

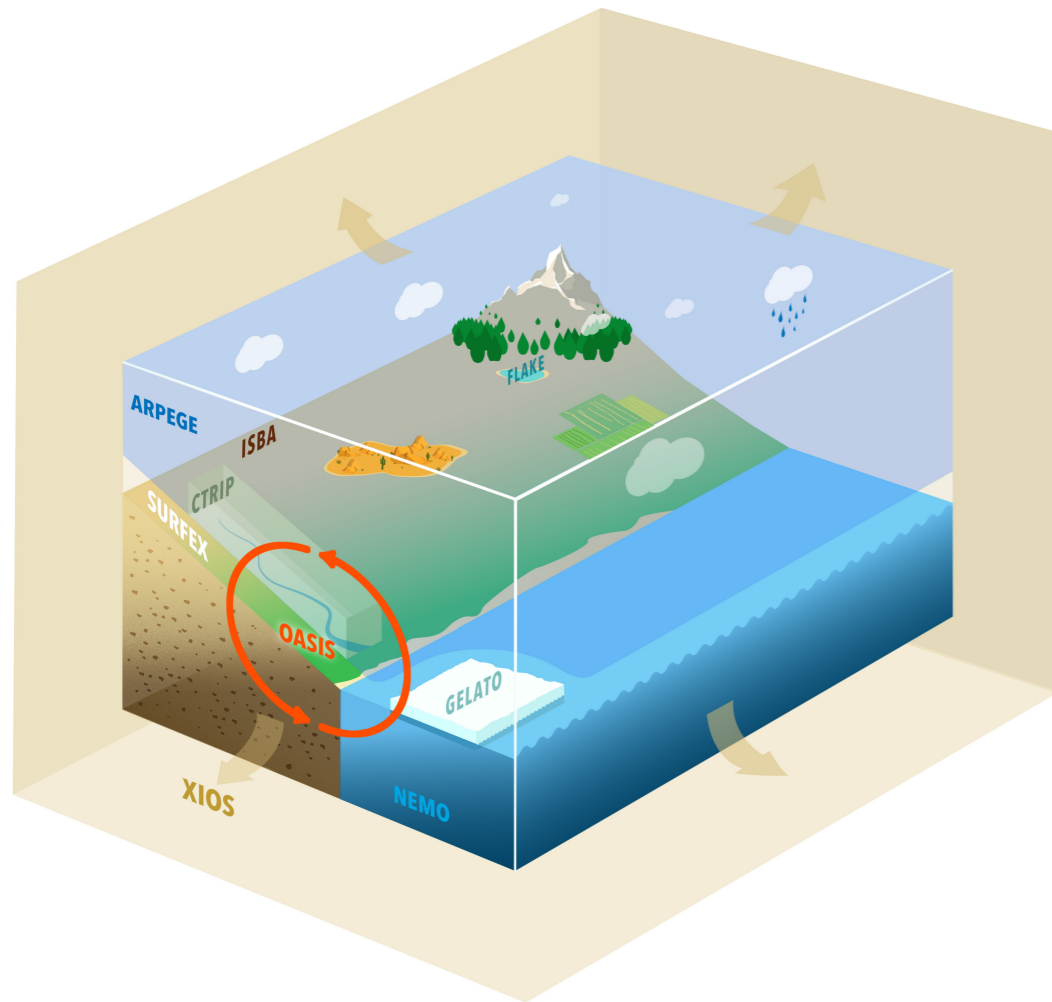
# Selected oceanic features of the CNRM-CM6 models

Rym Msadek  
on behalf of the  
CNRM-CERFACS group

*Nemo Users Meeting. October 11-12, 2018  
Toulouse, France*

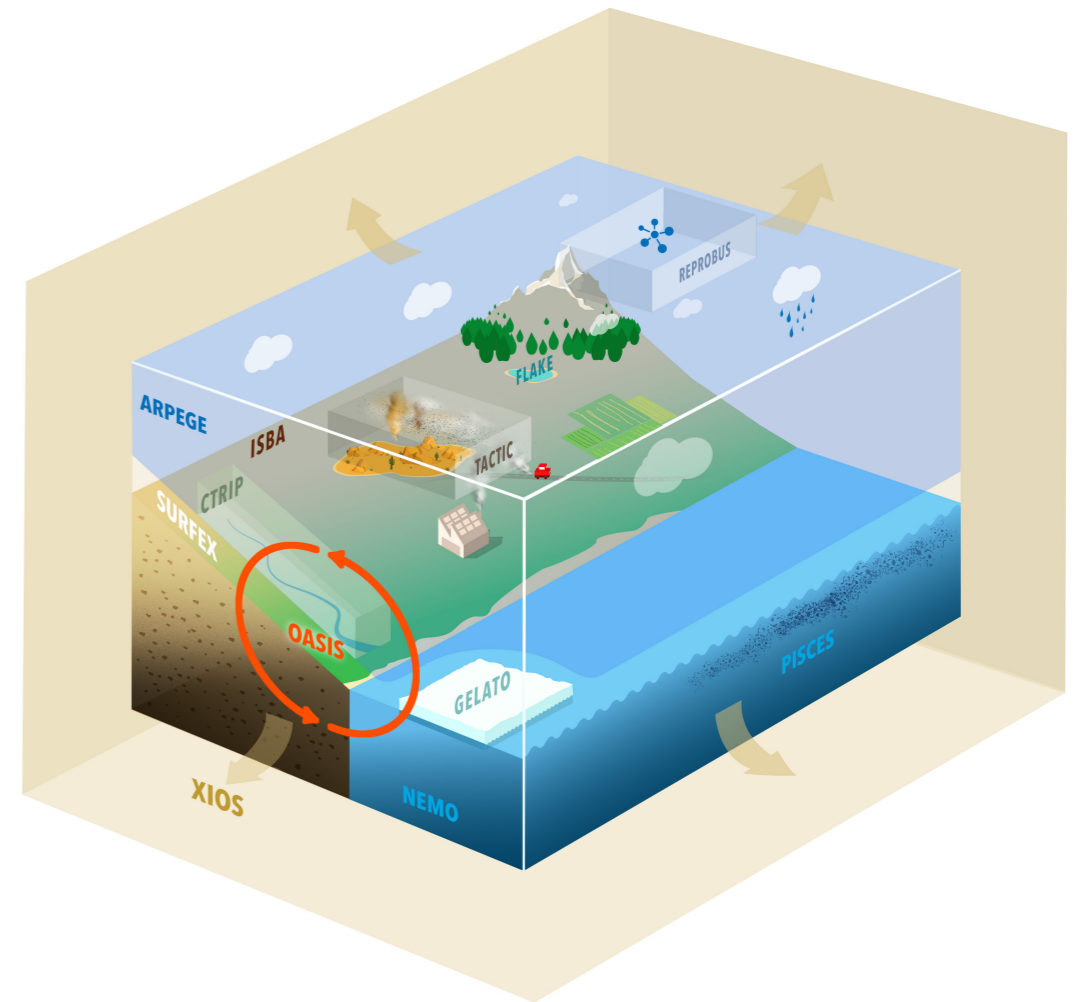


# CNRM-CM6 models



**CNRM-CM**

**CNRM-CM6-1**  
**CNRM-CM6-1-HR**



**CNRM-ESM**

**CNRM-ESM2-1**

NEMO 3.6  
GELATO v6 for Sea-Ice  
PISCESv2-gas in the ESM version  
ARPEGE-SURFEX for atm/land

2 resolutions:  
LR: ORCA1 / ATM ~140km  
HR: ORCA025 – ATM ~50km

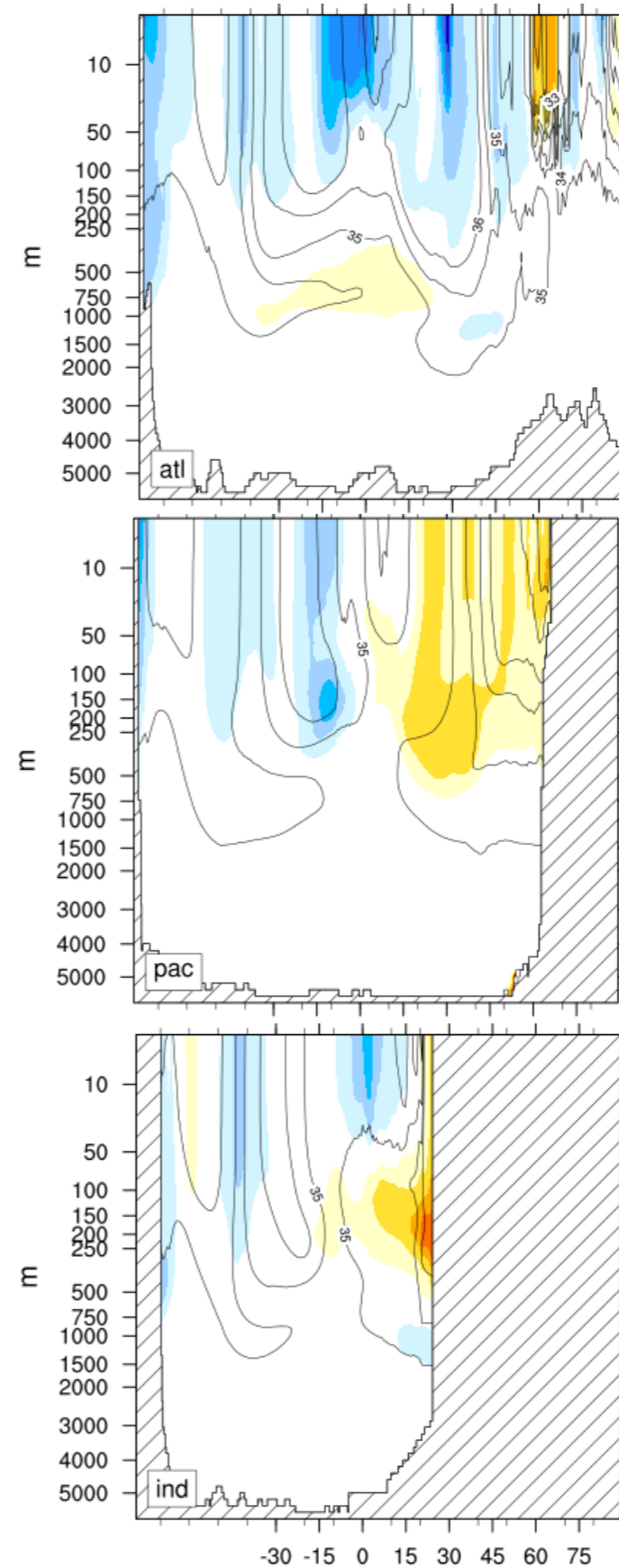
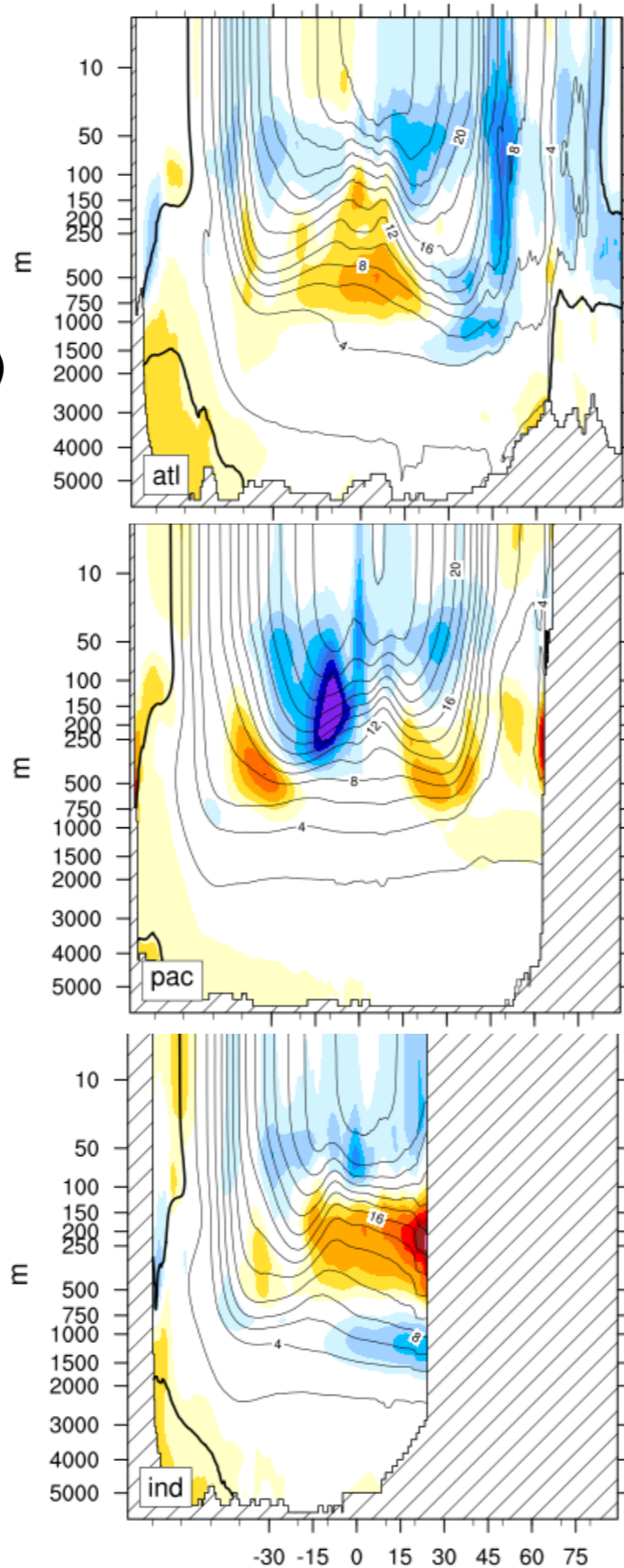
Potential temperature

Salinity

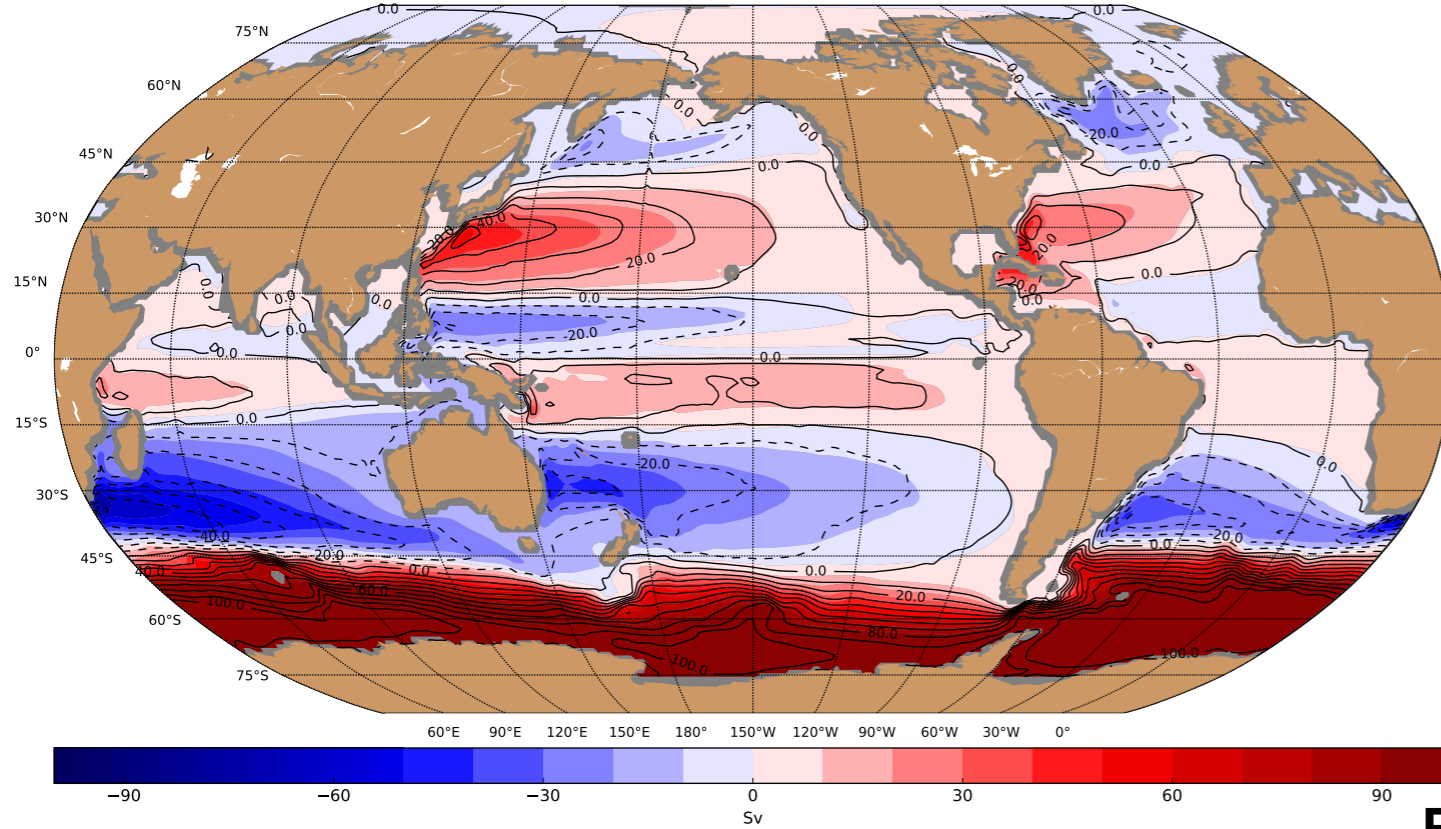
Contours : observed climatology from WOA13

Shading : model bias historical mean (1981-2010)

