Low energy electrons

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Contributions from: S. Dubyagin, I. Sillanpää, J.-C. Matéo-Vélez, S. Glauert, R. Horne

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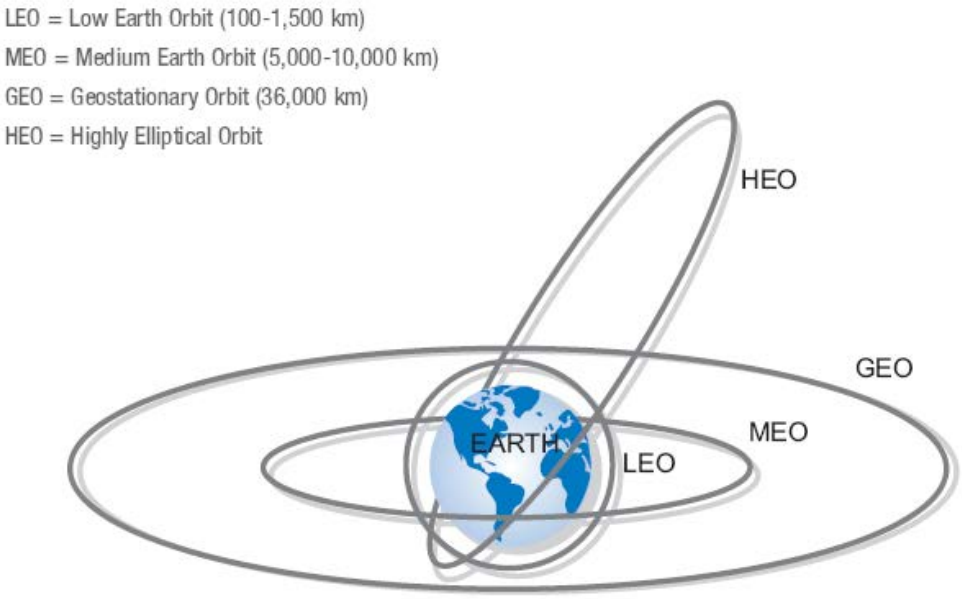
Need to have a model for low energy electrons in the near-Earth space



- No continuous measurements of radiation environment.
- No continuous simultaneous measurements of spacecraft potential
- Need to know what level of low energy electron flux (level of risk of surface charging) is and will be at times and locations where we do not have any measurements.
  KNOW NOW AND PREDICT

With the development of the **Inner Magnetosphere Particle Transport and Acceleration model (IMPTAM),** the computational view on the low energy electron fluxes in the near-Earth space is now feasible

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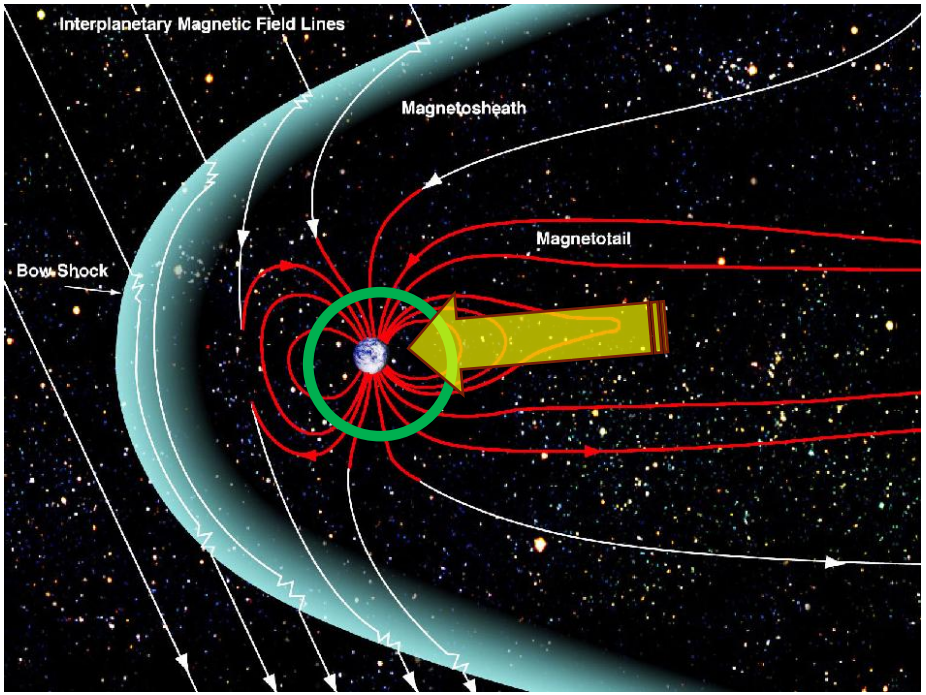
Challenges for modeling of low energy electrons in the near-Earth



