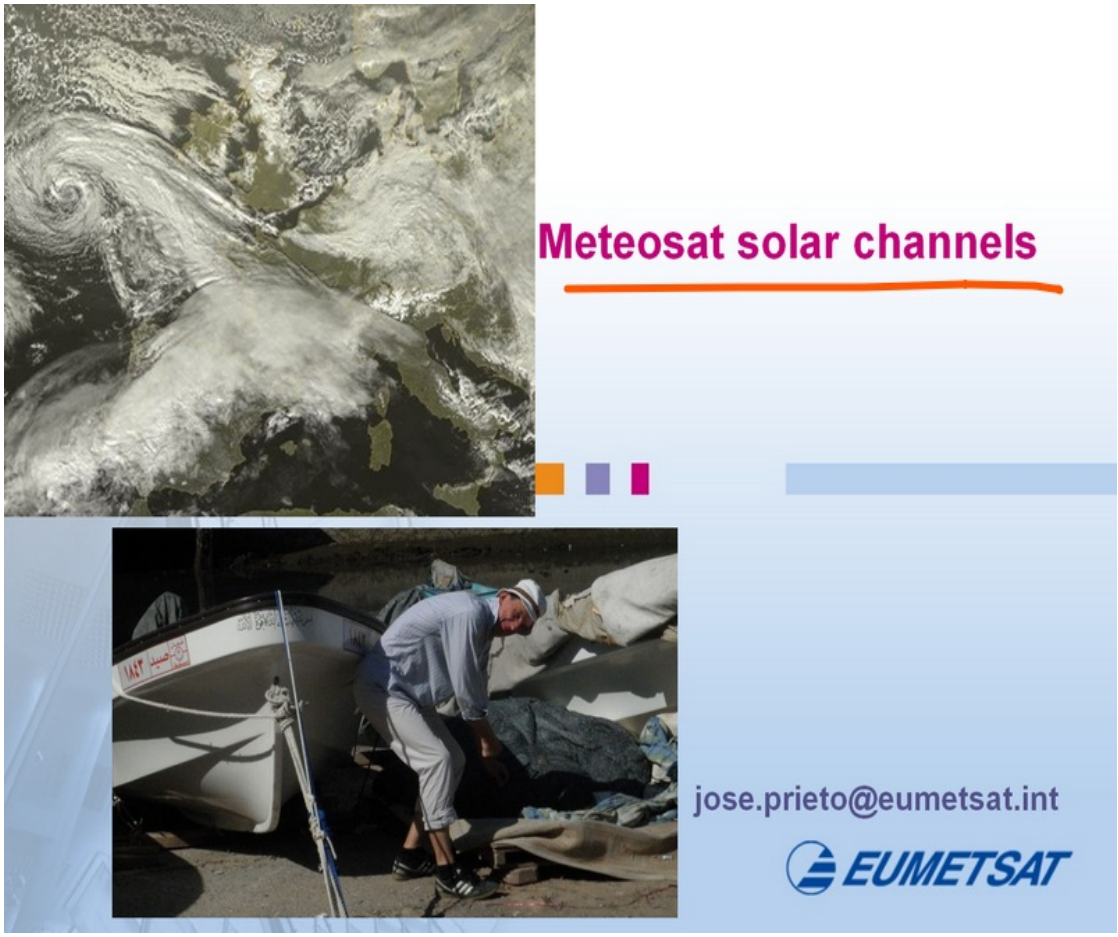
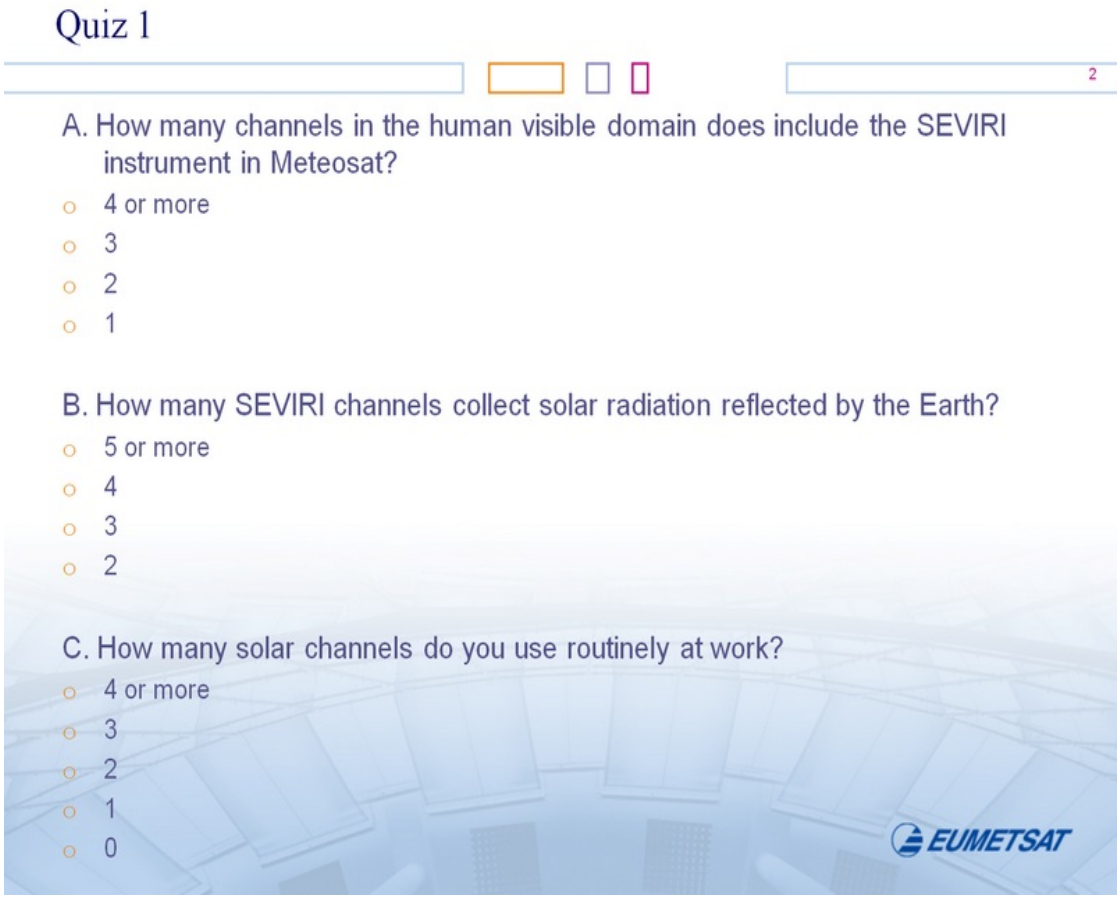
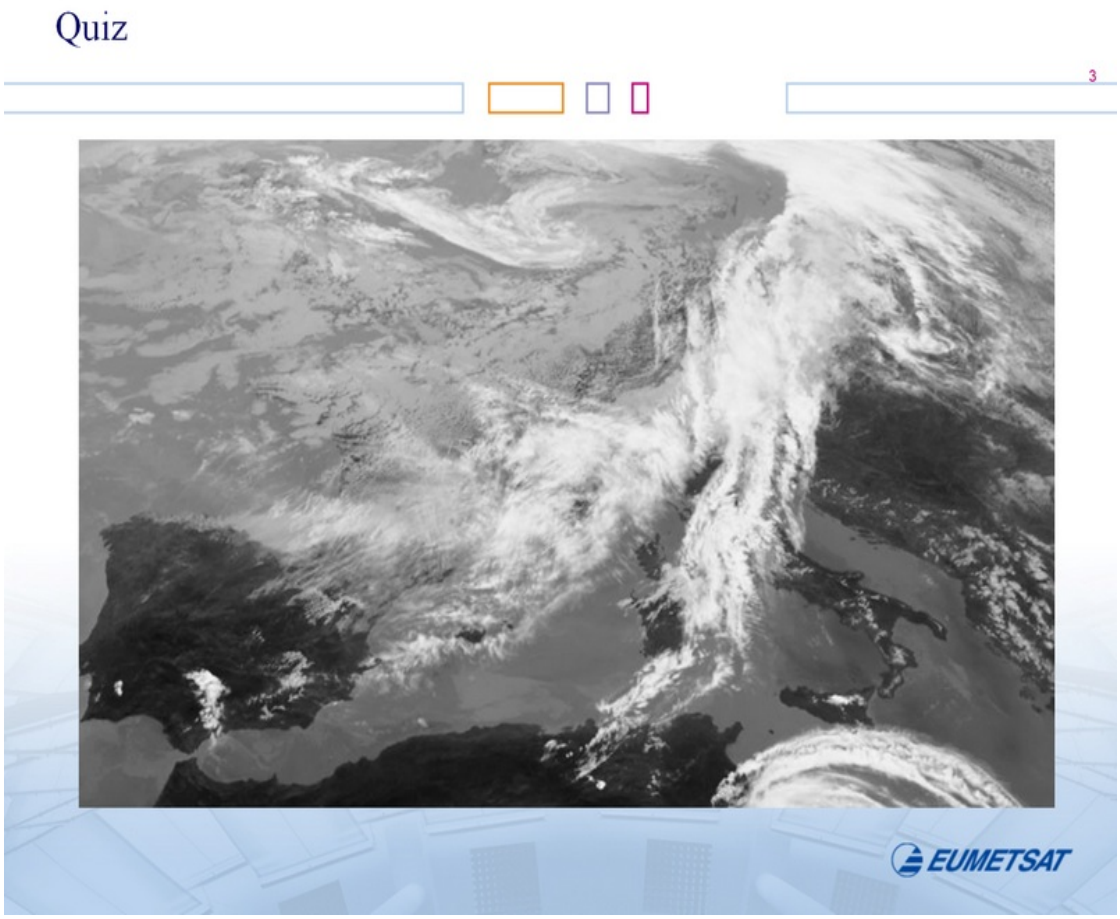
Jose_01.PNG


Meteosat solar channels
jose.prieto@eumetsat.int
EUMETSAT

Jose_02.PNG

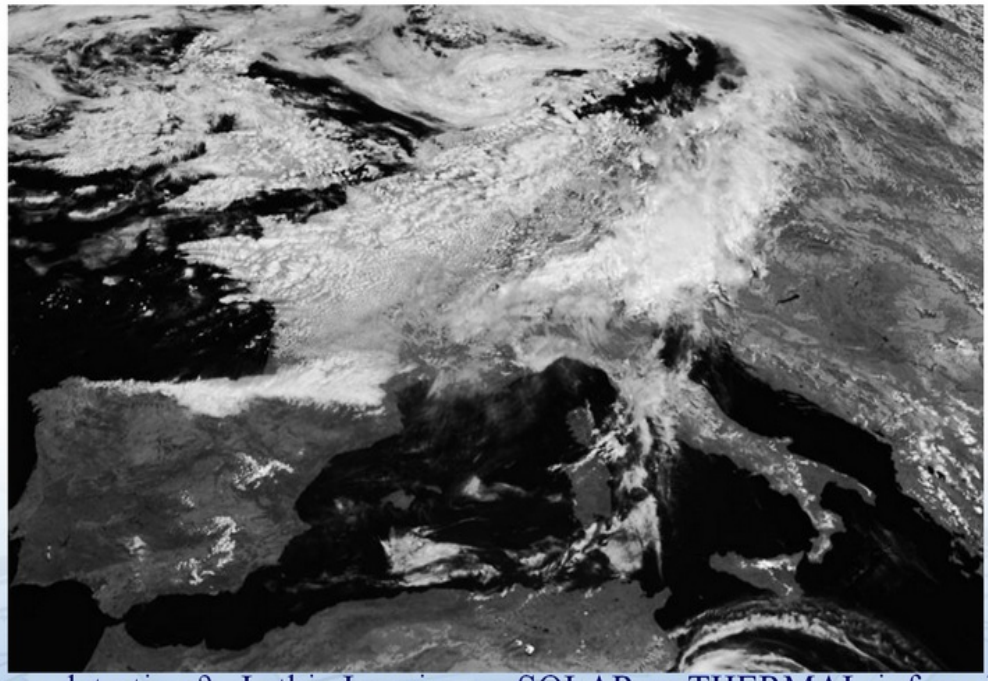

Quiz 1
2
A. How many channels in the human visible domain does include the SEVIRI instrument in Meteosat?
4 or more
3
2
1
B. How many SEVIRI channels collect solar radiation reflected by the Earth?
5 or more
4
3
2
C. How many solar channels do you use routinely at work?
4 or more
3
2
1
0
EUMETSAT

Jose_03.PNG



Jose_04.PNG

Quiz



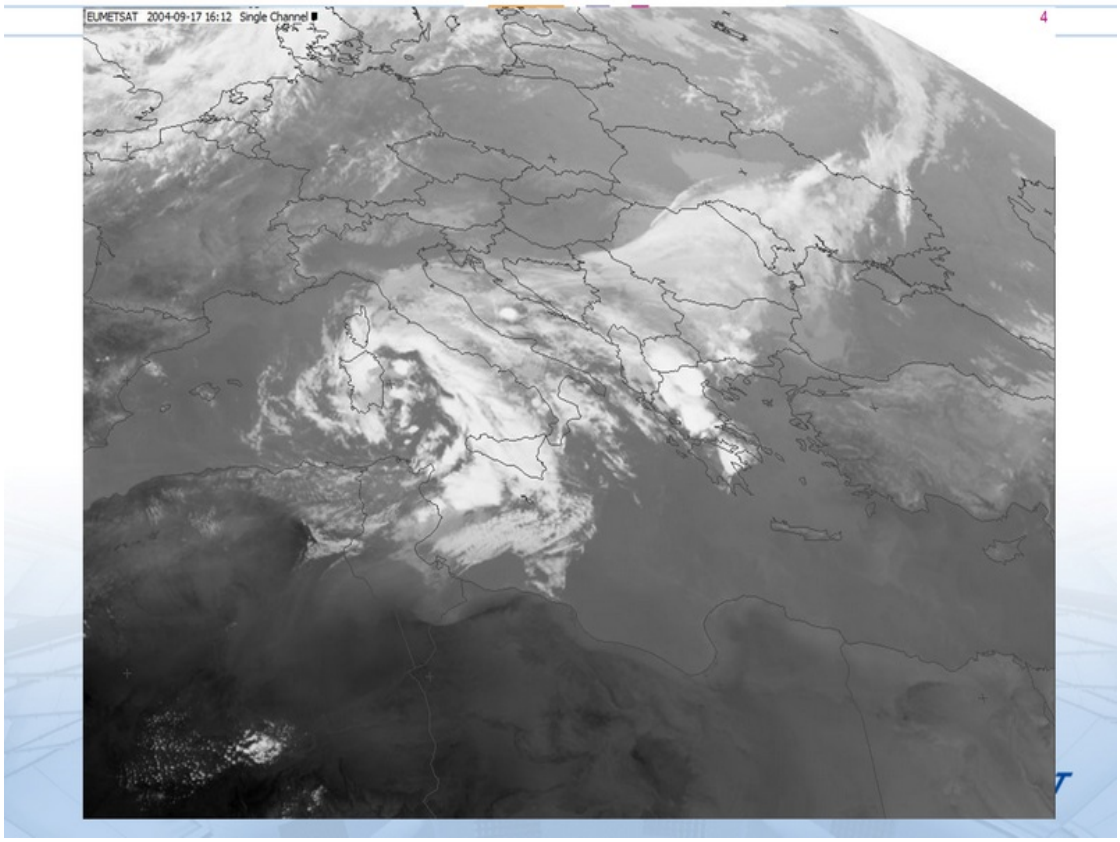
Same date-time? Is this June image SOLAR or THERMAL-infrared?

YES NO

EUMETSAT

Jose_05.PNG

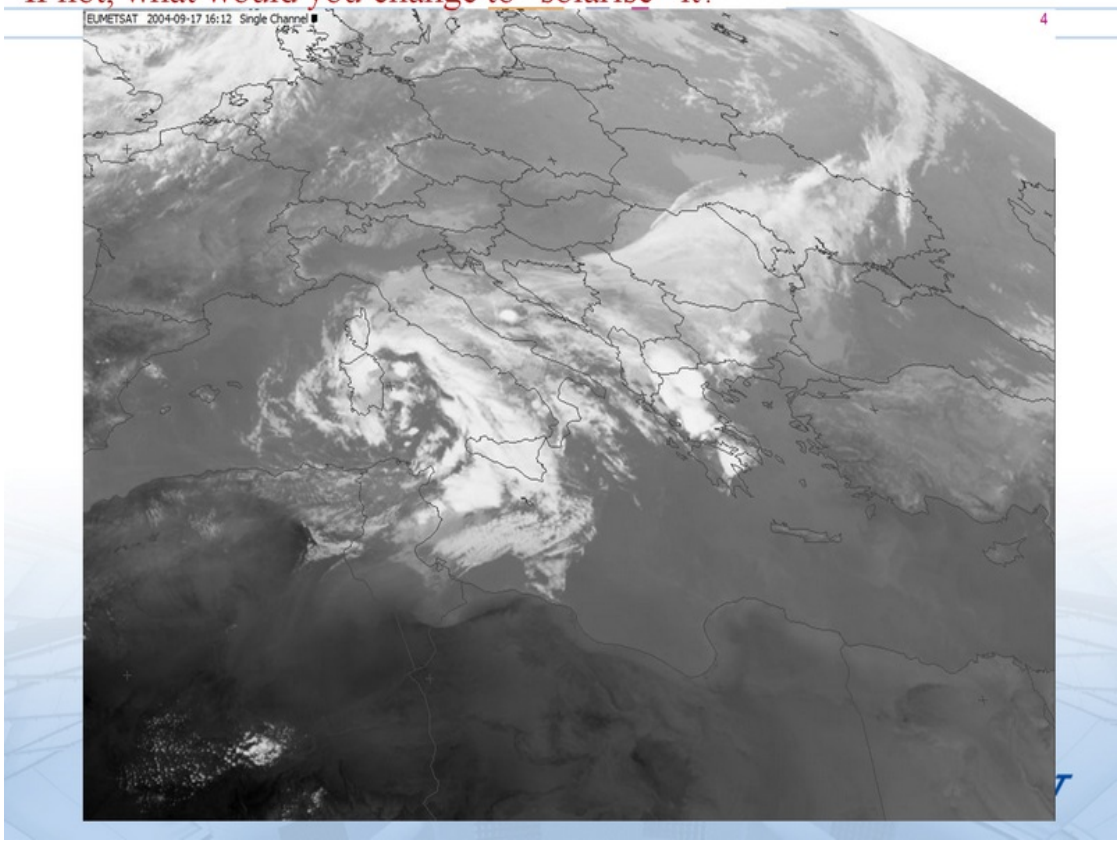
Is this solar? YES NO



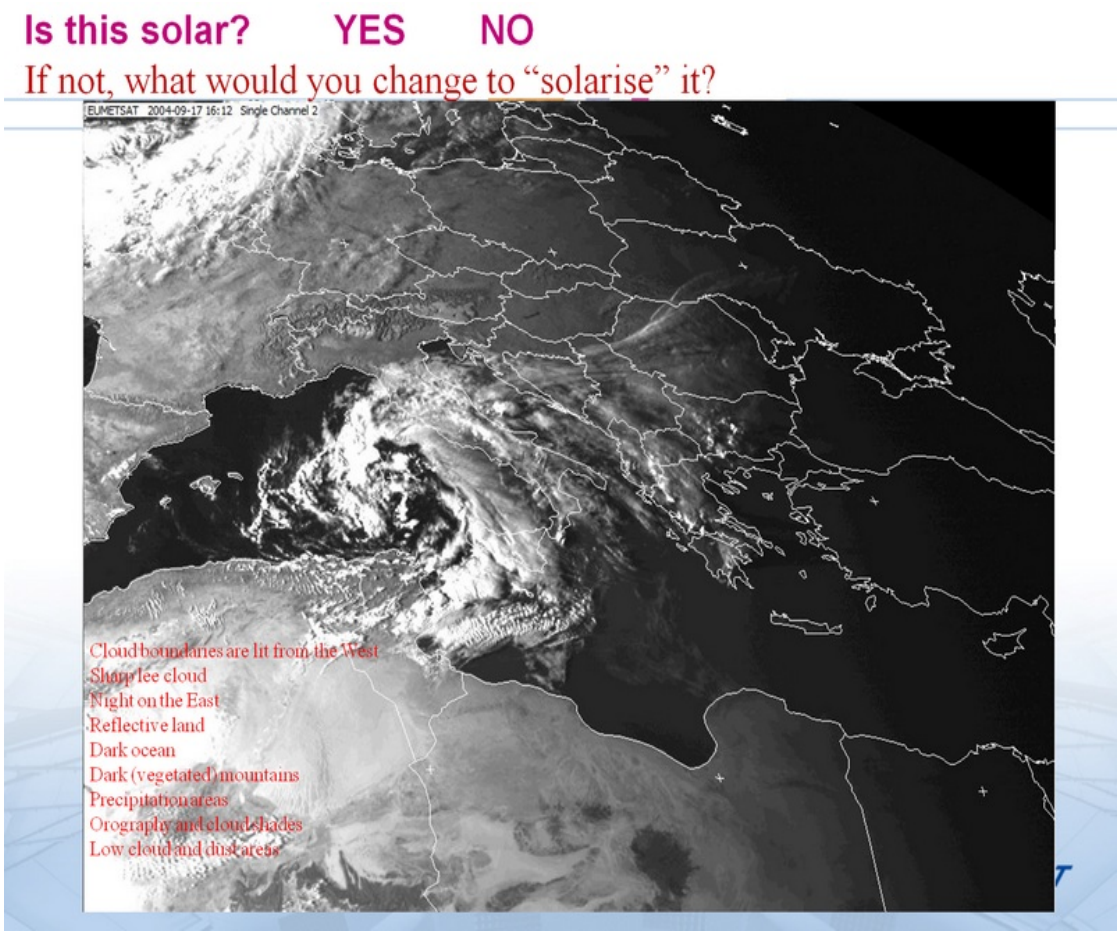
Jose_06.PNG

Is this solar? YES NO

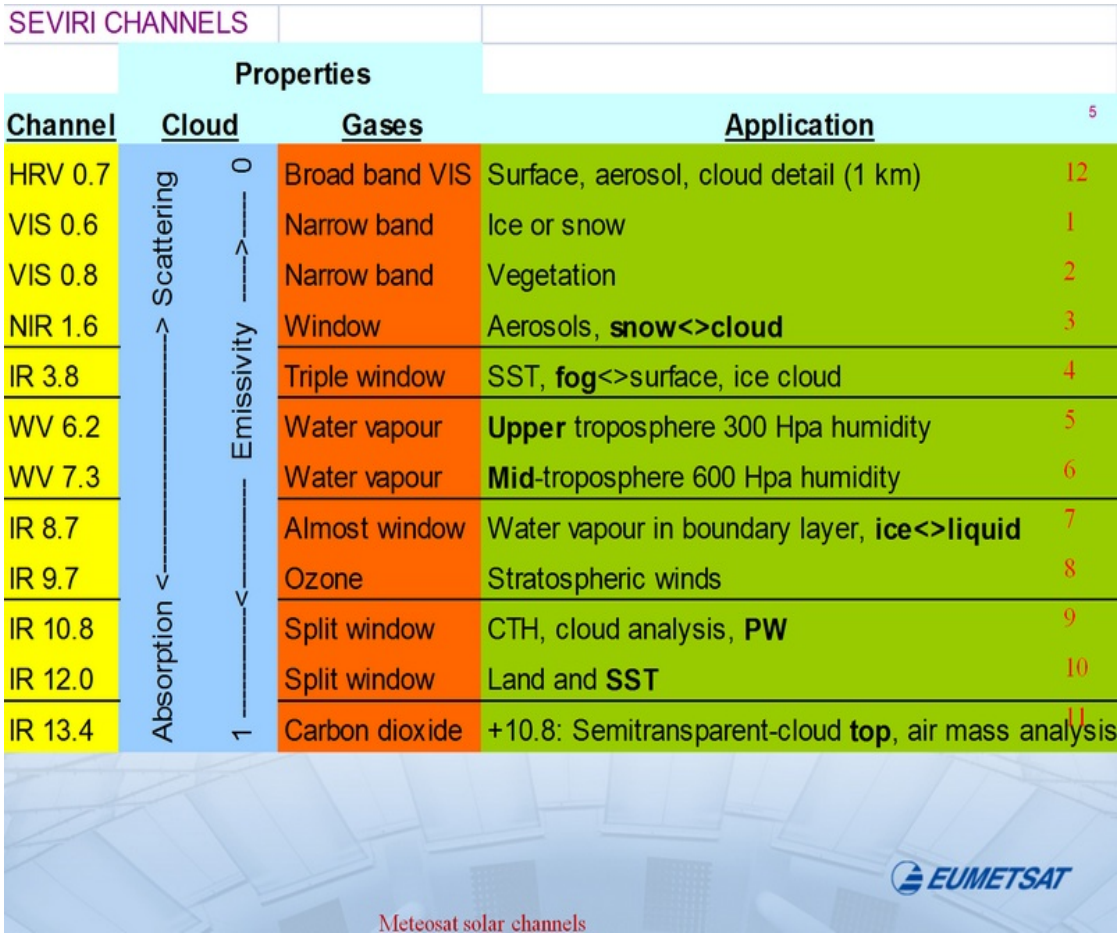
If not, what would you change to "solarise" it?



Jose_07.PNG


Is this solar? YES NO
If not, what would you change to "solarise" it?
EUMETSAT 2004-09-17 16:12 Single Channel 2
Cloud boundaries are lit from the West
Sharp lee cloud
Night on the East
Reflective land
Dark ocean
Dark (vegetated) mountains
Precipitation areas
Orography and cloud shades
Low cloud and dust areas

Jose_08.PNG


SEVIRI CHANNELS
Properties
Channel
Cloud
Gases
Application
HRV 0.7
VIS 0.6
VIS 0.8
NIR 1.6
IR 3.8
WV 6.2
WV 7.3
IR 8.7
IR 9.7
IR 10.8
IR 12.0
IR 13.4
Absorption <----------> Scattering
1 <---------- Emissivity ----> 0
Broad band VIS
Narrow band
Narrow band
Window
Triple window
Water vapour
Water vapour
Almost window
Ozone
Split window
Split window
Carbon dioxide
Surface, aerosol, cloud detail (1 km)
Ice or snow
Vegetation
Aerosols, snow<>cloud
SST, fog<>surface, ice cloud
Upper troposphere 300 Hpa humidity
Mid-troposphere 600 Hpa humidity
Water vapour in boundary layer, ice<>liquid
Stratospheric winds
CTH, cloud analysis, PW
Land and SST
+10.8: Semitransparent-cloud top, air mass analysis
5
12
1
2
3
4
5
6
7
8
9
10
11
EUMETSAT
Meteosat solar channels

Jose_09.PNG

SEVIRI channel similarity

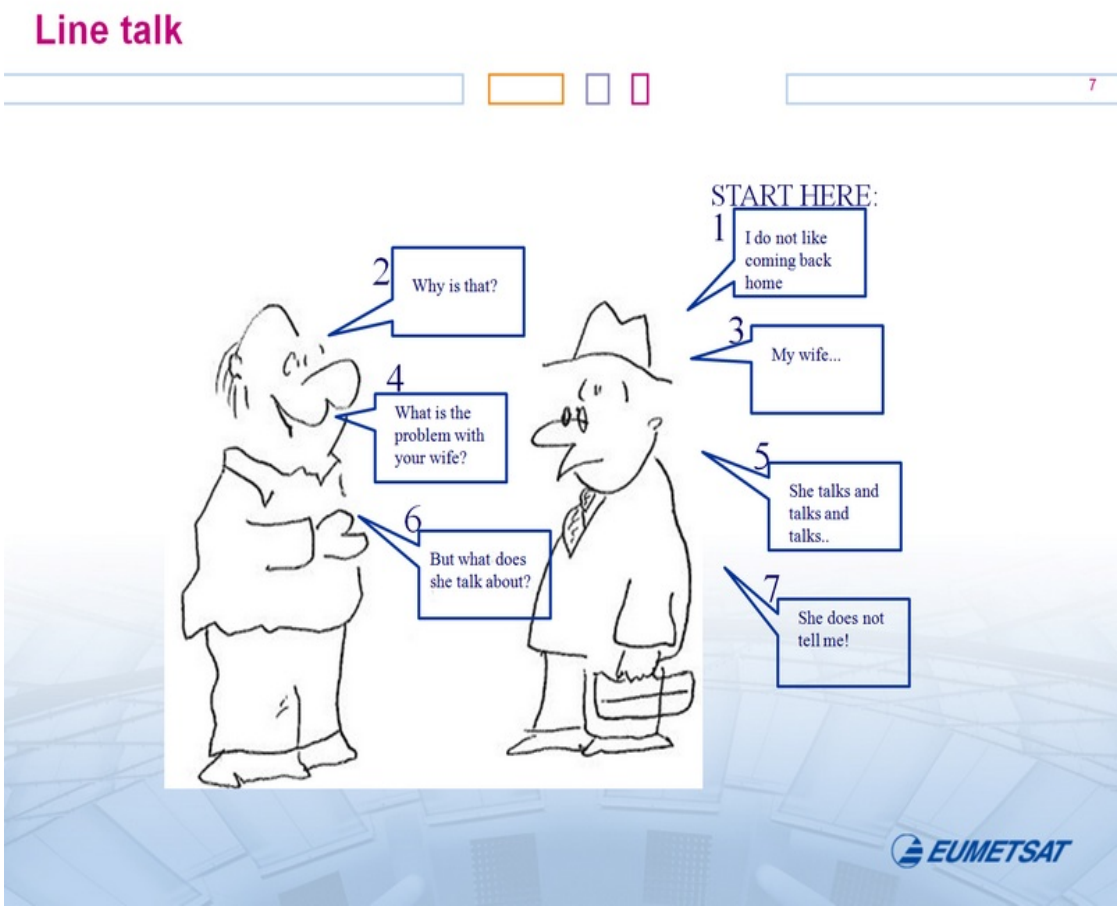
← solar → ←3.9→ ← thermal →

Channel	1	2	3	4	5	6	7	8	9	10
1										
2	0.99									
3	0.82	0.89								
4	0.26	0.35	0.60							
5	-0.47	-0.48	-0.46	0.08						
6	-0.46	-0.44	-0.34	0.42	0.80					
7	-0.61	-0.66	-0.68	0.00	0.80	0.83				
8	-0.60	-0.65	-0.66	-0.02	0.76	0.80	0.99			
9	-0.60	-0.64	-0.68	-0.02	0.82	0.83	0.99	0.97		
10	-0.58	-0.61	-0.61	0.10	0.86	0.91	0.97	0.94	0.98	
11	-0.56	-0.56	-0.49	0.26	0.83	0.97	0.89	0.86	0.90	0.96

- Solar channels 0.6 and 0.8 µm are very similar
- Those two channels are dissimilar of 1.6 µm
- All three have a NEGATIVE radiance correlation with the thermal. Why? GROUND? OCEAN? CLOUD?

