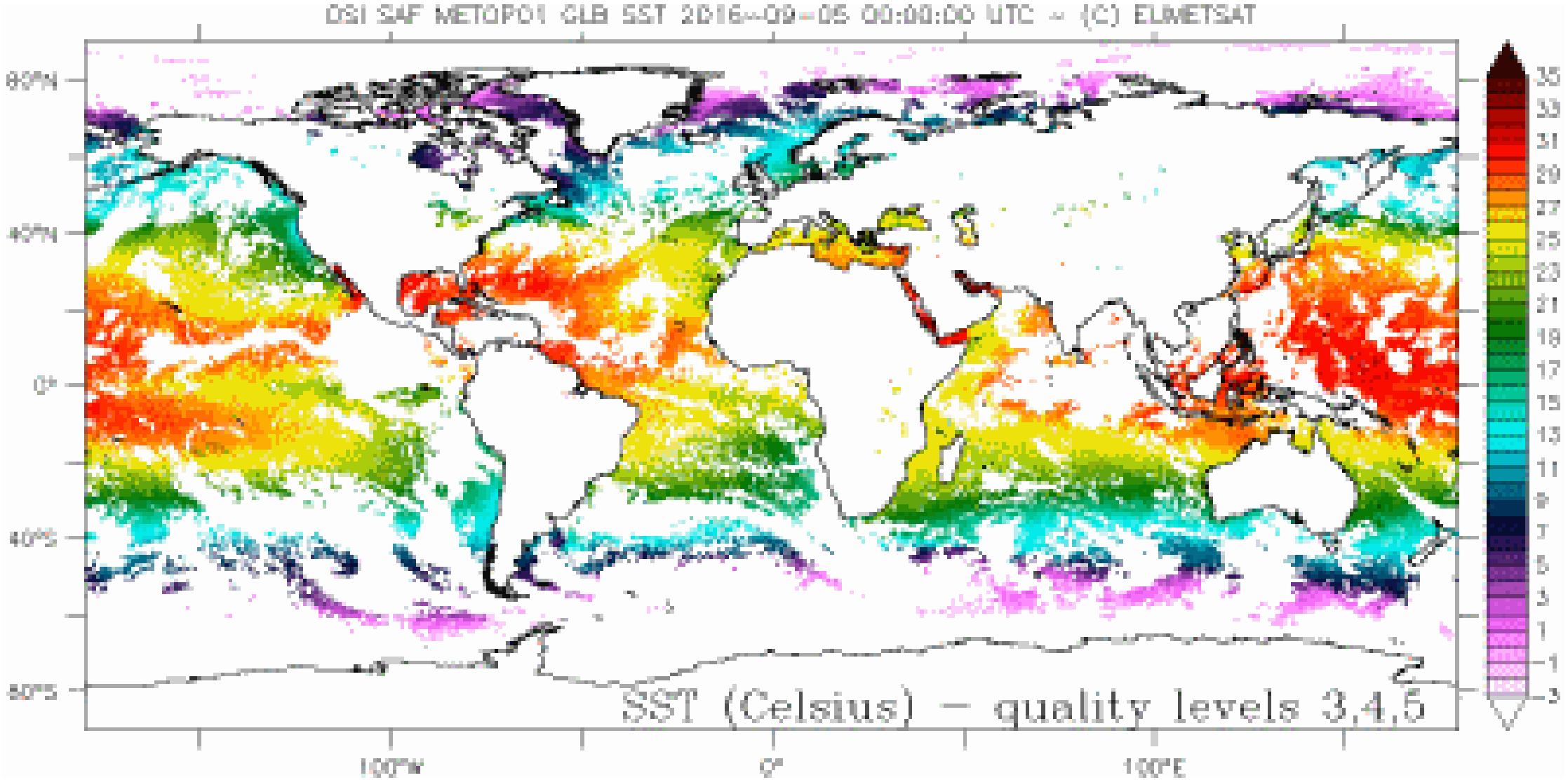
Warm waters glow more than cold



Infrared windows see the ocean skin temperature, not the air temperature

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Big picture or detail: Image or sounding

sli.do #EUMSC2) B

IMAGERS (compared with SOUNDERS)

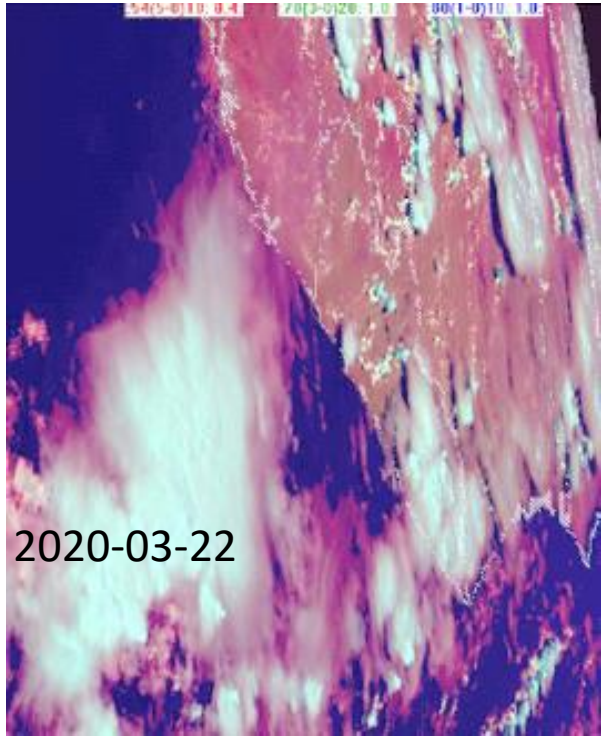
+Bandwidth

-Pixel size

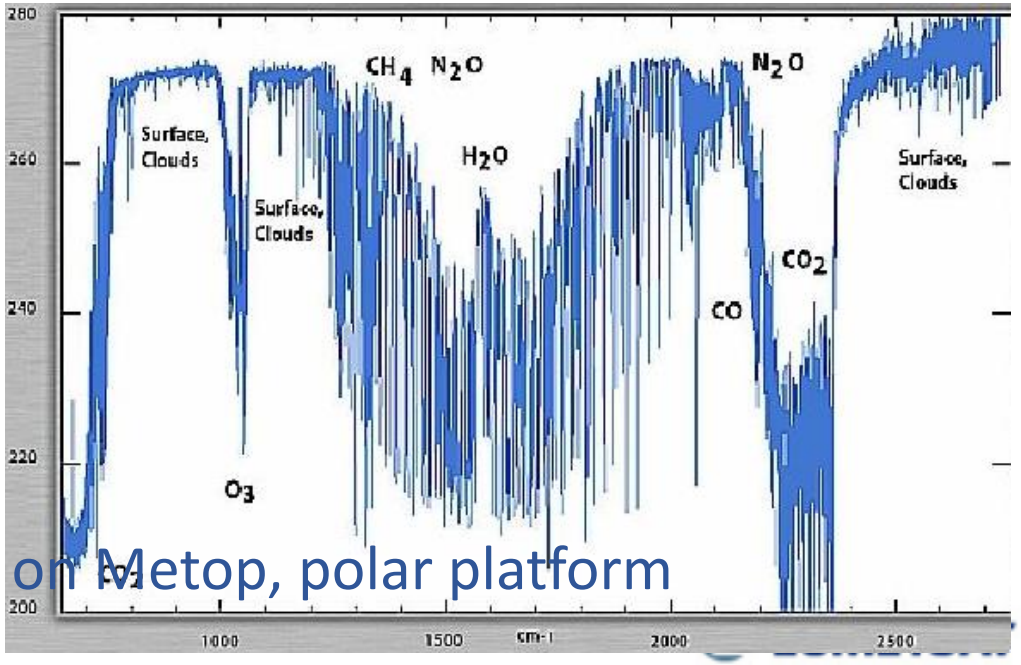
-Sampling time

-Air absorption

+Horizontal than vertical



ABI on GOES-E 2020-03-22
15:50 UTC

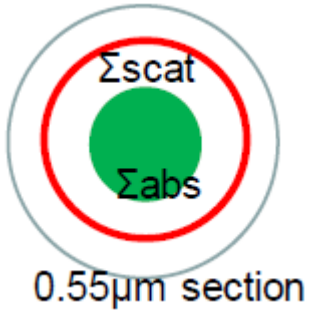


IASI on Metop, polar platform

Satellite meteorology

Chapter 1:

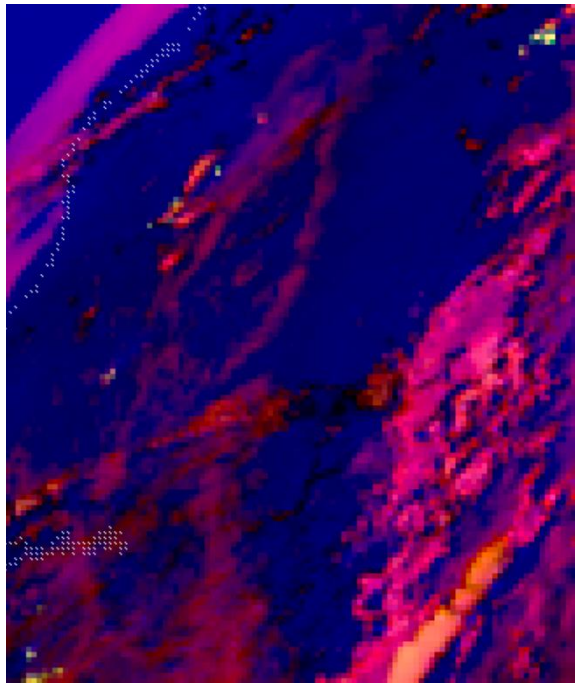
- SOLAR: scattering by Earth surfaces
- INFRARED: emission by Earth surfaces



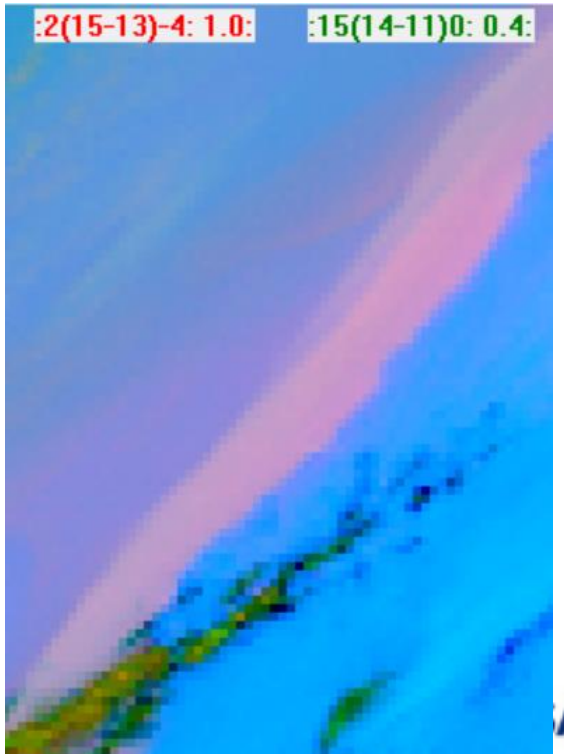
Chapter 2:

+ emission by hot surfaces

+ scattering by small particles



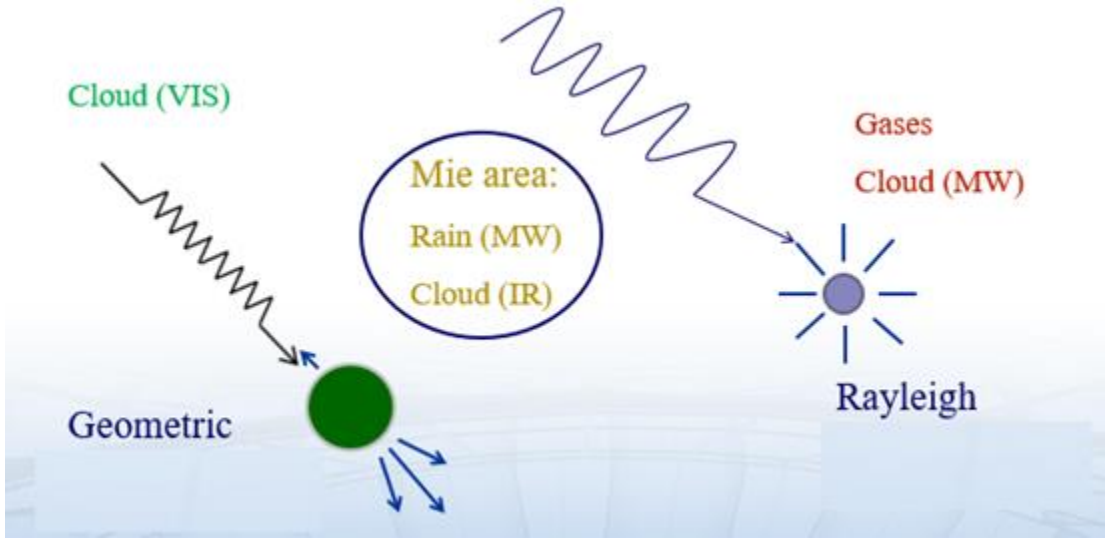
2020-08-23
21UTC



Radiation meets matter

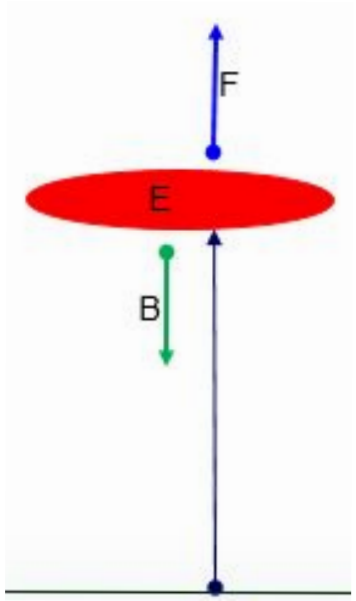
”…and I should still have delayed [its printing], had not the Importunity of Friends prevailed upon me”
(I.Newton *Opticks*)

Big obstacles prefer to scatter forward, rather than backward.
Very small or very large targets absorb better than they scatter.
For a fixed liquid amount in cloud, small droplets reflect better.
Satellites pick solar backward-scattering or infrared forward-scattering, but no absorbed radiation.

