MSG Derived Instability Indices Overview

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Instability

- Conditional and latent instability: parcel method (stability of an air parcel to vertical displacements)
- Can lead to severe convection
- Satellite measurements: find out about this instability during pre-convective conditions
- MSG GII product (GII = global instability indices) derives this product operationally on a ~10km scale for the entire MSG field-of-view (~4 km for RSS)

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- Lifted Index:

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

- K-Index:

  $KI = (T^{obs(850)} - T^{obs(500)}) + TD^{obs(850)} - (T^{obs(700)} - TD^{obs(700)})$

- KO-Index:

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

- Maximum Buoyancy Index:

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

- Total Precipitable Water, Layer Precipitable Water in 3 Layers

These parameters are part of the MSG GII product.

Instability: Index must exceed a certain threshold (which depends on the parameter, e.g. <0 deg for LI, > 20 deg for K)

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Method is a Physical Retrieval

- Iterative retrieval of the temperature and humidity profile:

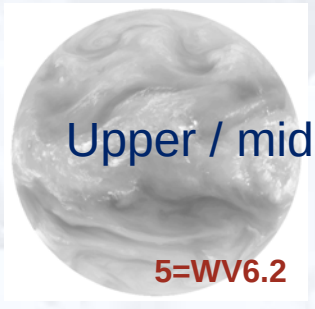
$$x_{n+1} = x_0 + (S_x^{-1} + K_n^t S_e^{-1} K_n)^{-1} * (K_n^t S_e^{-1} (T_B - T_B^n + K_n (x_n - x_0))$$

Observation vector x of iteration step n can be found from:

- first guess profile x_0
- error of measurement S_e
- error of first guess S_x
- observed brightness temperatures T_B
- change of brightness temperatures with a changed profile K_n

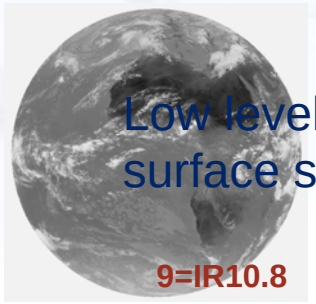
- The retrieval changes the first guess profile such that it best matches the satellite observations (practically a 1-DVar type of retrieval, using 6 MSG thermal channels)
- First guess is the ECMWF forecasted profile

