WHAT PHYSICAL PARAMETERS OF SATURN'S CLOUD LAYER AT THE 2010 EQUINOX DIFFER FROM PREVIOUS THREE? A. P. Vidmachenko[1]. [1]National University of Bioresources and Nature Management of Ukraine, 03041, Kiev, st. Heroes Oborony, 15.

Comparing the photometric and polarimetric spectral data obtained under different conditions of Saturn's illumination by Sun with results of our calculations [4], we determined some optical parameters of the atmosphere for planet's equinox moments in 1966, 1980, 1995, and 2010. It was assumed that reflected radiation in spectral range of 300-890 nm is formed in the atmosphere, represented by pair of homogeneous layers. The upper layer is an optically thin gas layer with an optical thickness of scattering component τ_c; and lower one is a semi-infinite gas-aerosol layer, which is characterized by the albedo of single scattering of aerosols in absorption band ω_ν and in continuous spectrum ω_c. Scattering indicatrix $\chi(\alpha)$ is calculated for particles with refractive indices $1.35 \le n_r \le 1.42$, with normal-logarithmic function distribution in size with an average radius of ~1 μm and dispersion of size 0.12. Were calculated volumes scattering coefficient in clouds $\sigma_0(\lambda)$, parameter $\beta=\sigma_g/(\sigma_g+\sigma_a)$, volume concentration of aerosols n, $R_{\nu 0}(\lambda)$, spectral brightness coefficients $r_c(\lambda)$ in center of belts at equator and at moderate latitudes in absorption bands and in continuous spectrum. Also, ω_c, $\omega_{\nu 0}$ and $\tau_{\nu 0}$ was found. Here we used the following notation: $\omega_\nu=\sigma_0/(\sigma_0+\kappa+\alpha_\nu)$, $\omega_c=\sigma_0/(\sigma_0+\kappa)$,$\sigma_0(\lambda)=(\sigma_g(\lambda)+\sigma_a(\lambda))$ – volume scattering coefficient; κ and α_ν – volume absorption coefficients, respectively, in continuous spectrum and in absorption band; σ_g and σ_a are volumetric scattering coefficients, respectively, for gas and aerosol. The calculations assumed that the aerosol consists of ammonia, which almost does not absorb in the visible range, and a small number of absorbing impurities. The best agreement between the calculated values and observational data was obtained under the condition that the above-clouds haze is either purely gaseous or containing an aerosol with a size $r_0 << 0.1$ μm. Then the observed differences in the latitudinal belts of Saturn in different λλ can be explained by the difference in the volume concentration of aerosols in the clouds, the values of the optical thickness of the gas above the clouds τc, as well as of spectral values of imaginary part of the refractive indices n_i of cloud particles [6, 19]. We estimated the degree of differences by the distributions of brightness on the disk obtained at the equinoxes of 1966, 1980, 1995, and 2010. in the continuous spectrum and in the absorption bands at 619, 725 and 890 nm. In equinox seasons of 1966, 1980 and 1995 in previously closed equatorial regions – impurities were usually 15-20% more than in other regions. In 2010 in southern hemisphere, which had been illuminated by Sun for 14 years, for some reason more absorbing impurities remained at latitude of about -9°: $n_i=1.70 \cdot 10^{-4}$ versus $1.51 \cdot 10^{-4}$ in 1980. Where as in the previously closed equatorial zone, in 2010, number of absorbing impurities – for an unknown reason – did not increased. An increase in absorption by methane and hydrogen [10] indicates that line-of-sight aerosols in clouds and in fog above the clouds were much less obscured by ammonia and methane gases. That is under rings in both hemispheres, visible layer of clouds lies deep, and above-cloud haze there is very thin. At all equinoxes, all orbital characteristics of Saturn are repeated [5, 17], but response to their change for some reason differs only in 2010. The southern hemisphere (as before 1980) was directly illuminated by Sun, and by equinox it had accumulated 25% more energy from Sun than northern hemisphere during the same period. This was also the case for opposite hemispheres before equinoxes in 1966 and 1995. But in 2008-2010, after clouds in the northern hemisphere came out from under rings to direct solar illumination, the expected formation of high clouds did not occur; the ammonia gas did not condense and then did not turn into ice. That is, gaseous ammonia near the tropopause remained quite "warm" and could not turn into ice. Our analysis of observational data carried out in [16, 18] indicated the existence of a delay effect in changes in the atmosphere of Saturn [11, 12-14, 20-23]. The time of such a delay at different altitude levels in the atmosphere varies from several months to several years. Images of Saturn obtained by the spacecraft (SC) "Cassini" [5] in 2010 showed a weakening of convection in the atmosphere. This could well lead to a change in the bulk density of the clouds and cause the clouds to remain below, and the optical thickness of the haze above the clouds could increase. These processes could lead to a change in