

ABSTRACT

Although the most rapid recent warming observed in the Antarctic Peninsula has taken place on the west coast during winter, significant summer warming has also occurred. The greatest summer warming is observed in the eastern parts of the Peninsula. Summertime temperatures here appear to be strongly correlated to the strength of the circumpolar westerly winds, as measured by an index of the Southern Hemisphere Annular Mode (SAM). Towards a more positive SAM index (stronger westerlies) may thus be contributing towards summertime warming in this region. Observations, and results from a regional climate model, indicate that temperatures on the eastern Peninsula are more sensitive to changes in the SAM than those on the west. This differential response probably results from the interaction of the westerly flow with the Peninsula mountain barrier.

ANALYSIS OF STATION DATA

We have investigated the summertime (December-January-February) atmospheric circulation anomalies associated with summertime temperature variations at Antarctic Peninsula stations using ERA-40 atmospheric reanalyses and station temperatures from the READER database. The mean sea level pressure anomaly pattern associated with extreme summer temperatures at Esperanza (Fig. 1.) bears a striking resemblance to the structure of the Southern Hemisphere Annular Mode (SAM), the leading mode of SH tropospheric variability. The SAM is characterised by a nearly zonally-symmetric variability in the strength of the circumpolar westerlies and is said to be in a high (low) index state when the westerlies are strong (weak).

Correlation of summertime temperature variations with an index of the SAM (Table 1) shows that the influence of the SAM is strongest in the northern part of the Peninsula. Temperatures at Esperanza, to the east of the Peninsula barrier, show the greatest sensitivity to SAM variations. The sensitivity at O'Higgins, a mere 50 km away but on the west (climatologically upwind) side of the barrier, is only one third of that at Esperanza. The ratio of the long-term summer warming trends at the two stations is similar to that of the regression coefficients.

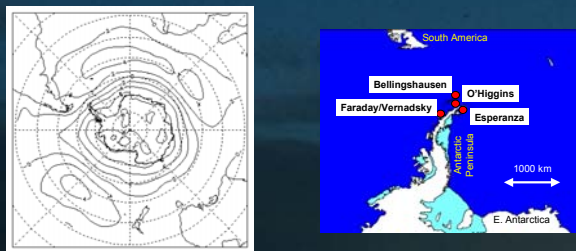


Figure 1. Composite mean sea level pressure anomaly (hPa) for the four warmest summers (DJF) at Esperanza minus that for the four coldest summers over the period 1970-2000.

Station	Correlation Coefficient	Regression slope (degC/unit)	Temp. Trend (degC/yr)
Faraday	-0.19	-0.063	0.010
Bellingshausen	0.38	0.008	0.022
O'Higgins	0.36	0.071	0.013
Esperanza	0.57	0.256	0.048

Table 1. Correlation coefficients and regression relationships between (DJF) temperature and DJF SAM index observations and DJF values of a...

THE WIDER PICTURE

Station data suggest an amplified sensitivity to the SAM on the eastern (climatologically downwind) side of the Peninsula barrier, but Esperanza is the only station in this region. In order to confirm that Esperanza is representative of the eastern side of the barrier, we have examined surface temperature data derived from 18 years of satellite infrared measurements (Comiso, 2000) and surface air temperatures from a 7-year run of a 14 km resolution regional climate model, RACMO (van Lipzig et al, 2004). For both of these sources of data we have computed composite temperature anomalies for high minus low SAM index months (Figs. 2 & 3). Both composites show enhanced sensitivity to the SAM along the northern part of the east coast of the Peninsula to around 66°S. Further south, the response is weaker or even reversed.

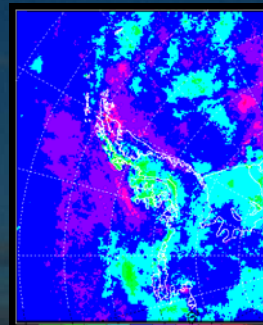


Figure 3. Composite surface temperature anomalies for summer (DJF) months with a high SAM index minus those with a low SAM index. Derived from infrared satellite measurements.

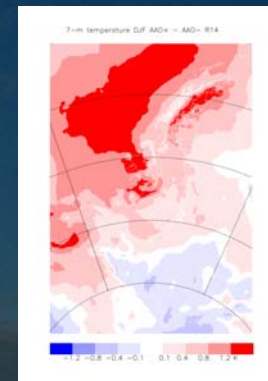


Figure 4. Composite 7m temperature anomalies for summer (DJF) seasons with a high SAM index minus those with a low SAM index. Derived from the RACMO regional climate model.

IMPLICATIONS FOR REGIONAL CLIMATE CHANGES

Over the past 3 decades the SAM index has trended towards positive values, indicating a strengthening of the westerly winds. The strongest trends being seen during summer and autumn. The correlation that we find between summer temperature variations and the SAM index in the northern part of the Peninsula suggests that the significant summer warming observed in this region may be due to an increase in the strength of the westerlies. The greatest recent summer warming trend in the Peninsula is at Esperanza, to the east of the barrier, that is climatologically downwind of the barrier. Satellite observations suggest that the region south of Esperanza, over the Lemaire Channel, may be even more sensitive to the strength of the westerlies. Interactions between the westerlies and the mountain barrier of the Peninsula (Orr et al., 2004) may be responsible for this downwind warming, but the mechanisms for this need to be investigated further. Since SAM-associated warming is reproduced in a regional climate model, this 7-year integration is a powerful tool for such investigations.

Climate model experiments indicate that the recent positive trend in the SAM is largely driven by greenhouse gas increases (Marshall et al., 2004). Summertime warming in the northern part of the Peninsula is therefore, (at least in part) a regional response to anthropogenic forcing. Over the coming century, increased anthropogenic forcing is expected to result in further strengthening of the summertime westerlies, which will drive further warming in the northern part of the Peninsula. However, in the southern part of the Peninsula, the summertime warming trends are likely to remain small if the relationships that we have determined remain robust.

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