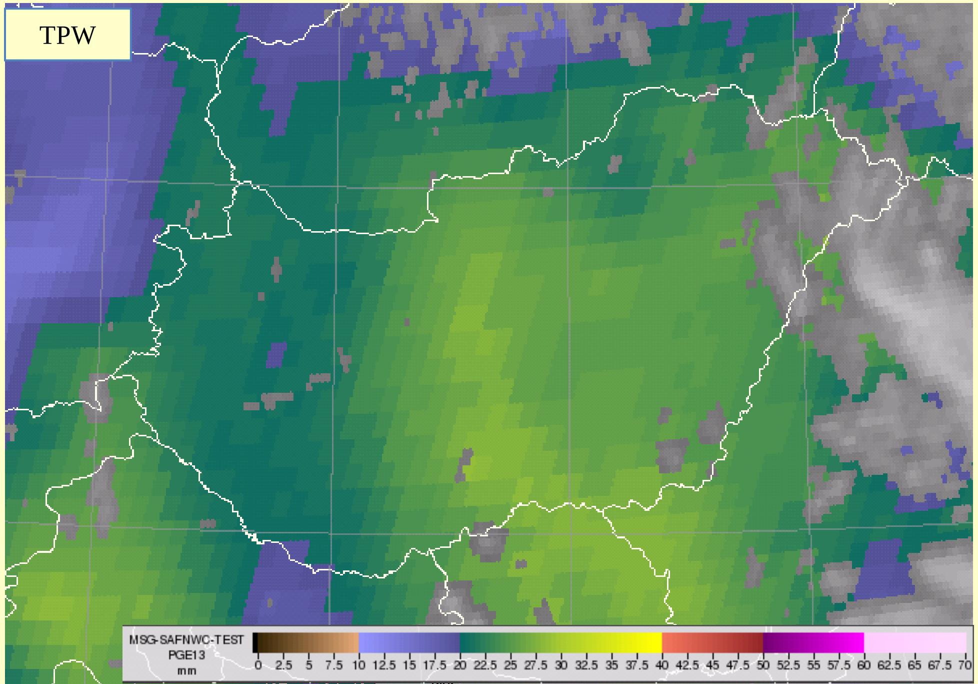
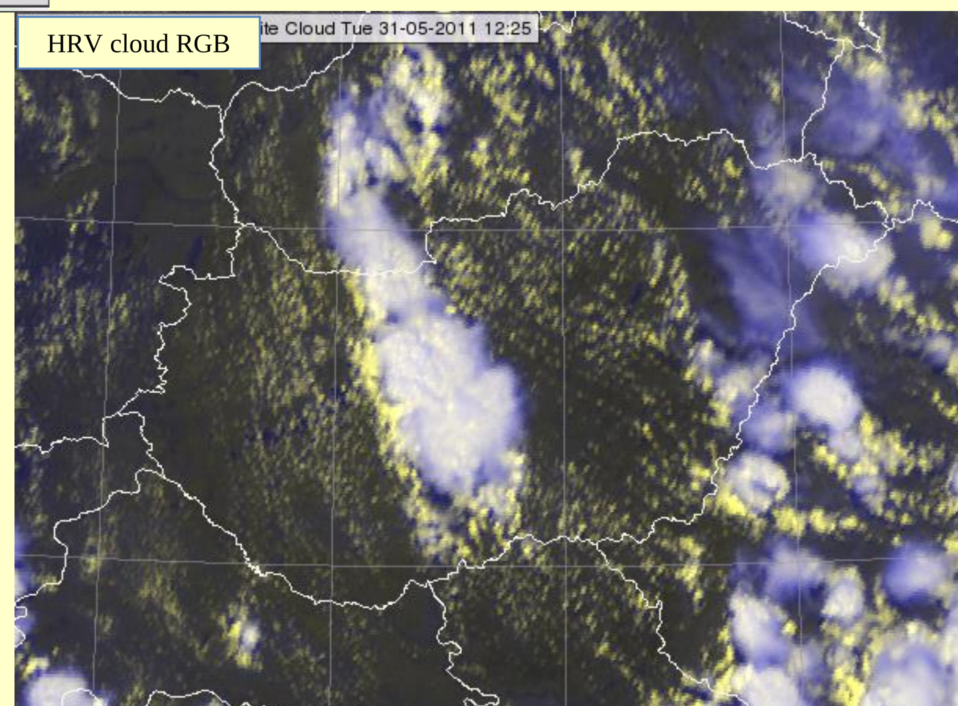



# Applications of the Clear Air Products

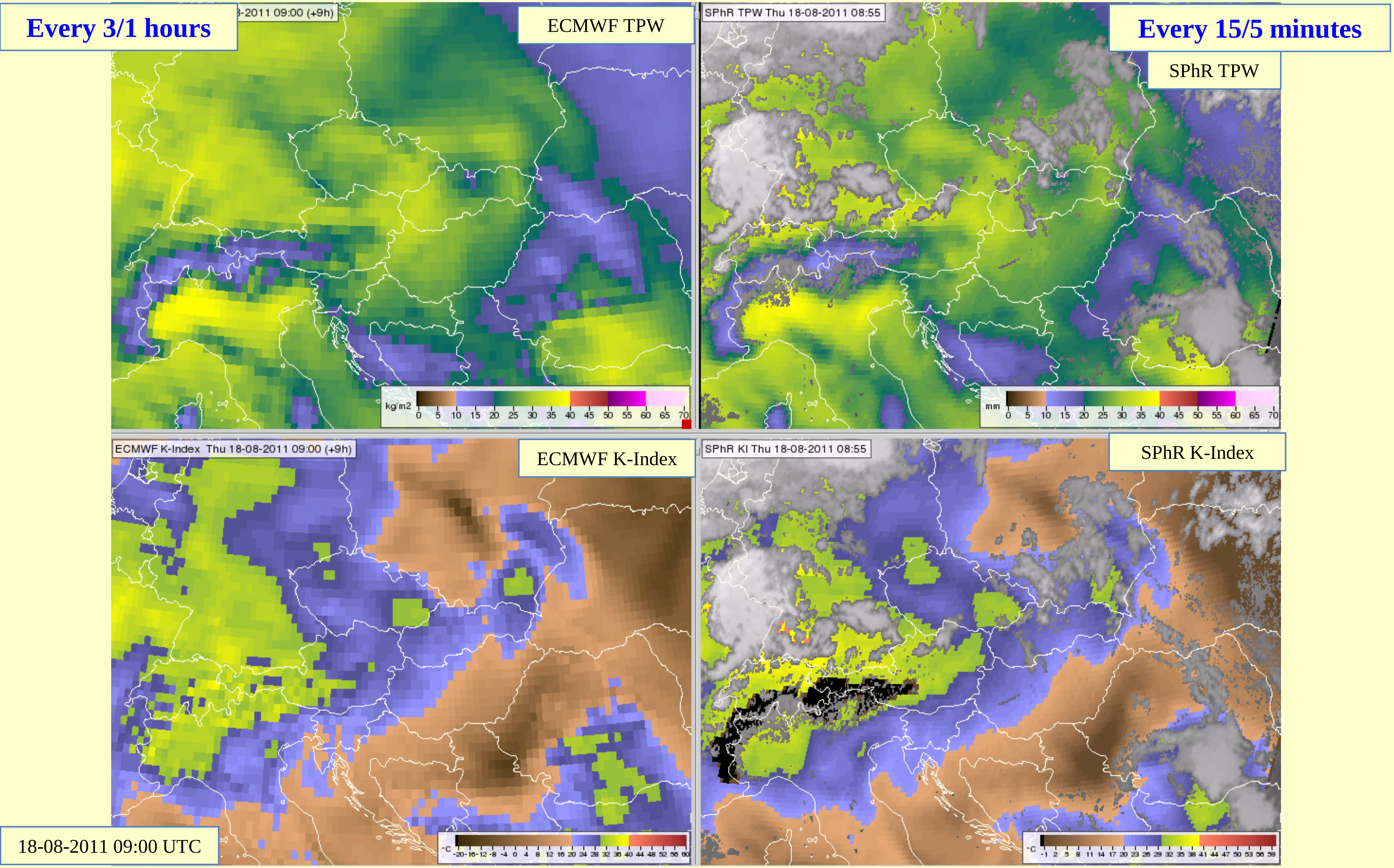
Mária Putsay

Hungarian Meteorological Service

NWCSAF event week, 19 November 2013



## **Water vapor content** and **instability indices** from **SEVIRI** + **NWP** data



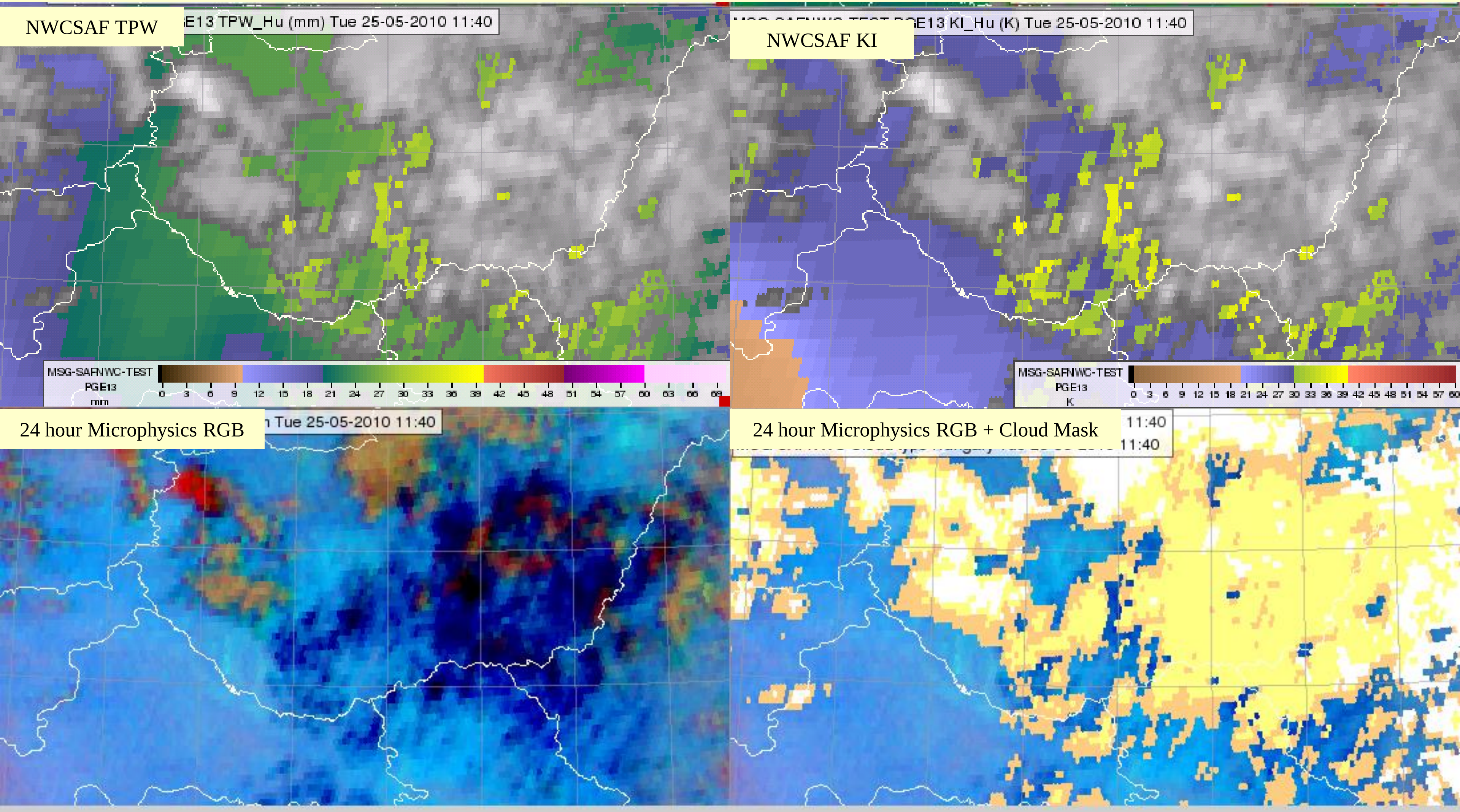

Excellent **temporal resolution**: **15/5 minutes -** essential at convection monitoring/forecasting.

The **spatial resolution is good.** The nominal spatial resolution is **9 x 9 km** by default. It can be reduced to 3 x 3 km.

