

Satellite meteorology

Part 2

Textbooks and web sites references for this lecture:

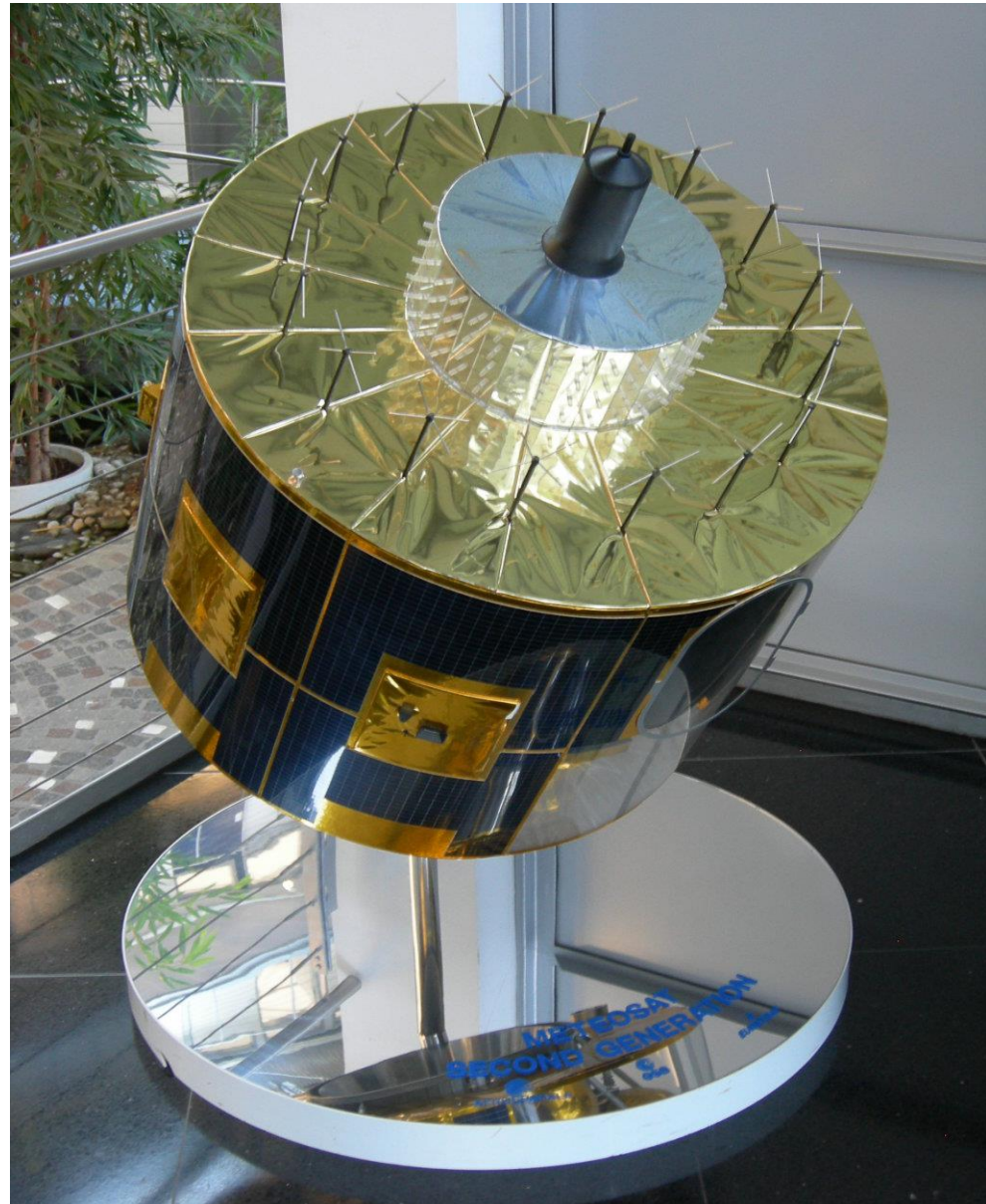
- Stanley Q. Kidder, Thomas H. Vonder Haar (Author) Satellite Meteorology: An Introduction, 1995, ISBN-13: 978-0124064300, Academic Press
- Manual of satellite meteorology (ZAMG):
<http://www.zamg.ac.at/docu/Manual/SatManu/main.htm>

MSG

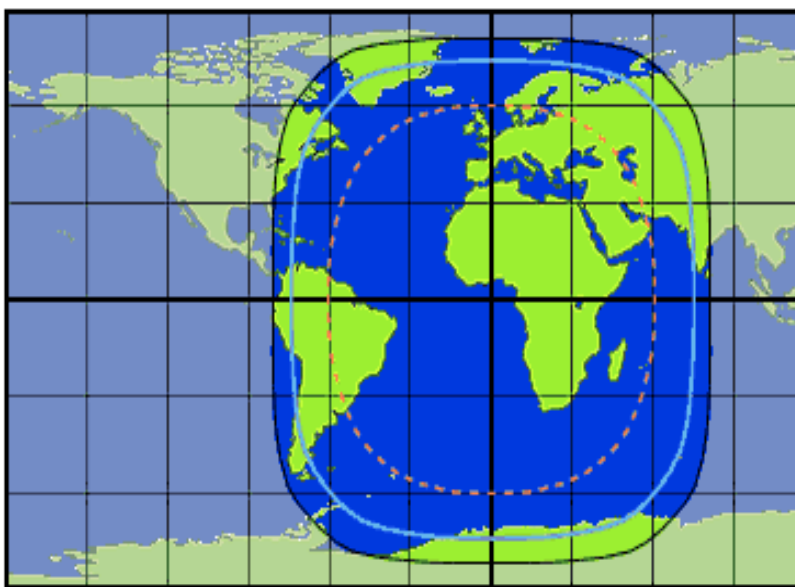
(Meteosat Second Generation)

Due satelliti meteorologici (uno attivo e uno di riserva):

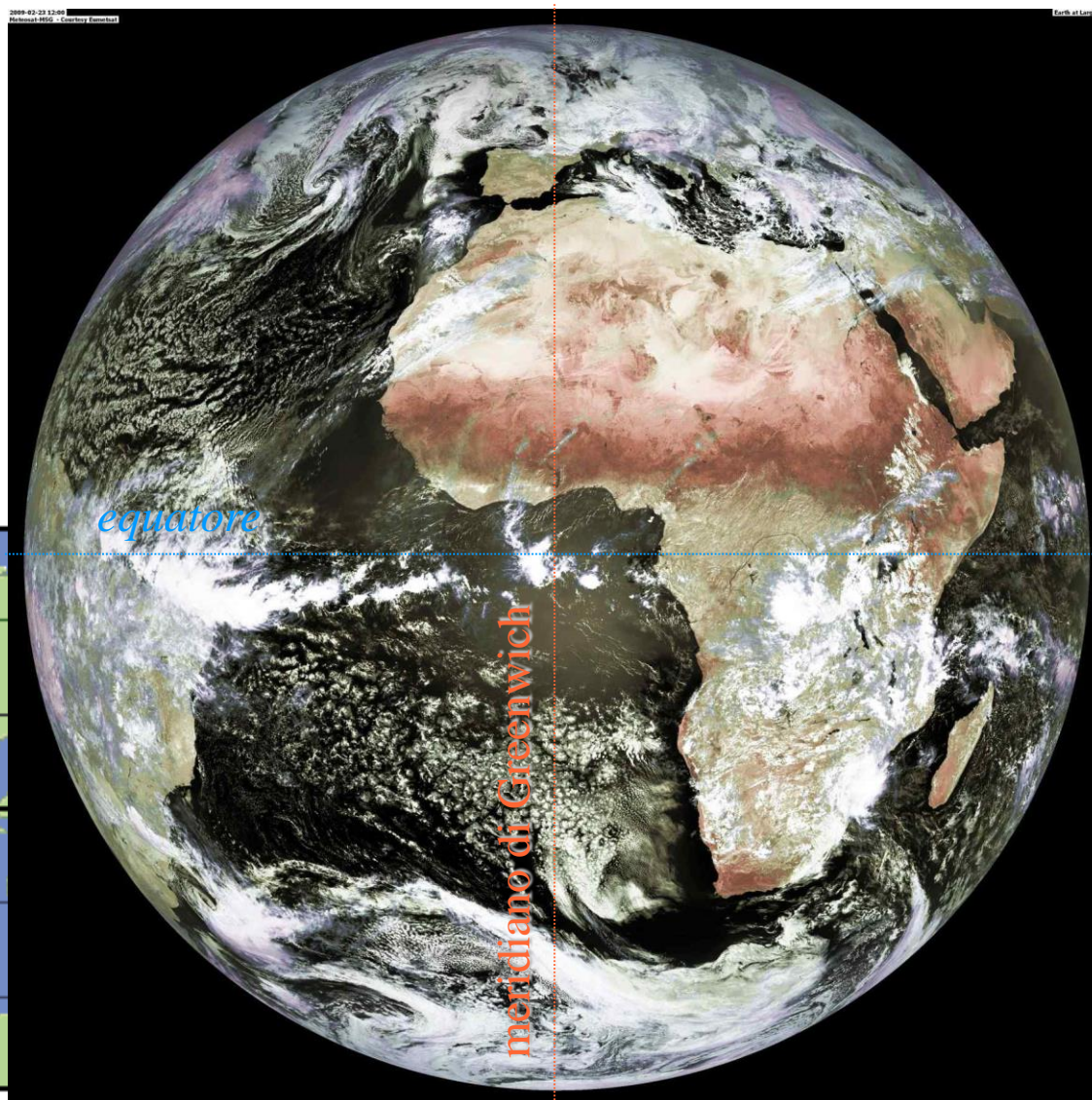
- lanciati a partire dal 2002
- ARPA Piemonte riceve le relative immagini mediante un sistema composto da una antenna parabolica, più una serie di server di elaborazione.



- Orbita geostazionaria
- Posizione:
 - *Latitudine* = 0°
 - *Longitudine* = 0°
 - Quota ~ 36000 km



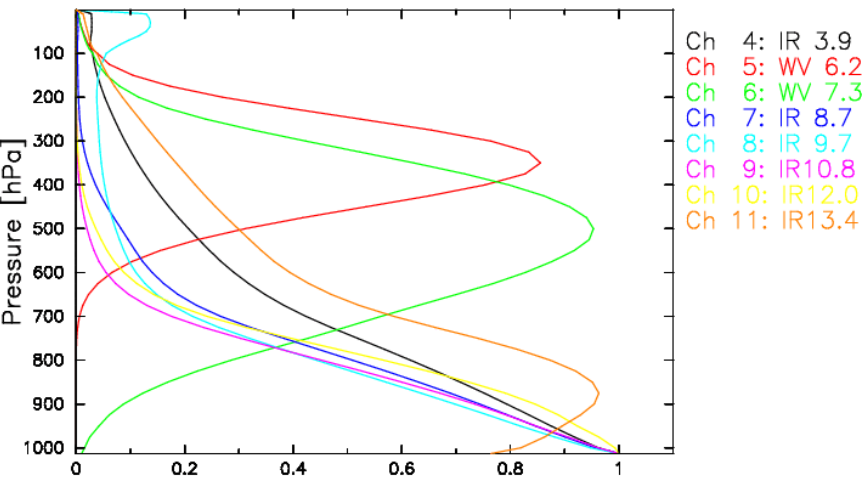
- Maximum theoretical coverage
- Imaging and telecommunications coverage
- - - Meteosat images within this area used quantitatively



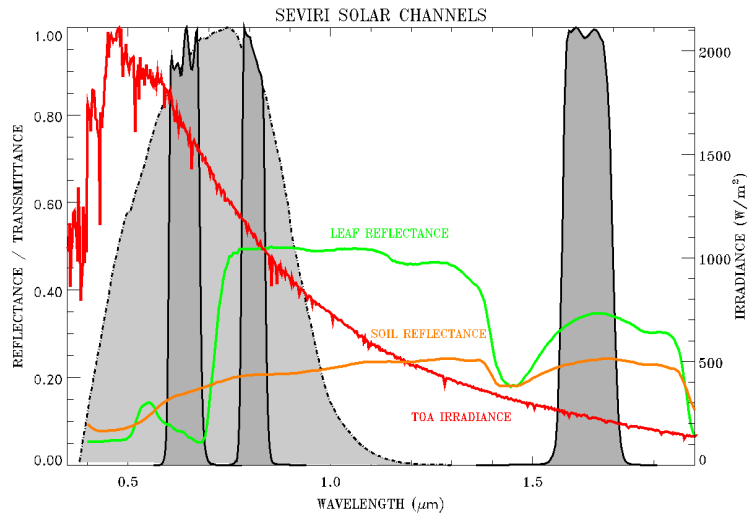
Meteosat 8

CARATTERISTICHE DEI CANALI SPETTRALI

Standard Mid-Latitude Summer Nadir



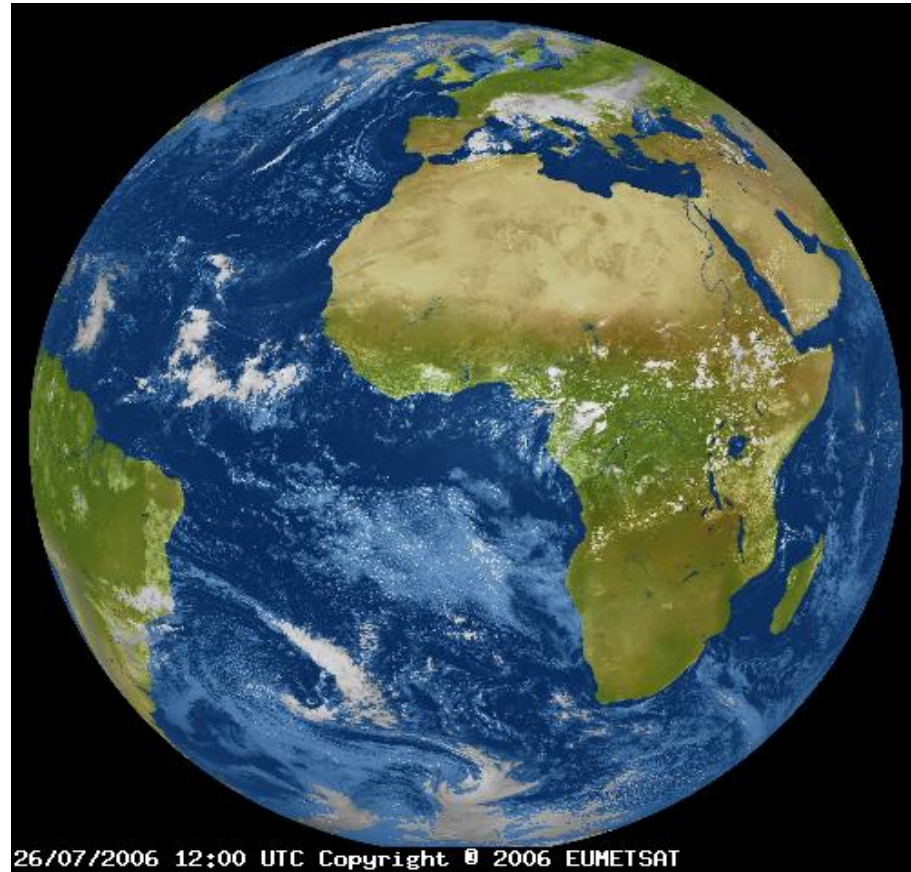
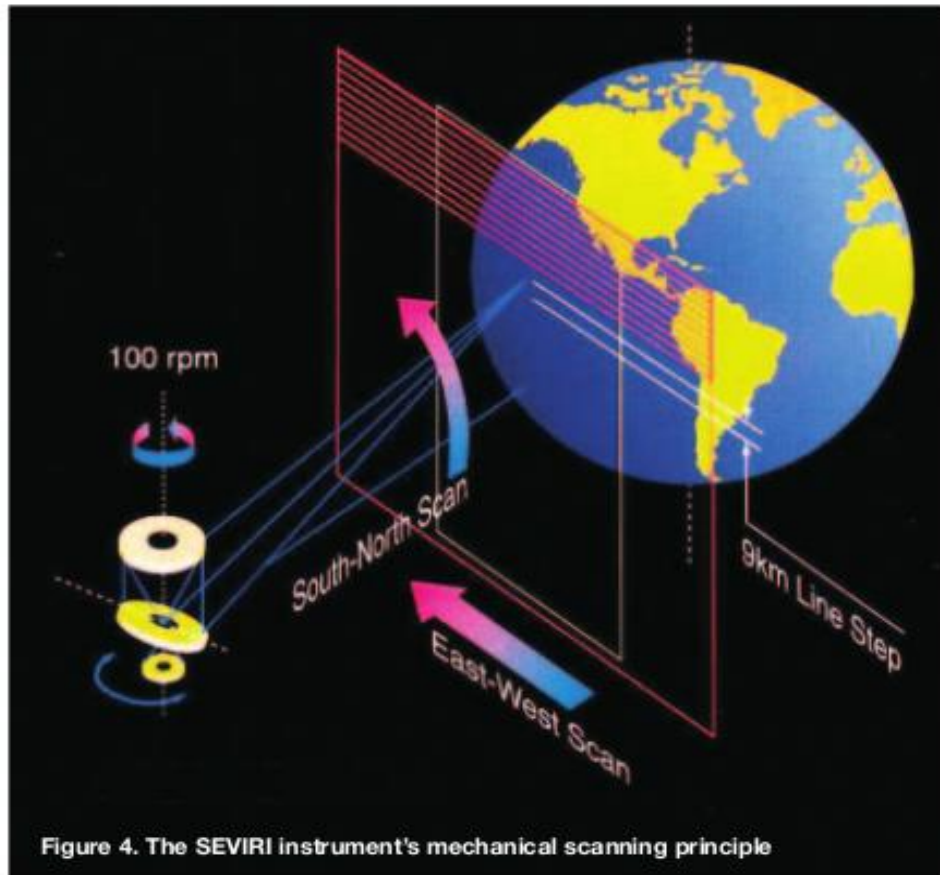
Normalised Weighting Function



Channel No.	Spectral Band (μm)	Characteristics of Spectral Band (μm)			Main observational application
		λ_{min}	λ_{max}	λ_{center}	
1	VIS0.6	0.635	0.56	0.71	Surface, clouds, wind fields
2	VIS0.8	0.81	0.74	0.88	Surface, clouds, wind fields
3	NIR1.6	1.64	1.50	1.78	Surface, cloud phase
4	IR3.9	3.90	3.48	4.36	Surface, clouds, wind fields
5	WV6.2	6.25	5.35	7.15	Water vapor, high level clouds, atmospheric instability
6	WV7.3	7.35	6.85	7.85	Water vapor, atmospheric instability
7	IR8.7	8.70	8.30	9.1	Surface, clouds, atmospheric instability
8	IR9.7	9.66	9.38	9.94	Ozone
9	IR10.8	10.80	9.80	11.80	Surface, clouds, wind fields, atmospheric instability
10	IR12.0	12.00	11.00	13.00	Surface, clouds, atmospheric instability
11	IR13.4	13.40	12.40	14.40	Cirrus cloud height, atmospheric instability
12	HRV	Broadband (about 0.4 – 1.1 μm)			Surface, clouds

Risoluzione spaziale
 IR: 3 km al NADIR
 HRV: 1 km al NADIR

Scanning principle



Sensore: **SEVIRI**
(Spinning Enhanced
Visible and InfraRed
Imager)

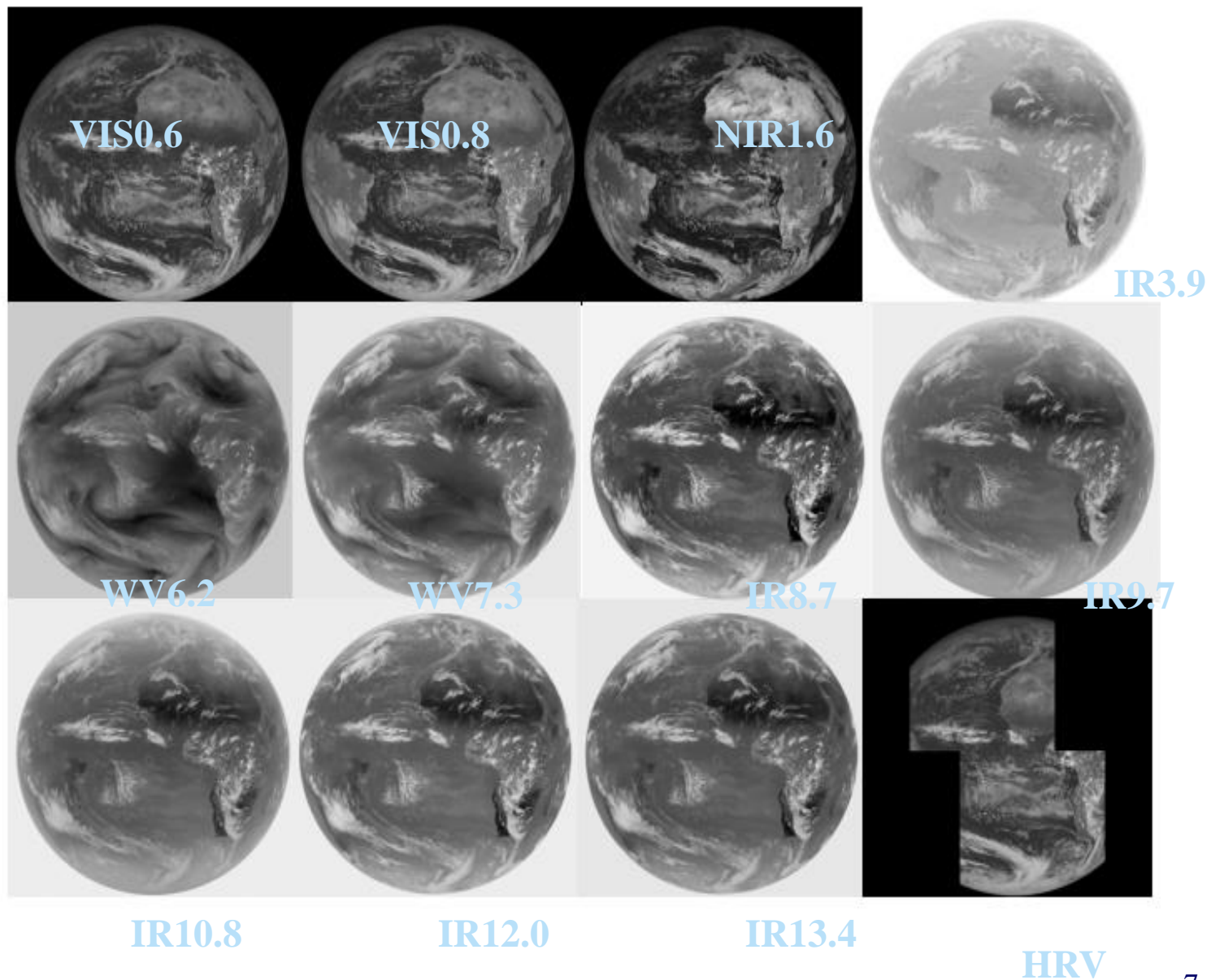
12 canali spettrali:
 > 2 nel visibile
 > 1 nel visibile ad alta
 risoluzione (HRV)
 > 1 nell'infrarosso vicino
 > i rimanenti
 nell'infrarosso

Frequenza di
 acquisizione:
 15 min.