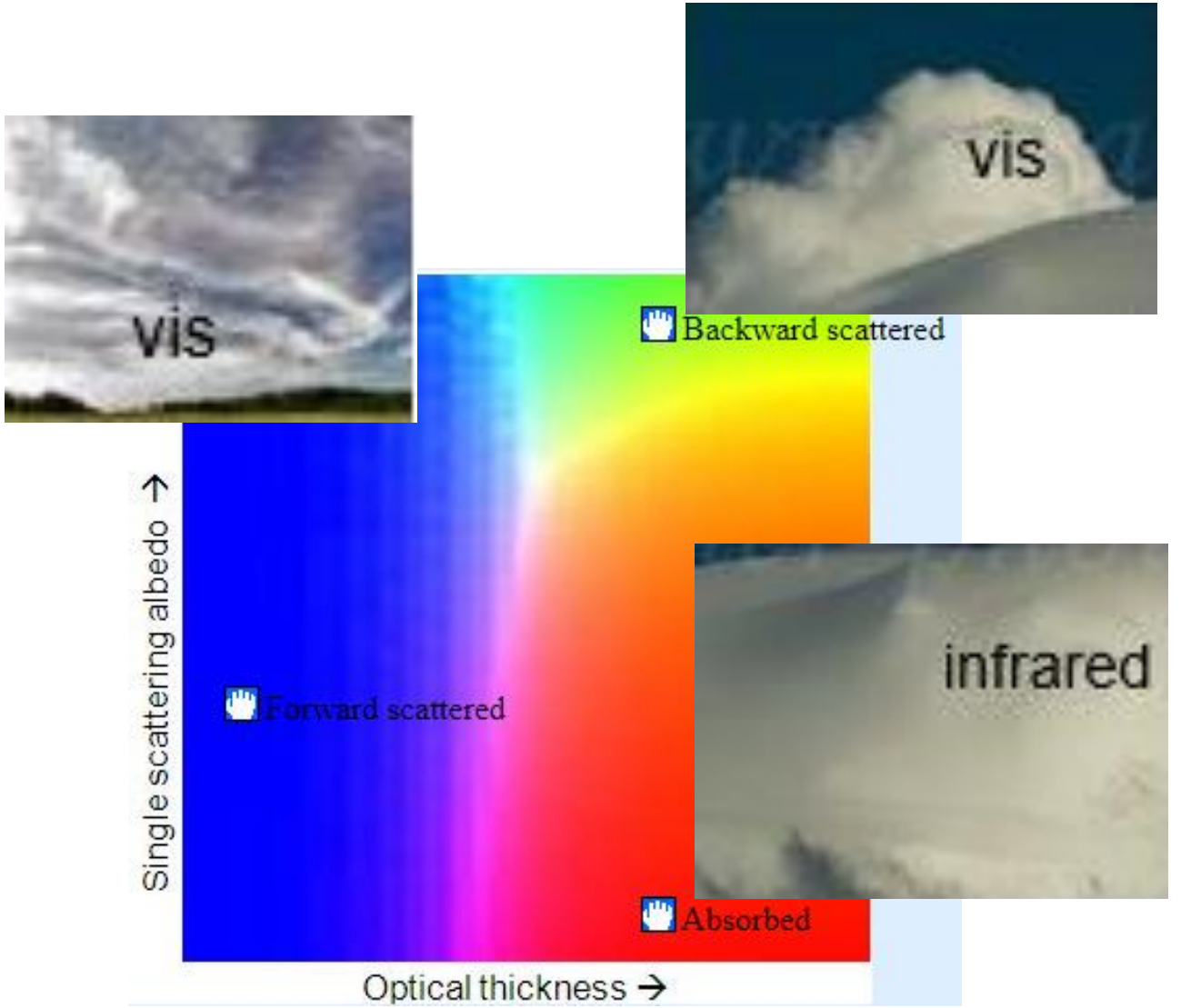


← BIG particles SMALL→

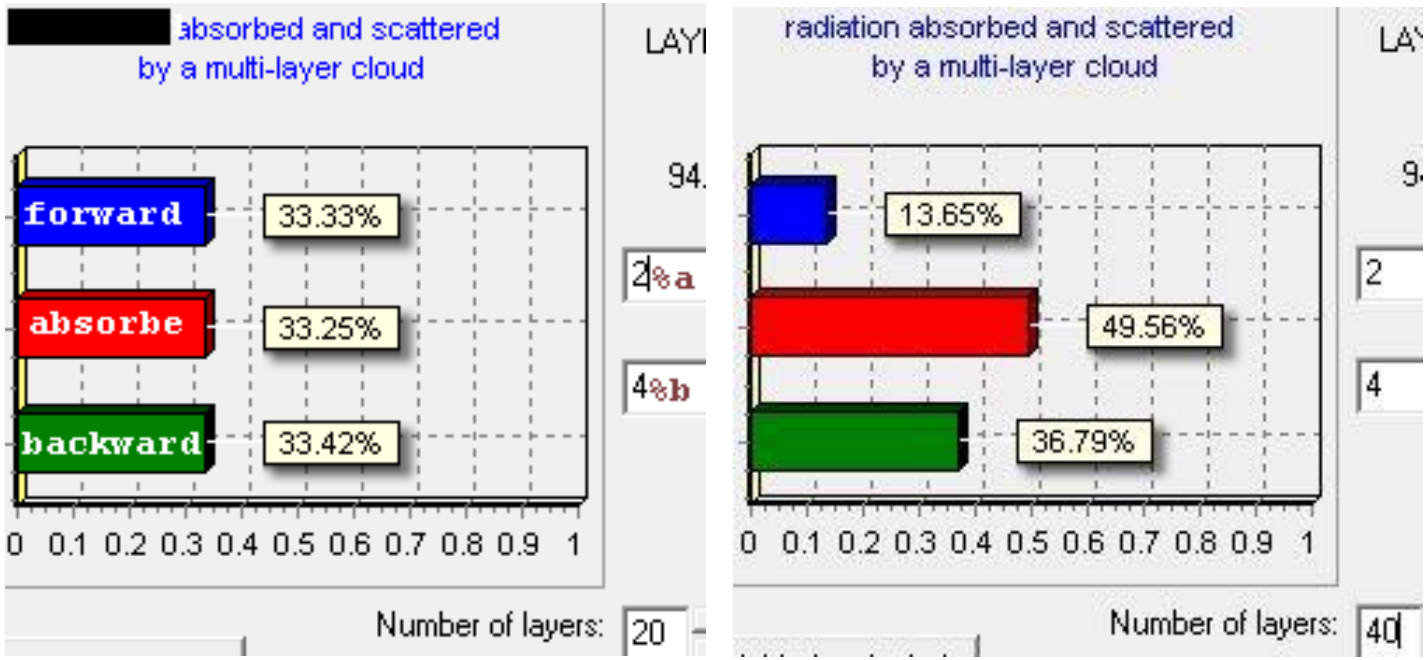
Absorption and scattering

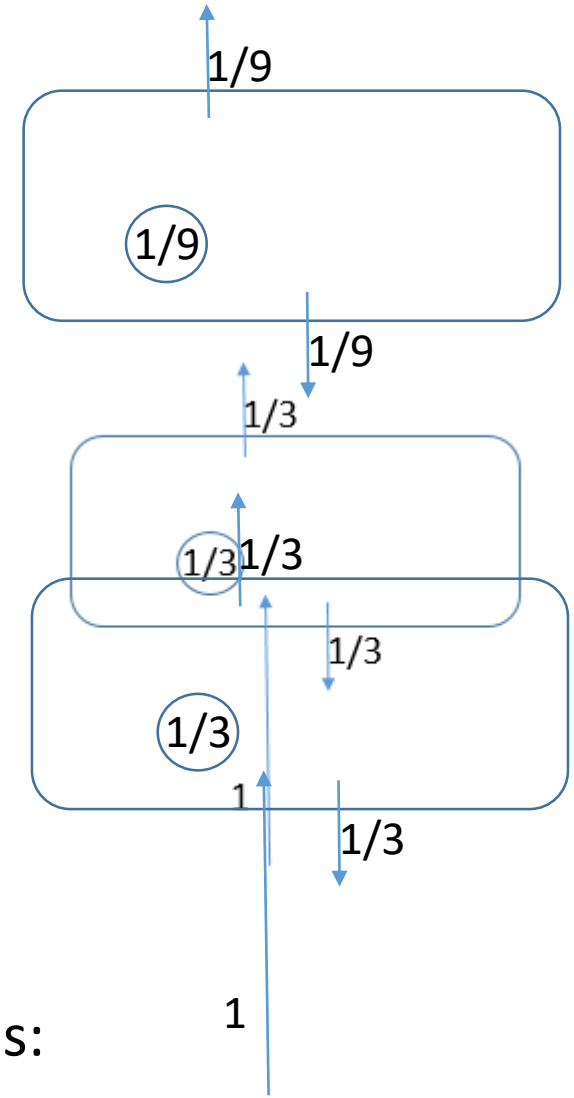


Radiation source:
Surface (for INFRARED)



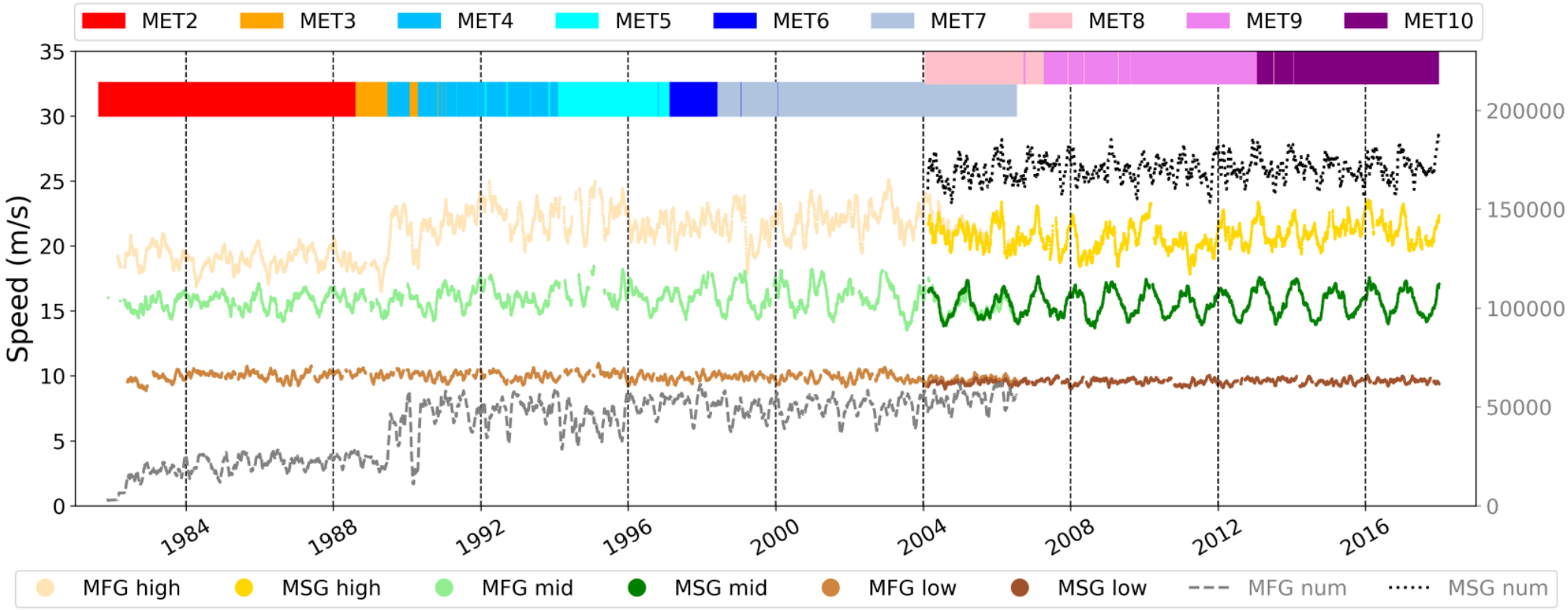
Absorption and scattering
(sli.do #EUMSC2) D





Let us try to predict the behaviour of doubling a cloud thickness:
Will the absorption prevail over the backscattering?

Satellite – NWP dialogue, the meaning of data



ıt is it like?

e locations

ıt of cloud

s changed.

- Then I have to re-assimilate…

Some years and many meetings later the convergence is called reprocessing or reanalysis, currently ERA-6.

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Satellite – NWP cooperation

- Reprocessing
- Observation (innovation)
- Partial description (cloud, dust, wind)
- Linear approximation
- Extrapolation (nowcasting)
- Strong in nowcasting
- Current weather (diagnosis)

- Reanalysis
- Assimilation (simulation)
- Full state of the atmosphere
- Growth and decay
- Propagation (forecasting)
- Strong some days ahead.
- Future weather (prognosis)
- Media like it: TV, Windy..

Examples

Channels: Solar, infrared, water vapour

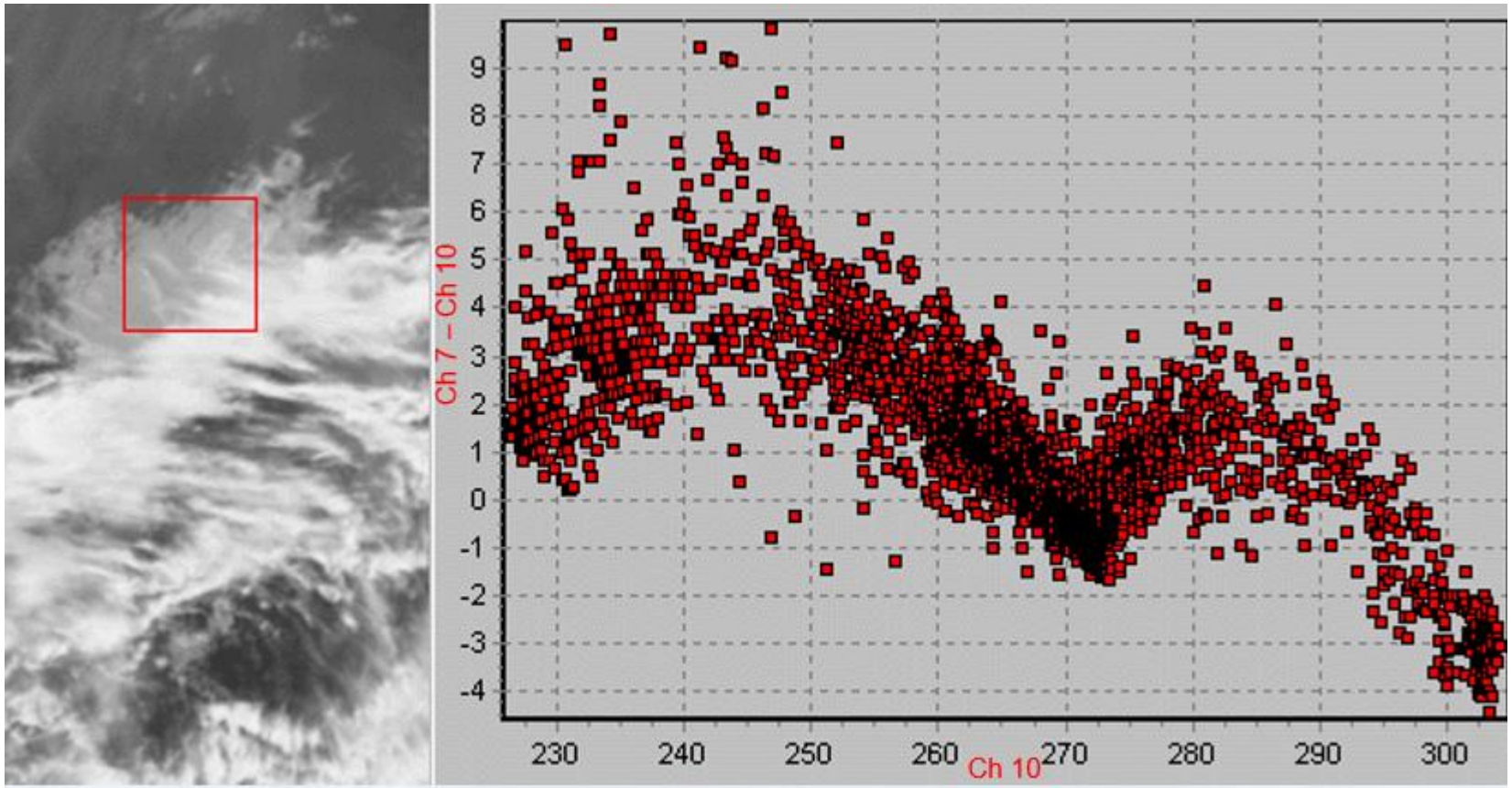
Events: Dust, smoke, fire

Exceptions: Sunglint, eclipse, parallax

Test on your know-how. You know which image is solar, but perhaps cannot tell how you decide

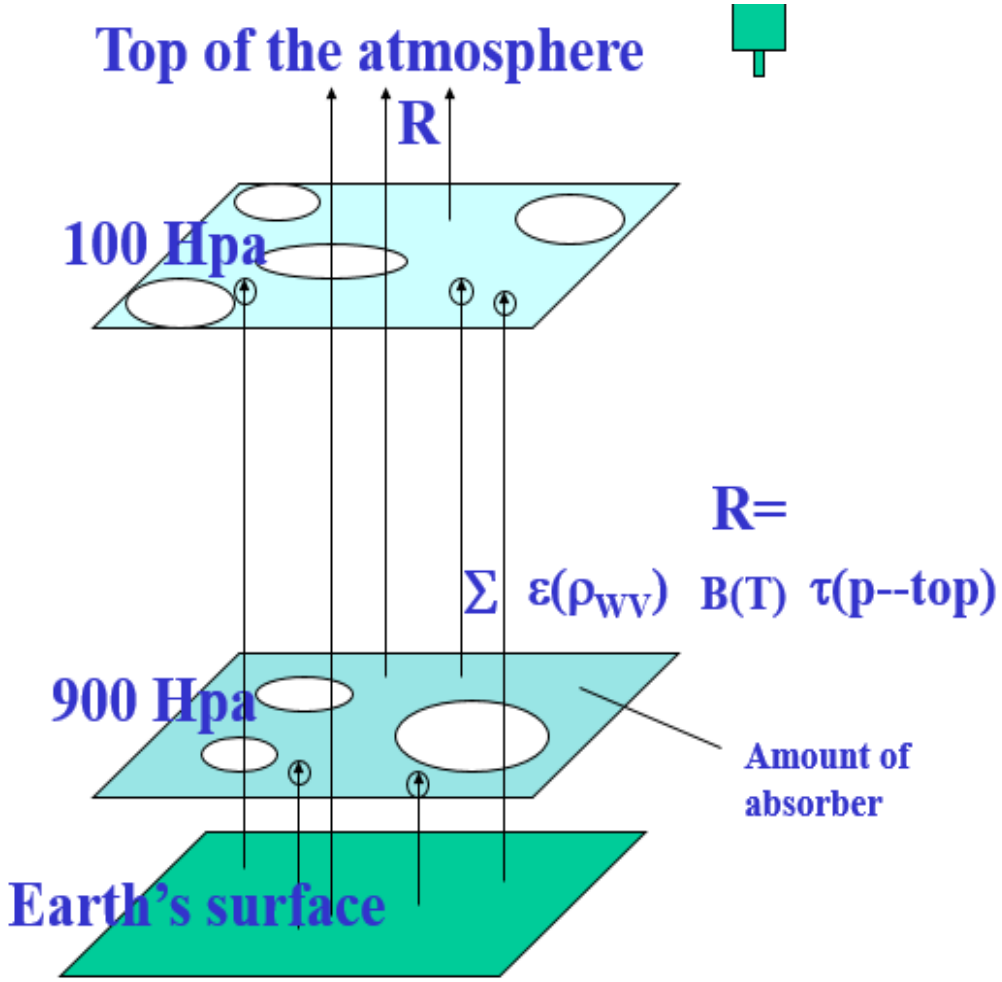
Same date-time in June for both images.
Solar OR thermal-infrared?

Semi-transparent cloud: mixing levels inside a pixel



Ch9 17-Feb-03 midday over desert

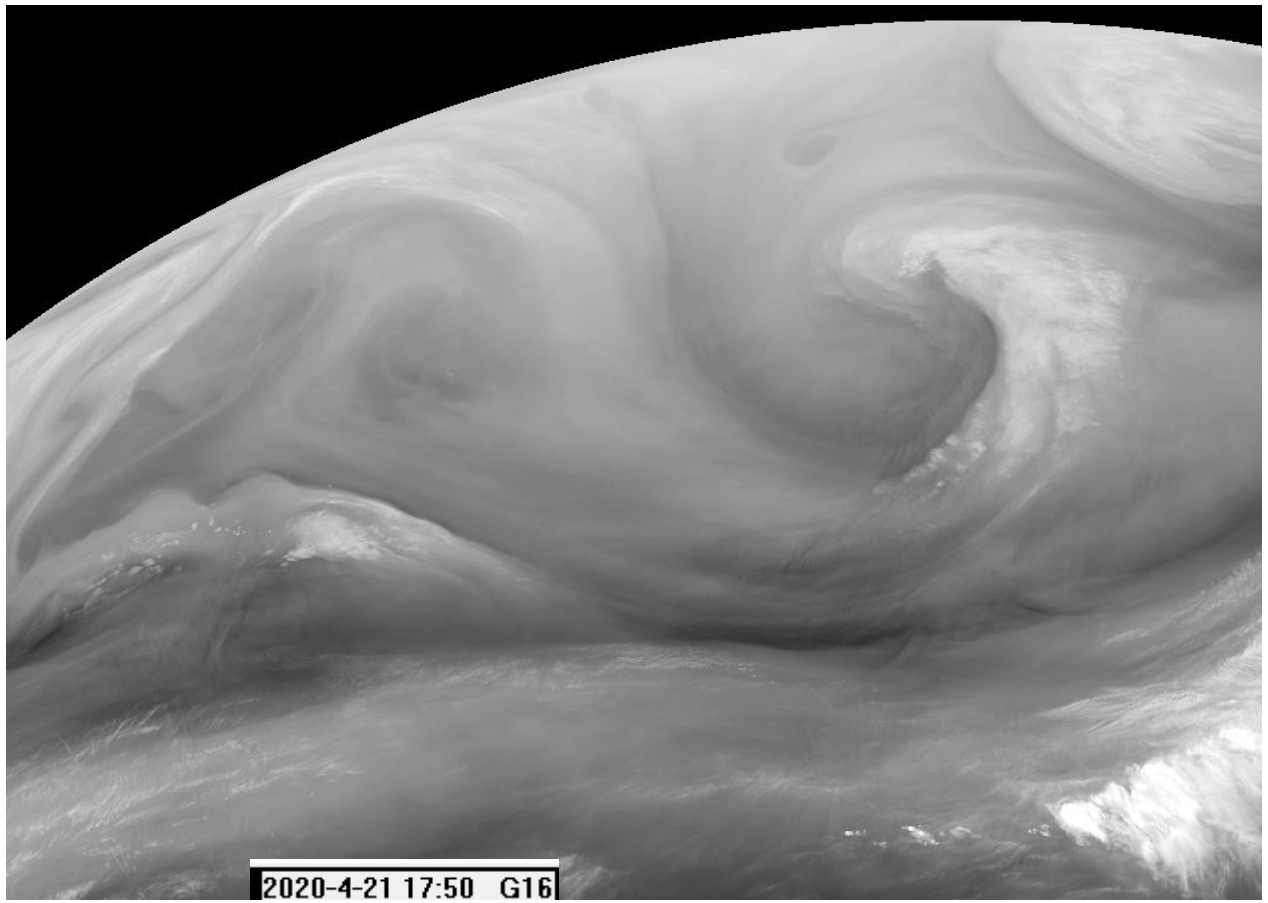
The eventful way upwards at infrared absorption bands (e.g. water vapour 6 µm)



