Impact of interannual atmospheric forcing on the Mediterranean Outflow Water variability in the Atlantic Ocean

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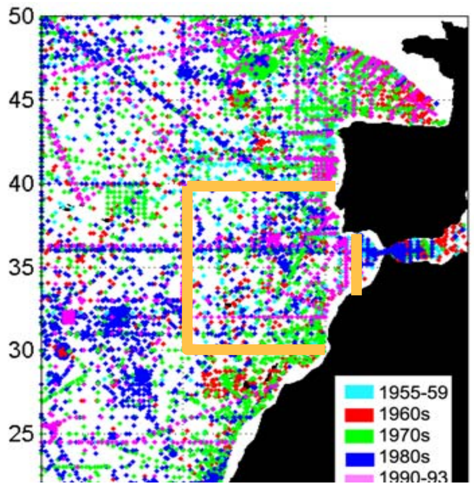
Background

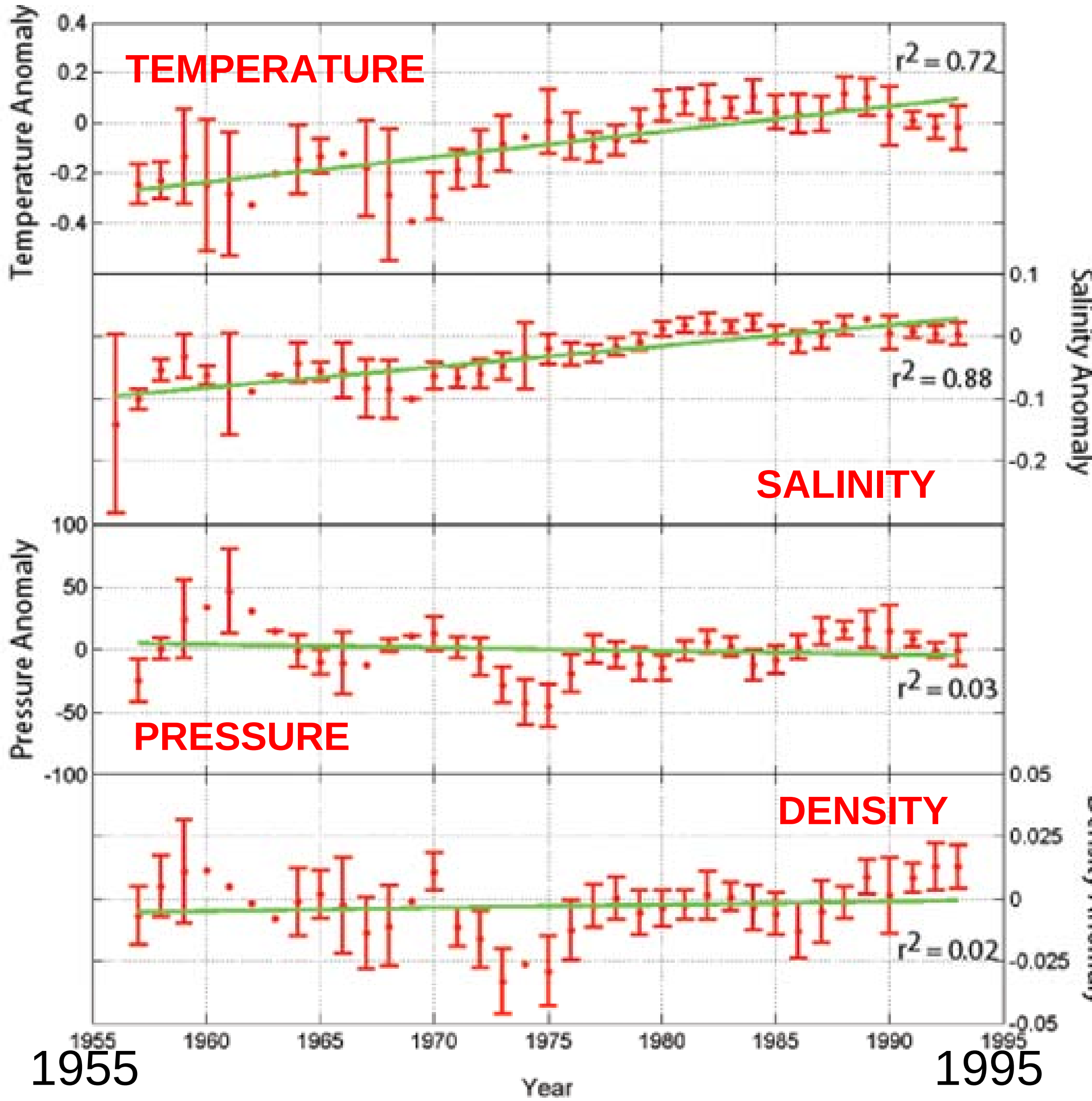
Trends in water properties of the Mediterranean Outflow Water reservoir (Potter and Lozier, 2004):

Observations:

