GASES OF THE MIDDLE ATMOSPHERE AND SHORT-TERM SOLAR RADIATION VARIATIONS

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Now there is no good agreement between theoretical and experimental data of ozone (O3) response to 27(13)-day solar ultraviolet irradiance variations (SUVIV)(Brasseur et al,1987;Hood,1987,1988 a,b;Keating et al,1987). But a few days duration SUVIV (accompinied ,for example,solar flares (SF)) has not been studied yet. So the main purpose of our research is to investigate amplitudinal,duirnal,seasonal,latitudinal and phase parameters of ozone and other trace gases of atmosphere to such short-term SUVIV.

First,our method for revealing O3 response to SUVIV,caused by fast flare processes is discribed(Danilin et al,1987).We using SF as an indicator of solar activity(Gibson,1973). 3B(N) and 2B(N) SF with time interval of more than 6 days between them were chosen from (Solar-Geophysical Data,1971-1984). Given such SF we selected ozone profiles O_{3i} (The Ozone Data for the World,1971-1984) (simultaneously with W and F10.7 data for the same day) in time interval of ± 2 days from SF occurence. Ozone response ε_i was defined as

$$\varepsilon_i=\frac{O_{3i}-\bar{O}_{3i}}{\bar{O}_{3i}}\cdot 100\%, \qquad (1)$$

where $\bar{O}_{3i}$ -month-averaged ozone concentration at i-level(i=9 (height z>42km), 8(37.5km<z<42.6km), 7(32.7km<z<37.5km), 6(28.2km<z<32.7km),TO-total ozone). In this way we analysed 1939 individual measurements for Jan.1971 - Sept.1984 (see Fig.1). It is important to stress statistically represantative ozone profile response (1-1.8%) and TO response time delay deep into the atmosphere.

We used one-dimensional radiative-photochemical model for study trace gas responses to 27(13)-day SUVIV (Danilin,1989). This solar irradiance perturbations were taken in sinusoidal form with spectral profile $\delta(\lambda)$ according to (Hood et al,1988a;Fig.1b) and δ(205nm)=2.57%. The value of $\delta(\lambda)$ was decreased by factor of 0.9 for 13-day SUVIV. Temperature response for 27-day SUVIV was adopted according to (Brasseur et al,1987;Fig.3,line 1).

For 27(13)-day SUVIV j-th gas photodissociation rate at height z takes form (2):

$$J_j(z,\chi)=\int_0^{\infty} I_o(\lambda)\times(1+\delta(\lambda)\times\sin\frac{2\pi t}{27(13)})\times\sigma_j(\lambda)\times\phi_j(\lambda)\times\tau(\lambda,z,\chi)d\lambda \qquad (2)$$

here $I_o(\lambda)$-the solar flux at the top of the atmosphere,

$\sigma_j(\lambda)$-cross-section of j-th molecula,

$\phi_j(\lambda)$-quantum yield,

$\tau(\lambda,z,\chi)$-atmosphere transmission function.

Ozone response was defined both in therms of "sensitivity" (i.e.

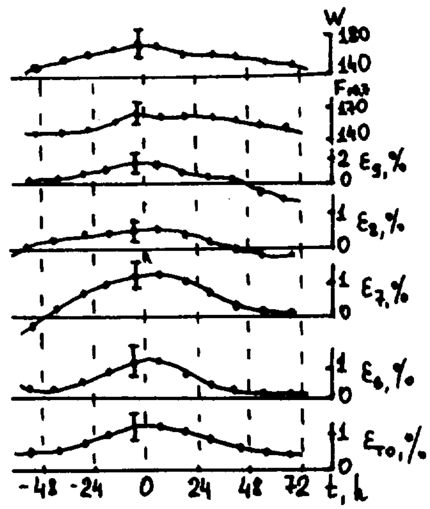

FIG.1.Time dependences of ozone responses ε_i (%) in 6th,7th, 8th and 9th layers,in TO and corresponding 12 hours-averaged values of W and F10.7 relatively time of flare occurence (t=0).