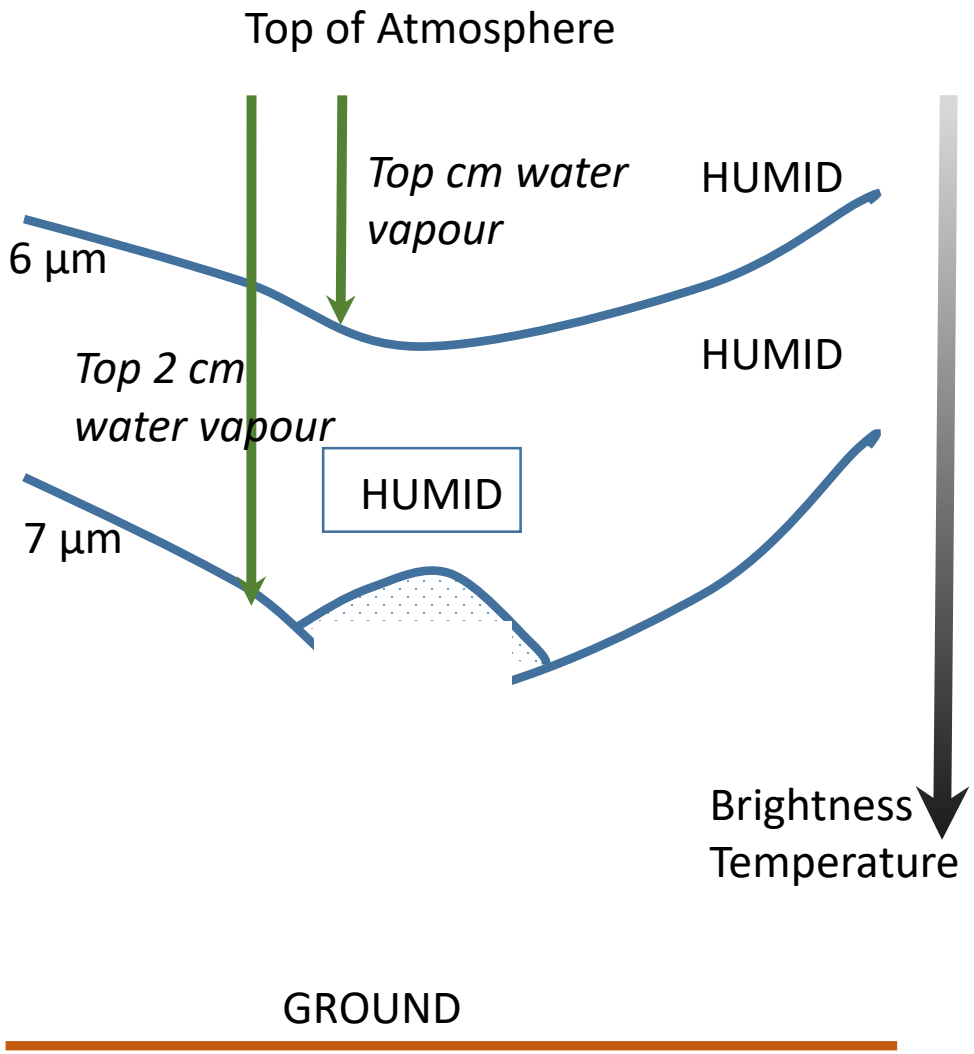
The layer emissivity is also the fraction of radiation absorbed (Kirchhoff)

Absorption reduces the radiation reaching the satellite (when the atmosphere is colder than the ground)

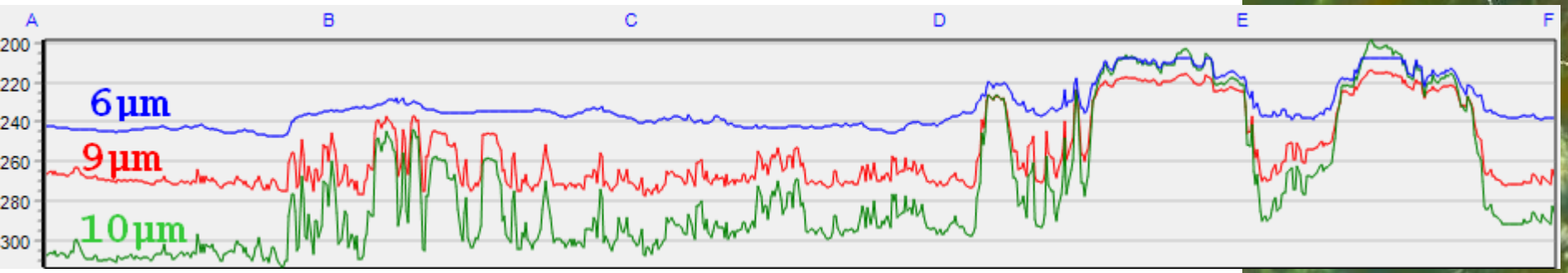
Carved in water vapour



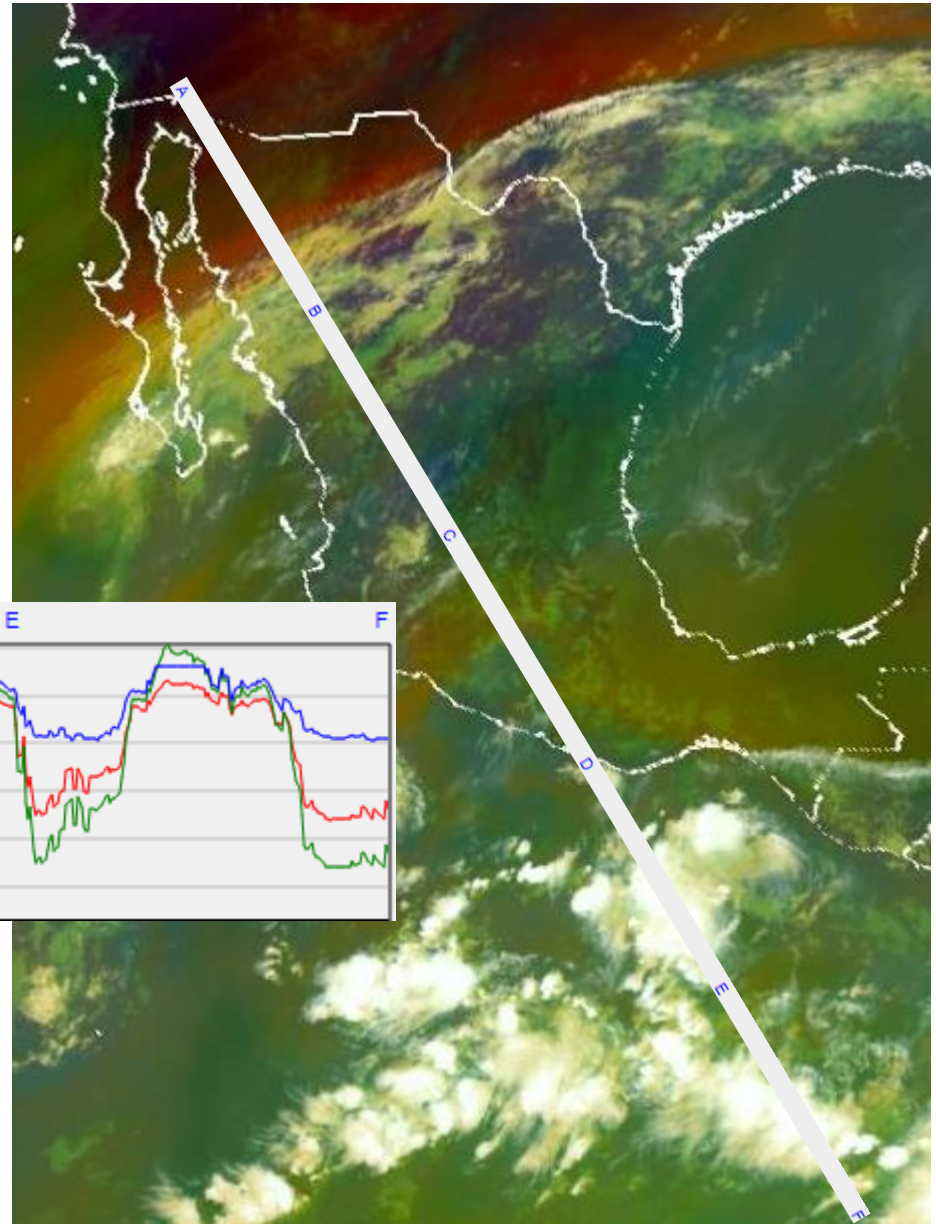
6.2µm (200K-250K) gamma=0.7



AIRMASS ANALYSIS:
standard RGB formula



The crossing of 9µm and 10µm gives the average T of the ozone layer



ABI 6µm-7µm : 9µm-10µm : -6µm

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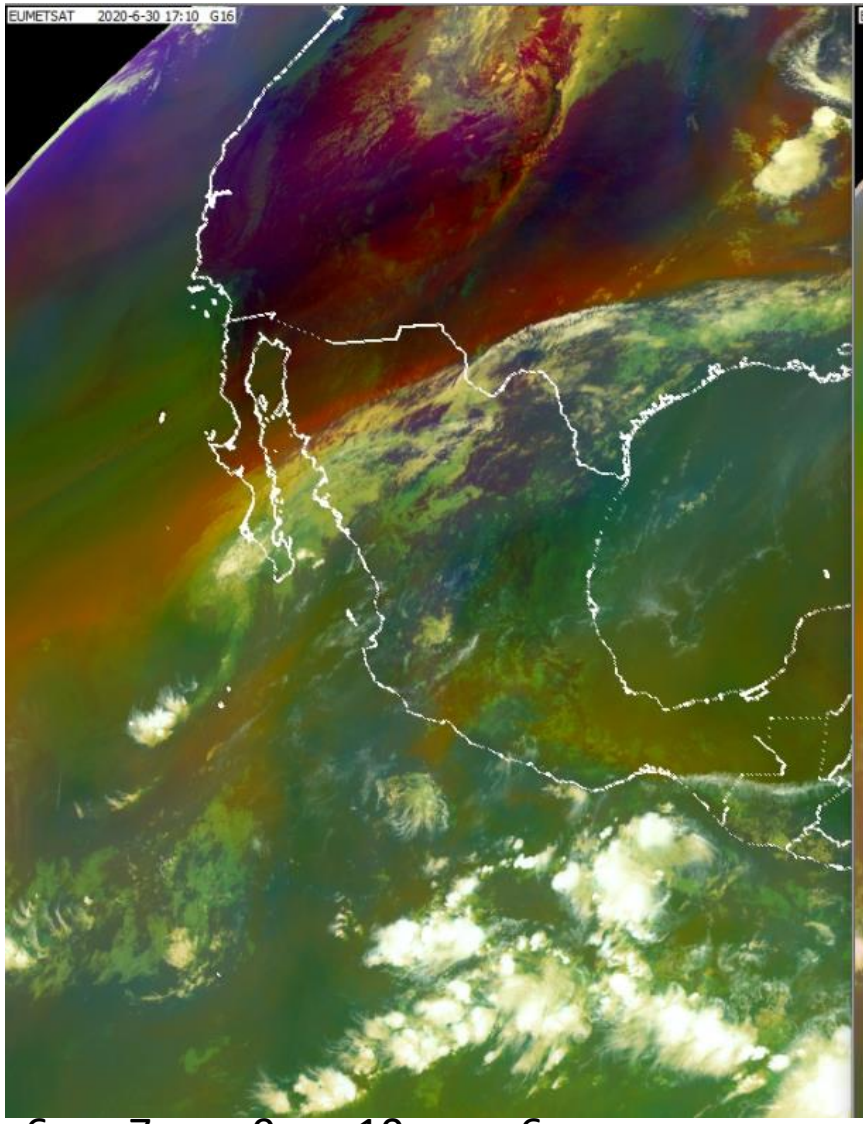
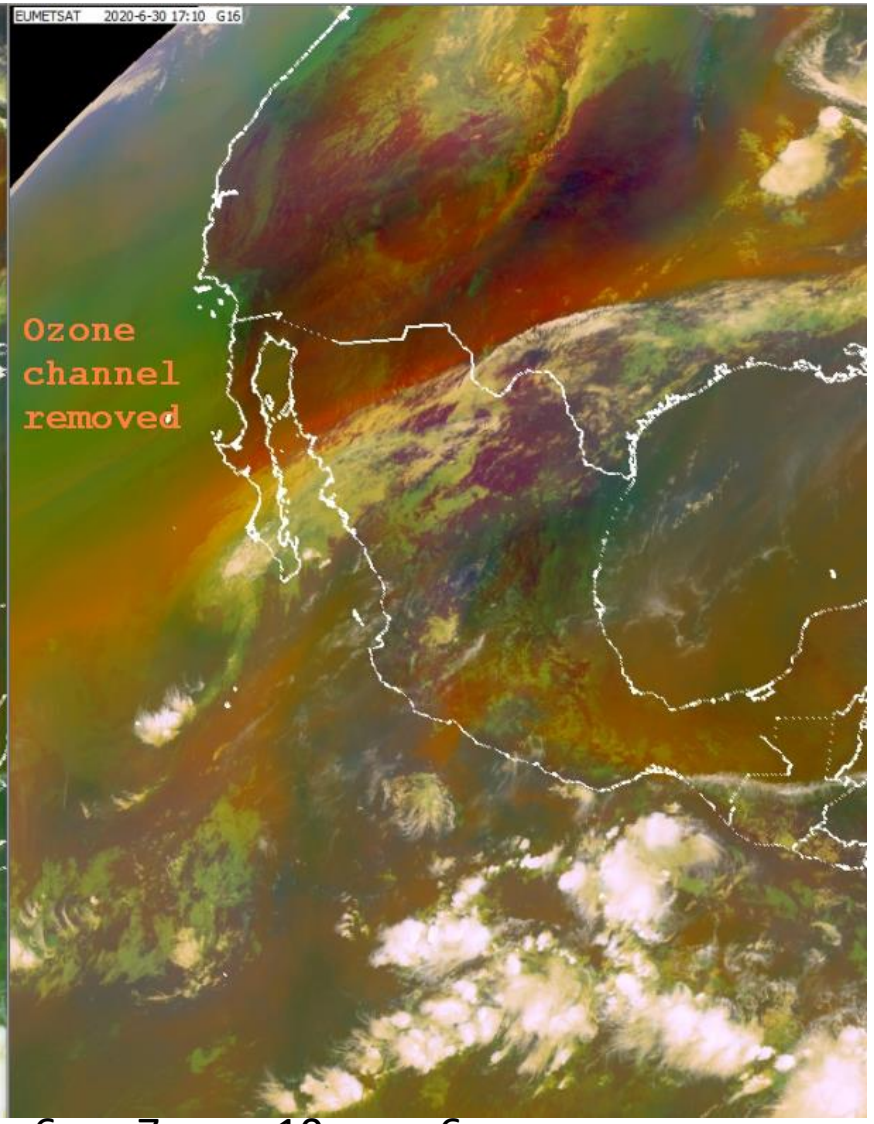
AIRMASS ANALYSIS



6µm-7µm : 9µm-10µm : -6µm

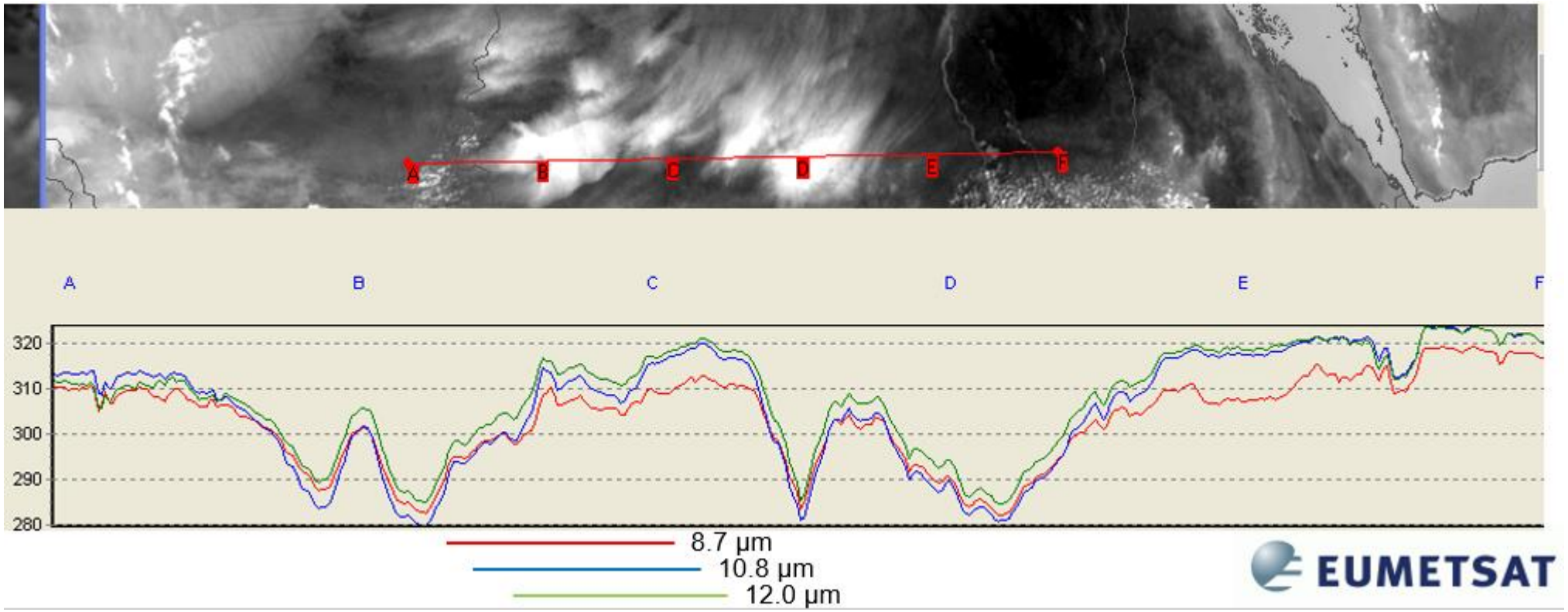


6µm-7µm : -10µm : -6µm

Ozone channel informs about radiative absorption in the ozone layer.
This stratospheric layer is not relevant to weather, and does not warm up if the tropopause folds into the troposphere.
The red beam is a difference between water vapour absorption channels, redder for stratospheric intrusions.