EUMETSAT

Jose_10.PNG

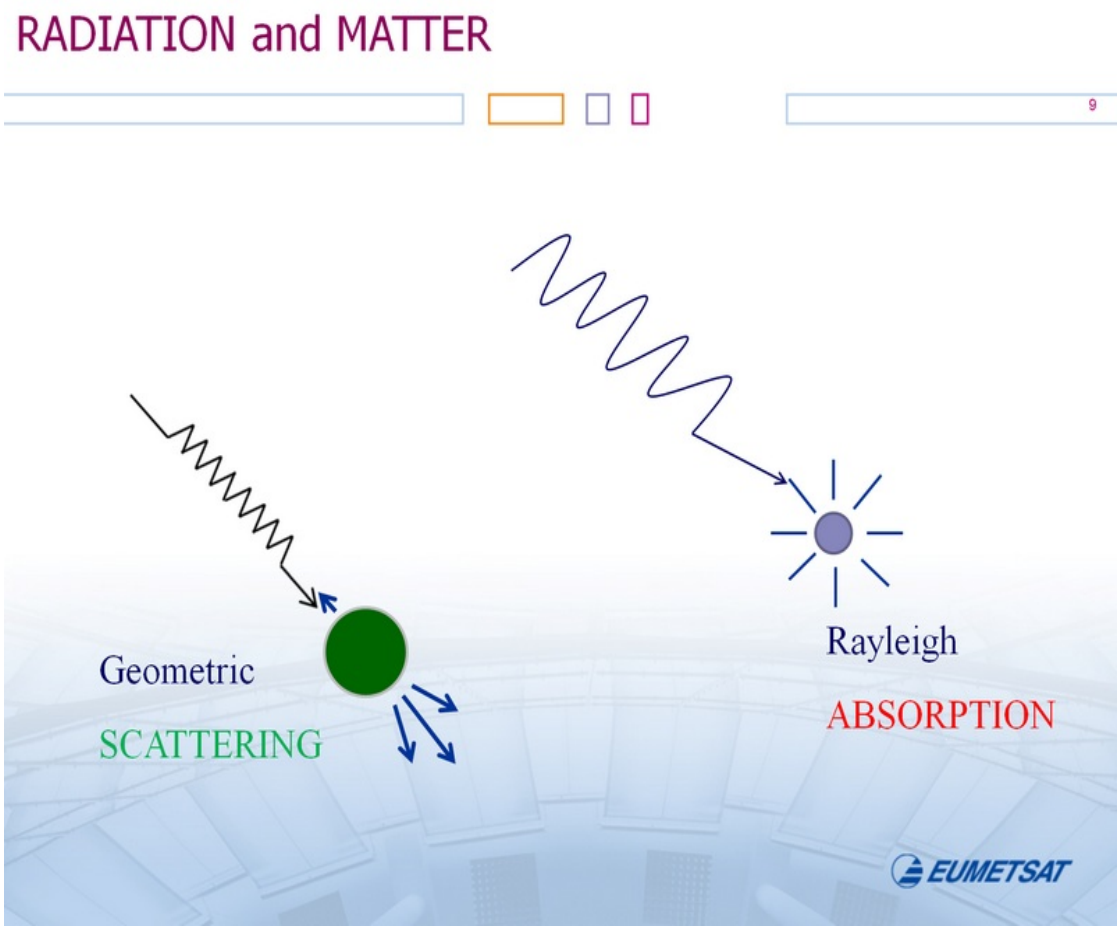

Line talk
7
START HERE:
1
I do not like coming back home
2
Why is that?
3
My wife...
4
What is the problem with your wife?
5
She talks and talks and talks..
6
But what does she talk about?
7
She does not tell me!
EUMETSAT

Jose_11.PNG

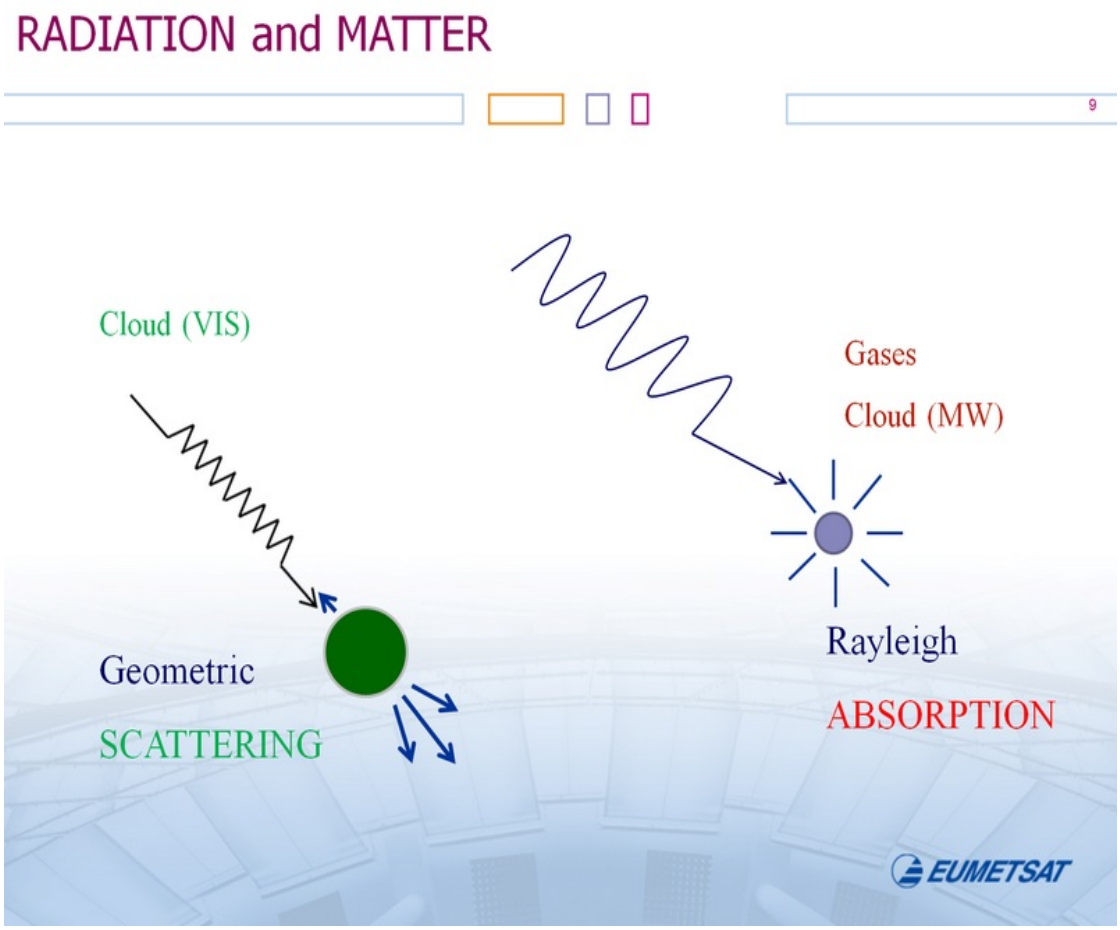
Contents

- Where is LIGHT absorbed ?
- Is the neighbour's GRASS greener?
- Is ICE always cyan?
- Is DUST enhancing visibility?

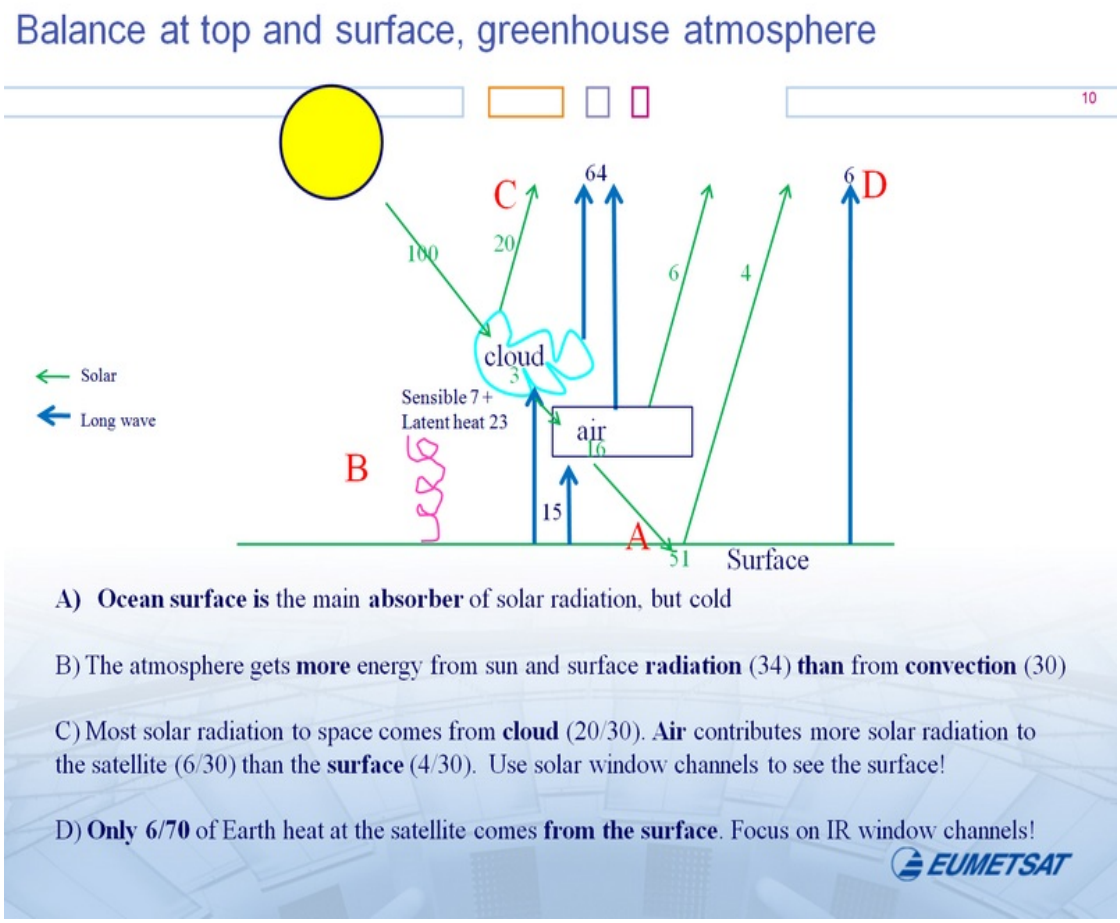
Jose_12.PNG


RADIATION and MATTER
9
Geometric
SCATTERING
Rayleigh
ABSORPTION
EUMETSAT

Jose_13.PNG


RADIATION and MATTER
9
Cloud (VIS)
Gases
Cloud (MW)
Geometric
SCATTERING
Rayleigh
ABSORPTION
EUMETSAT

Jose_14.PNG


Balance at top and surface, greenhouse atmosphere
10
C
64
6 D
100
20
6
4
cloud
3
Solar
Long wave
Sensible 7 +
Latent heat 23
air
16
B
15
A
51
Surface
A) Ocean surface is the main absorber of solar radiation, but cold
B) The atmosphere gets more energy from sun and surface radiation (34) than from convection (30)
C) Most solar radiation to space comes from cloud (20/30). Air contributes more solar radiation to the satellite (6/30) than the surface (4/30). Use solar window channels to see the surface!
D) Only 6/70 of Earth heat at the satellite comes from the surface. Focus on IR window channels!
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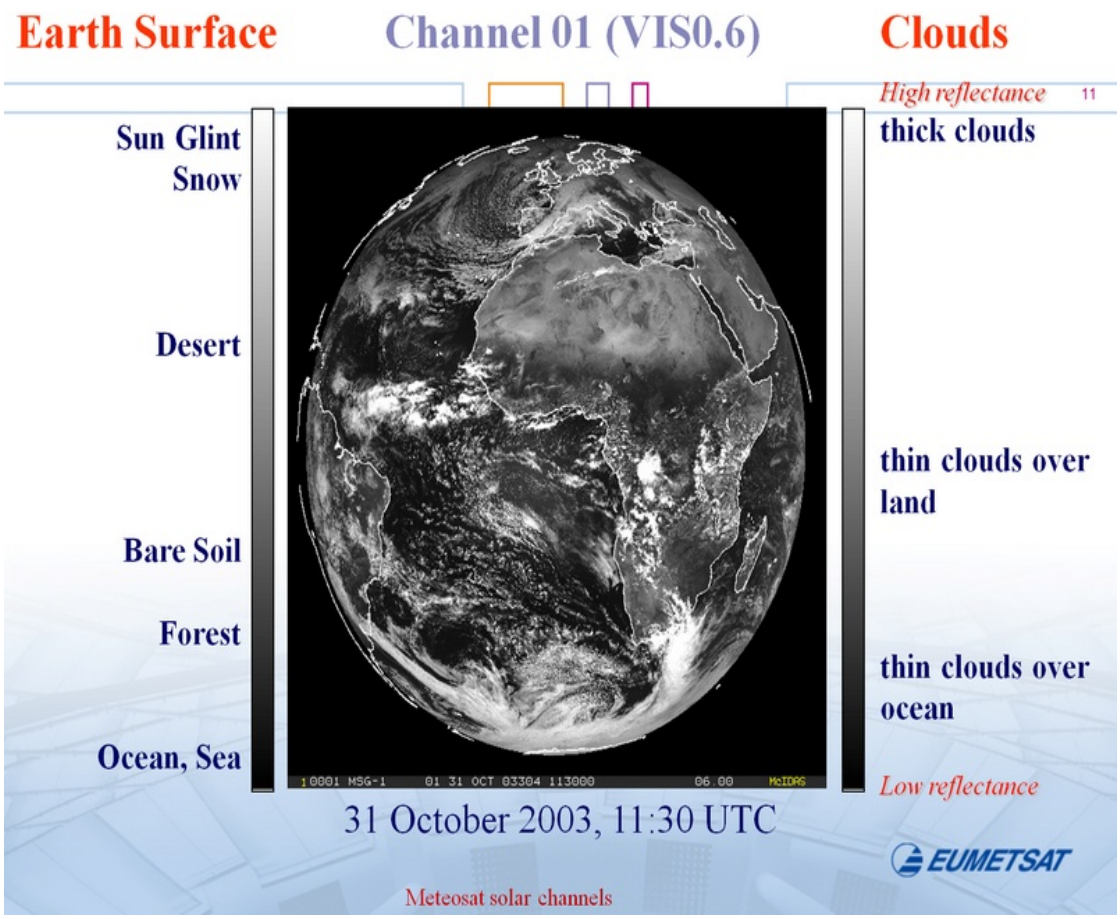
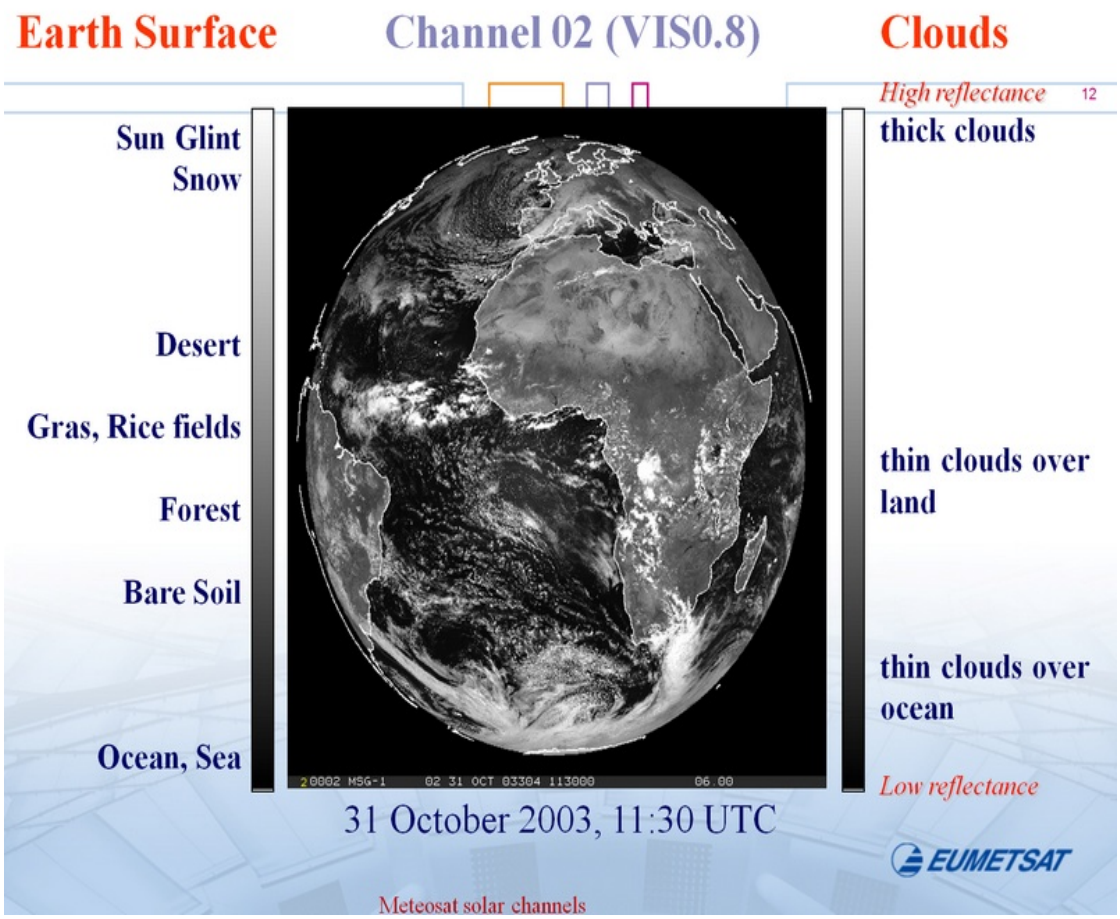
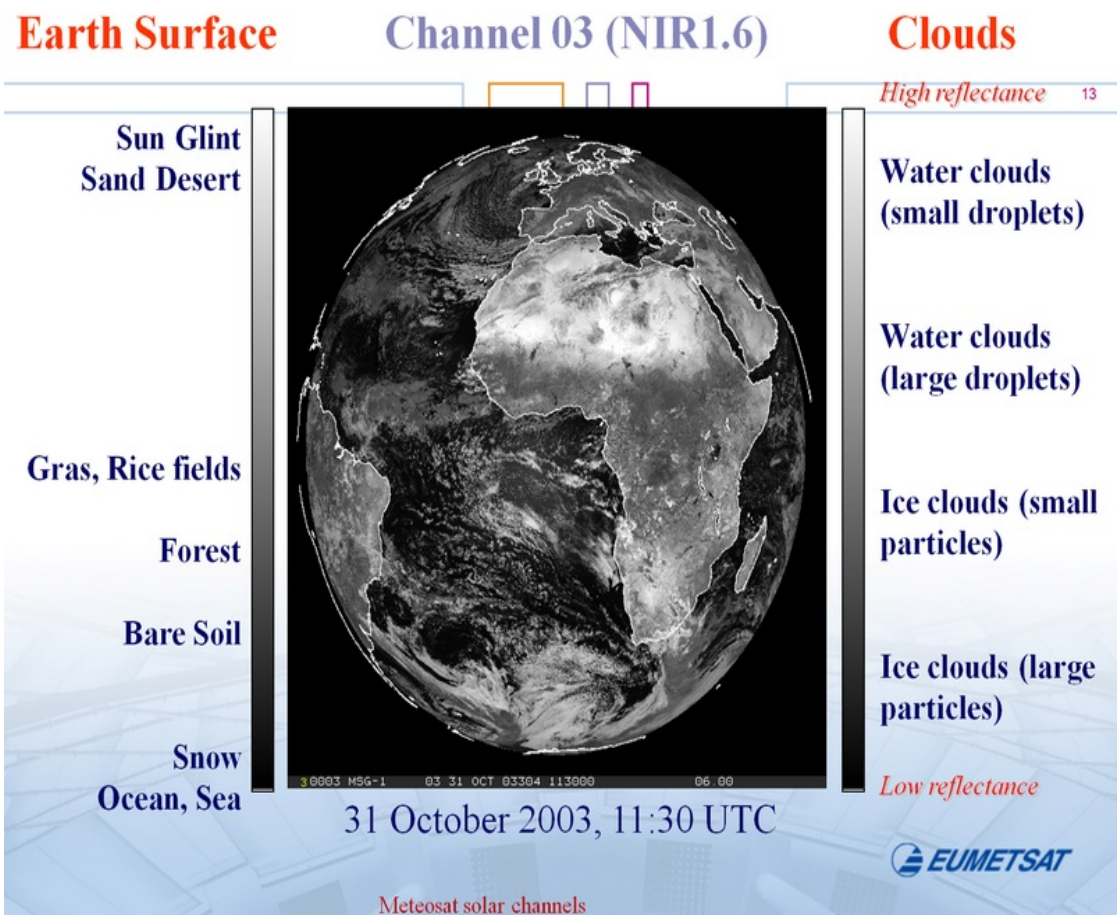
Jose_15.PNG


Earth Surface
Channel 01 (VIS0.6)
Clouds
High reflectance
11
Sun Glint
Snow
Desert
Bare Soil
Forest
Ocean, Sea
thick clouds
thin clouds over land
thin clouds over ocean
Low reflectance
1 0001 MSG-1 01 31 OCT 03304 113000 06.00 MeIDAS
31 October 2003, 11:30 UTC
EUMETSAT
Meteosat solar channels

Jose_16.PNG


Earth Surface
Channel 02 (VIS0.8)
Clouds
High reflectance
12
Sun Glint
Snow
Desert
Gras, Rice fields
Forest
Bare Soil
Ocean, Sea
thick clouds
thin clouds over land
thin clouds over ocean
Low reflectance
20002 MSG-1 02 31 OCT 03304 113000 06.00
31 October 2003, 11:30 UTC
EUMETSAT
Meteosat solar channels

Jose_17.PNG


Earth Surface
Channel 03 (NIR1.6)
Clouds
High reflectance
13
Sun Glint
Sand Desert
Gras, Rice fields
Forest
Bare Soil
Snow
Ocean, Sea
Water clouds (small droplets)
Water clouds (large droplets)
Ice clouds (small particles)
Ice clouds (large particles)
Low reflectance
31 October 2003, 11:30 UTC
EUMETSAT
Meteosat solar channels

Jose_18.PNG

SOLAR IMAGES

0.6 µm albedo scale:

Cb Snow Sand Shallow or broken cloud Ocean

CLOUD ALBEDO is the result of:
-optical depth= concentration * particle section * layer thickness
-liquid or ice (phase and shape)

Jose_19.PNG

SOLAR IMAGES

0.6 µm albedo scale:

Cb Snow Sand Shallow or broken cloud Ocean

CLOUD ALBEDO is the result of:
-optical depth= concentration * particle section * layer thickness
-liquid or ice (phase and shape)

Small droplets more reflective?
For the same volume, which distribution presents more section to the radiation?

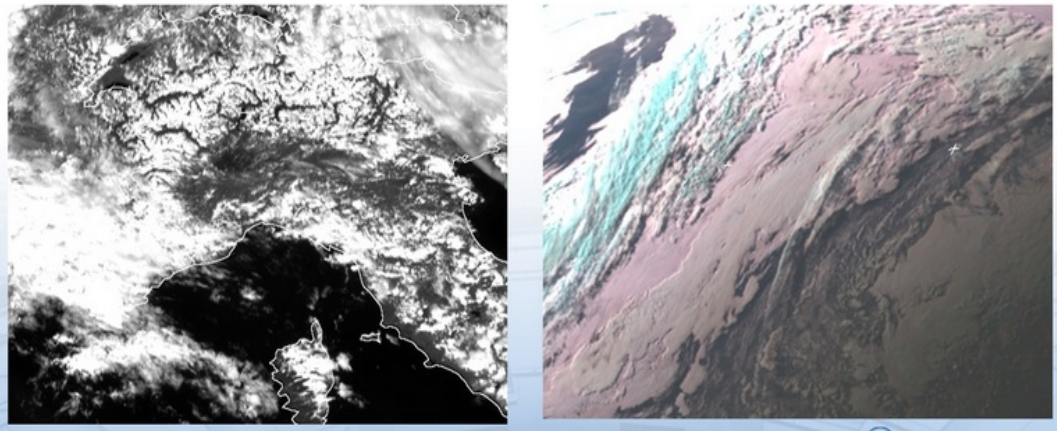
Updrafts prevent droplet merging, and keep reflection strong

EUMETSAT

Jose_20.PNG

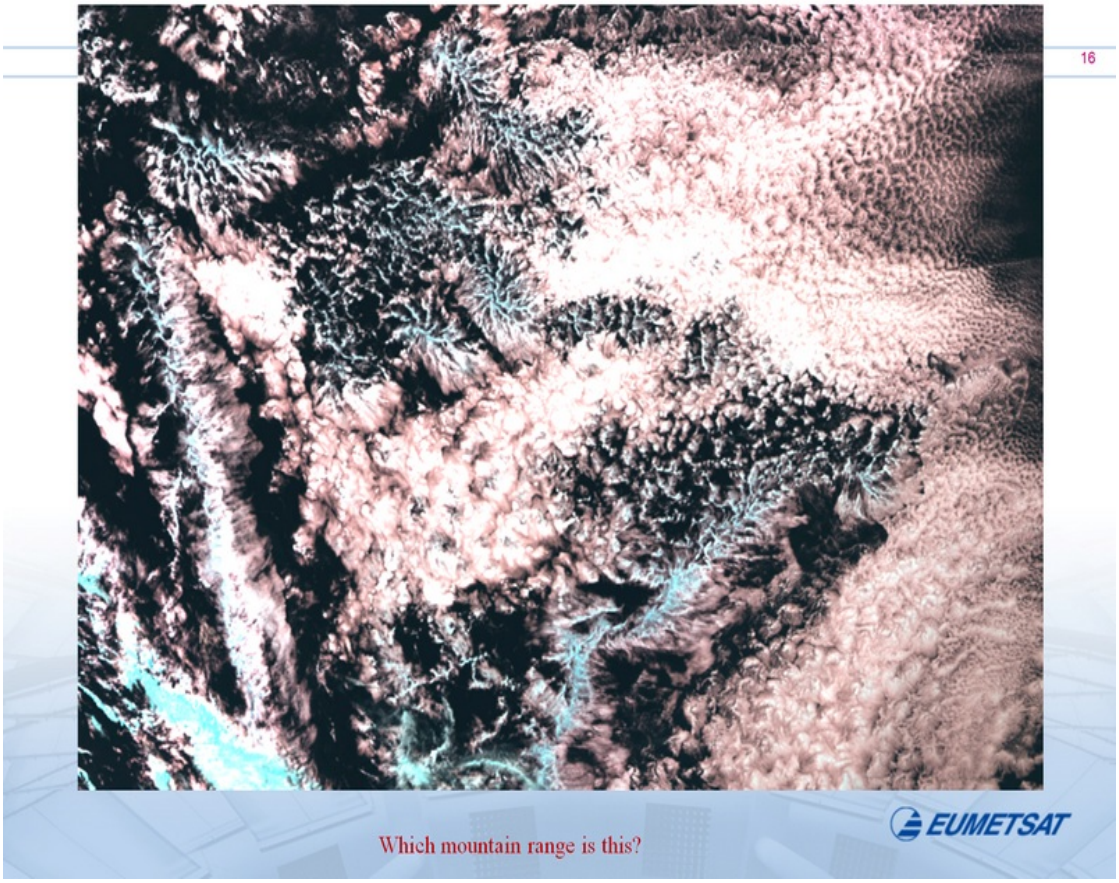
Special solar features

-**Shades**: oblique sun, vertical structure. Reflective boundaries
-**Water content** is related to optical thickness thru particle size
-**Texture** (local standard deviation): cloud type. Sc from St
-**Clouds** versus dendritic more permanent **snow**
-**Thin** Ci: frequently not detected, more visible over ocean. Better in IR



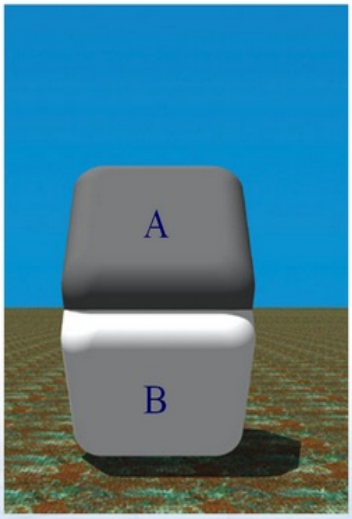
Meteosat solar channels

Jose_21.PNG



Jose_22.PNG

Do you believe your eyes?



Which is darker: A or B ?

Believing that colour is intrinsic to objects (colour constancy) leads to delusion

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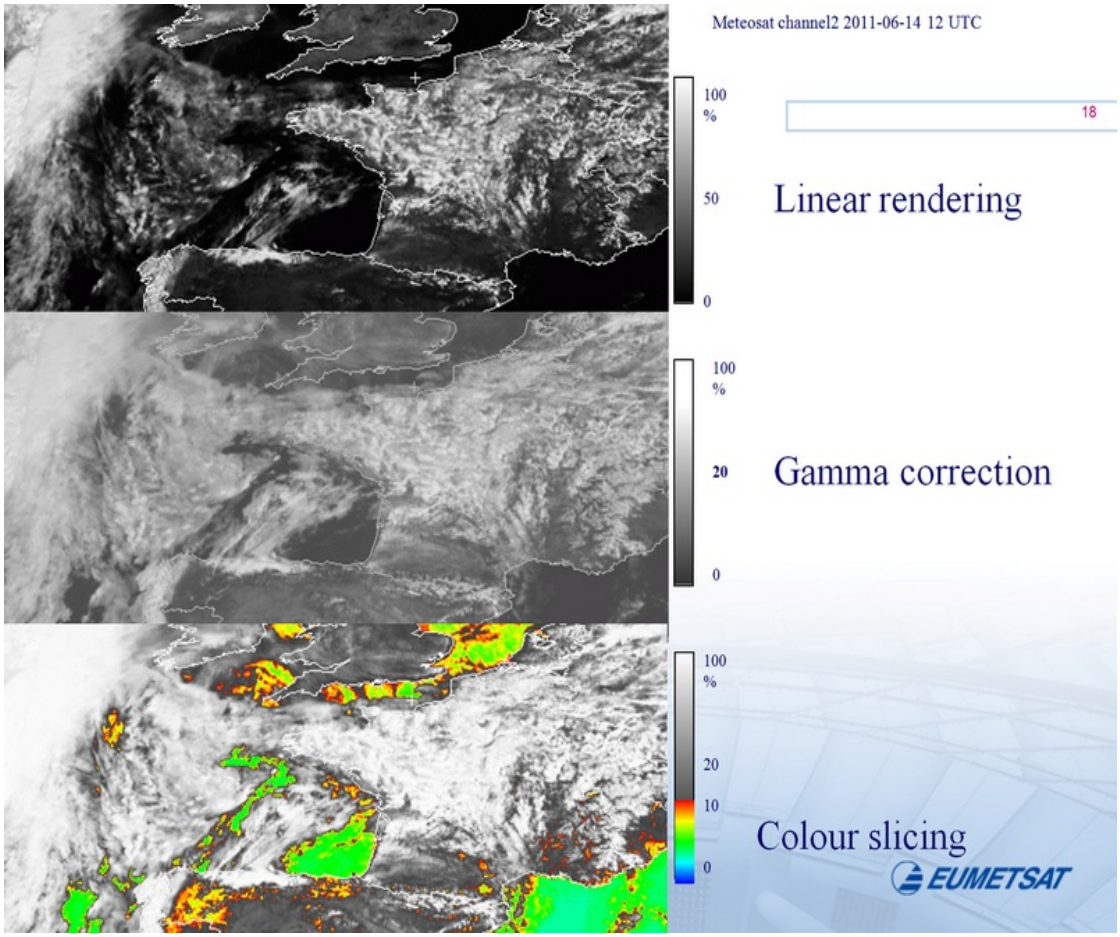
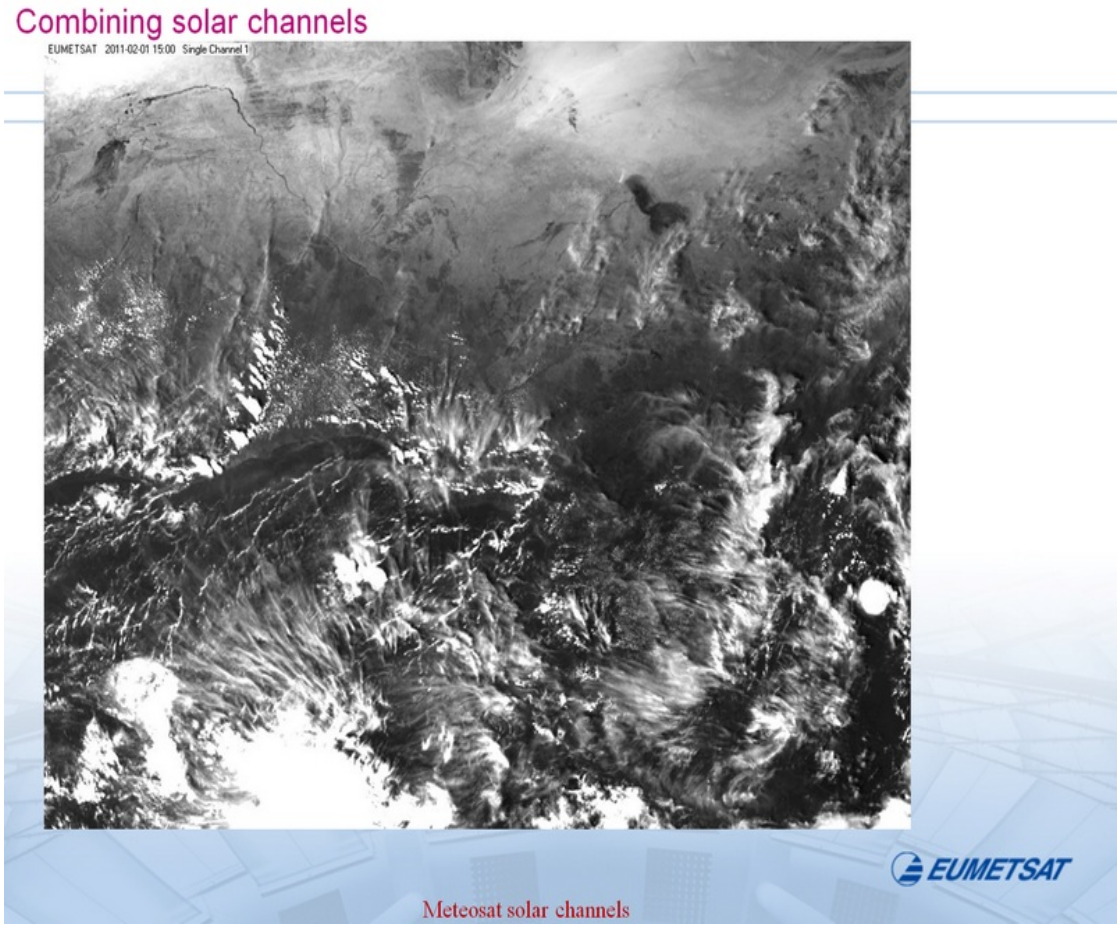
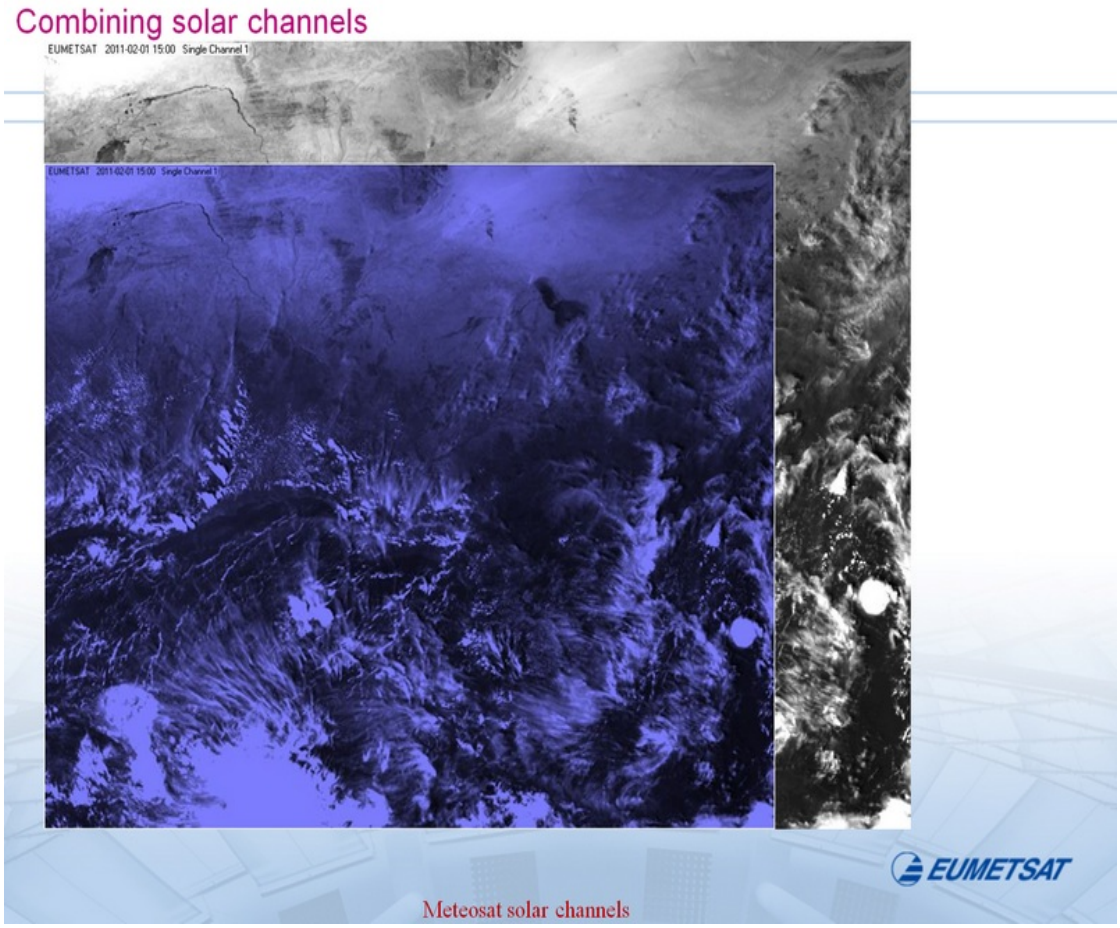
Jose_23.PNG


