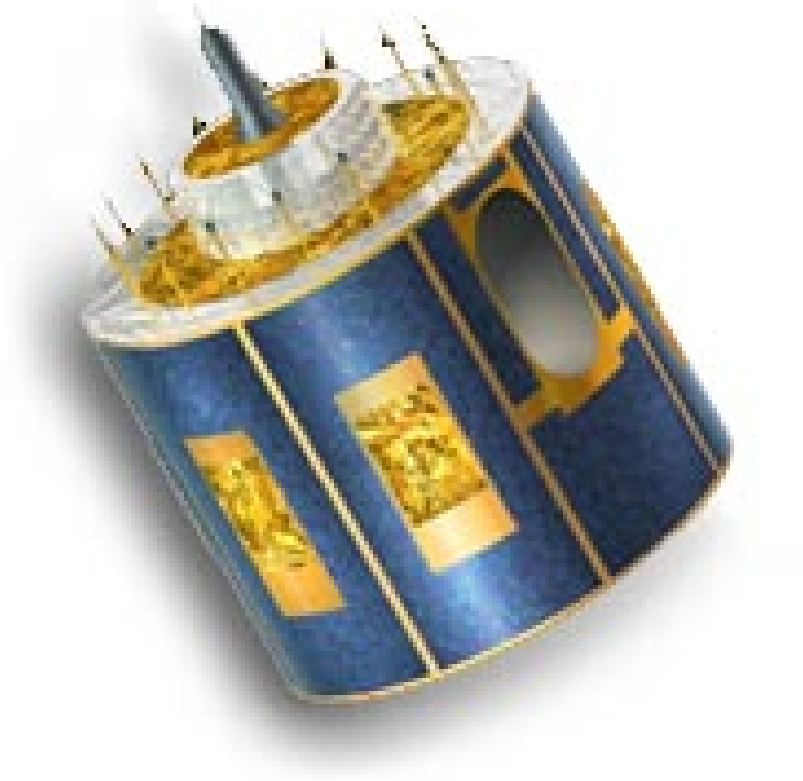
The MSG Instability Product



GII: Global Instability Indices

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Instability?

Conditional and latent instability – parcel method

Can lead to severe convection

Satellite measurements: find out about this instability in pre-convective situations

The MPEF GII Product

4 Instability Indices (empirical!):

Lifted Index

$LI = T^{obs} - T^{lifted\ from\ surface}$ at 500 hPa (LI < 0)

K-Index:

KI = (Tobs(850) - Tobs(500)) + TDobs(850) - (Tobs(700) - TDobs(700))
(KI > 25-30 C)

KO-Index:

$KO = 0.5 * (\Theta_e^{obs(500)} + \Theta_e^{obs(700)} - \Theta_e^{obs(850)} - \Theta_e^{obs(1000)})$

Maximum Buoyancy:

$MB = \Theta_e^{obs(maximum\ between\ surface\ and\ 850)} - \Theta_e^{obs(minimum\ between\ 700\ and\ 300)}$

And Total Precipitable Water

Some History

Channel selection on MSG also driven by a user demand for a GII-like product

1998: External study proposed a statistical (neural network based) scheme with 15 input parameters

2000-2001: Tests at EUMETSAT have shown major deficiency of statistical method, so algorithm was changed to a physical retrieval

What is a Physical Retrieval?

Optimal estimation or 1-DVar type of retrieval:

An atmospheric profile (T,q) is sought which best matches the MSG observed brightness temperatures

Background: Measurements T_B depend on the atmospheric profile; for a given profile the measurements can be simulated by a radiative transfer model

$$J = T_B - T_{B(sim.)}$$

J is called the "cost function" and is minimised

$T_{B(sim.)}$ depend on the atm. profile

Equation can be expanded to accommodate measurement and model errors and to account for a first guess or background profile

Solution Strategy

Minimisation of the cost function means its derivate is zero – this leads to an iterative solution of the form

$$x_{n+1} = x_0 + (S_x^{-1} + K_n^t S_e^{-1} K_n)^{-1} * (K_n^t S_e^{-1} (T_B - T_B^n + K_n (x_n - x_0))$$

Advantage of a Physical Retrieval

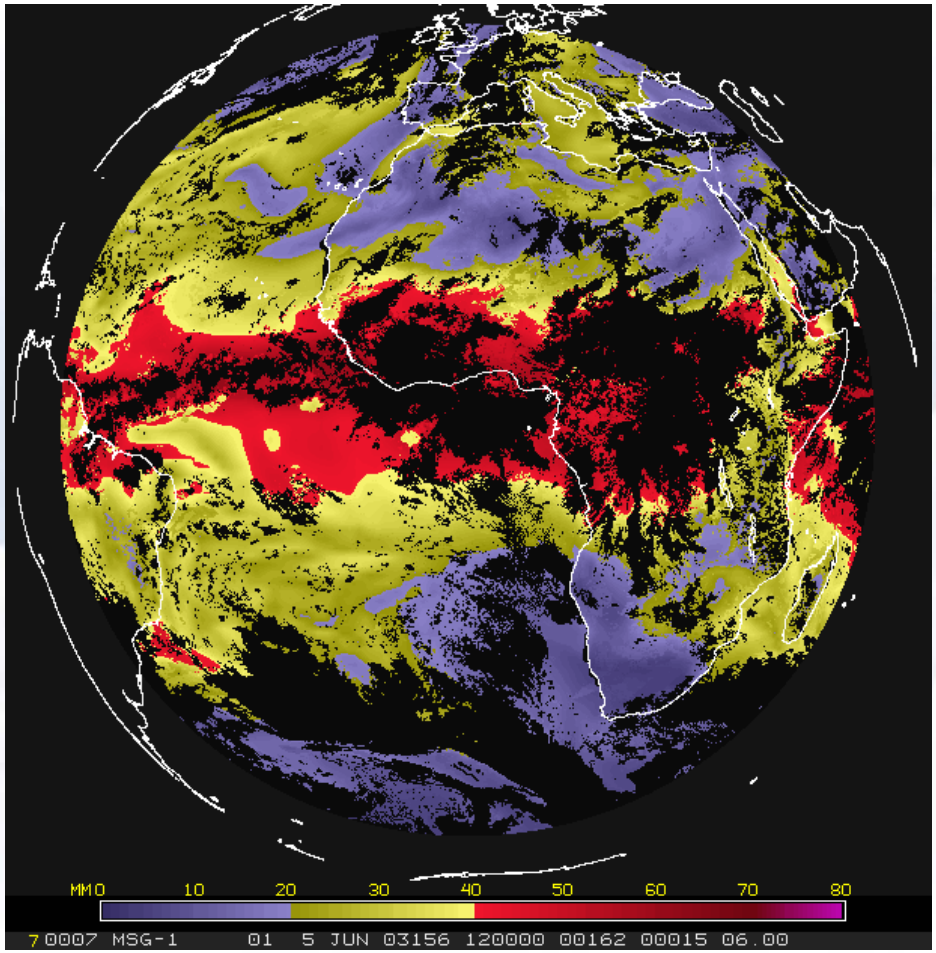
- Results are based on a sound physical background
- Method can be applied to any geographic region, to a different instrument, to a different set of channels, etc.
- First guess profile (=forecast profile) adds additional information, which is needed in case of MSG

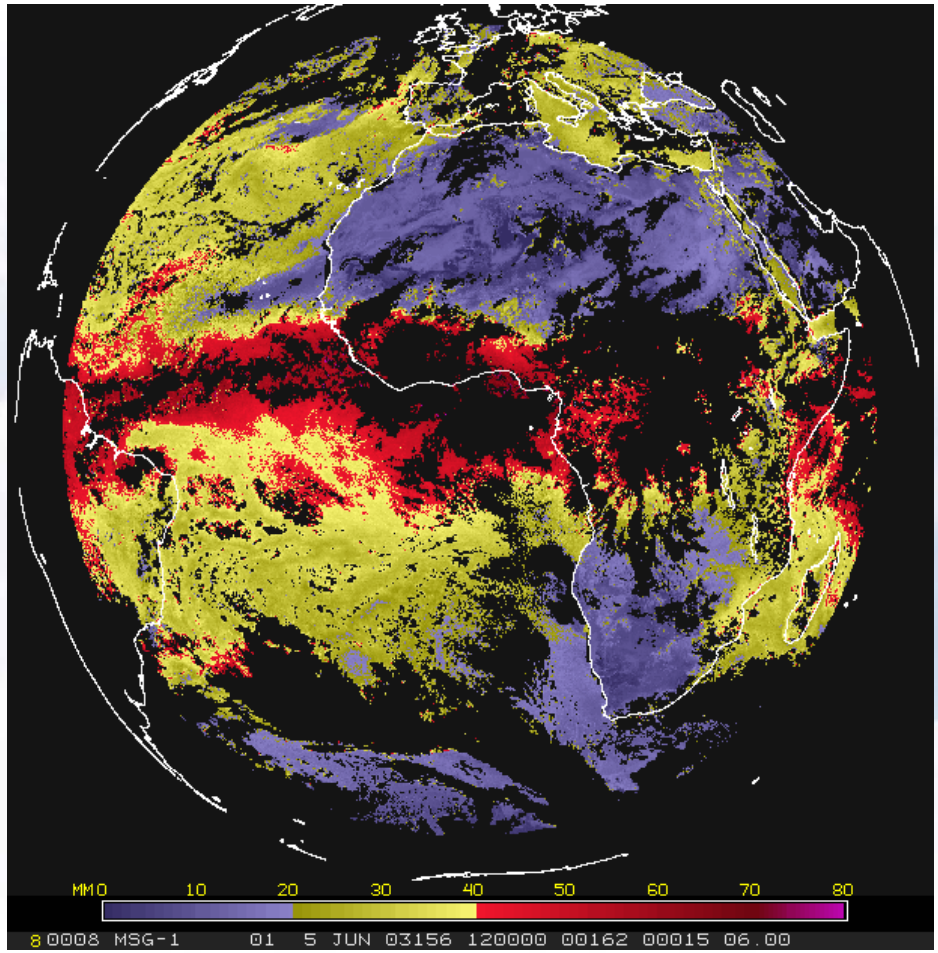
- Cloud detection is “inherent” in the product: we do not find a minimum of the cost function in case of clouds