the intensity of absorption bands [9]. Due to the difference in the value of the period of changing the seasons on Saturn (29.45 years) and the solar activity cycle (SA) (more than 11 years), the energy inflow to different hemispheres of Saturn could differ greatly due to the fact that the moments of equinox in different years fell on different parts of the SA cycle. The radiation constants of Saturn's atmosphere at different pressure levels depend on temperature, chemical composition, and other conditions, decreasing from almost a decade at cloud level – to months near the tropopause, and few days in the stratosphere. Saturn is characterized by low temperatures in photochemically significant regions of the atmosphere. Therefore, it is characterized by photochemical processes, mainly with the participation of hydrocarbons and ammonia. Note that, for example, polyacetylenes begin to absorb solar radiation from wavelength 400 nm, while hydrocarbons only start from 180 nm [15]. This is why the solar cycle, orbital motion and rings can cause compositional changes in the upper atmosphere. And the resulting photochemical haze can additionally change the access of the energy coming from the Sun to the layers in the atmosphere where the weather is formed. We assume that it is in this way that both direct and indirect influence of changes in the illumination of the atmosphere by the Sun on the structure, kinematics and dynamics of visible clouds is realized. So, at equinoxes 1966, 1980 and 1995 the SA index R was equal, respectively, 100, 150, 20. In 2010 Sun was in the SA minimum at R≈0, and the influence of solar irradiation on Saturn's atmosphere was minimal for 4 equinoxes in 1964-2020. At the same time, convection in the atmosphere of Saturn in 2010 was at the lowest possible levels [1, 5]. Therefore, coming out from under the rings, the clouds in winter northern hemisphere of the planet remained deep, in a "frozen" state in the absence of active changes on the Sun. Such processes are most noticeable in the ultraviolet (UV) region of the spectrum. Therefore, the previously closed inactive cloud layer remained at the same deep level, well below the tropopause. This allowed the terrestrial observer to register the methane-ammonia gas layer above these clouds [9]. Observations in the thermal region of the spectrum from Voyagers and Cassini made it possible to study their vertical distribution at pressures of 50-750 mbar [20]. The results showed the presence of a 10 K tropical warming near the tropopause, which occurred in one Saturnian year from "Voyager" to "Cassini". Below the tropopause, the atmosphere also showed slight fluctuations. Thus, warming at a latitude of about -15° in the southern hemisphere at the level of clouds with a pressure of 360 mbar amounted to 5 K, and 2 K – at a latitude of +15°. At latitudes between +10° and -10° at levels with pressures of 150 mbar and 750 mbar, there was a cooling of ~2 K. A significant change in atmospheric temperature by 10 K within one year – is 2-3 times greater than the usual seasonal change on several K in the same regions [3, 5]. That is, in addition to seasonal changes, Saturn has strong temporary changes that differ from the semiannual seasonal fluctuations [7]. Analysis of the data [20] shows that the heat wave "came" from the deep inner layers of the atmosphere, and as a result, both the southern and previously shaded by rings northern regions of the planet were warmed up "from the inside" to high altitudes, preventing the visible clouds up.

Analysis of the distributions of methane and UV absorptions in visible clouds of Saturn in 1964-2020 showed that the meridional course of absorptions at the equinoxes of 1966, 1995 have an antisymmetric course to the data obtained at the equinox of 1980. Quite unexpectedly, at the 2010 equinox, there was no difference in changes in methane and UV absorption in the northern and southern hemispheres of Saturn (similar to that obtained in 1980). Although the physical and orbital characteristics of the planet are actually repeated at all 4 equinoxes, they manifested themselves in different ways. And in 2010, after the clouds came out from under the rings, the expected formation of high clouds – did not happen. Observations of the Voyager and Cassini spacecraft showed that at the tropopause levels, the tropical regions of Saturn's atmosphere warmed up by more than 10 K in one Saturnian year (from 1980 to 2010). This warming in the tropopause substantially altered atmospheric stratification and stability, and affected the dynamics of the upper troposphere. Estimates show that taking into account convection and condensation conditions can change the dynamic time scale in the atmosphere of Saturn from tens of hours to several years. At the SA minimum, convection significantly decreased, and therefore mixing in the atmosphere of Saturn was virtually absent. This is exactly the picture we observed in 2010 in his northern hemisphere.

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