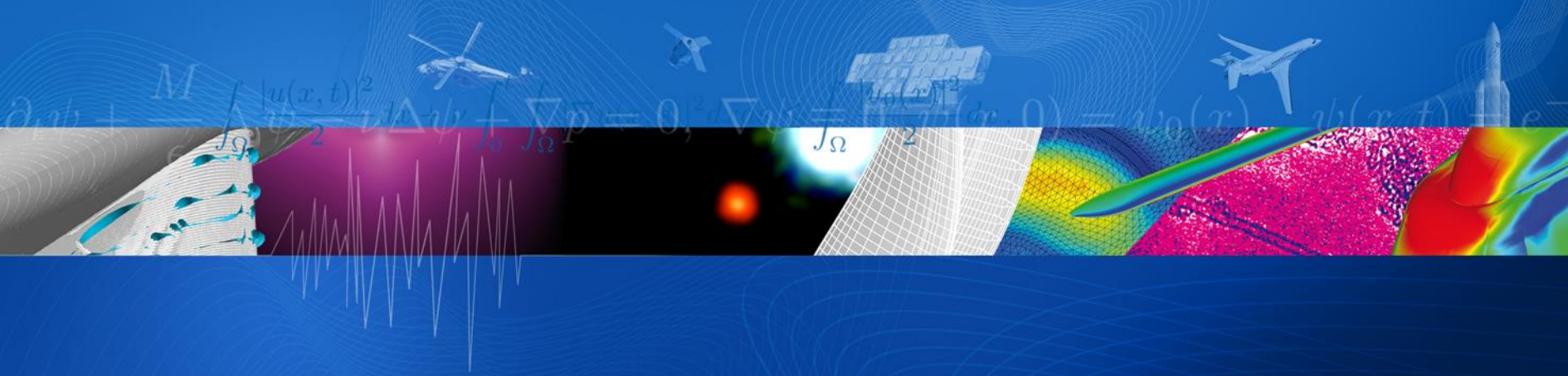

Data assimilation technique applied to electron Earth radiation belts

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70 2016 ans

ONERA

THE FRENCH AEROSPACE LAB

Outline

Introduction

Assimilation des taux de comptage

Erreurs de modèle

- Condition aux limites
- Interaction ondes-particules
- Diffusion radiale

Base de ré-analyse

Perspectives

Introduction

The data assimilation tool applied to Earth radiation belts is based on:

- The Salammbô physics based model
- In situ data from the IPODE database
- An ensemble Kalman filter with 200 members (i.e. 200 Salmmbô codes in parallel to represent model uncertainties).

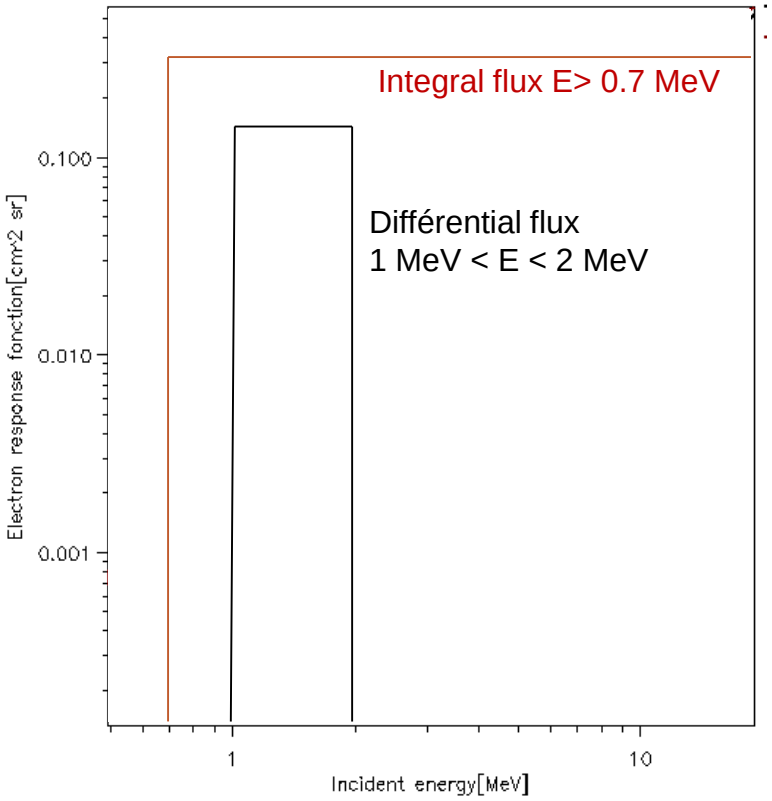
Activity funded by:

