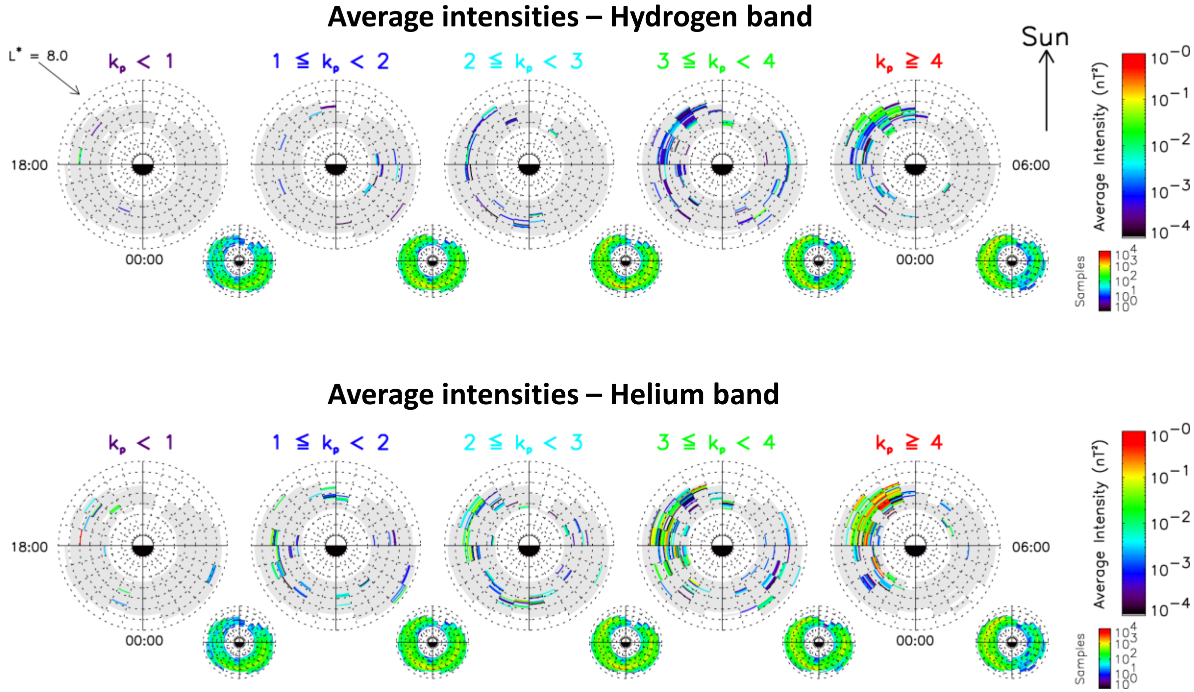
Modelling losses in the radiation belts caused by EMIC waves

T. Kersten, R. B. Horne, N. P. Meredith, S. A. Glauert

British Antarctic Survey, UK

Geospace revisited
Rhodes, 15-20/09/2014

CRRES EMIC wave database



- EMIC wave events binned by: L*, MLT, 5 magnetic activity levels
- Contains: Peak frequency f_m Spectral width d_f Peak intensity I_0

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BAS radiation belt model

- Fokker-Planck Equation

$$\frac{\partial f}{\partial t} = L^2 \frac{\partial}{\partial L}\left(\frac{D_{LL}}{L^2}\frac{\partial f}{\partial L}\right)\Bigg|_{\mu J} + \frac{1}{g(\alpha)}\frac{\partial}{\partial \alpha}\left(g(\alpha) D_{\alpha\alpha}\frac{\partial f}{\partial \alpha}\right)\Bigg|_{EL} + \frac{1}{A(E)}\frac{\partial}{\partial E}\left(A(E) D_{EE}\frac{\partial f}{\partial E}\right)\Bigg|_{\alpha L} - \frac{f}{\tau(\alpha, E)}$$

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Radial transport

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Radial transport

Pitch angle diffusion

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Radial transport

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Energy diffusion

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Radial transport   Pitch angle diffusion   Energy diffusion   Losses

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Radial transport　　Pitch angle diffusion　　Energy diffusion　　Losses

- Drift & bounce averaged diffusion coefficients $D_{LL}, D_{\alpha\alpha}, D_{EE}$ are activity, location and energy dependent

- Details in: Glauert et al. 2014

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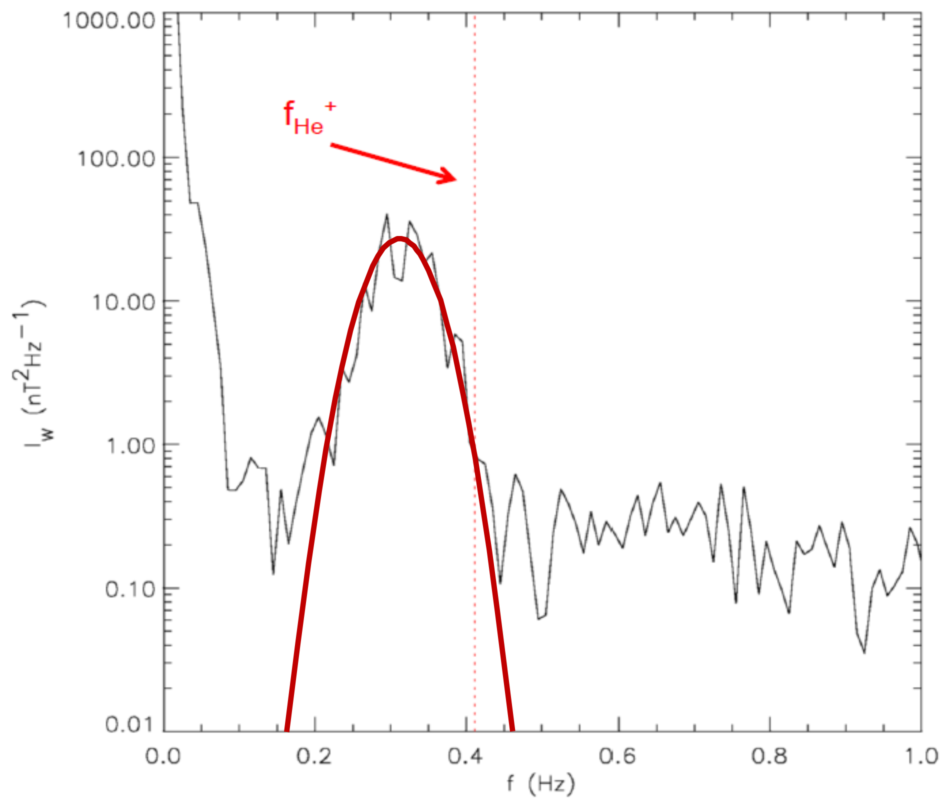
Calculating the diffusion rates

- Use the PADIE code (Glauert and Horne, 2005)

- Requires Gaussian distribution



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Calculating the diffusion rates

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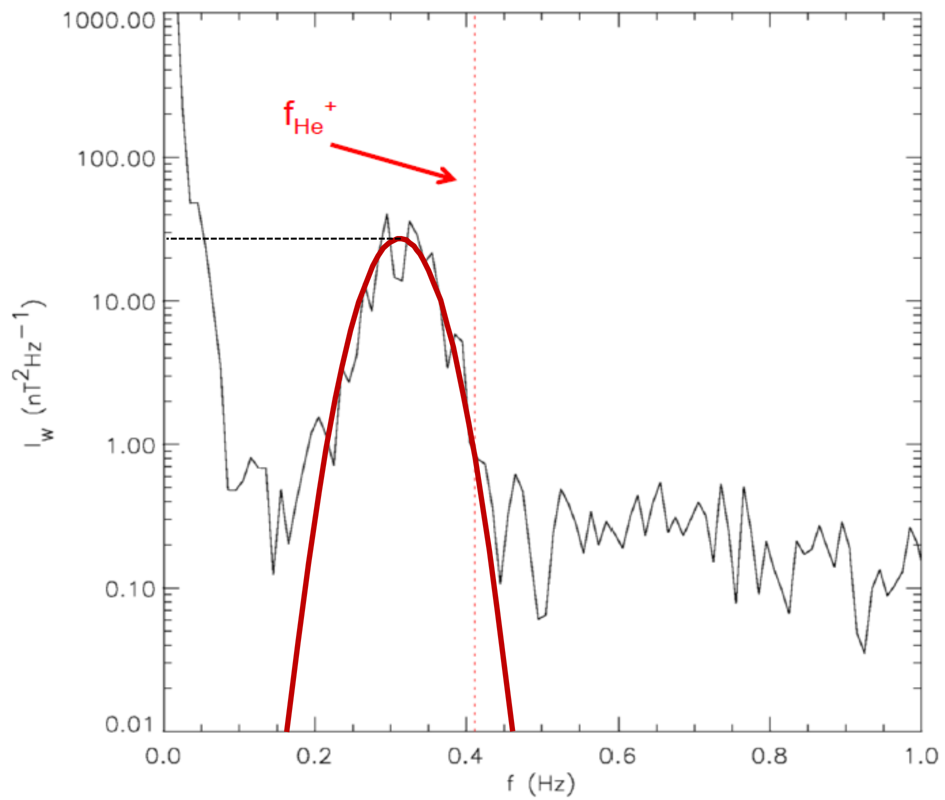
- Requires Gaussian distribution
  - Peak power: I_W



