Ventilation variability in the North Pacific in a coupled climate model

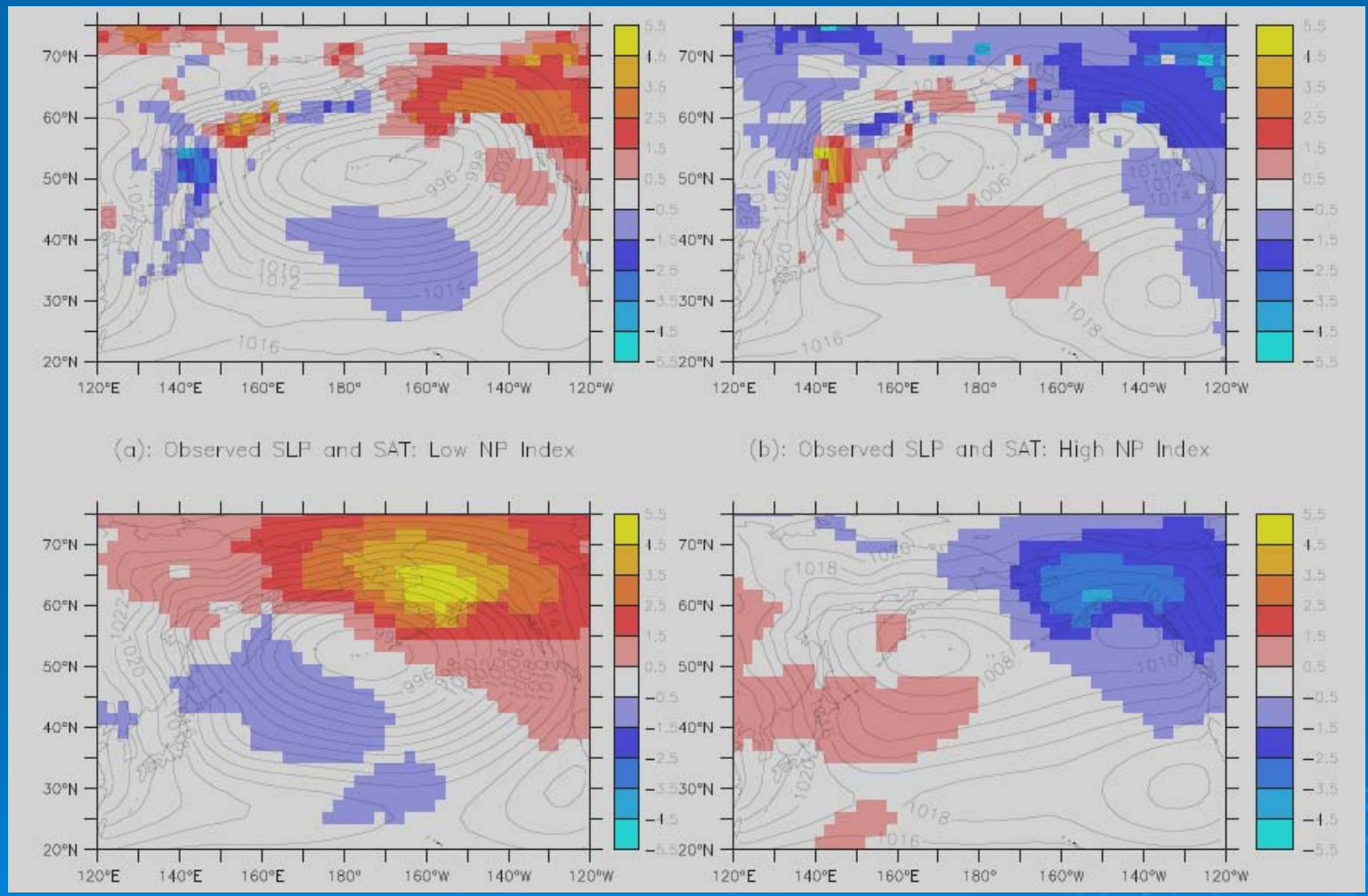
Anand Gnanadesikan
NOAA/GFDL
Princeton, NJ

The coupled model

- 2x2.5 degree atmosphere with state-of-the art physics.
- 1x1/3-1 degree level coordinate ocean with state-of-the-art physics.
- Reasonable simulation of El Nino, mean SST errors, SSS (compared with other AR4 models).

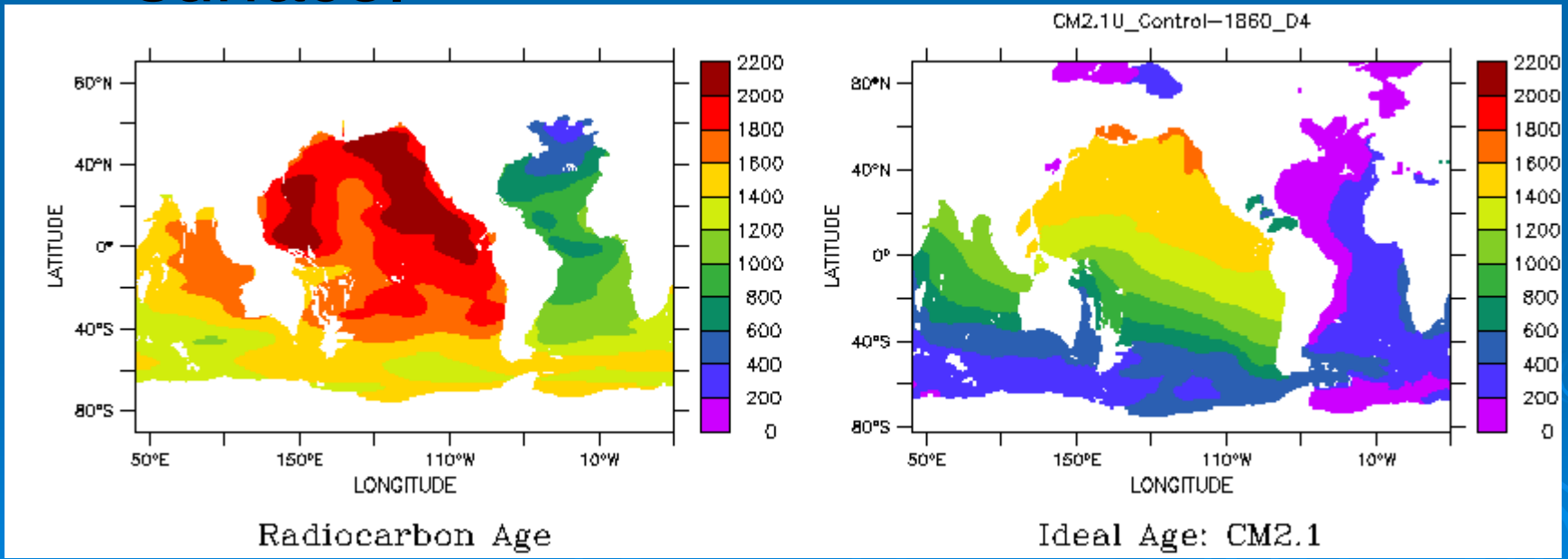
Delworth et al., (J. Clim., 2006); Gnanadesikan et al. (J. Clim., 2006)

