The Annual Wave in the Temperature of the Low Stratosphere

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Goldie *et al.* (1958) mention that in middle latitudes, equatorward of ~50°, the annual march of 100-mb temperatures shows a striking change of phase compared with that of the troposphere, with the highest values in spring and the lowest in late summer and fall. We found that this is true in the Northern Hemisphere between 25° and 45° when a zonal average is considered, but that south of this zone the temperature is higher in the

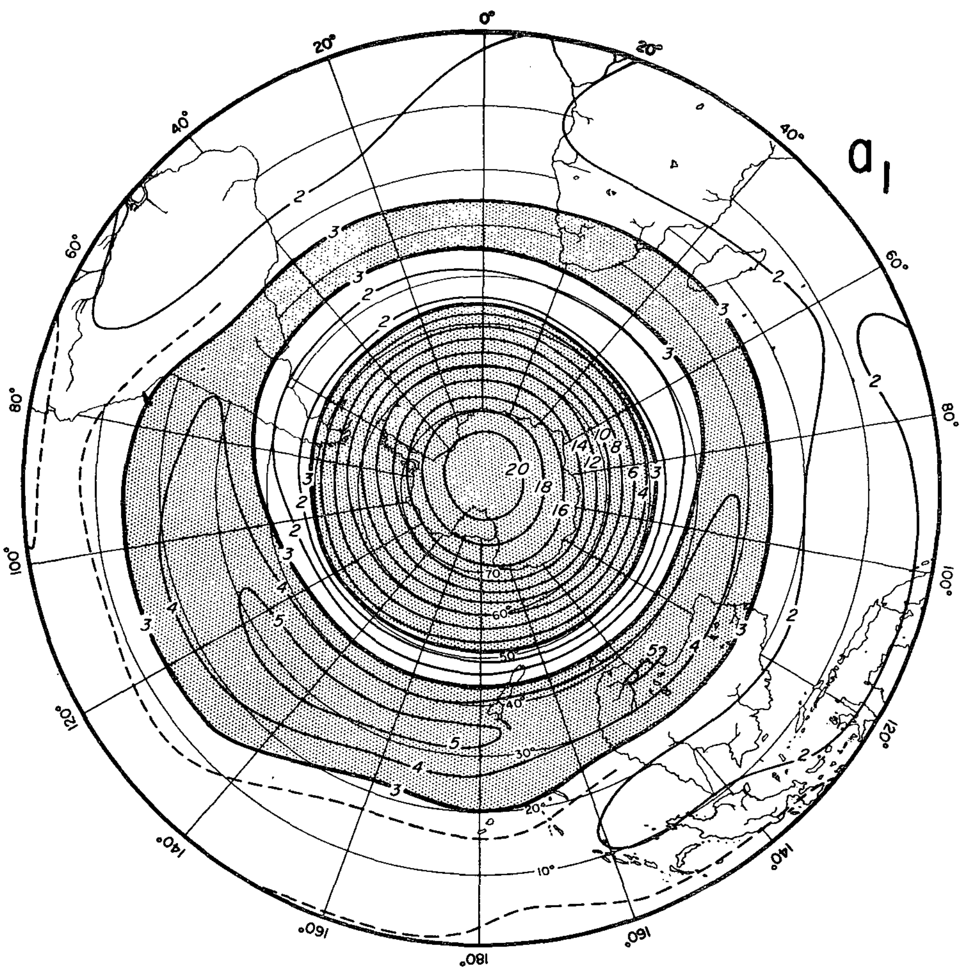

FIG. 1. Amplitude (°C) of the first harmonic of the 100-mb temperature in the Southern Hemisphere.

