The relationship between oceanic mesoscale variability and atmospheric convection on 10°N in the eastern tropical Pacific Ocean

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Abstract
As part of the Pan American Climate Study (PACS), an air-sea interaction mooring was deployed at 10°N, 125°W in the eastern tropical Pacific for 17 months. There were intraseasonal fluctuations in SST caused by meridional advection by mesoscale motions. Analysis of this signal in the broader spatial and temporal context afforded by satellite altimetry data indicates that this intraseasonal (40 to 100-day period) velocity variability on 10°N can be interpreted as Rossby waves with some Doppler shifting by the mean westward flow. The PACS buoy observations further indicate that there is variability in surface solar radiation coupled to the SST signal of the Rossby wave.

The hypothesis is that the SST signals of oceanic Rossby waves and other mesoscale variability may affect atmospheric convection is investigated using satellite measurements of SST, columnar cloud liquid water (CLW), and cloud reflectivity. A statistically significant relationship between SST and these cloud properties is identified within the wavenumber-frequency band of oceanic Rossby waves. Analysis of seven years of data indicates that 10-35% of the variance in the logarithm of CLW at intraseasonal periods and zonal scales on the order of 10° longitude can be ascribed to SST signals driven by oceanic Rossby waves.

Introduction
As part of the Pan-American Climate Studies (PACS) field program, a mooring was deployed at 10°N, 125°W for 17 months, measuring upper-ocean temperature, salinity, and velocity. The buoy also carried a complete surface meteorological instrument package measuring wind velocity, air temperature, incoming short and long wave radiation, humidity, barometric pressure, and precipitation. Sea heat fluxes were calculated via bulk formulas (Fairall et al., 1996). The mooring site is within the eastern Pacific warm pool and is near the northernmost climatological location of the Intertropical Convergence Zone (ITCZ).

As part of the Pan American Climate Study (PACS), an air-sea interaction mooring was deployed at 10°N, 125°W in the eastern tropical Pacific for 17 months. There were intraseasonal fluctuations in SST caused by meridional advection by mesoscale motions. The SST expression of the mesoscale variability along 10°N consists of a high-pass filtered SST field. The high-pass filtered SST field has zonal scales much larger than the oceanic mesoscale. For example, there are variations in visible reflectivity during May and June that span nearly the full zonal domain of the plot above. When the cloud reflectivity is filtered in the same way as SST, a relationship to mesoscale SST fluctuations can be seen more clearly (below).

The SST expression of the mesoscale variability

Characteristics of the mesoscale variability and attendant cloud signals

Interpretation of the velocity fluctuations as Rossby waves


- The mooring observations revealed energetic fluctuations in velocity, dynamic height, and SST at a period of about 60 days (see figures above and below). The SST gradient was primarily meridional during the mooring deployment period, as can be seen from satellite SST (above). Comparison of terms in the mixed layer balance shows that this meridional gradient, together with the strong meridional velocity fluctuations, contributed to a substantial modulation of the local SST at intraseasonal periods during the first half of 1998. The PACS mooring observations reveal variability in surface heat fluxes that appears coupled to this SST variability. While it is not surprising that there are signals in latent and sensible heat fluxes, the signal in solar heat flux suggests that the mesoscale oceanic variability may modify cloudiness. The goal of this study is to examine the relationship between mesoscale SST variability on 10°N and cloud properties.

- Most of the variance in SST along 10°N during 1998 (above) is at large spatial and temporal scales (basin and seasonal scales). However, some relatively small variations in SST (0.05°C) can be seen to propagate westward with some Doppler shifting. These westward propagating SST variations can be seen more clearly when a longitudinal high-pass filter is applied to suppress variability at zonal scales larger than 10° longitude.

- A similar relationship exists between cloud liquid water and oceanic mesoscale SST fluctuations. The log CLW is used because there are larger seasonal variations in CLW at the local conditions shift from the trade wind regime in Jan-April to ITZC conditions during the summer. The correlation coefficient of the filtered SST and CLW fields above is also about 0.30.

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