Application to MSG

- The instability parameters are derived from measured brightness temperatures in the six SEVIRI channels centred at 13.4 µm, 12.0 µm, 10.8 µm, 8.7 µm, 7.3 µm, and 6.2 µm wavelength
- The instability parameters can only be computed over cloud-free areas.
- An iterative retrieval scheme is used to compute the current atmospheric profiles of temperature and humidity. The scheme starts with a “first guess” (e.g. forecasted profile) and adjusts this profile to match the observed brightness temperatures.
- The underlying radiation model is RTTOV (also K-version)

Comparison Phsical – Statistical (EUM Version)





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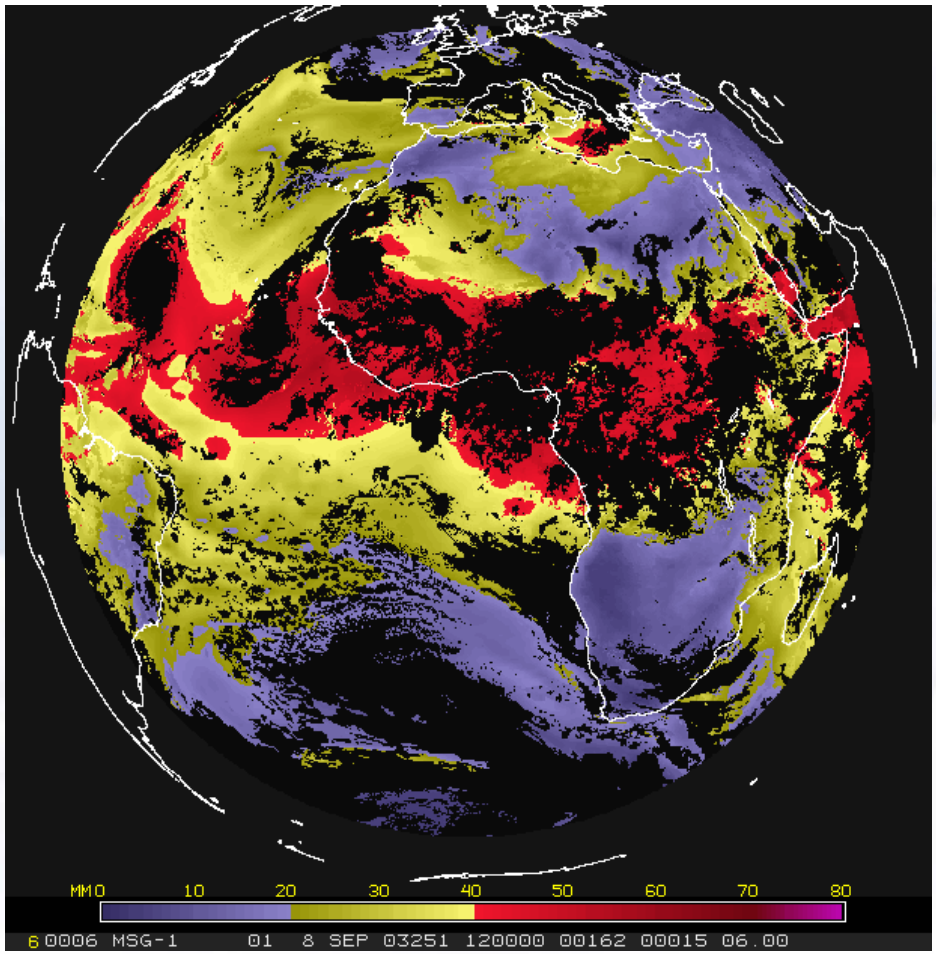
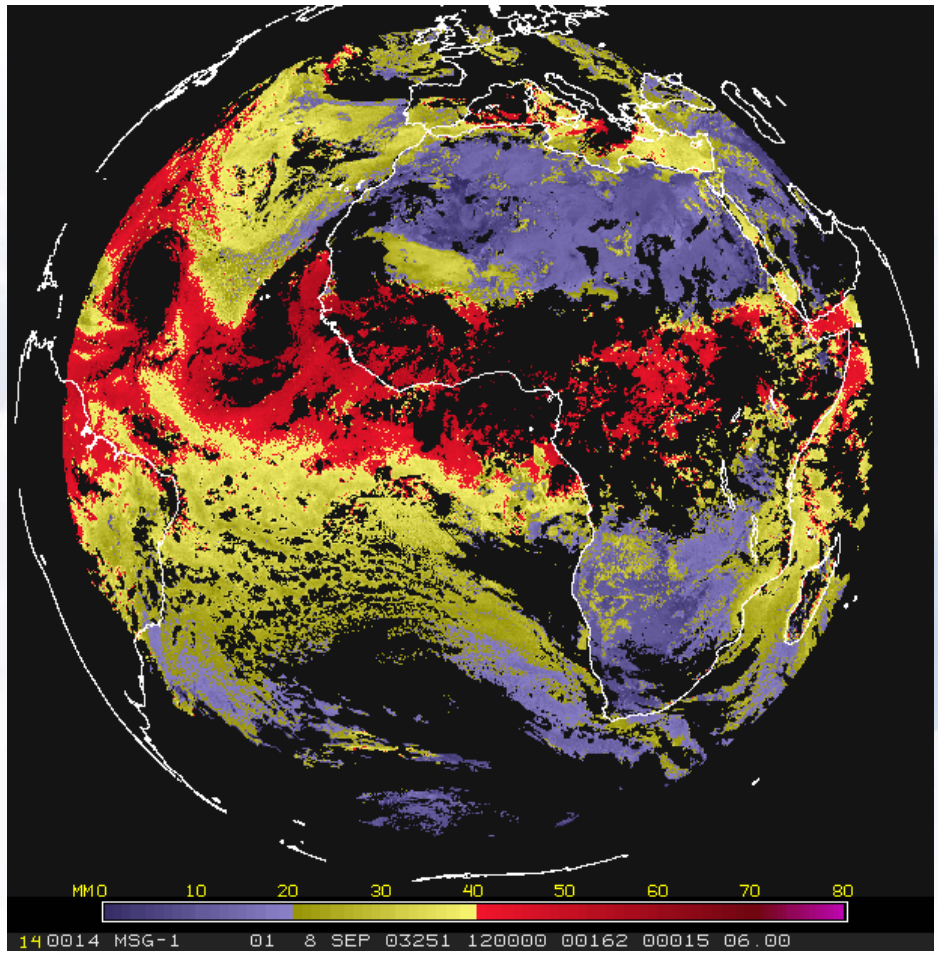
Comparison Phsical – Statistical (EUM Version)





