Eddy observations from VOCALS

James Holte[1] Fiamma Straneo[1] Carlos Moffat[2] Robert Weller[1] Tom Farrar[1]
[1] Woods Hole Oceanographic Institution [2] University of Concepción, Chile jholte@whoi.edu

Introduction and motivation

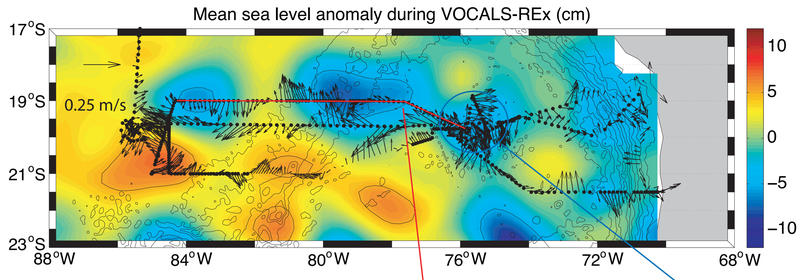
The sea surface temperature (SST) of the southeast Pacific Ocean is often too warm in climate models. Observation-based heat budgets in the region reveal that the upper ocean needs an input of cold water to balance an incoming net radiation gain (Colbo and Weller, 2007). Colbo and Weller determined that the gyre circulation accounted for nearly half of the imbalance and that Ekman transport and pumping made a negligible contribution. They proposed that eddy flux divergence accounted for the remainder.

Eddies form near the coast and propogate westward (Chaigneau and Pizarro, 2005; Johnson and McTaggart, 2010). Eddies have been linked to high sardine catches off of northern Chile due to increased nutrient supply to the surface layer (Hormazábal et al.). Modeling studies have shown that the eddy heat flux divergence is not spatially coherent, so eddies likely do not impact the heat budget in the southeast Pacific (Zheng et al. 2010).

We examined the VOCALS-REx data, supplemented with Argo and satellite data, for evidence of eddy heat transport and its contributions to the SST.

VOCALS-REx Cruise

- 23 October to 30 November, 2008
- 438 UCTD profiles
- Cruise crossed many sea level anomaly (SLA) highs (anticyclonic eddies) and lows (cyclonic eddies)
- Underway ADCP velocities (averaged over 100-400 m) are consistent with the eddy SLA signature
- A nearly constant stream of eddies originate at the coast and propogate westward

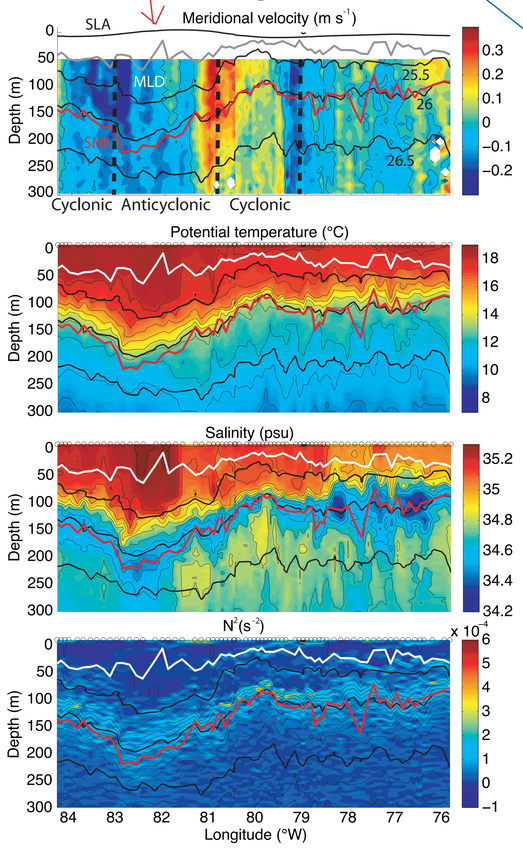


Cyclonic and anticyclonic eddies along 19°S

What are the general properties of the cyclonic and anticyclonic eddies observed during VOCALS-REx?

