Key Satellite Measurements

(MSG, Metop IASI, AQUA AIRS, ...)

Franz H. Berger (DWD) and Dieter Klaes (Eumetsat)

EUMETSAT

Motivation

measurement of cloud & atmospheric properties during cloud evolution, especially of convective precipitating / non-precipitating clouds

➔complete cloud life cycle

various 4D – fields are needed: PTU, wind, geometrical (top, base, multi-layered), optical (thickness), microphysical (radius, LWC/IWC, phase) cloud properties, aerosols (type, radius), radiation (insolation, DLR, OLR, ...), surface properties (reflectance, LST/SST)

Use of satellite - remotely sensed data:

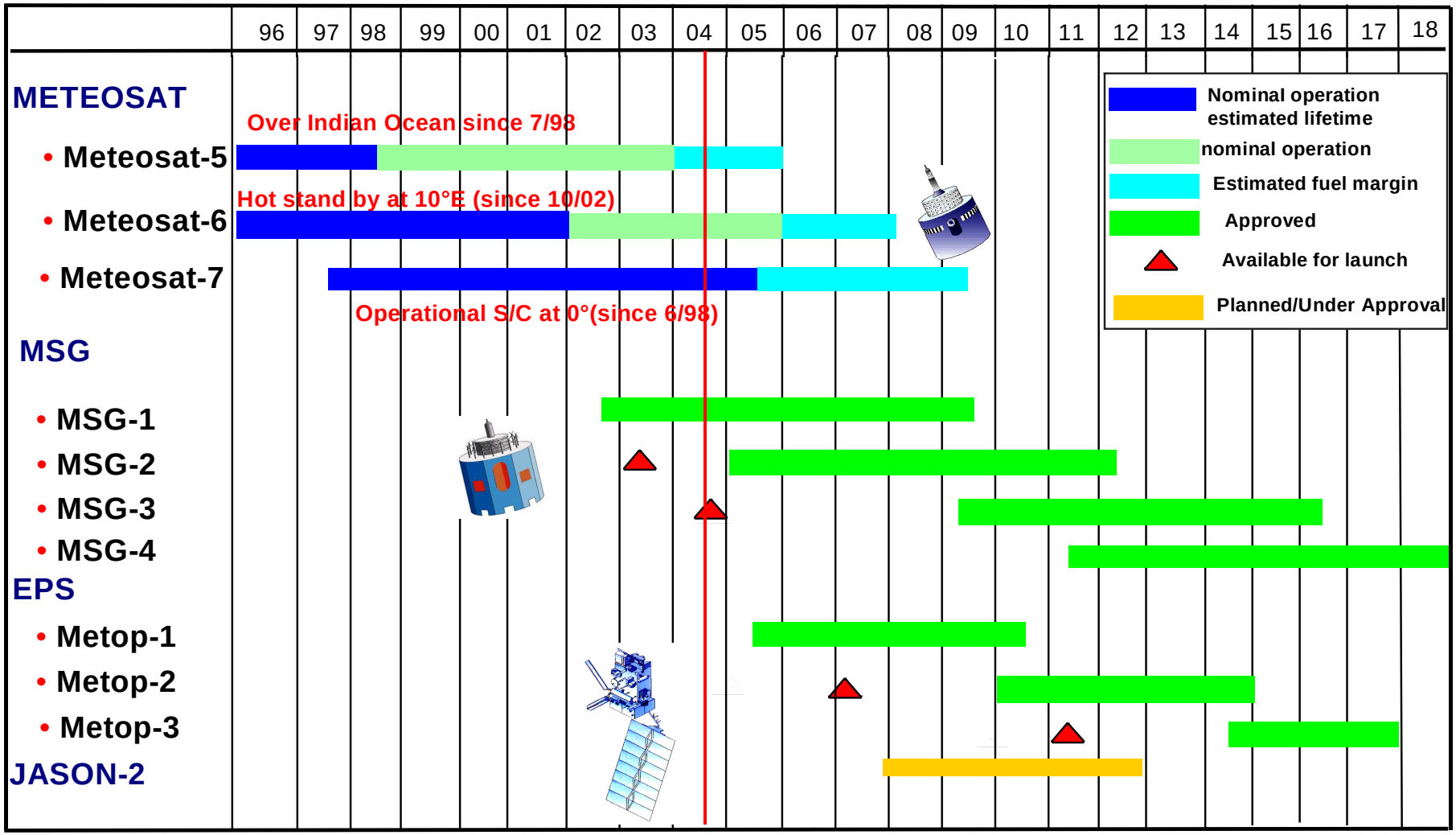
1. independent determination of atmos. properties (incl. synergy of sensors at seperate / same platform and with surface based remotely sensed data)
2. validation of numerical models
3. initialisation of numerical models
4. assimilation of remotely sensed data into numerical models (nudging, 1D/3D/4DVAR)

Which satellite data are available during COPS?

- **geostationary satellites** (Meteosat Rapid Scan, Meteosat Second Generation)
- **polar-orbiting satellites** (Envisat, A-Train, Metop, ...)

- only some examples -
not a complete discussion of current and future satellite sensors

EUMETSAT SATELLITE PROGRAMMES

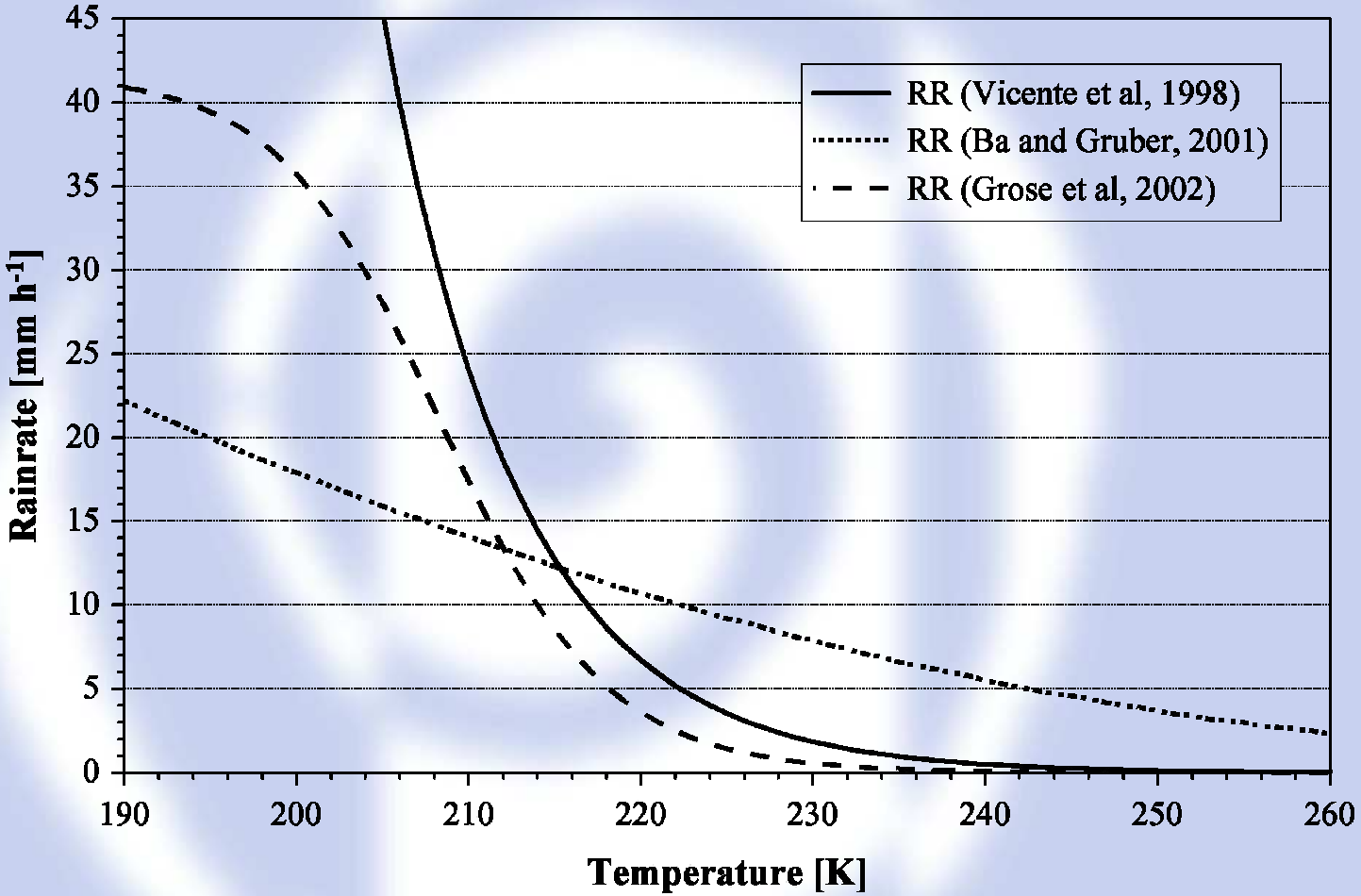


Meteosat Rapid Scan:

