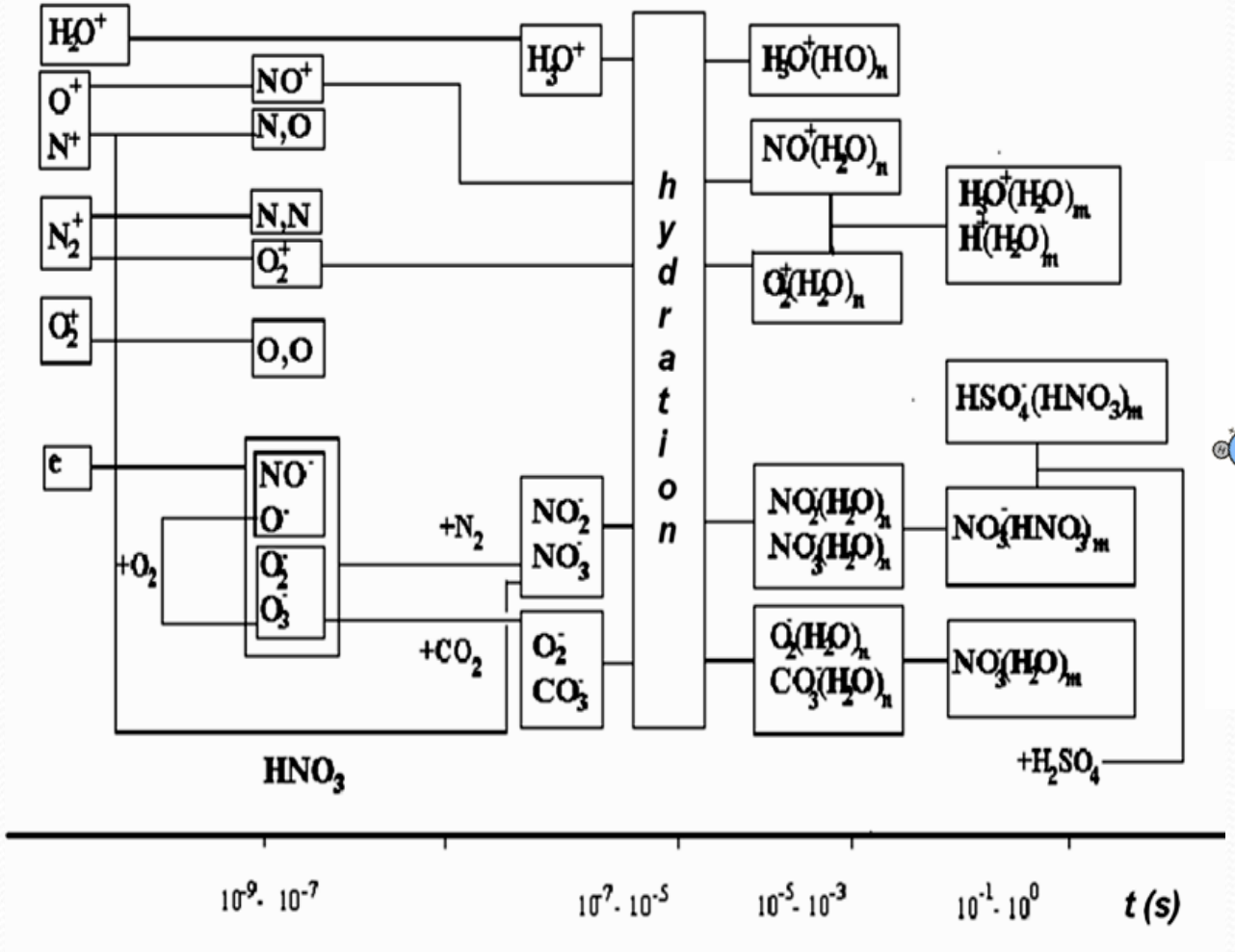
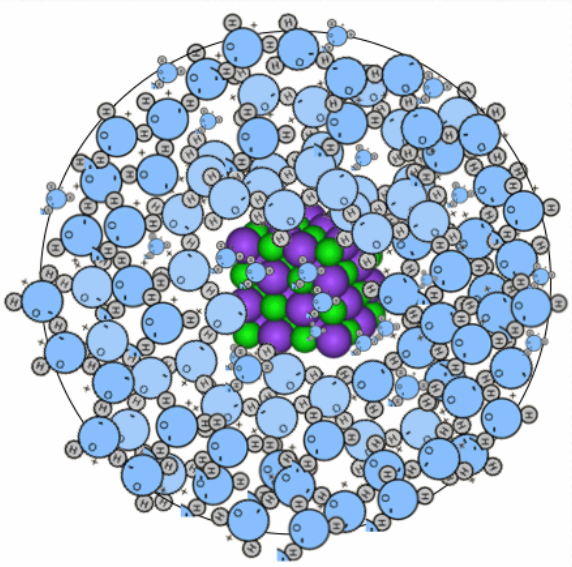
The role of Galactic Cosmic Rays in dynamics of hurricanes and typhoons and Global change

Sergey Pulinets

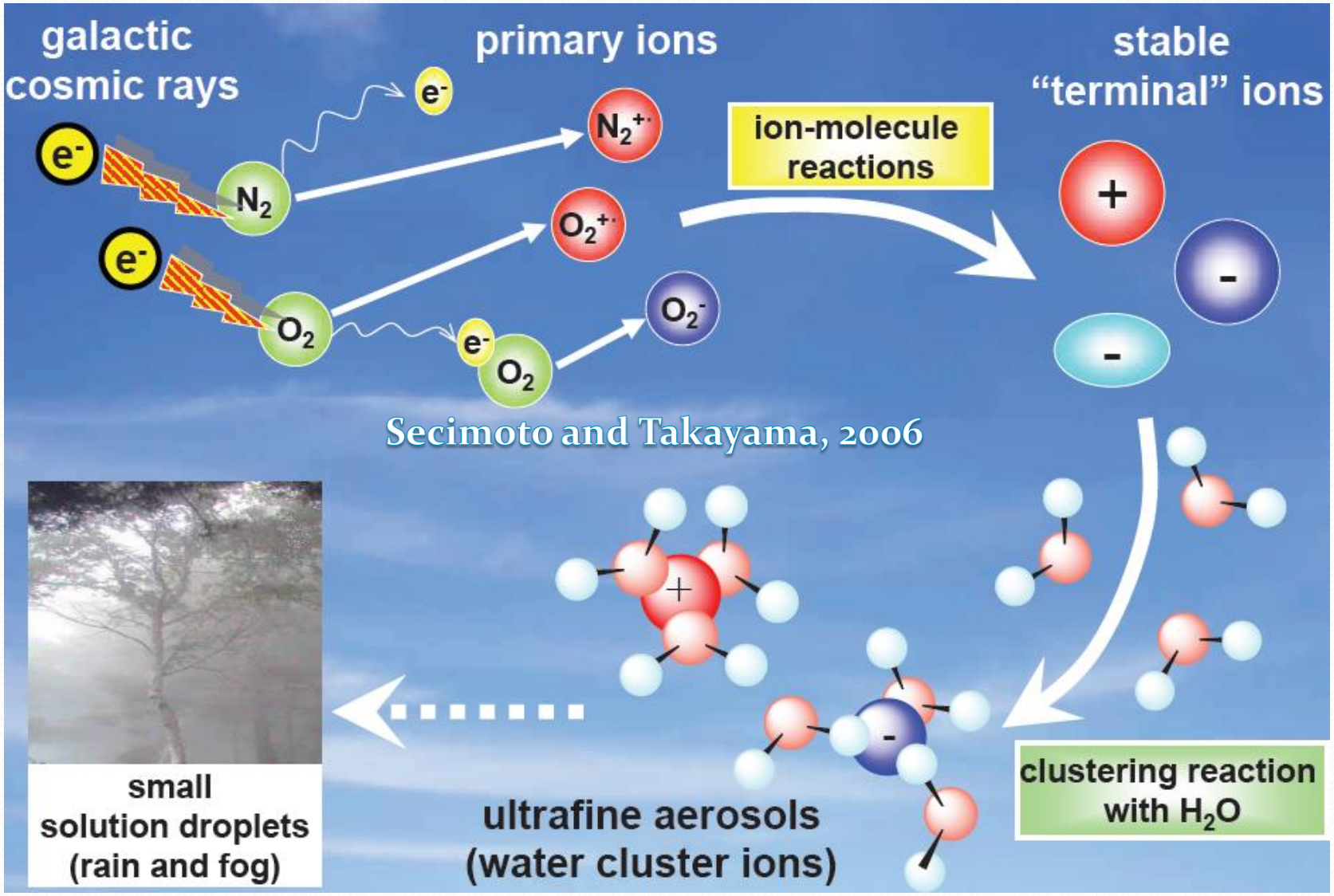
Space Research Institute, Russian Academy of Sciences, Moscow, Russia