Meteosat channel2 2011-06-14 12 UTC
100
%
50
0
18
Linear rendering
100
%
20
0
Gamma correction
100
%
20
10
0
Colour slicing
EUMETSAT

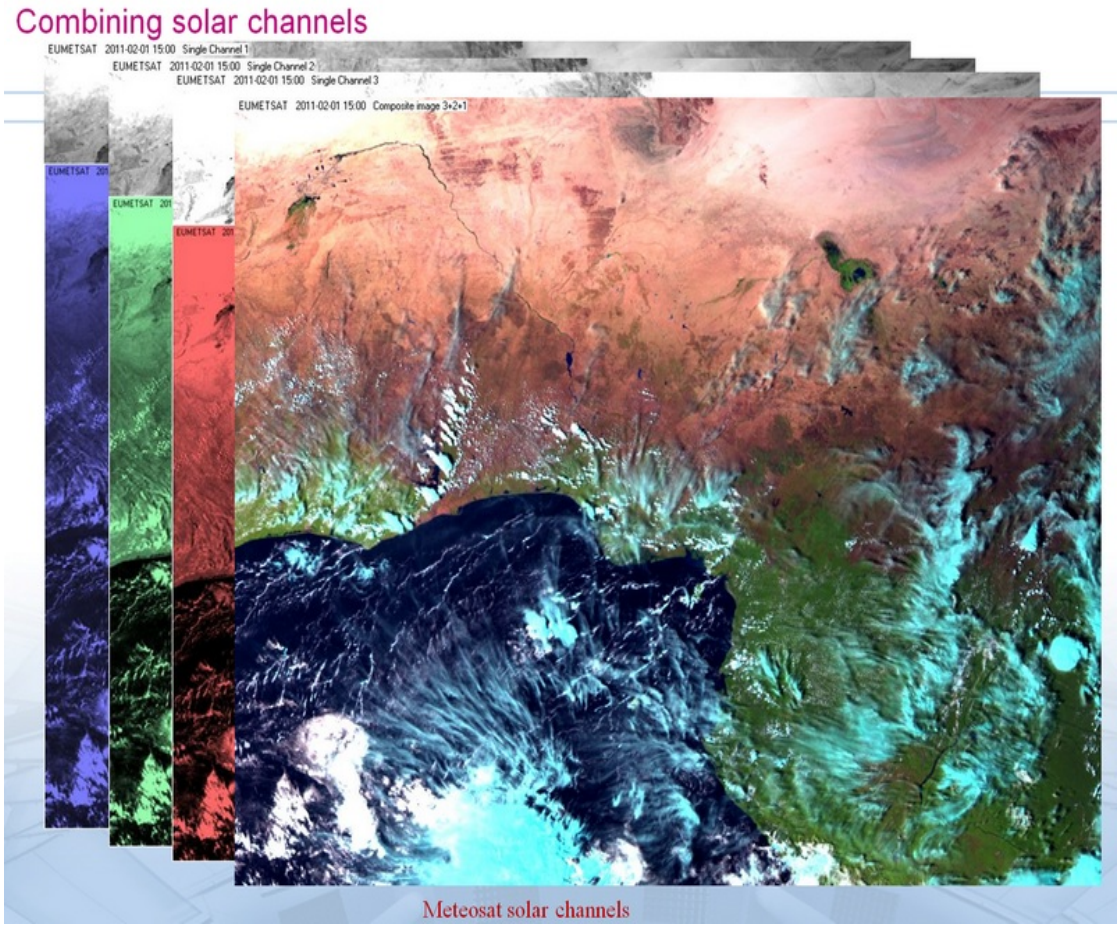
Jose_24.PNG


Combining solar channels
EUMETSAT 2011-02-01 15:00 Single Channel 1
EUMETSAT
Meteosat solar channels

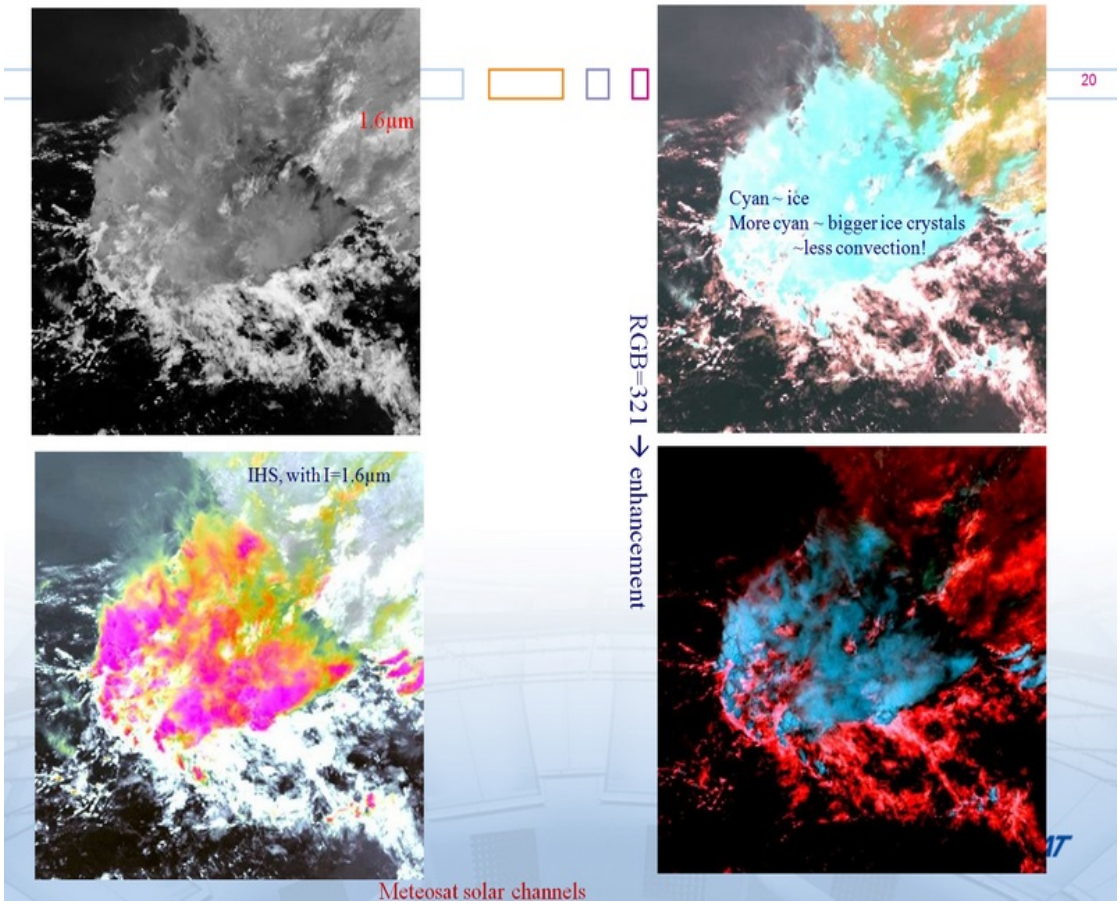
Jose_25.PNG


Combining solar channels
EUMETSAT 2011-02-01 15:00 Single Channel 1
EUMETSAT
Meteosat solar channels

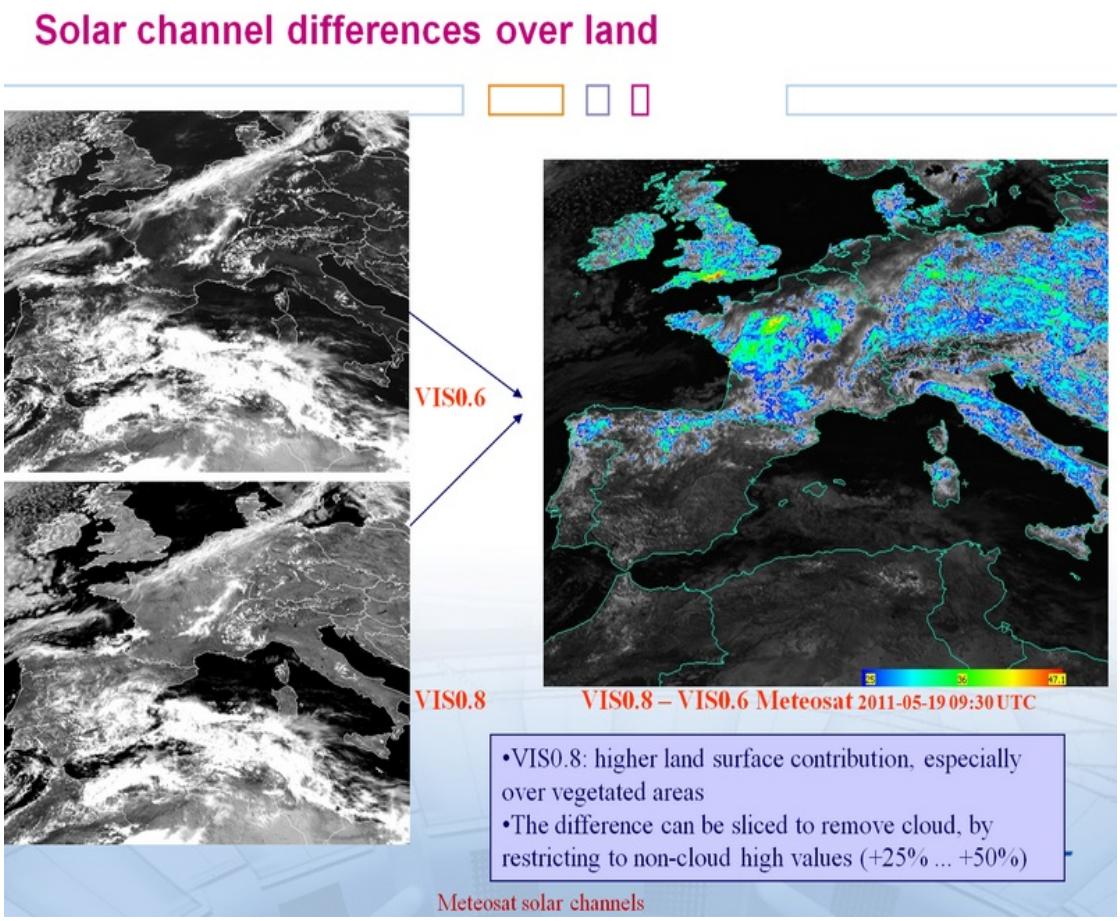
Jose_26.PNG


Combining solar channels
EUMETSAT 2011-02-01 15:00 Single Channel 1
EUMETSAT 2011-02-01 15:00 Single Channel 2
EUMETSAT 2011-02-01 15:00 Single Channel 3
EUMETSAT 2011-02-01 15:00 Composite image 3+2+1
Meteosat solar channels

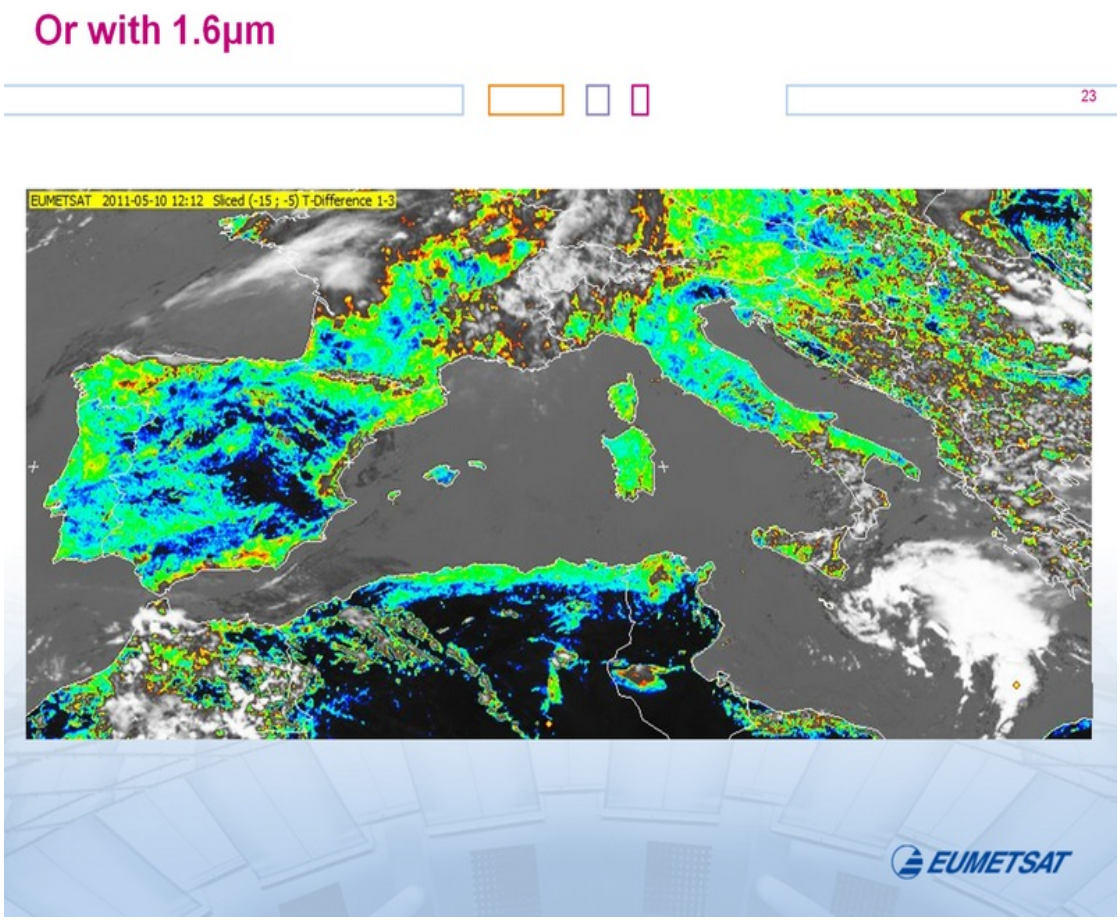
Jose_27.PNG


20
1.6µm
Cyan ~ ice
More cyan ~ bigger ice crystals
~less convection!
RGB=321 → enhancement
IHS, with I=1.6µm
Meteosat solar channels

Jose_28.PNG

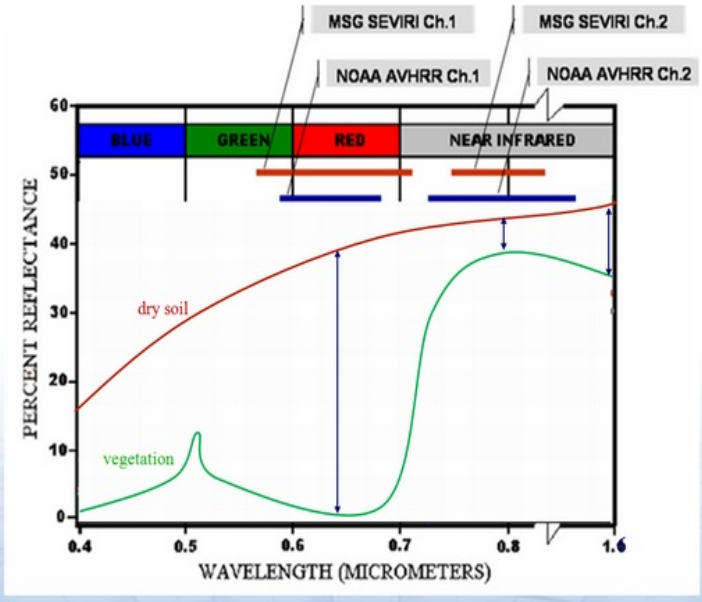

Solar channel differences over land
VIS0.6
VIS0.8
VIS0.8 – VIS0.6 Meteosat 2011-05-19 09:30 UTC
•VIS0.8: higher land surface contribution, especially over vegetated areas
•The difference can be sliced to remove cloud, by restricting to non-cloud high values (+25% ... +50%)
Meteosat solar channels

Jose_29.PNG


Or with 1.6µm
23
EUMETSAT 2011-05-10 12:12 Sliced (-15 ; -5) T-Difference 1-3
EUMETSAT

Jose_30.PNG

Vegetated and dry soils

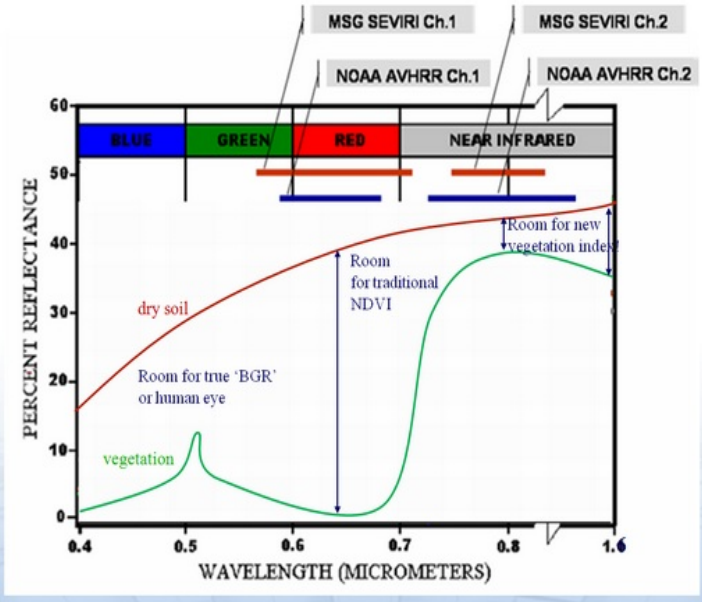


The vegetation response to wavelengths in our colour perception is similar to those between 0.6µm to 1.6µm: happy coincidence!

EUMETSAT

Jose_31.PNG

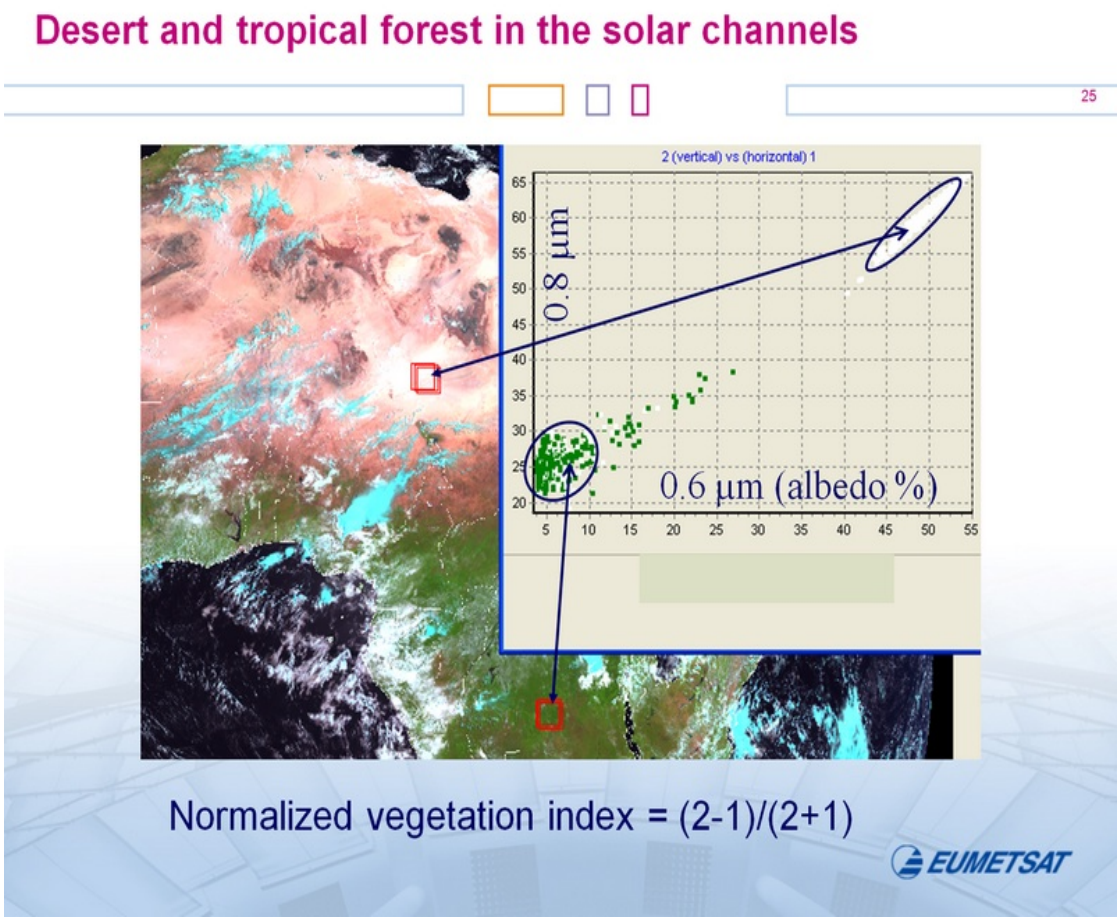
Vegetated and dry soils



The vegetation response to wavelengths in our colour perception is similar to those between 0.6µm to 1.6µm: happy coincidence!

EUMETSAT

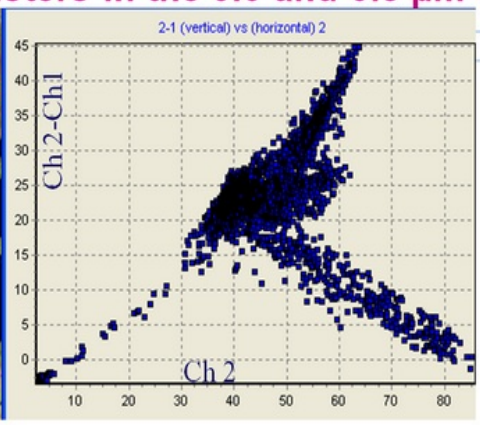
Jose_32.PNG


Desert and tropical forest in the solar channels
25
2 (vertical) vs (horizontal) 1
0.8 µm
0.6 µm (albedo %)
Normalized vegetation index = (2-1)/(2+1)
EUMETSAT

Jose_33.PNG

Exercise: identify the clusters in the 0.6 and 0.8 µm channels

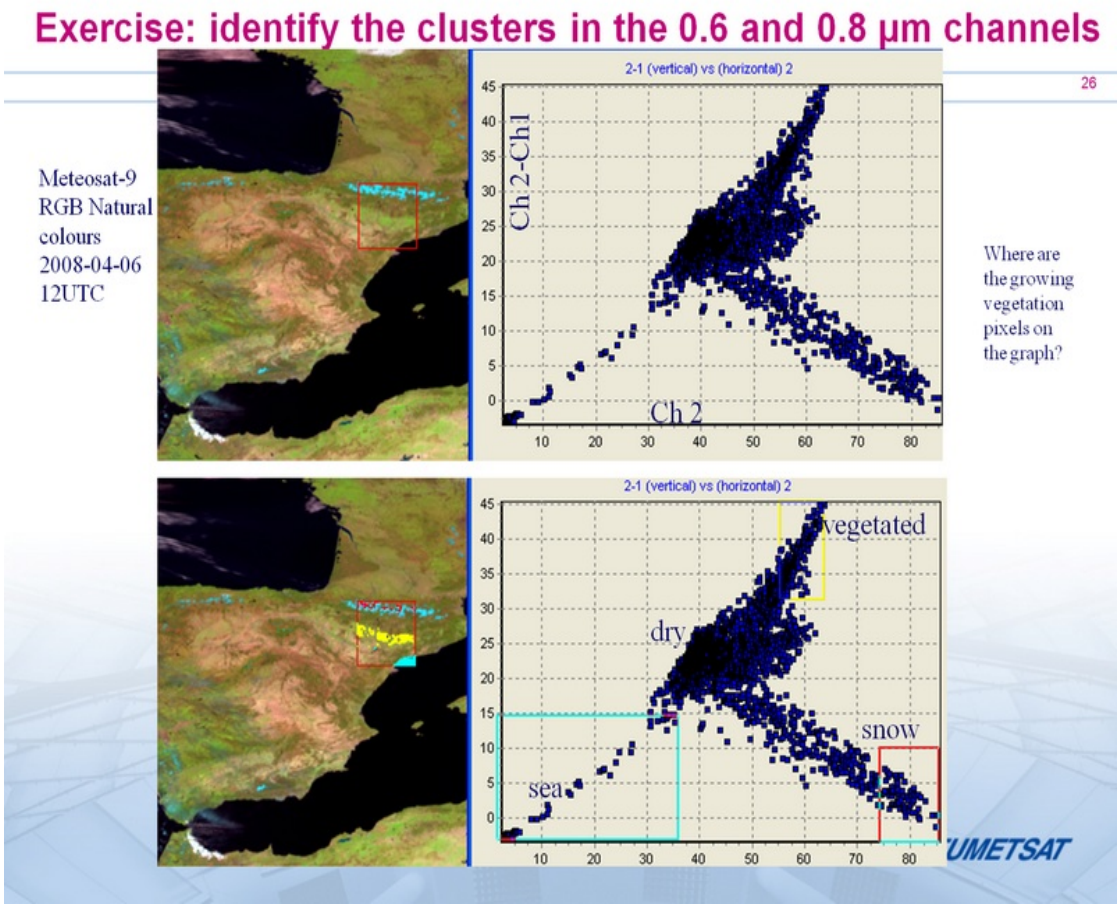
Meteosat-9
RGB Natural
colours
2008-04-06
12UTC



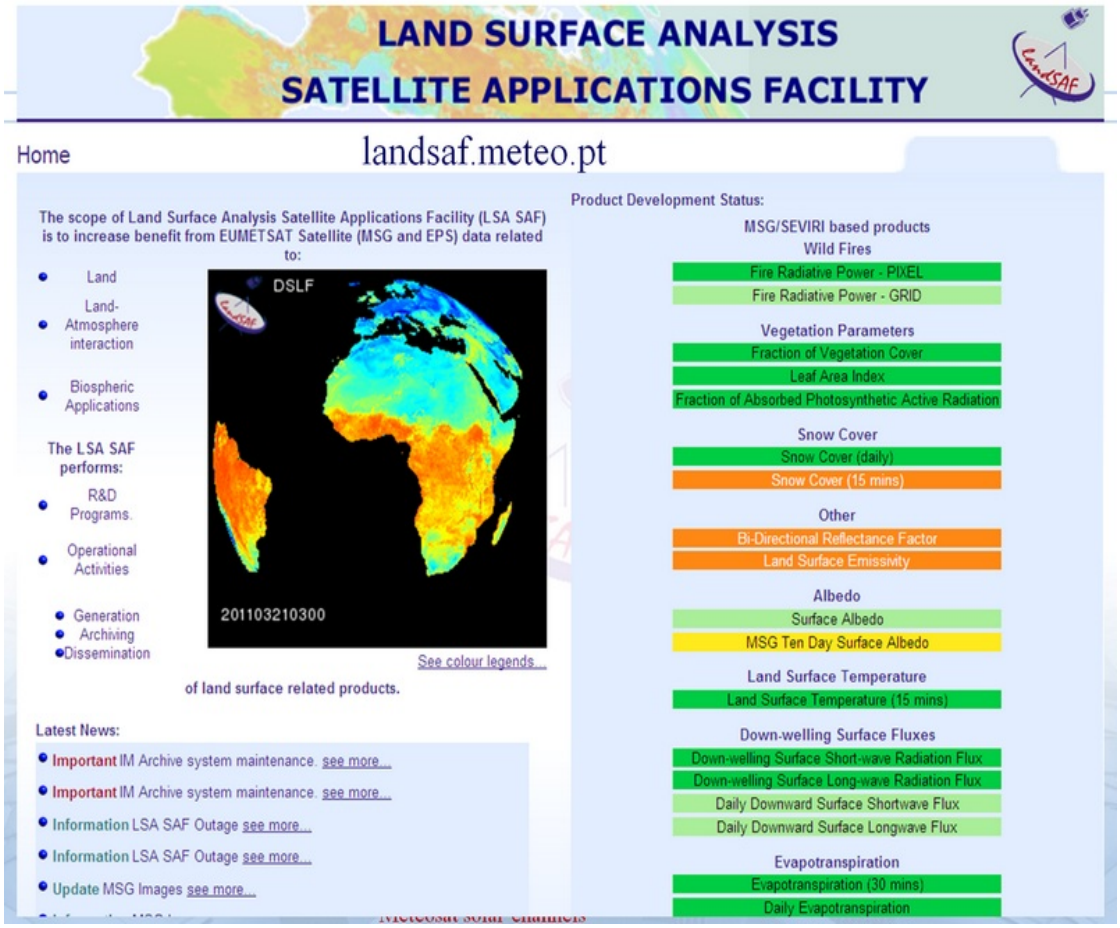
Where are the growing vegetation pixels on the graph?