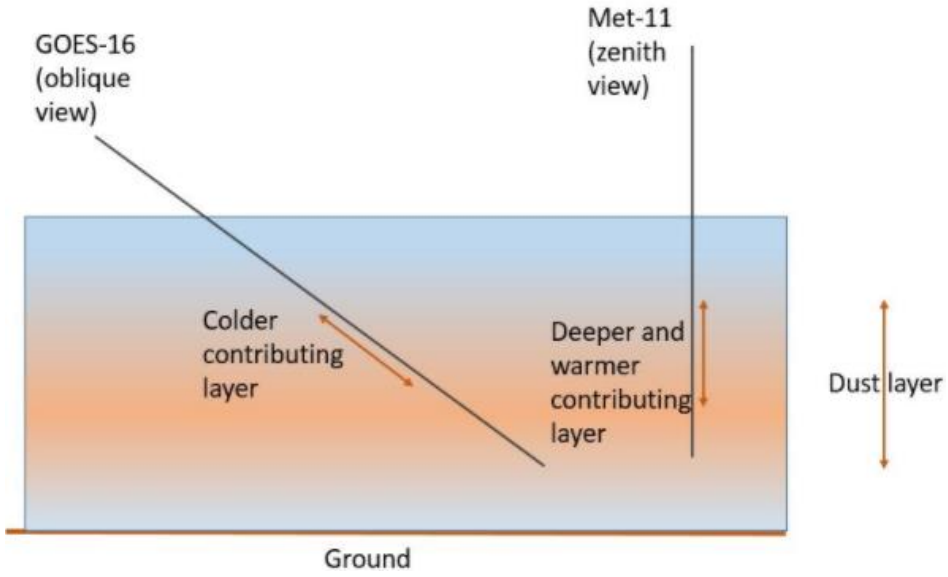
EUMETSAT

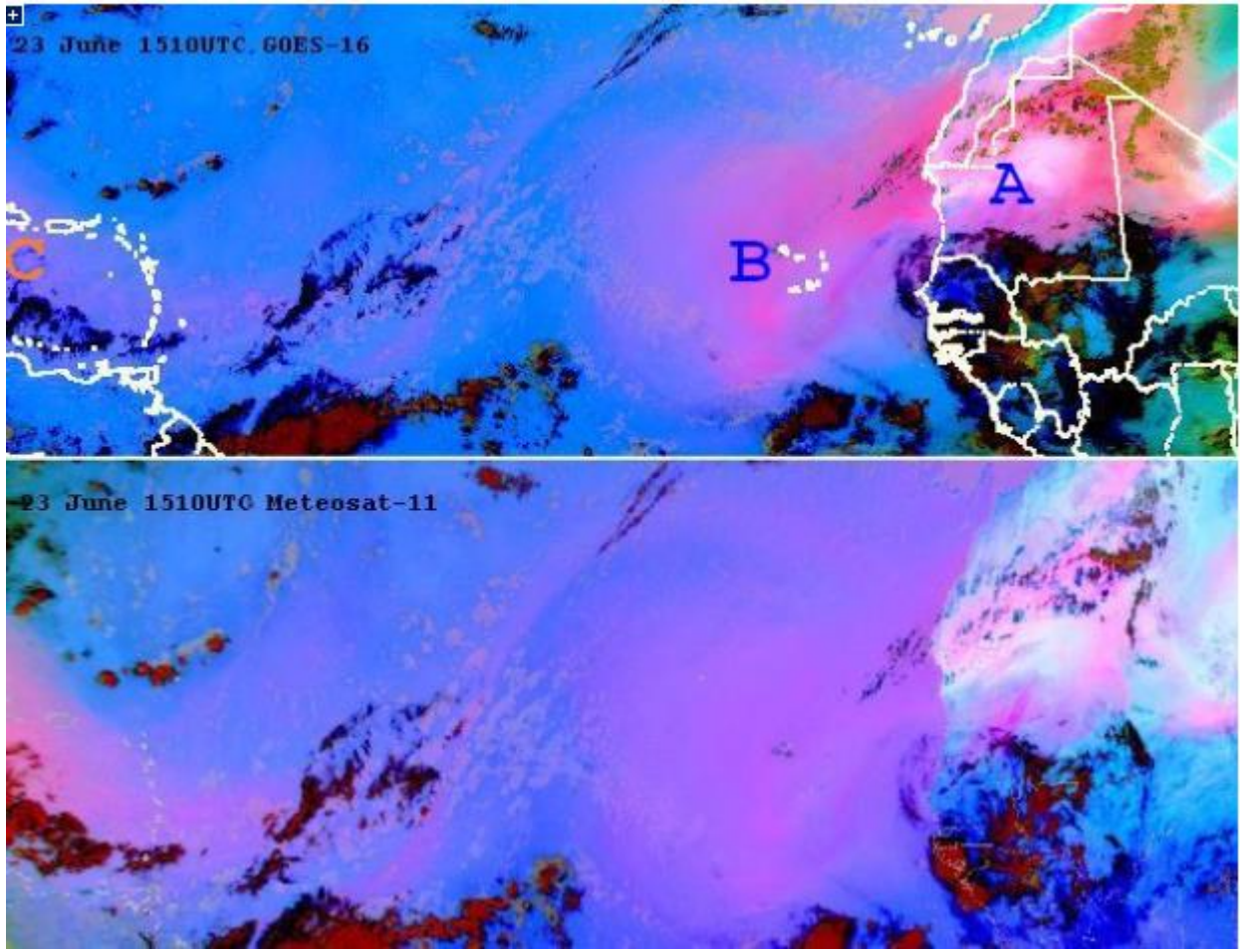
DUST ANALYSIS



Aerosol thermal effect	SOLAR	INFRARED
BACKSCATTER	Cools	Warms
ABSORPTION	Warms	Warms

Dust thickness





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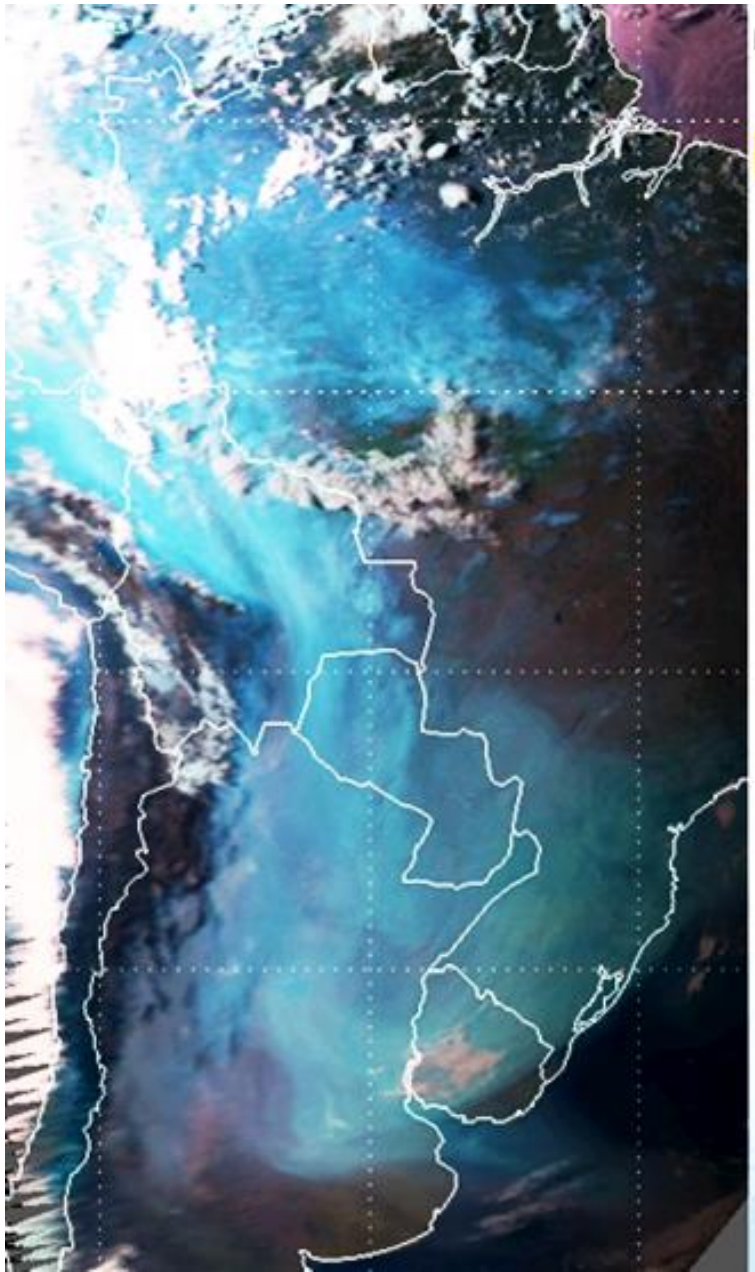
Smoke all over



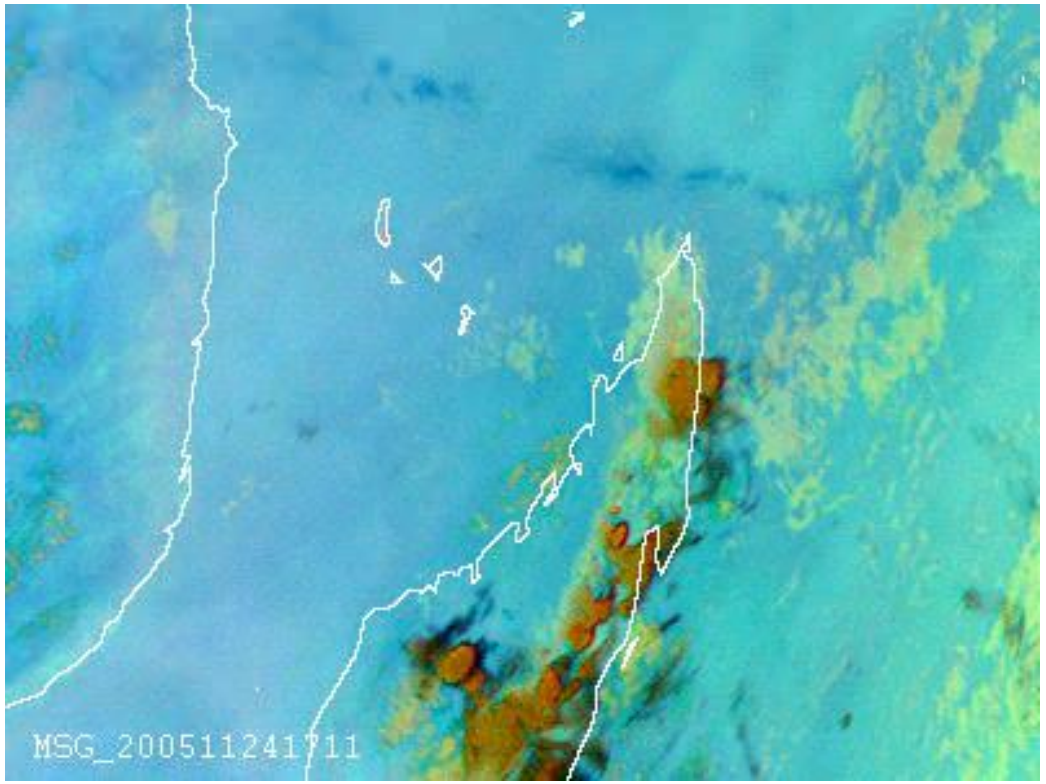
Meteosat9, 2010-08-21 2015 UTC

- Smaller wavelengths favoured by forward scattering
- Blue-cyan colour due to 1.6 µm rather Rayleigh
- Scattering intensity higher in the western late afternoon

EUMETSAT

Gas, ash and cloud

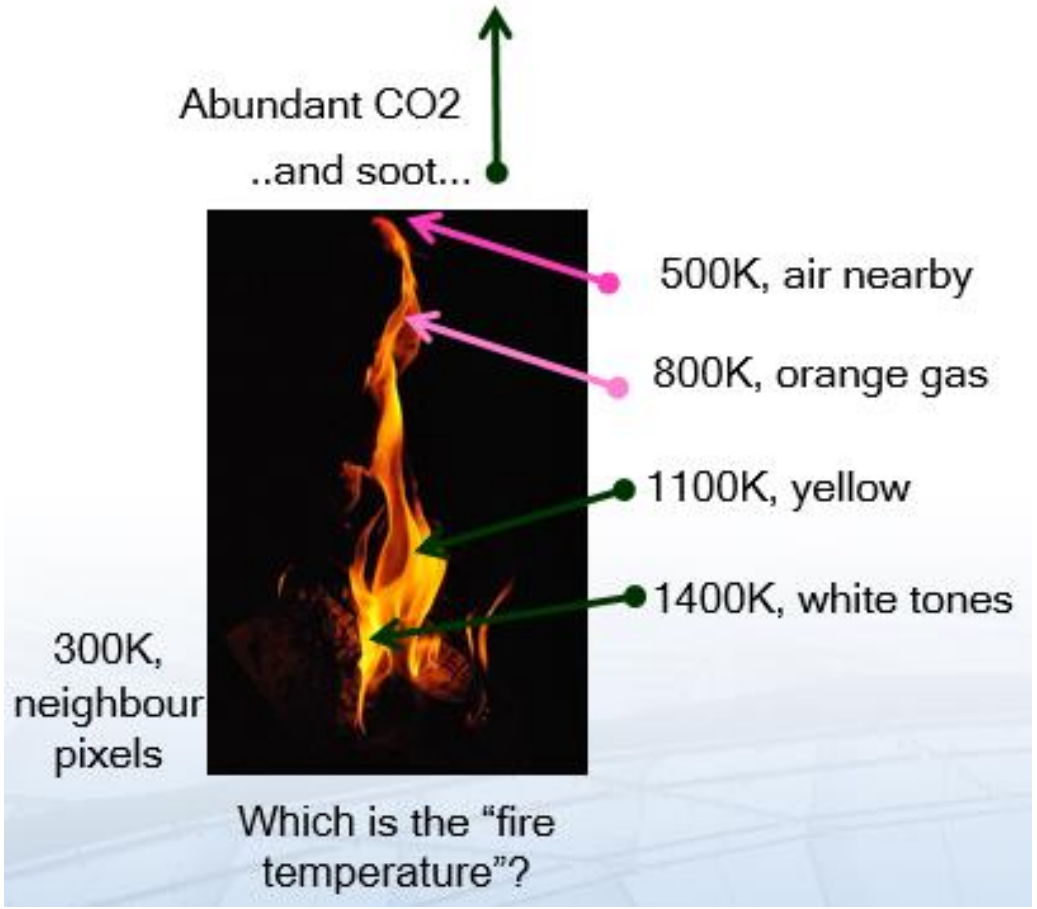
Karthala crater (from Wikipedia)

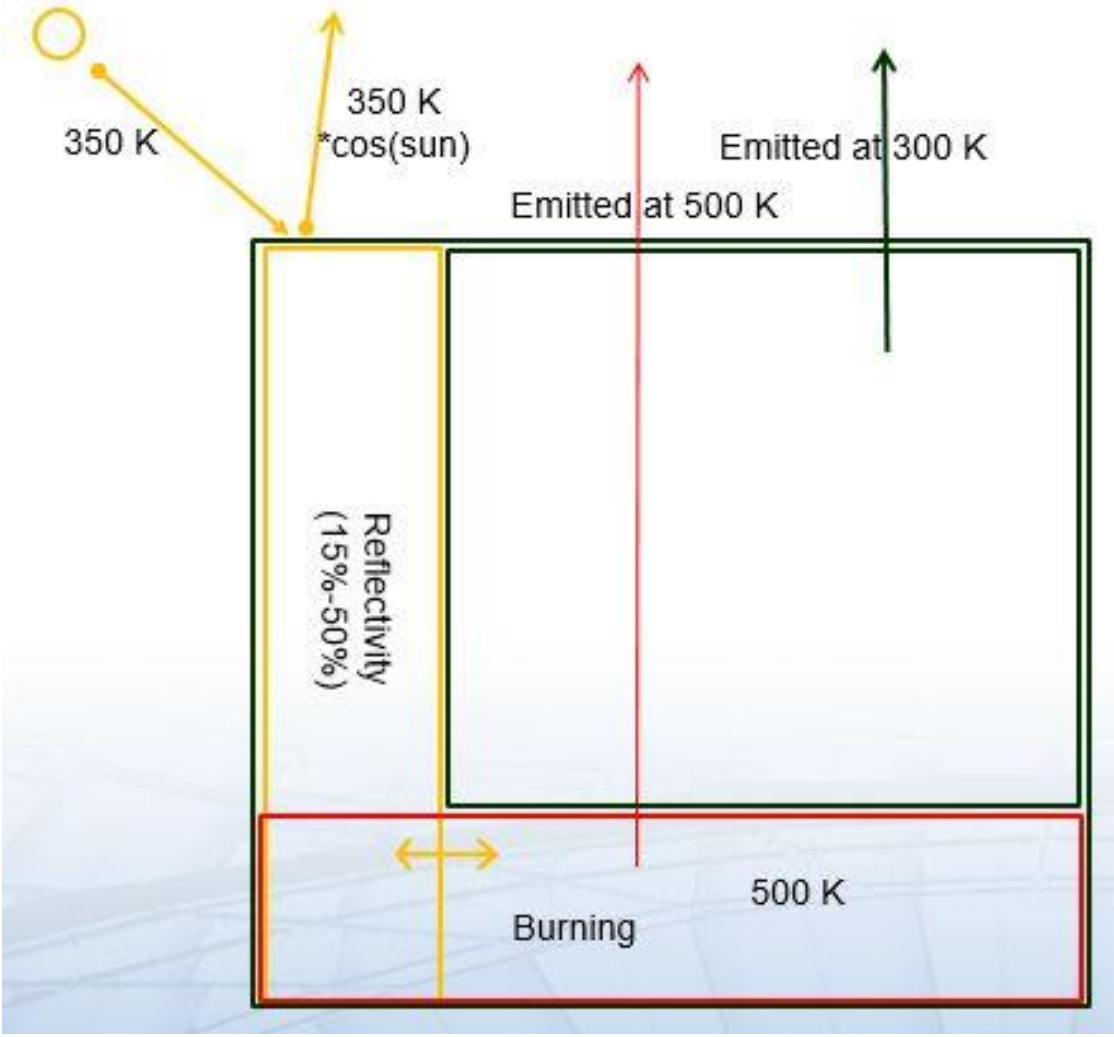


Meteosat-8 infrared-window composite

Which fire temperature do satellites measure?

