

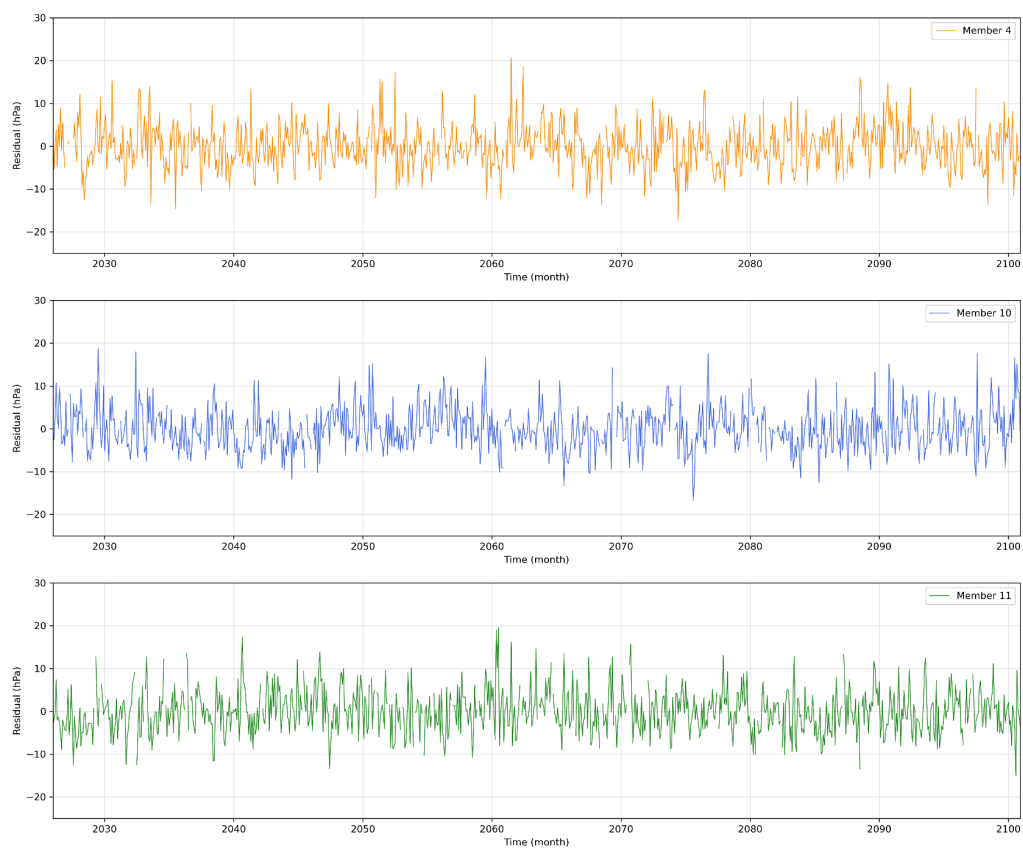


Fig. 1: Time series plots showing detrended ASL indices calculated from CESM2 members for the period 2026-2100 under SSP245. Considerable variance around center 0 suggests the possibility of extremes that are present even when the seasonal cycle and long-term linear trend are removed.

