Verification of global instability indices, derived from satellite data over wider Croatian area

Ivan Smiljanić*, Nataša Strelec Mahović*, and Maja Telišman Prtenjak**

**Meteorological and Hydrological Service of Croatia, Zagreb, Croatia*
***AMGI, Department of Geophysics, Faculty of Science, University of Zagreb, Zagreb, Croatia*

1. Introduction

A deep, moist convection that occurs in the 'clean air' is one of almost daily occurrences in the atmosphere of our latitudes, and elsewhere. Unlike e.g. the frontal convection, convection in 'clean air' is harder to predict. These are situations when in the morning we have 'quiet' atmosphere, but a few hours after coming to the intensive development of convective clouds, which are among other things, the cause of many material damages. Therefore in this work we used four indices of instability (K, KO, LI and TPW), whose values may very well indicate areas in an atmosphere suitable for the development of severe convection. The aim was to make their verification over greater area of Croatia. Indices were obtained by synthesis of short-term forecasts and satellite measurements, with the help of 'Physical Retrieval Method' (i.e. PRM) method. As such, they have much better spatial and temporal resolution (if compared with radio-sounding measurements), and cover large areas (e.g. greater than the radar measurements). A verification of the indices is made for four summer days and for one day in the winter season.

2. Indices and PRM method

Instability index values are associated with the probability of occurrence of the convective development. In other words, it is possible to determine the typical threshold for each index, above or below which it will represent the stability or instability of the atmosphere. These thresholds are not fixed, but can vary depending on observed season, synoptic conditions, geographical location and climatic conditions of the observed area.

The goal of PRM method is to find the vertical profiles of temperature and humidity, using satellite measurements of radiation of the Earth and its atmosphere, and using these profiles to gain the required indices of instability. For this purpose so-called 'inversion technique' is used to find the vertical profiles of temperature and humidity that best simulate the radiation recorded at the top of the atmosphere (i.e. satellite image) (Rodgers, 1976). There are many combinations of vertical profiles of temperature and moisture that could give the same radiation image. Therefore iterative scheme is applied. It is performed insomuch that first is determined the initial background profile, so-called 'first guess', in our case that would be 6-hour forecasts of a numerical model (ECMWF). Then, from step to step profile is gradually modified to obtain the radiation corresponding to the satellite image. Iterative scheme is usually stopped at that stage in which the brightness temperature difference, in 6 satellite channels, is less than 1.5 K (König and de Coning, 2008).

3. Methods of verification

The first method of verification is a visual comparison of the distribution and intensity of indices, and the development of convective clouds. This is a subjective insight into causal connection between instability indices and the development of convection, but it is not completely reliable way to obtain tangible evidence of correlation between instability and convective processes. For this reason, other methods of verification are used.

Second kind of verification is based on a comparison of morning index values with the development of convective instability later in the day, via the number of detected lightning (Fig. 1). Each of the four indices was averaged in the four morning hours and was compared with next 10-

hour sum of detected lightning. This is more objective way of verification and can give more reliable results.

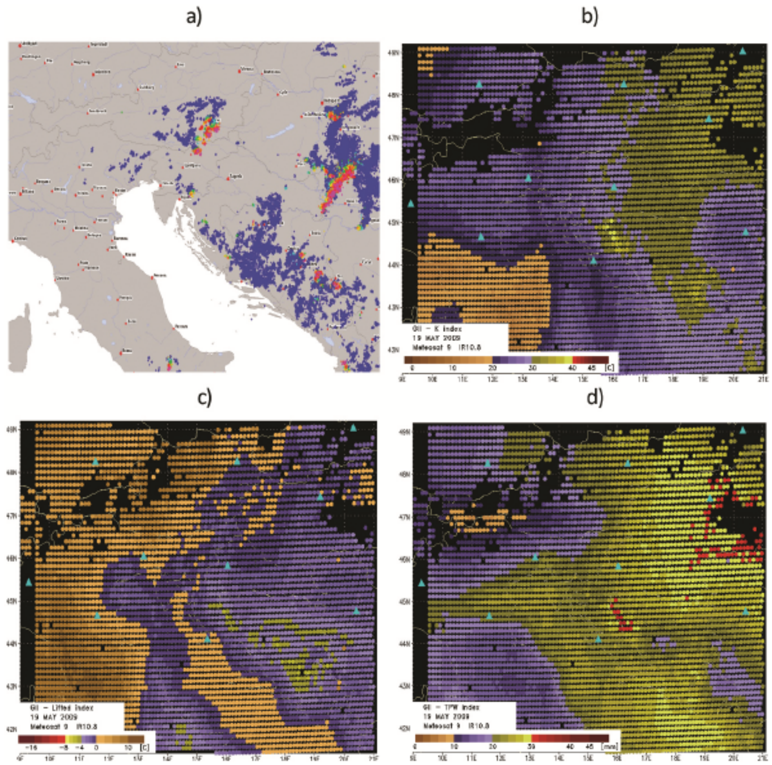

Figure 1. Distribution of lightning (a) in the period 08:00 to 18:00 UTC and spatial distribution of time-averaged value of K (b), LI (c) and TPW (d) index between 04:00 UTC and 08:00 UTC for the 19th May 2009. Blue triangles are marked positions of the observed radiosounding stations.

Last kind of verification is one done with radiosounding data, and it is also more objective approach. From this radiosounding data, values of four instability indices are gained and compared with 'satellite' indices at the point of sounding. That was done for 10 radiosounding stations in observed area, at 00:00 UTC.

4. Conclusions

Verification showed that the KO index was not efficient because of absence of 1000 hPa isobaric surface. A similar problem occurred with the generation of K index in areas where no isobaric surface was greater than 850 hPa. Full development of convection is followed 5 to 10 hours after the indices are showing instability, thus enabling the ‘forecast’ of convection. The differences between pointed areas of instability by indices and areas of actual convection development were sometimes present, mostly due to wind advection of air masses with prevailing winds. Favorable correlation between satellite-based and radiosounding-based indices, also normal distribution around zero of their difference, shows adequacy of PRM method. The results indicated the thresholds of instability indices somewhat vary from common values. Correction for the K index would be 10°C, for LI index -4°C and +20 mm for TPW indeks.

References

König, M., and E. de Coning, 2008: The MSG global instability indices product and its use as a nowcasting tool. *Weather Forecast*., **24**, 72-85.

Rodgers, C. D., 1976: Retrieval of atmospheric temperature and composition from remote measurements of thermal radiation. *Rev. Geophys*., **14**, 609-624.