Low energy electrons (5-50 keV) at geostationary AMC 12: CEASE II ESA instrument data analysis and modeling

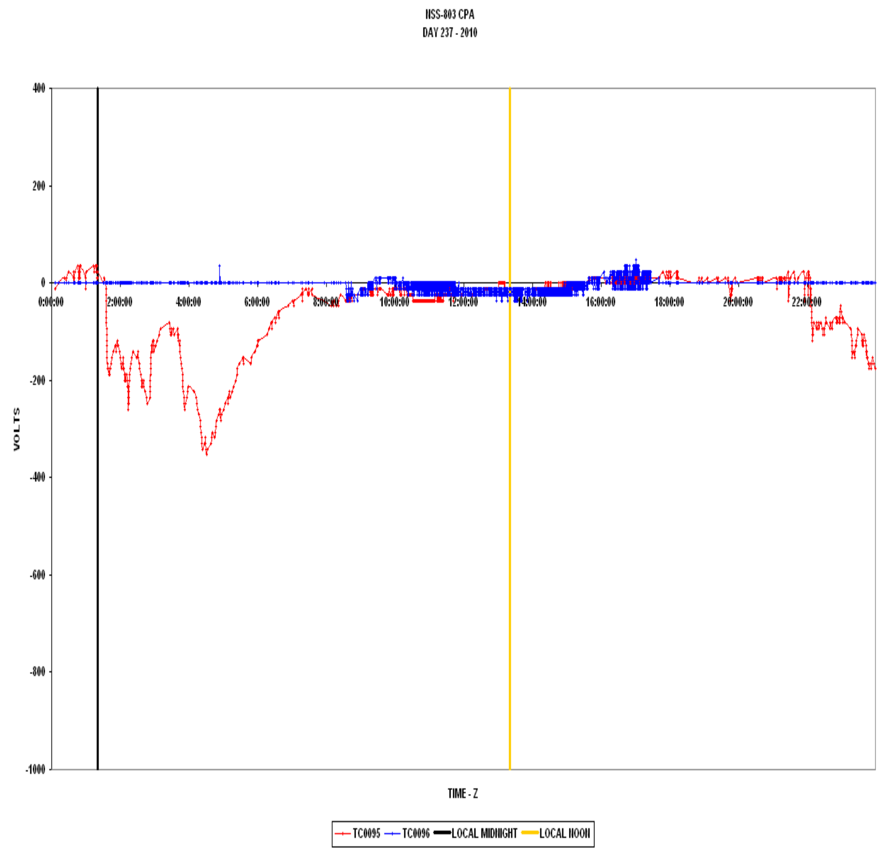
N. Ganushkina (1, 2), O. Amariutei (1), and D. Pitchford (3)

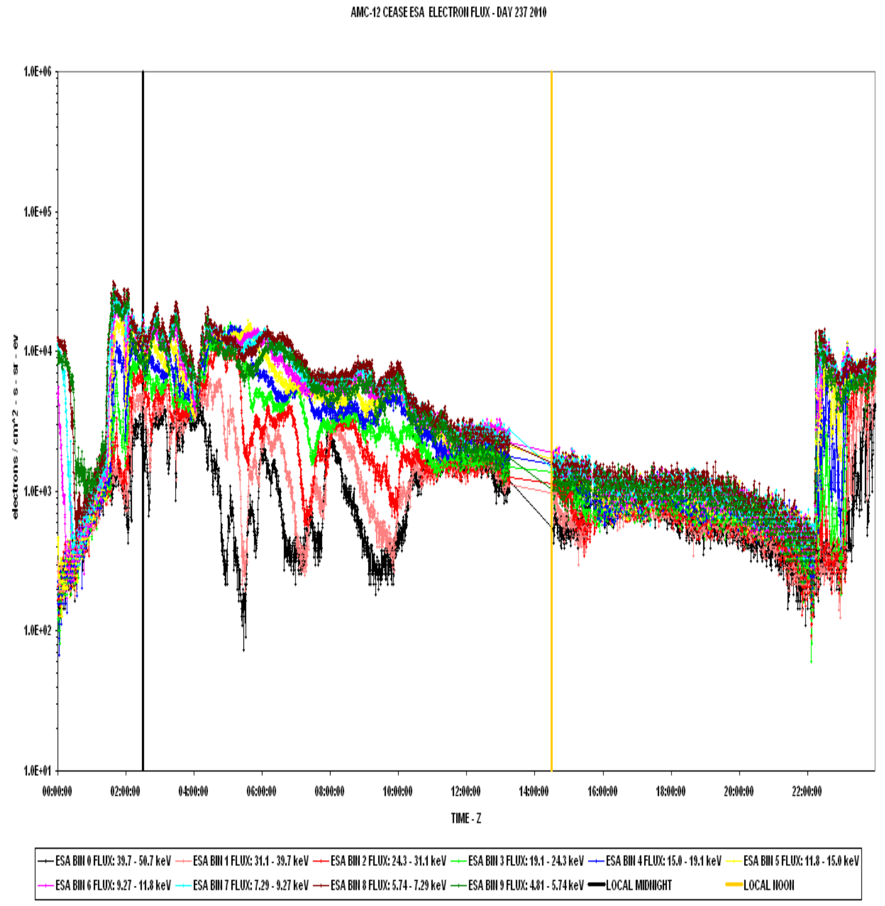
(1) Finnish Meteorological Institute, Helsinki, Finland
(2) University of Michigan, Ann Arbor MI, USA
(3) SES ENGINEERING, Luxembourg.