**Only for cloud-free areas** - no microwave channels

# For a pixel misdetected as cloud-free the algorithm retrieves too moist and unstable atmosphere

25 May 2010 11:40 UTC

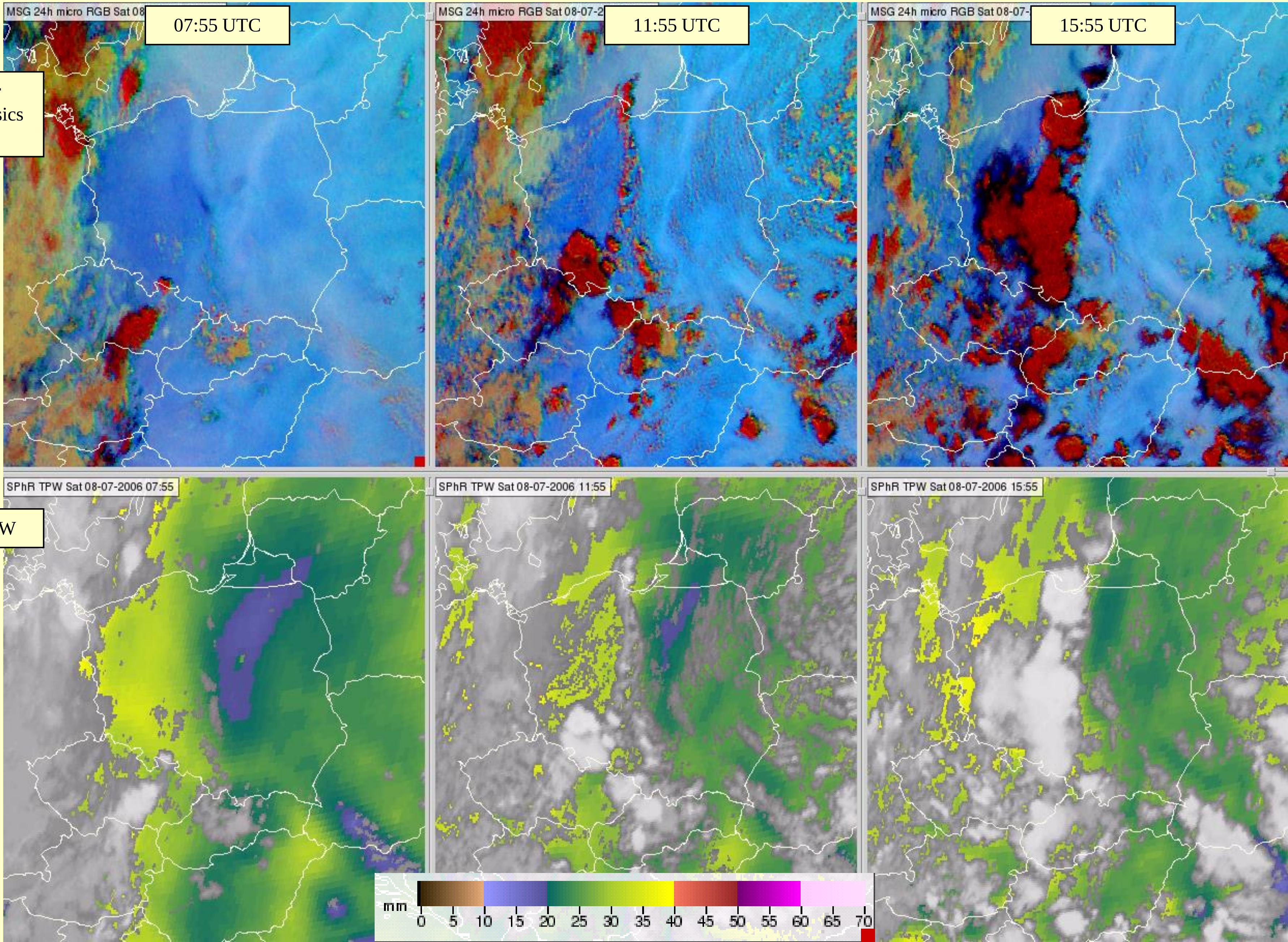


# moisture boundary, moisture gradient

08 July 2006

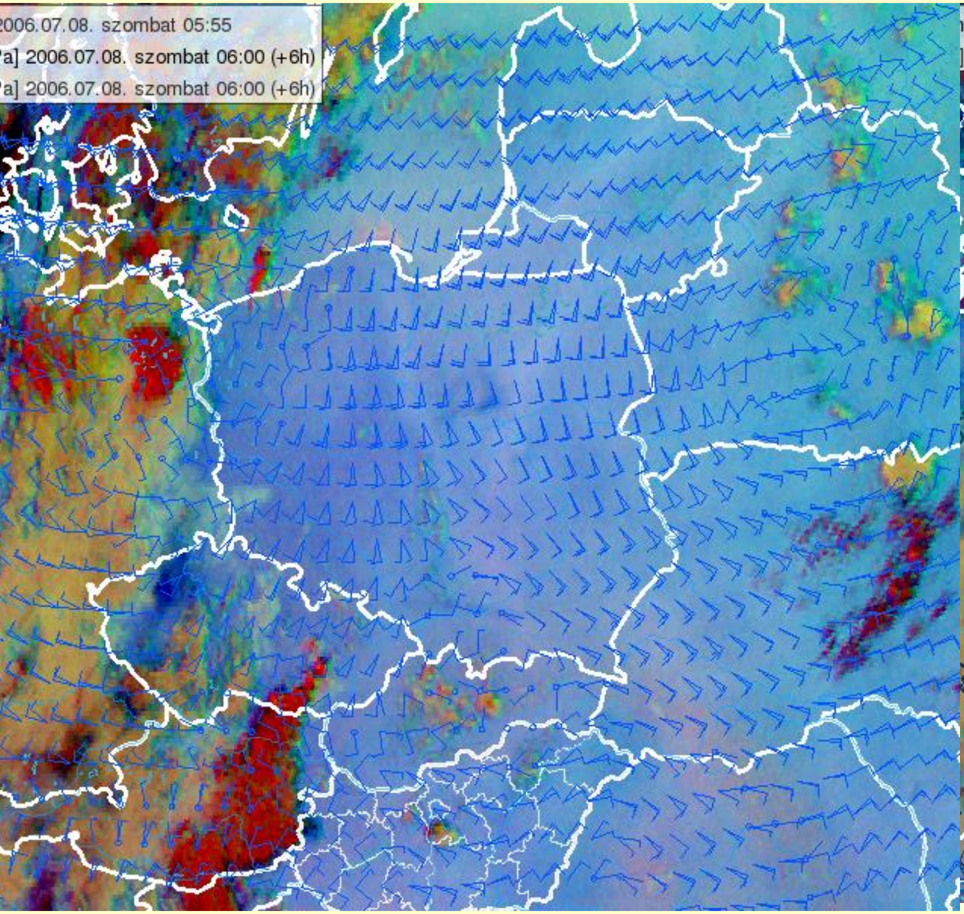
24 hour Microphysics RGB

SPhR TPW



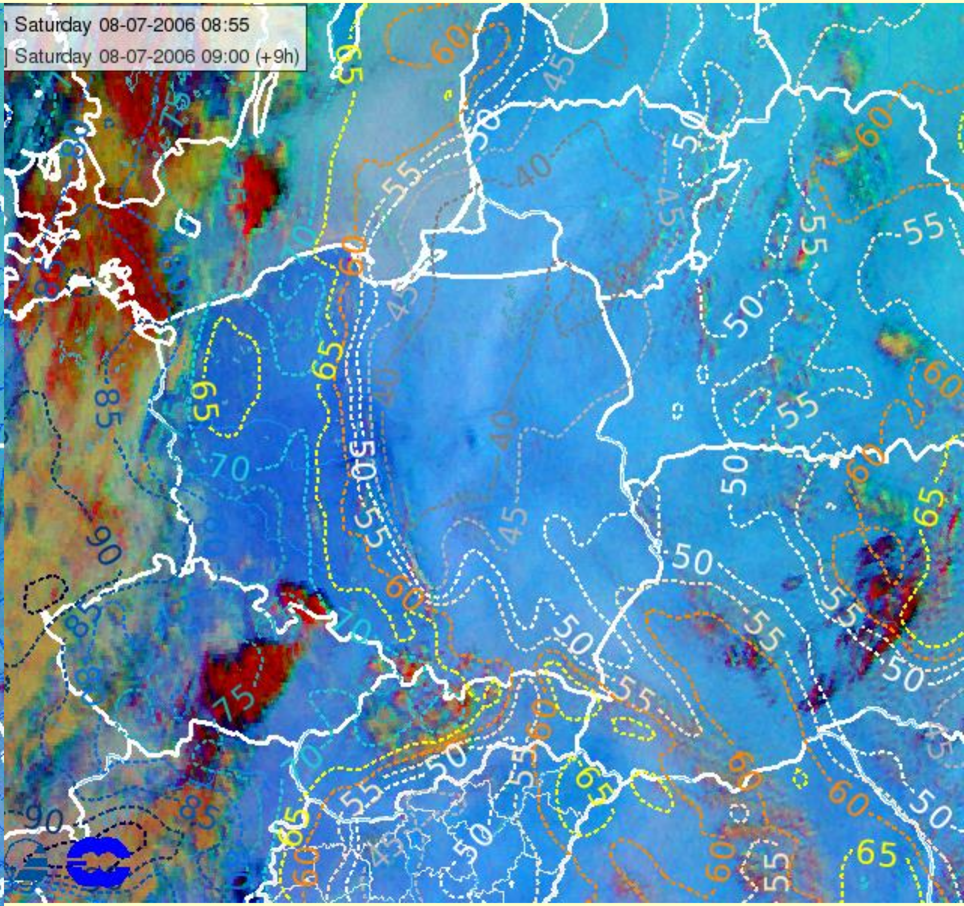
Moisture - accordance with NWP 08 July 2006 08:55 UTC

05:55 UTC



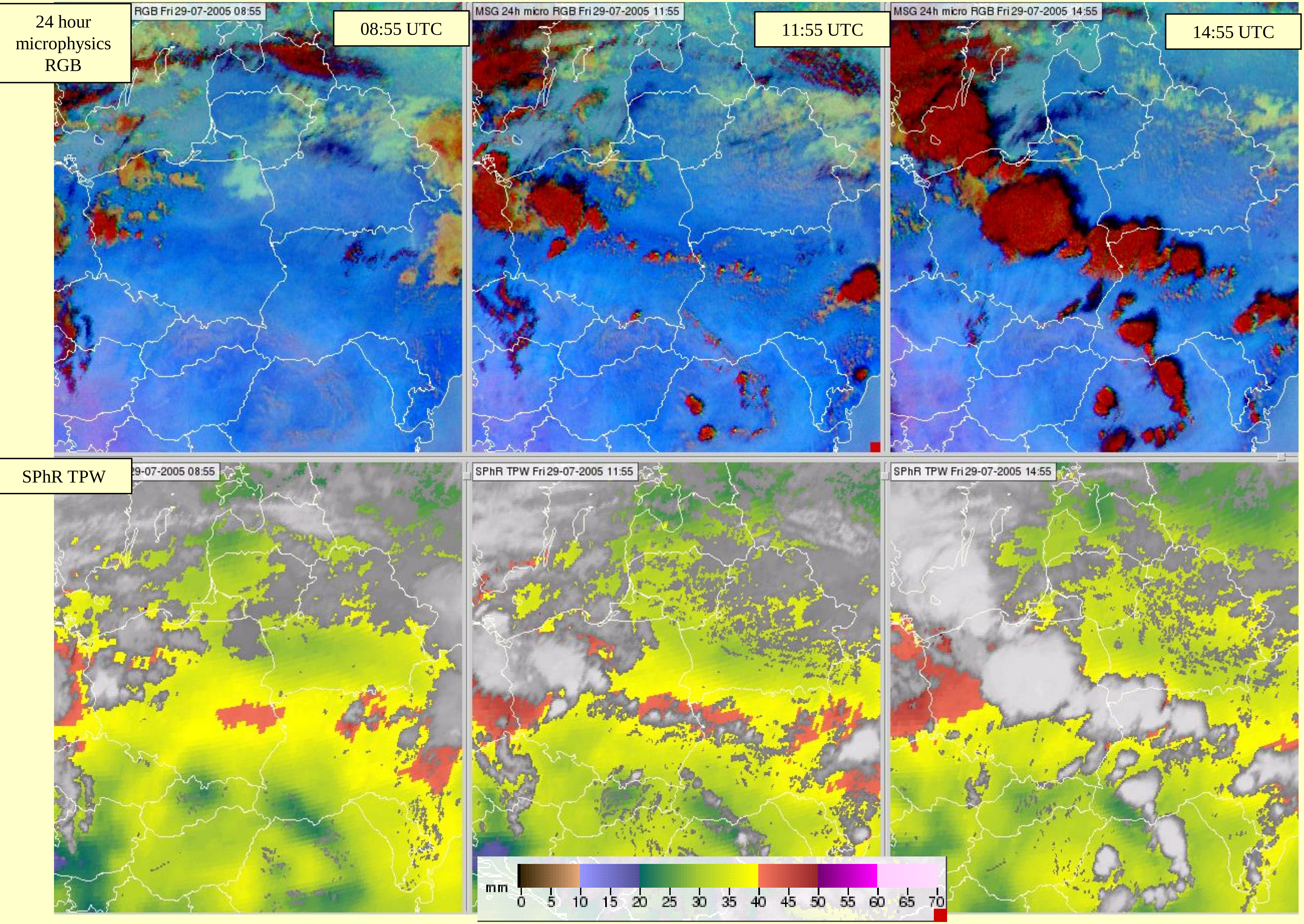

**24 hour Microphysics RGB +**
**ECMWF 850 and 925 hPa wind fields**
**(00+06 UTC)**

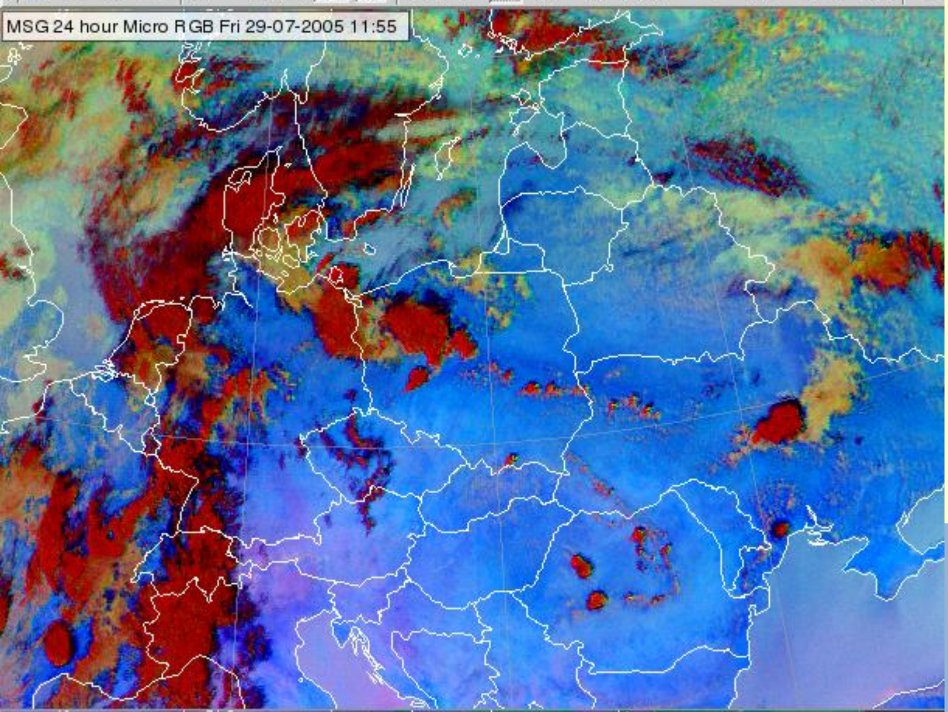
08:55 UTC




**24 hour Microphysics RGB +**
**average of the 1000, 925, 850 and 700 hPa**
**ECMWF Relative Humidity forecast fields**
**(00+09 UTC).**

# Moisture – no accordance with NWP 29 July 2005

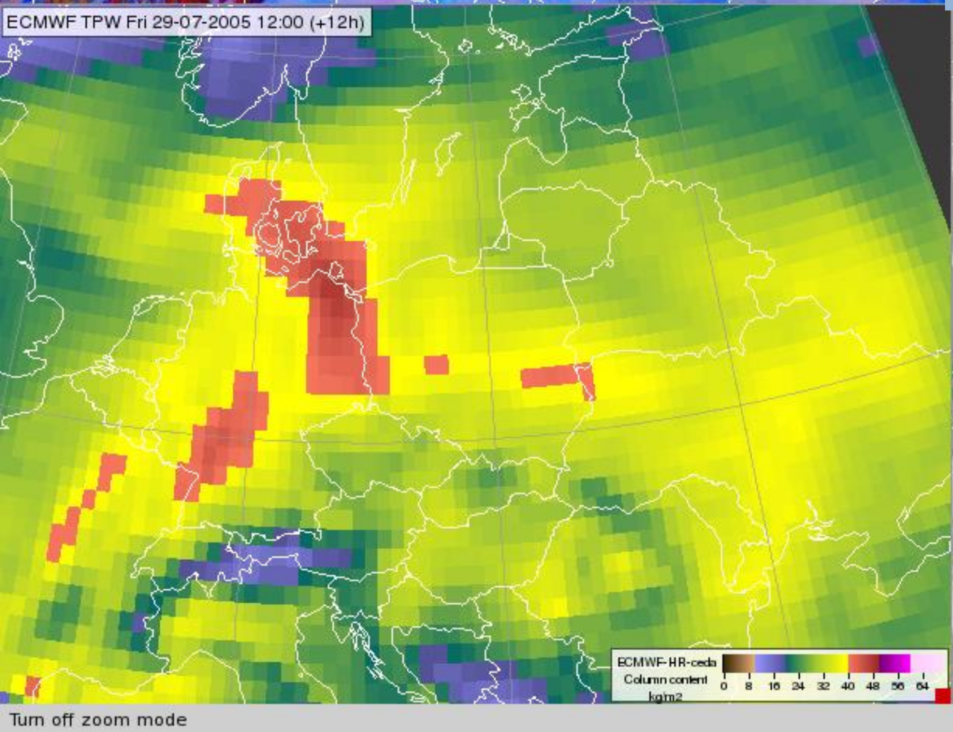


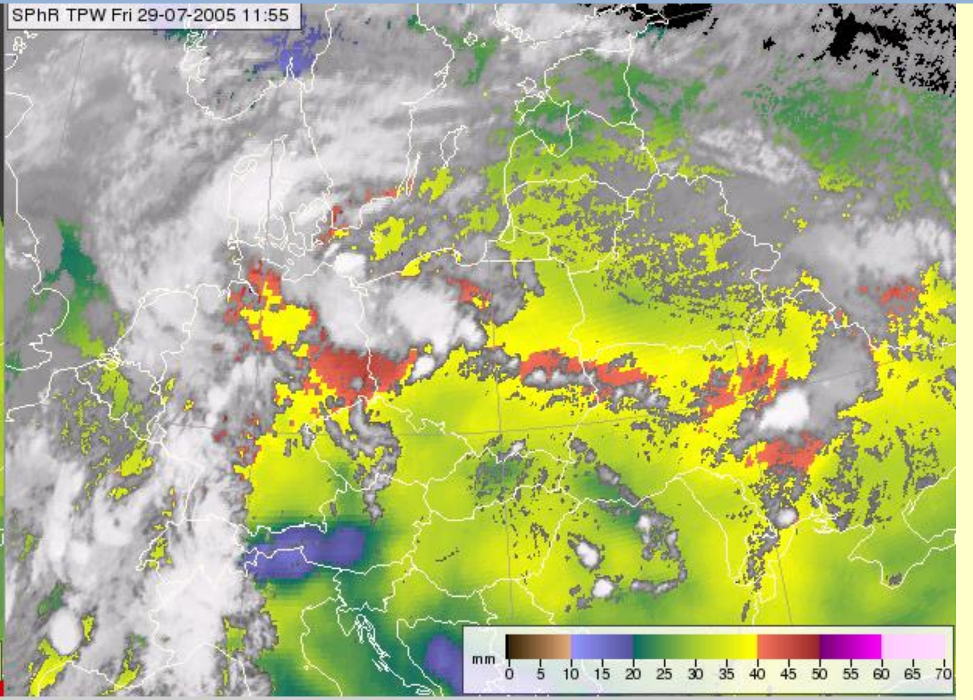



In this case the satellite retrieved moisture had an **added value to the NWP moisture forecast.**

29 July 2005 12 UTC

**SPhR can improve the shape of some mesoscale features**: e.g. location of a **moisture boundary**, **moisture gradient**.

