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SEVERE ATMOSPHERIC CONDITIONS OVER ALBANIA: DECEMBER 2005 NUMERICAL ANALYSIS AND SIMULATION

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PËRMBLEDHJE

Rajoni i Mesdheut është goditur shumë shpesh nga reshje ekstreme por e veçanta e tyre në këtë rajon, përfshirë edhe Shqipërinë është intensiteti me të cilin reshjet bien dhe pasojat e tyre. Gjeografia e Mesdheut e bën këtë rajon shumë të ndjeshëm ndaj impaktit negativ të fenomeneve ekstreme të motit. Përgjithësisht, efekti i orografisë dhe shkëmbimi i nxehtësisë në sipërfaqe kontribuojnë drejtpërdrejt në furnizimin me ajër të lagësht të celulave konvektive lokale dhe të reshjeve me intensitete të larta. Kushtet e mësipërme të shoqëruara me faktorë të tjerë si struktura atmosferike favorizuese të llojit prerje atmosferike apo luginë potenciale në prezence të nxehtësisë latente rritin potencialin për reshje atmosferike ekstreme. Në këtë studim do të prezantohen parametrat meteorologjike domethënës për dy episode me reshje ekstreme të vrojtuara në Shqipëri gjatë dimrit të vitit 2005, të cilat gjeneruan përmbytje të shumë zonave të vendit duke shkaktuar në këto zona shumë dëme ekonomike. Janë analizuar fushat e gjeopotencialit në nivelin 500 hPa si edhe në modelet numerike të parashikimit meteorologjik, është simuluar orografia si një faktor fizik stabël dhe faktori I nxehtësisë latente, si një faktor dinamik jostabël. Rezultatet e arritura janë krahasuar me vrojtimet reale në sipërfaqen e tokës.

ABSTRACT

Mediterranean area is frequently affected by sudden extreme rainfalls but their crucial aspect in this area, including Albania, is the intensity with which the rainfalls occur and the consequences. The Mediterranean geography makes this region very sensitive to the impact of the extreme weather phenomena which is our reason of studying. In general, the effects of orography and surface heat exchanges contribute to sustenance of moist inflow for localized deep convection and rainfalls of very high intensities. The above conditions and other factors including atmospheric patterns like cut-offs or short wave troughs and the presences of latent heat contribute to a high potential for extreme rainfalls. We are going to present significant meteorological parameters of two extreme rainfall episodes during the winter of 2005 which produced a wide flood and causing many damages all over the country. We used analysis of geopotential field at 500 hPa and we simulate numerically the orography as a physical stable factor and the latent heat released, as a dynamical unstable factor and the results are then compared with surface based observations.

Key words: extreme rainfalls, atmospheric patterns, Albanian floods, numerical simulation

INTRODUCTION

Mediterranean area is frequently affected by sudden events of extreme rainfalls but their crucial aspects in this area, including Albanian territory, is the rainfall intensity and consequences. High rain intensities contribute generally to the seasonal torrent and river overflowing causing severe floods which have a great social, economic and landscaping impact and these aspects, closely agree with the consequences during two Albanian episodes of December 2005 which produced a wide flood over the country. This work presents the atmospheric pattern shapes as extreme rainfall producers using hand analysis of geopotential field at 500 hPa and numerical simulation of the orography as a physical factor and latent heat as a dynamical factor to estimate the factor indication on the extreme rainfall generation. We have selected these factors to simulate because they play an important role in extreme rainfall formation (proved in other cases to be extreme rainfall producers). The orography of Albania is rich with high mountains placed only some km far from the sea and the latent heat released by the Adriatic and Ionian seas, is an important factor when warm moist air is coming from the south or southwest. The data from National Center for Environmental Prediction/National Center for Atmospheric Research of USA archives (hereafter, NCEP/NCAR) are used for the atmospheric pattern analysis and the Mesoscale Model, known as numerical model MM5 (hereafter, MM5) with analysis grids from the European Centre for Medium Range Weather Forecast, is used to monitor the meteorological state evolution and to simulate numerically in order to get out the main role of the selected simulated factors in extreme rainfall formation over Albania. In a final step, after analyses the results are compared with the surface based observations.

