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Magnitude and frequency of palaeofloods of the Duero River (Spain and Portugal) in the context of climate variability during the last 15 ka

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The Duero River is one of the three major rivers in the Iberian Peninsula, draining a catchment area of 98,073 km² (20% in Portugal and 80% in Spain) to the Atlantic Ocean. Extreme flooding in the western Duero River is associated with winter Atlantic fronts leading to some of the highest specific discharges to be found in European rivers. A paleoflood record in the Duero canyon, at the Spanish-Portuguese boundary, provides evidence of magnitude, frequency and timing of such extreme phenomena during the last 15 ka. Slackwater flood deposits (SWDs) are preserved in thick, high-standing benches in canyon expansions and tributary mouths. Fourteen high-resolution stratigraphic profiles were studied in two reaches, next to Bemposta and Saucelle dams, at the Arribes Natural Park. The paleoflood chronology was established using optically stimulated luminescence (OSL) and AMS radiocarbon dating. Flood discharge associated with each flood bed was estimated from hydraulic modelling (HEC-GeoRAS v.5).

The most complete record is found at the Duero-Tormes river junction (Bemposta reach), which comprises five inset SWD benches at elevations between 15 m and 25 m above river water level (arwl). The highest bench comprises six flood units within four sequences, dated to 13.8ka, 8.4ka, 2.4ka and post-2.4ka. At 23.5 m arwl, the second flood bench recorded 23 flood units organized into four sequences separated by well-developed paleosols, and dated to 11.6ka, 9.5ka, 4.4ka, 2.2ka and <0.5ka. The third inset bench (20 m arwl) comprises 19 flood units dated between 11.6ka and 10.5ka, whereas in the fourth inset bench (17.5 m arwl) 17 flood units were dated to 14.9ka, 12.6ka and 11.5ka. About 1 km downstream, a flood bench deposited at a channel expansion records 14 flood beds over the last 1.8ka with discharges >5000 m³/s.

The composite stratigraphic record comprises 62 floods over the last 15ka grouped into 10 flood phases (FP1 to FP10) with minimum discharges ranging between 4000 m³/s and 11,000 m³/s. The hydroclimatic analysis of the flood events, supported with historical flood analysis, shows a good temporal correlation between the occurrence of catastrophic floods and the existence of anomalous negative NAO index phase. The Duero's palaeoflood record correlates in timing with flood episodes recorded in other Iberian rivers (e.g. Tagus, Guadiana) and lake sediments (e.g. Lake Sanabria),

which highlights the impact of atmosphere-ocean hemispheric coupling conditions on extreme floods in the region. These findings suggest a response, at centennial scale, between climatic factors and the outcome variability in the magnitude and frequency of floods.