Pacific Decadal Oscillation



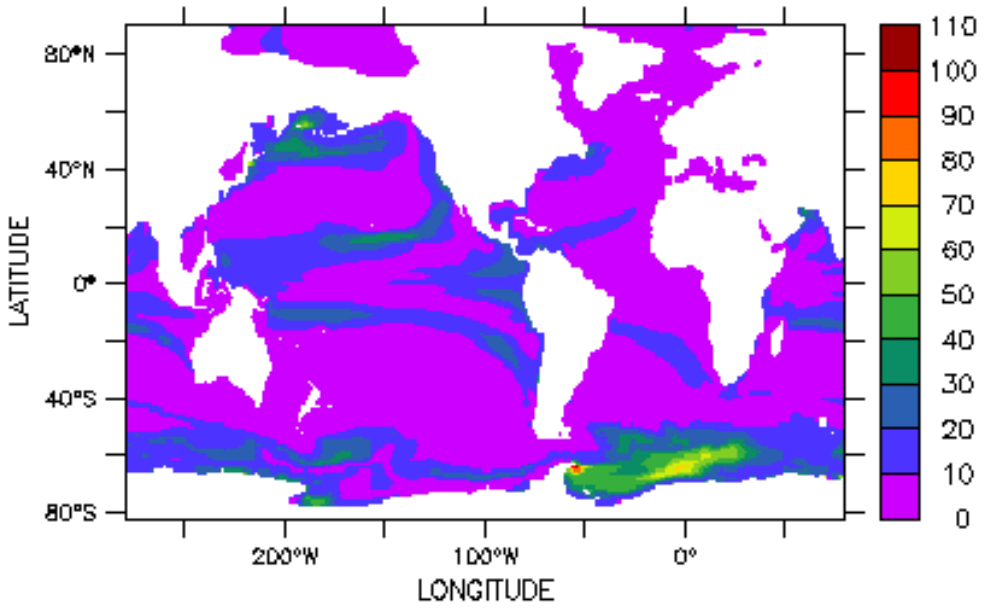
Ideal age

- Set to zero in the surface.
- Ages at 1 yr/yr below the surface.
- Effectively shows time since water saw surface.

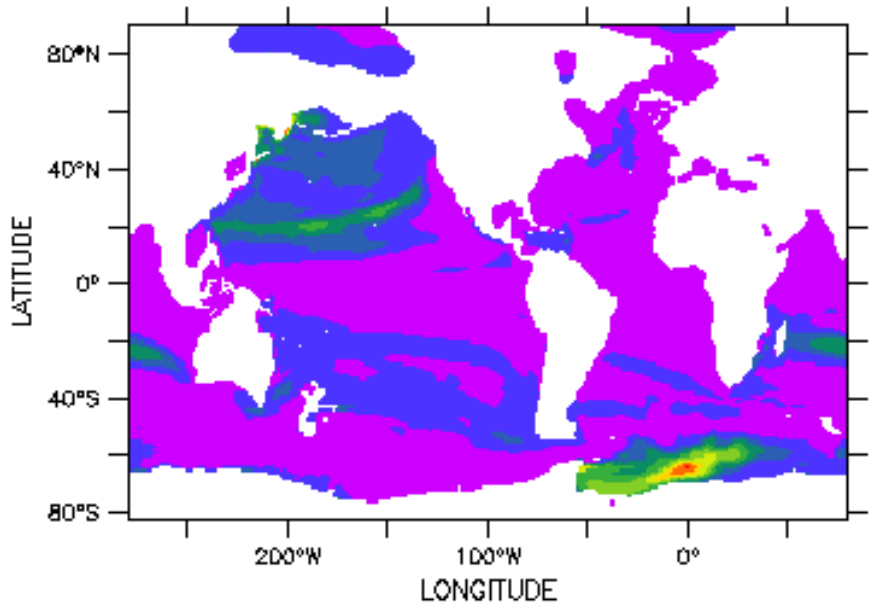


Data from Key et al. GLODAP data set.