A flame is gas at high temperatures, but at 3.9µm only ash and CO_2 absorb.





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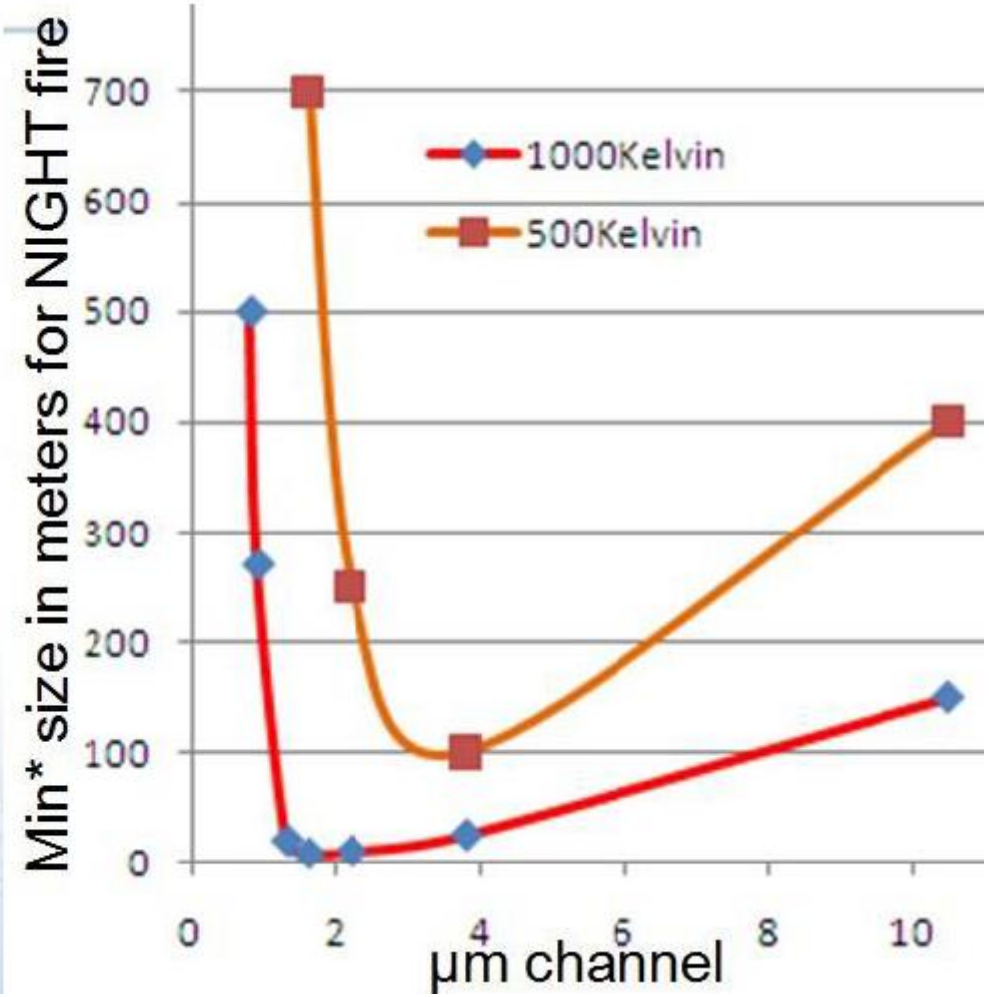
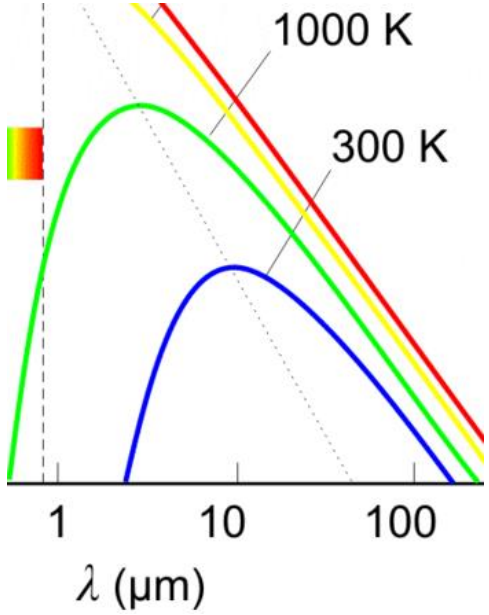
Fire traffic light RGB (sli.do #EUMSC2)E

- A fire at 500K will be sensed, as it grows
- first by 3.9µm(at ~100m)
- second by 2.25µm (250m)
- third by 10.8µm (400m)
- An RGB=(3.9;2.2;10.8) might be a good indicator for severity of a fire.
- For a hotter fire (1000K), typically gas flares, channels in the solar domain react faster than 3.9µm

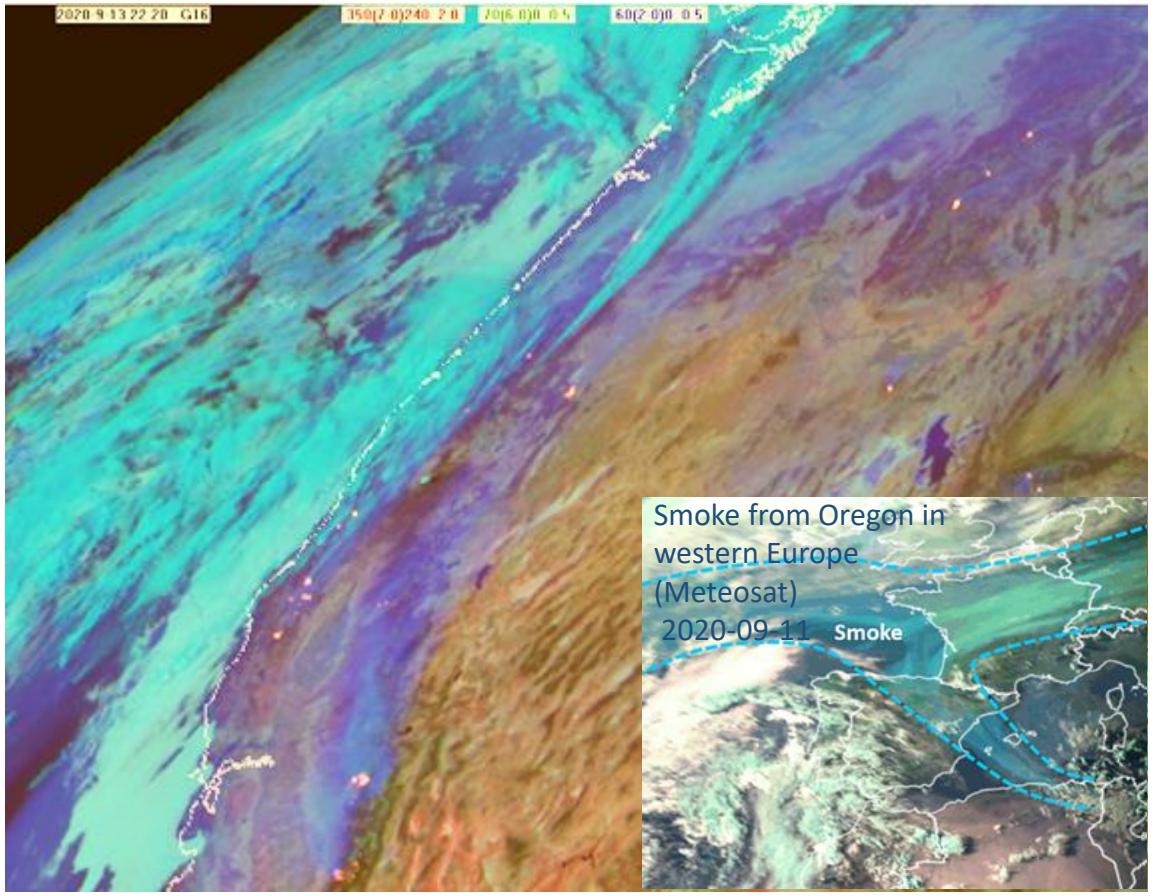


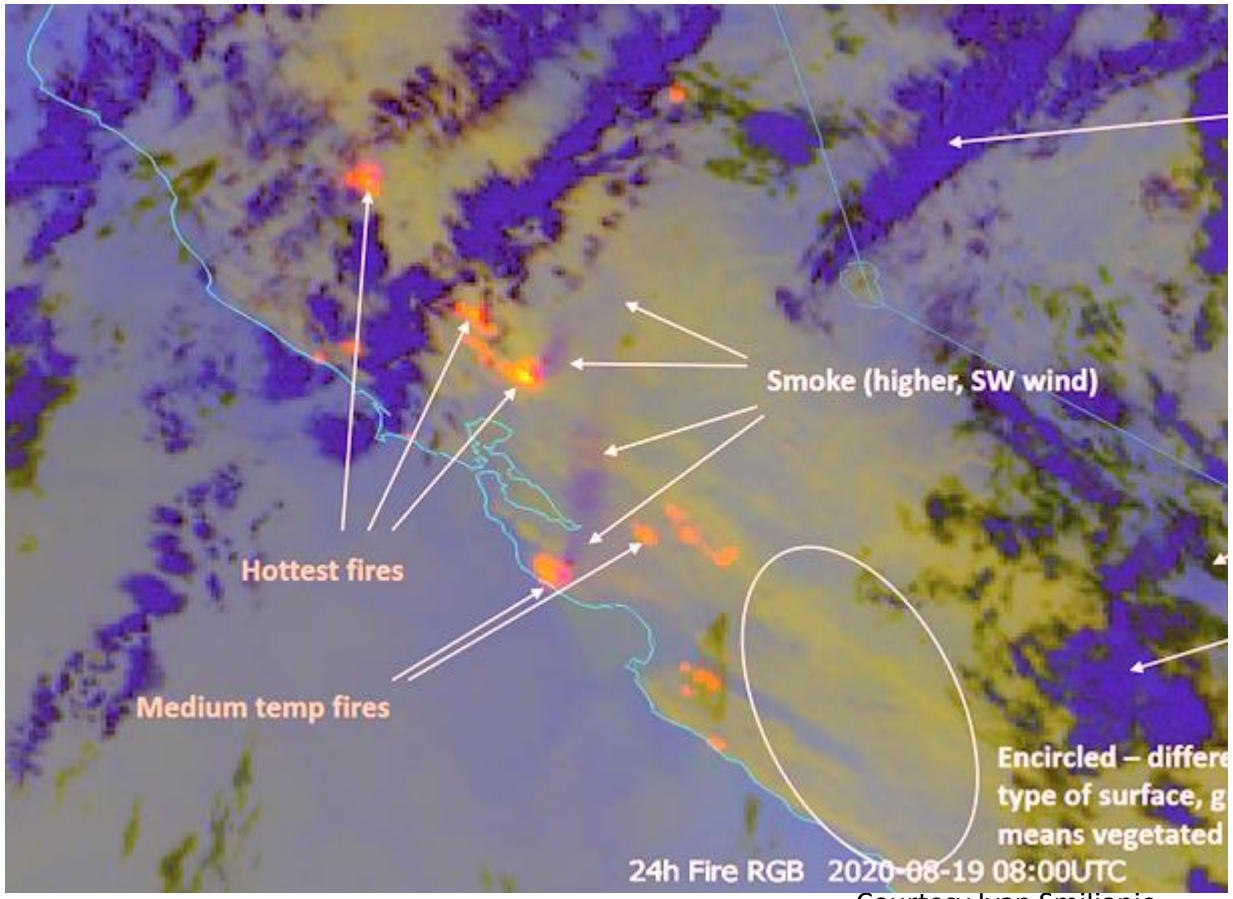


"Fire temperature" will be shown best at the Wien-wavelength:
higher intensity fires also show on solar channels (night)

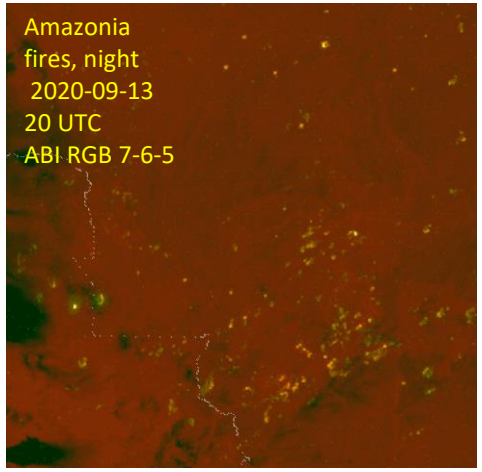
Big blazes as hotspots and smoke in solar or infrared channels

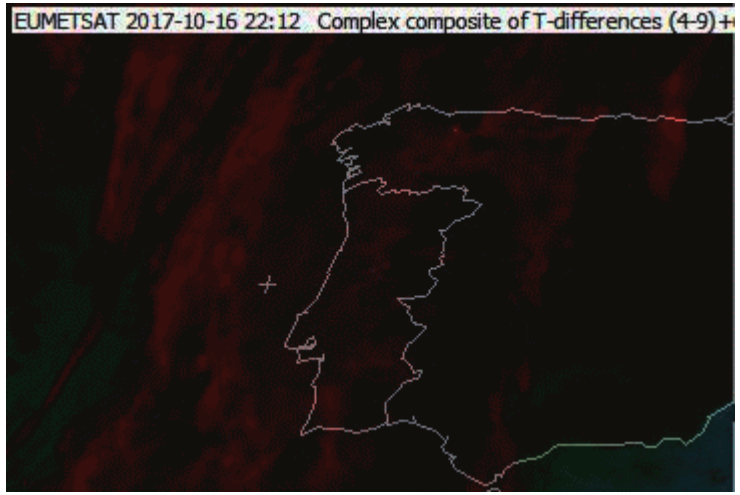
	SOLAR	INFRARED
DAY	Smoke	(Smoke) and (Hotspots)
NIGHT	**Very Hot**spots	Hotspots



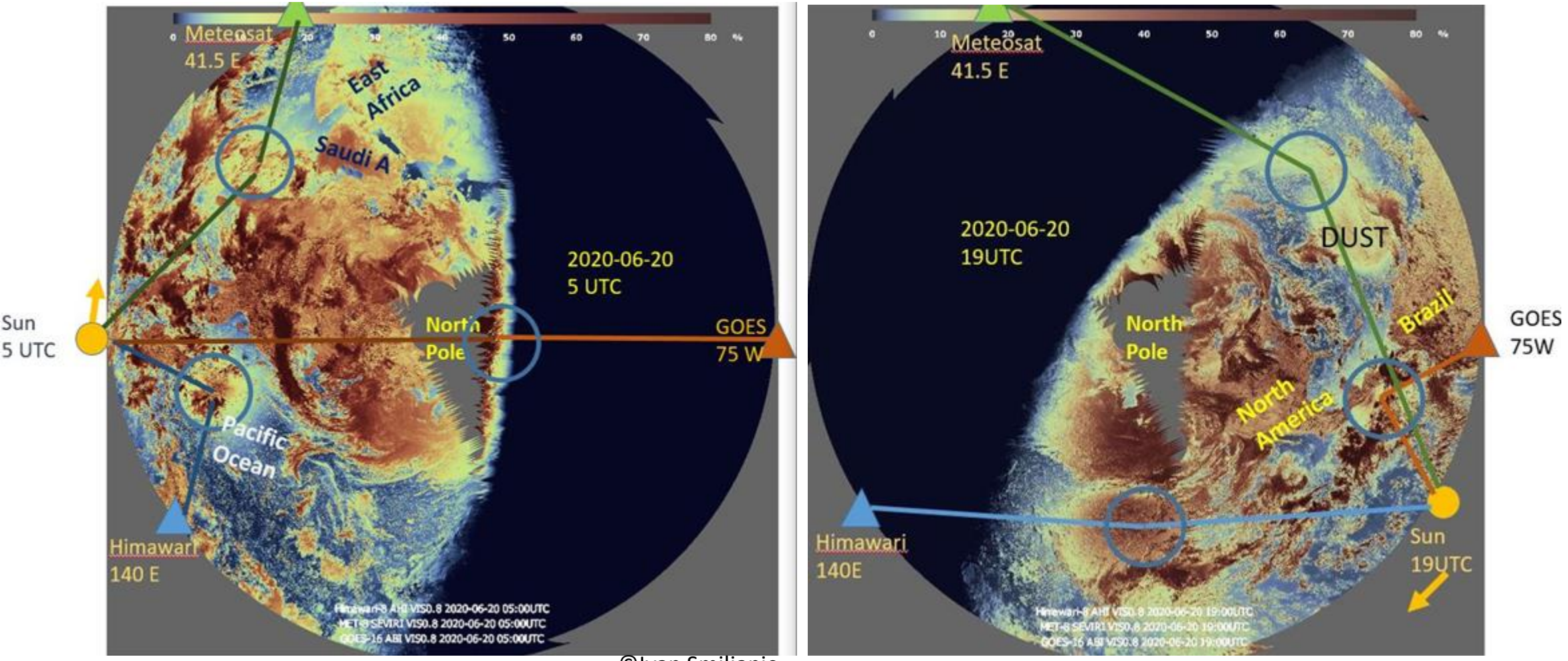


Courtesy Ivan Smiljanic





Sunglint



©Ivan Smiljanic

Sunglint causes false alarms in fire detection algorithms
Sunglint increases the apparent cloud reflectivity
Forward Sunglint is stronger than backward
Applications: sea ice, sea roughness, wave fields, stratus, haze and dust detection

