Magnetically Self-Consistent Ring-Current Simulations for the Storm of 19 October 1998

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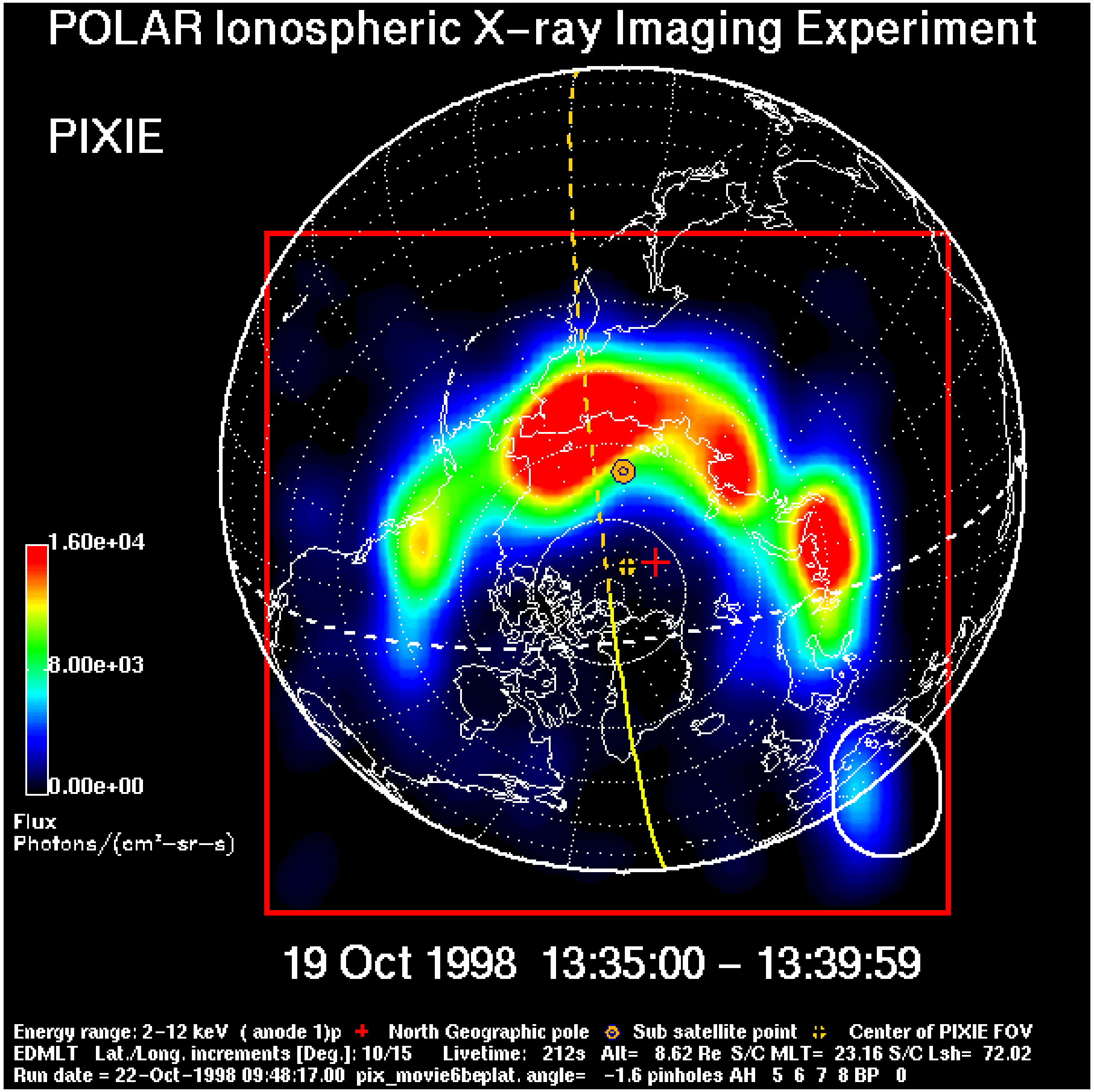
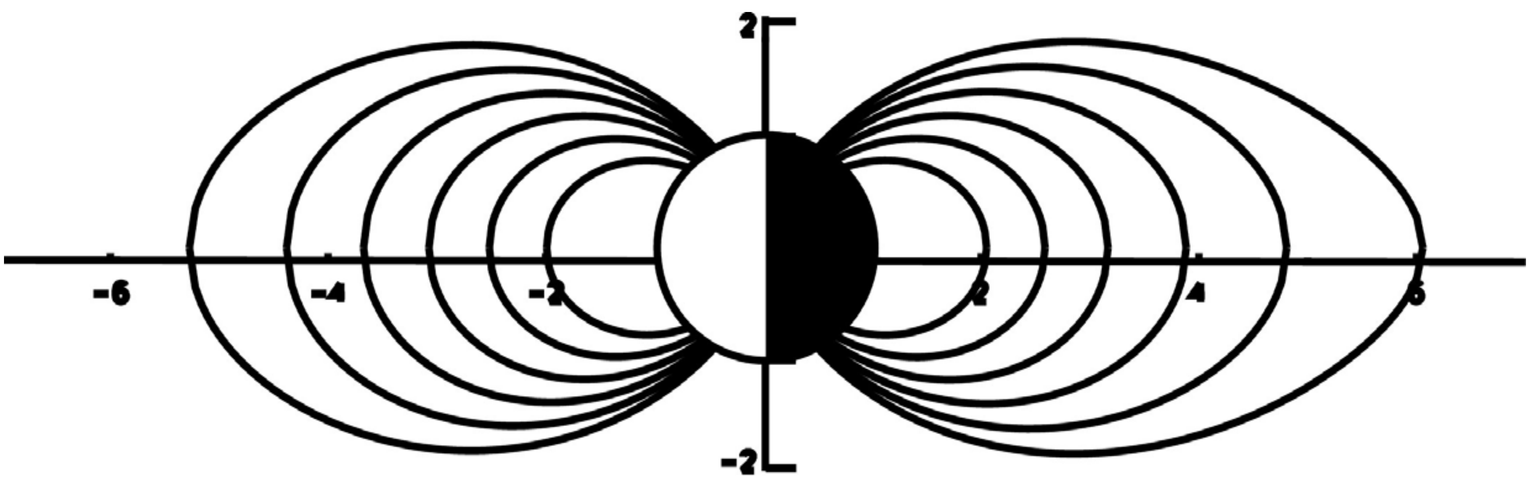

