ZONAL WIND SPEED AT HIGH LATITUDES IN THE VENUSIAN ATMOSPHERE FOUND FROM RADIO OCCULTATION (RO) MEASUREMENTS OF THE VENERA -15 AND -16 SPACECRAFT.

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Introduction: The available data indicate a zonal rotation of the Venusian atmosphere from East to West. The wind speed changes almost monotonically with altitude, reaching about 100 m/s at the level of the upper cloud layer. The cyclostrophic balance approximation and the results of temperature and pressure determination from the radio occultation data of the Pioneer Venus Orbiter were also used to determine the zonal wind profiles by [1, 2]. The zonal wind speed at altitudes from 40 to 80 km in the latitude range from 15° to 85° under the assumption of the Northern and Southern hemispheres symmetry was determined by [1]. The authors of this work indicated that the radio occultations used in their study had been carried out in general in the Southern hemisphere at low latitudes and in the Northern hemisphere at high latitudes. Nevertheless, they did not exclude the possibility of hemispheric asymmetry at high latitudes. In this connection, it is interesting to determine the zonal wind speeds for the Northern and Southern hemispheres separately.

Processing and analysis of experimental data: For determining the zonal wind speed we used the cyclostrophic approximation balance and RO measurements at latitudes from 60° to 87° in 17 regions of the Southern hemisphere, and in 27 regions of the Northern hemisphere of Venus. These measurements were made during the period from October 1983 to September 1984. Orbits of the Venera-15 and -16 spacecraft were such that the entries into occultation took place in the Northern hemisphere and exits in the Southern one. Some details about the Venera-15 and -16 spacecraft investigations, the dates and location of RO measurements in latitude, longitude, solar zenith angle can be found in [3–6]. The aim of this work is to determine the zonal wind speed in the polar and near-polar regions of Venus at altitudes from 50 to 80 km from RO data of the Venera-15 and -16 spacecraft. To find the zonal wind speed, we used the altitude profiles of temperature and pressure obtained from the processing of RO data at a decimeter radio wavelength (λ = 32 cm). The characteristic properties of the radio occultation technique and of the experimental data processing are described in [3, 6]. The result of the RO data processing are temperature T and pressure P altitude profiles, which give the values of these parameters at various altitudes in the interval from 40 to 90 km [3]. In the range of pressure variations corresponding to this altitude interval we marked 28 fixed "standard" pressure levels from 1098 to 5 mb.

The temperatures at these pressure levels was found by linear interpolation of temperatures nearest to the chosen fixed levels. The number of chosen levels allowed the retention of individual characteristics of the temperature profiles. Fig. 1 shows the temperature dependence on the latitude φ at four pressure levels (602, 181, 122 and 55 mb) in the Southern hemisphere. The temperature values obtained from RO data at the corresponding latitudes and pressures are shown by circles and squares in Fig. 1. The circles apply to the curves 1 and 3, the squares – to the curves 2 and 4. The curves describing the latitude-temperature dependence are the cubic polynomials fitted by the least squares technique to the experimental data. These least squares fits were used by us to obtain the latitude-temperature gradients. The quality of fitting is defined by the rms variance σ on every "standard" pressure level (representative values of σ are drawn as error bars for each curve in Fig.1 and 2).

The fitted curves in Fig. 1 show the latitudinal dependence of the temperature at different pressure levels. The temperature decreases with increasing latitude at a pressure level 602 mb in the latitude interval from 66° to 82°. This trend is characteristic also for temperature-latitude dependence at lower pressure levels down to 180 mb. The transitional region lies within the pressure range of 180 to 120 mb, corresponding to the altitude interval from 61 to 63 km, where a change of the sign of temperature-latitude gradient occurs in the latitude interval from 66° to 82° as shown in Fig. 1 (curves 2 and 3). Small temperature contrasts between the polar and near-polar atmosphere are characteristic of the transitional region [3]. In the Southern hemisphere the temperature increases with increasing latitude at fixed pressure levels from 120 to 30 mb, which correspond to altitudes from 63 to 70 km.

For determining the zonal wind speed in the Northern hemisphere, we use the temperature and pressure data obtained from radio occultations in 27 regions at latitudes greater than 60° [3]. The circles refer to curves 1 and 3, and squares to curves 2 and 4 in Fig. 2. The temperature decreases with increasing latitude at the level of 602 mb in the latitude interval from 69° to 84°. This trend continues at lower levels down to 220 mb. A change of sign of the latitude-temperature