Формирование гидратированных кластерных ионов в результате ионизации

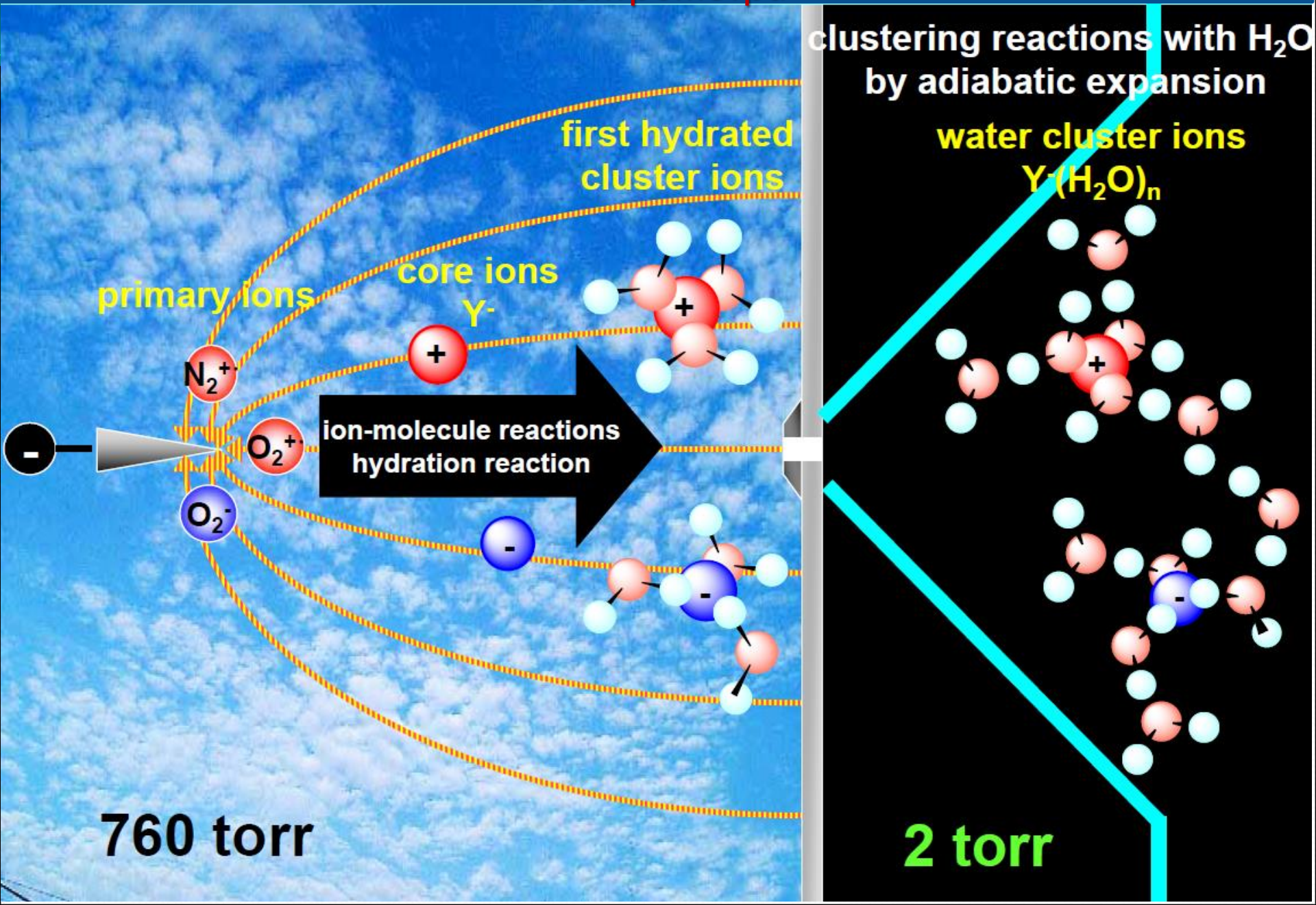


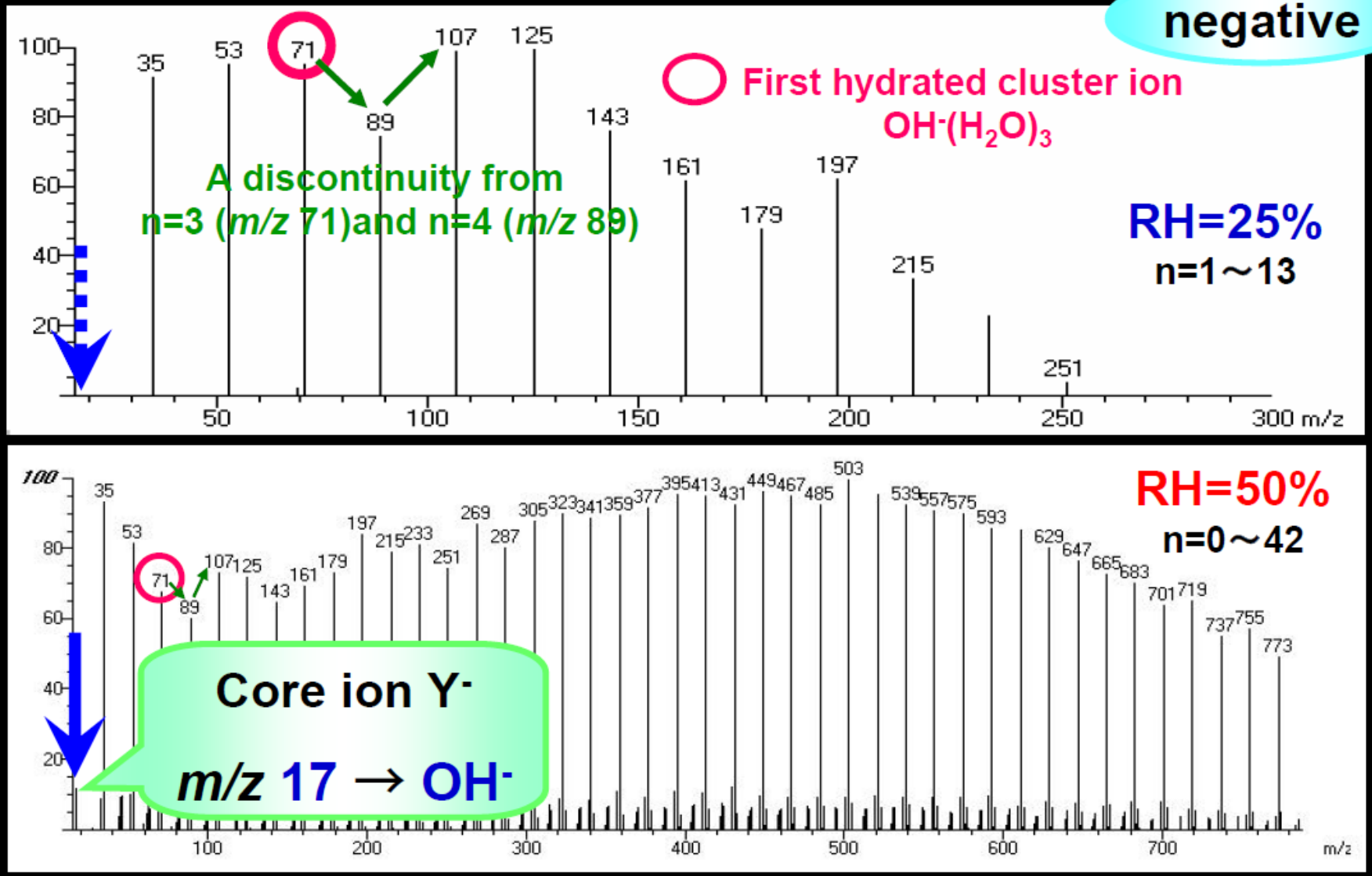


Экспериментальная демонстрация эффекта гидратации ионов

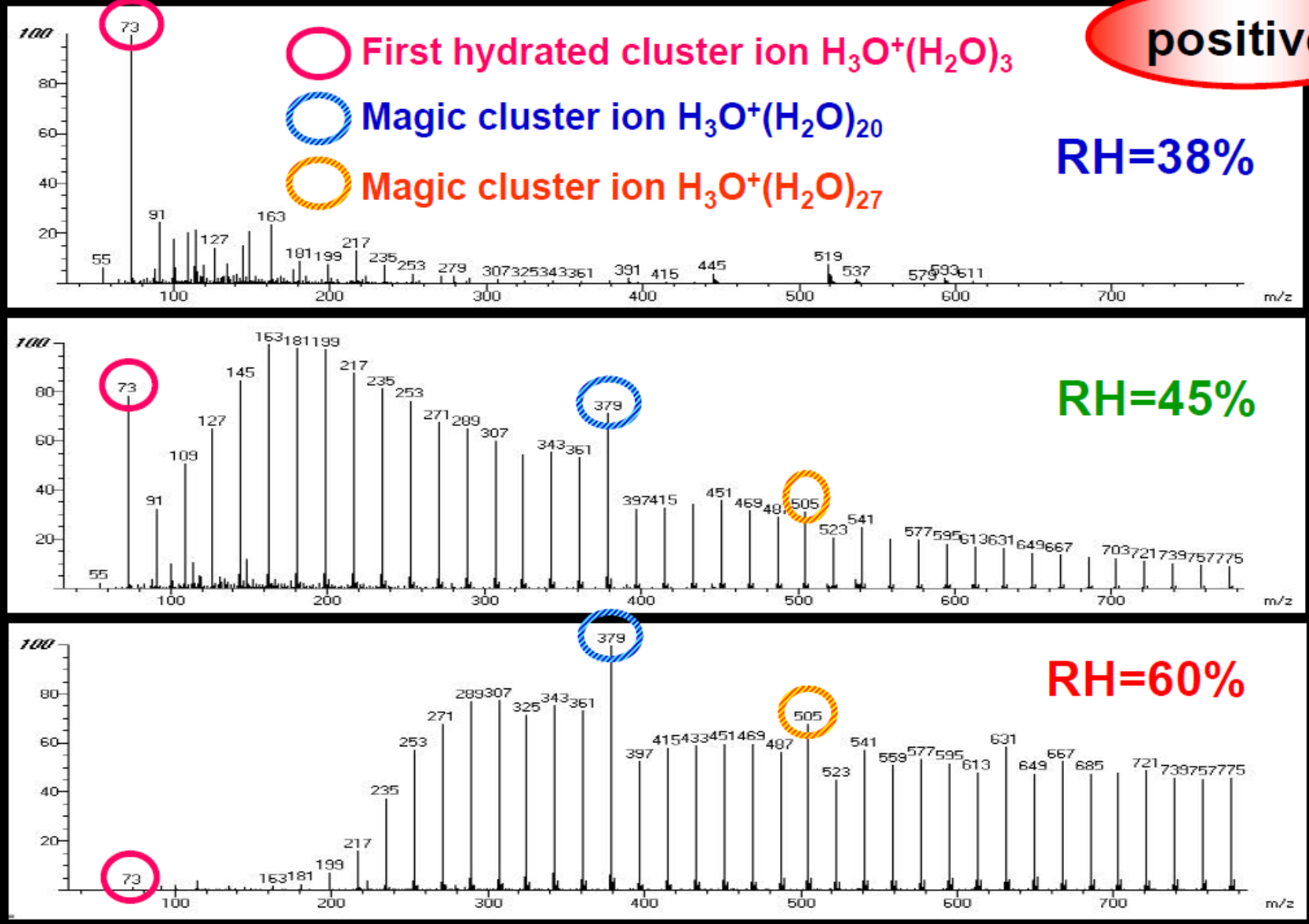


Ионизация с помощью коронного разряда, анализ с помощью масс-спектрометра



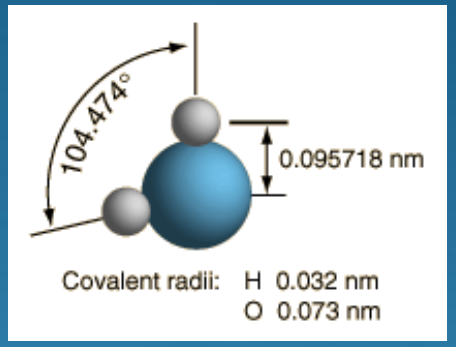


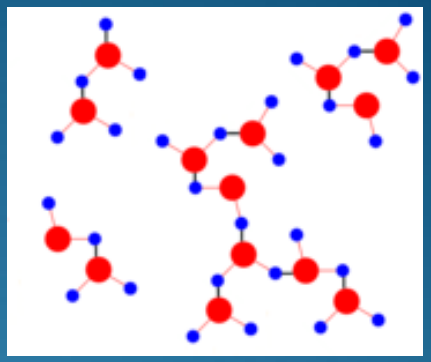
The mass spectra of $OH^-(H_2O)_n$ in ambient air with two different relative humidities at 24℃.

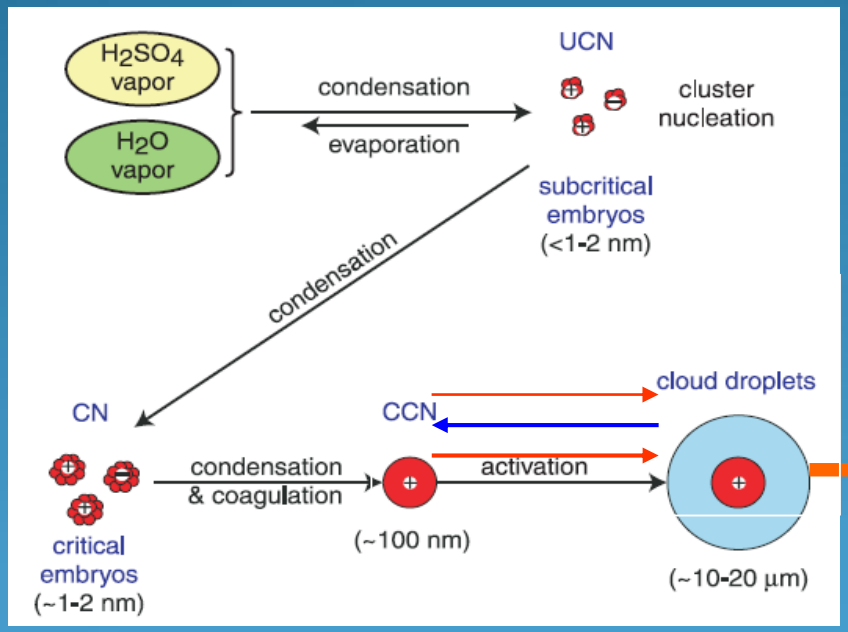


The mass spectra of $H_3O^+(H_2O)_n$ in ambient air with three different relative humidities at 24℃.