EUMETSAT

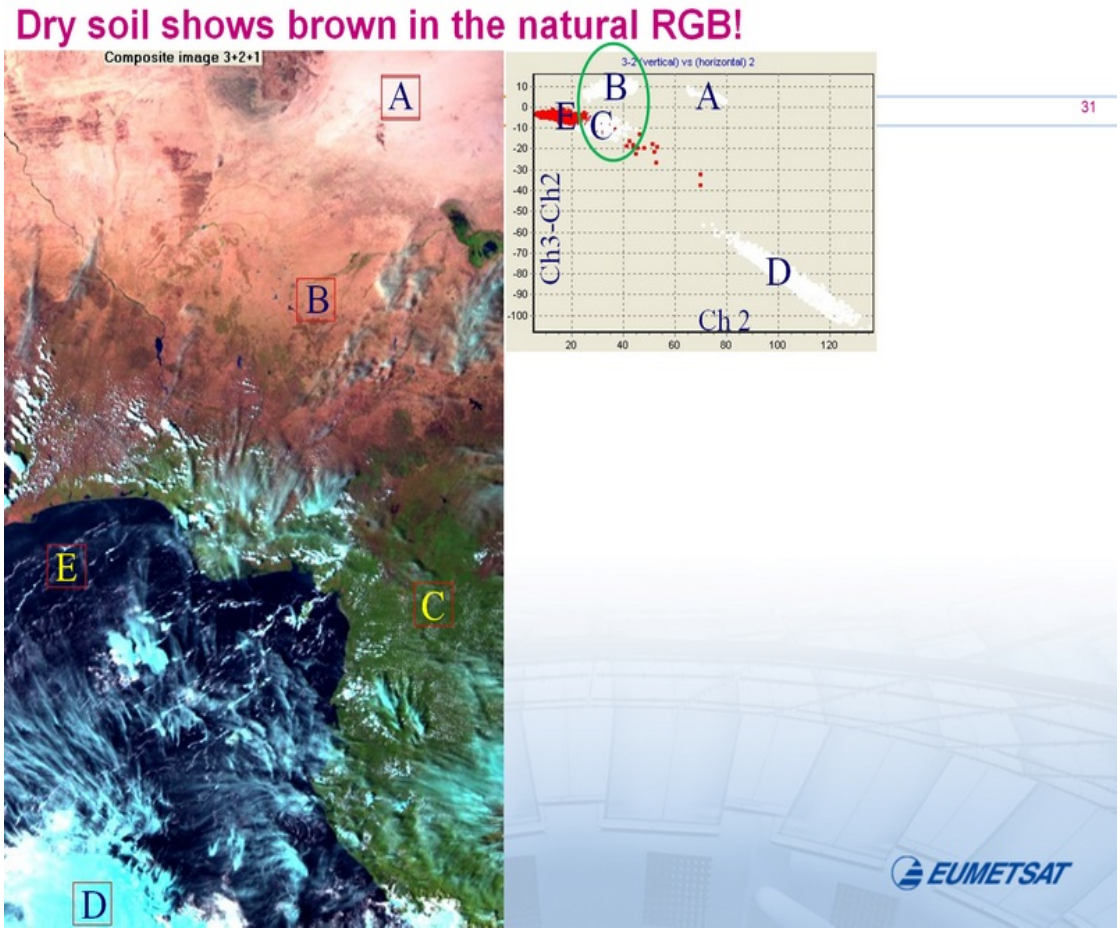
Jose_34.PNG


Exercise: identify the clusters in the 0.6 and 0.8 µm channels
26
Meteosat-9
RGB Natural
colours
2008-04-06
12UTC
2-1 (vertical) vs (horizontal) 2
Ch 2-Ch1
Ch 2
Where are
the growing
vegetation
pixels on
the graph?
2-1 (vertical) vs (horizontal) 2
vegetated
dry
snow
sea
UMETSAT

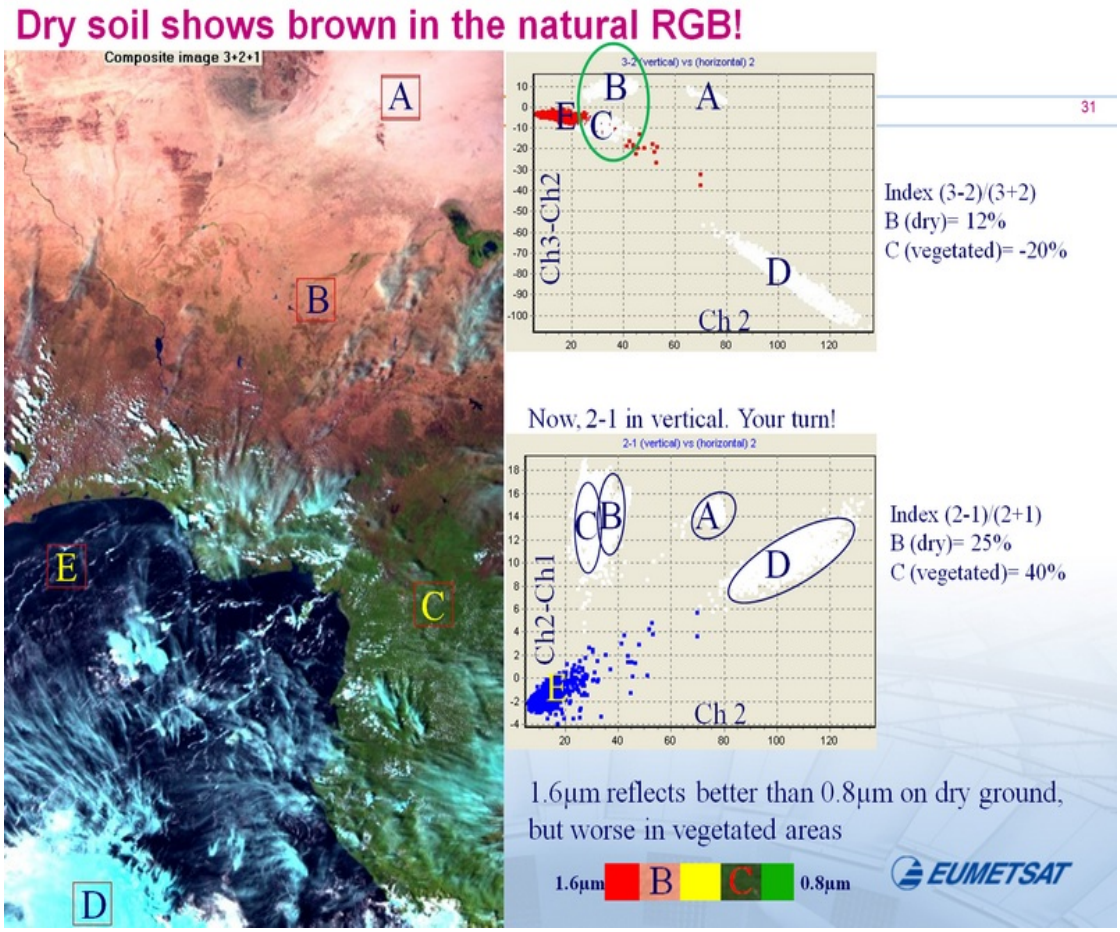
Jose_35.PNG


LAND SURFACE ANALYSIS
SATELLITE APPLICATIONS FACILITY
Home
landsaf.meteo.pt
The scope of Land Surface Analysis Satellite Applications Facility (LSA SAF) is to increase benefit from EUMETSAT Satellite (MSG and EPS) data related to:
Land
Land-Atmosphere interaction
Biospheric Applications
The LSA SAF performs:
R&D Programs.
Operational Activities
Generation
Archiving
Dissemination
DSLF
20110321030O
See colour legends...
of land surface related products.
Latest News:
Important IM Archive system maintenance. see more...
Important IM Archive system maintenance. see more...
Information LSA SAF Outage see more...
Information LSA SAF Outage see more...
Update MSG Images see more...
Product Development Status:
MSG/SEVIRI based products
Wild Fires
Fire Radiative Power - PIXEL
Fire Radiative Power - GRID
Vegetation Parameters
Fraction of Vegetation Cover
Leaf Area Index
Fraction of Absorbed Photosynthetic Active Radiation
Snow Cover
Snow Cover (daily)
Snow Cover (15 mins)
Other
Bi-Directional Reflectance Factor
Land Surface Emissivity
Albedo
Surface Albedo
MSG Ten Day Surface Albedo
Land Surface Temperature
Land Surface Temperature (15 mins)
Down-welling Surface Fluxes
Down-welling Surface Short-wave Radiation Flux
Down-welling Surface Long-wave Radiation Flux
Daily Downward Surface Shortwave Flux
Daily Downward Surface Longwave Flux
Evapotranspiration
Evapotranspiration (30 mins)
Daily Evapotranspiration

Jose_36.PNG


Dry soil shows brown in the natural RGB!
Composite image 3+2+1
A
B
C
D
E
3-2 (vertical) vs (horizontal) 2
Ch3-Ch2
Ch 2
31
EUMETSAT

Jose_37.PNG


Dry soil shows brown in the natural RGB!
Composite image 3+2+1
A
B
C
D
E
3-2 (vertical) vs (horizontal) 2
Ch3-Ch2
Ch 2
Index (3-2)/(3+2)
B (dry)= 12%
C (vegetated)= -20%
31
Now, 2-1 in vertical. Your turn!
2-1 (vertical) vs (horizontal) 2
Ch2-Ch1
Ch 2
Index (2-1)/(2+1)
B (dry)= 25%
C (vegetated)= 40%
1.6µm reflects better than 0.8µm on dry ground, but worse in vegetated areas
1.6µm
0.8µm
EUMETSAT

Jose_38.PNG

Which kind of soil or cloud is at the arrow point?

Fog

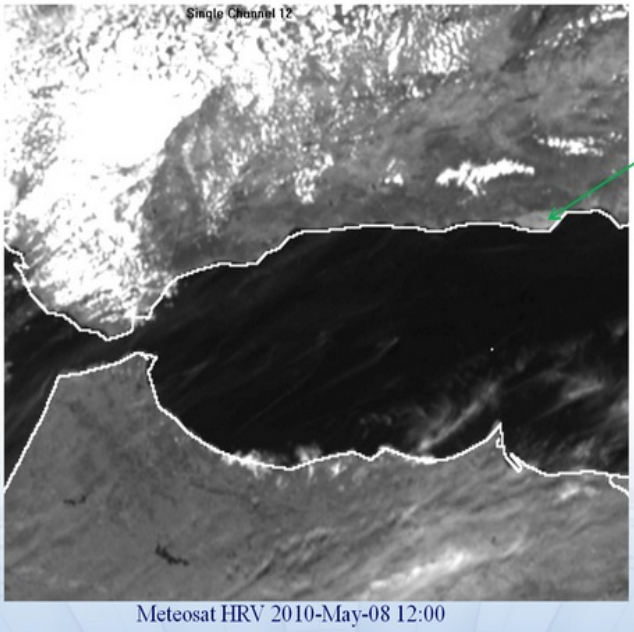
Sand

Glass

Cirrus

Smoke

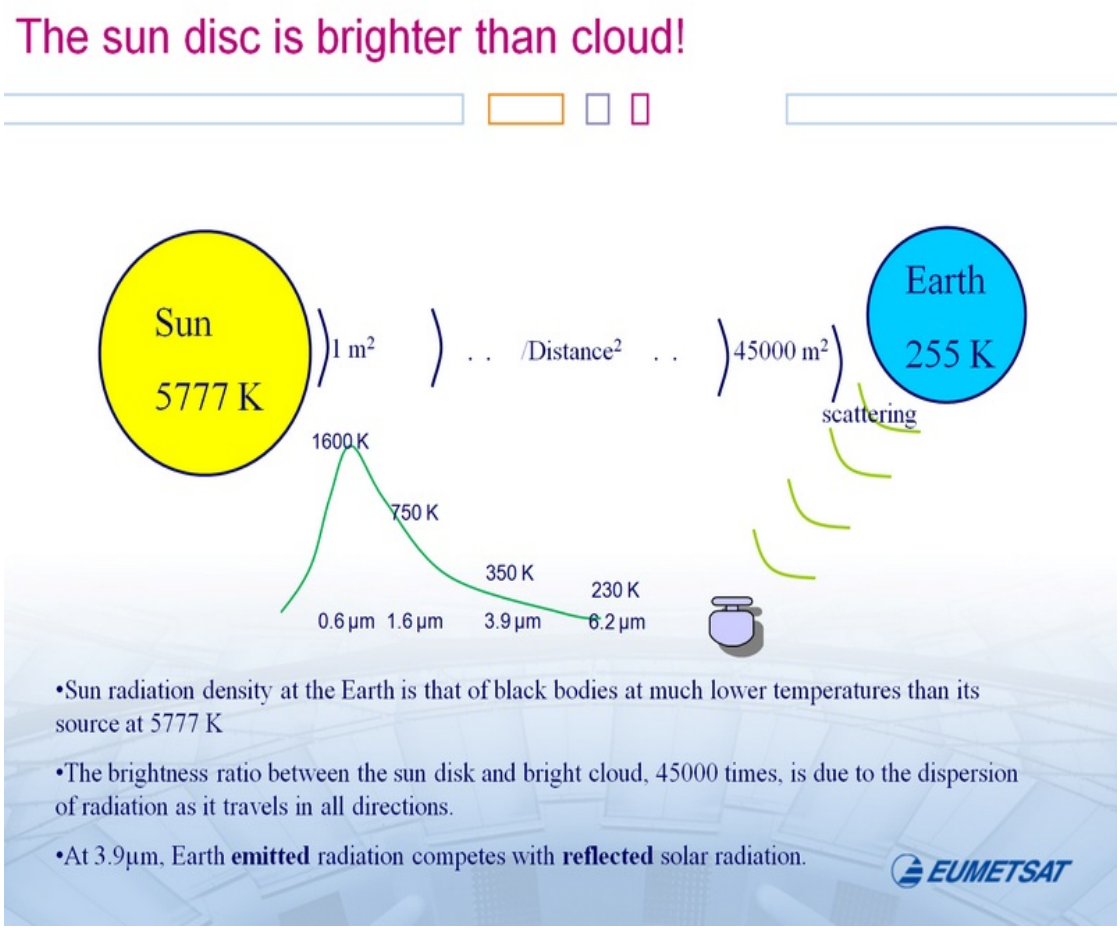
Litter



Meteosat HRV 2010-May-08 12:00

EUMETSAT

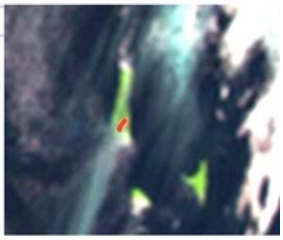
Jose_39.PNG

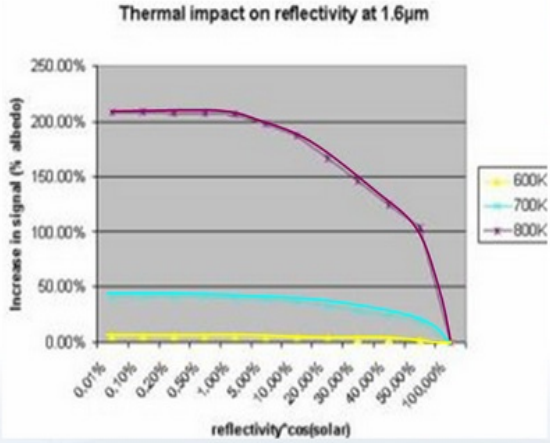

The sun disc is brighter than cloud!
Sun
5777 K
1 m²
/Distance²
45000 m²
Earth
255 K
scattering
1600 K
750 K
350 K
230 K
0.6 µm
1.6 µm
3.9 µm
6.2 µm
•Sun radiation density at the Earth is that of black bodies at much lower temperatures than its source at 5777 K
•The brightness ratio between the sun disk and bright cloud, 45000 times, is due to the dispersion of radiation as it travels in all directions.
•At 3.9µm, Earth **emitted** radiation competes with **reflected** solar radiation.
EUMETSAT

Jose_40.PNG

Emission sources in the solar channels

Karthala, Met-8, 29 May 2006, 12:15 UTC
Natural colours RGB 1.6µm 0.8µm 0.6µm

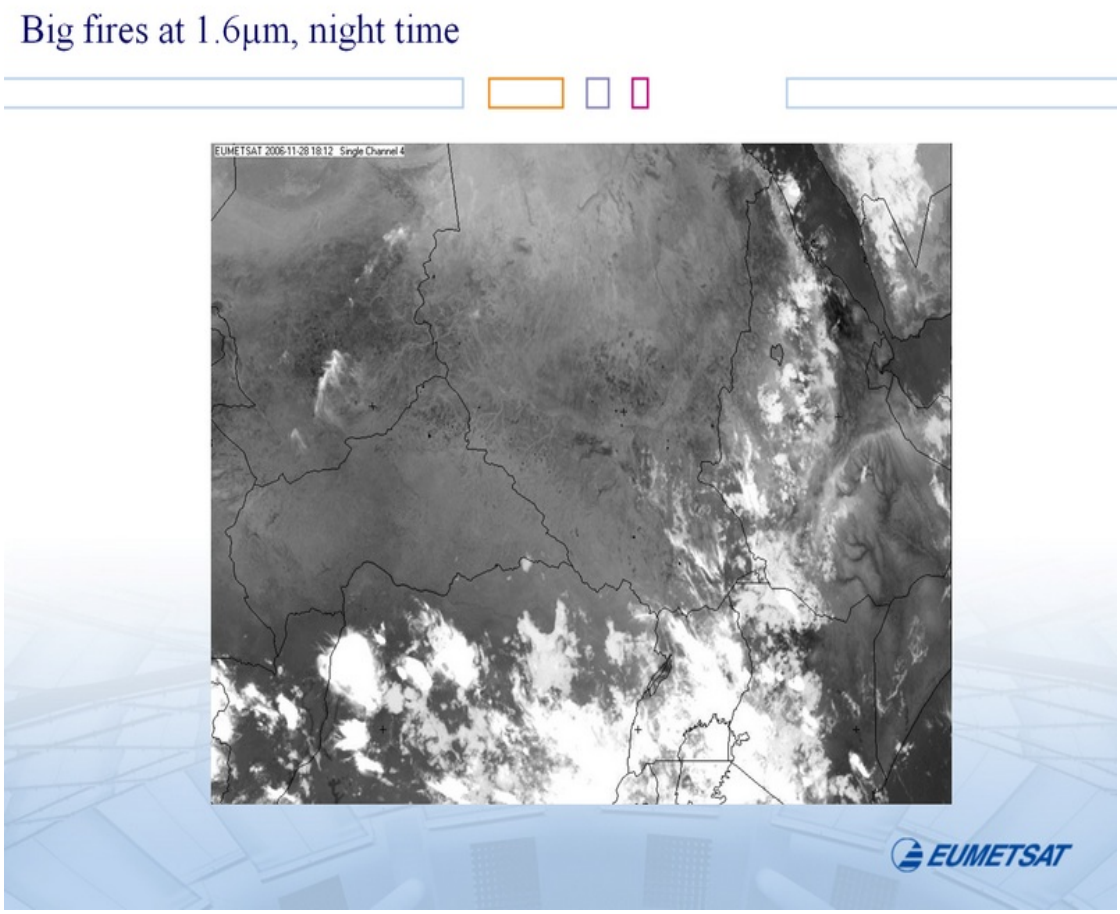




- Very **hot sources** (e.g. lava) **emit** as much as the sun contribution and **enhance** 1.6µm signal
- Sun contribution at 1.6 µm is equivalent of a black body at 750K
- Big fires can be detected at night at the 1.6µm channel

EUMETSAT

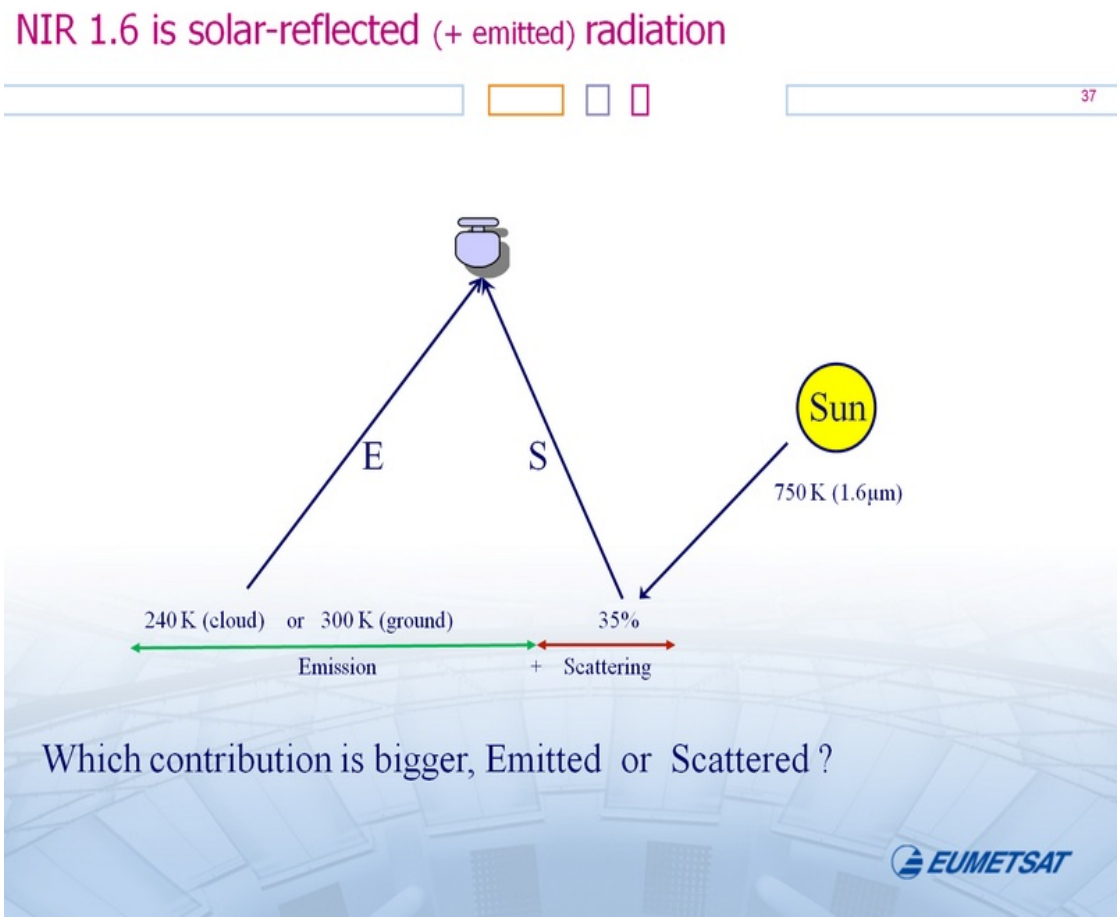
Jose_41.PNG


Big fires at 1.6µm, night time
EUMETSAT 2006-11-28 18:12 Single Channel 4
EUMETSAT

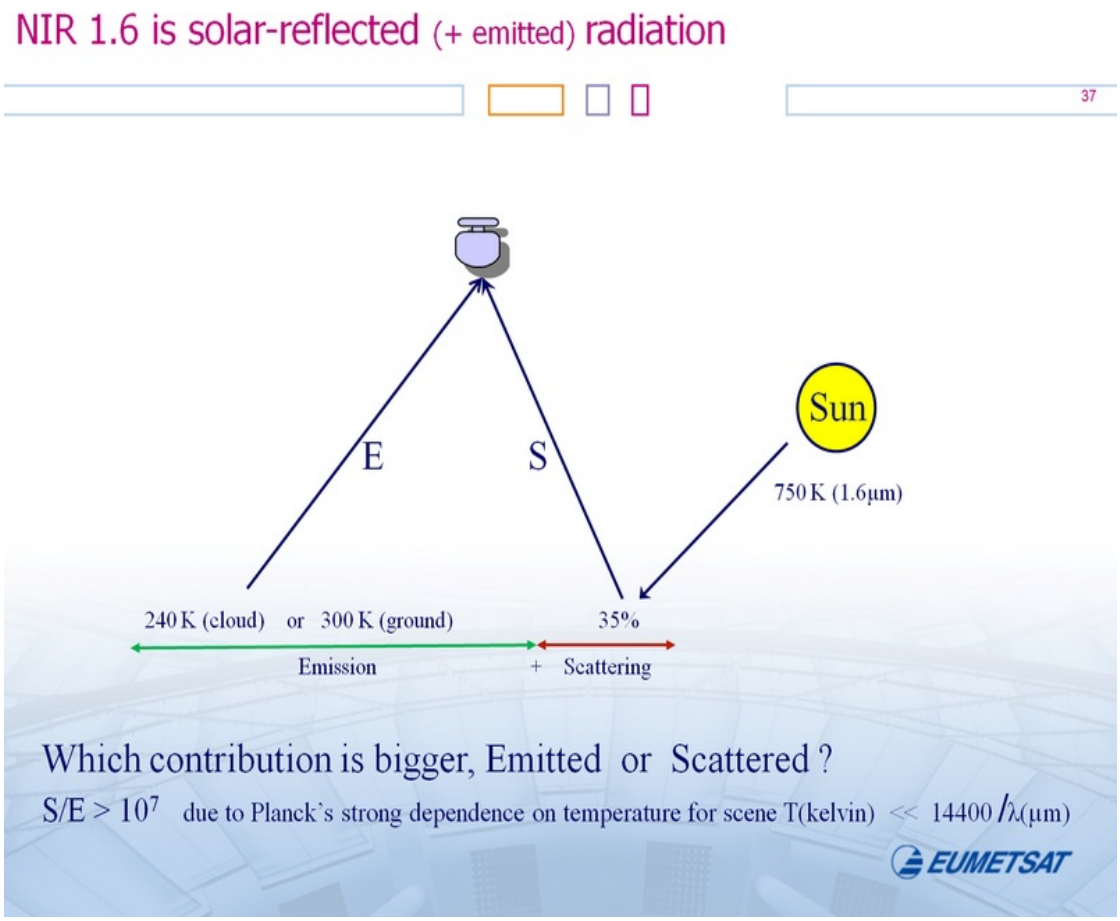
Jose_42.PNG


Big fires at 1.6µm, night time
EUMETSAT 2006-11-28 18:12 Single Channel 3
EUMETSAT

Jose_43.PNG

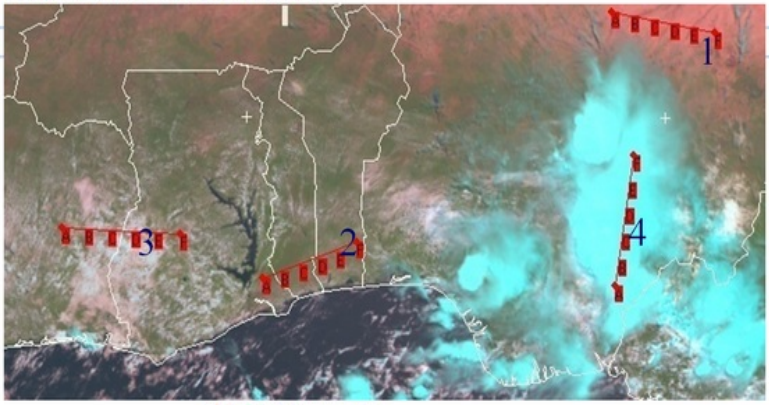

NIR 1.6 is solar-reflected (+ emitted) radiation
37
E
S
Sun
750 K (1.6µm)
240 K (cloud) or 300 K (ground)
Emission
35%
+ Scattering
Which contribution is bigger, Emitted or Scattered ?
EUMETSAT

Jose_44.PNG


NIR 1.6 is solar-reflected (+ emitted) radiation
37
E
S
Sun
750 K (1.6µm)
240 K (cloud) or 300 K (ground)
Emission
35%
+ Scattering
Which contribution is bigger, Emitted or Scattered ?
S/E > 10^7 due to Planck's strong dependence on temperature for scene T(kelvin) << 14400 /λ(µm)
EUMETSAT

Jose_45.PNG

Cloud in the solar channels



ch3 ch2 ch1 composite

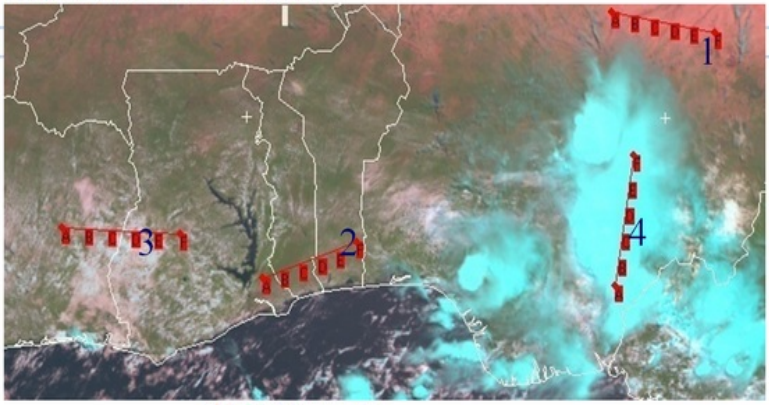
1. Dry
2. Vegetation
3. Thin cloud above vegetation
4. Thick cloud

- Scene "3" is a weighted average of scenes "2" and "4" with the cloud fraction
- 0.8µm is the most reflected radiation by cloud or vegetation, not by dry grounds (1.6µm)
- Ice cloud is less 1.6µm reflective than liquid cloud

EUMETSAT

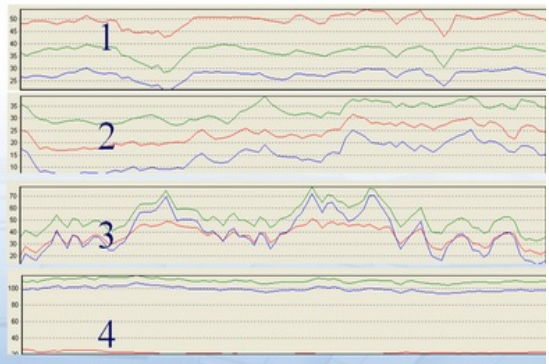
Jose_46.PNG

Cloud in the solar channels



ch3 ch2 ch1 composite

1. Dry
2. Vegetation
3. Thin cloud above vegetation
4. Thick cloud

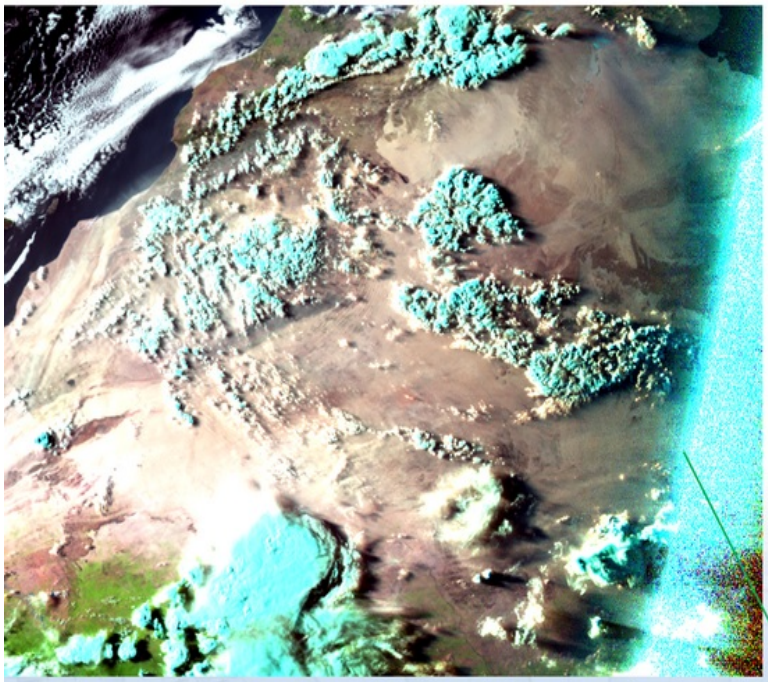


- Scene "3" is a weighted average of scenes "2" and "4" with the cloud fraction
- 0.8µm is the most reflected radiation by cloud or vegetation, not by dry grounds (1.6µm)
- Ice cloud is less 1.6µm reflective than liquid cloud

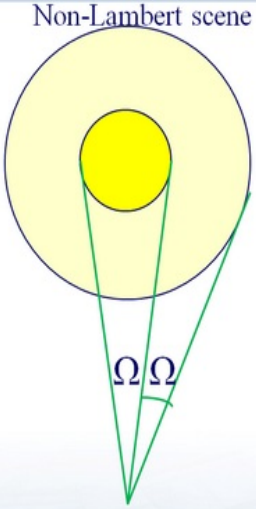
EUMETSAT

Jose_47.PNG

Lambert's approximation



Non-Lambert scene



Day-night boundary

- Lambert: same brightness close and far from the boundary of a spherical target
- Lambert examples: rough ocean surfaces or snow, non-directional reflection
- Non Lambert: desert surfaces or sun glint on oceans, **directional** reflection