Risoluzione spaziale:
 3.2 km (1.6 km per
 HRV)

Channel No.	Spectral Band (μm)	Characteristics of Spectral Band (μm)			Main observational application
		λ_{cen}	λ_{min}	λ_{max}	
1	WISO.6	0.635	0.56	0.71	Surface, clouds, wind fields
2	WISO.8	0.81	0.74	0.88	Surface, clouds, wind fields
3	NIR1.6	1.64	1.50	1.78	Surface, cloud phase
4	IR3.9	3.90	3.48	4.36	Surface, clouds, wind fields
5	WV6.2	6.25	5.35	7.15	Water vapor, high level clouds, atmospheric instability
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8	IR9.7	9.66	9.38	9.94	Ozone
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10	IR12.0	12.00	11.00	13.00	Surface, clouds, atmospheric instability
11	IR13.4	13.40	12.40	14.40	Cirrus cloud height, atmospheric instability
12	HRV	Broadband (about 0.4 – 1.1 μm)			Surface, clouds

L'intero
globo
terrestre
visualizzato
o nelle
varie
bande di
SEVIRI



Esempi: confronto VIS-IR

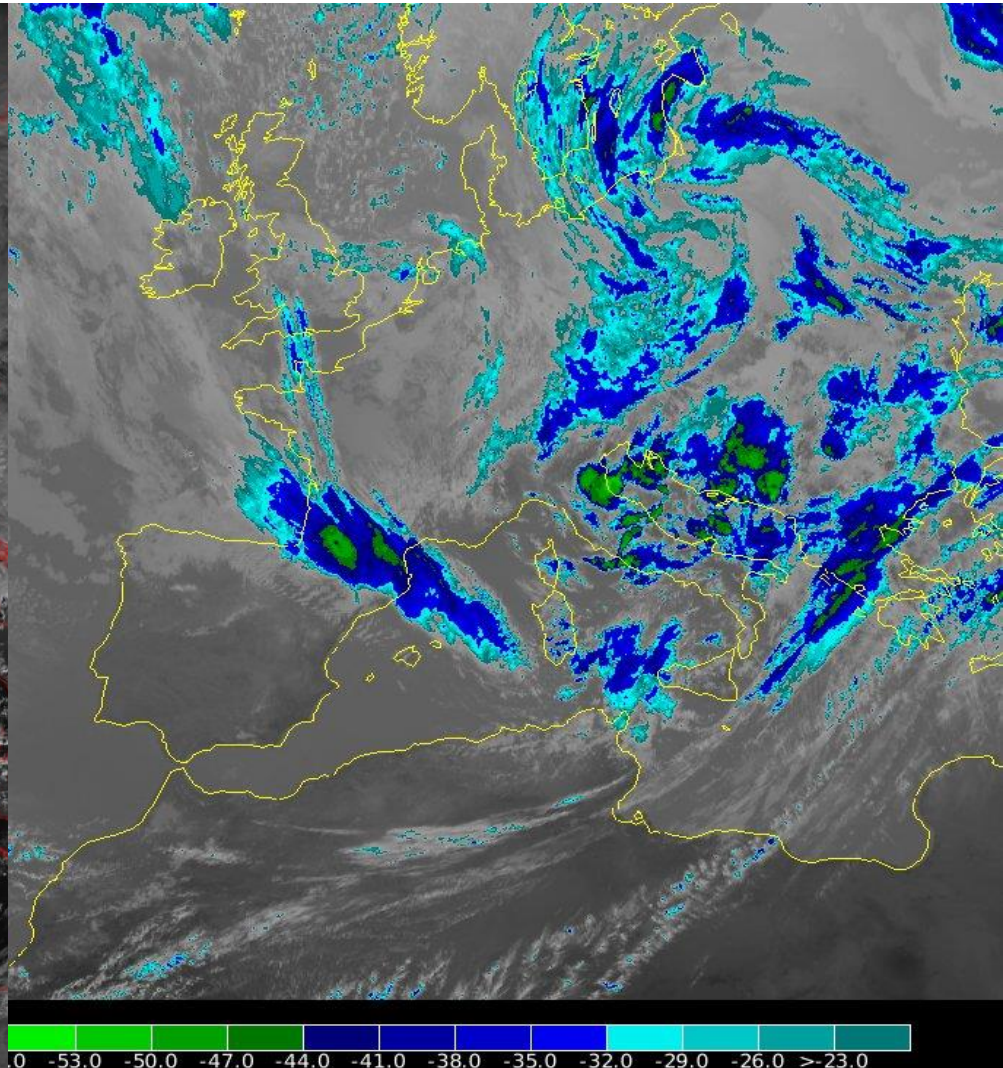
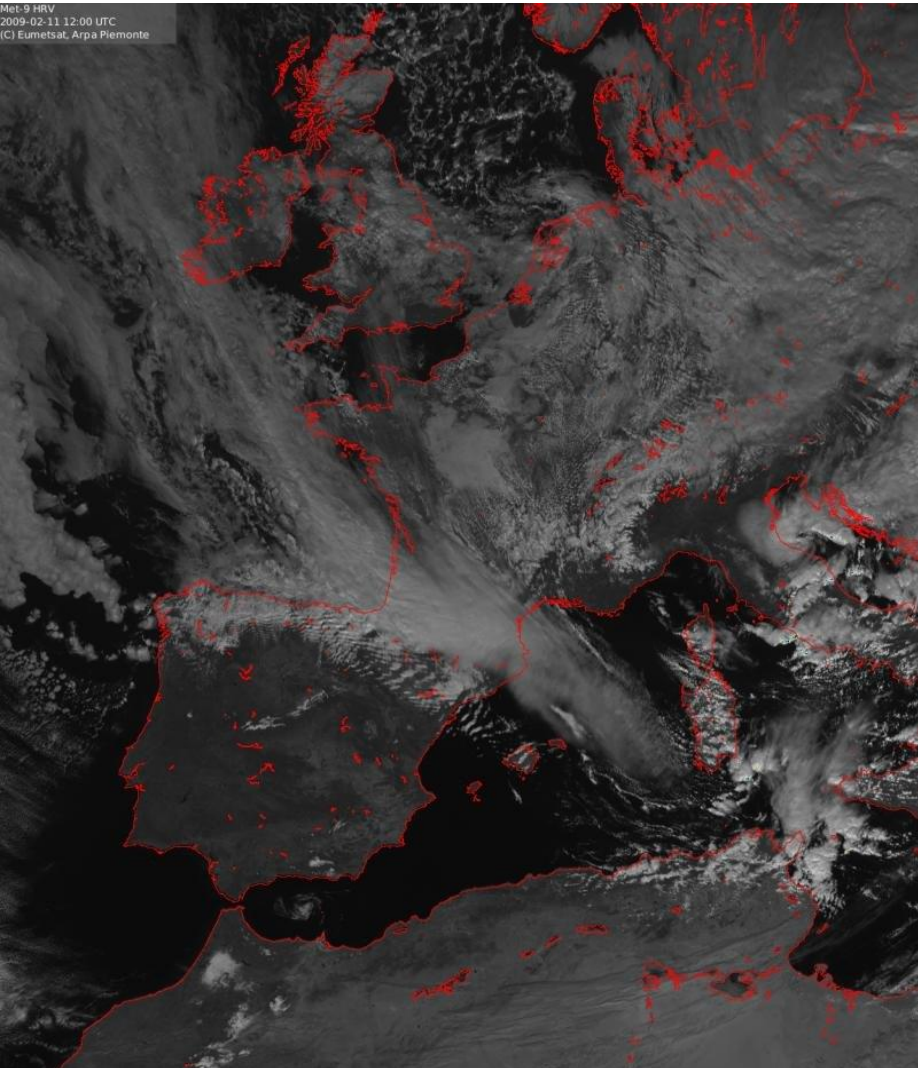
Queste nubi alte sono chiaramente visibili nell'infrarosso. Essendo molto sottili non sono altrettanto evidenti nel visibile



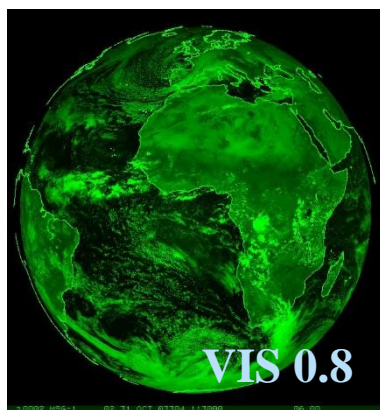
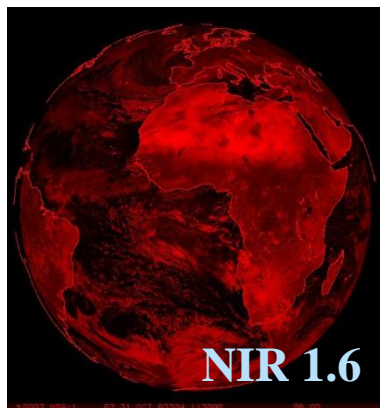
Singole bande in scala di grigi (11/02/2009 – ore 12:00 UTC)

HRV : visibile ad alta risoluzione - consente di discriminare tra nuvole e superficie terrestre

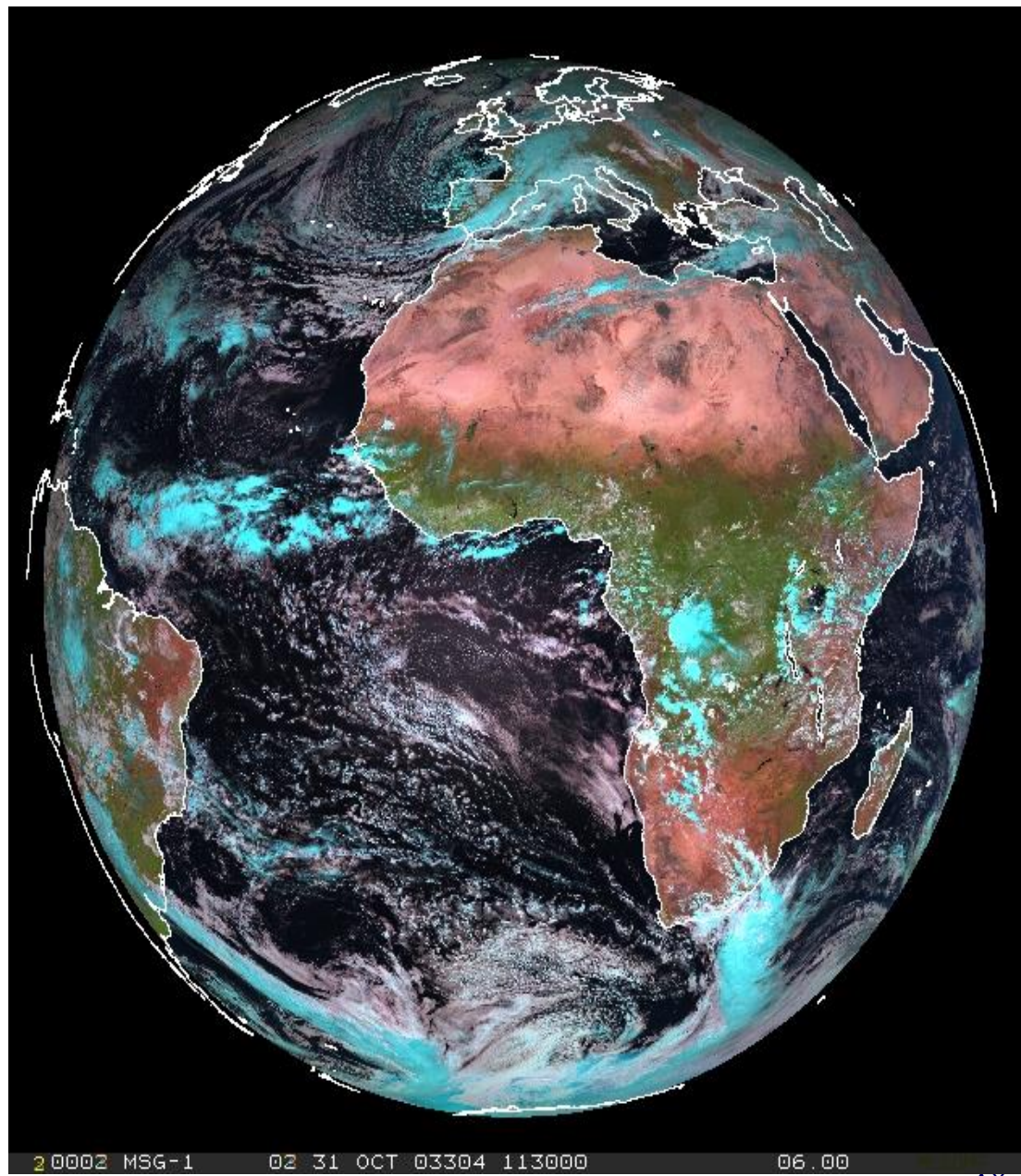
IR10.8 : disponibile anche di notte – temperatura di radianza delle nuvole, del terreno, del mare



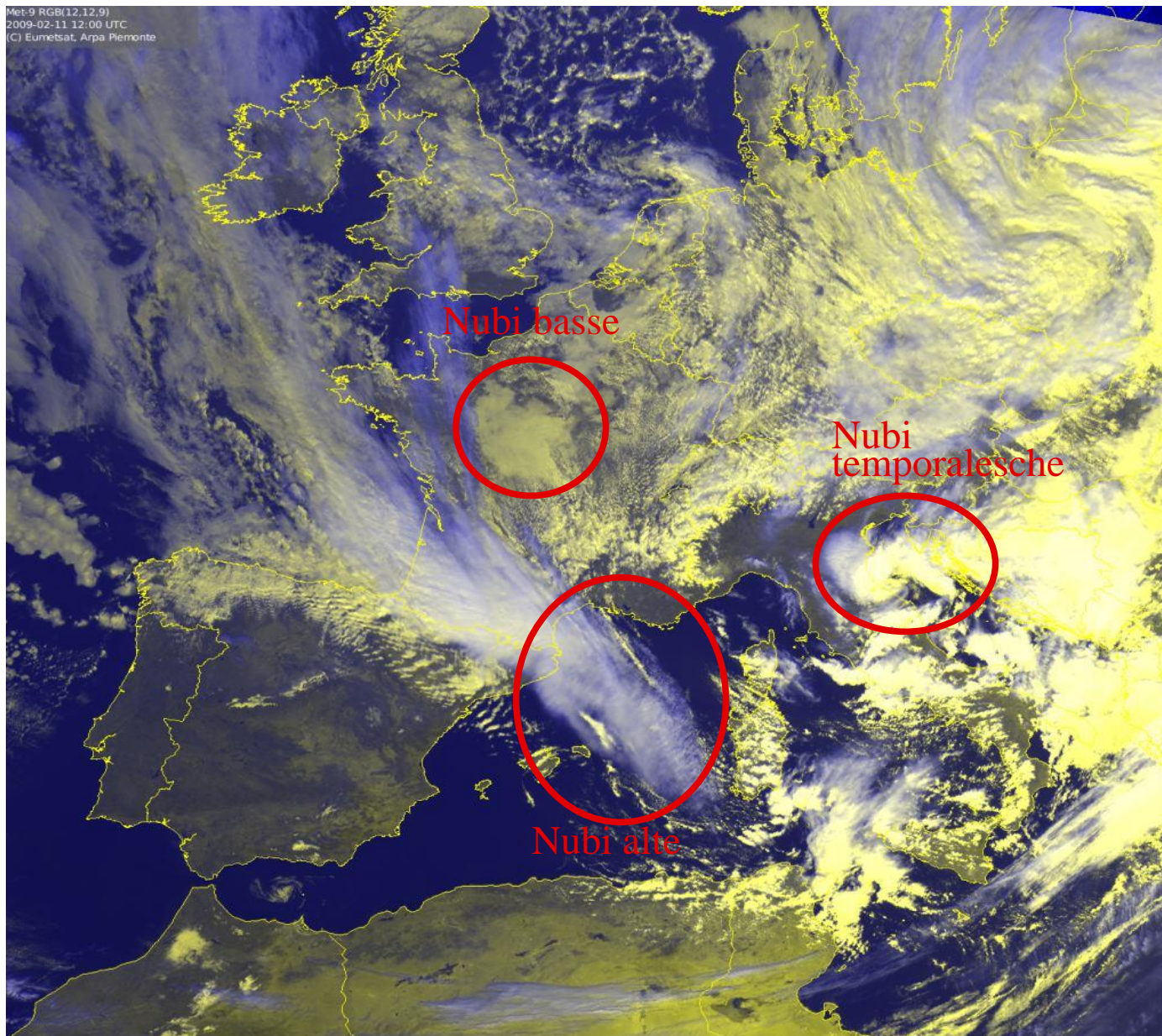
R=rosso,
G=verde, B=blu,
sono i tre colori
fondamentali con
cui si riescono a
formare tutti gli
altri.



Assegnando ad
ognuno di questi
tre colori una
banda di MSG, si
ottengono
immagini a colori
che restituiscono
maggiori
informazioni sui
tipi di nubi



Esempi di RGB elaborati da ARPA Piemonte: immagine bispettrale

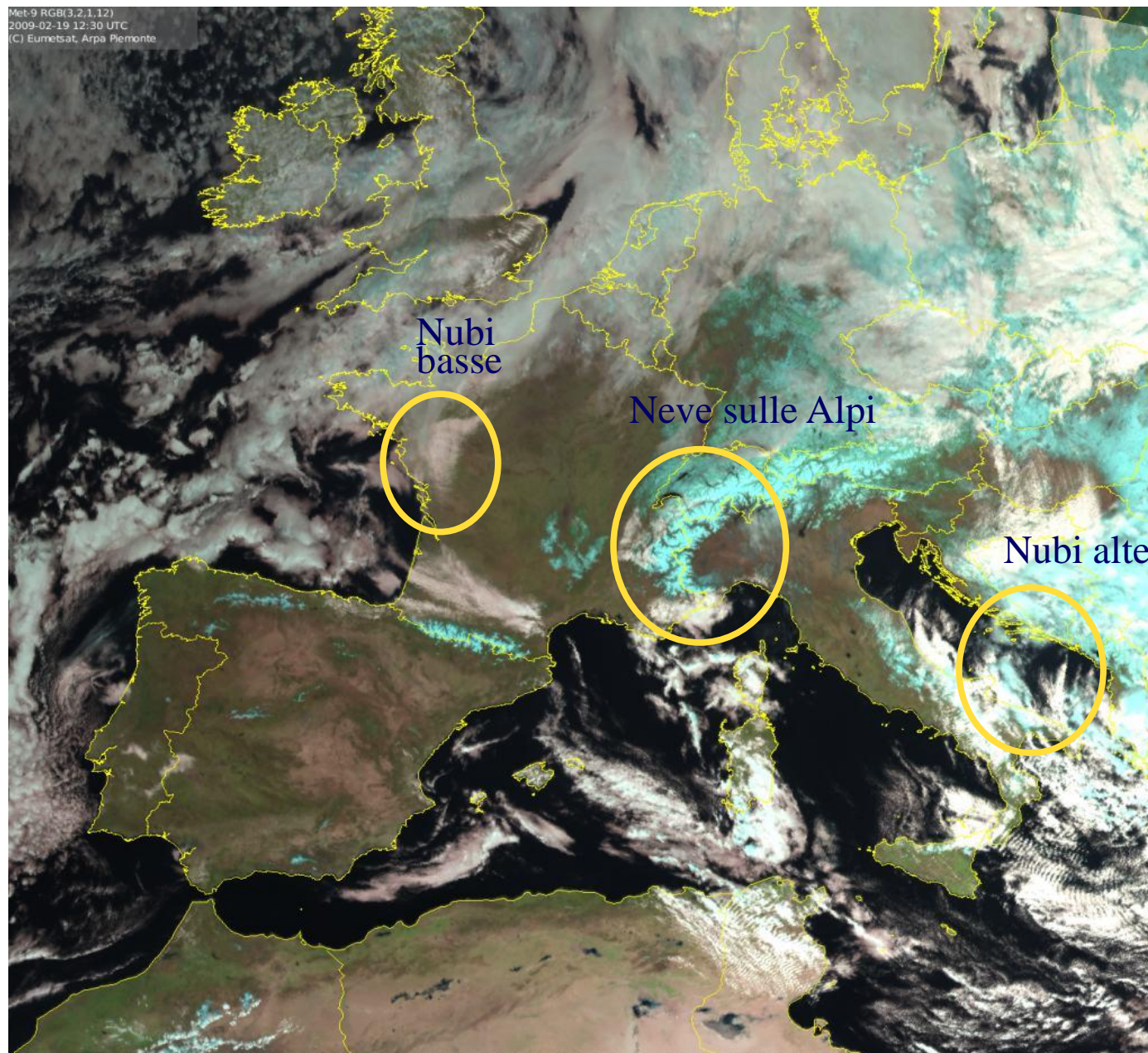


HRV cloud
(11/02/2009 - ore
12:00 UTC): è
composta dal HRV e
dal IR10.8

Le nubi a quote
basse e medie
appaiono in giallino.
Anche la neve al
suolo è gialla.

