On the effect of the seed population: a comparison of low energy boundaries in the BAS Radiation Belt Model

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Introduction

- Recent work has shown the importance of the seed population
- Captured in models by the low energy boundary condition

- Here we use different low energy boundary conditions in the BAS Radiation Belt Model
  1. Using POES MEPED data – two methods developed
  2. Using Van Allen Probes MagEIS data
  3. Using a Kp driven statistical method derived from CRRES data – see Glauert et al., 2014

- POES satellites operate in a polar orbit
- Orbit the Earth ~14 times each day
- Cross a range of L*
- Rapid coverage of the radiation belt region
- >19 years of data
- Up to 5 POES satellites – multiple MLT planes

- Two main challenges:
  1. Integral flux data
  2. Low equatorial pitch angle

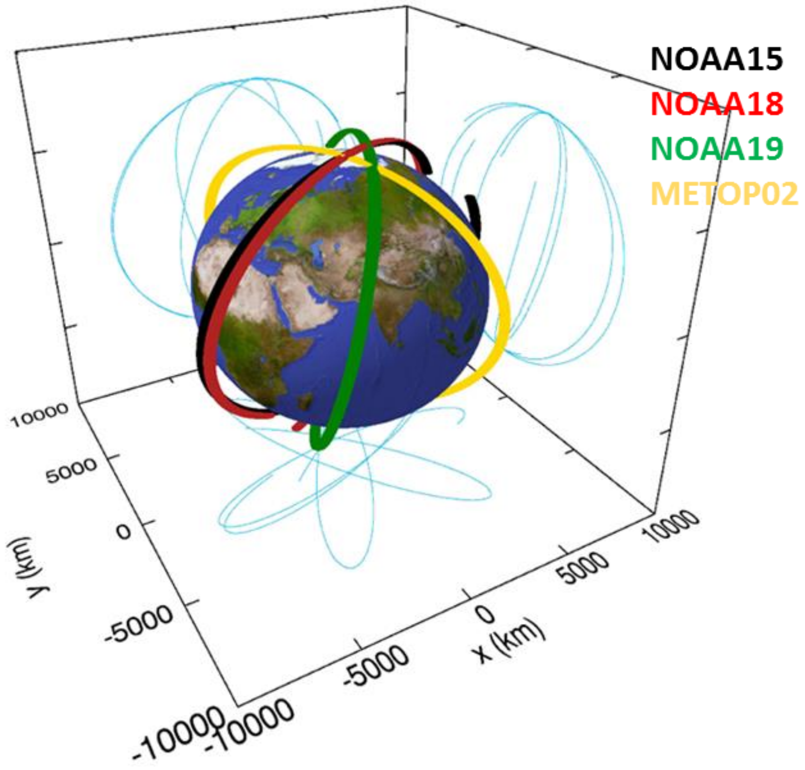
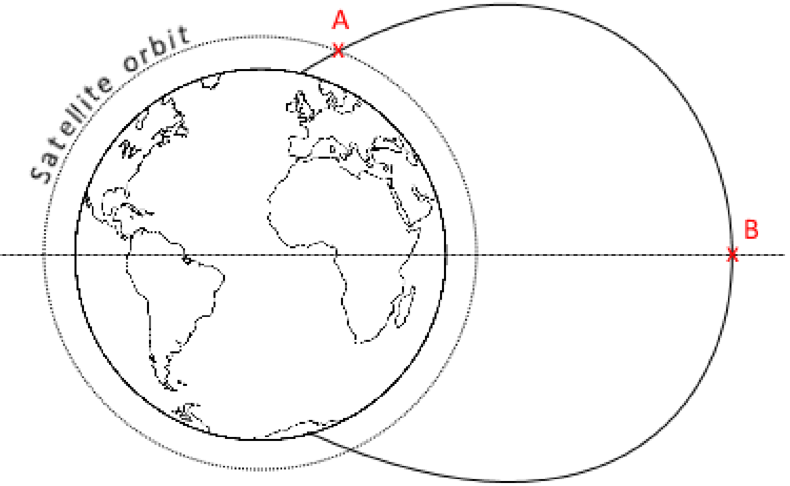


Figure 1 – Trajectories of all available POES satellites from 2014-06-22 23:00:00 to 2014-06-23 00:40:00

