The Stability of the Atlantic Meridional Overturning Circulation in HadCM3

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- Fov in HadCM3
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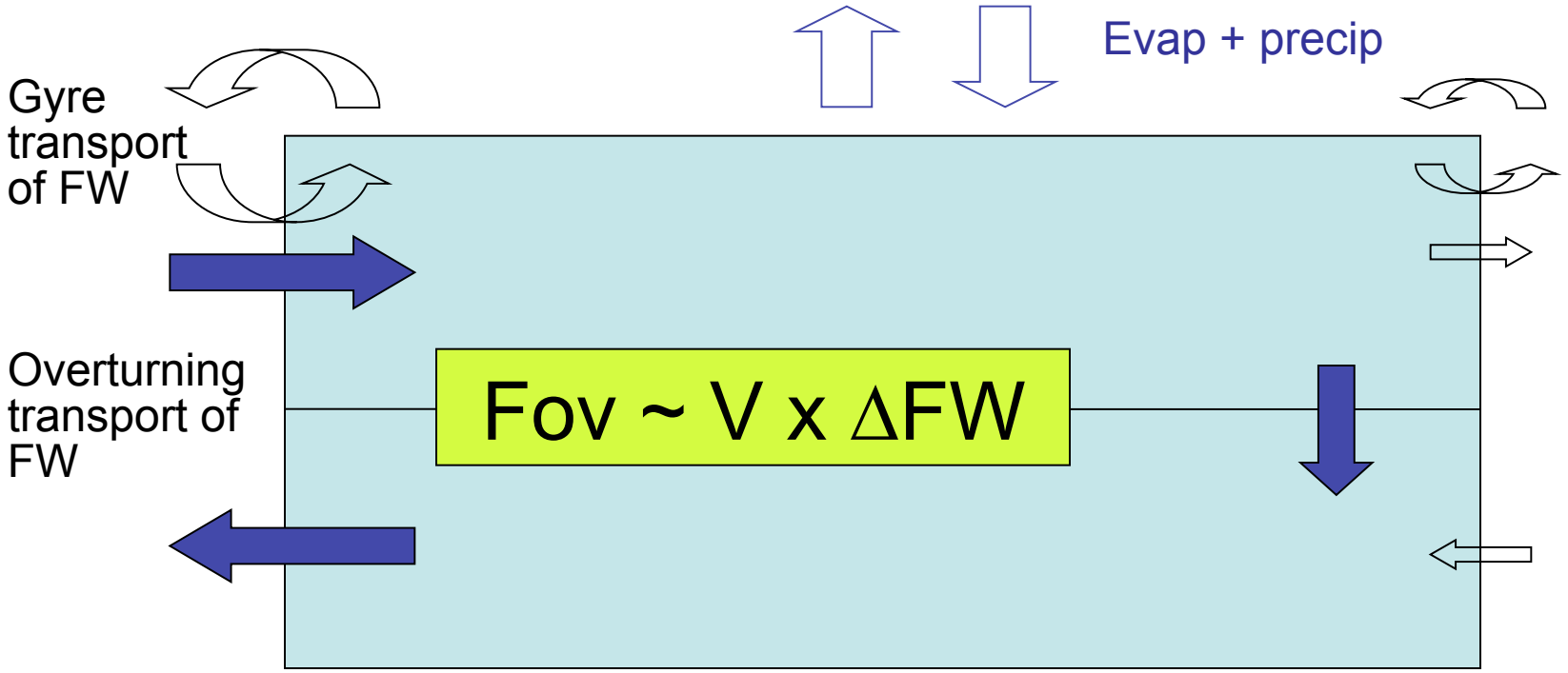
The fresh water transport into the Atlantic by the overturning circulation.



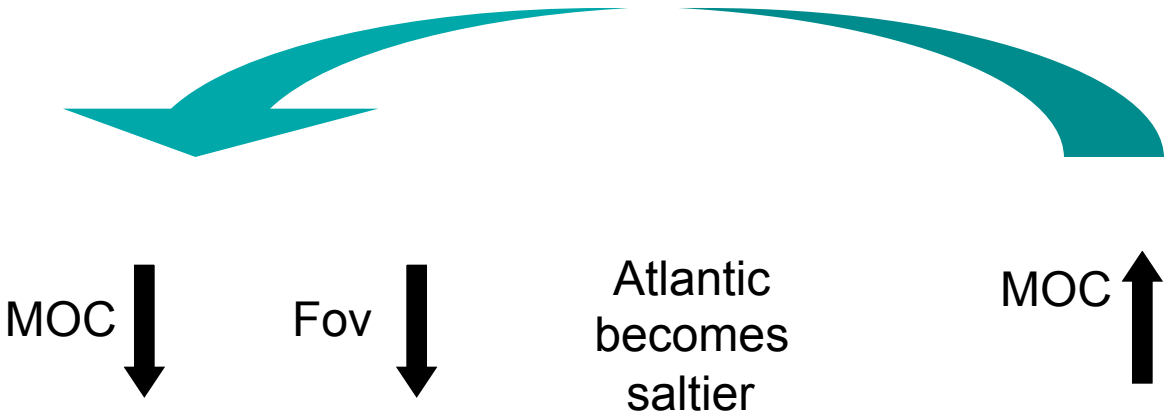
South Atlantic.
Latitude of S tip of Africa

