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# THE ENERGETICS OF MODERN CLIMATE CHANGE

*Possible approaches to climate variation based on solar-geomagnetic activity*


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**1). We consider the impact of microwave emissions of the ionosphere as the result of solar flares and magnetic storms on the troposphere.**

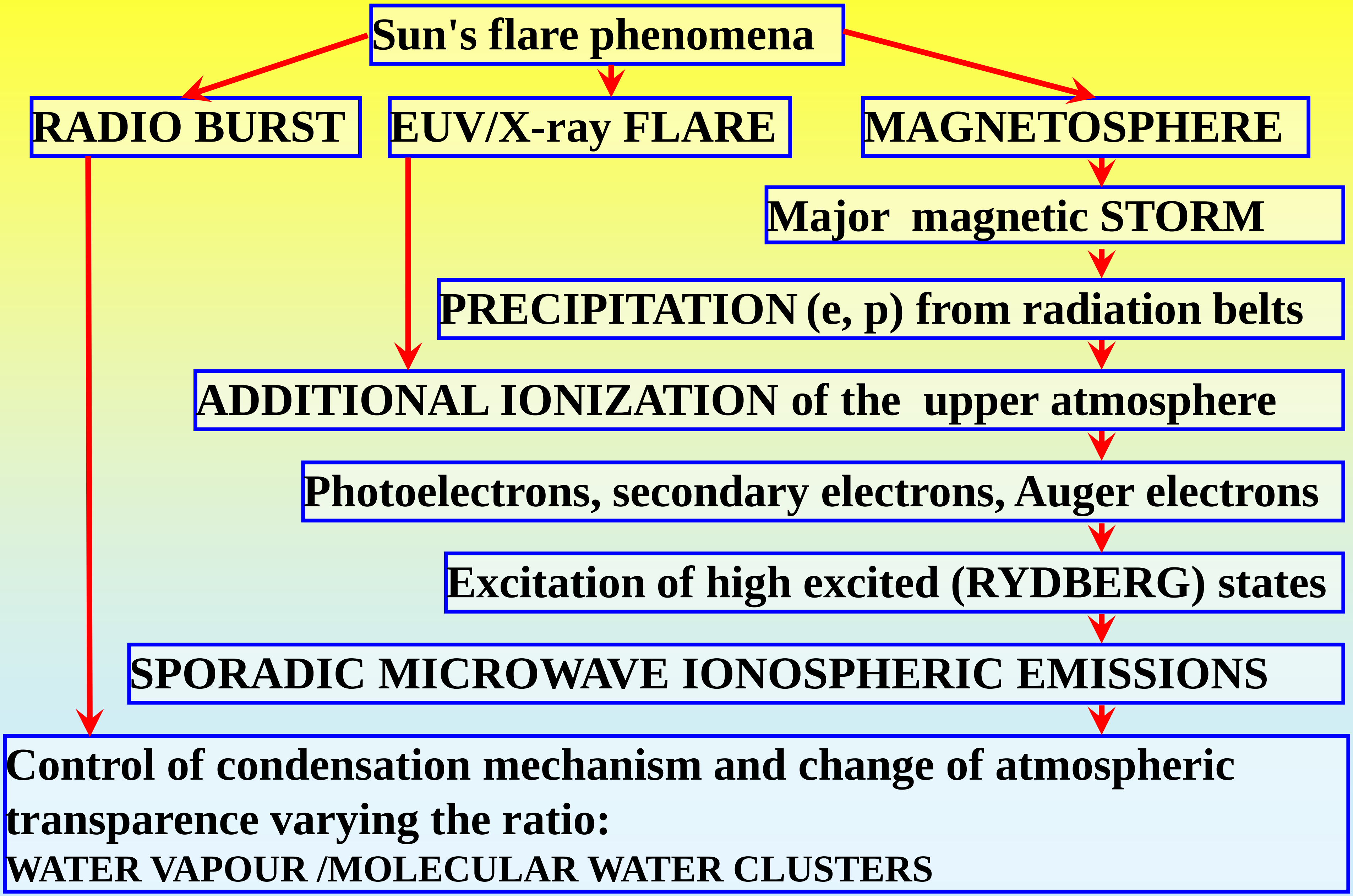
**We suggest a radio-optical trigger mechanism consisting of the following three stages:**

- **the ionosphere absorbs ionizing solar radiation and particles from the radiation belts and transforms them into microwaves through the excitation of Rydberg states;**

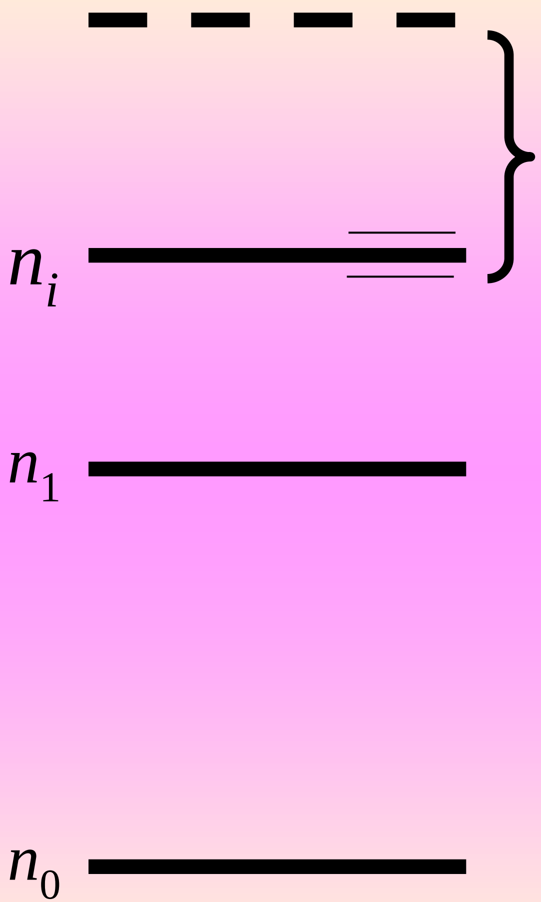
- **the rates of formation and destruction of water cluster ions in the troposphere are regulated by the microwave radiation;**

- **water clusters contribute to the formation of cloud, which affects the energy flux of the solar radiation at the troposphere and the flux of the outgoing heat from the underlying surface.**

