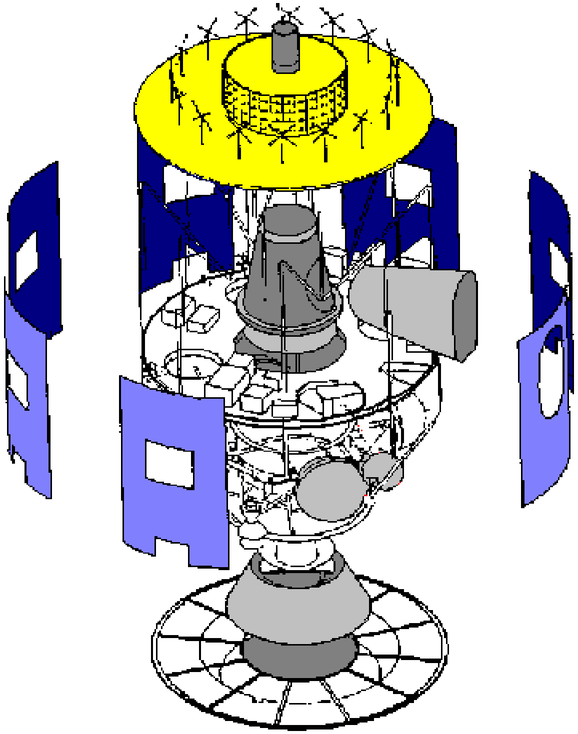
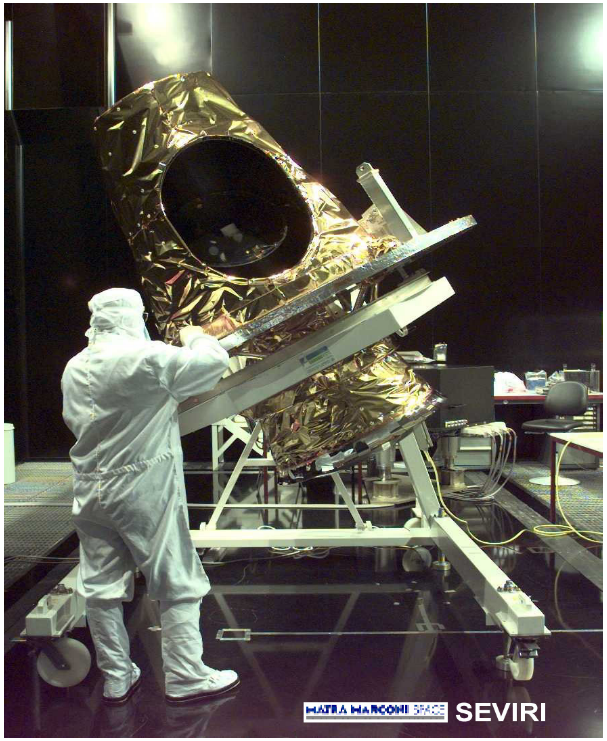
Introducing Meteosat Second Generation

Lectures in Maratea
22 – 31 May 2003

Paul Menzel
NOAA/NESDIS/ORA

SEVIRI

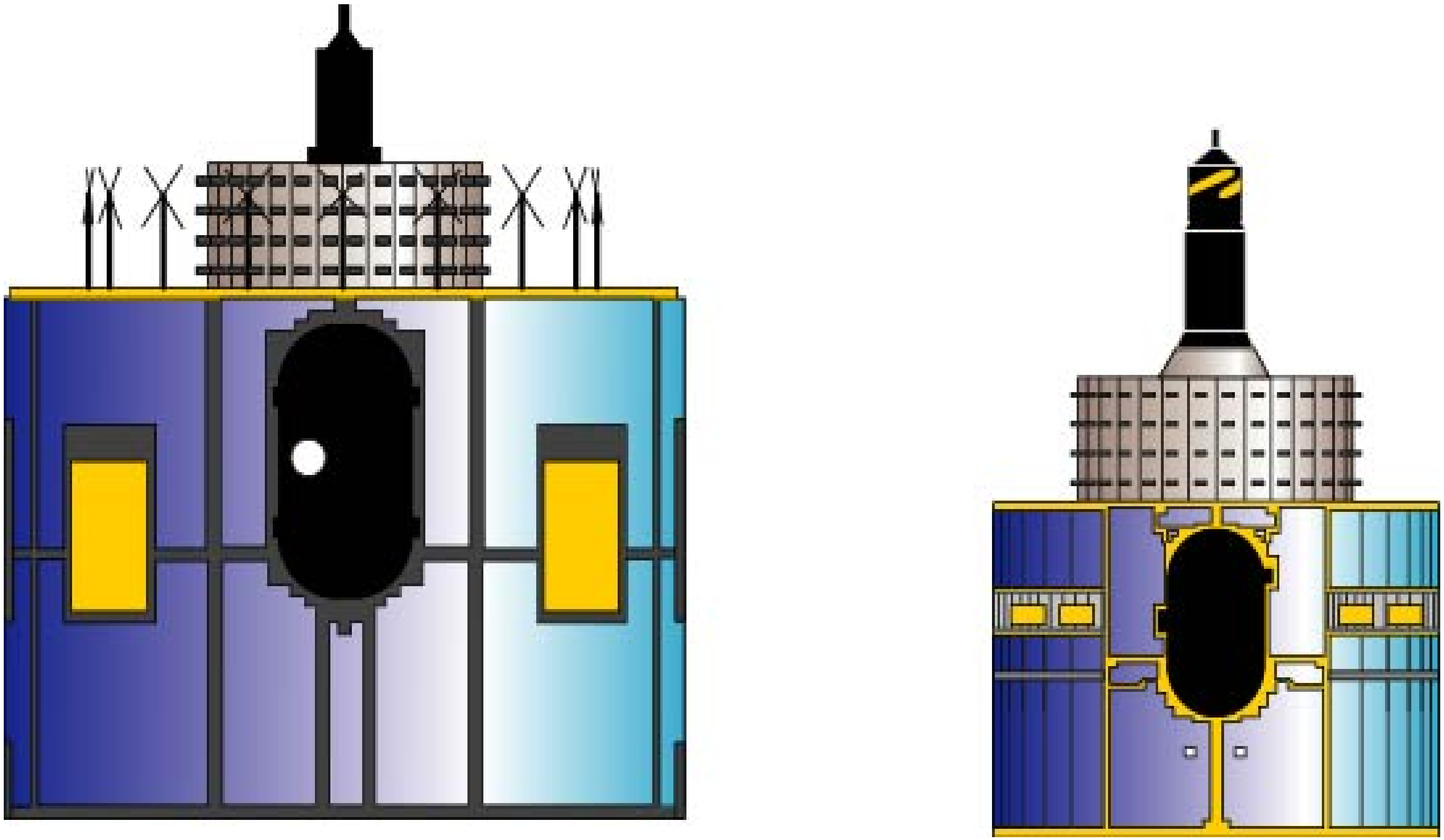




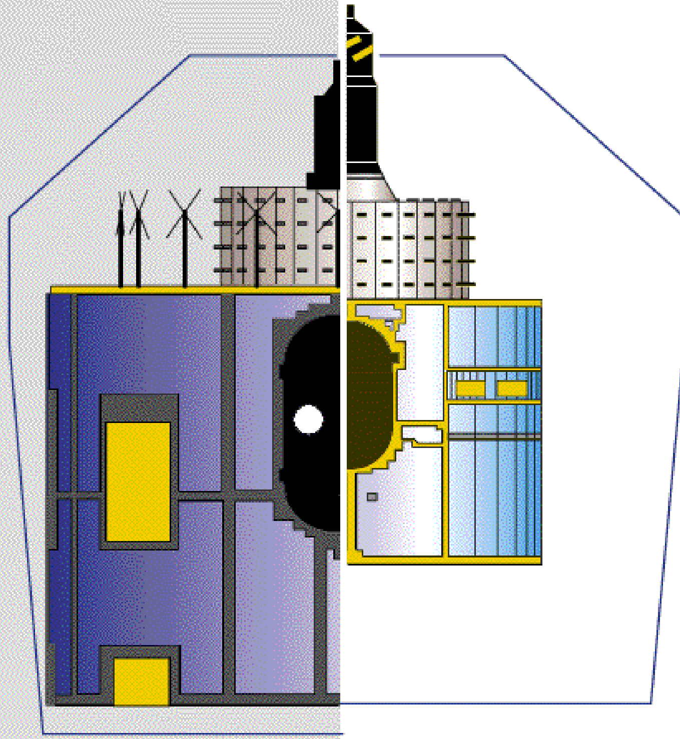
Spinning Enhanced Visible and InfraRed Imager

MSG launch
28 Aug 2002

Evolving from Meteosat to MSG



From Meteosat Ops to MSG: comparison



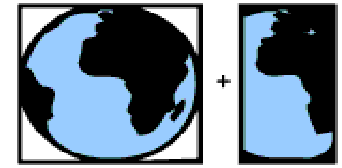
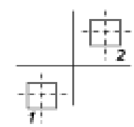
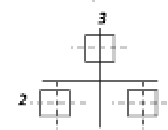
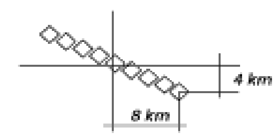
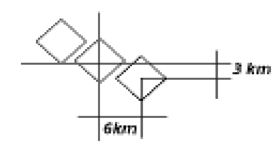
MSG

- 12 channels enhanced imaging and pseudo sounding radiometer.
- 100 rpm spin stabilized body
- Bi-propellant unified propulsion system
- 500W power demand
- 2000kg in GTO
- Design compatibility with Ariane 4 (spelda 10) & Ariane 5

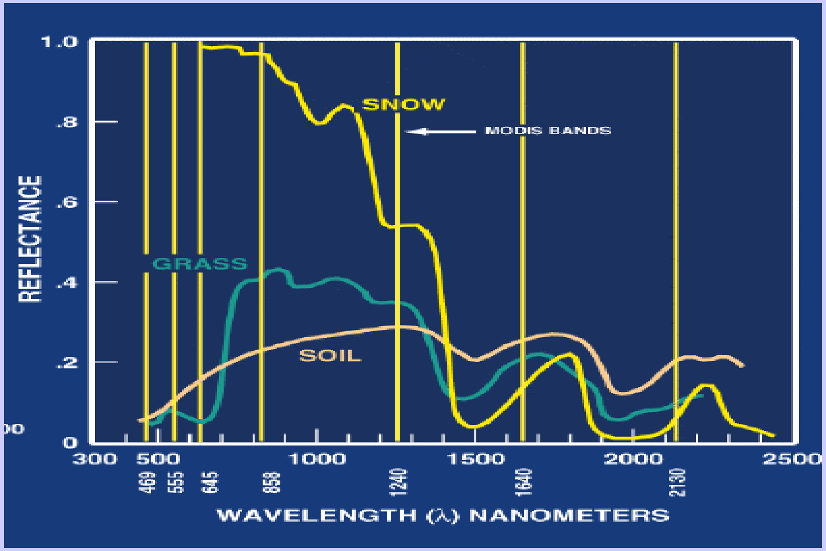
MOP

- 3 channels imaging radiometer
- 100 rpm spin stabilized body
- Solid apogee boost motor
- 200W power demand
- 720 kg in GTO
- Flight qualified with Delta 2914, Ariane 1-3-4

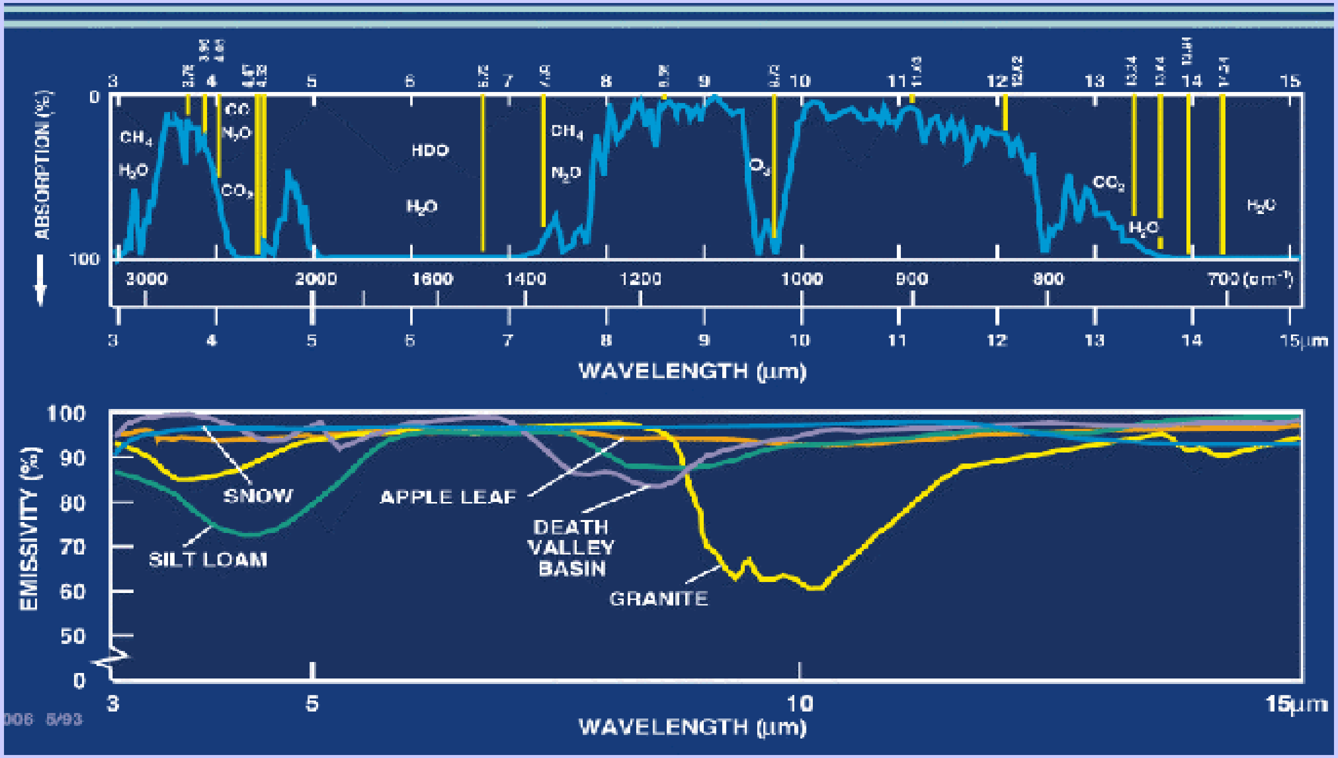
From MOP to MSG: the main improvements

		1 st generation	2 nd generation
IMAGING/PSEUDO SOUNDING MISSION			
Imaging Format Imaging cycle		 30 mn	 15 mn
Channels		BROADBAND	
	Visible	0.5 - 0.9	HRV VIS 0.6 VIS 0.8 IR 1.6
	Water Vapour	WV 6.4	WV 6.2 WV 7.3
	IR window	IR 11.5	IR 3.8 IR 8.7 IR 10.8 IR 12.0
	Pseudo sounding		IR 9.7 IR 13.4
Sampling distance		2.25 km (Visible) 4.5 km (IR + WV)	1 KM (HRV) 3 KM (others)
Pixel size		2.25 km (Visible)  5 km (IR + WV) 	1.4 km (HRV)  4.8 km (others) 
Number of detectors		5	42
Telescope diameter		400 mm	500 mm
scan principe		scanning telescope	Scan mirror
DATA CIRCULATION MISSION			
Transmission raw data rate		0.333 Mb/s	3.2 Mb/s
Disseminated image		0.166 Mb/s	1 Mb/s
			Search & Rescue package

	SEVERI Spectral Bands in μm			Applications
	λ_{cen}	λ_{min}	λ_{max}	
HRV	**Broadband visible 0.4 – 1.1 um**			**Surface, clouds, high resolution wind fields**
VIS0.6	**0.635**	**0.56**	**0.71**	**Surface, clouds, wind fields**
VIS0.8	**0.81**	**0.74**	**0.88**	**Surface, clouds, wind fields**
NIR1.6	**1.64**	**1.50**	**1.78**	**Cloud phase**
IR3.9	3.90	3.48	4.36	Surface, clouds
WV6.2	6.25	5.35	7.15	Water vapour, clouds, atmospheric instability, wind fields
WV7.3	7.35	6.85	7.85	Water vapour, atmospheric instability
IR8.7	8.70	8.30	9.10	Clouds, atmospheric instability
IR9.7	9.66	9.38	9.94	Ozone
IR10.8	10.80	9.80	11.80	Surface, clouds, wind fields, atmospheric instability
IR12.0	12.00	11.00	13.00	Surface, clouds, wind fields, atmospheric instability
IR13.4	13.40	12.40	14.40	High level clouds, atmospheric instability



MSG



HRV	Broadband
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NIR1.6	1.64
IR3.9	3.90
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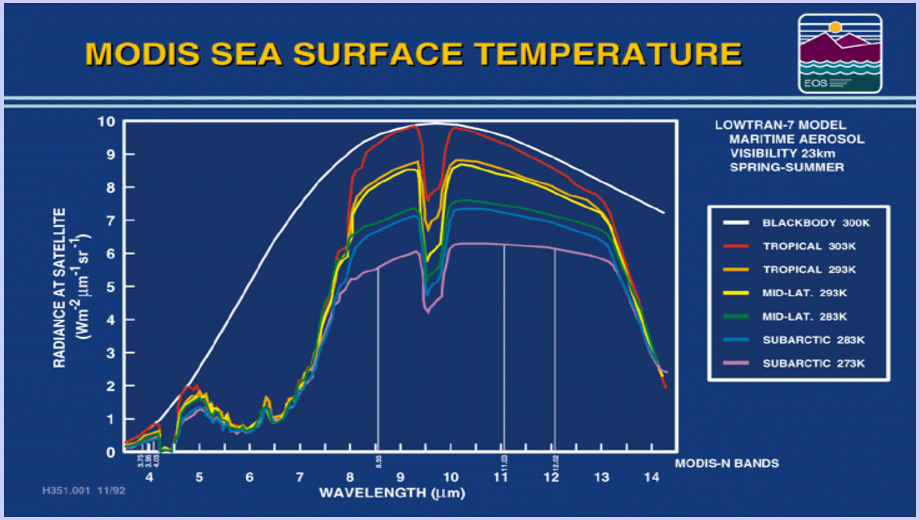
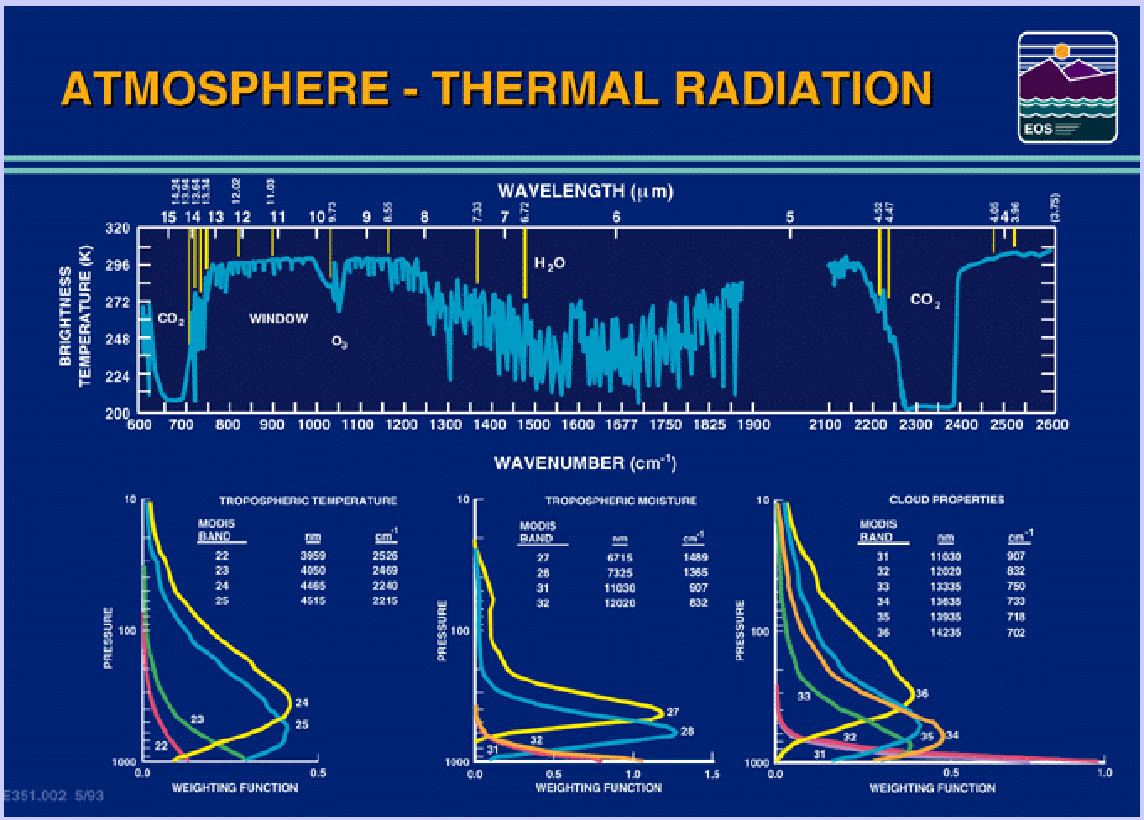
IR12.0	12.00
IR13.4	13.40





MSG

HRV	Broadband
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IR8.7	8.70
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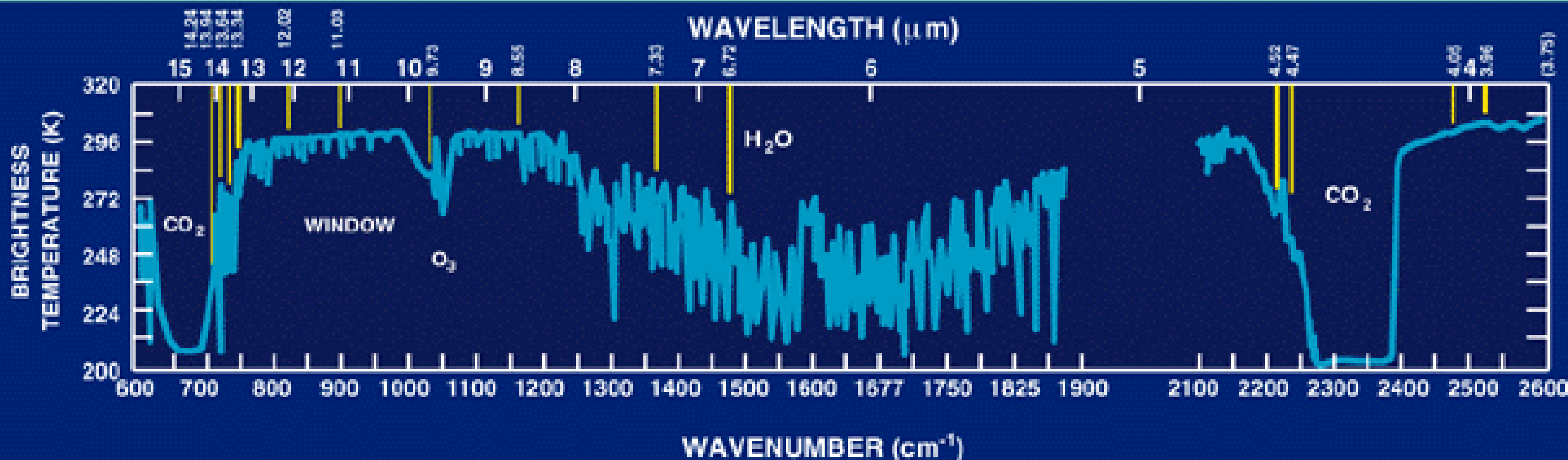
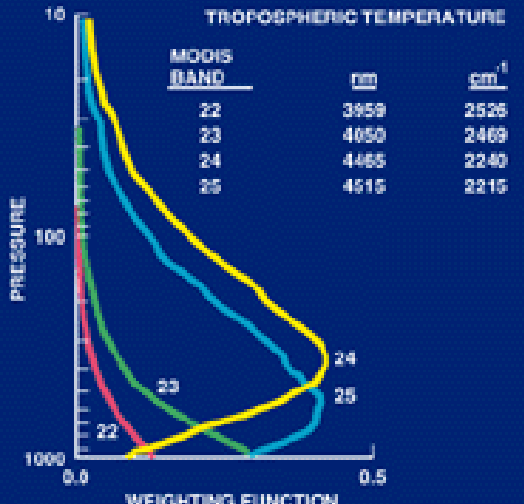
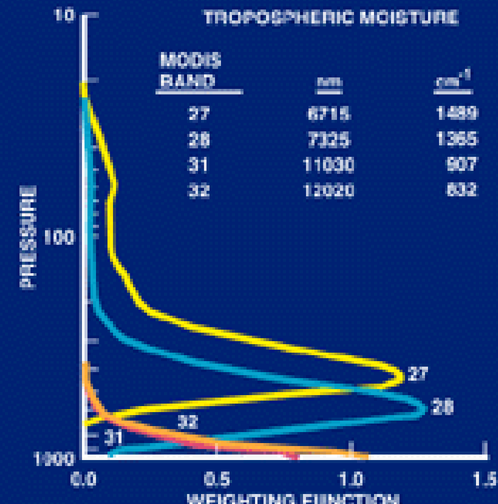
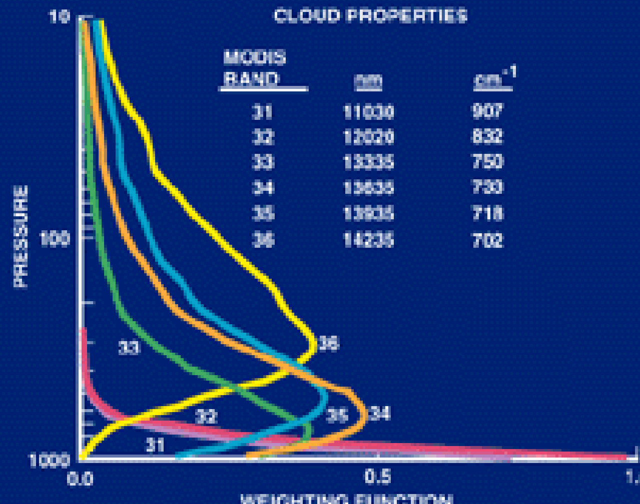
IR10.8	10.80
IR12.0	12.00
IR13.4	13.40