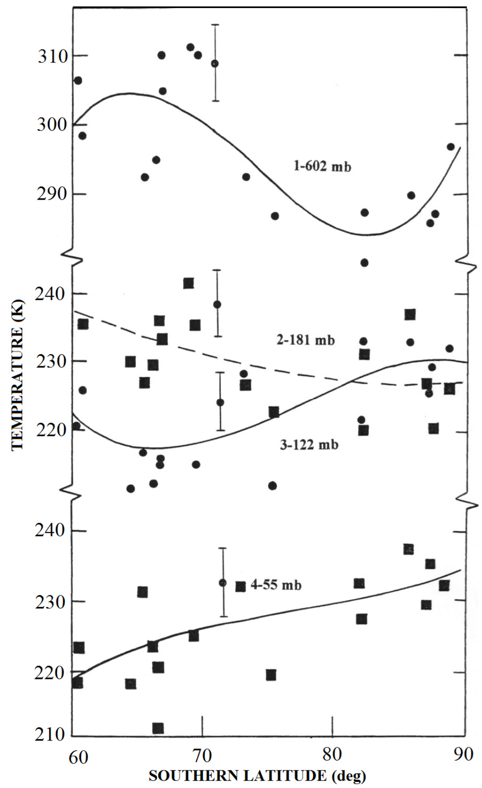

Figure 1. Profiles of temperature on latitude at four pressure levels in the Southern hemisphere of Venus: 1–602 mb; 2–181 mb; 3–122 mb; 4–55 mb.

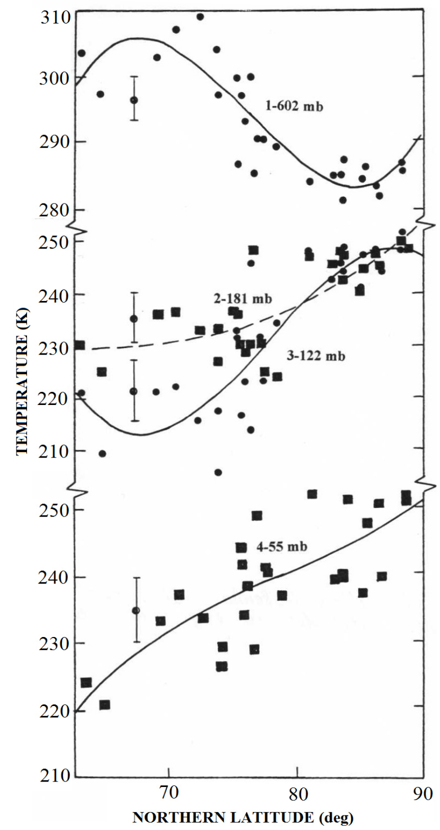

Figure 2. Profiles of temperature on latitude at four pressure levels in the Northern hemisphere of Venus.

gradient at latitudes from 69° to 84° occurs in the pressure range from 220 to 180 mb. A transitional atmospheric region for which small values of the latitude-temperature gradient are characteristic, exists in this pressure range corresponding to the altitude interval from 60 to 61 km. Curve 2, corresponding to the upper boundary of this transitional region, illustrates this tendency. A temperature rise with increasing latitude (curves 3 and 4) is observed at pressure levels lower than 180 mb. By comparing the latitude profiles of the temperature in the Northern and Southern hemispheres one notices that the latitude-temperature gradients are negative at pressures from 1100 to 220 mb at latitudes from 70° to 80°, and that their values are almost the same at corresponding latitudes and pressure levels in the Northern and Southern hemispheres of Venus. It testifies to a symmetry of the atmospheric thermal structure of both hemispheres in this pressure range. However, this symmetry no longer exists at pressures lower than 220 mb, i.e. at altitudes higher than 60 km.

Conclusion: Temperature and pressure data in the Venusian atmosphere obtained by the radio occultation method using the Venera-15 and -16 spacecraft from October 1983 to September 1984 are used for a wind speed analysis. The altitude and latitude profiles of zonal wind speed in the middle atmosphere of Northern and Southern hemispheres of Venus at altitudes from 50 to 80 km in the latitude interval from 60° to 85° have been found.Wind speeds were determined assuming cyclostrophic balance of the planetary atmosphere. A jet with a maximum speed 100–115 m/s located at altitude of approximately 60 km at 73°–75° N is shown to exist in the Northern near-polar atmosphere. Above 65 km the wind speed usually decreases with altitude, as the polar atmosphere in the Northern hemisphere is warmer than the near-polar one at these altitude levels. The speed of zonal wind increases with altitude at high latitudes of the Southern hemisphere above 70 km, showing a possibility of the existence of a jet at altitudes greater than 70 km

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References: [1] Newman M. et al. (1984) *JAS, 41,* 1901–1913. [2] Limaye S.S. (1985) *ASR*, *5,* 51–62. [3] Yakovlev O.I et al. (1991) *Icarus, 94*, 493–510. [4] Gubenko et al. (2001) *Cosmic Res., 39,* 439–445. [5] Gubenko et al. (2003) *Cosmic Res., 41,* 135–140. [6] Gubenko et al. (2008) *JGR, 113,* E03001.