Near and Mid-Term Needs for a Radiation Belt Modelling Upgrade

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Outline

- Static radiation belt models
- Dynamic electron belt models
- Dynamic proton belt models
- Conclusions

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Static radiation belts models

- AE8/AP8 are now three solar cycles old
- They are based on limited data sets
- The solar cycle modulation is poorly reproduced (only min/max)
- The secular drift of the magnetic field model not consired
- …

BUT

- AE8/AP8 are world-wide used (space industries)
- Fairly good coverage in Energy-Position space
- All other models are only very localized and makes space industries even more puzzled

Static radiation belts models

Developing a new model is a **big challenge !!**
… and there is enough work for every groups around the world

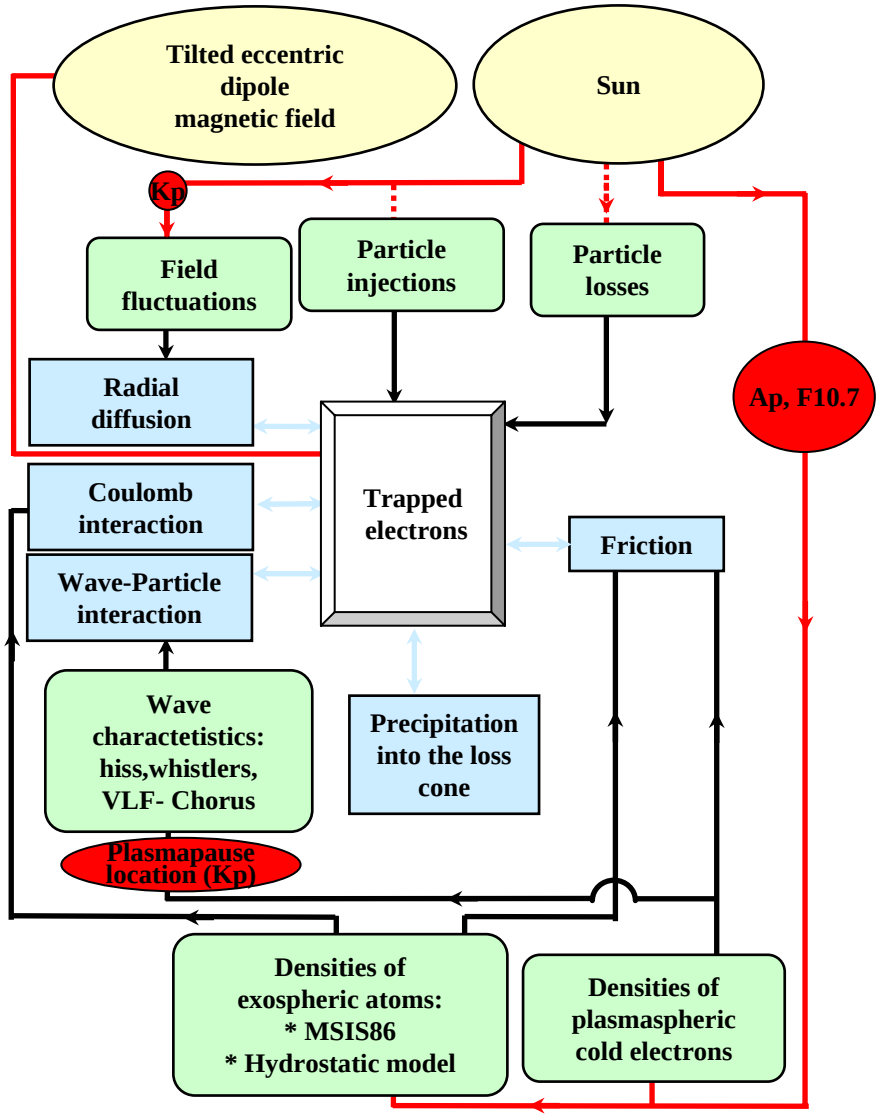
At this point **COSPAR Panel on Radiation Environment Modeling** (PRBEM) can play a key role in co-ordination of world-wide activities.

Currently a set of standard User's needs, Guidelines, and Procedures are being made available:

K http://wwwe.onecert.fr/craterre/prbem/home.html

K http://wwwe.onecert.fr/craterre/prbem/Reference_documents.html

Dynamic electron belts models



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Dynamic electron belts models

Electron: pure radial diffusion model (from Y. Y. Shprits, R. M. Thorne, G. D. Reeves, and R. Friedel, Radial diffusion modeling with empirical lifetimes: comparison with CRRES observations, Annales Geophysicae, 23, 1467 1471, 2005)