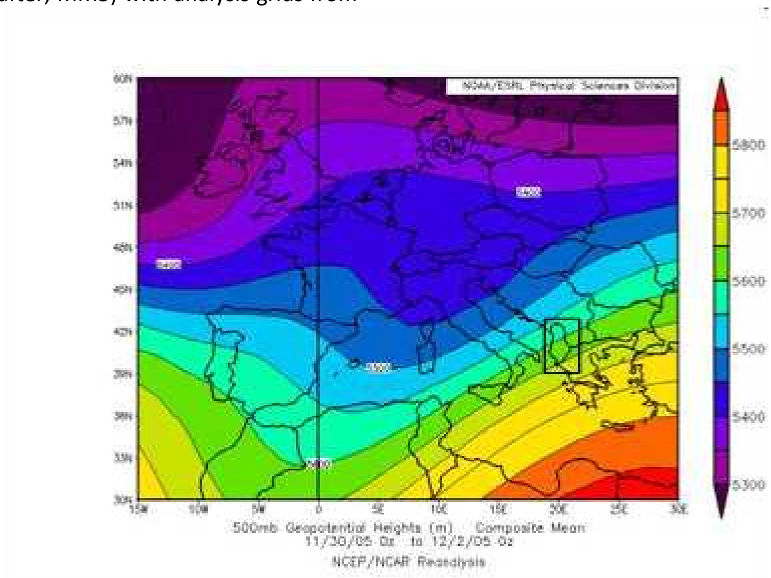


Figure 1 (a) – Atmospheric pattern which produced extreme rainfalls of winter 2005.

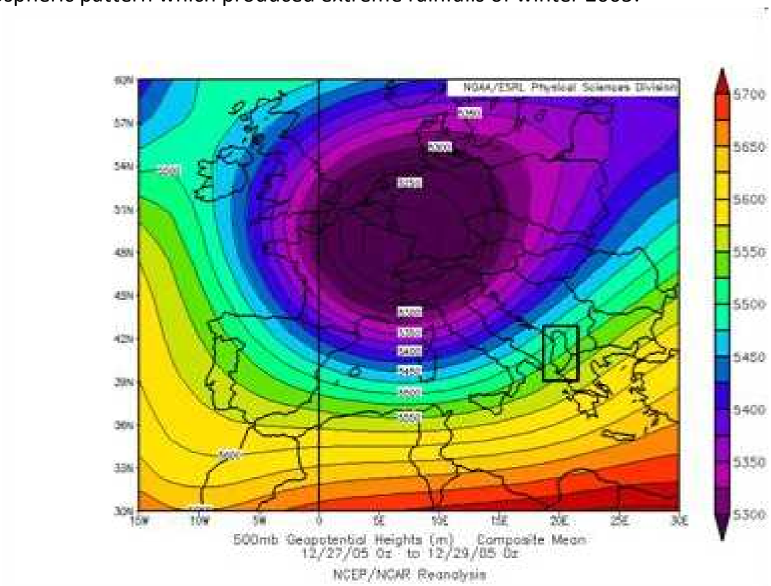


Figure 1 (b) – Atmospheric pattern which produced extreme rainfalls of winter 2005.

DATA AND METHODOLOGY

The data used consist on the 24-hours rainfall accumulation observed from the Meteorological Network of Albania for the cases under study where rainfalls are recorded from 36 stations situated over the entire country with an extensive set of data that could provide local climatology (see the graphic 1 a, b). The distribution data used are collected for 36 stations matched for a period between 07:00 UTC (Coordinated Universal Time or formerly known as Greenwich Mean Time, hereafter UTC) of day D and 07:00 UTC of day D+1. The 500-hPa geopotential data used in the study (2.5 x 2.5 resolutions) are from NCEP/NCAR reanalysis (Reference 1) and are available four times in a day whereas rainfall data matched for a 24 h period between 07:00 UTC of day D and 07:00 UTC of day D+1 and we took into account a great part of the western Mediterranean (30N – 60N and -15W – 35E). To consider a correspondence between extreme rainfalls and the atmospheric patterns we analyzed the air circulation, based on the geopotential field at 500 hPa that affects the meteorological conditions in 70% of the year over Albania (Reference 4). Atmospheric pattern analyses related to extreme rainfalls deals with the geopotential shape as cut off-s or troughs and also with the pattern flow (see figure 1a, 1b). To describe the indication of different factors like deep moist air, very-low surface pressure and high vertical ascent in creating the favorable conditions for extreme rainfalls we simulated the orography and the latent heat using the MM5 numerical model. Numerical simulations consist on modifying the fields of orography and latent heat released in a 3-resolution domain (30 km, 10 km and 3.3 km) with a space relation coefficient of 1/3 in order to find out the indication of each of the modified field on 24-hours rainfall accumulation. The Civil Emergency Office data from the Ministry of Interior are used to estimate the damages on the ground and also, the governmental action under the civil emergency conditions. The data consist in the large flooded area, nearly 16 000 ha, caused by extreme rainfalls mainly placed in the south-west of Albania in the cities like Vlora, Fieri, Berati, Gjirokastra (see the figure 2) and also a few local floods in the north-west lowland like Shkodra, Lezha, etj. The data from the Civil Emergency Office presents monetary estimated damages and the governmental refunding action to the families under the flood areas (see the graphics 2a, 2b).