# CONTROL CONDENSATION MECHANISM DURING DISTURBANCES IN SOLAR AND GEOMAGNETIC ACTIVITIES.



# Rydberg atom




Ionization Potential

**Rydberg levels**

**($n_i$ > 10)**

**$l$ = (from ($n_\mathrm{i}$ – 1) to 0)**

Resonance level

Ground level

# Radioemissions of Oxygen Atom

**dm radioemission:**

**Δn = 0 at n = 20-40**

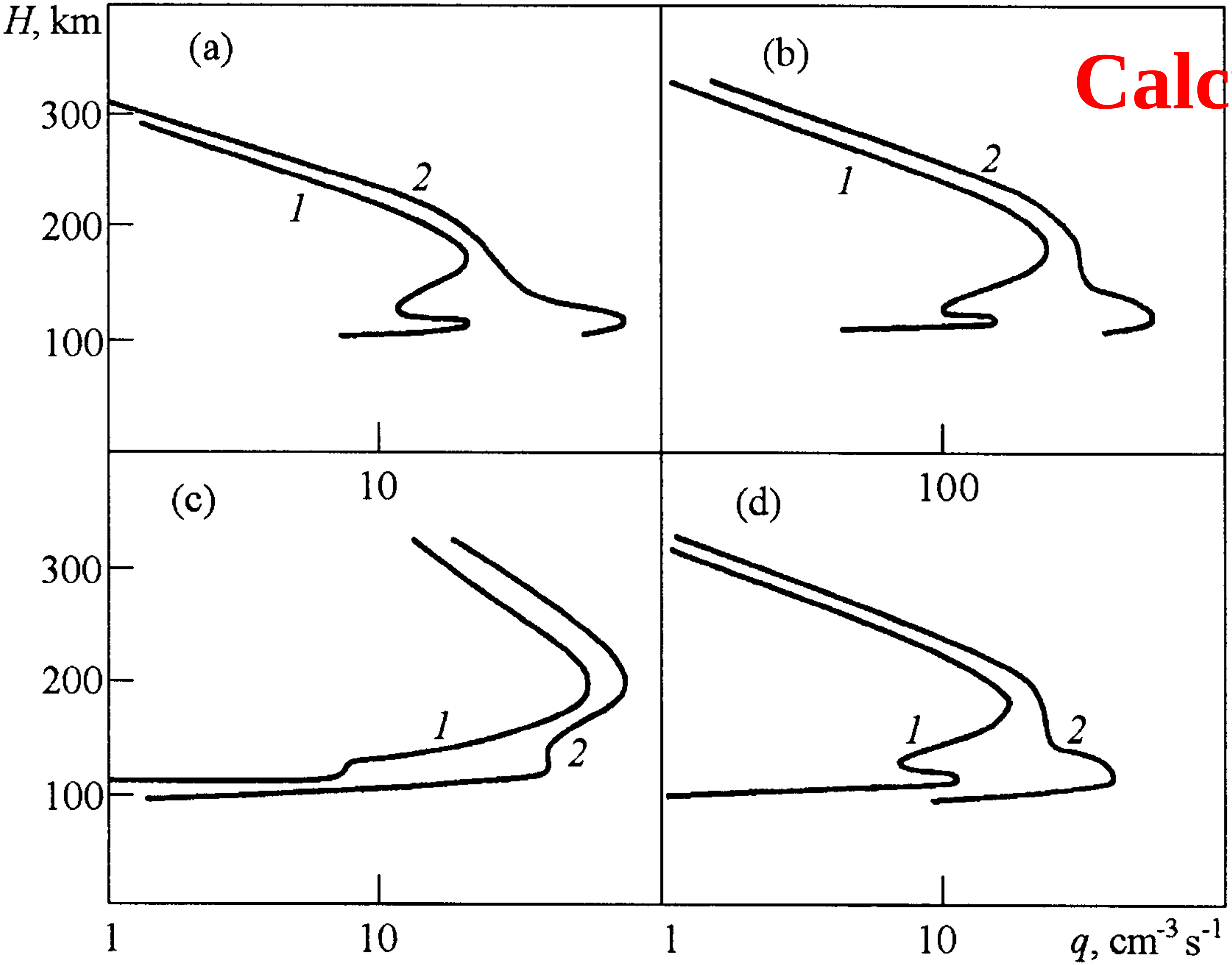
**cm radioemission:**

**Δn = 1 at n = 10-20**

**mm radioemission:**

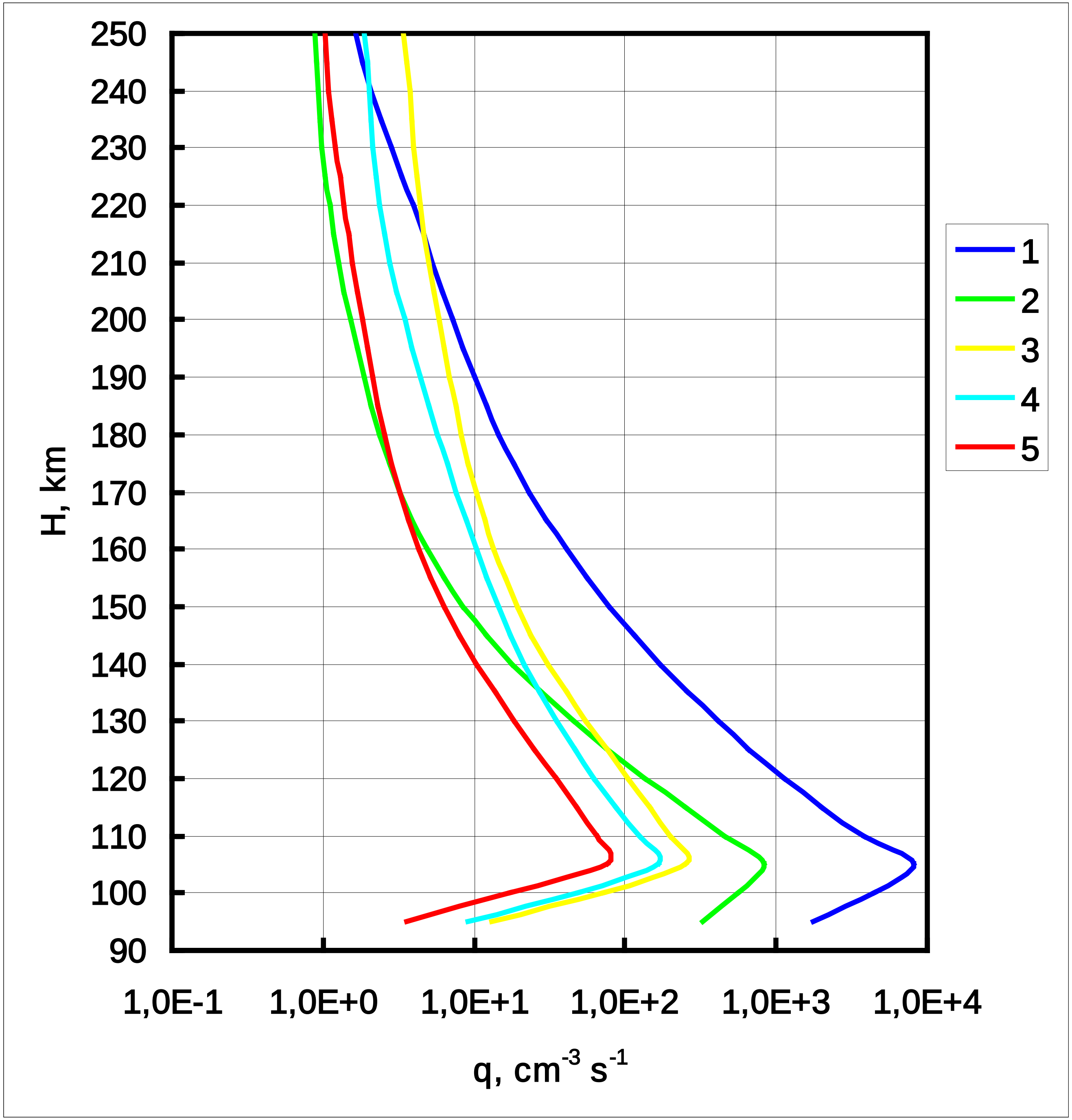
**Δn > 1 at n > 10**

# Calculations




**Vertical profiles of Rydberg state excitation rates:** 1-quiet Sun; 2-solar **flare X1** (a), (b), (c) total excitation for the oxygen and nitrogen molecules and oxygen atom, respectively, in transition ($\Delta s = 1$); (d) partial excitation of level $c'^{1}_{4}\Sigma_u^+ (\upsilon' = 0)$ of the nitrogen molecule.

**Avakyan, Voronin, Serova, 1997.**




**The excitation rates for Rydberg states for auroral zone (night aurora, IBC II):**

**1) the total excitation for nitrogen molecule,**

**2) the total excitation for oxygen molecule,**

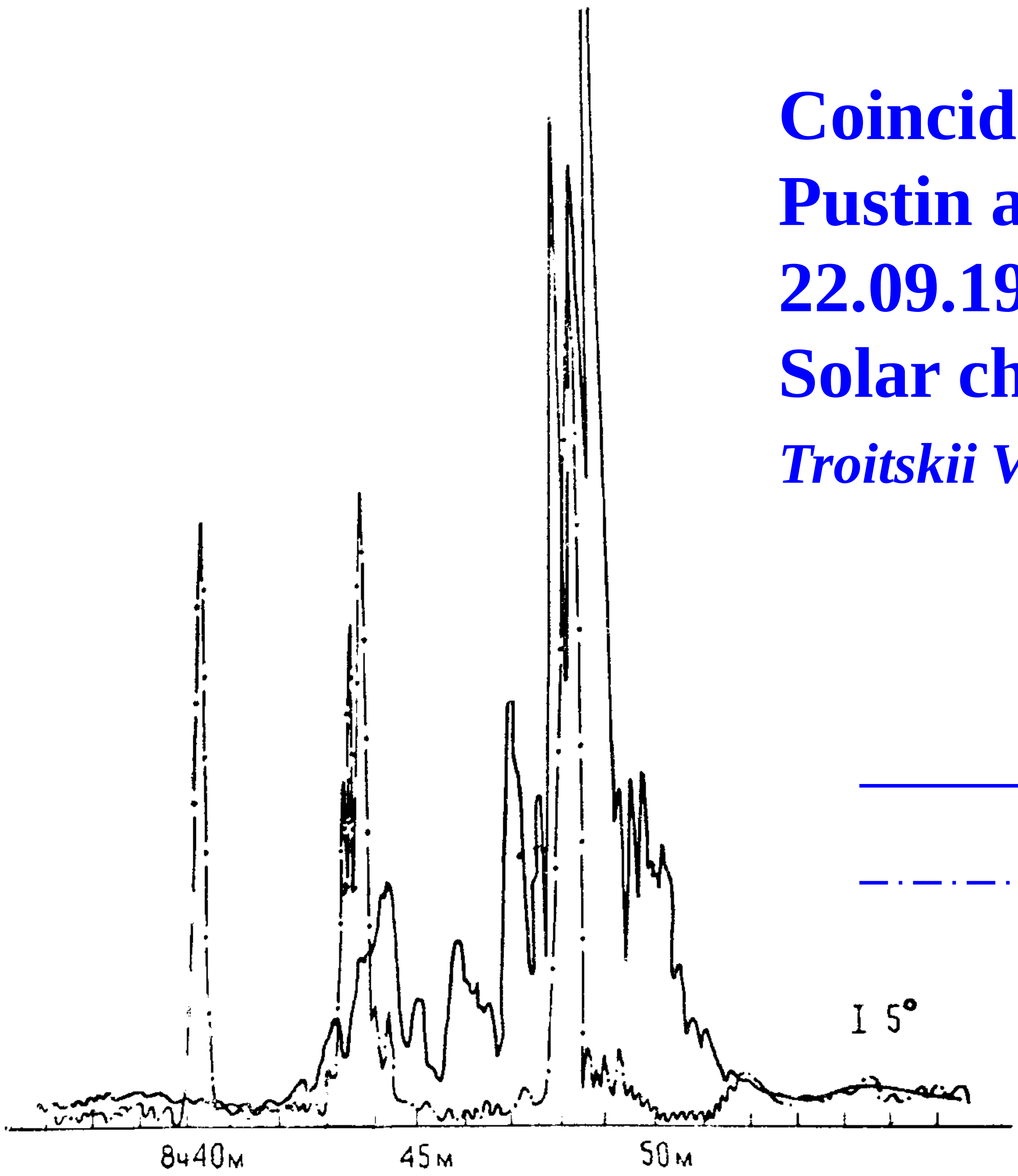
**3-5) the partial excitation for atomic oxygen**

**(3 - $\Delta s$ = 0,**

**4 - $\Delta l$ = 1, $\Delta s$ = 0,**

**5 - $\Delta l$ = 0, $\Delta s$ = 0).**

***Avakyan S.V., 25th General Assembly of URSI, 1996, France,***




# Coincidence bursts in Pustin and Ussuriisk 22.09.1970 , λ = 50 cm. Solar chromospheric flare.

*Troitskii V.S., 1973*.

——————— **Pustin, Ural;**

–·–·–·–·–·– **Ussuriisk, Far East;**

**RUSSIA**

*Troitskii V.S., 1973*

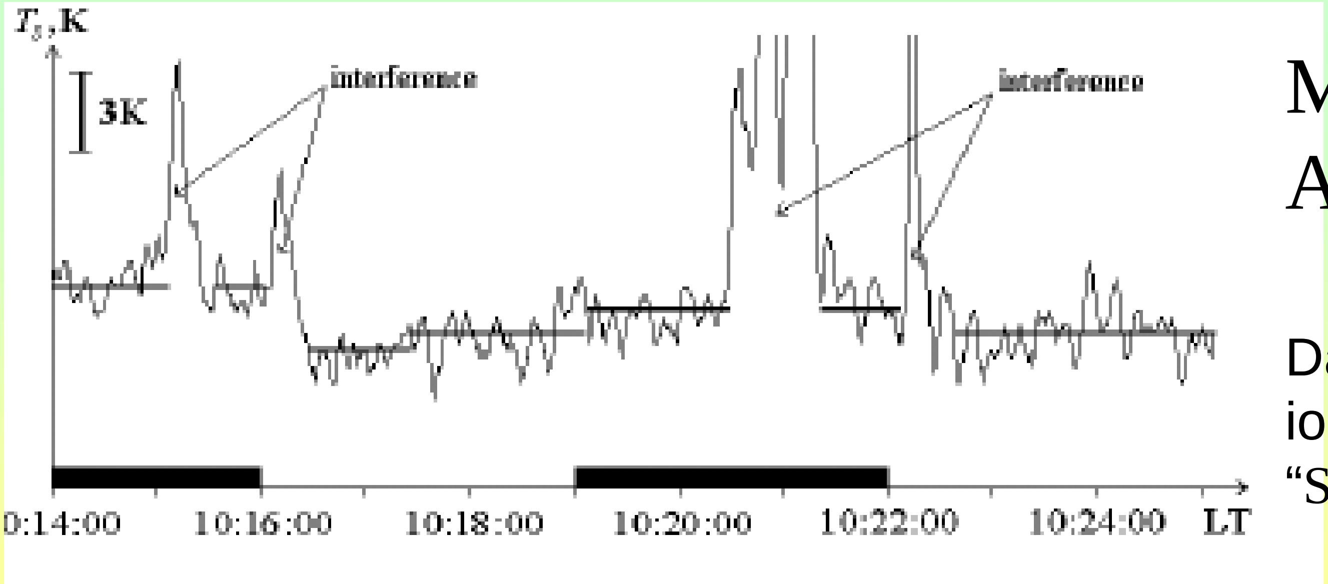
## ENERGETICS OF MICROWAVE IONOSPHERIC GENERATION

The ratio of the energies dissipated in the ionosphere when there is a medium solar flare and during a geomagnetic storm shows that the flux of microwave radiation can be factor of 10–100 greater in intensity in the period of a magnetic storm. In this case, the radiation in the centimeter and decimeter ranges can now exceed $10^{-11}$–$10^{-12}$ W cm$^{-2}$.

A calculation of the excitation rates of the Rydberg states of the oxygen atom gave a value of about $10^9$ particles cm$^{-2}$ sec$^{-1}$ in a column of the ionosphere during the period of a medium class-2B solar flare.

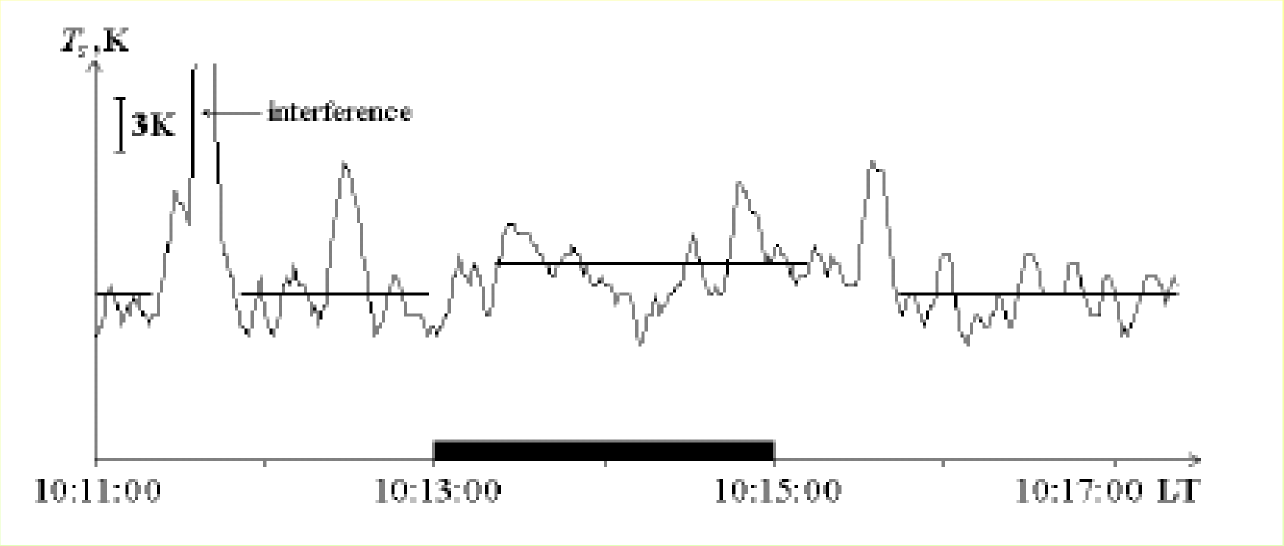
For values of the quantum energy in the centimeter range of $2\text{x}10^{-23}$ (for Lambda=1 cm) –$2\text{x}10^{-24}$ J (for Lambda =10 cm) in this column in ten allowed transitions, we have a flux density of microwave radiation of $2\text{x}10^{-13}$–$2\text{x}10^{-14}$ W cm$^{-2}$. This flux density is the lower limit for transitions with delta n=1 (only for delta l=1), i.e., those of the type n', l'=n'−1→n'−1, l''=n'−2, where n'=11–20 for an oxygen atom.

