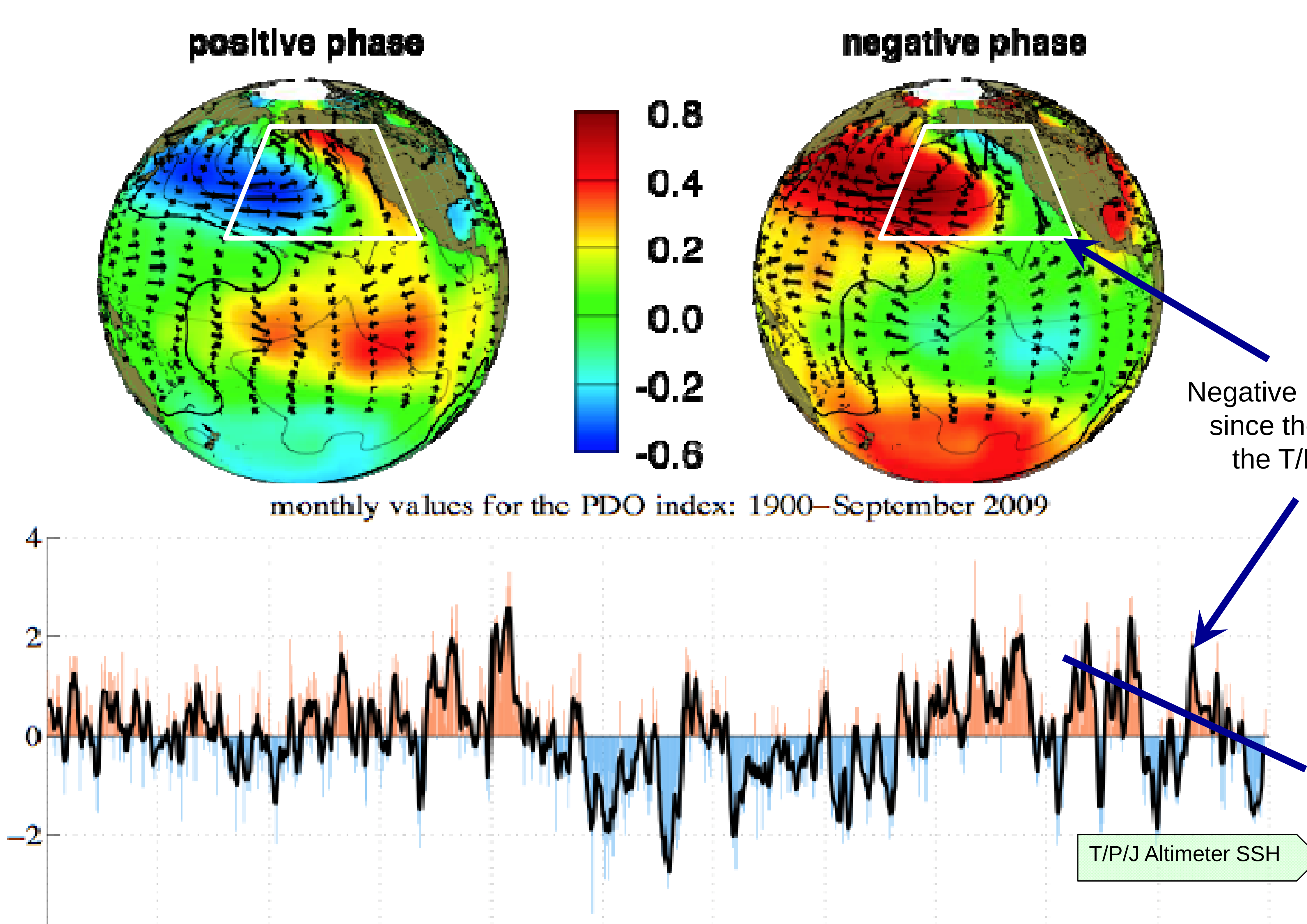
Satellite-observed changes in the upper ocean heat Budget of the Northeast Pacific During 1993-2004