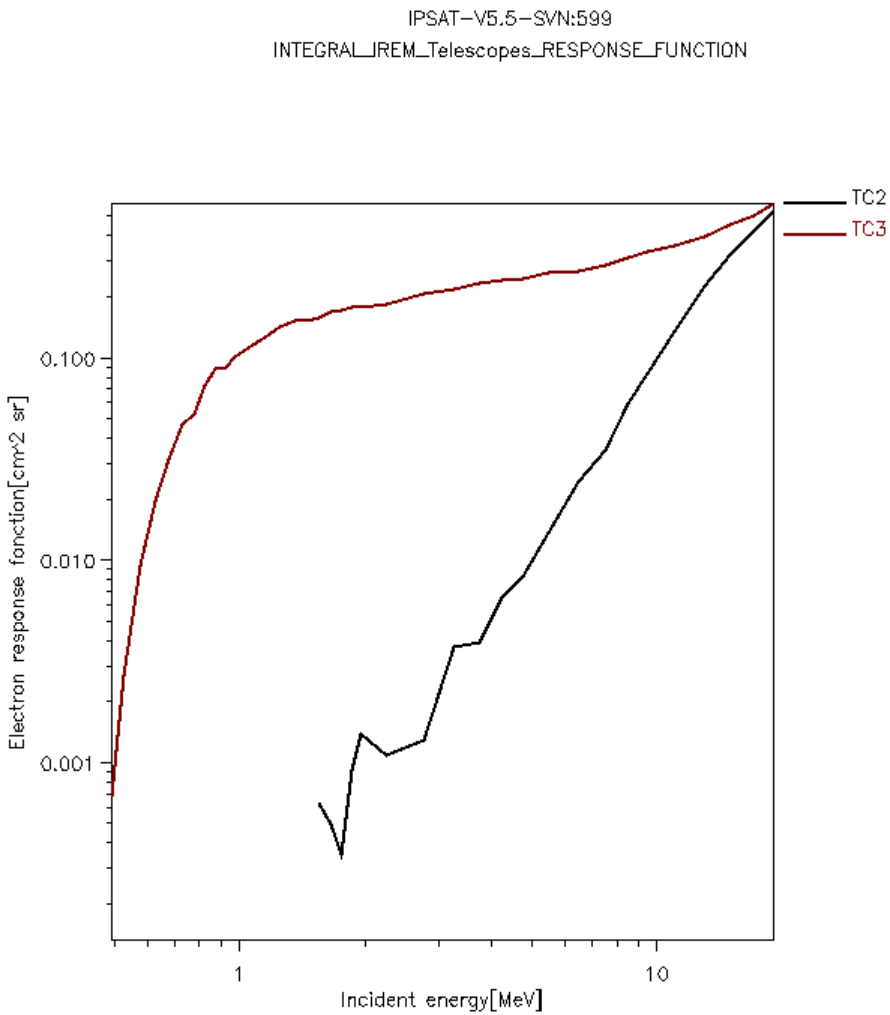
- R&T CNES
- European Union – FP-7 MAARBLE project

Count rate data assimilation

Radiation monitor response function:

Ideal case

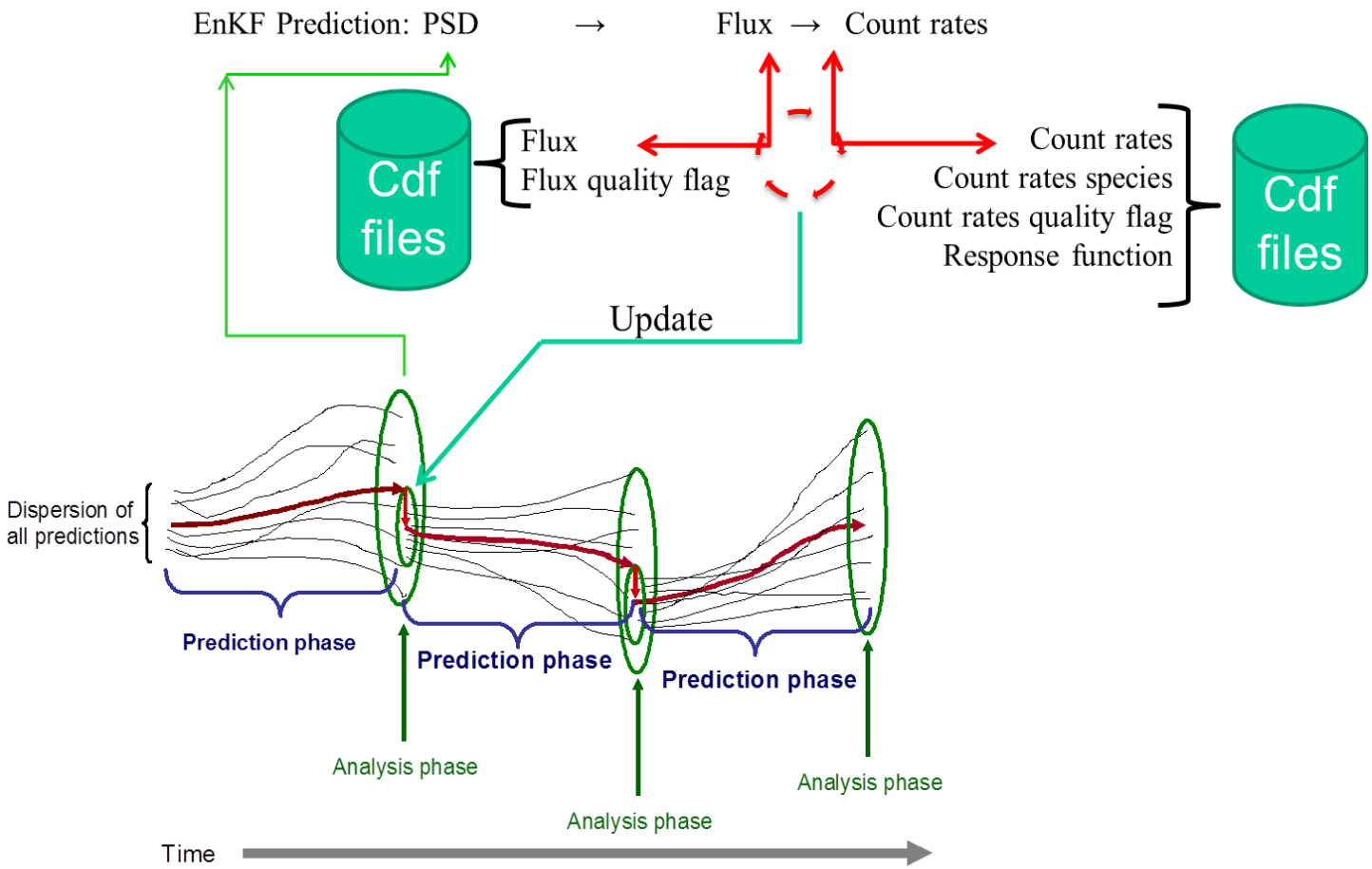




Count rate data assimilation

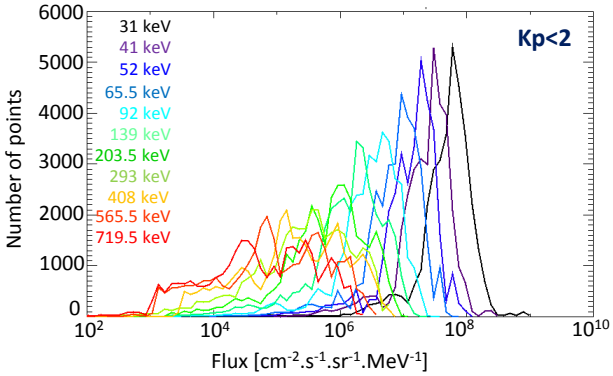
$$Flux(E) = 2\pi \int_0^{\pi} PSD \times p^2 \times sin\alpha \, d\alpha$$

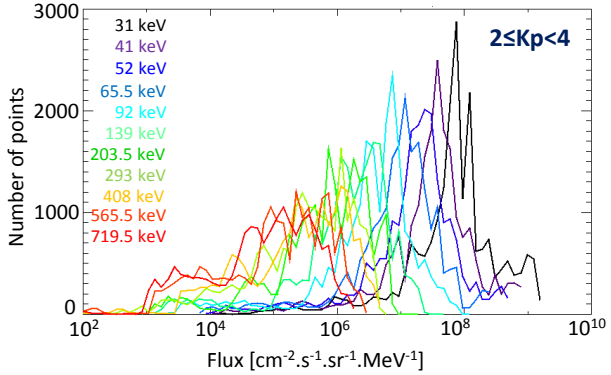
$$Count\ rate = \int_0^{\infty} Flux(E) \times Respfunc(E) dE$$

