HYDROLOGICAL RAINFALL ANALYSIS COUPLED WITH METEOROLOGICAL INFORMATION

Gabriele S.[1], Chiaravalloti F.[2]

[1]CNR-IRPI, Via Cavour 4-6, 87030 Rende (CS) - Italy, gabriele@irpi.cnr.it
[2]CNR-IRPI, Via Cavour 4-6, 87030 Rende (CS) - Italy, chiaravalloti@irpi.cnr.it

I. Introduction

Rainfalls represent the final step of a complex process of atmospheric moisture transport and interactions with land and sea. Extreme precipitation events, although localized, especially in case of intense convective rainfalls which can produce flash-floods in small catchments, are clearly included in a broader meteorological context which feeds them in energy and moisture. Presence of orography greatly influences rainfall intensity at both local and regional scale and, for an exhaustive analysis of extreme events, coupling of meteorological and hydrological data is desirable.

Regional analysis of rainfall characteristics is widely used in hydrology to reduce uncertainty in estimation of maximum rainfall of assigned return period. Identification of "homogeneous" region, wherein statistical index like skewness or coefficient of variation (Matalas et al., 1975) may be considered constant, allows to estimate the parameters of the rainfall frequency distribution using a great amount of data. Normally, the investigation of homogeneity in the area of interest is pursued using rain gauges data and numerical modelling like cluster analysis, but at-site data are not always able to identify comprehensive spatial trend. Moreover, in areas affected by frequent convective storms, with high rainfall variability in space and time, also dense rain gauge networks may fail to identify homogeneity.

This study analyzes meteorological characteristics, in terms of distribution of CAPE (Convective Available Potential Energy) values during events that represent the annual maxima of daily rainfall, to verify the possibility of identify meteorological homogeneity which can be assimilated with hydrological homogeneous areas.

II. PRESENTATION OF RESEARCH

For this study, rainfall data are retrieved from SIVAPI (informative system for Italian flood evaluation) archive, containing daily rainfall for the whole Italian territory from the 1921 till today.

Meteorological analysis was carried out using the re-analysis GRIB files of the ECMWF (European Centre for Medium-Range Weather Forecasts) data archive ERA-40 (ECMWF 40 Year Re-analysis). The horizontal resolution of the GRIB files is 0.5°x0.5° and the level type are 23 pressure levels; data are available at main hours 00:00, 06:00, 12:00 and 18:00 TU. While ERA-40 archive starts from 1958, the analysis based on both meteorological and hydrological data has been realized in the interval 1958-1988.

For each rain gauge station the CAPE was computed for the days corresponding to annual maxima of daily rainfall, considering the maximum value in the four available GRIB intervals. The atmospheric data contained at different pressure levels of the GRIB file, at the coordinates corresponding to the position of the rain gauge station, were considered as result of a radiosounding and a synthetic CAPE index was then calculated using the Lifted Parcel Theory (Manzato and Morgan, 2003):

$$CAPE = g \int_{LFC}^{EL} \frac{T_p - T_e}{T_e} dz \cong g \sum_{LFC}^{EL} \frac{T_p - T_e}{T_e},$$

where T_p and T_v are the virtual temperatures of parcel and environment respectively (Doswell and Rasmussen, 1994). Values of the CAPE, for about 2500 stations, are then obtained for events corresponding to maximum annual rainfall from 1958 to 1988. Finally, a frequency analysis of CAPE values is carried out calculating, for each rain gauge station, the percentage of cases with CAPE > 500 J.

III. RESULTS AND CONCLUSIONS

Figure 1 shows, black lines, the actual 12 homogeneous regions defined in Italy with VAPI (Italian Flood Evaluation) project where homogeneity has been verified independently for each region of the "hydrologic compartment" of the Italian Hydrological Service (Fiorentino et al., 1987). Symbols over regions represent the frequency of CAPE > 500 J. The frequency is evaluated using all the available events at each station. High values mean that the events causing annual maxima for that station are probably due to convective events.

According to the Two Components Extreme Value (TCEV) distribution, which hypothesizes that hydrological events are a mixture of "normal" and "extraordinary" population (Rossi et al., 1984; Gabriele and Arnell 1988), regions in Figure 1 with high value of skew indicate a presence of a significant percentage of extraordinary events. Normally, extraordinary events in Italian peninsula are associated with convective storms while normal events happen during stratiform rainfall. Looking the map, the occidental and south side of the peninsula shows high percentage of convective events that decrease in the north-east side.

Except in border lines, the map shows a good agreement with homogeneity valuated with rainfall data. Figure 1 suggests also that Italy can be split in three regions alone instead of the 12 considered in VAPI: west-south (red circles prevalent), centre (green triangles prevalent), north-east (dark circles prevalent).

