LOCAL SUBSIDENCE FLOW IN A SURFACE BOUNDARY LAYER ON THE SLOPED ICE SHEET AT MIZUHO STATION, EAST ANTARCTICA (EXTENDED ABSTRACT)

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Antarctica in the southern hemisphere serves as the major "heat sink" in the thermal balance of this planet. Thus, the transfer of mass and heat from low to high latitudes, as well as vertical air motion in the atmosphere in high-latitude areas, plays the major role in the distribution of atmospheric energy.

RUBIN and WEYANT (1963) calculated the mean value of vertical air motion using radiosonde data from ten Antarctic stations in 1958 during the International Geophysical Year (IGY, 1957–1958). According to them, the maximum value of downward motion of the air mass was about 0.35 cm/s in the middle troposphere for the entire Antarctic atmosphere.

WHITE and BRYSON (1967) inferred vertical air velocities from data obtained periodically by upper-air radiometers and radiosondes at three Antarctic stations during the four-year period, 1959–1962. They computed a mean vertical air velocity for the mean meridional Antarctic atmosphere between 850 and 75 mb. They also showed that the rate of sinking of an air mass was 0.34 cm/s at 850 mb in the atmosphere above 80°S. The above two studies utilized a circular equivalent, with a radius of 2000 km, of the Antarctic Continent.

Meanwhile BUSINGER and RAO (1965) made measurements, using a circular area, smaller in scale, with a radius of 125 m on the Blue Glacier located in the center of Olympic National Park on the northeastern slope of the Mount Olympus massif. They found that vertical downward velocities of air masses on the snow dome were on the order of 1 cm/s at a height of 1 m above the snow surface under conditions of fair weather and no prevailing wind.

In 1980 the present authors who belonged to the 21st Japanese Antarctic Research Expedition, carried out direct measurements of the mean vertical wind

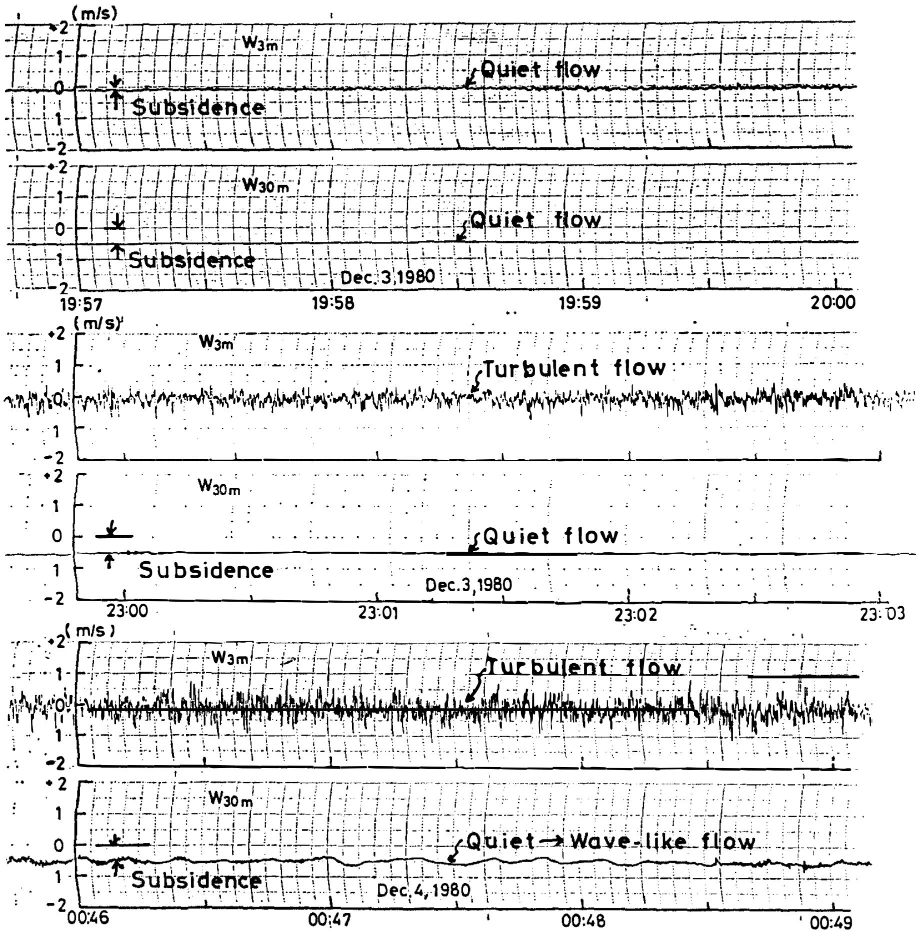

Fig. 1. Variations in vertical wind speed (W_{3m}, W_{30m}, respectively, at the heights of 3 and 30 m) measured by two sonic anemothermometers.

