The evolution of ring current ion energy density and spectrum during geomagnetic storms based on Van Allen Probes measurements

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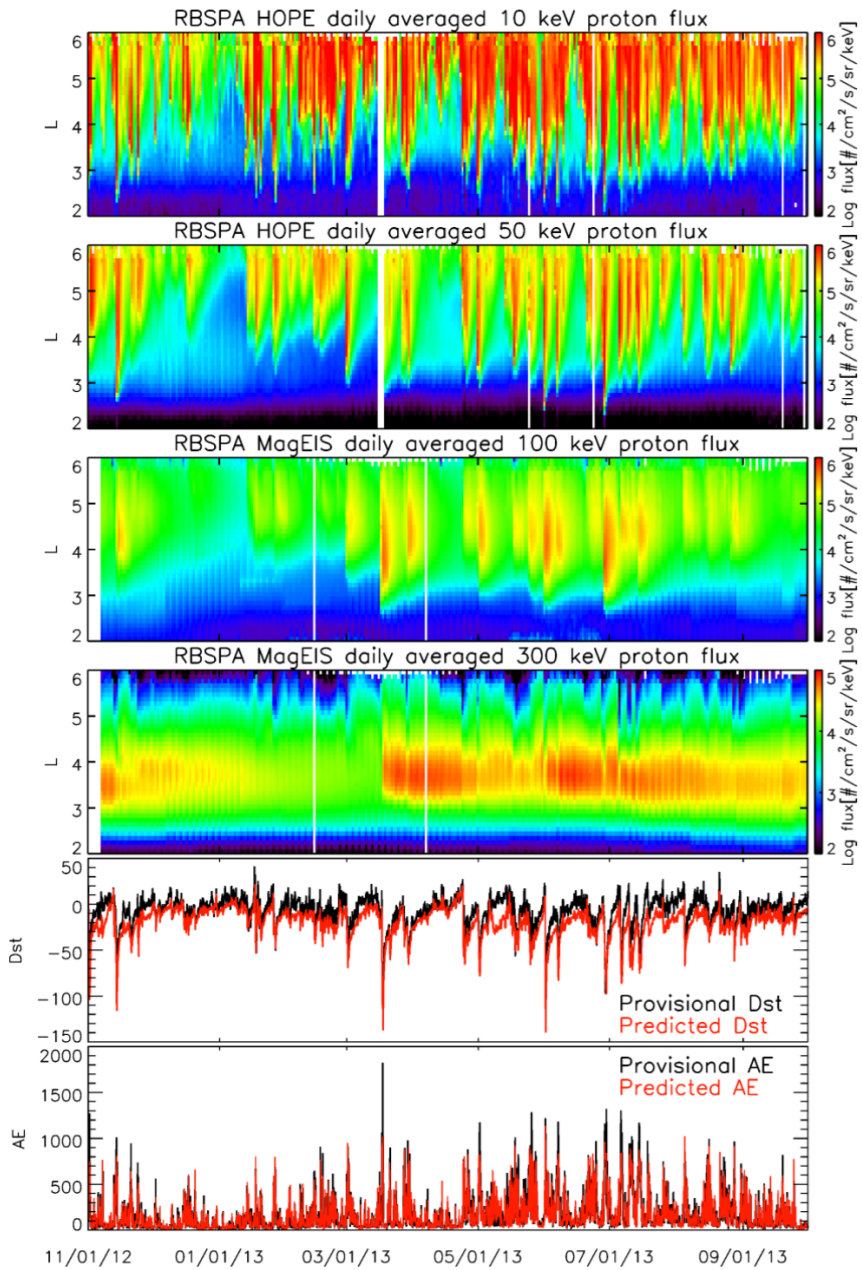
"Whereas many of the results have been known for some time, this paper does a nice job of tying them all together in one publication, and of using the better quality data provided by the Van Allen Probes to confirm many of those points."