Variability of ideal age



RMS Age Variability, 300m

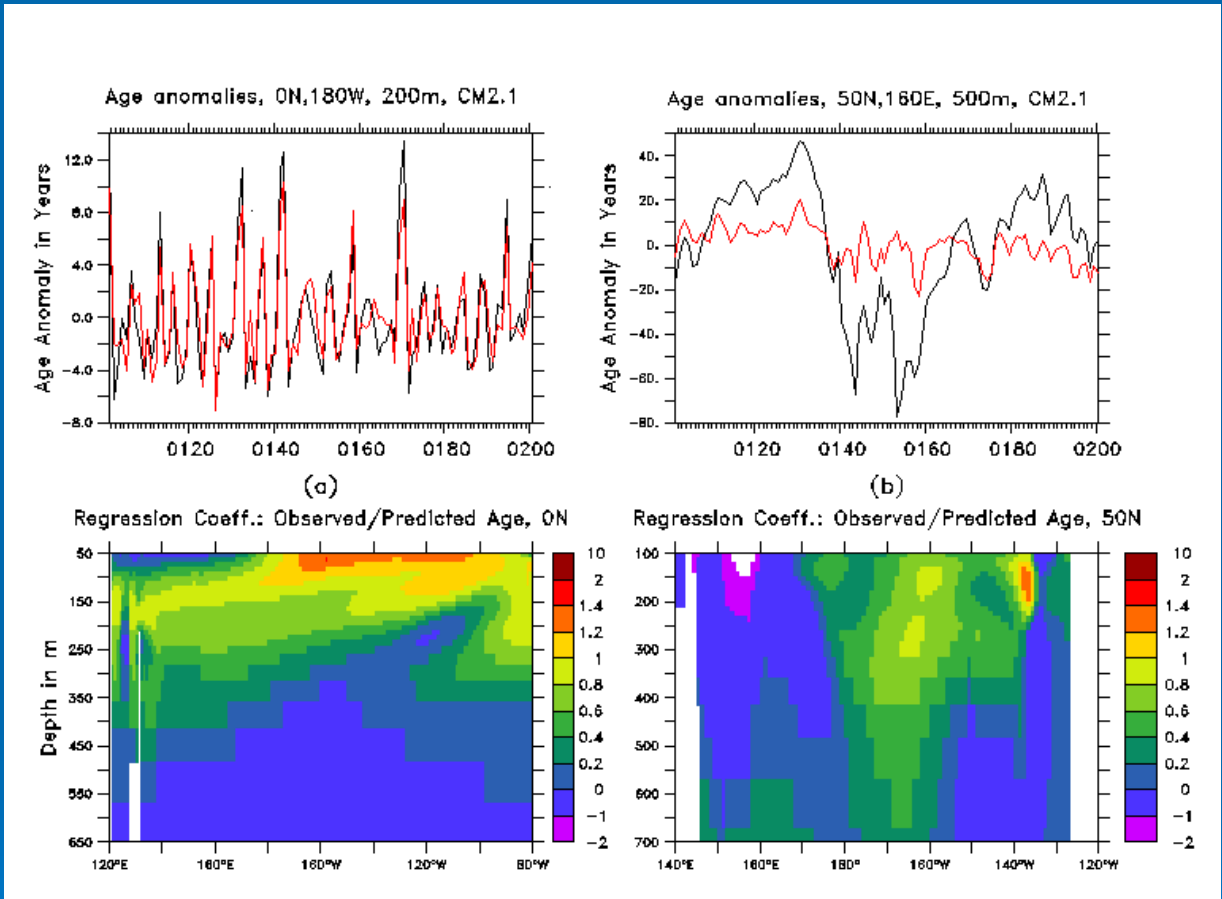


RMS Age Variability, 800m

Types of regions with high variability

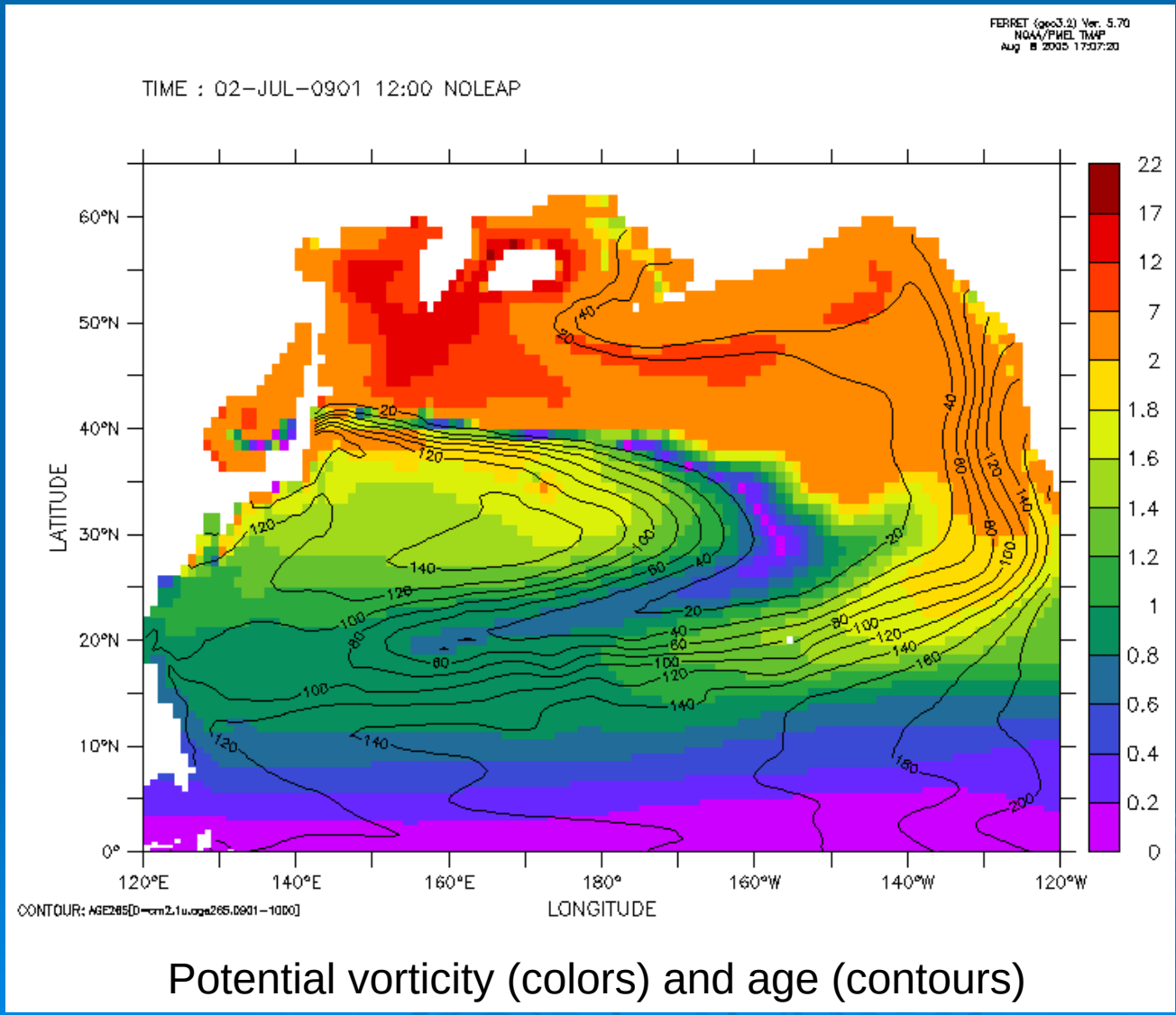
1. Equatorial zone
2. Gyre edges
3. Deep convection regions

How much of this is due to isopycnal heaving?



