North Atlantic Decadal Climate Variability

M. van Reenen, R. J. Haarsma, F. M. Selten, and J. D. Opsteegh

Results from a 1750-year integration with the ECBILT-MOM climate model are presented. A mode in the North Atlantic region with a preferred time scale of 11 years is described. This mode compares well with one found in observations.

1. Introduction
In this project the contribution of air-sea interaction processes in the North Atlantic ocean to decadal climate variability will be investigated. A number of experiments will be performed with the ECBILT-MOM climate model. Each experiment potentially important processes can be turned on or off, allowing us to detect positive and negative feedback mechanisms.

Our current research focuses on a decadal mode of variability found in observations (Deser and Blackmon, 1993), in which surface wind anomalies induce sea surface temperature (SST) anomalies through changes in heat flux. Results of Selten et al. (1999) will be validated and further investigated with the MOM model as improved ocean component (instead of a flat-bottom ocean model).

2. The Model
The ECBILT-MOM model is an EMIC (Earth system Model of Intermediate Complexity) and has a modular structure. The current model configuration is listed below:

- atmosphere: ECBILT2: T21, 3 layers, QG
- ocean: MOM3: 5.6°x5.6°, 15 layers, PE
- sea ice: thermodynamic model
- land: bucket model

3. The Experiment
We performed a 1750-year integration and analyzed the last 250 boreal winter half-years. The data were filtered using a three-year running mean. SST is calculated as the temperature averaged over the first 100 meters of the ocean. Only modes of variability that are relevant to this study are discussed.

3.1 Mean fields and second EOFs
The second empirical orthogonal function (EOF) of geopotential height at 800 hPa is a tripole with one cell located to the south of Iceland and two weaker cells of opposite sign to the north and south of the first (Fig. B). The two southern cells together represent the model’s North Atlantic oscillation (NAO) pattern since they modulate the strength of the model jet.

The second EOF of SST has two large cells of opposite sign in the north-eastern and south-western North Atlantic, and a smaller cell in the Norwegian Sea (Fig. C).

3.2 SVD analysis: an 11-year mode
To locate dominant patterns of covariability a singular value decomposition (SVD) analysis was performed. The patterns of the second SVD mode (Fig. D) are very similar to the corresponding second EOFs.

The patterns of the second SVD mode can be explained in terms of an anomalous atmospheric forcing of SST. When the northern cell of the geopotential height pattern is in a positive (negative) phase, there is a positive (negative) anomaly in SST directly to the south of that cell. This is due to a decrease (increase) in latent and sensible heat fluxes owing to a negative (positive) anomaly in cold, westerly winds from the North American continent. Similar reasoning can be applied to the southern cell of the geopotential height pattern.

The covariance spectrum of this SVD mode indicates a preferred time scale for the SST of 11 years (Fig. E). This peak is significant at the 95% a priori confidence level.

3.3 Comparison with observations
The patterns found in the SVD analysis are similar to anomaly patterns found in observations by Deser and Blackmon (1993). They, too, find covarying dipole patterns of geopotential height and SST (their Fig. 4). The modeled time scale of 11 years is comparable to the observed (their Fig. 3b).

4. Conclusion
A dipole pattern of geopotential height covaries with a dipole pattern of SST at a preferred time scale of 11 years. The mechanism causing the covariability is an anomalous atmospheric forcing of SST owing to anomalous heat fluxes caused by anomalous winds. The results compare well with those of an analysis of observations by Deser and Blackmon (1993).

References