Nowcast Model for Low Energy Electrons in the Inner Magnetosphere

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SPACESTORM

1. Introduction

What do we present?
IMPTAM (Inner Magnetosphere Particle Transport and Acceleration model): nowcast model for low energy (< 200 keV) electrons in the inner magnetosphere, operating online under the **SPACECAST project (http://fp7-spacecast.eu)**

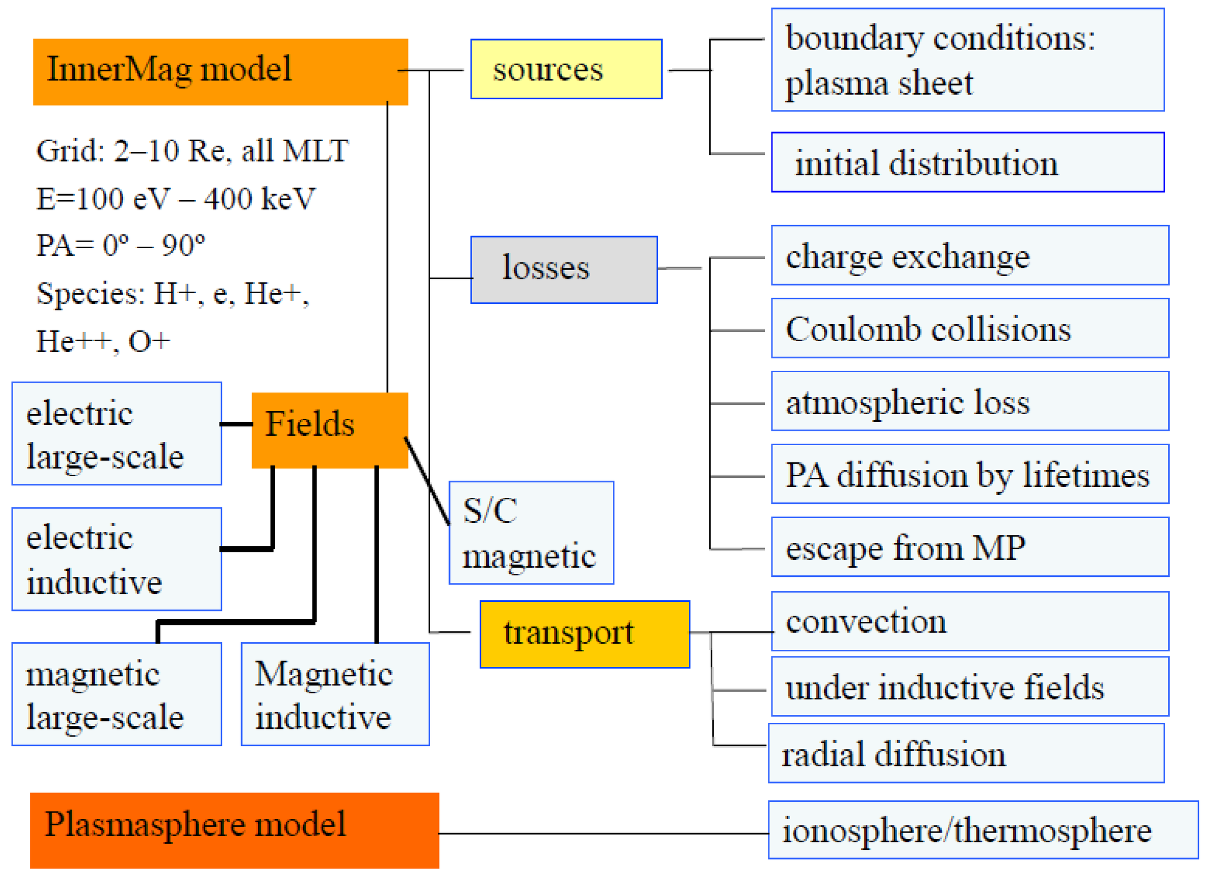
Why this model is important?
Low energy electron fluxes are very important to specify when hazardous satellite surface charging phenomena are considered. They constitute the low energy part of the seed population for the high energy MeV particles in the radiation belts

What does the model provide?
The presented model provides the low energy electron flux at all L-shells and at all satellite orbits, when necessary.

