Applications of the SEVIRI window channels in the infrared

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SEVIRI CHANNELS

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

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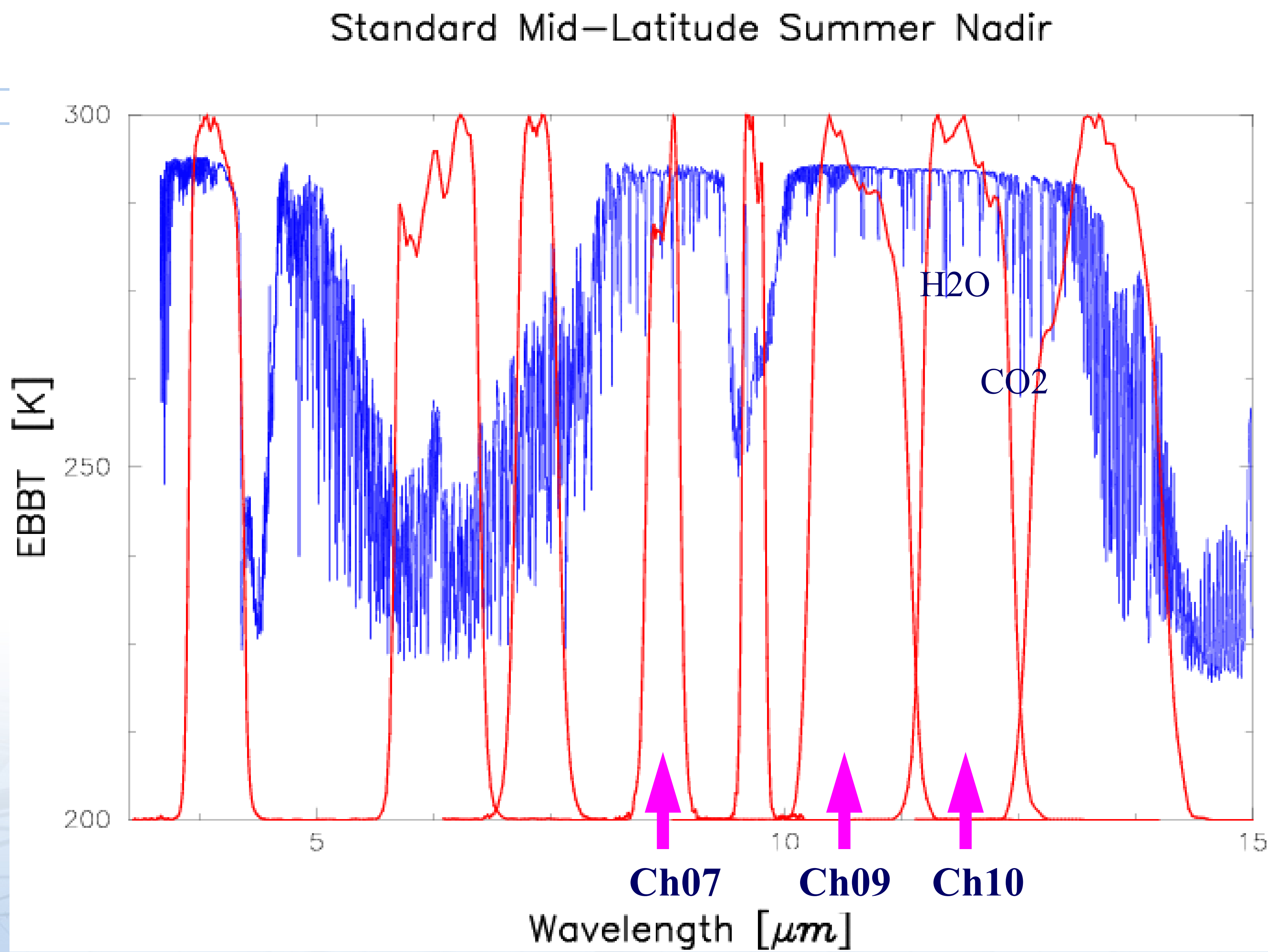
Energy spectrum



Window channels characteristics

- Low absorption by water vapour
- Higher absorption by bigger droplets
- Poorer cloud texture than VIS
- Cloud Top Height and Sea Surface Temperature
  - Land is a gray body (emissivity < 1)
  - Cloud emissivity increasing with drop size
  - Thin cloud looks warmer (semitransparency) than thick cloud
  - Skin (a few microns thick) is neither bulk nor air temperature
- Coastlines (especially summer and winter)
- Cirrus well depicted: higher cloud opacity than in visible channels

Lesson objectives

❖Learn which are the window channels in the infrared portion of SEVIRI

❖Review the general characteristics of window channels

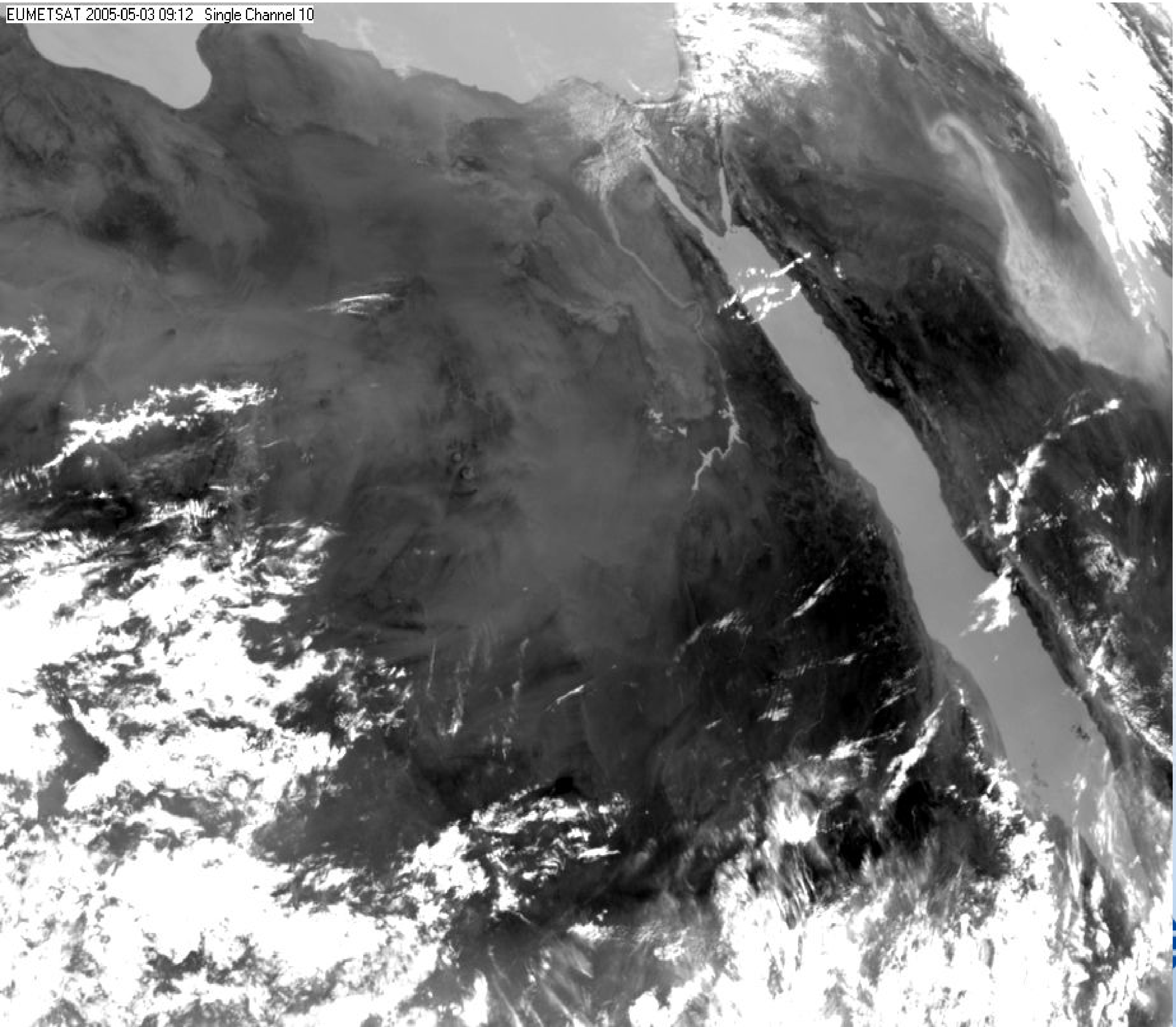
❖Understand the behaviour of channels at 8.7, 10.8 and 12.0µm for different ground surfaces and cloud types

❖Practice and exercise on scene identification through window channel differences, like 10.8 – 12.0µm

❖Review the concept of semi-transparency

❖Becoming aware of applications to precipitation, sea surface temperature and ash monitoring

Channels at 8.7, 10.8 and 12.0 µm

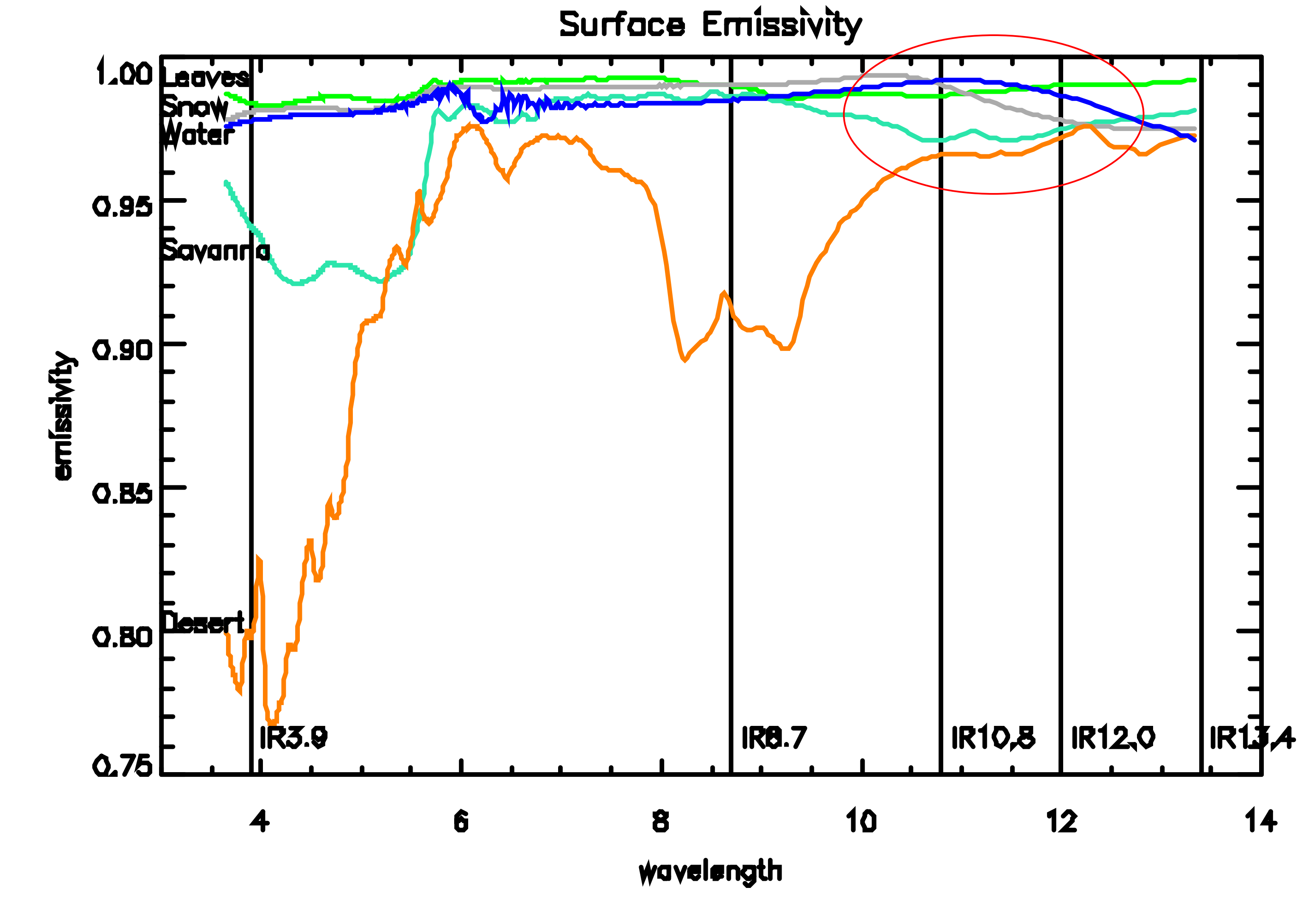


Channel 7

Channel 9

Channel10

Surface properties



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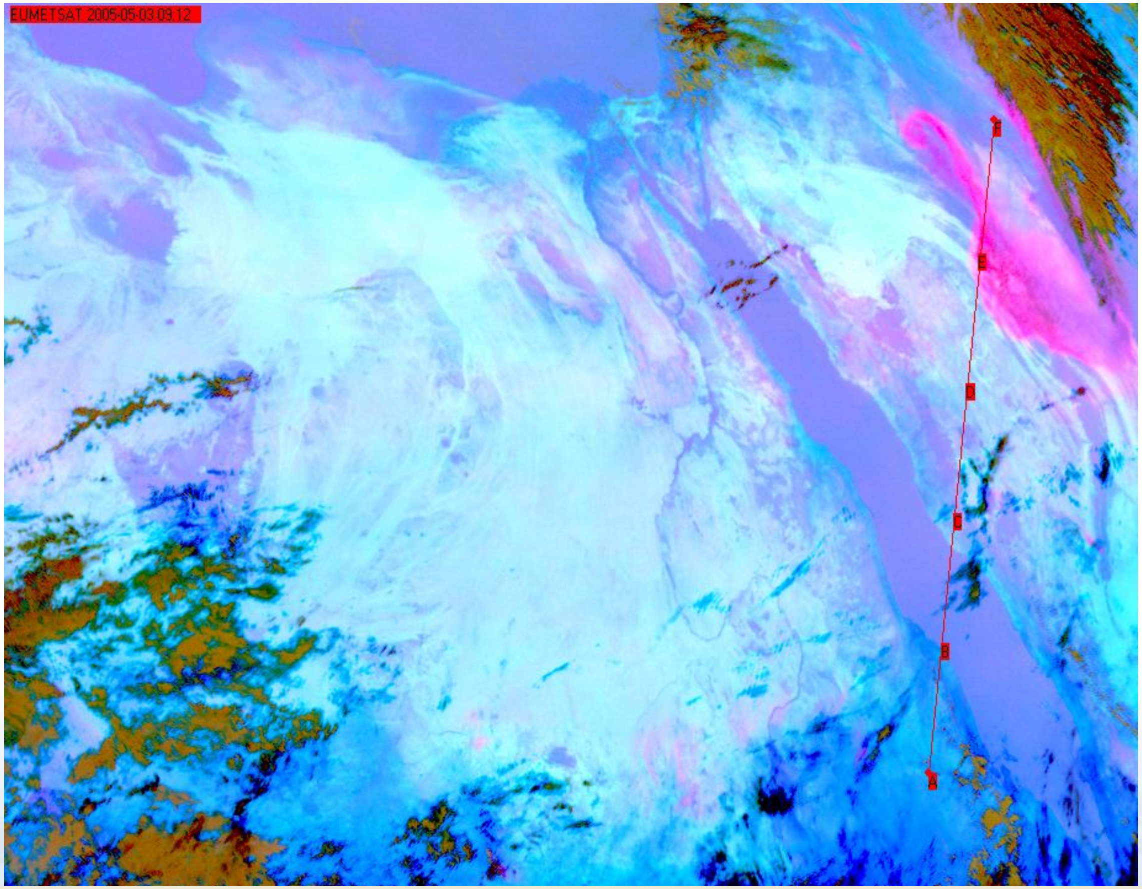
Compositing 8.7, 10.8 and 12.0 µm

