Implementation of EUMETSAT GII/RII software to SHMÚ ALADIN operational suite and first validation results

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Parameters used for diagnostics of instability of the atmosphere

The most precise information about temperature and humidity vertical profiles that are used for determination of stability of the atmosphere comes from aerological measurements. Unfortunately density of aerological stations provides only very rare information which can be used only locally or inside of certain airmass.
In recent years new possibility in determination of atmospheric stability is to use multispectral data from geostationary satellite - measured brightness temperatures by IR channels to retrieve temperature and humidity profiles and to compute instability parameters in regular high resolution grid.

What is GII software

GII is a software package offered to our institute by EUMETSAT. Aim of this programme is to use MSG IR brightness temperatures and NWP outputs as a first guess to determine realtime temperature and humidity profiles of the atmosphere and to use determined profiles for computation of atmospheric instability indices.
GII version of this software uses GLOBAL NWP temperature and humidity profiles and RII version uses REGIONAL data based on outputs from limited area NWP models (Aladin, Slovakia domain).
Resolution of RII version is much closer to MSG pixel resolution (3x3, 1x1) and local model provides us also with more precise forecast data.

Parameters suitable/considerable for instability diagnostics of the atmosphere

There are several classical indices for which the satellite derived profiles can be used. Indices available by GII software, already validated in Central Europe conditions (IMGW) are:
- K-index (Running operationaly at SHMÚ)
- Lifted index (Running operationaly at SHMÚ)
- Total precipitable water content (Running operationaly at SHMÚ)

Following microburst indices have to be tested in Central Europe conditions:
- WI (Wind Index)
- TeD (Theta-e Difference)

•WMSI (Wet Microburst Sevirity Index
These parameters are planned to be implemented at SHMÚ, tested and validated in near future. Definitions of microburst indices can be find in:
http://www.star.nesdis.noaa.gov/smcd/opdb/aviation/mb.html

GII software overview

- is based on RTTOV Library (NWP SAF) where Radiative Transfere Model is implemented
- NWP outputs (Temperature, Humidity, Pressure) are used as a first guess
- brightness temperatures from 6 IR SEVIRI channels are used as input to radiative transfere model
- The basis of the method is 1D-var retrieval iterative algorithm
- Cloud mask is used to determine clear atmosphere where only the retrieval can be performed
- When temperature and humidity profiles are retrieved indices can be computed and visualised

Note: IR channels available from MSG SEVIRI instrument used as input to retrieve temperature and humidity profiles are 6.2, 7.3, 8.7, 10.8, 12.0 and 13.4 μm.

Model ALADIN inputs and domain definition

- Temperature field (3D)
- Relative humidity (3D)
- Surface pressure (2D)
- Surface temperature (2D)
- Temperature in 2 m (2D)

Note: 3D fields contain from 34 horizontal layers.

- Grid step 0.049 deg (~5.5km)
- Grid size 400x250 points
- ALADIN domain area lon 7.525E / 27.475E
lat 41.275N / 53.725N

Details of local GII/RII Installation in Slovakia:

- Threshold of retrieval 1.5 K
- Max number of retrieval iterations 4
- Running in 1x1 MSG pixel resolution
- every 15 minutes using MSG-2 and 1 hour Aladin inputs interpolated into 15 minutes time slots
- Processing on Intel Pentium-4 3GHz within 5 minutes (using 4 iterations or within 3 minutes using 2 iterations)
- K-index, Total precipitable water content or Lifted index are visualised in combination with single IR channels or Airmass RGB

