Use of Time Series Reference Sites to Assess Numerical Weather Prediction Reanalyses: Surface Heat Fluxes and Surface Cloud Forcing in the Eastern Tropical Pacific

Meghan Cronin (NOAA Pacific Marine Environmental Laboratory) Meghan.F.Cronin@noaa.gov

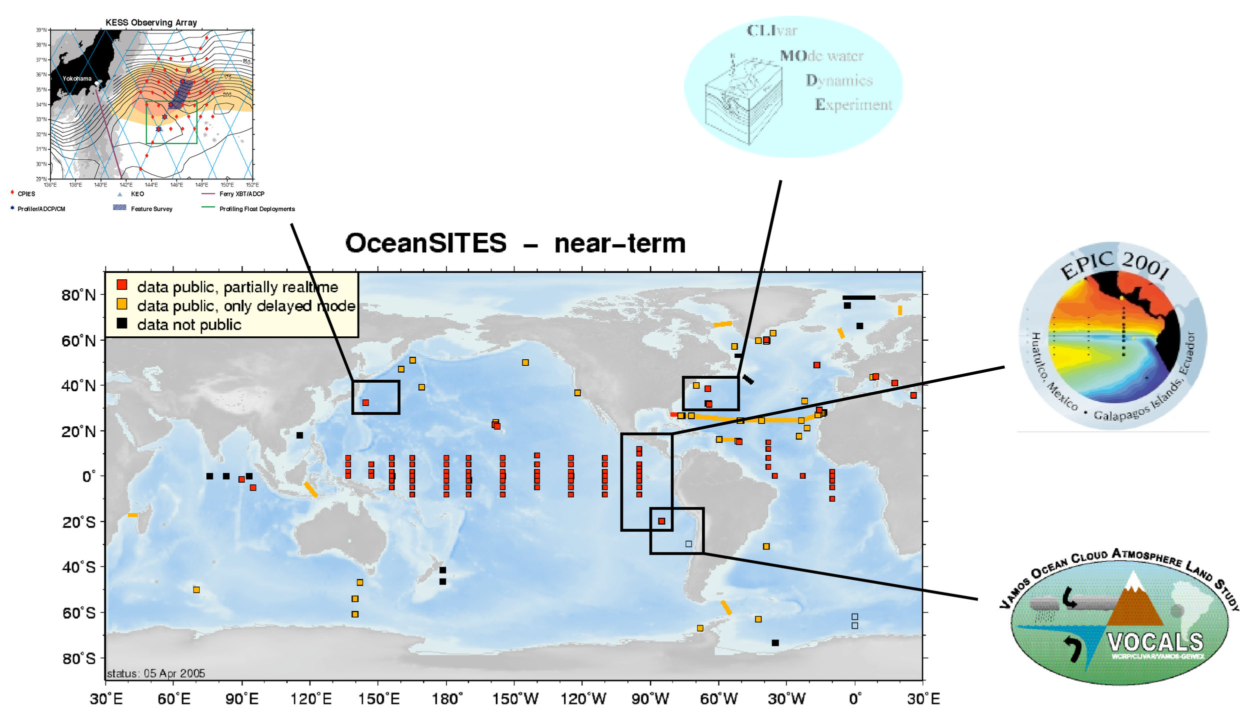

Fig. 1. The OCEAN Sustained Interdisciplinary Timeseries Environment observation System (OceanSITES) network of time series reference sites are indicated by squres. Red squares indicate surface meteorological sites. The boxed regions indicate U.S. CLIVAR process studies, including the Eastern Pacific Investigation of Climate (EPIC), VAMOS Ocean Cloud Atmosphere Land Study (VOCALS), Kuroshio Extension System Study (KESS), and the Climate MOde water, Dynamics Experiment (CLIMODE).