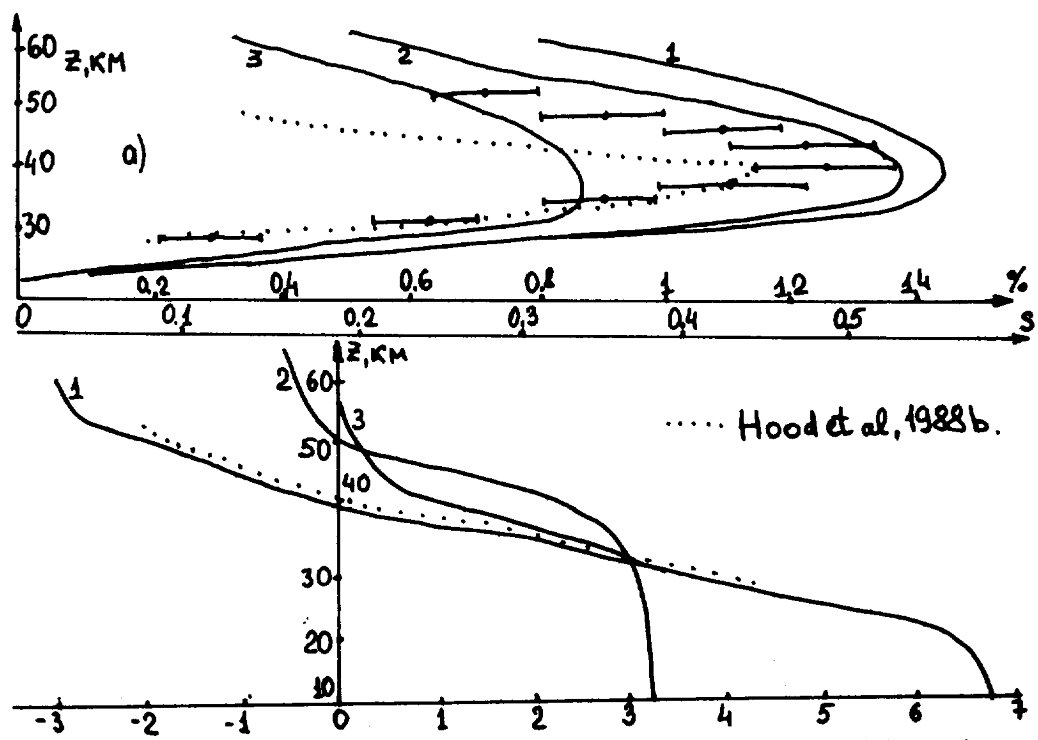

FIG.2. a)Ozone responses to 27 day SUVIV by our model(equator, June):1-midday ,2- 24-hours-averaged,3- 13-day-averaged values - and the same by (Hood et al,1988b,point line) and Nimbus-7 data (Keating et al,1987);
b)Lag of O3 response (days) for the following scenario: 1 & 3- 27-day SUVIV with and without temperature feedback; 2- 13-day SUVIV with temperature feedback.