POLAR Ionospheric X-ray Imaging Experiment
PIXIE
1.60e+04
8.00e+03
0.00e+00
Flux
Photons/(cm²-sr-s)
19 Oct 1998 13:35:00 – 13:39:59
Energy range: 2-12 keV (anode 1)p + North Geographic pole Sub satellite point Center of PIXIE FOV
EDMLT Lat./Long. increments [Deg.]: 10/15 Livetime: 212s Alt= 8.62 Re S/C MLT= 23.16 S/C Lsh= 72.02
Run date = 22-Oct-1998 09:48:17.00 pix_movie6beplat. angle= -1.6 pinholes AH 5 6 7 8 BP 0

Simulation Model

- Magnetic field lines: $r = L\boldsymbol{a}\,[1 + 0.5(r/b)^3]\,\sin^2\theta$ where b is a stretching factor that varies with L and ϕ. These field lines lie in meridional planes. Electric potential function:

$$\Phi_E(L,\phi) = q\left[-\frac{V_{cor}}{L} + V_0\left(\frac{L}{L^*}\right)^2 \sin\phi + \Delta V\left(\frac{L}{L^*}\right)\sin\phi\right]$$

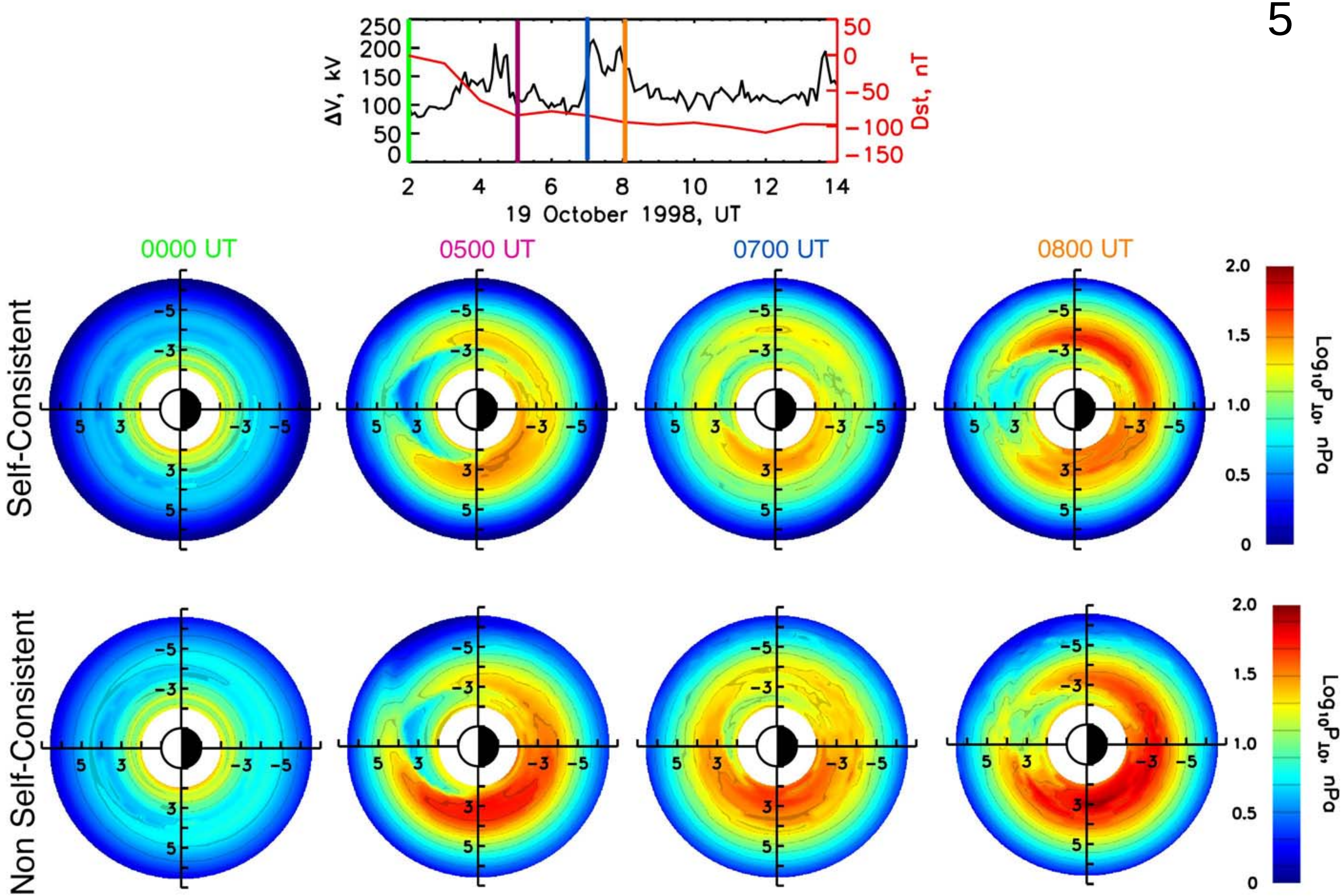
where V_{cor} = 90.3 kV; V_0 = 25 kV, $\Delta V = \Delta V(t)$

