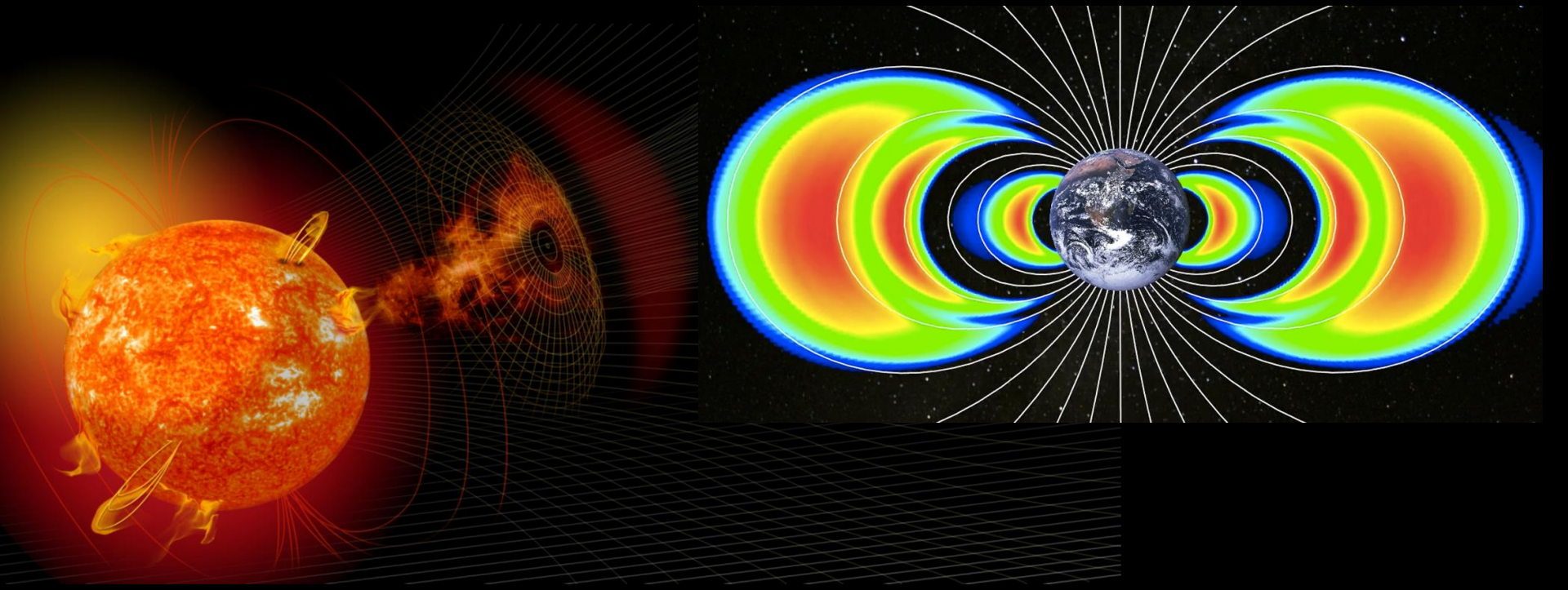