Scott Springer
Gary Lagerloef

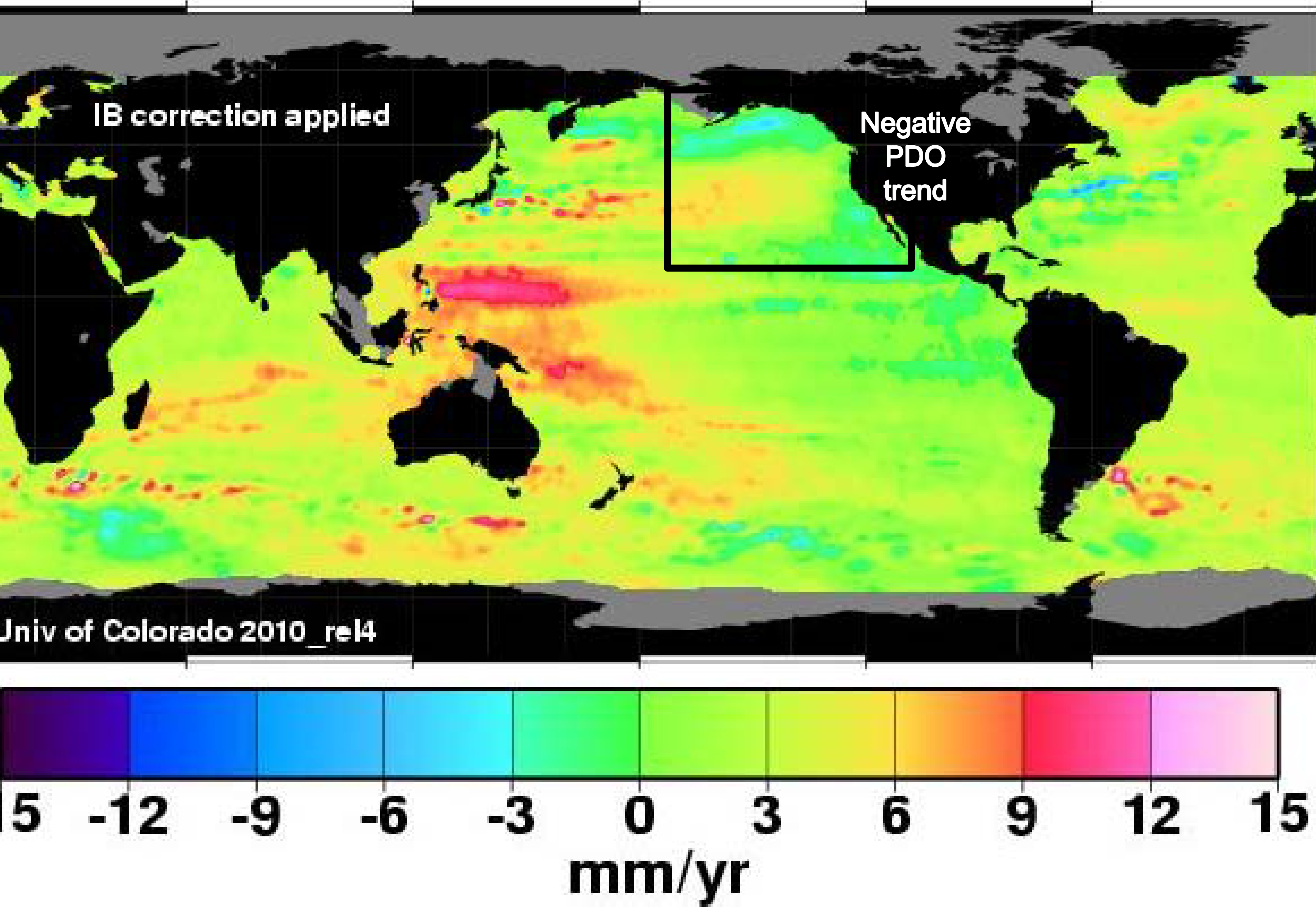
Earth and Space Research

Seattle WA

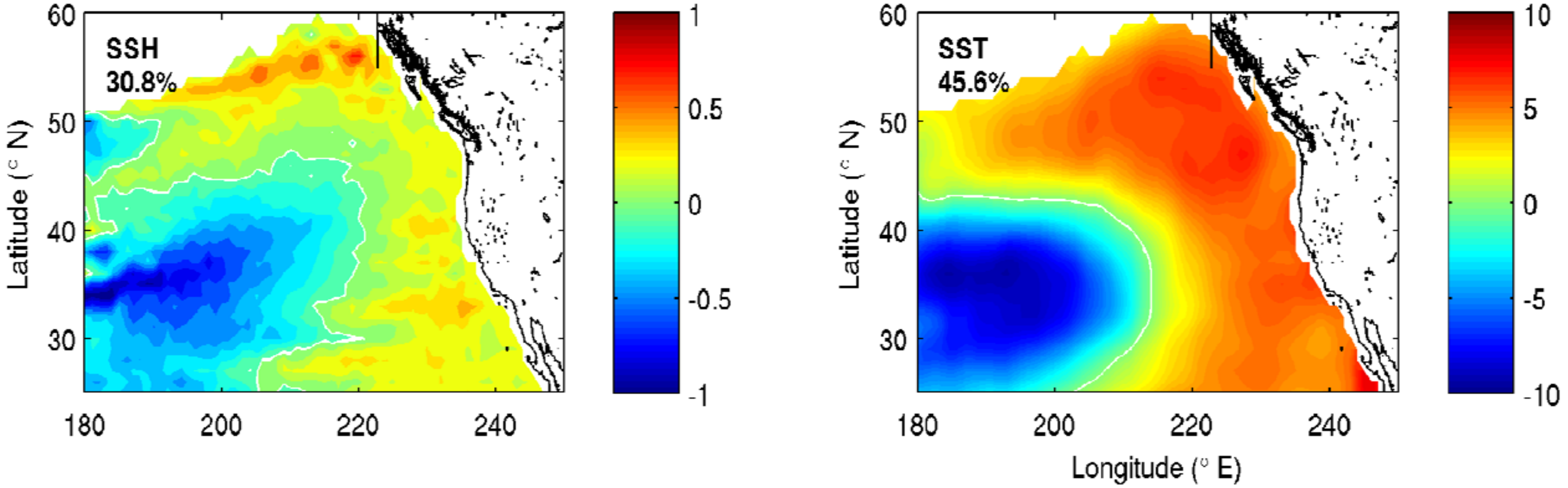
http://www.esr.org



positive phase
negative phase
0.8
0.4
0.2
0.0
-0.2
-0.6
Negative
since th
the T/
monthly values for the PDO index: 1900–September 2009
4
2
0
−2
T/P/J Altimeter SSH


