The dynamics of electrons under the radiation belts in the minimum of solar activity cycle

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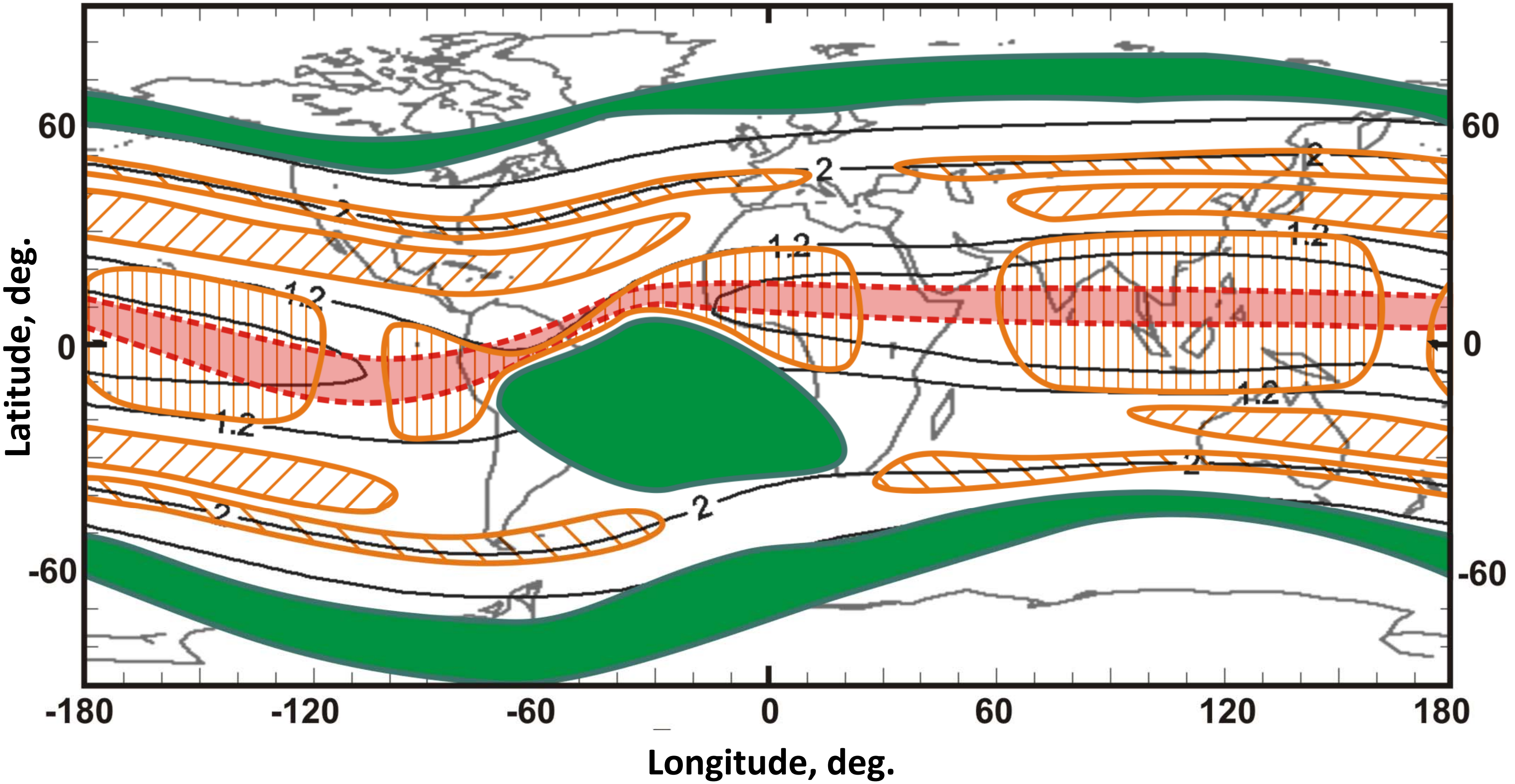


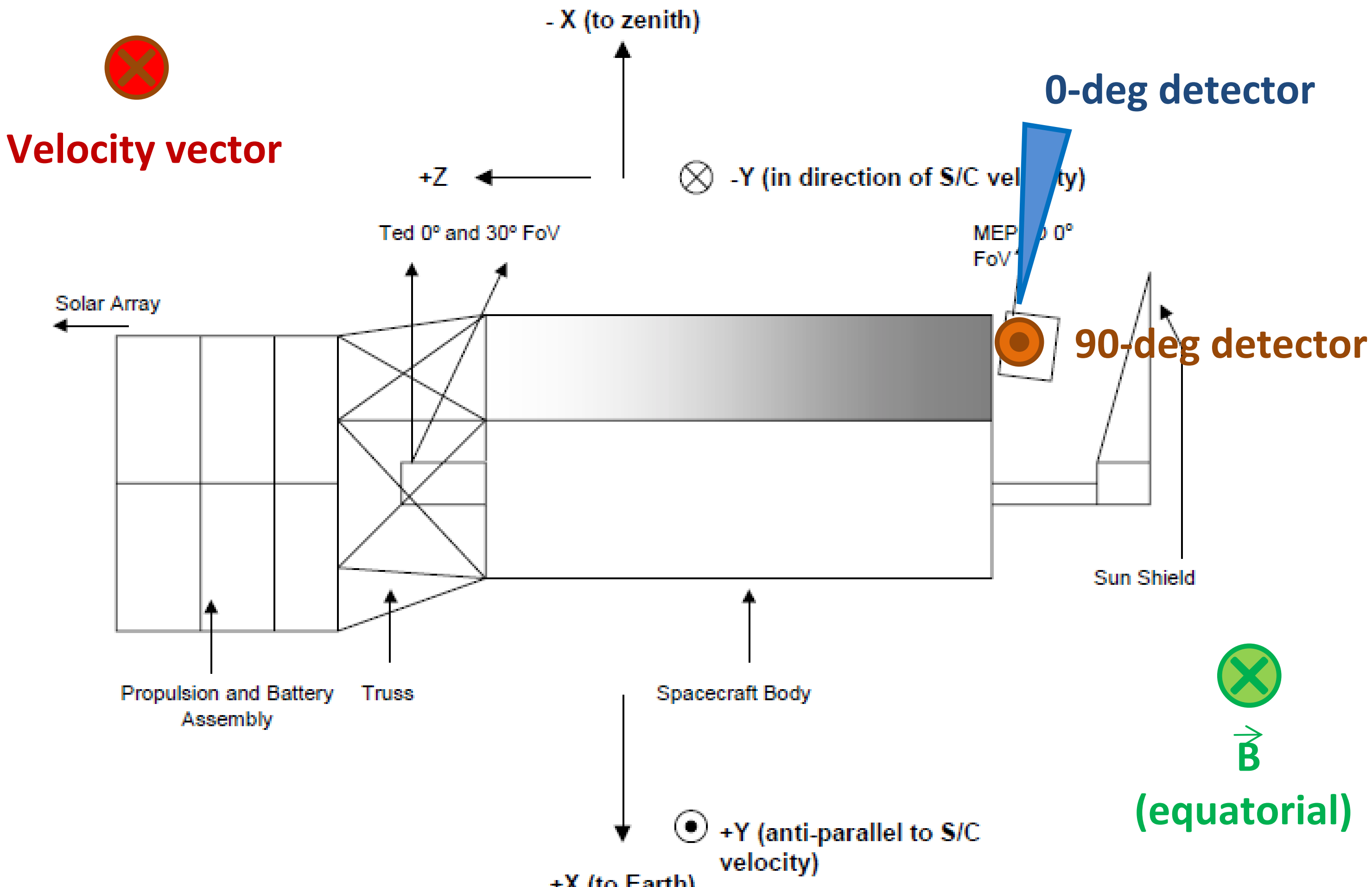
Areas of increased electrons fluxes at low altitudes. The slice of 600 km. Green – radiation belts; orange vertical – areas of sporadic fluxes of tens-to-hundreds keV electrons. Orange diagonal – middle-latitudinal increased fluxes of electrons.

