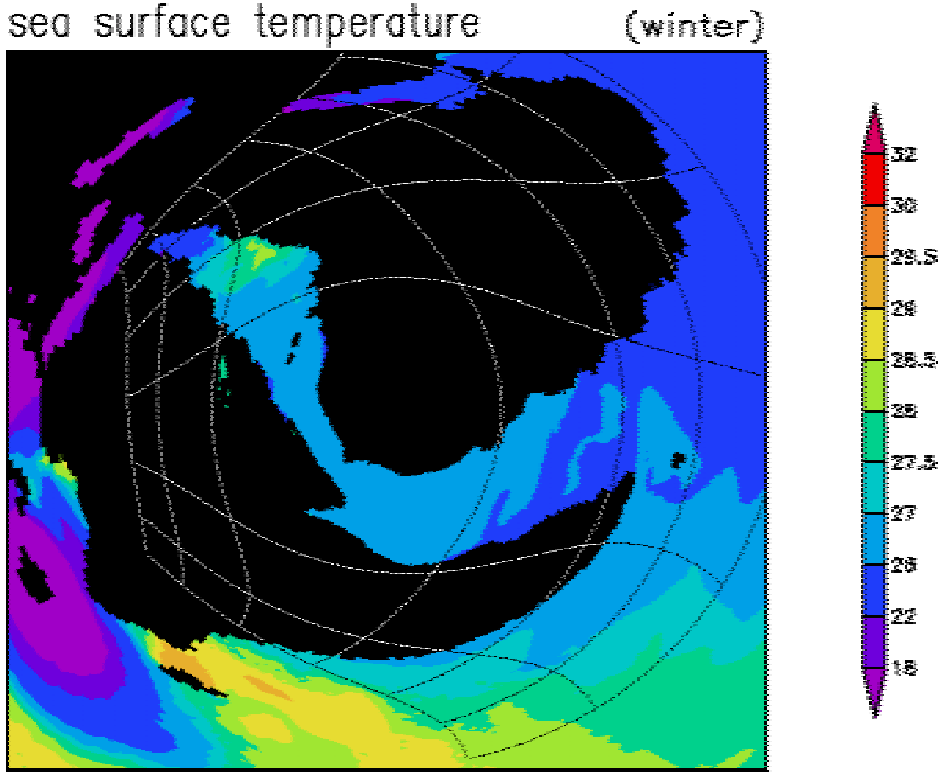
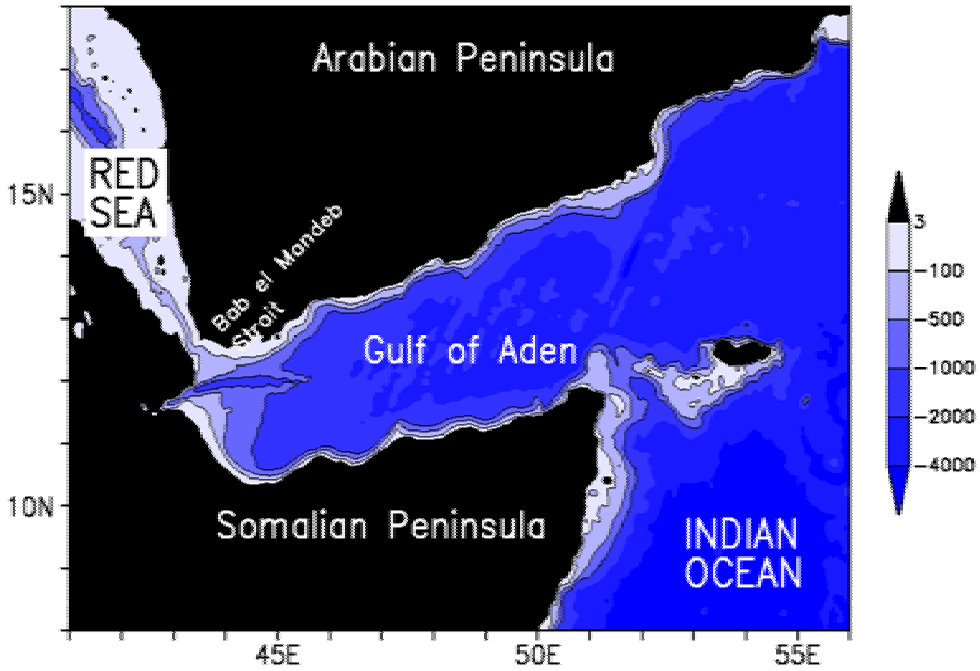
Red Sea Outflow simulated in a locally high-resolution OGCM - seasontal variation and interaction with the Somali current -

by H. Aiki, K. Takahashi, H. Sakuma and T. Yamagata (JAMSTEC/Univ.of Tokyo)