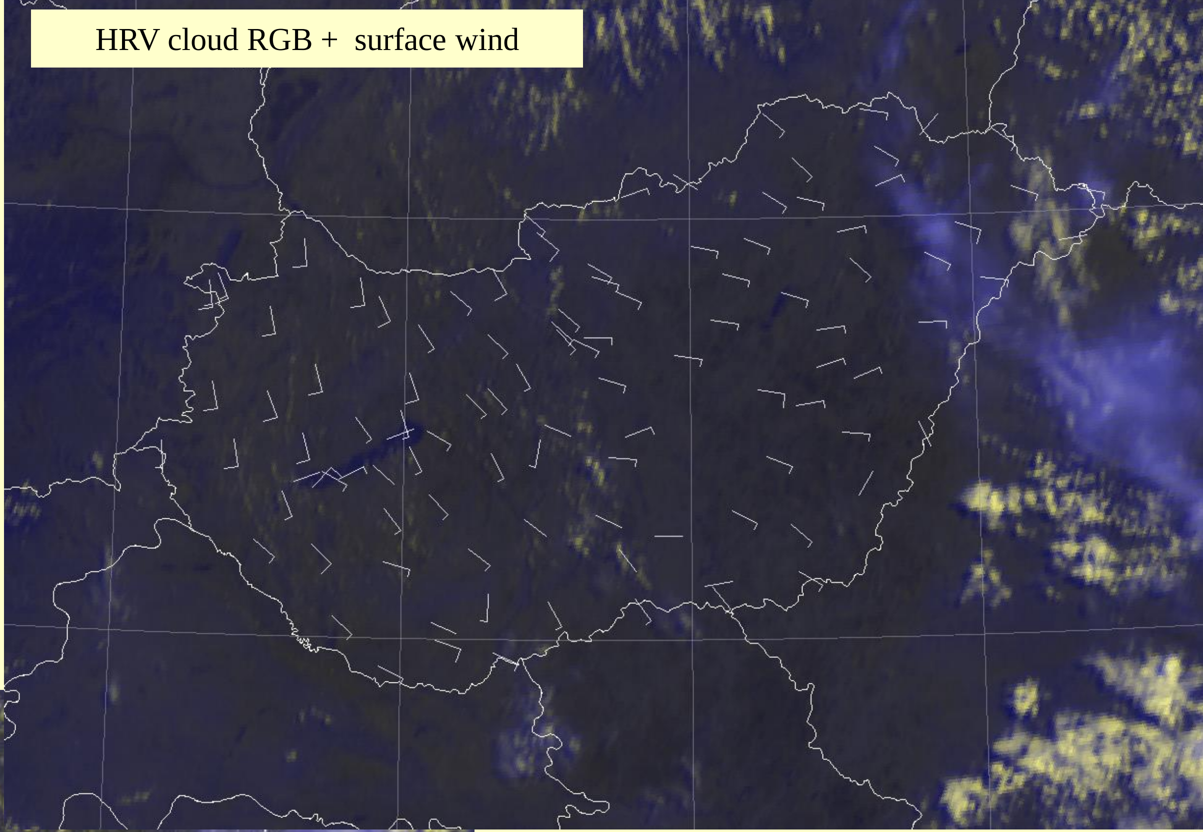


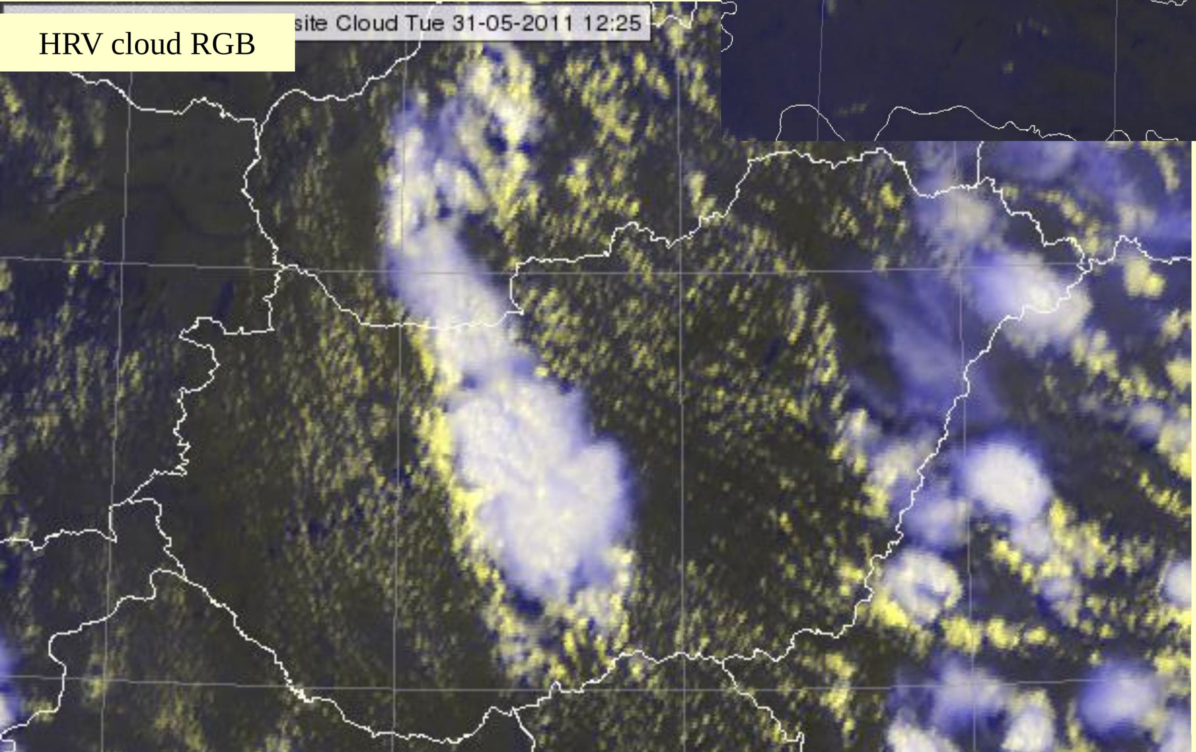



# 31 May 2011

## Convection along a convergence line over Hungary

10 m wind barbs (**9:00-9:10 UTC**), measured at automatic stations

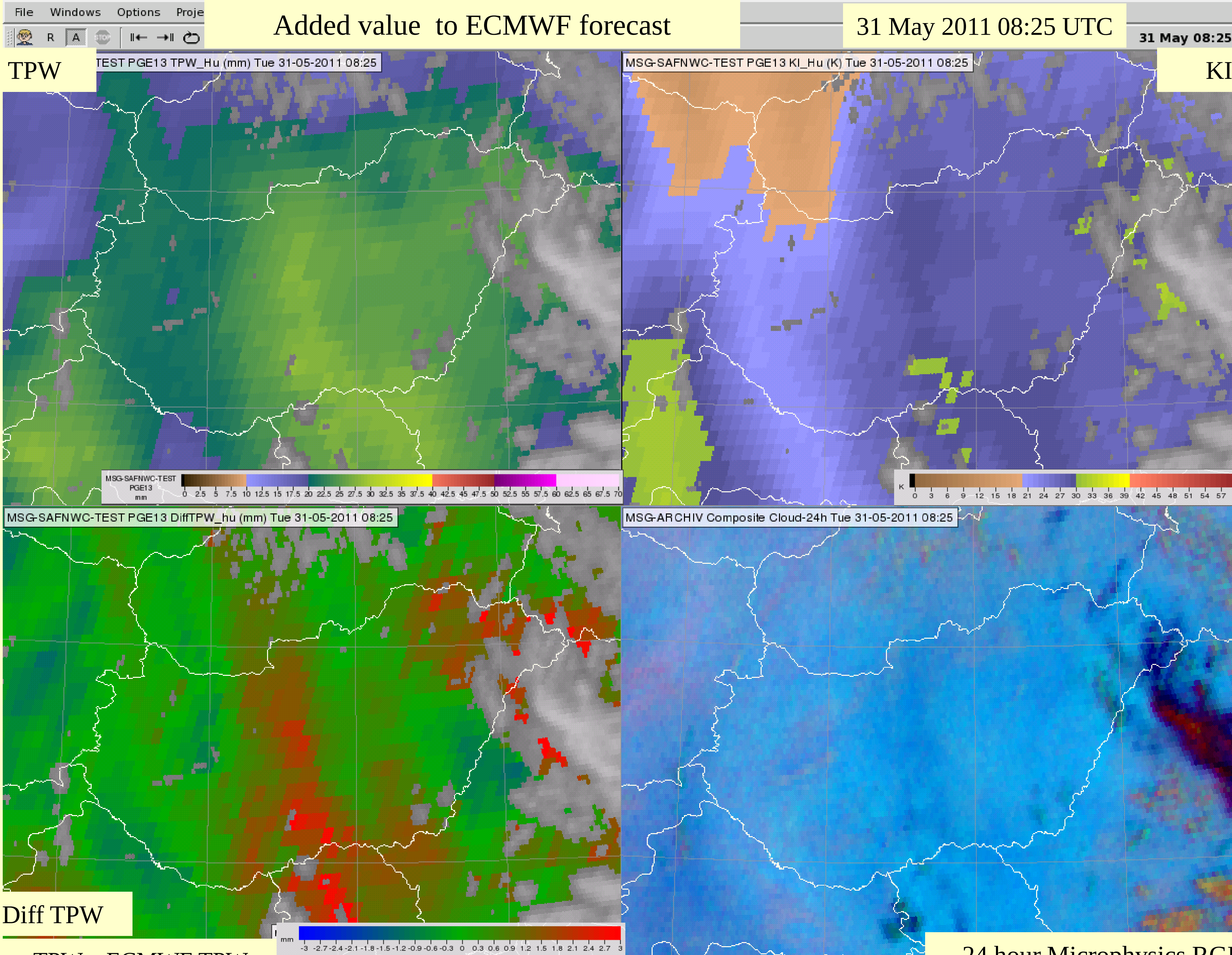



Convergence is seen by the orientation of the cloud streets. (**12:25 UTC**)

