ON THE EVENING ONSET OF DEEP MOIST CONVECTION IN COMPLEX OROGRAPHY

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I. INTRODUCTION

The frequency of deep moist convection (hereafter DMC) is characterized by seasonal and diurnal cycles, related to the interplay between the different elements which force and sustain it, e.g., onset, instability, vertical wind shear. This work deals with the hourly DMC frequency on the southern side of the Alps, as observed in the Friuli Venezia Giulia region (Giaiotti and Stel, 2001; Nordio et al, 2003), describing its peculiarities and proposing a possible explanatory mechanism for the observed features.

II. HOURLY FREQUENCY OF DMC ON THE SOUTHERN SIDE OF THE ALPS

Hourly thunderstorm frequency in complex orography sometimes shows a bimodal behaviour, with a relative maximum centred around 12-13 UT (13-14 CET) and the other centred around 19-20 UT (20-21 CET) as it is shown by hourly cloud-to-ground lightning and rain distribution (figure 1ab). This bimodal feature is not present in the whole alpine souhern side, as shown by Calza et. al (2007)

Assuming hourly cloud-to-ground lightning distribution as a marker for the hourly thunderstorm distribution, it can be shown (Tosoratti and Giaiotti., 2003), that the maxima timing and shape is different for different geographic areas (figure 2ab). In particular, it is possible to see that evening maximum (19-20 UT) has a comparable height and amplitude on the areas characterized by a steep orography (Danubian area, Inner alpine, Carsic area) while areas prone to relatively smooth orographic transitions are characterized by the prominence of one maximum: afternoon maximum for Prealpine area; evening maximum for Piedmont, Plain (low and middle) and Coastal area.

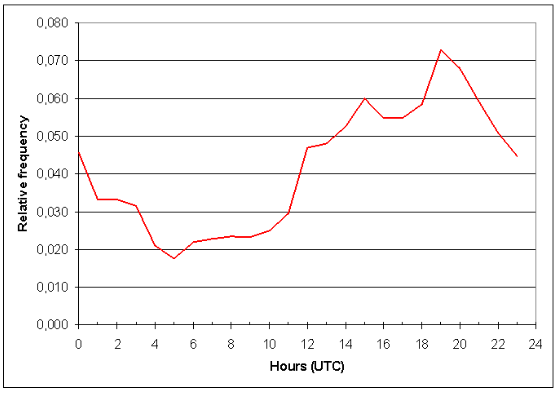

FIG. 1a: Hourly distribution of CG lightning frequency for the whole Friuli Venezia Giulia region.

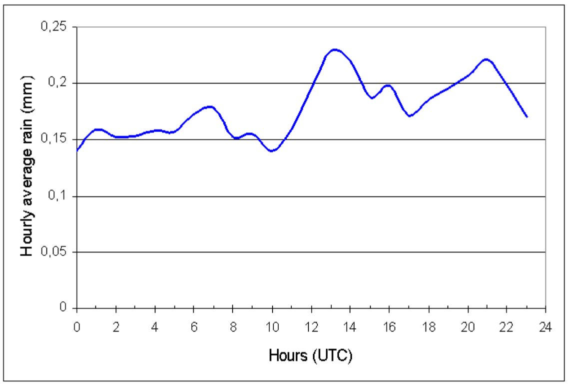

FIG. 1b: Hourly distribution of rain amount as measured for Udine, in the middle of Friulian plain..

III. A CONCEPTUAL MODEL FOR THE HOURLY DMC FREQUENCY

The development of a conceptual model devoted to explain the onserved features is carried out looking for the diurnal trends in DMC ingredients, e.g., onset, instability and vertical wind shear. Since the bimodal behaviour of DMC hourly distribution is not observed in the whole alpine space, it is here assumed that Because the afternoon maximum in DMC frequency takes place slightly after the occurrence in maximum solar radiation (11:30 UT in the study area) and slightly before the maximum temperature occurrence (13-14 UT in the study area), it is interpreted as a consequence of the maximum in the atmospheric instability. In fact, it seams reasonable to assume that, for a randomly distributed forcing, the onset of DMC should occur near to the maxima values in atmospheric instability, i.e., when atmosphere has the greatest amount of available energy. The reason why afternoon maximum is more pronounced in steep topography (Danubian, Inner Alpine, Prealpine, Carsic) is that slanted relieves receive larger amounts of energy for a fixed solar elevation.