ATMOSPHERE - THERMAL RADIATION



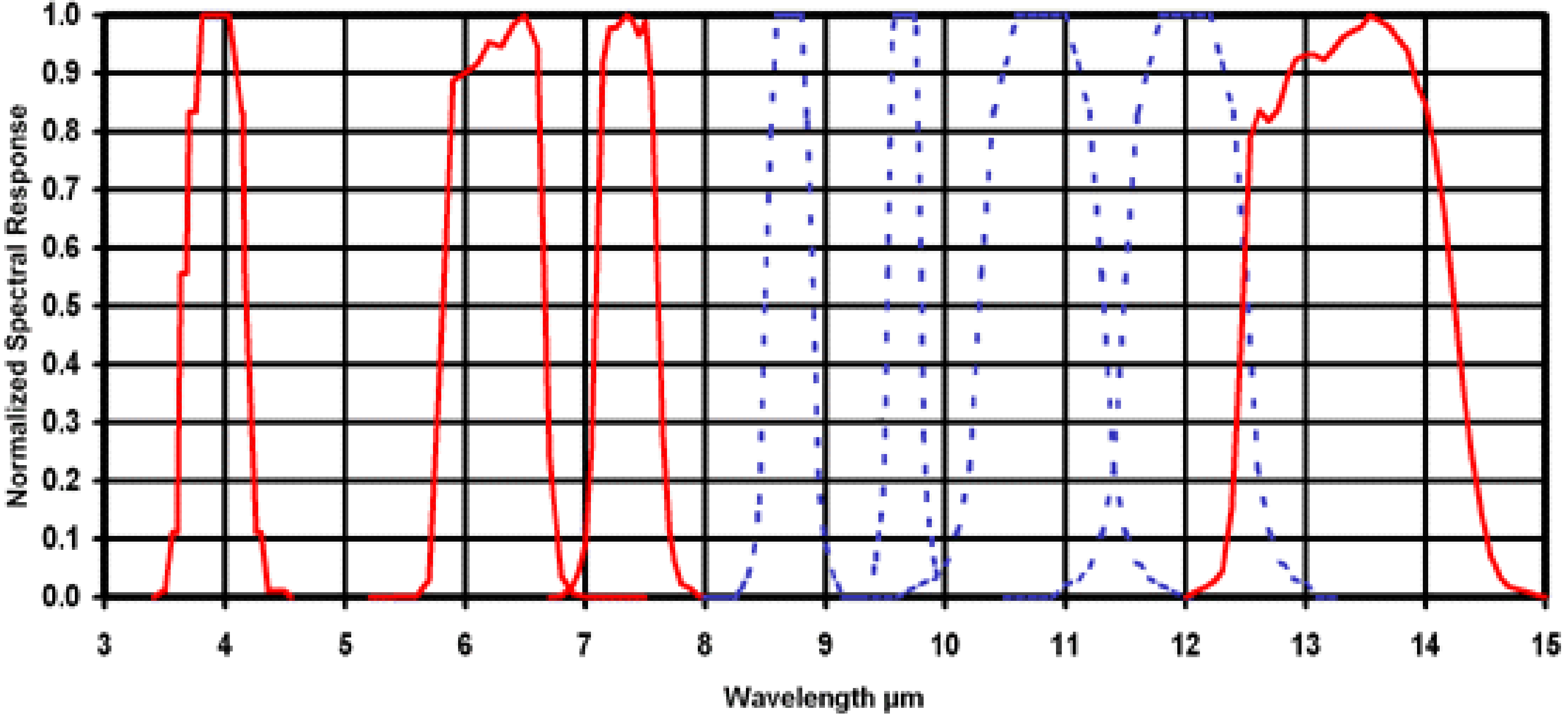




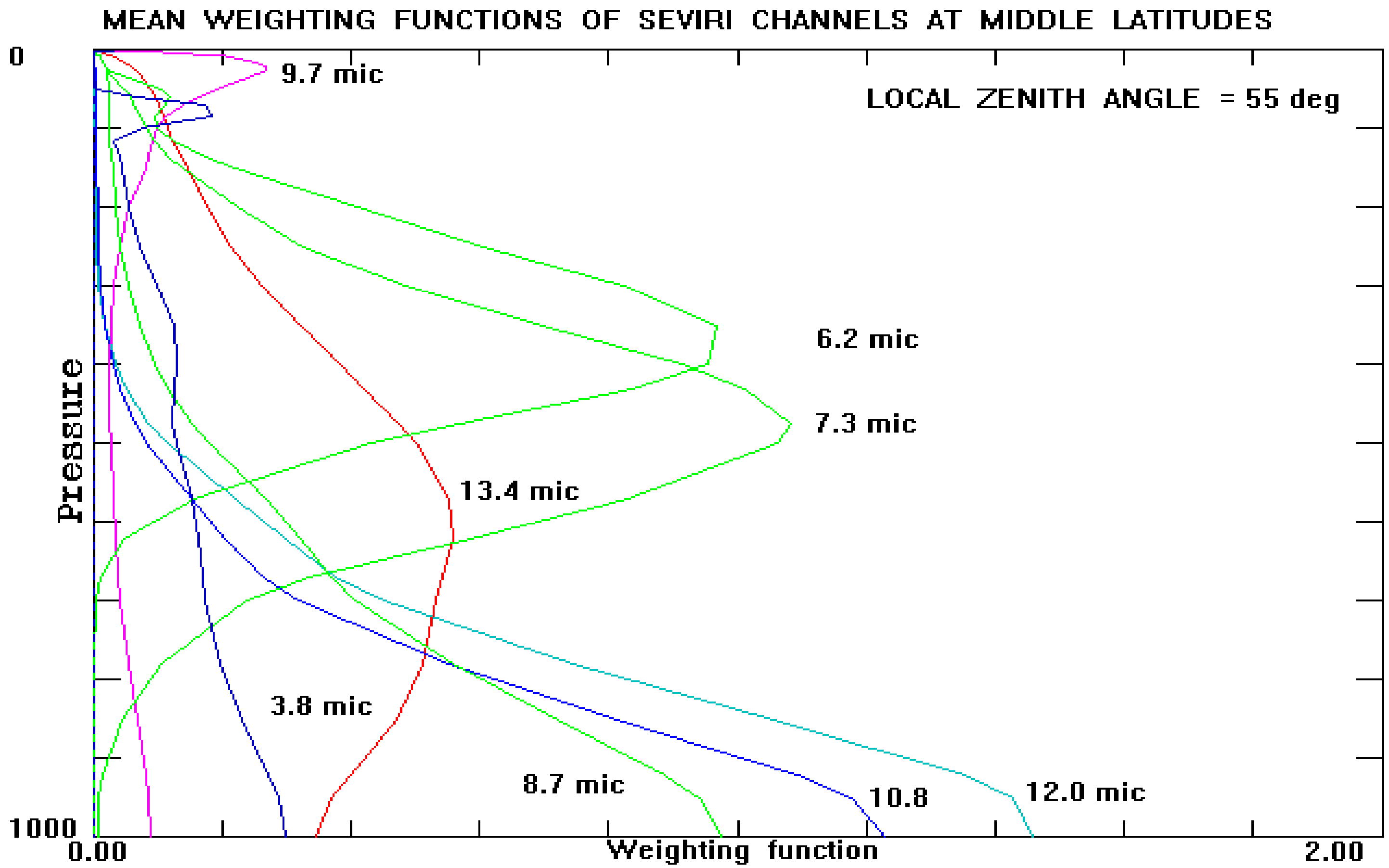


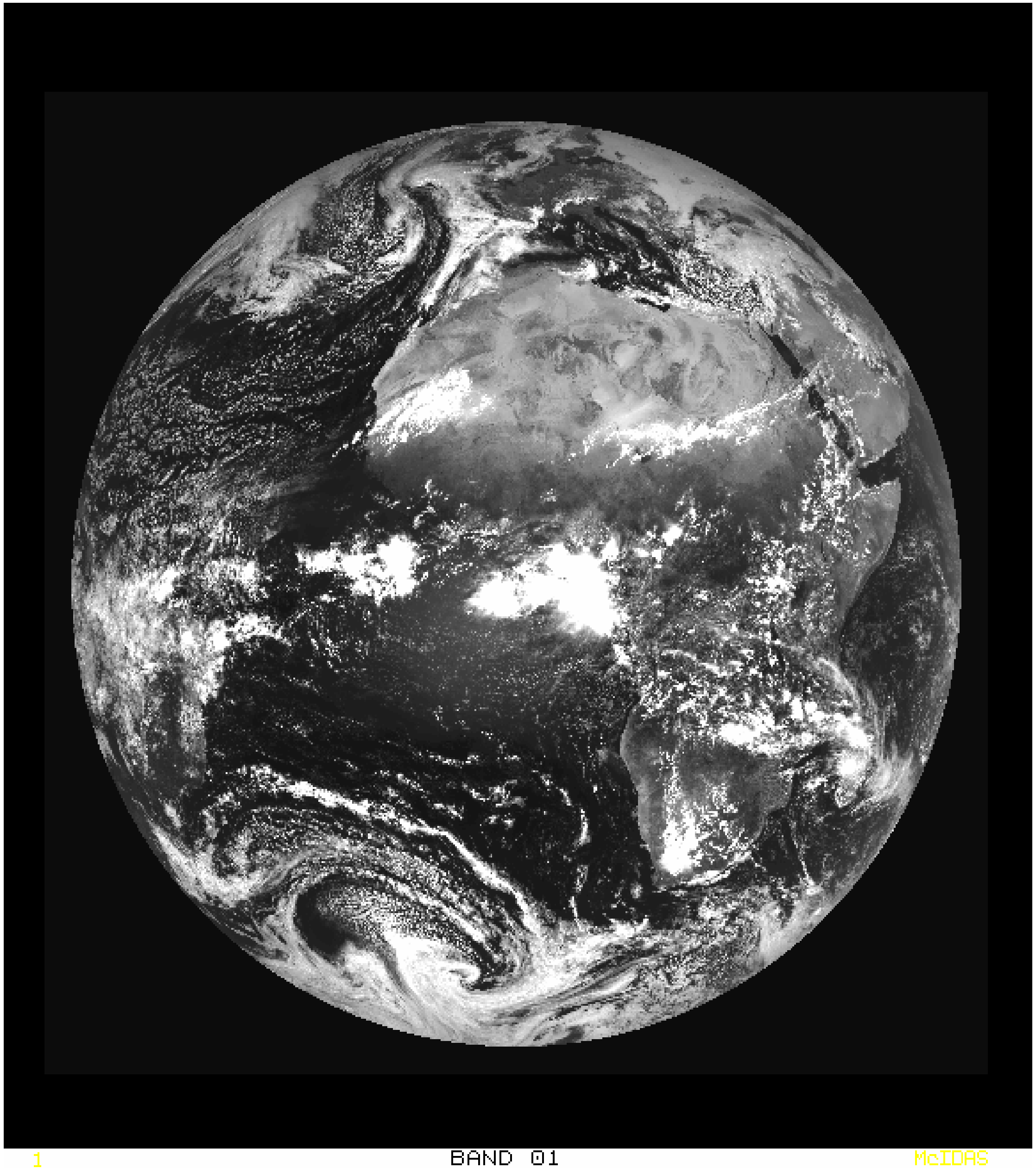
E351.002 5/93

MSG IR Spectral Bands



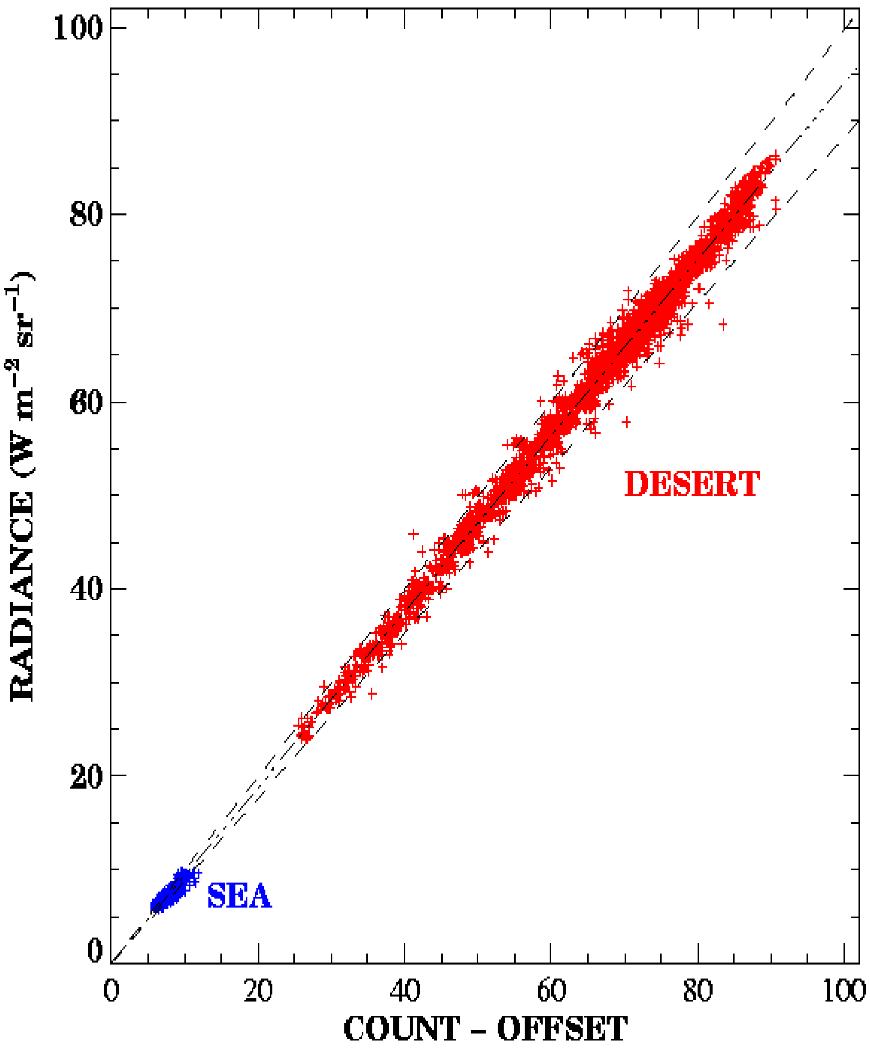
SEVIRI Channels Weighting Functions

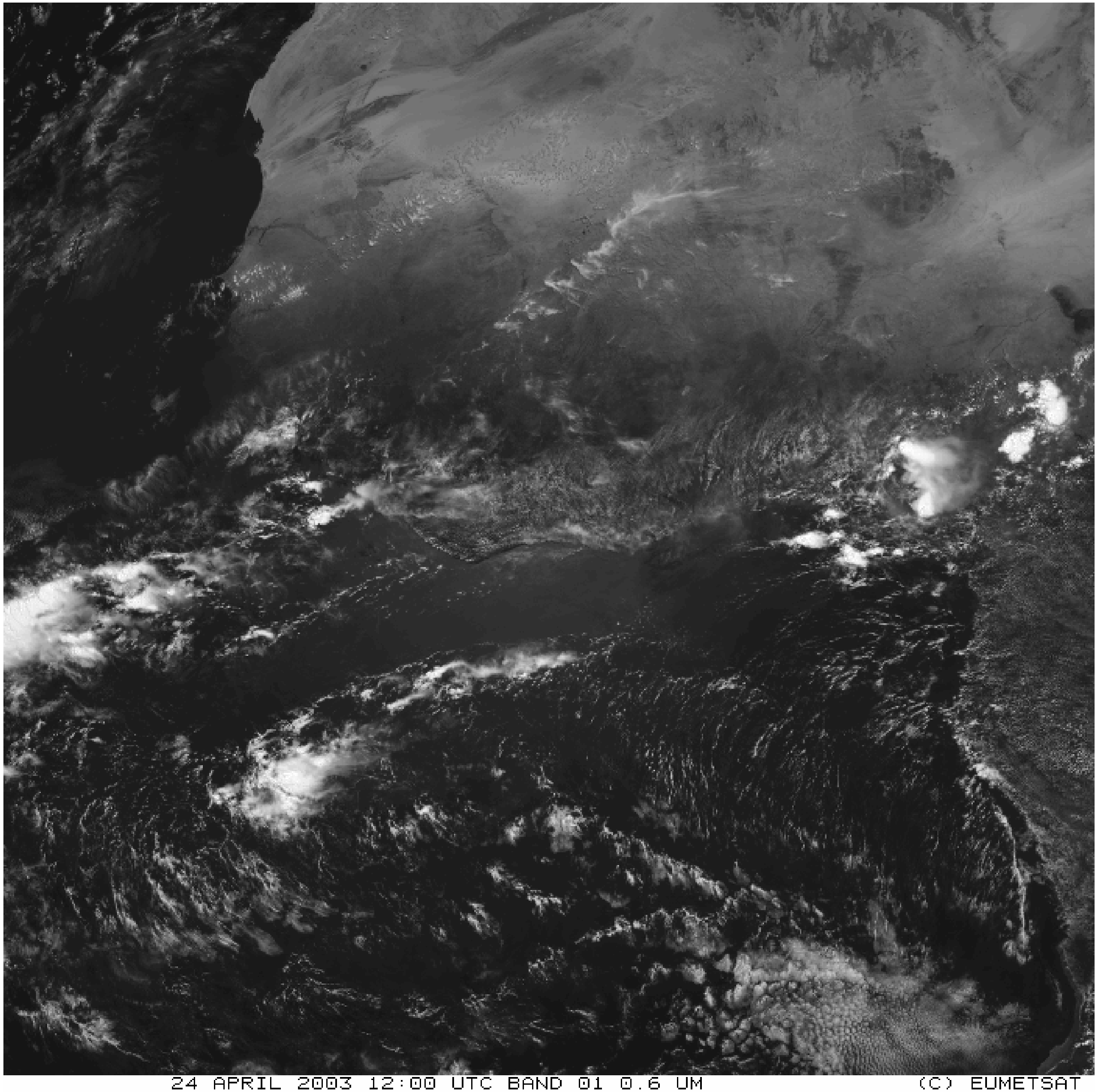




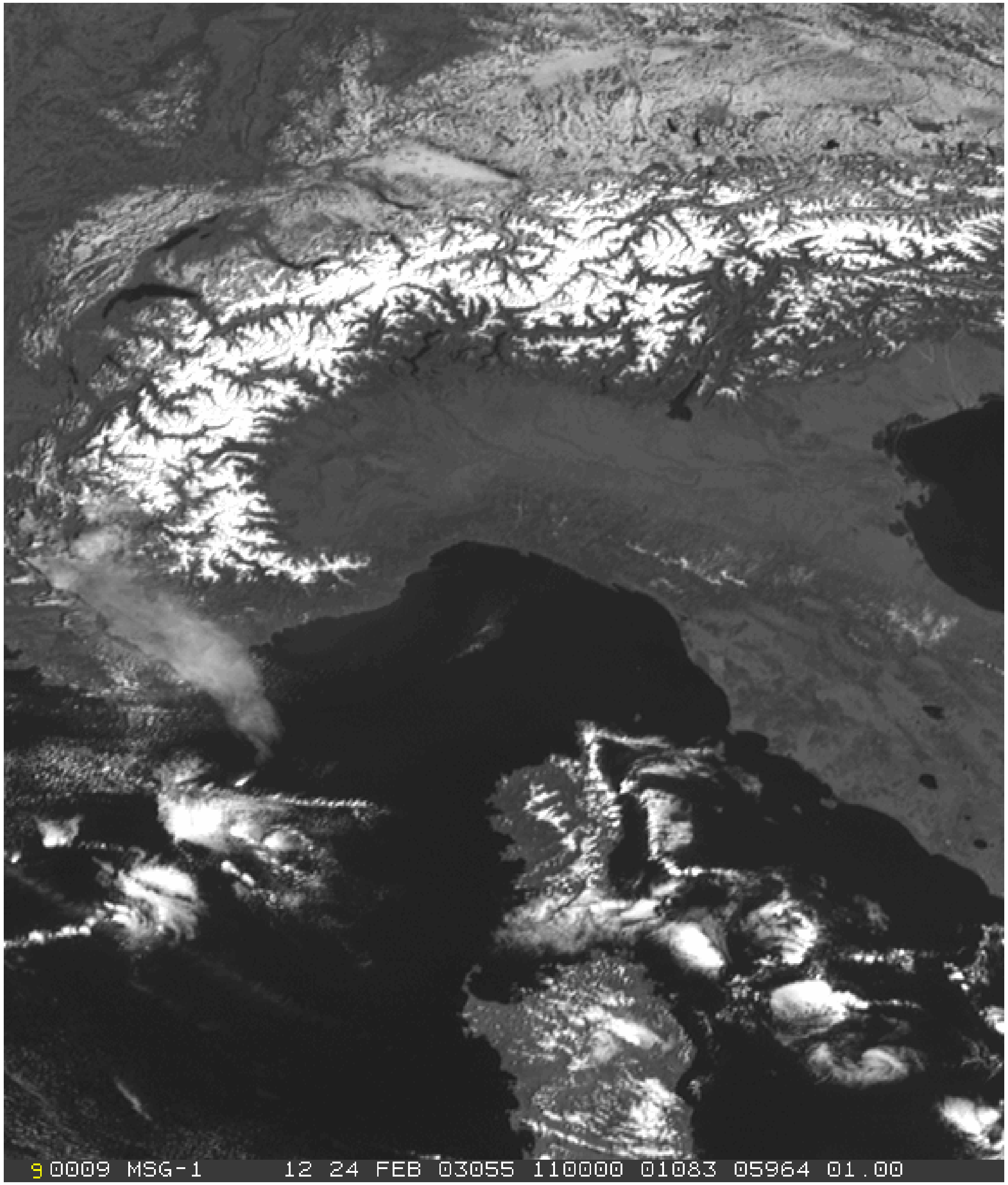
Sequence of all channels

- Thermal IR channels use on-board calibration: Accuracy: about 1K
- Solar channels use vicarious calibration Accuracy: toward 5%





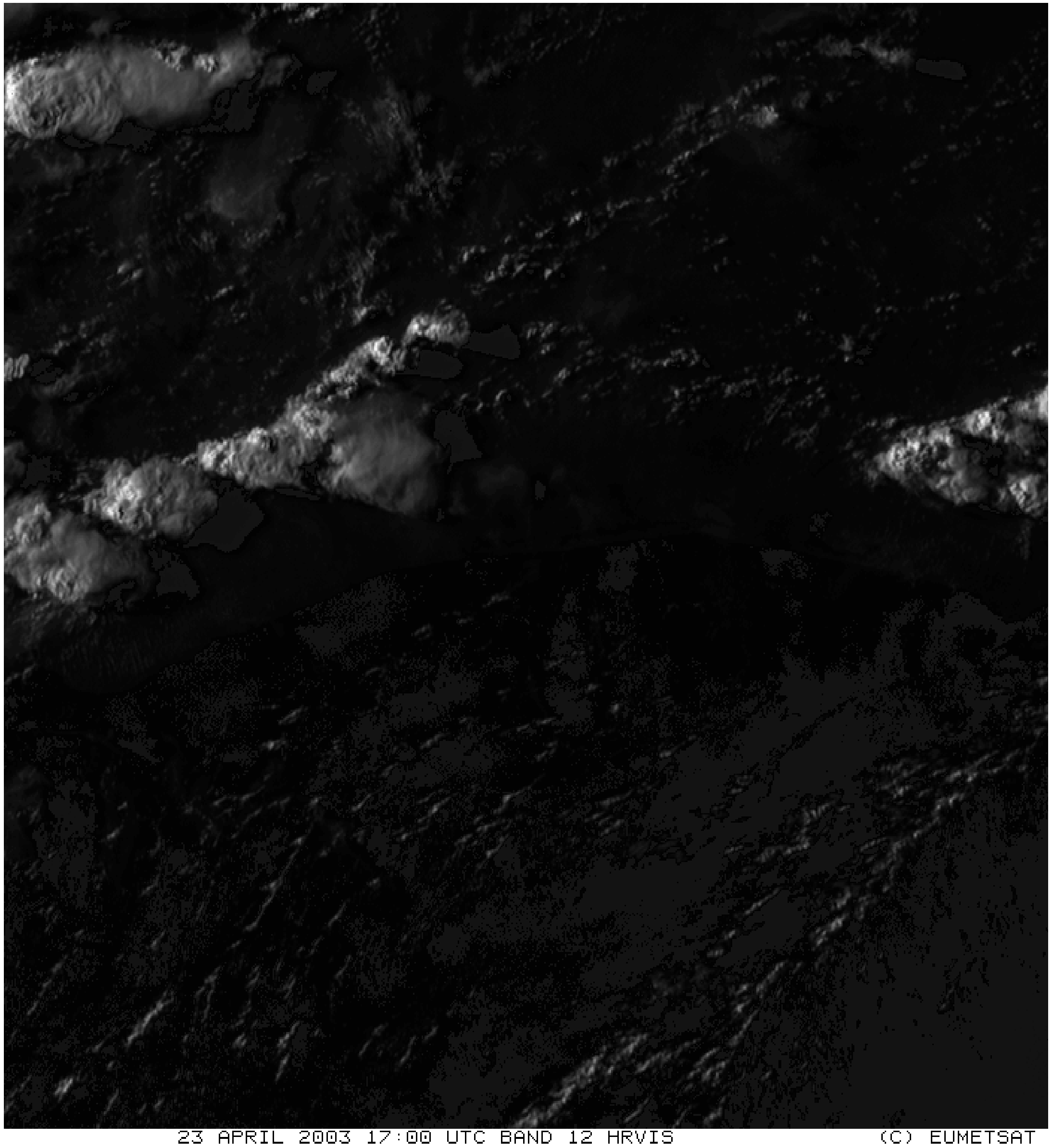
SEVIRI Channels 1 - 11 on MSG-1 24 Apr 03



