Invariant altitude (h_{inv}) for mapping the radiation belt fluxes in low-altitude environment

(h_{inv},λ) useful coordinate set to visualise, interpret and map data from satellites at low altitude

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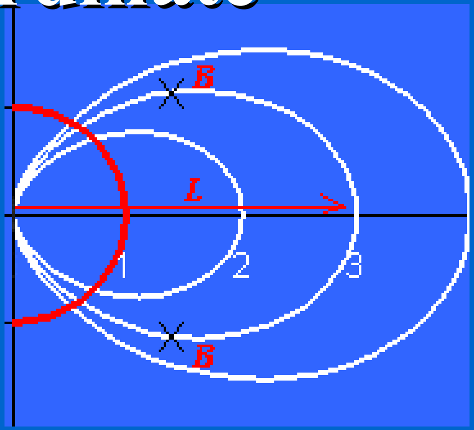
Outline

- Remind of the definition of the geomagnetic coordinates (B,L)
- Description of AE8, AP8 radiations models
- Definition of the coordinates (h_{inv},λ)
- Comparisons between coordinates
- Examples with satellite data fluxes.
- Conclusion

McILWAIN 1961
Invariant coordinates

Real Field | **Dipole Field** M = 0.311653 gauss Re^3

Invariant value | **Magnetic coordinate**



- Magnetic moment → • Mirror point

$\mu = W/B \longrightarrow B$

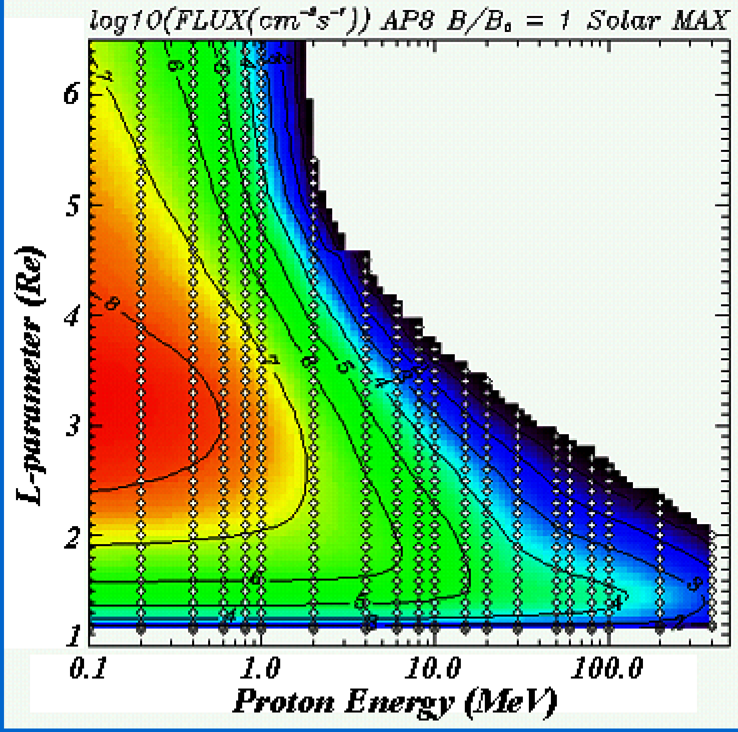
- Integral Invariant → • L-parameter

$I \longrightarrow I \rightarrow L$ (Re=6371.2 Km)

