Use of Meteosat Second Generation Data for Convection Nowcasting

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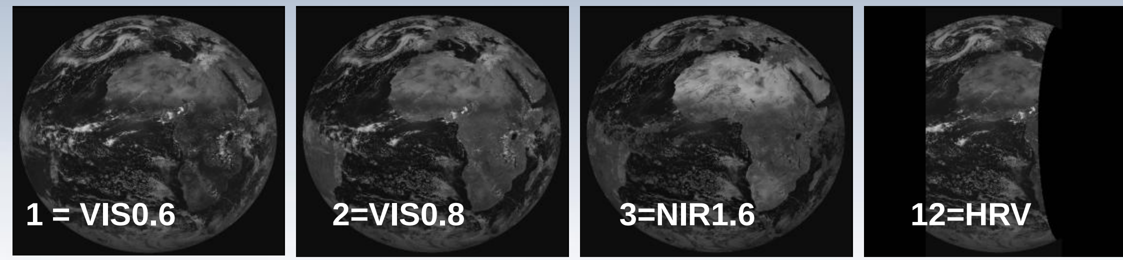
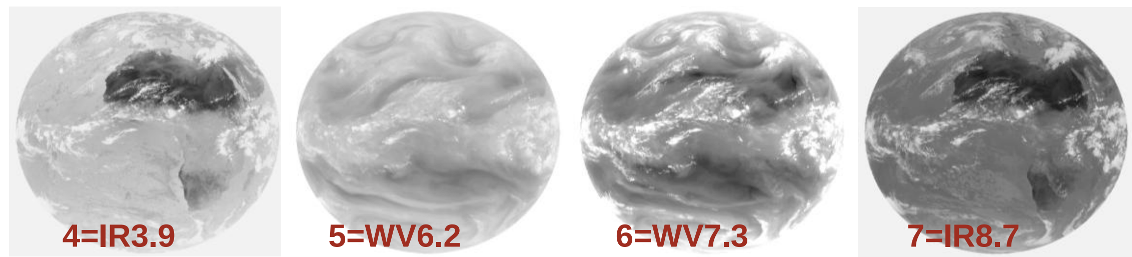
MSG: Meteosat Second Generation

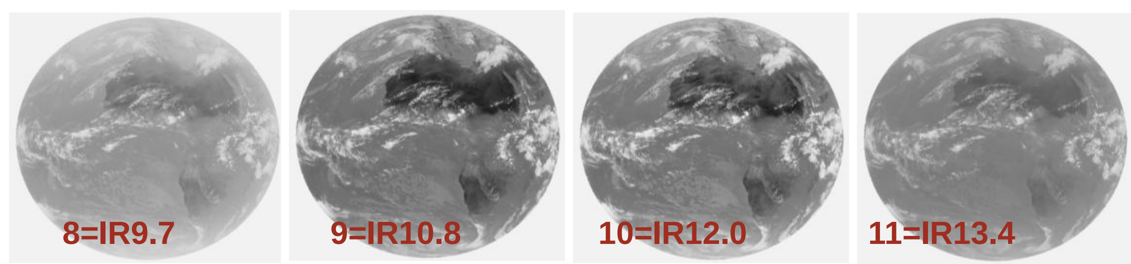
MSG SEVIRI*:

12 channel instrument
3 (1) km pixel sampling distance
Repeat cycle 15 minutes
(5 min. in "rapid scan service")

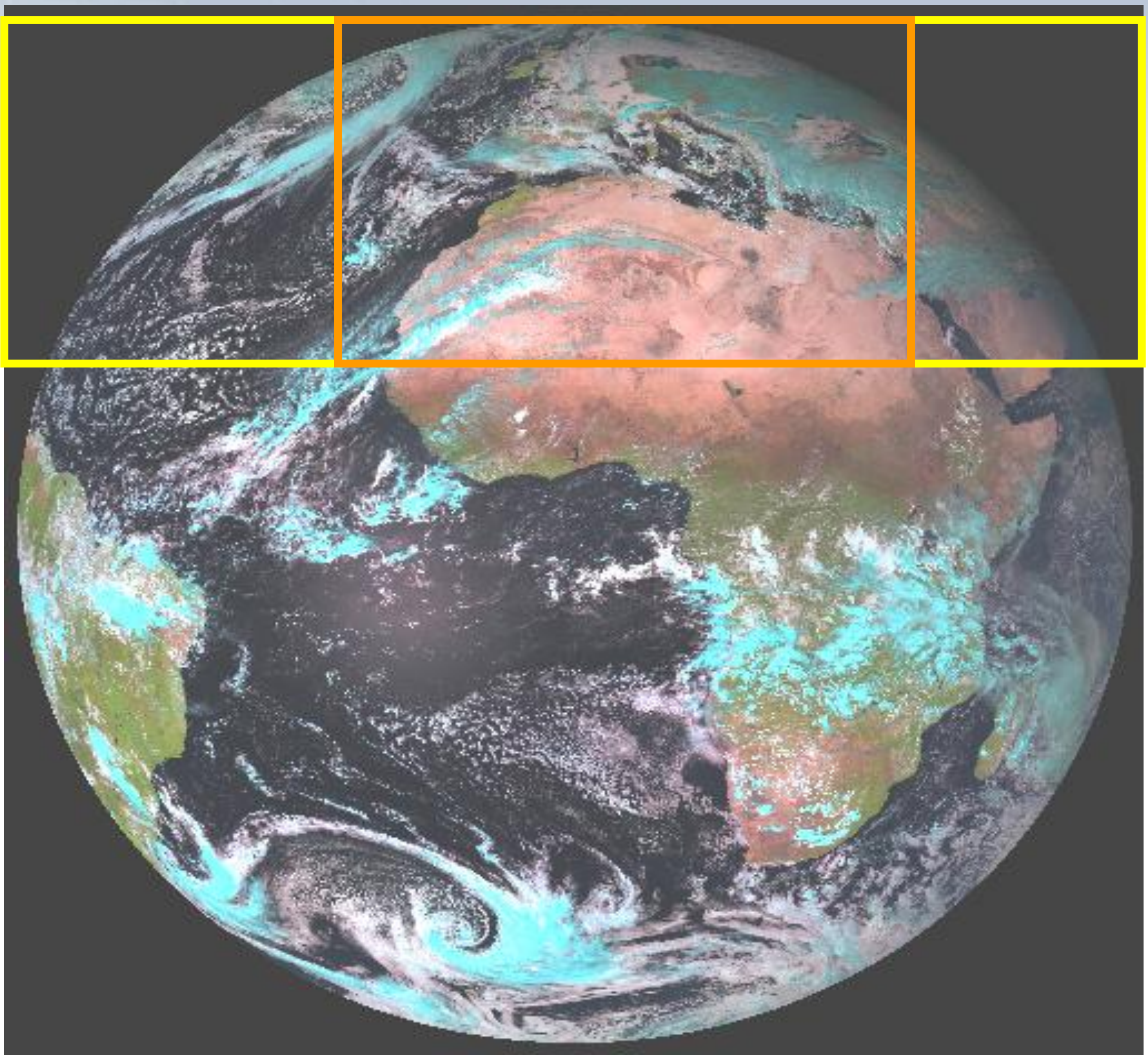




*: SEVIRI :
Spinning Enhanced Visible and InfraRed Imager



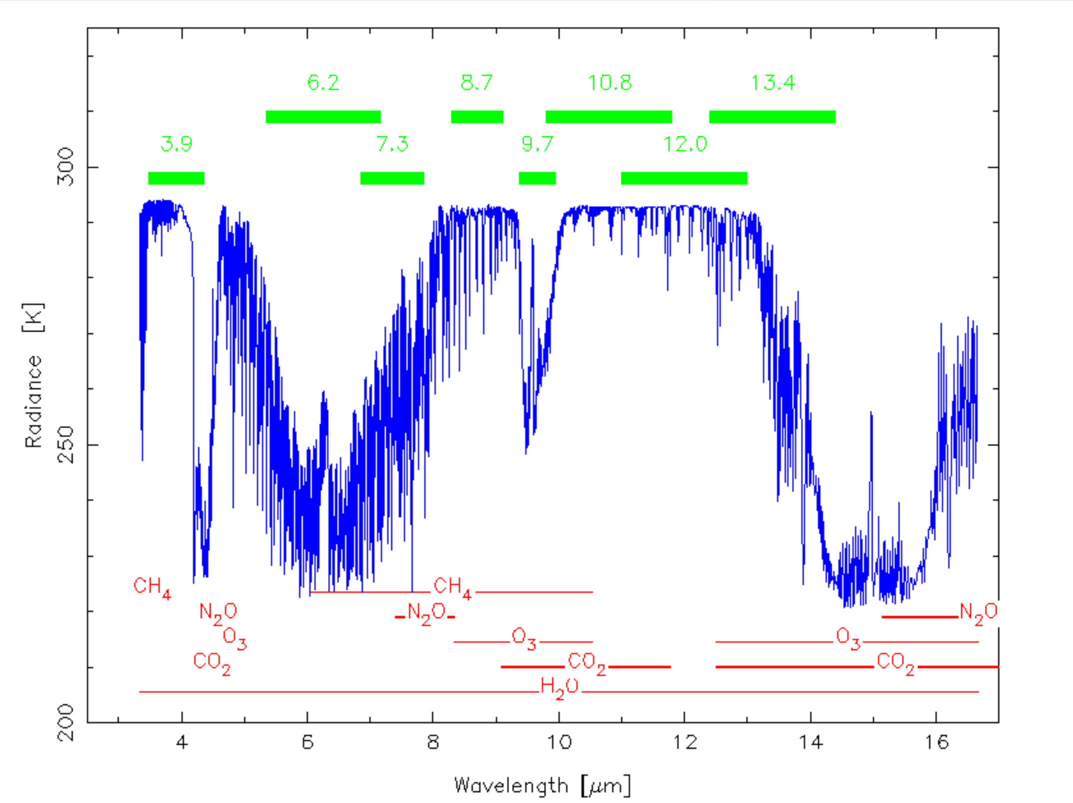
MSG Scans

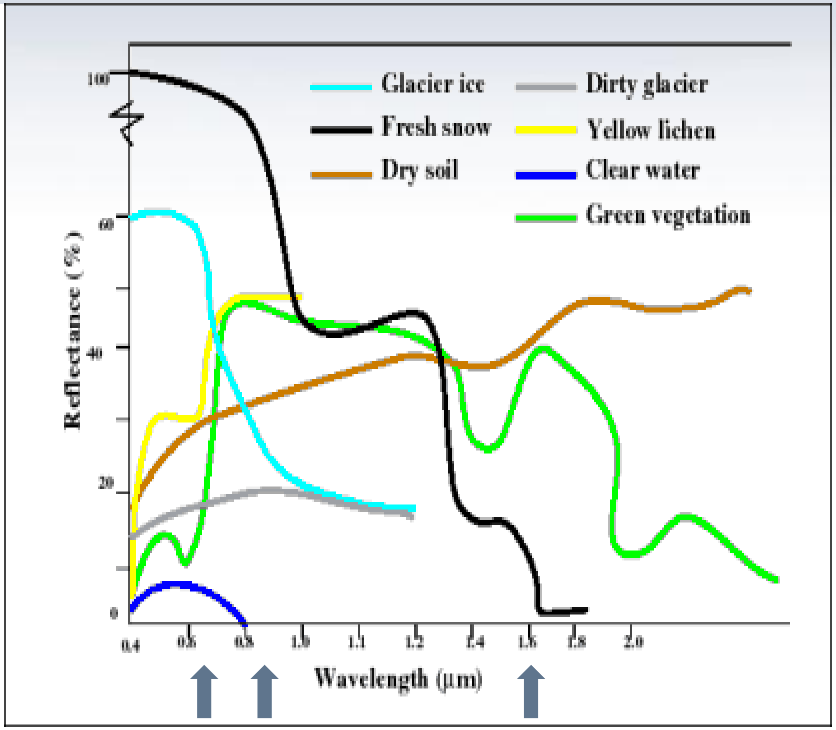


5 Minutes RSS: Meteosat-8

15 Minutes: Meteosat-9

Channel Information Content





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Spectral Information = Information!

