OZONE PROBLEM: FINAL SOLUTION

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ABSTRACT

Fields of seasonal and long-period variability of the total ozone content (TOC), including circumpolar regions, have been studied. It is shown that long-period variability of all TOC series (with spatial resolution of 3° latitude x 5° longitude) comes down to parametric resonance with the lowest frequency of tidal oscillation (18.6-year period). After eliminating this effect, series trends for all cells (3° x 5°) become vanishingly small (having different signs) and statistically insignificant. The obtained results are completely incompatible with the anthropogenic version of "ozone depletion". It is demonstrated that the revealed phenomenon of parametric resonance is also observed in the lithosphere with regard to the global tectonic activity.

Keywords: Ozone, seasonal and long-period variability, trends, tidal oscillation, parametric resonance

1. PROBLEM STATEMENT AND BACKGROUND

Over the last four decades, the ozone problem has been drawing attention of not only specialists, but also general public. Its essence comes down to the explanation of the nature of the observed long-term changes in the condition of the Earth ozone layer. The essence of disagreements on this issue among scientists all over the world is given in our review [1]. It also provides information about economic aspects of the problem.

The purpose of this paper is to obtain a statistical description of series of satellite observations, to obtain parameters of seasonal and long-period variability and their global distribution, and to recognize physical reasons of the observed changes in the ozone layer condition. In order to gain this purpose, satellite sounding [2] data were used, as they provide the most global view and have the highest homogeneity as compared to all ground-based TOC measuring devices and the longest series among satellite measuring devices. The period under analysis was ~35 years (1978-2014, except from May 1993 to July 1996).

2. ANALYSIS METHODS

All data of satellite observations were organized into series of daily reports averaged by:

- cells (with spatial resolution of 3° latitude x 5° longitude);
- latitudinal zones (with spatial resolution of 3°);
- Earth surface with weights proportional to areas of latitudinal zones.

Then, seasonal variability was isolated in each of the mentioned series using the equation:

$$X(t) = \sum_{k=0}^{n}[a_k \cos(k\omega t) + b_k \sin(k\omega t)] + Rez_Y t \quad (1)$$

where: X(t) - values of TOC series at t; $\omega = \frac{2\pi}{T_Y}$; T_Y = 365.24 days - period of the first harmonic of the annual variation; $Rez_Y(t)$ - residual seasonal variation. Harmonics were chosen by the least-squares procedure among values of the Student statistics [3] at the reliability level of 95%. The seasonal variation was isolated not only to reduce the dispersion $Rez_Y(t)$ as compared to X(t), which helped to isolate long-term variability from $Rez_Y(t)$ in a more reliable way, but also due to the fact that X(t) values in high-latitude regions during a polar night have a significant value for calculating the energy balance of the Earth climatic system, as ozone is a greenhouse gas. Trend values were calculated for series of $Rez_Y(t)$, then a regression analysis was performed again using a similar expression:

$$Rez_Y(t) = \sum_{k=0}^{n}[a_k \cos(k\Omega_2 t + b_k \sin(k\Omega_2 t) + \\ + c_k \sin(k\Omega_3 t) + d_k \sin(k\Omega_3 t)] + Rez_{2-3}(t) \quad (2)$$

where: $\Omega_n = \frac{2\pi}{nT_{tide}}$; T_{tide} = 18.6 years - the period corresponding to the lowest frequency in the tidal oscillation spectrum [4]. The selection of the model (2) is conditional upon the fact that the analysis of long-period variability of the global tectonic activity [5] revealed its parametric resonance [6] with the specified frequency. It was obvious to expect a similar effect in the atmosphere, as a geosphere that is much more exposed to tidal phenomena than the lithosphere. After building the model (2) of the series $Rez_{2-3}(t)$, trend values were calculated again in order to assess relative contributions of resonance phenomena and unidirectional processes to the long-period variability of the TOC field condition.