What are the drivers of the model?
The model is driven by the real time solar wind and IMF parameters with 1 hour time shift for propagation to the Earth's magnetopause, and by the real time Dst index.

***Ganushkina et al.**, Nowcast model for low energy electrons in the inner magnetosphere, Space Weather, accepted, December 2014.*

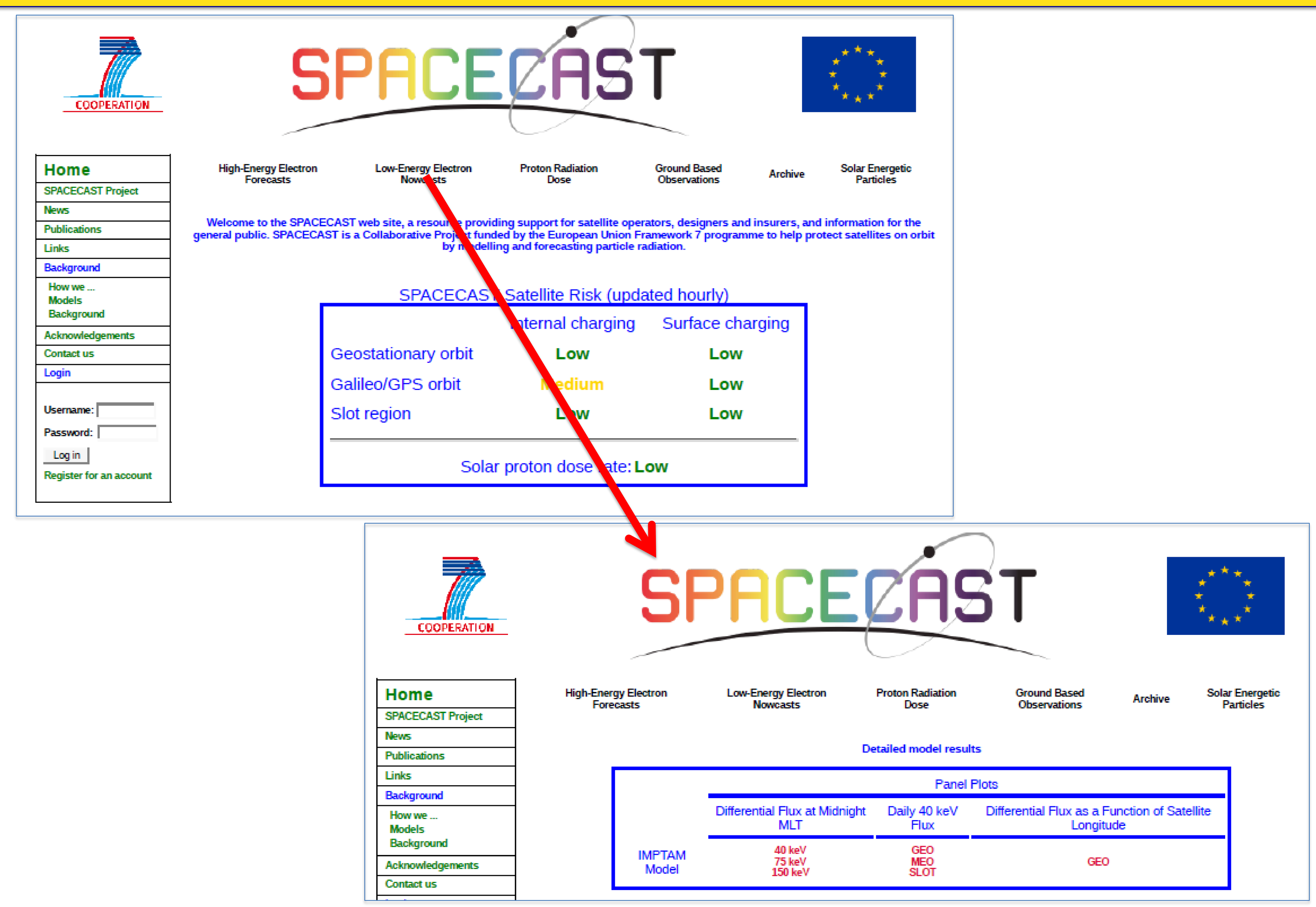
2. Inner Magnetosphere Particle Transport and Acceleration Model