- spectral resolution: 3 channels (VIS, WV, IR)
- temporal resolution: 10 minutes
- spatial resolution: 2.5/5 km (nadir)

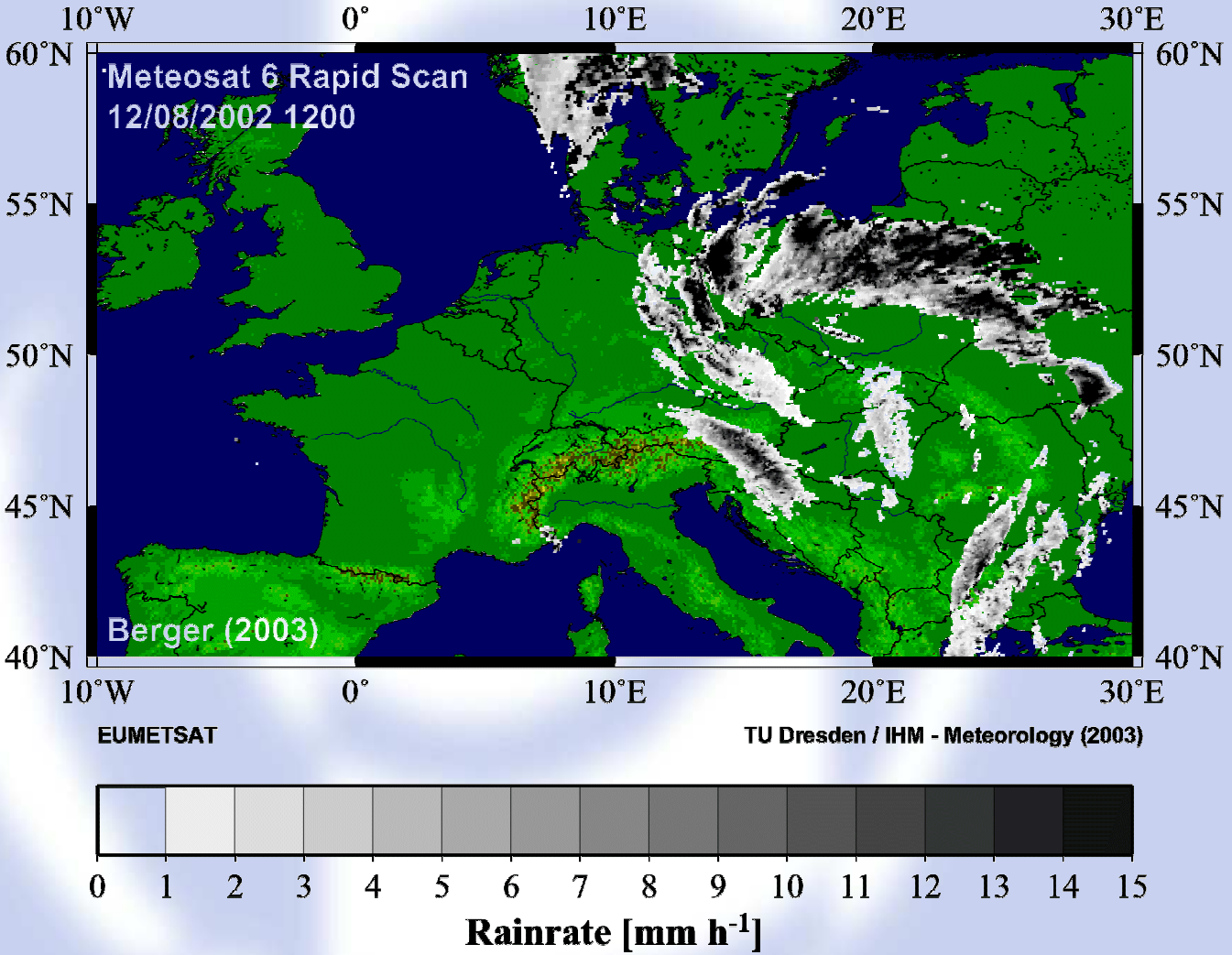
Rain rate estimates:

1. **IR methods**: Vicente et al (1998), Ba and Gruber (2001), Grose et al (2002)
2. **IR/WV methods**: Kurino (1997)
3. **IR/WV/numerical model**: Reudenbach et al (2001)
4. **IR/WV/cloud life cylce method**: Berger, 2003
5. **Eumetsat Multi-sensor Precipitation Estimate** (MPE): Heinemann et al, 2003


RR (Vicente et al, 1998)
RR (Ba and Gruber, 2001)
RR (Grose et al, 2002)
Rainrate [mm h-1]
Temperature [K]
0
5
10
15
20
25
30
35
40
45
190
200
210
220
230
240
250
260

Deutscher Wetterdienst

Meteorologisches Observatorium Lindenberg



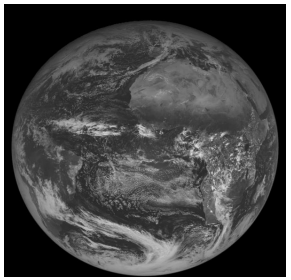
Meteosat-8 (MSG) SEVIRI / GERB

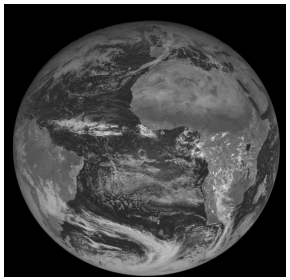
- spectral resolution: 12 channels / 2 channels
- temporal resolution: 15 minutes
- spatial resolution: 3 km (nadir), 1 km (HRV)
  45x40 km^2 (GERB)

