WORKSHOP ON
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Front Cover: Annual mean surface currents (0-45 m) from a high resolution (18 km, 30 level) model of the Arctic Ocean driven by 1992 ECMWF 3-day averaged winds for 7 years. A unit vector represents a flow of 20 cm/s. A vector at each grid point is used to show narrow currents in the complicated geometry. Boundary currents narrower than 100 km are seen to be the primary means for distributing properties throughout the Arctic Ocean and between the Arctic and the North Atlantic. The map has been chosen to show maximal information on a single page. More quantitative information can be obtained from larger velocity maps which are available on request.

The coupled Arctic Ocean/Sea Ice model has been developed with DOE and NSF support and is being run by Wieslaw Maslowski, Yuxia Zhang, and Albert Semtner at the Naval Postgraduate School. Detailed information including two manuscripts (in PDF format) submitted for publication can be found at http://vislab-www.nps.navy.mil/~braccio/maslowski/arctic.html.

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3.6 DESIGN OF A CLOSED-BOUNDARY REGIONAL MODEL OF THE ARCTIC OCEAN

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1. Introduction

The link between the Atlantic circulation and the mild climate in Northern Europe has been qualitatively described already by Humboldt(1854). He did not mention explicitly the consequence from the observation that the surface flow of the Atlantic is predominantly northwards which must be compensated by a deep return flow. Else we should celebrate him as the inventor of the "conveyor belt" circulation which is now attributed to Broecker (1987). Despite (or rather because of) its simplistic structure with its deliberate shortcomings, it has been widely (but not commonly) accepted as a structural sketch of the large scale oceanic circulation. Its form has been derived from the distribution of geochemical tracers like oxygen and phosphate. The distribution of CFC's and $\Delta^{14}C$ provide information about the speed. The driving force, however, is not so obvious. Cold and dense water is formed at the southern and at the northern boundary of the Atlantic Ocean. Due to the different thermohaline conditions at both ends, there is a delicate balance between the various effects that determine the density. Maier-Reimer et al. (1993) have shown that even mild shifts in the formulation of present days thermohaline boundary conditions may yield substantial variations in the overturning circulation of their Ocean general circulation model (the formulations differ primarily in high latitudes). In contrast, Toggweiler and Samuels (1993) showed with their model that variations in the assumed southern hemisphere windstress field may yield modifications of the overturning circulation by a similar amount: The water that is additionally pushed from the Austral Ocean with moderate density into the Southern Atlantic has to move far northwards for joining after cooling the deep circulation.

Applying circulation models for studies of the effects of deep water formation in detail, we need rather high resolution in the critical regions. Global high resolution models are restricted by the tremendous computer resources that are needed. Regional models, in contrary, are hampered by the need for artificial boundary conditions which, at best, reflect some prescribed state of climate. In this note, I give a short ouline of a potential escape from the dilemma.

2. The model

Formulation of a circulation model code on a distorted grid is greatly facilitated if the grid originates from a regular grid via some kind of conformal mapping. An easy way to construct a family of conformal maps of geographical coordinates is derived from the identity of the Riemann sphere and the complex plain which is interpreted geometrically as the stereographic projection. In the standard projection the poles are mapped onto the complex numbers 0 and ∞. Complex analysis guarantees that any differentiable function can be interpreted as a conformal mapping within the two-dimensional plain. A rational function, for instance,

$$z^* = \frac{az+b}{z+c} \qquad (1)$$

allows to locate the poles arbitrarily to any points. The identification with geographical coordinates is achieved by a reverse stereographic projection. For the present application, I choose the transformation $(0,\infty)$ to (60N50E, 55N110W). Fig.1 shows the resulting coordinate lines with 10^o increment. Due to the asymmetry of eq.(1) with respect to the poles and the asymmetric position on the real globe, the focus of resolution is in the European part of the Arctic Ocean. The model is a modified form of the HOPE model as described by Drifhout et al. (1996), reduced to a C-grid version witha resolution of 2^o. Hydrostatic and Boussinesq approximations are used, sealevel variations follow from the equation of continuity for the barotropic motion. The model is, up to now, driven with climatological standard forcing forcing fields. Fig. 2 displays the sealevel after appr. 400 years of integration in an equidistance gridpoint