Acknowledgements: The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no **262468 SPACECAST project**, and is also supported in part by the Academy of Finland and NSF and NASA grants.

10th European Space Weather Week, November 18-22, 2013, Antwerp, Belgium

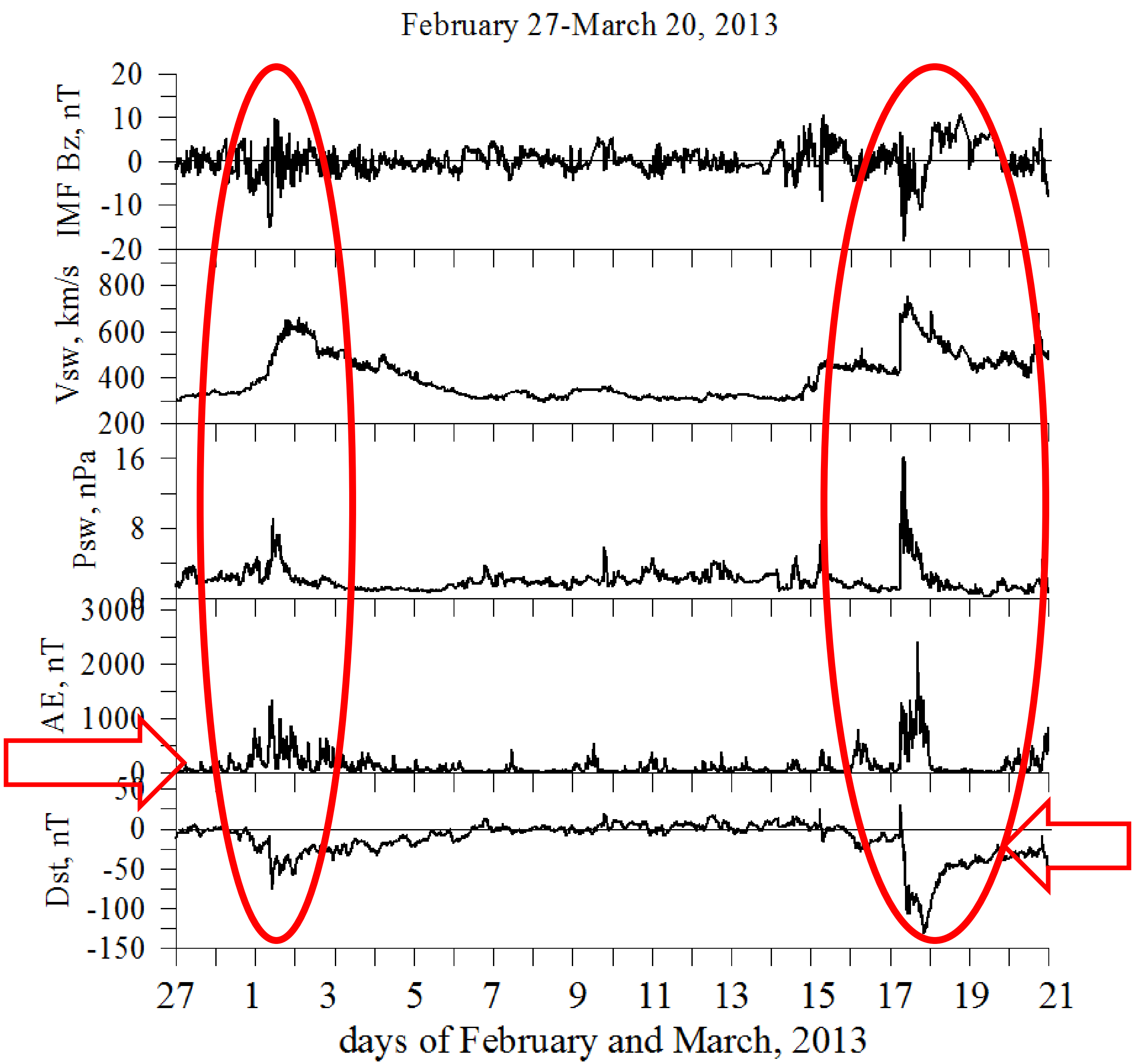
Instrumentation and Data:
AMC 12 satellite, CEASE II ESA instrument