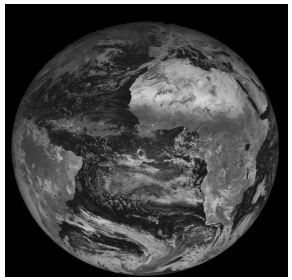
Meteosat-8 (MSG-1) normal mode

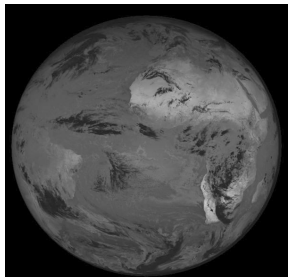
Meteosat-9 (MSG-2) rapid scan mode

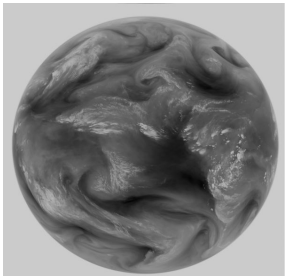
MSG capabilities

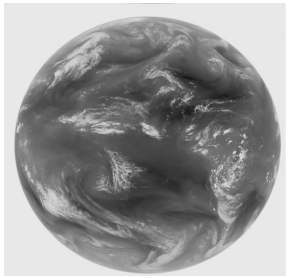

VIS 0.6 µm

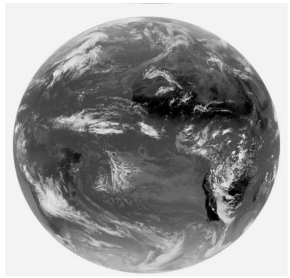

VIS 0.8 µm

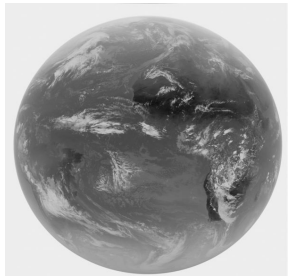

NIR 1.6 µm

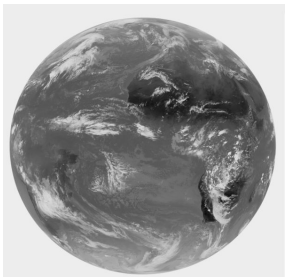

NIR 3.9 µm

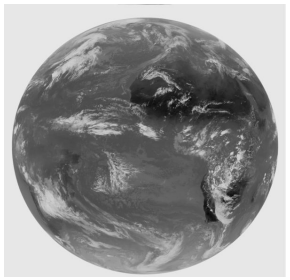

WV 6.2 µm

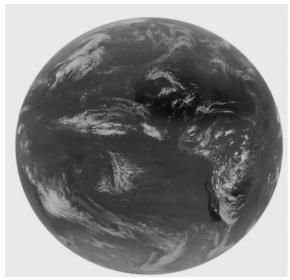

WV 7.3 µm


IR 8.7 µm


IR 9.7 µm


IR 10.8 µm


IR 12.0 µm


IR 13.4 µm

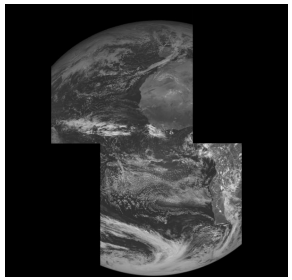
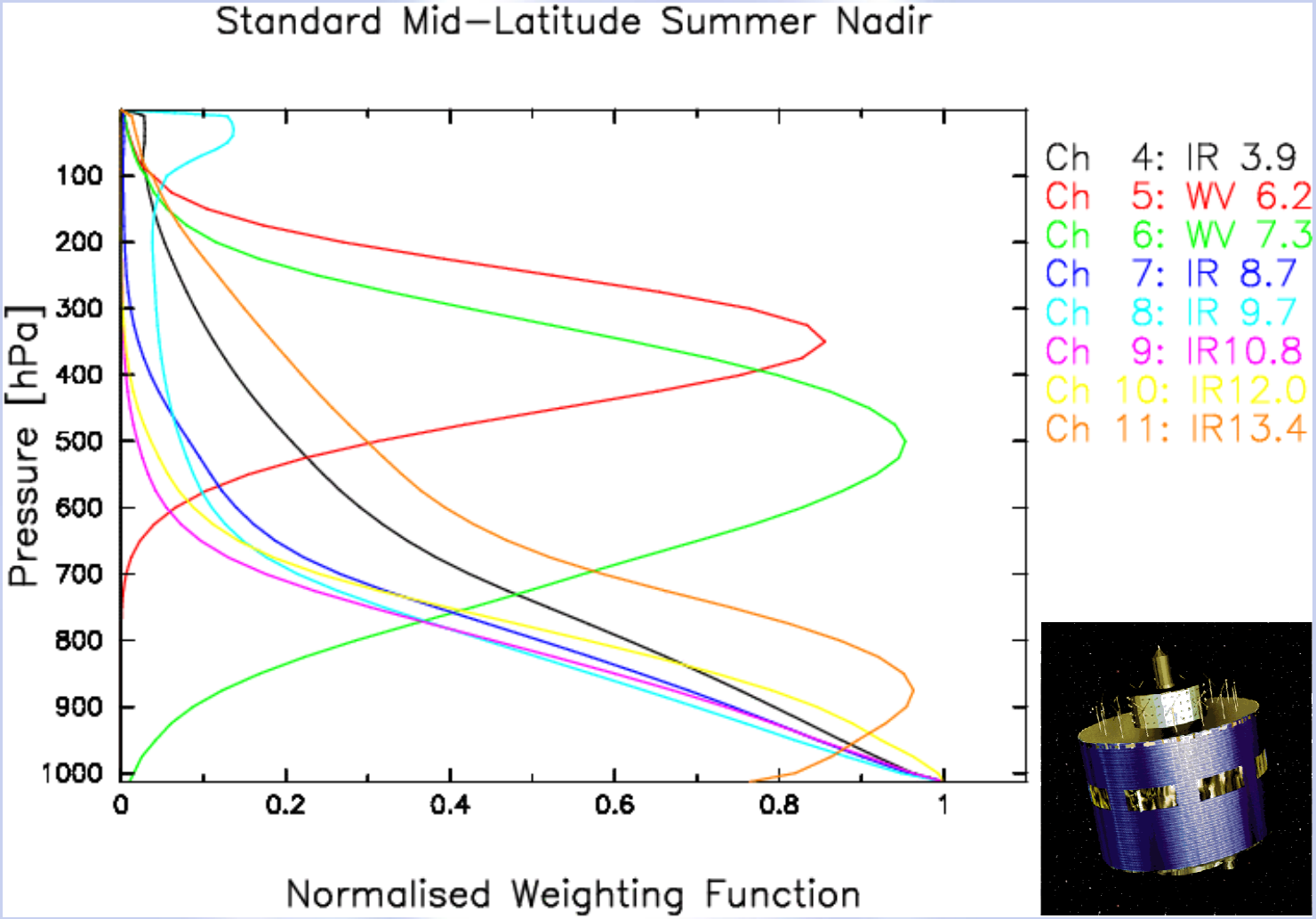

HRVIS

TABLE 1. Spectral channel characteristics of SEVIRI providing central, minimum, and maximum wavelength of the channels and whether the channel is an absorption or a window channel. A concise summary of the use of the spectral channels is given in the section titled "SEVERI spectral channels."

Channel no.		Characteristics of spectral band (μm)			Main gaseous absorber or window
		λ_{cen}	λ_{min}	λ_{max}	
1	VIS0.6	0.635	0.56	0.71	Window
2	VIS0.8	0.81	0.74	0.88	Window
3	NIR1.6	1.64	1.50	1.78	Window
4	IR3.9	3.90	3.48	4.36	Window
5	WV6.2	6.25	5.35	7.15	Water vapor
6	WV7.3	7.35	6.85	7.85	Water vapor
7	IR8.7	8.70	8.30	9.10	Window
8	IR9.7	9.66	9.38	9.94	Ozone
9	IR10.8	10.80	9.80	11.80	Window
10	IR12.0	12.00	11.00	13.00	Window
11	IR13.4	13.40	12.40	14.40	Carbon dioxide
12	HRV	Broadband (about 0.4 – 1.1)			Window/water vapor

Schmetz et al BAMS 2002


Standard Mid–Latitude Summer Nadir
Pressure [hPa]
100
200
300
400
500
600
700
800
900
1000
0
0.2
0.4
0.6
0.8
1
Normalised Weighting Function
Ch 4: IR 3.9
Ch 5: WV 6.2
Ch 6: WV 7.3
Ch 7: IR 8.7
Ch 8: IR 9.7
Ch 9: IR10.8
Ch 10: IR12.0
Ch 11: IR13.4

- **VIS0.6 & VIS0.8**: cloud detection, aerosol, landsurface and vegetation monitoring
- **NIR1.6**: snow / cloud discrimination, ice / water cloud discrimination, cloud effective droplet radius / crystal diameter
- **IR3.9**: cloud / fog discrimination, fires
- **WV6.3 & WV7.3**: WV-observation, atmosperic motion winds
- **IR8.7**: additional information about ice clouds and ice / water cloud discrimination
- **IR9.7**: ozone-monitoring (total ozone)
- **IR10.8 & IR12.0**: landsurface temperature/emissivity
- **IR13.4**: temperature of lower troposphere

Recommended Differences

NIR1.6 - VIS0.6	optical thickness, phase, particle size
IR3.9 - IR10.8	optical thickness, phase, particle size, emissivity
IR8.7 - IR10.8	optical thickness
IR12.0 - IR10.8	optical thickness
WV6.2 - IR10.8	overshooting tops
WV6.2 - WV7.3	overshooting tops

