



*Inter-basin versus Meridional
Ocean Freshwater Disparity
and Global Ocean Conveyor*

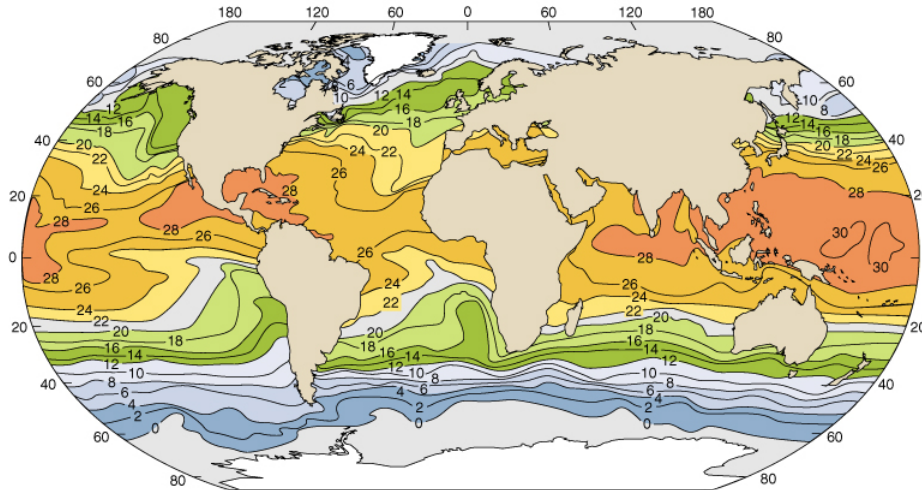
Dan Seidov & Bernd J. Haupt

<http://www.personal.psu.edu/dxs60>

<http://www.personal.psu.edu/bjh18>

AGU Fall Meeting 2003

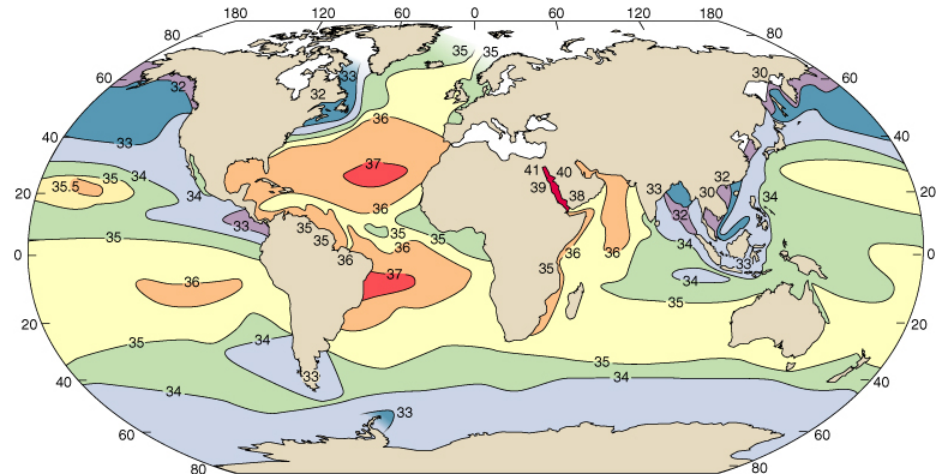
Inter-basin versus Meridional Contrasts in Sea Surface Salinity



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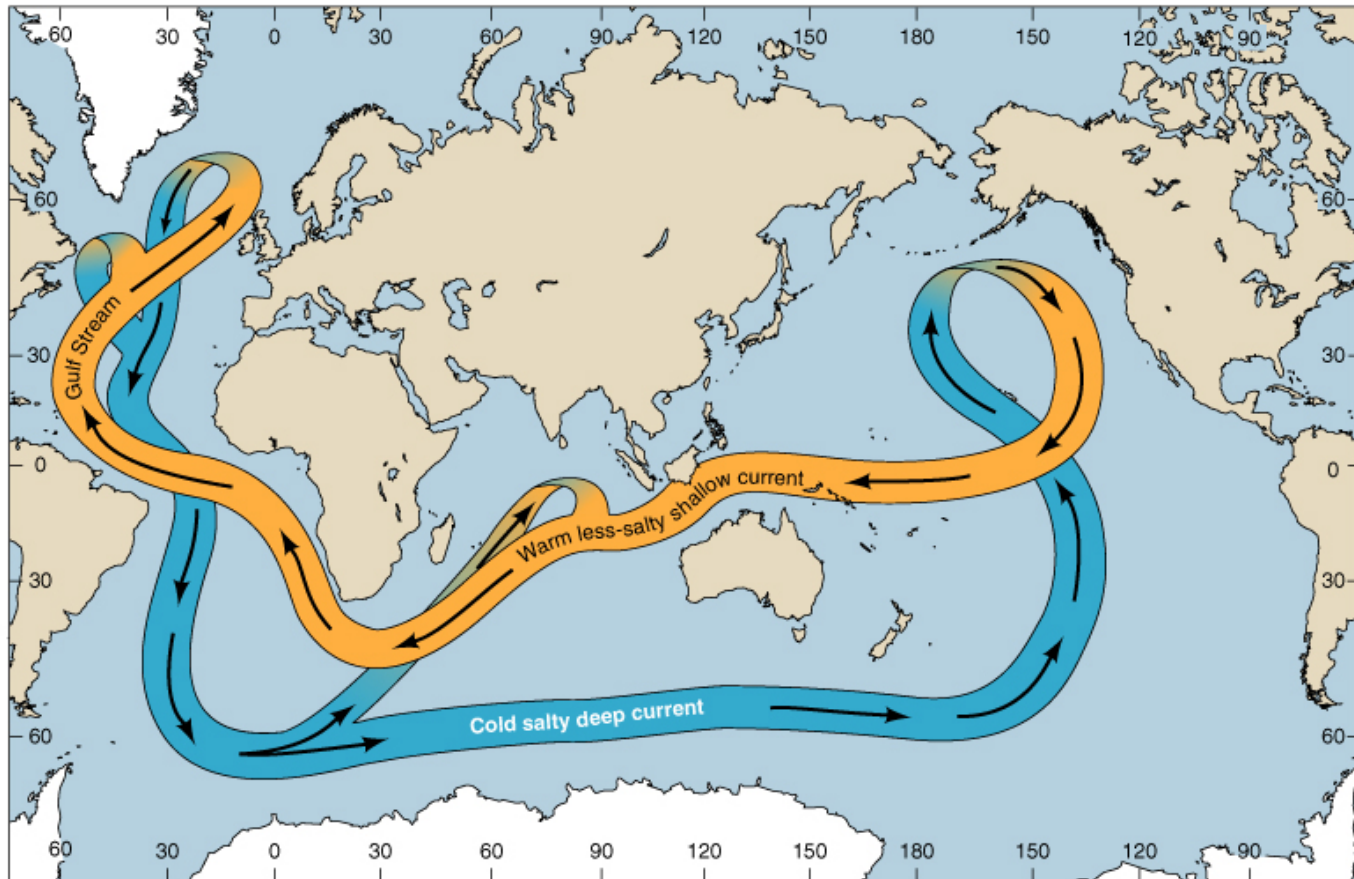
Sea Surface Temperature (SST) shows quasi-zonal and equatorially quasi-symmetrical patterns