16 November 2010

Period 1: February 27 – March 20, 2013

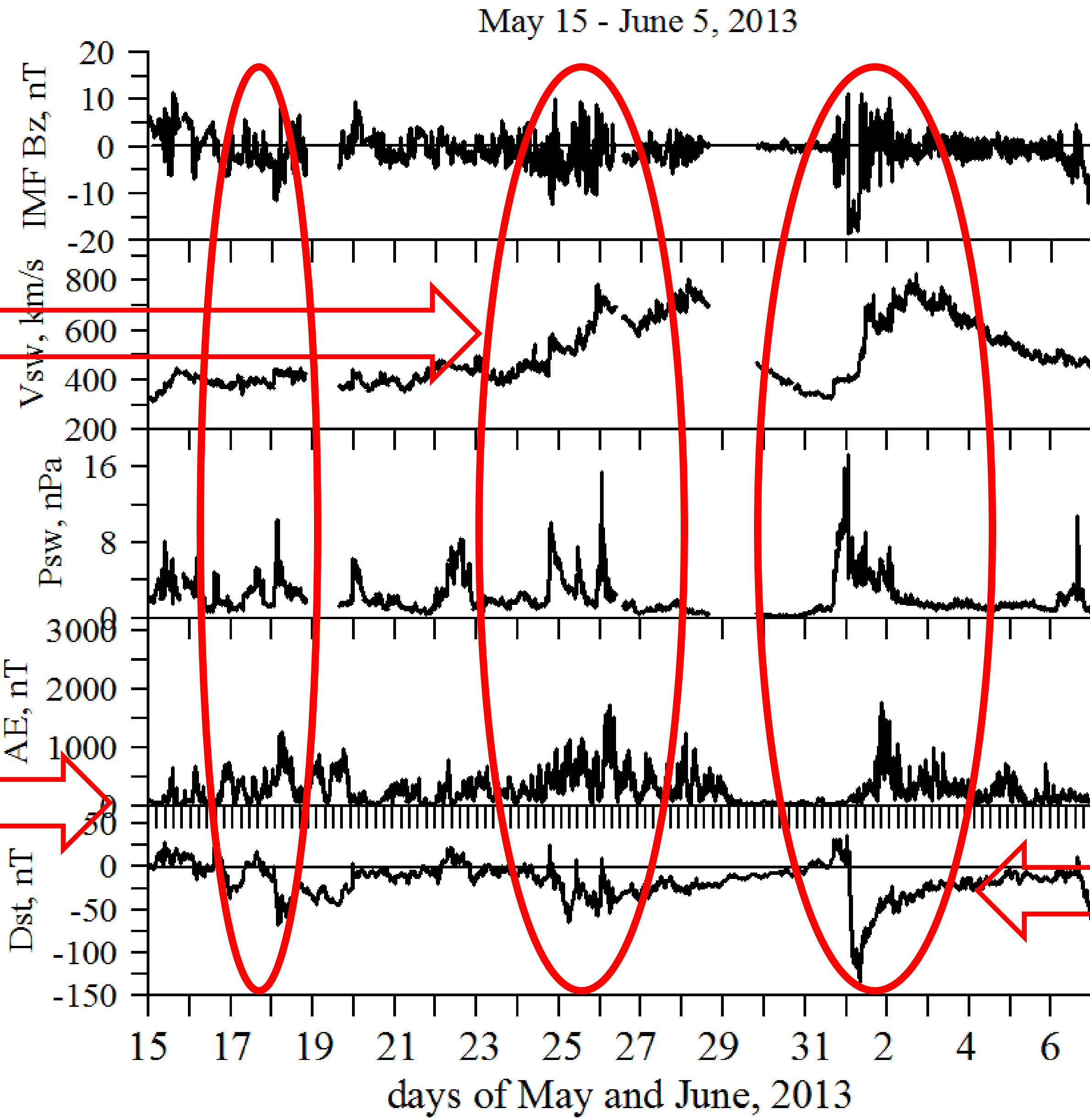


small, CIR-driven storm with Dst of 75 nT

moderate, CME-driven storm with Dst of 130 nT

Period 2: May 15 – June 7, 2013

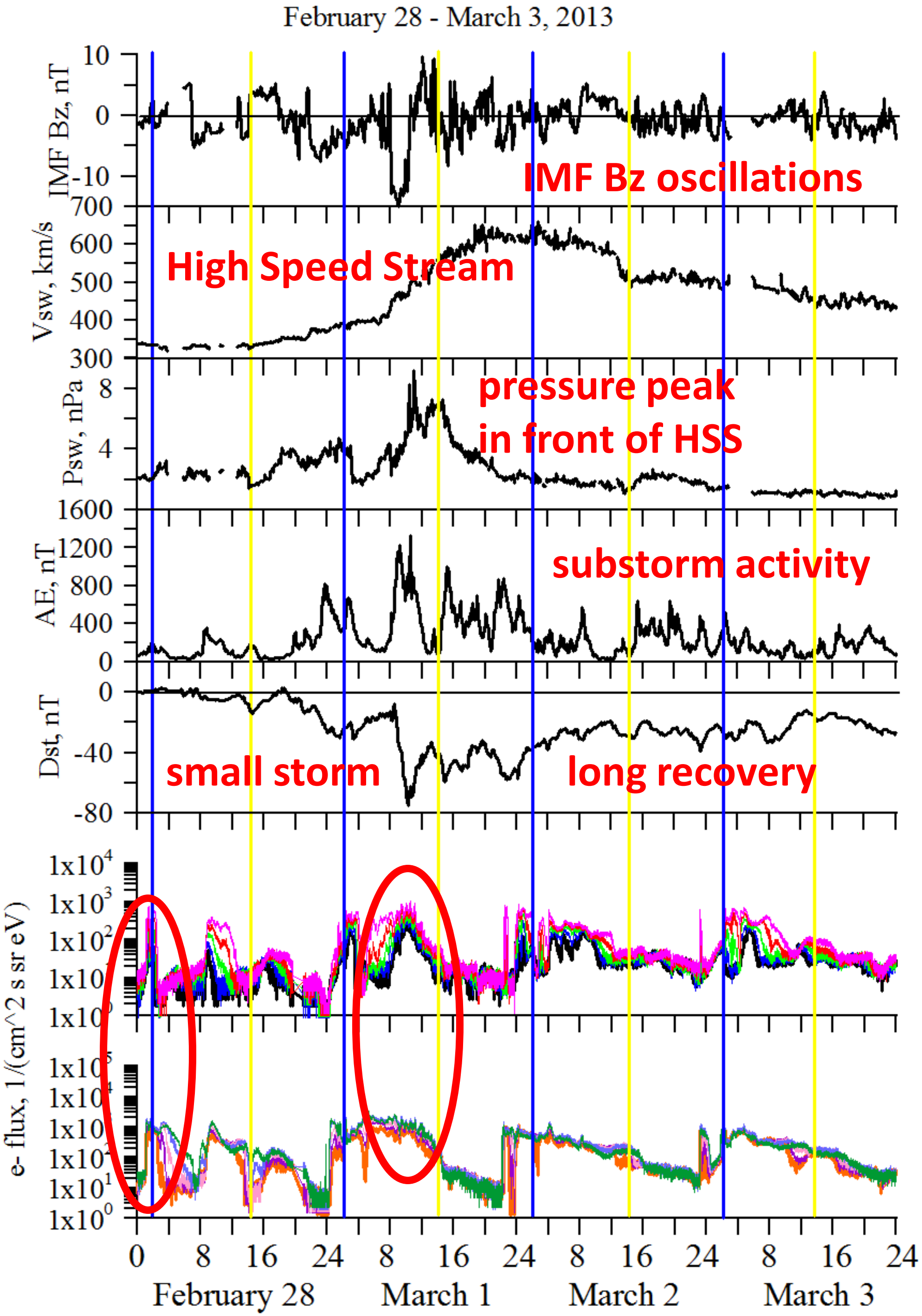
small,
CIR-driven
storm with
Dst of 65 nT