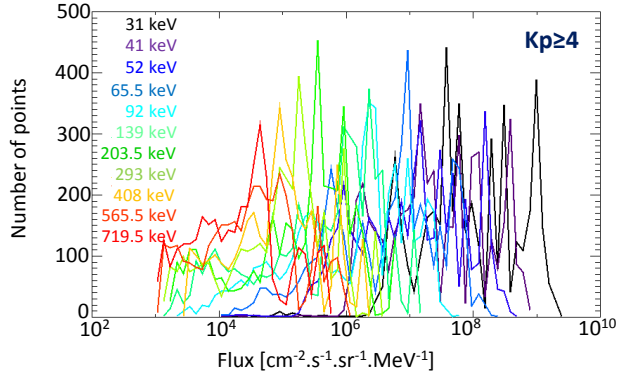


Model uncertainties: boundary conditions

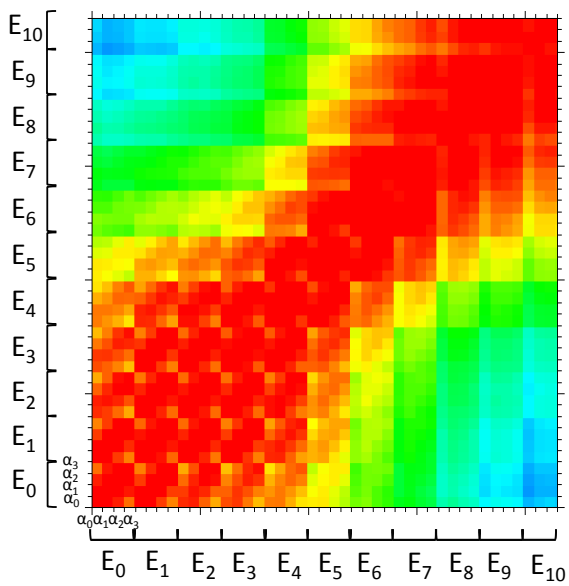
Boundary condition at L=8*



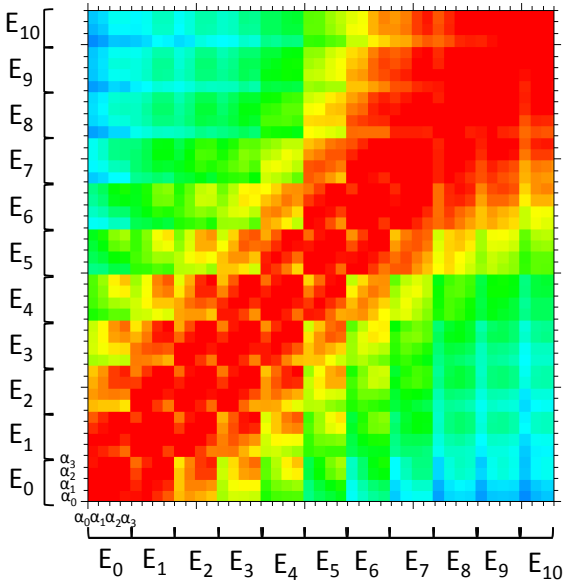




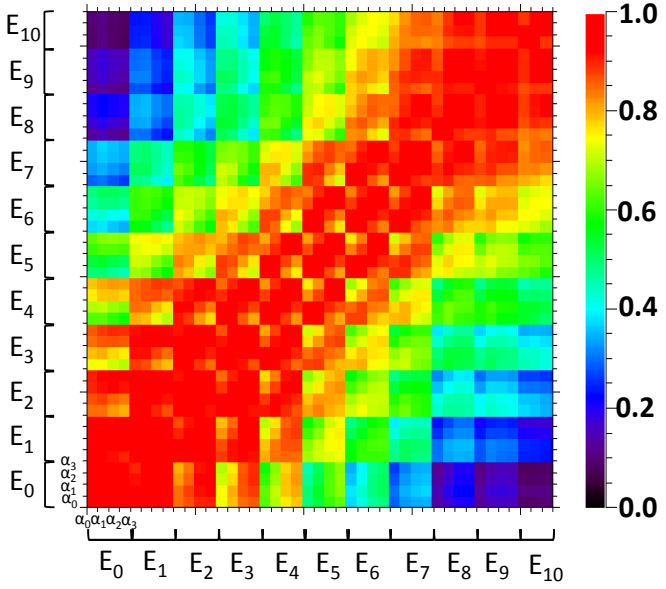
Correlation coefficient at Kp=0



Correlation coefficient at Kp=2

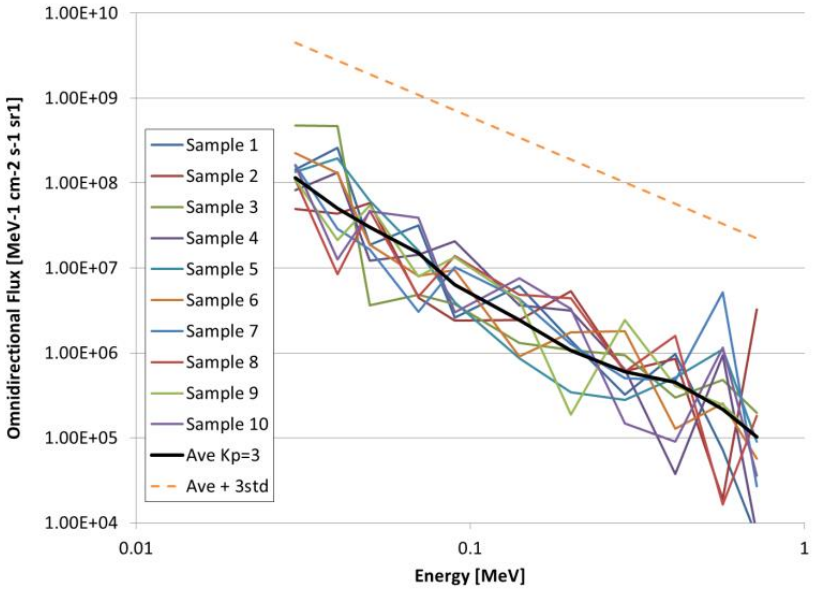