HRV sequence over the Alps

12 Feb 2002

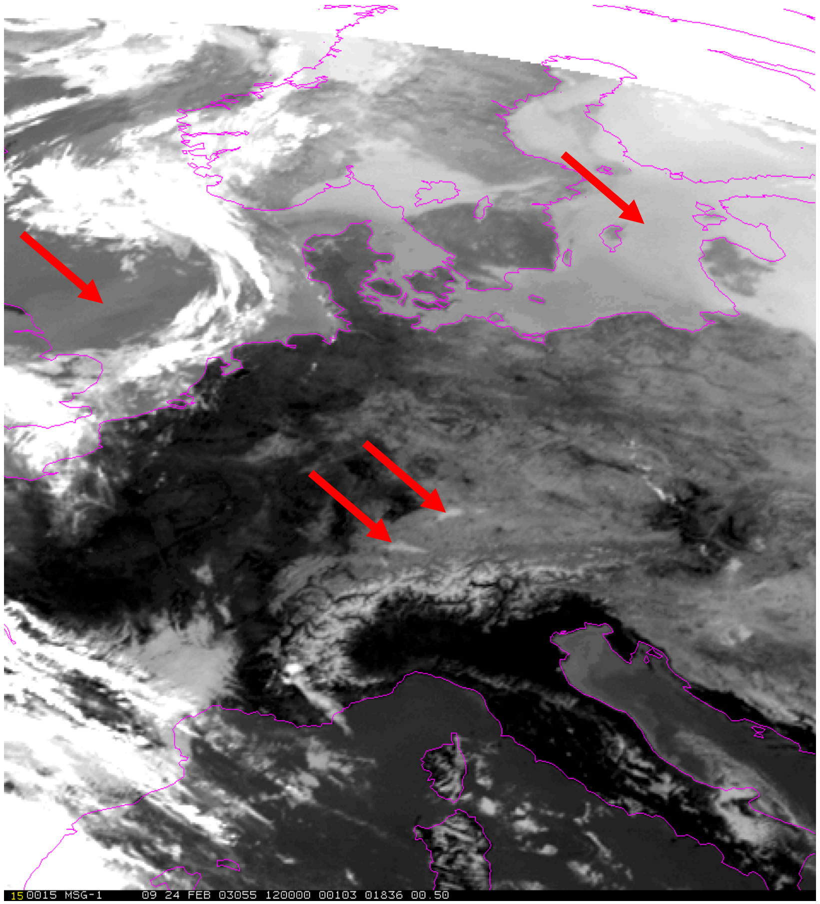
from 11:00 to 12:45 UTC



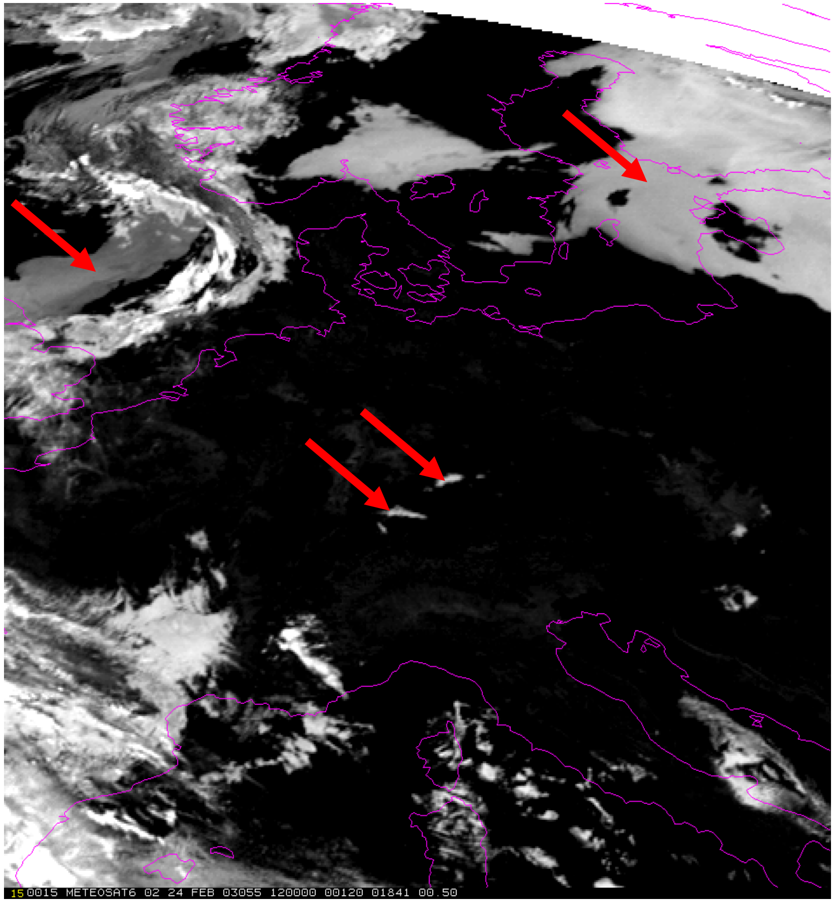
24 hours of MSG HRV over the tropics

Sea Breeze

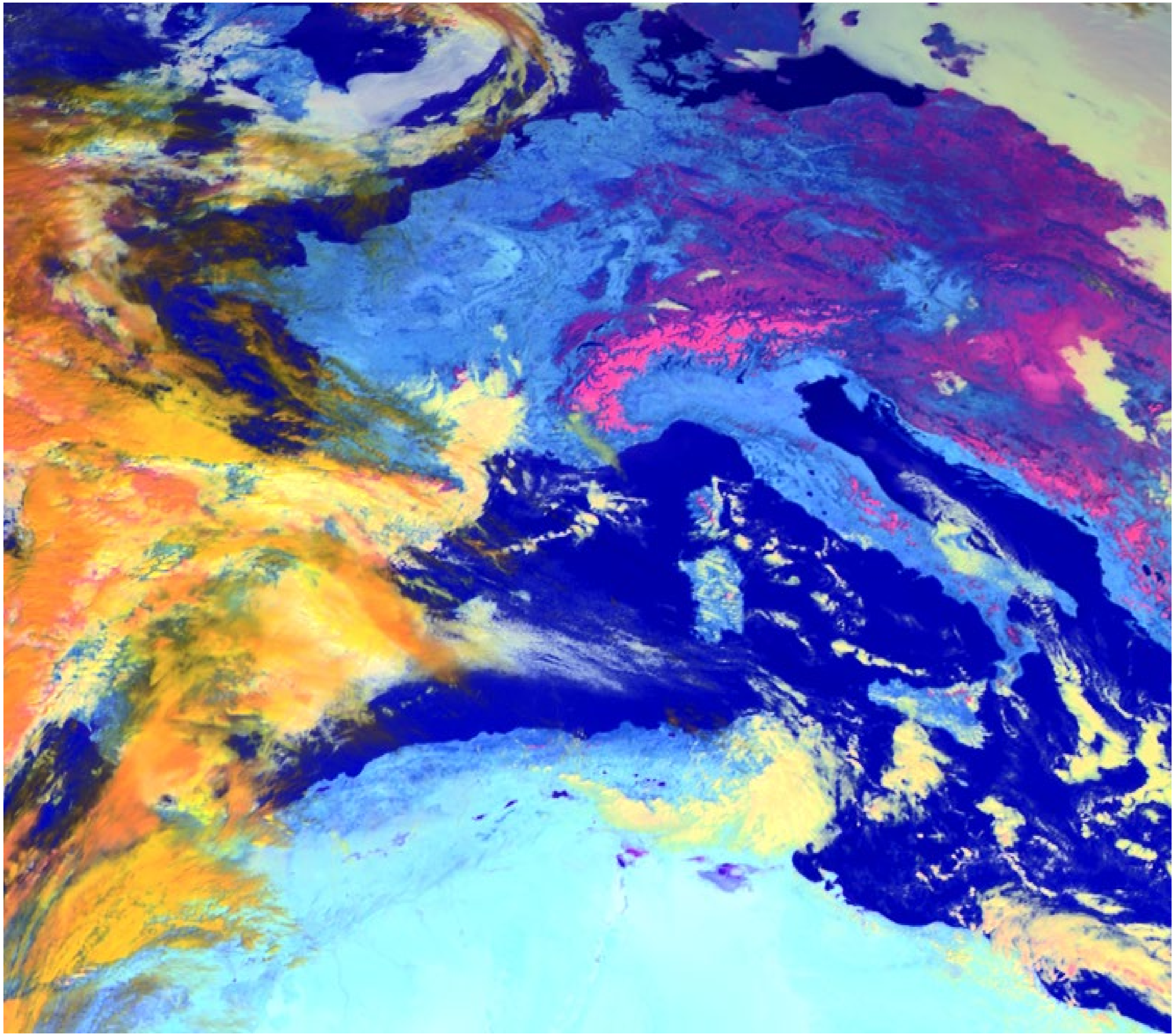
Example of fog detection



MSG 10.8 µm channel only

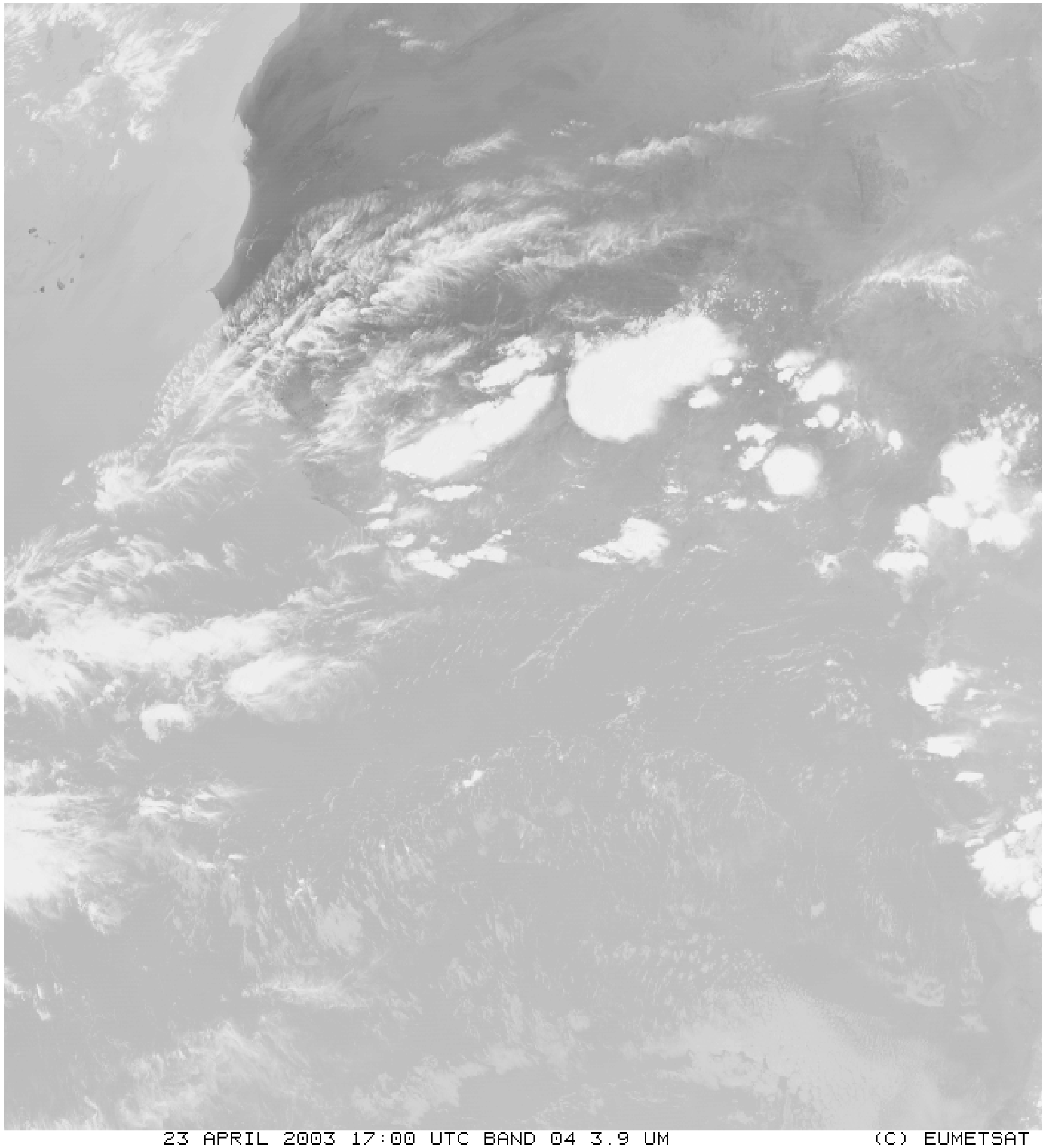


3.9 minus 10.8 µm channel



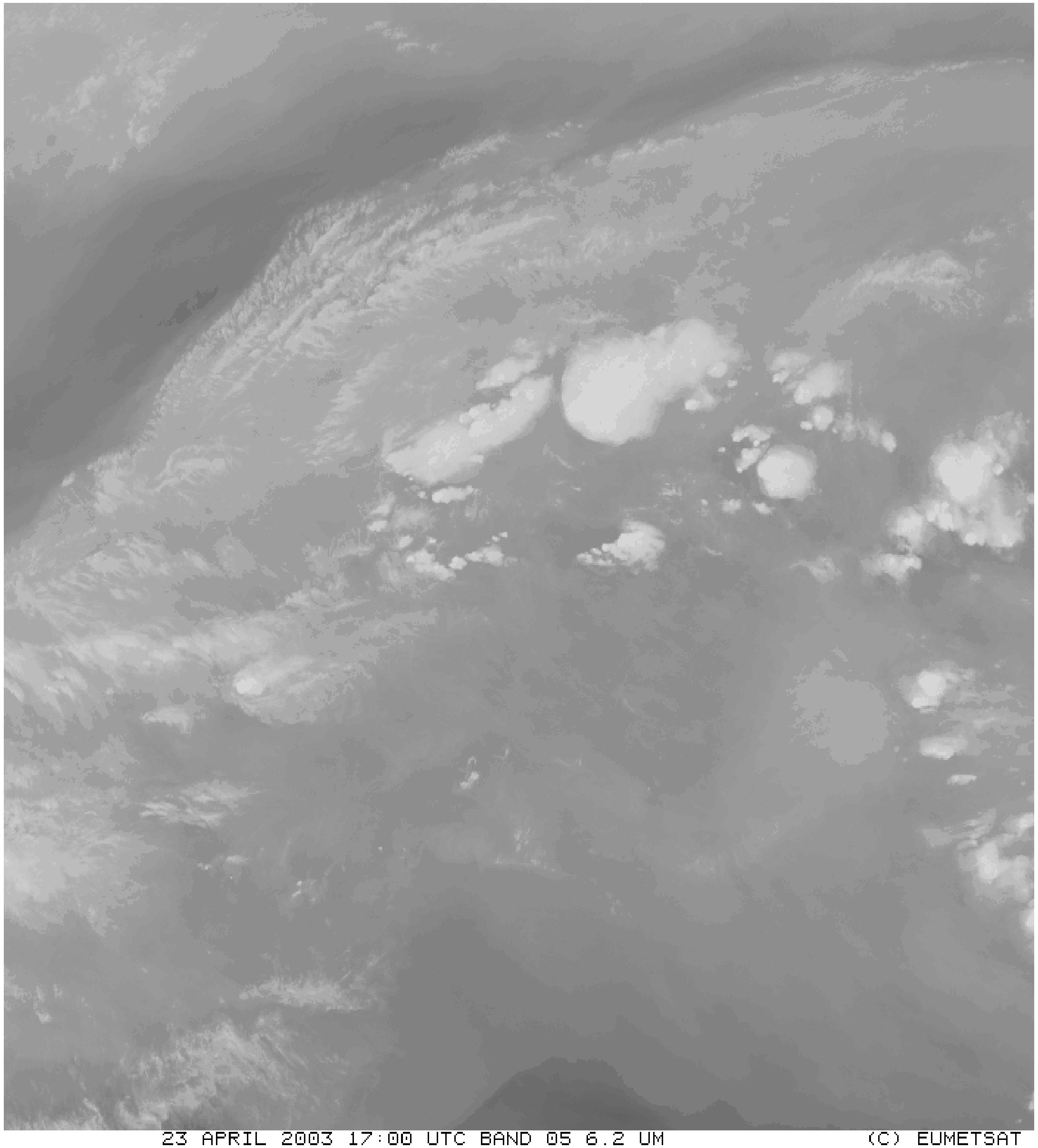
MSG
24 Feb 03

red = 0.6 µm
green = 1.6 µm
blue = 10.8 µm



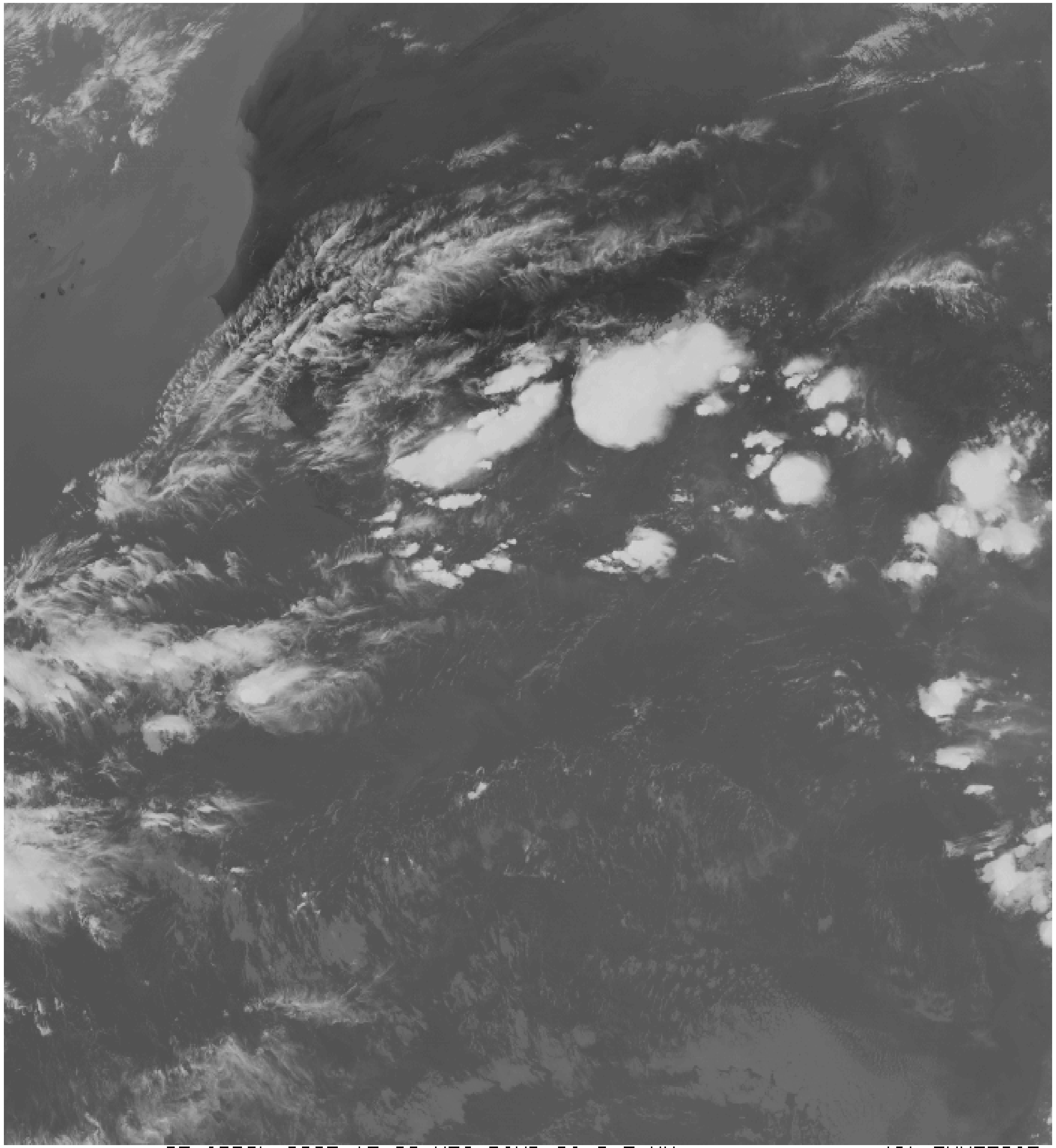
24 hr sequence of MSG 3.9 µm over the tropics

Sun-glint;
Diurnal cycle of the low cloud top temps show the reflected solar contribution

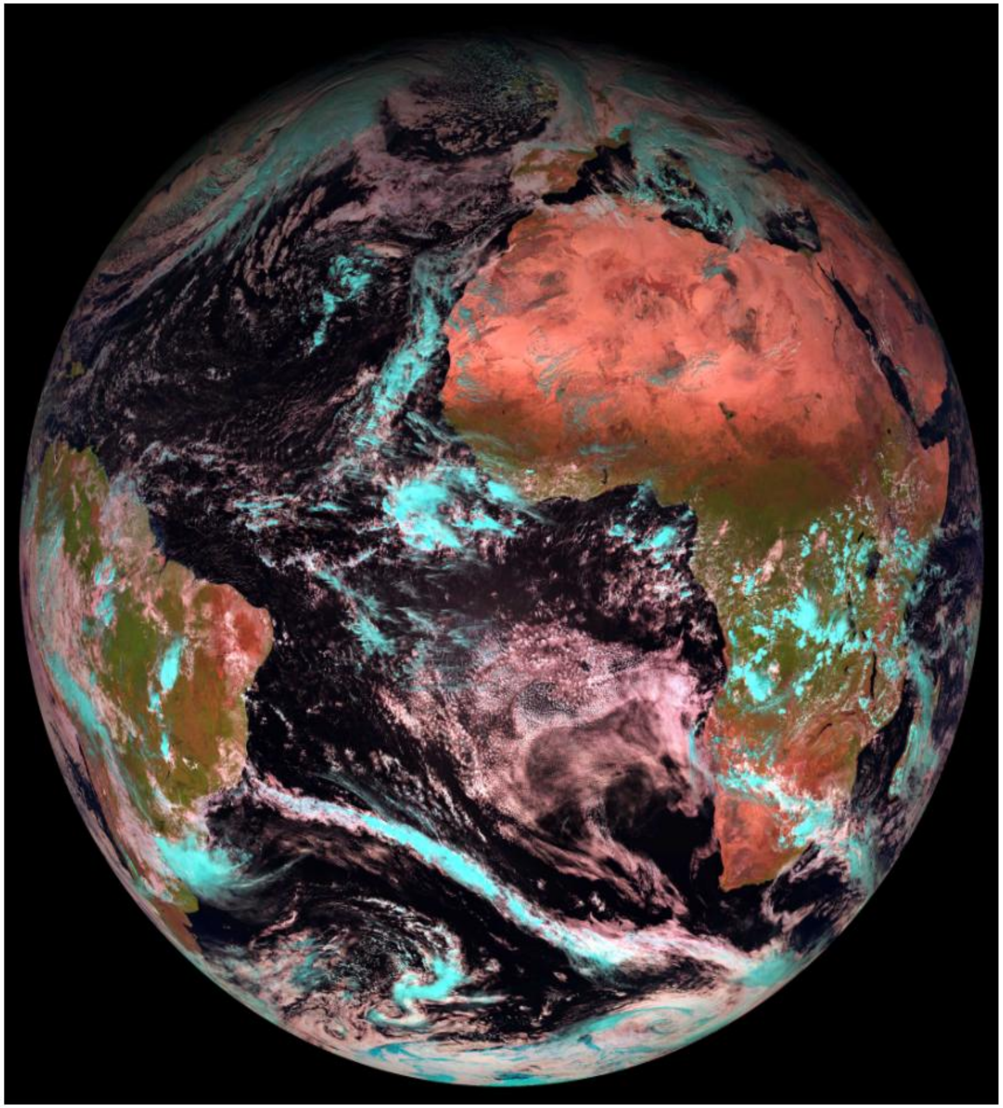


24 hr sequence of MSG 6.2 µm over the tropics

Build up of convection

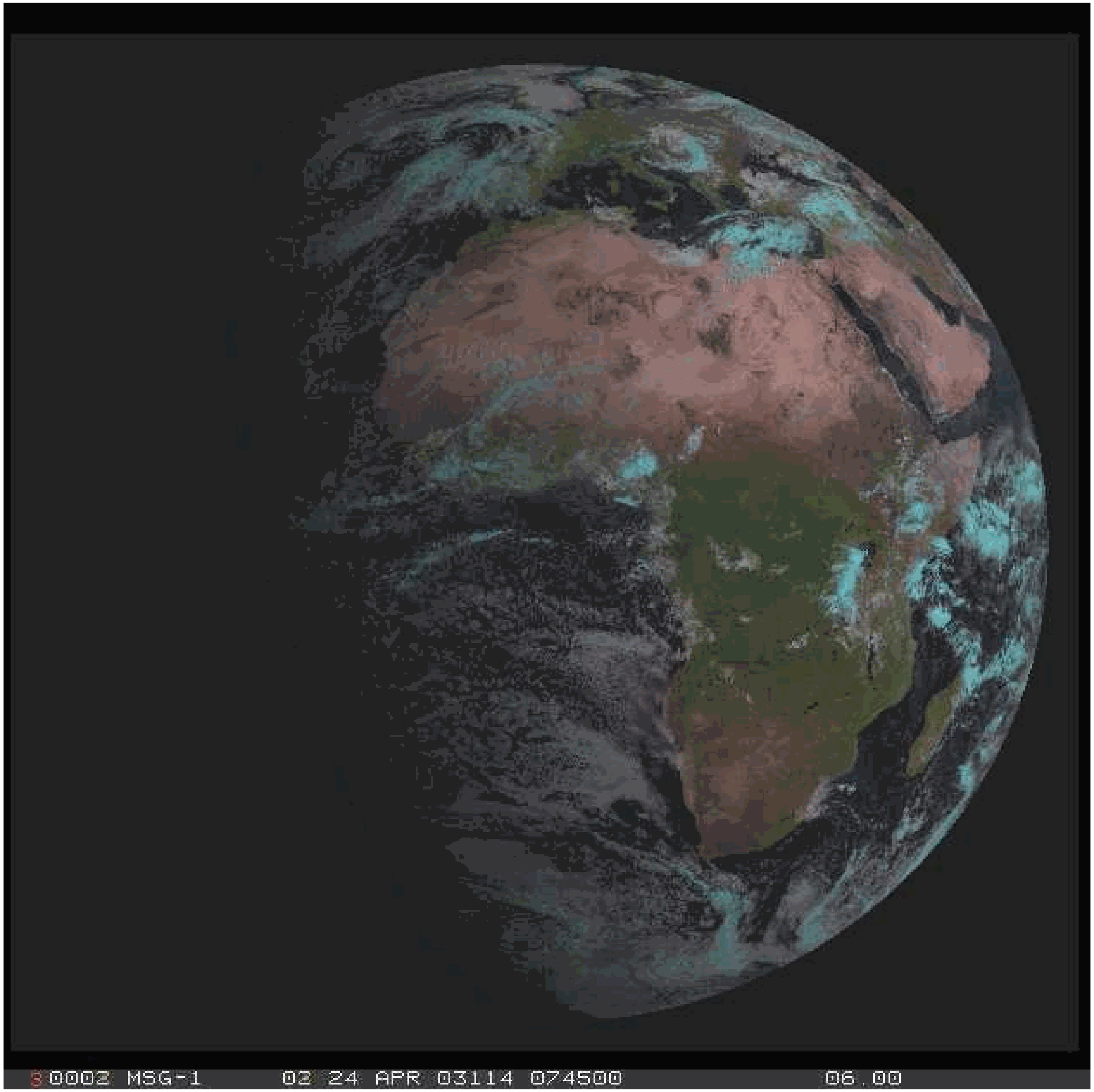


24 hr sequence of MSG 9.7 µm over the tropics



MSG-1 SEVIRI RGB Image:

0.6 µm => blue
0.8 µm => green
1.6 µm => red



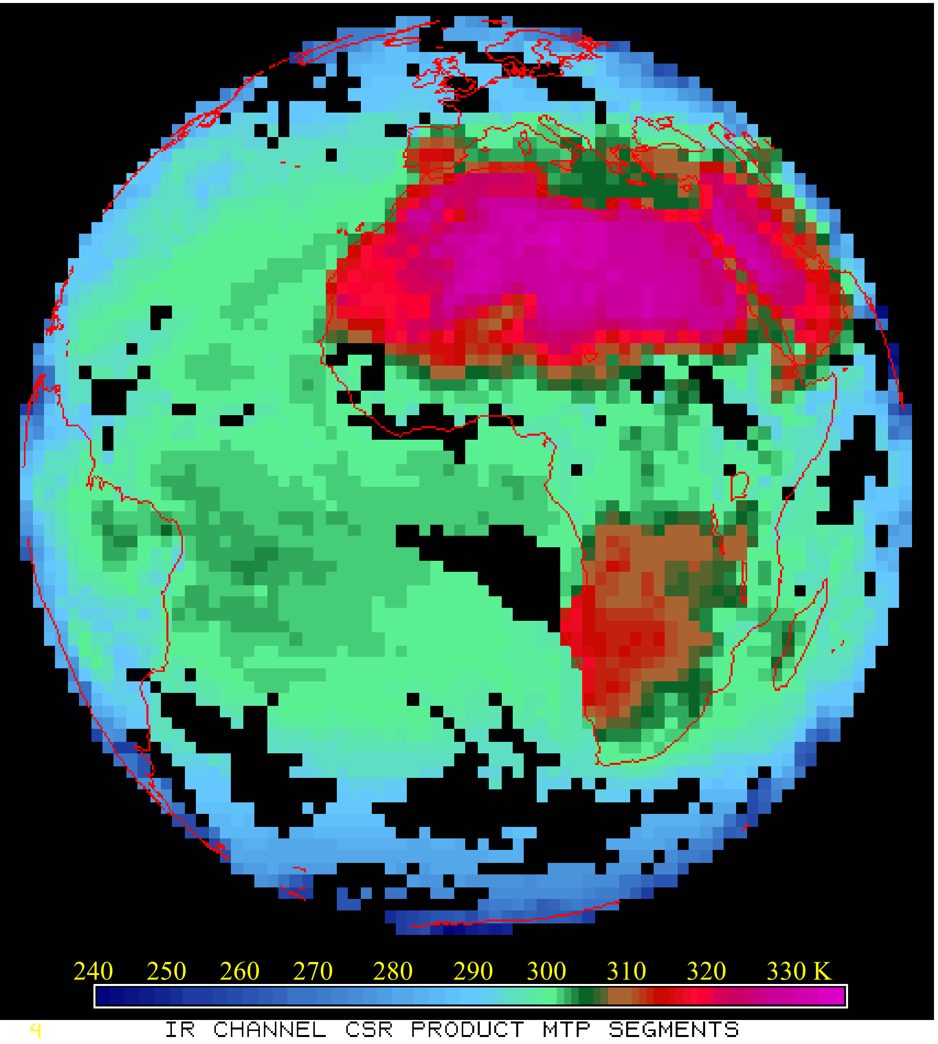
24 hr sequence MSG RGB over the tropics

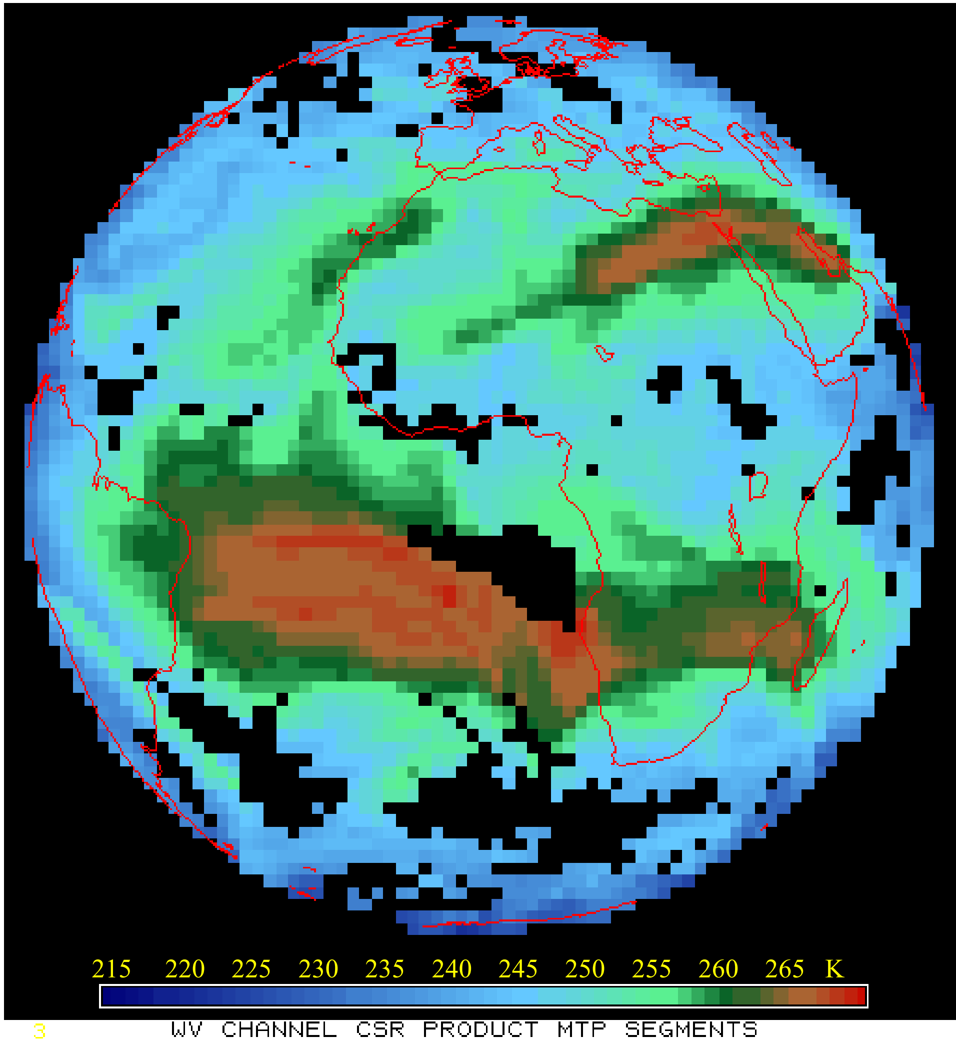
Red
Green
Blue

Products from the Central Processing at EUMETSAT

MPEF = Meteorological Product Extraction Facility

- Atmospheric Motion Vectors (AMV)
- Calibration Monitoring (CAL-MON)
- Clear Sky Radiance (CSR)
- Climate Data Set (CDS)
- Cloud Analysis (CLA)
- Cloud Top Height (CTH)
- Global Instability (GI)
- ISCCP Data Set (IDS)
- GPCP Precipitation Index (PI)
- Total Ozone (TOZ)
- Tropospheric Humidity (TH)