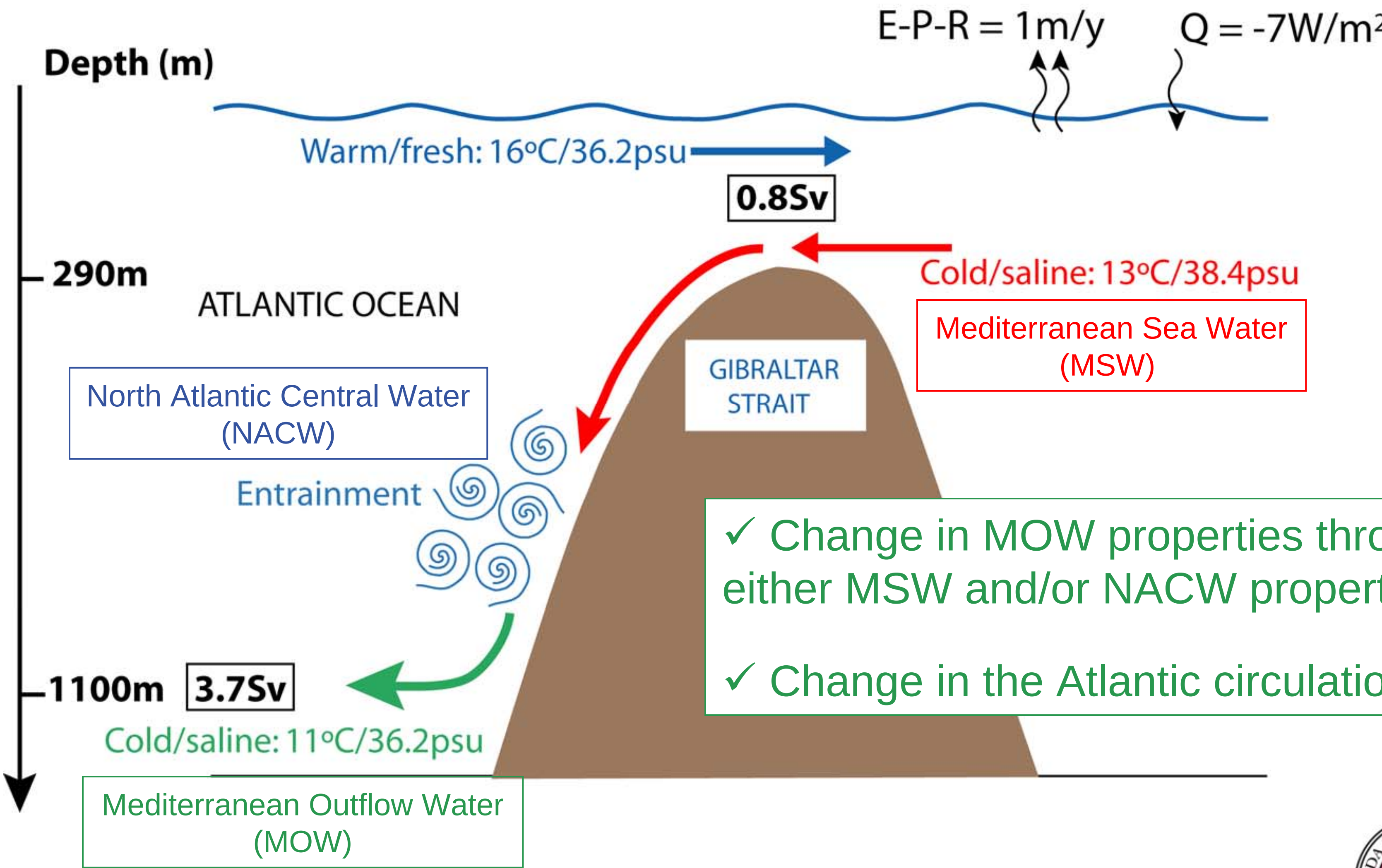
- Max of S of each profiles
- Time period : 1955 to 1993
- 3 year moving average

S-Trend (psu/decade)	T-Trend (ºC/decade)
0.0283+/- 0.0067	0.101+/- 0.024





Source of Variability for the MOW Reservoir



- ✓ Change in MOW properties through either MSW and/or NACW properties
- ✓ Change in the Atlantic circulation

Mediterranean Sea Water variability

Lozier and Sindlinger (2009)

Derived MSW salinity using different E-P products (NCEP/NCAR, ECMWF, DaSilva)

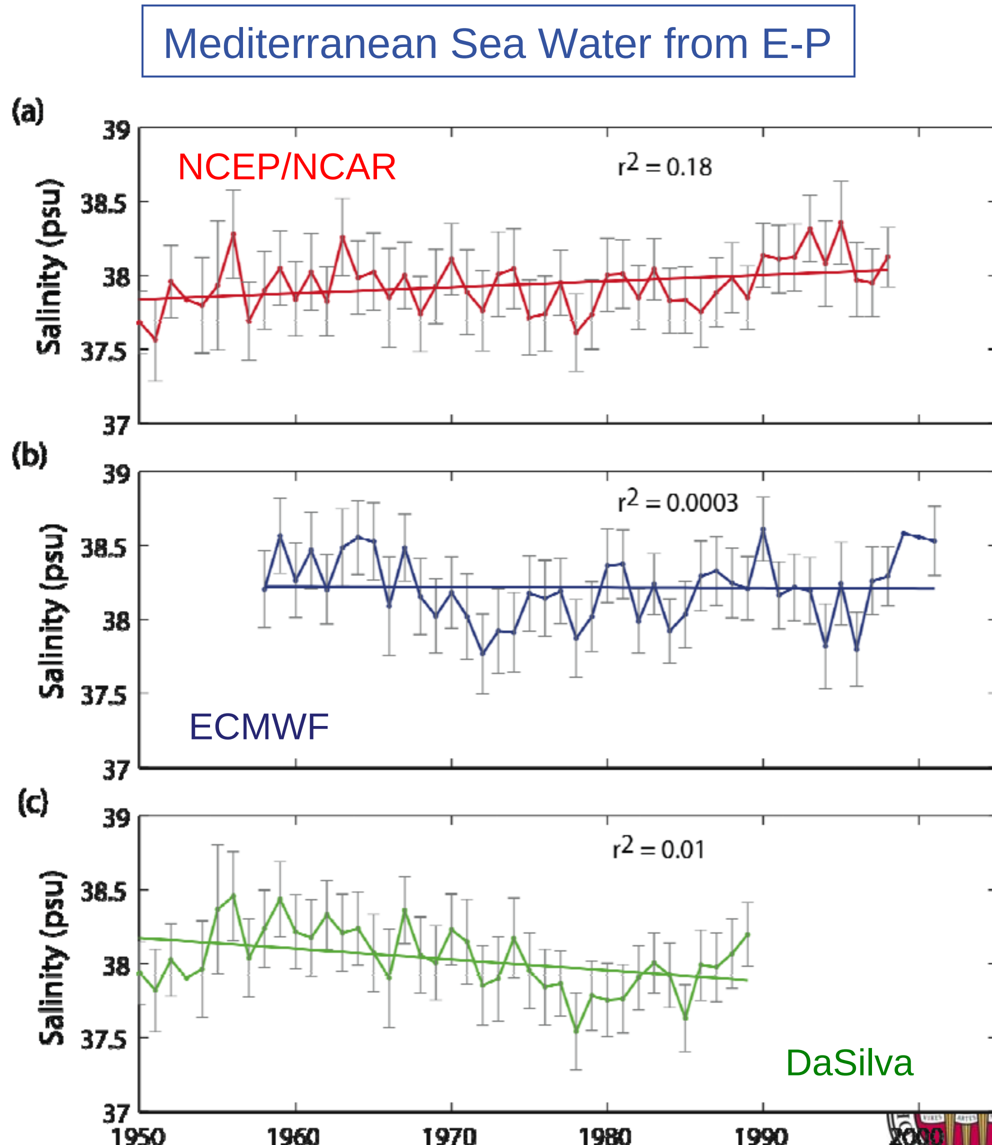
✓ NCEP/NCAR Med Sea Water:

S-Trend: +0.037 ± 0.018 psu/decade

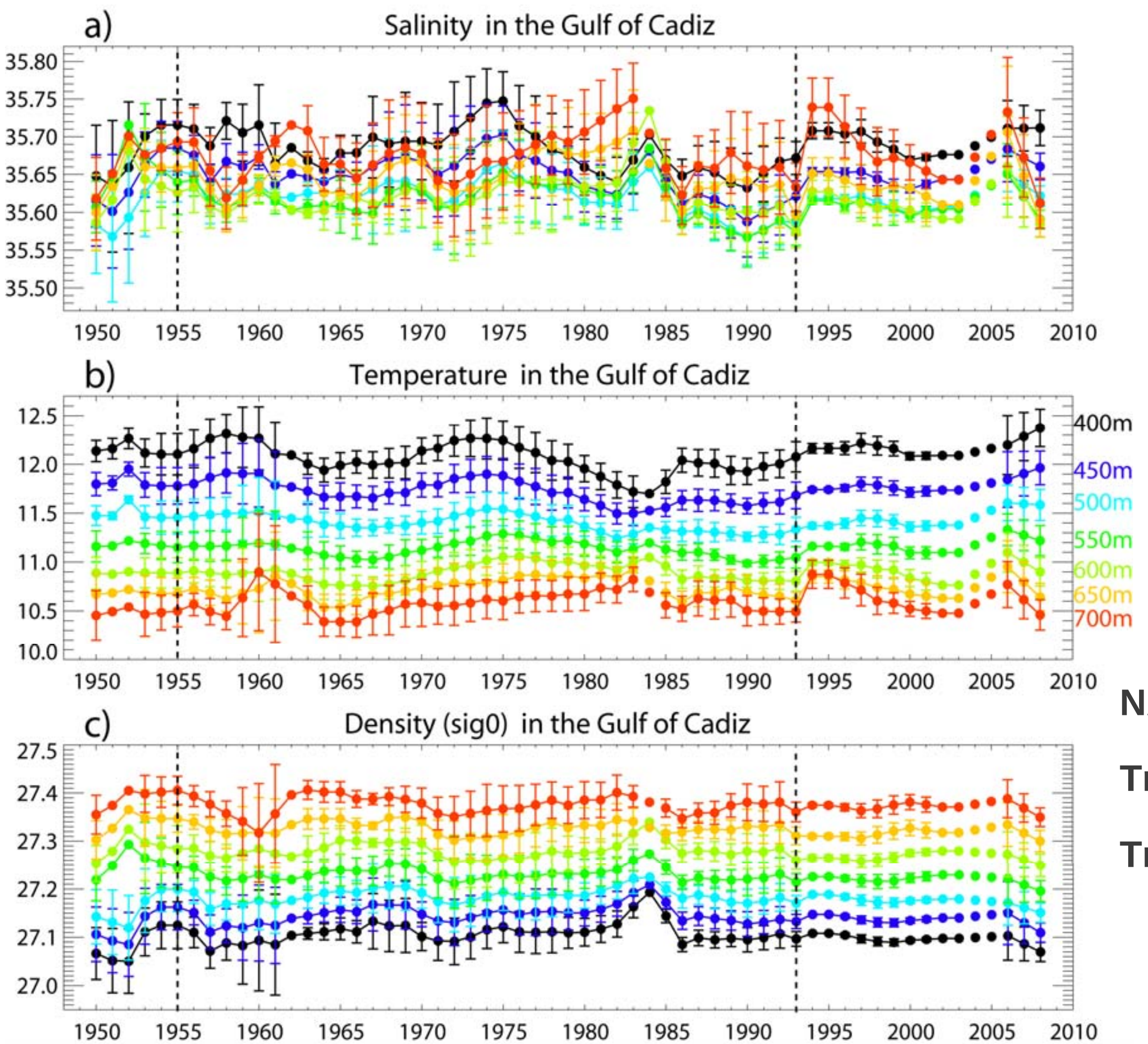
✓ Resulting MOW reservoir salinity (assuming NACW constant in Price and Yang (1998)):

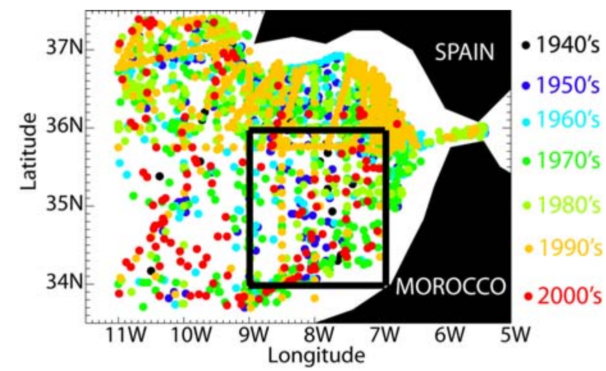
S-Trend:+0.0024 ± 0.0014psu/decade

=> 10 times lower than observations



NACW entrained variability





From HydroBase 2

NACW trends between 1955-1993:

Trend S at 600m: +0.0025±0.0090 psu/dec.