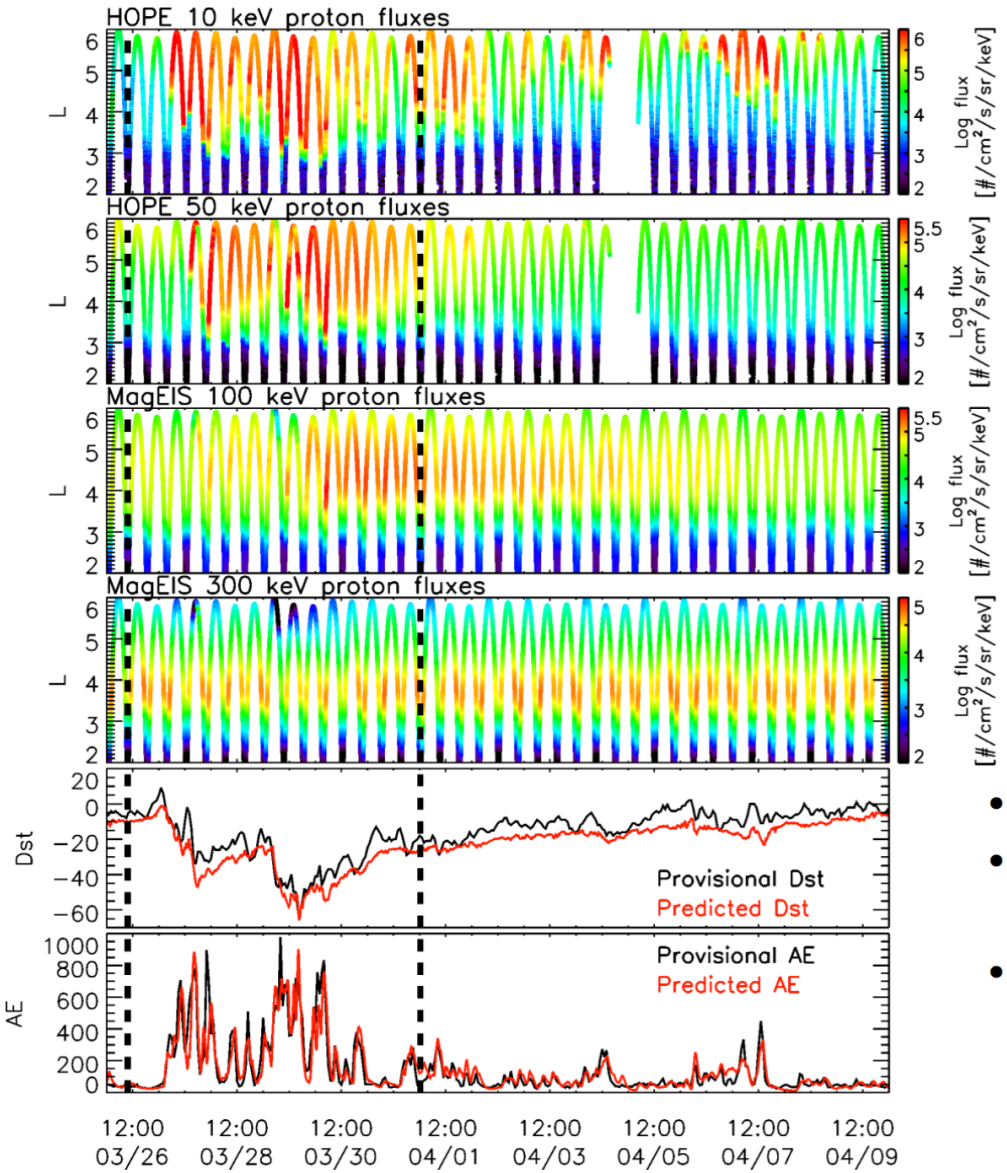
Don Mitchell

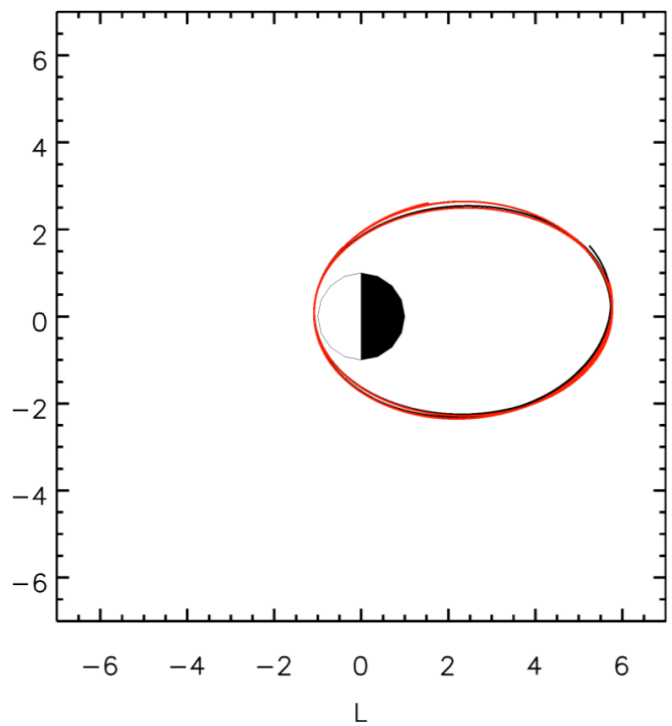
Long-term variation of ring current proton fluxes