$j(B,I) \longrightarrow j(B,L)$

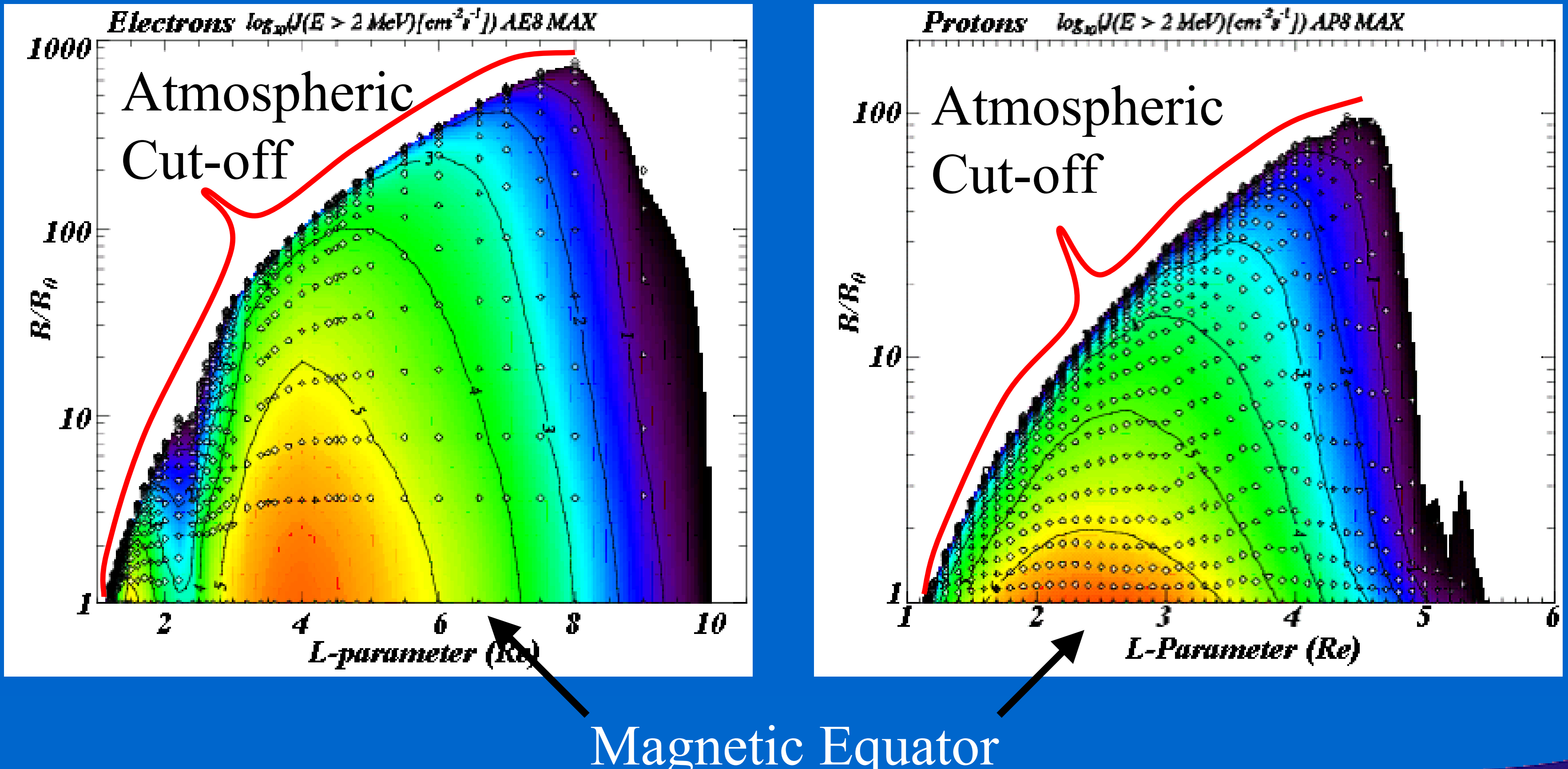
AE8-AP8 Models

- Omnidirectional Integrated Flux
  Energy vs B/B_0 vs L-parameter ($B_0=M/L^3$)
- AE8 → Electrons
- AP8 → Protons
- 40 keV < Ee < 7 MeV
- 0.1 MeV < Ep < 400 MeV
- 1 Re < L < 15 Re
- B/B_0 steps of constant log(Flux) increments



http://modelweb.gsfc.nasa.gov/

Log(B/B0) vs L-parameter for E > 2 MeV AE8 AP8 MAX



h_{inv}-λ invariant coordinates

- $(R,\lambda) \rightarrow (B,L)$ from Dipole Field
- $L = R/\cos^2\lambda$
- $B = MR^{-3}\,[1+3\sin^2(\lambda)]^{1/2}$
- Inverse equation

$$(BB_0^{-1})^2\,(RL^{-1})^6 - (4 - 3\,RL^{-1}) = 0$$

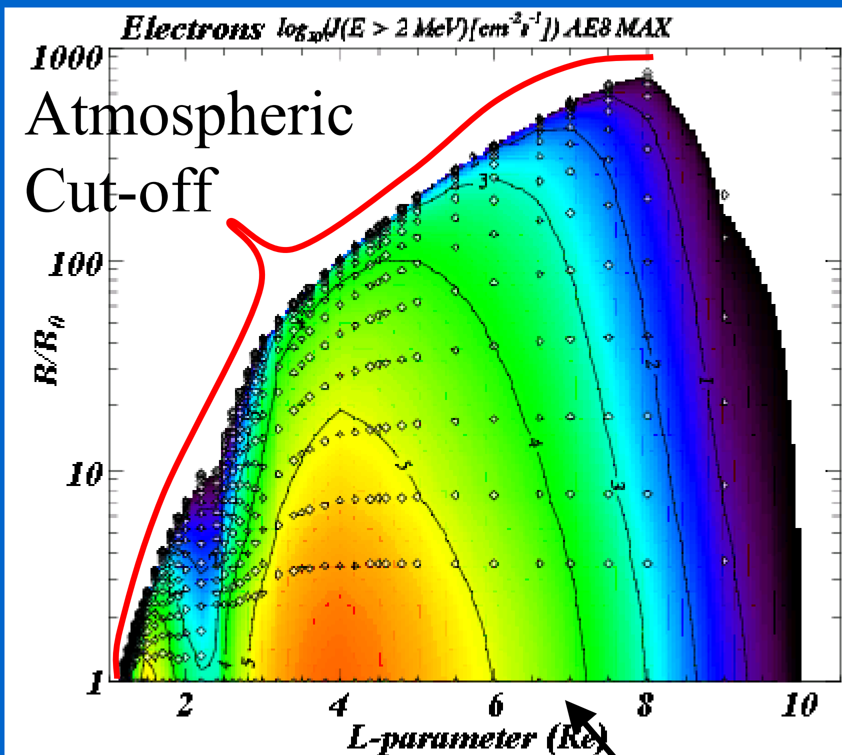
- Newton-Raphson algorithm $(B,L) \rightarrow (h_{inv},\lambda)$
- h_{inv} = R-Re ; Re = 6371.2 km