Sea Surface Salinity (SSS) shows neither zonal, nor meridional symmetry



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The Atlantic-Pacific (A-P) SSS asymmetry is believed to be the key requirement for running the global ocean thermohaline circulation, also known as the “salinity conveyor belt” (*Broecker, 1991*)



Two concurrent hypotheses have been offered to explain the conveyor belt linked to the A-P SSS asymmetry:

Hypothesis #1: Water vapor transport from the Atlantic to the Pacific Ocean over the Central America **sustains** the conveyor. The conveyor **prevents** continuous build up of the salty surface pool in the North Atlantic Ocean (e.g., *Broecker, 1989; Birchfield and Broecker, 1990; Wang and Birchfield, 1992*).

Hypothesis #2: The conveyor **causes** of the build up of the salty pool in the North Atlantic. The freshwater removal from the North Atlantic at the surface is secondary to the freshwater removal by the conveyor itself (e.g., *Gordon, 1986; Manabe and Stouffer, 1988; 1999*).

The Conveyor Paradigm: The conveyor can be **accelerated** or **slowed down** by **decreasing** or **increasing** the meridional freshwater transport, especially in the North Atlantic Ocean (*Rahmstorf, 1975, 1997; Manabe and Stouffer, 1995, 1997*).

Recent ocean-only simulations

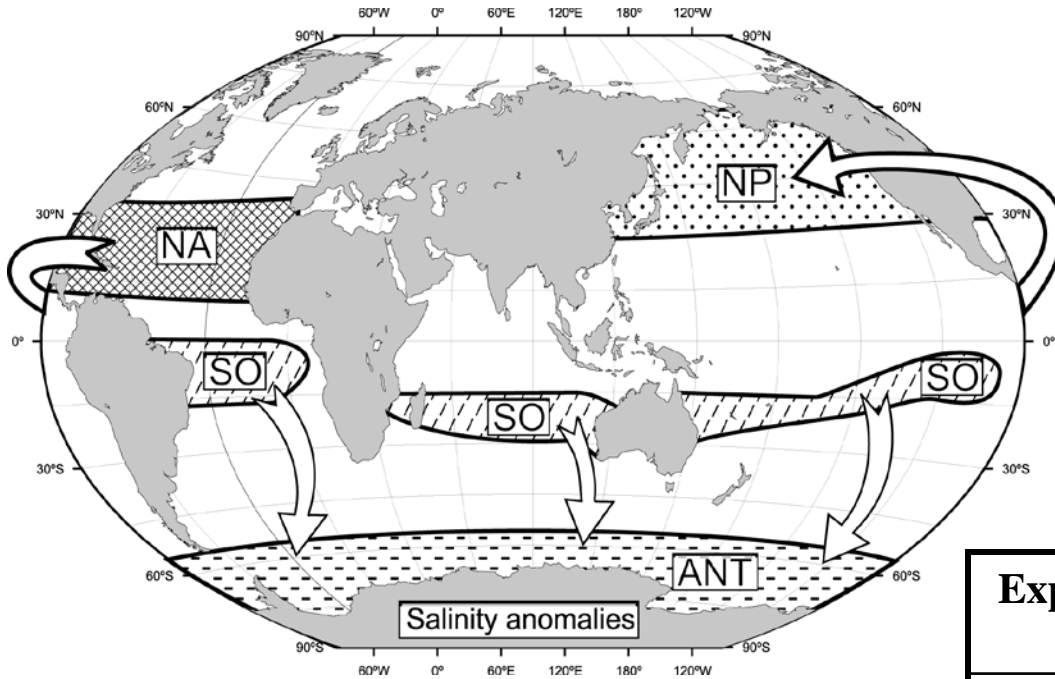
In a series recent publications (*Seidov et al*, 2001; *Seidov and Haupt*, 2001, 2002, 2003), it has been shown that the current paradigm is biased.