Deutscher Wetterdienst

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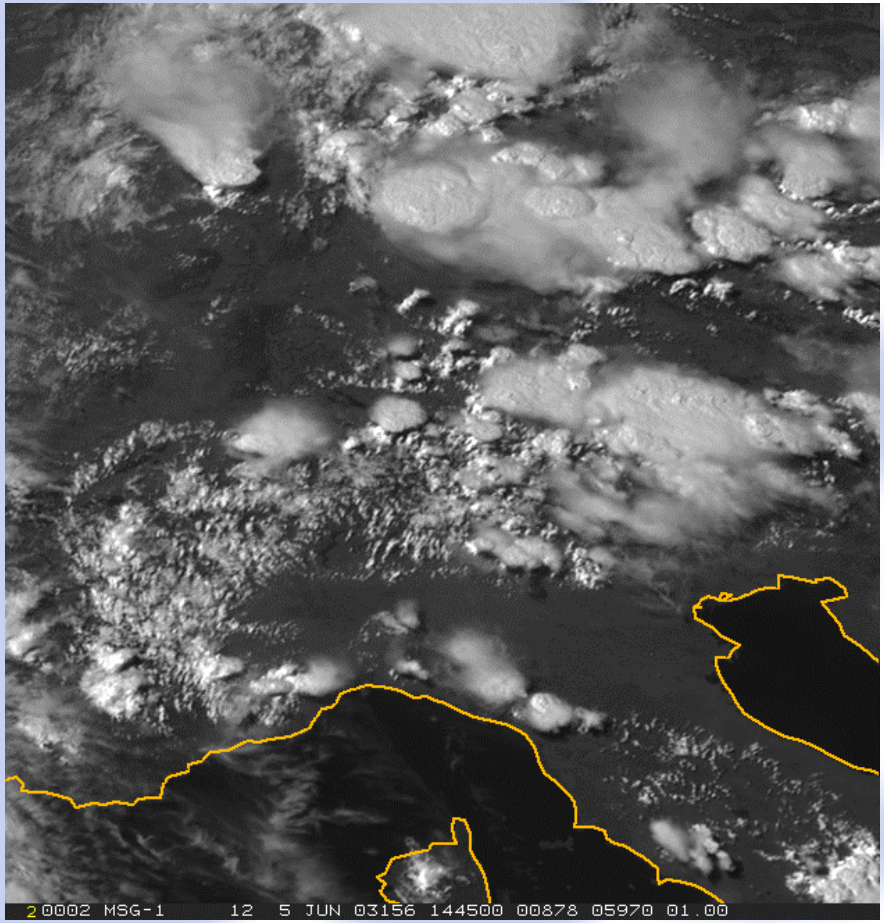
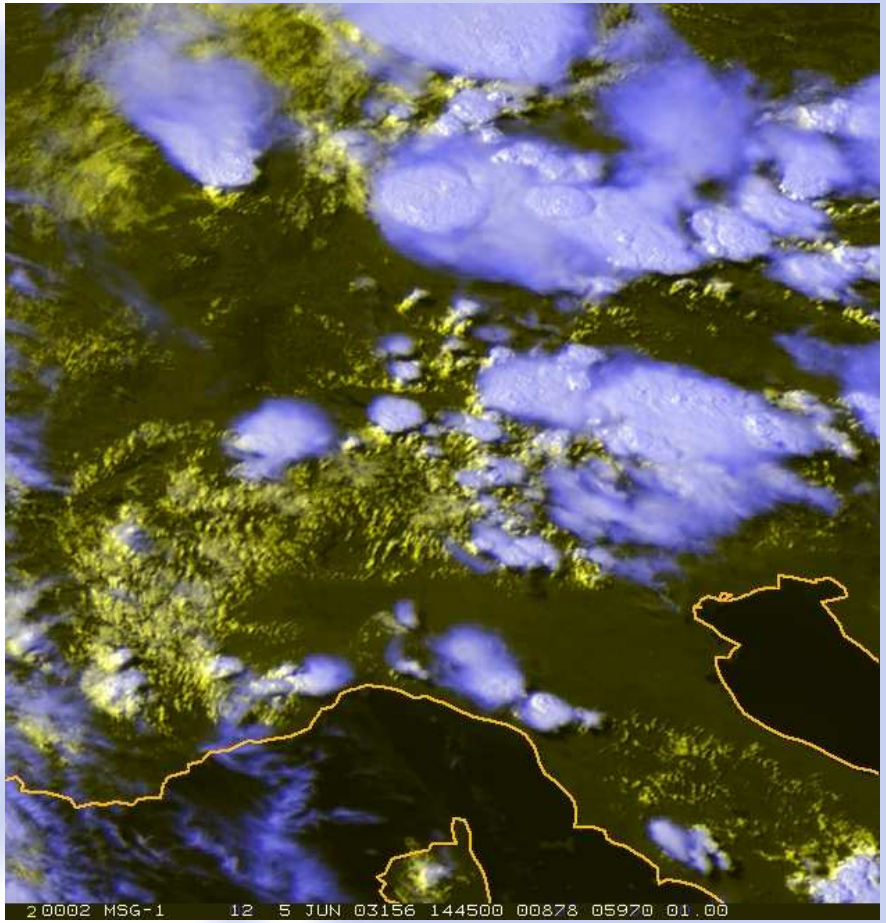


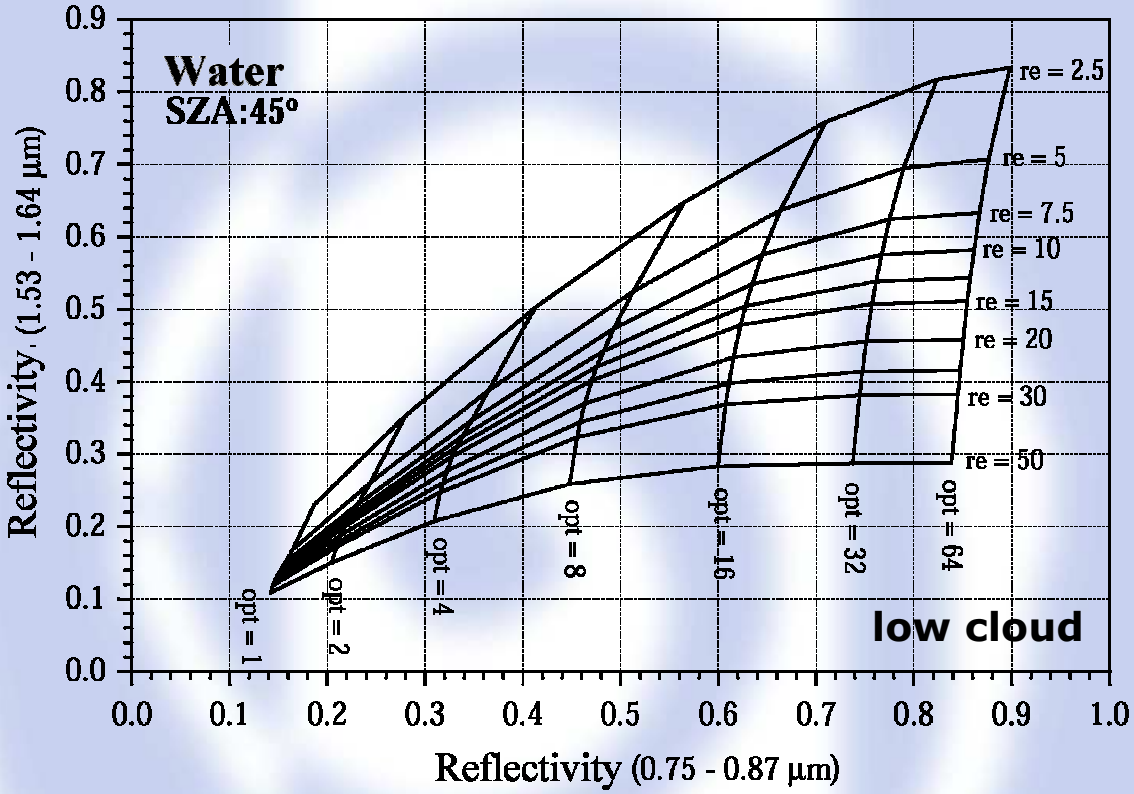
Channel 12 (HRV)



RGB HRV-HRV-IR10.8

MSG-1, 5 June 2003, 14:45 UTC

Rosenfeld (2003)



(after Nakajima et al, 1990; Halecker, 2000)

r_e at cloud top indicating updrafts!

➔ Liquid / Ice Water Path: $LWP \cong \frac{2}{3}\frac{r_e \delta_c}{\rho_l}$ $IWP \cong \frac{D_e \delta_c}{3.68}$

