Langmuir Parameterization: One way to mess with CFCs

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NCAR side: S. Peacock, W. Large, G. Danabasoglu
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OMWG Dec. 10, 2008; 9:40-10:00

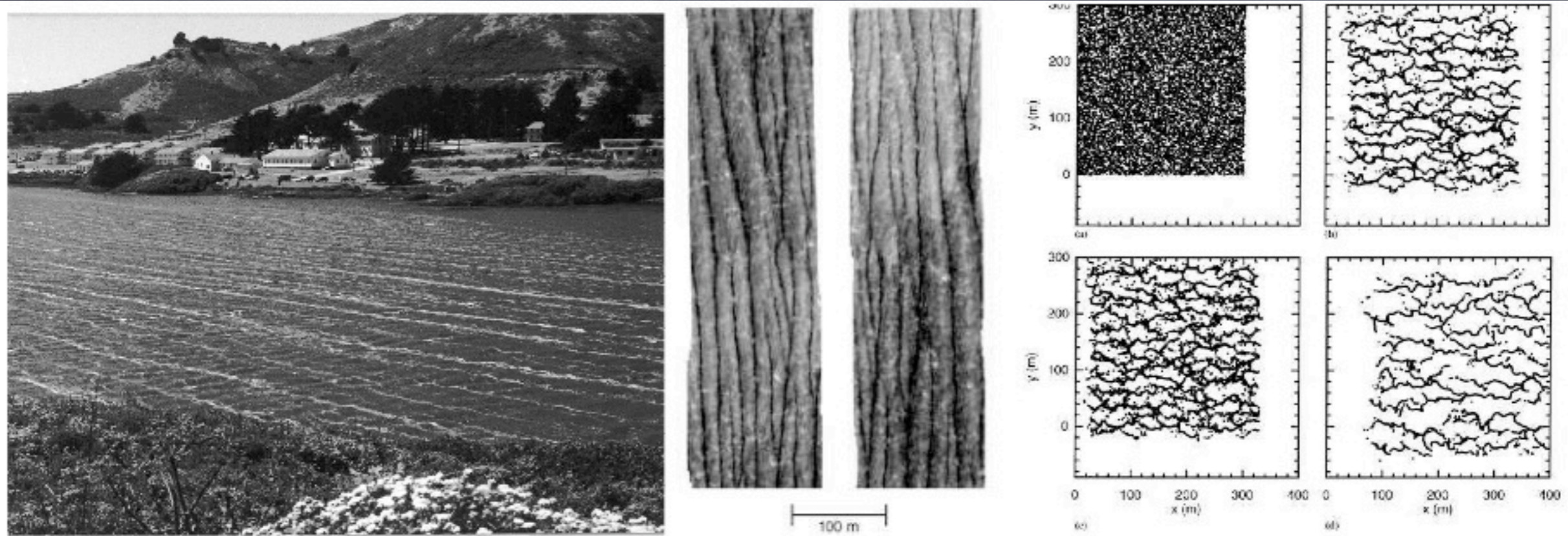# What are Langmuir Circulations?

Figure 1. Images of Langmuir circulation windrows: (a) a photograph of Rodeo Lagoon in CA (Szeri 1996), (b) an infrared image of the surface of Tampa Bay (courtesy of G. Marmorino, NRL, D.C.), and (c) the evolution of surface tracers in a LES of Langmuir turbulence (McWilliams et al. 1997).

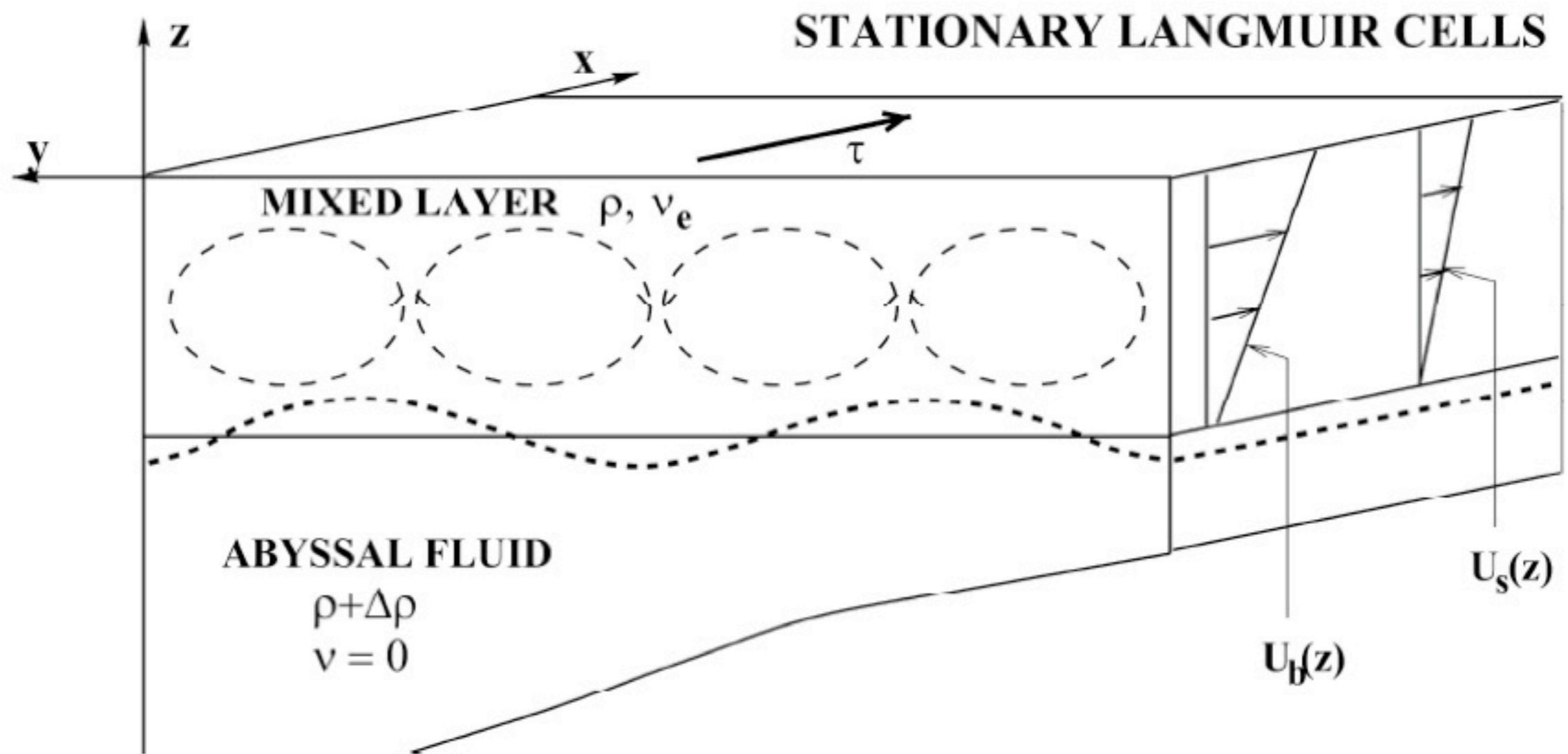# What are Langmuir Circulations?

