

horizontal wind field, the forcing spectrum becomes more complicated, and a spectrum of waves is generated that is not a direct reflection of the spectrum of the surface height variation. Model spatial resolution required depends on the amplitude of forcing; for very nonlinear cases considered, vertical resolution was 250 m, and horizontal resolution was slightly greater than 1 km. For smaller forcing amplitudes, spatial resolution was much coarser, being 1 km in the vertical and about 10 km in the horizontal. Background static stability and mean wind are typical of those observed in the Venus atmosphere.

Computations to date have considered a periodic sinusoidally varying surface height. Such forcing is relevant to the situation in which surface topography consists of a series of ridges extending over a region largely compared to the dimensions of each individual ridge. Because of the particular variations with altitude of static stability and mean wind in the Venus atmosphere, an evanescent region exists between about 15 km altitude and just below the cloud layer for waves having horizontal wavelengths less than about 100 km. This means waves generated at the surface having short wavelengths do not propagate to cloud levels with significant amplitude. At longer wavelengths (> 100 km), waves easily reach cloud levels and above. With surface wind speeds of several m/s and surface slopes having values in the vicinity of 0.02 (not unreasonable values in the higher mountainous regions of Venus such as Aphrodite), wave amplitudes are large enough to cause considerable nonlinear effects. From the surface to cloud levels and above, wave spatial patterns are relatively complicated and the spectra exhibit much shorter wavelengths than typical of the surface height variation, the dominant wavelength being somewhat less than 100 km for a surface height wavelength of 400 km. For this same case, maximum vertical winds at middle cloud levels associated with the waves are typical of the 2–3 m/s vertical winds observed by the VEGA balloon as it overflew the Aphrodite region. Wave horizontal wind amplitude at middle cloud levels is about 10 m/s. To date, with reasonable values of the surface forcing, we have not been able to generate waves having sufficient amplitude to cause wave breaking. Wave-induced mean winds are largest near the surface, and can become comparable to the low-altitude background wind.

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MIDDLE ATMOSPHERE OF VENUS AND ITS CLOUDS: LATITUDE AND SOLAR TIME VARIATIONS. L. V. Zasova, Space Research Institute, Russian Academy of Sciences, Moscow 117810, Russia.

The structure of the middle atmosphere of Venus and its upper clouds, derived from infrared spectrometry (from 250 to 1650 cm^{-1}) on Venera 15 [1–5] are discussed. Poleward increasing of temperature, monotonous on the average, at altitudes $h > 70$ km changes to poleward decreasing at $h < 60$ km. Temperature inversion at 85–95 km at low latitudes was observed as a half-day wave with two minima near 9:00 a.m. and 9:00 p.m., with a more pronounced morning feature. At high latitudes the inversion with temperature minimum near 64 km exists. There are several minima depending on solar time, but the most pronounced is one on the dayside, where the depth of inversion may reach more than 40 K (near 10:00 a.m.; we have no observations closer to noon). Another minimum is situated symmetrically on the nightside. Usually in the polar region the temperature inversion is situated deeper in the atmosphere (near 62 km). A jet at latitudes 50° – 55°N divides Venus into two drastically different latitude zones: pretty homogeneous at 56–95-km zone $< 50^\circ\text{N}$ with diffuse clouds and daily temperature variations

near cloud tops about several degrees, and zone $> 55^\circ\text{N}$ (where such dynamic structures as cold collar and hot dipole were observed) with dense low clouds (with the exceptions of the regions at 55° – 80°N outside the cold collar).

We separate Venus into four latitudinal zones with approximate latitude boundaries, where the different IR-features were observed. They are characterized by different cloud scale height, H , and observed position of upper boundary of clouds (optical thickness is reached unit): $h(1152)$ is for spectral region with maximal aerosol absorption coefficient (1152 cm^{-1}), and $h(365)$ for the spectral region with minimal aerosol absorption coefficient (365 cm^{-1}). They are

1. $l < 55$ – rather homogeneous, low and mid latitudes, with $H_a = 3.5$ – 4 km, and $h(1152) = 67$ – 69 km, and $h(365) = 57$ – 59 km.

2. $55 < l < 75$ – the most inhomogeneous latitudes as for aerosol, and for temperature. Two types of areas are found here: (1) cold collar, with $H_a \leq 1$ km, $h(1152) = 60$ – 62 km, and $h(365) = 58$ – 60 km, and (2) inhomogeneous areas outside cold collar with $H_a \geq 4$ – 5 km, $h(1152) = 70$ – 72 km, and $h(365) = 56$ – 60 km.

3. $75 < l < 85$ – the hot dipole. The temperature is only several degrees higher in hot dipole than outside it near the upper boundary of the clouds at the same levels in the atmosphere. The clouds are situated lower and have larger scale height. For the hot dipole $H_a = 1$ – 1.5 km, $h(1152) = 59$ – 63 km, and $h(365) = 56$ – 58 km, and outside it, $H_a \leq 1$ km, $h(1152) = 63$ – 64 km, and $h(365) = 61$ – 63 km.

4. $l > 85$ – usually the clouds here have a very sharp upper boundary, with $H_a \leq 0.5$ km, $h(1152) = 62$ – 64 km, and $h(365) = 62$ – 64 km.

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SO₂ IN THE MIDDLE ATMOSPHERE OF VENUS: IR MEASUREMENTS FROM VENERA 15 AND COMPARISON TO UV. L. V. Zasova¹, V. I. Moroz¹, L. W. Esposito², and C. Y. Na², ¹Space Research Institute, Russian Academy of Sciences, Moscow 117810, Russia, ²Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO, USA.

Two sets of measurements of SO₂ bands in the Venus spectra are presented and compared: IR spectra obtained on the USSR Venera 15 orbiter [1–3] and UV spectra from the American Pioneer Venus orbiter and sounding rockets [4–6]. The 40-mbar level was chosen as a reference level for comparison. The UV data are referred to this level. There are three SO₂ bands in the infrared spectrum: at 519 cm^{-1} , 1150 cm^{-1} , and 1360 cm^{-1} . The levels of their formation in the atmosphere may differ significantly, more than 10 km. In principal, it allows us to obtain the vertical profile of SO₂ from 58 to 72 km, in the best case. So the IR data are sensitive to the 40-mbar level (maybe with exception of the cold collar). For low and mid latitudes, both data give a mixing ratio, f , of several tens of ppb and SO₂ scale height (H) of 1.5–2.5 km, which is in a good agreement with the photochemically predicted values [7]. This confirms that the photochemical processes dominate in the upper clouds at low and mid latitudes. Both data show an increase of abundance to several hundreds of ppb at high latitudes, but there are differences in scale-height latitudinal behavior. Decreases to 1 km are seen according to UV, but according to the IR the high latitudes of Venus are seen to be strongly inhomogeneous. Dynamic features with low position of