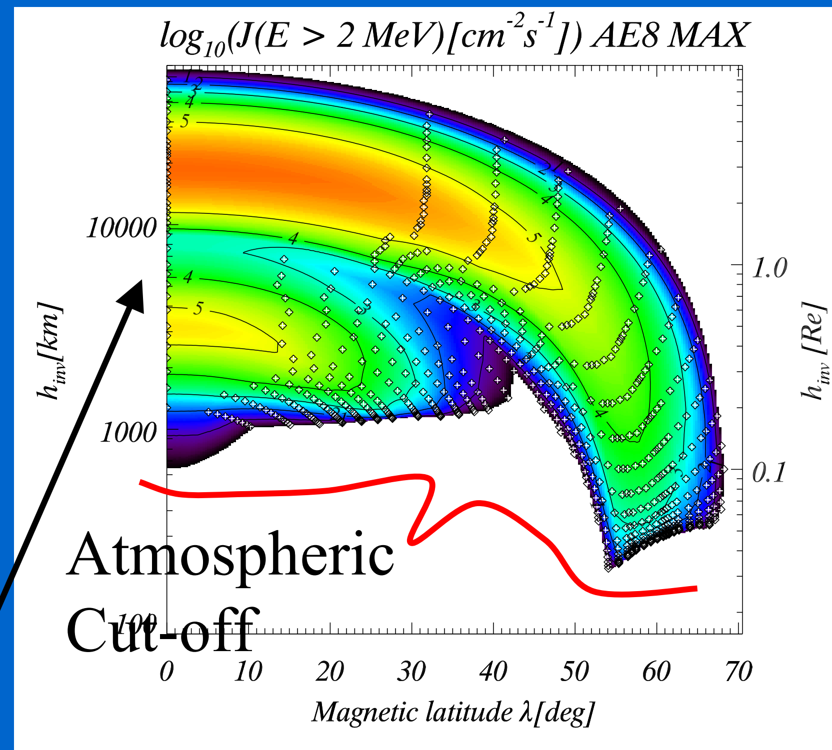
λ: magnetic latitude

R: distance to center dipole

Comparisons

B/B_0-L vs h_{inv}-λ

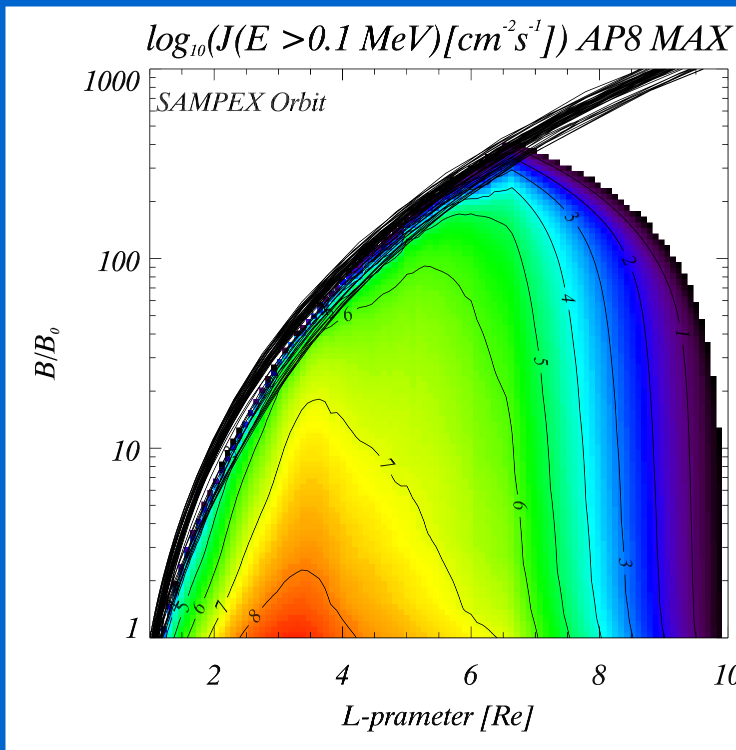


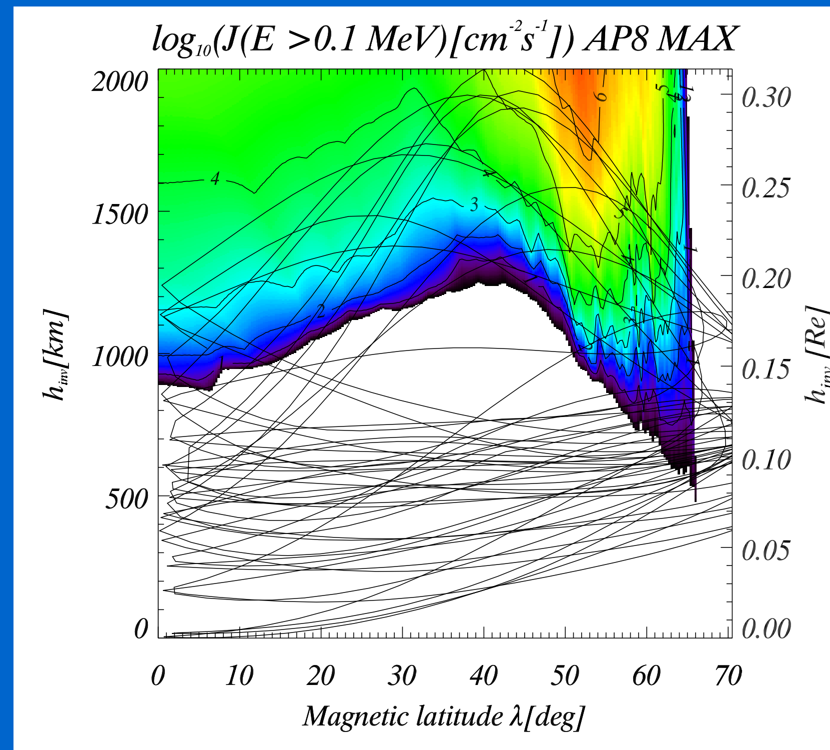