3. OBTAINED RESULTS

The results obtained during the analysis of the seasonal variability of the TOC field are generalized in Fig. 1. The first noticeable thing is a significant phase opposition of seasonal variations at circumpolar latitudes of both hemispheres. The spring maximum in the Northern hemisphere corresponds to the spring minimum in the Southern hemisphere. This fact mainly explains the effect of the so called “spring Antarctic ozone hole”. Its inadequate explanation based on the Freon version and inevitable annual periodicity in its formation are detailed in our paper [7]. The long-period variability also makes a noticeable contribution to the formation of the specified anomaly, especially in its northern part (see below). The results obtained by modeling the long-period variability are shown in Fig. 2. In particular, it explains why the adherents of the Freon ozone depletion began discussing [8] the positive effect of the Montreal protocol on recovery of the ozone layer and reduction of the “Antarctic hole”. Moreover, the figure shows why the lowest TOC values have been observed in the Antarctic. A more vivid demonstration is given in Fig. 3.

How proper account of long-period variability influenced the TOC trends, the frightening values of which served as a palliative for the scientific rationale of the Montreal protocol, can be seen from Fig. 4. A separate paper will study why the remains of the complete model $Rez_{2-3}(t)$ resemble white noise. Here we will only give a remark that the values of the Durbin-Watson statistics for all latitudes belong to the range (1.96, 2.04), and the regression coefficient for the integrated periodogram of remains on the line crossing the origin of coordinates is at least 97% for any latitude.

4. CONCLUSIONS

The statistical modeling of seasonal and long-period variability of the TOC field shows:

- the so called “Antarctic ozone hole” is mainly attributable (especially in the southern part) to the seasonal variation of the total ozone content, and in other respects it is formed due to long-period variability;
- long-period variability of TOC right up to 3° latitude x 5° longitude is totally attributable to the parametric resonance with tidal oscillation with a period of 18.6 years, i.e. it consists of oscillations with periods of 55.8 and 37.2 years and their harmonics;
- proper account of the parametric resonance effect totally excludes the presence of any trends in evolution of the TOC field and, consequently, once again denotes the complete absence of any preconditions for the Freon “ozone depletion” – the majority of Russian scientists have been insisting on this for a long time [9].

The physical mechanism of the resonance response of the ozonosphere to slow tidal oscillation is also completely clear. The primary oscillation process attributable to the annual periodicity of the ozonosphere insolation level responses to the long-period variability of such parameters as vertical distribution of oxygen and ozone density, as well as optical activity of aerosol.

5. ACKNOWLEDGMENTS

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6. REFERENCES

1. A.M. Zvyagintsev, G.M. Kruchenitsky Ozone crisis: 20 years later. Russia in the surrounding world. 2005 (Analytical year-book) / Under general editorship of N.N. Marfenin, S.A. Stepanov - M.: Modus-K - Eterna, 2006. P. 125-145.
2. ftp ://toms. gsfc .nasa. gov/pub/omi/data/ ozone/
3. Hudson D.J. Lectures on elementary statistics and probability. Geneva. 1964. 242 p.
4. G.I. Marchuk, B.A. Kagan “Dynamics of oceanic tides”, L., Hydrometeoizdat, 1982, 359 p.
5. Statnikov K., Kruchenitsky G. Statistical Modelling of Global Tectonic Activity and some Physical Consequences of its Results. Journal of Systemics, Cybernetics and Informatics, v. 13, #1, 2015, p.p. 51-55.
6. L.D. Landau, E.M. Lifshits “Mechanics”, M., Fizmatgiz, 1958, p. 103-109.
7. A.M. Zvyagintsev, V.V. Zuev, G.M. Kruchenitsky T.V. Skorobogatyi On the contribution of heterogeneous processes to the forming of the spring ozone anomaly in the Antarctic. Earth exploration from the space. 2002. No. 3. P. 29-34.
8. Pawson S., Steinbrecht W., Charlton-Perez A.J., Fujiwara M., Karpechko A.Yu., Petropavlovskikh L, Urban J., Weber M. Update on Global Ozone: Past, Present, and Future. - WMO Ozone Report No. 55. Scientific Assessment of Ozone Depletion: 2014. Geneve: 2014.
9. A.M. Zvyagintsev, V.I. Bekoryukov, T.V. Kadygrova, S.I. Perov, E.L. Alexandrov et al. The variability problem of ozone layer, climate, UV exposure to the biosphere and the proposed concept of the national policy for the ozone problem. Physical problems of ecology (physical ecology). All-Russian scientific conference, June 23-27, 1997, M., MSU. V.1, p. 42-43.

