September 4, 2012

Using historical surface data verify the Twentieth Century Reanalysis for Oceanographic Applications (NA11OAR4310084, PI: James Carton)

Final Report (total cost: $75K, 09/01/2011 - 08/31/2012)

Background This proposal examines the Twentieth Century (20CRv.2) Reanalysis Project of Compo et al. (2010) by supporting exploration of the surface winds from the 20CRv.2 in two stages. The first stage will involve comparison of the 20CRv.2 and other multi-decadal reanalyses to wind observations such as those contained in ICOADS (which were not used in the 20CRv.2 assimilation). The second stage will involve examination of output from a simulation of an ocean general circulation model driven by reanalysis winds in comparison with the historical hydrographic record. Both aspects of this work have been completed and have also served as the MS research topic for a UMD student Adam Greeley. Here I reiterate the discussion of Stage 2 from the annual report (this is a 1 yr grant). The two sets of results will be presented together in a research paper that is under construction now.

Results Eight members of the 20CRv2 were used to drive 138 year-long ocean simulations using the same model as used in the SODA reanalysis (Carton and Giese, 2008). Figure 1 examines the time mean structure of surface wind stress curl and net surface heat flux computed over contemporaneous time periods. Let's consider wind stress curl first. Note the zone of negative curl surrounding the Antarctic continent which is too weak in 20Crv2 reflecting insufficient strength in the polar easterlies. Connected to this, there is a $10W/m^2$ net downward heat flux into the Southern Ocean. Note also the insufficient zone of positive curl over the region of the Gulf Stream corresponding to an insufficient zone of outgoing heat flux. However, over much of the ocean the time mean 20CRv2 heat flux is generally consistent with the observation sets.

In **Figures 2** and **3** we examine two aspects of decadal variability in the eight ocean simulations, focusing on SST and 0/300m average temperature (essentially 0/300m heat content). In **Figure 2** we examine the ensemble average Pacific Decadal Oscillation (PDO). The ensemble average EOF and PC time series are both quite consistent with previously published results. Among the interesting results: the uncertainty in the EOFs is quite small. The uncertainty in the PC time series indicates that there is no meaningful information prior to 1900. However, the results do indicate a period of positive PDO early in the 20^{th} century that is not apparent in published time series.

In **Figure 3** we examine the Atlantic Multidecadal Oscillation (AMO). For the AMO SST the results from the simulation is quite consistent with independent estimates of the spatial structure and time series of the AMO and the uncertainty levels are low. What is new here is the corresponding picture of 0/300m temperature. The North Atlantic corresponds to a zone of positive heat, while the eastern equatorial Pacific is a zone of negative temperature.