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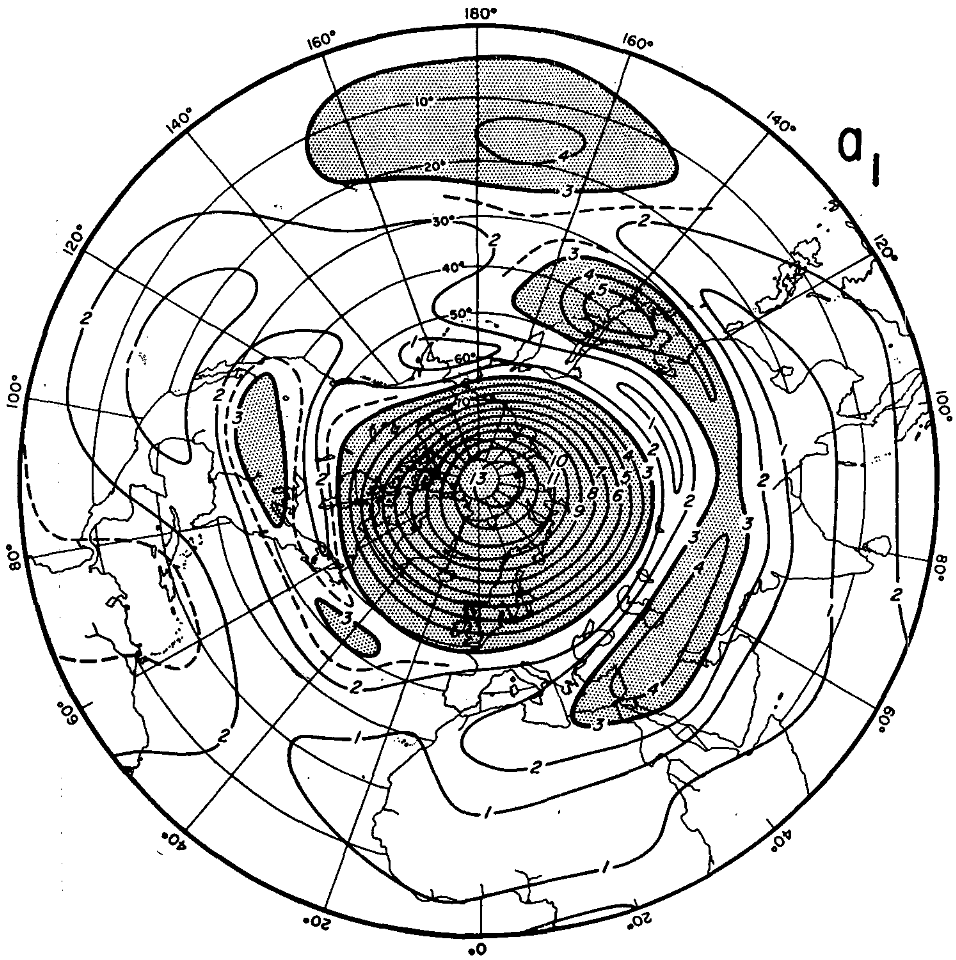

FIG. 2. Same as Fig. 1 except for the Northern Hemisphere.

northern summer than in winter (van Loon and Jenne, 1969). Since this condition continues to 45S, the zonal mean temperature is in phase over the whole range of latitudes between 25N and 45S. Clarkson (1951) noted that the tropical lower stratosphere is warmer in July–August than in January–February, and Gabites (1953) found the highest 100-mb temperatures of the year in August and September between 15S and 45S near 170E.

The purpose of this note is to map out the features noted above. Harmonic analyses were made of the temperature at 100 mb to find the amplitude and phase of the annual cycle (first harmonic) at points 5° of latitude and longitude apart. The sources of the temperatures are two atlantes in the NAVAIR series. The atlas of the Southern Hemisphere (Taljaard *et al.*, 1969) includes upper air data from January 1950 to October 1966; that of the Northern Hemisphere (Crutcher and Meserve, 1970) is based on data from the period 1950–64. This does not mean that all the radiosonde stations worked during the whole of the period.

