Salinity Variations in the California Current

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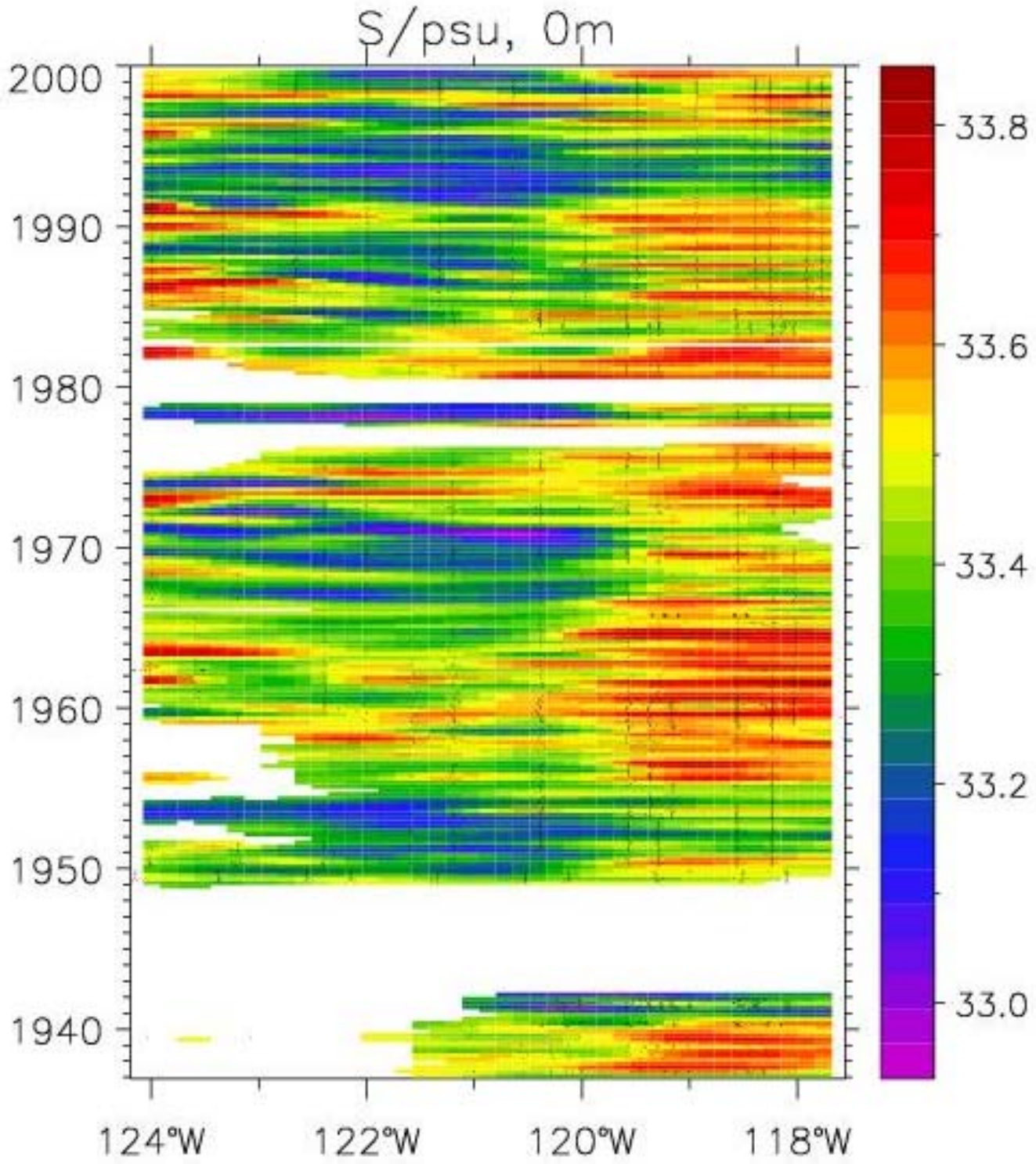
Introduction
Large-scale background
Data
Temperature and salinity variations
Relationship to climate indices
Salinity dynamics
Conclusion


S/psu, 0m
2000
1990
1980
1970
1960
1950
1940
124°W
122°W
120°W
118°W
33.8
33.6
33.4
33.2
33.0

- Salinity variations in the California current are dominated by variance at decadal time scales.
- These variations are independent of halocline heave, the dominant temperature signal, ENSO, PDO and local upwelling.
- Halocline heave reflects ENSO.
- Decadal salinity variations are density compensated.
- Salinity variations are consistent with the accumulation of anomalous, long-shore advection along the mean long-shore flow trajectory.
- Anomalous long-shore current anomalies are independent of large-scale forcing, and *possibly* result from synoptic eddies.

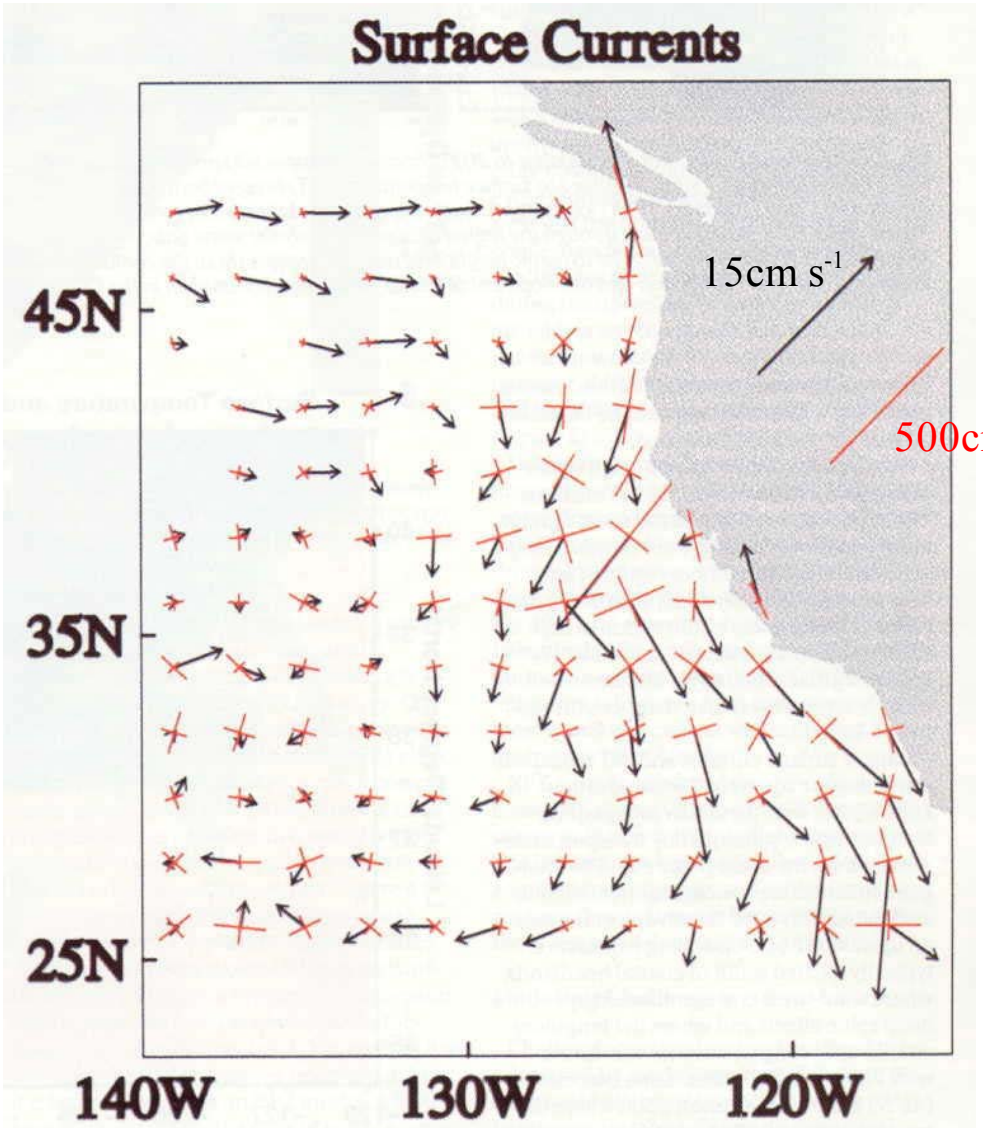
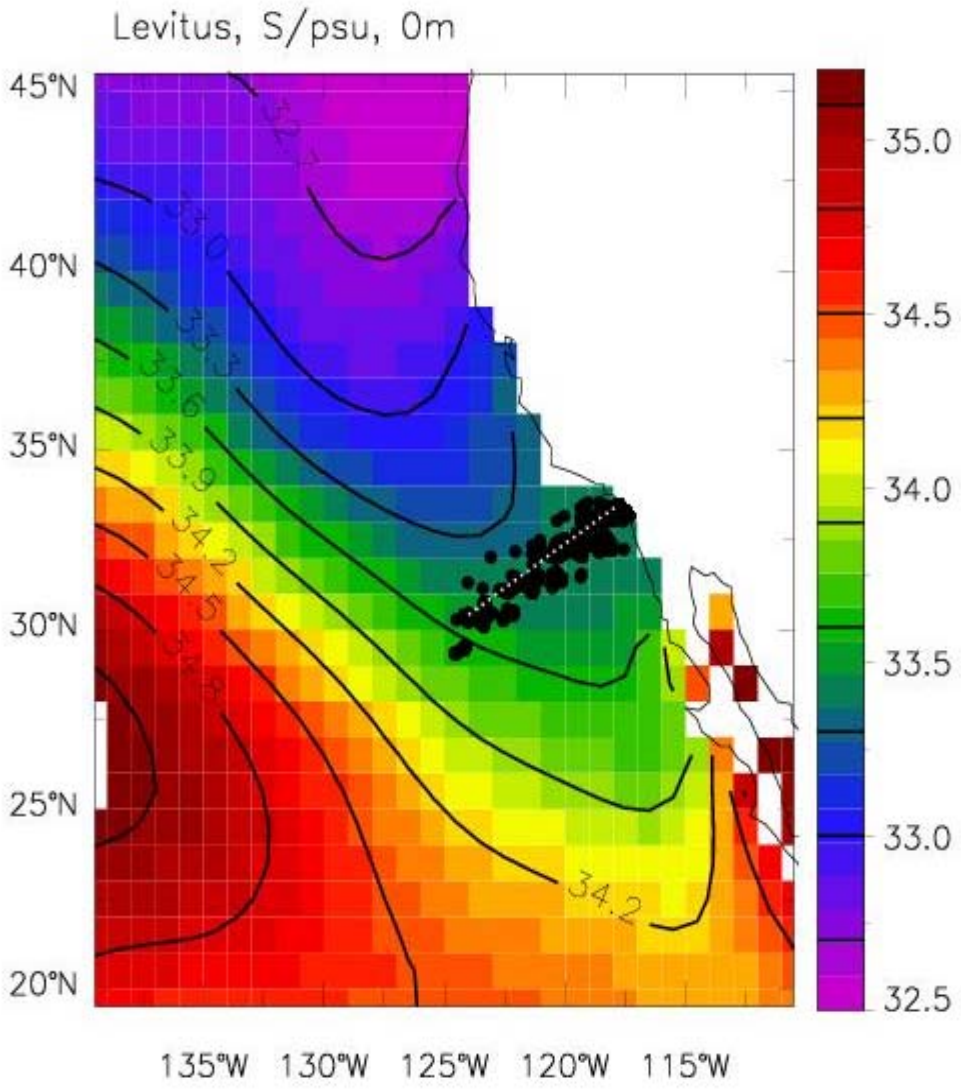
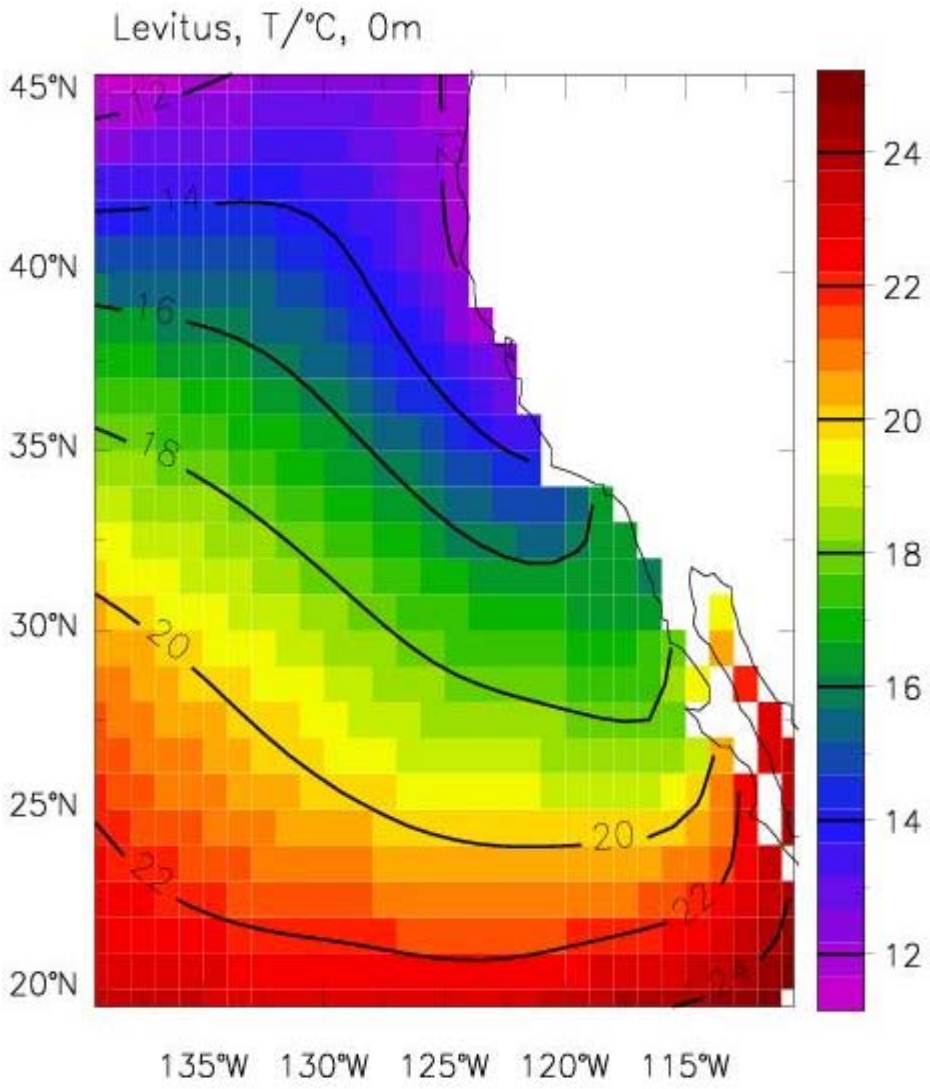