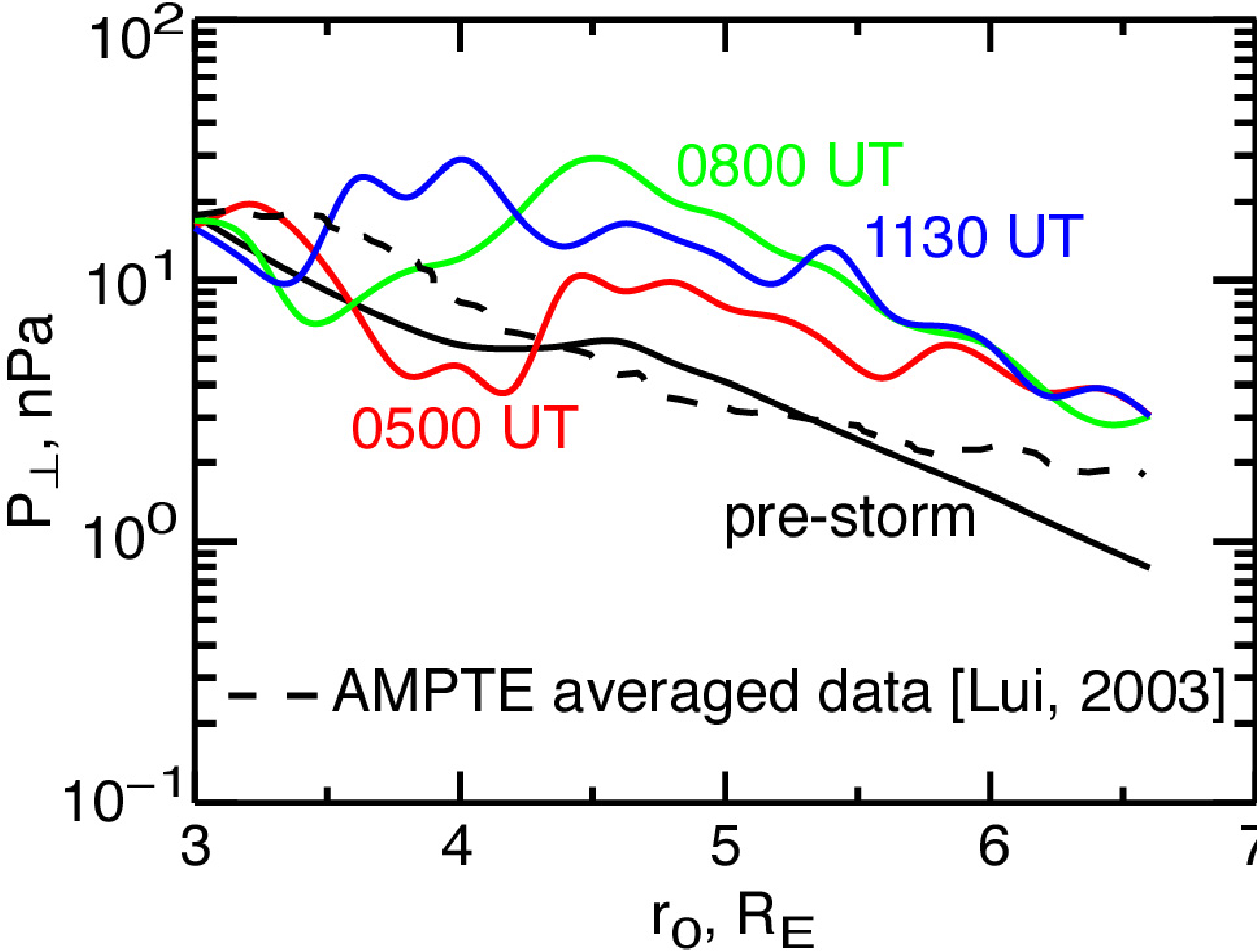


Simulation Model, cont.

