

Possible Usage of IASI L2 Profiles in Nowcasting

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1. Comparison of the GII retrieved parameters and the same parameters derived from the profiles of IASI L2 product
 - Statistics from data for the MSG disk
 - Visual comparison for 7 cases
2. Evaluation of other IASI L2 environmental parameters

This work was done part of EUMETSAT study (EUM/CO16/4600001802/KJG).

Quantitative comparison of the GII retrieved parameters and the same parameters derived from the profiles of IASI L2 product

The GII parameters (KI, LI, MB, KO, TPW, and Layer precipitable water) were calculated from IASI L2 profiles **in the same way**

Comparison to **15 minute EUMETSAT processed GII parameters**

Statistics were calculated **over land and sea, over areas and in parameter intervals**

Areas:

Northpole: $\text{Lat} \geq 60^\circ$

North: $30^\circ < \text{Lat} < 60^\circ$

Tropic: $-30^\circ < \text{Lat} \leq 30^\circ$

South: $-60^\circ < \text{Lat} \leq -30^\circ$

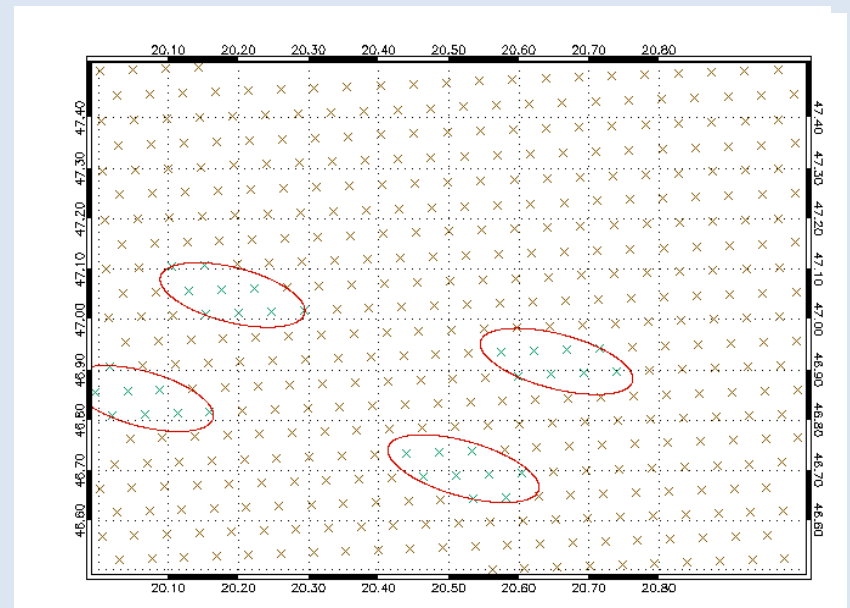
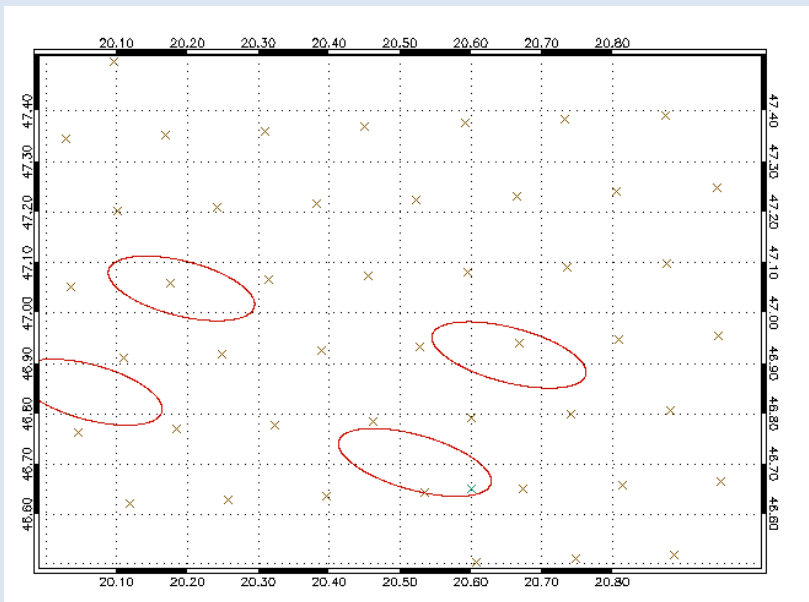
Southpole: $\text{Lat} \leq -60^\circ$

Both Metop A and B data were processed

Period: **April – October 2016**

IASI and GII pixel Co-location

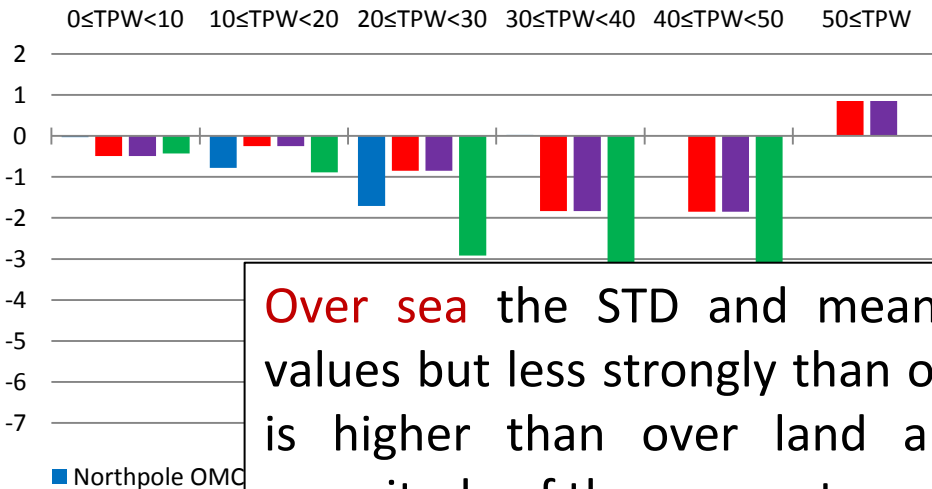
- 1 GII 'pixel' is derived on 3x3 MSG pixels
- GII 'pixels' were re-scaled to MSG pixel resolution.
- MSG pixels within the IASI ellipse were **averaged**, and then the statistics (**Mean Error, RMSE, STD, and correlation**) were **calculated** for land and sea, in specific regions and parameter intervals.



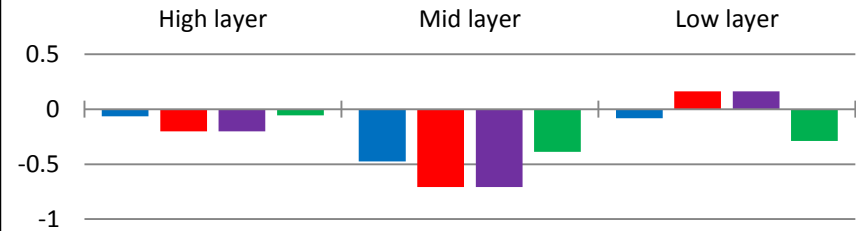
Precipitable Water – Over Land

Metop-B

TPW - Mean Error

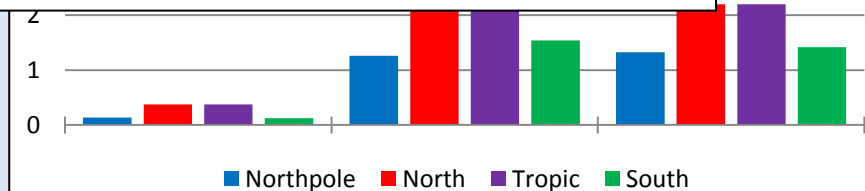
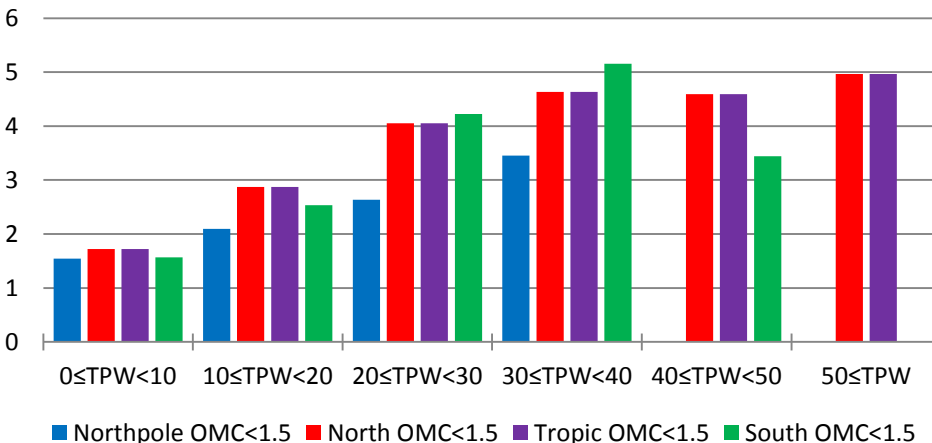