Droplets formation

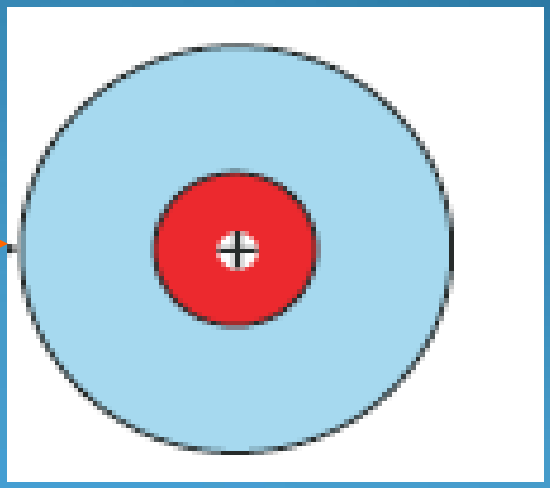






Three—stage droplet formation

Rain drop



UCN Ultrfine condensation nuclea

CN Condensation nuclea

CCN Cloud condensation nuclea

Galactic cosmic rays and clouds formation

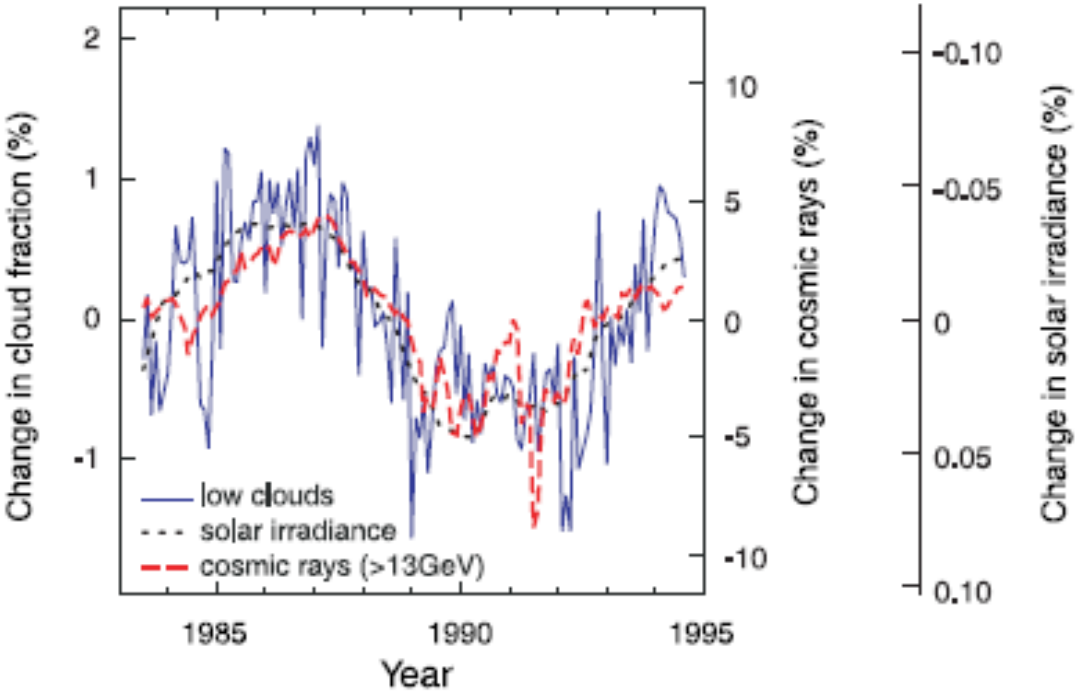
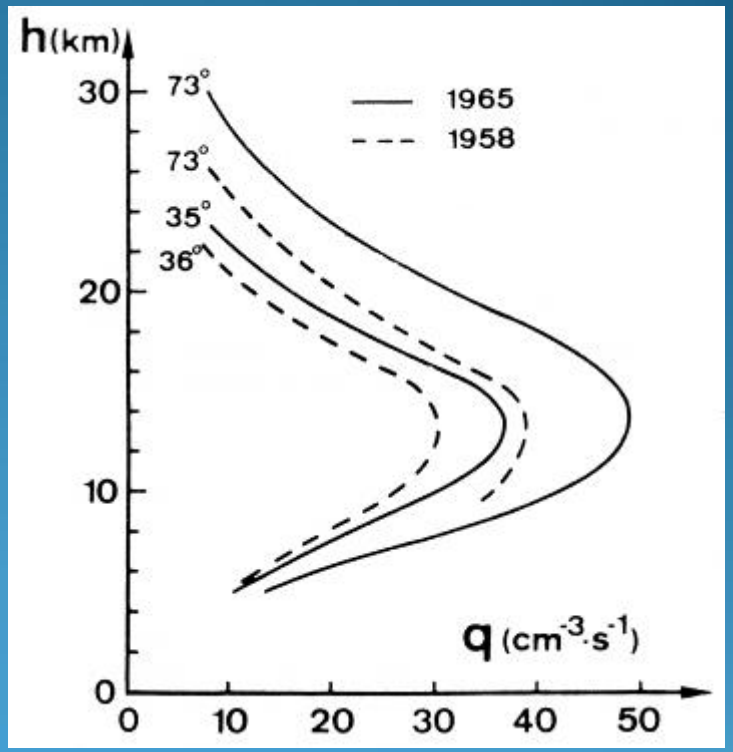
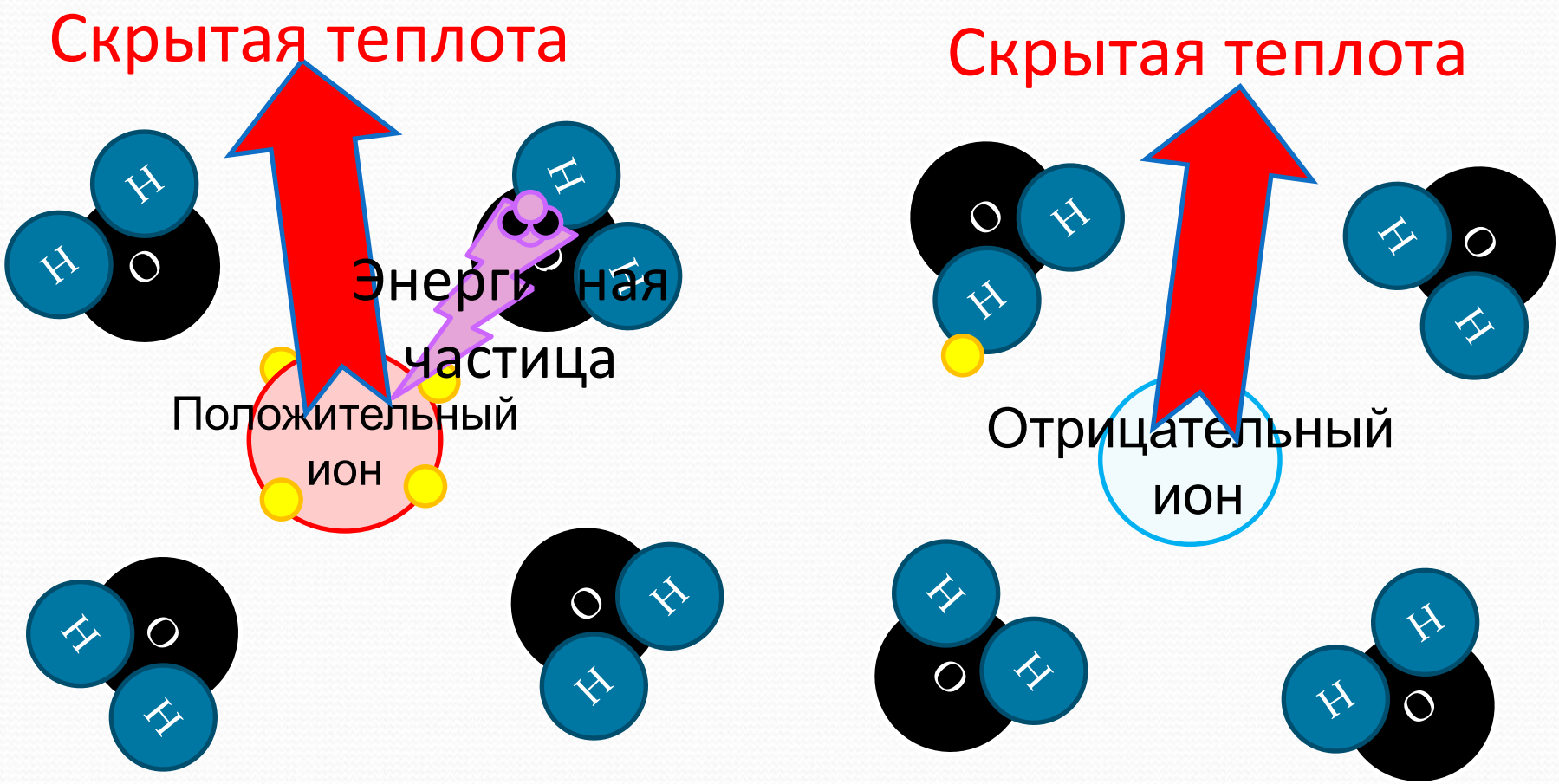


Fig. 1. Variation of low-altitude cloud cover, cosmic rays, and total solar irradiance between 1984 and 1994. The cosmic ray intensity is from Huancayo observatory, Hawaii. [Adapted from (*4*)]



