Case studies with Van Allen Probes and IMPTAM modeling

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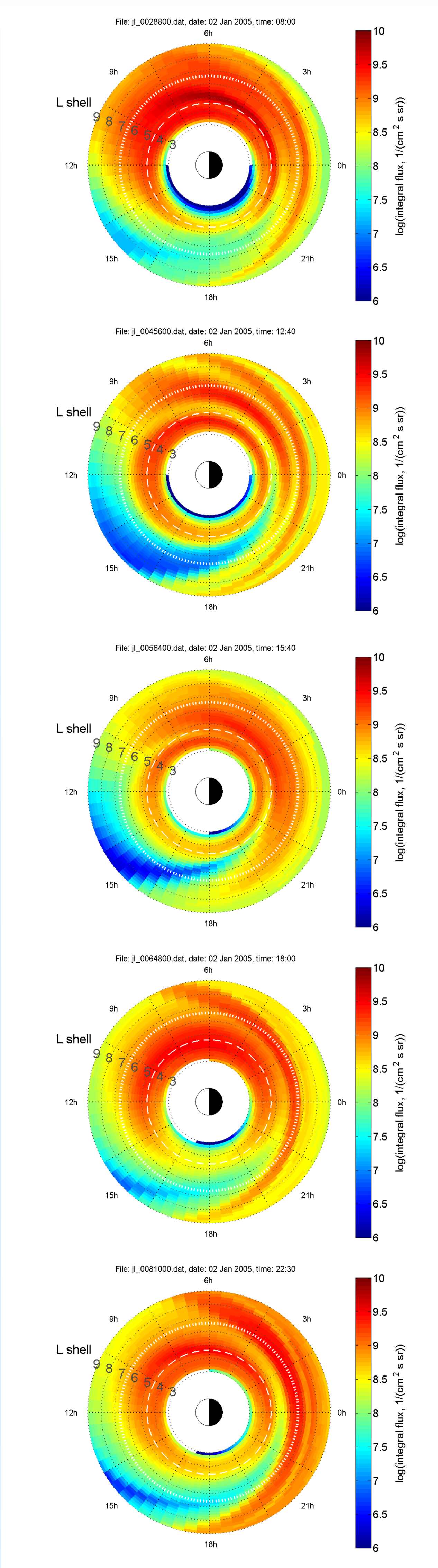
IMPTAM
Inner Magnetosphere Particle Transport and Acceleration Model



MOTIVATION

Van Allen Probes (aka Radiation Belt Storm Probes - RBSP, in orbit since August 2012) are two satellites (A and B) on twin elliptical orbits (perigee at altitude of 600 km, apogee 5.5 R_E). They observe the inner magnetosphere with a suite of plasma instruments. Van Allen Probes are some of the few spacecraft providing low energy electron data for the MEO orbits. HOPE instruments [1] provide measurements of electron from about 25 eV to 50 keV, and MagEIS instruments [2] from electrons in the energy range from 35 keV to several MeVs.

The keV energy range plasma is important for spacecraft charging effects and it acts as a seed population for high energy particles in the magnetosphere.

IMPTAM MODELING

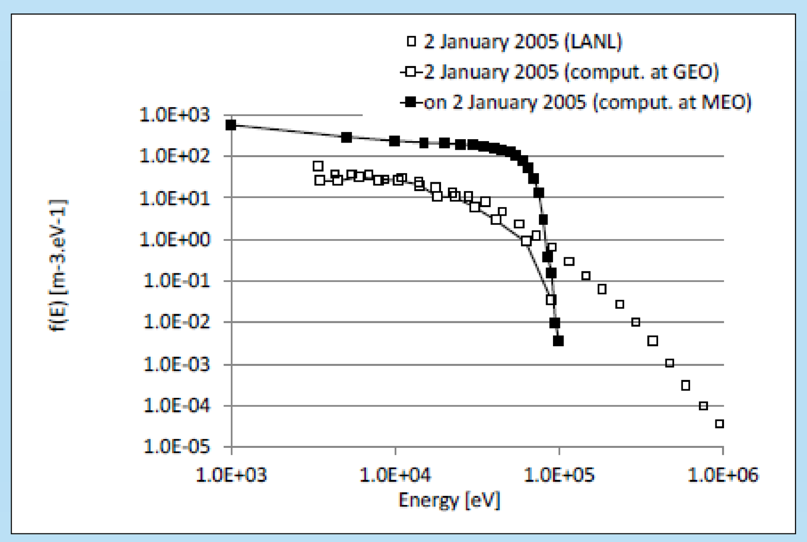
With IMPTAM electrons with keV range energies can be modeled with actual solar wind and IMF inputs. Electrons move from the plasma sheet to the inner magnetosphere regions. Results can be directly compared with geosynchronous and MEO satellite observations. Realtime IMPTAM results are available at http://imptam.fmi.fi Numerous case studies with IMPTAM modeling for specific geomagnetic storms have been published [e.g., 3,4,5].

