A CLIMATIC INVESTIGATION OF INTENSE PRECIPITATION ASSOCIATED WITH 500-HPA CYCLONES WHICH ARE AFFECTING GREEK TERRITORY DURING WARM PERIOD OF THE YEAR

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I. INTRODUCTION

Intense precipitation events are closely related to natural hazards such as flash flood and soil erosion. These natural hazards are usually producing severe damages in both natural and anthropogenic environment. They are also very destructive to plantations and agriculture in general, especially during the warm period of the year when plants are in active development stage. Precipitation occurrence in Greece under various synoptic conditions has been studied in the past (Laliotis, 1977) and several factors (surface depressions, fronts etc) were identified. However, during warm season of the year in this Mediterranean region these factors are lacking. Identifiable synoptic features are usually found only at the upper levels (i.e. 500 hPa). The most common features related to precipitation are closed lows which are also described as upper air cyclones. Cold air masses usually accompany such lows and extend to lower and higher levels. This is the reason for naming these synoptic features as "cold pools" (Papagiannakis, 1967) in the early stages of synoptic meteorology. Weather conditions have been studied only for certain places in Greece (Maheras, 1982) during the domination of such synoptic features. For example in Thessaloniki, Maheras notices the slow movement of cold pools toward the east and the production of a daily precipitation on the average 5.3 mm. The long lasting cloud cover, the high relative humidity (70% on the average) and the small daily variation of the temperature are also noticed.

II. METHODOLOGY AND DATA

The 40-year (1958-1997) NCEP/NCAR reanalysis gridded data of geopotential height with a 2.5ºx 2.5º spatial and 6-h temporal resolution (00, 06, 12, 18 UTC) are used in this study (Kalnay et al., 1996). The investigation covers the warm season of the year (15 April to 15 October). Lows or Cyclones were determined as local minima in each 3X3 matrix of geopotential height values in the area of investigation (Spanos et al., 2003). The investigated area covers parts of central and east Mediterranean region (30º north to 50º north latitude and 5º east to 35º east longitude). A variation of the "nearest neighbour" track algorithm (Trigo et al., 1999) is employed in the determination of tracks. A sub-area which consists of 36 grid points and includes Greek peninsula is selected for the investigation of the relationship between cyclone occurrence and intense precipitation events. When detected cyclones in the sub-area are parts of the same track, the occurrence with the lowest geopotential height is considered. Cyclone occurrence in the sub-area is divided in 9 groups. Each group consists of 4 grid points and is characterized by its orientation within the investigated area. The characterization involves two letters (i.e. SW represents the southwest group) and is presented in FIG. 1. The number below the name of the group indicates the number of cyclone occurrences. Intense precipitation episodes are examined only during these occurrences.

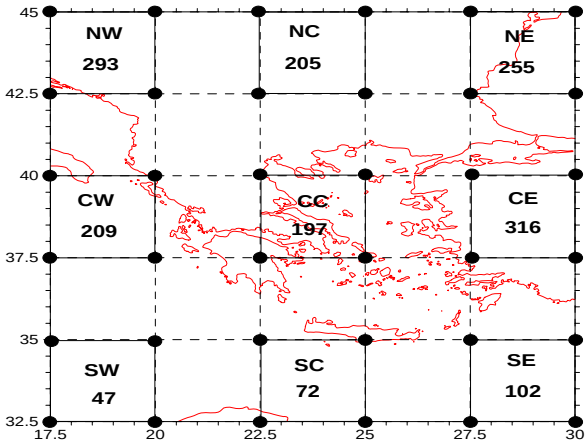

FIG. 1: Characterization of cyclone groups according to the relative orientation within the investigated area.

Intense precipitation events were determined from daily precipitation data collected at a 20-station network which was operational during the same time period. Intense precipitation days are defined those with a precipitation amount exceeding a threshold value. Intense precipitation is considered as rare event in each of the stations and a probability distribution is required to accurately determine the threshold. However, probability distributions are different in the 20 stations. In a similar study by Maheras et al., (1999) for Thessaloniki station (included in data base) a value of 30 mm/day is selected. The same value is maintained in this study also for comparison purposes.

