Вариации оптической и инфракрасной прозрачности атмосферы Земли под действием космических лучей и изменение термодинамических параметров атмосферы *И.В.Кудрявцев* Физико-Технический Институт им А.Ф. Иоффе РАН, С.- Петербург, Россия



Figure 3. Variability over a solar cycle in the vertical profiles of Ion pair production over Thule, which is situated at a high magnetic latitude (adapted from Neher, 1971). Due to geomagnetic shielding, the levels of ionisation are reduced at lower latitudes, but essential features in the vertical profile are similar.

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High-Pass-Mode (HPM) mass spectra of positive ions, obtained by mass spectrometric measurements in the upper troposphere and additionally 3 modeled spectra for H_2SO_4 concentrations of $1*10^6$, $3*10^6$ and $1*10^7$ cm⁻³. Spectrum 1: Reference case, ions up to an m of 400 are present. Spectrum 2: Massive ion event, ions up to a m of 2500 are present (*S. Eichkorn et al*, 2002)



Fig. Mean size distributions for cases satisfying the criteria for recent new particle formation: mid- and high-latitude UT/LS (7 to 13 km), tropical troposphere (7 to 17km) and high-latitude stratosphere (17 to 21km). Results from a simulation of the IIN model after 2-day nucleation evolution are shown for a comparison with the midand high-latitude UT/LS case. The model uses _80% of the measured peak noontime *P*H2SO4 and the other average conditions observed for samples showing the feature of new particle formation (table S1). (**Inset**) The average size distribution at the mid- and high latitudes for samples showing no recent particle formation. (*Lee et al, 2003*)



Fig.2. Comparison of measured and simulated particle- size distributions for two cases: high and low ultrafine particle production. (**A**) Particle number-size distributions measured over 18 minutes on 25 January 2000 at 11.2 km, latitudes from 59°N to 60°N, and longitudes from 4°E to 6°E (blue circles). Particle size distributions as a function of time as simulated by the IIN model (black curves). The model uses a peak noontime P_{H2SO4} of 300 cm⁻³ s⁻¹, corresponding to [OH] of two-thirds of the measured value and a fractional sun exposure of 0.25. Other input parameters, including a background particle mode, were as measured in flight (table S1). The $[H_2SO_4]$ derived from the model is ~1*10⁶ cm⁻³. (**B**) Particle-size distributions measured over a 12-minute period on 10 December 1999 at 12.5 km, latitudes from 67°N to 70°N, and longitudes from 19°E to 22°E (red triangles). Particle-size distributions as a function of time as simulated by the IIN model, initialized with parameters measured aboard the aircraft (table S1), (black curves).

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Fig. IR spectrum with enhanced ionisation divided by spectrum from ambient background ionisation, showing areas of enhanced absorption at 12.3 and 9:1 mm (810 and 1095cm⁻¹). The absorption at 13 mm is due to CO_2 . Absorption bands, likely to be from molecular cluster-ions can be seen at 12.3 and 9:2 mm (815 and 1090cm⁻¹) (Aplin and McPheat, 2005)

Fig. Concentration of particles of aerosol larger that 3 nm in diameter, formed during 3 hours





Fig. Long-term variations of the solar radiation input $\delta(SQ)$ in the geographic latitudinal belt j165±688 (thin line) and of GCR intensity dN (dashed line); the thick line displays the 2-yr running average of $\delta(\Sigma Q)$ *S.V. Veretenenko**, *M.I. Pudovkin*, 1999.

It is possible to separate two steps in the process of generation of NO_3^- ion (G.A.M. Dreschhoff1, ...,I.V. Koudriavtsev et al, 1999).