Trend T at 600m: +0.0069±0.0029 ºC/dec.

- ✓ The variability of the Mediterranean Sea water and of the North Atlantic Central water are too weak to be responsible for the variability of the MOW in the Atlantic.

- ✓ Hypothesis: The variability is due to the interannual variability of the atmosphere (wind and/or buoyancy forcing).

Experimental Set-up

3 simulations using 1/3º Atlantic HYCOM with the **Marginal Sea Boundary Condition** (Price and Yang, 1998).

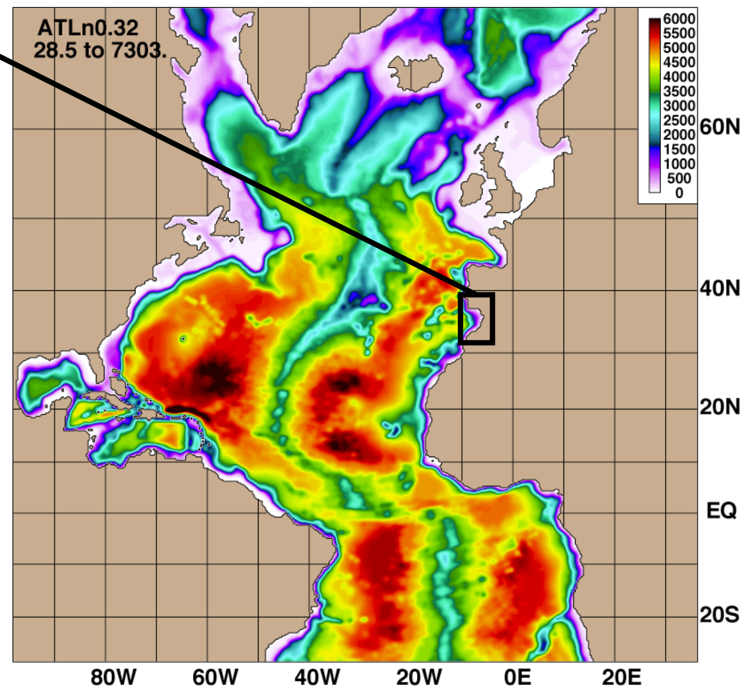
✓Spin-up of 30 years

✓60 years simulations

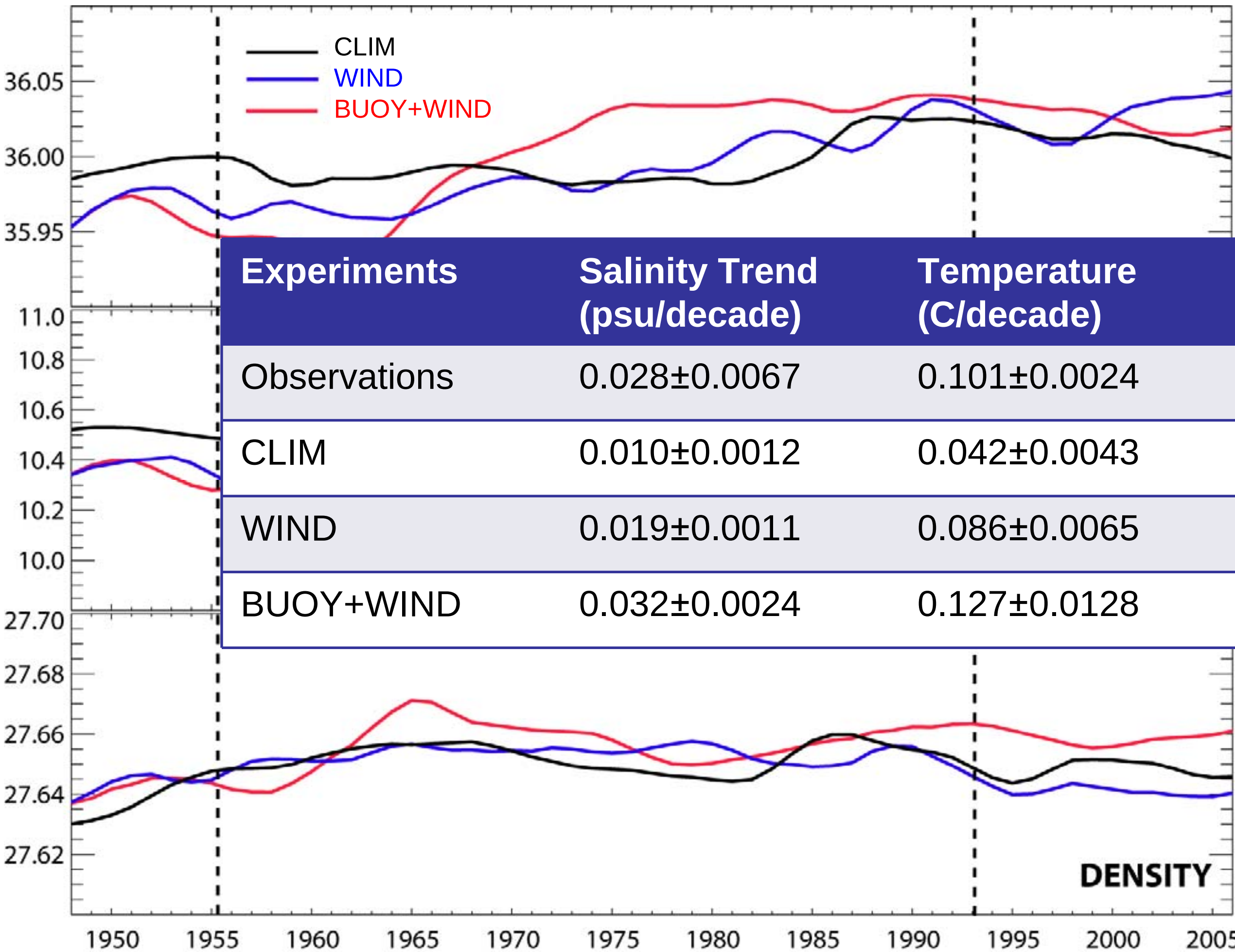
✓**Constant properties of the MSBC MOW**:

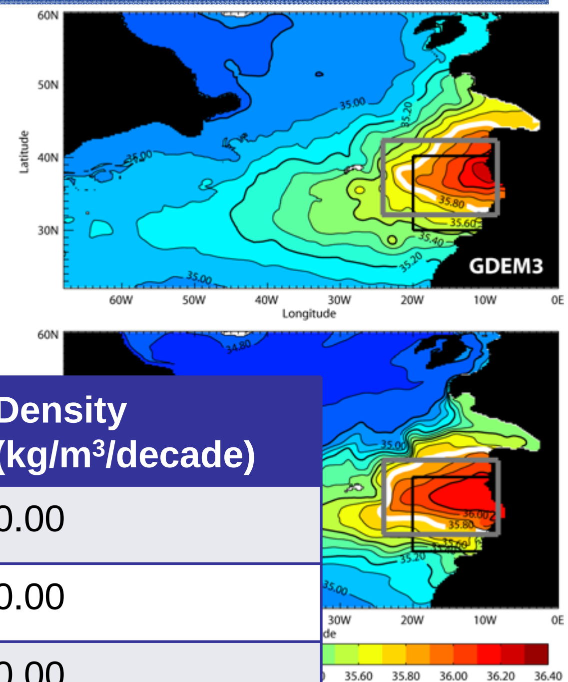
T=11ºC, S=36.2psu,Transport =4Sv.

Experiments	Atmospheric Forcing
CLIM	**Climatological** ECMWF (ERA15)
WIND	**Interannual wind-stress** (NCEP 1948-2006) and **climatological** ECMWF **buoyancy forcing**
BUOY+WIND	**Interannual buoyancy and wind forcing** (NCEP 1948-2006)



MOW Reservoir Trends in HYCOM

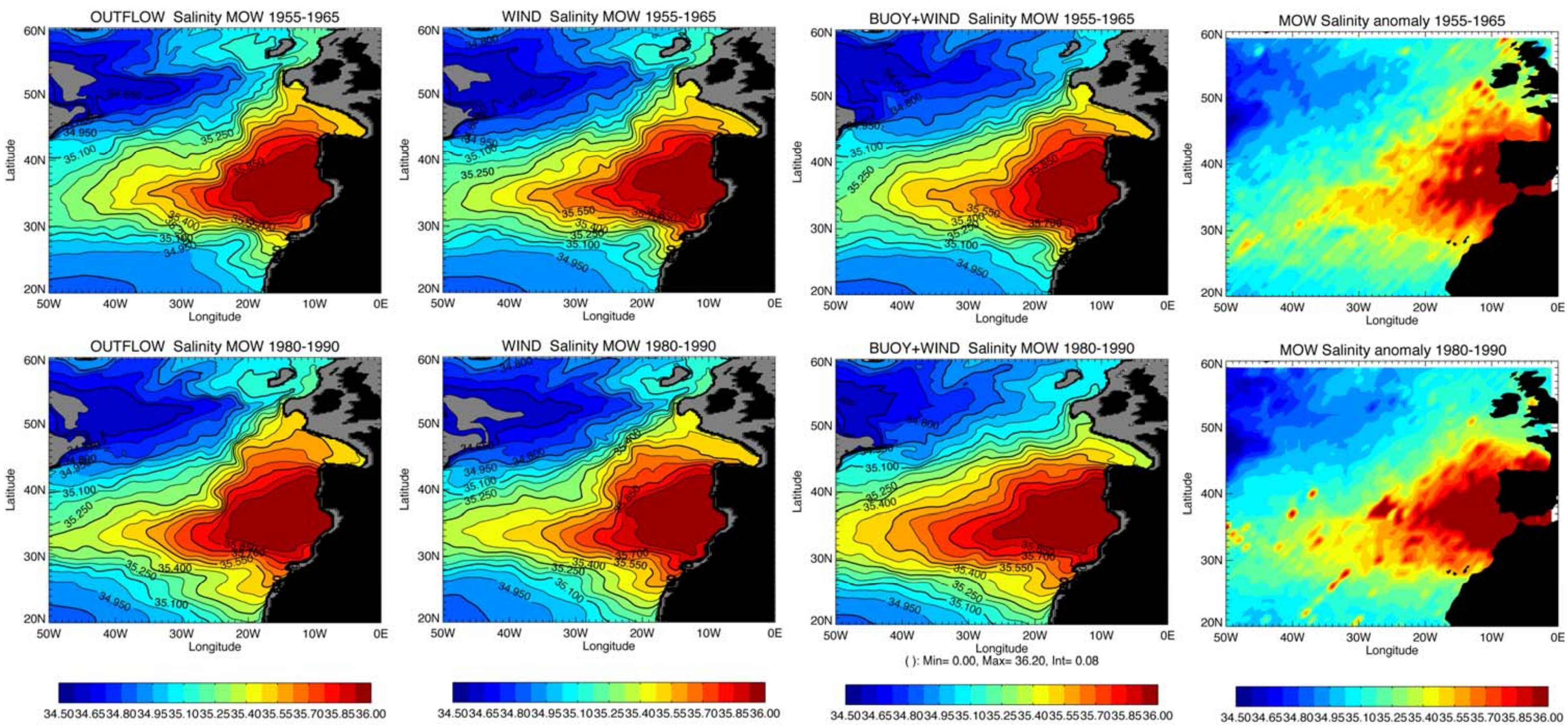




Experiments	Salinity Trend (psu/decade)	Temperature (C/decade)	Density (kg/m³/decade)
Observations	0.028±0.0067	0.101±0.0024	0.00
CLIM	0.010±0.0012	0.042±0.0043	0.00
WIND	0.019±0.0011	0.086±0.0065	0.00
BUOY+WIND	0.032±0.0024	0.127±0.0128	0.01