Each channel has got its own spectral signature:

Different reflectivities (VIS) / emissivities (IR) / absorption (VIS and IR) of different surfaces/ clouds / atmospheric gases contribute to the measurement

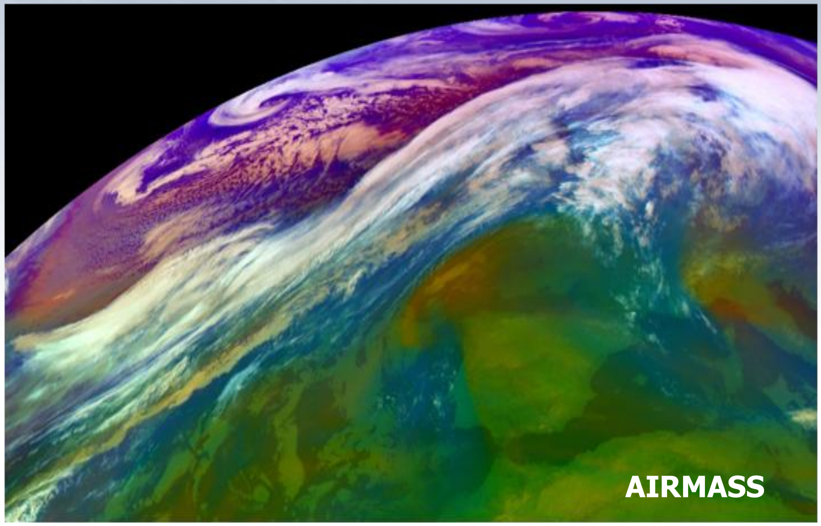
→ **"Intelligent" channel combination provides maximum information**
(visually or through objective satellite products)

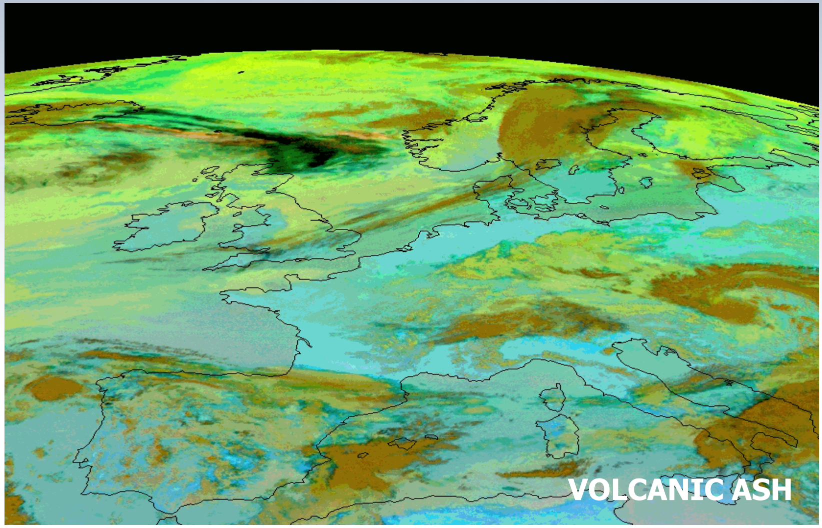
Visual "Products" : (RGB: Red-Green-Blue Colour Composites)

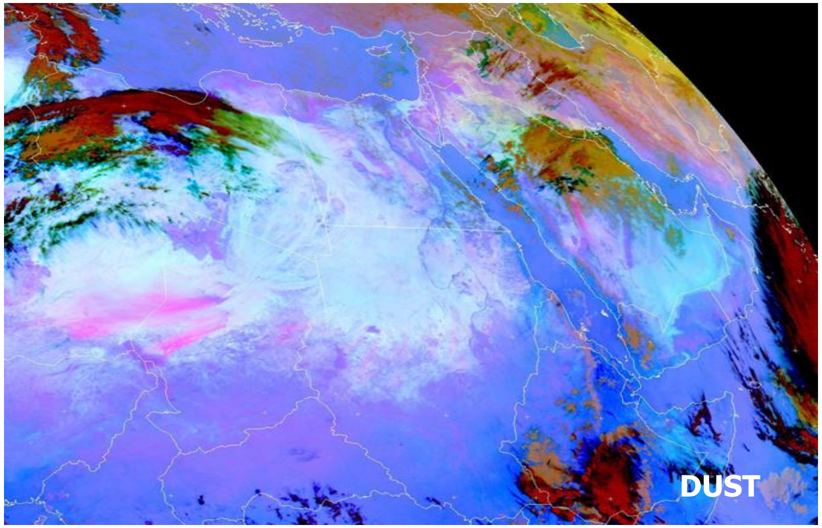
- Airmass analysis
- Fog detection
- Cloud typing, especially volcanic ash
- Convection***

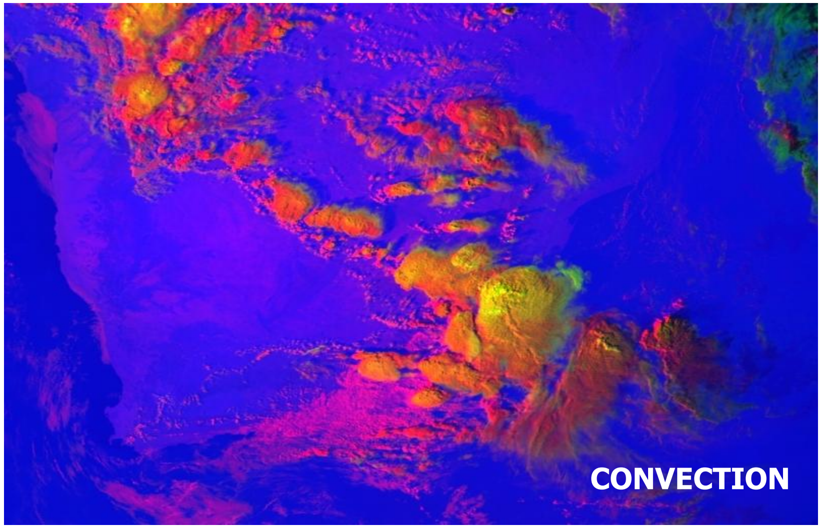
- Use of the rapid image updates - animations!

RGB Examples

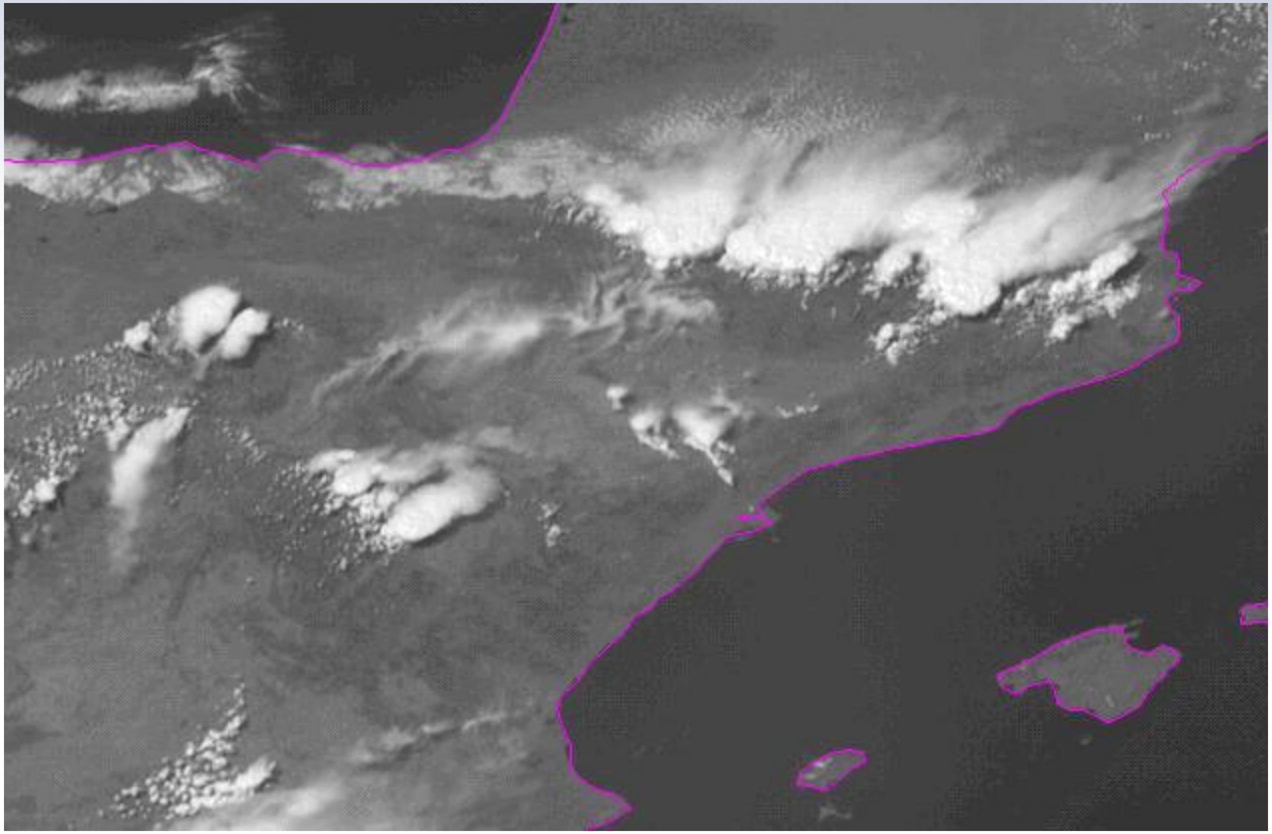








Convection: 30.06.2008, 1330 – 1815 UTC RSS (HRV)



Observing the Stages of Convection

- Pre-convective environment
  (airmass stability)

- First convective activity – convective initiation

- Mature convective clouds – cloud top features



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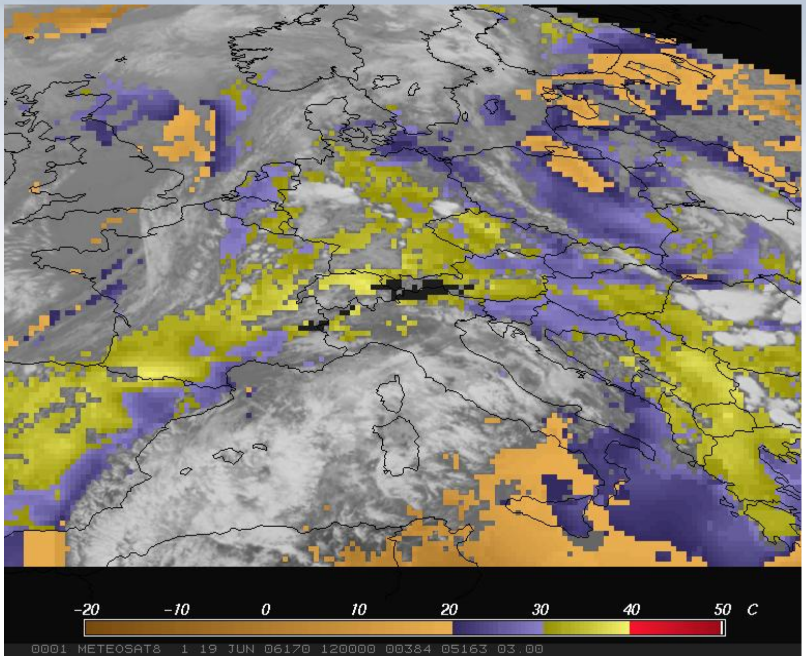
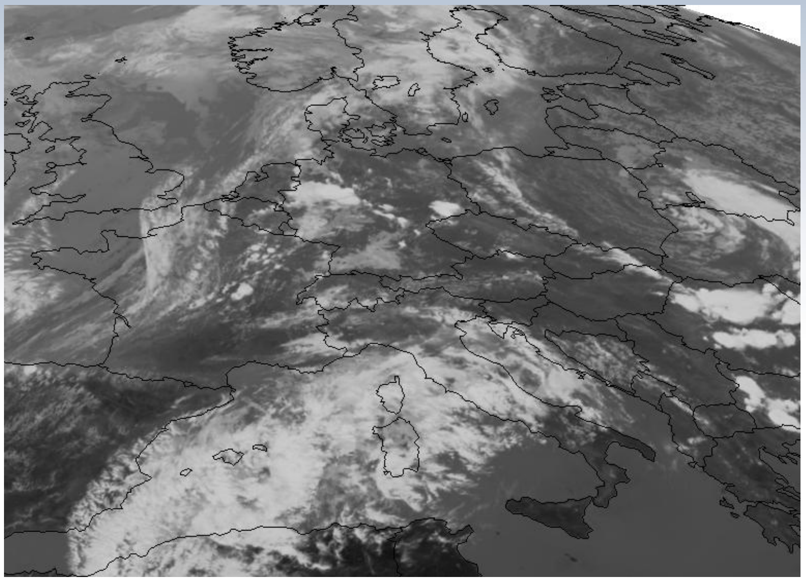
Pre-Convective Environment

Multi-spectral image data in combination with short-range forecast profiles allow the derivation of stability indices (e.g. Lifted Index, K-Index ..) in clear sky conditions, i.e. before the first clouds form:

Provide a general "first warning" as to the potential of convective activity

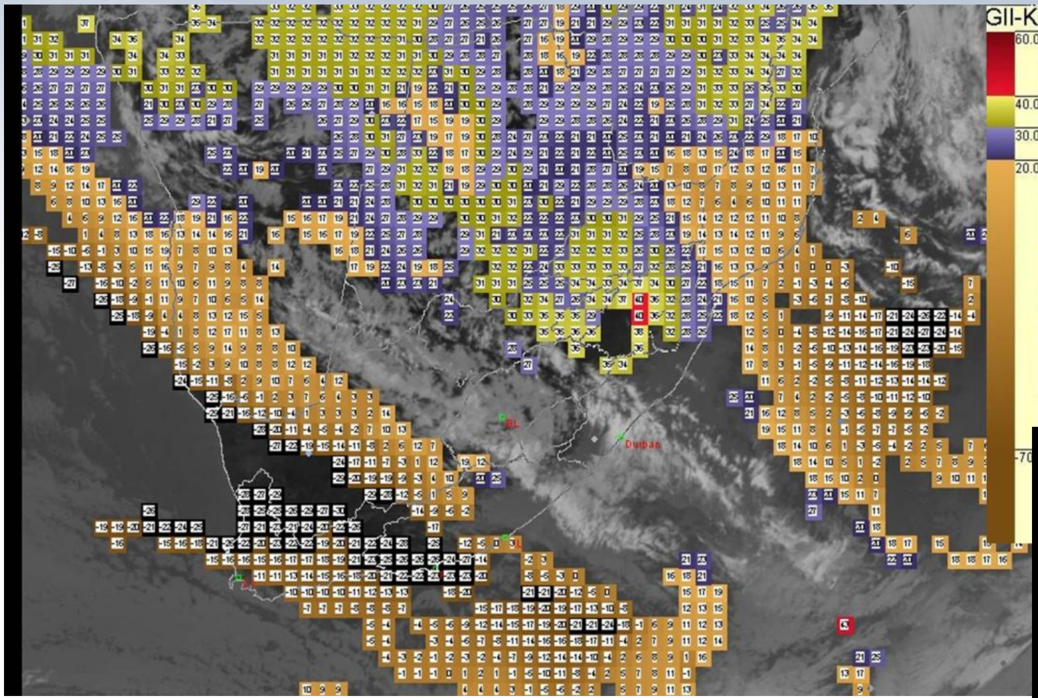
K-Index – Example





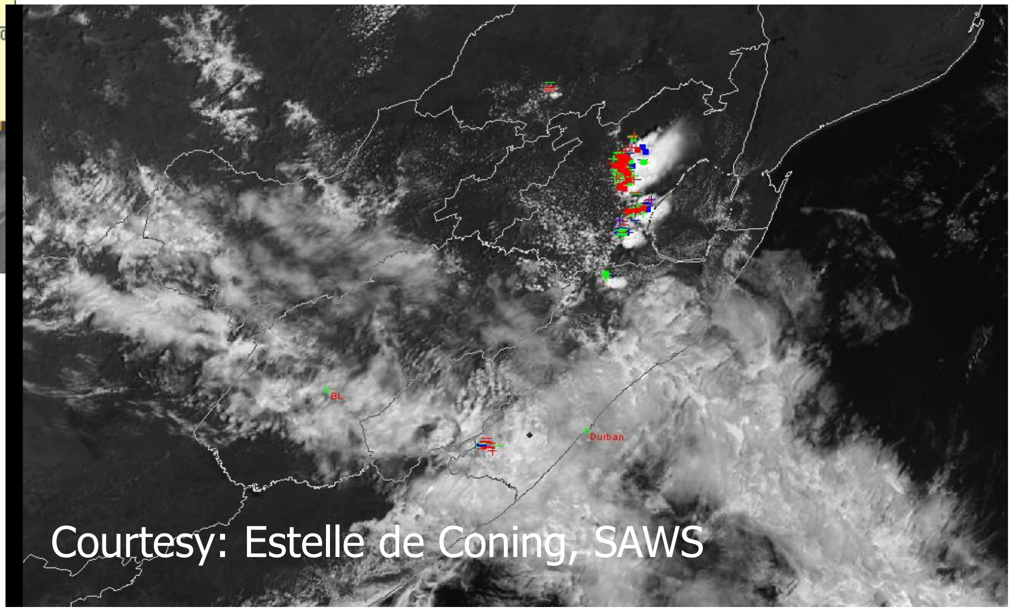
K-Index and IR Image: Instability product only over cloud free areas

GII – Application at South African Weather Service (SAWS)



26. October 2006, 0800 UTC

26. October 2006, 1100 UTC



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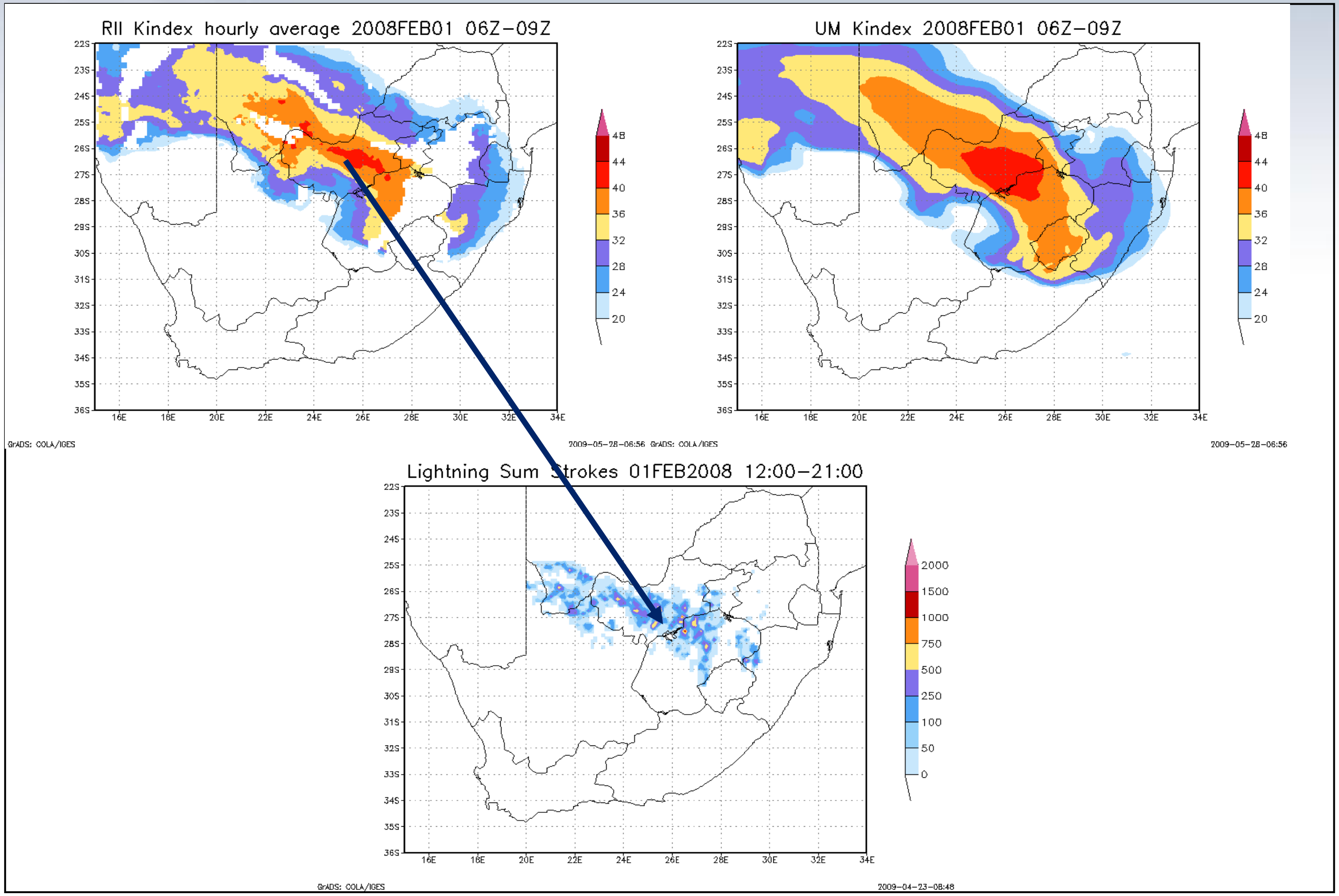
GII at SAWS: Detailed Case Study 01 Feb 2008



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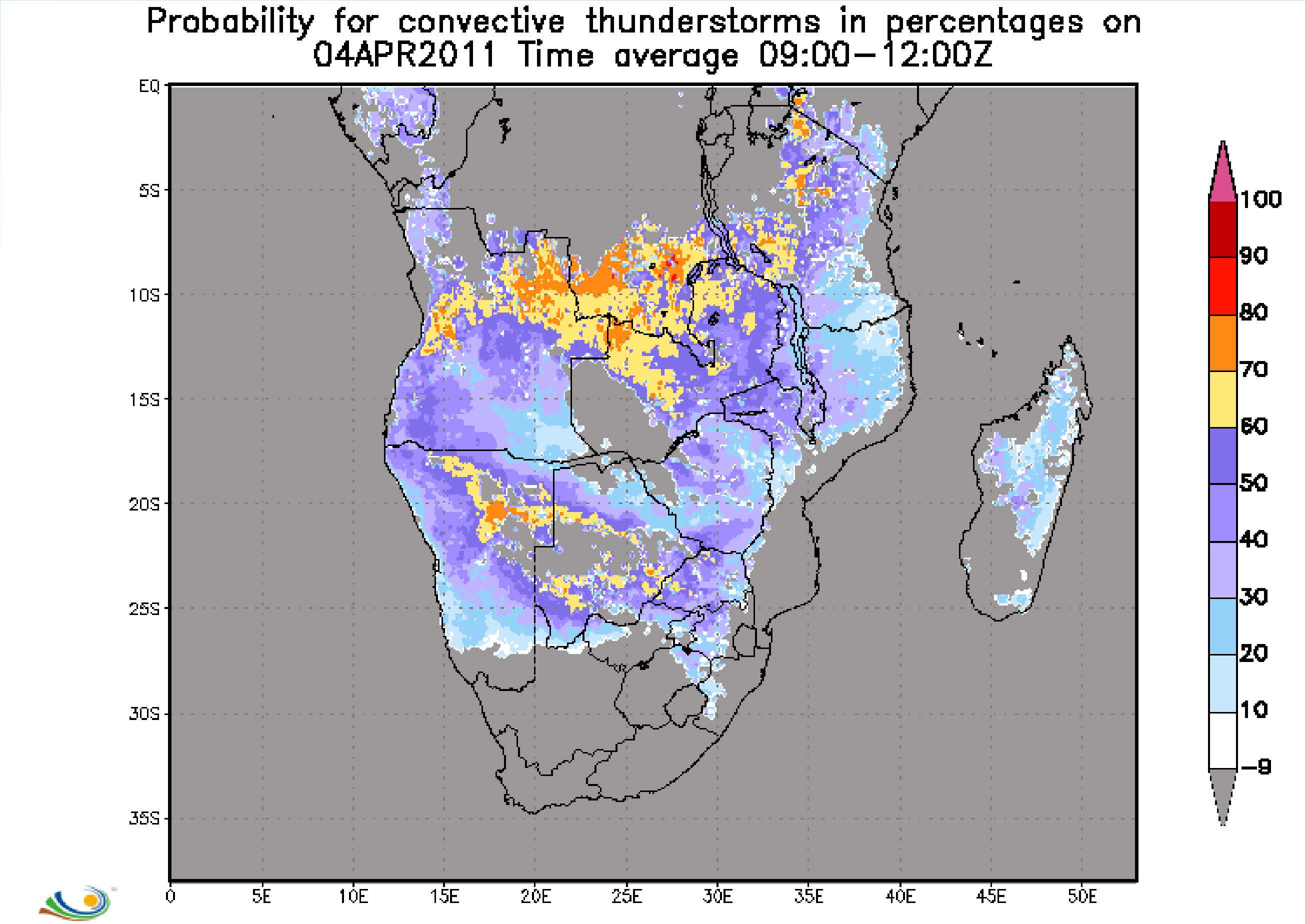
Combination of Different Instability Indices to Assess Lightning Probability (SAWS)



CII: Combined Instability Index – different indices are combined and trained with lightning observations to have an overall probability of lightning occurrence in the next 6-9 hours

South African Weather Service

All SAWS results: courtesy Estelle de Coning

References Instability Analysis

Koenig, M. and E. De Coning, 2009: The MSG Global Instability Indices Product and Its Use as a Nowcasting Tool Wea. Forecasting, 24, 272-285

De Coning, E. and M. Koenig, 2010: The Combined Instability Index: A New Very Short-Range Convection Forecasting Technique for Southern Africa, DOI 10.1002/met.234

Early Convection Stage: Convective Initiation (CI)