This value increases to $10^{-11}$–$10^{-12}$ W cm$^{-2}$ during a magnetic storm.




M.G. Grach et al.
Ann. Geoph,2002

Data from the ionospheric heater at "Sura" Russia.




Signal from the ionosphere on frequency~***600 MHz***
($\lambda$ = 50 cm) from heights ~190-270 km during and after heating by powerful short radiowaves ~***6 MHz***.

# Authors (Grach et al.) interpretation of experimental data as Rydberg excitation by energetic ionospheric electrons

***THE CITATION (2002):***

- **“A more credible mechanism of the emission generation conditioned by the electron acceleration is related to the EXCITATION of the high RYDBERG STATES of the neutrals (atom O and molecule $N_2$) by electron impact, and the transition of electrons between high Rydberg levels.”**

- **“A similar mechanism of UHF/VHF generation, namely the EXCITATION of the high RYDBERG STATES of atmospheric gases by photoelectrons, is attracted *by Avakyan et al. (1997)* for an interpretation of sporadic UHF/VHF radio emission of the ionosphere.”**

# Discovery of sporadic radioemission for the terrestrial ionosphere during solar flares and aurorae ($\lambda$ = 3 cm - 50 cm)

**Forsyth P.A., Petrie W., Currie B.W.,** On the origin of ten centimeter radiation from the polar aurora, Can. J. of Res., 28A, 3, 324, **1950**.

**Troitskii V.S., Starodubtseva A.M., Bondar' L.N., et al** Search for sporadic radio emission from cosmic space at centimeter and decimeter wavelengths. Radiophysics., v. XVI, N 3, pp. 323-342, **1973.**

**Musatenko S.I.,** Radioemission of a circumterraneous space as result of influence of solar flares on magnetosphere and ionosphere of the Earth, Geomagnrtizm and aeronomy., v. 20, N 5, pp. 884-888, **1980**.

**Klimenko V.V.**, UHF waves from polar ionosphere, Dissertation, Irkutsk, 129 p., **2002.**

**Energetics of ionospheric microwaves**

***From SUN*:**

**–to low atmosphere 1367 W/m$^2$**

**–– to ionosphere 10$^{-2}$ W/m$^2$**

***From geomagnetosphere***

**During a large magnetic storm(e, p):**

**– To the ionosphere: several W/m$^2$**

***Troitskii's experimental data concerning ionospheric microwaves (λ~3÷ 50 см)***

– 2 - 40 times more than the radioemission from quiet Sun:

– 6 - 120·10$^{-16}$ W/см$^2$ ≈ 6 - 120·10$^{-12}$ W/см$^2$

(in the 1 GHz band) *(B.B.Troitskii, 1973/75)*

***Our calculations:Ionospheric microwaves*** *(λ~3÷50 см):*

- *During middle Solar Flare at the* **(λ=50 см)**: **10$^{-13}$ W/см$^2$**

– During a strong magnetic storm **10$^{-13}$÷10$^{-11}$ W/см$^2$**

*(C.B. Avakyan, H.A. Voronin 2006)*

# «RADIOOPTICAL THREE STAGE TRIGGER» IN SOLAR – WEATHER / CLIMATE LINKS

**Ist stage**

Energy conversion **in the ionosphere** of the solar and geomagnetic activity **to the MICROWAVE FLUX, which penetrates to the earth surface**

↓

**2nd stage**

The microwave radiation control of **the RATES OF FORMATION AND DESTRUCTION of WATER VAPOUR CLUSTER IONS** **in lower atmosphere at altitude** more than 2 km

↓

**3rd stage**

The contribution of the water vapour clusters to the formation of **cloudiness and atmospheric aerosol layers** which **absorb and reflect the solar irradiance as well as thermal radiation coming out from the underlying surface**

# CONTROL BY MICROWAVE RADIATION
# of ion cluster chemistry in the lower atmosphere

**THE INCREASE OF MICROWAVE FLUX**
**FROM SUN AND TERRESTRIAL IONOSPHERE**

**AT THE DESTRUCTION OF CLUSTERS:**
**Decrease of dissociative recombination rate for cluster from the water vapor after formation of the stable RYDBERG STATES (*l*>2) in the microwave field.**
***Bates D.R., "Collisional dissociative recombination" of cluster ions, 1981.***

**AT THE FORMATION OF CLUSTERS:**
**Increasing of association rate for polyatomic molecules with formation of the stable RYDBERG ORBITAL (*l*>2) in the microwave field.**
***Gallas J.A.C. et al., 1985.***

# *EXPERIMENTAL CONFIRMATION*

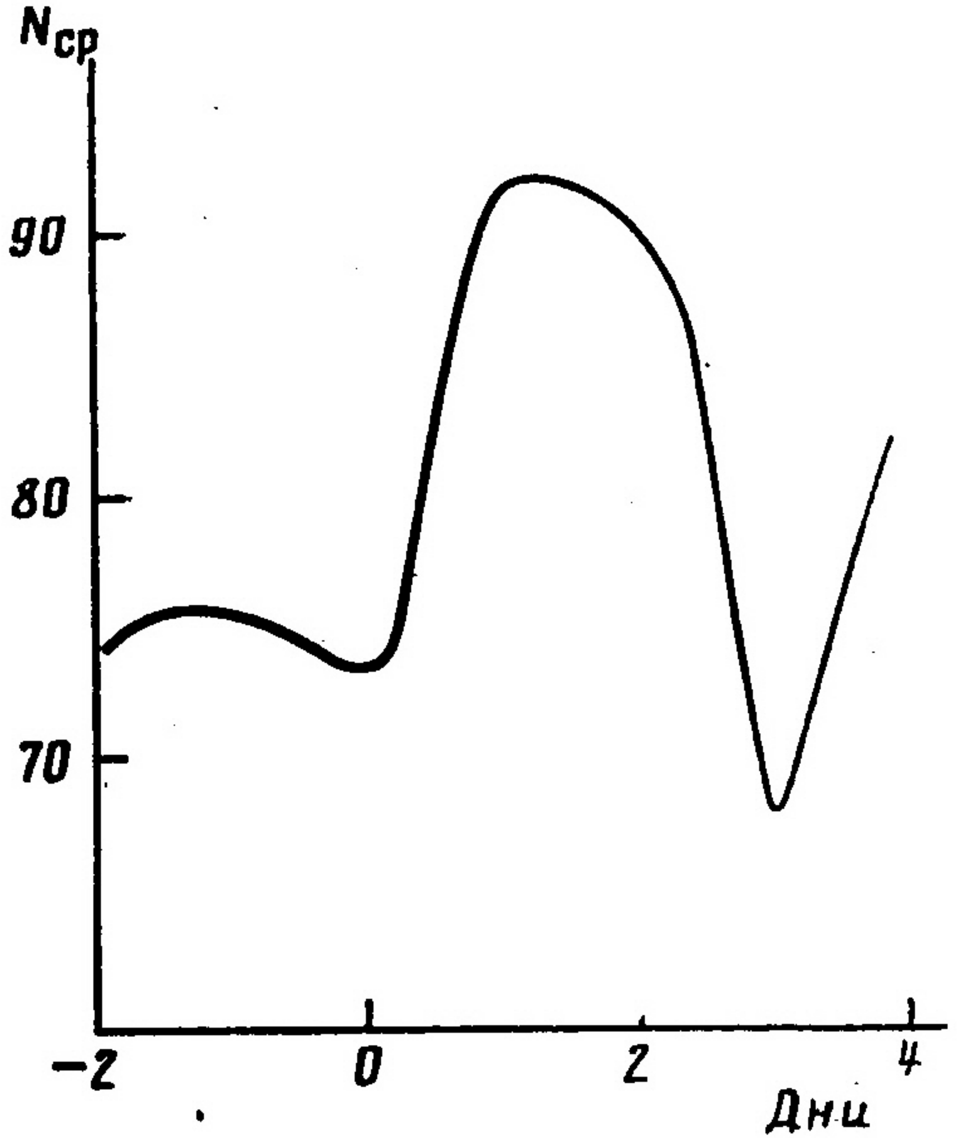
**- all the stages of the proposed mechanism were confirmed experimentally:**

**-The microwave radiation of the ionosphere intensifying during solar and magnetic storms was detected (V.S.Troitskii et al., 1973).**

**-The control of humidity at heights exceeding 3 km by both the microwave radiation of the Sun and solar flares was recorded by Krauklis et al., 1990; Nikol'skii and Shul'ts, 1991.**

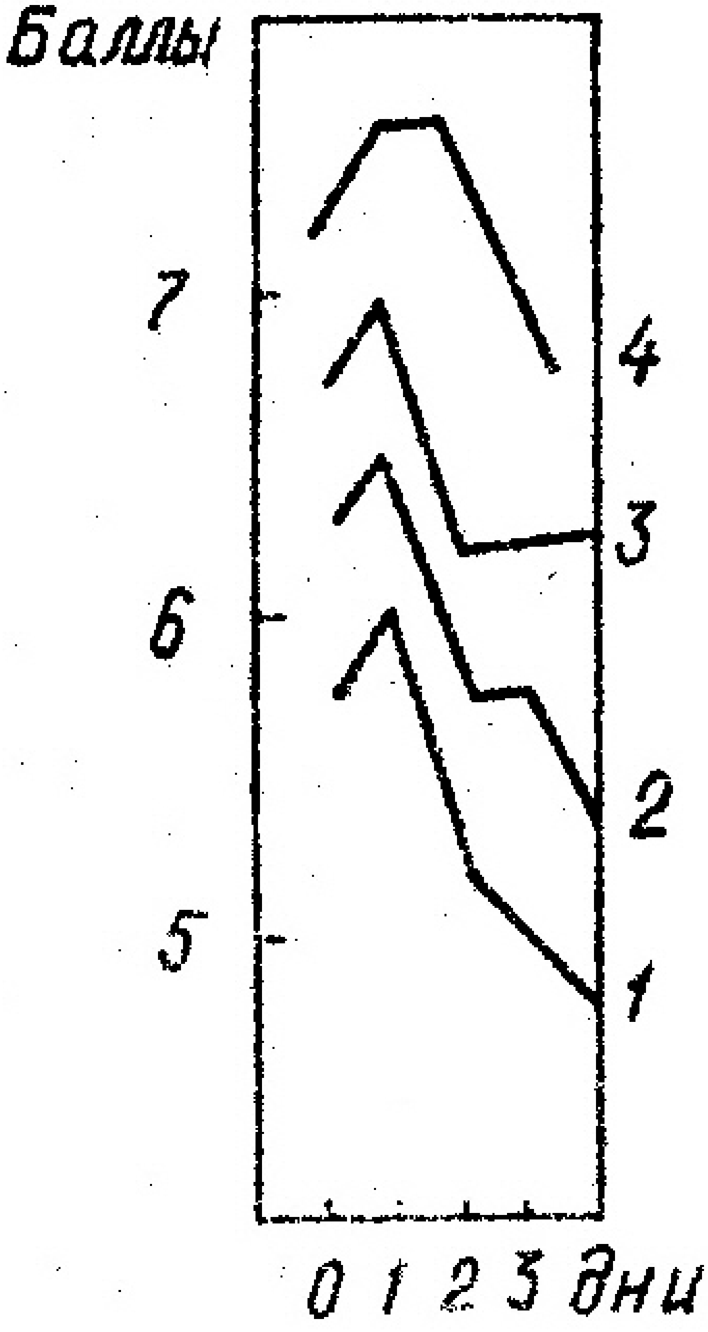
**-The direct influence of solar and magnetic storms on total cloudiness was reported by Dmitriev and Lomakina, 1977; Veretenenko and Pudovkin, 1996.**