# Added value to ECMWF forecast

31 May 2011 08:25 UTC

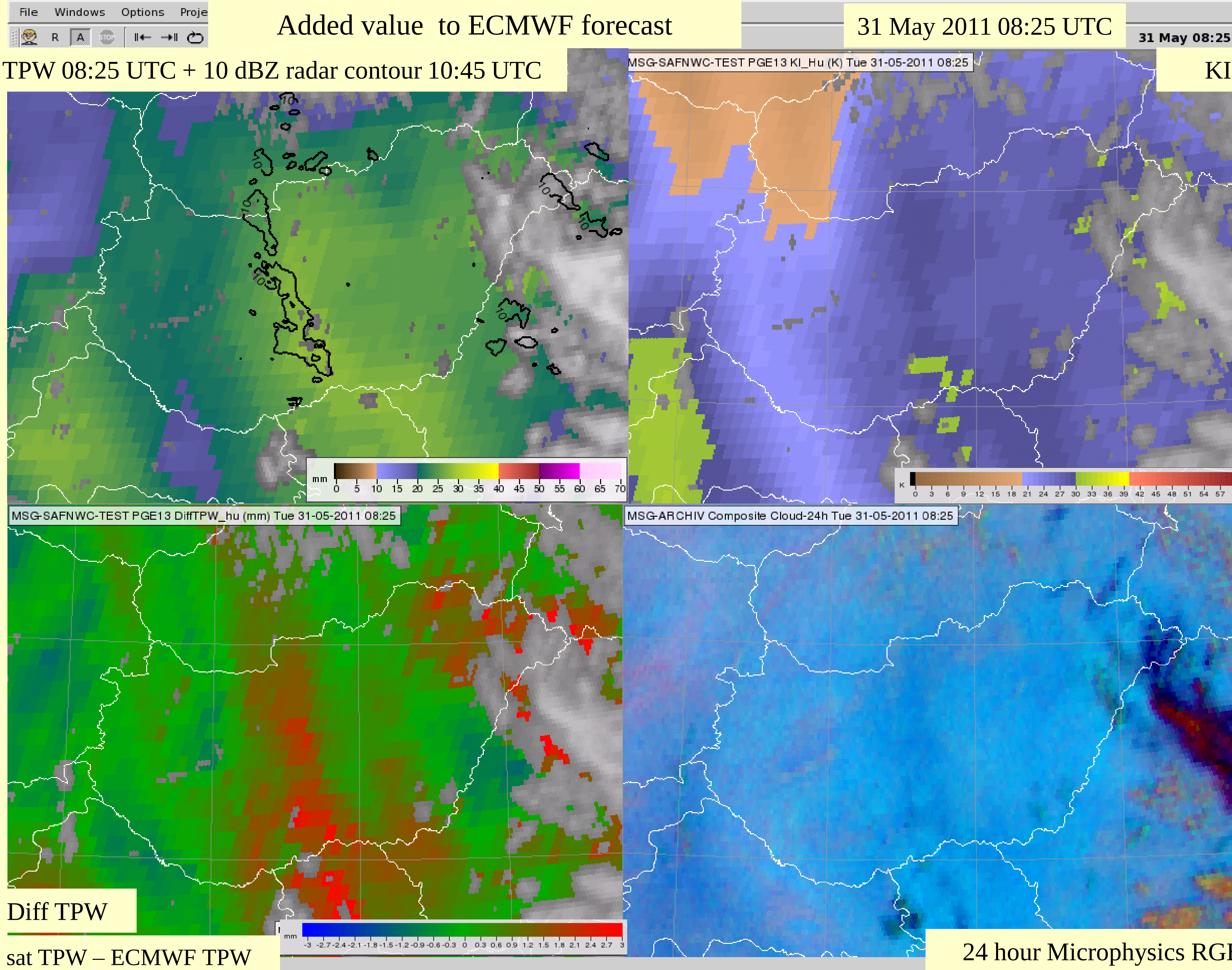



sat TPW – ECMWF TPW

24 hour Microphysics RGB

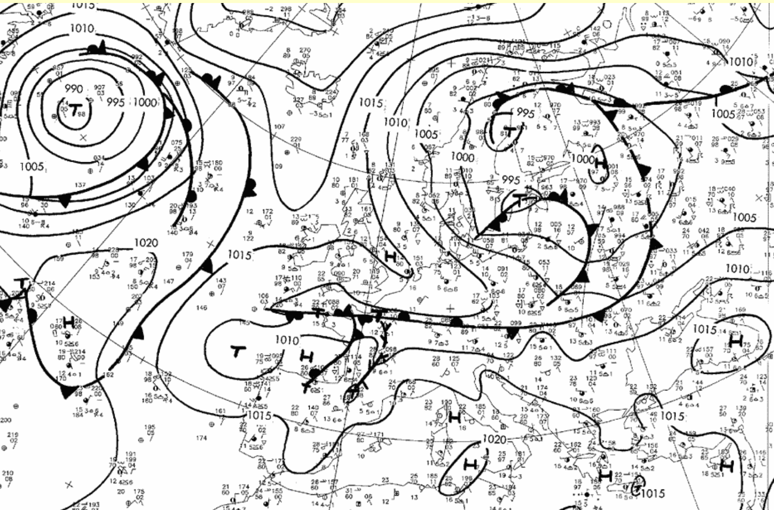
# Added value  to ECMWF forecast

31 May 2011 08:25 UTC

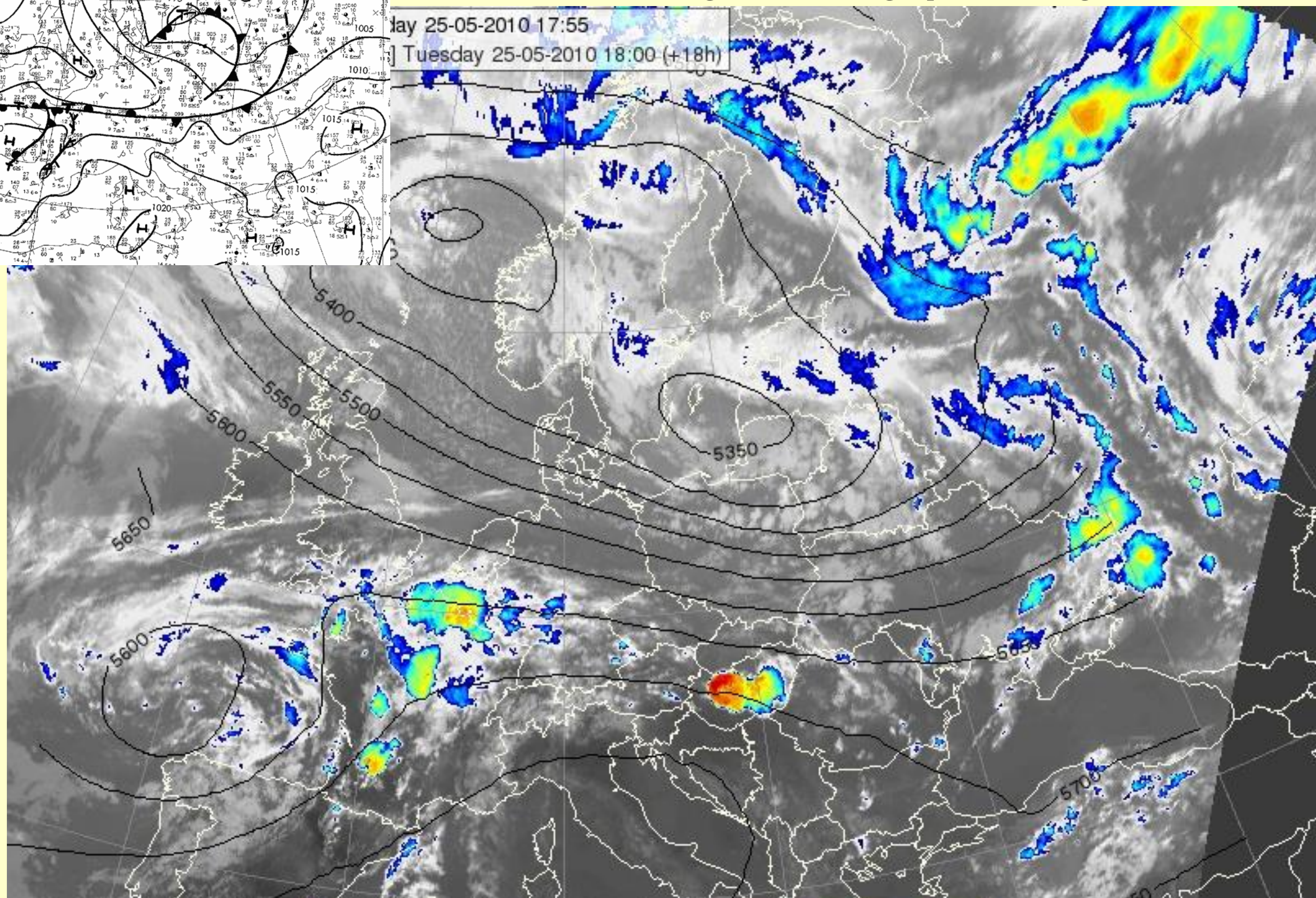


Case study
25 May 2010
Severe storm


Surface chart of DWD, 25 May 2010 12 UTC, www.wetter3.de



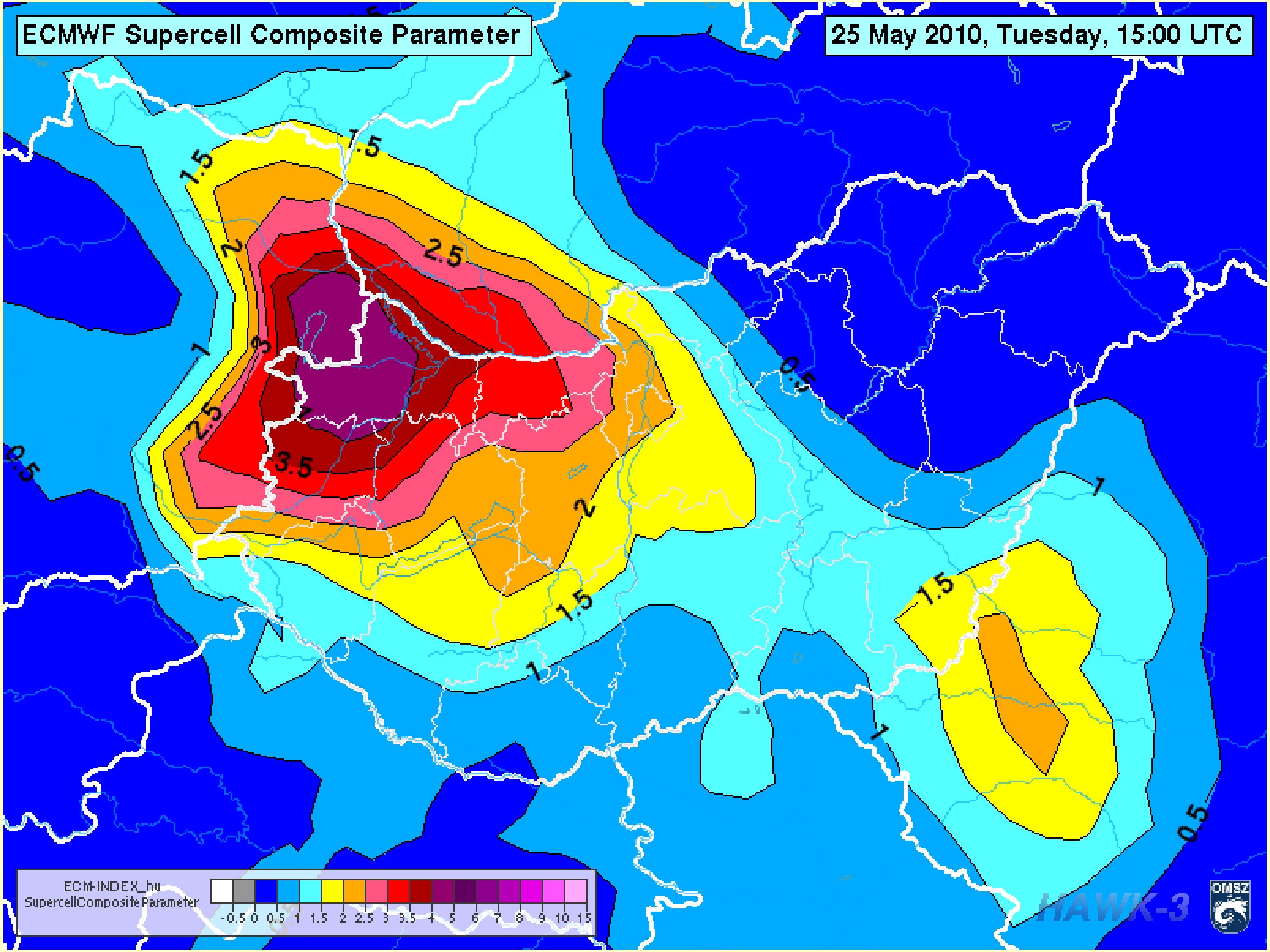
18 UTC, IR10.8 image + ECMWF geopotential height at 500 hPa





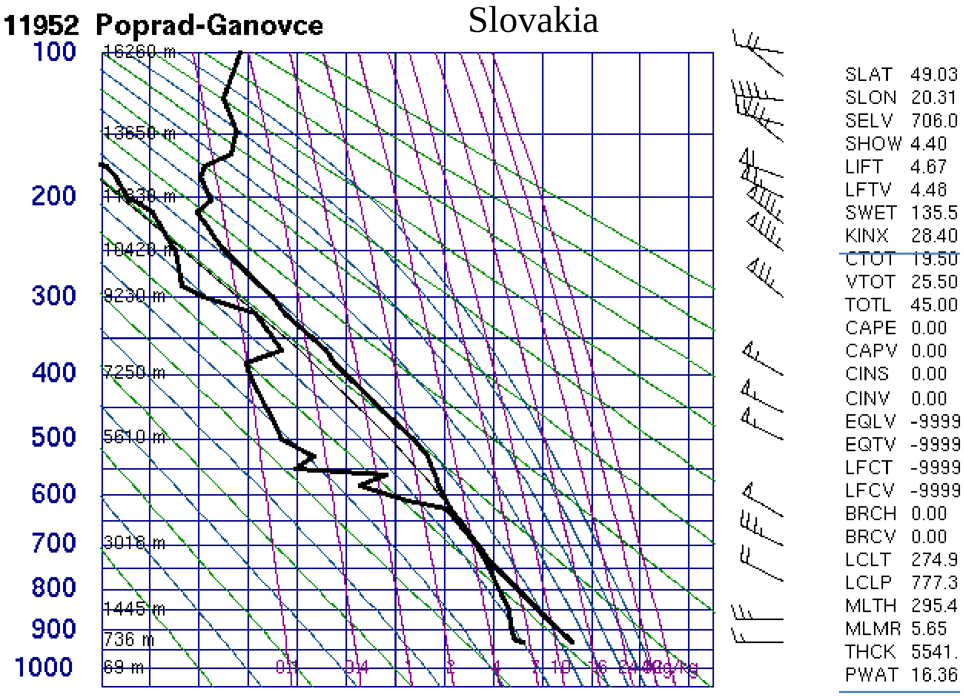
The severe MCS developed ahead a cold front

ECMWF forecasted an environment favorable for forming severe storms.
ECMWF forecasted strong wind shear, moderate MLCAPE, low level convergence for 15 UTC over western Hungary.