IB correction applied
Negative
PDO
trend
Univ of Colorado 2010_rel4
15
-12
-9
-6
-3
0
3
6
9
12
15
mm/yr

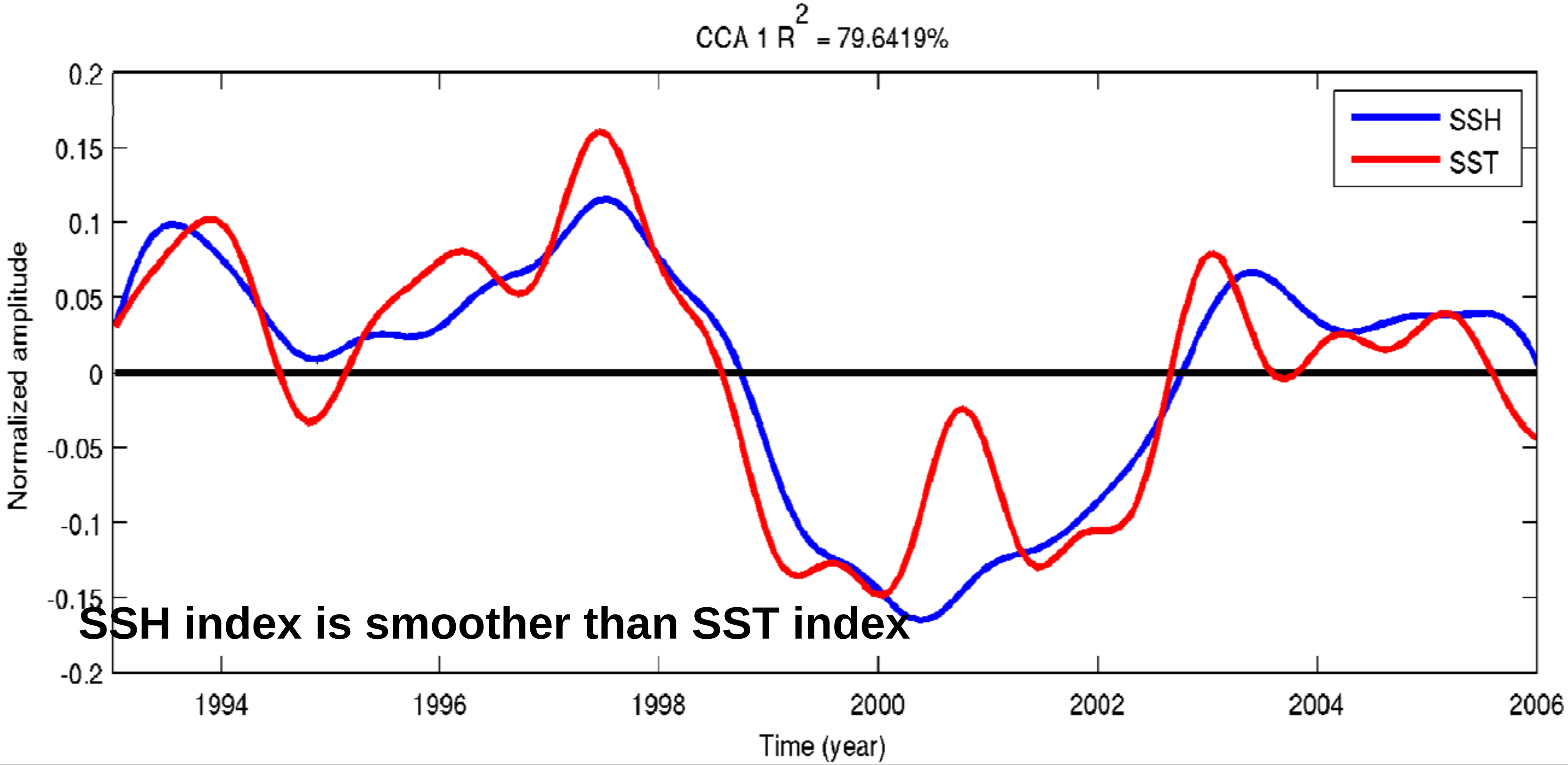
SSH CCA Mode 1 **SST**



0

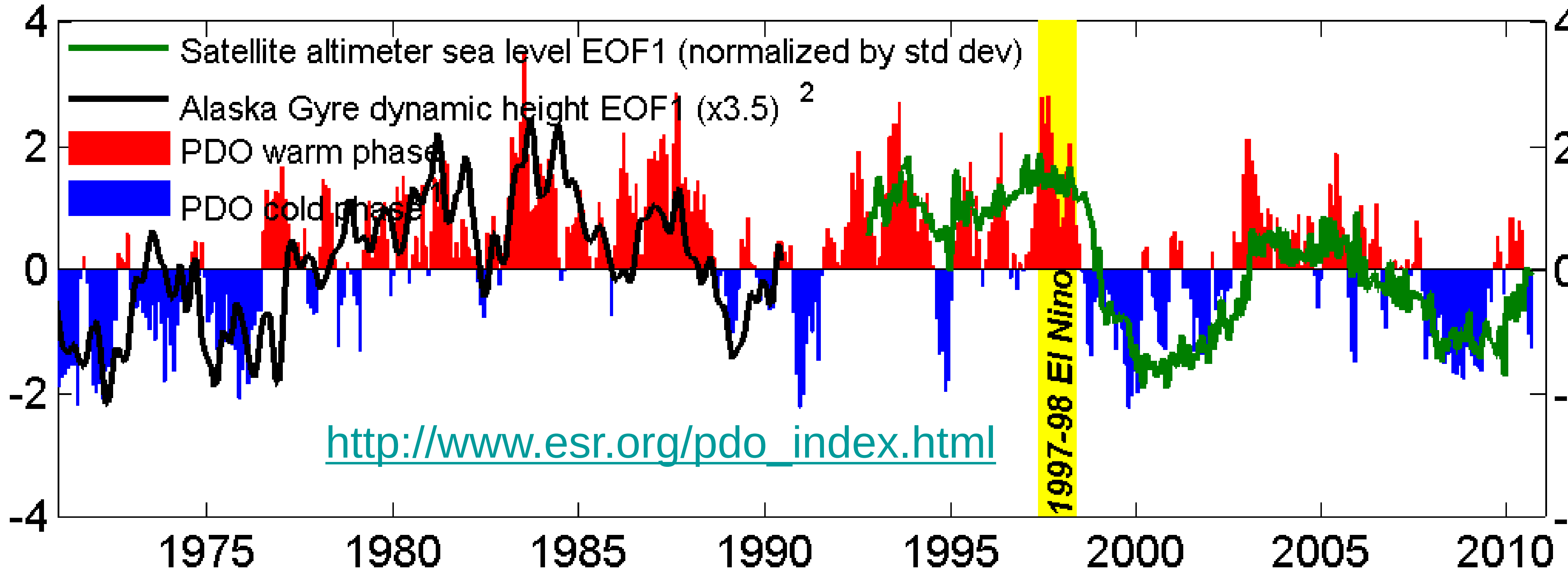
.8

monthly
tology
ved



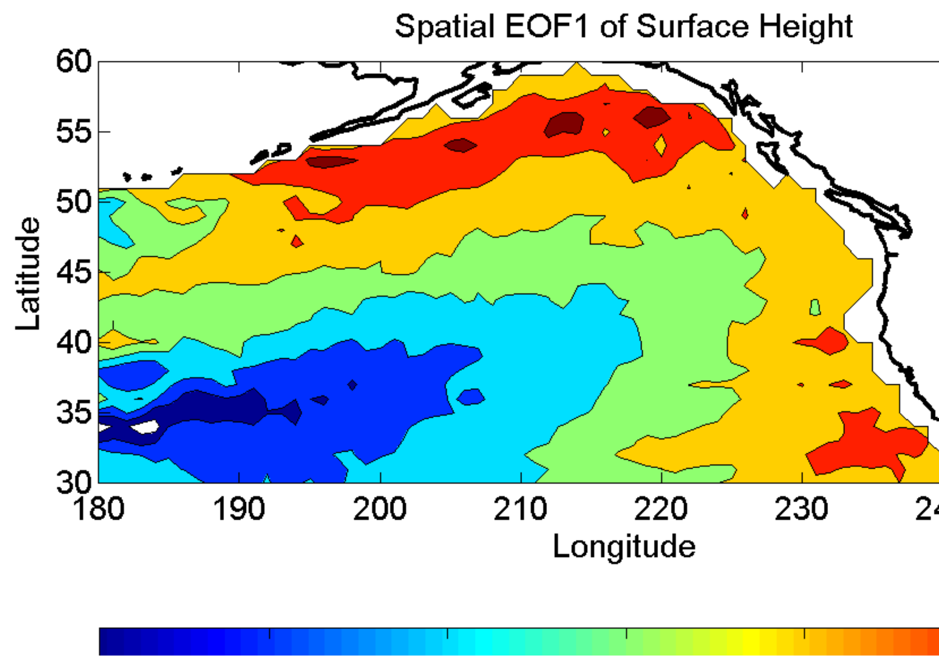
Cummins, Lagerloef, and Mitchum (2005)

PDO SST Index and Surface Height EOF's as of Sep.28,2010



[1]Mantua et al. (1997)