Magnetic Equator

Comparisons

B/B_0-L vs h_{inv}-λ



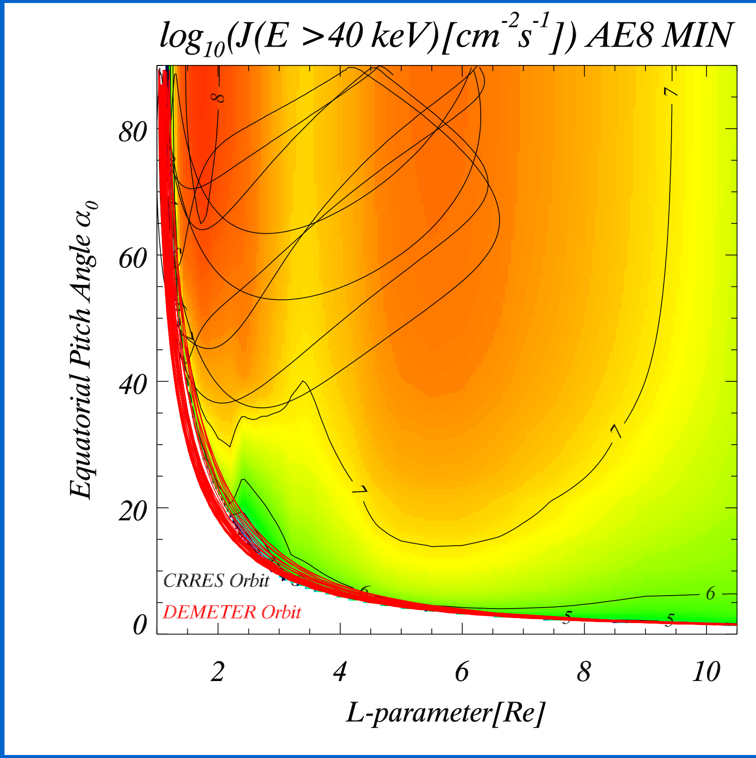


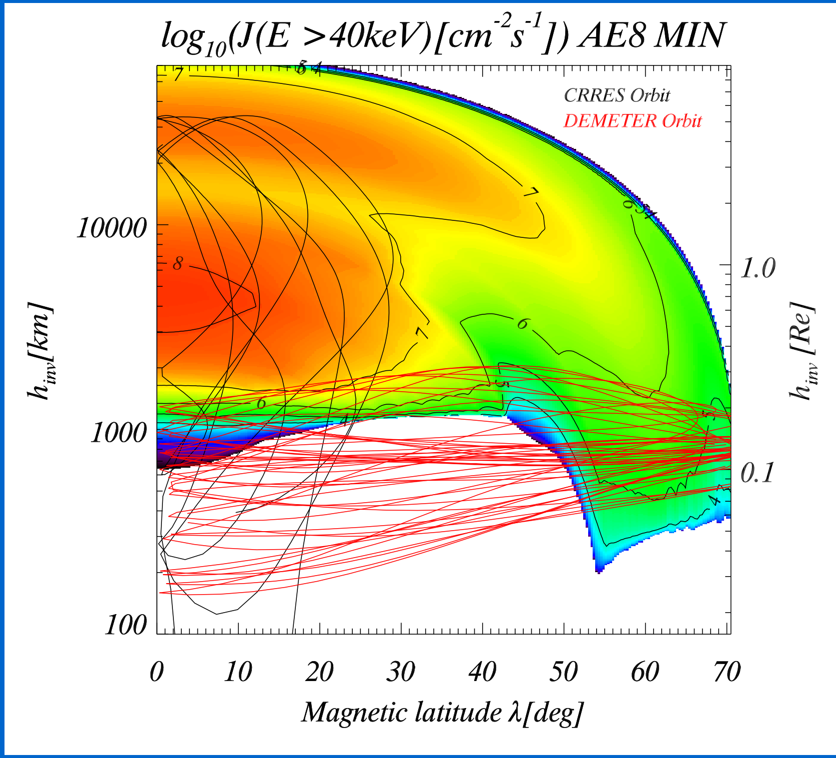
SPENVIS orbit generator
http://www.spenvis.oma.be/