- We model motion of electrons in **magnetic and electric fields:** Correct models for these fields are extremely hard to develop
- There is still a debate going on about the locations and timing of **electron transport and energy increase** when they come to GEO and inside (MEO)
- Specification of correct losses is very nontrivial

We use the **best available models to set our IMPTAM**

Very good agreement with the measurements indicates that the assumptions and physics in IMPTAM are correct and model can be trusted when made operational

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Importance of keV electrons in the inner magnetosphere

- **Louis Lanzerotti – one of the fathers of the space physics and space weather:**

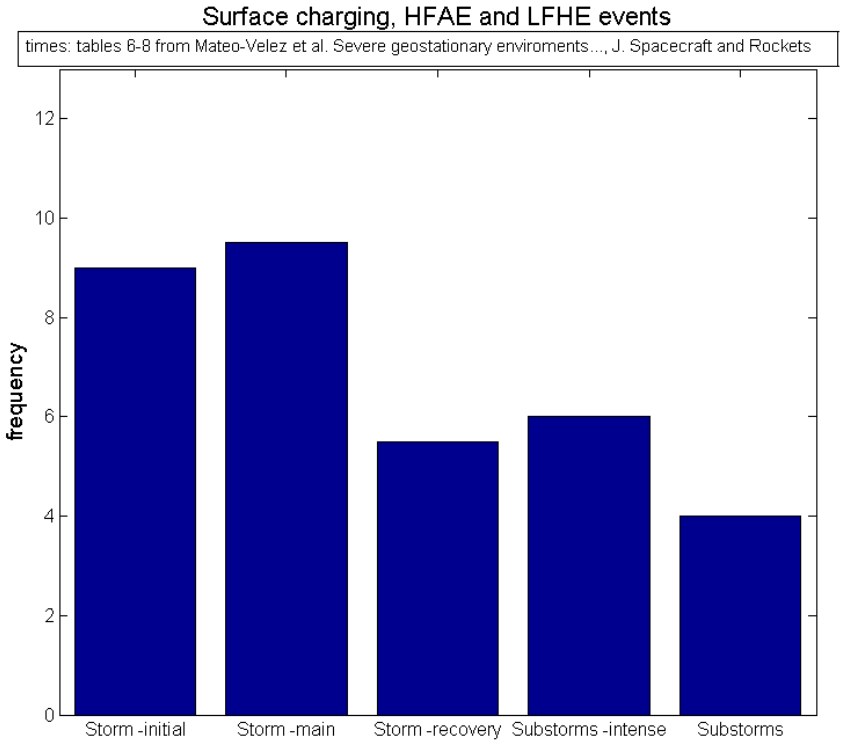
Space weather is more than storms

It is **NOT necessary to have even a moderate storm for significant surface charging** event to happen

- The electron flux at the keV energies varies significantly with geomagnetic activity **variations on time scales of minutes!**

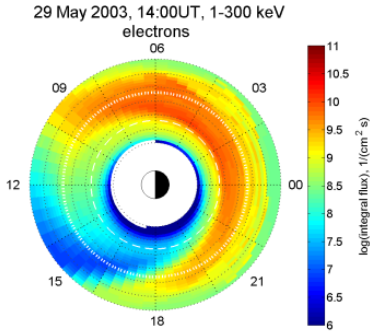
No averaging over an hour/day/orbit!

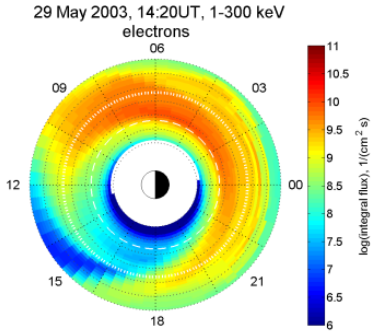
Surface charging vs. geomagnetic conditions

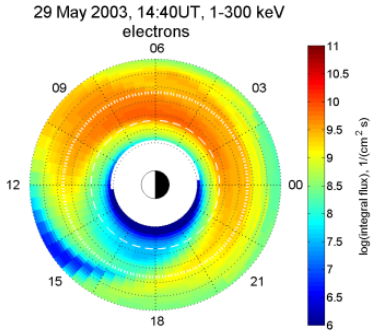


Matéo Vélez et al., Severe geostationary environments: from flight data to numerical estimation of spacecraft surface charging, *Journal of Spacecraft and Rockets, 2016.*