**Still large biases in all basins even if improved in the Atlantic and Indian oceans with respect to CNRM-CM5**



**Historical mean (1981-2010) BSF**

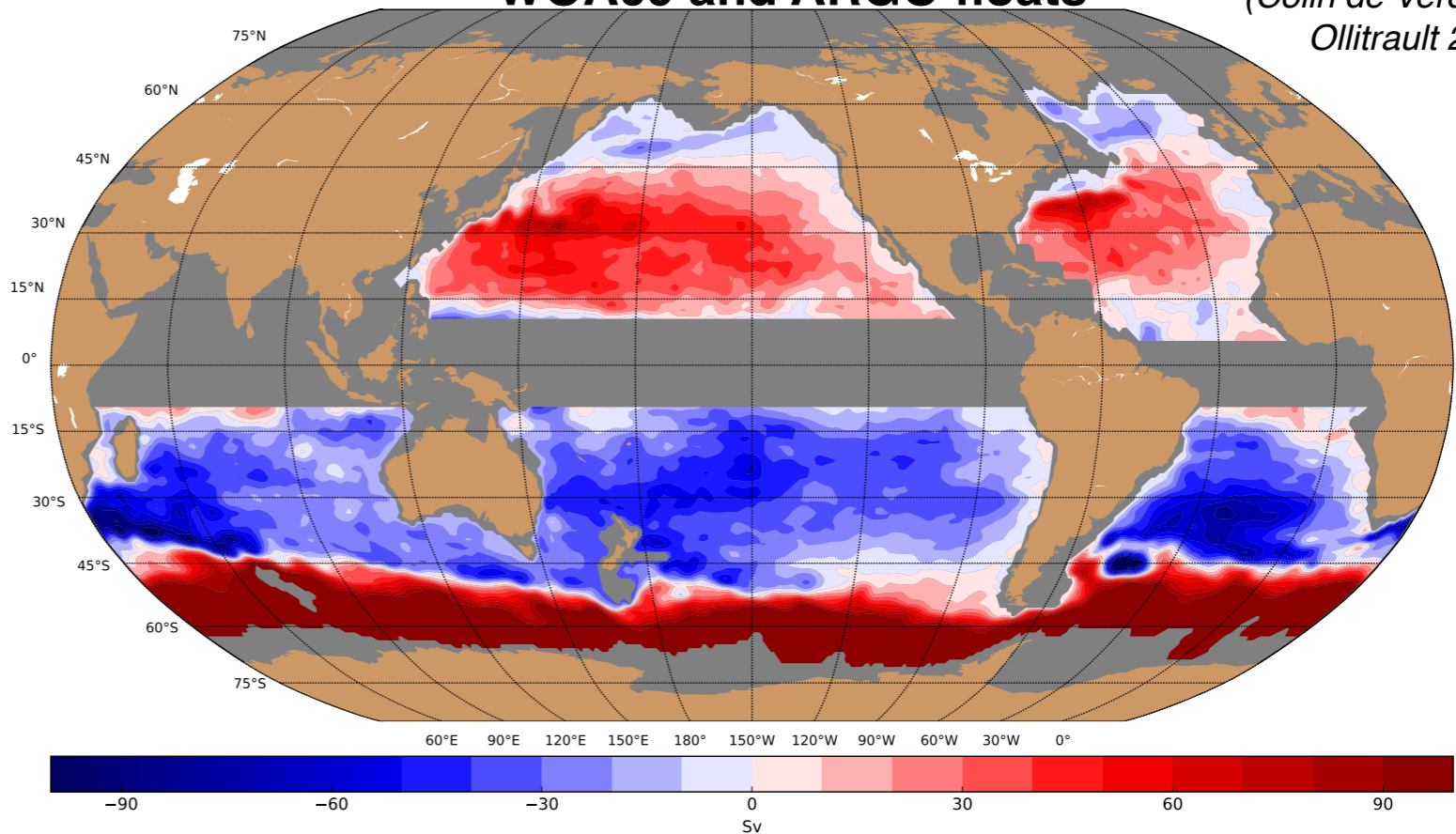


**Not too bad but:**

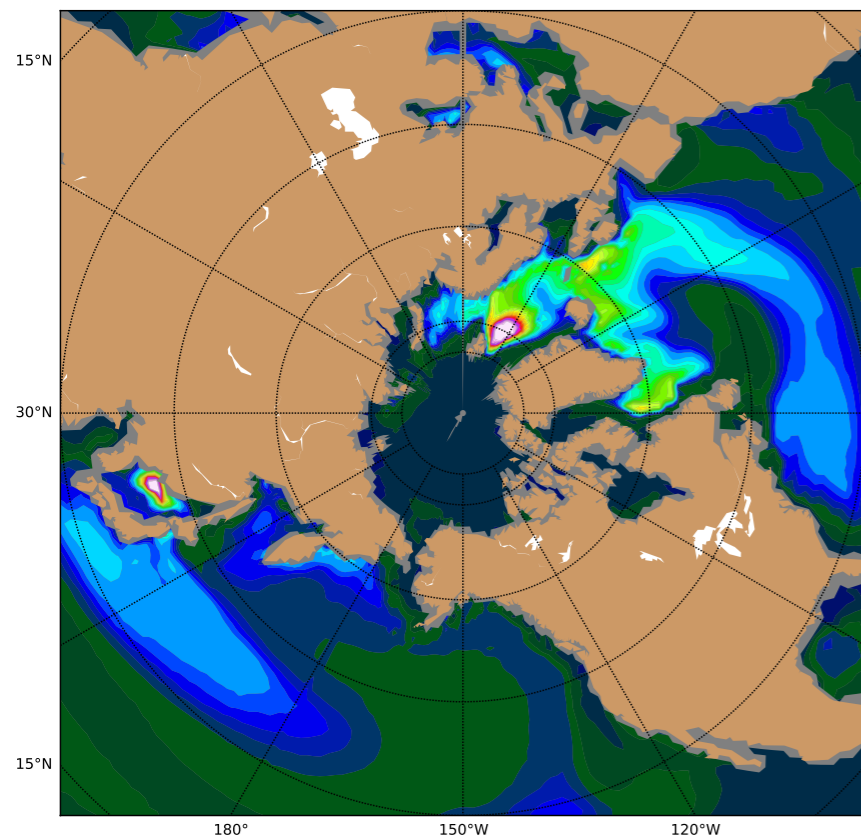
- **Too weak**
- **Too zonal**
- **Too much southward**

**Reconstructed BSF from WOA09 and ARGO floats**

*(Colin de Verdière and Ollitrault 2016)*



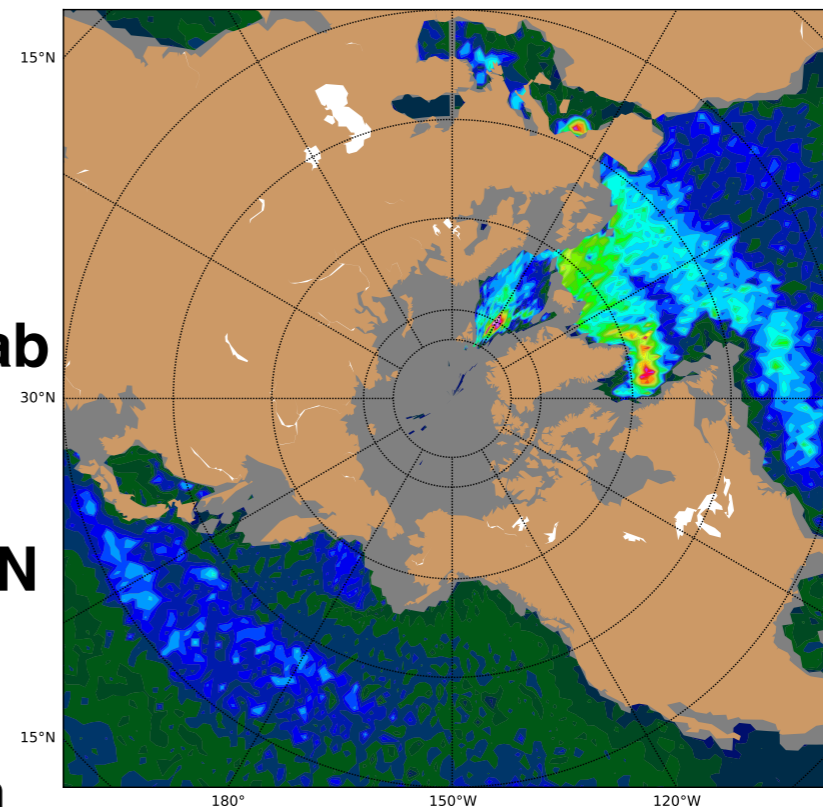
**Historical mean (1981-2010)  
Annual max mixed layer depth**



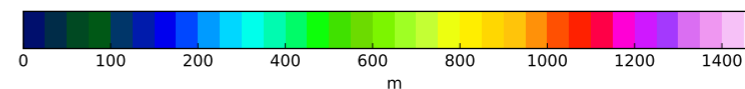
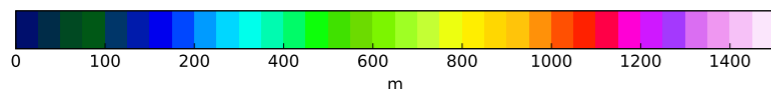
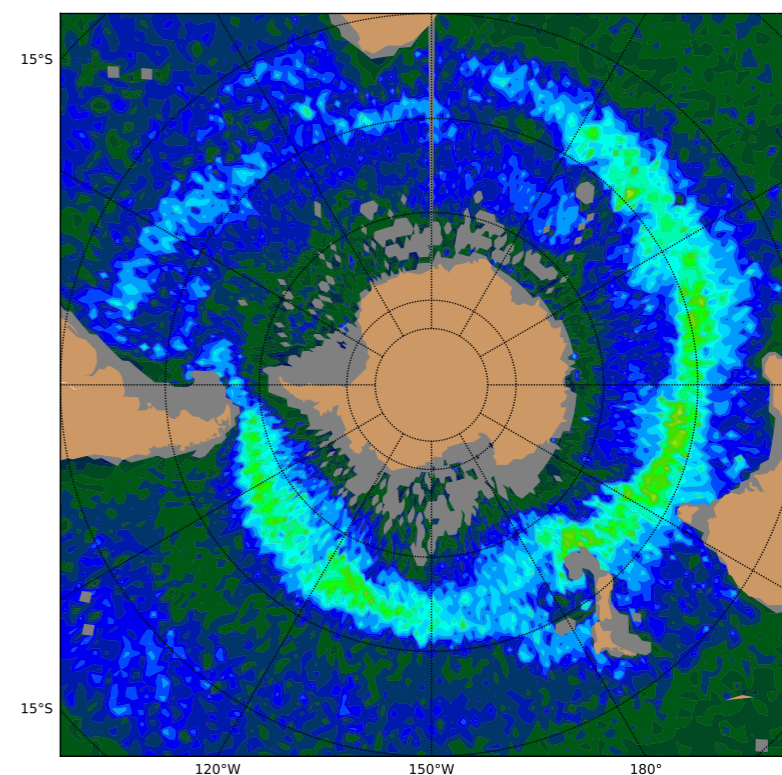
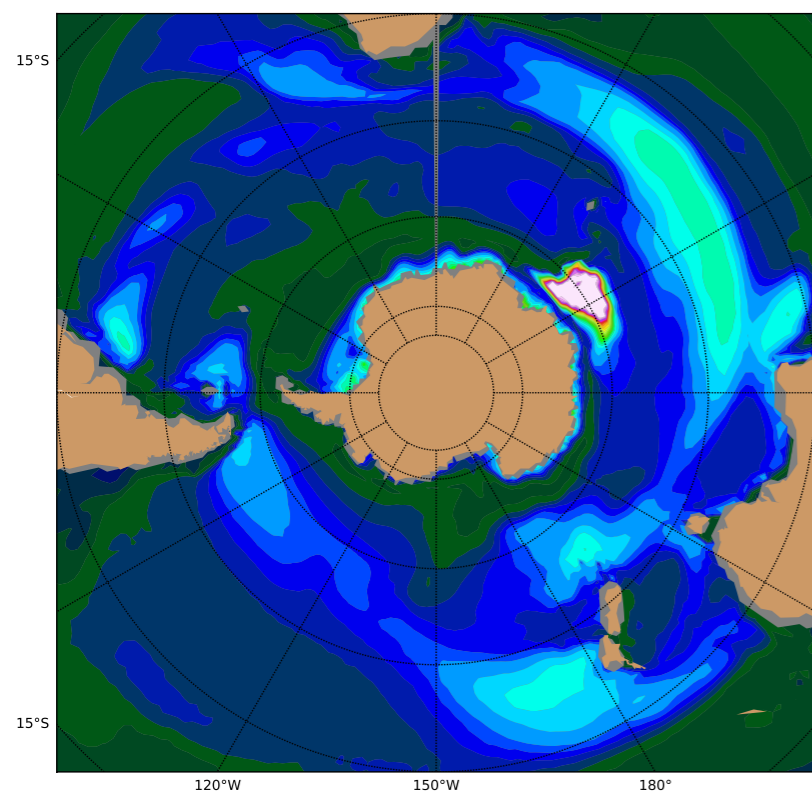
- **Deep water formation in the Lab Sea and GIN Sea**
- **Too large in the GIN Seas**
- **Unrealistic polynia in the Southern Ocean**

- **No deep water formation in the Wedell Sea or Ross Sea**

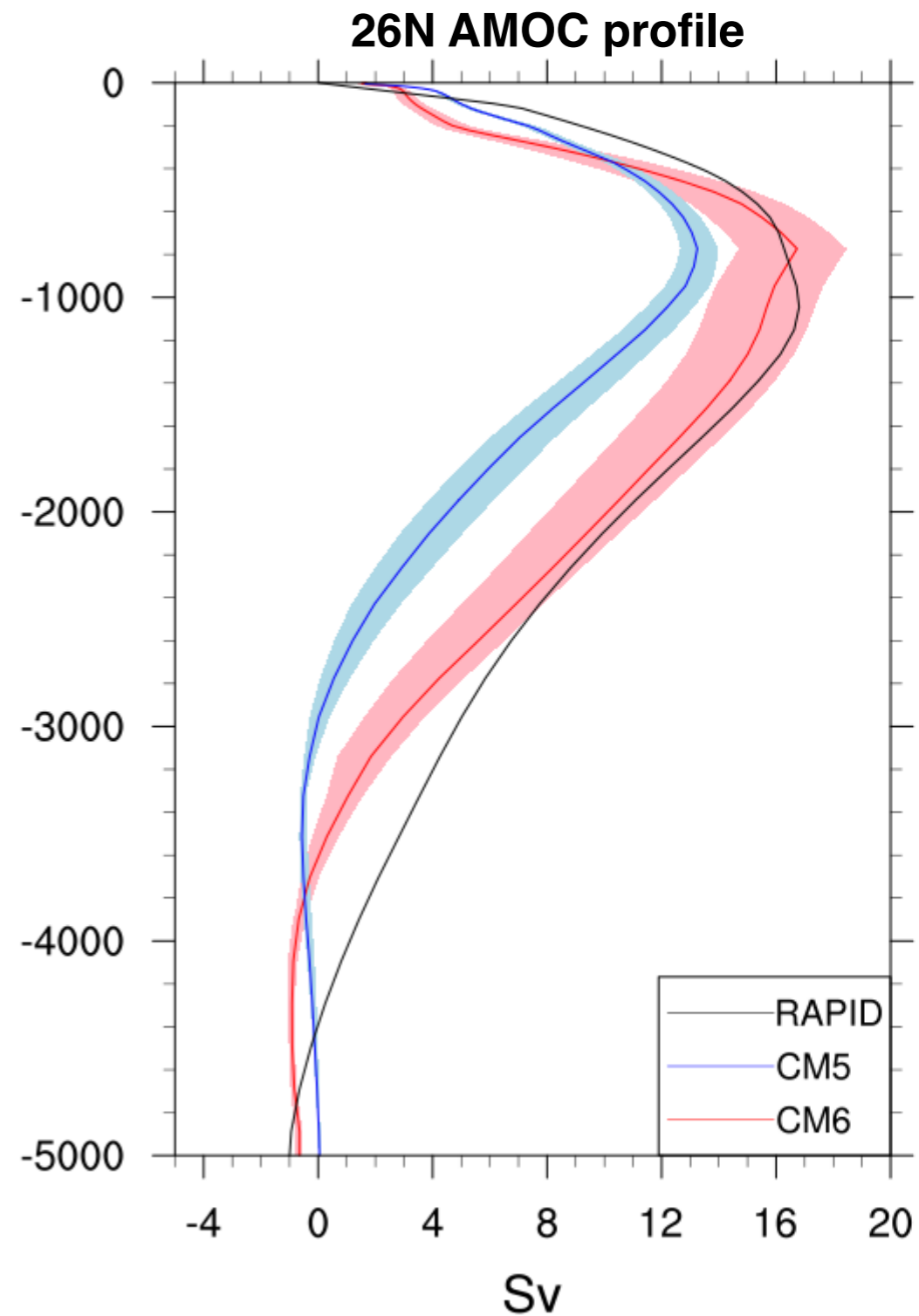
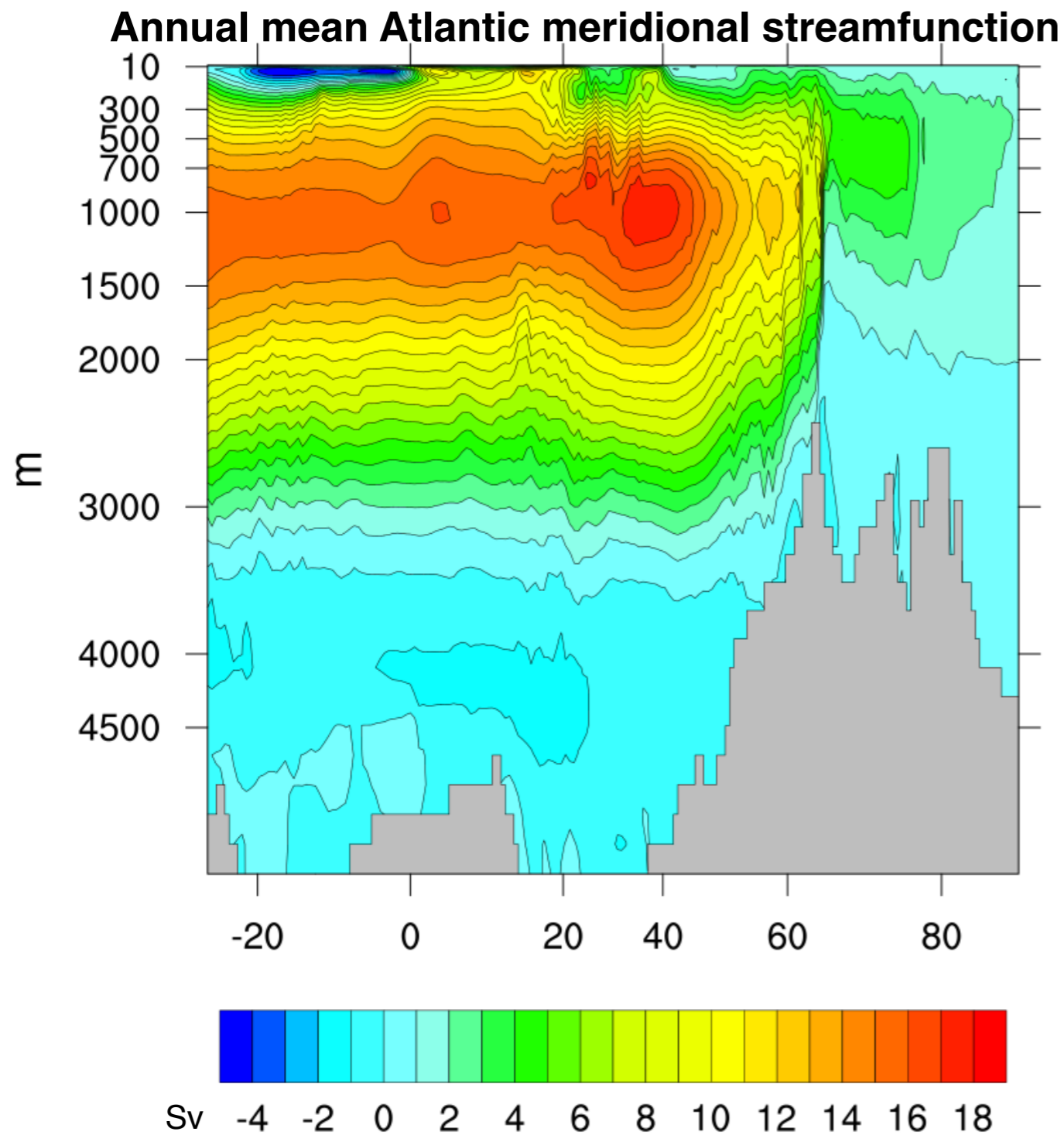
**ARGO observed (2004-2018)  
Annual max mixed layer depth**