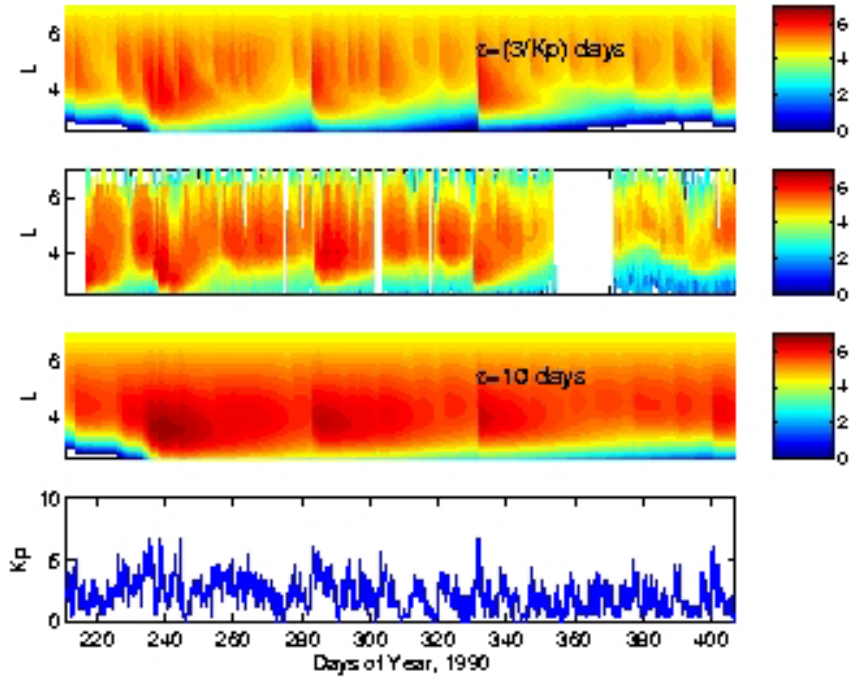

Fig. 1. Comparison between 0.95 MeV electron fluxes in $\log_{10}$ (cm^{-2} sr s MeV) computed by our radial diffusion model with empirical lifetimes (first panel), electron flux measurements on CRESS satellite (second panel). Model simulations with constant lifetimes of 10 days are shown (third panel). The fourth panel shows the evolution of the K_p index used for the calculation of the D_{LL} and τ.

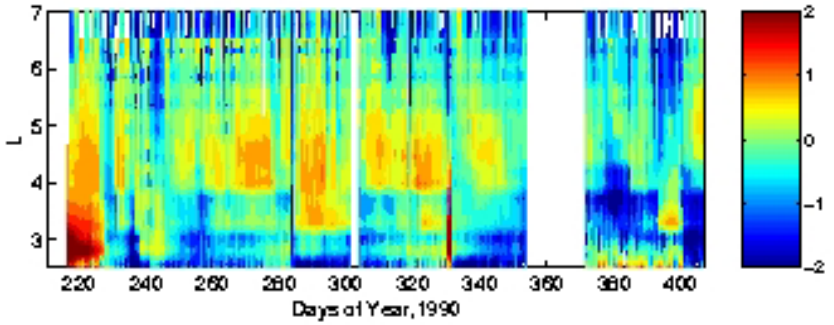

Fig. 2. Logarithm of ratio of 0.95 MeV HEEF CRRES electron fluxes to those produced by the optimized radial diffusion model.

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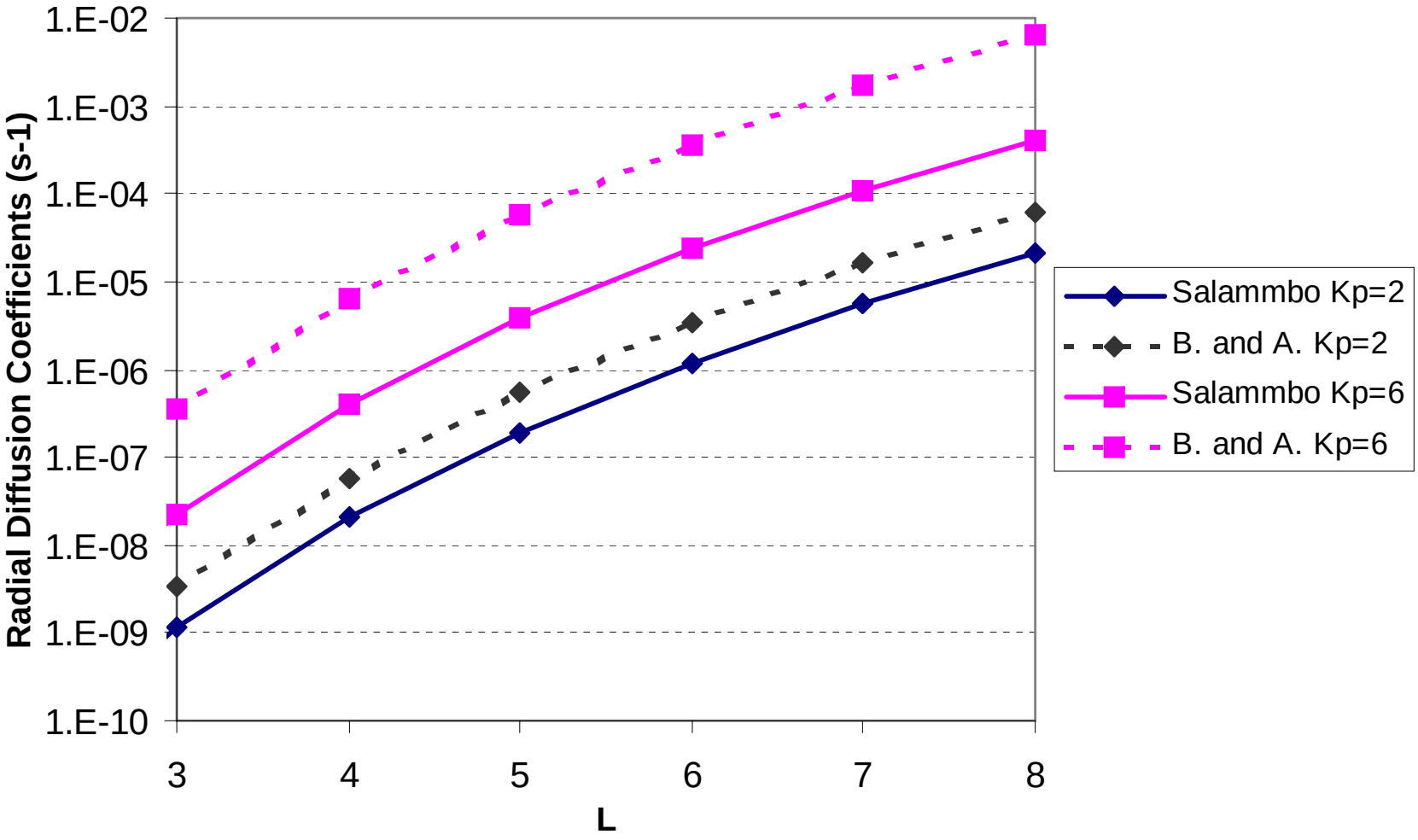
Dynamic electron belts models