North Boundary.
Arctic-Atlantic boundary

Fov>0 => -ve feedback

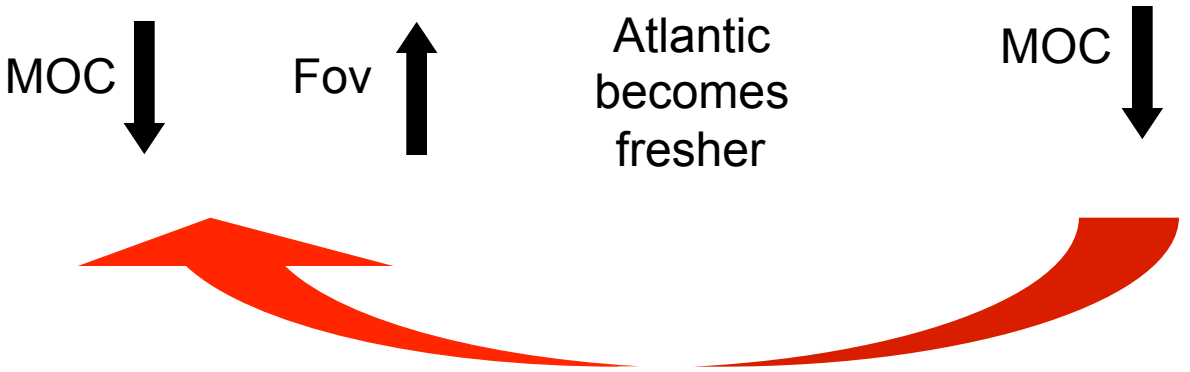
Fov >0
V>0
ΔFW>0

net transport of FW into Atlantic



Fov <0
V>0
ΔFW<0

net transport of FW out of Atlantic

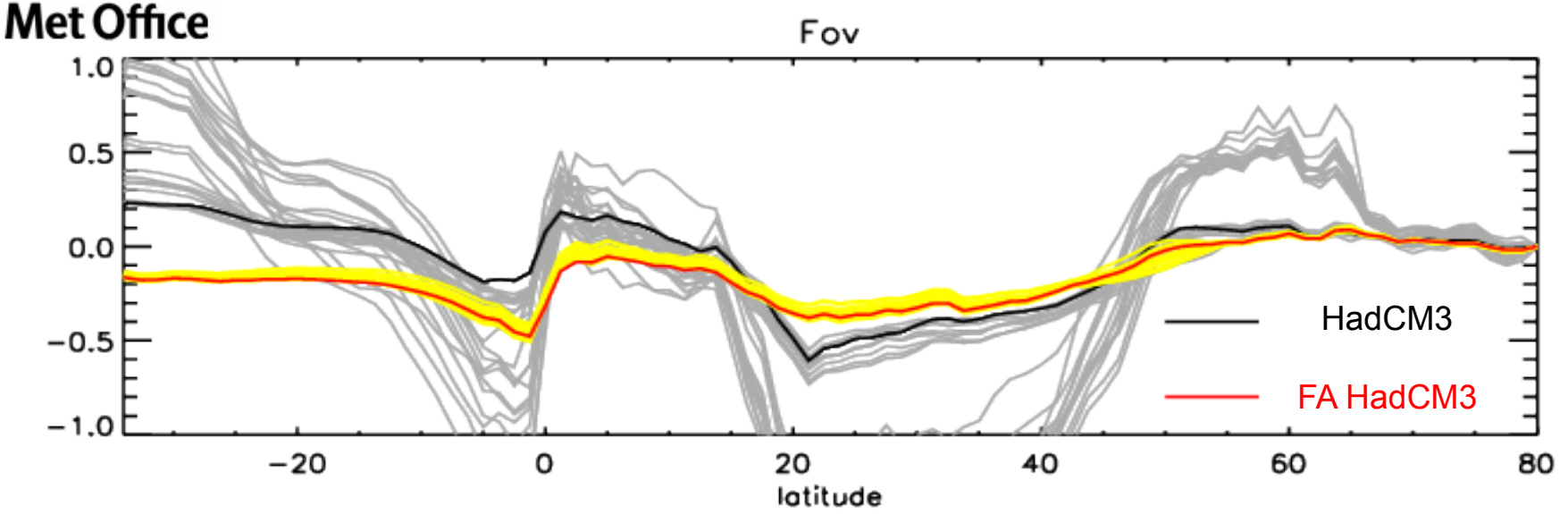


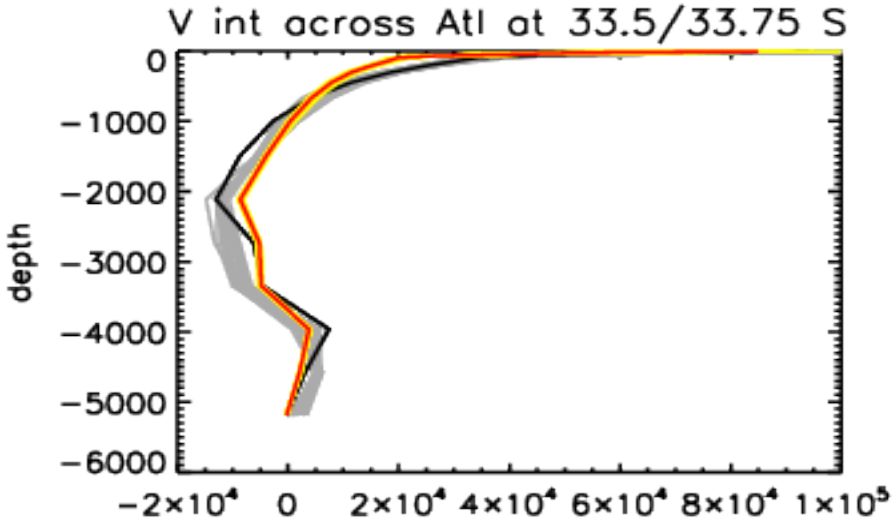
Fov<0 => +ve feedback

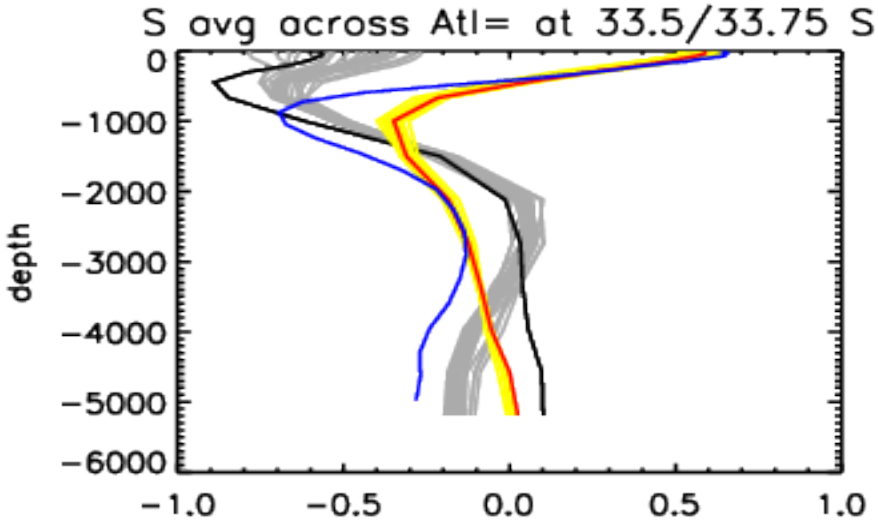
Fov as a stability indicator

- Initially suggested by Rahmstorf (1996)
- Theory behind Fov as stability indicator assumes:
  - Sign of Fov indicates positive/negative feedback
  - Other components of FW budget less important
  - MOC strength is controlled by salinity of Atlantic
- Observations and reanalyses suggest Fov<0 (MOC bistable)
- Most GCMS have Fov>0
- Important to find out reason for bias and whether it indicates bias in stability.