I cirri e le nubi alte
sono violette. Le
nubi fredde e
spesse (come ad
esempio i
cumulonembi
temporaleschi)
tendono al bianco.

Esempi di RGB elaborati da ARPA Piemonte: immagine quadrispettrale



HRV Natural Colors
(19/02/2009 – ore 12:30 UTC):
VIS006+VIS008+
IR016+HRV

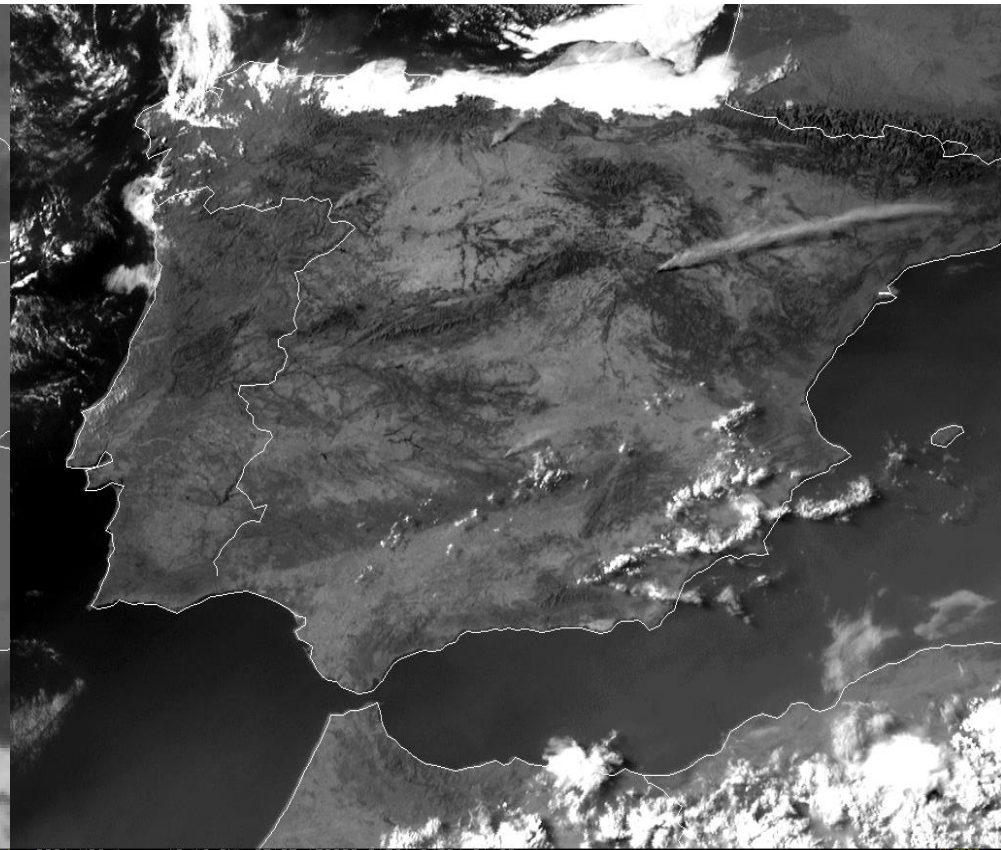
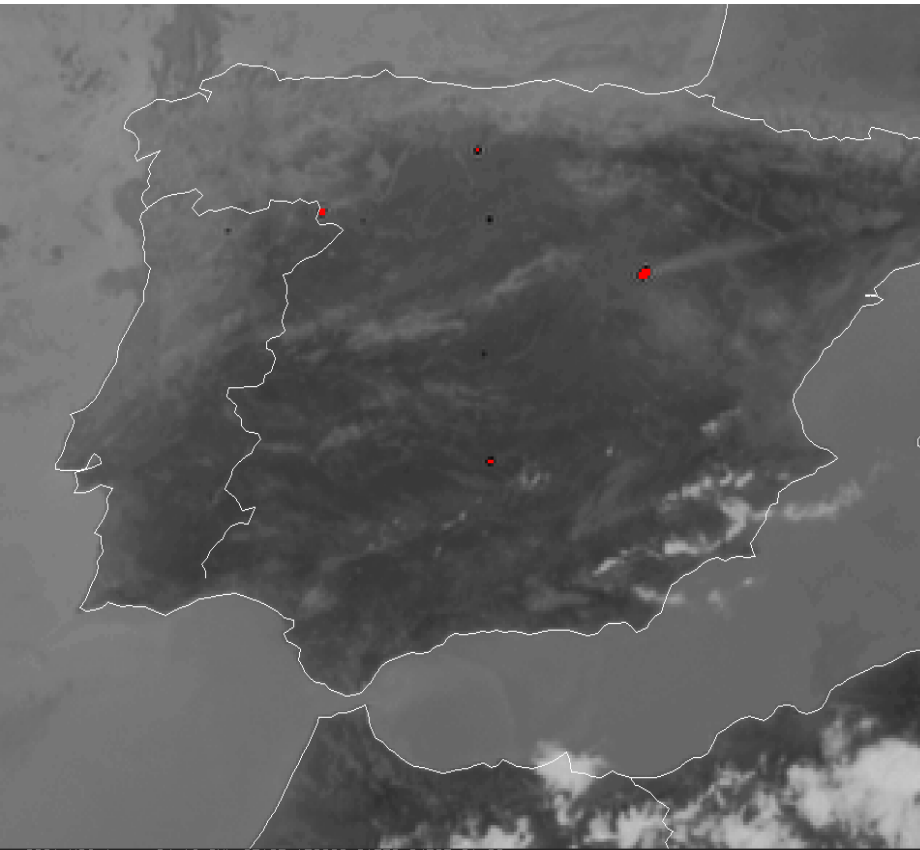
Distingue vegetazione e zone aride; le nubi basse appaiono con un rosa pallido; le zone coperte di neve appaiono in ciano, da non confondere con l'azzurro più acceso delle nubi alte e fredde.

Utilizzo di immagini MSG per rilevare fenomeni particolari

Incendi catastrofici in Spagna (16 Luglio 2005)

IR 3.9: con questa banda è possibile vedere l'anomalia termica (in rosso) dovuta agli incendi

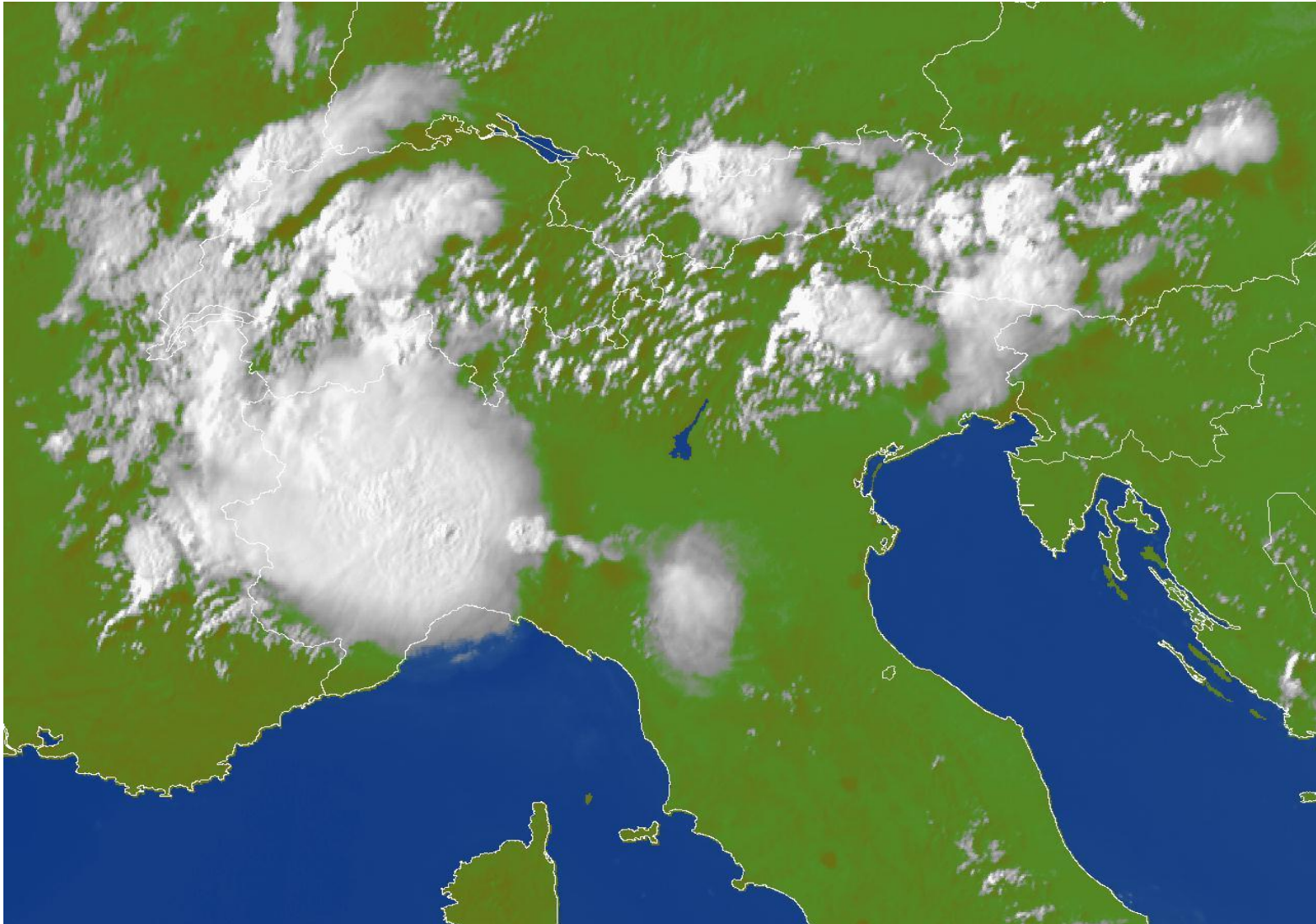
HRV: con questa banda ad alta risoluzione è invece possibile notare i pennacchi di fumo causati dagli incendi, che si estendono verso est



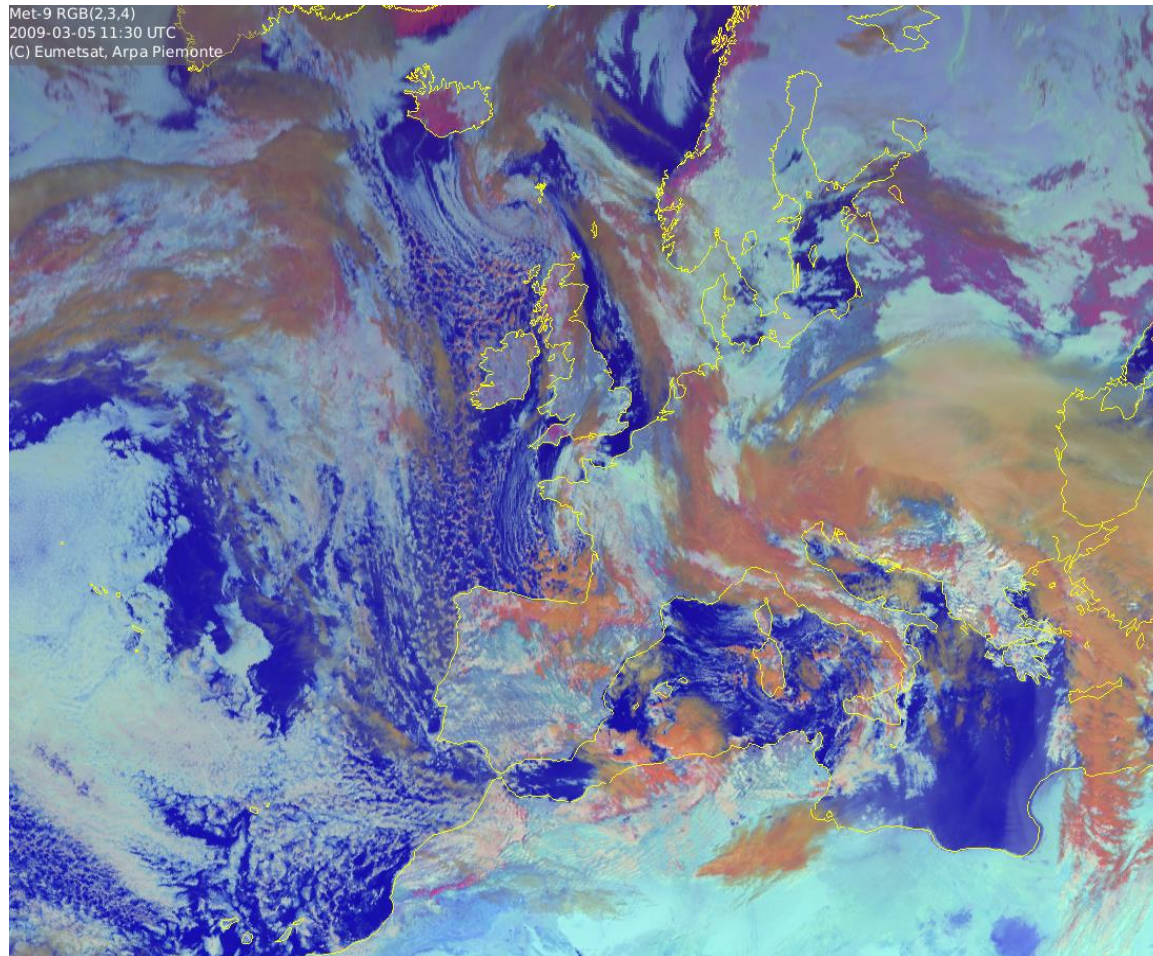
Utilizzo di immagini MSG per rilevare fenomeni particolari

Fenomeni convettivi intensi su Torino e il Piemonte

HRV (24/06/2006 – dalle ore 14:00 alle 16:00 UTC)



Immagini tri-spettrali MSG

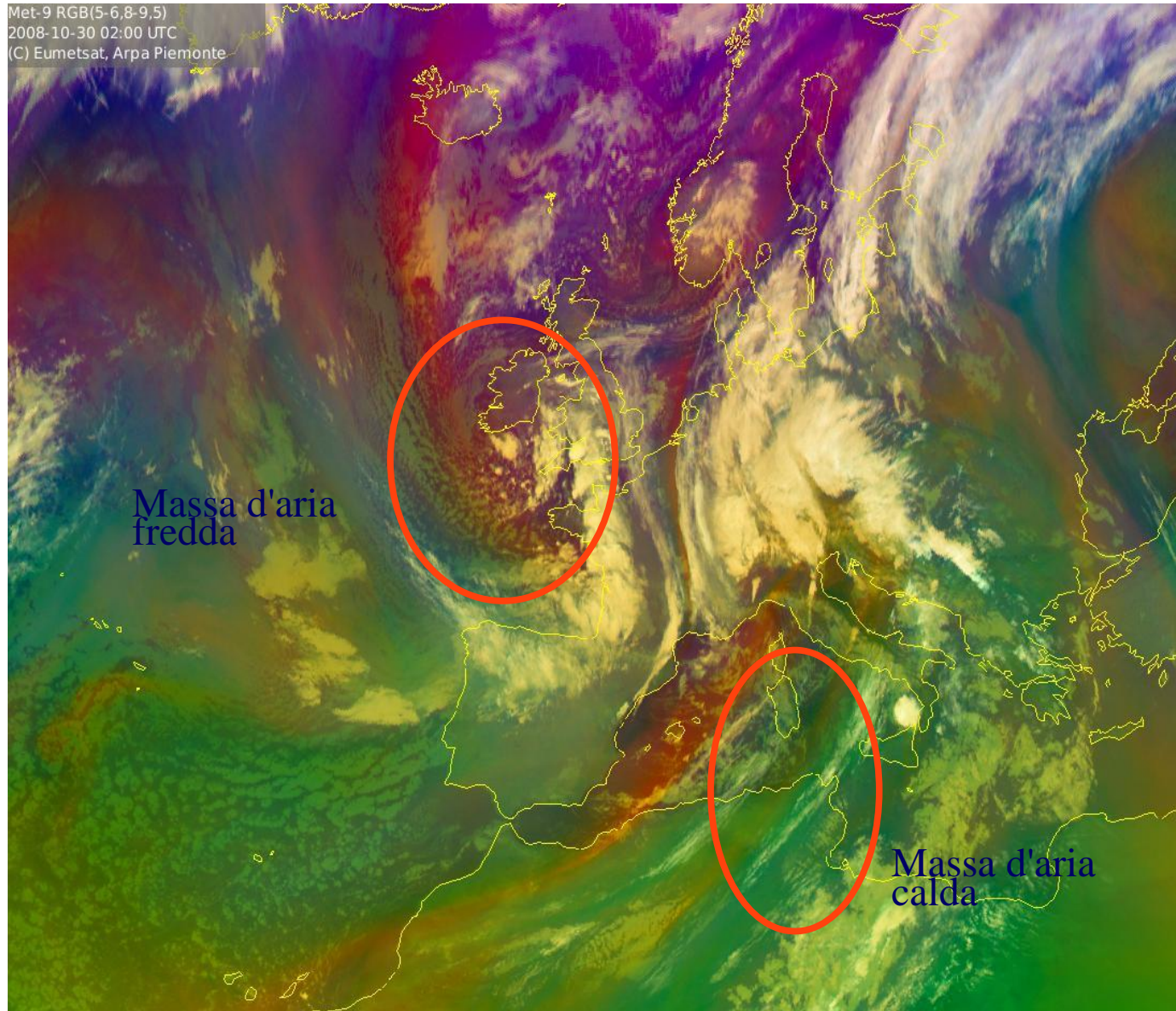


Day Solar

VIS008+IR016+IR039

Mette in evidenza la copertura nevosa, in tonalità accese del rosso. Le nubi basse appaiono in bianco o in azzurro chiaro. Le tonalità del giallo e dell'arancione mostrano nubi alte e fredde

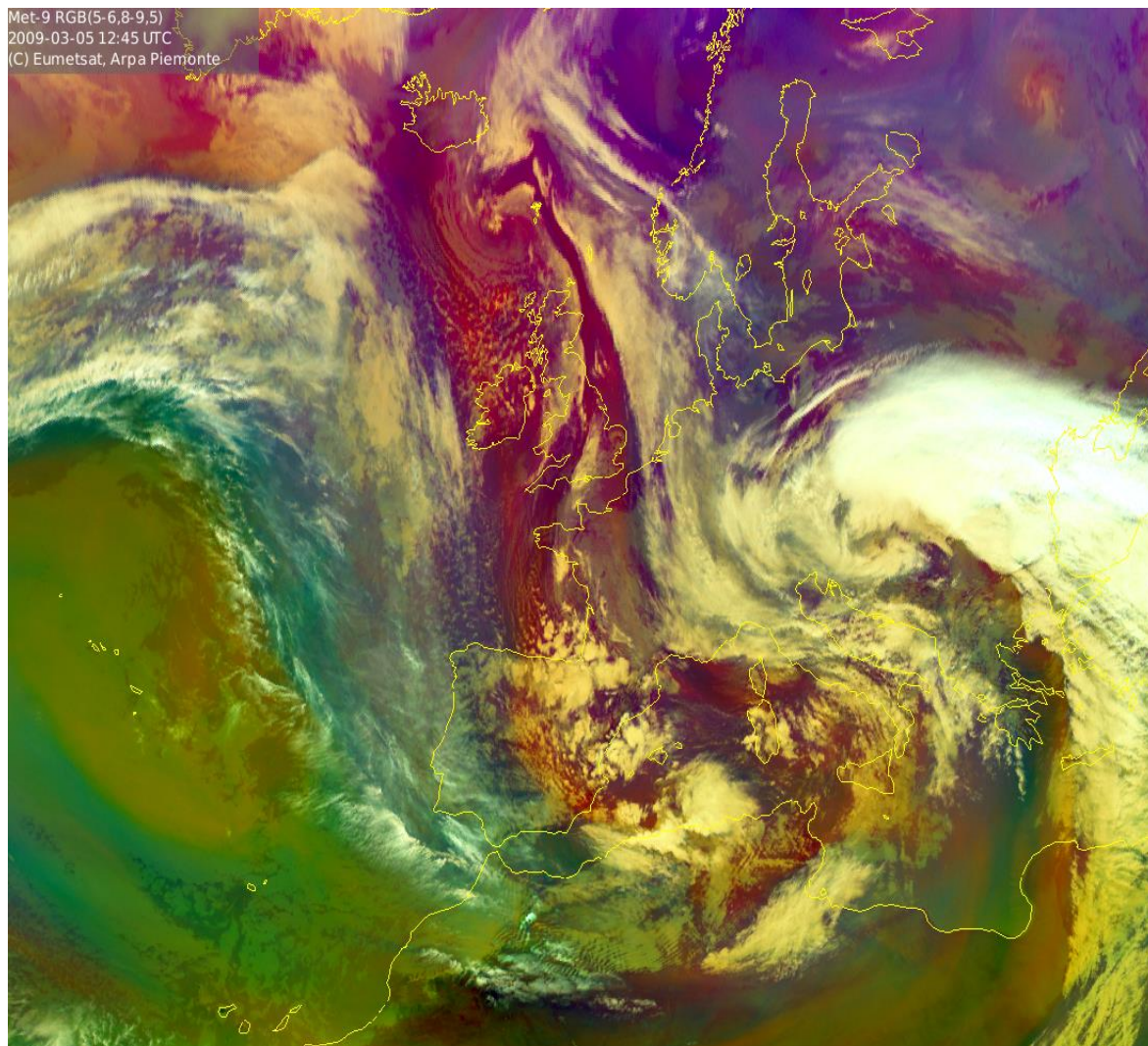
Esempi di RGB elaborati da ARPA Piemonte: immagine trispettrale



**Airmass (30/10/2008 –
ore 02:00 UTC):**
(WV062-
WV073)+(IR097 –
IR108)+ WV062

Consente di distinguere i tipi di nubi (in bianco quelle alte, in tonalità arancioni e tendenti al verde scuro quelle medie e basse) e anche le differenti masse d'aria. In verdino sono visualizzate le masse d'aria calda, in blu quelle d'aria fredda; le masse d'aria ad alta vorticità potenziale sono in rosso.