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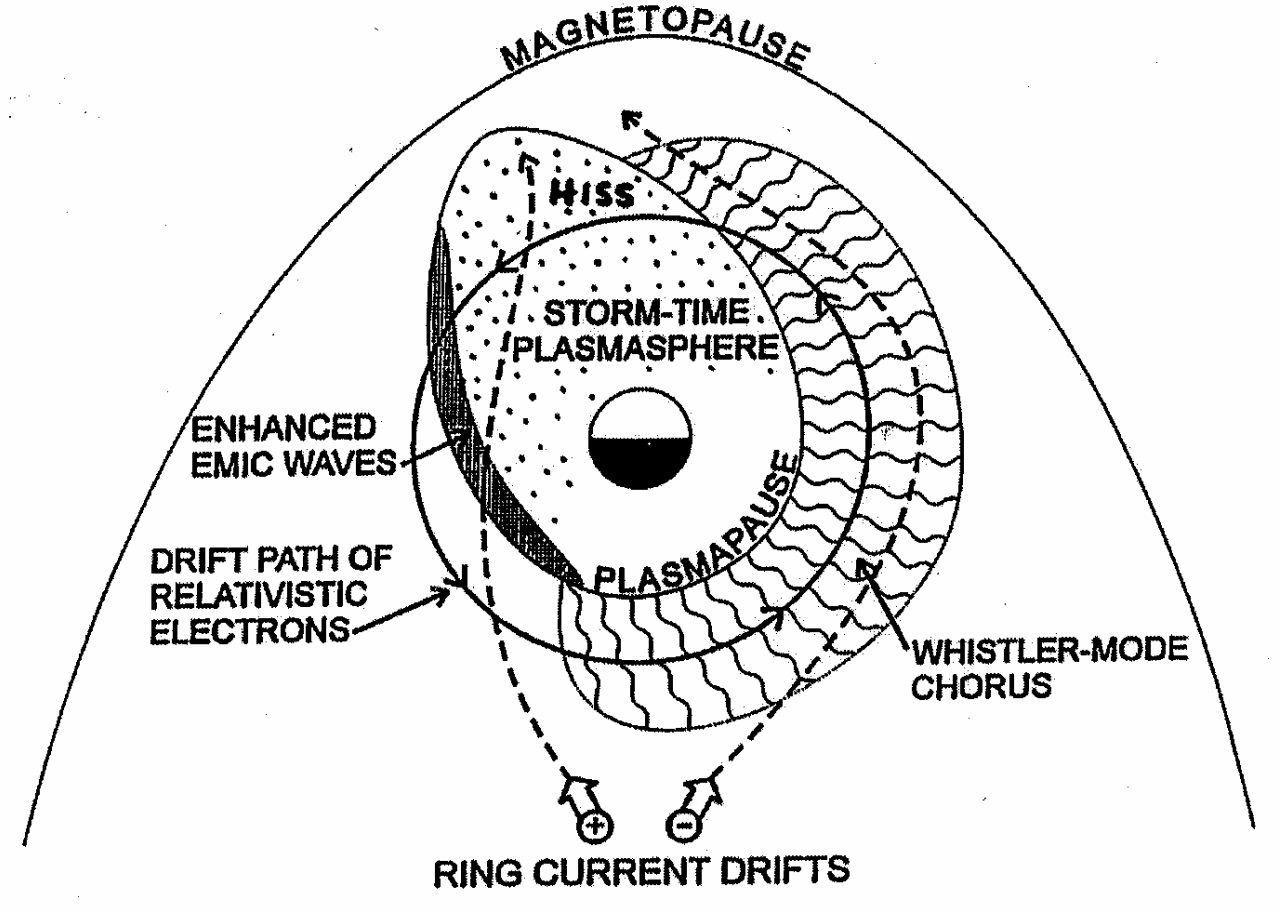
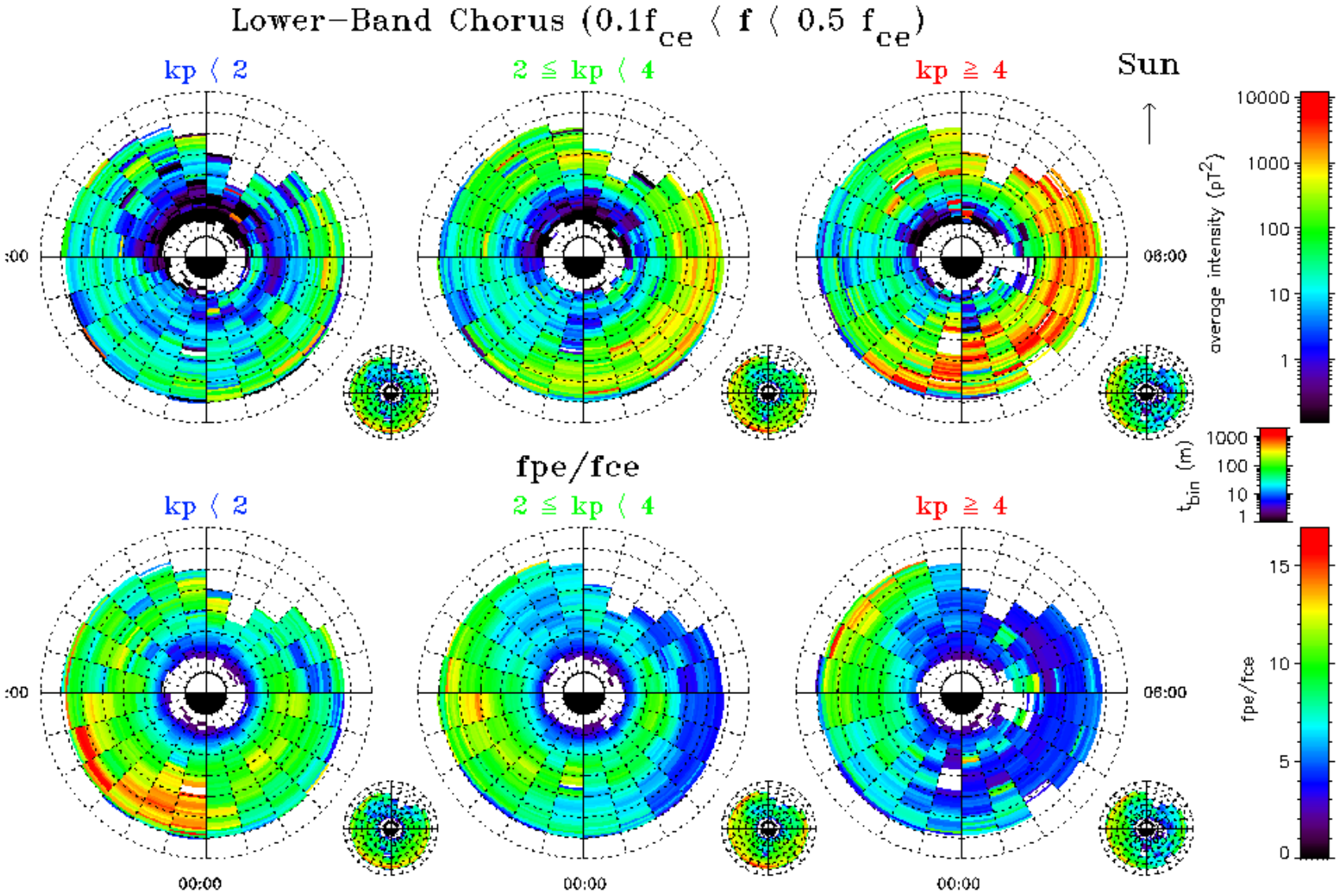