**High-altitude observations of atmospheric transparency and water vapour cooncentration has shown that *solar microwave bursts and flares have an influence on clustering of water molecules (Kondrat'ev et al, 1990, 1991, 1995)*;**




CLOUDINESS AFTER SOLAR X-RAY FLARES

**(Dmitriev and Lomankina 1977)**




**CLOUDINESS AFTER X-RAYS SOLAR FLARES**

Южное полушарие:

1 - плотная облач-ть

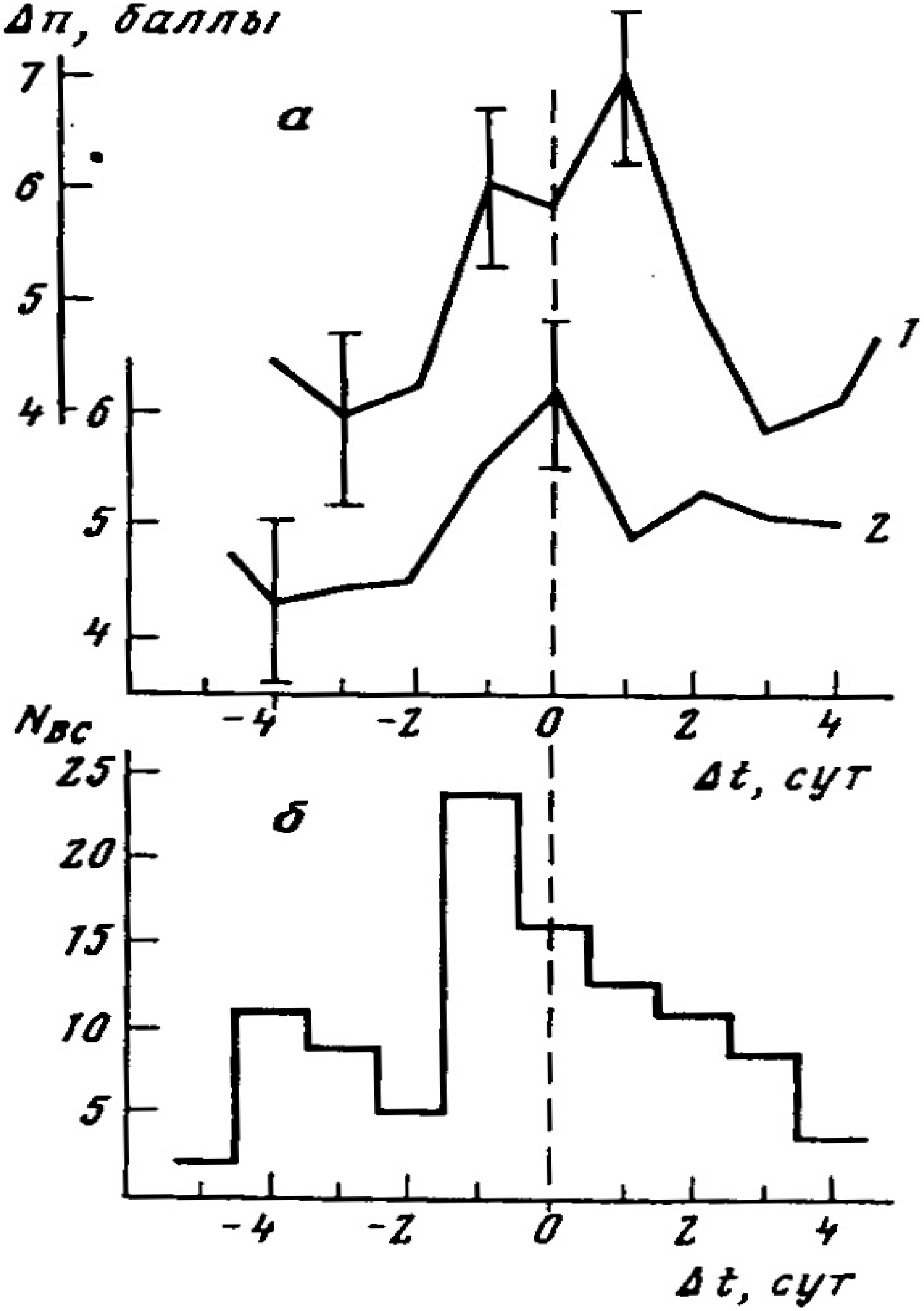
2 - с размыт. полями,

Северное полушарие

3 - плотная,

4 - с размыт. полями

*(По Дмитриеву,1990)*




# CLOUDINESS AFTER SOLAR COSMIC RAYS

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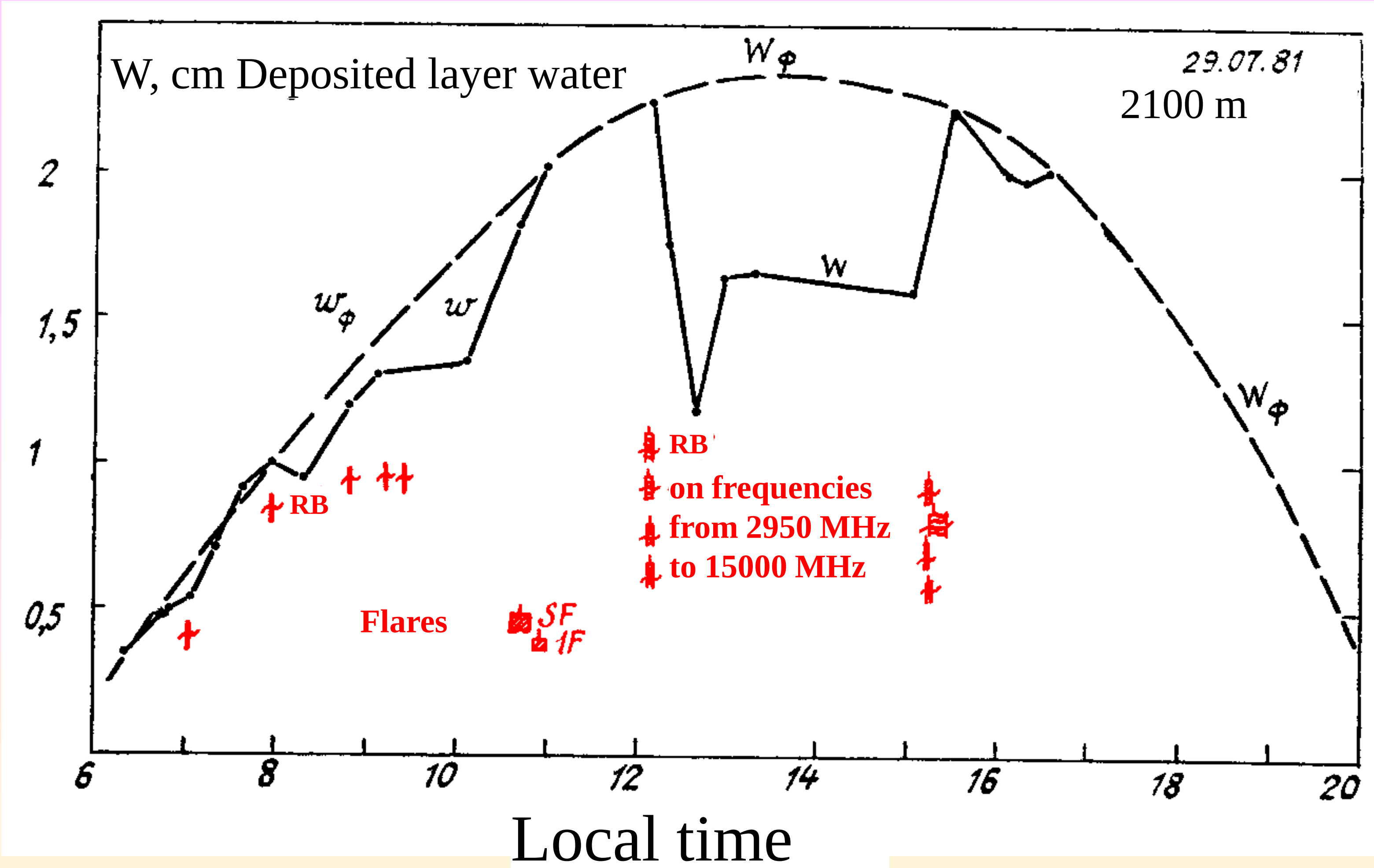
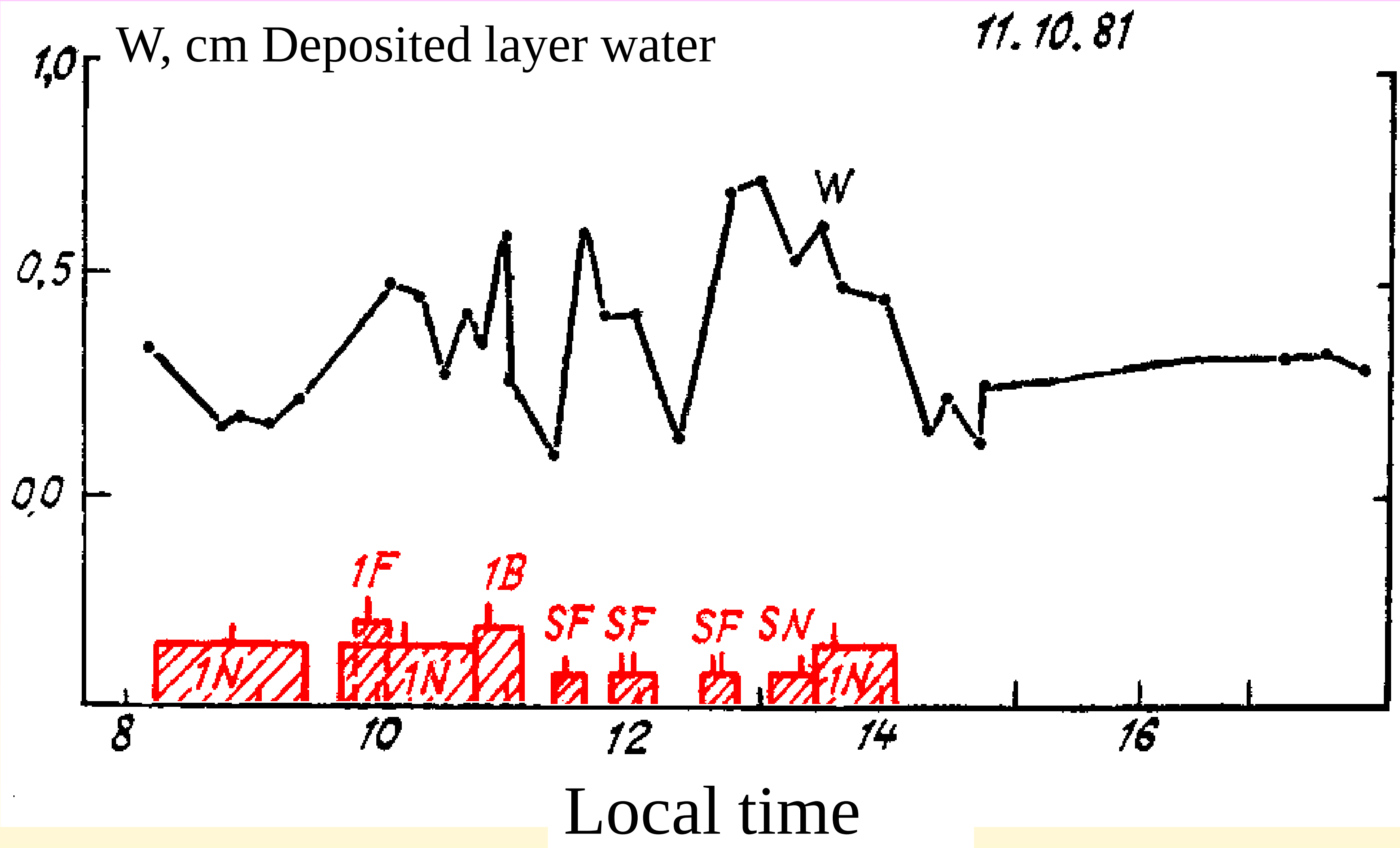
# The NUMBER of SOLAR X-ray FLARES




The day time dependence of total content of water vapour above 2.1 km altitude for July 29, 1981. $W_\phi$ – additional water above W, the estimated normal day-time content. In the bottom part of figure **are the duration and power of solar flares (SF, IF) and radio bursts (RB).** **G.A. Nikol'skii,** Shults E.O., **1991.**