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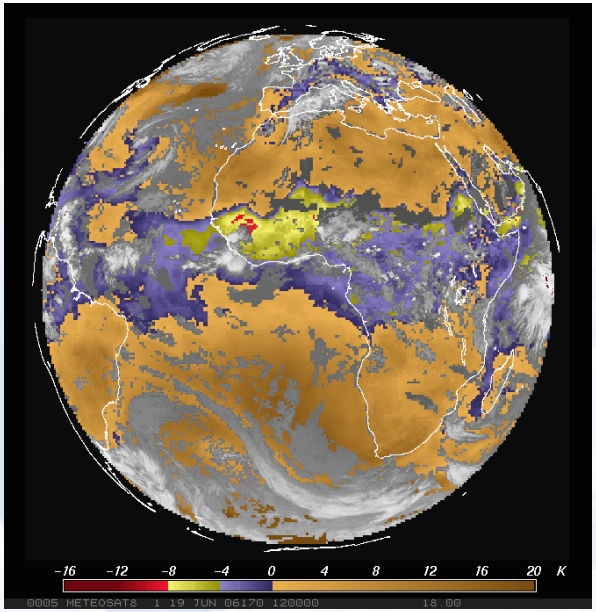
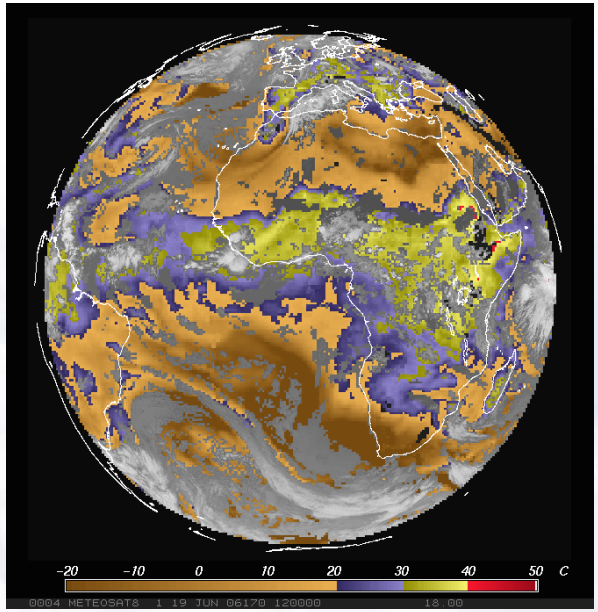
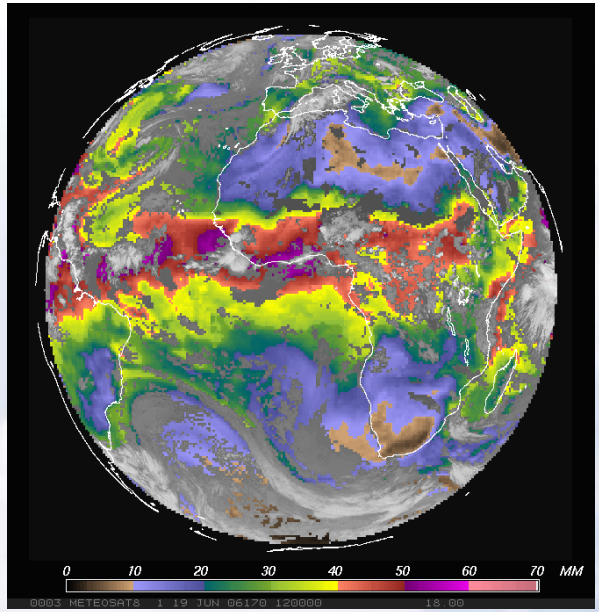
Current Operational Product



Lifted Index



K-Index



TPW

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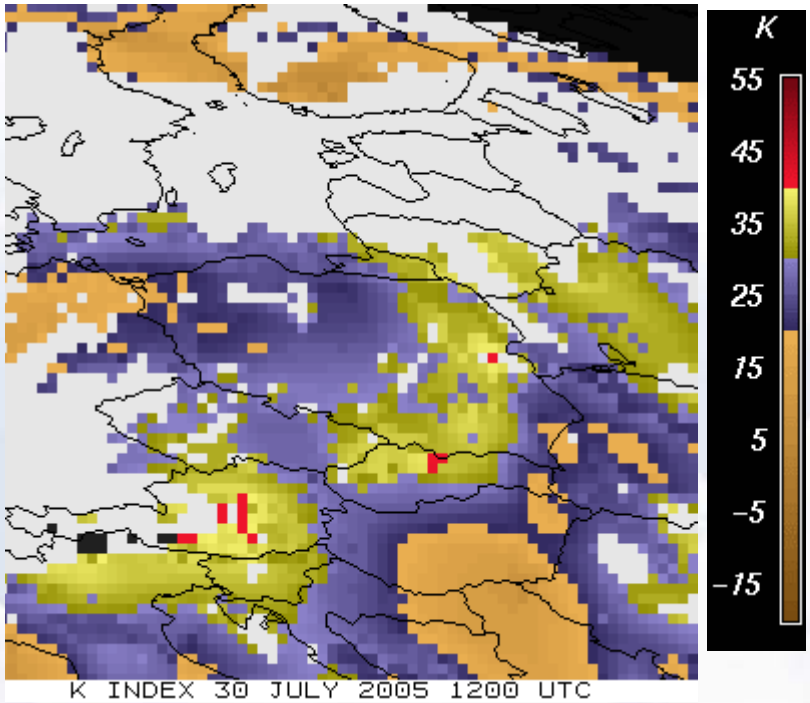
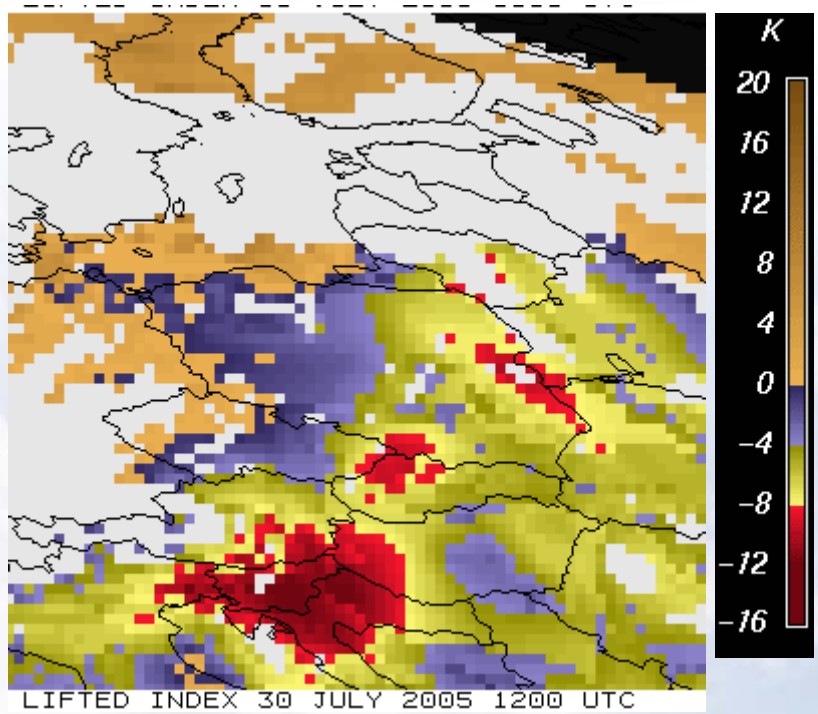
Example: 30 July 2005