LEO Orbit

Comparisons

α_0-L vs h_{inv}-λ

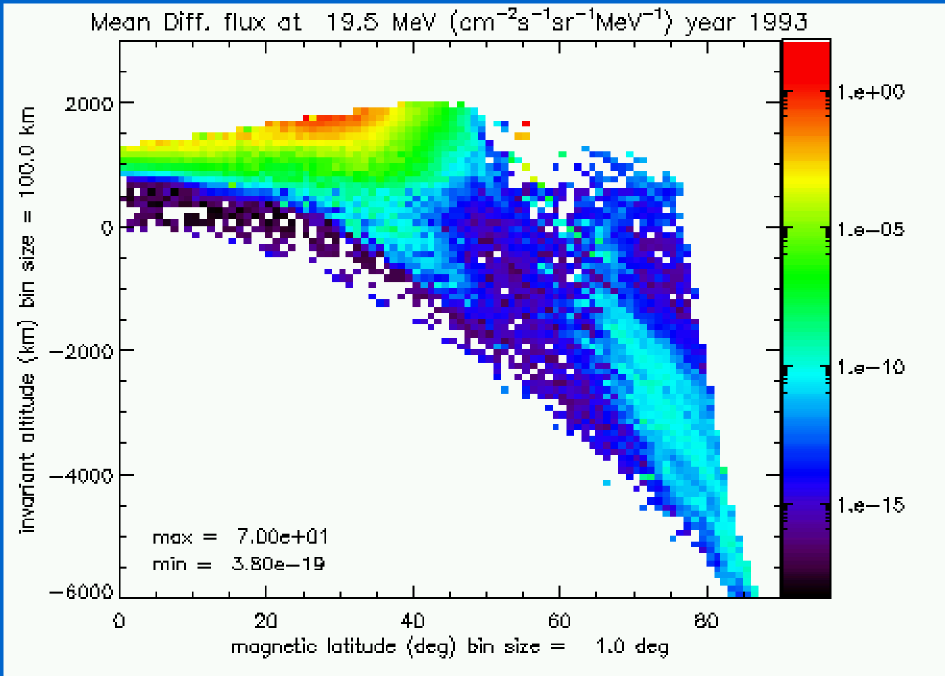




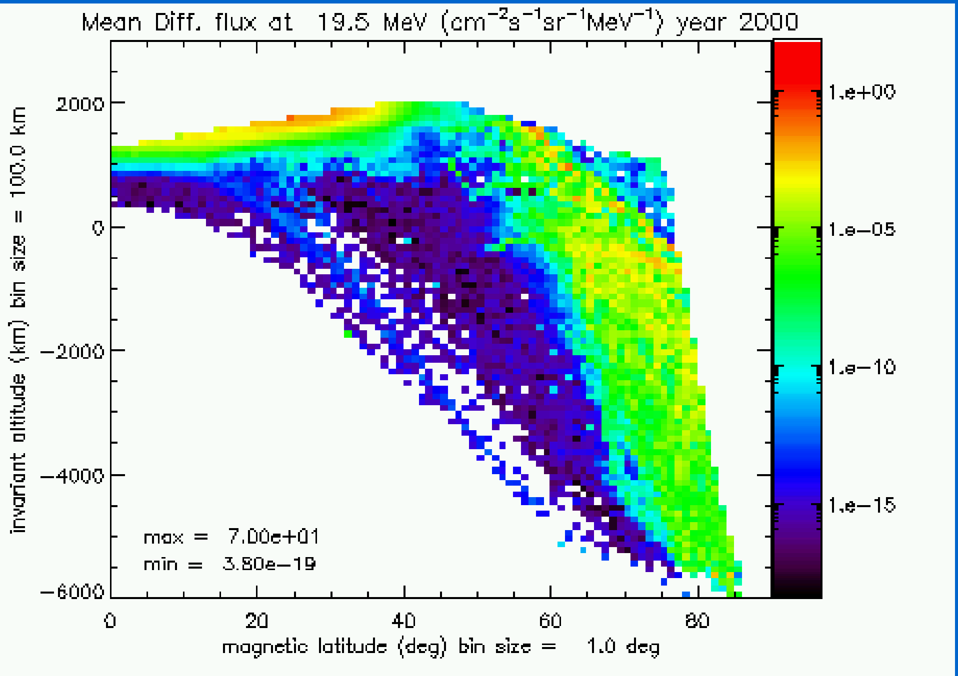
geosynchronous transfer orbit and LEO Orbit

