Tuning of RGB products and new RGB products from MTG FCI

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Outline

1) Motivation: why RGBs ?

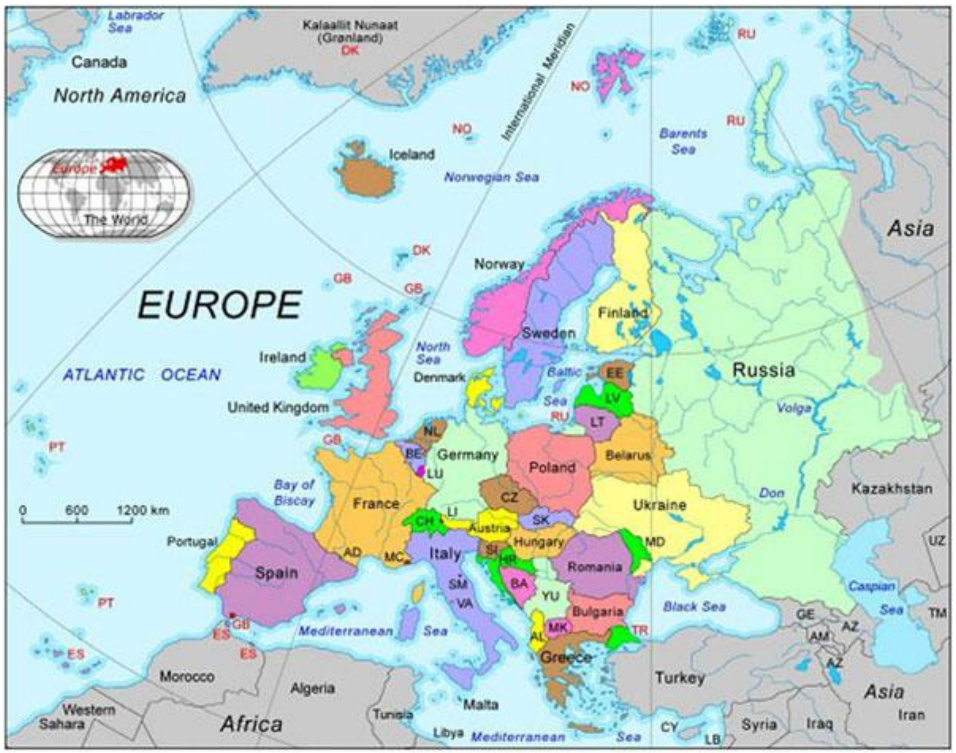
2) RGBs for operational forecasting

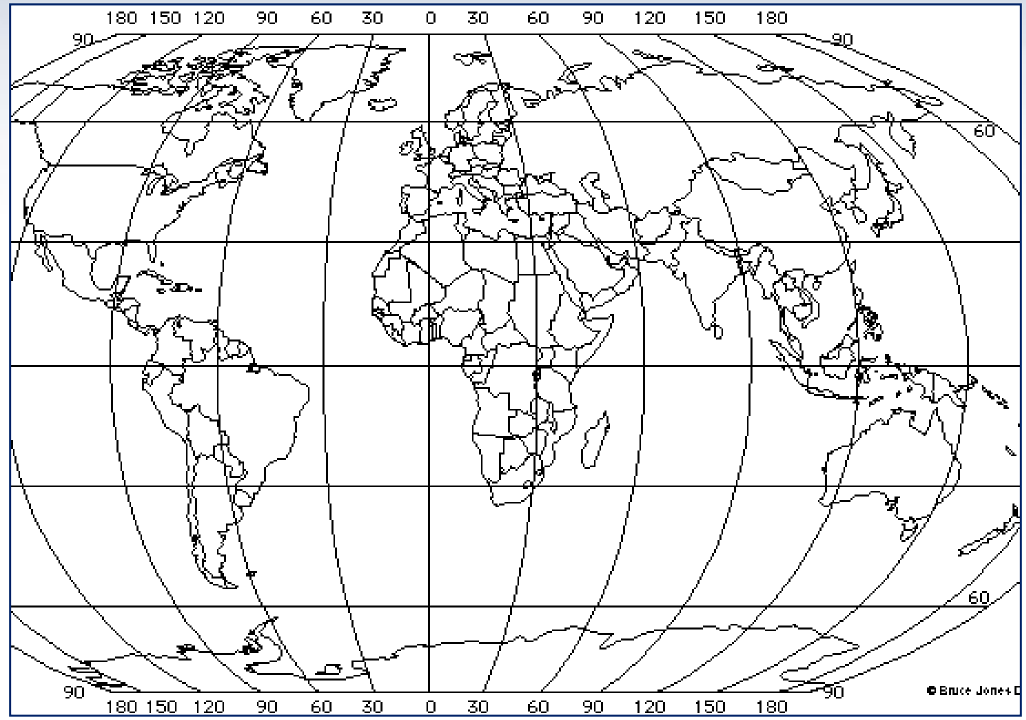
3) Other standard RGBs

4) Tuning of RGBs to FCI channels

5) New RGBs with new channels

Where are you ?





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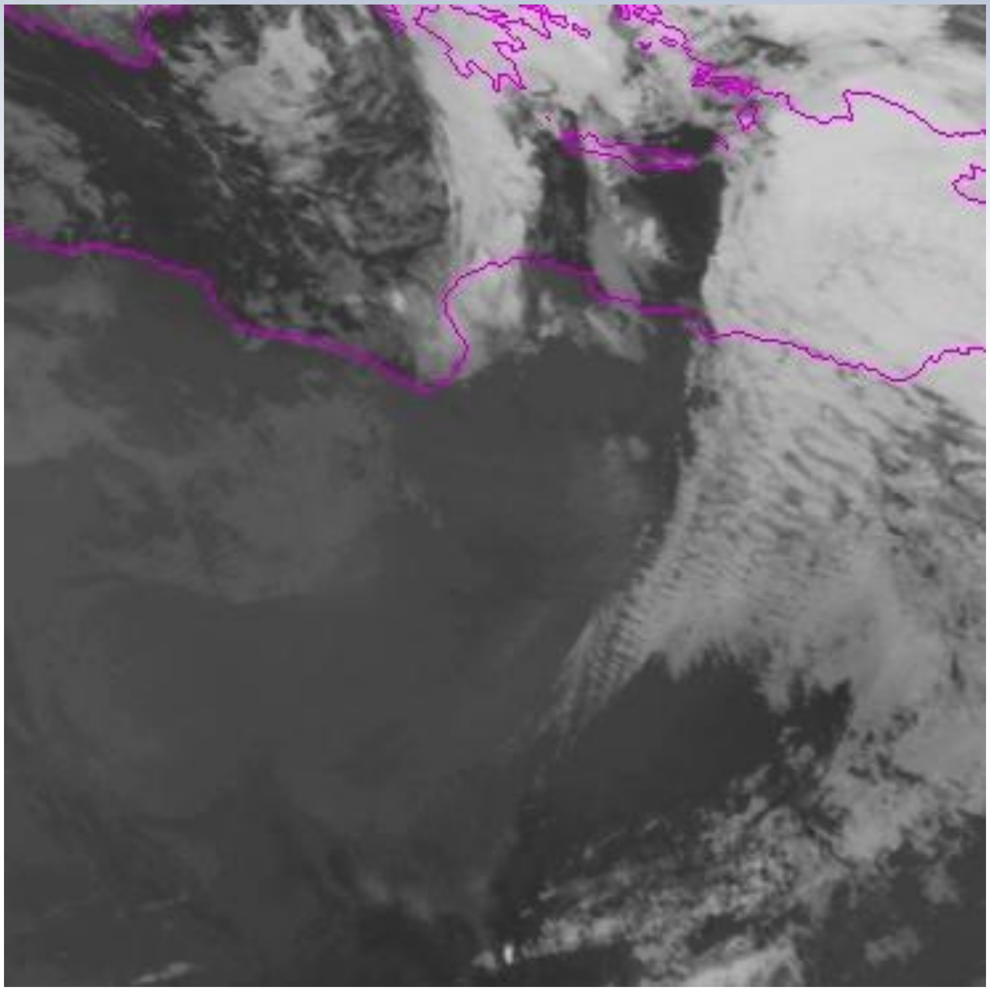
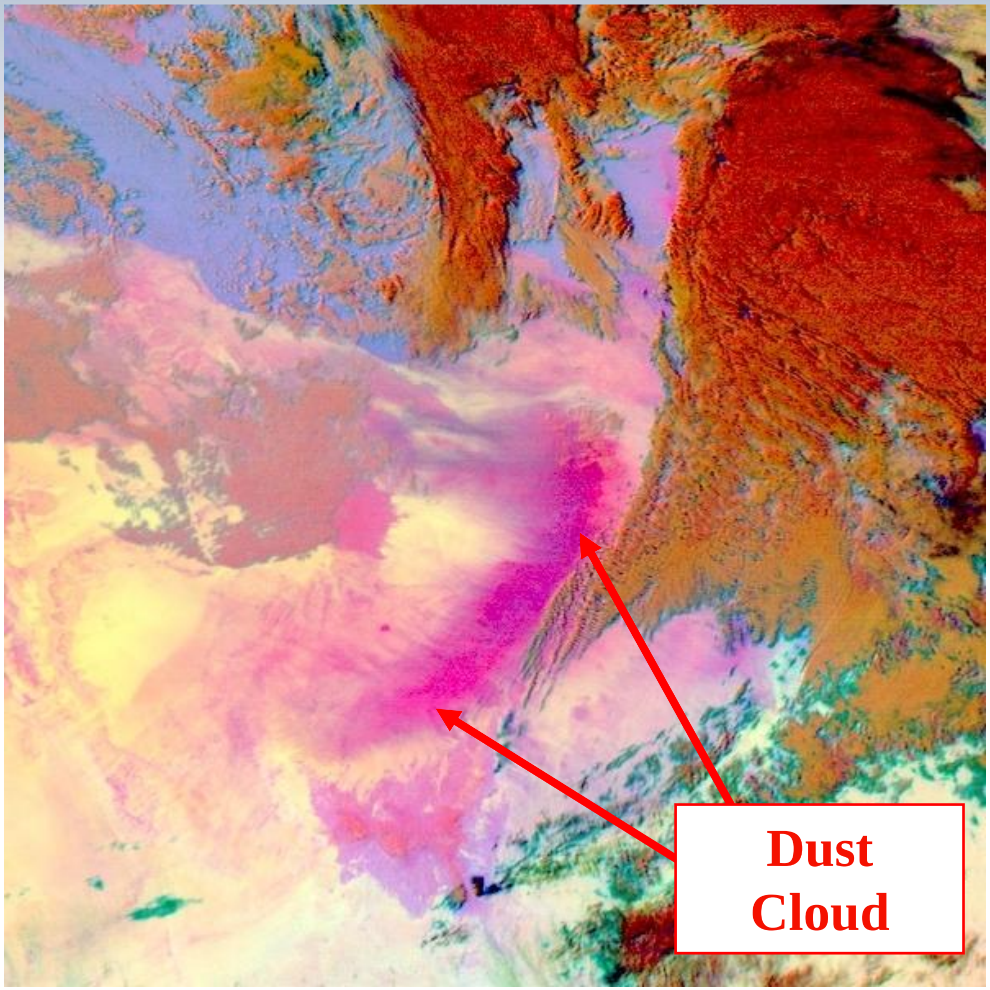
Motivation: Why RGBs

MSG Improvements: Aerosols (Dust, Ash, Smoke)



MFG IR Channel



MSG Dust RGB

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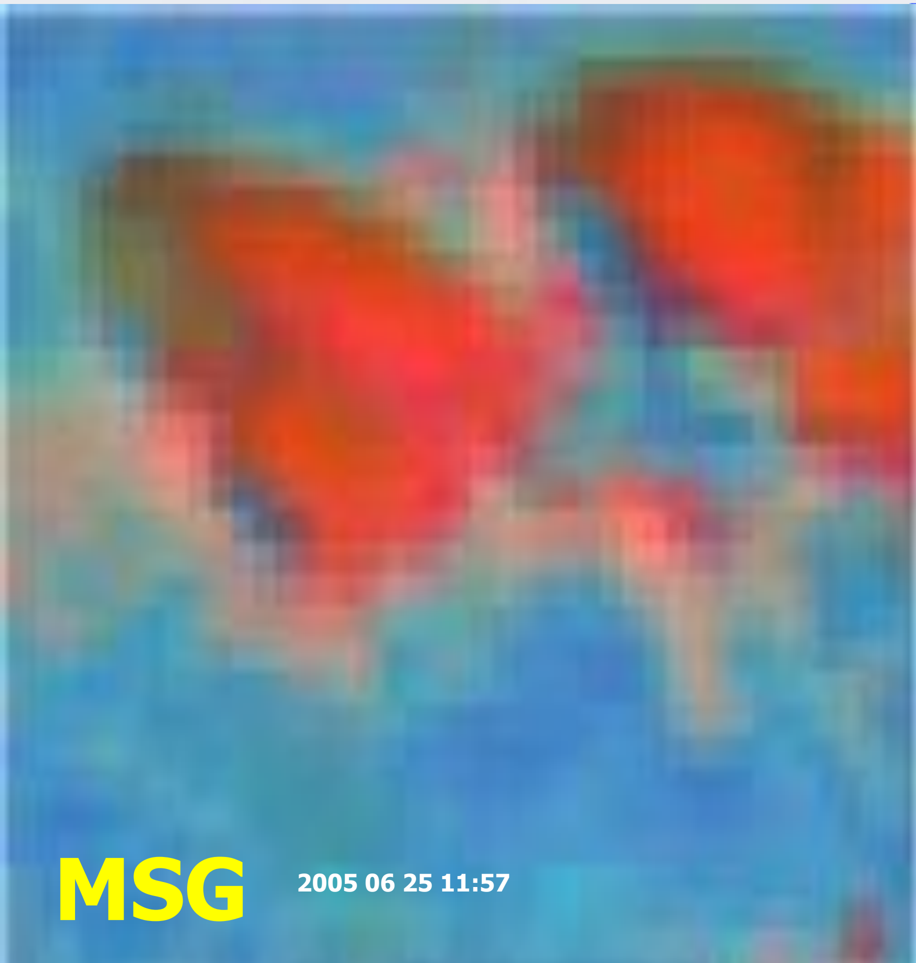
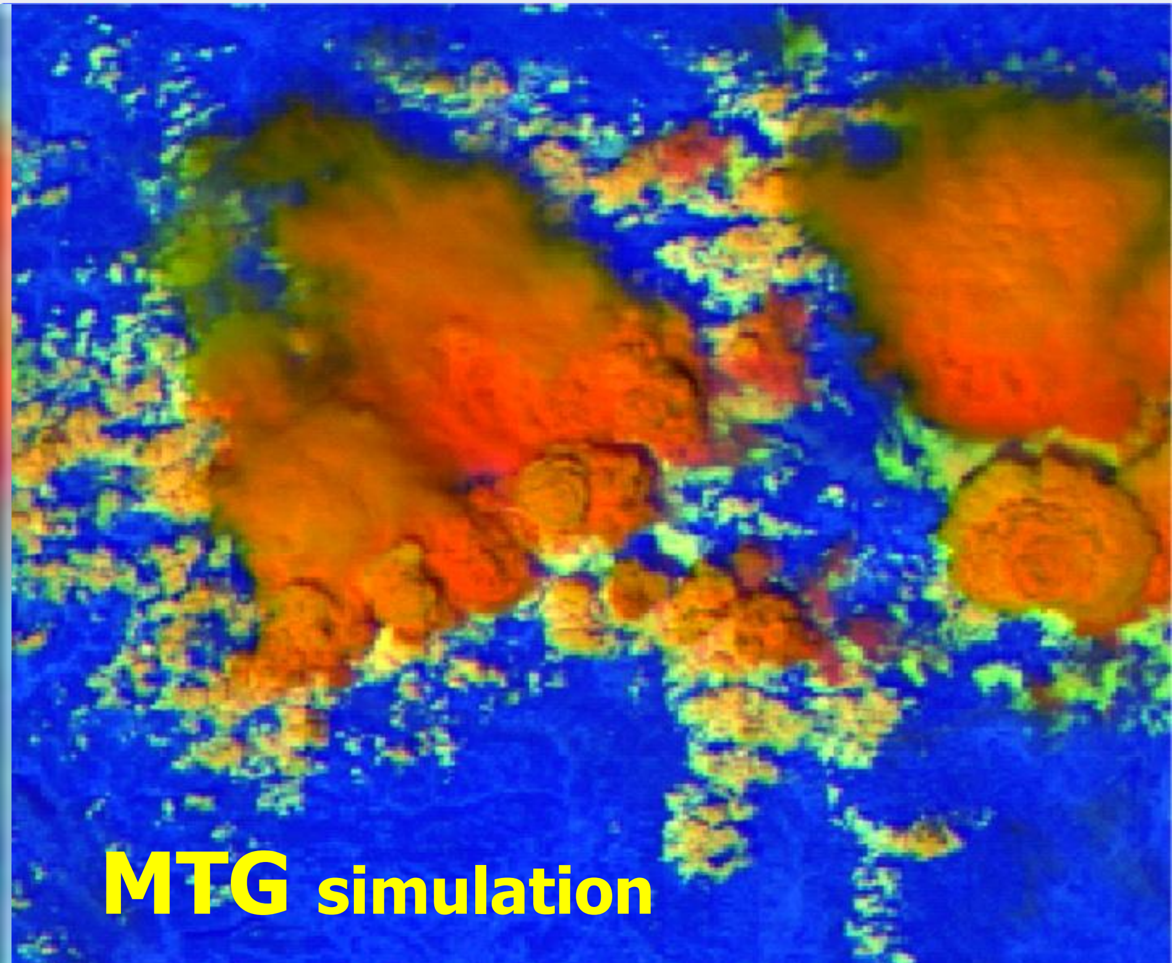
MTG Improvements: horizontal sampling (up to 0.5 km)

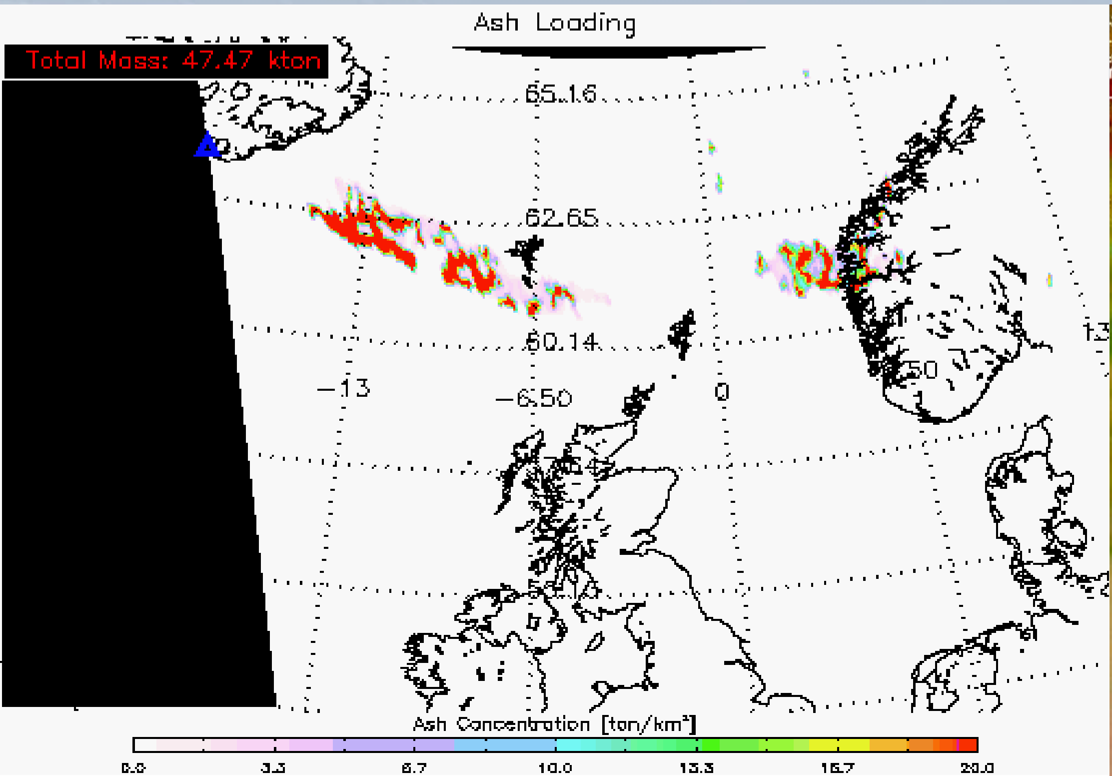
(courtesy D. Rosenfeld)





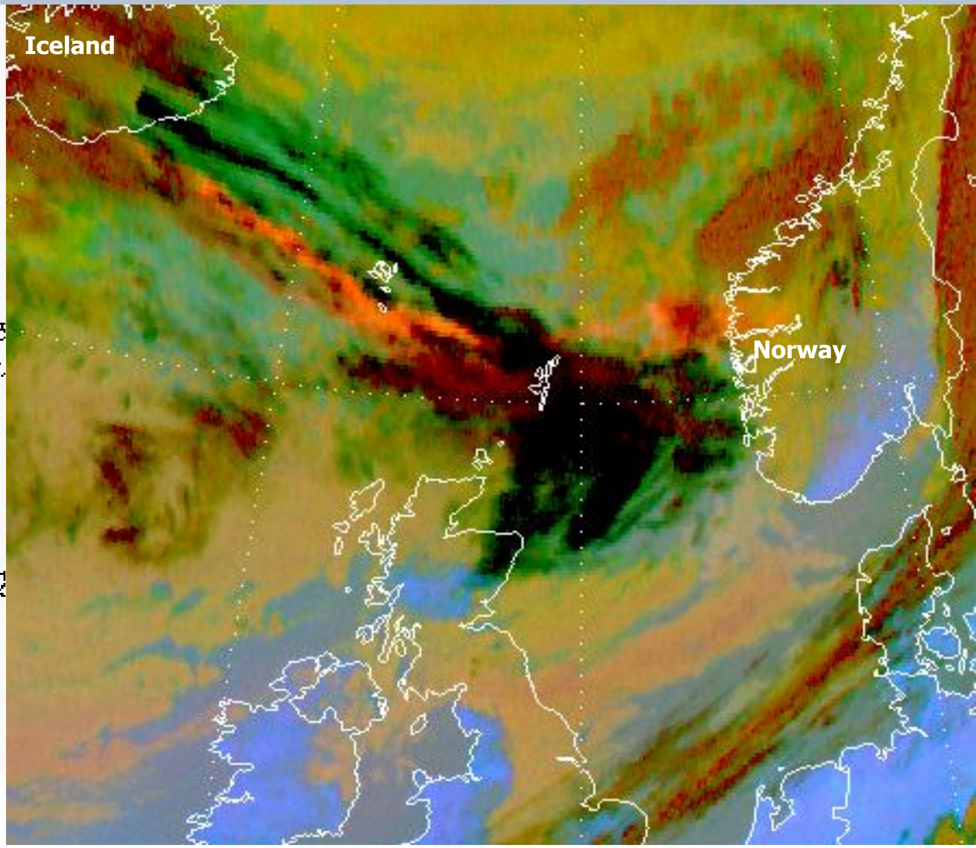
Combined use of RGBs and derived products

SEVIRI Ash Load



Source: M. Pavolonis

Dust RGB



Eruption Eyjafjallajokull, 15 April 2010

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Recommended SEVIRI RGBs (for operational forecasting)