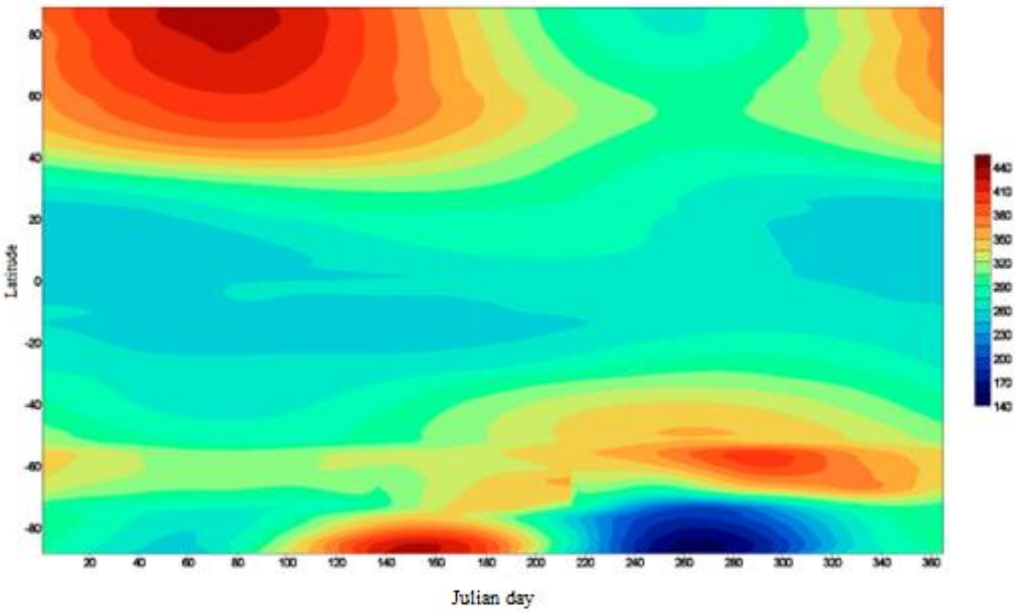
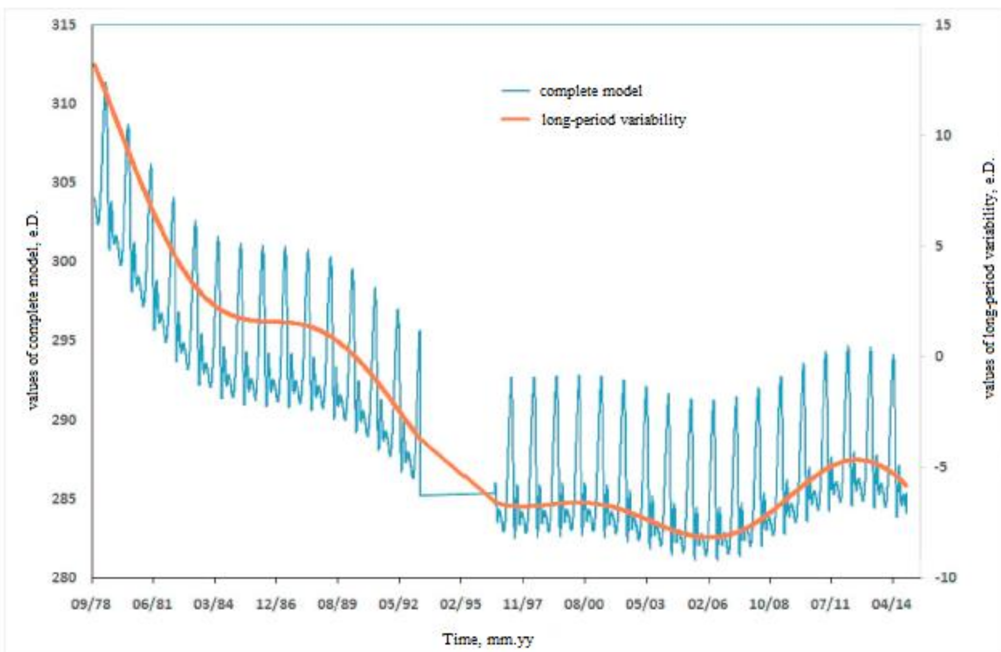
