Atlantic Water movement in the Arctic - the state of the AOMIP analysis and an update on AOMIP relevant results with NAOSIM

M. Karcher\textsuperscript{1,2}, F. Kauker\textsuperscript{1,2}, R. Gerdes\textsuperscript{1}

\textsuperscript{1}Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
\textsuperscript{2}O.A.Sys. – Ocean Atmosphere Systems GbR, Hamburg, Germany
AOMIP coordinated analysis 1948 to 2002
AW circulation (depth about 300m) in

1955

LANL

Hunke

1975

UW

Zhang

AWI
Conclusions I:

It turns out that this behaviour of the AW is governed by a fragile balance between the wind driven barotropic mode (anticyclonic) and the baroclinic mode (cyclonic).

• all 3 models start anticyclonic in 1948
• LANL turns cyclonic in the 1970s: caused by a very warm and saline pulse of Atlantic Water entering through Fram Strait.
• UW circulates anticyclonic - hypothesis: open boundary conditions in the Nordic Seas and also the use of a non-monotonous advection scheme for tracers are responsible for that behaviour.
• AWI turns persistently cyclonic in the 1950s
• even a very strong BG can not suppress a fully developed AW circulation (AWI 100y Reconstruction in 1910s)
• AWI forced with OMIP-climatology shows persistent anticyclonic CB: strange Barents Sea watermasses?
AWI noFCT experiments

FCT for tracer advection is replaced by centered-differences in two experiments:

• noFCT I:
  Centered-differences from the start of the AOMIP period (1948)

• noFCT II:
  FCT replaced by centered-differences in AOMIP run in 1975
  (when cyclonic AW is fully developed in the AOMIP run)
AWI noFCT experiment I

AW circulation (300m)

1955

1965

Centered-differences from 1948 on

AW circulates anticyclonically, similar to (old) UW model.
AWI noFCT experiment II

AW circulation (300m)

Switch to centered-differences after 1975 – start from strong cyclonic AW circulation

1976

1981

Breakdown and reversal of the cyclonic AW circulation in 1981.

Unit: cm/sec
Conclusions II: noFCT experiments

- the use of a non-monotonous scheme for tracer advection leads to a loss of cyclonic AW flow: diffusion/less conservation of water mass properties, probably BG dominates
Sense of rotation depending on net lateral PV flux

Transport velocities

Standard run

PV flux out > PV flux in

Validity for 3d GCMs?

……Interpretation of AOMIP GCMs

[Yang, 2005]
AW Potential Vorticity on $\sigma = (27.7 - 28.1)$

$[10^{-2} \text{ m}^2/\text{s}^2]$  

NCEP run initial condition  
= year 50 of OMIP forcing  

Both basins rotate differently:  
EB cyclonic, CB anticyclonic  

NCEP forcing  
Year 1994  

A band of low PV is associated with the  
cyclonic boundary current
Difference in mean surface fluxes
OMIP - NCEP

Heatflux

Saltflux
High density outflow in case of OMIP forcing
New exp: cool only in Barents (start from IC or full flow)
Potential density section before St. Anna Trough

OMIP y50

NCEP 1994
Potential density section behind St. Anna Trough

OMIP y50  
NCEP 1994

High density outflow in case of OMIP forcing  
New exp: cool only in Barents (start from IC or full flow)
AOMIP 1952 (y5)  AOMIP noFCT EXP I 1952 (y5)

AOMIP noFCT EXP II (y5)
Conclusions III: PV analysis

• Counterrotating OMIP flow despite higher net PV input: no determination of flow direction by PV lateral fluxes
• Role of lower boundaries of AW!
• Role of BG likely (BG/halocline upper boundary of AW!)
• noFCT experiments show no conservation of PV (prevents lateral flux interpretation)

• NEW EXPERIMENTS:
  - Barents Sea cooling exp. based on NCEP or restored AOMIP
  - More complex PV-model exps. (multi-layer, adaptation processes) based on Yangs work
• FURTHER MODEL INTERCOMPARISON: detailed PV source/sink analysis?!
New AOMIP relevant results with NAOSIM

• A mid 1990s freshwater export event

• A recent warming of AW
NAOSIM model setup

- Atmospheric forcing: NCEP 1948-2004

NAOSIM Group:
- Fieg
- Gerdes
- Karcher
- Kauker
- Köberle
A fresh flush from the Arctic – on the sources of a large freshwater export event in the 1990s

FW-Transport through Fram and Denmark straits

EGC freshwater convergence

(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)
A fresh flush from the Arctic – on the sources of a large freshwater export event in the 1990s

Top 250m FW Content and anomalies

(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)
Simulated surface concentration of $\delta^{18}O$

1983-88

1989-94

1995-2002
Surface concentration of $\delta^{18} \text{O}$

Changes

1989-94 minus 1983-88


Freshwater retreat...

...restructuring
A fresh flush from the Arctic – on the sources of a large freshwater export event in the 1990s

(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)
Recent warm events entering the Atlantic Layer of the Arctic Ocean
Observations and model results (NAOSIM)

Polyakov et al. (submitted)
Ivanov et al. (Poster at EGU)
ASOF-N WSC 250m temperature (Beszczynska et al)

Temperature at mooring F2 at the depth ca. 250m after removing seasonal signal

NAOSIM WSC temperature 320-380 m