Immagini tri-spettrali MSG

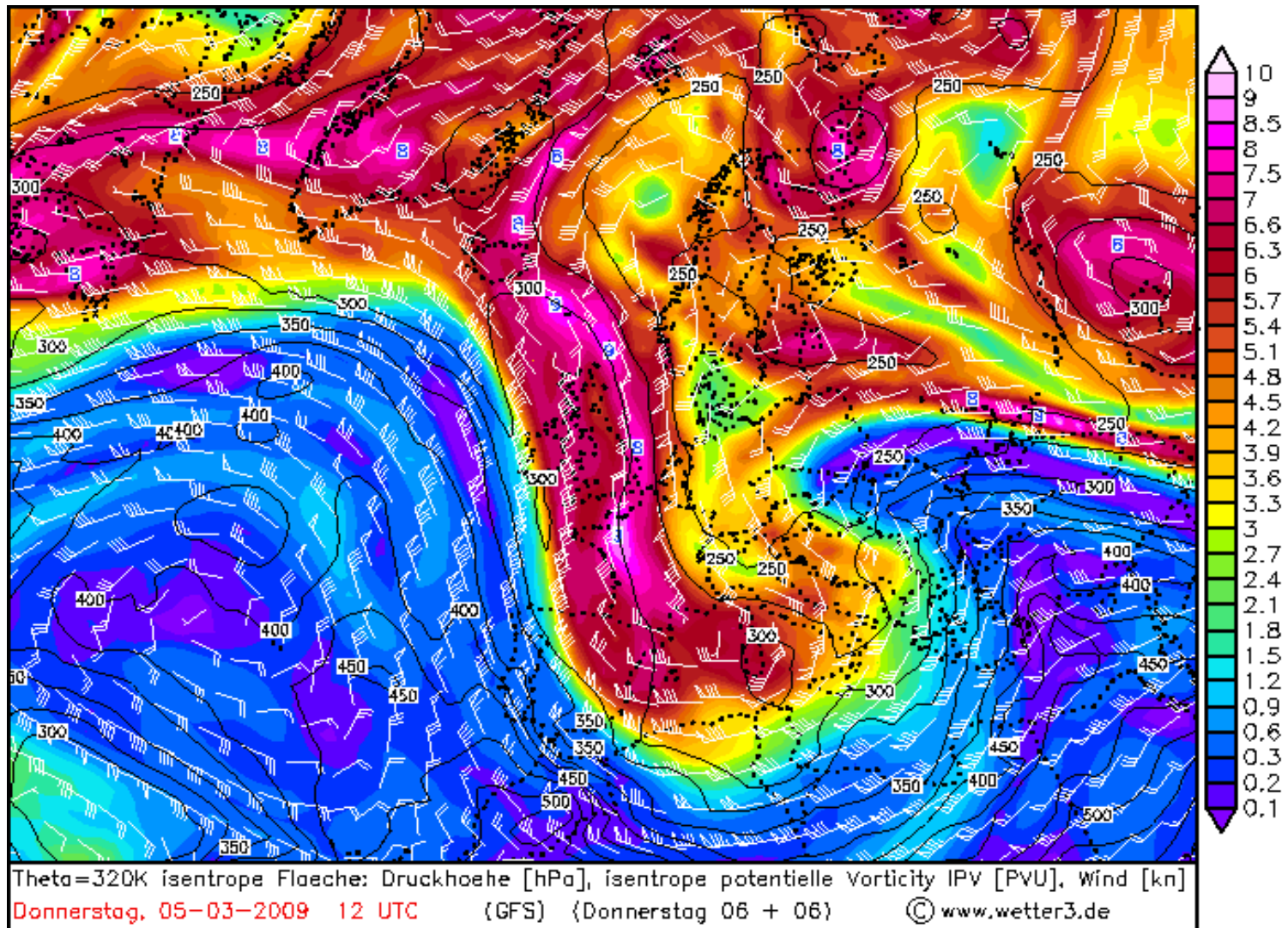


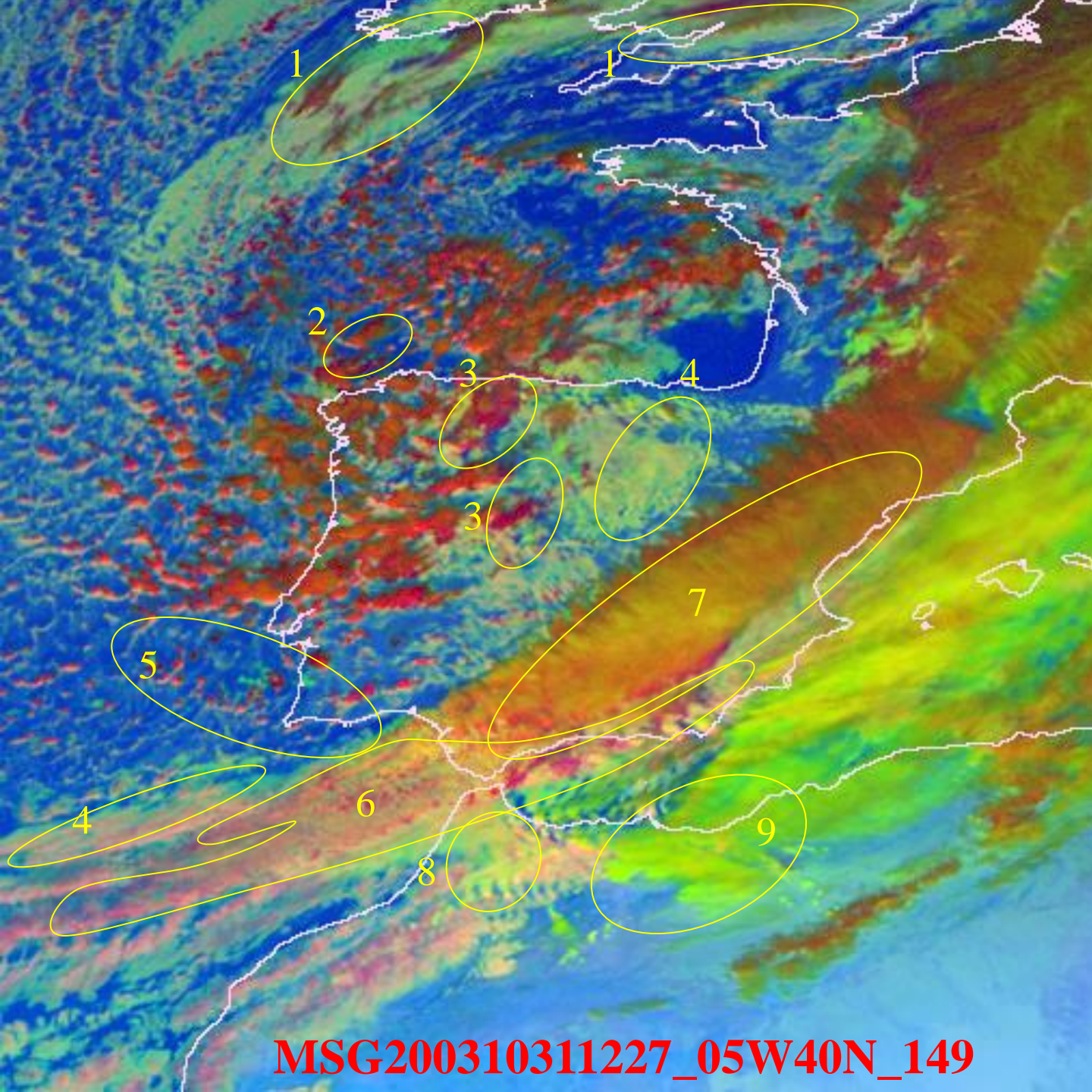
Airmass

$(WV062-WV073)+(IR097-IR108)+WV062$

Consente di distinguere i tipi di nubi (in bianco quelle alte, in tonalità arancioni e tendenti al verde scuro quelle medie e basse) e anche le differenti masse d'aria. In verdino è visualizzata l'aria calda, in blu quella fredda; le masse d'aria in un 'Advection jet' (con alta vorticità potenziale PV) sono in rosso.

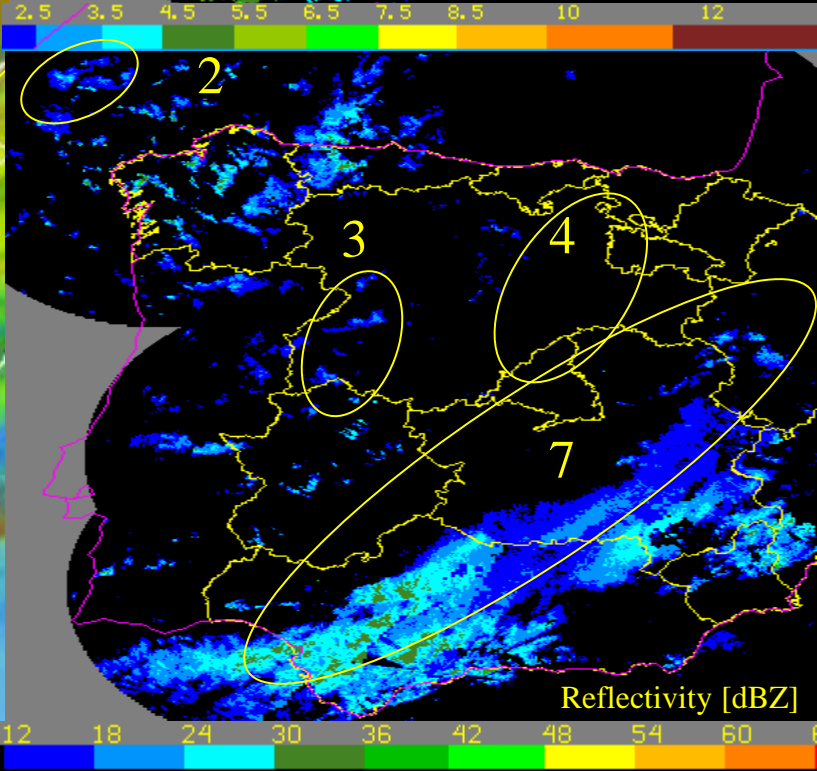
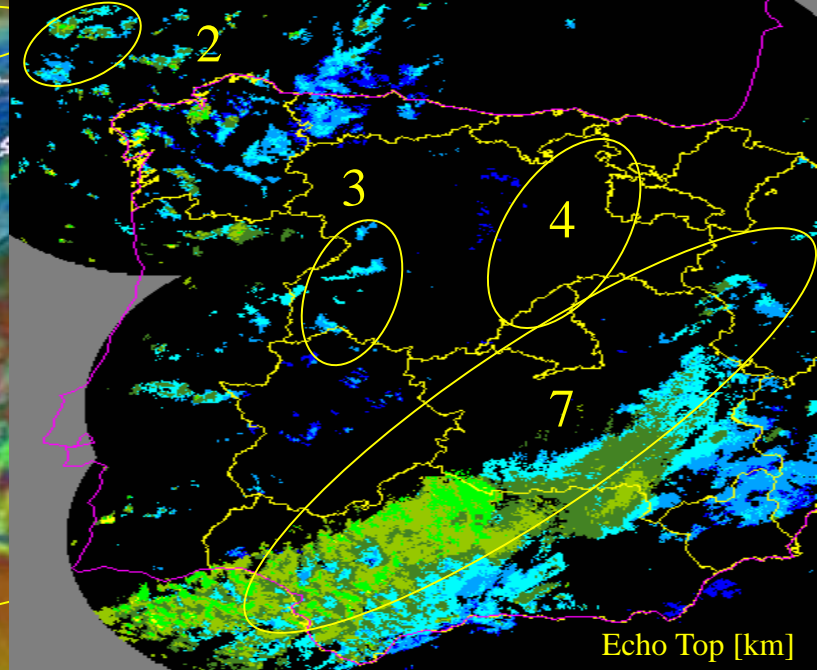
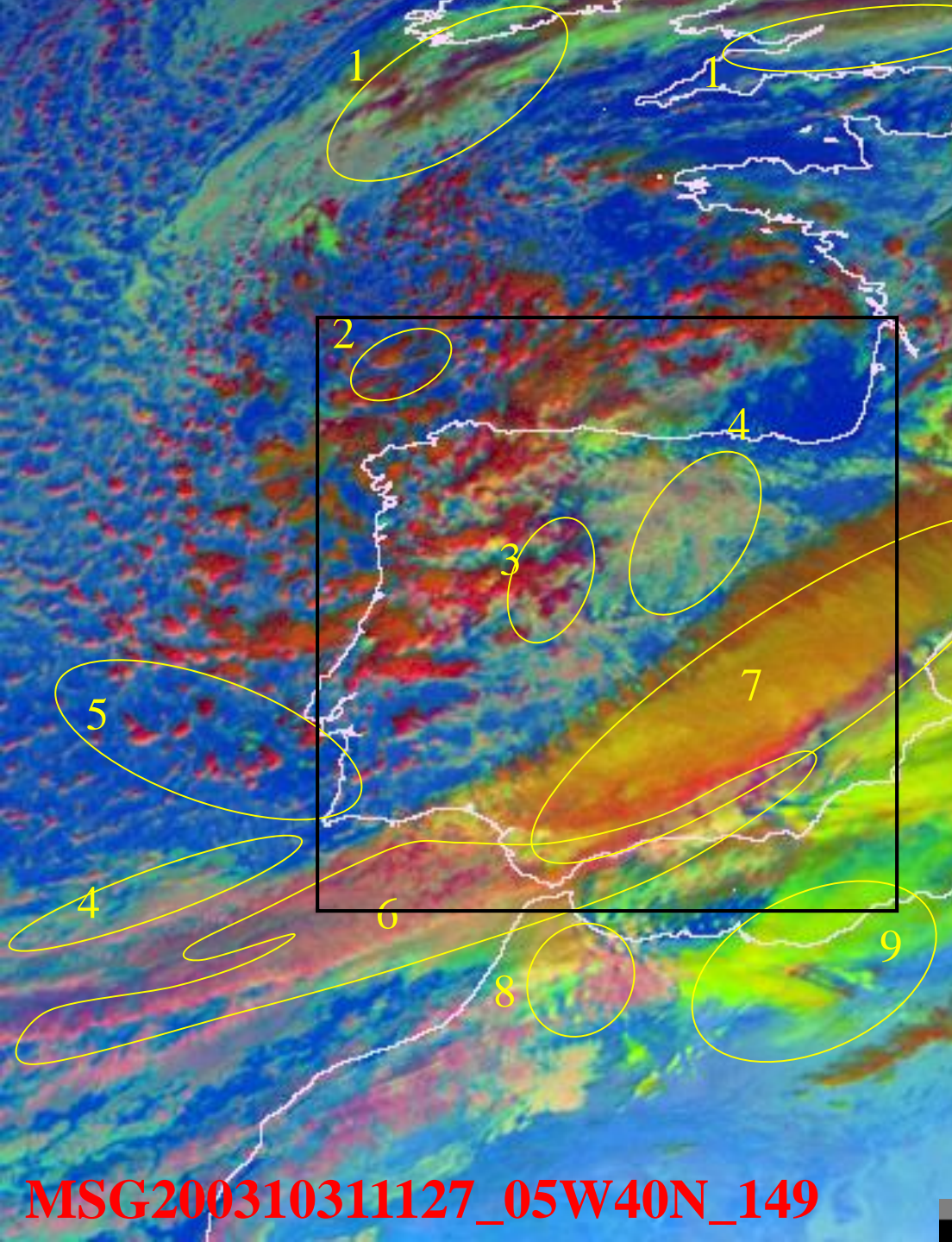
Immagini tri-spettrali MSG



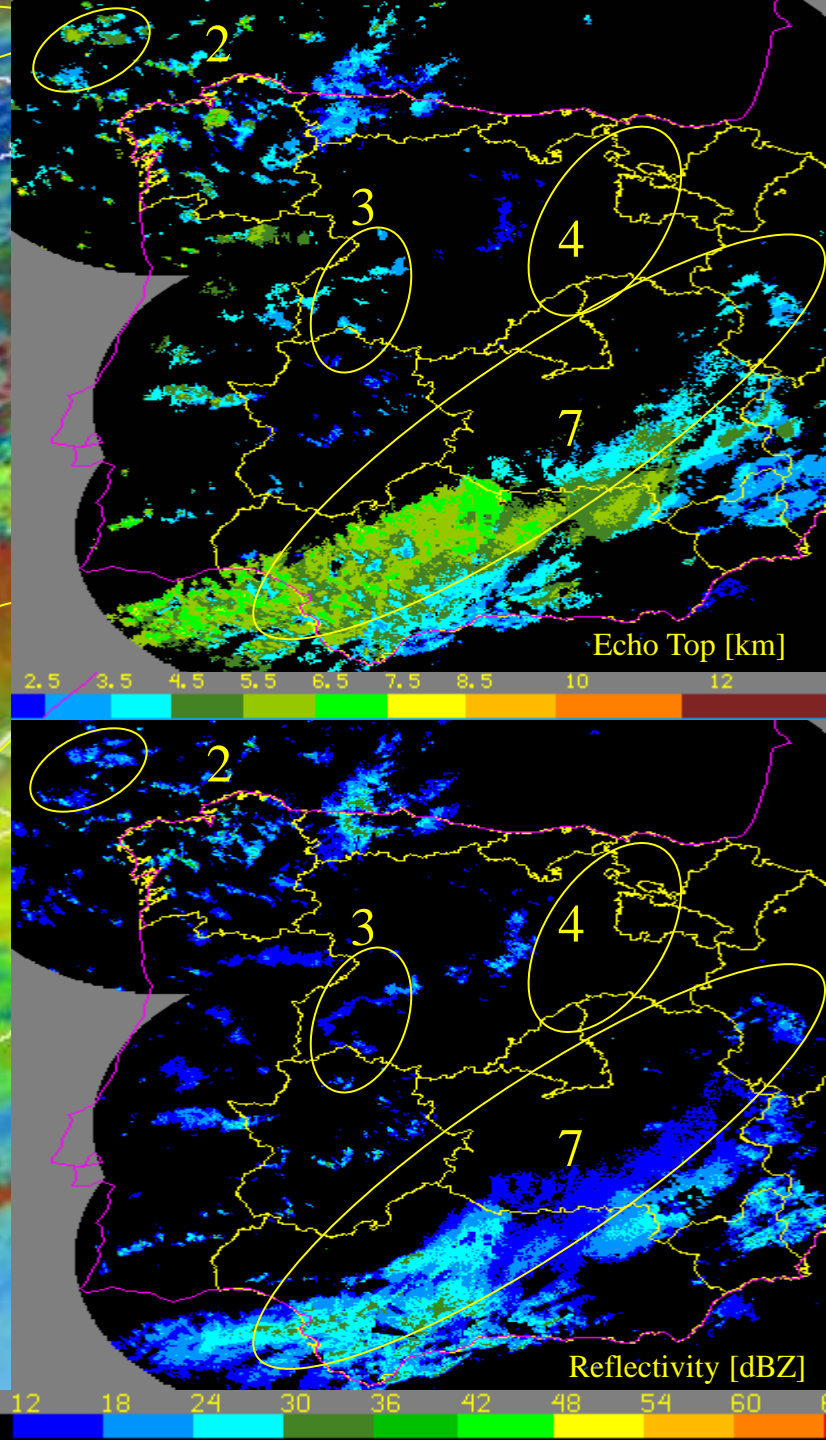
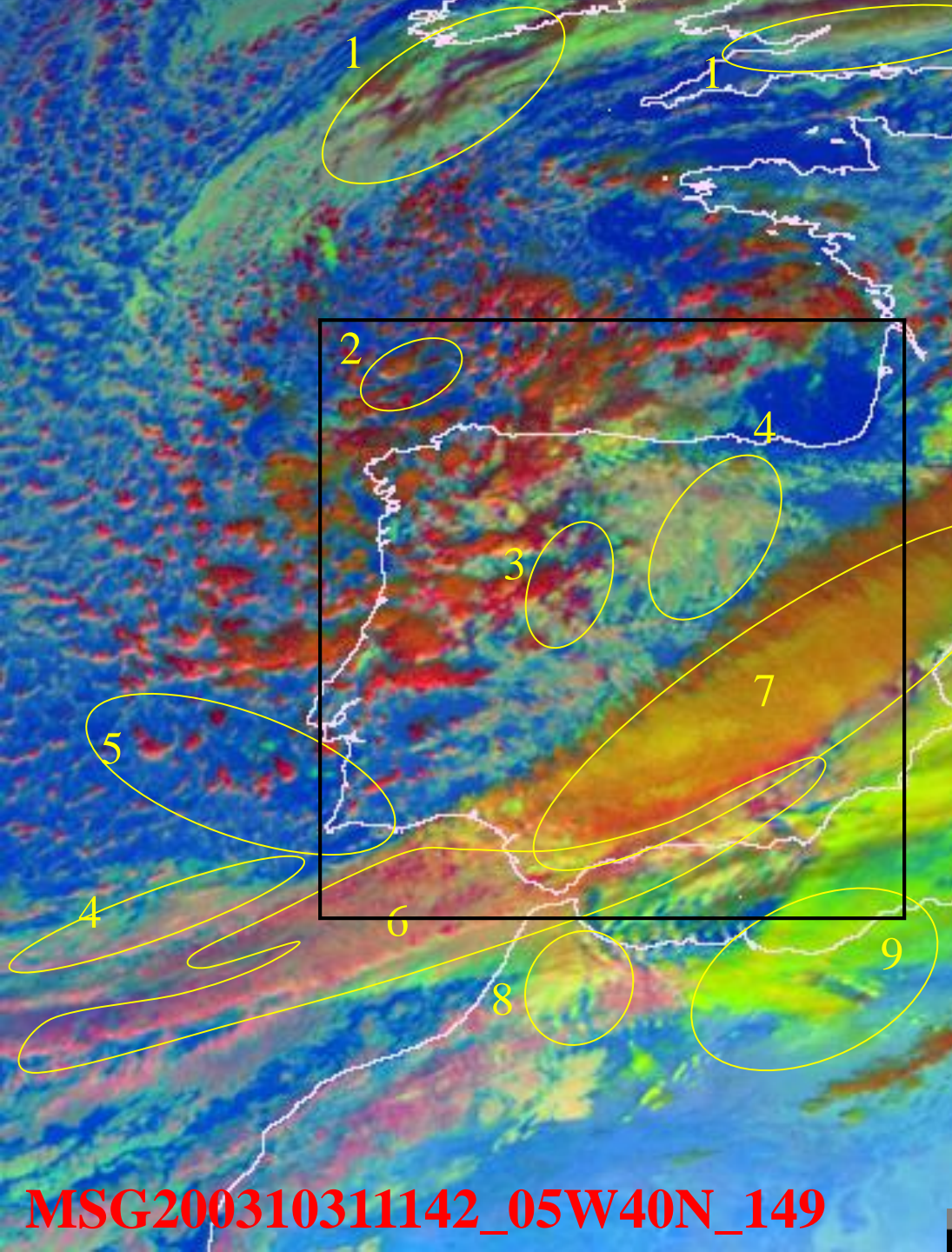


1. Multilayer mature cloud. Low cirrus above Low Cu+Sc. Little or no rain.
2. Thunderstorms.
3. Mature rain cloud, moderate rain.
4. Supercooled Sc+Cu. Little or no precip.
5. Local heavy rain shower.
6. Frontal rain band (red) under broken water layer (yellow) cloud.
7. High level shield (orange) overlying frontal rainband (red), raining on the east side.
8. Mid-level orographic clouds (yellow). No rain
9. Cirro-cumulus. No rain.