MSG Channels of Interest for GII

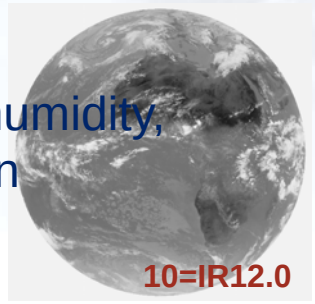


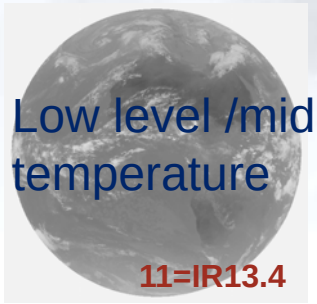
Upper / midlevel humidity

Low level humidity, surface skin



Low level humidity, surface skin





Low level /midlevel temperature

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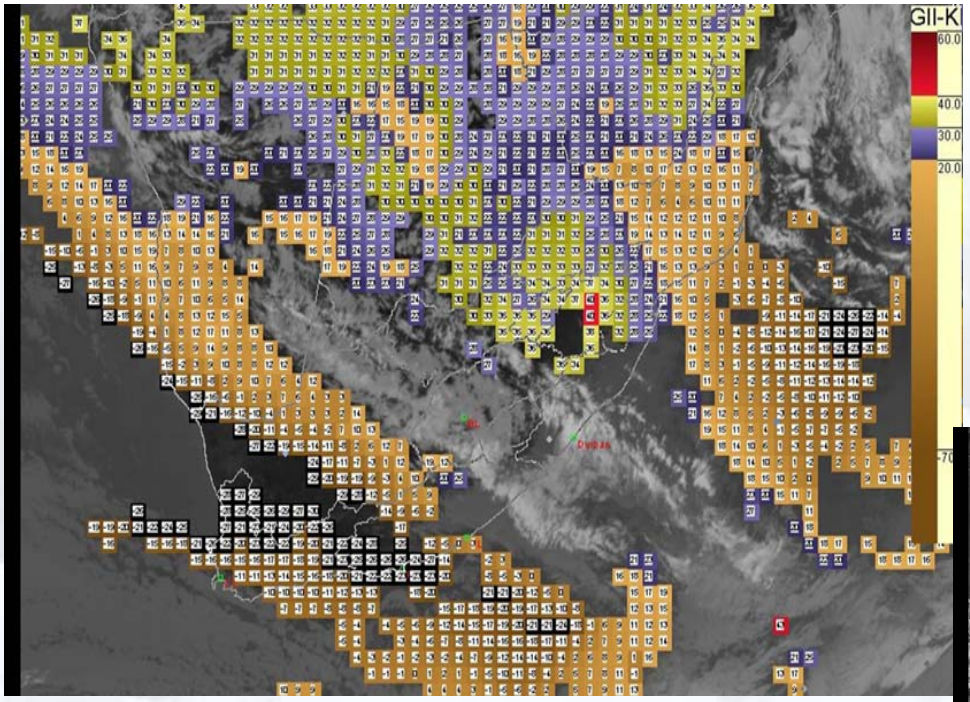
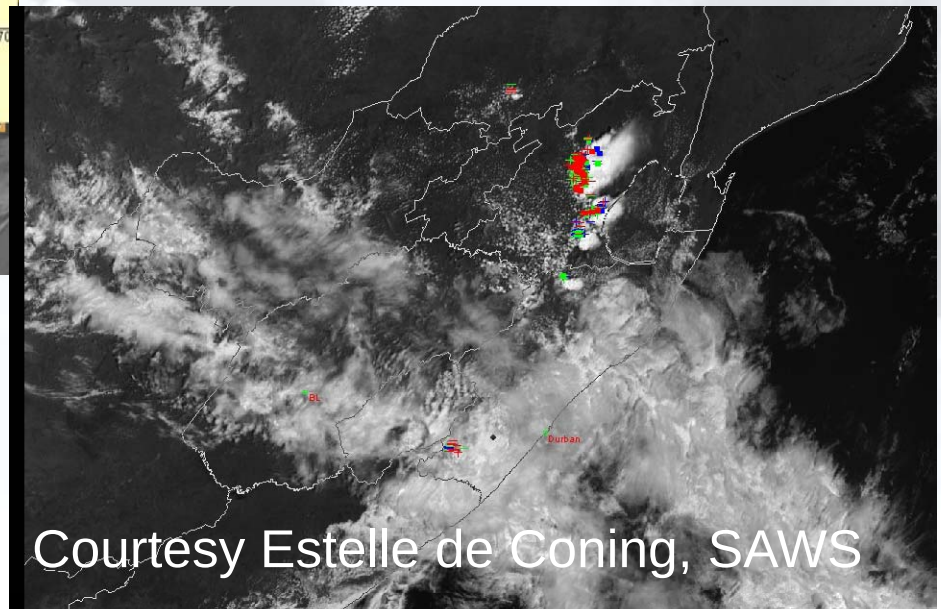
GII – Use Case



