Barometric Pressure Variations Associated with Eastern Pacific Tropical Instability Waves

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As part of the Eastern Pacific Investigation of Climate Processes (EPIC), 13 TAO moorings were enhanced with Paroscientific Inc. barometric pressure sensors. In this study, data from the 2N, 110W and 0, 110W buoys are used to test whether sea surface temperature (SST) variations induce pressure gradients large enough to influence the atmospheric boundary layer.

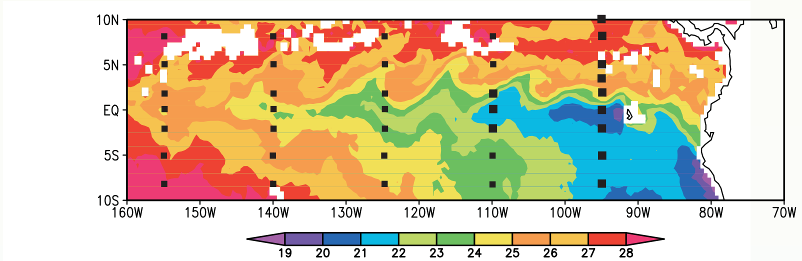


Fig. 1. Tropical Instability Waves (TIW) cause crest-like features in the SST front. Large squares indicate TAO moorings with barometric pressure sensors.

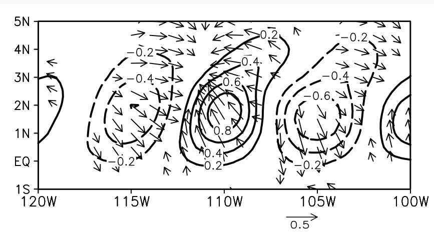


Fig. 2. QuikSCAT wind and TMI SST anomalies associated with TIW-band SST variability at 2N, 110W (based on regression analysis to band-passed SST at 2N, 110W). Units are C and ms^{-1}/C.

The Great Debate

Lindzen and Nigam (1987): *SST gradients cause pressure gradients that drive low-level winds. Maximum southerlies south of SST warm anomaly.*

Wallace et al. (1989): *SST affects stability of boundary layer and mixing from aloft. Maximum southerlies over warm anomaly.*

Question: *Can oceanic tropical instability wave SST variations cause barometric pressure gradients large enough to influence the atmospheric boundary layer? (Answer: Yes.)*

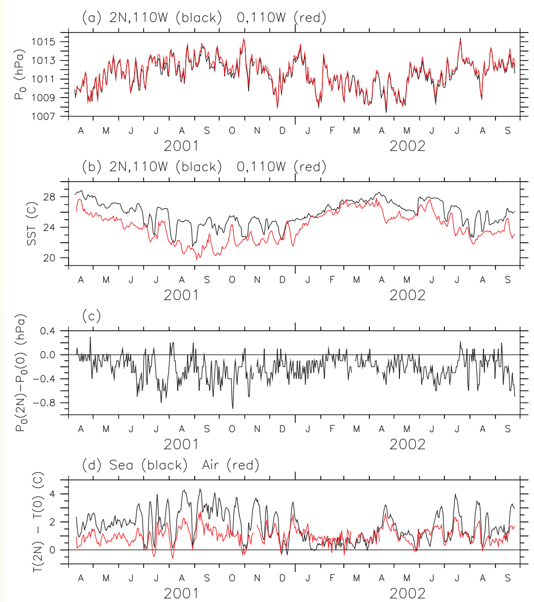


Fig. 3. Barometric pressure (P_0) variations are dominated by tides and large-scale upper atmosphere waves that influence both sites coherently.

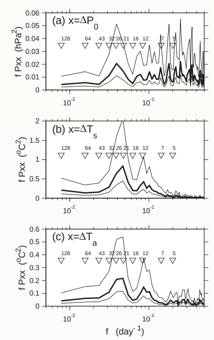
However, differences between2N and equator ΔP_0 are detectible and appear to be associated with SST and consequently air temperature (Ta) frontal variations.

From April 2001 through September 2002 roughly 11 TIWs propagated westward past 110W.

TIW signal can be seen in ΔP_0, ΔSST, and ΔTa.

Fig. 4. **The 2N - equator differences in SST, Ta and P_0 all had spectral peaks in the TIW band (20-30 days).**

TIW band variances were respectively $(0.6\ C)^2$, $(0.3\ C)^2$, and $(0.1\ hPa)^2$.



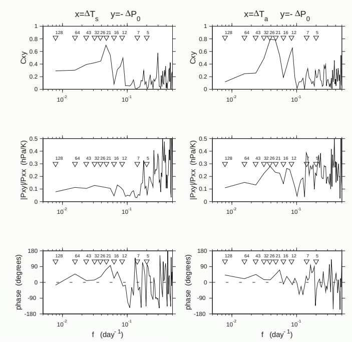


Fig. 5. *(Top)* Temperature and P_0 gradients are highly coherent within TIW band.
(Middle) Transfer functions $-\Delta P/\Delta Ts$ ~ 0.16 hPa/K and **$-\Delta P/\Delta Ta$ ~ 0.3 hPa/K (nearly as large as predicted by Lindzen and Nigam)**.
(Bottom) $-\Delta P$ and ΔTa are nearly in phase as expected. However, $-\Delta P$ leads ΔTs by upto 4 days. **Advection may account for the phase lag between SST and Ta (and thus barometric pressure).**

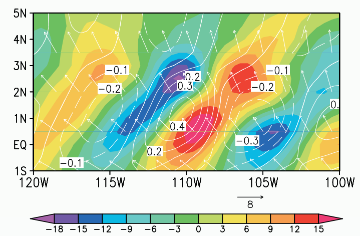


Fig. 6 Advection of TIW meridional momentum, in units $10^{-6}\ ms^{-2}/C$ (shaded), computed from mean winds and regressed winds shown in Fig. 2. TIW regressed meridional winds, in units ms^{-1}/C from Fig. 2 (contoured). Mean winds, in units ms^{-1} (vectors). **For comparison, SST-induced meridional pressure gradient forcing ~ $2.7\times10^{-5}\ m\ s^{-2}/K$ -- much larger than these advective terms!**

Conclusion: SST-induced pressure gradients are an order one term in the TIW meridional momentm balance.

Phase relations between SST and meridional winds may be too subtle near the equator to distinguish forcing mechanisms, i.e., SST-induced pressure gradient (Lindzen and Nigam 1987) vs. SST-induced vertical mixing (Wallace et al. 1989), particularly since advection may cause phase shifts between air temperature and SST. **Direct pressure measurements show that both processes are in action.**

Cronin, M. F., S.-P. Xie, and H. Hashizume, 2002: Barometric pressure variations associated with eastern Pacific tropical instability waves. J. Climate, submitted.

Lindzen, R. S., and S. Nigam, 1987: On the role of sea-surface temperature gradients in forcing low-level winds and convergence in the tropics. J. Atmos. Sci., 44, 2440-2458.

Wallace, J. M., T. P. Mitchell, and C. Deser, 1989: The influence of sea surface temperature on surface wind in the eastern equatorial Pacific: Seasonal and interannual variability. J. Climate, 2, 1492-1499.