small,
??-driven
storm with
Dst of 60 nT

moderate,
CME-driven
storm with
Dst of 135 nT

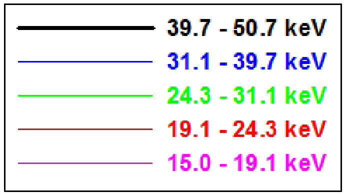
CIR-driven storm (1)

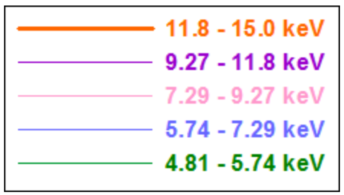


Small, CIR-driven storm with **Dst of 75 nT** **IMF Bz** of -5 -10 nT, **Vsw** from 350 to 650 km/s, **Psw** peak at 8 nPa, **AE** peaks of 800-1200 nT

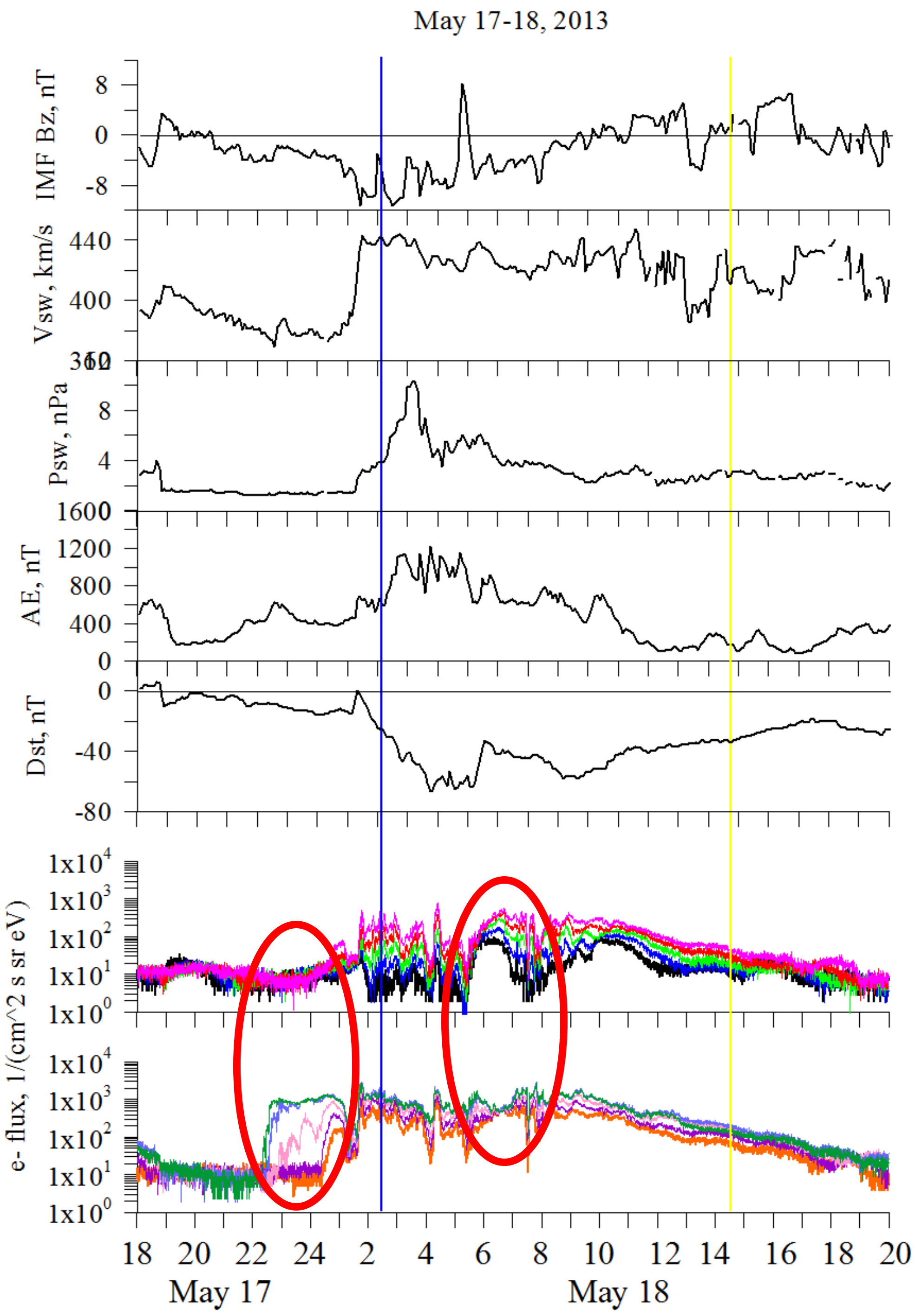
AMC12 electron data

- peaks in both 15-50 keV and 5-15 keV electron fluxes show correlation with AE
- 2 orders of magnitude increase
- all energies increase at midnigth when AE is only 200 nT
- same order of increase for AE = 800 nT and even for 1200 nT
- peaks for 15-50 keV more dispersed
- daily gradual decrease of fluxes from midnight to dawn-noon-dusk
- peak in 15-50 keV at Dst min but not in 5-15 keV





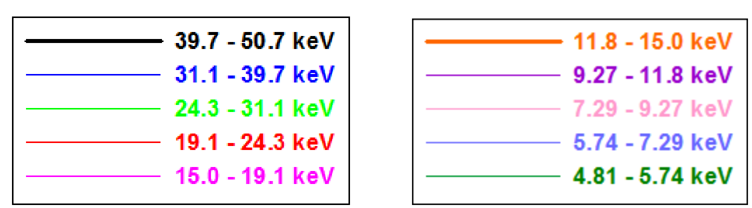
CIR-driven storm (2)



Small, CIR-driven storm with **Dst of 60 nT IMF Bz** of -8 nT, **Vsw** from 360 to 440 km/s, **Psw** peak at 9 nPa, **AE** peaks of 1200 nT

