A timescale analysis of the NH temperature response to volcanic and solar forcing in the past millenium

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This paper examines the timescale dependence of the response of simulated and reconstructed temperature records to the external forcing factors. The proxy data underlying the reconstructed forcings are independent of the datasets used for the temperature reconstructions. The question of whether the forced signal in the reconstructions is plausible, given the response characteristics of the climate system, can therefore be considered as an assessment of their quality.

1. Introduction

External forcings (Fig. A) have been shown to play an important role in generating Northern Hemisphere (NH) temperature variations during the past millenium. Here it is examined how the large-scale temperature response depends on the timescale by using;

1) a **set of simulations with the ECBilt climate model**, driven by reconstructed forcings (Crowley, 2000),

and

2) **seven high-resolution temperature reconstructions** that go back to 1000 AD at least (J098- Jones et al., 1998; Ma99- Mann et al., 1999; Cr00- Crowley and Lowery; 2000; Ma03- Mann and Jones, 2003; Br00- Briffa, 2000; Es02- Esper et al., 2002; Mo05- Moberg et al., 2005).

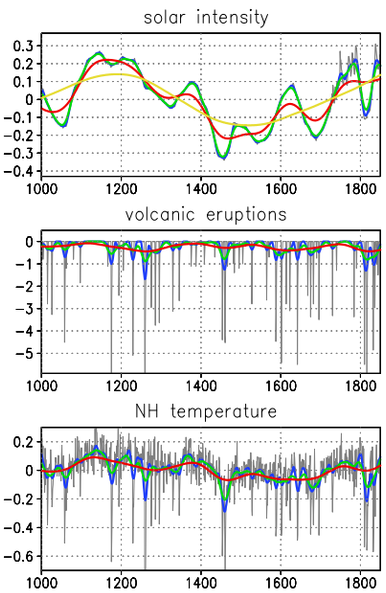

Figure A. *The radiative forcing (in W/m²) and the simulated anomalies in NH temperature (in °C) from one of the volcanic-solar forced ECBilt runs for the pre-anthropogenic period (time in years AD). The low-pass filter periods are chosen such that filtering of the records results in visually different signals, reflecting annual, decadal (20 yrs; blue), interdecadal (40 yrs; green), centennial (150 yrs; red) and longer timescales (400 yrs; yellow).*

2. Temperature response for different timescales

The simulated and reconstructed NH temperature response is analysed as a function of timescale by computing the regression and correlation with the forcing for a range of low-pass filter periods (Figs. B and C).

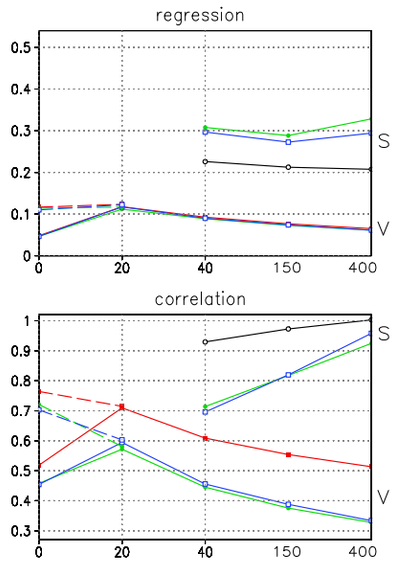

Figure B. *The regression (in °C per W/m²) for different low-pass filter periods (in yr) of the NH temperatures on the volcanic and solar forcing, indicated by V and S, in the ECBilt experiments driven by solar-volcanic forcing (blue and green lines), solar forcing alone (black line) and volcanic forcing alone (red line), and same for the correlation. Data are smoothed with a 10-yr low-pass filter (solid lines) and unsmoothed (dotted lines).*

The regression on the volcanic forcing is very consistent among the model runs and reconstructed data, taking into account that the reconstructions do not capture the pronounced response to volcanic eruptions at annual timescales. The regression on the solar forcing is largely consistent in the interdecadal-centennial timescale range (*R* constant). However, five reconstructions show anomalously high regression at the longest temporal scales (overestimating climatic variability at these timescales?). Two of the records exhibit no correlation at all with the solar forcing at multi-centennial timescales.

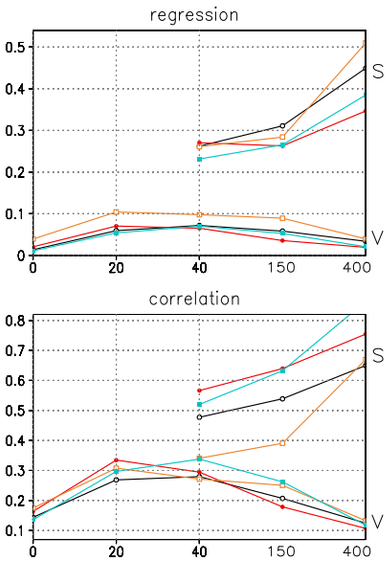

Figure C. *Same as Fig. B, but now for four of the reconstructed temperature records (J098 yellow; Ma99 red; Ma03 greenblue and Cr00 black line).*

3. Conclusion

The response to solar forcing equilibrates at interdecadal timescales, reaching equilibrium values of R_{sol}=0.2-0.3 °C per W/m^2. On the other hand, the response to volcanic forcing never equilibrates (R_{volc} <0.1 °C per W/m^2 for all timescales) as the time interval between volcanic eruptions is typically too long. The downward trend (over the pre-anthropogenic period) in all reconstructions can not be explained from the combined effect of solar and volcanic forcing, but orbital forcing may play a role.

References

Weber, S.L., 2005. A timescale analysis of the NH temperature response to volcanic and solar forcing in the past millenium. Submitted to Past Climates.

Weber, S.L., T.J. Crowley and G. van der Schrier, 2004. Solar irradiance forcing of centennial climate variability during the Holocene. Climate Dyn., *22, 539-553.*

Reconstructions are available at the World Data Center for Paleoclimatology (http://www.ngdc.noaa.gov/paleo).

The MITRIE project *aims firstly, to aid public understanding by providing a web site with information, data and software; secondly, to contribute to the scientific debate by reviewing recent work on large-scale temperature reconstructions. (http://home.badc.rl.ac.uk/mjuckes/mitrie/).*

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