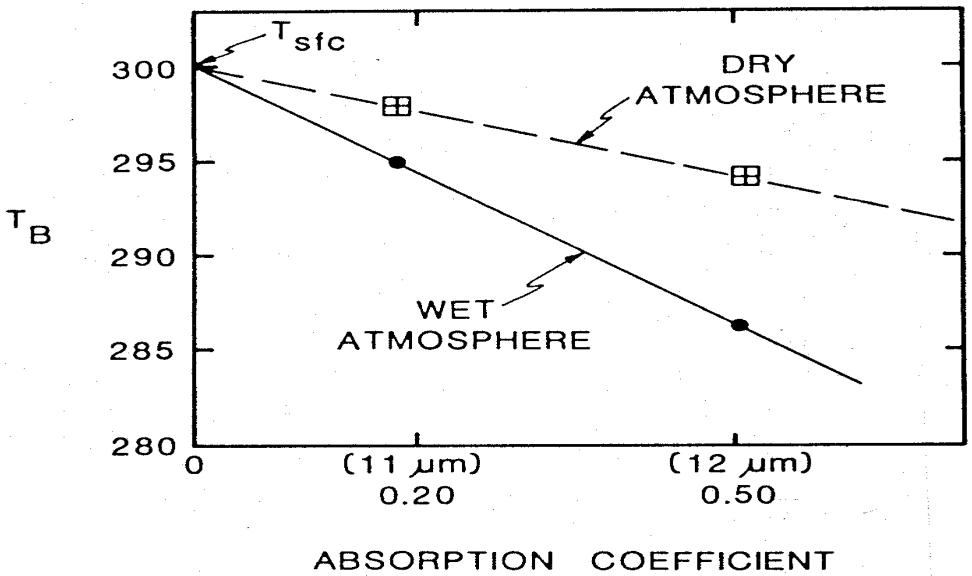


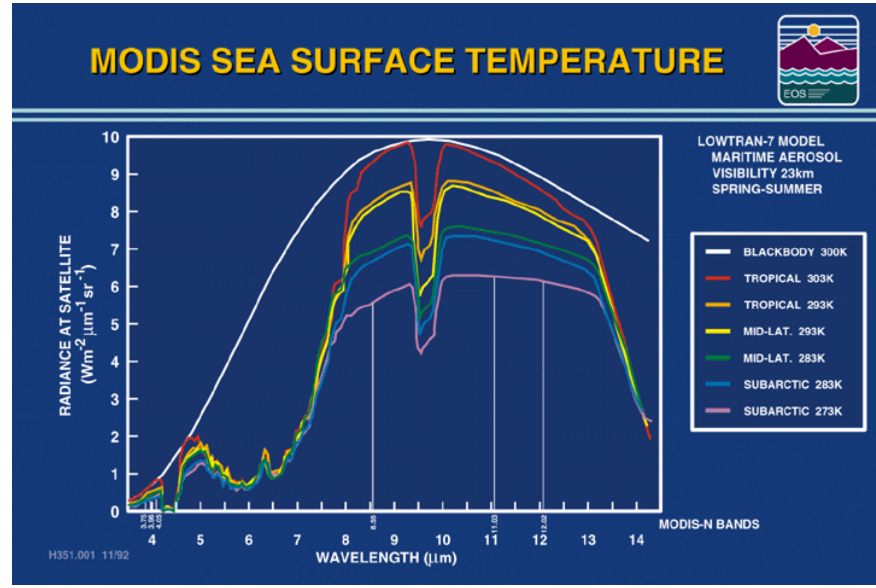
IR window

WV

Clear sky radiances

for image segments





Detecting Clouds (IR)

IR Window Brightness Temperature Threshold and Difference Tests

IR tests sensitive to sfc emissivity and atm PW, dust, and aerosols

BT11 < 270

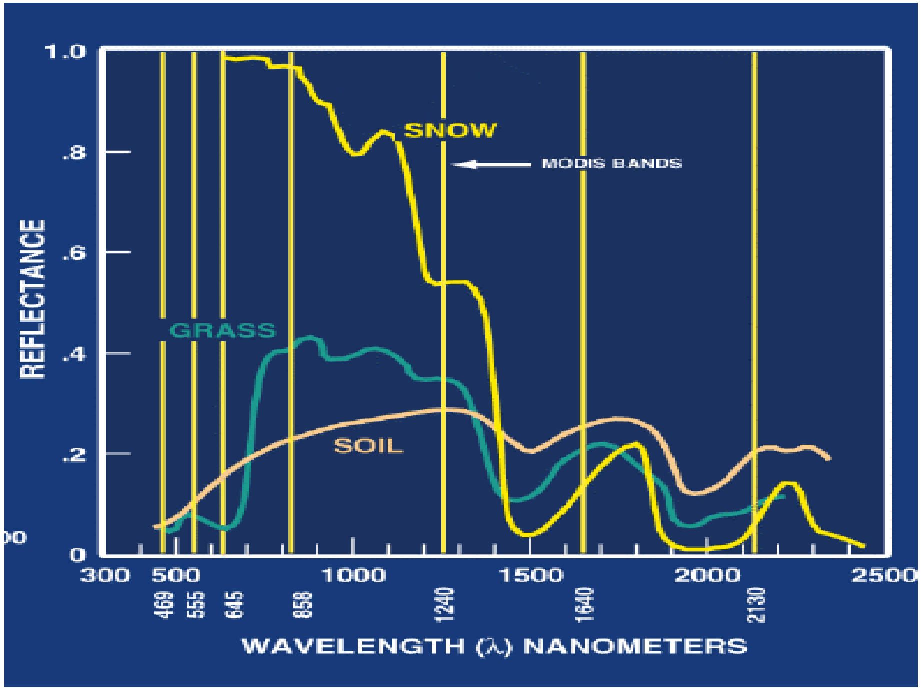
BT11 + aPW * (BT11 - BT12) < SST

BT11 + bPW * (BT11 - BT8.7) < SST

aPW and bPW determined from lookup table as a function of PW

BT3.9 - BT11 > 3 indicates presence of partial or thin cloud cover

BT11 - BT6.3 large neg diff for clr sky over Antarctic Plateau winter and temporal and spatial gradients of IRW and WV



Detecting Clouds (vis)

Reflectance Threshold Test

r3.9 > 6% considered to be cloudy and < 3% considered to be snow/ice
problems in bright deserts

Reflectance Ratio Test

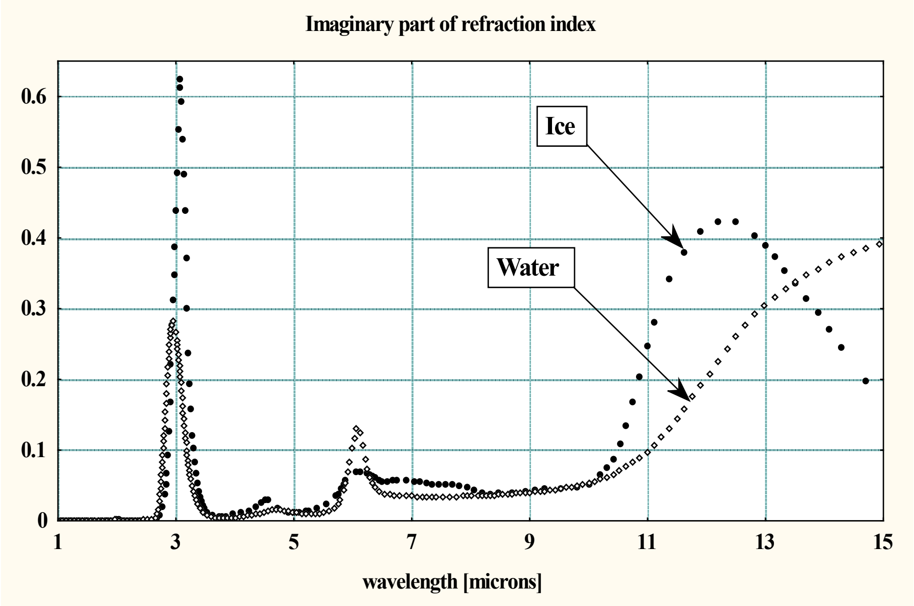
r.84/r.63 between 0.9 and 1.1 for cloudy regions
must be ecosystem specific

Snow Test

NDSI = [r.63-r1.6]/ [r.63+r1.6] > 0.4 and r.84 > 0.1 then snow

Estimating Cloud Properties

13.3/11 ratio reveals p_c cloud top pressure (since ε11~ε13)



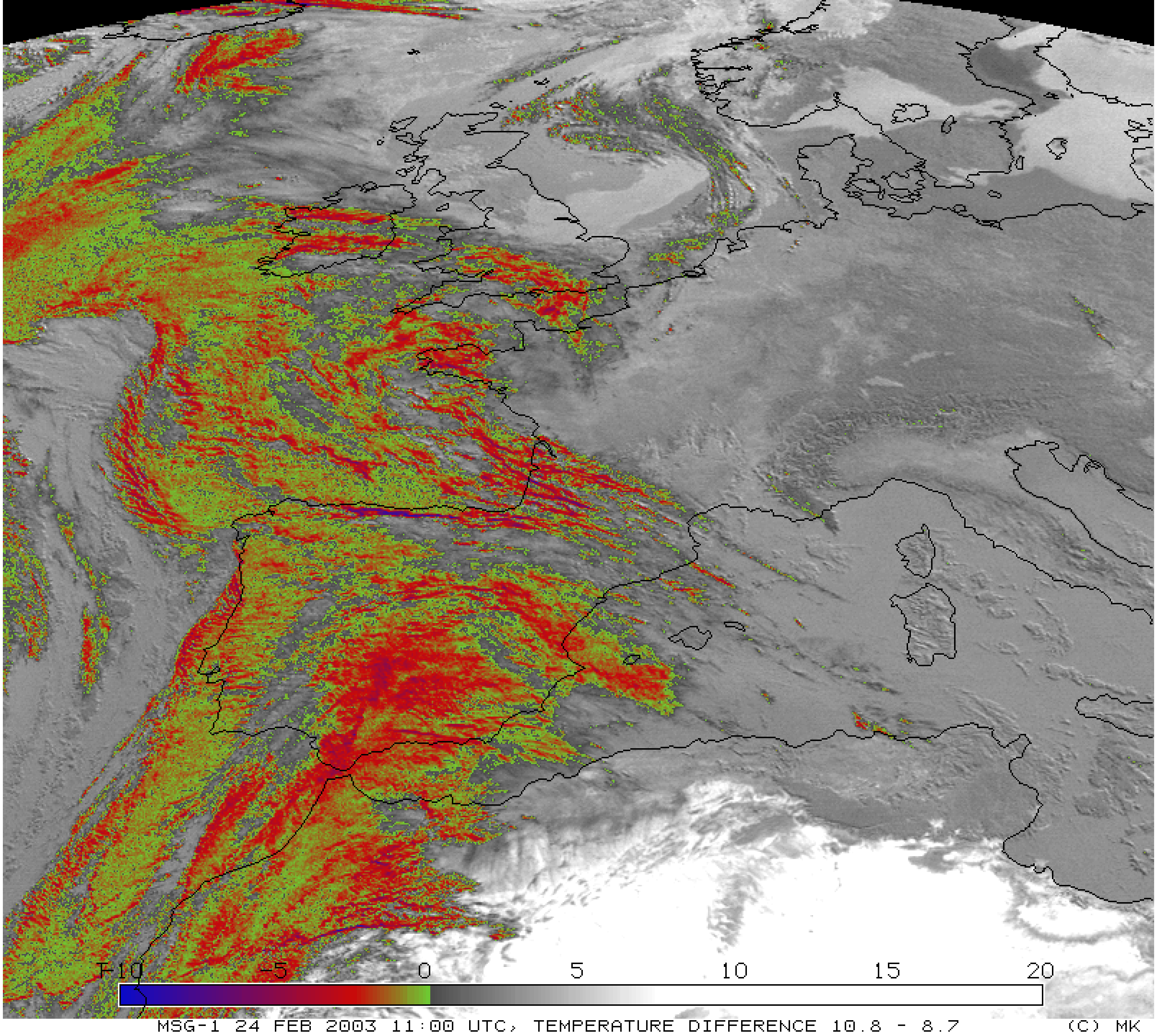
Meas Calc

$$\frac{(I_{\lambda 1}-I_{\lambda 1}^{clr})}{(I_{\lambda 2}-I_{\lambda 2}^{clr})} = \frac{\eta \varepsilon_{\lambda 1} \int_{p_s}^{p_c} \tau_{\lambda 1} \, dB_{\lambda 1}}{\eta \varepsilon_{\lambda 2} \int_{p_s}^{p_c} \tau_{\lambda 2} \, dB_{\lambda 2}}$$

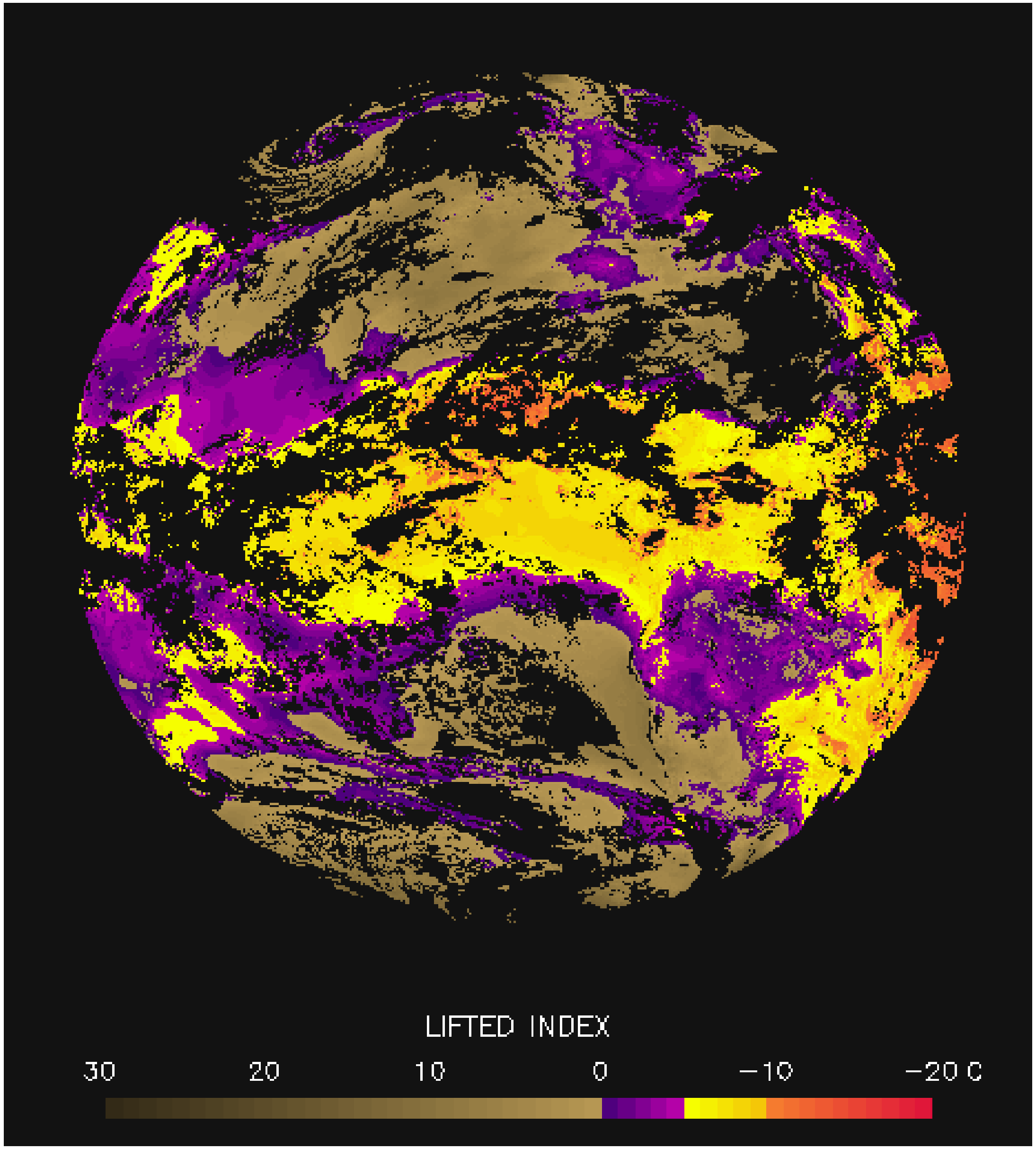
Given p_c an effective cloud amount(or effective emissivity) can be evaluated from 11 um (IRW)

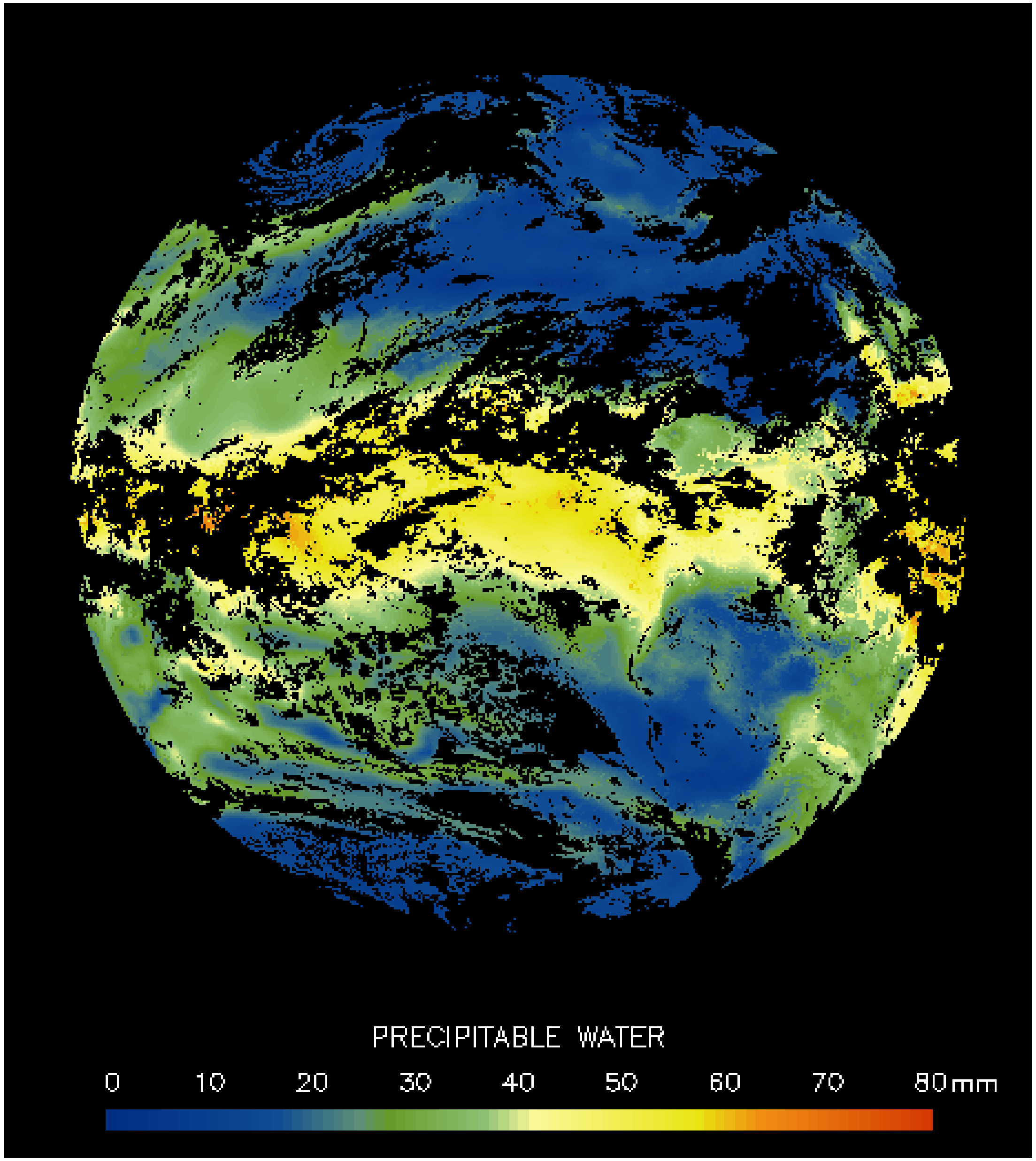
$$N\varepsilon = \frac{I(w) - Iclr(w)}{B[w, T(Pc)] - Iclr(w)}$$

BT8.7 – BT11 identifies cloud phase; if >0 then ice; if <0 then water


-10
-5
0
5
10
15
20
MSG-1 24 FEB 2003 11:00 UTC, TEMPERATURE DIFFERENCE 10.8 - 8.7
(C) MK

MSG Lifted Index



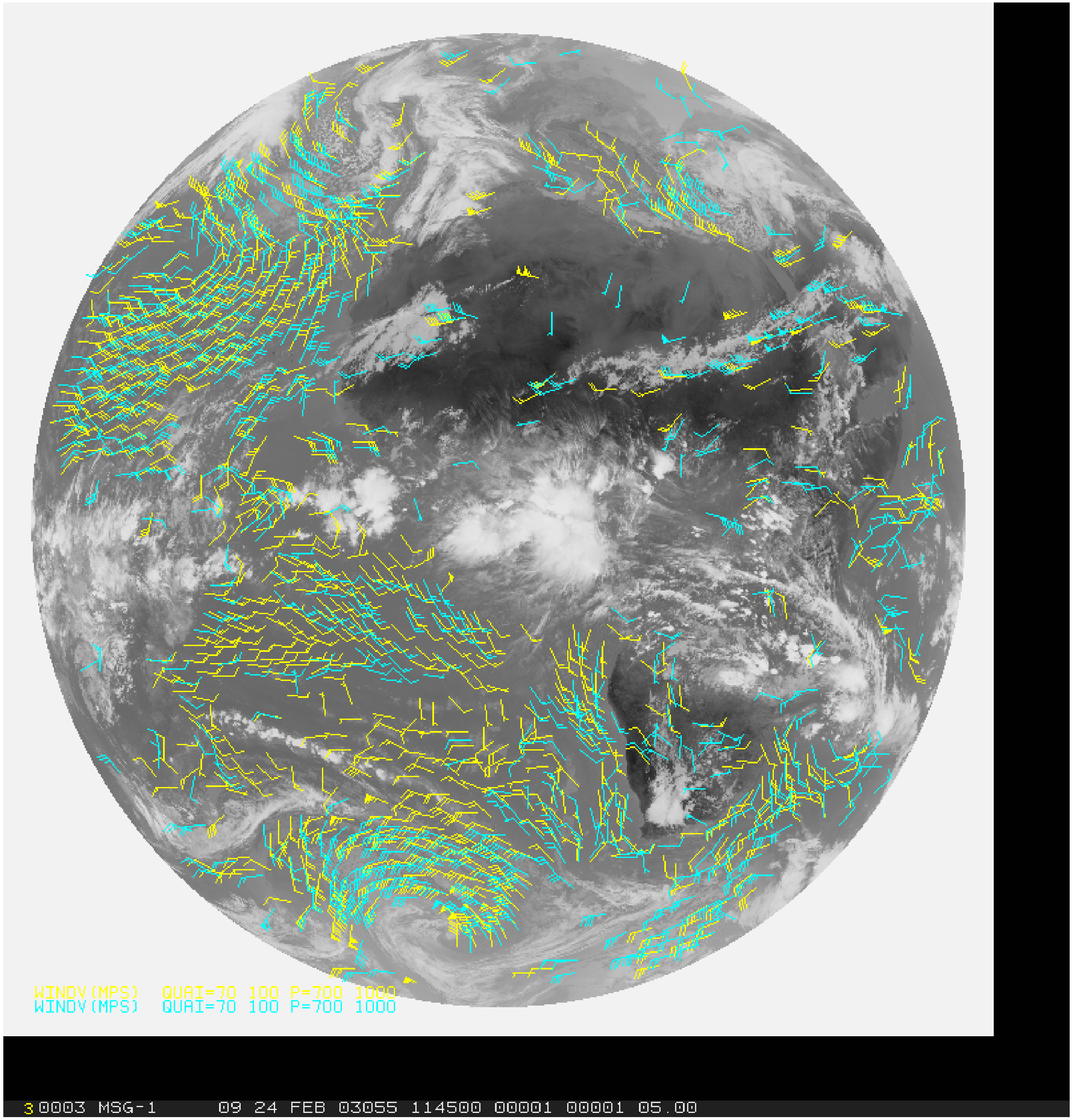


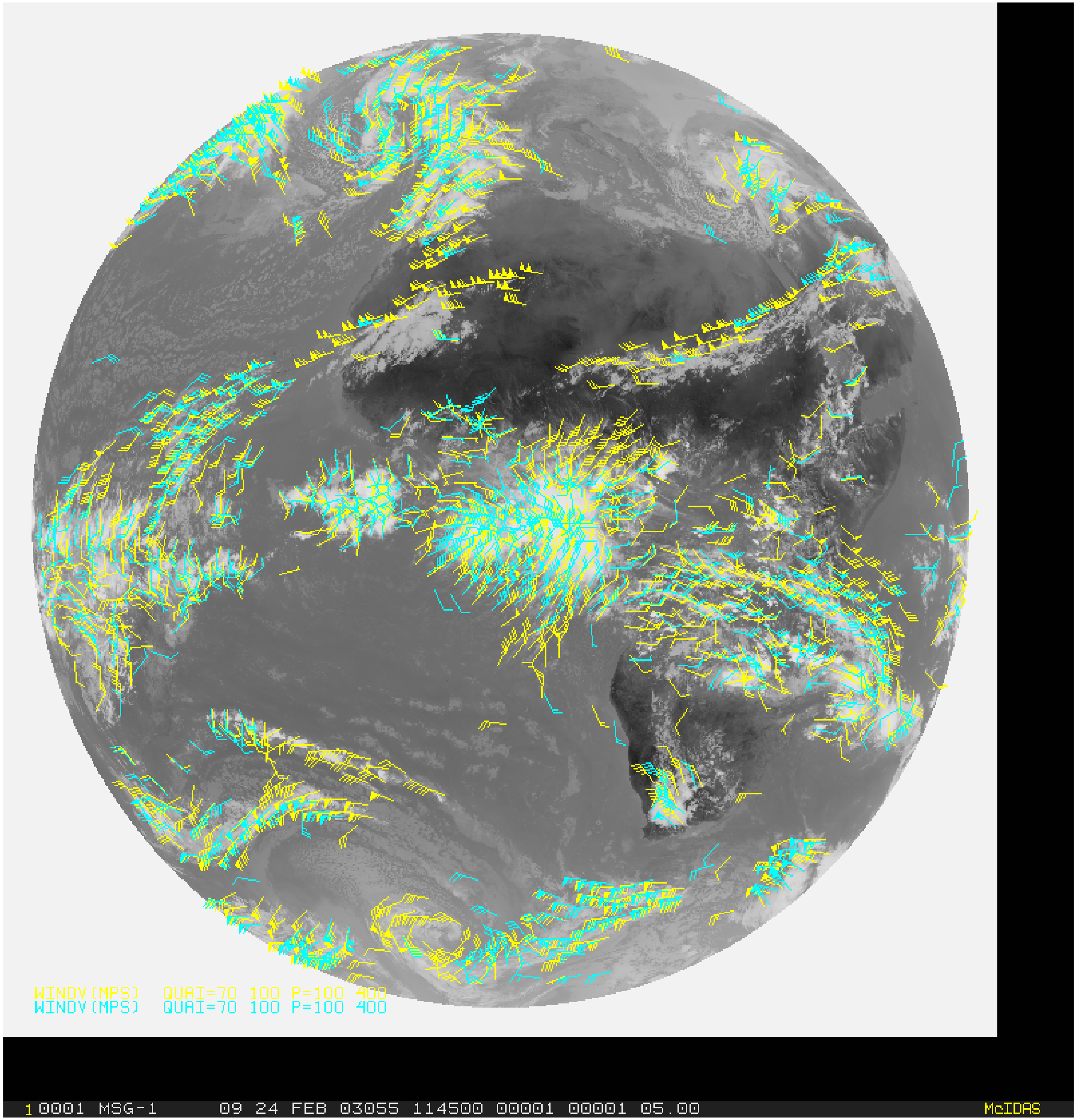
MSG Precipitable Water

Atmospheric Motion Vectors from MSG

- **Tracking channels**
  - IR10.8, WV6.2, WV7.3, VIS0.6, VIS0.8
  - OZ9.7, IR3.9, HRVIS
- **Resolution**
  - 100 (50) km, every 15 min., final product every hour
- **Height Assignment**
  - IR EBBT
  - IR/WV semi-transparency correction
  - CO_2-ratioing