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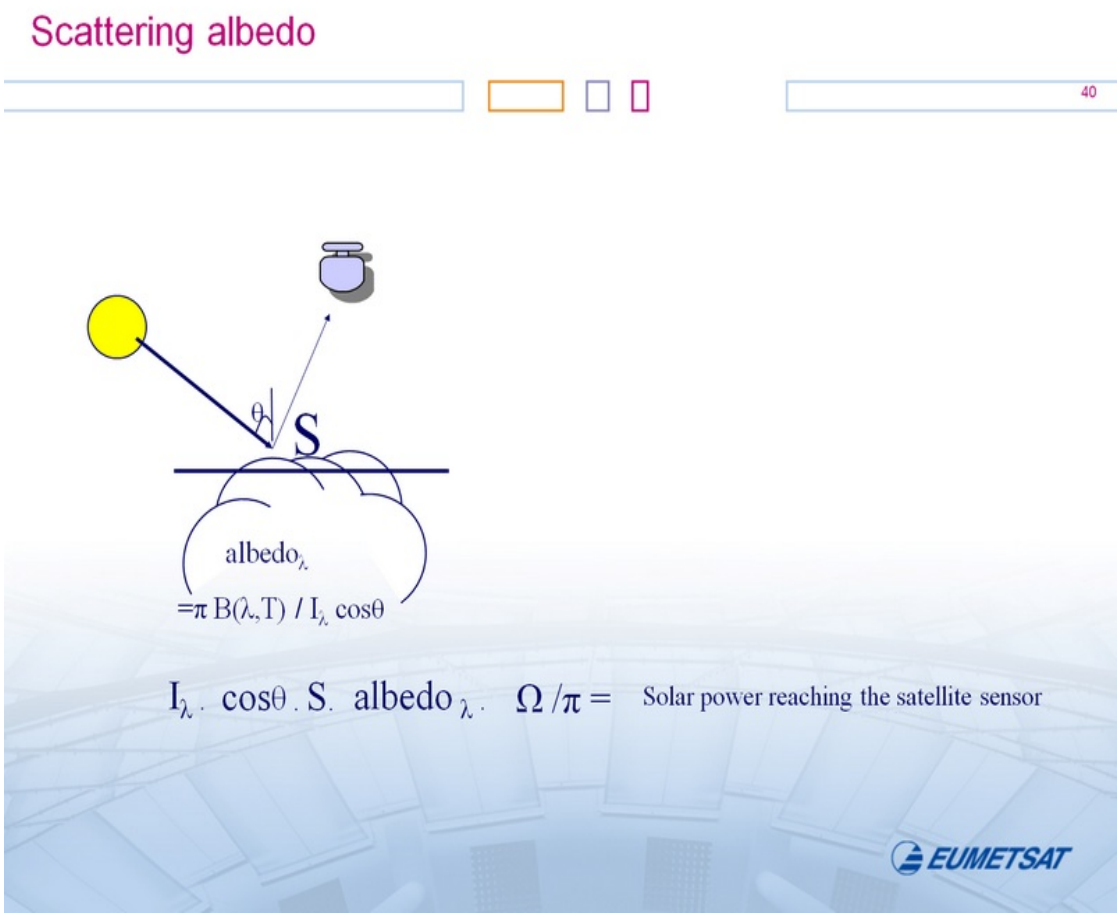
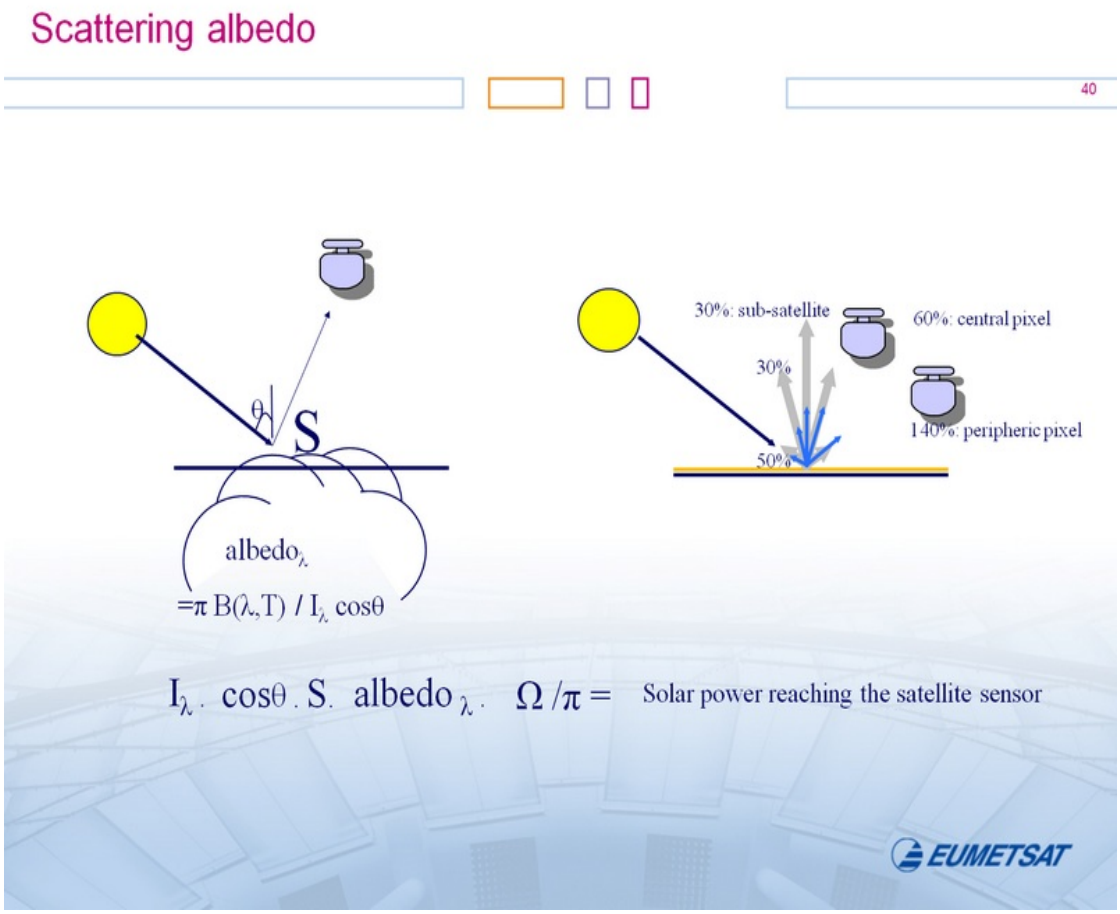
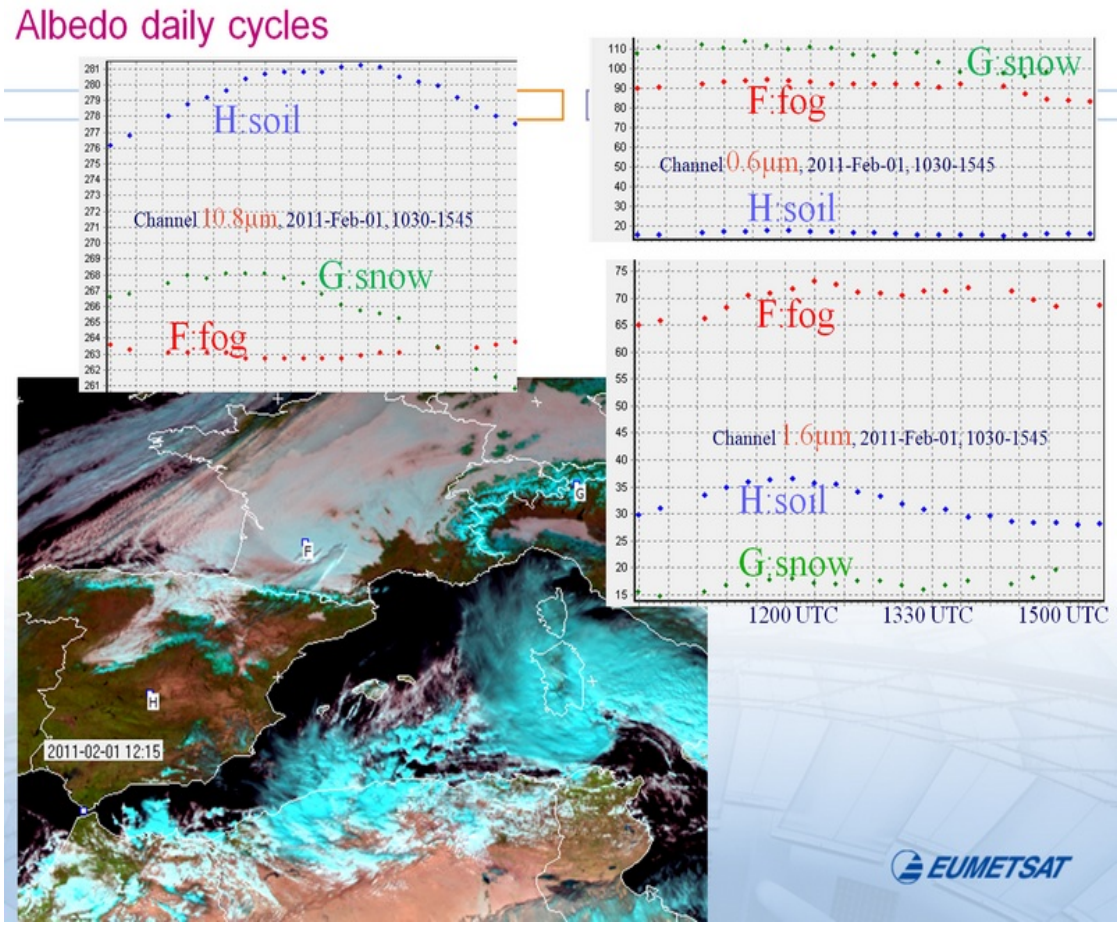
Jose_48.PNG


Scattering albedo
40
θ
S
albedo$_\lambda$
$=\pi B(\lambda,T) / I_\lambda \cos\theta$
$I_\lambda . \cos\theta . S . \text{albedo}_\lambda . \Omega/\pi =$ Solar power reaching the satellite sensor
EUMETSAT

Jose_49.PNG


Scattering albedo
40
θ
S
albedo$_\lambda$
$=\pi B(\lambda,T) / I_\lambda \cos\theta$
30%: sub-satellite
60%: central pixel
30%
40%: peripheric pixel
50%
$I_\lambda . \cos\theta . S . \text{albedo}_\lambda . \Omega / \pi =$ Solar power reaching the satellite sensor
EUMETSAT

Jose_50.PNG


Albedo daily cycles
H:soil
Channel 10.8µm, 2011-Feb-01, 1030-1545
G:snow
F:fog
G:snow
F:fog
Channel 0.6µm, 2011-Feb-01, 1030-1545
H:soil
F:fog
Channel 1.6µm, 2011-Feb-01, 1030-1545
H:soil
G:snow
1200 UTC
1330 UTC
1500 UTC
2011-02-01 12:15
EUMETSAT

Jose_51.PNG

The impact of illumination direction on the albedo calculation

Where is the retrieved albedo more dependent on the time of the day?

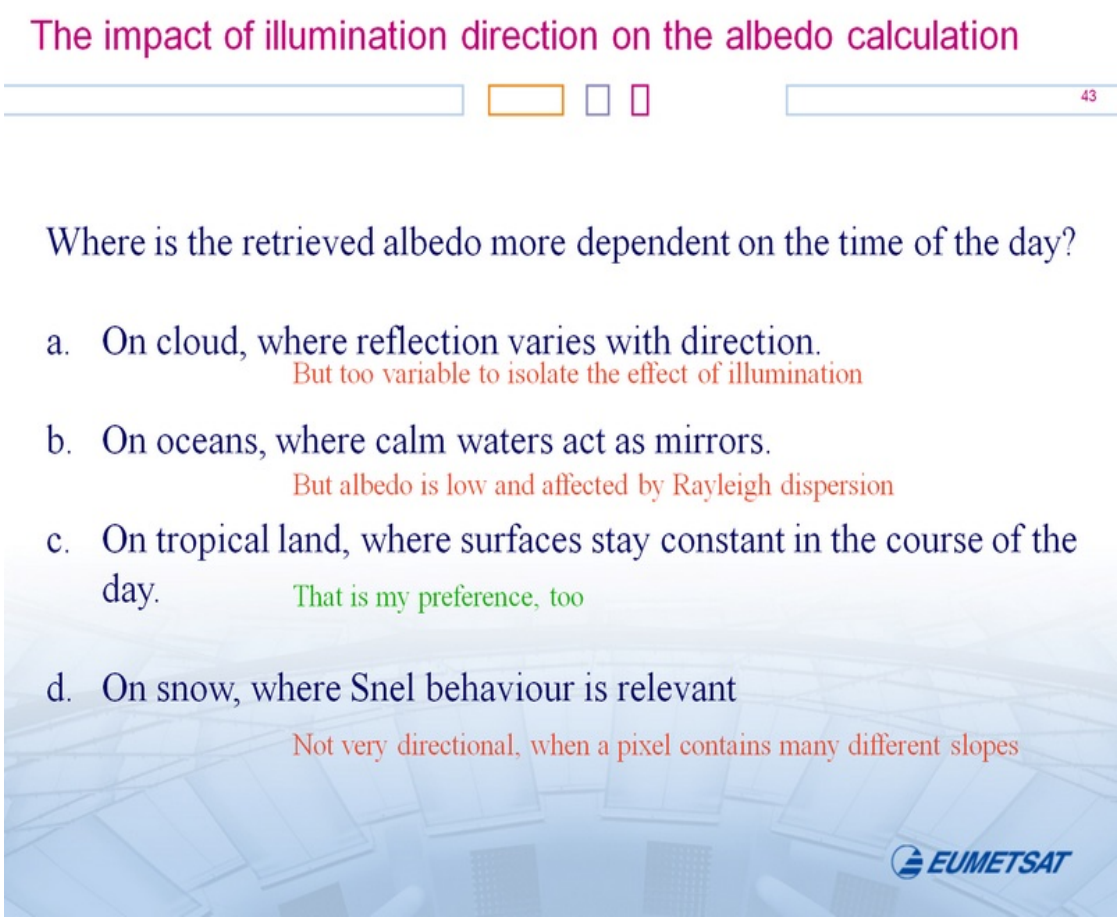
a. On cloud, where reflection varies with direction.

b. On oceans, where calm waters act as mirrors.

c. On tropical land, where surfaces stay constant in the course of the day.

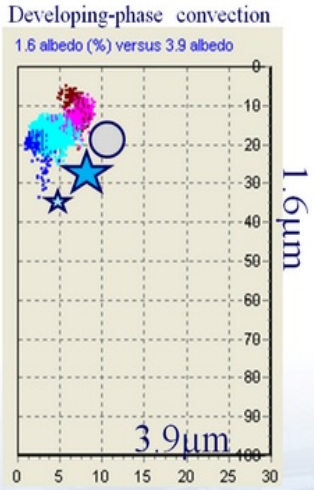
d. On snow, where Snel behaviour is relevant

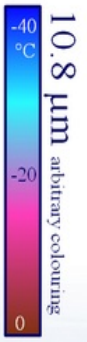
Jose_52.PNG


The impact of illumination direction on the albedo calculation
43
Where is the retrieved albedo more dependent on the time of the day?
a. On cloud, where reflection varies with direction.
But too variable to isolate the effect of illumination
b. On oceans, where calm waters act as mirrors.
But albedo is low and affected by Rayleigh dispersion
c. On tropical land, where surfaces stay constant in the course of the day.
That is my preference, too
d. On snow, where Snel behaviour is relevant
Not very directional, when a pixel contains many different slopes
EUMETSAT

Jose_53.PNG

Towards ice and size vertical profiles





Both SIZE and ICE reduce particle reflectivity

At lower levels, ice particles are bigger and less icy than at high level.
Reduced or increased reflectivity at lower levels??

Reduced at 1.6µm, the channel more sensitive to...
ICE / SIZE ??

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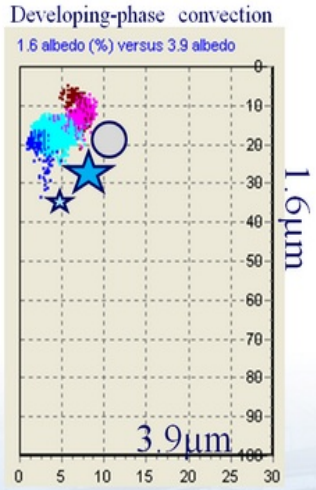
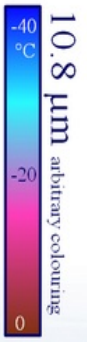
Jose_54.PNG

Towards ice and size vertical profiles





Both SIZE and ICE reduce particle reflectivity

At lower levels, ice particles are bigger and less icy than at high level.
Reduced or increased reflectivity at lower levels??

Reduced at 1.6µm, the channel more sensitive to...
ICE / SIZE ??

Reduced at 1.6µm (vertical), responding to SIZE
Increased at 3.9µm (horizontal), responding to ICE

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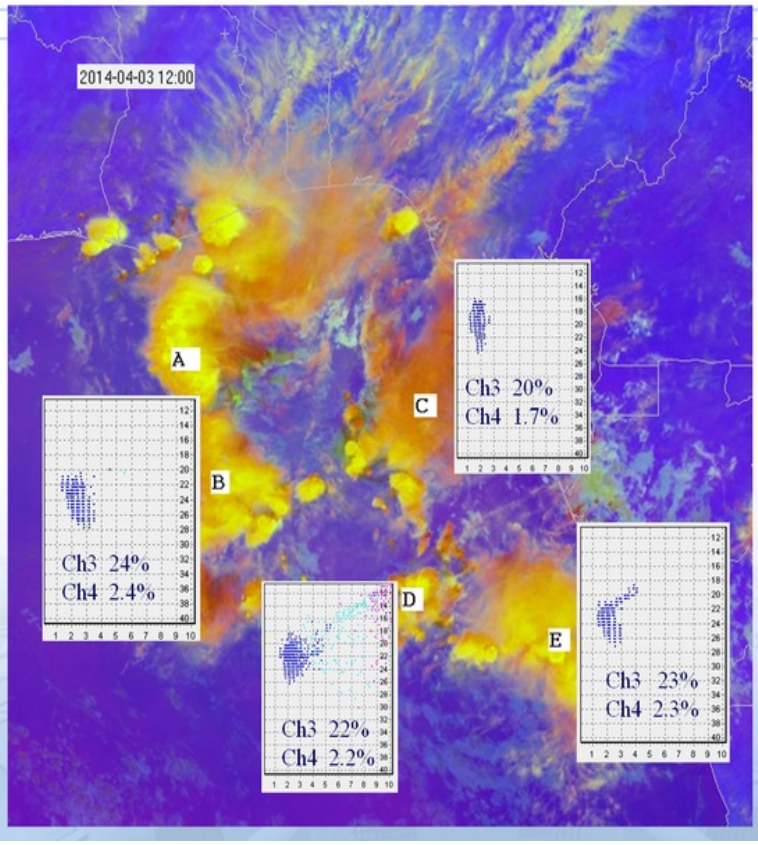
Jose_55.PNG

[1.6µm versus 3.9µm] reflectance technique (convection)



48

Average reflectivity on the frozen cloud tops of convection are roughly 10 times higher for channel 1.6µm than for 3.9µm

Rule "20+ 10-" for **severe convection** in a region 100km across :

<Ch3> > 20%

Ch3/Ch4 < 10

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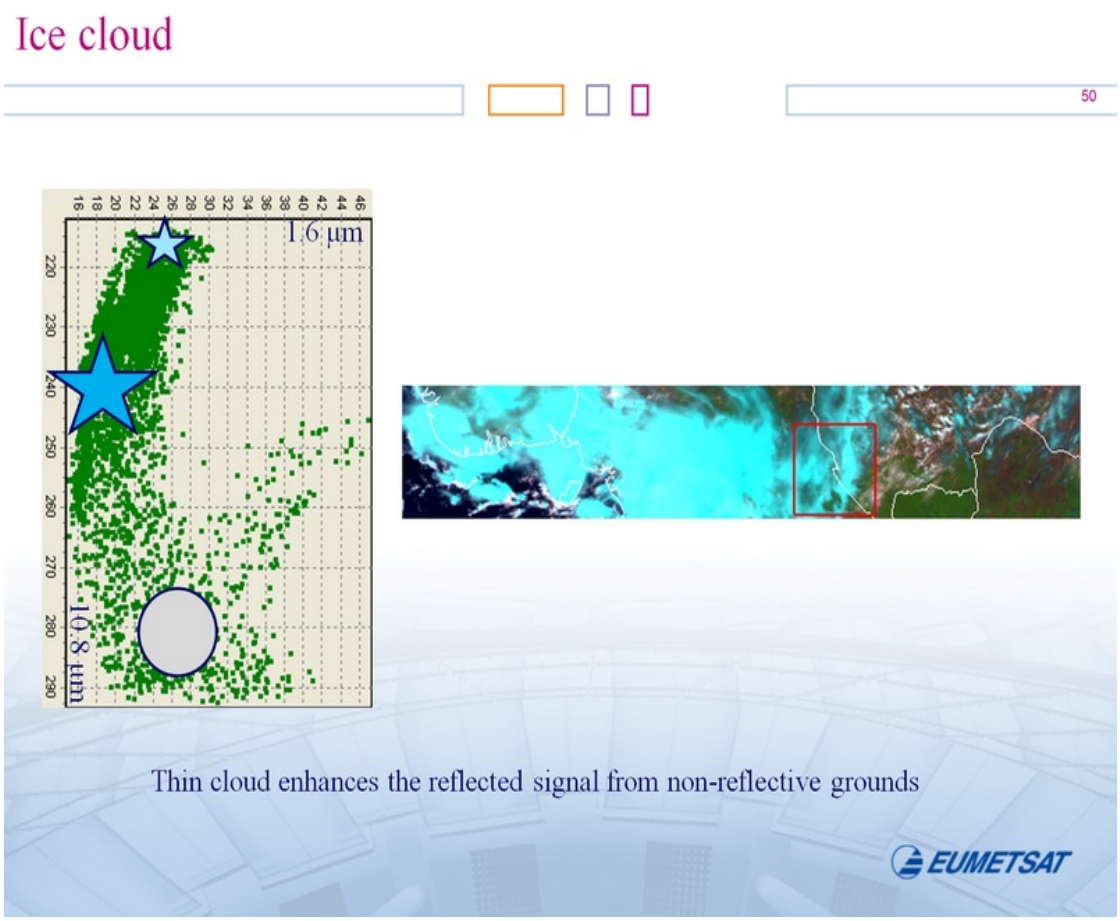
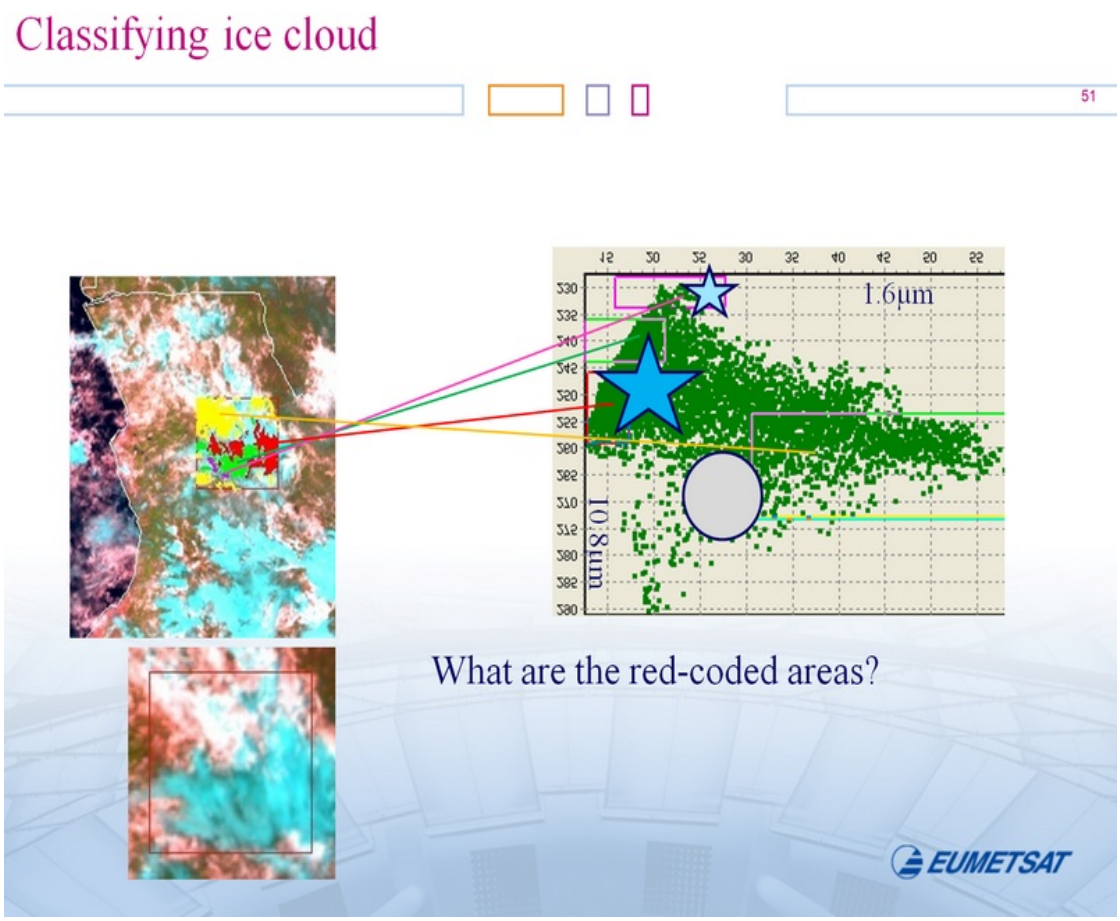
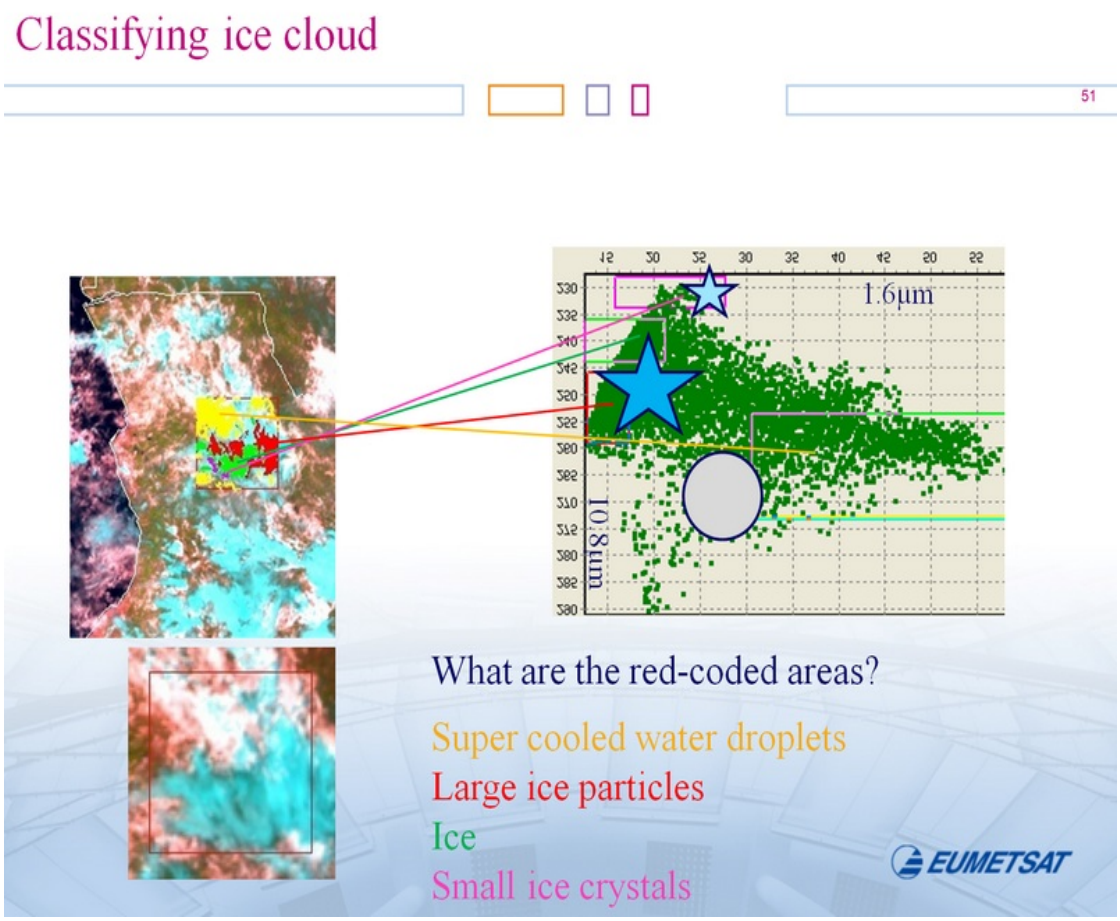
Jose_56.PNG


Ice cloud
50
1.6 µm
10.8 µm
Thin cloud enhances the reflected signal from non-reflective grounds
EUMETSAT

Jose_57.PNG

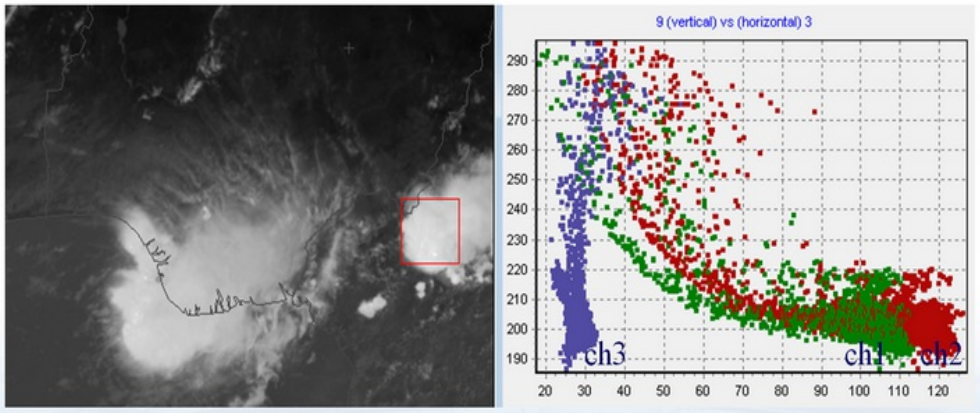

Classifying ice cloud
51
1.6µm
10.8µm
What are the red-coded areas?
EUMETSAT

Jose_58.PNG


Classifying ice cloud
51
1.6µm
10.8µm
What are the red-coded areas?
Super cooled water droplets
Large ice particles
Ice
Small ice crystals
EUMETSAT

Jose_59.PNG

Physical limit values in clusters



Why 25-33% limits in the 1.6µm reflectivity at 200 K ?

a. Cloud tops are made of non reflective ice crystals, too small to show variation.
b. Reflectivity at 1.6µm is almost constant for any cloud.
c. Analysed pixels are uniform, all in the same updraft phase.