NOAA POES satellites

No	Satellite	Years of operation	Orbit	Comments
1	NOAA TIROS-N	1978-1981	Out of operation	SEM-1 instrument, not all data
2	NOAA POES-06	1979-1986	Out of operation	SEM-1 instrument, not all data
3	NOAA POES-07	1981-1985	Out of operation	SEM-1 instrument, not all data
4	NOAA POES-08	1983-1985	Out of operation	SEM-1 instrument, not all data
5	NOAA POES-10	1986-1991	Out of operation	SEM-1 instrument, not all data
6	NOAA POES-11	1988-2002	Out of operation	SEM-1 instrument, not all data
7	NOAA POES-12	1991-2002	Out of operation	SEM-1 instrument, not all data
8	NOAA POES-14	1995-2004	Out of operation	SEM-1 instrument, not all data
9	**NOAA POES-15**	**Launched in 1998**	**807 km (curr.), 98.5°**	**SEM-2 instrument, operation**
10	**NOAA POES-16**	**Launched in 2001**	**849 km curr.), 99.0°**	**SEM-2 instrument, operation**
11	**NOAA POES-17**	**Launched in 2002**	**810 km (curr.), 98.7°**	**SEM-2 instrument, operation**
12	**NOAA POES-18**	**Launched in 2005**	**854 km (curr.), 98.7°**	**SEM-2 instrument, operation**
13	**NOAA MetOp-2/A**	**Launched in 2006**	**817 km (curr.), 98.7°**	**SEM-2 instrument, operation**
14	**NOAA POES-19**	**Launched in 2009**	**870 km (curr.), 98.7°**	**SEM-2 instrument, operation**

Polar, sun-synchronous orbit , ~800 km, inclination 98°
Continuous data since 1998
Electrons > 30 keV; > 100 keV; > 300 keV

MEPED instrument of NPOES satellite



(POES technical description
http://poes.ngdc.noaa.gov/docs/sem2_docs/)

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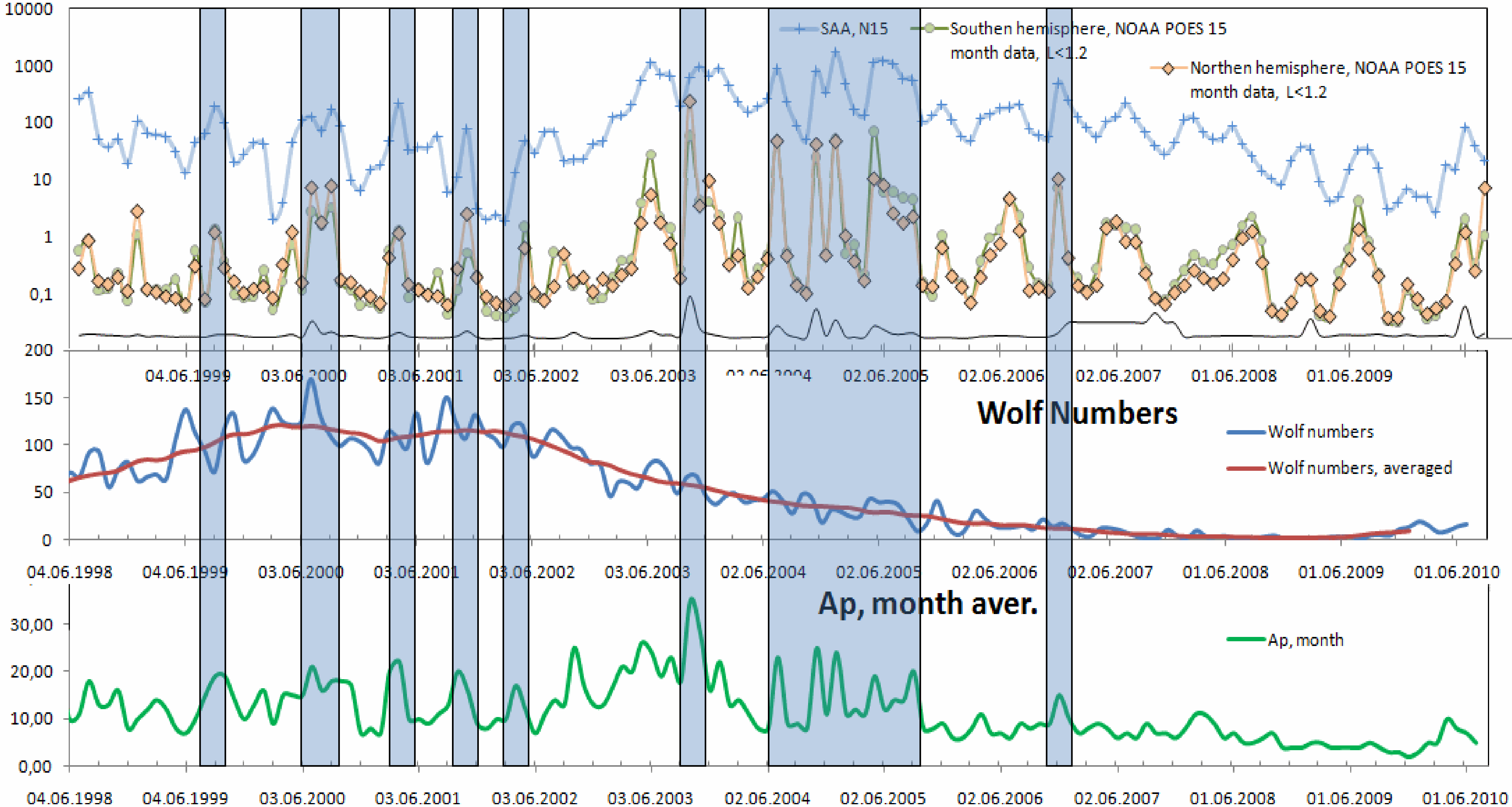
НИИЯФ МГУ

