IMPTAM: Seed population electrons during November 6-7, 1997 storm

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Inner Magnetosphere Particle Transport and Acceleration Model: Convection transport

(*Ganushkina et al., AnnGeo, 2005, JGR, 2006***)**

- Changes in distribution function f and flux calculations for ions and electrons **with arbitrary pitch angles** using ***Liouville*'s theorem** taking into account **loss processes**.

$$\frac{df}{dt} = \frac{\partial f}{\partial \phi} \cdot V_{\phi} + \frac{\partial f}{\partial r} \cdot V_{r} + sources - losses$$

- **Boundary distribution**: at any location from 6.6 to 10 Re
- **Transport of particles**:
  - Drifts with velocities, radial and longitudinal, as sum of **ExB and magnetic drifts, 1**st and 2nd inv = const in **time-dependent magnetic and electric fields** with self-consistent magnetic field

$$\mathrm{Vdrift} = \frac{\vec{E} \times \vec{B}}{B^2} + \frac{m v_{\perp}^2}{2qB^3}\left(\vec{B} \times \nabla B\right) + \frac{m v_{II}^2}{q} \frac{\vec{R}_c \times \vec{B}}{R_c^2 B^2}$$

$$\left\langle v_0 \right\rangle = \frac{\mathbf{E}_0 \times \mathbf{B}_0}{B_0^2} + \frac{2p}{q \tau_b B_0} \nabla I \times e_0, \qquad I = \int_{S_m}^{S_m'} \left[1 - B(s)/B_m\right]^{1/2} ds,$$

Inner Magnetosphere Particle Transport and Acceleration Model: Diffusion

Next **Radial diffusion** is applied (*Schulz and Lanzerotti*, 1974)

$$\frac{df}{dt} = L^2 \frac{\partial}{\partial L}\left(\frac{1}{L^2} D_{LL} \frac{\partial f}{\partial L}\right) - \frac{f}{\tau}$$

with diffusion coefficients D_{LL} (*Brautigam and Albert,* 2000)

$$D_{LL} = 10^{0.056 Kp - 9.325} L^{10}$$

And **Pitch- angle diffusion** by introducing electron lifetimes

- by *Chen et al*. (2005) for strong diffusion
- and *Shprits et al*. (2007) for weak diffusion

Inner Magnetosphere Particle Transport and Acceleration Model: Electrons' Lifetimes

Strong diffusion: $$\tau_{sd} = \left(\frac{\gamma m_0}{p}\right)\left[\frac{2\Psi B_h}{1-\eta}\right]$$

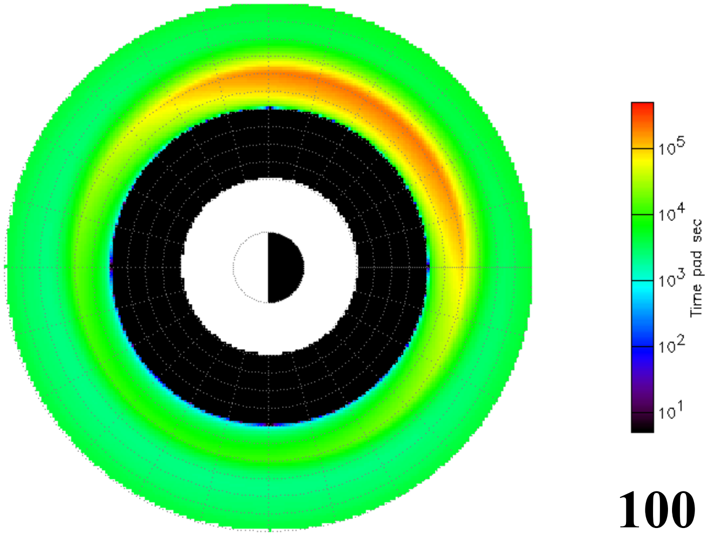
p is the particle momentum, γ is the ratio of relativistic mass to rest mass, Bh is the magnetic field at either foot point of field line, Ψ is the magnetic flux tube volume, η =0.25 backscatter coefficient (25% of electrons that will mirror at or below 0.02 Re are scattered back to flux tube instead of precipitating into atmosphere)

Weak diffusion: $$\tau_{wd} = 4.8 \cdot 10^4 B_w^{-2} L^{-1} E^2, \quad B_w^2 = 2 \cdot 10^{2.5+0.18Kp}$$

