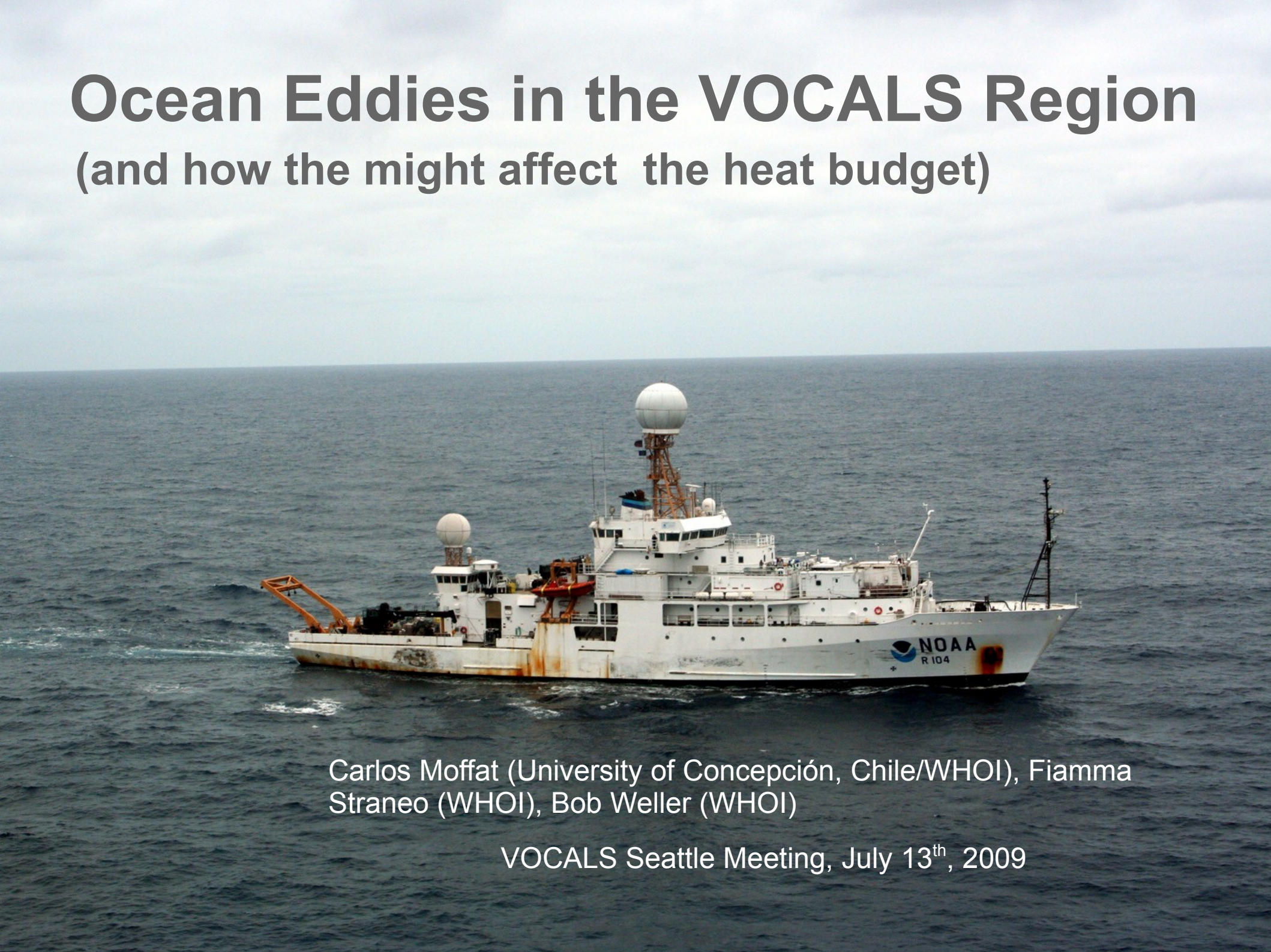
Ocean Eddies in the VOCALS Region

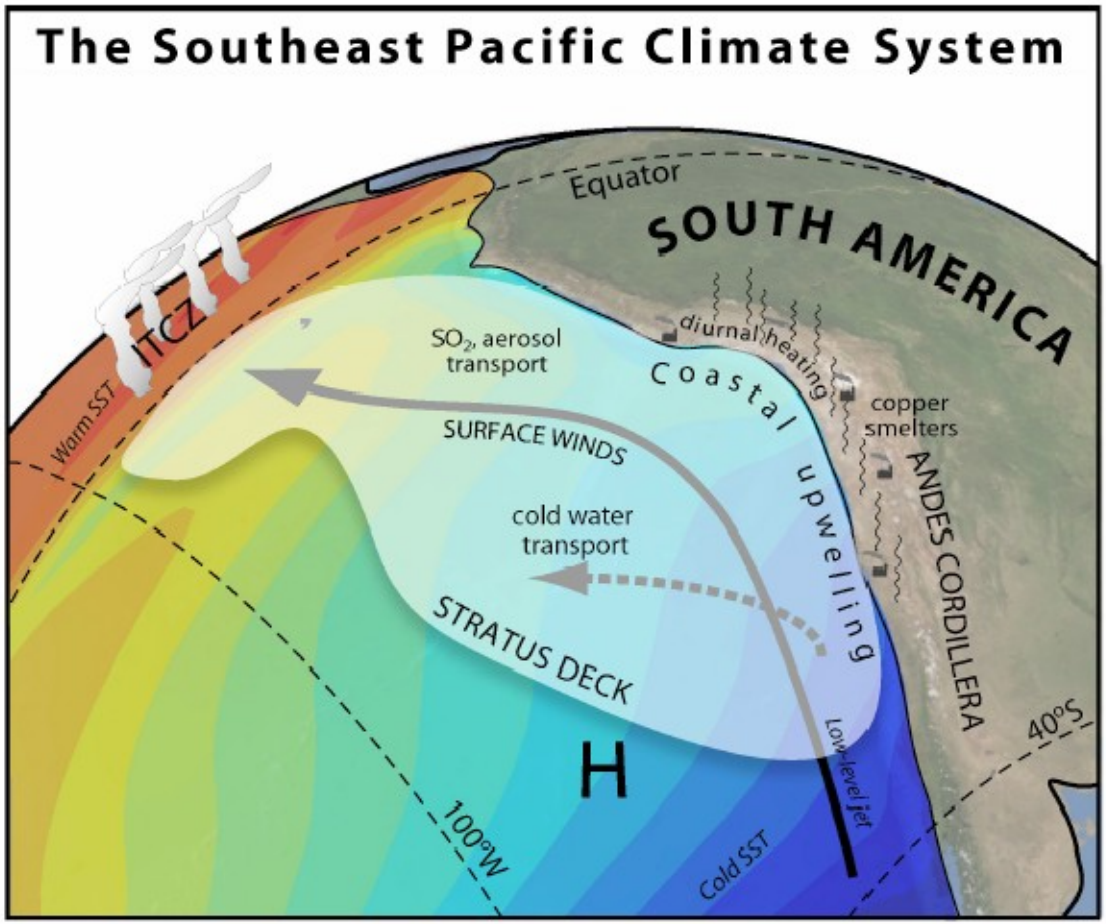
(and how the might affect the heat budget)