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Calculating the diffusion rates

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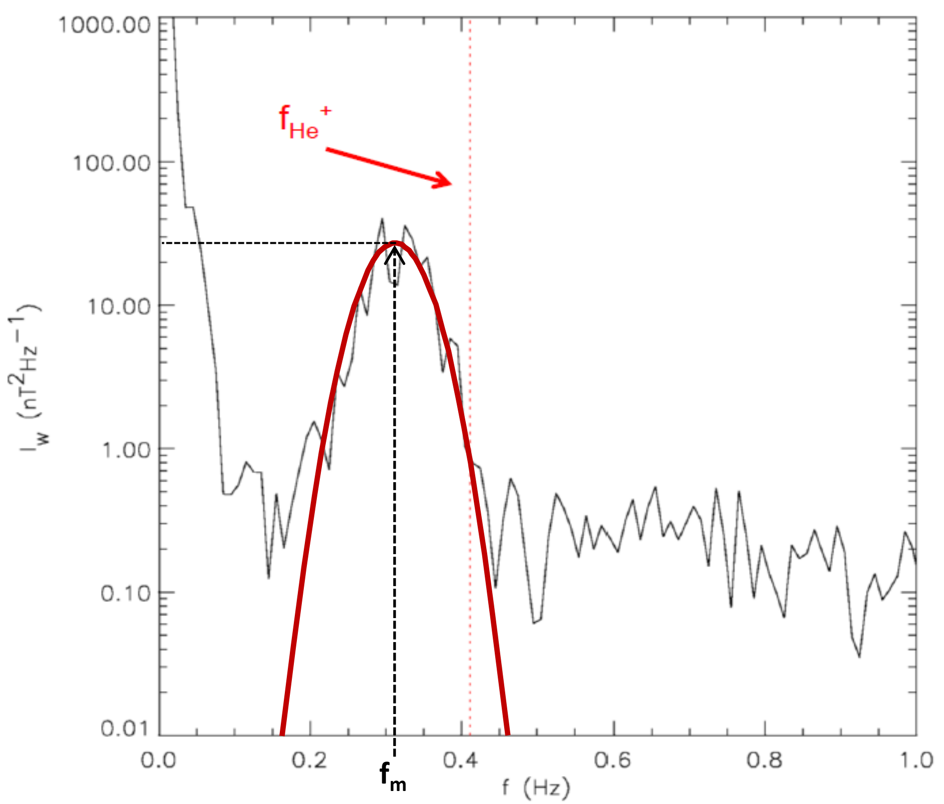
  - Peak frequency



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Calculating the diffusion rates

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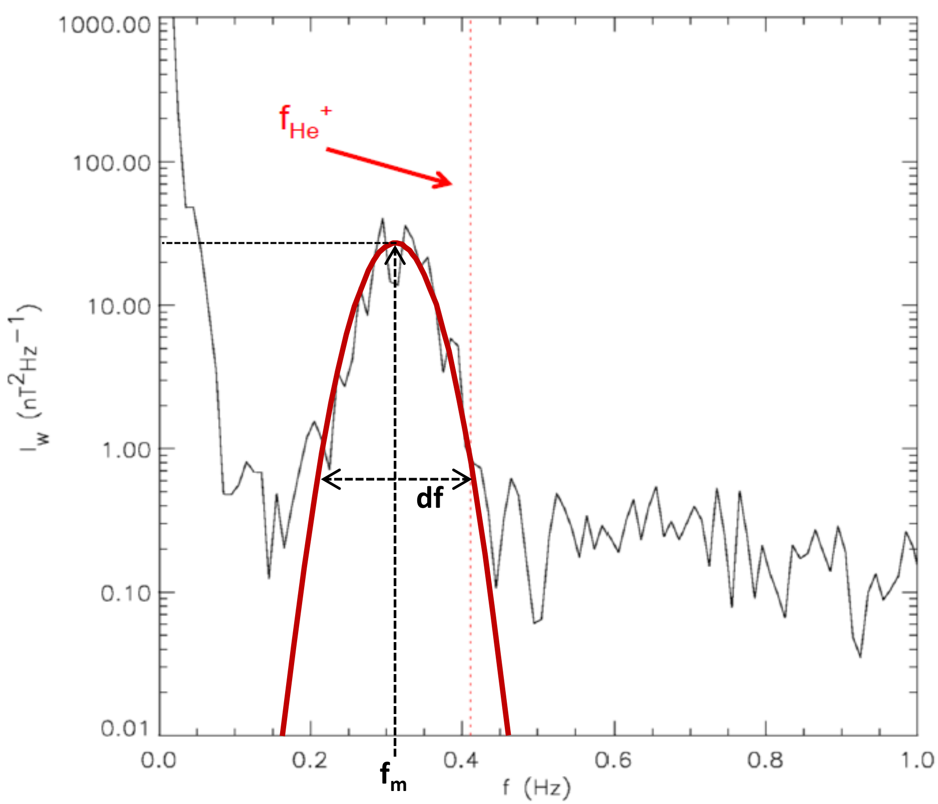
  - Peak power: I_W
  - Peak frequency
  - Width of the Gaussian



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Calculating the diffusion rates

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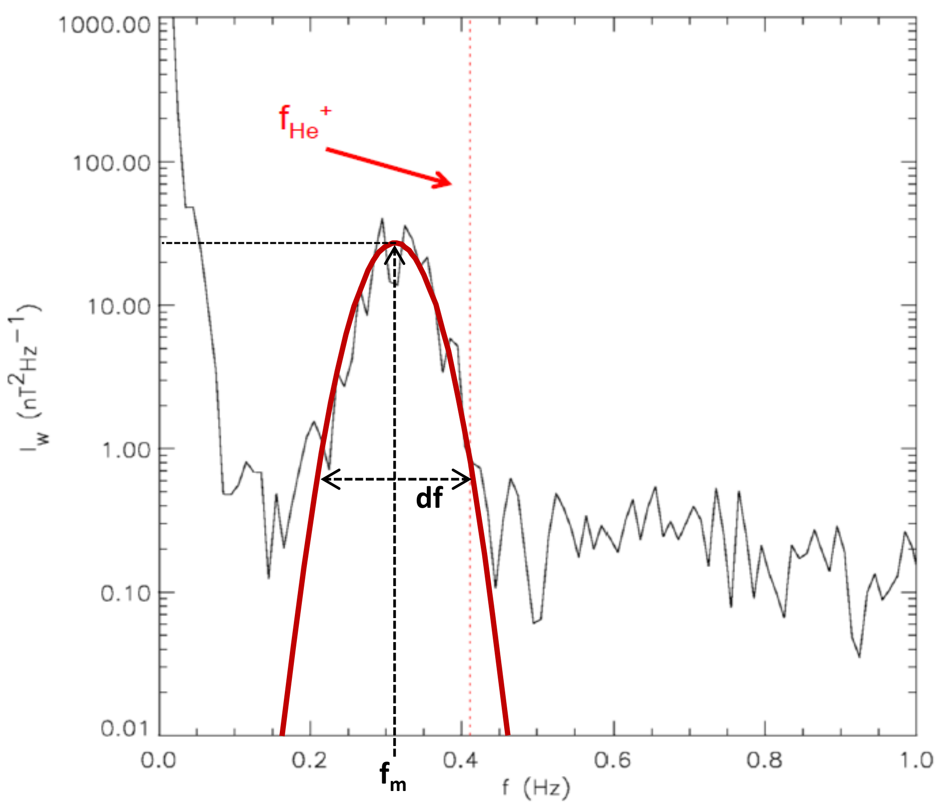
  - Cut-off frequencies