At first step the capture of electron by oxygen and nitrogen molecules and origination of O_3^- takes place

$$e^{-} + O_2 \rightarrow O^{-} + O; O^{-} + O_2 + M \rightarrow O_3^{-} + M (M=N_2,O_2)$$

 $e^{-} + O_3 \rightarrow O_3^{-}$
 $e^{-} + O_3 + O_2 \rightarrow O_3^{-} + O_2$

At second step the interaction between ion O_3^- and molecules NO_x takes place. This interaction leads to the origination of the ions NO_3^- and molecules CO_2^- .

$$\begin{array}{c} O_{3}^{2} + CO_{2} \rightarrow CO_{3}^{2} + O_{2}^{2}; CO_{3}^{2} + NO_{2} \rightarrow NO_{3}^{2} + CO_{2} \\ \rightarrow NO_{2}^{2} + ...; NO_{2}^{2} + O_{3}^{2} \rightarrow NO_{3}^{2} + ... \\ + NO_{2}^{2} & \longrightarrow & NO_{3}^{2} + ... \\ O_{3}^{2} & \longrightarrow & NO_{3}^{2} + ... \\ + NO & \longrightarrow & NO_{2}^{2} + ...; NO_{2}^{2} + O_{3}^{2} \rightarrow NO_{3}^{2} + ... \end{array}$$



Рис. Временные серии вэйвлетно-фильтрованные в полосе 55-147 лет (использован базис МНАТ).

А– кривая 1 – H1, кривая 2 - июльская температура в континентальной части северной Фенноскандии [Lindholm and Eronen, 2000]; В – кривая 1 – H1, кривая 2 - средняя температура сезона вегетации в приморской части северной Фенноскандии [Briffa et al., 1992];

(Огурцов,2002)

ОСНОВНЫЕ УРАВНЕНИЯ

$$\frac{dW}{dz} = \alpha_1 \rho (1 + \delta_1) W \quad ; \quad \frac{dA}{dz} = \alpha_2 \rho (1 + \delta_2) (A - fE) \quad ; \quad \frac{dB}{dz} = \alpha_2 \rho (1 + \delta_2) (fE - B)$$
$$dQ = (\alpha_1 \rho (1 + \delta_1) W + \alpha_2 \rho (1 + \delta_2) A + \alpha_2 \rho (1 + \delta_2) B - 2\alpha_2 \rho (1 + \delta_2) fE + (\frac{d}{dz} \lambda \frac{dT}{dz})) dz$$

где *W*- поток солнечного коротковолнового (видимого) излучения;

А. В- потоки инфракрасного излучения, распространяющиеся вниз и вверх; α_1 , α_2 - коэффициенты поглощения видимого и инфракрасного излучения в атмосфере, без учета дополнительного поглощения, вызванного влиянием КЛ; δ_1 , δ_2 - описывает дополнительное поглощение видимого и инфракрасного излучения, вызванное влиянием КЛ; $E = \sigma T^4$, σ - постоянная Стефана-Больцмана; T – температура воздуха; коэффициент f < 1 показывает, на сколько длинноволновое излучение атмосферы меньше чем излучение абсолютно черного тела.

 $\sigma_1 = \beta \sigma$, ; $\tau_{v0} = \beta \tau_0$; , t.e. $\tau_v = \beta \tau$; $\tau(0) = 3.78$, $\beta = \alpha_1 / \alpha_2 = 0.2$

1) Долговременные вариации прозрачности и распределения температуры в атмосфере. dQ =0



Рис. Распределение температуры в атмосфере



Изменение температуры $\Delta T=T-T_1$ для различных значений поглощающего слоя: 1 - $\delta_1 = 0,005$; $\delta_2 = 0$; 2 - $\delta_1 = 0,01$; $\delta_2 = 0$; 3 - $\delta_1 = 0,02$; $\delta_2 = 0$; 4 - $\delta_1 = 0$; $\delta_2 = 0,025$; 5 - $\delta_1 = 0$; $\delta_2 = 0,05$; 6 - $\delta_1 = 0$; $\delta_2 = 0,1$ Кратковременные вариации прозрачности и распределения температуры в атмосфере







Вариации атмосферного давления





Variations of the mean temperature profiles for the anticyclonic conditions before the SCR burst: 1 - on the key day (t=O): 2 - on the third day (t=+3). (M. I. Pudovkin et al, 1996).

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Figure 8. Vertical Profile of ionisation density in the atmosphere. Included are the major ion species at various altitudes (adapted from Viggiano and Arnold, 1995).

$$dQ = \frac{C_v \rho_{\theta} dT}{dt} dz$$

