Geophysical Research Abstracts,
Vol. 11, EGU2009-9530-2, 2009
EGU General Assembly 2009

Extracting a common pulse like signal from Time Serie using a non linear Kalman Filter

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To understand the nature and cause of natural climate variability, it is important to attribute past climate variations to particular forcing factors. In this work, our main focus is to introduce an automatic assimilation procedure to estimate the magnitude of strong but short-lived perturbations, such as large explosive volcanic eruptions, using climate/proxies time series. The extraction and decomposition procedure is run on real multivariate time series of sulfate from ice cores drilled at different sites in Greenland. The sulfate ejected by volcanoes is transported through the stratosphere towards the poles and deposited via sedimentation near the pole. Sulfate in Greenland is then a marker of huge volcanic eruptions which occur all over the world. Such pulse-like processes are highly non linear, as much in time as for their intensity. If they are not detected, such pulse-like signals of extreme and rare events can perturb an objective calculation of the trend. This work is then as much an estimation procedure for such signals, as a first step to estimate a posteriori trend in the time series.

Our extraction algorithm handles multivariate time series with a common but unknown forcing. This statistical procedure is based on a multivariate multi-state space model and a non linear Kalman Filter. The non linearity is solved using the calculation of a twice conditional expectation and variance. It can provide an accurate estimate of the timing and duration of individual pulse-like events from a set of different series covering the same temporal space. It not only allows for a more objective estimation of its associated peak amplitude and the subsequent time evolution of the signal, but at the same time it provides a measure of confidence through the posterior probability for each pulse-like event. The flexibility, robustness and limitations of our approach are discussed by applying our method to simulated time series and to the Monte-Carlo method to test the accuracy of the decomposition.