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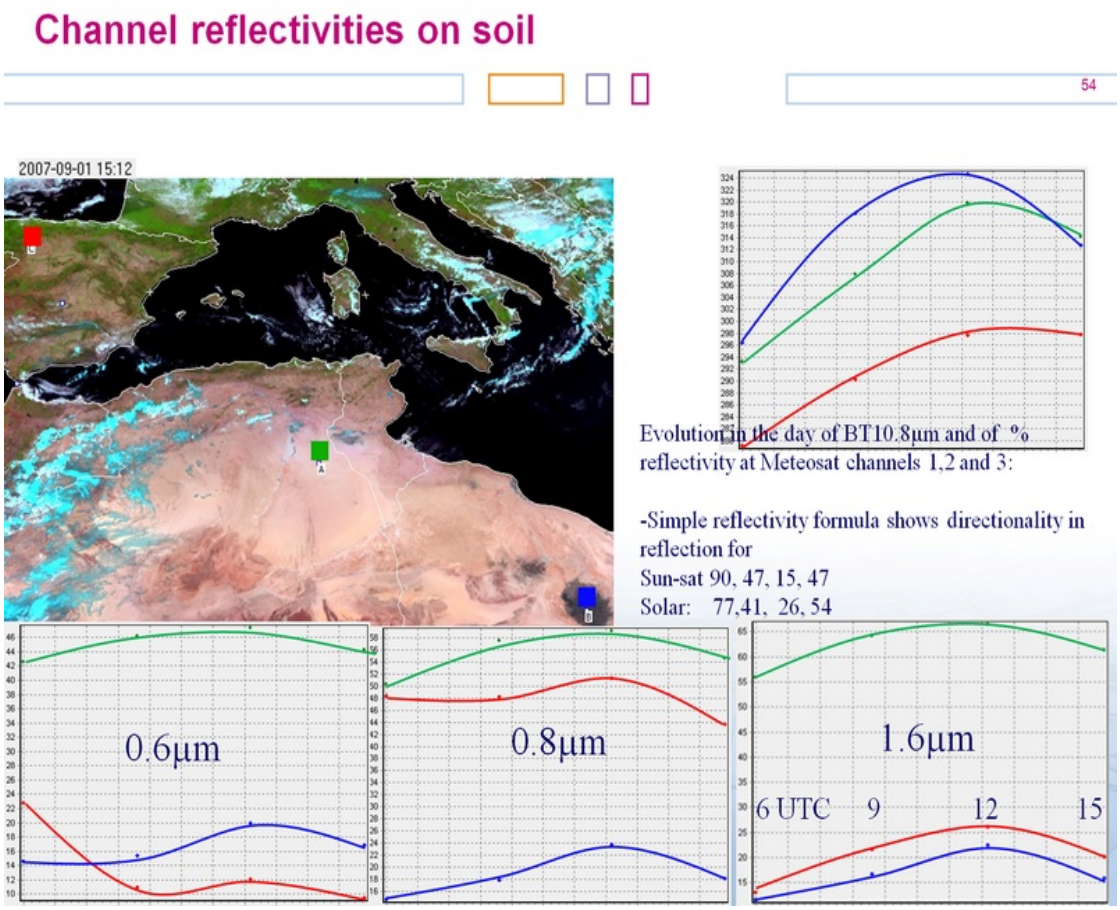
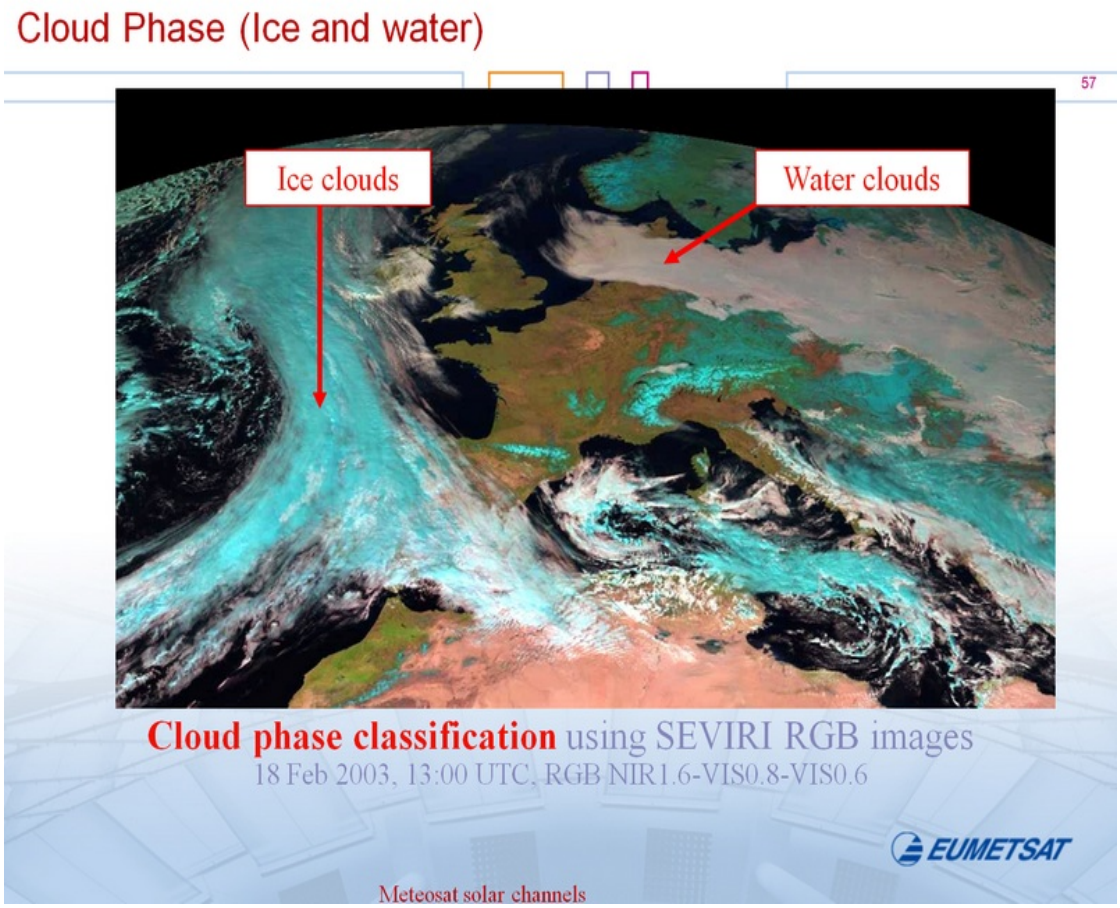
Jose_60.PNG

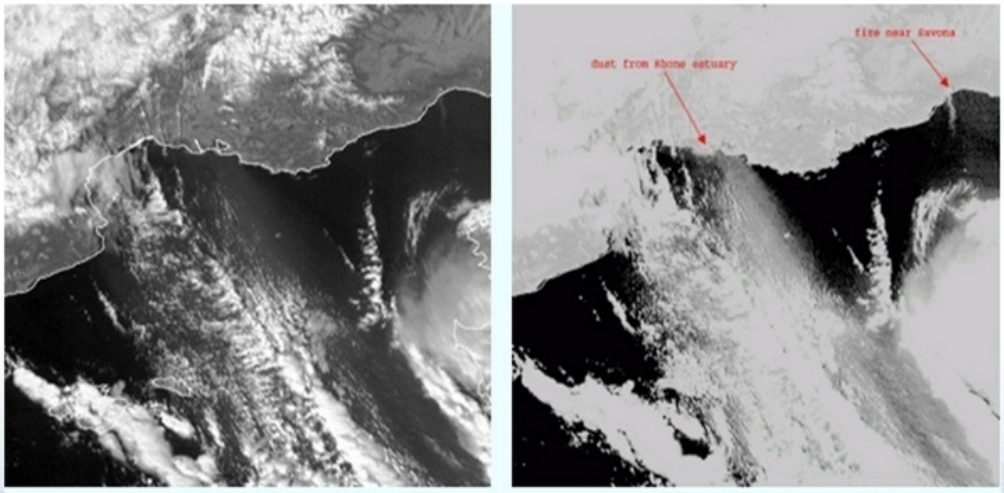

Channel reflectivities on soil
54
2007-09-01 15:12
Evolution in the day of BT10.8µm and of % reflectivity at Meteosat channels 1,2 and 3:
-Simple reflectivity formula shows directionality in reflection for
Sun-sat 90, 47, 15, 47
Solar: 77,41, 26, 54
0.6µm
0.8µm
1.6µm
6 UTC
9
12
15

Jose_61.PNG


Cloud Phase (Ice and water)
57
Ice clouds
Water clouds
Cloud phase classification using SEVIRI RGB images
18 Feb 2003, 13:00 UTC, RGB NIR1.6-VIS0.8-VIS0.6
EUMETSAT
Meteosat solar channels

Jose_62.PNG

Rough surfaces due to mistral



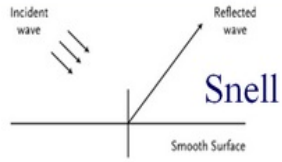
Met-8, 14 February 2005, 13:45 UTC
Channel 12 (HRV)

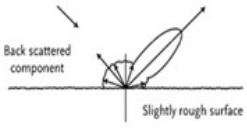
Met-8, 14 February 2005, 13:45 UTC
Channel 12 (HRV, enhanced)

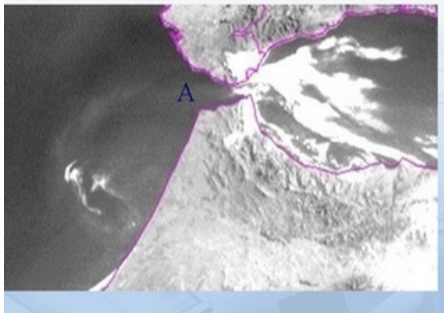
EUMETSAT

Jose_63.PNG

Sun glint, wind and rough seas







- Sun glint (strong specular sun reflection to the satellite) occurs for a particular geometry Sun-pixel-Satellite, in an area of 1000 km across (geostationary satellites)

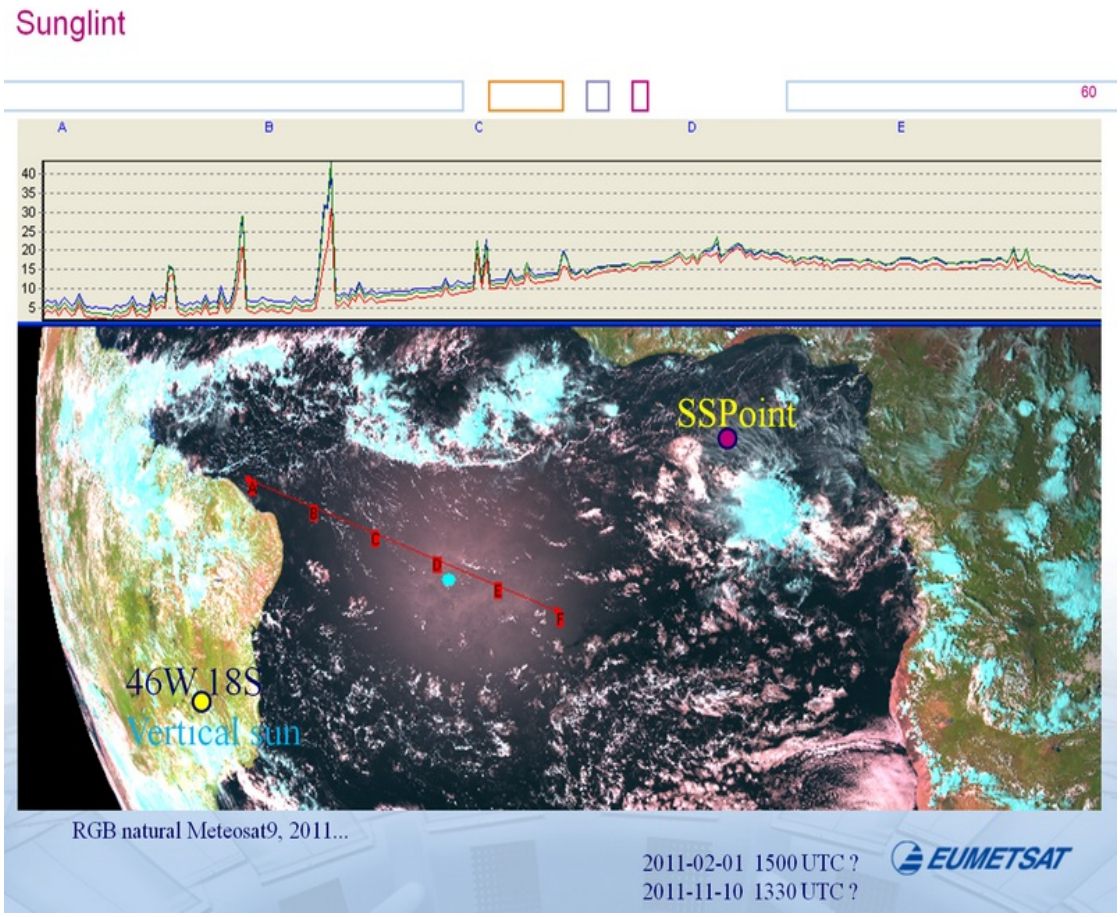
- For areas **far from the sun glint** zone, a weak wind **increases** roughness and scattering to the satellite on the sea surface.

- In the **sun glint zone** itself, the wind **decreases** the scattering to the satellite.

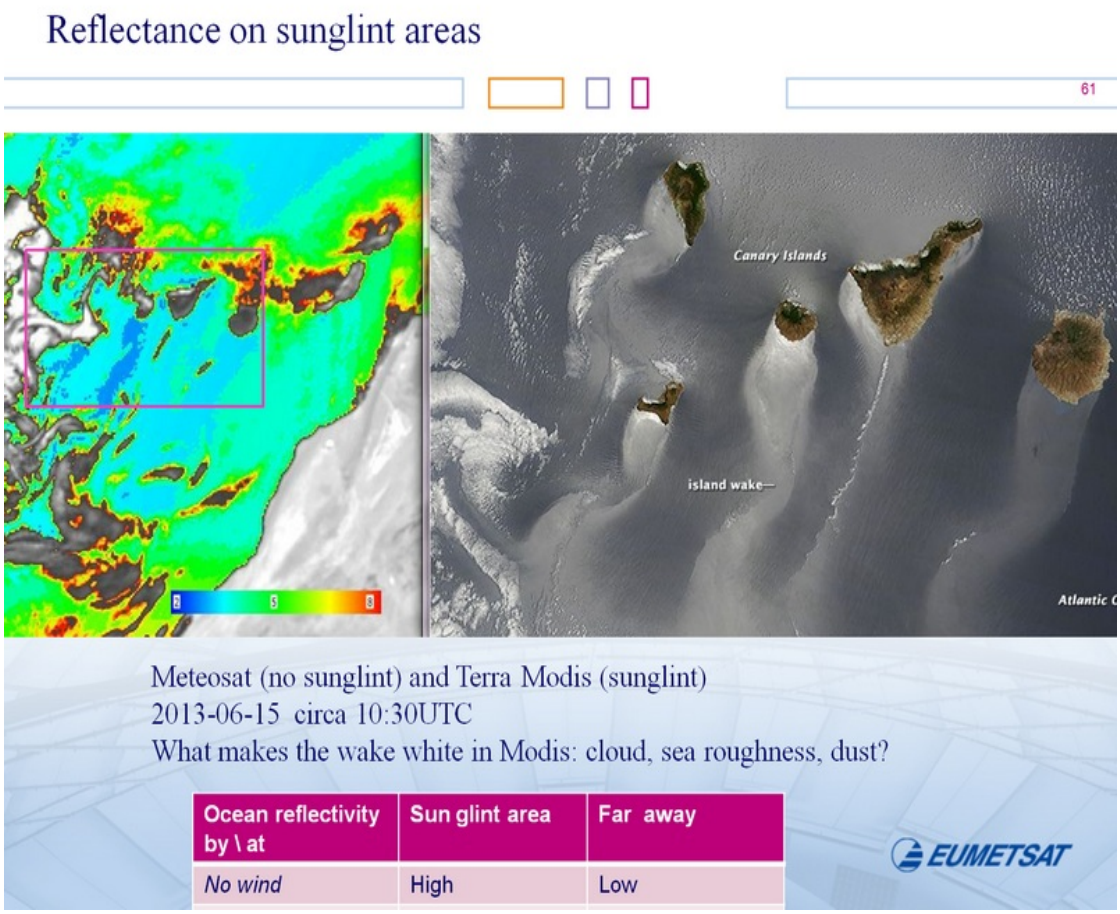
- A **strong** wind can increase reflectance by generating:
  - **-foam**
  - -jet depression and droplet **condensation**
  - -bringing **dust** from land into the see

Ocean reflectivity by \ at	Sun glint area	Far away
No wind	High	Low
Moderate wind	Medium	Medium
Strong wind	Medium	High

Jose_64.PNG


Sunglint
60
A
B
C
D
E
40
35
30
25
20
15
10
5
SSPoint
46W,18S
Vertical sun
RGB natural Meteosat9, 2011...
2011-02-01 1500 UTC ?
2011-11-10 1330 UTC ?
EUMETSAT

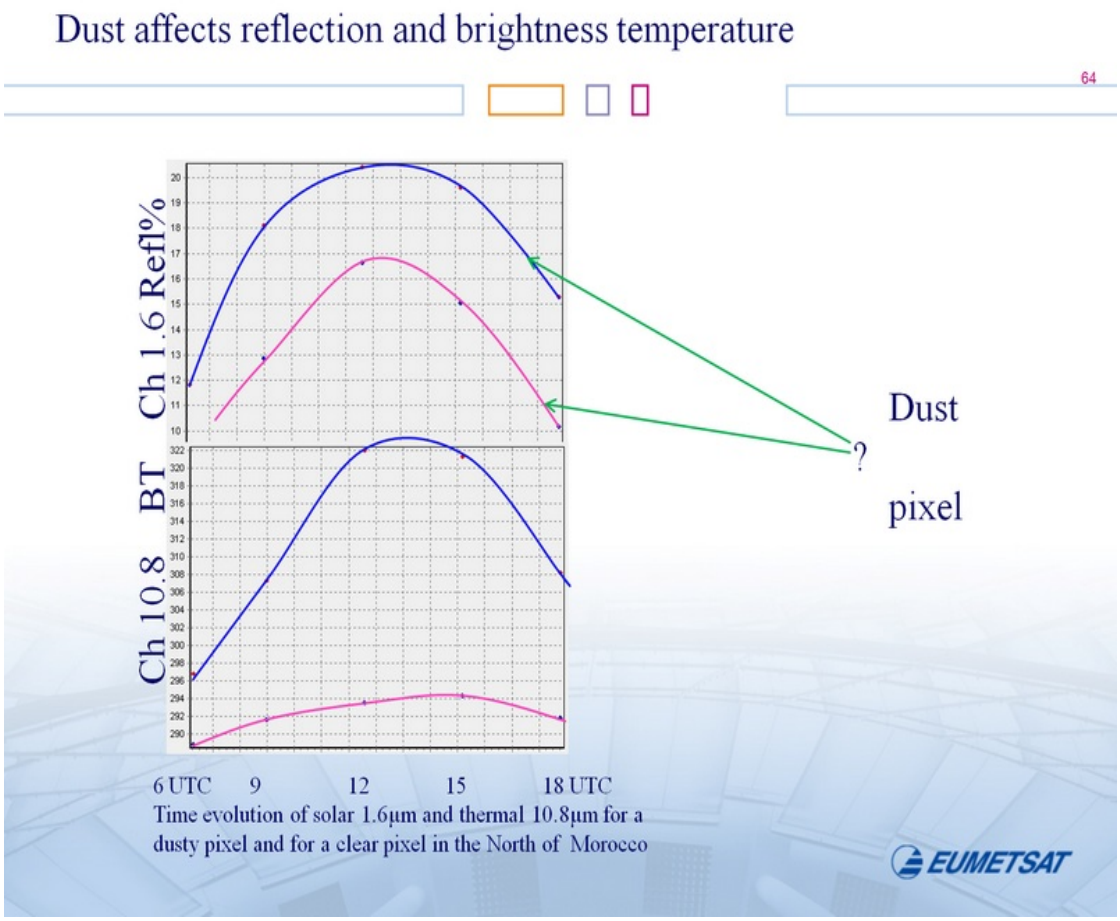
Jose_65.PNG


Reflectance on sunglint areas
61
Canary Islands
island wake
Meteosat (no sunglint) and Terra Modis (sunglint)
2013-06-15 circa 10:30UTC
What makes the wake white in Modis: cloud, sea roughness, dust?
Ocean reflectivity by \ at
Sun glint area
Far away
No wind
High
Low
EUMETSAT

Jose_66.PNG


62
N
S
2012-june-20 at 2330 UTC Meteosat-9 Natural RGB 321
What are the bright spots north of Iceland?:
Cloud, sea surface, ash? Mind the image date!
EUMETSAT

Jose_67.PNG


Dust affects reflection and brightness temperature
64
Ch 1.6 Refl%
Ch 10.8 BT
Dust
?
pixel
6 UTC
9
12
15
18 UTC
Time evolution of solar 1.6µm and thermal 10.8µm for a dusty pixel and for a clear pixel in the North of Morocco
EUMETSAT

Jose_68.PNG

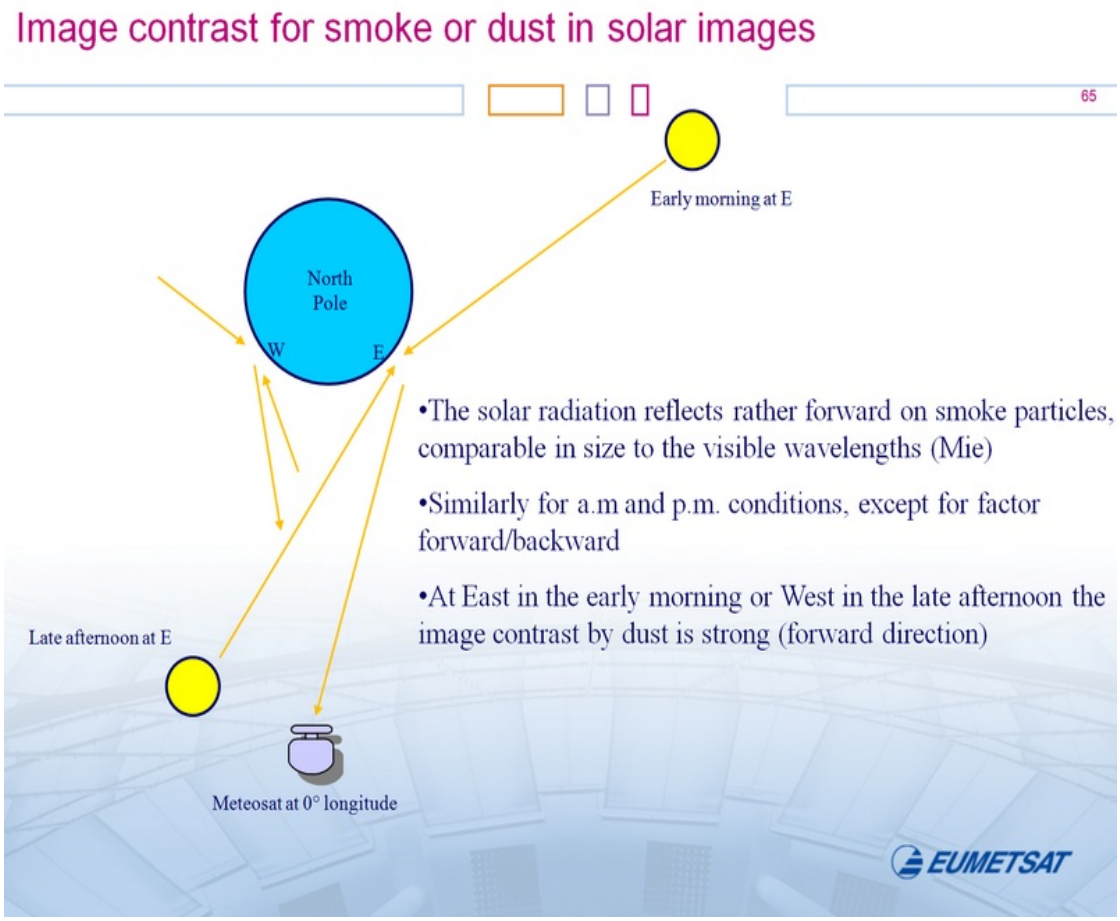
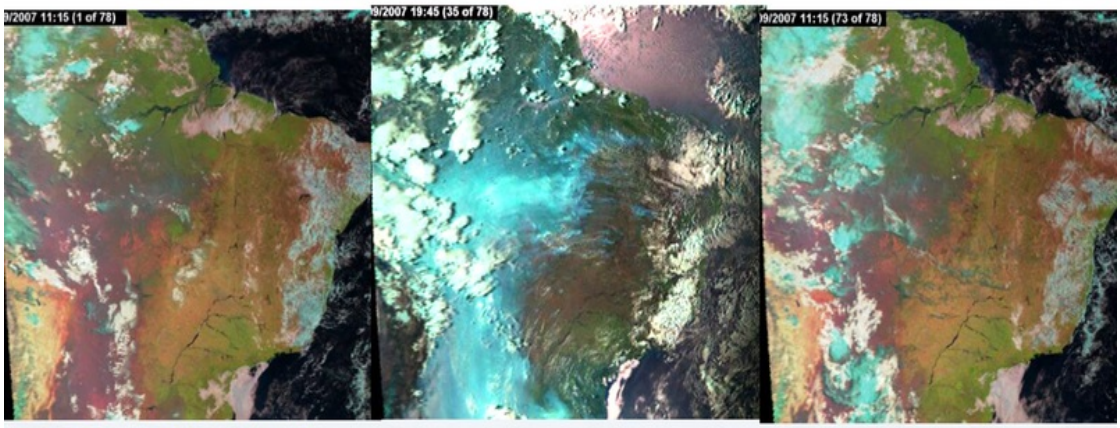


Image contrast for smoke or dust in solar images
65
Early morning at E
North Pole
W
E
•The solar radiation reflects rather forward on smoke particles, comparable in size to the visible wavelengths (Mie)
•Similarly for a.m and p.m. conditions, except for factor forward/backward
•At East in the early morning or West in the late afternoon the image contrast by dust is strong (forward direction)
Late afternoon at E
Meteosat at 0° longitude
EUMETSAT

Jose_69.PNG

Pastures burning and deforestation activity in Bolivia

sunrise sunset sunrise

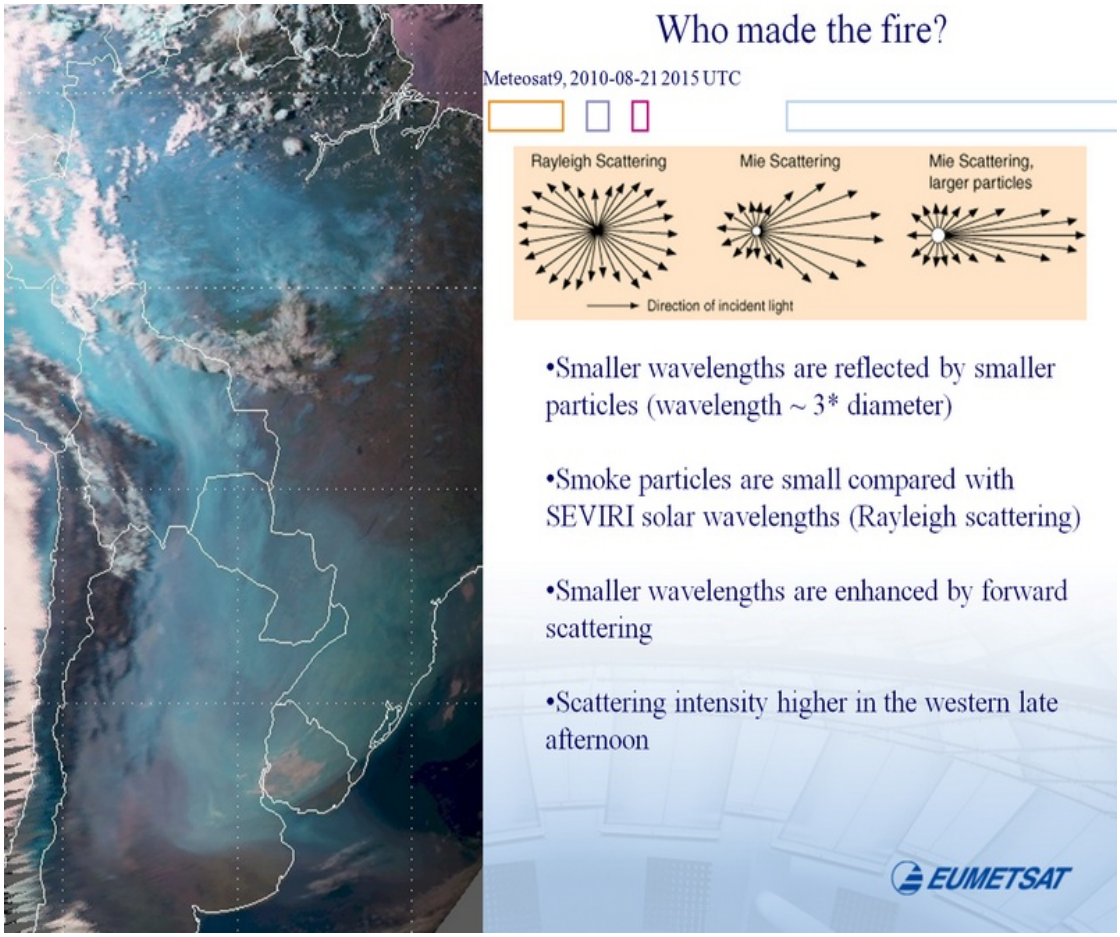


5-6 September 2007, Meteosat-9
Around sunrise and sunset times for central south America

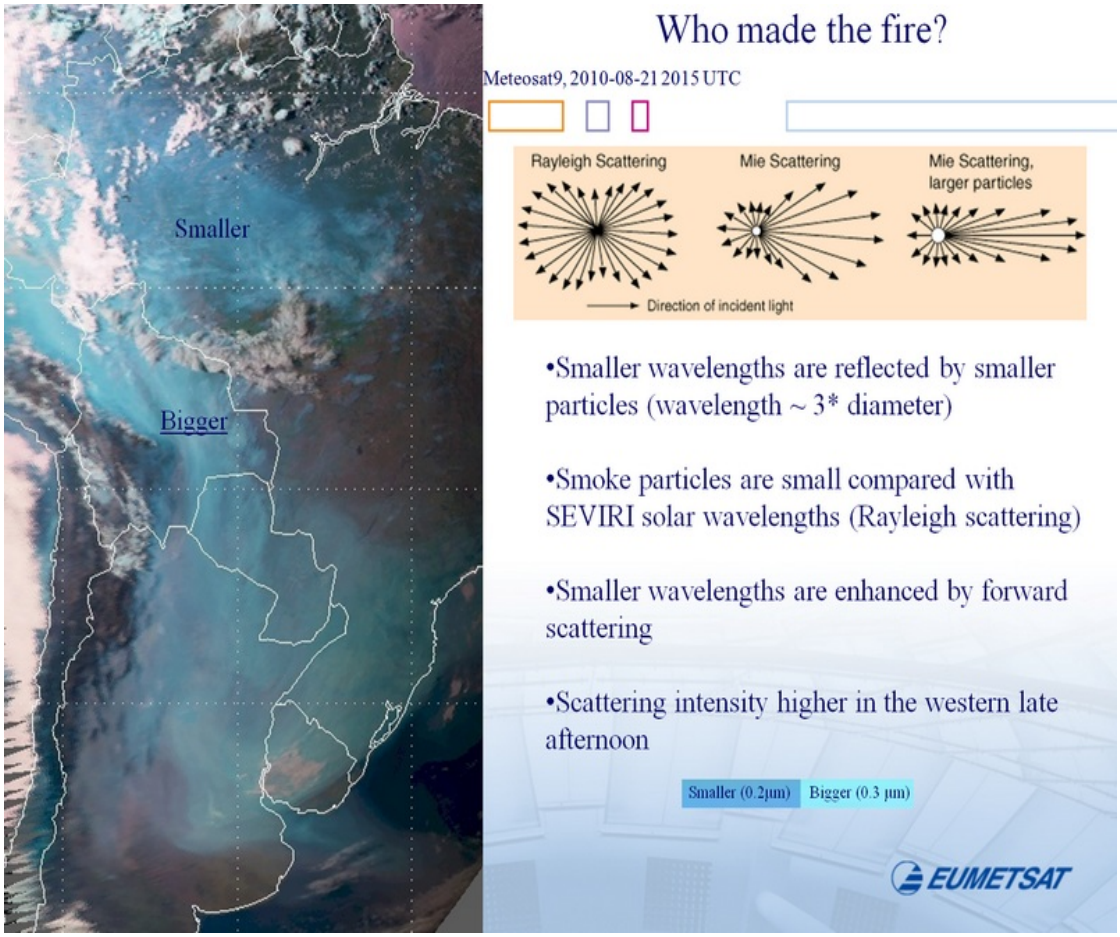
Assuming no major smoke sink or source in 24 hours, the intensity difference is due to directional reflection **(asymmetry factor)**

EUMETSAT

Jose_70.PNG


Who made the fire?
Meteosat9, 2010-08-21 2015 UTC
Rayleigh Scattering
Mie Scattering
Mie Scattering, larger particles
Direction of incident light
•Smaller wavelengths are reflected by smaller particles (wavelength ~ 3* diameter)
•Smoke particles are small compared with SEVIRI solar wavelengths (Rayleigh scattering)
•Smaller wavelengths are enhanced by forward scattering
•Scattering intensity higher in the western late afternoon
EUMETSAT