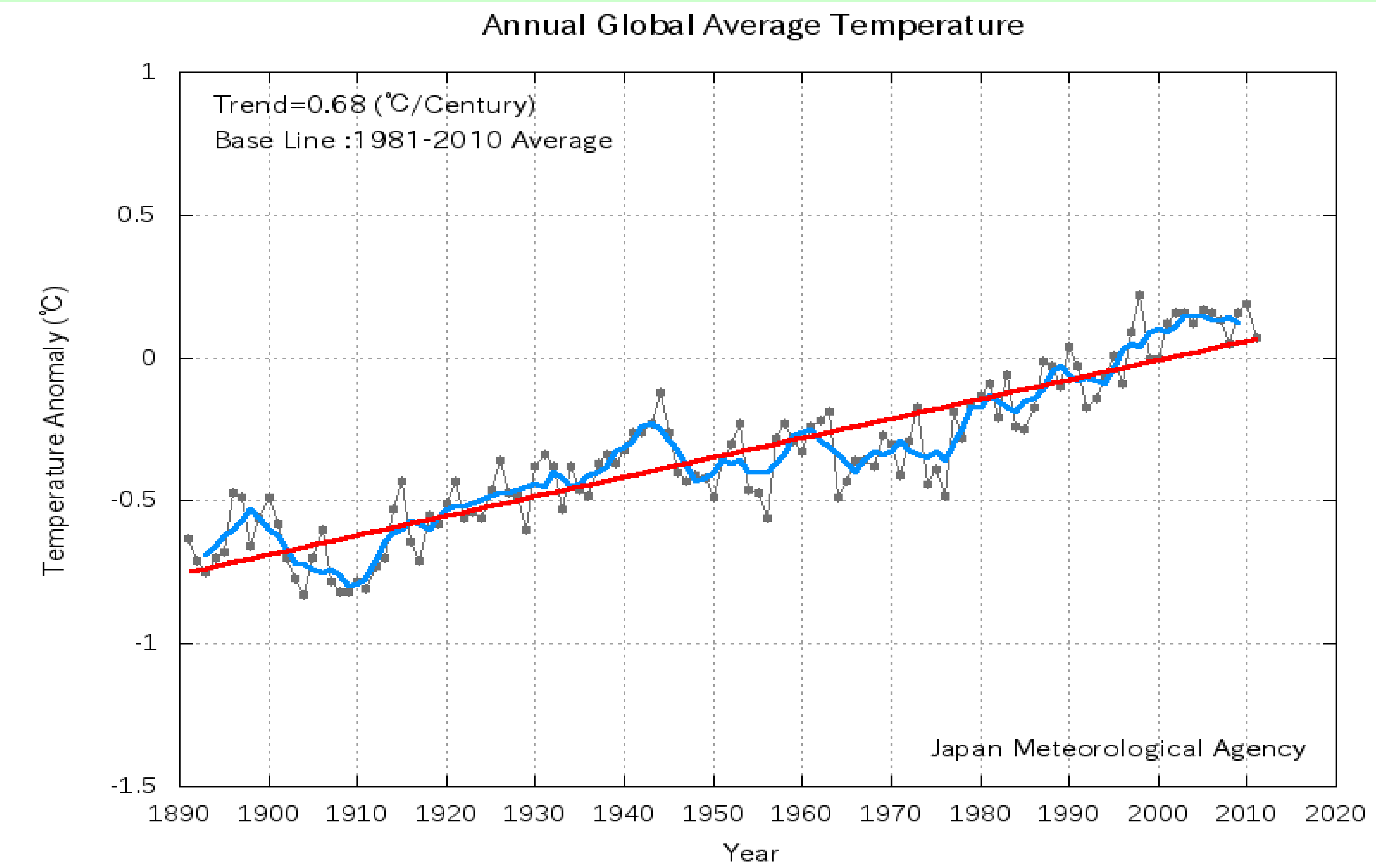

The day time dependence of total content of water vapour W from above 2.1km altitude from a broadband filter actinometer. Observations 11.10.1981. The times of **solar flares are shown on the x axis.** **G.A. Nikol’skii,** Shults E.O., **1991.**

***The Varying role that Cloud-Cover plays in Global Warming:***

**“The net radiative properties of a cloud are mainly dependent on its altitude and optical thickness. Optically-thin clouds at high and middle altitudes cause a net warming due to their relative transparency at short wavelengths but opacity in the IR region, whereas thick clouds produce a net cooling due to the dominance of the increased albedo of short-wave solar radiation”. (*J. Kirkby, A. Laaksonen*, 2000).**

# Here endeth the first lesson

On a more controversial front, let us briefly consider global warming effects:




# Japan Meteorological Agency

(http://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/ann_wld.html.

# THE ENERGETICS OF SPACE FACTORS

***The magnitudes of energy fluxes, coming to terrestrial atmosphere***

**SUN**

**Solar luminosity**
**1367 $W \cdot m^{-2}$**

**UV**
**0,1 $W \cdot m^{-2}$**

**Solar wind**
**$3 \cdot 10^{-4}$ $W \cdot m^{-2}$**

**Solar cosmic rays**
**$2 \cdot 10^{-3}$ $W \cdot m^{-2}$**

**Radiation belts during magnetic storms**
**1 $W \cdot m^{-2}$**

**Galactic cosmic rays**
**$7 \cdot 10^{-6}$ $W \cdot m^{-2}$**

***Magnitude of energy fluxes, absorbed in the earth atmosphere***

**FROM SUN**

**IN LOW ATMOSPHERE**
***$7 \cdot 10^{-5}$ $W \cdot gramm^{-1}$***

**IN IONOSPHERE**
***$10^{-3}$ $W \cdot gramm^{-1}$***

**FROM RADIATION BELTS DURING MAGNETIC STORMS**

**IN IONOSPHERE**
***$10^{-1}$ $W \cdot gramm^{-1}$***

**The IONOSPHERE IS *THE PRIMARY CANDIDATE FOR THE ROLE* OF TRIGGER IN THE PHYSICS OF SOLAR-TERRESTRIAL LINKS**

# *THE NUMBER OF DISTURBING EVENTS PER YEAR*

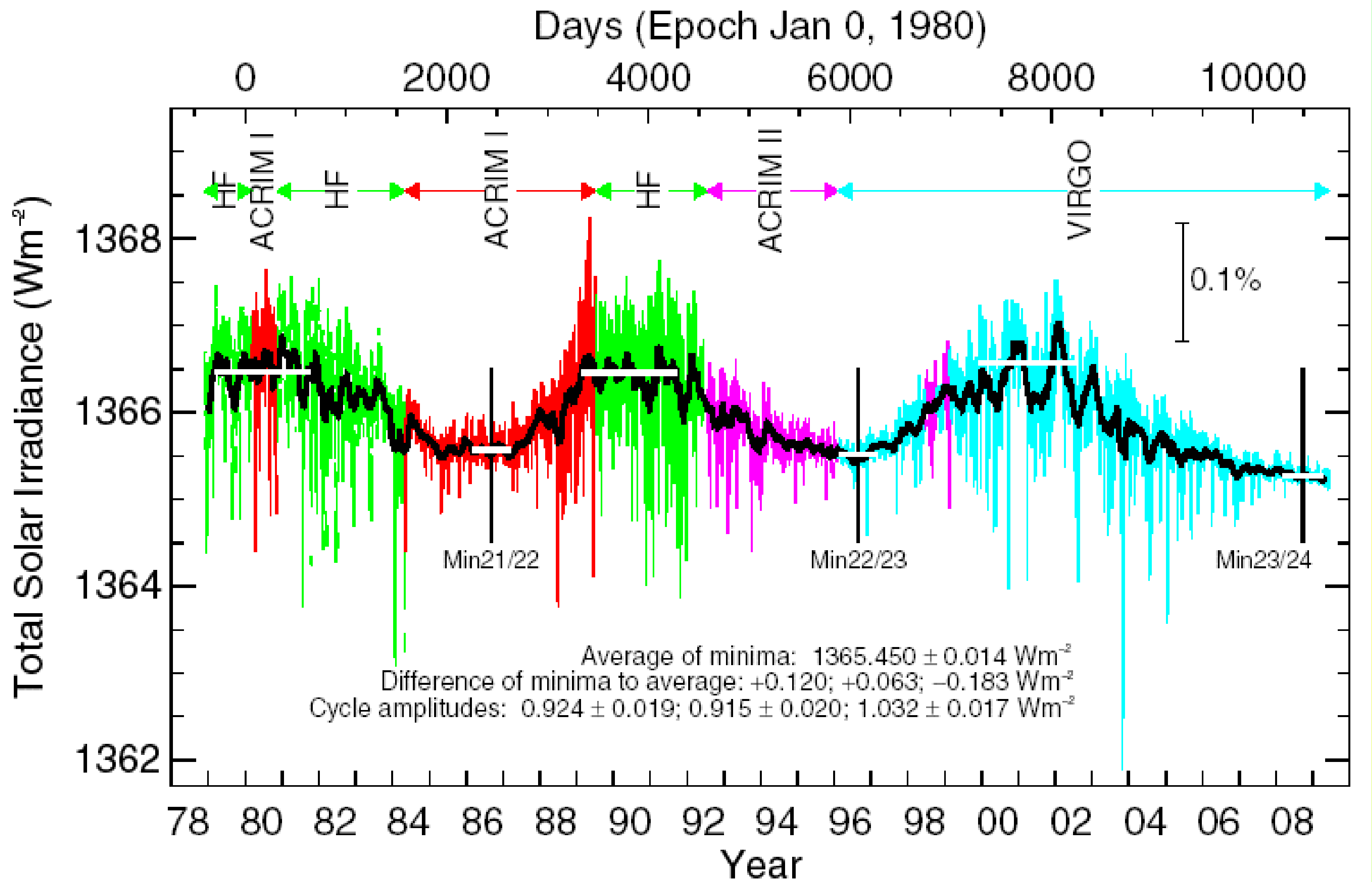
**FORBUSH DECREASE EVENTS:** ***1* (at 10 - 20%),**
***2 – 4* (at more than 3%, out of periods of geomagnetic storms and SCR).**

**SOLAR PROTON EVENTS (SCR):** ***5* (at the energy more than 100 MeV)**

**GEOMAGNETIC STORMS:** ***20 – 70* (*for Kp more than 5*).**

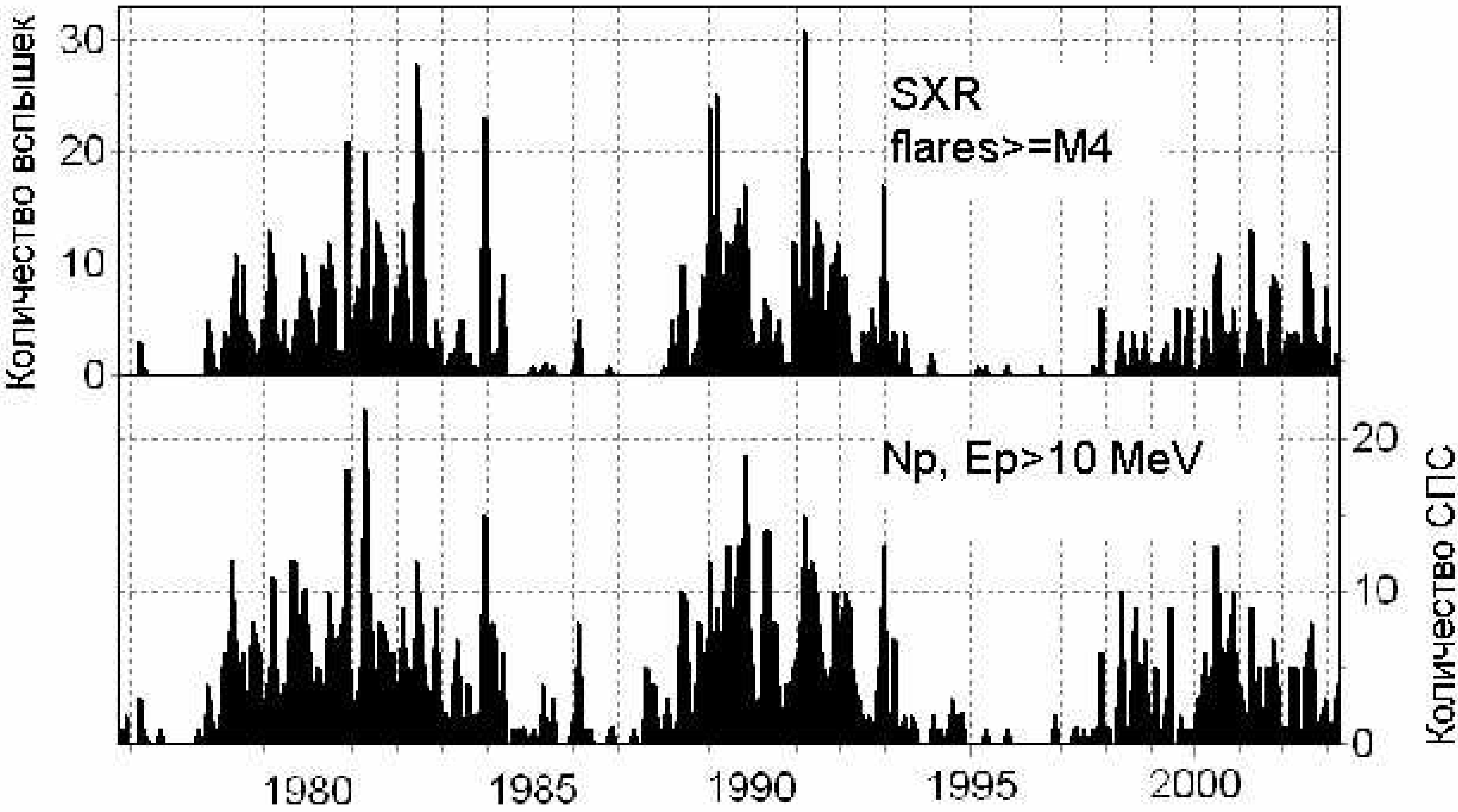
**SOLAR FLARES:** ***50* (*for class more than M5*).**