Work of John Mecikalksi (UAH) together with EUMETSAT:

CI product aims at identifying a growing Cu cloud at a very early stage, preceding radar observations (by up to one hour)

Method SATCAST: Satellite Convection Analysis and Tracking, originally developed for GOES, adapted to the enhanced (spectral) capabilities of MSG

CI: MSG Interest Fields

MSG IR Interest Fields per Physical Process

Cloud Depth

- 6.2-10.8 μm difference
- 6.2-7.3 μm difference
- 10.8 μm T_B
- 7.3-13.4 μm
- 6.2-9.7 μm difference
- 8.7-12.0 μm difference

Glaciation

- 15-min Trend Tri-spectral
- Tri-spectral
- 30-min Trend Tri-spectral
- 15-min 8.7-10.8 μm
- 15-min 12.0-10.8 μm Trend
- 15-min 3.9-10.8 μm Trend
- 12.0-10.8 μm difference

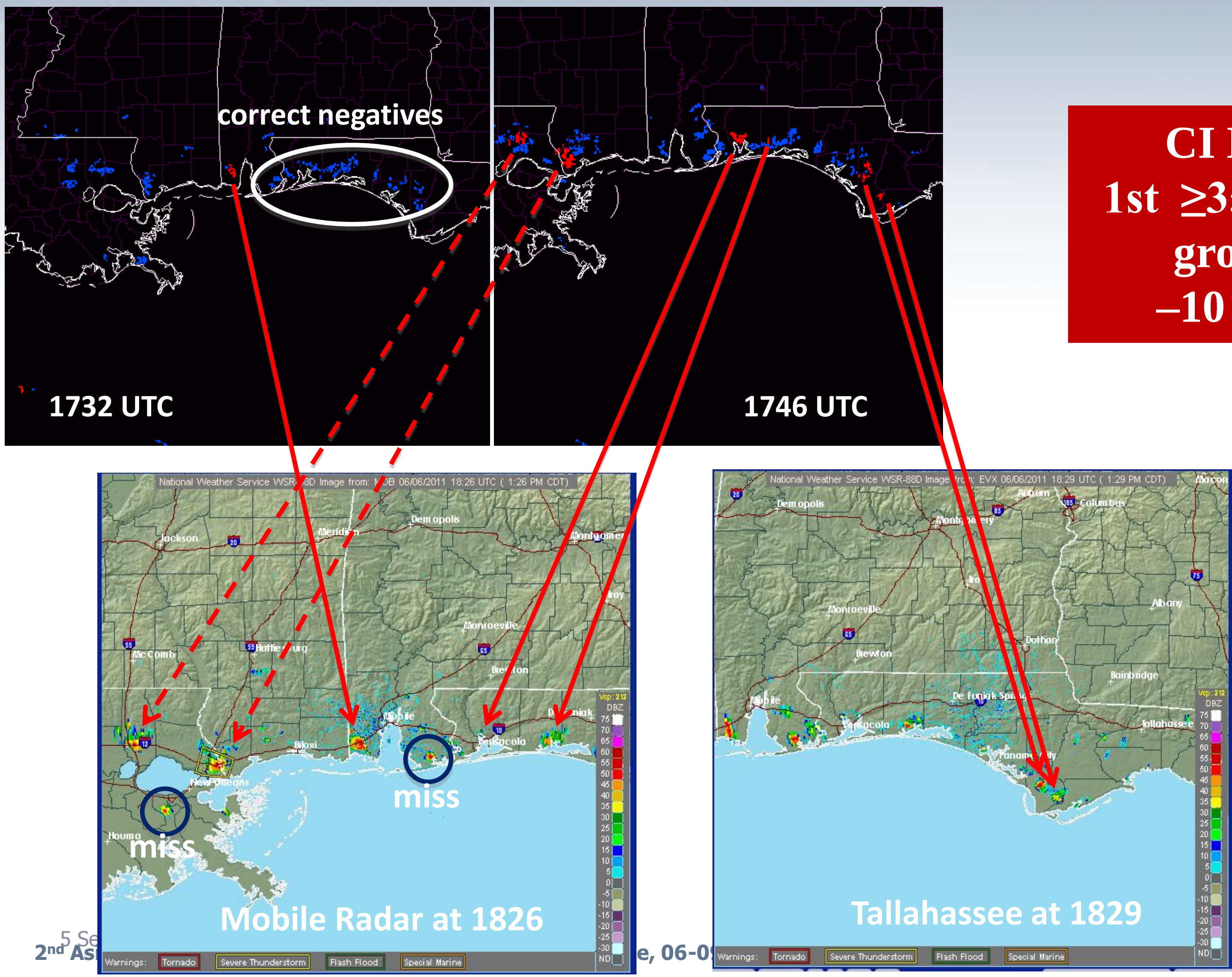
Updraft Strength

- 30-min 6.2-7.3 μm Trend
- 15-min 10.8 μm Trend
- 30-min 10.8 μm Trend
- 15-min 6.2-7.3 μm Trend
- 30-min 9.7-13.4 μm Trend
- 30-min 6.2-10.8 μm Trend
- 15-min 6.2-12.0 μm Trend
- 15-min 7.3-9.7 μm Trend

Channels related to the following were found to contain redundant information as they were highly correlated:

8.7-13.4 μm, 8.7-10.8 μm, 7.3-10.8 μm, 13.4-10.8 μm, 8.7-12.0 μm, and Time Trends of these fields.

SATCAST Example (GOES)



CI Definition:
1st ≥35 dBZ echo at ground, or at –10 ºC altitude

Courtesy J. Mecikalski and J. Walker, UAH

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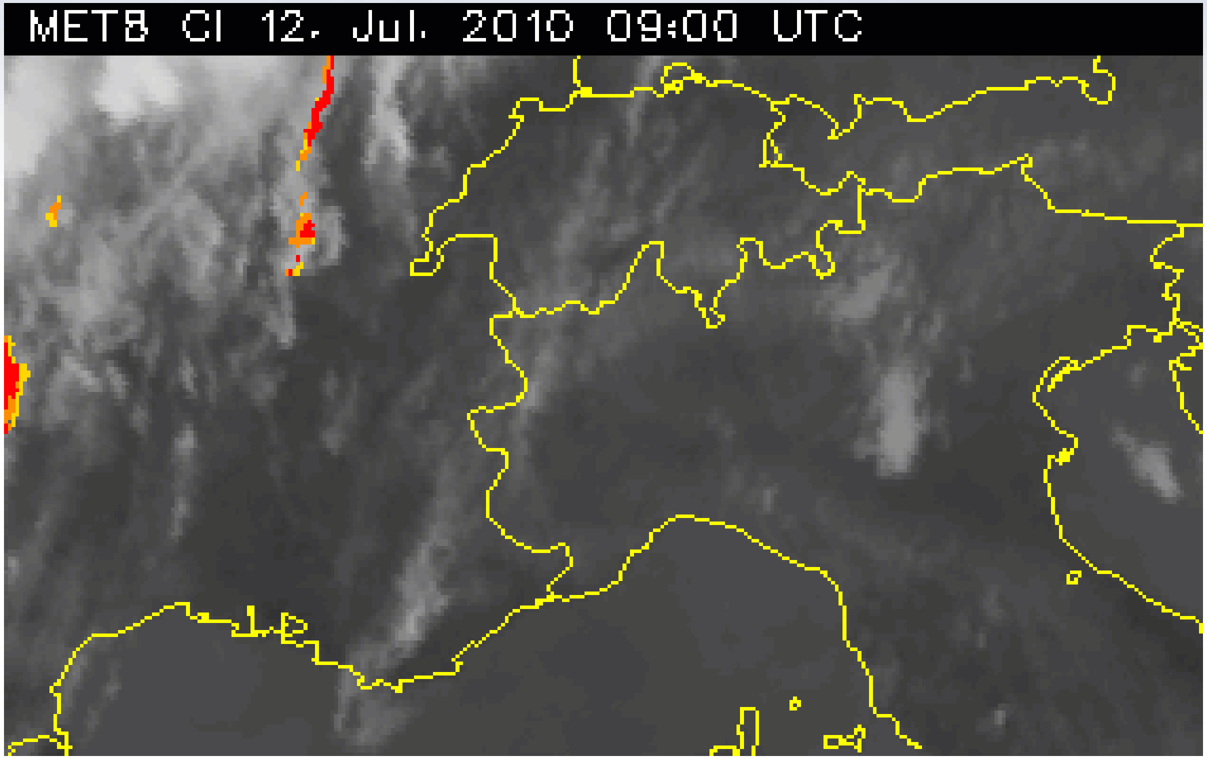
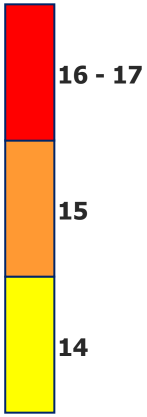
CI MSG Example: Switzerland, 12 July 2010 RSS



Number of Interest Fields



Courtesy Luca Nisi, Meteo Swiss

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CI Literature References

Mecikalski, J. And K. Bedka, 2006: Forecasting Convective Initiation by Monitoring the Evolution of Moving Cumulus in Daytime GOES Imagery. *Mon. Wea. Rev.,* **134**, 49-89

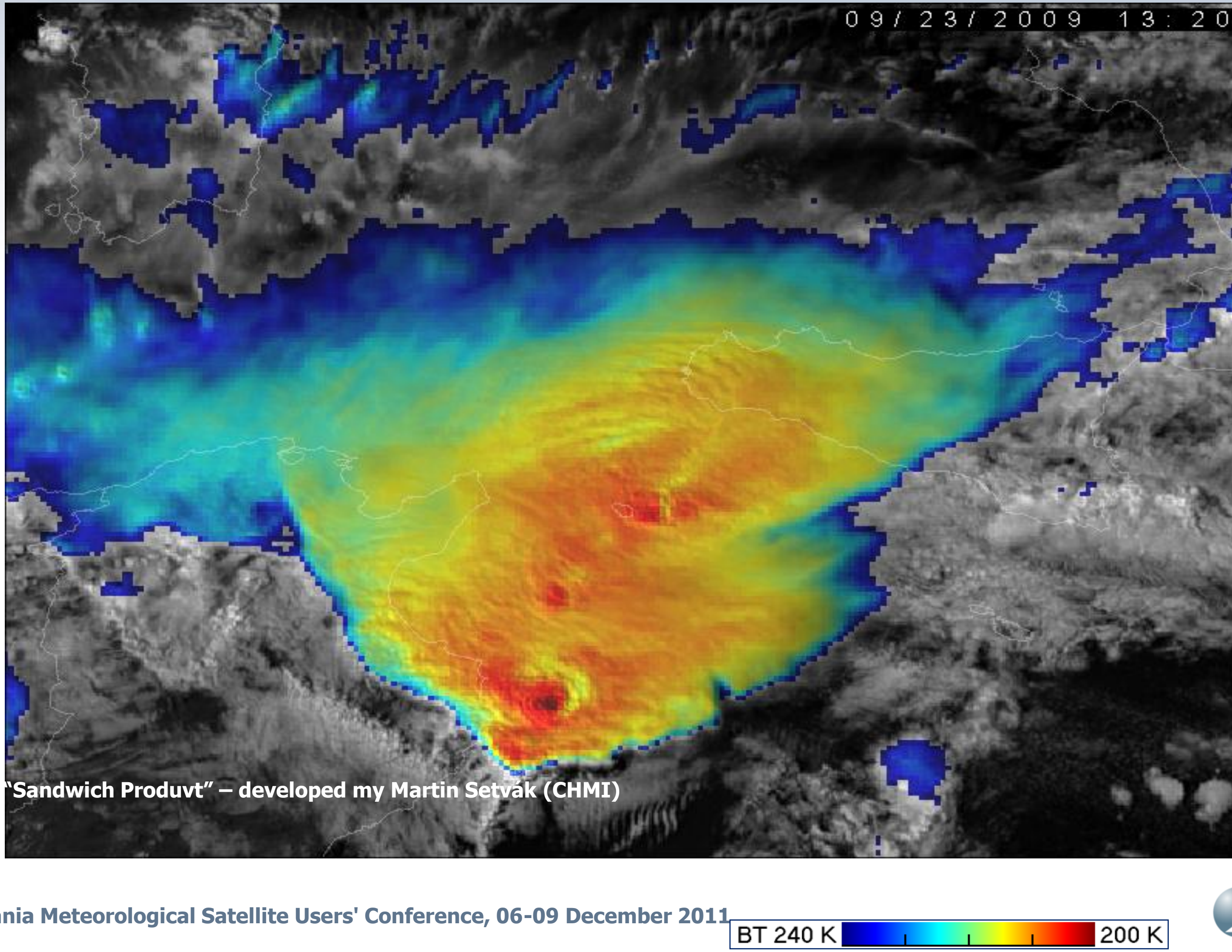
Siewert, C. et al., 2010: Application of Meteosat Second Generation Data Towards Improving the Nowcasting of Convective Initiation. DOI 10.1002/met.176