Jose_71.PNG


Smaller
Bigger
Who made the fire?
Meteosat9, 2010-08-21 2015 UTC
Rayleigh Scattering
Mie Scattering
Mie Scattering, larger particles
Direction of incident light
•Smaller wavelengths are reflected by smaller particles (wavelength ~ 3* diameter)
•Smoke particles are small compared with SEVIRI solar wavelengths (Rayleigh scattering)
•Smaller wavelengths are enhanced by forward scattering
•Scattering intensity higher in the western late afternoon
Smaller (0.2µm)
Bigger (0.3 µm)
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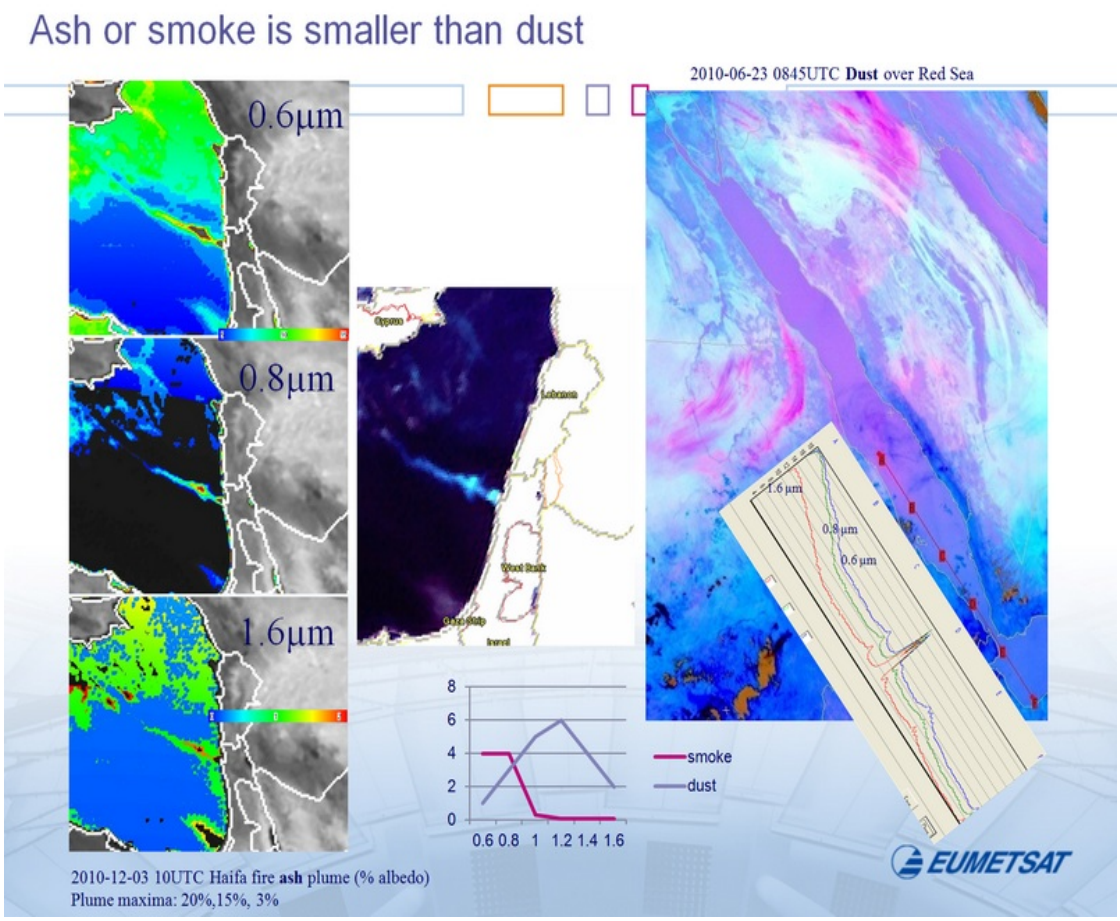
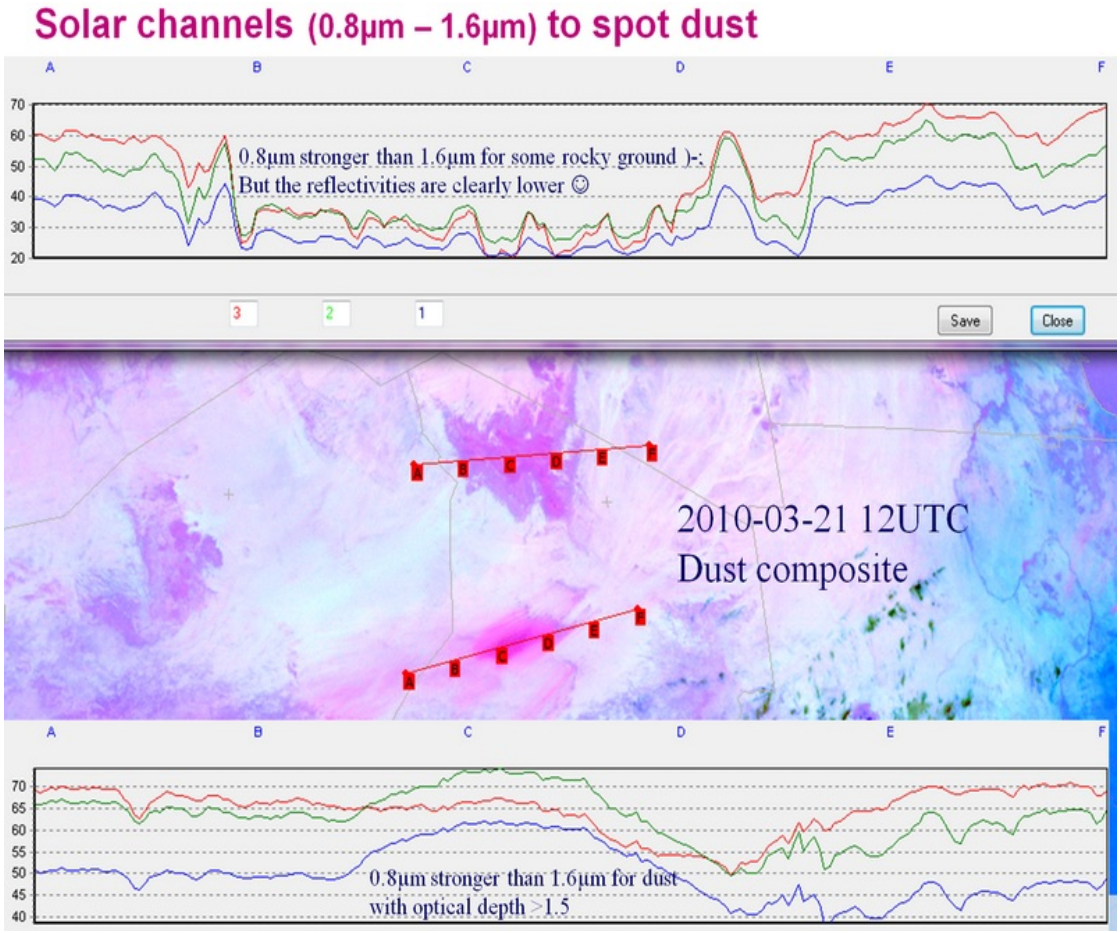
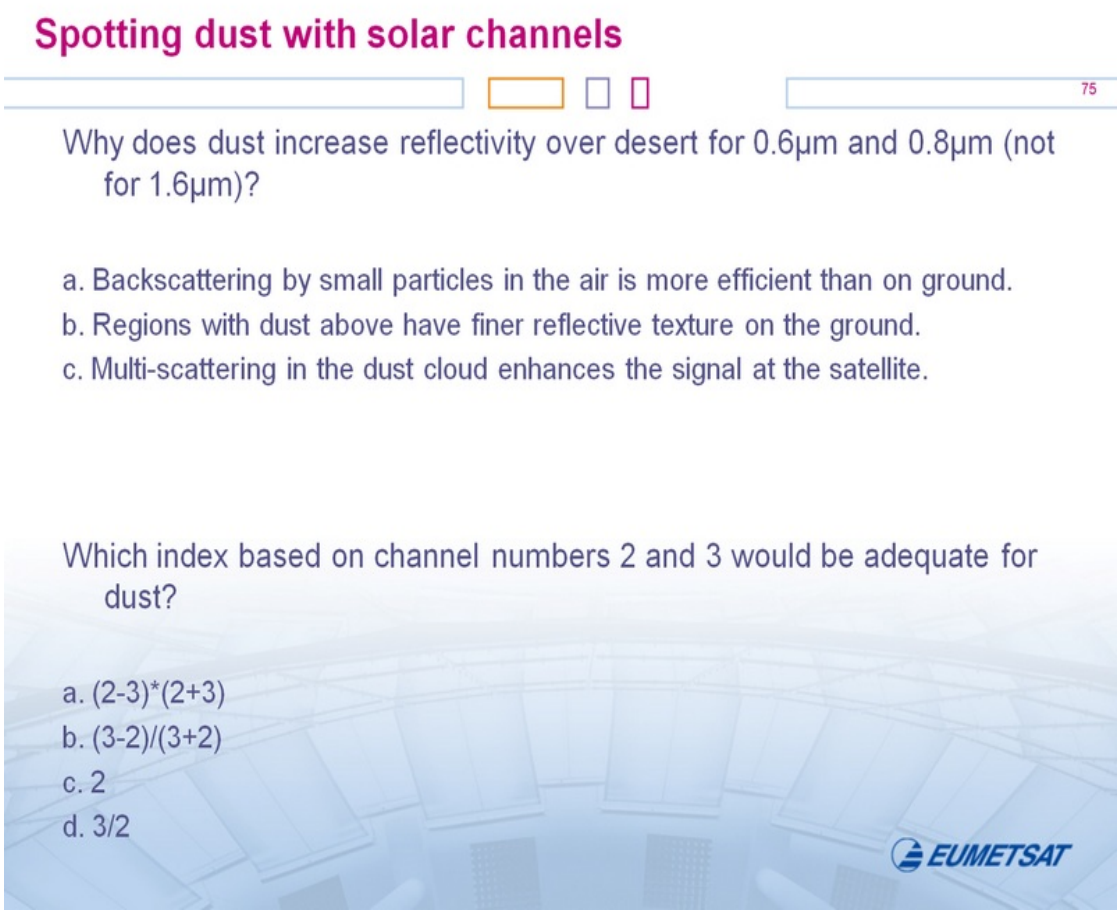
Jose_72.PNG


Ash or smoke is smaller than dust
0.6µm
0.8µm
1.6µm
2010-06-23 0845UTC Dust over Red Sea
1.6 µm
0.8 µm
0.6 µm
8
6
4
2
0
0.6 0.8 1 1.2 1.4 1.6
smoke
dust
EUMETSAT
2010-12-03 10UTC Haifa fire ash plume (% albedo)
Plume maxima: 20%,15%, 3%

Jose_73.PNG


Solar channels (0.8µm – 1.6µm) to spot dust
A
B
C
D
E
F
70
60
50
40
30
20
0.8µm stronger than 1.6µm for some rocky ground)-:
But the reflectivities are clearly lower ☺
3
2
1
Save
Close
2010-03-21 12UTC
Dust composite
A
B
C
D
E
F
70
65
60
55
50
45
40
0.8µm stronger than 1.6µm for dust
with optical depth >1.5

Jose_74.PNG


Spotting dust with solar channels
75
Why does dust increase reflectivity over desert for 0.6µm and 0.8µm (not for 1.6µm)?
a. Backscattering by small particles in the air is more efficient than on ground.
b. Regions with dust above have finer reflective texture on the ground.
c. Multi-scattering in the dust cloud enhances the signal at the satellite.
Which index based on channel numbers 2 and 3 would be adequate for dust?
a. (2-3)*(2+3)
b. (3-2)/(3+2)
c. 2
d. 3/2
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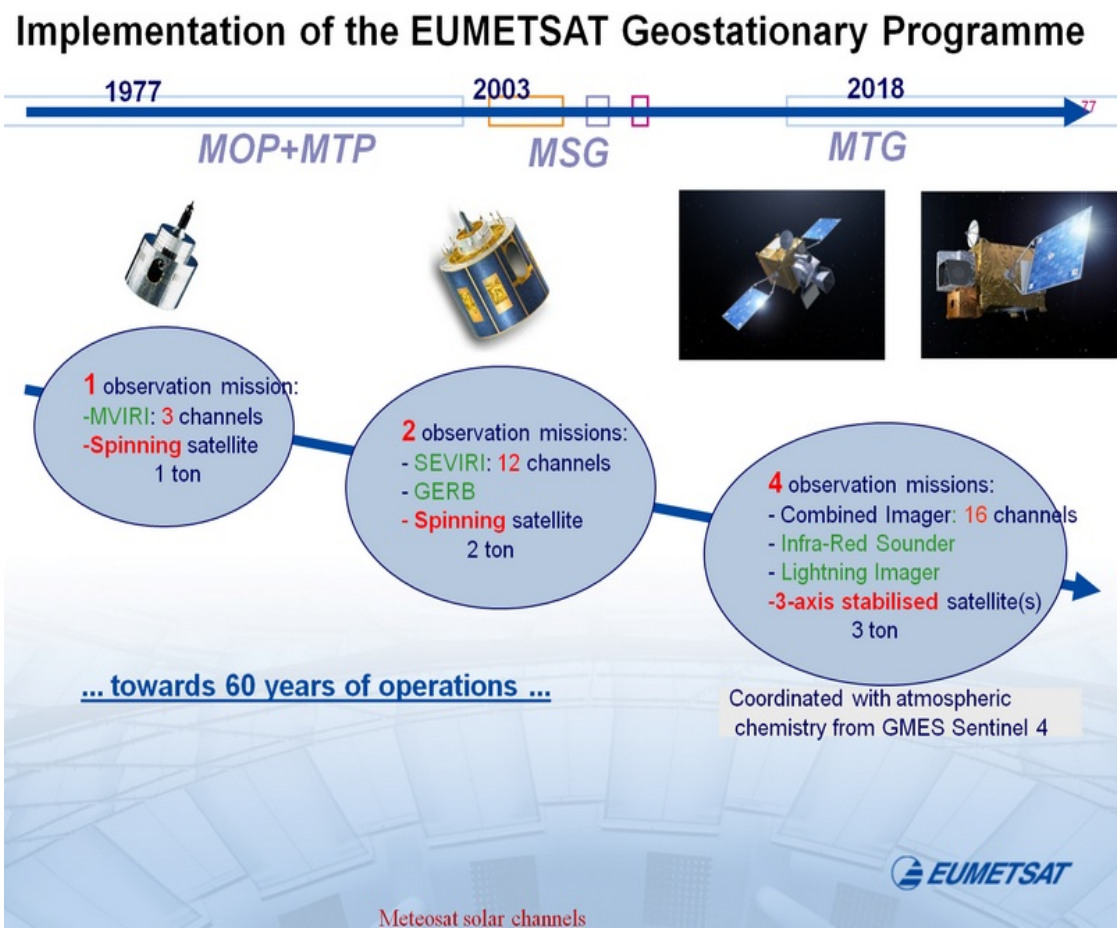
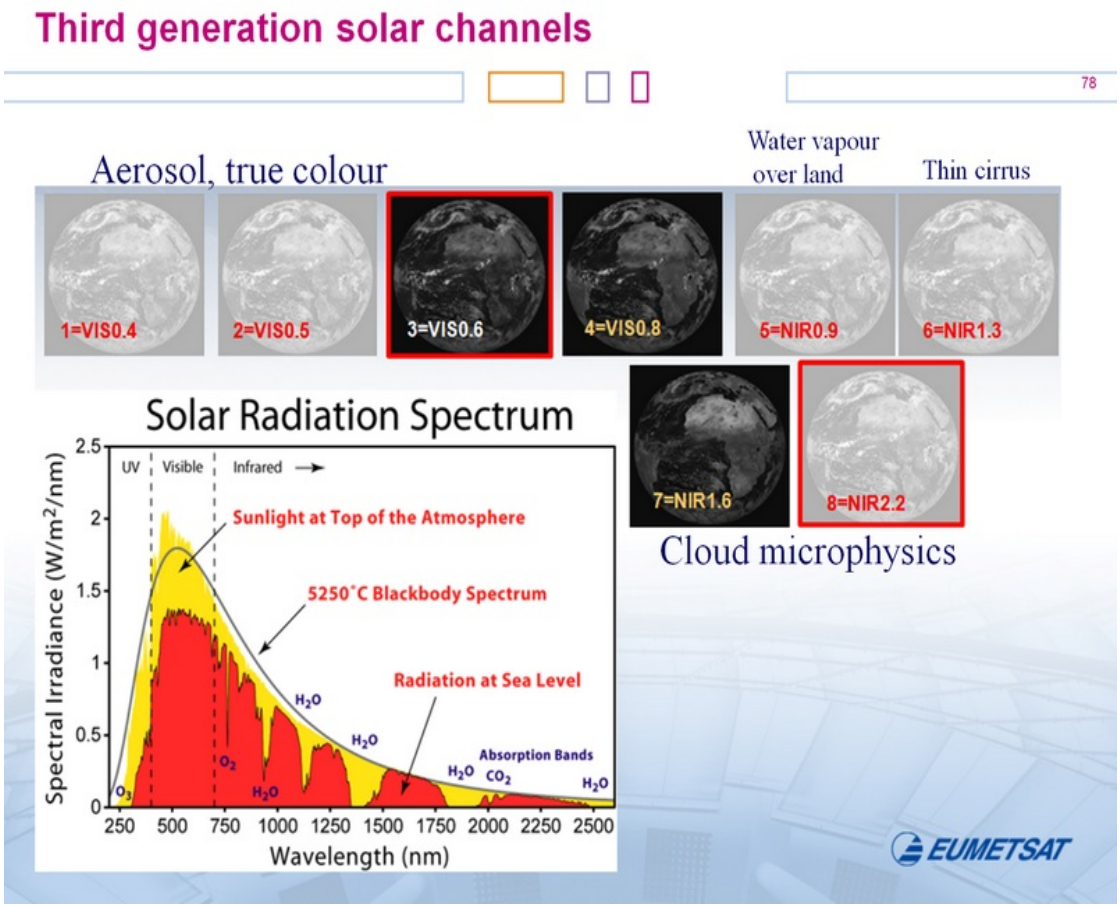
Jose_75.PNG


Implementation of the EUMETSAT Geostationary Programme
1977
2003
2018
MOP+MTP
MSG
MTG
1 observation mission:
-MVIRI: 3 channels
-Spinning satellite
1 ton
2 observation missions:
- SEVIRI: 12 channels
- GERB
- Spinning satellite
2 ton
4 observation missions:
- Combined Imager: 16 channels
- Infra-Red Sounder
- Lightning Imager
-3-axis stabilised satellite(s)
3 ton
... towards 60 years of operations ...
Coordinated with atmospheric chemistry from GMES Sentinel 4
EUMETSAT
Meteosat solar channels

Jose_76.PNG


Third generation solar channels
78
Aerosol, true colour
Water vapour over land
Thin cirrus
1=VIS0.4
2=VIS0.5
3=VIS0.6
4=VIS0.8
5=NIR0.9
6=NIR1.3
Solar Radiation Spectrum
UV
Visible
Infrared
Sunlight at Top of the Atmosphere
5250°C Blackbody Spectrum
Radiation at Sea Level
Absorption Bands
Spectral Irradiance (W/m²/nm)
Wavelength (nm)
7=NIR1.6
8=NIR2.2
Cloud microphysics
EUMETSAT

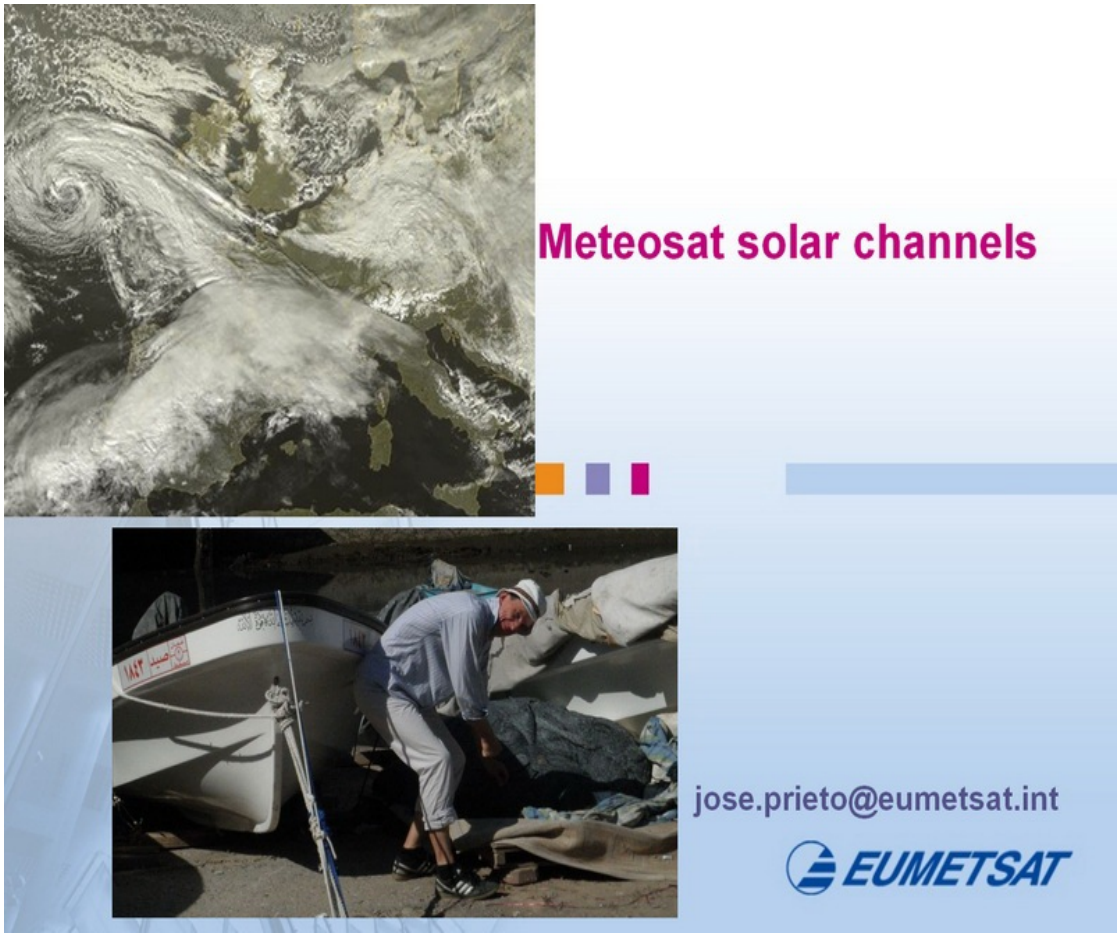
Jose_77.PNG


Aerosol, ocean colour, flooding
79
True color RGB 1 km
0.4 0.5 0.6 µm
MODIS 20061124 12:20
EUM/MTG/VWG/10/0307
EUMETSAT

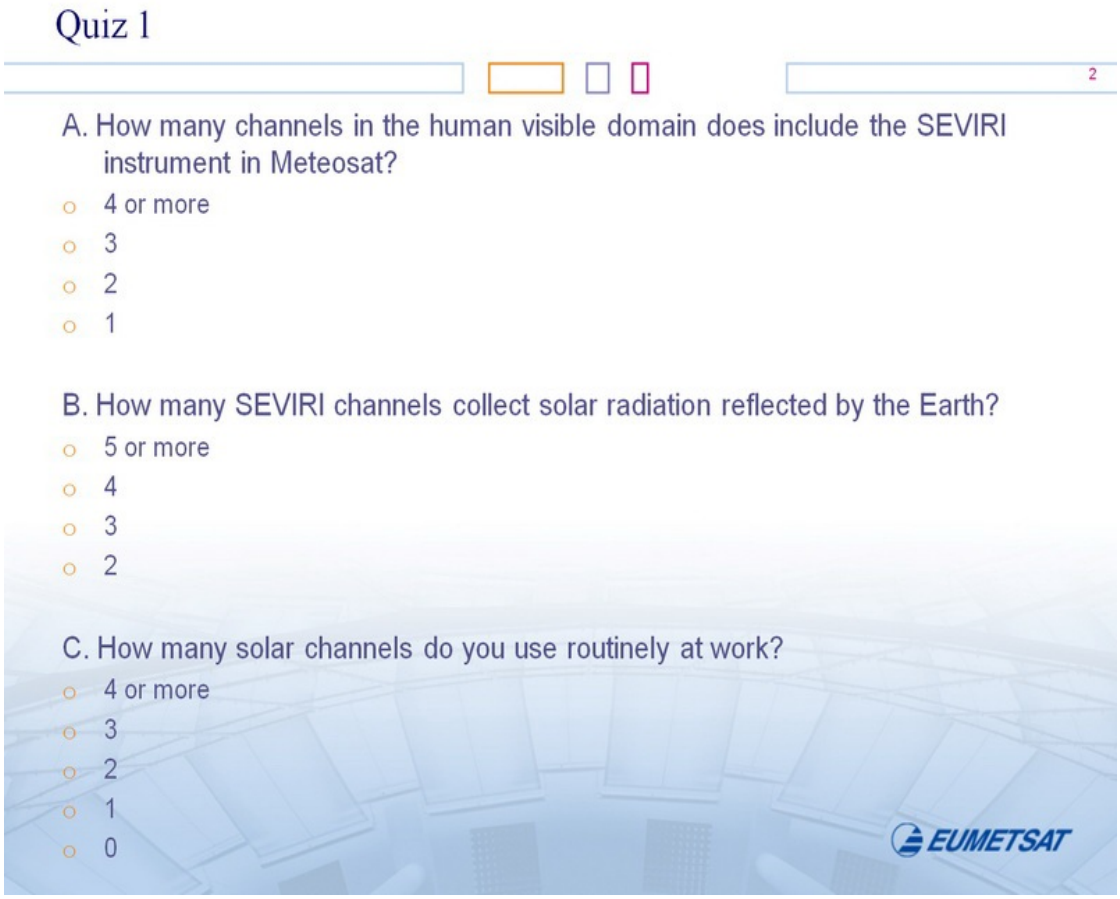
Jose_78.PNG


81
Thank you for your attention
Meteosat 10
2014-04-11 1215 UTC
EUMETSAT

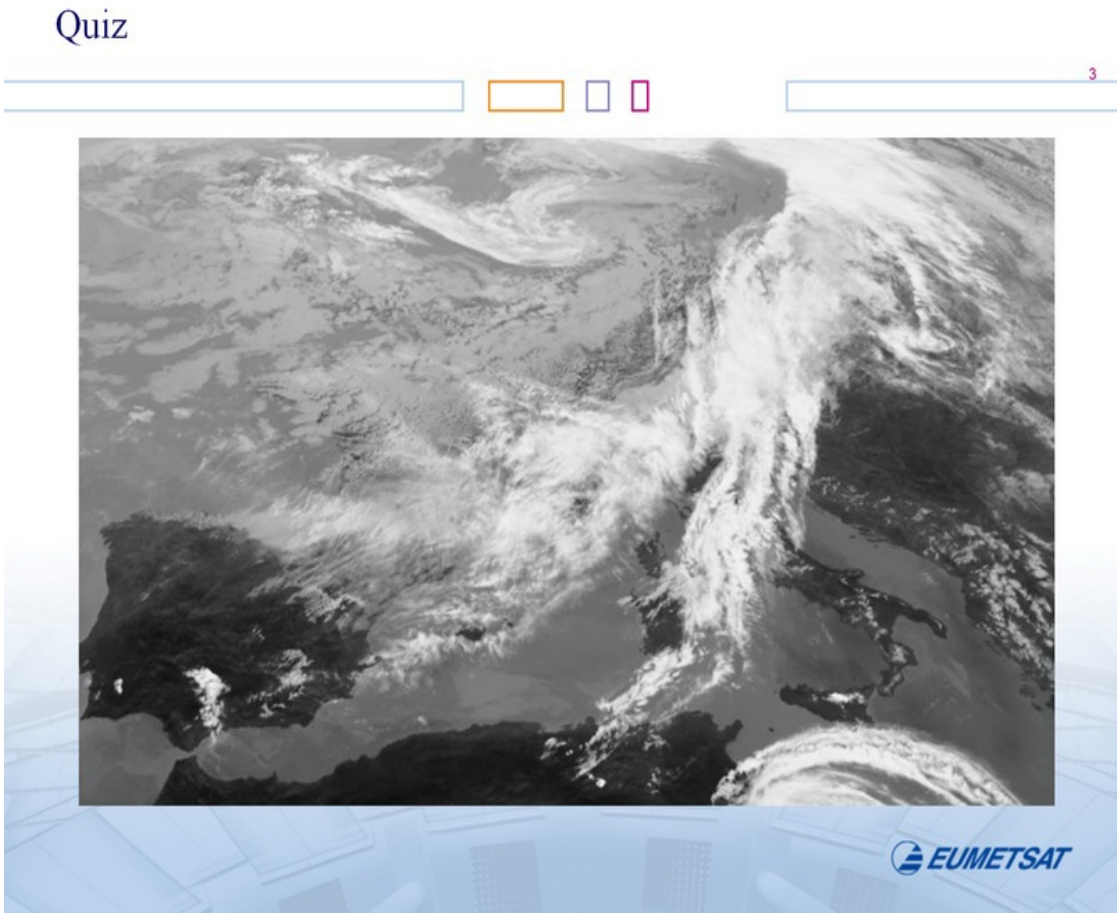
Jose_79.PNG


Meteosat solar channels
jose.prieto@eumetsat.int
EUMETSAT

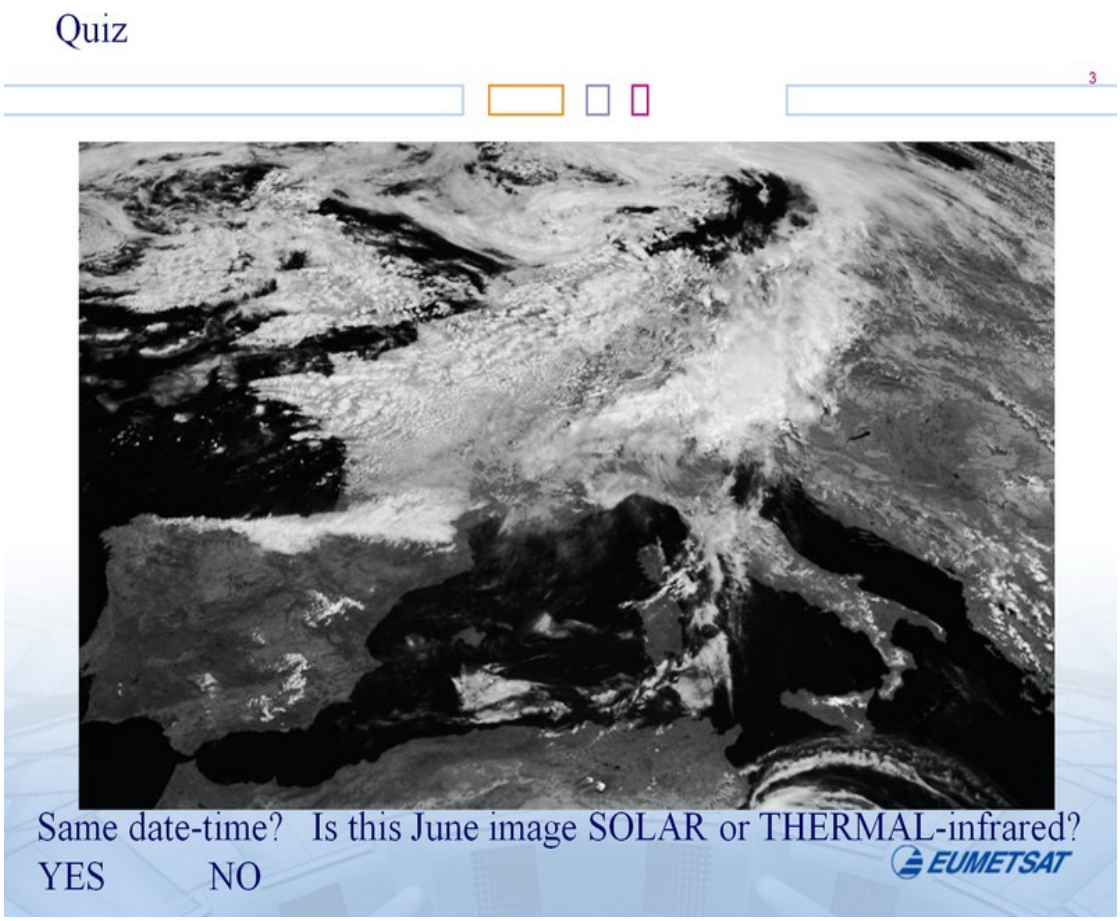
Jose_80.PNG


Quiz 1
2
A. How many channels in the human visible domain does include the SEVIRI instrument in Meteosat?
4 or more
3
2
1
B. How many SEVIRI channels collect solar radiation reflected by the Earth?
5 or more
4
3
2
C. How many solar channels do you use routinely at work?
4 or more
3
2
1
0
EUMETSAT

Jose_81.PNG

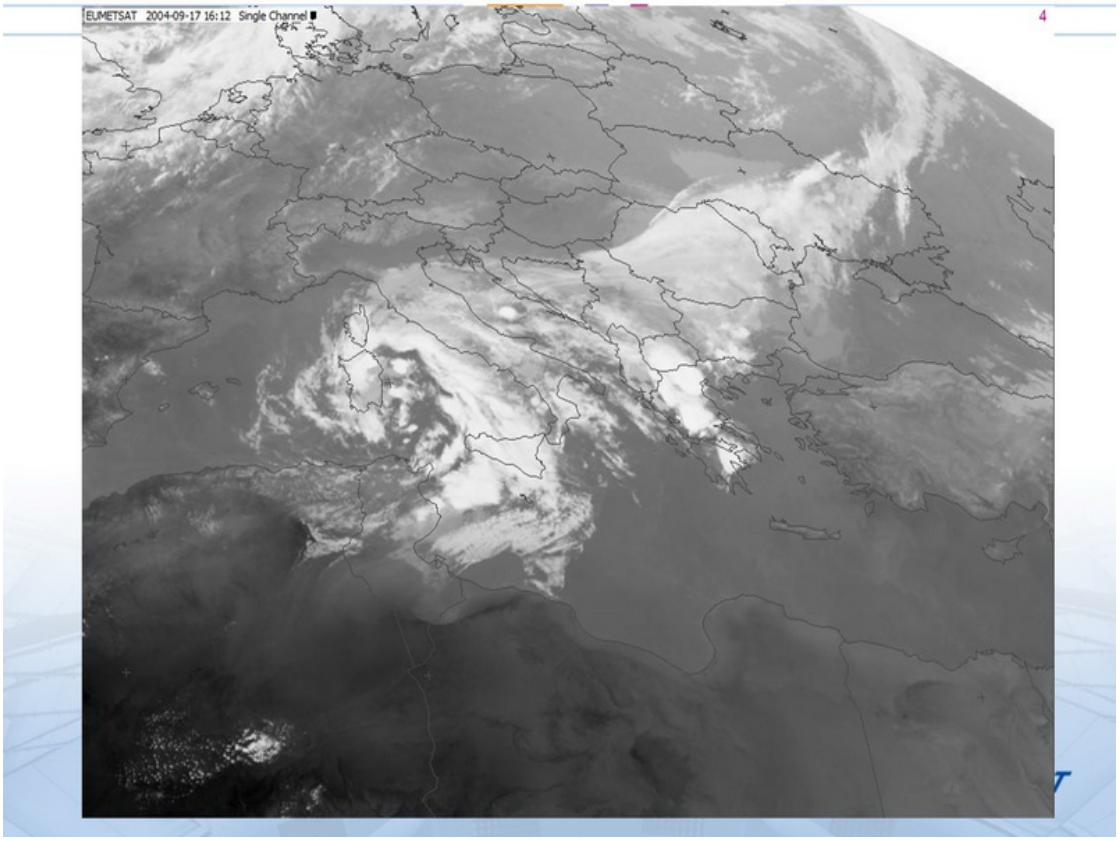


Jose_82.PNG


Quiz
3
Same date-time? Is this June image SOLAR or THERMAL-infrared?
YES NO
EUMETSAT