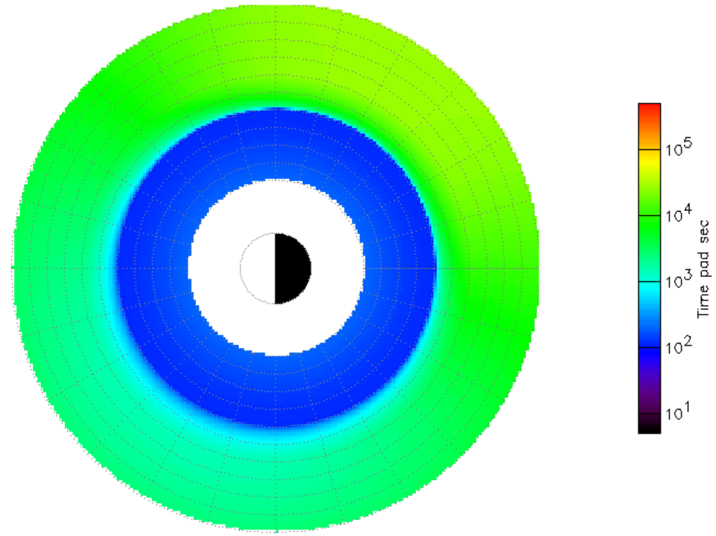
Bw is the local wave amplitude, E is kinetic energy in MeV

Electrons' life times

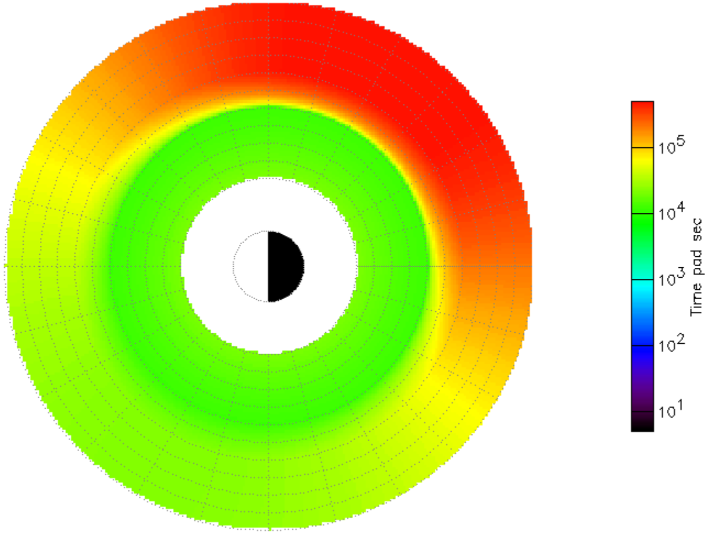
1 keV



10 keV



100 keV



Model-dependent Dst calculations during storms

1. Using **Dessler-Parker-Sckopke relationship**:

The energy in the ring current can be expressed by $\boxed{\frac{\Delta \vec{B}}{B_E} = -\frac{2}{3}\frac{W_{RC}}{W_{mag}}\hat{k}}$, where

$W_{mag} = \frac{4\pi}{3\mu_0} B_E^2 R_E^3$ is the total energy in the Earth's dipole magnetic field above the surface, B_E is the magnetic field at the Earth's surface, R_E is one Earth radii (6371 km).