Carlos Moffat (University of Concepción, Chile/WHOI), Fiamma Straneo (WHOI), Bob Weller (WHOI)

VOCALS Seattle Meeting, July 13th, 2009

(A few) VOCALS Hypotheses

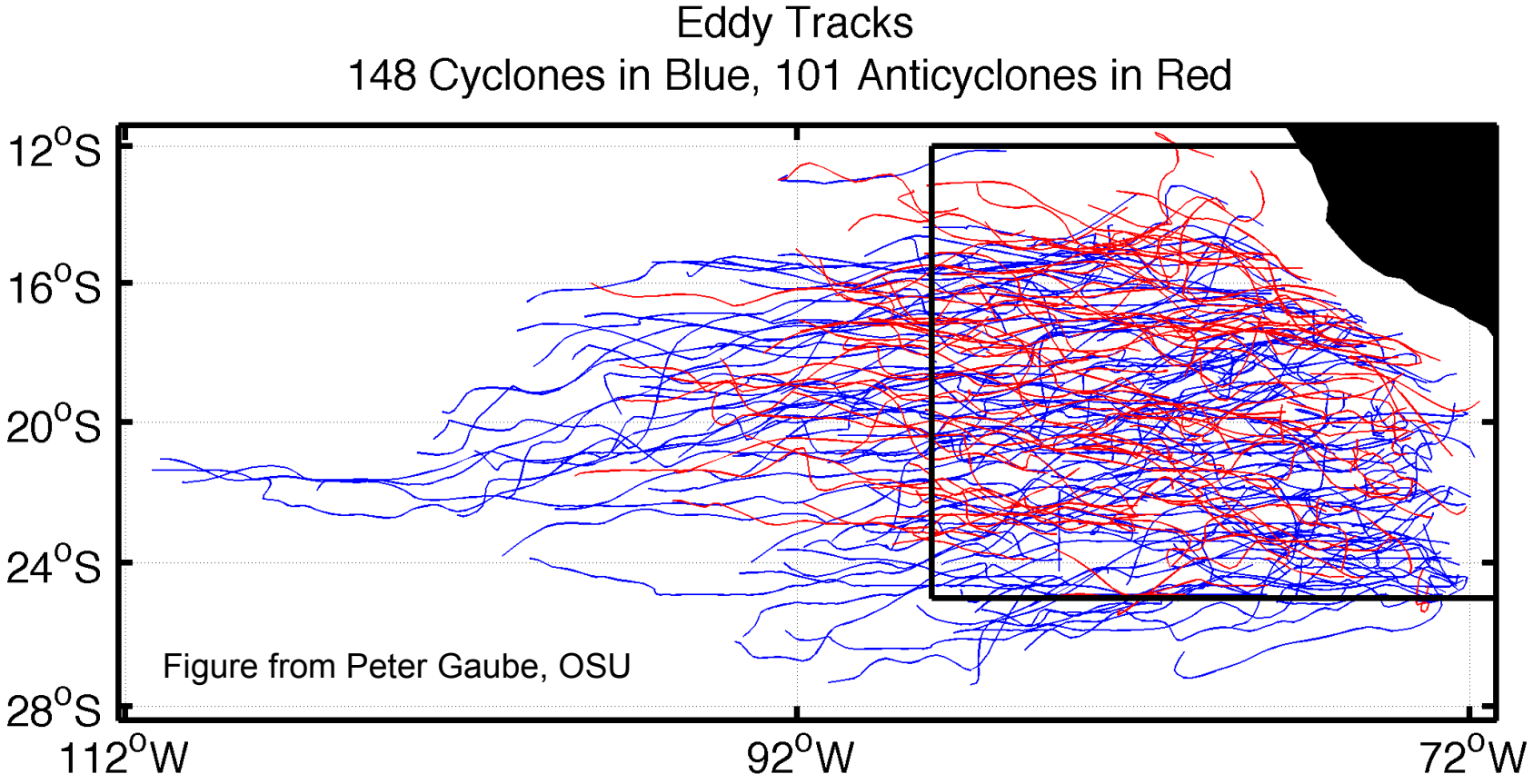


- Oceanic mesoscale eddies play a major role in the transport of heat and fresh water from coastally upwelled water to regions further offshore.
- The entrainment of cool fresh intermediate water from below the surface layer during mixing associated with energetic near-inertial oscillations generated by transients in the magnitude of the trade winds is an important process to maintain heat and salt balance of the surface layer of the ocean in the SEP.