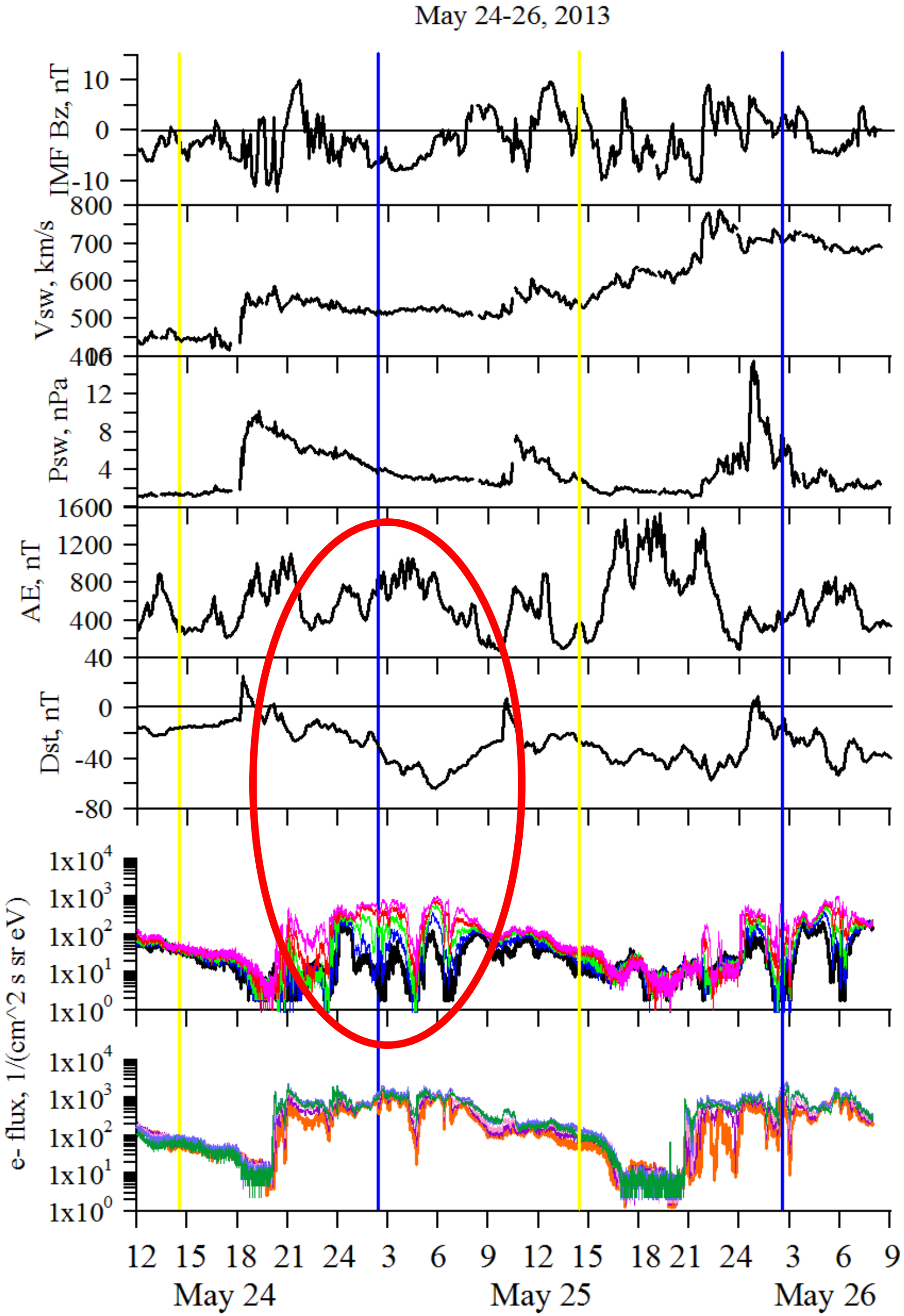
AMC12 electron data

- peaks in 15-50 keV more clear
- coming from dusk, near midnight: increase of 2 orders only for 5-15 keV (AE=600 nT)
- electron fluxes show correlation with AE
- saw-tooth-like oscillations during Dst drop
- 2 orders increase for 15-50 keV but 1 order for 5-15 keV
- at dawn peak in 15-50 keV with Dst increase and IMF Bz positive jump
- daily gradual decrease of fluxes from midnight to dawn-noon-dusk



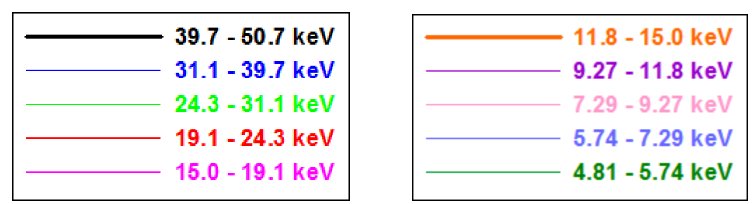
CIR-driven storm (3)