Layer PW- Mean Error



Over sea the STD and mean error increases towards higher values but less strongly than over land. The correlation over sea is higher than over land and depends much less on the magnitude of the parameter.

TPW - STD



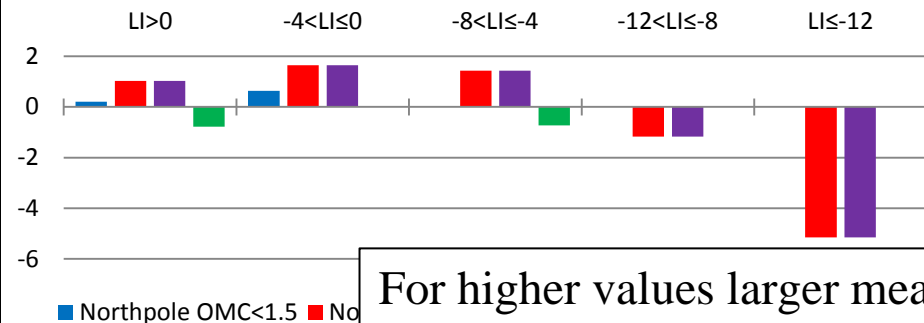
Systematic difference between IASI and GII derived TPW, ML. IASI derives lower TPW, ML.

For higher TPW values higher mean error and STD also lower correlation.

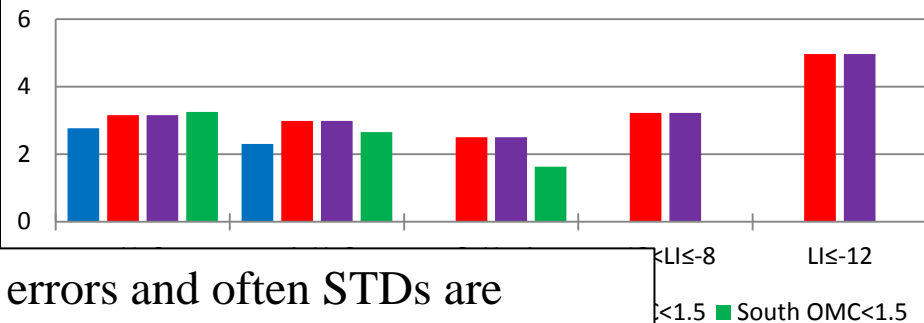
Overall good correlation between GII and IASI PW.

Instability Indices - Over Land (Metop-B)

LI - Mean Error

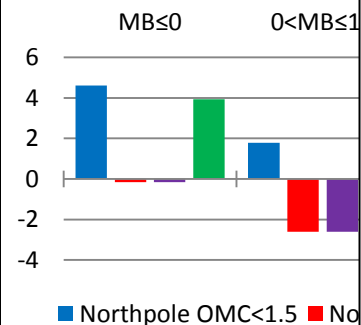


LI - STD



For higher values larger mean errors and often STDs are observed.

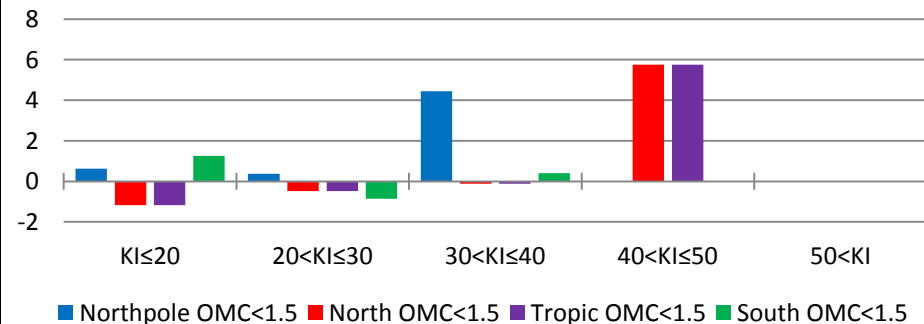
MB



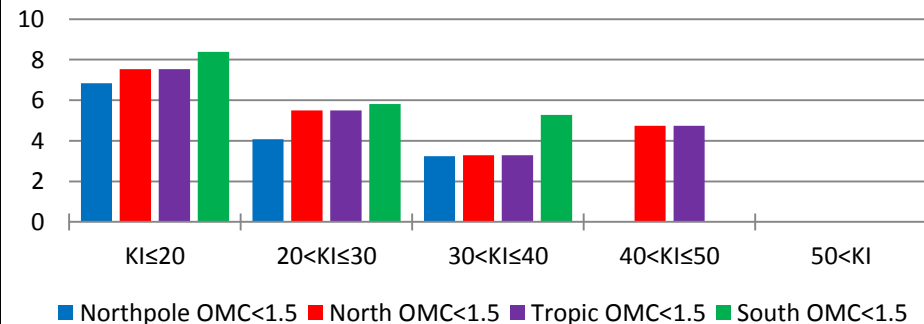
The correlation for higher values is usually lower. For stable areas the correlation is good (0.8-0.9), for the MB a little less (more dependent of the actual profile???)

Over sea the same pattern can be seen for these indices. For most indices and categories the mean error and STD values are smaller than over land.