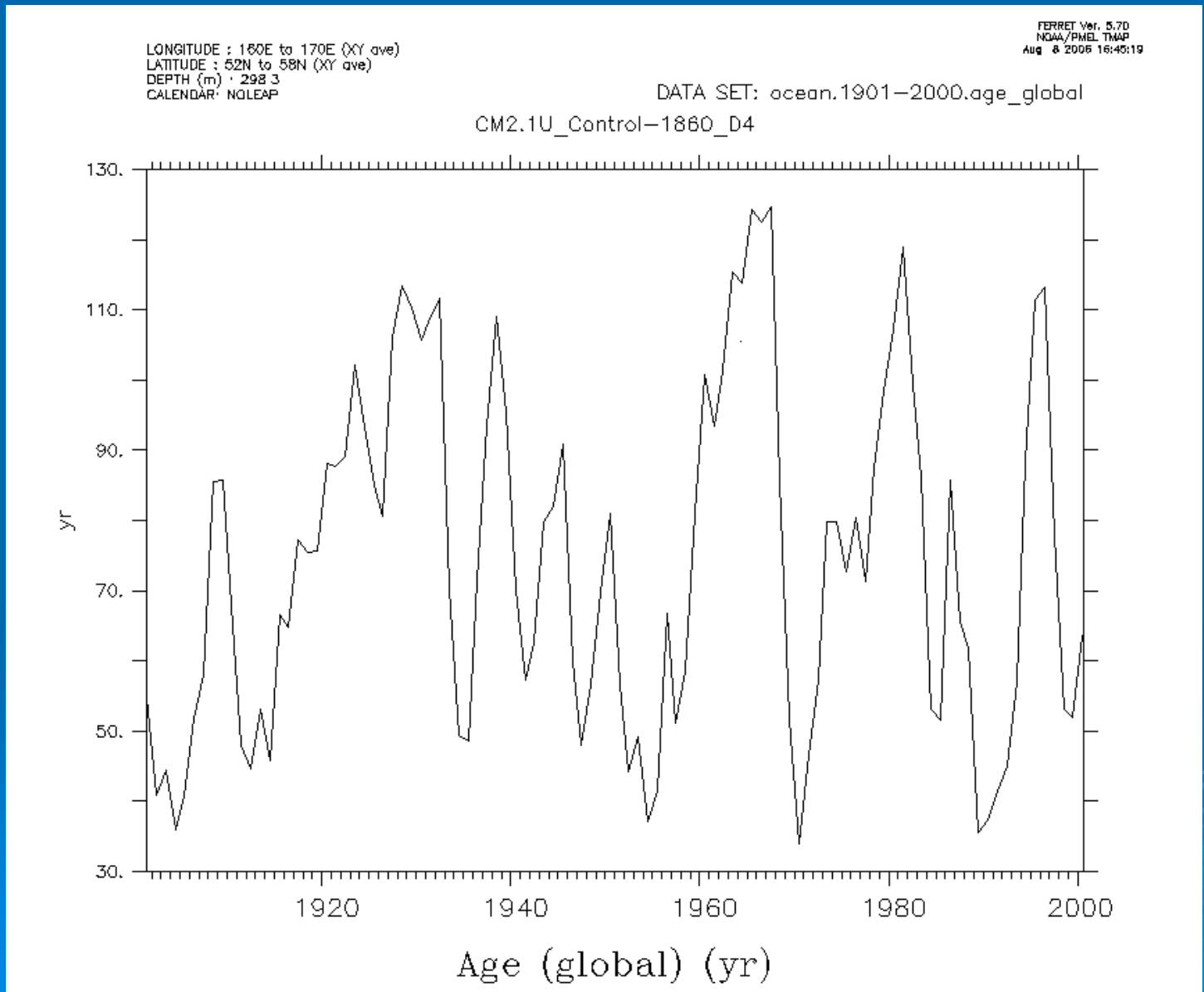
Most of variability along the equator, some in Northeast Pacific, very little in Northwest Pacific.

Age variability along an isopycnal

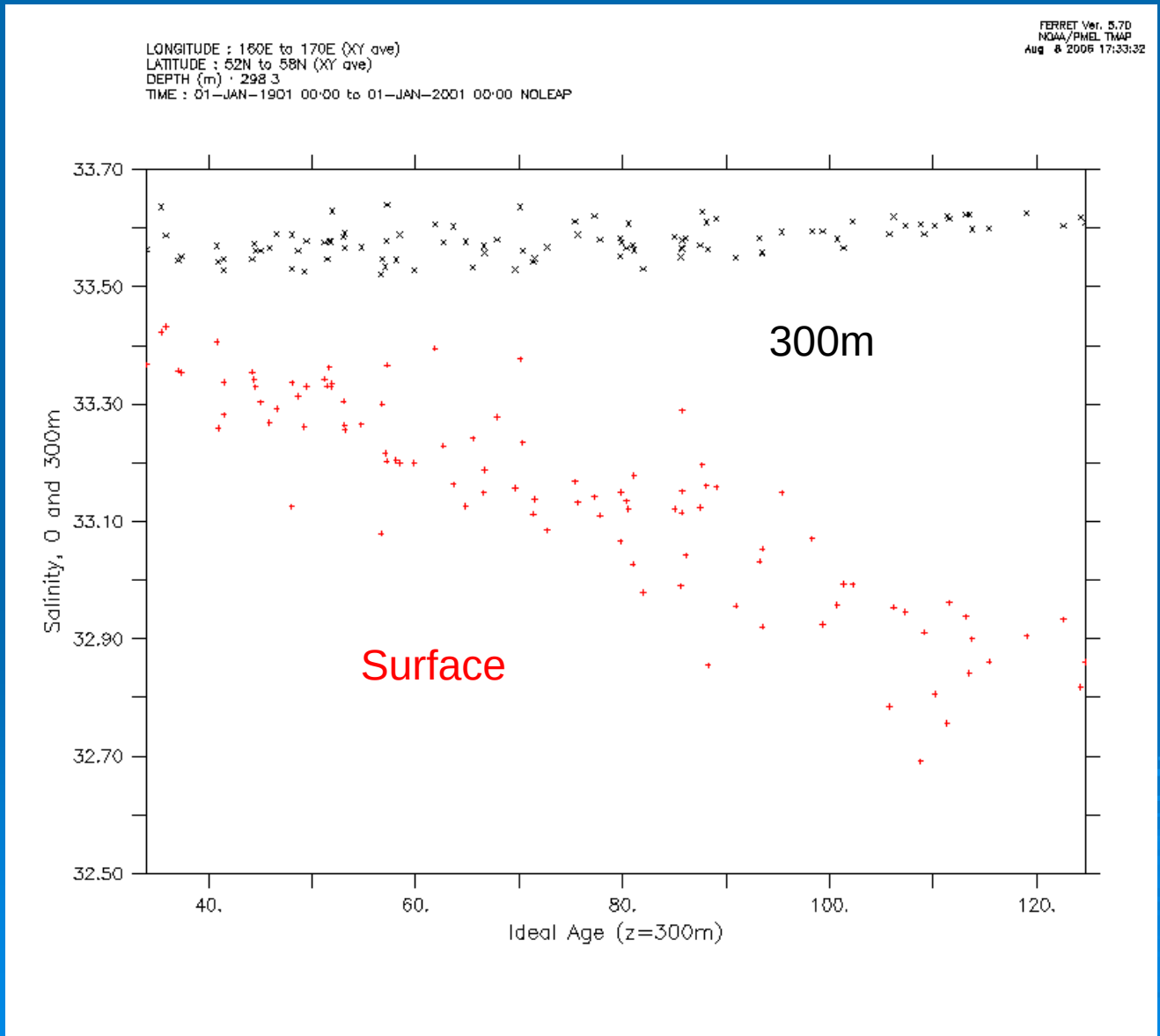


Potential vorticity (colors) and age (contours)