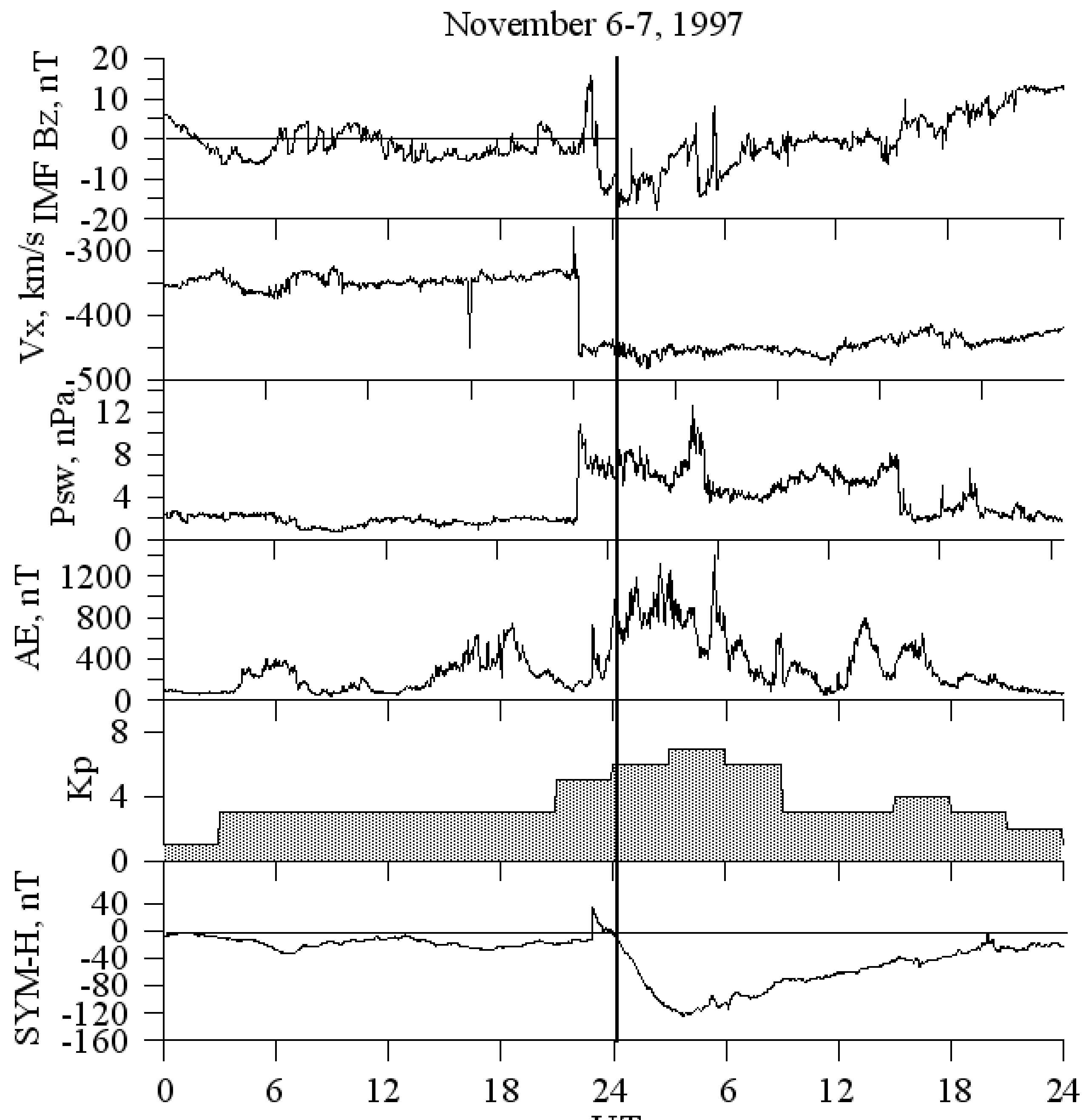
$\Delta \vec{B}$ is the change in B measured at the surface of the Earth (Dst).

2. Calculating from the model ring current by **Biot-Savart law**:

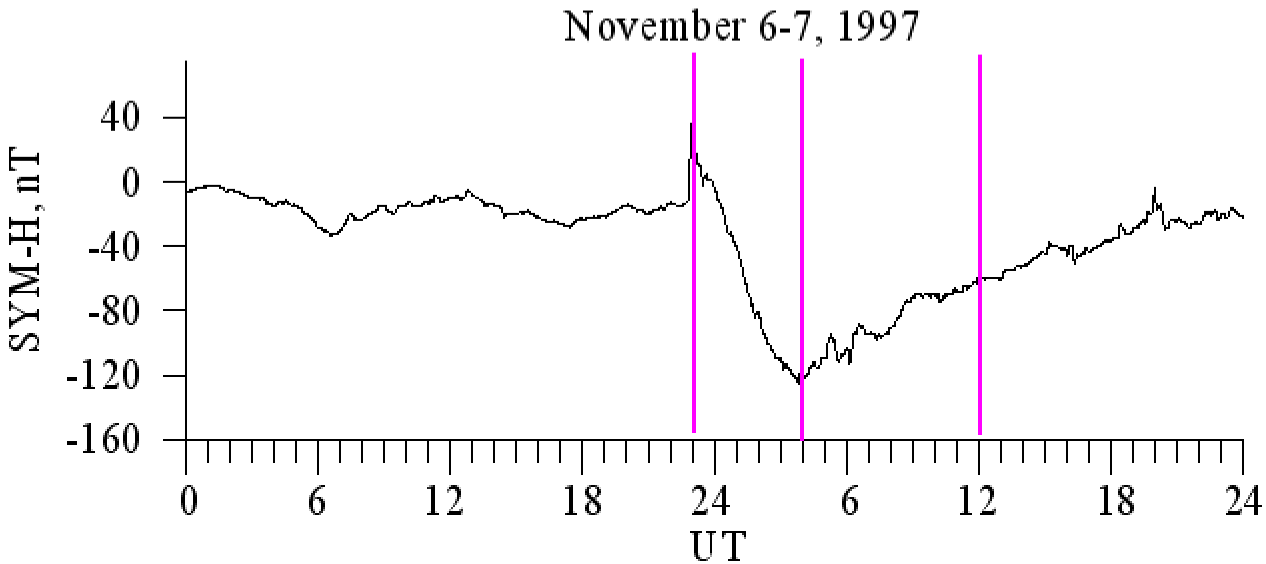
The magnetic disturbance parallel to the earth's dipole at the center of the earth *ΔB* induced by the azimuthal component of $J_\perp$, is given by