Svensmark, 1998

Неучтенный фактор в прежних моделях



Thermal balance of atmosphere

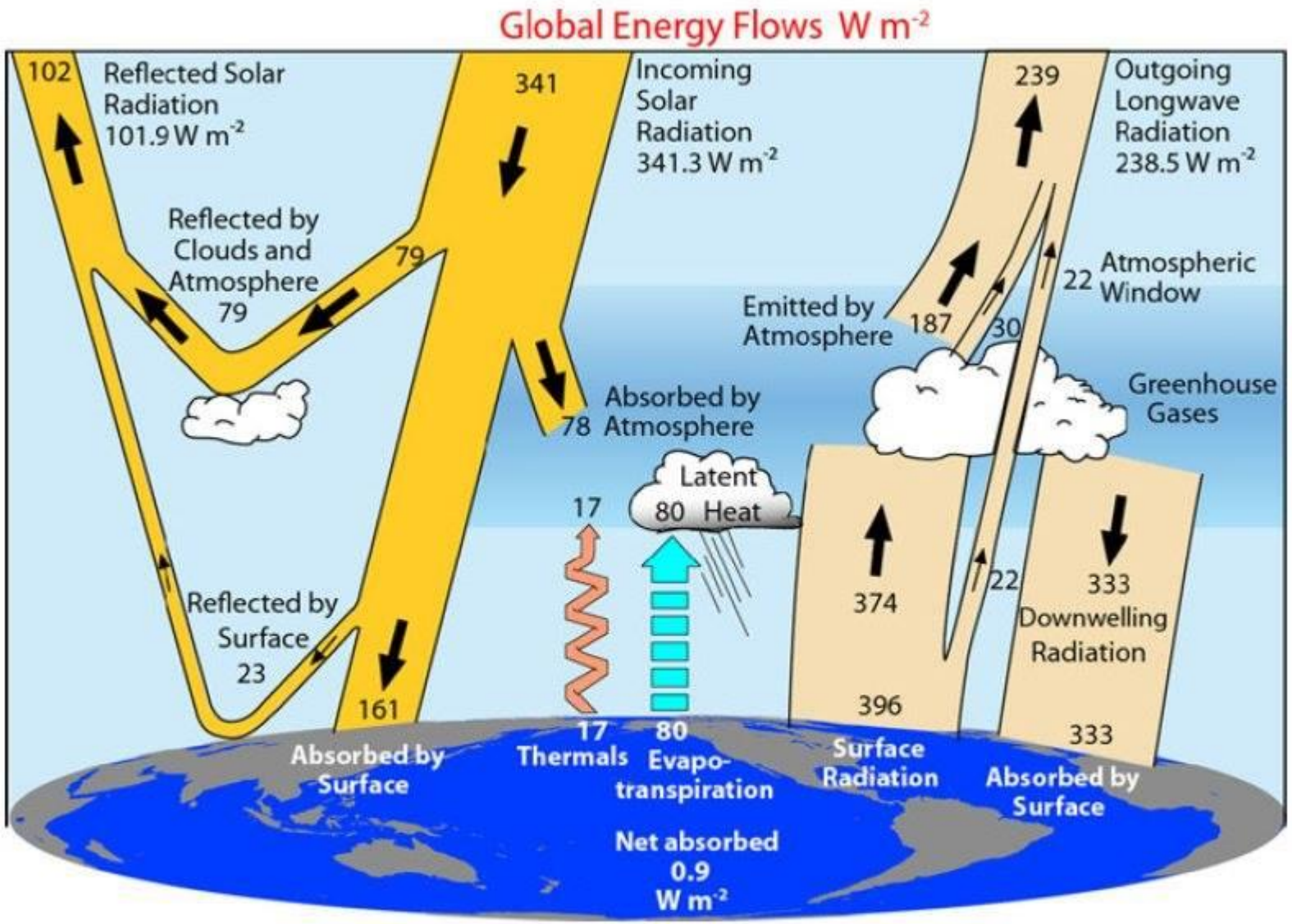


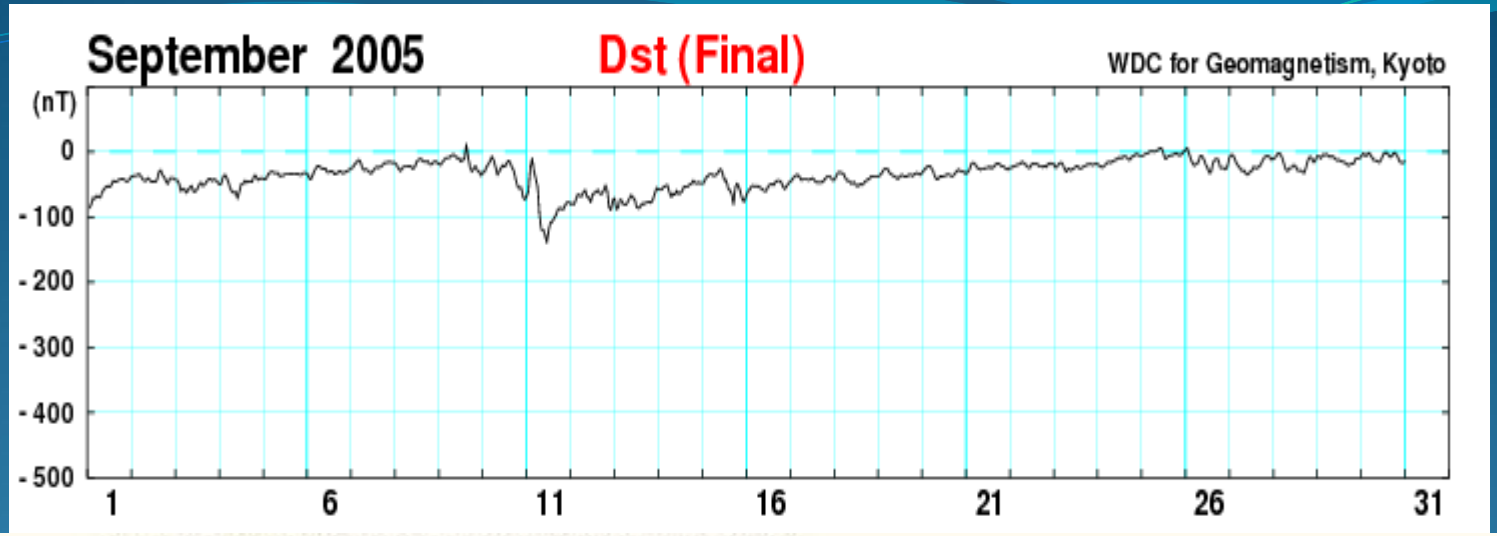
Fig. 1 The global annual mean earth's energy budget for 2000–2005 (W m^{-2}). The *broad arrows* indicate the schematic flow of energy in proportion to their importance. Adapted from Trenberth et al. (2009) with changes noted in the text

Comments

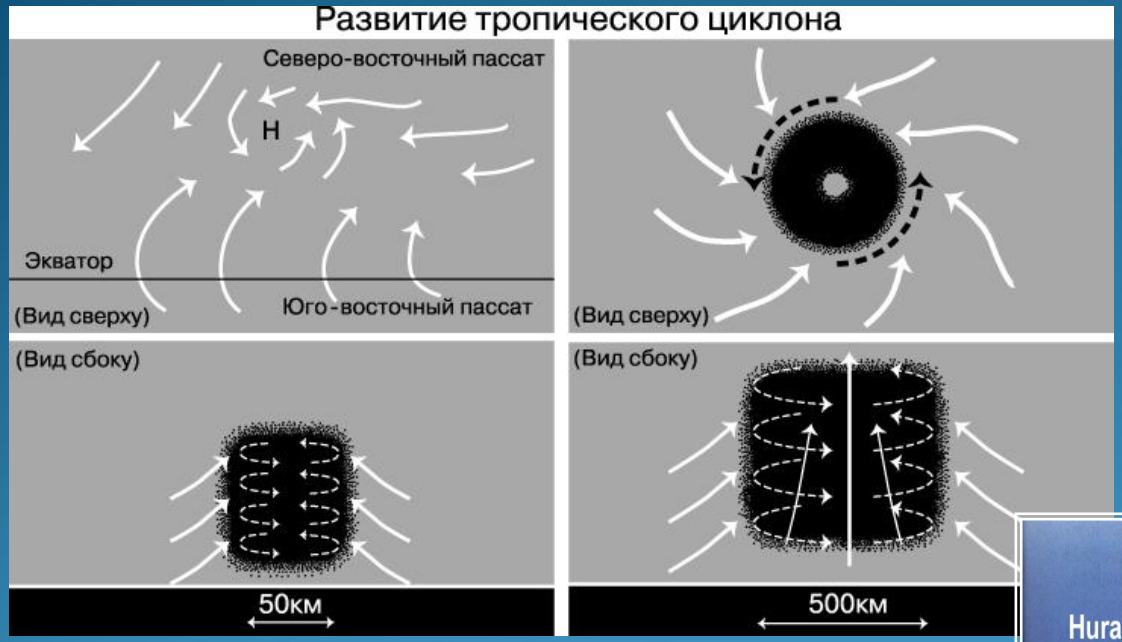
- Ionization accompanied by ion's hydration leads to the latent heat release and increase of the tropopause layer temperature.Effectivenes of the process $Q>>1$ ($10^4 \div 10^{10}$)

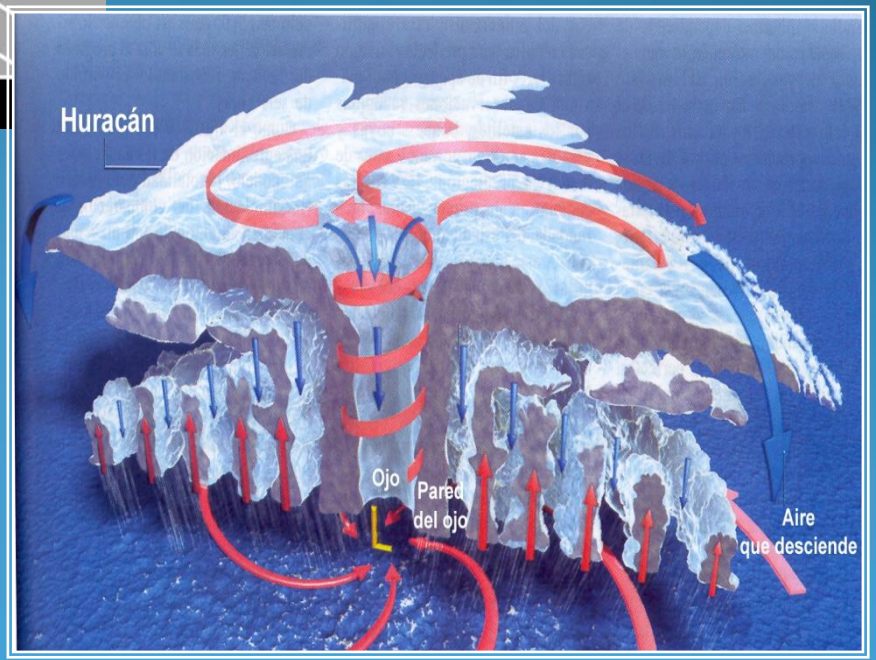
- If in stationary conditions the flux of ionization sources drops, the latent healt flux drops, and the layer temperature drops