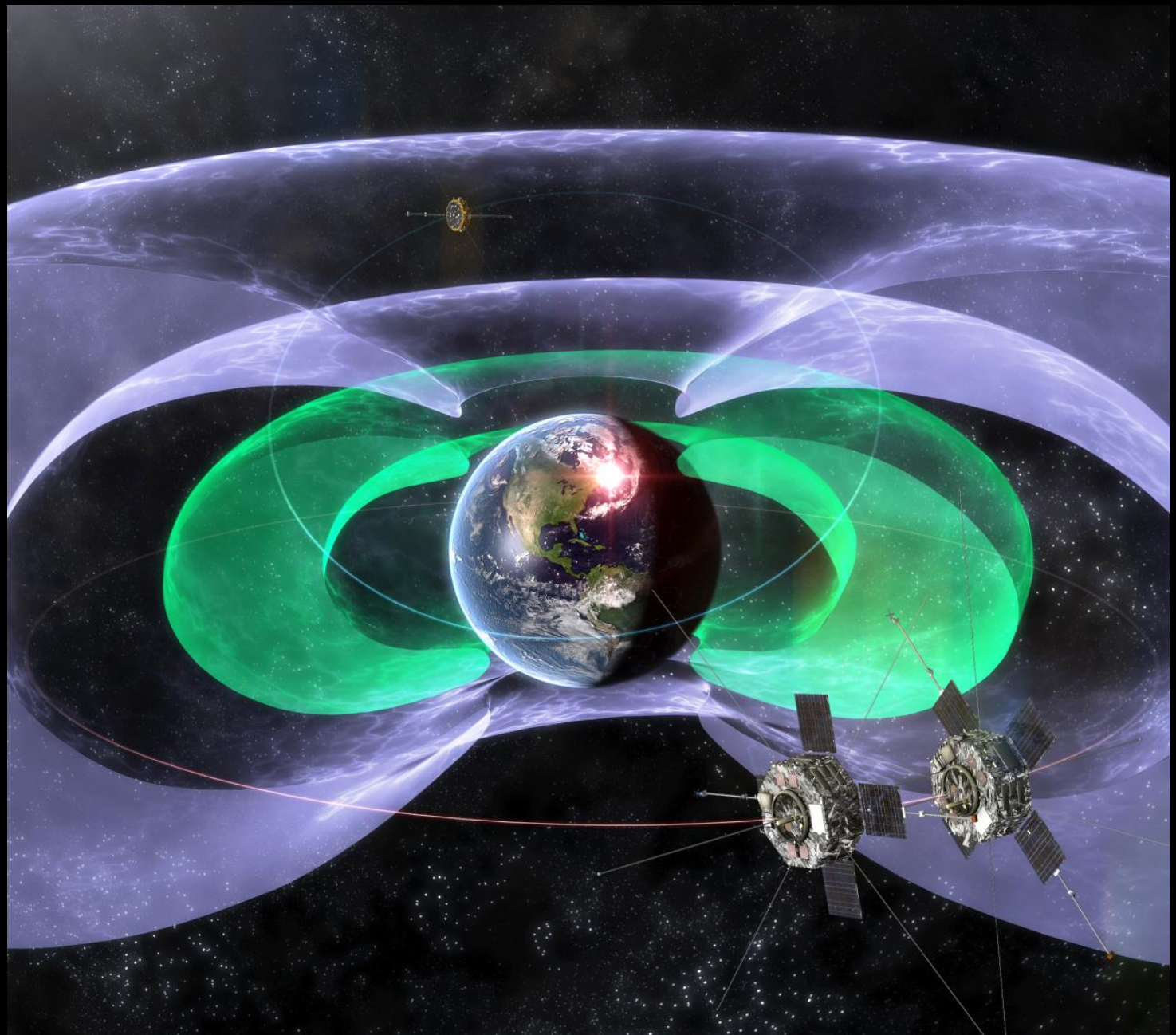