Outline

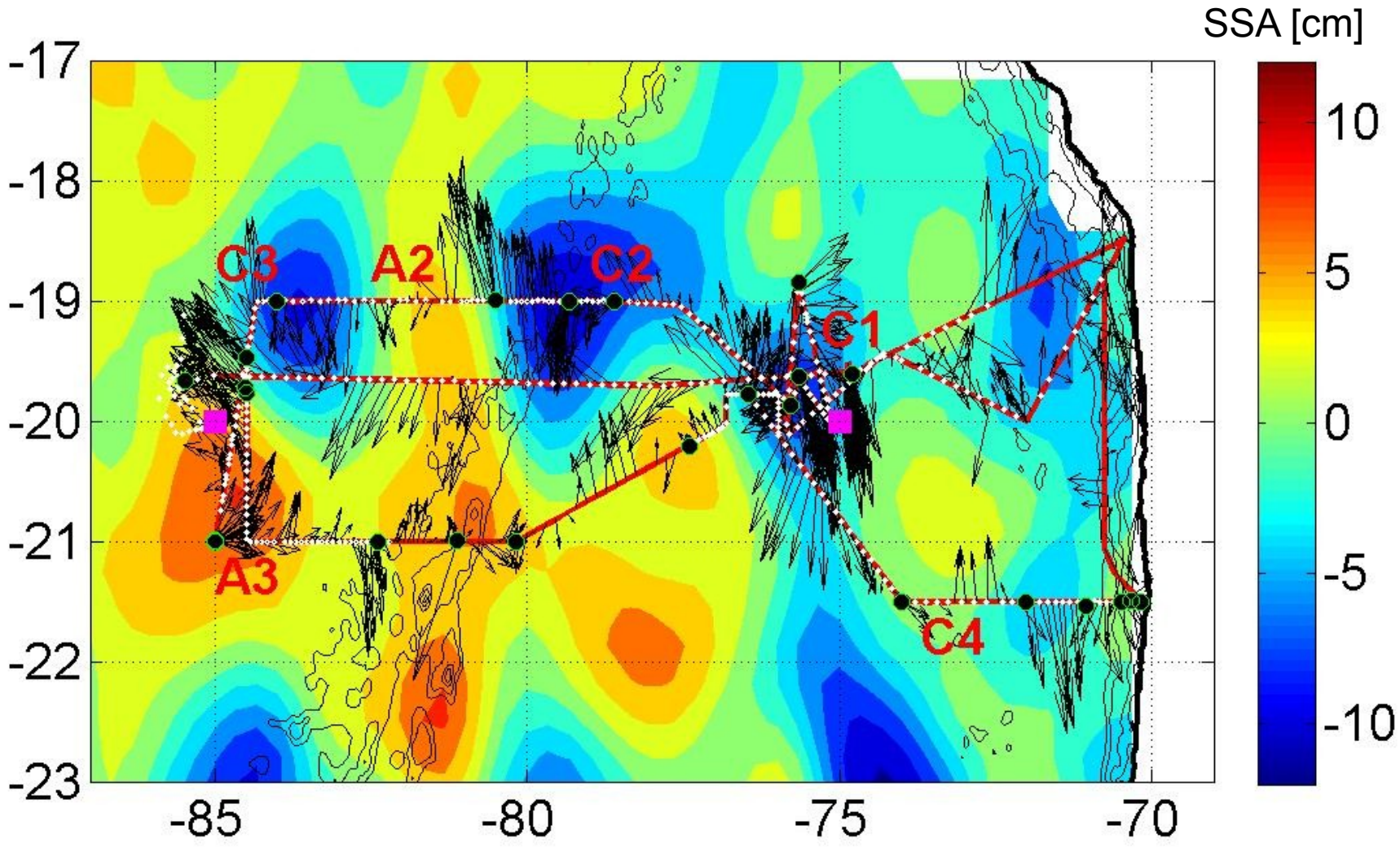
- Eddies from Space
- Observations During VOCALS-Rex
- Characteristics of Eddies in SEP Region
- The effect of eddies on upper ocean structure

Eddies in the VOCALS Region from Historical Satellite Observations



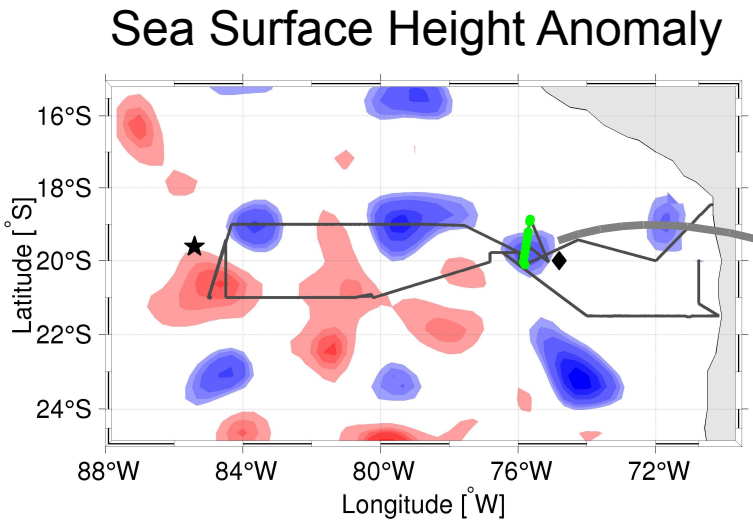
Eddies SST anomaly signature from satellite data is ~0.2 °C (work by P. Gaube, D. Chelton, A. Chaigneau, O. Pizarro).

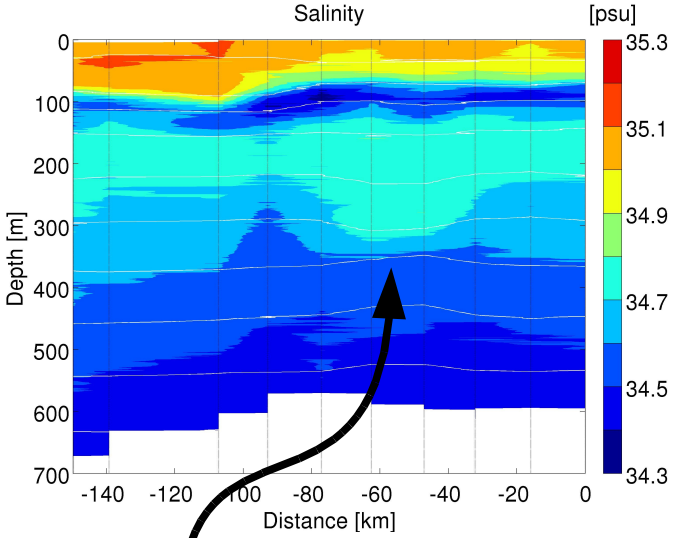
Hydrographic and Velocity Observations during VOCALS-Rex