Magnetic storms and Forbush decreases of GCR fluxes

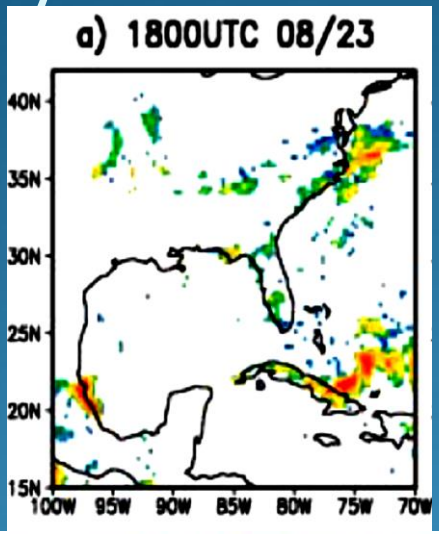


Hurricane formation





Katrina hurricane formation dynamics



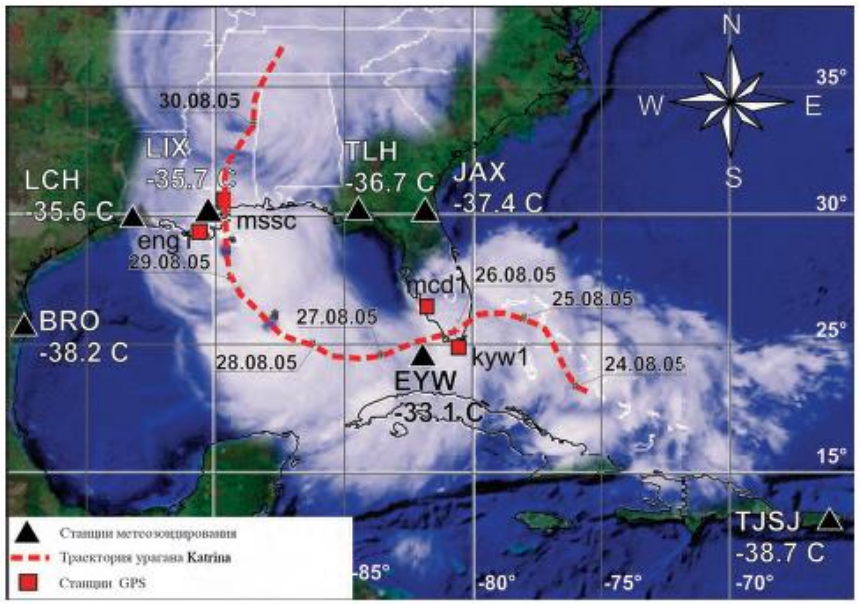
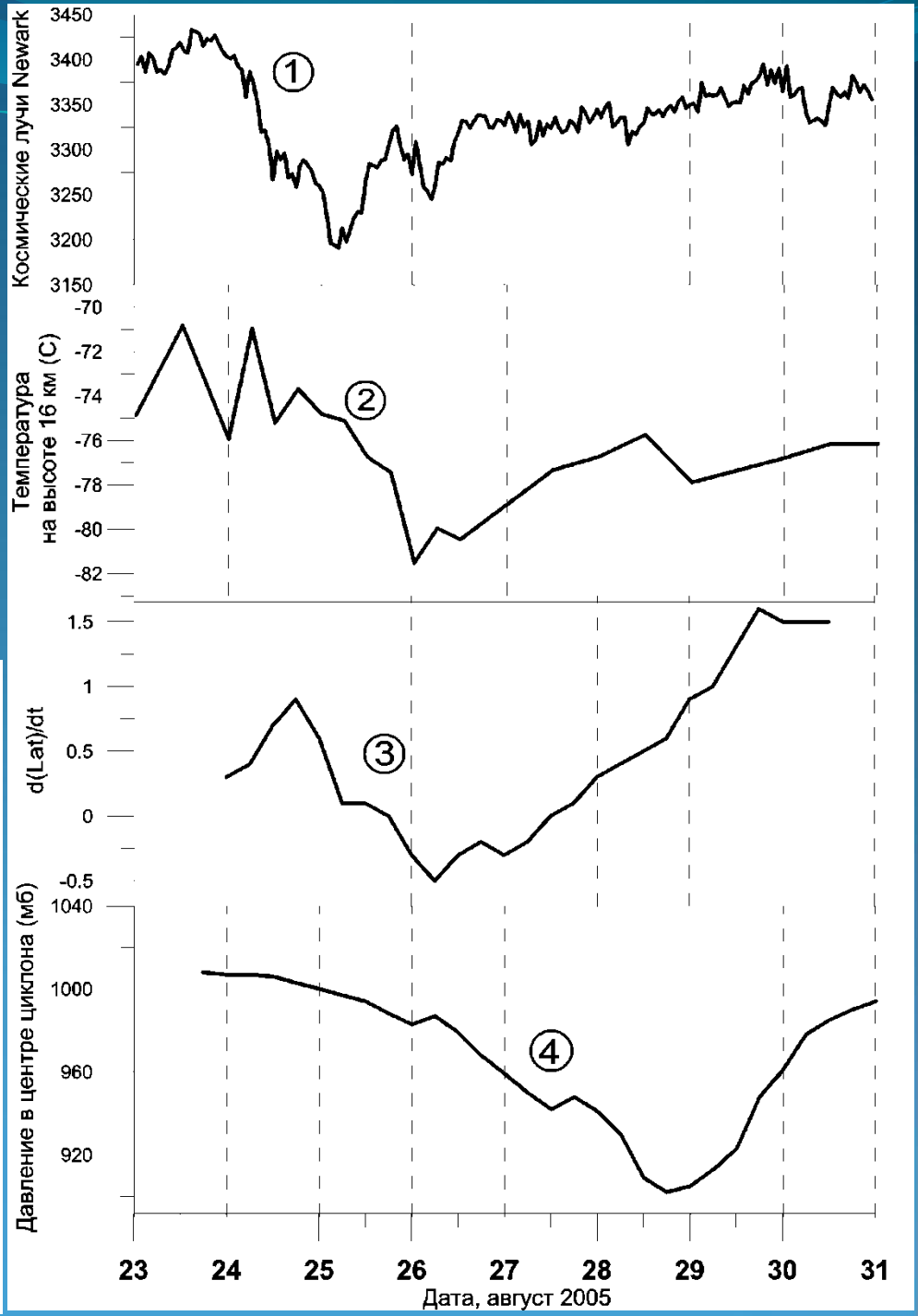
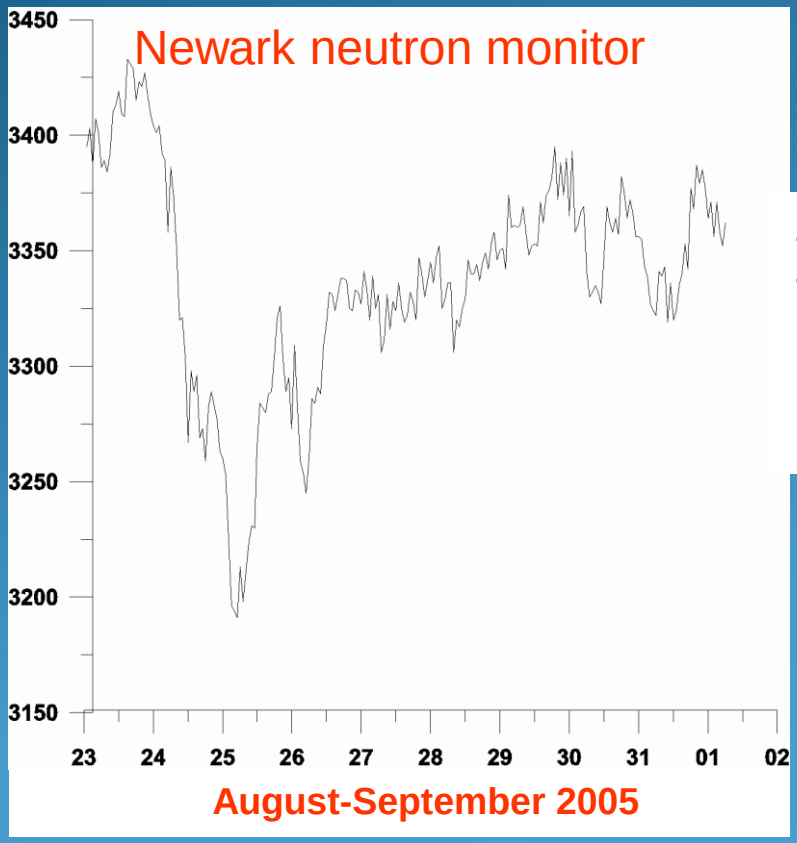
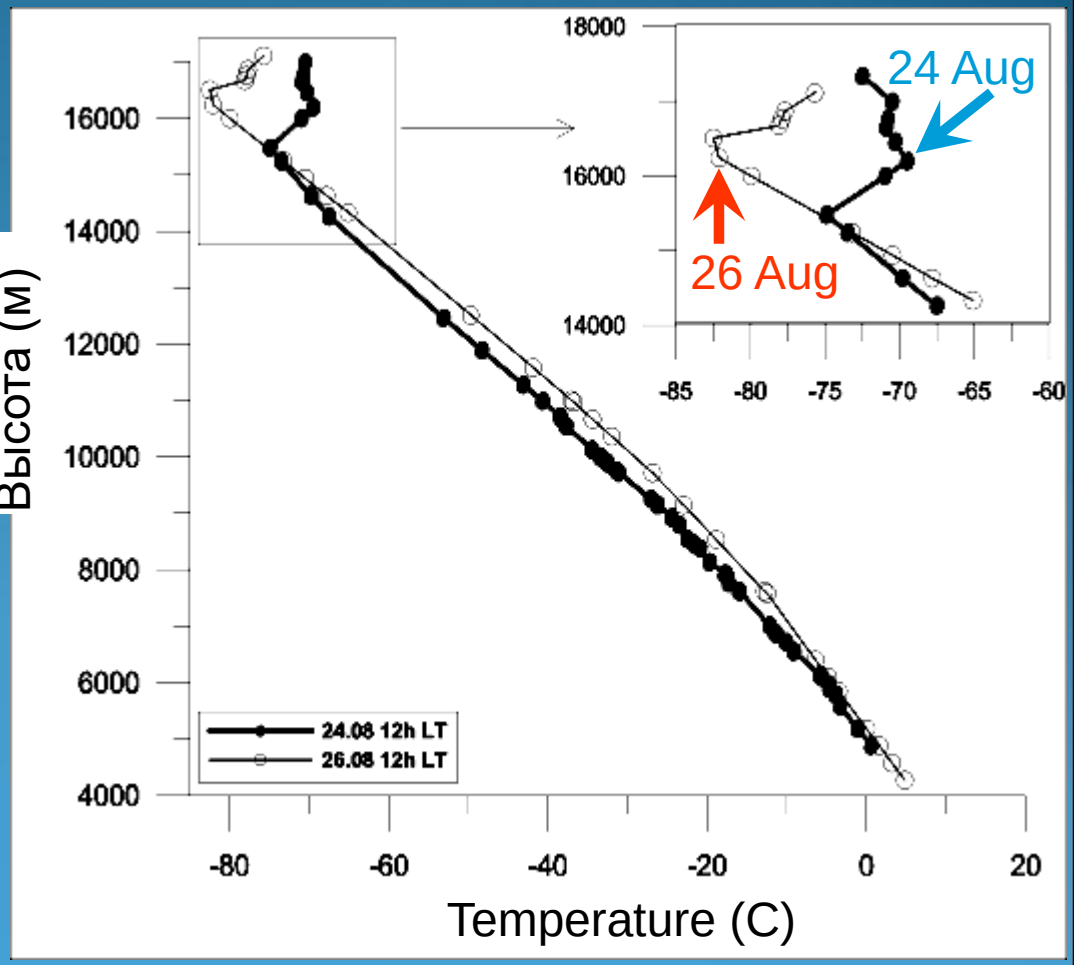


Рис. 1. Динамика развития и траектория урагана Katrina, построенная по данным спутника GOES-11. Положение станций метеозондирования обозначено черными треугольниками, рядом указаны значения температуры воздуха на высоте 10 км по данным этих станций. Положение приемников GPS обозначено красными квадратами.

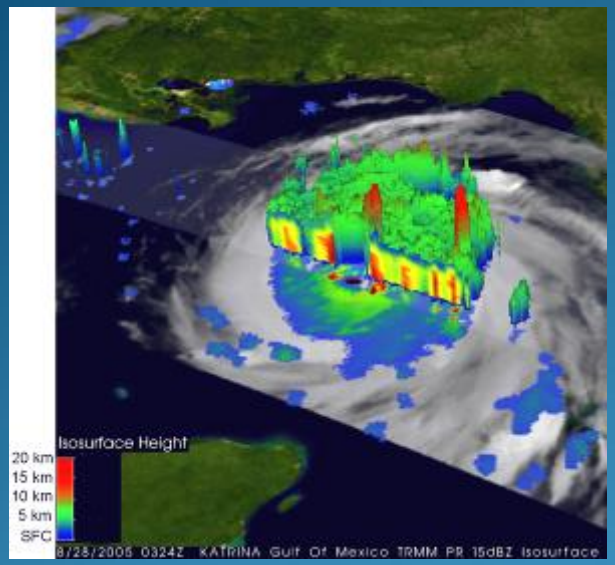


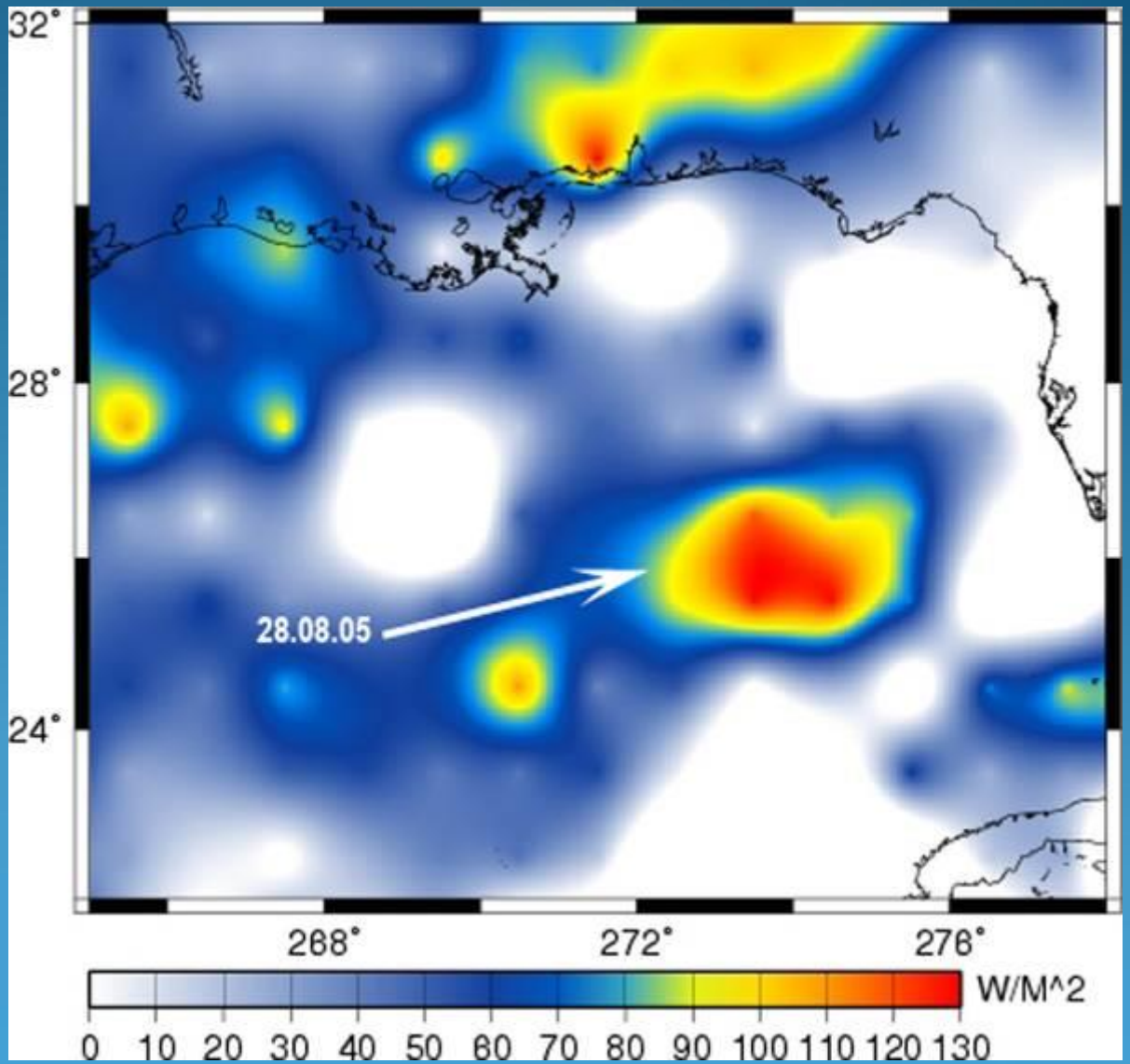
GCR decrease during the Katrina hurricane formation