- The enhancement of fluxes of protons with lower energies occurred much more often than those of higher energy protons, while 300 keV proton fluxes only exhibit great enhancement during very intense geomagnetic storms and decay very slowly;
- Protons with lower energies can penetrate deeper than higher energies;
- Lower energy protons also decayed much faster than those of higher energies.

Event study: 2013/03/26-2013/04/10



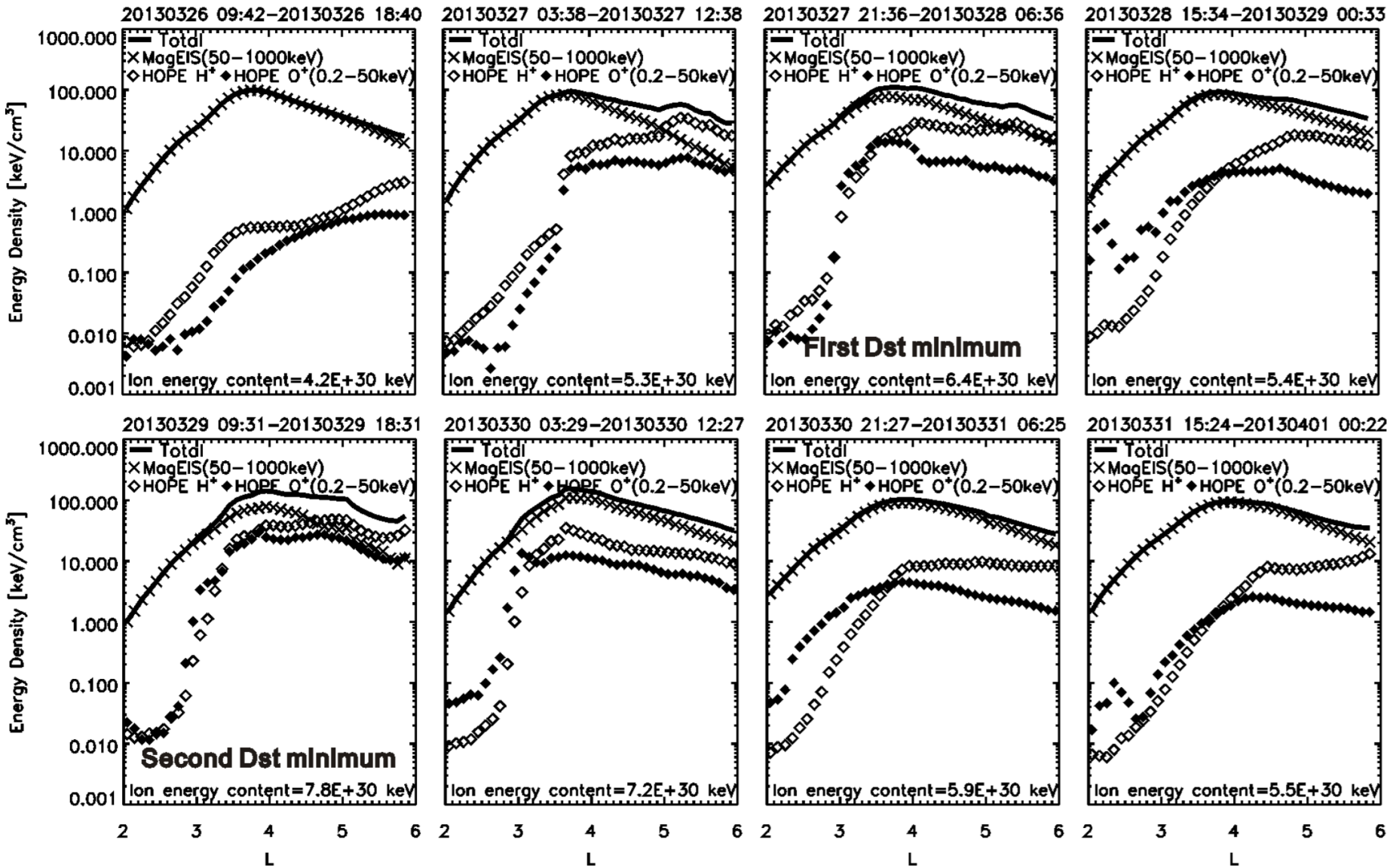


- Moderate storm with double Dst minima
- The apogee of Van Allen Probe was around midnight
- Fluxes of 10, 50 and 100 keV protons enhanced significantly; while 10 keV proton fluxes enhanced earlier than fluxes of higher energies.