Five-Plus Years of Radiation Belt Measurements: Space Weather in Earth's Neighborhood

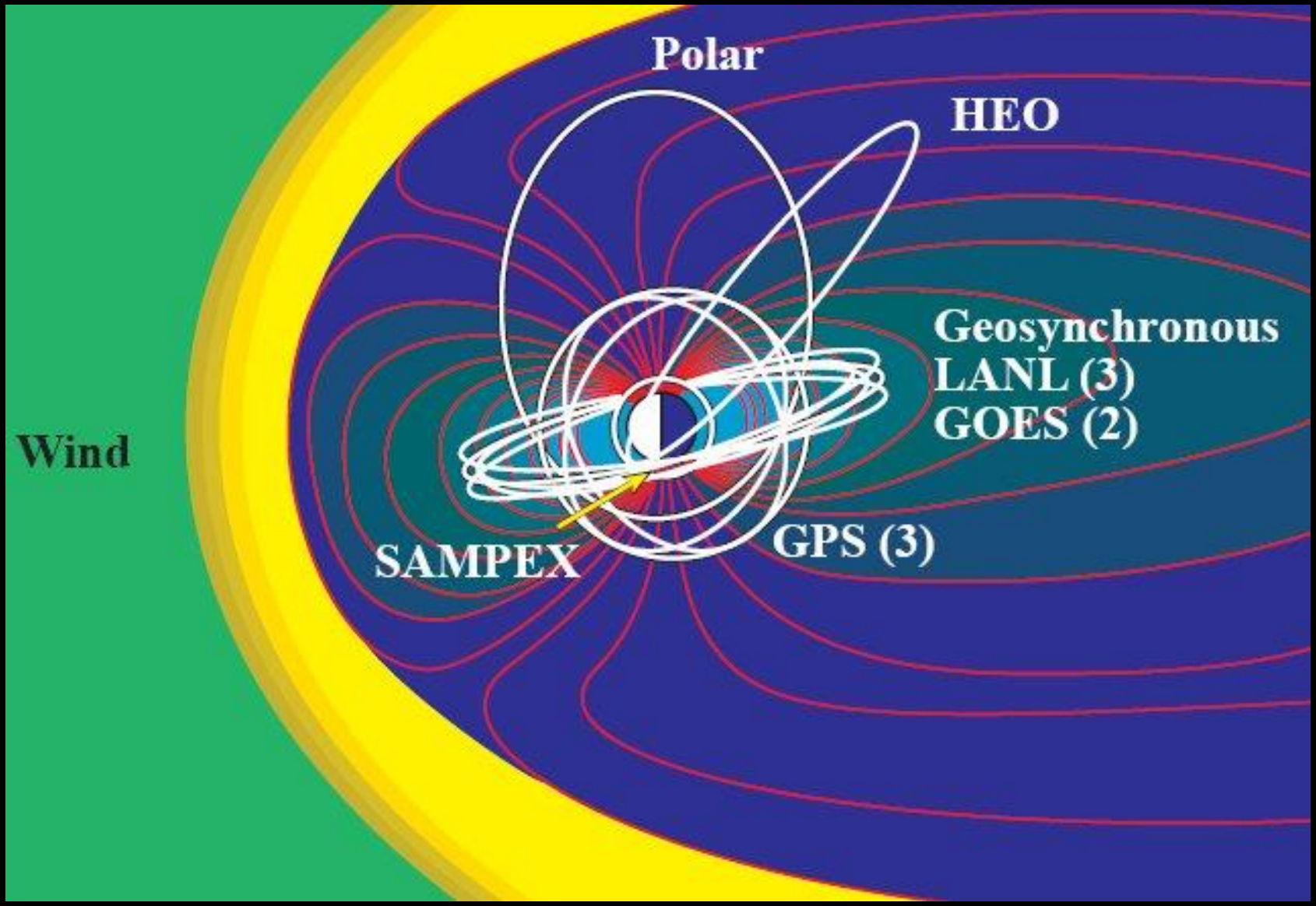
Daniel N. Baker
Laboratory for Atmospheric and Space Physics
University of Colorado – Boulder