Figure 1: Cartoon of Langmuir Cells

Satellite Altimetry:
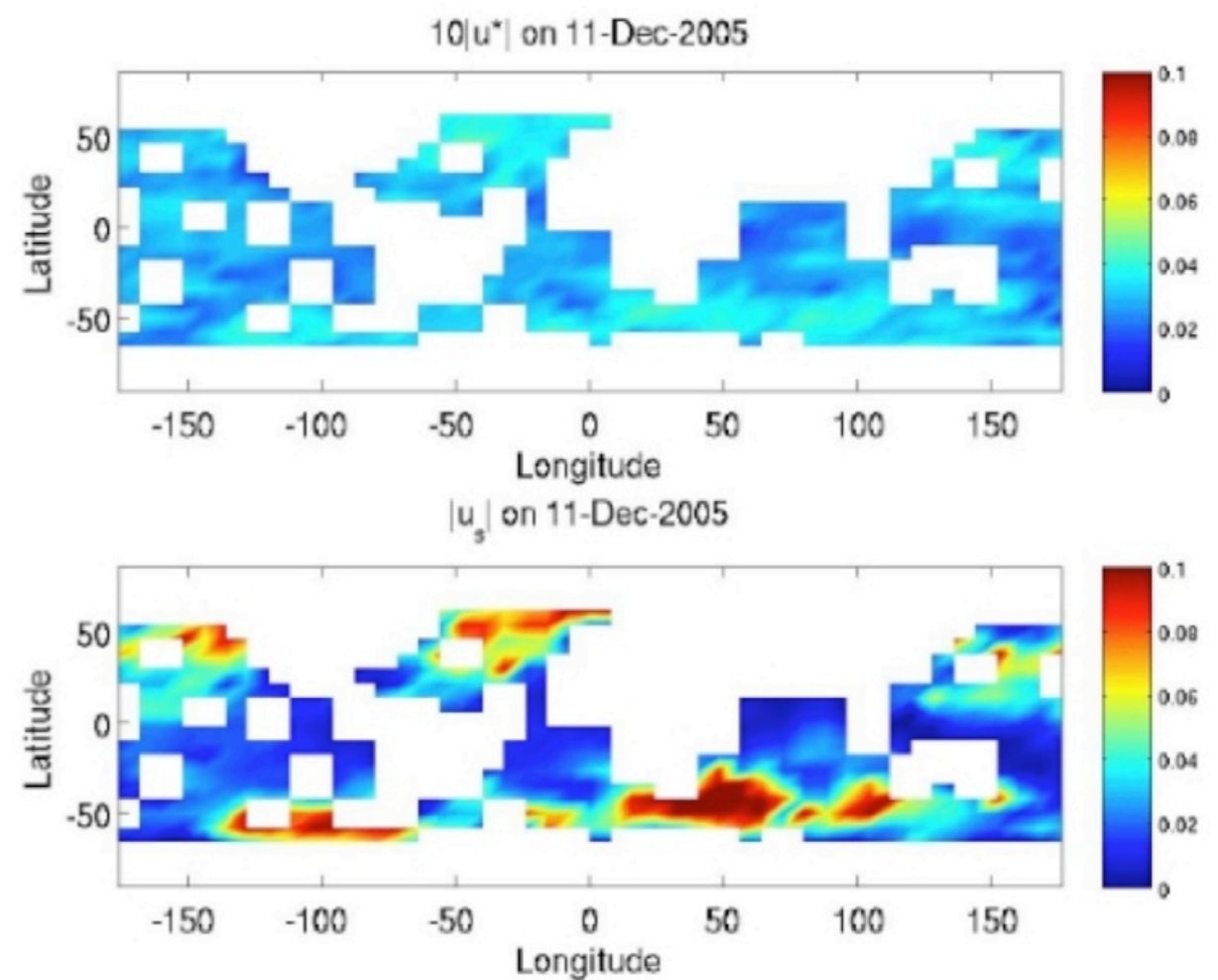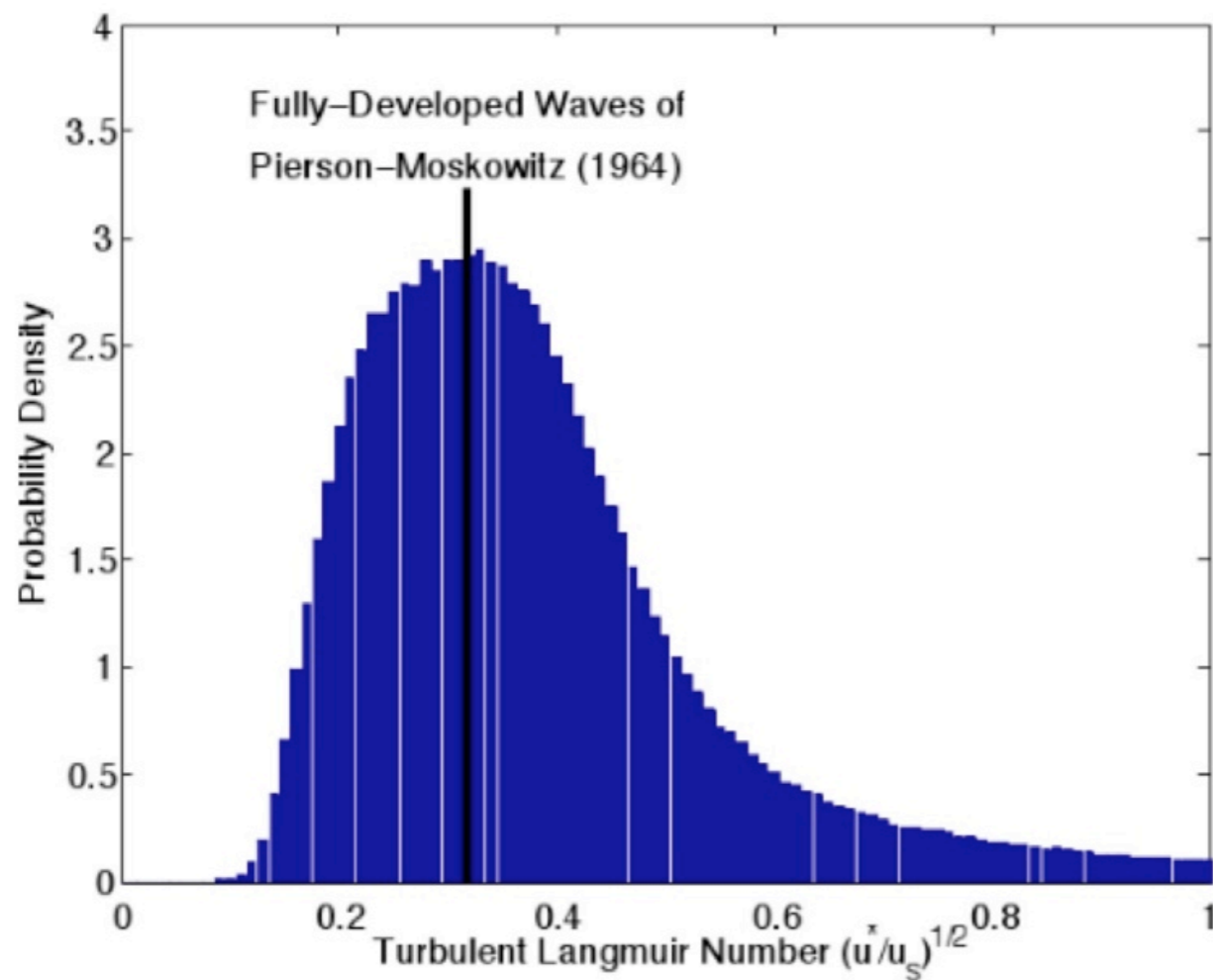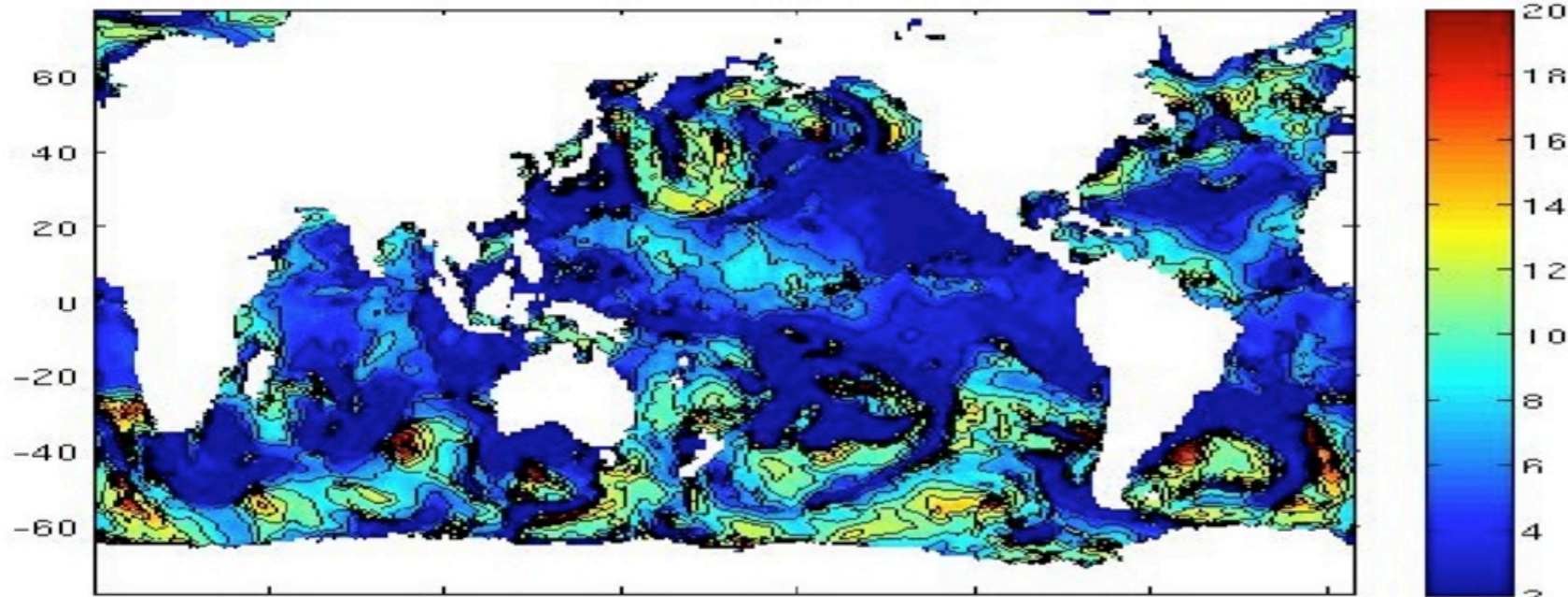## Observations of Langmuir C. Forcing