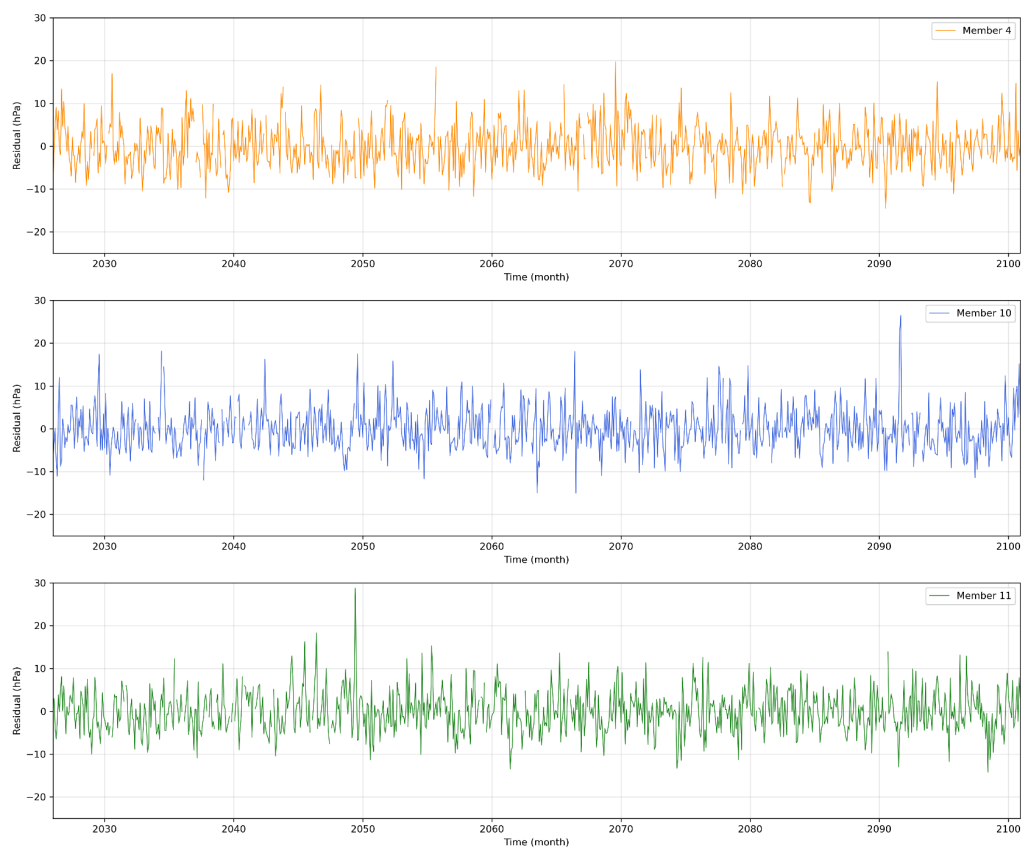


Fig. 2: Time series plots displaying detrended ASL indices calculated from CESM2 members for the period 2026-2100 under SSP585. Considerable variance around center 0 suggests the possibility of extreme behaviour that is present even when the seasonal cycle and long-term linear trend are removed.