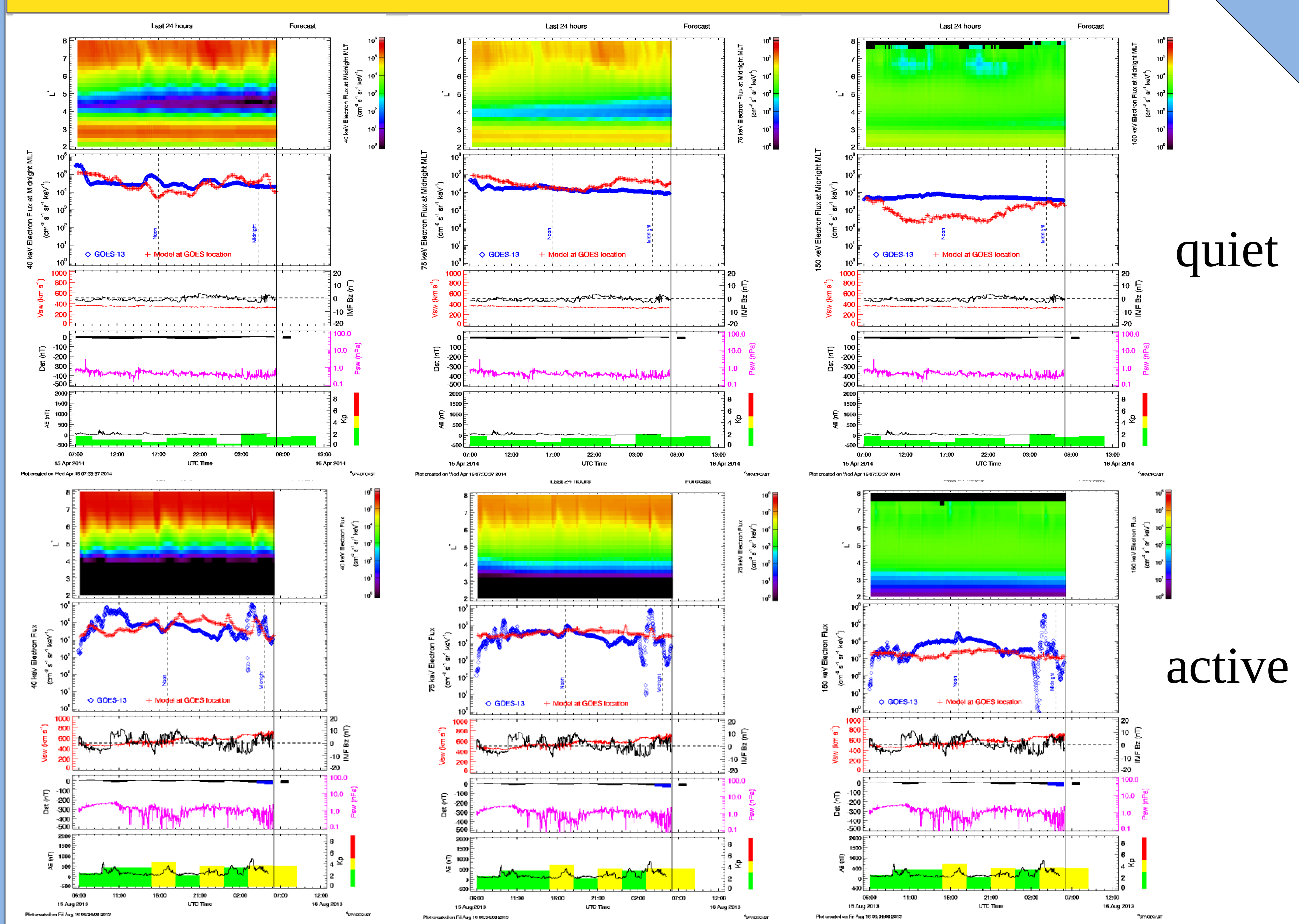
- traces ions and electrons with arbitrary pitch angles from the plasma sheet to the inner L-shell regions with energies up to hundreds of keVs in time-dependent magnetic and electric fields;
- traces a distribution of particles in the drift approximation under the conservation of the 1st and 2nd adiabatic invariants; Liouville theorem is used to gain information of the entire distribution function;
- for the obtained distribution function, we apply radial diffusion by solving the radial diffusion equation;
- electron losses: convection outflow and pitch angle diffusion by the electron lifetimes;
- advantage of IMPTAM: it can utilize any magnetic or electric field model, including self-consistent magnetic field and substorm-associated electromagnetic fields.