Fig. 1. Mean 15-m velocity (black arrows, 15 cm/s) and its variance (red crosses, 500 cm^2/s^{-2}) in the California Current System (CCS) and eastern Pacific from available surface drifters (National Oceanic and Atmospheric Administration Global Drifter Center, Web site: www.aoml.noaa.gov/phod/dac/gdc.html) during the period 1985-1998. Symbols are plotted at the center points of a 2° grid.

Miller et al. 1999

Climatology



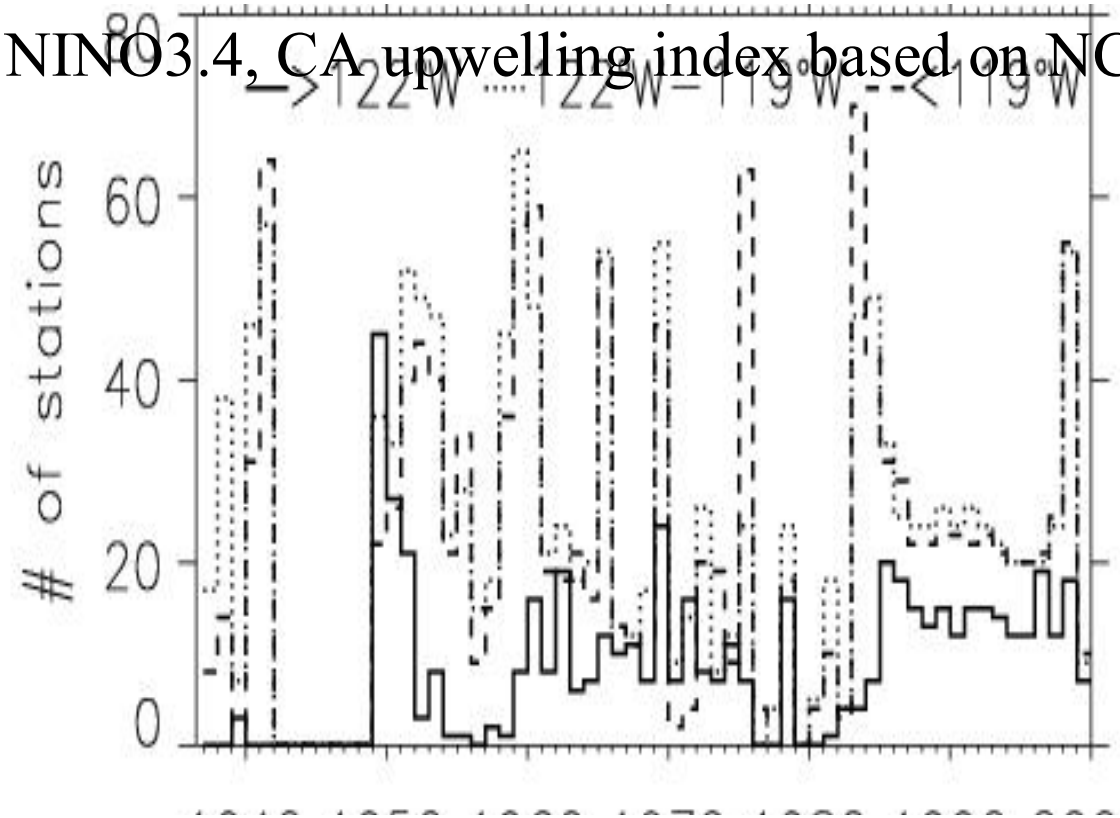