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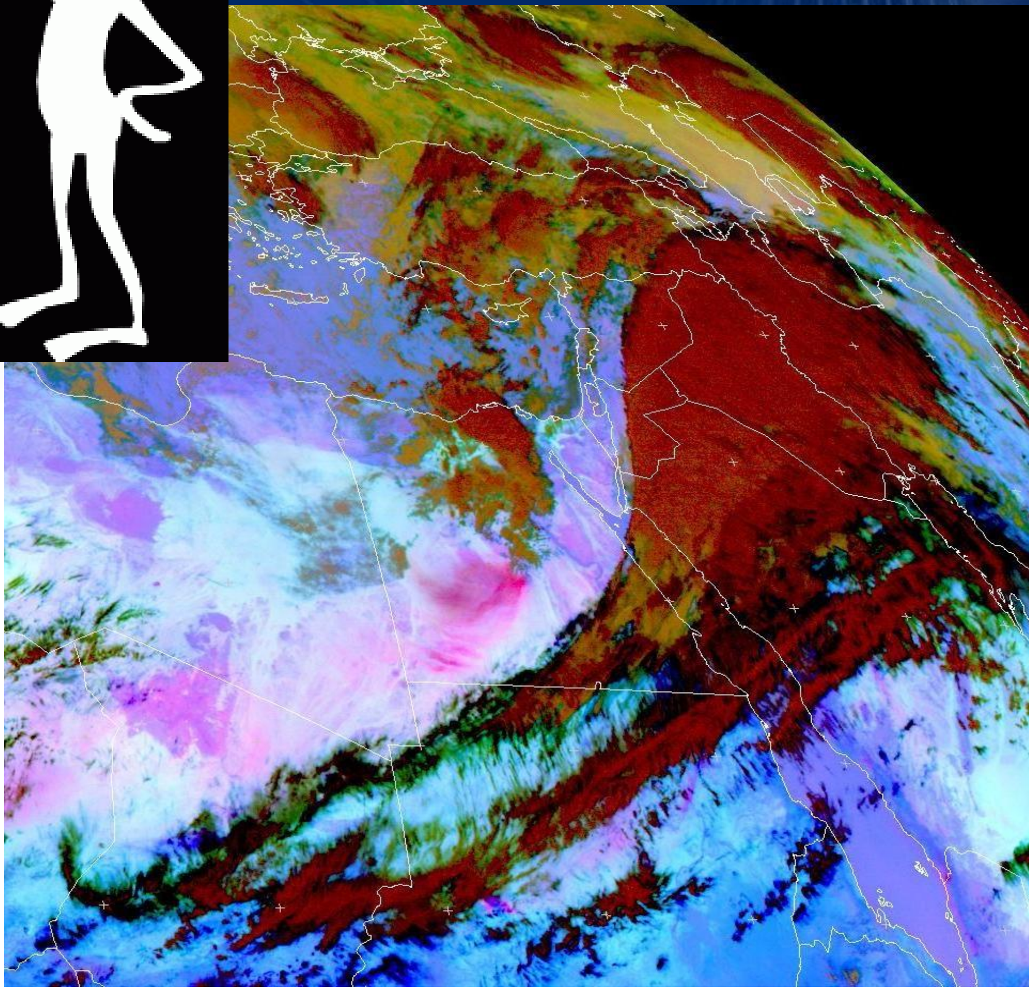
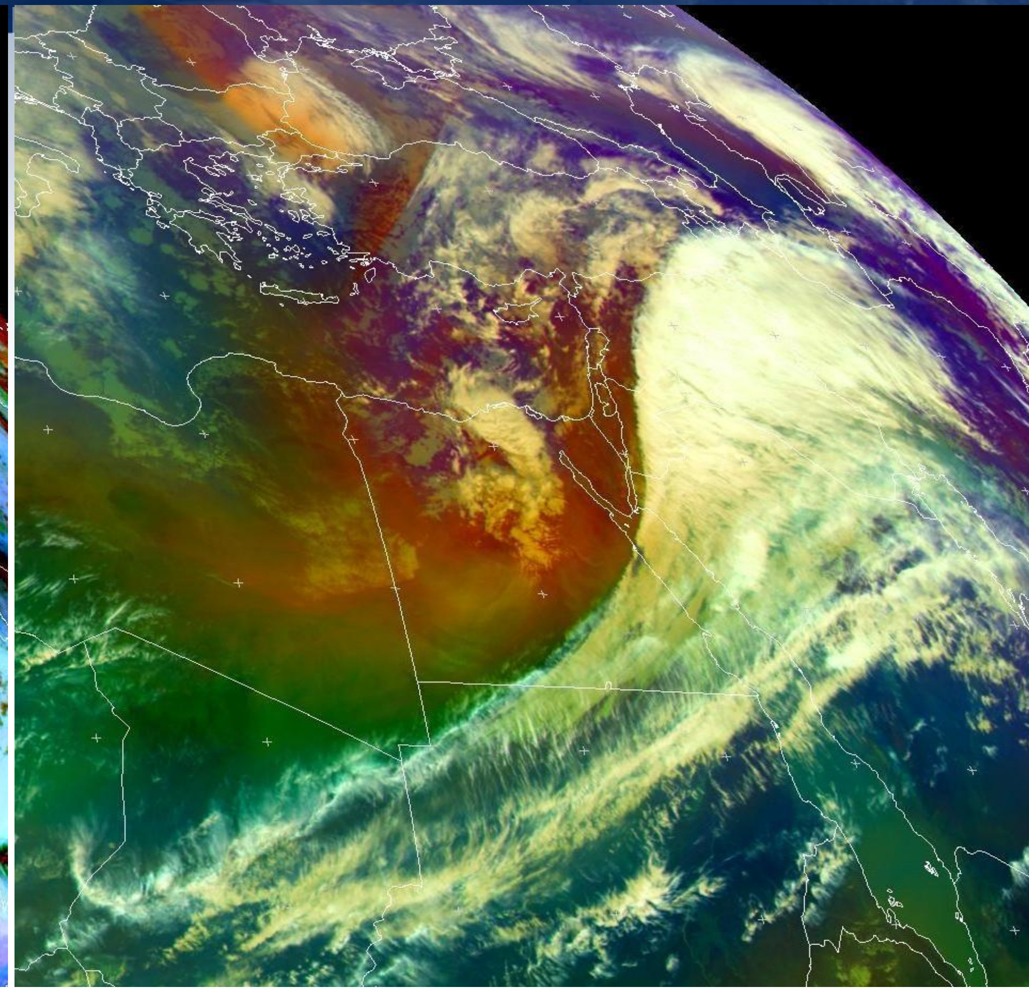
Most important RGBs (for Operational Forecasting)



24-h Microphysics (Dust) RGB



Airmass RGB

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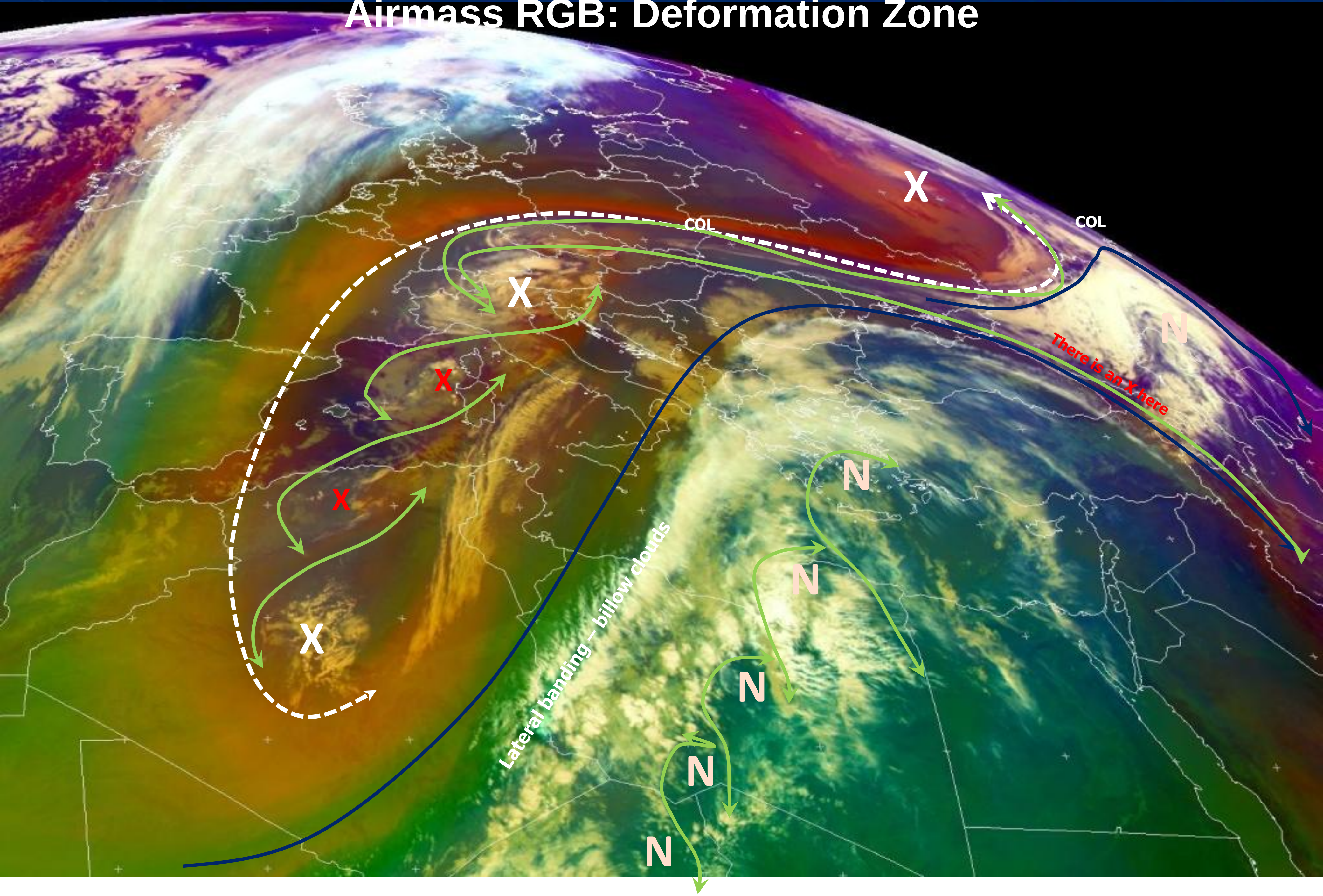
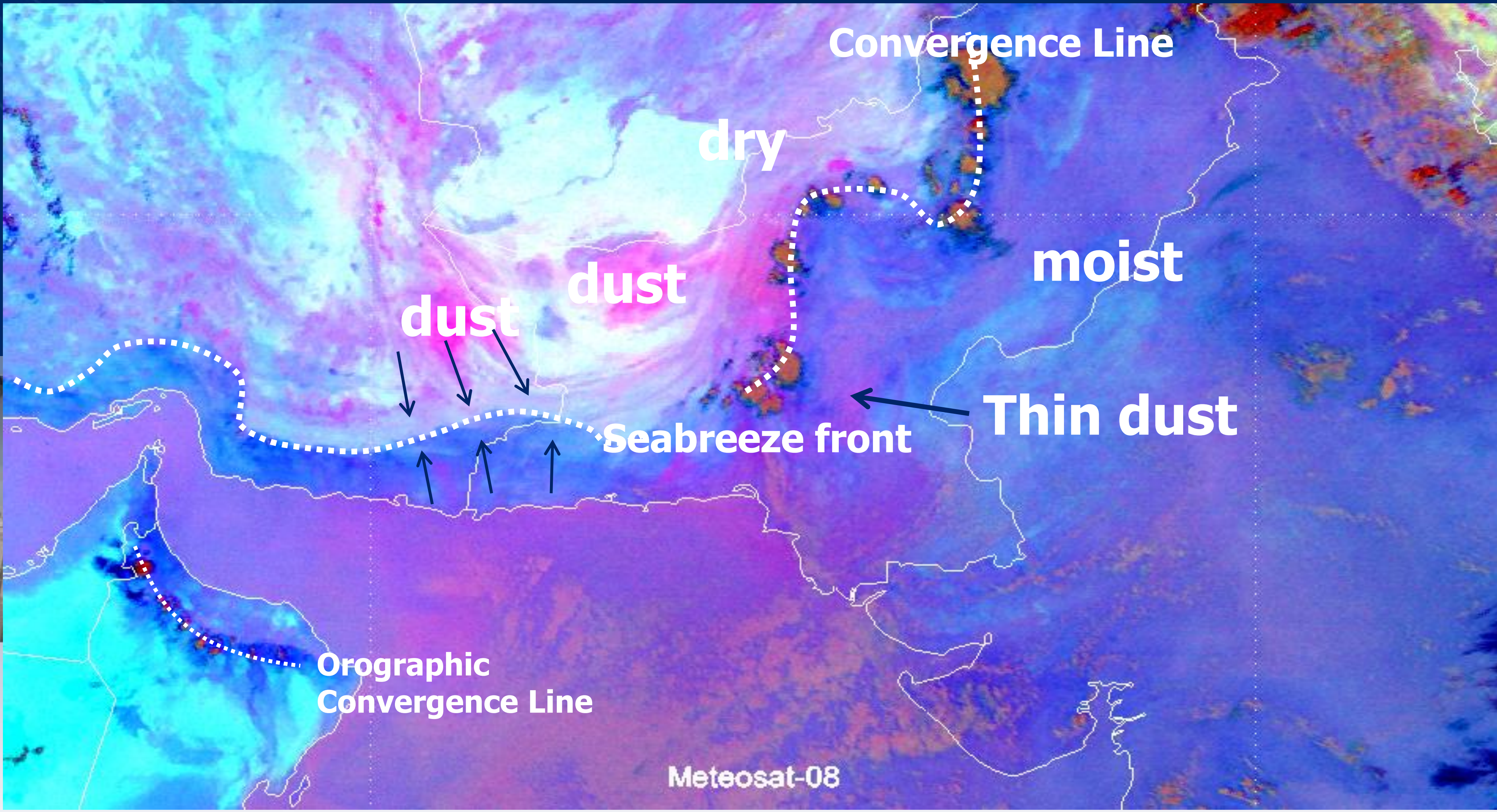
Airmass RGB: Deformation Zone



MSG Improvements: Moisture Boundaries



5 September 2016, 12:00 UTC

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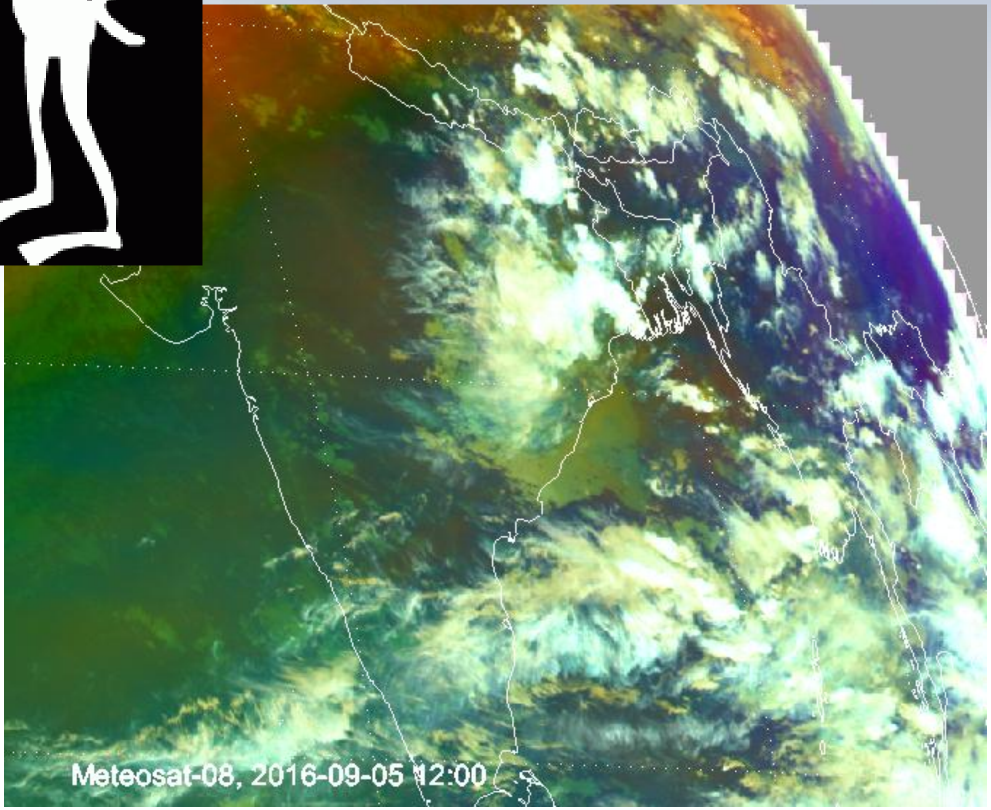
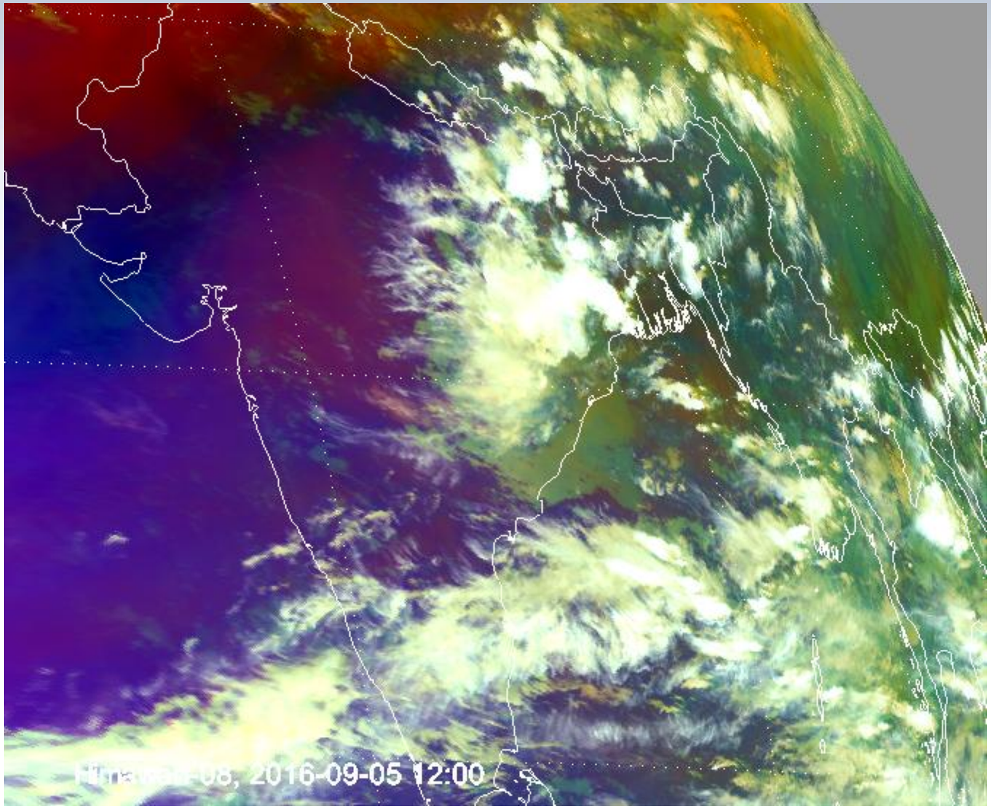
Limb cooling in Airmass RGB



Met-08



Him-08

5 September 2016, 12:00 UTC

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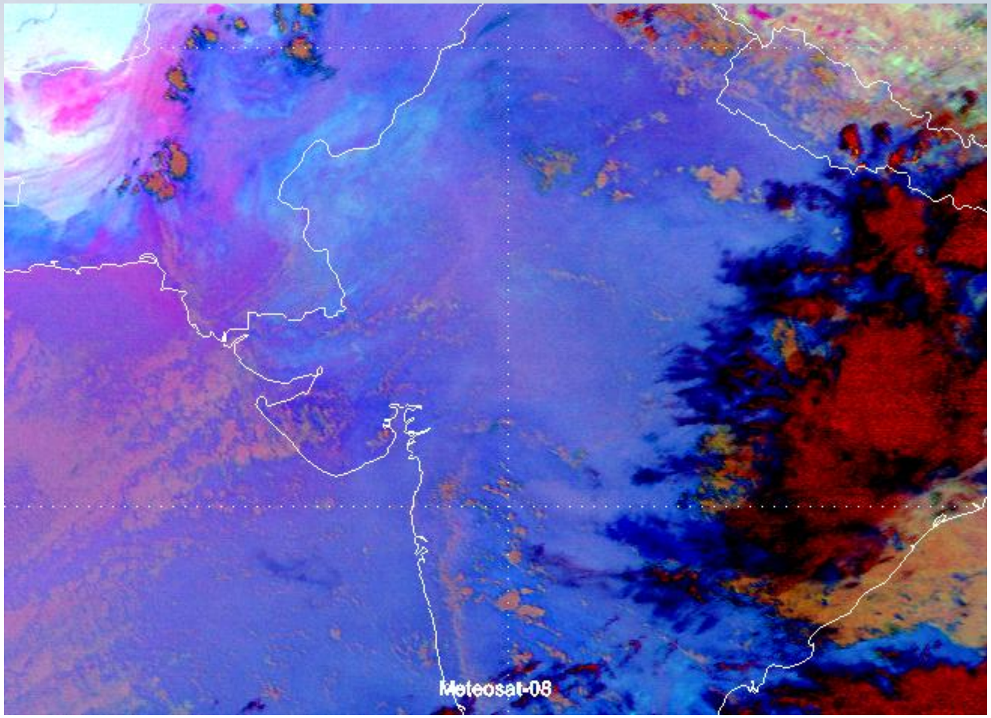
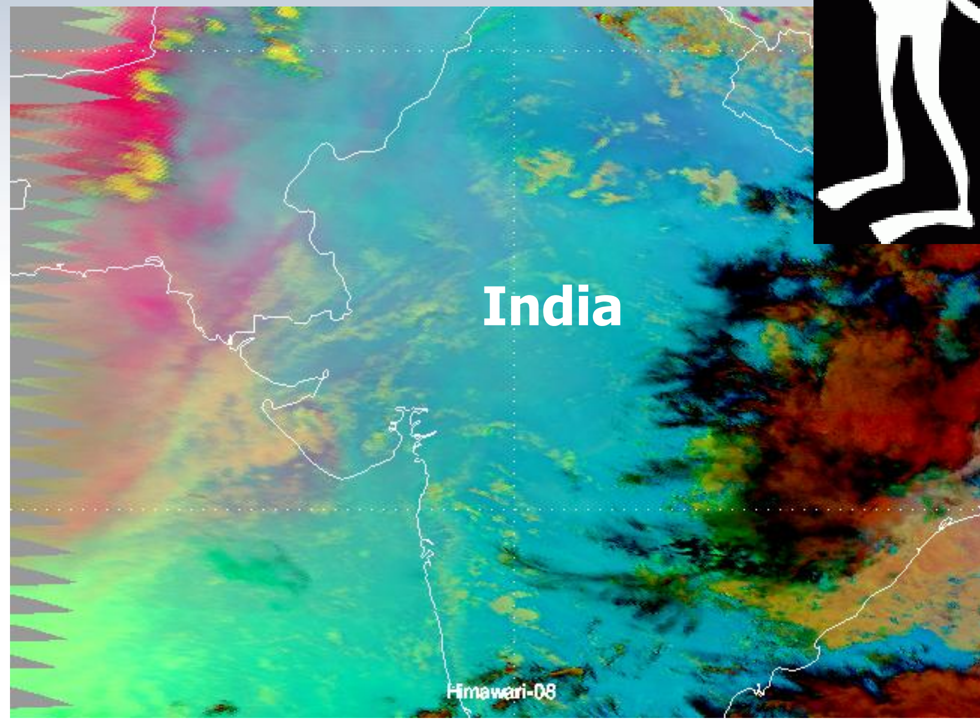
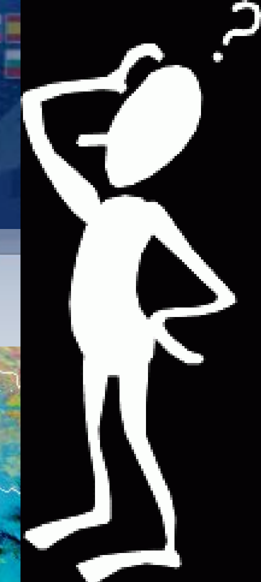
Impact of viewing angle on dust detection



Met-08



Him-08



5 September 2016, 12:00 UTC

Dust (and smoke) often better detected at high viewing angles
(NADIR view is not always the best one)

