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Reconstructing atmospheric circulation and sea-ice extent in the West Antarctic over the past 200 years using data assimilation

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Ocean and ice sheet in the West Antarctic sector have witnessed large climate changes during the second half of the 20th century including a strong and widespread continental warming, important regional changes in sea-ice extent and snow accumulation, as well as a major mass loss from the melting of some ice shelves. However, the potential links between those observed changes are still unclear and instrumental data do not allow determining if they are part of a long-term evolution or specific to the recent decades. In this study, we analyze the climate variability of the past two centuries in the West Antarctic sector by reconstructing the key atmospheric variables (atmospheric circulation, near-surface air temperature and snow accumulation) as well as the sea-ice extent at the annual timescale using a data assimilation approach. To this end, information from Antarctic ice core records (snow accumulation and $\delta^{18}O$) and tree-ring width sites located in the mid-latitudes of the Southern Hemisphere are combined with the physics of climate models using a data assimilation method. This ultimately provides a complete spatial reconstruction over the west Antarctic region. Our reconstruction reproduces well the main characteristics of the observed changes over the instrumental period. We show that the observed sea-ice reduction in the Bellingshausen-Amundsen Sea sector over the satellite era is part of a long-term trend, starting at around 1850 CE, while the sea-ice expansion in the Ross Sea sector has only started around 1950 CE. Furthermore, according to our reconstruction, the Amundsen Sea Low pressure (ASL) displays no significant linear trend in its strength or position over 1850-1950 CE but becomes stronger and shifts eastward afterwards. The year-to-year sea-ice variations in the Ross Sea sector are strongly related to the ASL variability over the past two centuries, including the recent trends. By contrast, the link between ASL and sea ice the Bellingshausen-Amundsen Sea sector changes with time, being stronger in recent decades than before, Our reconstruction also suggests that the continental response to the variability of the ASL may not be stationary over time, being significantly affected by modification of the mean circulation. Finally, we show that the widespread warming since 1958 CE in West Antarctica is unusual in the context of past 200 years and is explained by both the deeper ASL and the positive phase of the Southern Annular Mode.