Dynamic electron belts models



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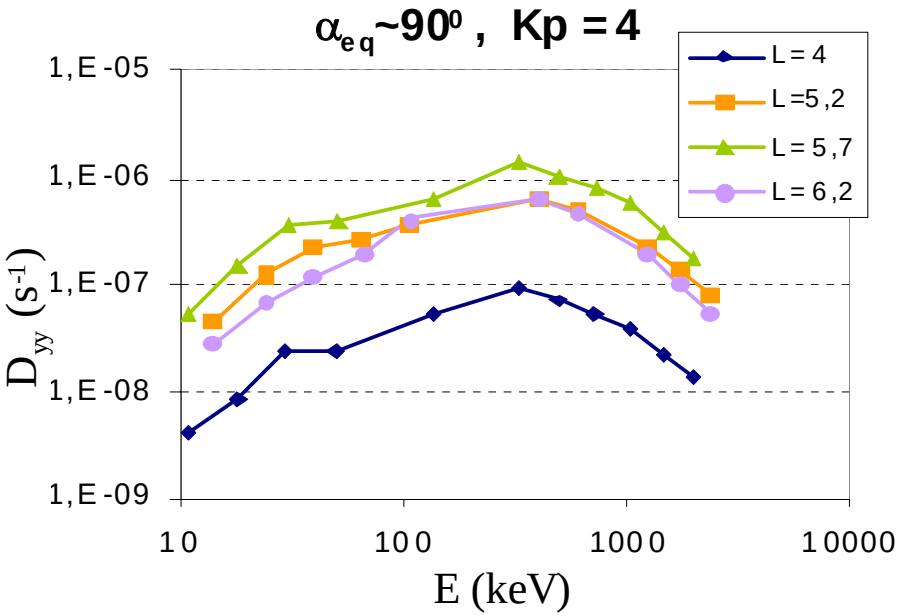
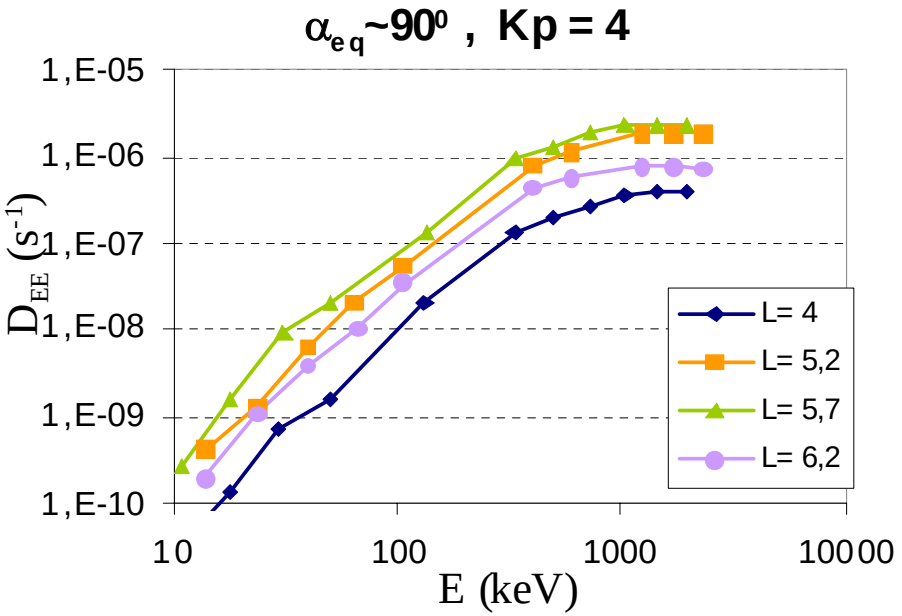
Dynamic electron belts models