Even if the conveyor is only sensitive to the changes in meridional sea surface salinity contrasts, the **southern** connections are stronger than the **northern** ones – much smaller variations of SSS in the Southern Ocean alter the conveyor far stronger than the equivalent SSS changes in the North Atlantic.

It has also been shown that the conveyor runs only if the A-P SSS contrasts are over some thresholds. Moreover, sufficient A-P SSS contrasts are the only **necessary** condition for the true global conveyor, with North Atlantic – North Pacific linked by the conveyer.

We also will argue today that a new paradigm would mediate between the Hypothesis #1 and #2.

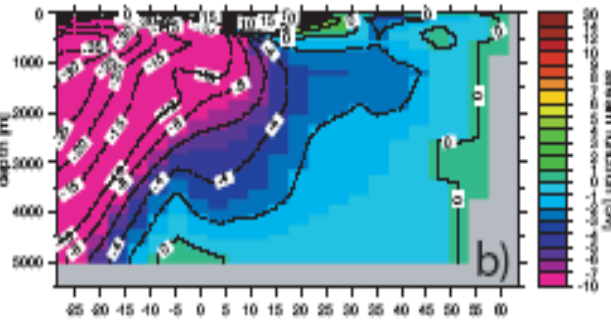
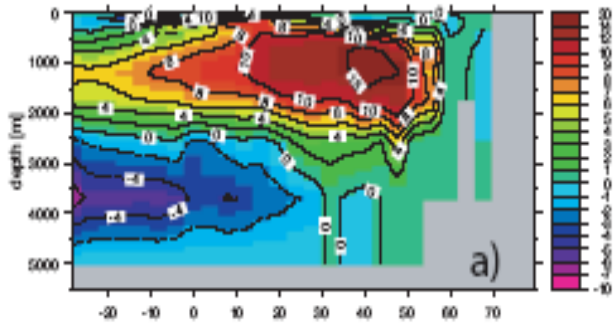
Restoring Numerical Experiments



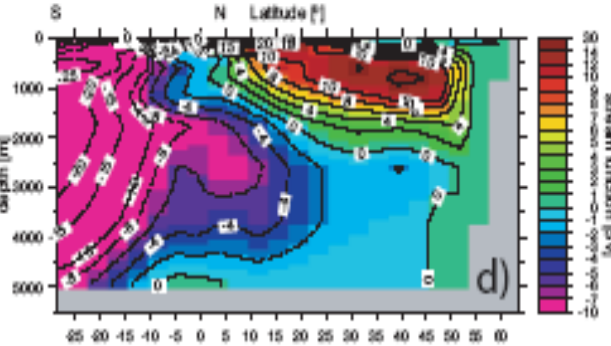
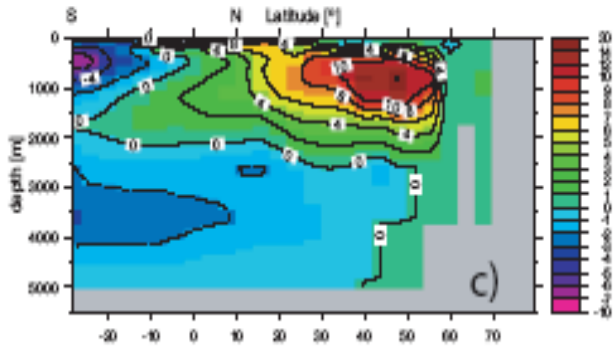
Note: The results of the simulations of the freshwater impacts in the Southern Ocean will be shown as a poster at the Poster OS21C-1140 poster session on 12/09/03.

Exp.	Description of sea surface boundary conditions
1	Annual SST and SSS
2	Annual SST and SSS=const=34.25 psu everywhere
3	Annual SST and SSS=34.25 everywhere, except for the North Atlantic and North Pacific, i.e., only the A-P SSS contrast (2.5 psu) exists.
4	Annual SST and SSS zonally averaged (retaining no inter-basin SSS contrasts)

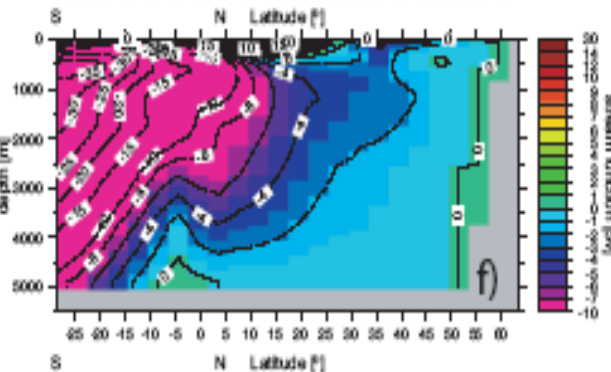
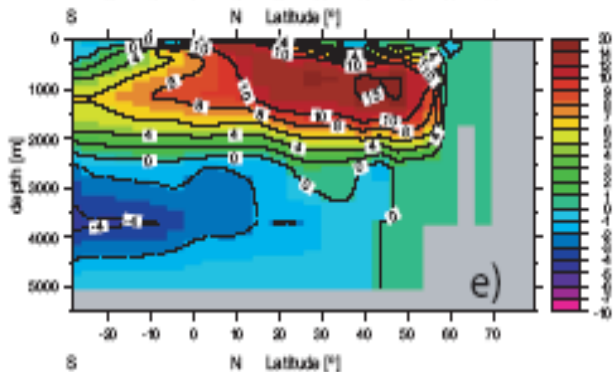
Meridional Overturning in the Atlantic (left) and North Pacific (right) Oceans (in Sv; $1 \text{ Sv} = 10^6 \text{ m}^3/\text{s}$).



