Analysis of atmospheric instability indices based on radio sounding and ALADIN data, weather types and lightning detection

Martina Ćurić1, Maja Telišman Prtenjak1, Tomislav Stilinović2, Vinko Šoljan3

1Andrija Mohorovičić Geophysical Institute, Department of Geophysics, Faculty of Science, University of Zagreb, Zagreb, Croatia

2Meteorological and Hydrological service, Zagreb, Croatia

3Croatia Control, Aeronautical Meteorology, Zagreb, Croatia

email: martina.curic@yahoo.com and telisman@gfz.hr

INTRODUCTION

- Atmospheric instability indices have long been used in forecasts of deep convection by describing convective activity with a single number.
- Instability indices can be calculated either from radiosoundings, numerical atmospheric models or on the basis of satellite data.
- Here we tried to estimate instability indices thresholds (by stations, season and time of day) and correlate them with detected lightning.
- The instability thresholds (for LI, SI, SWEAT, K, TT, CAPE, CIN, TPW) are found using the frequency distribution method (Fontana, 2008) and Peirce skill score (Manzato, 2006).
- Comparison between radiosonde and ALADIN model is made for increased set of indices. For each index different statistical parameters are computed.

AIM

- Find a connection between instability indices from radiosounding data and deep convection.
- Set a threshold for a particular instability index above which the probability of successful predictions of deep convection was acceptable.
- Find geographical features of the occurrence of convection in land and coastal areas.
- Link certain wind directions and weather types with the occurrence of deep convection and instability indices.
- Compare instability indices obtained from radiosounding data with indices derived from the ALADIN mesoscale model for the Zagreb area.

DATA

- Radiosounding data for 7 stations (Zagreb, Zadar, Vienna, Budapest, Szeged, Udine and San Pietro Capofiume (SPC)) during a 7-year period (1st January 2007 – 31st December 2013) .
- Instability indices derived from the ALADIN model for a representative area of Zagreb for a 6-year period (1st January 2008 – 31st December 2013).
- Lightning data from LINET - an international lightning detection network in Europe (Betz et al., 2009).