Small, CIR-driven storm with **Dst of 65 nT** **IMF Bz** of -8 -10 nT, **Vsw** from 450 to 7500 km/s, **Psw** peak at 10-14 nPa, **AE** peaks of 800-1600 nT

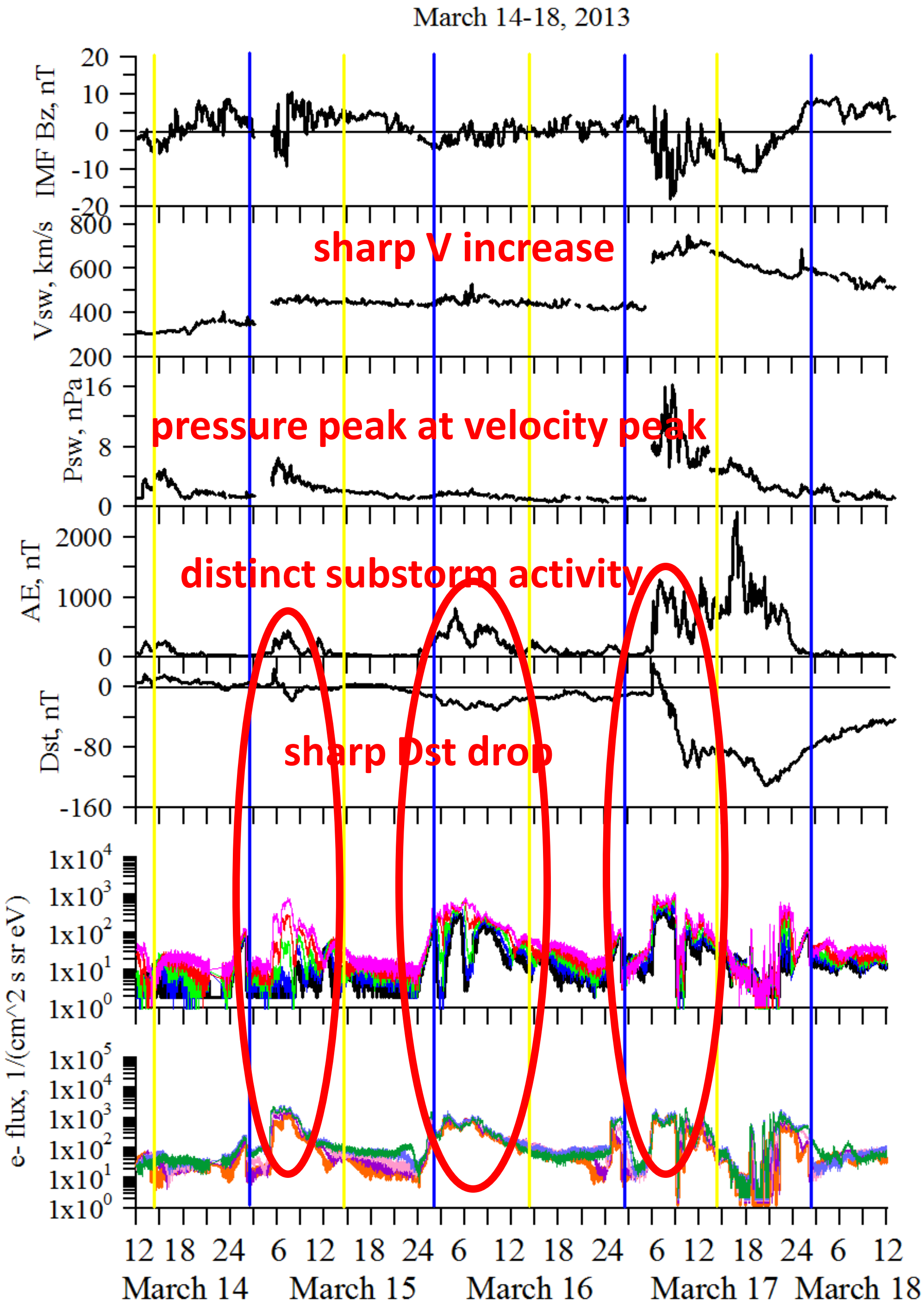


AMC12 electron data

- peaks in 15-50 keV more clear and show more variations
-variations of 15-50 keV during Dst gradual drop (midnight) due to AE variations
- electron fluxes show correlation with AE
- 2 orders increase for 15-50 keV but 1 order for 5-15 keV
- daily gradual decrease of fluxes from midnight to dawn-noon-dusk