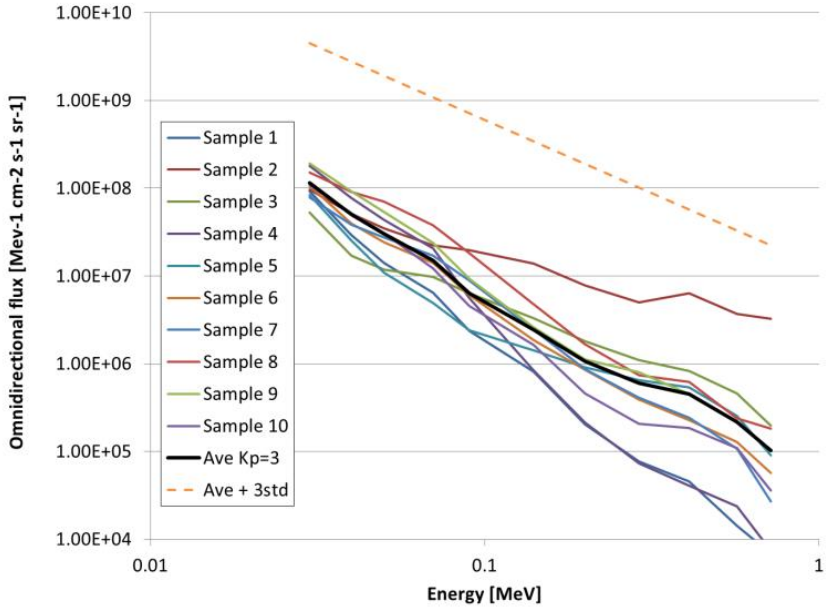
Correlation coefficient at Kp=4



Model uncertainties: boundary conditions

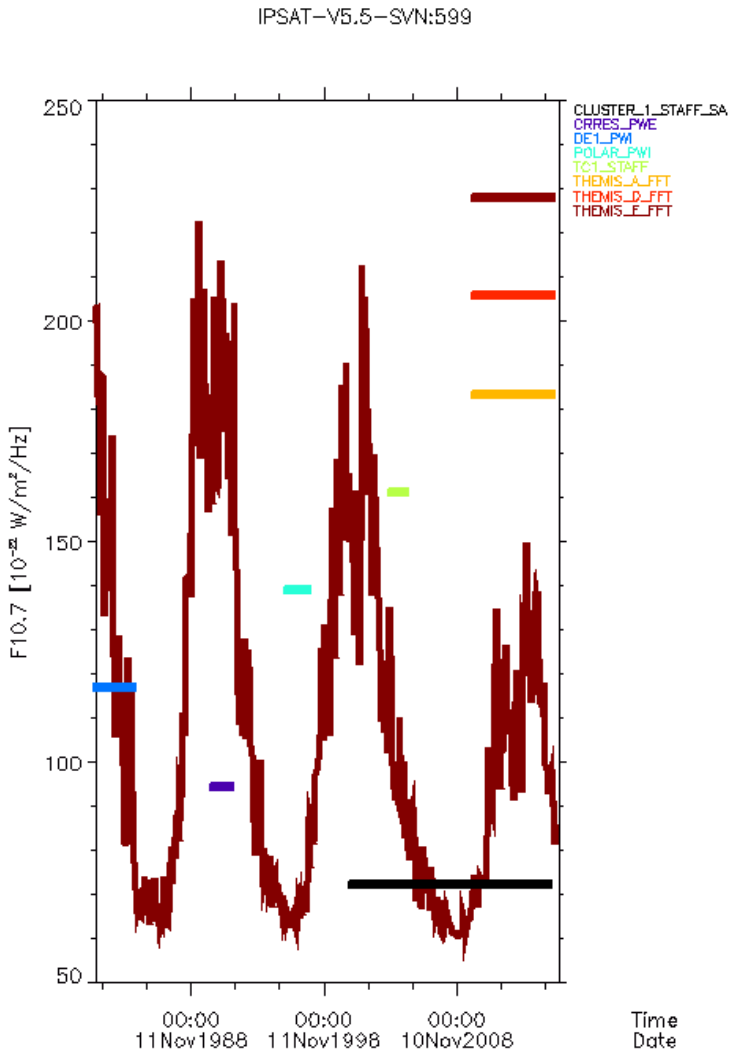
Boundary condition at L=8*

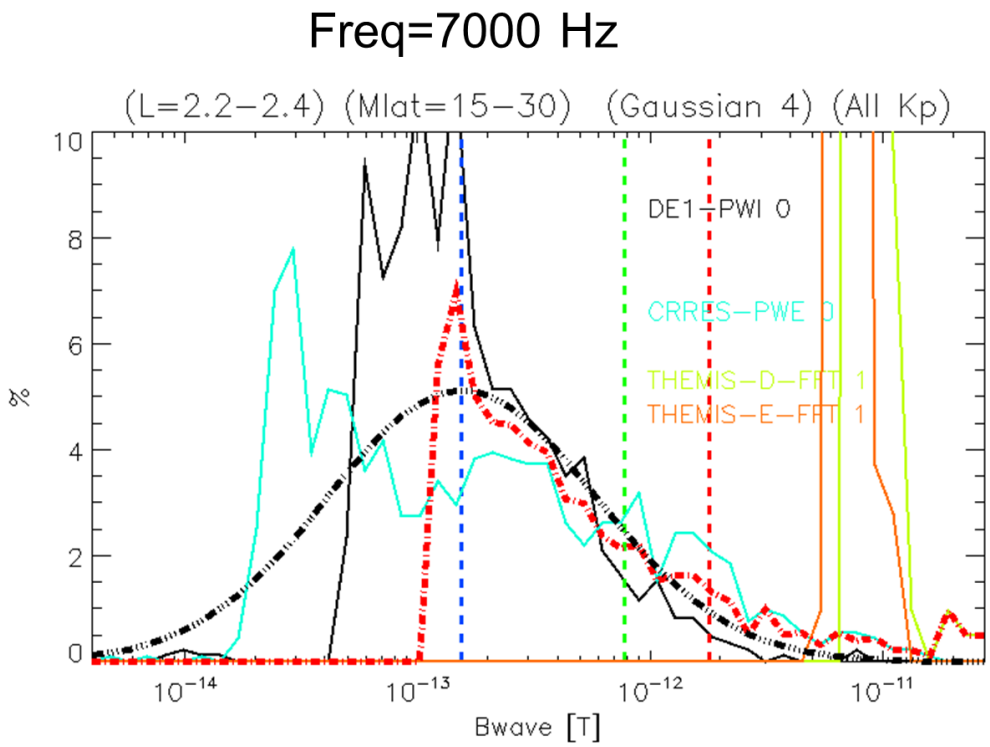




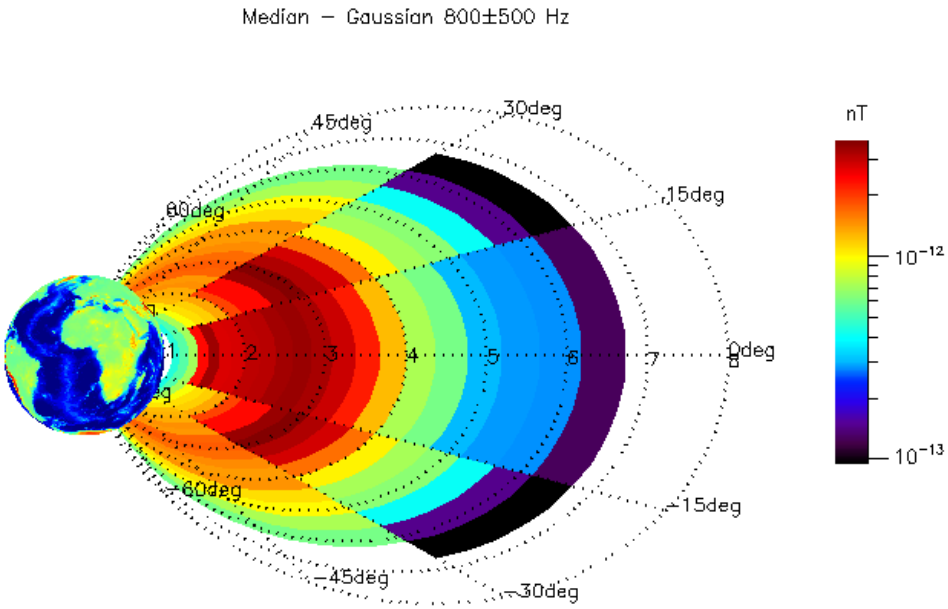
Model uncertainties: wave-particle interactions