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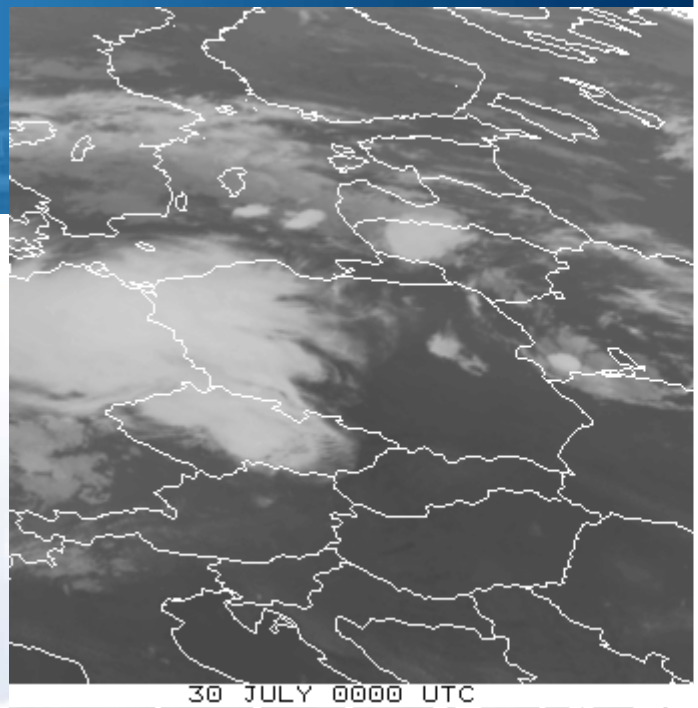
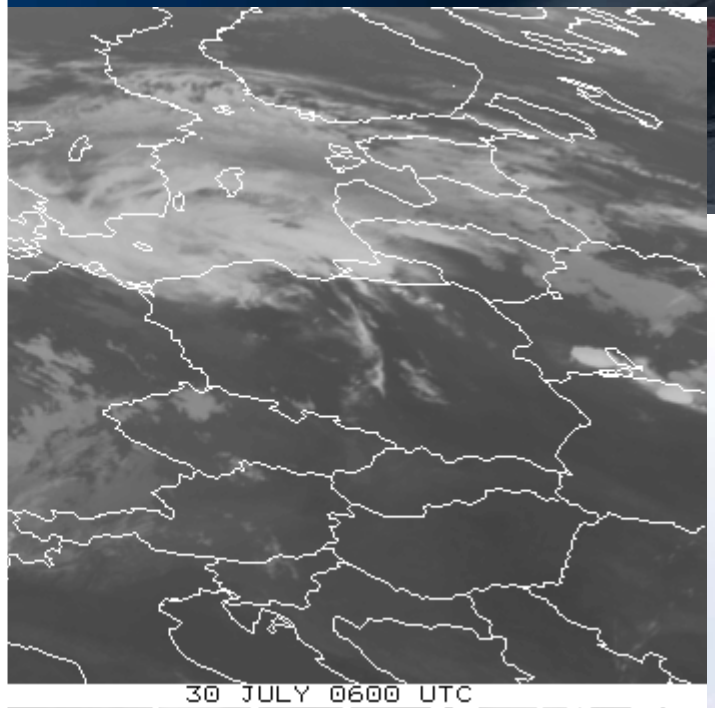
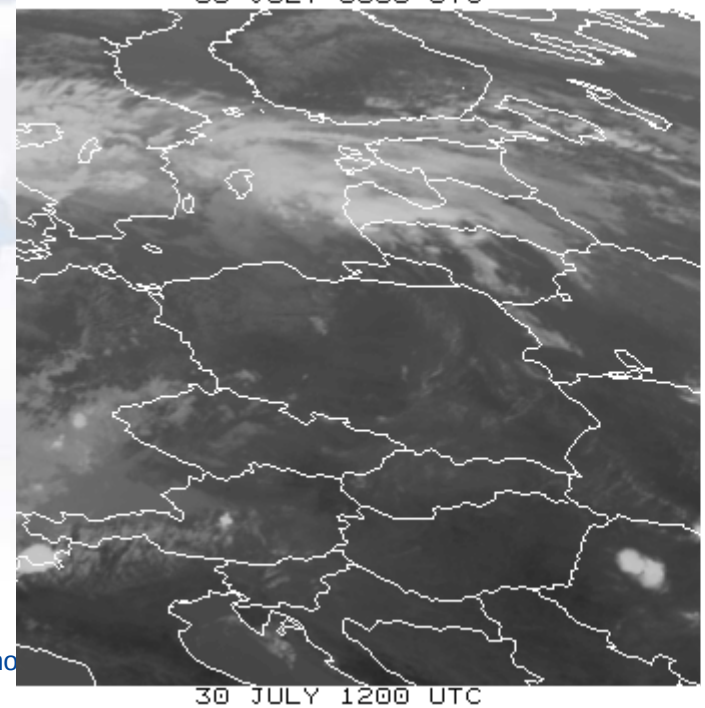
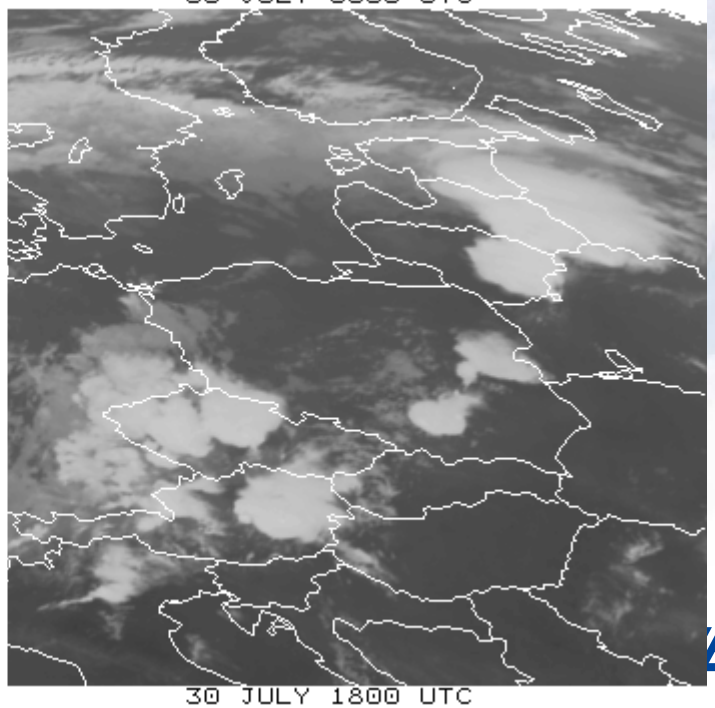
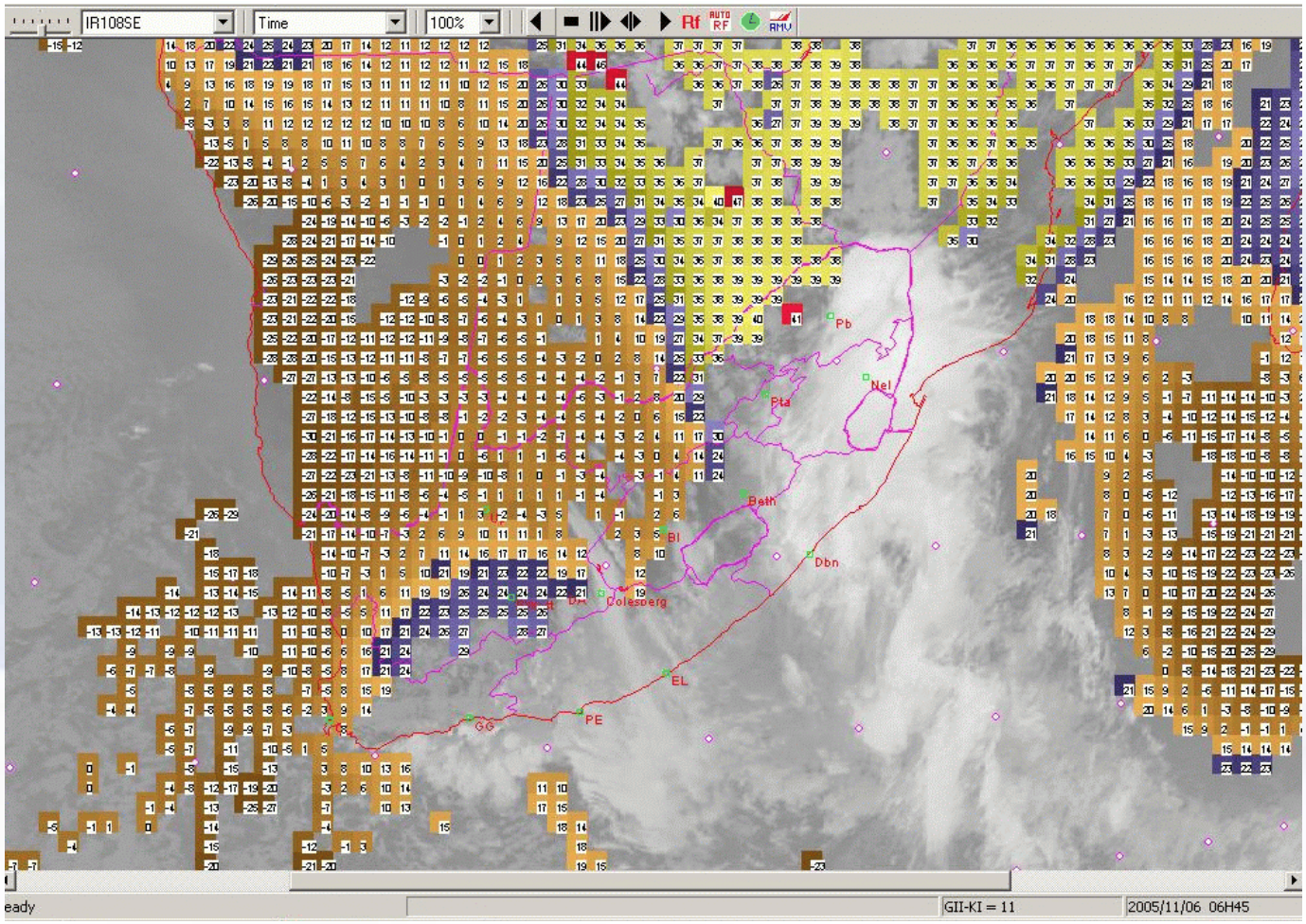