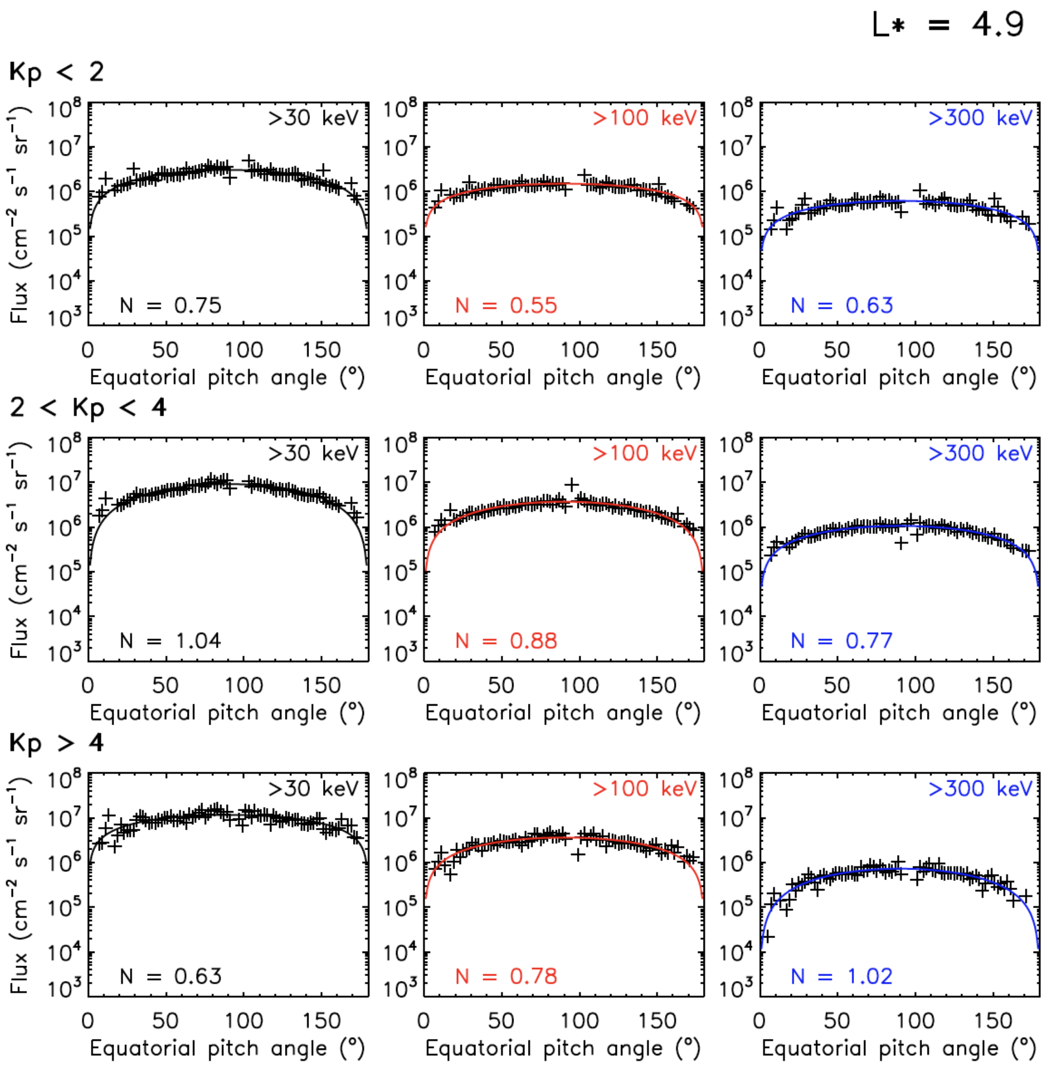
Convert to Omnidirectional flux

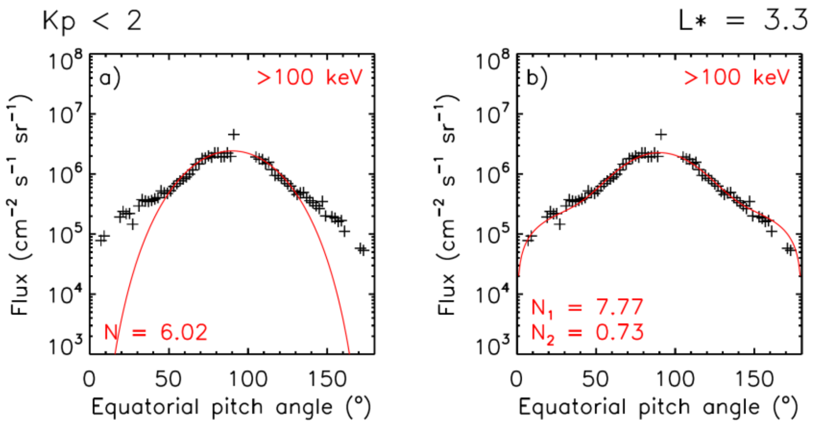


- Assume: integral flux measured = flux at the magnetic equator with a pitch angle given by conservation of μ
- Assume an equatorial pitch angle distribution for the integral flux
- Integrate over this distribution to get omnidirectional flux
- POES measures >30, >100, and >300 keV flux – use 3.5 years of MagEIS data to find equatorial pitch angle distributions

Convert to Omnidirectional flux

- $F(E > E_t, \alpha) = F(E > E_t, 90^o)\sin^{N(E_0)}\alpha$
- Integrate the MagEIS data
- Find equatorial pitch angles of the MagEIS pitch angle bins
- Sort by Kp and L*





