Kinetic energy fluxes into the Southern Ocean

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The northern boundary of the Southern Ocean (SO) may be defined as the Subtropical Front, which lies roughly along 40^{o}S around much of the hemisphere. Defined in this way it occupies about 20% of the surface area of the global ocean. A reflection of the global importance of fluxes into the SO is that water masses formed in there account for more than 50% of the volume of the world ocean (Godfrey and Rintoul 1998). The region is subject to a wide variety of variability mechanisms (Simmonds 2003). We here make use of the NCEP-2 reanalysis data set (Kanamitsu *et al.* 2002) over the period 1979 to 2002, to diagnose aspects of the largescale atmospheric variability and the flux of mechanical energy from the atmosphere to the ocean. The latter is of central importance in determining the nature of oceanic wave climate.

The very baroclinic conditions over the high and mid latitudes in the SO means that it is a region of intense cyclonic activity. This activity is reflected in the structure of the 'directional constancy' of the low-level (10m) wind, which is defined as the ratio of the magnitude of the mean vector wind and the mean wind speed. In NCEP-2 the constancy exhibits a midlatitude band (particularly wide in the Indian Ocean) over which the 'constancy' exceeds 0.6 (Fig. 1), while displaying very low values in the immediate subantarctic region. This overall structure can be understood in terms of the high frequency of cyclones near, and to the south of, 60^{o}S (Simmonds and Keay 2000, Simmonds *et al.* 2003).

The cyclones play an important role in determining the rate at which kinetic energy is deposited into the SO. If the atmospheric density and momentum exchange coefficient are regarded as constant, this rate is proportional to the mean of the cube of the wind speed. This mean is presented in Fig. 2 for the winter season. There is band of high mechanical energy input at about 45^{o}S from the eastern Indian to the west Pacific Ocean which attains its maximum (in excess of 4000 m^3s^{-3}) in the vicinity of Kerguélen. The values attest to the well-deserved reputation of the SO as having some of the strongest winds and largest waves over the global ocean. Significant fluxes are also diagnosed over the sea ice region. More complete details of this work may be found in Simmonds and King (2004).

Godfrey, J. S., and S. R. Rintoul, 1998: The Role of the Oceans in Southern Hemisphere Climate. *Meteorology of the Southern Hemisphere.* D. J. Karoly, and D. G. Vincent, Eds., American Meteorological Society, 283-306.

Kanamitsu, M. et al., 2002: NCEP-DOE AMIP-II Reanalysis (R-2). *Bull. Amer. Meteor. Soc.,* **83,** 1631-1643.

Simmonds, I., 2003: Modes of atmospheric variability over the Southern Ocean. *J. Geophys. Res.,* **108,** 8078, doi: 10.1029/2000JC000542.

Simmonds, I., and K. Keay, 2000: Mean Southern Hemisphere extratropical cyclone behavior in the 40-year NCEP-NCAR reanalysis. *J. Climate,* **13,** 873-885.

Simmonds, I., K. Keay and E.-P. Lim, 2003: Synoptic activity in the seas around Antarctica. *Mon. Wea. Rev.,* **131,** 272-288.

Simmonds, I., and J. C. King, 2004: Global and hemispheric climate variations affecting the Southern Ocean. *Antarctic Science,* (submitted).

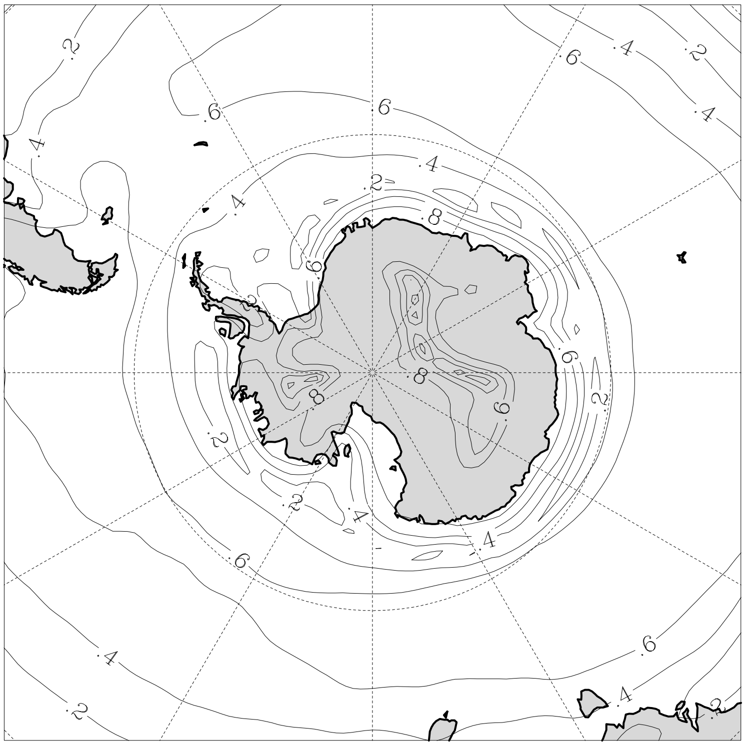

Figure 1: Annual mean directional constancy.

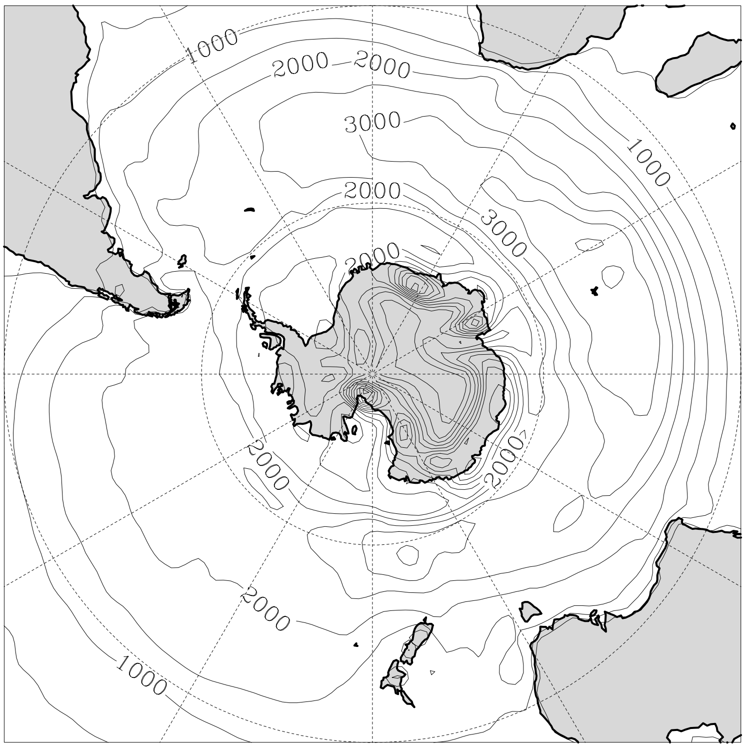

Figure 2: JJA climatology of the mean of the cube of the 10m wind speed. The contour interval is 500 m^3s^{-3}.