The amplitude for the two hemispheres is shown in Figs. 1 and 2, and the phase in Figs. 3 and 4; the latter as the date when the harmonic is at its maximum. In both hemispheres marked peaks in the amplitude, roughly between 25 and 40S and between 30 and 45N, lie where the harmonic reaches its maximum in the late winter of the hemisphere. The parts of the Northern Hemisphere where this happens are conspicuous (Fig. 4) because they are surrounded by belts where the phase changes fast. In the Southern Hemisphere there is a similar, rapid change of phase on the poleward side of the peak in the amplitude (Fig. 3), but on the equatorward side the phase merges with that of the tropics.

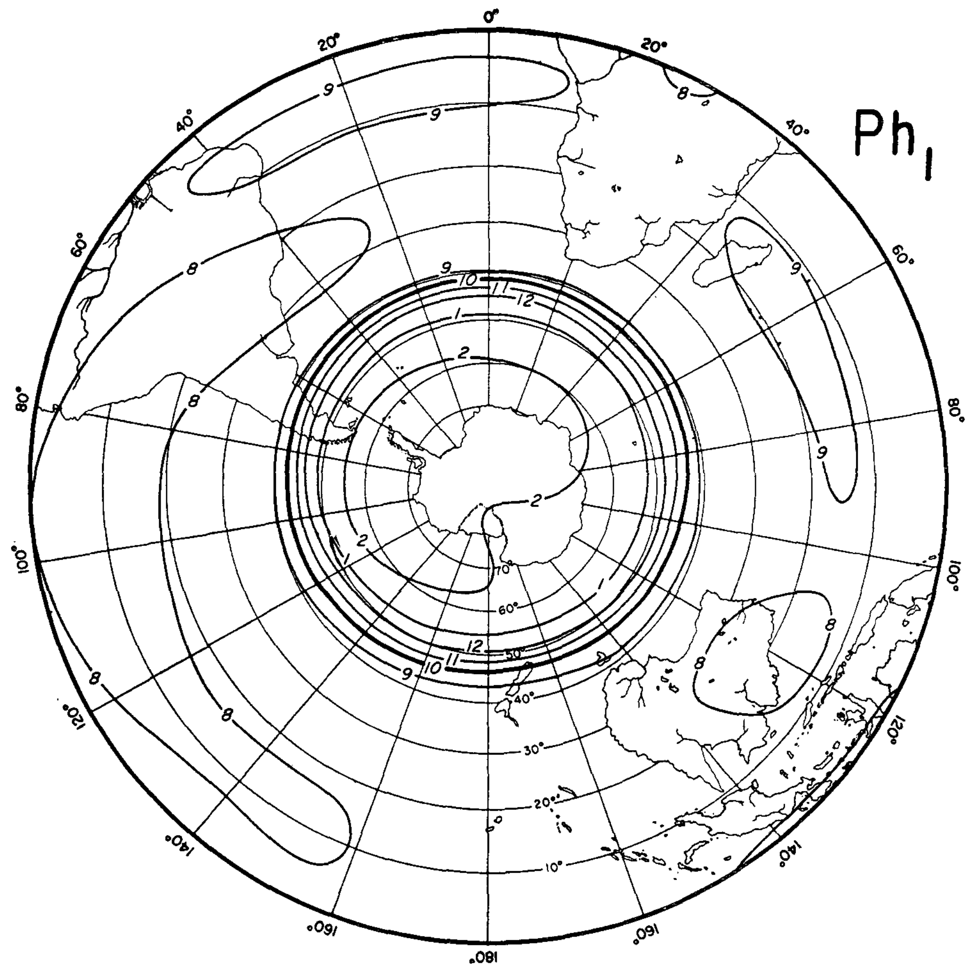

FIG. 3. Phase of the first harmonic of the 100-mb temperature in the Southern Hemisphere shown as the date when the harmonic reaches its maximum. The phase is so computed that 1=1 January, 2=1 February, etc.