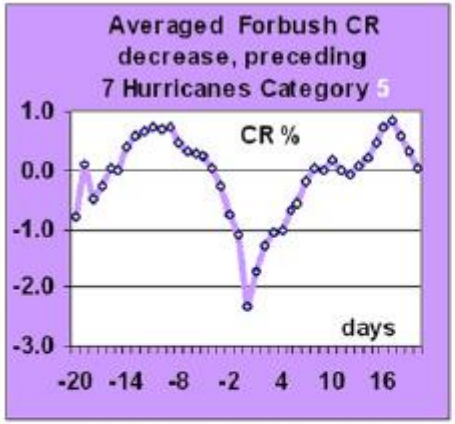


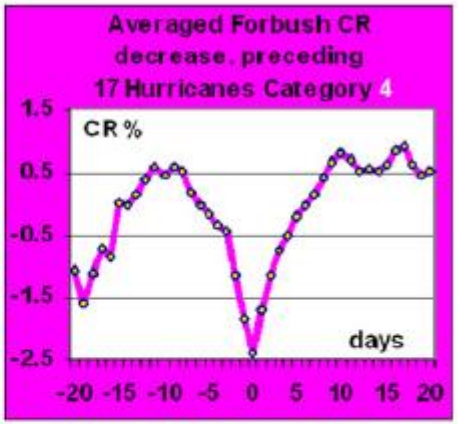
OLR from Katrina

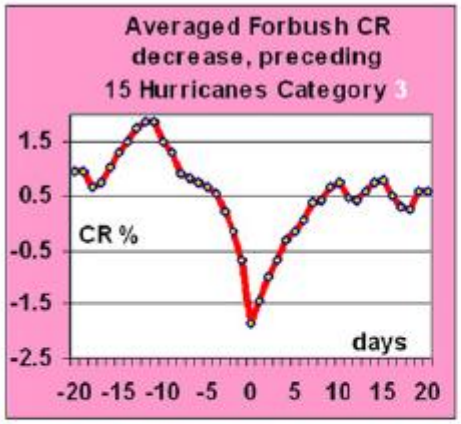


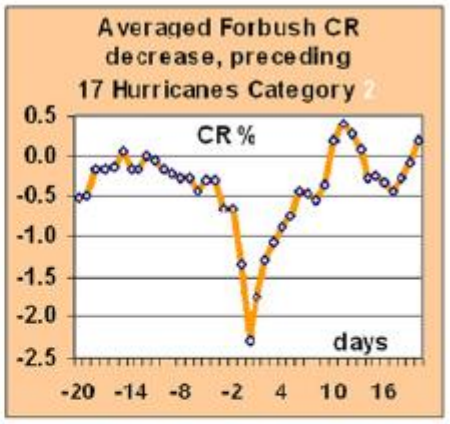


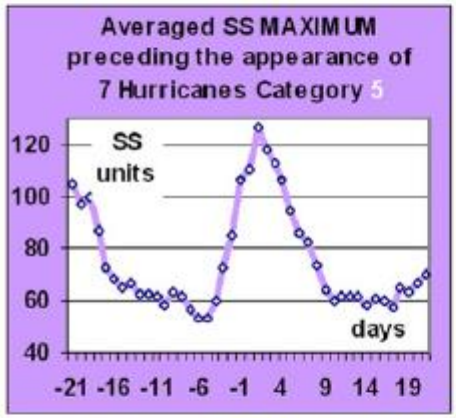
Atlantics tropical cyclones statistics

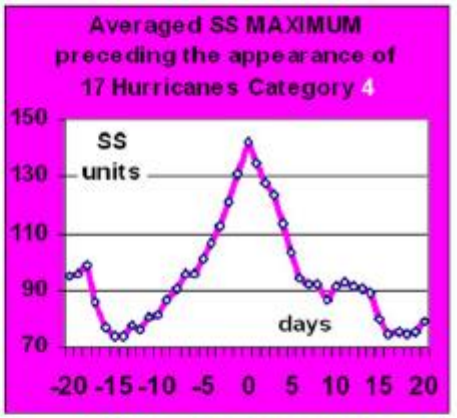


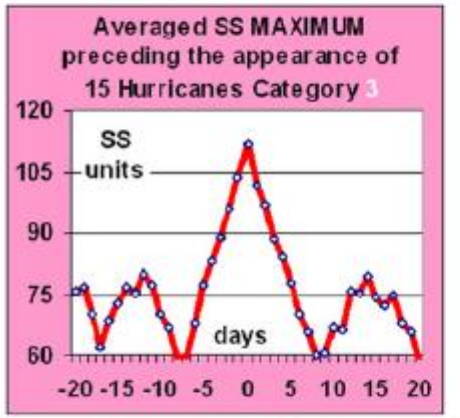


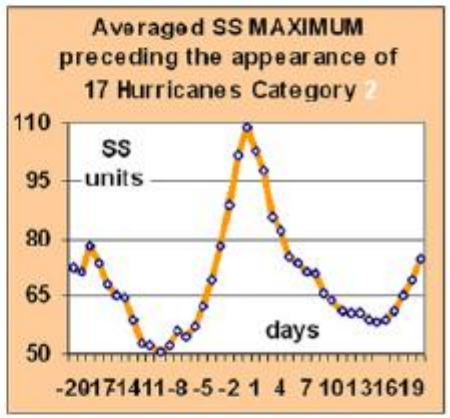


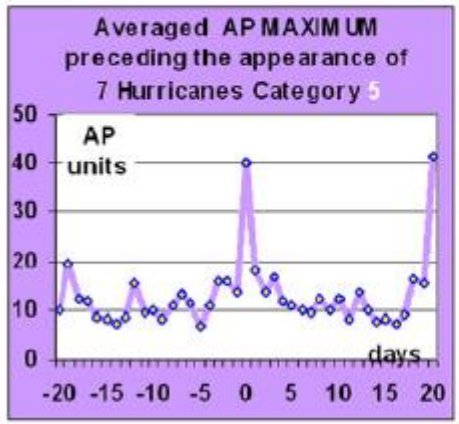


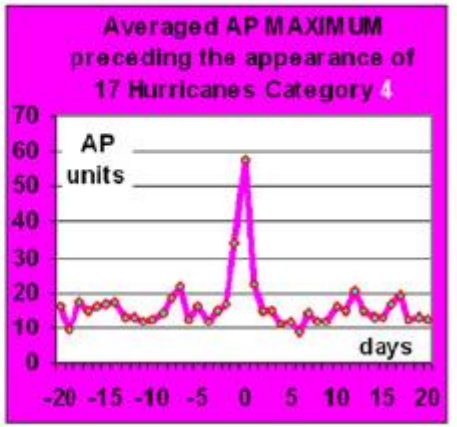


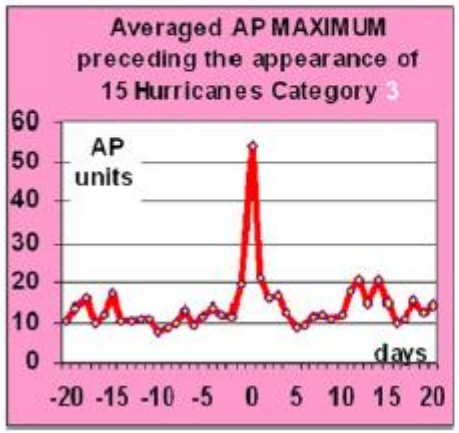


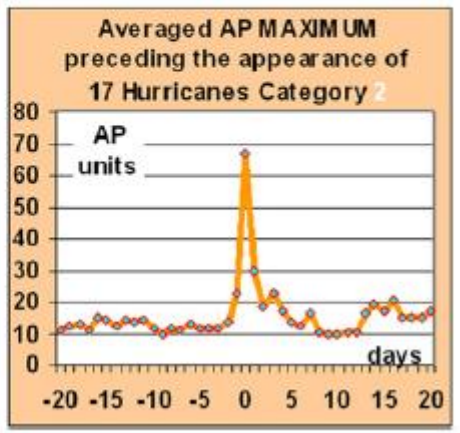






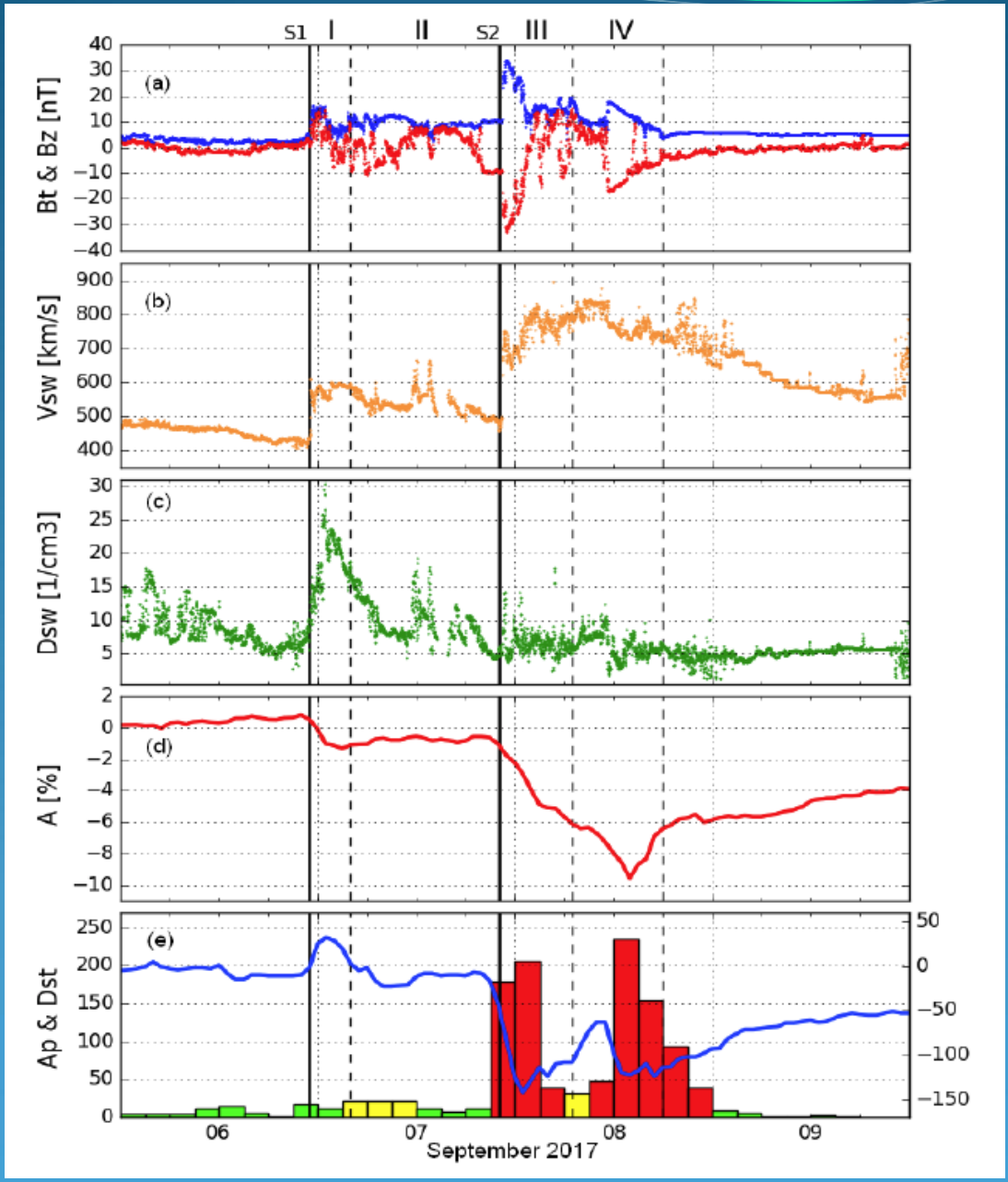




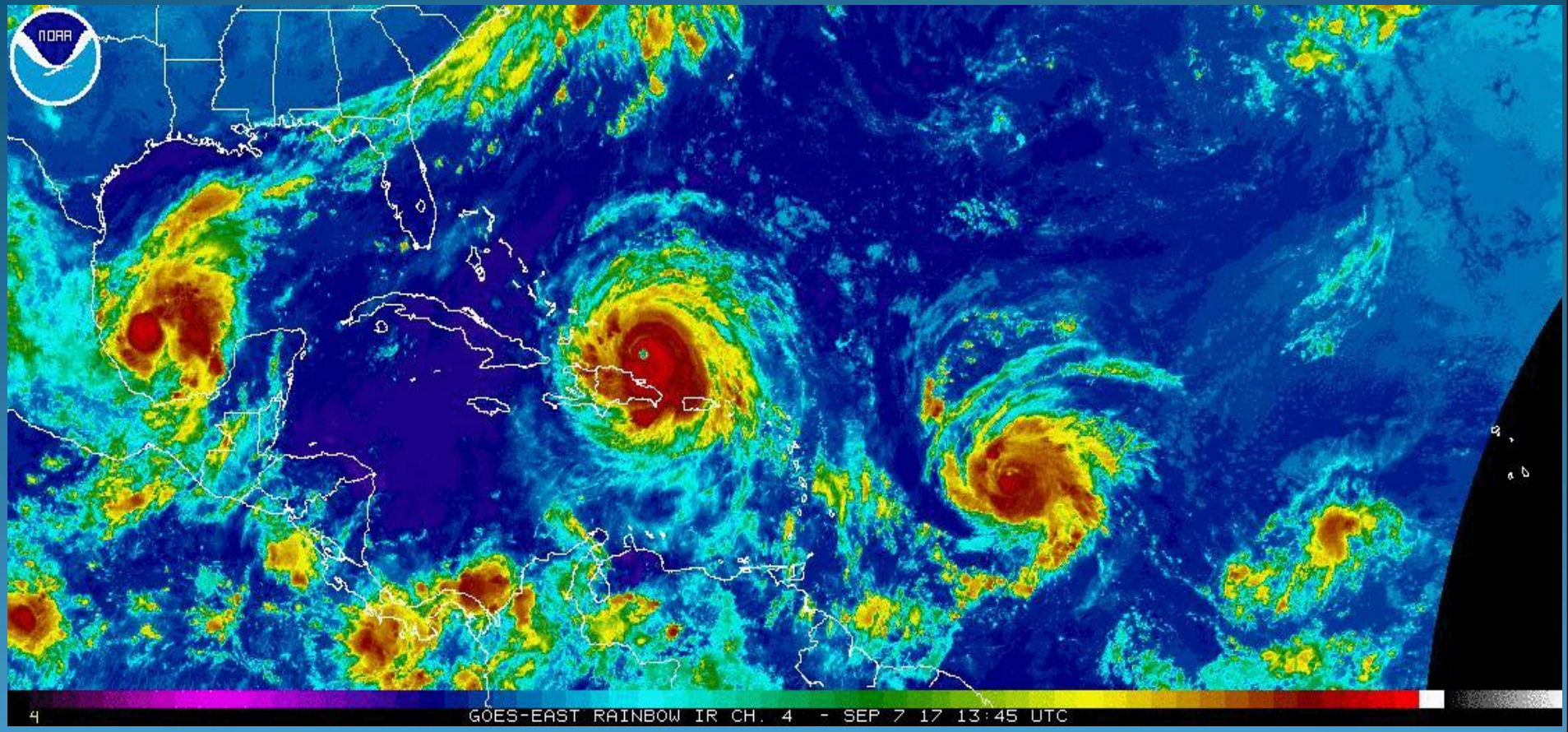


Statistical data of the Forbush-decreases and Atlantic ocean hurricanes development

