Five-Plus Years of Radiation Belt Measurements: Space Weather in Earth’s Neighborhood

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Thanks to: V. Hoxie, H. Singer, and ECT Team
Twin Van Allen Probes (9/2012 – Present)
Rad Belt Work With Non-GTO Spacecraft

Wind

Polar

HEO

Geosynchronous
LANL (3)
GOES (2)

SAMPEX

GPS (3)
Long Runs of Geostationary Orbit Data

Example: 10 years of E > 2 MeV Electron Fluences [H.-L. Lam, JASTP, 2004]
GEO: The Tip of the Iceberg

Van Allen Probes: September 2012 to November 2017

Looking at $E \sim 2$ MeV electrons just around geostationary orbit ($L > 6.0$)
GPS: Below the Tip of the Iceberg

Examining $E \sim 2$ MeV electron fluxes over the range obtainable from Global Positioning System operational sensors ($L > \sim 4.2$)
Van Allen Probes: The Whole Iceberg

Measuring the full range of radial distances in the radiation belts for relatively fine differential energy slices has been a key contribution of the Van Allen Probes mission.
 Courtesy: Xinlin Li
Van Allen REPT Data: 3 Years

Ukhorskiy et al., 2016
Electron Flux (cm$^2$ s sr MeV$^{-1}$)

REPT A & B

4.2 MeV Electrons
REPT – The Space Weather Movie
REPT – 2015 to 2017

Van Allen Probes ECT-REPT A & B

2015-01-01

4.2 MeV Electron Flux (cm$^2$ s sr MeV$^{-1}$)
SWPC Experimental Test Product >2 MeV Electrons
NASA Van Allen Probe Inside GEO and GOES

- Complements GOES observations of electron flux at GEO with flux inside GEO
- GOES and Van Allen Probe Orbits shown; sun on right; bottom of scale (blue) is alert threshold
- New test product for forecasters and satellite operators inside of GEO

Electron Flux (cm$^2$ s sr)$^{-1}$

SWPC (Singer, Steenburgh, and Onsager) collaboration with JHUAPL and NASA (Ukhorskiy, Romeo, Fox, and Kessel)
Conclusions

• Results from the Van Allen Probes mission demonstrate remarkable, previously unobserved features about radiation belt structure, acceleration, transport, and rapid loss.

• Long-term observations reveal distinctive behavior: Multi-belt structure and impenetrable barrier to inward penetration of ultra-relativistic electrons at L ~2.8: No cases of high fluxes of E > 1.5 MeV electrons inside of L ~ 2.5 in over five years of measurements.

• Van Allen Probes data clearly show there are extended periods of gradual change in the (super- and ultra-) relativistic electron populations punctuated by abrupt losses and rapid subsequent acceleration.

• Van Allen Probes data show that ultra-relativistic electrons were low around 2014 sunspot max and have now been increasing dramatically due to strong solar wind streams in declining sunspot phase (southern solar hemisphere). We will rue the day that such SWx info is gone.
Questions?
**5.2 MeV Electron fluxes, L vs Time, 9/1/2012 - 11/10/2017**

- "Ultra Relativistic" (E ~ 5.2 MeV)
- "Impenetrable Barrier" @ L ~ 2.8

**6.3 MeV Electron fluxes, L vs Time, 9/1/2012 - 11/10/2017**

- "Ultra Relativistic" (E ~ 6.3 MeV)
Van Allen Probes Observations:
Acceleration, Remanence, and Sudden Loss