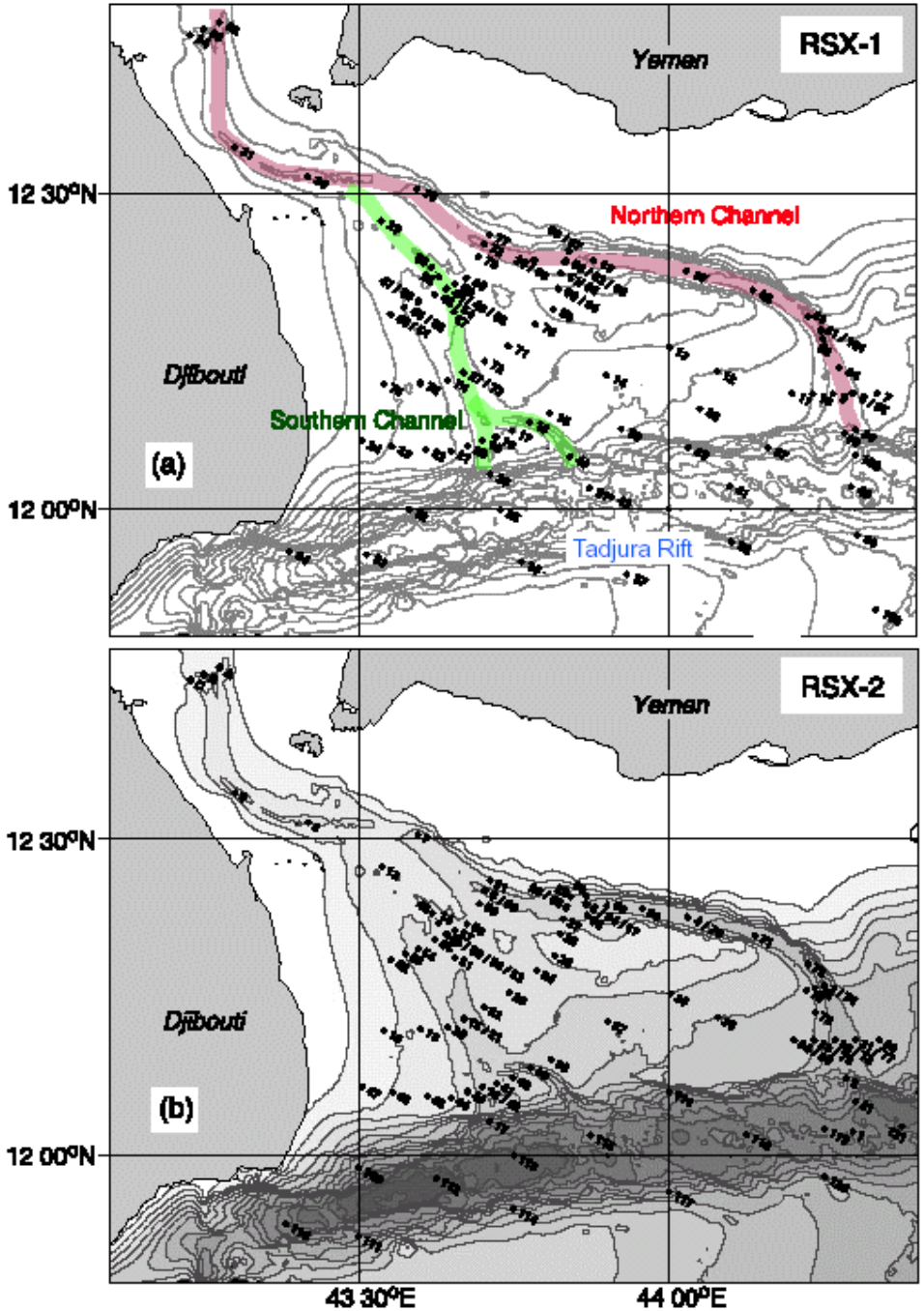
OUTLINE

1. Introduction
2. New ocean model
3. 15 years integration
4. Sensitivity experiments
5. Summary

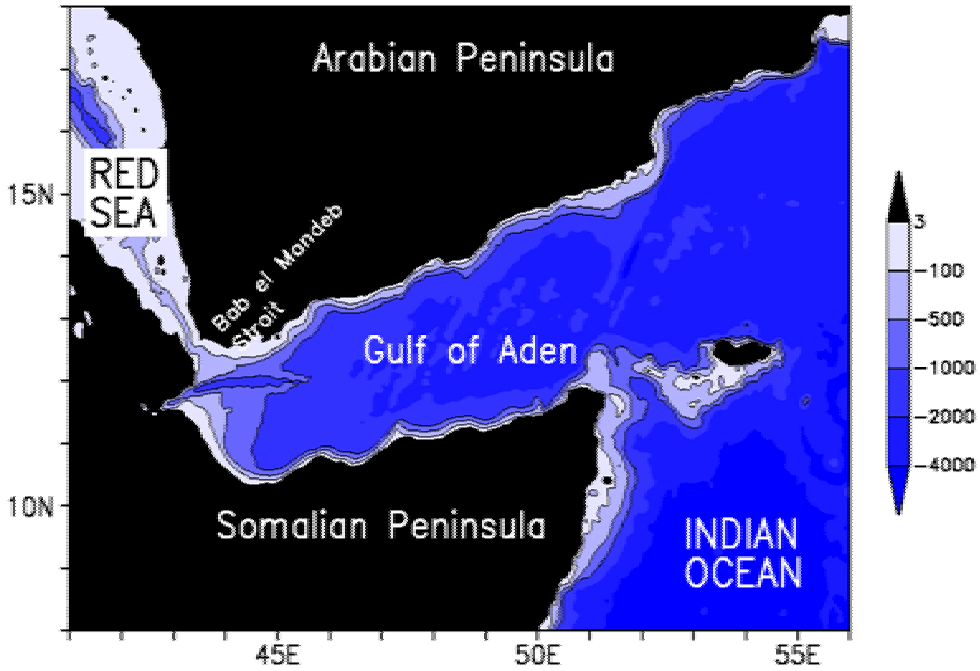




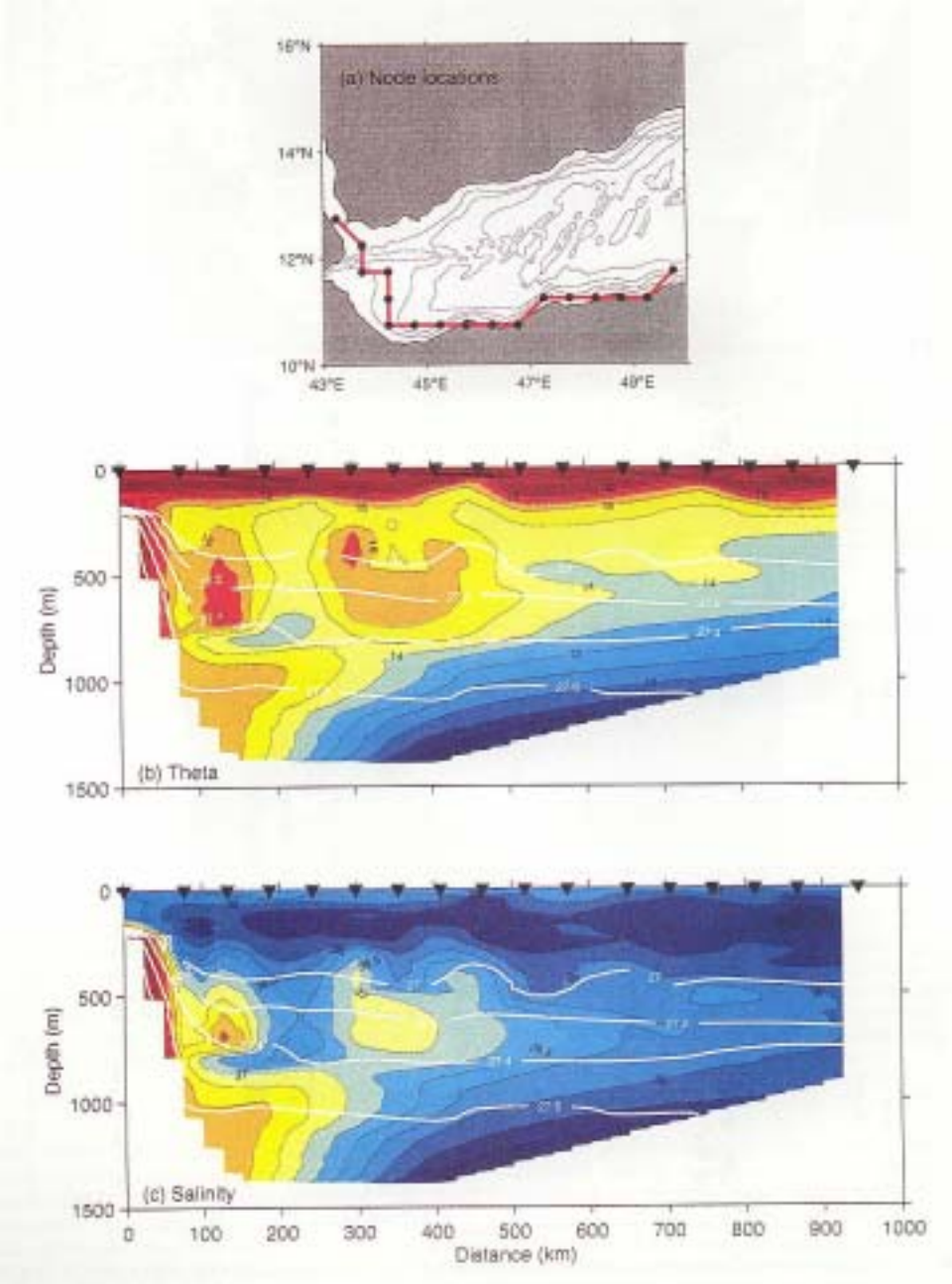
- BAM strait: 5km wide, 160m deep



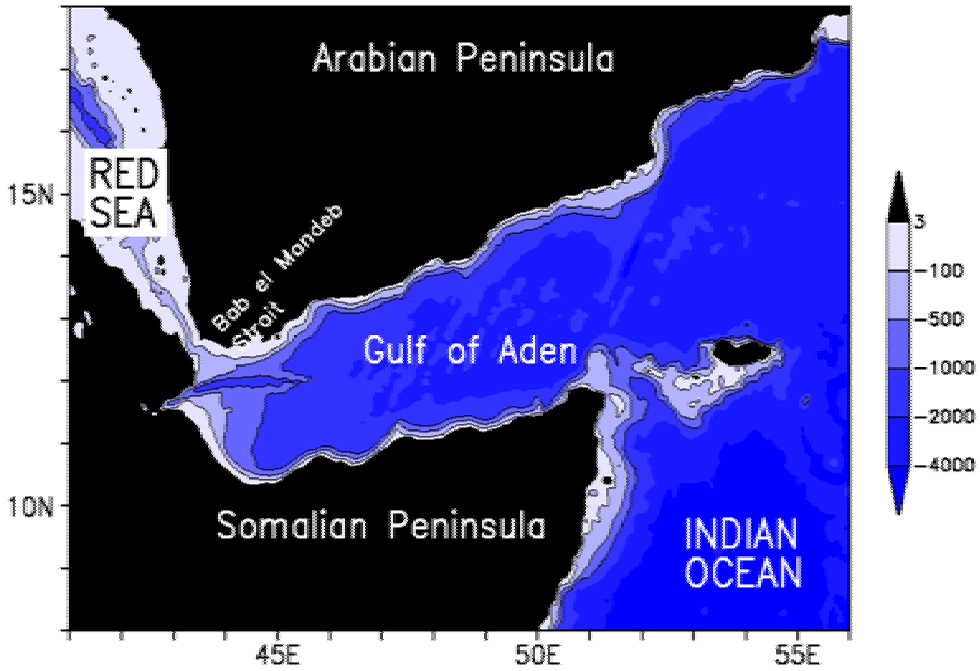
Peters et al. (2003)



- BAM strait: 5km wide, 160m deep
- salinity of Red Sea water: 41psu



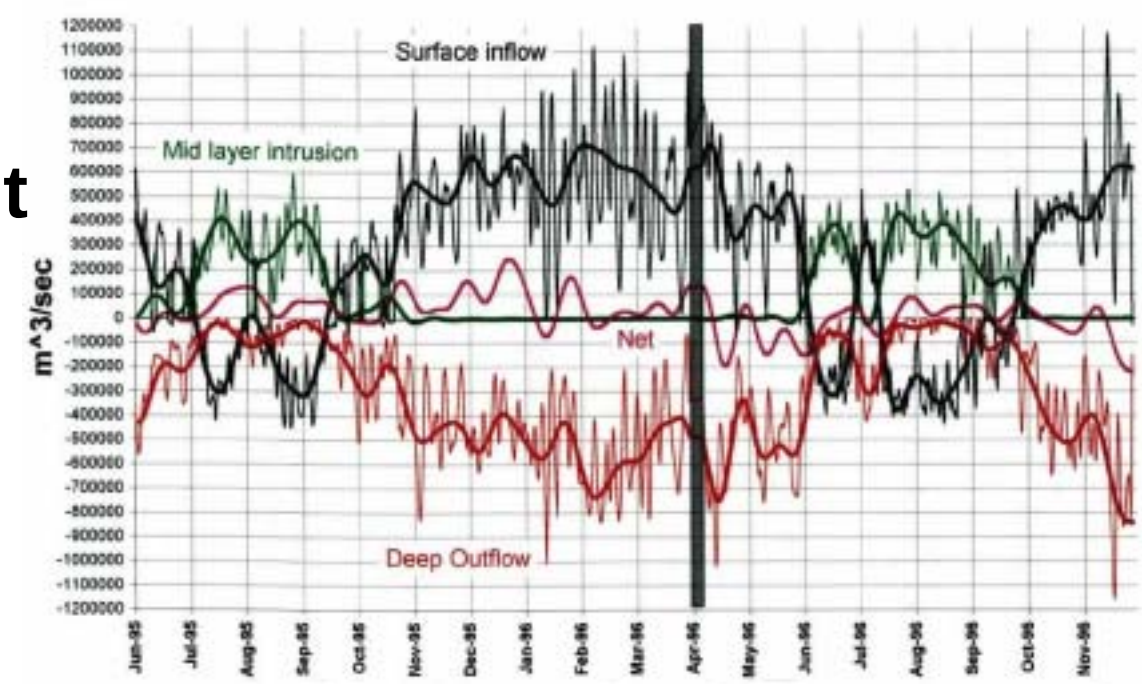
Bower et al. (2000)

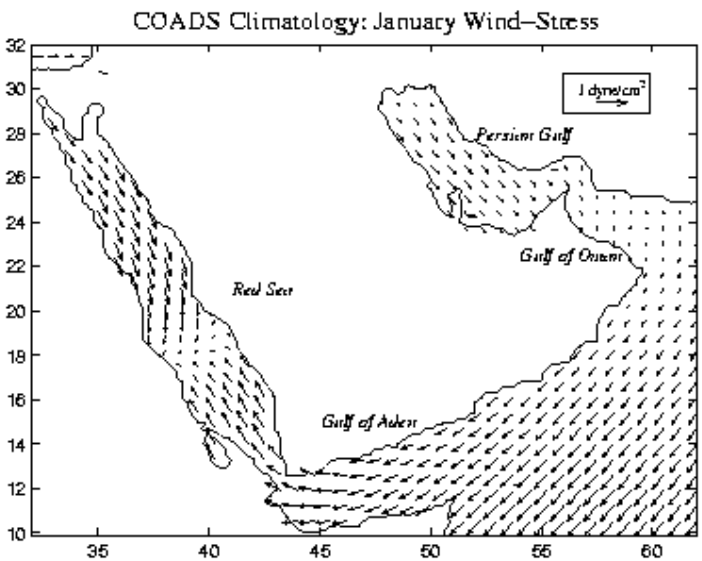


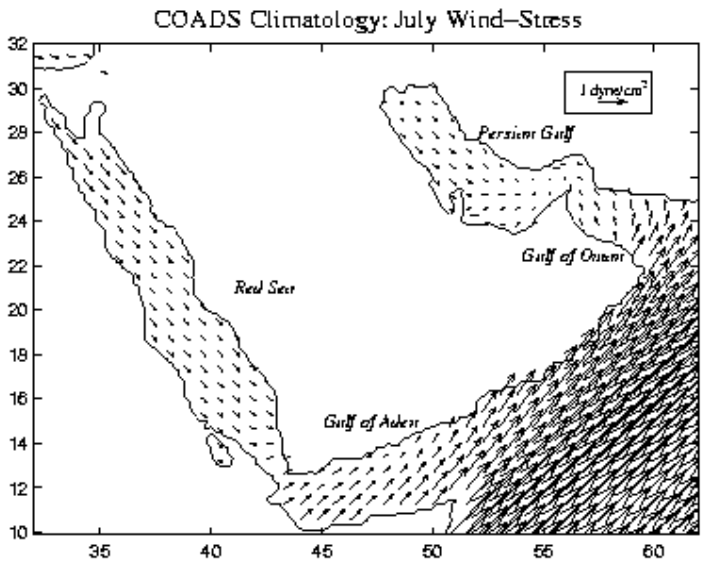
- BAM strait: 5km wide, 160m deep
- salinity of Red Sea water: 41psu
- seasonal outflow: 0.6 Sv (winter) 0.05 Sv (summer)