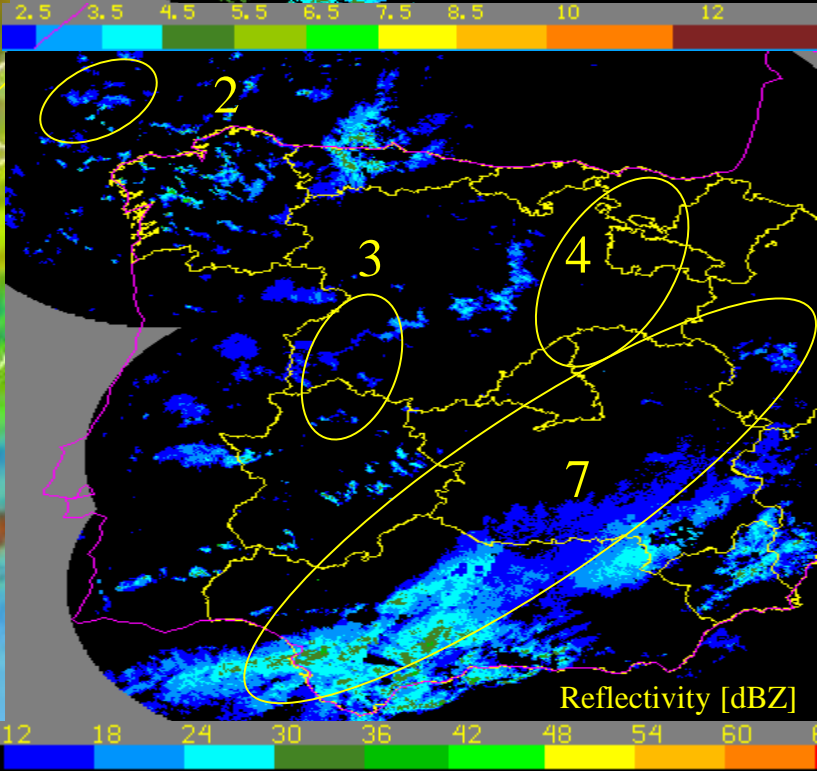
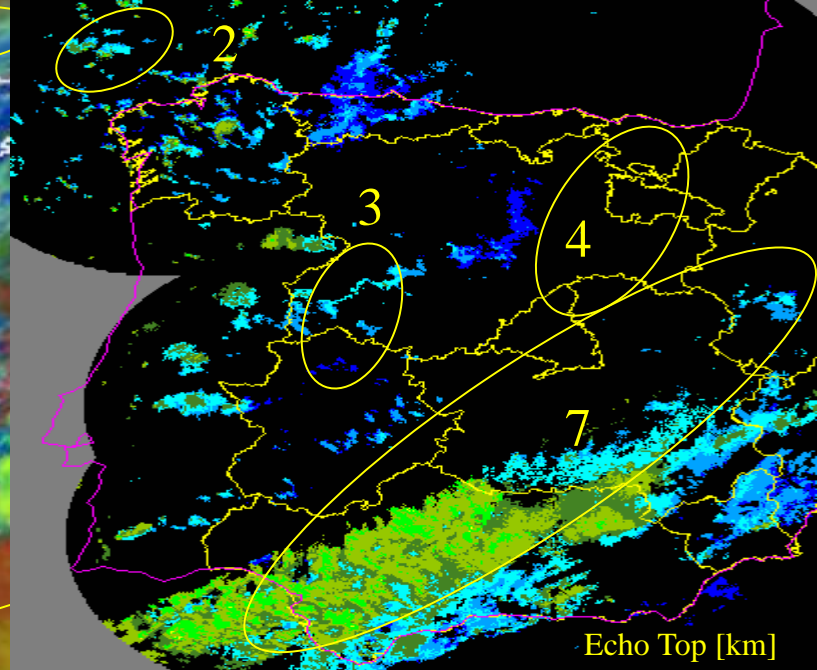
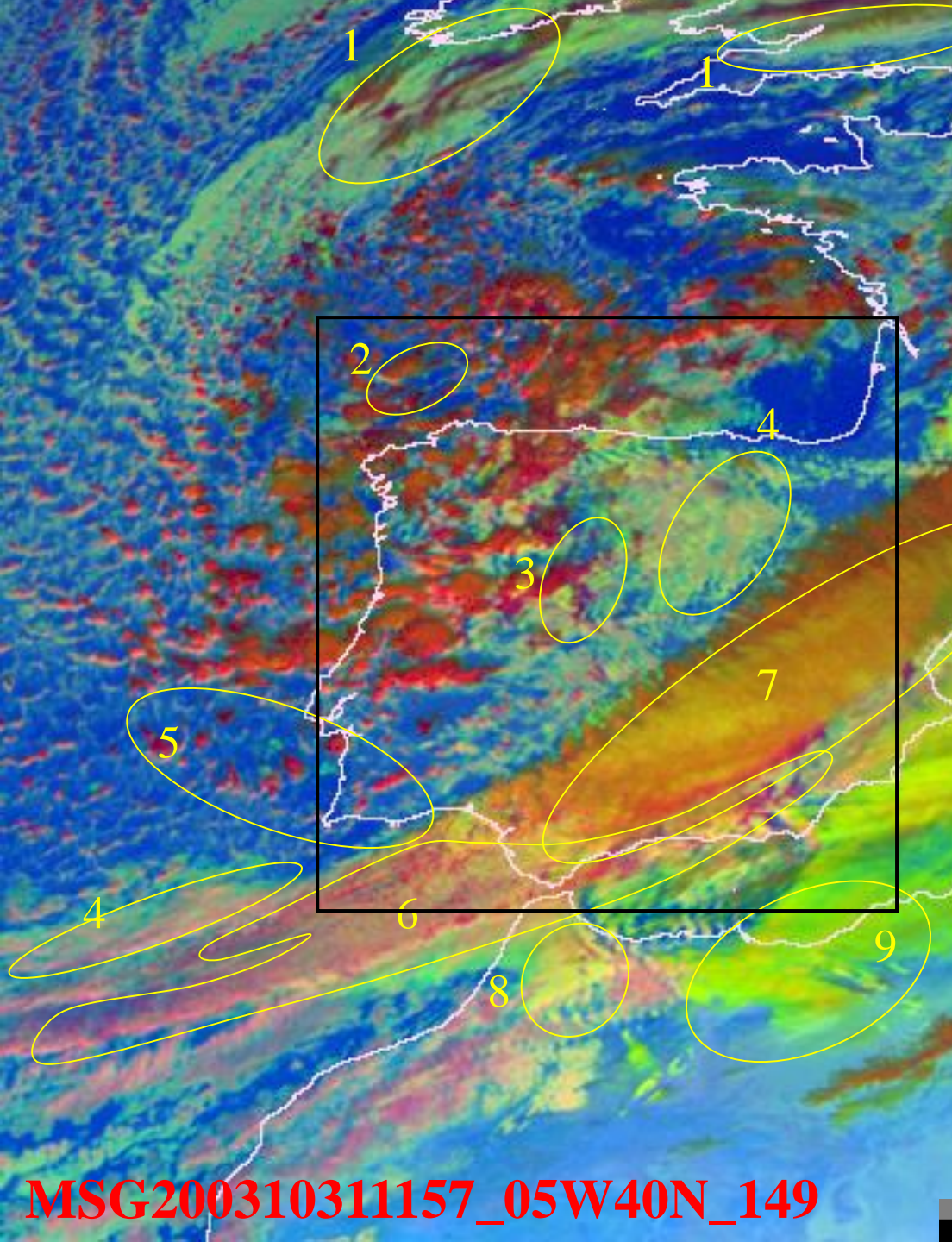
MSG200310311227_05W40N_149



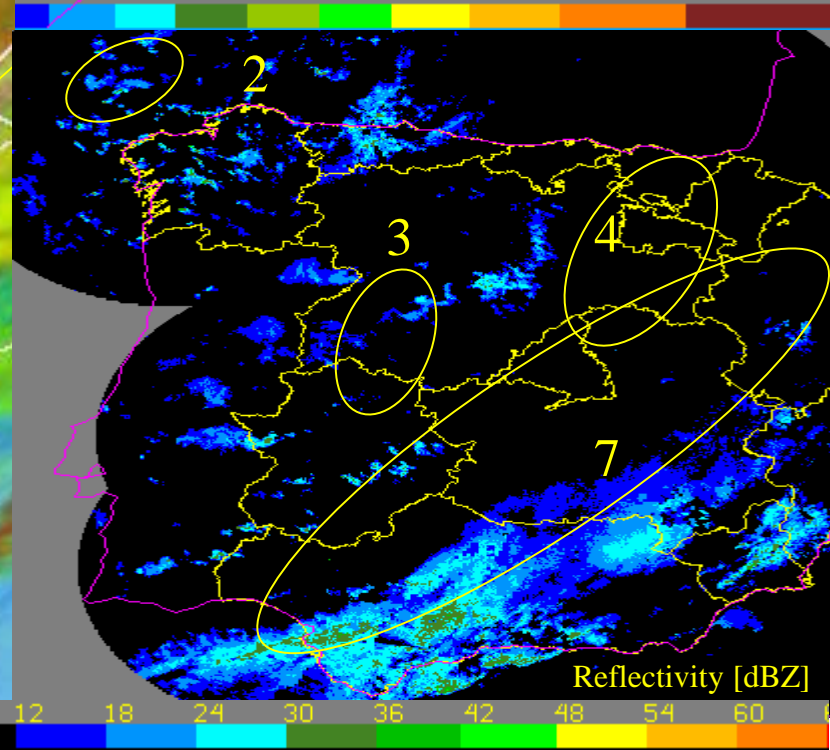
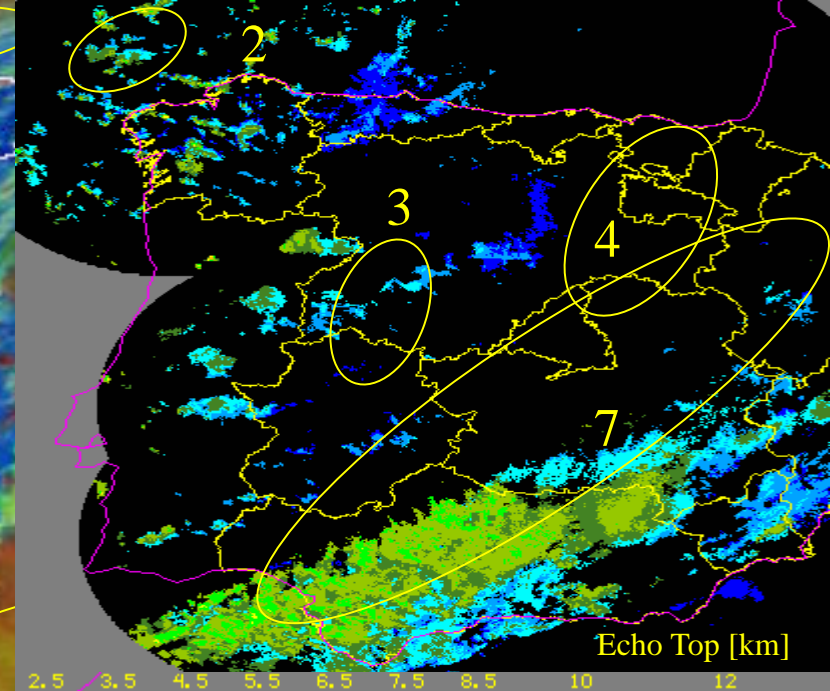
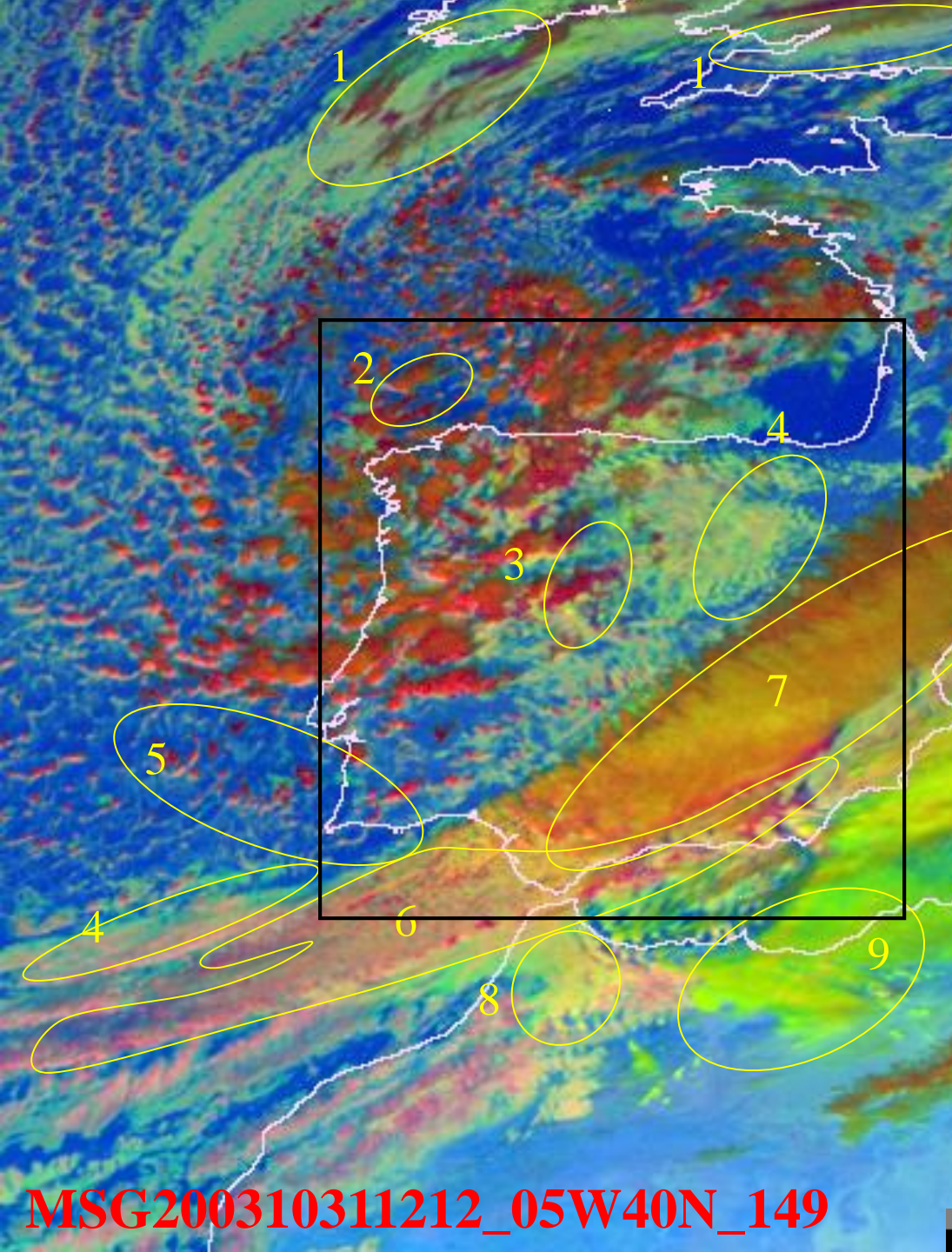
MSG200310311127_05W40N_149



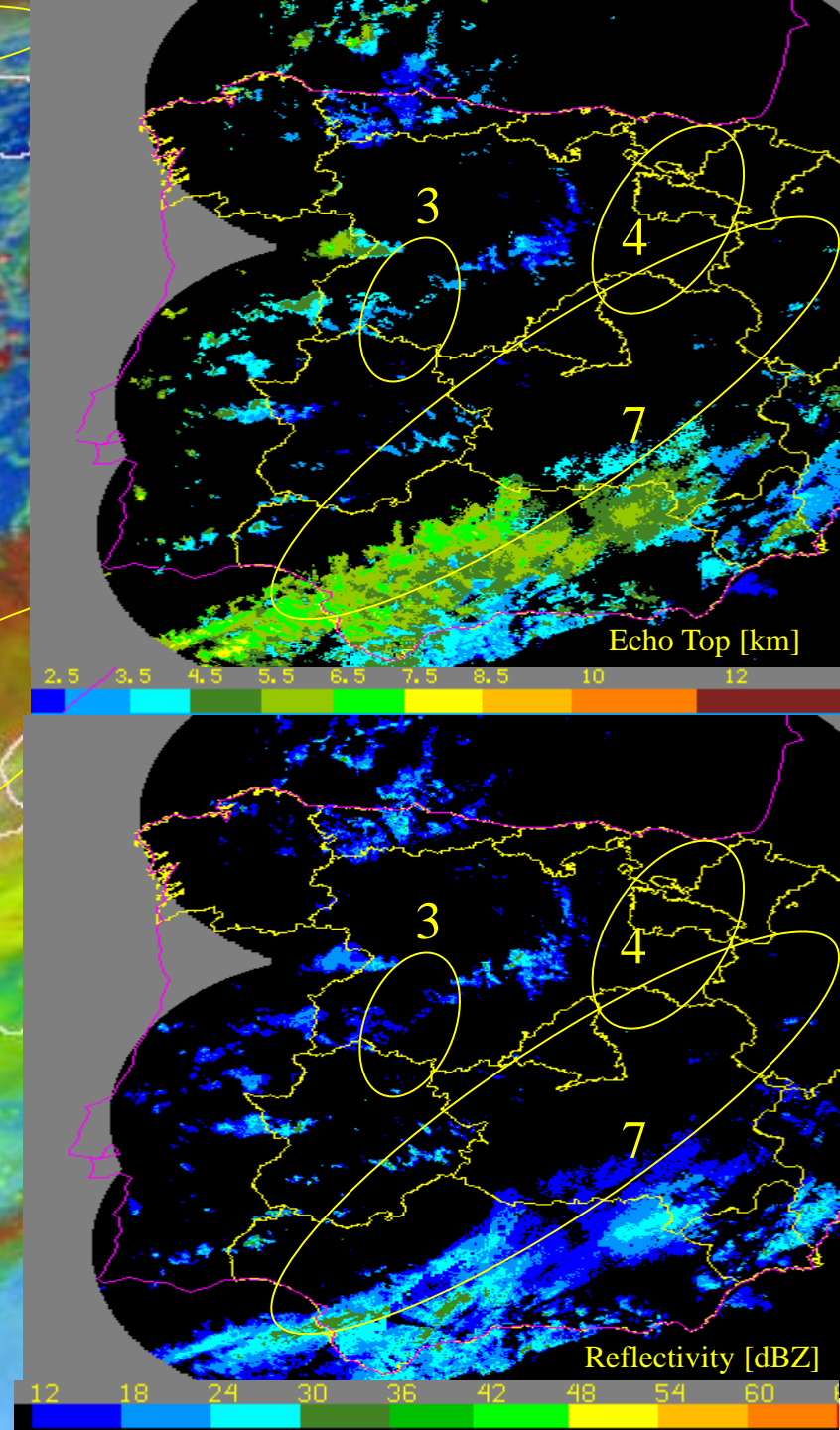
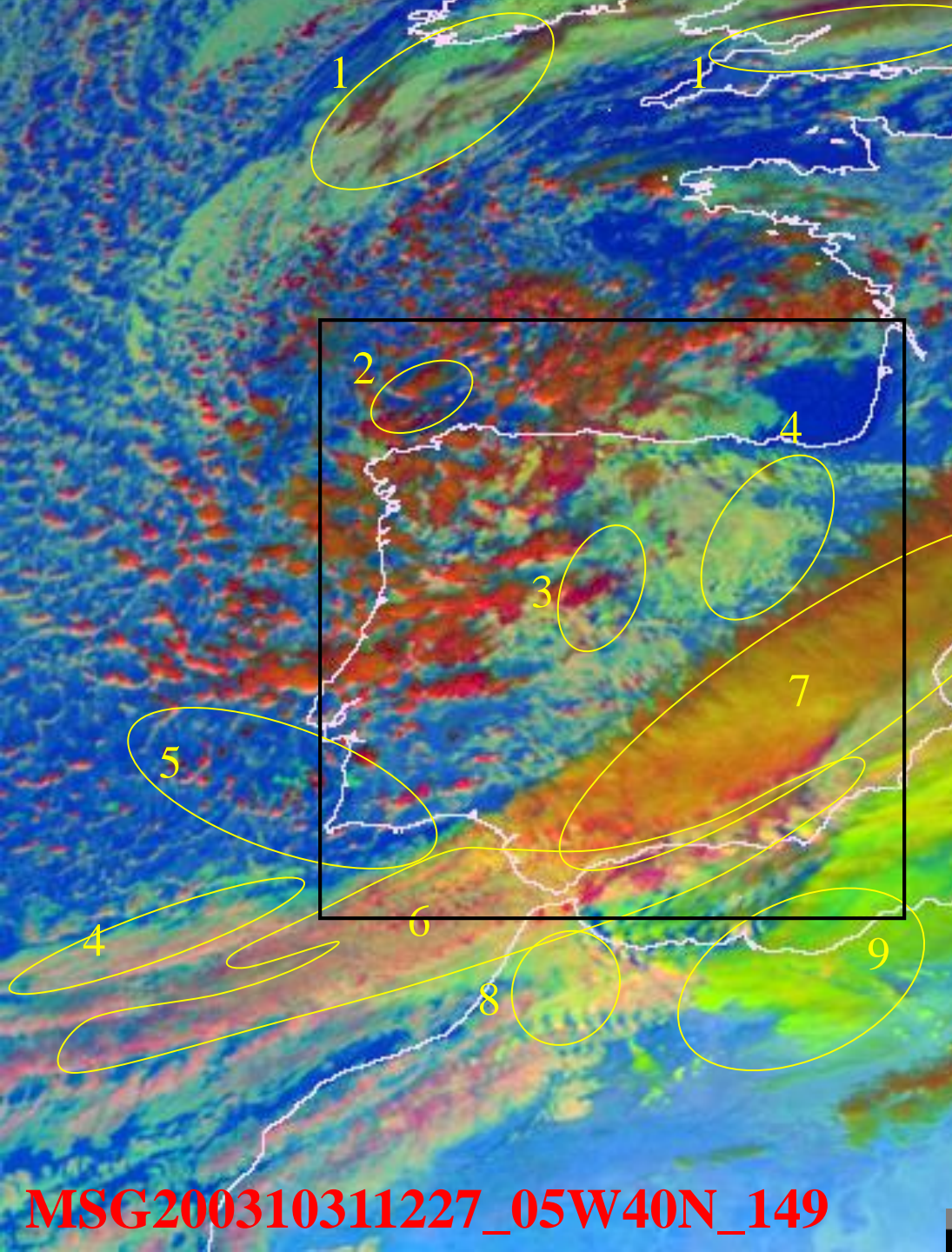
MSG200310311142_05W40N_149