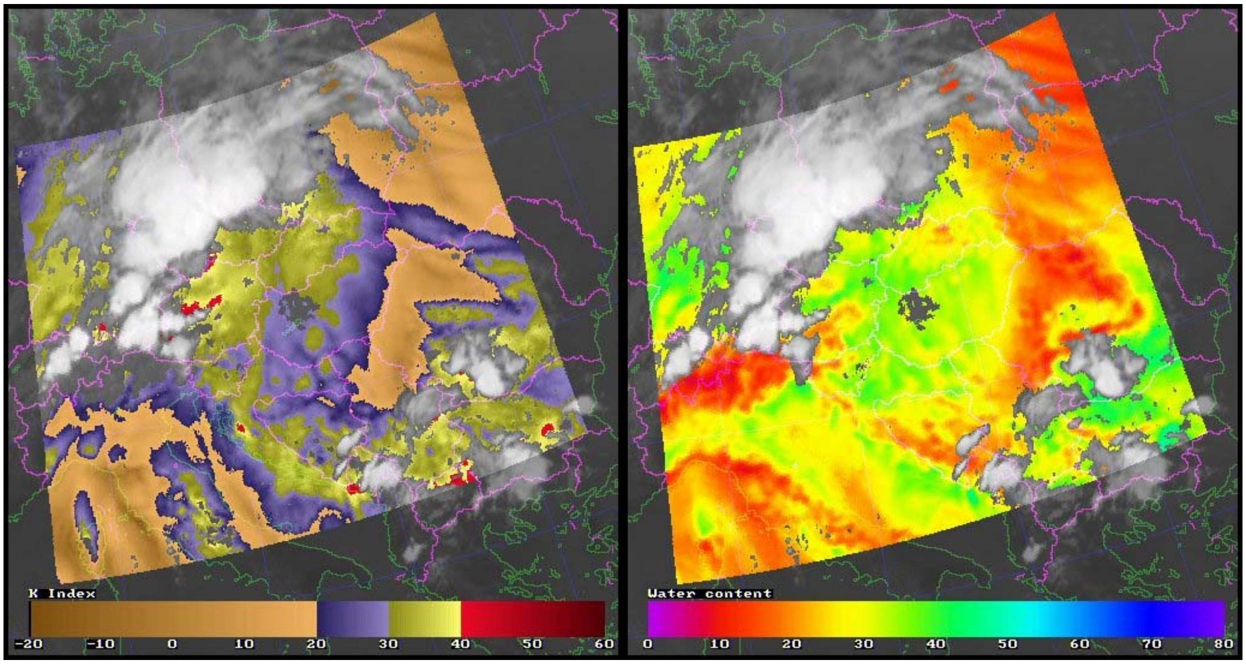

Fig 1: K-index and Total precipitable water content combined image for 25th June 2008 17:00 UTC

Preliminary validation results

Validation was based on 23 stormy days in 2008 and 2009 convection seasons over Slovakia or central Europe. These stormy days firstly were identified by mesosynoptic analyses, then indices were reprocessed and finaly validated against Aladin model outputs, radar precipitation measurements and lightning detection. List of selected cases is in table 1.

Table 1:

30.5.2008	25.6.2008	14.7.2008	11.6.2009
31.5.2008	26.6.2008	1.8.2008	16.6.2009
1.6.2008	30.6.2008	14.8.2008	18.6.2009
2.6.2008	7.7.2008	15.8.2008	6.7.2009
23.6.2008	12.7.2008	7.9.2008	18.7.2009
24.6.2008	13.7.2008	11.5.2009	

It is rather natural that in mountain areas lower TPW values were resulted from RII because of absence of low water vapour levels. Similarly higher K values were obtained for these areas due to missing T_{850} level. Generaly high values of K index and TPW are usualy overlaped except in some cases in mountain areas.
It is real advantage that we have real-time TPW and K index fields development and we have possibility to find almost all thunderstorms in areas with high K and TPW values. As results from mesosynoptic analyses show high K and TPW values does not guarantee occurrence of thunderstorms. There are many other factors which influence thunderstorm development and especially trigerring: vertical wind shear, frontal boundaries, insolation and orography.

K index is very sensitive to relative humidity in middle troposphere, simultaneously lack of water vapor in these levels provides strong downbursts potential and therefore comparison K index with TPW is useful.

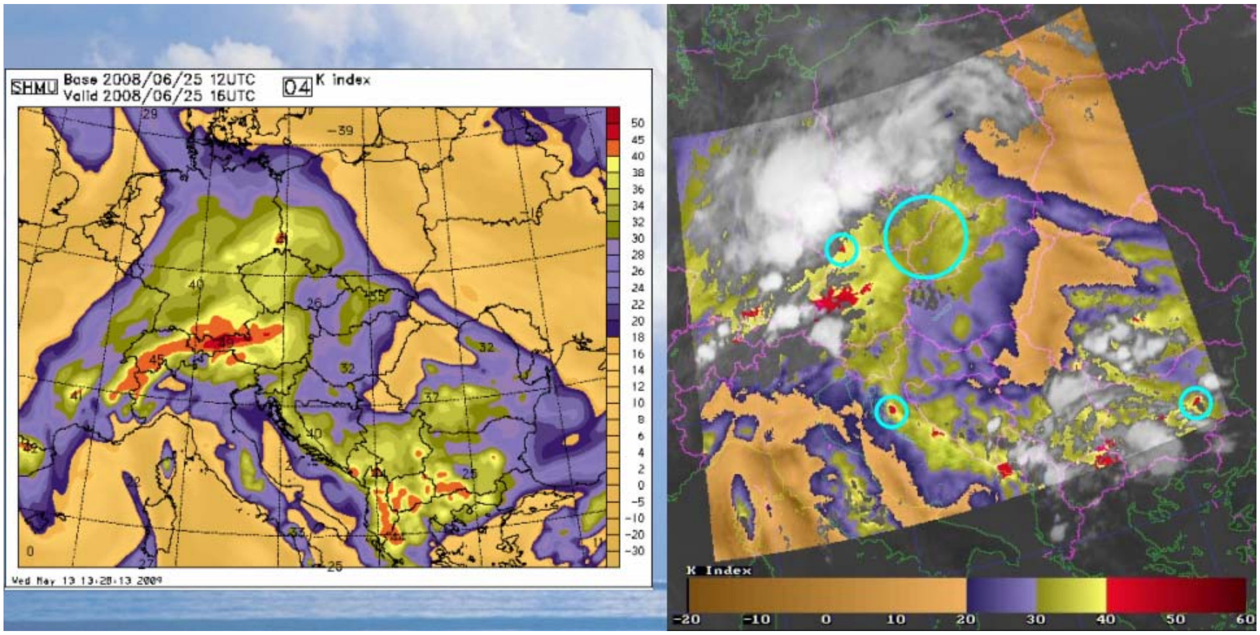

Fig 2: Comparison of K index computed by Aladin model (left) and by GII/RII software (right). 25 June 2008 16:00 UTC. Critical differences are highlighted by cyan circles.