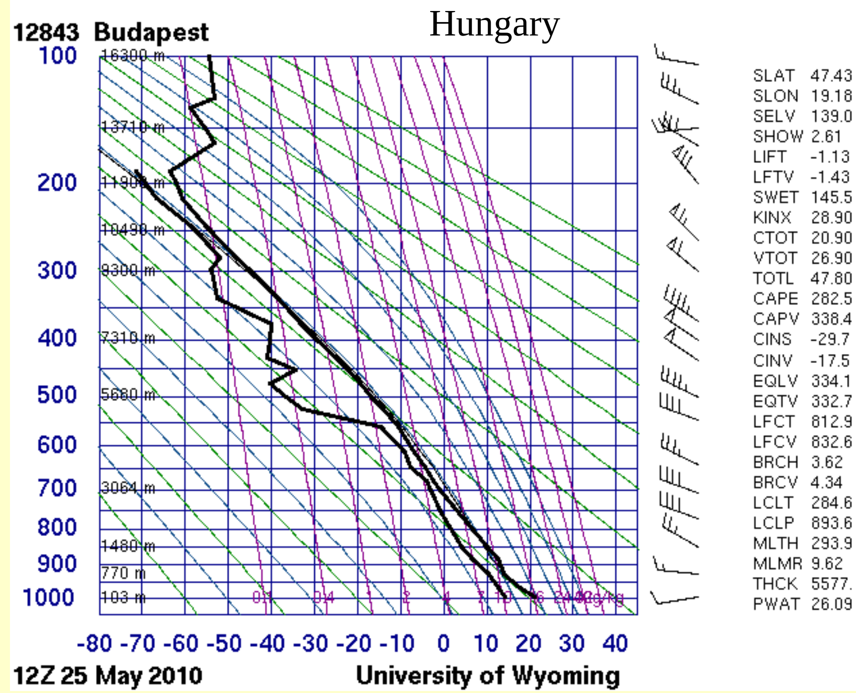


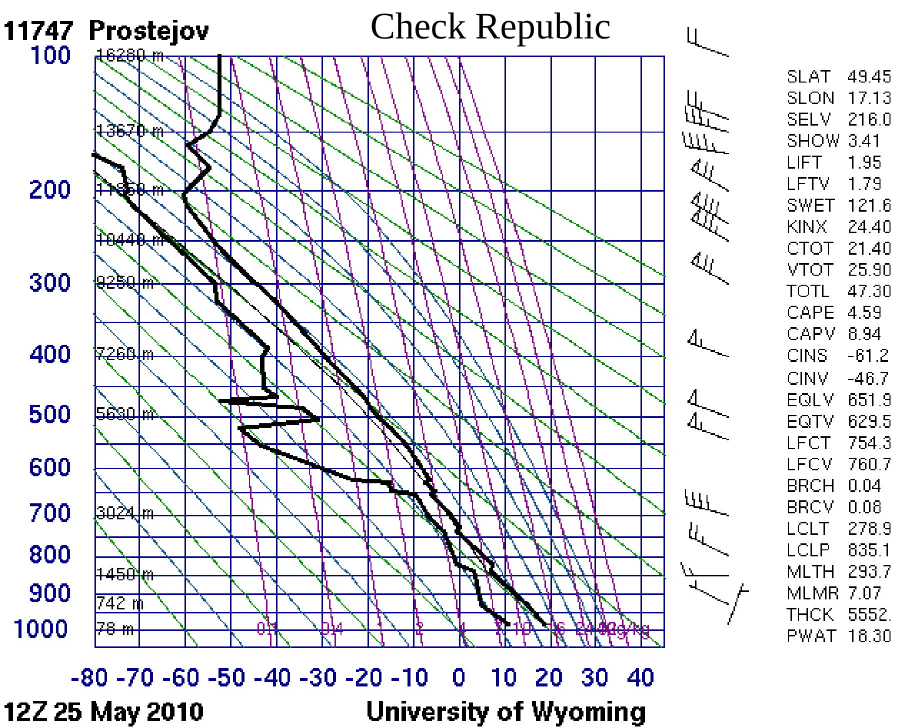

15 UTC ECMWF supercell composite parameter (colors and lines)

# Radiosonde measurements




Dry mid-layer

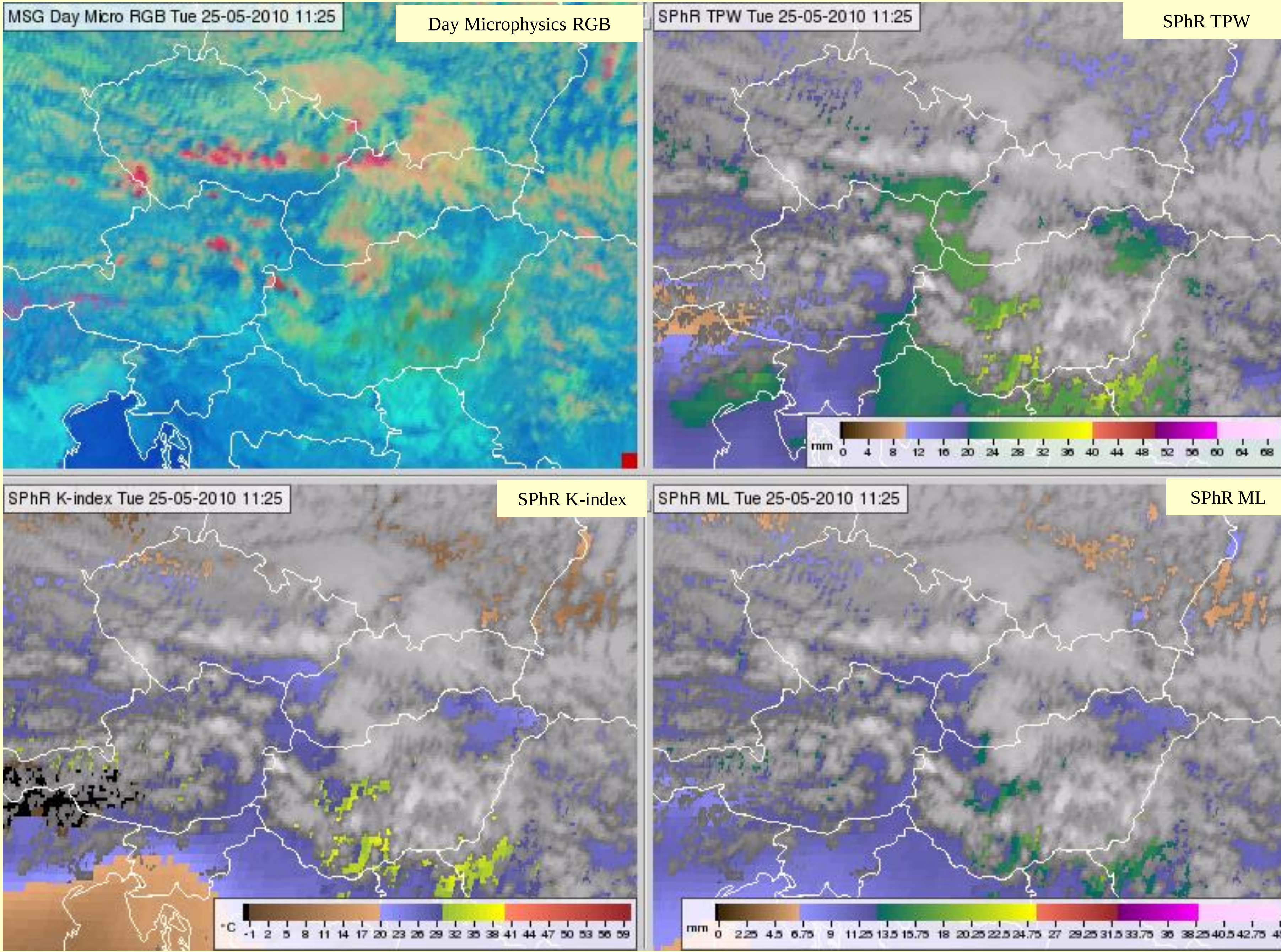



Dry mid-layer
strong wind shear

PWAT is the TPW
KINX is the K-index

# Initiation of the first cells 25 May 2010 11:25 UTC

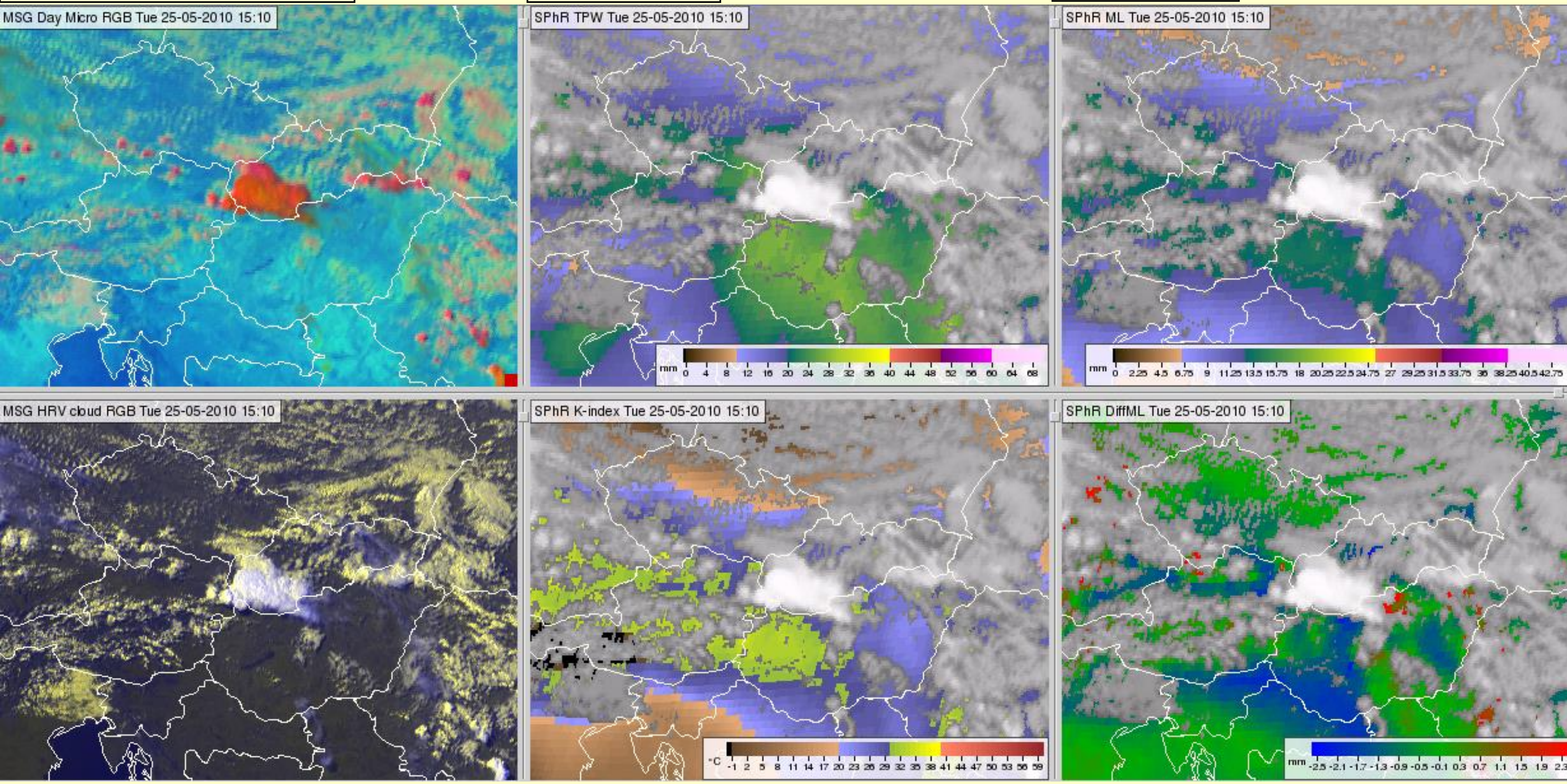


# The MCS approaches Hungary 25 May 2010 **15:10 UTC**

Day Microphysics RGB

SPhR TPW

SPhR ML




HRV cloud RGB

SPhR K-index

Diff ML | sat ML – ECMWF ML

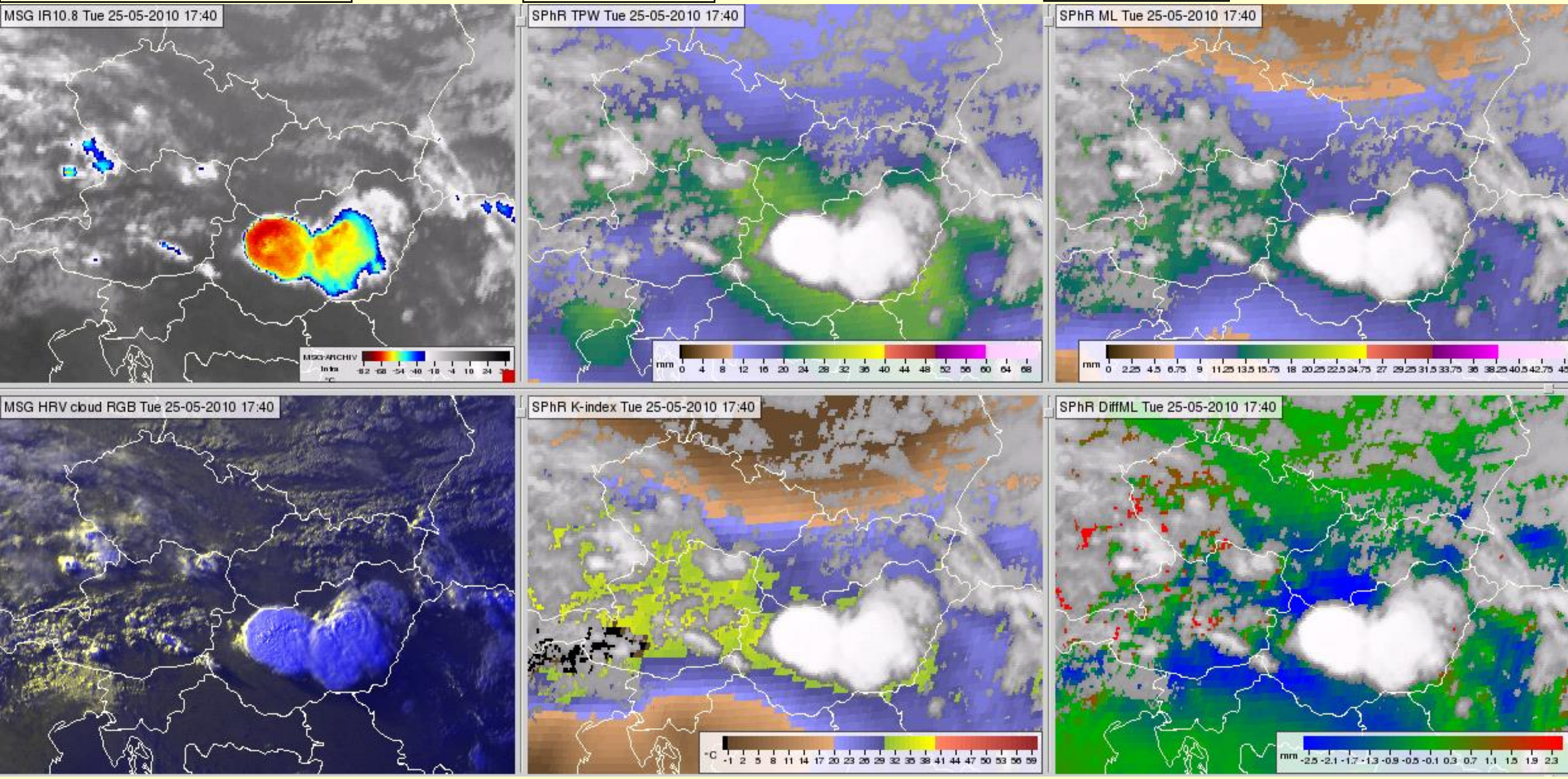
The MCS approaches Hungary just at the time when ECMWF forecasted the most favorable environment for forming severe storms.

## Mature phase 25 May 2010 **17:40 UTC**

Day Microphysics RGB

SPhR TPW

SPhR ML



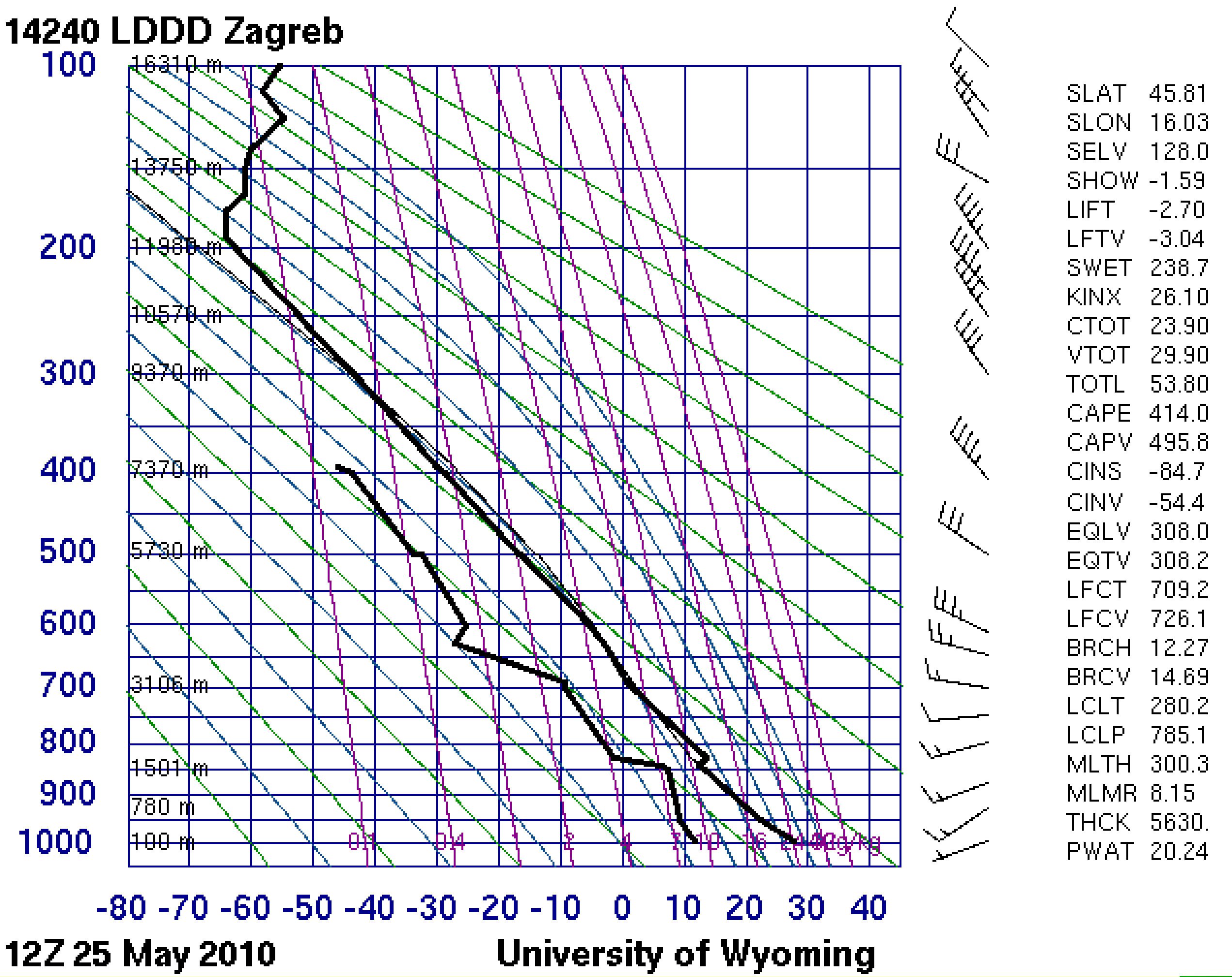

HRV cloud RGB

SPhR K-index

Diff ML

sat ML – ECMWF ML

Blue color means that the mid-layer was even drier than it was forecasted. The environment was even more favorable for forming severe storms.

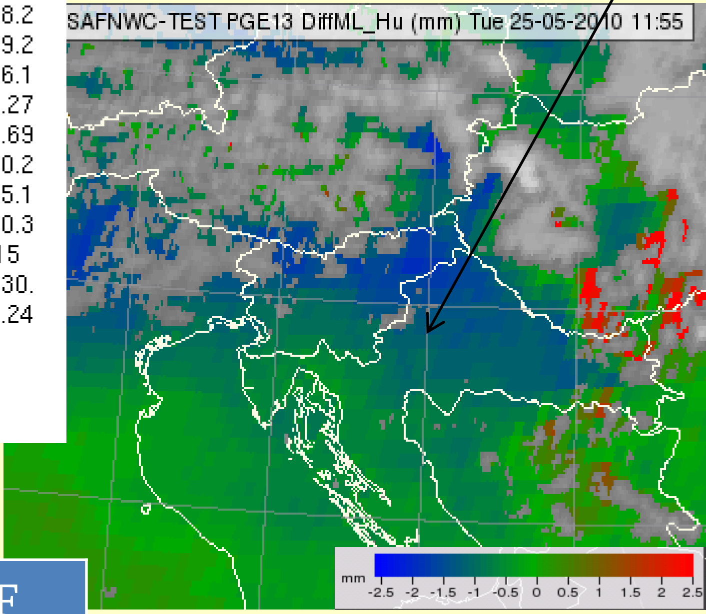



# Comparison with a radiosonde measurement

(for a cloud-free pixel at 12 UTC)

The background data of SPhR is ECMWF, it makes a correction to it.

In this case the correction was made in good direction, ECMWF was improved.




| | TEMP | SPhR | ECMWF (00+12) |
|---|---|---|---|
| TPW [mm] | 20.24 | 21.2 | 23.6 |
| K-index [°C] | 26.1 | 24.7 | 26.9 |

## Definitions of the instability indices:

**Lifted Index:**

**LI = T(500) – T(lifted adiabatically from the ‘lowest 100 hPa’ to 500 hPa),**

where T(500) is the temperature of the environment at 500 hPa.

The air parcel is lifted adiabatically from ‘inside’ the 100 hPa thick layer just above the surface to 500 hPa and its temperature is compared to that of the environment. The initial temperature and humidity of the virtual lifted parcel are the average values of this layer.

**Showalter Index:**

**SHW = T(500) – T(lifted adiabatically from 850hPa to 500 hPa),**

where T(500) is the temperature of the environment at 500 hPa pressure level.

The air parcel is adiabatically lifted from 850 hPa to 500 hPa and its temperature is compared to that of the environment.

**K-Index:**

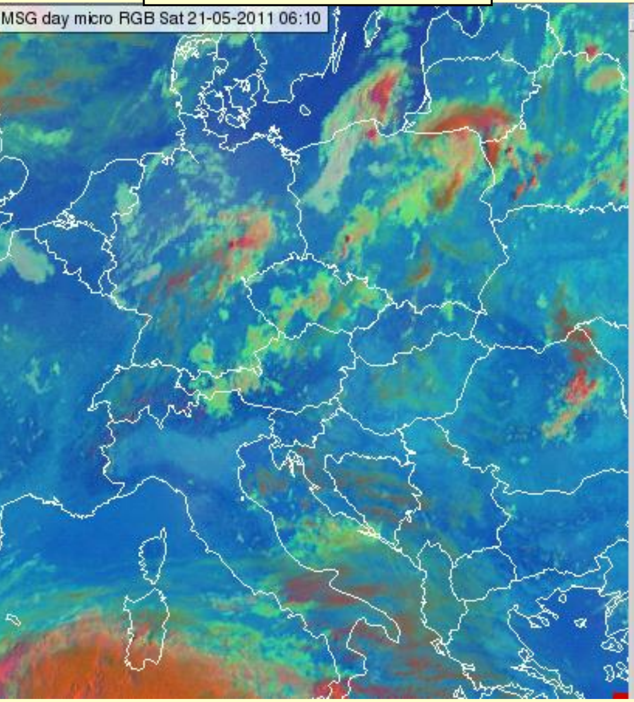
**KI = (T(850) - T(500)) + TD(850) - (T(700) - TD(700) )**

where T(p) is the observed temperature and TD(p) is the dew point temperature at p hPa pressure level.