Figure 2: Aviso merged satellite dataset from 11/12/05 to 5/27/08 was used to calculate the (a) average Langmuir number and (b) compare $10|u^*|$ to $|u_s|$

$$u^* \equiv \sqrt{\tau/\rho} \qquad u_s \approx \frac{\pi^3 H_s^2}{gT_s^3} \qquad La \equiv \sqrt{u^*/u_s}$$

Wave Model--agree with Obs, plus frequency and direction

Comparison Between 1/La^2 and NWW3 on 5/21/08

$1/La^2$ – Sec/Inf (05/21)

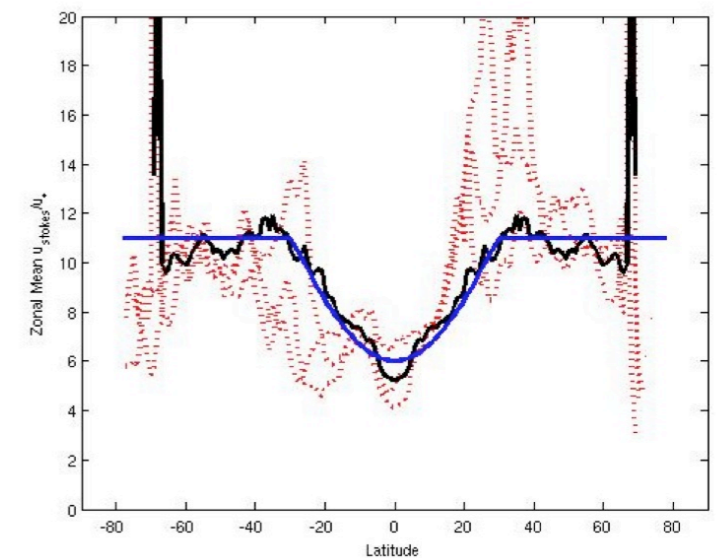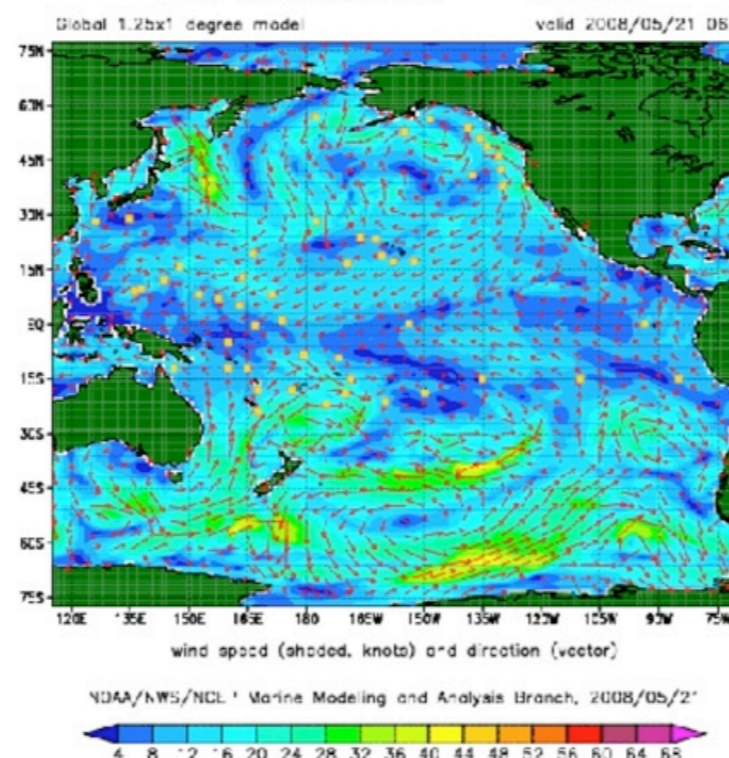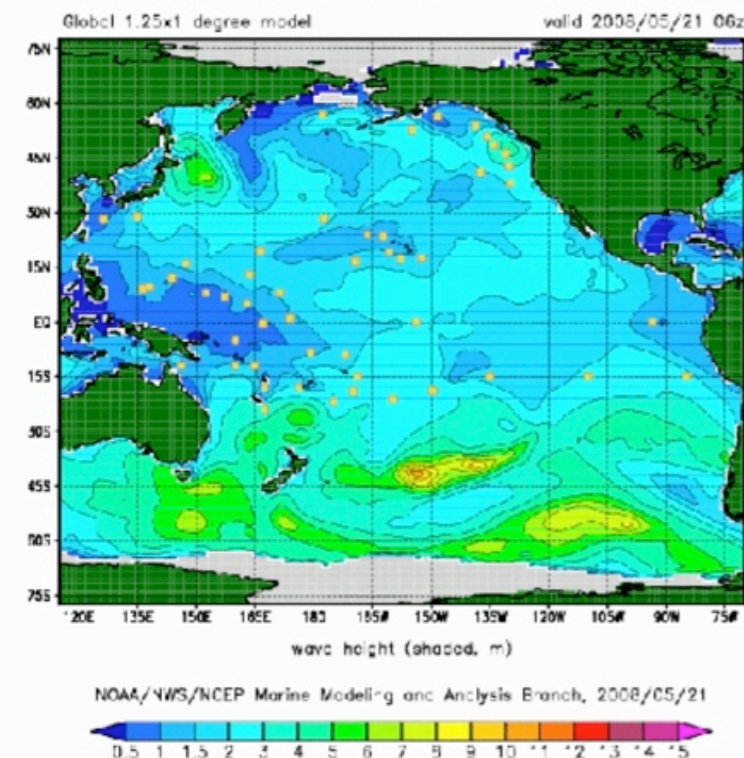NWW3 20080521 t06z   hindcast

NWW3 20080521 t06z   hindcast

Figure 3: Calculation of inverse turbulent Langmuir number squared, $(La^{-1})^2$, (top) using NOAA WaveWatch III model global output data (bottom)

Figure 4: Climatology of $(La^{-1})^2$ (*blue*) based on zonal and seasonal averages (*black*) with summer seasonal data (*red*)

Provides wave period & direction:
for better Stokes Drift

A Simple Scaling for Langmuir Depth/Entrainment:
(Li & Garrett, 1997)

