Modeling the radiation belt environment

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The effects of the radiation belt particles on spacecraft are well known. Electrons produce charging which can in turn induce electrostatic discharges. Protons produce Single Event Effects in electronics. These two effects are space weather ones as they are well correlated to the instantaneous environment. Moreover, electrons as well as protons induce total dose effects which are responsible to modifications of the characteristics of electronics, coatings and optics onboard satellites. Therefore, it is essential to dispose of reliable radiation belt models, either long term or short term, to prevent these effects. The existing and currently used long term models have to be updated, as they were developed at the beginning of the space age, when the radiation belt dynamics was not enough understood. Nevertheless, the update of these models is complex as it needs:
- good measurements, made on different orbits,
- a physical understanding of the variability and dynamics of the belts, and a physical modeling to interpolate between measurements.
- the model development, including validation and recognition. We will review these three factors, how they interfere and how a loop on them can improve models. For the measurements (or monitoring), they must be performed on different types of spacecraft:
- scientific ones, with well chosen orbits, to deliver absolute calibration and to make possible intercalibration between measurements available on different satellites,
- technology ones, to make a relation between the environment and its effects. These satellites are essential as new technologies and new materials are flying,
- operational ones, to obtain long term variations of the environment, in particular along the solar cycles, and for intercalibration between scientific and technology satellites.

We will show an example of the intercalibration between operational satellites (the LANL geosynchronous satellites and GPS), using the scientific and technology satellite CRRES as the link between them. For the physical modeling, a tool like Salammbô is very useful as it allows:
- understanding of the variations of the environment on short term and long term basis,
- interpolation between measurements to obtain a global nowcasting of the radiation belts,
- extrapolation for space weather applications, and to give long term forecasting of the belts,
- representativity of the data set (e.g. CRRES quiet versus active) We will show results of Salammbô using synchronous measurements to built the entire electron radiation belts, and the comparison with other orbit measurements. As for the construction of a model, using geosynchronous satellites, we will show the different steps of a long term model construction:
- intercalibration between measurements,

- absolute calibration,
- construction of the model,
- physical interpretation,
- comparison and validation.