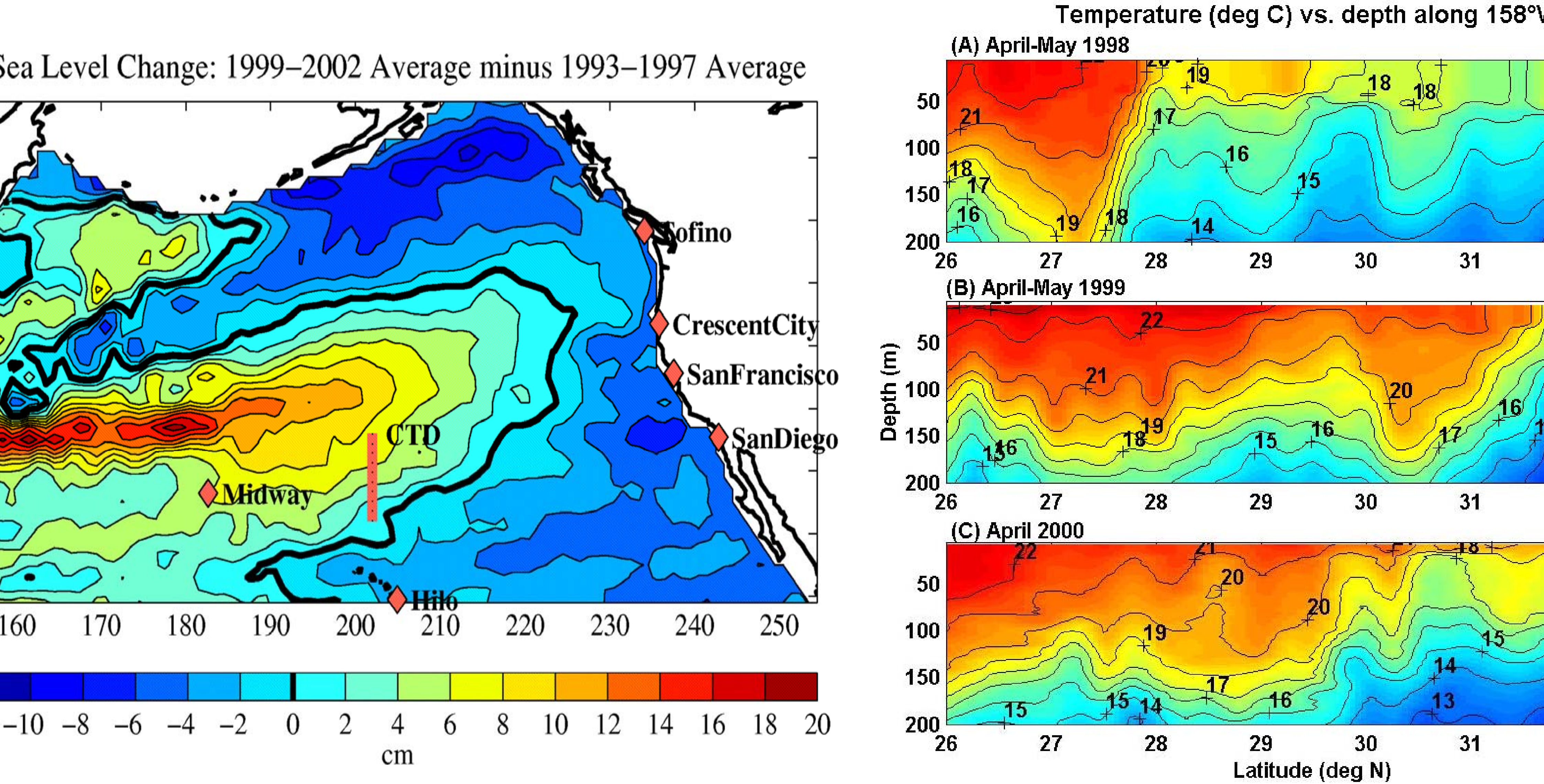
[2]Lagerloef (1995)



The SSH principal component has much less short term variability than the conventional SST index

<u>SSH provides a more robust index of the PDO state</u>

Cummins, Lagerloef, and Mitchum (2005)



gure 2.4 : (Left) Northeast Pacific satellite SSH difference between multi-year averages after minus before 1998, resembling the incipal PDO pattern. The north-south CTD transect is shown near the southern perimeter of the SSH anomaly pattern. (Right) early CTD transects before and after the 1998 transition, showing extensive changes to the upper ocean heat content and thermoclin ructure (courtesy J.Polovina and M.Seki, NOAA/NMFS, Honolulu).

at processes explain the coherent variations between SSH and SST in the northeast Pacific at interannual time and space scales?

1) What processes control SSH (and pycnocline depth)?

2) What are the processes that control SST?

answer these question using simple models and satellite observed quantities.

- ea surface height Aviso gridded altimetry
- ea surface temperatures Reynolds gridded SST
- Vinds Ocean vector winds from QuikScat
- ea surface velocities from OSCAR
- CEP-2 heat fluxes

Sea surface height anomalies are due to displacements of pycnocline

$$\frac{\partial \eta}{\partial t} - C_x \frac{\partial \eta}{\partial x} = -\frac{\Delta\rho}{\rho} W_E - \lambda\eta$$