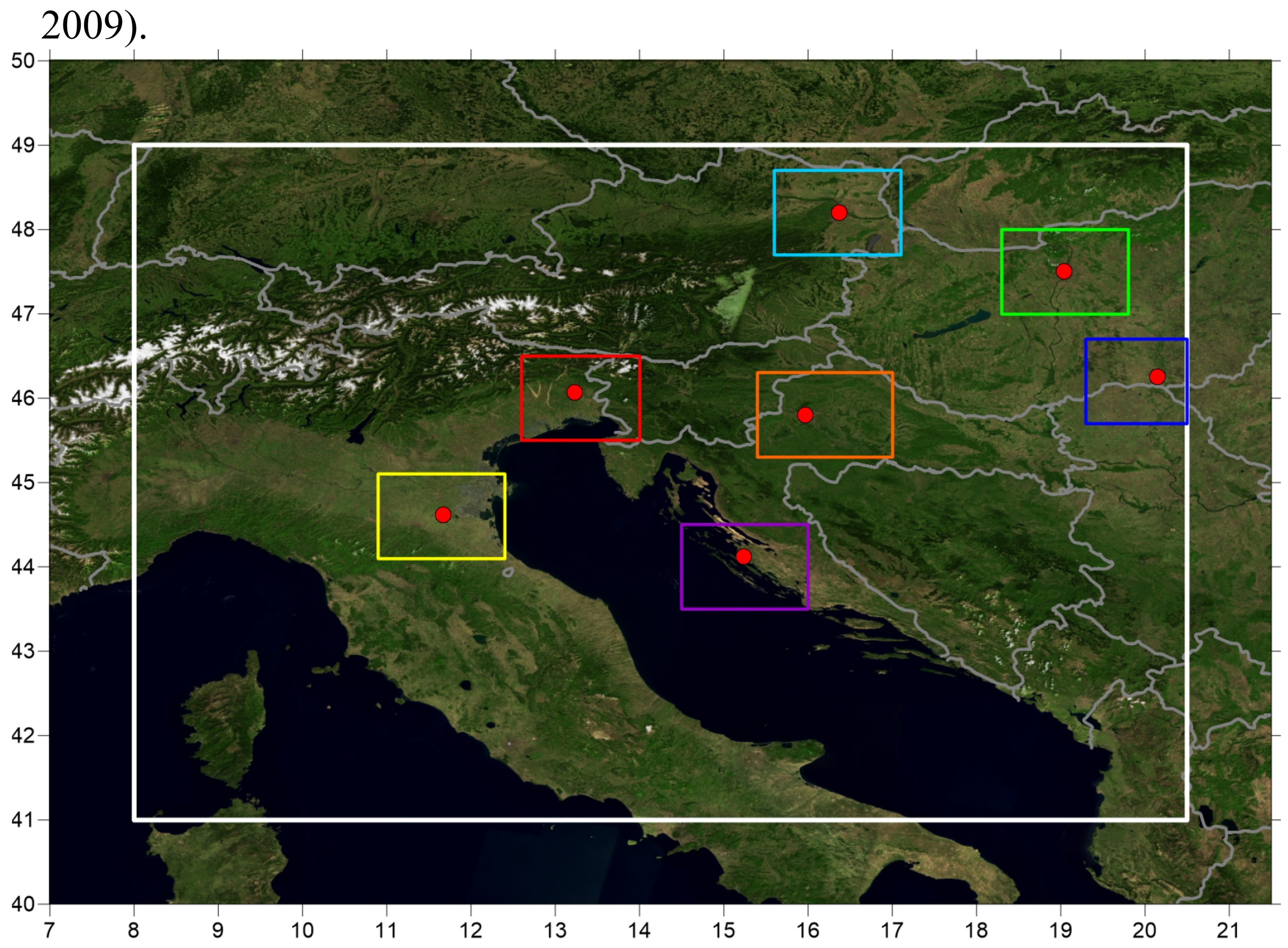


Figure 1: Domain with available LINET data (white rectangle) and observed subdomains; SPC (yellow), Udine (red), Zadar (violet), Zagreb (orange), Vienna (light blue), Budapest (green) Szeged (blue).

CONCLUSIONS

- There is no index that can define a drive mechanism for convection only from radiosounding.
- Indices are a valuable diagnostic parameter used in forecasting.
- Both Peirce skill score and the frequency distribution method give very similar instability thresholds for LI and SI. These results are consistent with Smiljanić et al. (2013) and thresholds for indices described by NOAA (National Oceanic and Atmospheric Administration).
- Peirce skill score method is more rigid than frequency distribution method for other indices.
- Instability thresholds for SWEAT and CAPE obtained by Peirce skill score matches the threshold given by NOAA.
- Instability thresholds for K and TT obtained by Peirce skill score matches the threshold given by NOAA.
- Precipitation regime and non-gradient pressure field are connected with convection.
- SW (southwest) wind direction is connected with convection.
- ALADIN model has been successfully predicted indices that are derived from temperature and wind at significant levels.