Fov in HadCM3





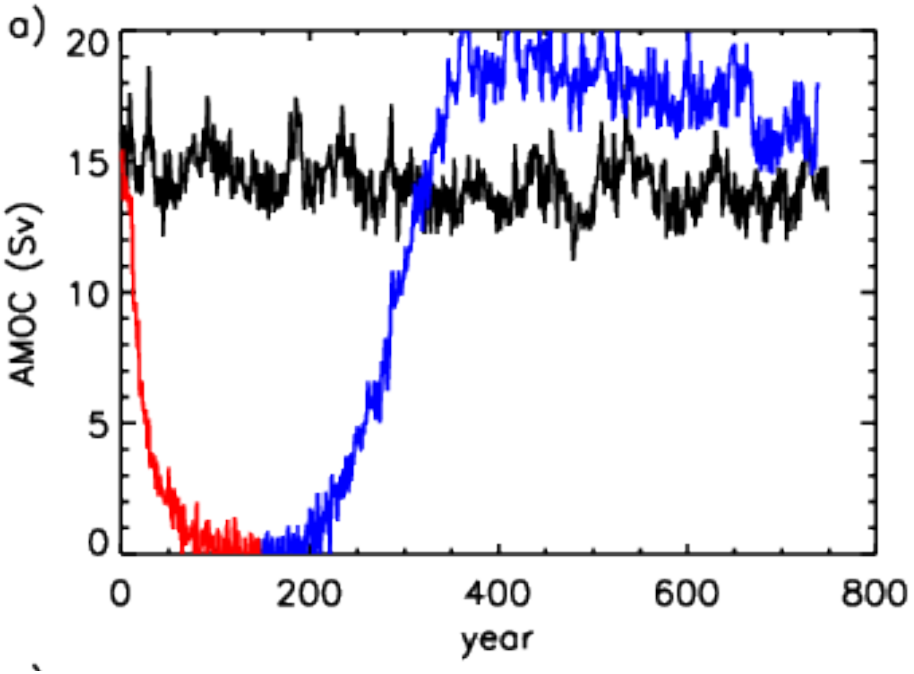


Experiments

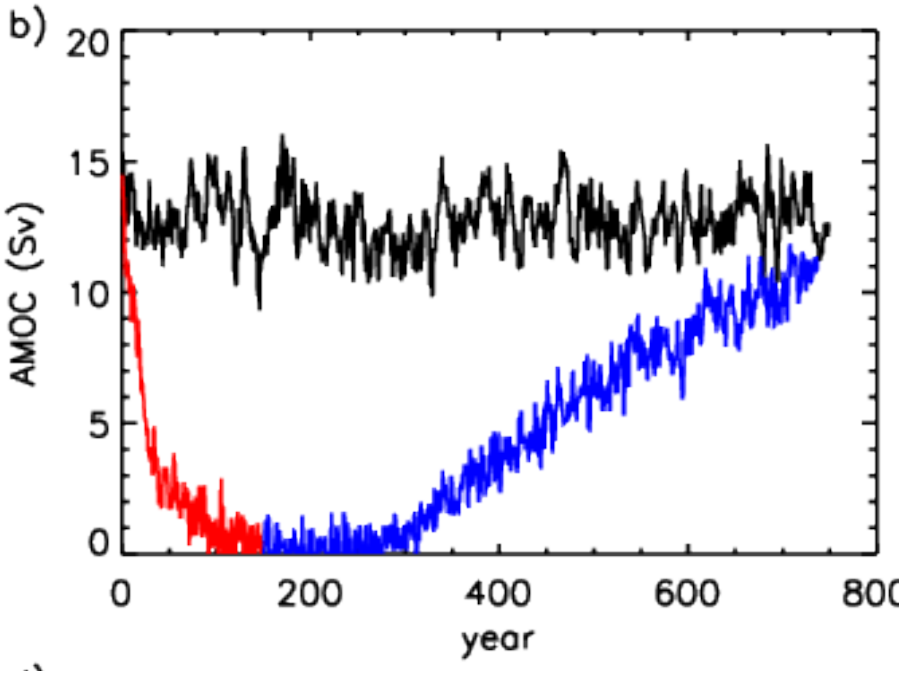
- Test whether sign of Fov affects MOC stability
- Parallel experiments with normal, unfluxadjusted (NFA) HadCM3 and fluxadjusted (FA) HadCM3
- Hosing experiments with 1Sv extra of freshwater applied over 50-80N in Atlantic through surface fluxes.
- Balanced by removing FW from surface flux elsewhere.
- 150 years of hosing, followed by 600 years with the hosing removed.

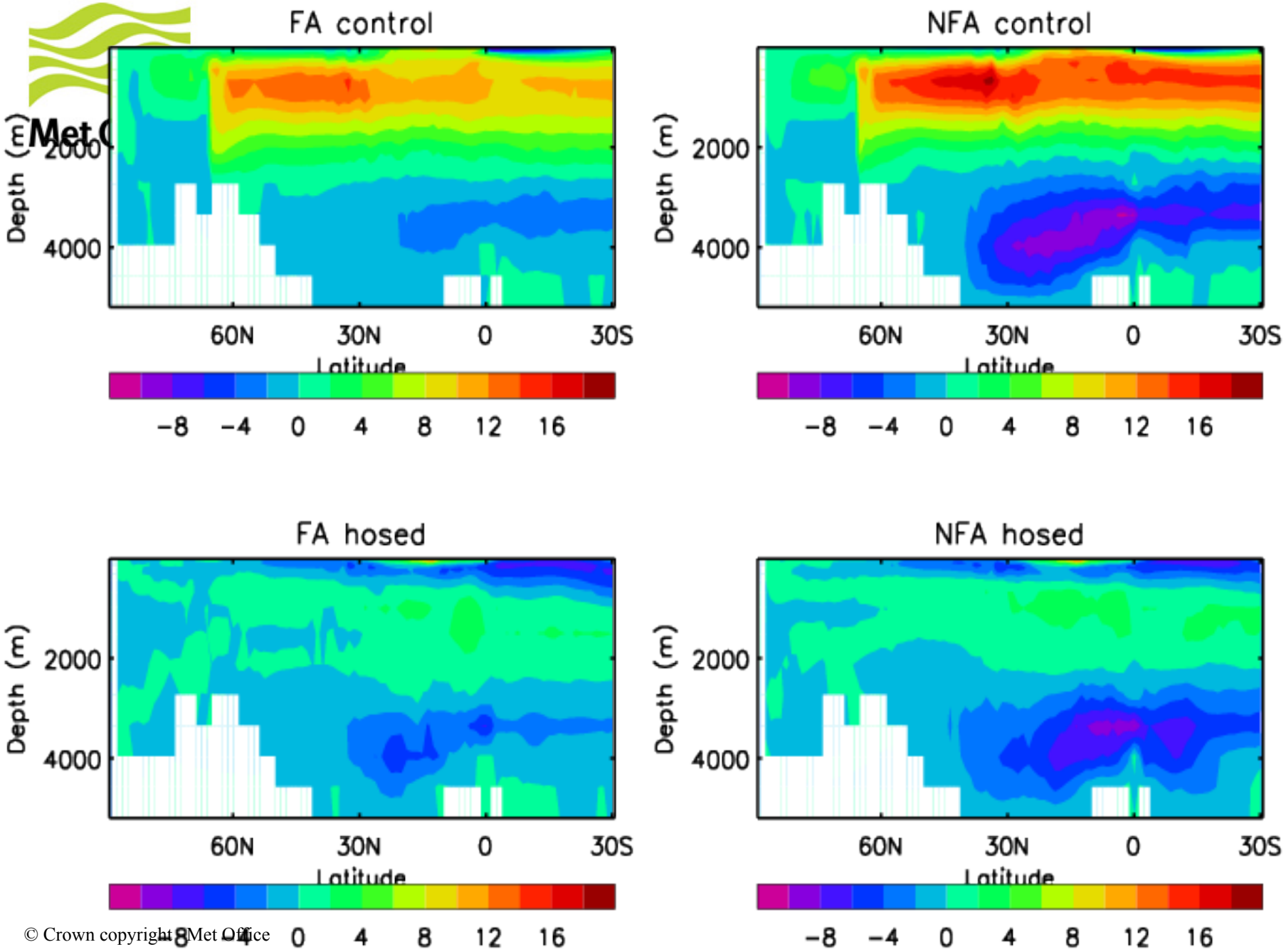
MOC timeseries

NFA (Fov >0)

