

Changes in the Climate Record Due to Changes in the Ocean Observing System

Mark A. Bourassa, COAPS/Florida State Univ., Tallahassee, FL

Prior studies have shown that long-term changes in latent heat fluxes in the tropical Pacific Ocean are associated with changes in wind speed. The data used in these studies spans over five decades. The early period is solely in situ observations, and the later decades are dominated by satellite observations. This study finds that the differences in physics of surface observations and satellite observations accounts for the magnitude and pattern of the largest changes in the tropical Pacific Ocean. The key physics (Bourassa 2006) will be explained and the calculated differences will be shown.

Surface turbulent heat fluxes and stress are functions of wind shear. The in situ observing system measures wind (at or adjusted to a 10m height) relative to the fixed earth. It is typically assumed that the earth is not moving, and the vertical wind shear is the difference between this adjusted wind speed and the non-moving surface. Satellite observations are dependent on surface characteristics that are more closely related to stress than to wind: they account for shear and the derived winds are relative to the moving surface (currents and wave motions). It has been accepted for some time that considering ocean currents could be important for studies of ENSO (Luo et al. 2005).

Surface turbulent stress in the tropical oceans has been shown (Kara et al. 2007) to be modified by swell (surface water waves generated by distant storms). For the published example for 0Z on January 1, 2005, the change in wind shear ($U_{10} - U_{sfc}$) was modified by from -15% to +10%, and the monthly average was changed by from -10% to +5%. However, the focus of that study was the change in wind shear and the drag coefficient. Herein, the changes in surface turbulent heat fluxes are examined. For some months, the bias due to ignoring waves can exceed 5Wm^{-2} . The probability distribution of wave-induced changes in sensible and latent heat fluxes will be presented, for 6 hourly values as well as for monthly averages. Regional and seasonal differences within discussed.

The biggest short-term changes are associated with waves induced by the local winds, typically associated with meso-scale events such as atmospheric fronts and cold air

outbreaks, which are relatively infrequent. Swell, waves generated from distant weather events rather than the local winds, also cause differences in the fluxes. These differences are much smaller than for severe weather, but in some parts of the globe they are much more persistent. The short-time scale patterns are associated with synoptic scale weather. On seasonal time scales, larger scale patterns can be identified. For example (Fig. 1), monthly biases in the near equatorial Pacific Ocean are typically about 5Wm^{-2} in the Western end of the basin, and about -1Wm^{-2} in the eastern end of the basin. Such biases in latent heat flux quite large for ENSO applications.

The biases associated with ignoring wave-related modification of the fluxes are physically important, although they are small compared to other errors in many surface flux products. Hypothetically, the magnitude of the tropical fluxes is sufficient to impact ENSO characteristics, which would then feed back on modeled global weather patterns, also influencing the mid-latitude storms and hence modifying the patterns of swell that cause the tropical biases. Clearly wave-related modification of surface fluxes should eventually be considered in climate models, and is likely to improve the usefulness of NWP reanalyses. They are also of interest because scatterometers seem to respond to the ocean surface in a manner that accounts for wave (and current) related changes in the surface stress.

The errors associated with treating satellite observations in the same manner as in situ observations results in spurious change in the climate record, and is likely to adversely impact studies that assimilate satellite data for several years. A colleague at the ECMWF (Hans Hersberger, personal communication, 2009) recently tested if considering waves would reduce the observed differences between satellite and in situ data, and found that considering waves did account for a substantial reduction in the rms differences between satellite and in situ data. This finding supports the physics described above, and the implications on the climate record and data assimilation.

Bourassa, M. A., 2006, Satellite-based observations of surface turbulent stress during severe weather, *Atmosphere - Ocean Interactions*, Vol. 2., ed., W. Perrie, Wessex Institute of Technology Press, Southampton, UK, 35 – 52 pp.

Kara, A. B., J. Metzger, M. A. Bourassa, 2007: Ocean Current and Wave Effects on Wind Stress Drag Coefficient and Fluxes over the Global Ocean. *Geophys. Res. Letts.*, **34**, L01604, doi:10.1029/2006GL027849.

Luo, J.-J. S. Masson, E. Roeckner, G. Madec, and T. Yamagata, 2005: Reducing Climatology Bias in an Ocean–Atmosphere CGCM with Improved Coupling Physics. *J. Clim.*, **18**, 2344–2360. DOI: 10.1175/JCLI3404.1

Example of Results

Change in LHF Due to Waves: March 1999

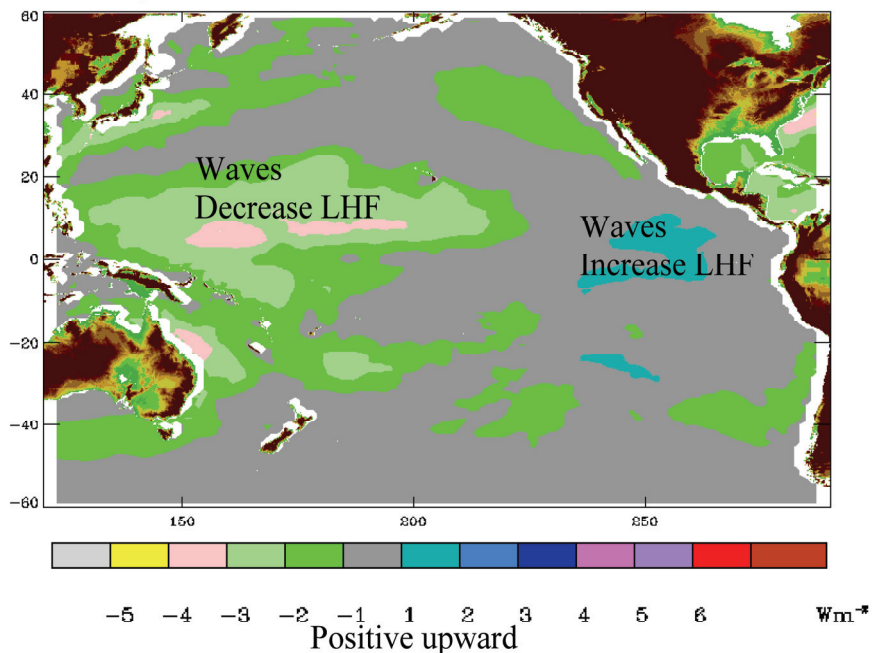


Fig. 1. Example change in latent heat flux due to considering some of the differences in physics between in situ observations and satellite observations. In particular, the differences associated with surface water waves are considered.