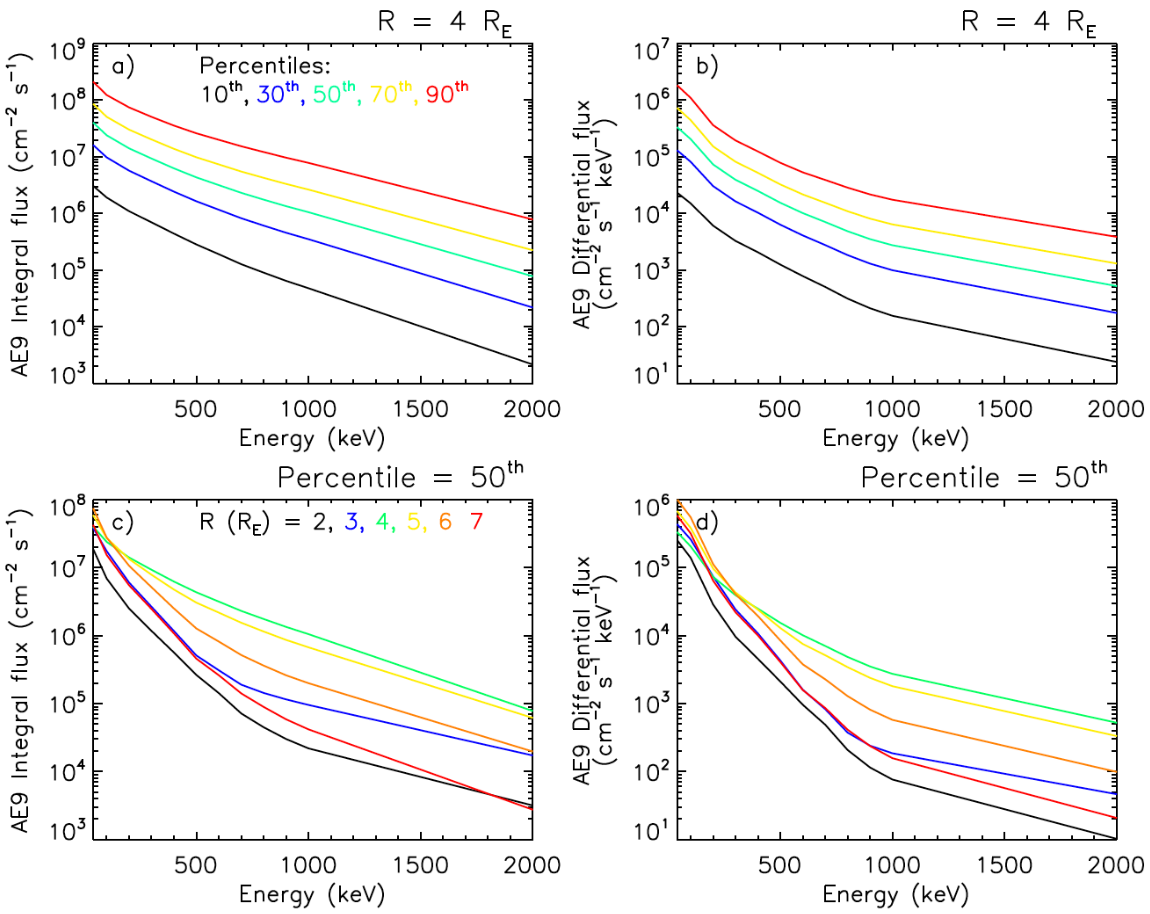
$$F(E > E_t, \alpha) = AF(E > E_t, 90^o)\sin^{N_1(E_0)}\alpha + (1 - A)F(E > E_t, 90^o)\sin^{N_2(E_0)}\alpha$$

Use integral data to infer differential flux

-Two methods explored

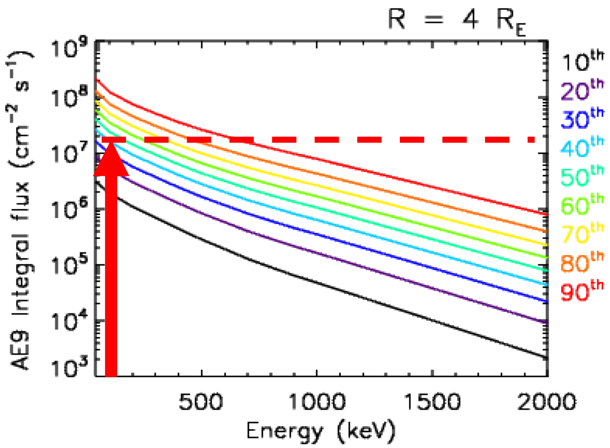
1) AE9 distributions method

- Use integral and differential flux distributions from the IRENE AE9 model
- For flux measured at a certain L* we take the flux-energy distributions at distances: (L* - 1 Re) < R < (L* + 1 Re)

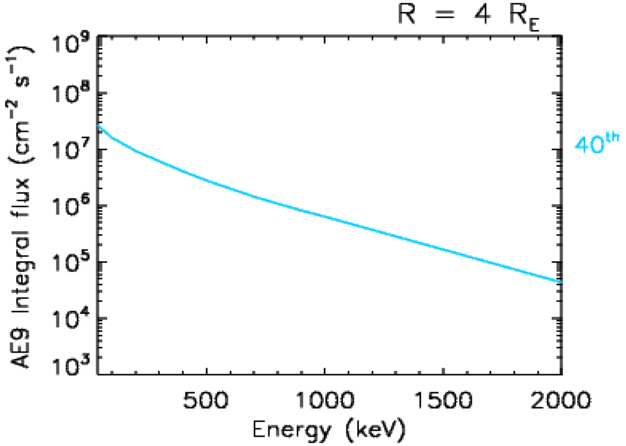


AE9 distributions method

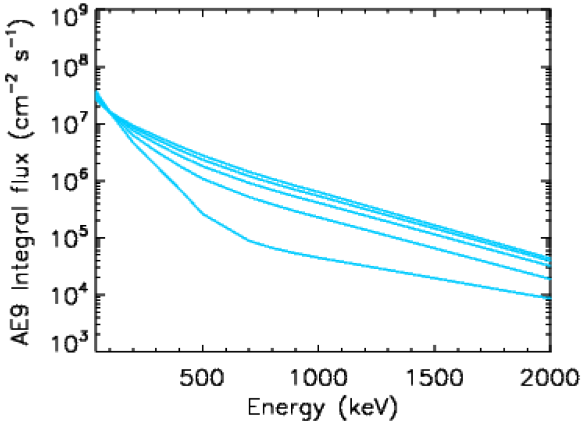
1] Compare the POES >100 keV flux to the AE9 integral flux distributions