RESULTS AND DISCUSSIONS

The analysis of the atmospheric pattern presents two very important patterns which produce the same south-westerly air flow over Albania during the two extreme rainfall episodes. For the first episode, we found a positively tilted trough which guides the moist air coming from the southwest to the Albanian coastal (fig. 1a) but the second episode has a well shaped cut-off placed over the Central Europe with extension down to the Adriatic Sea (fig. 1b).

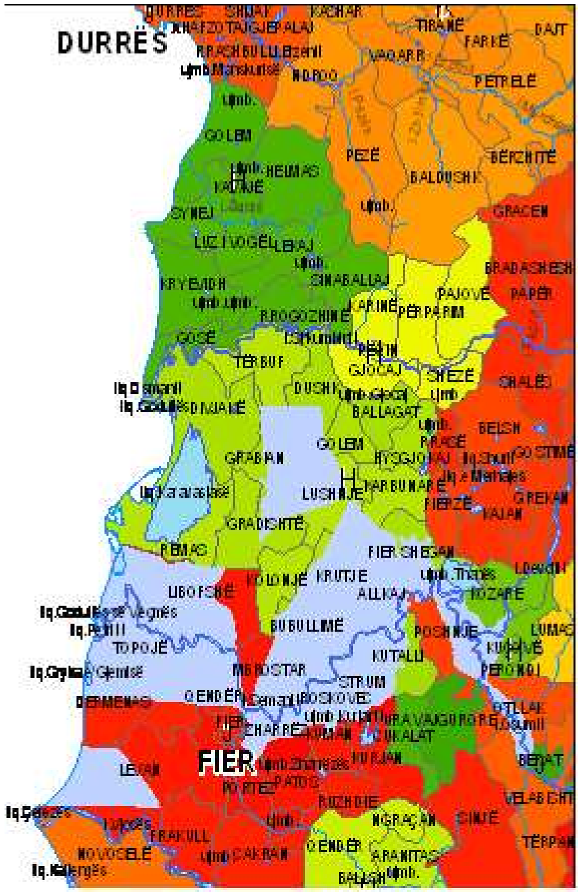


Figure 2 – Present a part of the Albanian areas under the flood conditions, mainly placed in the south-west of Albania (Vlora, Fieri, Berati, Gjirokastra)

According to these atmospheric patterns, in other studies, they proved that in favorable conditions are extreme rainfall producers (References 2, 3, 5). Resuming the MM5 numerical analysis (RAIN_CONTROL) and simulations of orography (ORO) and latent heat (LH), the results show that RAIN_CONTROL (see the figures 3a and 4a) reproduce a good situation of the real rain accumulations but when we simulate the physical factor ORO and the dynamical factor LH, the MM5 results present a very different rainfall situation.

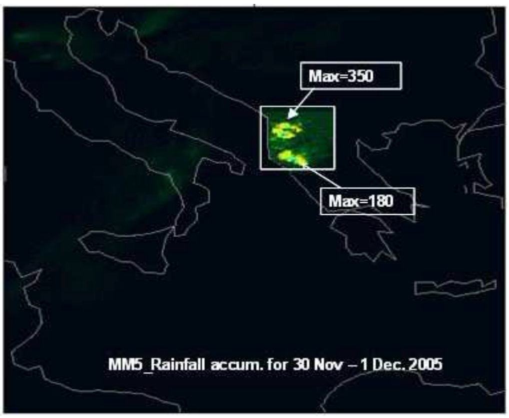


Figure 3a – The 24 hour rain accumulation of the first episode estimated by the numerical model MM5 during the RAIN_CONTROL process.

