OCEAN SURFACE CURRENT ANALYSES REAL-TIME: PROCESSING SYSTEM AND APPLICATIONS

National Oceanic and Atmospheric Administration

OSCAR Ocean Surface Current Analyses - Real time

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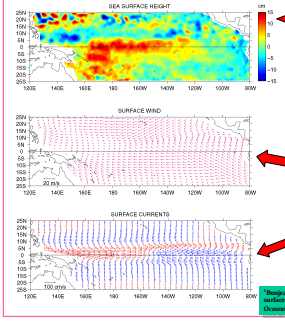
Tropical surface currents are inferred from satellite sea level and vector wind measurements[1] in near real-time



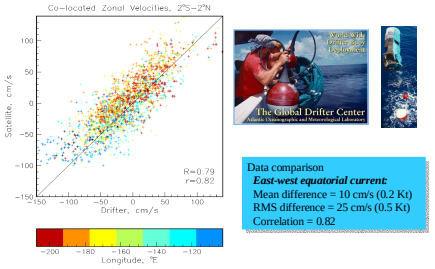
Jason-1 Altimeter sea level deviations *(These are added to the mean Levitus dynamic height, which is not shown here).*

QuikScat Scatterometer vector wind *Courtesy of COAPS*

Calculated current averaged over the top 30 m. (July 2002)

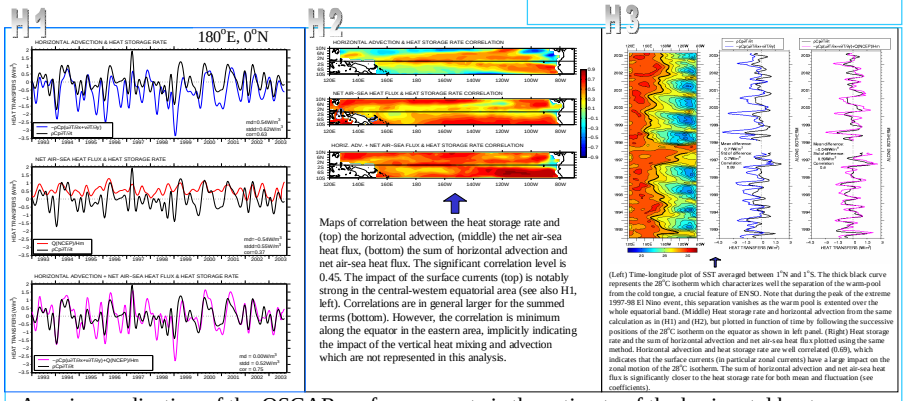
[1] Bonjean, F., and G.S.E. Lagerloef, 2002: Diagnostic model and analysis of the surface currents in the tropical Pacific Ocean, *Journal of Physical Oceanography*, 32, 2938-2954.

The Currents are Validated with Drifter Data



Data comparison
East-west equatorial current:
Mean difference = 10 cm/s (0.2 Kt)
RMS difference = 25 cm/s (0.5 Kt)
Correlation = 0.82

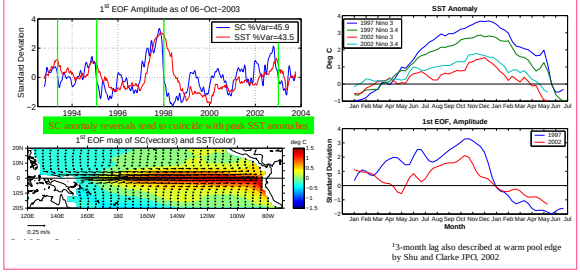
Partial heat budget analysis in the equatorial Pacific



Maps of correlation between the heat storage rate and (top) the horizontal advection, (middle) the net air-sea heat flux, (bottom) the sum of horizontal advection and net air-sea heat flux. The significant correlation level is 0.45. The impact of the surface currents (top) is notably strong in the central-western equatorial area (see also H1, left). Correlations are in general larger for the summed terms (bottom). However, the correlation is minimum along the equator in the eastern area, implicitly indicating the impact of the vertical heat mixing and advection which are not represented in this analysis.

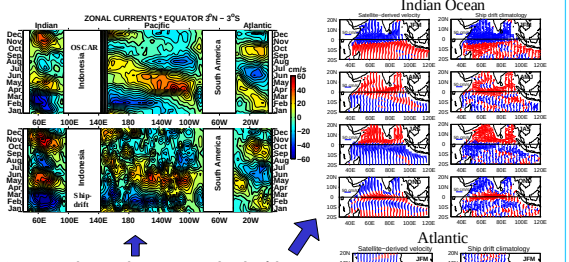
(Left) Time-longitude plot of SST averaged between 1°N and 1°S. The thick black curve represents the 28°C isotherm which characterizes well the separation of the warm-pool from the cold tongue, a crucial feature of ENSO. Note that during the peak of the extreme 1997-98 El Nino event, this separation vanishes as the warm pool is extented over the whole equatorial band. (Middle) Heat storage rate and horizontal advection from the same calculation as in (H1) and (H2), but plotted in function of time by following the successive positions of the 28°C isotherm on the equator as shown in left panel. (Right) Heat storage rate and the sum of horizontal advection and net air-sea heat flux plotted using the same method. Horizontal advection and heat storage rate are well correlated (0.69), which indicates that the surface currents (in particular zonal currents) have a large impact on the zonal motion of the 28°C isotherm. The sum of horizontal advection and net air-sea heat flux is significantly closer to the heat storage rate for both mean and fluctuation (see coefficients).