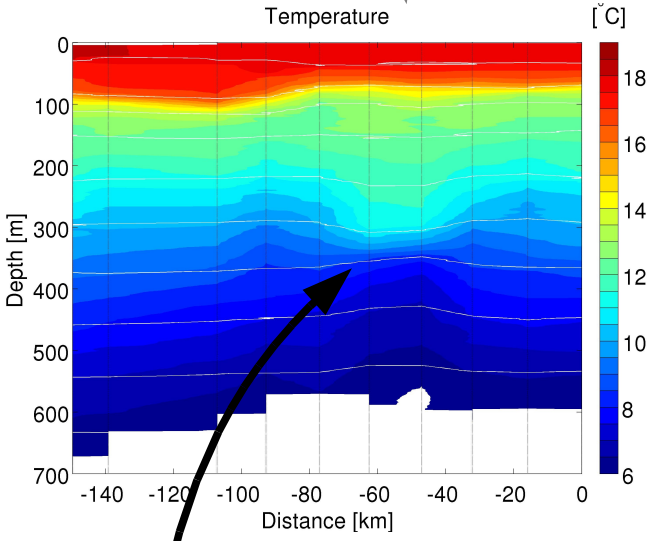
Structure of Cyclones

- Sub-surface intensified
- Horizontal Scale: 30-80 km.
- Vertical Scale: >600 m
- Max. Velocities ~ 30 cm/s

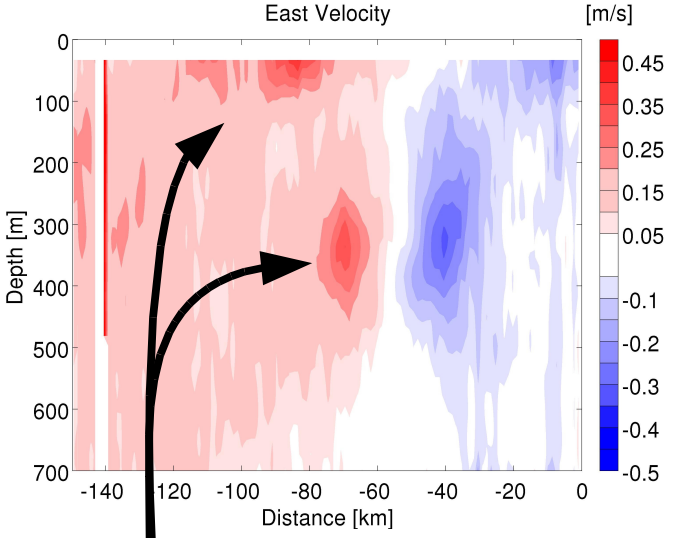




Salty, low stratification core underlying salinity minimum



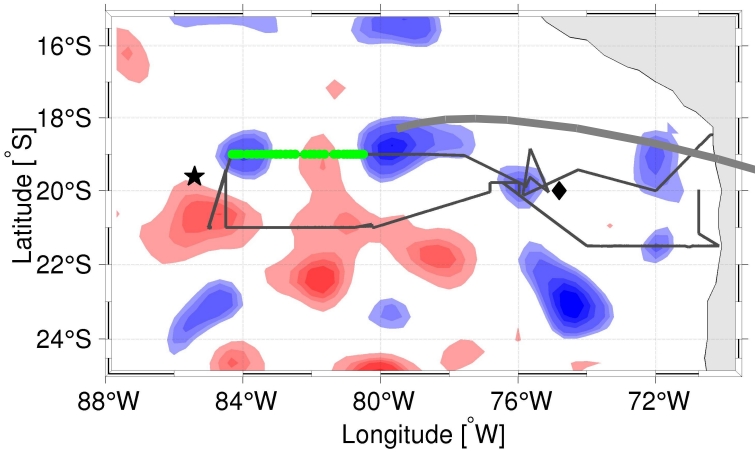
"Pinching" of deep isotherms is characteristic of cyclones



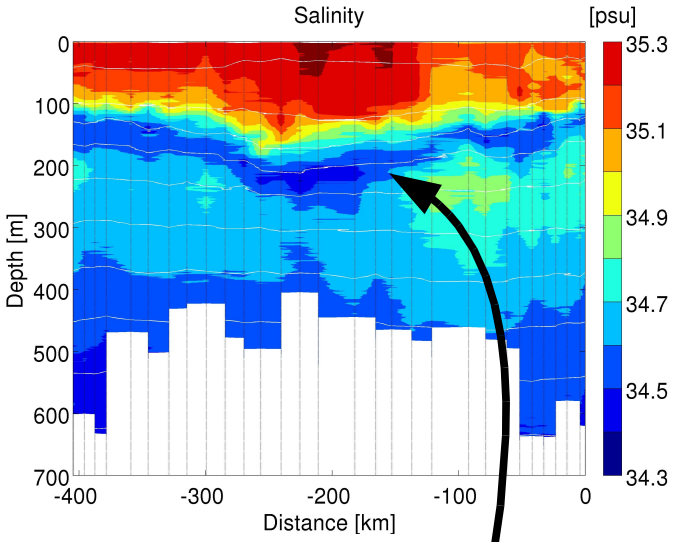
Surface expression of velocity with a sub-surface (300-400 m) maximum