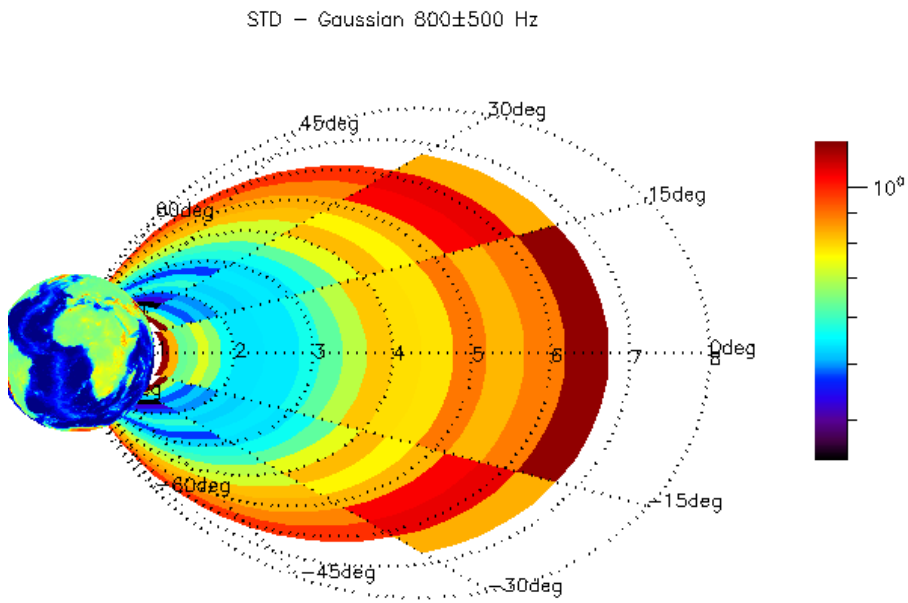
Wave database



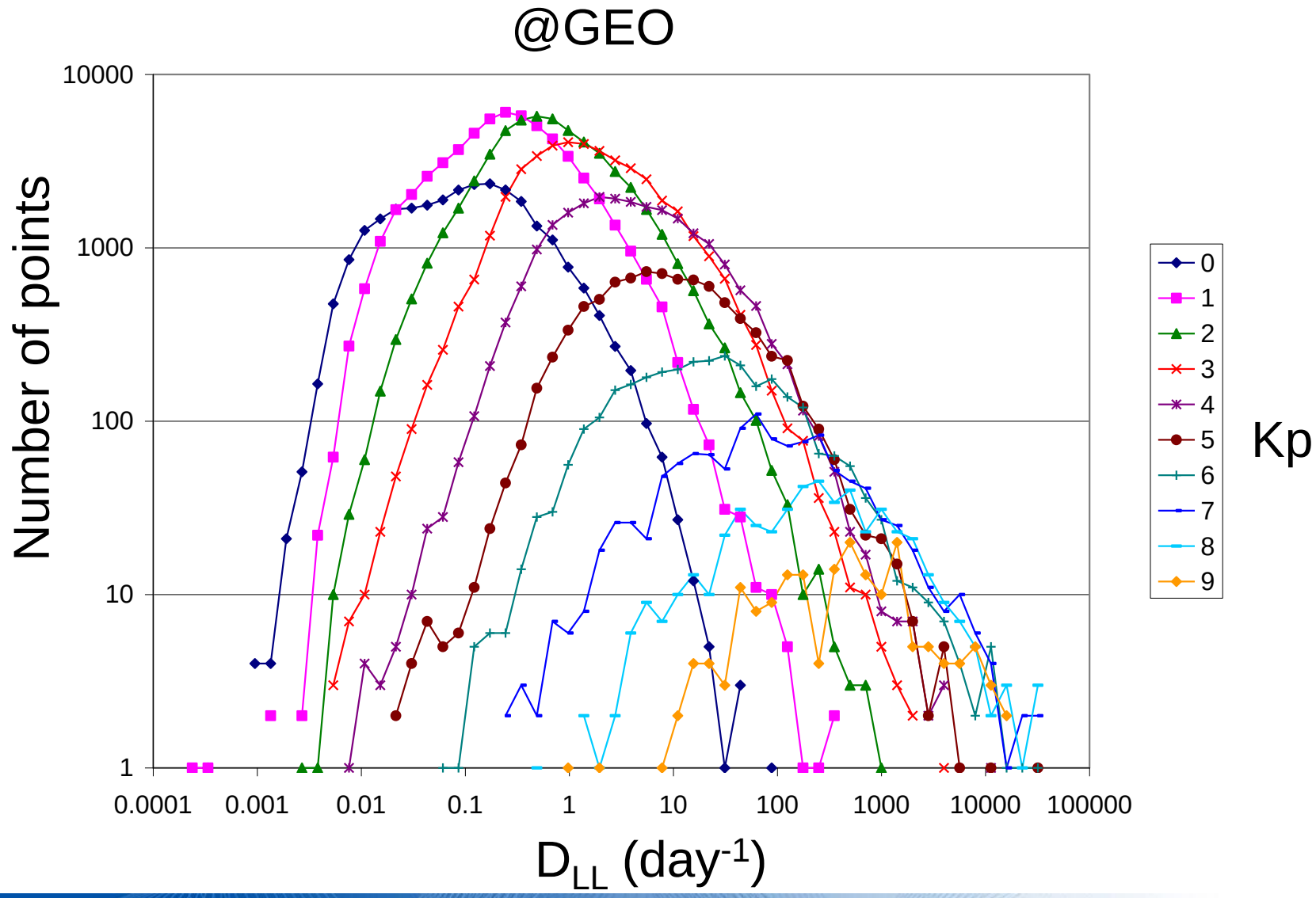


Model uncertainties: wave-particle interactions



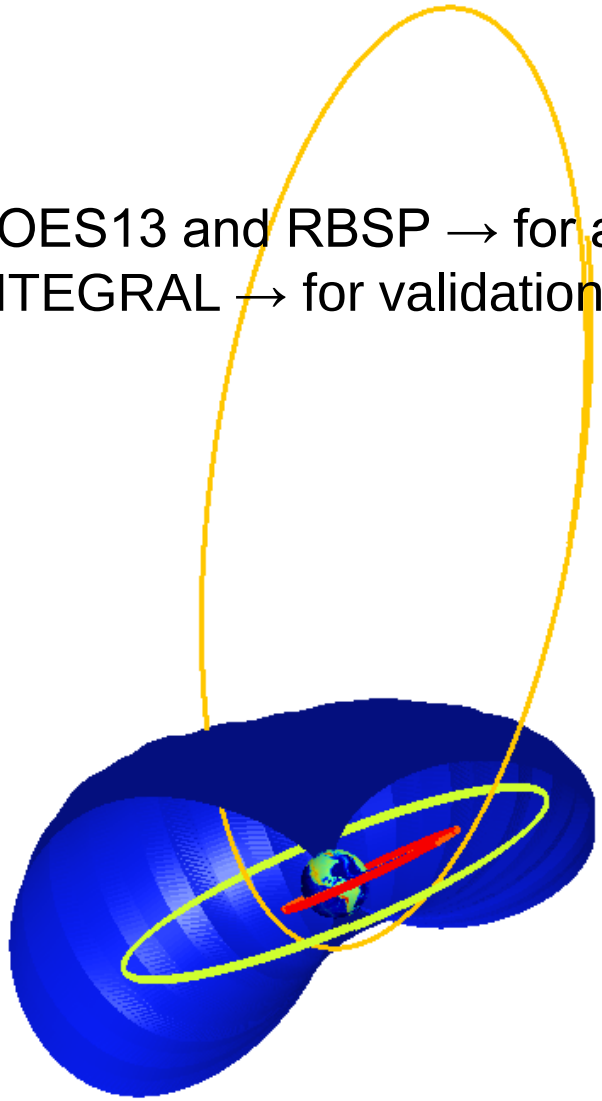