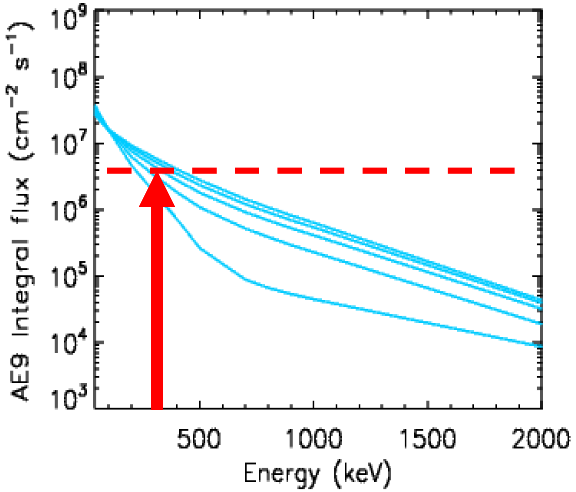
2] Extract distribution closest to data



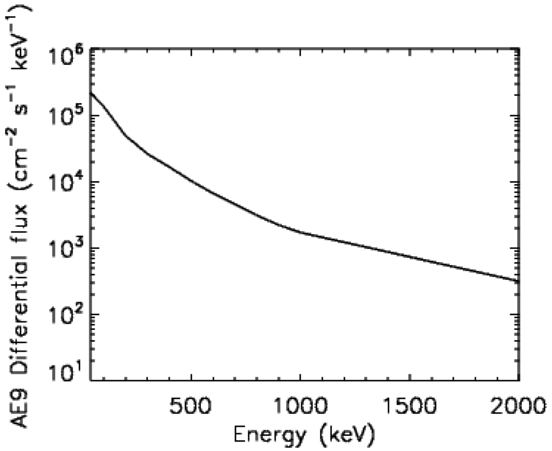
3] Repeat for other distances in range



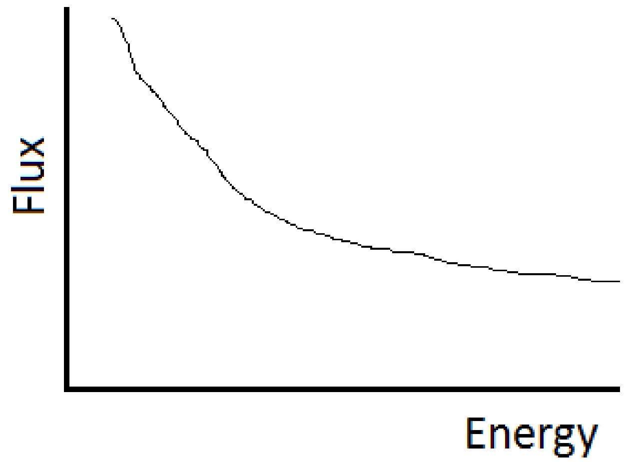
4] Compare POES >300 keV flux

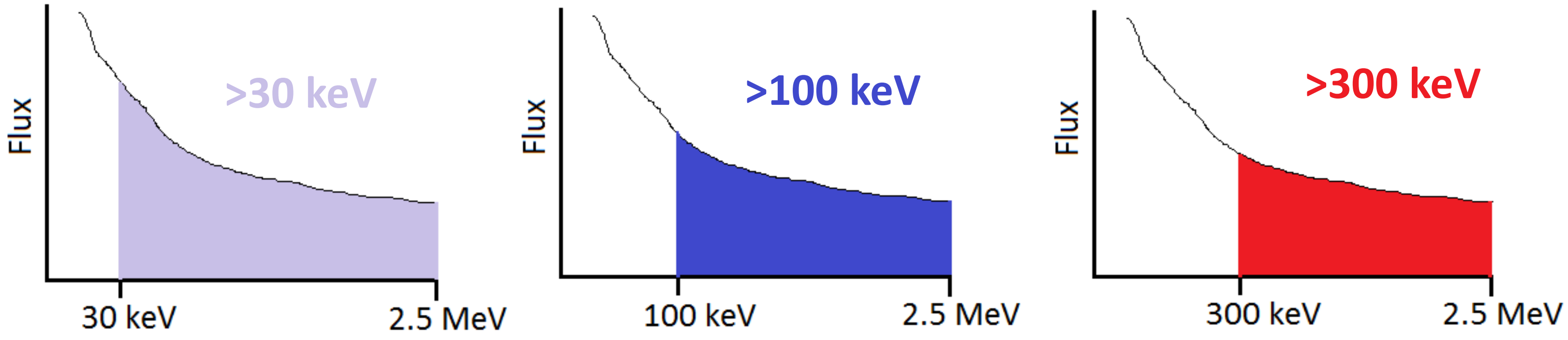


5] Use the equivalent differential flux distribution



2) Iterative method



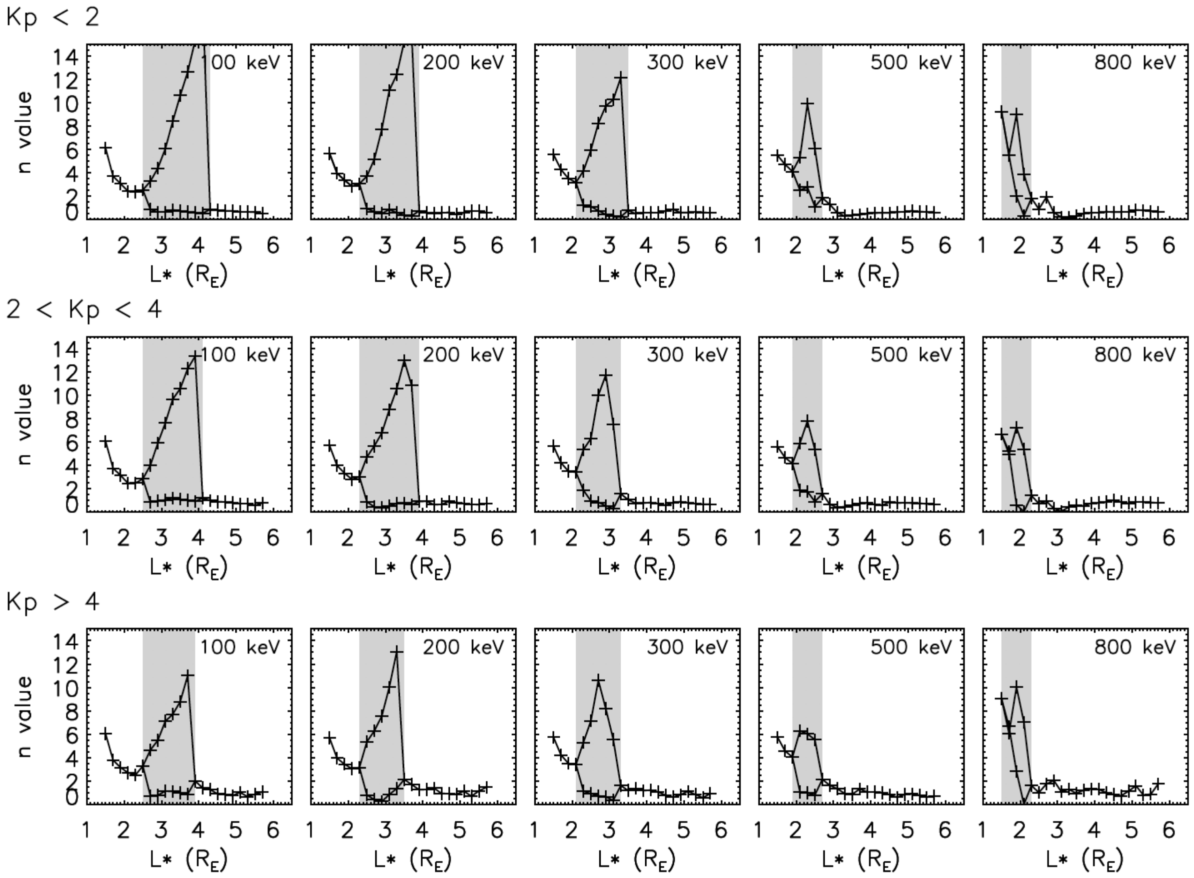


$$\chi^2 = \sum \frac{(f_{calc} - f_{obs})^2}{\sigma^2}$$

- Based on Reverse Monte Carlo
- Start with a distribution
- Calculate the three integrals
- Calculate X^2
