Atmospheric circulation patters linked to extreme flooding in the Pas river (Cantabria, N. Iberian Peninsula)

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Flooding from the rivers of the northern Iberian Peninsula exhibits some particular characteristics. Despite its relatively constant levels of streamflow, there is a long history of destructive floods, which, in the case of the River Pas, goes back to the 14th century, and being the summertime the epoch of the most catastrophic ones, associated with intense rainfall episodes, although the average precipitation is relatively scarce. Our objectives were to analyze the maximum discharge events in the River Pas (Cantabria, Northern Spain) and their relationships with the atmospheric environment, to improve our understanding of the hydroclimatology of the floods in this area and to lead to a predictive procedure in our region. Although our research focus on the Pas River, we postulate that the results are applicable to other watersheds in Cantabria and in the adjacent regions of Asturias and the Basque Country. Daily discharge data was collected from the gauge station of Puente Viesgo, in the low-middle course of the Pas River. Our criterion for defining a major flood was based on the instantaneous peak discharge: an event in which the peak discharge reached the magnitude of a 5 year recurrence interval was considered a 'major flood'. The 5 year threshold was found as a reasonable compromise between the need for a sufficiently large sample of floods required to produce significant results and the constraint resulting from the short observation period. The atmospheric data were taken from the NCEP/NCAR reanalysis data for a selected window (25W-15E and 25N-55N). Daily precipitation data from the stations of the watershed were provided by the INM (Instituto Nacional de Meteorología, Spain). Composite maps were used to characterize the atmospheric circulation conductive to those events, adding fields for several days prior to each event to study the evolution of the storms and to observe possible cumulative effects. The period between September 1969 to December 2003 was chosen as the study period, since it is the best covered by the sources of information. Our research shows that there are two different atmospheric circulations associated a large flooding in the Pas wathershed, diverse by their seasonality, type of and spatial and temporal distribution of the rainfall. Synoptic flows from northwest to north, related to a transition from zonal to meridional circulation regimes, are associated to the more frequent cold season floods. Precipitation, with moderated hourly values, is concentrated in the watershed head, due to an enhanced orographic effect linked to the strong upper level

winds and surface Atlantic air mass advections. Their effect is intensified by the high values of ground saturation and, sometimes, by a rapid snowmelt from the mountains. Convection associated to upper cold lows and warm sea surface temperatures generates torrential rainfalls (high hourly values), with a preferential location closer to the first orographic ridge and the coastline, driving to summer flooding events. Although absolute daily discharge data are very similar in both kinds of events, the environmental consequences (losses of human beings and cattle, destruction of infrastructures and buildingsÊ) are more destructive during the summer floods, a circumstance confirmed by historical analysis of documentary sources. Besides hydro-meteorological factors, we think that other factors also influence the magnitude of the damage, like the occurrence of high sea levels in the outlet, ground cover and forestry.