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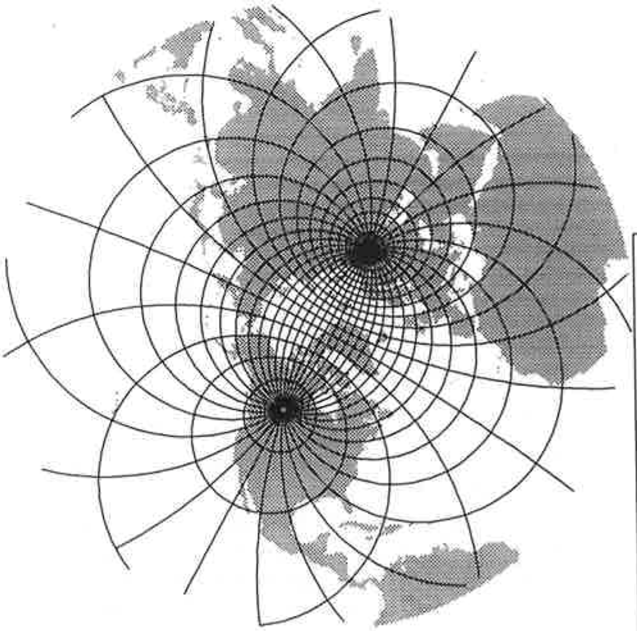

Figure 1:

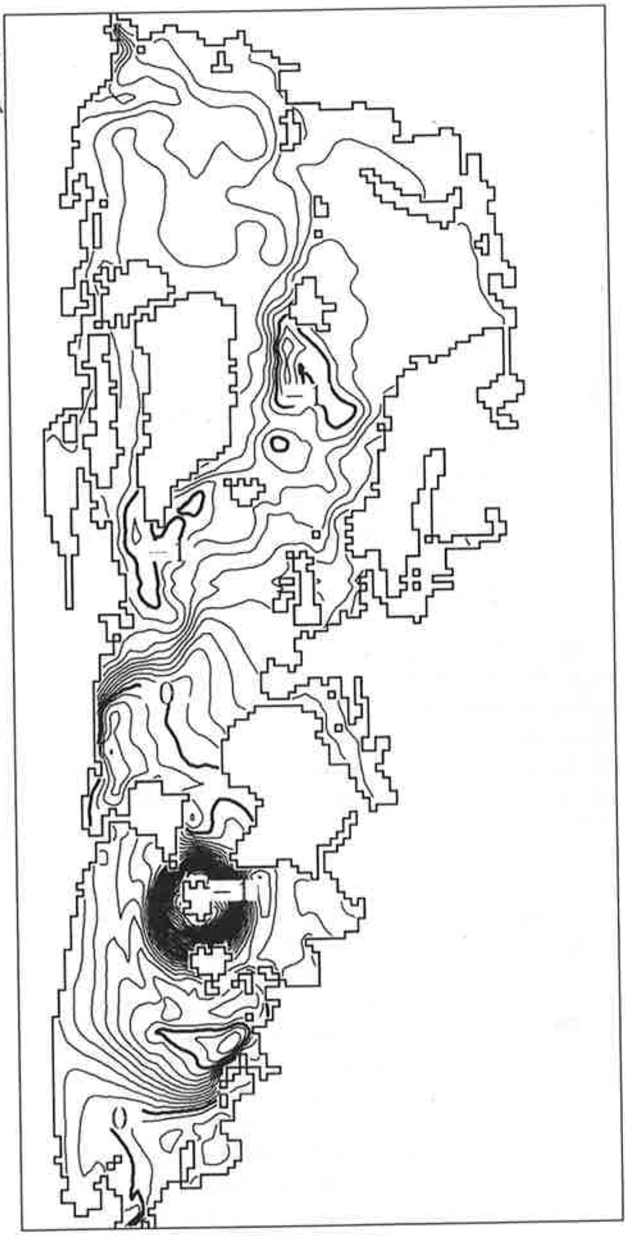

Figure 2:

representation. The model is global, but the Arctic Ocean contains more than half of gridpoints. Contour interval is 0.1 m, bold lines are for integer values of m.

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