V. REFERENCES

Doswell III C.A., Rasmussen E.N., 1994: The Effect of Neglecting the Virtual Temperature Correction on CAPE Calculations. *Wea. Forecasting*, 9(4), 625-629.

Fiorentino M., Gabriele S., Rossi F., Versace P., 1987: Hiearchical approach for regional frequency analysis. In: *Regional Flood Frequency Analysis* ed. by V.P.Singh, pp 35-49, Kluwer Boston Inc., Hingham, Ma.

Gabriele S., Arnell N.W., 1988: The performance of the two-component extreme value distribution in regional flood frequency analysis. *Water Resour. Res.*, 24(6), 879-887.

Manzato A., Morgan G. Jr., 2003: Evaluating the sounding instability with the Lifted Parcel Theory. *Atmos. Res.*, 67-68, 455-473.

Matalas N.C., Slack J.R., Wallis J.R., 1975: Regional skew in search of a parent. *Water Resour. Res.*, 11(6), 815-826.

Rossi F., M. Fiorentino, P. Versace, 1984: Two Component extreme value distribution for flood frequency analysis. *Water Resour. Res.*, 20, 847-856.

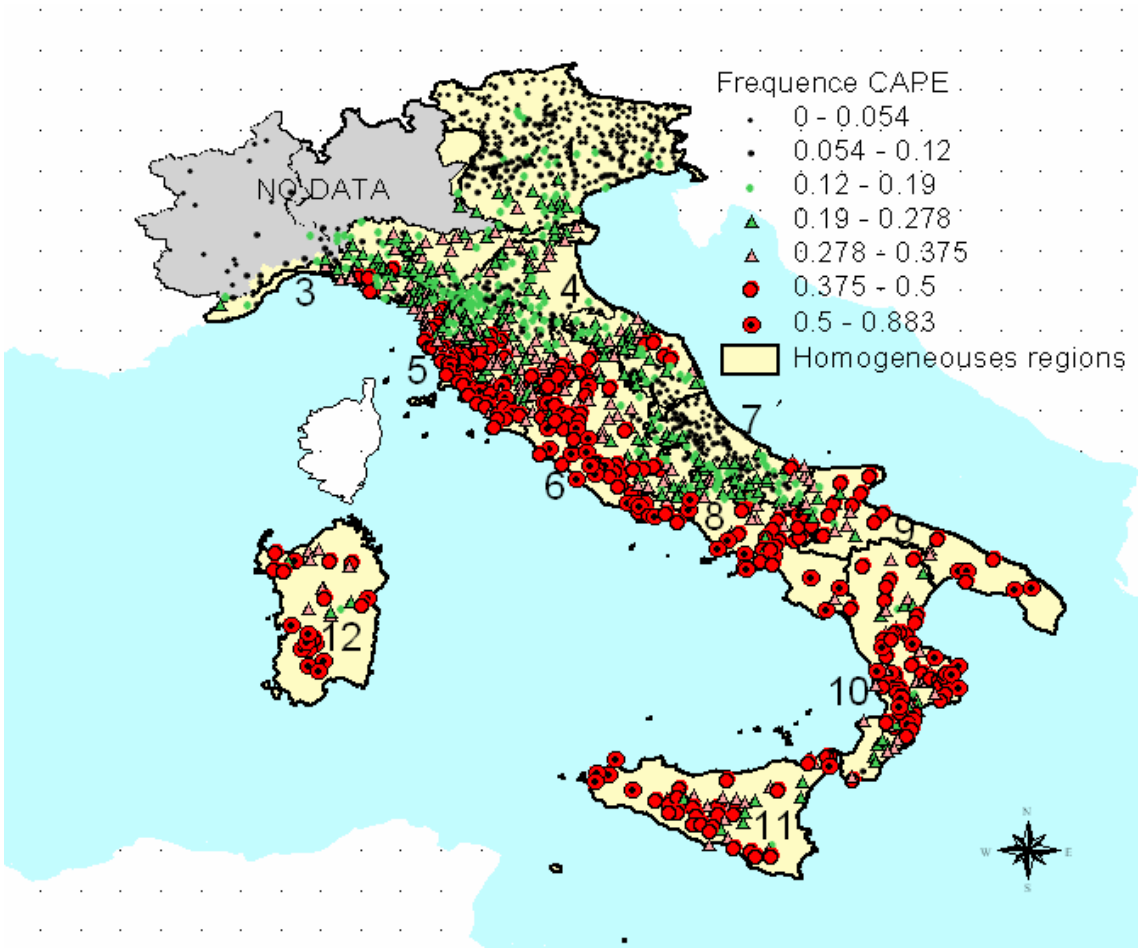

FIG. 1: Frequency of CAPE > 500 J for about 2500 rain gauges for events corresponding to maximum annual rainfall from 1958 to 1988; the 12 homogeneous regions (black lines) defined in the VAPI (Italian Flood Evaluation) project also are shown.