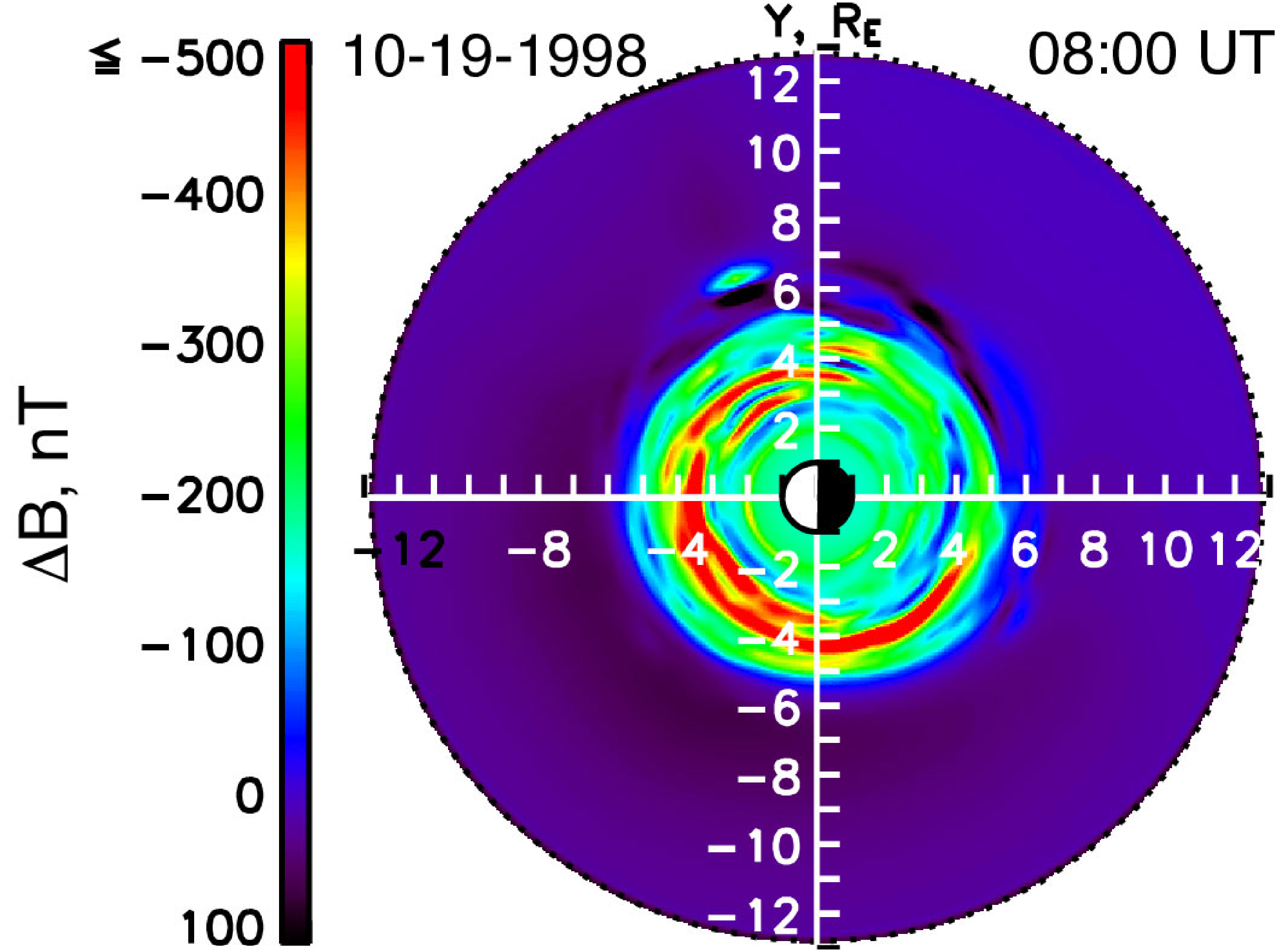
- Trace drifts of equatorially-mirroring ions & electrons, conserving M & J
- Initial conditions: solution to steady state transport equation
- Boundary conditions based on time-averaged LANL/MPA data at GEO [*Korth et al*., 1999]
- Proton loss: charge exchange
- Electrons loss: weak diffusion inside the plasmasphere [*Albert*, 1994]; enhanced scattering (due to ECH waves) outside [*Lyons*, 1974]
- Map phase-space density by Liouville's theorem, modified to account for losses
- Compute near-equatorial plasma pressure at each major time step
- Compute resulting $\Delta\mathbf{B}(\mathbf{r})$ normal to equatorial plane
- Update $\mathbf{B}(\mathbf{r})$ at each major time step (Δt = 20 min)
- Do the guiding-center simulation again for the updated $\mathbf{B}(\mathbf{r})$
- Iterate until convergence to desired self-consistent model (plasma and **B** field) is achieved