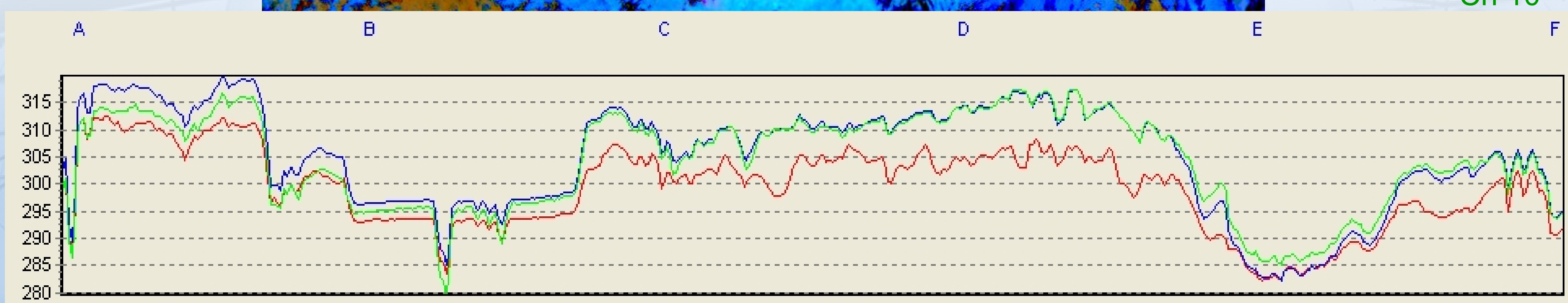
Dust composite



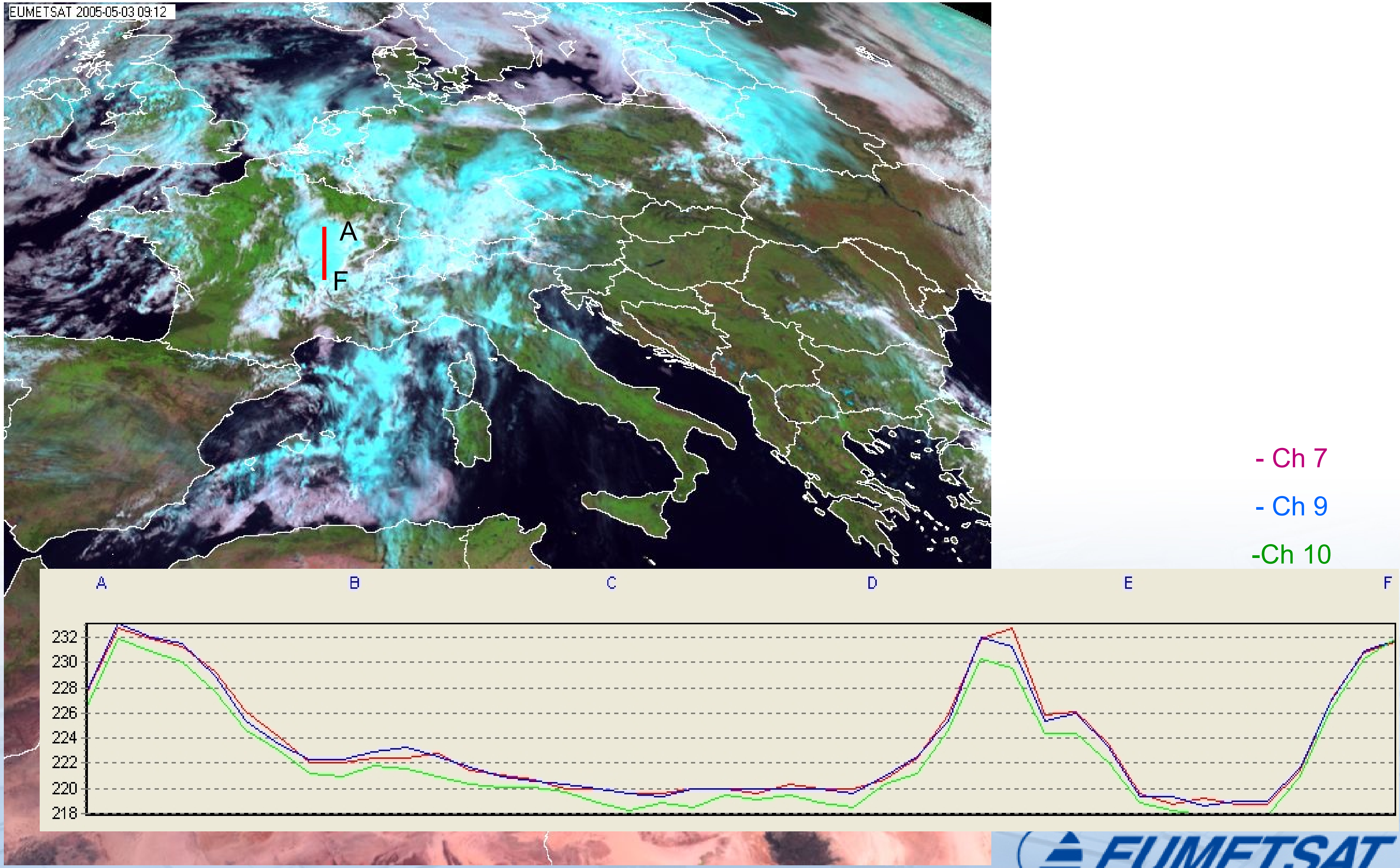
- Ch 7

- Ch 9

-Ch 10



Channel comparison on ice cloud

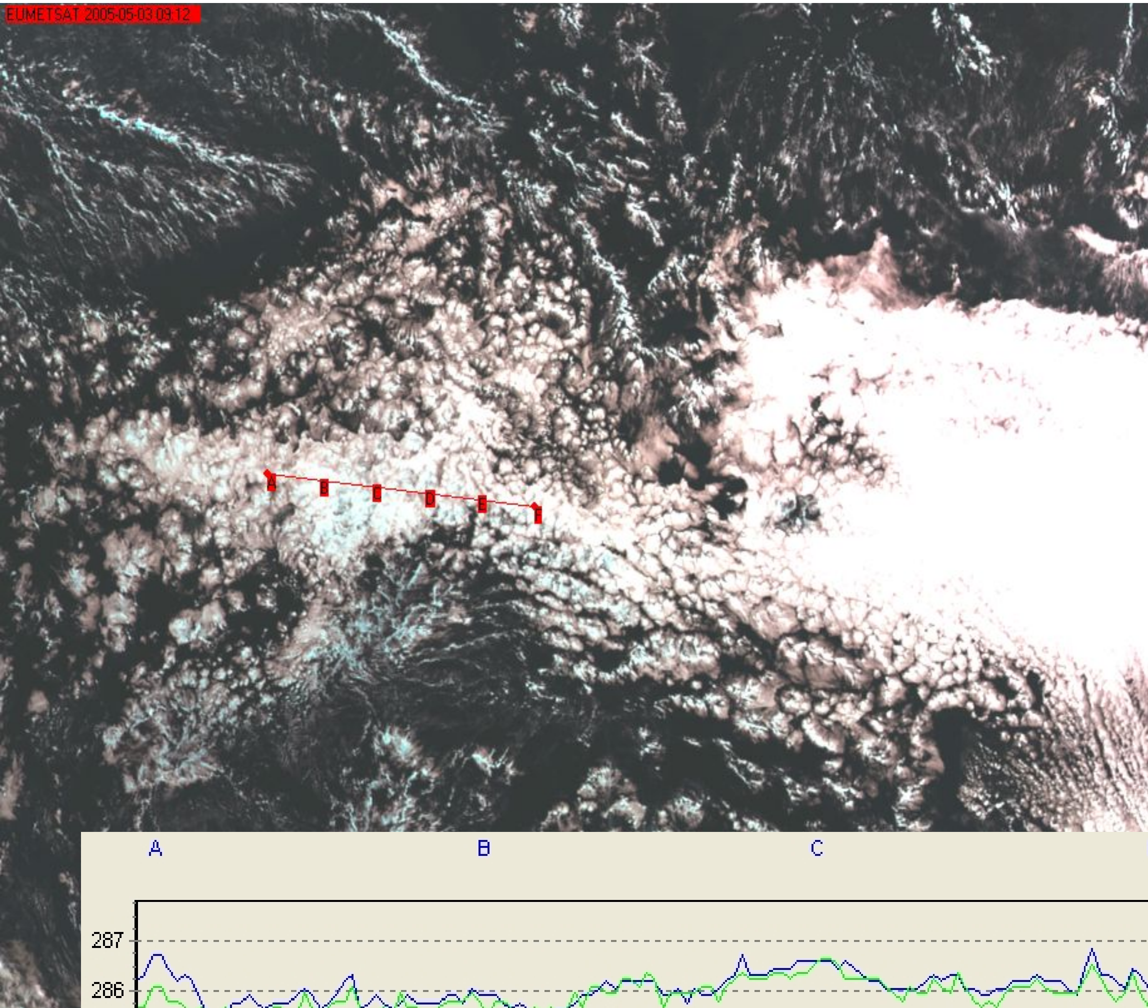


- Ch 7

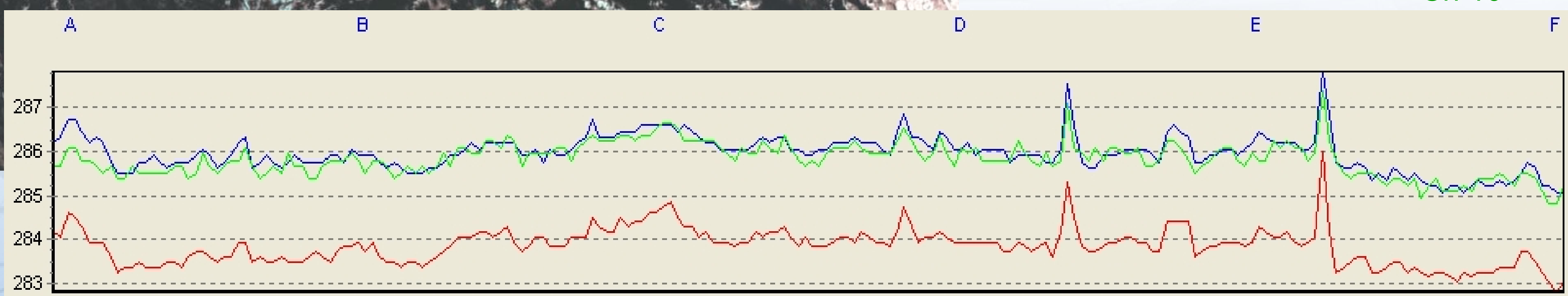
- Ch 9

-Ch 10

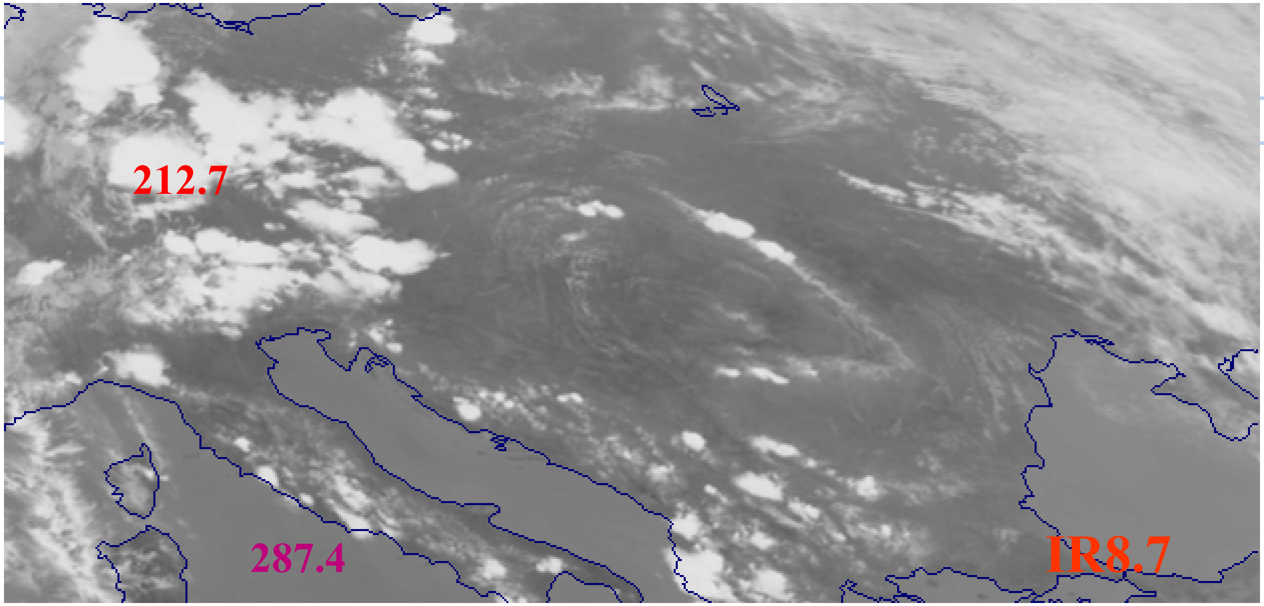
Channel comparison on water cloud



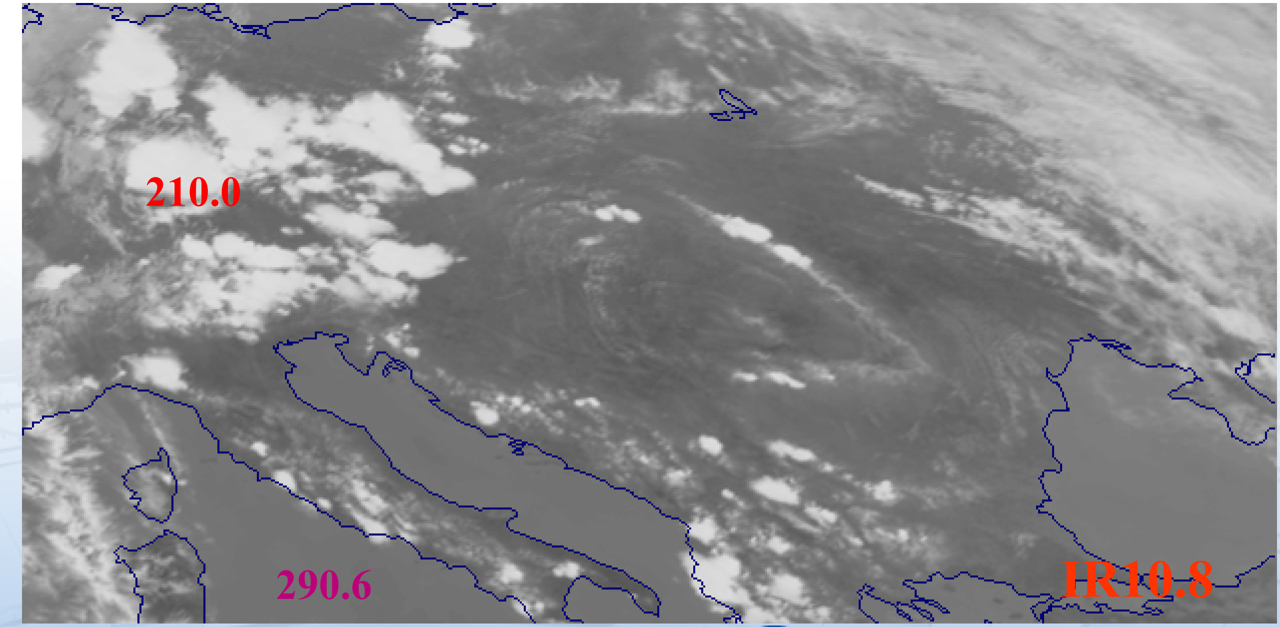
- Ch 7
- Ch 9
-Ch 10



Ice Cloud:
Stronger signal in IR8.7 because of higher emissivity



Cloud free ocean:
Weaker signal in IR8.7 because of water vapour absorption



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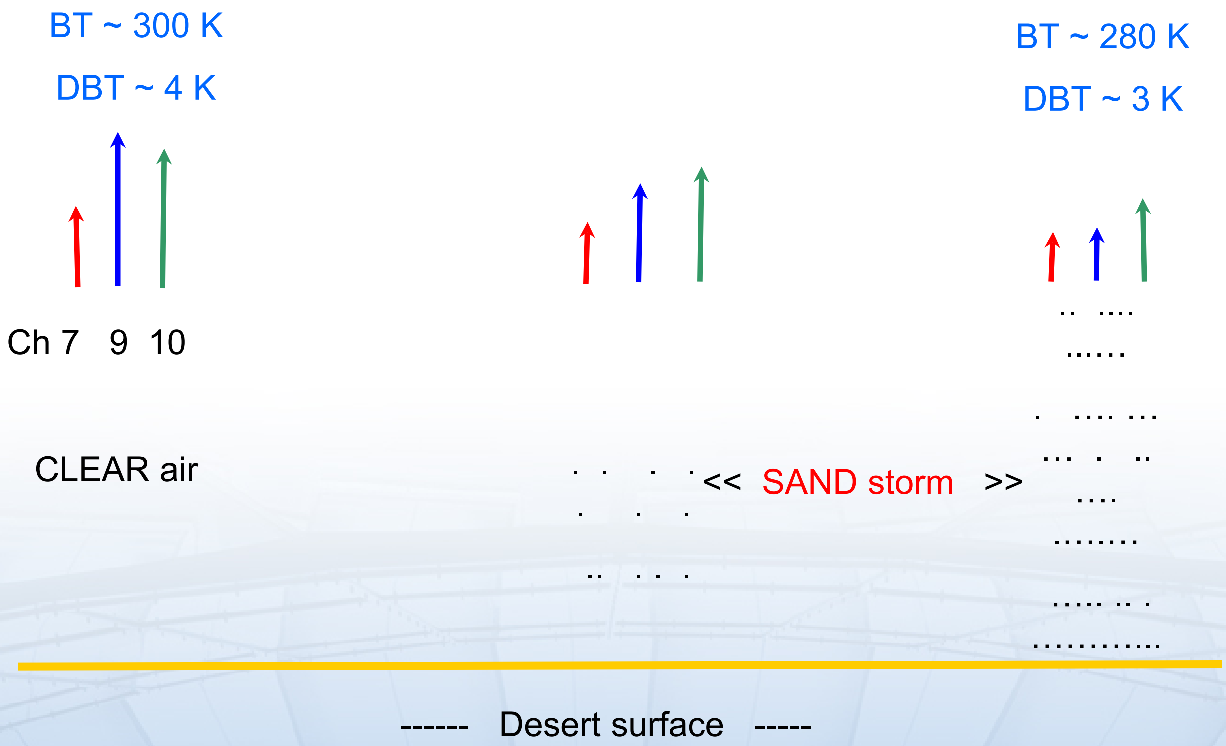
Differences for sand storms