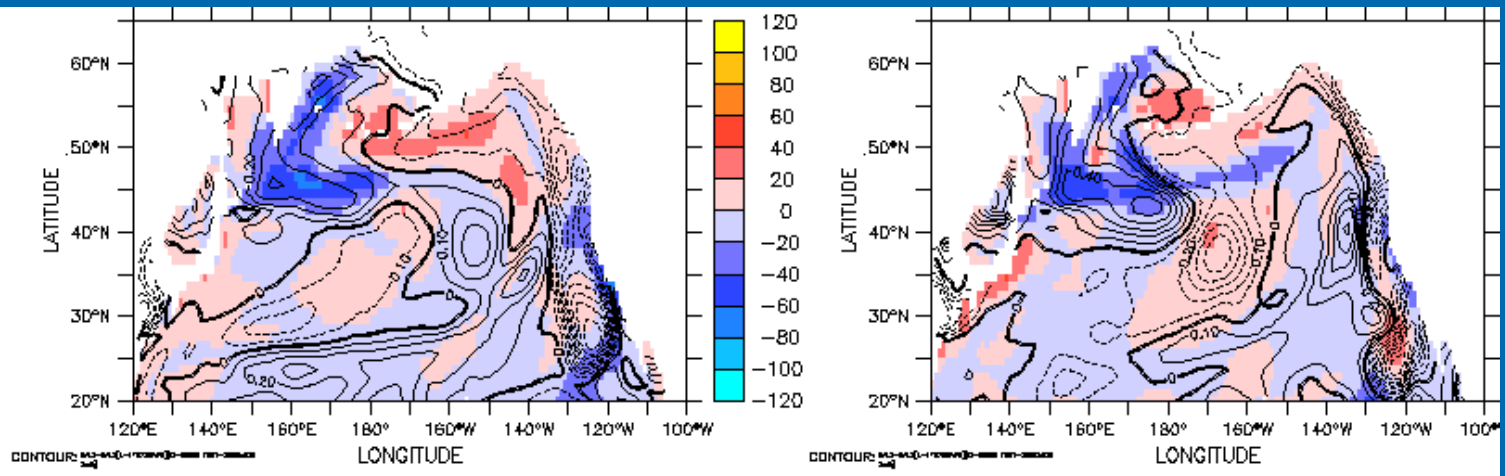
Bering Sea as a source of variability



Salinity as a driver for this variability

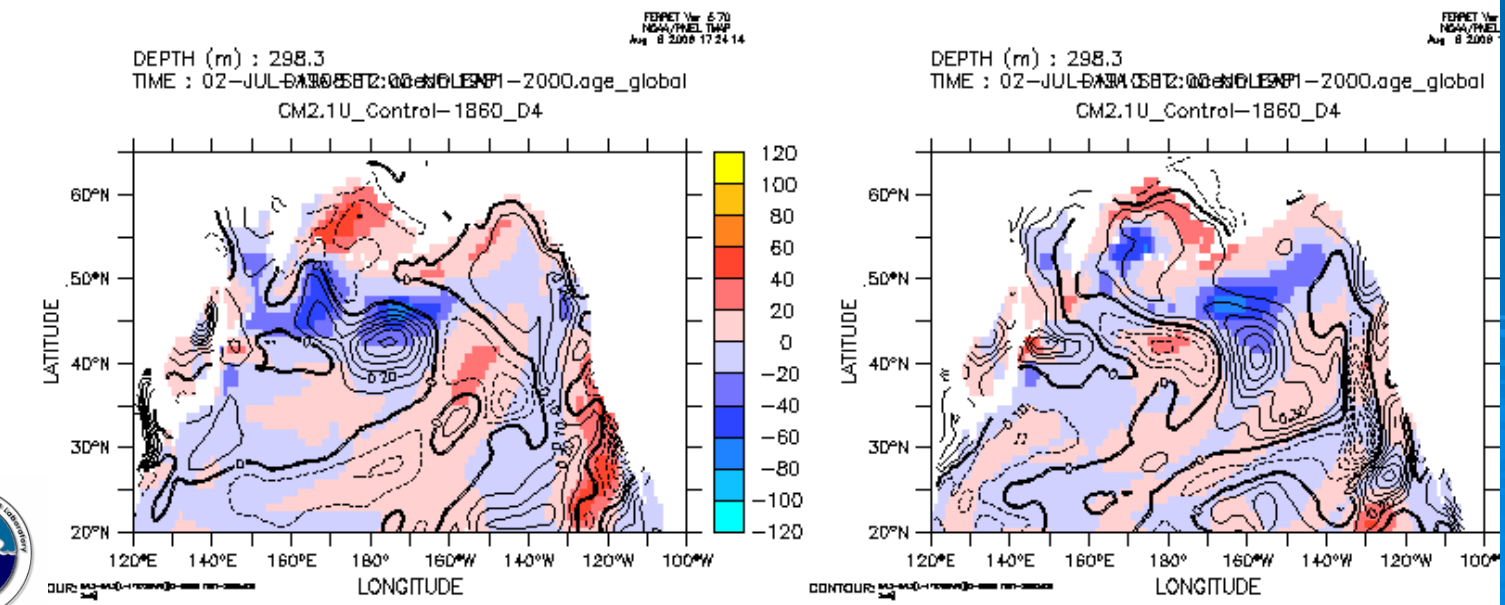


Salinity anomalies propagate around basin