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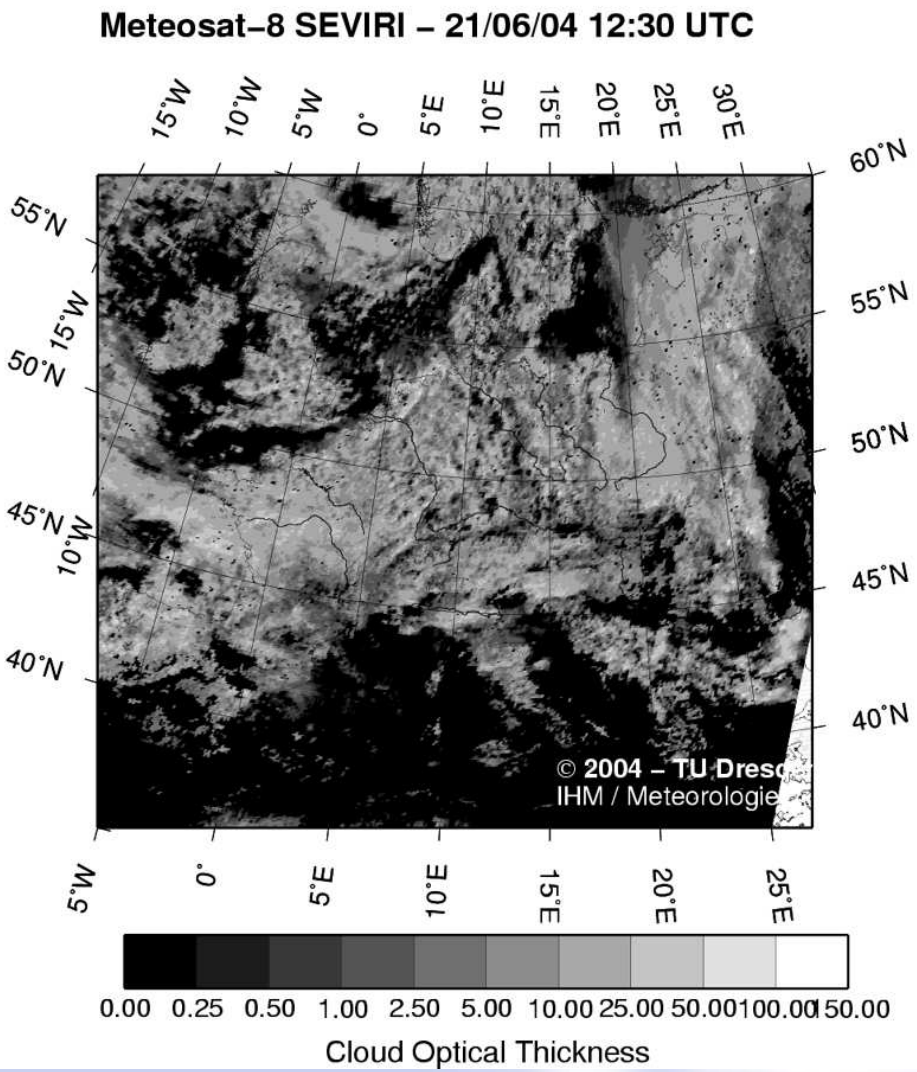
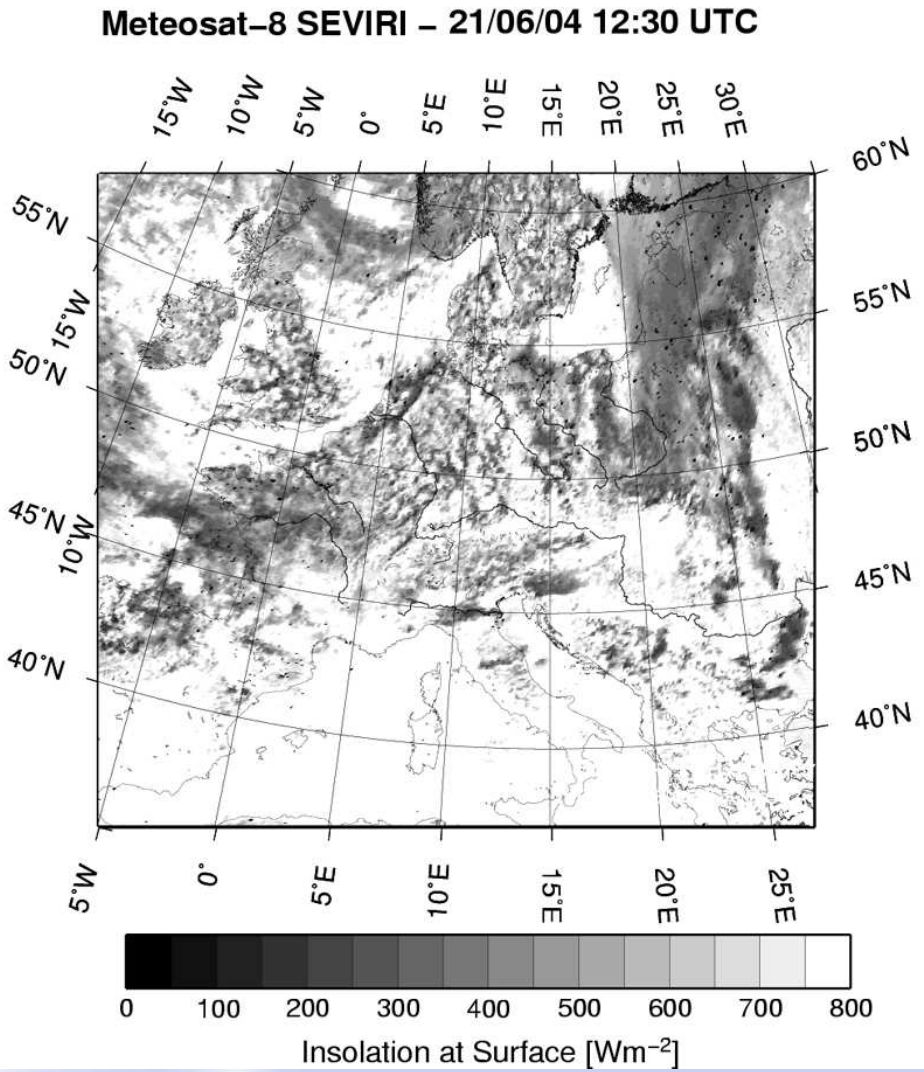
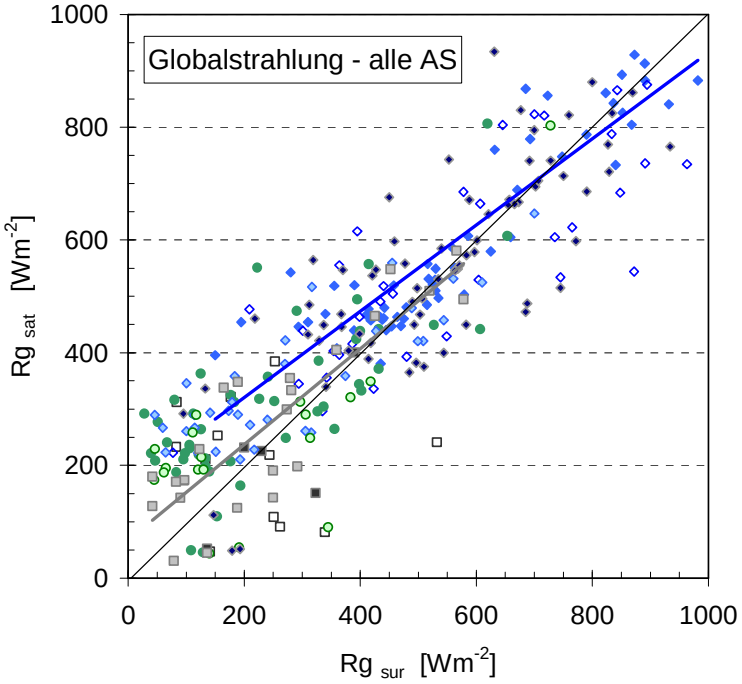
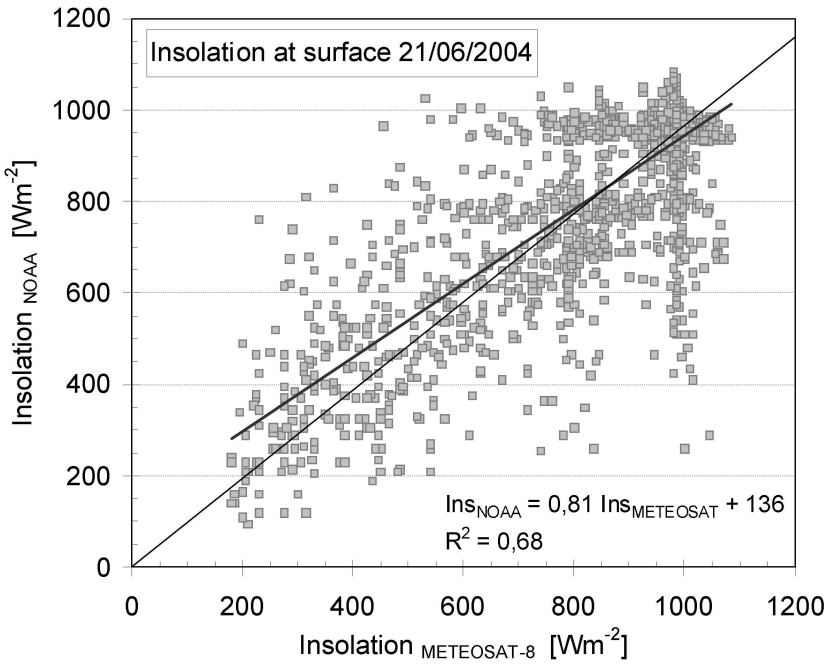




EUMETSAT


Globalstrahlung - alle AS
Rg sat [Wm-2]
Rg sur [Wm-2]
0
200
400
600
800
1000

wolkenlos (3,4)
tief+dick (5)
tief+dünn (6,7)
mehrfach geschichtet I (8,9)
mittelhoch+dick (10)
mittelhoch+dünn (11)
mehrfach geschichtet II (12,13)
hoch+dünn (14-16)
hoch+dick (17,18,24)


Insolation at surface 21/06/2004
Insolation NOAA [Wm-2]
Insolation METEOSAT-8 [Wm-2]
InsNOAA = 0,81 InsMETEOSAT + 136
R2 = 0,68
0
200
400
600
800
1000
1200