The position and shape of the areas where the subtropical peaks in the amplitude occur (Figs. 1 and 2) suggest a connection between the winter maximum in the 100-mb temperature and the strongest subtropical west wind near 200 mb. The vertical shear of the west wind from 200 to 100 mb is larger in winter than in summer in the subtropics. This implies that the equatorward drop of temperature in the lower stratosphere in accordance with the thermal wind relation must be steeper in winter than in summer. In this instance, that seasonal change is accomplished by the temperature rising more from summer to winter at 100 mb on the poleward side than on the equatorward side of the subtropical wind maximum.

The position of the wind maximum at 200 mb in the northern winter is well known; for orientation, there is a map in Fig. 5 of the zonal geostrophic wind at 200 mb in the winter of the Southern Hemisphere.

Reed and Vleck (1969) plausibly explain the annual temperature wave in the low equatorial stratosphere, with its maximum during the southern winter, as an outcome of the stronger mean rise of the air in the equatorial belt during the southern summer. The consequent adiabatic cooling of the lifted dry air in the lower equatorial stratosphere would thus be stronger in the southern summer. They attribute the stronger mean upward motion of the *southern* summer to an assumedly stronger tropical meridional circulation than in the

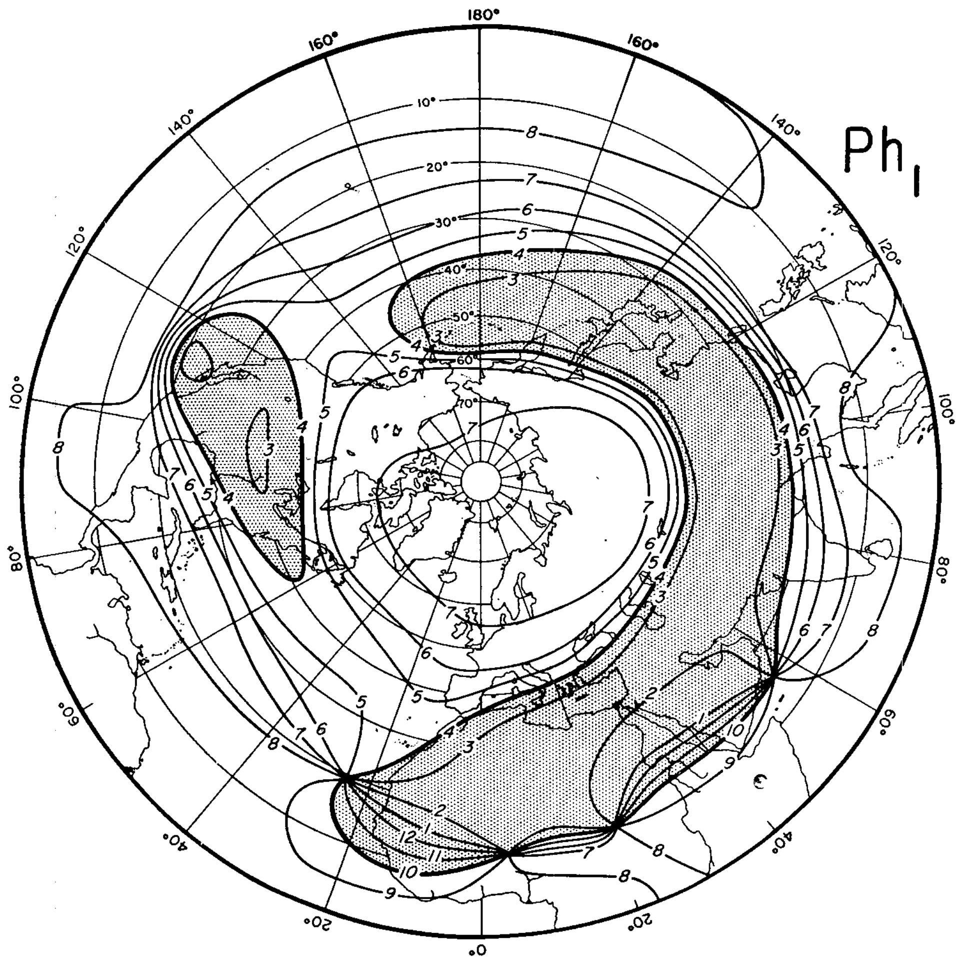

FIG. 4. Same as Fig. 3 except for the Northern Hemisphere.

northern summer. The circumstance, however, that the mean position of the rising branch is well inside the Northern Hemisphere in the northern summer along all of the circumference, but that it is nearer the equator in the southern summer, would *also* speak for stronger upward motion in the equatorial regions during the southern summer—regardless of which extreme season has the stronger meridional circulation in the tropics. In either event the phase of the peak of the first harmonic in the latitudes near the equator merges with that of the southern subtropics, but becomes the opposite of that in the northern subtropics.