Geophysical indices in the beginning of September 2017



The hurricanes series in the beginning of September 2017



Positive ionospheric anomaly over the Katrina hurricane

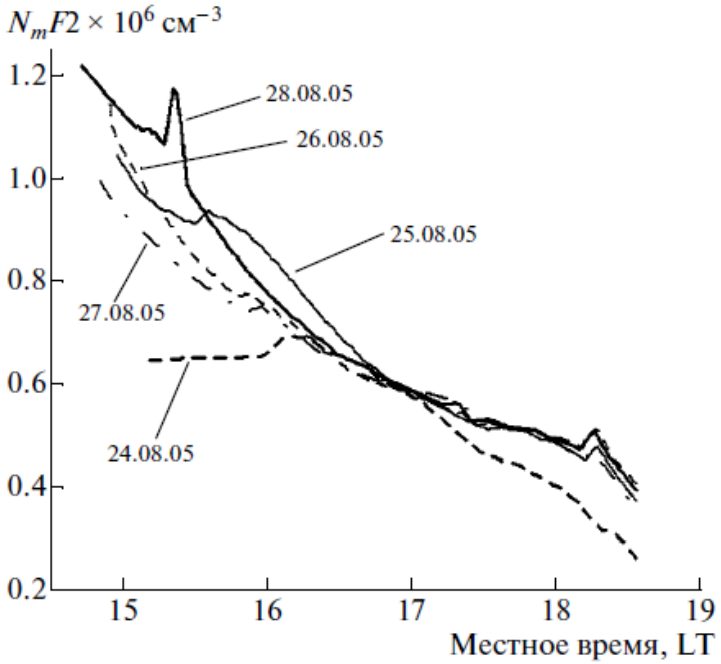


Рис. 6. Вариации электронной концентрации N_m в максимуме слоя $F2$ по данным спутника № 19 для интервала 24–28 августа 2005 г.

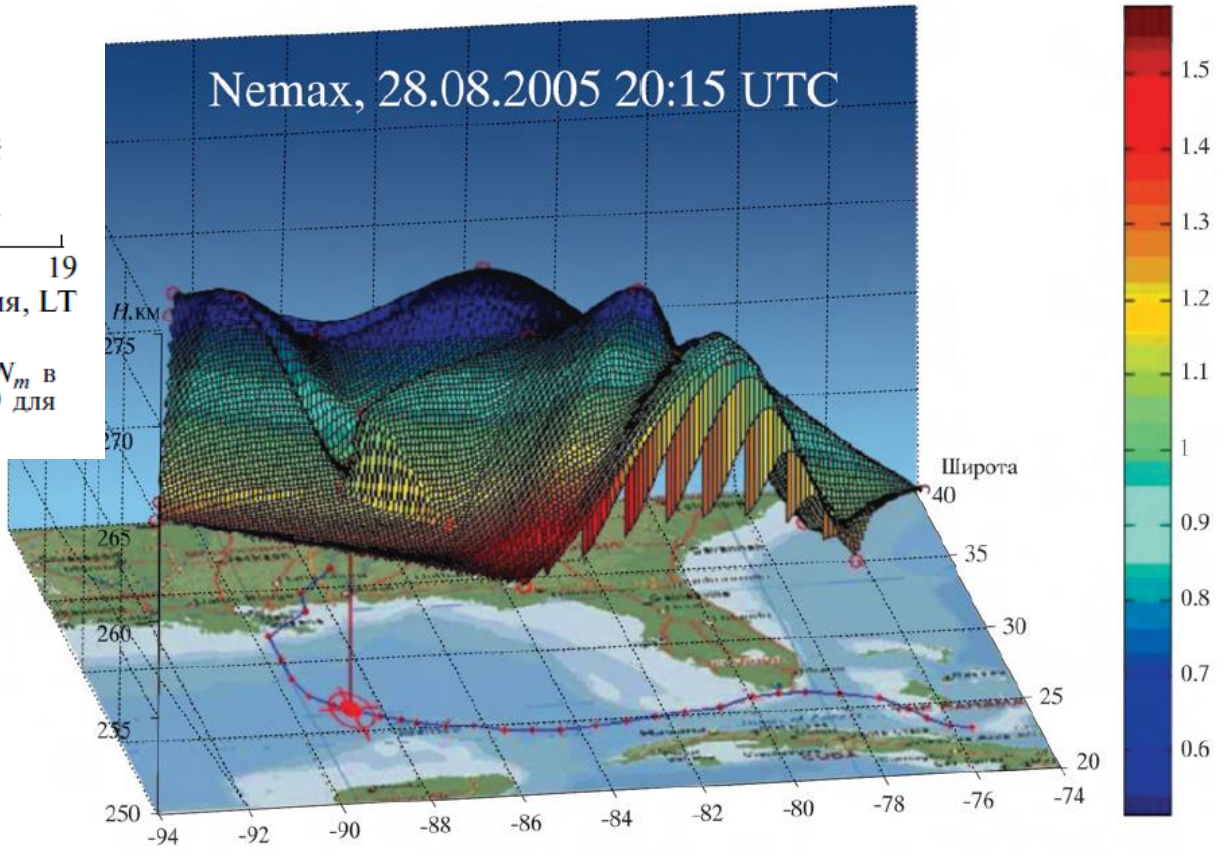
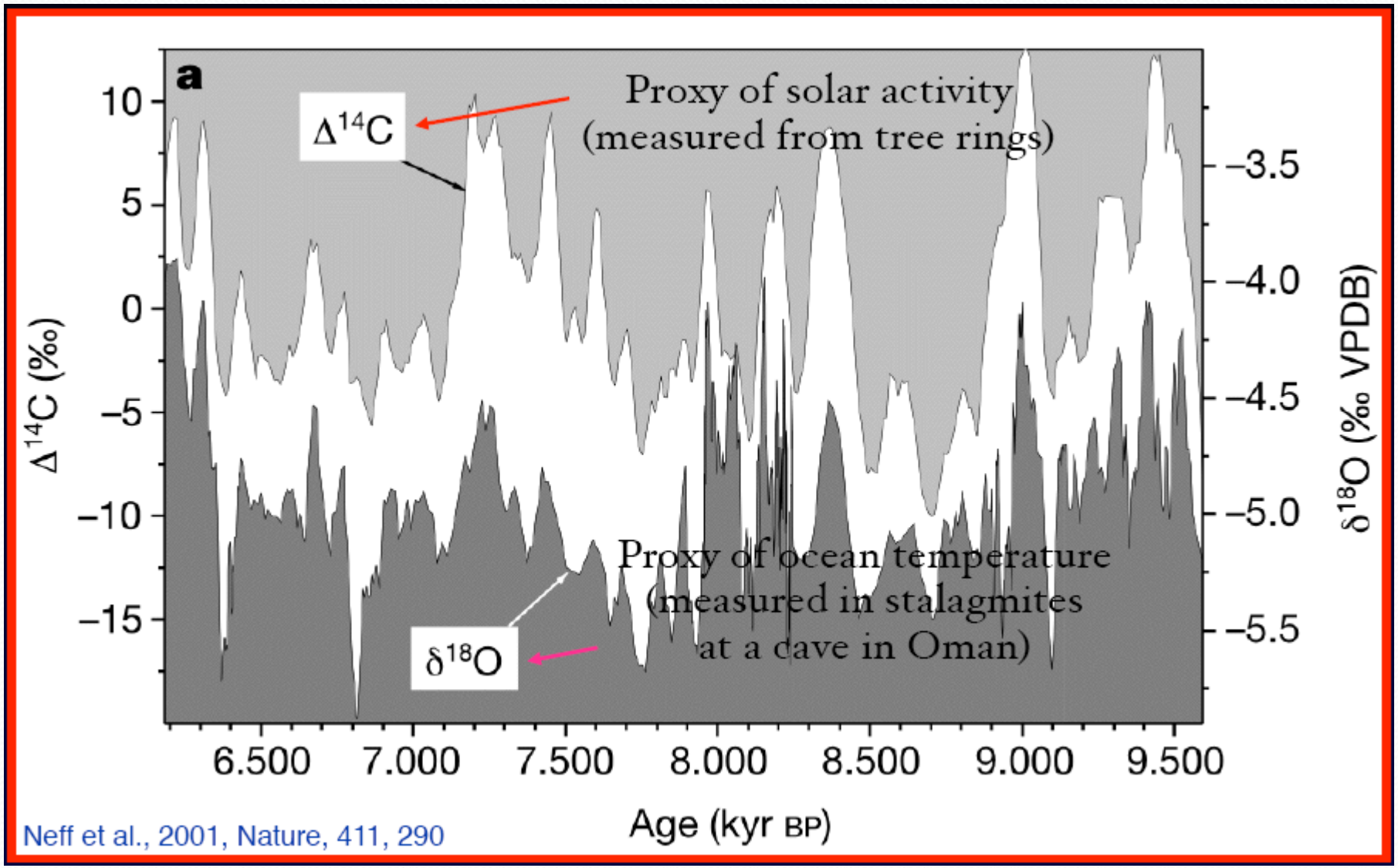


Рис. 10. Трехмерное представление положения высоты максимума электронной концентрации H_mF2 в слое $F2$ для 28 августа 2005 г. (интервал времени 20:00–20:30 UT). Цветная шкала справа – электронная концентрация N_e(× 10^6 см$^{-3}$).