Control run



SSS=34.45 psu everywhere



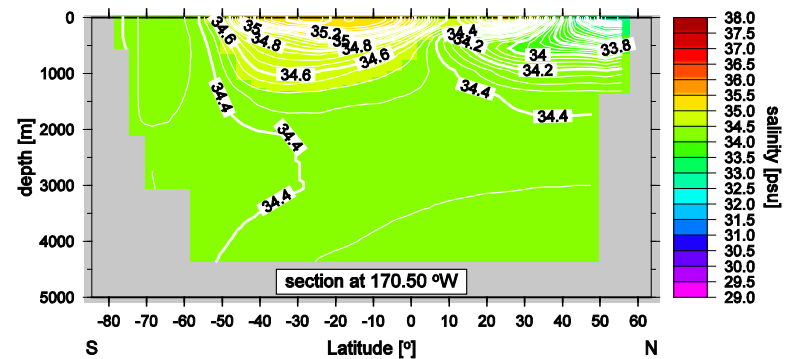
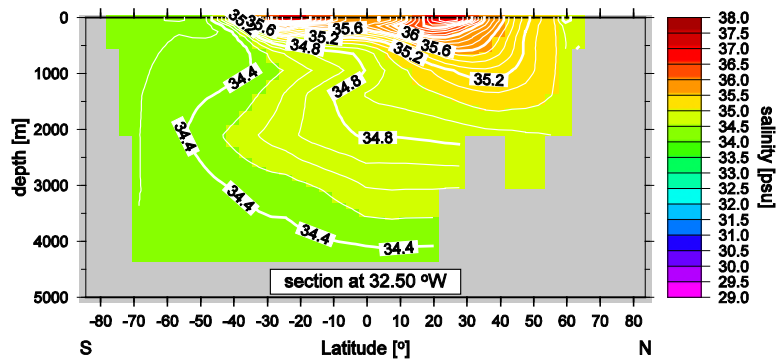
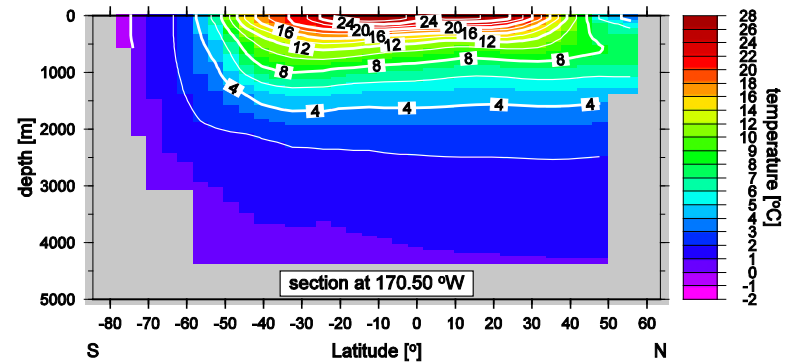
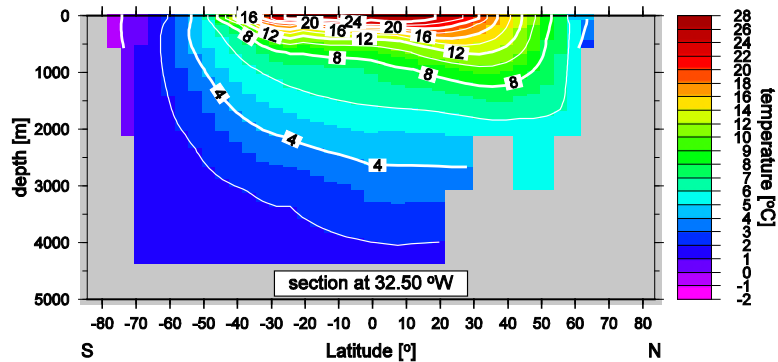
$\Delta \text{SSS (A-P)} = 2.5 \text{ psu}$

Atlantic

North Pacific

Meridional Temperature and Salinity Sections in the Atlantic (left) and Pacific (right) Oceans

Control run (Exp. #1)