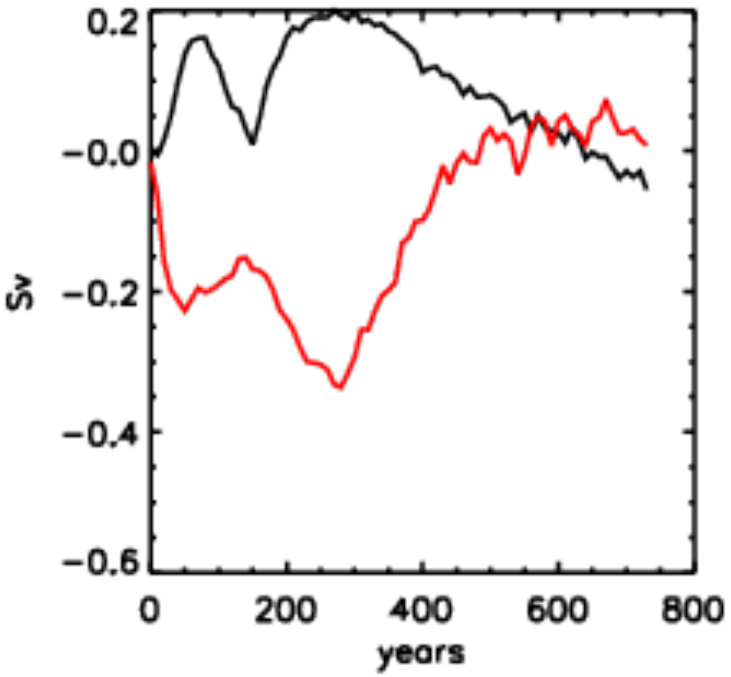


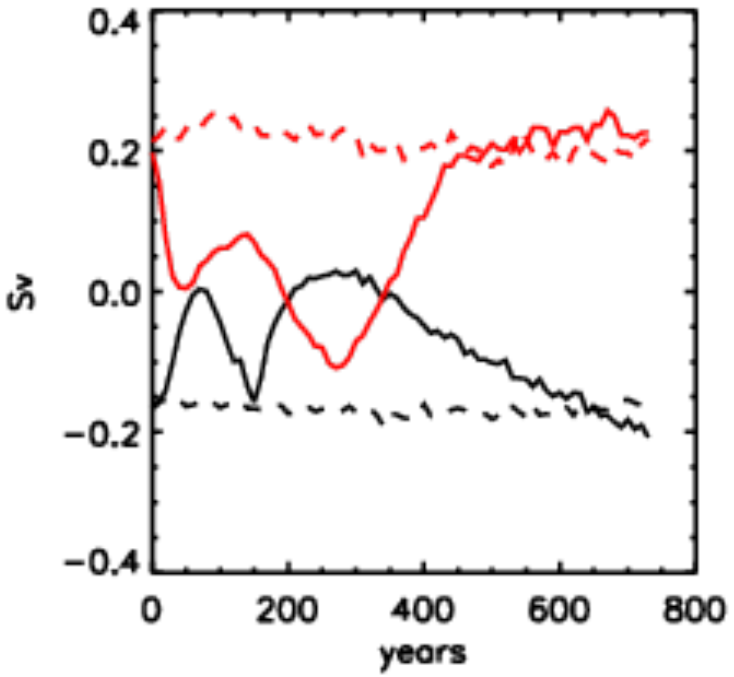
FA (Fov <0)





Sign of Fov indicates advective feedbacK?





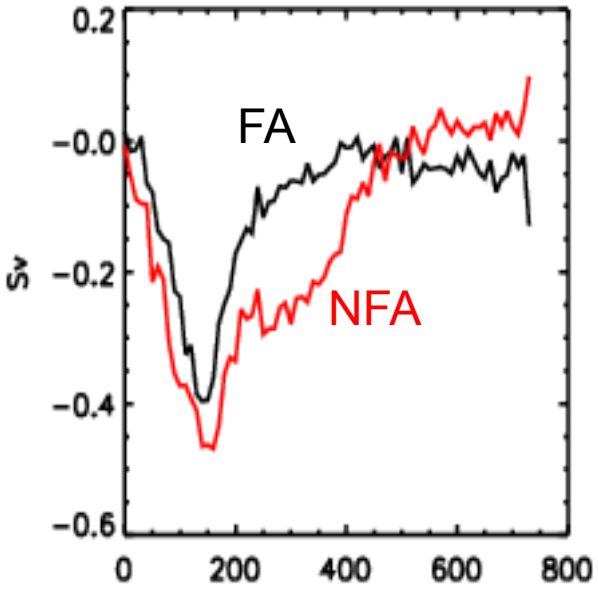
Fov ~ V x ΔFW

FA - Less FW out of Atlantic

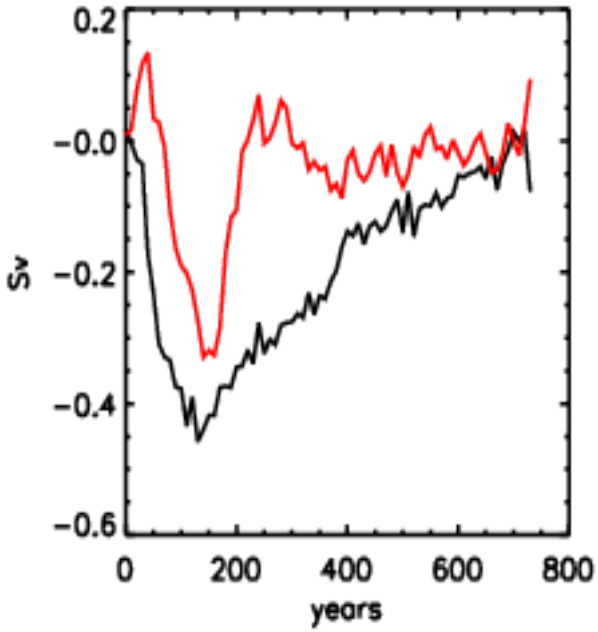
NFA - Less FW into Atlantic

Fov controls FW changes in Atlantic?