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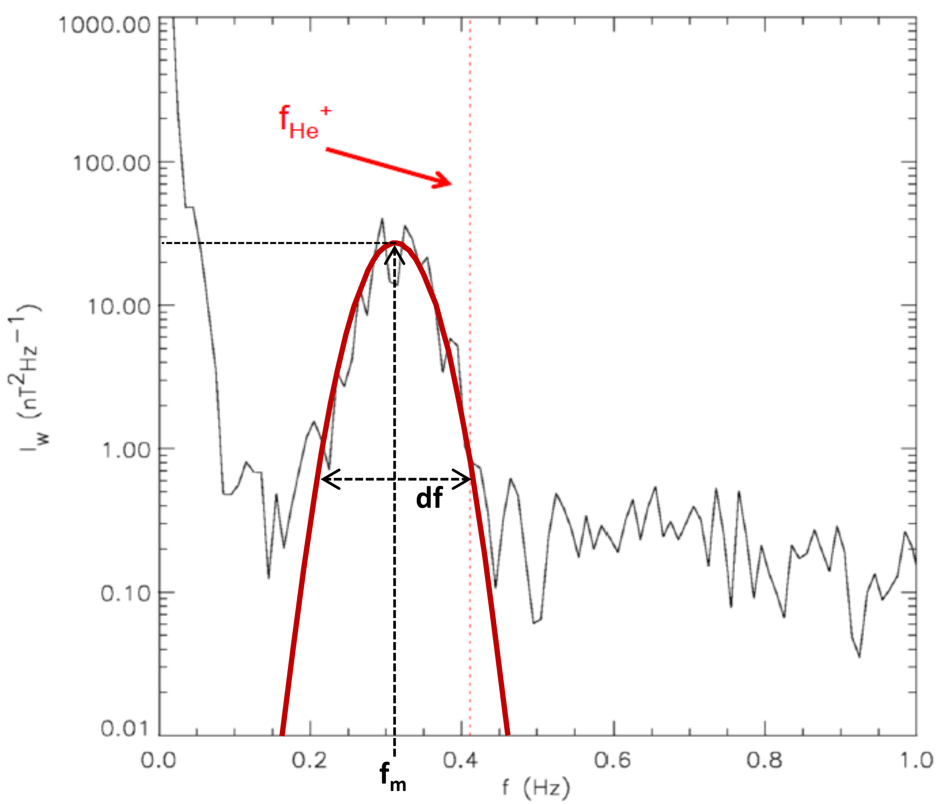
  - Width of the Gaussian
  - Cut-off frequencies
- Model for plasma density



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Calculating the diffusion rates

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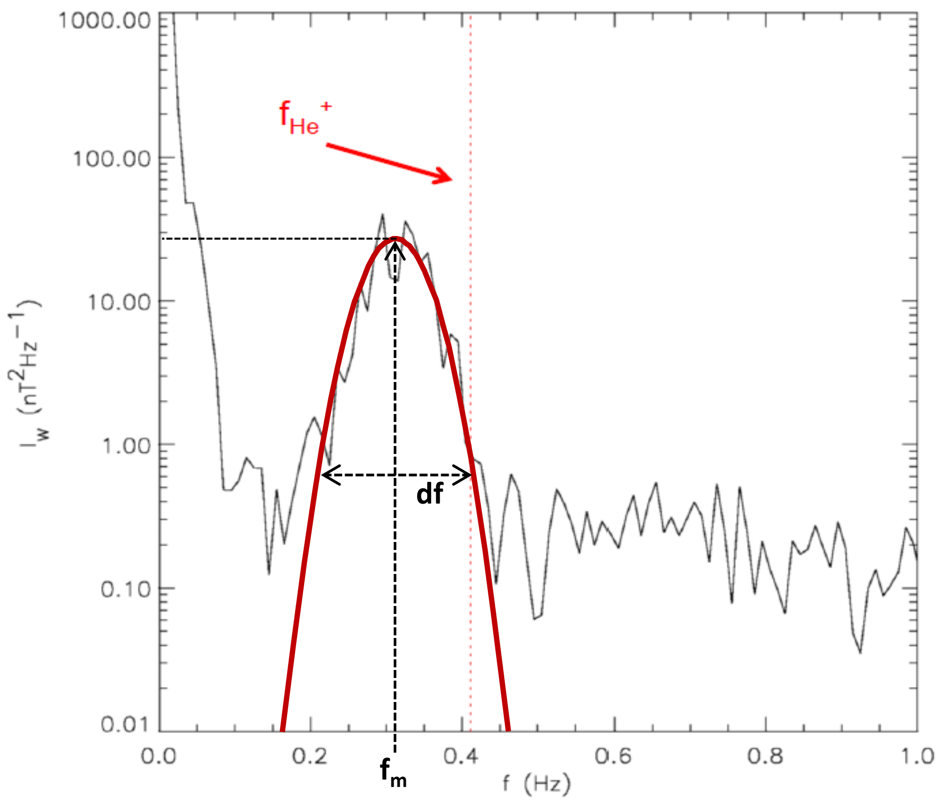
  - Cut-off frequencies
- Model for plasma density
- Ion composition



Modelling the radiation belts

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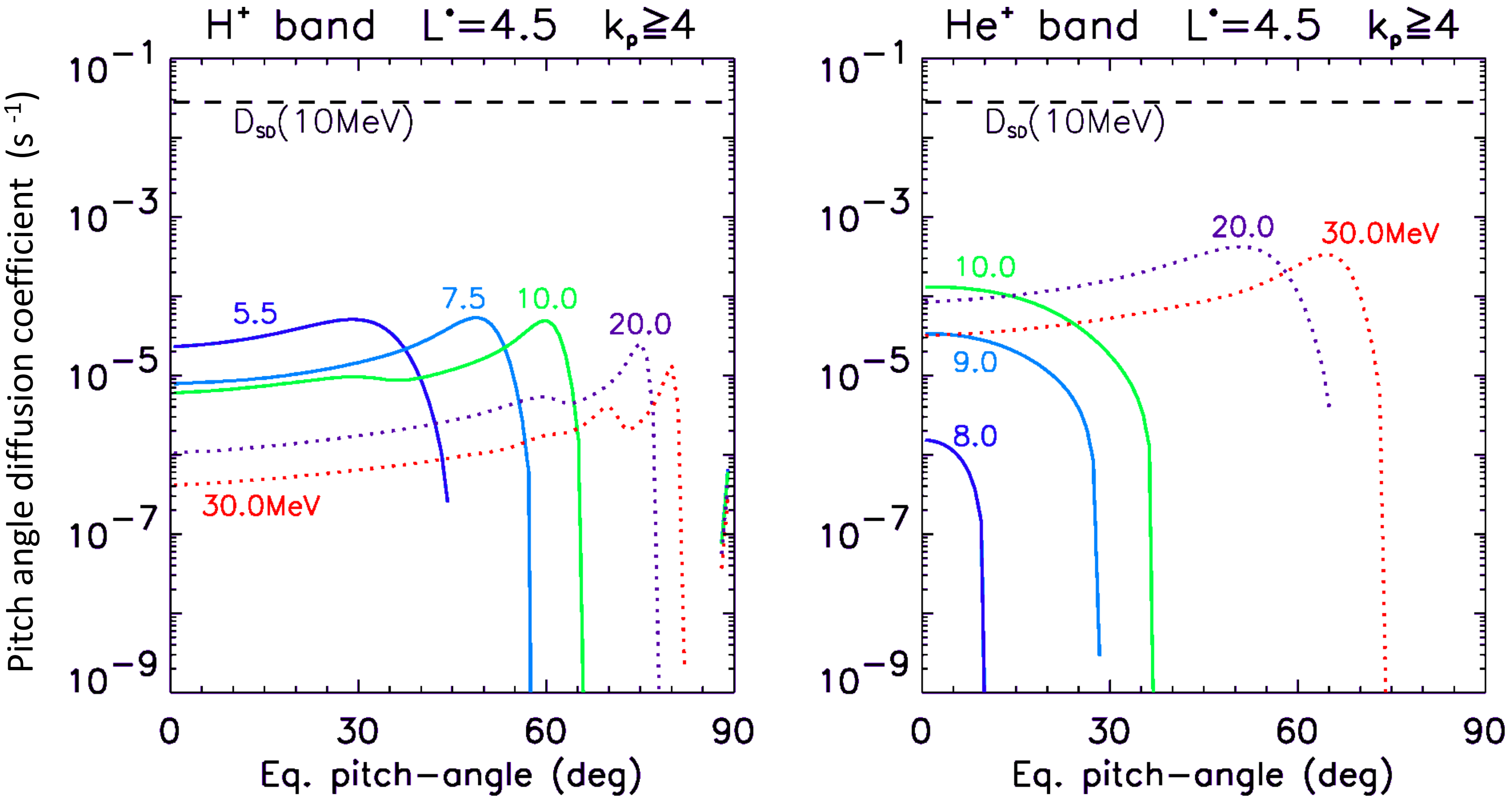
EMIC diffusion rates