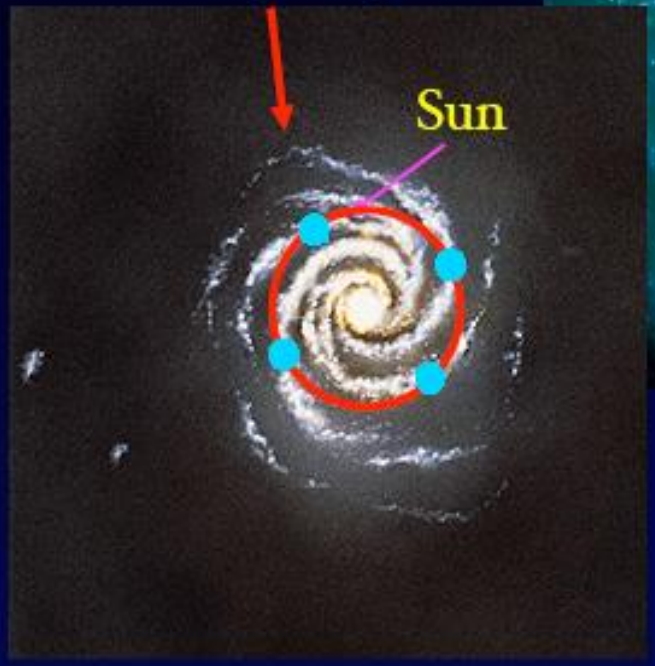
Indications that the sun affects the climate, over several millennia:



Intrinsic Variability of Galactic Cosmic Rays

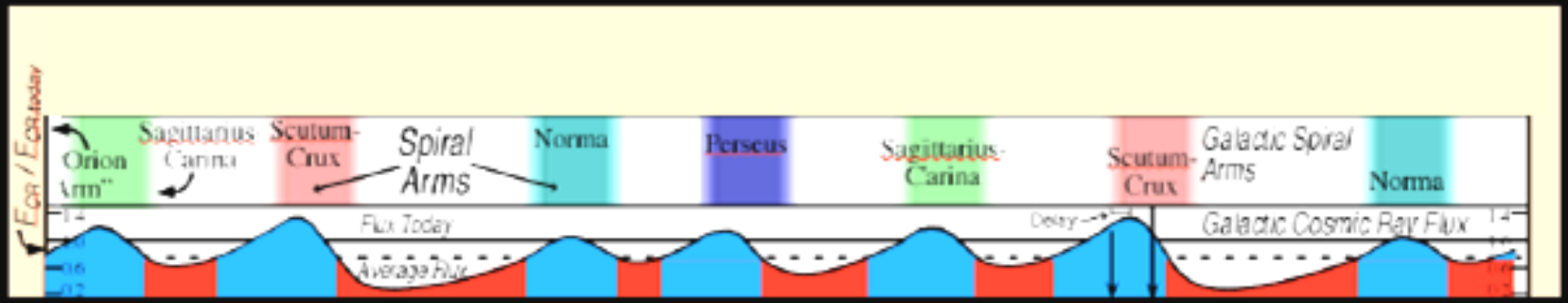
Supernova remnant where Cosmic Rays (with $E<10^{15}eV$) are accelerated

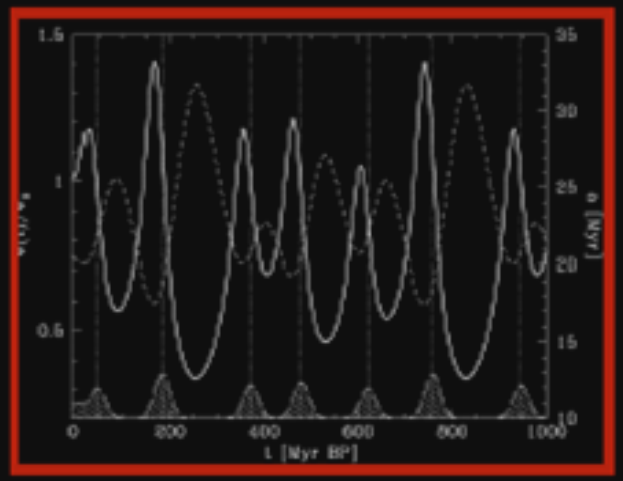
"Indirect Picture" of Milky Way



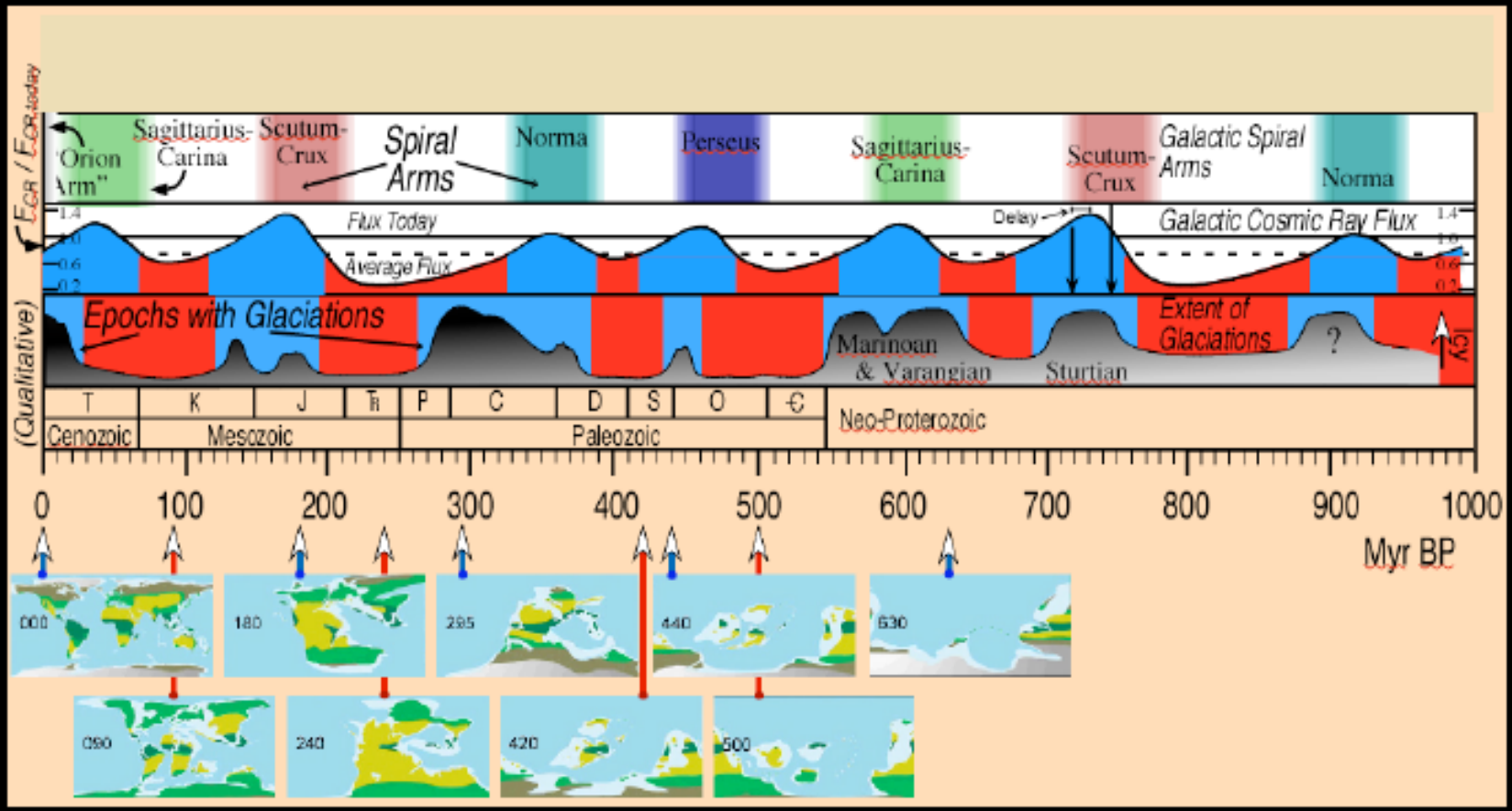
NGC 1232 Galaxy (Similar to Milky Way)

Galactic Rotation





Ice Epochs & Galactic Rotation



Ice Ages: Period = 145.5 ± 7 Myr

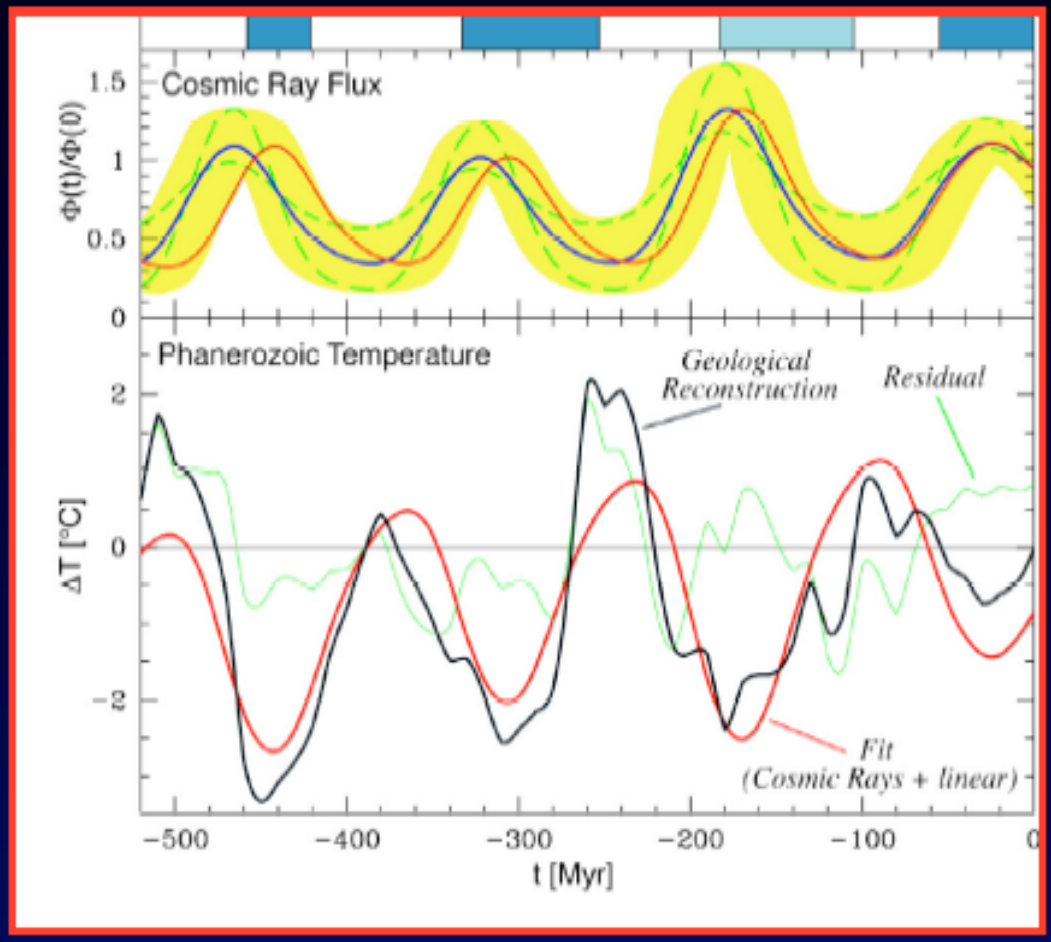
Spiral Arms: Period = 134 ± 25 Myr

And the phases agree!

Temperature vs. Cosmic Rays

- Comparison between Cosmic Ray Flux, Temperature prediction ($T=A*CRF(t)^{1/2}+B\,t + C$) and Temperature Measurement using ^{18}O.

75% of the Phanerozoic temperature variations can be explained by CRF variations. Probability that Random temperature realizations can have such a high correlation with CRF: 0.3%



Solar and/or CRF correlation with Climate

- Gyr time scale: Milky Way Star formation rate and glacial activity
- 150 Myr cycle: Milky Way arms
- 10-100,000: (Mostly) Solar activity & Climate
- 11 yr solar cycle: Solar activity and ΔT, clouds
- Days: Forbush events and various climate variables

Thank you very much