Wave (whisler mode chorus)-particle interaction from the PADIE code





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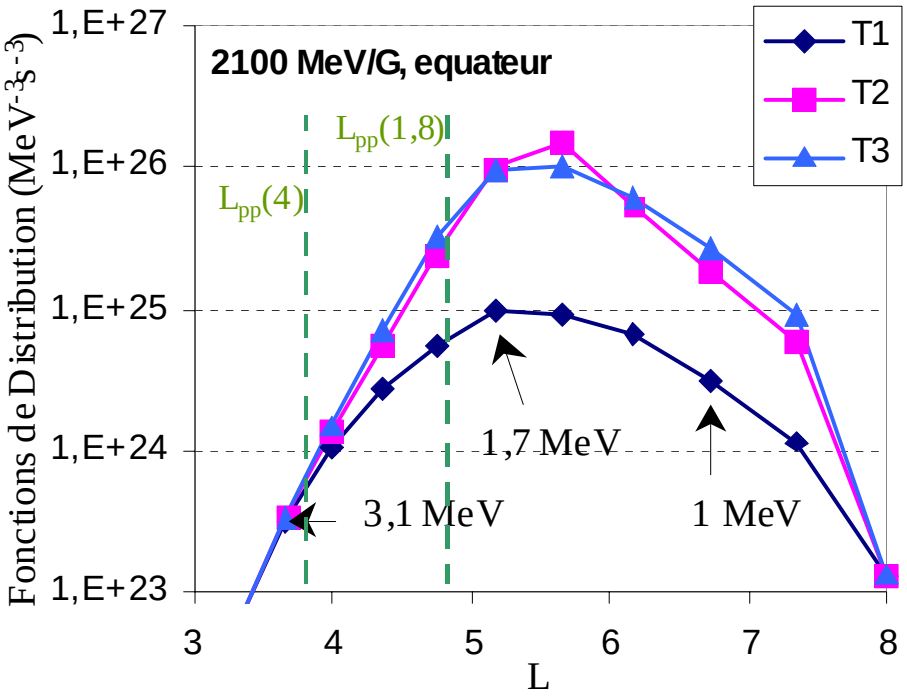
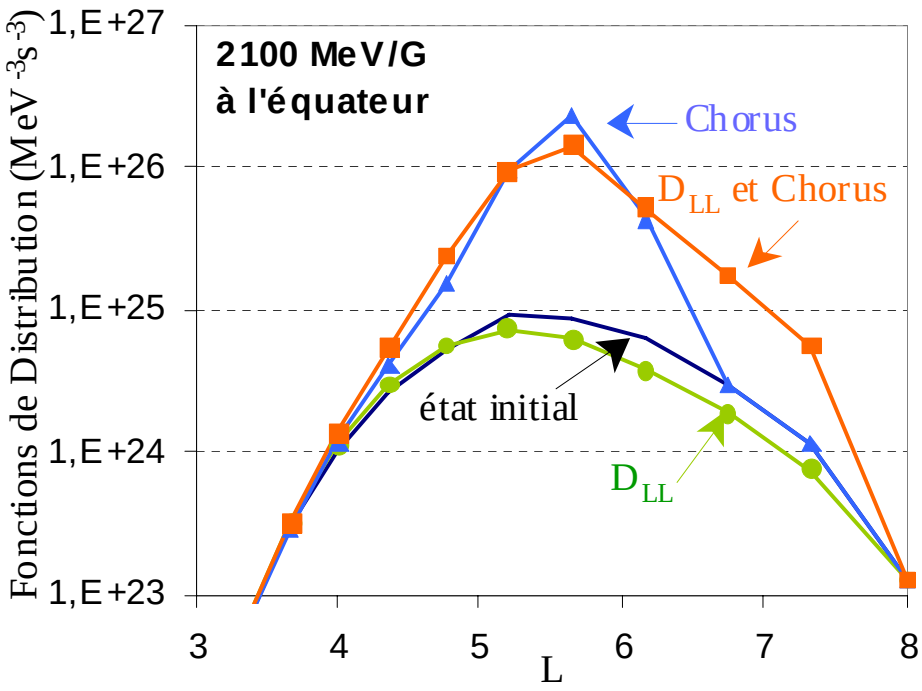
Dynamic electron belts models