*Holte et al (2017)*



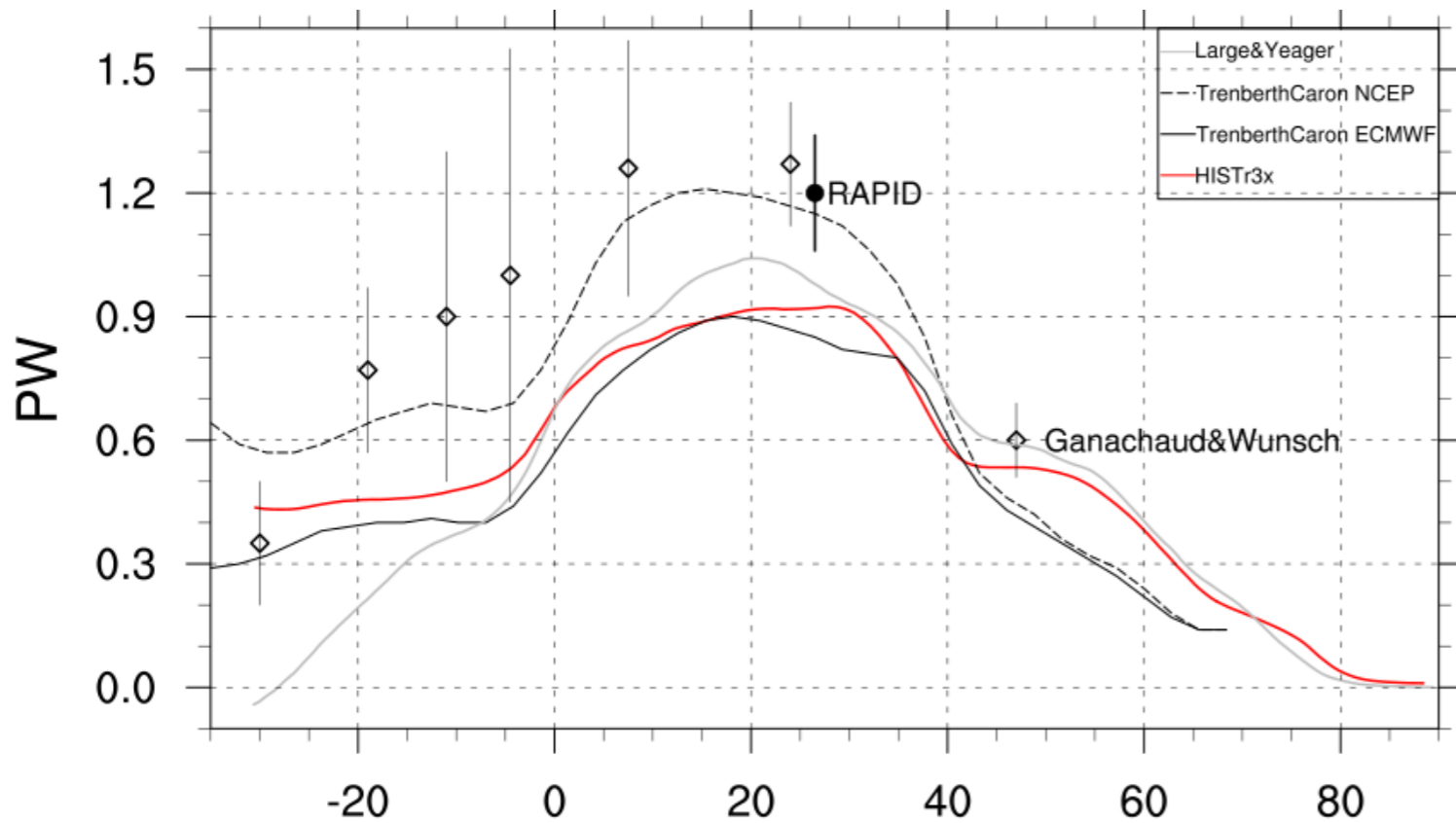
Historical mean (1981-2010)



● Realistic AMOC profile but still too shallow

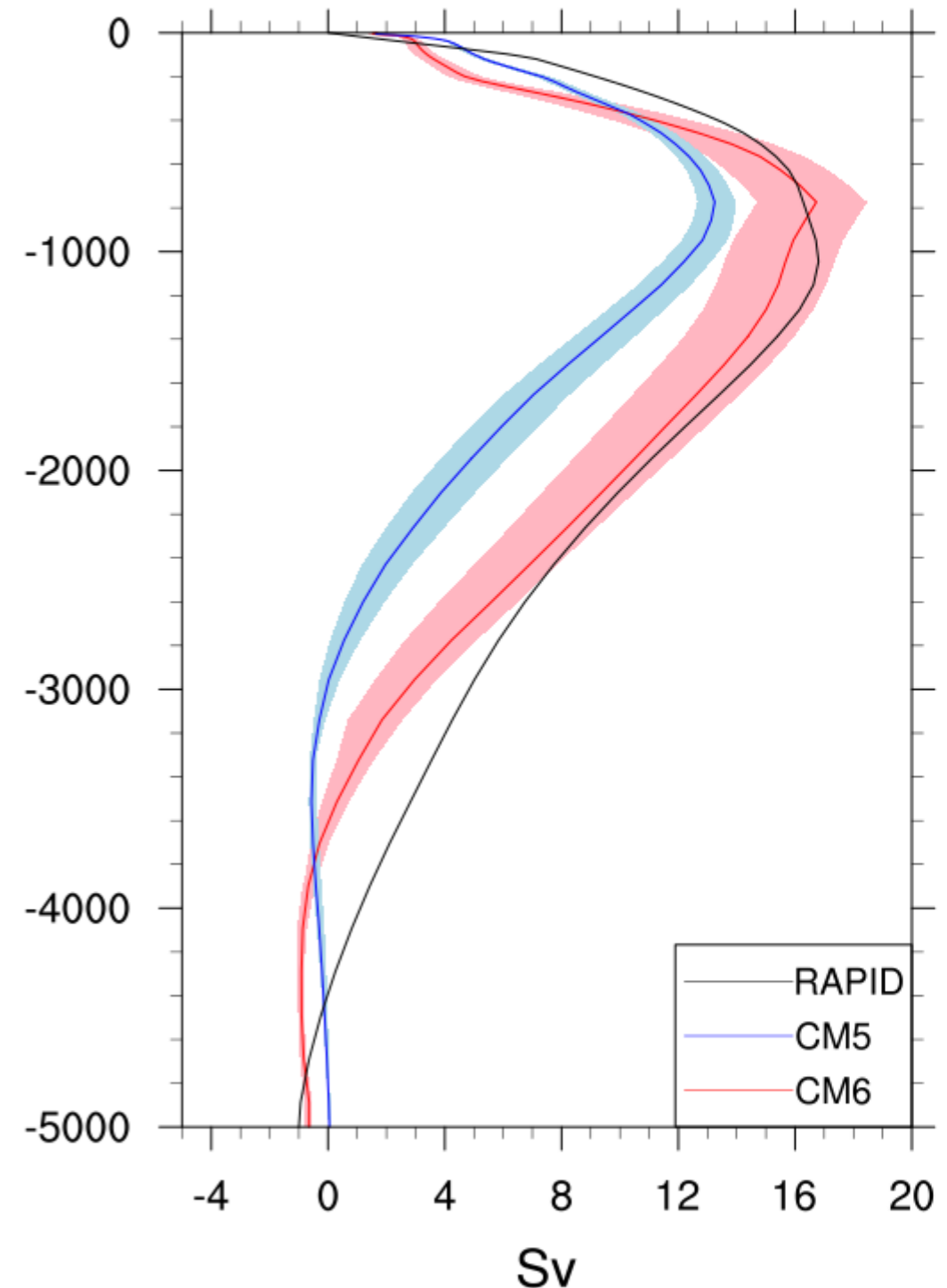
Historical mean (1981-2010)

Atlantic Meridional Ocean Heat Transport



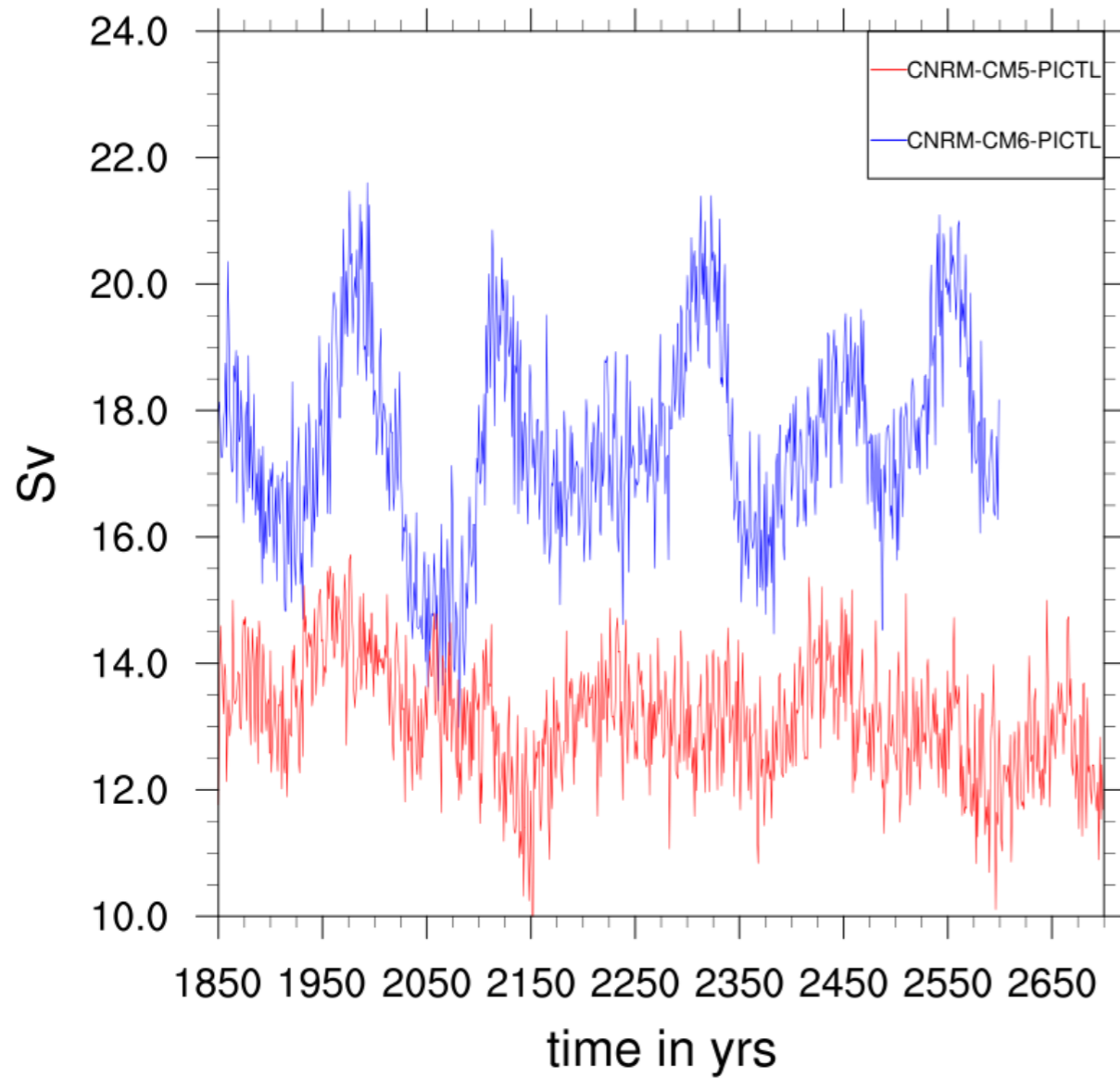
- **Still a weaker than observed Atlantic MHT despite the large AMOC**
- **Still biases in the temperature difference between the upper and lower NADW**

26N AMOC profile

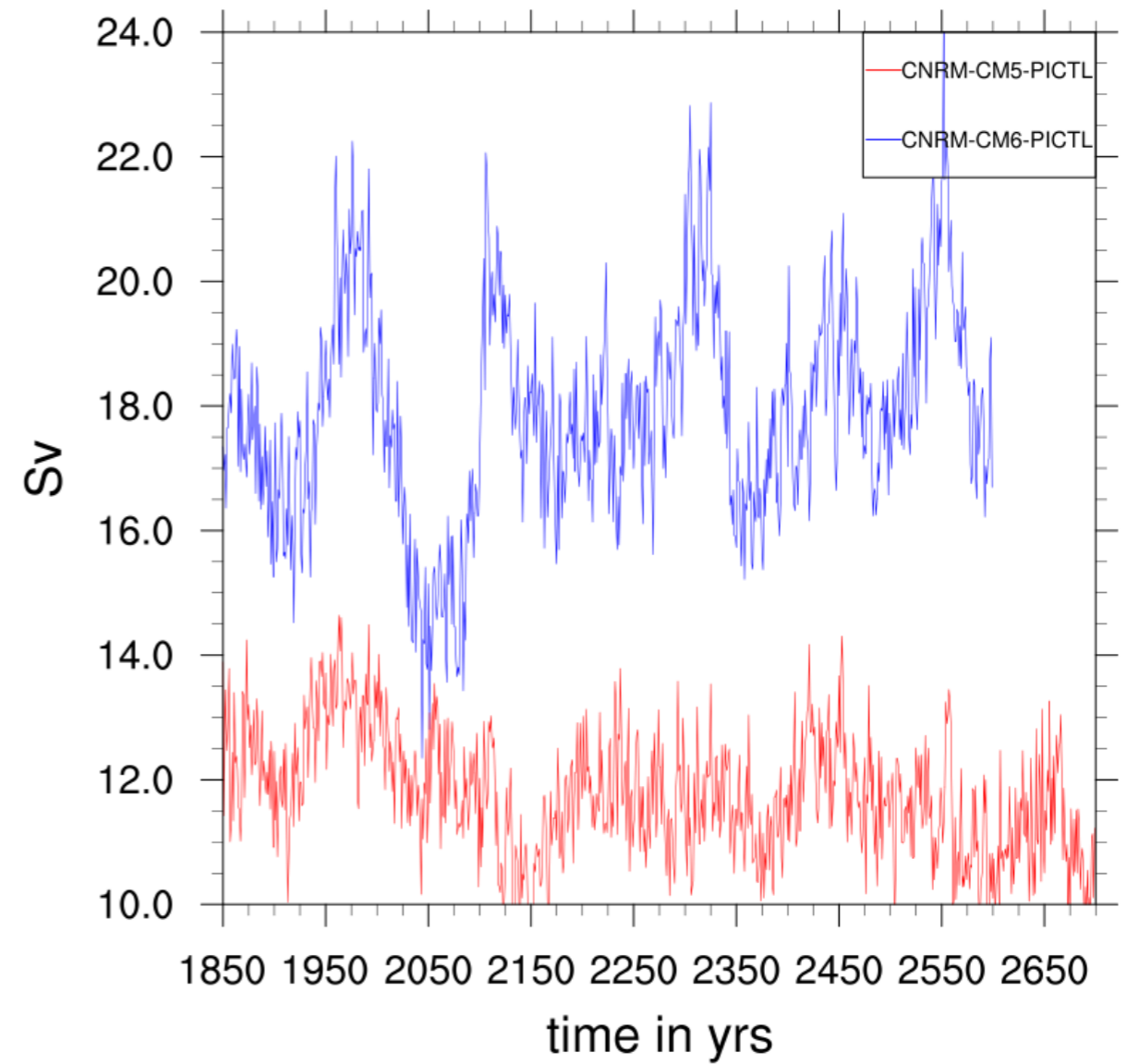


## Preindustrial Control

Max AMOC 26N



Max AMOC 40N

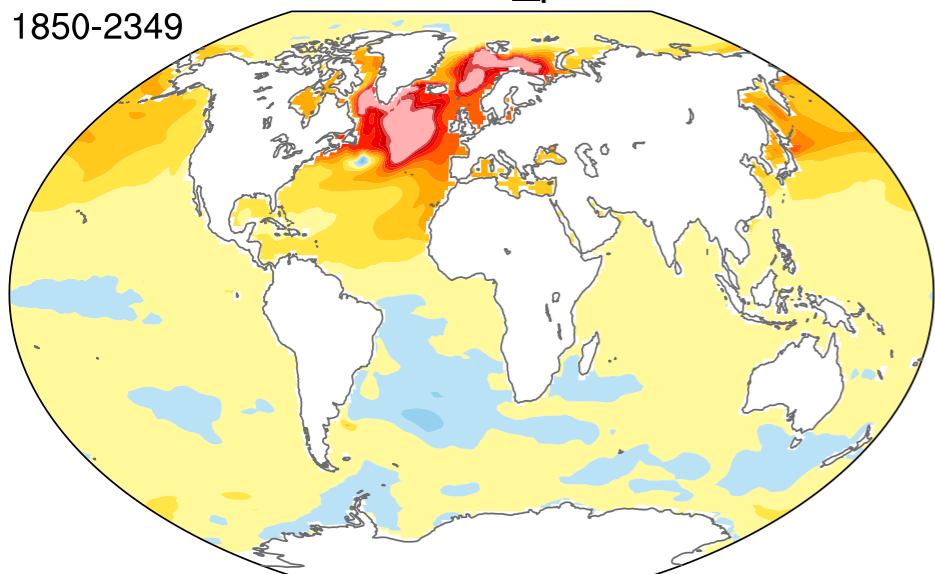


- **Large centennial variability in the AMOC**
- **Large oscillations (peak-to-peak variations)**