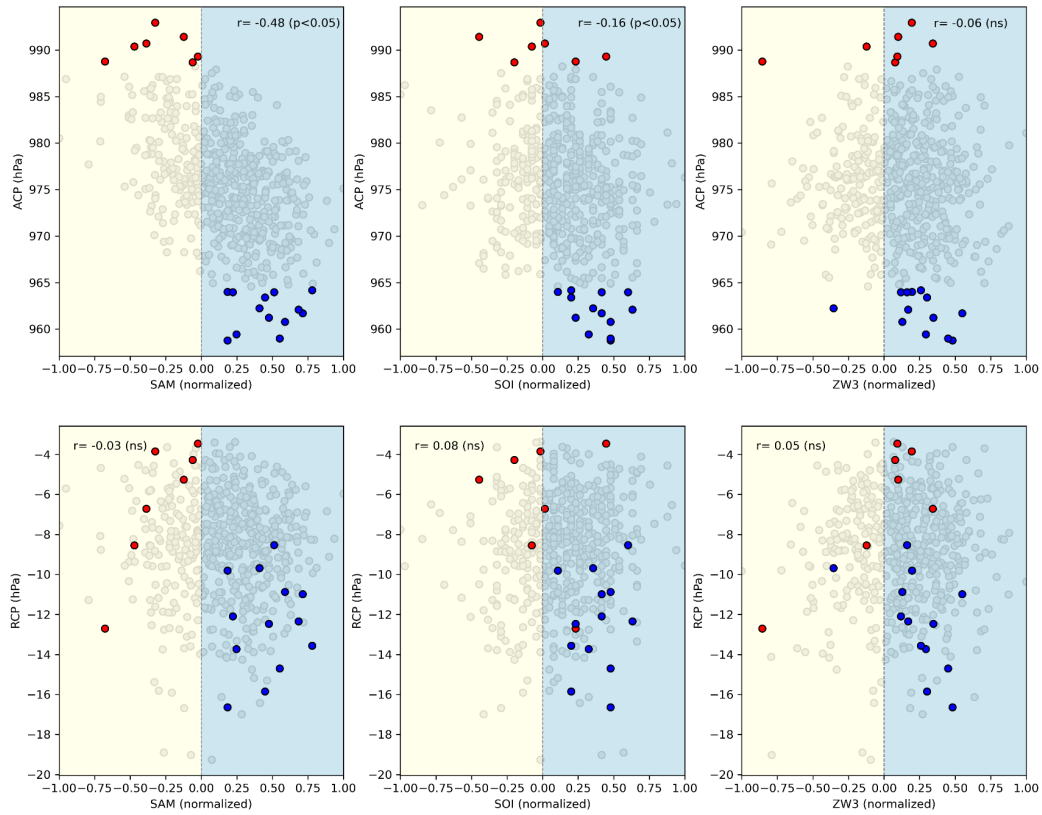


Fig. 3: Scatter plots visualizing the relationship between ASL ACP and normalized SAM, SOI, and ZW3 indices (top row). Results suggest the co-occurrence of extremely strong ASL events with the positive polarity of all three SH MOVs. An additional sensitivity test using RCP (bottom row) is conducted to confirm the robustness of our findings. Such testing reveals a continued association between extremely strong ASL events and the positive polarity of the three MOVs. In both instances, there is a weak link between extremely weak events and MOV phase.