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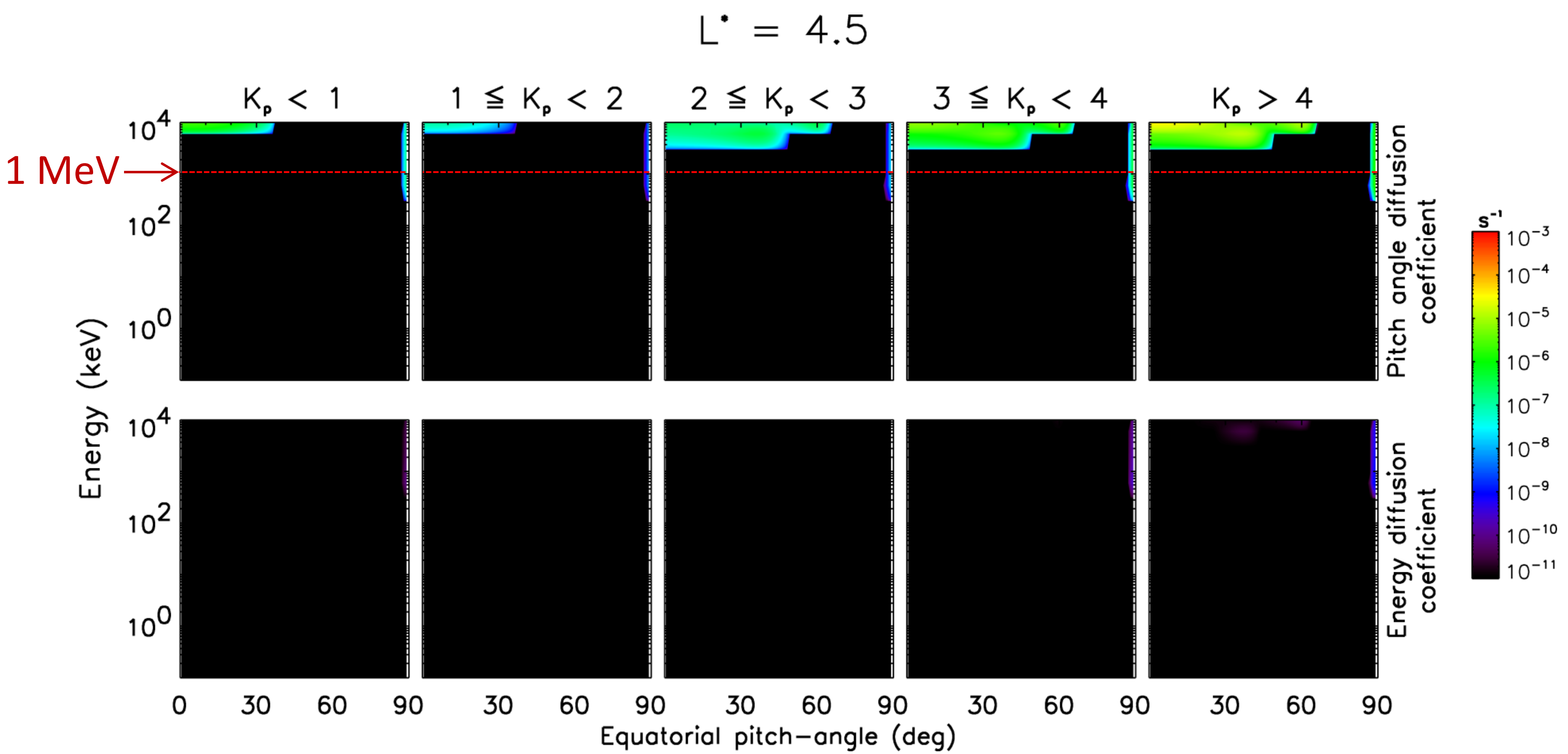
EMIC diffusion rates



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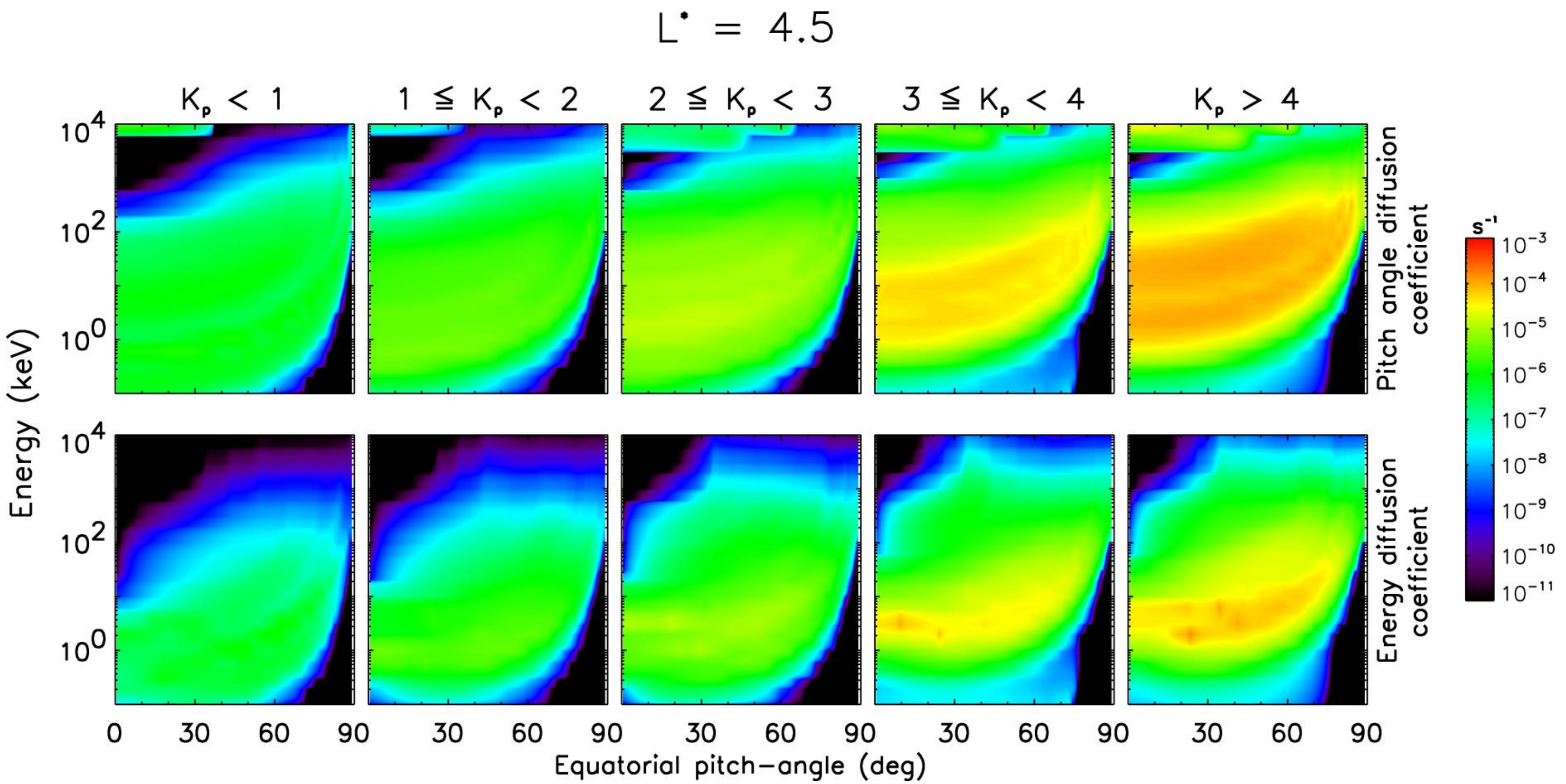
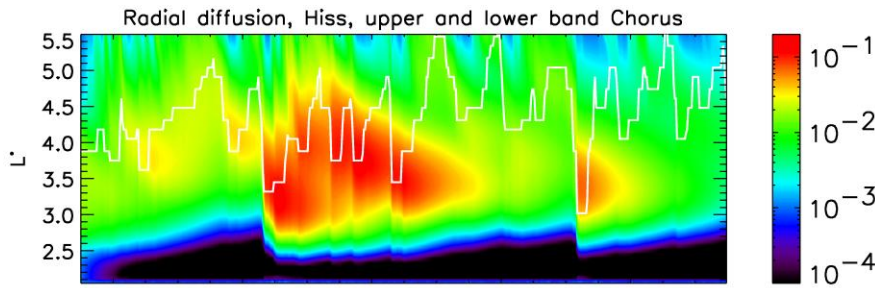
Combined EMIC and Chorus diffusion rates