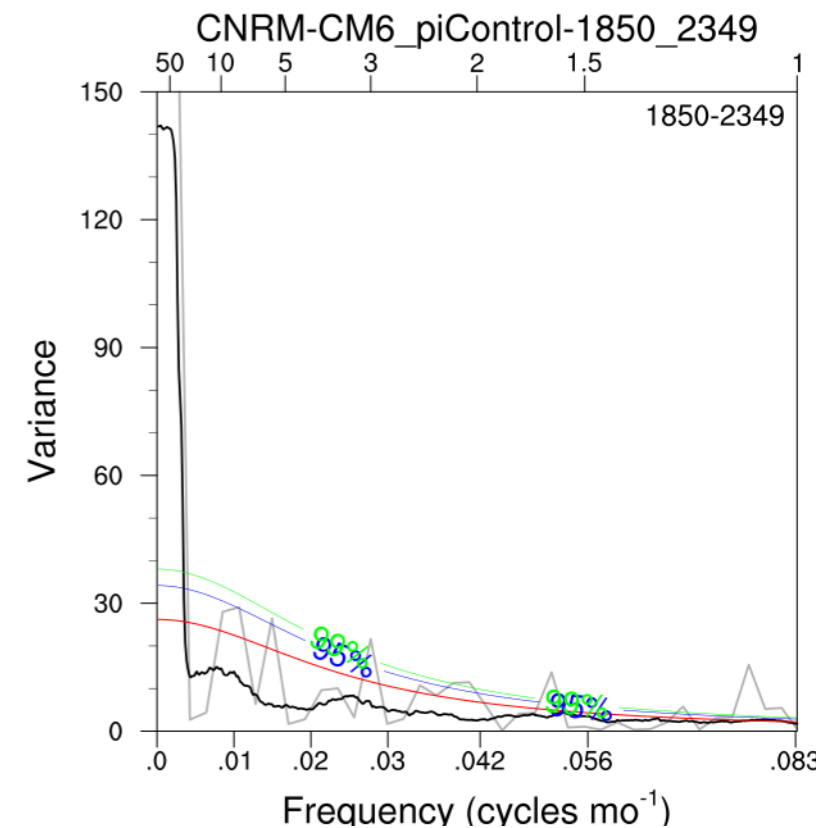
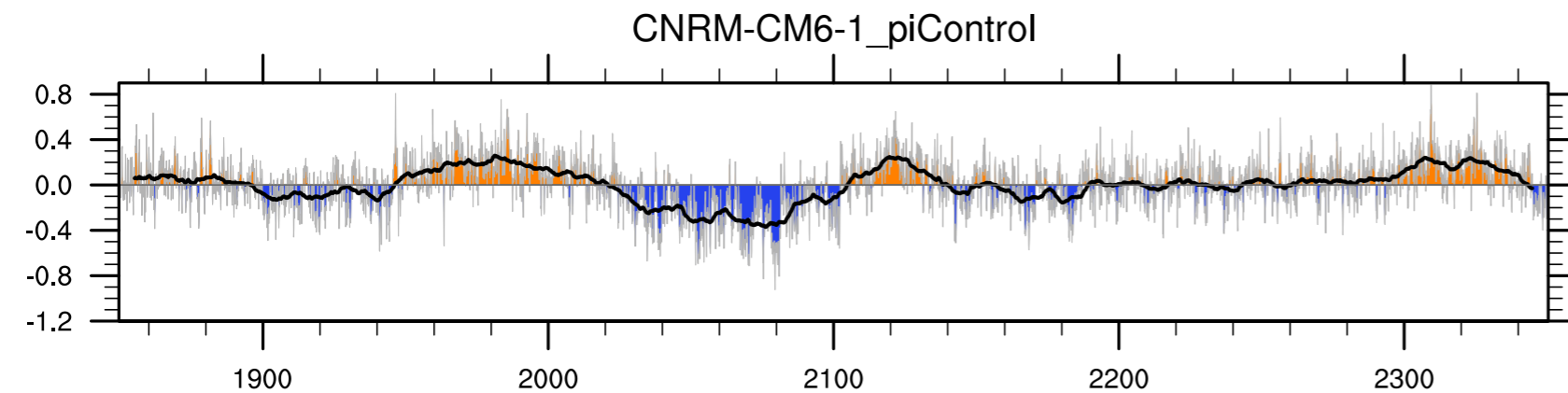
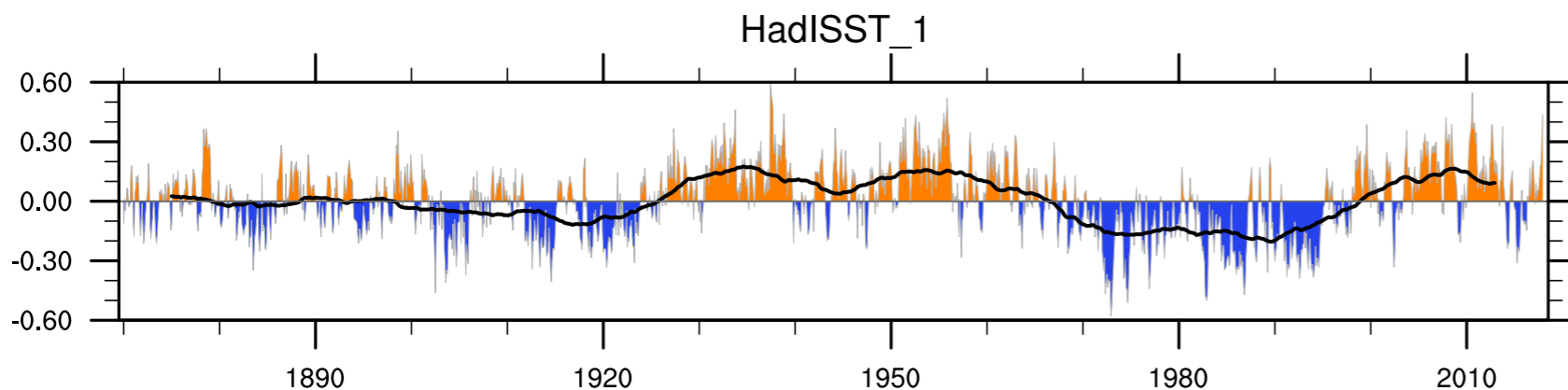
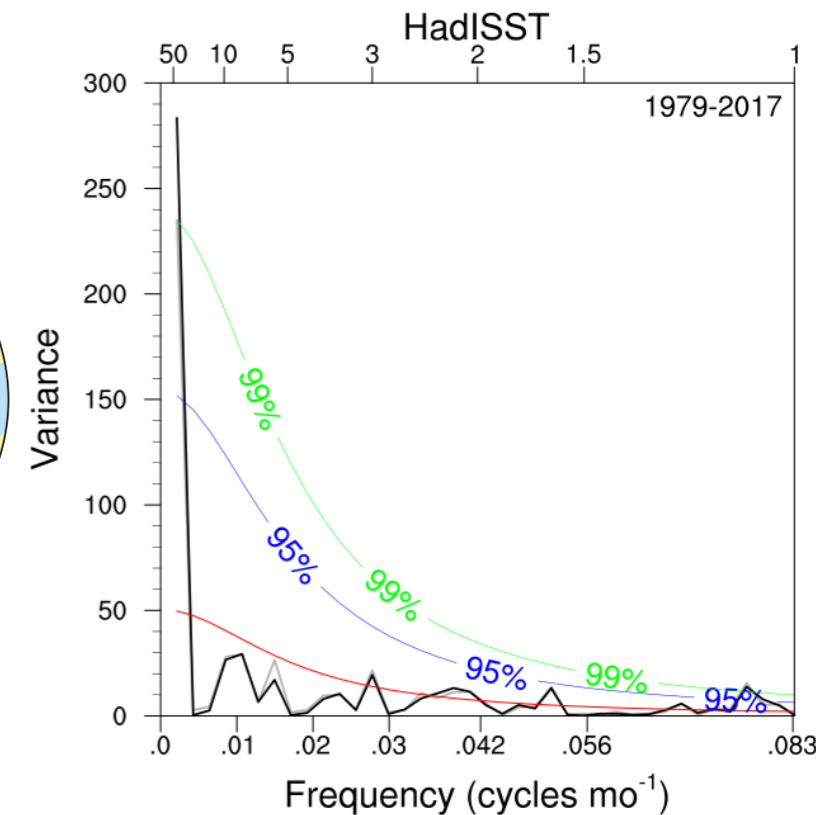
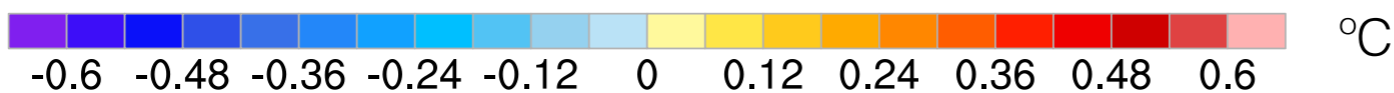
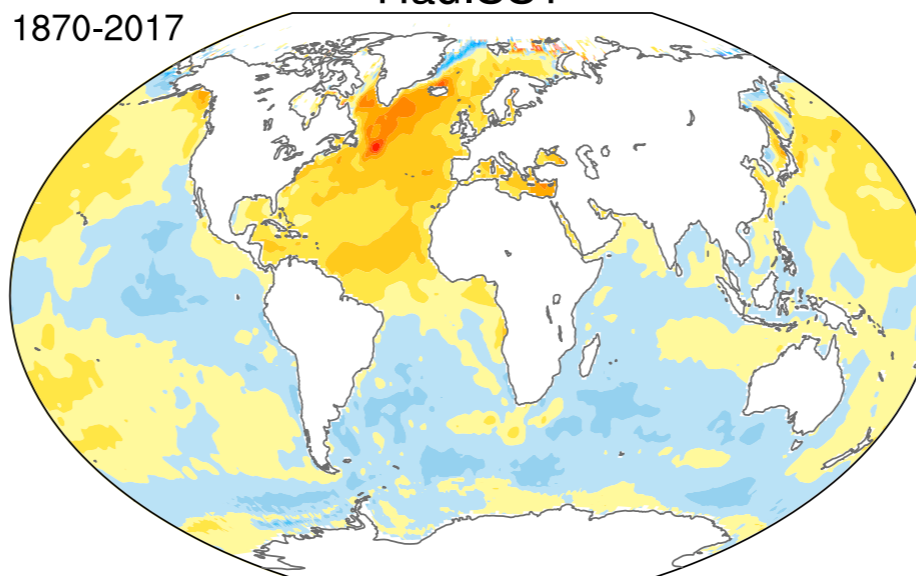


500 yrs

CNRM-CM6-1\_piControl

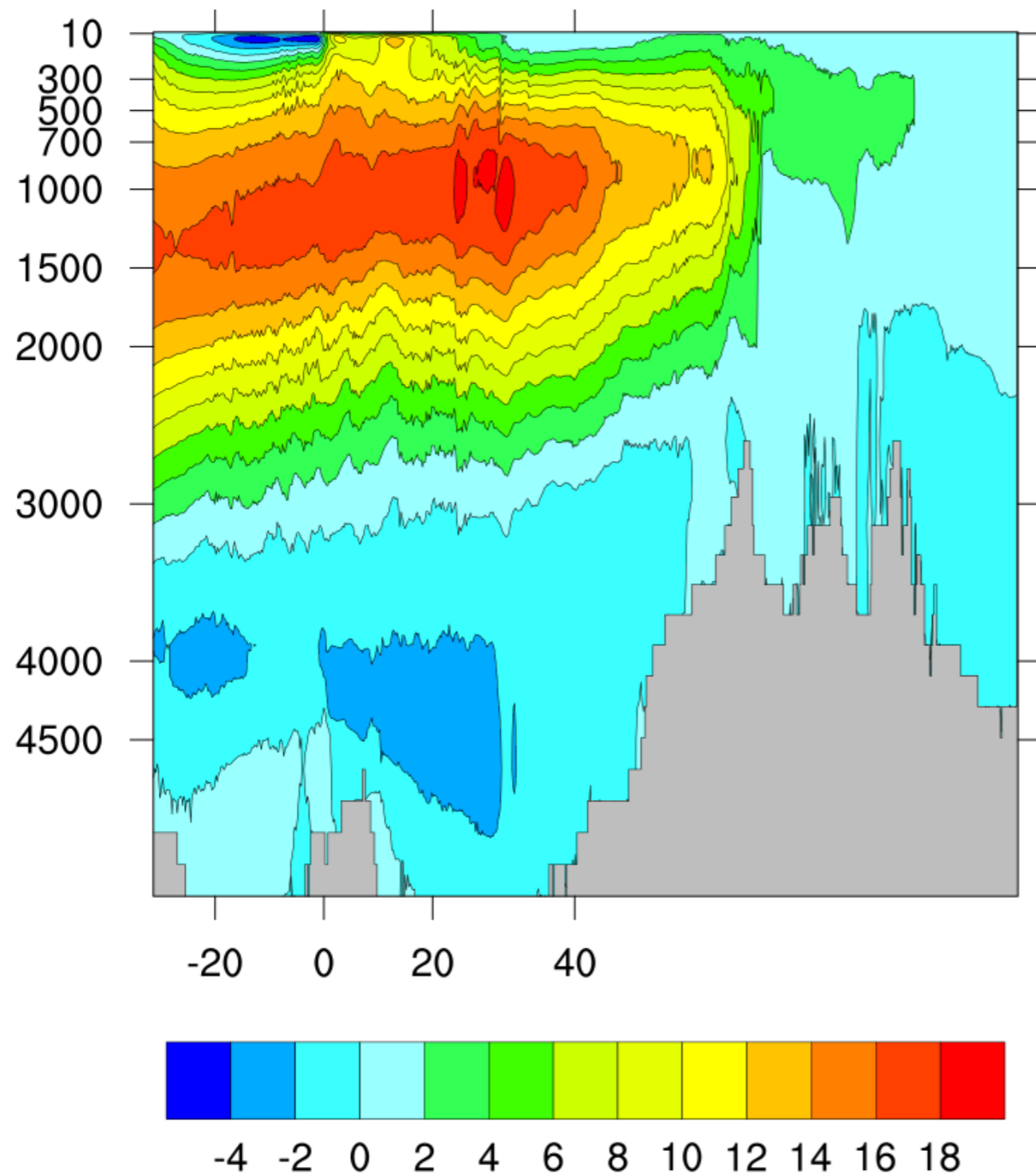


HadISST

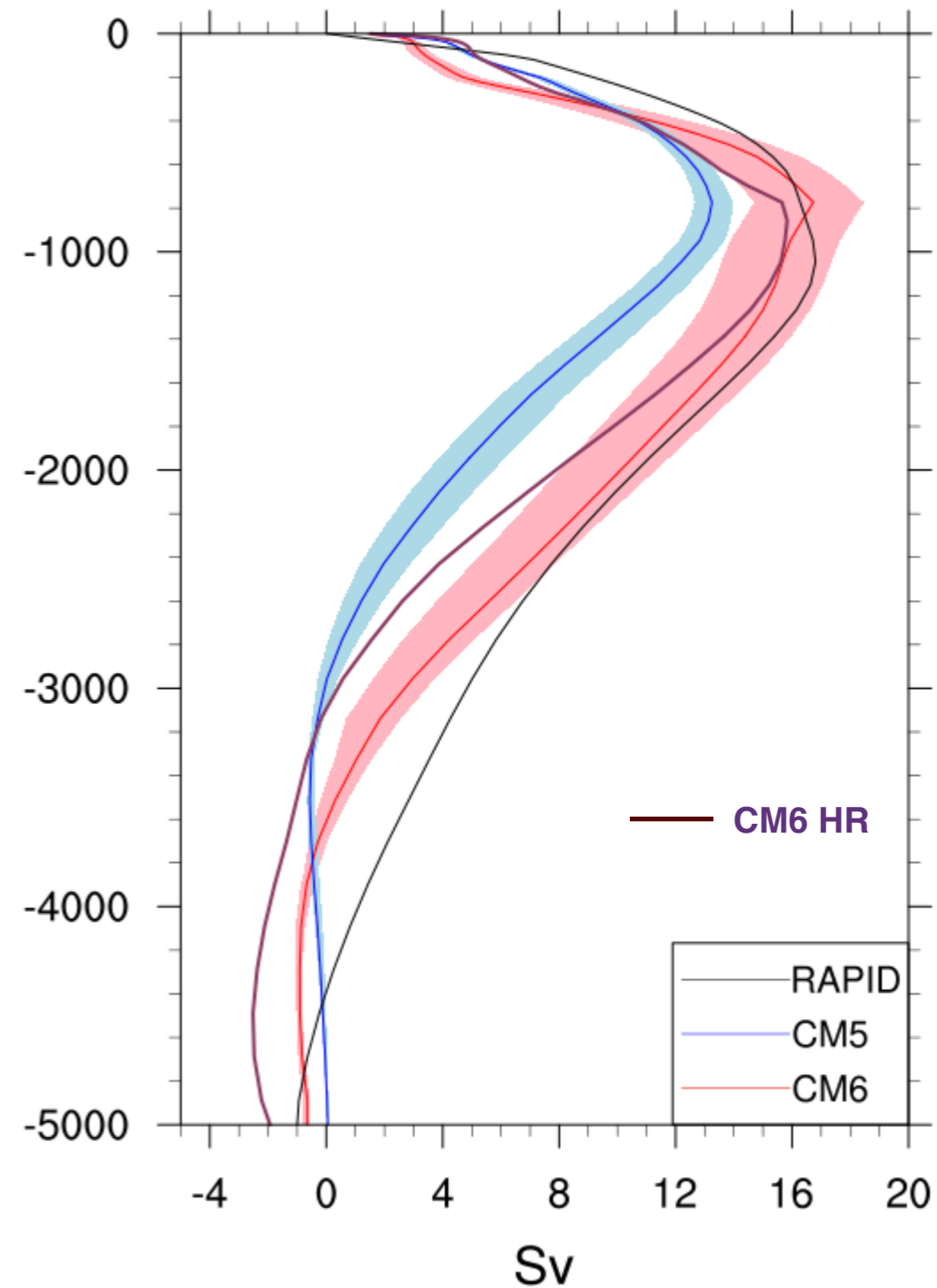


Historical simulation (1 member). Mean (1950-2014)

Annual mean Atlantic meridional streamfunction



26N AMOC profile

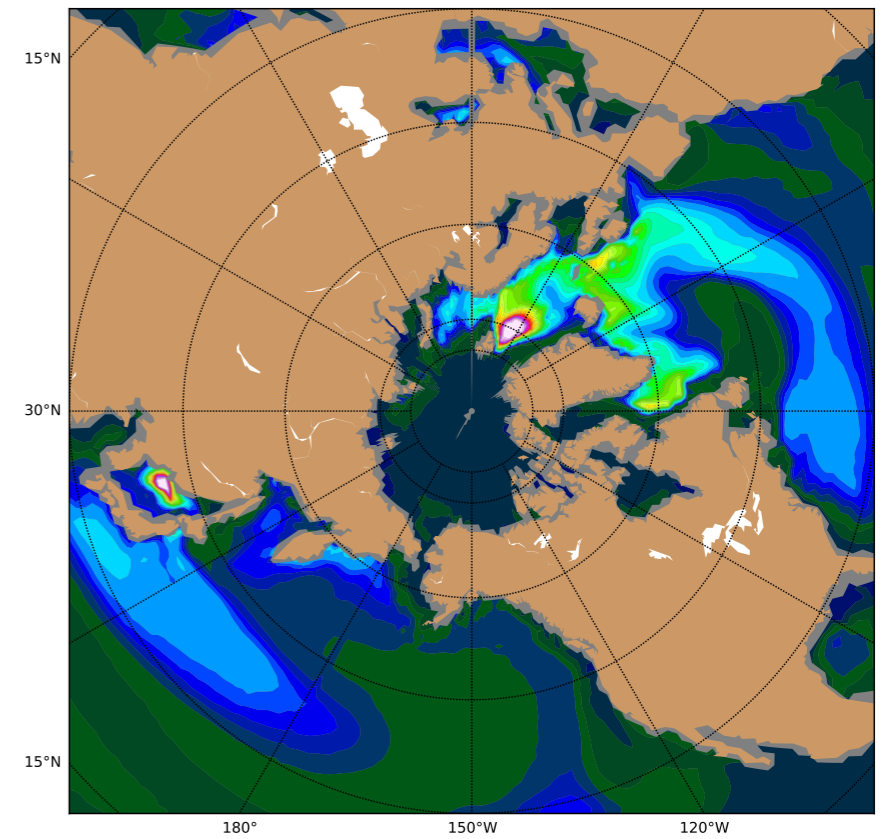
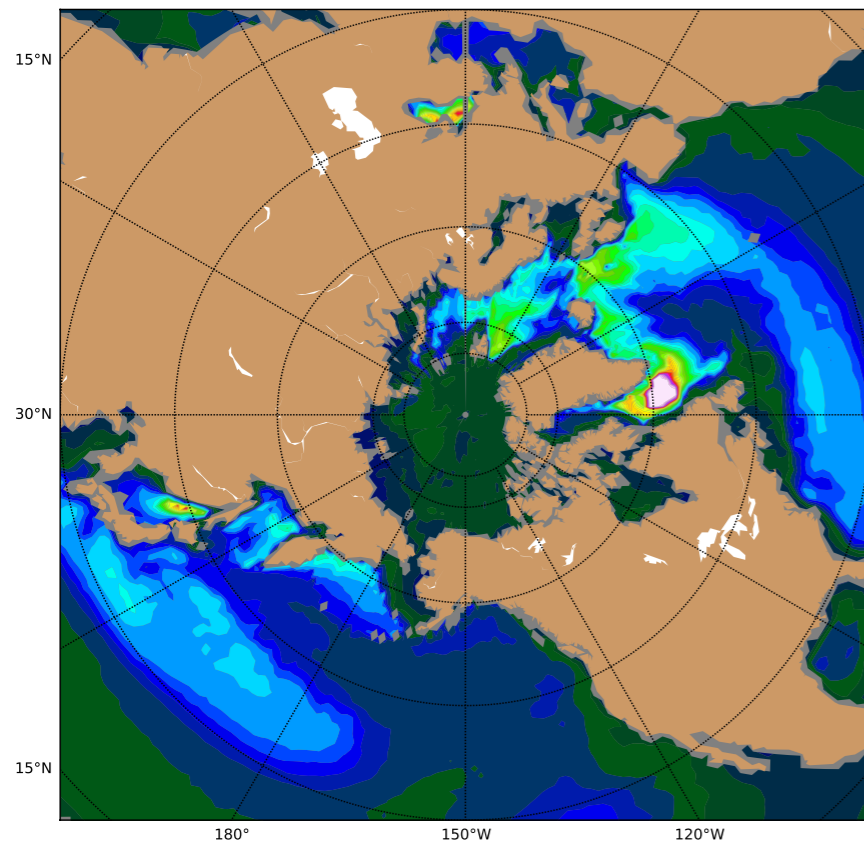