Ring current energy density and energy content

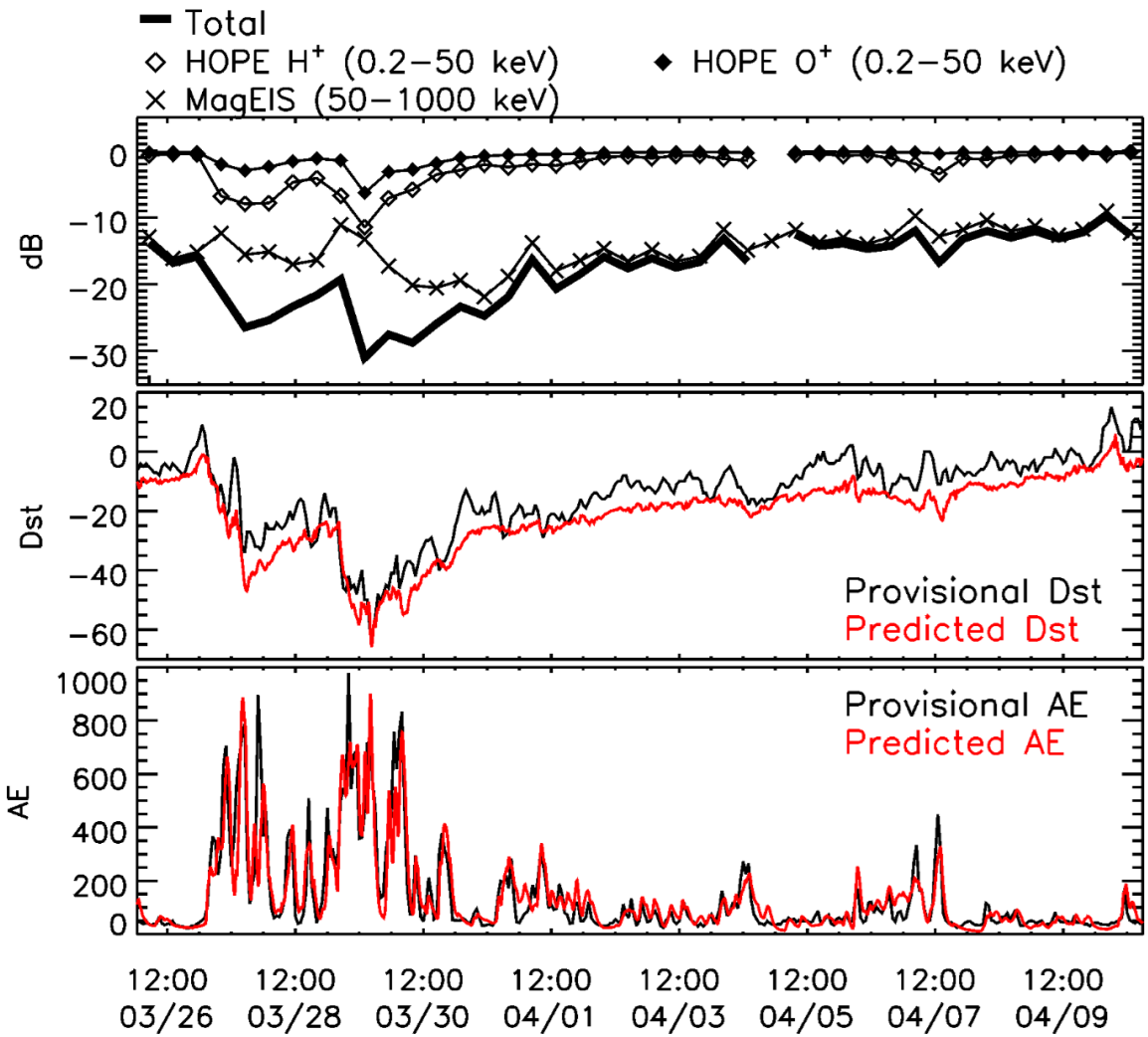
- Ring current energy density $\varepsilon = \int_0^\infty \sqrt{\frac{mE}{2}} J(E) dE$
- Ring current energy content $E_{rc} = \int \varepsilon dx^3 \approx \sum \varepsilon \Delta V(L)$
  - L: $L\_dipole(L = r/\cos^2\lambda)$; r, λ: radial distance/ magnetic latitude of S/C in centered dipole coordinates
  - $\varepsilon(L)$: energy density as a function of L shell
  - $V(L)$: volume contained between a dipole field line and the surface of the Earth; $\Delta V(L) = V(L + 0.05) - V(L - 0.05)$
  - Assume the energy density is constant at a fixed L in the dipole field