Bedka, K., et al., 2010: Nowcasting Convective Storm Initiation Using Satellite-Based Box-Averaged Cloud Top Cooling and Cloud Type Trends. DOI 10.1175/2010JAMC2496.1

Mecikalski, J. et al., 2010: Cloud-Top Properties of Growing Cumulus prior to Convective Initiation as Measured by Meteosat Second Generation. Part 1. Infrared Fields. *J. Appl. Meteor. Climate*, **49**, 521-534

Mecikalski, J. et al., 2010: Cloud-Top Properties of Growing Cumulus prior to Convective Initiation as Measured by Meteosat Second Generation. Part 2. Visible Fields. Accepted for publication in *J. Appl. Meteor. Climate*

Mature Stage: Cloud Top Texture



23. September 2009
Mediterranean Sea

Mature Stage: Automatic Detection of Overshoots

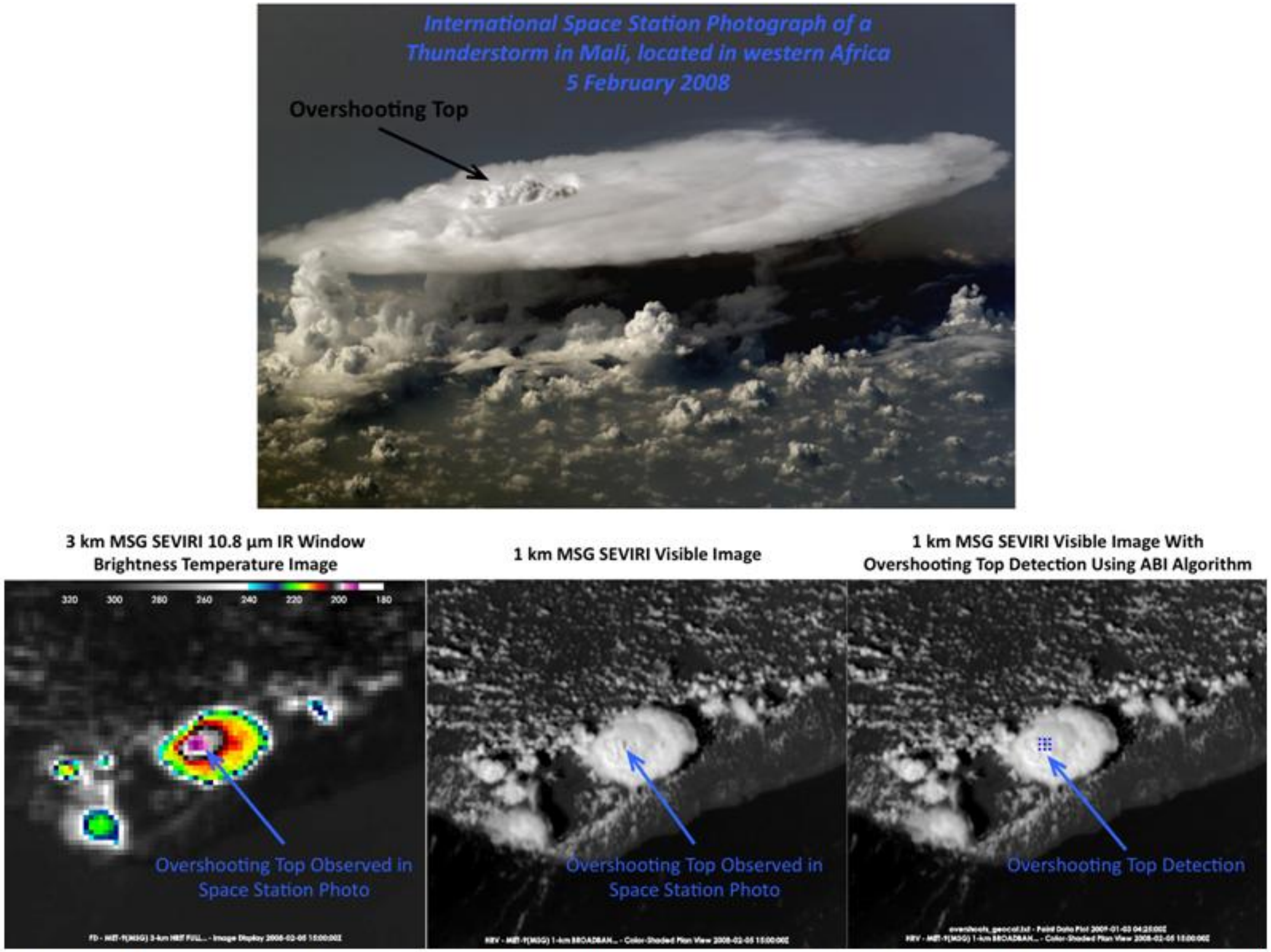
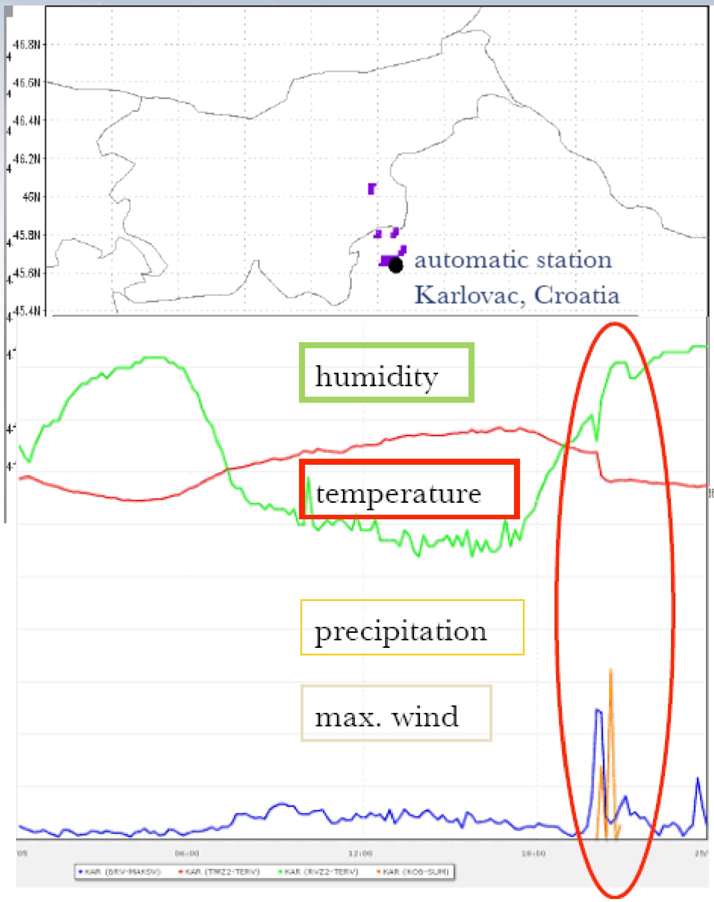


Figure 4: (top) A photograph of an overshooting top producing storm over Mali (western Africa) on 5 February 2008. (bottom panels) (left) 3 km MSG SEVIRI 10.8 μ temperature imagery, 1 km SEVIRI high-resolution visible with (right) and without (center) IRW-texture overshooting top detections.

Courtesy Kristopher Bedka, NASA

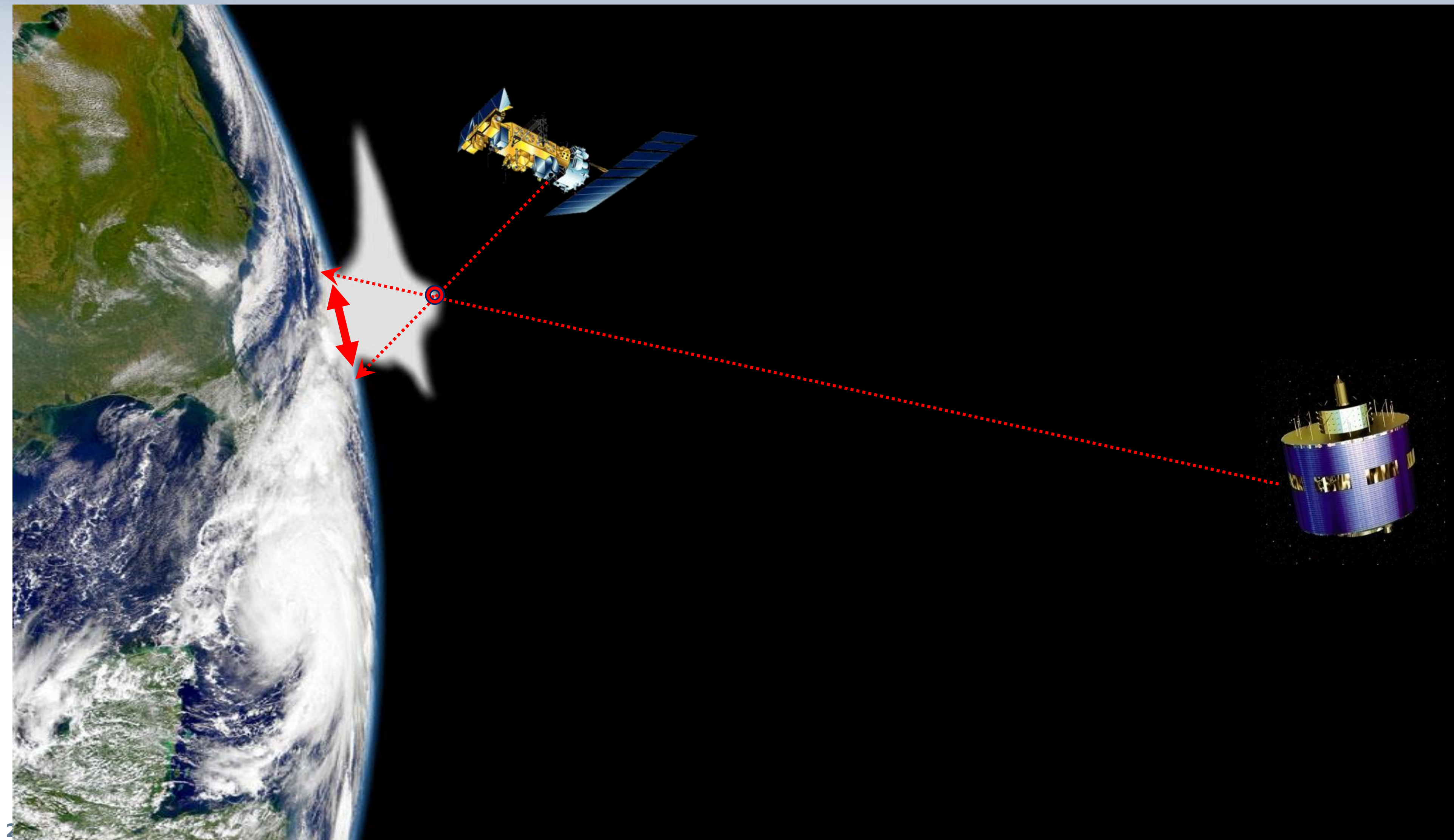
Mature Stage: Overshooting Top Detection