26. October 2006, 0800 UTC

26. October 2006, 1100 UTC



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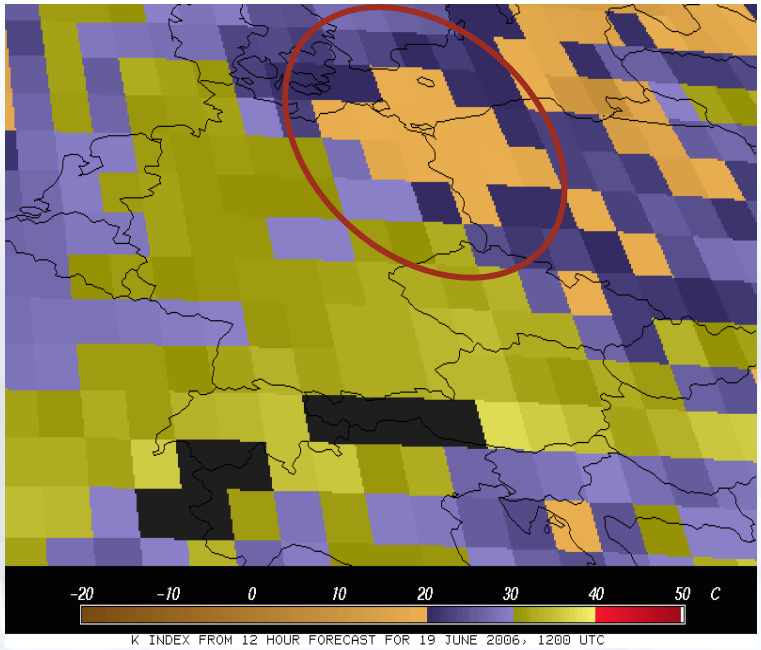
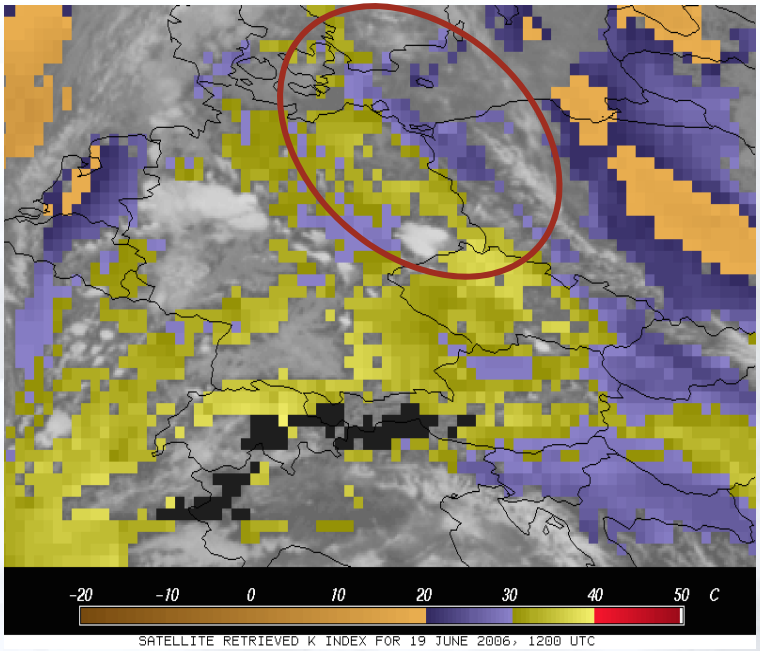
GII – Relation to Forecast





K-Index: ECMWF Forecast and GII product show differences: value added by the satellite