Low-level winds from MSG:
yellow: 10.8 µm
blue: 3.9 µm





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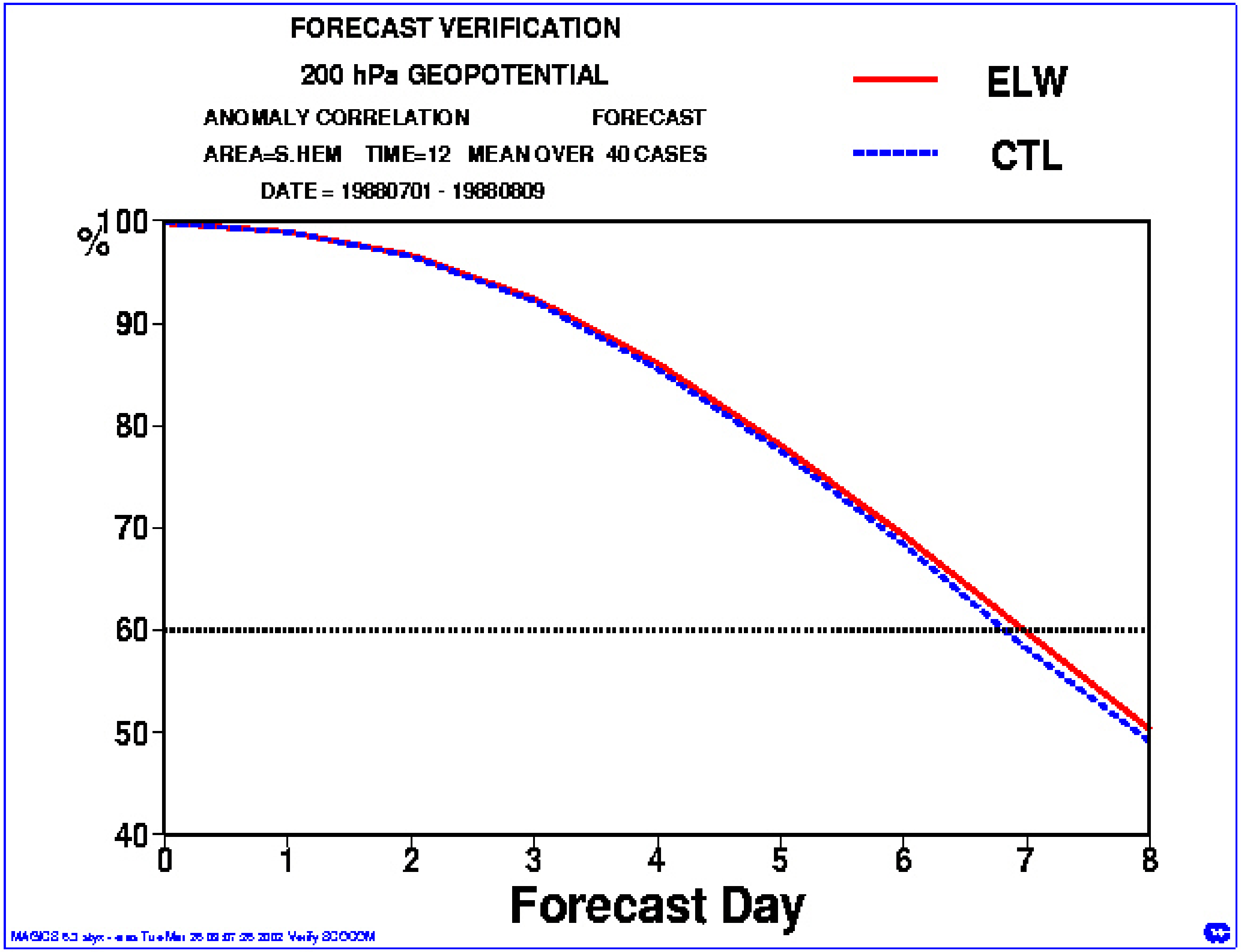
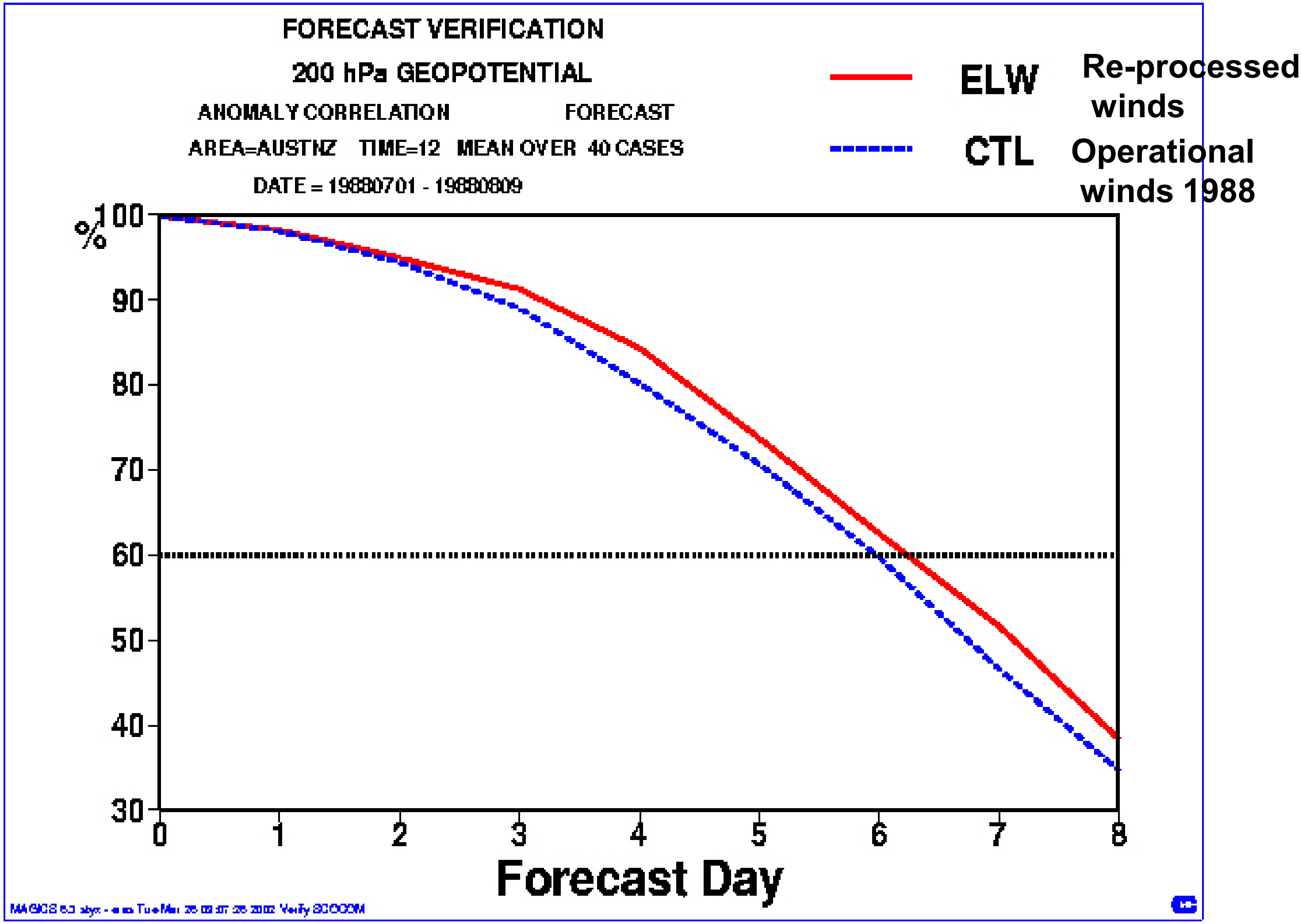
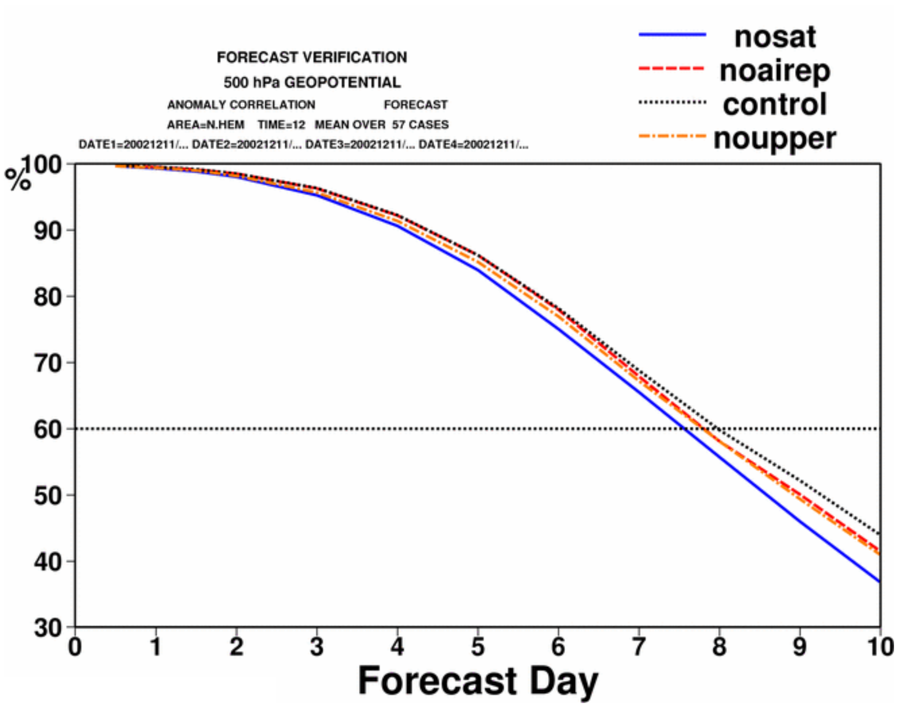

FORECAST VERIFICATION
200 hPa GEOPOTENTIAL
ANOMALY CORRELATION
FORECAST
AREA=S.HEM TIME=12 MEAN OVER 40 CASES
DATE = 19880701 - 19880809
ELW
CTL
%
100
90
80
70
60
50
40
0
1
2
3
4
5
6
7
8
Forecast Day



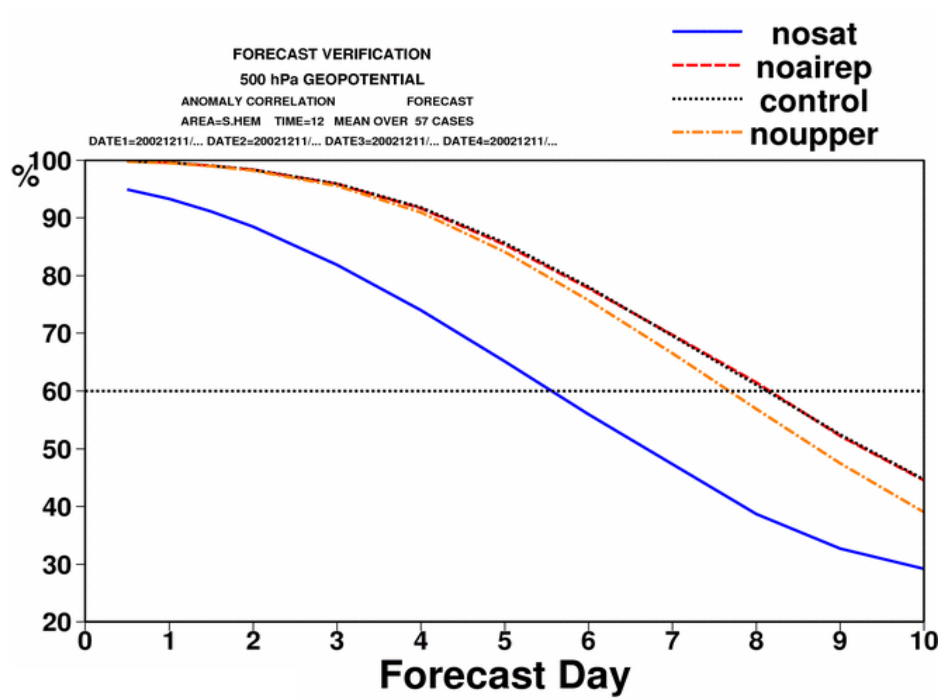
FORECAST VERIFICATION
200 hPa GEOPOTENTIAL
ANOMALY CORRELATION FORECAST
AREA=AUSTNZ TIME=12 MEAN OVER 40 CASES
DATE = 19880701 - 19880809
%
100
90
80
70
60
50
40
30
0
1
2
3
4
5
6
7
8
Forecast Day
ELW
Re-processed winds
CTL
Operational winds 1988