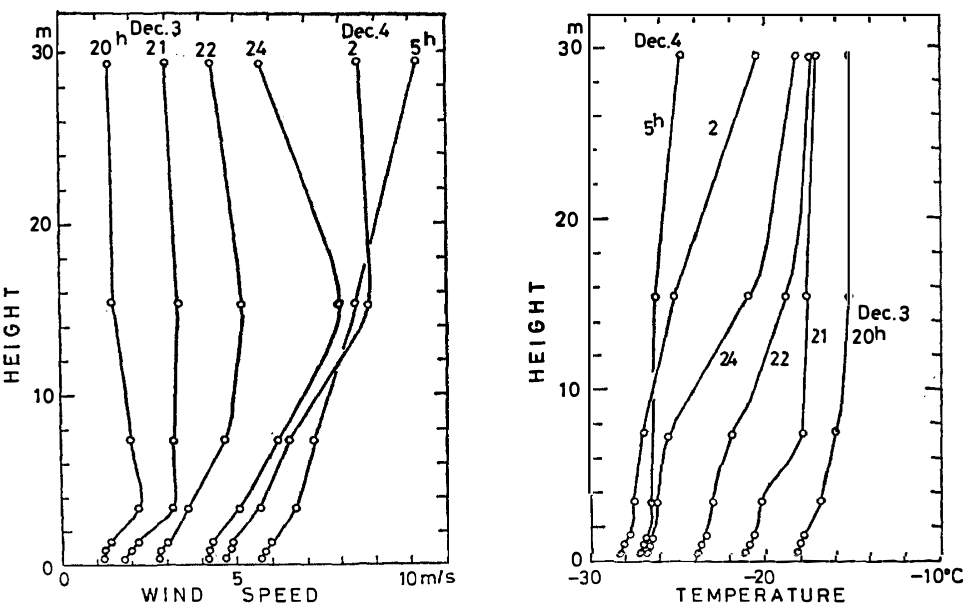

Fig. 2. Profiles of both wind speed and air temperature obtained at a 30-m-high micrometeorological tower at Mizuho Station.

component using two sonic anemothermometers, which they installed on a 30-m-high observation tower at Mizuho Station (70°42′S, 44°20′E; 2230 m above sea level) (MAE *et al.*, 1981). They mounted one each at heights of 3 and 30 m above the snow surface. Figure 1 shows the fluctuating vertical wind speed components obtained simultaneously at the two heights. The data at 3 m (W_{3m}) show the transition from quiet flow accompanied by subsidence of 10 cm/s to turbulent flow resulting from the effect of surface friction. However, the data at 30 m (W_{30m}) maintained quiet flow throughout the night, and subsidence flow was about 50 cm/s. Figure 2 gives examples of profiles of wind speed and air temperature obtained in the same period during the appearance of subsidence flow. Our results indicate that markedly high speeds of subsidence flow were measured compared with the speeds obtained by the investigators mentioned earlier. If a sonic anemothermometer is inclined by θ degrees from the vertical, then the apparent mean vertical wind is not zero even if the real one is zero, *i.e.* $\bar{w}=U\times\sin\theta$, where U is the horizontal mean wind speed. Namely, the apparent mean vertical wind speed measured increases with increasing horizontal mean wind speed. In Fig. 3 the two upper lines show the speeds of subsidence flow to be linearly dependent on the horizontal mean wind speed for $\theta=5°$ and $2°$; the lowest lines shows the slope of the Mizuho Station area ($\alpha=3\times10^{-3}$). The data of direct measurements of speed of mean subsidence flow obtained from November 28 to 29 and from December 3 to 4, 1980, show that the speed is not dependent on the horizontal mean wind speed, as shown in Fig. 3; therefore, it appears that the sonic anemothermometer was not inclined from the vertical.

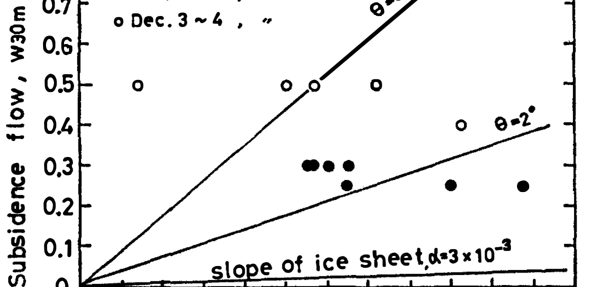

Fig. 3. Plots of subsidence flow speed vs. horizontal wind speed at the height of 30 m. Two solid lines mean that, if the sonic anemothermometer inclines from the vertical, for example, by $\theta=5°$ and $\theta=2°$, then mean vertical winds appear. One of the solid lines shows the relation between vertical wind speed and horizontal wind speed in the case in which the slope of the Mizuho Station area ($\alpha=3\times10^{-3}$) is taken into consideration.

These large values shown in Fig. 3 are capable of providing information about subsidence flow occurring on the local scale of 40 km if the thickness and speed of outflow in the horizontal are 500 m and 10 m/s, respectively. Namely, the mean subsidence velocity $\bar{w}$ over the area of the circle with radius R ($=20$ km) at the top of the outflow layer (H; thickness of 500 m) is given by

$$\bar{w}=\frac{Q}{\pi R^2}=\frac{2HU}{R},$$

where Q ($=2\pi RHU$) is the flow rate of air with horizontal velocity ($U=10$ m/s) that leaves from the circumference of the circle.

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