Comparison of K-index and TPW against precipitation fields showed that in prevalent number of cases high values of K-index and TPW indicated high precipitation amounts. However there are also cases when no significant rain amount was detected and K-index and TPW values indicated severe event.

Comparison of K-index & TPW maxima against lightning intensity measured by SHMÚ lightning detection system. The aim was localisation and isolation of intensive storm activity and identification of corresponding responses in GII products (K and TPW fields).

Fig 4: Cases 25.-26.June 2008 – documentation of damages caused by strong winds in Bratislava.

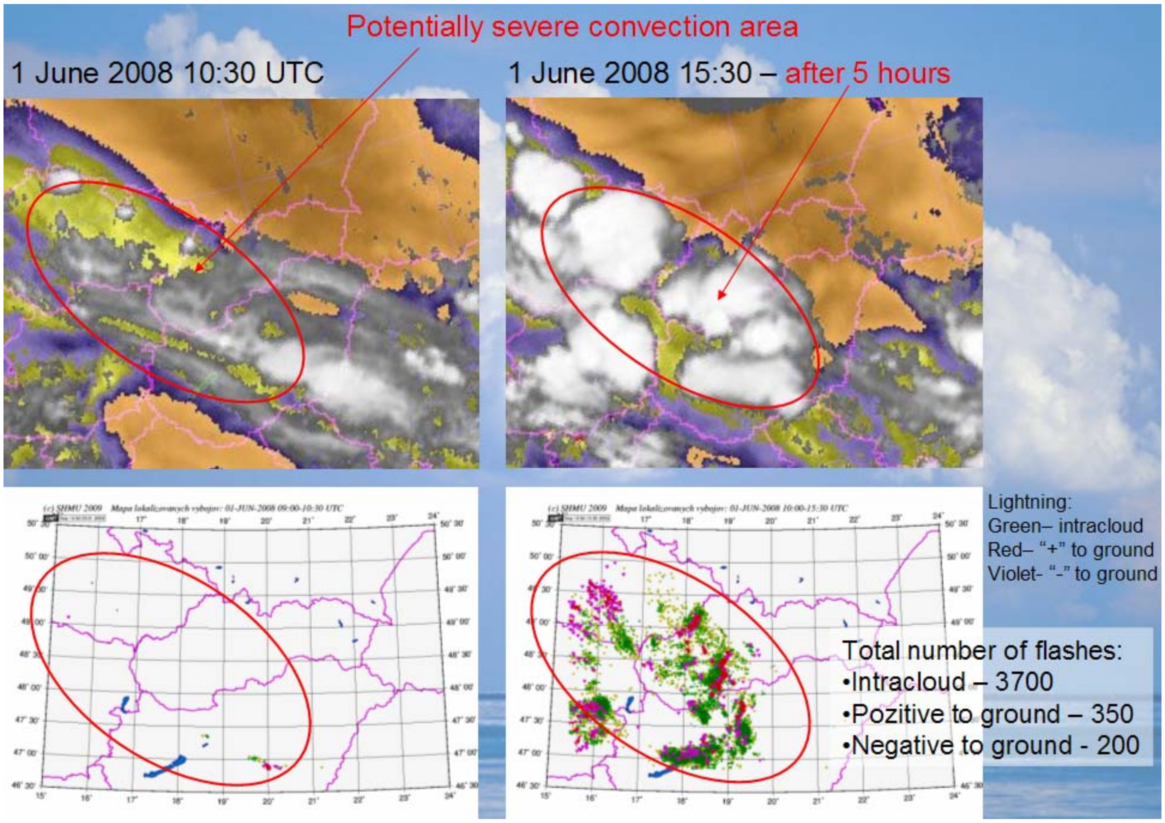

Fig 3: Comparison of K-index computed by GII/RII software against lightning intensity. 1 June 2008 10:30 and 15:30 UTC. High values of K index localised by red arrow (left) and strong storm development (right).

Conclusions

K index based on GII/RII can control model forecast against real development. TPW parameter is potentially important to control possible heavy rain intensities and useful because this parameter is not produced by Aladin model. Reliability of satellite derived indices very close to cloudiness is limiting factor in practical use. Quite difficulte task is to find convenient cases in given region for validation.

Acknowledgments

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