III. SPATIAL DISTRIBUTION OF RELATIVE FREQUENCY OF OCCURRENCE

The spatial distributions of intense precipitation occurrence frequency for each of the nine cyclone groups are produced and examined. The distributions are presented in the form of relative frequency charts which are also used as a diagnostic tool for probability estimation. The examination of local maxima in these distributions, revealed two main patterns. The first is when local maxima or high frequency values coincide with cyclone centres and the second when spatial differences are observed. The coincidence indicates vertical instability as the primary factor for precipitation development.

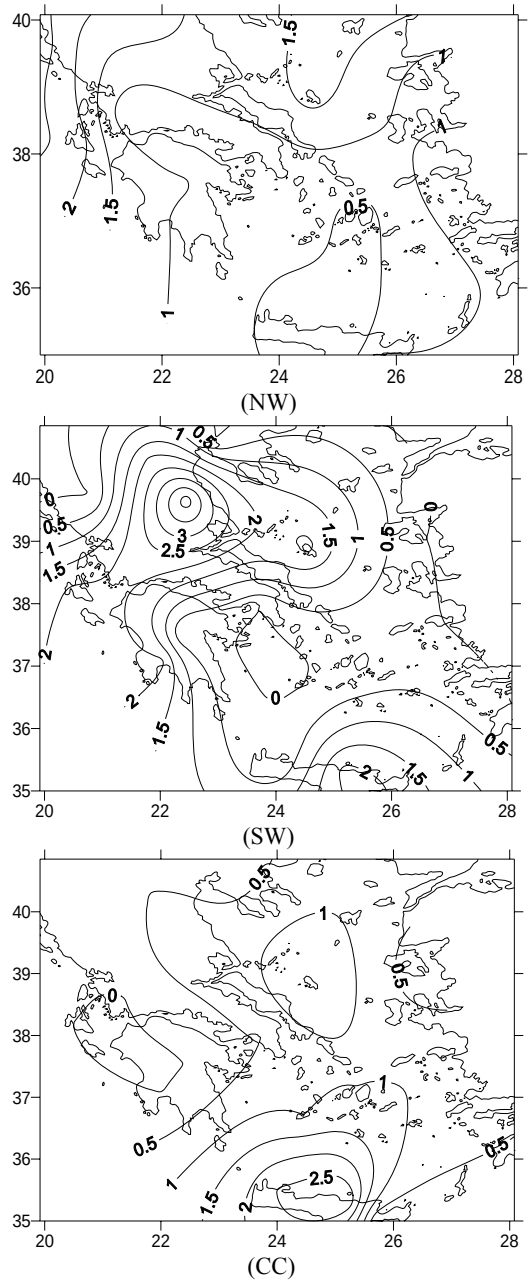

FIG. 2: Relative frequency (%) spatial distributions of intense precipitation for the cyclone groups NW, SW and CC.

In the second pattern the spatial differentiation can be attributed to two factors. The first factor is the mountain orientation relative to low level flow and the second is positive vorticity advection (PVA) related to major trough axis which accompanies the cyclone. FIG. 2 shows three representative distributions corresponding to the domination of the factors described above. Precipitation in the NW group of cyclones (FIG. 1) is related to vertical instability produced by the combination of upper cold air and low level heating over continental areas in the northwest of Balkans. Precipitation in the SW group (FIG. 1) is related to the orientation of Pindos mountain chain (at the centre of the Greek Peninsula) relative to low level flow. Cyclones of the SW group are usually accompanied by surface lows over Aegean Sea with an easterly flow toward the Pindos Mountains. The orographic effect enhances the precipitation over eastern slopes of the mountain chain (Prezerakos and Flocas, 1996). In the CC group (FIG. 1) precipitation is related to PVA centres which are usually located to the south or southeast of the cyclone centres (Spanos, 2004).

IV. CONCLUSIONS

Intense precipitation (more than 30 mm/day) during the warm season over Greek territory is a rare event with frequencies not exceeding 4% of the cases in which, a 500 hPa cyclone prevails in the synoptic situation. When a 500 hPa cyclone dominates in the vicinity of Greece three main factors contribute in the development of intense precipitation events. These factors act together but can be identified as primary factors for the various groups of cyclones. The first factor which is vertical instability is the dominant factor for the cyclones occupying the south and central parts (SC) or the northwest (NW) parts of the investigation area. The second factor is a combination of orography and the orientation of Pindos mountain chain relative to flow patterns. This factor plays an important role in the case of south west (SW) and central west (CW) cyclone groups. In all other cases the positive vorticity advection factor seems to be of primary importance for the intense precipitation events.

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