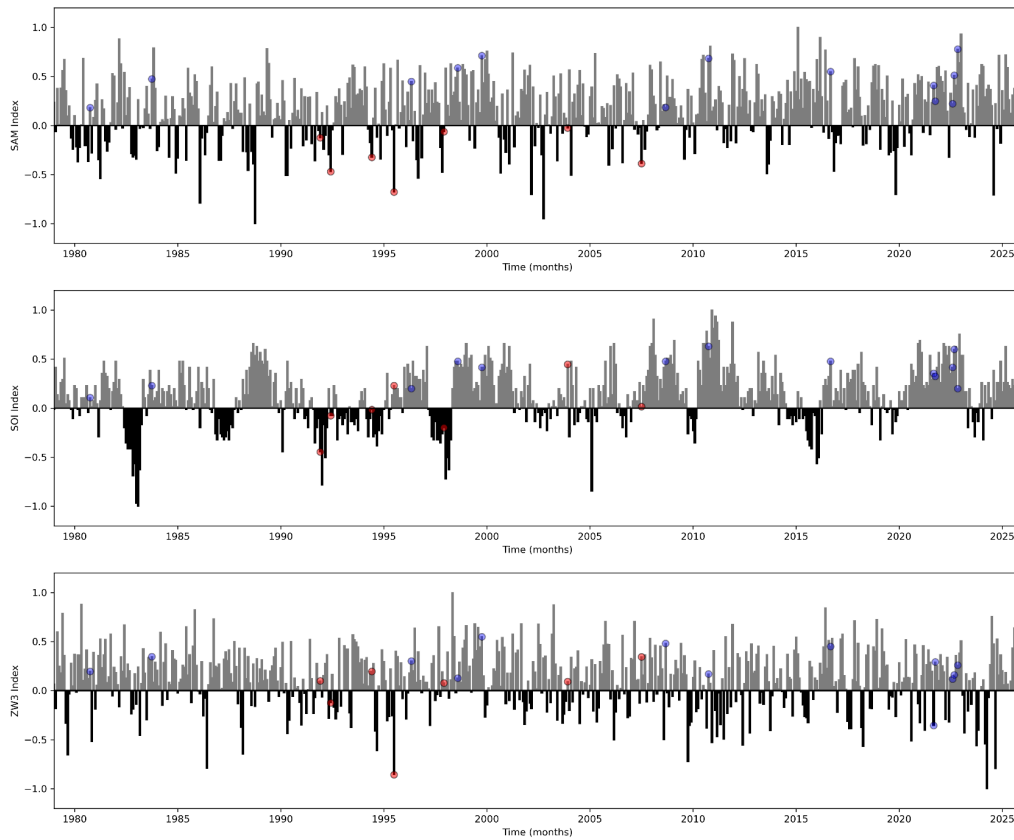


Fig 4: Time series showing fluctuations in the polarity of SAM, ENSO, and ZW3 during the period 1979-2025. The positive phase of each MOV is shown in gray and the negative phase in black. Extremely strong (blue) and weak (red) ASL events identified during the study period are overlaid to provide a visual comparison of the timing of occurrence. All extremely strong (weak) events co-occur with SAM+ (SAM-). However, there is more complexity in co-occurrence across ENSO and ZW3.

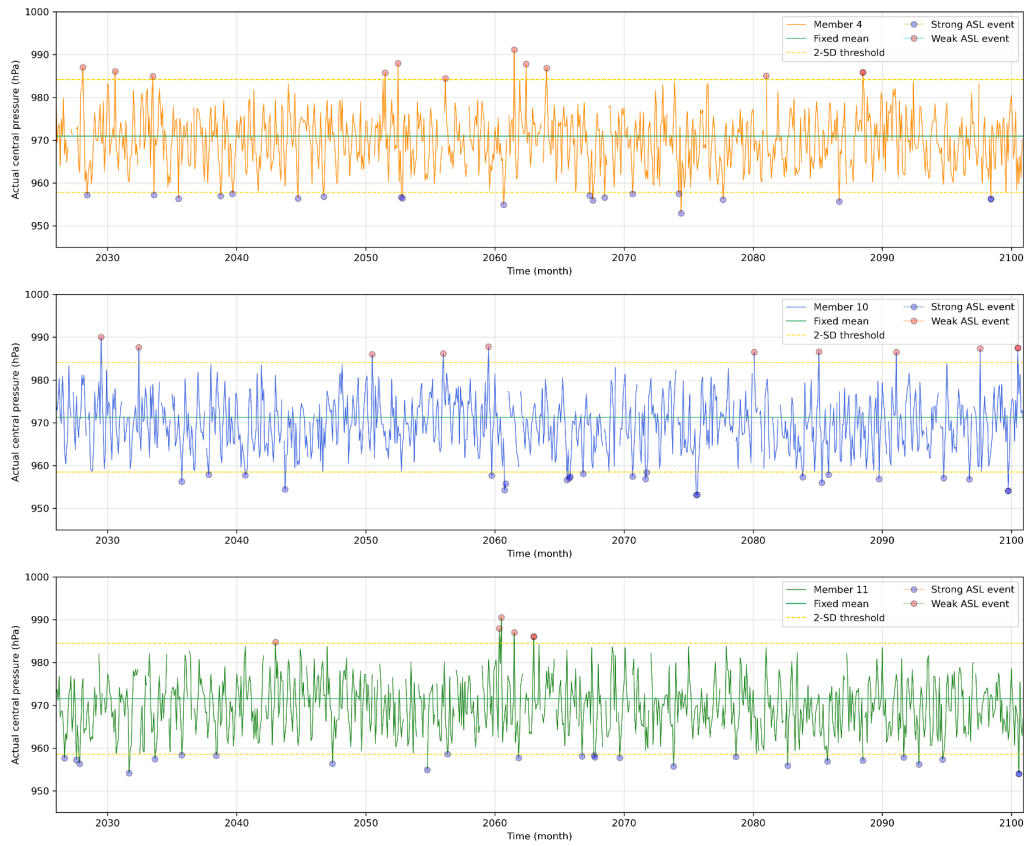


Fig. 5: Time series showing projected ASL variability for the period 2026-2100 under SSP245 conditions. Future extreme ASL events are identified using a fixed mean based on the historical period and are shown as red (weak) and blue (strong) circles in each of the three plots. Under a middle-of-the-road scenario, the three model members project the continued occurrence of both extremely strong and weak ASL events.