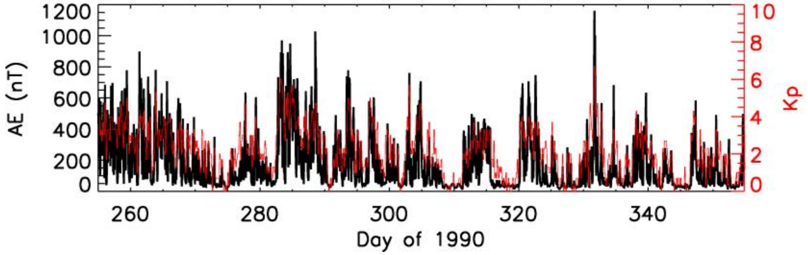


Electron flux: 100 day simulation – 90°

Without EMIC

90° flux ($cm^{-2}sr^{-1}s^{-1}keV^{-1}$) for 6MeV electrons





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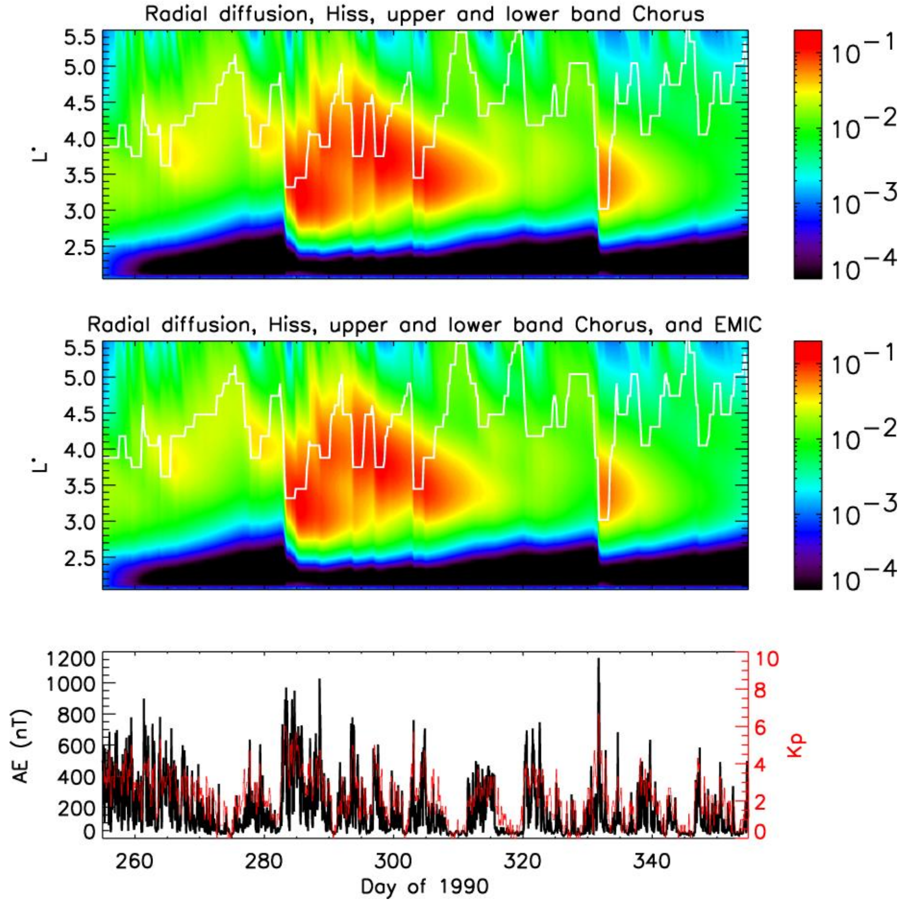
Electron flux: 100 day simulation – 90°

90° flux ($cm^{-2}sr^{-1}s^{-1}keV^{-1}$) for 6MeV electrons

Without EMIC

With EMIC



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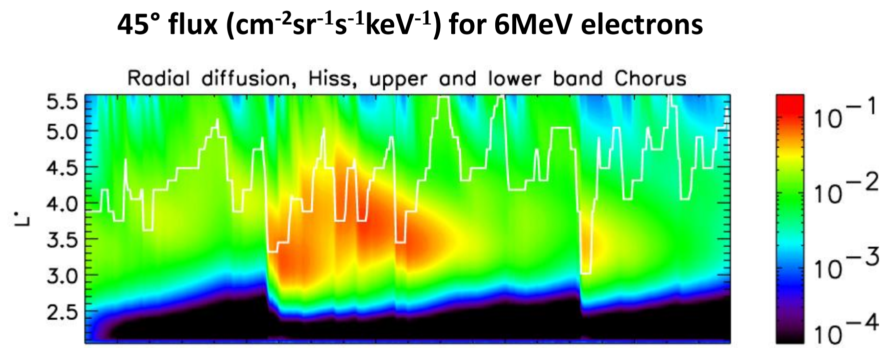
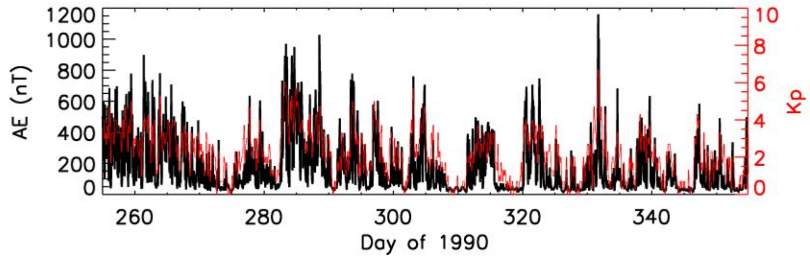
Electron flux: 100 day simulation – 45°

Without EMIC





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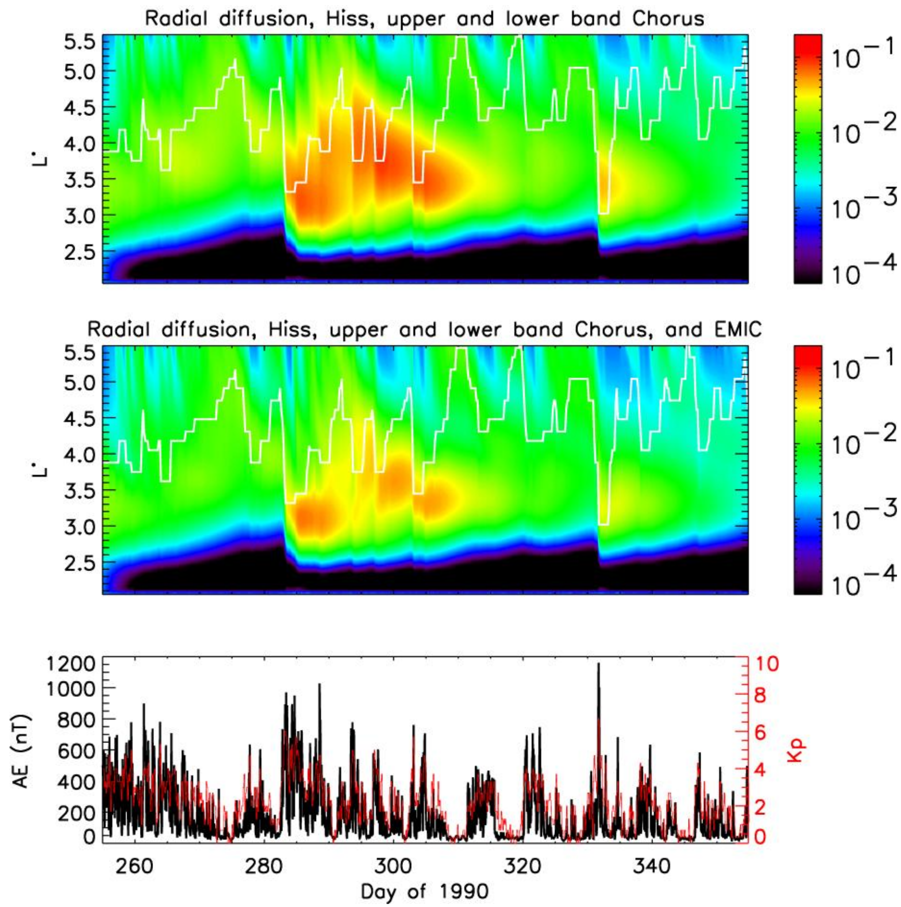
Electron flux: 100 day simulation – 45°