KI - Mean Error



KI - STD



Visual comparison

Limitations of IASI derived environmental parameters compared to GII parameters

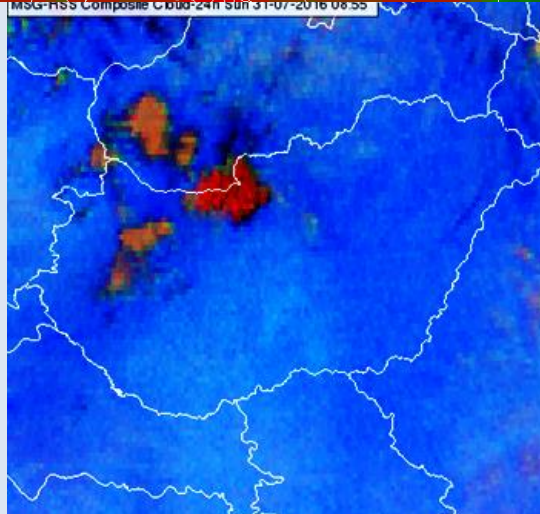
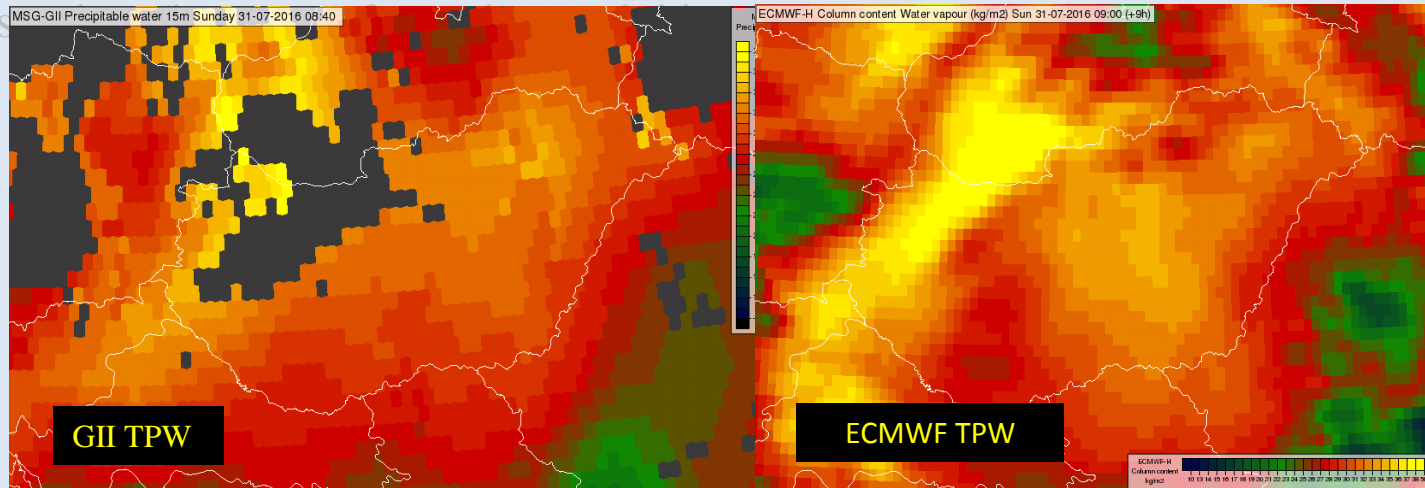
- Lower temporal and spatial distribution

Benefits of IASI derived environmental parameters compared to GII parameters

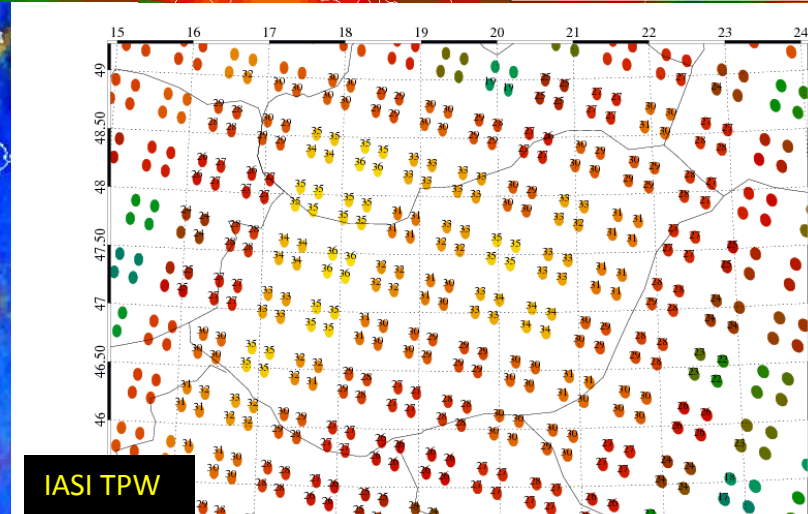
- Independent from NWP
- More accurate (more developed instrument and algorithm)
- It provides data also for cloudy areas (example)
- GII is sometimes product as well)

Retrieval works only for
cloud free areas

In this case the most
important area was
masked



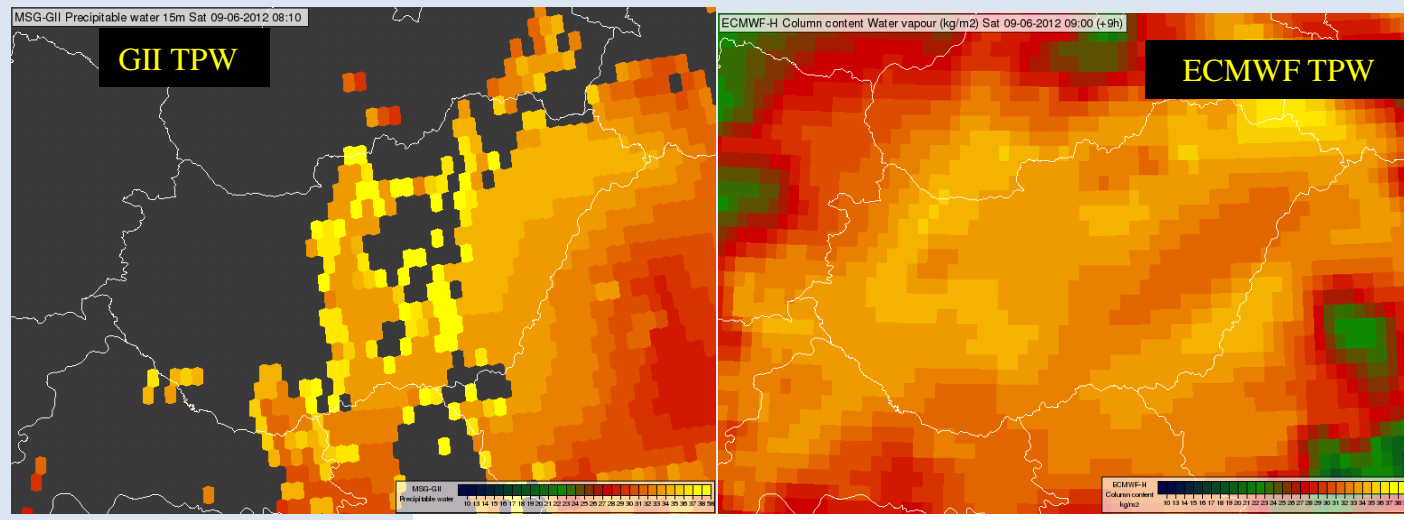
24h Micro RGB



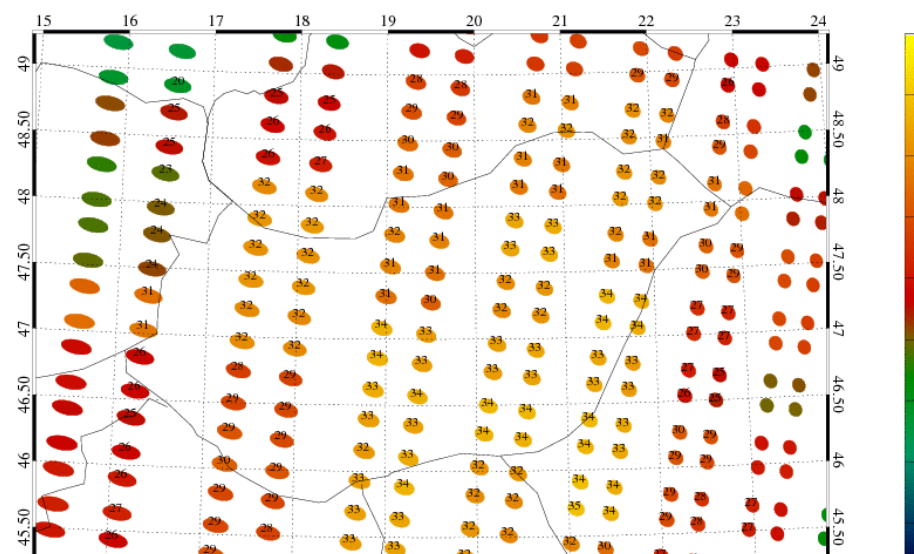
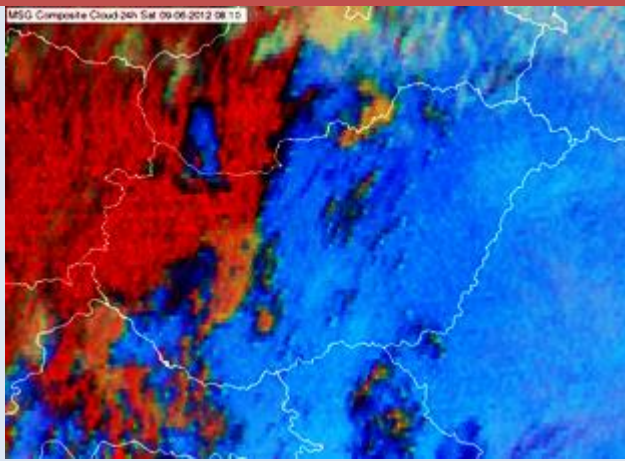
Benefits of IASI derived environmental parameters compared to GII parameters