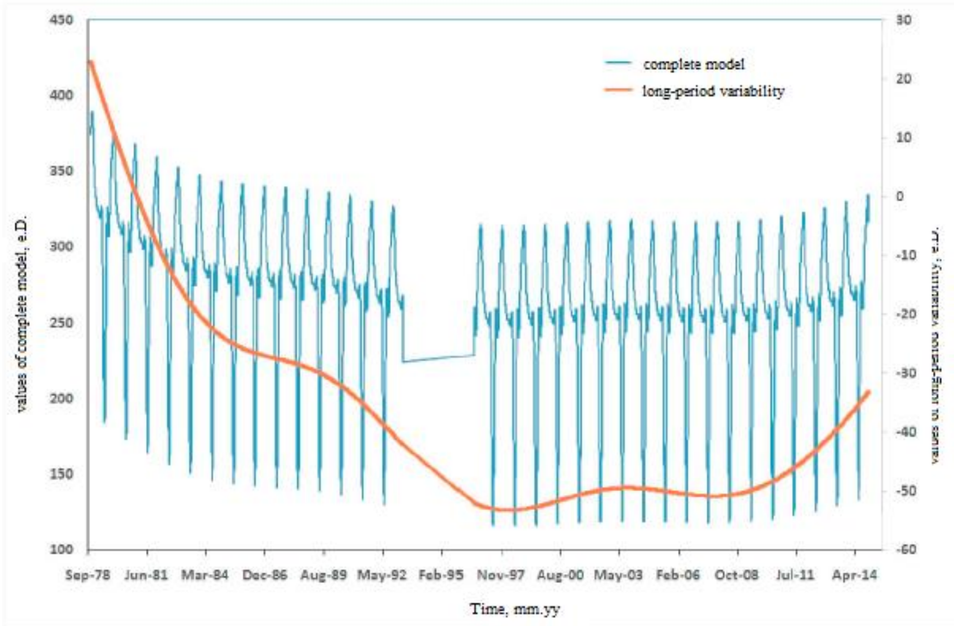