Thanks to: V. Hoxie, H. Singer, and ECT Team

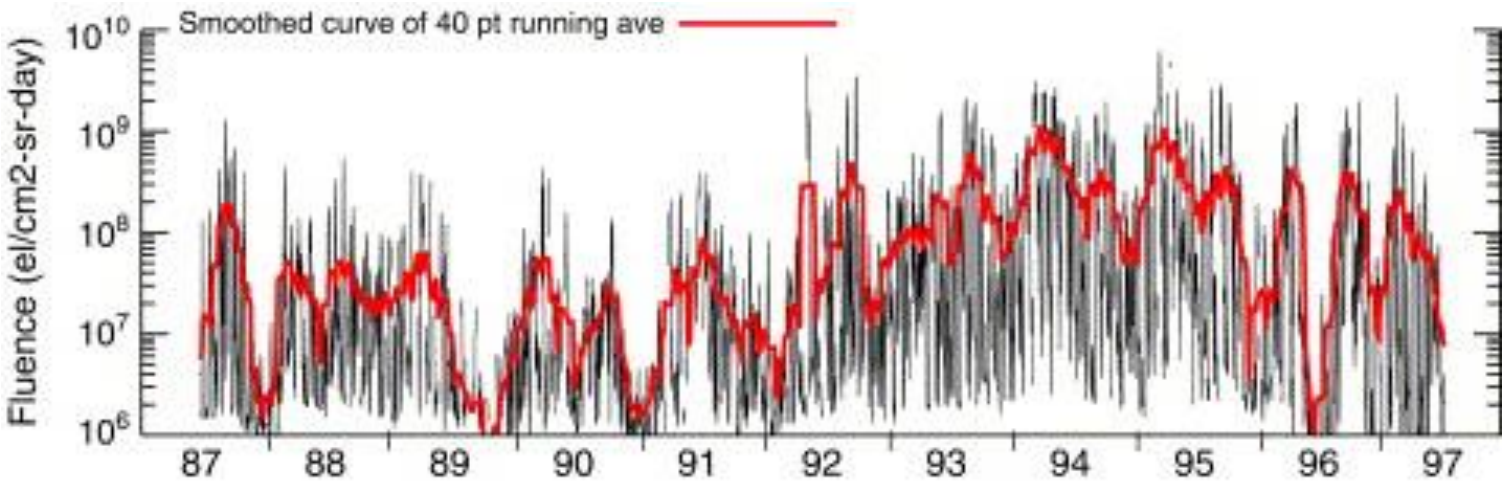
Twin Van Allen Probes (9/2012 – Present)