Principal surface current (SC) mode leads SST mode by ~3 Months[1]. The SC pattern is stronger in the west, the SST in the east.



[1]3-month lag also described at warm pool edge by Shu and Clarke JPO, 2002

Prospect: expansion of the processing system to the entire tropical ocean



Comparisons between the mean seasonal cycle of the currents calculated with the OSCAR method and a ship-drift climatology[1] on the equator. Total mean is removed from each field.

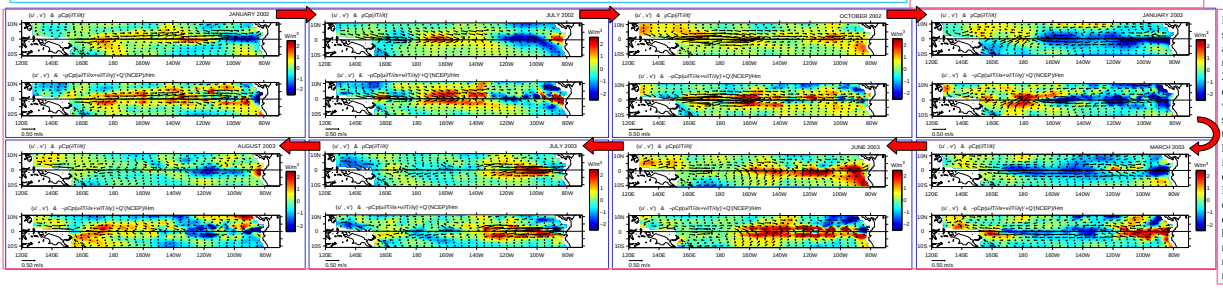
Surface current Anomalies

[1]Mariano, A.J., E.H. Ryan, B.D. Perkins and S.Smithers, 1995: The Mariano Global Surface Velocity Analysis 1.0. USCG Report CG-D-34-95, 55 pp.

A major application of the OSCAR surface currents is the estimate of the horizontal heat advection and the analysis of its role in the surface layer heat budget of the equatorial Pacific (Bonjean et al, in preparation). Due to strong variations of the equatorial currents on seasonal-to-interannual time scale, and large temperature difference between warm-pool in the west and cold-tongue in the east, heat transport by the currents significantly influences the sea surface temperature (SST) on the scale of ENSO. In this preliminary partial heat budget analysis (see H1 above), the surface heat storage rate (black curve) is estimated from the SST data of Reynolds and Smith (1994) during the 1993-2003 period. It is compared to (top) the surface heat advection derived from the OSCAR currents and the aforementioned SST product, (middle) to the net air-sea heat flux from NCEP reanalysis (red curve), (bottom) to the sum of heat advection and net air-sea heat flux. All terms are divided by the mixed-layer depth, which only appears explicitly in the air-sea heat flux term and is assimilated to its climatological values (NRL mixed layer depth climatology). To emphasize the year-to-year variations over this ~11 year period, the heat terms were smoothed using a 90-day low-pass filter. Around the dateline, horizontal advection cools down the ocean surface on average, which is compensated by warming from the net air-sea flux (see the coefficients md=mean difference, stdd=standard deviation of difference, cor=correlation in each panel, particularly how these coefficients evolve in the bottom panel). In terms of variability, the horizontal advection and net air-sea heat flux variations conjugate to match the heat storage rate variations better than they do alone (see stdd and cor coefficients).

This analysis shows quantitative evidence that the sum of horizontal heat advection and net air-sea heat flux explains a large part of the SST low-frequency variations in the central-western equatorial area. Moreover, the sum of these processes is also dominant in the zonal motion of the separation zone between warm-pool and cold tongue, including when such motion entails displacement of the separation zone far to the east during El Nino.

Outlook for 2002 El Nino and 2003



Monthly means of surface current anomalies, superimposed on (top map) heat storage rate anomalies and (bottom map) the sum of horizontal advection and net air-sea heat flux anomalies for key periods during 2002-2003. A large part of the anomalous warming during 2002 El Nino (Jan., Jul., Oct. 2002) coincided with positive horizontal advection anomalies (net air-sea heat flux anomalies were much weaker). The return to normal SST conditions from El Nino occurred from late 2002 to late Spring 2003, and was strongly influenced by westward anomalous currents on the equator (see Jan.03, Mar.03). Afterwards, transition to La Nina did not occur. Conversely, during the first half of Summer 2003, SST warming took place in the eastern half (Jun., Jul. 2003), coinciding with positive horizontal advection anomalies. Note that during these months and other monthly periods not shown, vertical mixing and advection most probably play an important role, especially in the cold tongue area.