Murray et al. (1997)

water exchange at the BAM strait







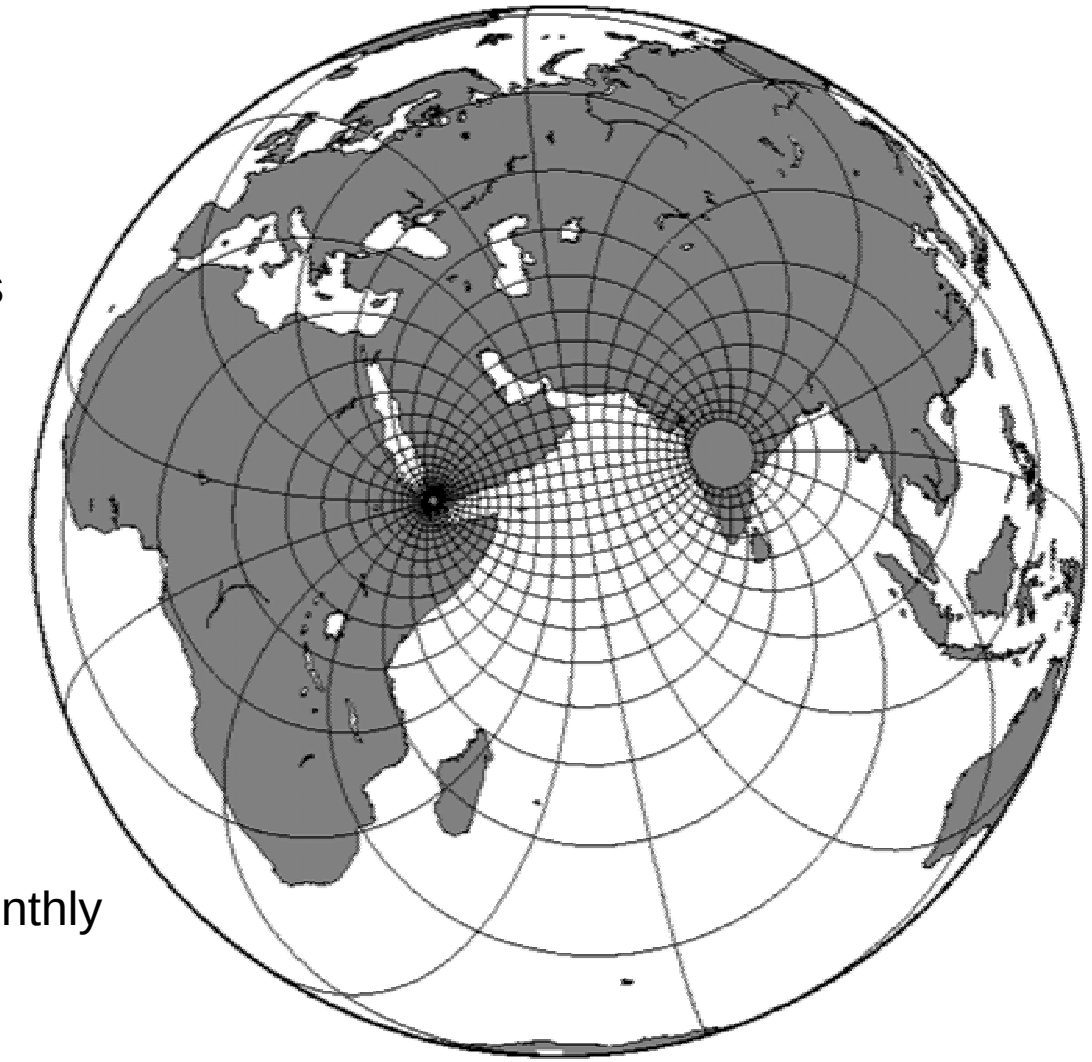
Strait-Resolving OGCM

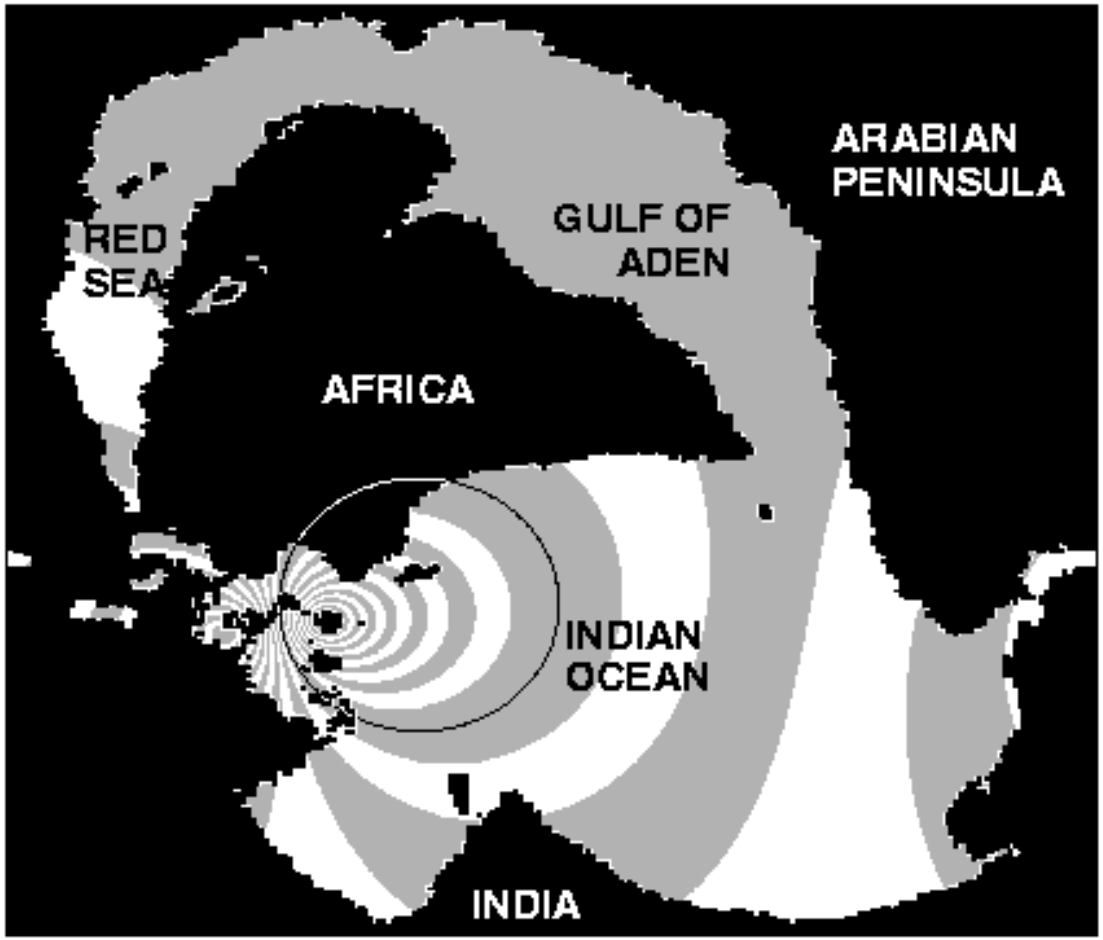
Non-hydrostatic formulation
stepped-sigma vertical coordinate

Transposed poles
curvelinear orthogonal coordinates
(Bentsen et al., 1999)

Global calculation
large scale feedback
tide potentials (M2, S2, K1, O1)

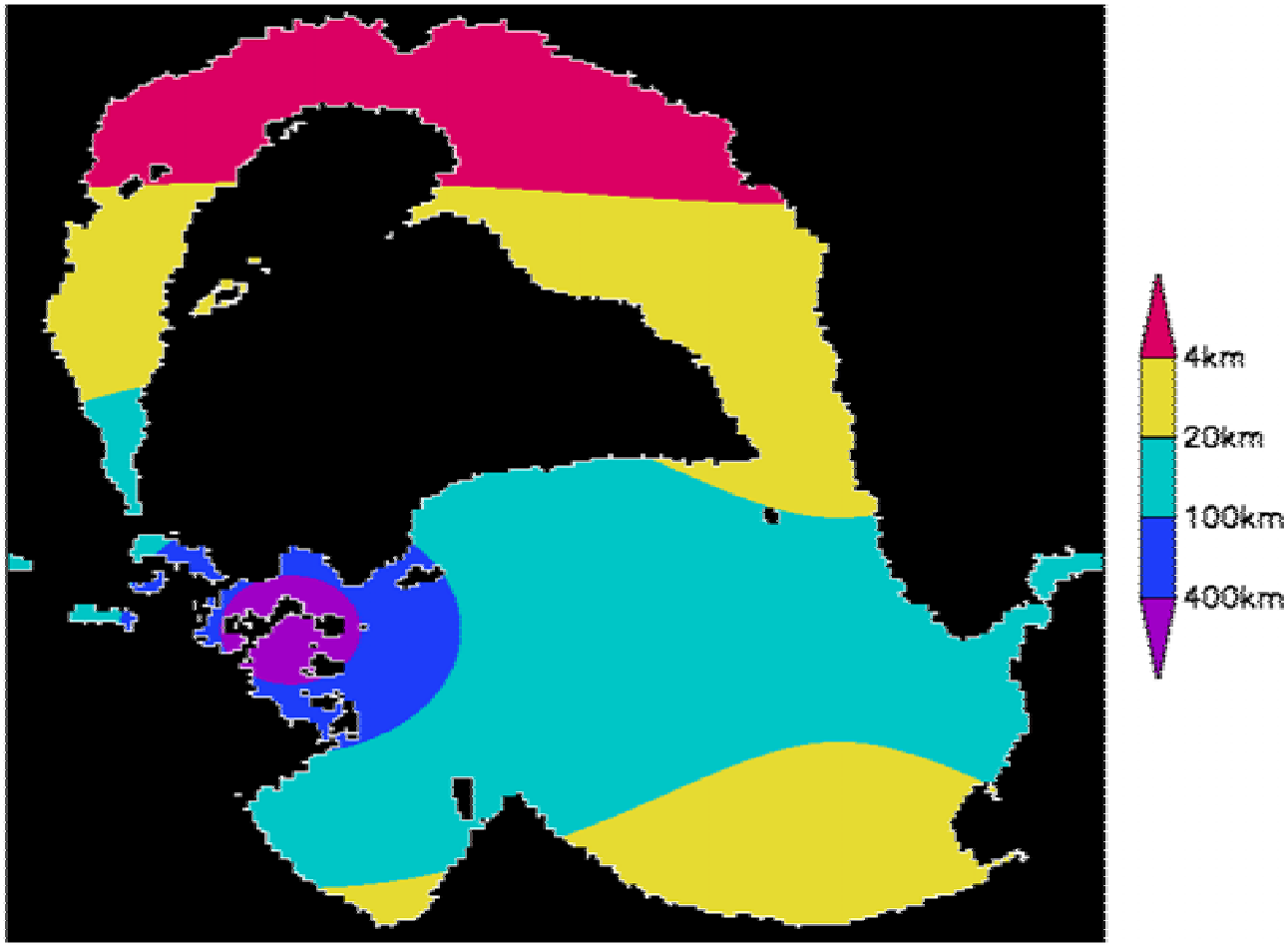
Climatology forcing
wind stress: ECMWF monthly
heat and water fluxes: COADS monthly