CNRM-CM6-1-HR

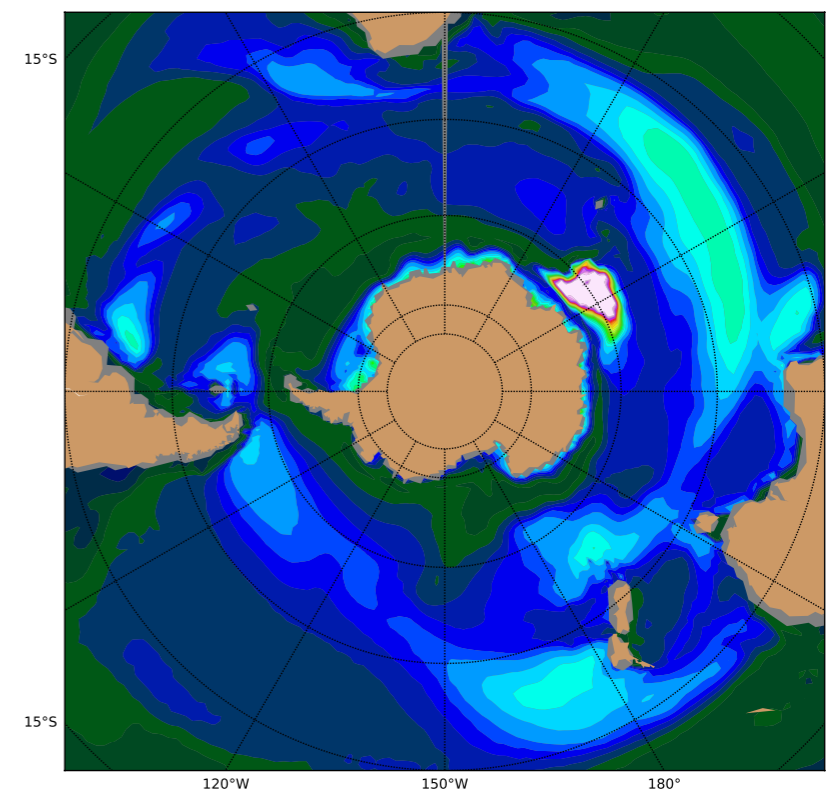
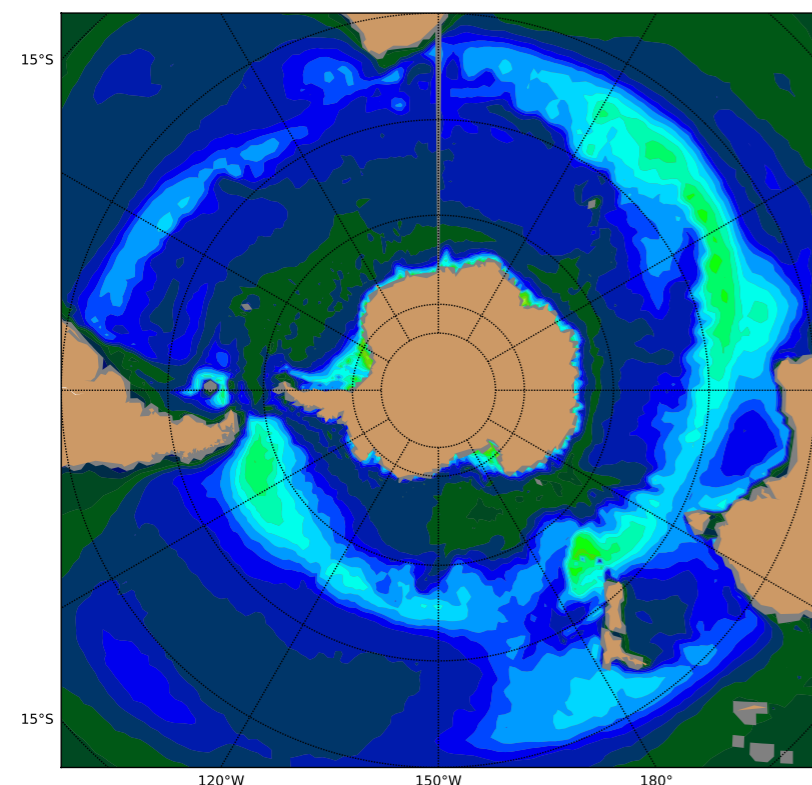
Mixed Layer Depth

CNRM-CM6-1-LR

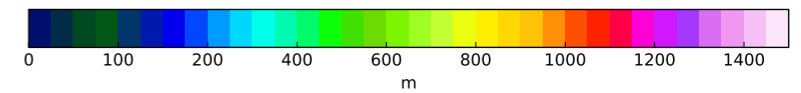
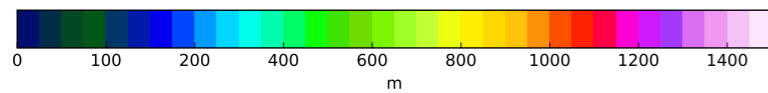
Historical mean (1981-2010)  
Annual max mixed layer depth



- **Better deep convection in the Labrador Sea in HR**



- **No unrealistic polynia in HR**



# Sea Ice Concentration

CNRM-CM6-1-LR

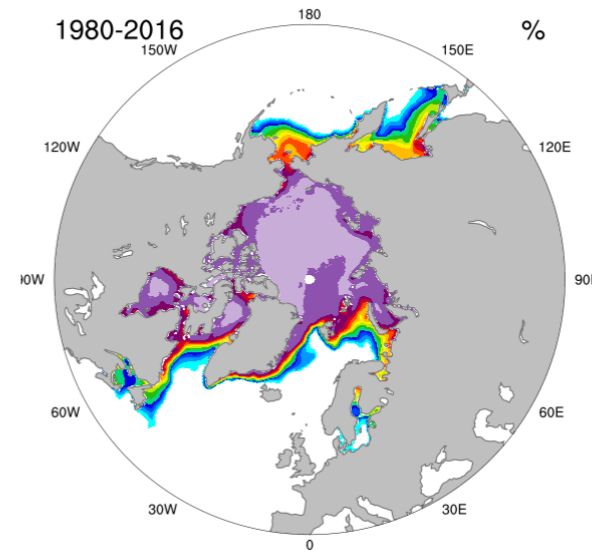
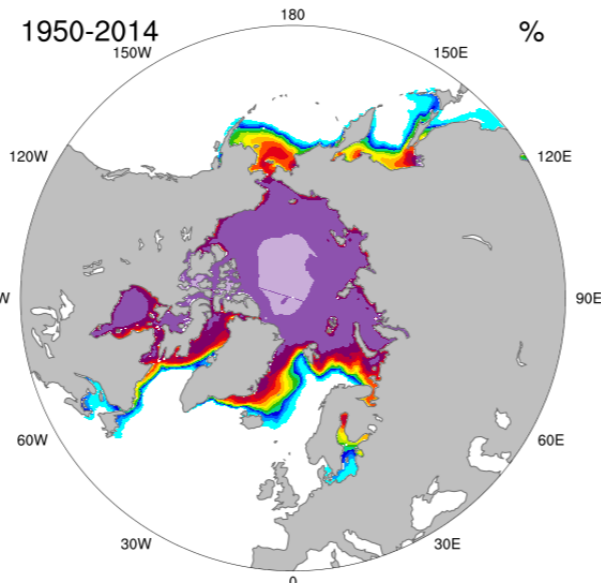
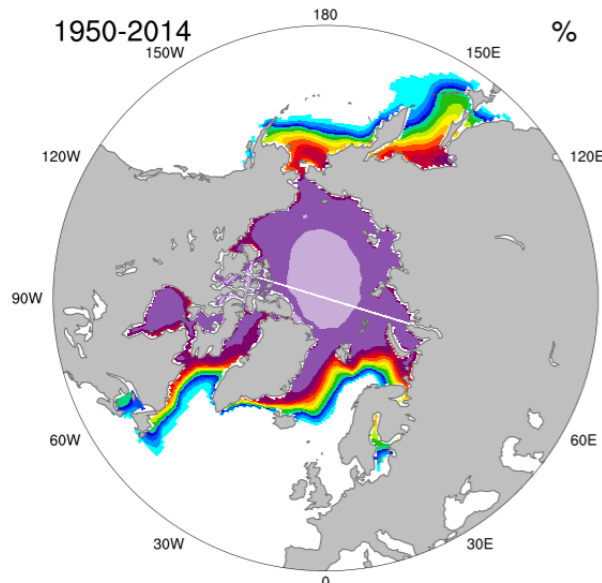
CNRM-CM6-1-HR

Observations

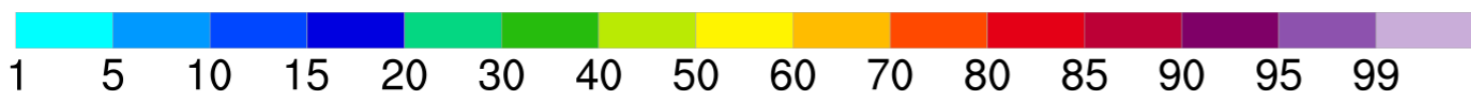
CNRM-CM6\_BR\_historical-1950\_2014

CNRM-CM6\_HR\_historical-1950\_2014

NASA Bootstrap NH



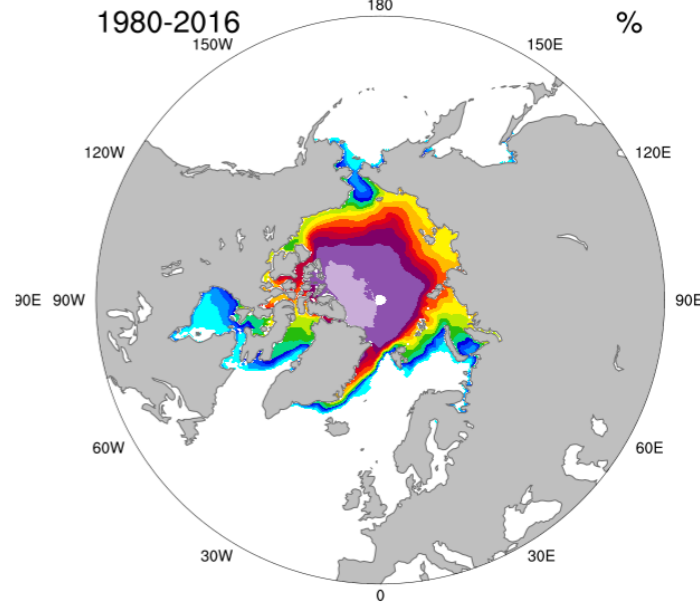
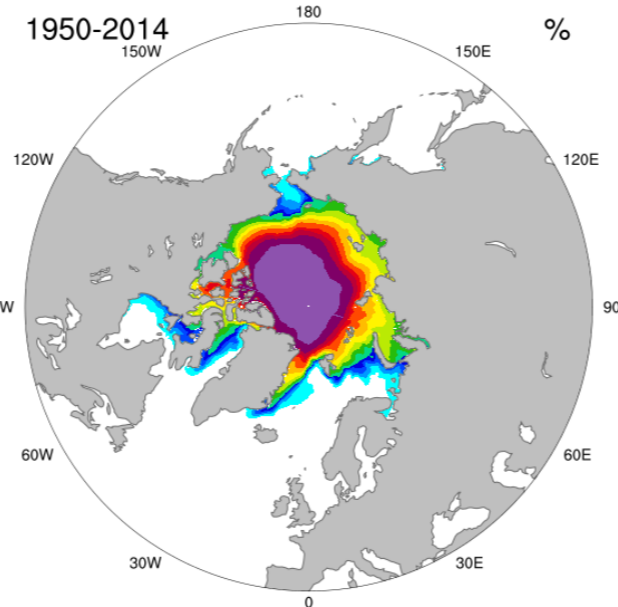
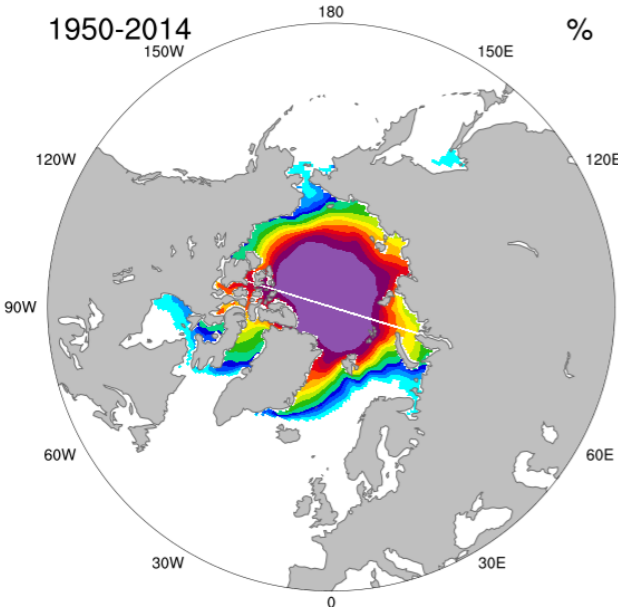
MAM



CNRM-CM6\_BR\_historical-1950\_2014

CNRM-CM6\_HR\_historical-1950\_2014

NASA Bootstrap NH



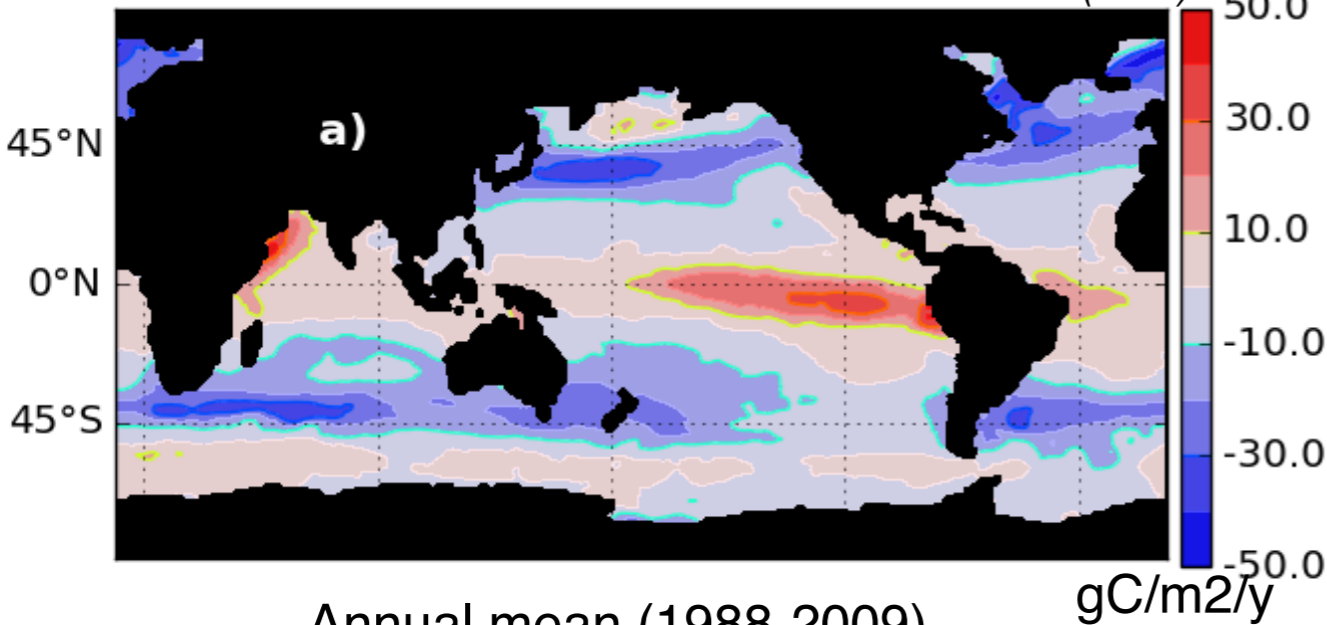
SON



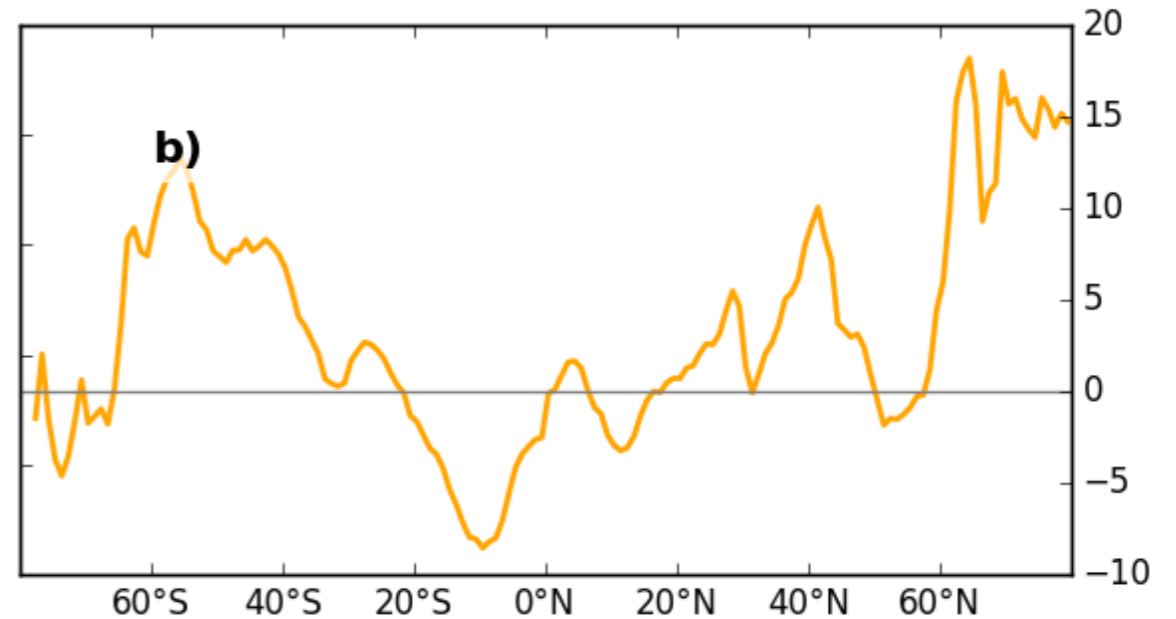
Annual mean (1982-2011)

