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Global Dimming and Brightening Versus Atmospheric Column Transparency in Europe, 1906-2013

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The main parameter in this work

p_2 – the **A**tmospheric **I**ntegral **T**ransparency **C**oefficient (**AITC**)
(the Bouguer coefficient of transparency)
at $m = 2$ (solar elevation $h = 29.9° \approx 30°$)

Calculation scheme — 2 steps

Step 1: calculation of the Bouguer coefficient, p_m

$$p_m = \left(\frac{S_m}{S_0}\right)^{\frac{1}{m}}$$

S_m – solar broadband irradiance on the ground level

S_0 = 1.367 – the solar constant

Step 2: reduction of the Forbes effect, transition: $p_m \rightarrow p_2$

Two compatible formulas (1–2 %)

$$p_2 = p_m \left(\frac{2}{m}\right)^{\frac{\log p_m + 0.009}{\log m - 1.848}}$$

The Estonian (Tartu) formula (Mürk, Ohvril, 1988)

$$p_2 = \left(\frac{S_m}{1.367}\right)^{\frac{\sin h + 0.205}{1.41}}$$

The Russian (Moscow) formula (Evnevich, Savikovsky, 1989)

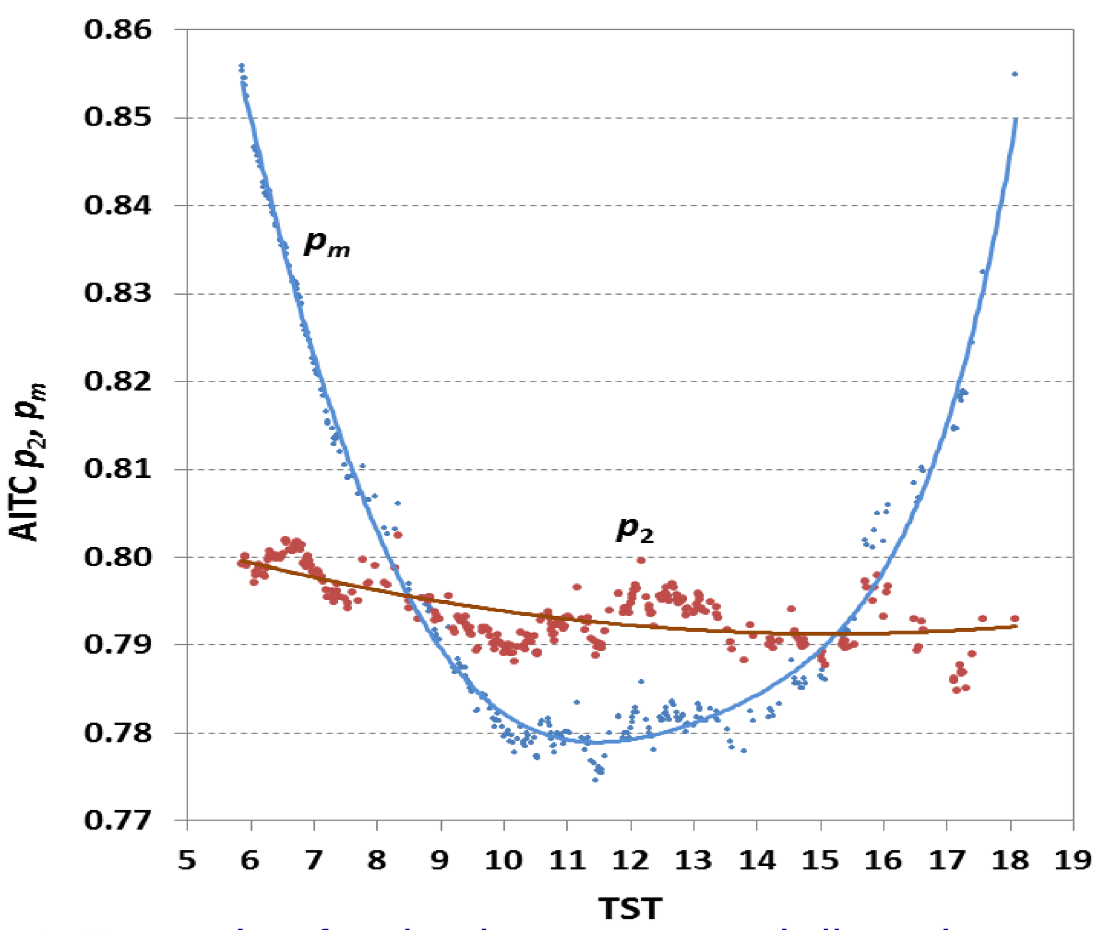

Fig. 1. Example of reduction: measured diurnal courses of p_m and p_2 during a clear day at Tõravere, Estonia, April 18, 2005.

Fig. 2. Six locations for which multiannual time series of column transparency were compiled:
Pavlovsk, Tiirikoja, Tartu, Tõravere, Moscow, Feodosiya; numbers 1, 2, and 3 indicate thermal electrical power stations.

Fig. 3. For several decades G. Gushchin (PhD) has observed solar radiation in the Crimea.

