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Impact of the SH sea-ice cover and ocean surface on the Southern Ocean atmospheric variability

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Satellite observations of the last 30 years have shown a slight increase in the Antarctic sea-ice area (SIA). This increase seems to be counterintuitive regarding global warming and the strong decrease observed in Arctic SIA. Thus, dynamical processes rather than thermodynamical processes would be a more plausible cause for the Southern Hemisphere (SH) sea-ice increase. This raises interest in understanding the dynamics of the Southern Ocean climate system and its recent changes.

Based on ERA-40 reanalysis data and satellite-borne HadISST1 observations for 1979-2008 we detect synchronous variability in the Southern Ocean mean sea-level pressure (SLP), sea surface temperatures (SST) and sea-ice concentration (SIC) fields. The strength of the Amundsen-Sea low (ASL) is strongly connected with the phase of a dipole-pattern in SICs and SSTs identified across the Western longitudes.

With the aid of a comprehensive climate model, we further investigate the one-way impact of the lower boundaries on the Southern Ocean atmosphere. Therefore, a set of sensitivity atmosphere-land-only simulations is performed forced either with inter-annually variable (the HadISST1 observations) or climatological input data of SICs and SSTs.

The sensitivity experiments exhibit a clear impact of both, the SSTs and the sea-ice cover on the Southern Ocean atmospheric inter-annual variability. For example, the variability of the ASL is drastically reduced in the experiment with climatological lower boundaries. The strongest decrease is due to the missing SST variability in the mid-latitudinal Pacific suppressing the generation of the so-called Pacific South America teleconnection, an ENSO-related wave pattern significantly influencing the state of the ASL. The wave generation is inhibited due to reduced variability of the latent heat flux. Further, variable sea ice impacts the SLP variability but to a lower degree. In summary, there is clear evidence that the Southern Ocean atmospheric variability is very sensitive to the variability of the lower boundary conditions and that any changes in SH sea-ice and its variability also feedbacks into the atmosphere. This result has also implications for the representation of the Southern Ocean climate in coupled Atmosphere-Ocean General Circulation Models (AOGCMs).