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Daily co-variations in near-surface relative humidity and temperature over the ocean

Stephan Pfahl and Noemi Niedermann
ETH Zurich, Institute for Atmospheric and Climate Science, Zurich, Switzerland (stephan.pfahl@env.ethz.ch)

Temperature and specific humidity variations over the ocean on different time scales typically are closely related to each other owing to the strong constraint of saturation humidity given by the Clausius-Clapeyron equation. However, deviations from this zeroth order relationship, perceptible in terms of relative humidity (RH) fluctuations, have important consequences, e.g., for air-sea interaction and changes of the hydrological cycle in a changing climate. It is thus important to understand the processes leading to such RH variations over the ocean and their correlation with temperature.
In this study, daily observations of humidity and temperature at fixed locations close to the ocean surface are analyzed with respect to temperature-RH correlations. As the number of appropriate measurements is limited, ERA-Interim reanalysis data are used in addition for obtaining a more complete picture in time and space. By analyzing data with a short, daily time resolution, the correlation signal of synoptic-scale weather processes can be explored in a straightforward way.
Consistent geographical patterns of correlation coefficients between RH and temperature are obtained from observations and reanalysis. In the tropics, a strong negative correlation with minimum values below -0.8 is found. The seasonal variation of the area with strongest anti-correlation is consistent with the movement of the intertropical convergence zone. In the subtropics, correlation coefficients mostly are around zero. Over the mid-latitude oceans, a positive correlation signal is observed. Maximum values in the order of 0.7 occur in the winter season of the respective hemisphere, the summer signal is less strong.
With the help of TRMM precipitation data, it is shown that the negative correlation in the tropics is strongly related to the local daily rain intensity. Precipitation, on the one hand, leads to an increase in RH due to saturated downdrafts and the evaporation of hydrometeors. On the other hand, these processes, and in addition the radiative effect of clouds, cause a cooling of near-surface air. In mid-latitudes, daily variations of temperature over the ocean are mainly controlled by advection, as indicated by backward trajectory calculations. Moreover, during days with low temperature and northward advection (in the northern hemisphere), strong heating of the air parcels, most probably due to boundary layer fluxes, is evident from the trajectory data. This heating leads to a destabilization of the air mass, and thus, on average, to a stronger vertical mixing and a stronger influx of low-RH air from above. All together, this causes the positive temperature-RH correlation.
Insight from this detailed process analysis can serve as an important prerequisite for a better quantitative understanding of the complex changes of relative humidity in a changing climate.