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SOUTH POLE MICROMETEOROLOGY PROGRAM: DATA ANALYSIS[1]

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Abstract. At the South Pole station in 1958 observations of wind and temperature in the lowest 8 meters of the atmosphere and of temperature in the upper 8 meters of the snow were recorded. The curvature characteristics of wind and air-temperature profiles (as measured by Deacon numbers) were analyzed in great detail; to express stability (and its change with height), Richardson number computation was employed, because it takes into account wind shear as well as temperature lapse rate. It was found that moderate to extreme stability represents the average condition at South Pole, resulting in a significant tendency to suppress mechanical turbulence. The maximum inversion was 14.7°C in the lowest 8 meters. Stability tends to be greatest in the early winter and at periods with lowest temperatures. A new method was developed for evaluation of the aerodynamic roughness parameter from wind data showing stability-affected profile curvature. The computed z_0 for the snowfield near South Pole has a mean value of 0.014 cm and is nearly constant for a wide range of bulk stability. In general the wind profile curvature decreases as stability increases. However, with great bulk stability, the wind profile Deacon number as a function of height reaches a minimum near 0.25 and then increases upward, in spite of height-increasing Richardson number. Temperature profile Deacon numbers do not show this behavior, indicating that the change of shearing stress with height (relative to the ground drag) must be an important factor in wind profile structure.

An analysis of the relation between winds near the snow surface and at the top of the inversion (on the average near 600 meters above ground, using aerological soundings) demonstrates that air motion in the lower atmosphere is controlled by surface friction and by the wind in the free atmosphere, modified by thermal winds due to horizontal temperature gradients resulting from the general slope of the terrain.

Eddy heat flux was computed, on the basis of estimated surface stress (using Kármán's constant, with Deacon-number-corrected wind shear) and vertical differences of potential temperature and wind speed, in the lowest layers where a similarity requirement was satisfied. To obtain representative climatological means of eddy heat flux, a statistical relationship was established between Quartermaster observations (concerning profile structure versus bulk stability) and U. S. Weather Bureau standard observations, using conveniently defined coefficients of stability and transfer of momentum and heat. For February through November, monthly values of surface stress ranged from 0.825 to 0.103 dyne/cm^2, monthly values of eddy heat flux from 0.0052 to -0.0239 ly/min.

Heat movement in the substratum was investigated by harmonic (Fourier) analysis of snow-temperature variations. A new method was derived which permits us to determine the layers in which genuine conduction of heat prevails. At South Pole it was found that the upper 4 meters of snow respond to other influences (radiation absorption, packing, etc.) in addition to genuine heat conduction.

To establish the surface energy budget, hourly values of net radiation from the U. S. Weather Bureau net radiometer were used. Monthly means of net radiation (R_0) were compared with those of eddy heat flux (Q_0) and heat flux in the snow (S_0) (which is a relatively small term). The latent heat flux (E_0), when treated as a remainder in the balance, indicates slight but significant deposition of hoarfrost in midwinter at South Pole, as illustrated by the following mean values: $R_0 = -56.5$, $Q_0 = -51.0$, $S_0 = -2.5$, $E_0 = -3.0$, all in ly/day. The error tolerances and possible systematic effects in these estimates are discussed, and a comparison is given for three other antarctic stations.

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curve, and produced a level of minimum temperature at 1.5 meters. As this minimum moved farther down it became less distinct, appearing at 2 meters by April 1, 3 meters by May 1, 5 meters by May 31, and 8 meters by August 1. Thus a nearly uniform temperature gradient in the 8-meter layer was established about 1 month before sunrise. Then the cycle reversed. Warming above and continued cooling below caused a level of maximum temperature at 1-meter depth by September 30, 2-meter by October 31, 3-meter by November 30, 5-meter by December 31, and 8-meter by January 30. These