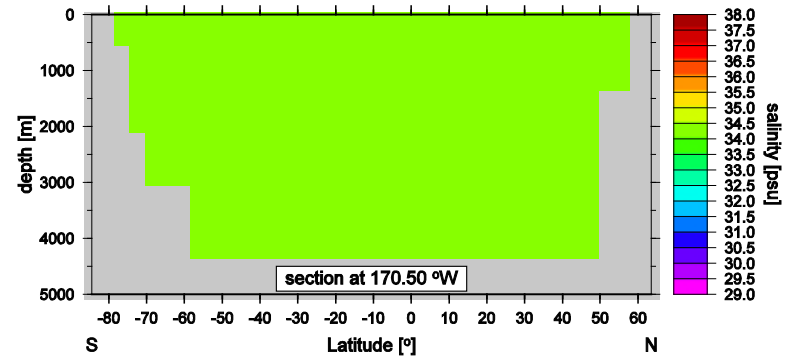
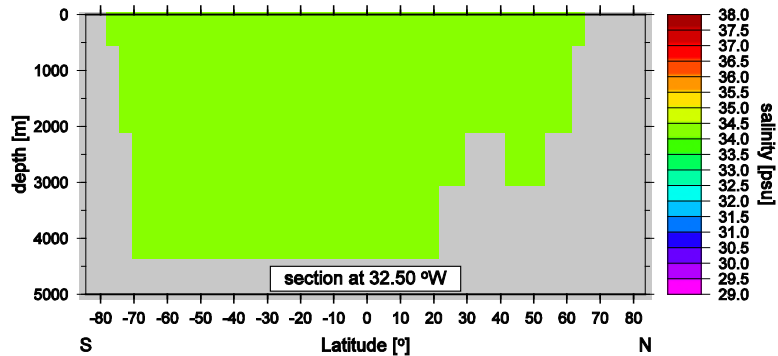
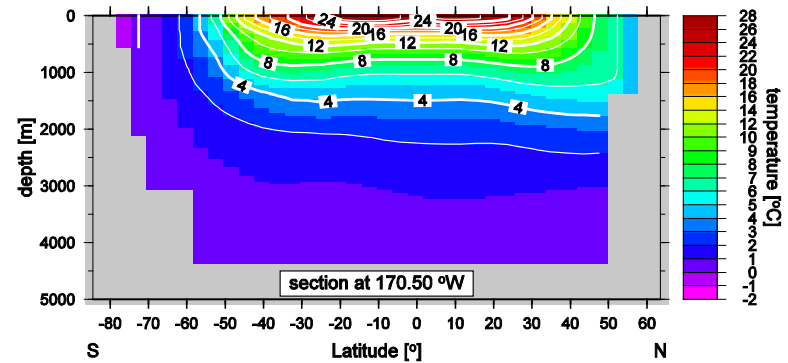
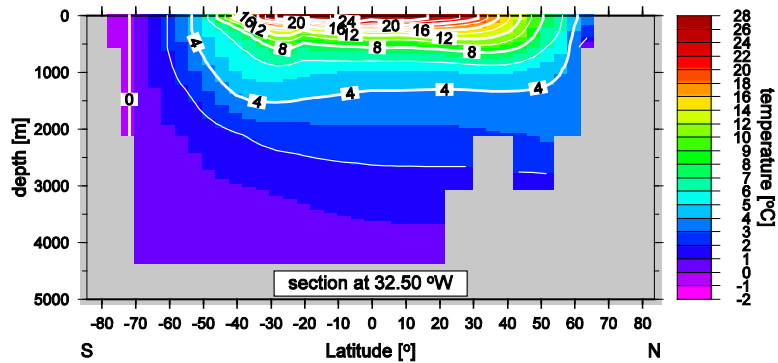


Atlantic

Pacific

Meridional Temperature and Salinity Sections in the Atlantic (left) and Pacific (right) Oceans

SSS=34.45 psu everywhere (Exp. #2)

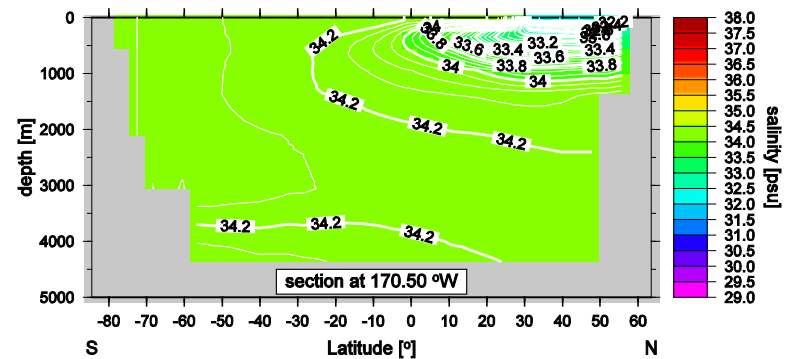
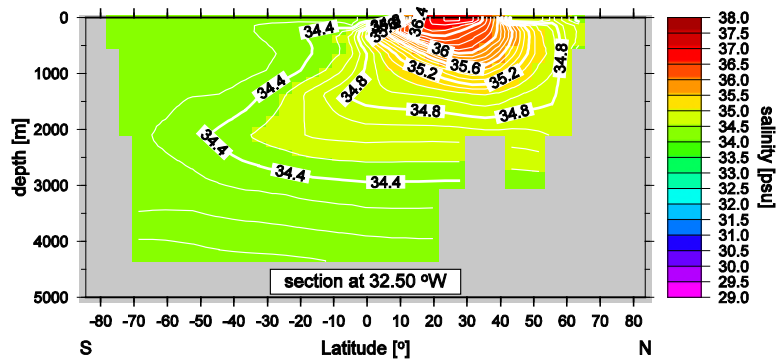
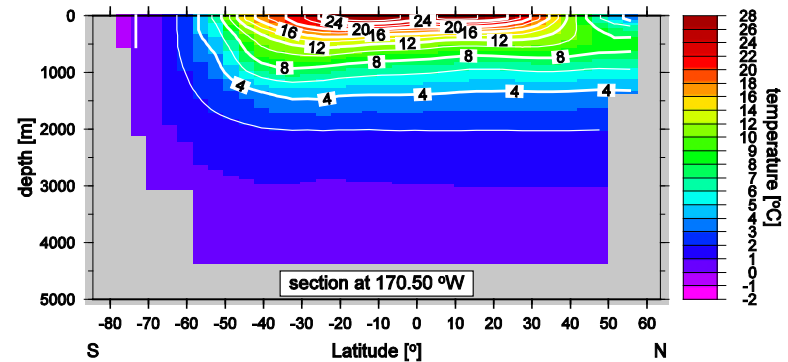
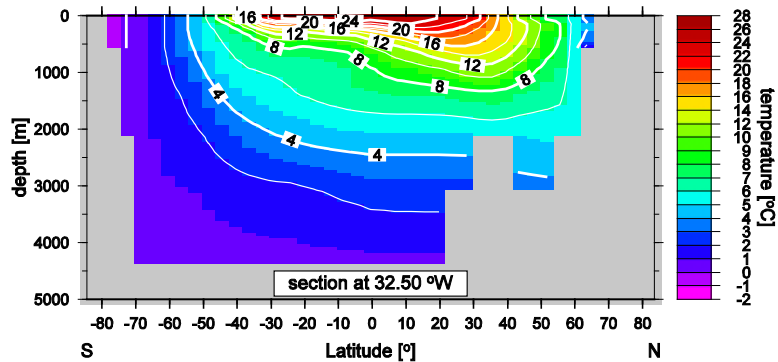