Observations

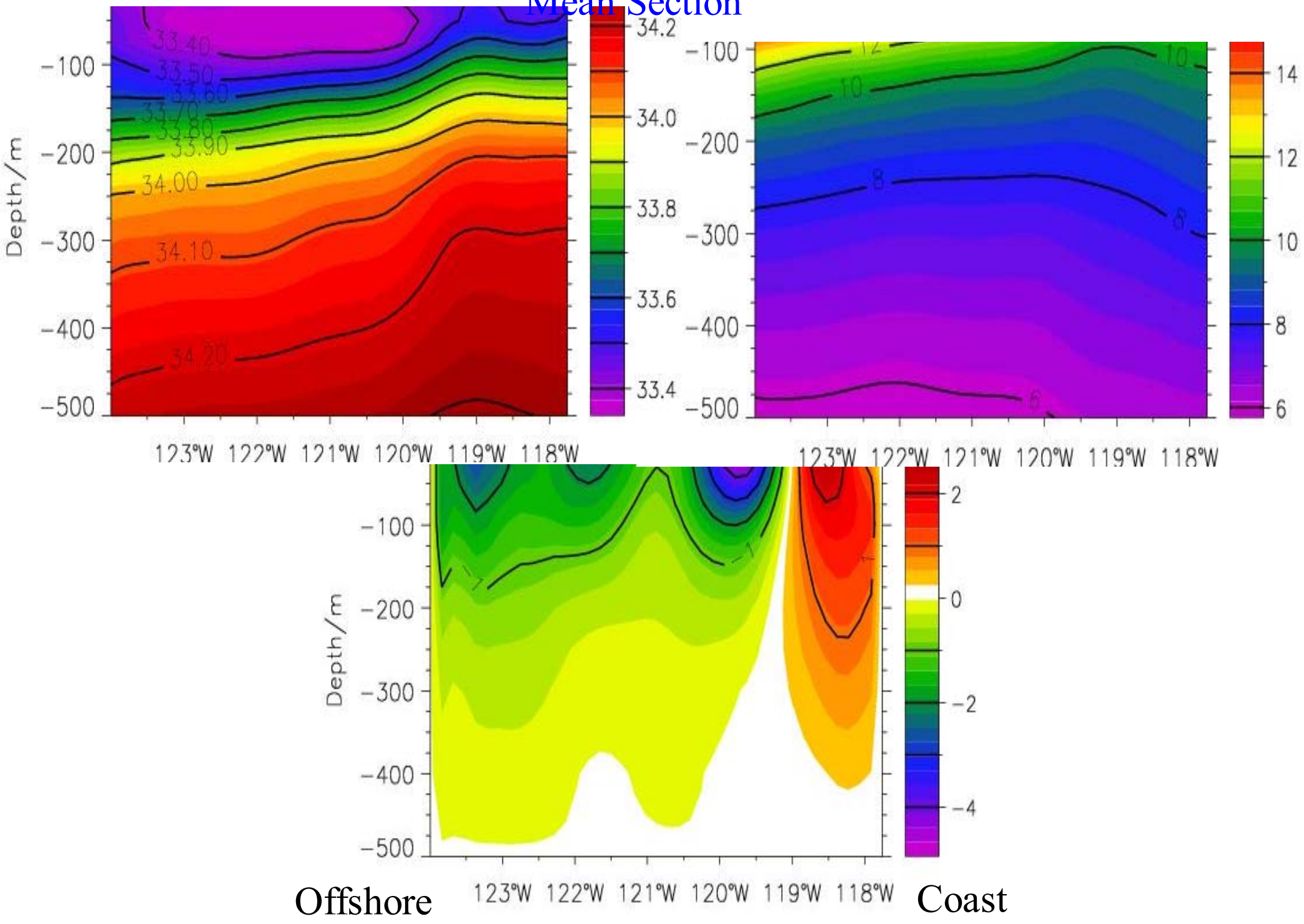
CalCOFI (California Cooperative Fisheries Investigation)
1949-2000
US Coast Guard, H. Sverdrup 1930s

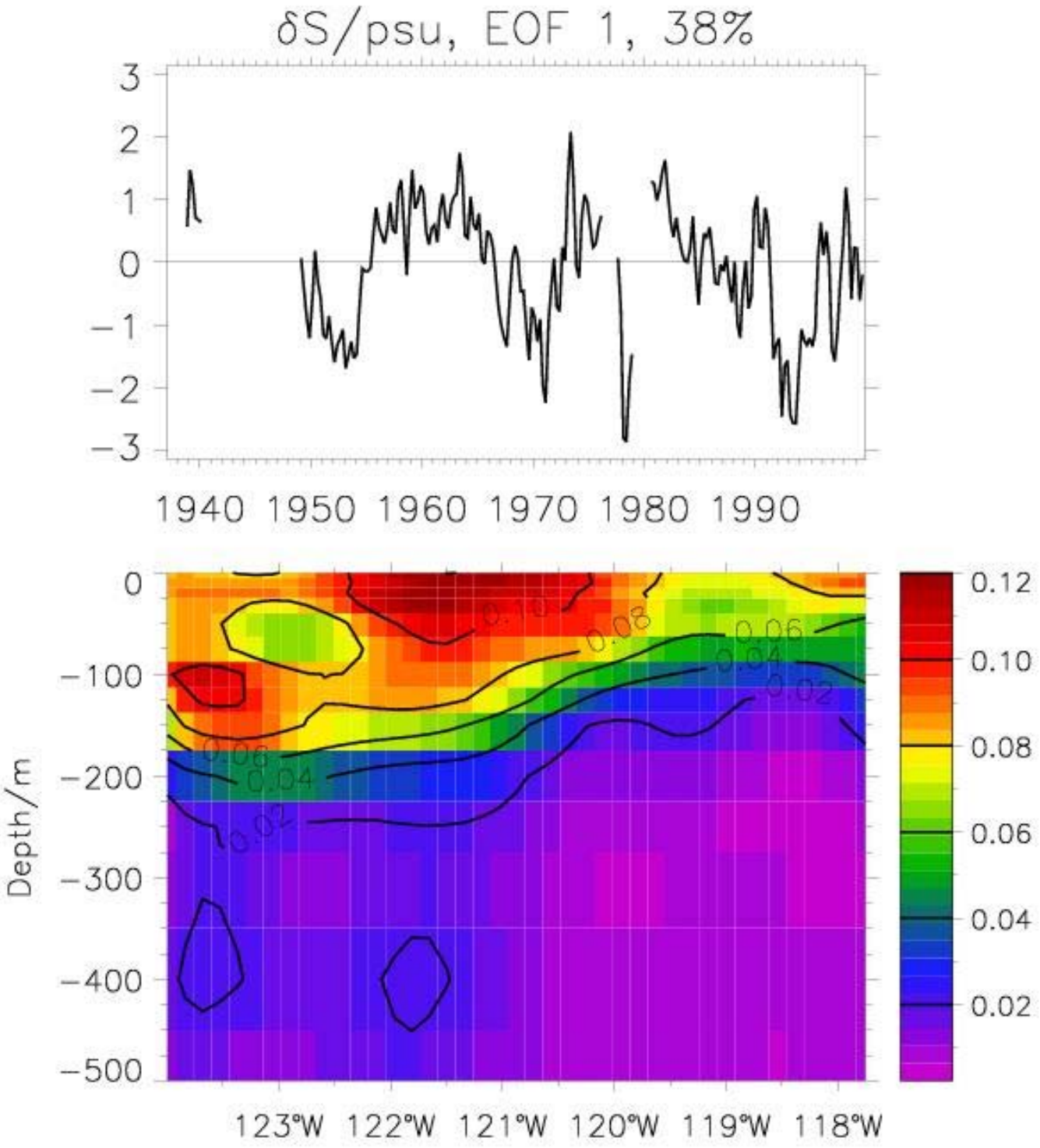
Temperature and salinity
surface to 500m, 11 levels
>600km offshore of Long Beach, CA, line-90
typically seasonal time resolution, but with many gaps

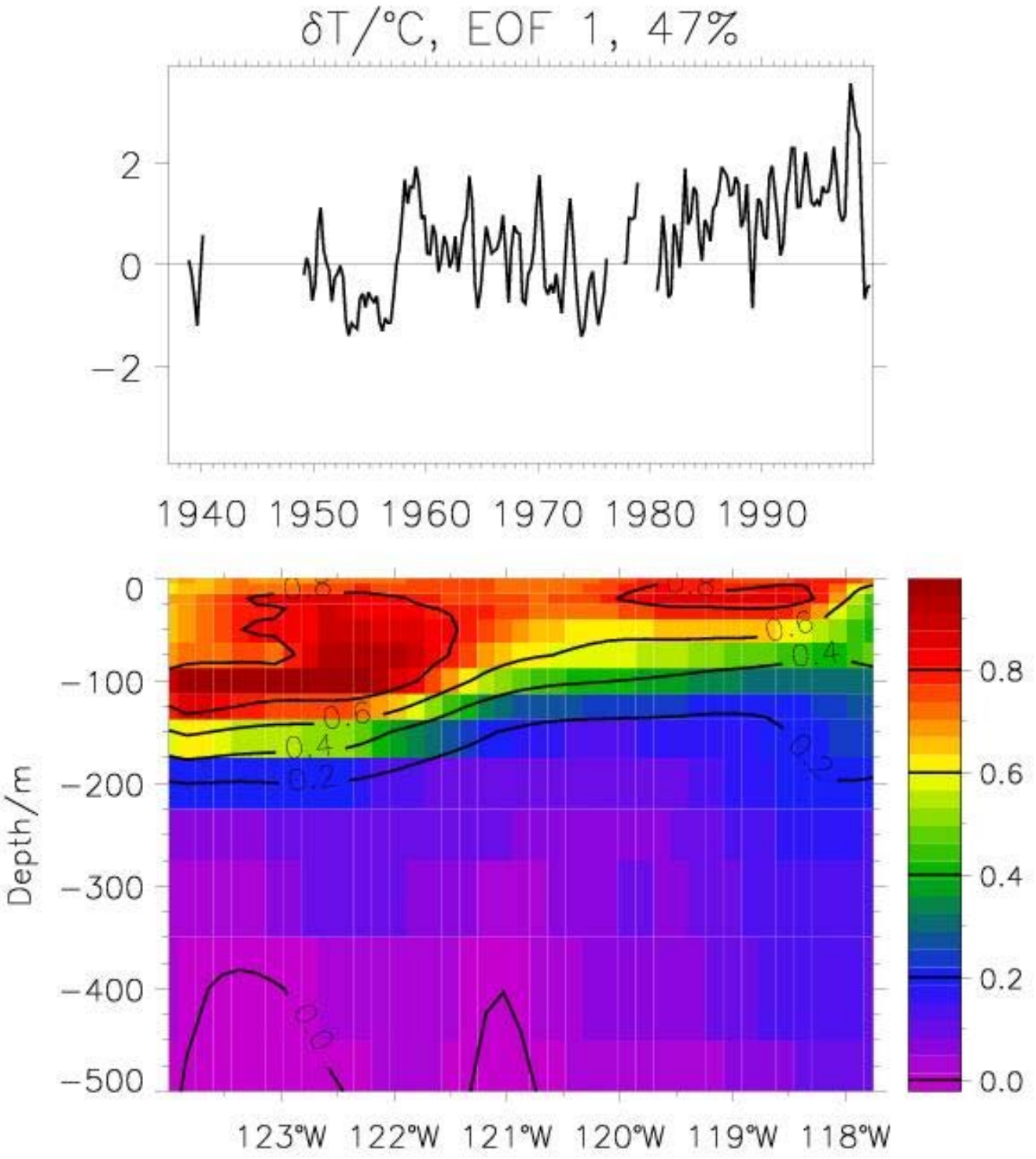
PDO, NINO3.4, CA upwelling index based on NCEP



