INTENSE PRECIPITATION PATTERN BY MEANS OF CONCENTRATION INDEX (CI) – EXAMPLES OF TWO BRAZILIAN SITES

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I. INTRODUCTION

Extreme events are infrequent within their statistical reference distribution (IPCC, 2001) and reflect distinct arrangements of variables and processes that occur at several scales. They present small radius of correlation over space and time but their local impacts such as flooding, erosion and landslides can cause major loss of property and life.

Part of the natural system extremes can, however, reduce the economic growth and obstruct competitiveness. High concentration of rainfall, in particular, is connected to high erosivity and floods and poses difficulties for managing water resources (Martín–Vide, 2004, Benhamrouche and Martín-Vide, 2012).

Because anomalous occurrences are rare by definition, long-term records are needed to determine significant changes in their frequency and intensity (Goklany, 2007; Sillmann and Roechner, 2008). However, despite precipitation series present few large daily amounts they represent a notable percentage in the total volumes (Martín-Vide, 2004).

A number of studies have attempted to identify the impacts of extreme events in Brazil: Nunes and Modesto (1996) evaluated the role of concentrated precipitation for triggering landslides in Guarujá, a coastal municipality. Evaluating extreme precipitation for the state of São Paulo Lieberman et al (2001) defined extreme daily episodes for 287 rain gauges and observed that most of them were recorded from October to March. Considering four decades of precipitation for Campinas, another Brazilian city, Vicente (2005) observed that recent periods experienced an increase in daily extremes, pattern also found by Silva Dias et al (2010) in their evaluation for the city of São Paulo from 1933 to 2010.

In this study, the weight of the largest amounts in the bulk of the series was defined by applying the Concentration Index (CI) proposed by Martín-Vide (2004), which considers the contribution of the days of greatest rainfall to the entire series, providing an understanding of the daily rainfall structure in a given location.

II. Presentation of Research

The Concentration Index was applied in a number of areas such as Peninsular Spain (Benhamrouche and Martín-Vide) and Europe (Cortesi et al, 2012). In this method the daily totals are divided into equal classes (for instance, 0 to 4,9 mm, 5,0 to 9,9 mm and so on), the higher amount contained in the last class. For a standard case the accumulated number of precipitation days (in %) versus the amount of accumulated precipitation (in %) can be expressed by a concentration curve. It shows that classes of smaller amounts have many more registers than classes of bigger amounts. Therefore, it is necessary an index to express the daily heterogeneity, which can be identified in Figure 1 as a function of the relatively separation of the equidistribution line of two fictitious stations, A and B, being station B more heterogeneous (Martín-Vide, 2004). The area S enclosed by the bisector of the quadrant and the polygonal line provides a measure of concentration, by using the Gini Index (GI=2S/10.000); this is so because the greater the area, the greater the concentration (Martín-Vide, 2004).

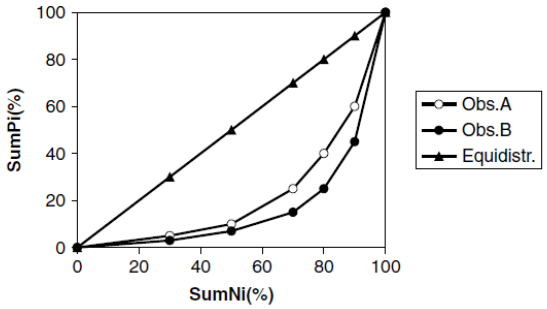

FIG 1: Concentration curves for two fictitious locations (A and B) in relation to the accumulated number of precipitation days versus amount of accumulated precipitation

After Martín-Vide, 2004

To improve the calculation in view of identifying the contribution of the largest amounts of daily precipitation in relation to the total amount of precipitation of every gauge, the weight of the accumulated percentage of precipitation (Y) in relation to the accumulated percentage of the precipitation days (X) can be expressed by a positive exponential function:

$$Y = aX \exp(bX)$$

where a e b are constants.