Atlantic

Pacific

Meridional Temperature and Salinity Sections in the Atlantic (left) and Pacific (right) Oceans

Δ SSS (A-P) = 2.5 psu (Exp. #3)

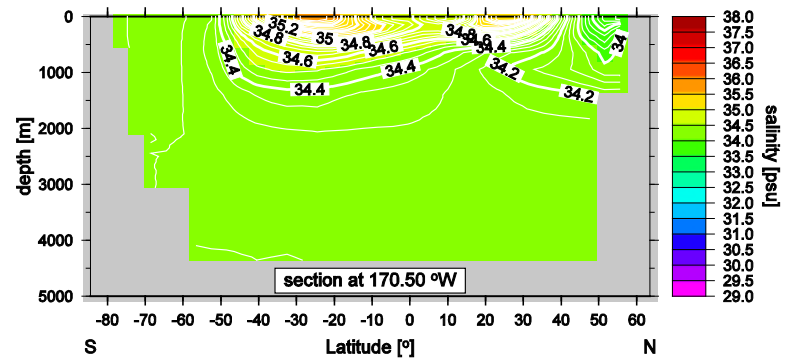
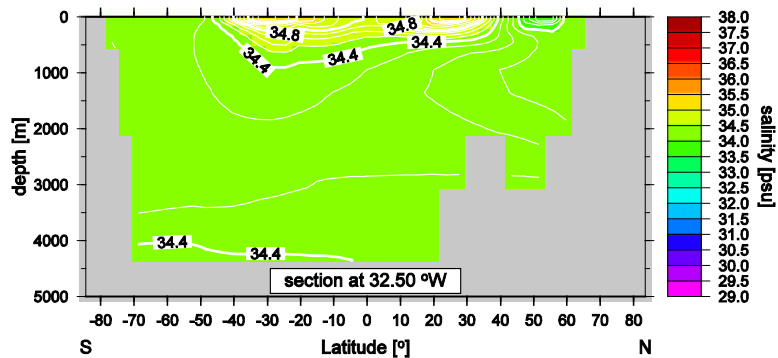
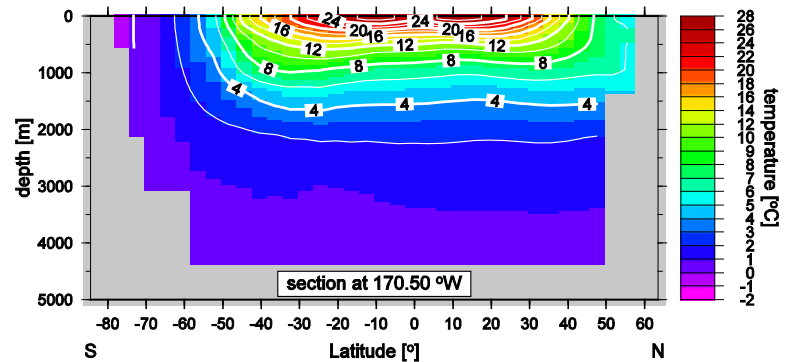
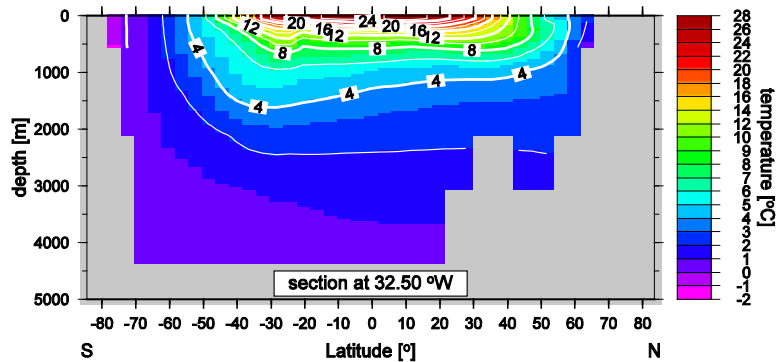