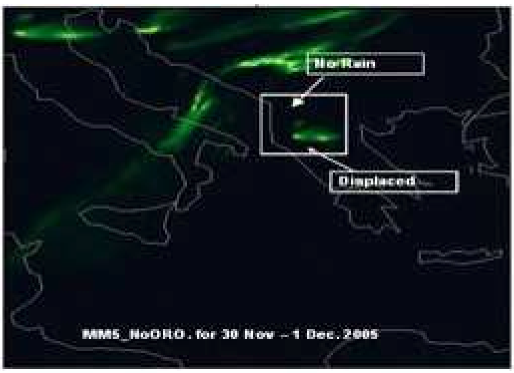


Figure 3b – The 24 hour rain accumulation of the first episode estimated by the numerical model MM5 during the orography simulation (ORO).

Figure 3c – The 24 hour rain accumulation of the first episode estimated by the numerical model MM5 during the latent heat simulation (LH).

The ORO-factor (see the fig. 3b and fig. 4b) plays a very important role not only in the rain accumulation quantities but also in their geographical location over Albania meanwhile the LH has an important role in the geographical rainfall location but only a small role in the rainfall quantities (see the fig. 3c and 4c). For the first episode, MM5 found two rainfall maximums over north and south of Albania with respectively 350 and 180 mm/24h and also for the other episode, we found two equal maximums over Albania with 200 mm/24h (see the figures 3a and 4a).

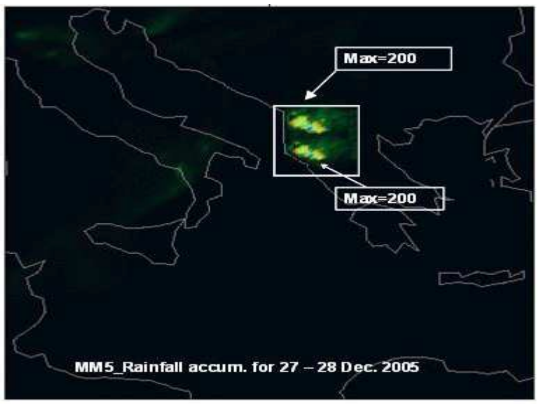


Figure 4a – The 24 hour rain accumulation of the second episode estimated by the numerical model MM5 during the RAIN_CONTROL process.

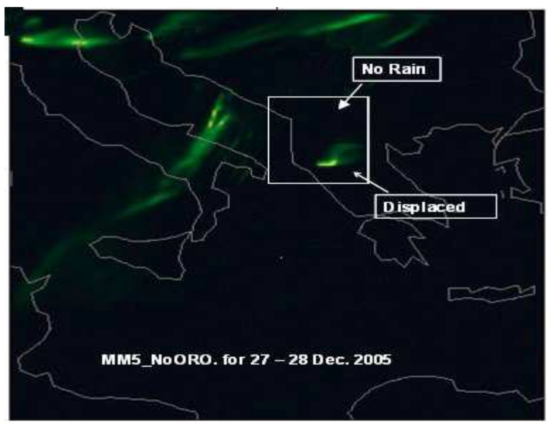


Figure 4b – The 24 hour rain accumulation of the second episode estimated by the numerical model MM5 during the orography simulation.

We found differences between the map of ground observed rainfalls (see the graph. 1a and 1b) and the MM5 RAIN_CONTROL (fig. 3a and 4a) especially in the maximums observed.