PERPENDICULAR PRESSURE



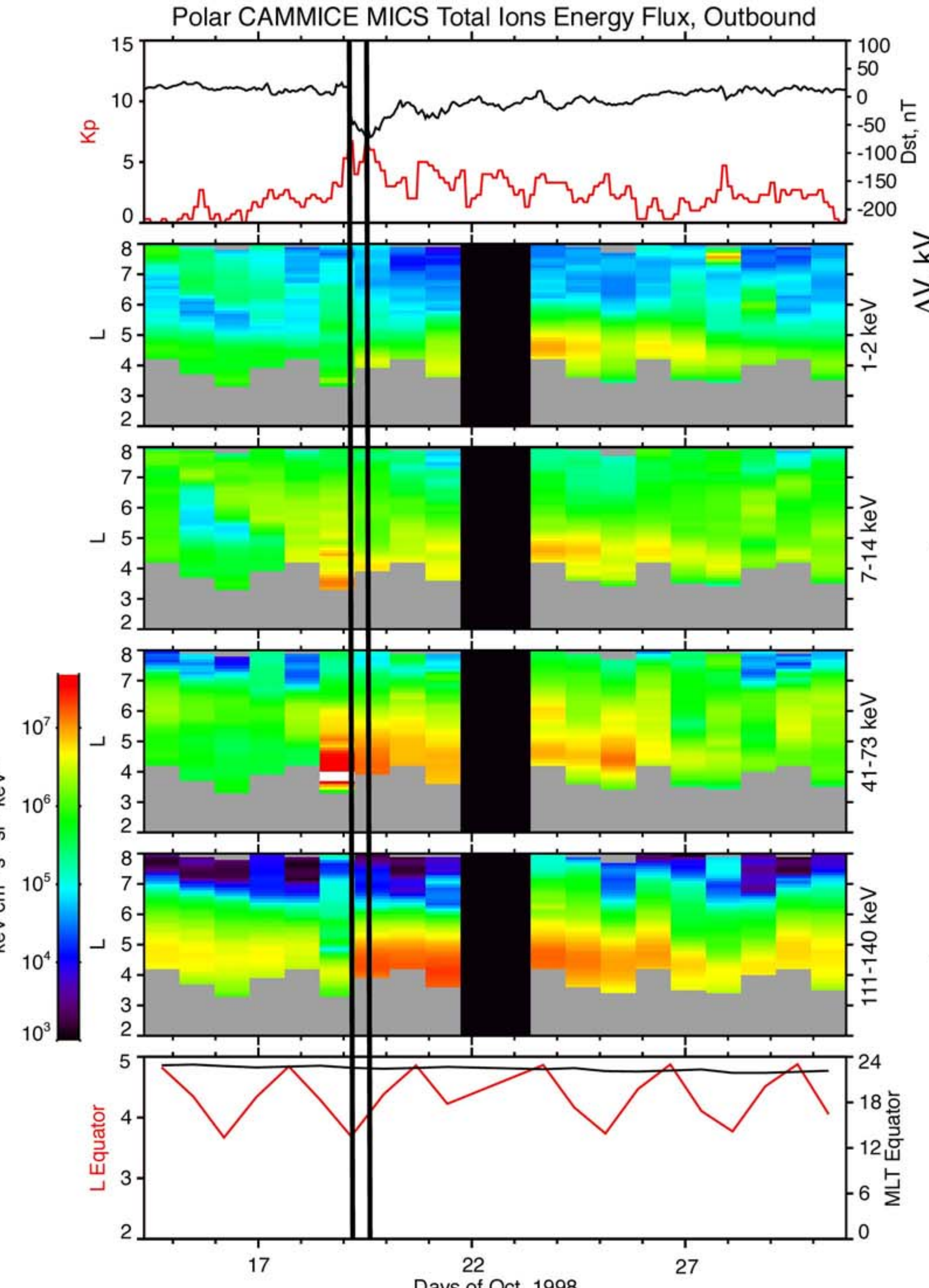


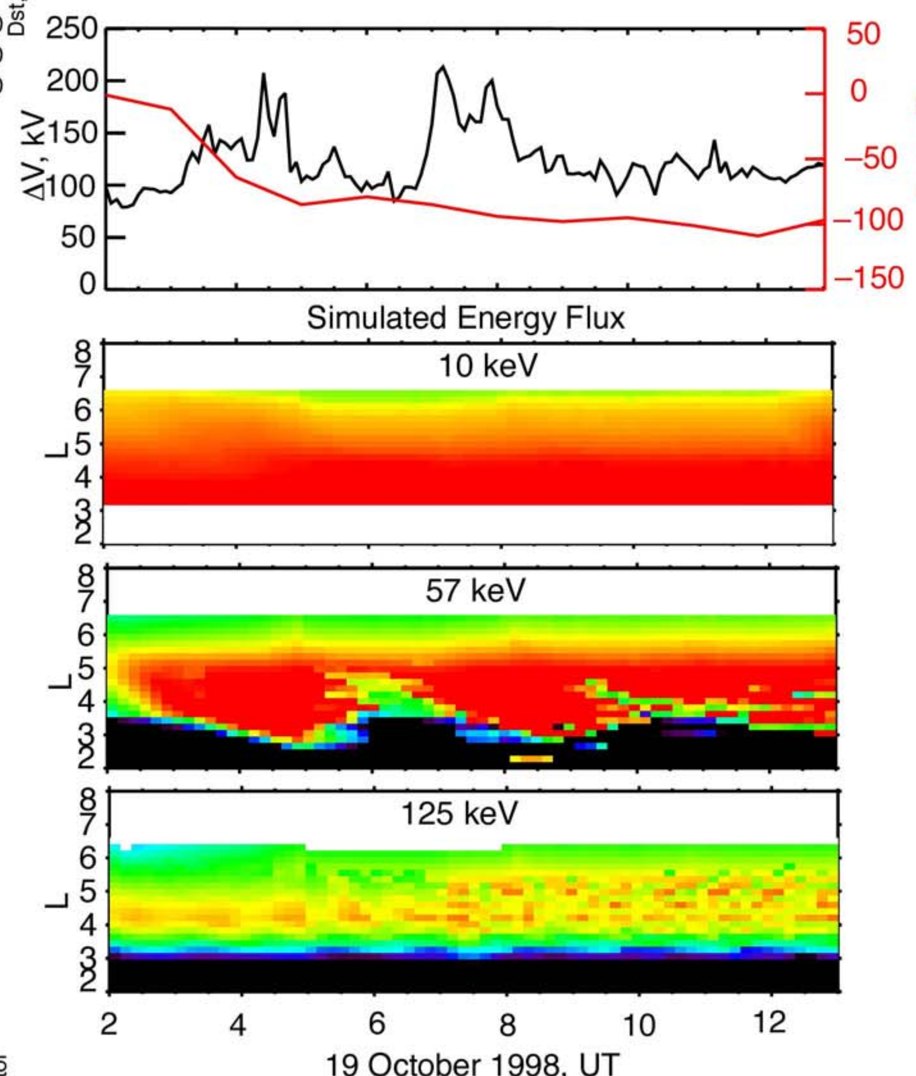
0800 UT
1130 UT
0500 UT
pre-storm
AMPTE averaged data [Lui, 2003]
10^2
10^1
10^0
10^{-1}
$P_\perp$, nPa
3
4
5
6
7
r_O, R_E


≤ −500
−400
−300
−200
−100
0
100
ΔB, nT
10-19-1998
08:00 UT
Y, R_E
12
10
8
6
4
2
−2
−4
−6
−8
−10
−12
−12
−8
−4
2
4
6
8
10
12