240 x 256 x 30 grids in the Mercator map

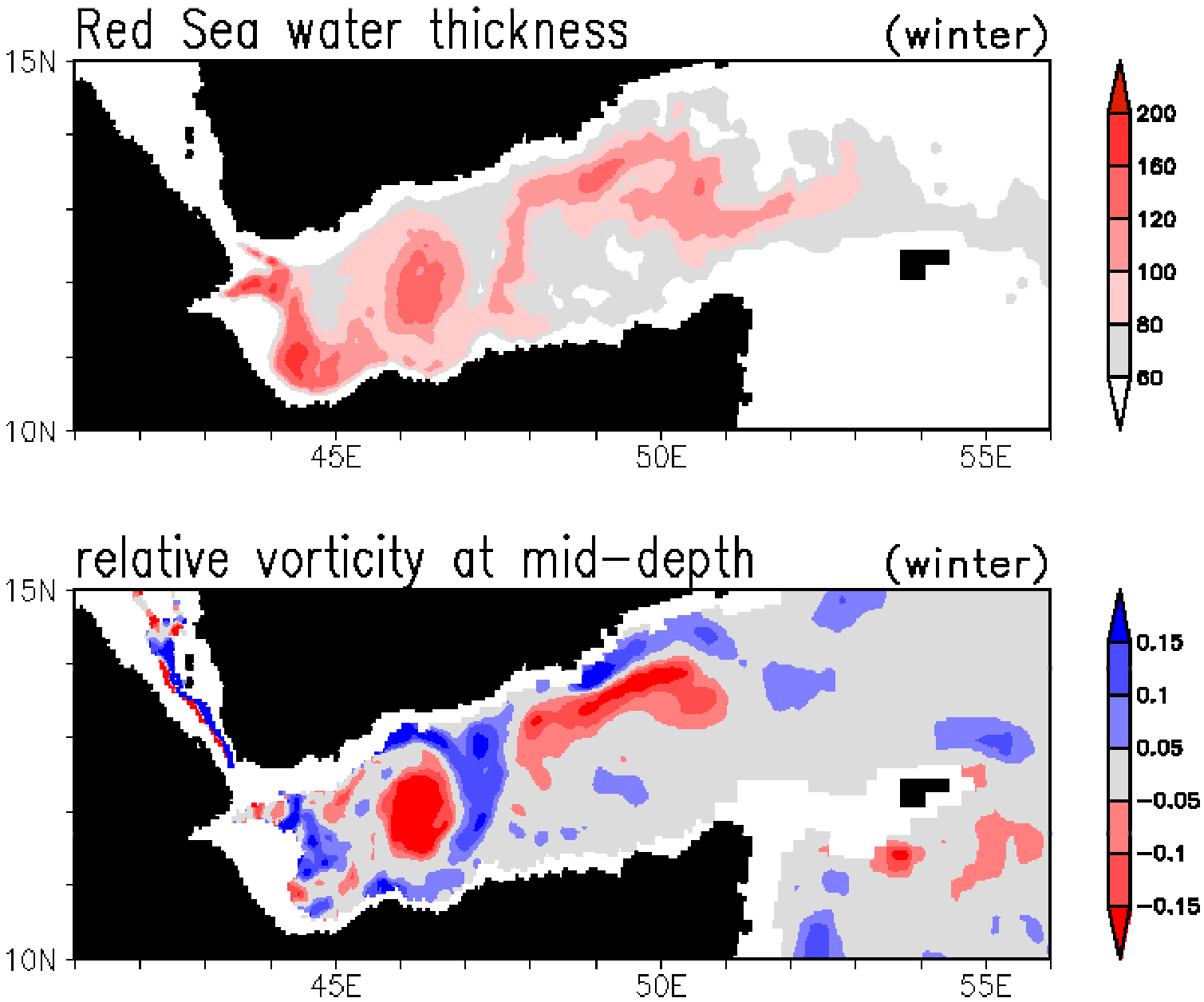
number of the horizontal points
240 x 256 = 61440
(1-deg global model: 360 x 180 = 64800)



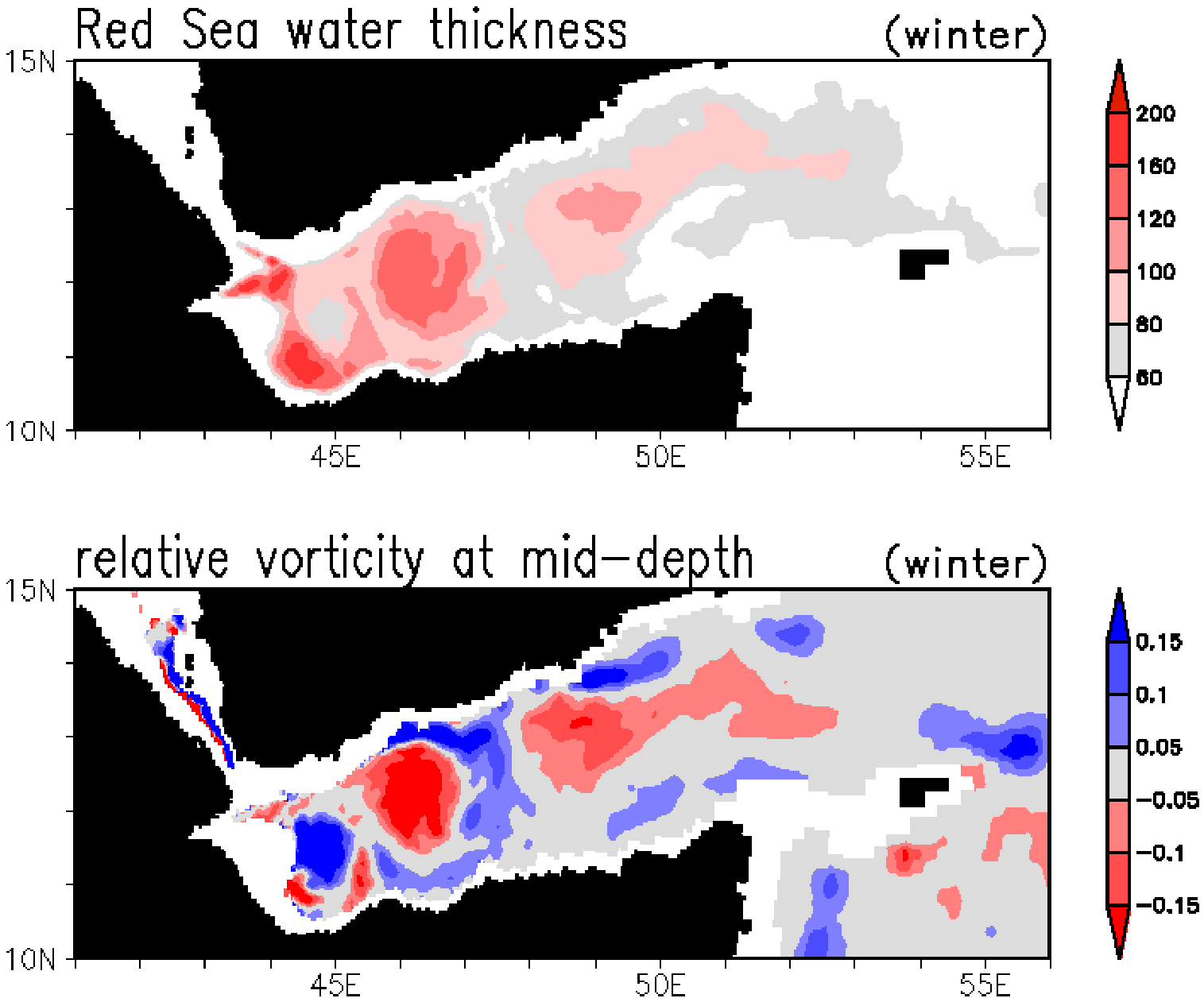
Horizontal Resolution

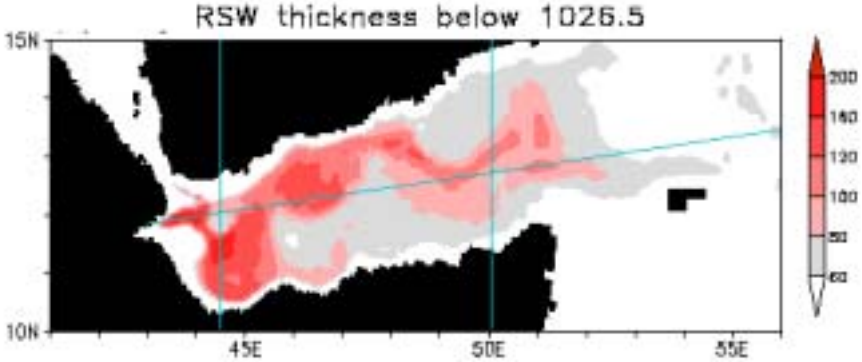
1.5km	BAM strait
20km	off the Somalian peninsula
80km	Indian Ocean
200km	Pacific/Atlantic Ocean

