Millennial scale control of European climate by the North Atlantic Oscillation from 12,500 BP: The Asiul speleothem record

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Contemporary climate in Europe is strongly influenced by the North Atlantic Oscillation (NAO), the atmospheric pressure dipole between Iceland and the Azores[1]. Under positive NAO conditions winter storm tracks associated with the Atlantic Westerly Jet (AWJ) migrate northwards, leading to wetter and warmer winter conditions in north-western Europe and dry conditions in southern Europe; including the Iberian Peninsula. Under the negative NAO phase, storm tracks weaken and shift southwards reversing the pattern[1]. Existing proxy records of the NAO suggest that this atmospheric process only began to dominate European climate at approximately 8000 years BP, related to the final breakup of the Laurentide ice shelf[2]. However, here we present evidence of precipitation changes from a high-resolution speleothem $\delta^{18}O$ record from northern Iberia, which indicates NAO-like forcing extending throughout the Holocene and into the Younger Dryas (YD) at 12,500 years BP. These variations in precipitation delivery relate to an underlying millennial scale cycle in NAO dynamics. The speleothem $\delta^{18}O$ is strongly correlated to existing records of North Atlantic Ocean ice rafted debris (IRD)[3], indicating an NAO-like connection with oceanic circulation during the Holocene[2]. These large-scale atmospheric processes have dramatically influenced the delivery of precipitation to northern Iberia and may have played a decisive role in environmental and human development in the region, throughout the Holocene.

[1] Hurrell *et al*., 2001. *Science*, Vol.291, 603–605.

[2] Giraudeau *et al.*, 2010 *Quaternary Science Reviews*, Vol.29, 1276–1287.

[3] Bond *et al.,* 1997. *Science,* Vol.278, 1257–1266.