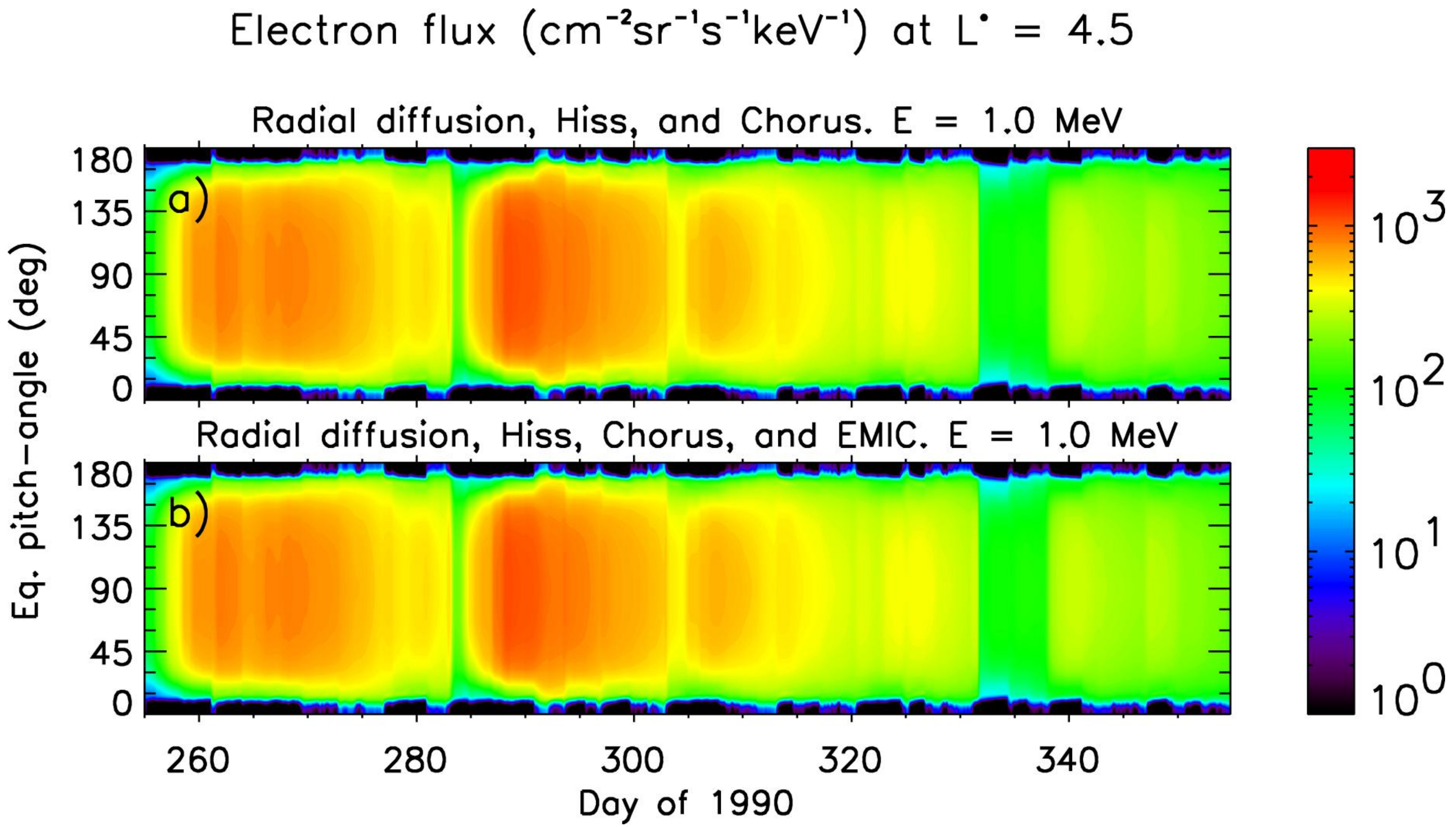
45° flux ($cm^{-2}sr^{-1}s^{-1}keV^{-1}$) for 6MeV electrons

Without EMIC

With EMIC



Pitch-angle distribution: 1 MeV



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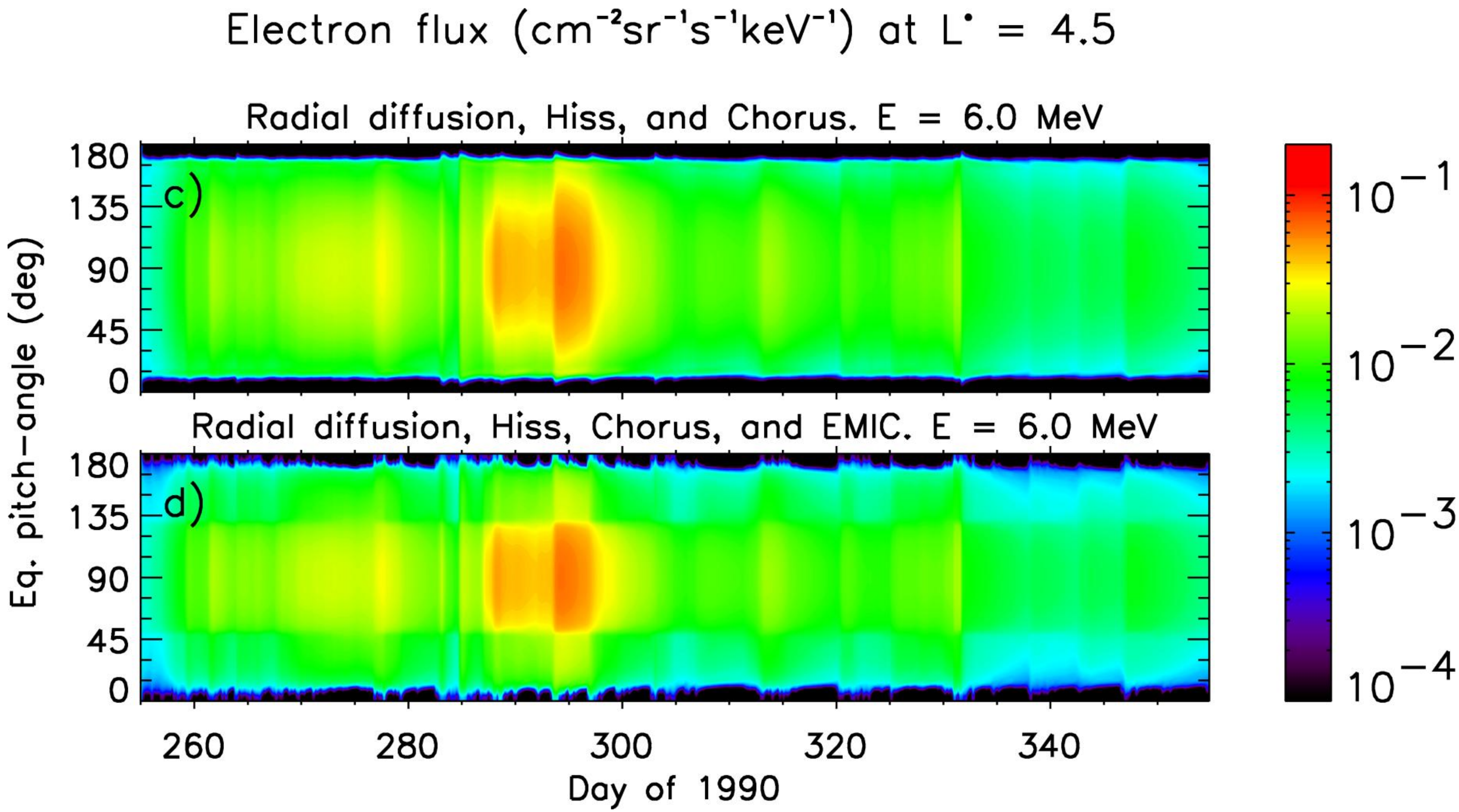
Pitch-angle distribution: 6 MeV