MSG200310311157_05W40N_149



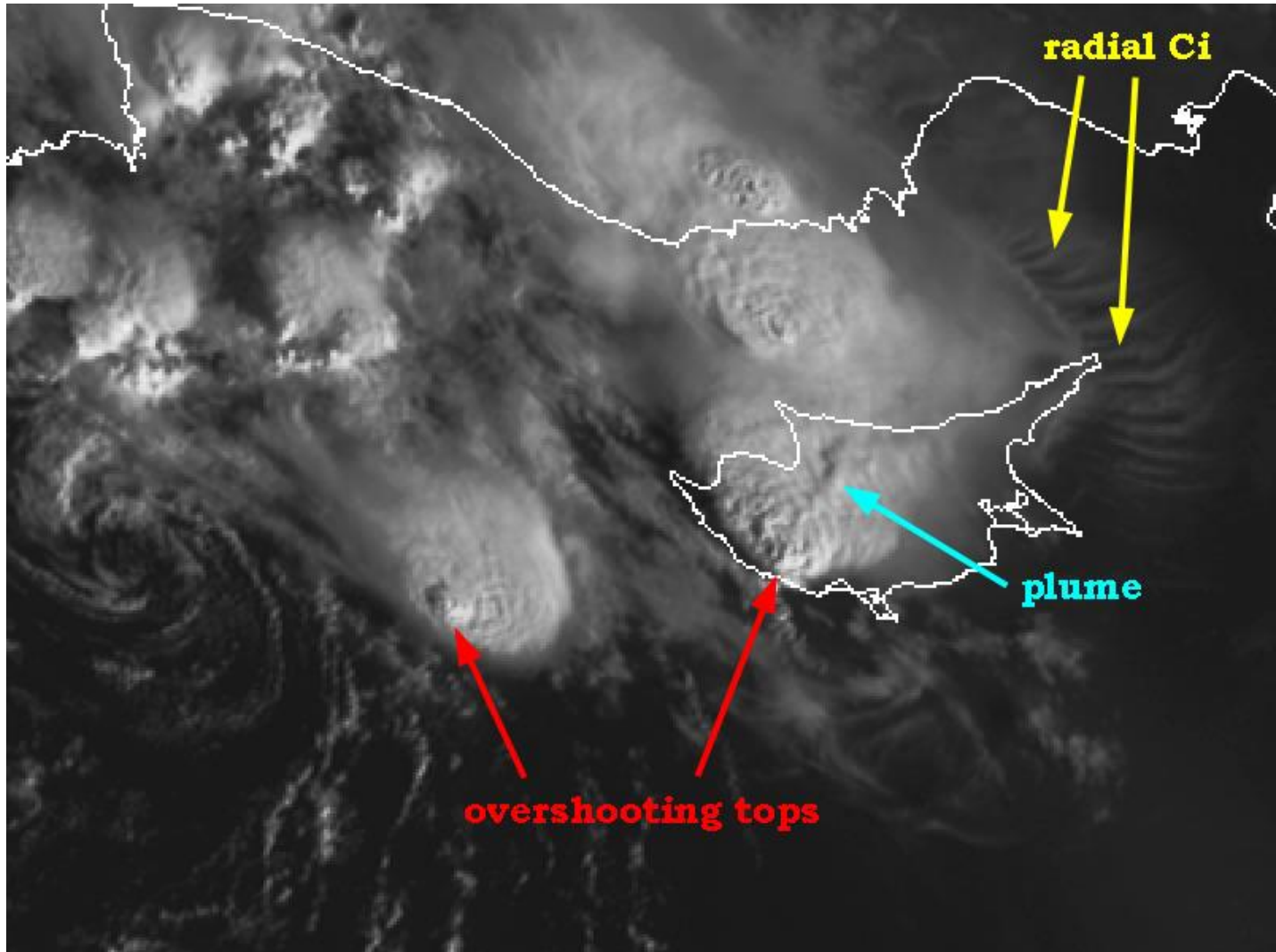
MSG200310311212_05W40N_149



MSG200310311227_05W40N_149

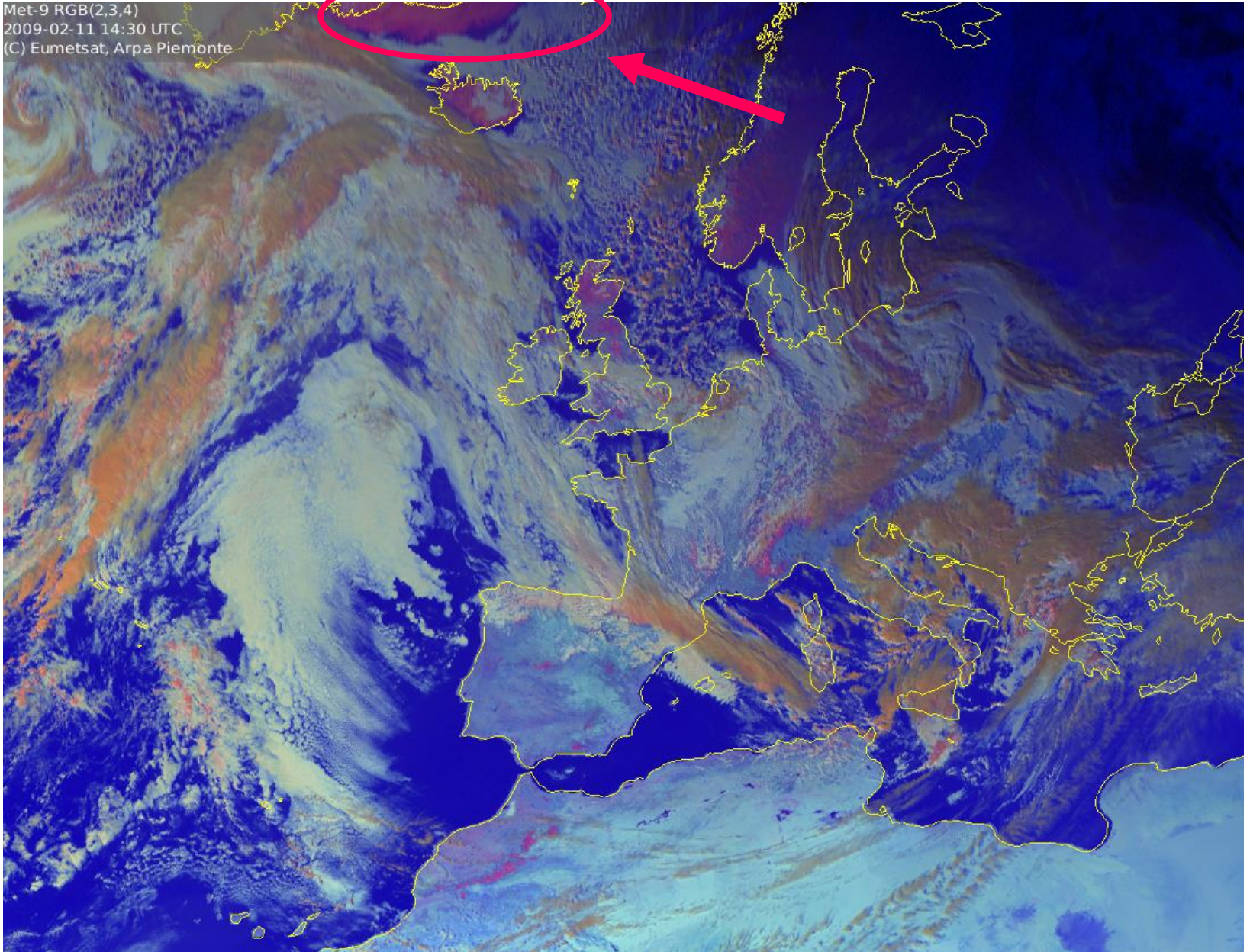
Convection

Severe convective storm with radial Ci clouds over Cyprus (13 October 2006)



cos'è ?

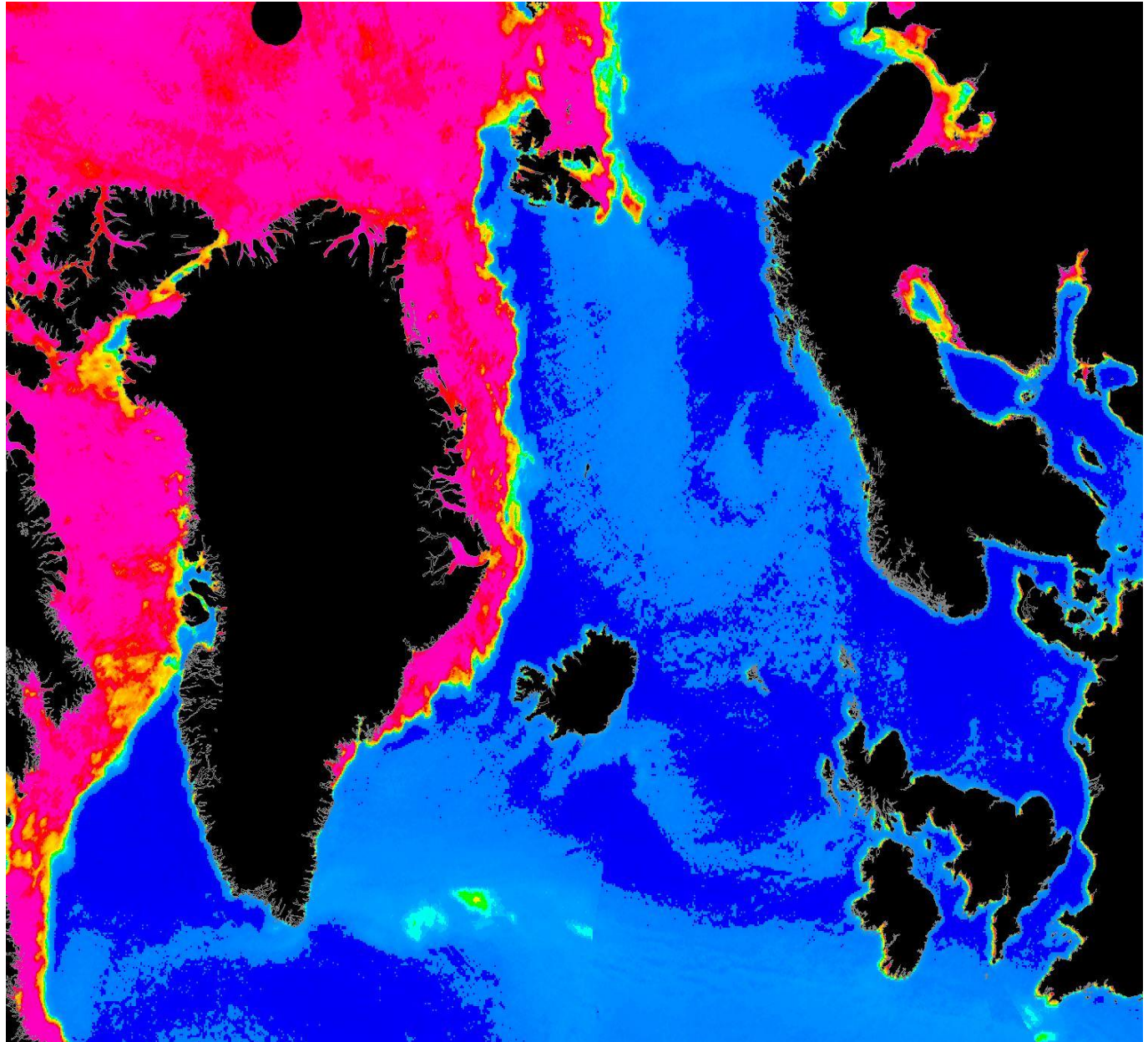
Met-9 RGB(2,3,4)
2009-02-11 14:30 UTC
(C) Eumetsat, Arpa Piemonte



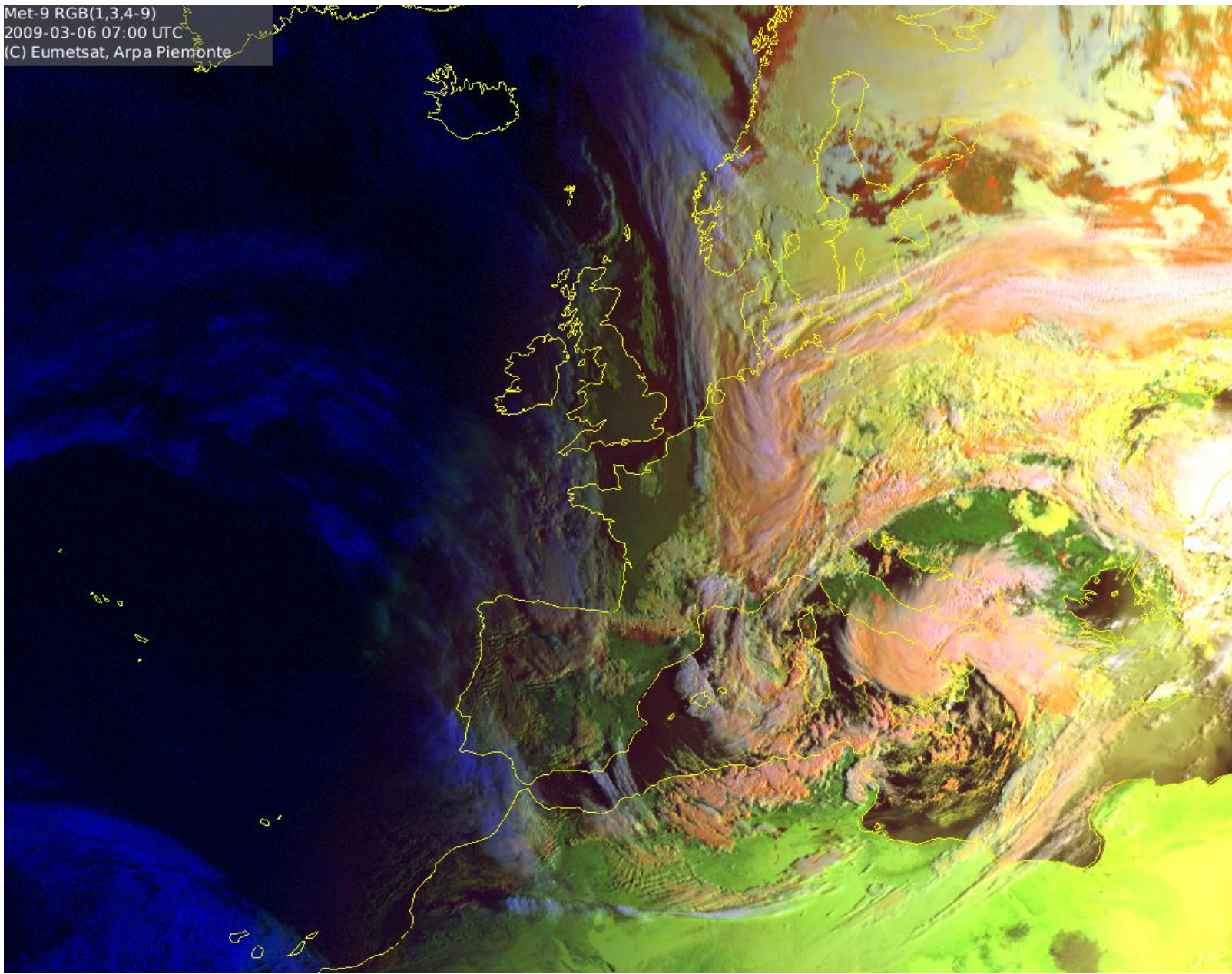
E' il pack!!

Nel periodo dell'anno a cui si riferisce quest'immagine MSG (metà Febbraio) si estende fino alle coste della Groenlandia

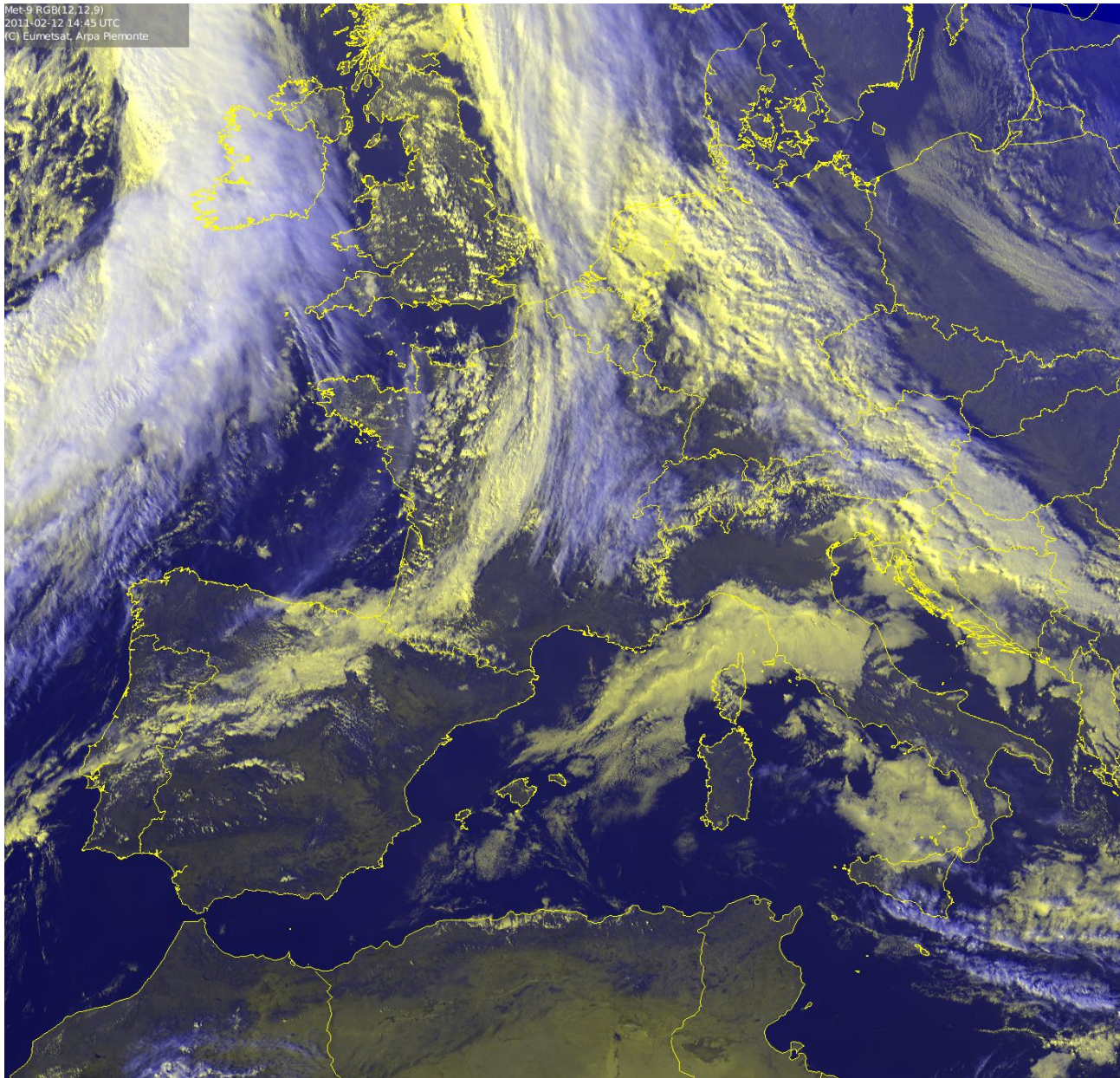
Si può notare bene da questa mappa di estensione dei ghiacci aggiornata a metà Febbraio 2009 (il pack è rosso e rosa)