The global network of OceanSITES time series reference sites provides the longer-term monitoring context for process studies. In this poster, we use surface heat flux and cloud forcing "benchmark" data sets collected during the EPIC experiment to assess Numerical Weather Prediction (NWP) Reanalyses.

Methodology

Net Surface Heat Flux: $Q0 = (1-a)SWR - \varepsilon(\sigma T_s^4 - LWR) - Qlat - Qsen$

Latent Heat Loss (Qlat) and Sensible Heat Loss (Qsen) were computed with the Fairall et al. (2003) COARE v3.0 bulk algorithm using hourly data or telemetered daily averages when high resolution data were not available. These data included winds relative to surface currents, air temperature, relative humidity, and skin temperature. Bulk SST was extrapolated to the surface using the algorithm's warm layer and cool skin model. For more details on the latent heat flux calculation, see Cronin et al. (2006a)

Solar Cloud Forcing = downwelling shortwave radiation - clearsky shortwave radiation
Longwave Cloud Forcing = downwelling longwave radiation - clearsky longwave radiation

Clearsky shortwave radiation was computed from Iqbal (1988) algorithm with decimal yearday, latitude, longitude, and estimates of integrated water vapor, and aerosol optical depths.
Clearsky longwave radiation was computed from the Fairall et al. (2006) algorithm with SST, specific humidity, air temperature, and latitude.

For more details on the surface cloud forcing calculation, see Cronin et al. (2006b).

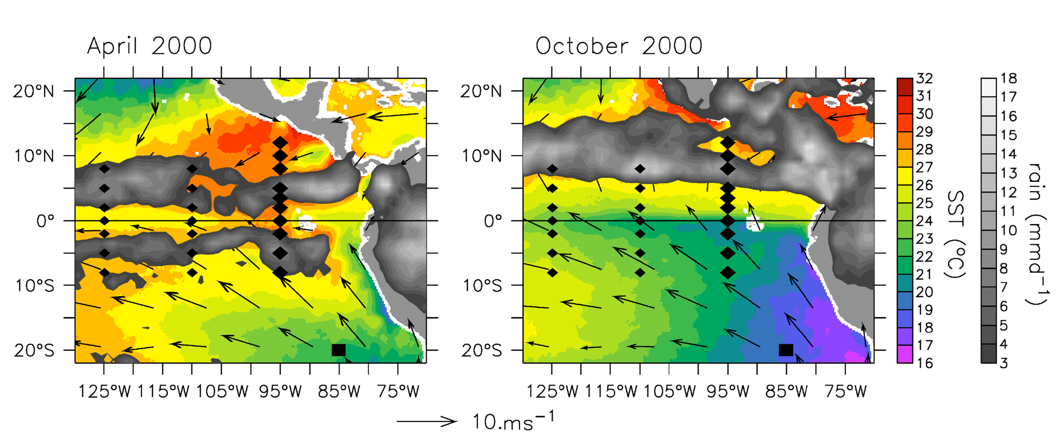

Fig. 2. The EPIC mooring array, shown in relation to the April 2000 and October 2000 mean TMI SST, TRMM rain rate, and QuikScat surface winds. Diamonds indicate TAO buoys. Large diamonds indicate EPIC-enhanced 95°W TAO buoys. The Woods Hole IMET buoy is indicated by a large square.

The objective of the Eastern Pacific Investigation of Climate Studies (EPIC) was to observe and understand the ocean-atmosphere processes responsible for the structure and evolution of the large-scale atmospherics heating gradients in the stratus deck / cold tongue / ITCZ complex, with the goal of improving short-term climate analysis and prediction systems for the Americas.