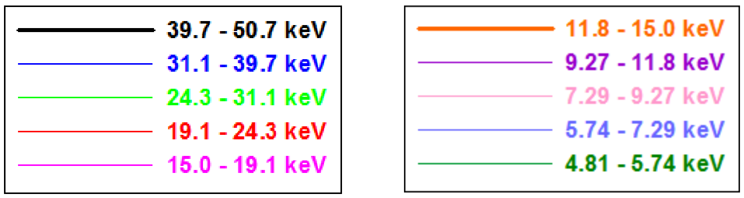
CME-driven storm (1)



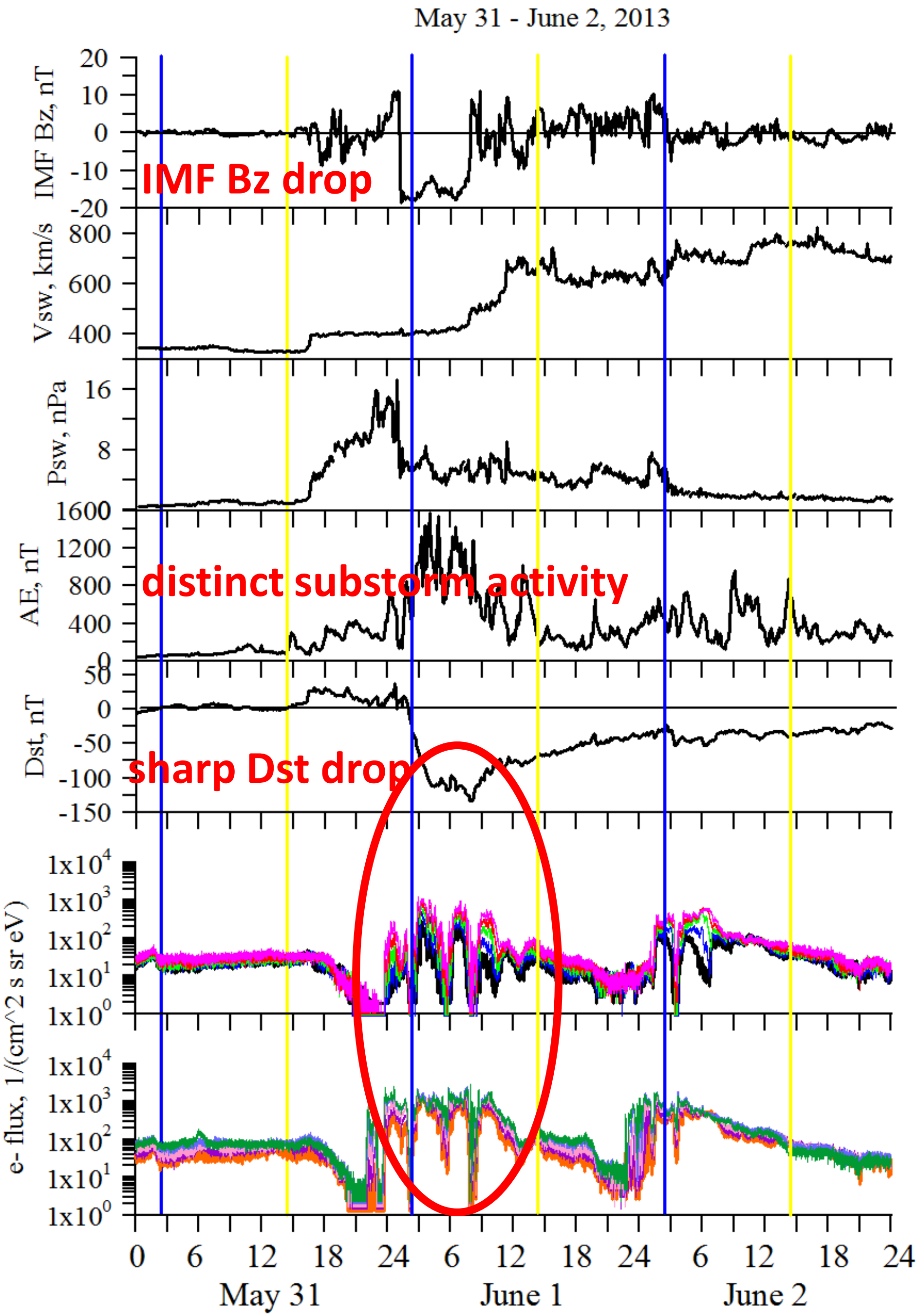
Moderate, CME-driven storm with **Dst of 130 nT, IMF Bz reaching -20** nT, **Vsw** from 400 to 700, **Psw** peak at 16 nPa, **AE** peaks of 1000-2500 nT