(Sahara) sand absorbs most at 10.8 µm



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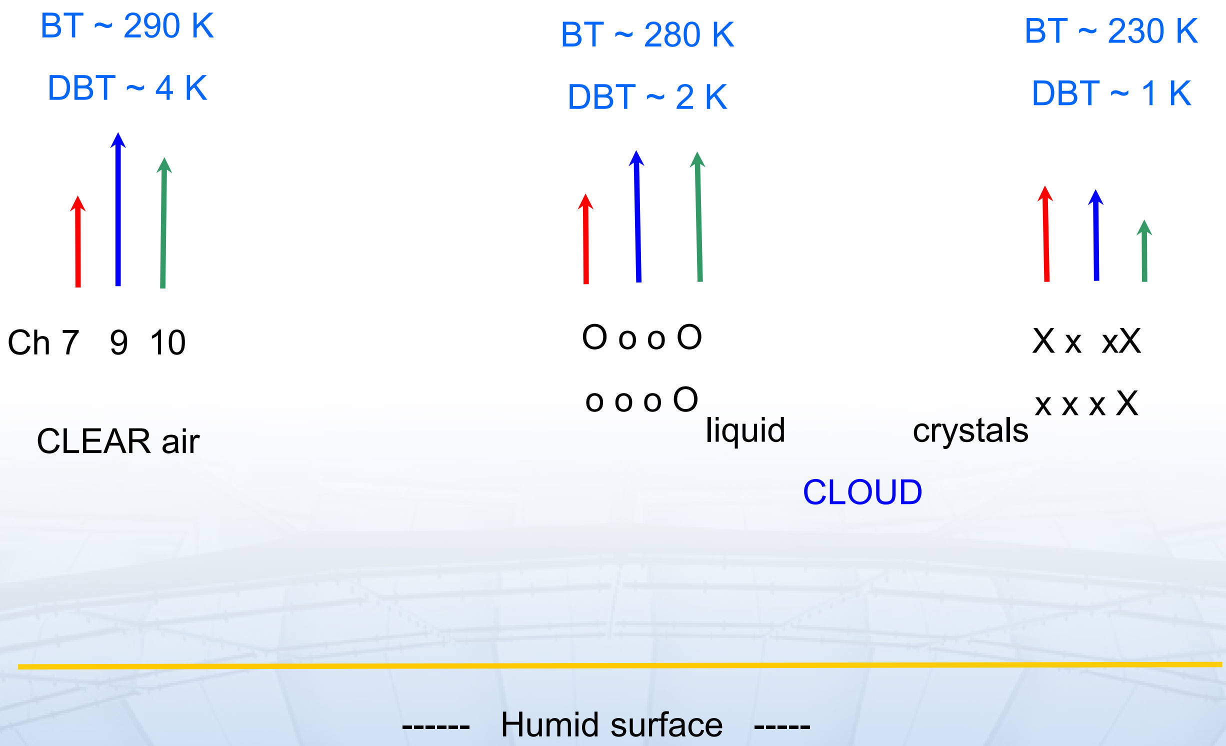
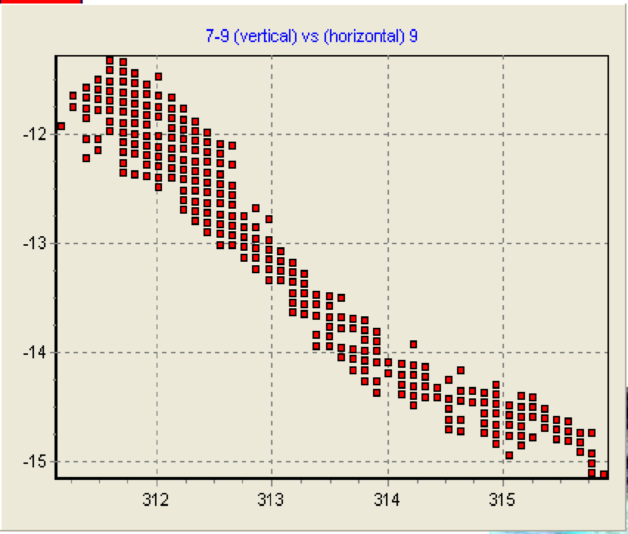
Differences for cloud

Channel difference 8.7µm-12.0 µm is an ice-cloud index



The 7-9 difference



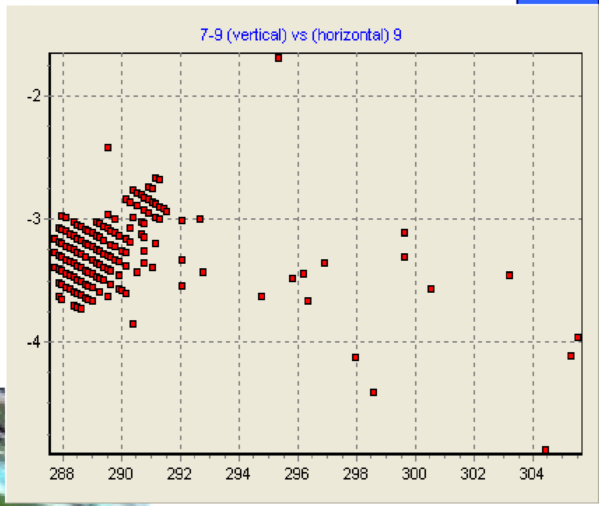
5 June 2003 12:00

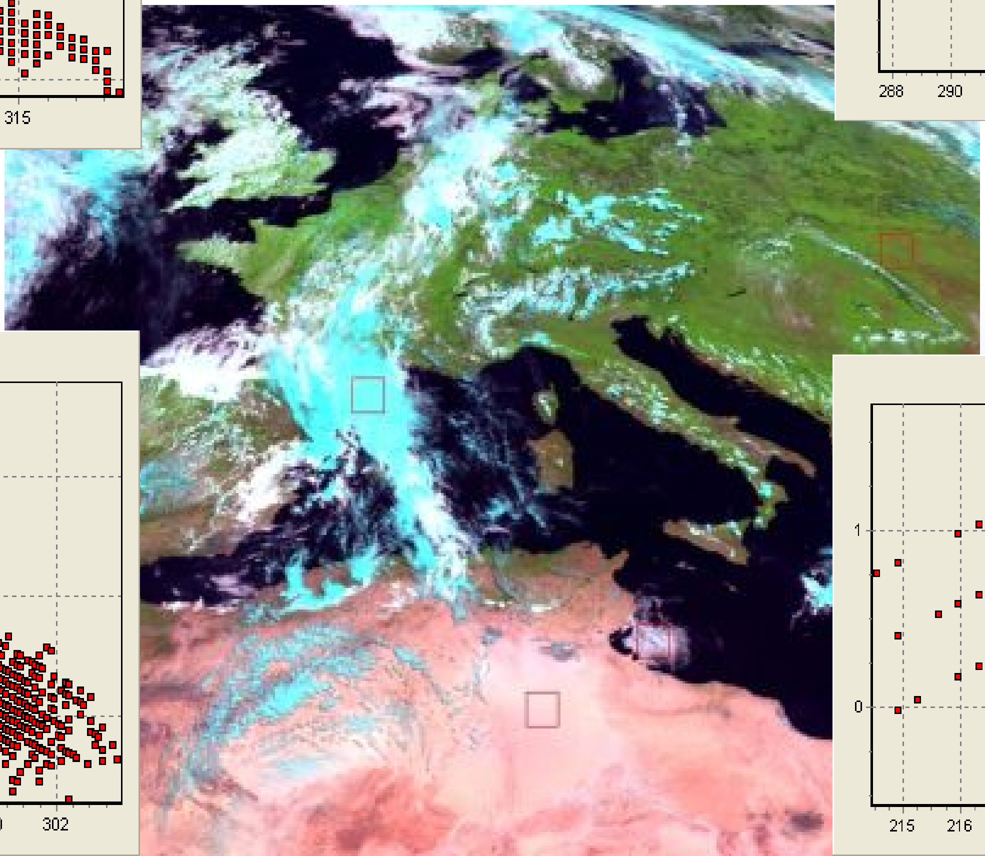
Liquid cloud gulf of Sirte

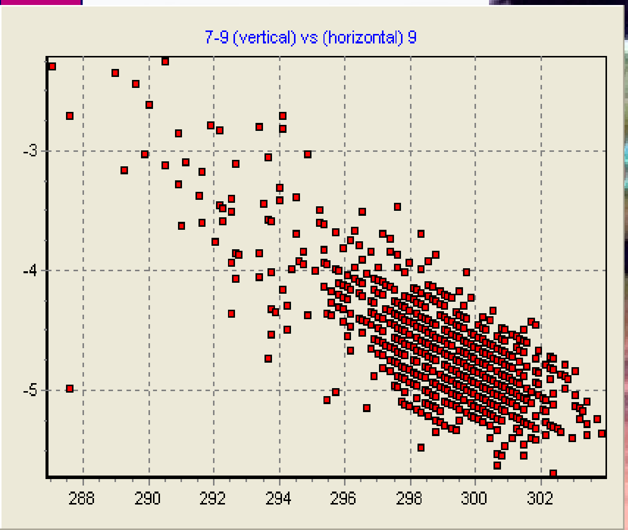
Ice cloud over Pyrenees

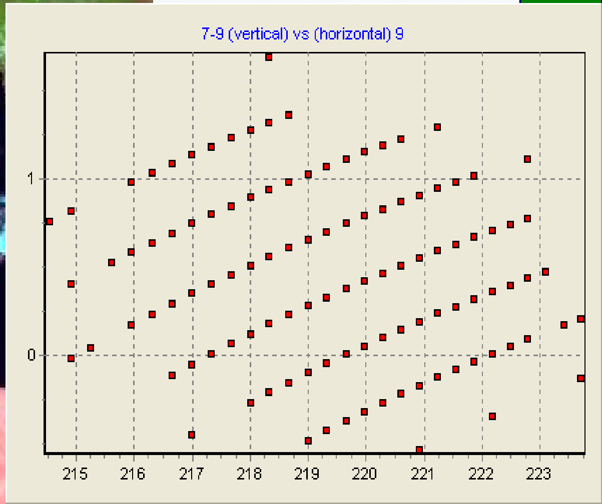
Clear over grass

Clear desert





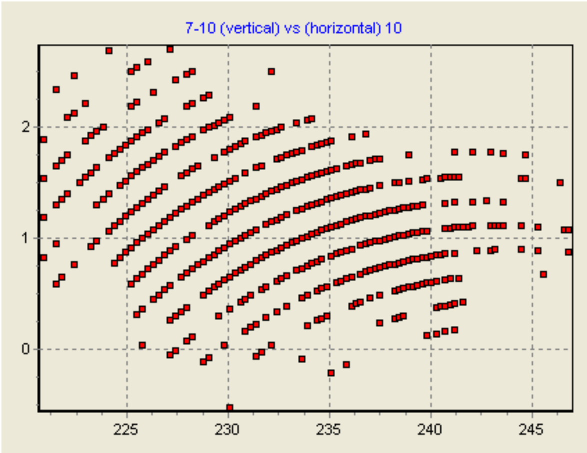


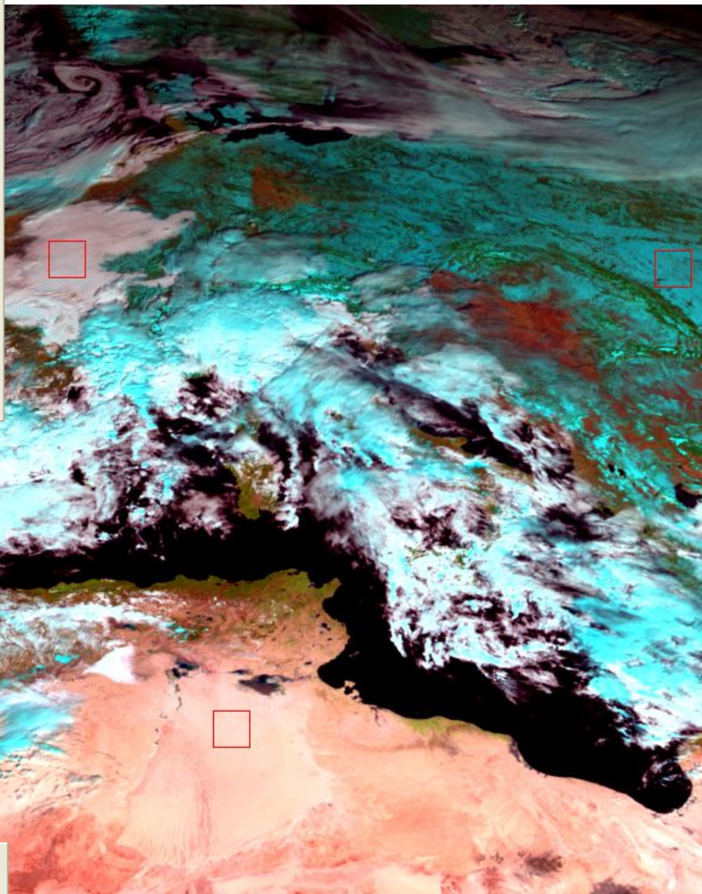


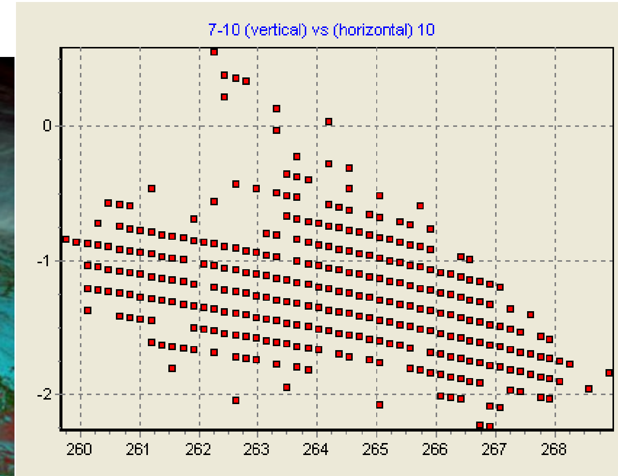
The 7-10 difference

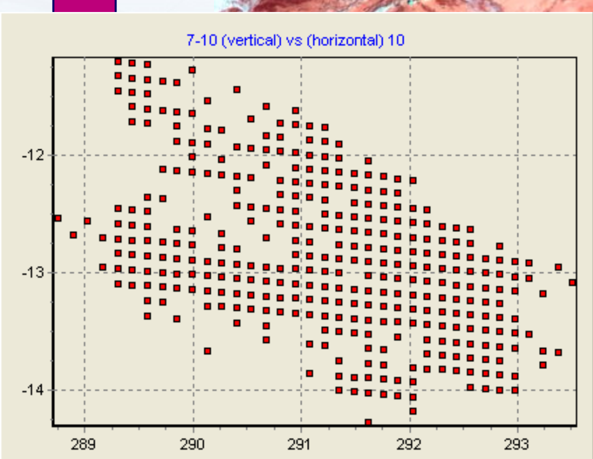
27 January 2006 11:00

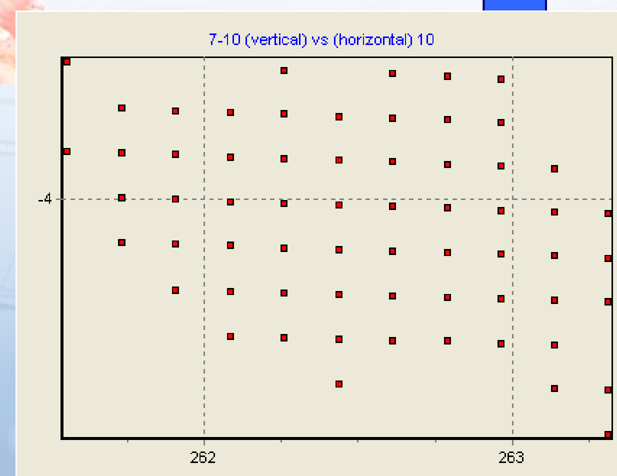
(cold and cloudy)











Fog over France

Thick cloud over Iberia

Clear desert over Libya

Snow Ukraine

Absorption in the window channels

Absorption \ Channel	*8.7µm*	*10.8 µm*	*12.0 µm*
Water vapour absorption	-3K	-1K	-2K
Cloud absorption (liquid), n'	4%	8%	19%
Cloud absorption (ice), n'	4%	19%	42%
Desert/clay emissivity	85%	96%	98%
Ocean emissivity	Similar in all (99%+)		

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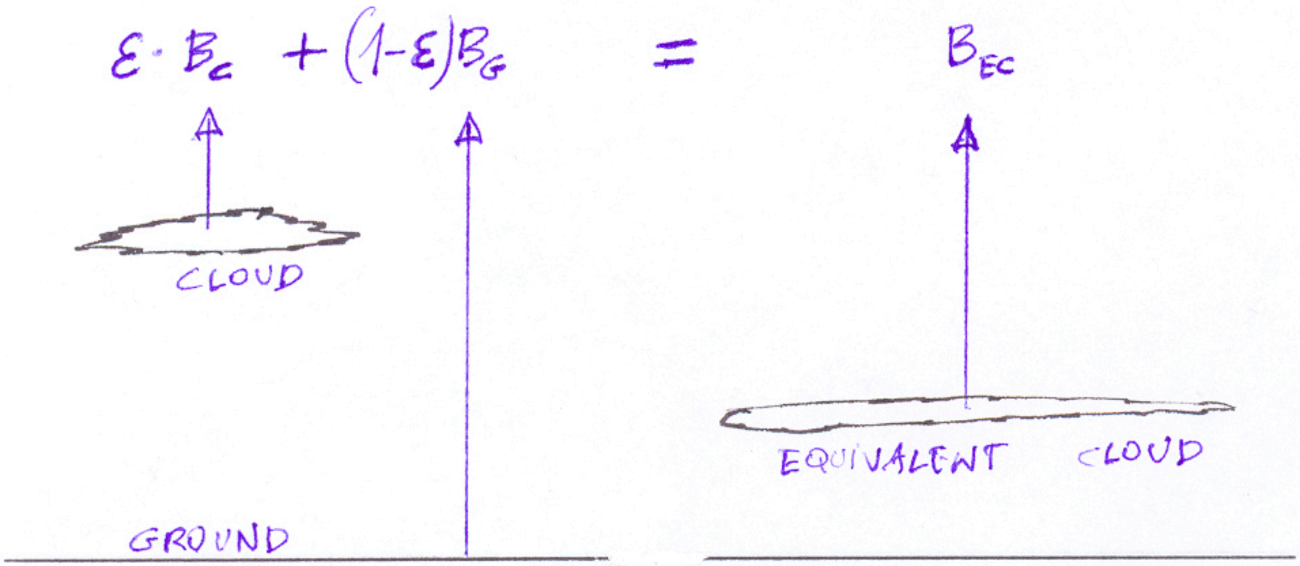
Semi-transparency