All details are given in
***Ganushkina, N. Y.**, M. W. Liemohn, O. A. Amariutei, and D. Pitchford (2014), Low-energy electrons (5–50 keV) in the inner magnetosphere, J. Geophys. Res. Space Physics, 119, doi:10.1002/2013JA019304.*
***Ganushkina, N. Y.**, O. A. Amariutei, Y. Y. Shprits, and M. W. Liemohn (2013), Transport of the plasma sheet electrons to the geostationary distances, J. Geophys. Res., 118, doi:10.1029/2012JA017923.*

3. Online nowcast model for low energy electrons (< 200 keV) in the inner magnetosphere, SPACECAST project (http://fp7-spacecast.eu)



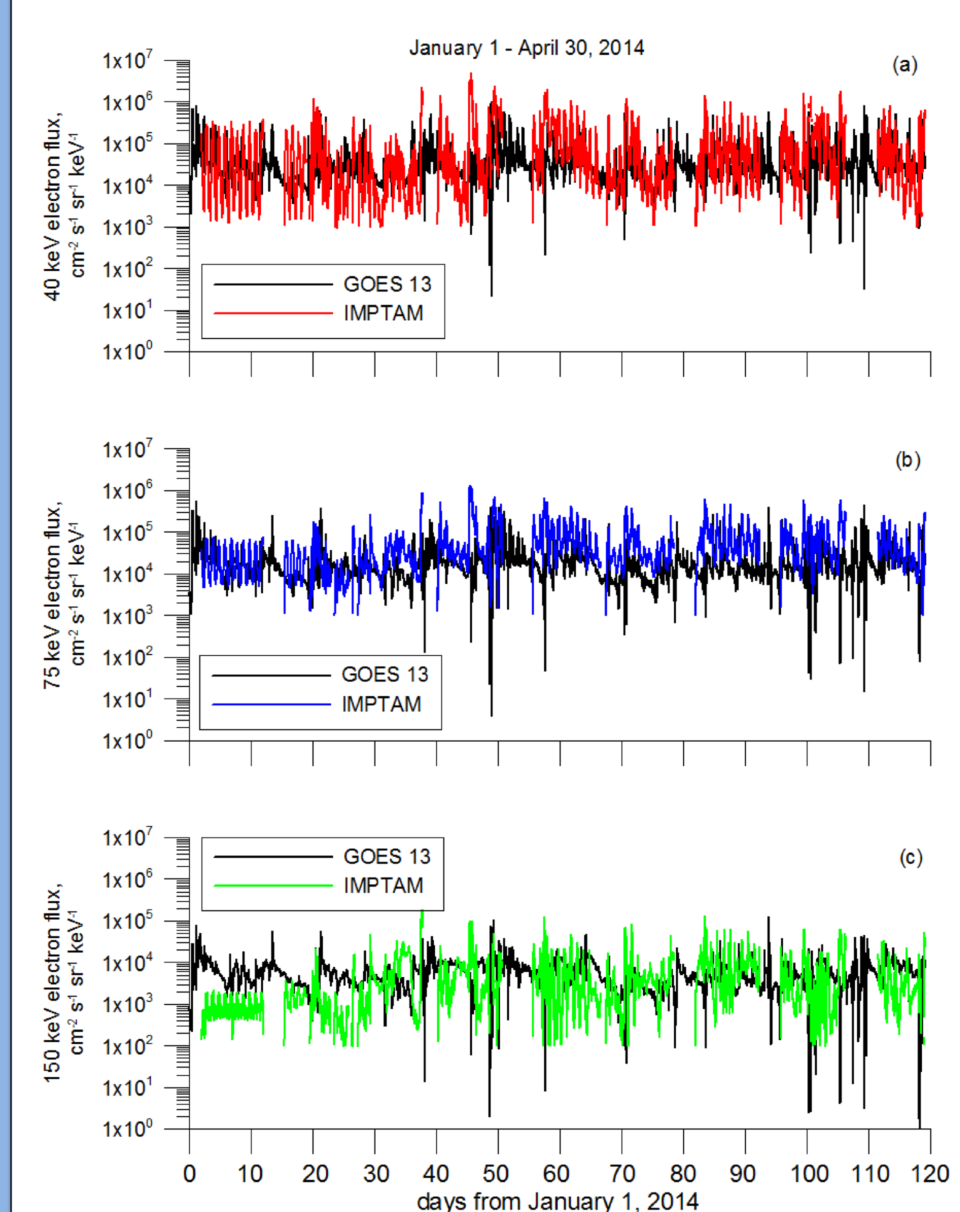
4. 40 keV 75 keV 150 keV



quiet

active

5. Model performance



Normalized root-mean-square deviation (NRMSD) and the associated **standard deviations σ_{obs}** of the observations (in units of $cm^{-2}\,s^{-1}\,sr^{-1}\,keV^{-1}$):
0.0324 // 8.288×10^4 (40 keV); **0.0153** // 3.438×10^4 (75 keV); **0.0307** // 5.737×10^3 (150 keV)

Model performance determined from the binary event tables for 1 hour window in the time-dependent IMPTAM output with 2201 events in total

40 keV

Flux level, $cm^{-2}\,s^{-1}\,sr^{-1}\,keV^{-1}$	Hit	False Alarm	Miss	Correct Rejection	Hit Rate	False Alarm Rate	Heidke Skill Score
5×10^4	348	721	179	953	0.660	0.431	0.170
1×10^5	109	612	121	1359	0.474	0.311	0.084
2×10^5	34	403	73	1691	0.318	0.192	0.051
3×10^5	16	288	39	1858	0.291	0.134	0.049
4×10^5	5	228	22	1946	0.185	0.105	0.017

75 keV

Flux level, $cm^{-2}\,s^{-1}\,sr^{-1}\,keV^{-1}$	Hit	False Alarm	Miss	Correct Rejection	Hit Rate	False Alarm Rate	Heidke Skill Score