Examples: SAMPEX/PET data

ONE YEAR MEAN DIFFERENTIAL PROTON FLUX



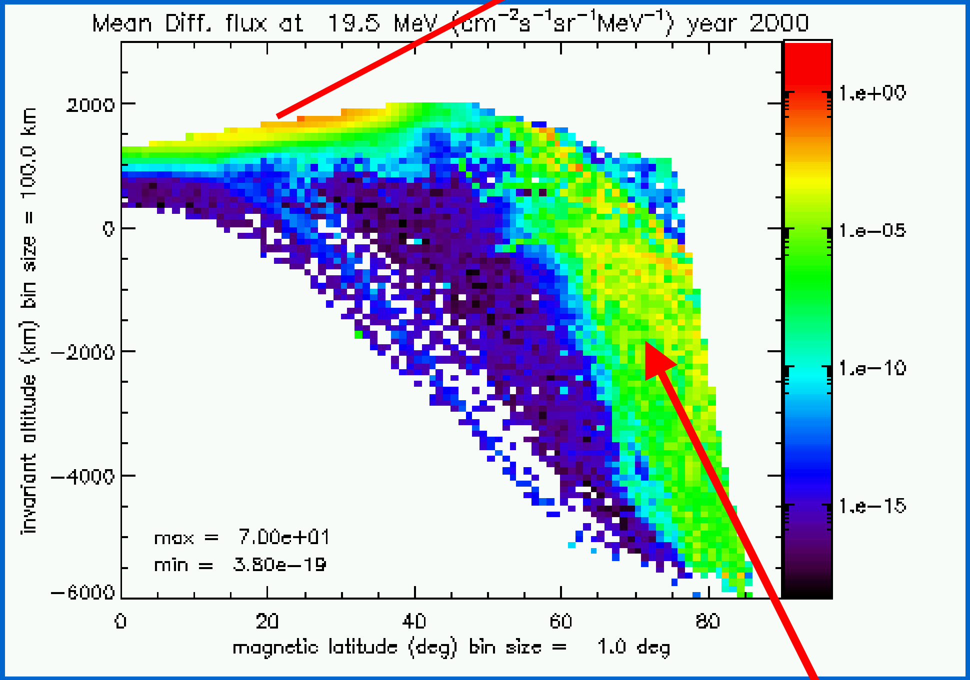
1993



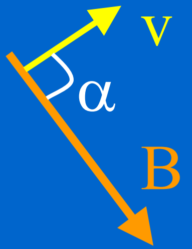
2000

Examples: SAMPEX/PET data

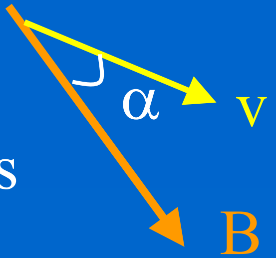
Proton Belt



Pich angle $\alpha \sim 90°$
Mirror point at satellite location



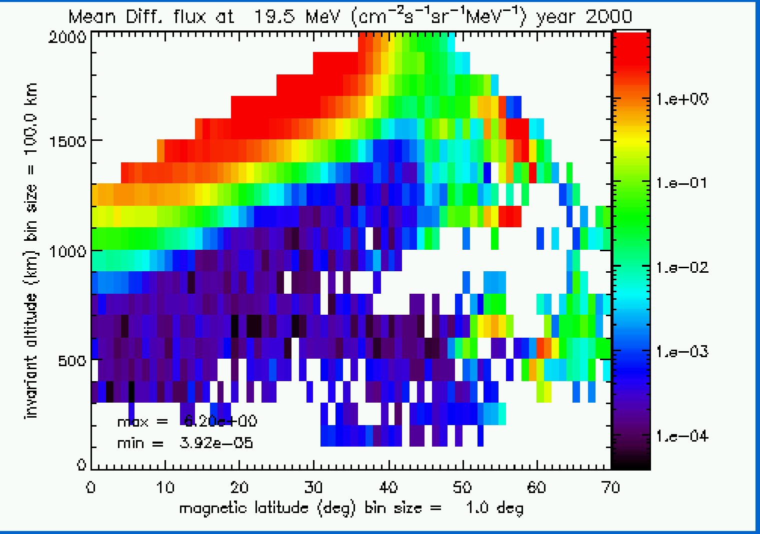
Pich angle $\alpha < 90°$
Mirror point inside the Earth