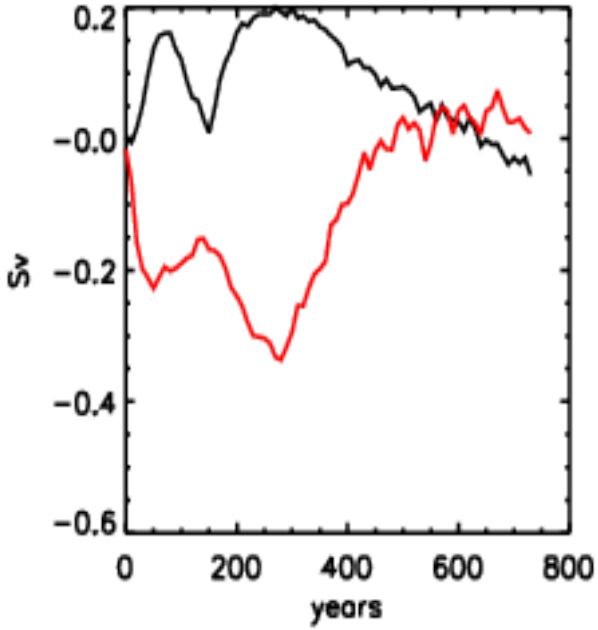
Total FW flux at 34S



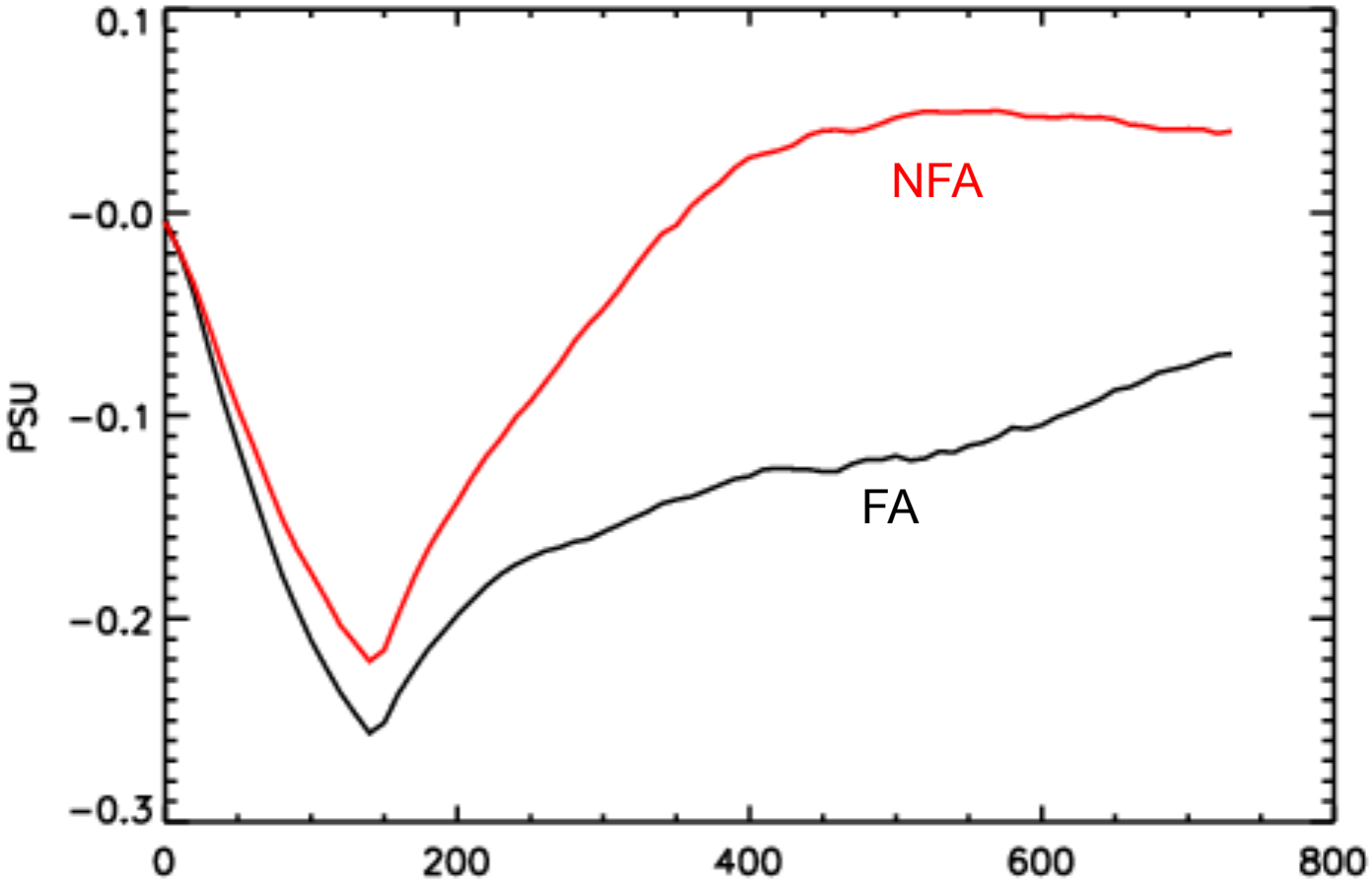
Faz



Fov

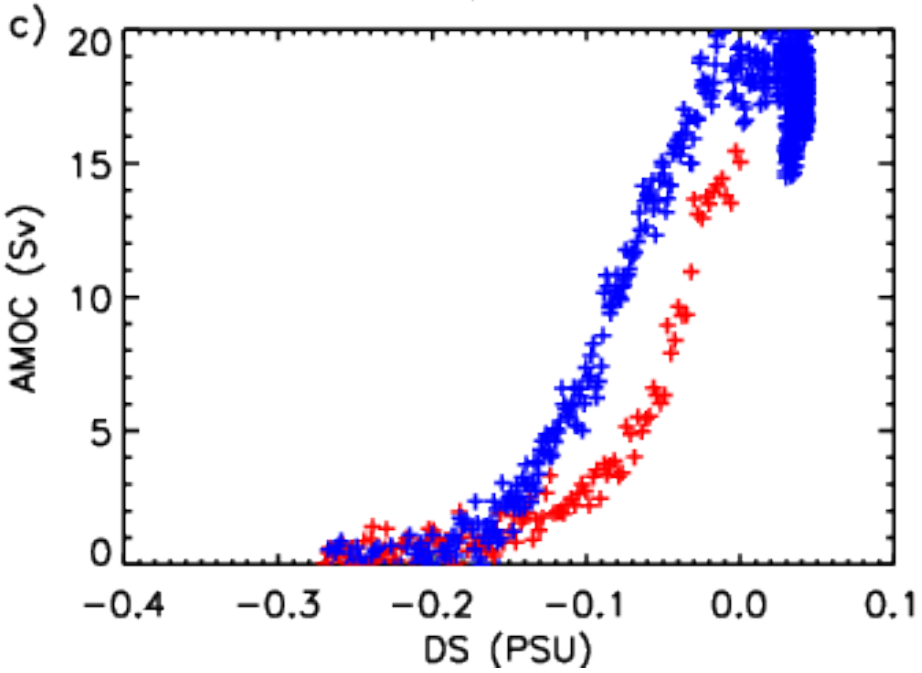


FA: Less FW removed => fresher!

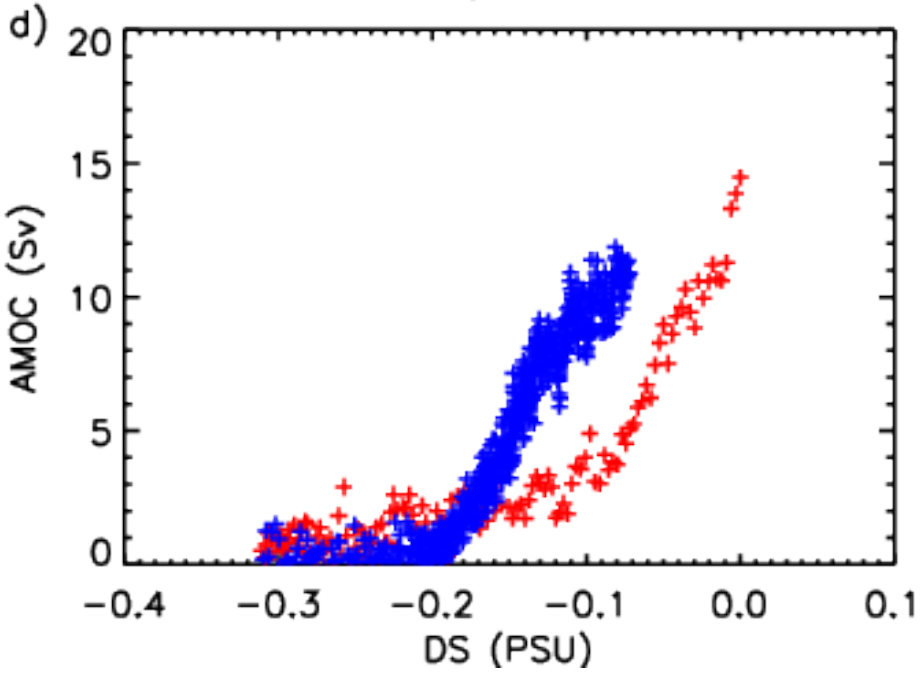


Relationship between AMOC and Atlantic salinity?

NFA (F_{ov} >0)

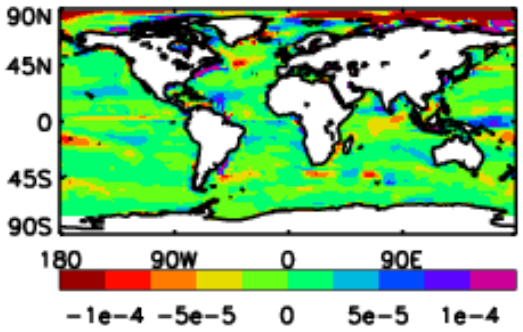


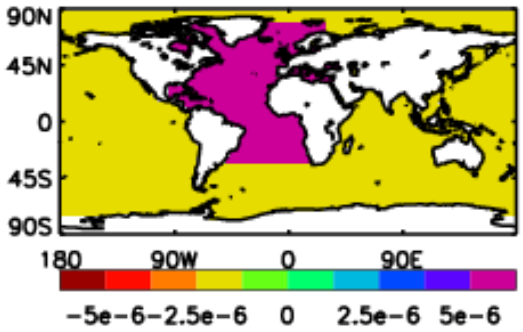
FA (F_{ov} <0)



Why is Fov<0 with flux adjustments?