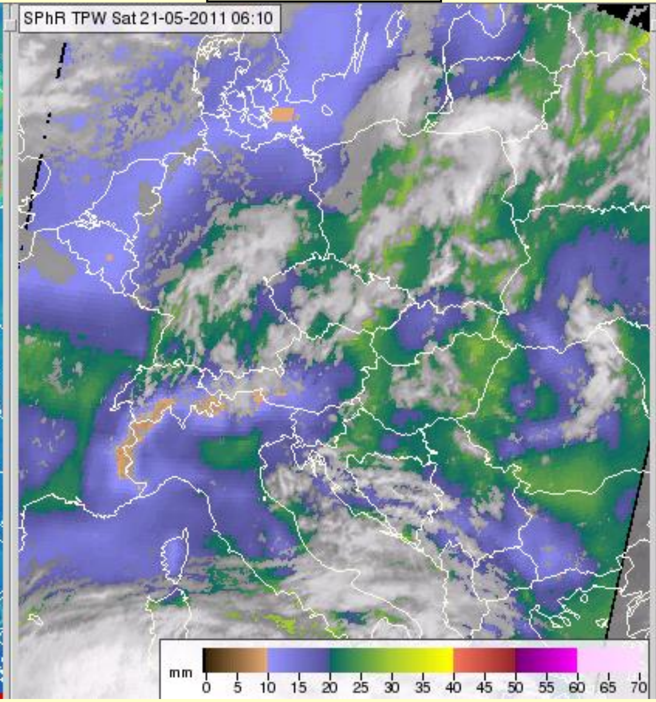
# Instability Indices

**21 May 2011** 06:10 UTC

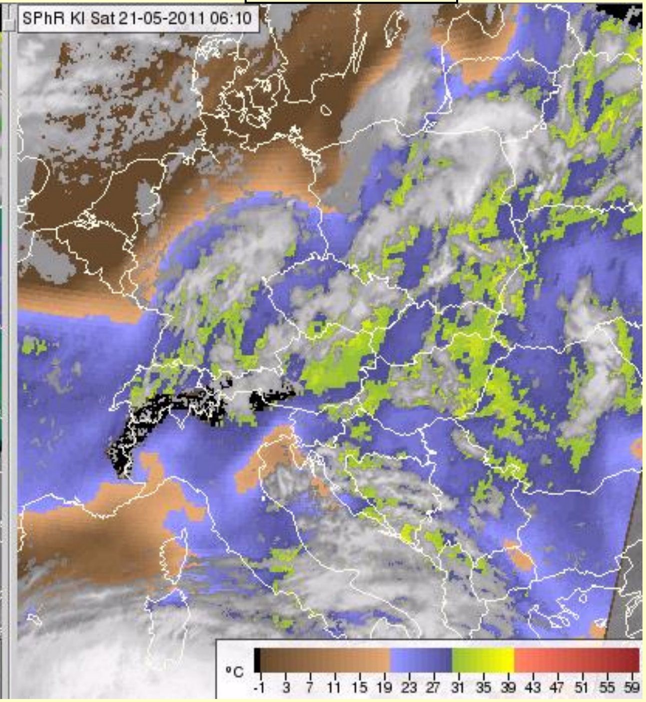
Day Microphysics RGB




SPhR TPW



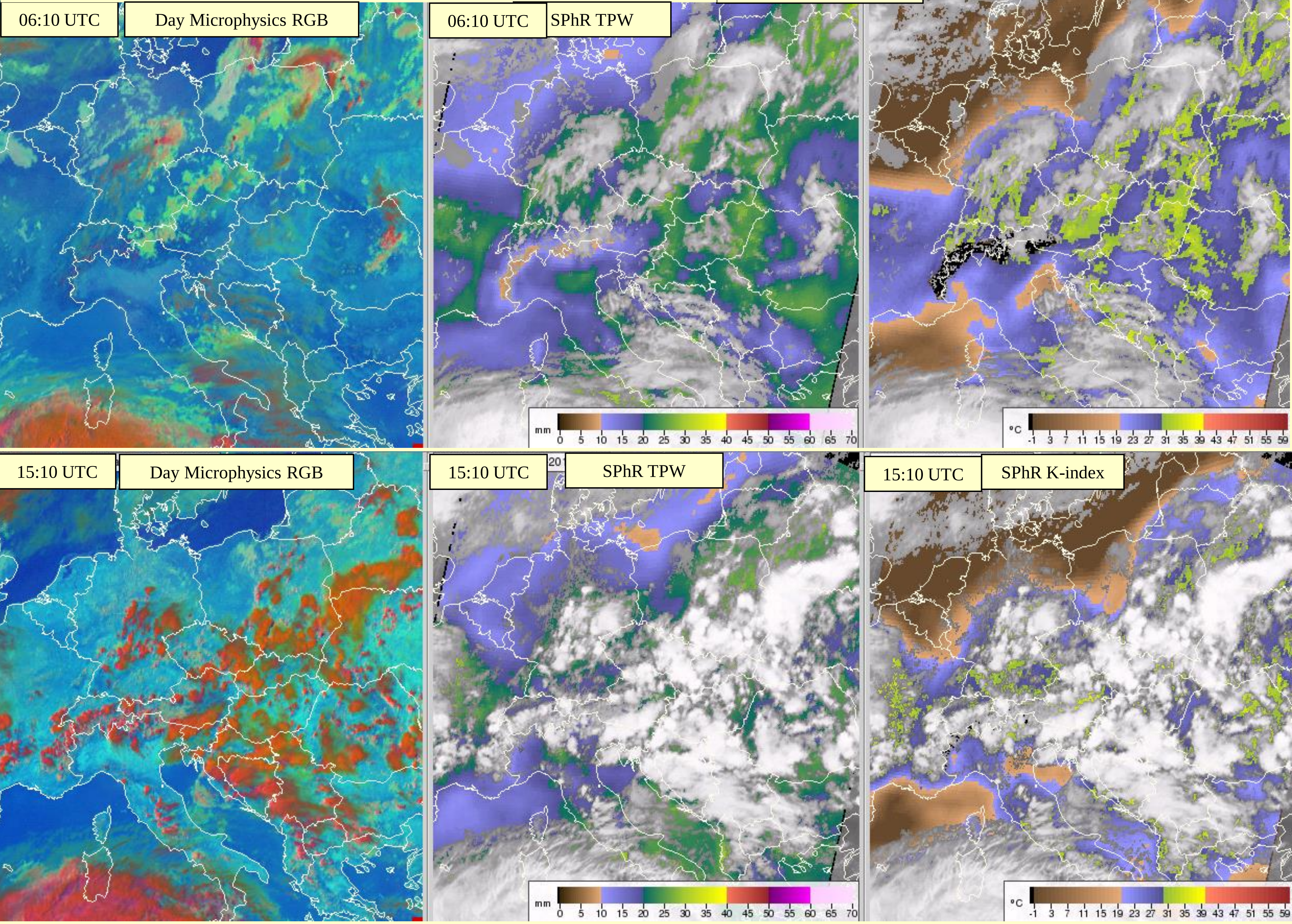

SPhR K-index




Where do you **NOT** expect thunderstorm in the afternoon?

**Instability Indices**, Stable environment: K-Index < 20 °C

**21 May 2011**



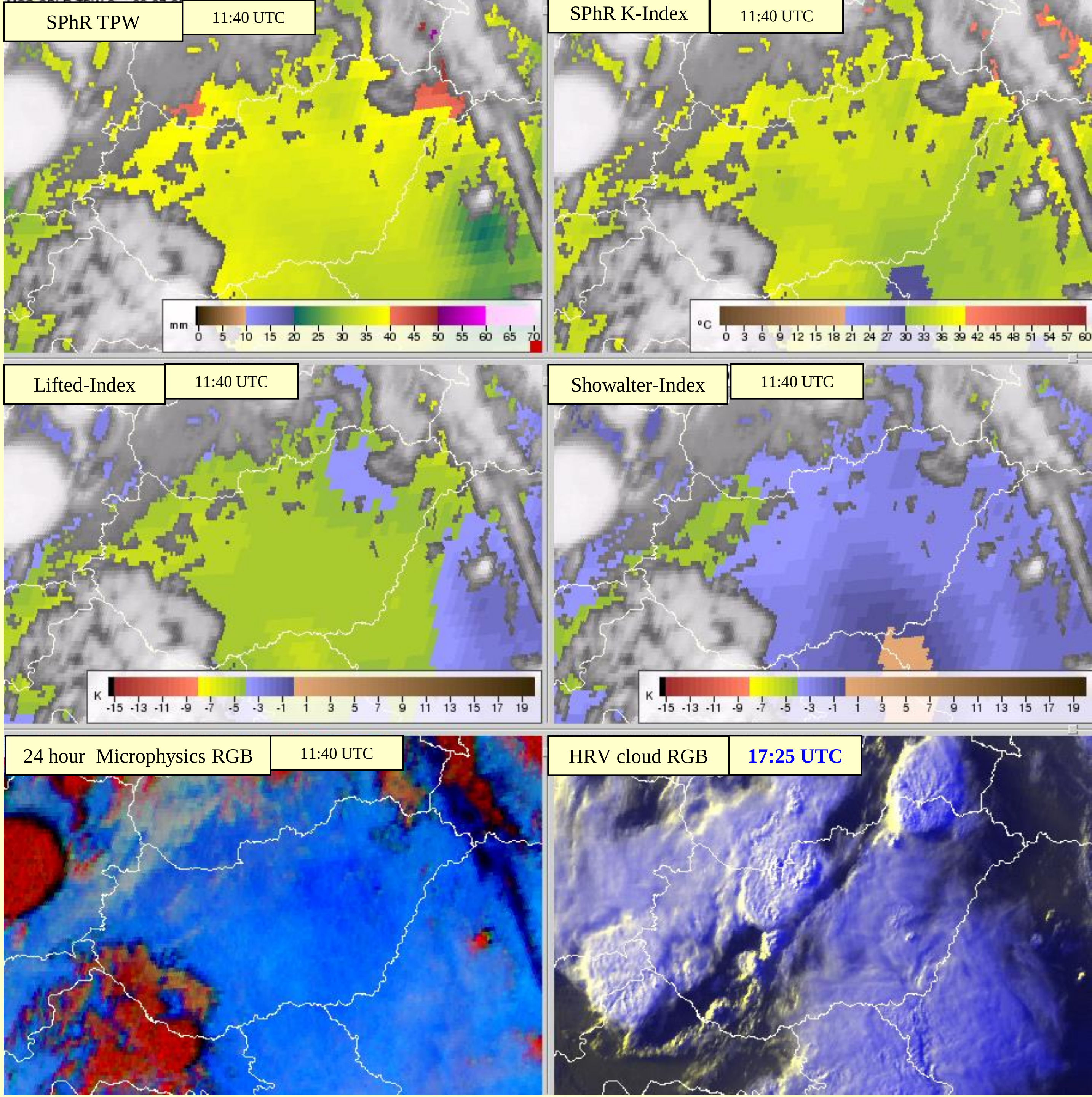
# 29 July 2012

**High water vapor content**

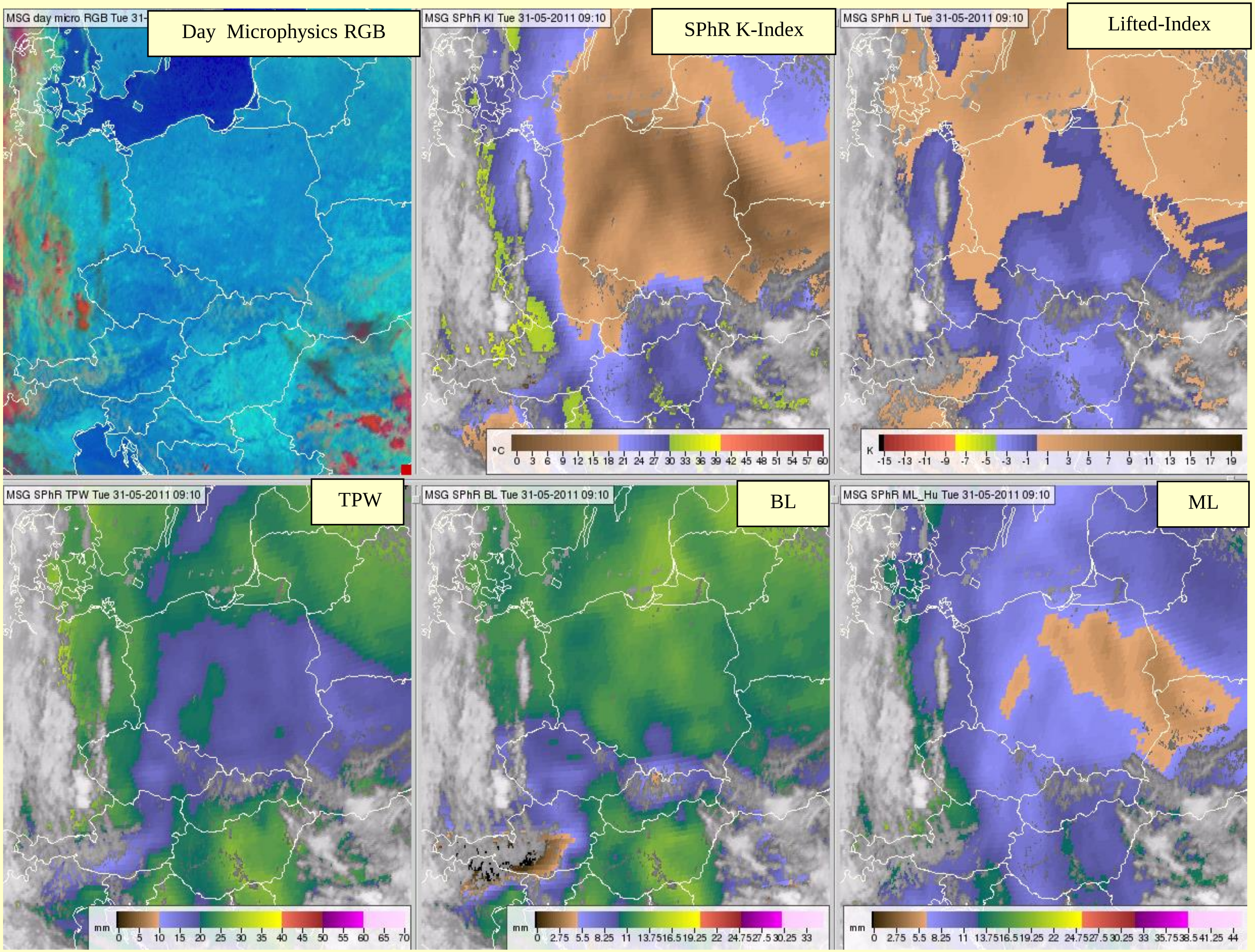
**+**

**All indices indicate high instability**

**Unstable environment**:
K-Index >20K
Lifted index < 0 K.
Showalter index < 0 K.

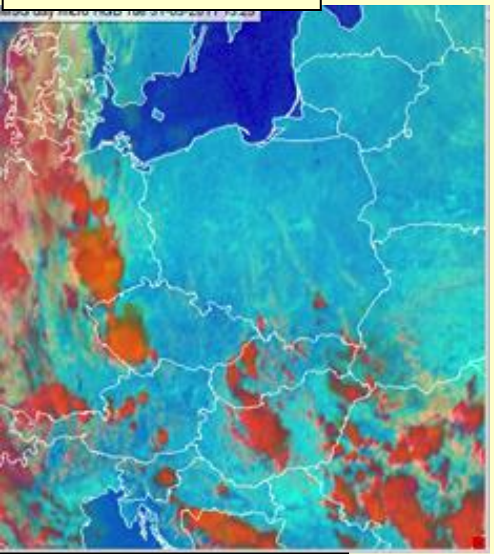


# ‘Contradiction’ between the instability indices?   Poland  31 May 2011 09:10 UTC




Would you expect thunderstorm initiation above Poland in the afternoon?

**31 May 2011** 13:25 UTC



Day Microphysics RGB

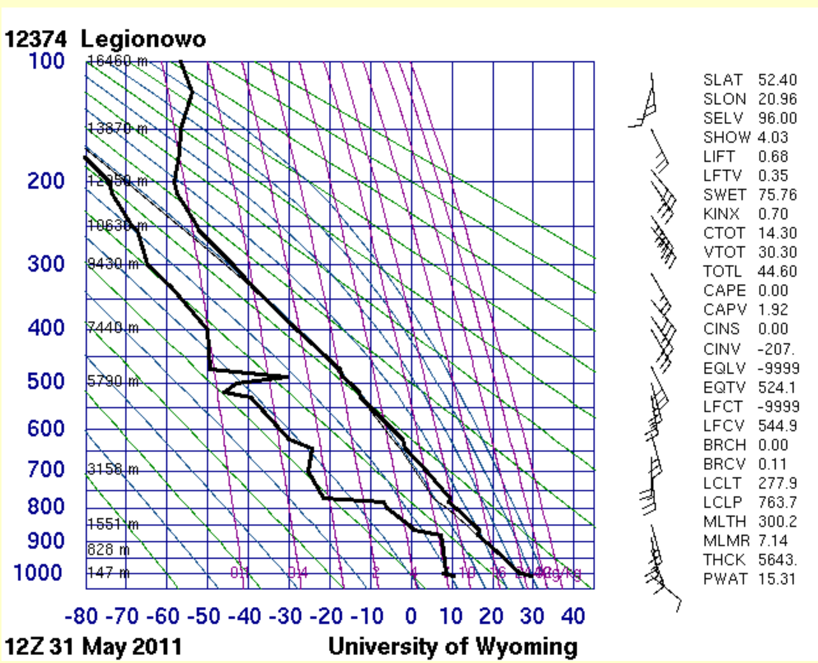
**K-Index = (T(850) - T(500)) + TD(850) - (T(700) - TD(700) )**

K-Index was low because the 700 hPa dew point depression was high.