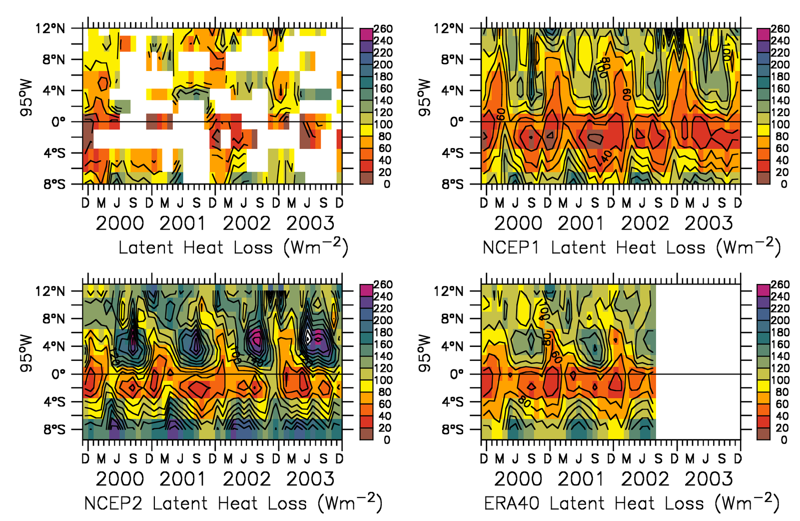

Fig. 3. Monthly averaged latent heat loss from (top left) 95ºW TAO/EPIC buoy measurements, (top right) NCEP/NCAR reanalysis, (bottom left) NCEP/DOE reanalysis, and (bottom right) ECMWF 40-year reanalysis

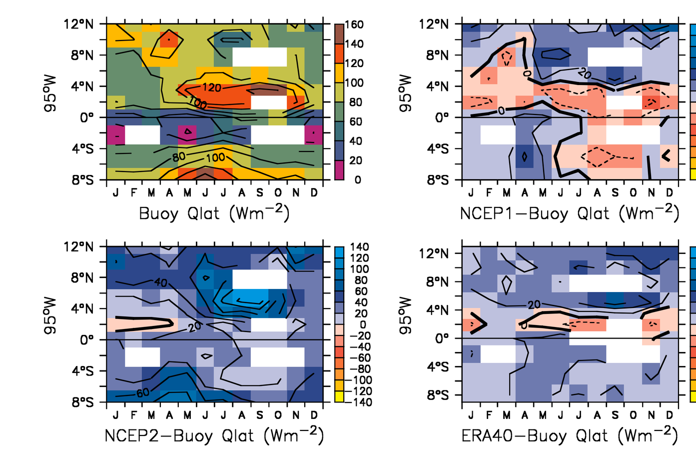

Fig. 4. (top left) Mean annual cycle of latent heat loss from buoy measurements, and mean annual cycle of difference between reanalysis latent heat loss and buoy field for (top right) NCEP/NCAR, (bottom left) NCEP/DOE, and (bottom right) ECMWF 40-year reanalyses

- **The TAO/EPIC 95ºW buoys suffered extensive data loss due to vandalism.**
- **NCEP/DOE reanalysis tends to produce too much latent heat loss, particularly in the frontal region north of the cold tongue and in the region south of 5ºS.**