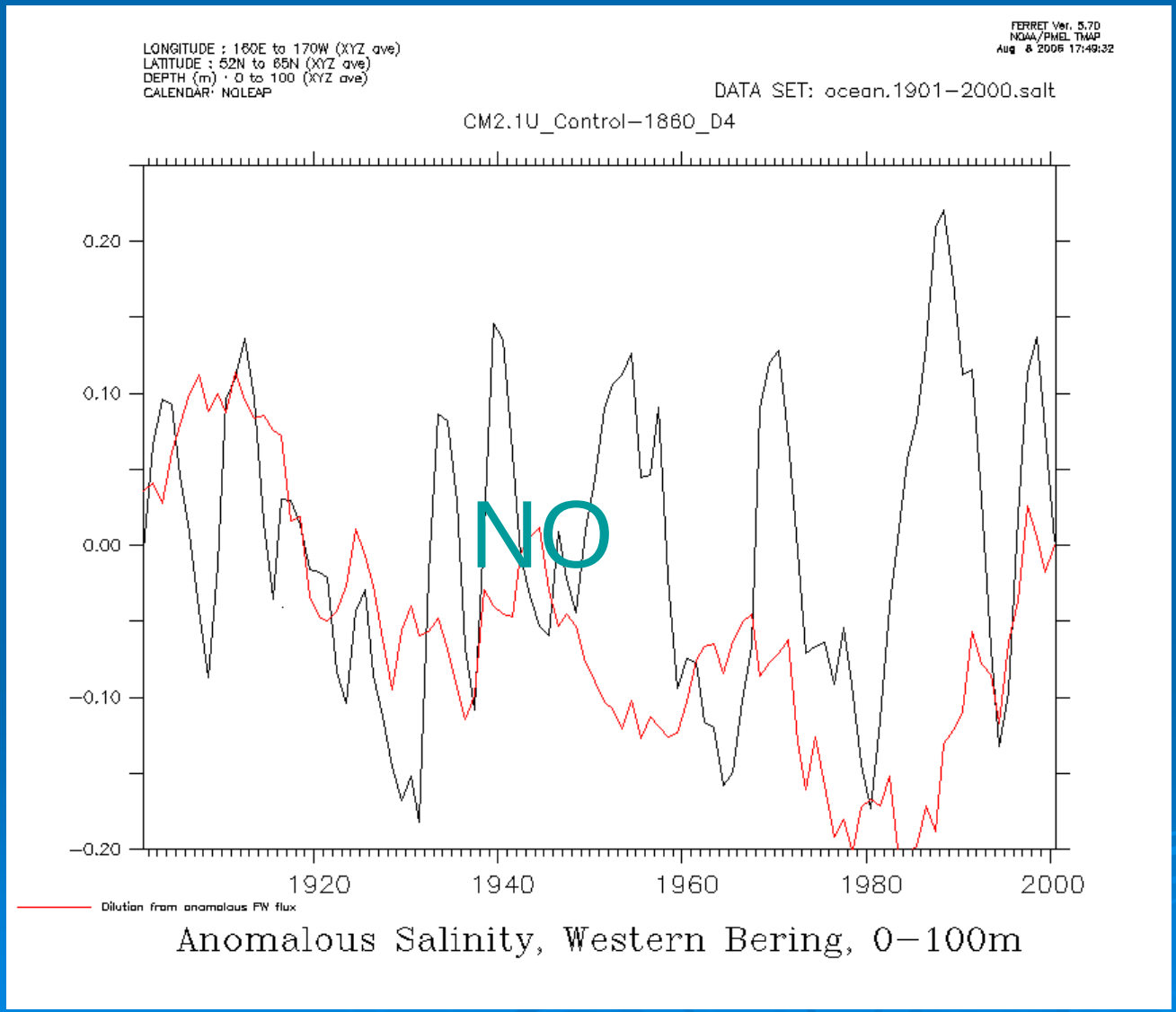


SSS and 300m Age Anomaly

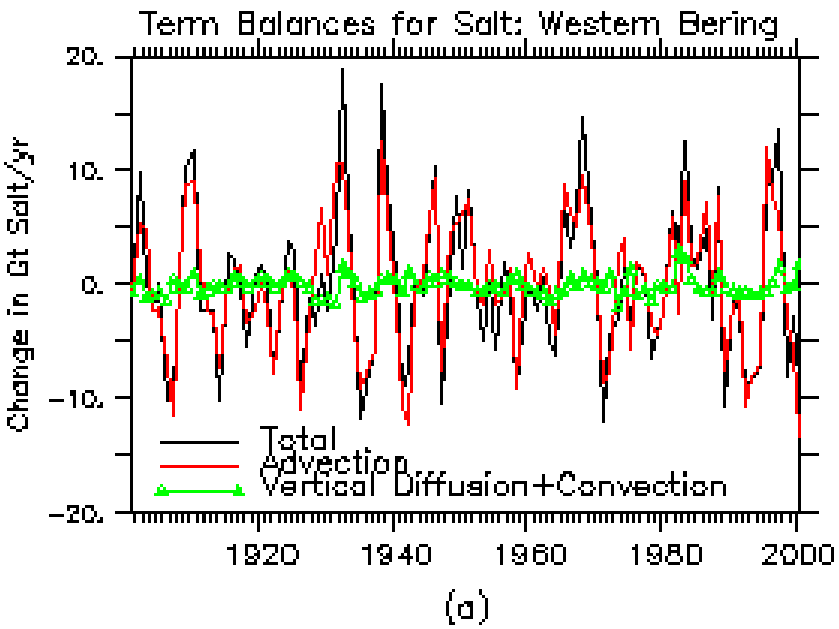
SSS and 300m Age Anomaly

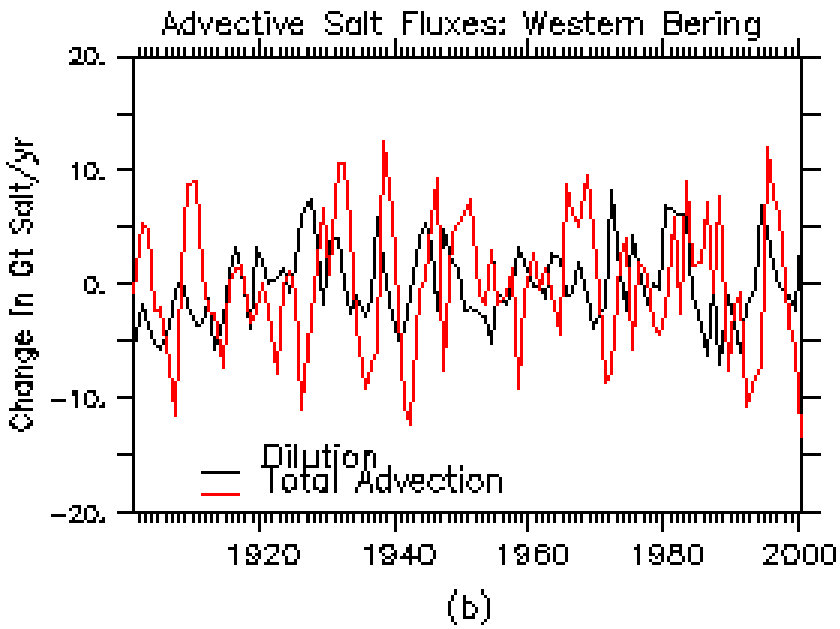


Is this variability due to surface fluxes?