Latest Observing-System Experiments

Northern hemisphere



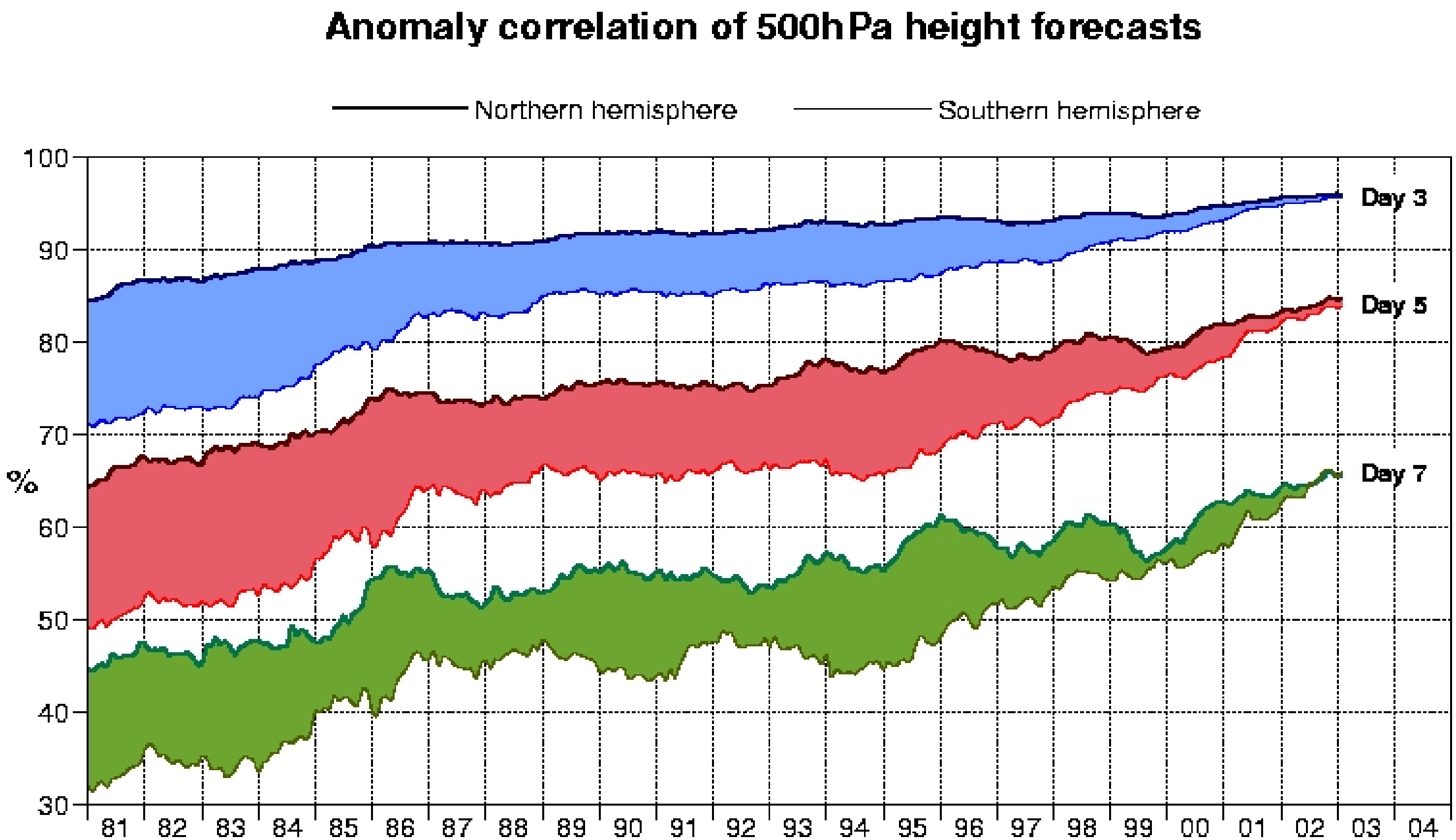
Southern hemisphere



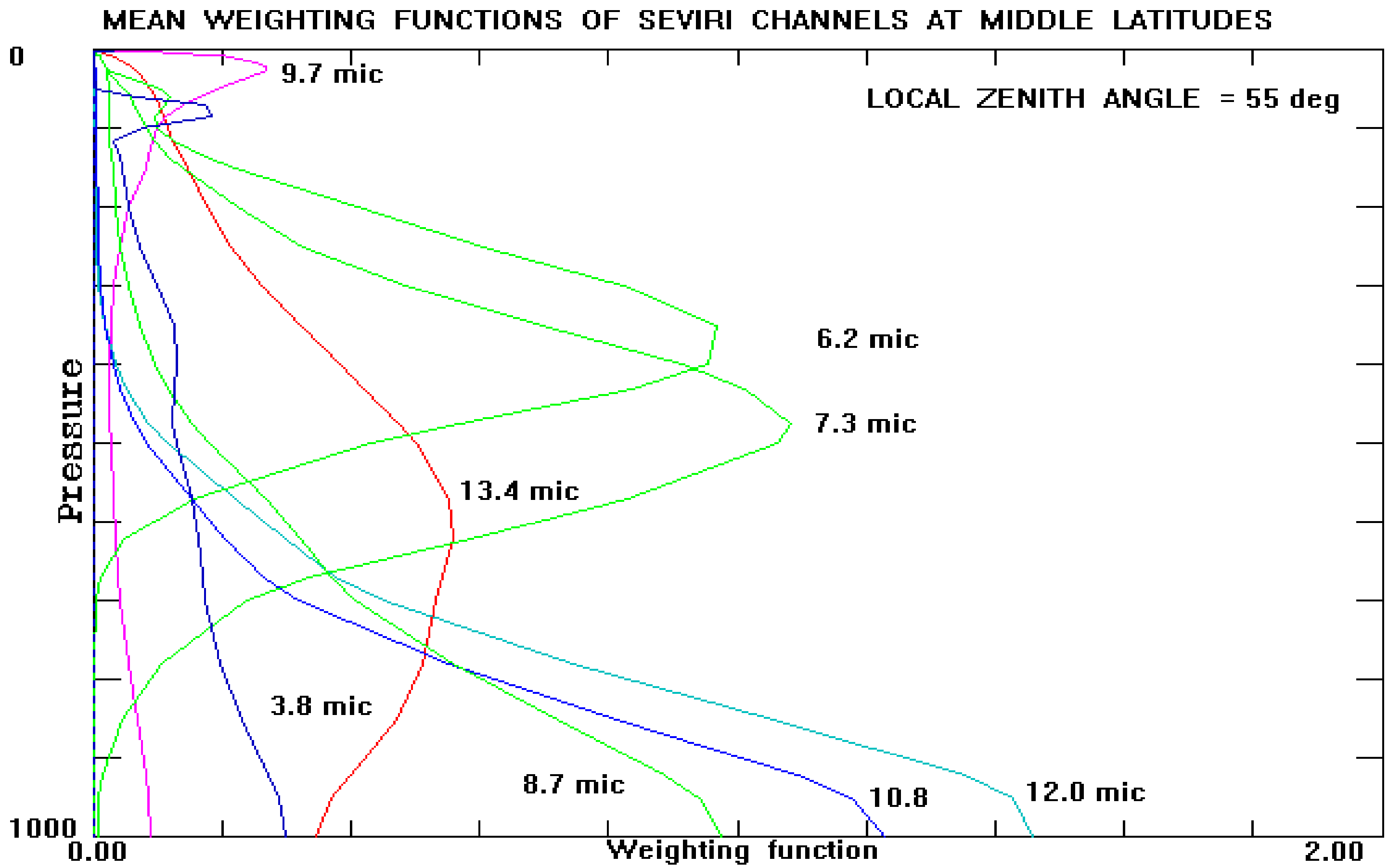
Verification against control analysis

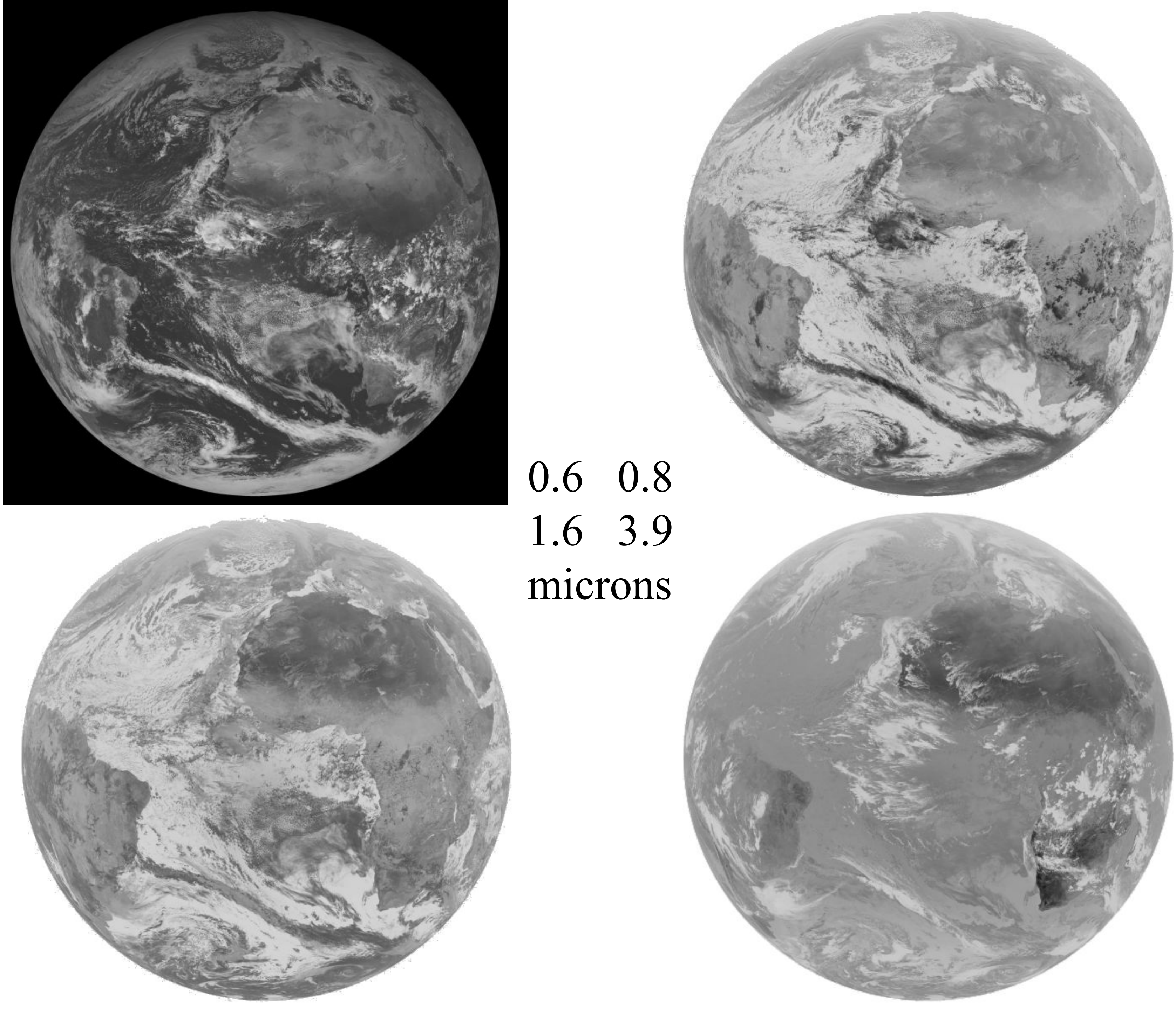
from ECMWF

ECMWF Evolution of forecast skill for northern and southern hemispheres

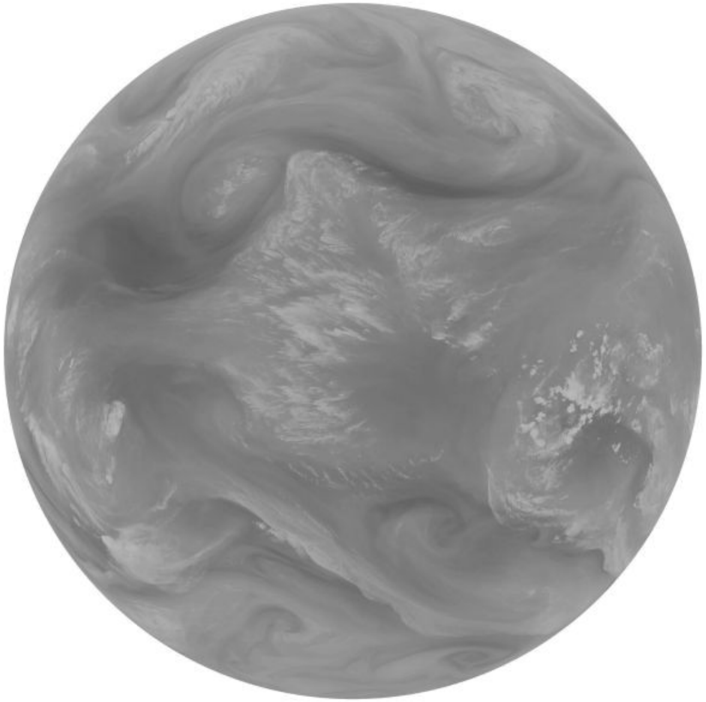


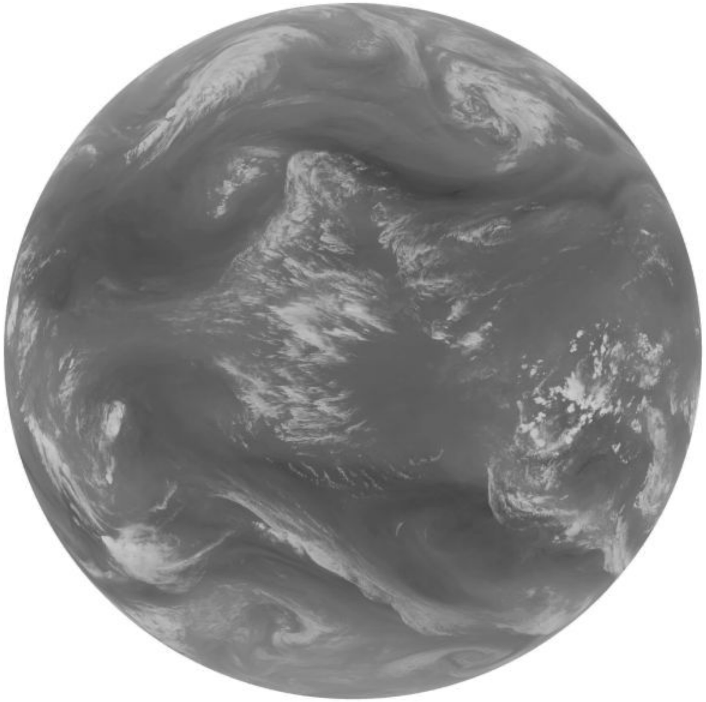
SEVIRI Channels Weighting Functions



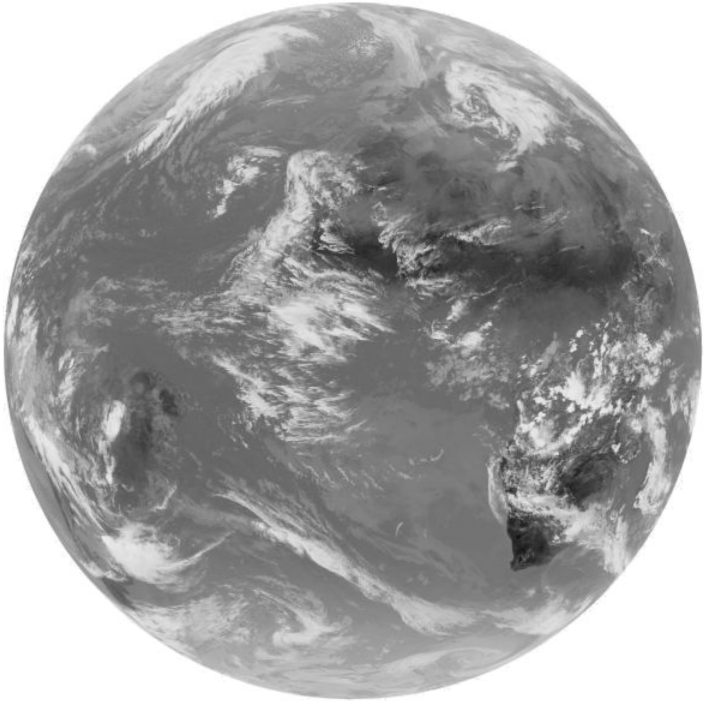


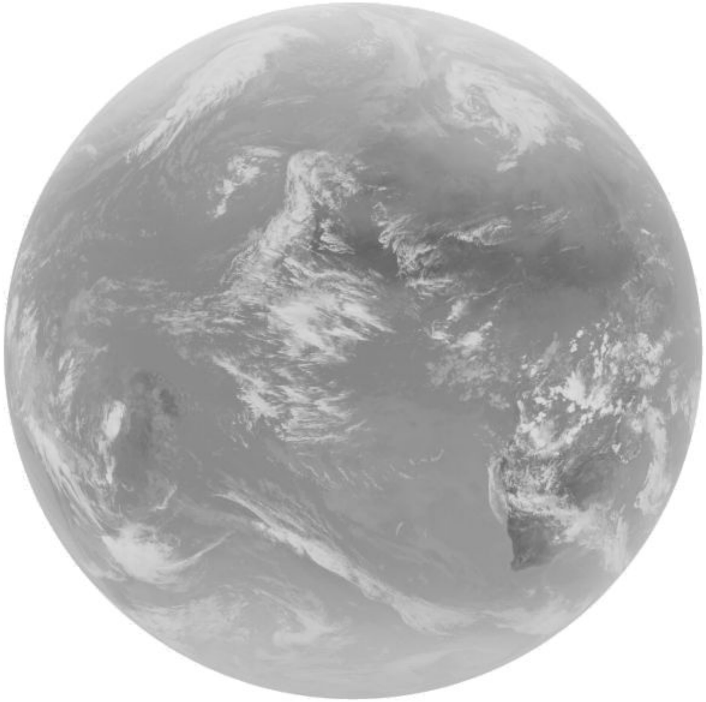
0.6 0.8
1.6 3.9
microns

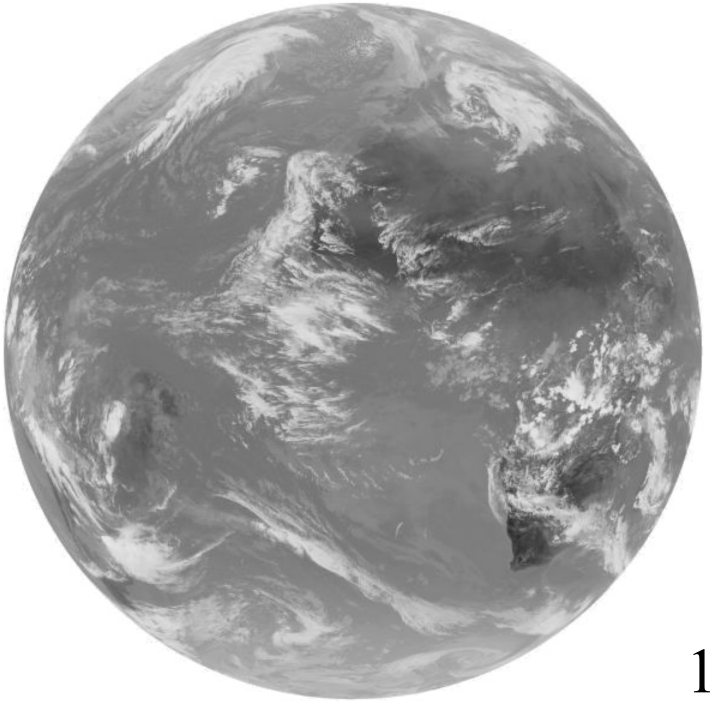


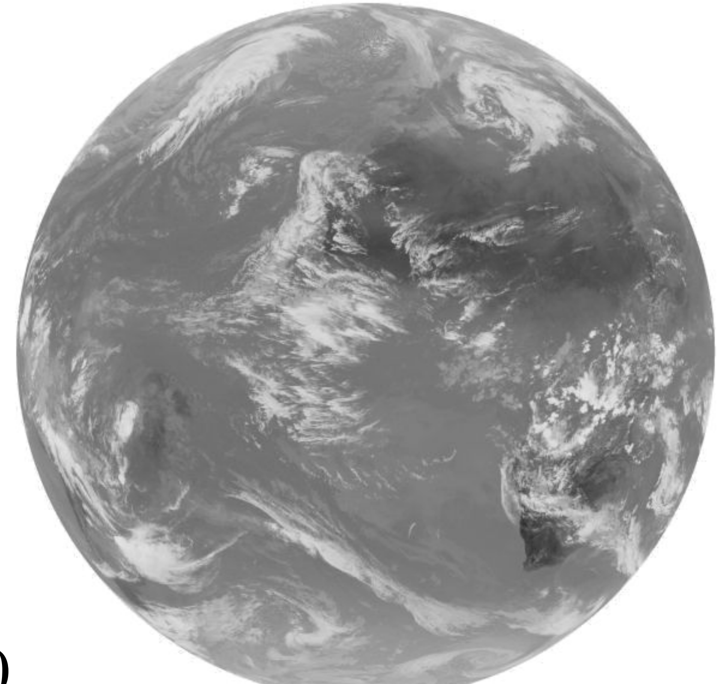


6.2 7.3
8.7 9.7
microns

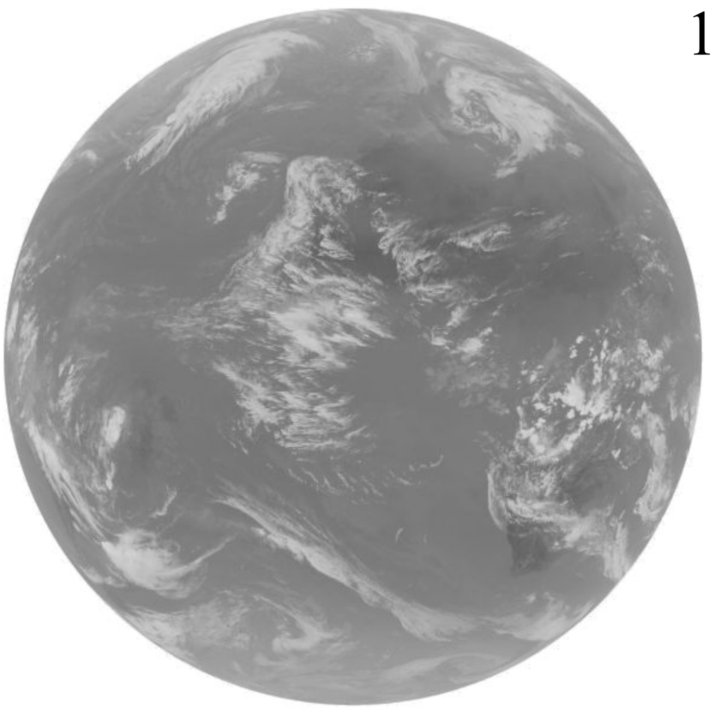


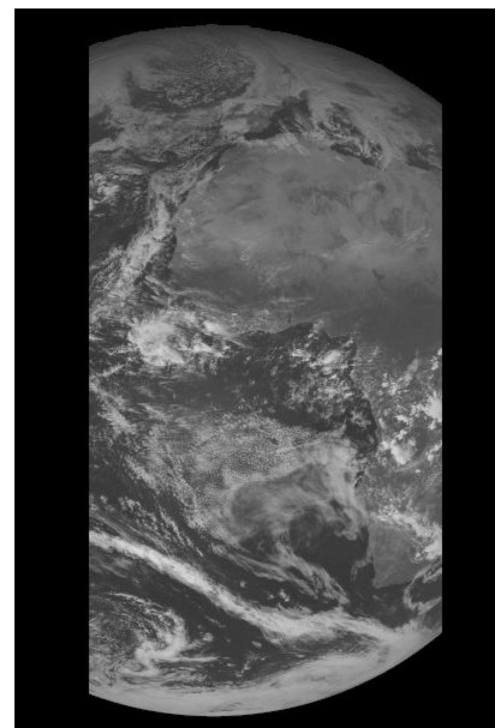


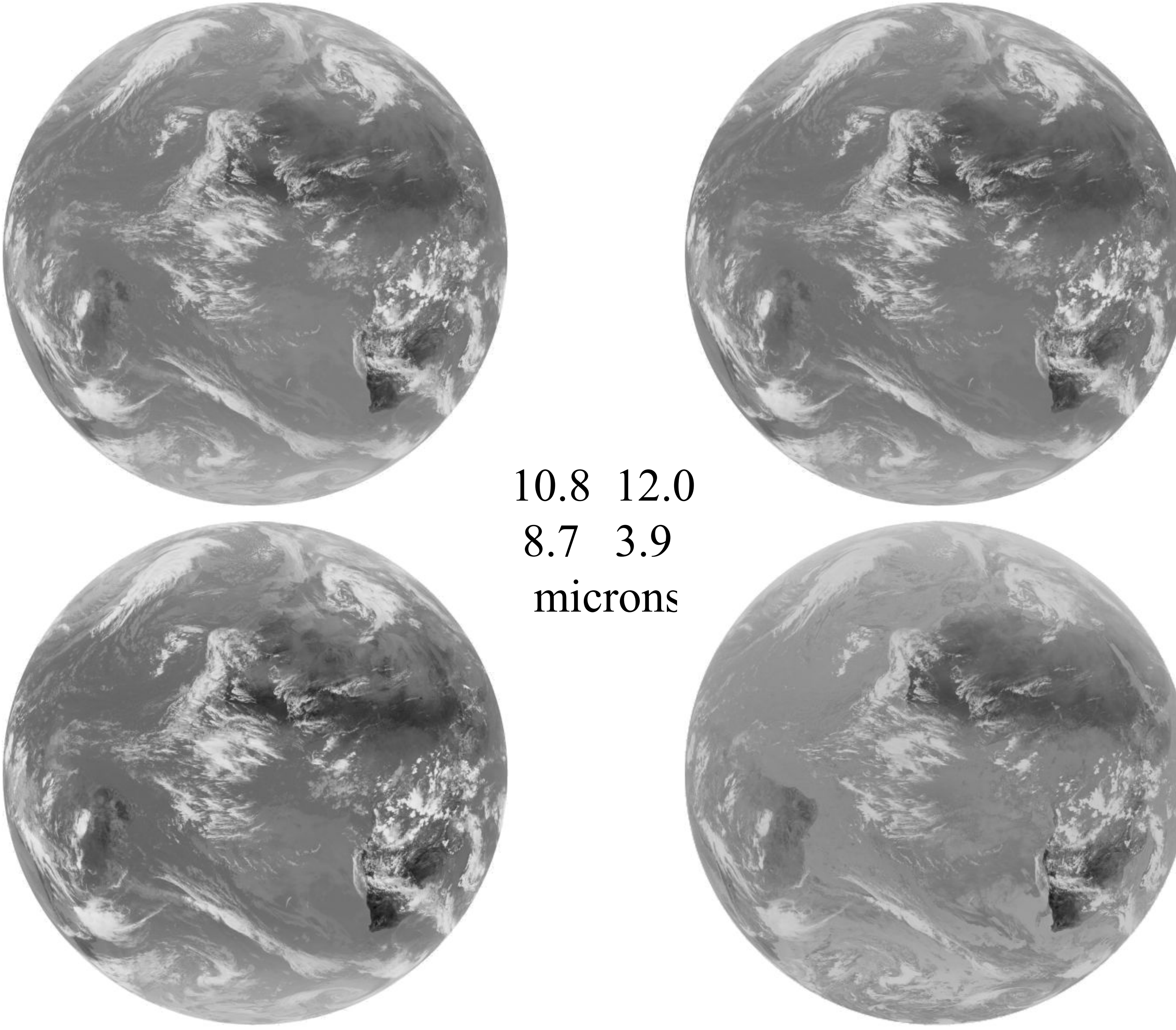


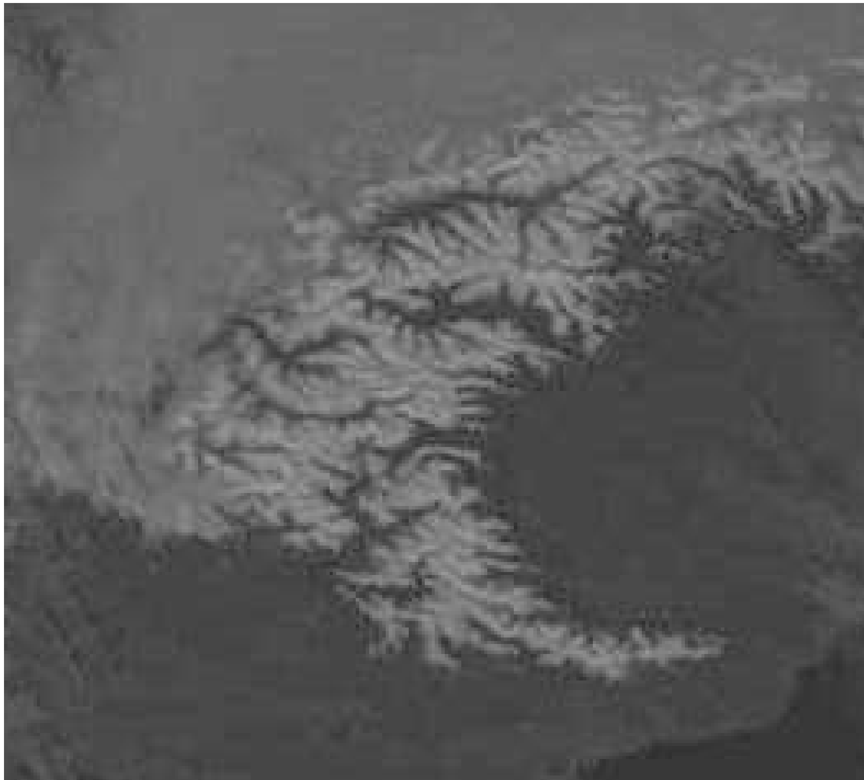


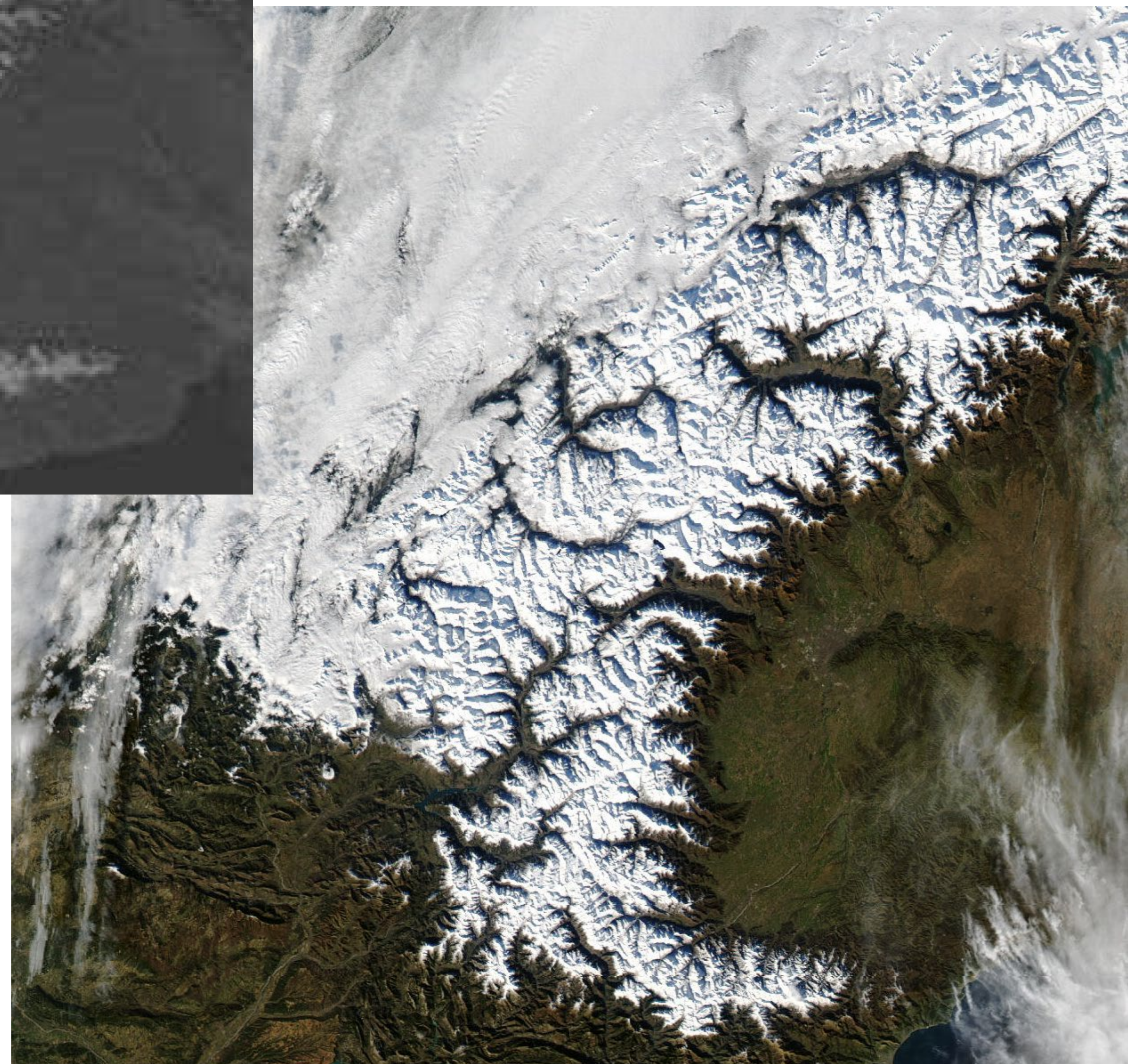
10.8 12.0
13.4 HRV
microns



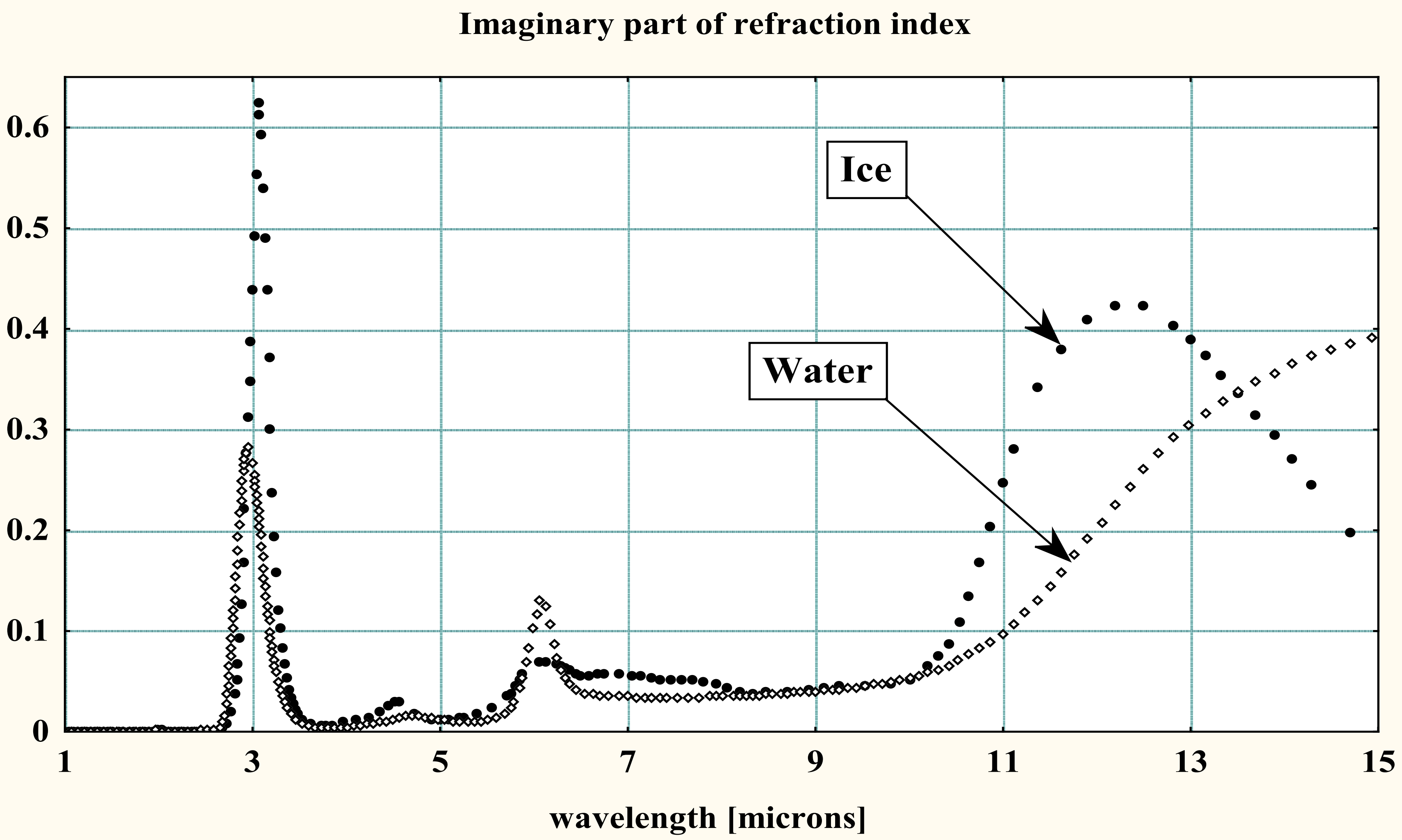



10.8 12.0
8.7 3.9
microns



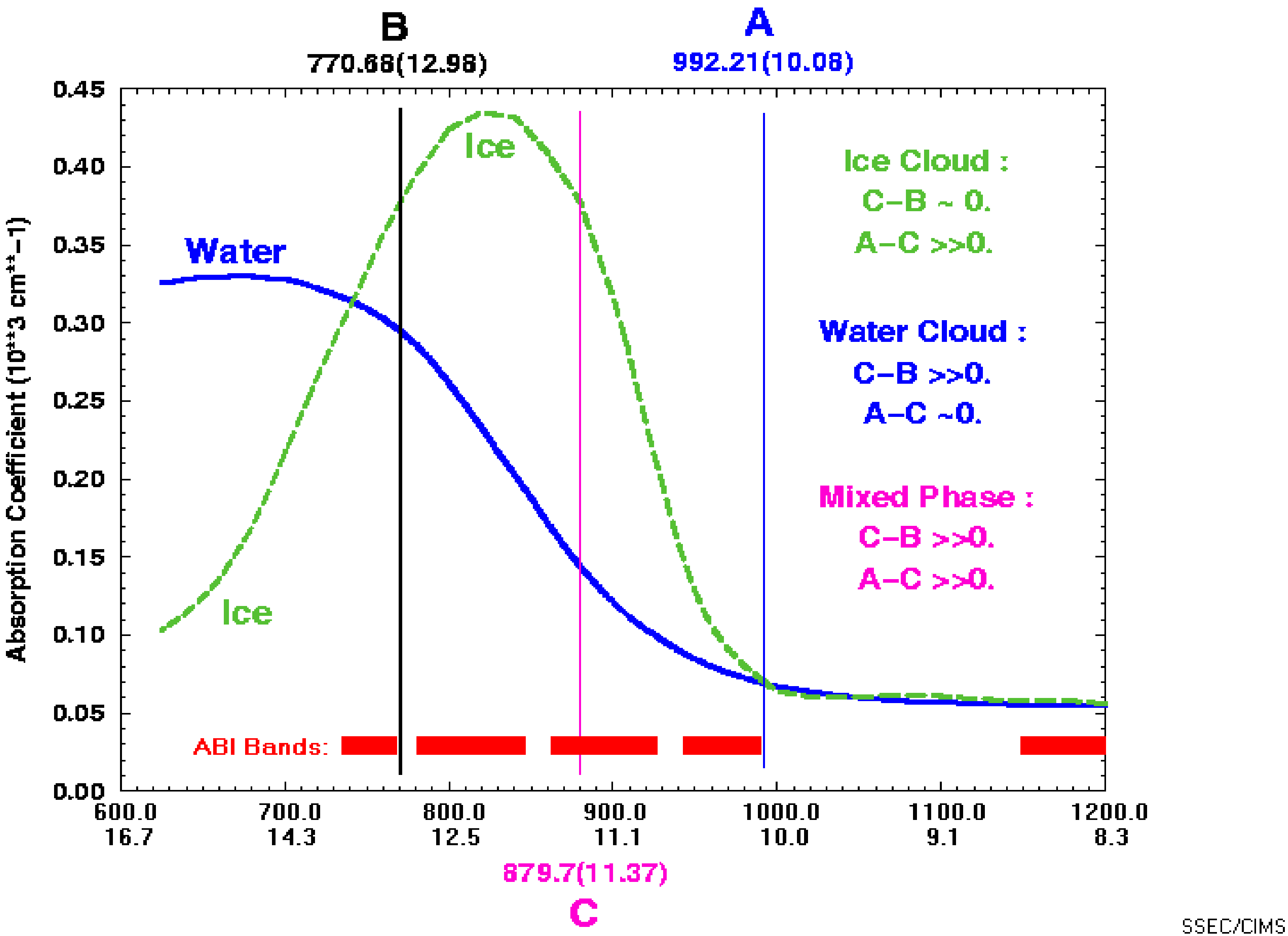


Optical properties of cloud particles: imaginary part of refraction index

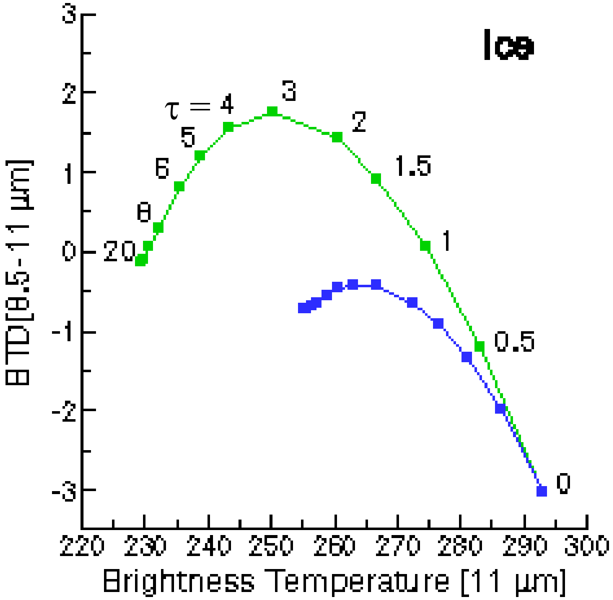


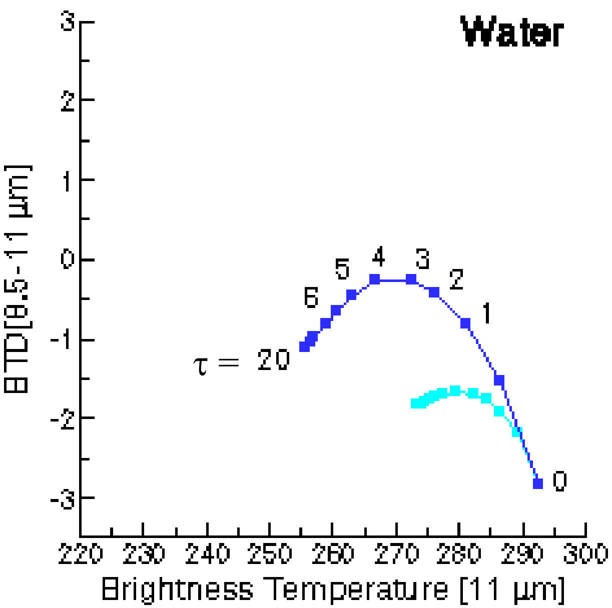
BT8.6 – BT11 differences are used for cloud phase identification
If >0 then ice; if <0 then water