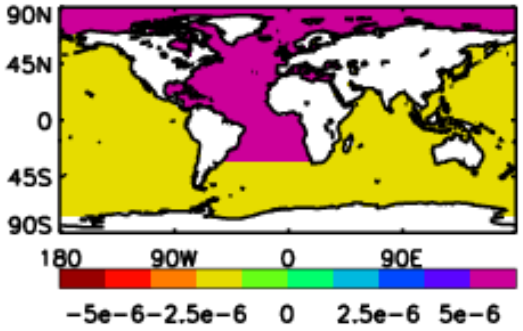
Fov < 0

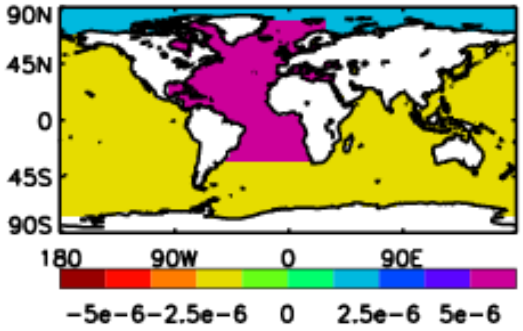




Fov < 0

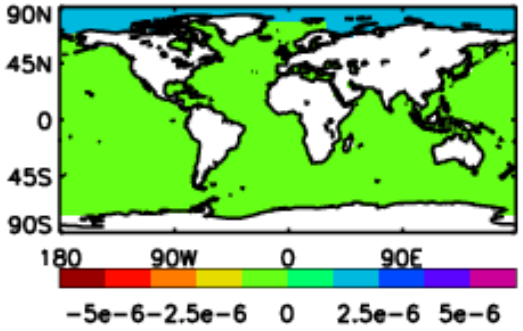
Fov < 0

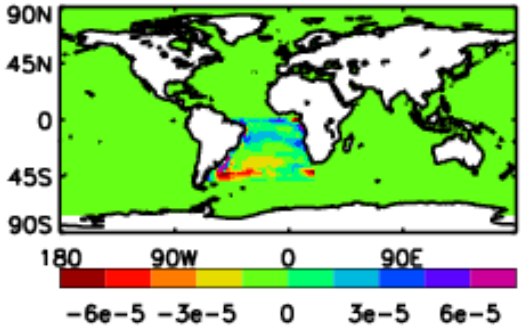




Fov < 0

Fov > 0





Fov > 0

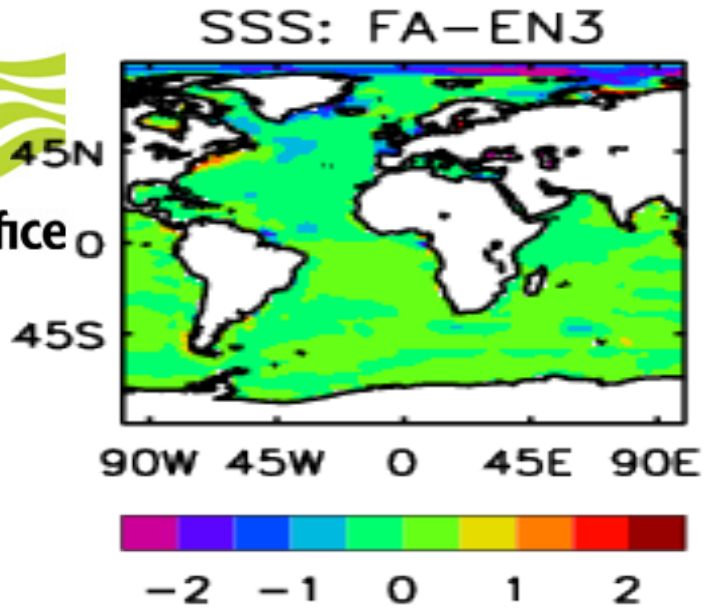
Conclusions

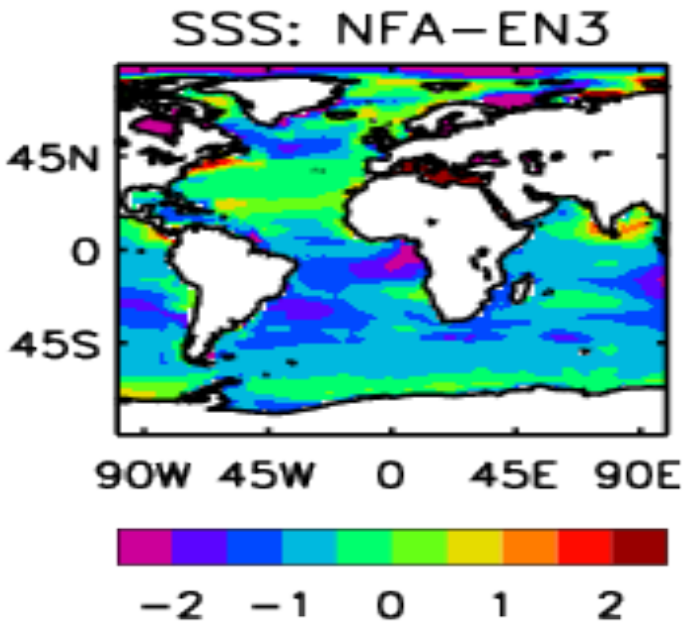
- Sign of Fov in control affects stability of MOC.
- MOC still seems to recover eventually
- Unfluxadjusted HadCM3 (and many other climate models) have Fov>0 (though HadGEM3 has Fov<0!)
- Fluxadjusted HadCM3 has Fov<0...
- (… probably because it corrects the Atlantic saline bias)

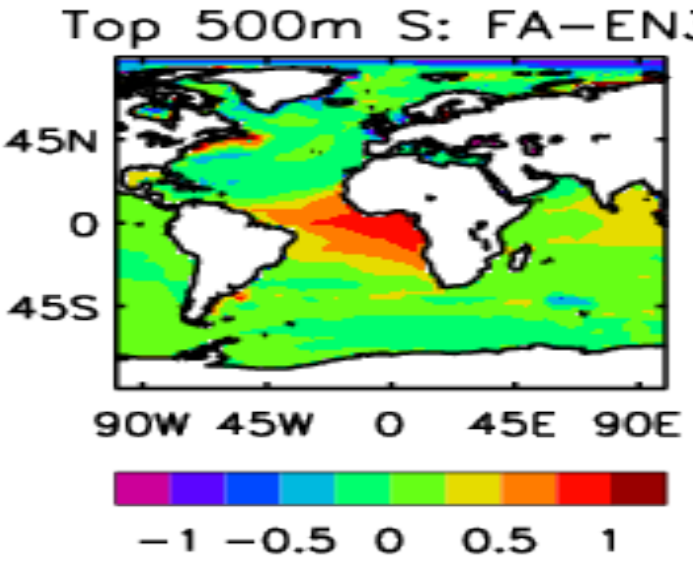
Thanks, any questions?

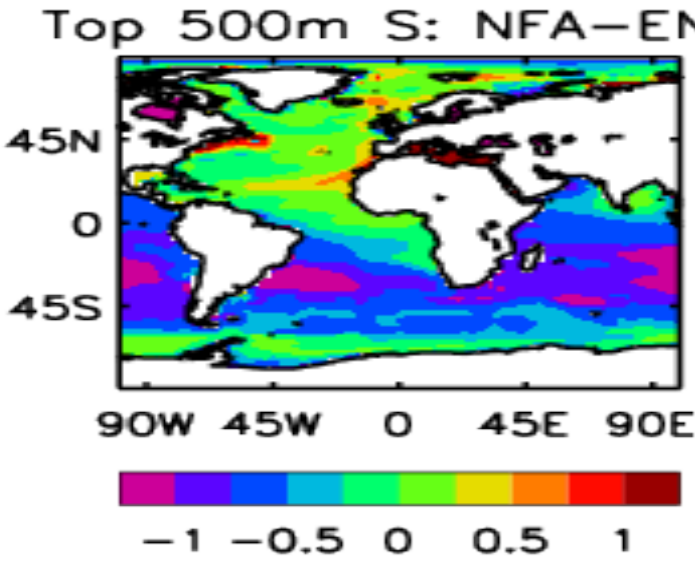
More Questions

- Why does change in Faz oppose Fov?
- Are later changes in Fov important and what causes them?
- Why does FA start recovering eventually?
- What about changes in deep water formation/ mixed layer depth?
- What about changes in Antarctic Intermediate water cell?
- Test other theories about MOC stability