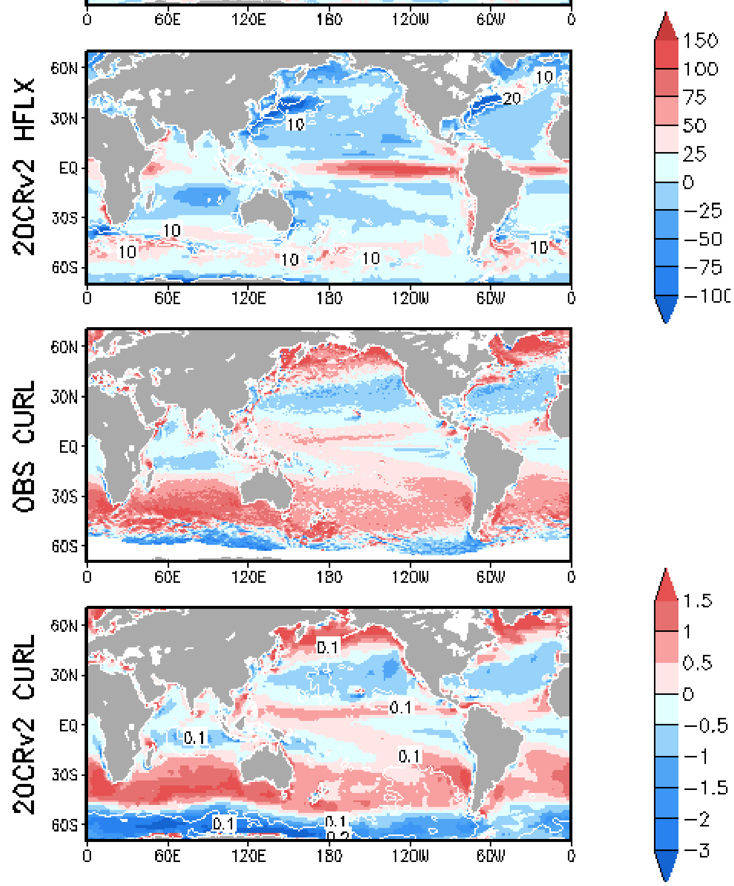

Figure 1 Comparison of observed and 20CRv2 reanalysis time mean net surface heat flux (upper two panels, W/m2) and wind stress curl (lower two panels, N/m3 x 10^6). Observed net heat flux is the OAFLUX heat flux (averaged 1984-2008) of *Yu et al. 2008*. The global/time average heat flux is removed from each data set (OAFLUX: 29.7 W/m2 and 20CRv2: 3.4 W/m2) Observed wind stress curl is the scatterometer-based estimate (averaged 1999-2007) of *Risien and Chelton (2008)*. The reanalysis estimates are averaged over matching time periods. Color shows ensemble time mean while contours show 1 standard deviation of the ensemble.

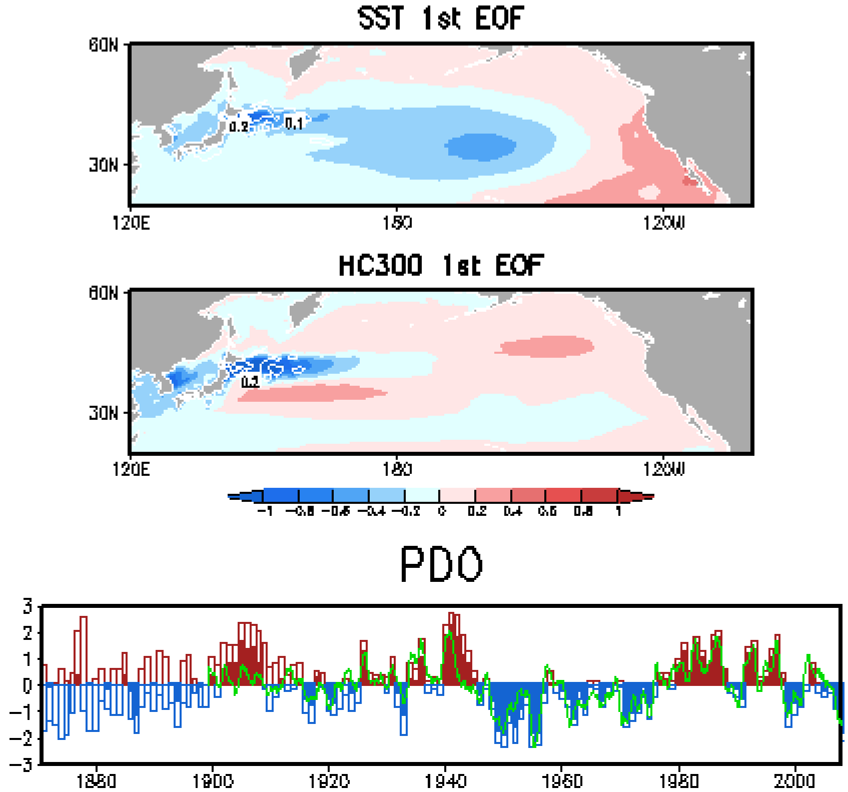

Figure 2 Pacific Decadal Oscillation as computed from the ensemble of ocean simulations driven by ensemble members of 20CRv2. Upper two panels show the average of first EOFs of annual average SST and 0/300m average temperature (20^o-60^oN) after removal of the linear trend (colors). Contours show the 2σ uncertainty based on the ensemble of estimates. Lower panel show the ensemble mean time series of the first principal component of SST. Outline marks the ±95% uncertainty levels. The NOAA ESRL PDO index time series is superimposed in solid green curve.