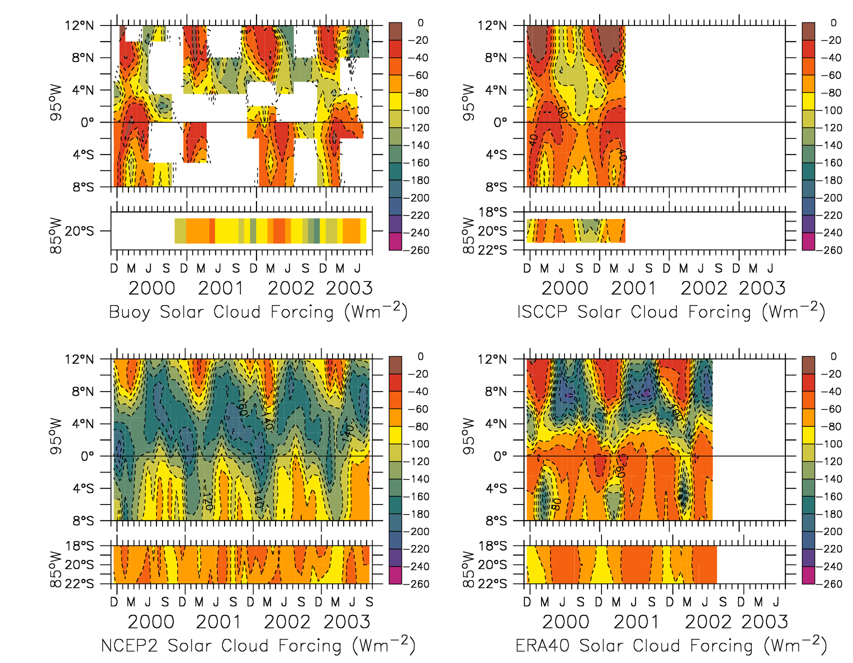

Fig. 5. Monthly averaged solar cloud forcing from (top left) buoy measurements, and (top right) NCEP/NCAR, (bottom left) NCEP/DOE, and (bottom right) ECMWF 40-year reanalyses.

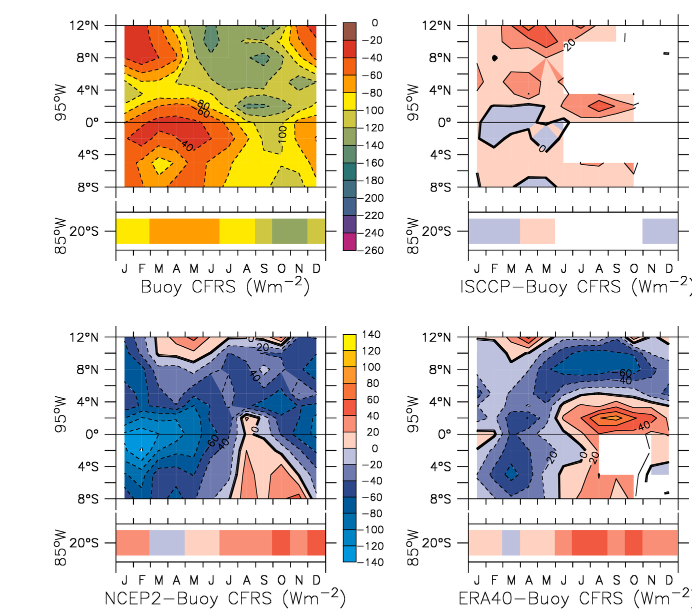

Fig. 6. (top left) Mean annual cycle of solar cloud forcing from buoy measurements, and mean annual cycle of difference between reanalysis solar cloud forcing and buoy field for (top right) NCEP/NCAR, (bottom left) NCEP/DOE, and (bottom right) ECMWF 40-year reanalyses.

- **ISCCP seasonal climatology compares relatively well with the buoys**
- **NCEP/DOE has too much cloudforcing on the equator during the warm season. During the cold season when stratus tends to form, there is too little cloud forcing in the NCEP/DOE and ERA40 reanalyses.**