15th WRMISS Workshop
Villa Mondragone
7-9 September 2010
Centro Congressi Villa Mondragone, Monte Porzio Catone, Roma (Italy)

Average monthly:



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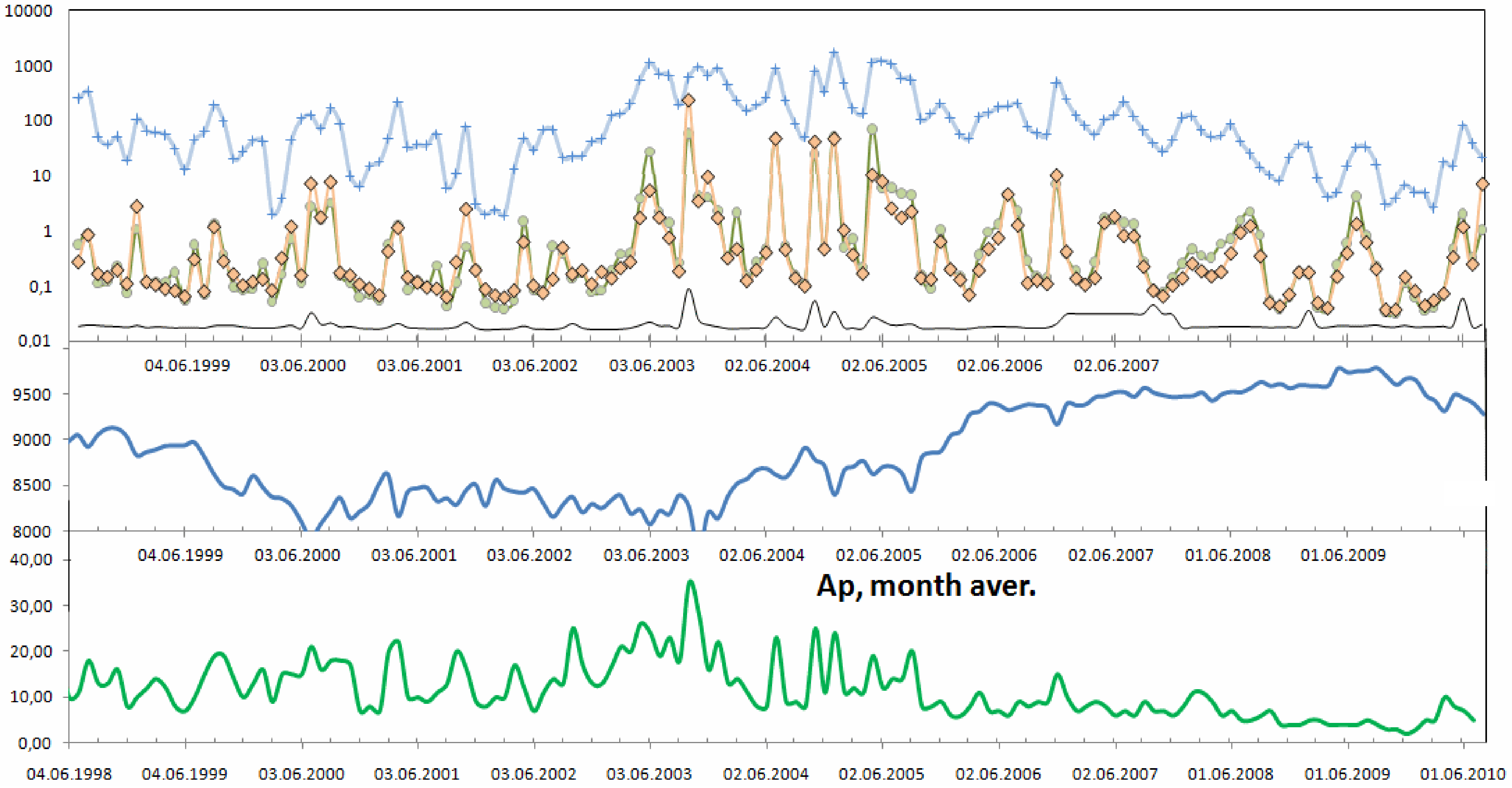