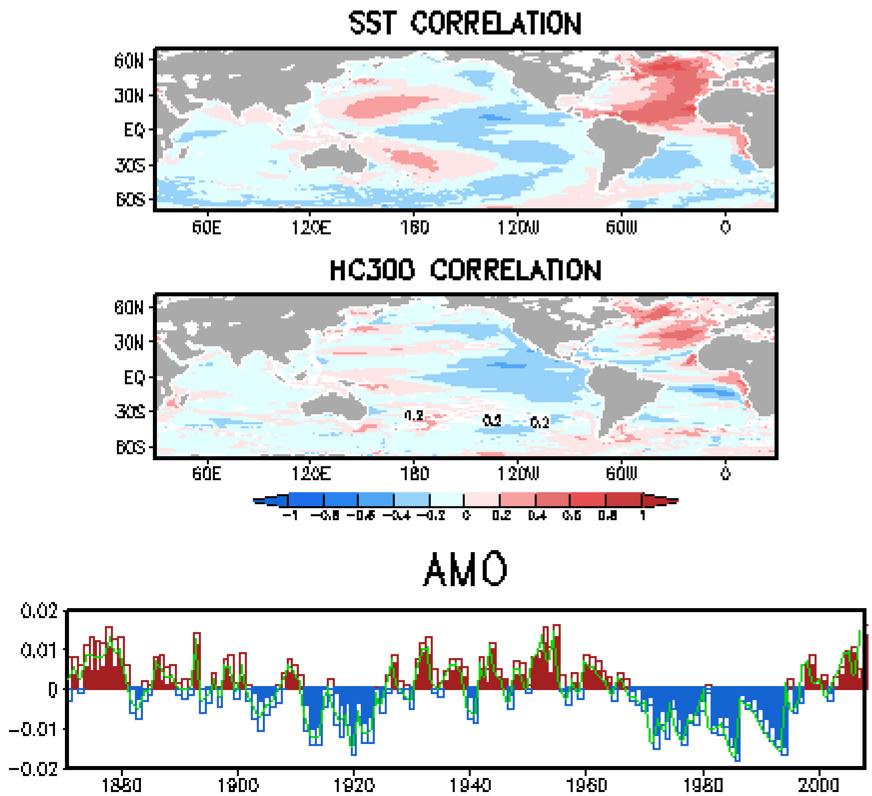

Figure 3 Atlantic Multidecadal Oscillation as computed from the ensemble of ocean simulations driven by ensemble members of 20CRv2. Lower panel shows the ensemble average computed as the spatial average of the 0°-70°N Atlantic SST (minus the 70°S-70°N SST global average). Outline marks the ±95% uncertainty levels. The NOAA ESRL PDO index time series is superimposed in solid green curve. Upper two panels show the ensemble average of the correlation of SST and 0/300m average temperature (colors). Contours show the 2σ uncertainty based on the ensemble of estimates.

References

Yu, L., X. Jin, and R. A. Weller, 2008: Multidecade Global Flux Datasets from the Objectively Analyzed Air-sea Fluxes (OAFlux) Project: Latent and sensible heat fluxes, ocean evaporation, and related surface meteorological variables. Woods Hole Oceanographic Institution, OAFlux Project Technical Report. OA-2008-01, 64pp. Woods Hole. Massachusetts.

Risien, C.M., and D.B. Chelton, 2008: A Global Climatology of Surface Wind and Wind Stress Fields from Eight Years of QuikSCAT Scatterometer Data. J. Phys. Oceanogr., 38, 2379-2413.