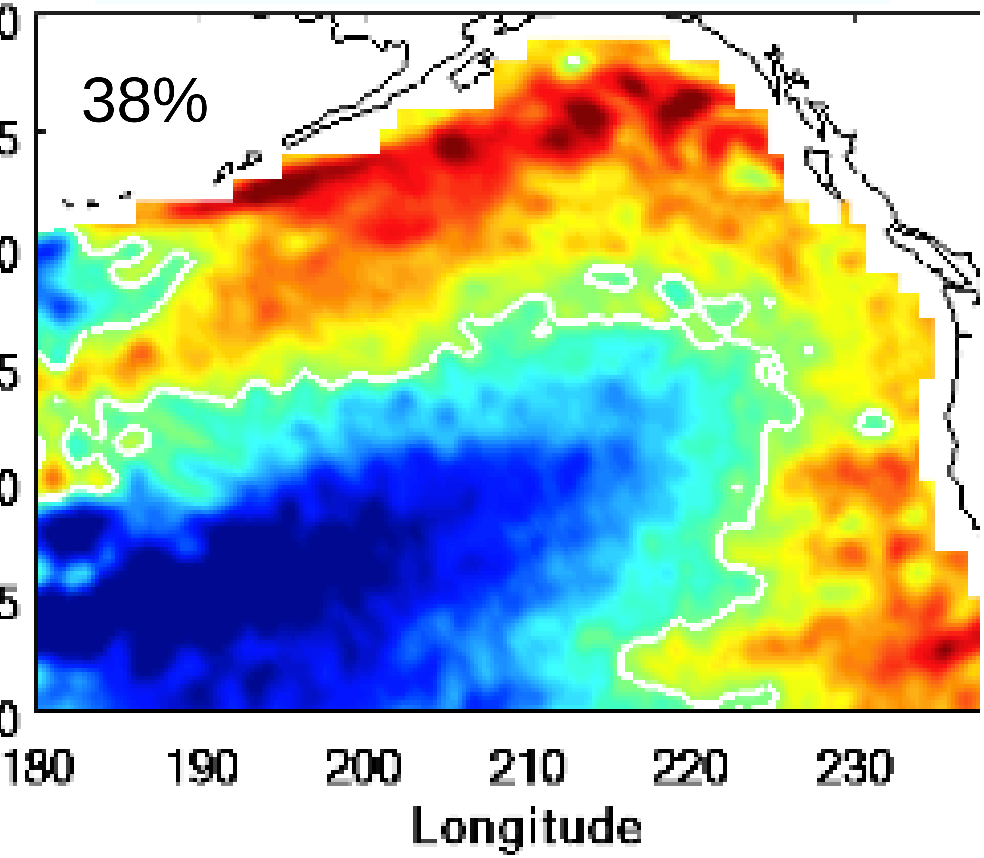
=0

Damping to climatology by unresolved ocean dynamics (mixing, etc.) assumed spatially uniform