30 JULY 0000 UTC


30 JULY 0600 UTC


30 JULY 1200 UTC


30 JULY 1800 UTC

Example from South Africa



05 November 2005, 0645 UTC – operational K-Index

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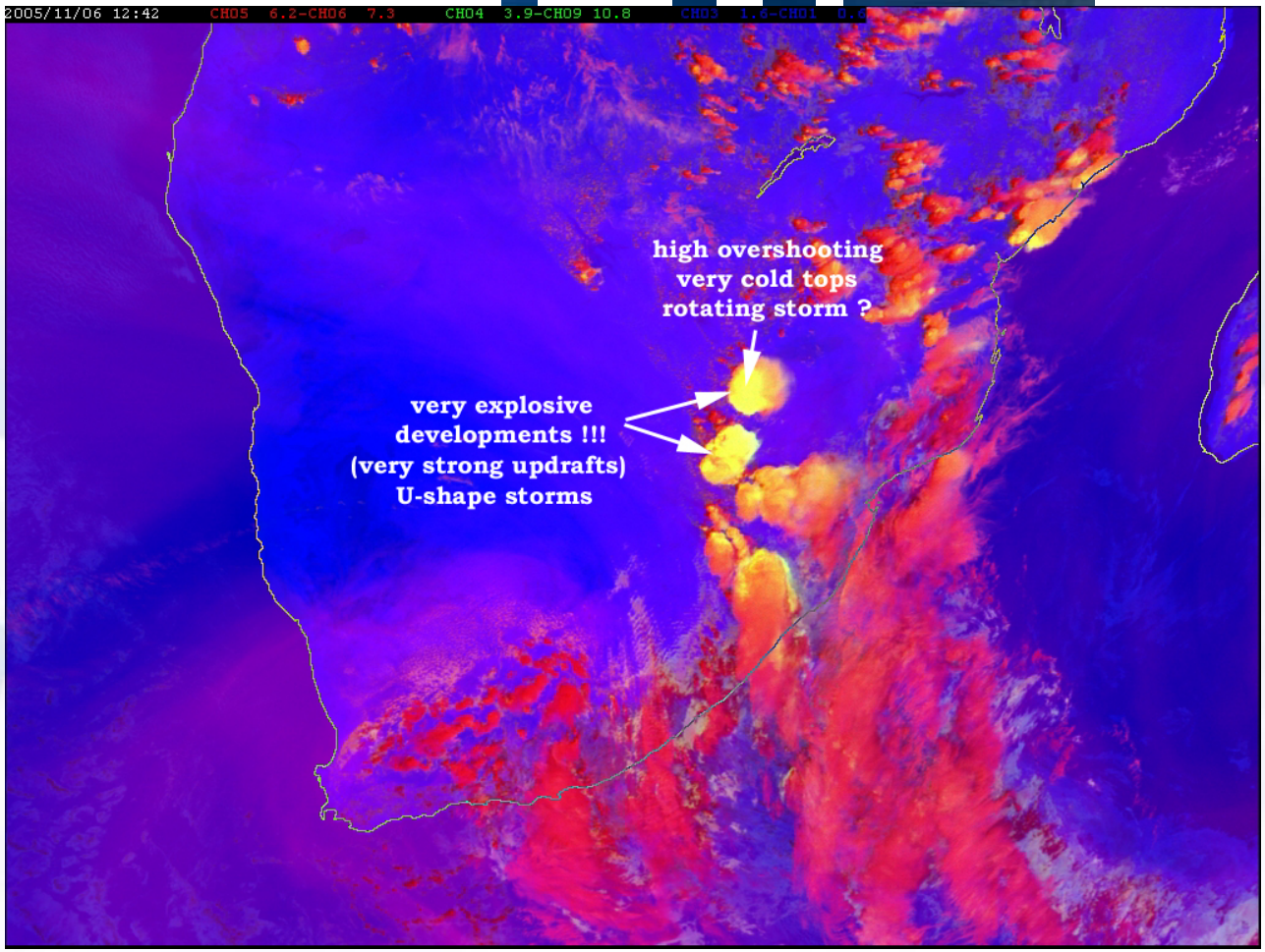
Convective Development 6 Hours later



05 November 2005, 1200 UTC – convection RGB

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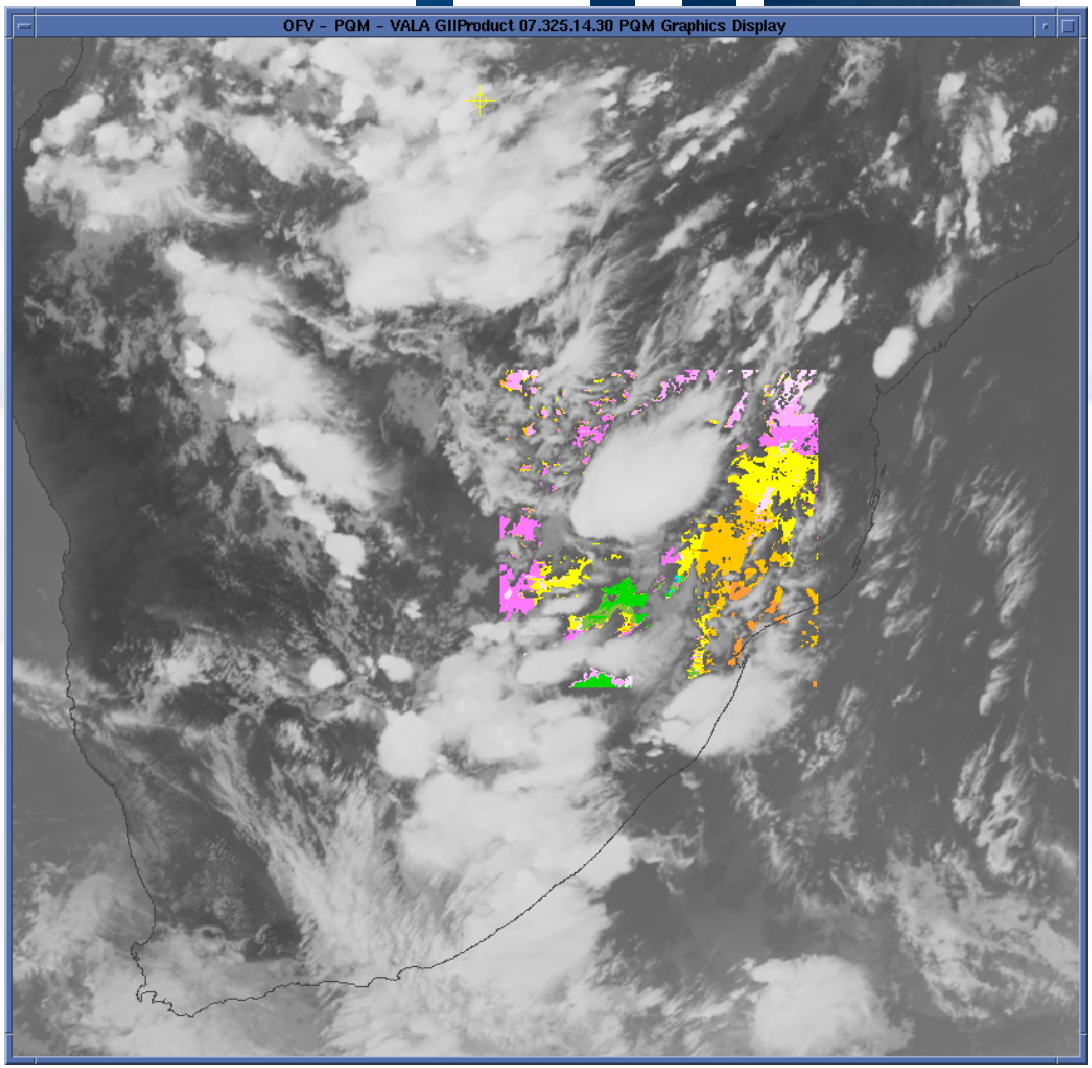
Operational Implementation

Product is derived every 15 minutes, as averages over 15 by 15 MSG pixels

Coarse resolution is seen as a problem, will be improved with MPEF hardware upgrades in 2008

A regional product is available (via ftp) on a pixel resolution: ~250 by 250 pixel region

RII Product over South Africa



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Local GII Installation in South Africa

With the South African Weather Service SAWS

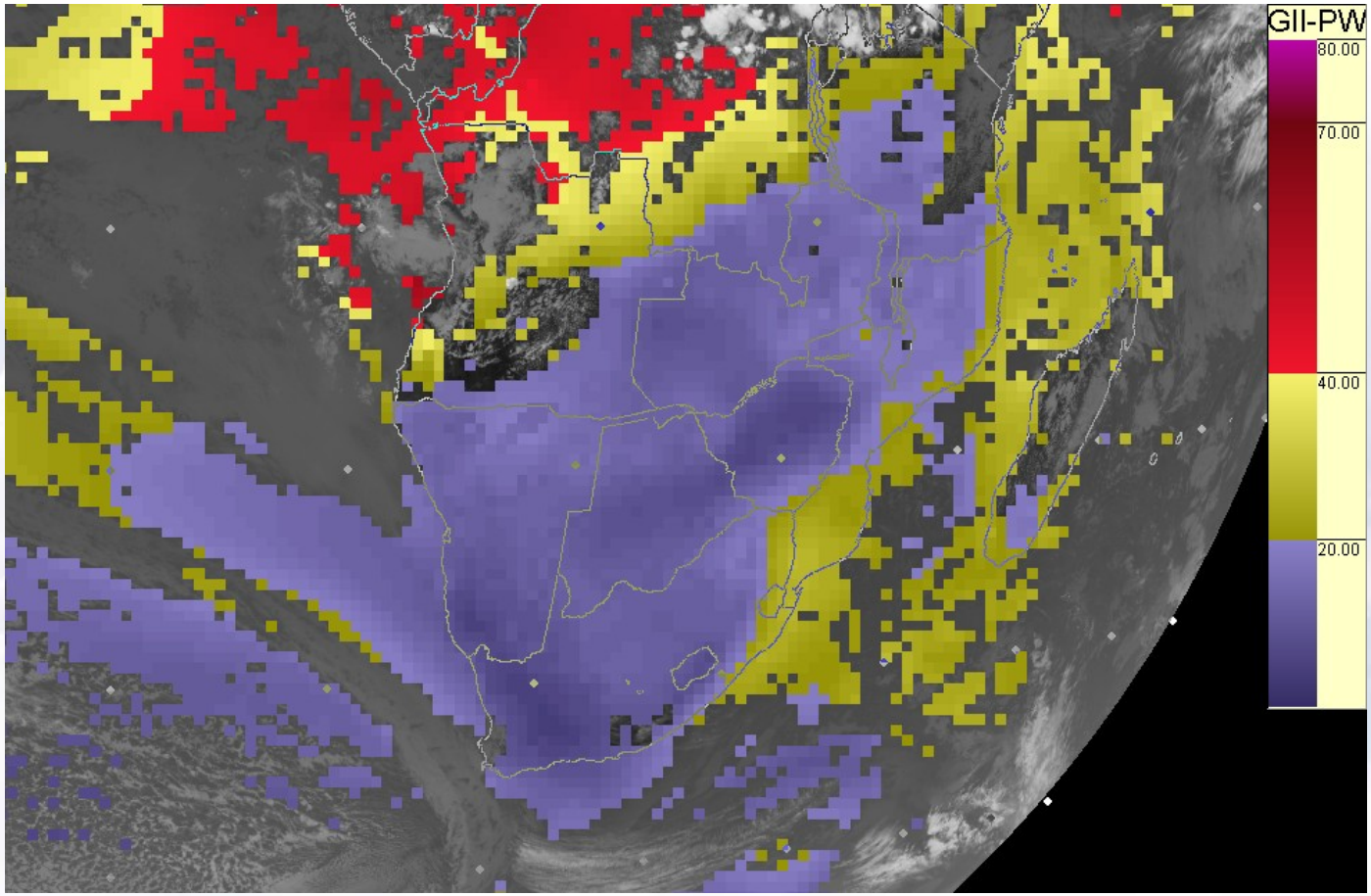
Using their regional model data as background (Unified Model)