Structure of Anticyclones

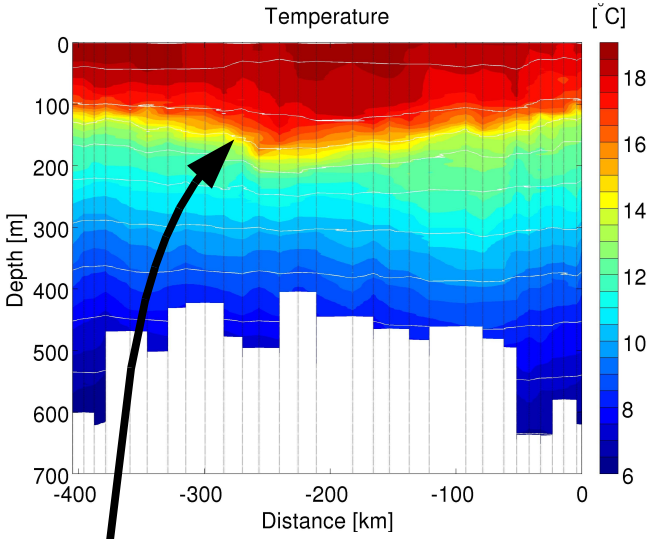
Sea Surface Height Anomaly



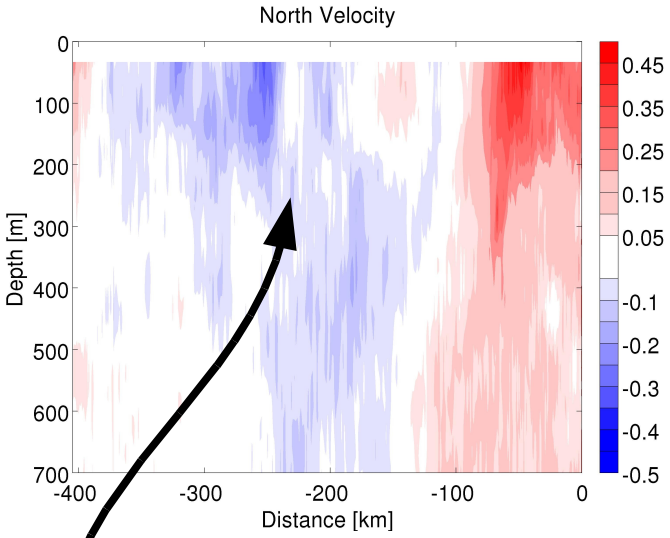
- Surface intensified
- Horizontal Scale: 80-100 km.
- Vertical Scale: < 300 m
- Max. Velocities ~ 10-15 cm/s



Deep salinity minimum

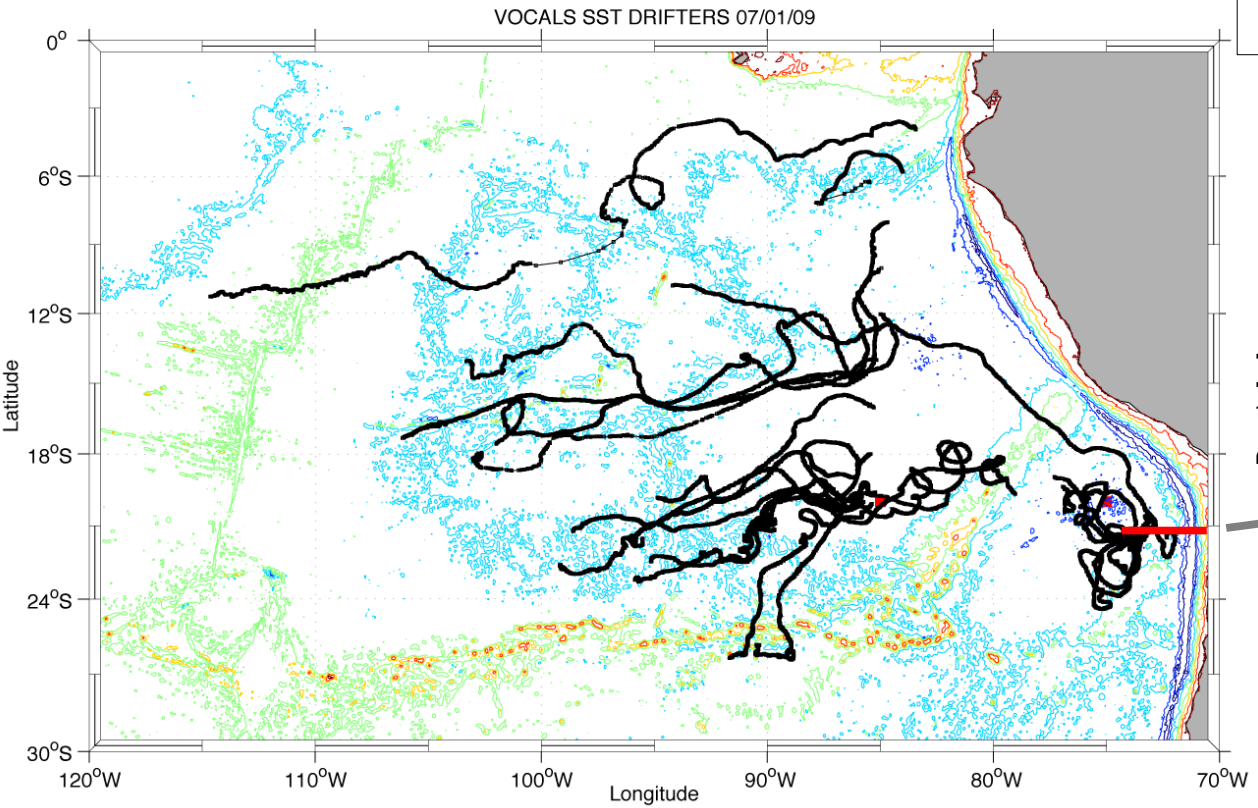


Deep mixed layer. No strong deep signature in temperature.