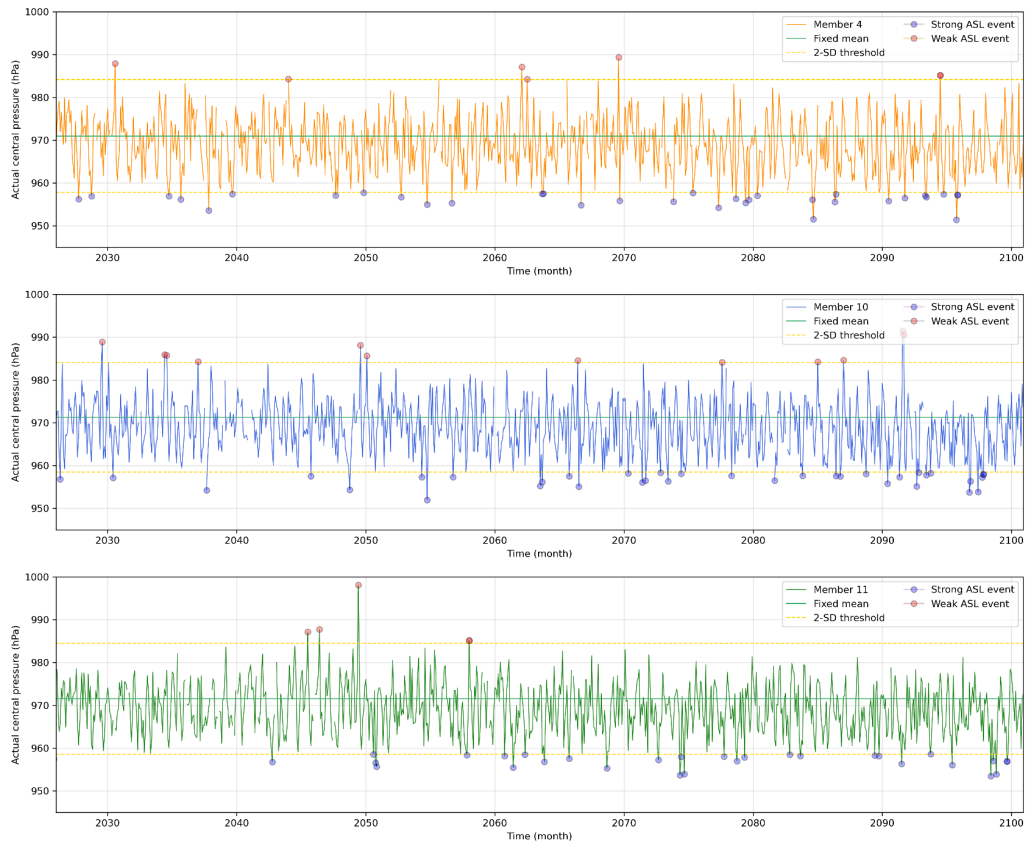


Fig. 6: Time series showing projected ASL variability for the period 2026-2100 under SSP585 conditions. Future extreme ASL events are identified using a fixed mean based on the historical period and are shown as red (weak) and blue (strong) circles in each of the three plots. Under a high-emission scenario, all three model members project extremely strong ASL events to develop more often than weak events.