- Move a random point – imposing the constraint that flux must fall with increasing energy
- Recalculate X^2
- If $X^2_{new} < X^2_{old}$ then accept move, if $X^2_{new} > X^2_{old}$ then accept move with probability $\exp(-\frac{\chi^2{}_{new} - \chi^2{}_{old}}{2})$

Convert to 90° equatorial pitch angle

- Have omnidirectional differential flux
- Again need to assume an equatorial pitch angle distribution
- Use average equatorial pitch angle distributions from MagEIS data



Fit either:

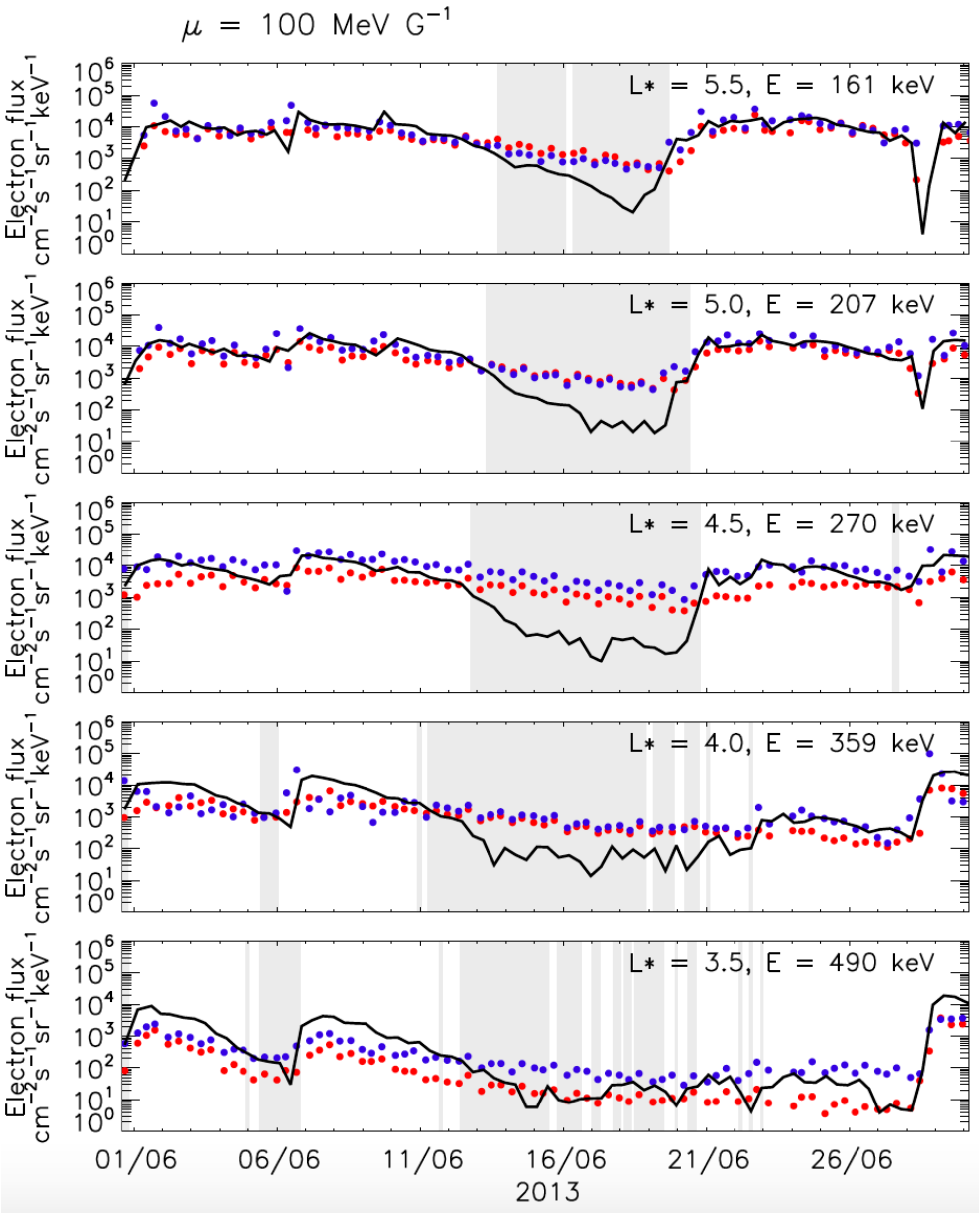
$$F(E > E_0, \alpha) = F(E > E_0, 90^o) \sin^{N(E_0)} \alpha$$