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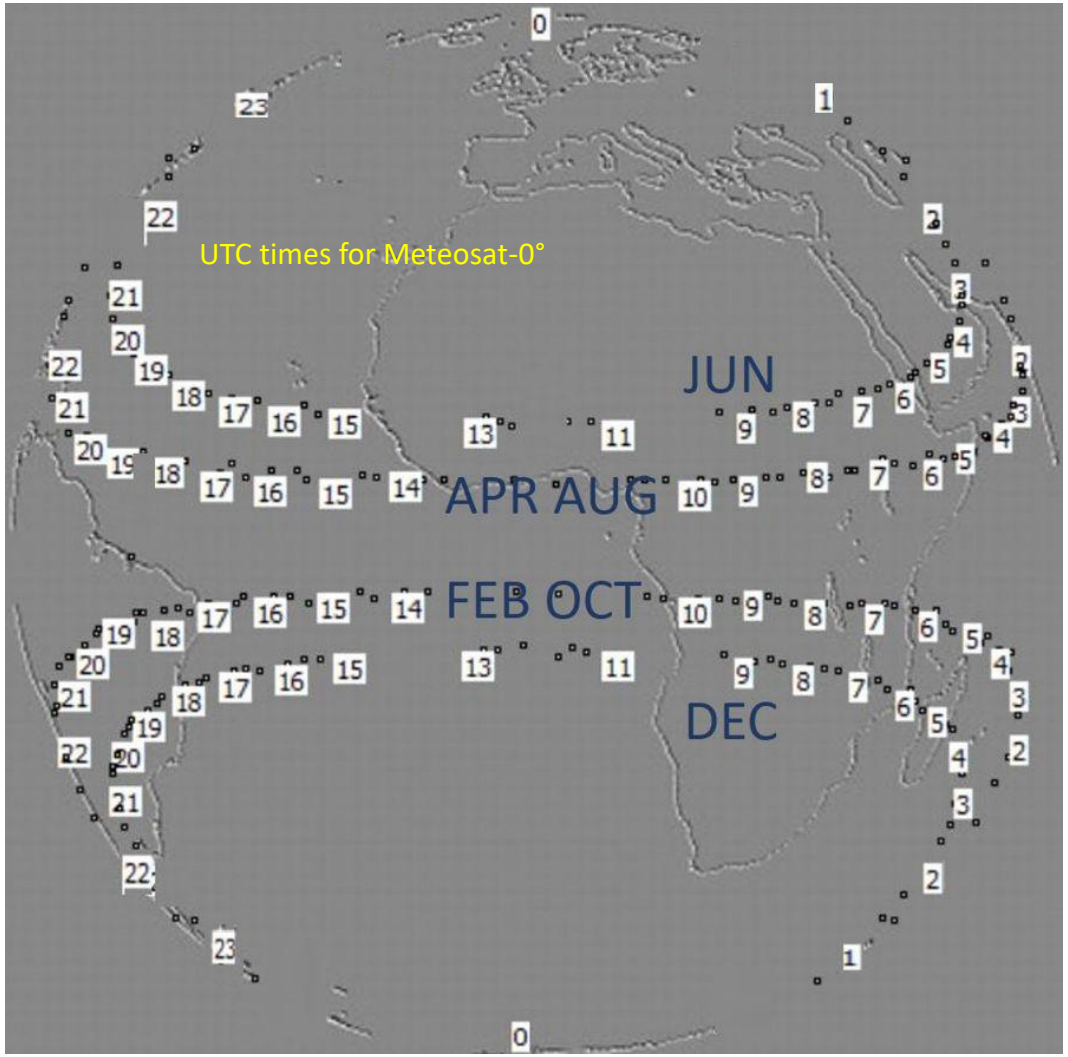
Sunglint calendar



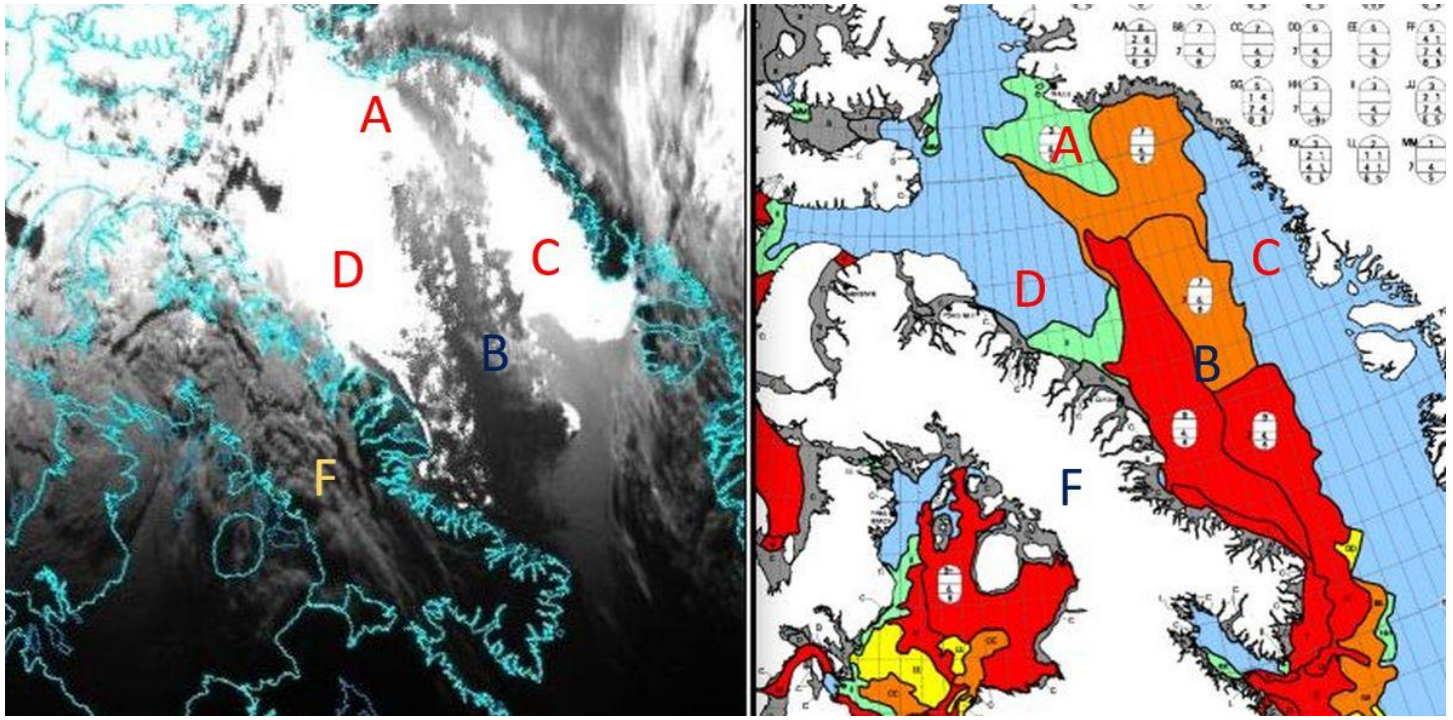
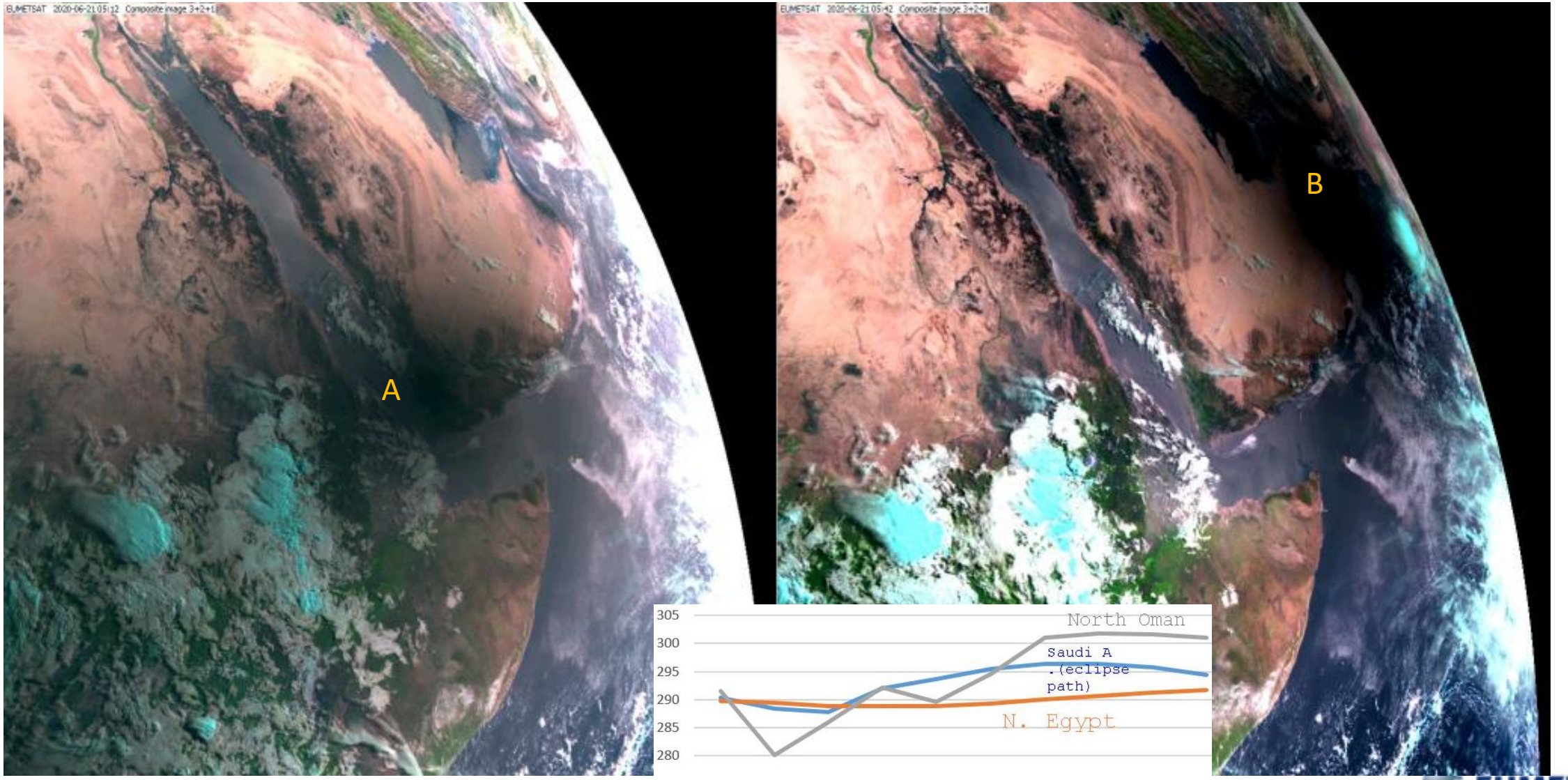


Figure 3: Comparison of GOES-16 ABI 0.8µm at 05:10UTC (left) with the ice concentration product of the Government of Canada (right) for 21 June 2020. Areas D and C show an anomalous liquid condition, whereas B is thick ice, not responsive to the sunglint geometry at that time. Quiet liquid surfaces offer perfect conditions for specular reflection of the mid-night sun at Baffin bay. Area B is thick ice, lacking flatness. F is similarly icy land, not regular for good reflection. Area A is of 10% ice concentration, which keeps it reflecting under both sunglint conditions and under normal illumination.

Moon eclipses sunglint

21-june-2020
0510 UTC-0540 UTC



Parallax

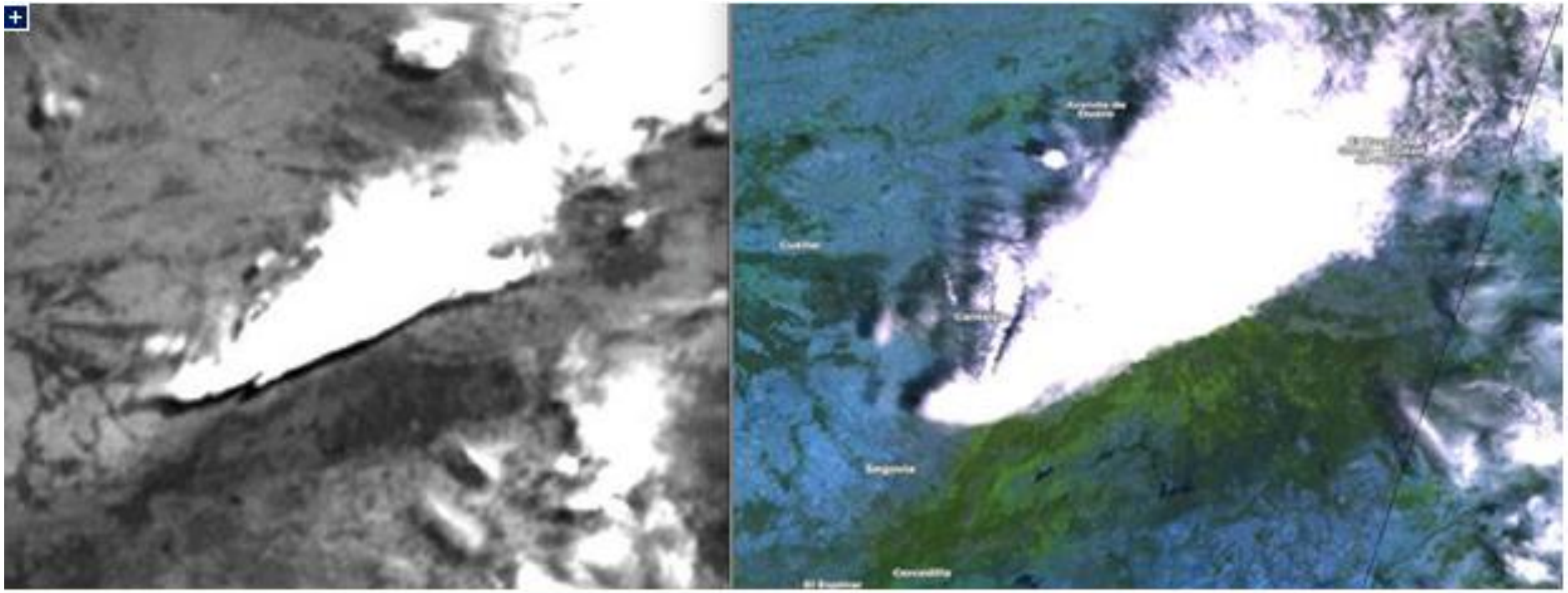


Figure 3: Meteosat-11 (left hand side) and Sentinel-3 (right) views on the same cloud system over central Spain, 27 June 11:00 UTC. Meteosat shows dark pixels south, Sentinel OLCI instrument north-west of the cloud.

- Cloud is projected off the sub-satellite point
- Vertical collocation: Storm follow-up, radar or lightning comparison, GIS.
- One- or two-satellite height retrievals and anaglyphs

www.eumetsat.int

- Viewer:

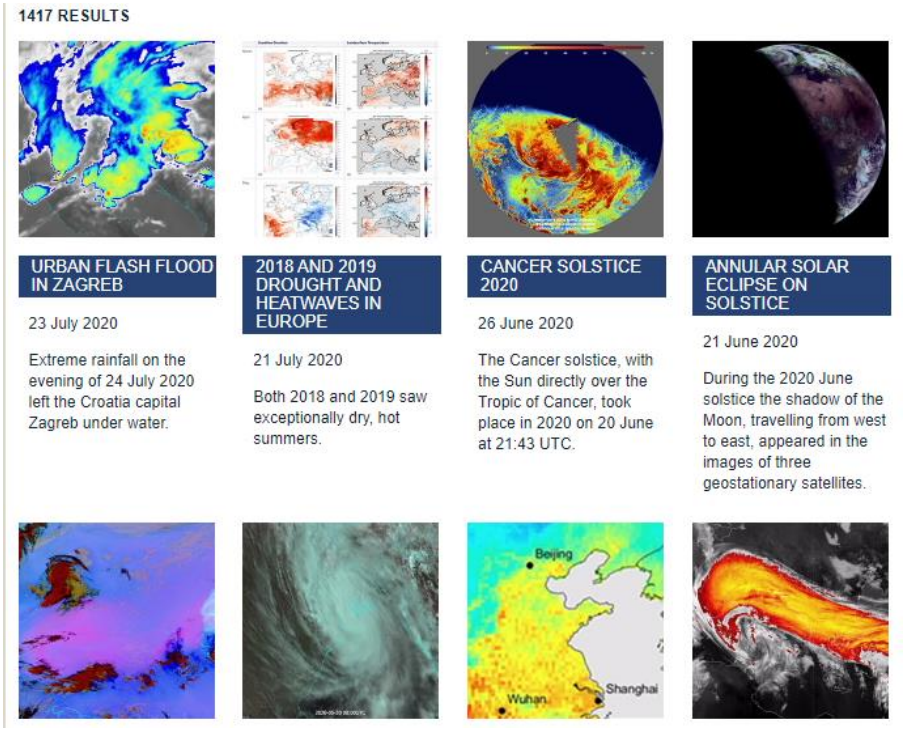
https://eumetview.eumetsat.int

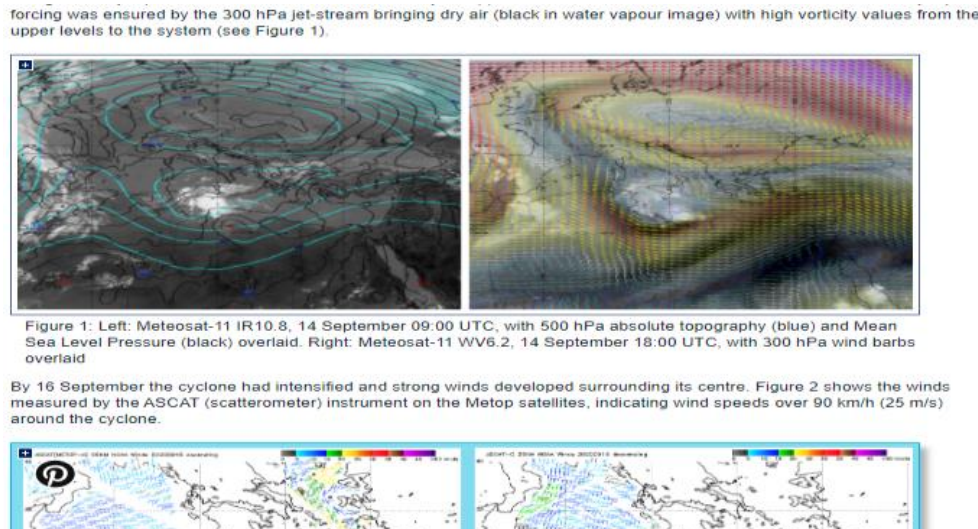
- Cases:

https://www.eumetsat.int/website/home/Images/ImageLibrary/index.html

- Product navigator:

https://navigator.eumetsat.int/start





Thank you!

“Do you have any question for my usual answers?”

