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Potential analysis of geophysical time series: from paleodata to current climate change

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We apply a new method of potential analysis to study several paleo and historic climatic records. The method comprises (i) derivation of the number of distinct global states of a system from time series, (ii)derivation of the potential coefficients using an Unscented Kalman Filter (UKF), yielding indications of possible bifurcations and transitions of the system.

The method is tested on artificial data and then applied to climatic records spanning progressively shorter time periods from 5.3 Myr (Raymo benthic stack), to GRIP and NGRIP paleorecords from 60kyr BP, and to recent times (historical reconstruction of the European temperature anomaly, Atlantic Multidecadal Oscillation index, and NOAA global temperature index).

We detect various transitions and bifurcations of the climate system. Most notable is a bifurcation at 25 kyr BP from two to one state which is confirmed in GRIP and NGRIP $\delta^{18}O$ and calcium records. Yet another biburcation is detected in the historic record of European temperature anomaly at the end of the 18th century (“Malda” anomaly).

The method can be applied to a wide range of geophysical systems where time series of sufficient length and temporal resolution are available and transitions or bifurcations are surmised.

[1] Livina V., F. Kwasniok, and T. Lenton, Potential analysis reveals changing number of climate states during the last 60 kyr, Clim. Past Discuss., 5, 2223-2237, 2009.