VOCALS Oceanography and Air-Sea Fluxes

Stratus Ocean Reference Station
20°S, 85°W

NOAA Ship *RH Brown*

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SHOA DART
20°S, 75°W
At the Stratus Ocean Reference Station (ORS) there is a strong annual cycle, the mixed layer deepening to ~135 m in mid-October, shoaling to < 50 m in Jan-Feb.

The mixed layer warms and becomes more saline each summer, yet balancing cooling and freshening offsets strong net evaporation and net heating averaging ~40 W m$^{-2}$. 
The shallow surface layer rides on top of a salinity minimum, and below the salinity minimum is a thick low oxygen layer characteristic of eastern South Pacific. Two deep basins, the Peru and Chile basins, separated by the Nazca Ridge.
How uniform over the VOCALS region is this?

Similar annual cycle, but warmer summer, cooler winter SSTs and winter mixed layer depth is shallower, ~75 m.
Progressive vector diagrams of ocean currents

Evidence for surface wind-driven flow and for eddy variability.

Defining mean advective fluxes in the thermocline is a challenge using the mooring data.
Surface drifters, drogued at 15 m, head south of west at several cm/s in the Vrex region. Exception – one drifter deployed in coastal current.

Profiling floats, cycling over 500m every 3 days, are carried west at 5 cm/s and less.

Both the surface and thermocline currents show energetic eddy variability.
Profiling floats, CTDs, two moorings point to a large scale, coherent structure. Mixed layer shoals to the east but has similar annual cycle; surface layer rides over salinity minimum and a deeper oxygen minimum.
Anomalies and more generally grad T and grad S are low in mixed layer. What is the role of the upper thermocline? Strong anomalies associated with eddies are one of the most prominent ocean signals.
Advective fluxes in the mixed layer vs vertical mixing in upper thermocline – more to come as work proceeds….
Surface forcing – the long term, area wide view

8-year (Oct 9, 2000 – Oct 8, 2008) means at Stratus ORS

Wind  6.1 m s\(^{-1}\) 0.0754 N m\(^{-2}\)  toward  304°
Bar press  1017.7 mb

Air temp  19.48°C
SST  20.36°C
Sens. heat flux  -7.4 W m\(^{-2}\)

RH/SH  74.0% / 10.4 g kg\(^{-1}\)
Latent heat flux  -103.3 W m\(^{-2}\) (evap of 10.5 cm yr\(^{-1}\))
Prate  0.0041 mm hr\(^{-1}\)
SSS  35.41 psu

SW ↓  204.0 W m\(^{-2}\)  SW ↓ ↑  192.7 W m\(^{-2}\)
LW ↓  375.7 W m\(^{-2}\)  LW ↓ ↑  -42.8 W m\(^{-2}\)

Net heat flux  39.2 W m\(^{-2}\)
**Annual cycle**

Well-defined annual cycle in air and sea temperatures, incoming shortwave, incoming longwave, barometric pressure.

Southern winter is a bit windier with more rain.
ERA40 climatology - blue; NCEP2 climatology - green
red - 6-year mean of daily buoy obs

Q_{net} (W m^{-2})

Tau mag (N m^{-2})
Diurnal cycle at Stratus: surface meteorology and fluxes

UTC-6 = Local
When the wind accelerates, strong near-inertial oscillations are generated in the upper ocean.
Ekman pumping of about 28 m yr\(^{-1}\) at Stratus ORS.
Generally the same regime across the region, with E-W trends.

<table>
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<th>Date Range</th>
<th>Parameter</th>
<th>DART</th>
<th>Stratus</th>
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<td>SW ↓</td>
<td>178.2 W m⁻²</td>
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<td>LW ↓</td>
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<td>SST</td>
<td>20.01°C</td>
<td>20.44°C</td>
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DART (20°S, 85°W) vs Stratus (20°S, 75°W)
Cloud forcing

Mean shortwave cloud forcing: -99.5 W m\(^{-2}\)
Mean longwave cloud forcing: 45.0 W m\(^{-2}\)

This is for Stratus site (20°S, 85°W); the seasonal cycle in SW cloud forcing is stronger (and the mean value larger) at DART (20°S, 75°W) due to increased cloudiness in southern winter.
A broad region, from 85°W to 75°W along 20°S, is characterized by:

- A strong annual upper ocean cycle, with summer warming, shoaling, of a layer that increases in salinity.
- The upper ocean has weak mean advection, little Ekman heat or freshwater transport in the mixed layer.
- The upper layer rides on top of a fresh, cool layer so perhaps exchange with water below allows needed closure of heat and salt budgets. Mixed layer depth and low salinity layer shoal to east by about 50 m.
- Strong eddy variability and related anomalies in upper thermocline are evident and a focus is on the role of the eddies.
- Directionally steady trade winds, slightly weaker to the east, with Ekman pumping.
- A strong annual cycle in surface heat flux dominated by annual SW signal; heat fluxes, stress from reanalysis products have biases/errors.
- Air temp about 1°C cooler than SST; both have strong annual cycles, ~11°C inshore, ~5°C offshore.
- Little ‘synoptic’ variability, but periodic sags in wind speed allow diurnal ocean warming, and a diurnal cycle is evident in the surface forcing, as are inertial oscillations in the upper ocean.
- Low clouds with SWCF of ~ -100 W m⁻² at Stratus and ~ -125 W m⁻² at DART (cloudier in winter)
- Heat loss also driven by latent heat flux - ~100 W m⁻² at Stratus, less at DART; evap. (10 cm month⁻¹); precipitation (0.3 cm month⁻¹)
- Net oceanic heat gain over the domain ~40 W m⁻² offshore and ~50 W m⁻² at DART.