Met-9 RGB(1,3,4-9)
2009-03-06 07:00 UTC
(C) Eumetsat, Arpa Piemonte



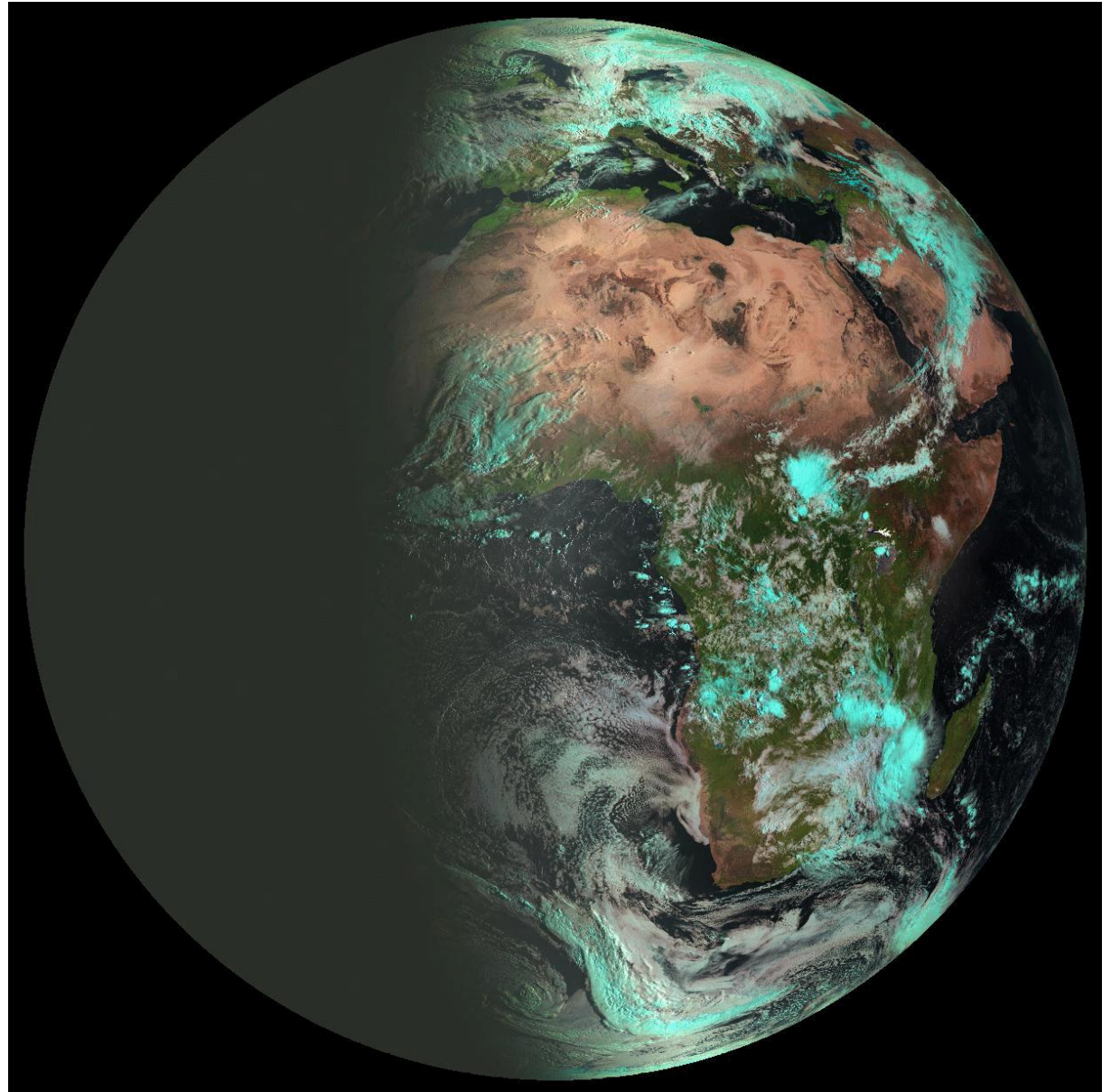
MSG – low stratus and fog on Tirreanean Sea



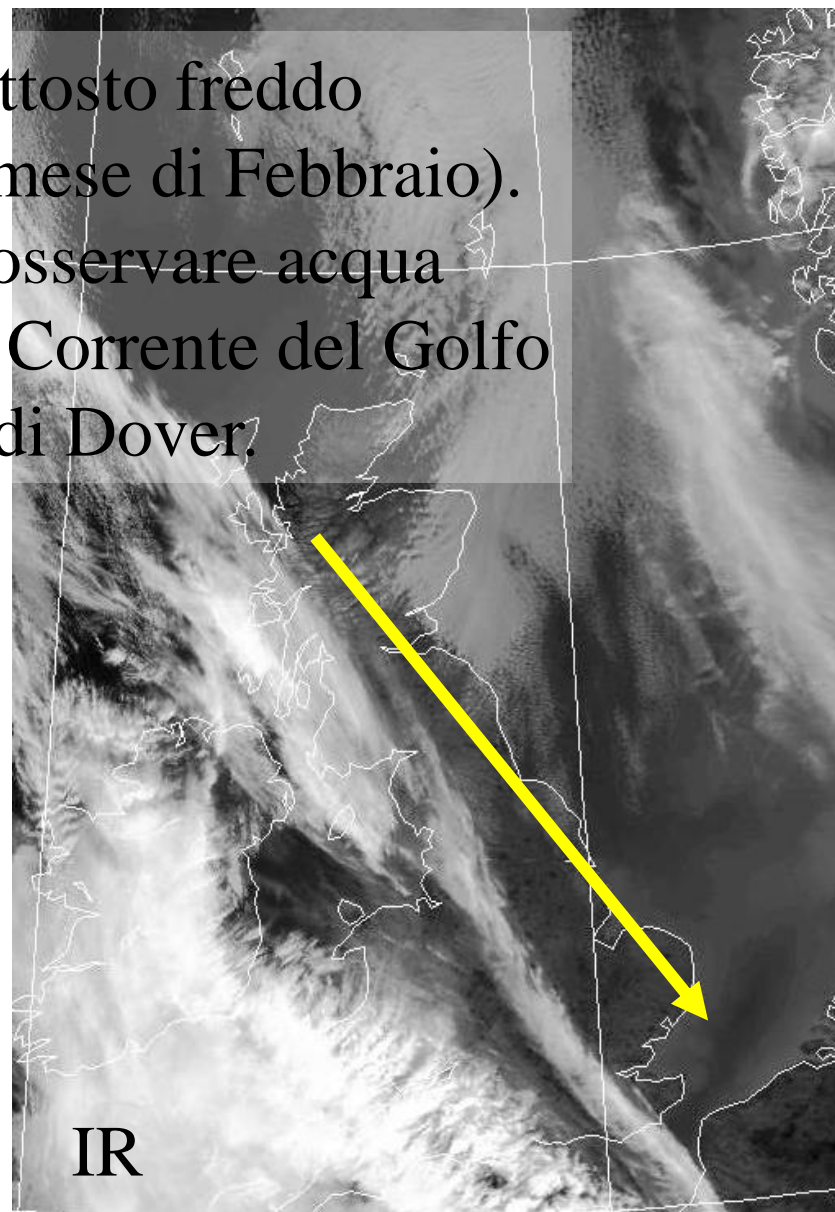
Cosa succede in
questa animazione
del globo terrestre ?

Qualcuno nota
qualcosa di
particolare ?

**Si tratta di
un'eclissi di Sole
ripresa da MSG,
e relativa al 29
Marzo 2006**



Il Mare del Nord é piuttosto freddo (immagine relativa al mese di Febbraio). Nell'infrarosso si può osservare acqua più calda portata dalla Corrente del Golfo che entra dallo stretto di Dover.

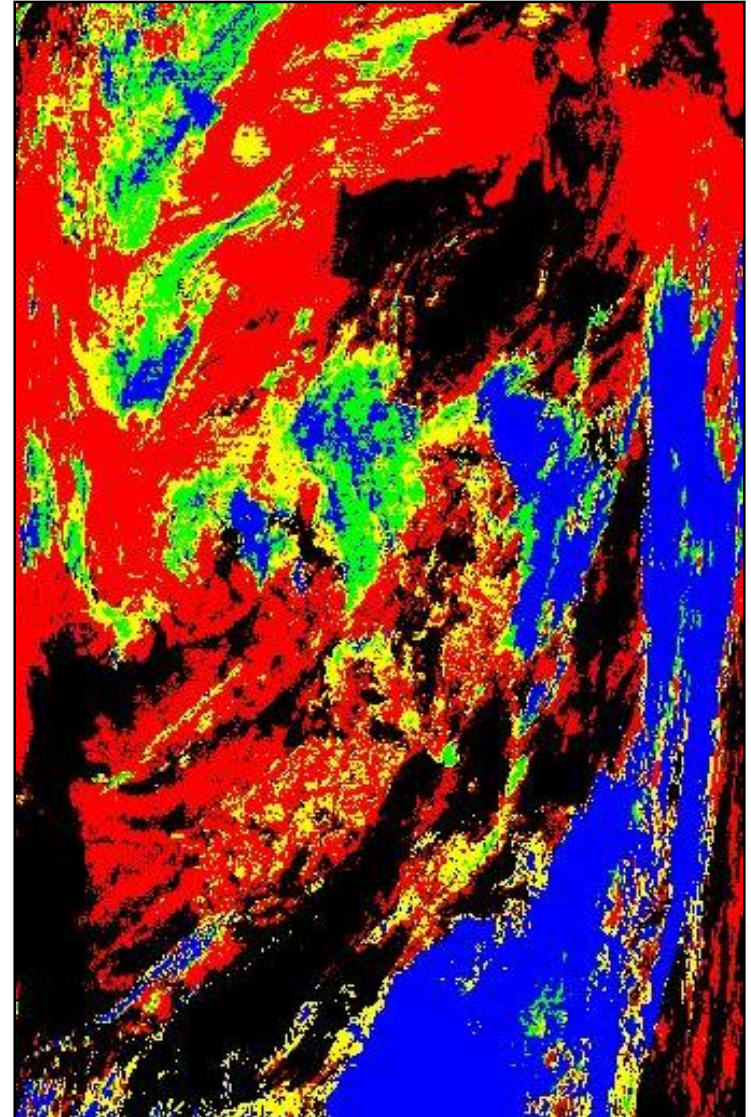
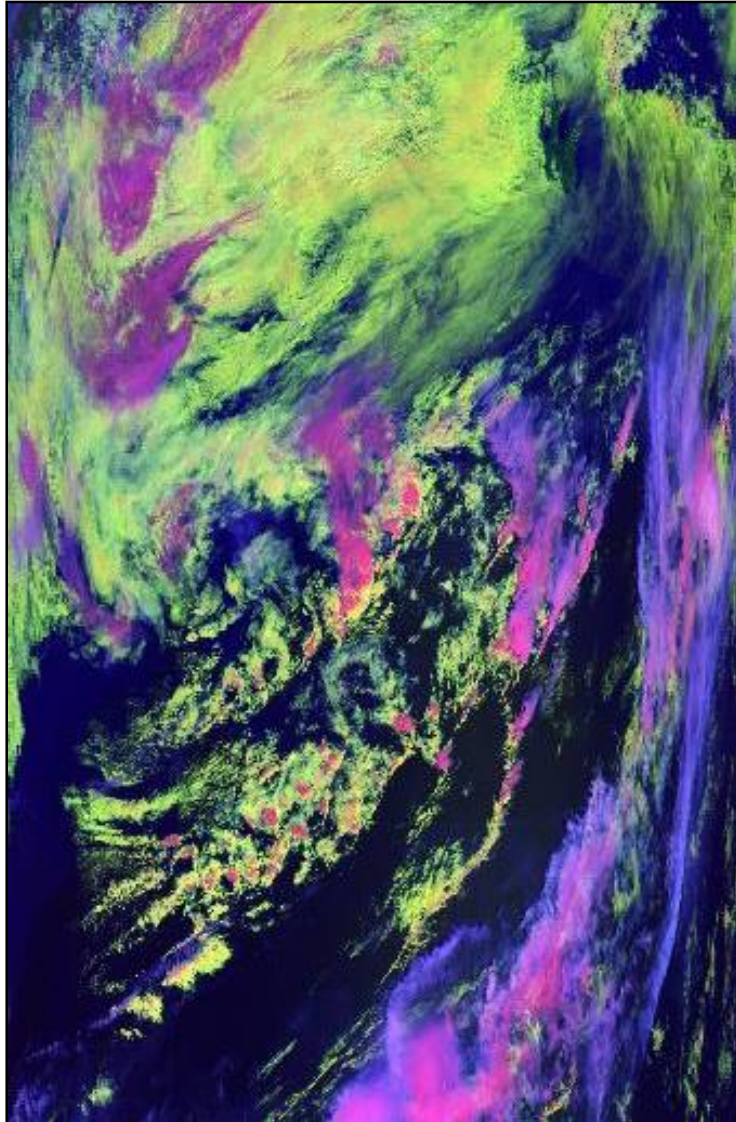


Cosa sono?



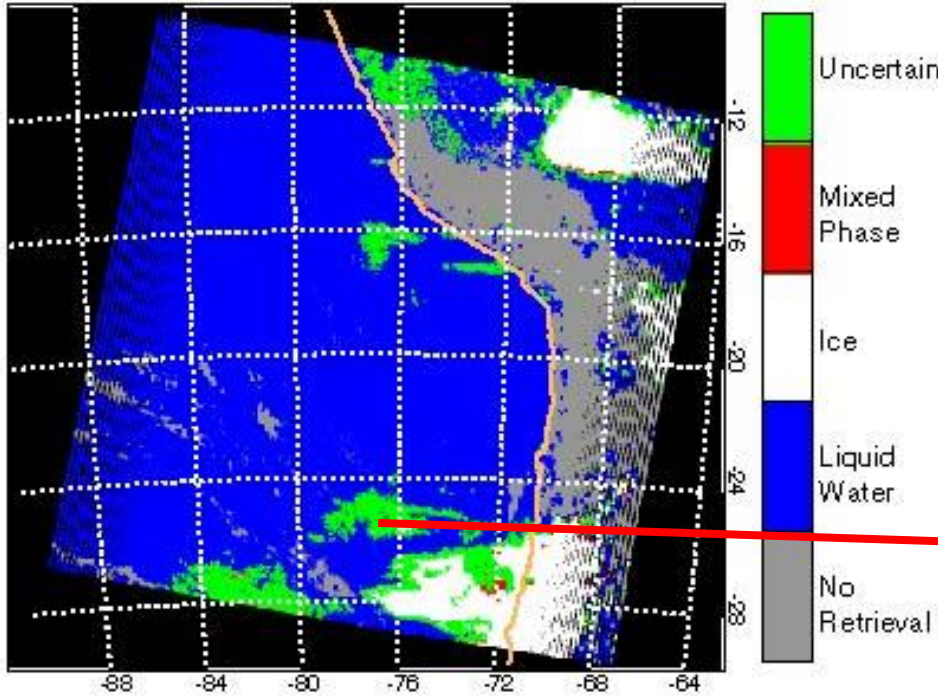
**Si tratta delle scie di
condensazione lasciate
dalle navi che
attraversano l'Atlantico**

