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Air-sea fluxes in the Southern Ocean during CAPRICORN experiment

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The Southern Ocean contributes to the global heat budget closure problem due to large uncertainties associated with air-sea fluxes. Despite previous efforts to understand various aspects of momentum (τ), heat (H_s) and moisture (H_l) flux variability over the region, the precise nature of these air-sea fluxes remains uncertain owing to inadequate reliable sampling and limited research into the key physical processes. There is also a poor consensus in satellite and reanalyses products due to errors in flux parameterization schemes and sampling over the Southern Ocean. Concerning these issues and a need for *in-situ* flux observations, the CAPRICORN (Clouds, Aerosols, Precipitation, Radiation, and atmospherIc Composition Over the southeRn oceaN) experiment was carried out as part of *R/V Investigator* voyage in the Australian sector of the Southern Ocean in March-April 2016. It was one of its first dedicated efforts to quantify the turbulent fluxes over this sector featuring high wind speeds. The voyage sampled one cyclonic cold-core eddy (6 days) and one anticyclonic warm-core eddy (4 days) and encountered several extratropical cyclones. The turbulent fluxes were measured using both the eddy covariance and inertial dissipation methods by the NOAA Physical Sciences Division flux system. These turbulent flux measurements were employed to validate bulk flux estimates obtained by the Coupled Ocean-Atmosphere Response Experiment (COARE 3.5) bulk algorithm. COARE 3.5 algorithm gives good estimates of τ (accurate within 6%) but underestimates $H_s$and H_l(accurate within $\sim$30% and $\sim$11%, respectively) for wind speeds of 5-20 ms^{-1}over the study region. An intercomparison of COARE 3.5 bulk fluxes with estimates obtained by European Centre for Medium-Range Weather Forecasts interim reanalysis (ERA-Interim), the Southern Ocean Flux Station buoy, the Australian Integrated Marine Observing System (IMOS) and the Objectively Analysed air-sea Heat Fluxes project (OAFlux) hybrid dataset reveals a good agreement among them over the Southern Ocean at the daily timescale.

Further, using COARE 3.5 bulk fluxes the surface flux variability is investigated under given wind conditions, over the oceanic eddies and extratropical cyclones during the field experiment. Surface flux sensitivity is also analysed for wave parameters and precipitation. The analysis reveals an increase in $H_s$and $H_l$with increasing wind speeds and significant wave heights (H_{sw}) in a non-linear manner. A discernible variation in τ, H_{sw}, $H_s$and $H_l$is also noted over eddies as compared to average voyage values. A higher mean net flux (H_s+H_l) value over the warm eddy ($\sim$141 Wm^{-2}) is reported as compared to the cold eddy ($\sim$-9 Wm^{-2}). As observed during the traversal of 9 extratropical cyclones, an increase in τ ($\sim$66% average) and a decline in H_s ($\sim$117%) and H_l ($\sim$60%) is noted in the warm sector, compared to pre-storm conditions, which are overturned after the passage of a cold front. The study aims to improve the understanding of physical mechanisms driving the air-sea interaction in the Southern Ocean.