- Independent from NWP
- More accurate (more developed instrument and algorithm)
- It provides data also for cloudy areas (example)
- GII is sometimes noisy (because of non detected thin cirrus clouds) (similar NWCSAF product as well)

Noise caused by non detected cirrus clouds



GII ‘cirrus effect’.
Seen both in TPW and in the instability parameters



Choice of parameters to be retrieved from IASI L2 data

- Three „ingredients” for convection: **instability, moisture, lift**
- From IASI L2 data we can derive parameters on instability and moisture, but as it does not contain wind profile we can not get information on
 - On lift (to see e.g. a convergence line), or
 - On **wind shear** would be also very important. It effects the life time and the severity of the storm.

All the parameters below were derived from IASI L2 product

Instability (and moisture)	Only moisture	Other
K-index (retrieved from GII and ECMWF)	TPW (retrieved from GII and ECMWF)	Convective Inhibition: MLCIN (retrieved from ECMWF)
Lifted index (from GII), Best Lifted Index (from ECMWF)	BL (Boundary layer prec. Water) (from GII)	lowest 100 hPa lapse rate (from ECMWF)
Max. Buoyancy (from GII)	ML (mid-layer prec. Water)(from GII)	<i>Significant heights:</i>
DTHETAE (from ECMWF)	RH (0-3km) (from ECMWF)	LCL/EL heights (from ECMWF)
SBCAPE (surface-based)	Td depression 2-8 km (from ECMWF)	-10°C/-20°C height (from ECMWF)
MLCAPE (mixed-layer) (from ECMWF)		<i>Lightning potential:</i> PFLI2
MUCAPE (max. unstable) (from ECMWF)		<i>Electric CAPE:</i> EI CAPE (CAPE between 0 and -20 °C)

Comparison of IASI and ECMWF vertical profiles of temperature and humidity –
lapse rates, dry layers, inversions (CIN areas),

Are IASI profiles useful? (not too smooth)?

Comparison of IASI derived parameters with ECMWF forecasts, GII fields

Qualitative comparison: spatial distribution (structure)

Quantitative comparison: magnitude, range of parameters

Comparison of IASI derived TPW with 24h Microphysics RGB images

Qualitative comparison: spatial distribution (structure)

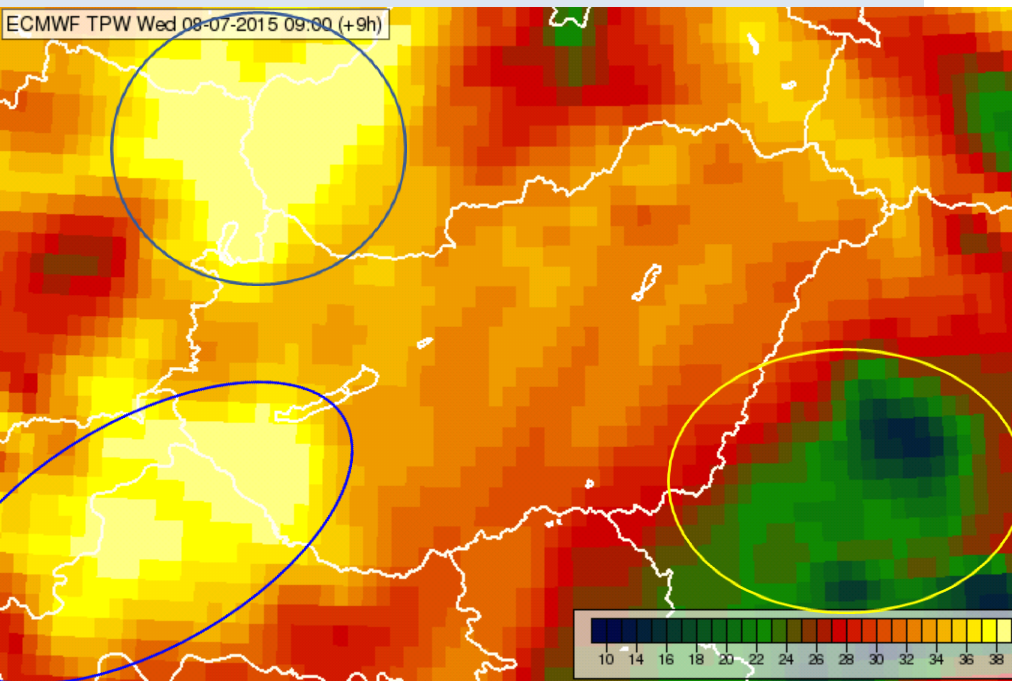
Difficulty of the comparison: Missing independent reference – very few soundings in time of the IASI data availability (e.g. at 09 UTC over Hungary)

Relationship with thunderstorms, which developed later on –

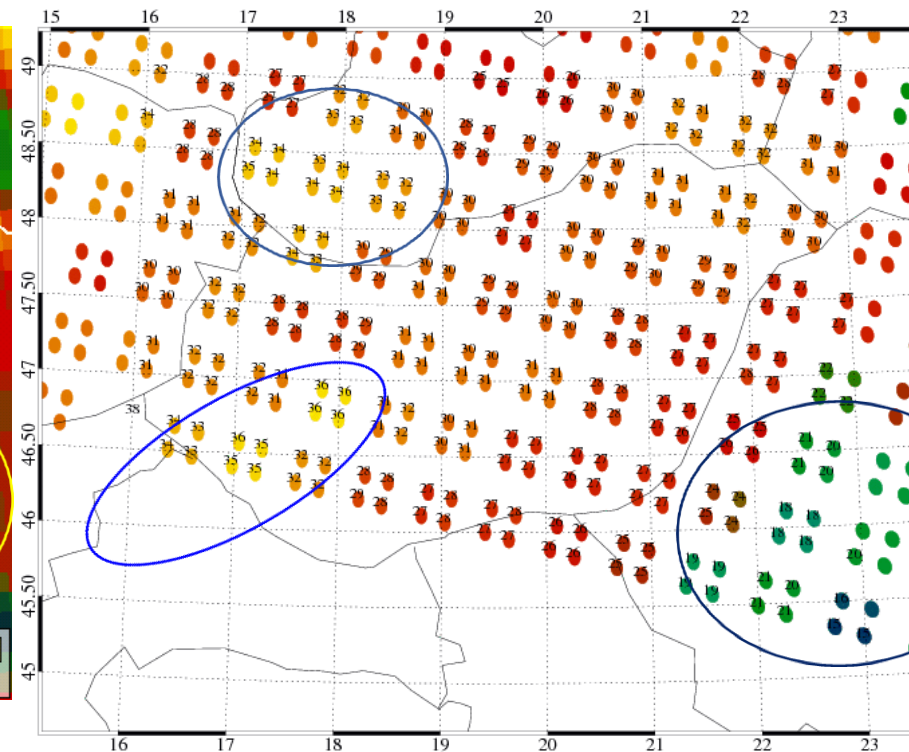
Are IASI profiles, IASI derived parameters ‘in contradiction’ with the thunderstorms later developed?

Is there some ‘added value’ from forecasting/nowcasting point of view?

We found often **similar structure** in ECMWF forecasted and in GII or IASI derived parameters.