CAM

related to CAM u* by WW3 Climatology

$$Fr = \frac{\omega}{NH} \approx 0.6 \qquad \omega \approx \frac{V}{1.5} \approx \frac{\sqrt{u^* u_s}}{1.5}$$
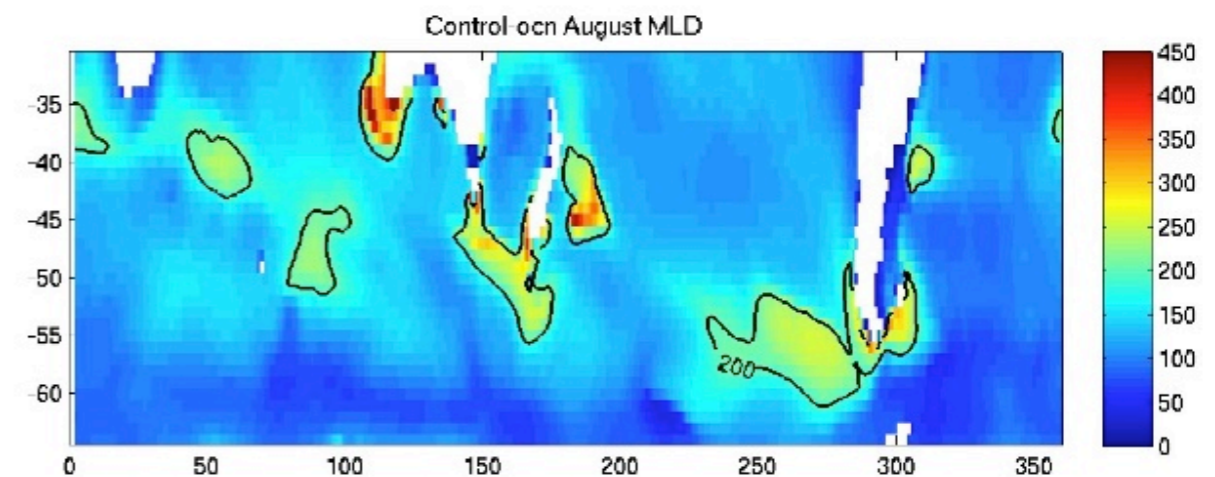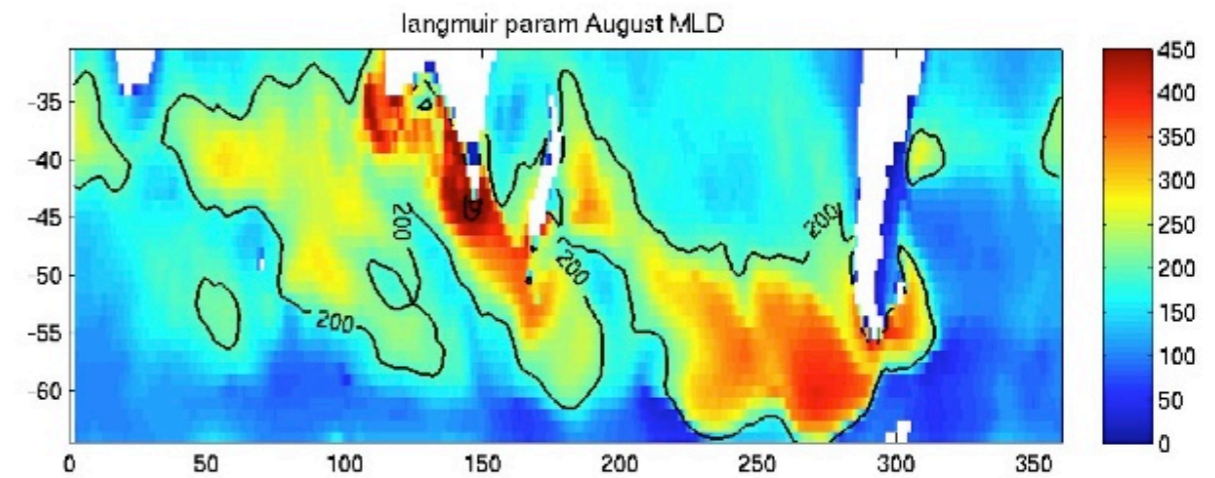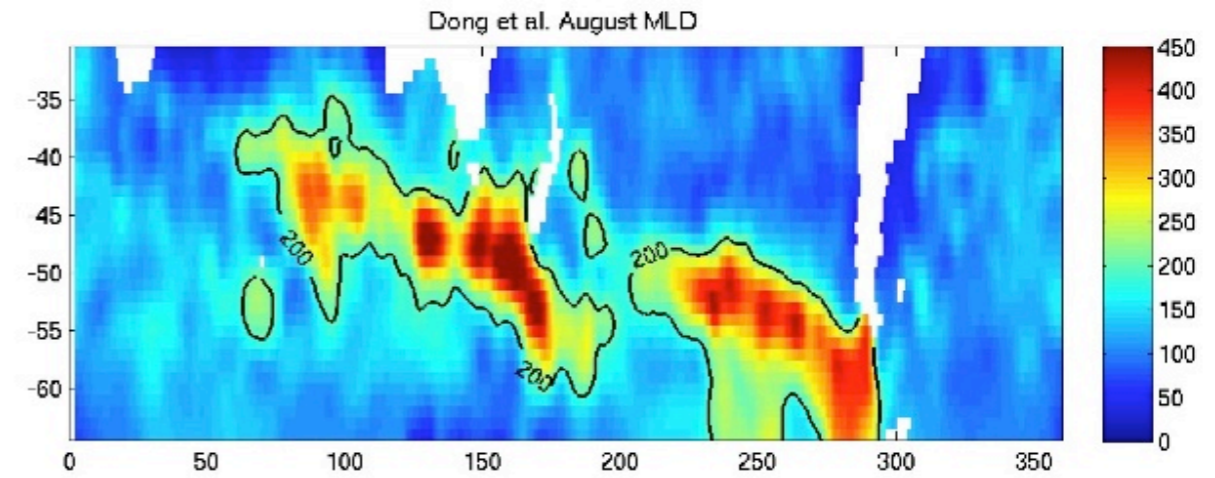
The Algorithm
  Use Fr to determine H
  If H is deeper than KPP Boundary Layer depth, use H

  Large came up with clever choices for N, H that
        lead to a robust implementation in KPP
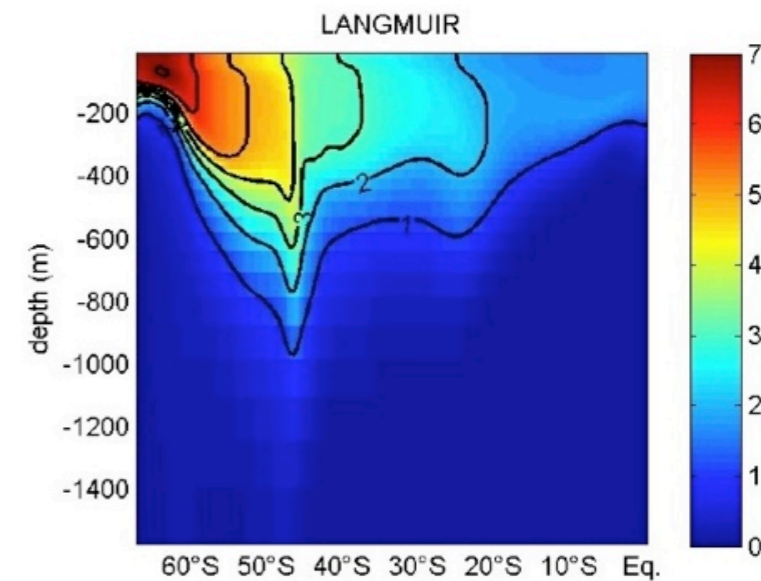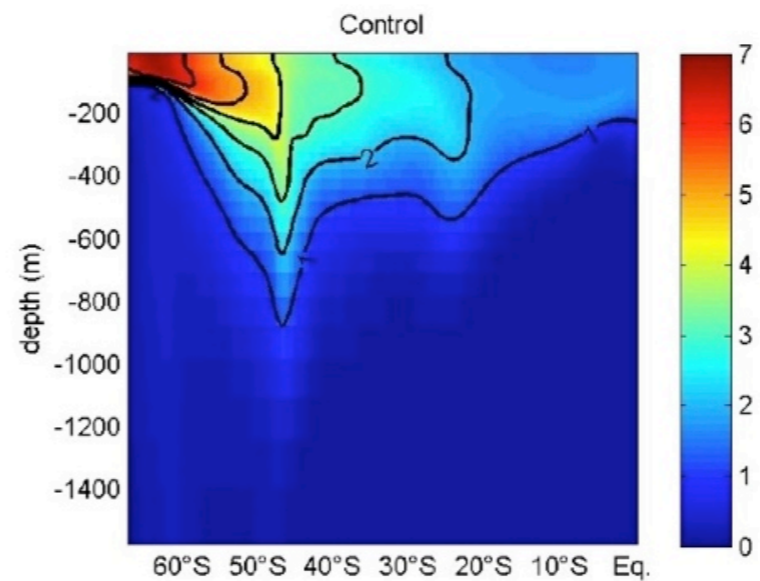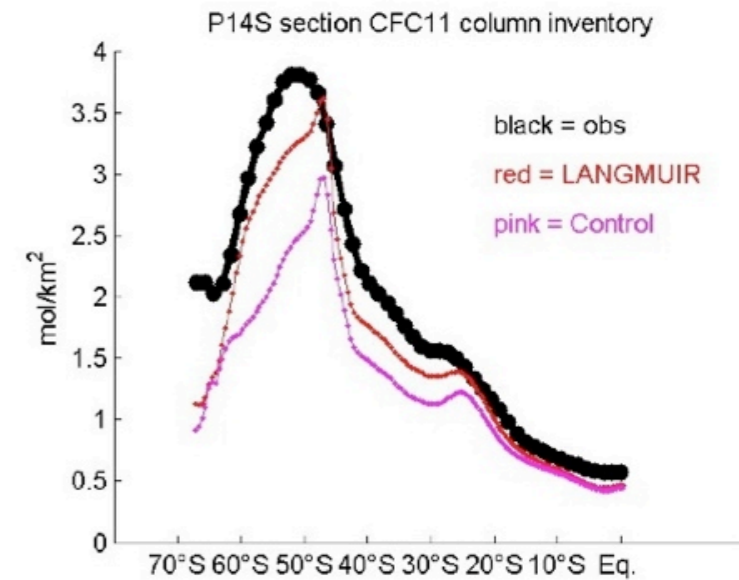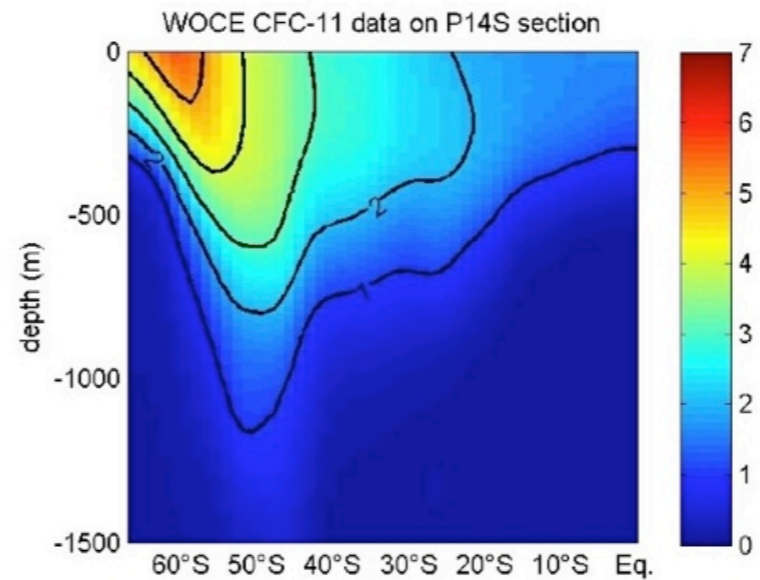With these choices, H and BLD converge over time.