Jose_83.PNG

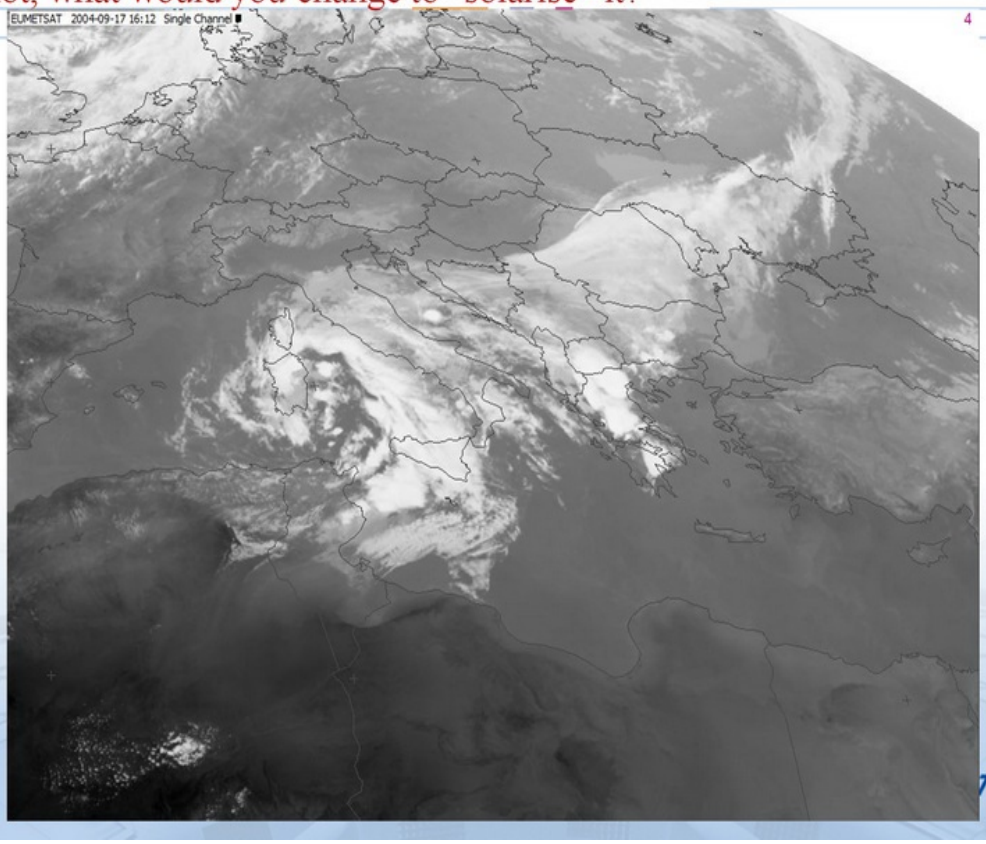
Is this solar? YES NO



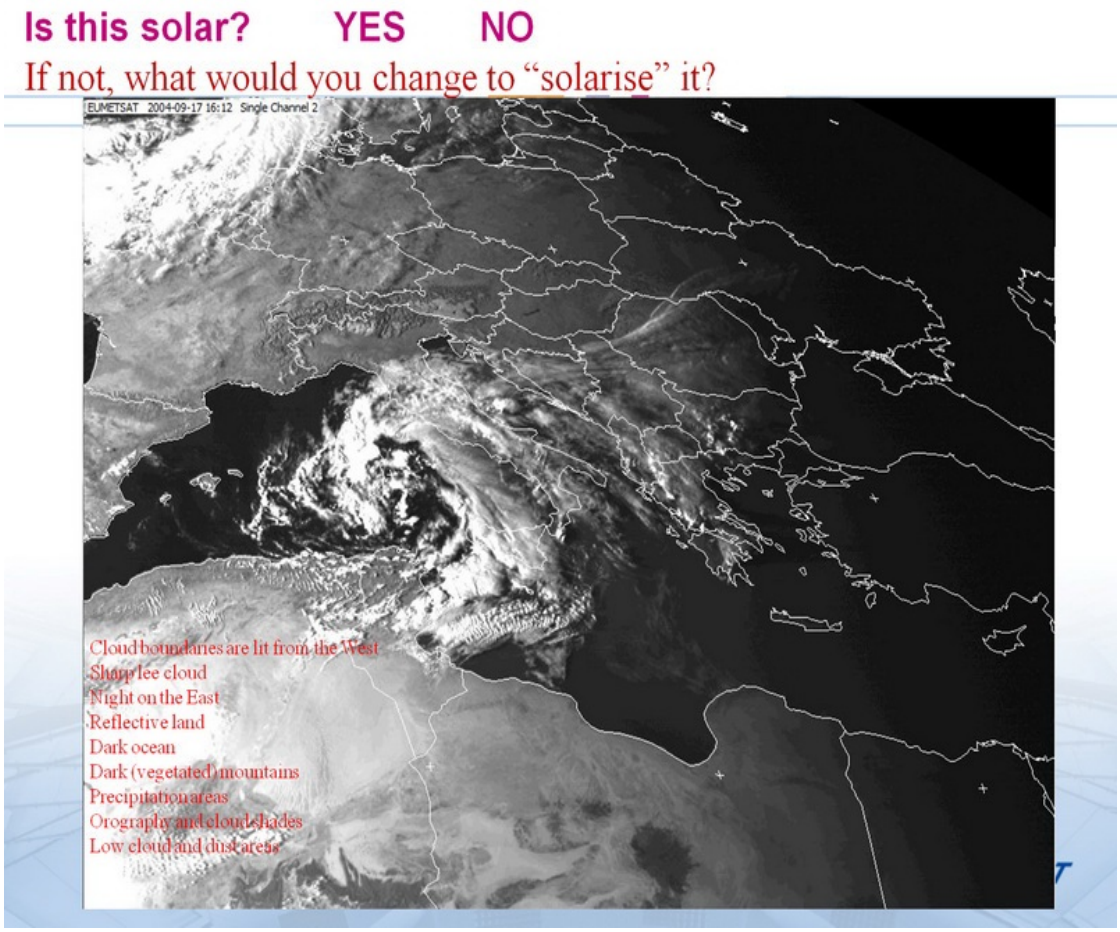
Jose_84.PNG

Is this solar? YES NO

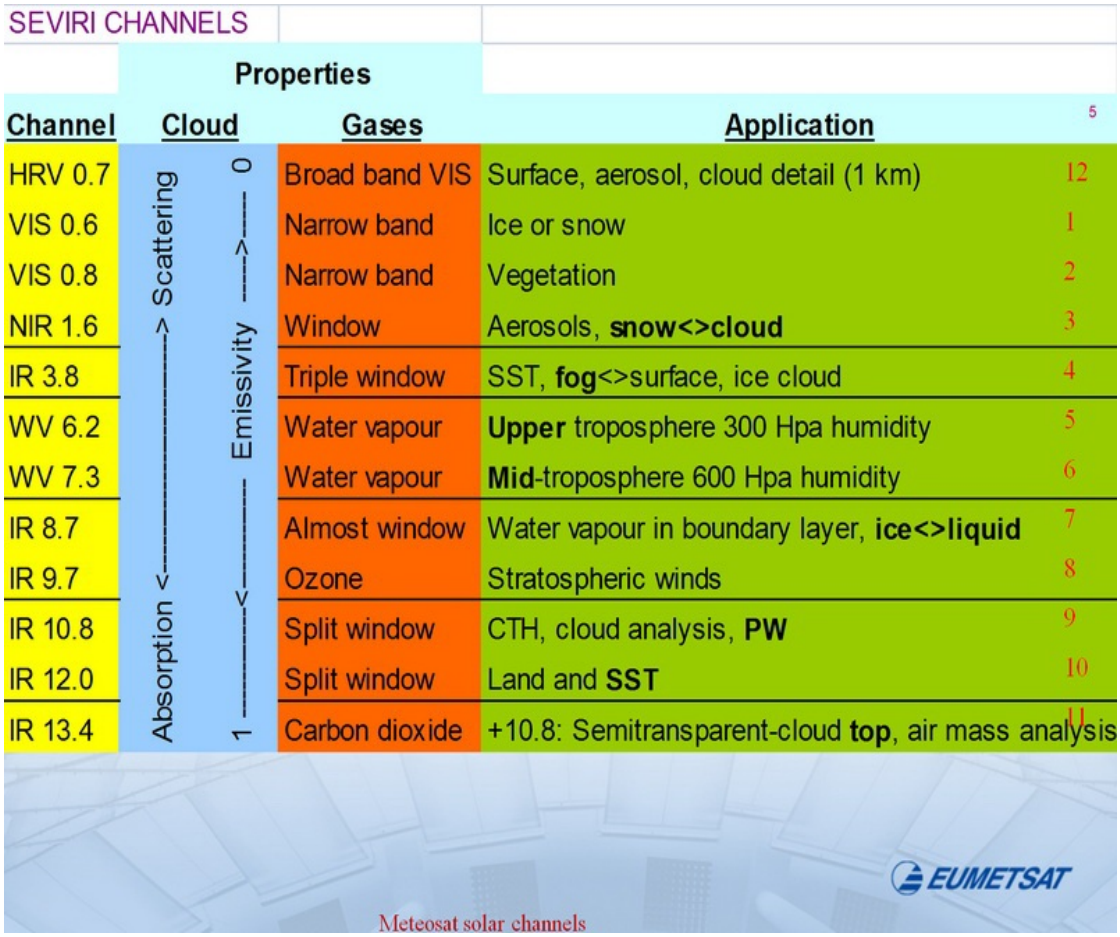
If not, what would you change to "solarise" it?



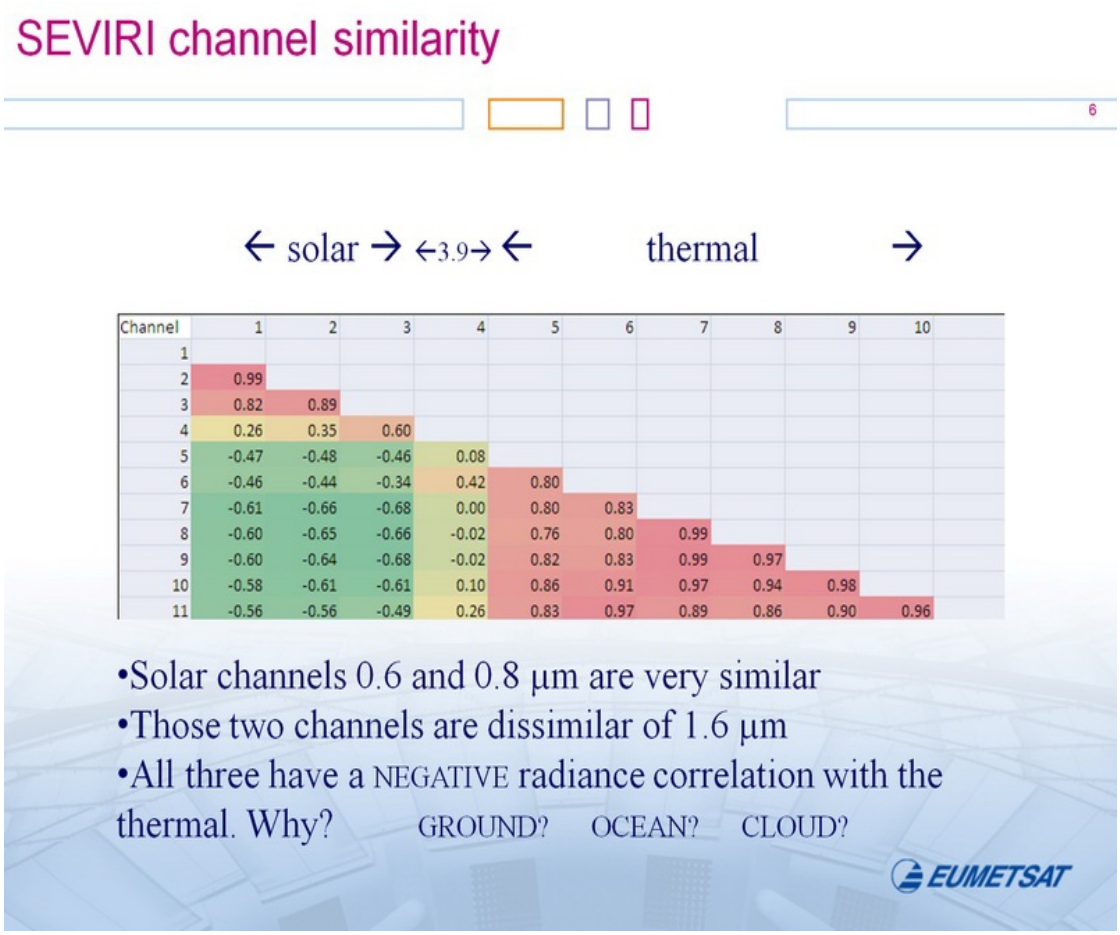
Jose_85.PNG


Is this solar? YES NO
If not, what would you change to "solarise" it?
EUMETSAT 2004-09-17 16:12 Single Channel 2
Cloud boundaries are lit from the West
Sharp lee cloud
Night on the East
Reflective land
Dark ocean
Dark (vegetated) mountains
Precipitation areas
Orography and cloud shades
Low cloud and dust areas

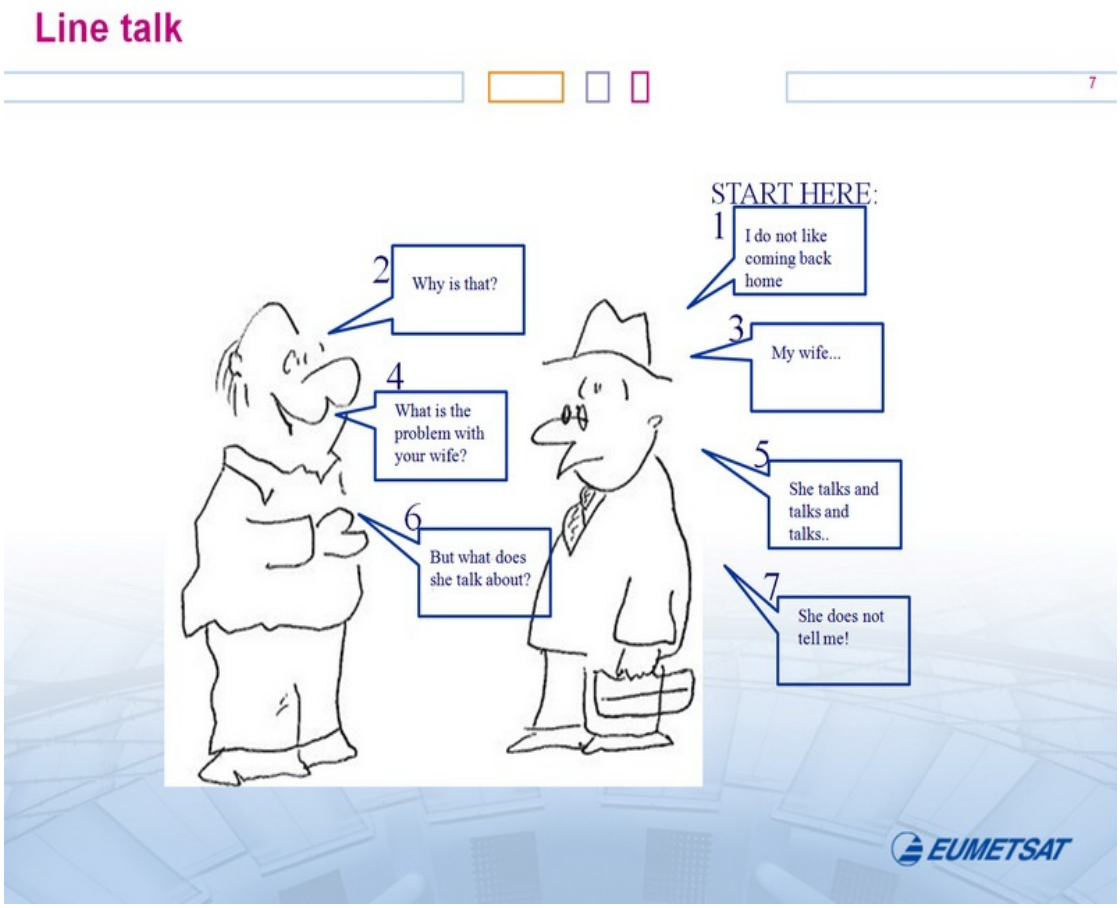
Jose_86.PNG


SEVIRI CHANNELS
Properties
Channel
Cloud
Gases
Application
HRV 0.7
VIS 0.6
VIS 0.8
NIR 1.6
IR 3.8
WV 6.2
WV 7.3
IR 8.7
IR 9.7
IR 10.8
IR 12.0
IR 13.4
Absorption <----------> Scattering
1 <---------- Emissivity ----> 0
Broad band VIS
Narrow band
Narrow band
Window
Triple window
Water vapour
Water vapour
Almost window
Ozone
Split window
Split window
Carbon dioxide
Surface, aerosol, cloud detail (1 km)
Ice or snow
Vegetation
Aerosols, snow<>cloud
SST, fog<>surface, ice cloud
Upper troposphere 300 Hpa humidity
Mid-troposphere 600 Hpa humidity
Water vapour in boundary layer, ice<>liquid
Stratospheric winds
CTH, cloud analysis, PW
Land and SST
+10.8: Semitransparent-cloud top, air mass analysis
5
12
1
2
3
4
5
6
7
8
9
10
11
EUMETSAT
Meteosat solar channels

Jose_87.PNG


SEVIRI channel similarity
6
← solar → ←3.9→ ← thermal →
Channel 1 2 3 4 5 6 7 8 9 10
1
2 0.99
3 0.82 0.89
4 0.26 0.35 0.60
5 -0.47 -0.48 -0.46 0.08
6 -0.46 -0.44 -0.34 0.42 0.80
7 -0.61 -0.66 -0.68 0.00 0.80 0.83
8 -0.60 -0.65 -0.66 -0.02 0.76 0.80 0.99
9 -0.60 -0.64 -0.68 -0.02 0.82 0.83 0.99 0.97
10 -0.58 -0.61 -0.61 0.10 0.86 0.91 0.97 0.94 0.98
11 -0.56 -0.56 -0.49 0.26 0.83 0.97 0.89 0.86 0.90 0.96
•Solar channels 0.6 and 0.8 µm are very similar
•Those two channels are dissimilar of 1.6 µm
•All three have a NEGATIVE radiance correlation with the thermal. Why? GROUND? OCEAN? CLOUD?
EUMETSAT

Jose_88.PNG


Line talk
7
START HERE:
1
I do not like coming back home
2
Why is that?
3
My wife...
4
What is the problem with your wife?
5
She talks and talks and talks..
6
But what does she talk about?
7
She does not tell me!
EUMETSAT

Jose_89.PNG

Contents

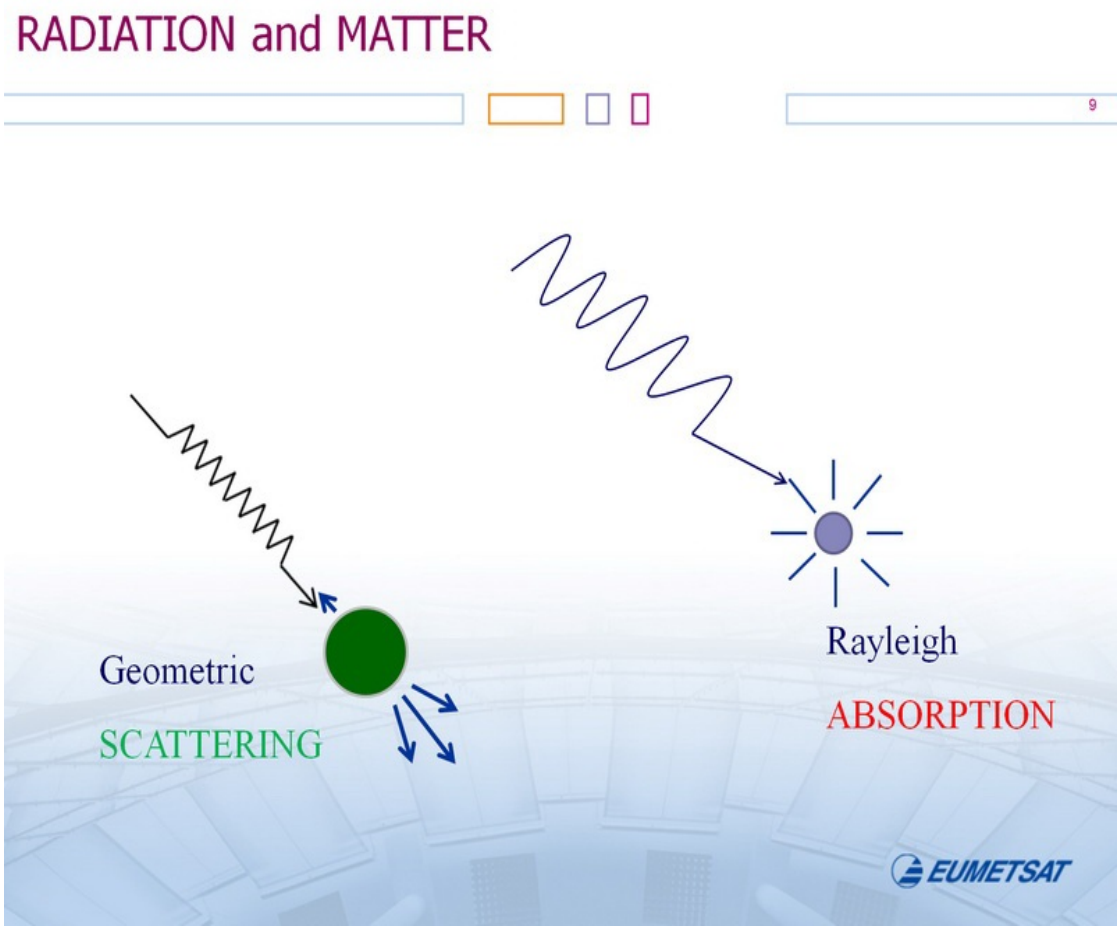
- Where is LIGHT absorbed ?

- Is the neighbour's GRASS greener?

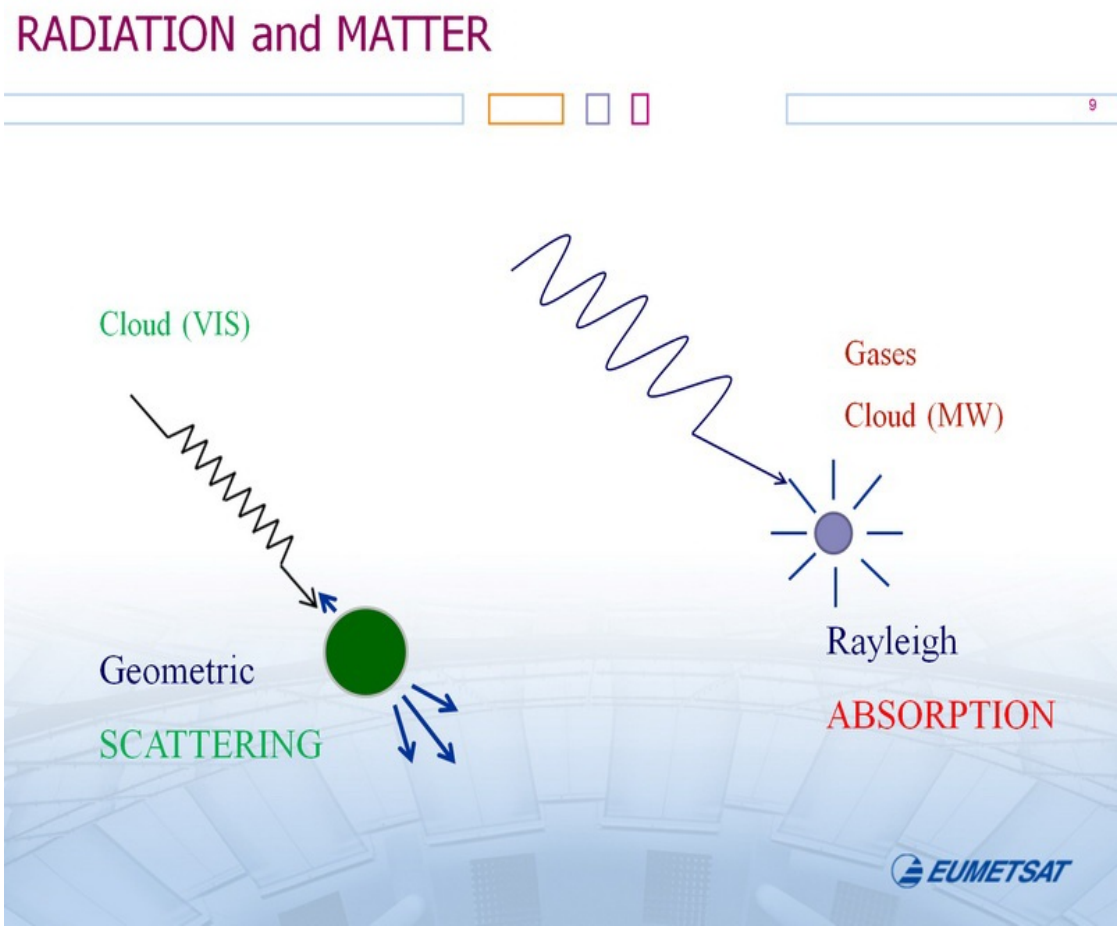
- Is ICE always cyan?

- Is DUST enhancing visibility?

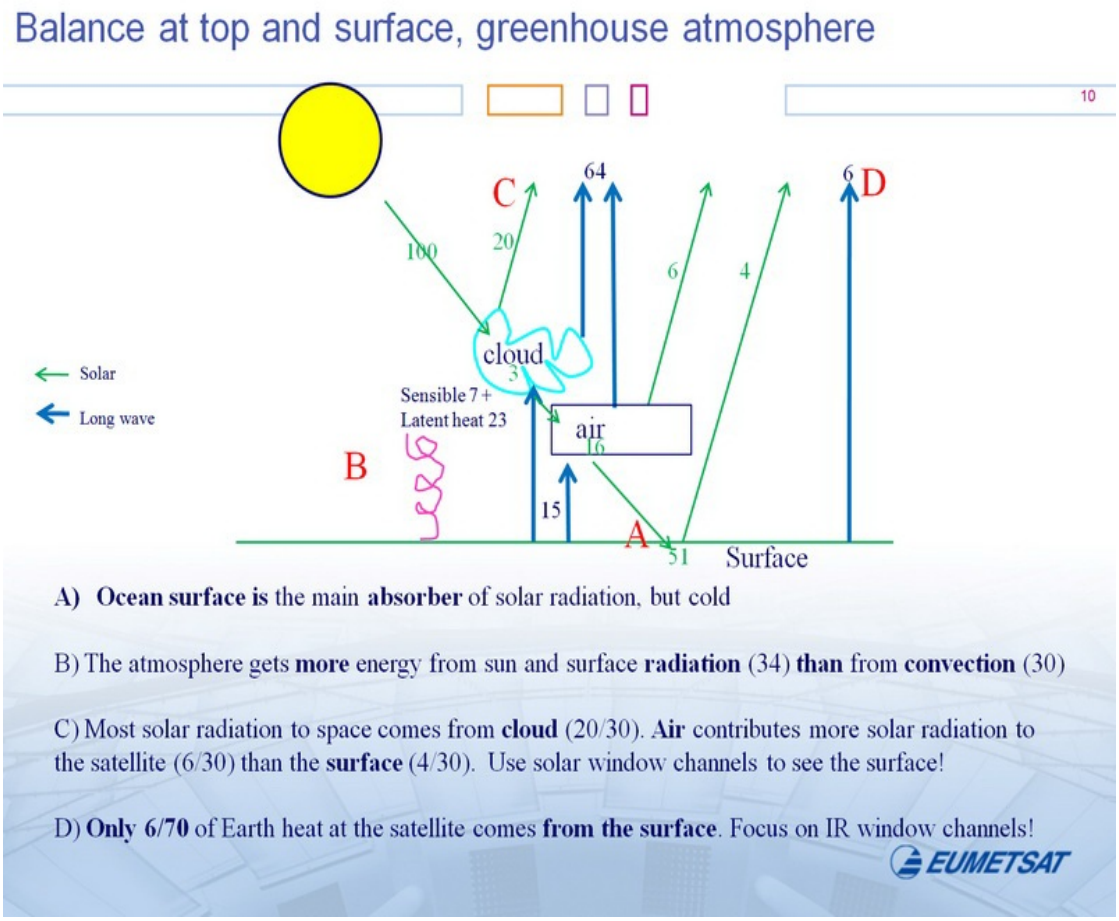
Jose_90.PNG


RADIATION and MATTER
9
Geometric
SCATTERING
Rayleigh
ABSORPTION
EUMETSAT

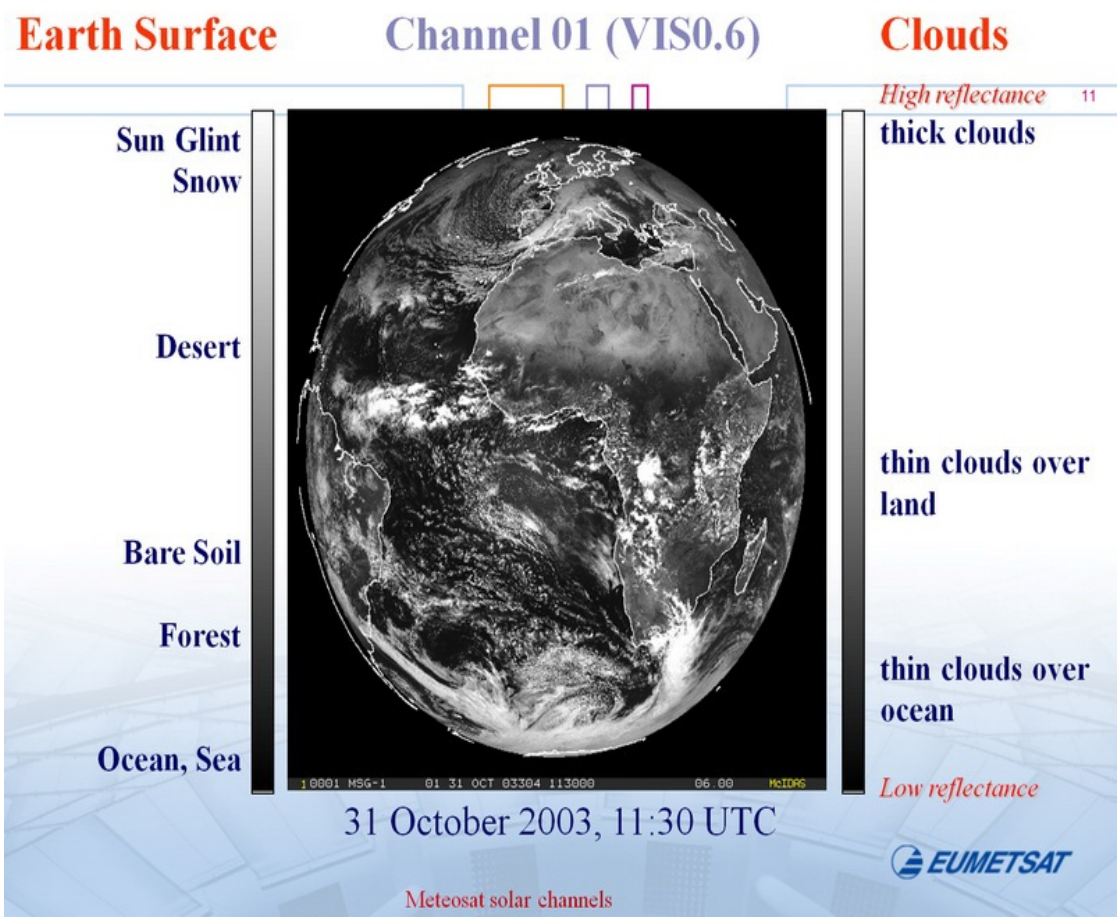
Jose_91.PNG


RADIATION and MATTER
9
Cloud (VIS)
Gases
Cloud (MW)
Geometric
SCATTERING
Rayleigh
ABSORPTION
EUMETSAT

Jose_92.PNG


Balance at top and surface, greenhouse atmosphere
10
C
64
6
D
100
20
6
4
cloud
3
Solar
Long wave
Sensible 7 +
Latent heat 23
air
16
B
15
A
51
Surface
A) Ocean surface is the main absorber of solar radiation, but cold
B) The atmosphere gets more energy from sun and surface radiation (34) than from convection (30)
C) Most solar radiation to space comes from cloud (20/30). Air contributes more solar radiation to the satellite (6/30) than the surface (4/30). Use solar window channels to see the surface!
D) Only 6/70 of Earth heat at the satellite comes from the surface. Focus on IR window channels!
EUMETSAT

Jose_93.PNG


Earth Surface
Channel 01 (VIS0.6)
Clouds
High reflectance
11
Sun Glint
Snow
Desert
Bare Soil
Forest
Ocean, Sea
thick clouds
thin clouds over land
thin clouds over ocean
Low reflectance
1 0001 MSG-1 01 31 OCT 03304 113000 06.00 MeIDAS
31 October 2003, 11:30 UTC
EUMETSAT
Meteosat solar channels