Orbit-averaged ring current energy density and energy content during 2013/03/29 geomagnetic storm



The comparison between calculated ΔB based on the DPS relation and the Dst index

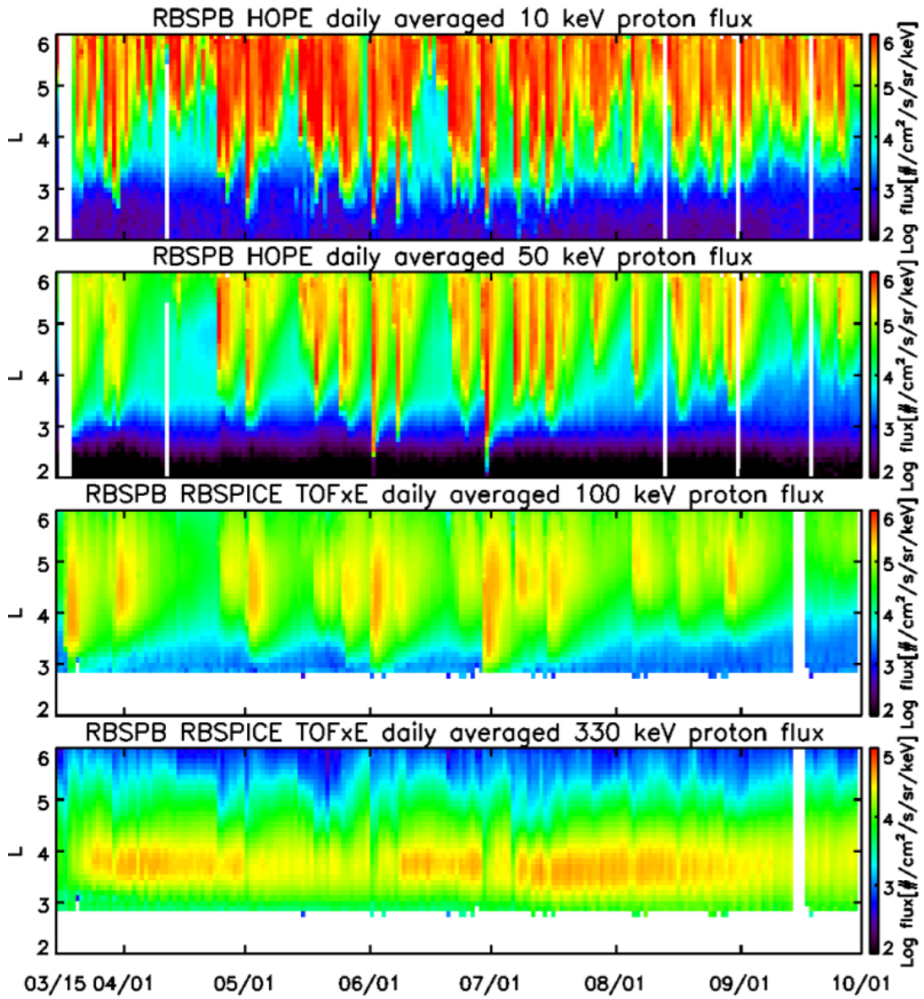
$$\frac{\Delta B}{B_S} = -\frac{2E}{3E_M} \qquad \Delta B = -\frac{E_{rc}[keV]}{2.51 \times 10^{29}}\, nT$$



- The depression of ΔB calculated by DPS relation accounts for ~45% of the Dst depression at the minimum Dst.
- The contribution of lower energy ions to ΔB dominated around the minimum of Dst;
- For higher energy protons measured by MagEIS, the contribution reached its maximum at the recovery phase rather than the time of minimum Dst.

Comparison of ring current proton/O^+ fluxes using data from HOPE and RBSPICE

Proton



O^+