Impact: MLD

- With reasonable parameters, can produce deeper mixed layers

- This often reduces bias in some regions, e.g., ACC
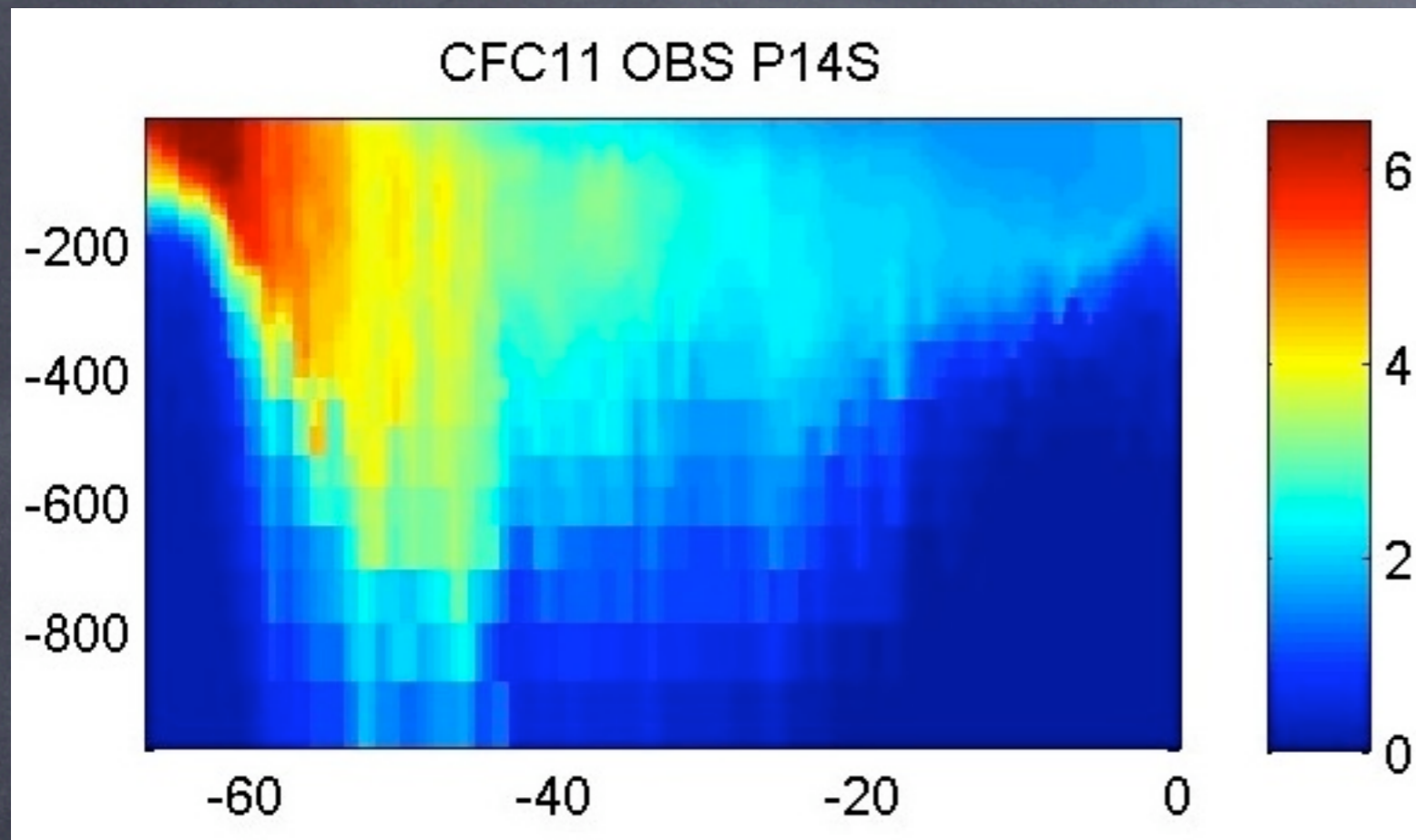

August mixed layer depths.