$$\boxed{\Delta B = \frac{\mu_0}{4\pi}\int_r \int_\lambda \int_\phi \cos^2 \lambda J_\phi (r, \lambda, \phi) dr d\lambda d\phi}$$

$$\vec{j}_\perp = \frac{\vec{B}}{B^2} \times \left(\nabla P_\perp + \frac{P_{II} - P_\perp}{B^2} \left(\vec{B} \cdot \nabla\right)\vec{B} \right)$$

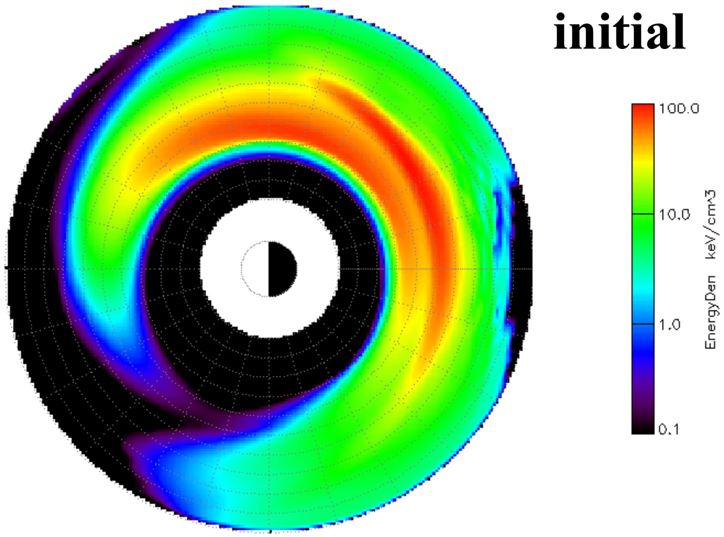

November 6-7, 1997
IMF Bz, nT
20
10
0
-10
-20
Vx, km/s
-300
-400
-500
Psw, nPa
12
8
4
0
AE, nT
1200
800
400
0
Kp
8
4
0
SYM-H, nT
40
0
-40
-80
-120
-160
0
6
12
18
24
6
12
18
24
UT