Running as 3 x 3 pixel averages, every 15 minutes

Validation study with lightning observations ongoing

2006/2007 findings: ~0.80 POD, ~0.30 FAR for K-Index

Example of Operational GII Product



15 x 15 averages, total prec. water

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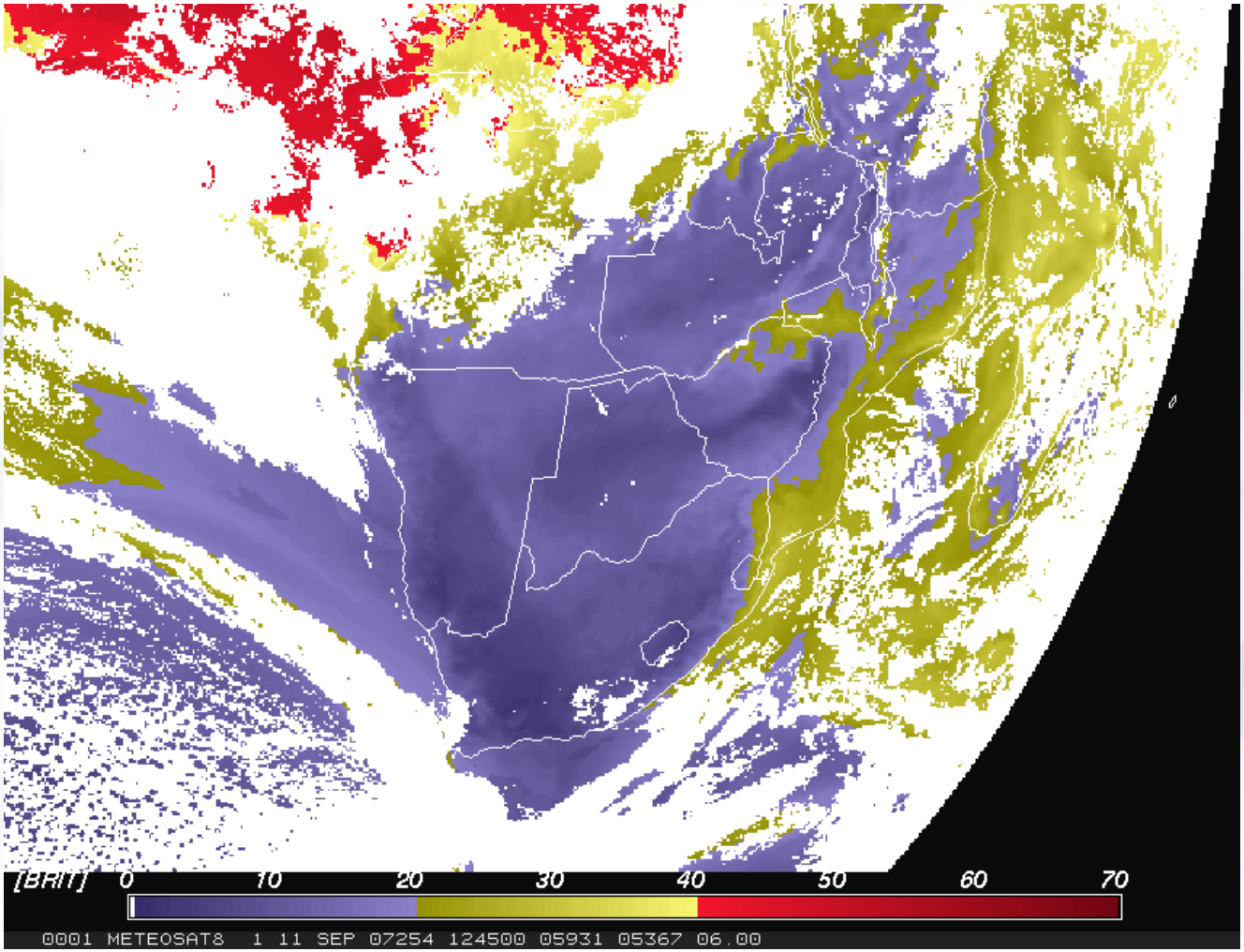
Local SAWS Product



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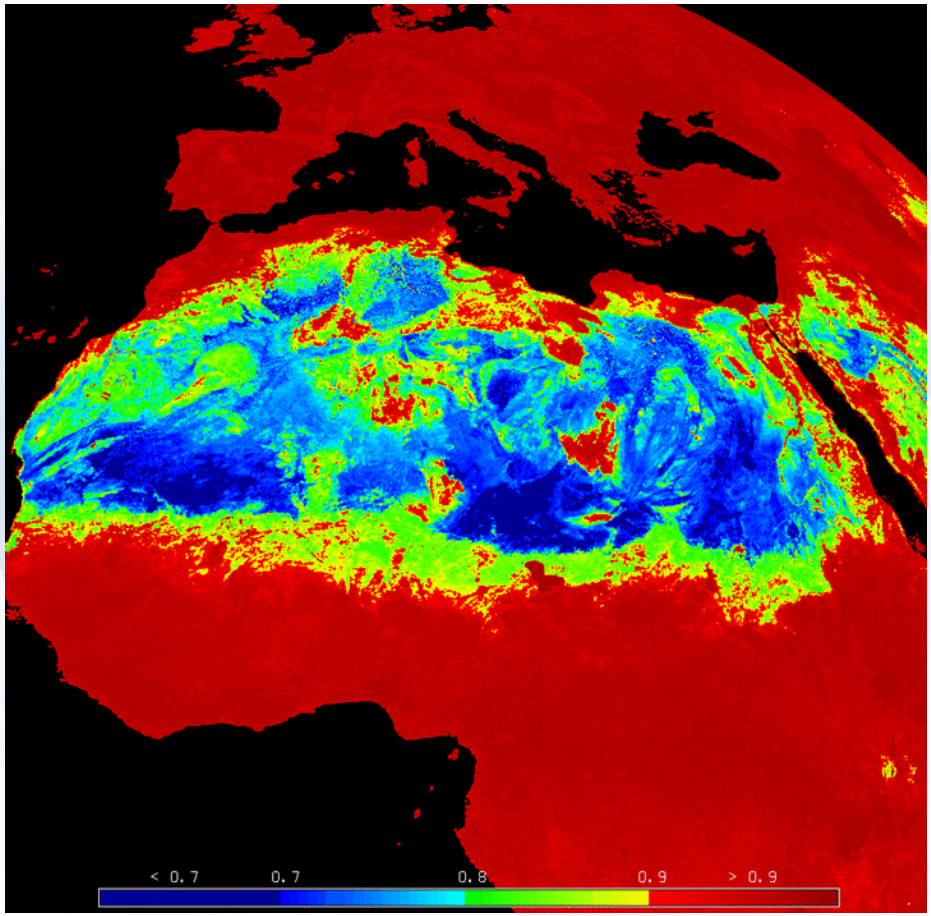
Latest Improvements

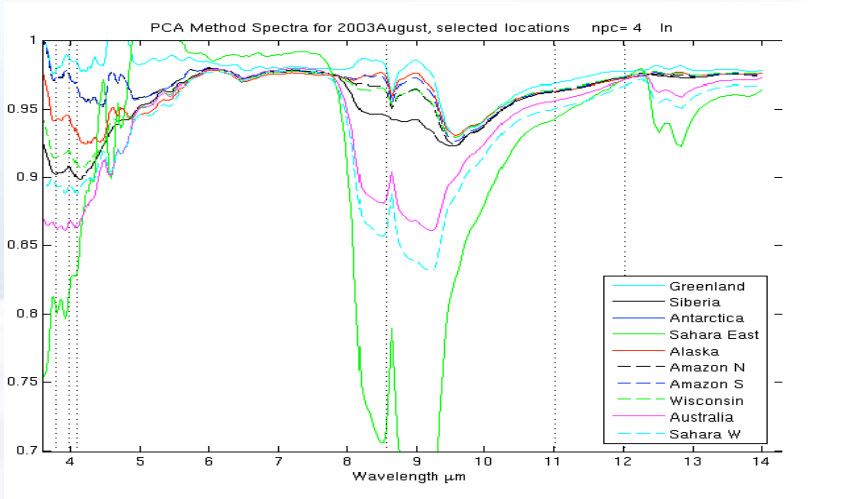
Proper consideration of surface emissivity