Multispectral data distinguishing ice vs water clouds



Simulations of Ice and Water Phase Clouds
8.5 - 11 μm BT Differences





High Ice clouds

- BTD[8.5-11] > 0 over a large range of optical thicknesses τ
- T_{cld} = 228 K

Midlevel clouds

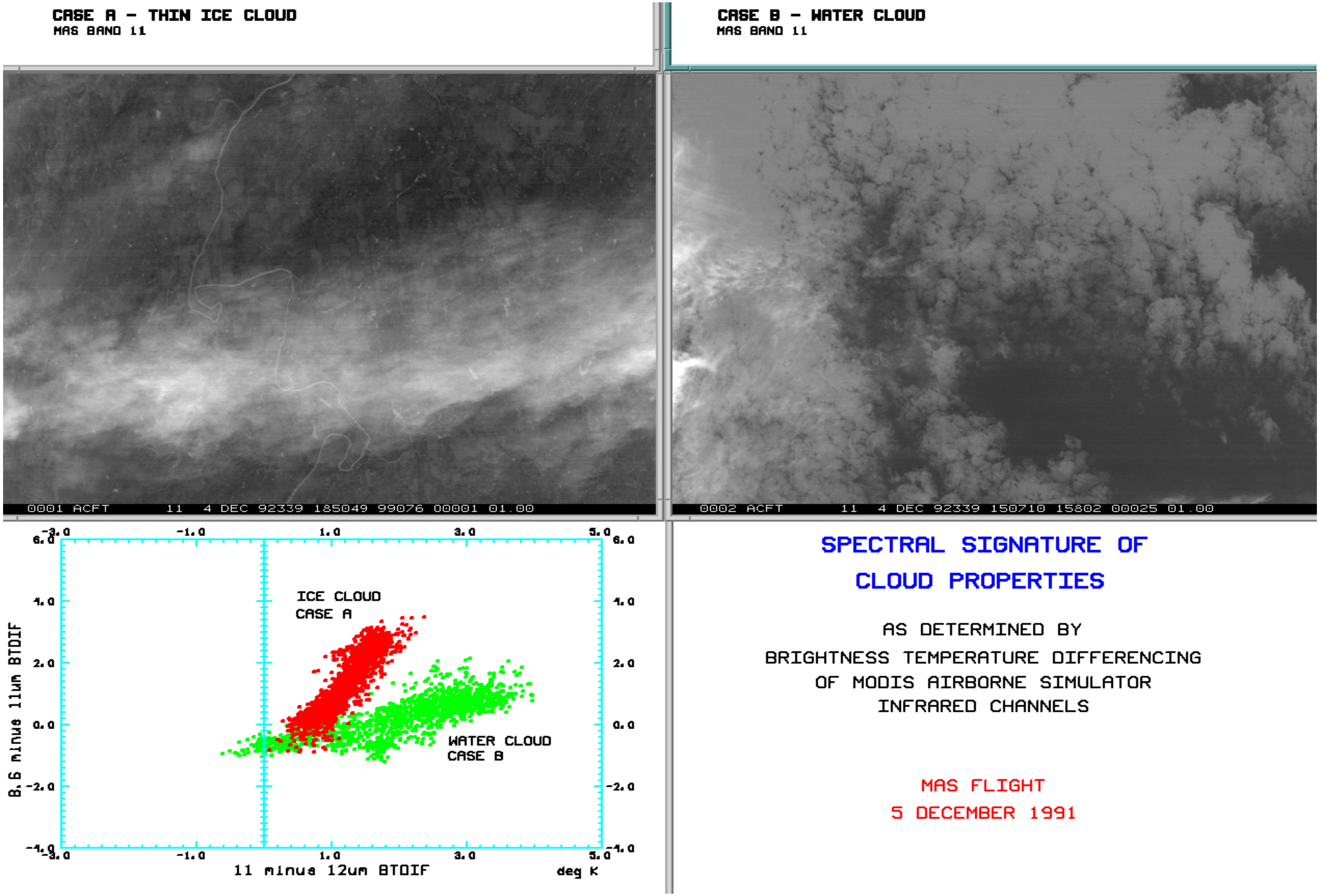
- BTD[8.5-11] values are similar (*i.e.*, negative) for both water and ice clouds
- T_{cld} = 253 K

Low-level, warm clouds

- BTD[8.5-11] values always negative
- T_{cld} = 273 K

*Ice: Cirrus model derived from FIRE-I in-situ data (*Nasiri et al, 2002)
Water: r_e=10 μm
Angles: θ_o = 45°, θ = 20°, and ϕ = 40°
Profile: midlatitude summer

Ice/Water Clouds Separate in 8.6-11 vs 11-12 um BT plots

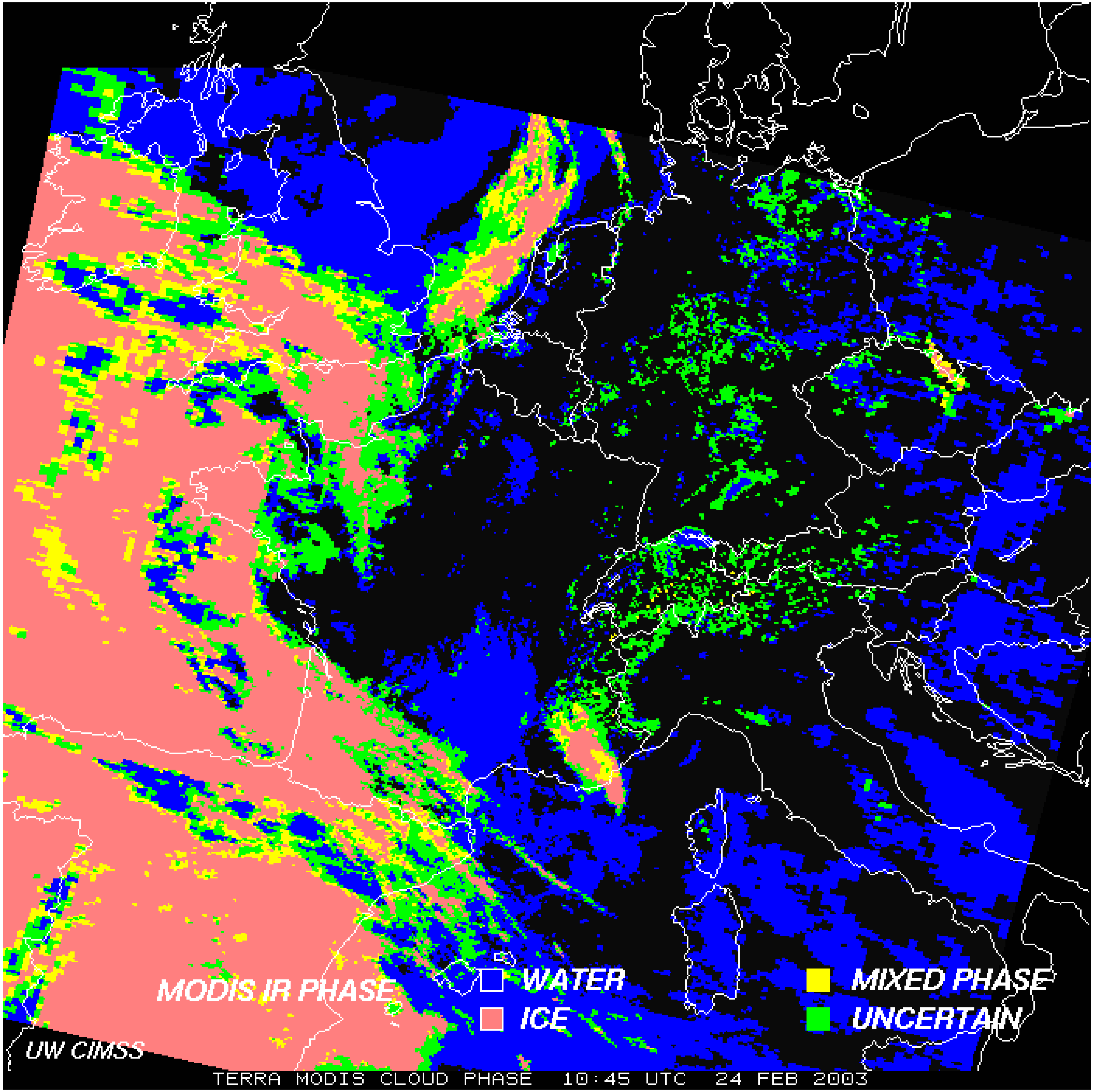


SPECTRAL SIGNATURE OF

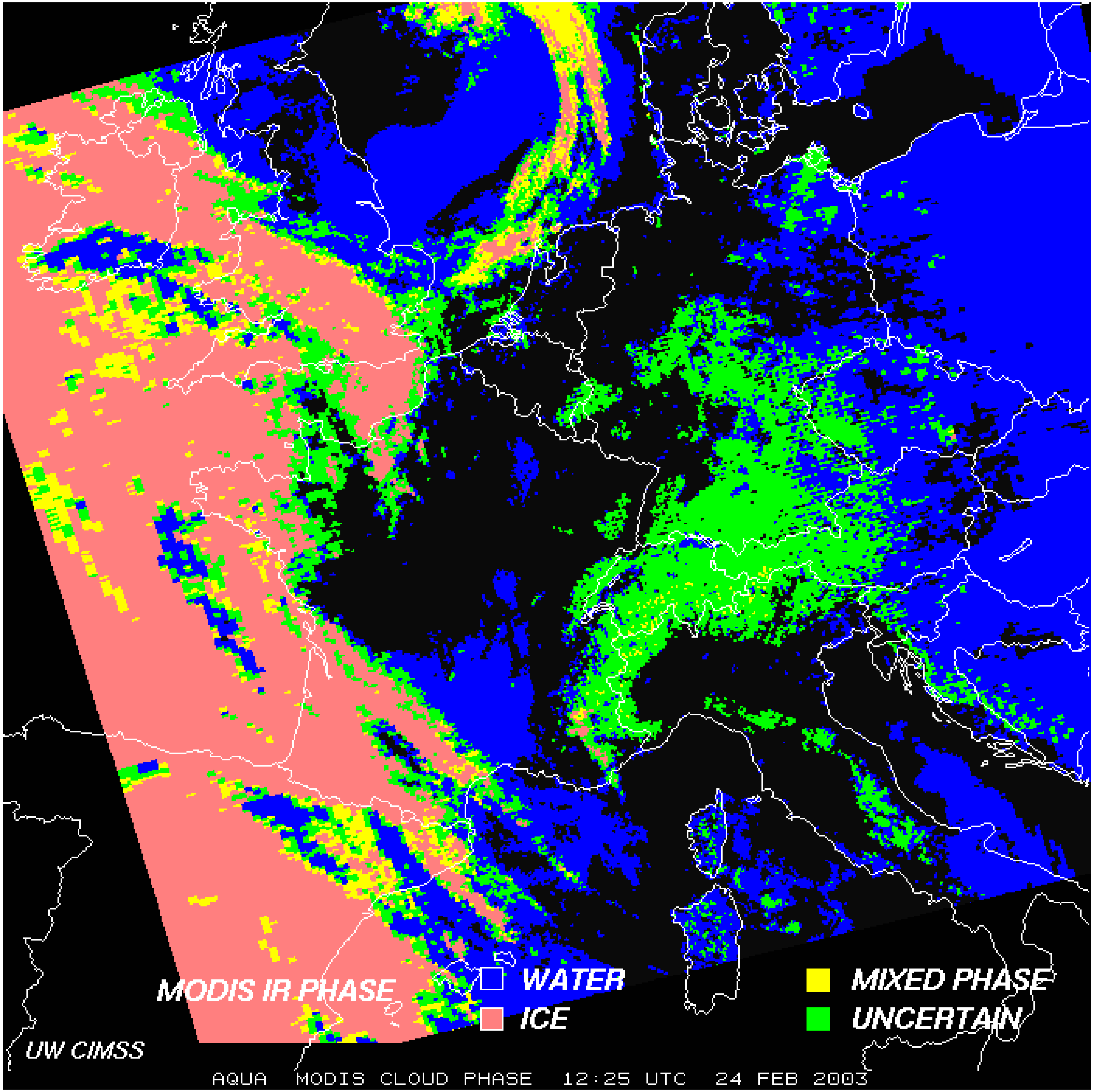
CLOUD PROPERTIES

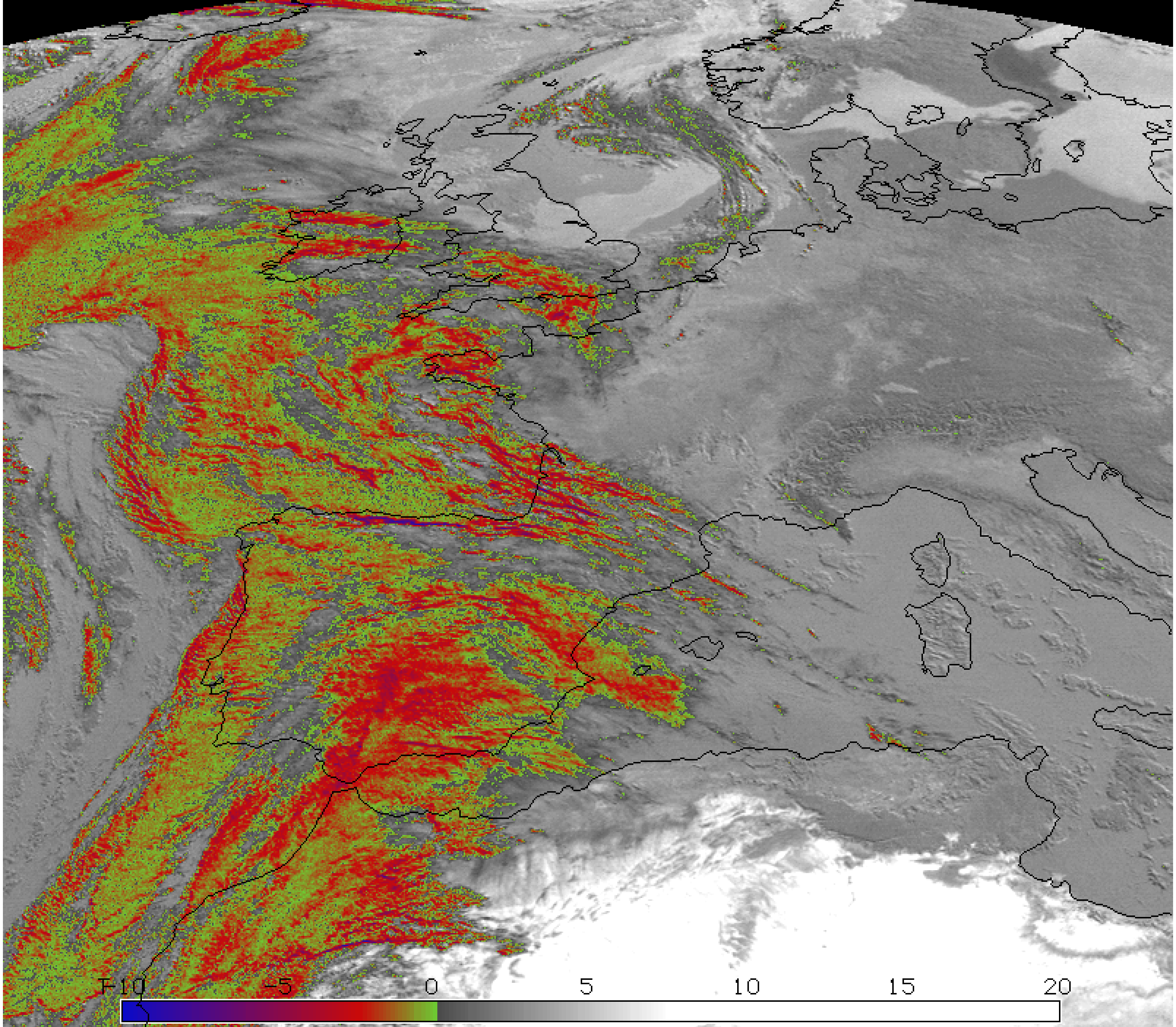
AS DETERMINED BY
BRIGHTNESS TEMPERATURE DIFFERENCING
OF MODIS AIRBORNE SIMULATOR
INFRARED CHANNELS

MAS FLIGHT
5 DECEMBER 1991

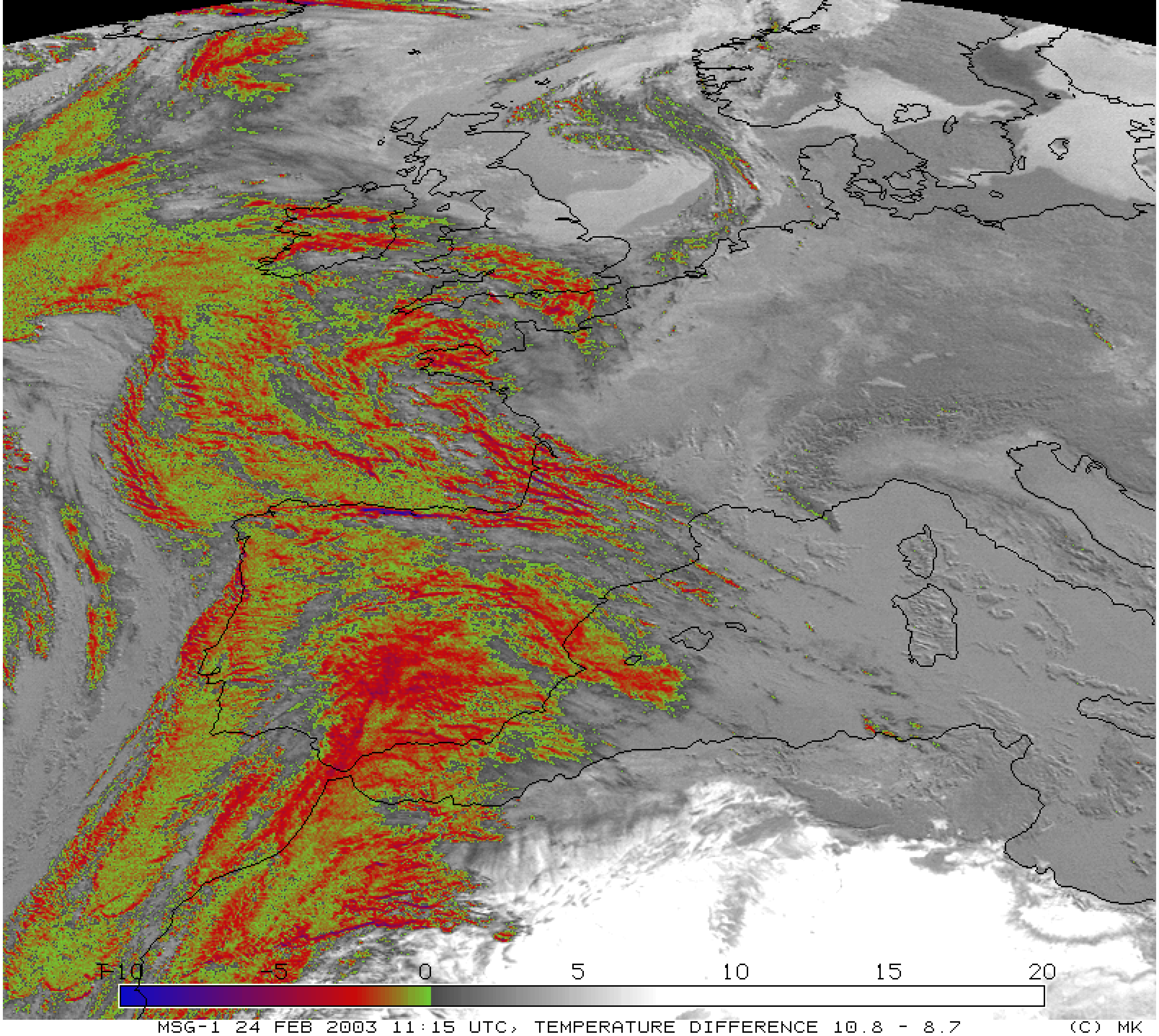


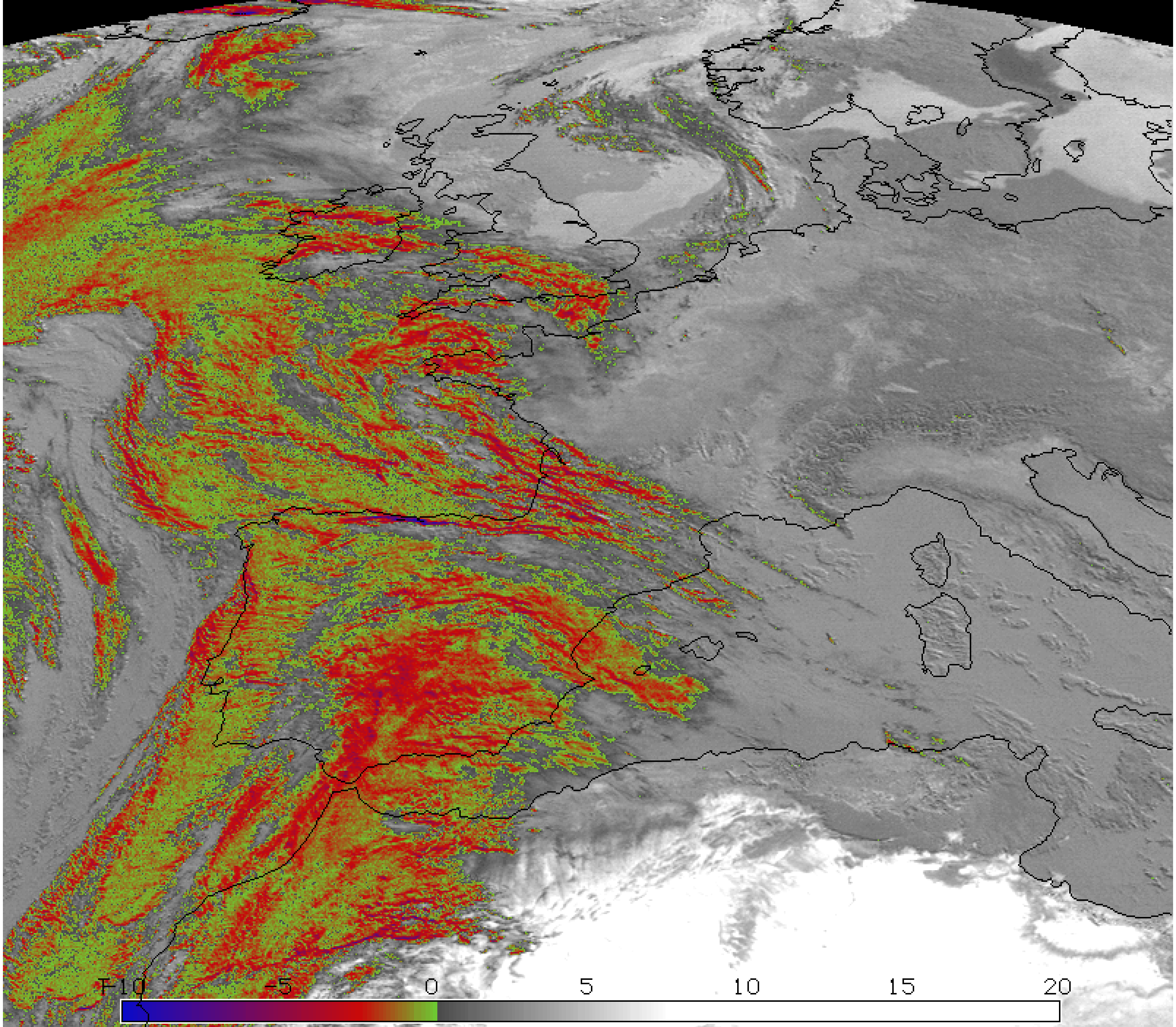
WATER
ICE
MIXED PHASE
UNCERTAIN
MODIS IR PHASE
UW CIMSS
TERRA MODIS CLOUD PHASE 10:45 UTC 24 FEB 2003