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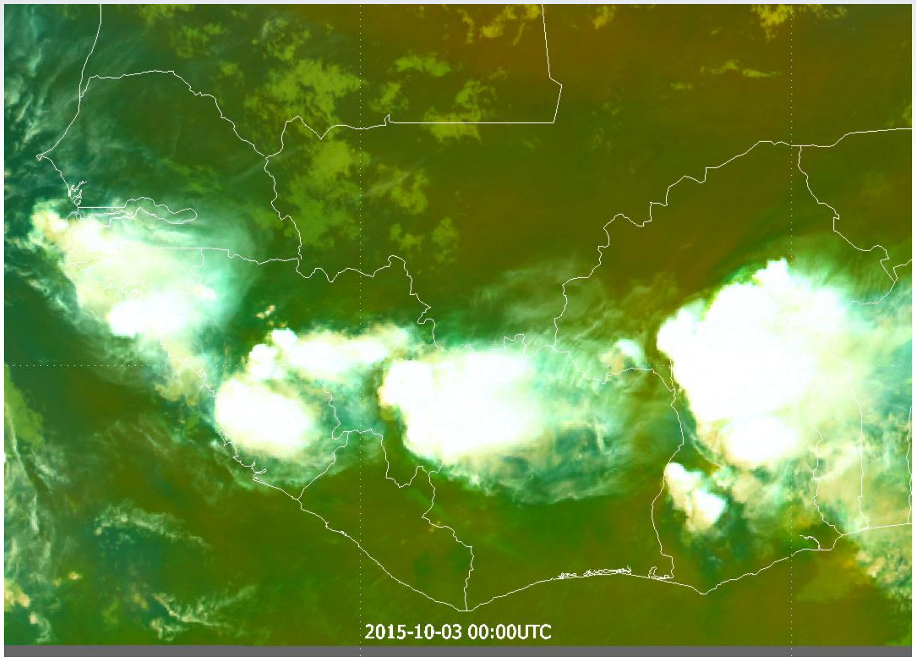
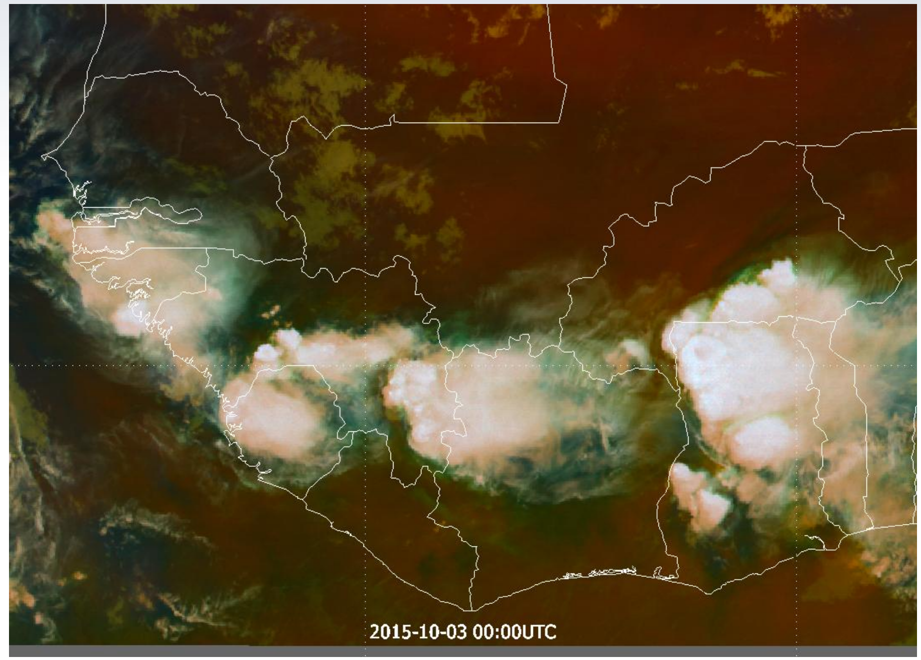
Tropical version of Airmass RGB (Overshooting Tops RGB)

	Standard	Tropical
R WV6.2 – WV7.3	-25 to 0 K	-25 to +5 K (6.2-10.8)
G IR9.7 – IR10.8	-40 to +5 K	-30 to +25 K (Gamma 0.5)
B WV6.2	243 to 208 K	243 to 190 K

Tropical version of Airmass RGB (Overshooting Tops RGB)



Standard



Tropical

3 October 2015, 00:00 UTC, West Africa

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Other SEVIRI RGBs

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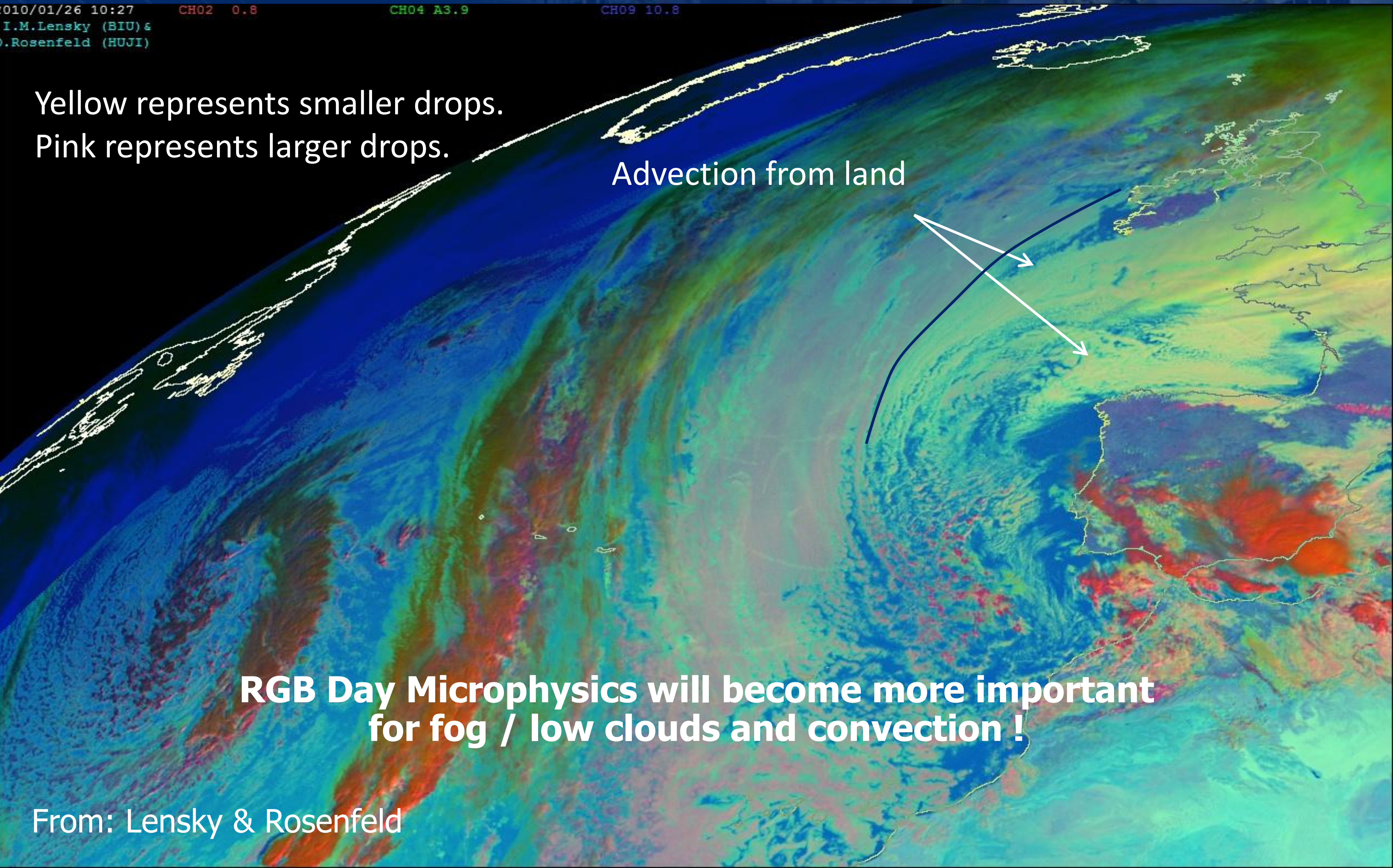
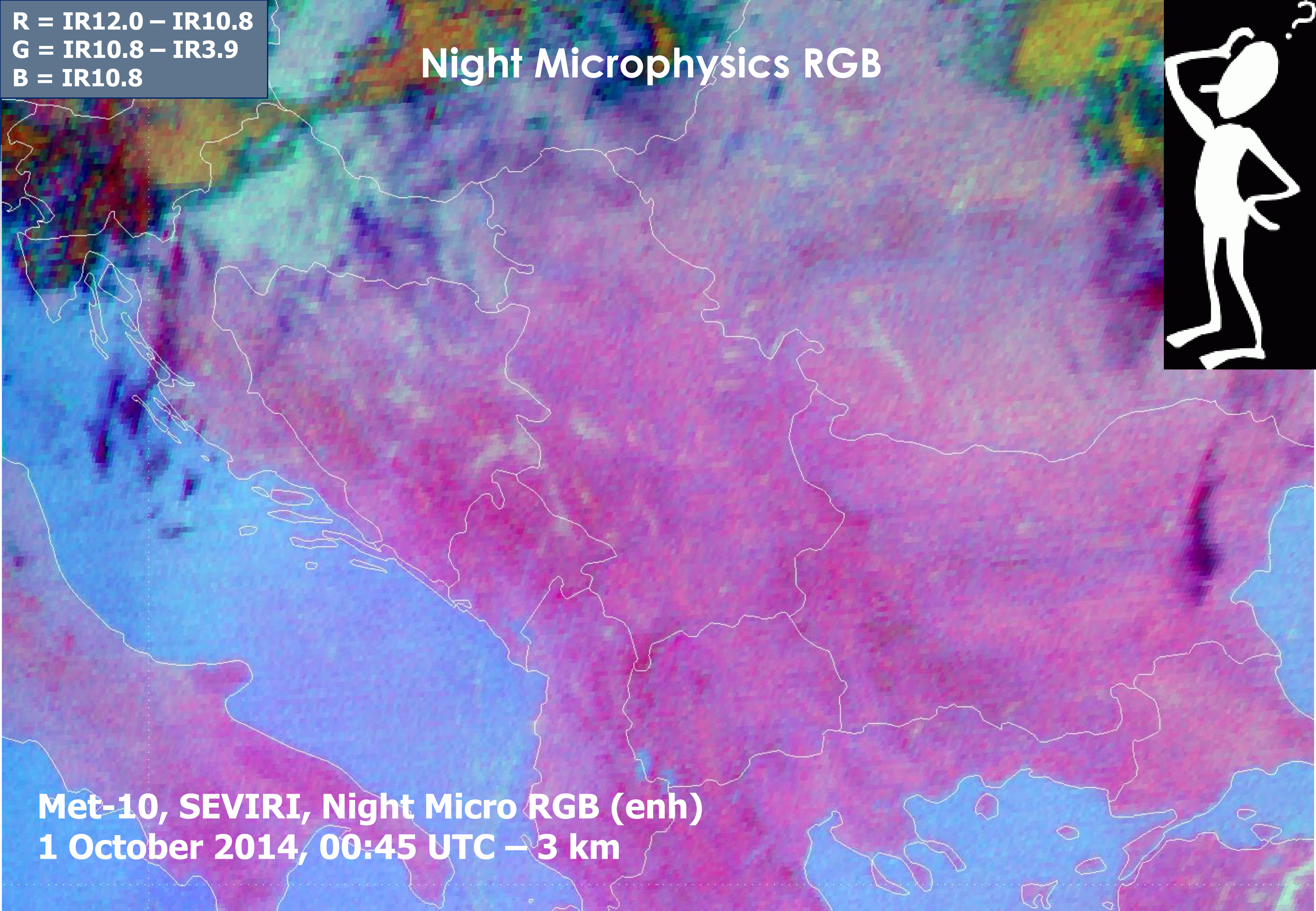
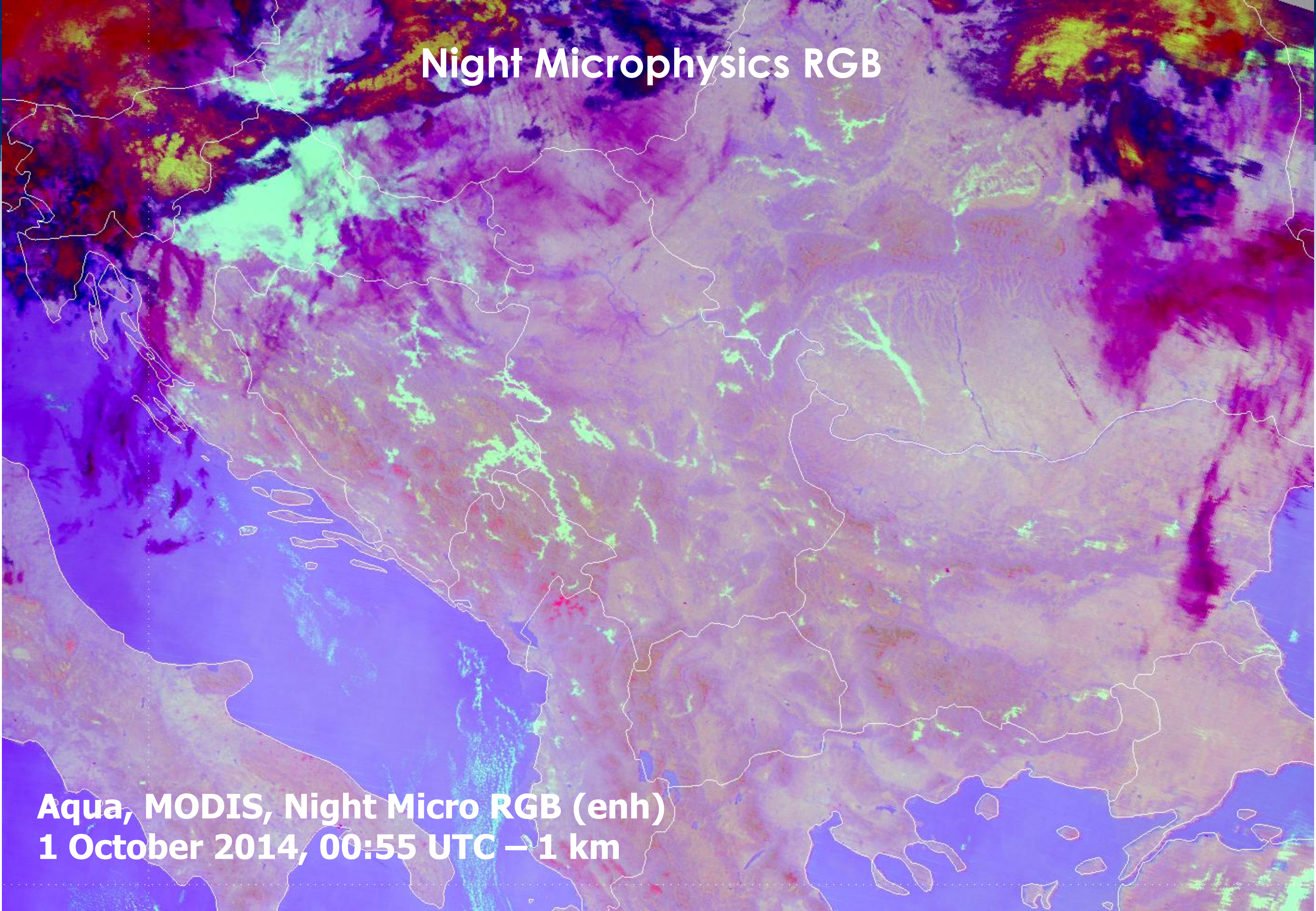
R = VIS0.8
G = IR3.9r
B = IR10.8

Day Microphysics RGB





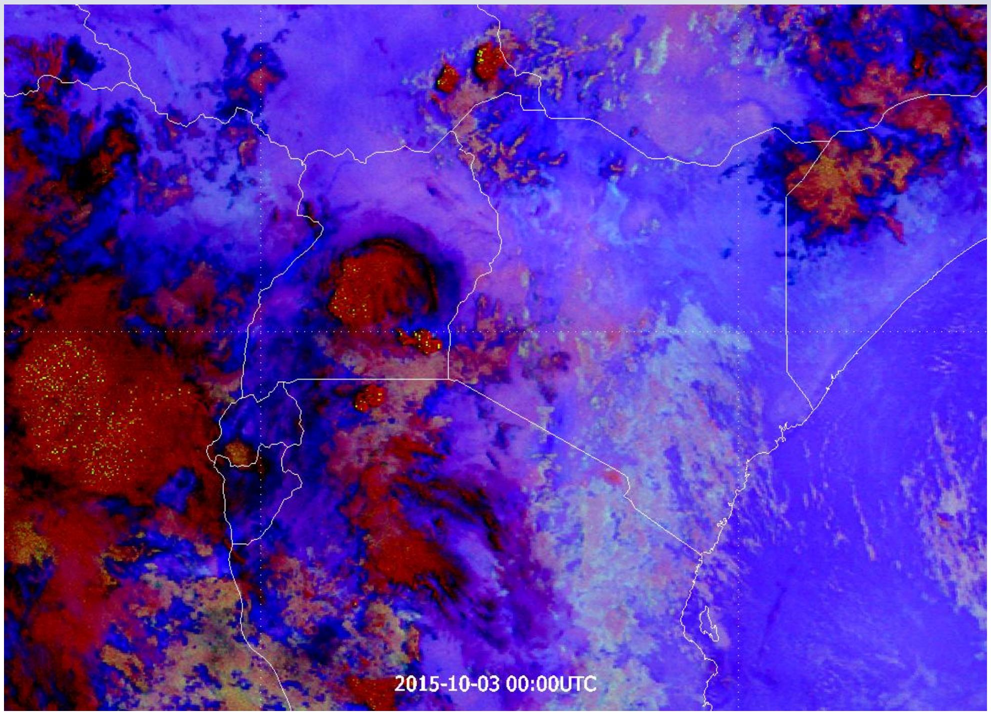
R = IR12.0 – IR10.8
G = IR10.8 – IR3.9
B = IR10.8
Night Microphysics RGB
Met-10, SEVIRI, Night Micro RGB (enh)
1 October 2014, 00:45 UTC – 3 km


Night Microphysics RGB
Aqua, MODIS, Night Micro RGB (enh)
1 October 2014, 00:55 UTC – 1 km

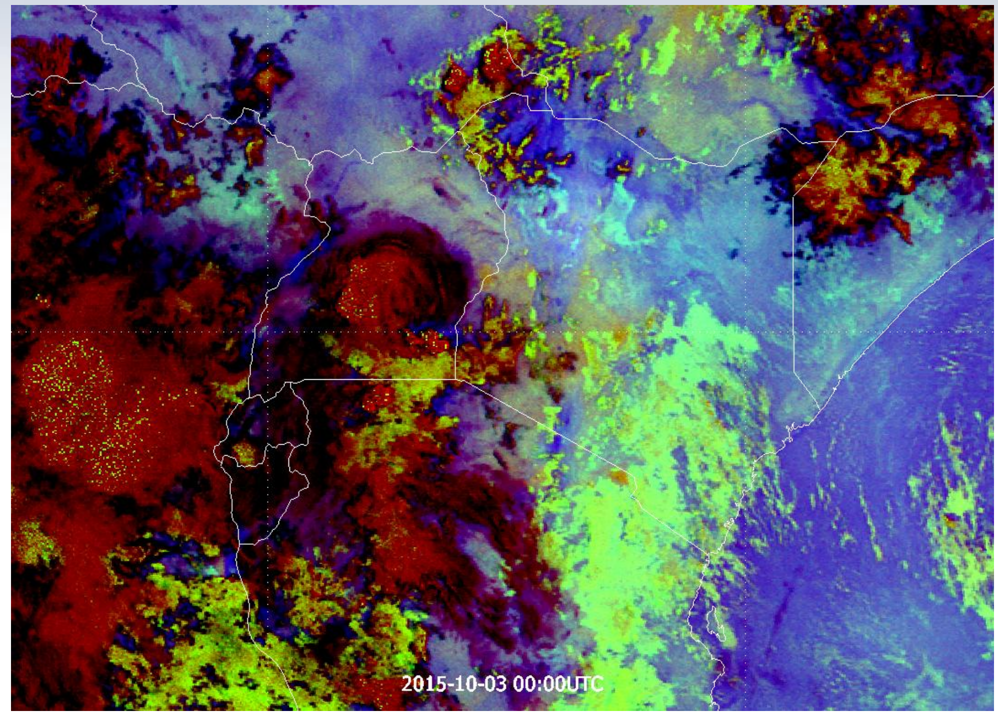
Tropical version of Night Microphysics RGB

	Standard	Tropical
R IR12.0 – IR10.8	-4 to +2 K	-4 to +2 K
G IR10.8 – IR3.9	0 to +10 K	0 to +5 K
B IR10.8	243 to 293 K	273 to 300 K

Tropical version of Night Microphysics RGB



Standard



Tropical

3 October 2015, 00:00 UTC, East Africa

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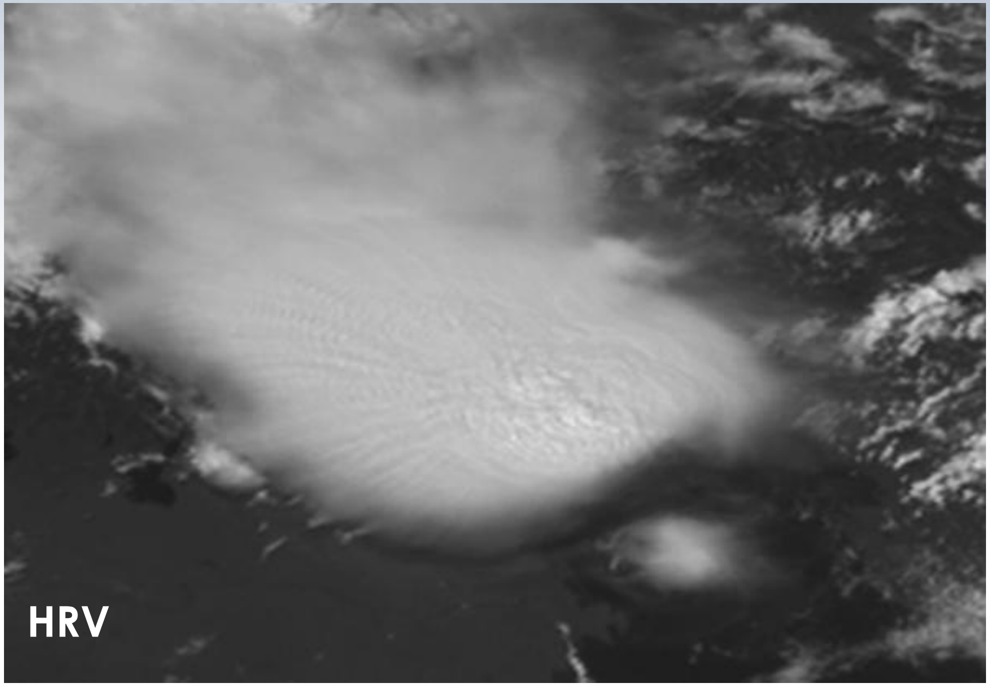
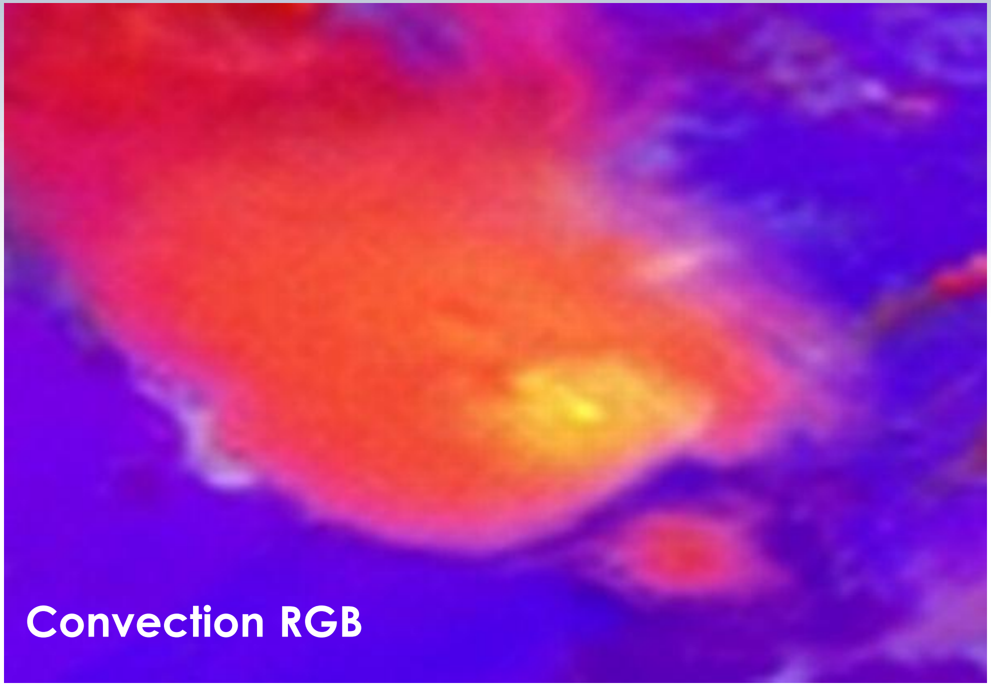
R = WV6.2 – WV7.3
G = IR10.8 - IR3.9
B = NIR1.6 – VIS0.6