Forecasted TPW



IASI L2 derived TPW

The **values and ranger** were sometimes similar, sometimes different.

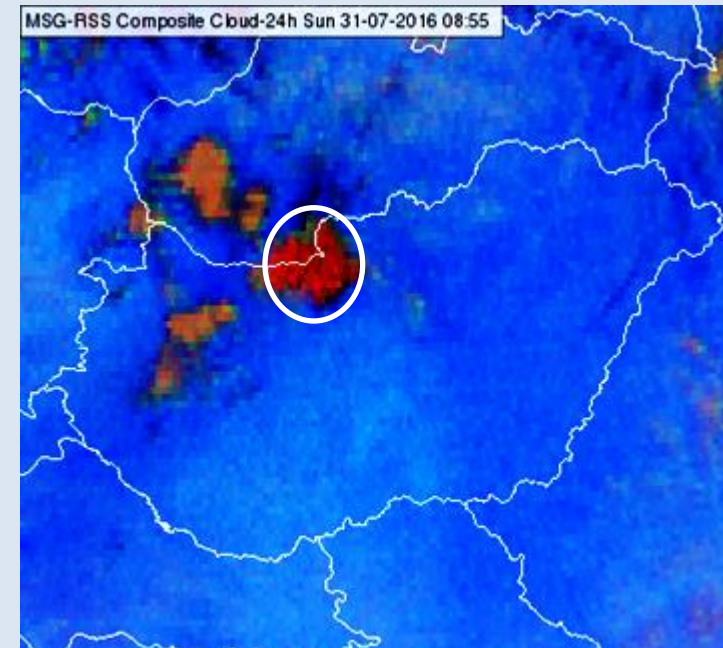
To **understand the reasons** of the differences of the derived parameters we analysed the IASI and the forecasted **profiles** in some locations.

Instability, lapse-rate

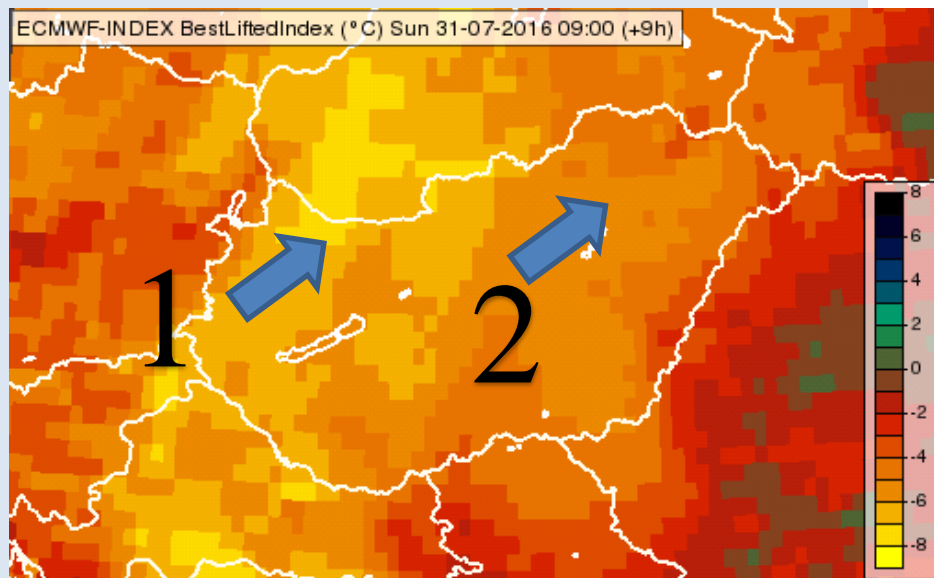
The IASI derived instability indices are often lower than the ECMWF analysed or forecasted ones (first of all the surface-based parameters)

This can be caused by

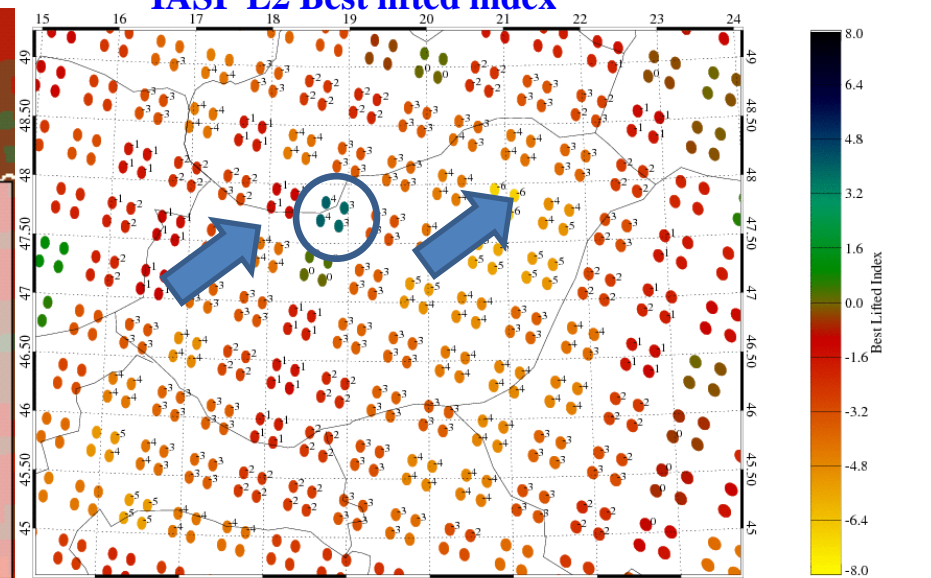
- different low-level moisture and temperature
- cloudy areas (possible precipitation) – colder surface/low levels, often not forecasted by the model (IASI see the actual situation)



ECMWF Best lifted index



IASI L2 Best lifted index

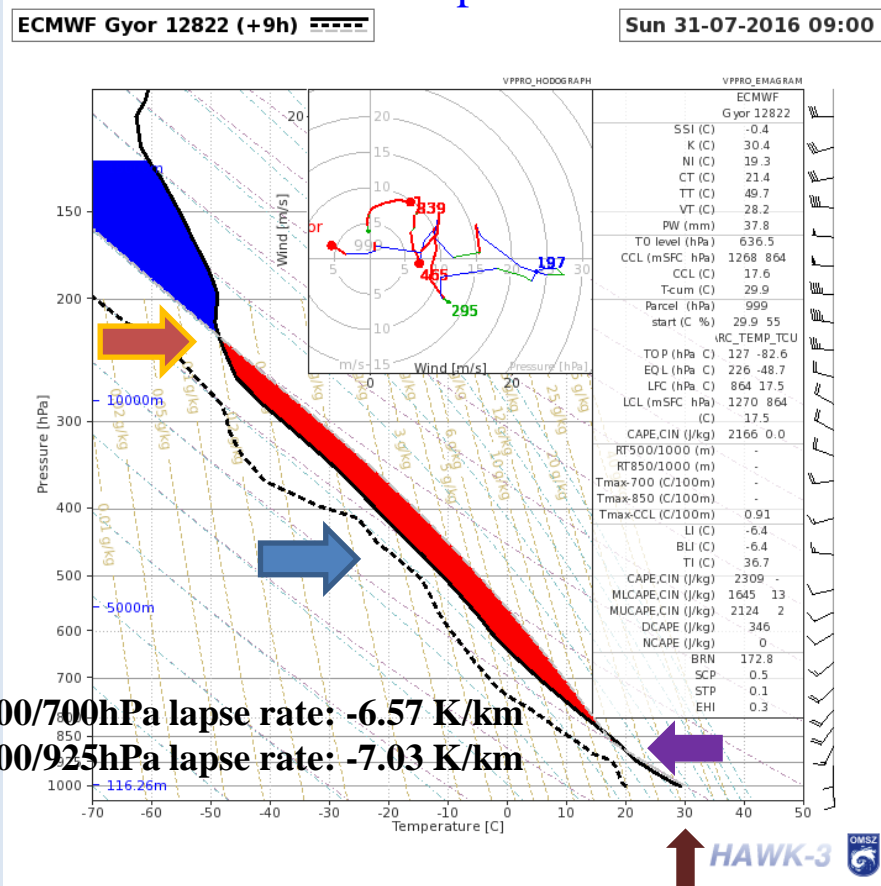


The profiles of two cities will be compared where the forecasted and IASI derived Best Lifted indices are different