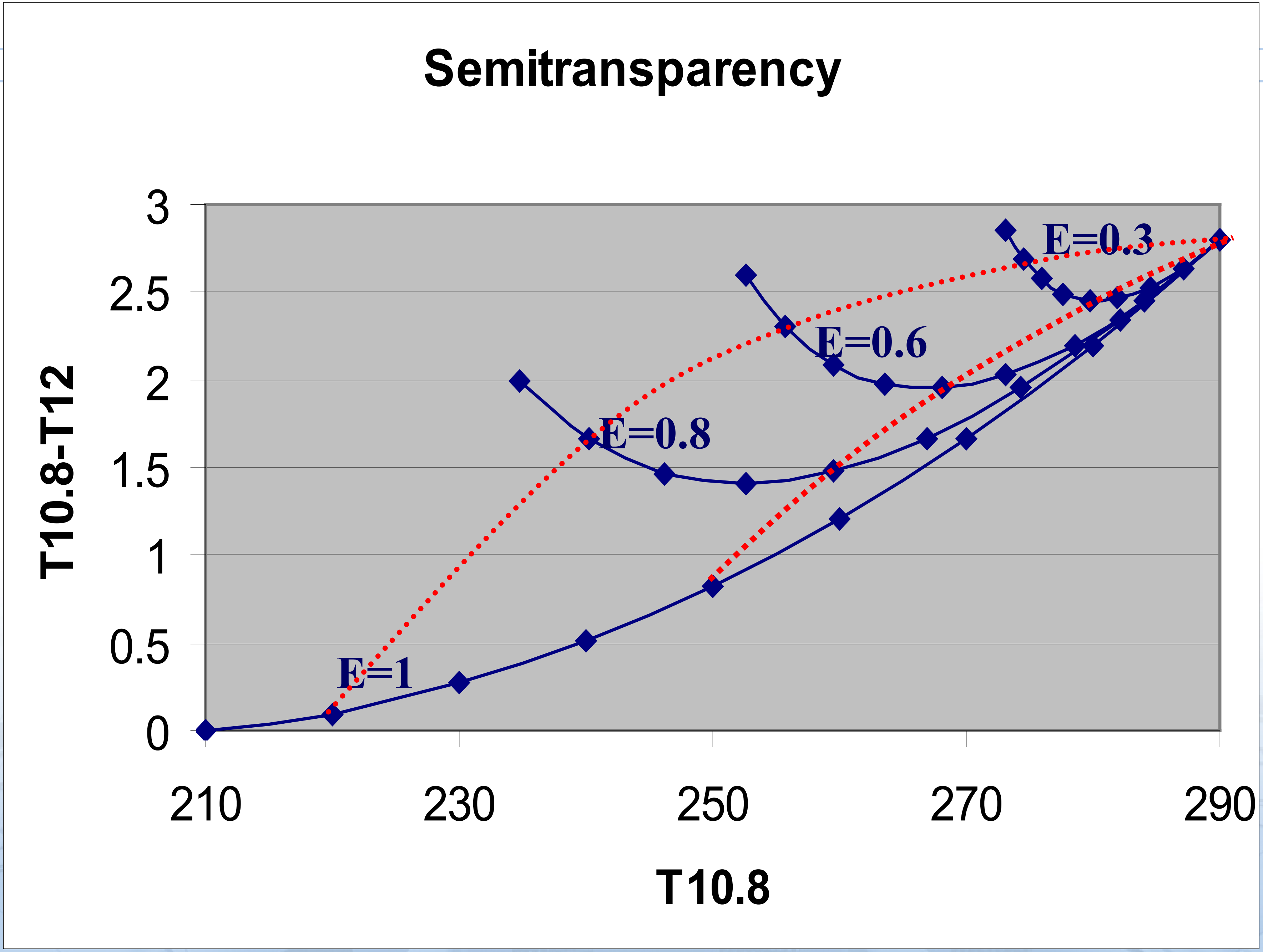
- E*Tc + (1-E)*Tg < BT WARM BIAS!

- Thin cloud pixels provide two contributions: cloud and ground, with a bias towards the warm source.

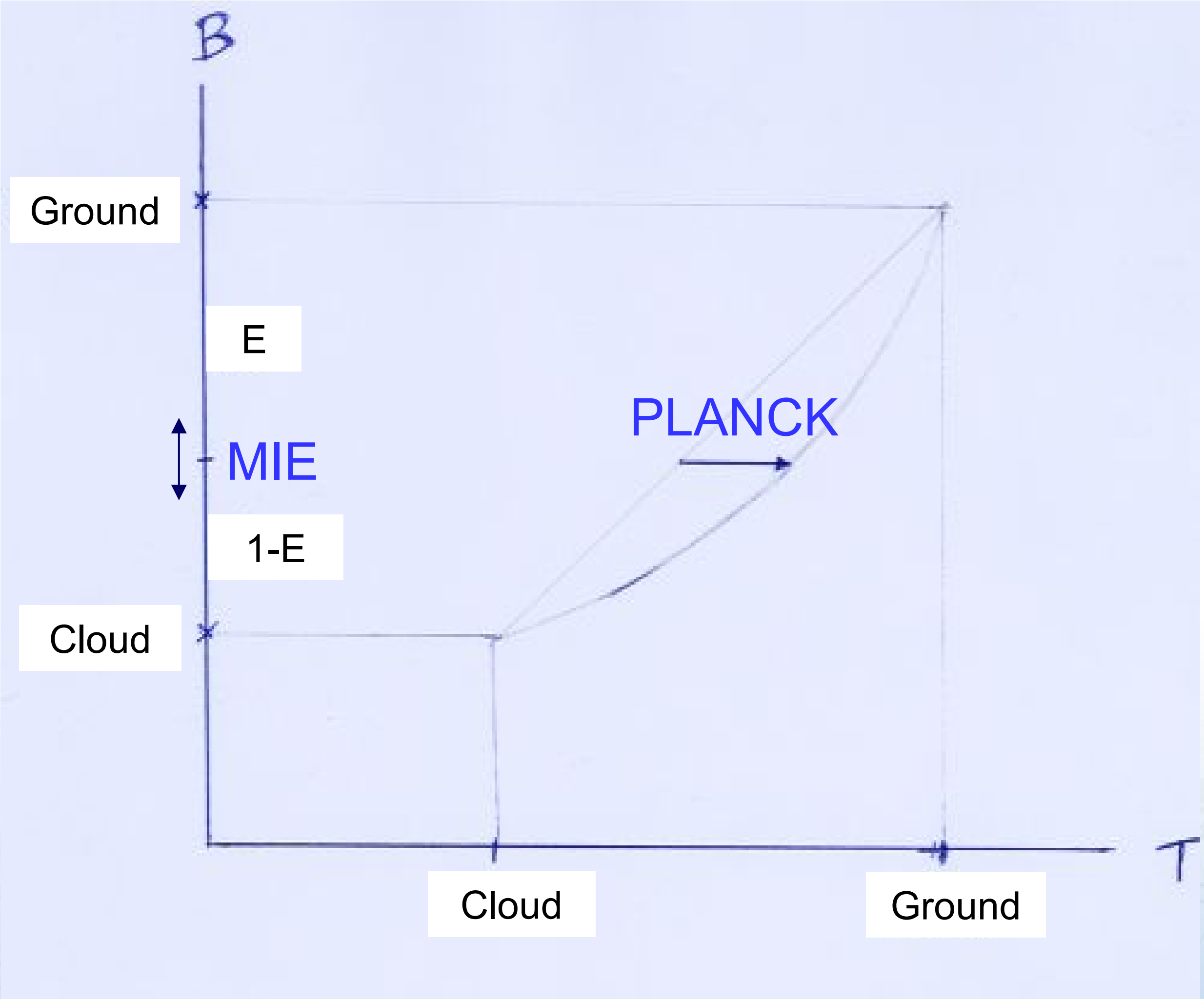
- The bias is weaker with increasing wavelength: flatter Planck response, lower S

- The bias grows with cloud height

Assume the same cloud emissivity in both channels: semitransparency effect



Transparency: Mie and Planck



Additional variation if different emissivities at the two channels

Planck dependencies: wavelength and temperature

1% temperature change results in a S% increase in the energy count:

S ~ 14400 / Wavelength (µm) / Temperature (K))

- *S=14% at 3.9µm and scene temperature of 260 K*
- *S ~ 4% for a warm scene at the split window*
- *Radiation = Temperature raised to the S-th power: R ~ T ^ S*

- *Inside a pixel,* S determines the *bias* towards the warm part of the signal
- Bigger bias for lower temperatures ⇒

Fire onset is better detected than its progress.

Cloud dissipation is better detected than cloud growth.

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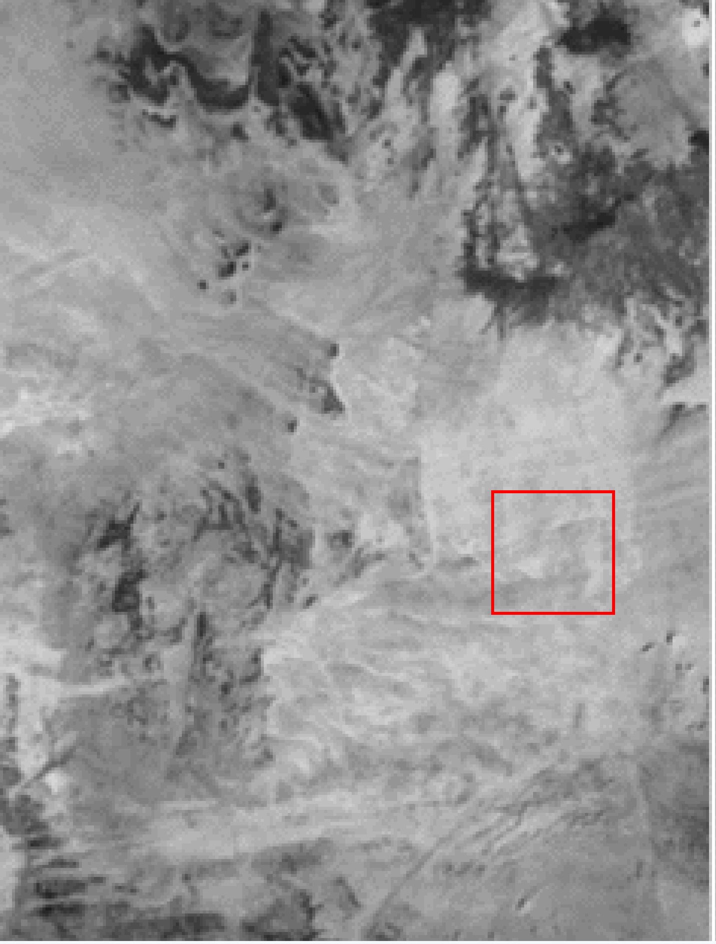
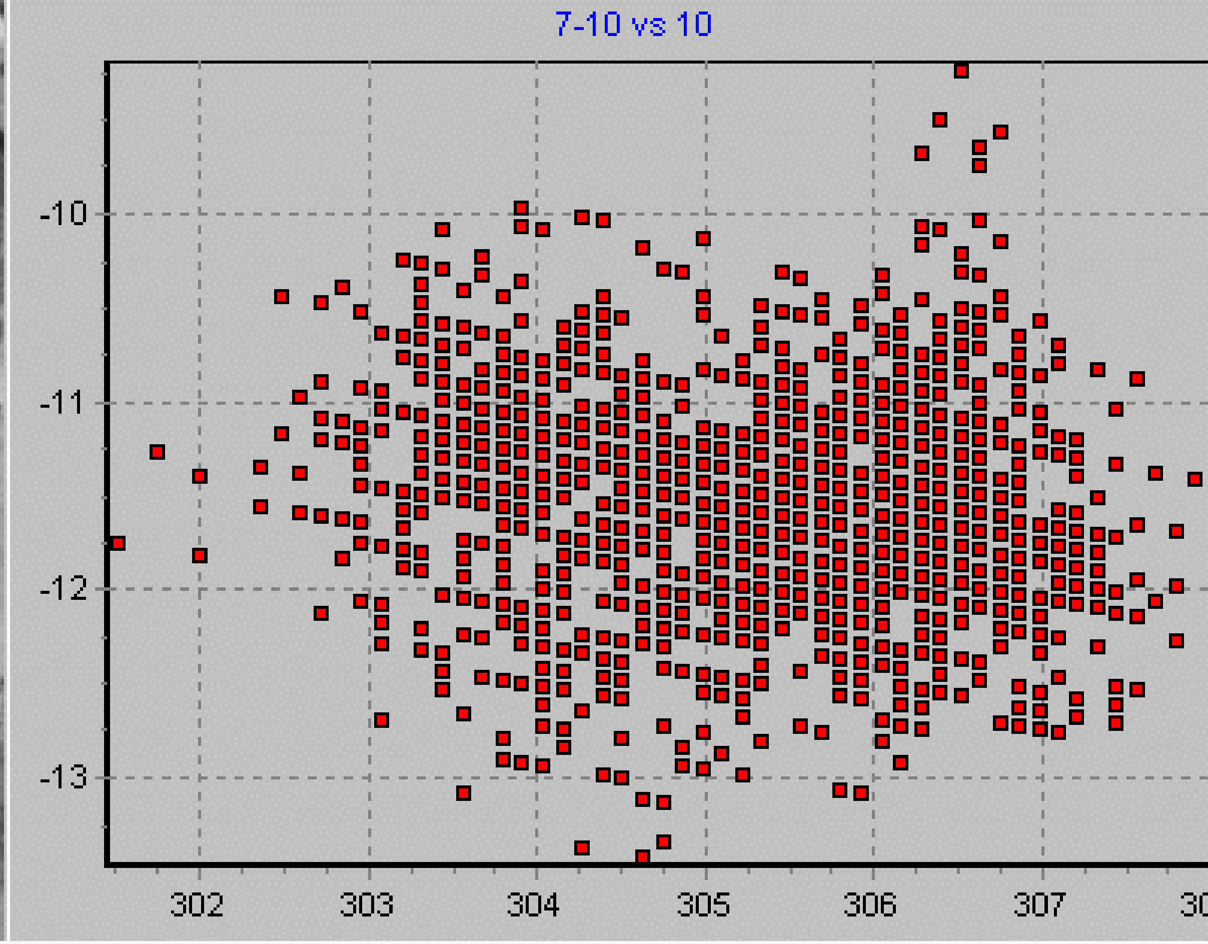
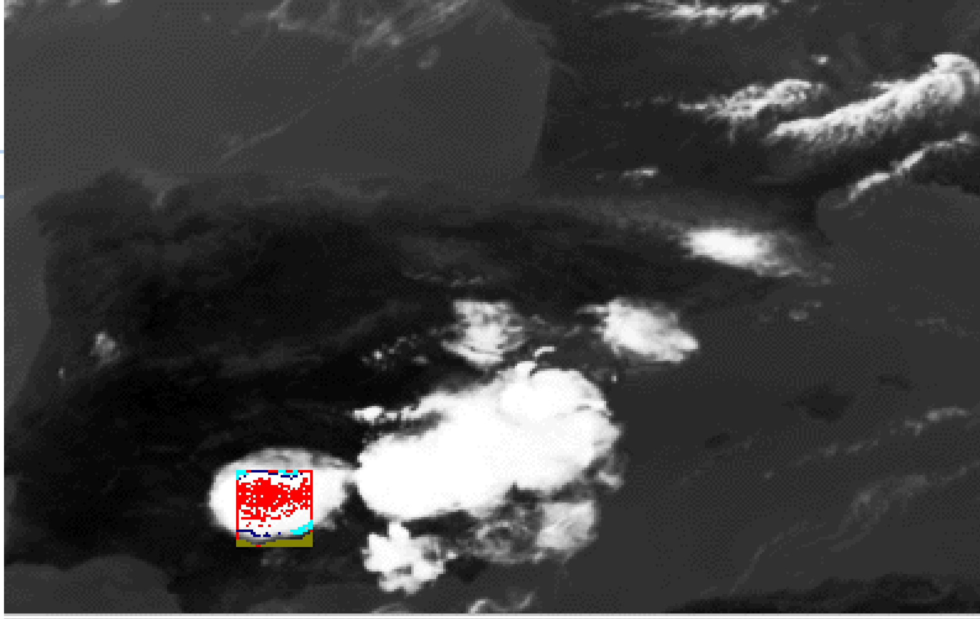


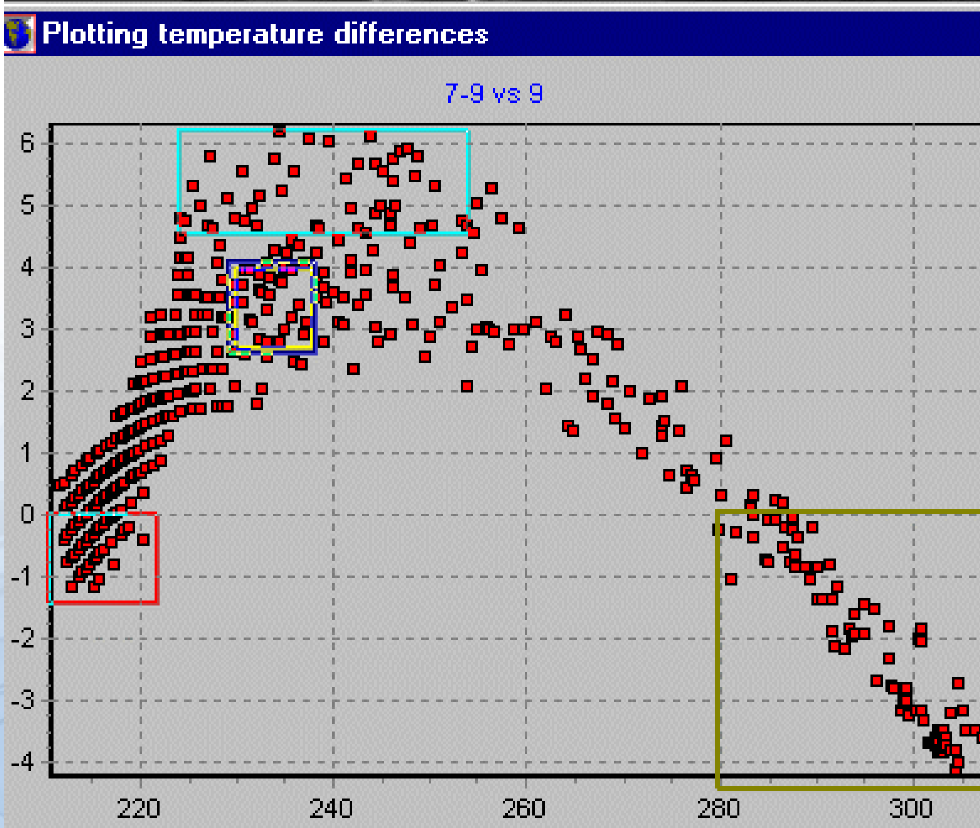


S (sensitivity) in channel 8.7µm and 305K is 5.3

Emissivity estimate: 1.0 -11.5/305 *S =0.8 for that desert.