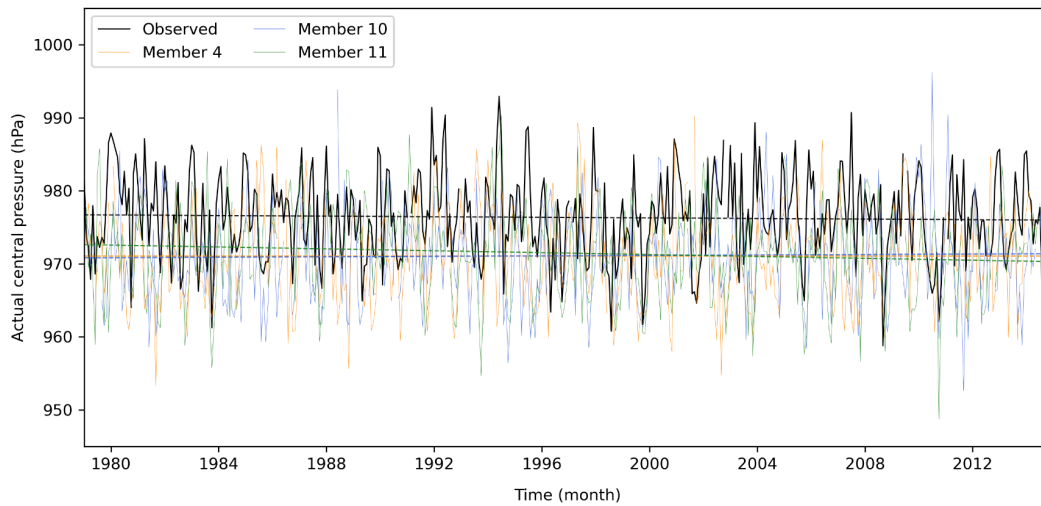


Fig. 7: Time series comparing observed versus simulated ASL variability over the historical period 1979-2014. Simulated pressure conditions are deeper than those observed using ERA5 reanalysis, indicating a negative model bias. However, all model members are able to capture general vascillations around the simulated mean, thus suggesting CESM2's ability to capture ASL variability.

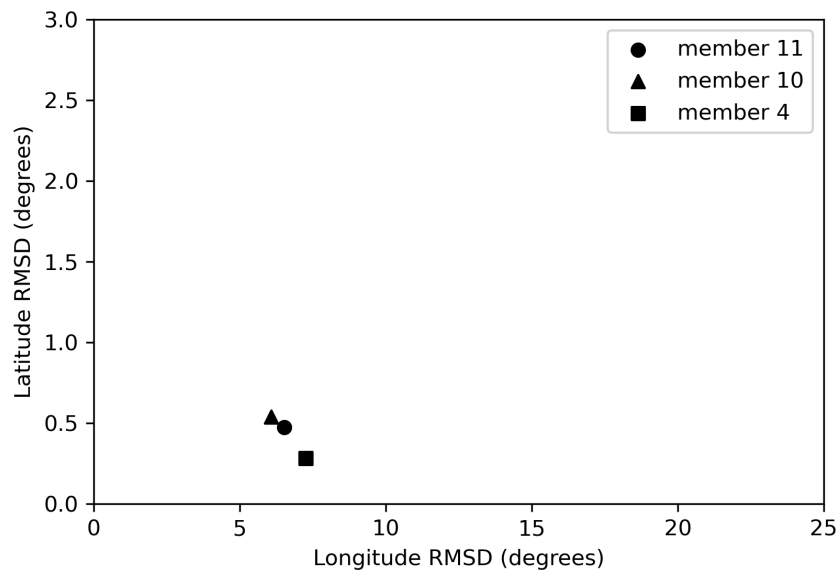


Fig. 8: Scatter plot of RMSD showing the magnitude of difference between the average and simulated position of the ASL using the three available CESM2 model members. RMSD values indicate a difference of less than ten degrees longitude and one degree latitude, thus providing some confidence in the ability of CESM2 to simulate the geographic position of the ASL.