(monthly pixel values, interpolated from MODIS measurements, provided by CIMMS)

Pixel values are now used within the radiation model with their correct surface emissivity

Main Problem: IR8.7 Channel





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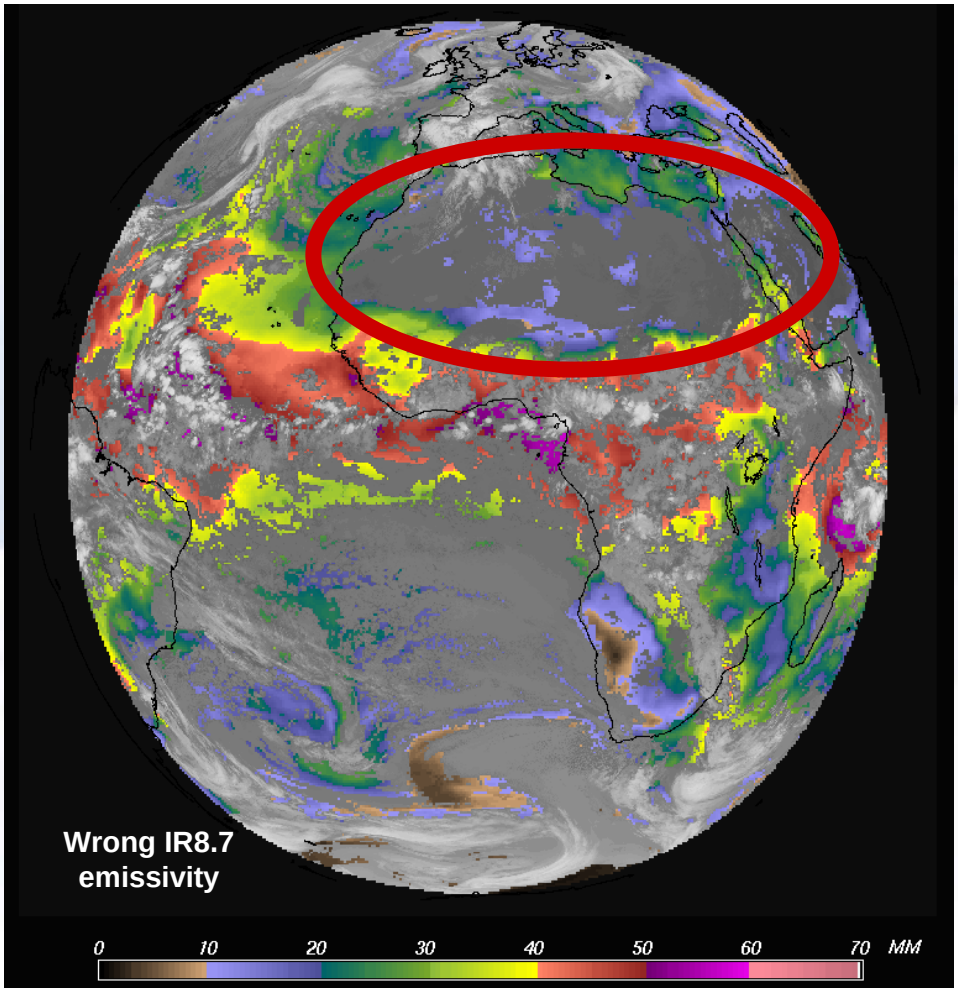
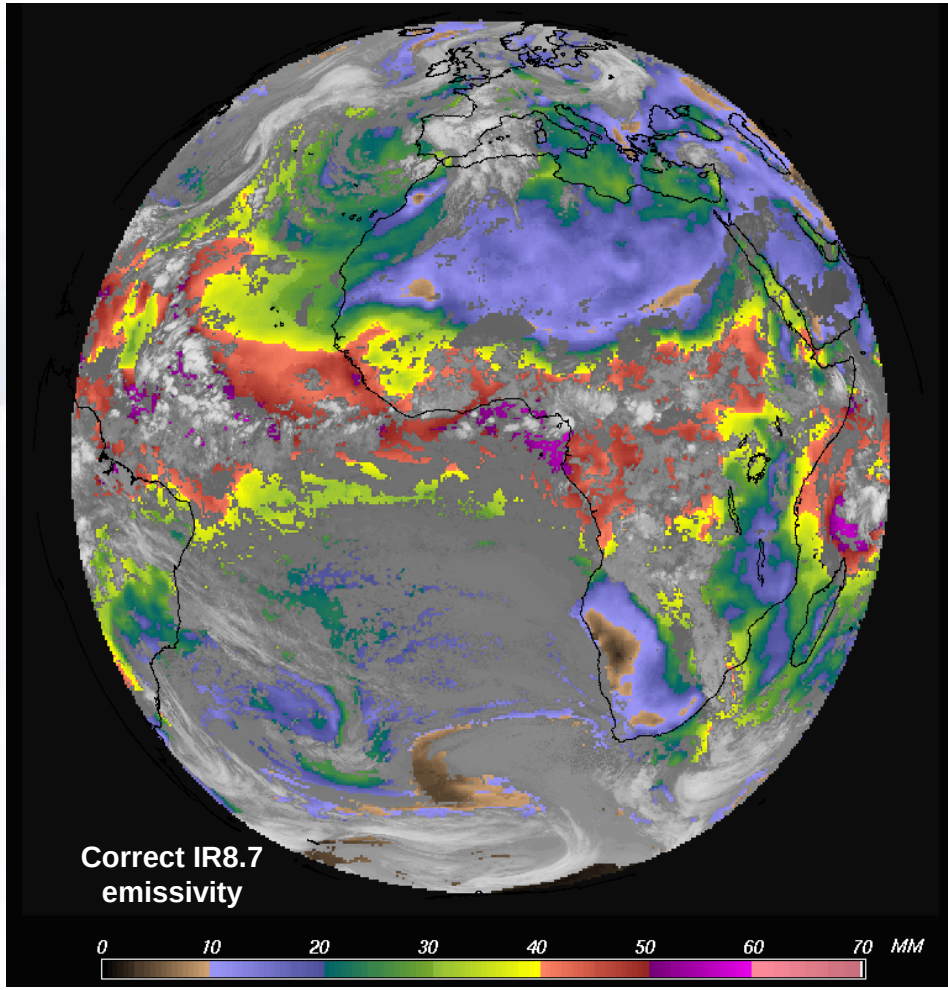
Effect on the Product





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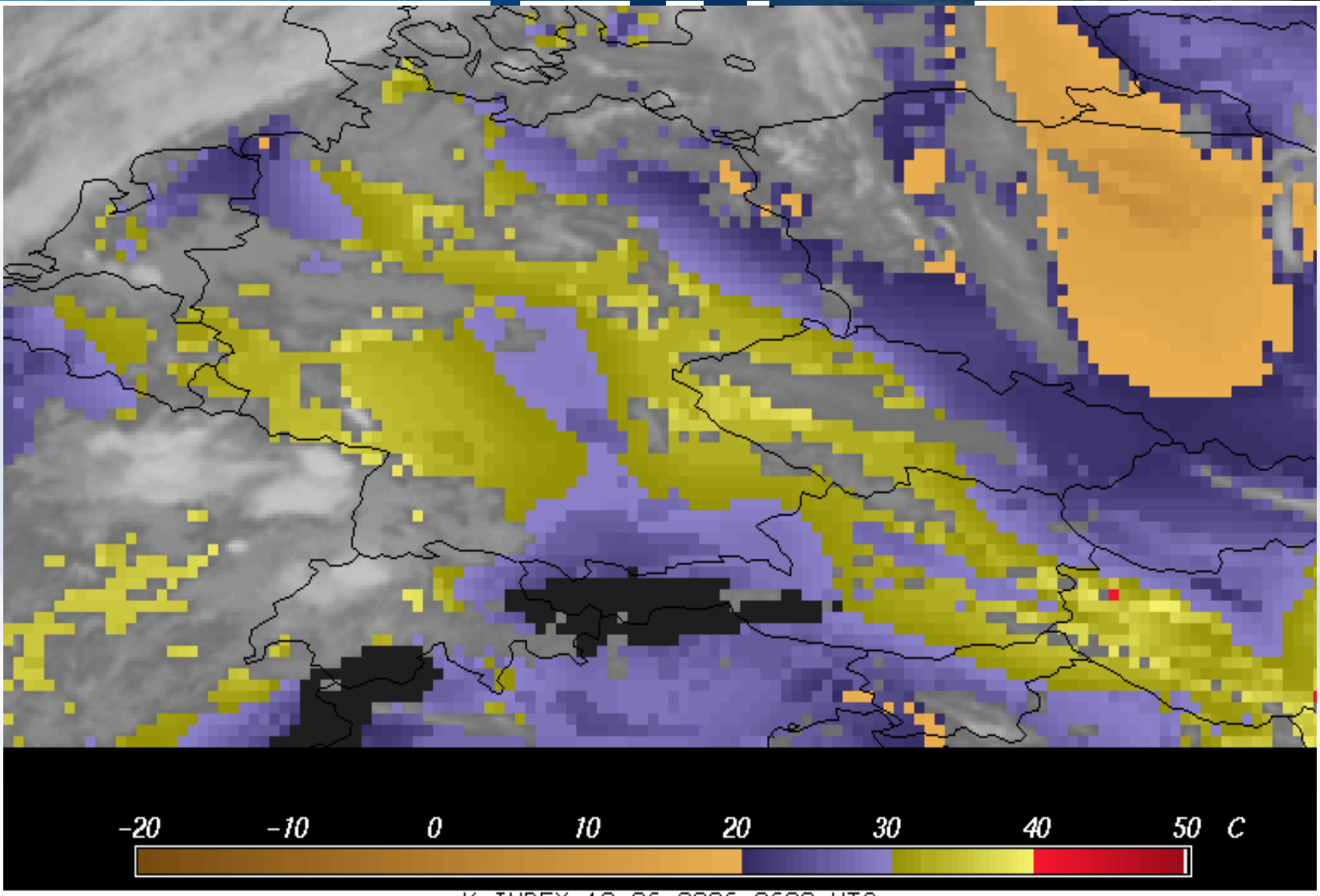
Impact of Forecast Data

The physical retrieval seems to give “reasonable” results.