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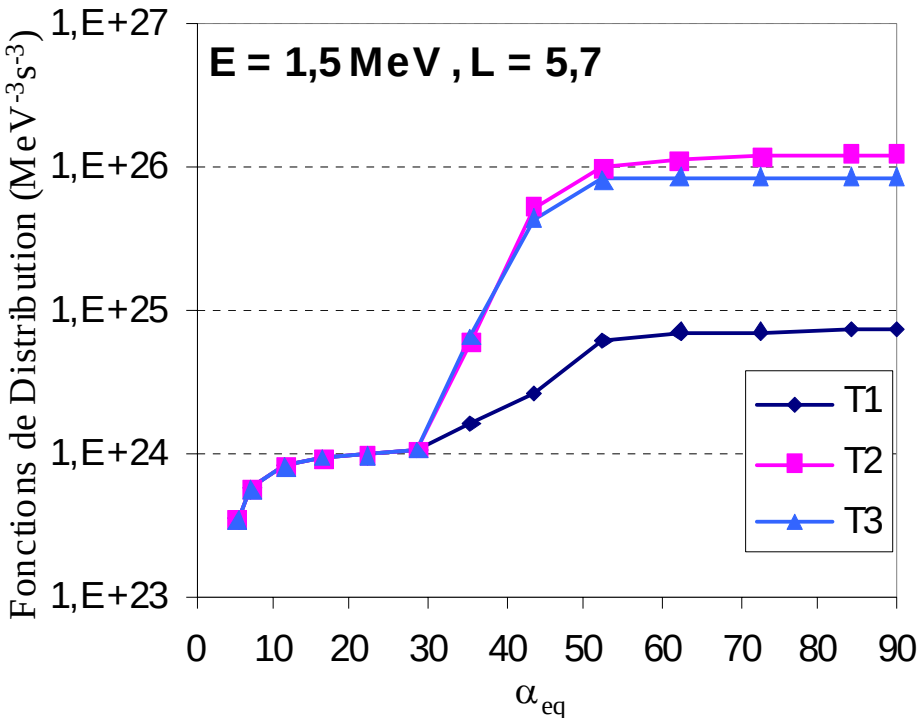

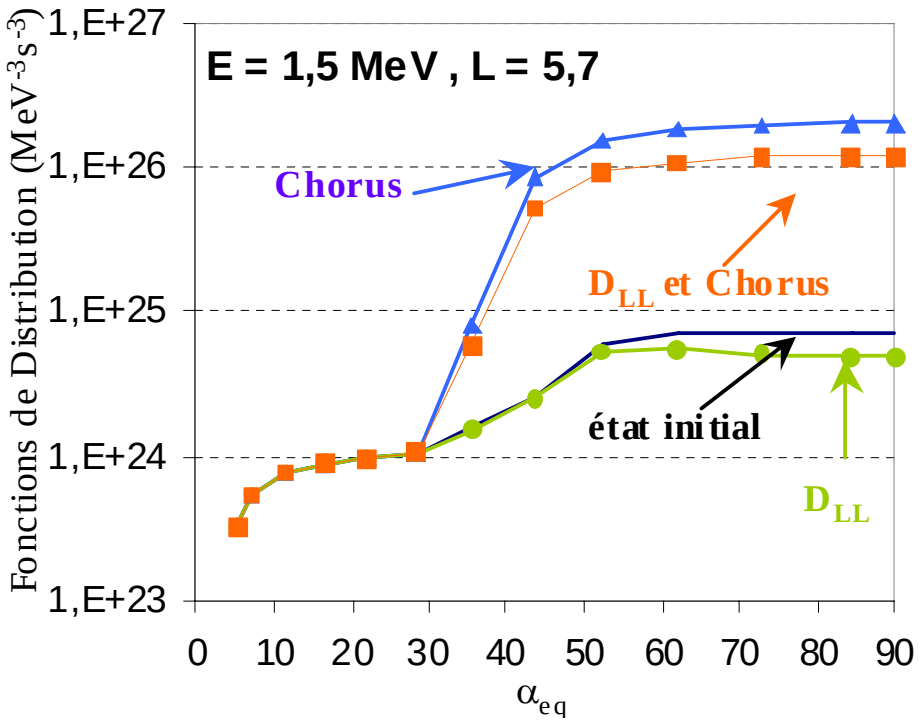

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Dynamic electron belts models

From a scientific model to an application model:

• Scientific models have allowed to identified important physics for electron belts (radial diffusion and wave-particle interaction, ...)

