

The Antarctic Peninsula - a “hotspot” for decadal- to century-scale climate variability

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INTRODUCTION

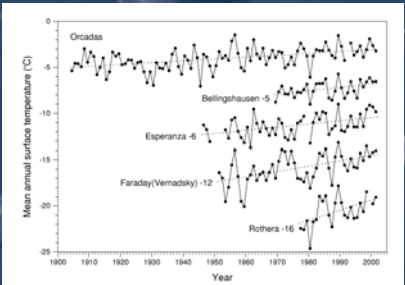
The Antarctic Peninsula and nearby islands possess some of the longest, unbroken instrumental climate records from high southern latitudes. Over the past 50 years, the Peninsula has warmed faster than any other region of the Southern Hemisphere, at a rate only equalled in parts of the Arctic. This warming has driven profound changes in both the physical and living environments. Warming rates are largest in central and southern parts of the west coast of the Peninsula during winter. In northern and eastern parts of the Peninsula, warming rates are smaller and show less seasonal variation. Interannual variations in Peninsula temperatures are strongly correlated with variability in atmospheric circulation and local sea ice conditions. Climate model experiments including natural and anthropogenic forcings do not simulate rapid warming in the Peninsula region, suggesting that such models do not adequately represent some of the complex processes at work in this region.

Warming of the Antarctic Peninsula

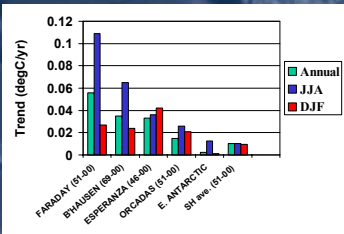
Over the past 50 years, temperatures across much of Antarctica have changed very little¹. In the Antarctic Peninsula region, however, station records reveal warmings of up to 3 degC over 50 years in annual mean temperature², making the Peninsula one of the most rapidly warming regions on Earth. Regional warming has driven profound environmental changes. These include the rapid retreat and collapse of ice shelves³, increased colonisation by terrestrial plants⁴ and changes in the relative abundance of certain penguin species⁵.



Climate stations in the Antarctic Peninsula



Annual mean temperatures at Antarctic Peninsula stations



Seasonal temperature trends in the Peninsula, compared with mean East Antarctic (10 stations, 1957-2000) and Southern Hemisphere (SH) trends



Collapse of the Larsen A Ice Shelf, February 1995. 8000 km² of ice shelves in the Peninsula have disappeared since the 1950s

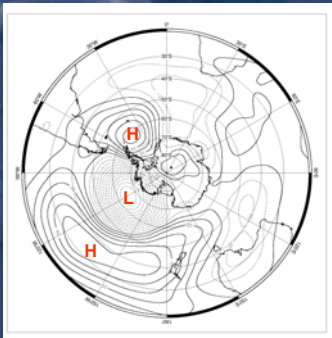
Causes of temperature variability in the Peninsula

Atmospheric Circulation Variations

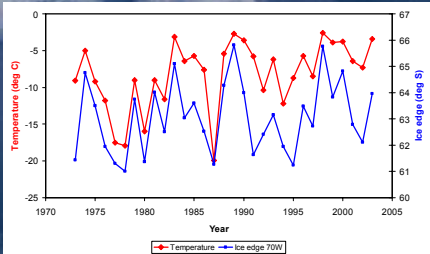
Interannual variations in winter temperatures on the west coast of the Peninsula are correlated with the Pacific-South American (PSA) mode of southern hemisphere atmospheric circulation variability⁶. The PSA pattern is associated with ENSO, hence teleconnections exist between Peninsula climate and the tropical Pacific⁷. The leading mode of SH variability, the Southern Annular Mode (SAM) also influences Peninsula winter temperatures⁸ and strongly controls summer temperature in the northern part of the Peninsula. Recent trends in the SAM may explain some of the observed warming⁹ but atmospheric data are not reliable enough to assess long-term trends in the PSA mode.

Sea-Ice and Ocean Variations

West Peninsula winter temperatures are strongly anticorrelated with sea ice extent in this sector¹⁰. Sea ice variations probably amplify the effect of atmospheric circulation variations. However, variability in ice cover may also result from changed advection of relatively warm Circumpolar Deep Water onto the continental shelf. The West Peninsula sector is one of the few Antarctic regions to have experienced a decline in sea ice extent over recent years¹¹, but this reduction has mainly occurred during summer.



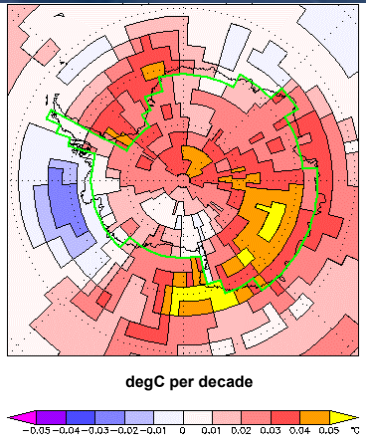
500 hPa height anomalies associated with warm winters at Faraday



July mean temperature at Faraday (red) and sea ice extent at 70°W (blue)

Is the Antarctic Peninsula warming a regional response to global forcings?

We have examined the results of experiments in which a number of leading global atmosphere-ocean models were driven with observed natural and anthropogenic radiative forcings over the 20th century. None of the model experiments highlights the Antarctic Peninsula as a region of exceptional warming. However, the models often represent the mean climate of the region poorly. For instance, in the Hadley Centre HadCM3 model, anomalously low sea-level pressure to the west of the Peninsula results in unrealistically low sea ice extent in this sector. HadCM3 does, however, reproduce recent observed trends in the SAM quite accurately¹². We believe that attribution of the observed Peninsula warming to natural or anthropogenic causes will require the use of global models, to simulate changes in the large-scale modes, in combination with regional models, in which the complex regional interactions between atmosphere, ocean and sea ice can be realistically represented.



Surface temperature changes from the 1950s to the 1990s as simulated by HadCM3, driven with observed natural and anthropogenic forcings. Note the lack of enhanced warming in the Antarctic Peninsula region

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