**Observations**

*Landshützer (2015)*

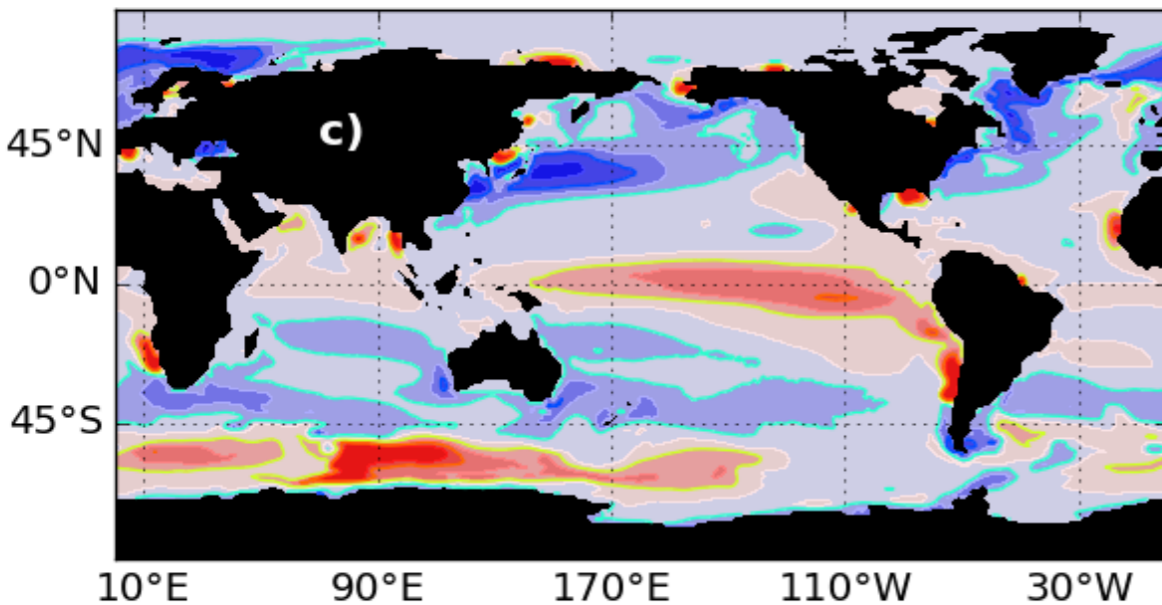


**Bias of zonal mean**



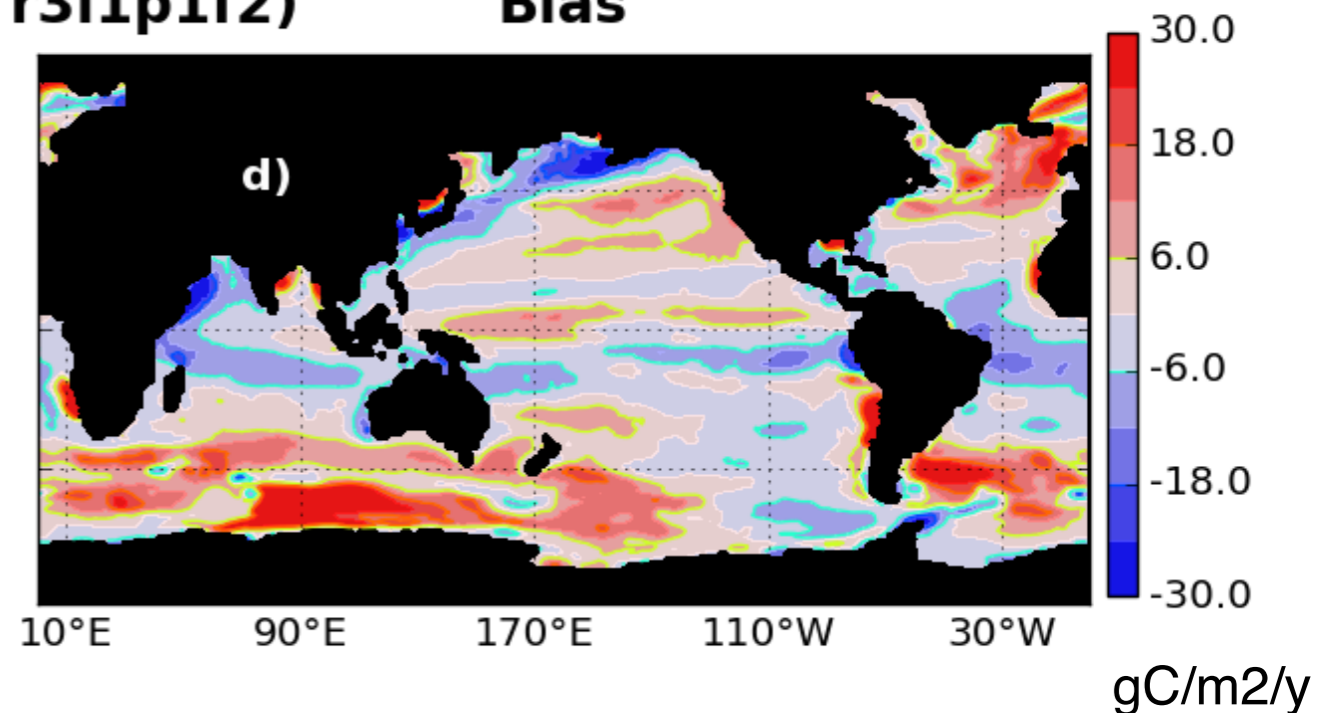
Annual mean (1988-2009)

**Ensemble mean (r1i1p1f2 + r2i1p1f2 + r3i1p1f2)**



**Bias**

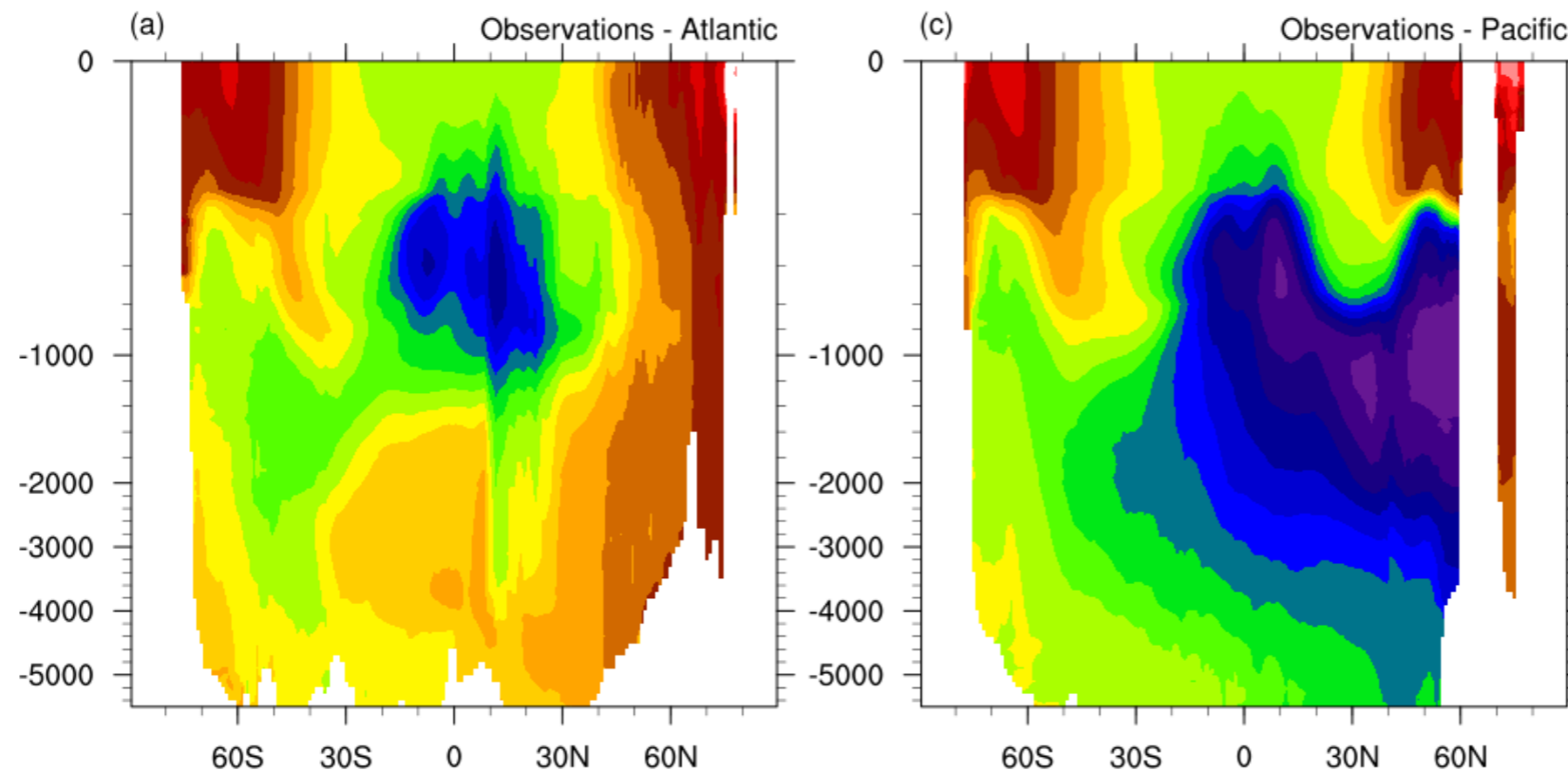
rmse = 9.91



- Large biases left in the Southern Ocean and in large mixing regions
- Improvements with respect to ESM1

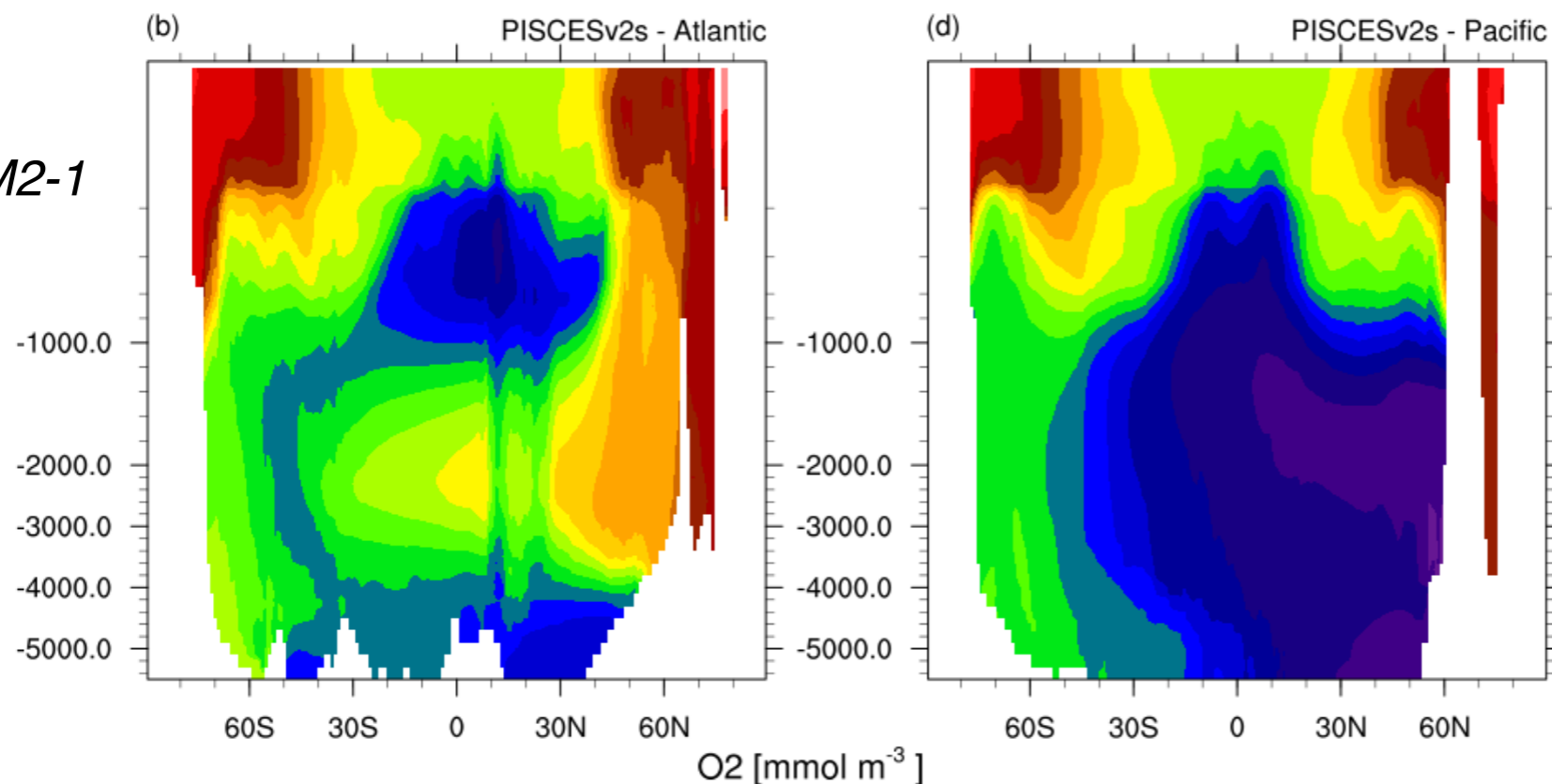
Annual mean (1986-2005)

WOA13



- Reasonably good distribution
- Too weak at depth : AABW bias

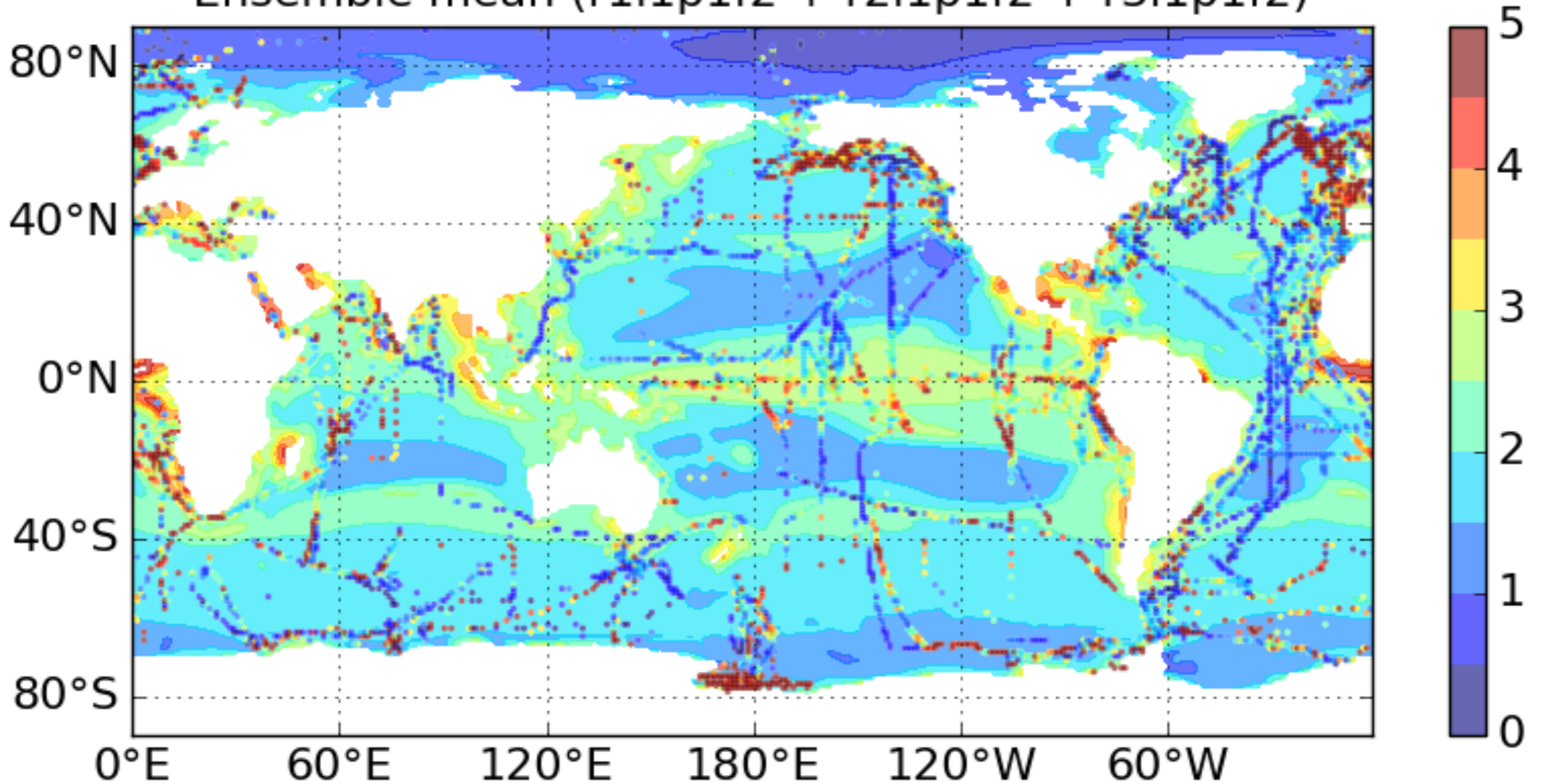
CNRM-ESM2-1



Shading : model  
 Dots : observations  
 (Lana et al. 2010)

Annual mean (1972-2009)

Ensemble mean (r1i1p1f2 + r2i1p1f2 + r3i1p1f2)



- The new DMS model yields better DMS fluxes toward the atmosphere

nmolS/L

That's it for today, thanks!

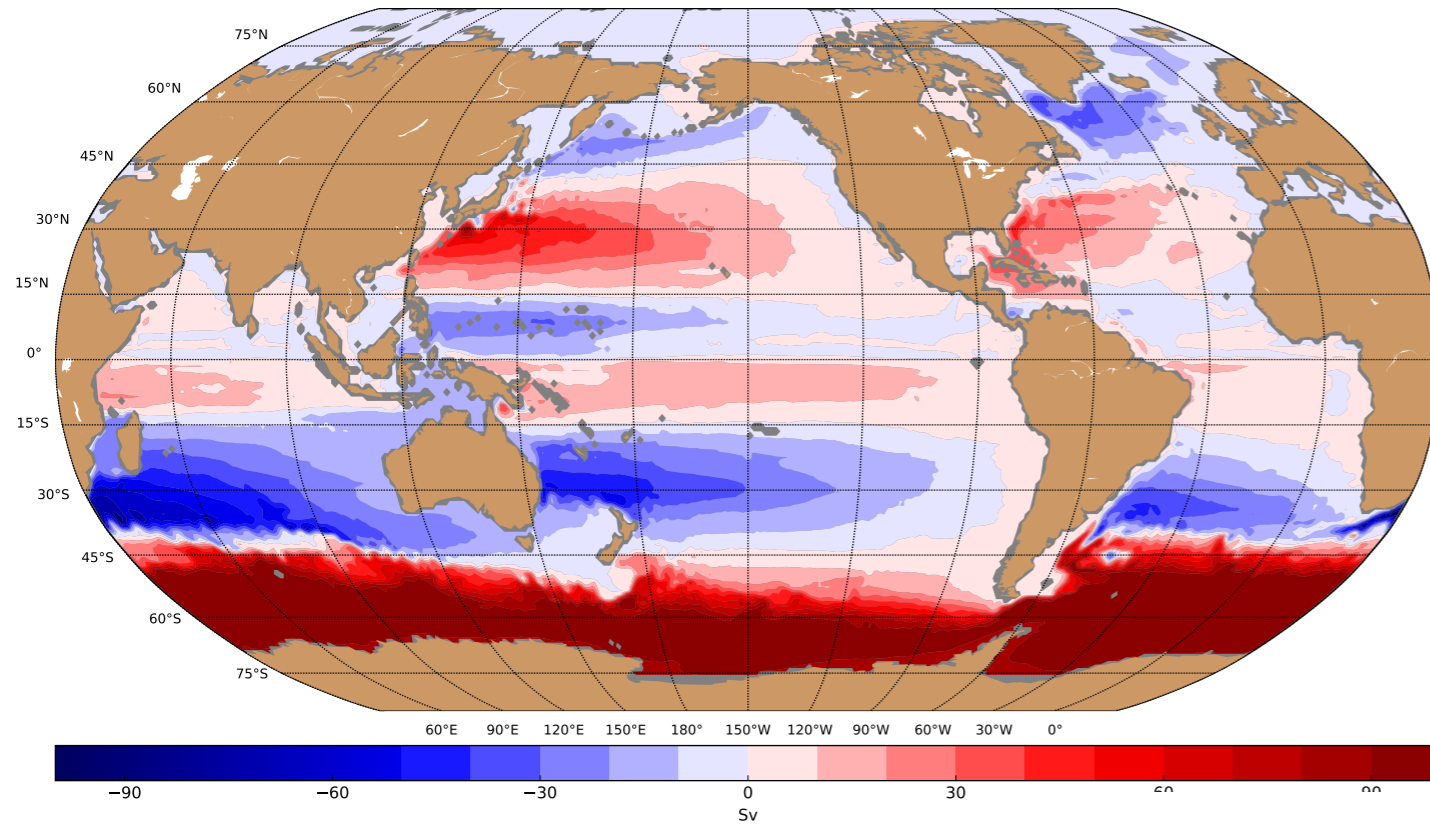
QUESTIONS ?



