to those of past decades, also occurred around 1960, and that strong negative trends occurred afterwards. This positive Antarctic oscillation index and large positive trend during a period before ozone-depleting chemicals were released into the atmosphere and before marked anthropogenic warming, together with the later negative trend, indicate that natural forcing factors or internal mechanisms in the climate system must also strongly influence the state of the Antarctic oscillation.

Until recently[6], it has not been possible to put the Antarctic oscillation index (AAOI) trends in past decades into a longer-term context, as comprehensive Southern Hemisphere data are limited to the reanalysis period (1948/58–present; NCAR–NCEP/ERA40 reanalysis). Our reconstructions are intended to cover the reanalysis period with a consistent estimate of the AAOI, as this has been questioned[7], and to extend this estimate further back. The new reconstructions are more reliable as they use more predictor stations and a statistical model fitted using ERA40 reanalysis, whose AAOI estimates are better than those from NCEP reanalysis[7].

We define the Antarctic oscillation as the first empirical orthogonal function, and the AAOI as the first principal component of the December–January mean extratropical sea-level pressure. A positive or negative AAOI indicates a strengthening or weakening, respectively, of circumpolar westerly flow. For our reconstructions, we used multiple regression to estimate the AAOI from the leading principal components of normalized station pressure. The model is fitted using detrended data, but the reconstruction is derived using undetrended data. One reconstruction (1905–2000) uses 22 stations (Fig. 1a); the second (1951–2000) uses 41 and provides improved coverage of the Antarctic oscillation centres of action (Fig. 1b). Cross-validation gives a correlation of 0.88 and 0.90 for the 1905 and 1951 reconstructions, respectively. (For methods, see supplementary information).

Both reconstructions show that the current positive values for the AAOI are not unprecedented (Fig. 1c). After the relatively stable first half of the twentieth century, there is a period of positive values (relative to the 1958–2000 mean) from 1958 to 1963, followed by a sharp drop to predominantly negative values until the mid-1980s, and then by a mostly positive phase up to the present. The maximum positive 25-year trends over recent years are of similar magnitude to those between the low values of the 1940s and the peak in the 1960s. Note that the trend over the past decades is caused by a combination of negative values in the 1970s and current positive values.

A positive AAOI around 1960, followed by a negative index, is also present in the NCEP and the ERA40 data, in a zonal index-based AAOI[7] and in earlier reconstructions[6]. Consistent with this Antarctic oscillation behaviour, station pressures around 1960 have positive anomalies in the mid-latitude centres of action and negative anomalies in the Antarctic centre of action. By contrast with our reconstructions, the 1960s peak is slightly lower than the 1990s peak in both reanalyses and the zonal index AAOI. Despite this small uncertainty about the exact values, the 1960s peak is a robust feature in all these data sets.

The fact that the austral summer behaviour of the Antarctic oscillation in recent decades seems not to be unprecedented indicates that natural forcing factors, such as solar or volcanic variability, or internal processes in the climate system, can strongly influence the state of the Antarctic oscillation. The question arises as to what the role of these factors has been over the past decades.

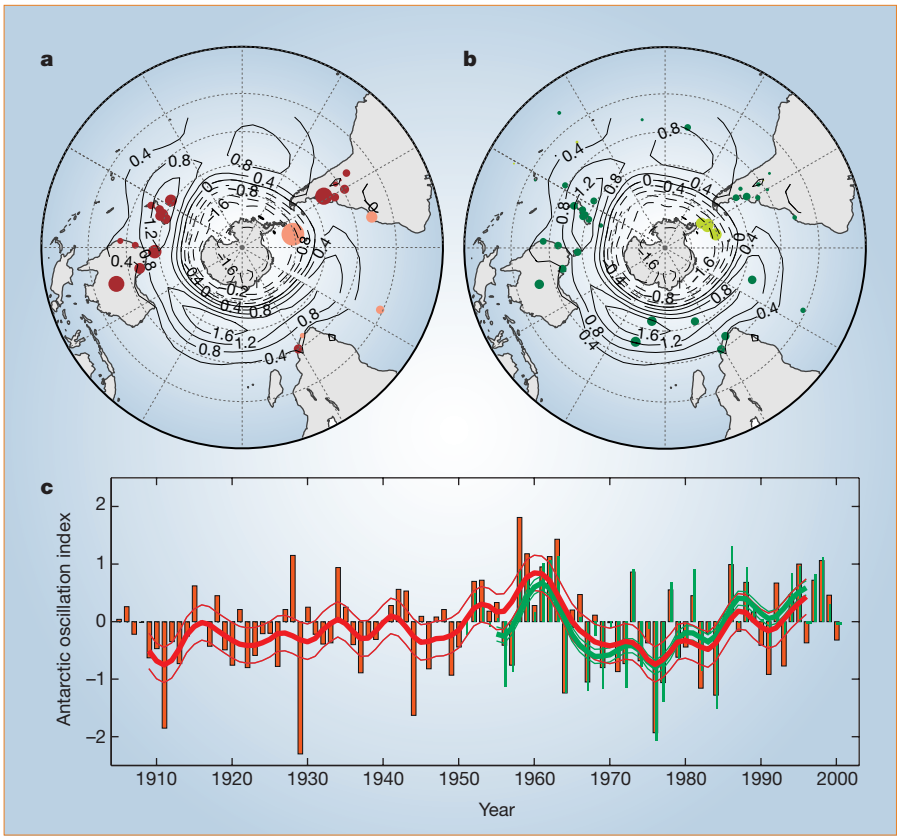

Figure 1 Reconstruction of the December–January Antarctic oscillation index (AAOI). **a,** The Antarctic oscillation pattern and regression weights for normalized station sea-level pressure used for the 1905 AAOI reconstruction. Isolines show the sea-level pressure anomaly (in hundreds of pascals) for the AAOI + 1. The red circles denote positive values and the pink circles denote negative ones; the area is proportional to the weight; **b,** as in **a**, but for the 1951 AAOI reconstruction, with dark green denoting positive values and light green denoting negative ones. **c,** Reconstructed December–January AAOI. Red bars show the 1905 reconstruction; green bars, the 1951 reconstruction. The thick red line is the nine-year low-pass-filtered 1905 reconstruction; the green, the 1951 reconstruction. The thin red and green lines show the 95% confidence intervals for the filtered data. Years are dated from December.

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Supplementary information accompanies this communication on *Nature*'s website.
Competing financial interests: declared none.

Corrigendum

Arrival synchrony in migratory birds

T. G. Gunnarsson, J. A. Gill, T. Sigurbjörnsson, W. J. Sutherland
Nature **431,** 646 (2004).

The line in Fig. 1a shows unity ($x = y$) and is not a regression line, as the legend describes it.

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Copper oxide superconductors: Sharp-mode coupling in high-T_c superconductors
T. Cuk, Z.-X. Shen, A. D. Gromko, Z. Sun & D. S. Dessau (doi:10.1038/nature03163)
Reply: J. Hwang, T. Timusk & G. D. Gu (doi:10.1038/nature03164)

Asteroseismology: Oscillations on the star Procyon
F. Bouchy, A. Maeder, M. Mayor, D. Mégevand, F. Pepe, D. Sosnowska (doi:10.1038/nature03165)