(H Kissinger to journalists)

jose.prieto@eumetsat.int

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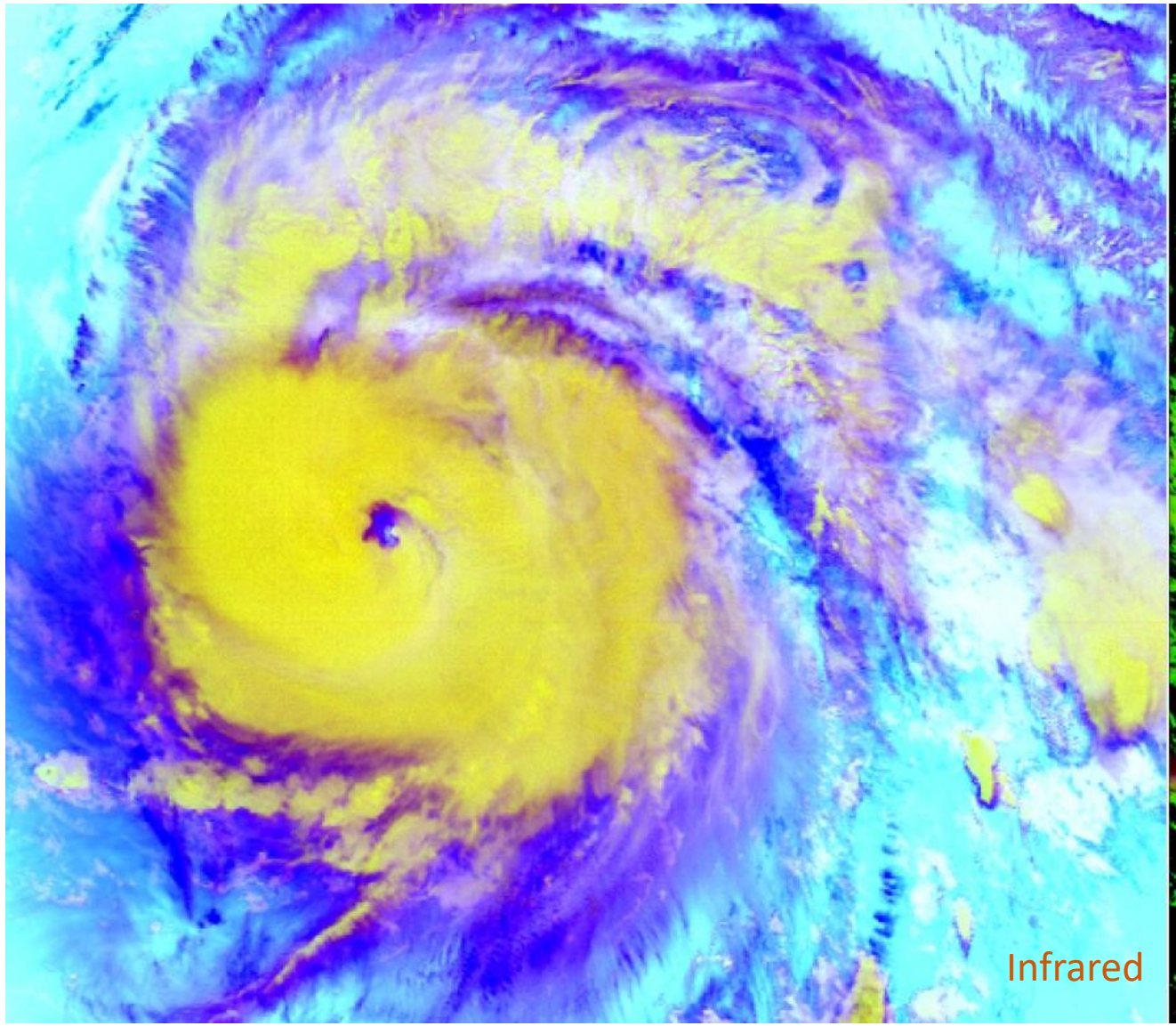
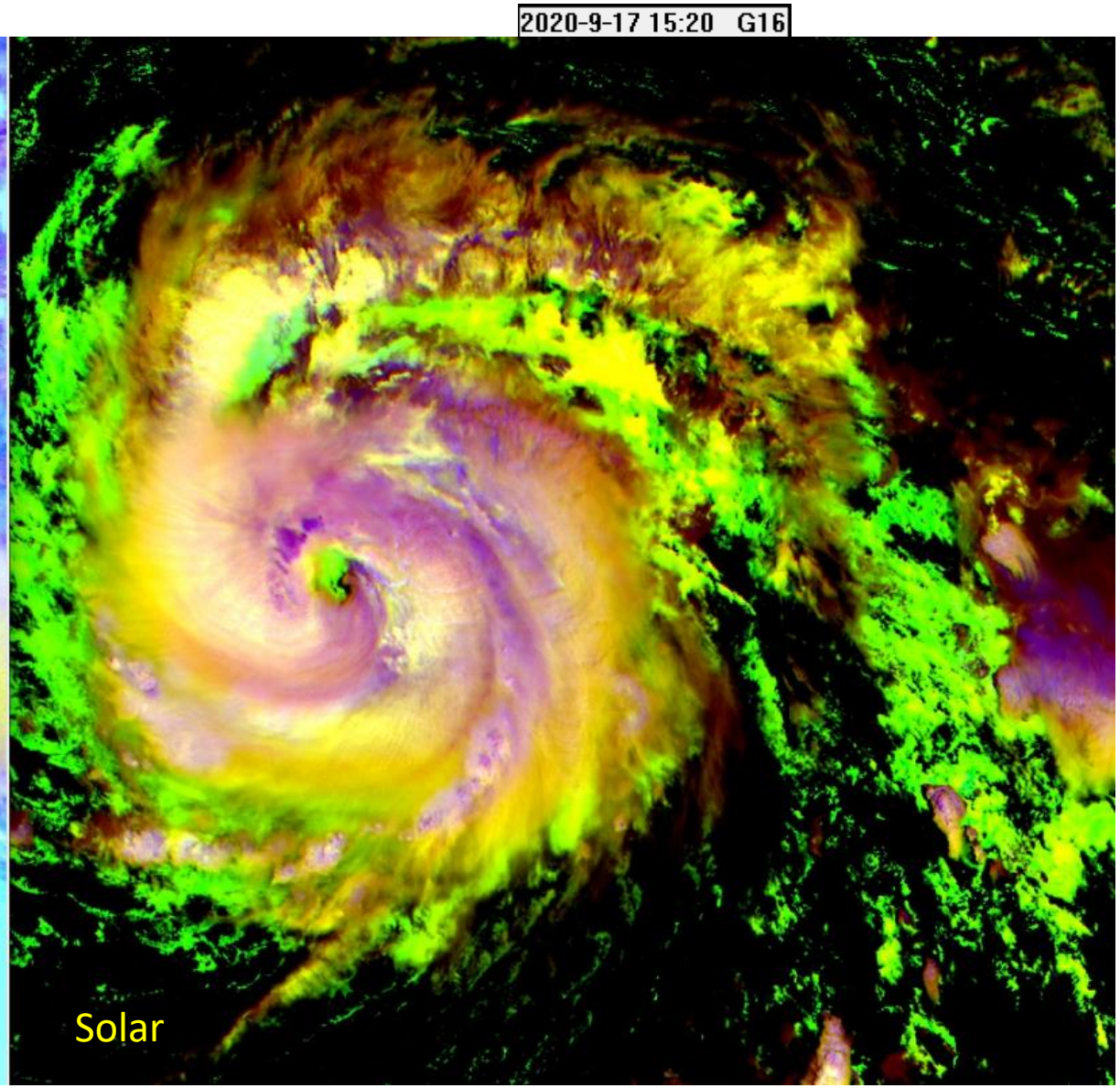
Discovery

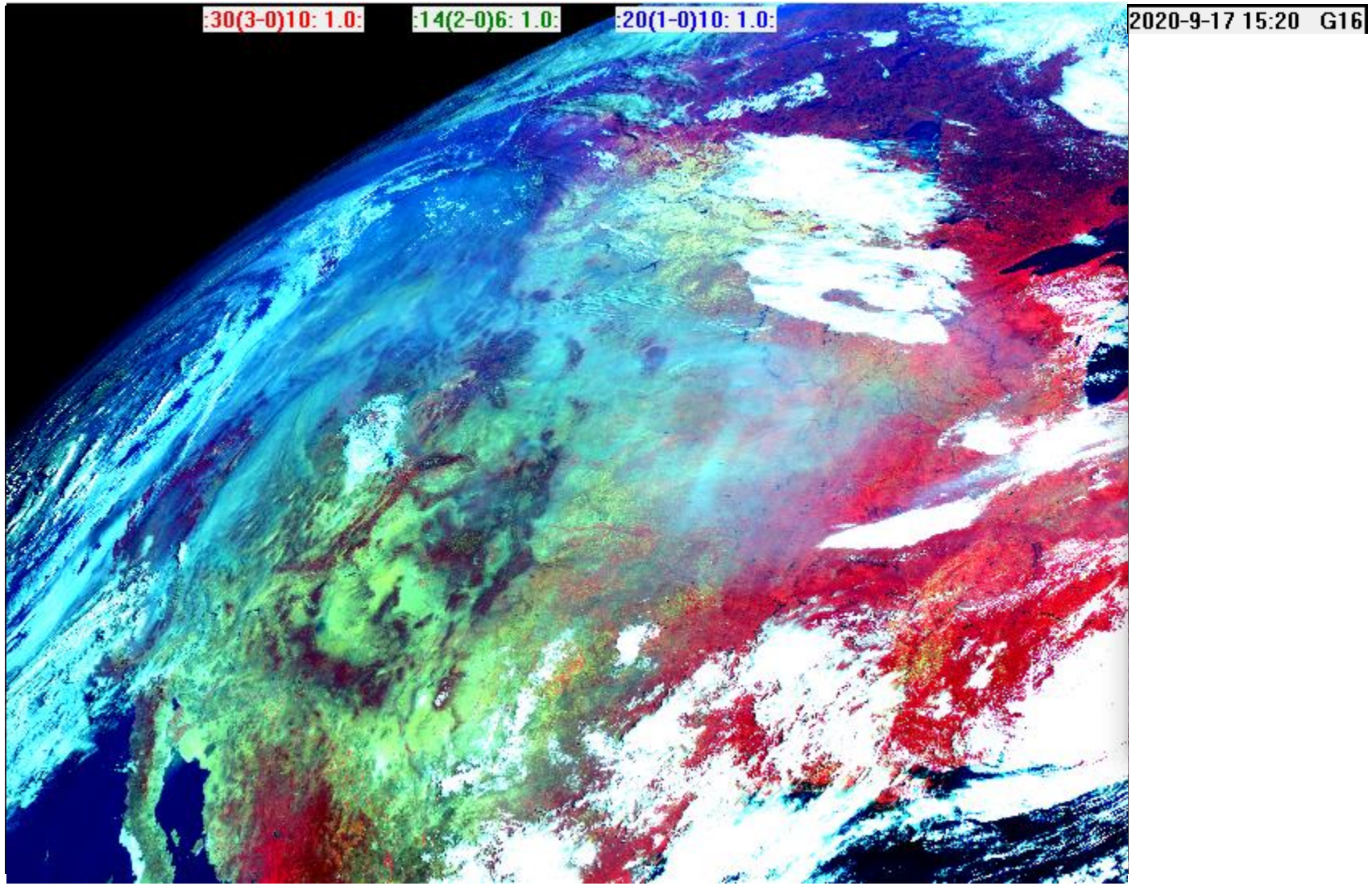
- A travel beyond standards for cloud and land surfaces.

Enhancing RGB, for focus on hurricane: narrow the range

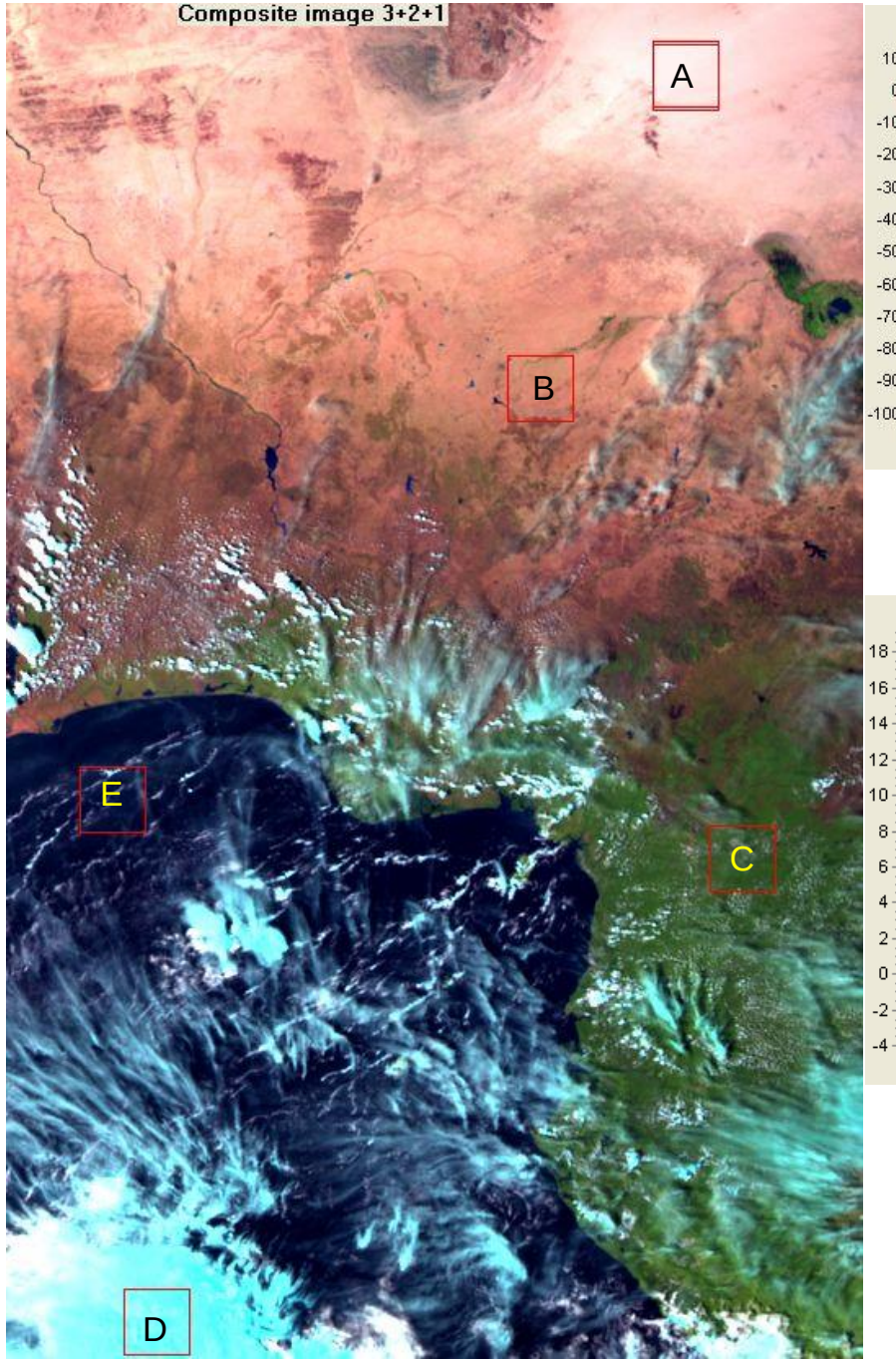


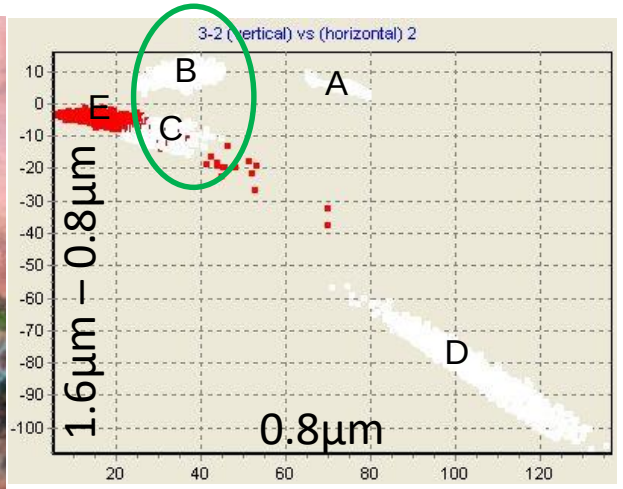


Enhancing RGB, for smoke detection: centre on low values

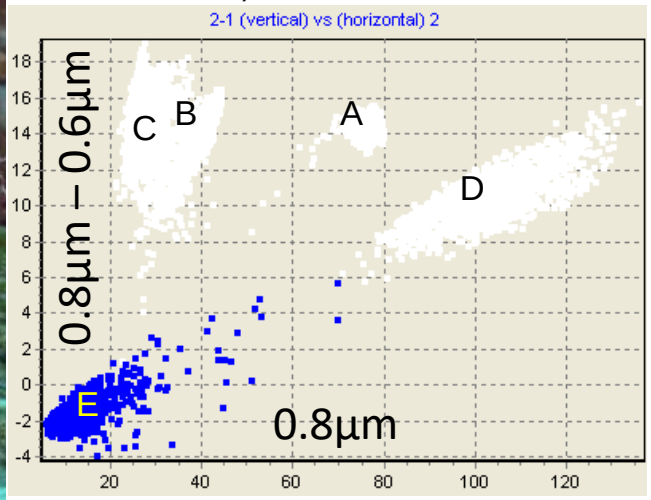


Images or numbers, use them all





Now, 2-1 in vertical



Channel 1.6µm reflects better than 0.8µm on dry ground (B), but worse in vegetated areas (C)

Red Green Blue

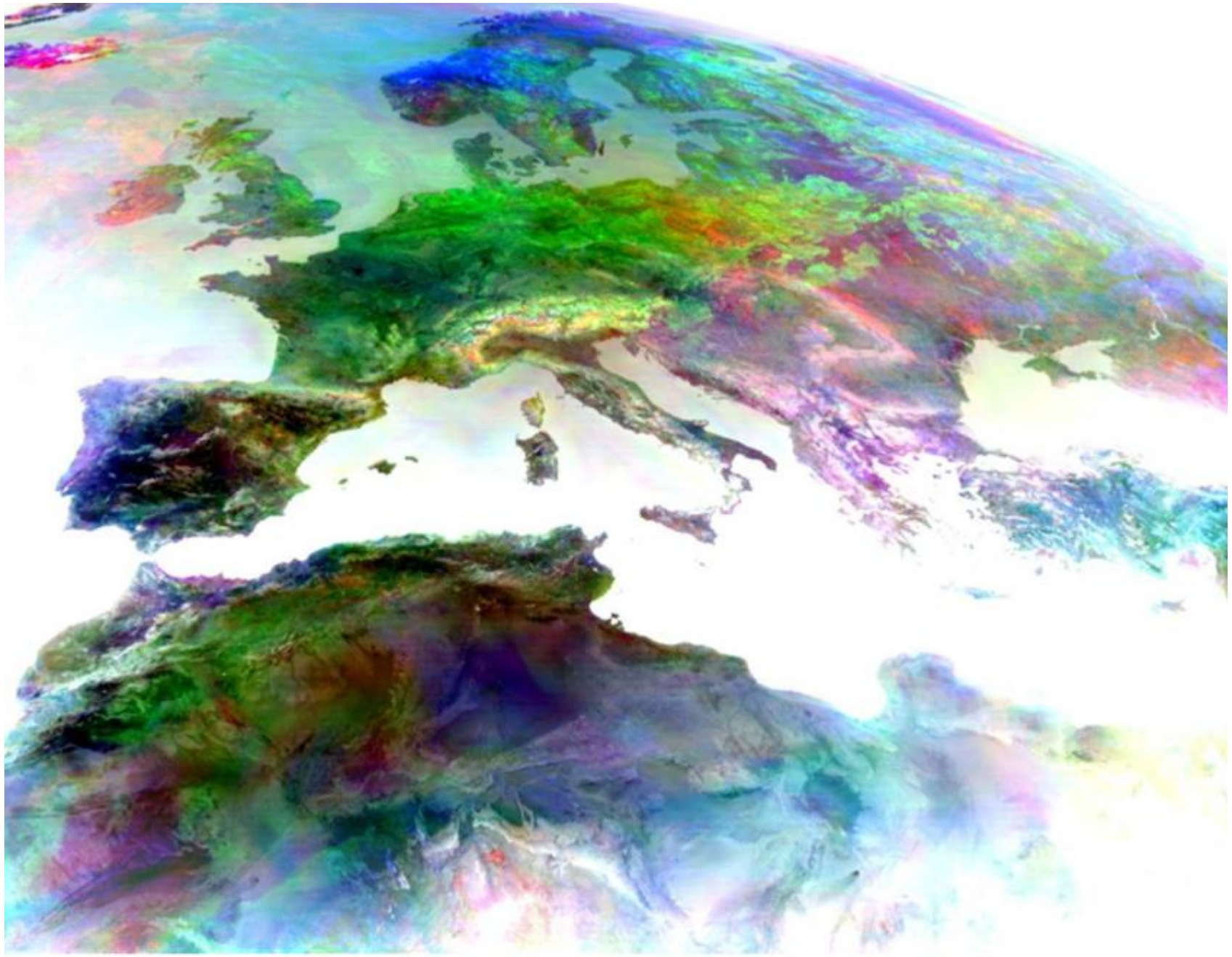
1) Satellite counts
2) PC combines images
3) Eyes-brain creates colour

TV: light-emitting diodes make up colour.