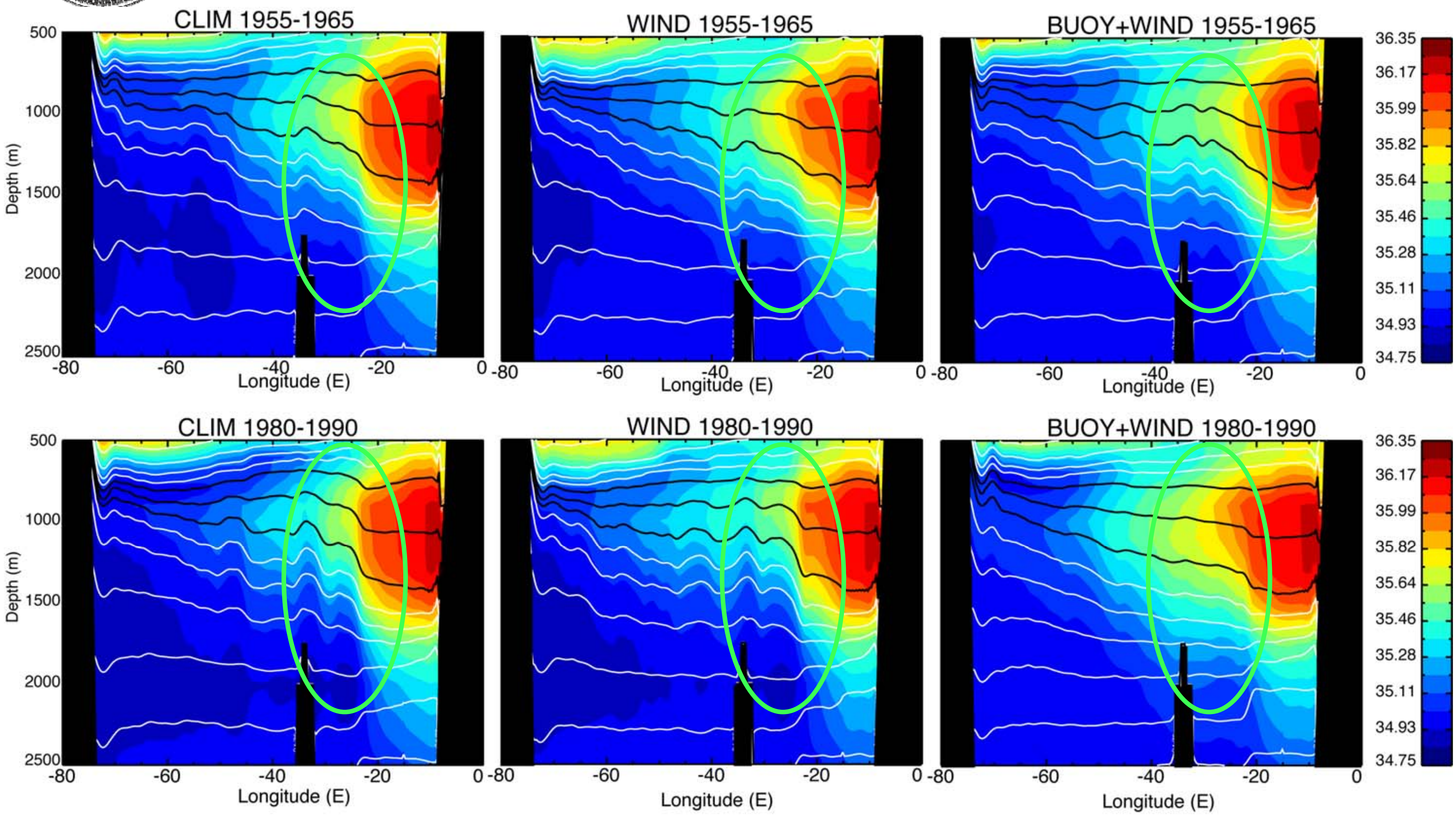
Spreading of the MOW

We compare the MOW tongue (♦$_2$=36.52) during 1955-1965 and 1980-1990 for each simulation:



CLIM WIND BUOY+WIND HYDROBASE

Why is the MOW tongue expanding?