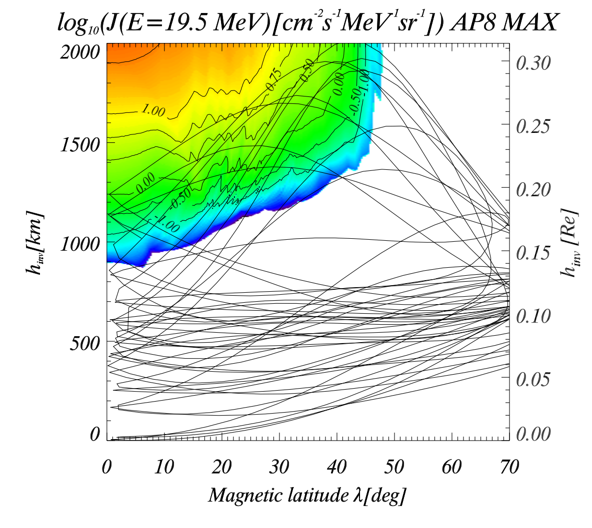


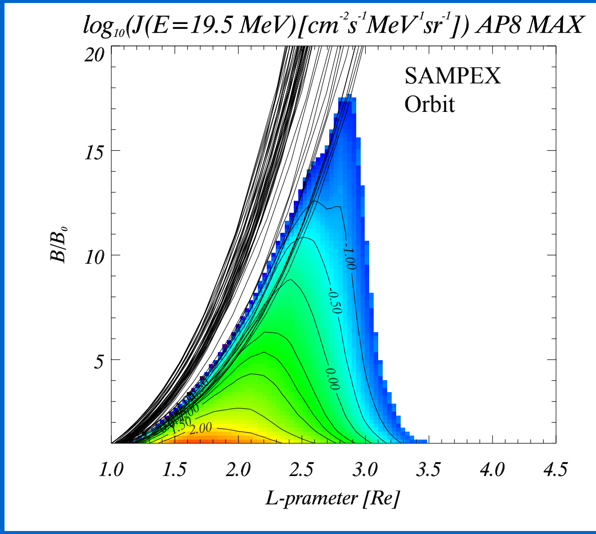
Precipitating protons
(Loss cone)

Examples: SAMPEX/PET data

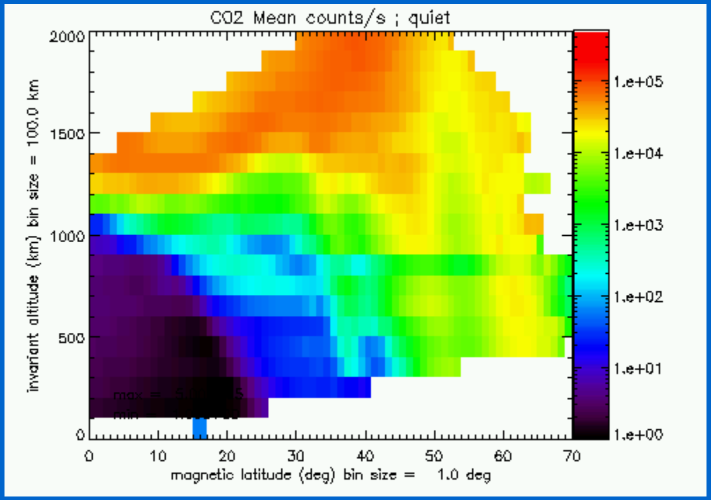
Pich angle
$\alpha \sim 90°$
Year 2000
Differential flux
Ep = 19.5 MeV