WATER
ICE
MIXED PHASE
UNCERTAIN
MODIS IR PHASE
UW CIMSS
AQUA MODIS CLOUD PHASE 12:25 UTC 24 FEB 2003



MSG-1 24 FEB 2003 11:00 UTC, TEMPERATURE DIFFERENCE 10.8 - 8.7 (C) MK


-10
-5
0
5
10
15
20
MSG-1 24 FEB 2003 11:15 UTC, TEMPERATURE DIFFERENCE 10.8 - 8.7
(C) MK



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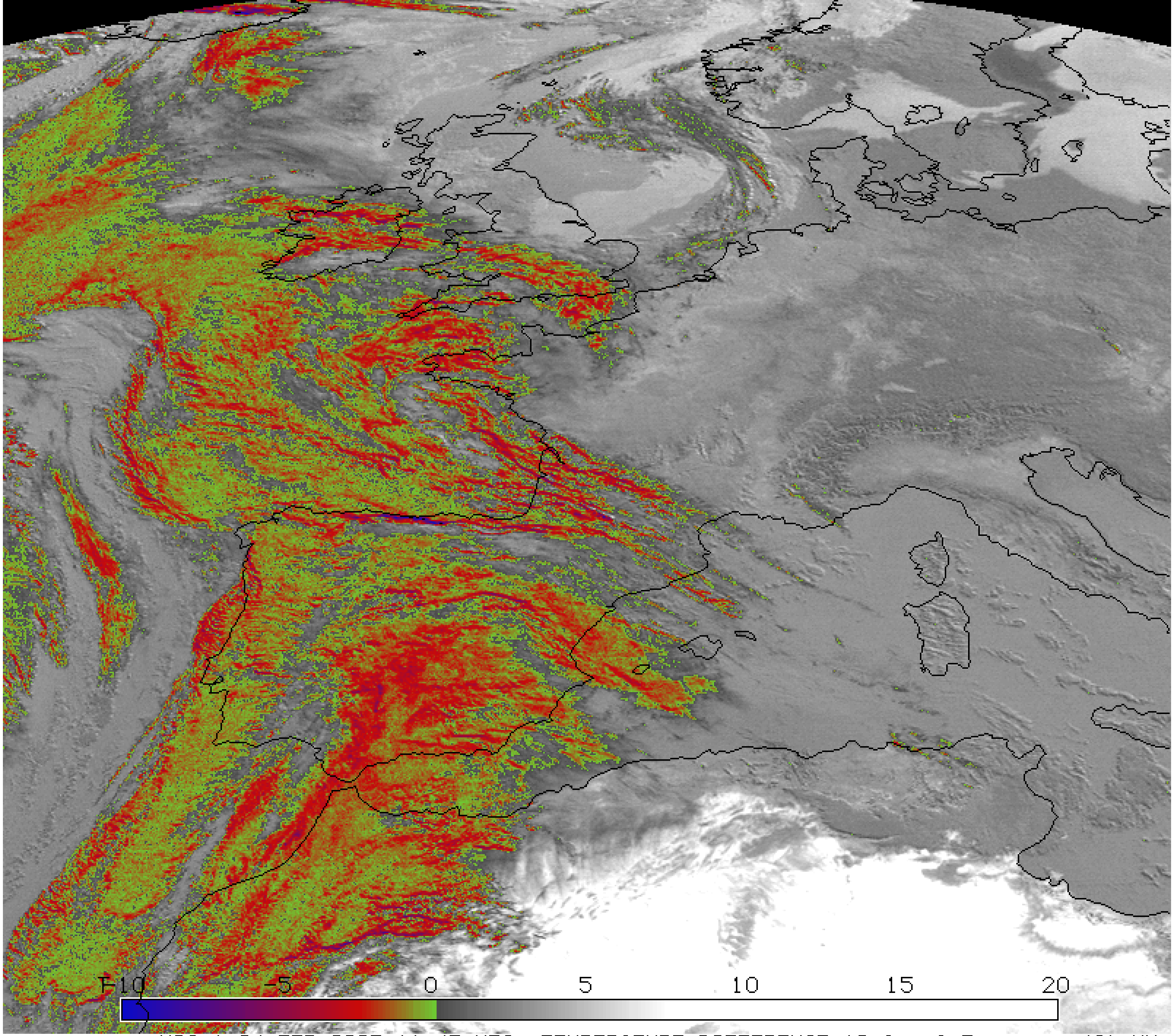

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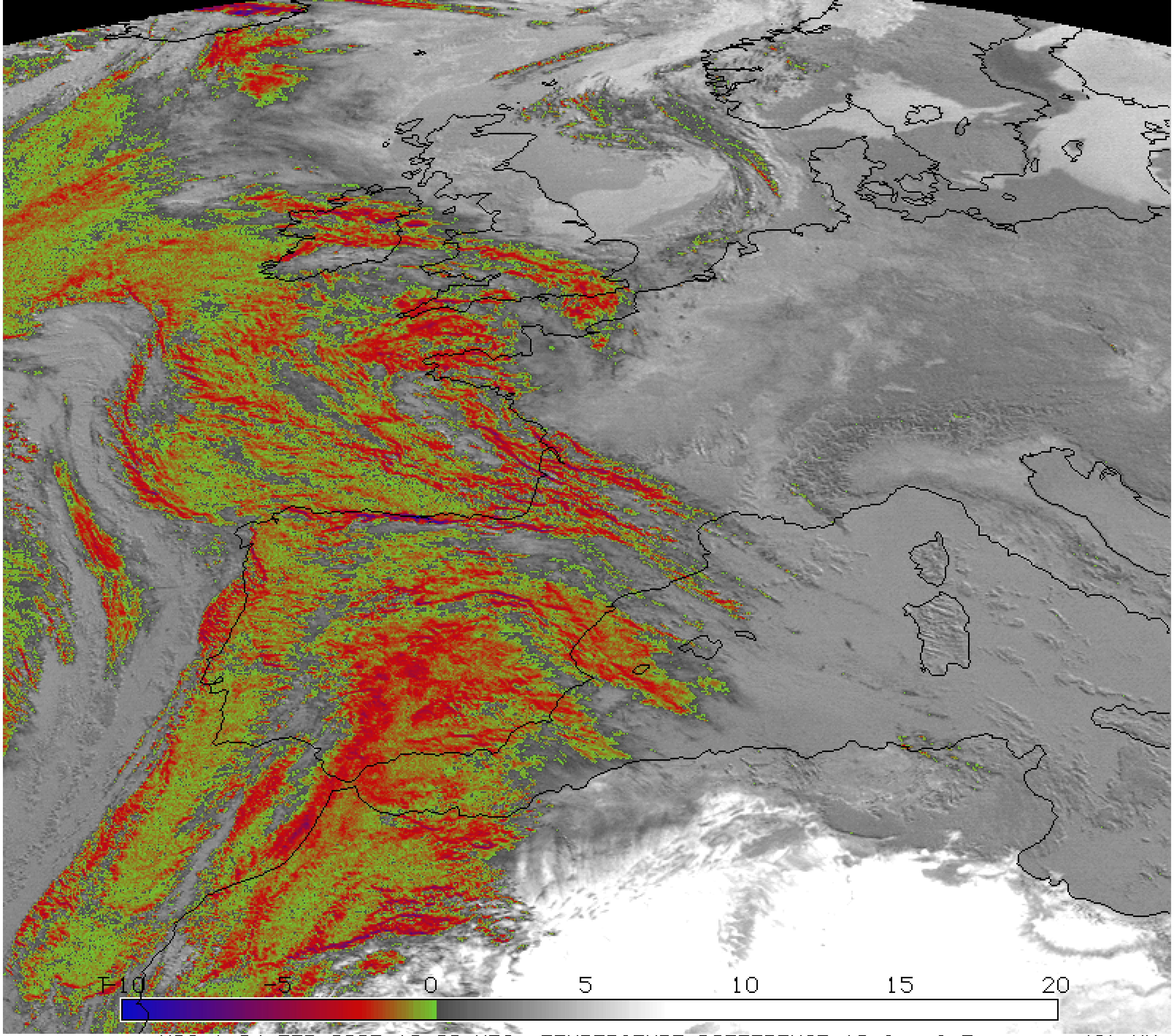

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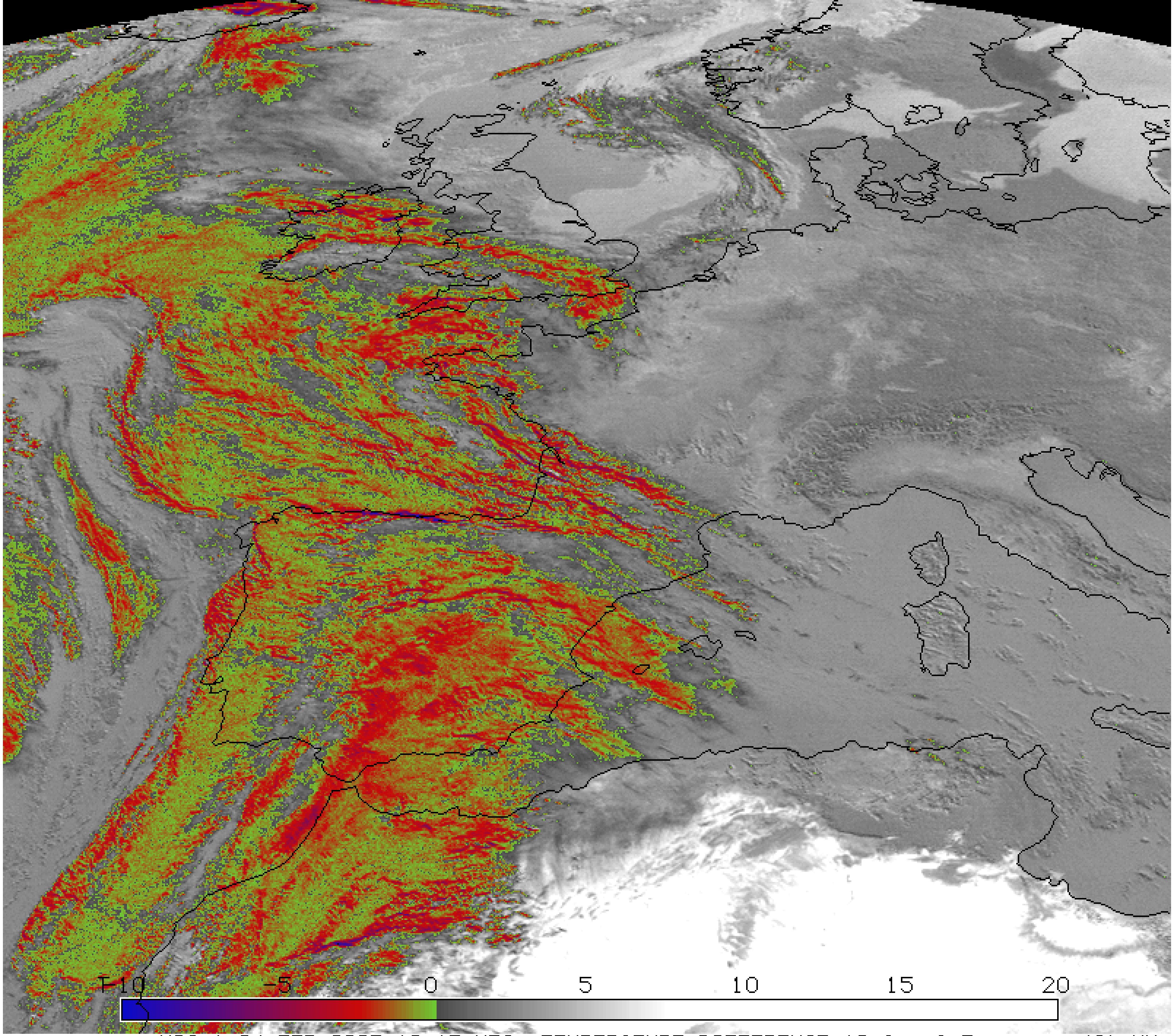

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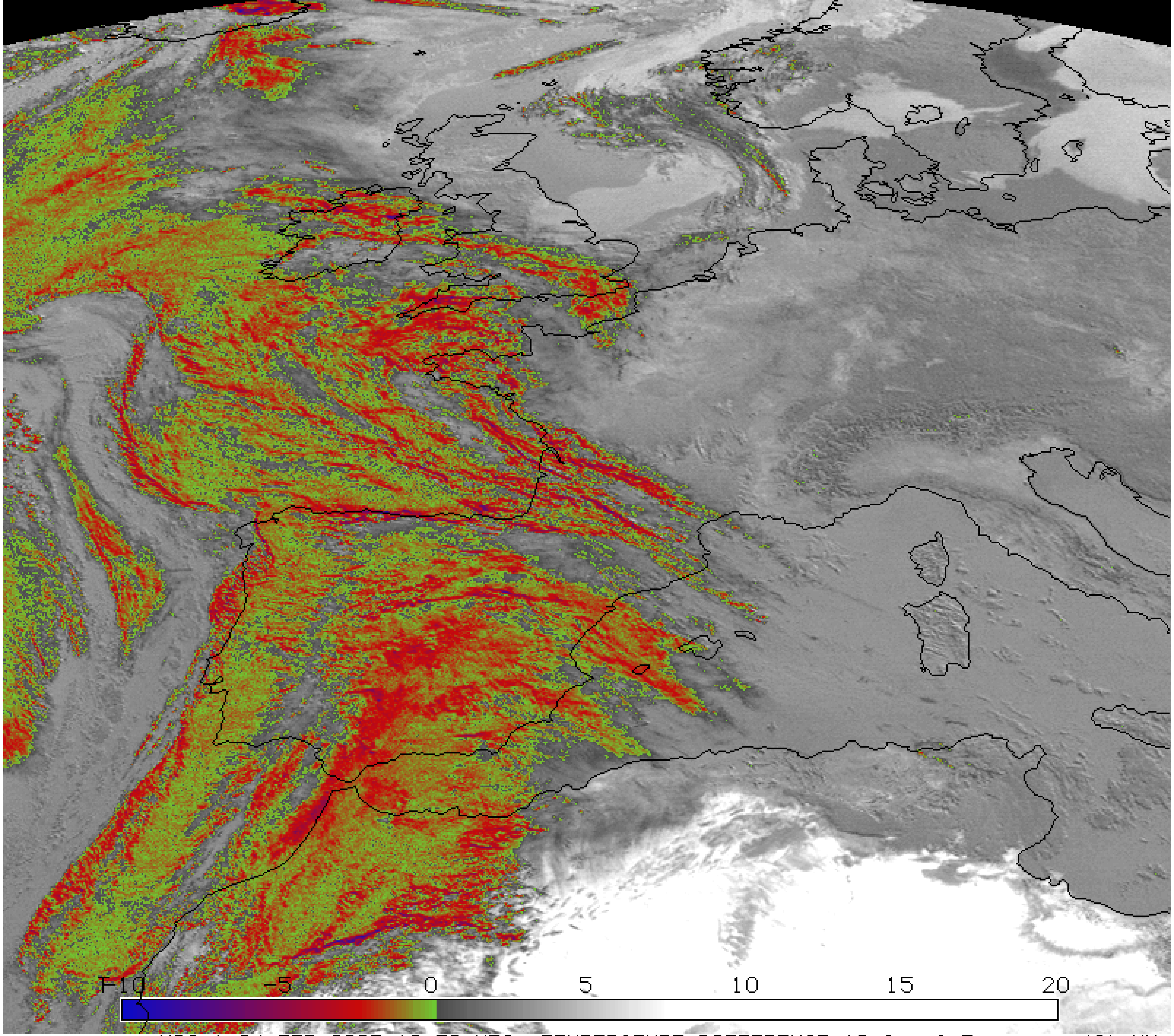
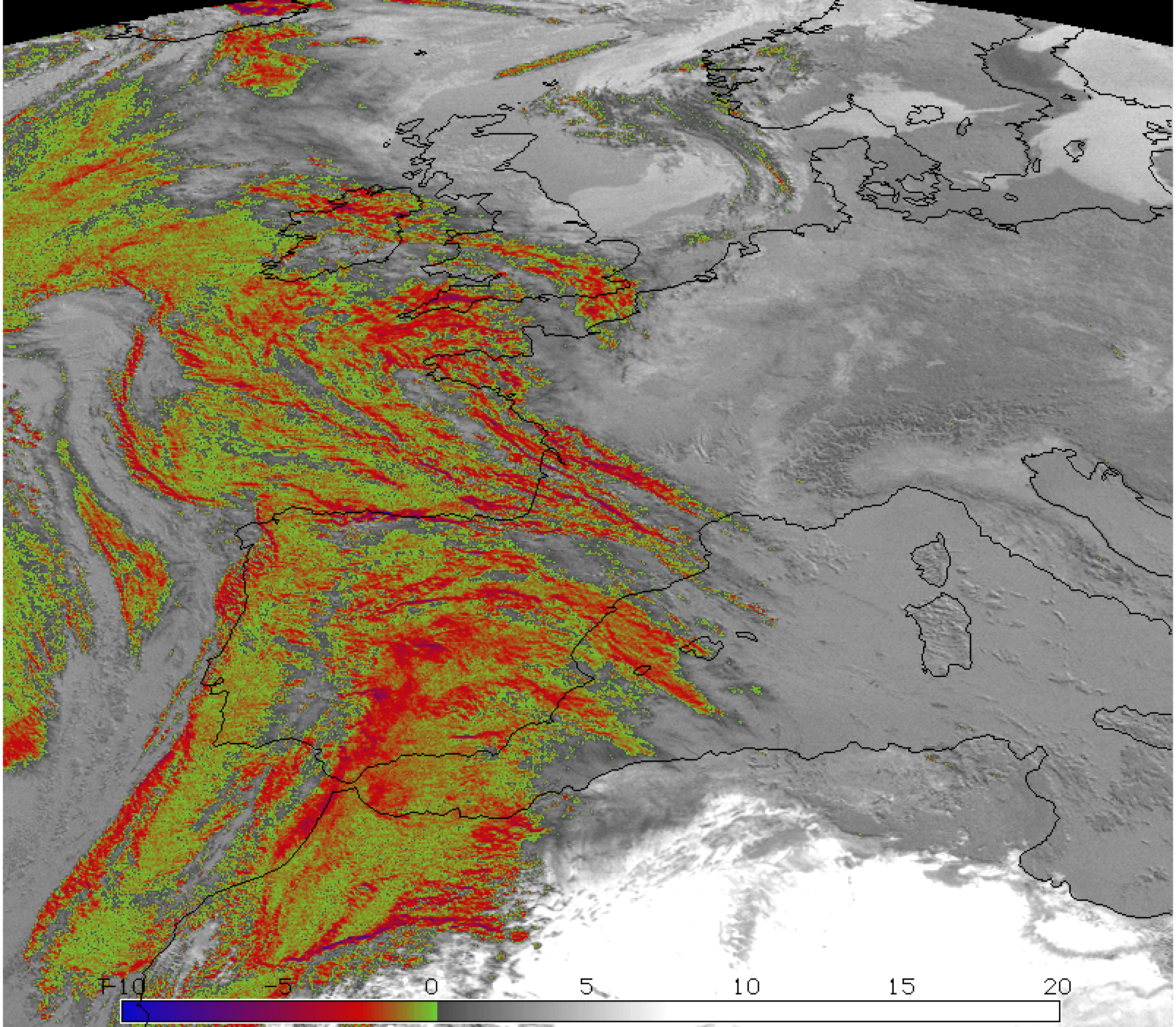


MSG-1 24 FEB 2003 12:30 UTC, TEMPERATURE DIFFERENCE 10.8 - 8.7 (C) MK



MSG-1 24 FEB 2003 12:45 UTC, TEMPERATURE DIFFERENCE 10.8 - 8.7 (C) MK

GERB (Geostationary Earth Radiation Budget) Science Objectives

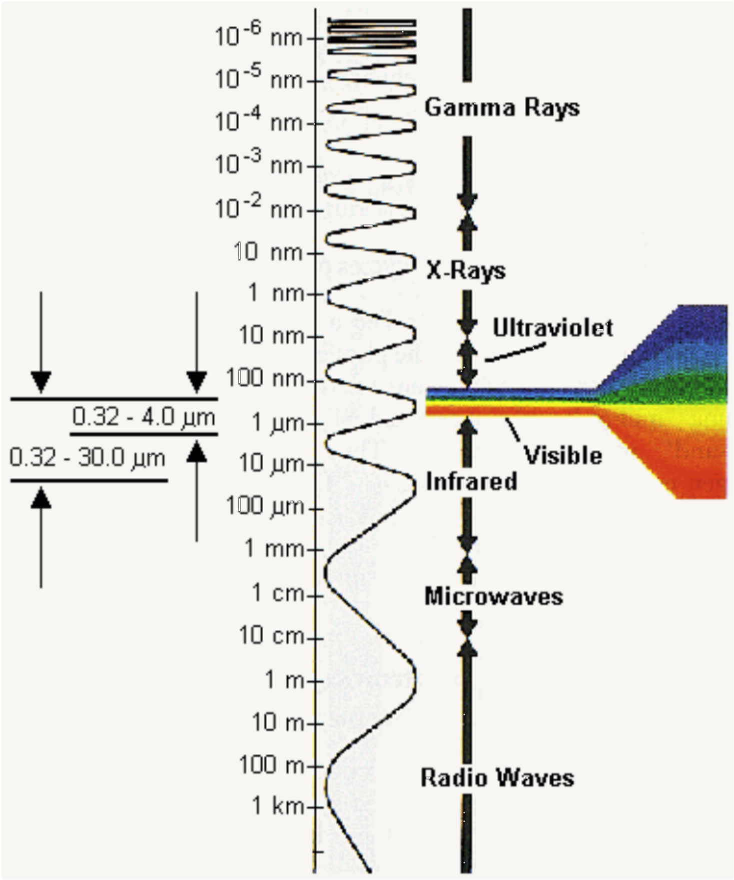
- Measure Total and short wave (SW) radiances
- Derive SW and LW fluxes
    - Validation of climate models
    - Observational studies of:
        - Tropical convection and marine stratocumulus, and their diurnal and synoptic variability.
        - The role of clouds in the ERB
        - The role of water vapour - radiative feedback
    - Validation of the TOA ERB in NWP models

GERB Imaging Principle - Frequency Bands

GERB measures in two frequency bands :

- a short wave (SW) band: 0.32 - 4.0 µm
- a TOTAL wave band: 0.32 - 30.0 µm
- the long wave (LW) band (4.0 - 30.0 µm) is obtained by subtraction of the SW from the Total)

The short wave band is achieved by the use of a quartz filter to block the lower frequency components.



Total channel

Short wavelength channel

Current Schedule (as of 14 May 2003)

MSG-1 Satellite

- Operated since September 2002 at 10.5 ° W
- Orbit inclination reduced to 1.5 ° (May 2003)
- Satellite performance test:
  - All satellite tests done except for SEVIRI but:
    - SEVIRI functionality widely and generally satisfactorily exercised
    - SEVIRI performance tests on-going and results achieved so far are encouraging
  - Satellite Commissioning Result Review held in March
  - Delta review end of June => review SEVIRI performance

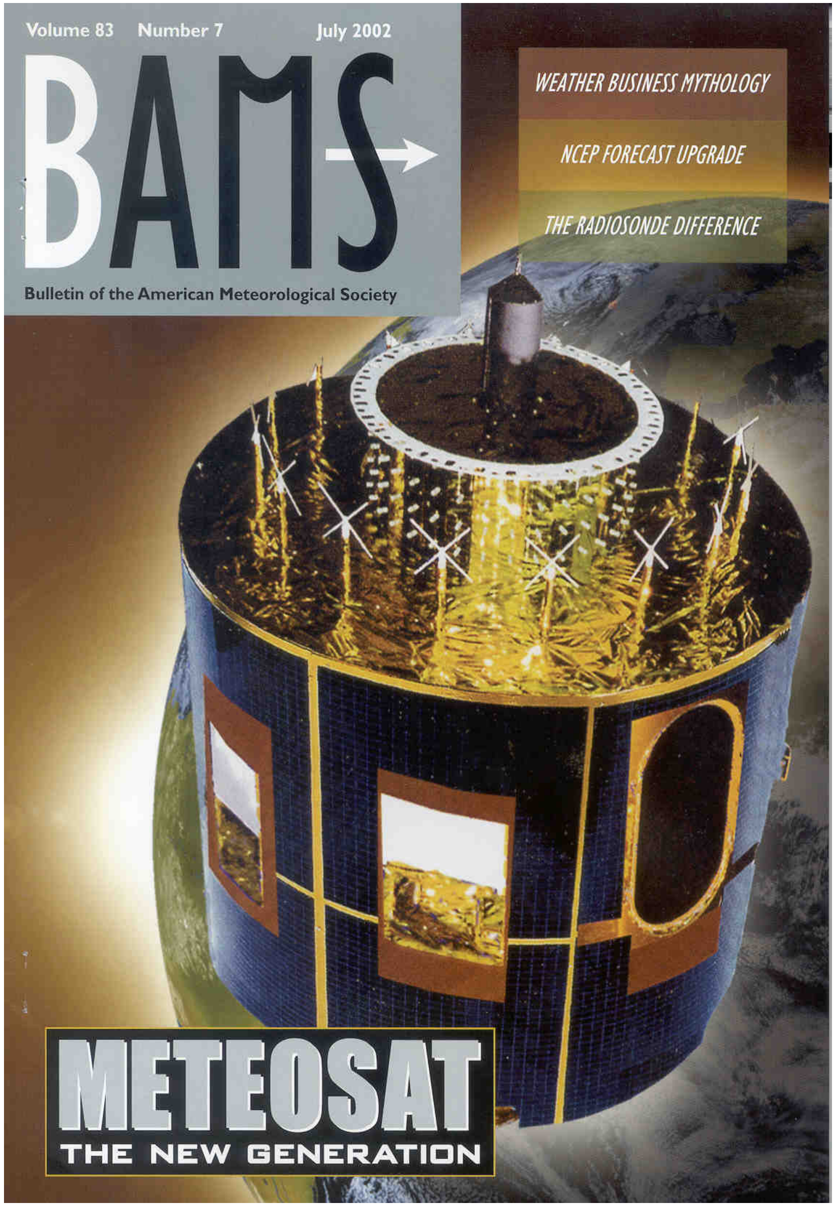
Current Schedule (as of 14 May 2003)

Alternative dissemination

- To recover SSPA failure, a project for a dissemination of MSG XRIT data over Europe has been initiated:
  - Use of DVB & FTP transfer technology
  - Low cost user terminal adaptation
  - First dissemination of SEVIRI images (via Hotbird 6) over Europe started 30th April. These images are rectified to 0 °
  - Regular SEVIRI image dissemination as of summer 2003.
  - Progressive dissemination of MET product starting mid September.
  - Aim at operational status over Europe by end 2003.

System Commissioning

- Completion of system commissioning by end 2003.



July 2002

AN INTRODUCTION TO METEOSAT SECOND GENERATION (MSG)

BY JOHANNES SCHMETZ, PAOLO PILI, STEPHEN TJEMKES, DIETER JUST, JOCHEN KERKMANN, SERGIO ROTA, AND ALAIN RATIER

Meteosat Second Generation (MSG), the new generation of European geostationary meteorological satellites, has greatly enhanced capabilities, especially for observing rapidly changing weather phenomena and for the derivation of quantitative products.

The meteorological community has benefited for more than two decades from the services of the current generation of the European geostationary meteorological Meteosat satellites, the first of which was launched in 1977. Since then it was followed by six successful launches of Meteosat satellites and *Meteosat-7* is currently the operational satellite at the nominal position at 0° longitude. The Meteosat series will be replaced by a new generation called Meteosat Second Generation (MSG). MSG provides the user community with continuity of services from the current Meteosat system, but will also significantly enhance services and products. As is the current Meteosat series, MSG satellites are spin stabilized (Fig. 1). However, MSG gives significantly increased information due to an imaging-repeat cycle of 15 min

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http://dx.doi.org/110.1175/BAMS-83-7-Schmetz-1 and
http://dx.doi.org/110.1175/BAMS-83-7-Schmetz-2.
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In final form 14 May 2002

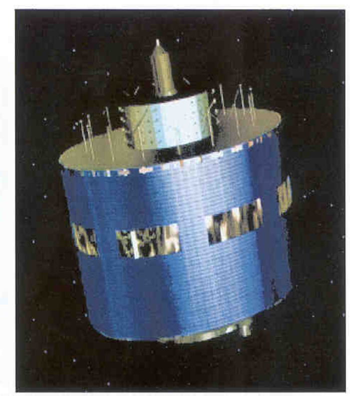

FIG. 1. MSG spacecraft; as with the current Meteosat series, MSG satellites are spin stabilized.