Impact: CFC

- With reasonable parameters, can affect CFCs

- This reduces bias in some regions, e.g., ACC versus WOCE

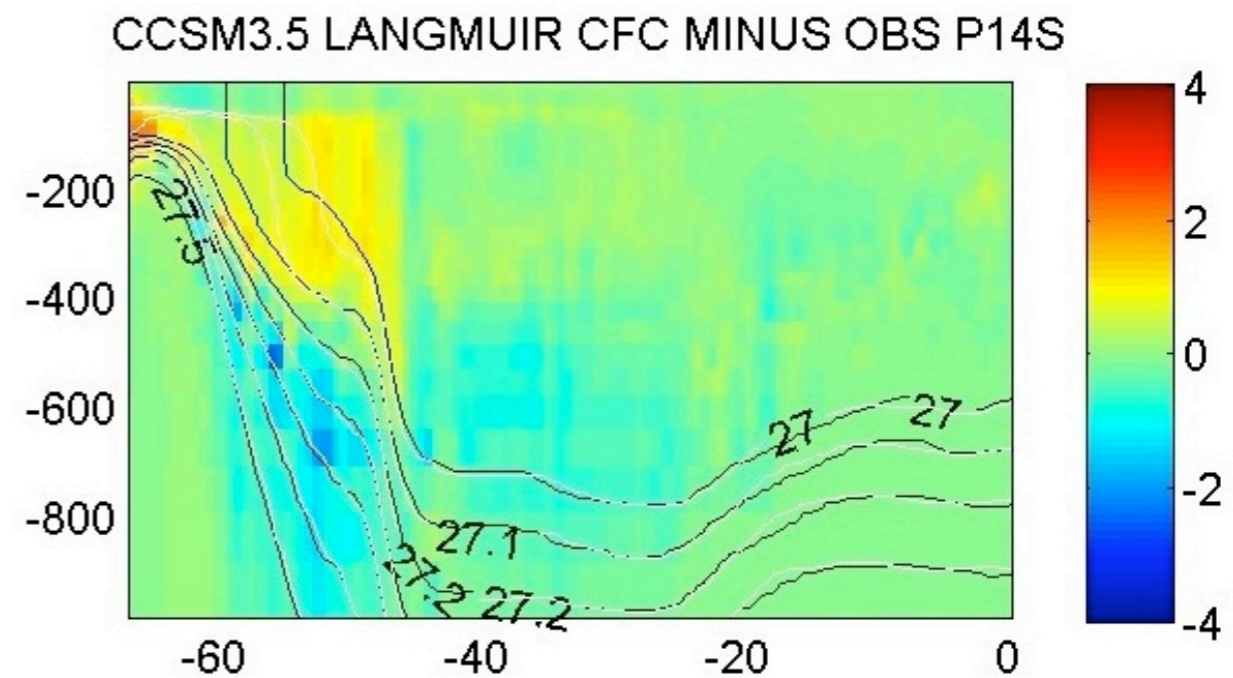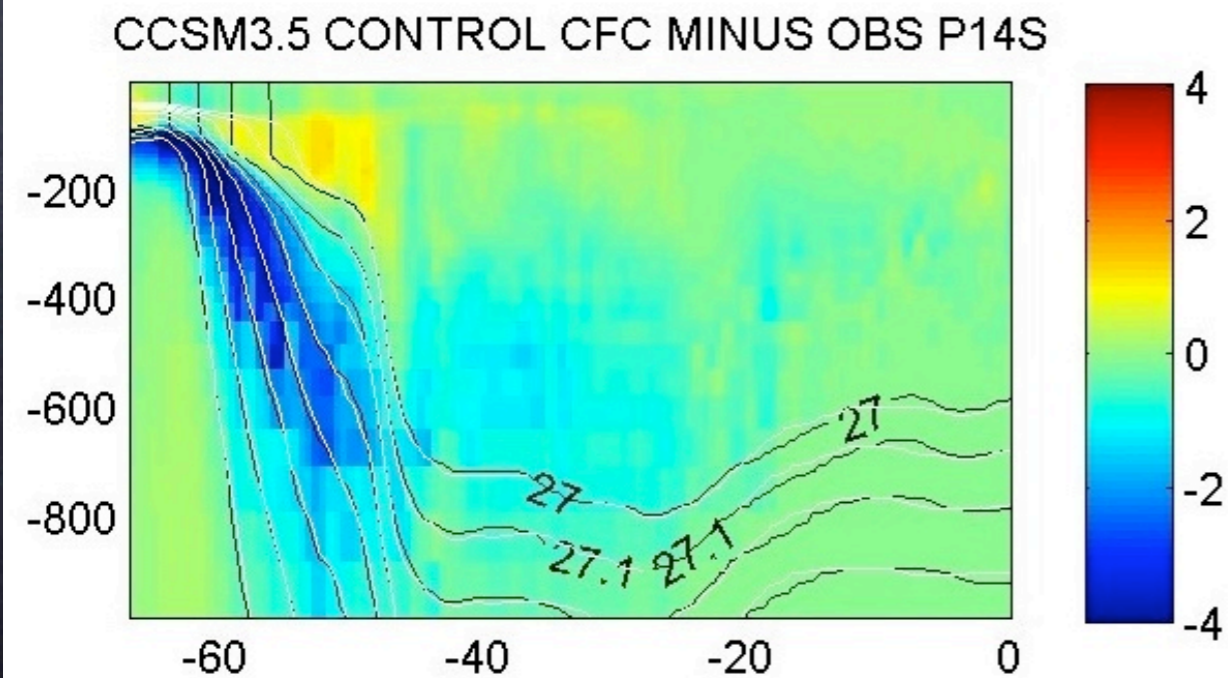- Potentially Large impact, change as large as bias

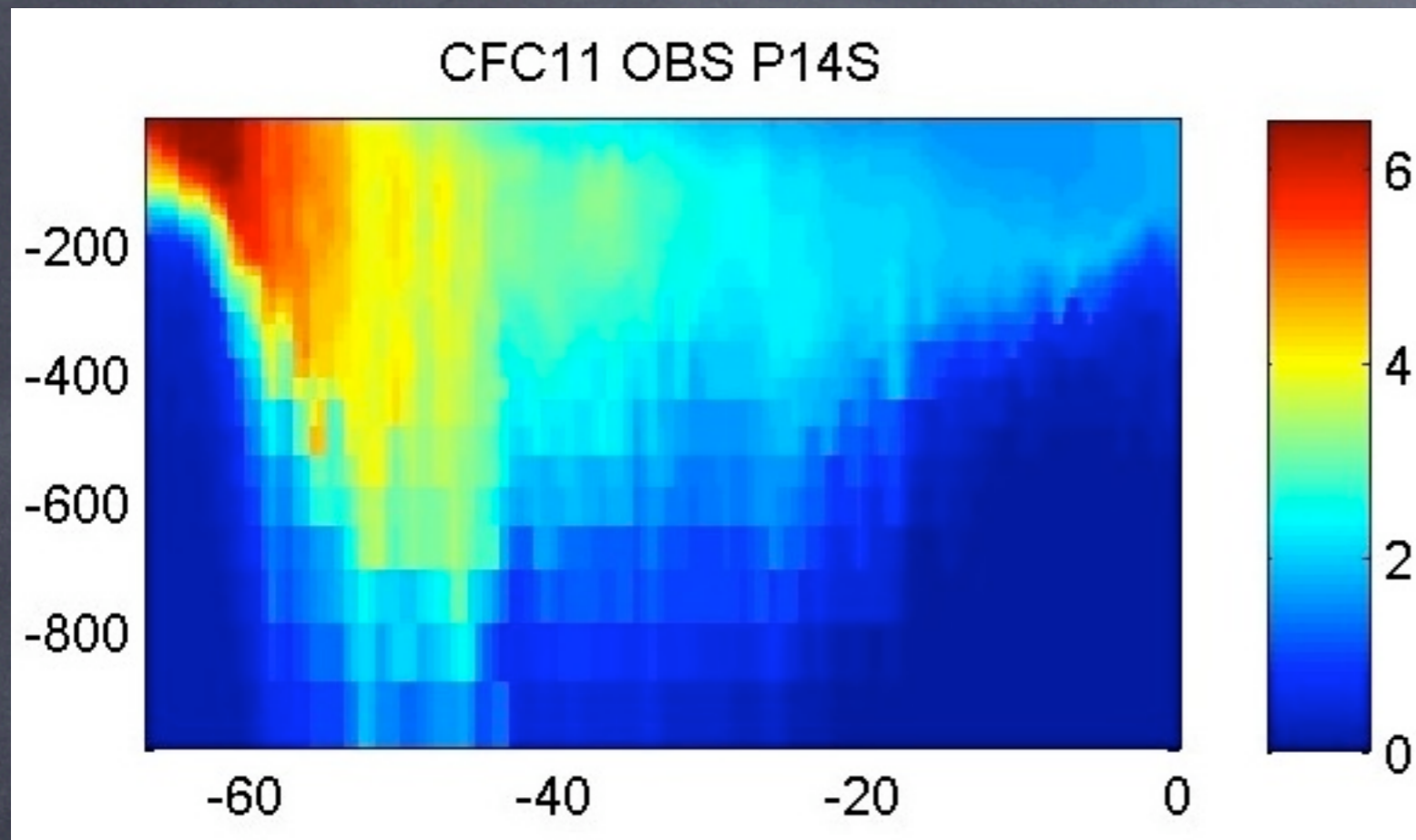CFC in CCSM & P14S WOCE observations.