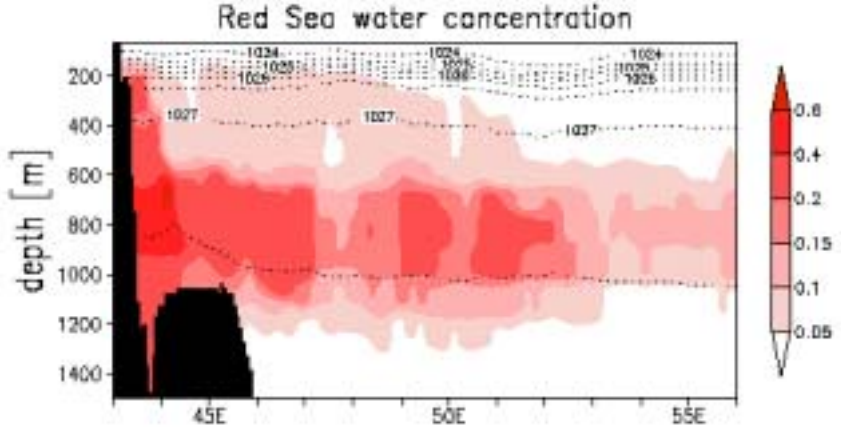
15th year results

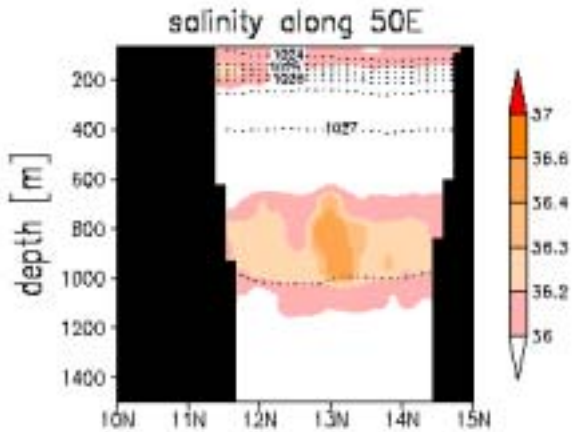


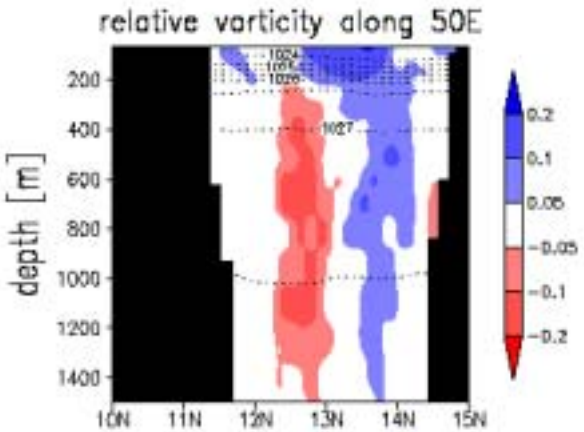
15th year results



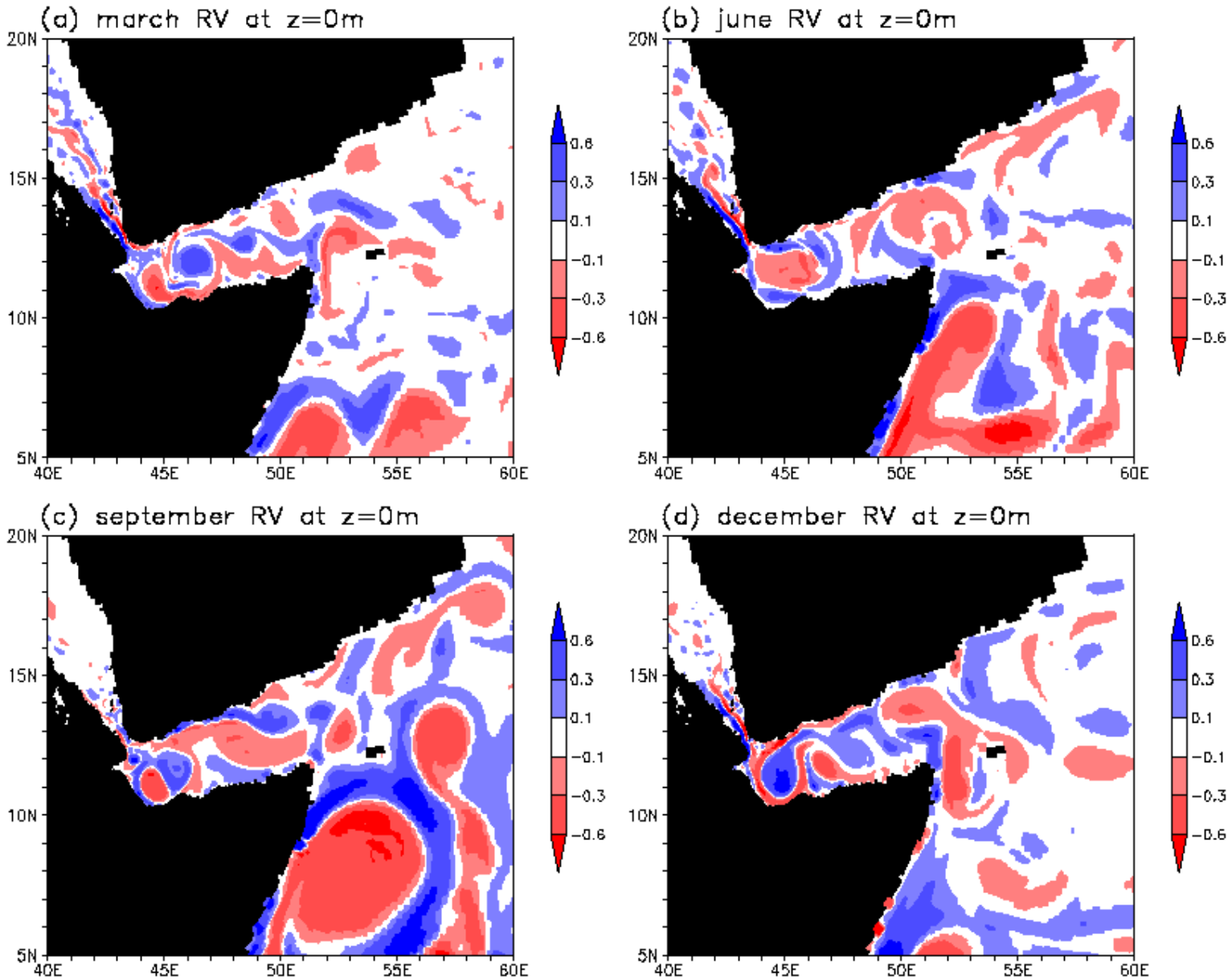

RSW thickness below 1026.5
15N
10N
45E
50E
55E
200
160
120
100
80
60


Red Sea water concentration
depth [m]
200
400
600
800
1000
1200
1400
45E
50E
55E
1027
0.6
0.4
0.2
0.15
0.1
0.05


salinity along 50E
depth [m]
200
400
600
800
1000
1200
1400
10N
11N
12N
13N
14N
15N
1027
37
36.6
36.4
36.3
36.2
36

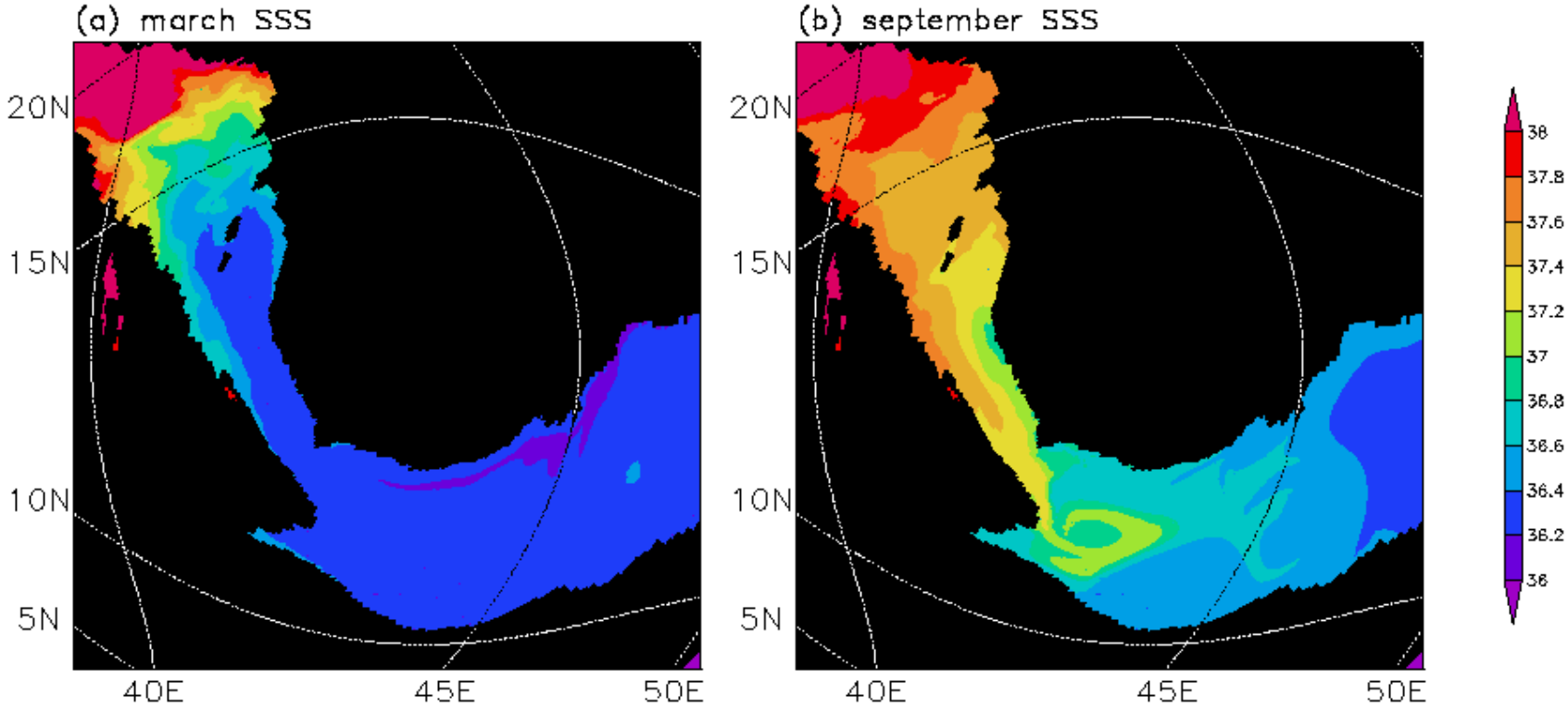

relative vorticity along 50E
depth [m]
200
400
600
800
1000
1200
1400
10N
11N
12N
13N
14N
15N
1027
0.2
0.1
0.05
-0.05
-0.1
-0.2