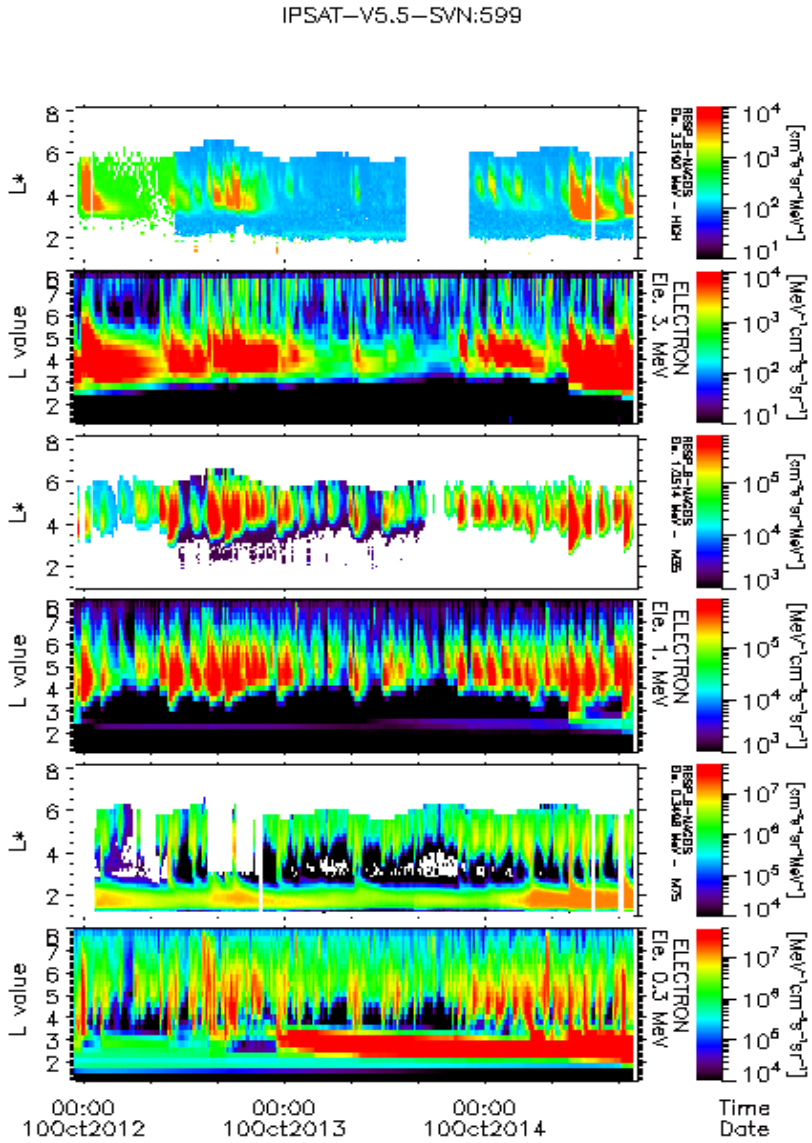
Model uncertainties: radial diffusion



Electron radiation belt re-analysis: September 25, 2012-July 13, 2015 (~33 months)