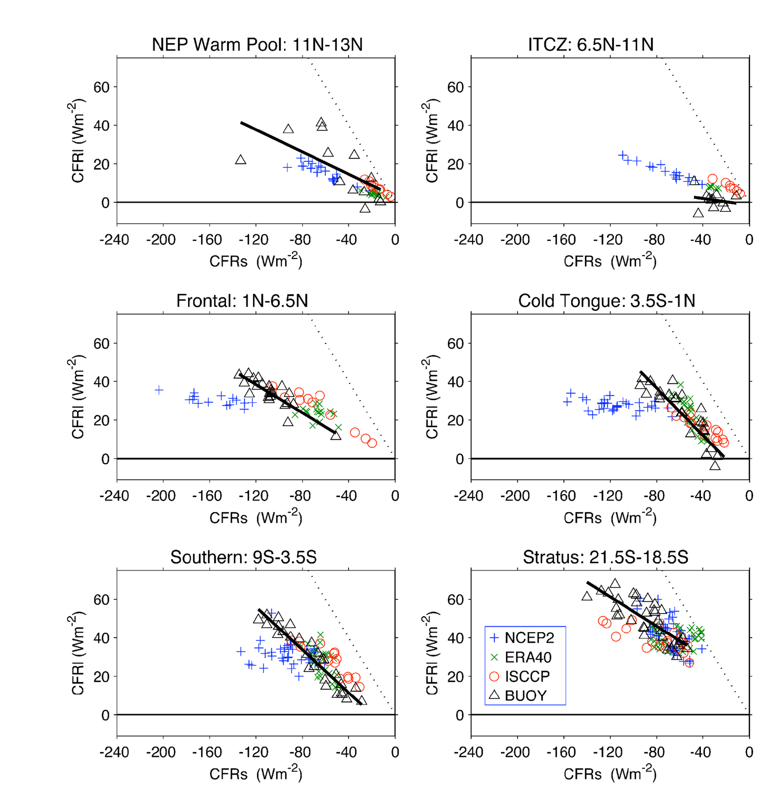

Fig. 7. Scatter plots of solar and longwave cloud forcing in different latitudinal bands for precipitating clouds. Significant rainfall was determined by TRMM rainfall fields.

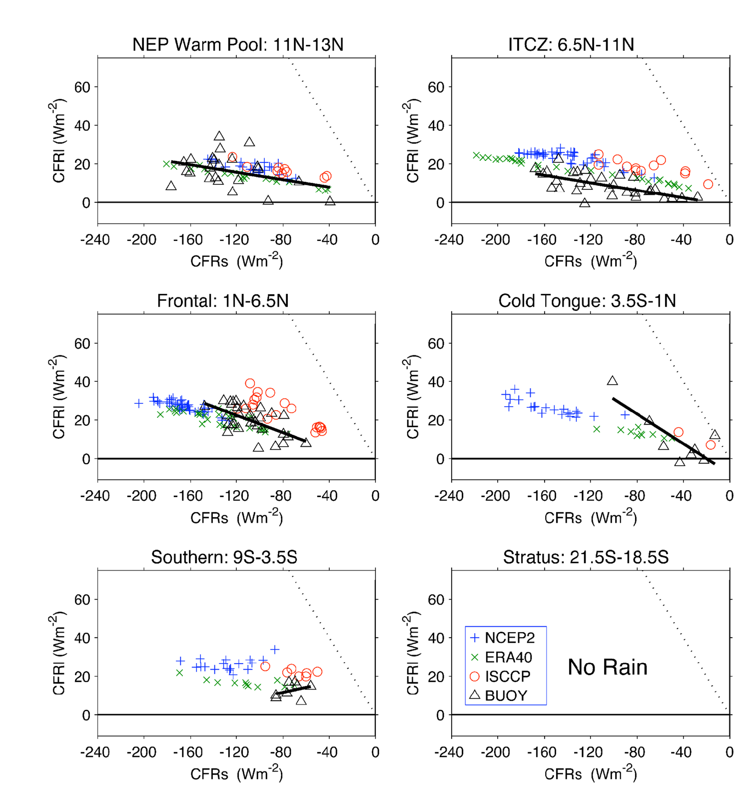

Fig. 8. Scatter plots of solar and longwave cloud forcing in different latitudinal bands for months with no significant rainfall.

