



1 / 7 NORTHERN CALIFORNIA WILDFIRES, AUGUST 2020

2020-08-19 Sentinel-3

A light on **heat**

What radiation tells about air,  
soil, fire and water

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# Expectation meets plan

agriculture  
harvest  
engineer  
sky  
fire  
light  
eumetsat  
soil  
satellite  
forecasting  
image

Sounder imager  
orbit sun-synchronous  
surface  
absorption  
radiation  
temperature satellite  
ice Lightning  
fire  
sun-glint  
measure eclipse forward-  
scattering trust meteorology  
Dust water co2  
contribution rgb  
brightness glow parallax

# 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.

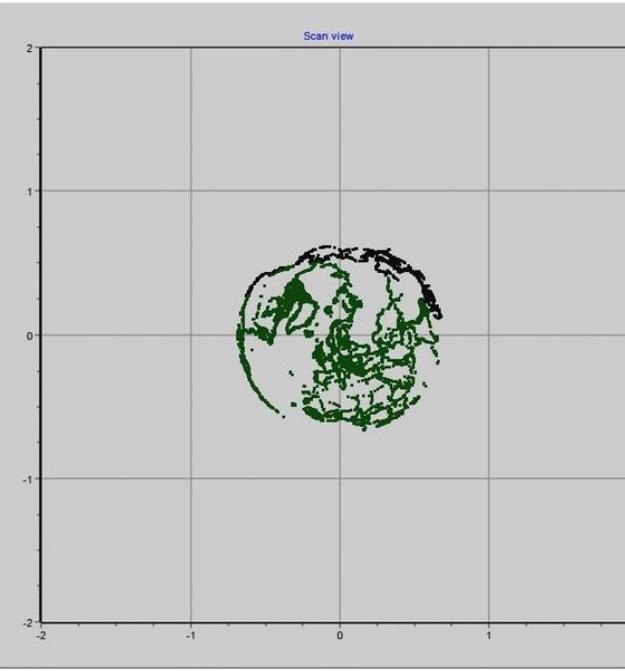
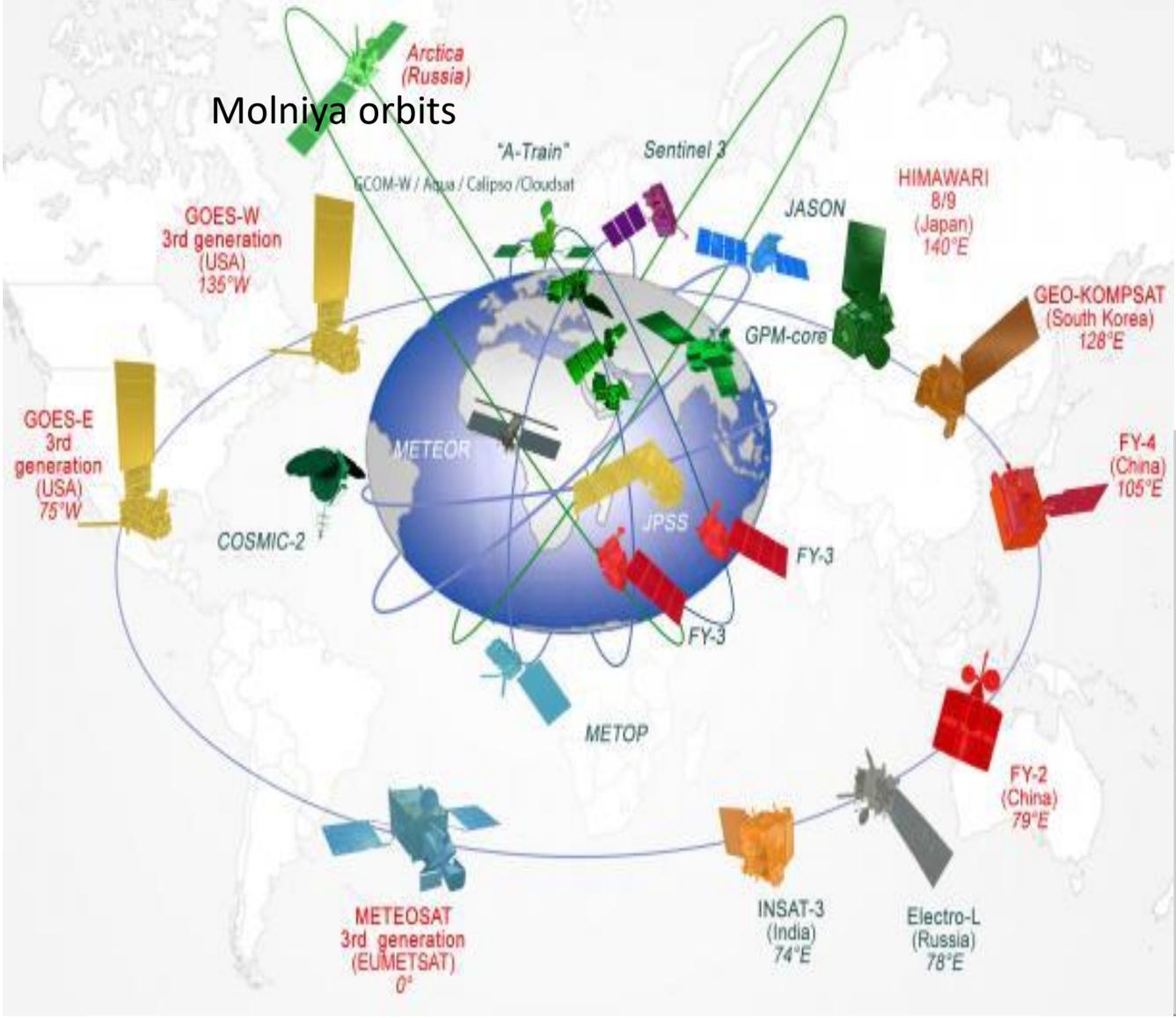


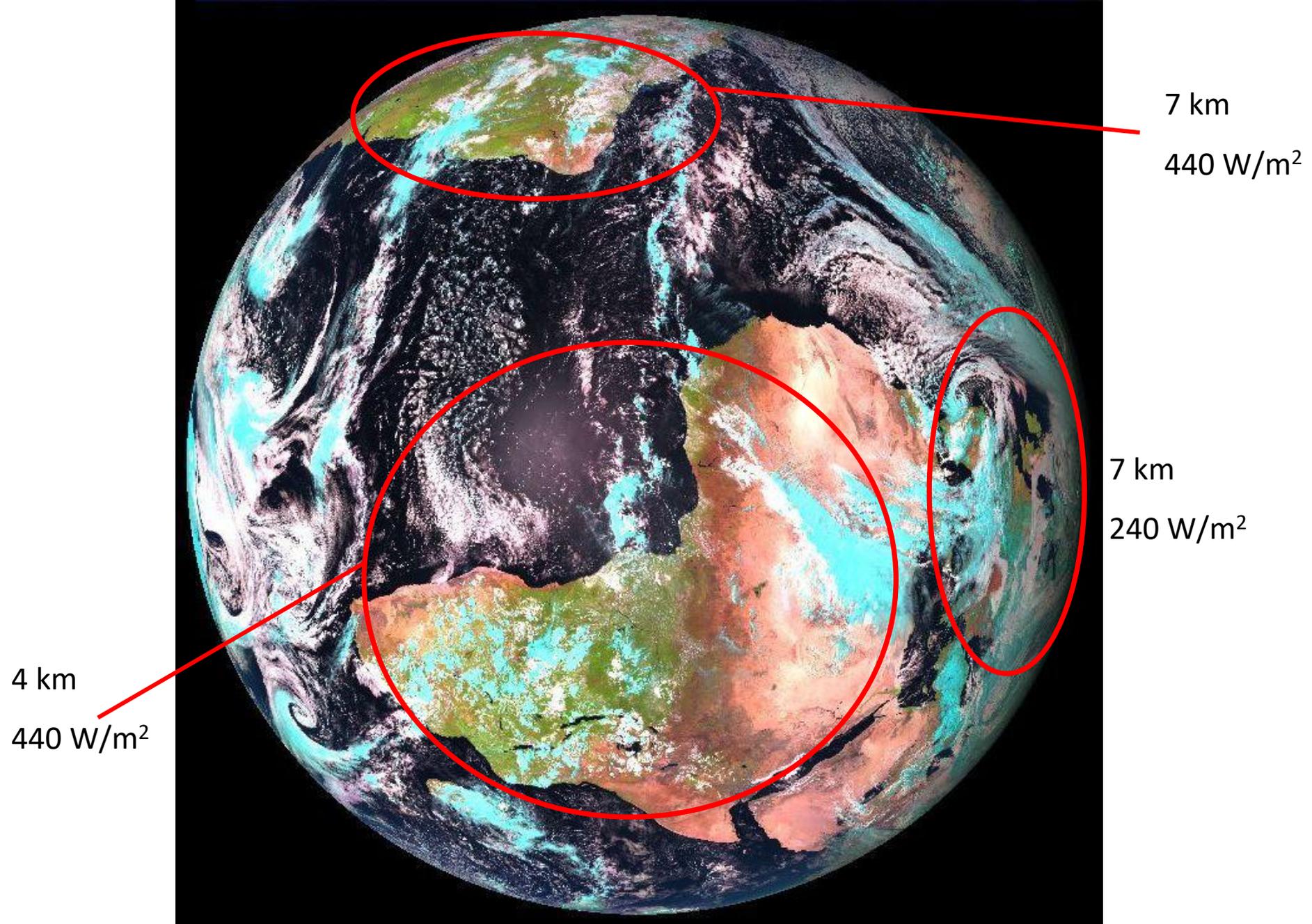
FRANKLIN'S EXPERIMENT, JUNE 1752.  
Demonstrating the identity of Lightning and Electricity, from which he invented the Lightning Rod.



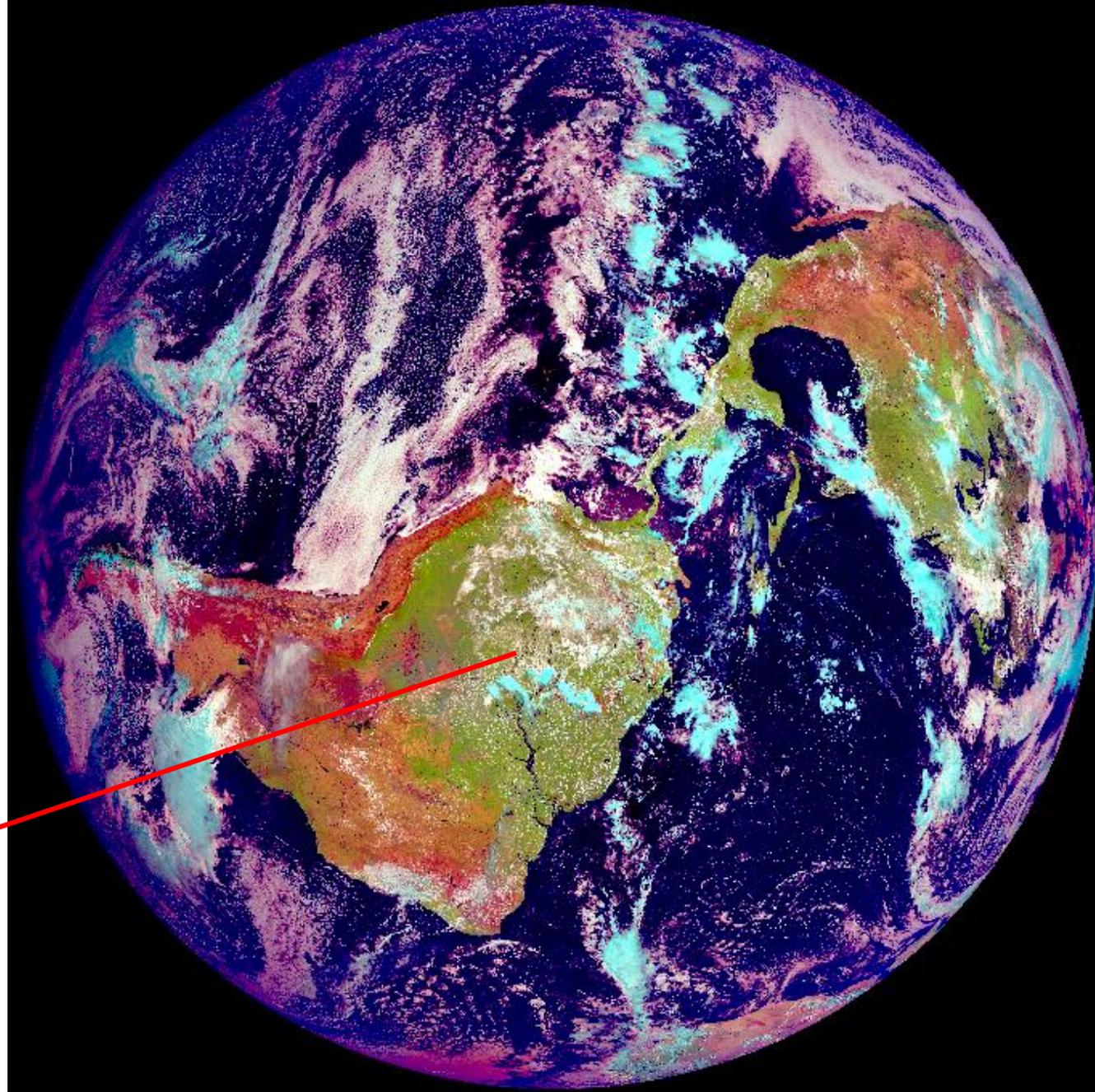
The ruins of St. Paul's Church following the quake. Credit: Jacques-Philippe Le Bas.

# WMO space programme





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



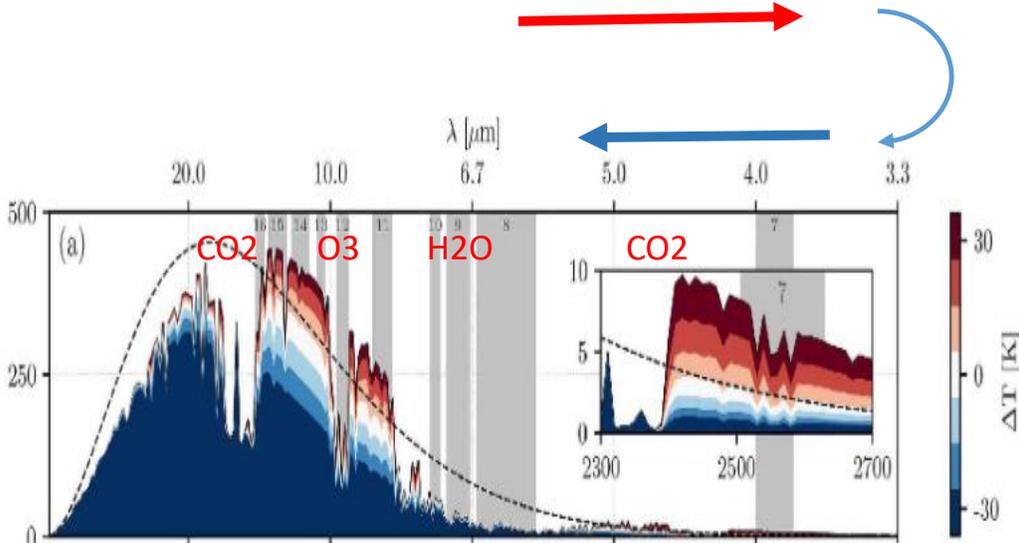
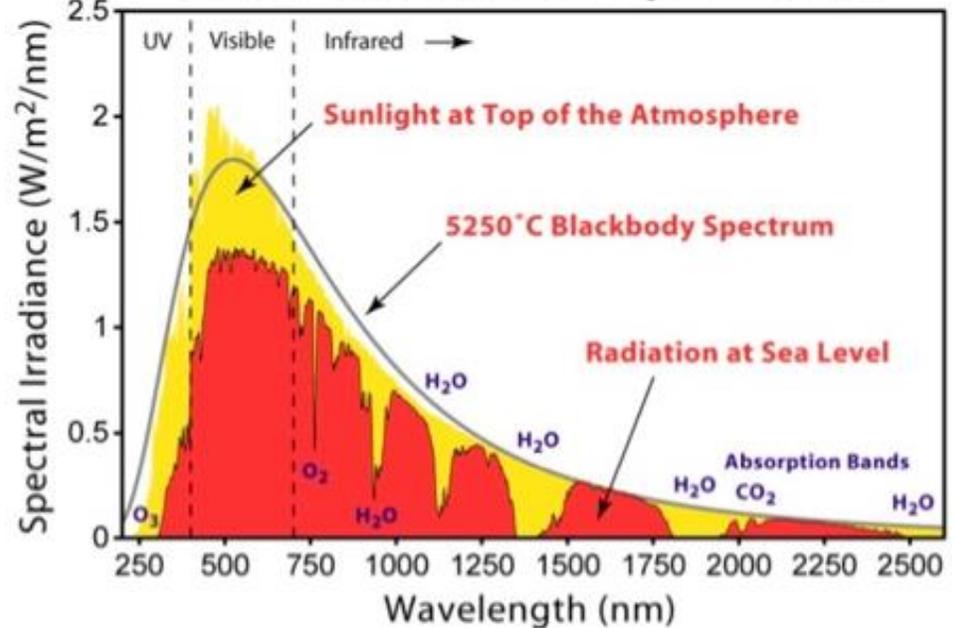
2 km  
440 W/m<sup>2</sup>

3 km  
240 W/m<sup>2</sup>

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

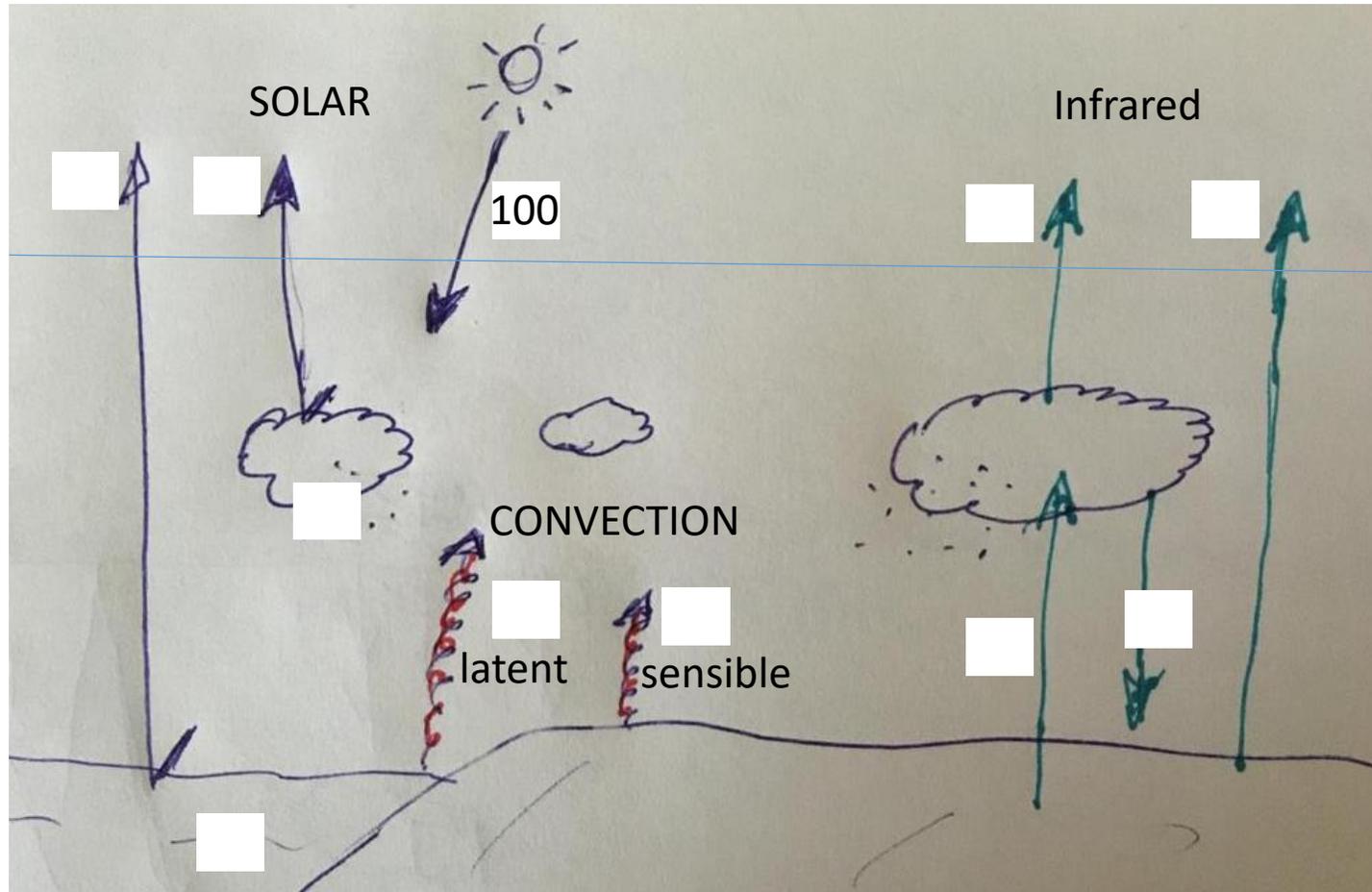
0.47μm	Blue, Rayleigh	<i>Fine aerosol</i>	1km
0.64	Red, high resolution	<i>Soil</i>	0.5
0.86	Near infrared	<i>Vegetation</i>	1
1.37	H2O absorption	<i>High cloud</i>	2
1.6	window	<i>Icy tops</i>	1
2.2	No absorption	<i>Particle size</i>	2
3.9	Shortwave window	<i>Fire, convection</i>	2
6.2	Upper-level water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