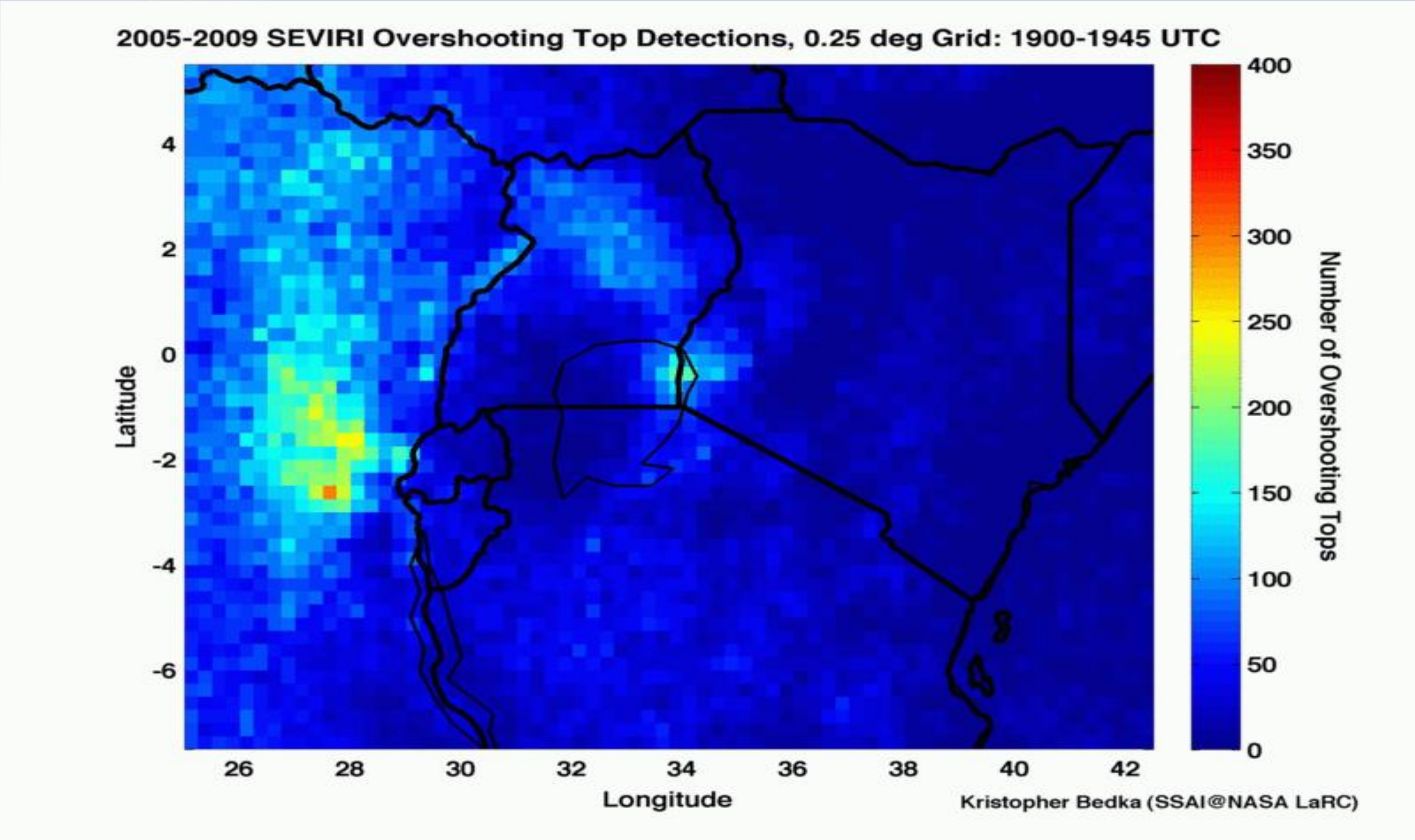
Significant correlation found between location of overshooting tops and occurrence of significant weather changes at the surface – most pronounced for precipitation and wind gusts

(Courtesy Petra Mikus and Natasa Strehec-Mahovic, Croatian Weather Service)

Attention- Parallax



Objective OT Detection: Climatological Tool



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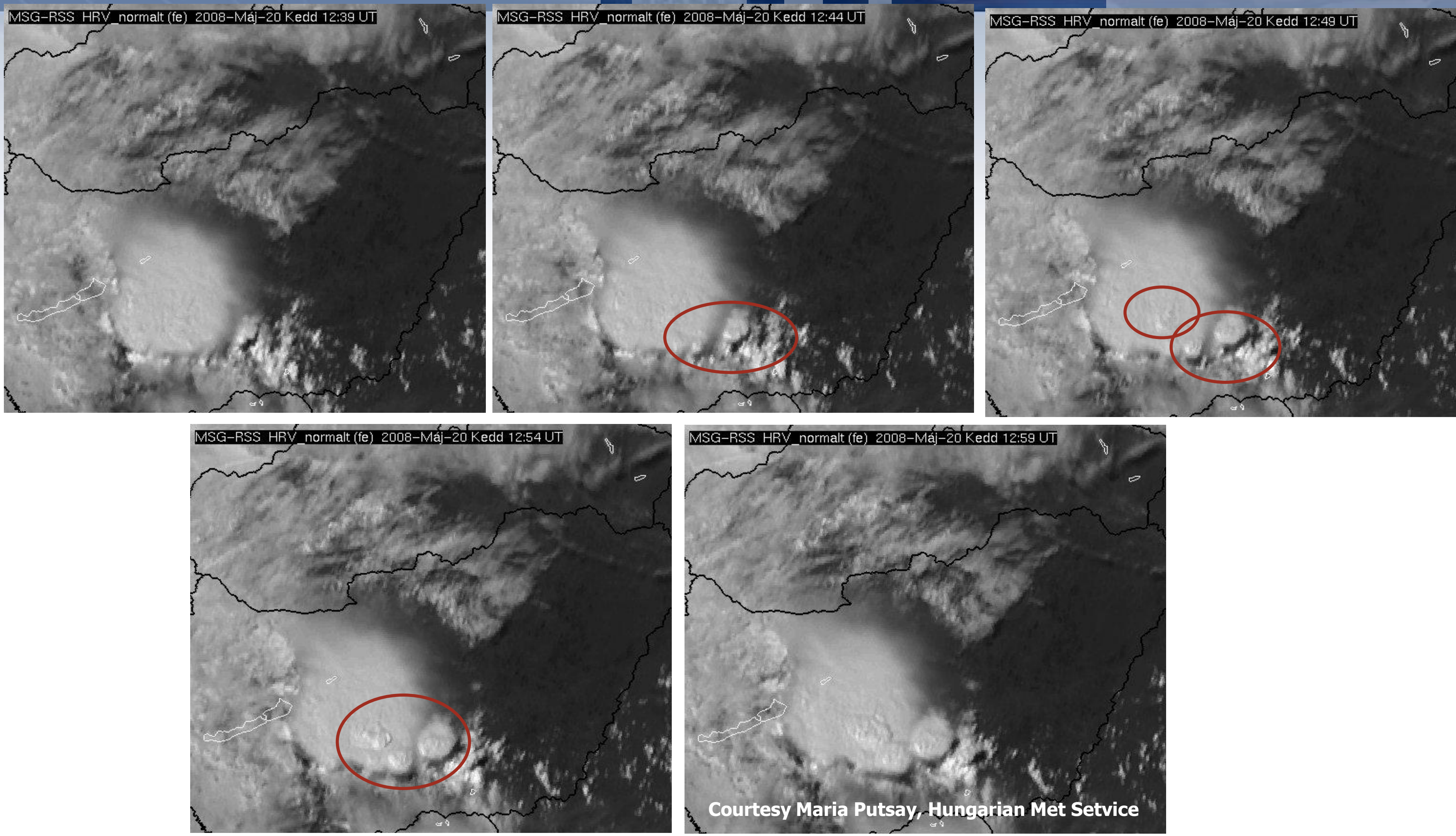
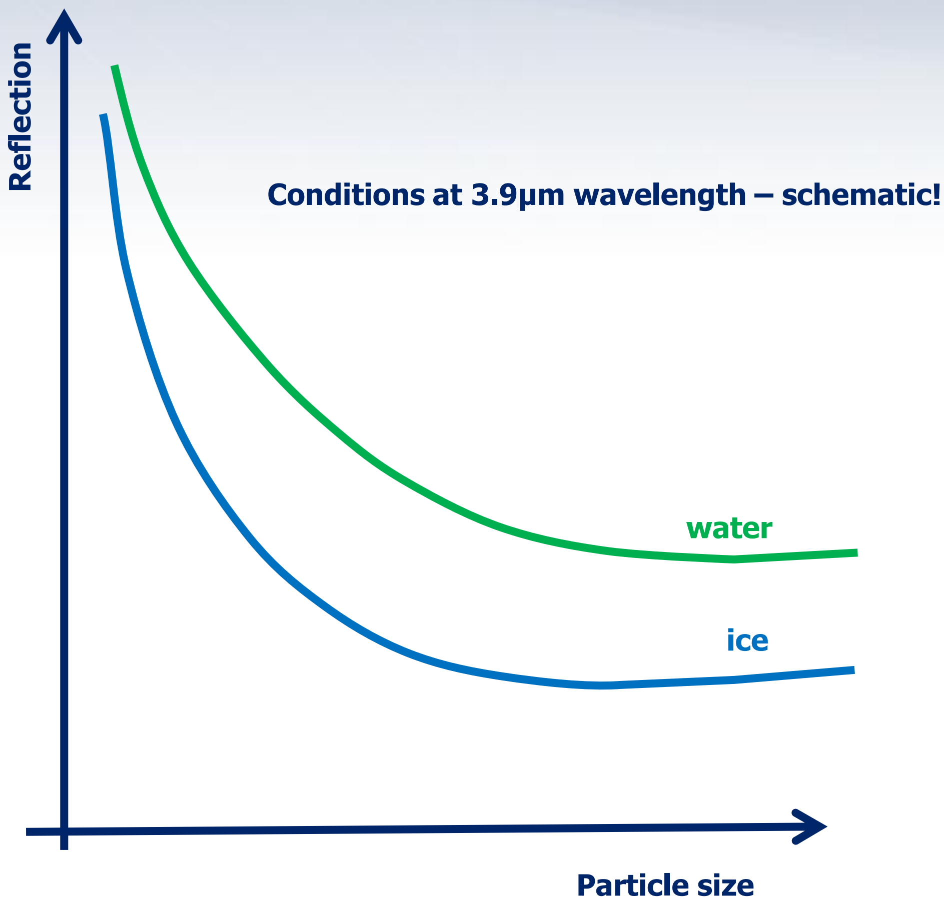
Added Value of High Temporal Resolution



Cloud Top Microphysical Parameters

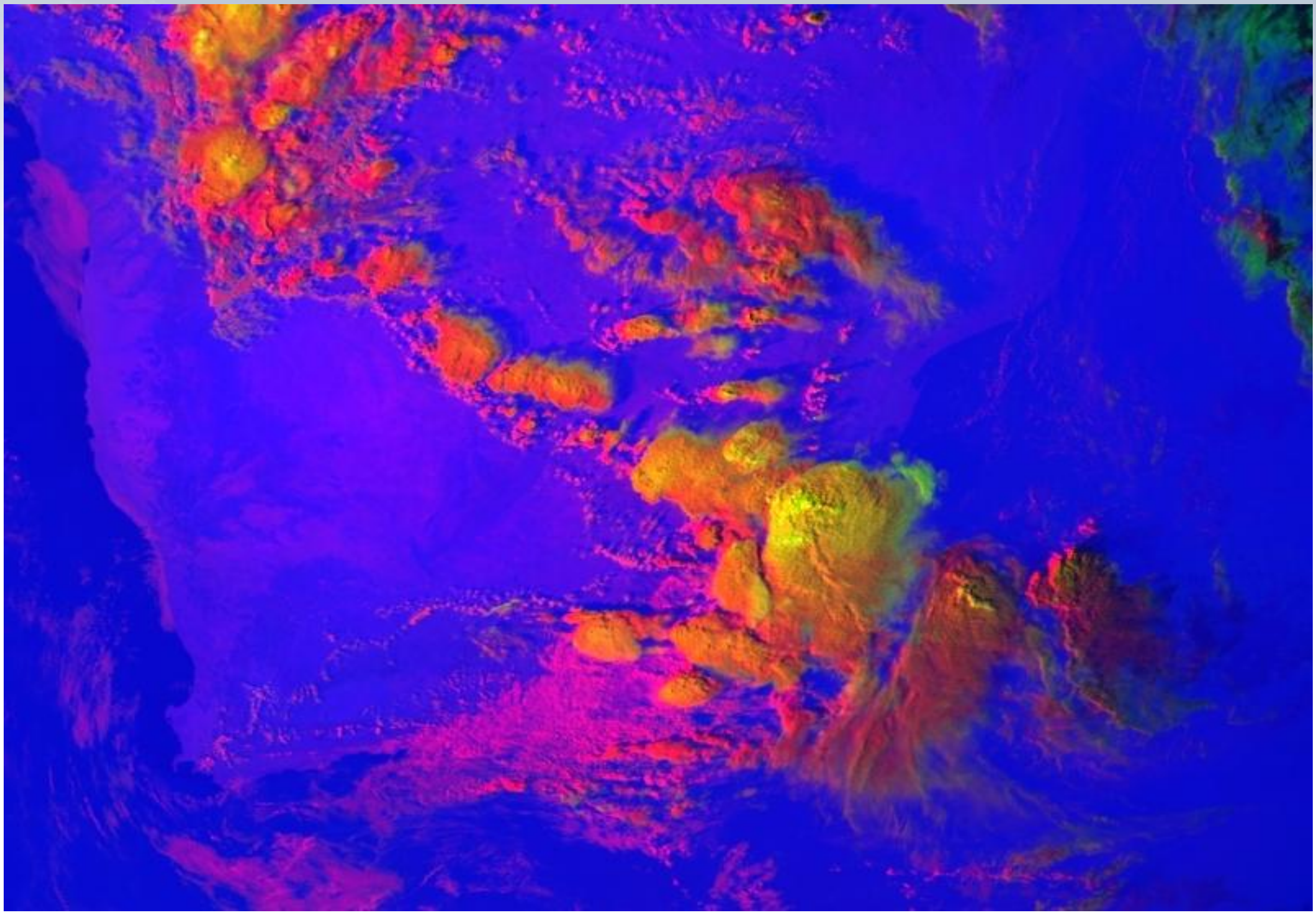


IR3.9 shows a higher reflectance for water clouds than for ice clouds

This reflection depends on the particle size:

Smaller particles show higher reflectivity

Convection RGB- Focus on Strong Updraft Regions



RGB
VIS0.8
IR3.9 – IR10.8
IR10.8

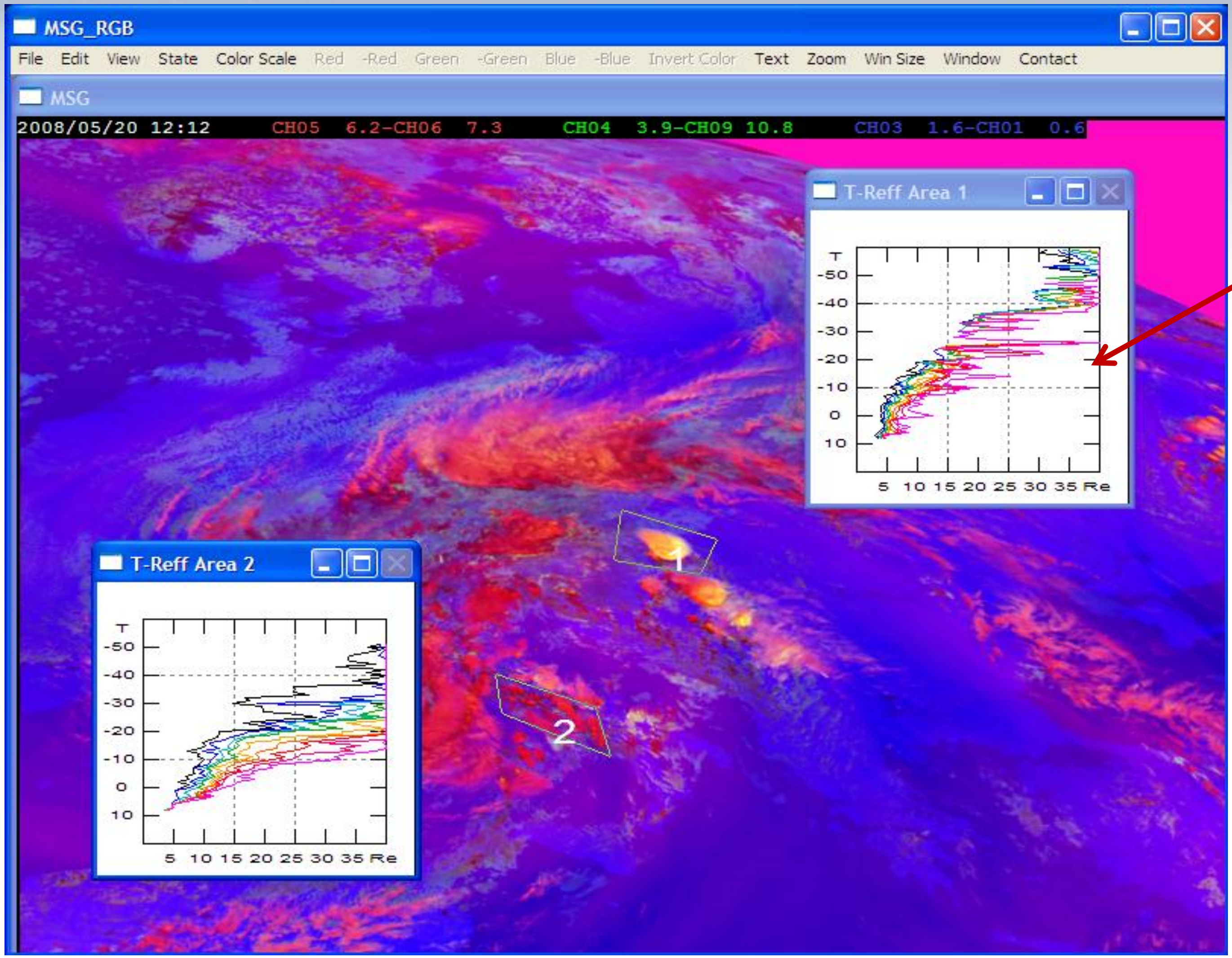
Small cold ice crystals in bright yellow

(attention: very cold clouds also show yellow signature)

Small ice – proxy for strong updrafts

27. Oct. 2004, 1200 UTC

Quantitative Use of Cloud Top Microphysics



Severe cloud signature

Courtesy D. Rosenfeld

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Cloud Top Microphysics Literature References

Lenský, I. and D. Rosenfeld, 2008: Clouds-Aerosols-Precipitation Satellite Analysis Tool (CAPSAT). Atmos. Chem. Phys., 8, 6739-6753

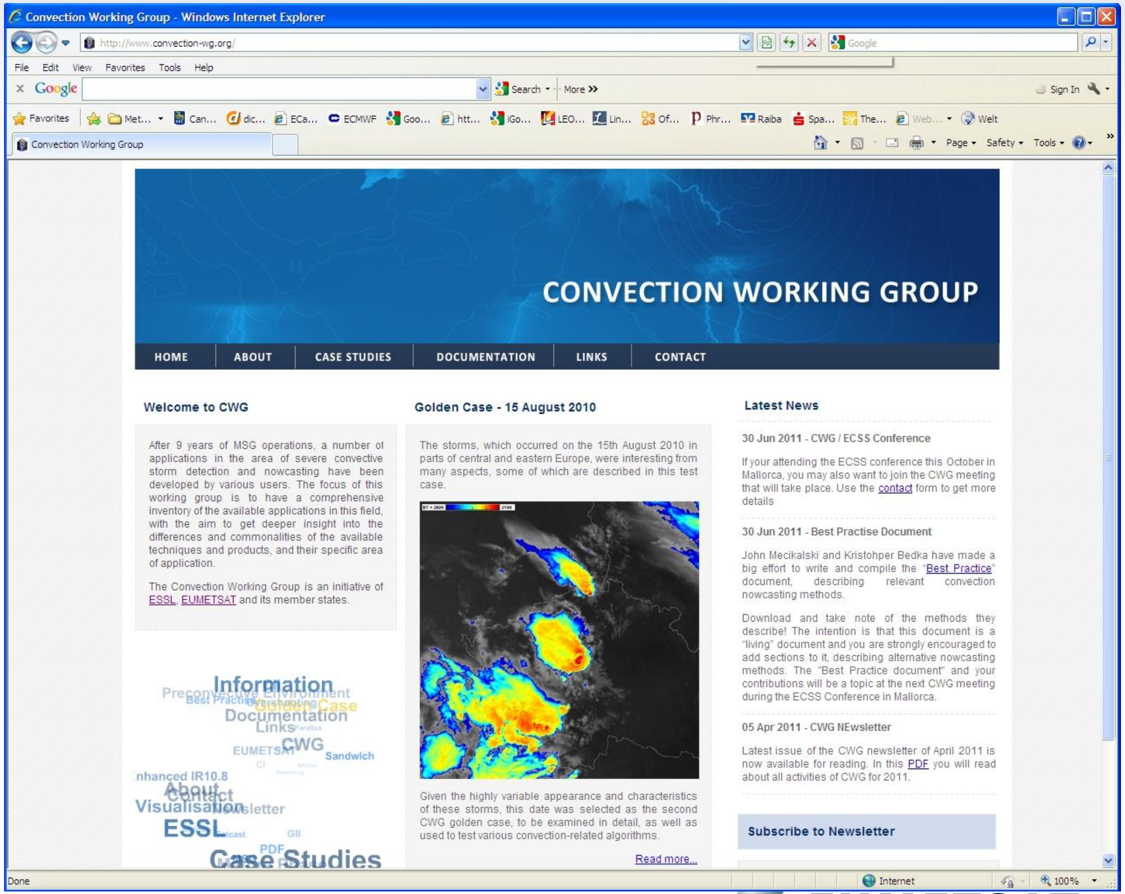
(and references therein)

Convection Working Group

This working group was (informally) founded in 2007 following an initiative of the Polish Met Service

After the first 5 years of MSG operations, a number of applications in the area of severe convective storm detection and nowcasting have been developed by various users. The focus of this working group is to have a comprehensive inventory of the available applications in this field, with the aim to get deeper insight into the differences and commonalities of the available techniques and products, and their specific area of application.

http://www.convection-wg.org



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Convection Working Group

WG Meetings:

December 2007 in Krakow, Poland

October 2009 in Landshut, Germany

Short WG meetings during the annual EUMETSAT User Conference (2008 in Darmstadt, 2010 in Cordoba)

A(short) meeting was held during the European Conference on Severe Storms, October 2011 in Mallorca

The next (long) WG meeting will take place in Prague/Czech Republic in March 2012

CWG Activities

Research and applications in the area of

- pre-convective atmosphere
- convective initiation
- developed convective storms, overshoots

WG deals with common test cases

WG has developed a "best practice" document (still in draft) for convection nowcasting

A very important activity is the transfer of development into an operational environment

Meteosat Third Generation (MTG) - Outlook

1977 | 2002 | 2017 and 2019

MOP/MTP

Observation mission:
- MVIRI: 3 channels

Spinning satellite
Class 800 kg

MSG

Observation missions:
- SEVIRI: 12 channels
- GERB

Spinning satellite
Class 2-ton

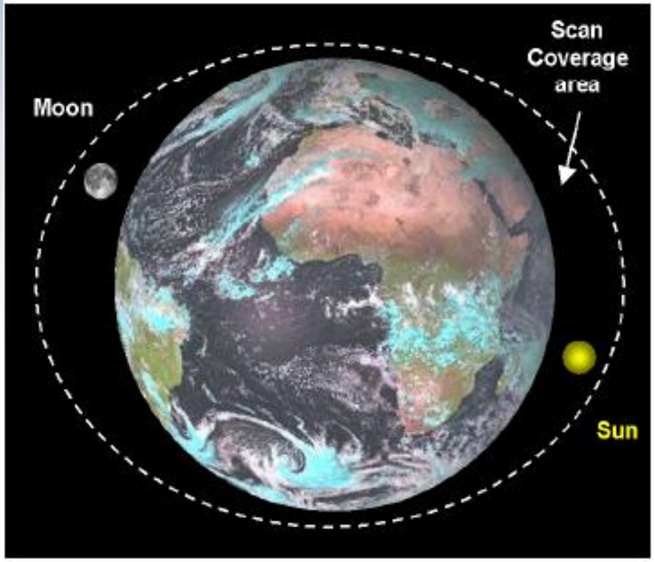
MTG-I and MTG-S

Observation missions:
- Flex.Comb. Imager: 16 channels
- Infra-Red Sounder
- Lightning Imager
- UVN

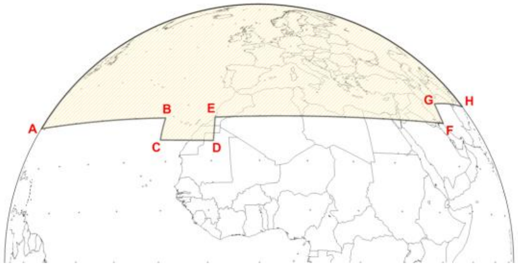
3-axis stabilised satellites
Twin Sat configuration
Class 2.5 - 3 ton

Meteosat Third Generation - Outlook

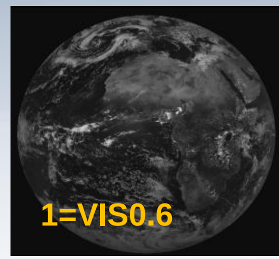
Full Disc Scans,
every 10 minutes

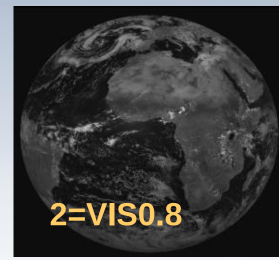


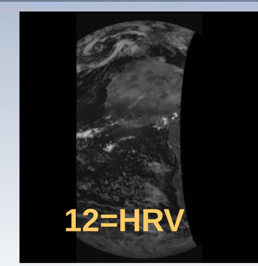
Regional Scans with
second MTG-I satellite
every 2.5 minutes