Relative vorticity at the sea surface



15th year results

Sea Surface Salinity

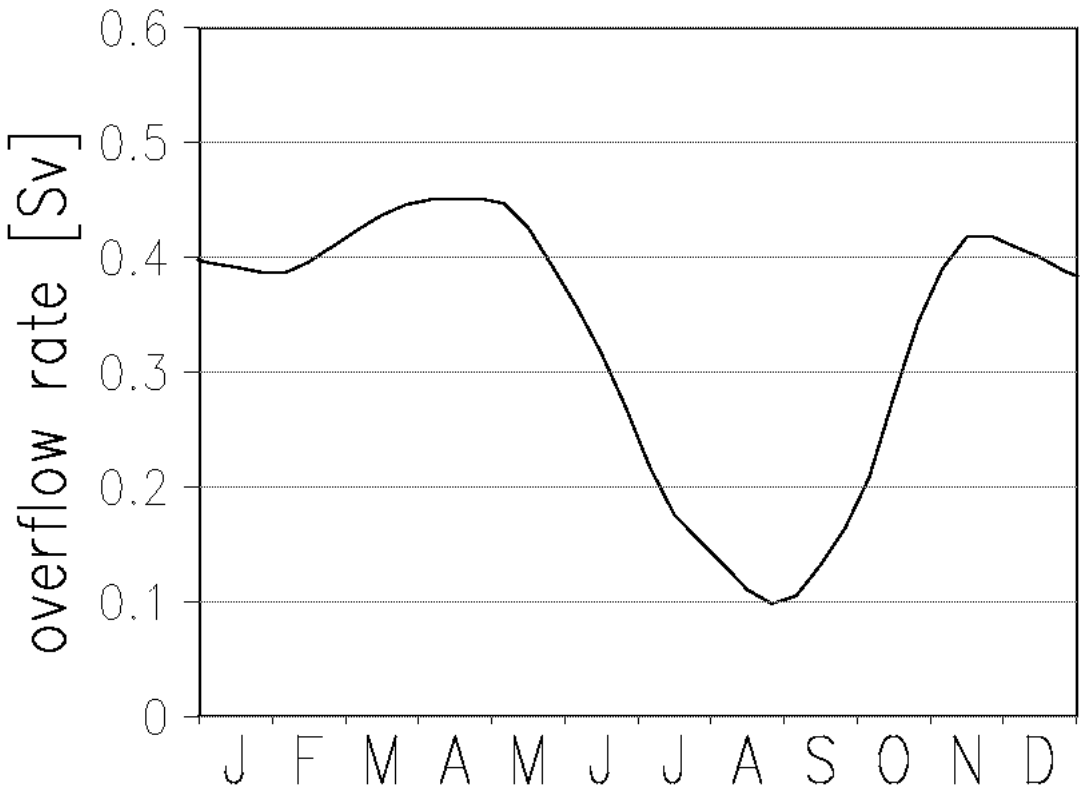


reference run

monthly wind stress

monthly water and thermal fluxes

Red Sea Water transport at the BAM strait

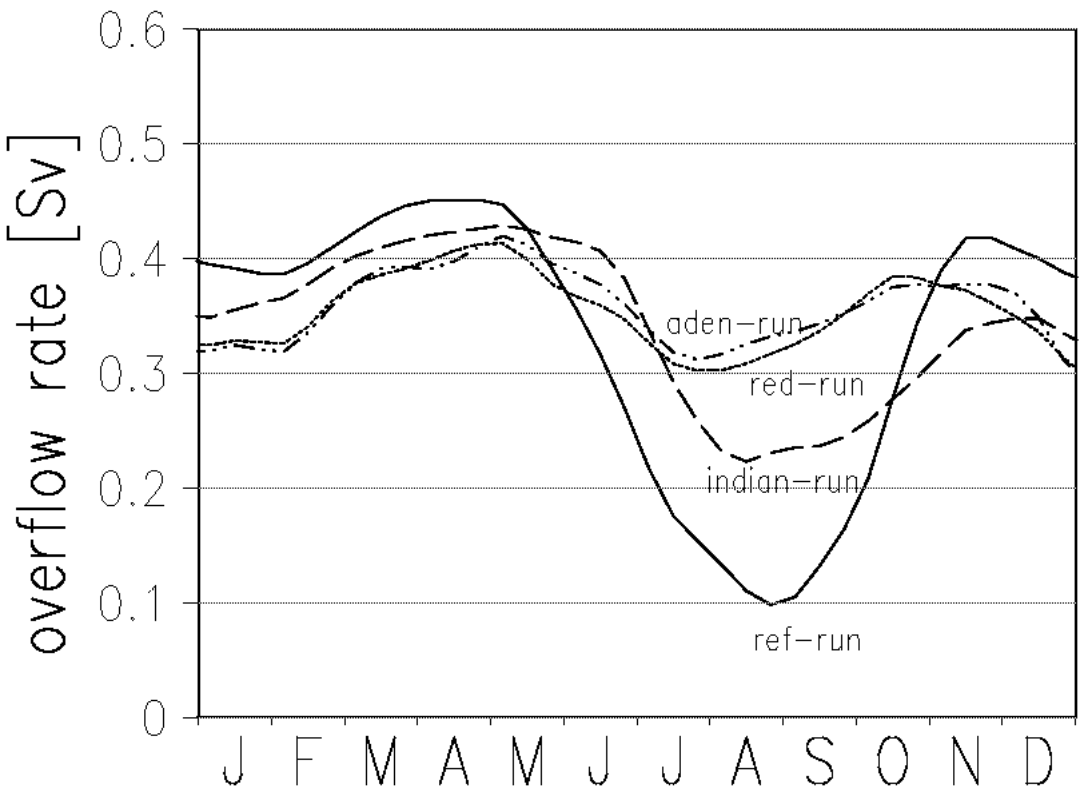


Where is wind stress important?

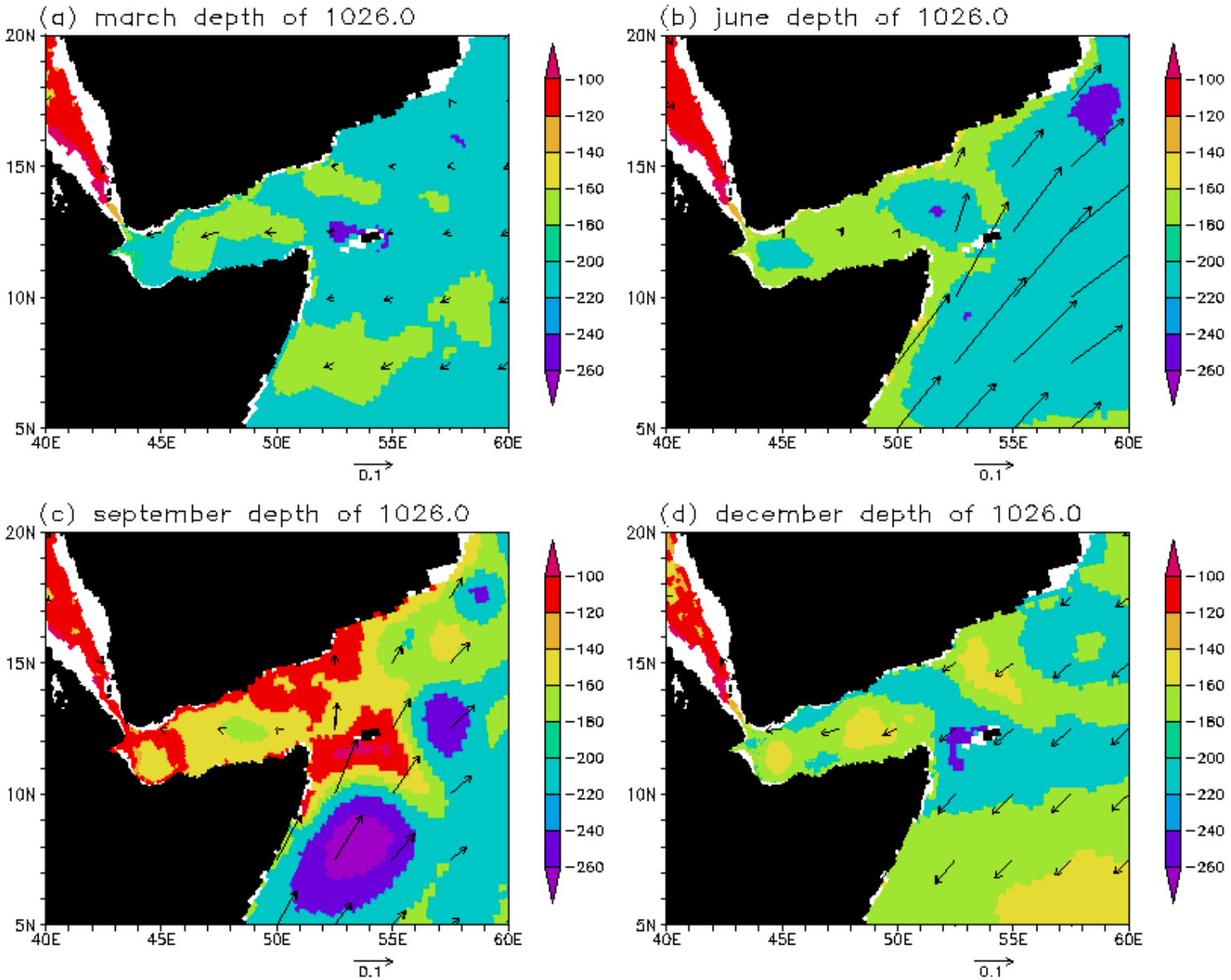
three sensitivity experiments

- monthly wind over the Red Sea
- monthly wind over the gulf of Aden
- monthly wind over the Indian Ocean

(elsewhere annual mean steady wind is applied)



seasonal evolution of Upper Thermocline Depth



Where in the Indian Ocean is wind stress important?

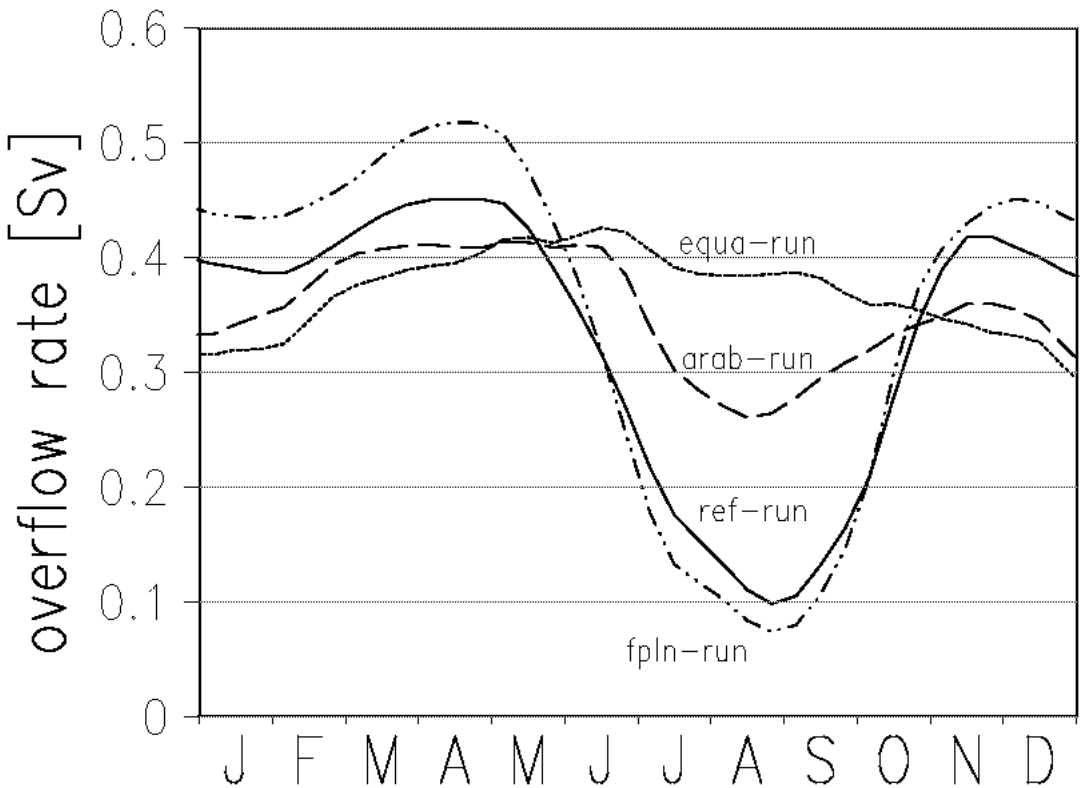
two sensitivity experiments

- monthly wind over the Arabian sea (north of 9N)
- monthly wind over the equatorial Indian Ocean (south of 9N)

(elsewhere steady wind is applied)

one sensitivity experiment

- Coriolis parameter is fixed in the Arabian marginal seas.



Summary

We have developed a strait-resolving OGCM to investigate seasonal variability of the Red Sea water outflow and its interaction with larger scale currents.