Solar Radiation Spectrum



Infrared radiation spectrum

# Earth radiative-convective balance

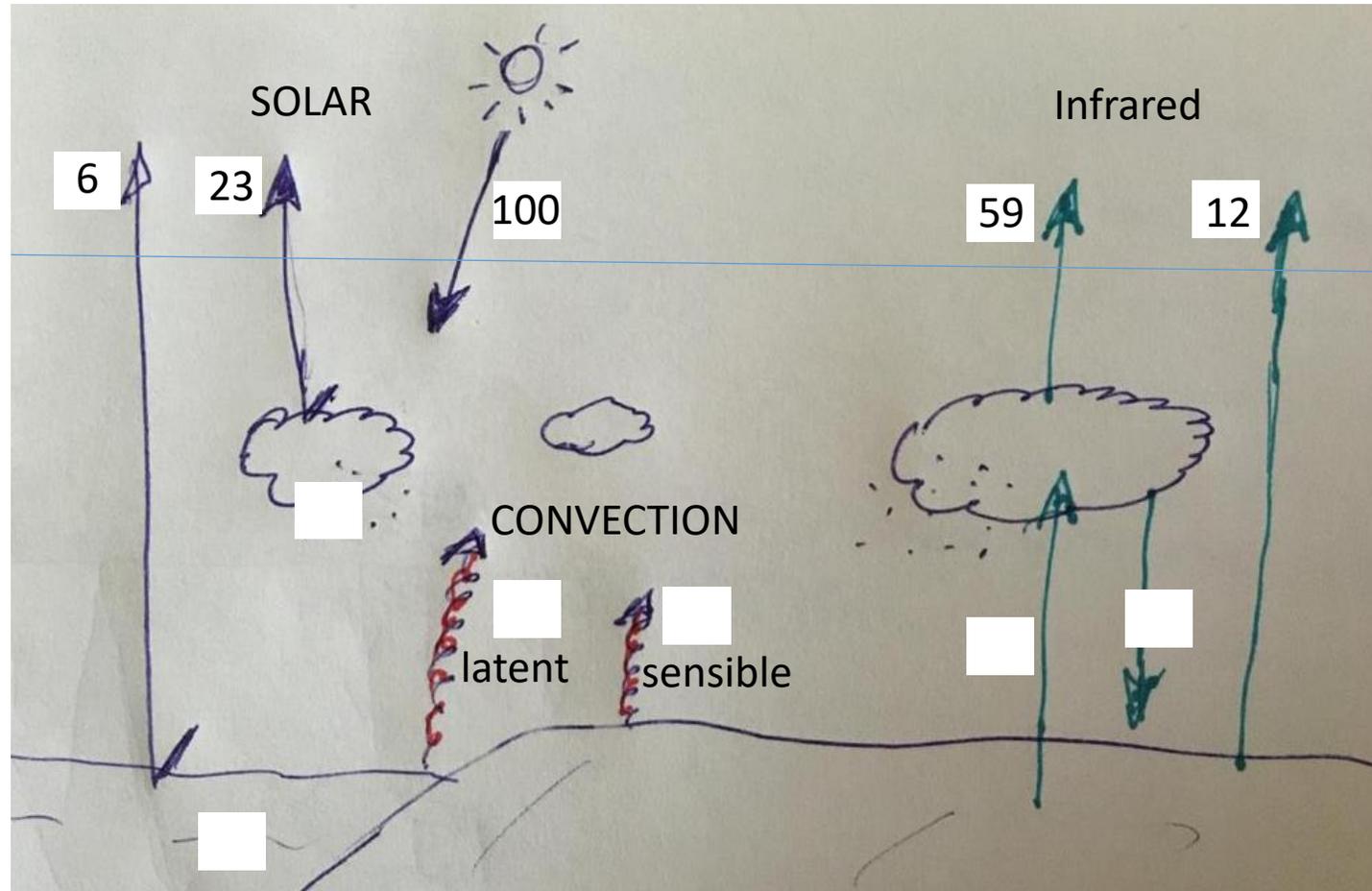


105  
100  
59  
48  
25  
23  
23  
12  
6  
6

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

“100” =  $342 \text{ Wm}^{-2}$  (SOLAR CONSTANT/4)

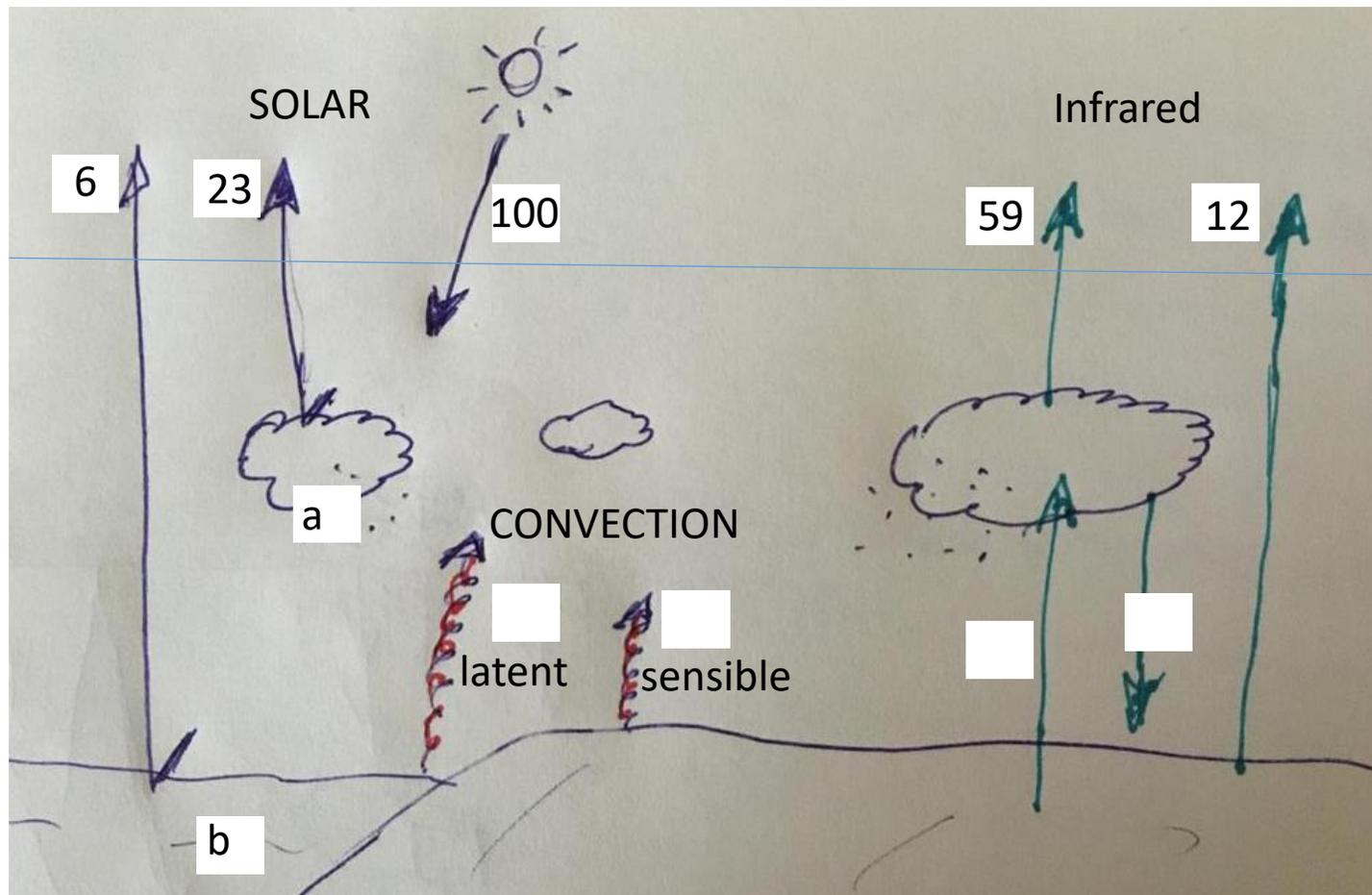
# Earth radiative-convective balance



105  
100  
48  
25  
23  
6

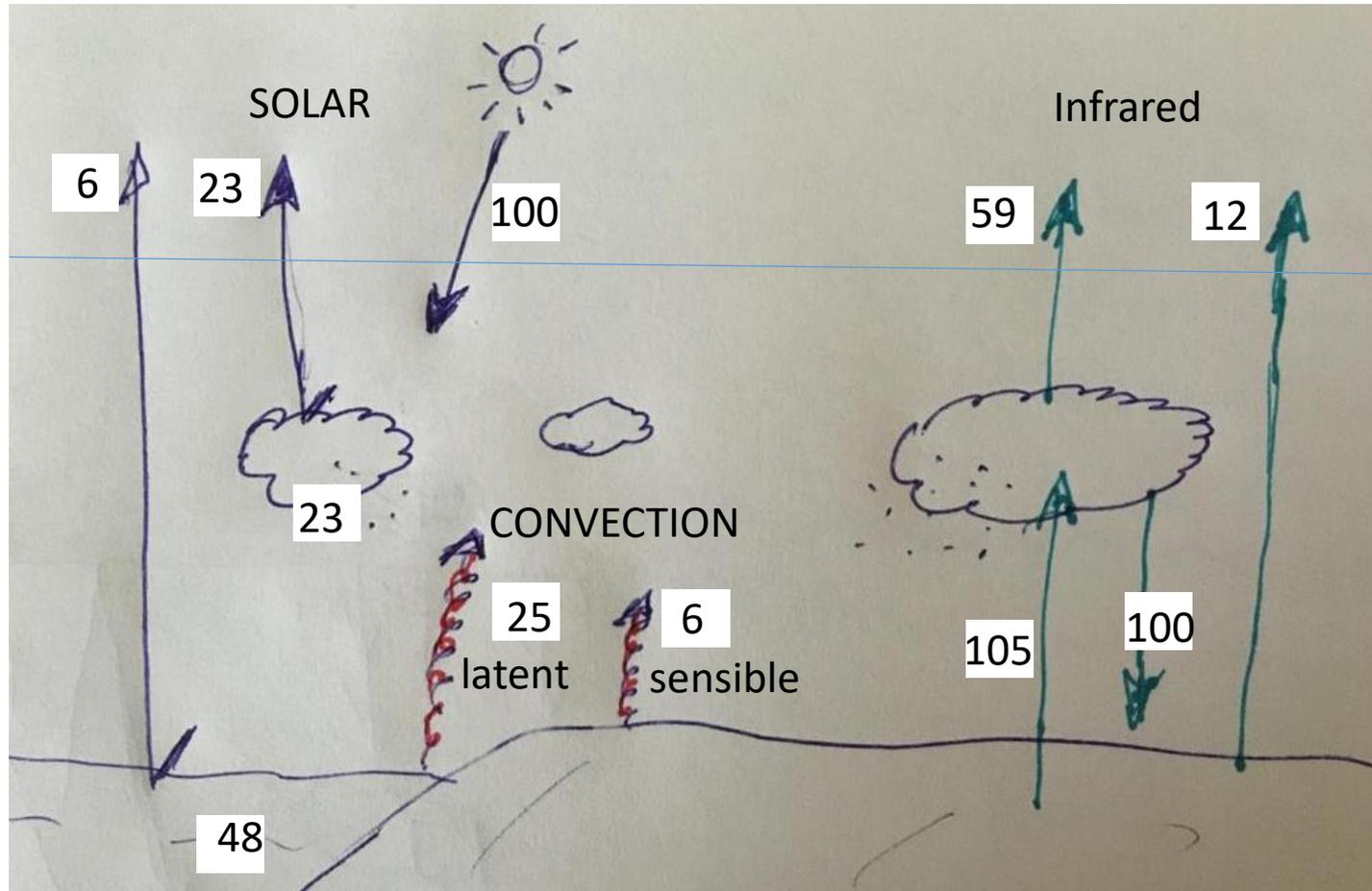
# Earth radiative-convective balance

(sli.do #EUMSC2) <sup>A</sup>



105  
100  
48  
25  
23  
6

# Earth radiative-convective balance



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

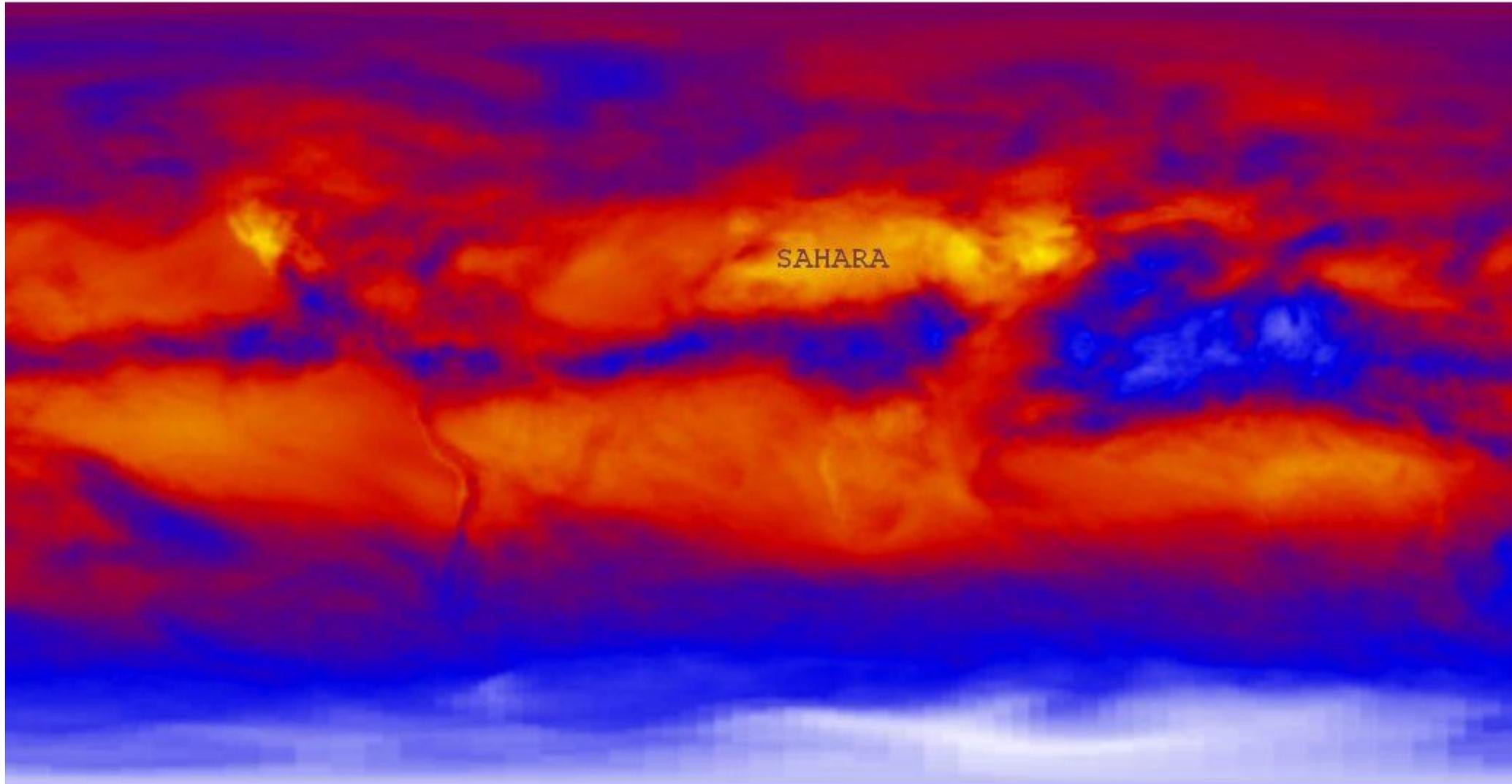
Earth **surface** makes 17% of the energy at the **infrared** channels.

**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.

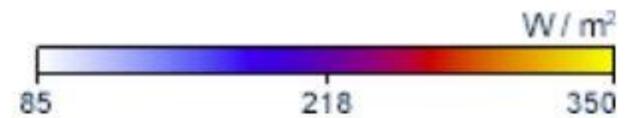
# OUTGOING LONGWAVE RADIATION (8 DAY)



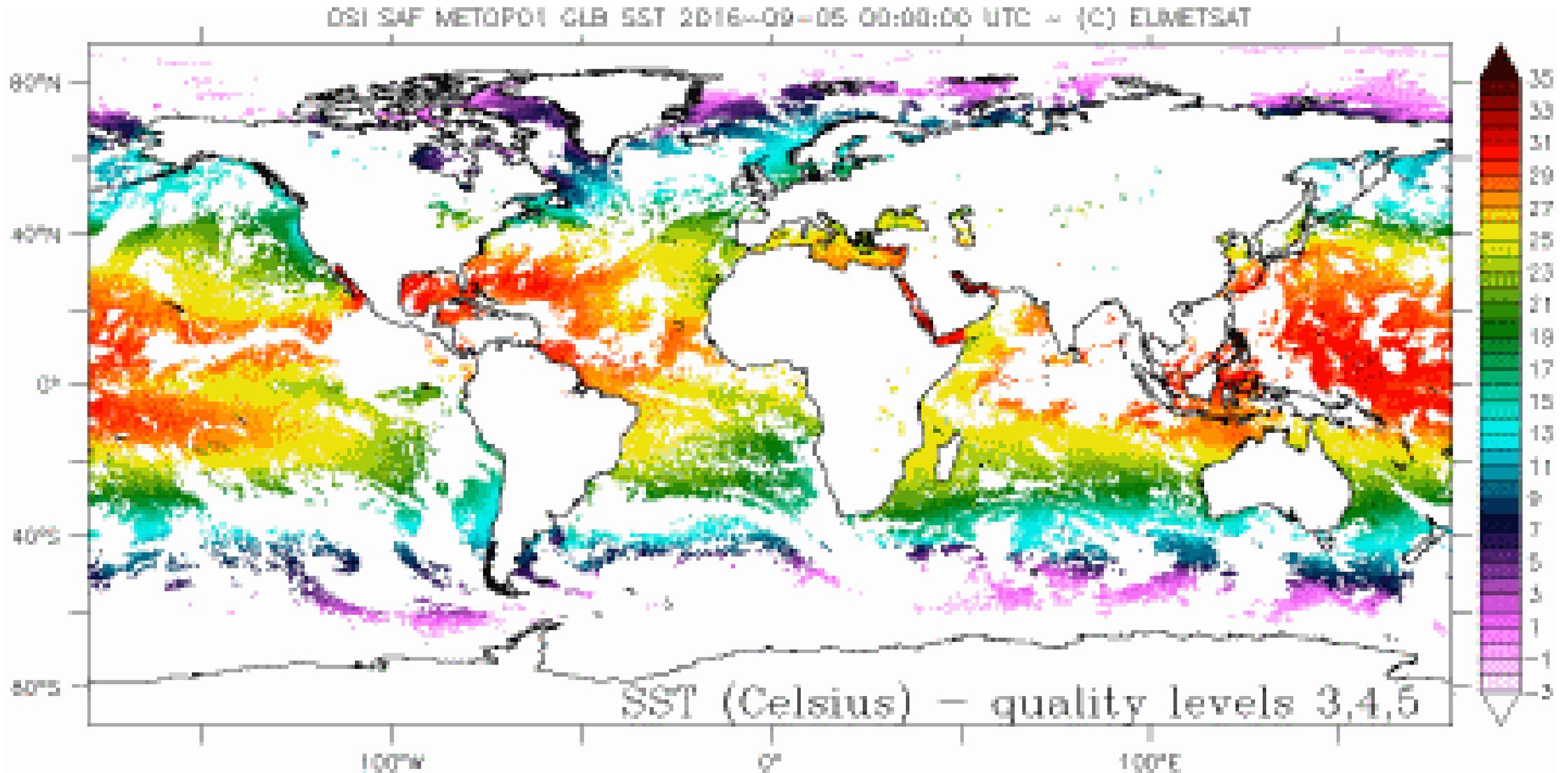
<https://neo.sci.gsfc.nasa.gov>

View by date:

1 day 8 day 1 mo



# Warm waters glow more than cold



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

# Big picture or detail: Image or sounding

sli.do #EUMSC2) B

## IMAGERS (compared with SOUNDERS)

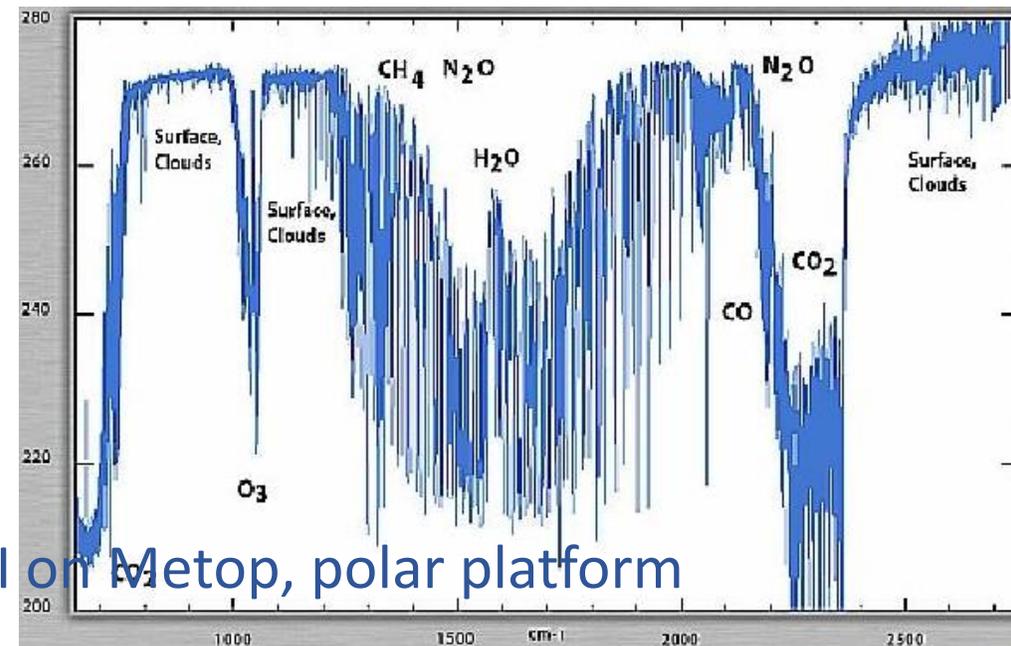
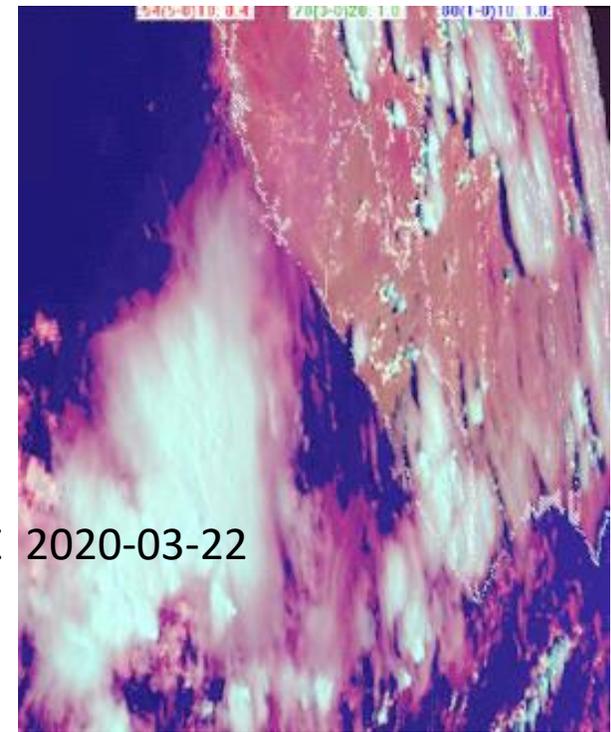
+Bandwidth

-Pixel size

-Sampling time

-Air absorption

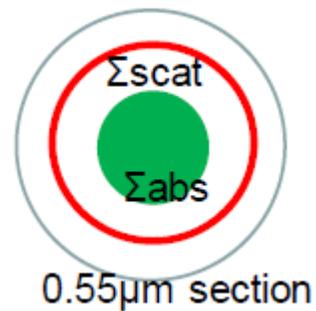
+Horizontal than vertical



# Satellite meteorology

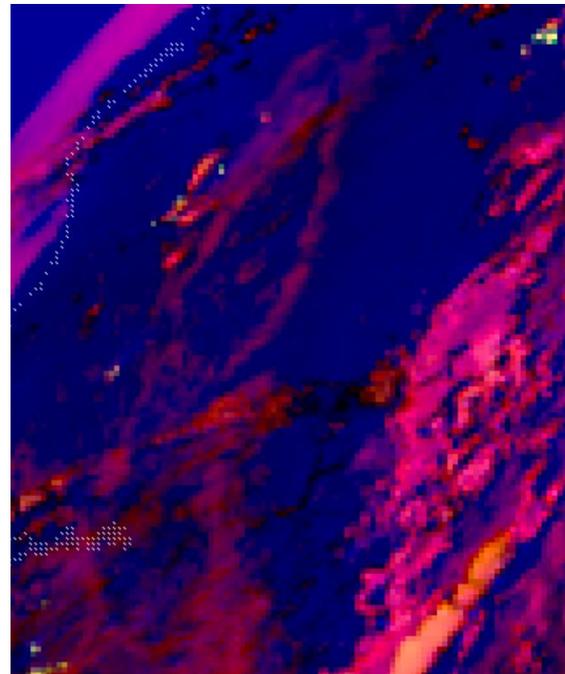
## Chapter 1:

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

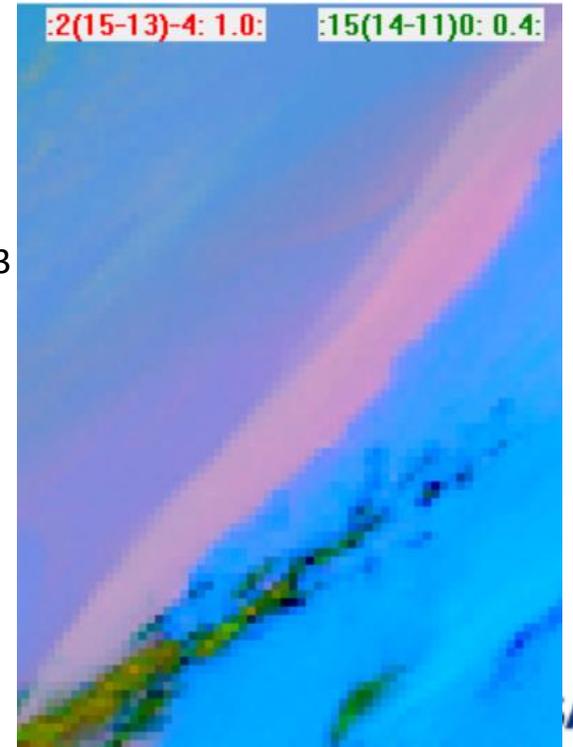


## Chapter 2:

- + emission by hot surfaces
- + scattering by small particles



2020-08-23  
21UTC



# Radiation meets matter

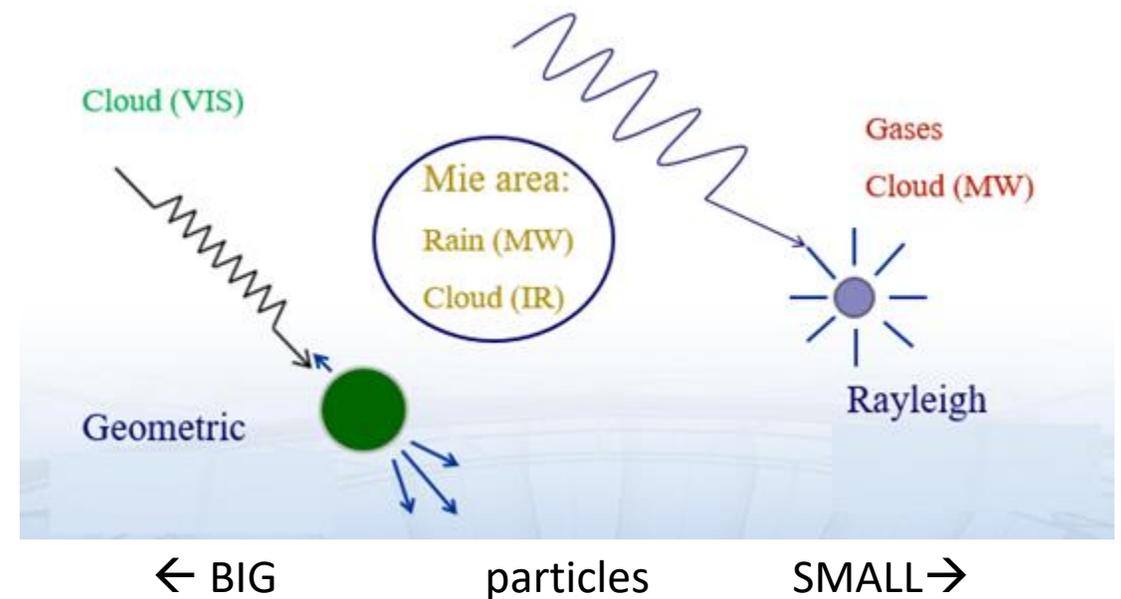
"...and I should still have delayed [its printing], had not the Importunity of Friends prevailed upon me"  
(I. Newton *Opticks*)

Big obstacles prefer to scatter forward, rather than backward.

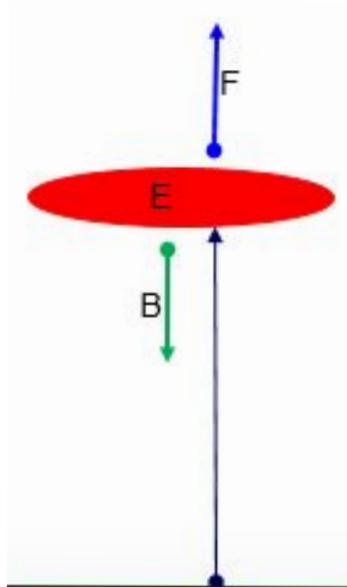
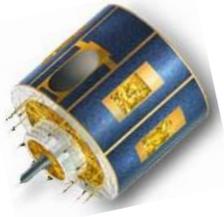
Very small or very large targets absorb better than they scatter.

For a fixed liquid amount in cloud, small droplets reflect better.

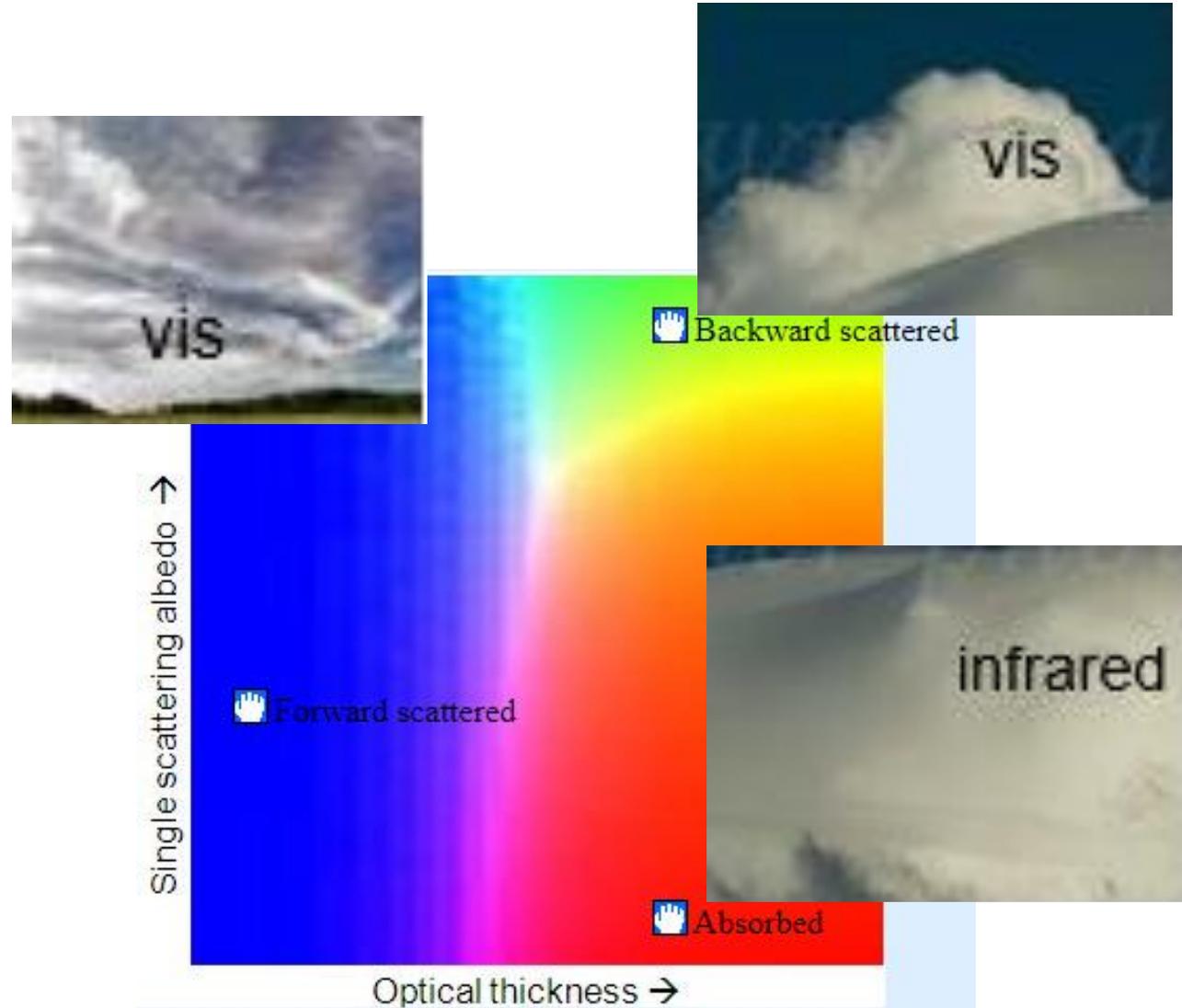
Satellites pick solar backward-scattering or infrared forward-scattering, but no absorbed radiation.



# Absorption and scattering

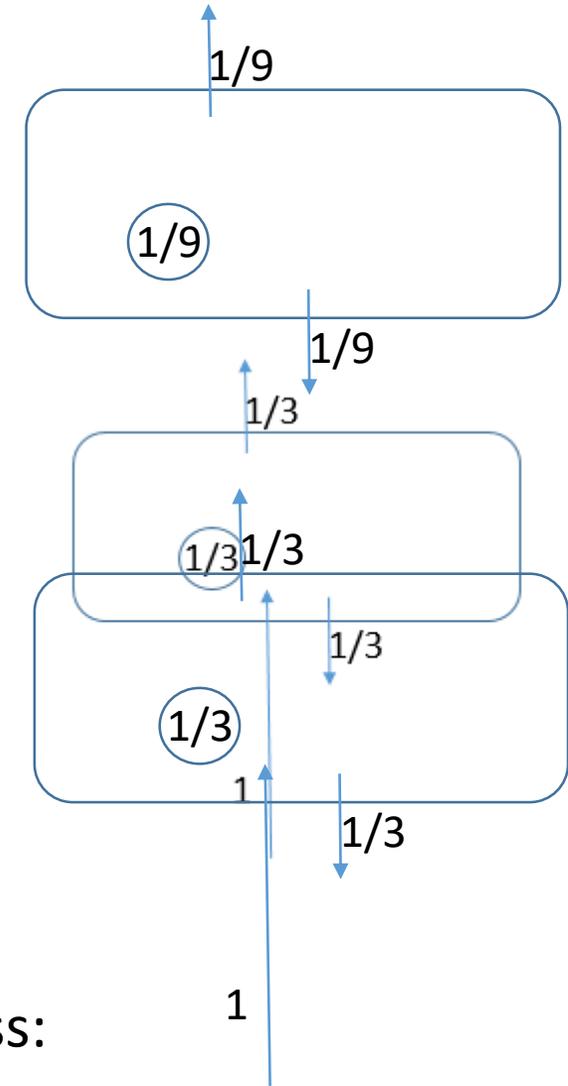
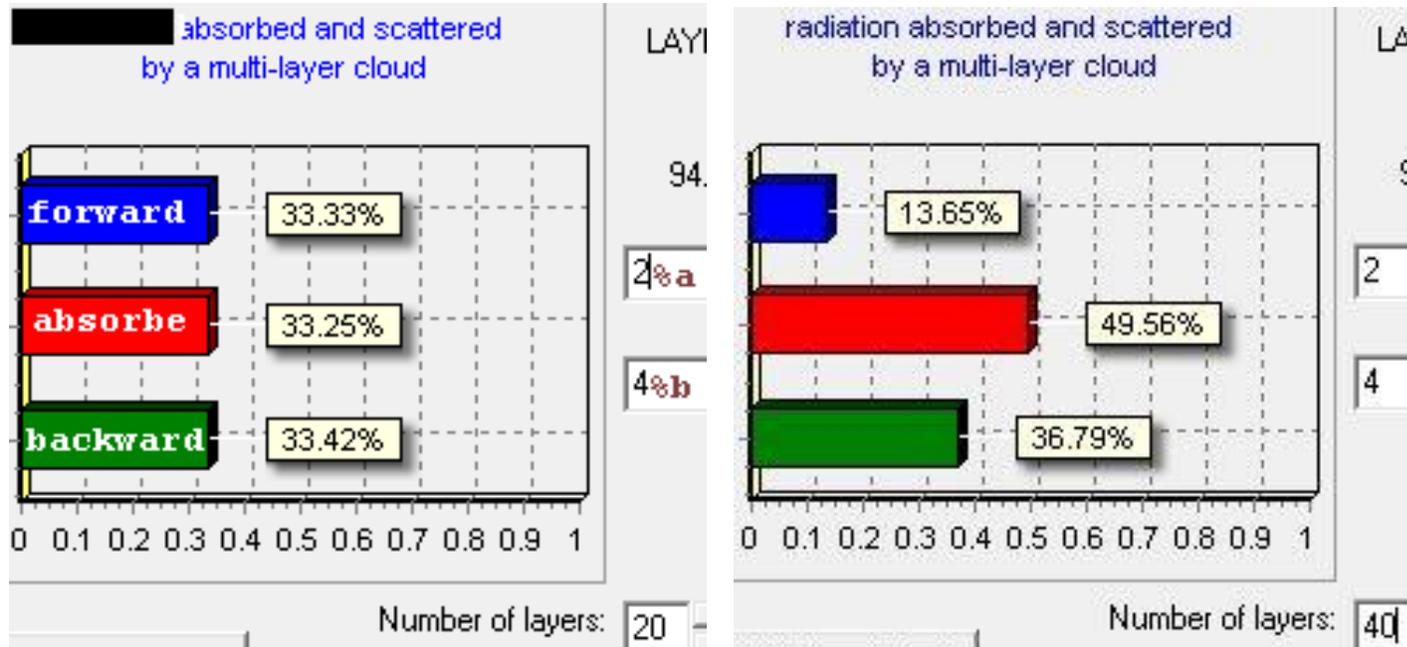


Radiation source:  
Surface (for INFRARED)



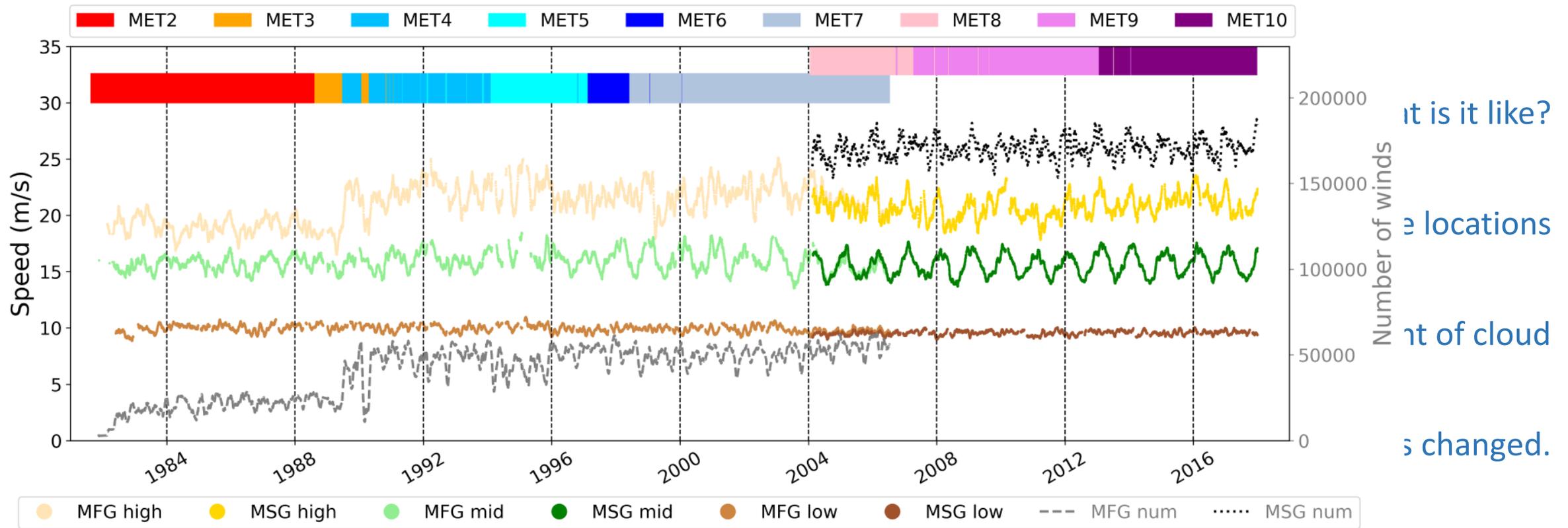
# Absorption and scattering

(sli.do #EUMSC2) <sub>D</sub>



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



- Then I have to re-assimilate...