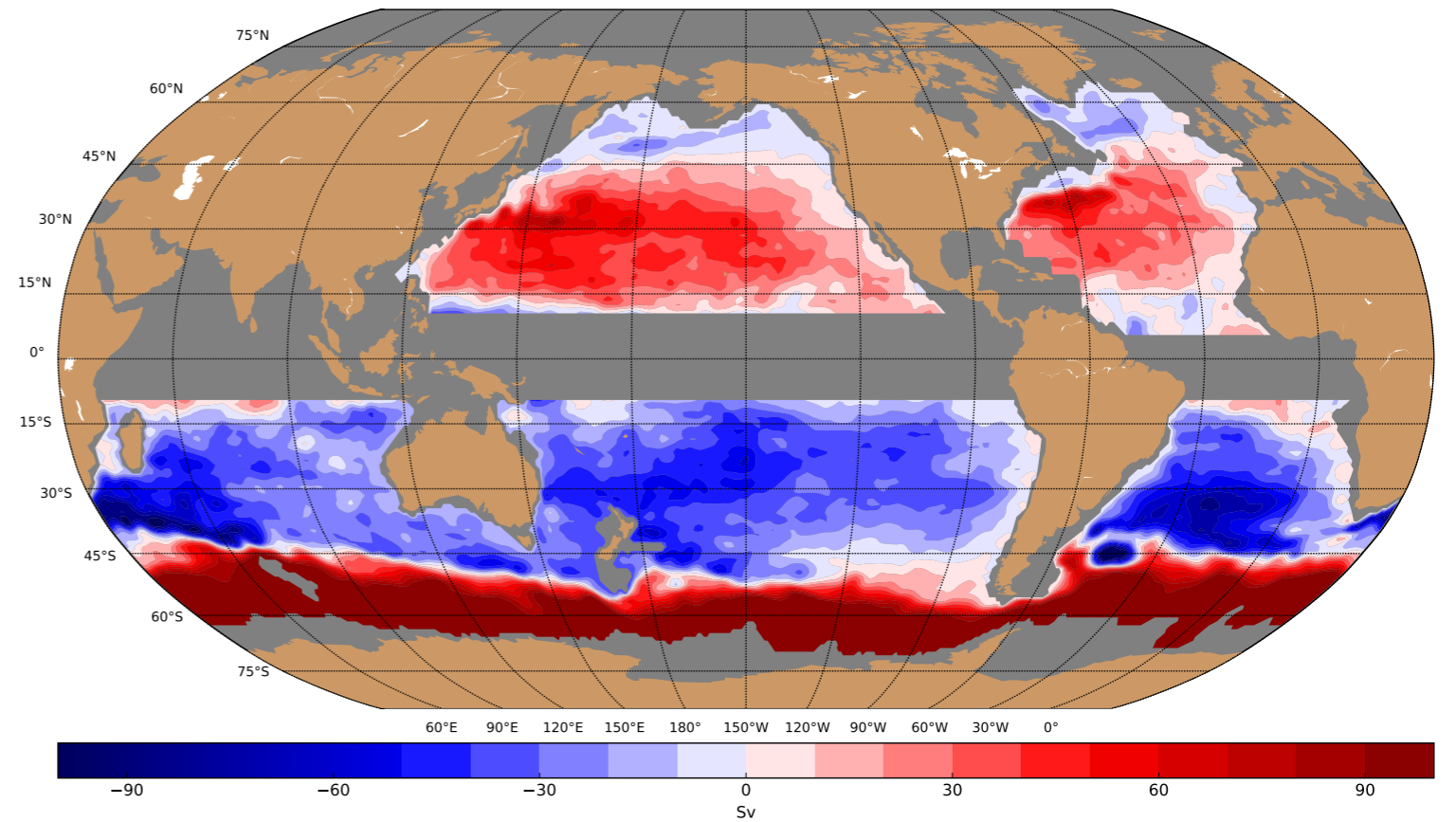
additional slides

# CNRM-CM6-1-HR

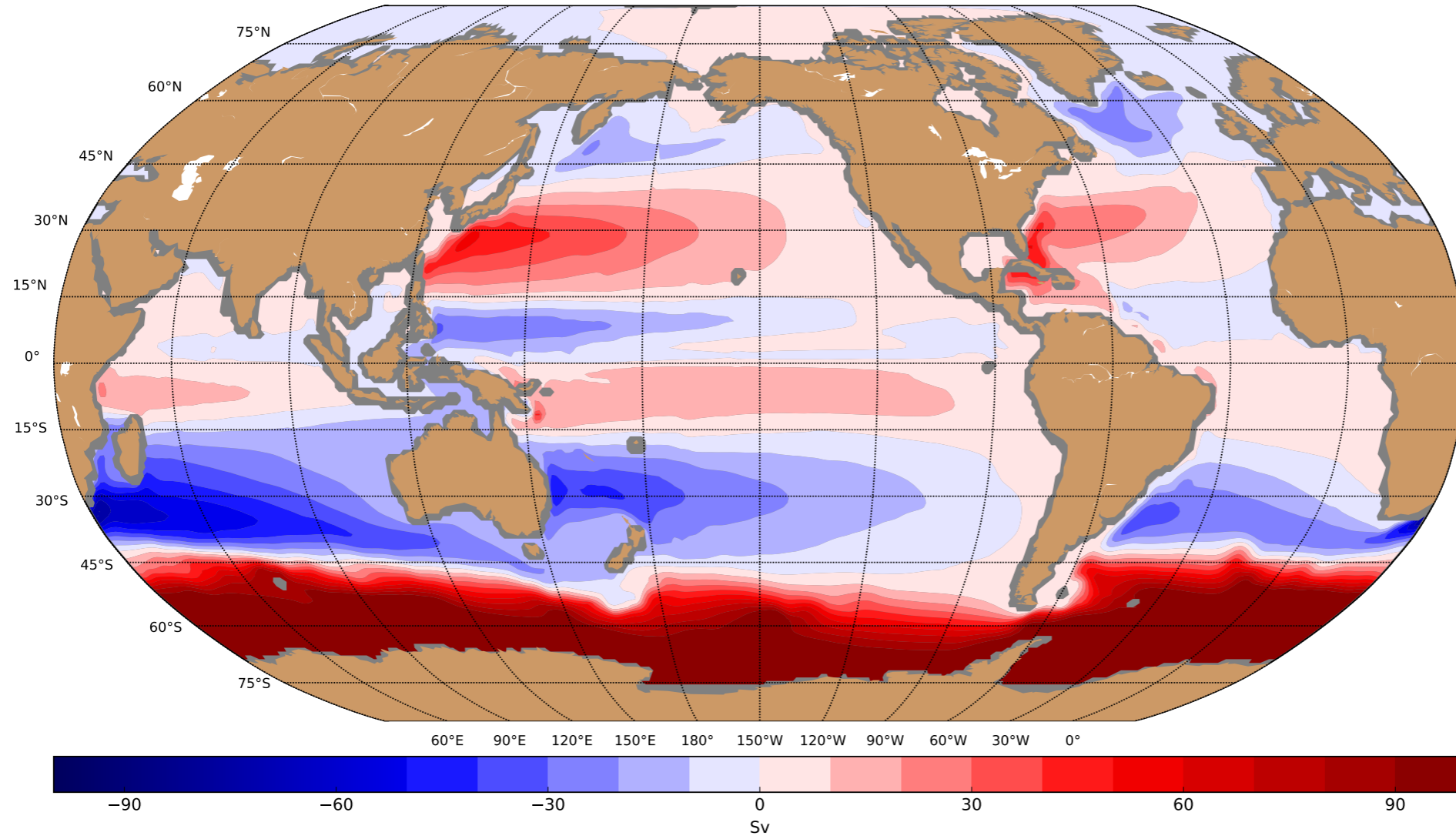
CNRM-CM6-HR historical (1981-2010) mean BSF (mean:8Sv, bias:2Sv, RMSE:6Sv)



Barotropic streamfunction from ARGO floats [Colin de Verdière 2016]



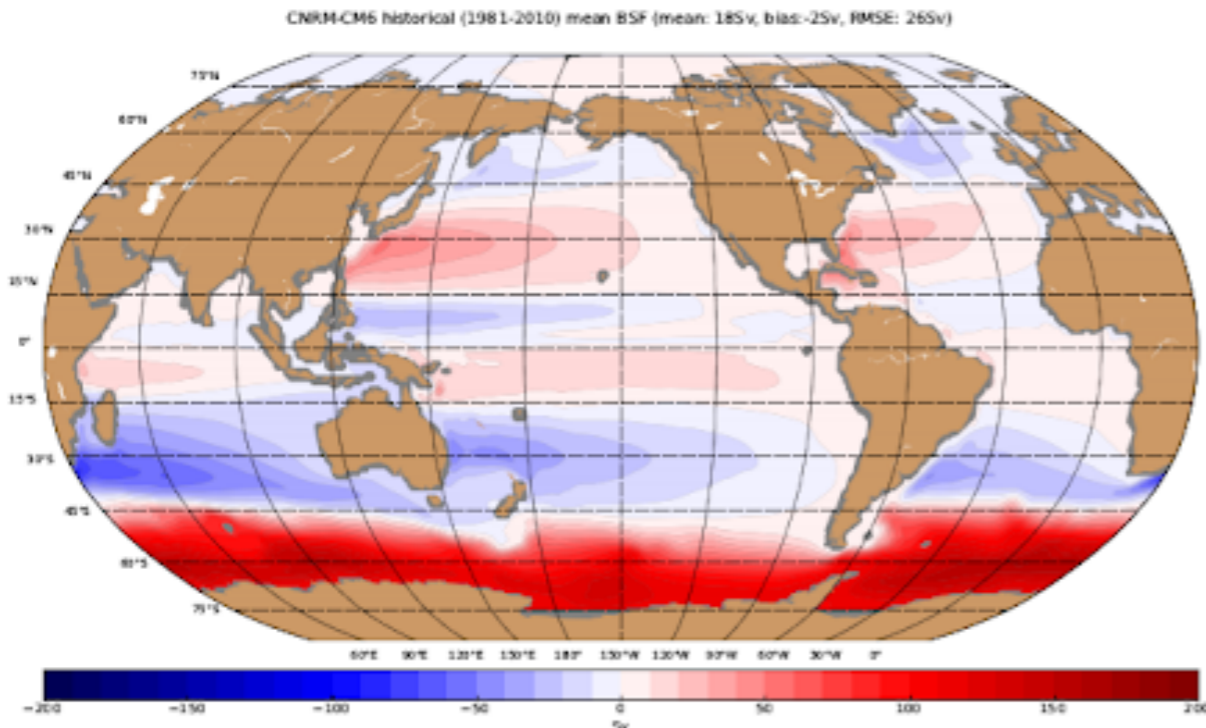
CNRM-ESM2 historical (1981-2010) mean BSF (mean:8Sv, bias:2Sv, RMSE:6Sv)



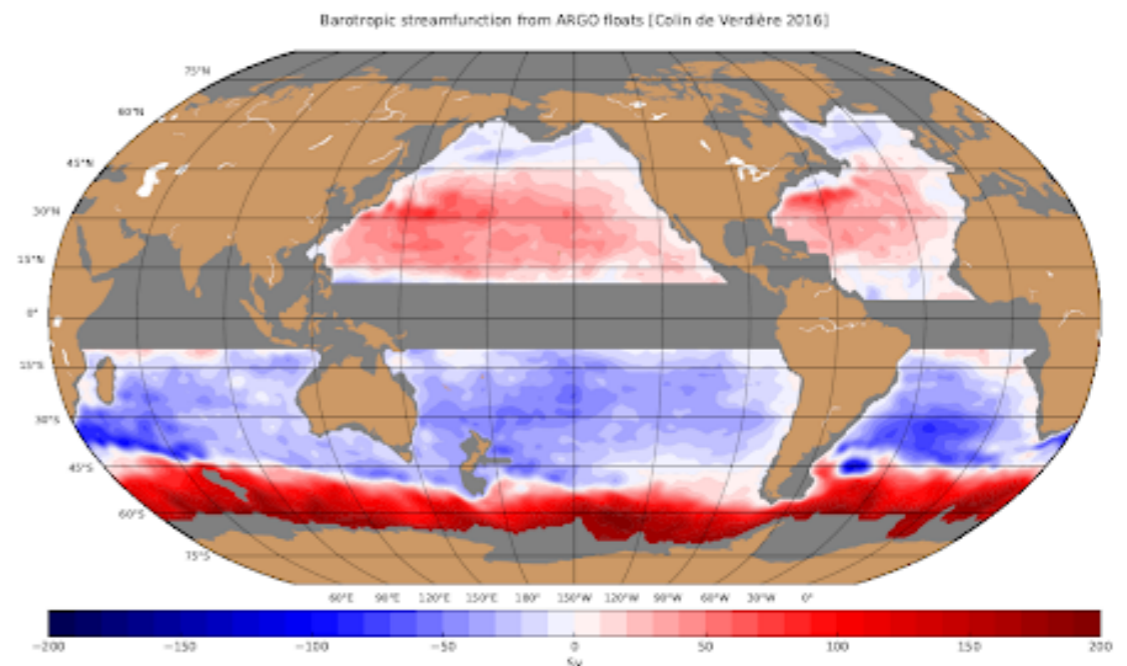
# CNRM-CM6

# LR

- All subtropical and subpolar gyres are present!
- General tendency of too weak circulation: because of unresolved mesoscale dynamics (in particular at western boundaries)
- Too equatorward separation between subtropical and subpolar gyres

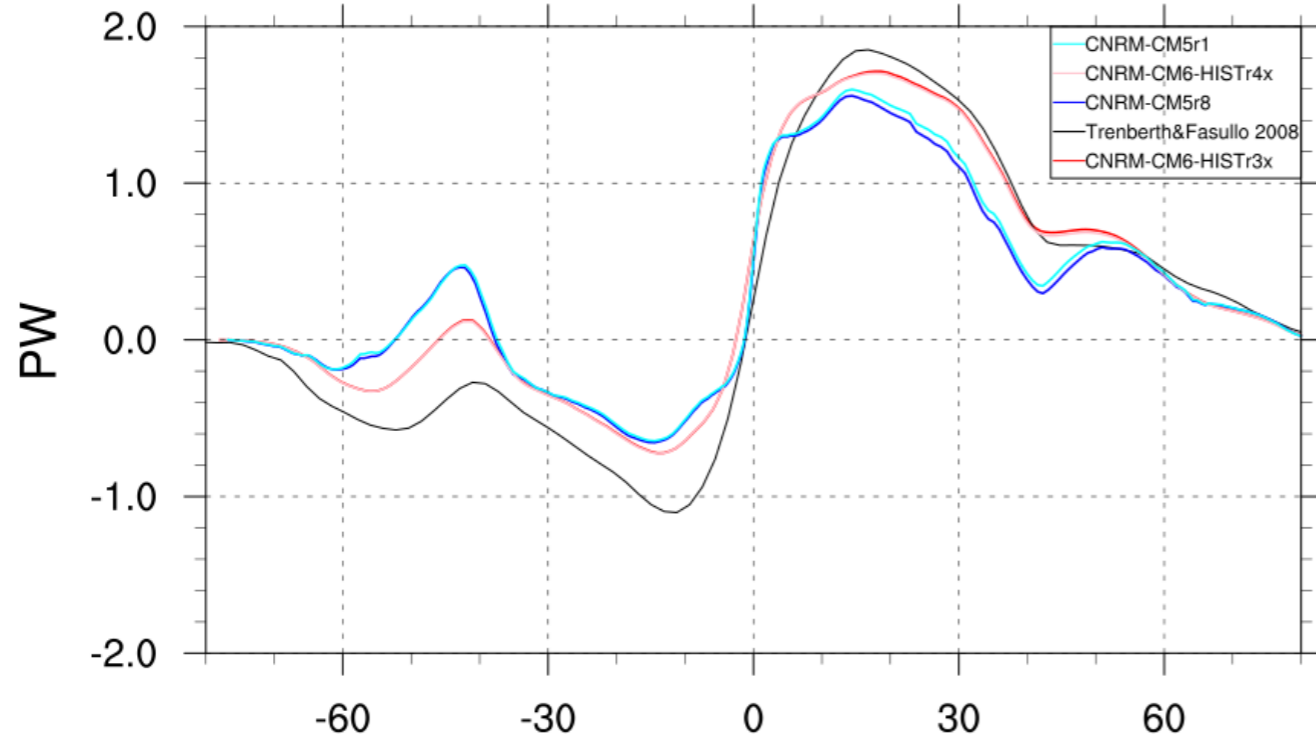


- The observed circulation is generally more intense
- It also displays very intense mesoscale features which are not resolved by CNRM-CM6: Southern Ocean eddies and meanders, western boundary currents and their recirculations.