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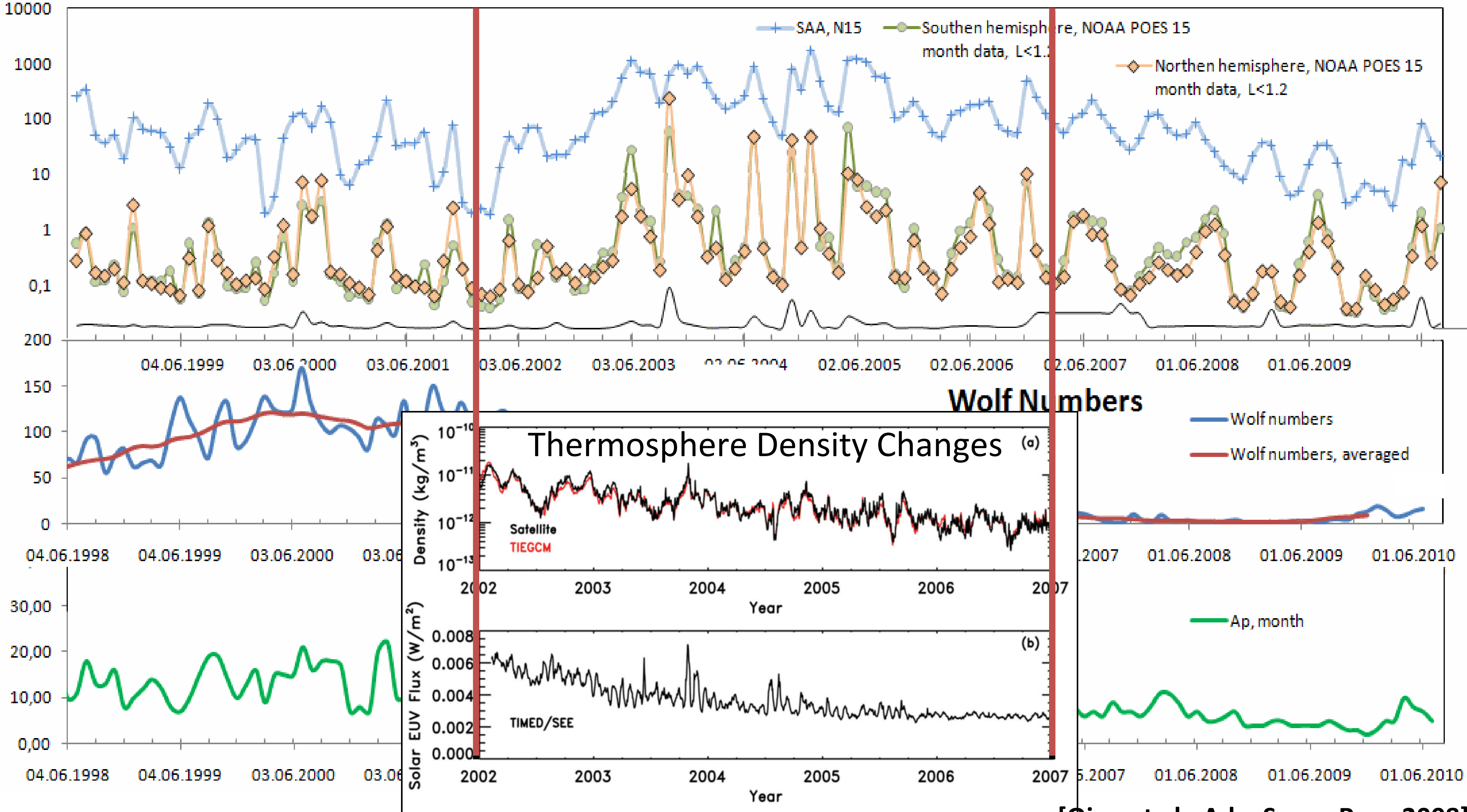
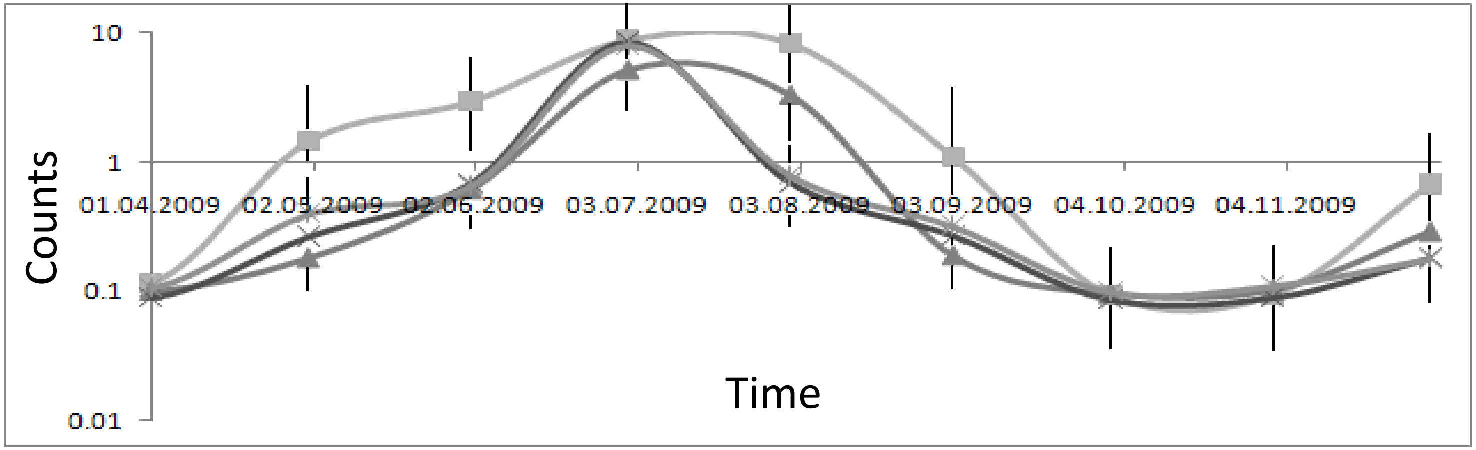


[Qian et al., Adv. Space Res., 2008]

NOAA data verification

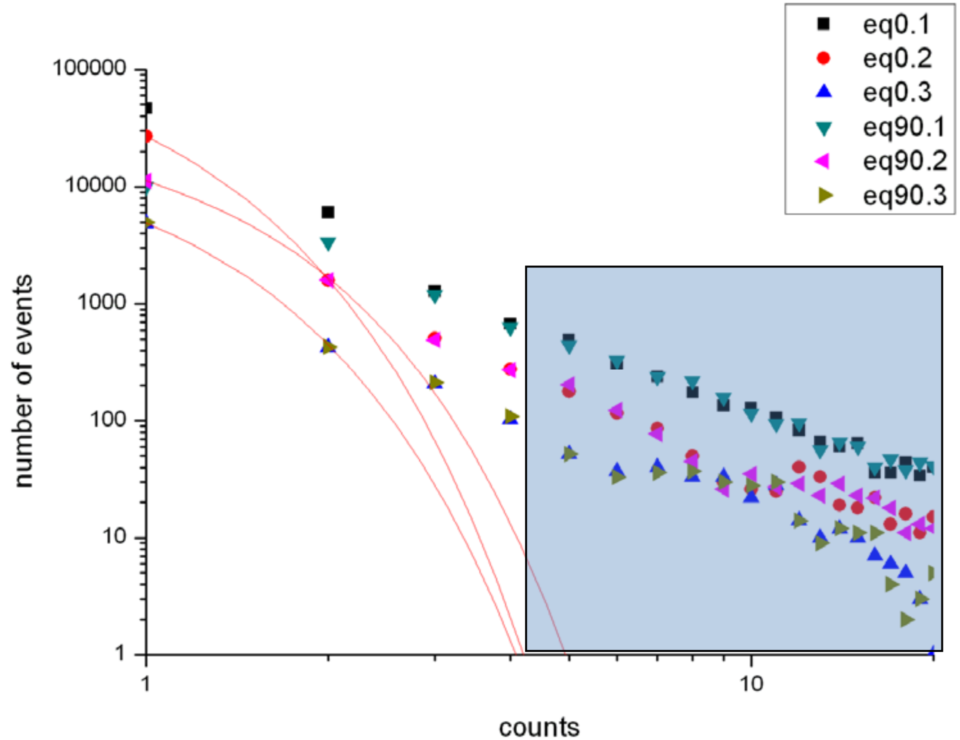
N15 … MetOp-2 satellites:

(one month average, L < 1.2; E_e < 70 keV, SAA is not included!)