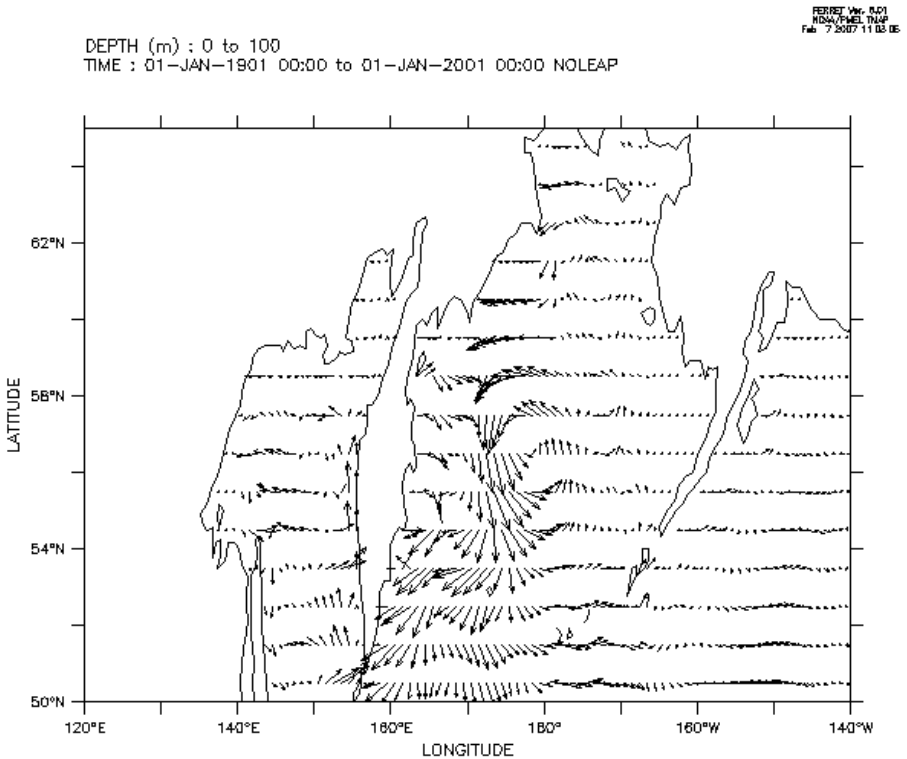
Dominant term is advection





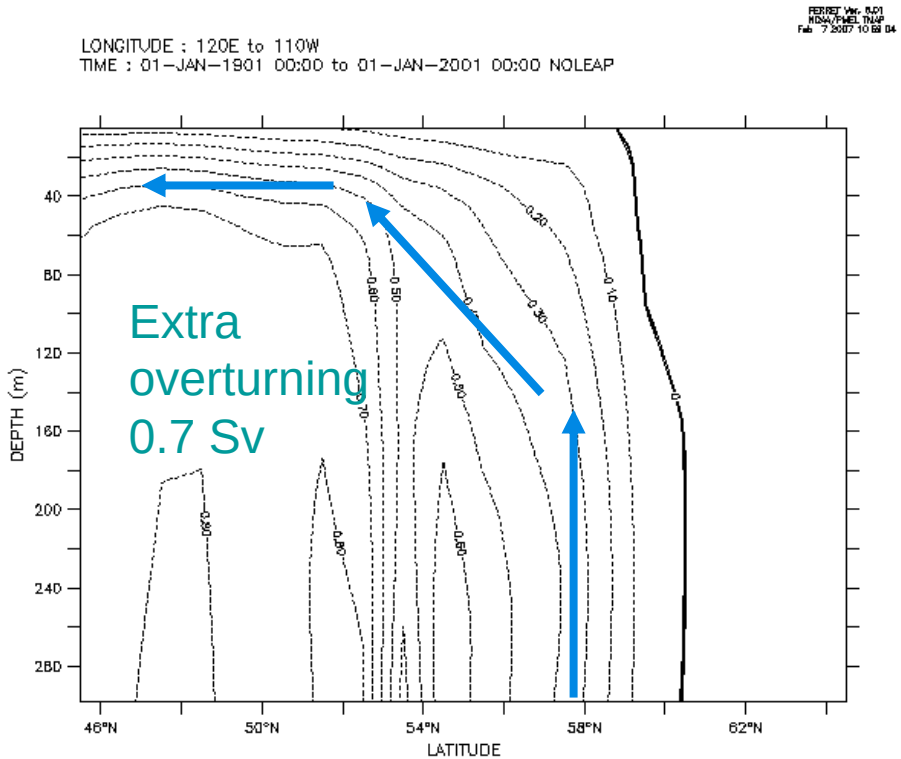
We can create an ensemble of time periods when the salt flux is unusually high and difference it relative to periods where the salt flux is unusually low.

Anomalous flow



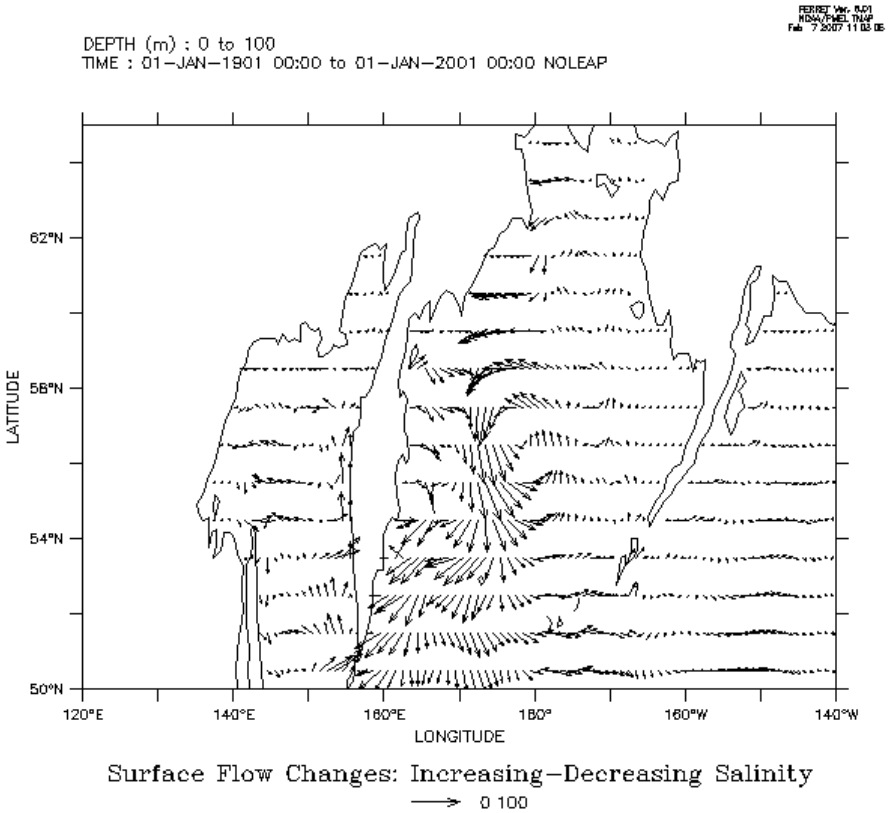
Surface Flow Changes: Increasing−Decreasing Salinity