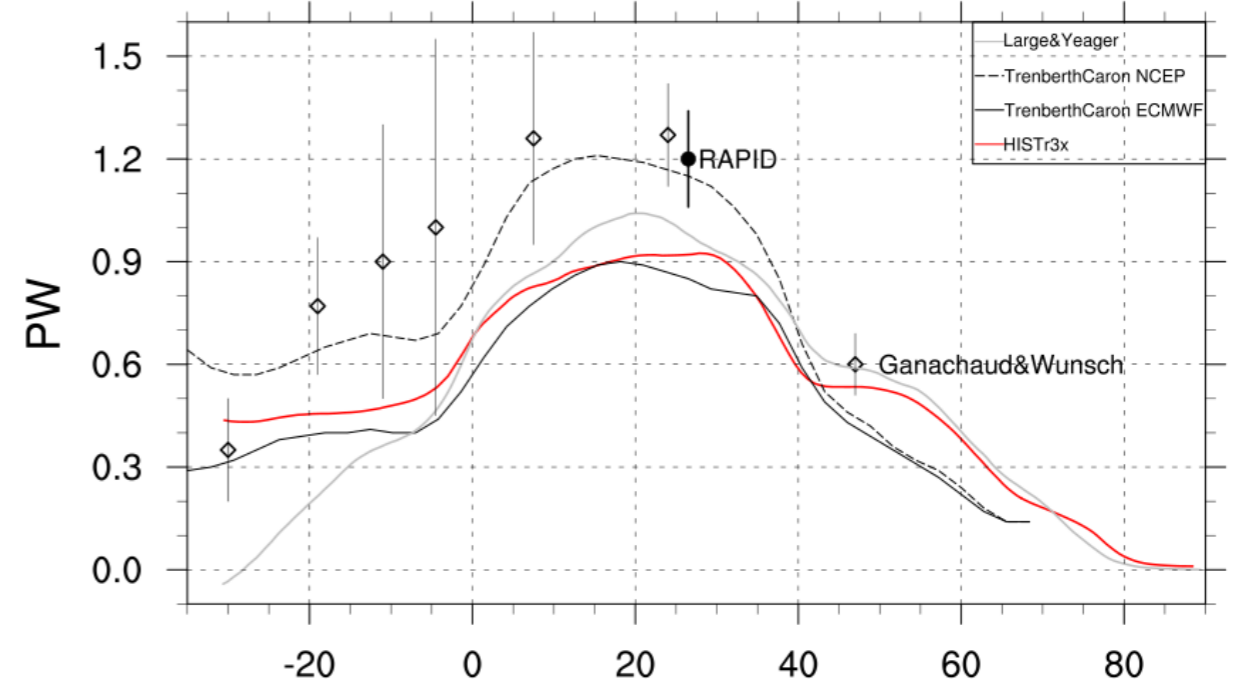


# CNRM-CM6

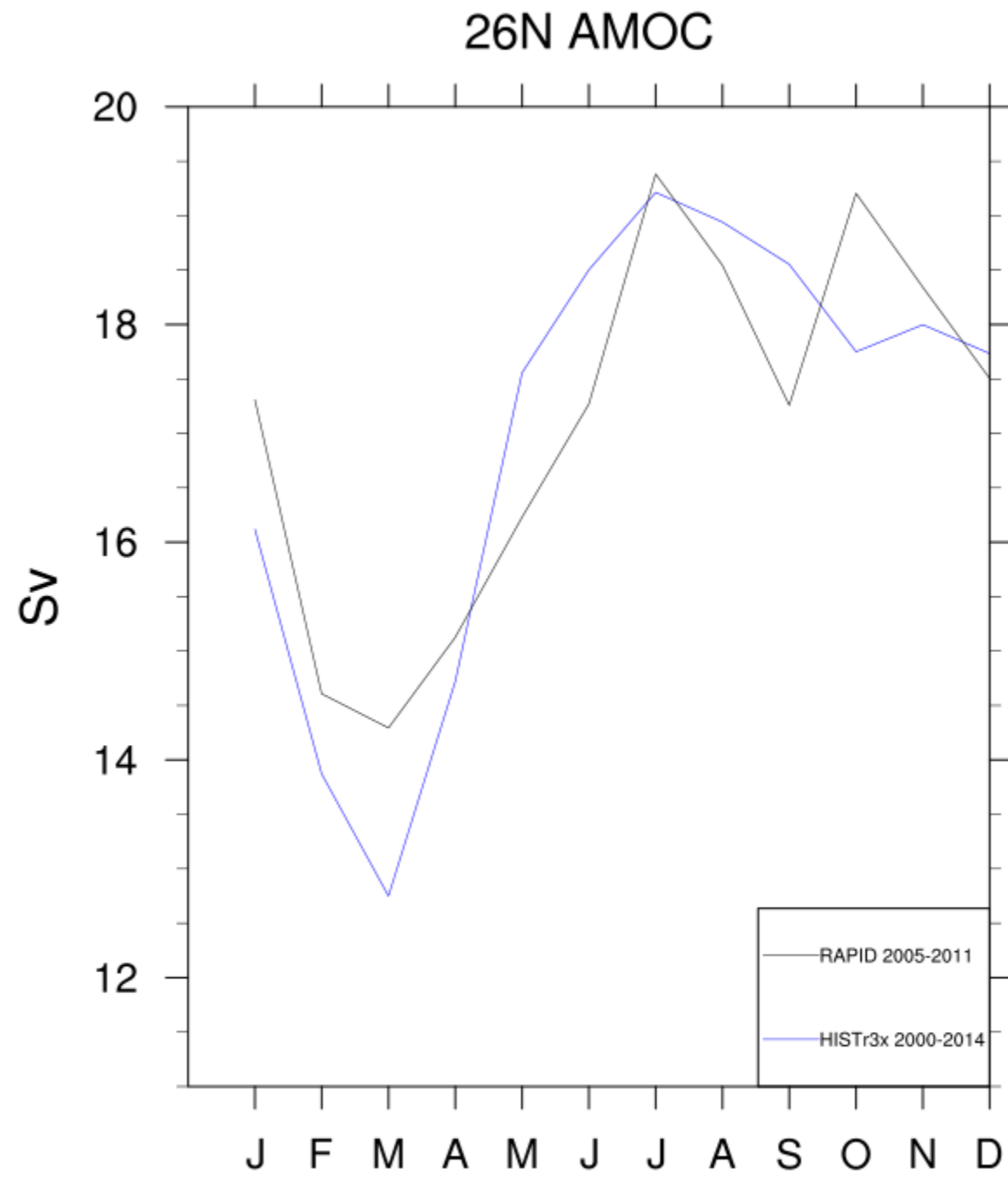
## Global Ocean Heat Transport



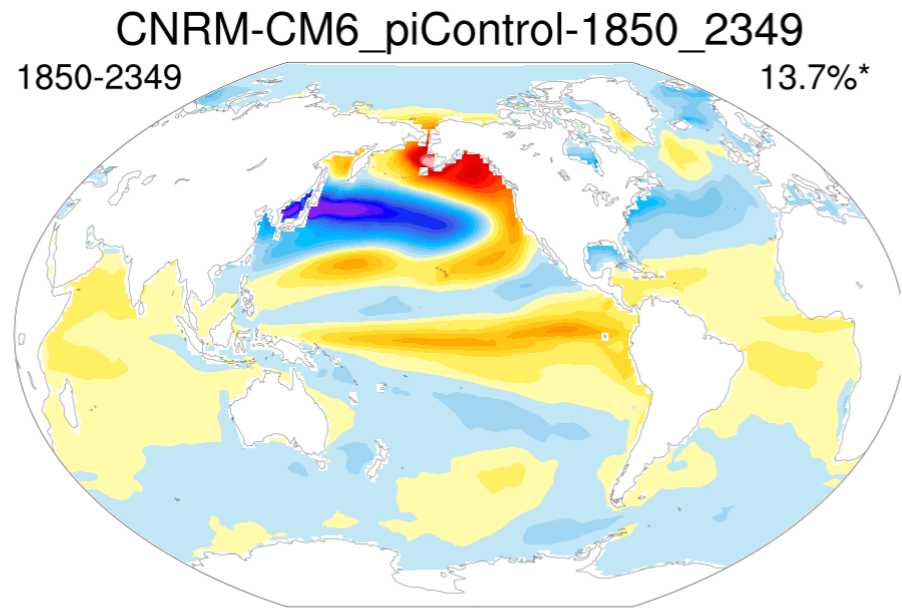
## Atlantic Ocean Heat Transport



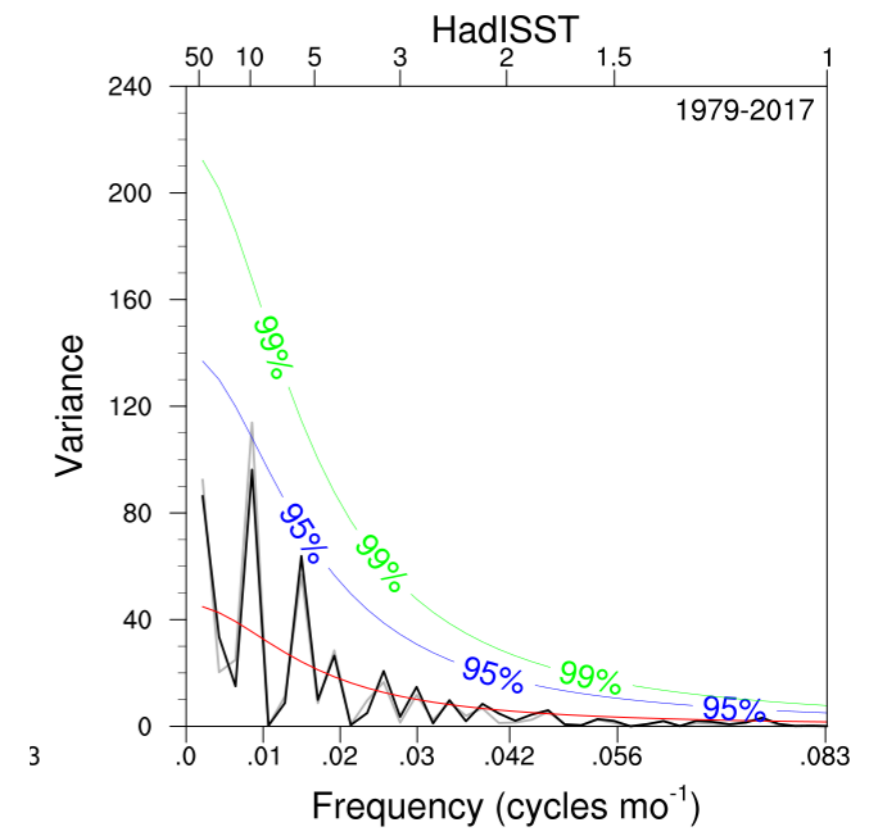
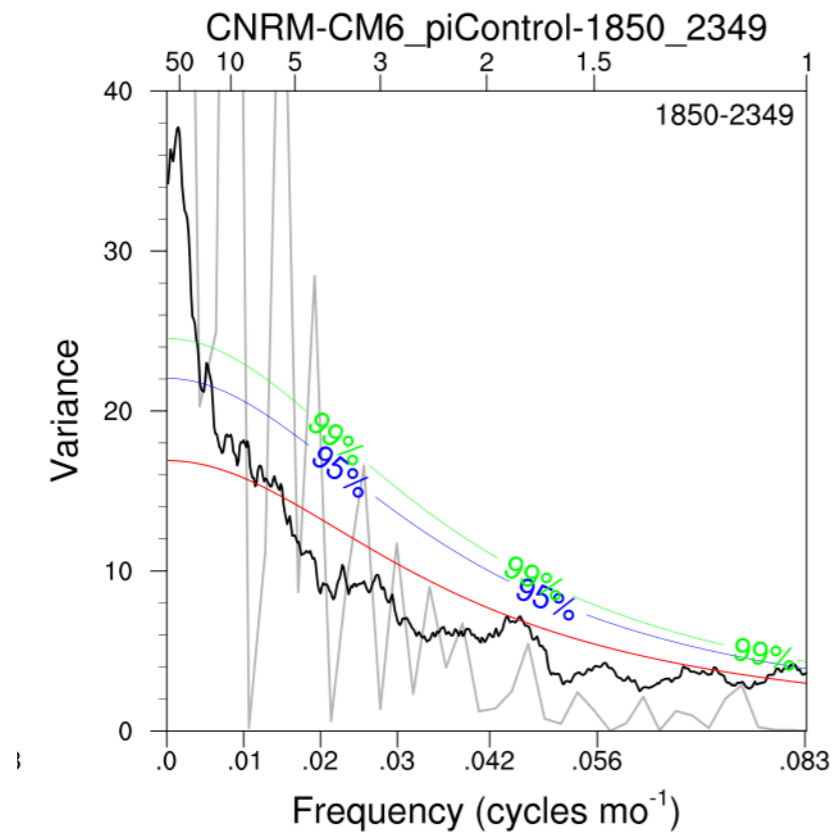
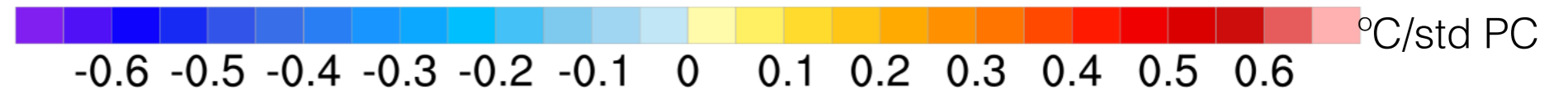
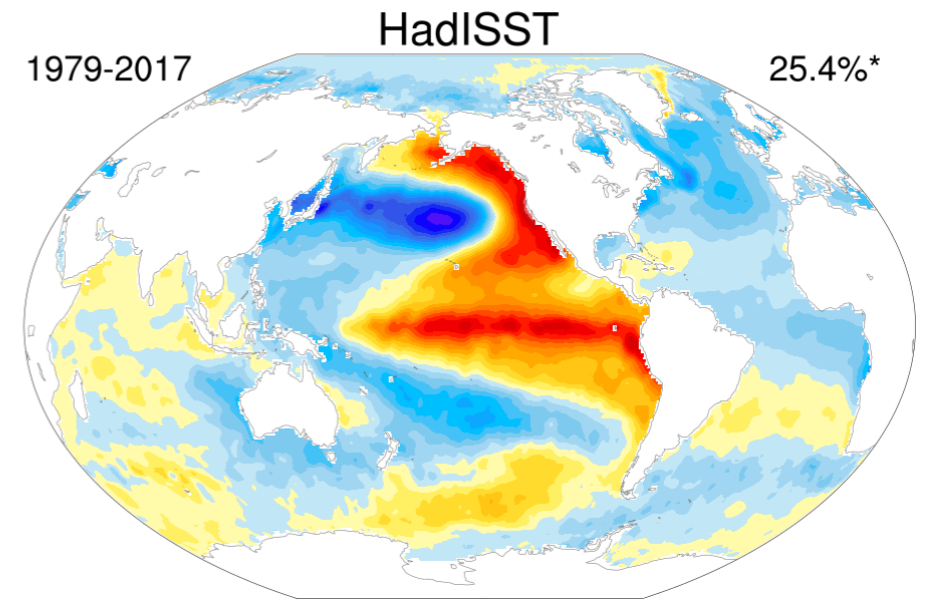
# CNRM-CM6



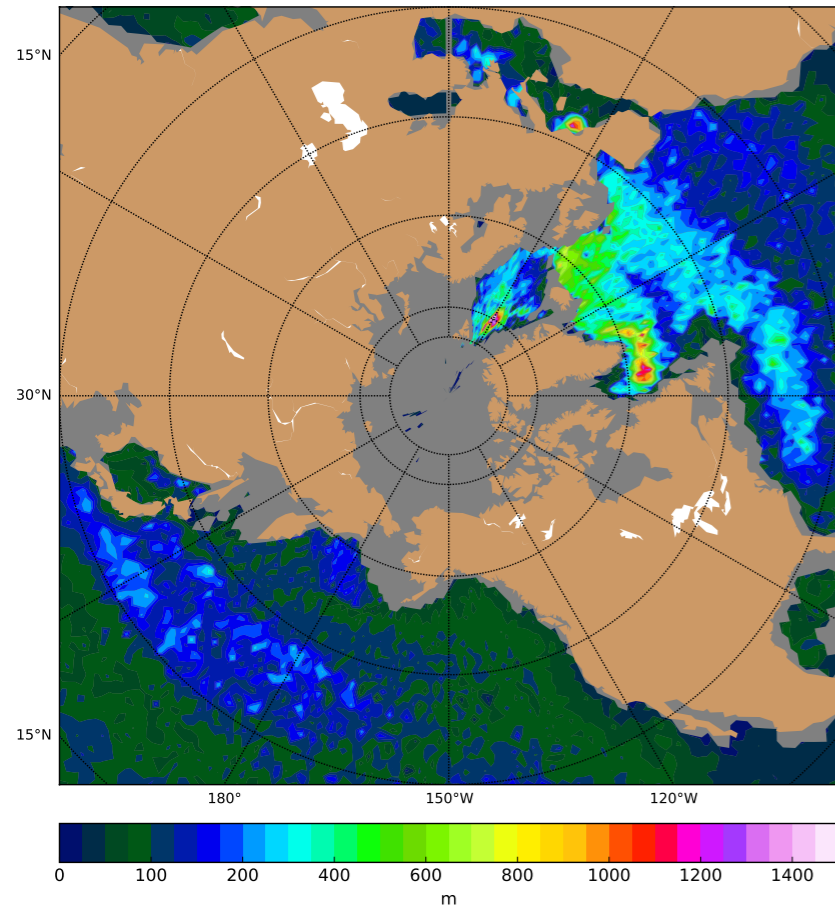
# CNRM



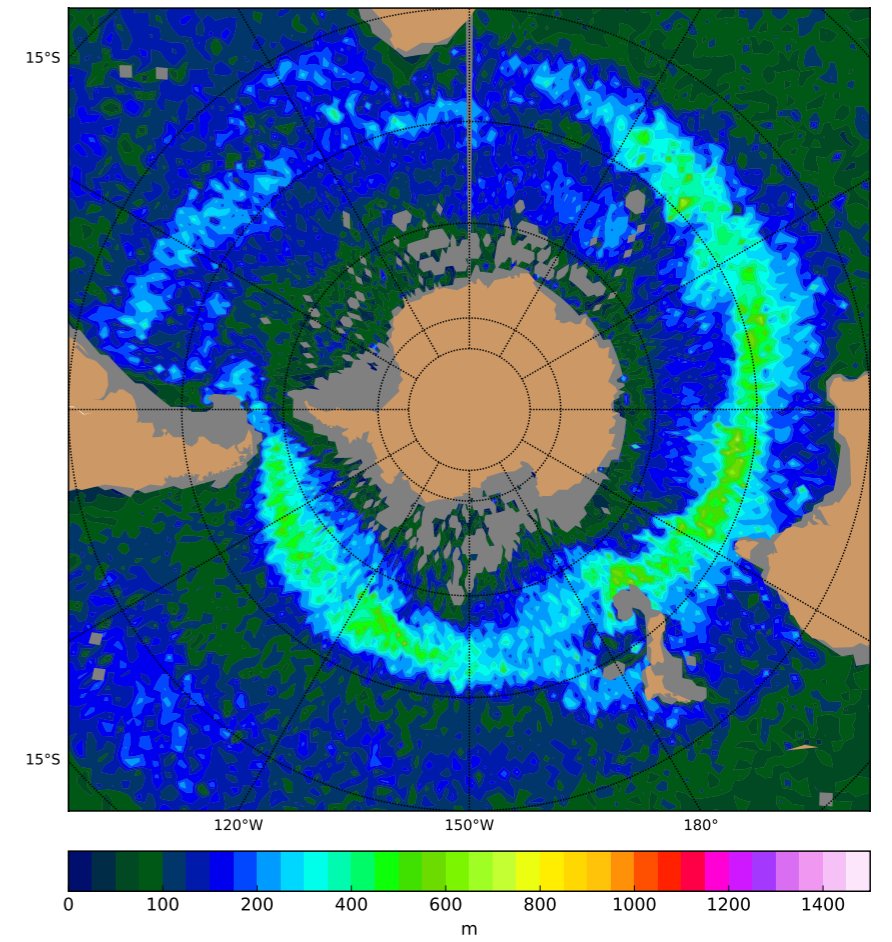
# PDO



ARGO observed (2004-2018) annual max MLD [Holte et al 2017]



ARGO observed (2004-2018) annual max MLD [Holte et al 2017]



CNRM-ESM2 historical (1981-2010) annual max MLD (mean:11m, bias:13m, RMSE:29m)