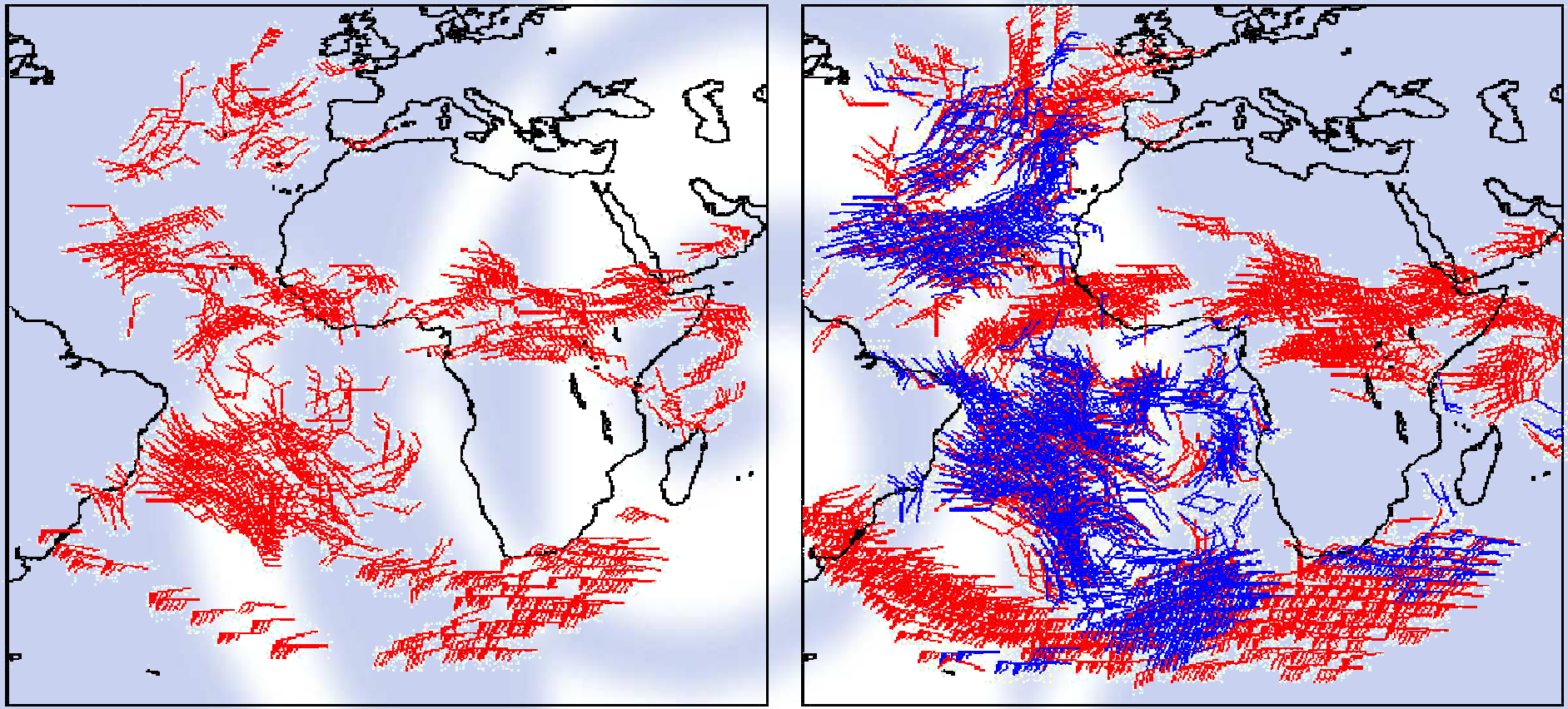
MPEF products

Cloud cover (CLA)
Cloud top height (CTH)
Clear sky radiances (CSR)
Tropospheric humidity (UTH, MTH)
Atmospheric motion winds (AMV)
ISCCP products (IDS)
High-resolution precipitation index (HPI)
Global instability index (GII)
Total Ozone – experimental

and a large variety of **SAFs products**

Deutscher Wetterdienst

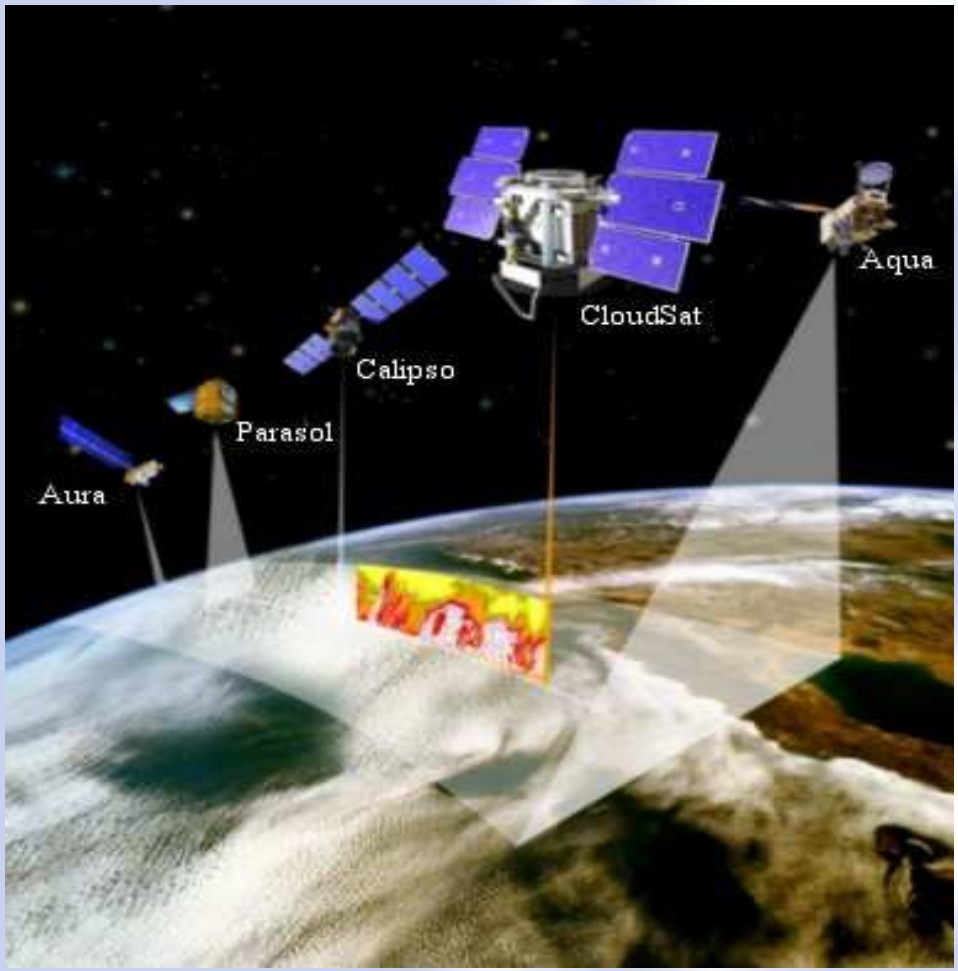
Meteorologisches Observatorium Lindenberg



Typical AMV coverage after ECMWF blacklisting (12z +/- 3h)

Jörgen Gustafsson, Leo van de Berg, Fausto Roveda, Ahmet Yilderim (Eumetsat)
Niels Bormann, Sakari Uppala (ECMWF)

The A-TRAIN



AQUA

CLOUDSAT

CALIPSO

PARASOL

AURA

MODIS-Moderate Resolution Imaging Spectroradiometer

CERES- Clouds and the Earth's Radiant Energy System

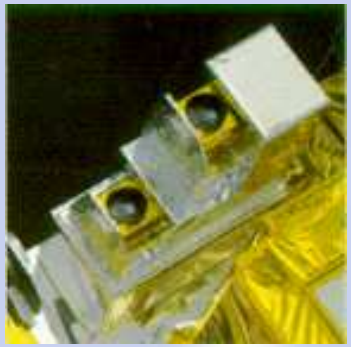
AMSR/E- Advanced Microwave Scanning Radiometer

AMSU-Advanced Microwave Sounding Unit

AIRS- Atmospheric Infrared Sounder

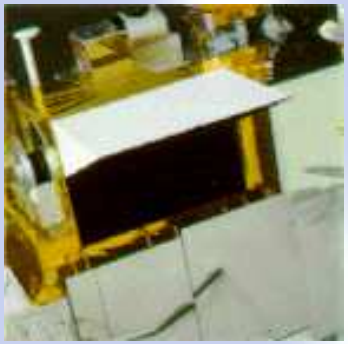
HSB- Humidity Sounder for Brazil

AQUA Instrument Specifications: Temperature and Moisture Sounding Suite



AMSU (Temperature and moisture profiles)
15 discrete channels in the range of 50 to 89 GHz

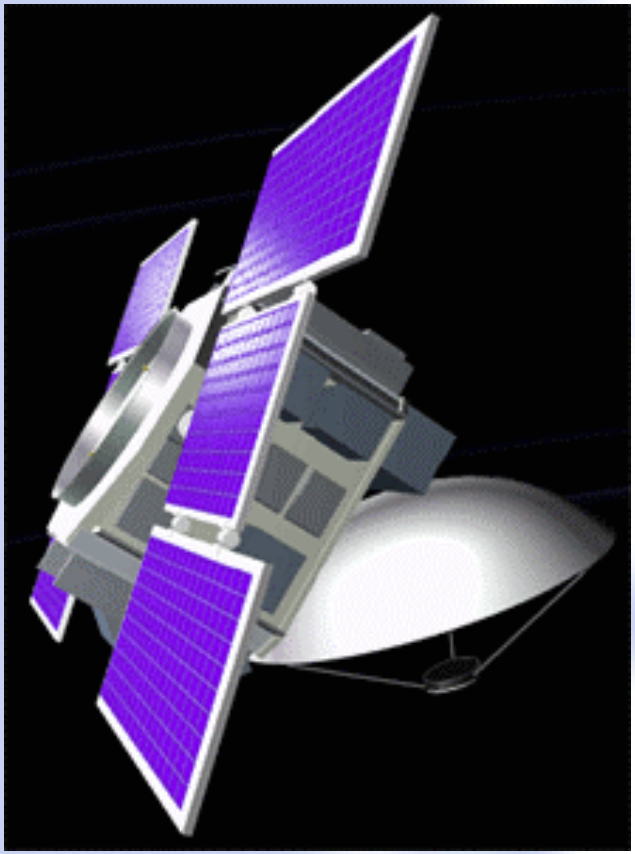
AMSR/E (Cloud properties, precipitation, total moisture) 12 channels at six discrete frequencies in the range of 6.9 to 89 GHz



