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A multiproxy reconstruction of NAO evolution in the Azores archipelago since 1350 AD

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The North Atlantic Oscillation (NAO) is the main atmospheric circulation pattern affecting climate variability in the Northern Hemisphere, having a major impact on both marine and terrestrial ecosystems. Instrumental records of the NAO are relatively short, and therefore paleoenvironmental multiproxy approaches become fundamental to better understand its behaviour for longer scale periods. The NAO is often defined as a large-scale meridional oscillation dipole of air pressure between the Azores High and the Iceland Low. Some of the NAO definitions include the use of sea level pressure from Ponta Delgada station in Azores, and thus any NAO reconstruction would gain in robustness if it includes paleoenvironmental information from this archipelago located at the southern end of the meridional dipole that characterizes the NAO pattern. However, to the best of our knowledge, very few historical and long-term reconstructions have been conducted in the Azores Islands. We present a ca. 600-year-long multiproxy reconstruction of the NAO evolution based on facies analysis, X-ray diffraction (XRD), X-ray fluorescence (XRF) core scanning, elemental and isotope geochemistry on bulk organic matter and the preliminary study of diatom and chironomid content from the sedimentary record of Lake Empadadas (37° 49' N - 25° 44' W, Azores Archipelago, Portugal).

The precipitation regime in Azores Archipelago (i.e. intra and inter-annual variability) is clearly influenced by the NAO index, thus periods with dominant positive NAO index values (NAO+) are usually characterized by low winter precipitation in the Azores. Conversely, negative NAO phases (NAO-) induce high winter precipitation in the archipelago. These patterns suggest that past (winter) precipitation changes on the Azores may be partially used as a proxy for NAO changes, and thus a proxy for more large-scale changes in the North Atlantic region. According to this multiproxy characterization of the Lake Empadadas sediments four main climatic (and NAO) stages since 600 cal years BP have been established. The first stage (1350-1460 AD) correspond to dark-brown to black mud facies with high values in lake productivity and moderately shallow waters, which however represent the deepest condition during the studied interval. Mineralogical composition and high organic matter content also suggest a humid climate with abundant precipitations that might be related to a predominantly NAO- phase. The second stage, spanning between 1460 and 1800 AD, is represented by a similar facies presented by the previous phase. This stage is however characterized by a transitional period from a wet to more arid climate, probably related to a change in NAO conditions (from NAO- to NAO+), with lower values of lake productivity and lake level than the previous stage. From 1800 AD until 1930 AD (third stage) banded brown to pale-brown silty and muddy facies were deposited. During this stage the lowest lake water table and productivity in the whole sequence were reached suggesting a predominantly NAO+ phase in concordance with instrumental NAO records. However, heavy rainfall catastrophic events are recorded in the sequence as very coarse (gravely) alluvial intervals that may be related with intense NAO- negative winters or alternatively to autumn Tropical Storms that can reach the archipelago. Finally, the uppermost interval of the sequence is composed by brown to ochre massive mud. A lake level rise and a progressive increase in the productivity suggest a relatively humid fourth stage from AD 1930 until present, a period characterized with more NAO- values.