Time moments for model output

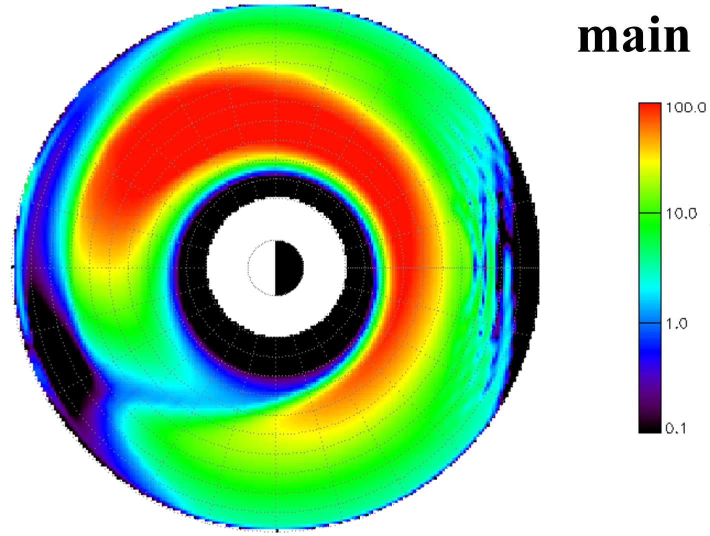


Electrons' energy density

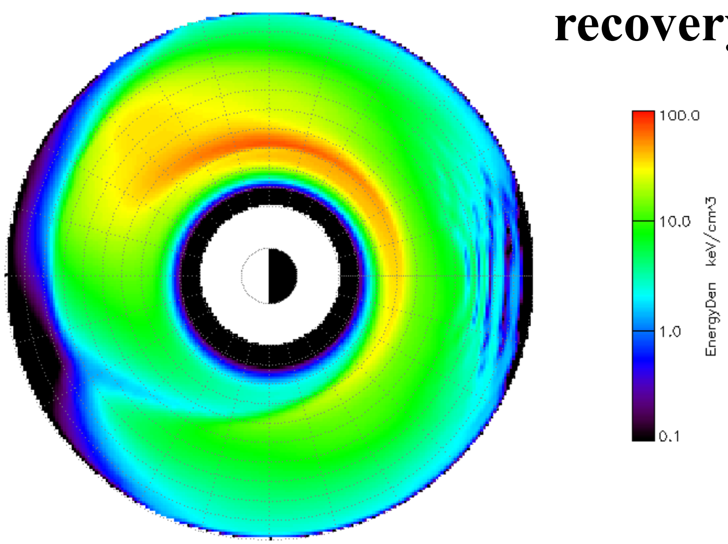
initial