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

# 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

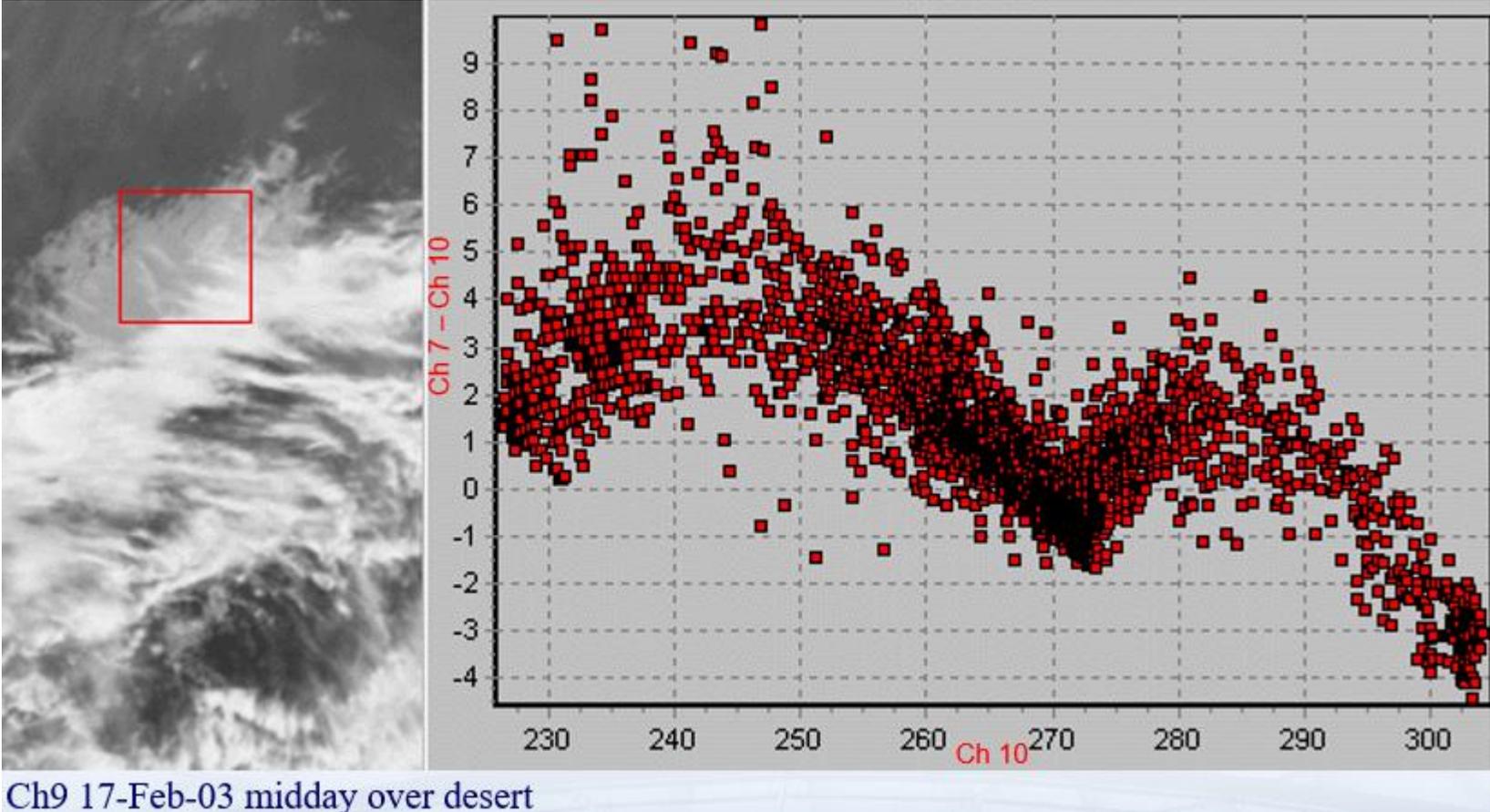
*Exceptions*: Sunglint, eclipse, parallax

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



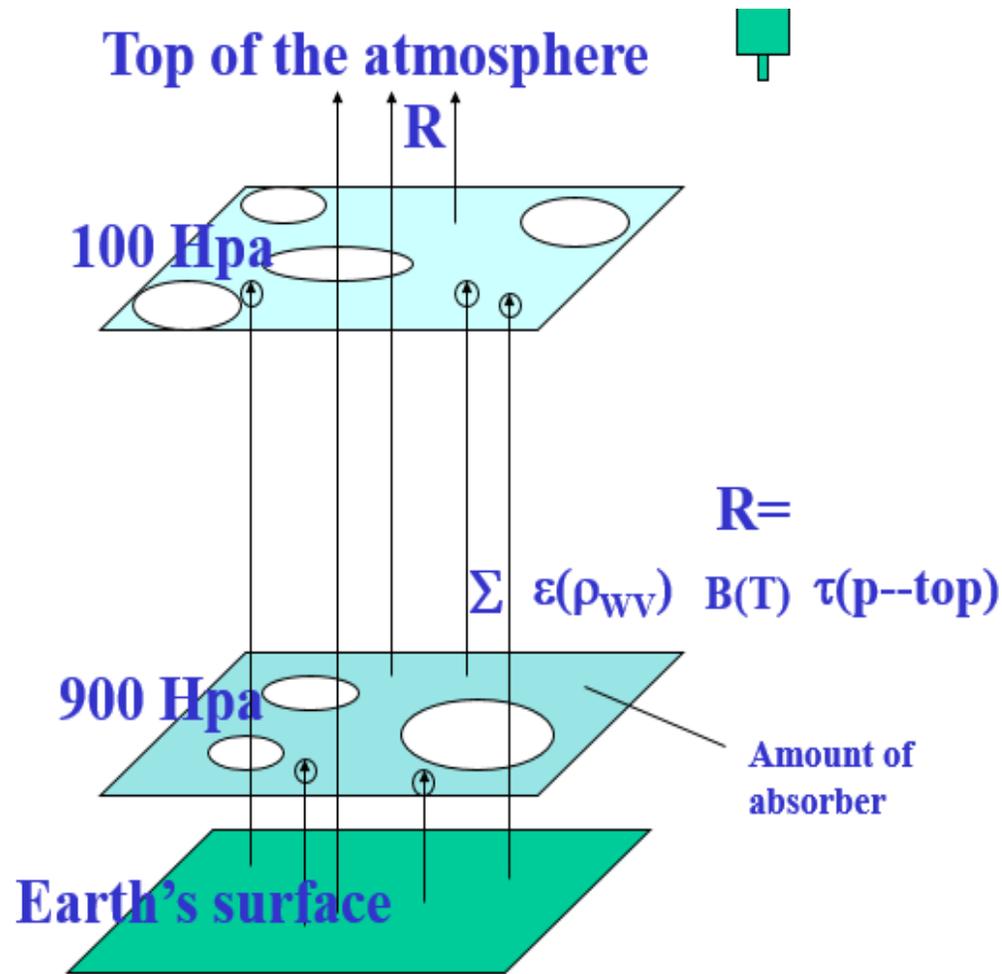
Same date-time in June for both images.  
Solar OR thermal-infrared?

# Semi-transparent cloud: mixing levels inside a pixel



Ch9 17-Feb-03 midday over desert

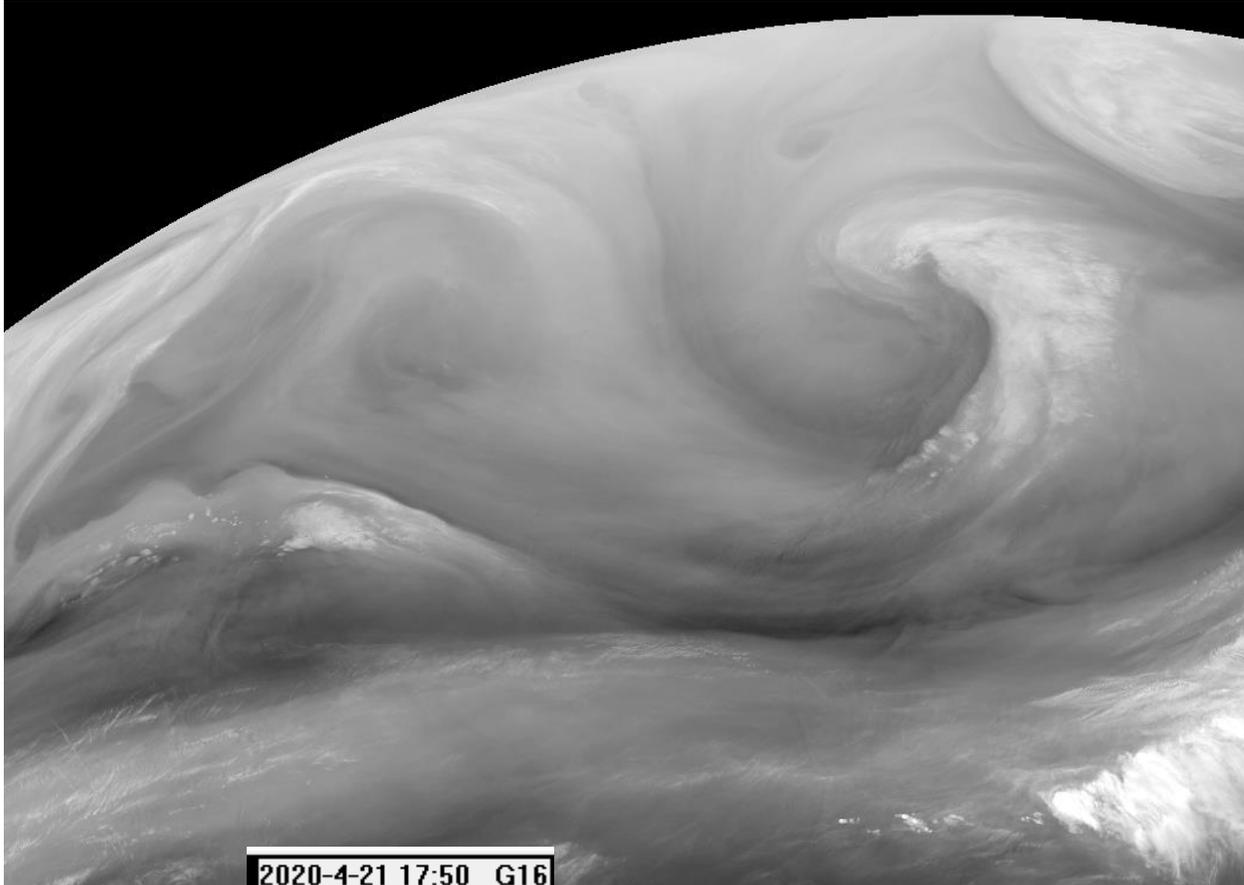
# The eventful way upwards at infrared absorption bands (e.g. water vapour 6 $\mu\text{m}$ )



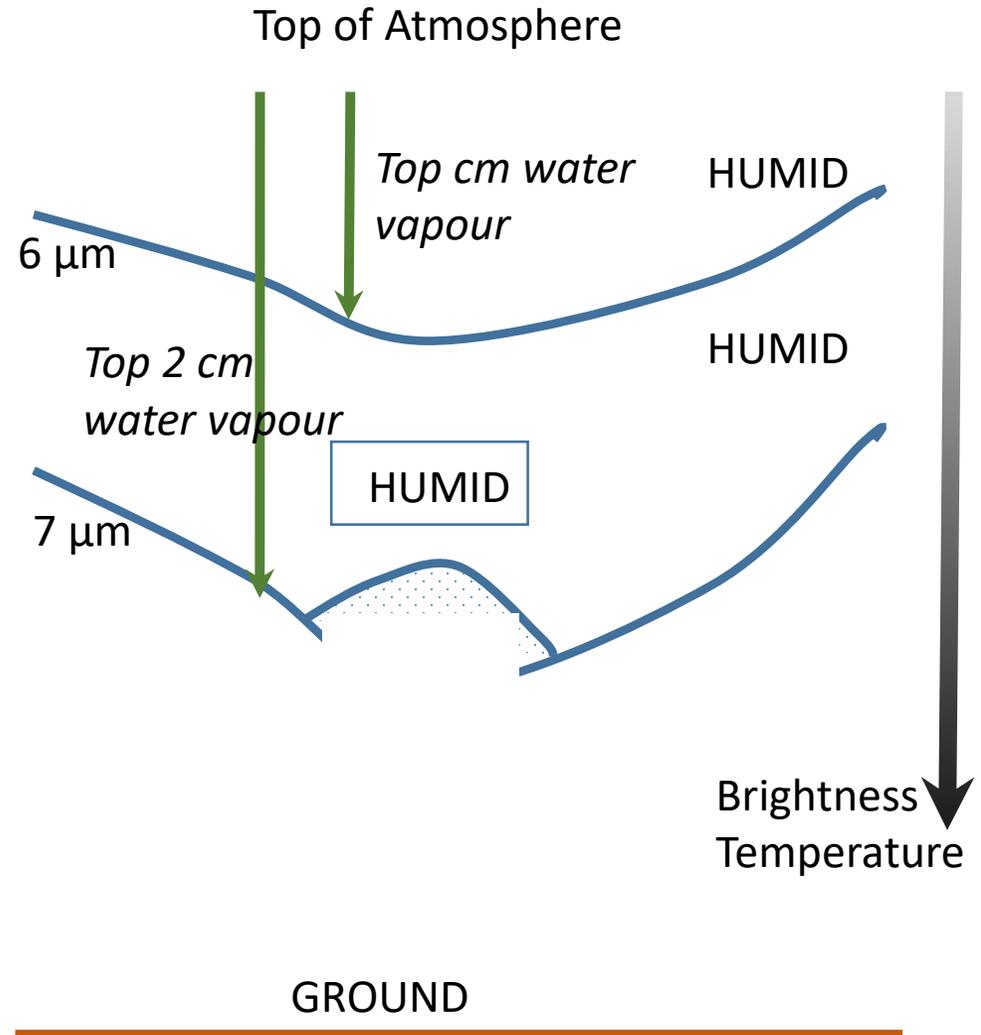
The layer emissivity is also the fraction of radiation absorbed (Kirchhoff)

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

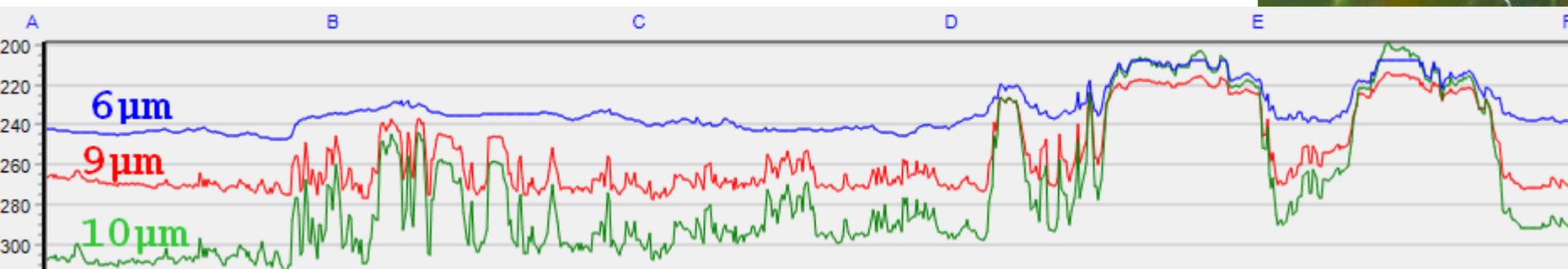
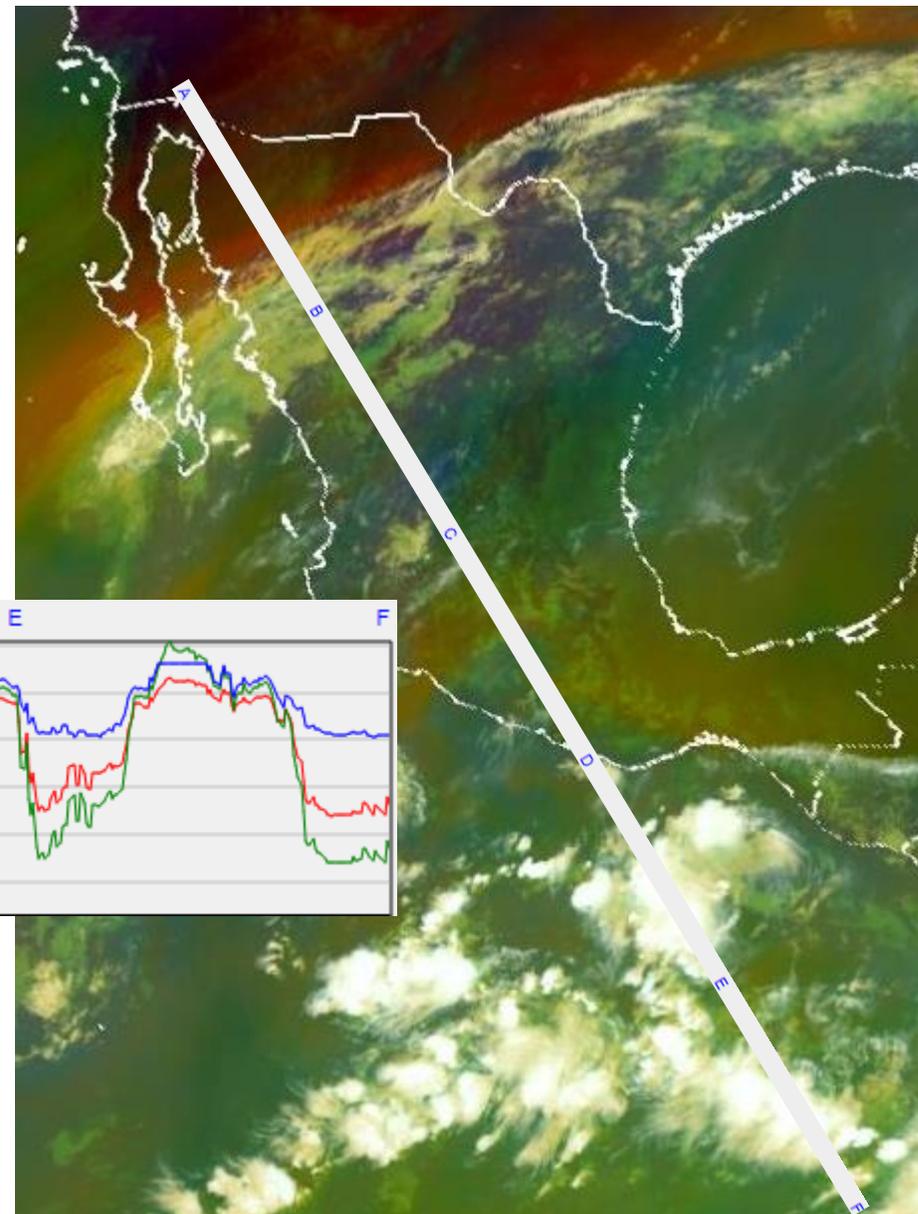
# Carved in water vapour