Day Convective Storms RGB





MSG-1, 6 November 2004, 12:00 UTC

- Small ice (high IR3.9r of 6-7%)
- Long-living storm system
- Convective outflow boundary
- Overshooting tops
- Gravity waves
- Radial Ci

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Tropical version of Convection RGB

	Standard	Tropical
R WV6.2 – WV7.3	-35 to +5 K	-35 to +5 K
G IR3.9 – IR10.8	-5 to +60 K Gamma 0.5	-5 to +75 K Gamma 0.33
B NIR1.6 – VIS0.6	-75 to +25 %	-75 to +25 %

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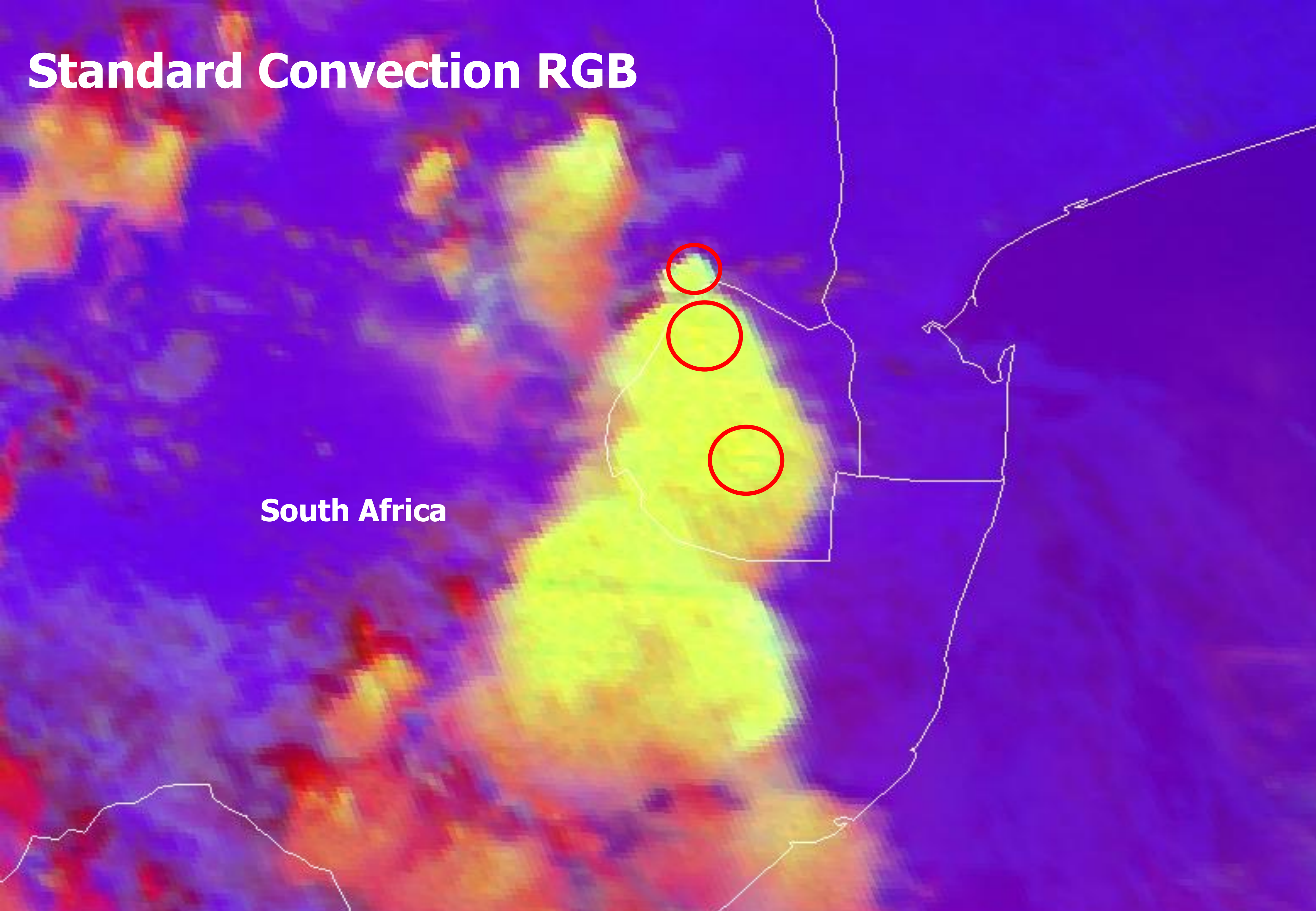
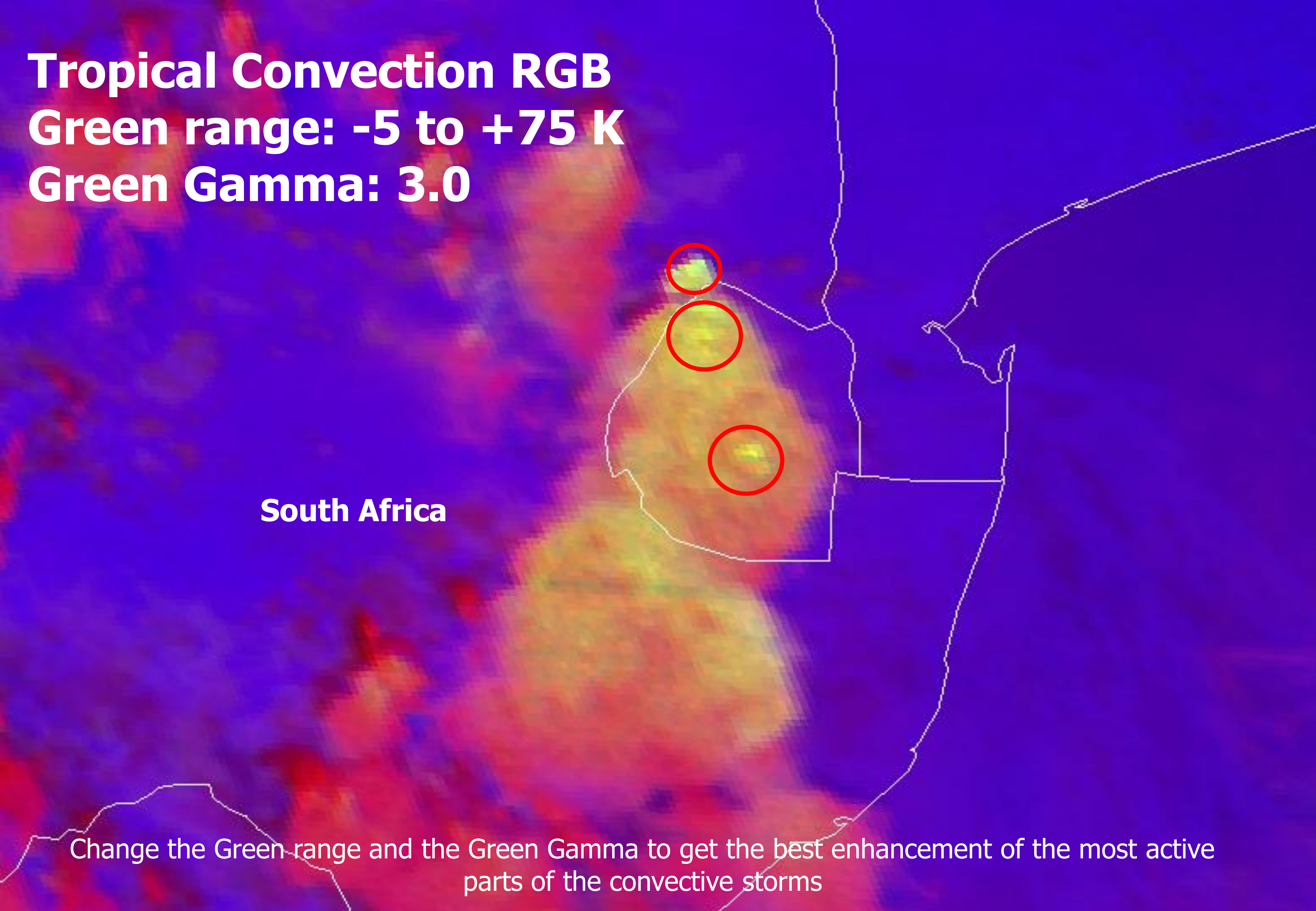
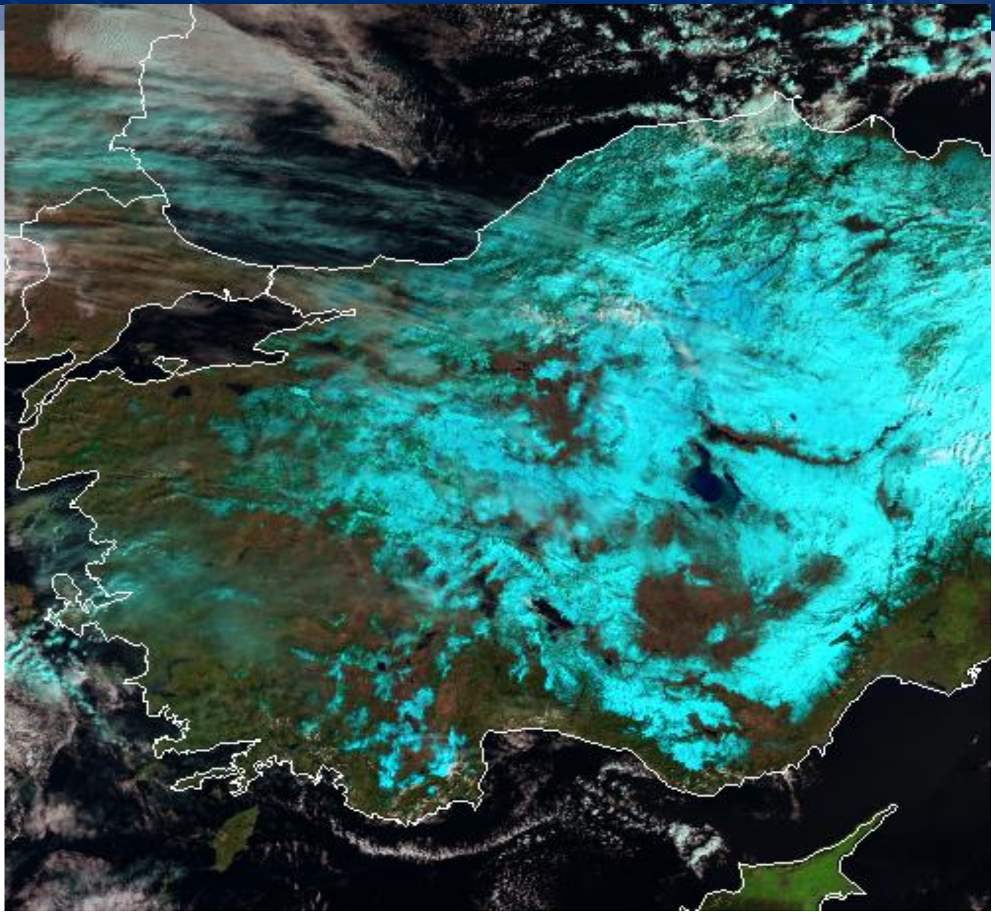

Standard Convection RGB
South Africa


Tropical Convection RGB
Green range: -5 to +75 K
Green Gamma: 3.0
South Africa
Change the Green range and the Green Gamma to get the best enhancement of the most active parts of the convective storms

R = NIR1.6
G = VIS0.8
B = VIS0.6

Natural Colours RGB (Metop AVHRR example)



Turkey in Winter

Turkey in Summer

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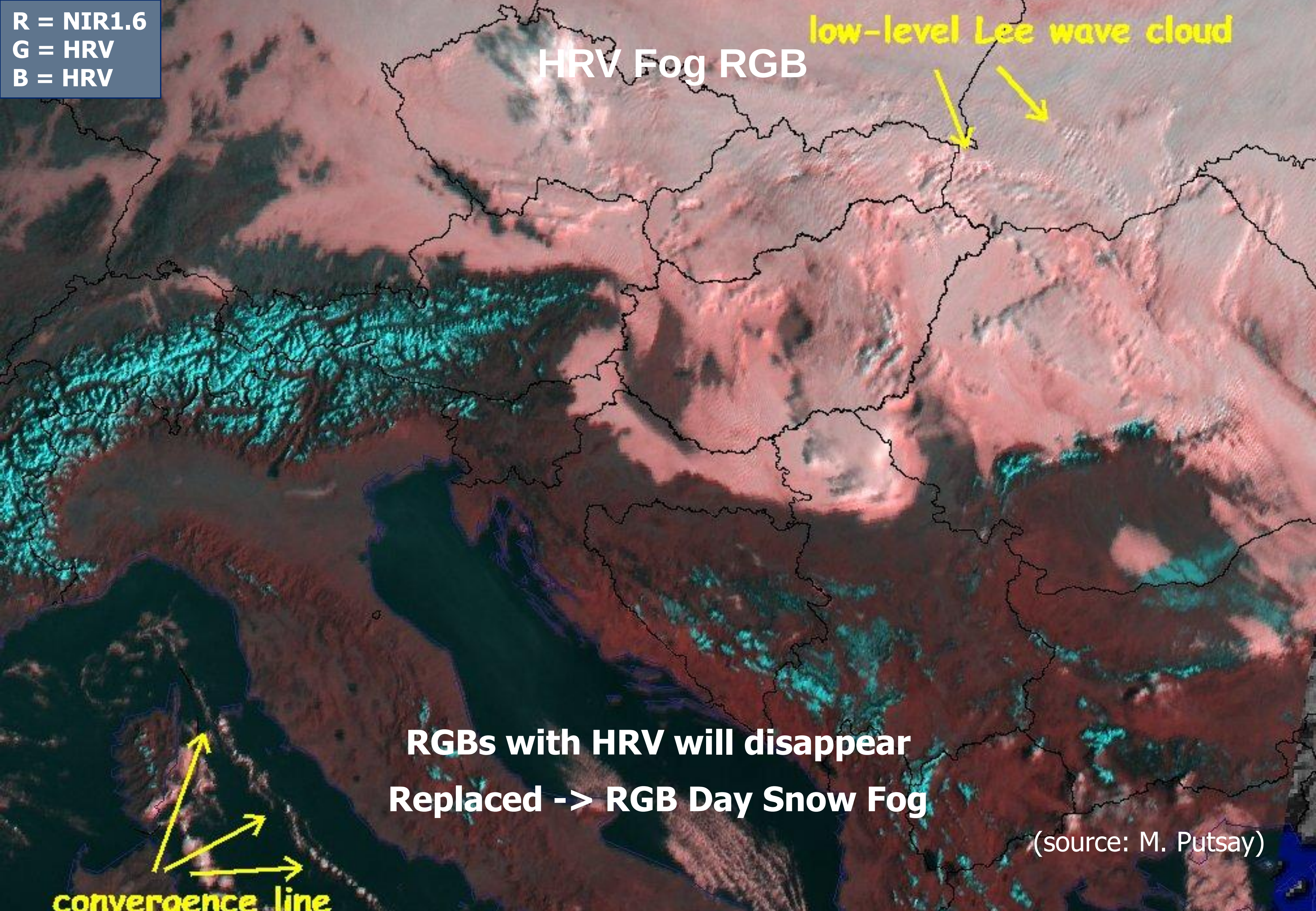
Day Snow-Fog RGB

RGB "Day Snow Fog" for low clouds / snow discimination

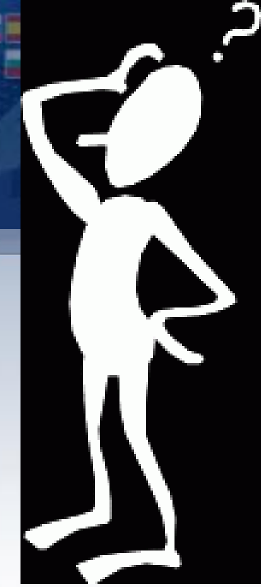
24 Feb 2003, 11:00 UTC



R = NIR1.6
G = HRV
B = HRV
HRV Fog RGB
low-level Lee wave cloud
RGBs with HRV will disappear
Replaced -> RGB Day Snow Fog
(source: M. Putsay)
convergence line

Tuning of RGBs to new channel characteristics

For which RGBs is tuning needed ?



FCI Channels

Spectral Channel	Central Wavelength, λ_0 (µm)	Spectral Width, $\Delta\lambda_0$ (µm)	On-ground spatial sampling distance (km)
VIS 0.4	0.444	0.060	1.0
VIS 0.5	0.510	0.040	1.0
VIS 0.6	0.640	0.050	1.0 / 0.5
VIS 0.8	0.865	0.050	1.0
VIS 0.9	0.914	0.020	1.0
NIR 1.3	1.380	0.030	1.0
NIR 1.6	1.610	0.050	1.0
NIR 2.2	2.250	0.050	1.0 / 0.5
IR1 3.8	3.800	0.400	2.0 / 1.0
IR1 6.3	6.300	1.000	2.0
IR1 7.3	7.350	0.500	2.0
IR2 8.7	8.700	0.400	2.0
IR2 9.7	9.660	0.300	2.0
IR3 10.5	10.500	0.700	2.0 / 1.0
IR3 12.3	12.300	0.500	2.0
IR3 13.3	13.300	0.600	2.0

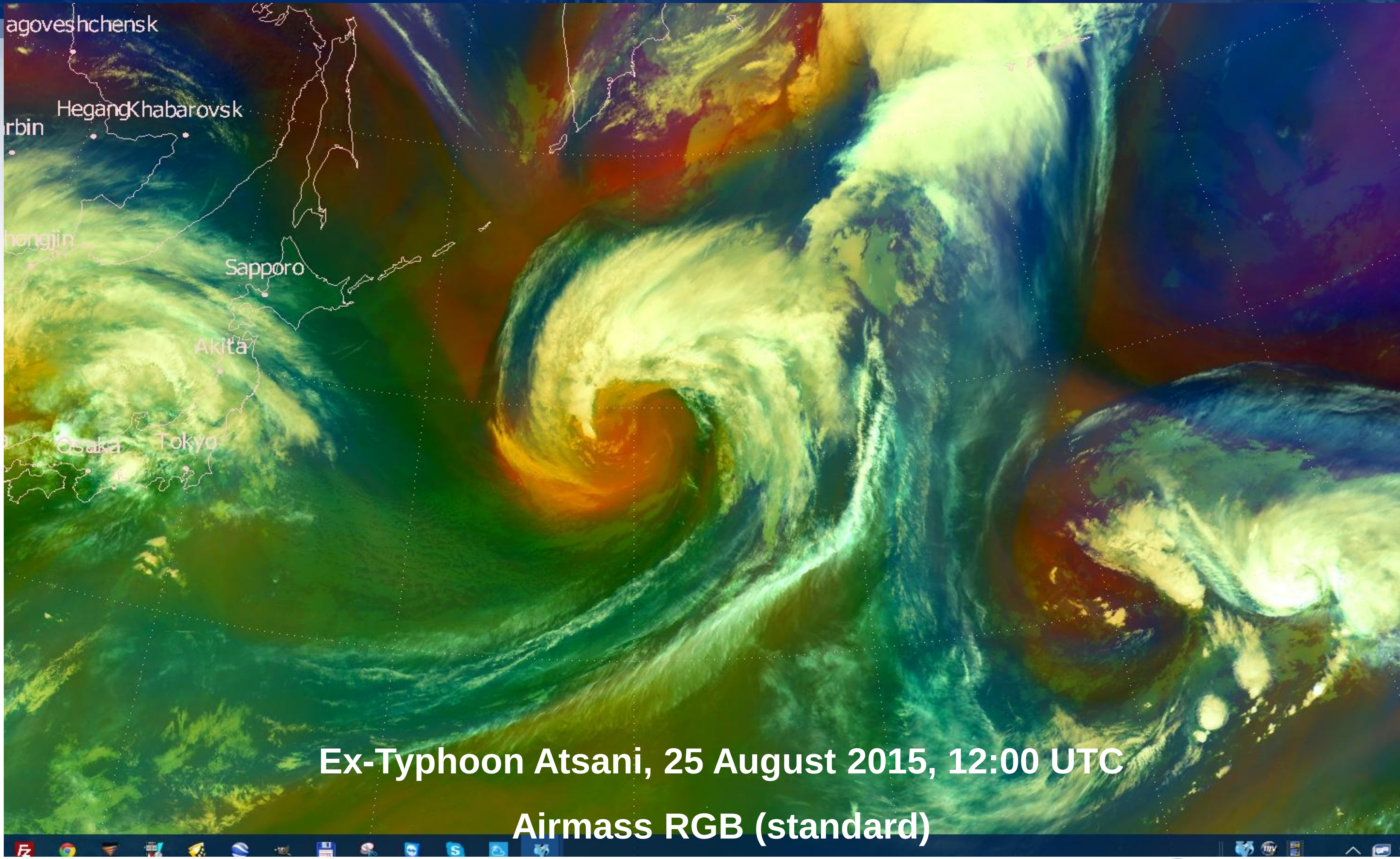
For which RGBs is tuning needed ?