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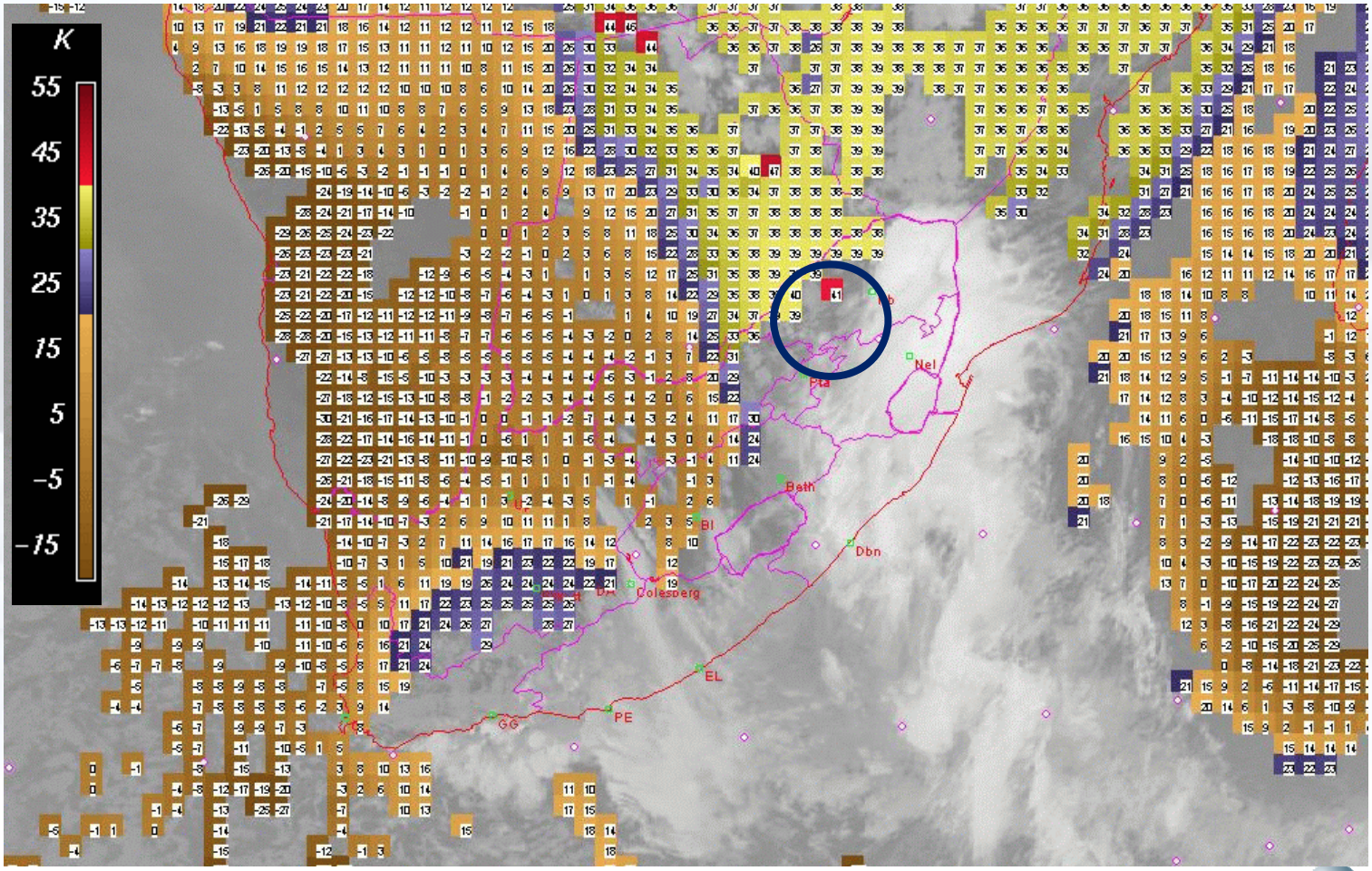
06 November 2005 Case



0645 UTC

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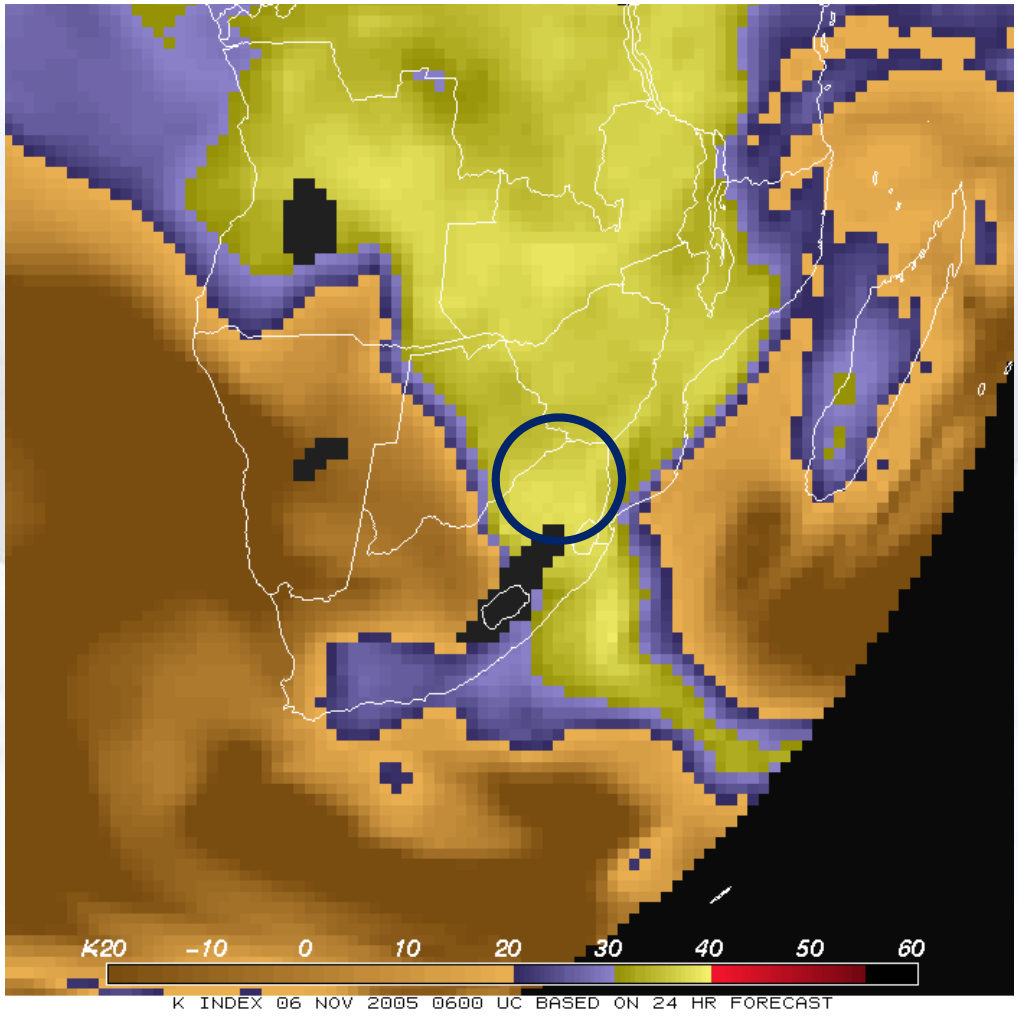
Relation to Forecast