6.2 $\mu$ m (200K-250K) gamma=0.7



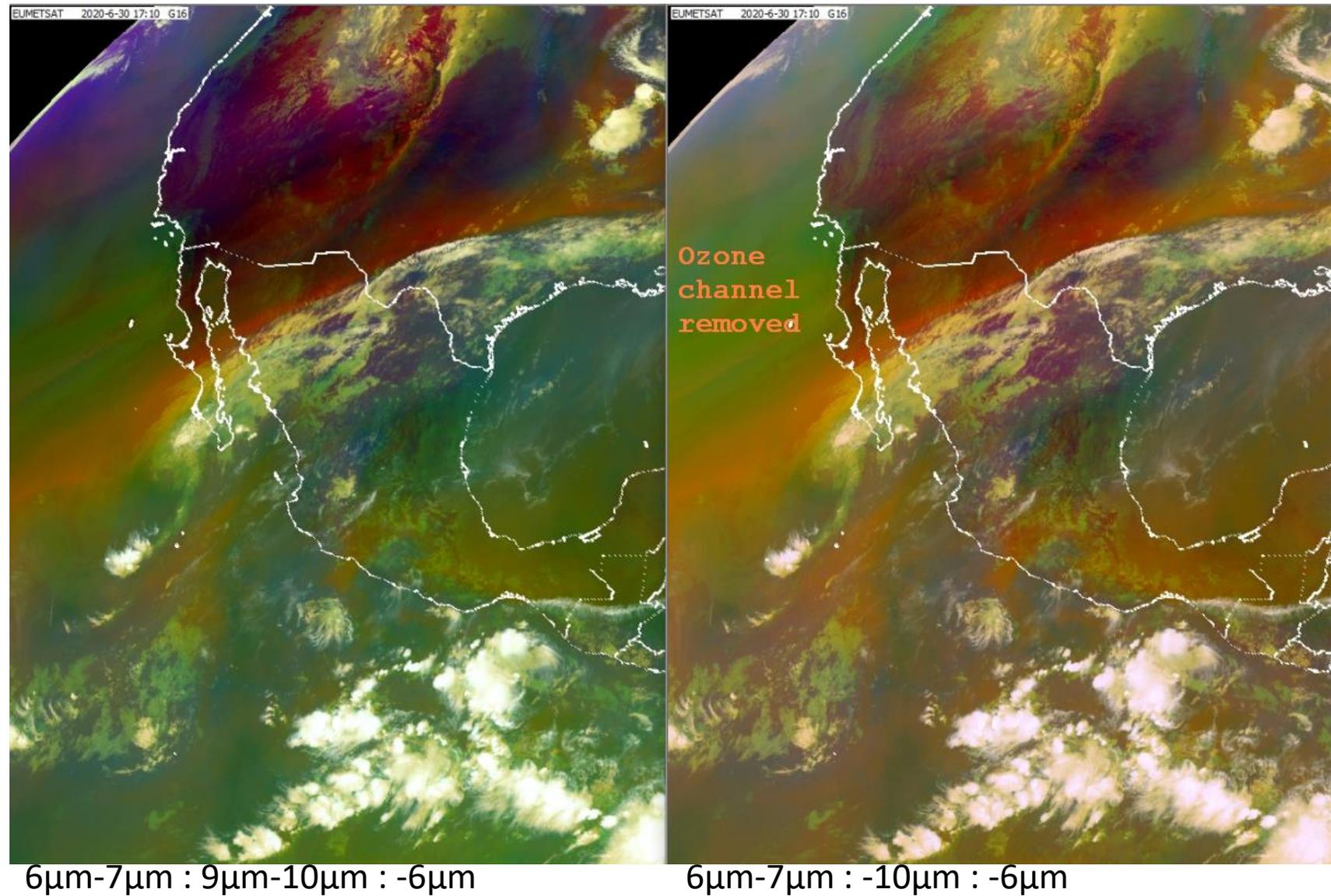
# AIRMASS ANALYSIS: standard RGB formula



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

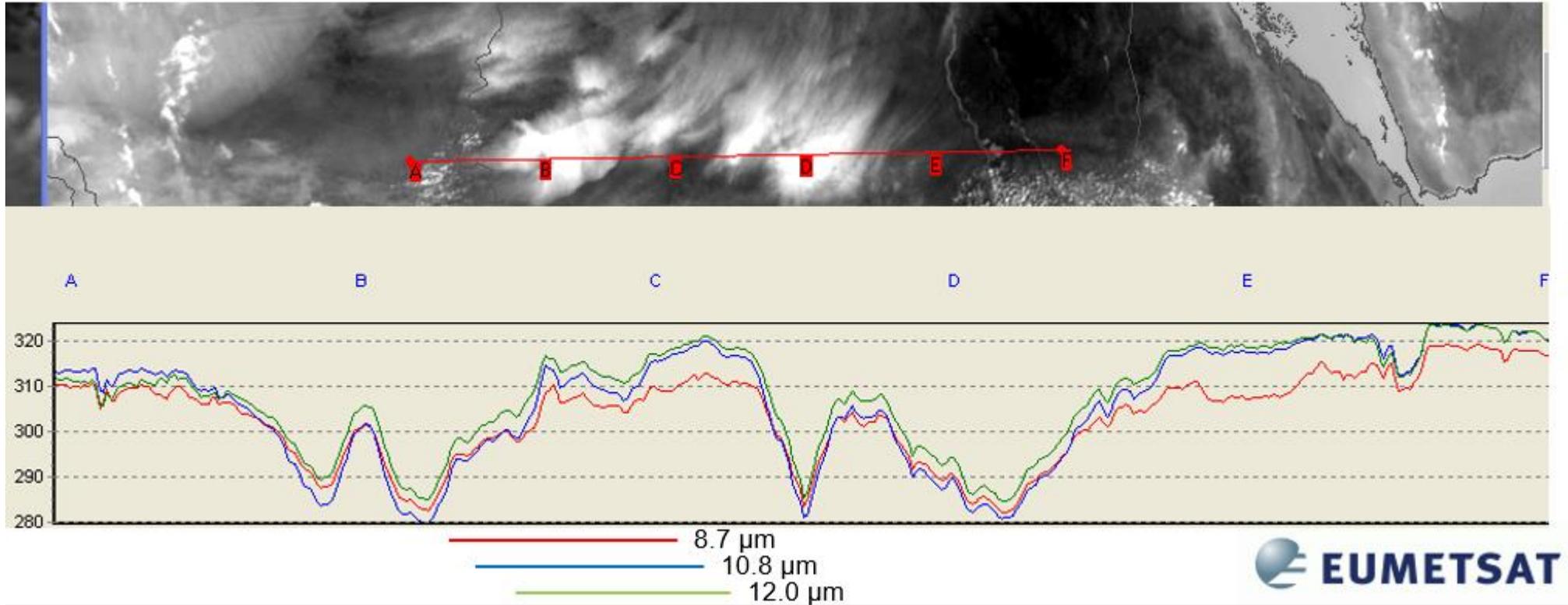
ABI 6μm-7μm : 9μm-10μm : -6μm

# AIRMASS ANALYSIS



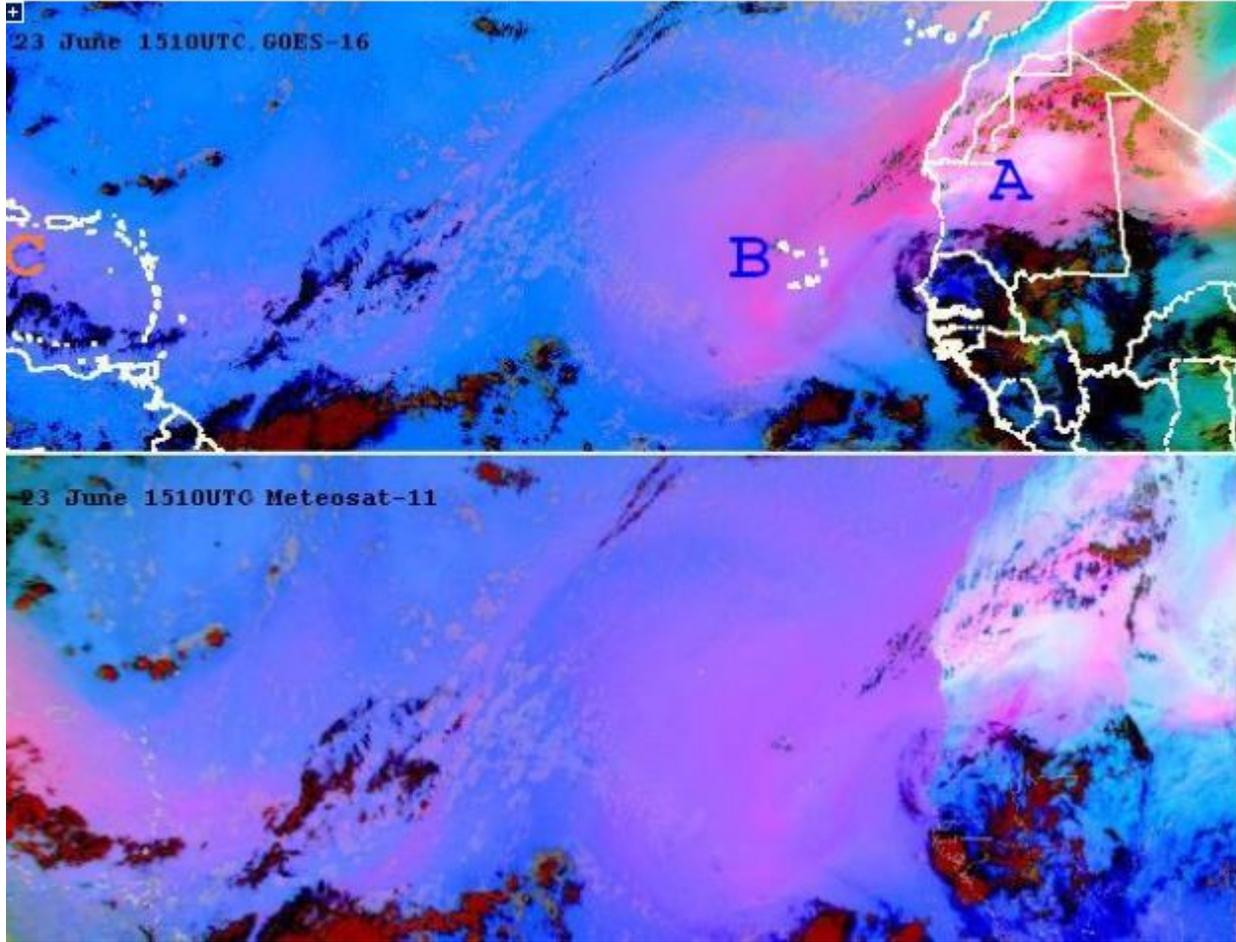
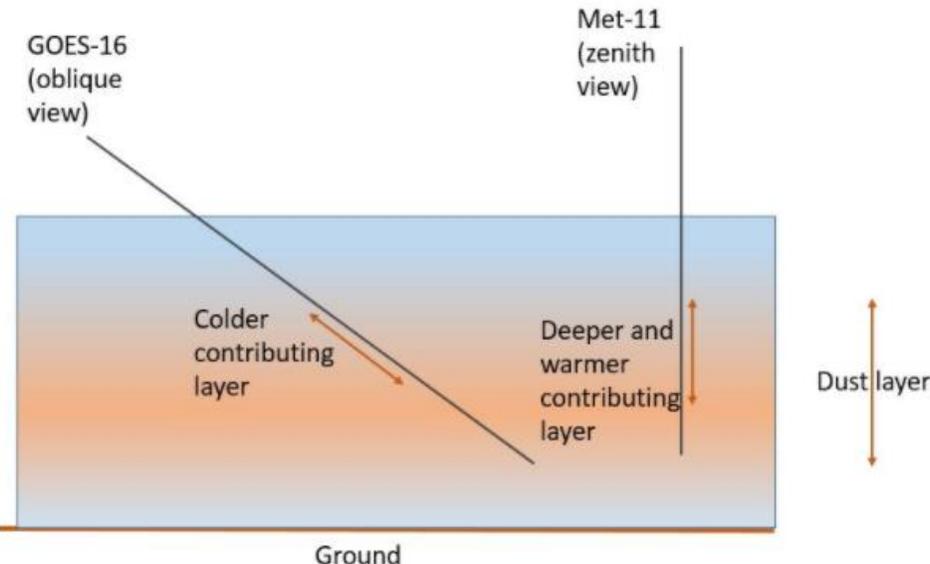
Ozone channel informs about radiative absorption in the ozone layer.  
This stratospheric layer is not relevant to weather, and does not warm up if the tropopause folds into the troposphere.  
The red beam is a difference between water vapour absorption channels, redder for stratospheric intrusions.

# DUST ANALYSIS



Aerosol thermal effect	SOLAR	INFRARED
BACKSCATTER	Cools	Warms
ABSORPTION	Warms	Warms

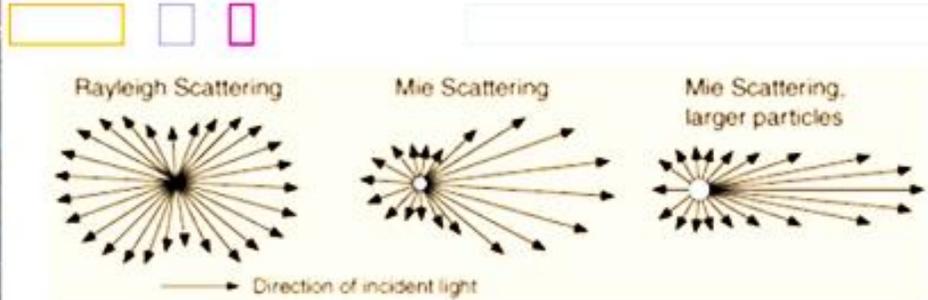
# Dust thickness



# Smoke all over



Meteosat9, 2010-08-21 1515 UTC



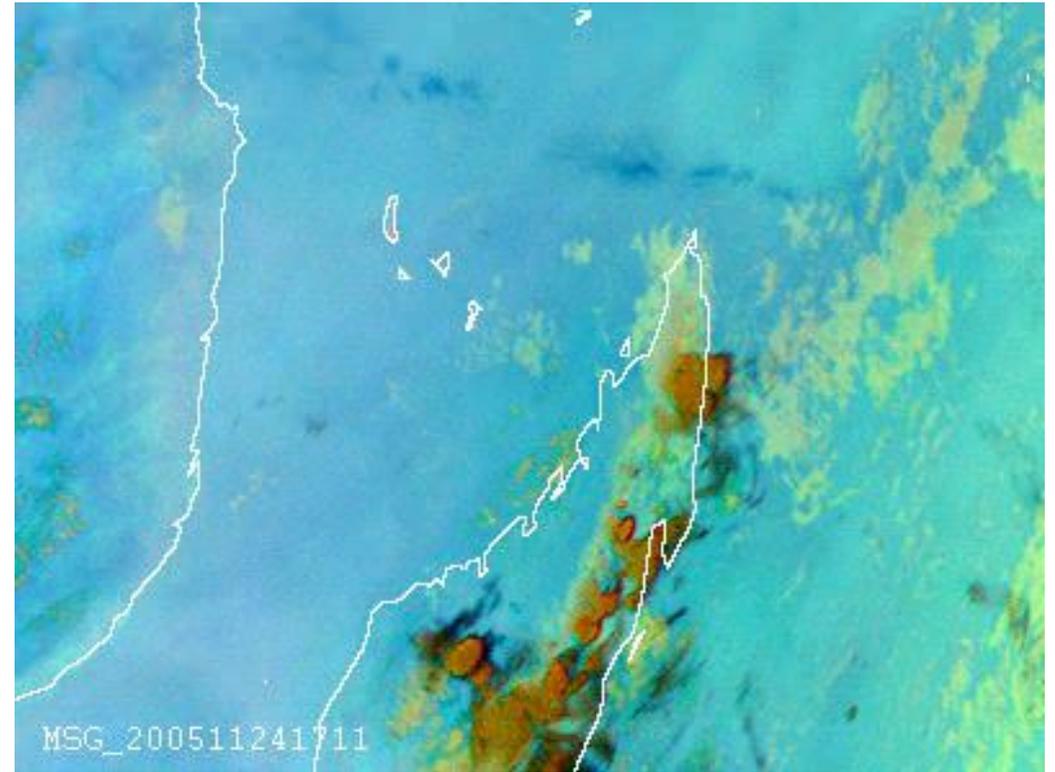
- Smaller wavelengths favoured by forward scattering
- Blue-cyan colour due to 1.6  $\mu\text{m}$  rather Rayleigh
- Scattering intensity higher in the western late afternoon



# Gas, ash and cloud



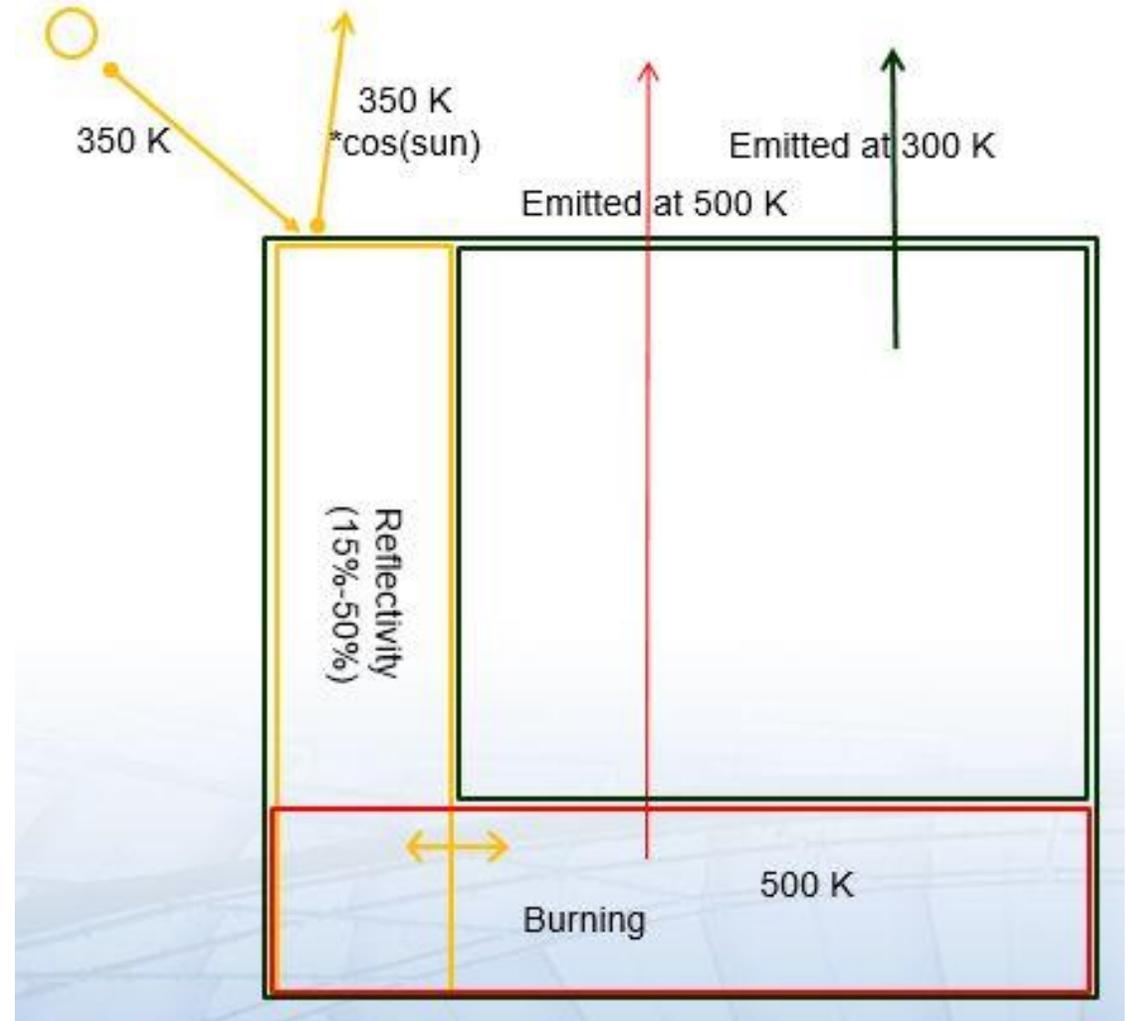
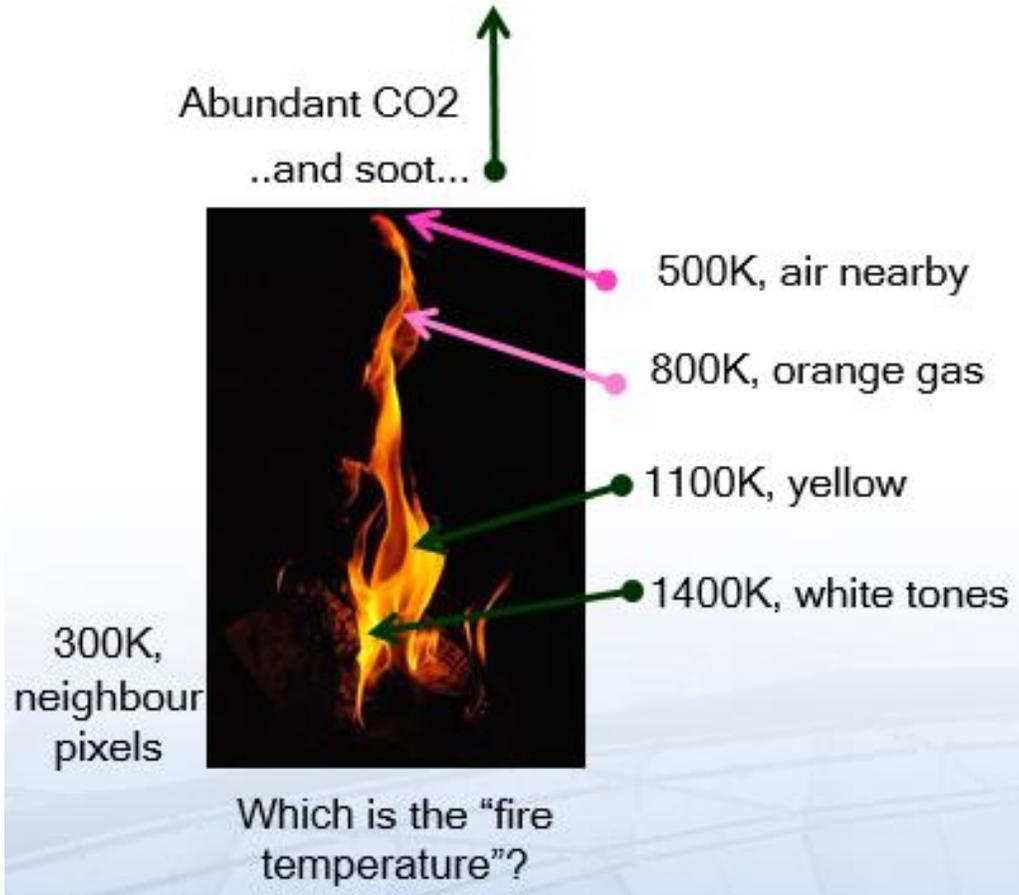
Karthala crater (from Wikipedia)