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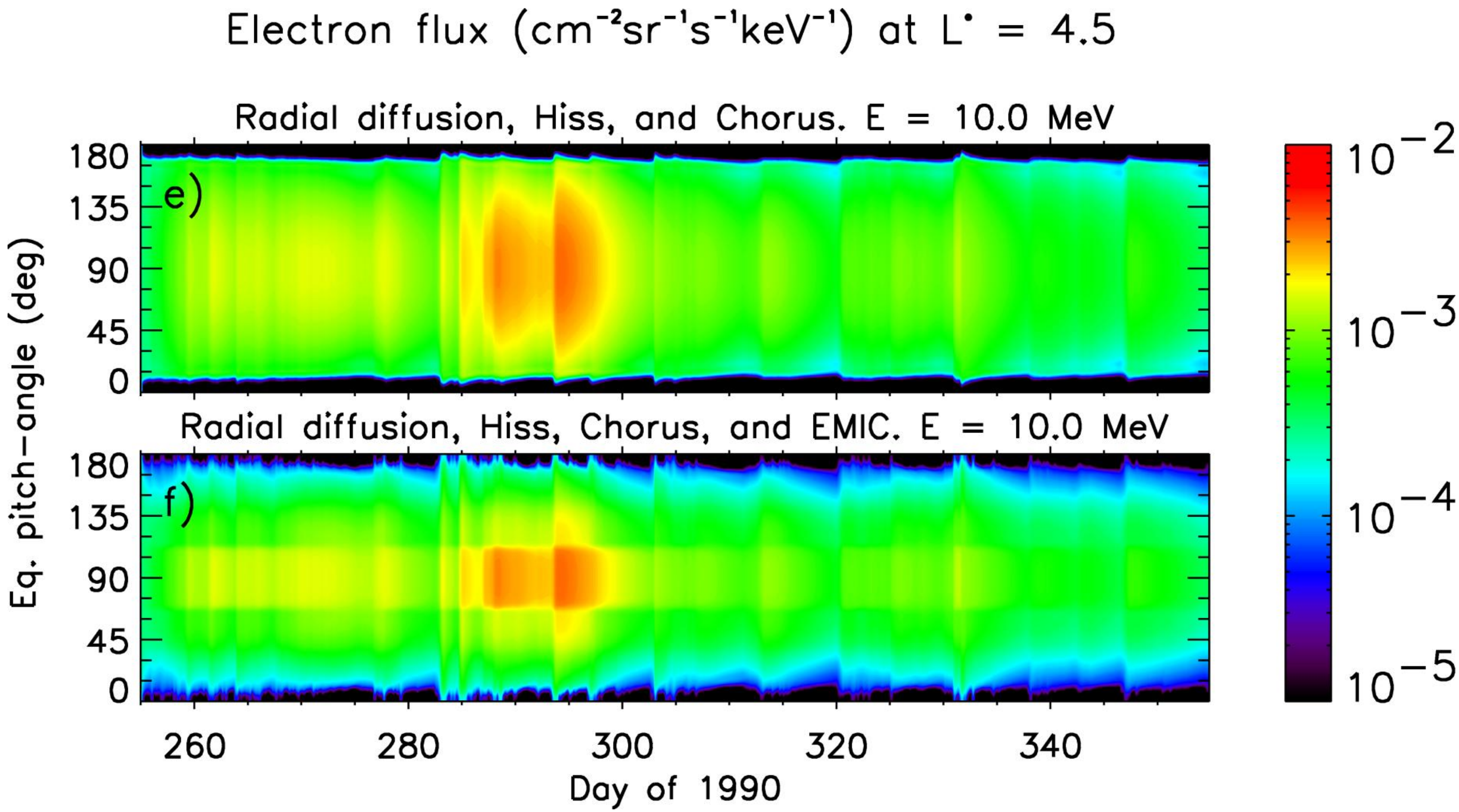
Pitch-angle distribution: 10 MeV



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Conclusions

- EMIC waves are effective at scattering electrons for E > 2MeV
- There is no significant energy diffusion
- EMIC waves lead to significant losses at pitch-angles < 60°
- EMIC waves will result in a peaked particle distribution for 70° < α < 90°
- Therefore, we suggest:

  Looking for particle distributions peaked near 90° and E > 2MeV in Van Allen Probes data

Acknowledgements

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Wave parameters

Parameter	Hydrogen band waves	Helium band waves
f_m/f_{cH}	0.4	0.15
df/f_{cH}	0.02	0.02
f_{lc}/f_{cH}	0.36	0.11
f_{uc}/f_{cH}	0.44	0.19
X_m	0.0	
ΔX	tan 15°	
X_{cut}	$2\ \Delta X$	
Resonances	$-10 \leq n \leq 10$	
f_{pe}/f_{ce}	10.0	
Ion composition	94% H^+ 5% He^+ 1% O^+	

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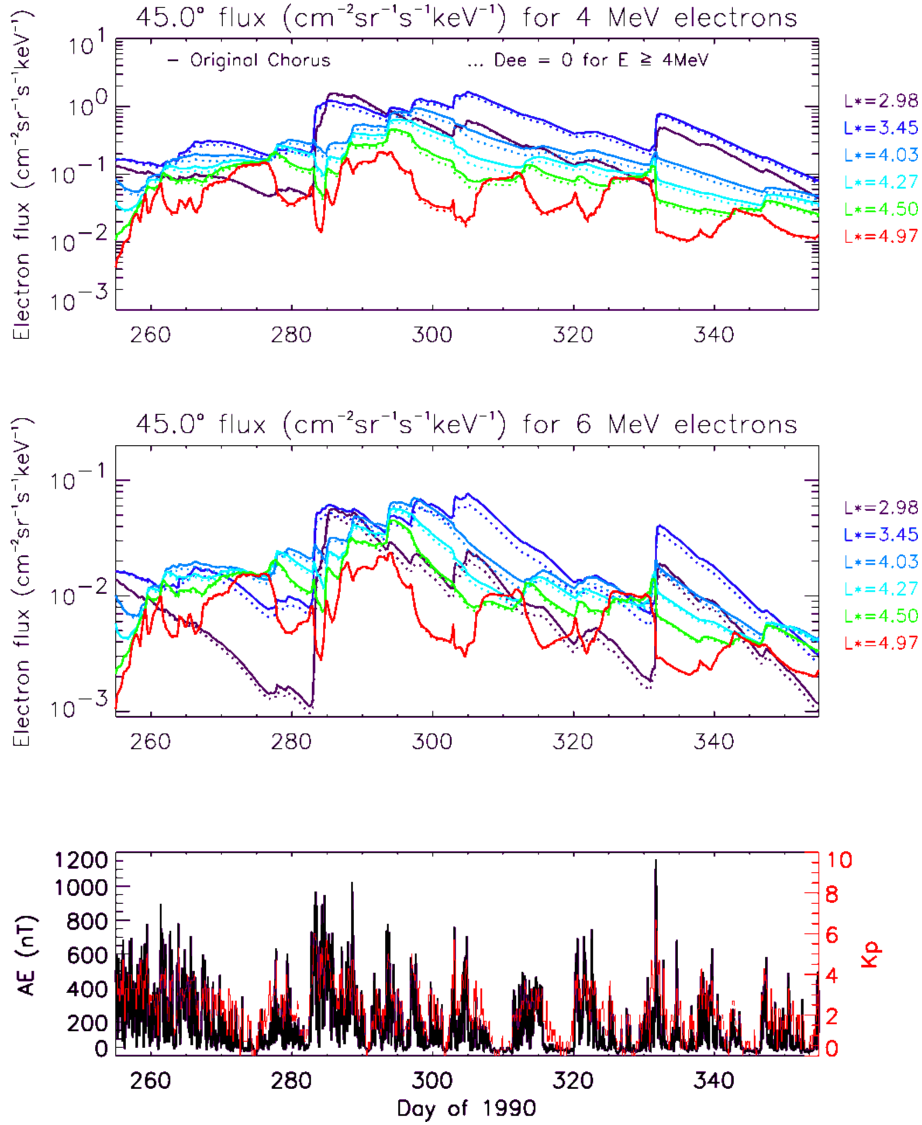