Atlantic

Pacific

Meridional Temperature and Salinity Sections in the Atlantic (left) and Pacific (right) Oceans

Annual SST and SSS zonally averaged (Exp. #4; retaining no inter-basin SSS contrasts)



Atlantic

Pacific

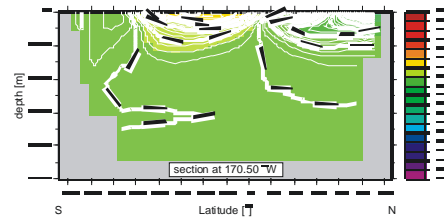
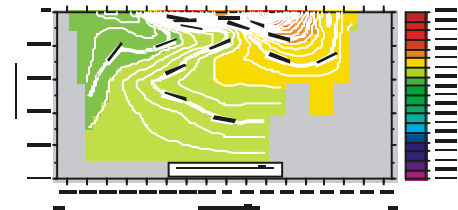
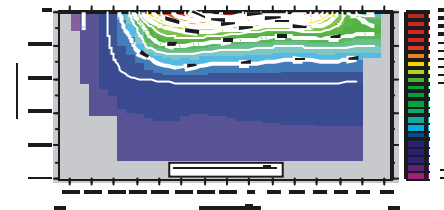
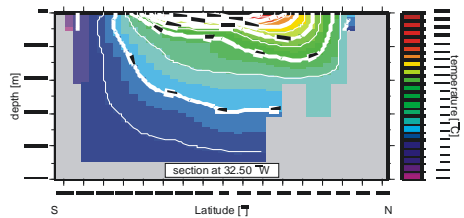
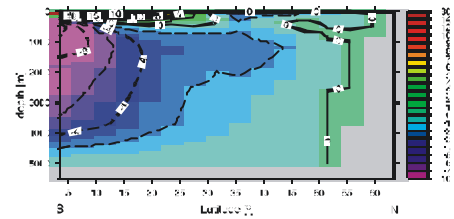
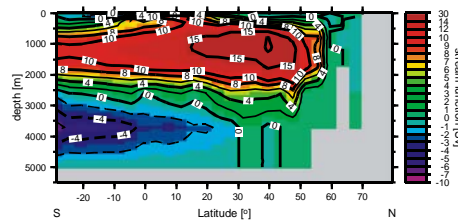
Experiments with Freshwater Fluxes

Control Run (observed SST and freshwater fluxes)

Initial salinity: 34.45 psu everywhere;

Boundary conditions: Annual SST and freshwater at the sea surface.

Surface freshwater budget is negative in the North Atlantic, positive in the North Pacific, and zero everywhere else.



Atlantic

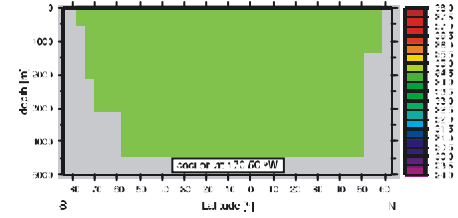
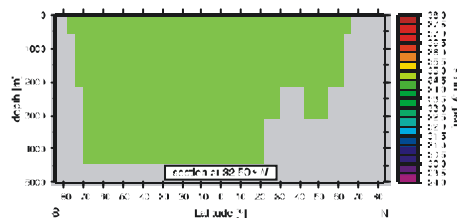
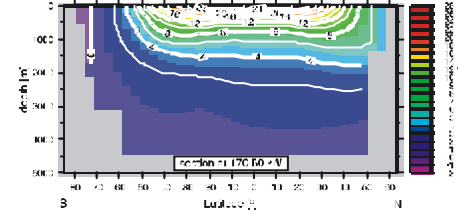
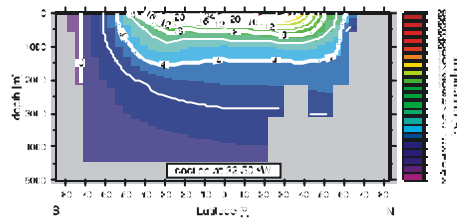
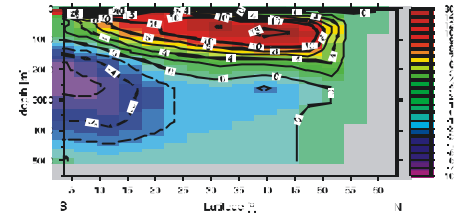
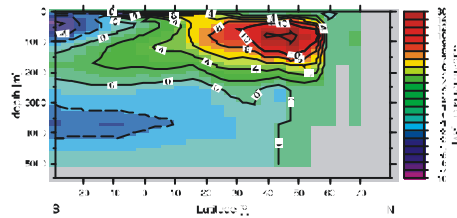
Pacific

No freshwater fluxes; $SSS = \text{const} = 34.45$ psu

Initial salinity: 34.45 psu everywhere;

Boundary conditions: Annual SST and freshwater at the sea surface.