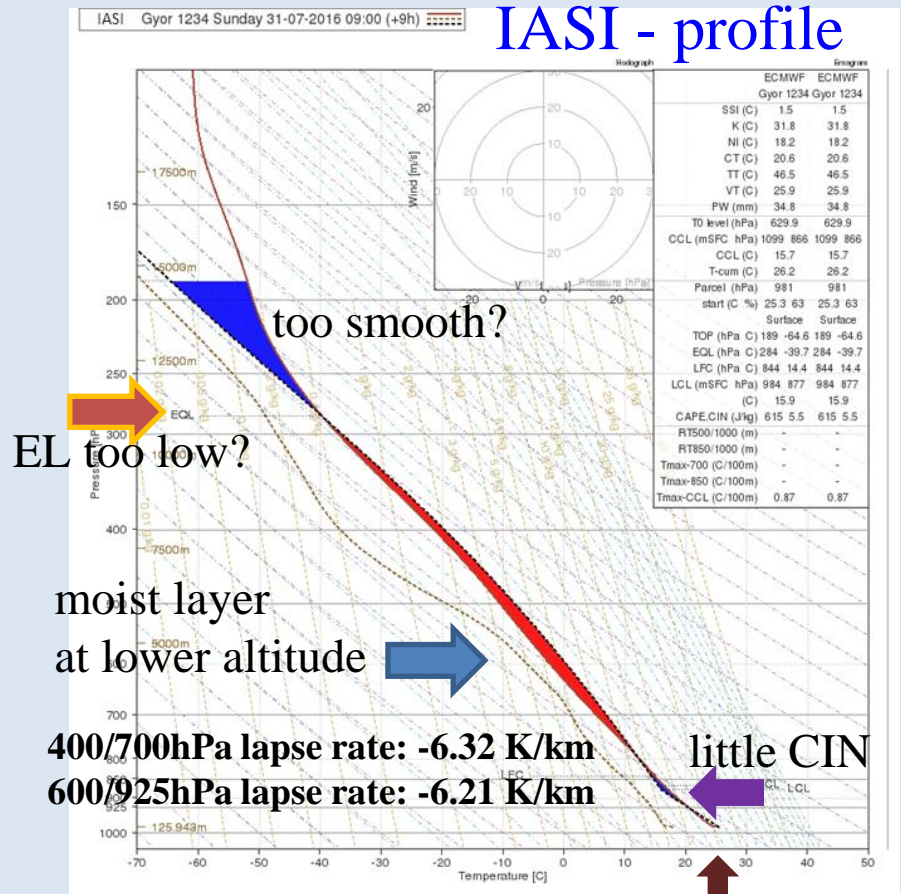
Vertical profile comparison – point 1

- In IASI: lower values of EL, 2m temperature, 2m dew point temp.
- Less steep lapse-rate in IASI, above all at lower levels
- Weak convective inhibition present in both profiles

forecasted profile



IASI - profile

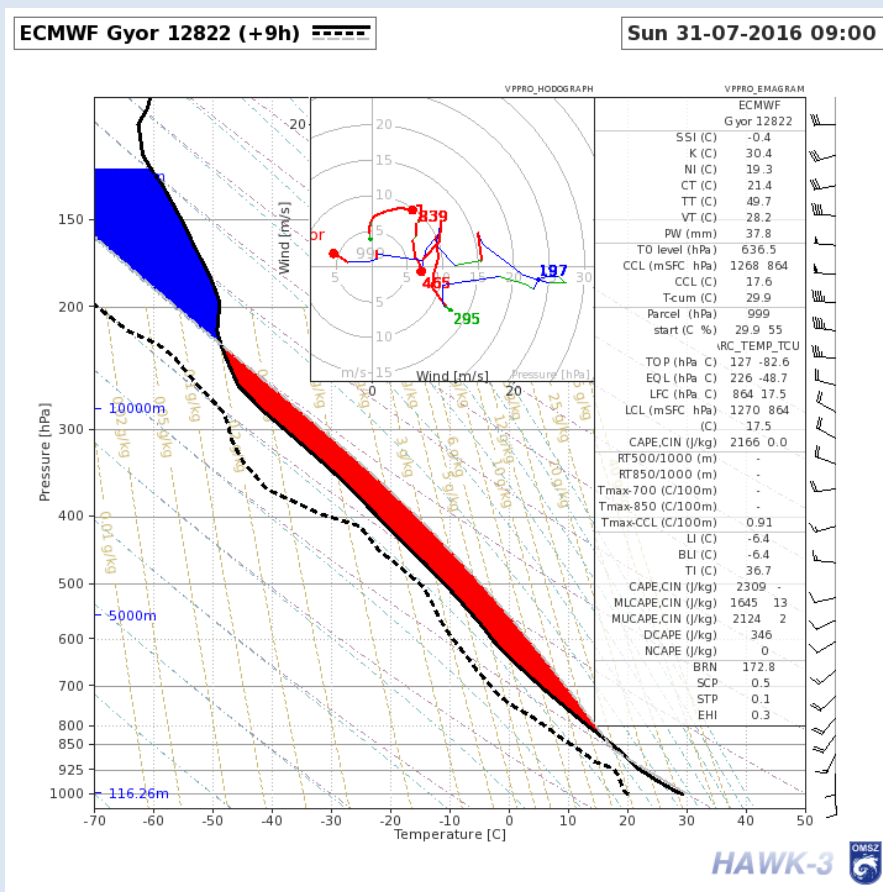


T2 colder (by 2°C) than surface measurement

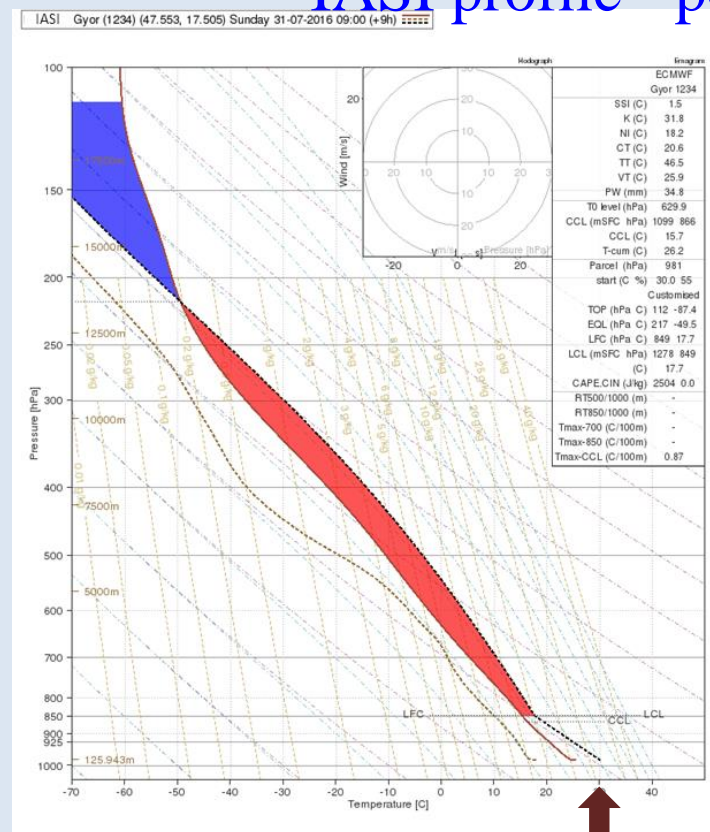
What caused the differences in CAPE?

