Controls and consequences of rapid environmental change on the atmosphere–sea ice–ocean system in the Larsen Ice Shelf area

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The catastrophic breakup of the Larsen A and B ice shelves in 1995 and 2002 stand as vivid examples of the effect of climate change on the cryosphere along the east coast of the Antarctic Peninsula (AP). While several studies have considered the physical causes of ice shelf breakup and the implications of their demise for ice sheet mass balance, little is known regarding the significance of these changes for the polar marine ecosystem. With the removal of ice shelves, primary production becomes possible in the previously dark, oligotrophic waters. High seasonal phytoplankton biomass and rates of primary production are now observed in the Larsen embayments, with the spatial extent of phytoplankton growth modulated by sea ice cover. Because open water is a necessary precursor for water column production, gaining an understanding of sea ice dynamics and the factors controlling sea ice cover can give insight into the present state and future evolution of the pelagic marine ecosystem. As part of the LARISSA (LARsen Ice Shelf System, Antarctica) project, we investigate the link between climate variability, regional atmospheric patterns and sea ice dynamics in the Larsen Ice Shelf region using high-resolution, in situ weather records spanning January 2010 – May 2013. These include data collected from AMIGOS (Automated Met-Ice-Geophysics Observation System) and cGPS met systems adjacent to the Larsen B. We find that opening of the embayments is tied to the frequency and intensity of foehn wind events, with the embayments acting much like coastal polynyas. Persistence of open water conditions is tied to both foehn winds and synoptic atmospheric circulation patterns. These winds are influenced by the Southern Annular Mode (SAM), with periods of positive SAM leading to more frequent warm, dry, and strong down sloping winds on the leeward side due to the orographic lifting of polar westerlies over and across the Antarctic Peninsula. Resulting surface air temperatures above 0ºC can extend spatially over 100 km from the peninsula mountain range, likely contributing to extensive sea ice melt. These results are confirmed using a 15-year, daily time series from the Argentinean research station at Matienzo on the Larsen Nunatak. This analysis indicates that foehn winds play a key role in the regional weather of the northeast Antarctic Peninsula, with influences on both the cryosphere and marine ecosystem.