Geophysical Research Abstracts
Vol. 18, EGU2016-14050, 2016
EGU General Assembly 2016

Matlab based automatization of an inverse surface temperature modelling procedure for Greenland ice cores using an existing firn densification and heat diffusion model

Michael Döring (1,2), Takuro Kobashi (1,2), Philippe Kindler (1a,2a), Myriam Guillevic (3), Markus Leuenberger (1,2)

(1) Climate and Environmental Physics, University of Bern, Switzerland, (2) Oeschger Centre for Climate Change Research (OCCR), Bern, Switzerland, (3) Federal Institute of Metrology (METAS), Bern, Switzerland, (1a) former, Climate and Environmental Physics, University of Bern, Switzerland, (2a) former, Oeschger Centre for Climate Change Research (OCCR), Bern, Switzerland

In order to study Northern Hemisphere (NH) climate interactions and variability, getting access to high resolution surface temperature records of the Greenland ice sheet is an integral condition. For example, understanding the causes for changes in the strength of the Atlantic meridional overturning circulation (AMOC) and related effects for the NH [Broecker et al. (1985); Rahmstorf (2002)] or the origin and processes leading the so called Dansgaard-Oeschger events in glacial conditions [Johnsen et al. (1992); Dansgaard et al., 1982] demand accurate and reproducible temperature data. To reveal the surface temperature history, it is suitable to use the isotopic composition of nitrogen (δ15N) from ancient air extracted from ice cores drilled at the Greenland ice sheet. The measured δ15N record of an ice core can be used as a paleothermometer due to the nearly constant isotopic composition of nitrogen in the atmosphere at orbital timescales changes only through firn processes [Severinghaus et. al. (1998); Mariotti (1983)].
To reconstruct the surface temperature for a special drilling site the use of firn models describing gas and temperature diffusion throughout the ice sheet is necessary. For this an existing firn densification and heat diffusion model [Schwander et. al. (1997)] is used. Thereby, a theoretical δ15N record is generated for different temperature and accumulation rate scenarios and compared with measurement data in terms of mean square error (MSE), which leads finally to an optimization problem, namely the finding of a minimal MSE.
The goal of the presented study is a Matlab based automatization of this inverse modelling procedure. The crucial point hereby is to find the temperature and accumulation rate input time series which minimizes the MSE. For that, we follow two approaches. The first one is a Monte Carlo type input generator which varies each point in the input time series and calculates the MSE. Then the solutions that fulfil a given limit or the best solutions for a given number of iterations are saved and used as a new input for the next model run. This procedure is repeated until the MSE undercuts a given threshold (e.g. the analytical error of the measurement data).
For the second approach, different Matlab based derivative free optimization algorithms (DFOAs) (i.a. the Nelder-Mead Simplex Method, [Lagarias et al. (1998)]) are studied with an adaptation of the manual method of Kindler et al. (2013). For that the DFOAs are used to find those values for the temperature sensitivity and offset for calculating the surface temperature from the oxygen isotope records of the ice core water samples minimizing the MSE.
Finally, a comparison to surface temperature records gained with different other methods for Glacial as well as Holocene data is planned.

References:

Broecker, W. S., Peteet, D., and Rind, D. (1985). Does the ocean-atmosphere system have more than one stable mode of operation? Nature, 315(6014):21-26.
Dansgaard, W., Clausen, H., Gundestrup, N., Hammer, C., Johnsen, S., Gristinsdottir, P., and Reeh, N. (1982). A new Greenland deep ice core. Science, 218(4579):1273-1277.
Johnsen, S. J., Clausen, H. B., Dansgaard, W., Fuhrer, K., Gundestrup, N., Hammer, C. U., Iversen, P., Jouzel, J., Stauffer, B., and Steffensen, J.P. (1992). Irregular glacial interstadials recorded in new Greenland ice core. Nature, 359:311- 313.
Kindler, P., Guillevic, M., Baumgartner M., Schwander J., Landais A. and Leuenberger, M. (2013). NGRIP Temperature Reconstruction from 10 to 120 kyr b2k. Clim. Past, 9:4099-4143.
Lagarias, J.C., Reeds, J. A., Wright, M. H., and Wright, P. E. (1998). Convergence Properties of the Nelder-Mead

Simplex Method in Low Dimensions. SIAM Journal of Optimization, Vol. 9 Number 1, pp. 112-147.
Mariotti, A. (1983). Atmospheric nitrogen is a reliable standard for natural 15N abundance measurements. Nature, 303:685- 687.
Rahmstorf, S. (2002). Ocean circulation and climate during the past 120,000 years. Nature,419(6903):207-214.
Severinghaus, J. P., Sowers, T., Brook, E. J., Alley, R. B., and Bender, M. L. (1998). Timing of abrupt climate change at the end of the Younger Dryas interval from thermally fractionated gases in polar ice. Nature, 391:141-146.
Schwander, J., Sowers, T., Barnola, J., Blunier, T., Fuchs, A., and Malaizé, B. (1997). Age scale of the air in the summit ice: implication for glacial-interglacial temperature change. J. Geophys. Res-Atmos., 102(D16):19483-19493.