• They have shown that reproducing electron belt dynamic is feasible

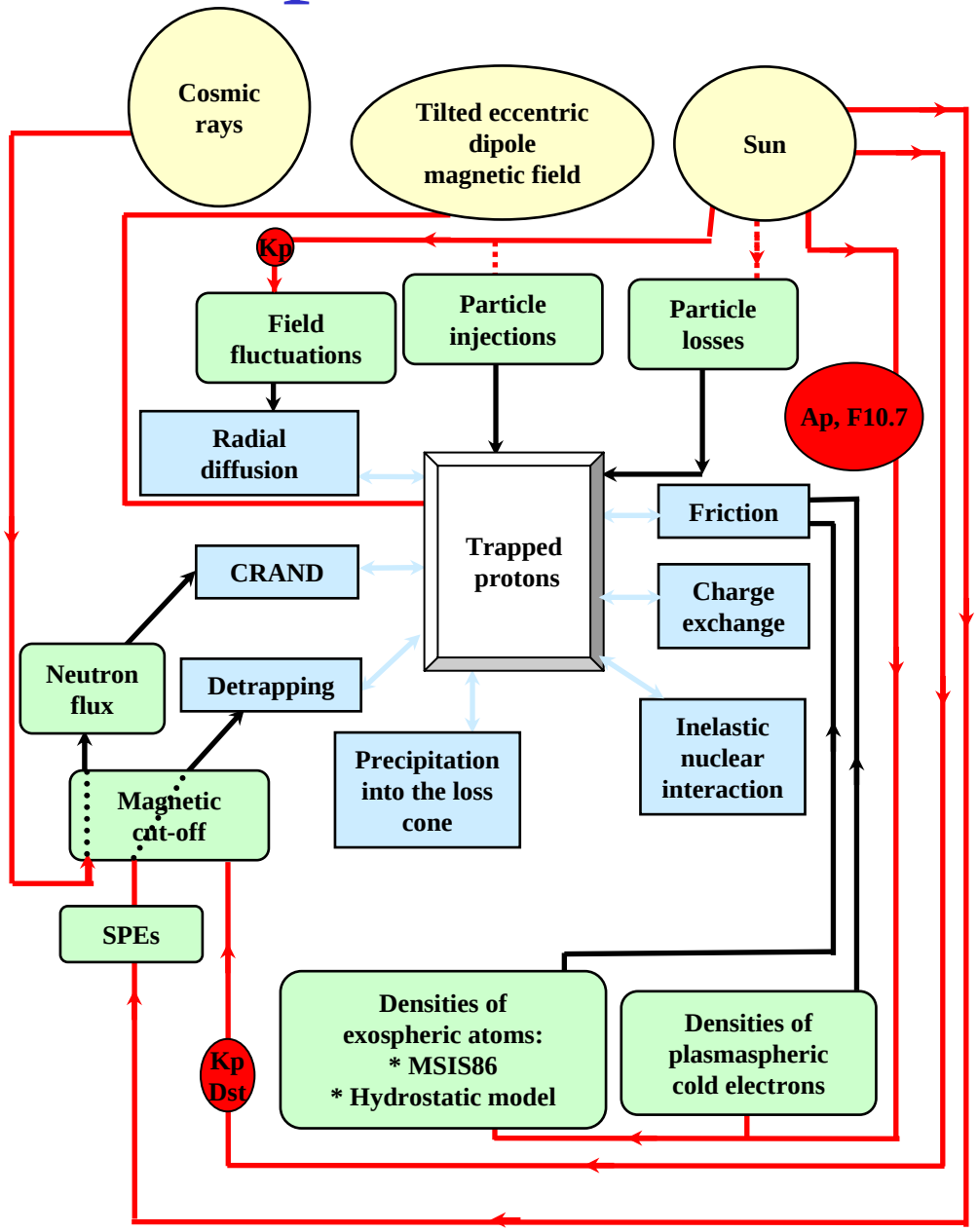
BUT

•Need to model more accuratly time dependent radial diffusion coefficients

• Need to model more accuratly wave-particle interaction (5 types of waves identified to be important)

• Need to improve numerical scheme to resolve diffusion equation when wave-particle is included (problem with cross-terms unsolved)