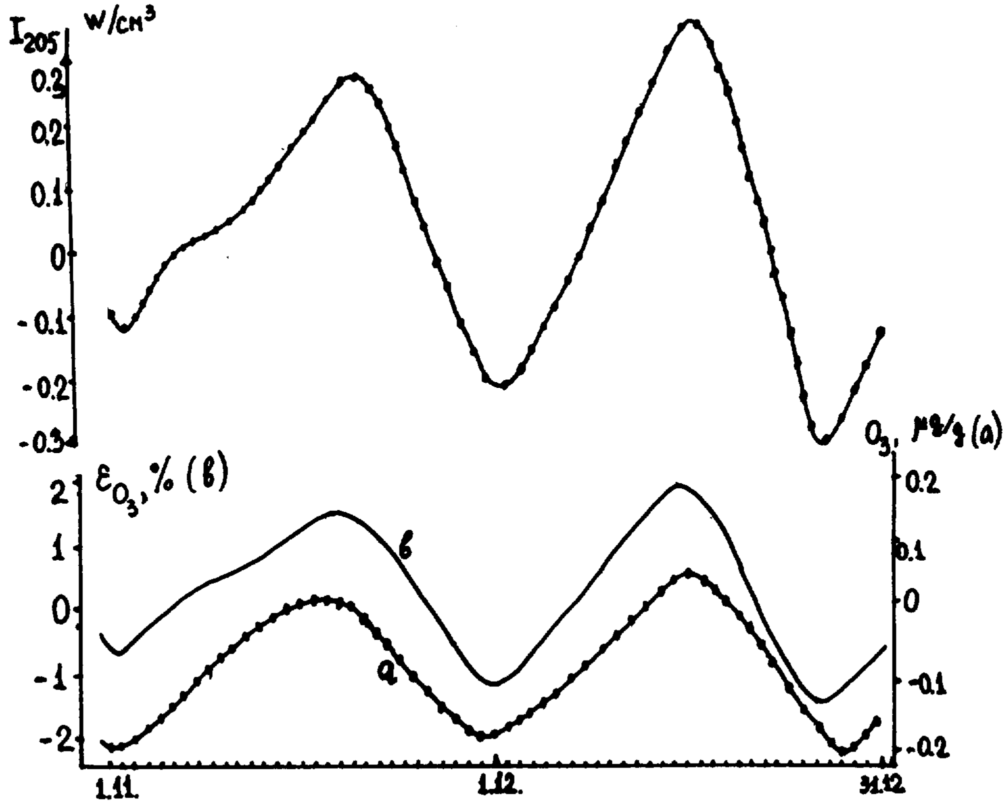

FIG.3.Detrended solar flux I205 (top) and ozone responses (bottom) accordingly to (Hood,1987)(a) and our model calculations(b) during November-December 1979.

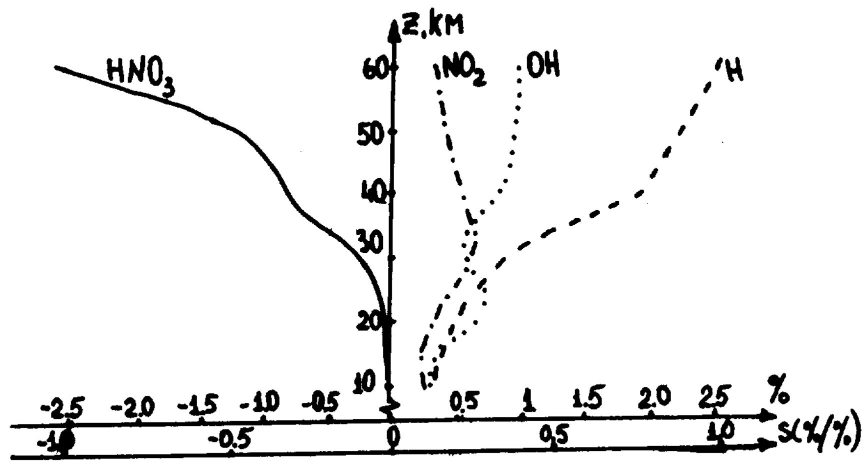

FIG.4.Responses of HNO3,NO2,OH and H to 27 day SUVIV (equator, June,model midday).

%O3/1% at λ=205nm) and in per cent deviation from undisturbed concentration. It was established that duirnal modulation of O3 response was very important. Actually lines 1 and 2 in Fig.2a correspond to ozone responses at model midday and 24 hour-averaged value for the day of 27-day SUVIV sinusoid maximum accordingly. Line 3 in Fig.2a shows the half-period averaged ozone response. Comparisons of our results with "Nimbus-7" data (Keating et al,1987) demonstrate closer agreement in the upper stratosphere,than similar results (Brasseur et al,1987;Hood et al, 1988b). These discrepances are due to different duirnal photodissociation rates model discriptions. Phase characteristics of ozone response are shown in Fig.2b for the mentioned scenario.

Fig.3 illustrates ozone responses at equator at 1.5 mbar (a)by (Hood,1987)and by our model results (b) at 44km (24 hour-averaged) to real profile I205 during November-December 1979. Good agreement between lines a) and b) confirms correctness of our theoretical calculations.

Studying seasonal and latitudinal dependence of O3 response we used the same temperature response dependence by(Chandra,1986). It was established that O3 response became maximum at equator in summer and minimum - in winter polar and midlatitude regions.

Responses of HNO3,OH,NO2 and H to 27-day SUVIV for model midday (equator,June) are shown in Fig.4. Strong HNO3 content decrease (especially in the mesosphere) was caused by increase of both HNO3 photodissociation rates and HNO3+OH -->NO3+H2O reaction rate. NO2 and OH responses were experimentally undetectable due to small values of their sensitivities.

We think that the development of more accurate satellite devices and consideration of dynamical regime change during 27(13)-day SUVIV and other geophysical effects (that mask styding effects)should constitute the main directions of further research.

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