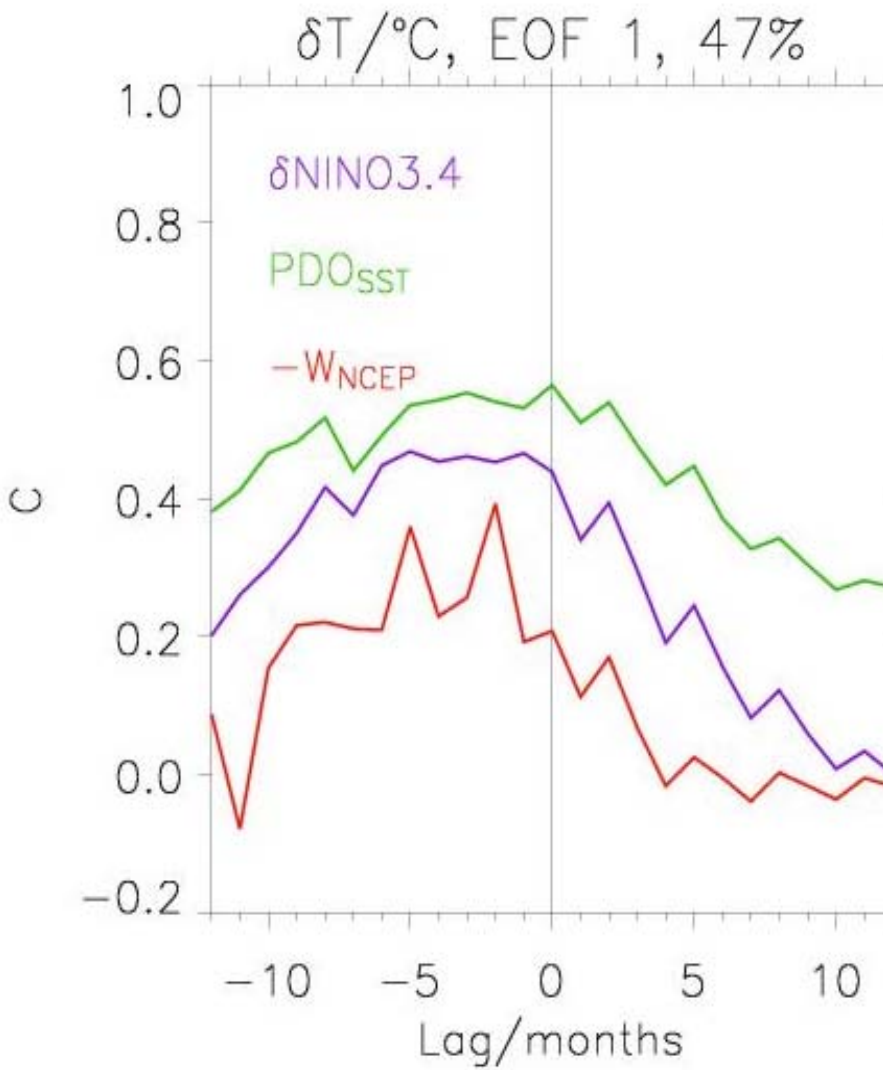
Mean Section

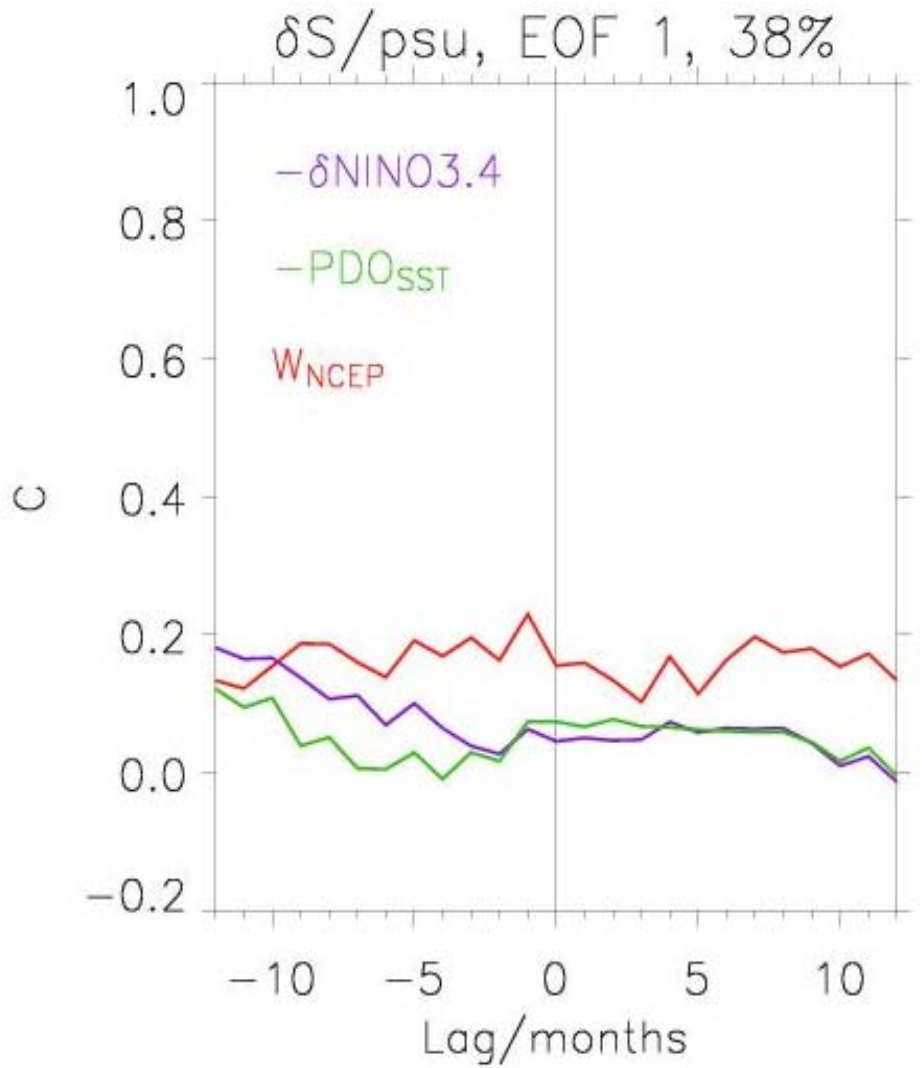



δS/psu, EOF 1, 38%
3
2
1
0
−1
−2
−3
1940 1950 1960 1970 1980 1990
0
−100
−200
−300
−400
−500
Depth/m
0.12
0.10
0.08
0.06
0.04
0.02
123°W 122°W 121°W 120°W 119°W 118°W

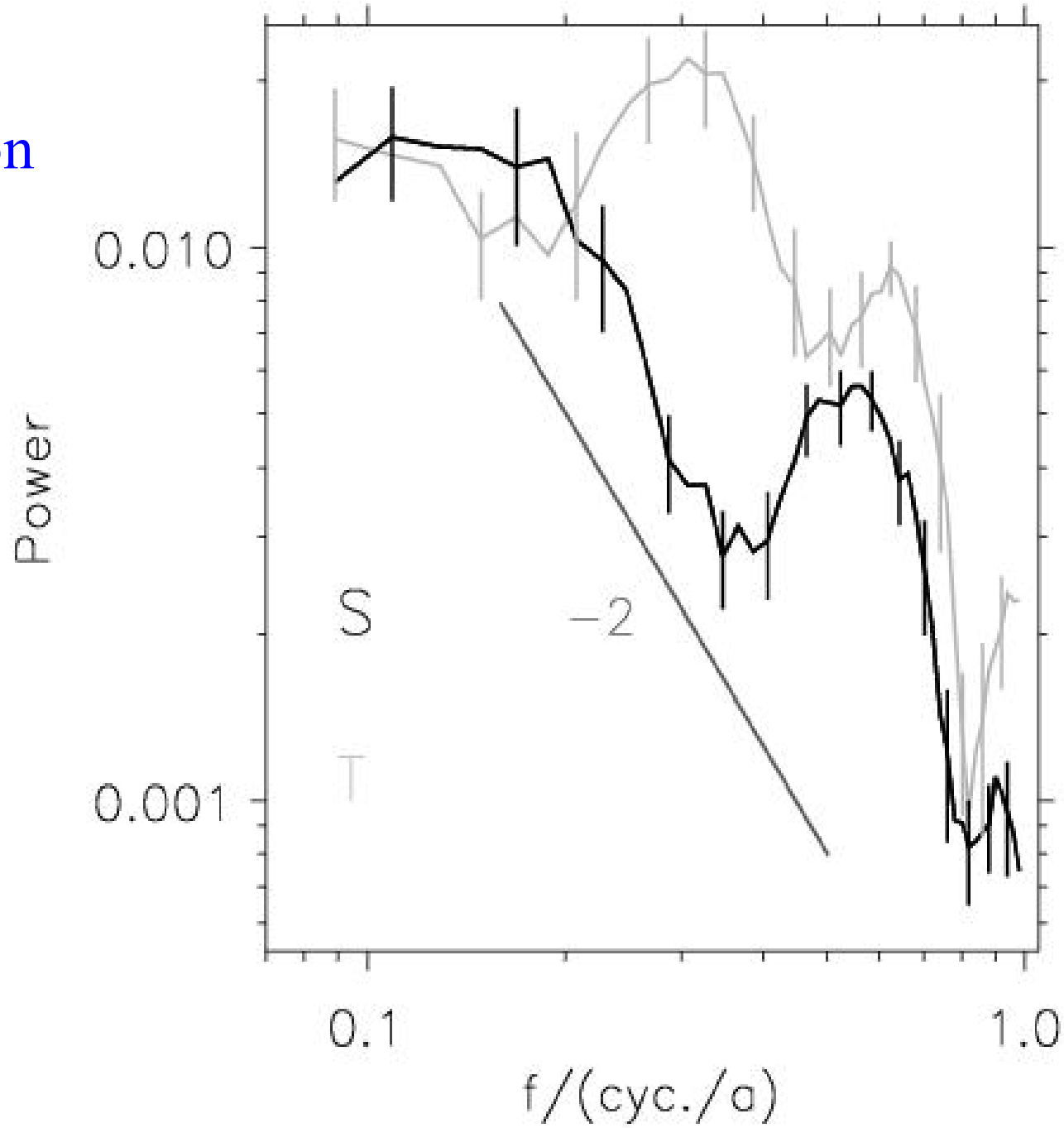

δT/°C, EOF 1, 47%
2
0
−2
1940 1950 1960 1970 1980 1990
Depth/m
0
−100
−200
−300
−400
−500
0.8
0.6
0.4
0.2
0.0
123°W 122°W 121°W 120°W 119°W 118°W