Dynamic proton belts models



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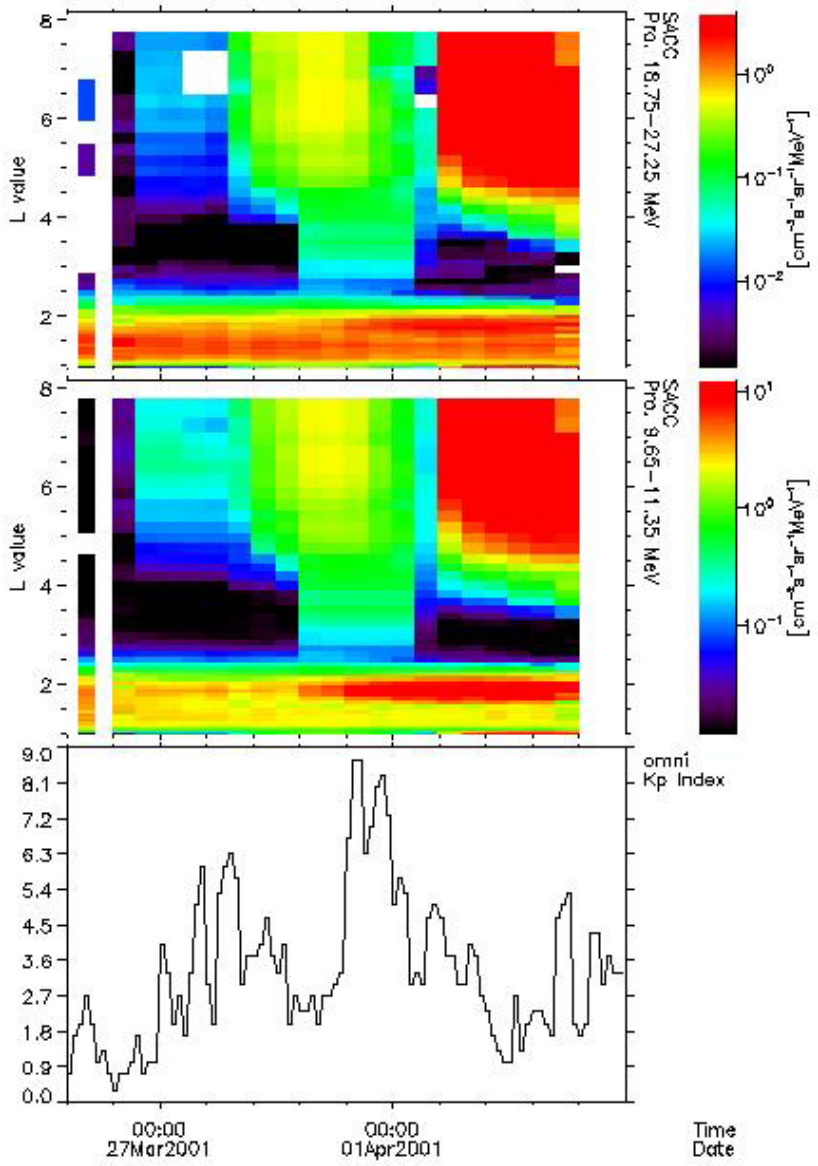
Dynamic proton belts models

Time dependent magnetic cut-off



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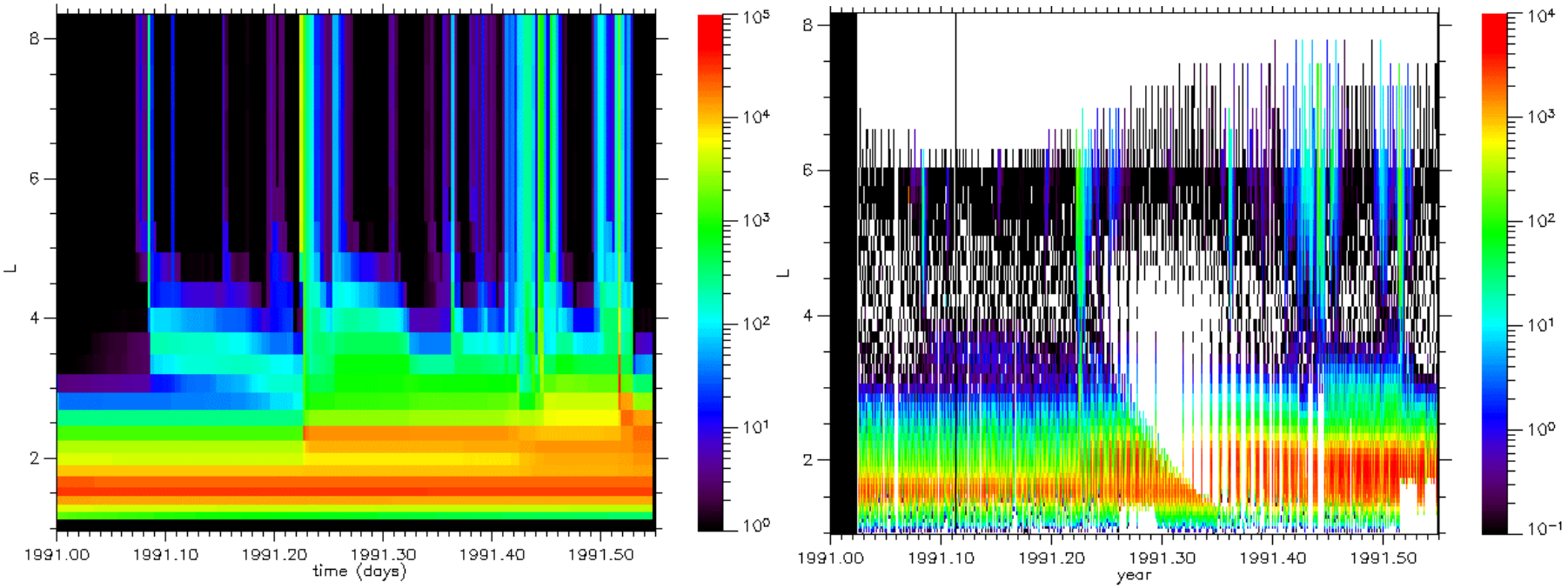
Dynamic proton belts models



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Dynamic proton belts models

From a scientific model to an application model:

• Scientific models have allowed to identified important physics for proton belts (radial diffusion magnetic cut-off, CRAND, ...)

• They have shown that reproducing proton belt dynamic is feasible

BUT

•Need to model more accuratly time dependent radial diffusion coefficients

• Need to model more accuratly time dependent magnetic cut-off

Conclusions

For space weather applications:

- Need to transform scientific model to application model
- Need to model unusual events when little or no data are available.
- Need to refine time dependent radial diffusion coefficients
- Need to develop wave models and interaction with particles
- Need to develop time dependent magnetic cut-off model
- Need to improve numerical scheme (for electrons)
- We have taken the first step to show the whole process is feasible, and very important. Now we need to extend and refine this.

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