The difference can be explained by satellites' altitude difference (up to 60…70 km), and also by the fact that N15, N17, M02 satellites work in the morning LT, but N16, N18, N19 - in the evening LT.

Background count rate in the detectors



Poisson distribution and detectors count rate

The example for L<1.2, outside the SAA for NPOES-15 is shown. Blue rectangle contains statistically significant events. Data were studied for the counting rate minus background.

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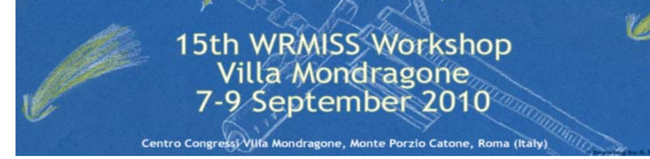

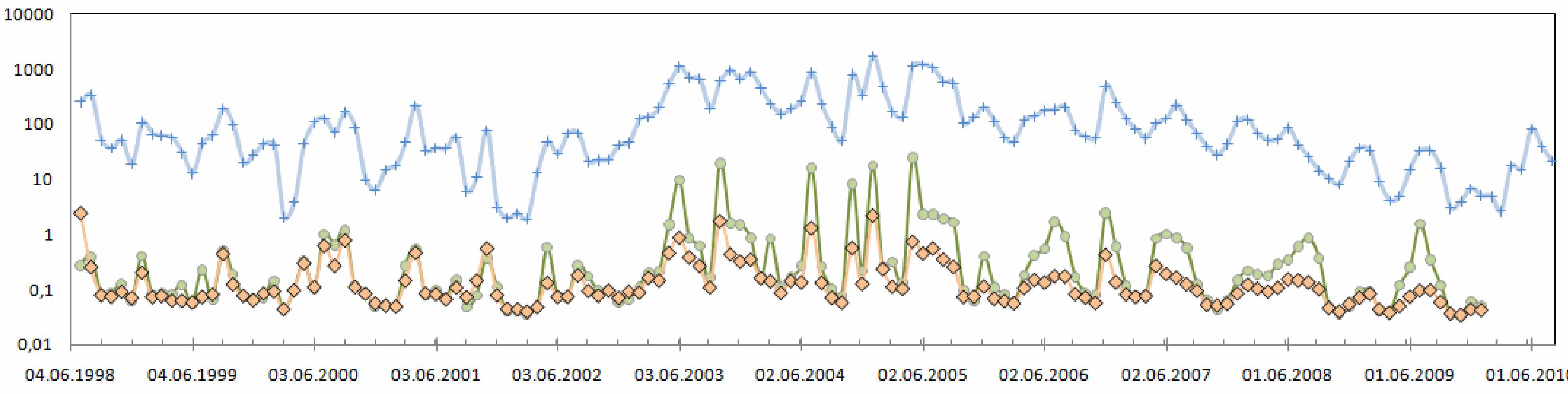

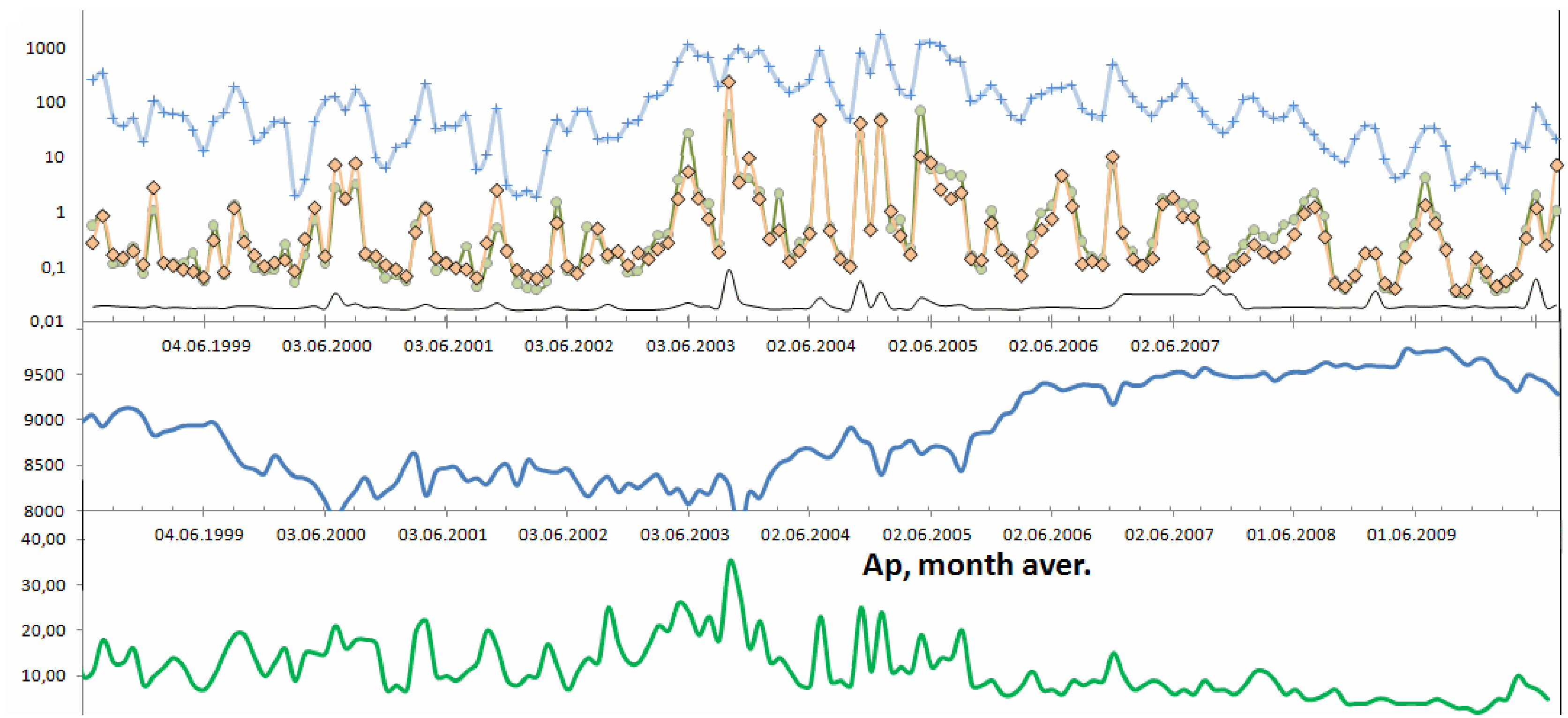

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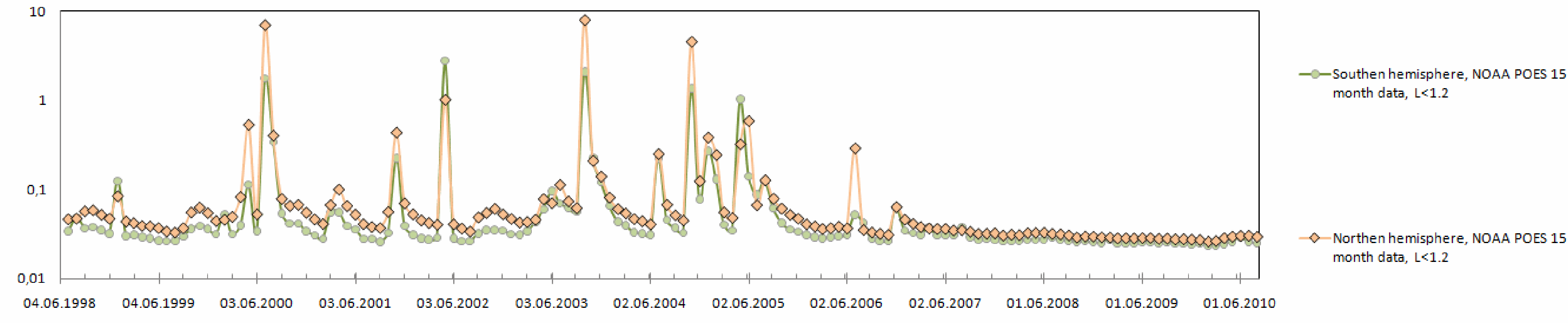
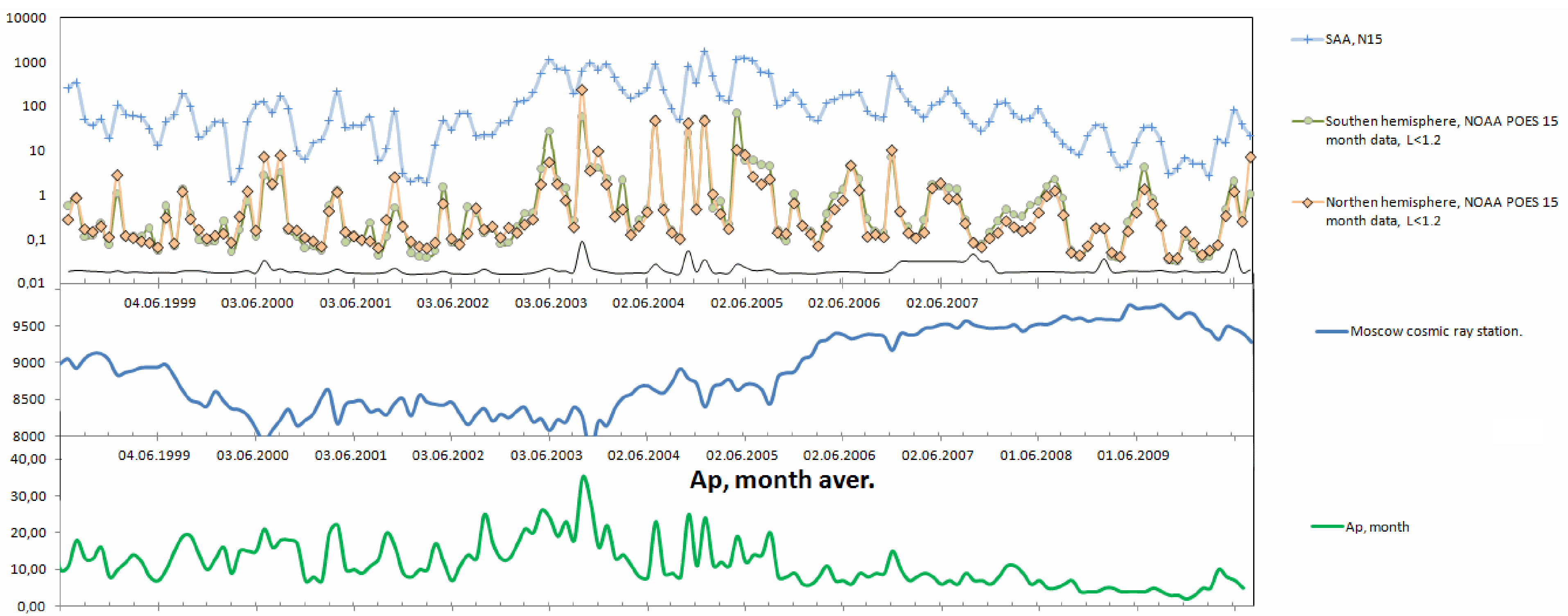
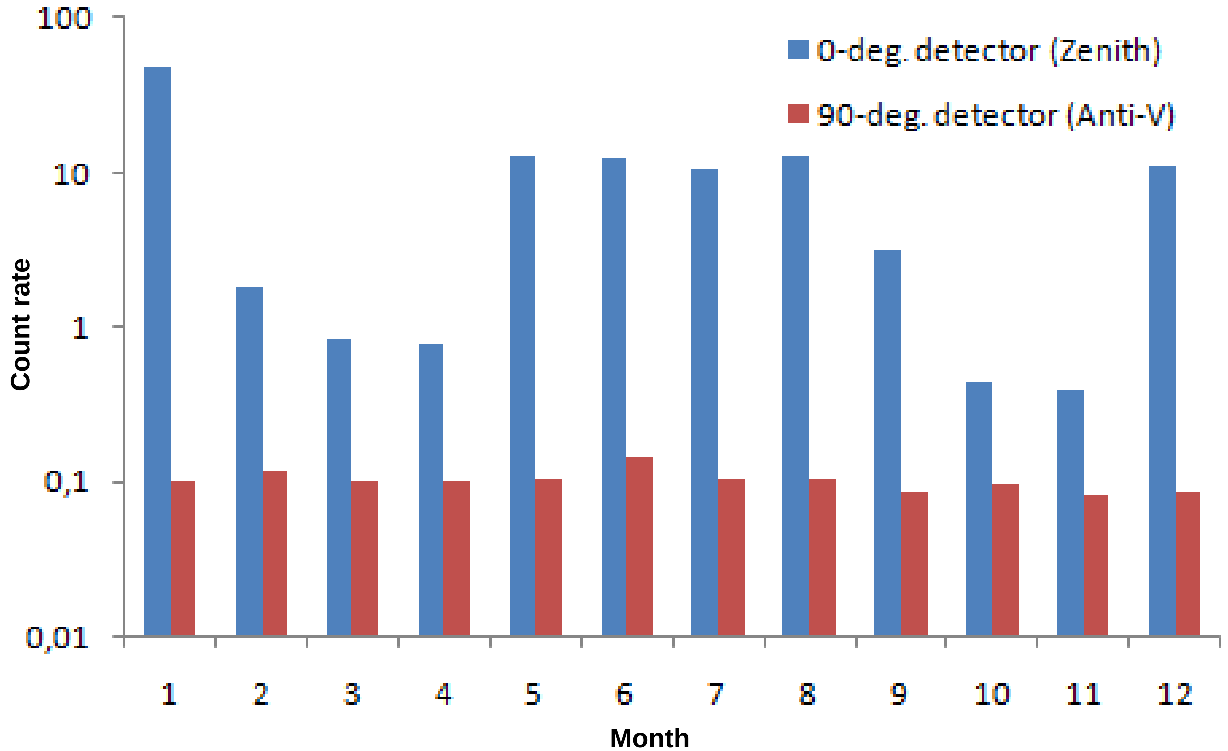