RGB had a slow adoption in meteorology:
K.-G. Karlsson (AVHRR)
C. Sahin (Meteosat-1st),
J.Kerkmann, D.Rosenfeld,
HP Roesli,… (MSG from 2003)

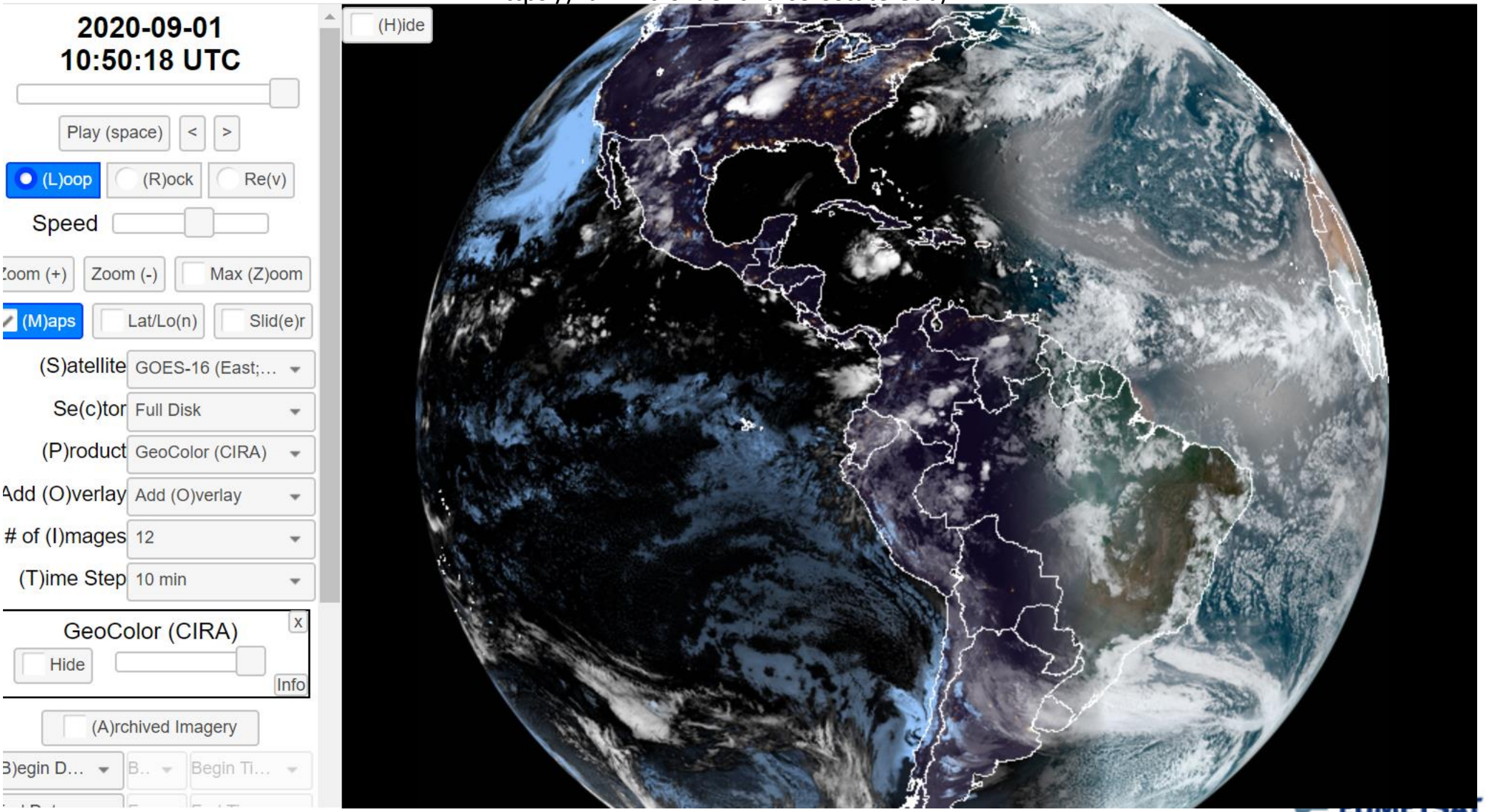
- Principal components
- products' RGB (temperature, humidity, sunshine)
- Temporal,…

Eumetview Rammb CIRA slider



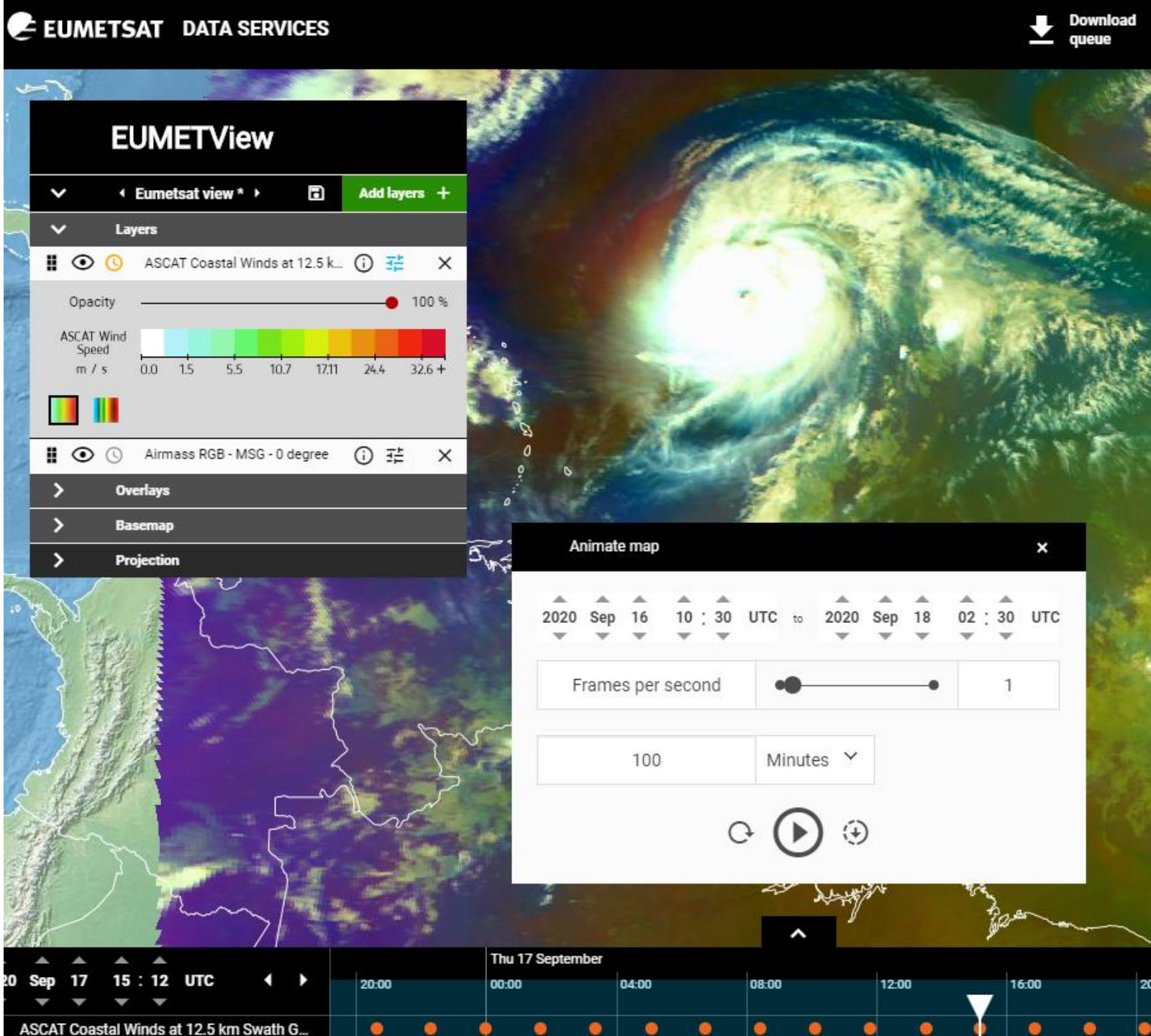
Brightness Temperature Evolution RGB, 24 June-28 July, daily at 13:45 UTC

https://rammb-slider.cira.colostate.edu/

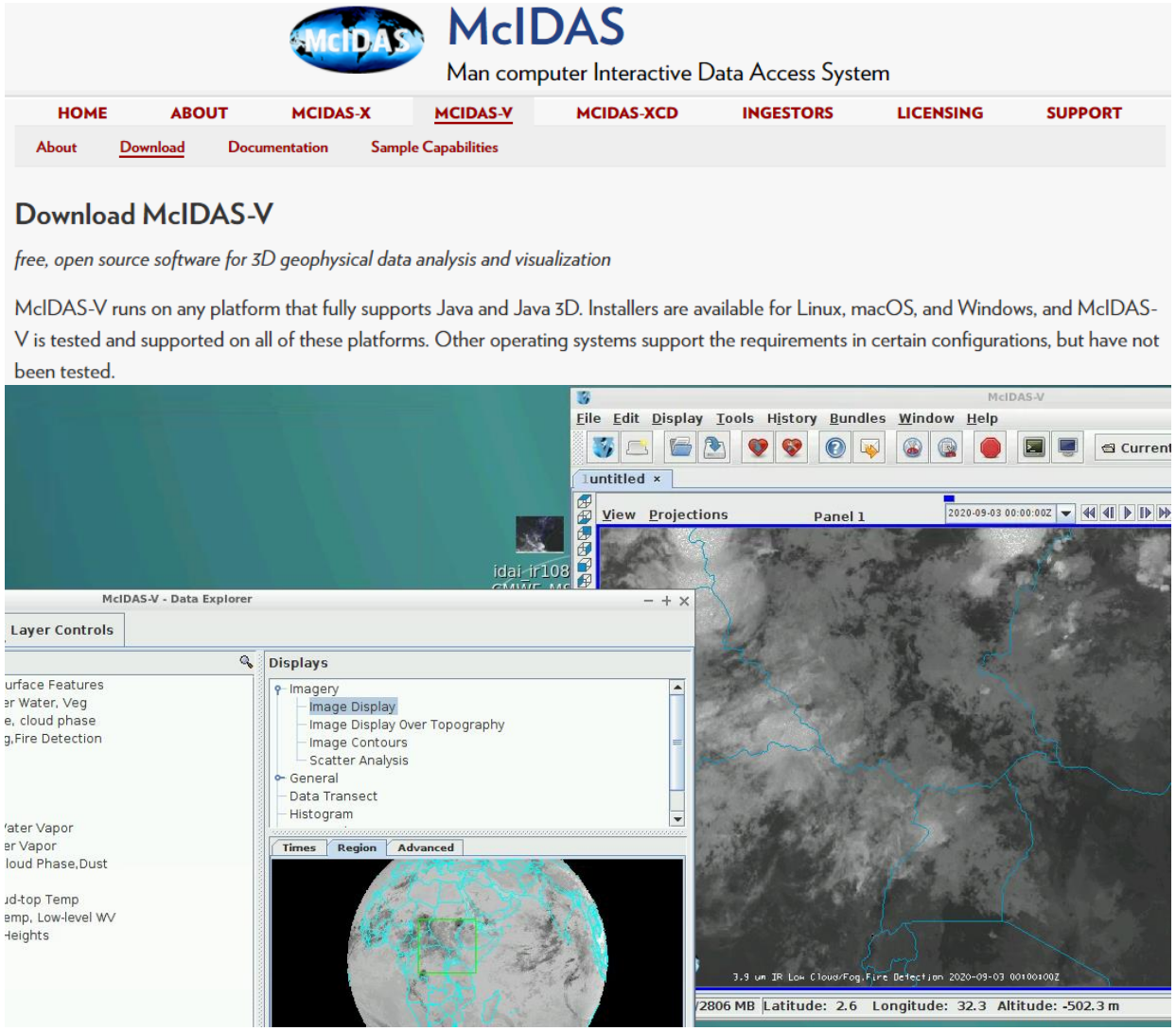


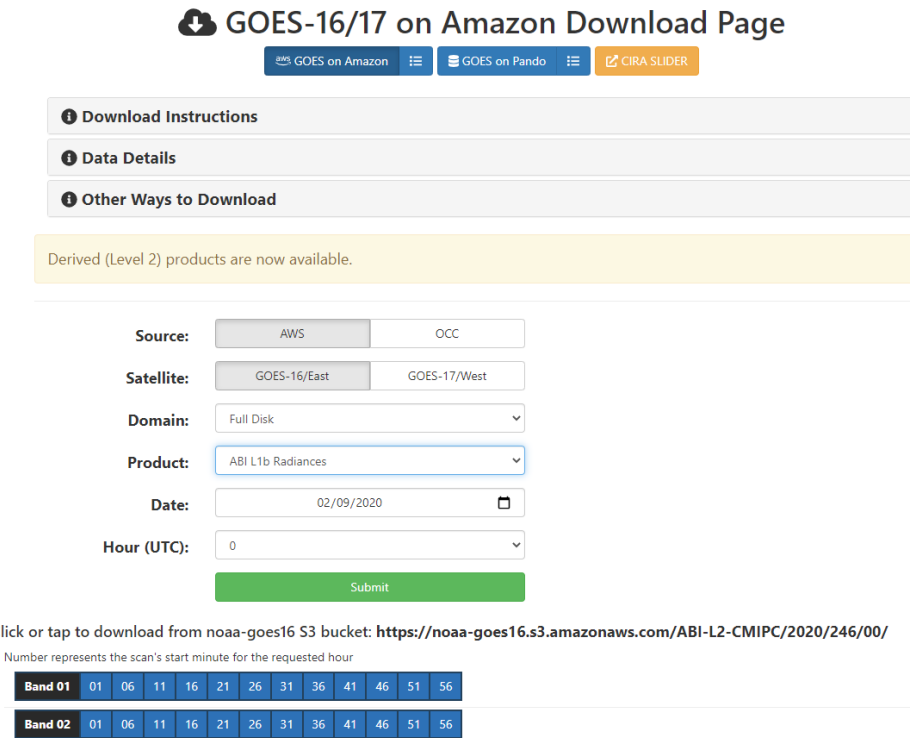
EUMETSAT map viewer

view.eumetsat.int



Tools and data sources





jh.herk@gmail.com (Jorge Bravo)

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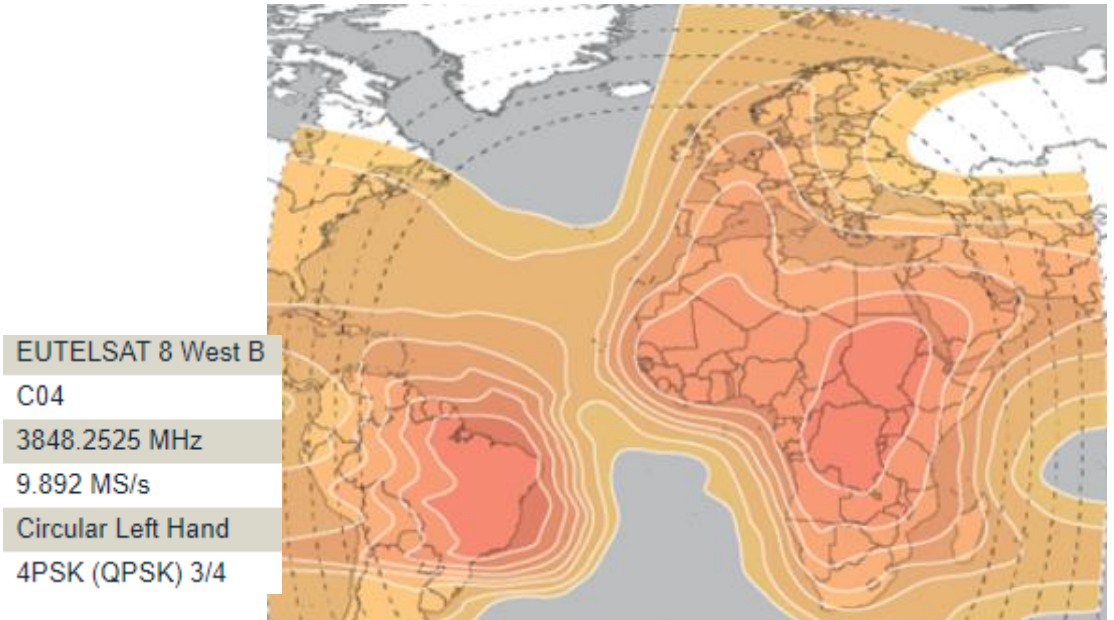
EUMETCast, based on Digital Video Broadcast for real-time access to the data

- Direct reception from telecomm satellites
- No data jamming, unlike internet
- Imagery from Meteosat, Metop, ABI (main channels)…
- Satellite application facilities: products
- For free



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