EOF ANALYSIS OF DATA FROM HAILPAD POLYGON

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I. INTRODUCTION

Continental part of Croatia is exposed to the thunderstorms with severe rain and hail, especially in the summer months. This area is very important in terms of agriculture. Hence, in order to document hail events in details, a hailpad polygon 30×20 km in size was installed in the north-western part of this area (Zagorje) before the hail fall season in 2002. The polygon is settled between three mountains (Fig. 1): Ivančica on the north, Medvednica on the south and Kalnik on the northeast. A dense network with 150 hail pads with linear spacing of 2 km (1 hail pad per 4 km^2) was obtained. Hail parameters that are obtained from hailpads can be used in climatologically and dynamical studies of hail.

In this study, we use the data gathered in the hailpad polygon within the period 2002 – 2010. We analyzed the intensity (kinetic energy, K.E.) of hail, the maximum hailstone diameter and the hail fall duration, but only the results for K.E. are shown here. The goal is to investigate what are the factors that have influence on spatial and temporal distributions of these parameters in the polygon. There are some indications that orography could have significant influence (Počakal et al. 2009). Our approach is to implement the empirical orthogonal functions (EOF) method to the data from the hailpad polygon in the above mentioned 9-years period and to inspect this hypothesis.

II. ANALYSIS

Within the 9-years period, 87 hail events were recorded on the hailpad polygon. EOF analysis is performed on the 87×150 matrix organized in a way that each column represents a time series for a certain point of the hail polygon (e.g. Ludwig et al. 2004). Prior to EOF analysis, time means are subtracted from each point of the hailpad polygon so that each column has zero mean. Since the hail parameters are discrete variables, in the calculation of the time mean for a certain hailpad point participate only the dates when hail is recorded at this point. This way the values of reconstructed temporal-spatial distributions of observed variable (using different number of EOF modes) are quantitatively conserved (Fig's. 1 and 3).

III. RESULTS AND DISCUSSIONS

Figure 1 shows a spatial distribution of mean kinetic energy on the hailpad polygon in the period 2002 – 2010. As shown by Počakal et al. (2009), it seems that this distribution is greatly influenced by the orography. Particularly, Ivančica (1059 m) on the north, Medvednica (1030 m) on the south and Kalnik (642 m) on the northeast could slow down the Cb cells which mostly infiltrate from the west giving the "C" shaped maximum values of K.E. within the polygon. We want to decompose this distribution into EOF modes and see whether these modes can tell us something more about this primary assumption.

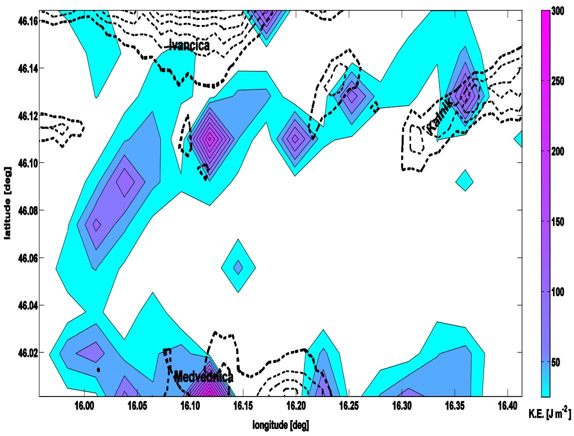

FIG. 1: Spatial distribution of the mean kinetic energy on the hailpad polygon in the continental part of Croatia in the period 2002 – 2010 (coloured contours). Black dashed lines denote orography every 50 m, starting from 270 m at the outer edge of certain mountain.

Figure 2 shows the percentage of variance of the mean K.E. spatial distribution explained by a certain mode of EOF analysis. It is seen that first 9 modes explain ≈ 86.6 % variability of mean K.E. distribution in the hailpad polygon.

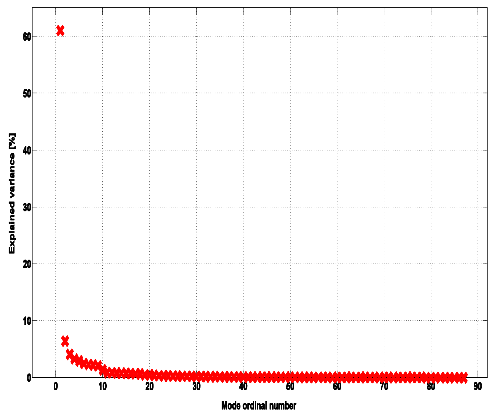

FIG. 2: Percentage of variance of the mean K.E. spatial distribution explained by a certain mode of EOF analysis.

Reconstructions of this distribution using different number of modes (Fig. 3) indicates that the first mode (which itself explains 61 % of variance) reveals the great influence of Ivančica mountain on the north due to the distribution of K.E. values below and parallel to this mountain. Also, the first mode already reveals some influence of Kalnik mountain at the northeast and Medvednica mountain on the south. According to this, it might be concluded that the primary directions of the incoming Cb cells above the polygon are west and southwest and that they are slowed down or even stopped primarily by Ivančica, but by Kalnik to some extent as well. This is already indicated in Počakal et al. (2009) and Počakal (2011).

Second, third and fourth modes, which cumulatively explain 13.8 % of variance, show the secondary influence of Medvednica to the hail distribution, west and east of the mountain. Fifth and sixth modes (cumulatively 5.4 % of variance) expand and connect areas at the front of Ivančica and Medvednica. Seventh mode (2.3 % of variance) starts to reproduce the less intense area of K.E. in the middle of the polygon between Ivančica and Medvednica. There is a small difference between reconstructions using eight and nine modes, but it is seen that nine modes reconstruct the mean distribution (Fig. 1) quite successfully.

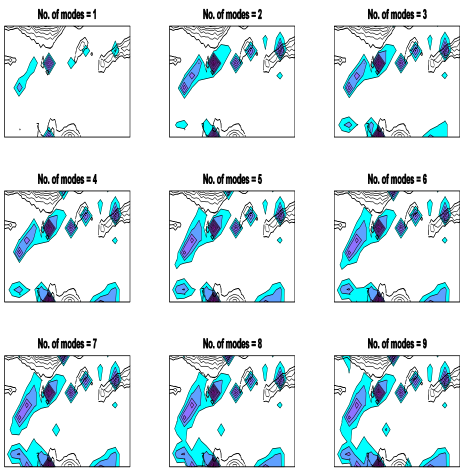

FIG. 3: Same as Fig. 1, but for the reconstructions using different numbers of EOF modes.

IV. SUMMARY

The EOF analysis is performed to the spatial – temporal distribution of kinetic energy of hail stones gathered on the hailpad polygon in the continental part of Croatia in the period 2002 – 2010. The great influence of orography to the hail distribution is confirmed. Ivančica has the greatest influence because it slows down or even stops the Cb cells which above the polygon most common come from west and southwest. Secondary influence of Kalnik on the northeast and Medvednica on the south is revealed as well.

V. REFERENCES

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