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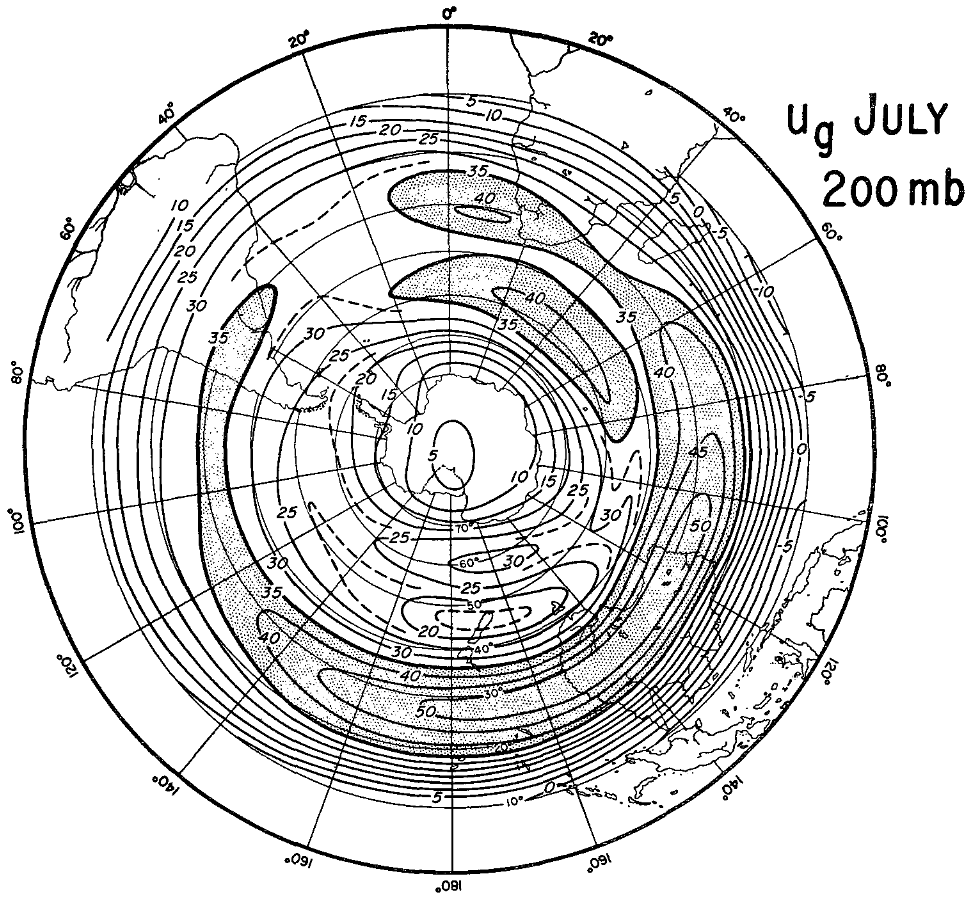

FIG. 5. The zonal component of the geostrophic wind (m sec^{-1}) in the Southern Hemisphere, July (winter) (from van Loon *et al.*, 1970).

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CORRIGENDUM

In the May 1970 issue of *J. Atmos. Sci.*, on page 494 of the article "Ground Level Pressure Fluctuations Connected with Ionospheric Disturbances" by Ivan Tolstoy and Joseph Lau, the footnote should read: Geophysical Fluid Dynamics Institute Contribution No. 23.