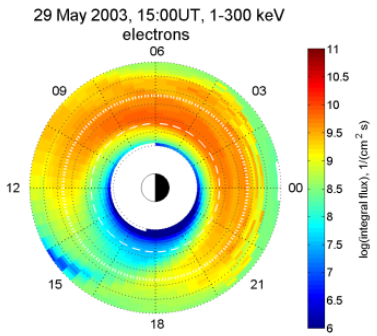
From surface charging event detected at GEO to max flux modeled at MEO

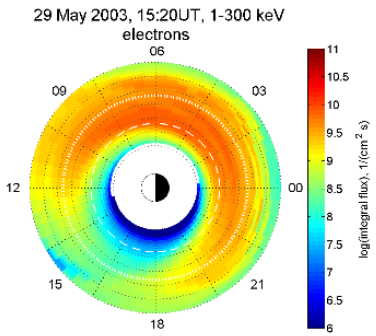


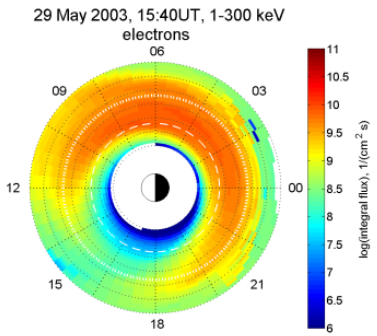




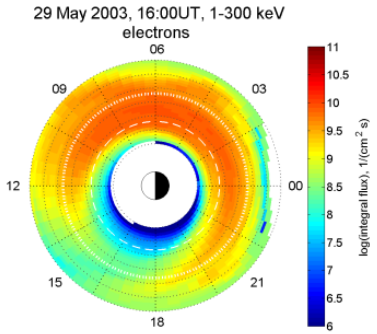
LANL surface charging

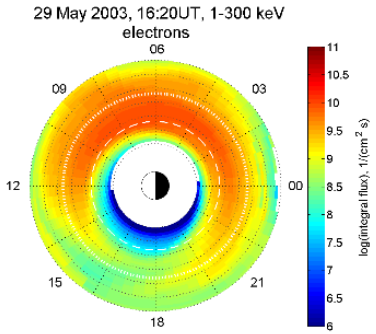


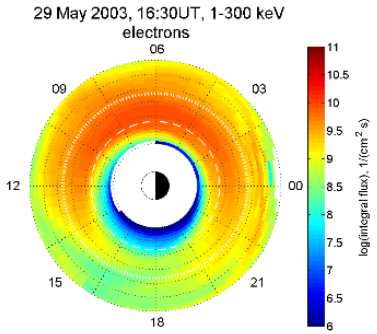




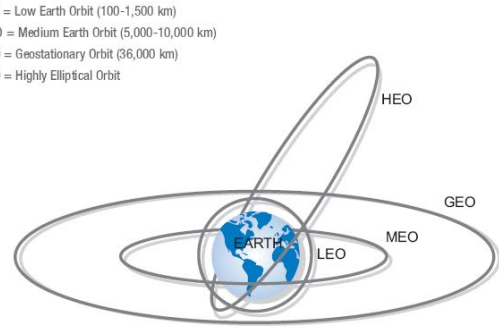
Max flux at MEO







Evolution of modeled electron fluxes from GEO location of LANL surface charging to MEO location of max modeled electron flux