Fig. 1. Latitudinal and temporal section of the seasonal variation of TOC



(a)



(b)

Fig. 2. Long-period variability and the complete model of TOC for average global values (a) and values averaged by latitudinal zone 66°S-69°S (b)

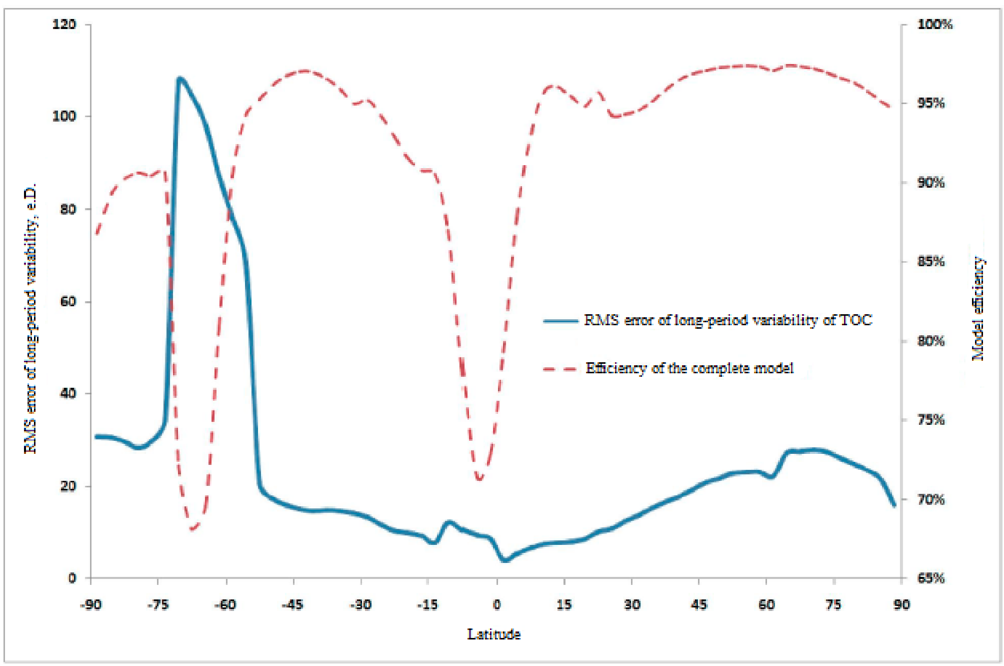


Fig. 3. Latitudinal variation of RMS error of long-period variability of TOC and efficiency

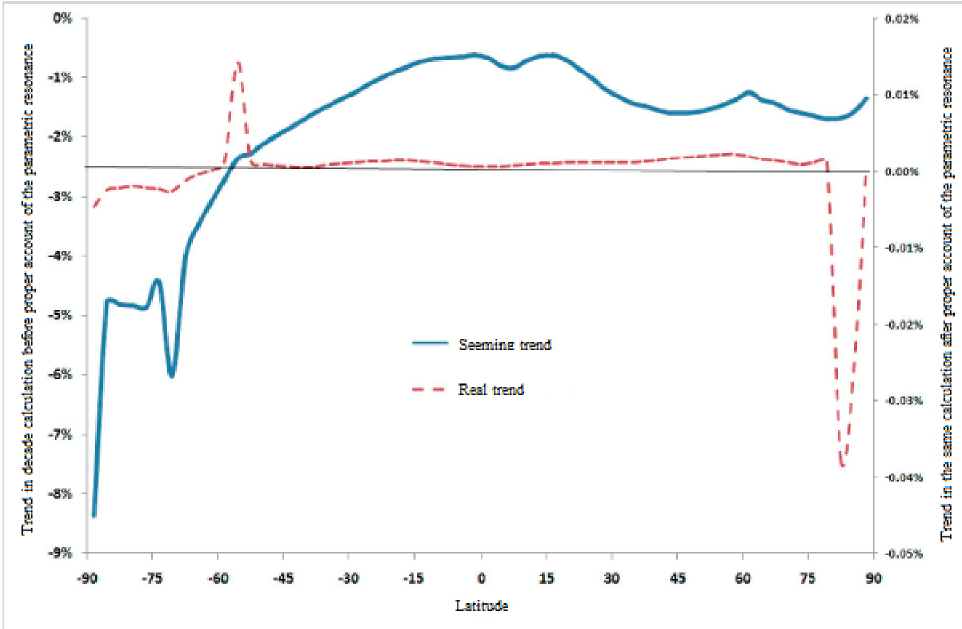


Fig. 4. Influence of proper account of long-period variability on values of zonal trends