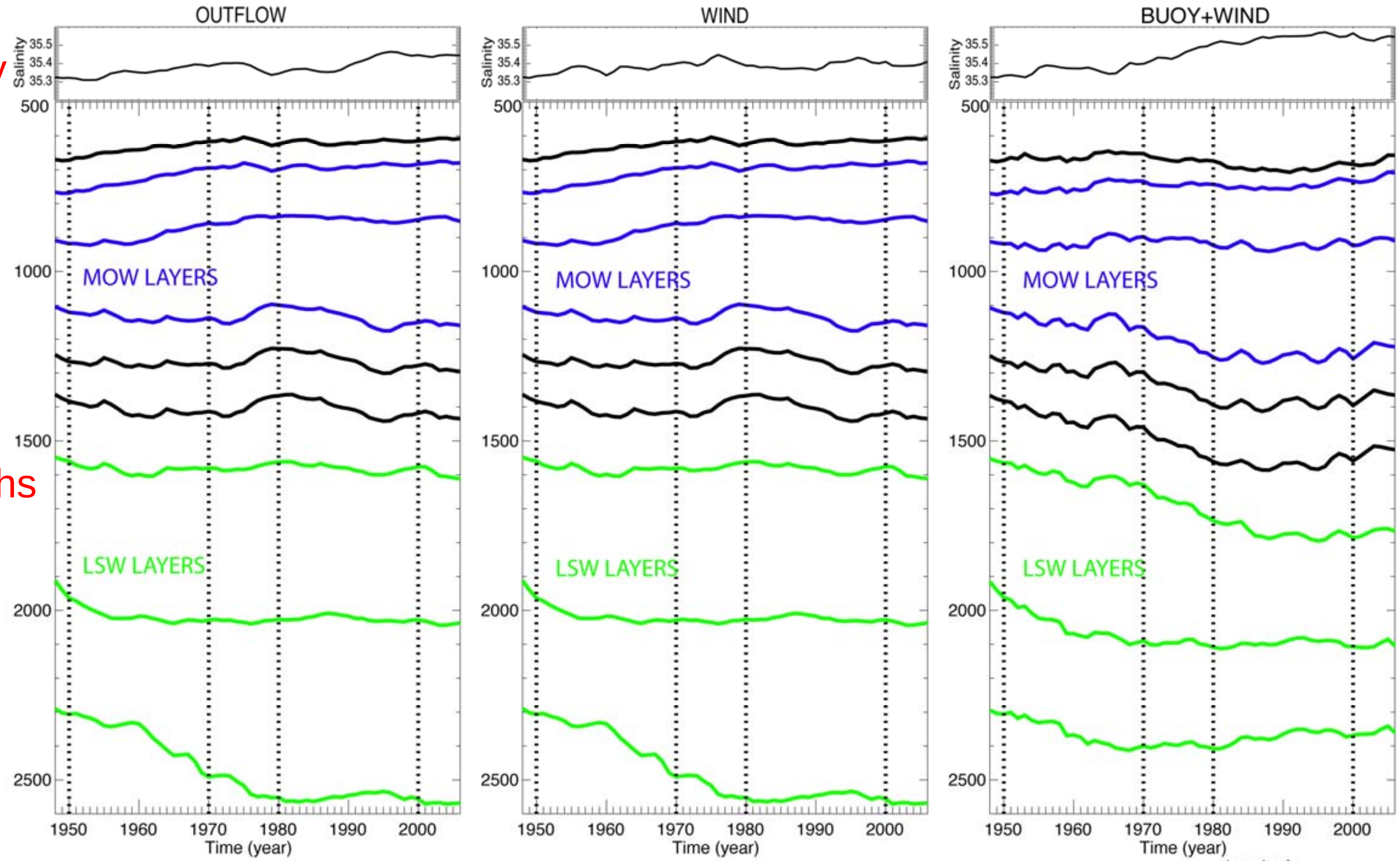


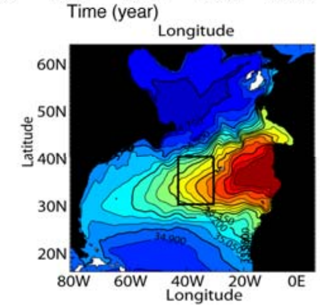
The cross section at 36ºN shows tilted isopycnals in BUOY+WIND compared with the other simulations.

Time Evolution of Interface Depths

MOW Salinity (psu)

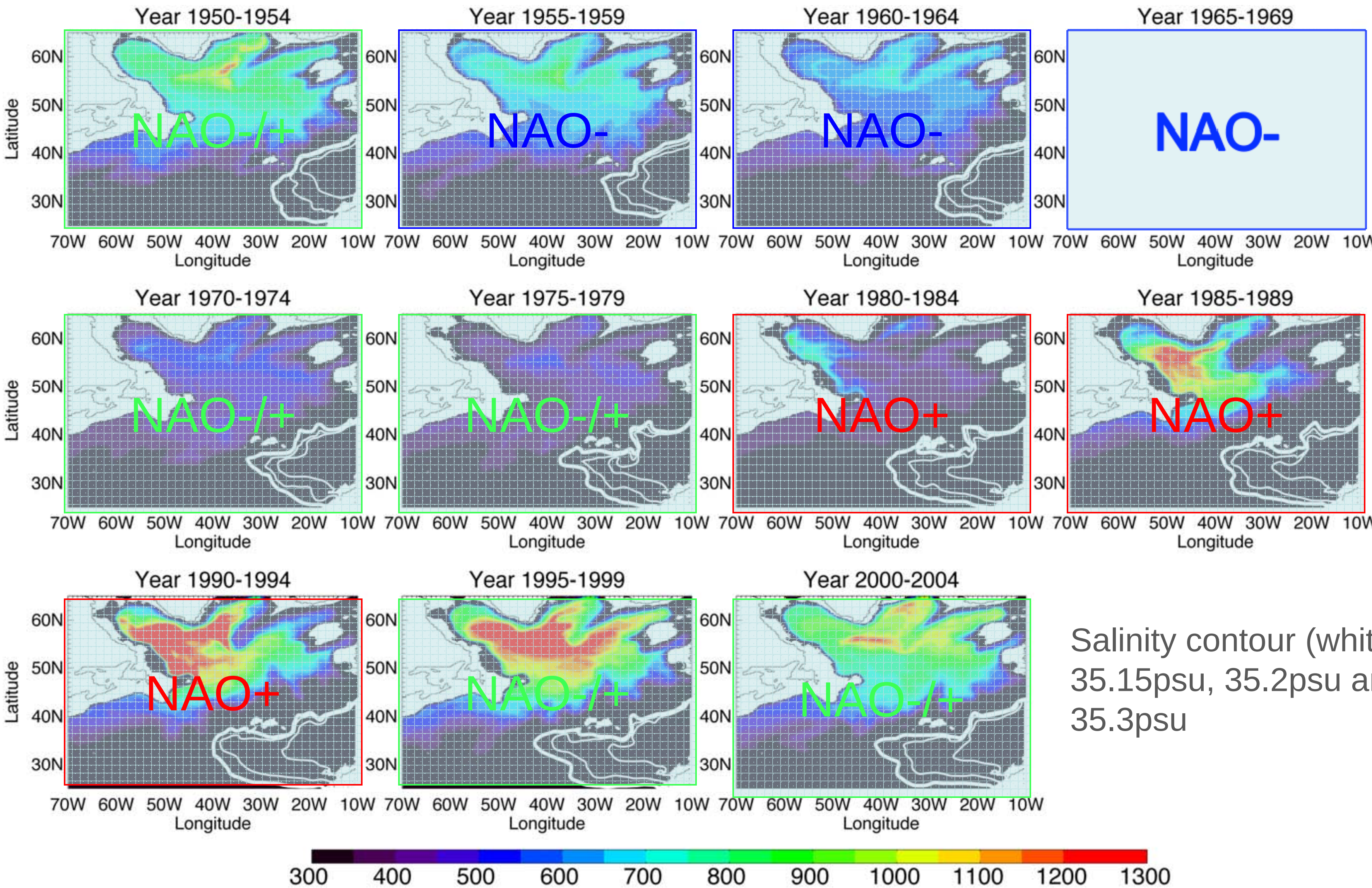
Interface depths (m)