How does it compare to the underlying forecast?

Do we actually add information?

K-Index, 19 June 2006 0600 UTC



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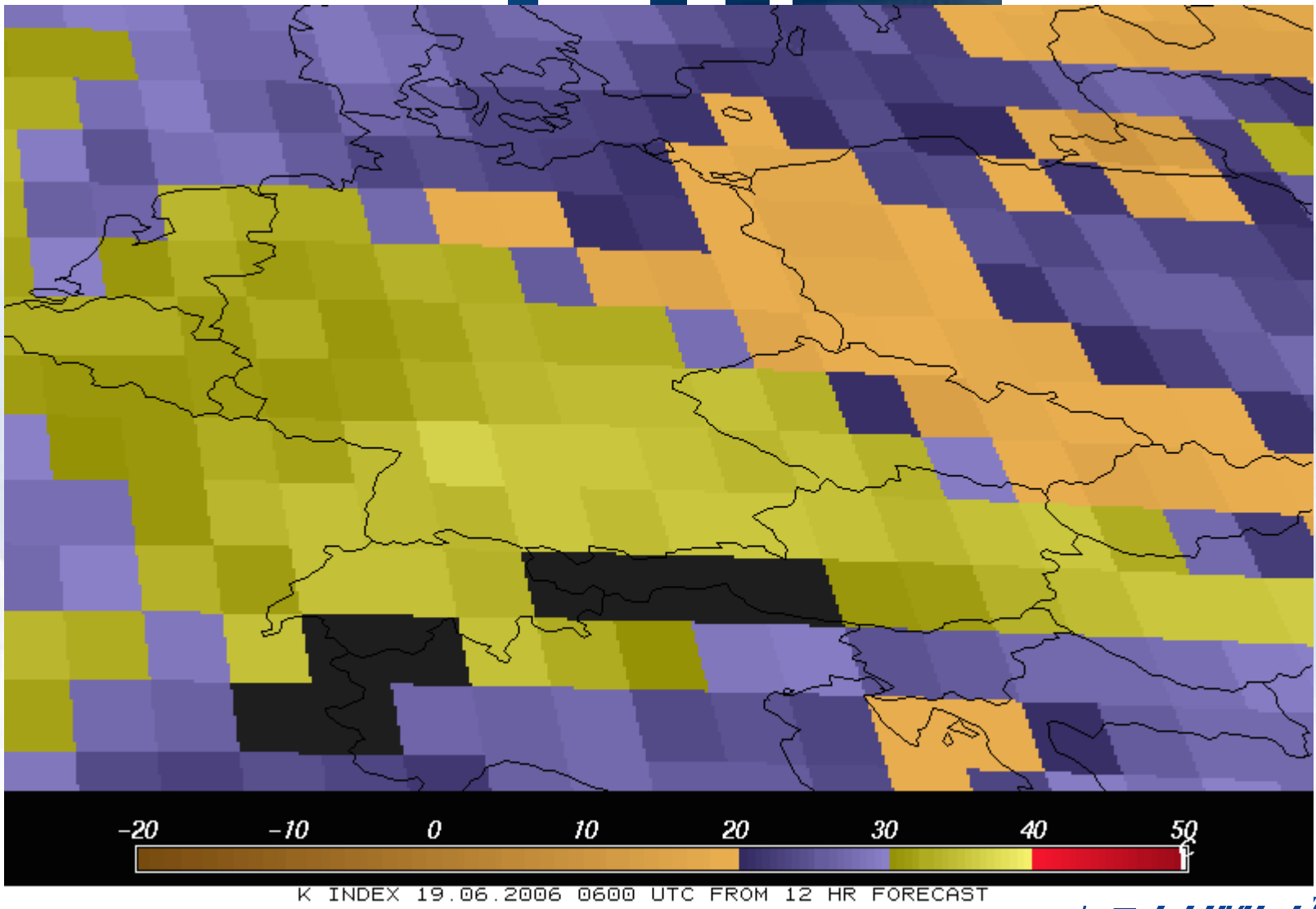
And from the 12 Hour Forecast



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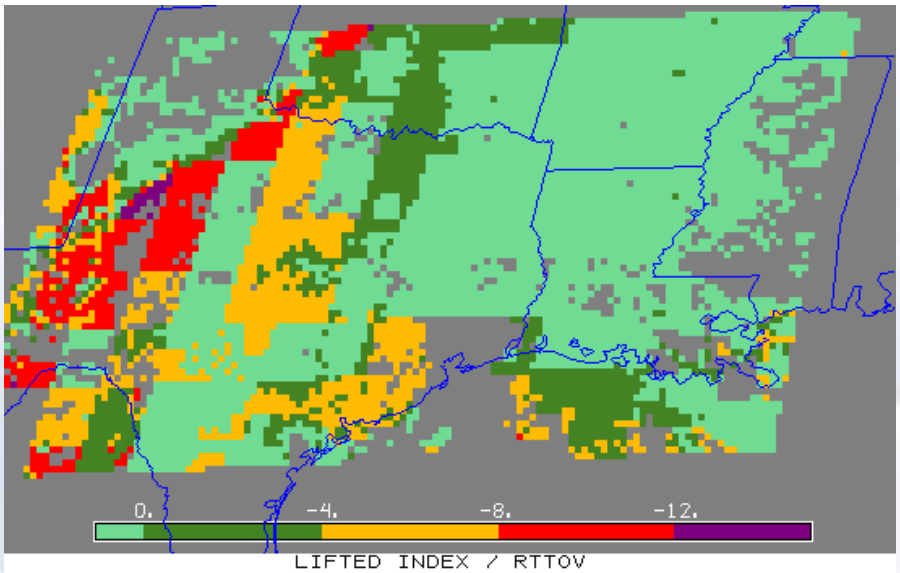
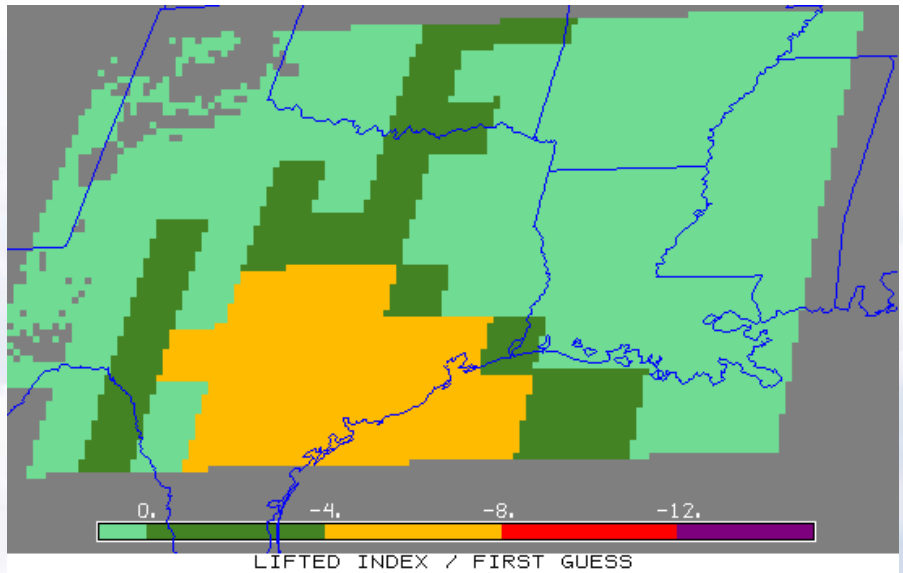
Old Example – GOES Sounder





For the forecaster the satellite products are important in case of a wrong forecast of a really severeevent!

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User Perspective

A number of case studies have been looked at
- with SAWS (South Africa)
- with ZAMG (Austria)
- with IMGW (Poland)

Training material has been developed (EUMeTrain)

"Convection Workshop" in Krakow (15-17/11/07) sees this product as one ingrdient of a series of severe convection warning measures

Summary

The physical retrieval, which uses the MSG measurements as additional information, does (mostly) not drastically change the forecast, but changes local extremes and gradients

- ⇒ **Satellite Measurements provide extra information (gradients, intensity)**
- ⇒ **Instability Indices are only one measure to describe potential of convection**
- ⇒ **Other contributing factors, e.g. mesoscale wind field, orography**