- We tested, how big the influence of the surface is on the CAPE calculation
- We used the IASI profile, but started the virtual air parcel with the measured T and Td
- With the **corrected surface parcel** we get even higher (2500 J/kg) CAPE than in the ECMWF forecast

forecasted profile



IASI profile - point 1

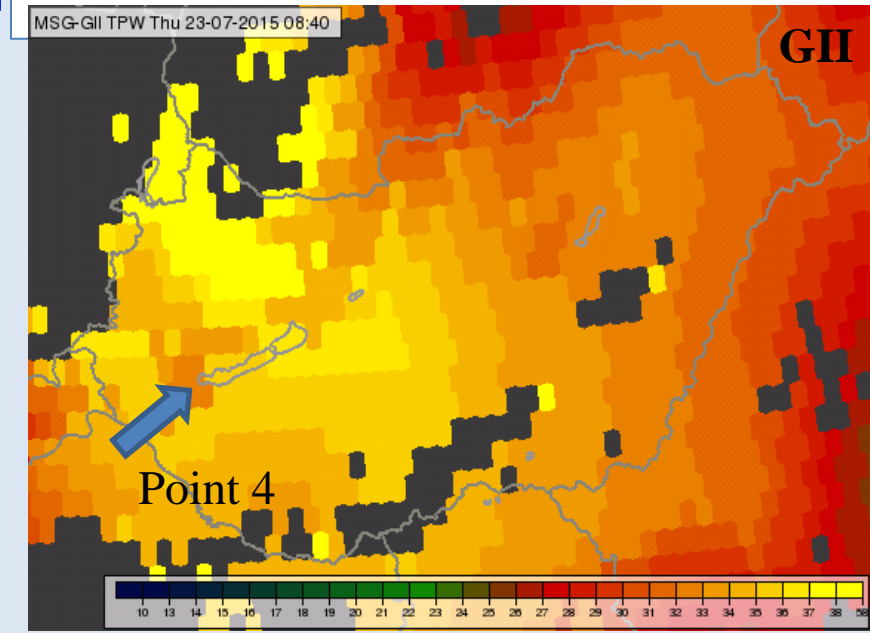
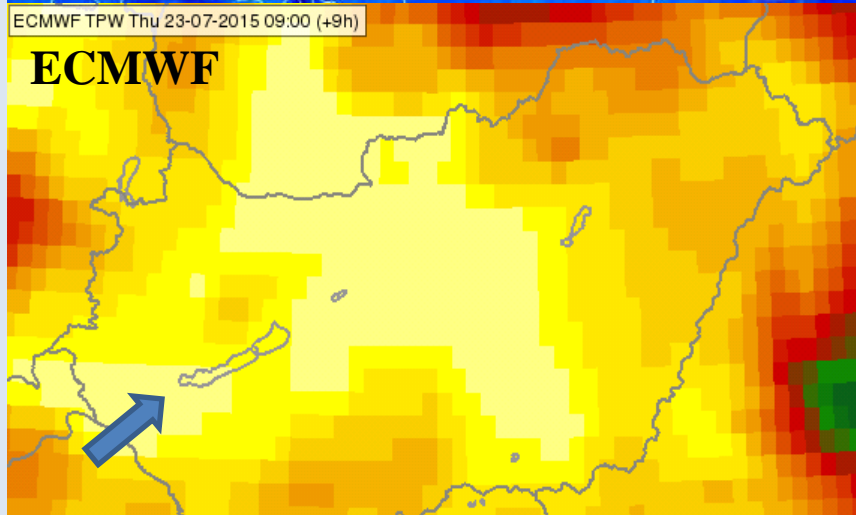
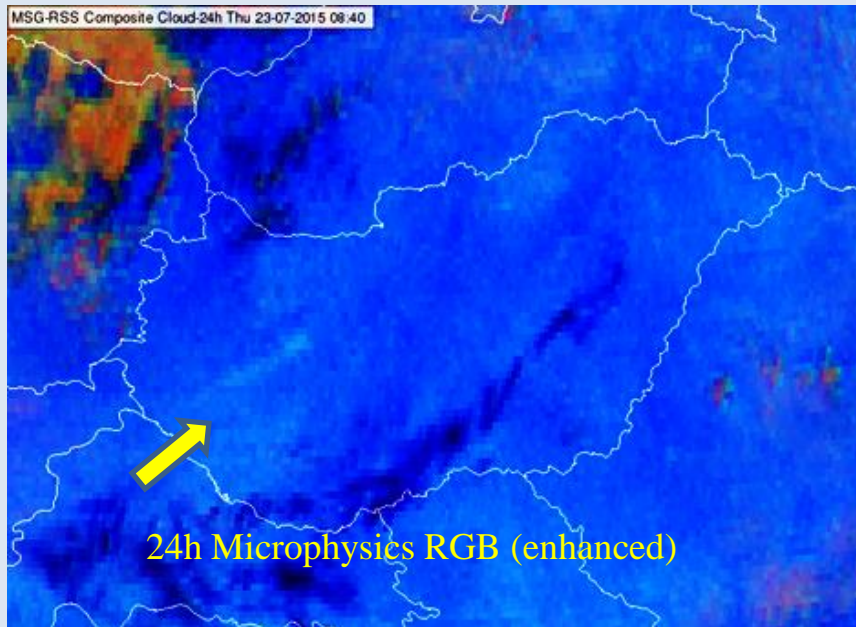


Corrected T2, Td2 by 2°C



Humidity, TPW

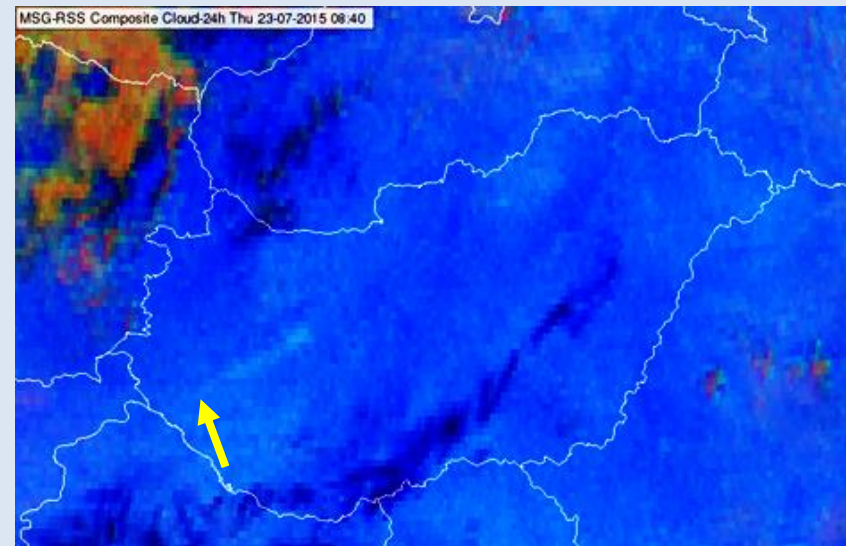
The IASI derived TPW at 'Point 4' was lower than the ECMWF forecasted one. GII also decreased here the forecast. The RGB image shows dryer environment here.



The profiles of two cities will be compared.