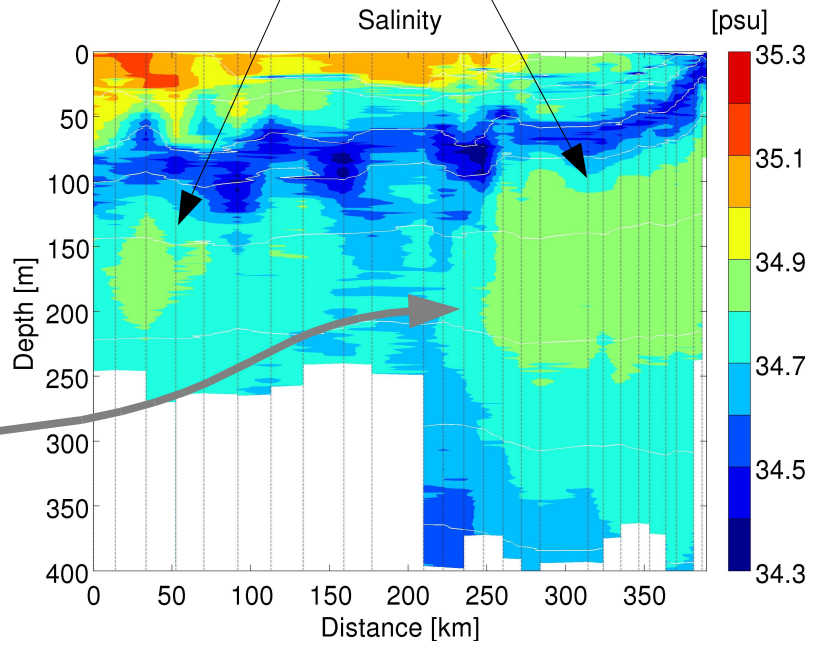


Velocity structure is, correspondingly, surface intensified

Surface Drifter Observations During VOCALS

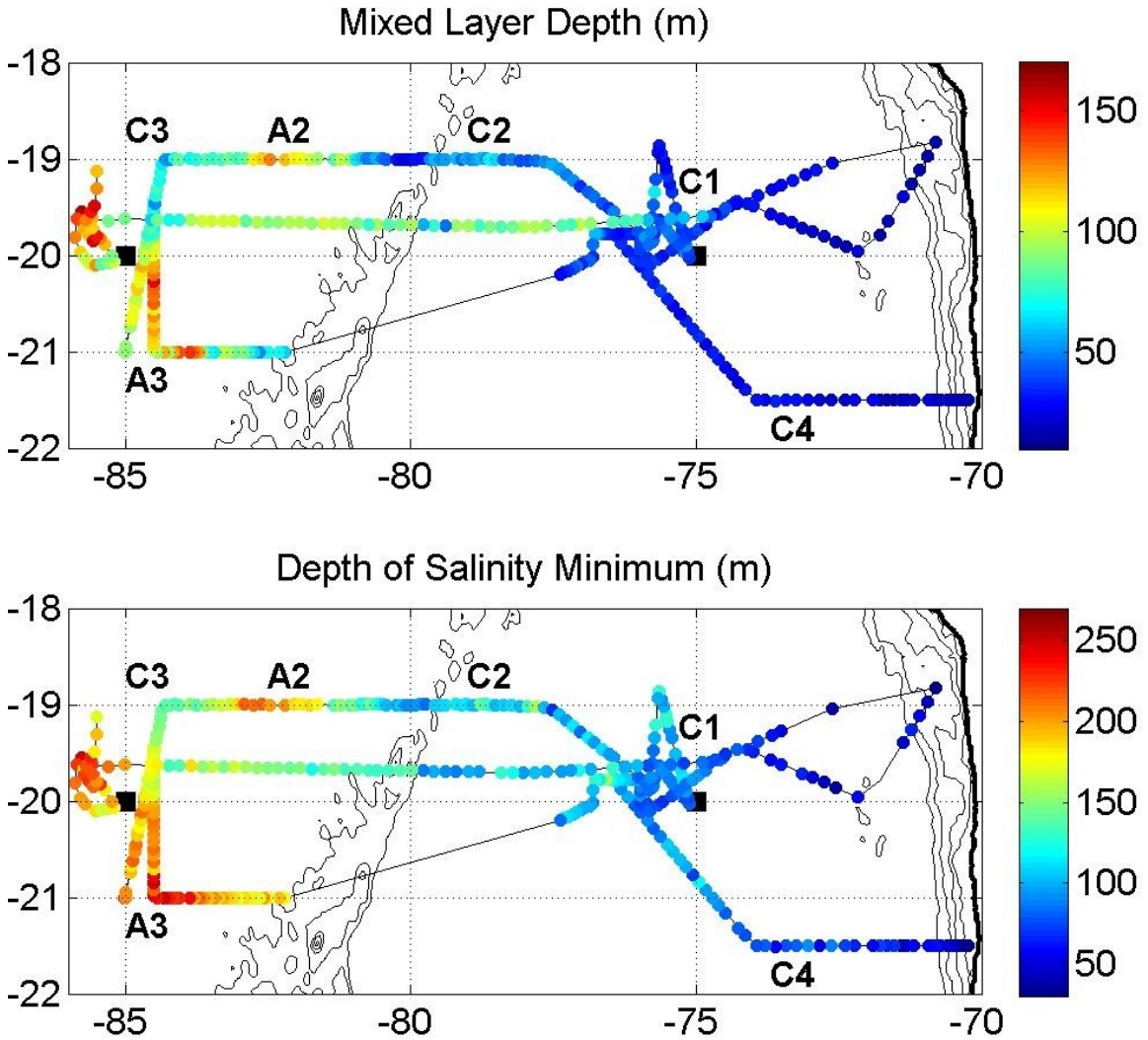


Coastal deep, salty water is also found in VOCALS cyclones



Drifters released during VOCALS show **westward propagation from upwelling region** consistent with satellite eddy tracking.

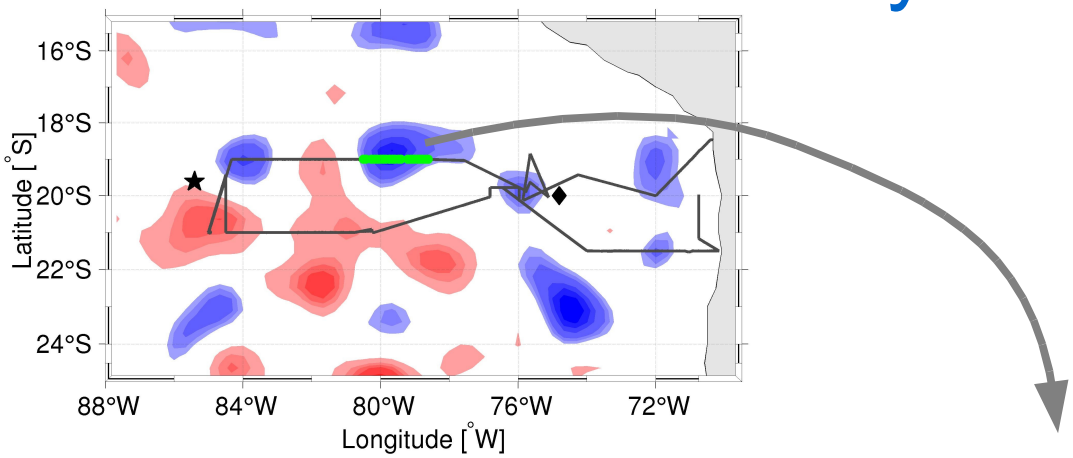
Upper Ocean Structure Modulation by Eddies

