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The examination of a downslope warming wind event over the Larsen Ice Shelf in Antarctica through modeling and aircraft observations.

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During the last 50-60 years temperatures over the Antarctic Peninsula region have increased more rapidly than anywhere else in the southern hemisphere, at several times the global average rate. At one station, the near-surface warming between 1951 and 2004 was 2.94 ^{o}C compared to a global average of 0.52 ^{o}C. However, the seasonal pattern of this regional warming has varied with location, with the east side having warmed more than the west in the autumn and summer seasons. This is important since the process of surface melting on the Larsen ice shelves, which are located on the east side, predominately occurs in summer. Crevasse propagation due to the weight of accumulated melt water is currently thought to have been the major factor in causing the catastrophic near-total disintegration of the Larsen B ice shelf in 2002, representing a loss of ice of area 3200 km^2. The larger and more southerly Larsen C ice shelf could also suffer a similar fate if the warming continues, with consequences for the ecology and for increased glacier flow, leading to sea level rise.

The difference in warming between the east and west side in these seasons is thought to have been driven by circulation changes that have led to increases in the strength of westerly winds. The high mountains of the Antarctic Peninsula provide a climatic barrier between the warmer oceanic air of the west and the cold continental air of the east. It has been suggested that increased westerlies allow warm winds to cross to the east side more frequently. The warming of westerly flow can also be enhanced by latent heat release on the upslope side and/or adiabatic descent of air from above, on the downslope side.

In January 2006 the British Antarctic Survey performed an aircraft flight over the Larsen C ice shelf on the east side of the Peninsula, which sampled a strong downslope warming wind event. Surface flux measurements over the ice shelf suggest that the sensible heat provided by the warm jets would be likely to be negated by latent heat losses from ice ablation. The main cause of any ice melting was likely to be due to shortwave radiation input. However, the warming from the jets is still likely to be important by acting as an on/off control for melting by keeping air temperatures above zero. In addition, the dryness of the winds is likely to prevent cloud cover and thus maximize exposure of the ice shelf to solar energy.

This case study has been simulated using the WRF mesoscale model. The model reproduces the strong downslope winds seen by the aircraft with good matches of wind speed and temperature profiles through the wind jets. The modeling agrees with the results of the aircraft study in suggesting that solar radiation input is likely to provide the largest amount of energy for melting of the ice surface.

The simulation also provides insight into the physics of the downslope winds. They are found to be driven by descent of air from high above the mountain caused by breaking mountain waves. This is a mechanism that is different from that often perceived to occur in the region, whereby air from below the mountain crest rises over the obstacle and descends on the lee side. The case is also characterized by a large degree of upstream blocking, a situation in which the previous literature has tended to assume such warming winds would not occur for this region. In fact, theoretical work suggests that the blocking may play a necessary role in producing the windstorm in this case. The production of warming on the east side of the Peninsula in blocked regimes is important as it would mean that it occurs at lower upstream wind speeds than previously thought. The possible consequence of this is that the suggested increase in the frequency of warming events over the past 50 years might not be justified

by consideration of the observed westerly wind speed increases alone, but that it may also be influenced by other factors, such as wind direction or the stability conditions. This work also shows that a high resolution is needed to model the small scale wave breaking that drives these events and thus the effect is likely to be completely absent at climate model resolution.