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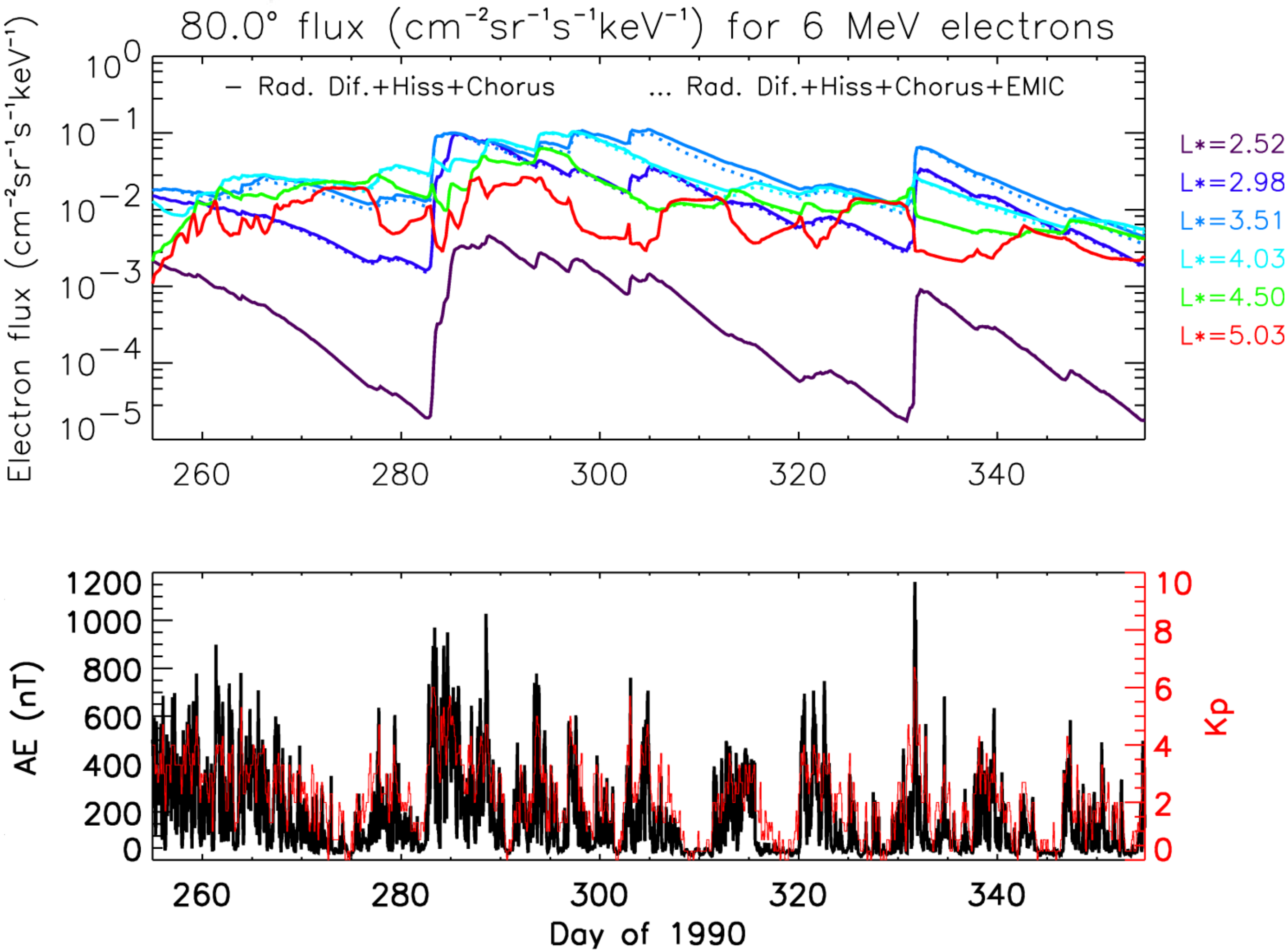

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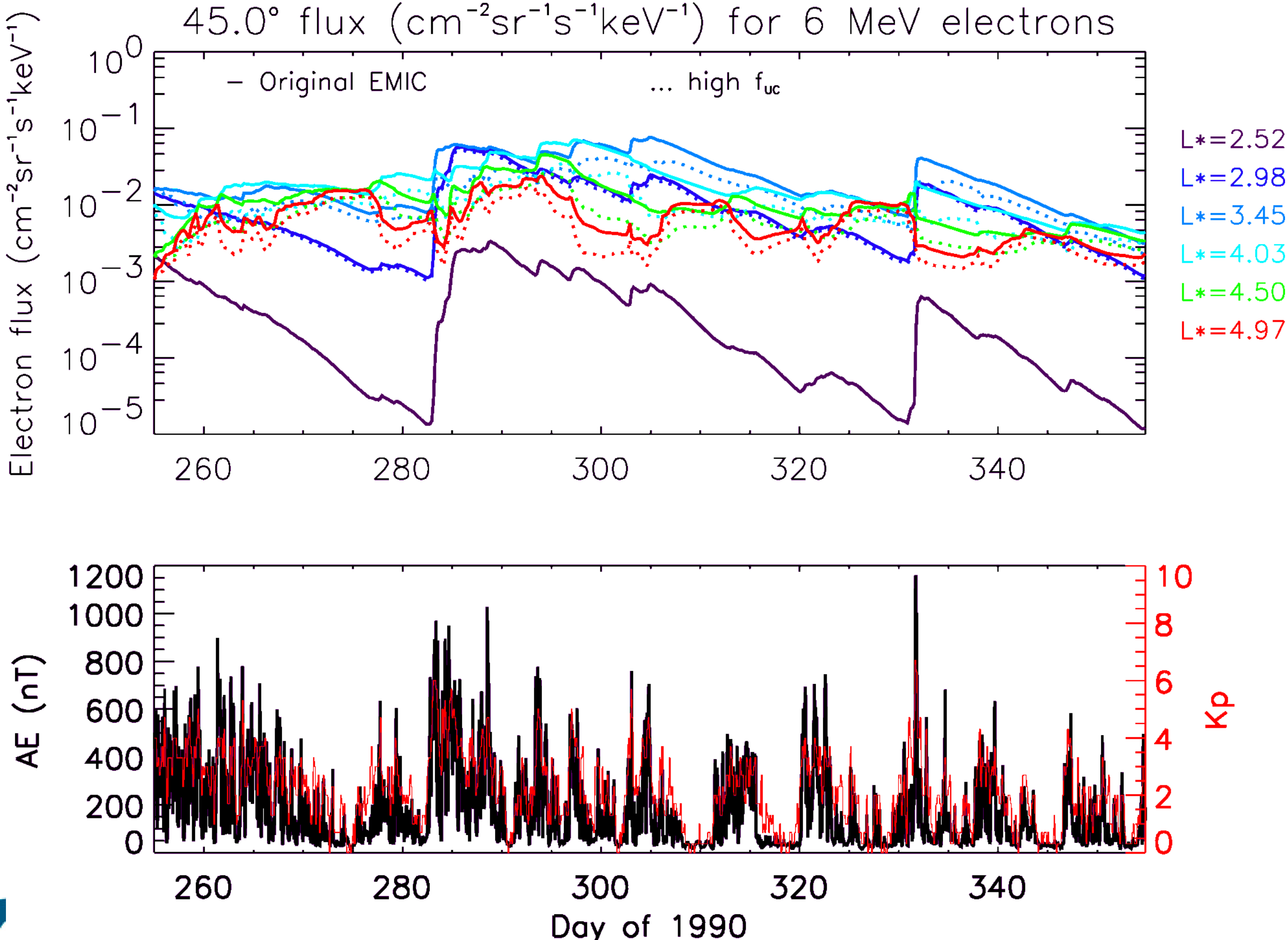

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