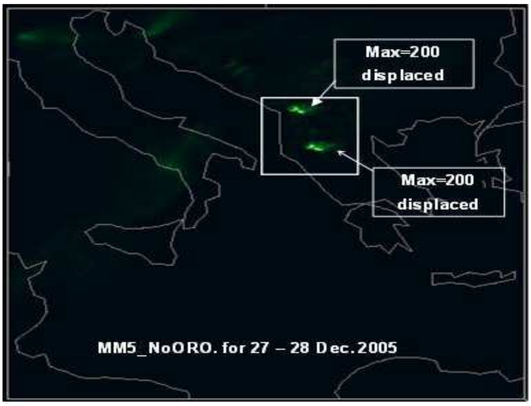
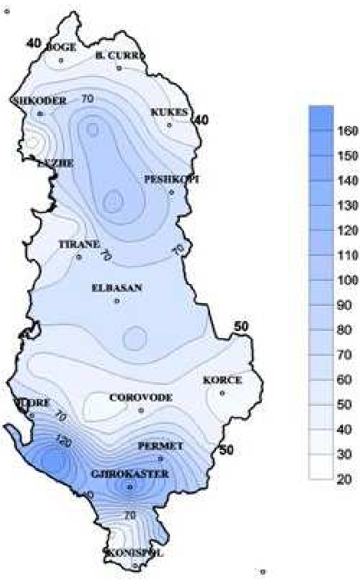
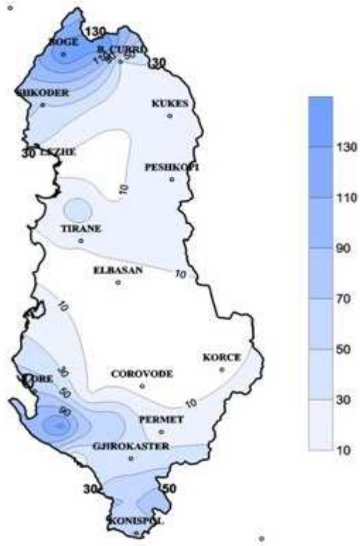


Figure 4c – The 24 hour rain accumulation of the second episode estimated by the numerical model MM5 during the latent heat simulation.

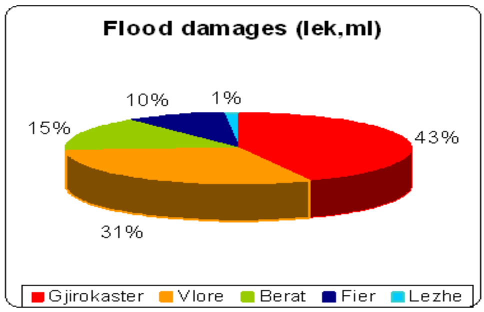
MM5 overestimates their values (a known problem of NWP models in estimation of rain accumulation of 24h or more than) but according to the rainfall location, we found that MM5 rainfall location is well placed. During the ORO simulation, the northern maximum is disappeared and the southern one, besides that it's very week, it is displaced to the east border (fig. 3b and 4b) meanwhile in the case of LH simulation, we saw that it doesn't play a big role in rainfall quantities but without the LH, the rainfalls are displaced a bit far from Albanian borders.



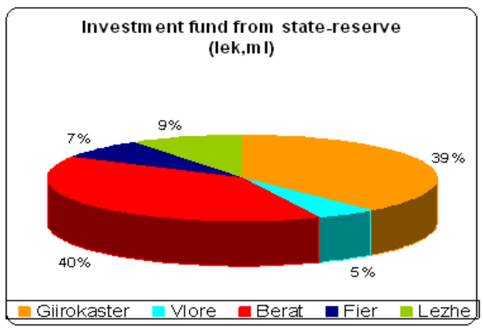
Graphic 1a. The 24h rain accumulations during the first episode.



Graphic 1b. The 24h rain accumulations distributed over Albania during the second episode.



Graphic 2a. Economical damages caused by the two extreme rainfall episodes.



Graphic 2b – Governmental fund given to the damaged community during the two rainfall episodes.

CONCLUSIONS

The atmospheric pattern of Positively Tilted Trough ahead of Albania and the atmospheric pattern of Cut-Off over Europe with an extension down to the Adriatic Sea force over Albania south-westerly air flows which then produce favorable extreme rainfall condition.

MM5 numerical model shows a good rainfall location but it overestimates the rainfall quantities. The physical factor of orography (ORO) plays the main role on extreme rainfalls because without the ORO, the rainfalls of the northern Albania disappear and the southern Albania rainfalls decrease and displace.

The dynamical factor LH plays also an important role on rainfall quantities over Albania because without the LH the rainfalls decrease with ≈ 30 mm/24h and the location of rainfalls displaces, mainly the coastal rainfalls.

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