This picture shows in the same colour scale the K Index as it would have been obtained by the model itself (this is the “first guess” that goes into the GII retrieval): Already here we see the area of unstable air (in yellow) in the storm area (circle) – however, if you compare with the previous slides, the MSG GII has actually changed these values to even stronger instability.

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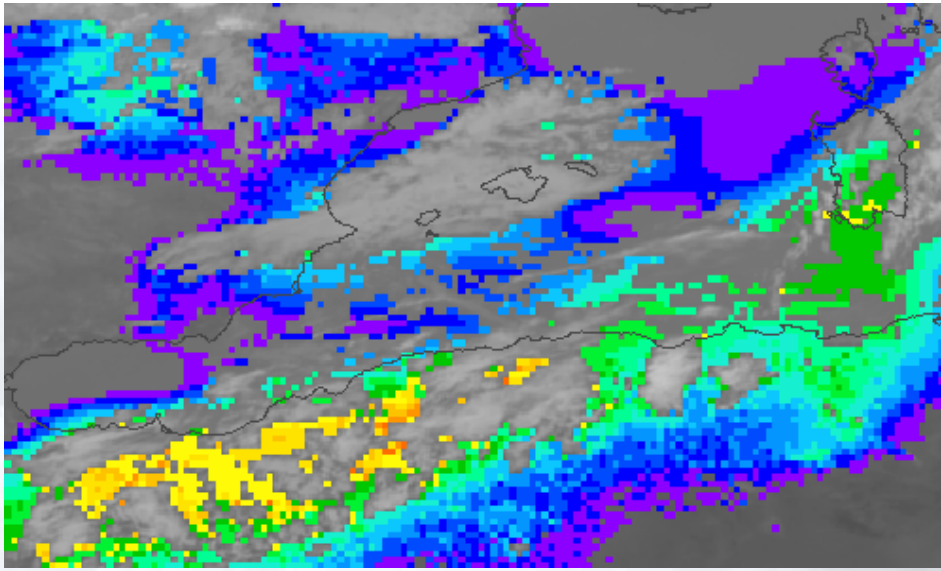
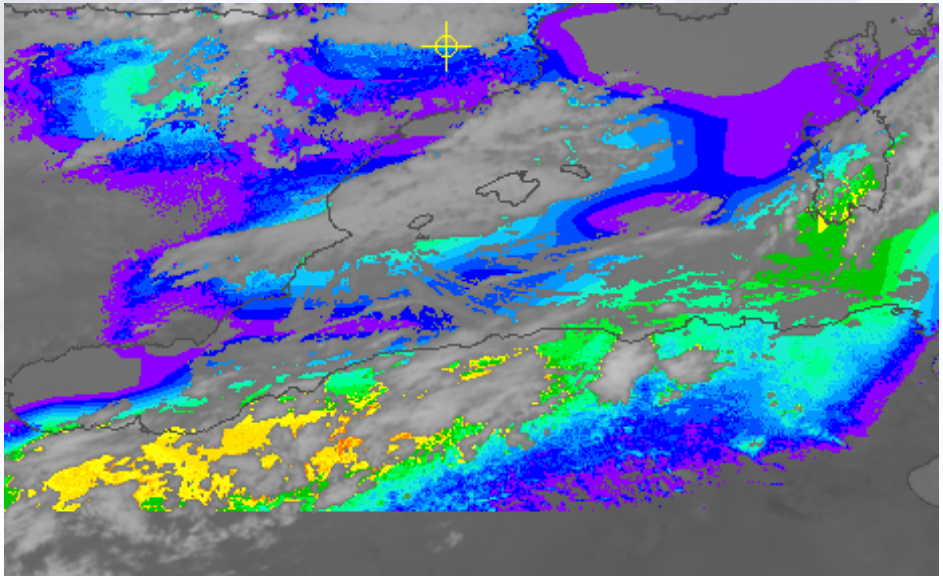
EUMETSAT Operational Setup