➡ **Spectral Response Function changed !!**

Spectral Channel	Central Wavelength, λ_0 (µm)	Spectral Width, $\Delta\lambda_0$ (µm)	On-ground spatial sampling distance (km)
VIS 0.4	0.444	0.060	1.0
VIS 0.5	0.510	0.040	1.0
VIS 0.6	0.640	0.050	1.0 / 0.5
VIS 0.8	0.865	0.050	1.0
VIS 0.9	0.914	0.020	1.0
NIR 1.3	1.380	0.030	1.0
NIR 1.6	1.610	0.050	1.0
NIR 2.2	2.250	0.050	1.0 / 0.5
➡ IR1 3.8	3.800	0.400	2.0 / 1.0
IR1 6.3	6.300	1.000	2.0
IR1 7.3	7.350	0.500	2.0
IR2 8.7	8.700	0.400	2.0
IR2 9.7	9.660	0.300	2.0
➡ IR3 10.5	10.500	0.700	2.0 / 1.0
➡ IR3 12.3	12.300	0.500	2.0
IR3 13.3	13.300	0.600	2.0

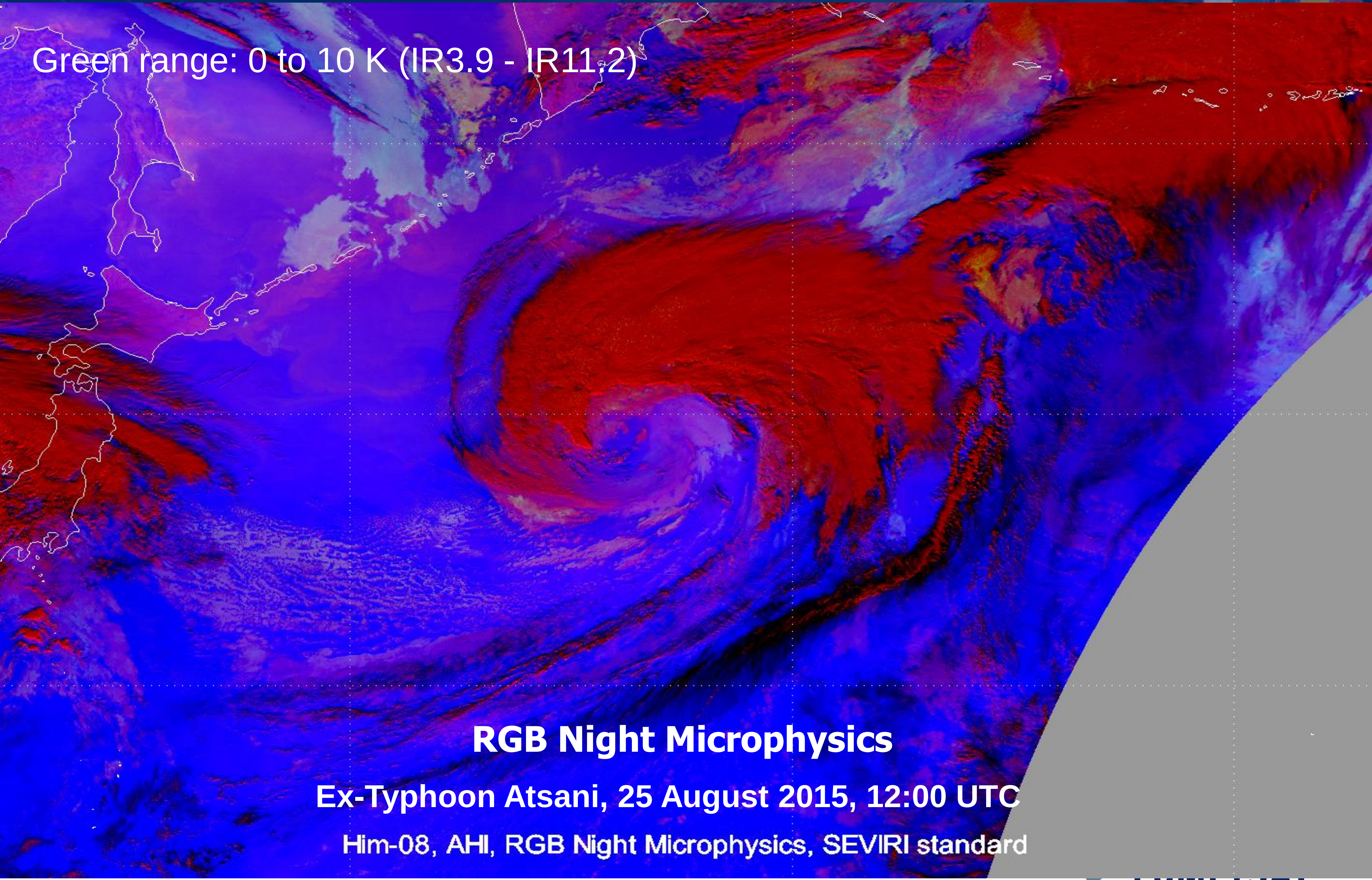
Mostly concerned: RGB Night Micro, RGB Dust (24-h Micro)

No tuning needed for Airmass RGB

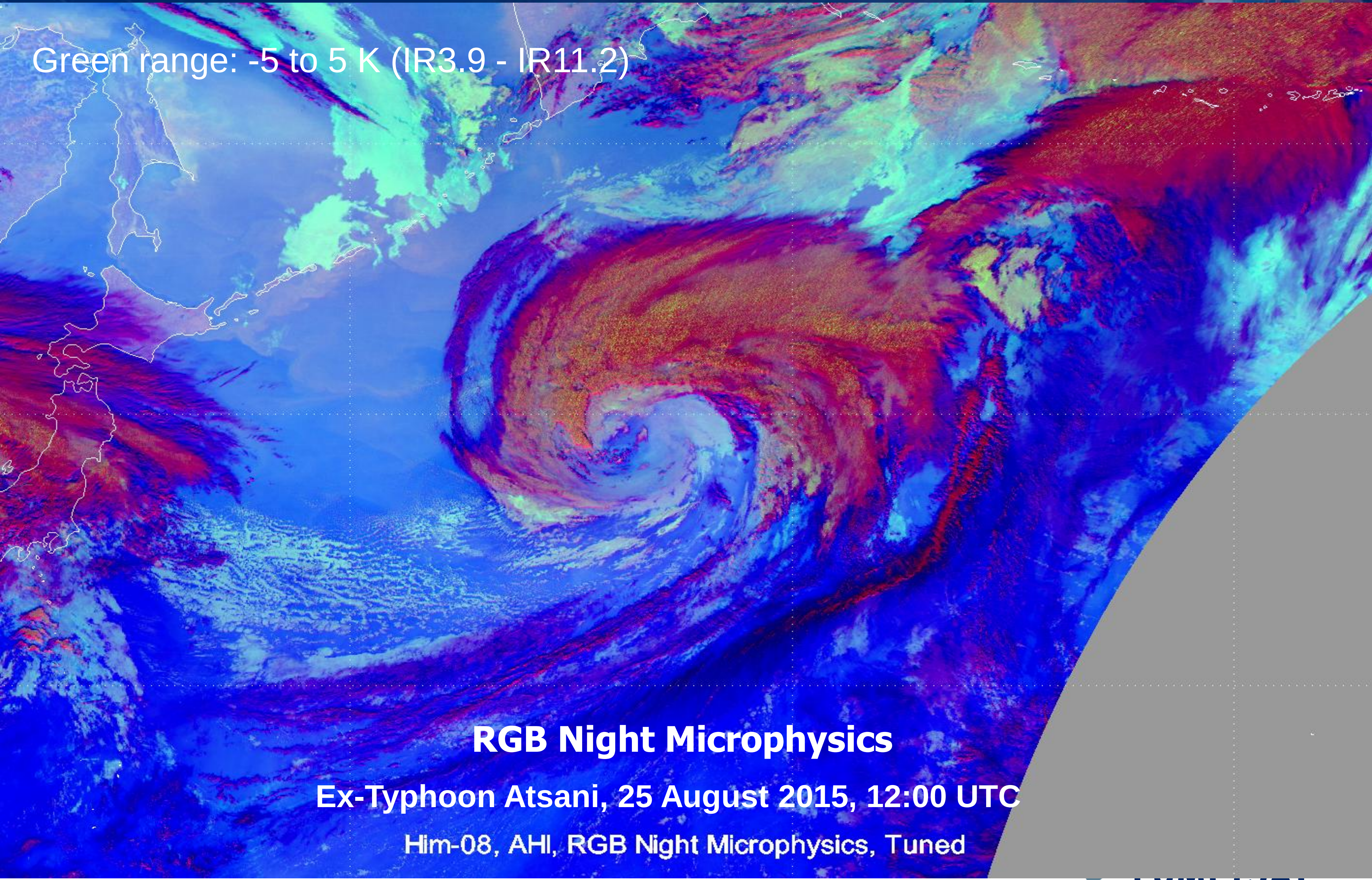


Ex-Typhoon Atsani, 25 August 2015, 12:00 UTC

Airmass RGB (standard)



Green range: 0 to 10 K (IR3.9 - IR11.2)
RGB Night Microphysics
Ex-Typhoon Atsani, 25 August 2015, 12:00 UTC
Him-08, AHI, RGB Night Microphysics, SEVIRI standard


Green range: -5 to 5 K (IR3.9 - IR11.2)
RGB Night Microphysics
Ex-Typhoon Atsani, 25 August 2015, 12:00 UTC
Him-08, AHI, RGB Night Microphysics, Tuned

RGB recipes adjusted for Himawari-8 using the JMA correlation / regression analysis

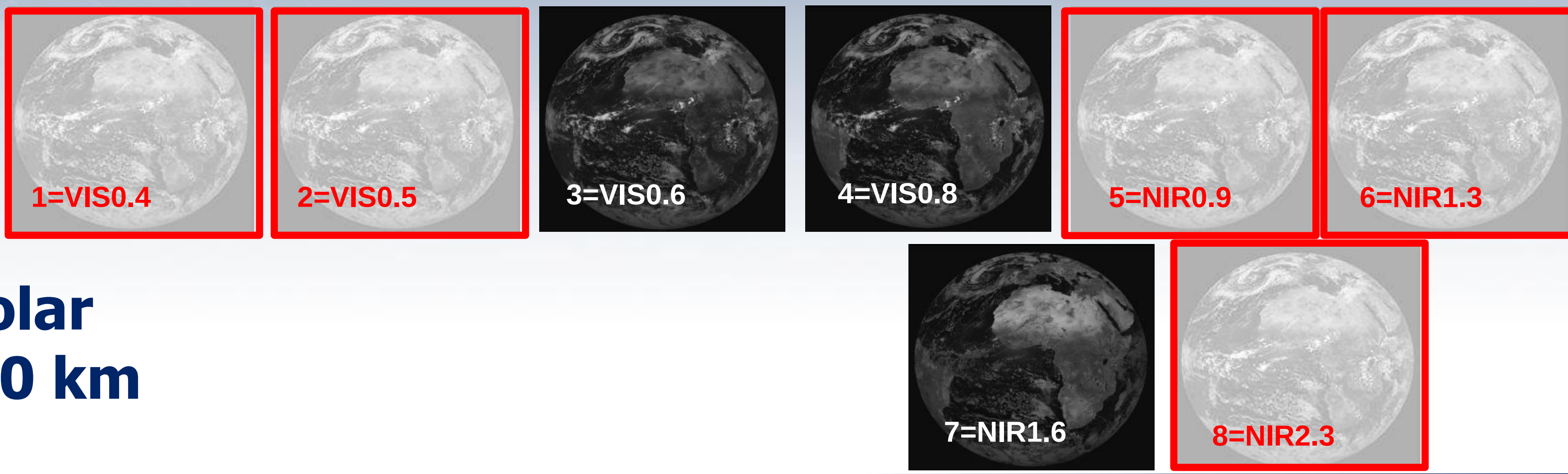
Dust RGB	Range	Gamma
12.0 – 10.4 micron	-6.7 to 2.6	1.0
10.4 – 8.7 micron	1 to 10.9	2.5
10.4 micron	261.2 to 288.7	1.0

from: "**Introduction of JMA VLab Support Site on RGB Composite Imagery and tentative RGBs**". AOMSUC-6 presentation by Akihiro Shimizu (JMA)

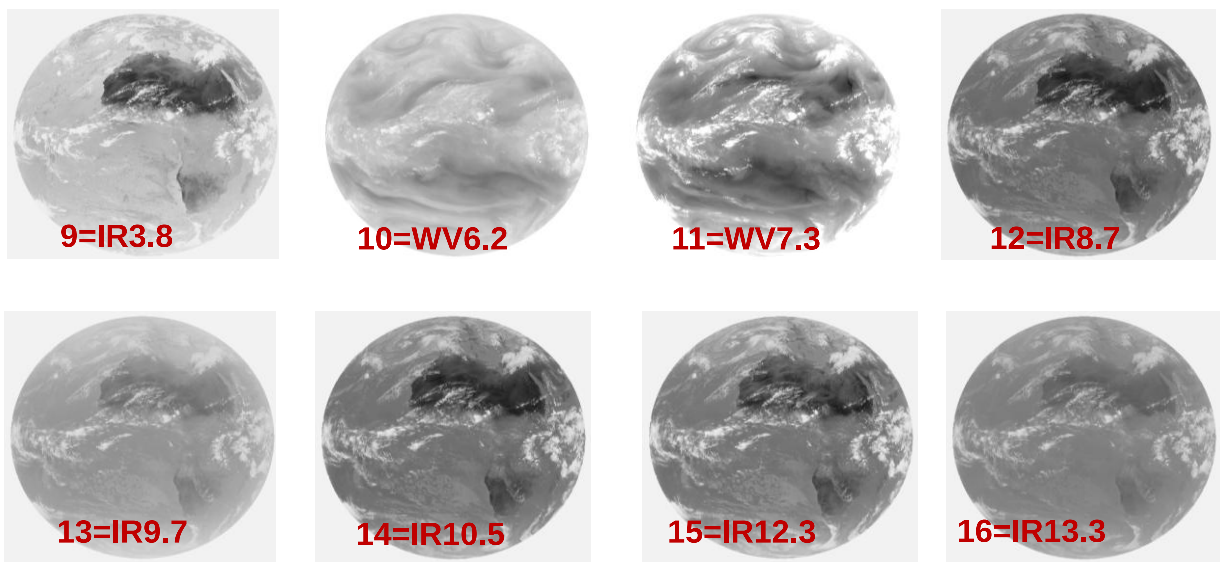
Night Microphysics RGB	Range	Gamma
12.0 – 10.4 micron	-6.7 to 2.6	1.0
10.4 – 3.9 micron	-3.1 to 5.2	1.0
10.4 micron	243.6 to 292.6	1.0

RGBs using new FCI channels

FCI on Meteosat Third Generation (MTG)



Solar
1.0 km



Thermal
2.0 km

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FCI – Benefits from new Channels

- The 0.96 µm channel is used for total column precipitable water (daytime)
- The 2.25 µm channel is used for cloud microphysics (daytime)
- The 0.444 µm and the 0.51 µm channels are used for true colour images and aerosol retrievals (daytime)
- The 1.375 µm channel is used for detection of very thin cirrus clouds (daytime)

FCI Optical Design

Spectral Channel	Central Wavelength, λ_0 (µm)	Spectral Width, $\Delta\lambda_0$ (µm)	On-ground spatial sampling distance (km)
VIS 0.4	0.444	0.060	1.0
VIS 0.5	0.510	0.040	1.0
VIS 0.6	0.640	0.050	1.0 / 0.5
VIS 0.8	0.865	0.050	1.0
VIS 0.9	0.914	0.020	1.0
NIR 1.3	1.380	0.030	1.0
NIR 1.6	1.610	0.050	1.0
NIR 2.2	2.250	0.050	1.0 / 0.5
IR1 3.8	3.800	0.400	2.0 / 1.0
IR1 6.3	6.300	1.000	2.0
IR1 7.3	7.350	0.500	2.0
IR2 8.7	8.700	0.400	2.0
IR2 9.7	9.660	0.300	2.0
IR3 10.5	10.500	0.700	2.0 / 1.0
IR3 12.3	12.300	0.500	2.0
IR3 13.3	13.300	0.600	2.0

AHI, ABI, VIIRS, MODIS (VIS 0.4)

AHI (VIS 0.5)

MODIS (VIS 0.9)

MODIS, VIIRS, ABI (NIR 1.3)

AHI, ABI, VIIRS (not MODIS) (NIR 2.2)

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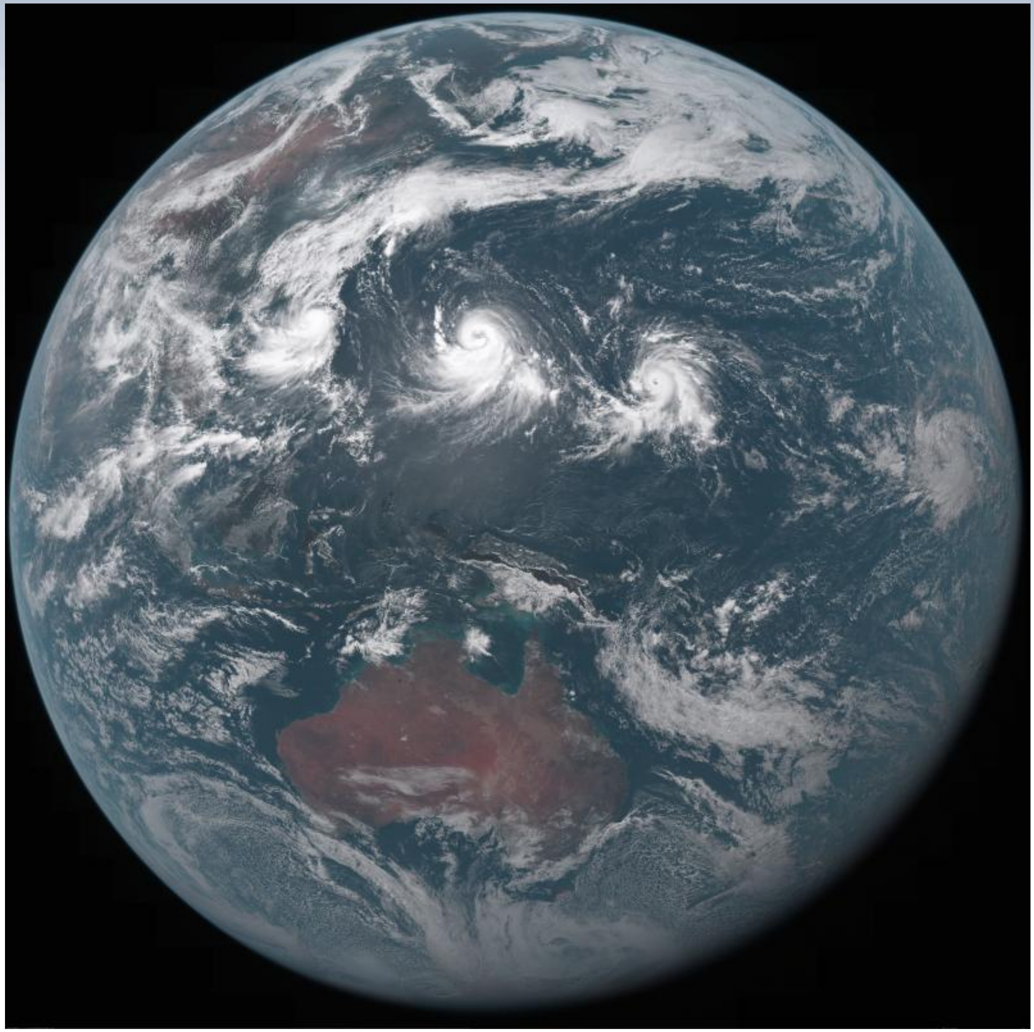
True Colour RGB from FCI

	Range
R VIS0.6	0 to 100 %
G VIS0.5	0 to 100 %
B VIS0.4	0 to 100 %

Attention: if the VIS0.6 channel has higher resolution, up- or down-scaling is needed!

FCI – "True" Colour Images



FCI and AHI
Have 0.51 µm band
(instead of 0.55)

This band is not on
ABI on GOES-R

Comparisons of
AHI true color
imagery to VIIRS &
MODIS showed
vegetation too
brown …

7 July 2015
Him-08, AHI, "True" Colour RGB, Source: JMA

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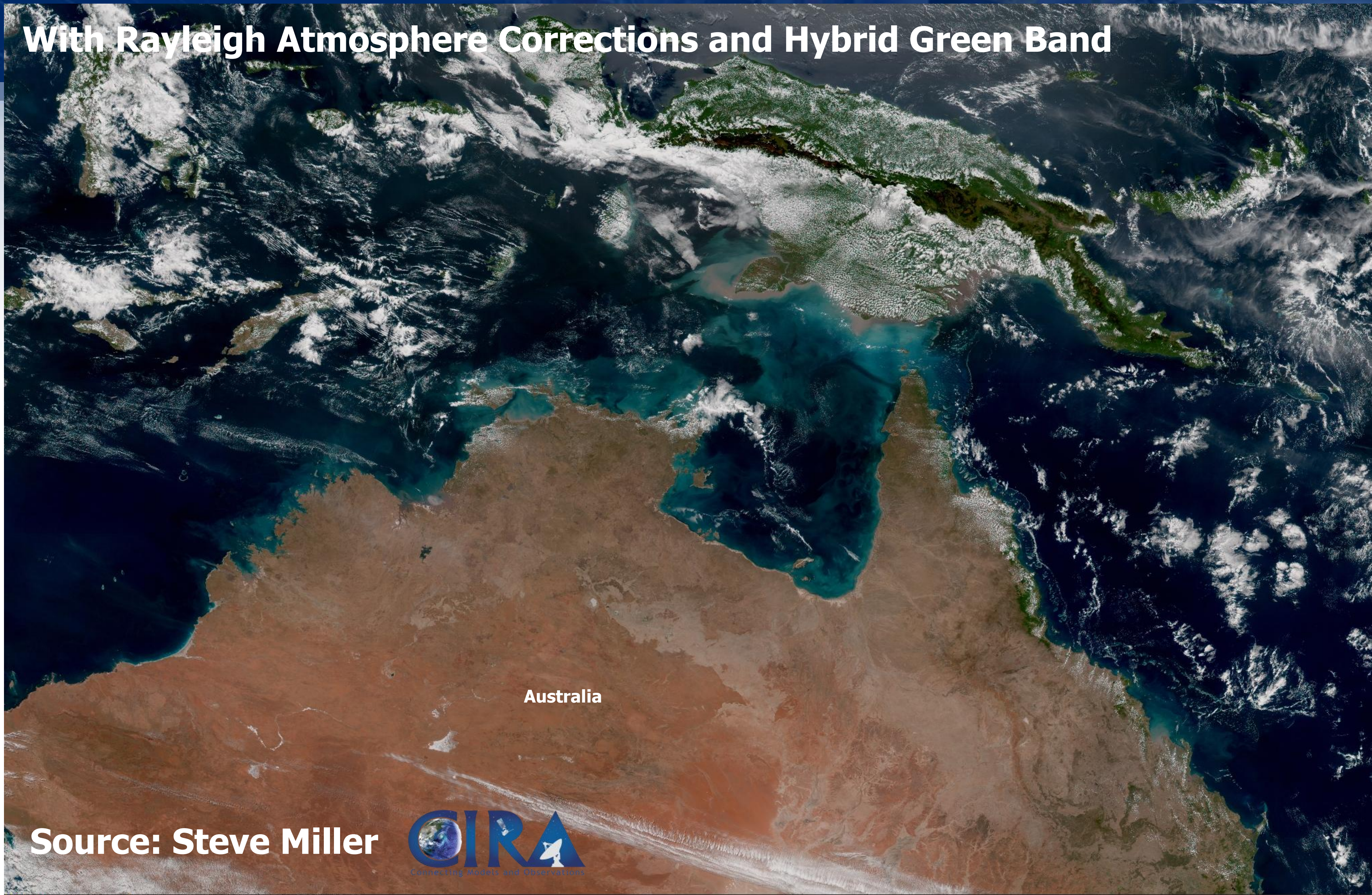
With Rayleigh Atmosphere Corrections and Hybrid Green Band



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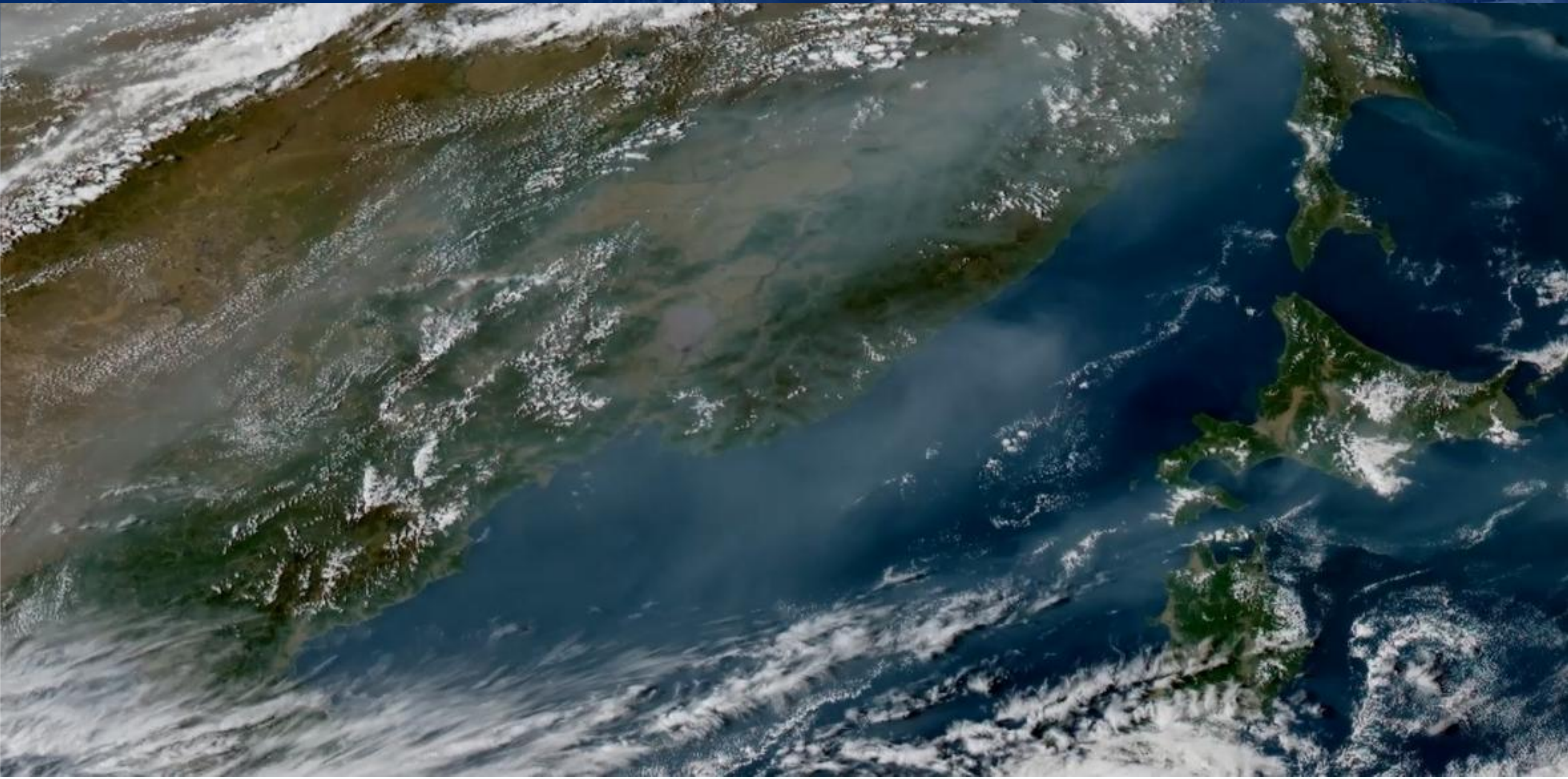
Smoke on the water, Sea of Japan