Figures to the left:
IMPTAM results for inner magnetosphere during a storm on 2 January 2005. Geostationary and example MEO orbit (at 6.6 and 4.6 R_E) are indicated.

CASE STUDIES AT MEO

Several surface charging events at GEO were identified [6] using LANL MPA, SOPA and EPD electron data for energies from 1 eV to several MeVs. As an example, we present the modeling results for the January 2, 2005 surface charging event which was the case of one of the top 100 events of 15 minutes worst cases with the criteria HFAE (High flux all energies). The event on January 2, 2005 was the intense substorm event with AEmax = 1600 nT which occurred between 13 and 17 UT. The surface charging event was recoded at 15:46:12 UT at around 05 MLT by LANL 1994-084 satellite (midnight at 14 UT).

Figure to the right:
Electron fluxes plotted with energy for the 2 January 2005 event from a LANL geosynchronous spacecraft and IMPTAM modeling at GEO and MEO.



IMPTAM modeled electron fluxes are in a good agreement with LANL MPA and SOPA measurements at GEO. The maximum flux of 1-100 keV electrons of an order of magnitude larger than that observed at GEO was detected at MEO at 06 MLT after 2 hours from the surface charging event detected at GEO by LANL.

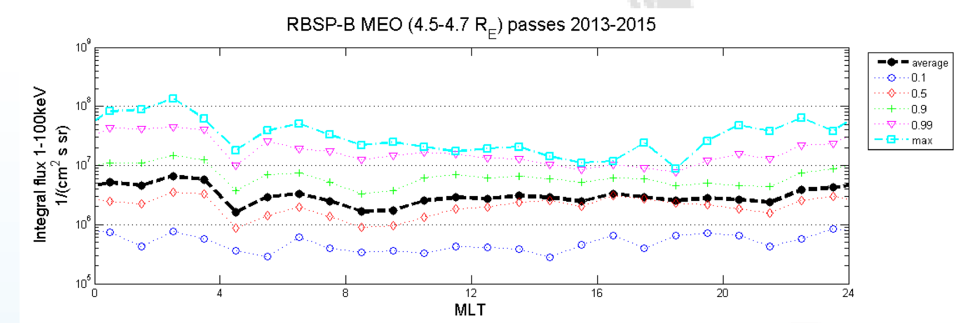
SOLAR WIND INFLUENCE AT MEO ORBITS

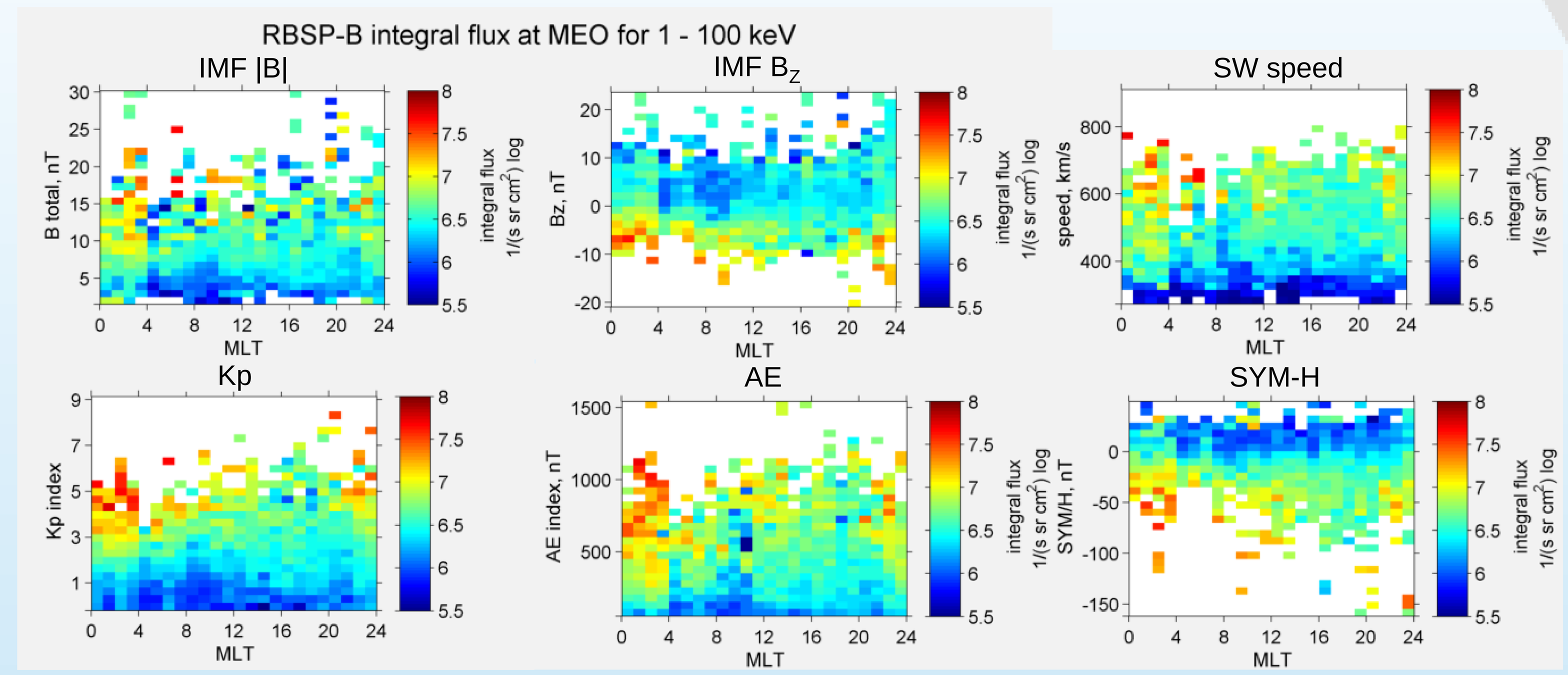