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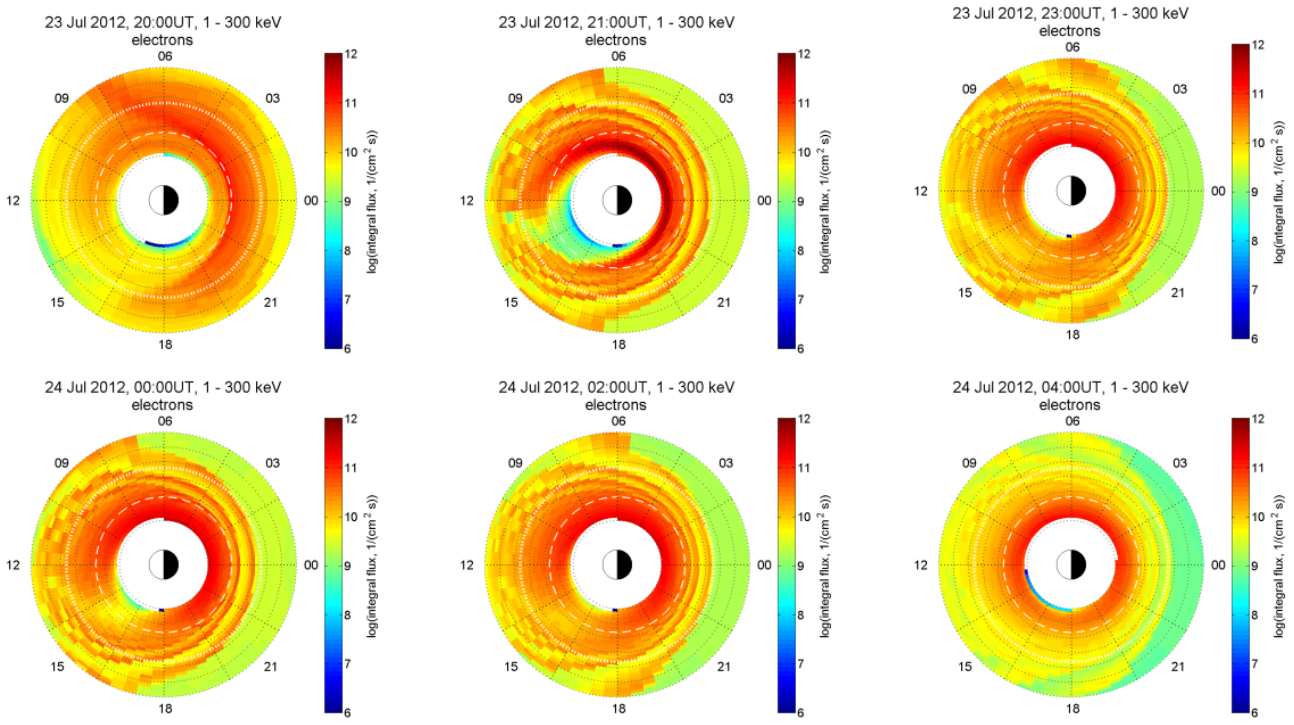
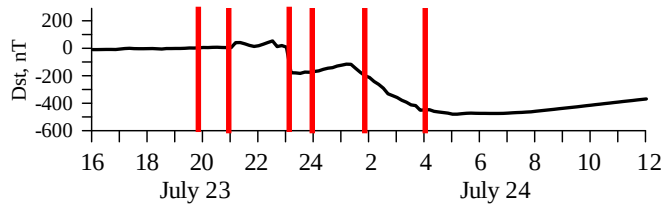
Huge CME-driven storm, July 23-24, 2012 (event that missed the Earth)

Dst = -500 nT (usually up to -200 nT), Psw=300 nPa (usually 50 nPa),
Vsw = 3000 km/s (usually 400-600 km/s)





keV electron fluxes are not significantly high during extreme event.

At GEO and MEO the fluxes may be even lower than during non-extreme event.

Magnetosphere becomes so stretched that electrons are lost since they happen to be on larger L-shells.