Meteosat-8 infrared-window composite

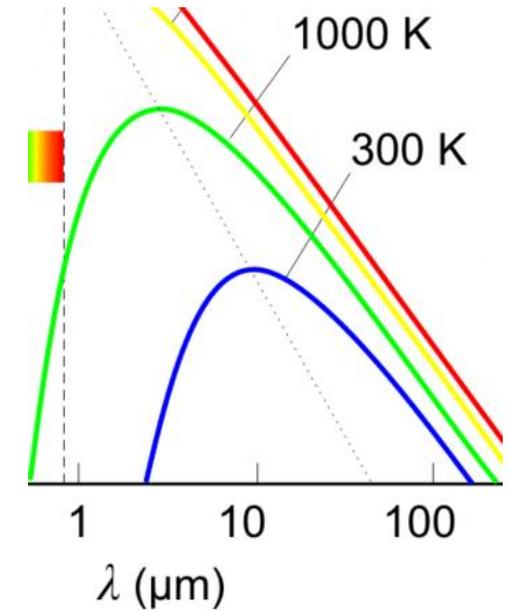
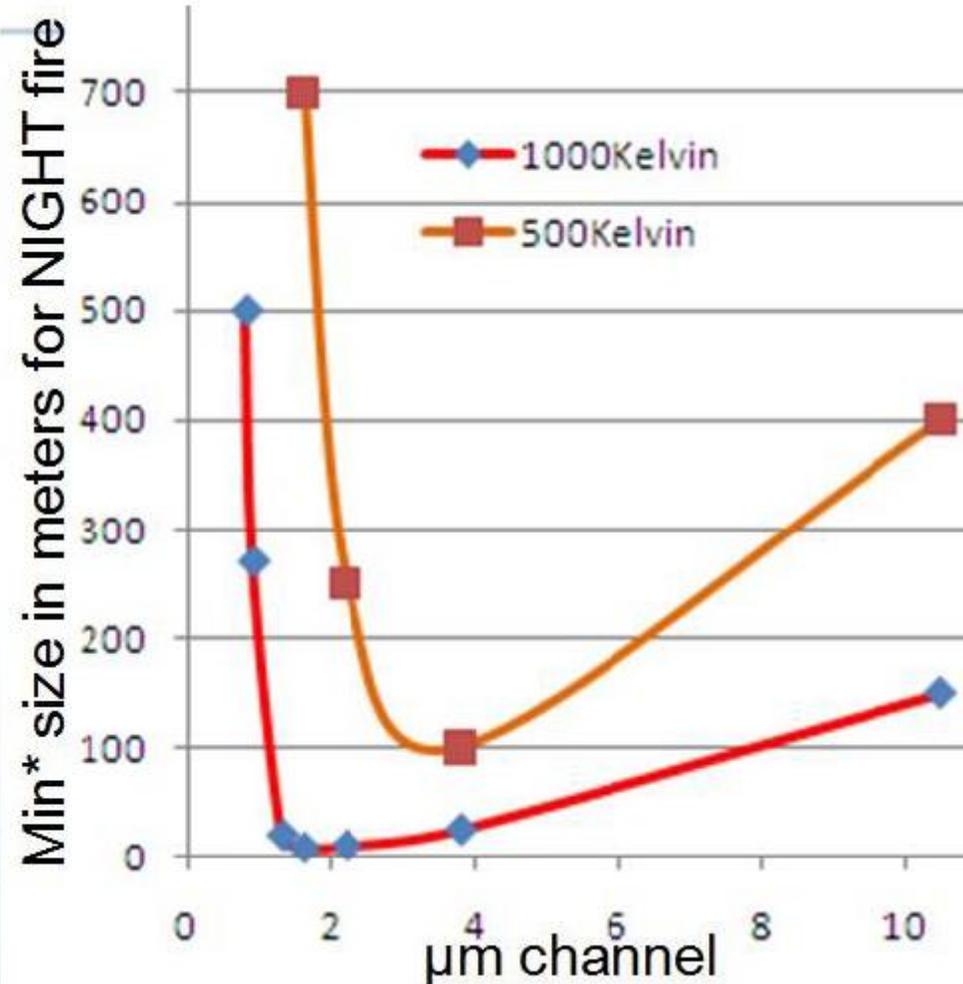
# Which fire temperature do satellites measure?

A flame is gas at high temperatures, but at 3.9 $\mu$ m only ash and CO<sub>2</sub> absorb.



# Fire traffic light RGB (sli.do #EUMSC2)<sub>E</sub>

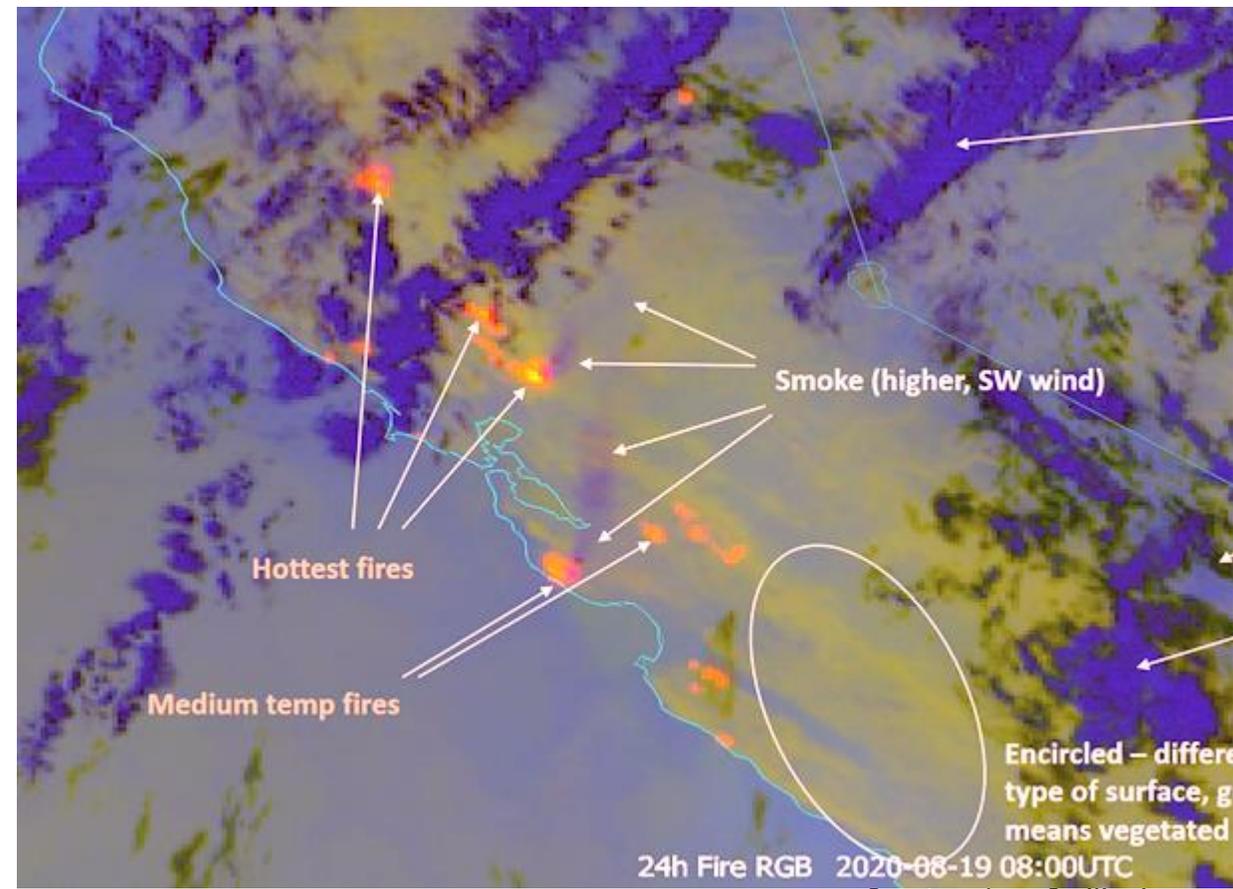
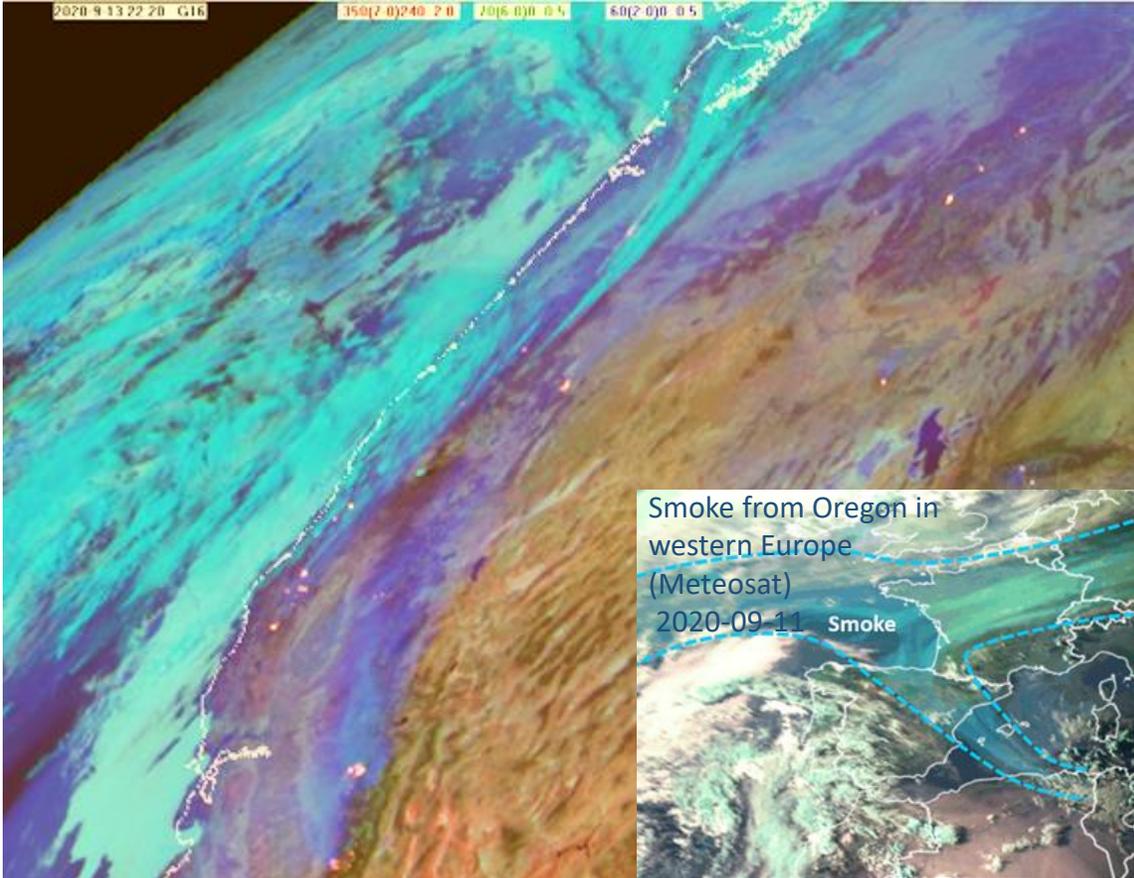
- A fire at 500K will be sensed, as it grows
- **first** by 3.9 $\mu\text{m}$  (at ~100m)
- **second** by 2.25 $\mu\text{m}$  (250m)
- **third** by 10.8 $\mu\text{m}$  (400m)
- An RGB=(3.9;2.2;10.8) might be a good indicator for severity of a fire.
- For a hotter fire (1000K), typically gas flares, channels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



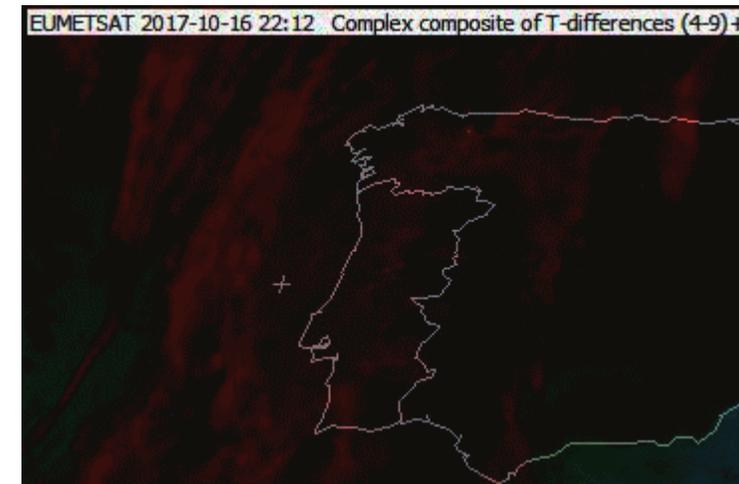
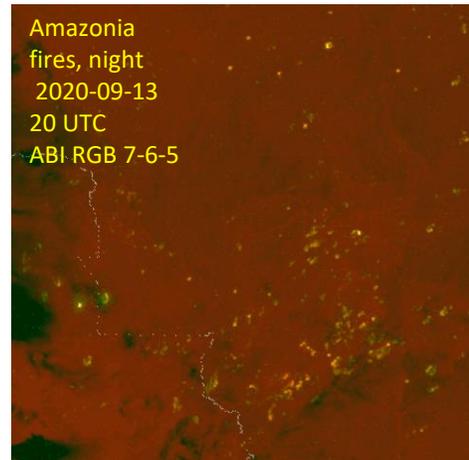
“Fire temperature” will be shown best at the Wien-wavelength:  
higher intensity fires also show on solar channels (night)

# Big blazes as hotspots and smoke in solar or infrared channels

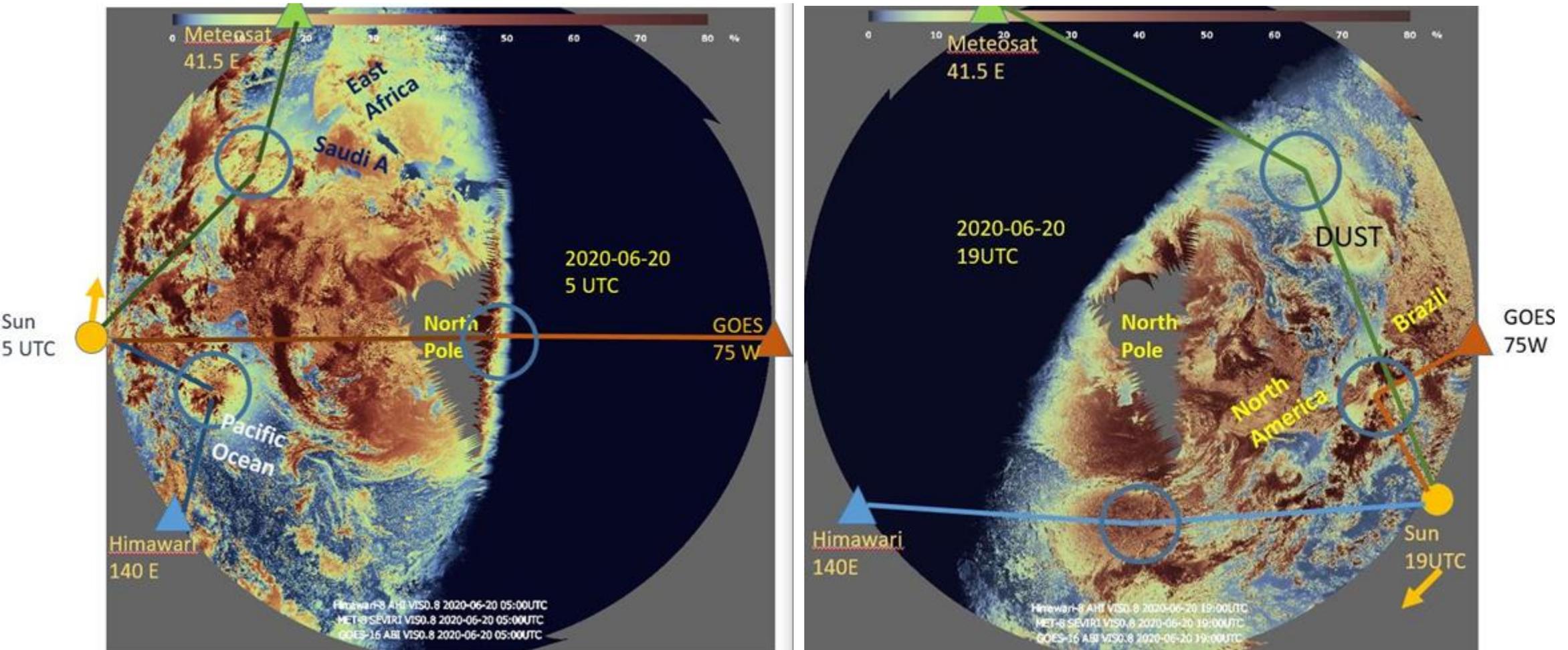
	SOLAR	INFRARED
DAY	Smoke	(Smoke) and (Hotspots)
NIGHT	<b>Very Hotspots</b>	Hotspots