RESULTS

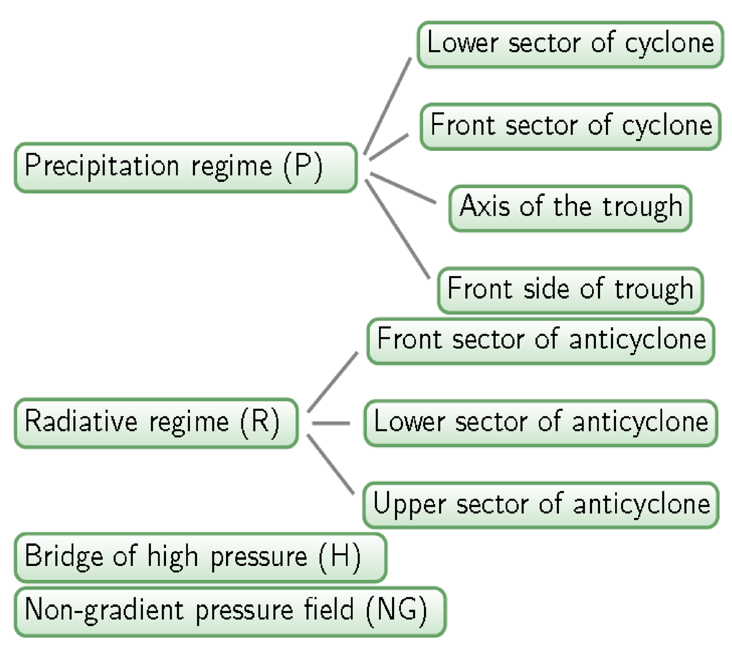
This research was focused on the warm part of year (from April to September) because the largest number of convective events is observed during that period every year. If more then 5 strokes per hour across at least one subregion were detected, the day was marked as the day with convection and was used in further analysis.

Instability indices thresholds

Table 1: Comparison of instability index thresholds calculated using the frequency distribution method and Peirce skill score for areas under study over the 7-year period (1st January 2007 – 31st December 2013).

Index	Frequency distributions method	Peirce skill score
Lifted index - LI	1 - 3 [°C]	1 - 3 [°C]
Showalter index - SI	1 - 3 [°C]	2 - 4 [°C]
Severe weather threat index - SWEAT	90 - 140	405 - 525
K index - K	23 - 27 [°C]	37 - 45 [°C]
Total Totals index - TT	45 - 47 [°C]	56 - 61 [°C]
Convective Avaliable Potential Energy - CAPE	160 - 180 [J/kg]	1549 - 2686 [J/kg]
Convective inhibition - CIN	-20 - -13 [J/kg]	-57 - -1 [J/kg]
Total precipitable water - TPW	23 - 27 [mm]	41 - 50 [mm]

Analysis of weather types



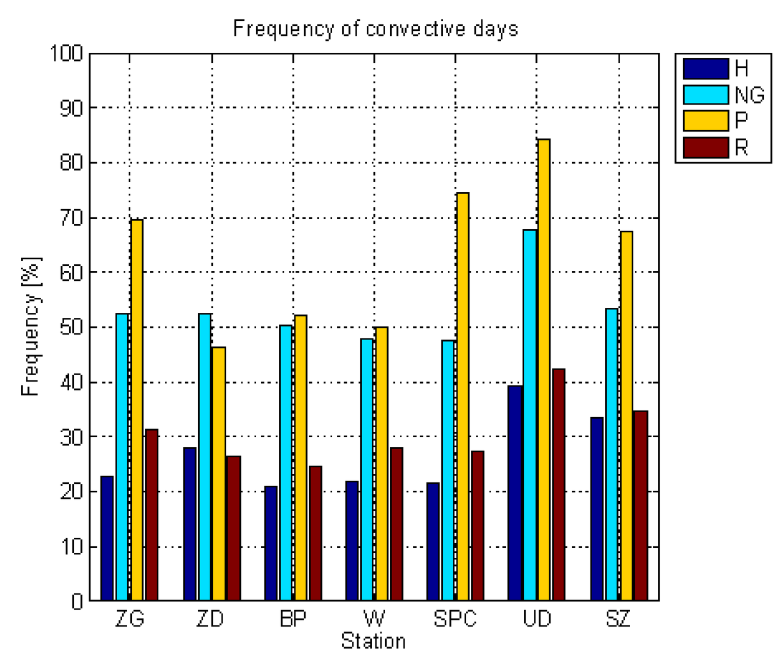


Figure 2: Frequency of convective days for weather types.