The difference Ch7 - Ch9





Water cloud ~ -3K

Ice cloud ~ 0K

Snow ~ -3K   (water vapour)

Cloud boundaries < 6K

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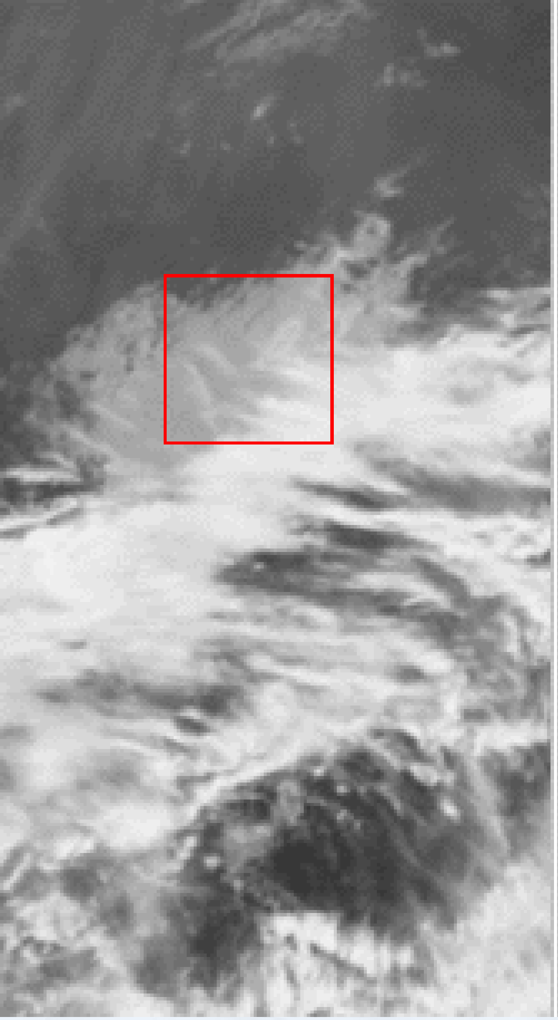
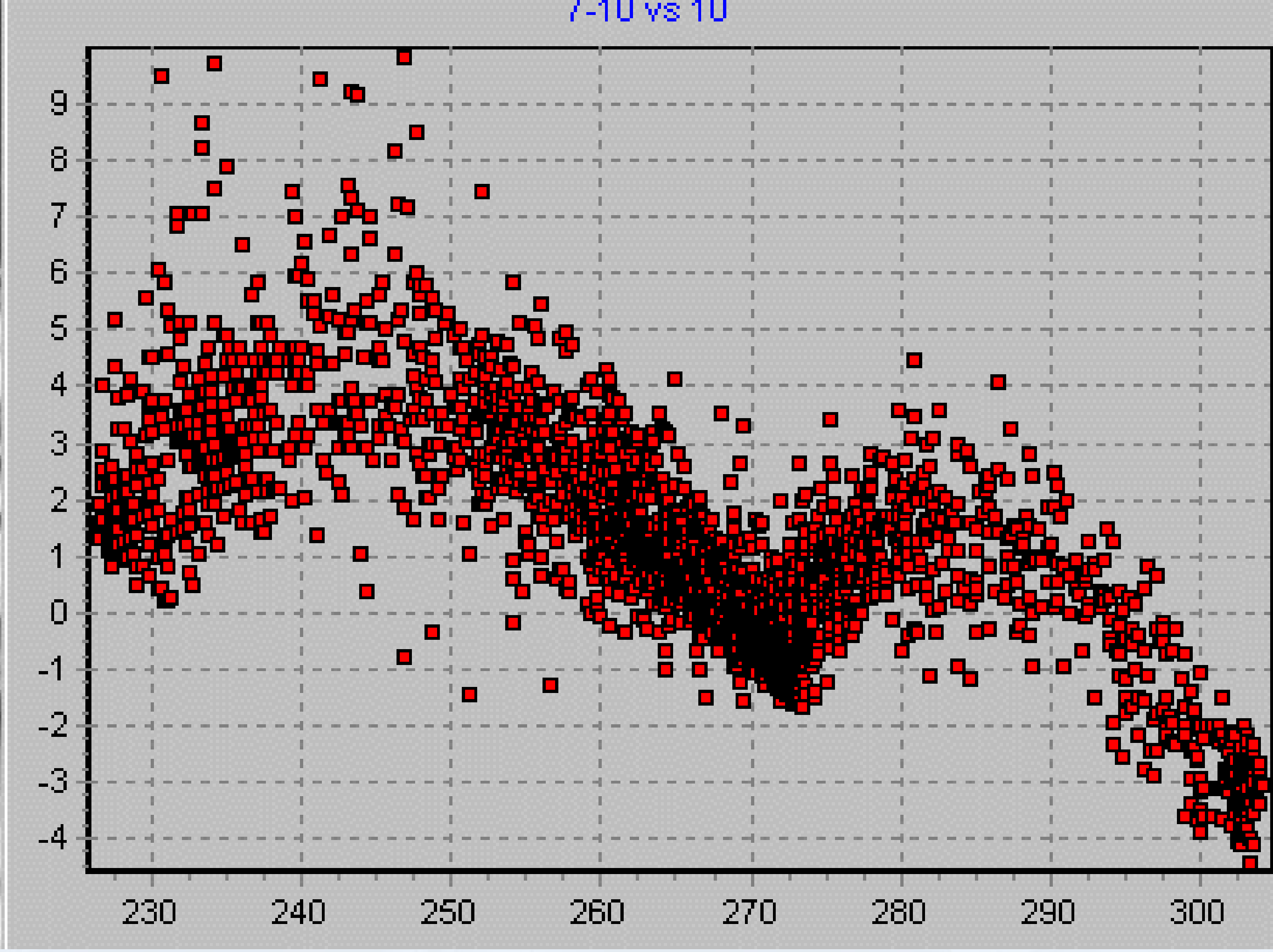
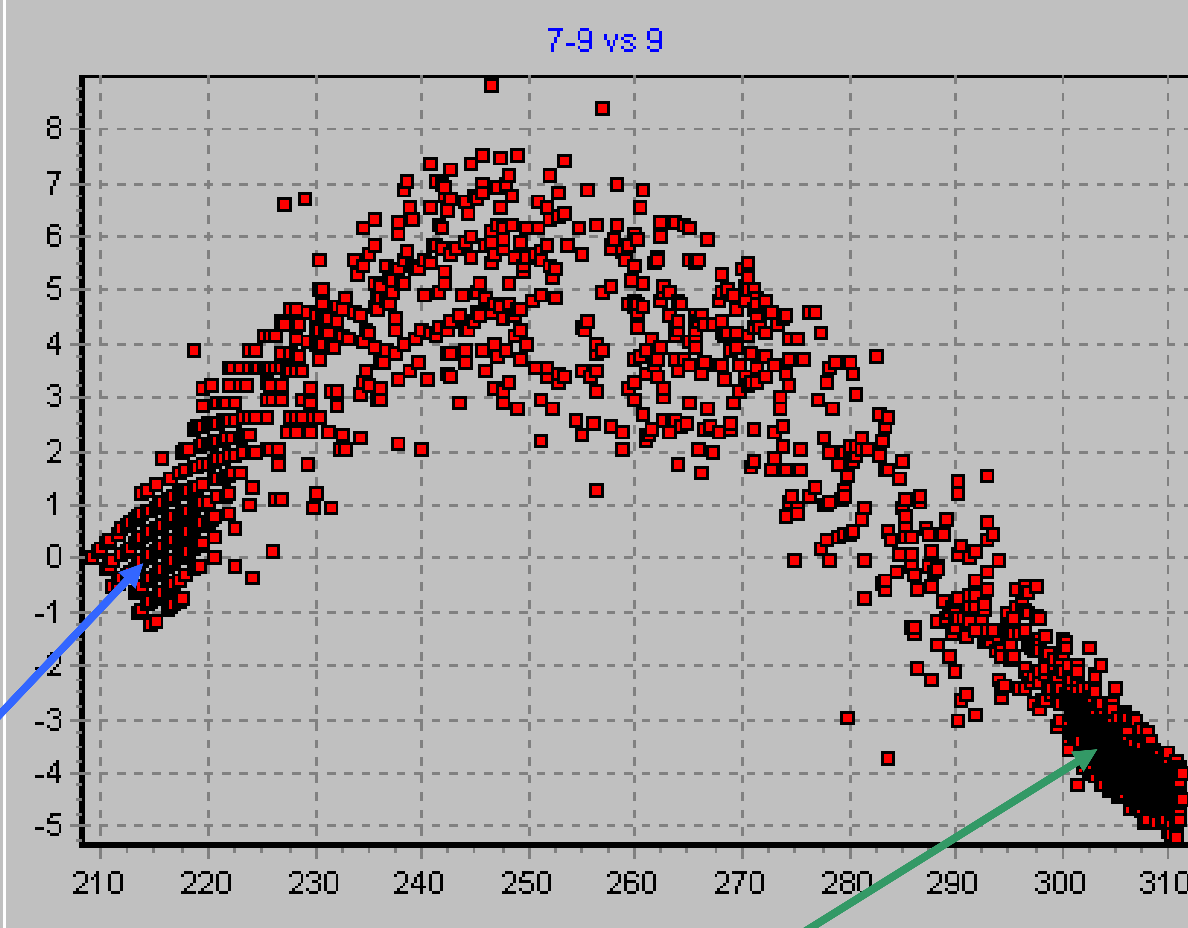




Ch9 17-Feb-03 midday over desert

- ❖Several arcs indicate multilayered cloud
- ❖Pixels with a mixture of scenes show in the highest part of the arcs



MSG Channel HRV, 16:00

Semitransparent cloud shows higher difference (in ch7-ch9 or ch9-ch10) than opaque cloud (left hand side of graph) or ground (right hand side of graph)

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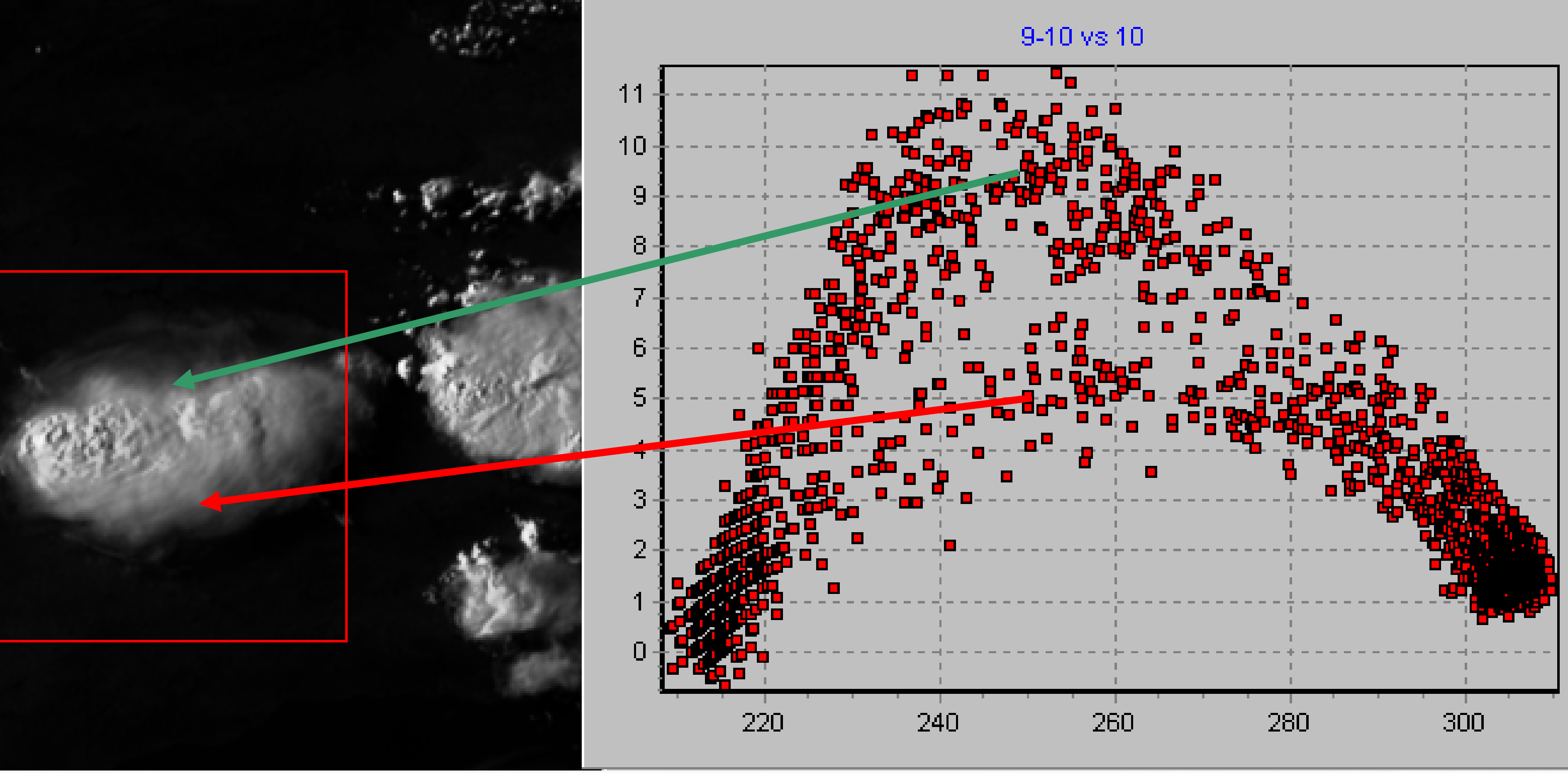

MSG Channel 12, 16:00

The difference Ch9 – Ch10

❖Semitransparent cloud shows higher difference (ch9-ch10) than in (ch7-ch9)

❖Double arch: southern boundary is lower in height

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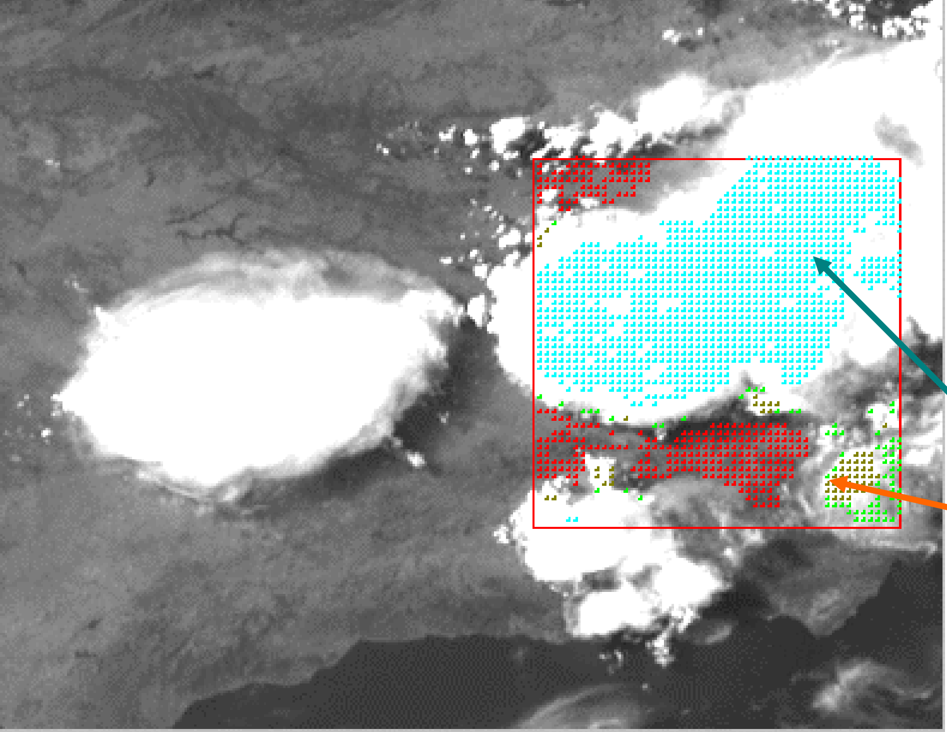
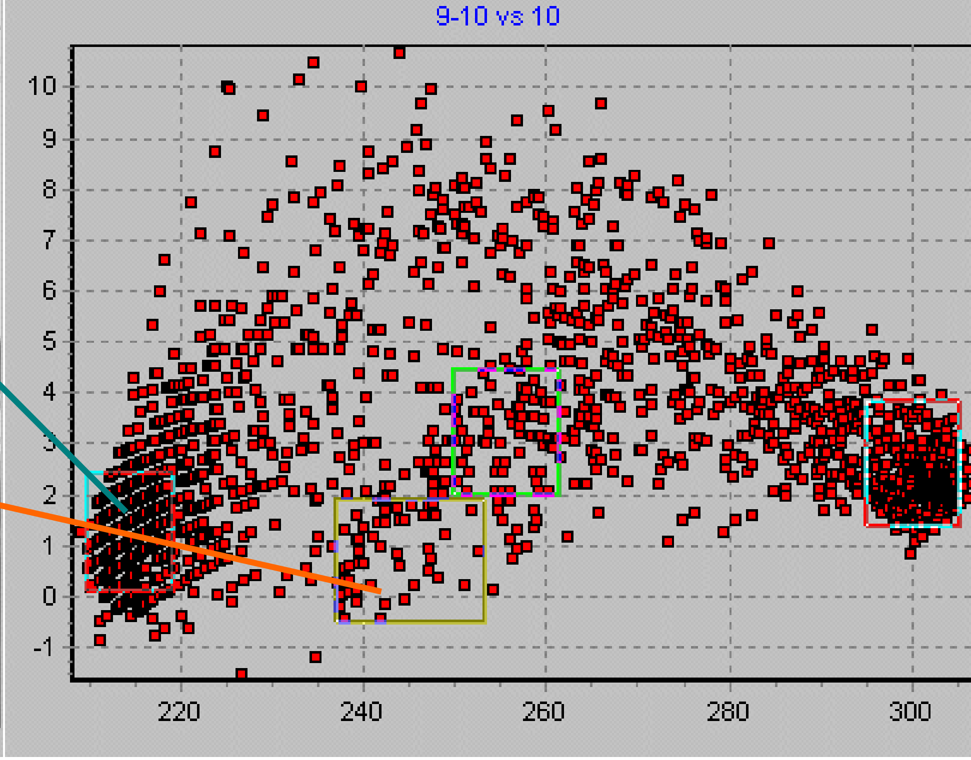
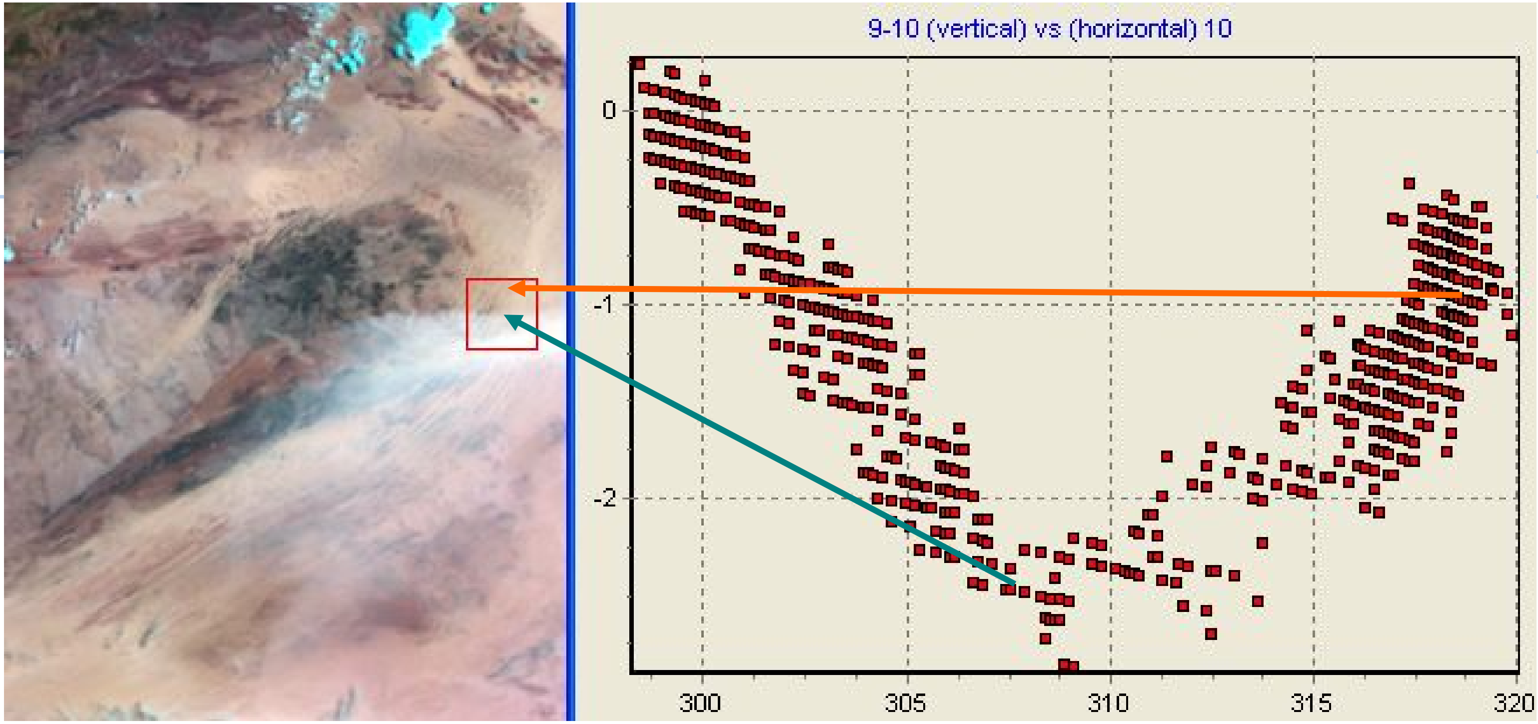