***S.E.C. User News, 2000***



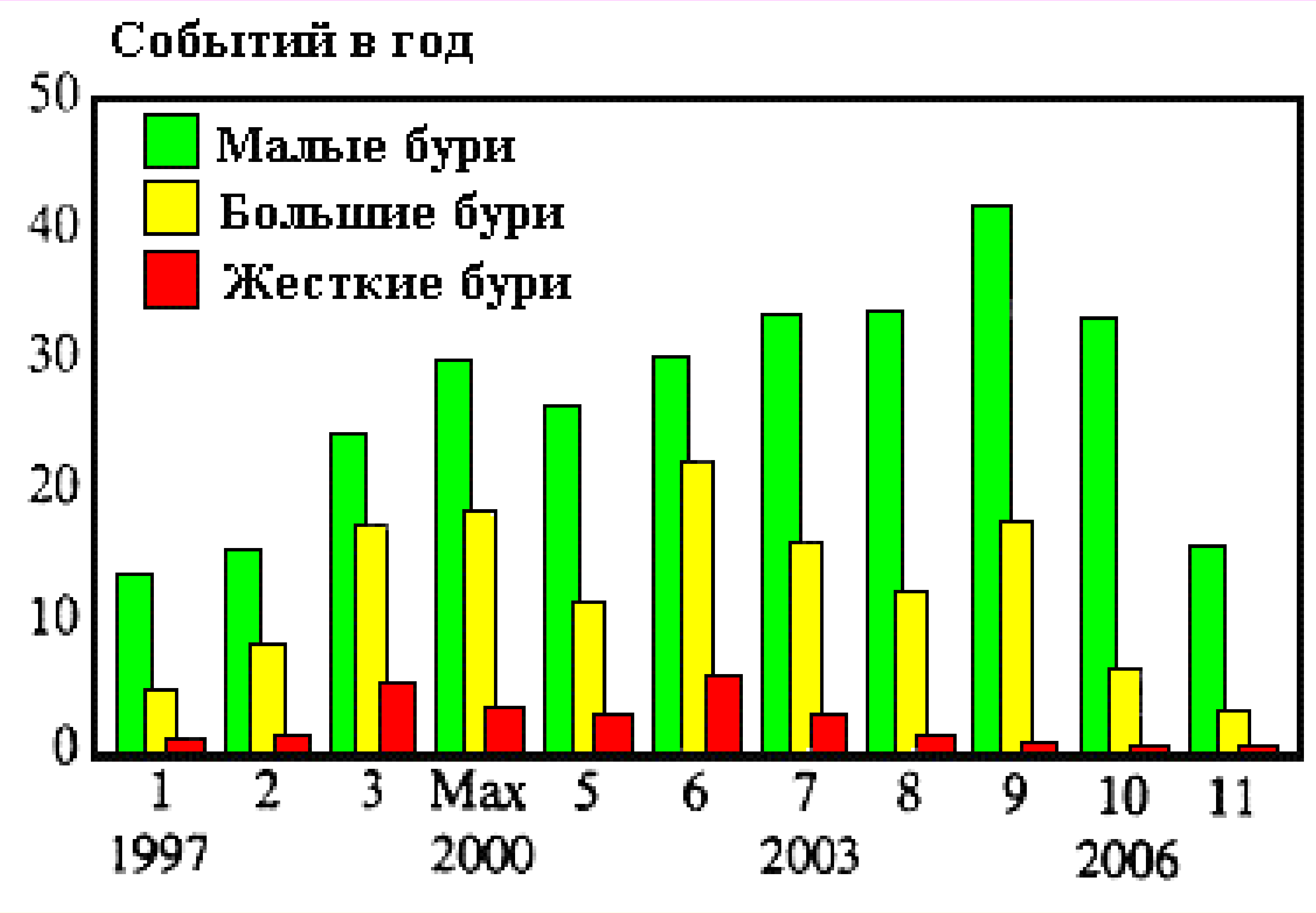

Irradiance is the total solar energy flux received at the top of the Earth's atmosphere (Frohlich, 2006, 2009).

Going down?



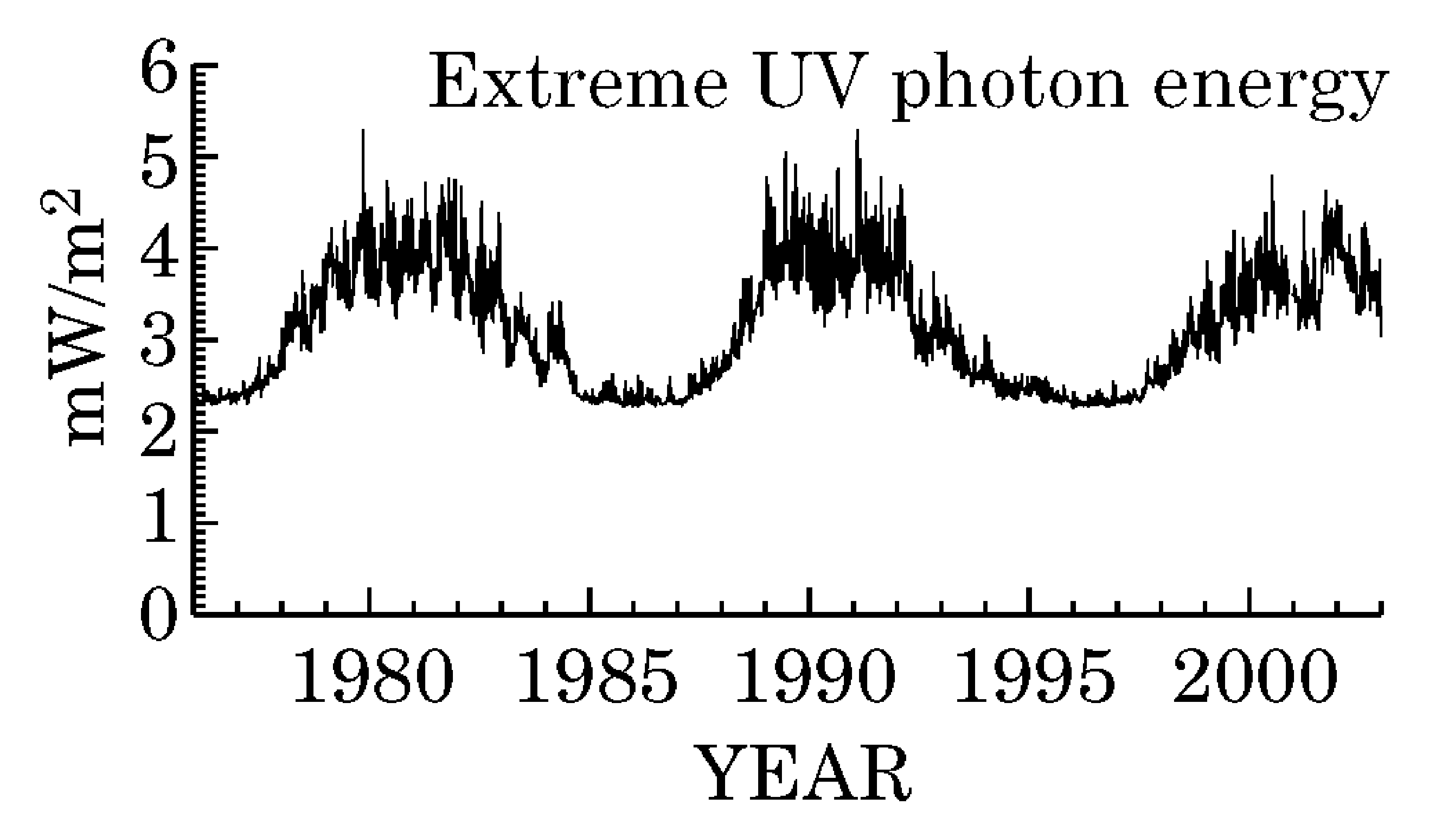

Временные вариации количества вспышек балла >=M4 и солнечных протонных событий (>10 МэВ), наблюдавшихся за месяц в 1975-2003 г

Going down?