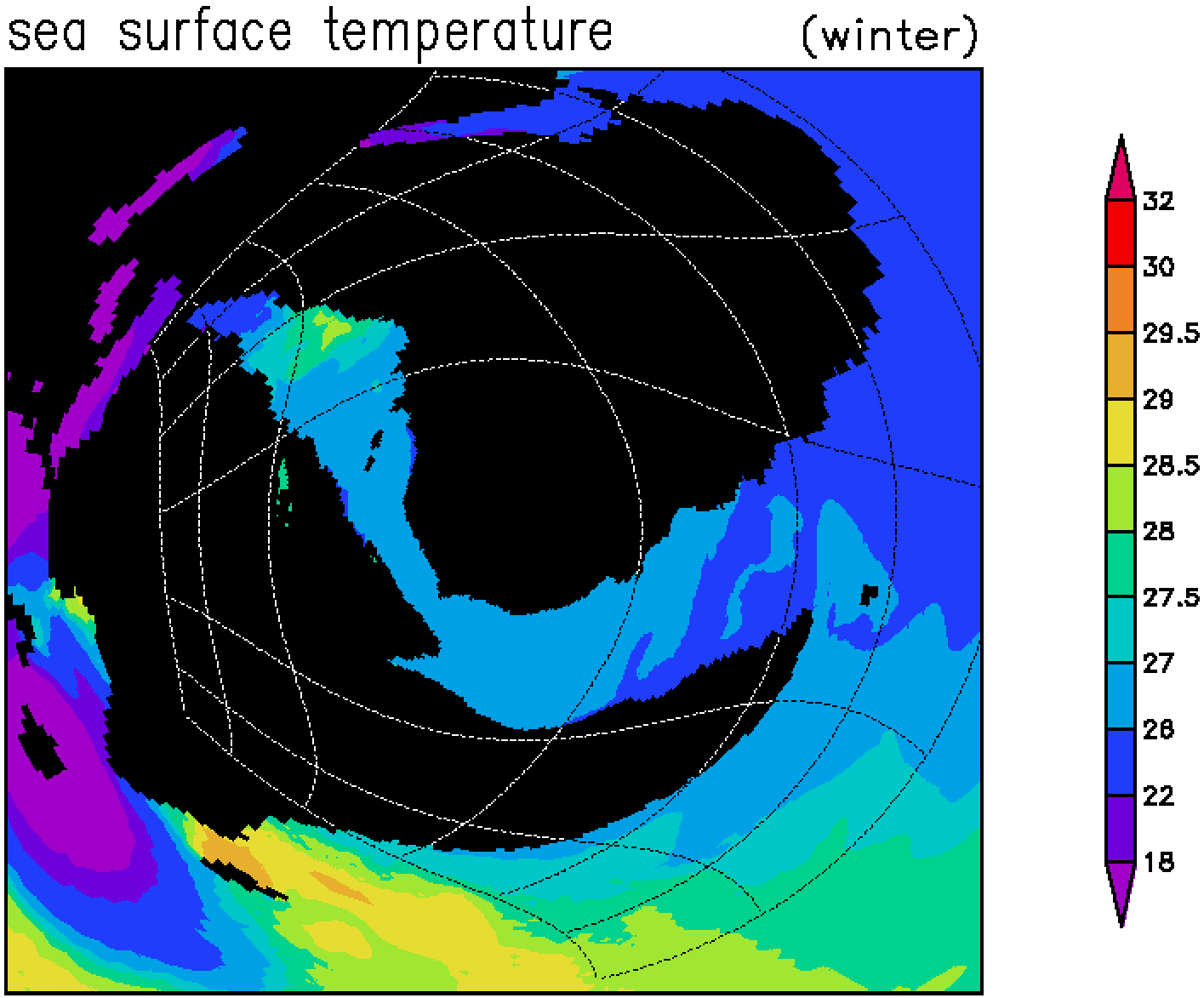
Indian Ocean

- Monsoon wind over the Arabian Sea remotely controls the strait water exchange.
- roles of coastal Kelvin waves rather than Rossby waves.

gulf of Aden

- discharged RSW (incoming Indian Ocean water) is characterized by anticyclonic (cyclonic) vorticity.
- less mixing in the strait (RSW concentration was 0.6), whereas more mixing by the frontal instability in the gulf of Aden (concentration reduced to 0.2).

15th year results



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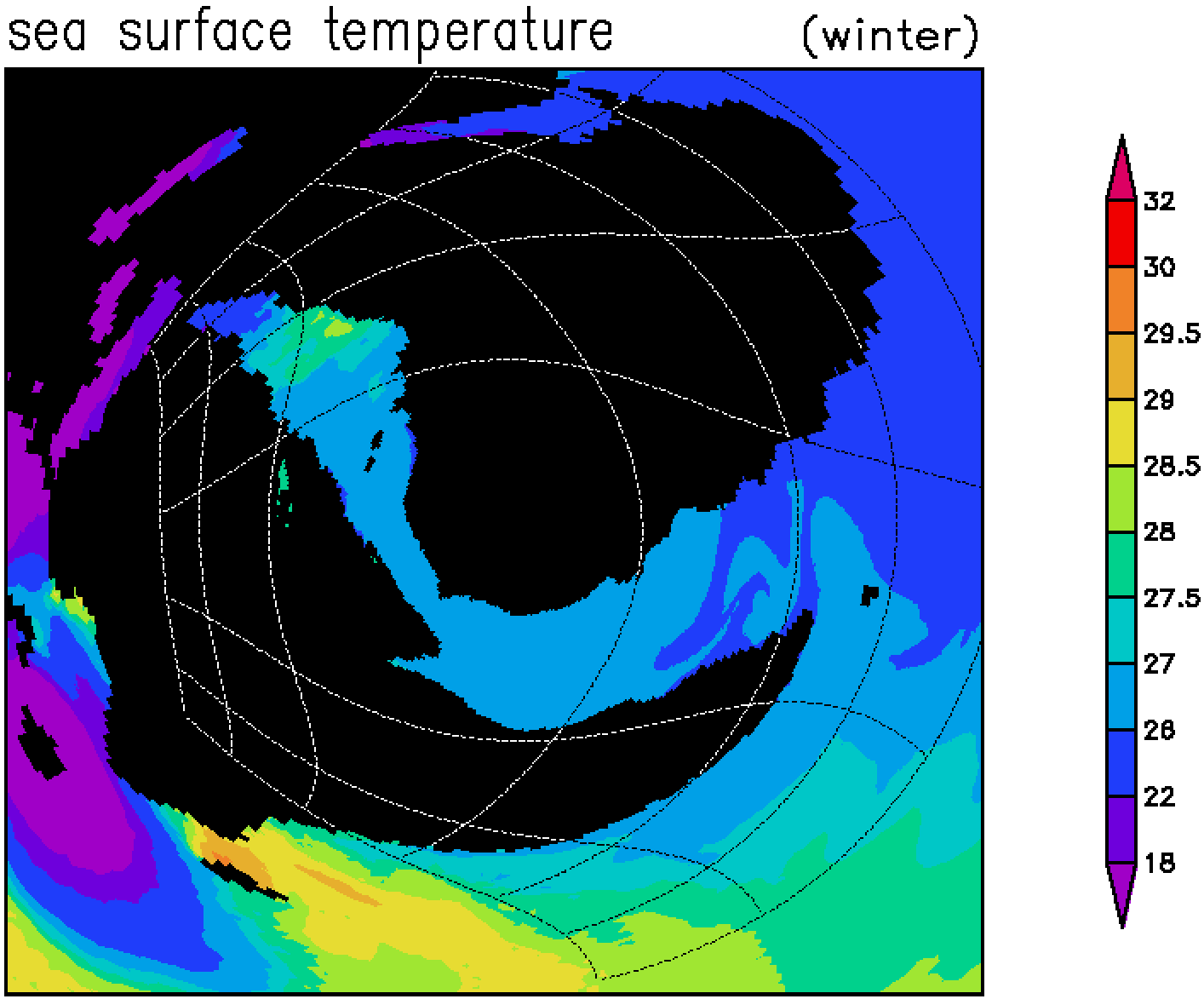
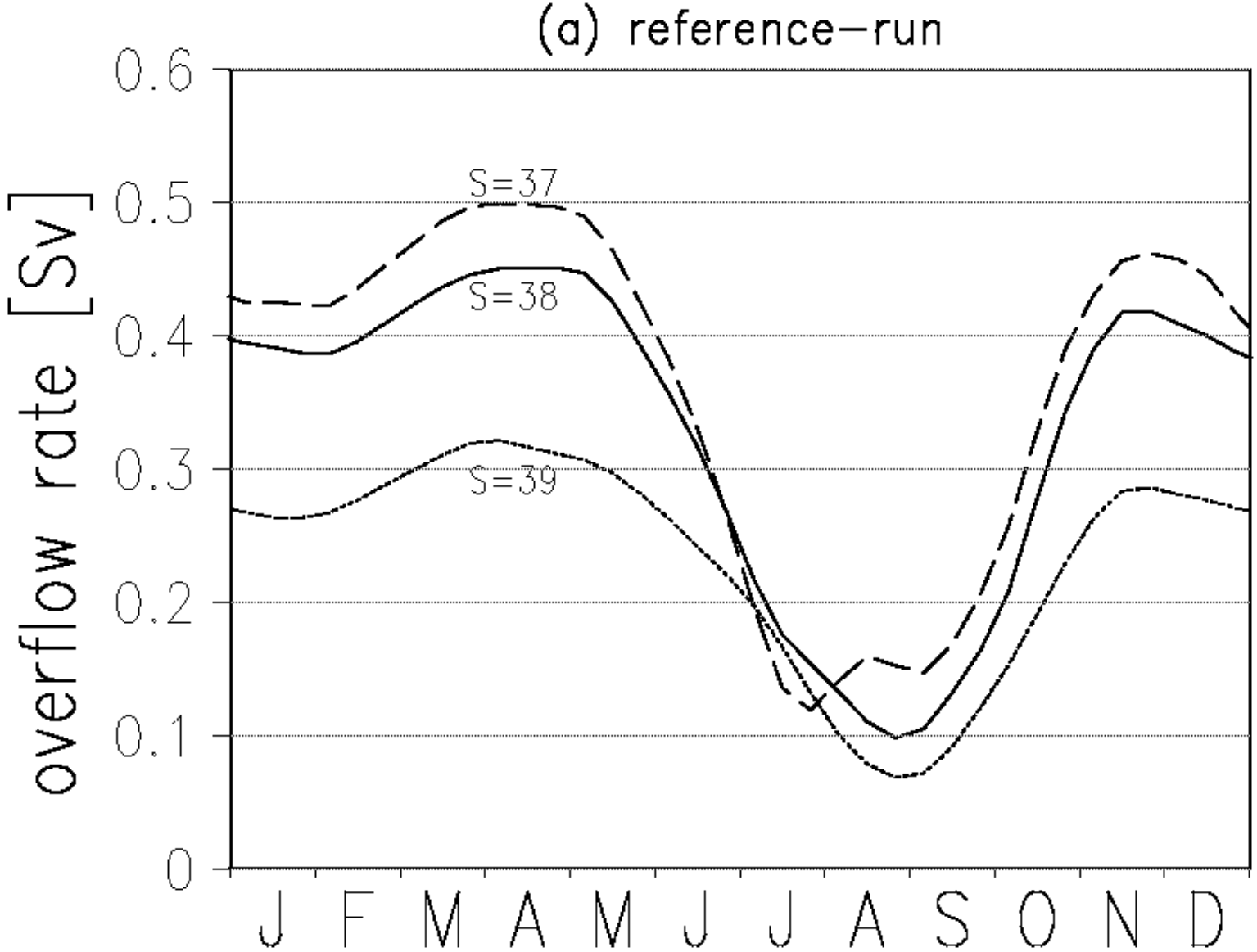


Red Sea water transport at the BAM strait



Wind or Buoyancy forcing ?