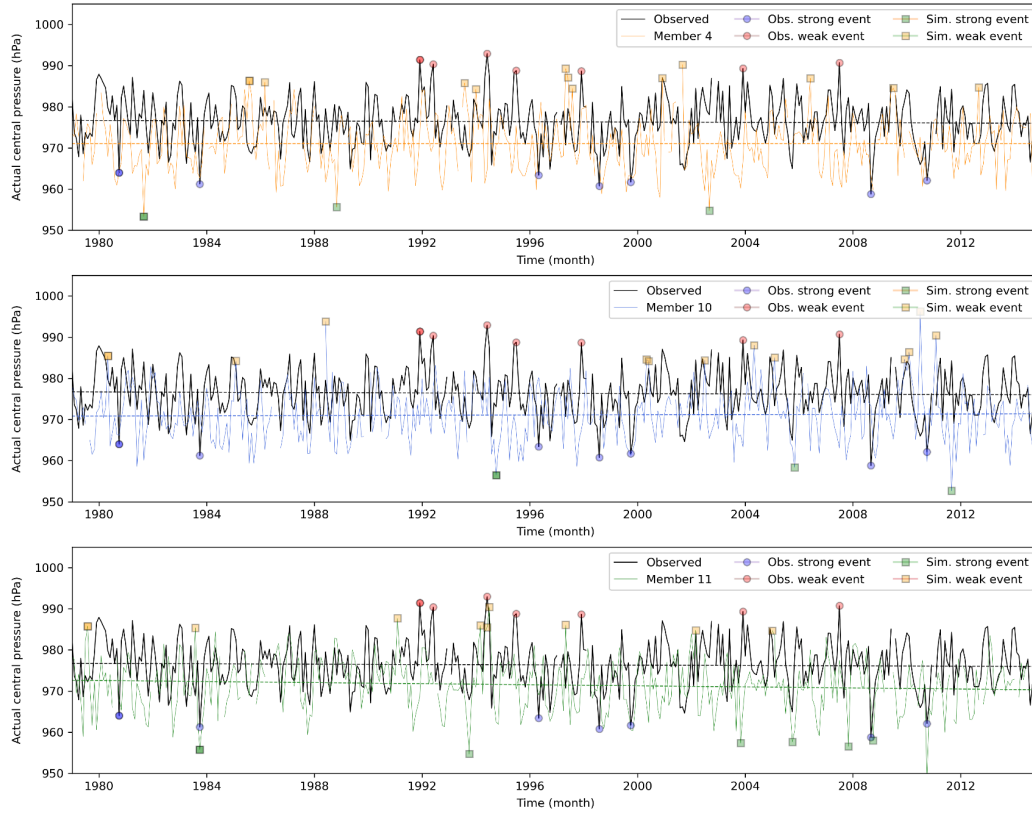


Fig. 9: Time series comparing observed versus simulated ASL variability for all three CESM2 model members during the historical period 1979-2014. By applying our extreme-event identification method to historical model output, we find that all members reproduce ASL variability and have the capacity to yield extreme events. Member eleven is the member that most closely captures the timing of some observed extremes.

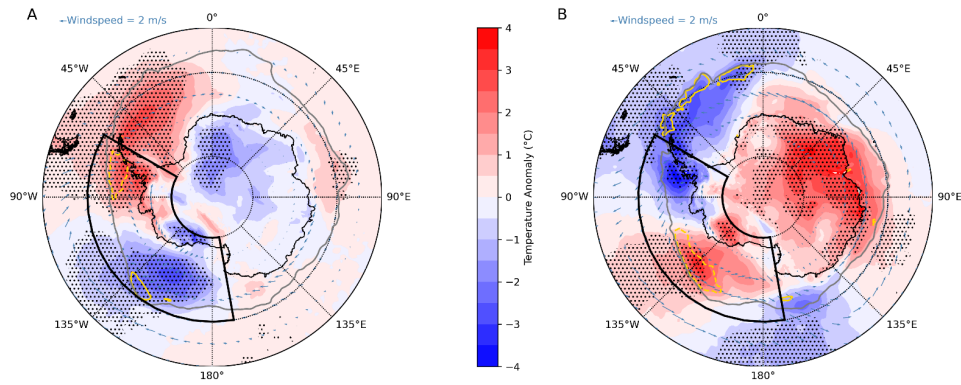


Fig. 10: Anomaly composite maps of extremely strong (a) and weak (b) ASL events with stippling indicating regions of statistical significance for temperature anomalies only. Large swaths of the West Antarctic region, where circulation anomalies influence surface temperature and sea ice, undergo changes during extreme ASL events that are unlikely to occur by chance. During extremely strong ASL events, a dipole of statistically significant negative and positive temperature anomalies sets between the Ross Sea and the Antarctic Peninsula, respectively. A similar pattern is observed during extremely weak ASL events, although increases in temperature over the southernmost parts of Amundsen and Ross Seas region are insignificant.