The Earth’s Magnetic Field in the past 100 kyr

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One step on the way for the understanding of the variations of the Earth’s magnetic field is the study of the past variations. These past variations can be found in various geological archives. One possibility are lake sediments in which the magnetic minerals can store information about the direction and the intensity of the Earth’s magnetic field.

However, when we measure the magnetic properties of these sediments, the measurements will also contain a large climatic impact. For example, the concentration or the grain size of the magnetic minerals depends on the weathering processes which on the other side depend on the climate.

Finally, we always measure a mixture of climate and real Earth’s magnetic field signals when we measure rock magnetic parameters. Since we are interested only in the information about the Earth’s magnetic field, we apply the independent component analysis in order to separate a clear signal of the Earth’s magnetic field. This method separates the observations in independent components (the components of the PCA are only uncorrelated, but not independent in general).

Data

In this work we use data sets from the two Italian lakes Lago di Mezzano and Lago Grande di Monticchio, which contain various rock magnetic measurements and span a time range up to 100,000 years before present. The aim is to separate a signal which contains only the intensity of the Earth’s magnetic field.

For this task, three rock magnetic measurements were chosen: the natural remanent magnetization (NRM), the anhysteretic remanent magnetization (ARM) and the susceptibility (κ).

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Results

The independent components s1, s2 and s3 obtained with ICA from rock magnetic measurements of Lago Grande di Monticchio. The first component contains rather probably a signal of the past Earth’s magnetic field and the two other components contain a climate signal.

Correlation coefficients between the ICs and the underlying signals as well as the proxy data for the climate, reveal a clear distinction of these signals.

In the palaeo magnetic community the ratios of NRM and κ, and NRM and ARM are usually used as proxies for the intensity of the Earth’s magnetic field. These both ratios correlate well with the first component, however, each of them correlates also with one of the second and third component. This is a clear sign that these ratios still contain some rock properties, especially the grain size, and are, therefore, impacted by a climate signal.

Furthermore, the first ICs contain much less climate impact as the usually used ratios of NRM with ARM and κ, respectively.

The signal of the past intensity of the Earth’s magnetic field which was obtained with the ICA from rock magnetic measurements of sediments gained from Lago di Mezzano (red and blue) and Lago Grandi di Monticchio (black). For comparison the palaeo intensity of the reference data SINT800 is provided.

A brief introduction about the ICA can be found on poster P1202 Independent Component Analysis of Sedimentary Rock Magnetic Data. Please have a look at it!