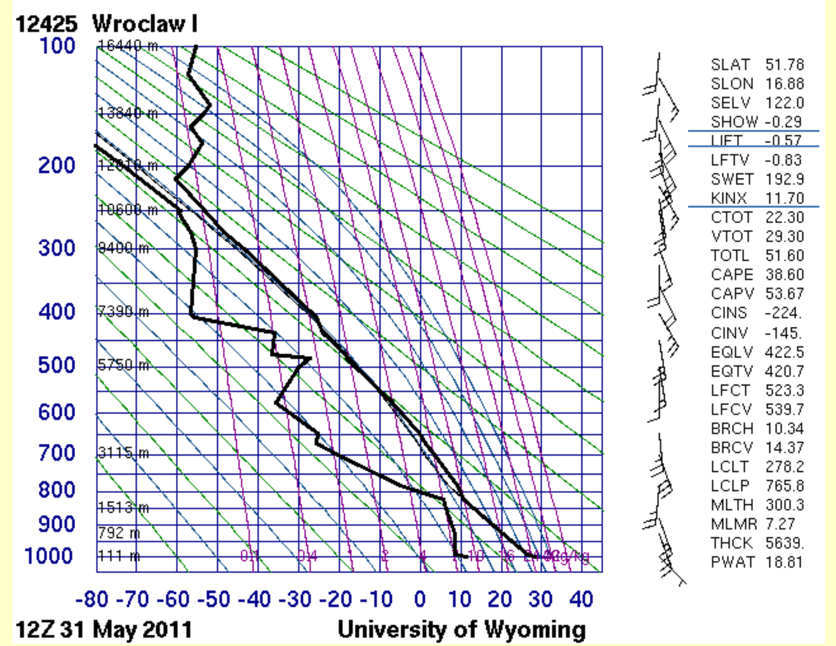
**Lifted Index:**
**LI = T(500) – T(lifted adiabatically from the 'lowest 100 hPa' to 500 hPa),**

The definition of Lifted Index does not include any information from around 700 hPa, only about the near surface environment and the 500 hPa environment. The Lifted Index values seem to be not affected by the very dry mid layer. Calculating the Lifted Index it is supposed that the virtual air parcel is lifted **adiabatically** up to 500 hPa. However, in reality the 'lifting' could not be really adiabatic, **some mixing with the environment is very likely to happen**.

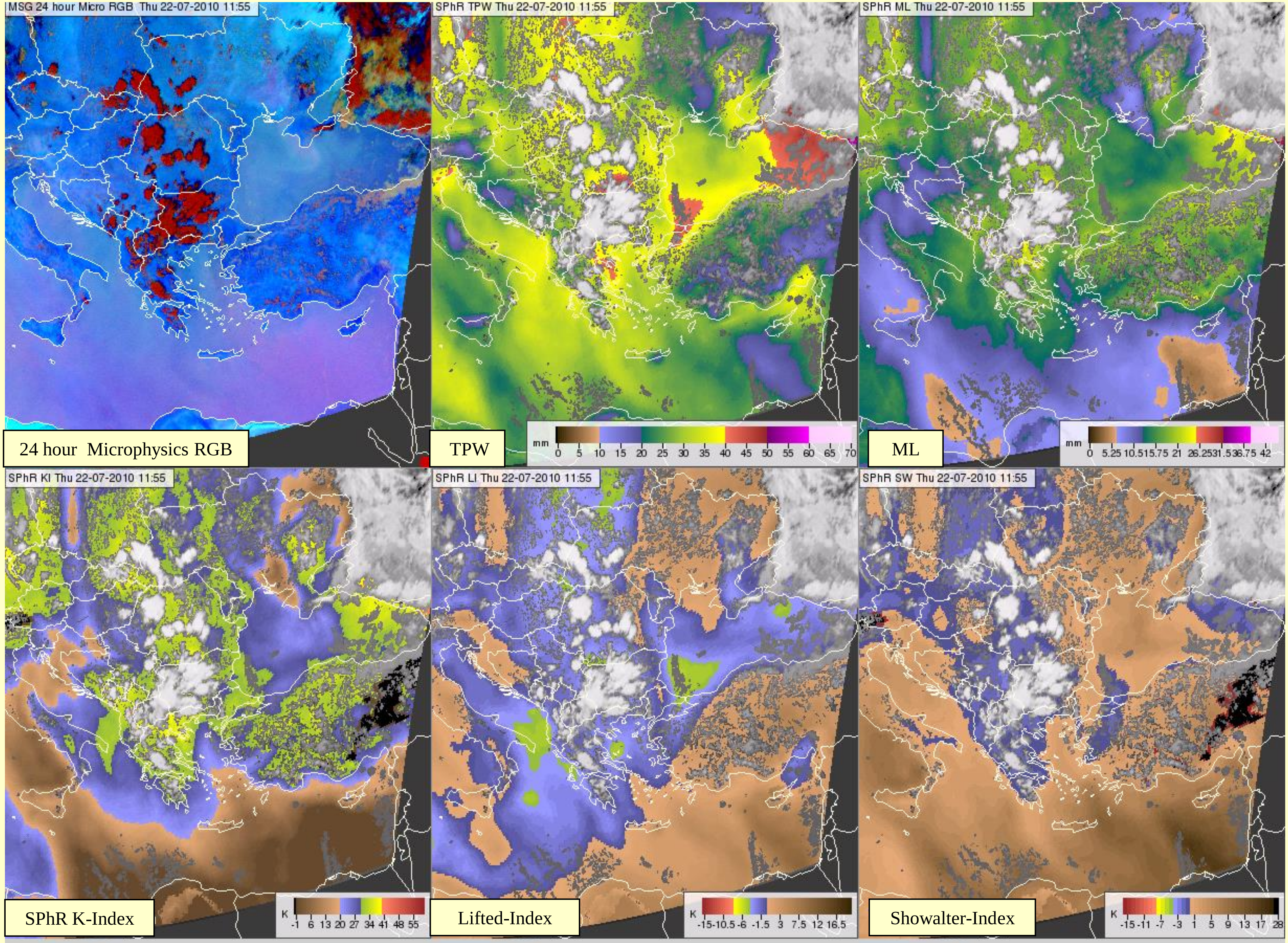
## Extreme dry mid-layer

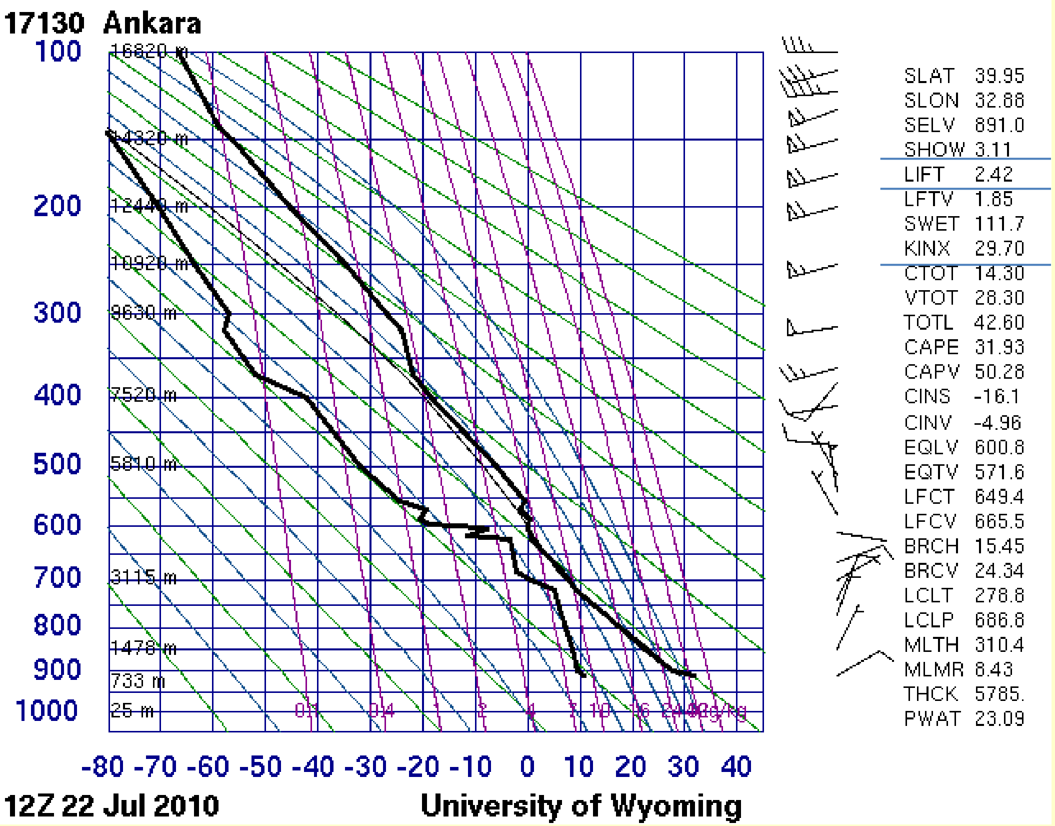



Good accordance with the satellite retrieving.



# ‘Contradiction’ between the instability indices?   Turkey   22 July 2010 11:55 UTC






Good accordance with the satellite retrieving.

The Lifted and Showalter Indices are high positive. The CAPE is negligible.

The K-Index was rather high **also** according the radiosonde measurements (29.7 ºC).

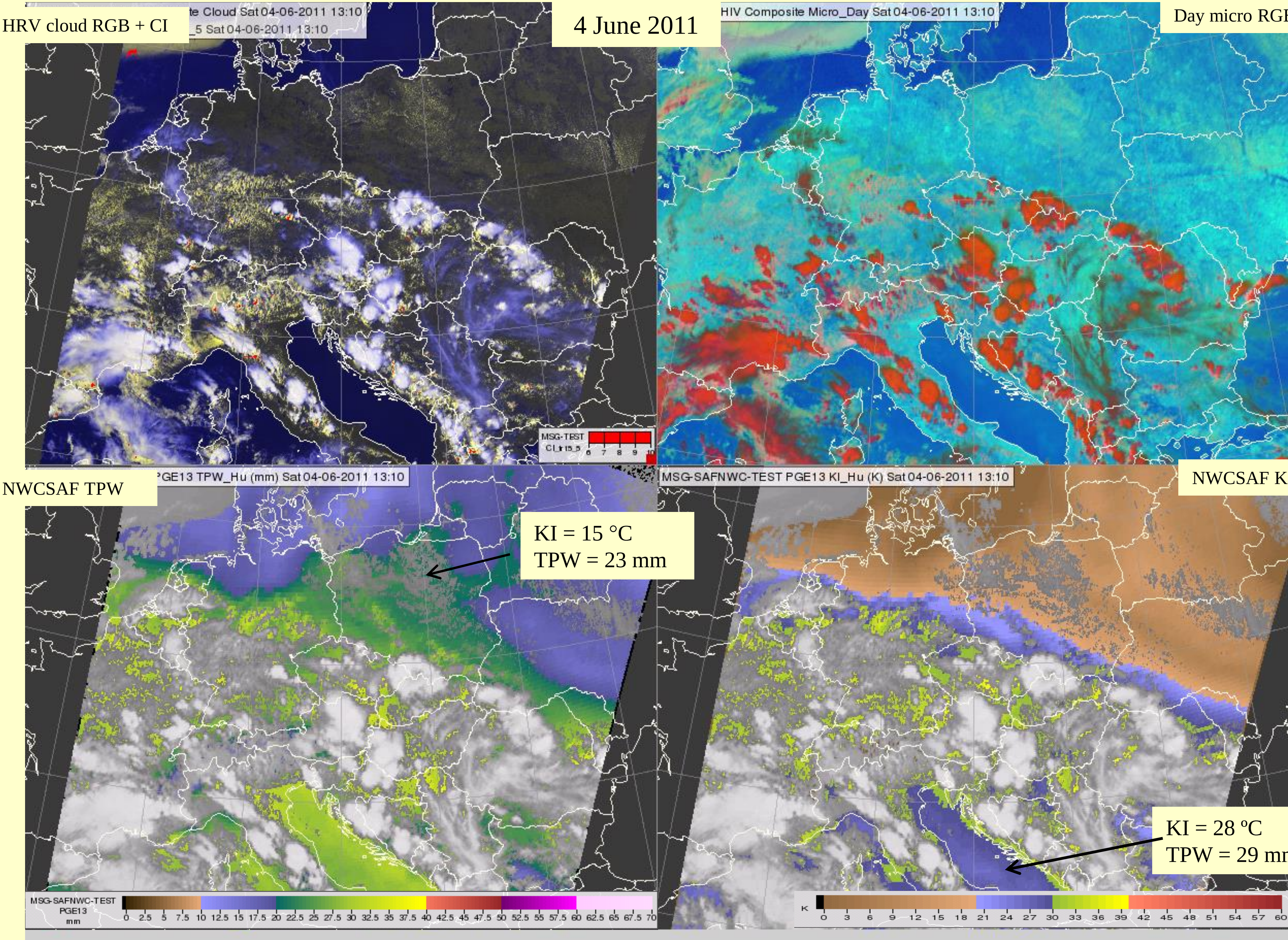
Radiosonde measurements in Ankara, Turkey at 12 UTC

**K-Index = (T(850) - T(500)) + TD(850) - (T(700) - TD(700) )**
where T(p) is the observed temperature and TD(p) is the dew point temperature at p hPa pressure level.

The K-Index was high due to the moist layer at around 700 hPa, and the fact that the dew point temperature at 500 hPa is not included in its definition.

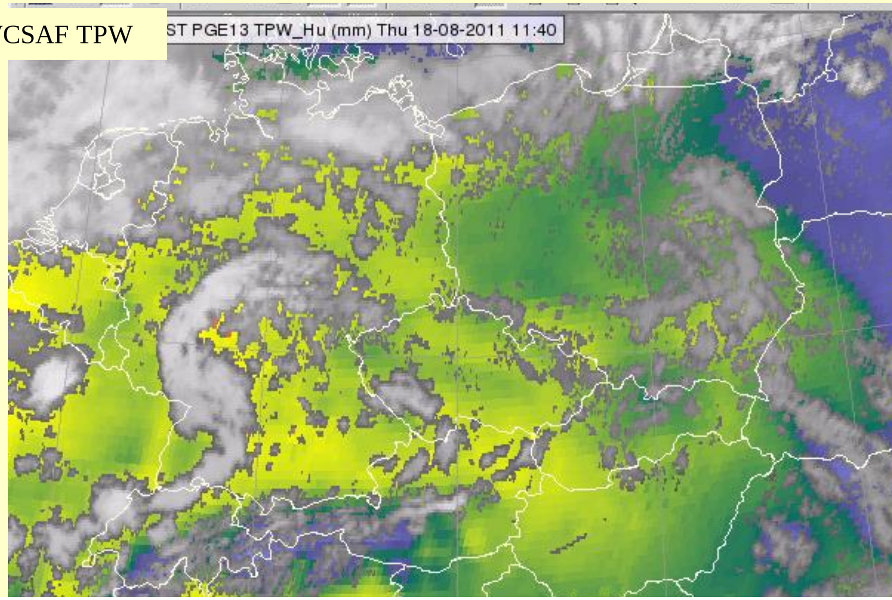
These examples show that the different definitions of the indices capture different situations. In such a ‘contradicting’ case the forecaster should try to understand what the reason of the differences is, and should look the combination of values.