Surface freshwater budget zero everywhere.

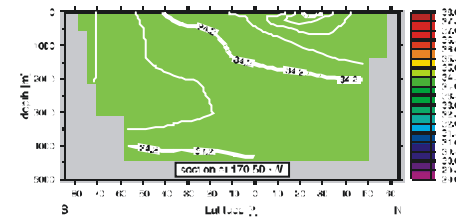
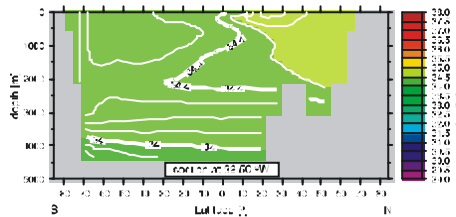
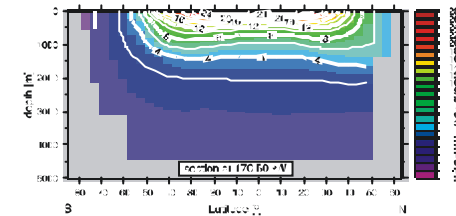
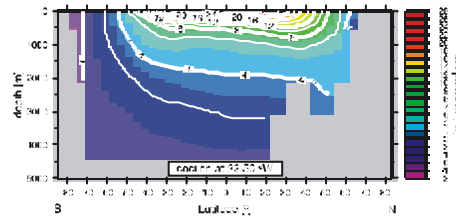
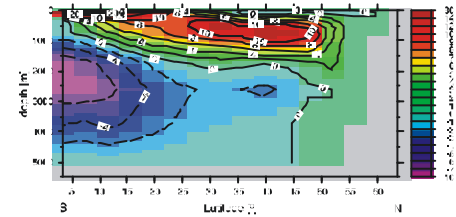
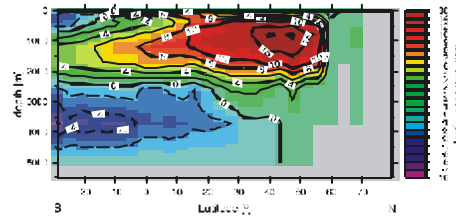


Atlantic

Pacific

NA-NP Freshwater Flux = 0.035 Sv

Initial salinity: 34.45 psu everywhere;
Boundary conditions: Annual SST and freshwater at the sea surface.
Surface freshwater budget is negative in the North Atlantic, positive in the North Pacific, and zero everywhere else.



Atlantic

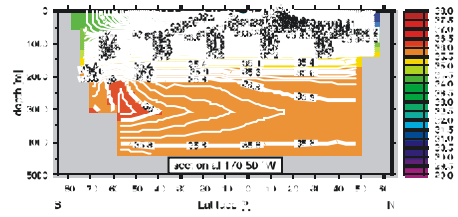
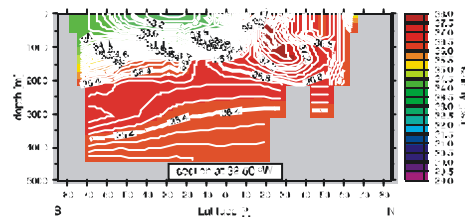
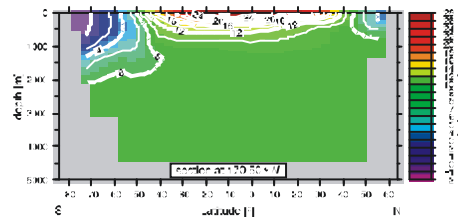
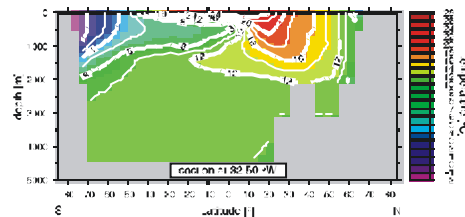
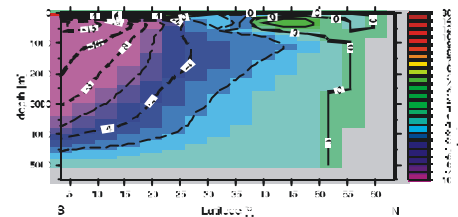
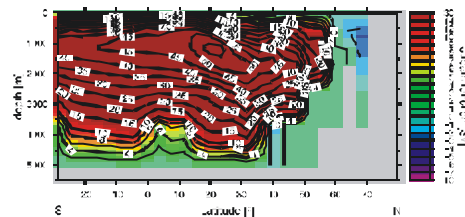
Pacific

NA-NP Freshwater Flux = 0.15 Sv

Initial salinity: 34.45 psu everywhere;

Boundary conditions: Annual SST and freshwater at the sea surface.

Surface freshwater budget is negative in the North Atlantic, positive in the North Pacific and Northern North Atlantic, and zero everywhere else.



Atlantic

Pacific

Conclusions

- **Atlantic–Pacific sea surface salinity contrasts are the most important element of the global conveyor–like connectivity in the World Ocean.**
- **The A-P SSS contrasts are more important than meridional SSS contrasts.**
- **The A-P freshwater redistribution in the atmosphere necessary but not sufficient condition for the global conveyor to emerge.**
- **The thermohaline conveyor works in synergy with the atmospheric redistribution of freshwater to build up the needed inter-basin salinity contrasts.**