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The Marine Atmospheric Boundary Layer structure over the Southern Ocean during the SOCRATES field campaign

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The thermodynamic structure of the marine atmospheric boundary layer (MABL) is examined in relationship to synoptic meteorology over the Southern Ocean (SO) using 109 dropsondes from 12 research flights undertaken by the NSF/NCAR Gulfstream-V HIAPER aircraft between January and February 2018 during the Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study (SOCRATES) campaign. A climatology of the MABL derived from upper-air soundings for the period 2006-2010 at Macquarie Island (54.62°S, 158.85°E, Lang et al, 2018) is used to evaluate how well the dropsonde observations can represent different synoptic conditions.

Lang et al. (2018) applied a K-mean clustering algorithm to the upper-air sounding data and found 5 discrete clusters: pre- and post-cold frontal, high pressure system, weak postfrontal and mixed conditions. Fifteen low-level thermodynamic variables including surface pressure, temperature, and relative humidity, as well as the temperature, relative humidity, zonal wind (u), and meridional wind (v) at 700, 850, 925 hPa pressure levels are employed in the clustering.

The SOCRATES dropsondes are assigned to the nearest cluster centroid defined in Lang et al. (2018). The results show that the forced-to-5 cluster proportion of the dropsondes is comparable to that in Lang et al. (2018), where cluster 5 is most frequently present (36.7%). This cluster is characterised by westerly winds extending throughout the troposphere with a maximum wind speed (15 m/s) present at 480 hPa. The characteristics of pre- and post-cold frontal conditions are well captured in the Cluster 1 (18.3%) and 4 (15.6%), respectively. Cluster 2 (22%) represents an environment more closely associated with a high pressure system, whereas Cluster 3 exhibits a larger variability of the surface pressure. In general, the dropsondes are well presented the climatology at Macquarie Island despite the fact that they were sampled across a larger geographical area over the SO.

Spatiotemporal collocated thermodynamic profiles from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis are compared with the observations to evaluate their representation of the MABL characteristics. The comparison shows that within the boundary layer, ERA5 reanalysis data can capture thermodynamic profiles over the SO with some skill except for the dew point temperature, where ERA5 profiles are moister than the dropsondes.