True Colour RGB with all corrections, source: CIRA

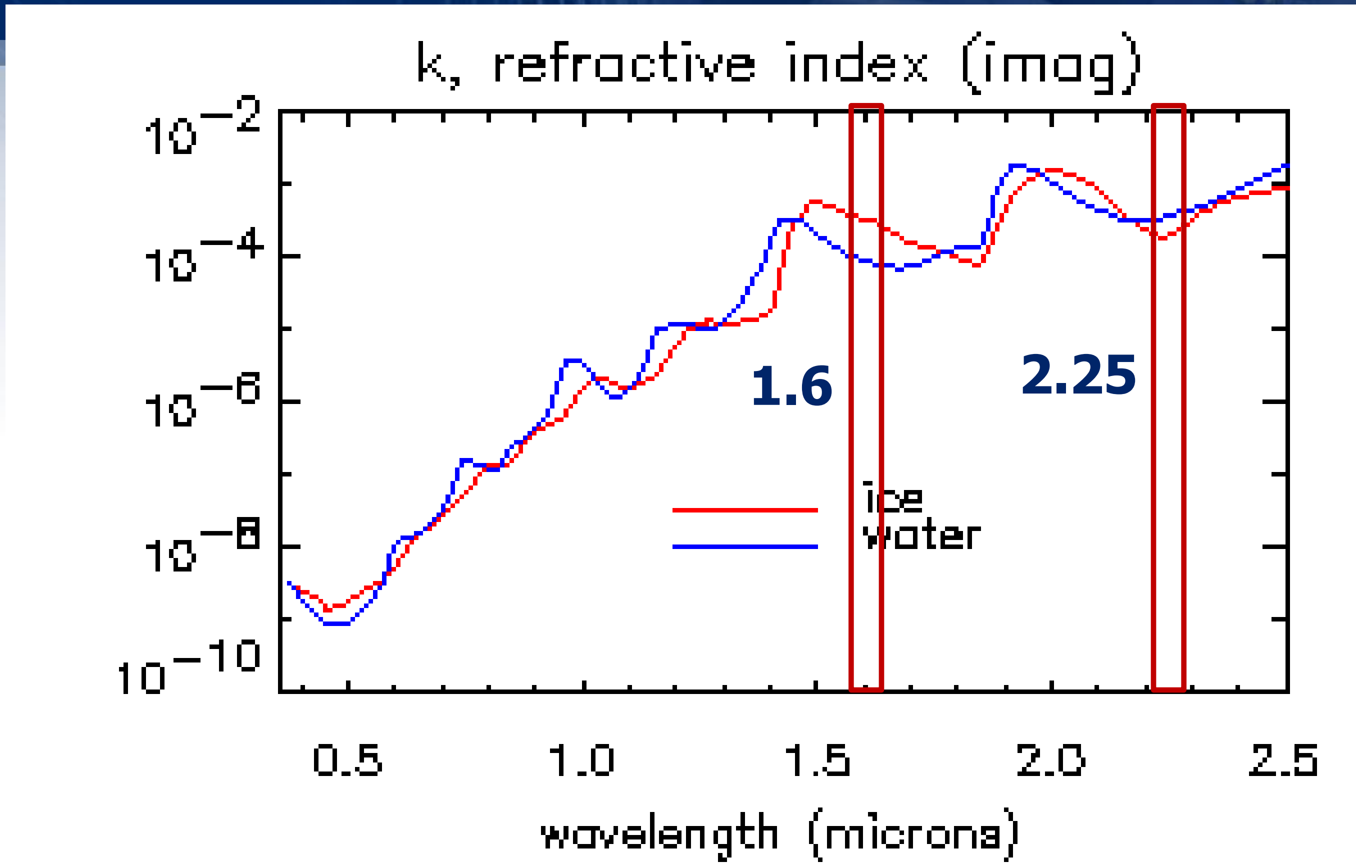

Smoke on the water, Sea of Japan
No Rayleigh corrections
21 September 2016, 6:00 UTC
RGB Composite NIR1.6-VIS0.8-VIS0.4

Cloud Phase RGB from FCI

	Range
R NIR1.6	0 to 50 %
G NIR2.3	0 to 50 %
B VIS0.5/VIS0.6	0 to 100 %

Attention: if the VIS0.6 channel has higher resolution, up- or down-scaling is needed!

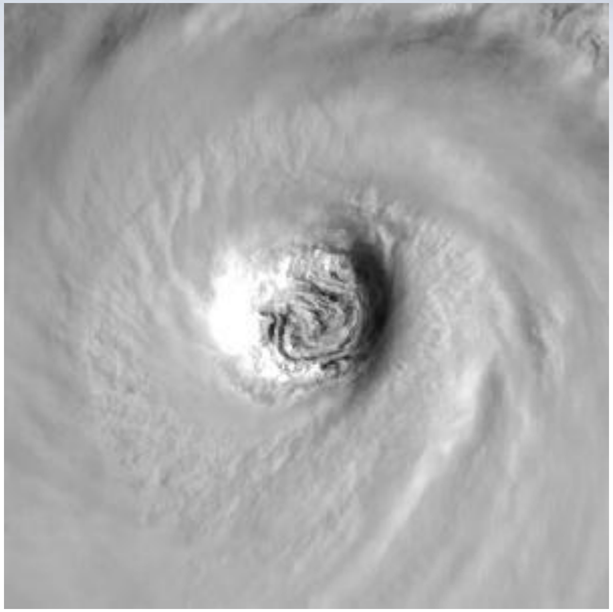
NIR2.25: Cloud Microphysical Channel



- MODIS 2.1 band has a central wavelength at 2.13 micron to be compared to the 2.25 micron for VIIRS, FCI, AHI/ABI
- Ice absorption changes a lot between 2.13 and 2.25

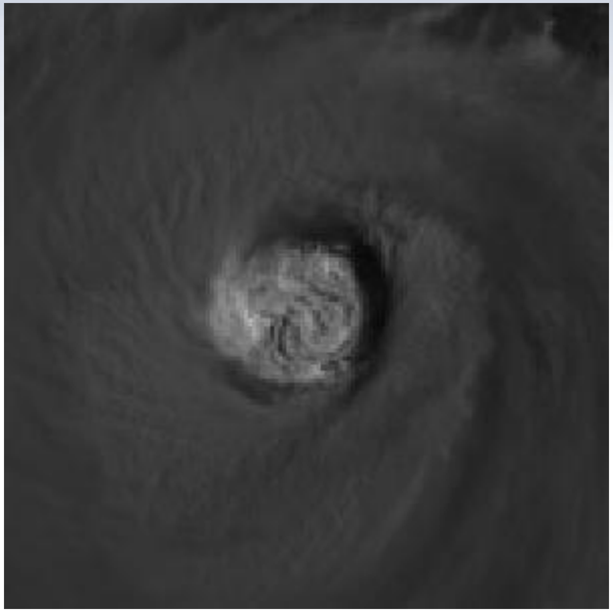
AHI Solar Bands - zoom

Band 4 (VIS0.8)



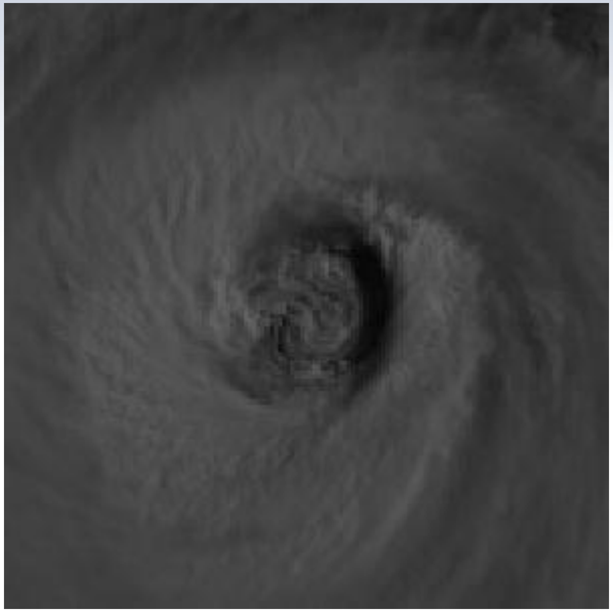
1 km

Band 5 (NIR1.6)



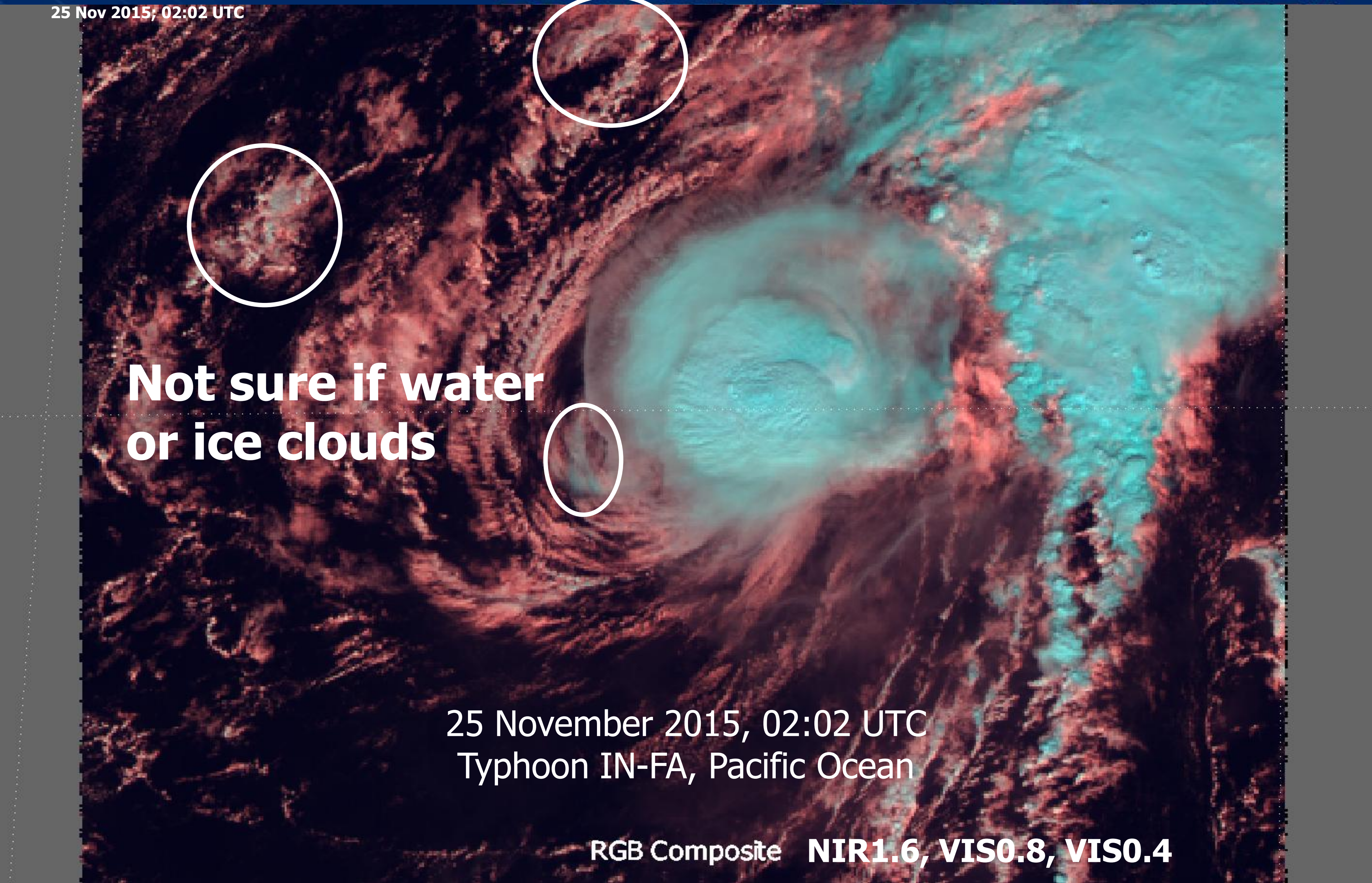
2 km

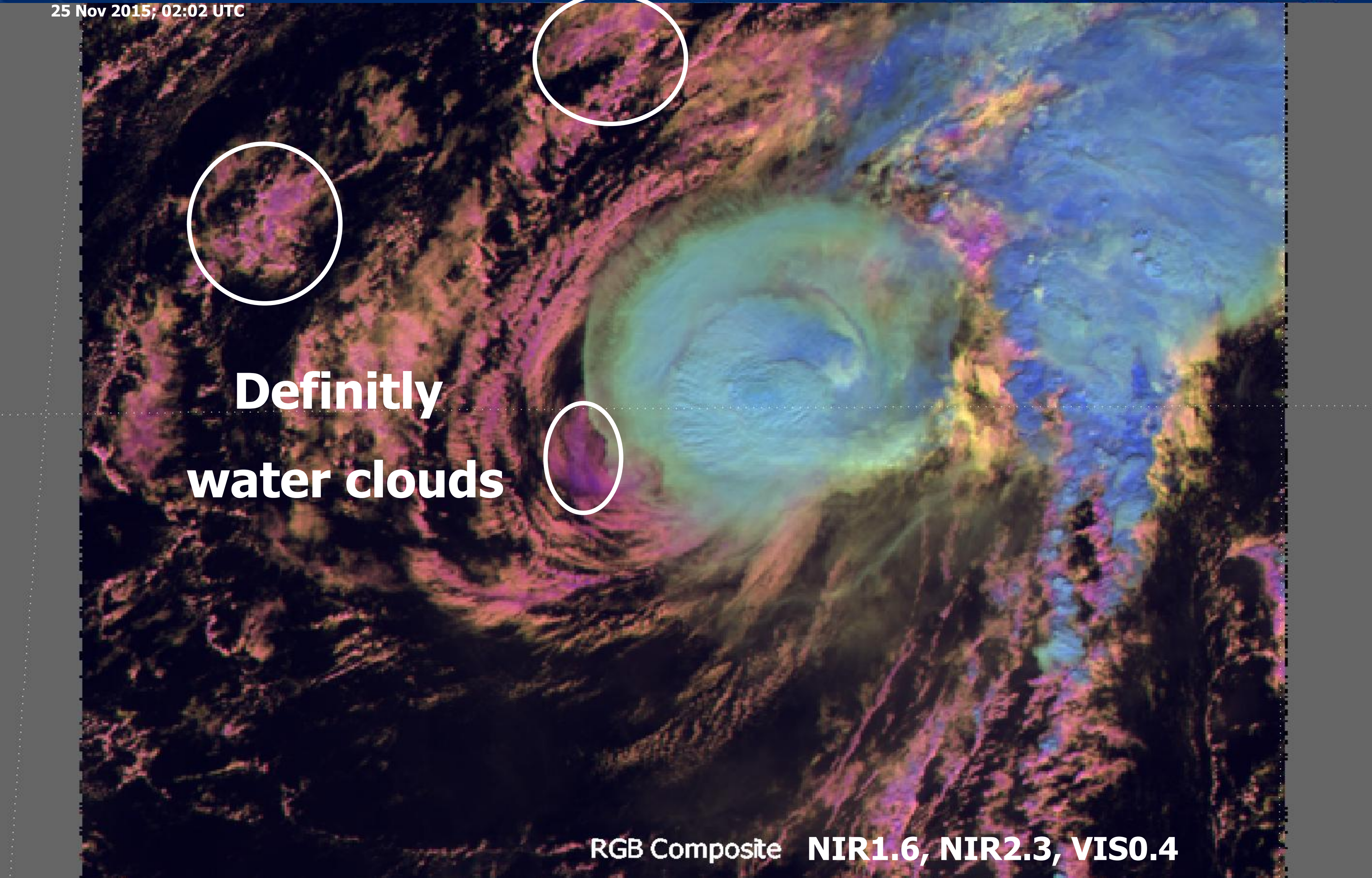
Band 6 (NIR2.3)



2 km

20 August 2015, 00:00 UTC
Typhoon Atsani, Pacific Ocean


25 Nov 2015, 02:02 UTC
Not sure if water
or ice clouds
25 November 2015, 02:02 UTC
Typhoon IN-FA, Pacific Ocean
RGB Composite NIR1.6, VIS0.8, VIS0.4


25 Nov 2015; 02:02 UTC
Definitly
water clouds
RGB Composite
NIR1.6, NIR2.3, VIS0.4

Fire Power (Temperature) RGB from FCI

	Range
R IR3.9	273 to 350 K
G NIR2.3	0 to 50 %
B NIR1.6	0 to 50 %

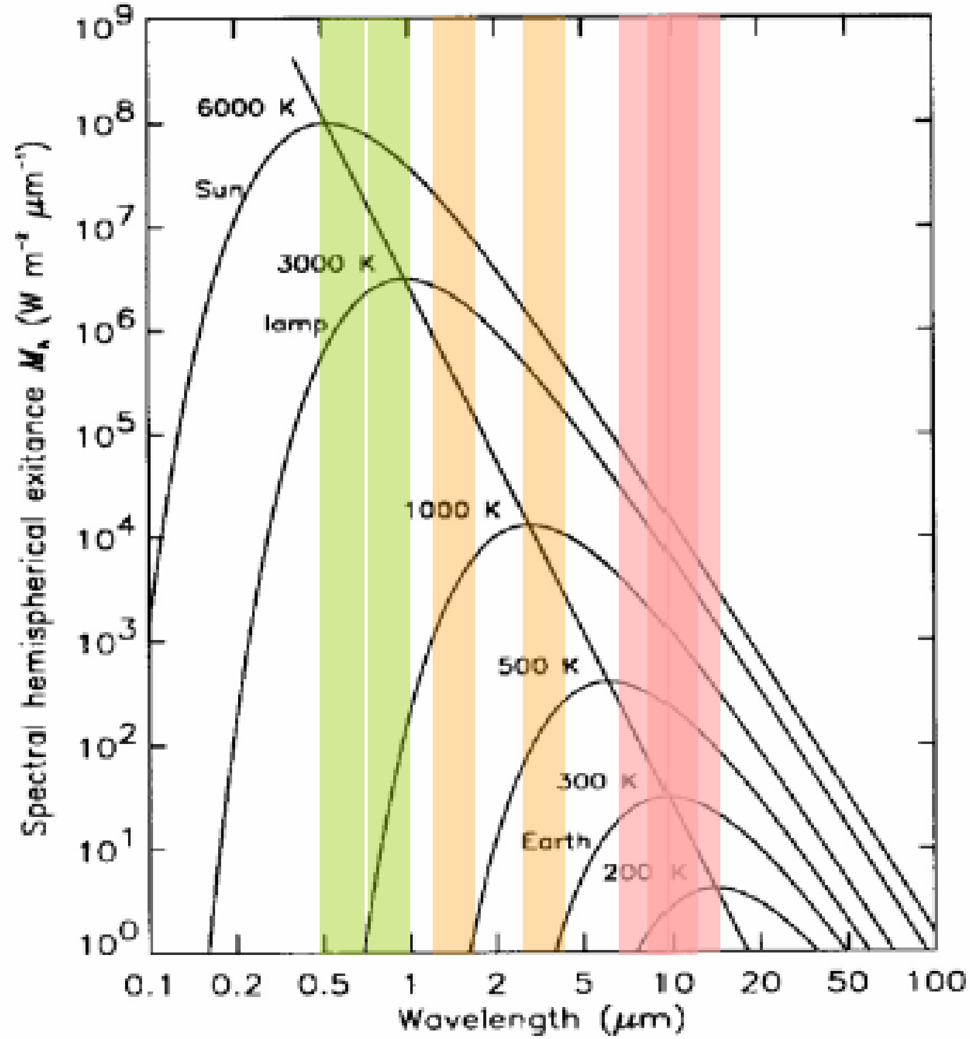
Attention: solar channels have higher resolution, up- or down-scaling is needed!

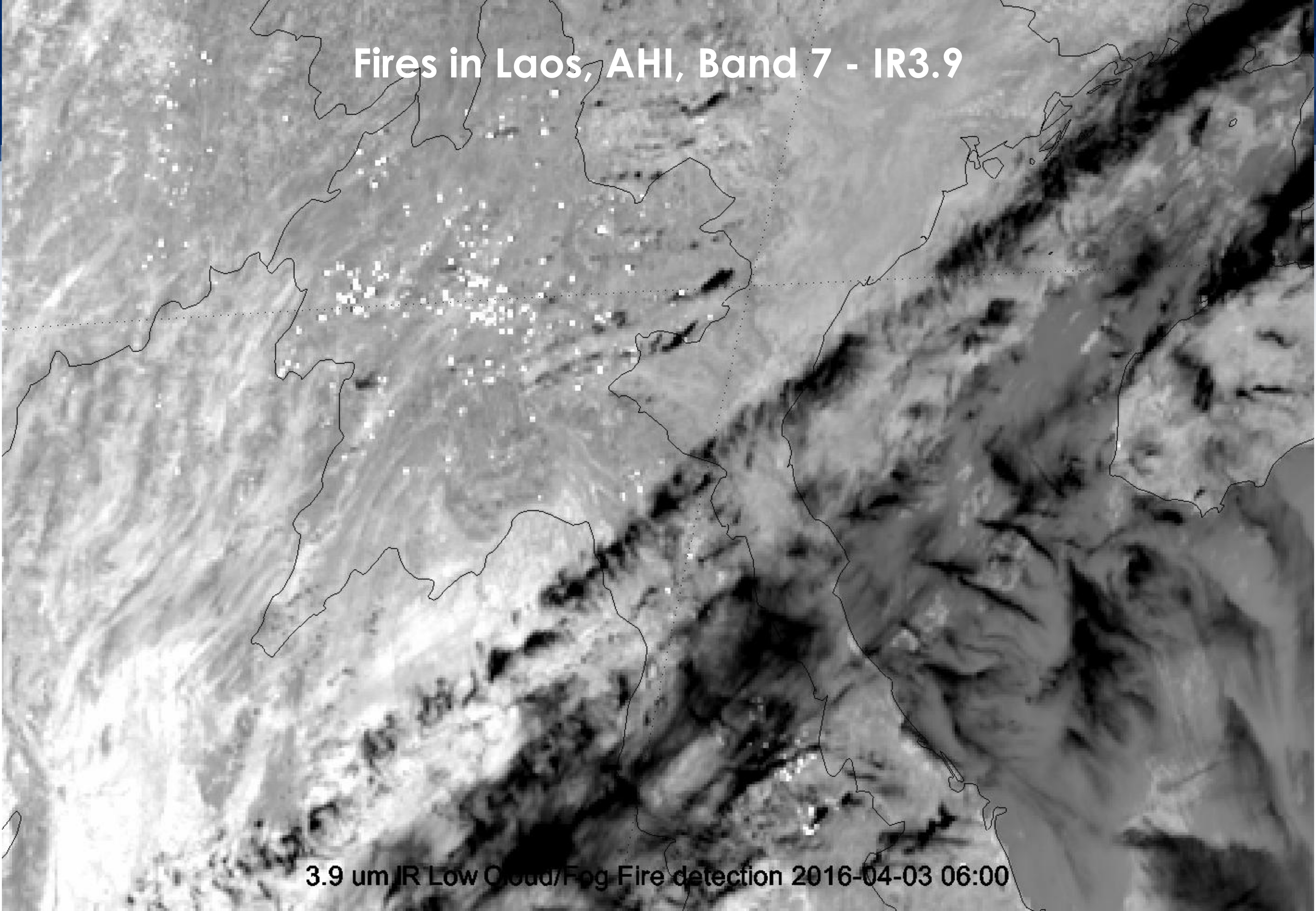
Planck's Radiation Law

Planck's Radiation Law

$$L(\lambda,T)=\frac{C_1}{\lambda^5(\exp(\frac{C_2}{\lambda T})-1)}$$

Fire temperatures range from a minimum of ~ 500 K (weak smoulding) to max ~ 1400 K (intense flaming). Emission peaks in the MIR region.