Large Scale Context

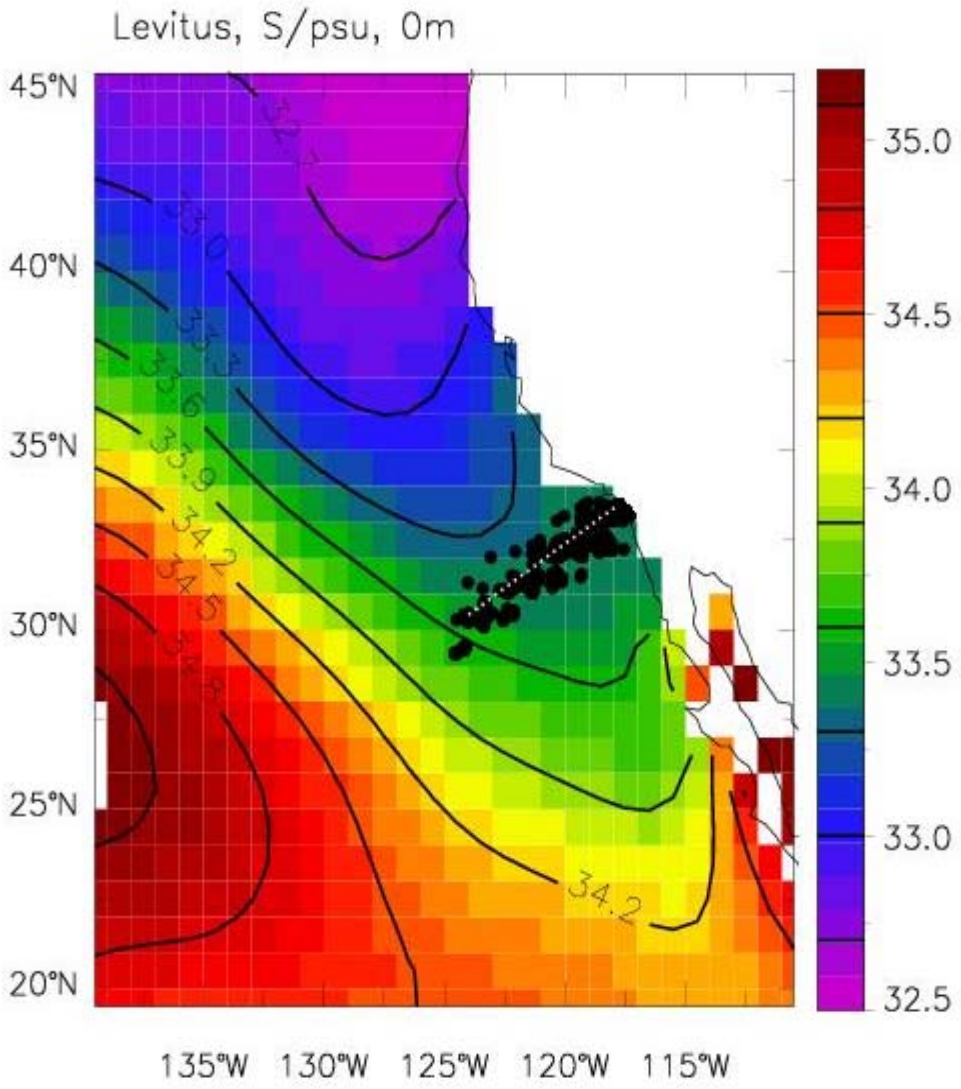


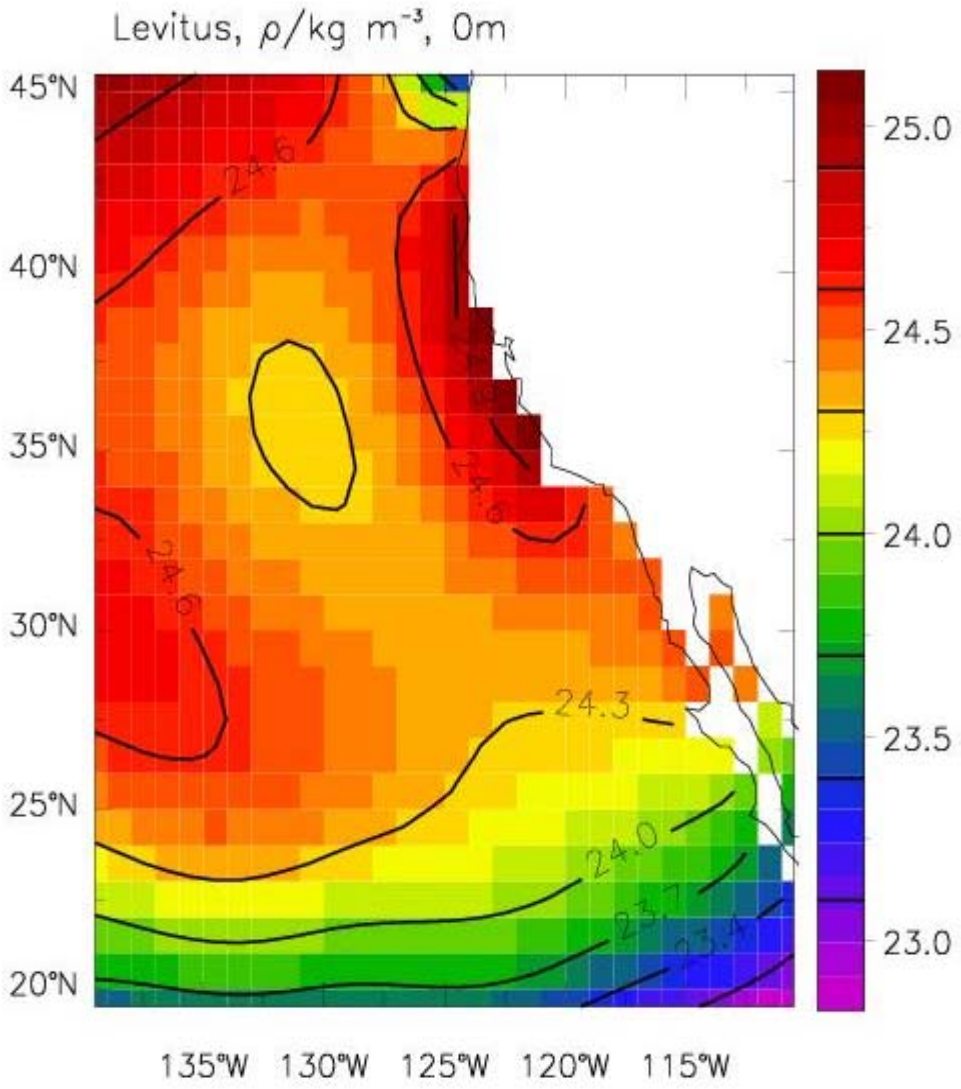


Storage and mean advection



Density: Tracer for vertical and cross-shore processes



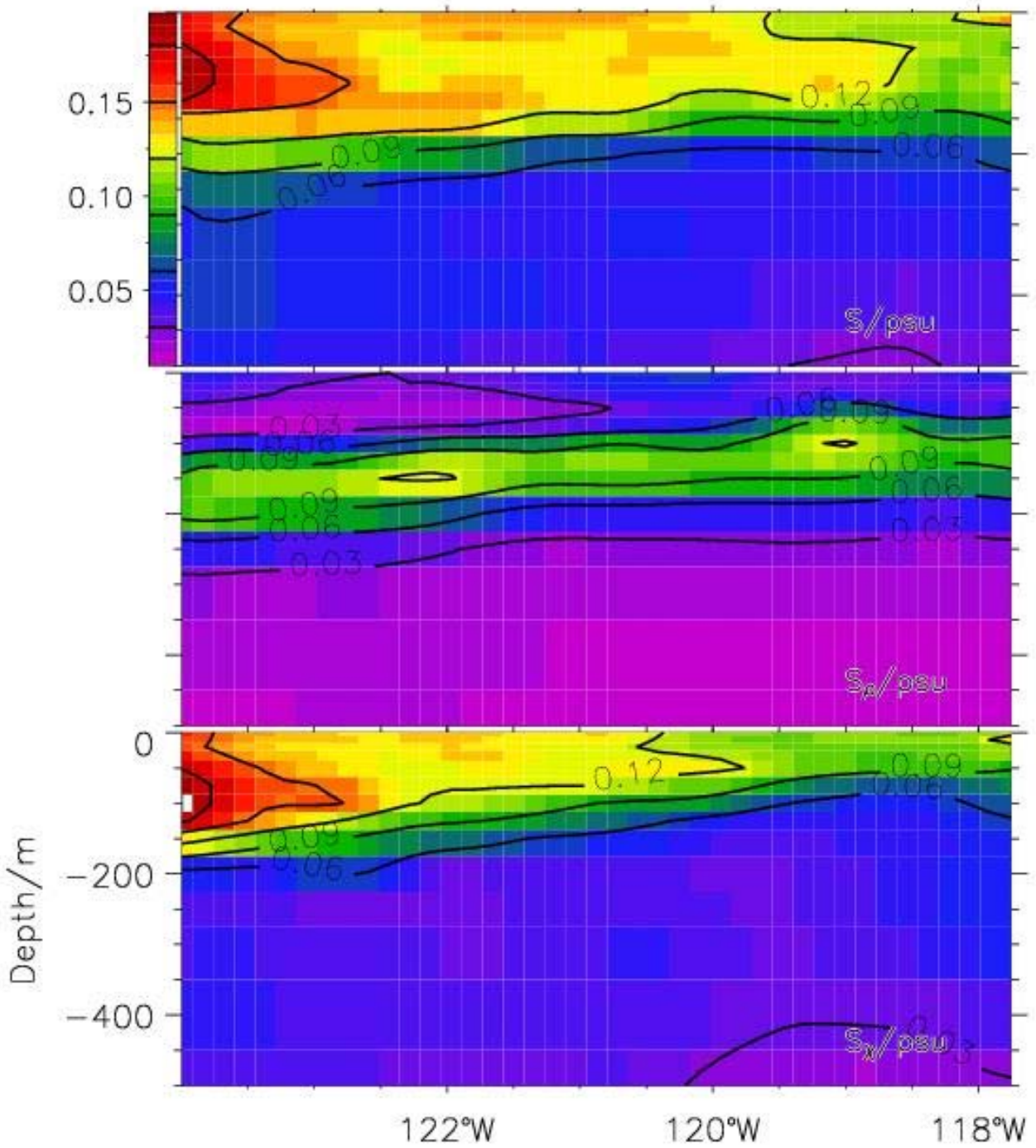


Cross shore and vertical processes: Density and Spiciness

$$dS_\chi = S - \overline{S}(\overline{\rho} + d\rho)$$