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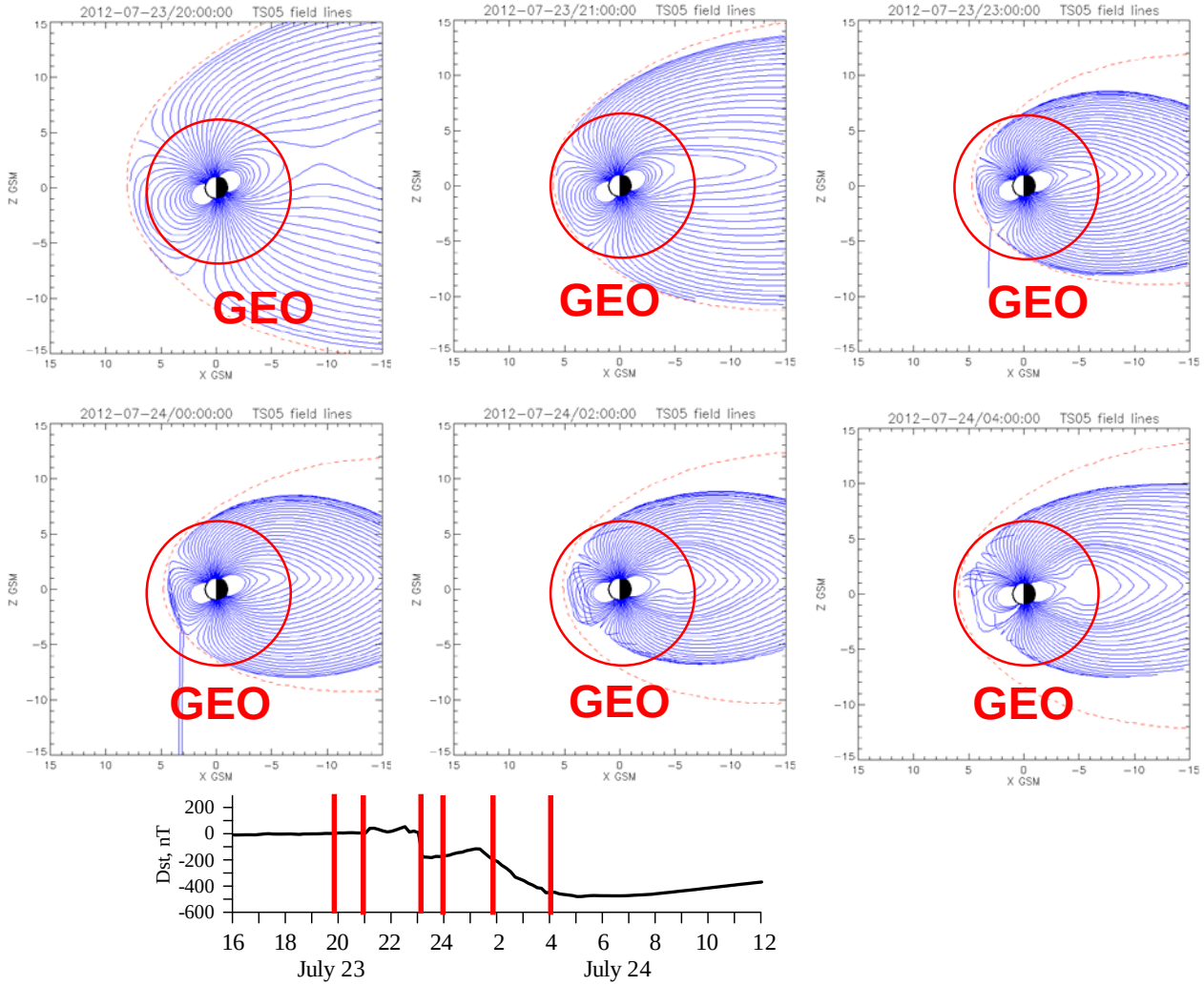

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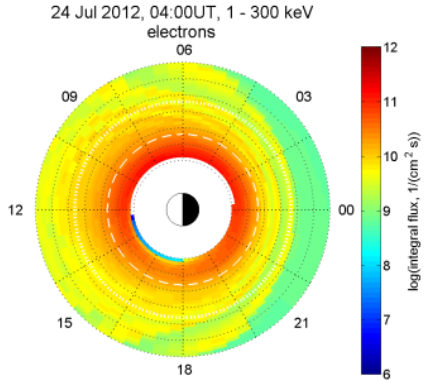
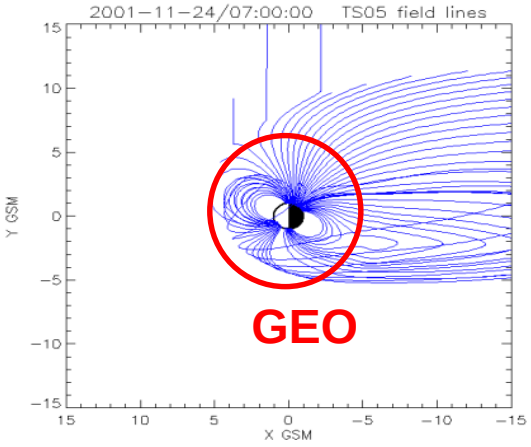
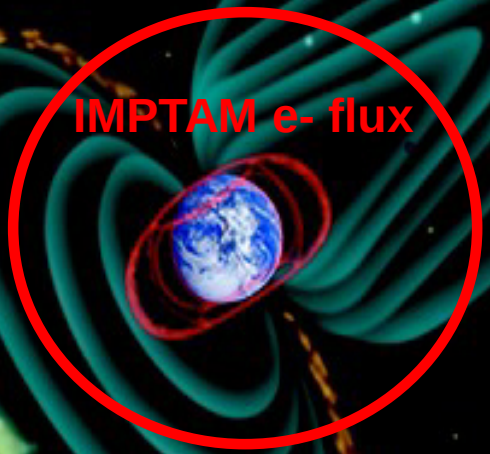
Extreme space storms

Low flux at GEO and MEO



Highly distrubed magnetic field lines





- For extreme surface charging to occur, no extreme storm is needed.
- keV electron fluxes can be even lower at GEO and MEO than during non-extreme event.
- Serious challenge: to model time-dependent variations of low energy electron fluxes. We are DOING THIS!

IMPTAM is online, near-real time,

provides output at any location and
at any orbit in the magnetosphere

http://fp7-spacecast.eu
imptam.fmi.fi
http://csem.engin.umich.edu/tools/imptam