MODIS Direct Broadcast
May 14, 2003 at 1458 UTC (Terra)
1-km resolution

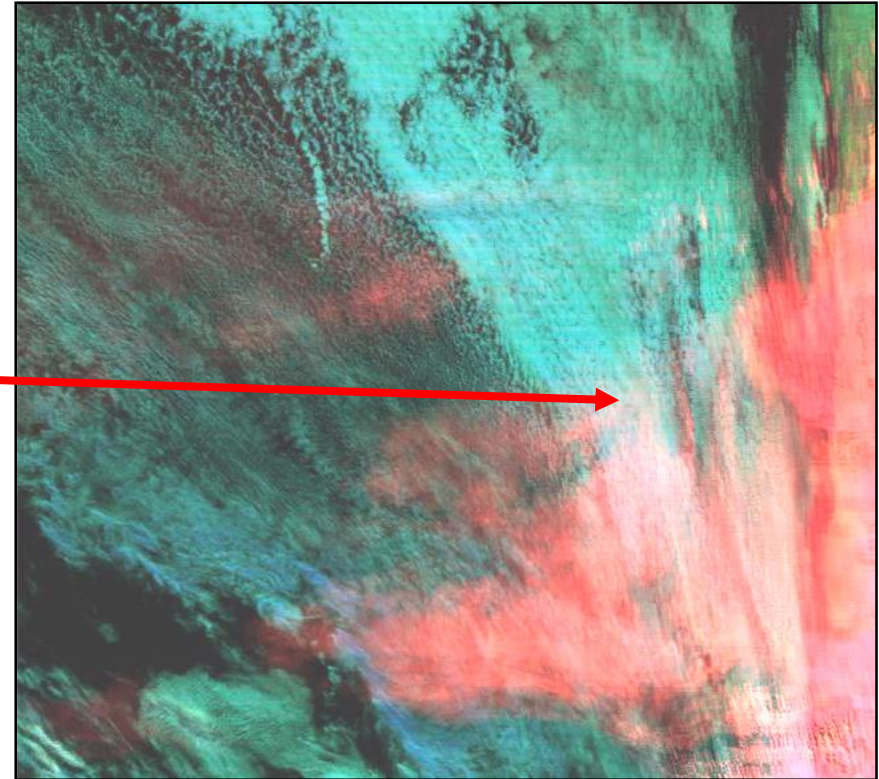


Multilayered Clouds

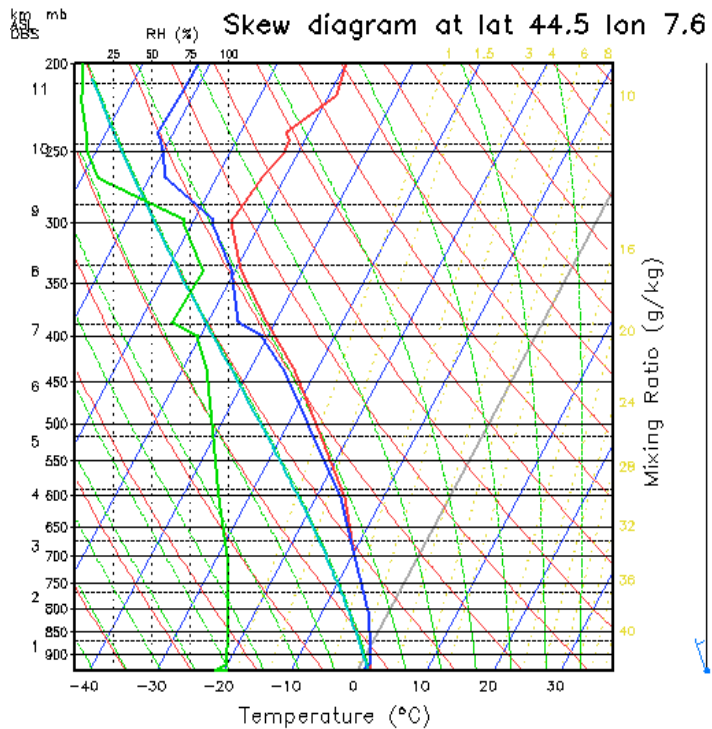
Bispectral IR Algorithm



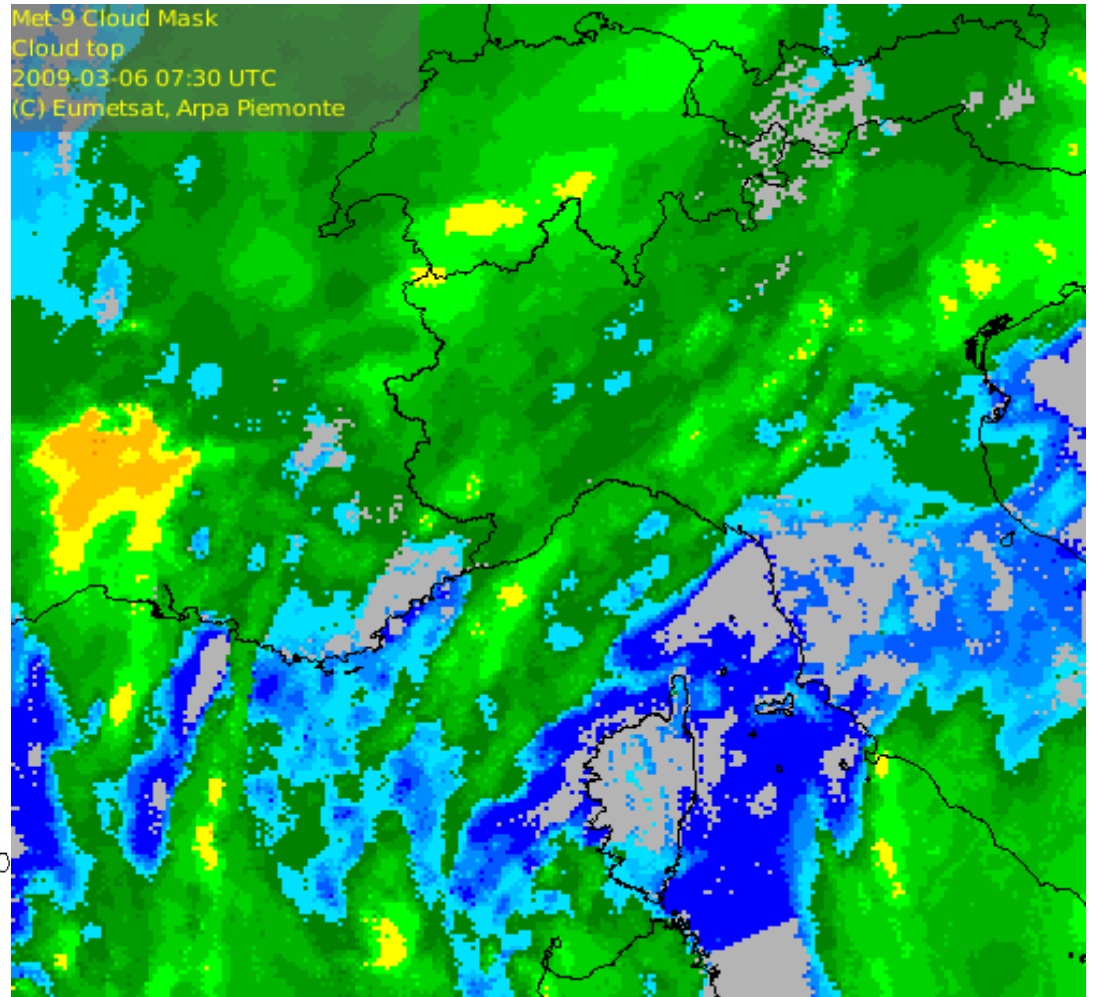
data



Cloud mask

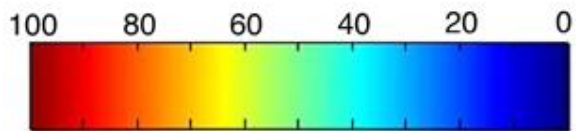
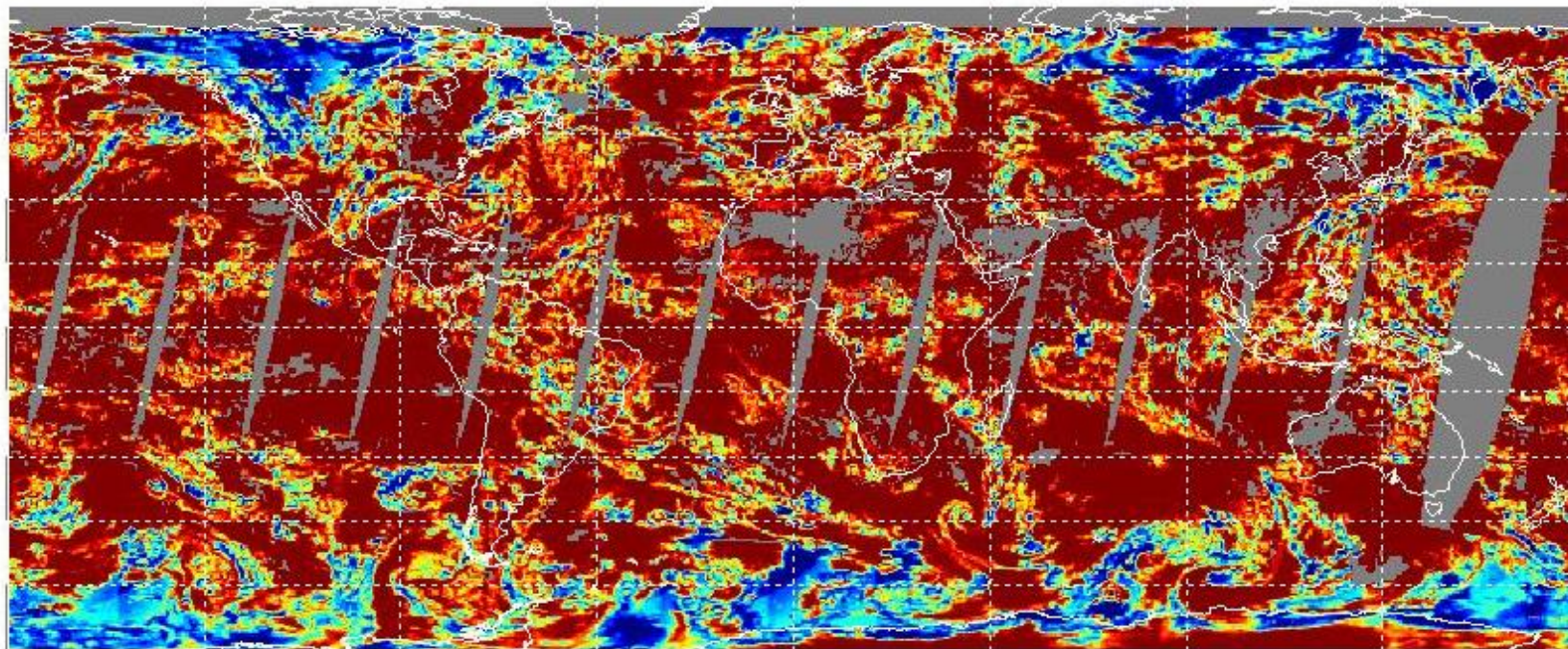


CUNEO-LEVALDIGI 386 m - Fri 06 MAR 2009 0



MODIS Cloud Thermodynamic Phase

Percentage Ice and Water Cloud
05 Nov. 2000 -Daytime Only

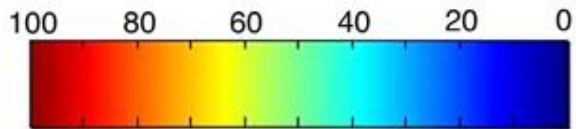
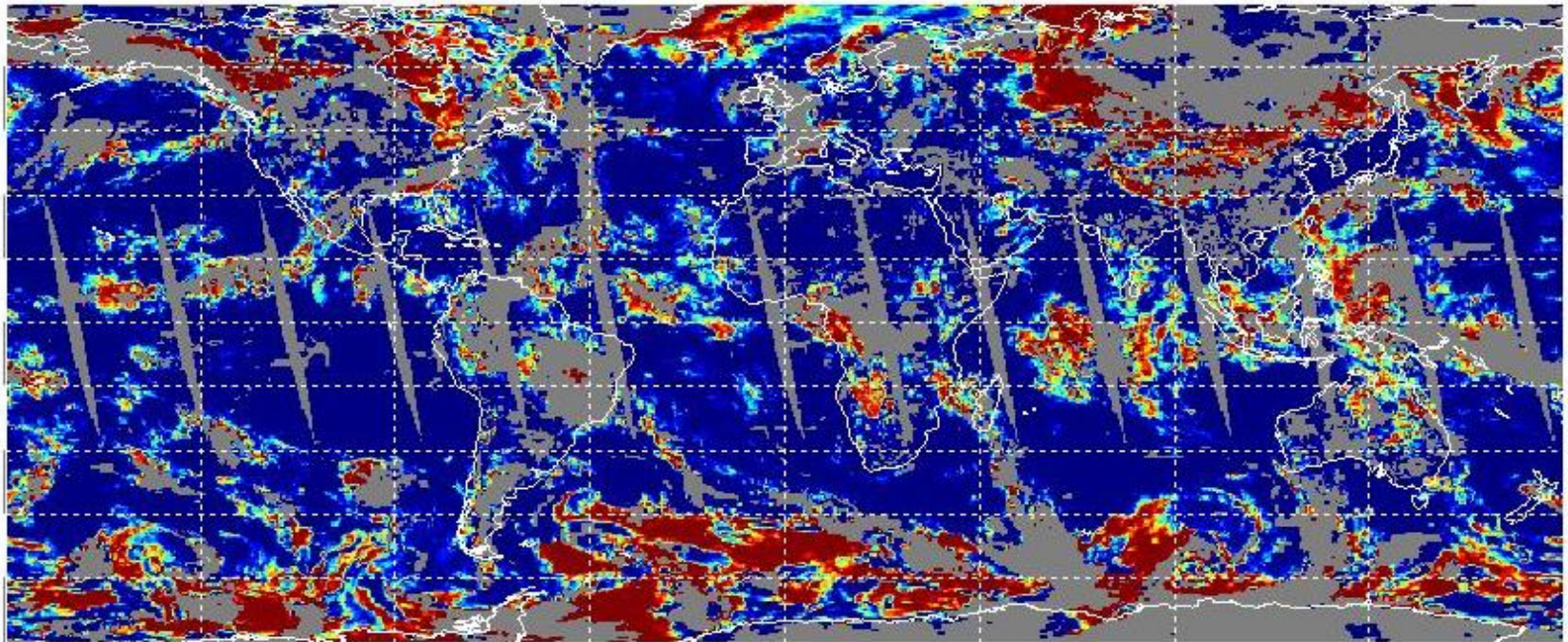


frequency of occurrence in percent (%)

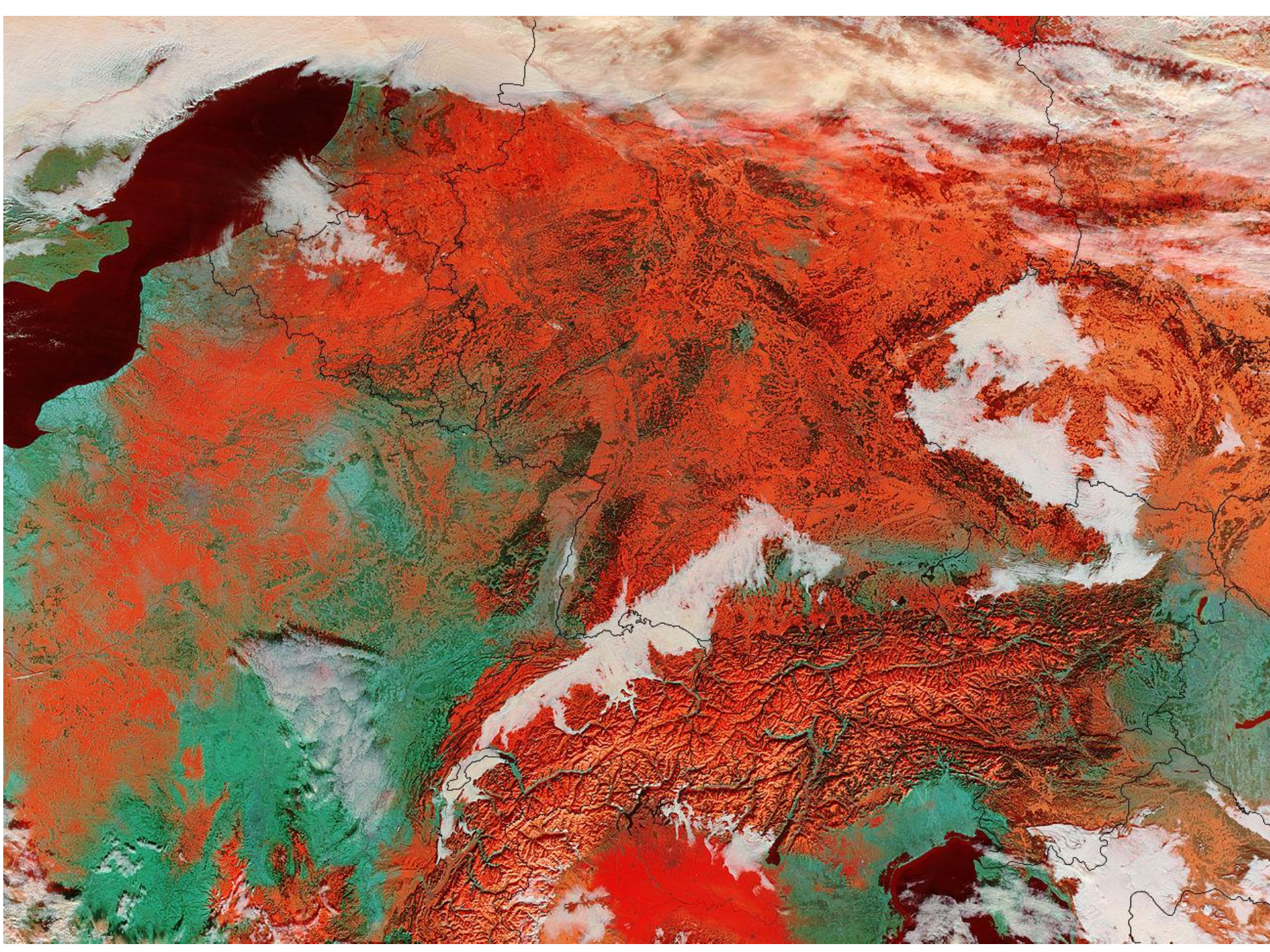
MODIS Frequency of Co-occurrence

Water Phase with $253 \text{ K} < T_{\text{cld}} < 268 \text{ K}$

05 Nov. 2000 - Night time Only



frequency of occurrence in percent (%)

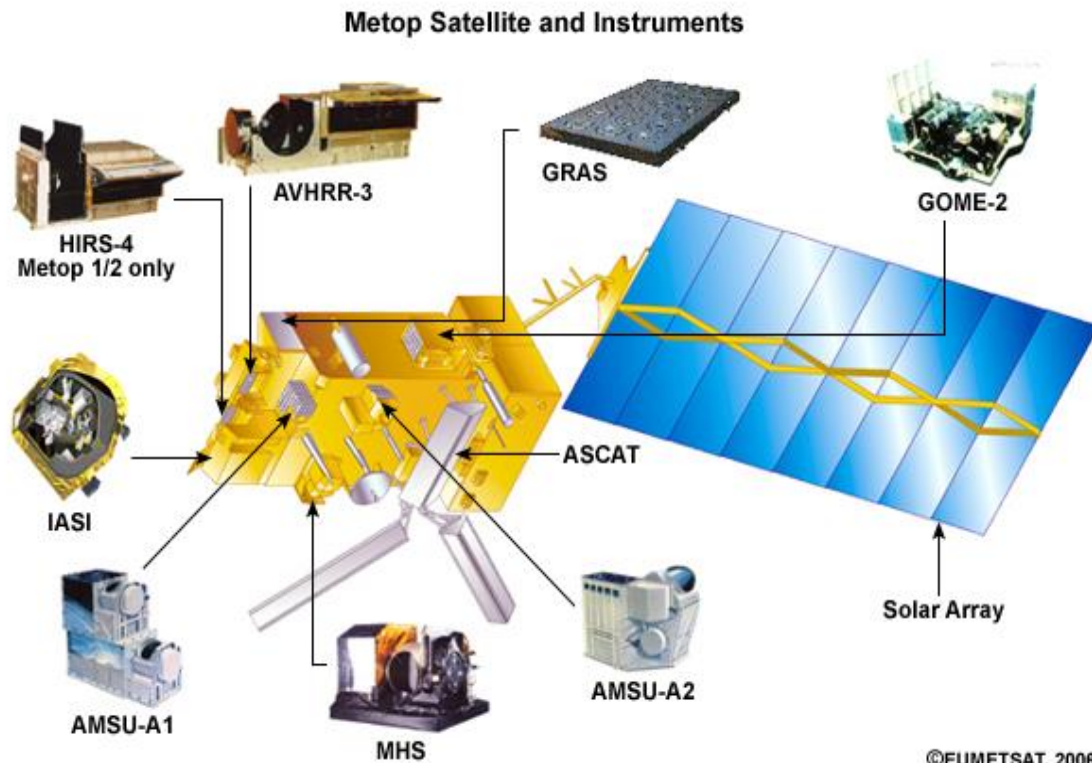


MODIS – AEROSOL IN Po Valley



Remote Sensing Satellite Data

EPS Metop-1



Sun-synchronous orbit

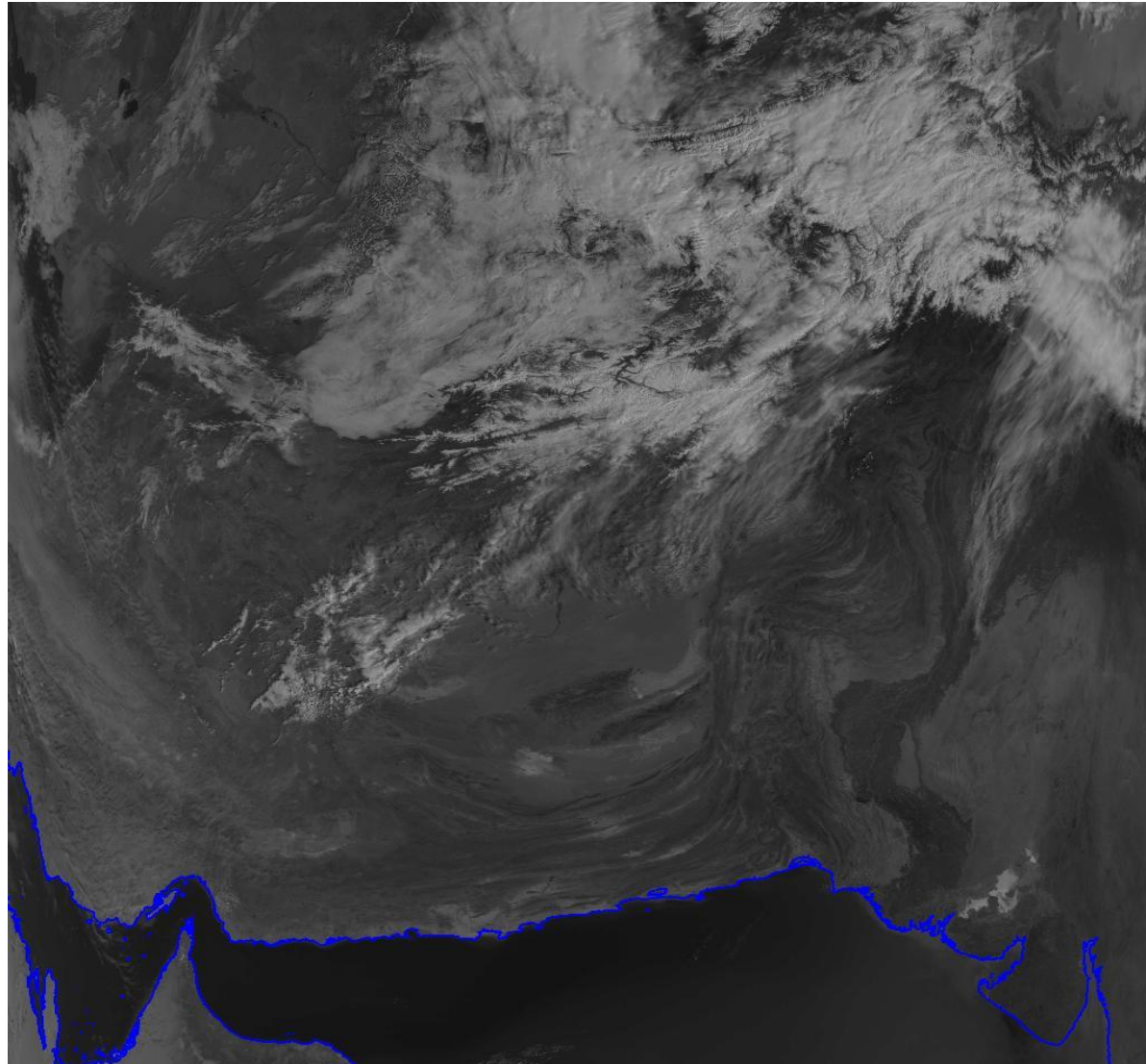
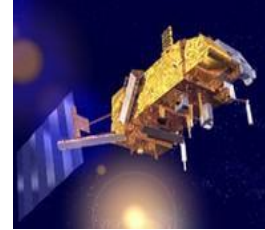
09.30 mean local solar time
(Equator crossing, descending
node)

101 minutes

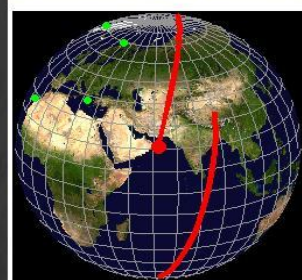
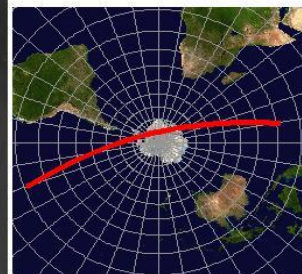
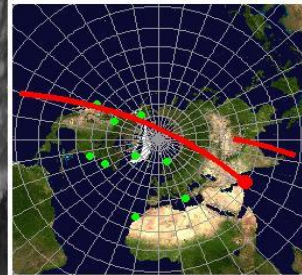
29 days

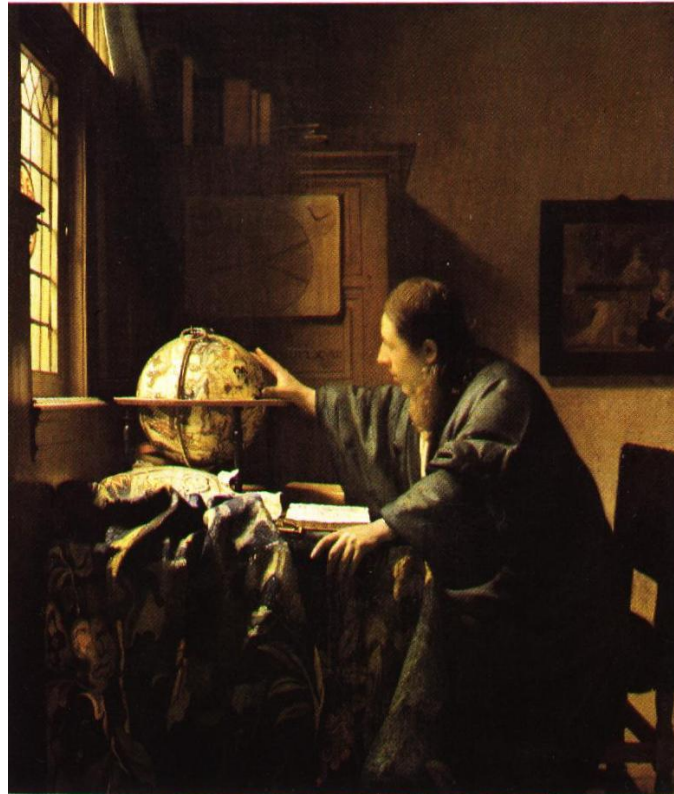
0.5 + 4.5 years

Metop-A



SPACECRAFT_ID: M02
INSTRUMENT_ID: AVHR
PROCESSING_LEVEL: 1B
RECEIVING_GROUND_STATION: SVL
SENSING_START: 20090306053403Z
SENSING_START_THEORETICAL: 20090306052400Z
SENSING_END: 20090308053703Z
SENSING_END_THEORETICAL: 20090308070800Z
PROCESSING_CENTRE: CGS1
PROCESSING_MODE: N





De revolutionibus orbium coelestium
Niccolò Copernico
Norimberga, 24 maggio 1543

« [Mi pare di] aver raggiunto la consapevolezza che i matematici non hanno idee chiare attorno a questi moti[...], essi non usano né gli stessi principî e ipotesi né le stesse dimostrazioni. Così alcuni usano soltanto cerchi omocentrici, altri eccentrici ed epicicli, e tuttavia con questi mezzi non raggiungono integralmente i loro scopi.[...]. Né furono in grado di scoprire oppure di dedurre da tali mezzi la cosa più importante: vale a dire la forma dell'universo e l'immutabile simmetria delle sue parti. »