AIRS (Temperature & moisture profiles, cloud properties)
2,300 spectral channels in the range of 0.4 to 1.7 µm and 3.4 to 15.4 µm

HSB (Moisture profiles)
5 discrete channels in the range of 150 to 183 MHz

CLOUDSAT



Launch planned 2005

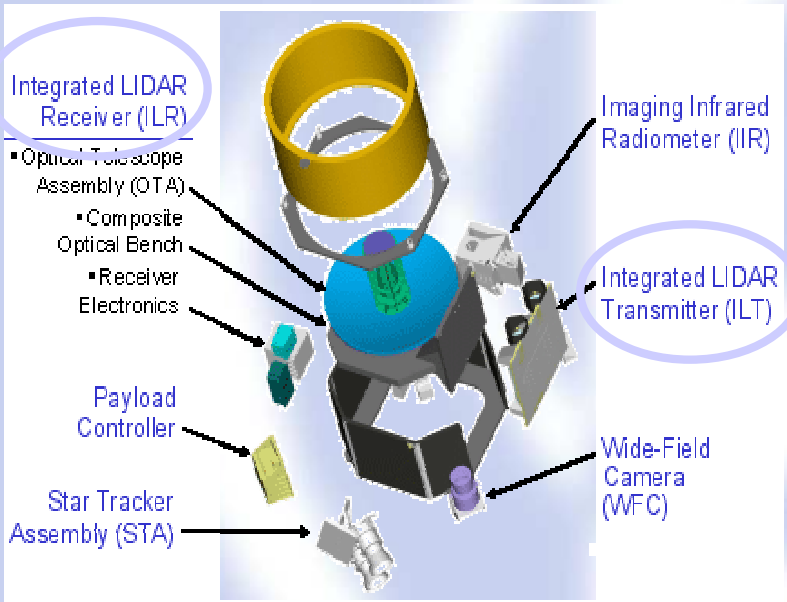
Measurements:

profiles of cloud liquid water and ice water content

Properties

94 GHz Cloud Profiling Radar (CPR); Nadir-viewing; 500 m vertical resolution; 1.2 km cross-track resolution, 3.5 km along track

CALIPSO Instrument Specifications: Lidar



Lidar

Measurements:

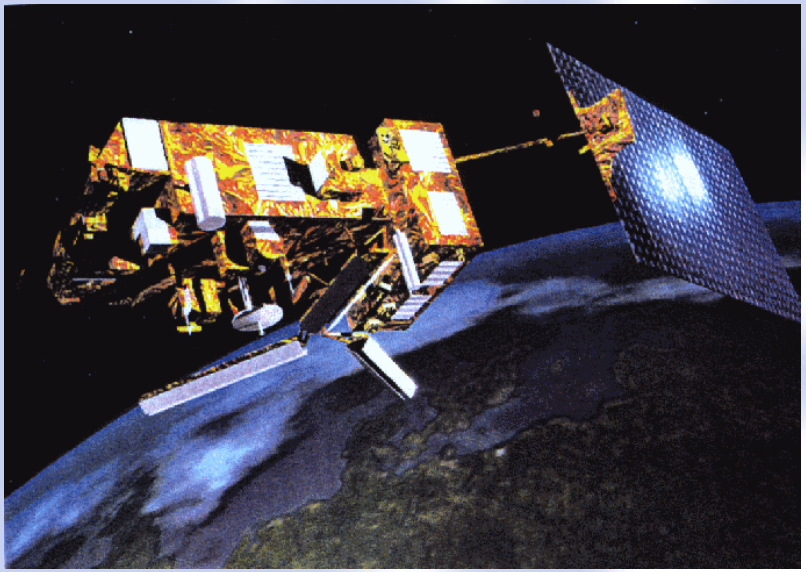
Backscattered radiances

Properties:

2-wavelength 532 nm and 1064 nm, polarization sensitive at 532nm; Horizontal/vertical resolution: 333 m/ 30 m (resolution will be decreased for getting good S/N ratio)

EUMETSAT POLAR SYSTEM

- Scheduled launch Oct 2005
- 14 years of operation



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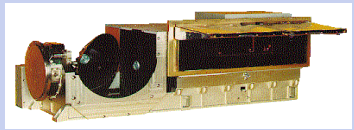
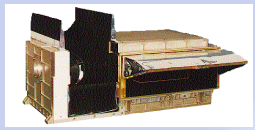