reference run

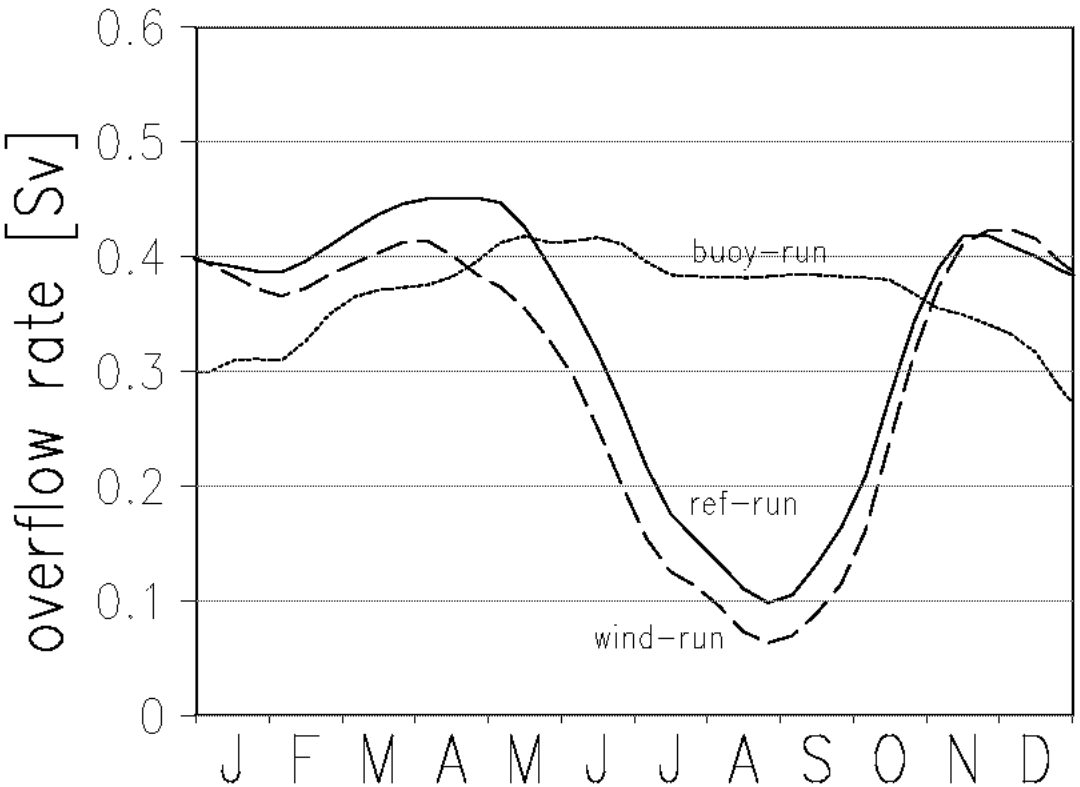
monthly wind stress

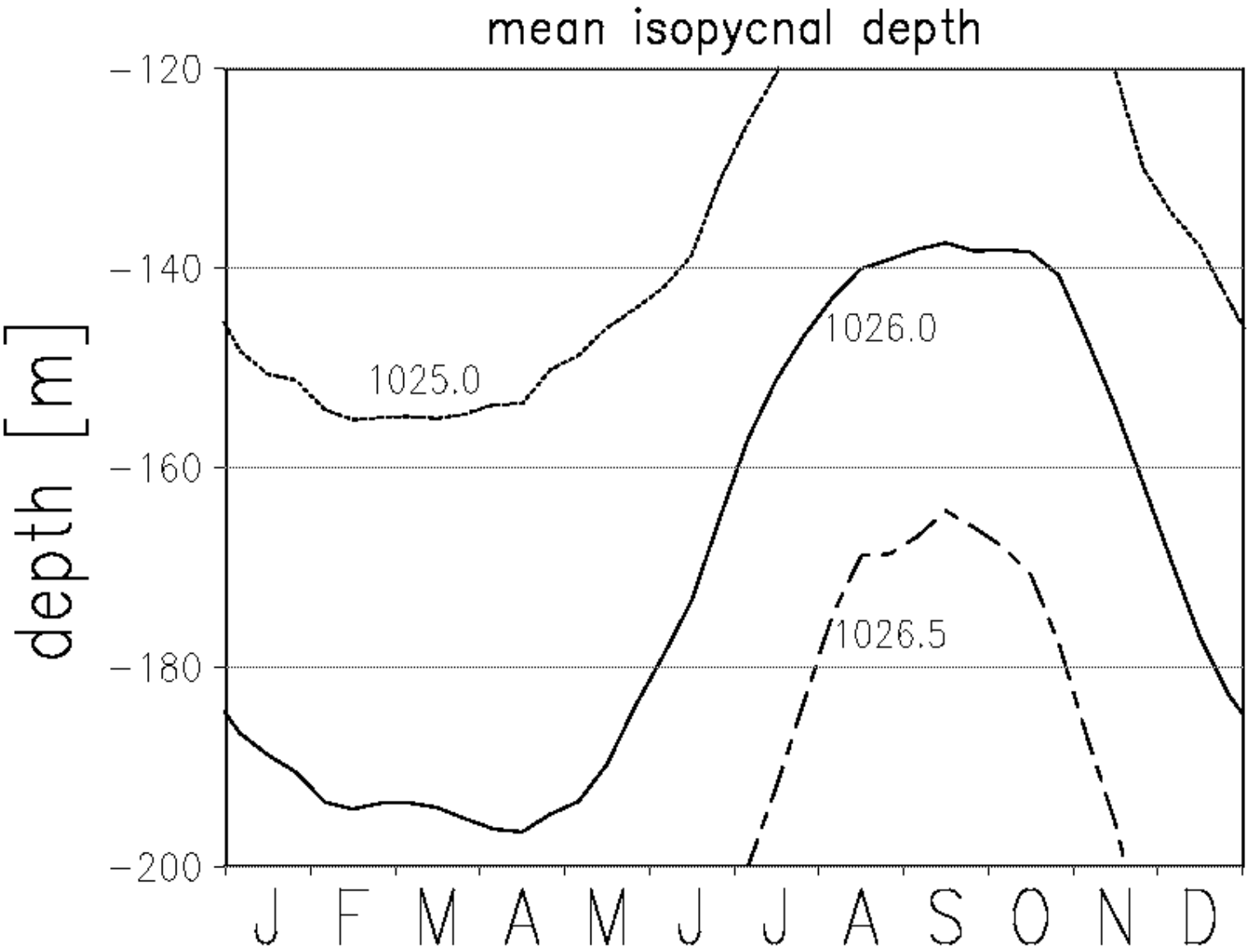
monthly water and thermal fluxes

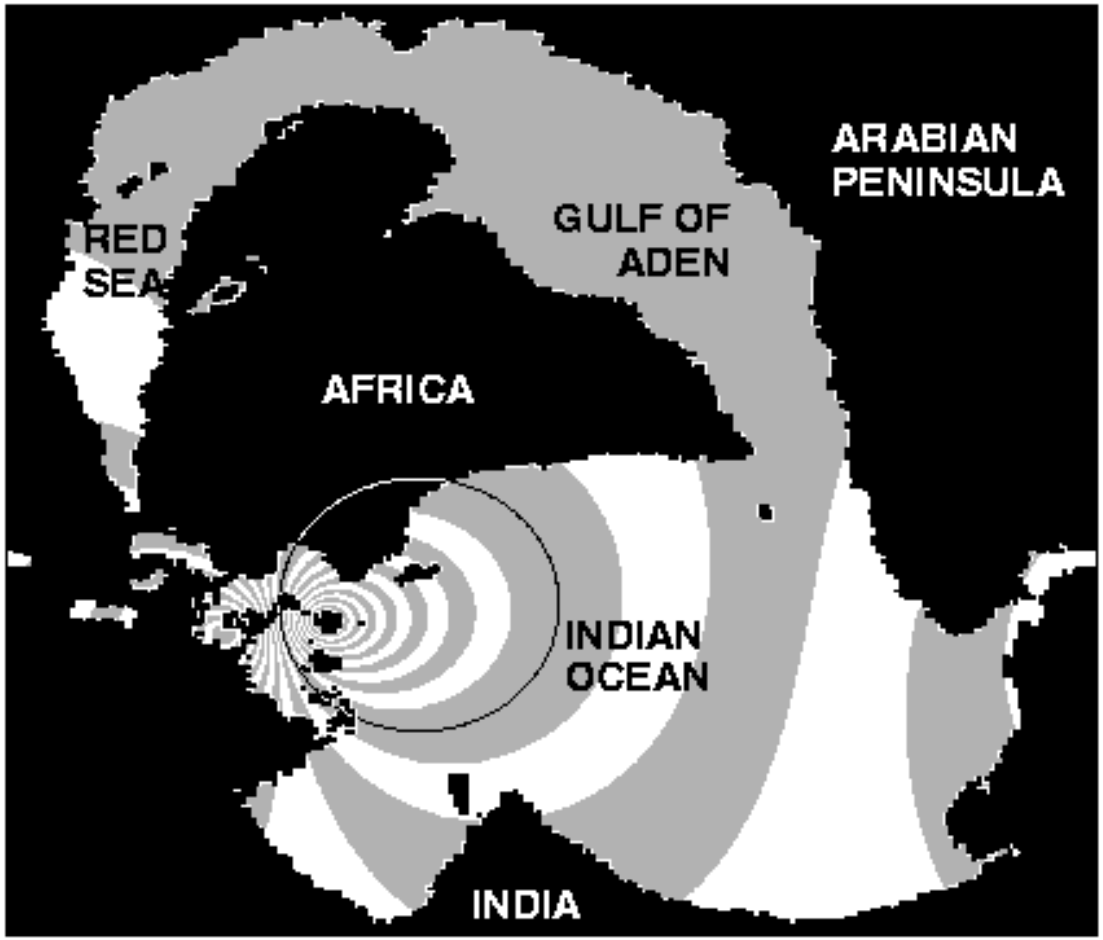
two sensitivity experiments

- monthly wind (steady buoyancy flux)
- monthly buoyancy flux (steady wind)

Red Sea Water transport at the BAM strait




mean isopycnal depth
depth [m]
−120
−140
−160
−180
−200
1025.0
1026.0
1026.5
J
F
M
A
M
J
J
A
S
O
N
D



240 x 256 x 30 grids in the Mercator map

Horizontal Resolution

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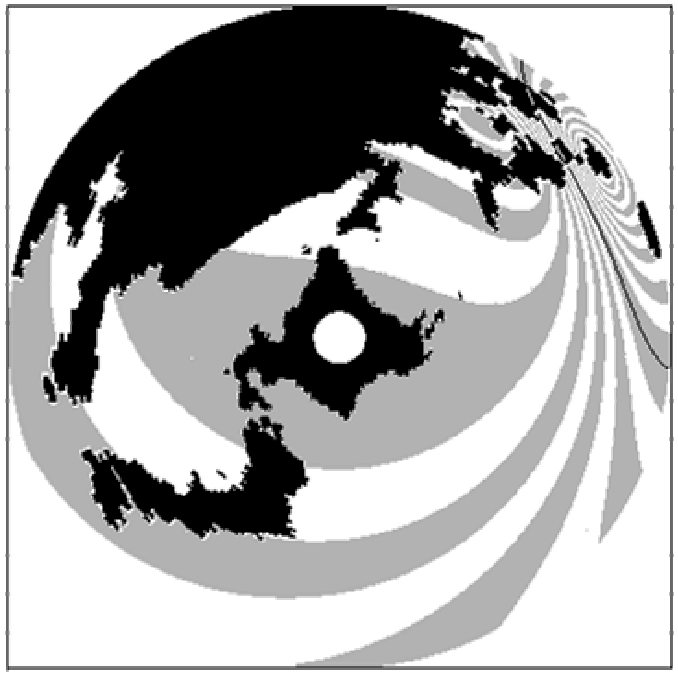

Summary

Seasonal variability of the Red Sea water outflow is investigated using a newly developed ocean model.

Indian Ocean

- Monsoon wind over the Indian Ocean remotely controls the strait water exchange.

gulf of Aden

- coastal upwelling in response to the Southwest Monsoon.
- overflowed RSW (incoming Indian Ocean water) is characterized by anticyclonic (cyclonic) vorticity.
- less mixing in the strait (RSW concentration was 0.6), whereas more mixing by the frontal instability in the gulf of Aden (concentration reduced to 0.2).

Red Sea

- less impact on the late summer stopping of the strait overflow.