Nuance--CCSM3.5 and CCSM4.0

CFC11 OBS P14S

CCSM3.5
showed improvement
or insignificant
change
in CFCs, S & T
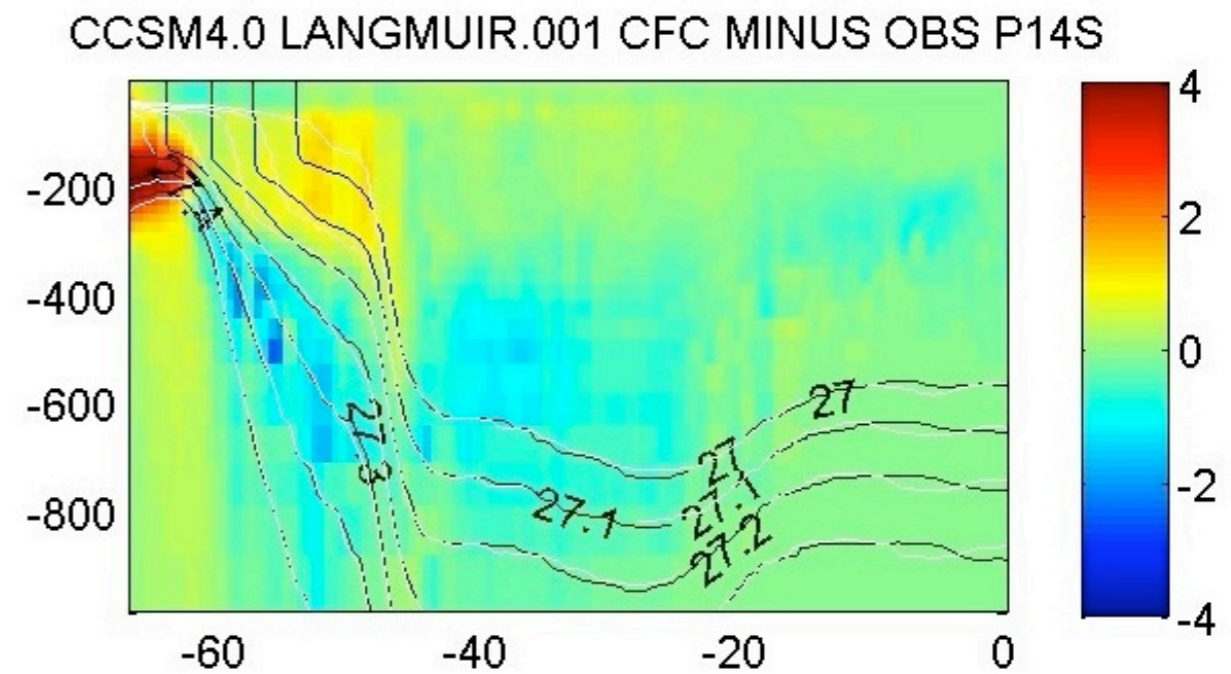with Langmuir.

CCSM3.5 CONTROL CFC MINUS OBS P14S

CCSM3.5 LANGMUIR CFC MINUS OBS P14S

Nuance--CCSM3.5 and CCSM4.0

CCSM4.0 did not have the same initial improvement!