$$dS_\rho = \overline{S}(\overline{\rho} + d\rho) - \overline{S}(\overline{\rho}$$

$$dS_\rho = \overline{\left(\frac{dS}{d\rho}\right)}\, d\rho$$

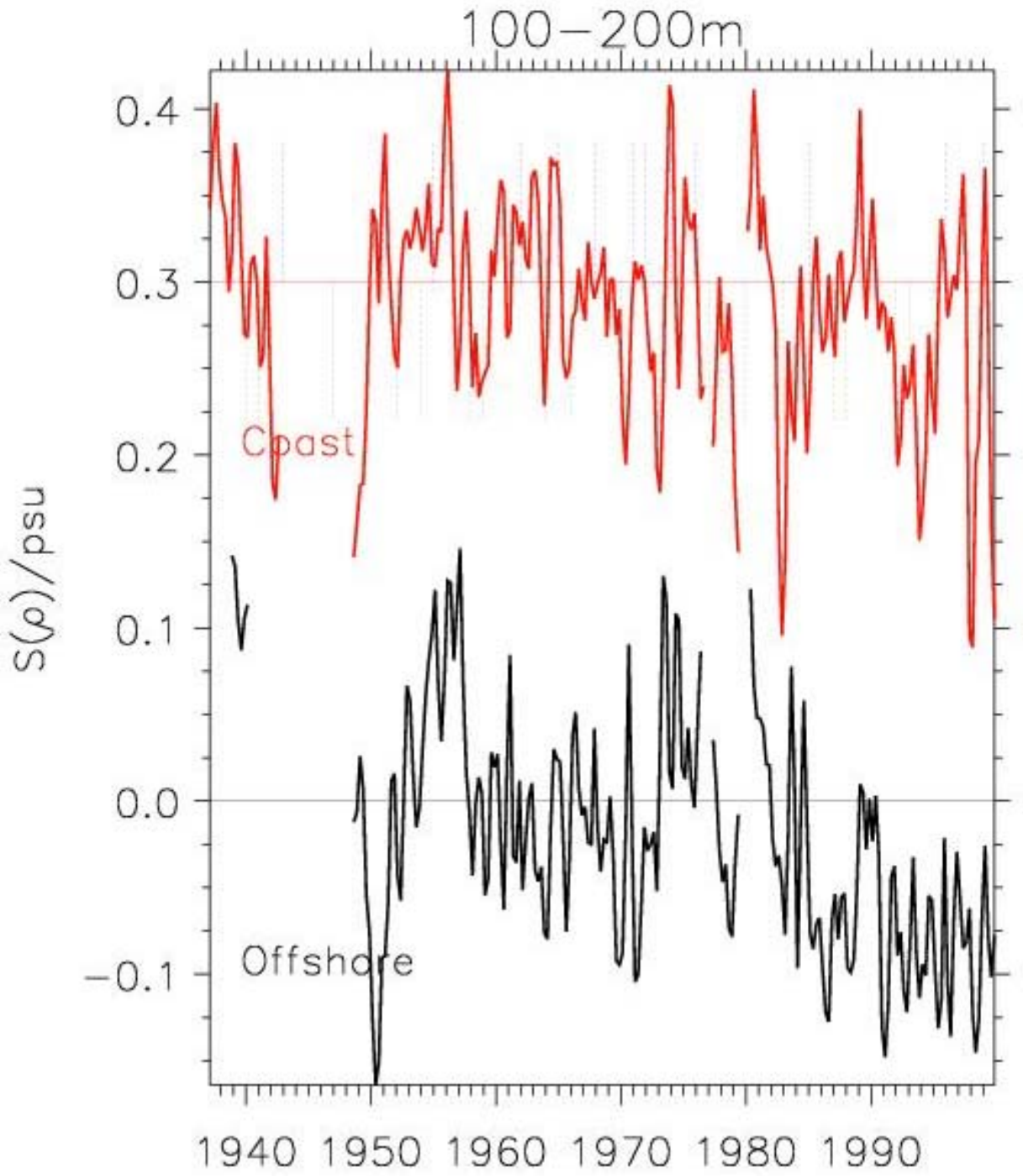

0.15
0.10
0.05
0.12
0.09
0.06
S/psu
0.09
0.06
0.03
S_ρ/psu
0
−200
−400
Depth/m
0.12
0.09
0.06
S_χ/psu
122°W
120°W
118°W