AMC12 electron data

- peaks in both 15-50 keV and 5-15 keV electron fluxes show clear correlation with AE peaks
- 2 orders of magnitude increase
- peaks for 15-50 keV more dispersed and more pronounced
- daily gradual decrease of fluxes from midnight to dawn-noon-dusk
- during quiet period before storm peaks with AE =500 nT similar to peaks with AE over 1000 nT at storm at midnight-dawn



CME-driven storm (2)



Moderate, CME-driven storm with **Dst of 135 nT, IMF Bz reaching -20** nT, **Vsw** from 400 to 700, **Psw** peak at 16 nPa, **AE** peaks of 1600 nT

AMC12 electron data

- peaks in both 15-50 keV and 5-15 keV electron fluxes show clear correlation with AE peaks
- 2 orders of magnitude increase
- peaks for 15-50 keV more dispersed and more pronounced
- daily gradual decrease of fluxes from midnight to dawn-noon-dusk
- at storm main phase saw-tooth-like oscillations at midnight correlated with AE
- at storm recovery peaks with AE =700 nT similar to peaks with AE=1600 nT at storm main phase at midnight

Features in fluxes of low energy electrons

Feature	Satellite location	Type of storm	Phase of storm
- peaks of **2 orders** of magnitude for **15-50 keV** and	around midnight-dawn	CIR and CME	all, AE peaks
1 order for 5-15 keV	around midnight-dawn	CIR	main
- correlated with **AE**	around midnight-dawn	CIR and CME	all, AE peaks
- **peaks similar** for small (200-400 nT) and large (1200-1600 nT) AE	midnight	CIR and CME	quiet and storm
- peaks for 15-50 keV more dispersed and pronounced	around midnight-dawn	CIR and CME	quiet and storm
- **daily gradual decrease** of fluxes	midnight to -dawn-noon-dusk	CIR and CME	quiet and storm
- **saw-tooth-like** oscillations correlated with AE	midnight	CIR and CME	main

Cases

- increase of 2 orders only for 5-15 keV (AE=600 nT)	from dusk, near midnight	CIR	before
- peak in 15-50 keV with Dst up and IMF Bz up	dawn	CIR	recovery

Modelling

Main question: which variations in the observed electron fluxes are caused by

(1) Variations of SW and IMF parameters (used in time-dependent boundary conditions, magnetic and electric fields;

(2) Electron losses;

(3) Variations of electromagnetic fields associated with substorms.

Magnetic field model: T96 (Dst, Psw, IMF By and Bz)

Electric field model: Boyle (Vsw, IMF B, By, Bz)

Boundary conditions: Tsyganenko and Mukai (Vsw, IMF Bz,Nsw)

Losses: Kp, magnetic field

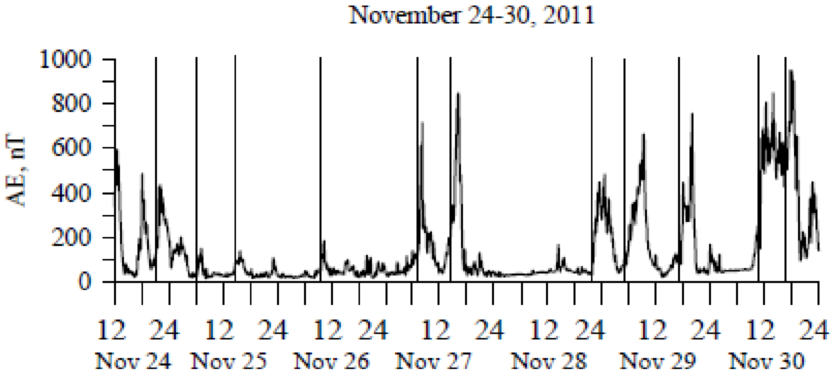
Strong diffusion (L=10-6): $\tau_{sd} = \left(\frac{\gamma m_0}{p}\right)\left[\frac{2\Psi B_h}{1-\eta}\right]$

Weak diffusion (L=2-6): $\tau_{wd} = 4.8\cdot 10^4 B_w^{-2} L^{-1} E^2, \quad B_w^2 = 2\cdot 10^{2.5+0.18Kp}$

Electromagnetic pulses at substorm onsets:

$$E_\phi = -E_0\left(1+c_1\cos(\phi-\phi_0)\right)^p \exp\left(-\xi^2\right),$$

Timing and amplitude from AE index



Summary from modelling presented at Plenary 9

1. The variations of fluxes for **5-50 keV electrons** observed by CEASE II ESA instrument onboard AMC 12 satellite during one small CIR- and one moderate CME-storms analyzed and modeled.

2. The variations in the observed electron fluxes are caused by

   (1) **Variations of SW and IMF parameters** (used in time-dependent boundary conditions, magnetic and electric fields:
   only main peaks and general pattern,
   when SW and IMF variations are significant
   (From the analysis of quiet events: IMF Bz = -11 nT, Vsw = 530 km/s,
   Psw = 6 nPa, Kp = 4, AE = 500 nT, Dst = -20 nT).

   (2) **Electron losses** (represented as electron lifetimes, dependent on magnetic field and Kp index):
   main trends in flux daily decrease when going duskward via noon.

   (3) Variations of electromagnetic fields associated with **substorms**:
   needed to explain flux variations correlated with AE index peaks,
   uniform representation of electromagnetic pulse scaled by AE value can not be used, flux peaks are not dependent on AE magnitude.