Fires in Laos, AHI, Band 7 - IR3.9
3.9 um IR Low Cloud/Fog Fire detection 2016-04-03 06:00


Fires in Laos, AHI, RGB Fire Power
RGB Composite IR3.9 - NIR2.3 - NIR1.6

New Day Microphysics RGB from FCI ?

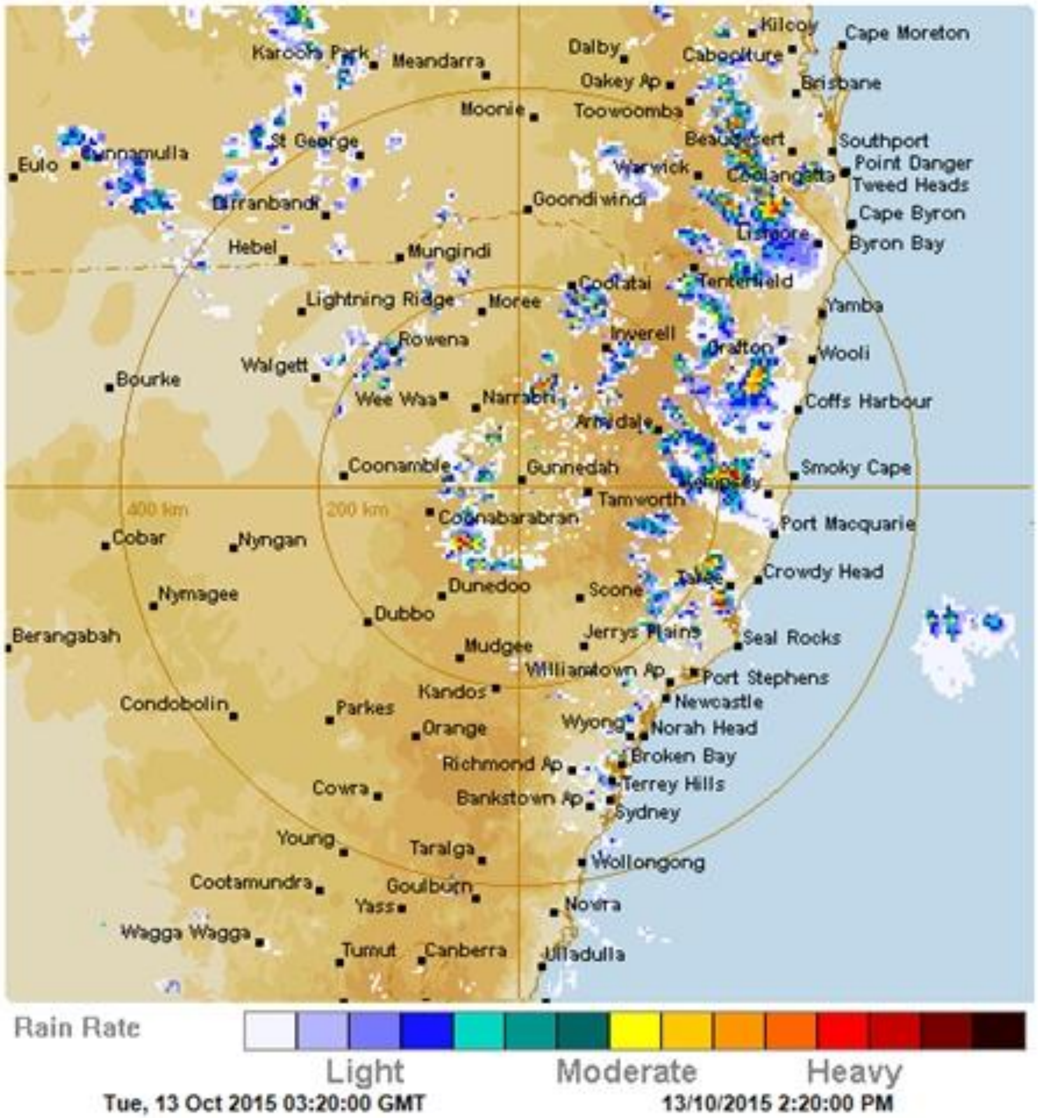
	Range
R VIS0.8	0 to 100 %
G NIR2.3	0 to 50 %
B IR10.5	200 to 300 K

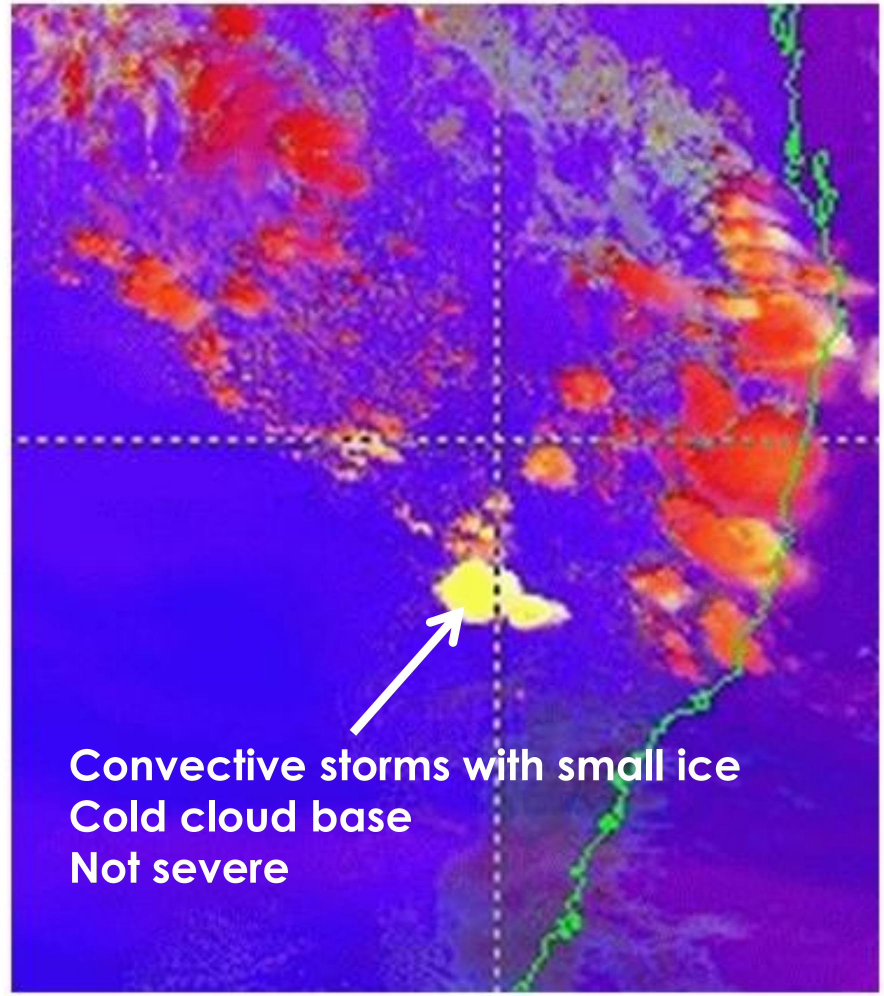
Advantage: No need to calculate solar component of IR3.9

Disadvantage: not so good for cloud phase

Attention: solar channels have higher resolution than IR channels, up- or down-scaling is needed!

Northern NSW storm, 13th October 0320UTC





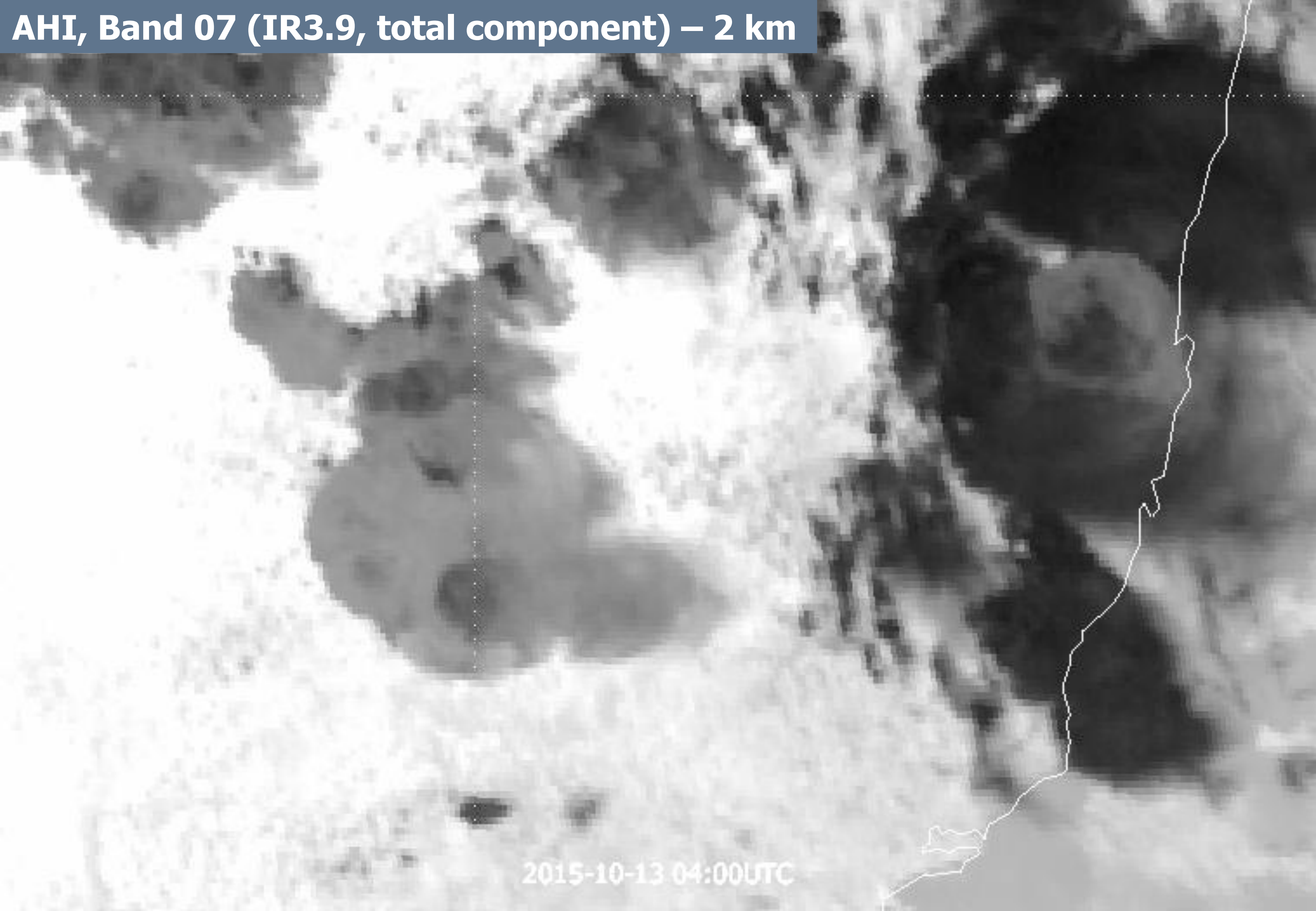
From: Bodo Zeschke, BoM

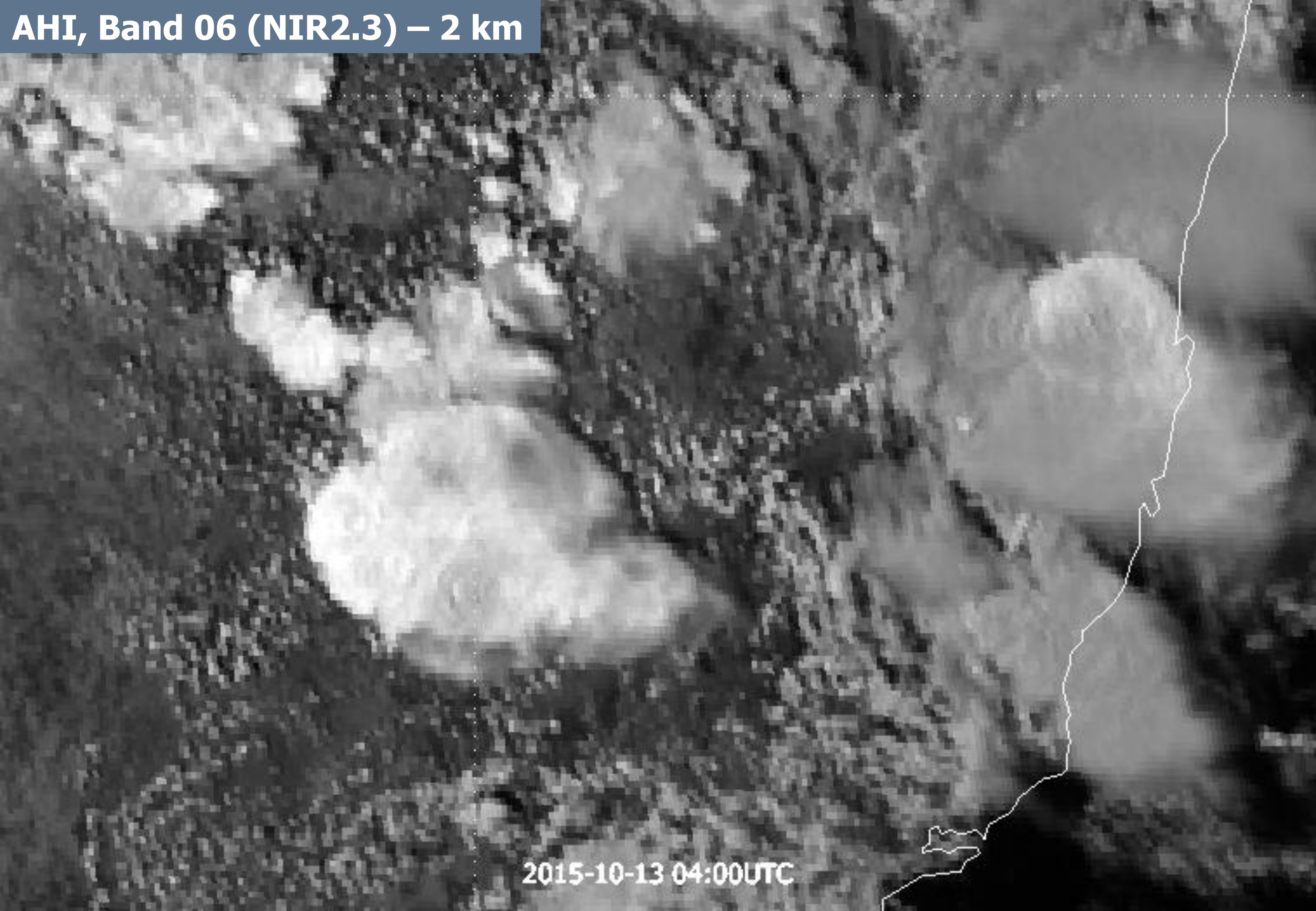
Gunnedah RADAR

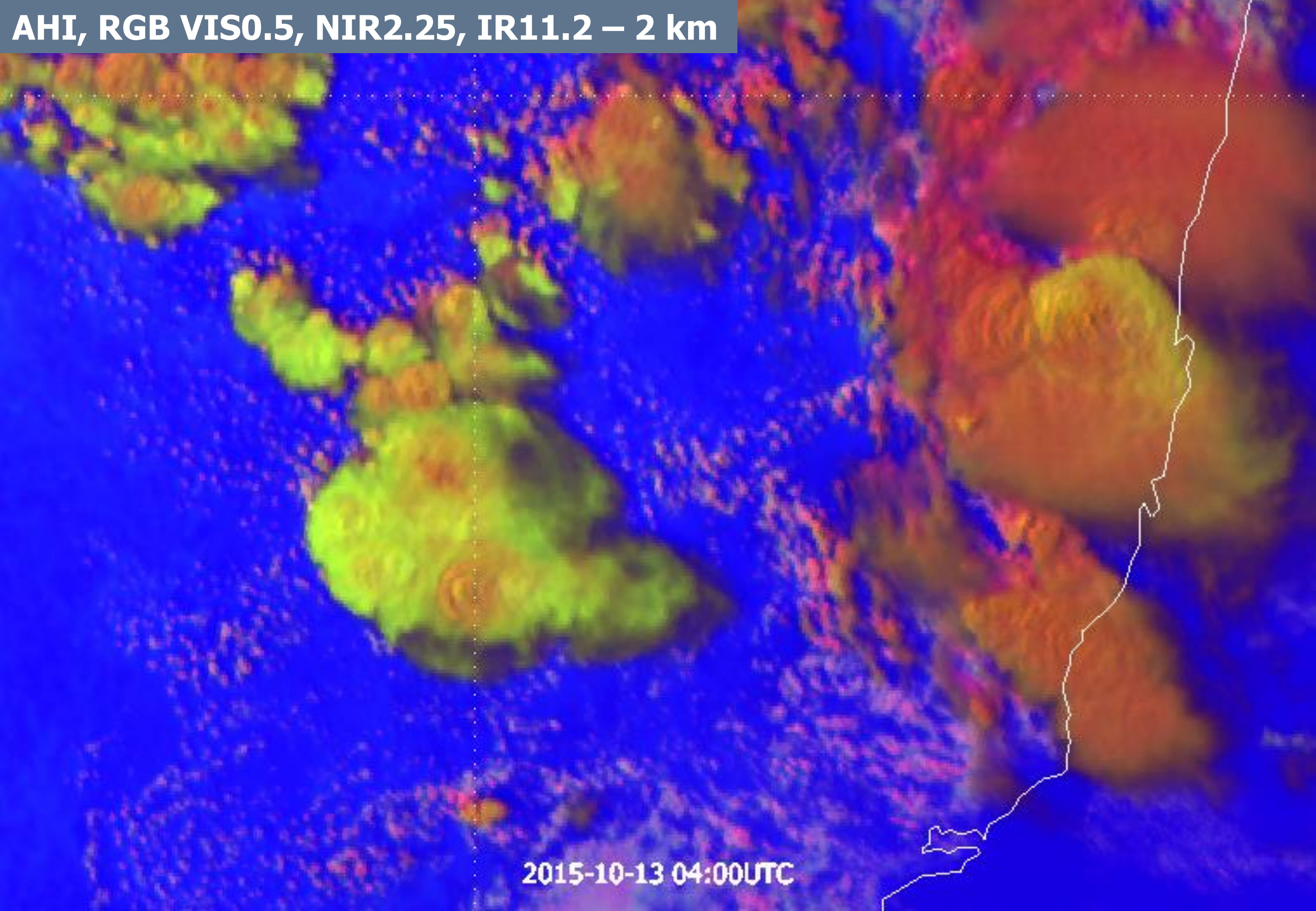
image courtesy Australian Bureau of Meteorology

Day Convection RGB product

image courtesy JMA / Jochen Kerkmann EUMETSAT


AHI, Band 07 (IR3.9, total component) – 2 km
2015-10-13 04:00UTC


AHI, Band 06 (NIR2.3) – 2 km
2015-10-13 04:00UTC


AHI, RGB VIS0.5, NIR2.25, IR11.2 – 2 km
2015-10-13 04:00UTC

New Natural Colour RGB from FCI ?

	Range
R NIR2.3	0 to 50 %
G VIS0.8	0 to 100 %
B VIS0.6	0 to 100 %

Disadvantage: NIR2.3 not so good for cloud phase

Attention: if the VIS0.6 channel has higher resolution, up- or down-scaling is needed!

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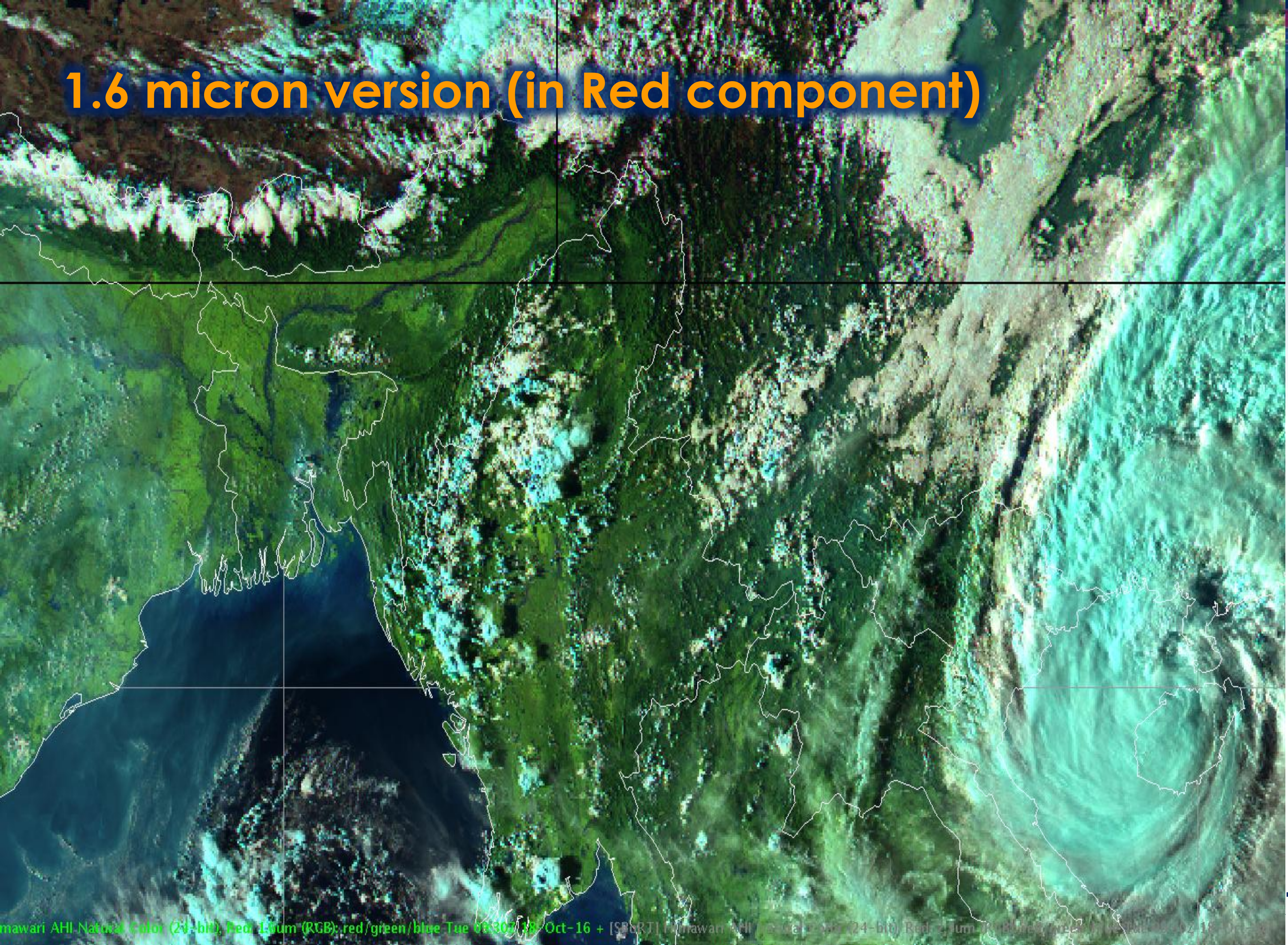
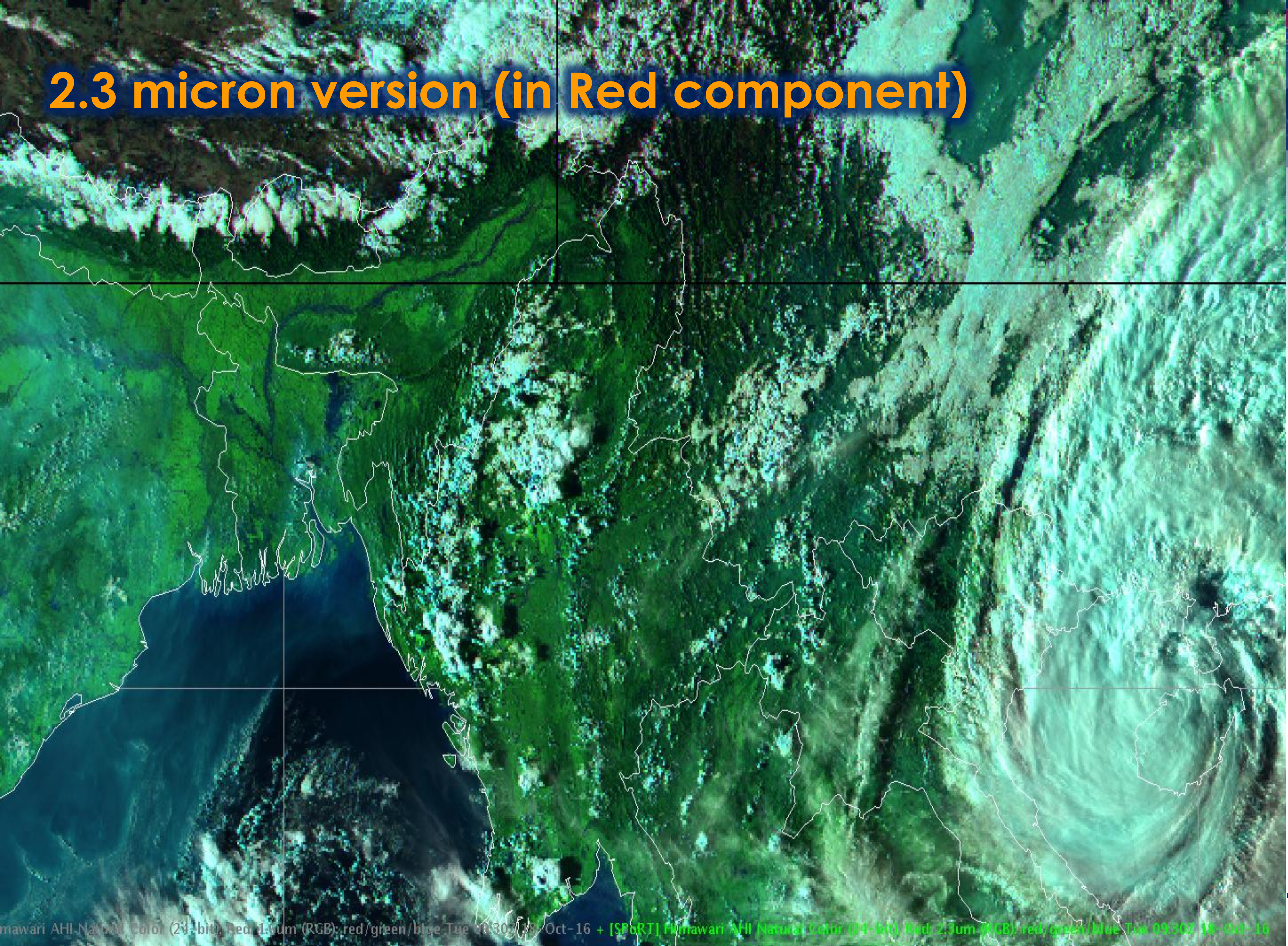
1.6 micron version (in Red component)



T

2.3 micron version (in Red component)



Day Cirrus RGB from FCI (RGB with NIR1.3) ?