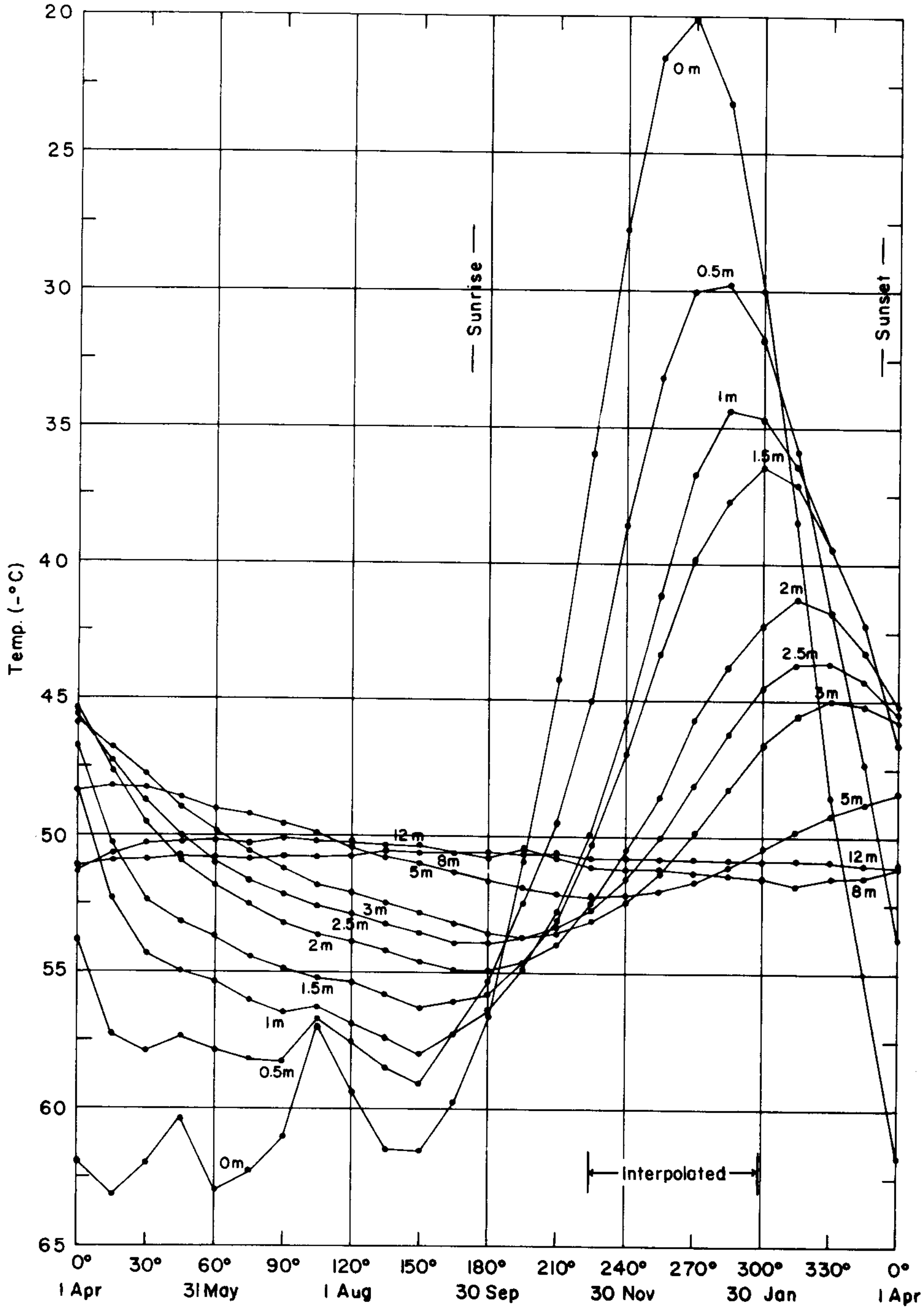

Fig. 18. Subsurface temperature versus time at South Pole, 1958.

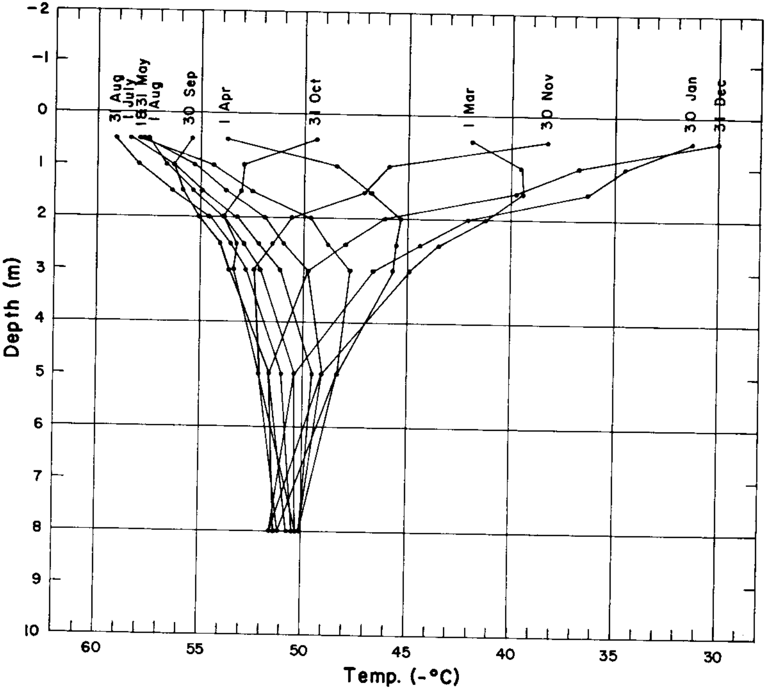

Fig. 22. Tautochrones, South Pole.