The evening maximum, differently from the afternoon maximum, is interpreted as a consequence of a night-time forcing related to the breezes regime. Rampanelli et al. (2004), among others, showed through numerical simulations that anabatic and katabatic flows related to mountain-valley breezes involve volumes of air larger than those of the valley itself. During the evening change in the breeze regime (in summer the switch from anabatic to katabatic flow occurs around 19-20 UT), katabatic flow can produce a wind convergence with vertical wind speeds of the order of several cm/s, which might represent a sufficient forcing for the onset of DMC. Moreover, it is reasonable to assume that this forcing should be the most relevant cause of DMC onset far (but not too far) from steep orography (Piedmont, Plain and Coast), where the afternoon heating due to solar radiation is lower than that experienced on tilted topography.

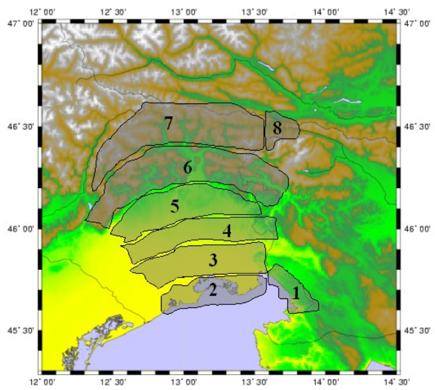

FIG. 2a: Division of Friuli Venezia Giulia in different areas: 1 Carso, 2 Coast, 3 Low plain, 4 Middle plain, 5 Piedmont, 6 Prealpine, 7 Inner alpine, 8 Danubian.

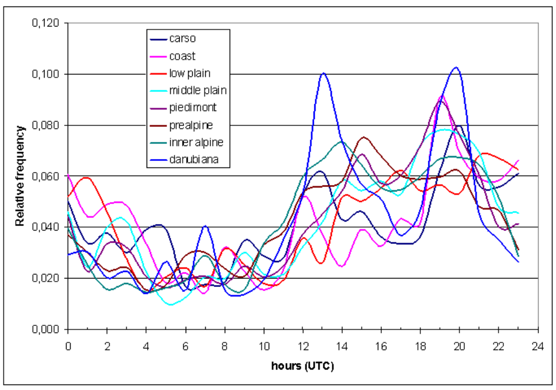

FIG. 2b Hourly frequency of DMC in the different areas showed in figure 2a.

IV. CONCLUSIONS

In this work the hourly frequency of DMC in areas characterized by different topographic features (Inner Alpine, Prealpine, Piedmont, Plain, Coast, Carso) is studied through CG lightning measurements. Two different behaviours are highlited: the bimodal shape and the single mode shape. Single mode shape is divided as well in two subclasses: afternoon maximum and evening maximum. All these features are interpreted through a simple conceptual model which takes into account the differential heating of slanted topography (instability mechanism, afternoon maximum) and the anabatic to katabatic shift in breeze regime (forcing mechanism, evening maximum). The interplay of these two mechanisms is able to explain, at least qualitatively, all the observations. The fact that this behaviour of DMC is observed in Friuli Venezia Giulia and not in neighbour regions (e.g., Veneto) is interpreted as due to the relatively small scale which characterize the former area. The anabatic to katabatic shift and the related wind convergence, in fact, should become negligible outside of the typical scale of breezes (50-100 km), which matches the extension of the study area.

V. ACKNOWLEDGMENTS

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