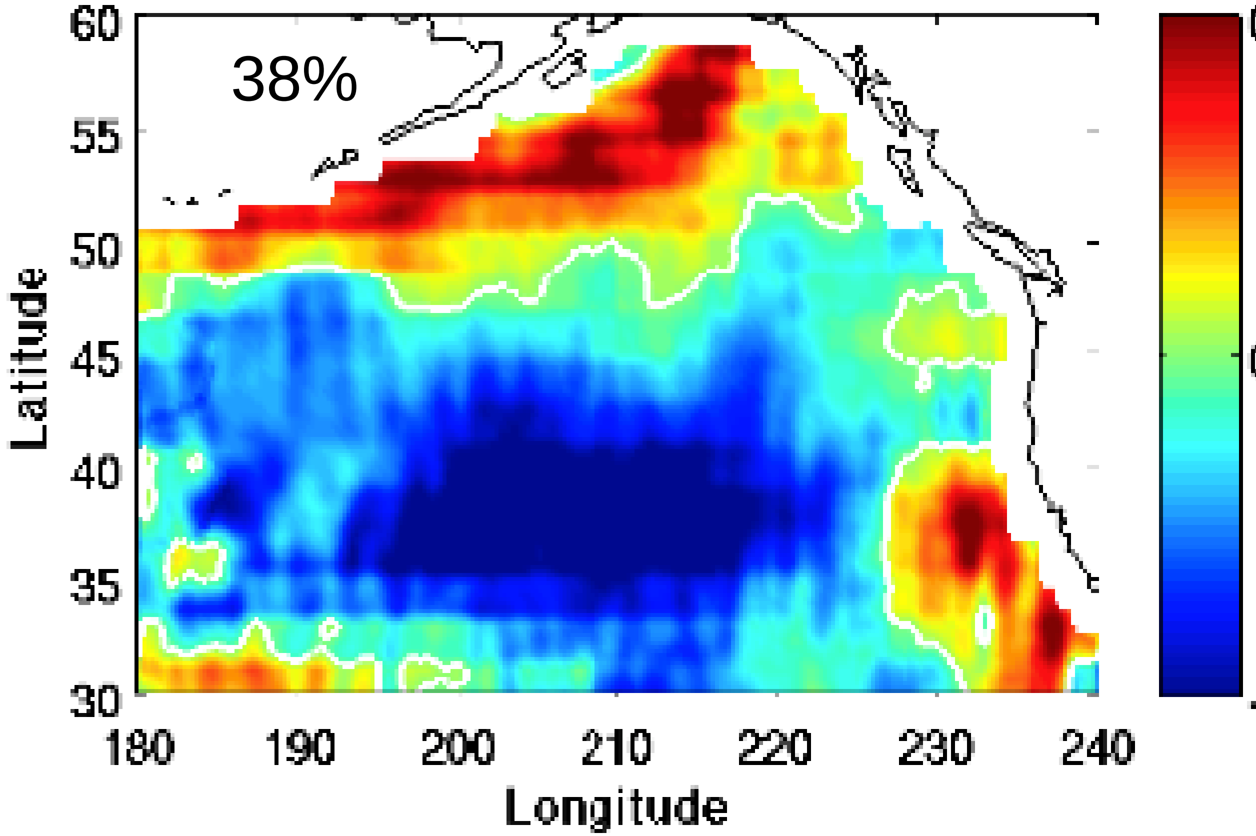
Integrate and form EOFs of both sides

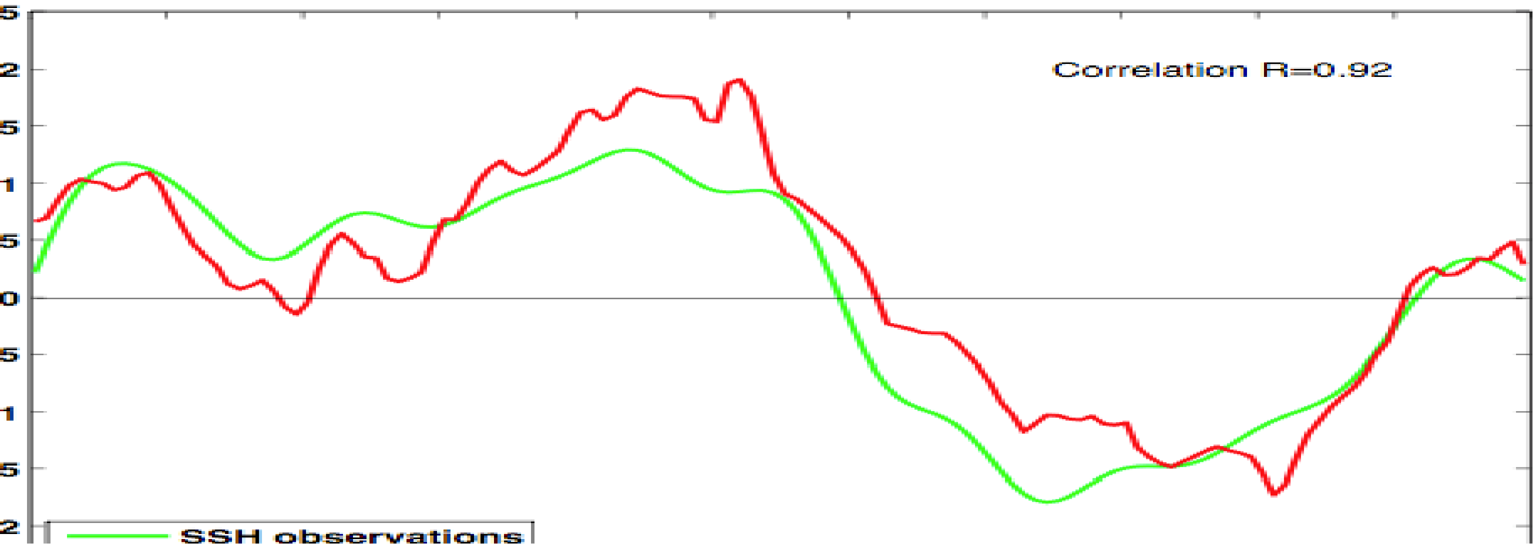
Best fit for λ^{-1}=18 months and $g\Delta\rho/\rho$ = .02 m^2/s.

SSH Observations Mode 1



SSH Model Mode 1





Temporal correlation
R=0.92

Spatial correlation
R=0.65

damping time = 18 montl

$$\frac{\partial T_I'}{\partial t} + \alpha T_I' \Big) \approx -\left(\vec{u}_I' \cdot \nabla \overline{T} + \overline{\vec{u}} \cdot \nabla T_I' + \overline{w}_E \frac{\partial T_I'}{\partial z} + w_E' \frac{\partial \overline{T}_I}{\partial z} \right) + \frac{q_I'}{\rho_0 C_p \overline{H}}$$

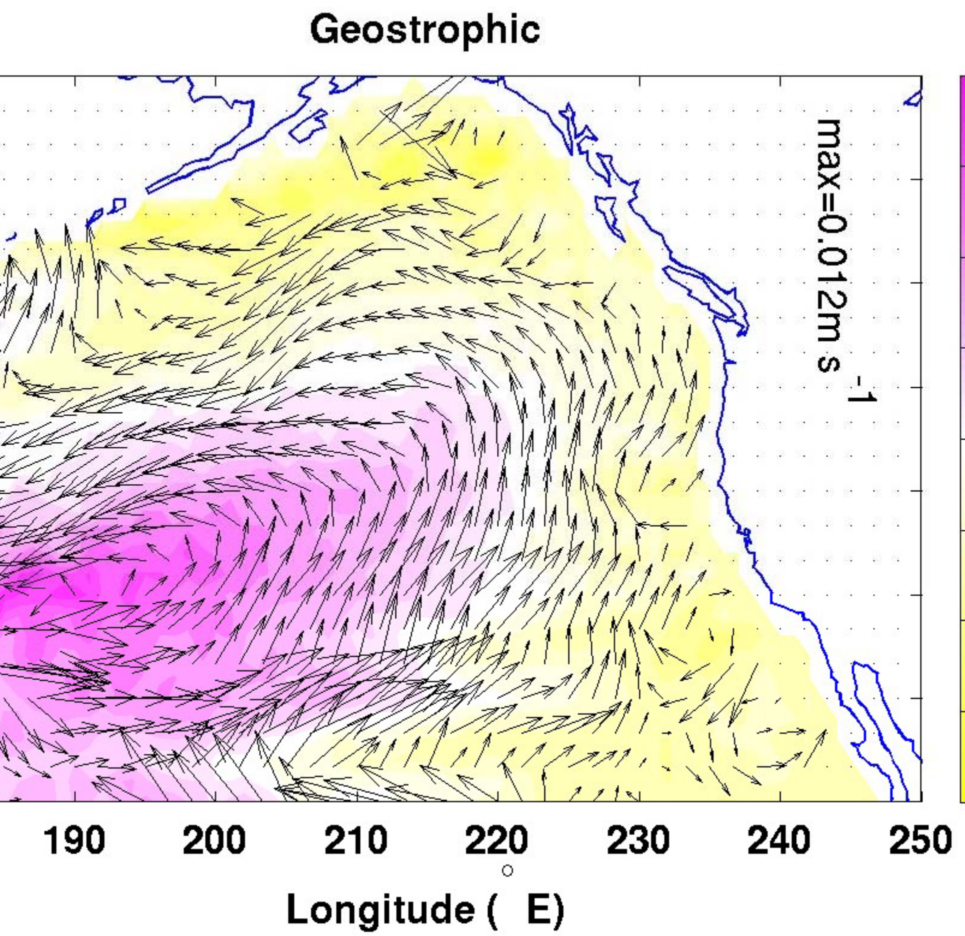
Subscript *I* denotes anomaly variables regressed against SSH PDO index.
Follows approach of Chhak et al. (2009)

