Eigenmodes in an Ocean - General - Circulation - Model in the Northern North Atlantic

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To examine if climatic fluctuations on time-scales between 10 and 1000 years can be understood as eigenmodes of the oceanic circulation a 3800 year integration of the Hamburg Large Scale Geostrophic OGCM[1] was done[2]. The model was forced with fresh water fluxes that were white in time and had a spatial correlation comparable to atmospheric synoptic systems.

We made a POP analysis[3] of the vector time series of several variables in the Northern North Atlantic (30°to 90°N and 95°W to 25°E). The result of a POP analysis are pairs of patterns (P_1,P_2), oscillation periods and decay times. For each time t each of the two pattern P_1 and P_2 have a uniquely determined time coefficient, $z_1(t)$ and $z_2(t)$. These time coefficients vary coherently and out-of-phase so that the system generates stochastic sequences $\cdots \rightarrow P_2 \rightarrow P_1 \rightarrow -P_2 \rightarrow -P_1 \rightarrow P_2 \rightarrow \cdots$. One cycle is completed in one oscillation period, on an average.

The most energetic mode is acting on a century time scale (330 years period; Fig.1) and was already identified by Mikolajewicz and Maier-Reimer[2] in an analysis of the global salinity fields. In the Labrador Sea this century time scale mode is explaining only little variance of the upper level salinity field. In this area another POP is dominant. It has a decay time of 14 years and an oscillation period of 30 years. The two patterns (Fig. 2) describe the appearance of salinity anomalies in the Labrador Sea followed by northwestward advection as well as southeastward advection into the Northern North Atlantic, where they are damped out. The salinity anomalies are accompanied by temperature-, heat flux- and ice thickness anomalies (not shown).

References:

[1]Maier-Reimer, E. et al., 1991, Max-Planck-Institut für Meteorologie Report 68
[2]Mikolajewicz, U. and E. Maier-Reimer, 1990, Nature 345, 589-593
[3]Storch et al. 1988, J. Geophys. Res. 93, D9, 11022-11036.

Figure 1.

The century time scale Principal Oscillation Pattern of upper level salinity in the OGCM experiment. This POP has an oscillation period of 330 years. The upper panel shows the P_1-pattern and the middle panel the P_2-pattern. In the lower panel the time coefficients $z_1(t)$ and $z_2(t)$ during the first 1500 years of the experiment are shown. The time coefficients vary such that the system performs the stochastic sequences $\cdots \rightarrow P_2 \rightarrow P_1 \rightarrow -P_2 \rightarrow -P_1 \rightarrow P_2 \rightarrow \cdots$

The area shown is the Northern North Atlantic (30°to 90°N and 95°W to 25°E).

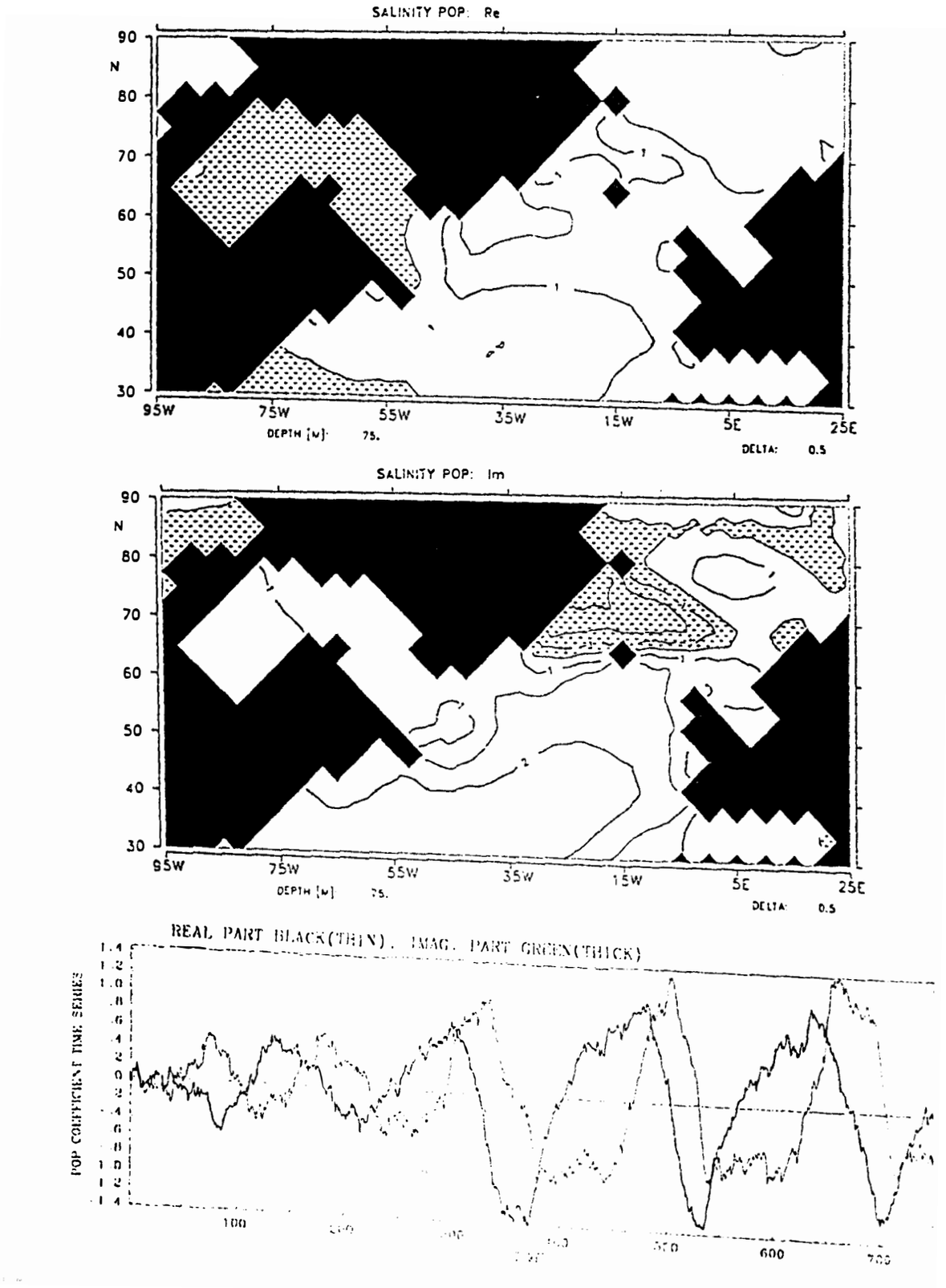

Figure 2.

The decadal time scale Principal Oscillation Pattern of upper level salinity in the OGCM experiment. This POP has an oscillation period of 30 years. The upper panel shows the P_1-pattern and the middle panel the P_2-pattern. In the lower panel the coherence squared spectrum of the time coefficients $z_1(t)$ and $z_2(t)$ are shown. The time coefficients vary such that the system performs the stochastic sequences $\cdots \rightarrow P_2 \rightarrow P_1 \rightarrow -P_2 \rightarrow -P_1 \rightarrow P_2 \rightarrow \cdots$

The area shown is the Northern North Atlantic (30°to 90°N and 95°W to 25°E).