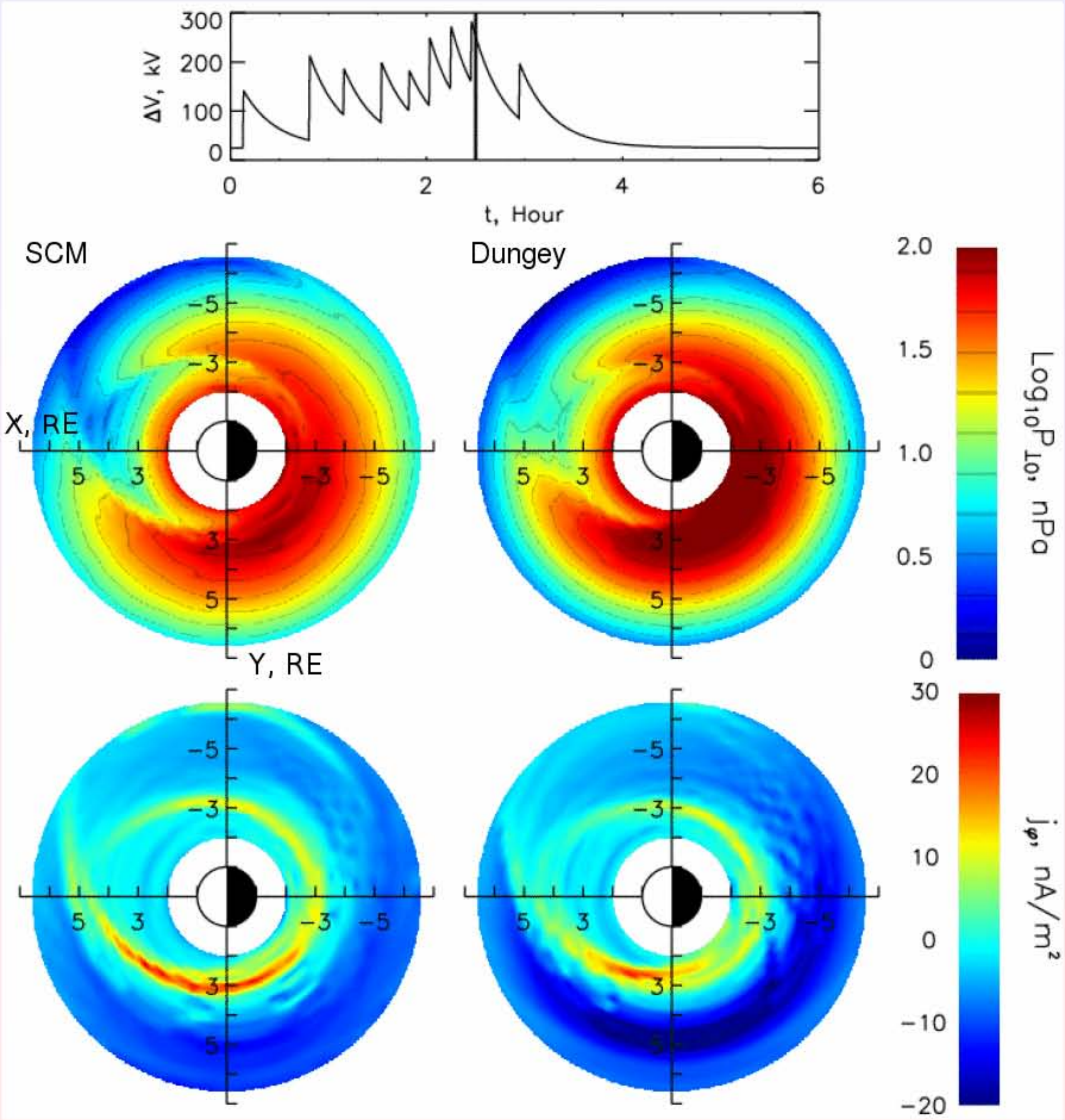
- Consistency of **B** field with hot-plasma population tends to mitigate energization of plasma during transport into the ring current, as compared to simulations that lack a self-consistent magnetic field. This confirms findings of RCM-E simulations [*Lemon et al*., 2004].

- Our model qualitatively reproduces features seen in statistically averaged observations of ring current [e.g., *Le et al*., 2004].


Polar CAMMICE MICS Total Ions Energy Flux, Outbound
Kp
Dst, nT
L
1-2 keV
7-14 keV
41-73 keV
111-140 keV
L Equator
MLT Equator
17
22
27
Days of Oct, 1998


ΔV, kV
Dst, nT
Simulated Energy Flux
10 keV
57 keV
125 keV
L
19 October 1998, UT

Comparison of the Simulated Pressure and Current Density



Comparison of simulated pressure and current density in self-consistent magnetic field model (SCM) and Dungey model (dipole plus a uniform southward field).

- Pressure in Dungey model is much larger. Note the scale is logarithmic.
- Westward current in Dungey model is larger, while eastward current in SCM is larger.

10

Comparison of $\Delta B(0)$