Analysis of wind directions

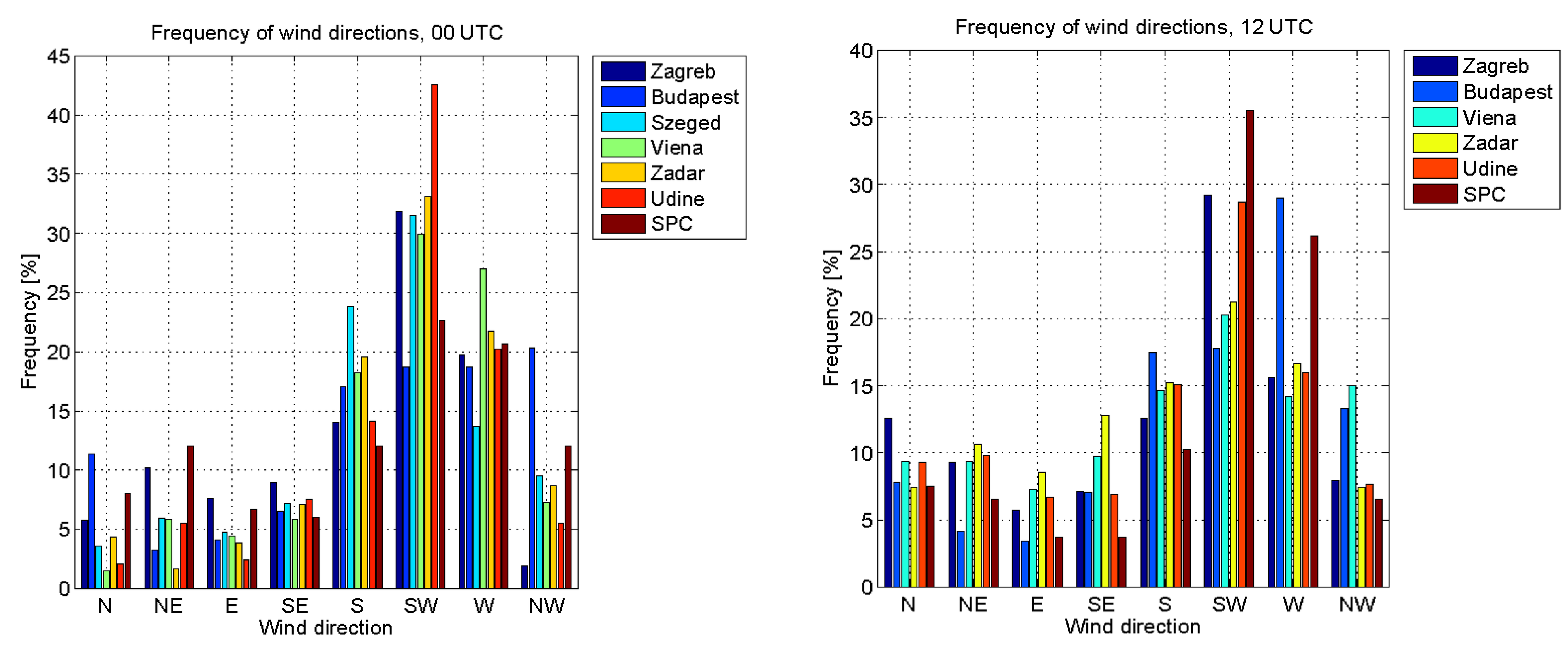


Figure 3: Frequency of wind directions for convective days in 00 UTC (left) and 12 UTC (right).

Comparison between indices from radiosonde and ALADIN model

For 32 indices different statistical parameters are computed; linear determination coefficient, bias, root-mean-squared error, root-mean-squared deviation, mean absolute error, relative absolute error and index of agreement (Manzato, 2008).

Results showed that the ALADIN model has been successfully predicted indices that are mainly derived from temperature and wind at significant levels. Weaker results were obtained for the indices that dependent on the specific levels, e.g., the level of condensation.

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