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

# Sunglint calendar

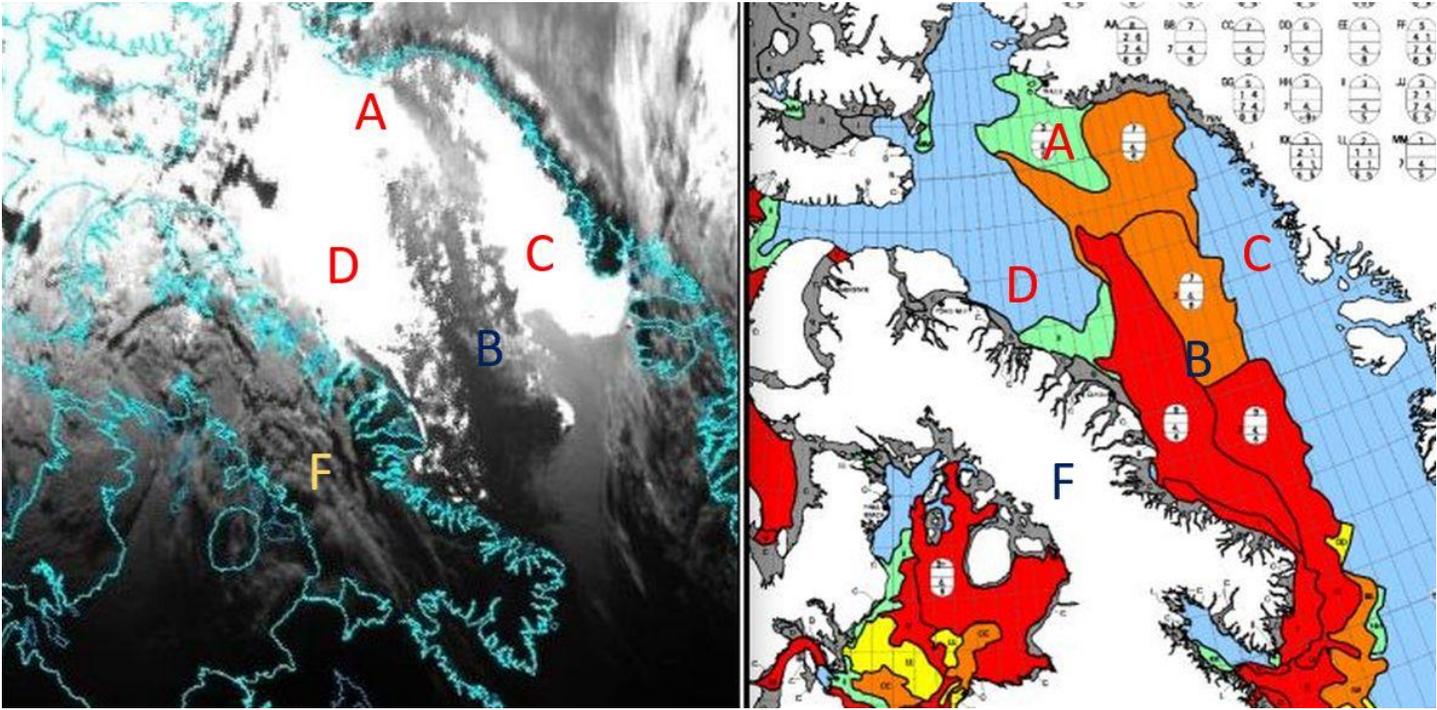
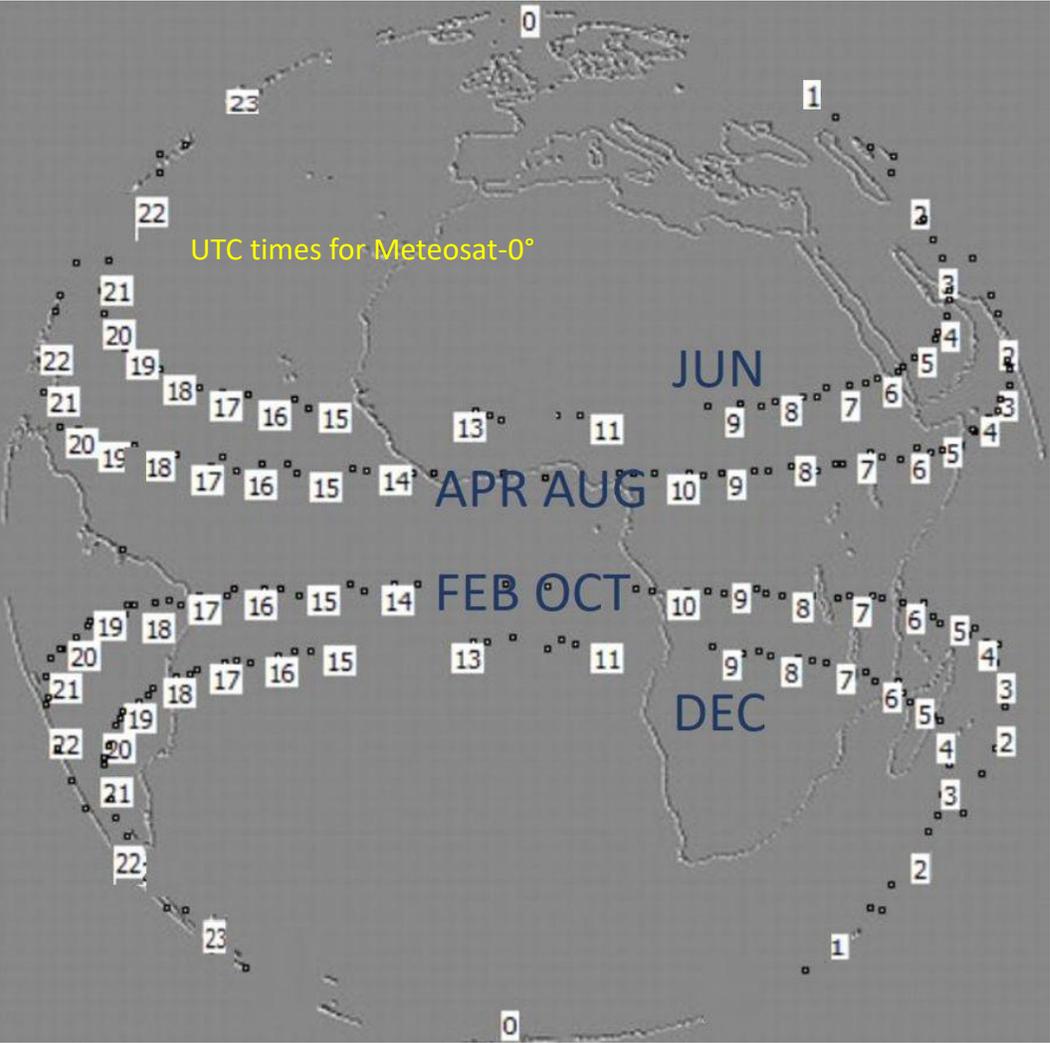
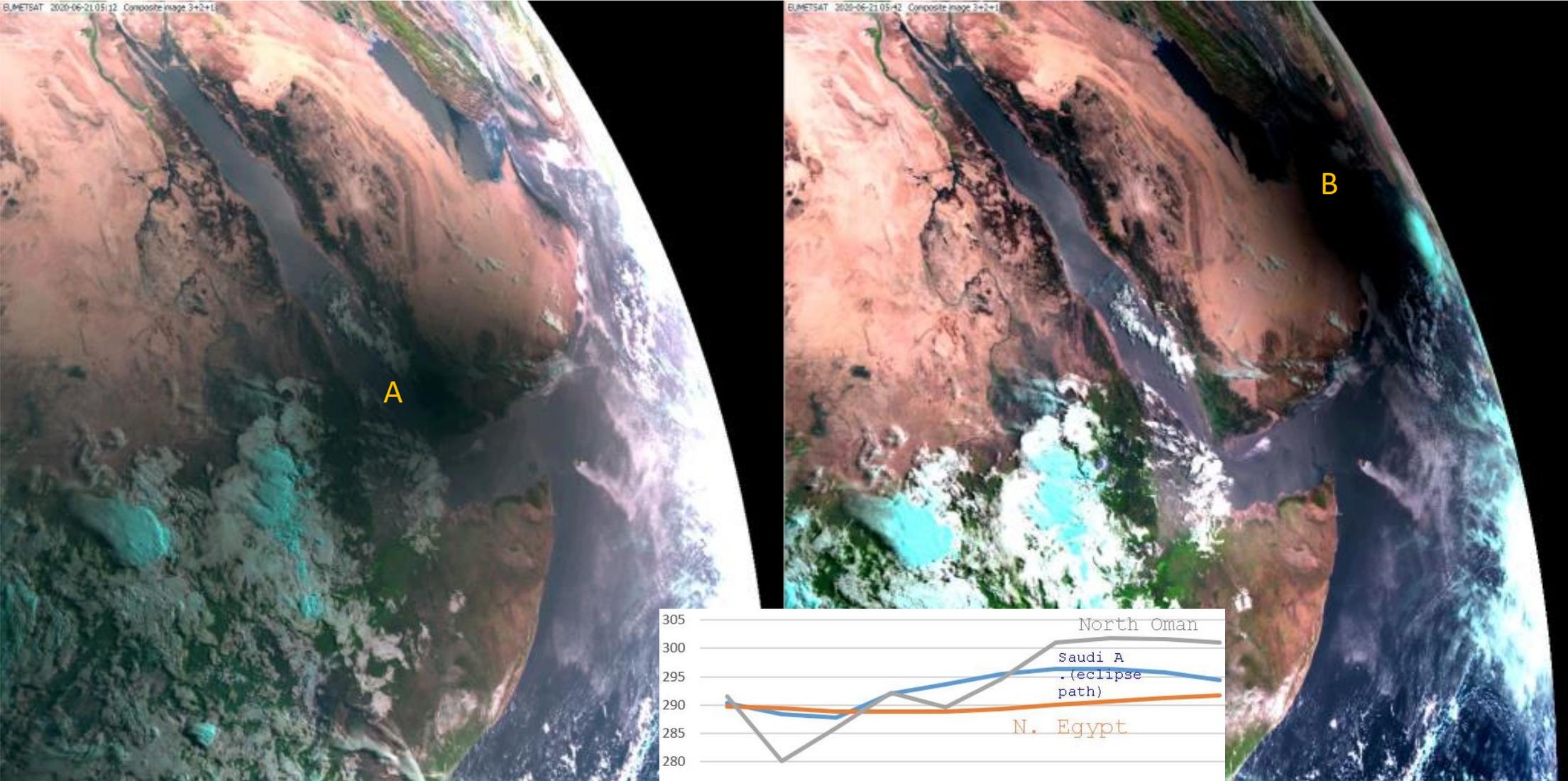


Figure 3: Comparison of GOES-16 ABI 0.8 $\mu$ m at 05:10UTC (left) with the ice concentration product of the Government of Canada (right) for 21 June 2020. Areas D and C show an anomalous liquid condition, whereas B is thick ice, not responsive to the sun glint geometry at that time. Quiet liquid surfaces 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 sun glint conditions and under normal illumination.

# Moon eclipses sunglint

21-june-2020  
0510 UTC-0540 UTC



# Parallax

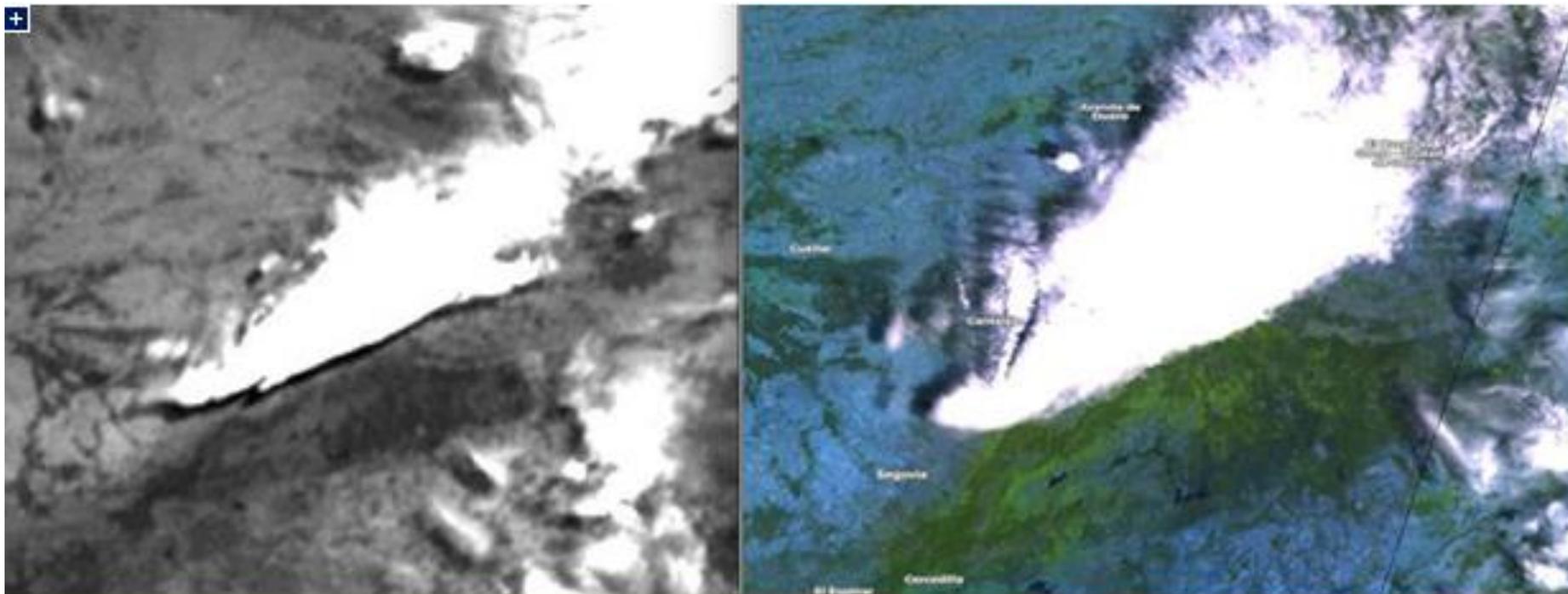


Figure 3: Meteosat-11 (left hand side) and Sentinel-3 (right) views on the same cloud system over central Spain, 27 June 11:00 UTC. Meteosat shows dark pixels south, Sentinel OLCI instrument north-west of the cloud.

- 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>

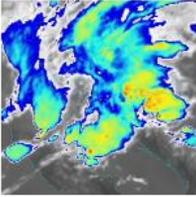
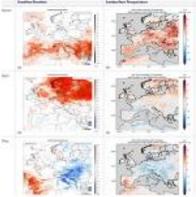
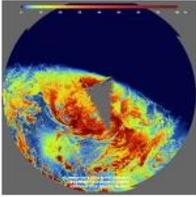
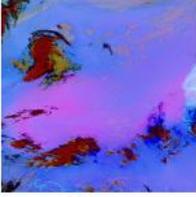
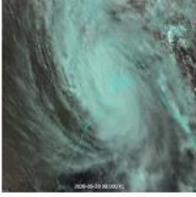
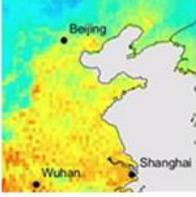
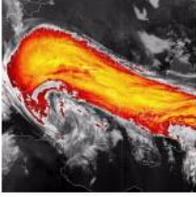
- Cases:

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

- Product navigator:

<https://navigator.eumetsat.int/start>

1417 RESULTS

 <p><b>URBAN FLASH FLOOD IN ZAGREB</b> 23 July 2020 Extreme rainfall on the evening of 24 July 2020 left the Croatia capital Zagreb under water.</p>	 <p><b>2018 AND 2019 DROUGHT AND HEATWAVES IN EUROPE</b> 21 July 2020 Both 2018 and 2019 saw exceptionally dry, hot summers.</p>	 <p><b>CANCER SOLSTICE 2020</b> 26 June 2020 The Cancer solstice, with the Sun directly over the Tropic of Cancer, took place in 2020 on 20 June at 21:43 UTC.</p>	 <p><b>ANNULAR SOLAR ECLIPSE ON SOLSTICE</b> 21 June 2020 During the 2020 June solstice the shadow of the Moon, travelling from west to east, appeared in the images of three geostationary satellites.</p>
			

forcing was ensured by the 300 hPa jet-stream bringing dry air (black in water vapour image) with high vorticity values from the upper levels to the system (see Figure 1).

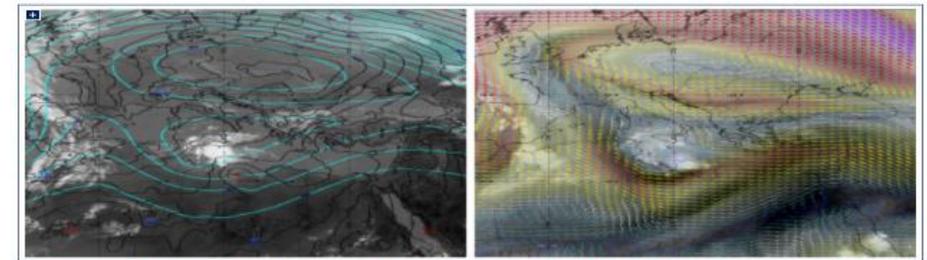


Figure 1: Left: Meteosat-11 IR10.8, 14 September 09:00 UTC, with 500 hPa absolute topography (blue) and Mean Sea Level Pressure (black) overlaid. Right: Meteosat-11 WV6.2, 14 September 18:00 UTC, with 300 hPa wind barsbs overlaid

By 16 September the cyclone had intensified and strong winds developed surrounding its centre. Figure 2 shows the winds measured by the ASCAT (scatterometer) instrument on the Metop satellites, indicating wind speeds over 90 km/h (25 m/s) around the cyclone.



# Thank you!

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

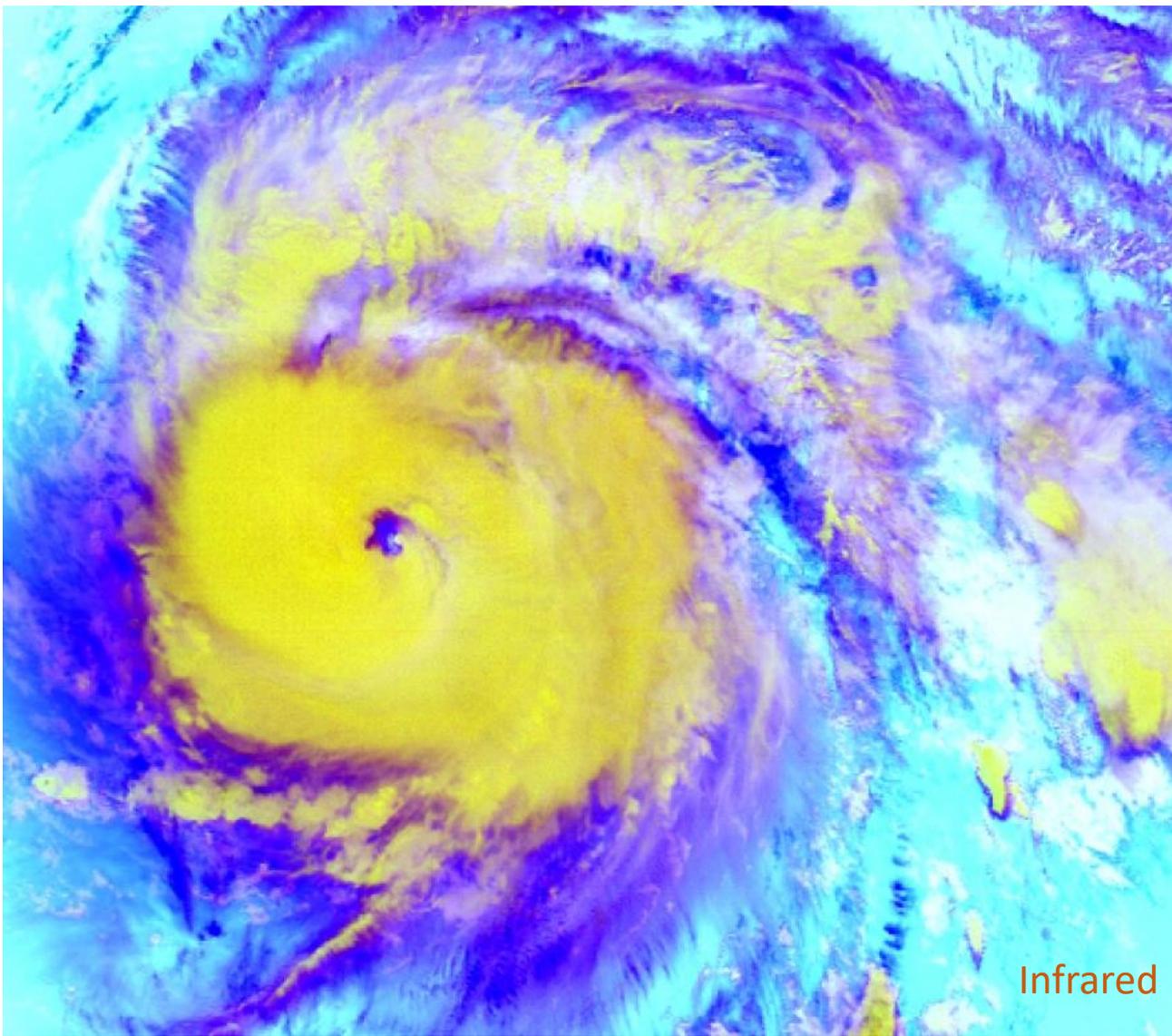
(H Kissinger to journalists)

# Discovery

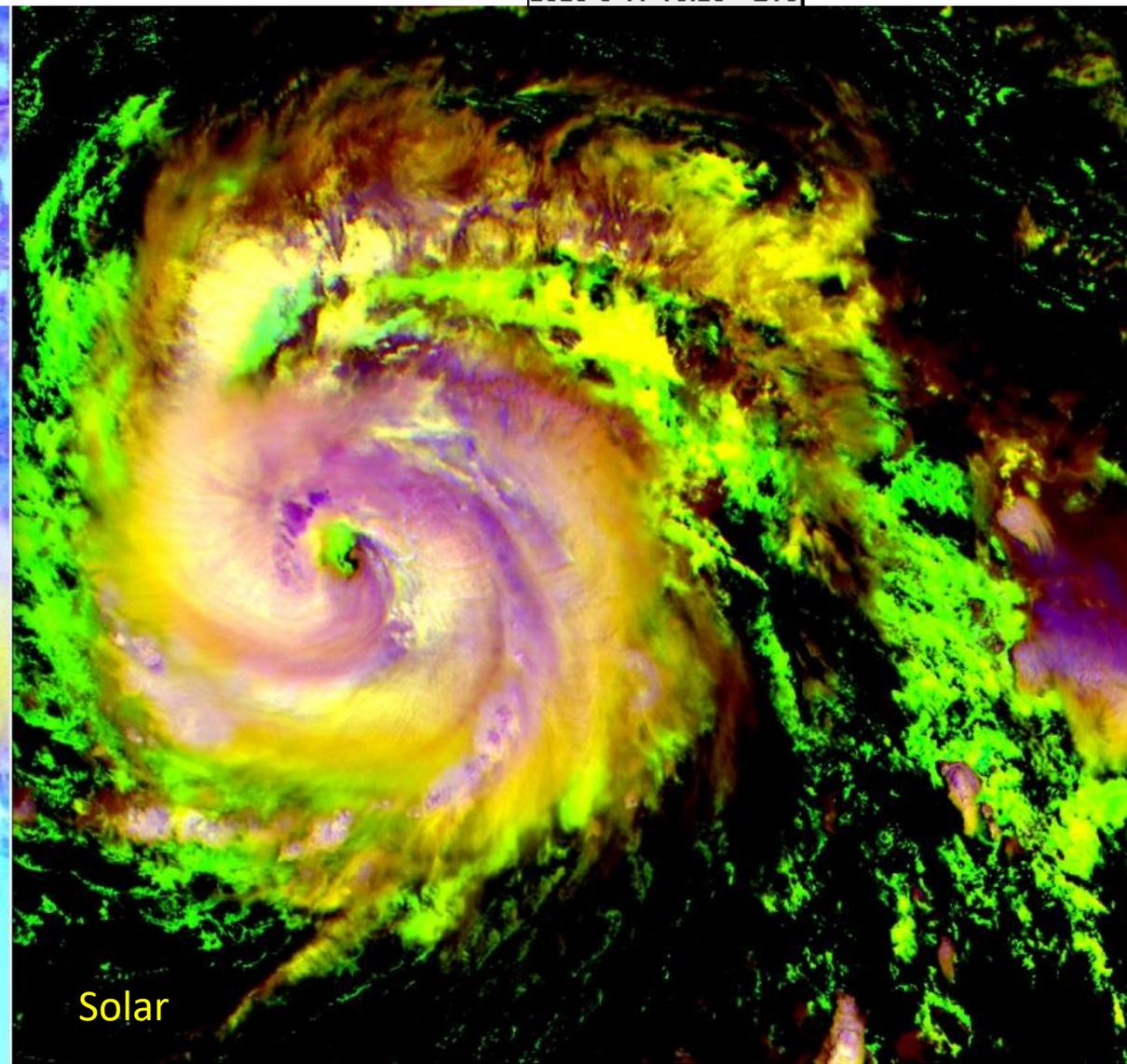
- A travel beyond standards for cloud and land surfaces.