MSG Channel 12, 16:00

- ❖ Double arc marks two cloud levels: arc height is cloud height
- ❖ Occasional negative difference in 9-10 due to small ice particles



MSG Natural RGB, 4-July-2003 10:00 UTC

- 10.8µm is more absorbed and backscattered by sand than 12.0µm
- For sand or ash, reversed arc for the semitransparent pixels

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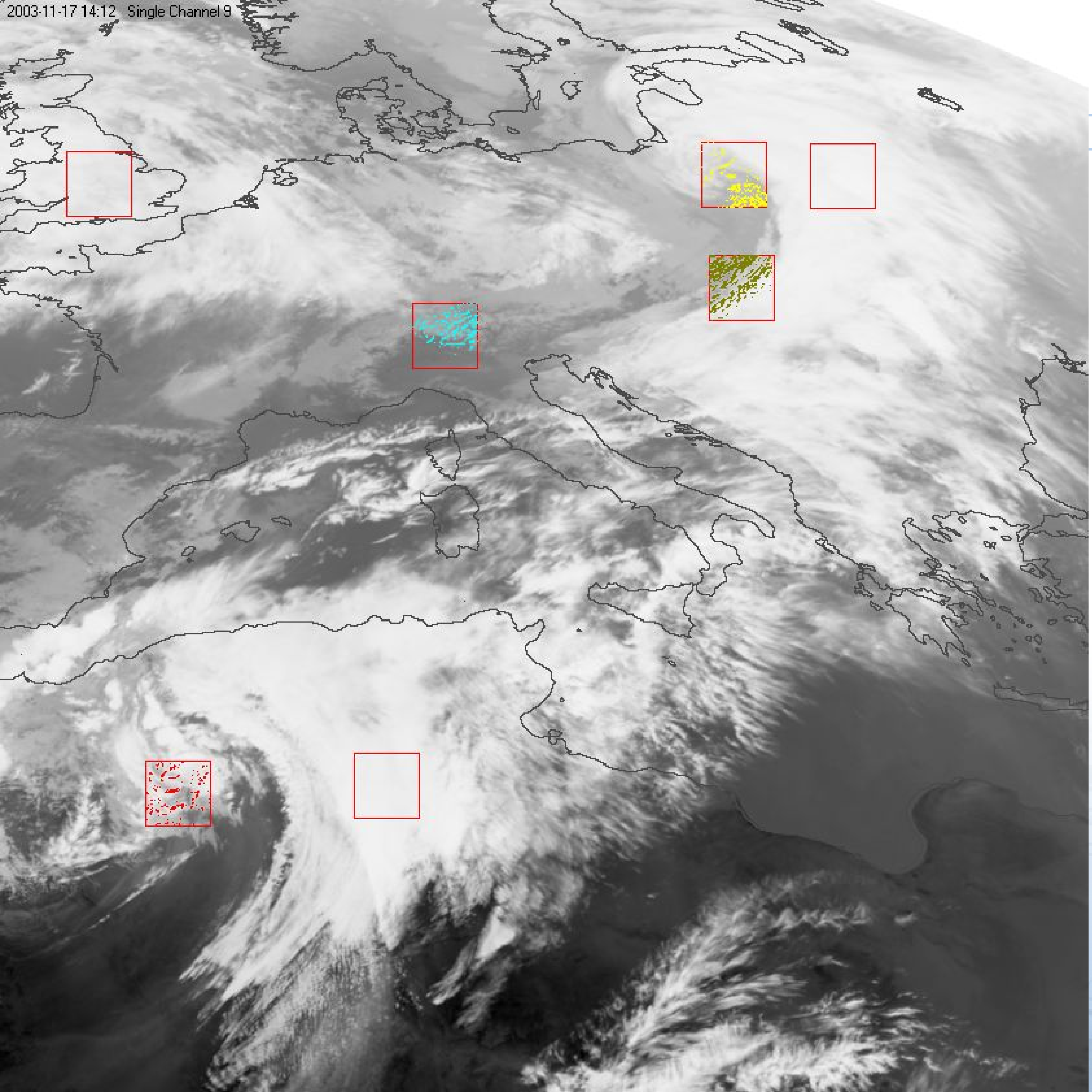

Negative ch9-ch10:

- ❖ Thermal inversions in humid valleys
- ❖ Dust cloud
- ❖ Ash silicates

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The difference 10.8 µm -12.0 µm

is slightly negative > -2K for:

- ❖ desert or clay surfaces under dry air
- ❖ dust cloud

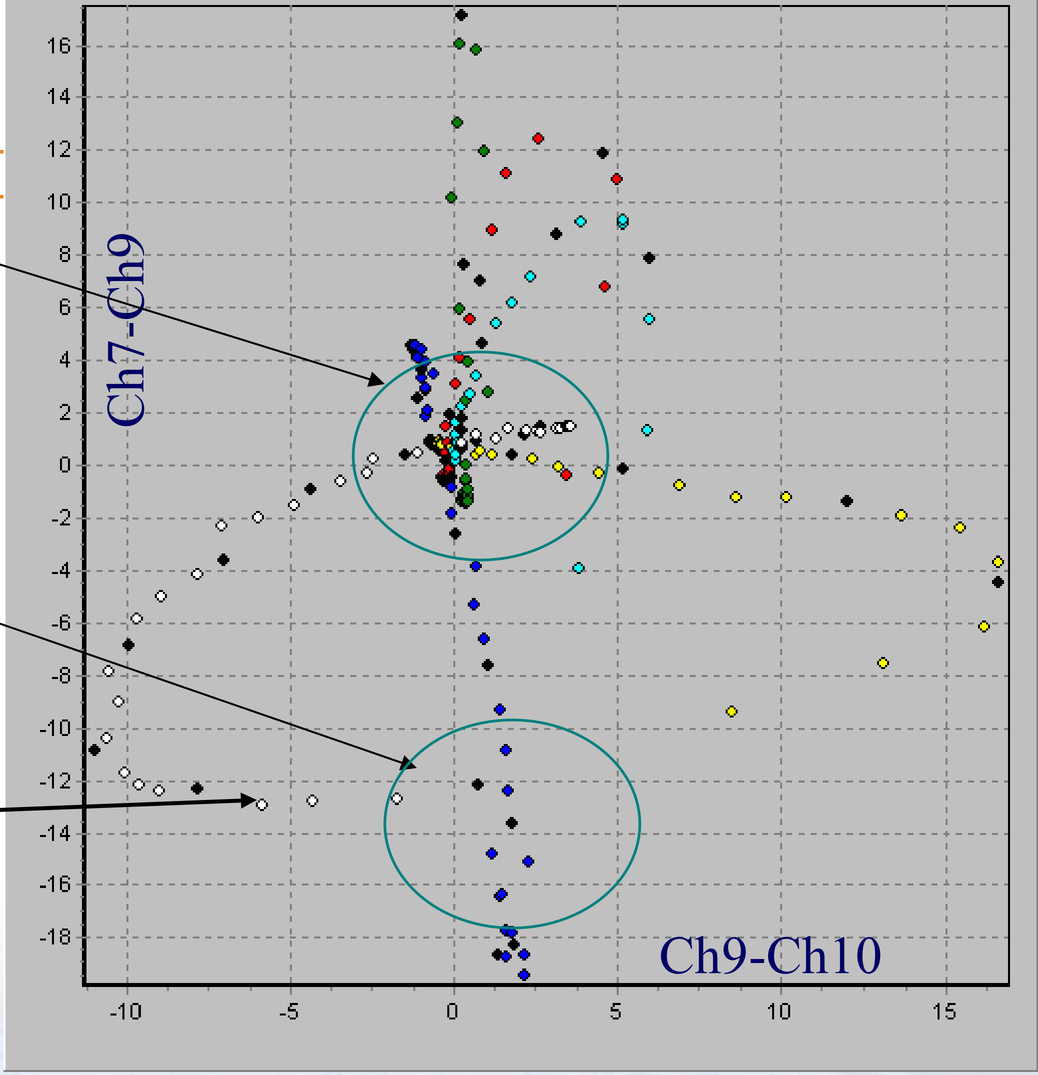
is positive < 15K for:

- ❖ ocean ~ 2K
- ❖ cloud or thin cloud

Thick cloud

Thin cloud

(over sandy ground)



○○○ very small ice particles

→ very small droplets

→ small ice particles

→ small droplets

→ big droplets

→ big ice particles

- Type of particles for thin cloud
- Difficult discrimination for thick cloud

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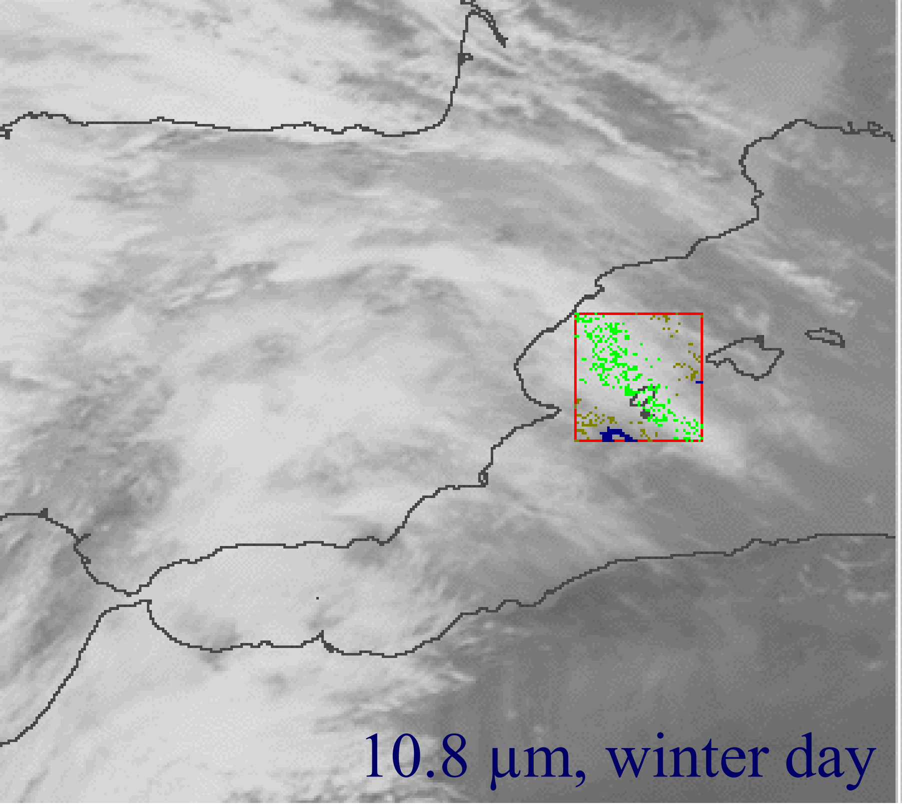

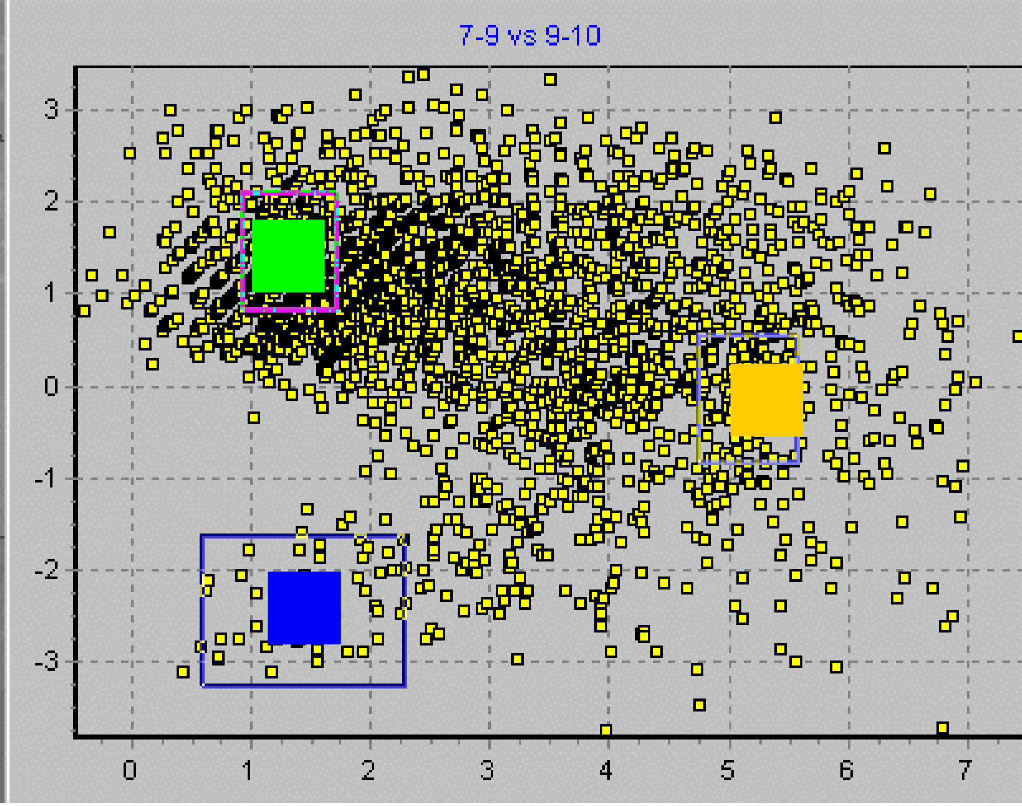

C. Sea

?