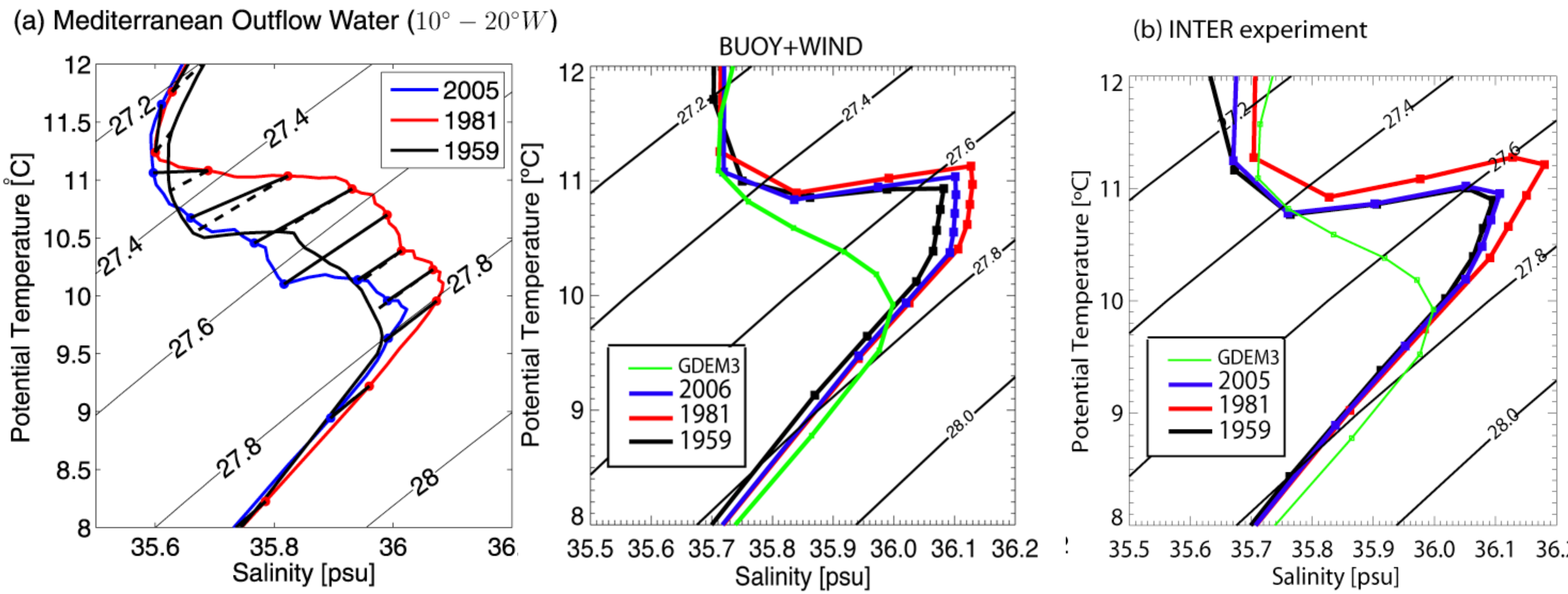
✓ MOW salinity increase coincides with a retraction of the Labrador Sea Water (LSW) from the Central Atlantic.

LSW thickness (♦$_2$=36.83)

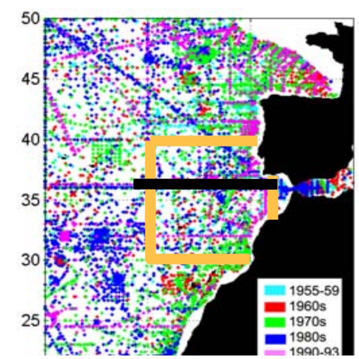


Salinity contour (white): 35.15psu, 35.2psu and 35.3psu

Trend reversal in the 2000s



From Leadbetter et al., 2007



Conclusions

- ✓ We are able to reproduce the MOW reservoir variability in the Atlantic for a constant MOW production.
- ✓ The observed MOW reservoir variability is due to circulation changes in the Atlantic Ocean induced by the atmospheric forcing.
- ✓ These circulation changes are primarily due to the variability in buoyancy forcing through the formation and flushing of Labrador Sea Water during high and low NAO periods.
- ✓ We can identify a 20-year cycle in phase with the NAO for the period 1950-2005. (i.e. time needed to fill and empty the "LSW reservoir").