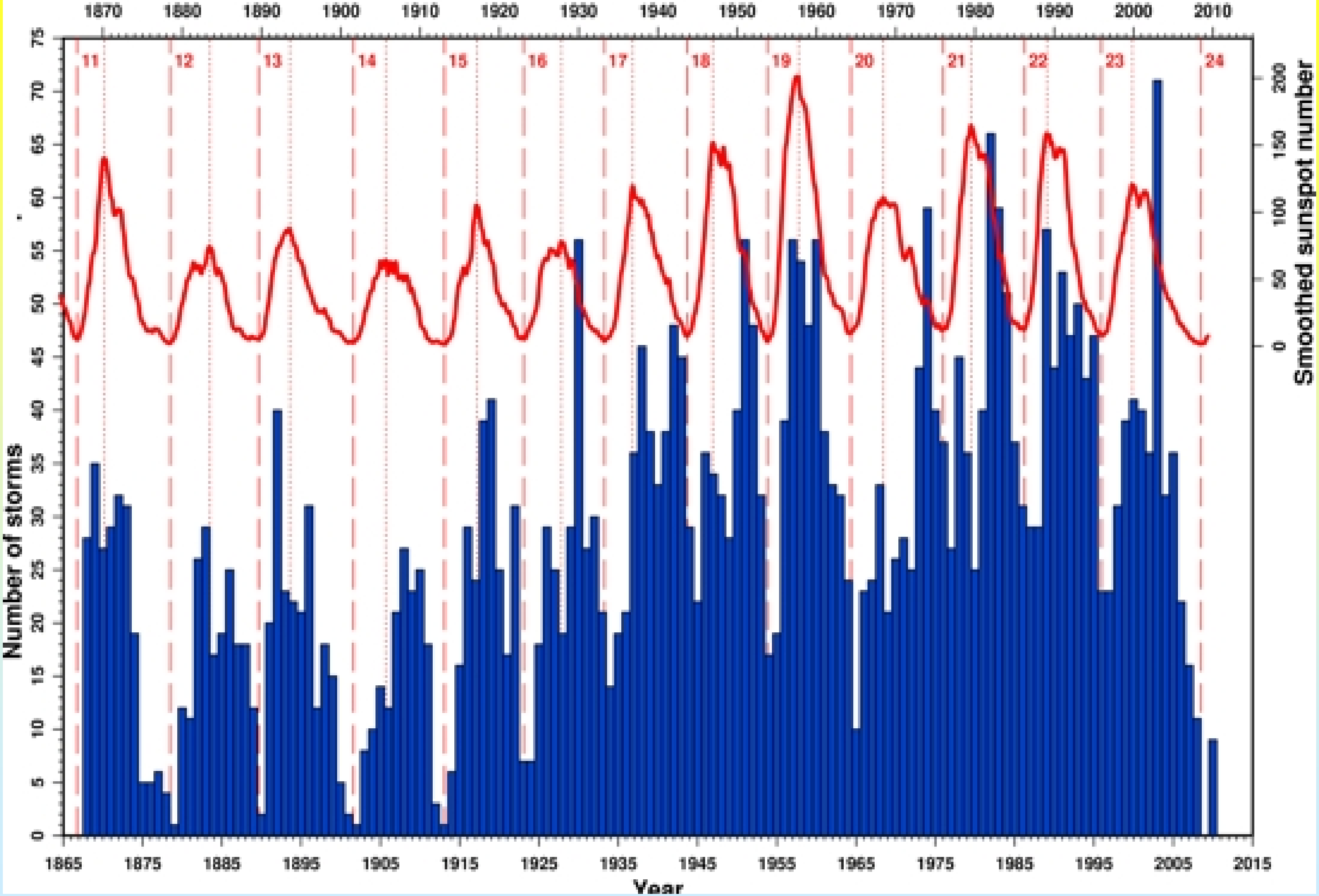

**There are two - three maxima of large geomagnetic storms during 23rd solar cycle**

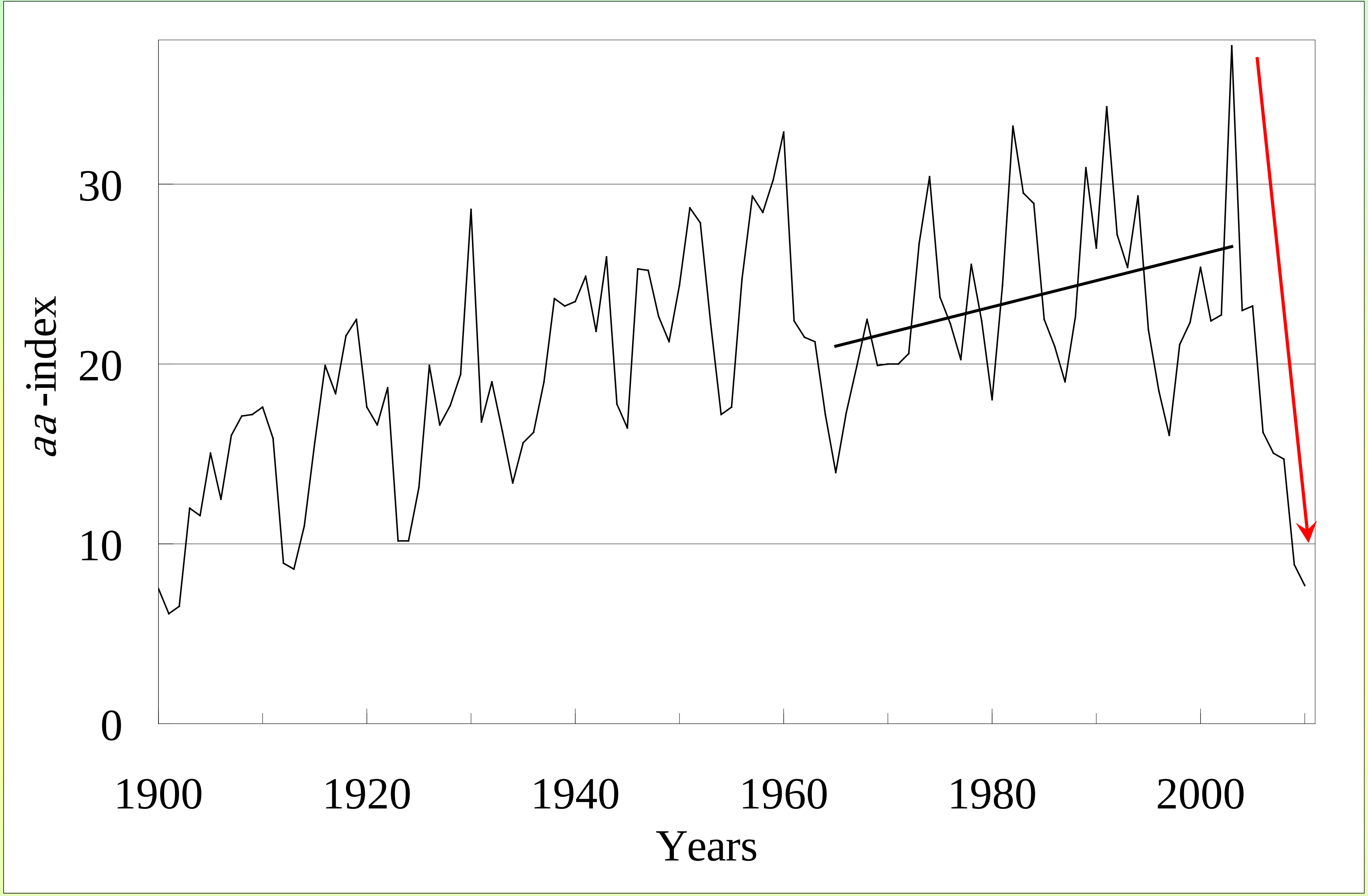
+




Shown are variations in the current total energy flux of EUV solar photons (Lean, 2005).

# Sunspot Cycle and Annual Number of Magnetic Storms



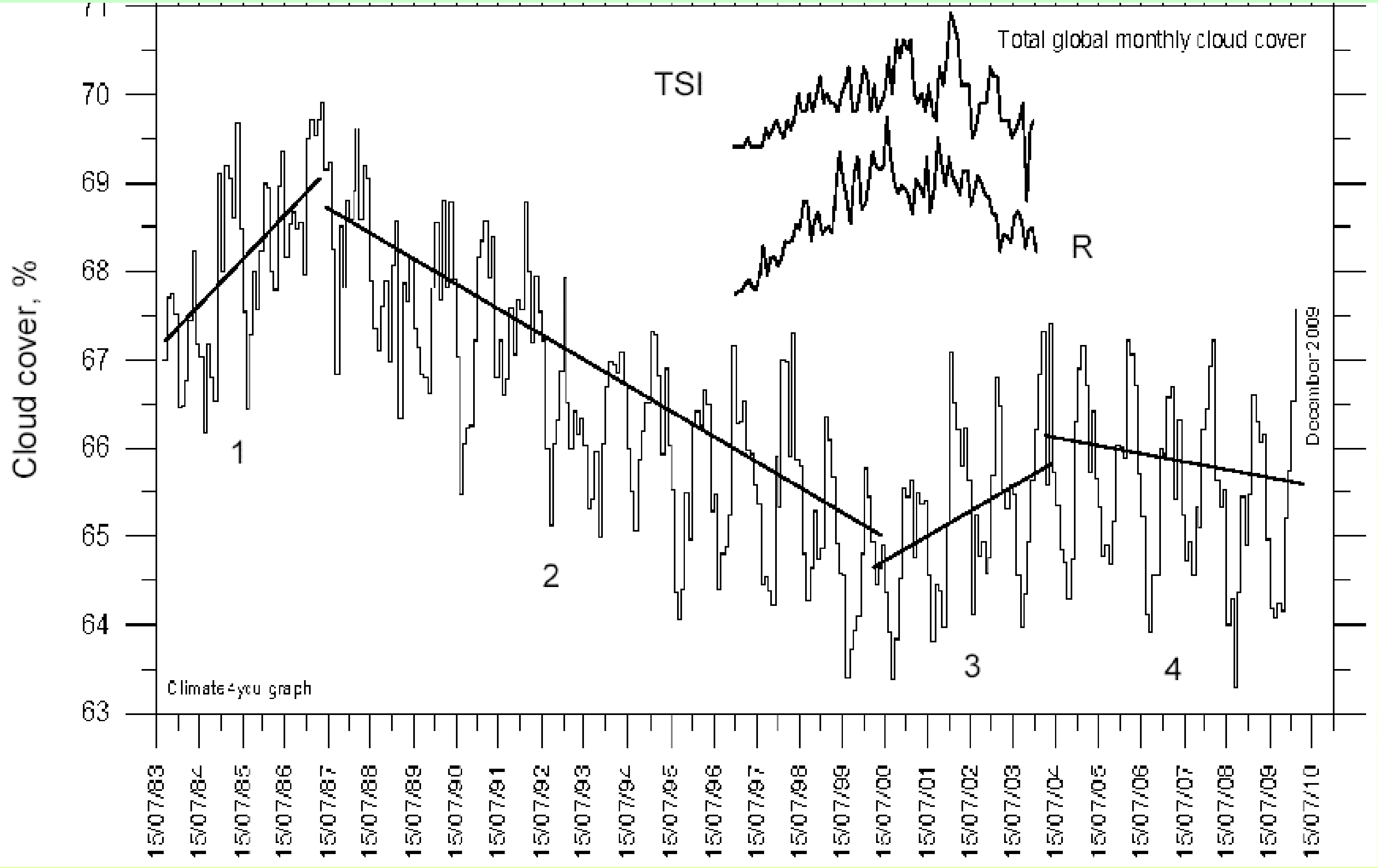



***aa*- INDEX** **HAS BEEN GOING UP TILL 2003 (+ 0.6 % / YEAR). AFTER NOV., 2003, GEOMAGNETIC ACTIVITY ALSO STARTED DECREASING VERY FAST AND BEFORE THE LEVEL NEAR VALUES OF *aa*-INDEX FOR 1900 YEAR.**

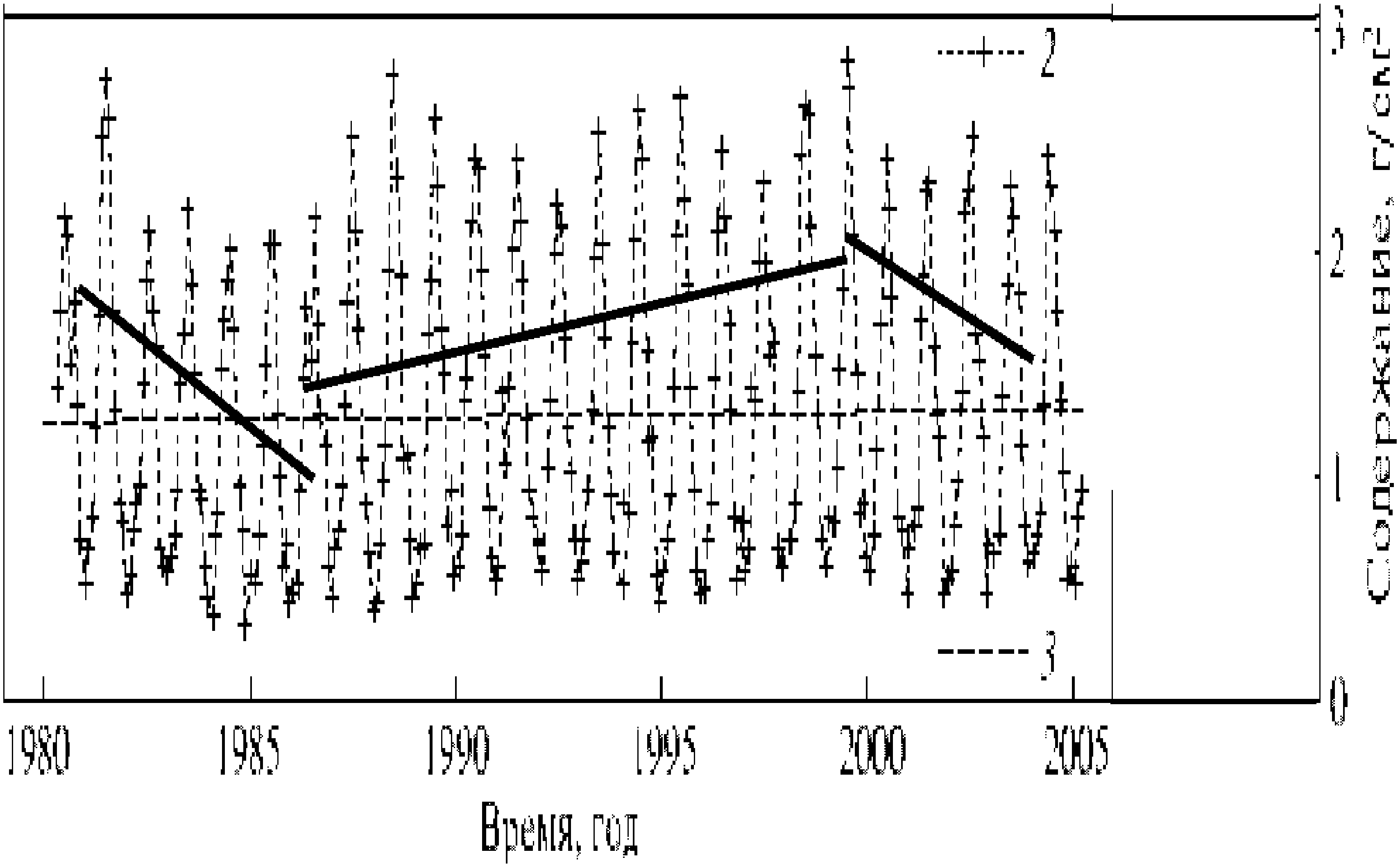
# FORECASTING OF FUTURE CLIMATIC CHANGES