S & T particularly bad

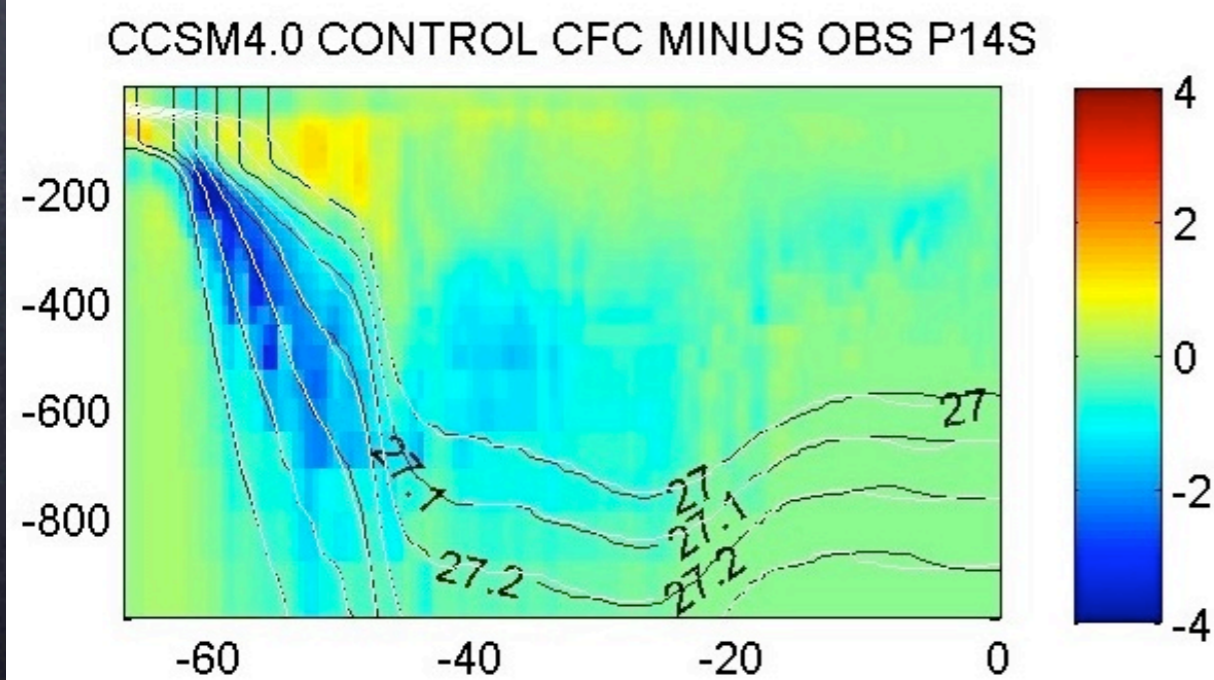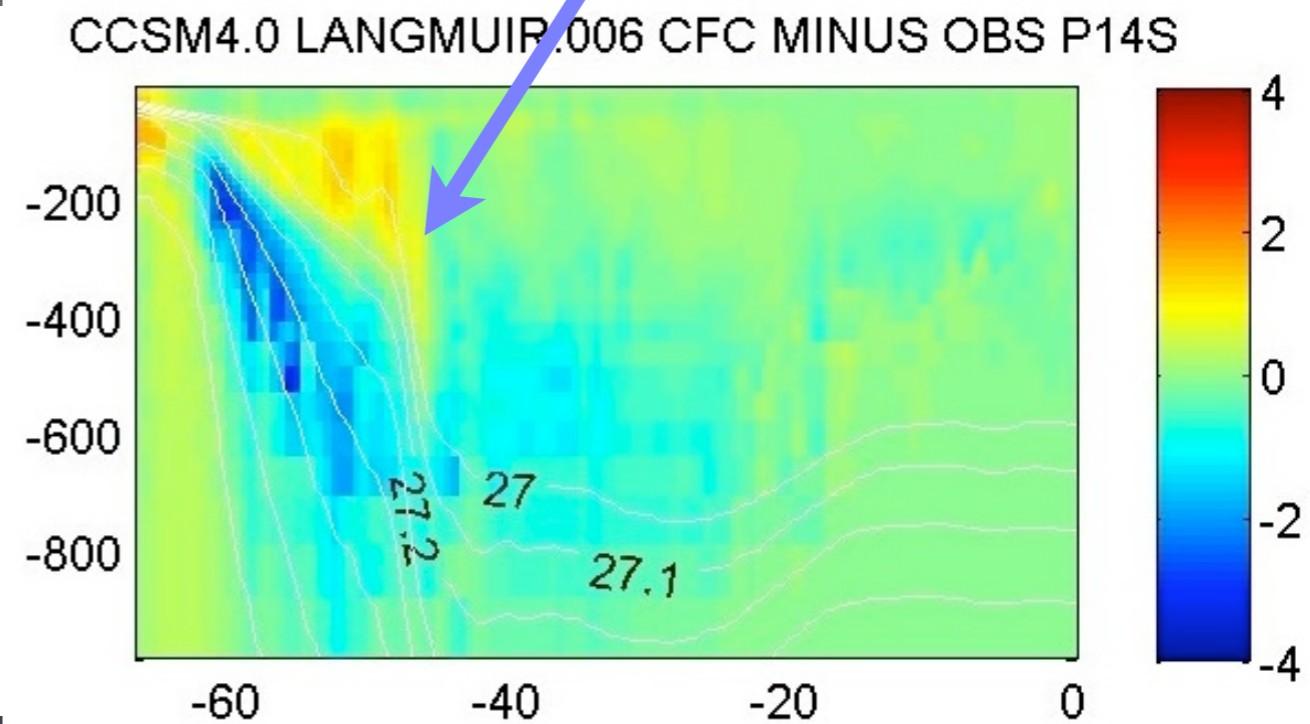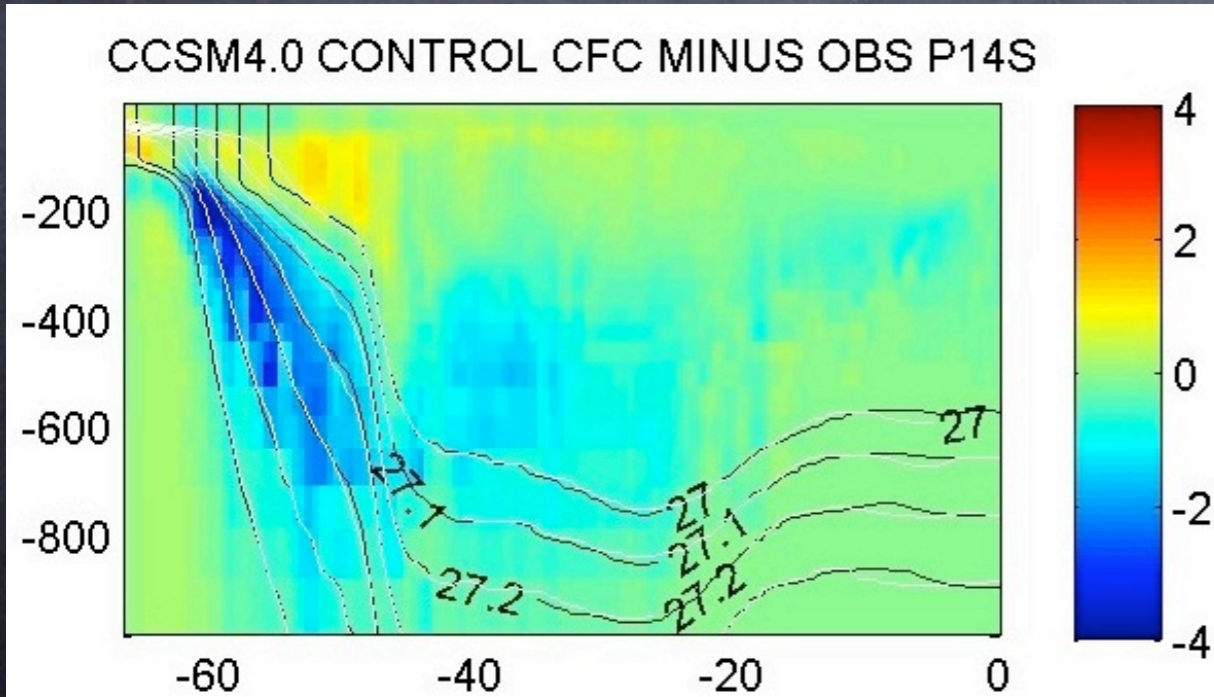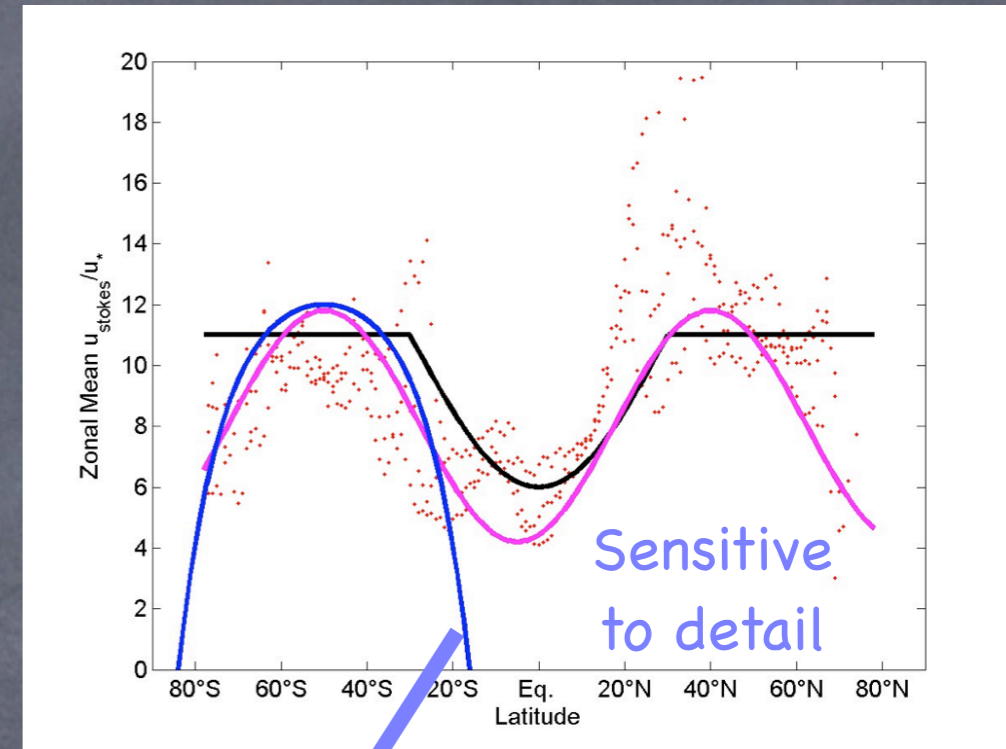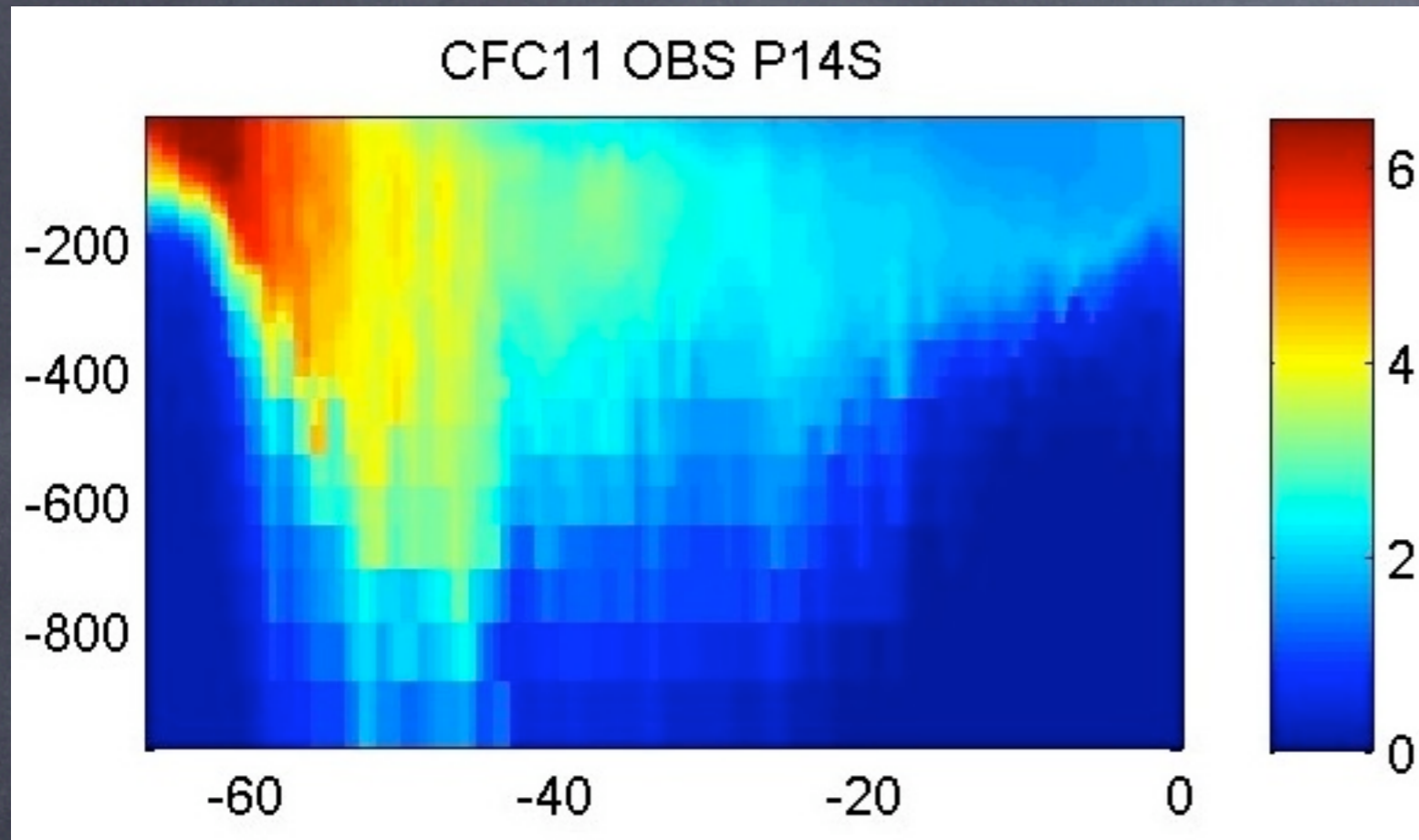Interactions with submeso?

Nuance--CCSM3.5 and CCSM4.0

CFC11 OBS P14S

Sensitive to detail

CCSM4.0 CONTROL CFC MINUS OBS P14S

CCSM4.0 LANGMUIR.006 CFC MINUS OBS P14S

Problems

- Demonstrated sensitivity and impact, so accuracy demanded. Accuracy will require:

  - Prognostic Wave Model coupled to CCSM

  - Better Parameterization of Langmuir Circulation mixing

  - Can include other surface wave effects (e.g., mixing by breaking, sea state affecting momentum & air-sea transfers)