S

S_ρ

S_χ

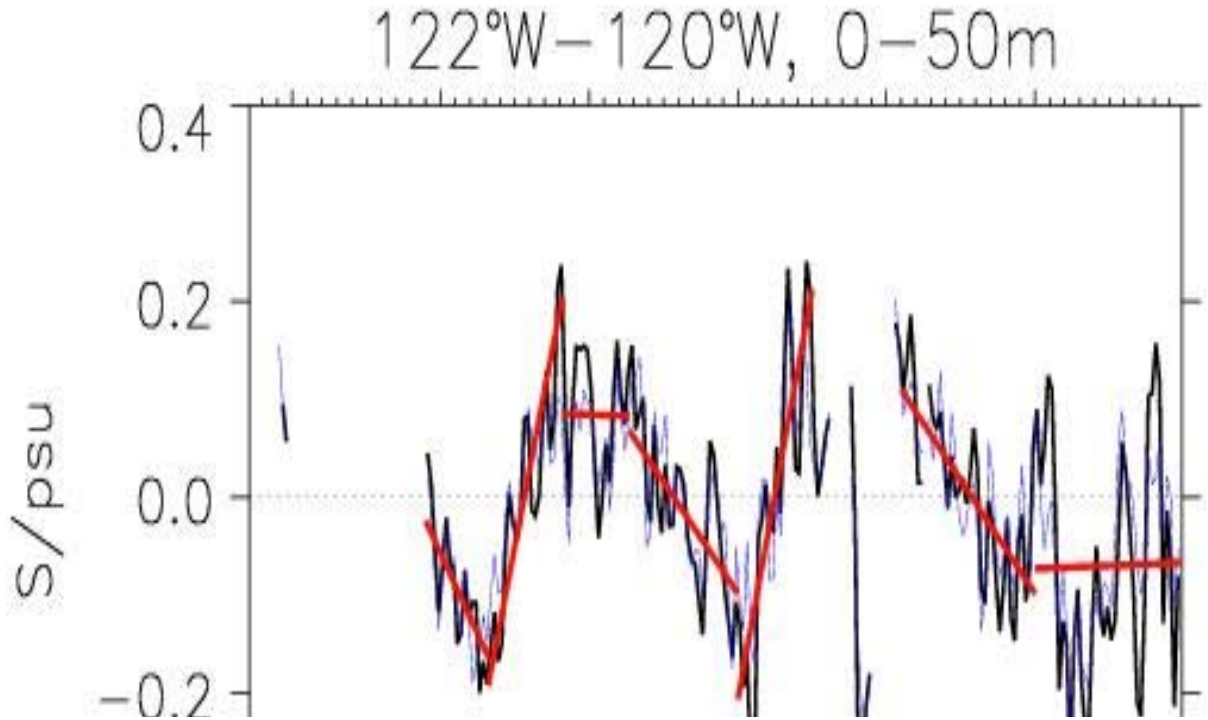
Heaving of the halocline



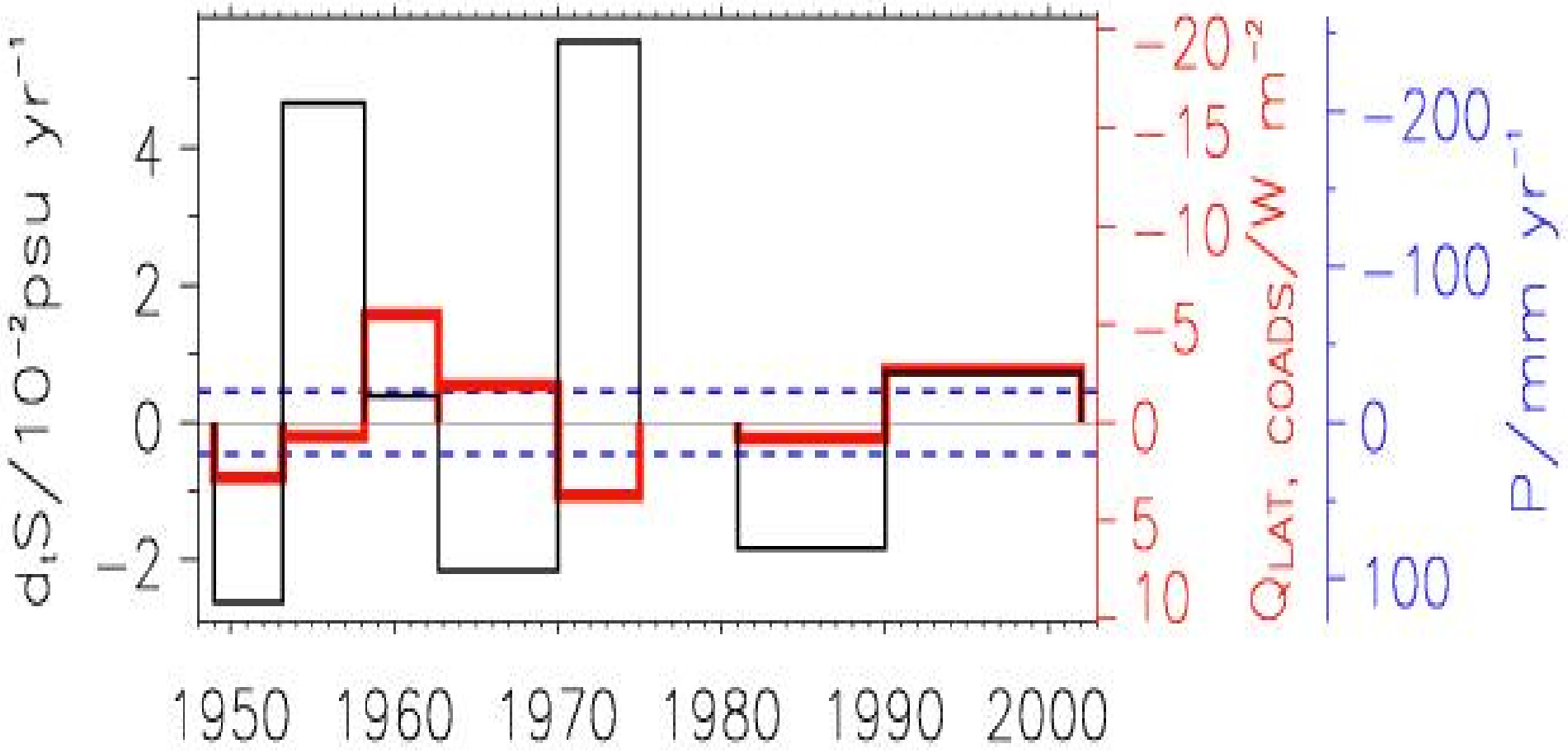
Halocline: Large scale forcing

		NINO3.4		TROSST		WNCEI	
$\gamma(\rho)$	Coast	-0.48	-1	-0.24	-3	-0.26	2
	Offshore	-0.25	-1	-0.28	-10	-0.14	-2

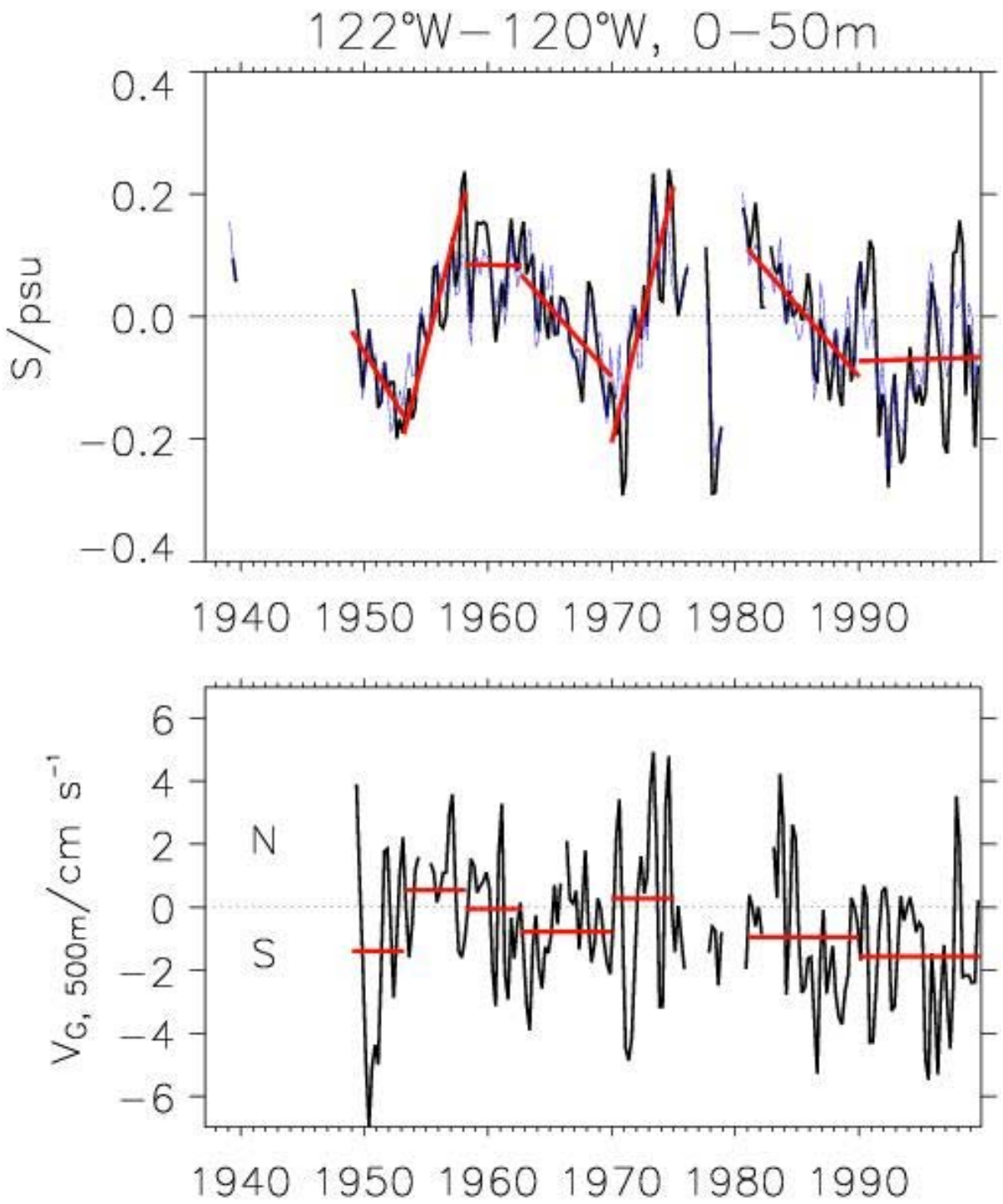
Salinity rate of change



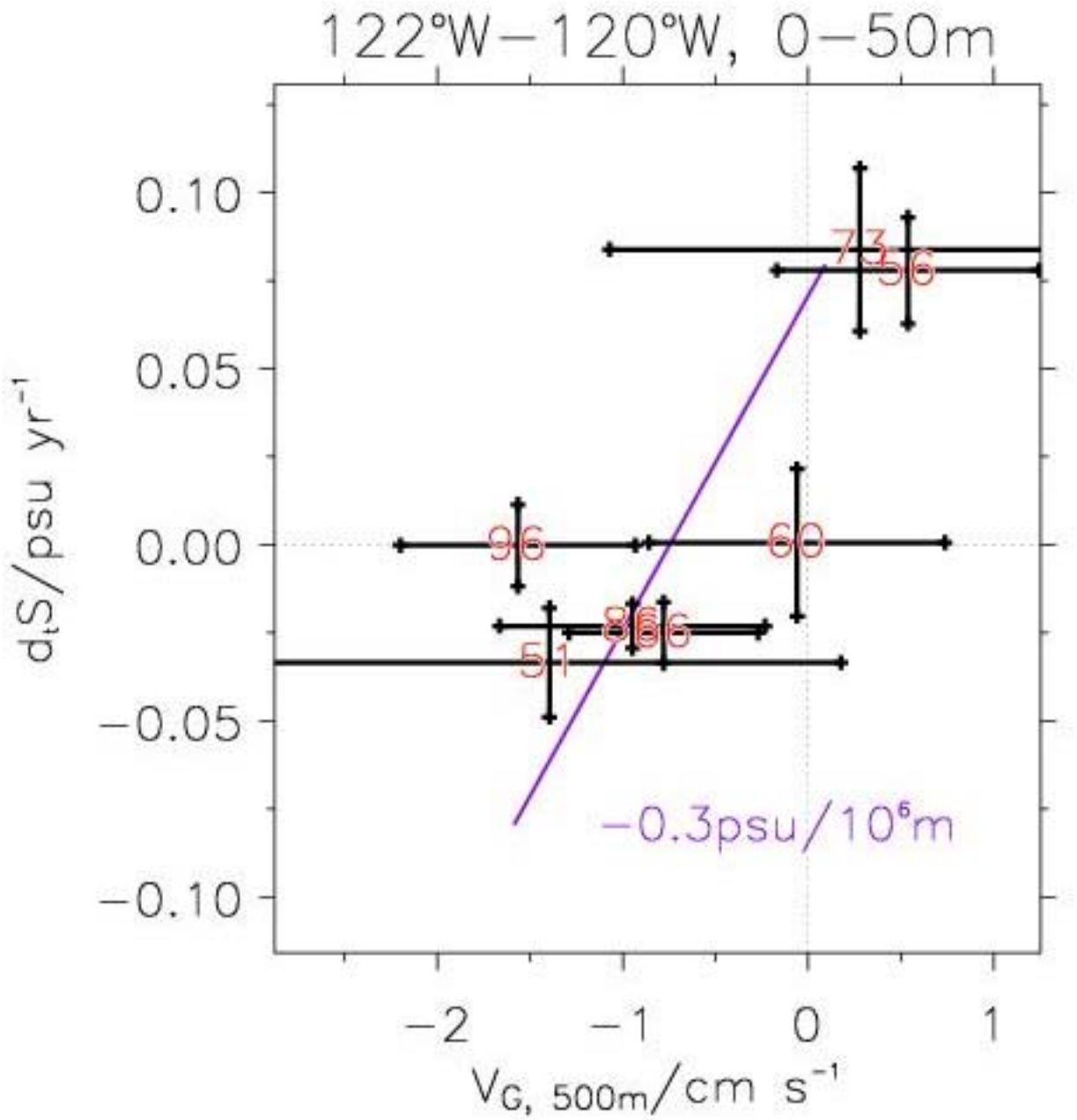
Surface Fresh Water Flux



Observed maximum wet season (winter) precipitation anomalies are less than 20 mm (Dettinger et al. 1998)