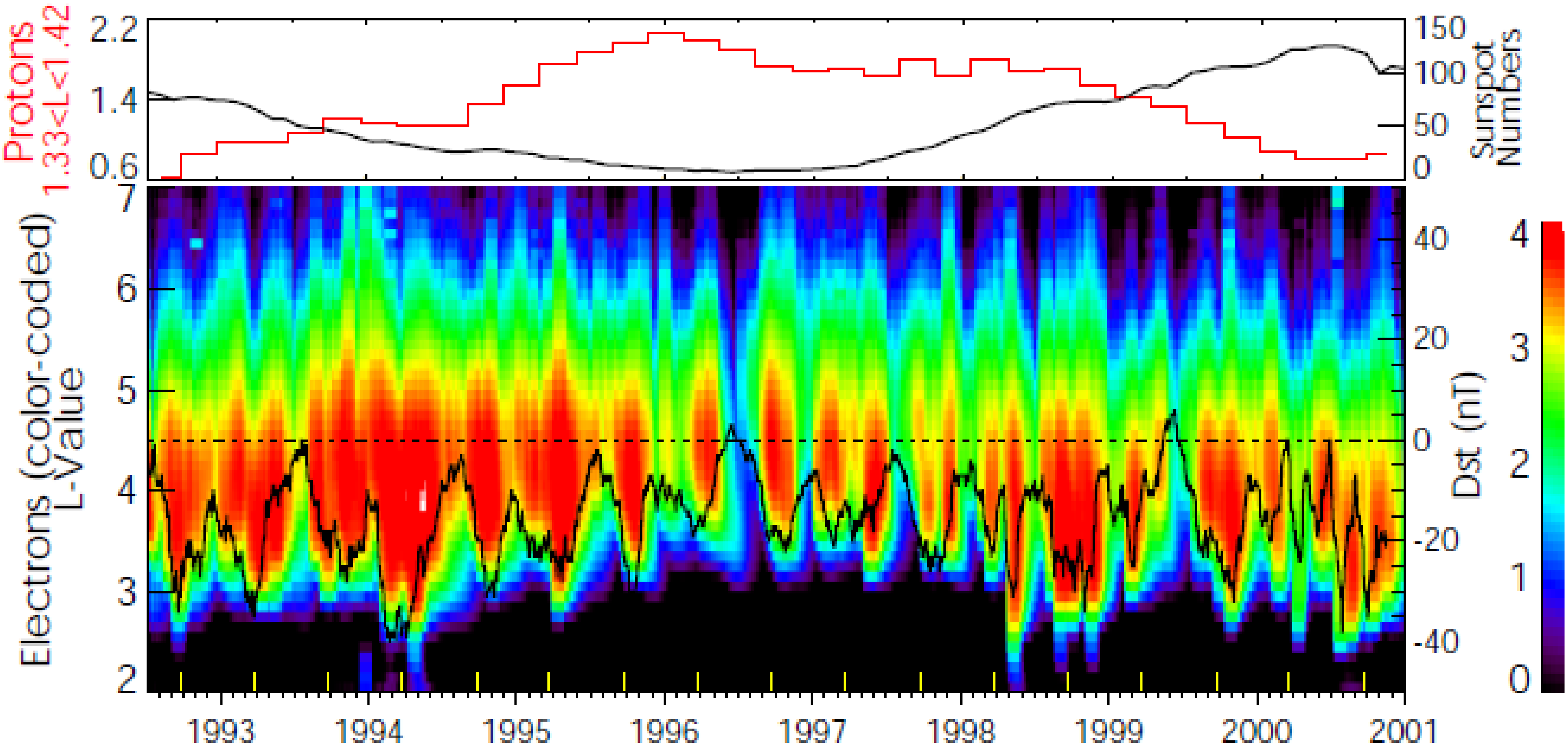


Semiannual variations of electron flux:



Averaged count rate per month in 2005-2009

Equinoctial effect and semiannual variations



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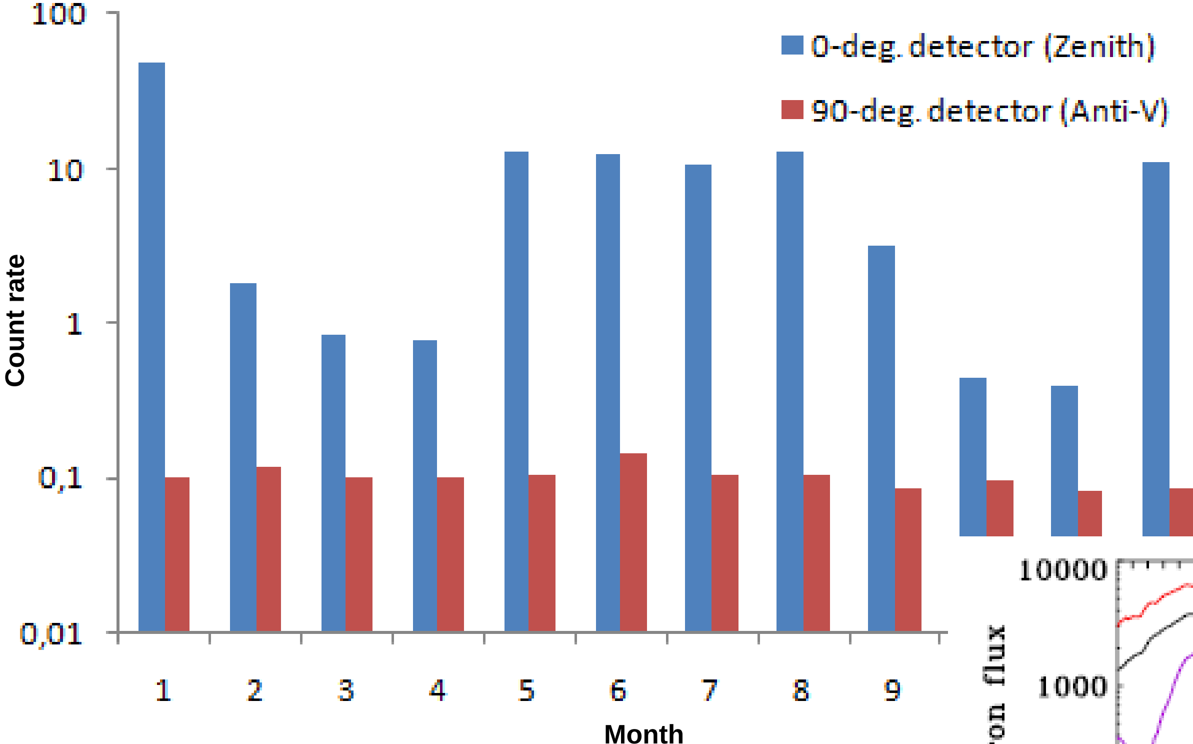

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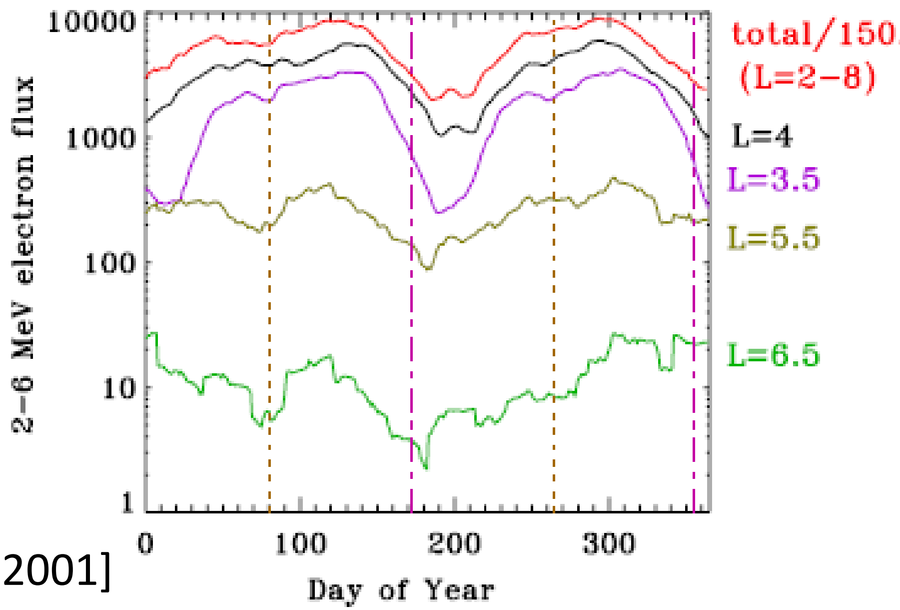

[Li, Baker et al., GRL, 2001]

Механизм потерь электронов вблизи экватора

Основной механизм потерь электронов на малых L-оболочках – циклотронный резонанс с ОНЧ-волнами, в результате которого частицы дрейфуют в конус потерь и высыпаются в атмосферу: $\omega - kv_{//} = \omega_e$ $\quad \frac{\partial f}{\partial t} = \frac{\partial}{\partial p_{\|}} p_{\perp}^2 D \frac{\partial f}{\partial p_{\|}}$

Коэффициент питч-угловой диффузии можно оценить как:

$$D \cong \omega_e^2 \left(\frac{\delta B}{B} \right)^2 \Delta t,$$

$$\text{где } \delta B - \text{амплитуда волны}, \delta B^2 = 5 \cdot 10^{-7} \gamma^2,$$

$$\Delta t \approx \frac{1}{2} \tau_{//} \approx 0.1\text{с} - \text{время взаимодействия},$$

$$\omega_e = \frac{eB}{mc} = 1.6 \cdot 10^{13} \text{ рад/с};$$

$$D = 1.7 \cdot 10^{-4} \text{ рад}^2/\text{с}$$

Из уравнения диффузии можно выделить соотношение $\frac{S_{\text{захв.}}}{S_{\text{высып.}}} \cong \frac{v_t}{D \sigma a z_0} \approx 10^1$ *для области L < 2. Данные оценки не противоречат наблюдаемым данным, но требуют дальнейшего уточнения.*

Conclusions:

The long-time behavior of low-energy electrons at the lower board of the inner radiation belt was studied using data from NOAA POES satellites.

Extremely long solar activity minimum led to radiation belts depletion. The averaged fluxes of electrons decreased up to the end of 2009. This means reduction of both the source of particles and the main driver of particle acceleration in the radiation belts.

Nevertheless, the decrease in the number of particles in the Earth's radiation belt did virtually no effect on the fluxes at $L < 2$ outside the SAA. The basic mechanism of electron dynamics in this area is pitch-angle diffusion. The anticorrelation of semiannual variations with the outer radiation belt suggests that the relationship between these regions is mediated. Possible cause of variations is equinoctial variation in the density of the ionosphere F2-layer.

Thank you for attention!