	Range
R ?	?
G ?	?
B ?	?

Using: NIR1.3, IR12.3-IR10.5, IR IR10.5-IR3.9

Cirrus colour should be dark (black) ?

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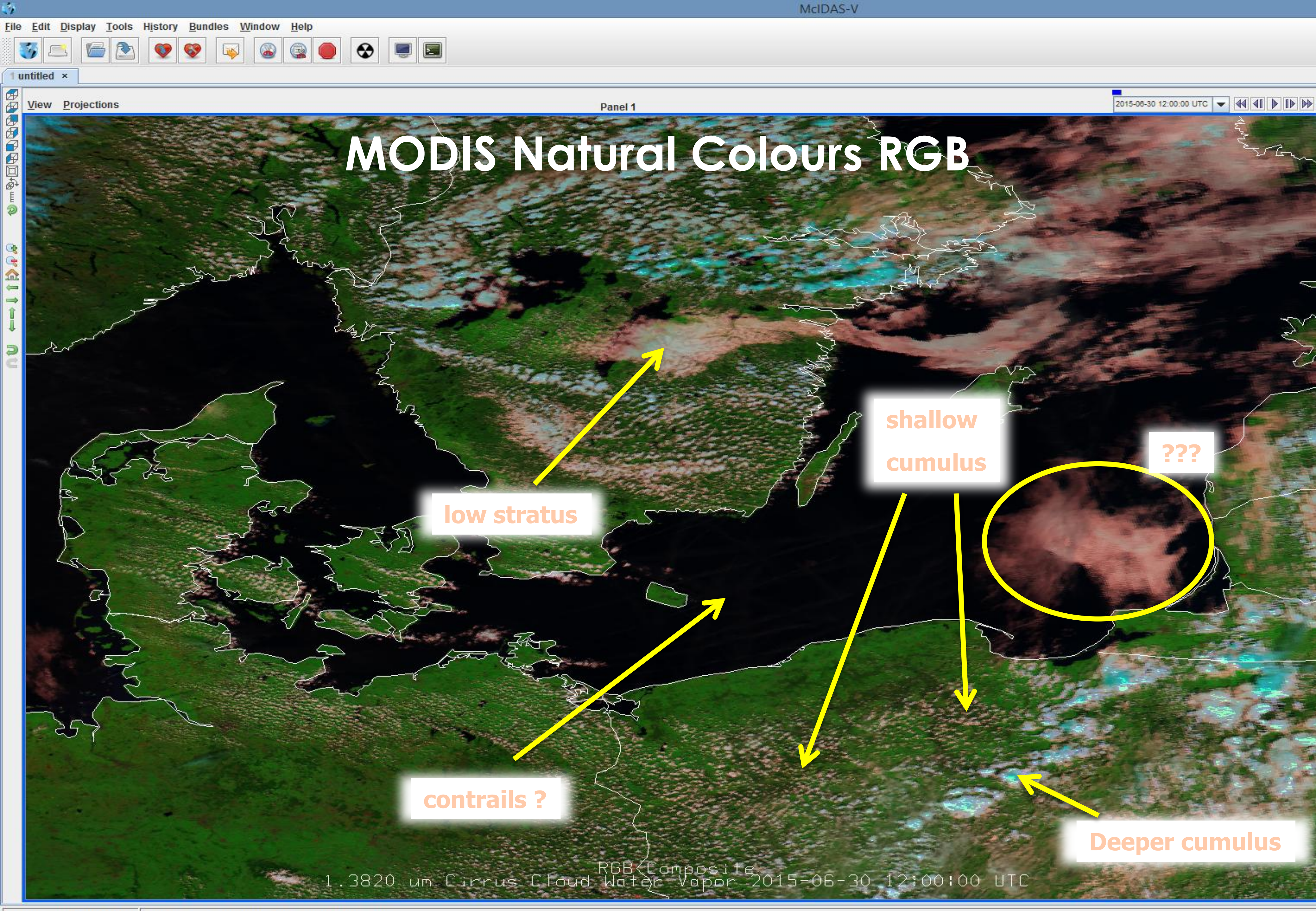
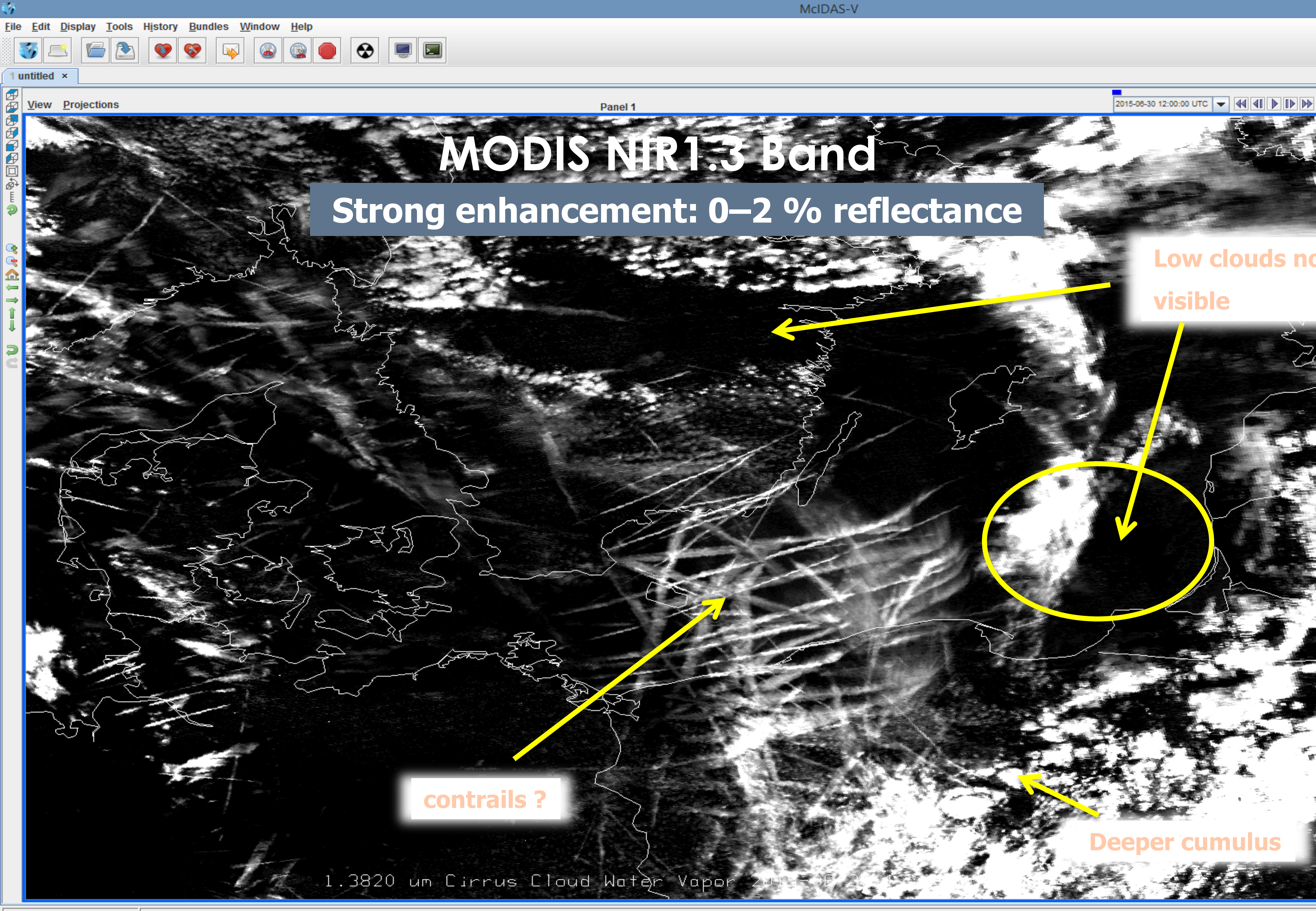

McIDAS-V
File Edit Display Tools History Bundles Window Help
untitled
View Projections
Panel 1
2015-06-30 12:00:00 UTC
MODIS Natural Colours RGB
low stratus
shallow cumulus
???
contrails ?
Deeper cumulus
RGB Composite
1.3820 um Cirrus Cloud Water Vapor 2015-06-30 12:00:00 UTC


McIDAS-V
File Edit Display Tools History Bundles Window Help
untitled
View Projections
Panel 1
2015-06-30 12:00:00 UTC
MODIS NIR1.3 Band
Strong enhancement: 0–2 % reflectance
Low clouds no
visible
contrails ?
Deeper cumulus
1.3820 um Cirrus Cloud Water Vapor

Moisture RGB from FCI (RGB with VIS0.9-VIS0.8) ?

	Range
R ?	**?**
G ?	**?**
B ?	**?**

- Using the weak solar absorption in 0.9 μm (difference 0.96 – 0.86 μm)
- Using the weak thermal absorption at 12 μm (difference 10.5 – 12.3 μm)

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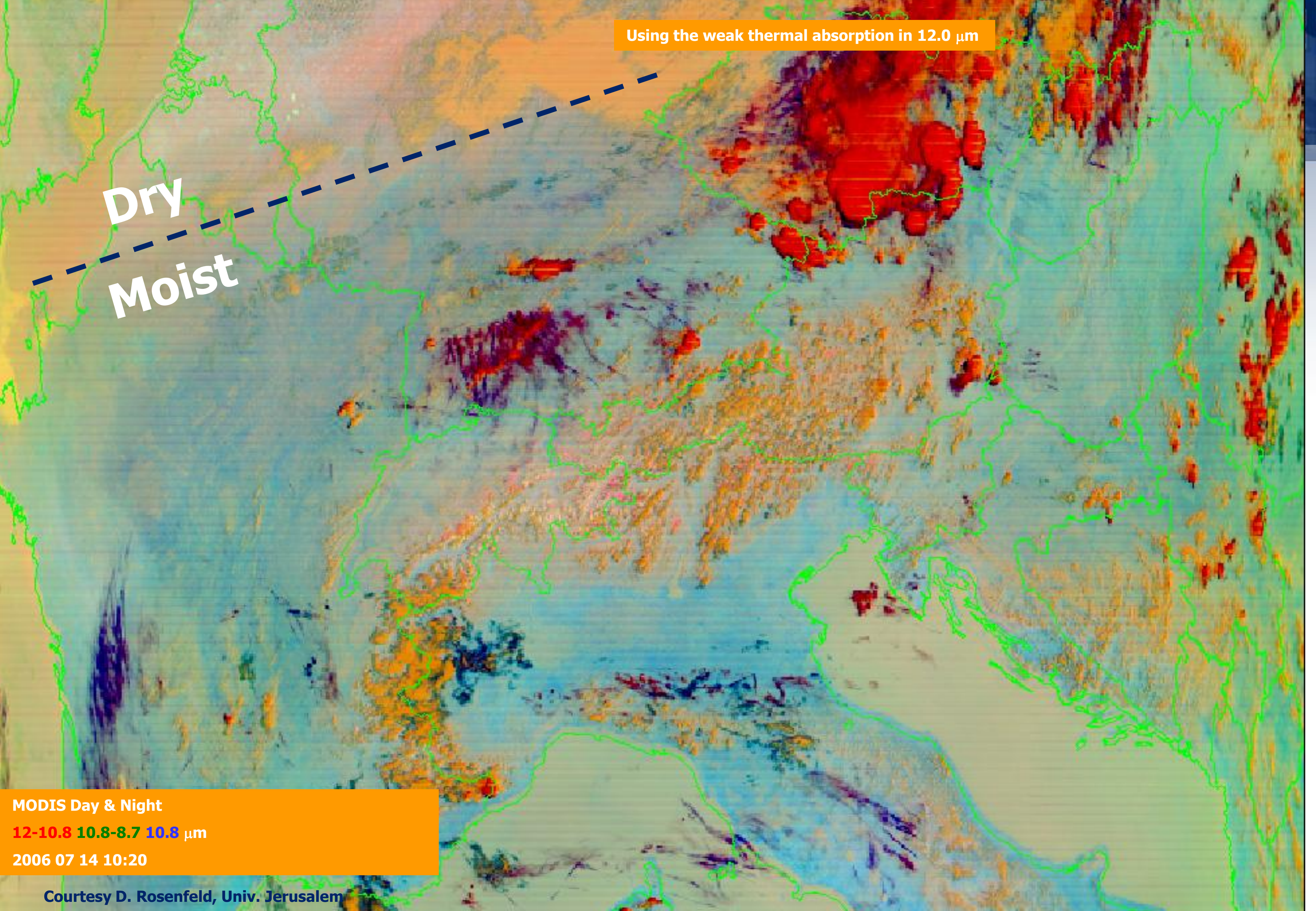
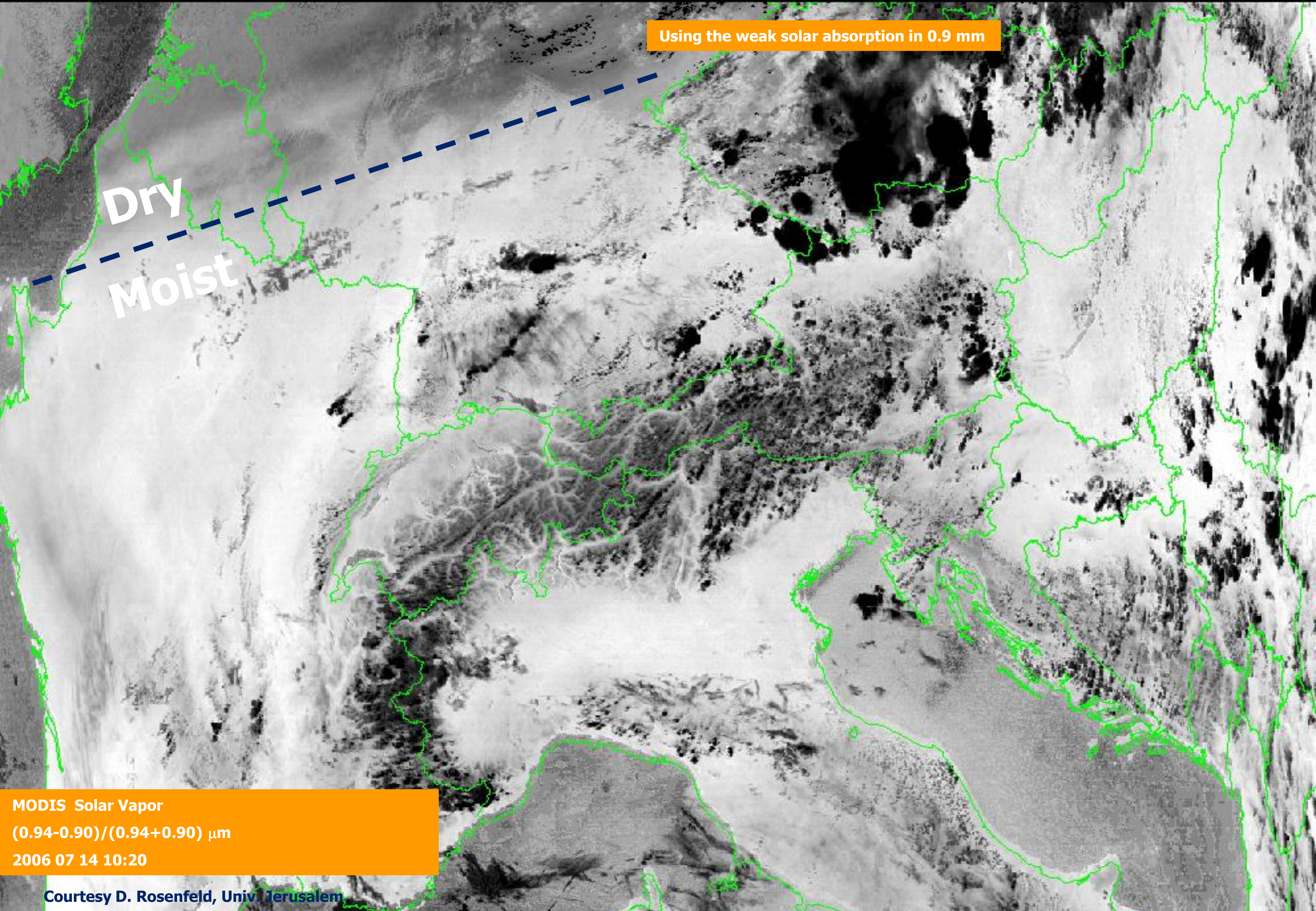

Using the weak thermal absorption in 12.0 µm
Dry
Moist
MODIS Day & Night
12-10.8 10.8-8.7 10.8 µm
2006 07 14 10:20
Courtesy D. Rosenfeld, Univ. Jerusalem

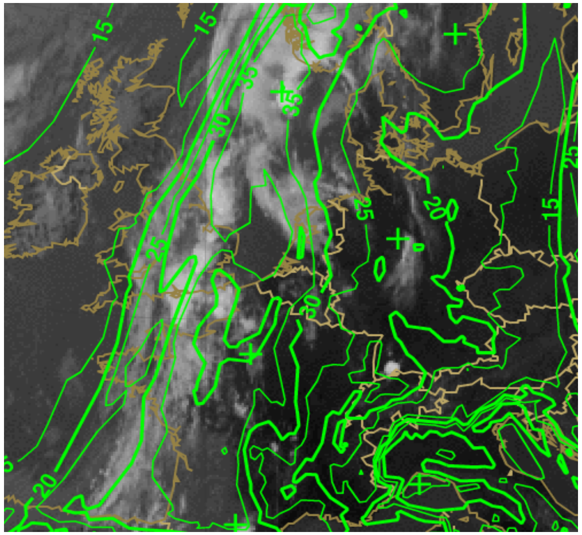

Using the weak solar absorption in 0.9 mm
Dry
Moist
MODIS Solar Vapor
(0.94-0.90)/(0.94+0.90) µm
2006 07 14 10:20
Courtesy D. Rosenfeld, Univ. Jerusalem

Conclusions

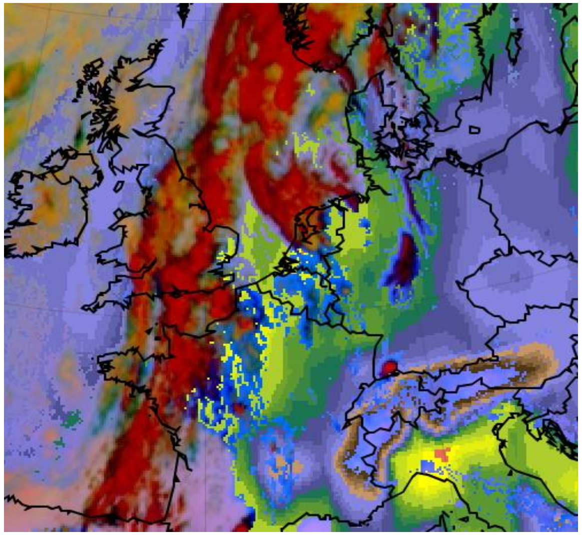
Phil Chadwick (Canada):

- **All NWP is *wrong* but some NWP is *useful*…**
- **It may look great but it's not real… don't be seduced!**

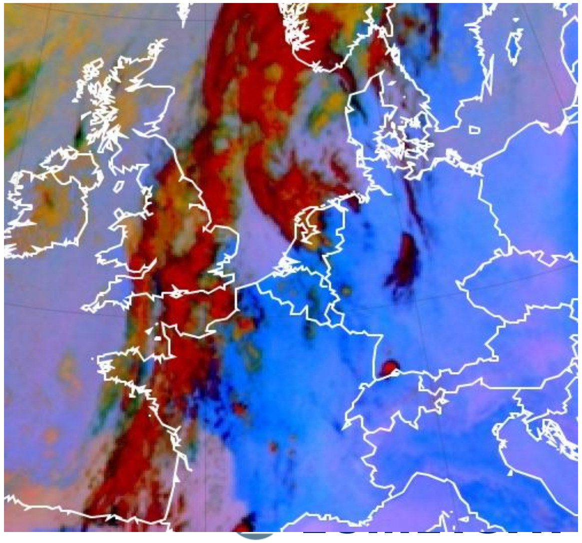
NWP (TPW)
Not Real



Derived Product (TPW)
"Semi" Real



RGB Image
Real



1st WMO RGB Workshop, Boulder, June 2007

First row, right to left:	Mr Jeff Wilson, Mr Hans-Peter Roesli (Chairman), Mr Richard Francis
Second row, right to left:	Mr Patrick Dills, Dr Andy Kwarteng, Dr Volker Gärtner, Mr Brian Motta
Third row, right to left:	Dr Don Hillger, Dr Adamou Garba, Mr Tom Yoksas, Mr Daniel Barrera

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2nd WMO RGB Workshop, Seeheim, September 2012

From left to right:

Front Row: Bodo Zeschke, Thiago Souza Biscaro, Carla Barroso, Hama Hamidou, Estelle de Coning, Brian Motta, Ignatius Gitonga, Ayako Takeuchi

Second Row: Sungwook Hong, Tahar Saouri, Michael Fromm, Renate Brummer, Jochen Kerkmann, Roland Winkler, Stephan Bojinski

Third Row: Ning Niu, Jian Liu, Virendra Singh, HansPeter Roesli, Andreas Wirth

Fourth Row: Kevin Fuell, Andrew Molthan, Sauli Joro, Tom Rink

Not in picture: Phil Watts, Volker Gärtner, Marianne König, Vesa Nietosvaara, Mark Higgins

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3rd WMO RGB Workshop, End 2017 ?

Larger Group ...

(picture from Convection WG, April 2016)

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