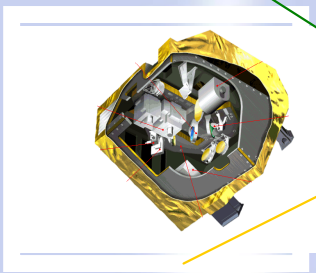
AVHRR-3

GRAS

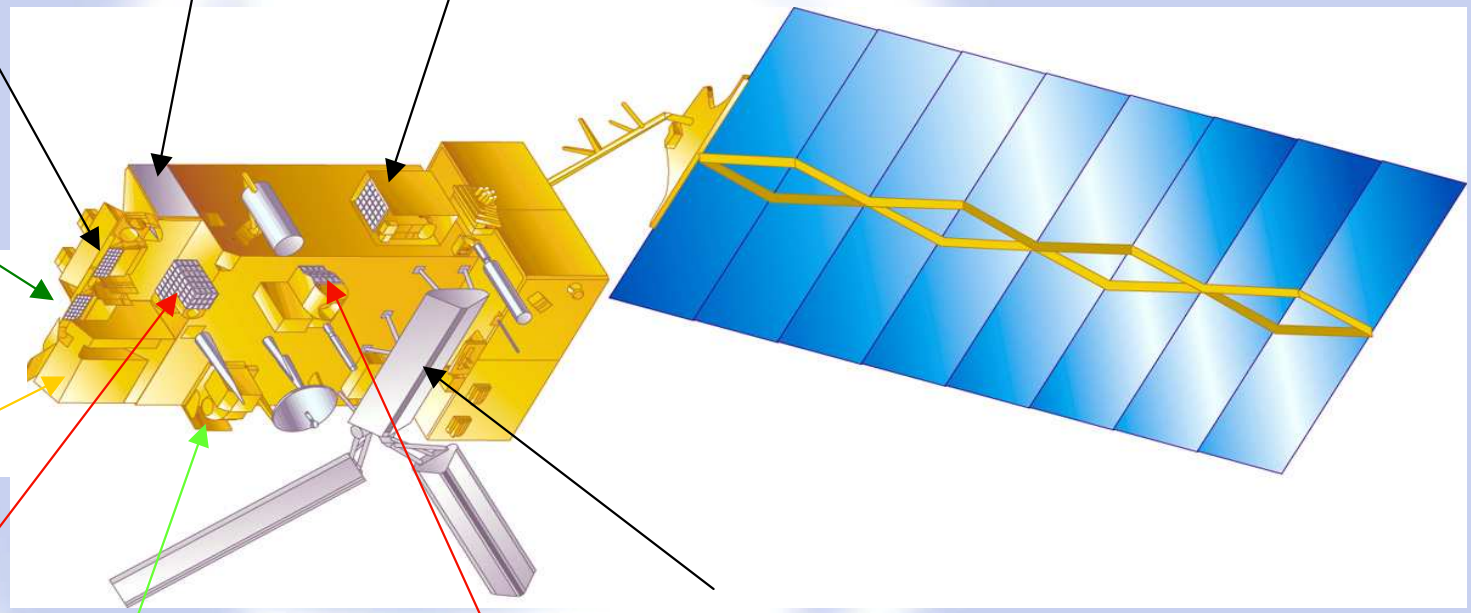
GOME-2



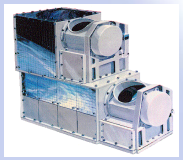
HIRS-4
Metop 1/2 only

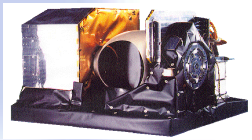


IASI



AMSU-A1

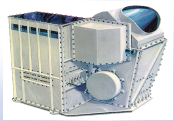




MHS

AMSU-A2

ASCAT



EUMETSAT

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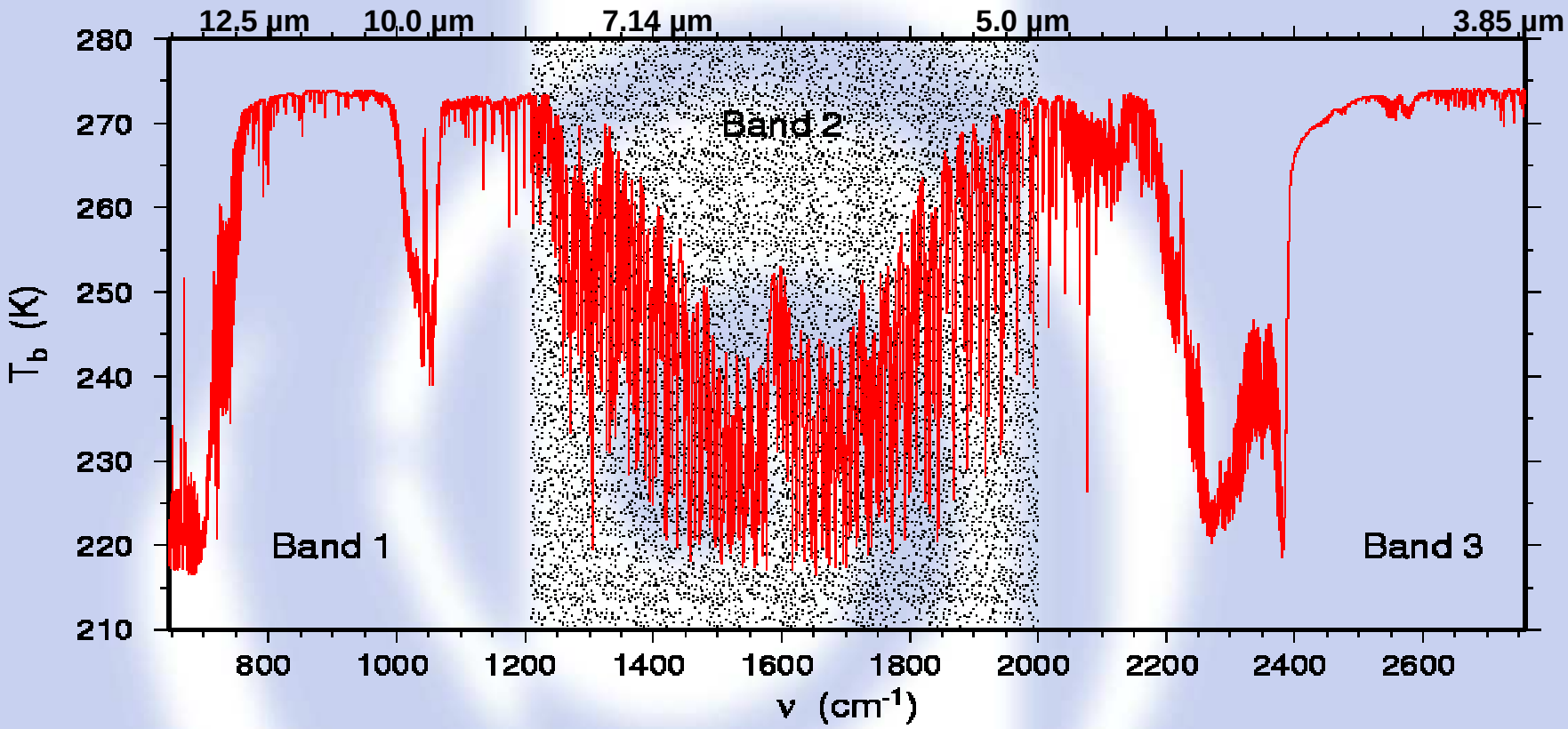
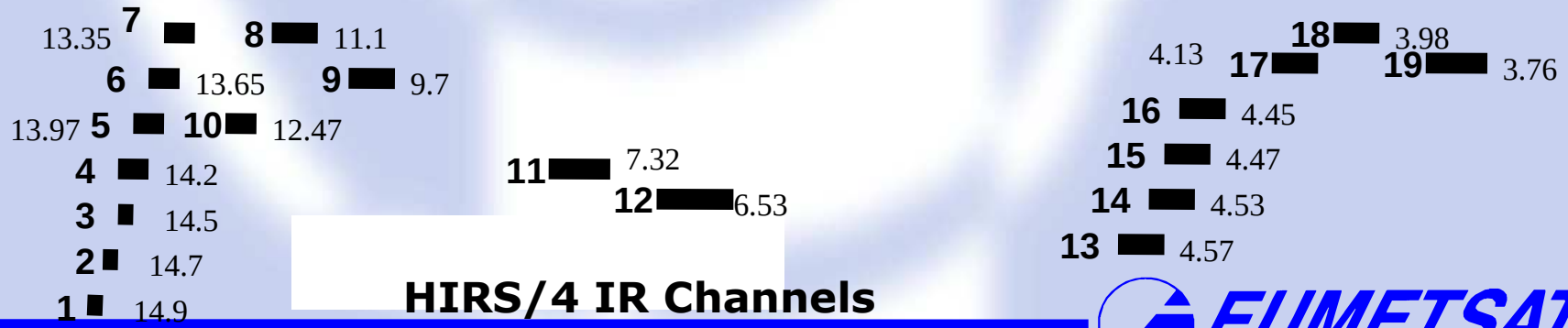
IASI Spectral Bands

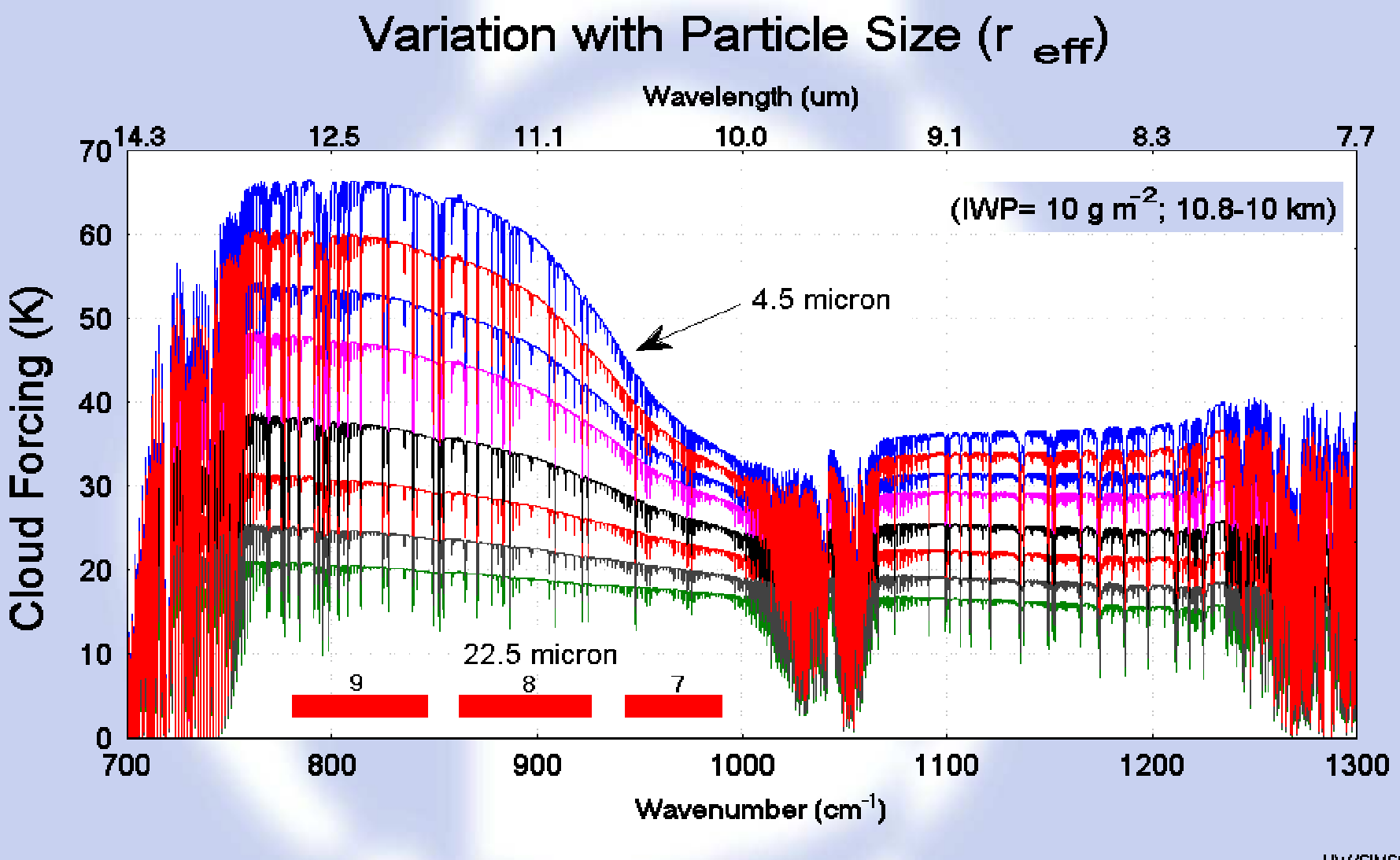




HIRS/4 IR Channels

EUMETSAT

FE LG



Example for enhanced capabilities: Cloud particle size can be derived with high spectral data

and much more satellite data ...

Thank you for your attention!