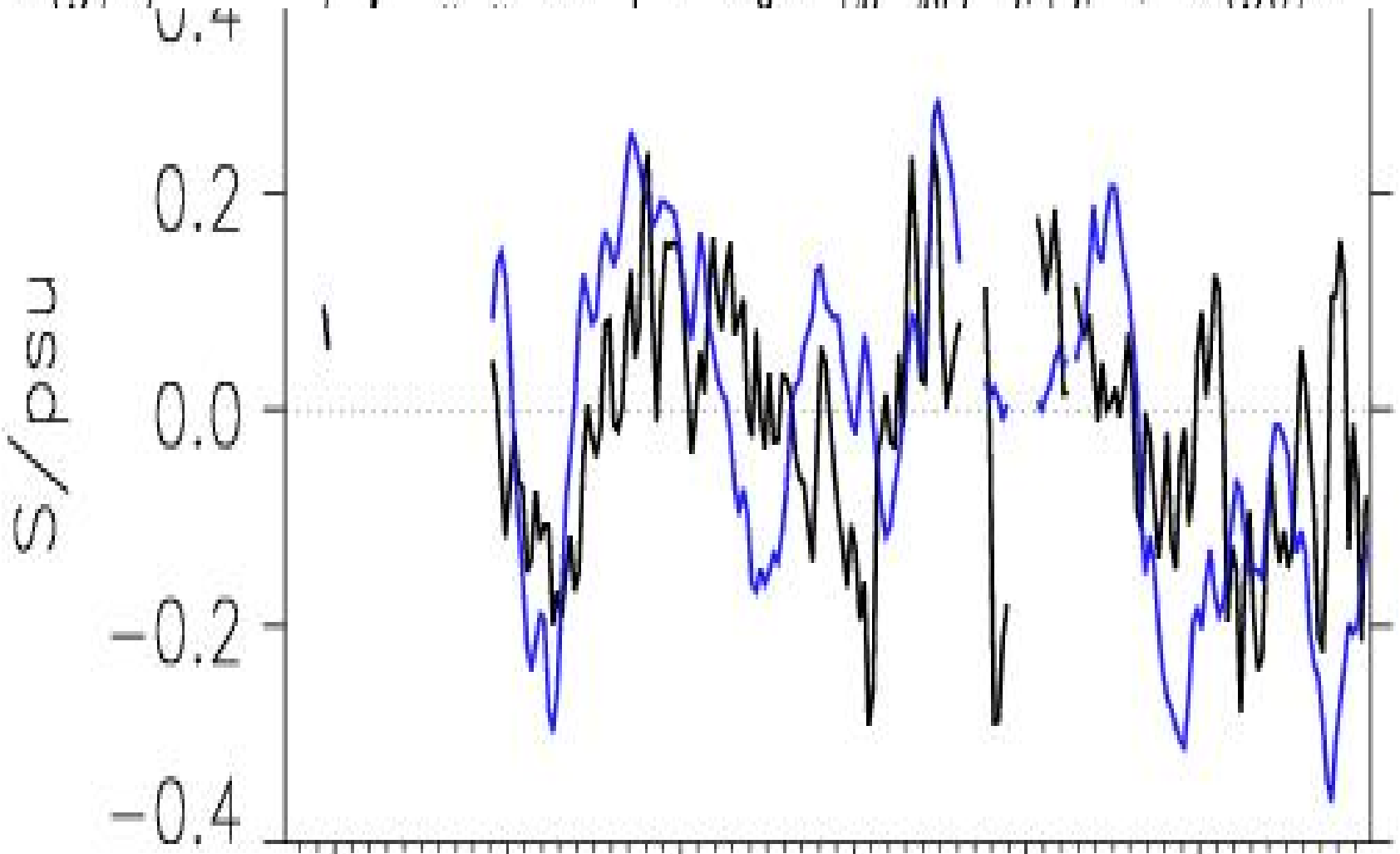

122°W–120°W, 0–50m
S/psu
0.4
0.2
0.0
−0.2
−0.4
1940 1950 1960 1970 1980 1990
$V_{G,\ 500m}$/cm s^{-1}
6
4
2
0
−2
−4
−6
N
S
1940 1950 1960 1970 1980 1990

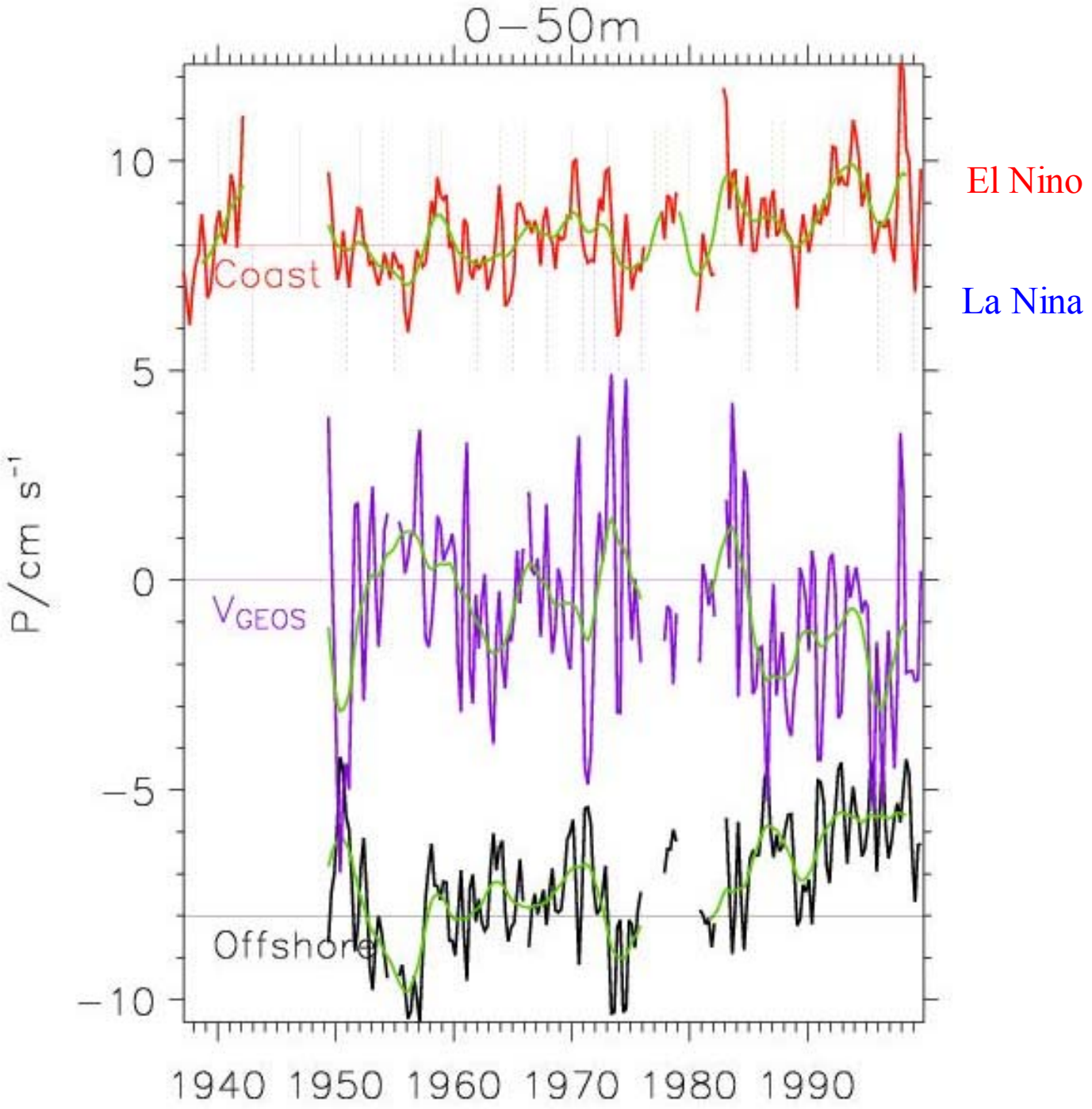
Anomalous long-shore advection



Anomalous advection

$$S(y,t) = -\gamma \int^{t} dt' \left[v' \overline{\partial_y S} \right]_{y=y(t,t')} + S(y_0, t - \frac{y - y_0}{\bar{v}})$$




0–50m
10
5
0
−5
−10
P/cm s⁻¹
Coast
VGEOS
Offshore
1940
1950
1960
1970
1980
1990
El Nino
La Nina

Origins of flow anomalies

		NINO3.4	PDO_{SST}	w_{NCEP}
P	Coast	0.60 -1	0.42 0	0.41 -2
	Offshore	0.29 -5	0.37 -4	0.25 -2
V_{GEOS}		0.20 -3	-0.23 10	-0.16 -7

$$s(t) = \sum_j \beta_j \int_{t-\tau_{ij}}^{t} dt' R_j(t')$$

Fit has less skill than integration of anomalous advection

Conclusions

- Salinity variations in the California current are dominated by variance at decadal time scales.
- These variations are independent of halocline heave, the dominant temperature signal, ENSO, PDO and local upwelling.
- Halocline heave reflects ENSO.
- Decadal salinity variations are density compensated.
- Salinity variations are consistent with the accumulation of anomalous, long-shore advection along the mean long-shore flow trajectory.
- Anomalous long-shore current anomalies are independent of large-scale forcing, and *possibly* result from synoptic eddies.
- Salinity variations *possibly* influence the source waters of eastern subtropical mode waters.