GII: Meteosat-9 full disk,
3x3 pixel product



K-Index, never mid the colour scale violet=7C, yellow=30C)



RII: Meteosat-8 RSS feed,
Pixel product

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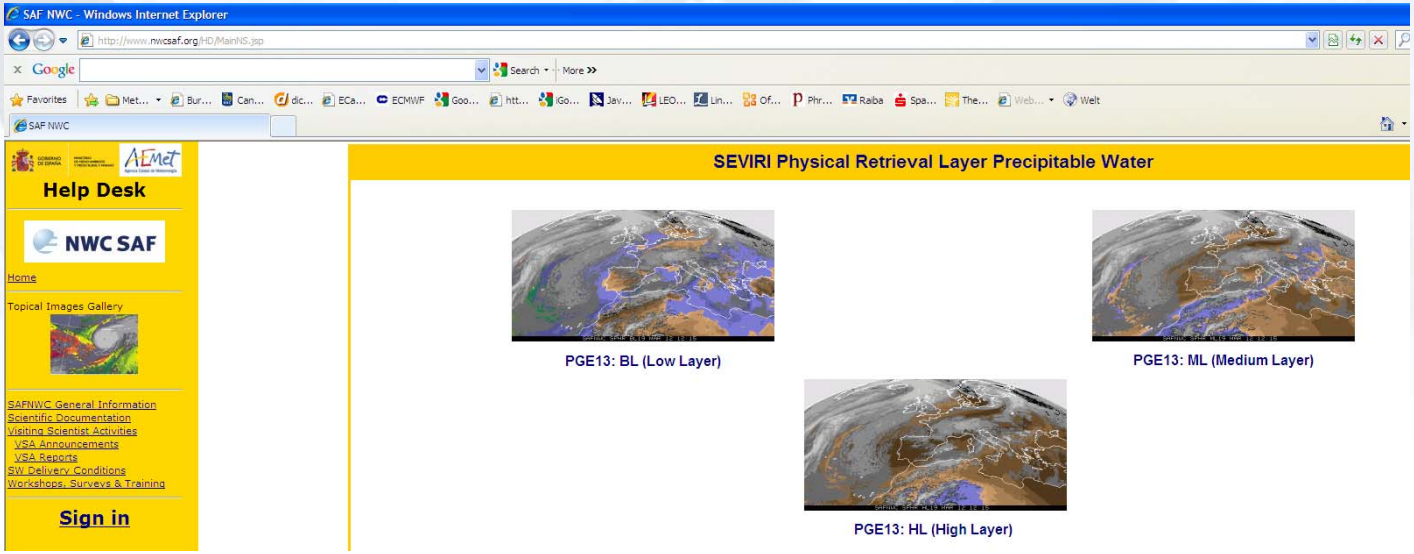
Respective NWC SAF Product: PGE13

www.nwcsaf.org



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