main



recovery



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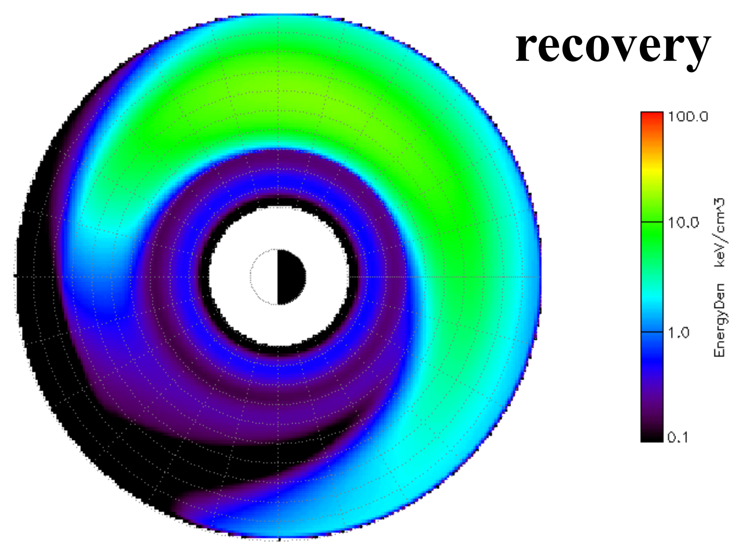
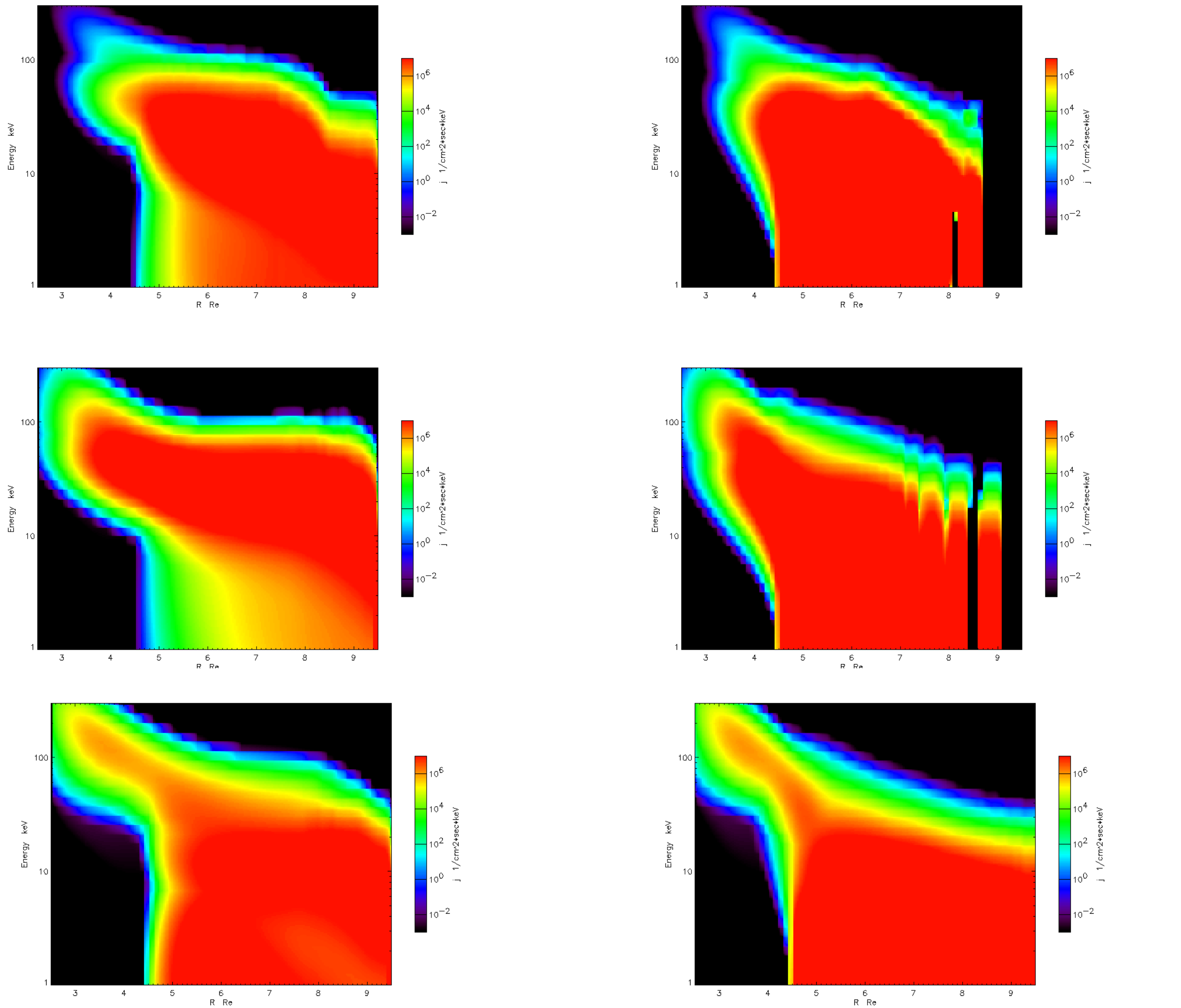