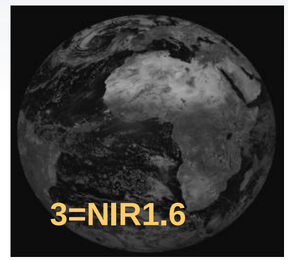


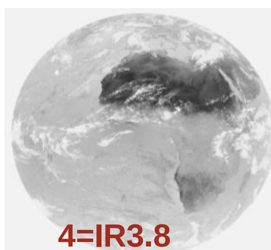
From MSG to the MTG Imager

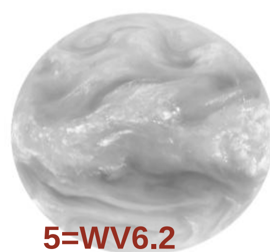


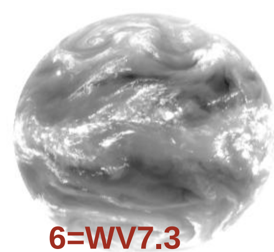


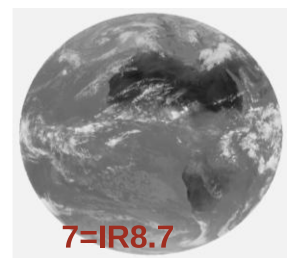


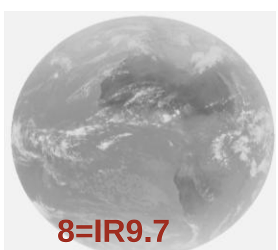


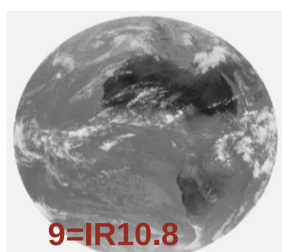


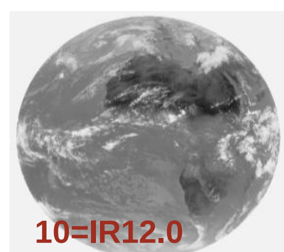


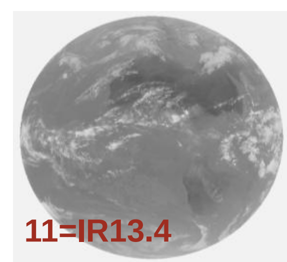




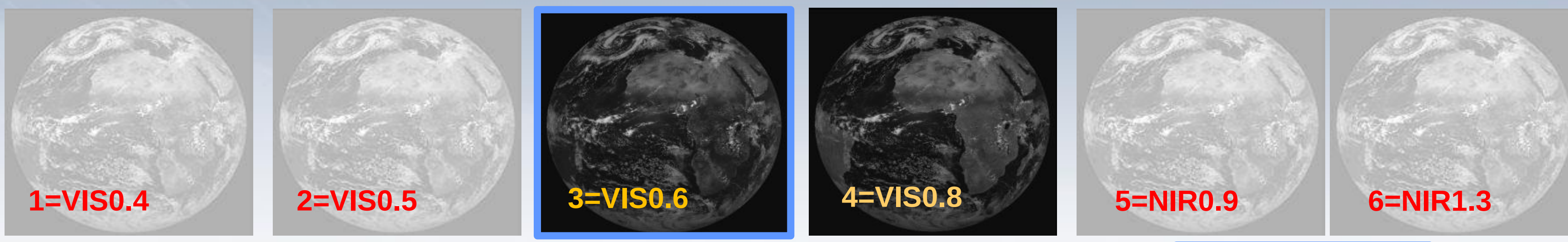




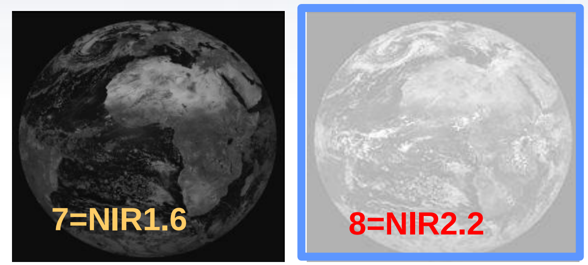




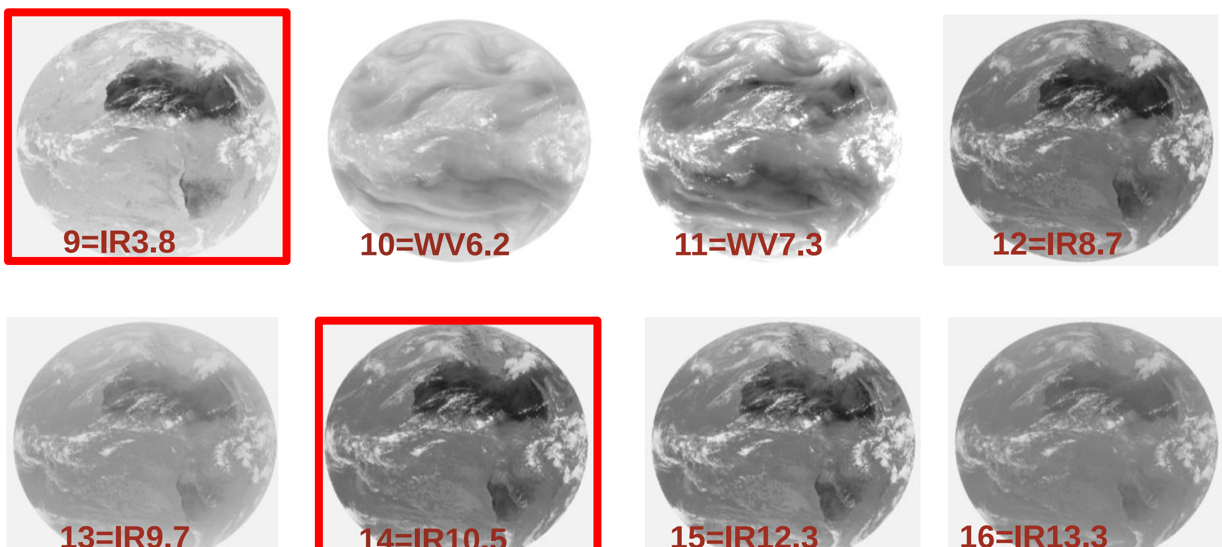
From MSG to the MTG Imager



solar channels provided in 0.5 km / 1.0 km resolution



thermal channels provided in 1 km / 2 km resolution



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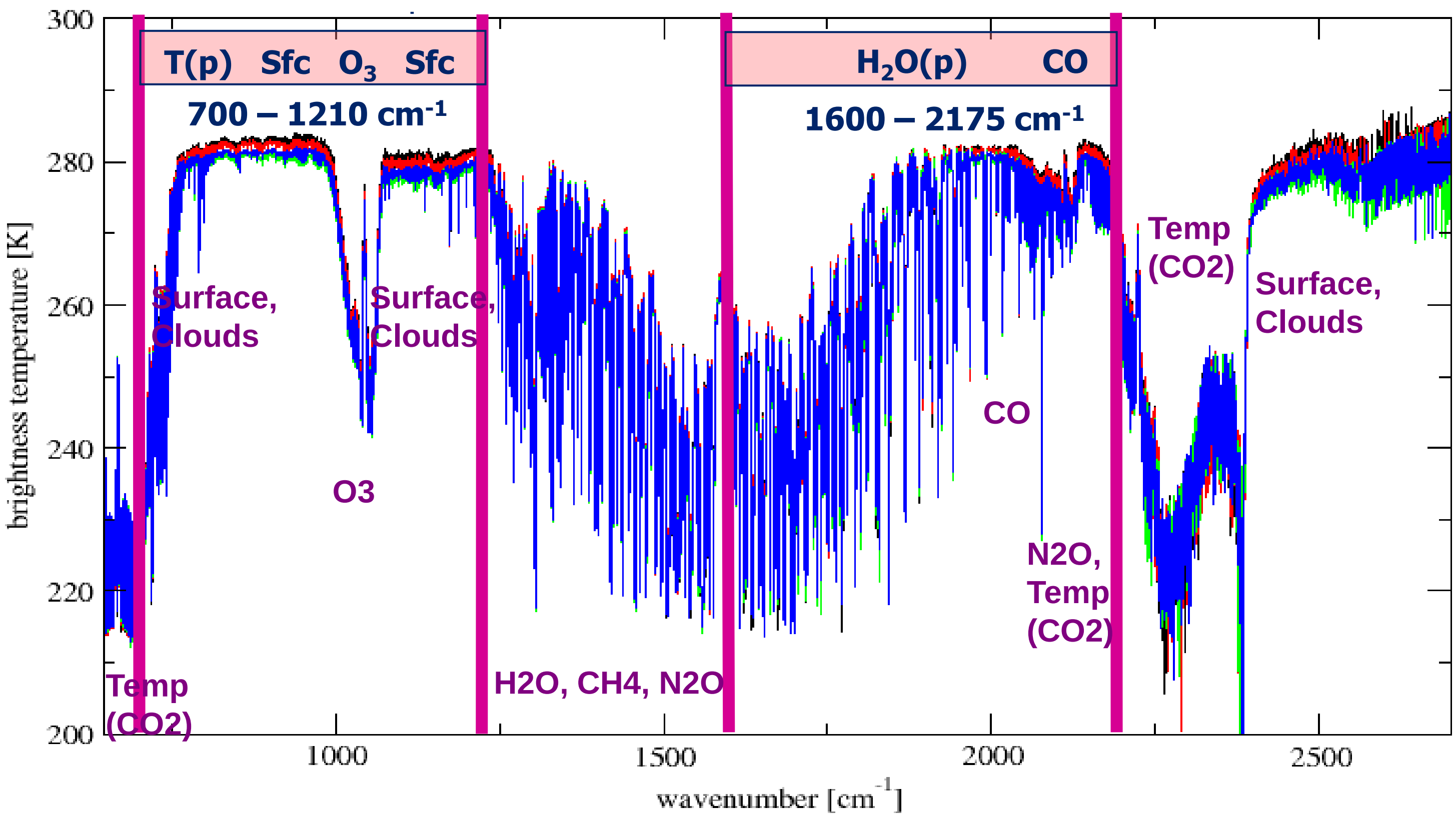
MTG Infrared Sounder (IRS)

MTG-IRS mission will deliver unprecedented information on horizontal and vertical gradients of moisture, wind and temperature between measurements of individual radiosondes and hyperspectral soundings from the polar orbiting satellites.



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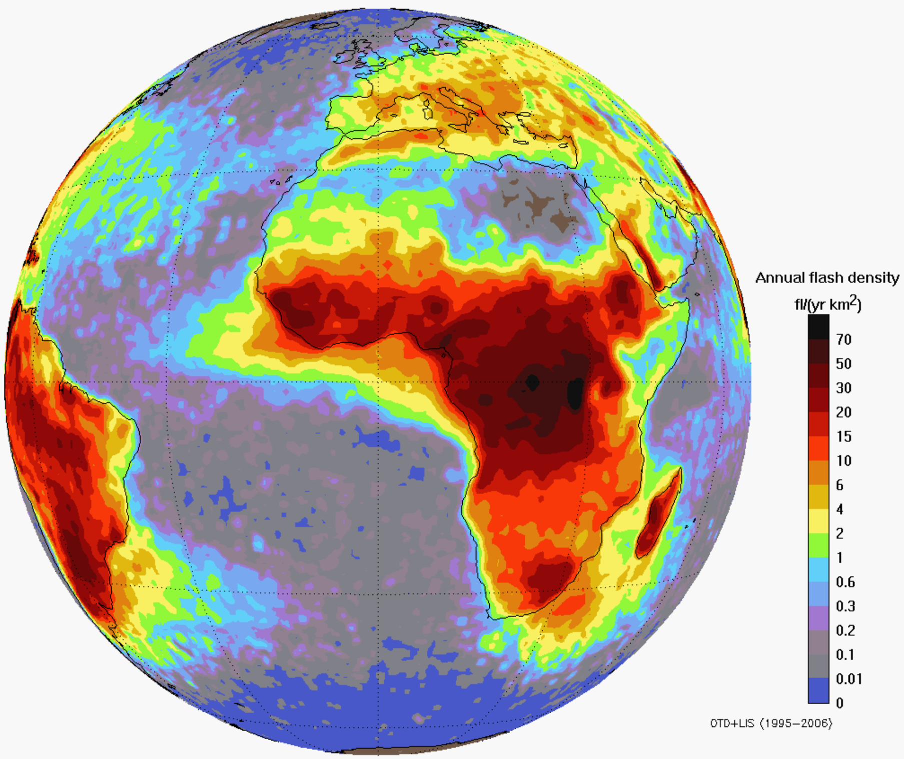
MTG Lightning Imager (LI)

The Lightning Imager (LI) on MTG measures/maps Total Lightning: Cloud-to-Cloud Lightning (IC) and Cloud-to-Ground Lightning (CG)



- Development (Intensity/Movement) of active convective areas
- Monitoring of Storm Lifecycle
- Validation of Convective Initiation Forecast
- Support to Climate and Air Chemistry

Thank you very much for your attention!