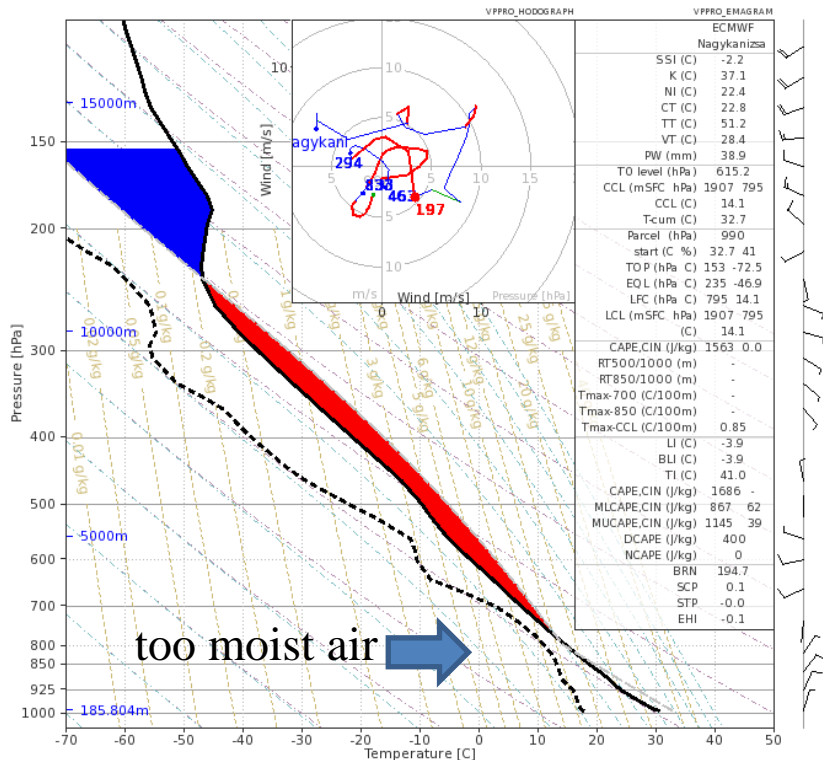
Evaluation – point 4

- IASI profile is less moist at 800 hPa
- The 24h Microphysics RGB indicated relatively dry air (green component: BT10.8-BT8.7), this agrees with IASI profile
- The thunderstorms in this area were short-lived,



ECMWF Nagykanizsa 12925 (+9h) -----

Thu 23-07-2015 09:00

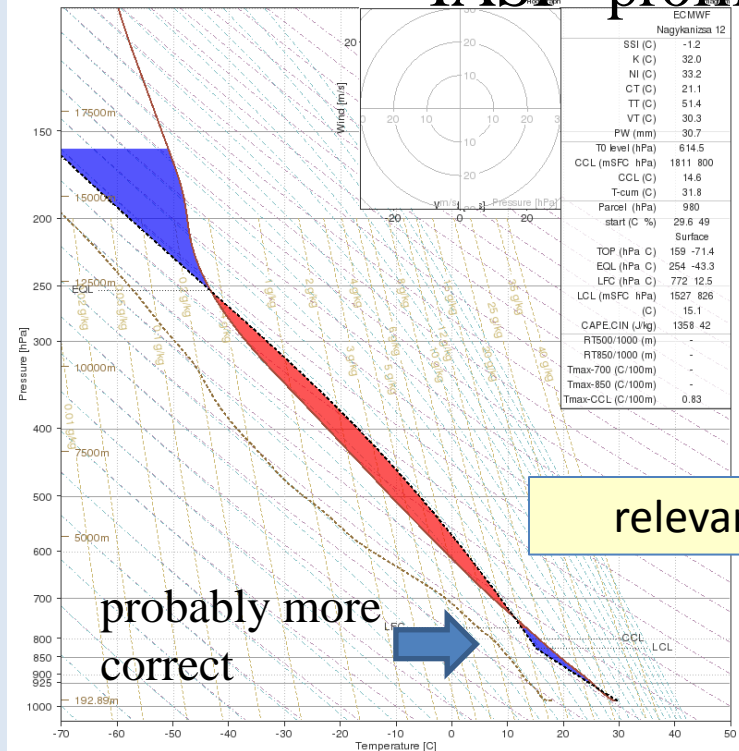


TPW 38.9 mm



ECMWF Nagykanizsa 1234 Thursday 23-07-2015 09:00 (+9h) -----

IASI - profile



relevant

probably more correct

TPW 30.7 mm

IASI indices/profile summary

- The IASI profiles are relatively smooth, yet, low-level inversions and inhibition layers can be still recognized.
- The IASI parameters showed often the same structure as the forecast.
- **The IASI indices/profiles mostly suggested possibility of convection in the studied situations.**
- As most environmental parameters are sensitive to the surface T and Td and as the IASI L2 profiles often underestimates the T2m (by 1.5 °C) it is more beneficial to use parameters, which are **less surface-dependent** (lapse rates, TPW, average humidity, etc.) and/or correct the profile with actual surface measurements.
- **Large differences between IASI parameters and the model forecasts** can indicate that
 - the forecast is not correct, or
 - the IASI profiles are not correct. To check this it is worth to look at the IASI T, Td **vertical profiles**, not only the indices. One could recalculate the IASI instability parameters **by correcting the IASI profiles with actual surface measurements.**
- One could recalculate the IASI instability parameters by using expected maximum temperature to get the expected maximum instability of that day.
- At mid-levels, the IASI humidity could eventually **correct** ECMWF forecasts, both at cloudy and cloud-free areas.

Benefits and limitations of IASI-derived environmental parameters

Benefits	Limitations
NWP – independent The NWP-based forecasts can be checked and corrected. In case of large differences a ‘warning signal’ might be given.	IASI profiles (mainly dewpoint) are very smooth , which might be misleading. The precision of low-level data is often uncertain.
Data are available in cloudy areas as well (big advantage with respect to GII).	Some parameters depend strongly on surface temperature and dewpoint temperature
Measured when only few upper-air data, often well before convection initiation. Information for many points	Low temporal resolution There is no information on lift or wind shear
The IASI derived convective parameter distribution mostly fits the situation and the later development of convection	In rapidly changing situations , its forecasting applicability is limited (though still better compared to soundings).
It can be also used as additional sounding or pseudotemp, <i>It might be beneficial to modify the profile with measured surface data.</i>	

Recommended Parameters from IASI L2 Profiles

Parameter:	Advantage:	Deficiency, limitations of use:
Temperature lapse rate (K/km)	Directly related to instability, independent of surface properties and moisture (suitable to diagnose also elevated convection). Low level lapse rate (compared to dry adiabatic lapse rate) could be used instead of CIN to assess the convective inhibition with respect to the surface	Severe storms can develop also by relatively moderate lapse rates, not much steeper than the moist-adiabatic one (~5 K/km). The availability of moisture must be retrieved separately
Total Precipitable Water	Assessed from IASI L2 with relatively good reliability, can be compared with 24h RGB Microphysics imagery. Indicates the absolute amount of moisture in the air, which is important in warm airmasses, where the relative humidity seems to be too low for thunderstorm development.	Can be somewhat underestimated in IASI L2 products because of uncertainty of low-level humidity detection.
K-index (K)	Not sensitive on surface temperature or dewpoint errors. Relatively robust and widely used in forecasting.	Presence of dry layers at mid-levels can decrease K significantly but this does not always inhibit deep or severe convection. In such cases retrieval of the vertical profile and comparison with other indices (e.g. Maximum Buoyancy) is recommended.
BestLI (K)	Less dependent on surface temperature and moisture than LI, well indicating conditions for thunderstorm development.	Over the sea, the conditions for deep convection can be exaggerated (if the near-surface layers are very moist). A version with mixed-parcel initiation could be tested
Maximum Buoyancy (K)	High values are often related to severe storms and also to high lightning activity.	In the present version it is quite dependent on the surface temperature and humidity. Averaging of the equivalent potential temperature from more levels could be more robust
MUGAPE		The CAPE type indices are usually sensitive on

Possible future development

- Construct new and/or refine old parameters, which are less dependent of surface properties (lapse rates, mixed-layer CAPE, LI, Maximum Buoyancy, etc.). Prepare **guide for forecasters**, how to use them properly.
- It would be beneficial to modify the profile with measured surface measurements.
- **Quality control for the users** (if there are too big differences with respect to NWP)
- **Ensemble products**? Taking into account the uncertainty of the surface properties, providing rather intervals than single values.

Thank you!