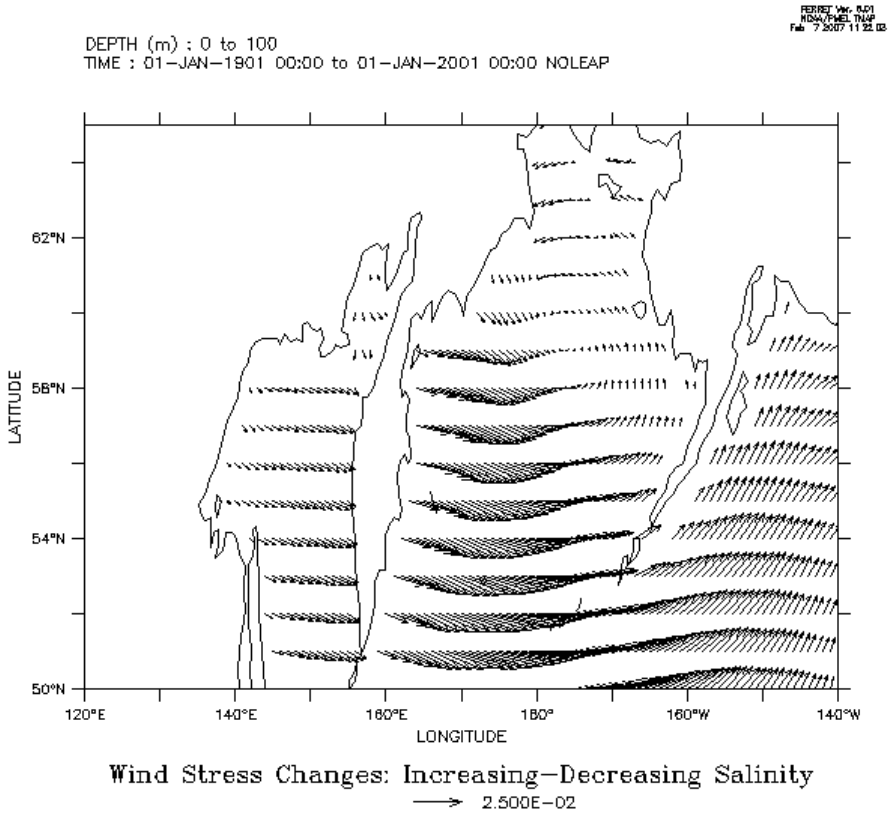
0 100



N. Pacific Overturning: Increasing − Decreasing Salinity

Wind stress

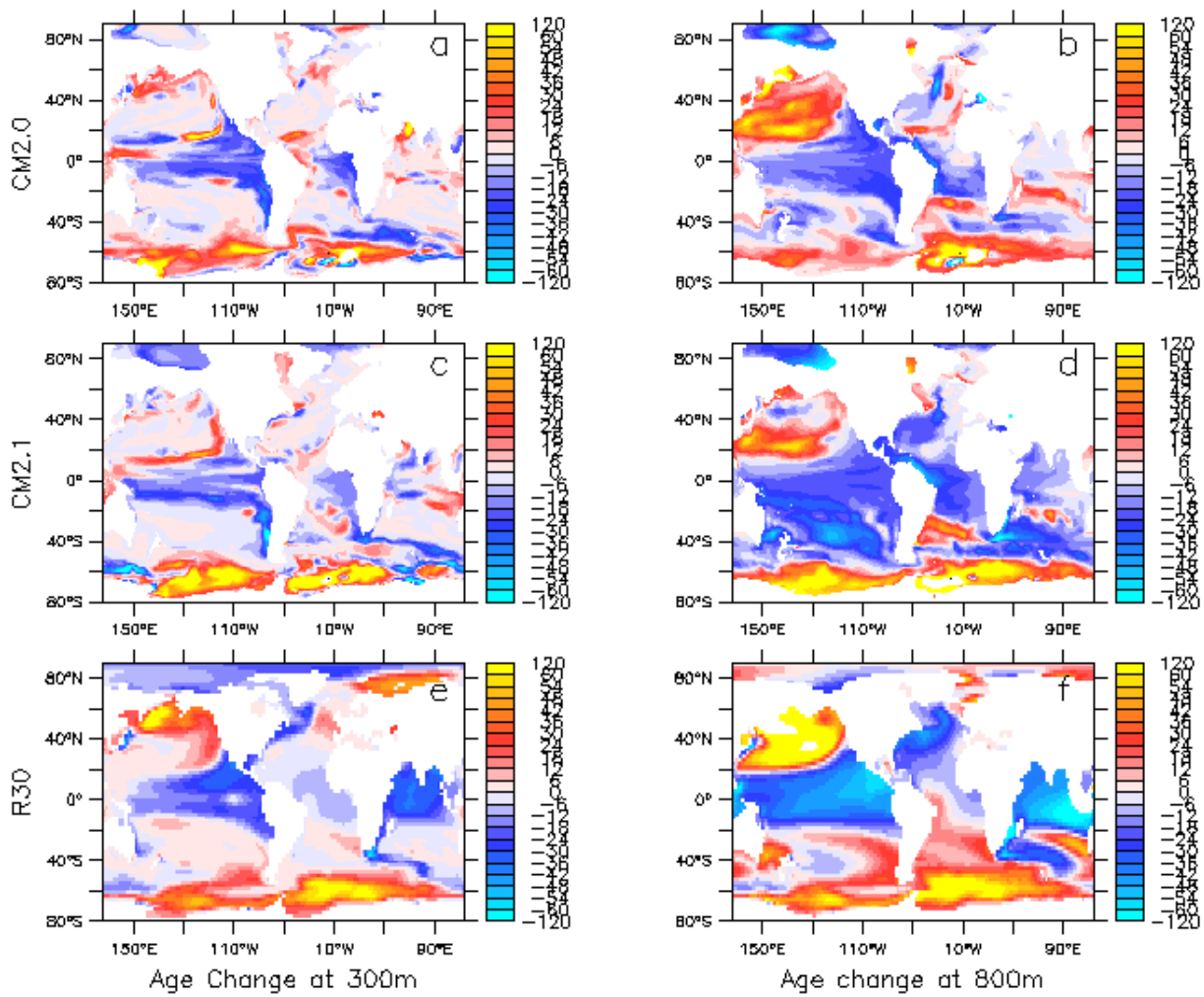

DEPTH (m) : 0 to 100
TIME : 01-JAN-1901 00:00 to 01-JAN-2001 00:00 NOLEAP
62°N
58°N
54°N
50°N
LATITUDE
120°E
140°E
160°E
180°
160°W
140°W
LONGITUDE
Surface Flow Changes: Increasing-Decreasing Salinity
0 100


DEPTH (m) : 0 to 100
TIME : 01-JAN-1901 00:00 to 01-JAN-2001 00:00 NOLEAP
62°N
58°N
54°N
50°N
LATITUDE
120°E
140°E
160°E
180°
160°W
140°W
LONGITUDE
Wind Stress Changes: Increasing-Decreasing Salinity
2.500E-02

Is this a model artifact?

- Similar features show up in atmospheric model coupled with isopycnal ocean model.
- In both modelsCFCs show patchy variability correlated with the age structure.
- Recent work by Mecking et al. (subm.) finds qualitatively similar variability in CFC data.

Future changes in age



Tropical changes related to decrease in deep upwelling

NW Pacific changes related to shutoff of periodic ventilation.

Gnanadesikan, Russell and Zhang (Ocean Science, 2007)

Conclusions

- Coupled models show a mode of ventilation variability in the North Pacific associated with intermittent ventilation in the Bering Sea.
- Driving mechanism involves anomalous winds destabilizing the halocline.
- Anomalies propagate throughout North Pacific.
- Changes in which mode is seen are important for explaining changes under climate change.