Or

$$F(E > E_0, \alpha) = AF(E > E_0, 90^o) \sin^{N_1(E_0)} \alpha + (1 - A)F(E > E_0, 90^o) \sin^{N_2(E_0)} \alpha$$

Validation

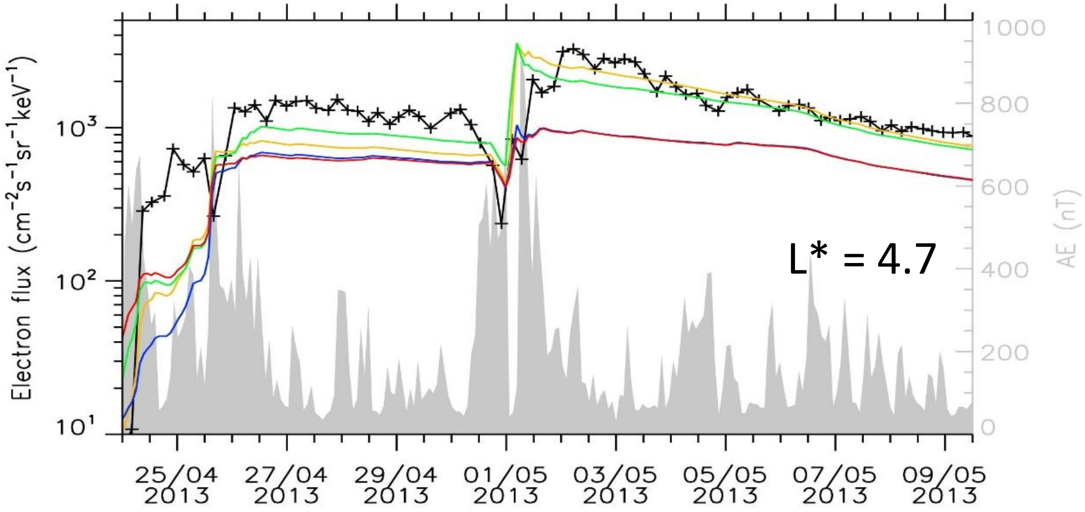
- Follow line of constant μ = 100 MeV/G

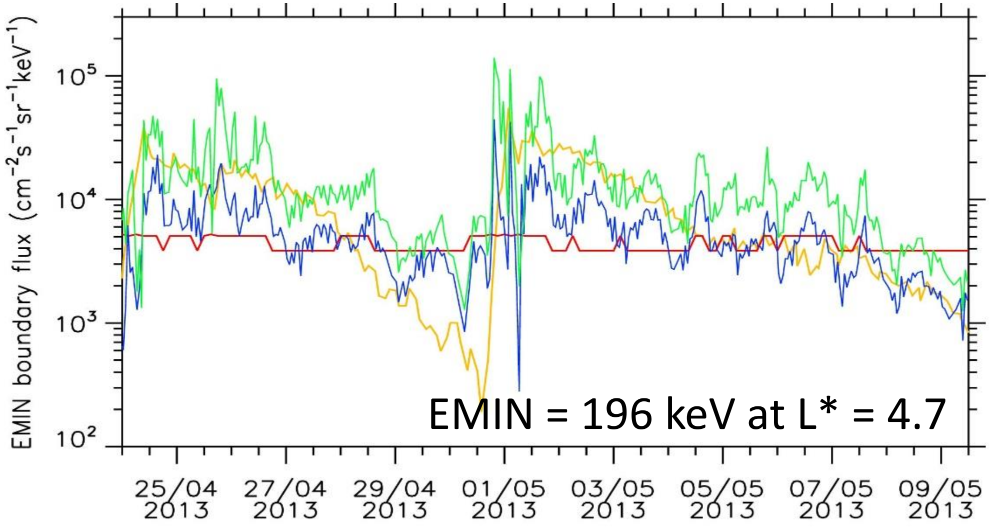


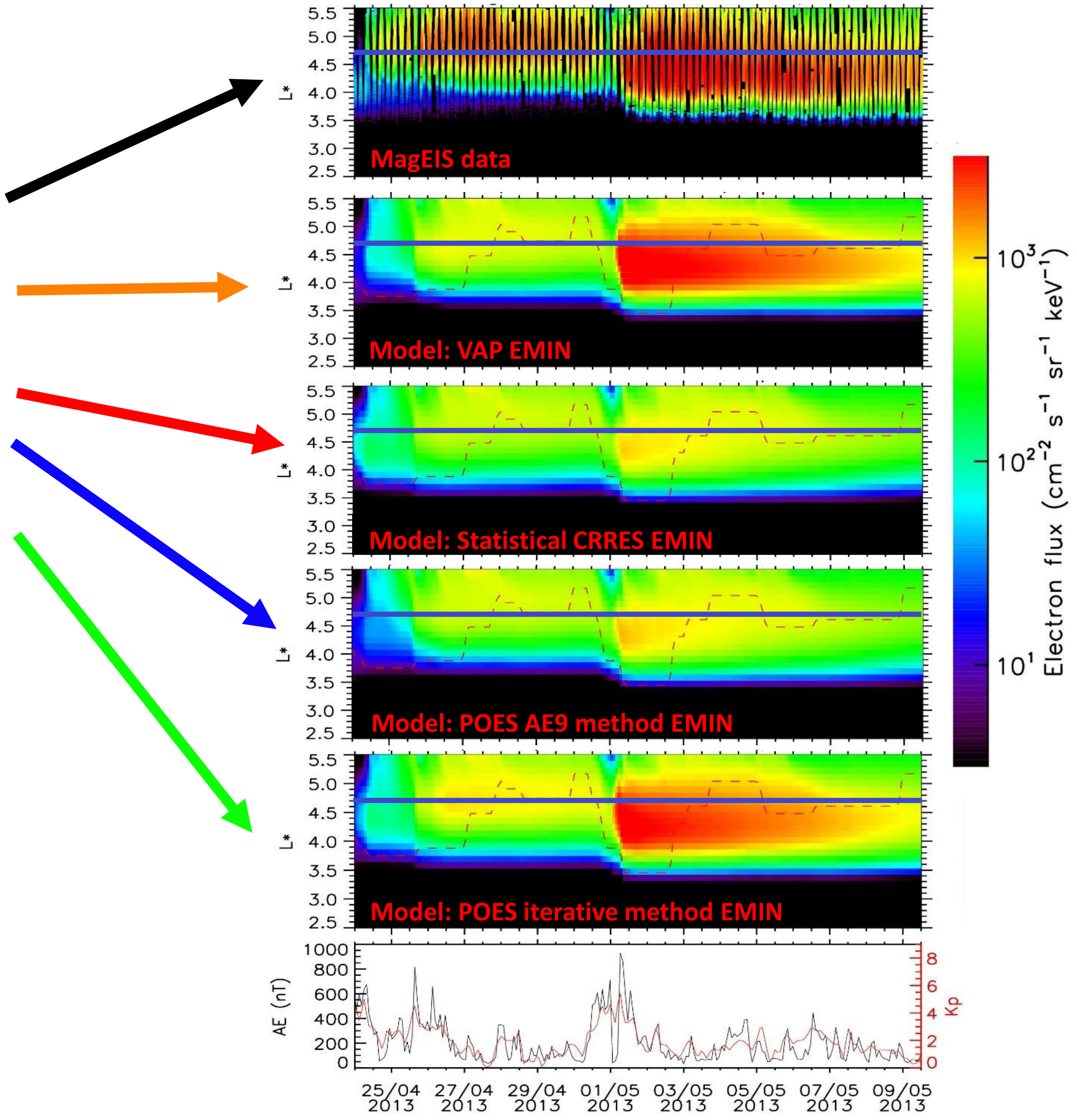
Finally, we can use this differential flux data at 90 degree pitch angle to calculate the PSD for the low energy boundary condition.