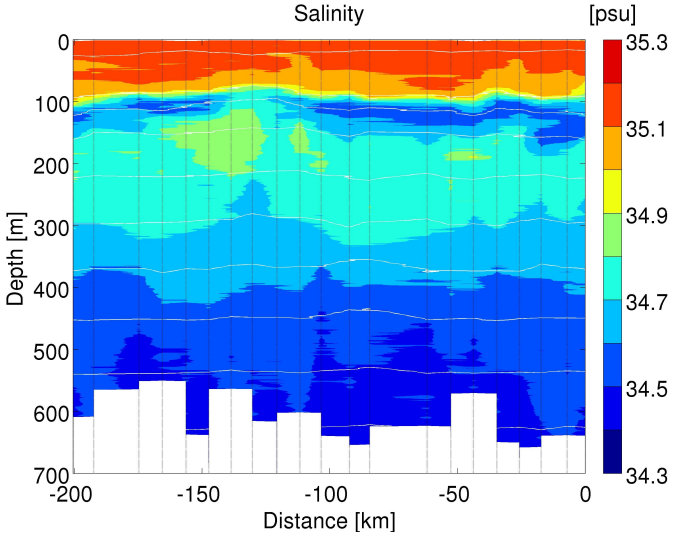


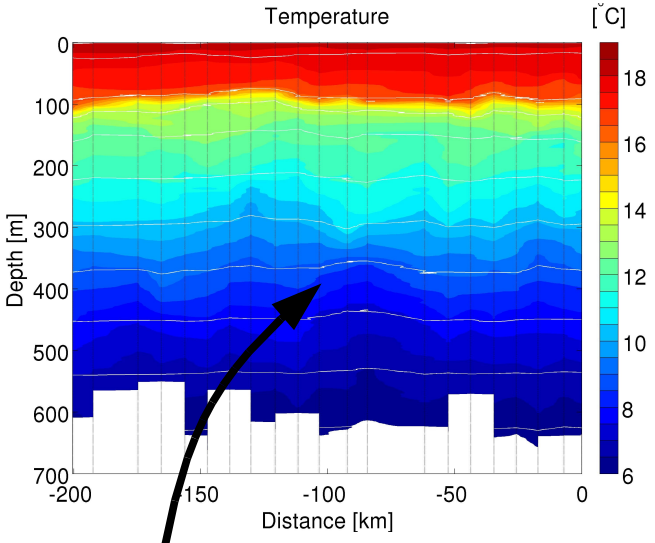
Summary

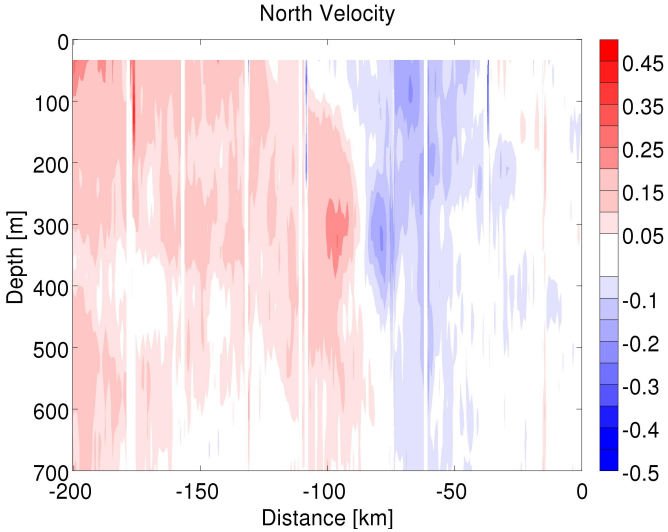
- Hydrographic properties of eddies (particularly **cyclones**) are consistent with origin in Perú-Chile upwelling system.
- **Cyclones** have a deep (>600 m) vertical structure, a subsurface maximum of velocity at 300-400 m, and relatively shallow mixed layers. Subsurface structure is relatively compact (30-40 km) in the horizontal.
- **Anticyclones** have a surface-intensified hydrographic and velocity structure, with relatively shallow (200-300 m) vertical scales, and deep mixed layers.
- Eddies modulate mixed layer depth and depth of salinity minimum.
- Consequences for heat budget and VOCALS hypotheses:
  - **Eddy fluxes** within the mixed layer **might be weak**, but...
  - They **modulate mixed layer depth** other upper ocean properties, and have significant velocity shear, which might **enhance vertical mixing of deep cold, fresh water**.