- **The relative reduction in solar radiation and increase in longwave radiation depends upon cloud type and varies with latitude.**
- **Longwave cloud forcing is larger for stratus clouds than for precipitating ITCZ clouds.**
- **However, for all regions, *solar cloud forcing is always larger than longwave cloud forcing.***

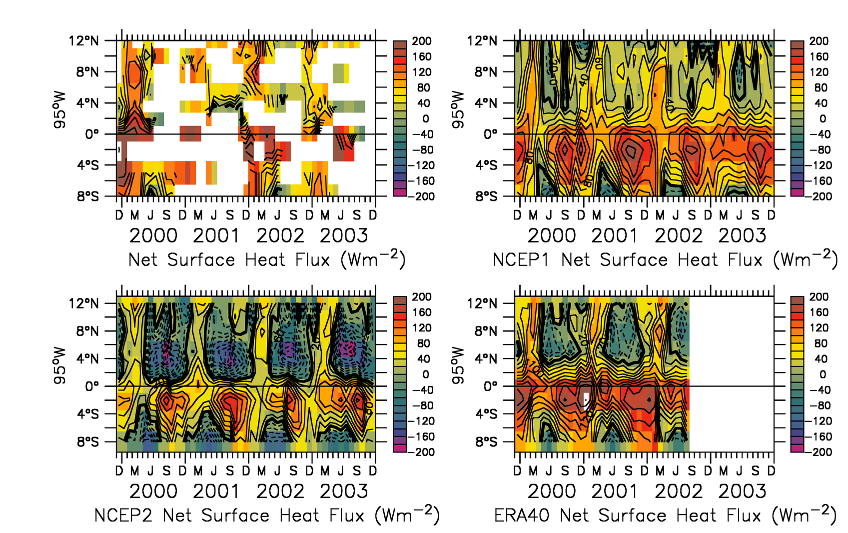

Fig. 9. Monthly averaged net surface heat flux into the ocean from (top left) 95ºW TAO/EPIC buoy measurements, (top right) NCEP/NCAR reanalysis, (bottom left) NCEP/DOE reanalysis, and (bottom right) ECMWF 40-year reanalysis.

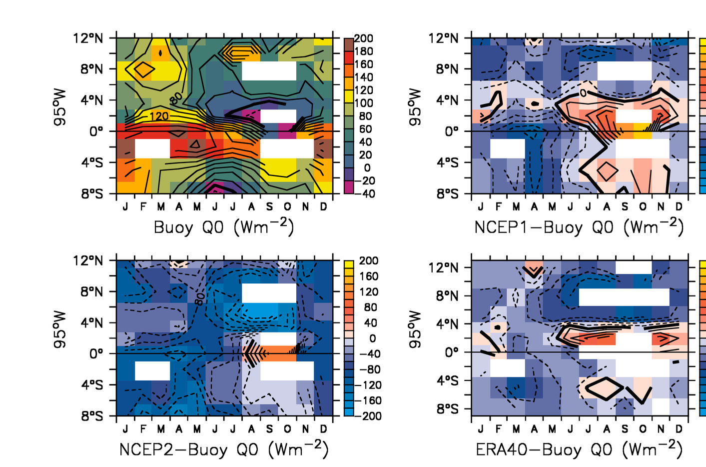

Fig. 10. (top left) Mean annual cycle of net surface heat flux from buoy measurements, and mean annual cycle of difference between reanalysis net surface heat flux and buoy field for (top right) NCEP/NCAR, (bottom left) NCEP/DOE, and (bottom right) ECMWF 40-year reanalyses.

- **On average net surface heat flux warms the ocean everywhere within the eastern tropical Pacific, except in the frontal region north of the cold tongue during the cool season.**
- **All 3 reanalyses (NCEP/NCAR, NCEP/DOE, and ERA40) do not have enough heat entering the ocean in the ITCZ regions.**
- **ERA40 and particularly NCEP/DOE reanalyses have net surface cooling in the northern ITCZ, rather than weak surface heat flux warming as observed.**
- **This is due to both improper cloud formation and cloud radiative balances, and to excessive surface latent heat loss.**

For more information

http://usclivar.org/
http://www.oceansites.org/
http://www.pmel.noaa.gov/tao/epic/

References

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