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Solar activity and the streamflow of the Paraná River

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Abstract. River streamflows are excellent climatic indicators since they integrate precipitations, infiltrations and evapotranspiration over large areas. We studied the streamflow records for the Paraná River, in South America, available from 1904 to date. We found a remarkable positive correlation between the streamflow series and solar activity, as measured by the sunspot numbers, in interdecadal scales.

1. Introduction

For decades, solar influence on climate has been studied confronting records of solar activity with records of temperature, mainly of the Northern Hemisphere's temperature (e.g. Friis-Christensen and Lassen 1991), but also of the sea surface temperature (White et al. 1997). Recently, other climatic variables were included in this kind of studies. For example, a correlation between solar activity and cloud cover, via the modulation of galactic cosmic rays by the solar wind, was reported (Svensmark and Marsh 2000), although it is far from universally accepted (e.g. Sun and Bradley 2002).

Other signs of this influence have been found in different records of atmospheric moisture. For example, coherence between the solar variability and the levels of the Asian monsoon has been reported (Neff et al. 2001; Agnihotri et al. 2002; Gupta et al. 2003; Fleitmann et al. 2003; Wang et al. 2005). In all these cases, higher levels of solar activity were found to be simultaneous with higher monsoon levels. Also, solar variability was found to be positively correlated with moisture over Alaska during the Holocene (Hu et al. 2003). On the other hand, higher solar activity was found to correspond with drought periods both in east Africa (Verschuren et al. 2000) and in Mexico, were was even proposed that an activity-related drought was one of the reasons for the Mayan decline (Hodell et al. 2001).

We studied whether a similar correlation can be found in the streamflow of one of the largest rivers of the world, the Paraná in southeastern South America. With a basin area of over 3,100,000 km^2 and a mean streamflow of 21.300 m^3/s, the Paraná is the fifth river of the world according to drainage area and the fourth according to streamflow. With its birth in the southernmost part of the Amazon forest, it flows South collecting water from the countries of Brazil, Paraguay, Bolivia, Uruguay and Argentina, and forms one of the mightiest deltas of the world before its outlet in the

Plata River, a few kilometers north of the City of Buenos Aires. Due to the fact that, unlike other rivers of similar size like the Amazon or the Congo, it flows through heavily populated areas, and that it is navigated by overseas trade ships, it has one of the longest streamflow data series, which covers the last century.

We analyzed the streamflow data measured at a gauging station located in the city of Corrientes, 900 km north of the outlet of the Paraná. It is measured continuously from 1904, on a daily basis. The Paraná's hydrological year goes from September to August, with maximum streamflow in the (Southern Hemisphere's) summer months of January, February and March. We therefore built our yearly series integrating the flow from September to August of the next year, and assigning the value to the first year.

We found that there is a very strong direct correlation between solar activity, as expressed by the yearly Sunspot Number, and the streamflow, in intermediate, interdecadal, scales. This correlation implies that wetter conditions in this region coincide with periods of higher solar activity, in agreement with the paleoclimatic studies of the Asian monsoon mentioned above.

This result can also be used for flood prediction in this region. It should be mentioned that the three largest floods of the Paraná during the 20th century have caused economic losses for over five thousand million dollars (Flamenco 1998).

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