Cyclones II

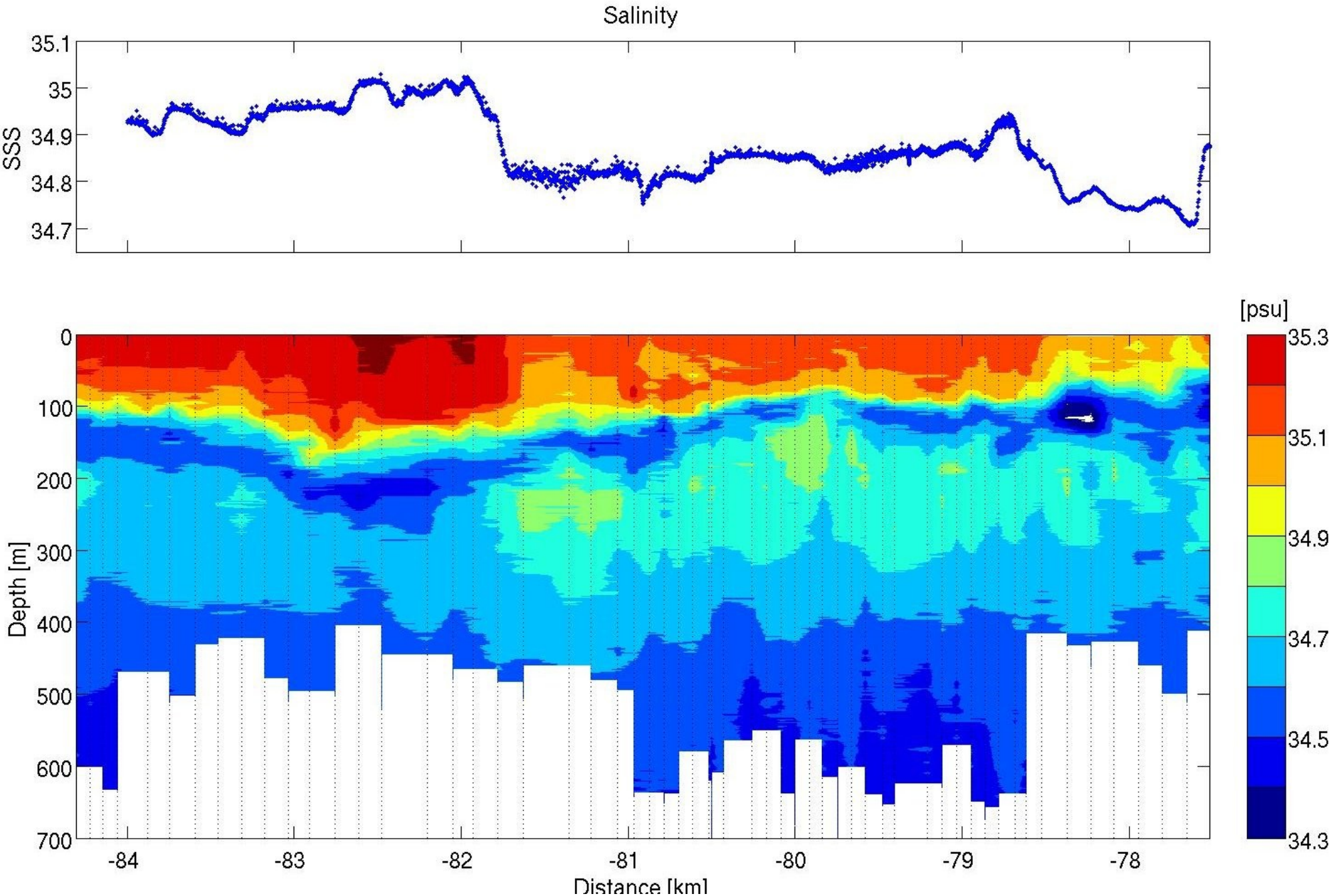


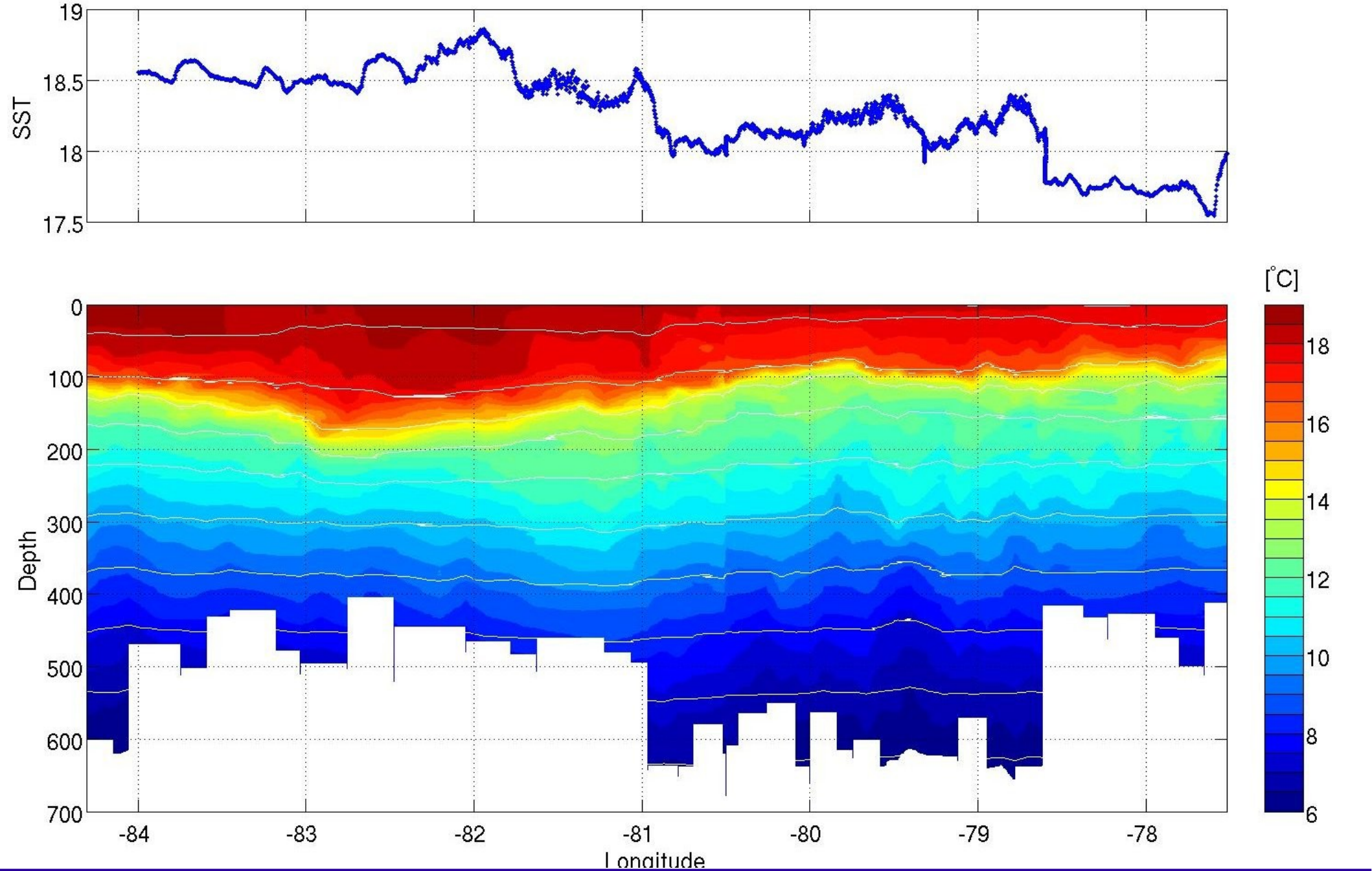






"Pinching" of Deep Isotherms is characteristic of cyclones


Salinity
SSS
35.1
35
34.9
34.8
34.7
[psu]
35.3
35.1
34.9
34.7
34.5
34.3
Depth [m]
0
100
200
300
400
500
600
700
-84
-83
-82
-81
-80
-79
-78
Distance [km]


SST
19
18.5
18
17.5
Depth
0
100
200
300
400
500
600
700
-84
-83
-82
-81
-80
-79
-78
Longitude
[°C]
18
16
14
12
10
8
6