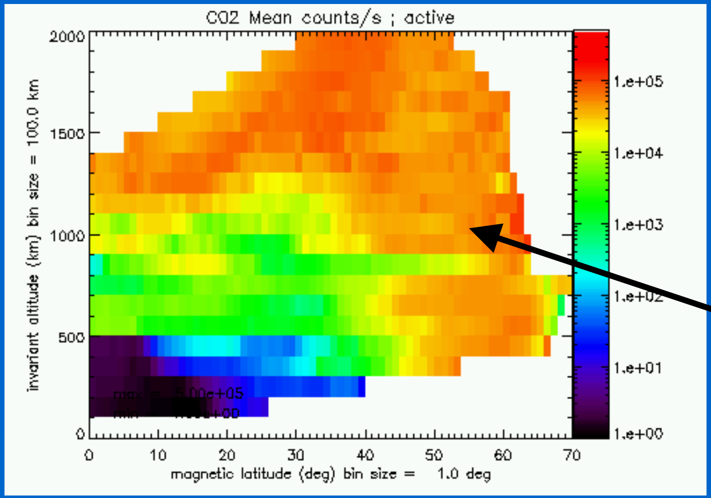






Examples: DEMETER/IDP data





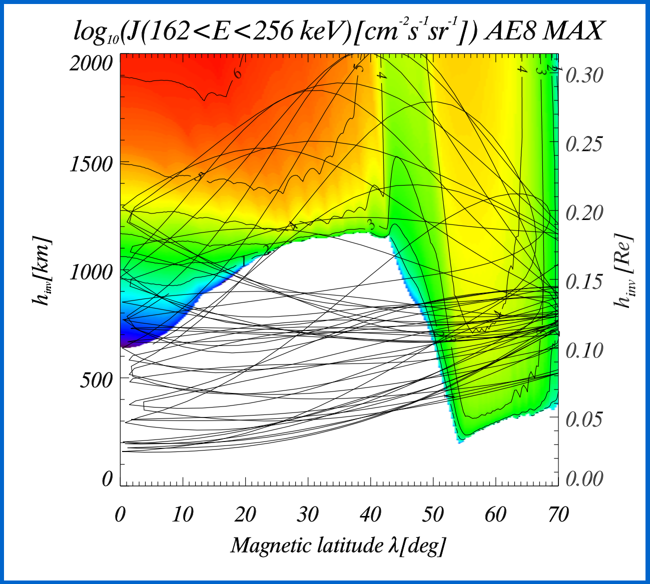
6 months data
1 Nov 2004
30 Apr 2005

Quiet periods
Dst > -50 nT
Kp < 4

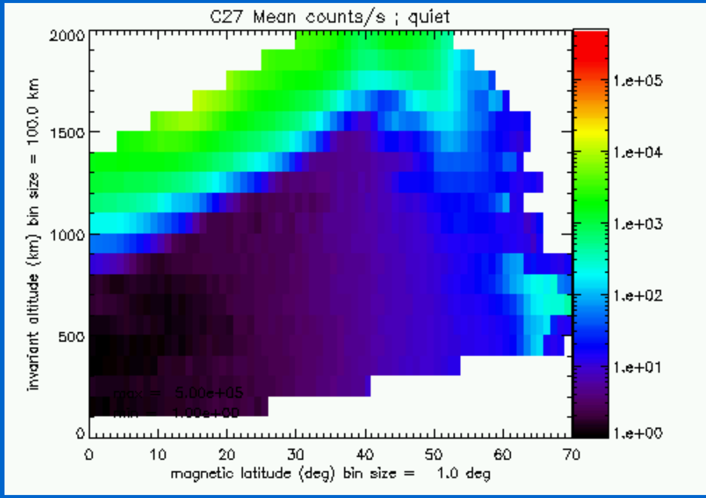
Active periods
Dst < -50 nT
Kp >= 4

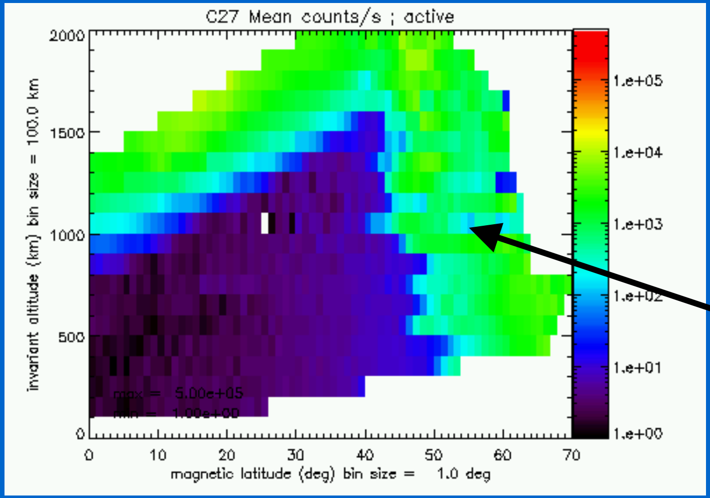
Injected electrons

Integral flux of Electrons
162 < E < 256 keV



Examples: DEMETER/IDP data



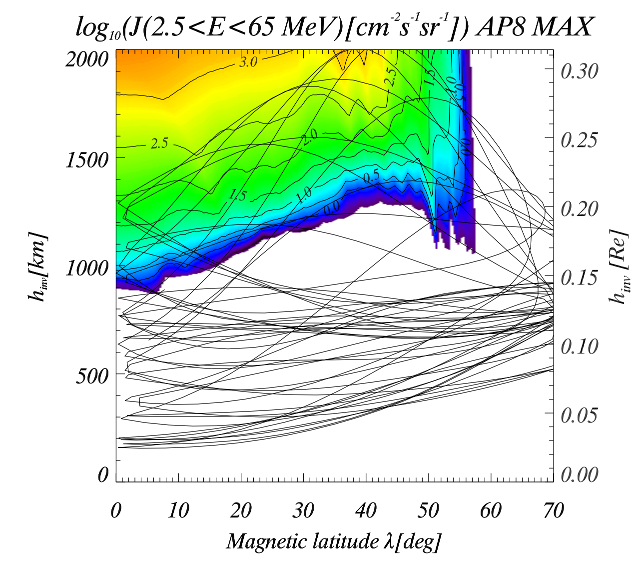


6 months data
1 Nov 2004
30 Apr 2005

Quiet periods
Dst > -50 nT
Kp < 4

Active periods
Dst < -50 nT
Kp >= 4

Integral flux of Protons
2.5 < E < 65 MeV



Injected protons

CONCLUSIONS

- The use of invariant altitude for mapping the radiations flux at low altitude improves the spatial resolution.
- Convenient way of visualisation and interpretation of data.
- The mapping of data from SAMPEX and DEMETER satellites is in progress.