Extreme precipitation events in Campinas, Brazil

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Environmental systems are highly complex and dynamic, presenting natural variability in their rhythms that includes normal and extreme events. However, the entire planet has been experiencing dramatic changes, which reflect modifications in the human-nature relationships and bring in turn new and different boundary conditions to the environment. A number of associated hazards are connected to these changes, among them an increase in floods, in general triggered by precipitation. Historically flood-prone areas were attractive for human settlement and agriculture (Beyer 1974, Reading *et al*. 1995), but now a considerable proportion of the inhabitants of the globe live in areas with high risk of floods and every year deaths and economic losses are registered everywhere (Beyer 1974, Smith 1992, Van Molle 1993, Reading *et al*. 1995, Smith 1997, Tobin and Montz 1997, Loster 1999). Floods occur when any abnormally high flow of water overtops the natural or artificial boundaries of a watercourse and inundates the adjacent floodplain, causing degradation of ecosystems, soil erosion, displacement of people, extensive damage to properties, destruction of crops and fields, contamination of drinking water, energy shortages, diseases and loss of life. Moreover, they can also trigger other hazards, such as slope failures.

Although no place can be totally safe from the threat of floods (Beyer 1974, Smith 1992, Park 1993), areas which are known to be flood-prone pose greater threat than others in which these events are rarer, and on a rational basis, living there should be avoided. However, lack of alternatives, in particular in poor nations, has led to a notorious intensification of floods hazards. From 1971 to 1995 floods affected more than 1.5 billion people all over the world, causing 318,000 deaths; in addition, more than 81 million people became homeless (The Red Cross *apud* Pielke Jr. and Downton 2000). These figures show that there is a worldwide tendency toward severe floods, which are particularly dramatic in places that concentrate population. Furthermore, a number of studies have demonstrated that variability of climatic elements is on the increase (Ben-Gai *et al*. 1998, Dai *et al*. 1998, Perrella 1999, Nunes 2000).

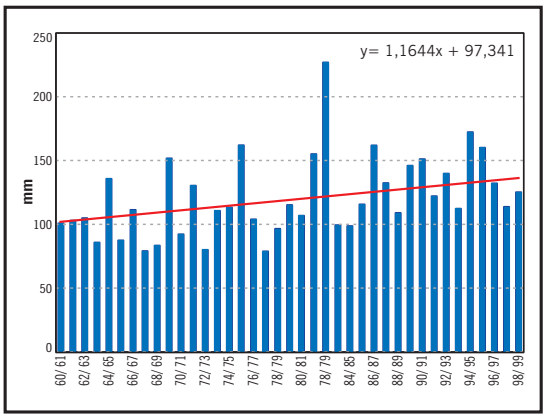

Figure 1 – Precipitation totals

The IPCC Reports of 1996 and 2001 (Houghton *et al.* 1996 and 2001) admitted that the balance of evidence suggests a discernible human influence on global climate, stressing that at regional scales there is a clear evidence of changes in some extremes and climate variability indicators. This aspect is investigated in this study by evaluating precipitation data in Campinas, one of the most important technological centers of Brazil: its GNP (US$8,870) is much higher than the national GNP (US$5,038), emphasizing the economic importance of the area

(Prefeitura Municipal de Campinas); in addition, the city has 1 million inhabitants and shows impressive urban and demographic growth. However, as with most Brazilian cities, its enlargement has occurred in a chaotic fashion, so that urban growth has been much faster than the infrastructure spread, contributing to reduce the impact thresholds in places under extreme episodes, resulting in an increase in the frequency and magnitude of floods and terrain collapses triggered by extreme events of precipitation. These problems bring great disorganization into the city, so this study evaluates the temporal trends of extreme daily events in Campinas, in view of establishing daily precipitation values for the area which can be considered anomalous, as well as the recent temporal trends of the extreme events. This contribution integrates a comprehensive study which evaluates the spatial repercussions of the extreme events in the area, the impact thresholds involved, and the vulnerability of society to these hazards.

Taking data into account from 1961 to 1999, analyzed at monthly levels, a general characterization of the area's precipitation is provided. The standardized values of monthly data are used for evaluating the broad precipitation trends on a monthly basis, and the daily extreme events are selected empirically. Although some authors used statistical methods to establish extreme daily events (Bärring 1987, Olaniran 1991, Brunetti *et al*. 2001) they are considered too linear and not applicable to the current study due to the unique climatic characteristics of Campinas. The city is located in a transitional zone regarding both large and meso-scale controls (at the boundary of The Tropic of Capricorn, influenced by tropical and extra-tropical air masses). Summer precipitation in the area is highly convective and strongly modulated by the presence of the South Atlantic Convergence Zone (SACZ), but a portion of the precipitation occurs as a result of cold fronts interacting with the warm air associated with the permanent tropical South Atlantic High and outbreaks of cold polar air associated with traveling anticyclones. After some attempts with different values, daily episodes in the area equal to or above 50 to 100 mm were considered extreme precipitation events. The latter illustrates the results.