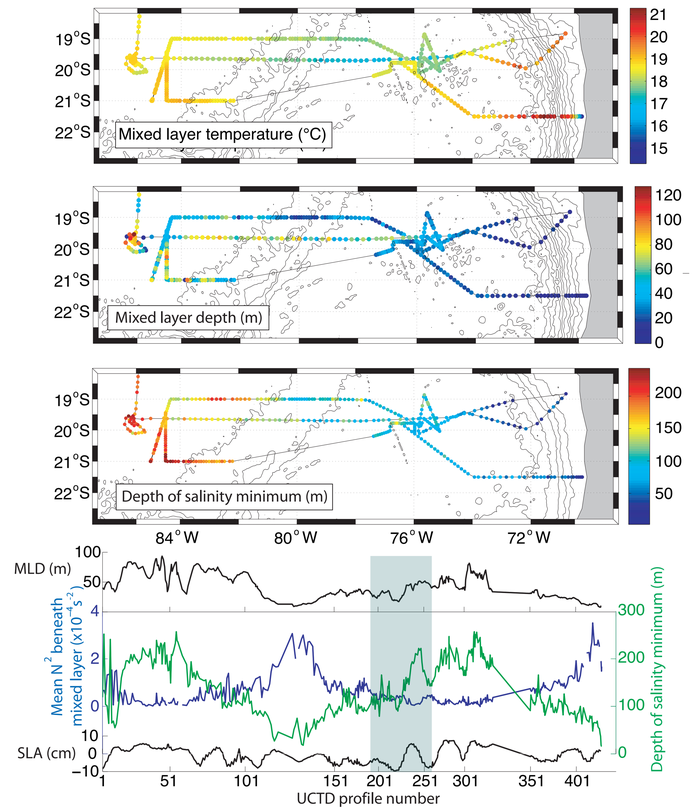
Anticyclonic eddies:
- SLA high
- Surface-intensified velocity signature
- Depressed isopycnals in the eddy
- Salinity minimum layer (SML) deepens
- Low stratification beneath the mixed layer

Cyclonic eddies:
- SLA lows
- Isopycnals shoal
- SML shoals
- Higher stratification beneath the mixed layer
- Pockets of high salinity water beneath the SML derive from the coastal current



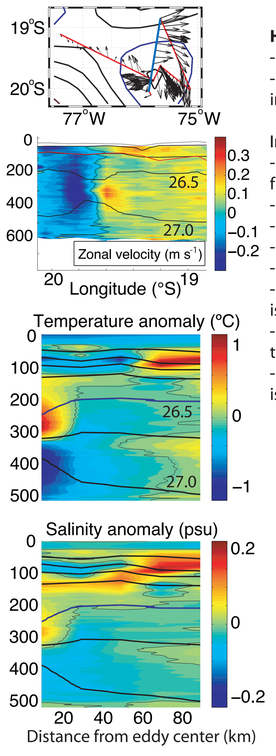
Eddy properties from VOCALS-REx

Do the eddy properties identified in the section along 19°S carry over to the rest of the cruise?



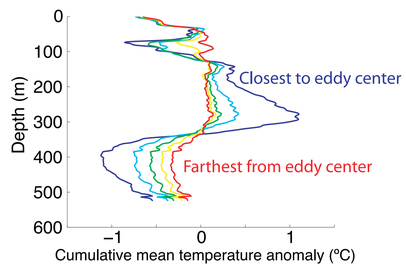
- For cyclonic eddies (SLA lows), the SML shoals, there is higher stratification beneath the mixed layer, and the mixed layer is generally shallower relative to anticyclonic eddies

Cyclonic eddy temperature anomaly



How might cyclonic eddies cool the surface layer?
- Eddies could transport cool water at depth
- Doming of isopyycnals could promote mixing of deeper, colder water into the surface layer