# Moist and unstable environment without deep convection – Adriatic Sea – no lift – no convection

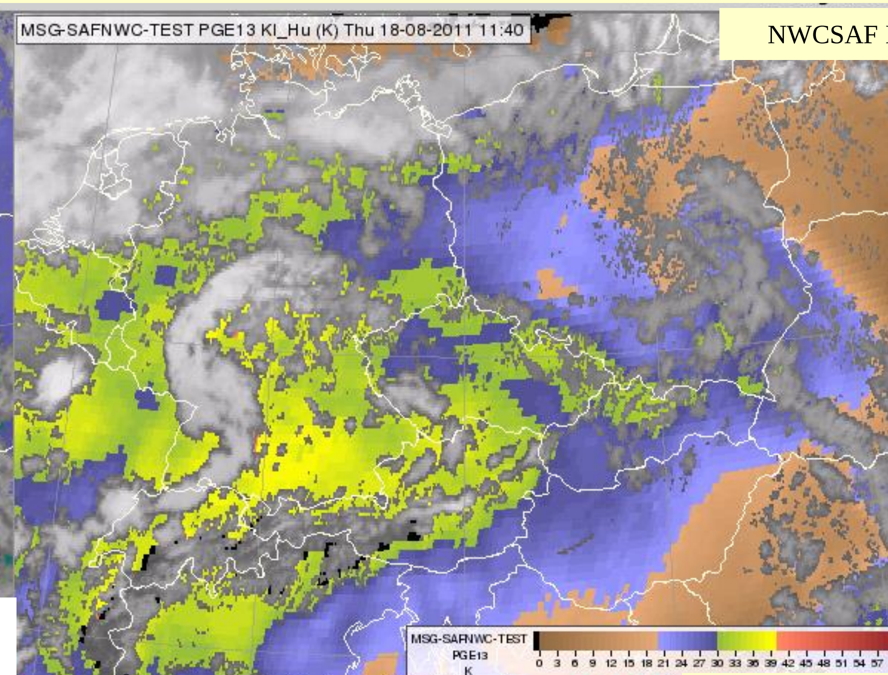


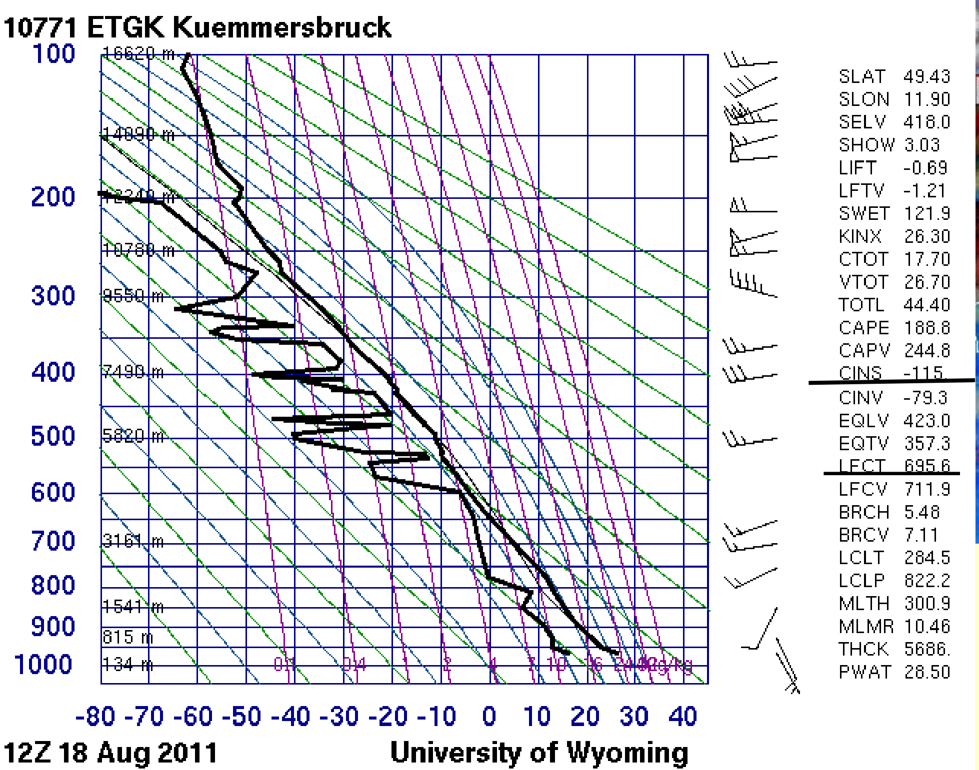
# South Germany - high TPW (up to 36 mm) and K-index (up to 38 °C), but no convection

NWCSAF TPW

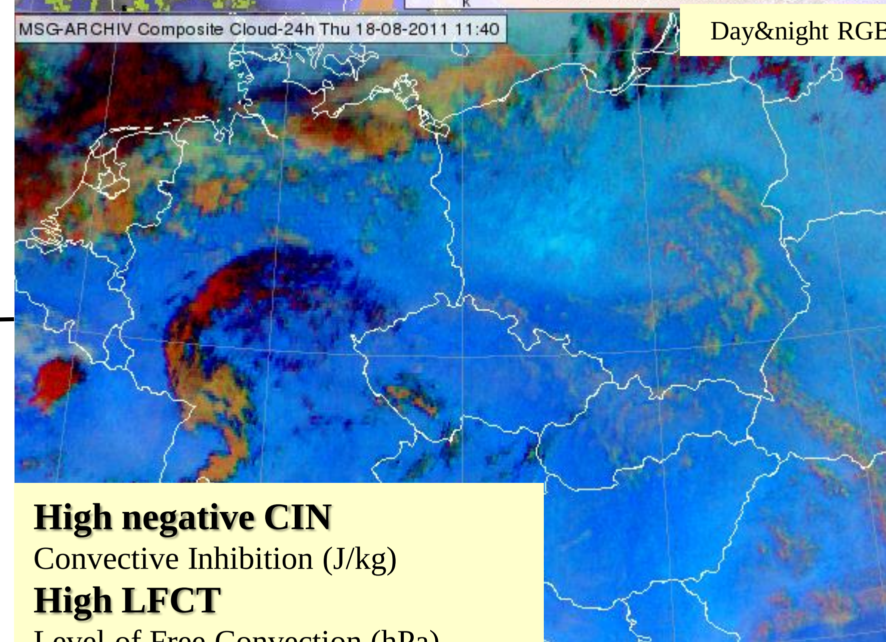



NWCSAF KI




Day&night RGB




**High negative CIN**

Convective Inhibition (J/kg)

**High LFCT**

Level of Free Convection (hPa)

More stable layer 900-750 hPa

18 Aug. 2011 11:40 UTC

# Instability indices over mountains

If the surface pressure is less than 850 hPa – only Lifted Index is defined

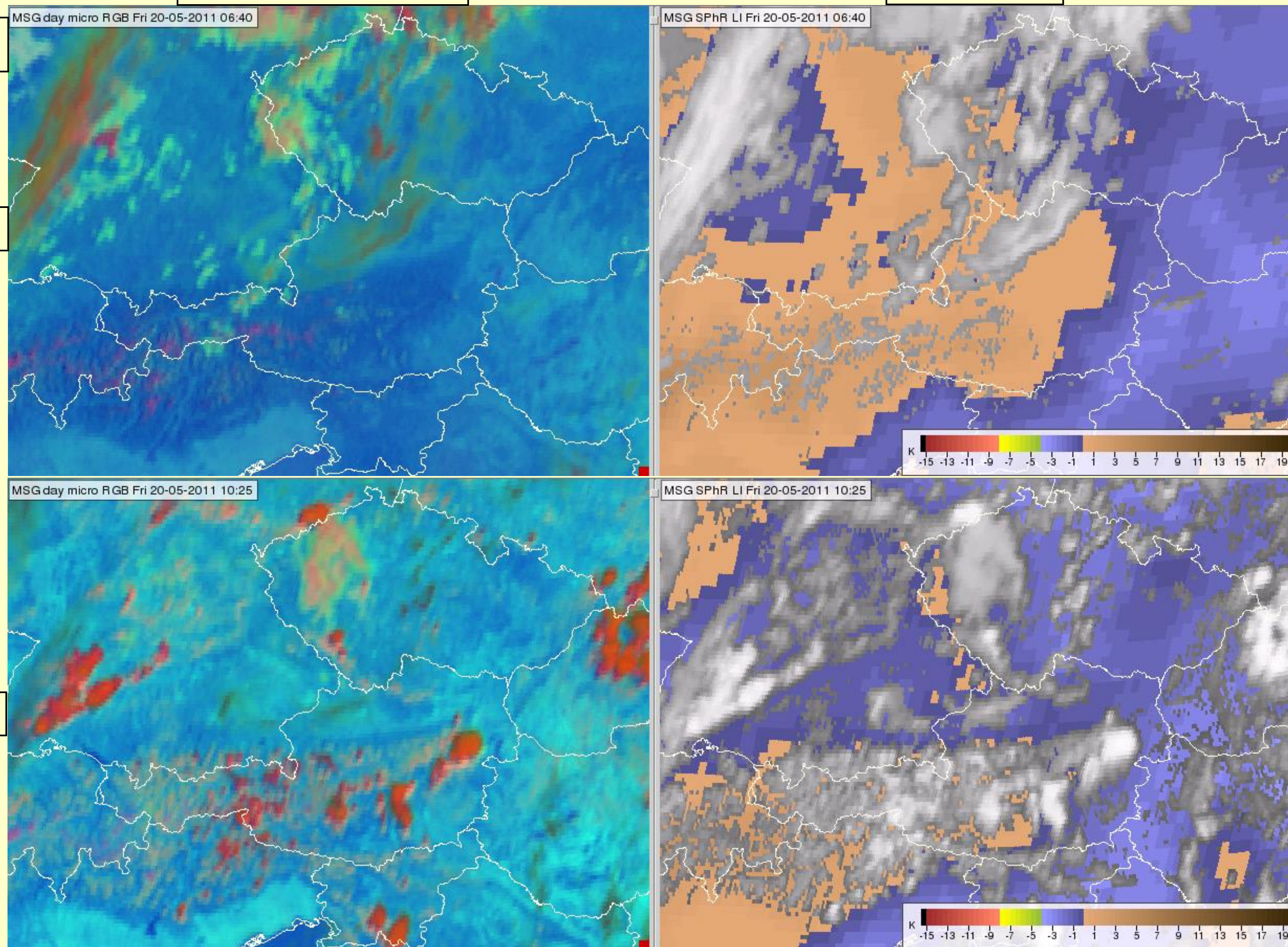
**20 May 2011**

24 hour Microphysics RGB

Lifted-Index

06:40 UTC

10:25 UTC



## Instability indices over mountains

We found (slightly) **positive Lifted Indices over mountainous** terrain in cases when convective clouds develop. How can it happen, as positive Lifted Index is supposed to indicate stable environment?

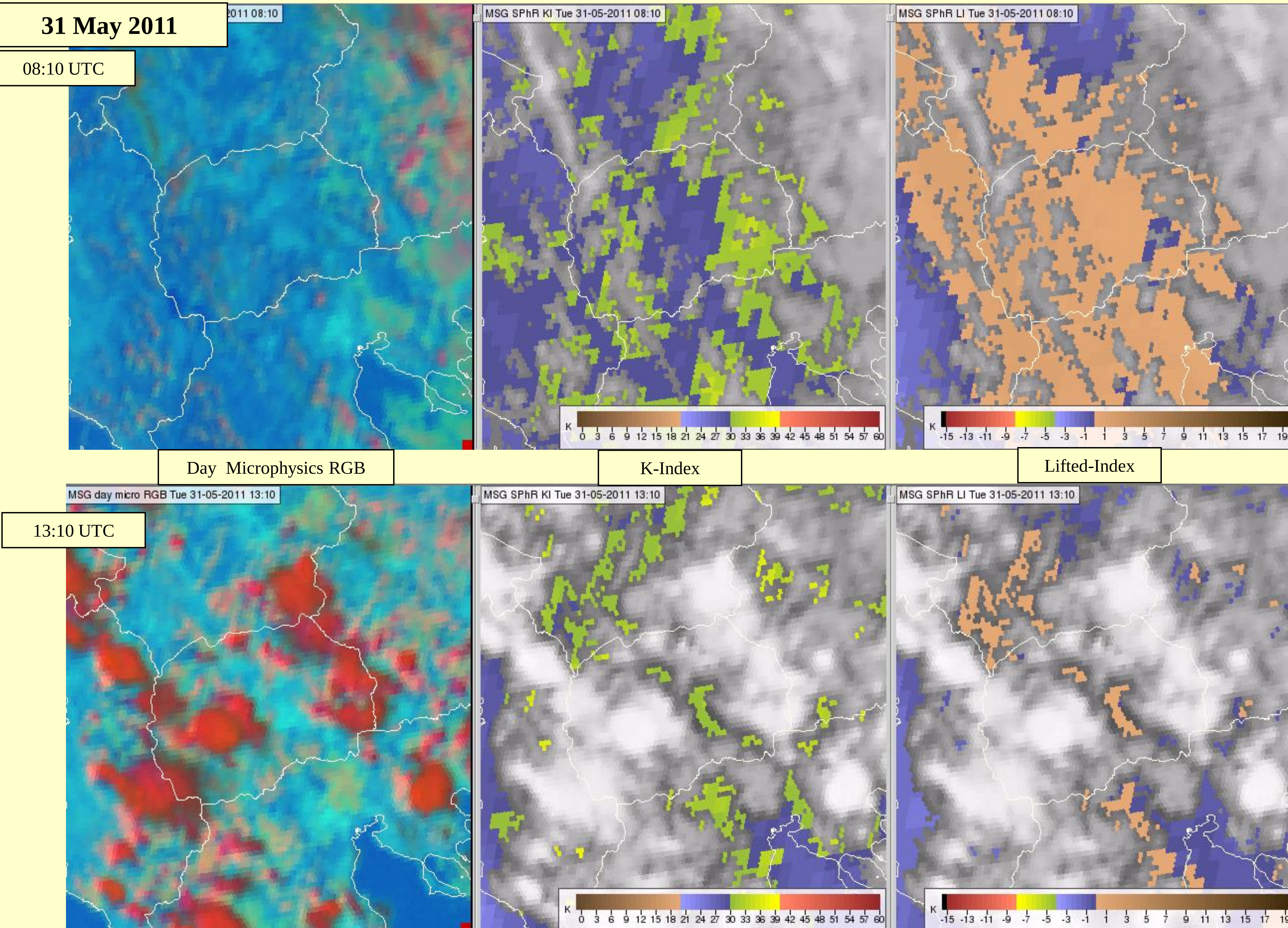
It can happen that the Lifted Index is really positive. **Weak convection is possible for 1-3 K Lifted Index if strong lifting is present**.

- The thunderstorm might originate from a valley (from below the ‘lowest 100 hPa over the surface’.)
- The mountains may lift the parcel above the ‘lower 100 hPa layer’ where (the stratification of) the atmosphere may be more unstable.

It can happen that the positive value of the Lifted Index is a mistake. **The Lifted Index retrieval is more uncertain over mountainous region.** The errors in the retrieval processing could be large due to **different topographies** (real topography, topography used in NWP model and in the satellite retrieval).

The **Lifted Index is closer to zero** anyway over mountains as the virtual air parcel is lifted from a pressure level closer to 500 hPa.

The lifted index is often close to zero over mountains. Thunderstorms may form also for positive lifted indices (0-2 K).



# Conclusions

**useful information on the convective environment**: (total and 3 layer) water vapor content and instability indices.

**Synergy of NWP forecast and satellite observation.**

It **highly increase the temporal resolution** and slightly correct the vertical profile of the moisture.

This small correction might be useful. **It might reflect better the local moisture gradient / moisture boundaries**. **Added value to the NWP forecast**

All the **instability indices** intend to characterize the instability of the atmosphere – with **different definitions** with **different approximations** – they should be used together **-** in case of contradiction the user should try to understand the reason of the differences.

High water vapor content and instability are not enough for deep convection. **Lifting (triggering) mechanism** is also needed.

The **non-detected thin cirrus clouds** may cause too high environmental parameters.

Over mountains we found lifted index around zero – in case storm formed.

---

A Product Tutorial will be published on the EUMeTrain website in 2014 http://www.eumetrain.org/

The SPhR products were created by the SAFNWC/MSGv2012 software


Thank you for the attention!

**Supercell Composite Parameter**

A multiple ingredient, composite index that includes effective storm-relative helicity (ESRH, based on Bunkers right supercell motion), most unstable parcel CAPE (muCAPE), and effective bulk wind difference (EBWD). Each ingredient is normalized to supercell "threshold" values, and larger values of SCP denote greater "overlap" in the three supercell ingredients. Only positive values of SCP are displayed, which correspond to environments favoring right-moving (cyclonic) supercells.

This index is formulated as follows:

$$SCP = (muCAPE / 1000\ J\ kg^{-1}) * (ESRH / 50\ m^2\ s^{-2}) * (EBWD / 20\ m\ s^{-1})$$

EBWD is divided by 20 $m\ s^{-1}$ in the range of 10-20 $m\ s^{-1}$. EBWD less than 10 $m\ s^{-1}$ is set to zero, and EBWD greater than 20 $m\ s^{-1}$ is set to one.