Radial profiles of electrons fluxes

noon **midnight**



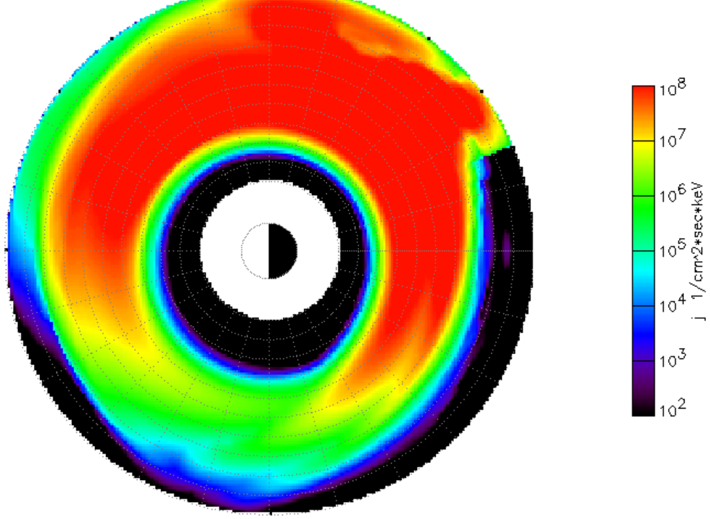
initial

main

recovery

Equatorial electron fluxes, 30 keV

initial



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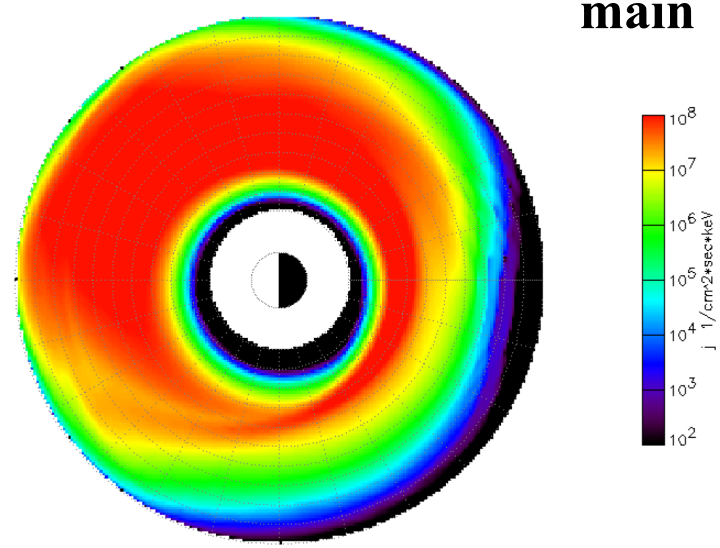
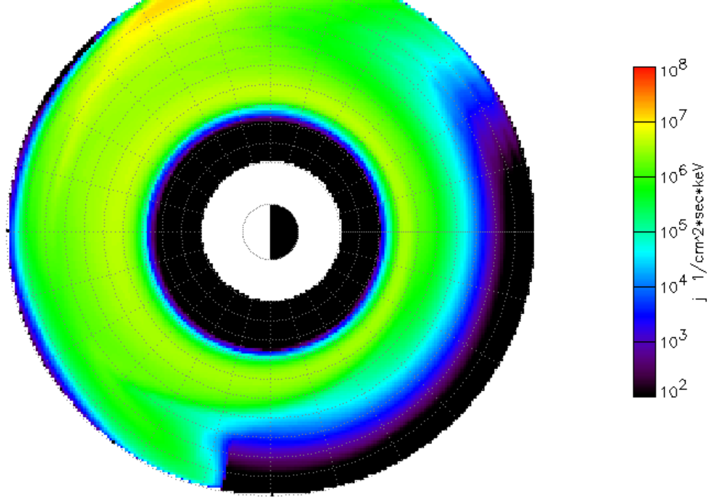
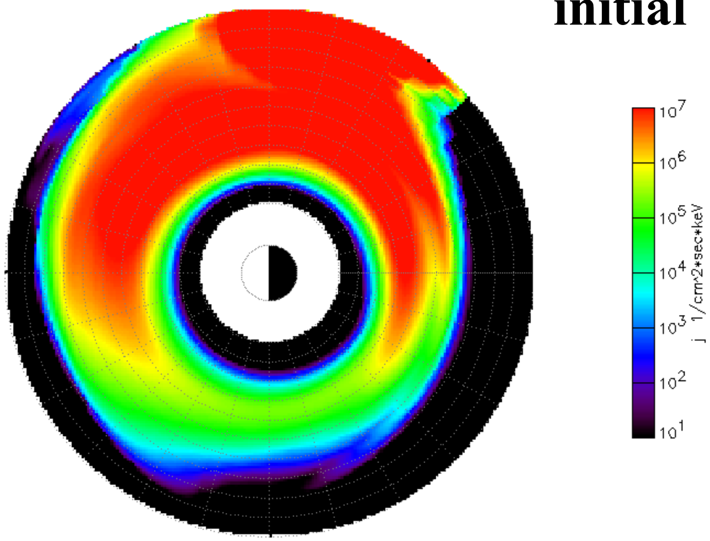