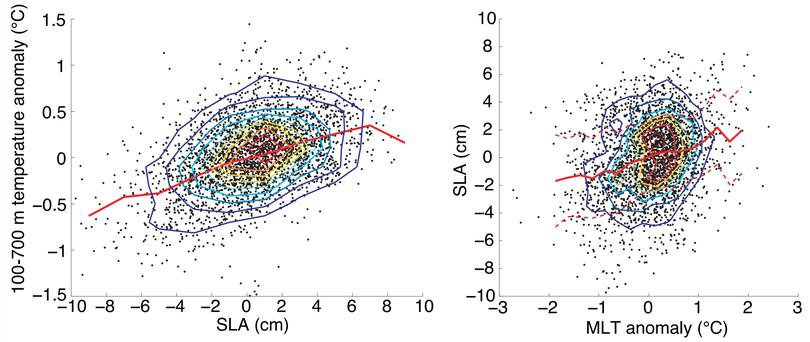
Intensive survey of cyclonic eddy at 20°S, 76°W
- Subsurface velocity core, with decreased surface velocities displaced from eddy core
- 26.5 and 27.0 isopycals pinched at eddy core
- ~30 km diameter at the core
- Construct a composite eddy anomaly (eddy field - mean field)
- Mean fields are calculated from 20 nearby UCTD profiles
- Cyclonic eddies are saltier than the background along the 26.5 isopycnal and highly stratified
- Doming of isopycnals at the eddy center creates a cold anomaly near the surface layer
- Integrating to the far edge of the eddy, the mean temperature anomaly is close to zero



Eddy temperature anomalies from Argo and satellites

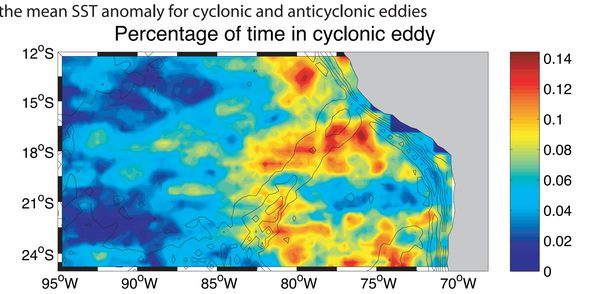
How do the synoptic observations of eddies from VOCALS-REx compare to larger data sets that sample larger areas and time periods?

- Utilize ~3000 Argo profiles in a boxed region from 17-22°S and 70-102°W
- The boxed region is divided into longitude bins with 3° width
- Monthly mean mixed layer temperature (MLT) and the mean temperature over 100 - 700 m depth are calculated for each bin
- The appropriate means are removed from each Argo profile to calculate the MLT anomaly and the 100 - 700 m temperature anomaly
- The SLA is interpolated to each Argo profile location and time



- Cyclonic eddies (SLA lows) have negative temperature anomalies over 100 - 700m; anticyclonic eddies have positive temperature anomalies
- Cyclonic eddies have cooler mixed layers than anticyclonic eddies

- 10 years of SLA and AMSR-E SST data are scanned for correlations between eddy SLA and SST
- Eddies are identified with a ±5 cm SLA criteria
- The SST fields are averaged to correspond to the weekly SLA fields
- The SST anomaly is calculated by smoothing the SST at each location with a 7 week running mean
- Calculate the mean SST anomaly for cyclonic and anticyclonic eddies



- Anticyclonic eddies are generally 0.1°C warmer and cyclonic eddies are generally 0.1°C cooler
- Anticyclonic and cyclonic eddies occur at similar frequencies

Conclusions

Cyclonic eddies:
- SLA lows (< 5 cm)
- Subsurface velocity cores
- Salinity minimum layer shoals, doming of isopycnals near the surface, higher stratification beneath the mixed layer, shallower mixed layers
- Negative mean temperature anomaly over 100 - 700 m
- Generally 0.1°C cooler SST

Anticyclonic eddies:
- SLA highs (> 5 cm)
- Depressed salinity minimum layer, lower stratification beneath the mixed layer, deeper mixed layers
- Positive mean temperature anomaly over 100 -700 m
- Generally 0.1°C warmer SST

Symmetry
- Anticyclonic and cyclonic eddies occur in equal numbers, but have opposite effects on the surface layer temperature

Conclusions
- Eddy temperature transport likely has zero net effect on the SST in the southeast Pacific Ocean
- There are still many eddy processes to investigate, especially mixing processes occurring on the eddy flanks

Acknowledgements

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