23^{rd} April 2013 – 9^{th} May 2013

1013.01 keV Electron flux, 90^{o} pitch angle







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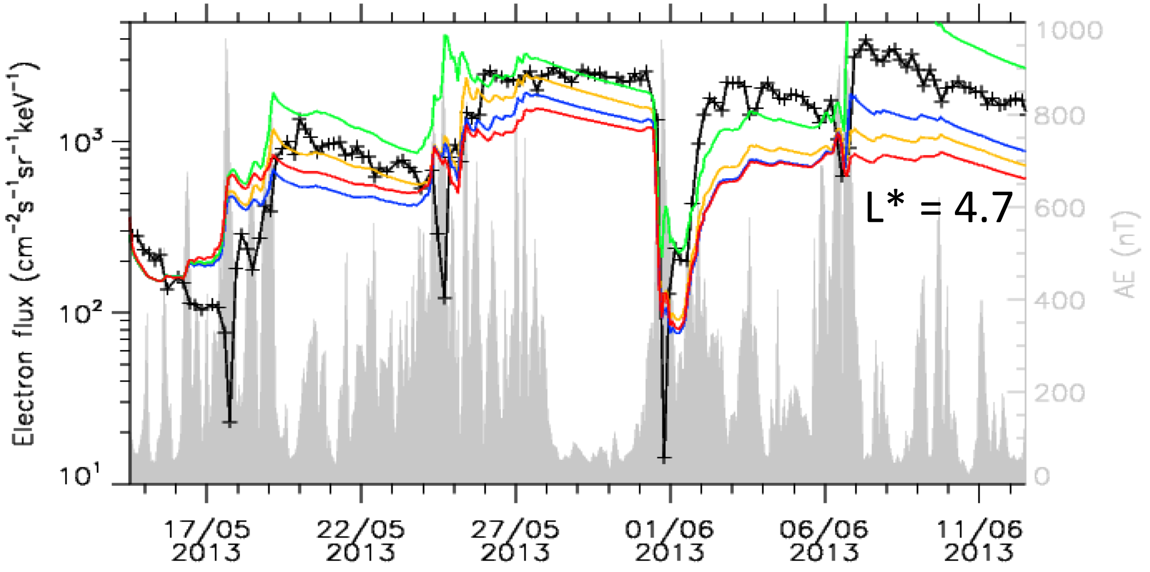
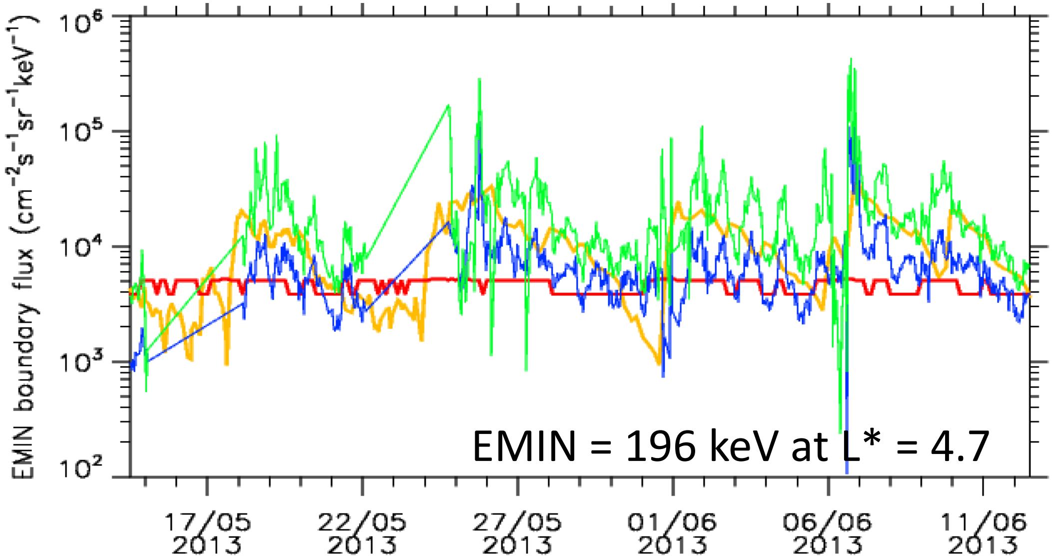
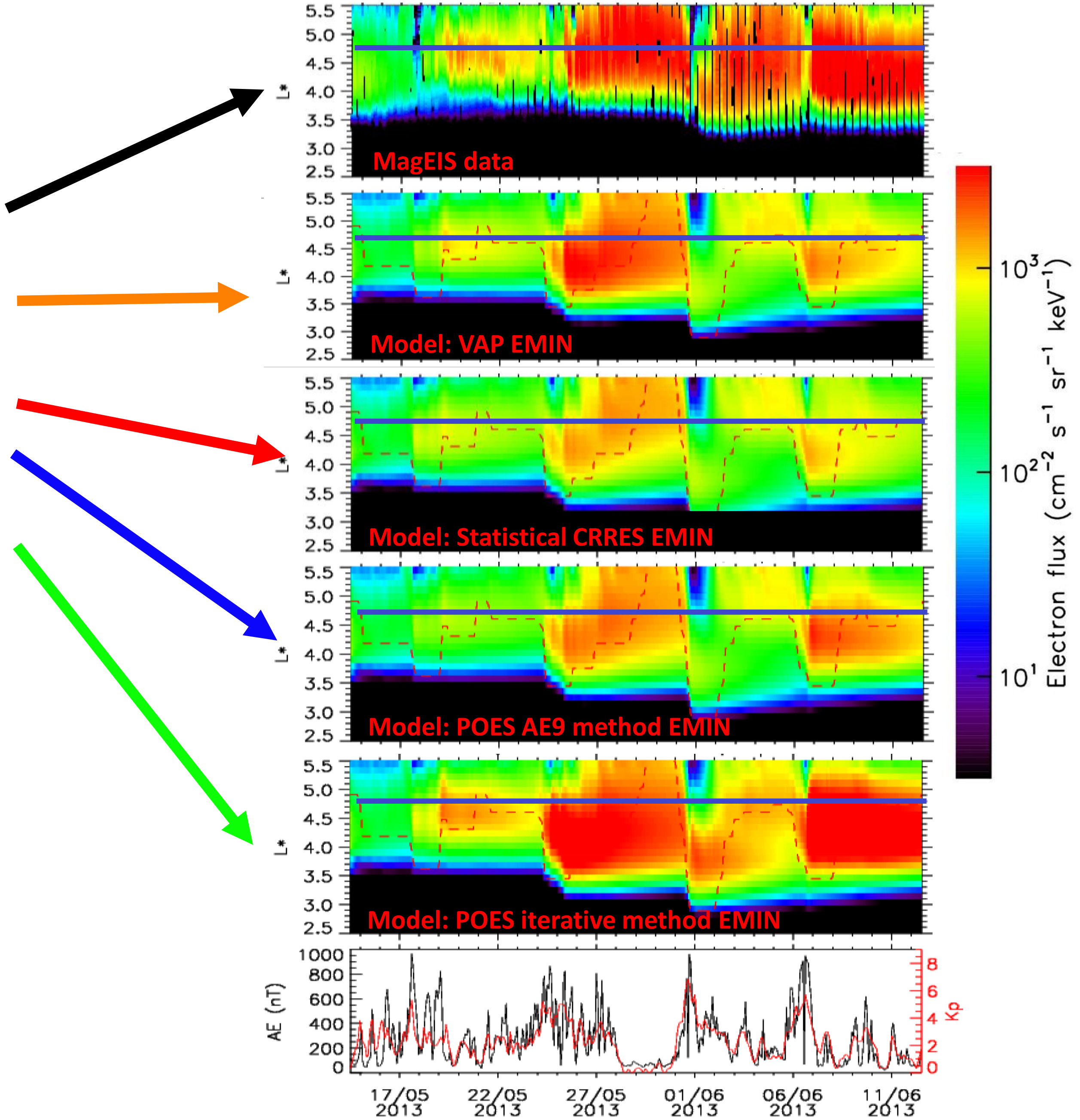
15^{th} May 2013 – 12^{th} June 2013

1013.01 keV Electron flux, 90° pitch angle







Conclusions

- Developed a method to generate event specific low energy boundary conditions from POES MEPED data
  - ➢ Useful when Van Allen Probes data is not available
  - ➢ High time resolution

- Using the POES generated low energy boundary performed better than the statistical model formed from CRRES data

- Varying the EMIN boundary condition resulted in variations in the ~1 MeV model output

- Examining variations in the low energy flux could improve our understanding of acceleration events