3×10^4	295	1043	104	759	0.739	0.579	0.084
5×10^4	82	816	85	1218	0.491	0.401	0.030
1×10^5	18	429	31	1723	0.367	0.199	0.034

150 keV

Flux level, $cm^{-2}\,s^{-1}\,sr^{-1}\,keV^{-1}$	Hit	False Alarm	Miss	Correct Rejection	Hit Rate	False Alarm Rate	Heidke Skill Score
3×10^3	34	403	73	1691	0.485	0.603	-0.077
3.5×10^3	16	288	39	1858	0.438	0.525	-0.065
1×10^4	5	228	22	1946	0.159	0.233	-0.064

$$RMSD = \sqrt{\frac{\sum_{t=1}^{n}\left(x_{1,t}-x_{2,t}\right)}{n}}, \quad NRMSD = \frac{RMSD}{\sigma_{obs}}$$

skilled prediction: NRMSD < 1
unskilled prediction: NRMSD > 1
- IMPTAM predicts fluxes reasonably well

$$HSS = \frac{2s(1-s)(H-F)}{s+s(1-2s)H+(1-s)(1-2s)F}$$

$$s = \frac{Hit+Miss}{all\ events} \qquad H = \frac{Hit}{Hit+Miss}$$

$$F = \frac{FalseAlarm}{FalseAlarm+CorrectRejection}$$

The perfect skill: HSS=1, the minimum: -1.

- Significant flux dropouts not present
- 40 keV: rather small HSS but reasonable hit and false alarm rates
- Best Hit Rate for 75 keV electrons
- 150 keV flux constantly smaller than the observed (1 order), hit rates reasonable, but the HSS is very small

Acknowledgements: The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreements **No 606716 SPACESTORM**, and was also supported in part by the **Academy of Finland and NSF and NASA grants.**

First attempts to model low energy electrons in real time at 10 minute resolution, basic level of observed fluxes reproduced:
working online near-real time nowcast of low energy electrons is a very important tool which provides highly valuable output