# Enhancing RGB, for focus on hurricane: narrow the range

2020-9-17 15:20 G16

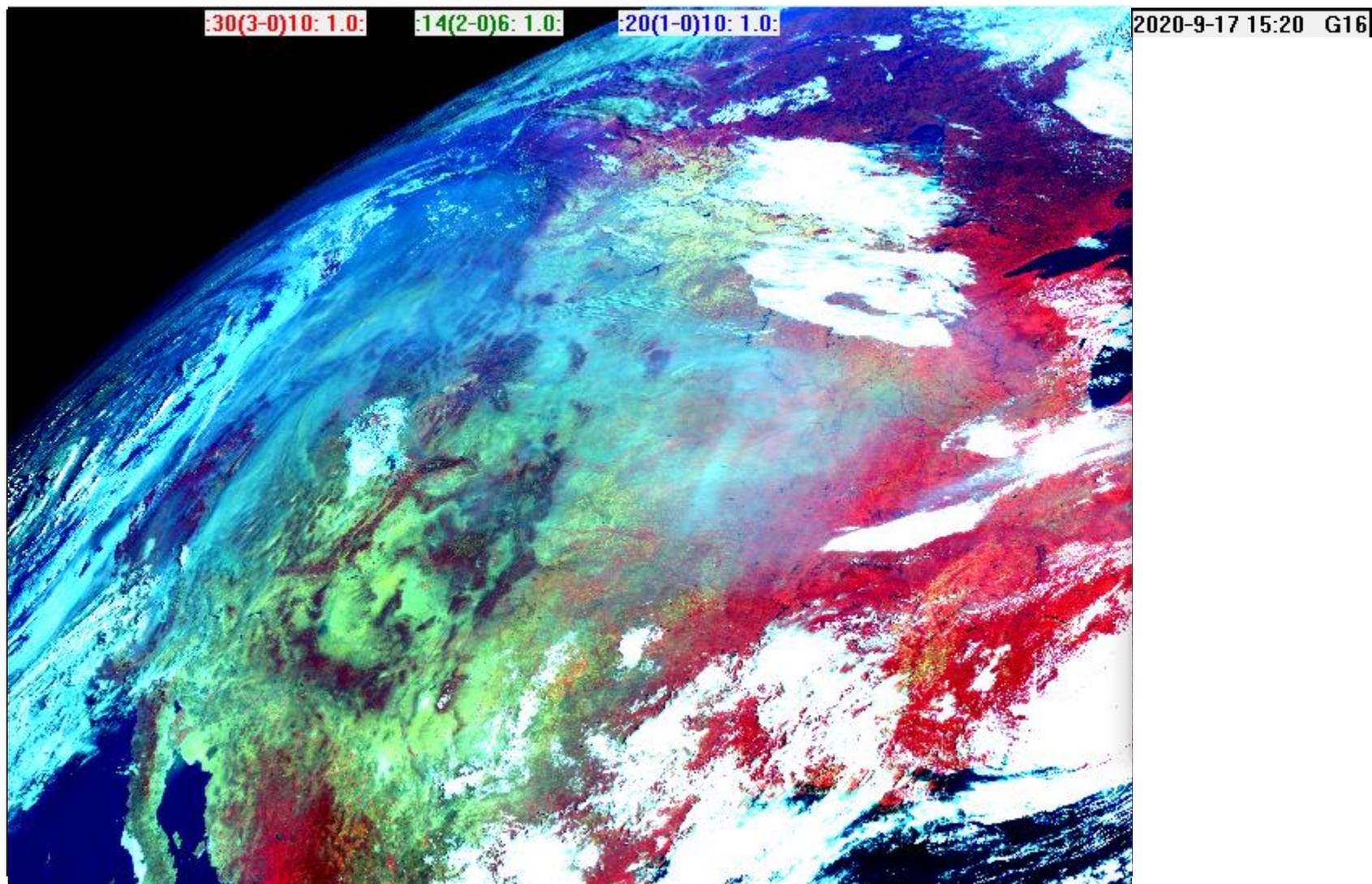


Infrared

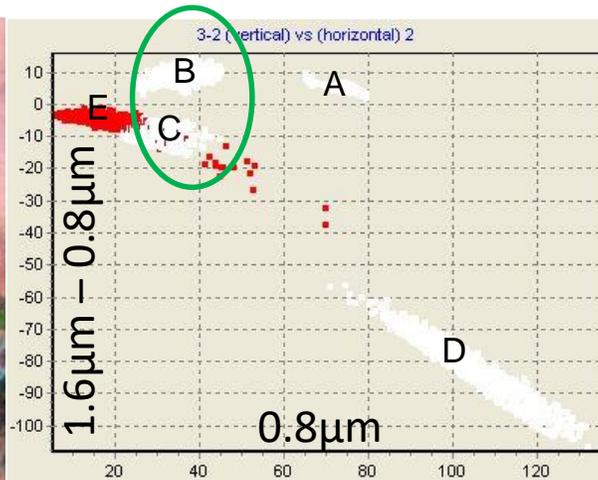
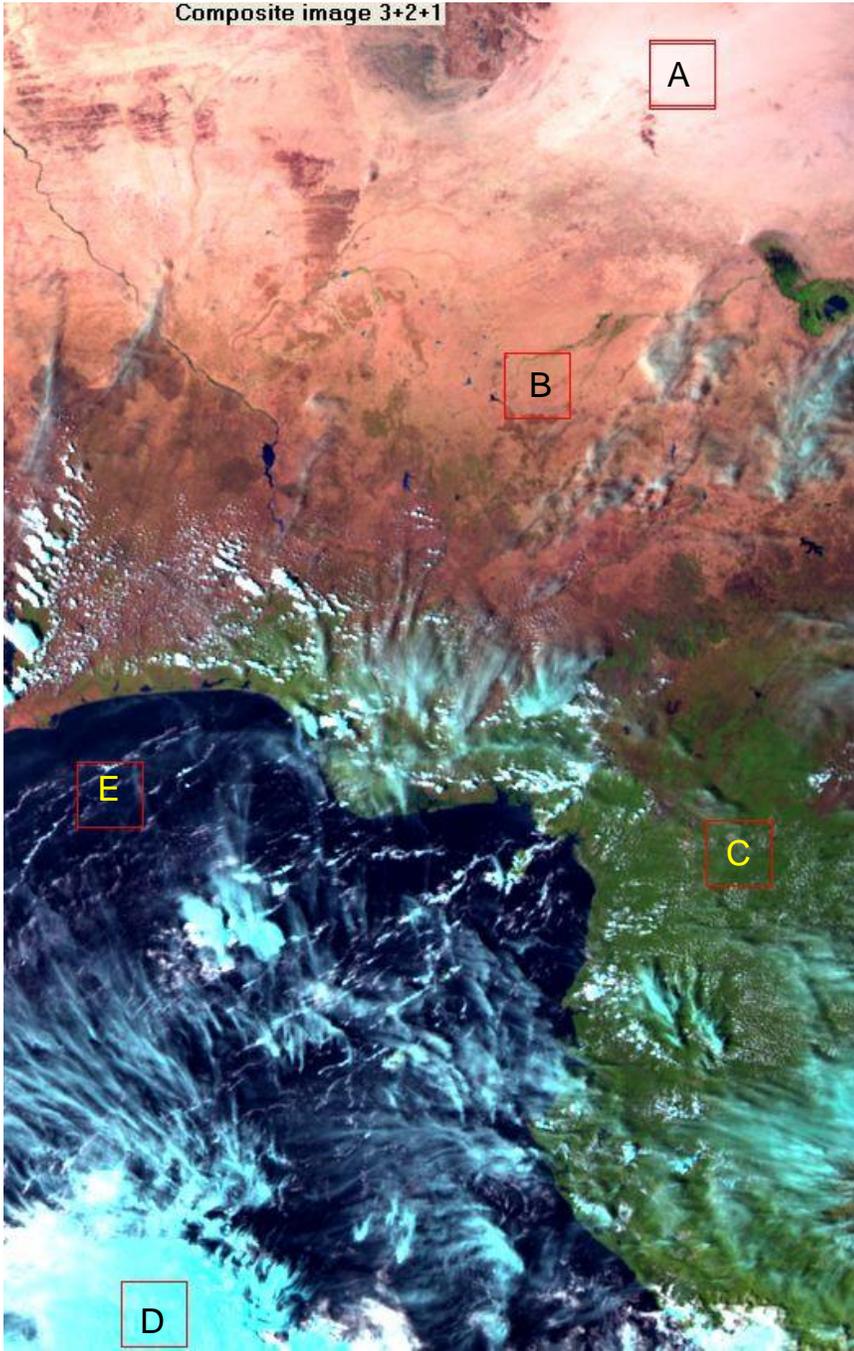


Solar

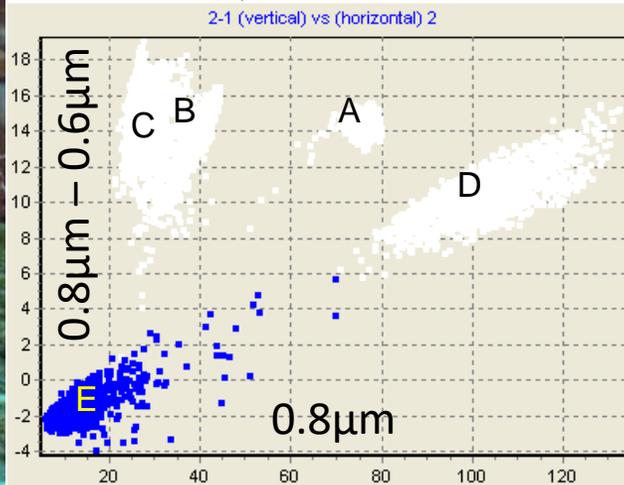
# Enhancing RGB, for smoke detection: centre on low values



# 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-1<sup>st</sup>),  
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

2020-09-01  
10:50:18 UTC

(H)ide

Play (space) < >

(L)oop  (R)ock  Re(v)

Speed

Zoom (+) Zoom (-)  Max (Z)oom

(M)aps  Lat/Lo(n)  Slid(e)r

(S)atellite GOES-16 (East;... ▾

Se(c)tor Full Disk ▾

(P)roduct GeoColor (CIRA) ▾

Add (O)verlay Add (O)verlay ▾

# of (I)mages 12 ▾

(T)ime Step 10 min ▾

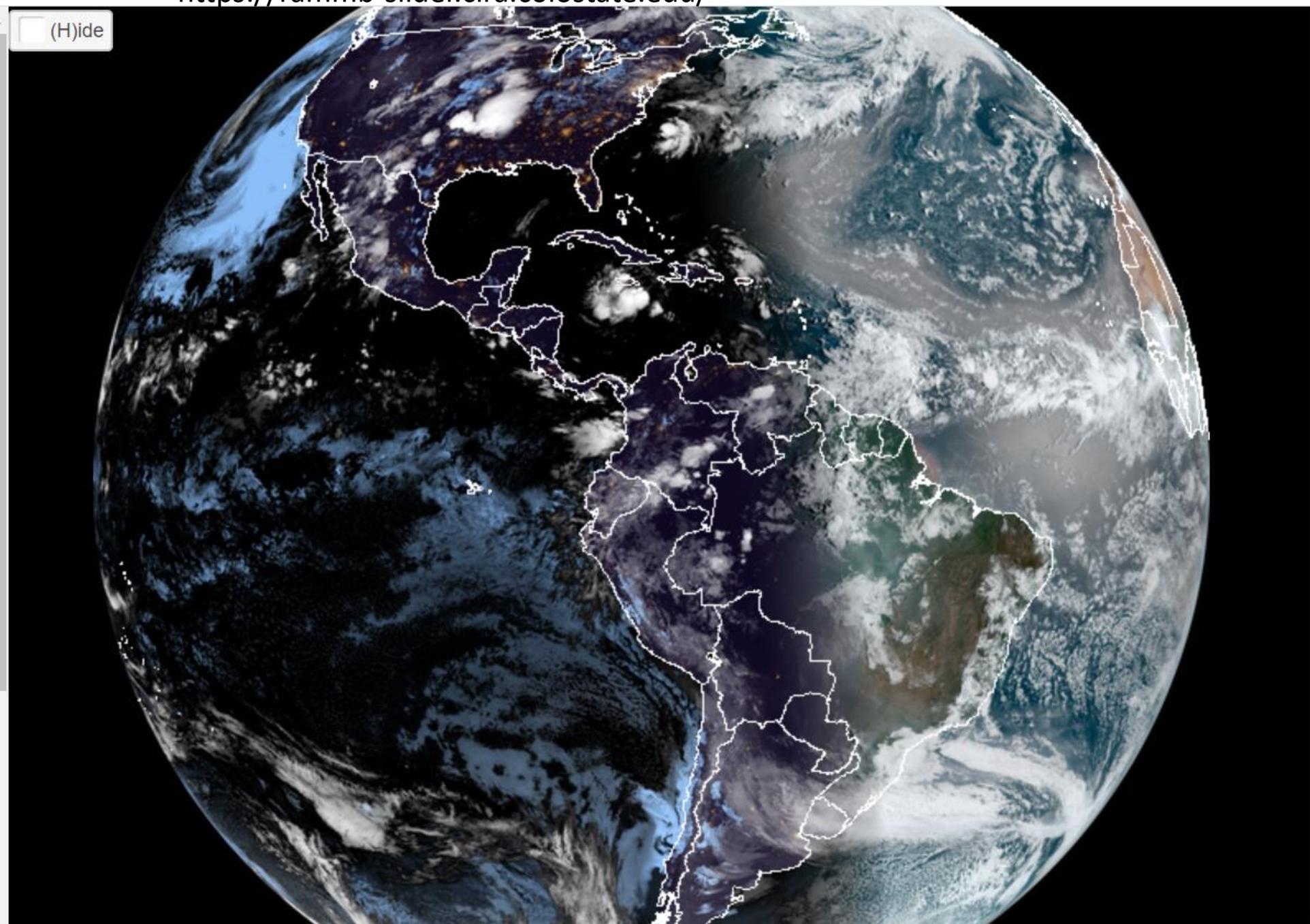
GeoColor (CIRA) x

Hide

Info

(A)rchived Imagery

Begin D... ▾ B... ▾ Begin TI... ▾



# EUMETSAT map viewer

[view.eumetsat.int](http://view.eumetsat.int)

**EUMETSAT DATA SERVICES** Download queue

## EUMETView

◀ Eumetsat view \* ▶ 📄 Add layers +

Layers

- 📄 👁 🕒 ASCAT Coastal Winds at 12.5 k... 📘 ⌵ ✕  
Opacity  100 %  
ASCAT Wind Speed m / s  

0.0	1.5	5.5	10.7	17.11	24.4	32.6 +
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🎨 🎨
- 📄 👁 🕒 Airmass RGB - MSG - 0 degree 📘 ⌵ ✕

Overlays  
Basemap  
Projection

Animate map ✕

2020 Sep 16 10 : 30 UTC to 2020 Sep 18 02 : 30 UTC

Frames per second  1

100 Minutes ⌵

🔄 ▶ 📍

20 Sep 17 15 : 12 UTC ◀ ▶

Thu 17 September

20:00 00:00 04:00 08:00 12:00 16:00 20:00

ASCAT Coastal Winds at 12.5 km Swath G...

# Tools and data sources

The image shows the McIDAS-V website and a screenshot of the software interface. The website header includes the McIDAS logo and the text "Man computer Interactive Data Access System". The navigation menu has tabs for HOME, ABOUT, MCIDAS-X, MCIDAS-V (selected), MCIDAS-XCD, INGESTORS, LICENSING, and SUPPORT. Below the menu, there are links for About, Download, Documentation, and Sample Capabilities. The main content area is titled "Download McIDAS-V" and describes it as "free, open source software for 3D geophysical data analysis and visualization". It states that McIDAS-V runs on Linux, macOS, and Windows. Below the text is a screenshot of the McIDAS-V software interface, showing a menu bar (File, Edit, Display, Tools, History, Bundles, Window, Help), a toolbar, and a main display area showing a satellite image of a region. A "Data Explorer" panel is visible on the left, showing "Layer Controls" and "Displays" options like "Image Display", "Image Display Over Topography", "Image Contours", and "Scatter Analysis". A small globe icon is also visible in the interface.

## GOES-16/17 on Amazon Download Page

[GOES on Amazon](#) [GOES on Pando](#) [CIRA SLIDER](#)

Download Instructions

Data Details

Other Ways to Download

Derived (Level 2) products are now available.

Source:  AWS  OCC

Satellite:  GOES-16/East  GOES-17/West

Domain:

Product:

Date:

Hour (UTC):

Click or tap to download from noaa-goes16 S3 bucket: <https://noaa-goes16.s3.amazonaws.com/ABI-L2-CMIPC/2020/246/00/>

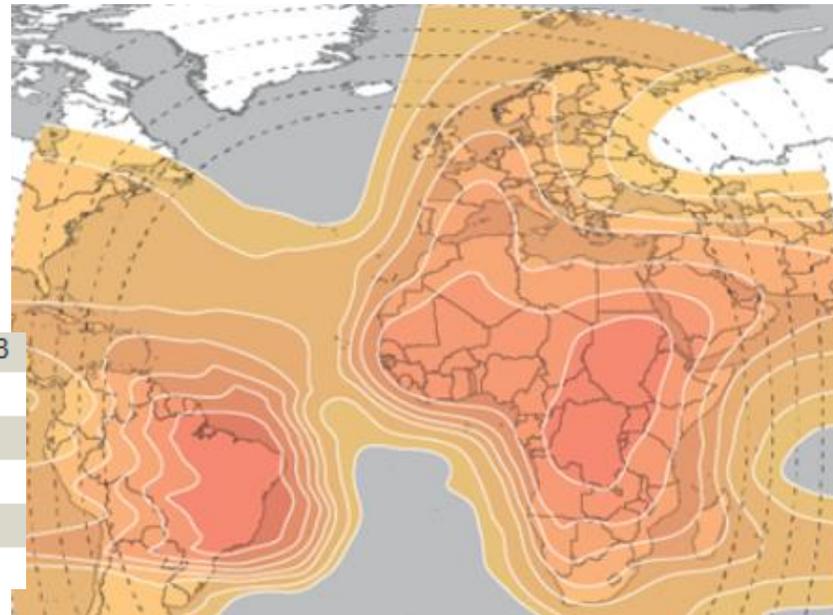
Number represents the scan's start minute for the requested hour

Band 01	01	06	11	16	21	26	31	36	41	46	51	56
Band 02	01	06	11	16	21	26	31	36	41	46	51	56

[jh.herk@gmail.com](mailto:jh.herk@gmail.com) (Jorge Bravo)

# 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



EUTELSAT 8 West B  
C04  
3848.2525 MHz  
9.892 MS/s  
Circular Left Hand  
4PSK (QPSK) 3/4