**(*DECREASE OF NATURAL CONTRIBUTION OF GLOBAL WARMING*)**

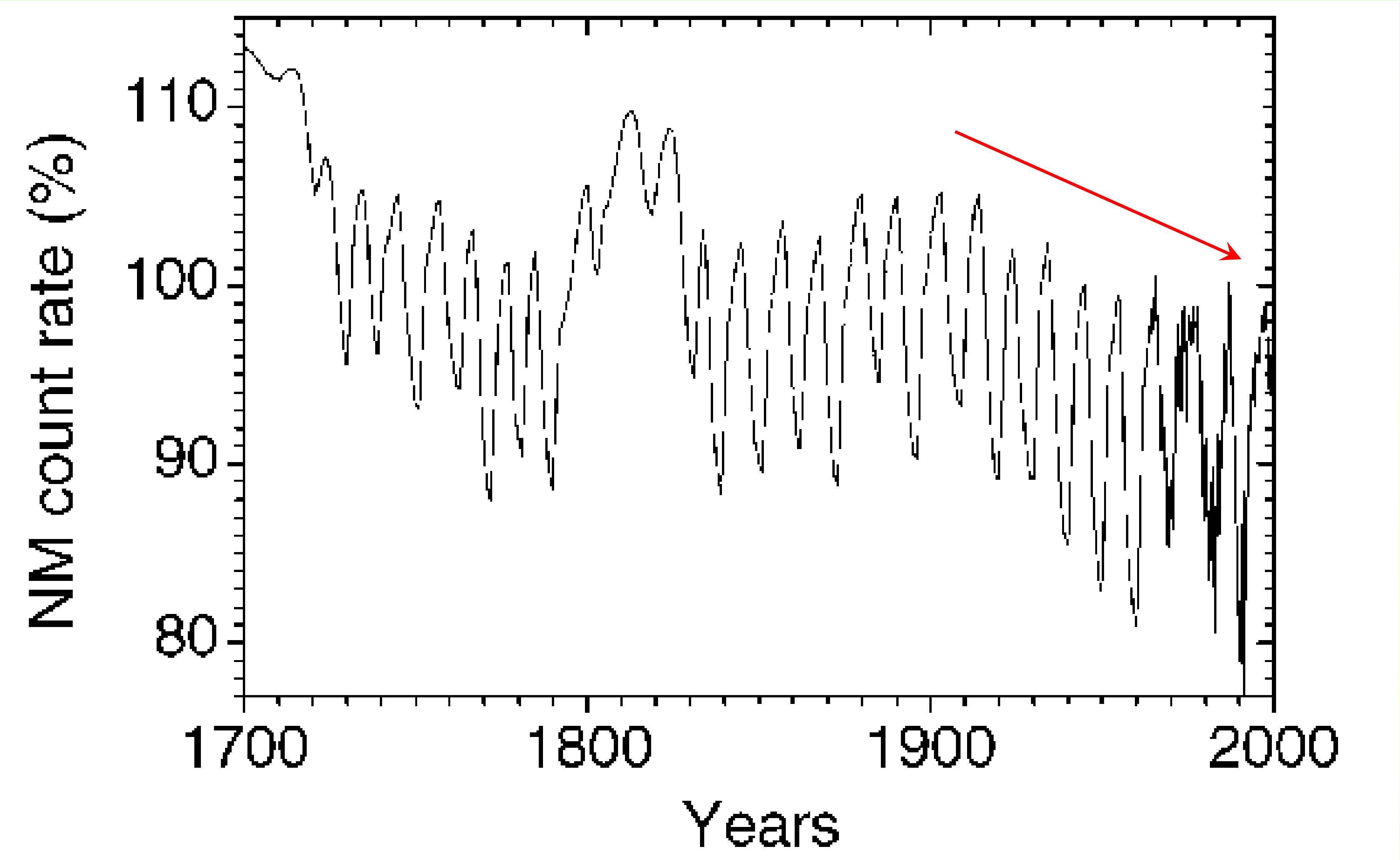
1) **The maximum of secular (quasi 100-yr and quasi 200-yr) cycle solar activity was observed in the 1980s**
2) **Since 1985 the total solar irradiance and EUV/X-ray ionizing fluxes have been decreasing.**
3) **Geomagnetic activity (aa - index) has been going up till 2003. This growth (+ 0.6 % per year since 1965) was replaced also by fast decline only after 2003.**
4) **This means that negative trends have come both for solar and geomagnetic activities.**
5) **What can we say about cloud cover?**



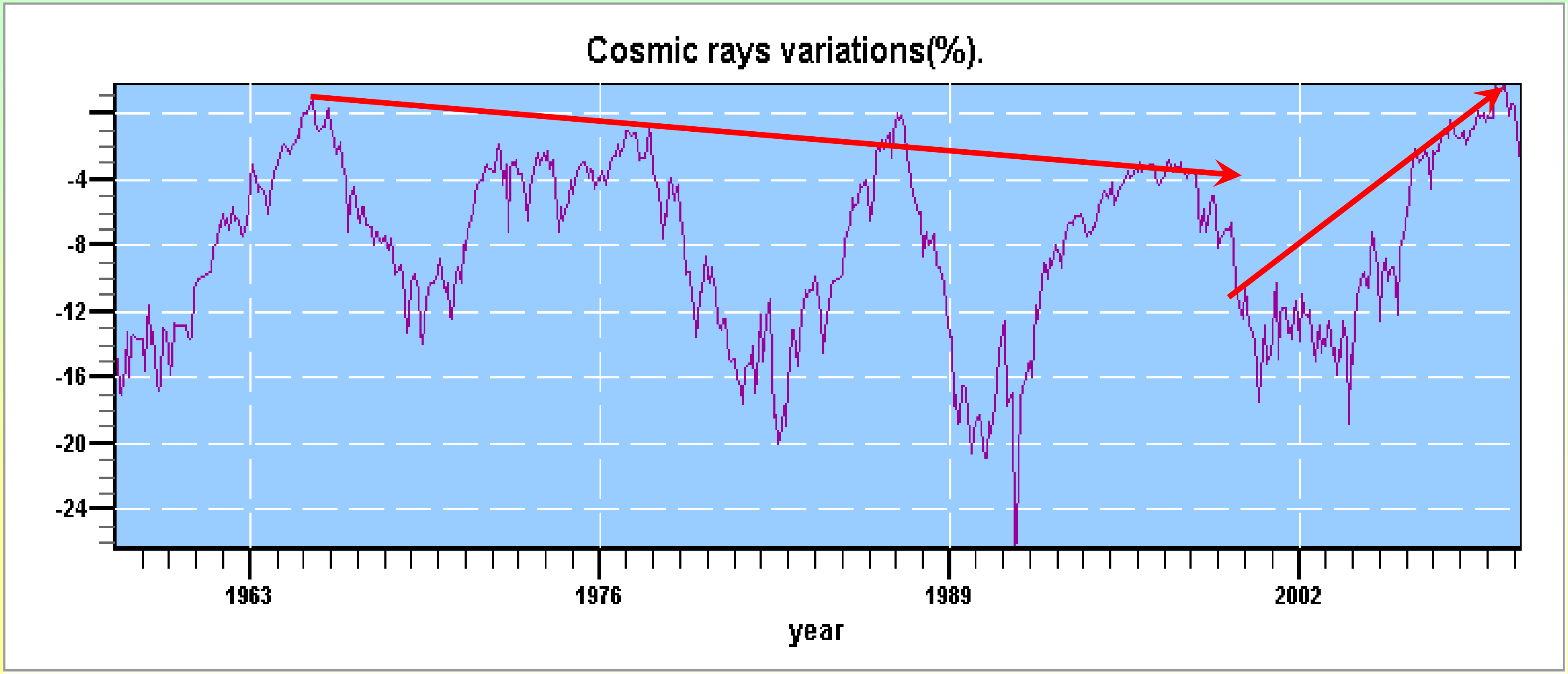

***Designated:*** ***1*** *- c period 1983 to 1985/7 years: the growth of clouds due to the increase in short-solar activity and an increase in the aa index of geomagnetic activity, as well as the world's number of magnetic storms, and* ***2*** *- the period c 1987 to 2000: the fall of EUV flux solar radiation [84] and the number of solar flares,* ***3*** *- from 2000 to 2003 : growth aa-index, continued until the end of 2003,* ***4*** *- from 2004: the overall decline of aa index of global magnetic storms and short electromagnetic activity of the Sun.*




The results of measurements of water vapor in the column of the atmosphere at high altitude (average value) and our approximation detectable trend




**COSMIC RAY CENTENNIAL VARIABILITY (RECONSTRUCTION OF A POLAR NEUTRON MONITOR (NM) COUNT RATE (USOSKIN AND KOVALTSOV, 2008).**




**Time dependence of monthly averaged cosmic rays variation at Dolgoprudny, Moscow region; (STOZHKOV ET AL., 2008).**

# IS THE MAIN AGENT OF GLOBAL WARMING OPTICALLY THIN CLOUDS?

**-This condensation-cluster haze - largely similar thin cirrus clouds (which are defined as "invisible", "transparent", "subvisual“).**

**- All these types of clouds can be considered “warming cloud” as, by passing shortwave (visible) solar radiation such clouds and condensation-cluster smoke (haze), have the ability to create a greenhouse effect, “delaying” about half the flow of heat radiation of the underlying ground.**

**EVOLUTION OF THE EARTH TOTAL RADIATION BALANCE IN 1985 – 2003 (GOLOVKO, 2003):**

**-growth of the value of outgoing long wave radiation amounts to approximately 15 $W/m^2$**

**-the value of outgoing short wave radiation reduced by approximately 10 $W/m^2$.**

**These facts agree with the estimates of the radiooptical mechanism effects. Indeed reduction of total cloud cover from Solar activity maximum in 1985/87 to 2000 amounts to 4 – 5 %. With mean cloud albedo equal to 0.5 – 0.8 and taking into account the Earth's sphericity we have:**

**$342\ W/m^2 x(0.04 - 0.05) x(0.5 – 0.8) = 6.8 – 13.7\ W/m^2$.**

**This corresponds to the decrease of the flow of outgoing short wave radiation. Its mean value is just 10 $W/m^2$ which is in agreement with results of satellite data processing, made in (Golovko, 2003).**

**ENERGETICS OF ANTHROPOGENIC AND RADIATION INFLUENCE ON THE EARTH CLIMATE DURING THE PRESENT SECULAR MAXIMUM OF SOLAR ACTIVITY:**

**According to Avakyan et al we can assume that the secular decrease of solar activity since 1985/86 and of geomagnetic activity since 2004 leads to the decrease of the energy of radiation influence on the Earth climate owing to the growth of the heat outgoing to space by 15 $W/m^2$ (Golovko, 2003).**

**This value:**
**- is 6 times as much as the effect of greengases 2.63 $W/m^2$,**
**- 2.3 times exceeds the effect of forest cutting down which sums up to 6.3 $W/m^2$ (Gorshkov, 2010),**
**- is 15 times as much as the declared contribution of TSI (up to 1 $W/m^2$ in various solar cycles)**
**- 3 – 6 times exceeds the range of effective flows (2.5 – 5 $W/m^2$) for the circulation changes (Borisenkov et al, 1989)**

# So, one possible conclusion?

**Negative trends have started for both solar and geomagnetic activity. By the radio-optical mechanism the natural global climate changes will go down to lower levels (J. Opt. Techn. 2010, №2)**