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Difference between Mean and Instantaneous Wind Direction associated with Air-Sea Fluxes

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Air-sea turbulent heat exchange is parameterized with wind speed and the difference in either humidity or temperature across the interface for latent and sensible heat fluxes, respectively. Thus, the wind direction only implicitly influences the fluxes, for example by transport of moisture and heat, which becomes of particular interest for the physical interpretation in regions with large temperature gradients in the atmosphere and ocean. Coincidentally, the region with the climatological-mean highest fluxes is found in the mid-latitudes along SST fronts associated with the Western Boundary Currents (WBCs), where also the largest variability of these fluxes occurs. From a climatological-mean viewpoint, the heat exchange in these regions would be associated with the time-mean westerlies that dominate the storm track regions. However, on synoptic time-scales the largest fraction of the exchange must be associated with the episodic events of meridional flow transporting cold air over warmer water. To pinpoint the relative value of the time-mean and synoptic viewpoint, we present striking differences of air-sea heat-exchange characteristics for the entire globe with respect to the associated wind direction.

We diagnose the latent and sensible air-sea heat exchange using the ERA-Interim data with instantaneous 6-hourly, as well as daily, weekly, and monthly mean fields. Our results show that the interpretation of the fluxes in the lower latitudes is consistent for all the different type of data, featuring the easterly trade winds as the main wind direction. On the other hand, the associated wind direction differs markedly in the extra-tropics for the different type of data. For weekly and monthly mean fields, the wind direction is mainly westerly, whereas for daily mean and 6-hourly data the wind direction has a dominant meridional component, which would also imply significant flow across the SST front. The dependence of the primary wind direction associated with the strongest heat fluxes at different latitudes and for different type of data pinpoints the necessity to consider sub-weekly time-scales in the mid-latitudes to describe the air-sea heat exchanges in a physical meaningful way.