izontal velocities have Ekman and geostrophic components:

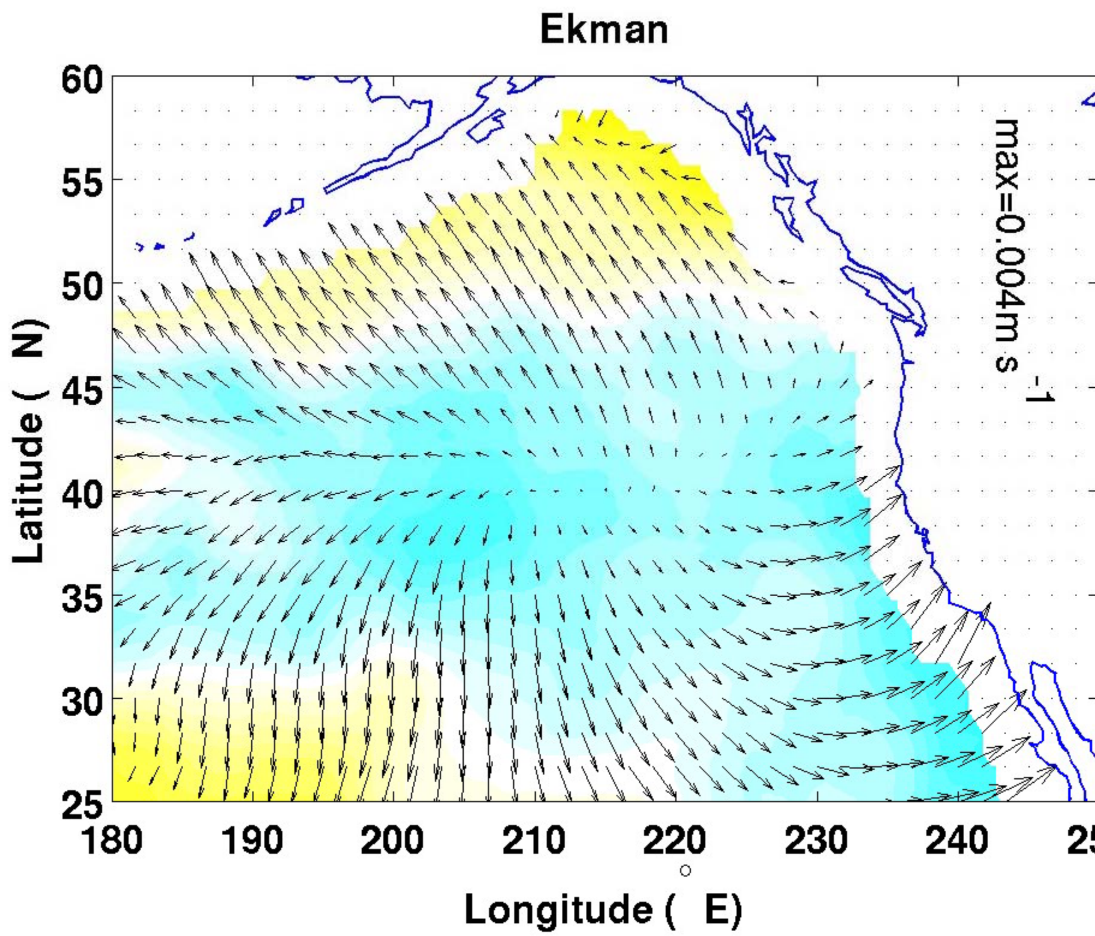
$u_{geo} + u_{ekman}$; $v = v_{geo} + v_{ekman}$

is Ekman pumping velocity

is wintertime mixed layer depth



Contours of SSH



Contours of Ekman pumping

ained by regressing OSCAR velocity components against SSH PC 1