We have studied the statistics RBSP electron fluxes at a distance of about 4.6 R_E from Earth during a three year period: 2013-2015. There is a MLT dependence especially with the largest electron fluxes with highest fluxes occurring near midnight from 22 to 04 in MLT (see the 99% quantile line in the figure below).

The RBSP electron fluxes were also organized by the solar wind and IMF and geomagnetic parameters. The strongest organization are by the parameters shown above: the IMF strength (B total), its Z component (B_Z) and solar wind speed. Kp, AE and SYM-H indices also organized the MEO electron fluxes.

Initial inspection indicates that a delay of 2-4 hours to the solar wind and IMF parameters gives the most organization to RBSP flux measurements.

Figures to the right and below:
RBSP-B integral flux statistics at MEO orbits. The dependences on magnetospheric local time (MLT) and solar wind and geomagnetic indices are shown with a 2-h lag time.





CONCLUSIONS

Study and analysis of keV electrons measured by the Van Allen Probes at MEO orbits is unique and highly useful as continuous measurements at these distances aren't currently available. The results indicate that solar wind parameters probably do have an impact on keV electron fluxes at MEO orbits. Especially IMF |B| and B_Z component and the solar wind speed seem to have a significant effect on electron fluxes.

Further investigation would be very valuable.

REFERENCES

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