Reconstruction of Large-Scale Atmospheric Circulation and Data Assimilation in Paleoclimatology

M. Widmann, J.M. Jones and H. von Storch

GKSS Research Centre, Geesthacht, Germany; widmann@gkss.de

Quantitative estimates of natural climate variability are essential for assessing human influence on climate. On long timescales they are derived from paleoclimatic proxy data, such as tree rings and varved sediments (e.g. DEKLIM-PROSIMUL), corals (e.g. DEKLIM-Corclim) and ice cores (e.g. DEKLIM-RESPIC). Past climates can also be simulated using numerical climate models (e.g. DEKLIM-GHOST, CLIMCYC, and the newly funded MIDHOL). Consistency tests between empirical and simulated climate estimates (e.g. Jones et al. 1998, Zorita et al. 2004) can reduce uncertainties, and contribute to the validation and improvement of climate models. In the DATUN (Data Assimilation Through Upscaling and Nudging) project, a new approach has been developed in which data and models are not compared but used jointly to provide estimates for past climate (von Storch et al. 2000, Jones and Widmann 2004). DATUN is a data assimilation technique that is tailored towards applications in paleoclimatology. It consists of an upscaling step, in which large-scale circulation is derived statistically from empirical data, followed by an assimilation step in which the atmospheric states in a climate model are forced to be consistent with the empirical estimates. Here we present an example for upscaling and test experiments with the assimilation method.

DATUN will be tested on instrumental data, before being applied to proxy data. We will force the ECHAM4 General Circulation Model (GCM) for the 20th century towards monthly or longer means of the amplitudes of the dominant circulation modes in the Northern and Southern Hemispheres, the Arctic and Antarctic Oscillations (AO, AAO), and then compare actual and simulated climate. Unlike in the Northern Hemisphere, gridded datasets for the Southern Hemisphere only extend back to the middle of the 20th century. We have thus reconstructed the strength of the AAO, the Antarctic Oscillation Index (AAOI), from long pressure measurements using a principal component regression method. Similar upscaling methods have been used to reconstruct numerous climate features from proxy data, including global- to regional-scale temperatures and the strength of atmospheric circulation modes (for an overview see Jones and Mann 2004). Our work builds on the station-based reconstruction of the Austral Summer (November-January) AAOI of Jones and Widmann (2003), who also produced a longer reconstruction using tree-ring width chronologies. The station-based reconstructions have now been extended to cover the four standard seasons. An example for Austral Autumn (March-May) is shown in Fig. 1a/b.

Assimilation simulations complement equilibrium runs and experiments with temporally varying.
Solar Variability and Holocene Climate: Evidence from Radiocarbon, Tree-Ring Proxies and Climate System Modeling

B. KROMER1, M. CLAUSSEN2, N. LATUSEK1, M. LÜKEN3, S. REMMELZ4,5 and G. SCHLESER3

1Heidelberger Akademie der Wissenschaften, Institut für Umweltphysik, INF 229, 69120 Heidelberg; bernd.kromer@iup.uni-heidelberg.de
2Potsdam Institut für Klimaforschung, Telegrafenberg A31, 14473 Potsdam
3Institut für Chemie und Dynamik der Geosphäre, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany
4Institut für Botanik-210, Universität Hohenheim, 70595 Stuttgart, Germany
5Heidelberger Akademie der Wissenschaften, Institut für Umweltphysik, INF 229, 69120 Heidelberg, Germany

Solar forcing of climate is a long-standing unresolved issue. Eddy (1976) was among the first to postulate a link between a widespread cooling event and a low level of solar activity, suggested by the absence of sunspots in the 17th century (Maunder minimum). Prior to visual observations of solar activity, only cosogenic isotopes, such as 14C, 10Be and 36Cl, preserved in well-dated archives, provide proxy information for solar heliomagnetic activity. Their production rate depends on the shielding of the Earth by the magnetic field around the Earth, i.e. the superposition of the Earth’s dipole moment and the solar wind (Masarik and Beer 1999).

In our project within DEKLIM, we focus on the reconstruction of solar activity using the decadal to century-scale fluctuations in atmospheric 14C levels of the past 12,000 years, and investigate climate proxies in tree-rings during intervals of quiet and active sun. The 14C level in the past is obtained from high-precision 14C analyses of decadal tree-ring sections, and 14C production is then calculated using a coupled atmosphere-ocean GCM and historic values of large-scale anomalies in preparation.

REFERENCES


For full references please consult: www.pages-igbp.org/products/newsletters/ref2004_2.html