A. Ice cloud

B. Thin cloud

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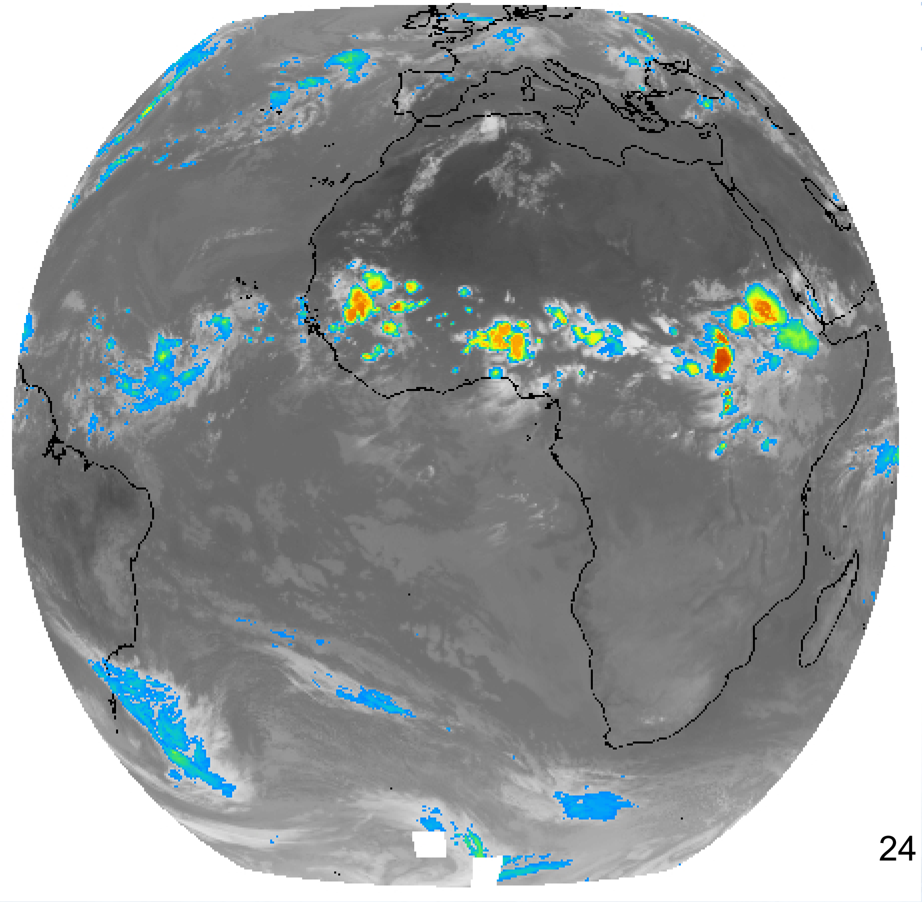
Applications of the split window

- Sea surface temperature
- Cloud top temperature
- Low level humidity
- Aerosol (saharan air layer, SAL)
- Semitransparent cloud
- Precipitation estimates (MPE)
- Clear-sky radiances for NWP

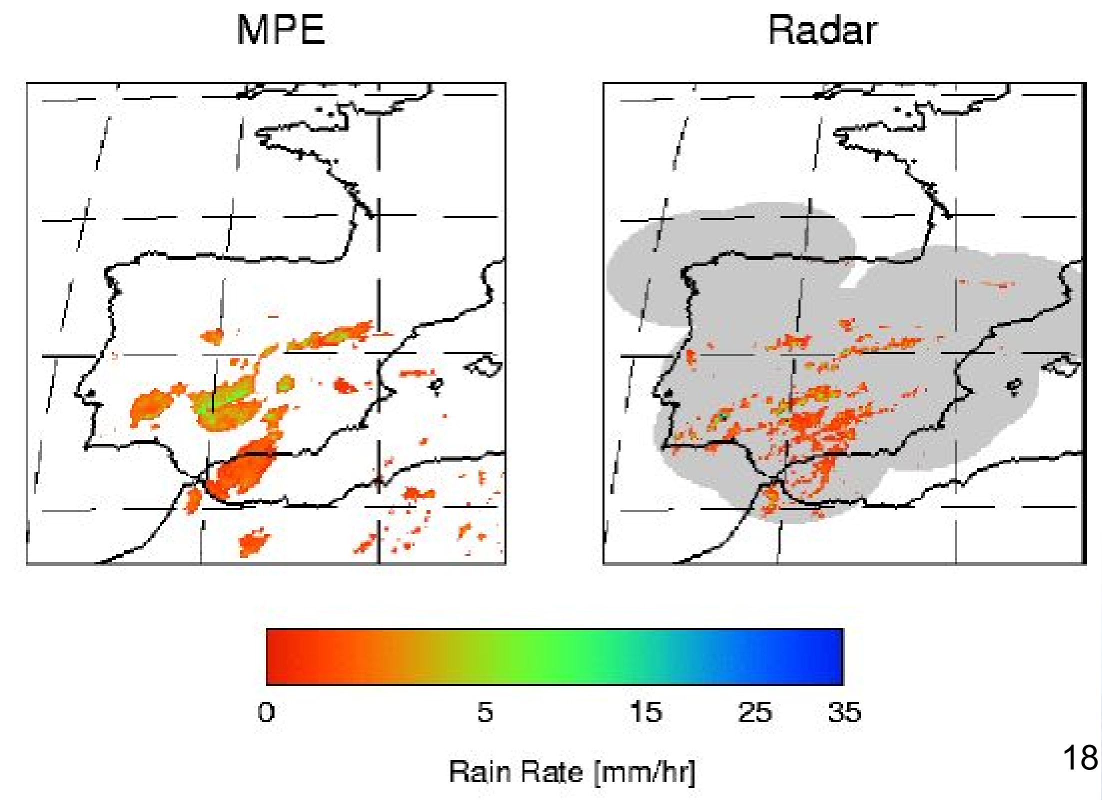
Precipitation estimation



24 July 2005 14:00

Multisensor Precipitation Estimate: IR calibrated with SSM/I

Precipitation estimation



- ❖ Adequate to estimate convective precipitation in tropical regions
- ❖ Underperformance for high latitudes

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Sea Surface Temperature

-Clear areas, exclude ice areas because of uncertain emissivity.

-First approach: channel 10.8µm brightness temperature

-Correction for humidity ~ T10.8 - T12.0

-Correction for viewing angle (cosine of zenithal angle)

-Example: SST= 1.03 *T10.8 + 2.6 *(T10.8 - T12.0) - 10.0

(McClain et al. 1985)

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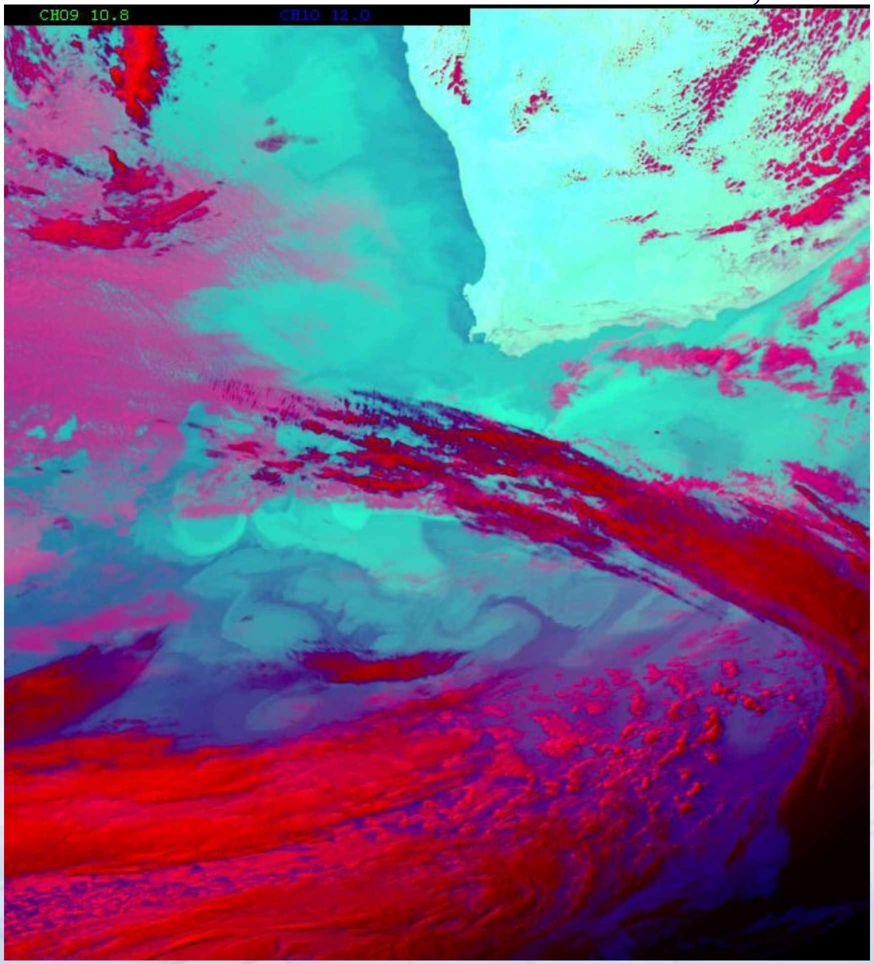
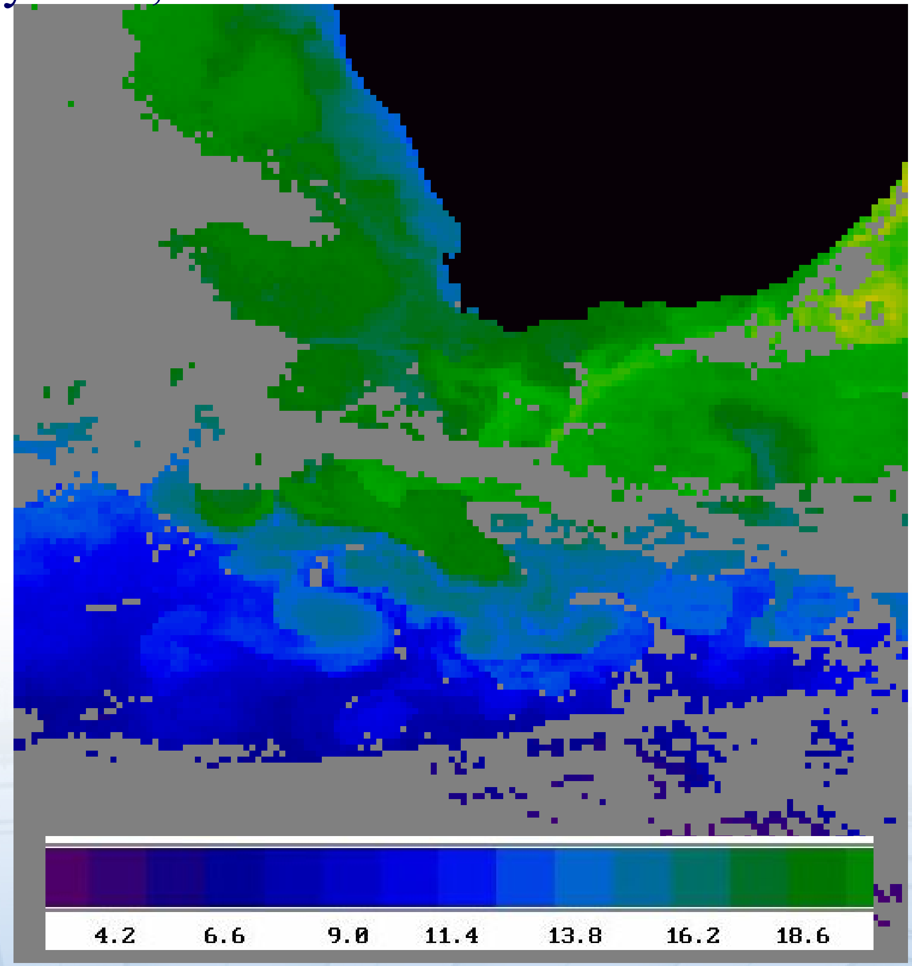
SST Eddies in the South Atlantic

MSG-1, 3 May 2004, 14:00 UTC



RGB Composite 02,09,10



OSI SAF 12-hourly SST Product

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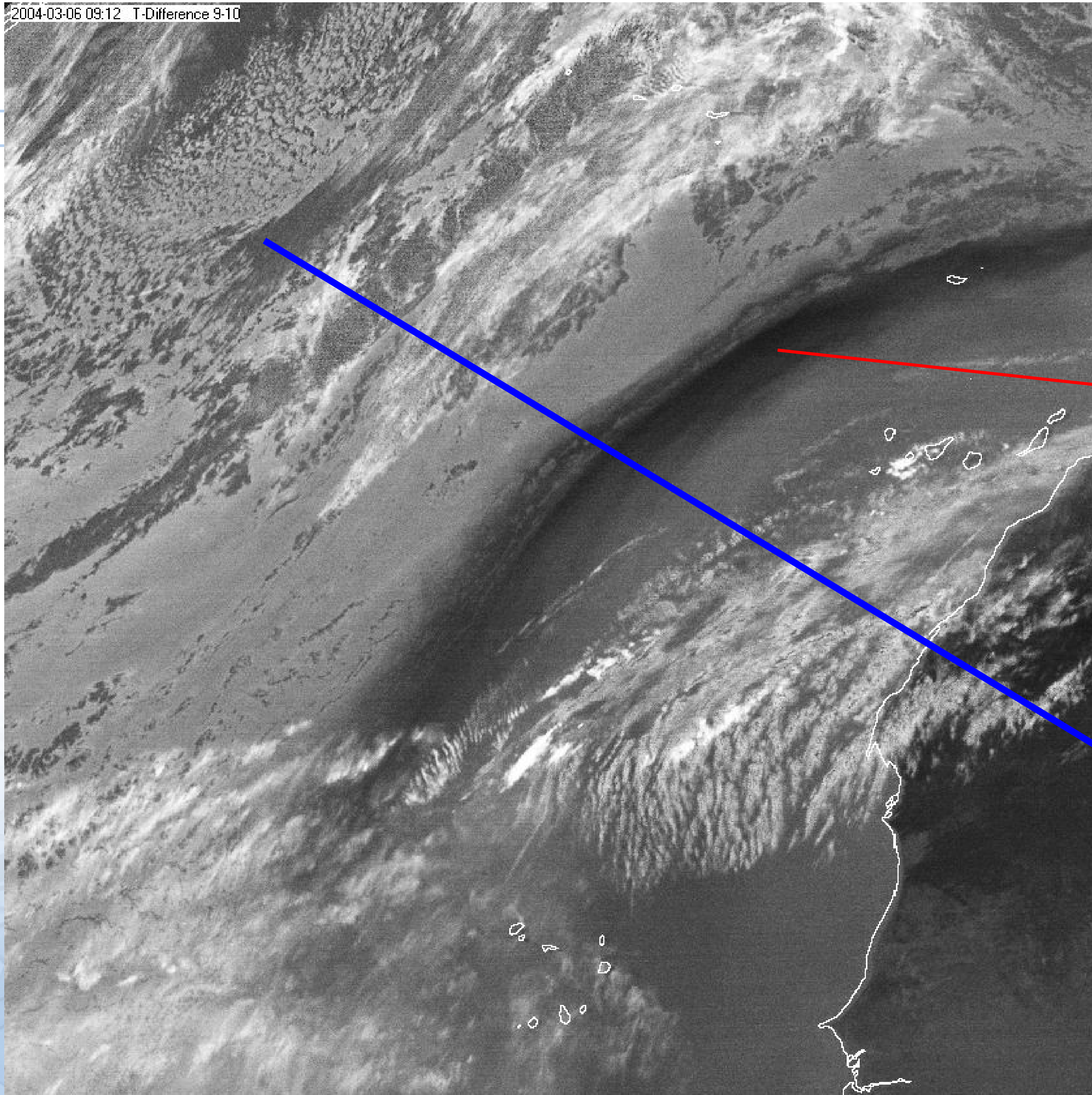
Ch9 – Ch10

6-March-2004



Sand front

(smooth transition)

Low cloud

(sharper boundaries)

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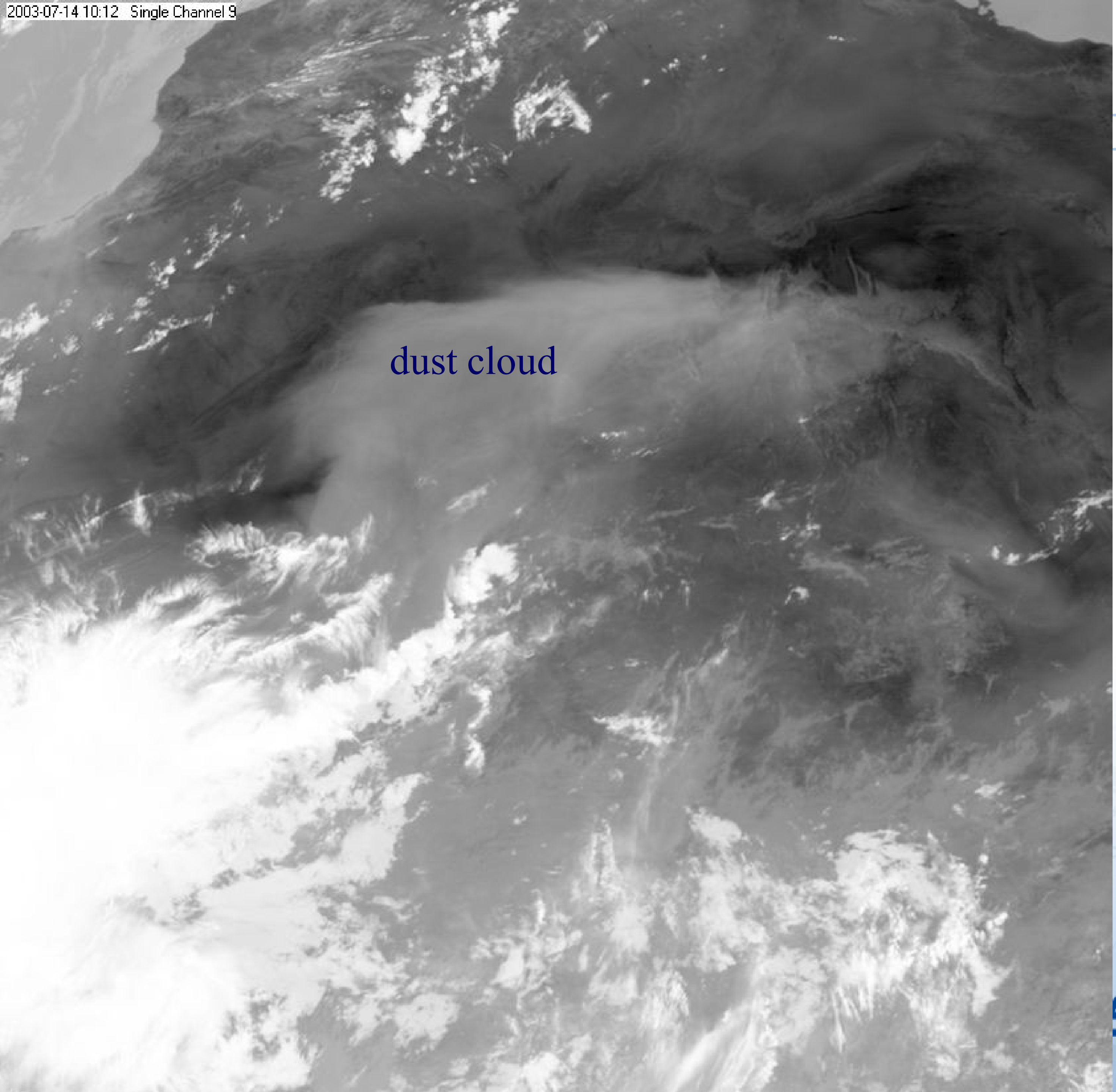