Information about extreme events and their impacts was selected from news published in newspapers (in some cases available on the Internet) and by the São Paulo State Civil Defense. Also were considered secondary sources, such as the Dartmouth Flood Observatory. The Barão Geraldo gauge was chosen to illustrate the results (four other gauges were evaluated in this study, showing the same behavior). Years are: December year x through November year x+1 (maintaining the rainy season, which corresponds to summer months).

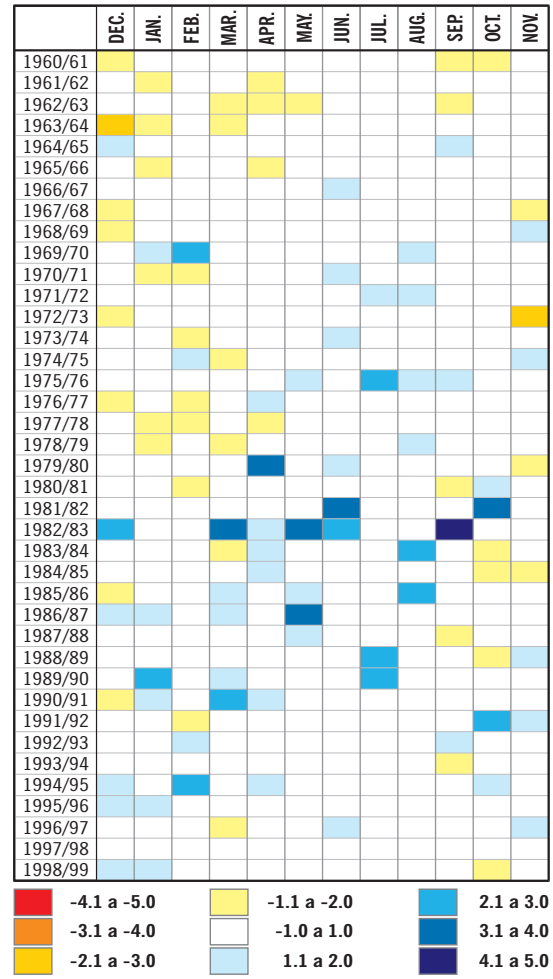

Figure 2 – Monthly precipitation departures (standardized values)

At the annual level (Fig. 1) the totals rose considerably, revealing a significant change, as can be seen on the regression trend line. The monthly data departures, expressed as deviations of the mean (Fig. 2) show that extreme positive events (above the average) were concentrated in recent years, particularly in the 80's. On a daily basis (Fig. 3) the number of anomalous episodes (>50 mm/day) is on the increase; note the two last decades, in which this trend clearly appears.

Analyzing the preliminary results, it can be seen that recent decades have experienced impressive changes in the precipitation pattern, with an increase in the volumes and in the frequency of extreme events, a trend found in other areas (Kunkel *et al*. 1999, New *et al*. 2001). However, the spatial repercussion of the same extreme event is quite

distinct in Campinas: on February 17th 2003, a storm caused by a cold front impacted a large area of Southeastern Brazil and in Campinas this event was the second highest in 120 years according to the Instituto Agronômico de Campinas, which has maintained a meteorological station since the late 19th century (140 mm in 24 hours, 115 mm in 90 minutes). But the impacts were mostly felt in the poorest sectors of the city (including seven deaths), underscoring the fact that extreme precipitation episodes play a role in intensifying the social differences in the area.

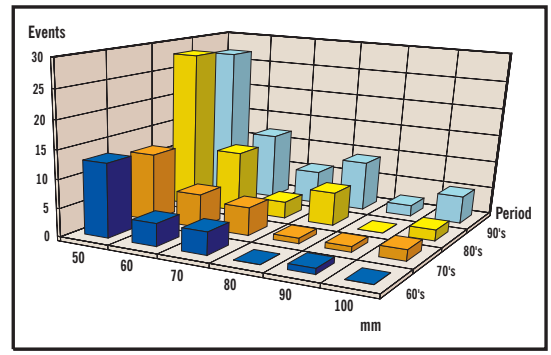

Figure 3 – Extreme episodes (over 50 mm/day) in four decades

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