GOES13 and RBSP → for assimilation
INTEGRAL → for validation

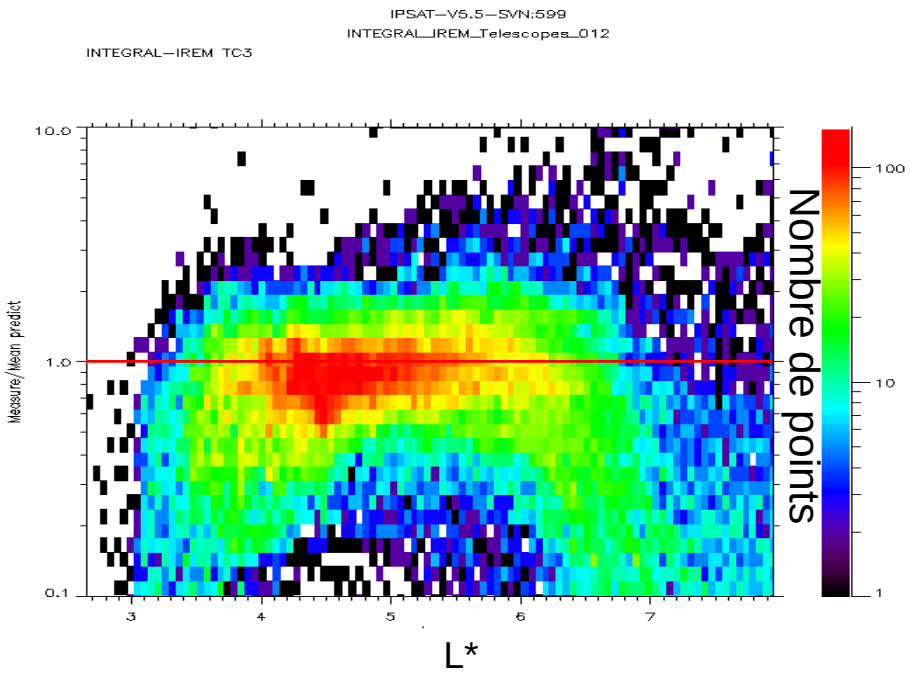


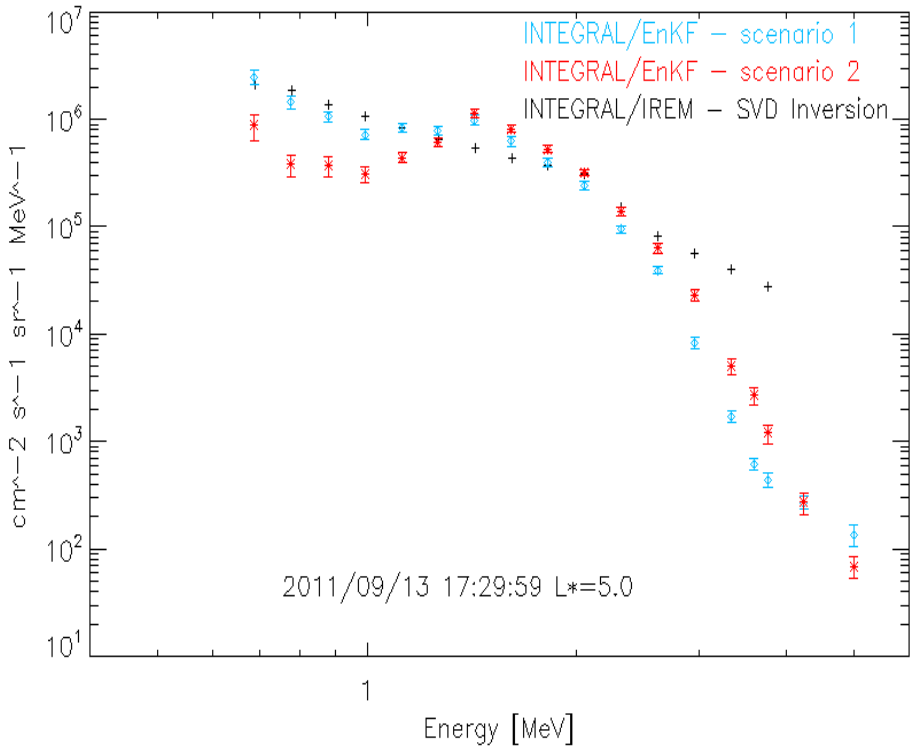


Electron radiation belt re-analysis: September 25, 2012-July 13, 2015 (~33 months)

Re-analysis data produced in only one run … 3 months CPU on a 20 core computer:

- the code is stable
- 1 month CPU for 1 full year (depends on number of observations available)
- Electron radiation belt dynamic with a 10 mn time step (can be lowered to 10s)
- results can be used for
  - Space Weather activities
  - engineering model development





Prospects

1. Apply the same strategy to trapped protons

2. Improve the core of the assimilation tool
   - Implement a bias detection and correction procedure (bias blind assimilation tool)
   - Implement a data assimilation tool not only sequential, like the EnKF, but which also consider the time history of the radiation belts (Smooth ensemble Kalman filter or 4Dvar)

3. Produce a re-analysis database at the solar cycle time scale

4. Transition to operational tool for radiation belt nowcast (Space Weather)

Radiation belt nowcast during the September 2011 storm