Evolution of European column transparency, 1906-2013

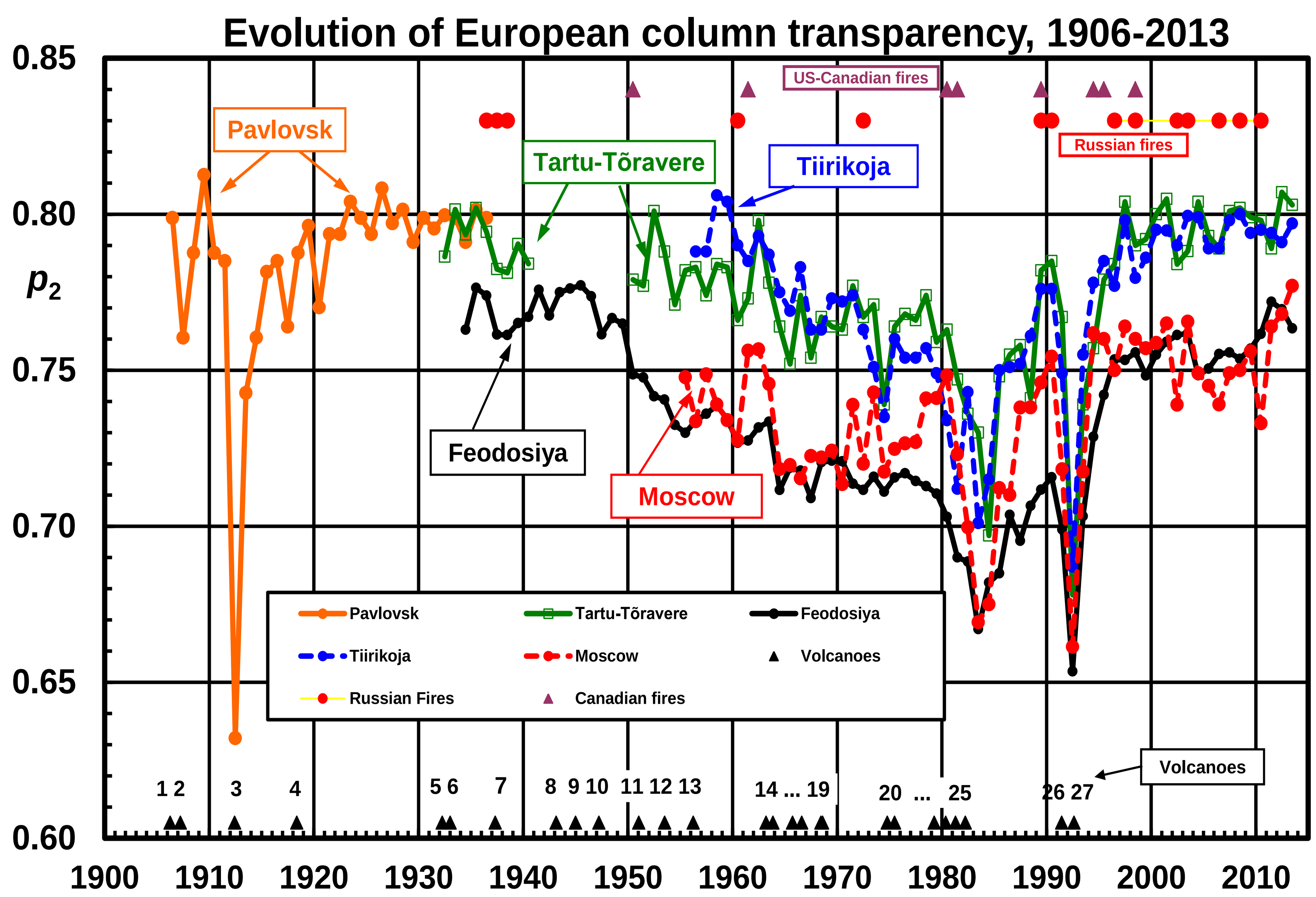

Fig. 4. Annual means of the atmospheric integral transparency coefficient for different locations. Black triangles at the bottom indicate dates of the largest volcanic eruptions. Circles and triangles above indicate Russian and American field fires. Coefficient of transparency for a clean and dry atmosphere, p_2 = 0.905.

Volcanic impact

- The lowest annual value of column transparency, p_2 = 0.632 in 1912, belongs to Pavlovsk and was caused by the eruption of the Katmai/Novarupta (Alaska) volcano.
- The Pinatubo (1991) impact was slightly less: in 1992 annual mean coefficient of transparency decreased at two Estonian locations to p_2 = 0.68–0.69 and in the Crimea and Moscow to p_2 = 0.65–0.66.
- A series of four successive volcanic eruptions during 1979–1982 ending with the El Chichón, caused drop in transparency down to the value p_2 = 0.70 in Estonia in 1983–1984, and to p_2 = 0.67 in the Crimea and Moscow in 1983.

Global dimming

- The highest annual mean of column transparency, p_2 = 0.813, was observed at Pavlovsk, in 1909. It is reasonable to conclude that the tropospheric, as well the stratospheric, Aerosol Optical Depth (AOD) were very low then.
- In the Crimea, a long decreasing tendency in column transparency started in 1945.
- For the US stations (Madison, Lincoln, Bluehill) it was noted even an earlier start of the decrease, from the end of the 1930s.
- In Estonia the decrease started in the1950s, also apparently due to increasing industrial and agricultural pollution.
- Multidecadal decreasing tendency in column transparency, according to observations in the Crimea, Estonia and Moscow, ended in 1983/1984.

Global brightening

- During the 8 years, 1983-1990 there was volcanically a calm interval during which stratospheric AOD apparently returned to its lowest values. Surprisingly, the column transparency was not entirely restored neither in Estonia nor in the Crimea, evidently indicating a significant contribution by aerosols in the troposphere.
- The second clearing of the atmosphere, after dissipation of emissions of the Mt. Pinatubo eruption, coincided with general economic decline in Eastern European countries after the collapse of the USSR in August 1991.