From this positive exponential curves, the Concentration Index (CI) is similar to the GI. CI is defined as the ratio of the area (S') delimited by the equidistribution line, the exponential curve of adjustment and the area of the triangle defined by the equidistribution line, so that: CI = S'/5000. The constants (a and b) are determined by means of the least-squares method, being N the number of nonzero classes:

$$\ln a = \frac{\sum X_i^2 \sum \ln Y_i + \sum X_i \sum X_i \ln X_i - \sum X_i^2 \sum \ln X_i - \sum X_i \sum X_i \ln Y_i}{N \sum X_i^2 - \left(\sum X_i\right)^2}$$

$$b = \frac{N \sum X_i \ln Y_i + \sum X_i \sum \ln X_i - N \sum X_i \ln X_i - \sum X_i \sum \ln Y_i}{N \sum X_i^2 - \left(\sum X_i\right)^2}$$

III. RESULTS AND CONCLUSIONS

The CI was applied for two Metropolitan Regions of Brazil: Baixada Santista/Santos (MRBS, 9 municipalities) and Campinas (MRC, 19 municipalities) (Figure 2a AND 2b). In both many episodes of concentrated precipitation are due to the South Atlantic Convergence Zone (ZCAS) - an extensive band cloud cover which remains semi-stationary for several days, contributing to flooding and landslides: Malvestio and Nery (2012) reported that 109 events of ZCAS from 1980 to 2011 caused 374 fatalities in the state of São Paulo. In Santos region the volumes of precipitation are higher due to the maritime influence.

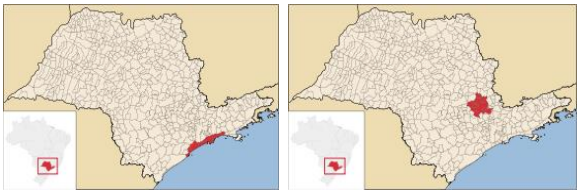

FIG 2a and 2b- Metropolitan Regions of Baixada Santista/Santos (left) and Campinas (right)

For each location daily homogeneous precipitation records of four rain gauges with good registration accuracy spanning from 1958 to 2003 were evaluated.

Results were obtained as follow, having station Campinas D4-46 (DAEE) as example: Column 1 presents class limits (0-4,9 mm; 5,0-5,9mm till the last, which for this station was 130,0-134,9mm); column 2 shows the midpoint of each class (for the first class, 2,5). Column 3 has the number of recorded precipitation days in each class (class 0-4,9, 13,670 days). The fourth column shows the cumulative frequencies obtained by adding the absolute frequencies of all the classes up to the one under consideration, the last one included. Values of the fifth column correspond to the total precipitation of each class, obtained by multiplying, class by class, the second column by the third one. In the sixth column the values of the previous column are added up so that the value of the last class corresponds to the total precipitation of the series (for the example, 95,195). The percentages of columns four and six are presented in columns seven and eight, respectively, i.e: the division of each value by the column's last value and multiplied by 100.

Values of CI for Santos region were 0.64 (2 stations) and 0.72 (2 stations), while for Campinas values were 0.69, 0.70 and 0.71 (2 stations). Although the mechanisms that generate rainfall in the regions are partially distinct, the indices for both are similar and can be considered high, enhancing that Santos and Campinas present important variability, fact that poses difficulties for forecasting and planning any activity in the sites, both very dynamic centres and with great potential for economic growth, attracting investments and population which, notwithstanding, are at permanent risk.

This evaluation integrates the project financed by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil), entitled: Assessment of Impacts and Vulnerability to Climate Change in Brazil and strategies for Adaptation Options (Proc. 2008/58161-1). Major objectives of the project include the identification of climate change across physical systems and their socioeconomic impacts at regional scale for some *core* areas, including the Metropolitan Regions of Baixada Santista and Campinas. Further studies will include evaluations for the entire state of São Paulo (47 stations) and the representation of CI by means of isopleth maps for each season, in order to identify the degree of irregularity of daily precipitation.

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