Geophysical Research Abstracts
Vol. 12, EGU2010-5794, 2010
EGU General Assembly 2010

Towards a quantitative climate reconstruction linking meteorological, limnological and sedimentological datasets: the Lake Sanabria (NW Spain) case.

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It is well-known that lacustrine sediment records constitute one of the best environmental sensors to reconstruct climate variability. Nevertheless, our knowledge of how the climate signal (precipitation, temperature, wind stress) is transferred from the atmosphere to the lake water masses (through the limnological variables such as pH, nutrient inputs or water chemistry) and to the sediments is very poor. Besides there are few reliable and temporal long limnological and/or meteorological datasets. This lack also prevents the conversion of these qualitative climate reconstructions into quantitative ones.

Lake Sanabria (Zamora) is located in the northwestern of the Iberian Peninsula (42°07'30" N, 06°43'00" W), at 1.000 m a.s.l. It is the largest glacial lake (368 ha, 51 m of water depth at the deepest point and 96 Hm^3 of water volume) in the Iberian Peninsula. The main water and sediments input and output is the Tera River.

Monthly limnological (secchi disk, water temperature profiles, conductivity, pH, dissolved oxygen), nutrients (nitrates, silicon, total phosphorous, reactive phosphorous, total chlorophyll and a-chlorophyll), hydrological (Tera river discharge) and meteorological (precipitation and air temperature from the Ribadelago meteorological station) datasets covering the period 1992 - 2005 were employed to explore the relationships between the atmosphere and the Lake Sanabria hydrological balance, and the limnological variables.

X-Ray Fluorescence (XRF) core scanner data of two gravity cores (SAN04-3A and SAN07-1M) allowed us to characterize with high resolution the evolution of the chemical composition of the uppermost sedimentary infill. SAN07-1M was dated using gamma-spectrometry (^{210}Pb) and a key bed corresponding to the dam failure of the Vega de Tera Reservoir located upstream occurred in 1959 AD. The relationships between the sedimentological and limnological datasets allowed us to characterize the transference of the climate signal from the limnological towards the sediments.

These relationships were studied using a statistical approach, such as ordination analyses (Principal Component and Redundancy Analyses), time series (auto- and cross-correlation funtions) and generalised linear models (glm).

The precipitation and temperature oscillations account for more than 75% of the total variance of the Tera River discharge, and only precipitation explained more than the 55%. The lake reacts inmediately to changes in the precipitation as shown by best correlation between the three variables occurring at 0 lag-time. When exploring the possible relationships between meteorological and the limnological and nutrient datasets, it was evidenced that total phosphorous showed the best fit with 28% of the total explained variance. The best correlation was also observed at 0 lag, indicating that the main nutrient input occurs by the Tera River.

Principal Component Analysis (PCA) on the XRF dataset showed that the first eigenvector explained more than 44% of the total variance and it was related mainly to the organic matter changes. Oscillations of this first

eigenvector have been interpreted in terms of fluctuations of the primary productivity of Lake Sanabria.

The comparison between the reconstructed primary productivity with the total phosphorous highlighted that lakes generally act as a low-pass filters, smoothing the climate signal when transfers it to the sediments. The explained variance between the smoothed reconstructed primary productivity and the total phosphorous is 24%, similar to that between the total phosphorous and the Tera River discharge.

This study opens the possibility to a quantitative reconstruction of past climate data (temperature and precipitation) from high-resolution sedimentological datasets.