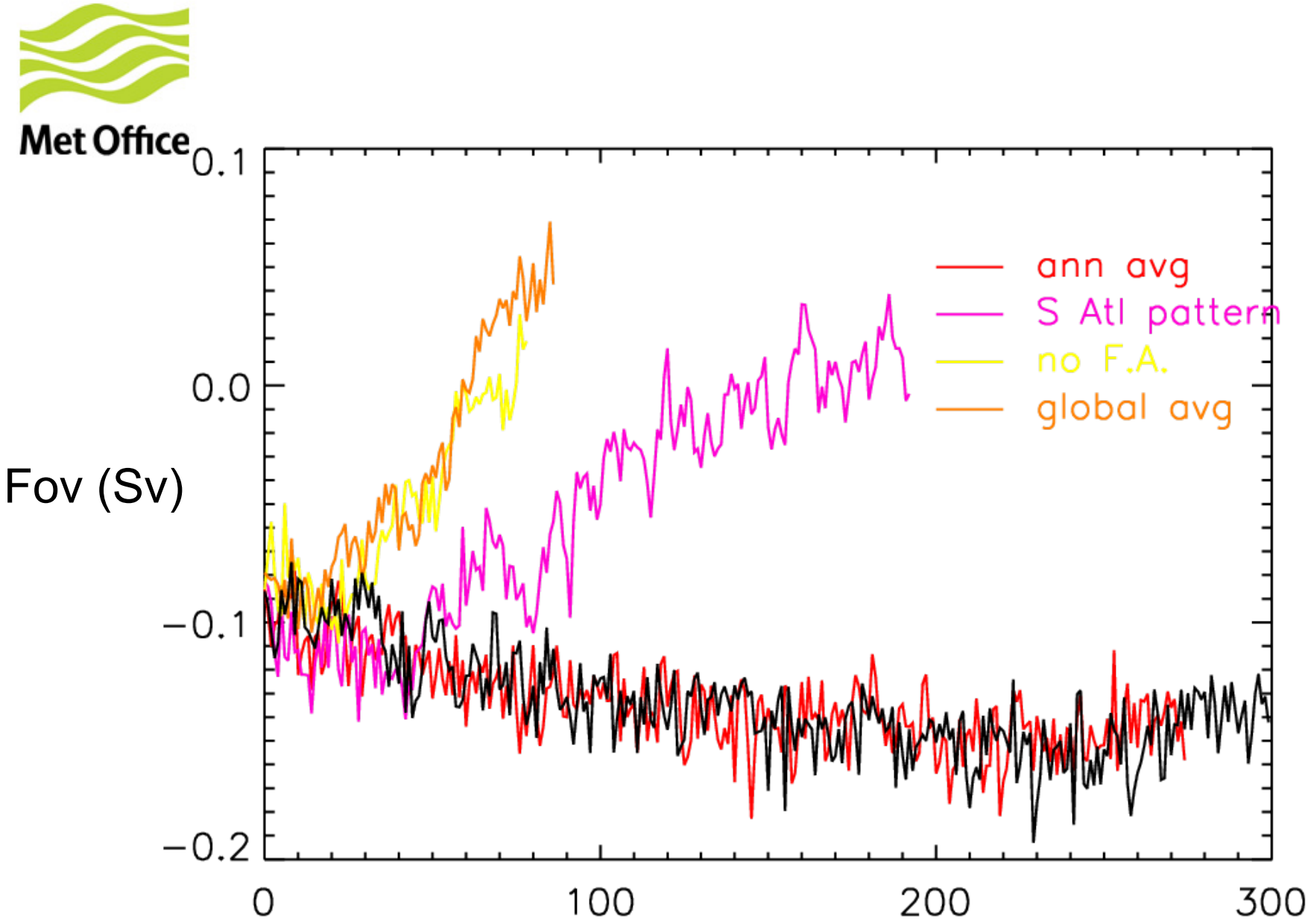


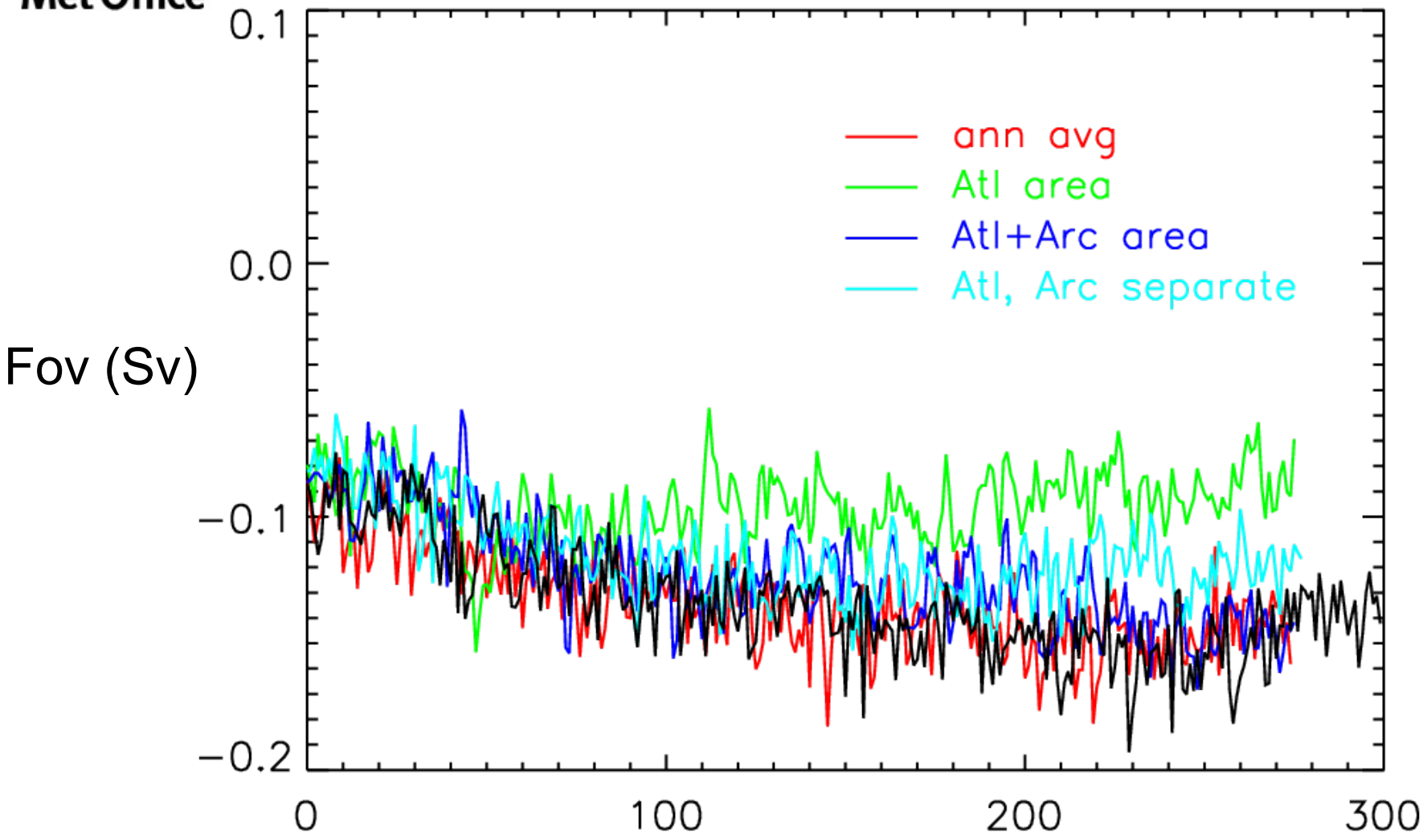




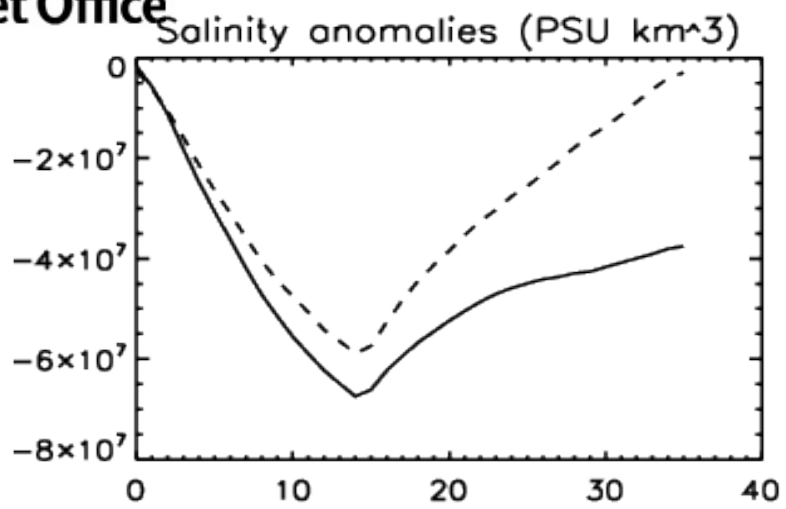
What is flux adjustment?

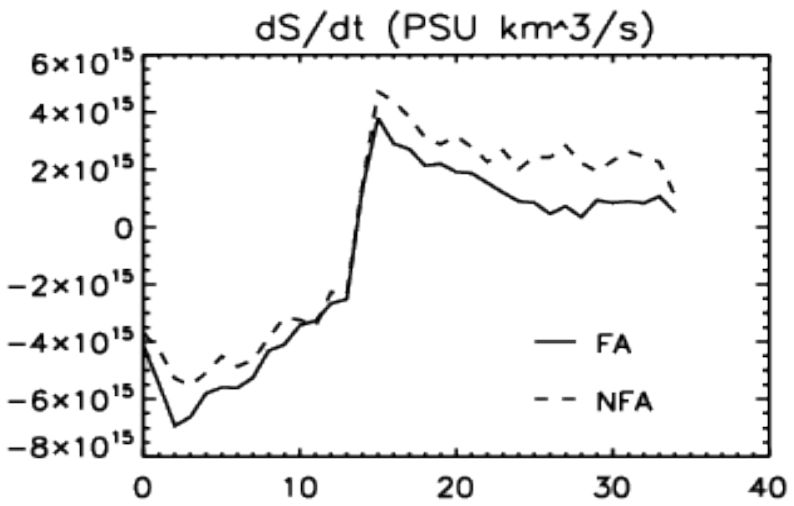
- Initial run relaxing SSS and SST to observations.
- Calculate climatology of anomalous surface heat and freshwater fluxes required.
