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Observations for climate: Comparison of ocean reference stations observations to the ECMWF-Interim Reanalysis products

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Easterly Trade Winds blow over ~50% of the World Ocean surface. Relatively small net air-sea heat fluxes (20-30 Wm^-2) under the Trade winds accumulate along very long trajectories to provide the bulk of the large diabatic heating in deep tropical convection that drives the global Hadley Circulation. Positive feedbacks to the Hadley circulations amplify signals (and errors) as small as 2 Wm^-2 within the Trades (Meehl et al., 2009). Accurately observing and modeling the spatial and temporal structures of the Trade wind fluxes and their components are essential for accurate and seamless climate prediction. Sustained high-quality measurements of marine meteorological variables, and derived air-sea fluxes, have been obtained from three moored Ocean Reference Stations (ORS) within different subregimes of the Trade Winds - the high pressure stratus area typical of the descending branch of the Hadley Cell, the core of the Trade Winds with its fair weather marine boundary layer, and the region of trade wind convergence into the deep convection found in the western near-equatorial portions of the Atlantic and Pacific. The observations and fluxes from these sites have been carefully cross-calibrated by state-of-the-art measurements from research vessels. Data from these sites have been withheld from atmospheric reanalysis products (RPs), which are critical for accurately benchmarking and initializing climate models. Comparing point measurements with atmospheric RPs has been difficult because of unknown differences due to spatial mismatch and RP biases. This is particularly challenging over the ocean where consistent, sustained, high quality observations are not available in sufficient quantities to estimate mean and variable spatial differences. Atmospheric RPs have now improved to the point where we have used them to assess the time-averaged local gradients of properties around the ocean reference site. Comparisons of ORS and RP wind, air pressure, sea and air temperature, humidity, and turbulent fluxes shows that biases are generally low for the ECMWF-Interim product at the three ORS sites. Correlations of daily means are relatively high. For each of the sites, the spatial distribution of mean and variance of met and flux variables have been mapped, and EOFs have been used to describe the space-time structure of the dominant variability. These results show the different structures of synoptic, seasonal and longer-term variations at the three sites. For each variable, the dominant variations occur in phase across the region, though not with uniform amplitude. The dominant source of variance is associated with the annual cycle. The results show that the Stratus and NTAS sites are representative of large regions. The area around the WHOTS site shows the largest mean spatial gradients, which are attributable to the influence of island orographic effects that can extend out more than 100 km orthogonal to the Trade wind flow. Patterns of synoptic variability, mean annual variations, interannual departures and record-length trends are discussed.