Channel 10.8 µm

14 July 03 12:00

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Aerosol, ash, fumes

- *Ash and dust* scatter mainly in the solar and near-infrared, but the split-window channels offer sharp differences

- Small negative channel difference 10.8 µm - 12.0 µm identifies silicates and volcanic ash

- Volcanic *gases* only show in the window channels, due to specific gas absorption: Channels 7.3µm and 8.7µm respond to SO2. At high level, the first is preferable. Negative channel difference (8.7 µm - 12.0 µm) identifies burnt sulphur compounds.
  - *Note*: possible confusion of SO2 with desert surfaces or dust cloud

- Over clear desert, the strong difference Ch7-Ch9 gets blurred by *dust* (more absorbing on 10.8 µm)

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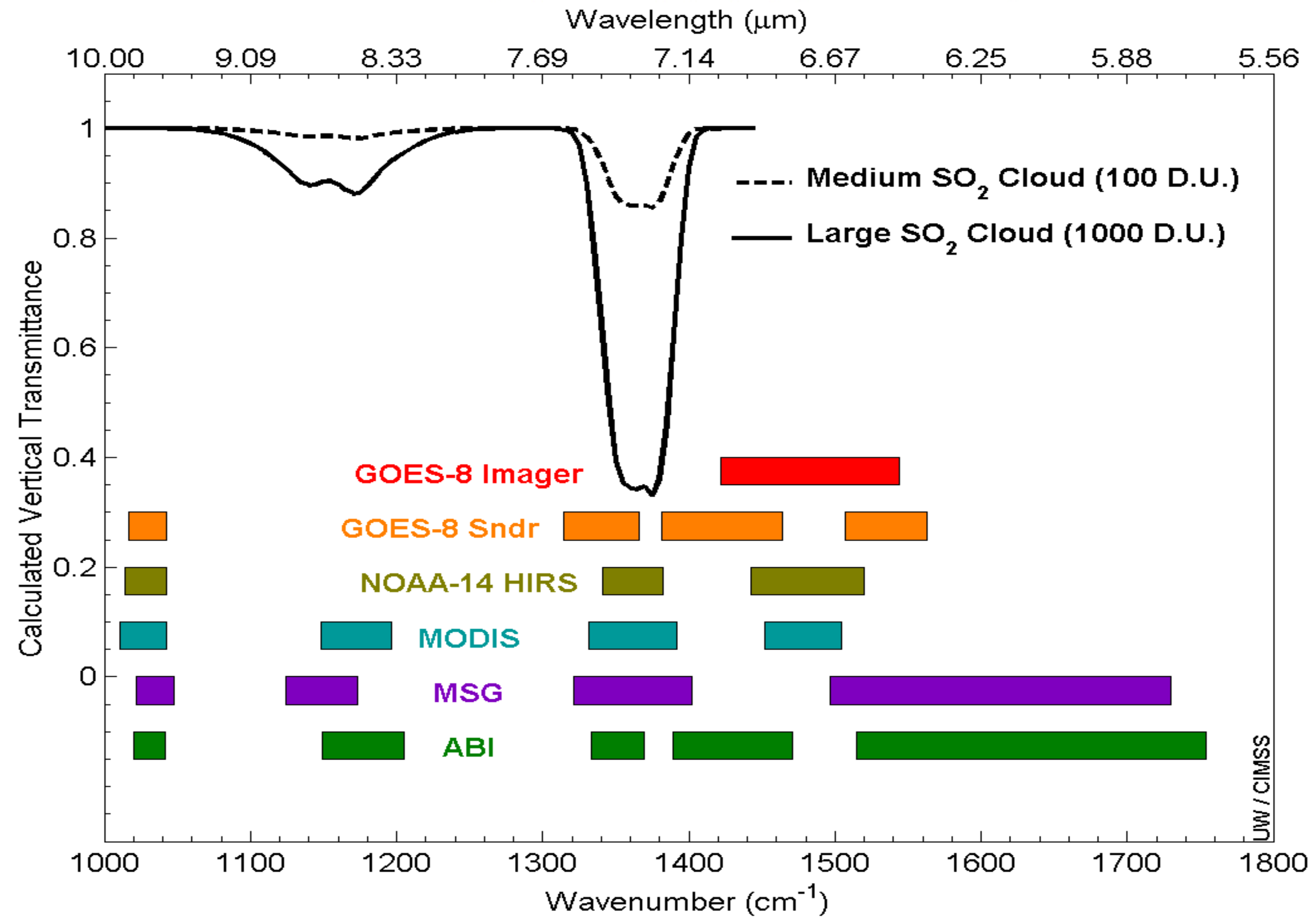
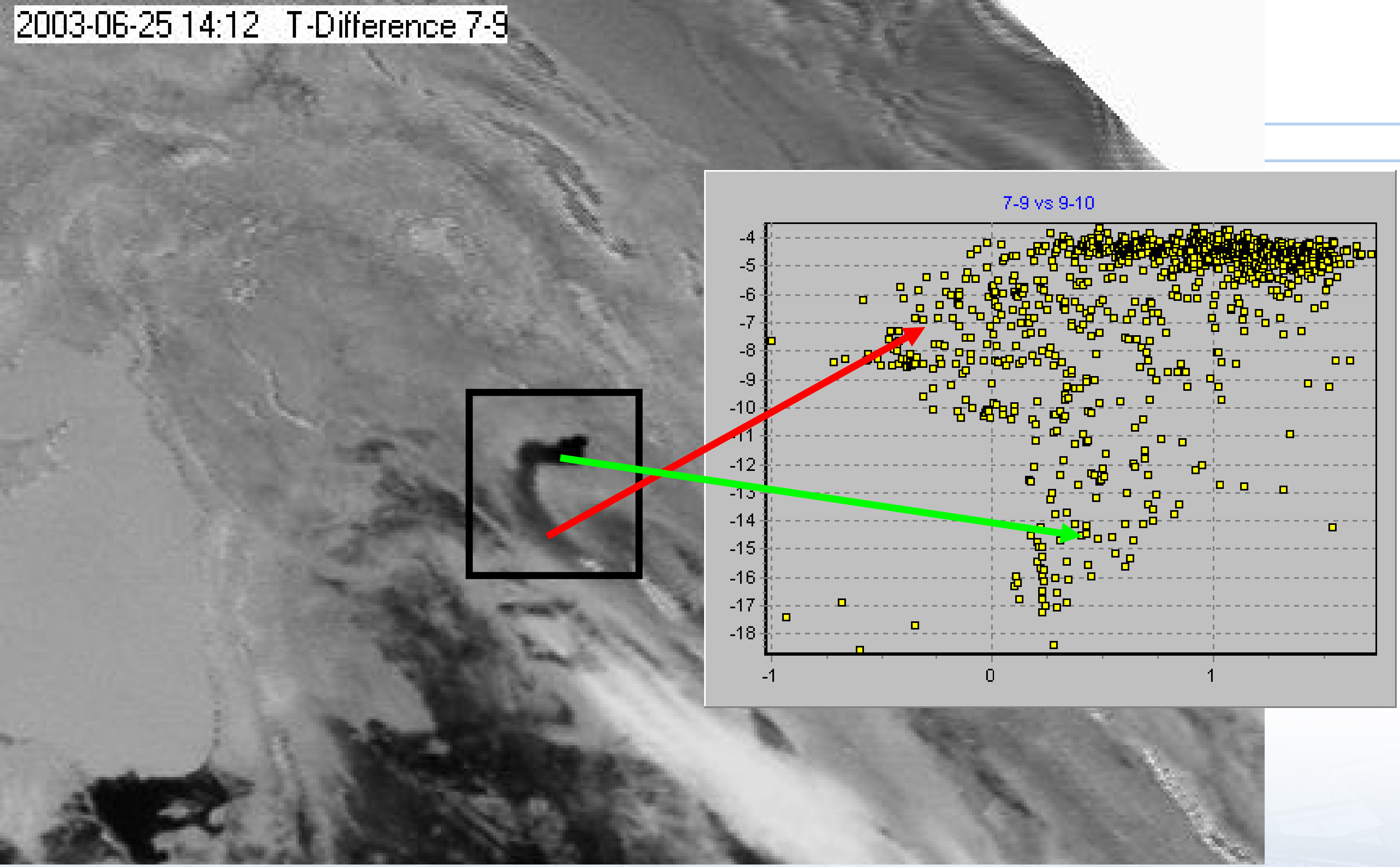

Wavelength (μm)
10.00 9.09 8.33 7.69 7.14 6.67 6.25 5.88 5.56
Calculated Vertical Transmittance
1 0.8 0.6 0.4 0.2 0
Medium SO_2 Cloud (100 D.U.)
Large SO_2 Cloud (1000 D.U.)
GOES-8 Imager
GOES-8 Sndr
NOAA-14 HIRS
MODIS
MSG
ABI
UW / CIMSS
1000 1100 1200 1300 1400 1500 1600 1700 1800
Wavenumber (cm^{-1})

Fred Prata



Low level sulphur oxide shows a strong 7-9 difference. After reaching the high level it dilutes and the difference decreases.

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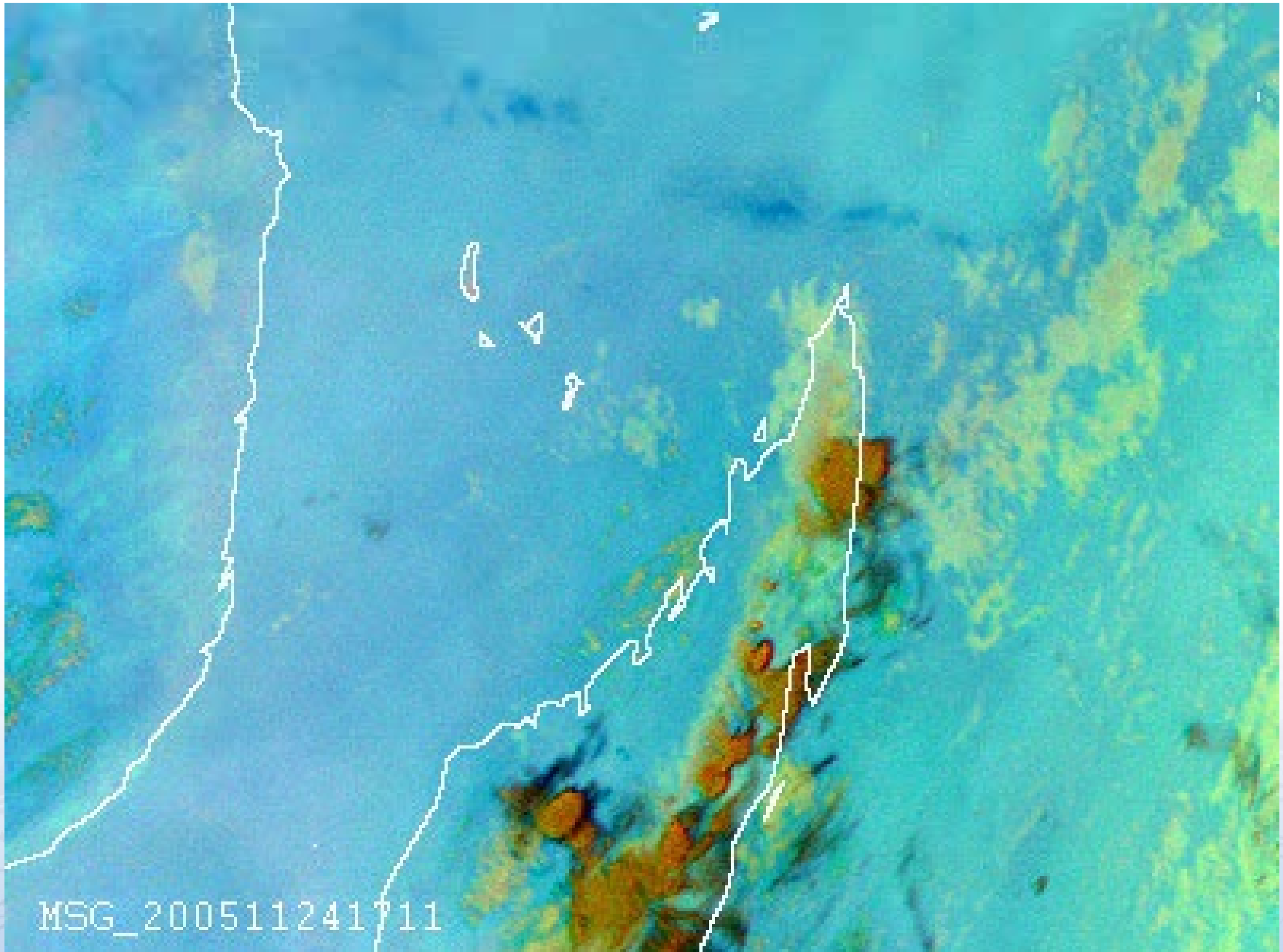
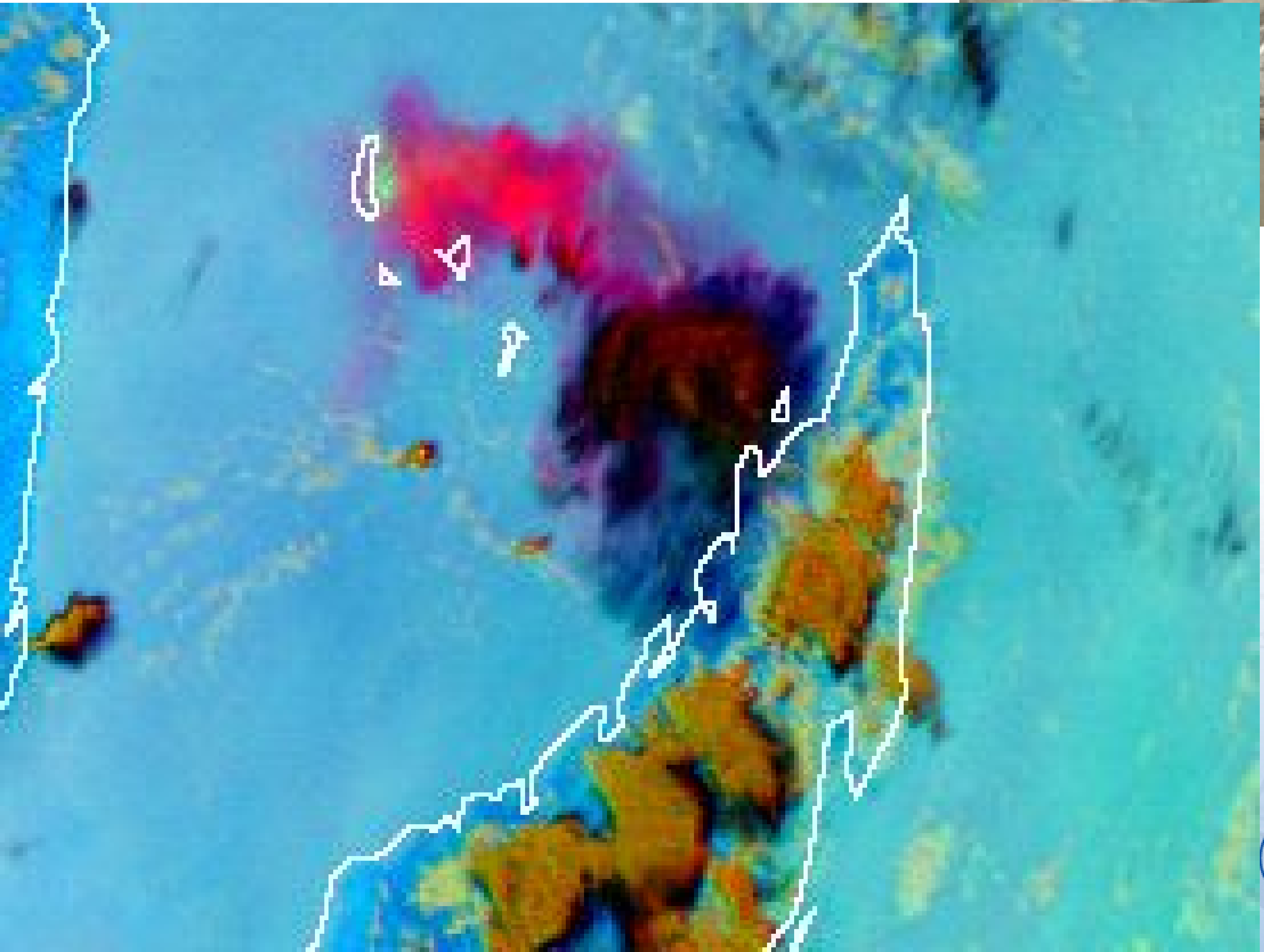
Ash RGB Product: Animation



Ash RGB Product



Eruption of

Karthala volcano

24-Nov-2005

Ash RGB

Recommended Range and Enhancement:

Beam	Channel	Range	Gamma
Red	IR12.0 - IR10.8	-4 … +2 K	1.0
Green	IR10.8 - IR8.7	-4 … +5 K	1.0
Blue	IR10.8	+243 … +303 K	1.0

Interpretation of Colours

Cold, thick, high-level clouds	Thin Cirrus clouds or Contrails	Volcanic SO2 clouds	Volcanic Ash clouds

Conclusions

- Channels at 8.7µm, 10.8µm and 12.0µm provide information on cloud phase and height, even allow inferences on particle size *for thin cloud*
- Those channels provide information on ground characteristics, in particular for discrimination of humid and arid areas
- A novel application is the monitoring of sand and smoke clouds, as a major risk for air navigation and ground pollution

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