- Final fluxadjusted runs applying these anomalous fluxes in addition to those in the model
- No relaxation in main run, so no damping of SST/SSS.

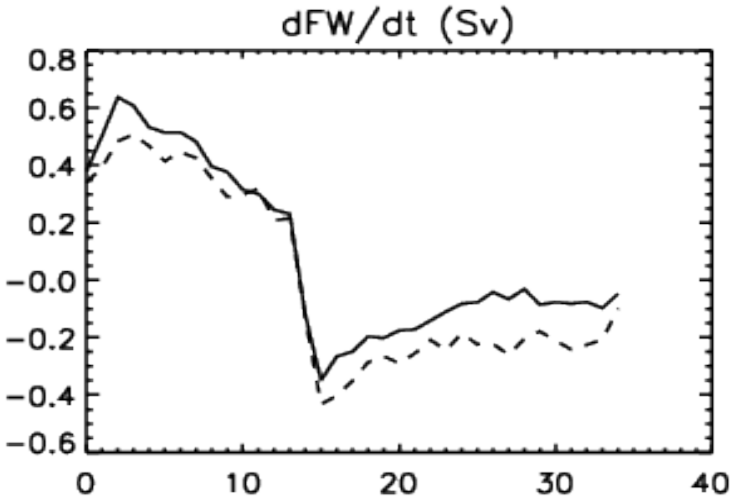


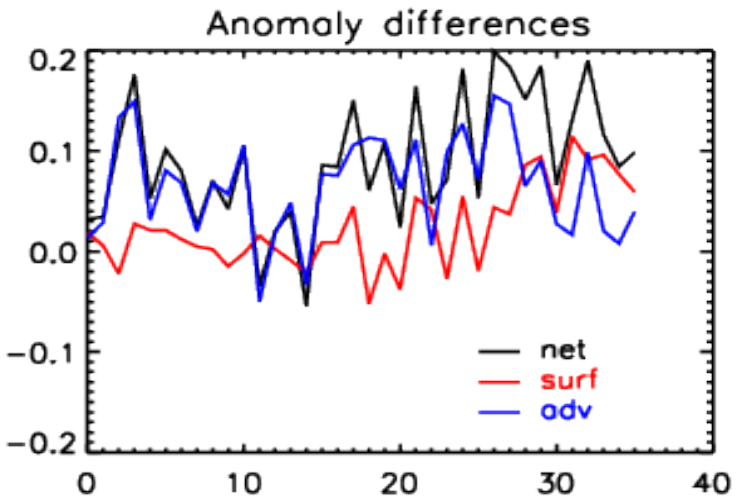


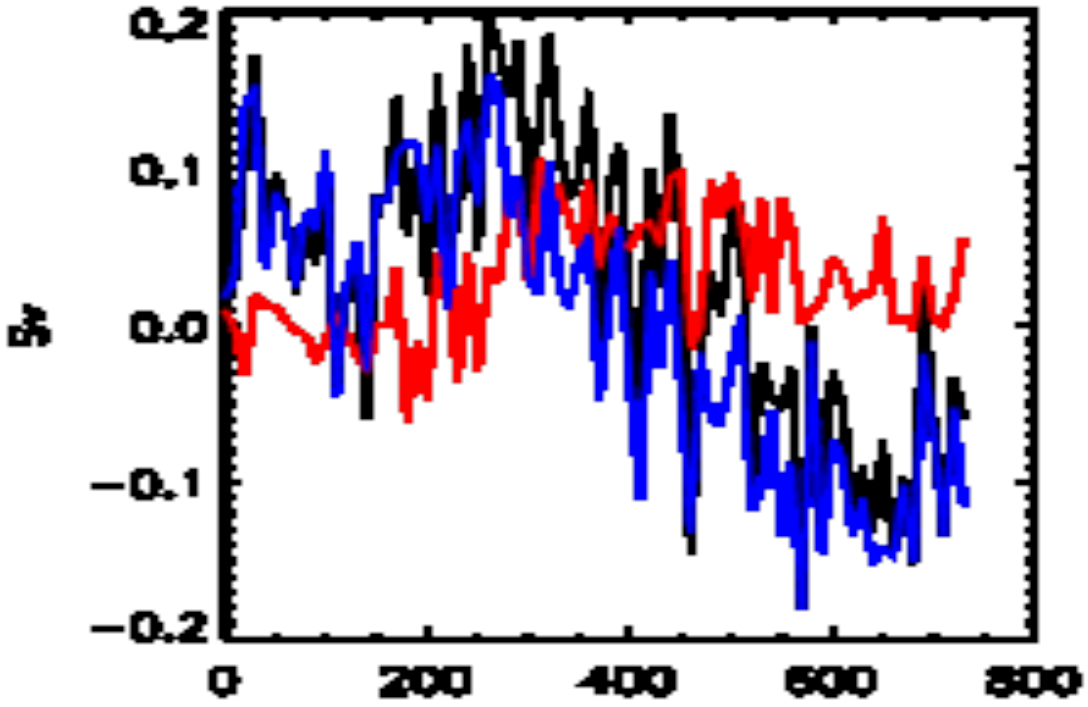
Salinity budget











Net

Surface

Advection