recovery



Equatorial electron fluxes, 50 keV

initial



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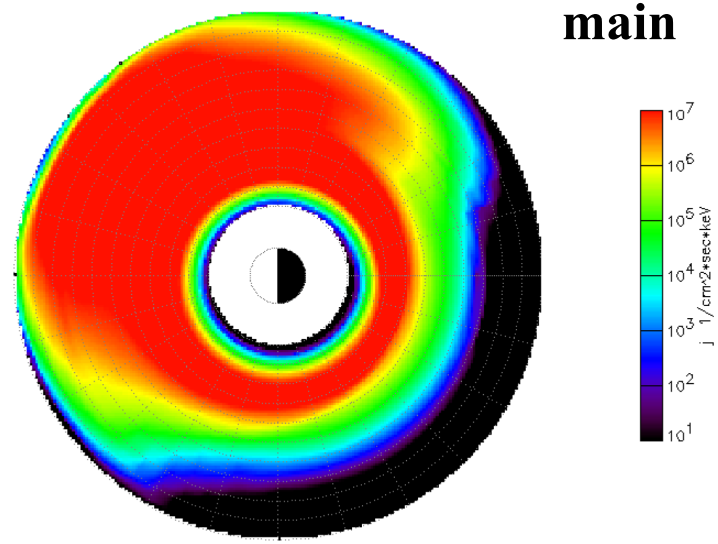
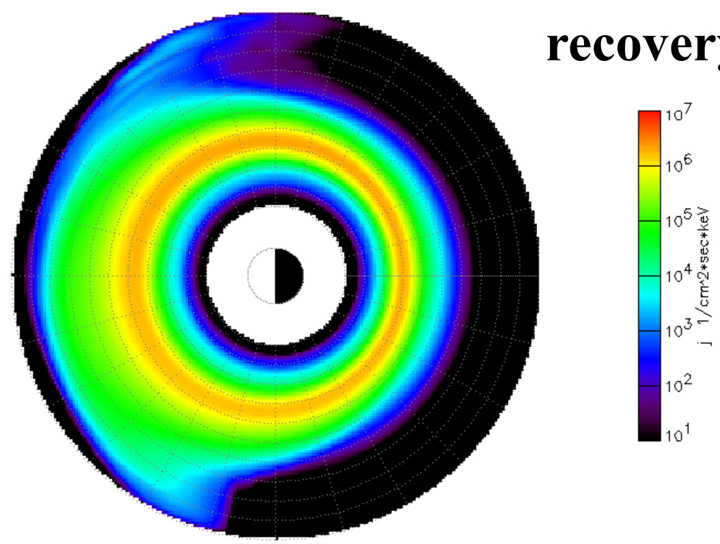
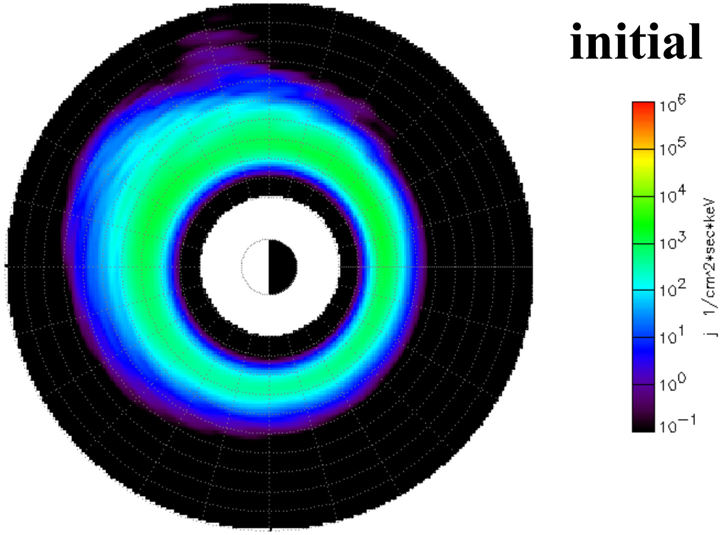


recovery



Equatorial electron fluxes, 100 keV

initial



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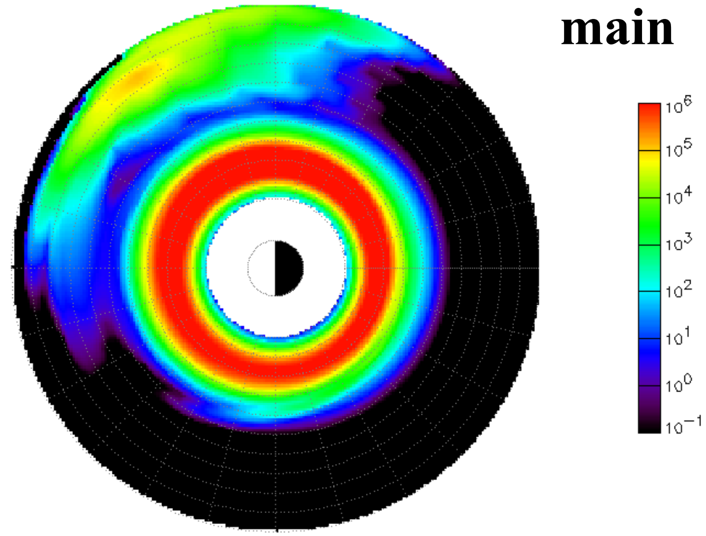

recovery