Rad Belt Work With Non-GTO Spacecraft

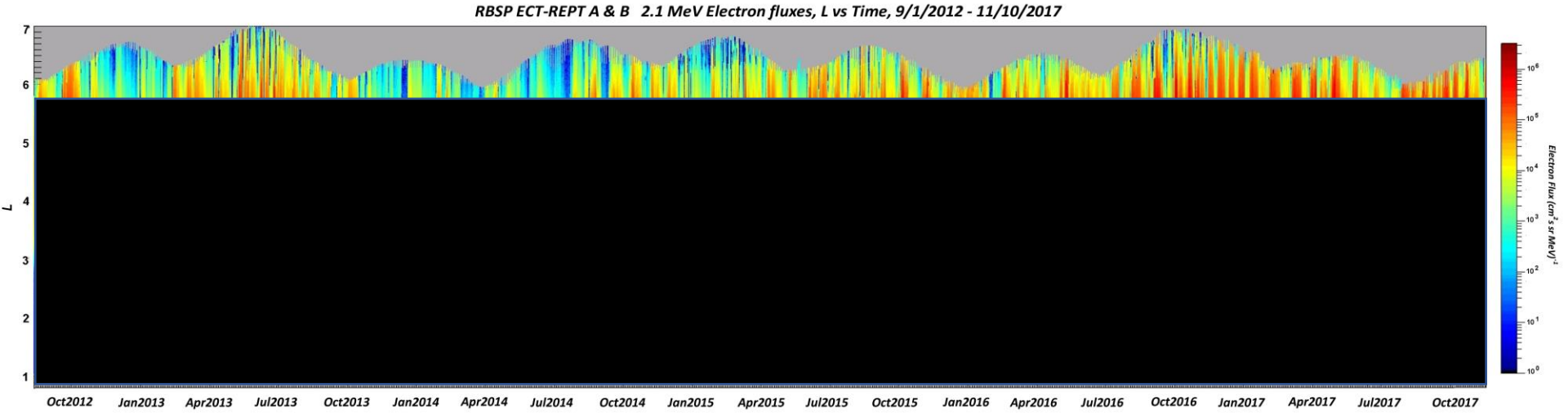


Long Runs of Geostationary Orbit Data



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

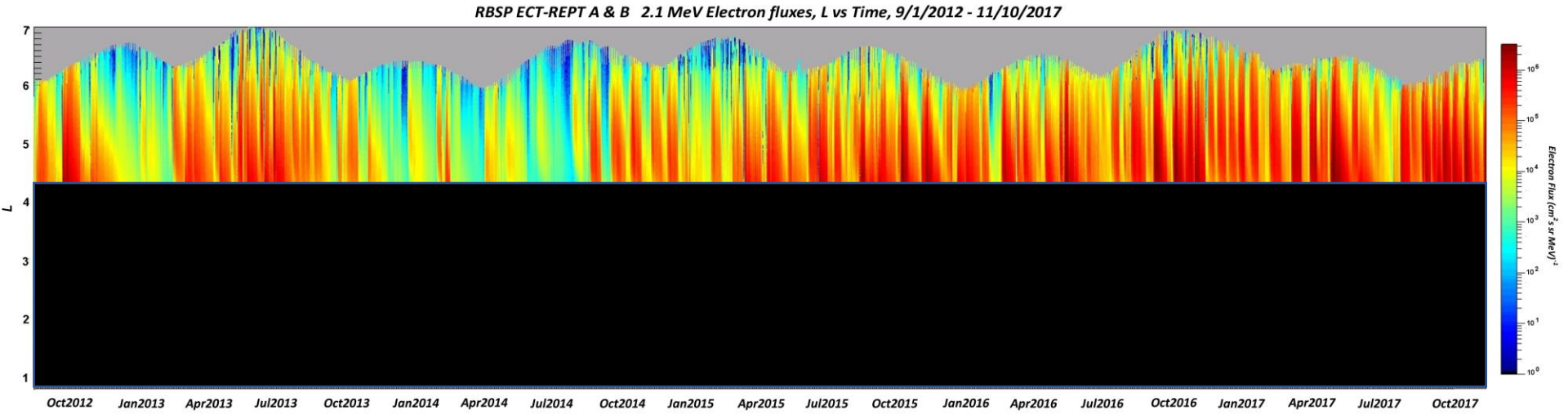
GEO: The Tip of the Iceberg



Van Allen Probes: September 2012 to November 2017

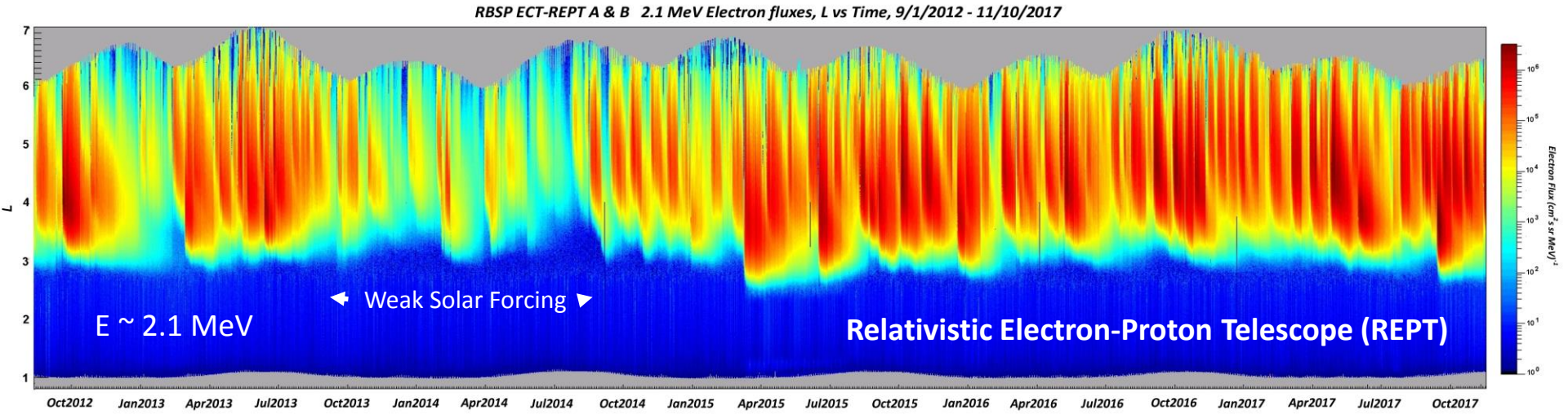
Looking at E ~ 2 MeV electrons just around geostationary orbit (L > 6.0)

GPS: Below the Tip of the Iceberg

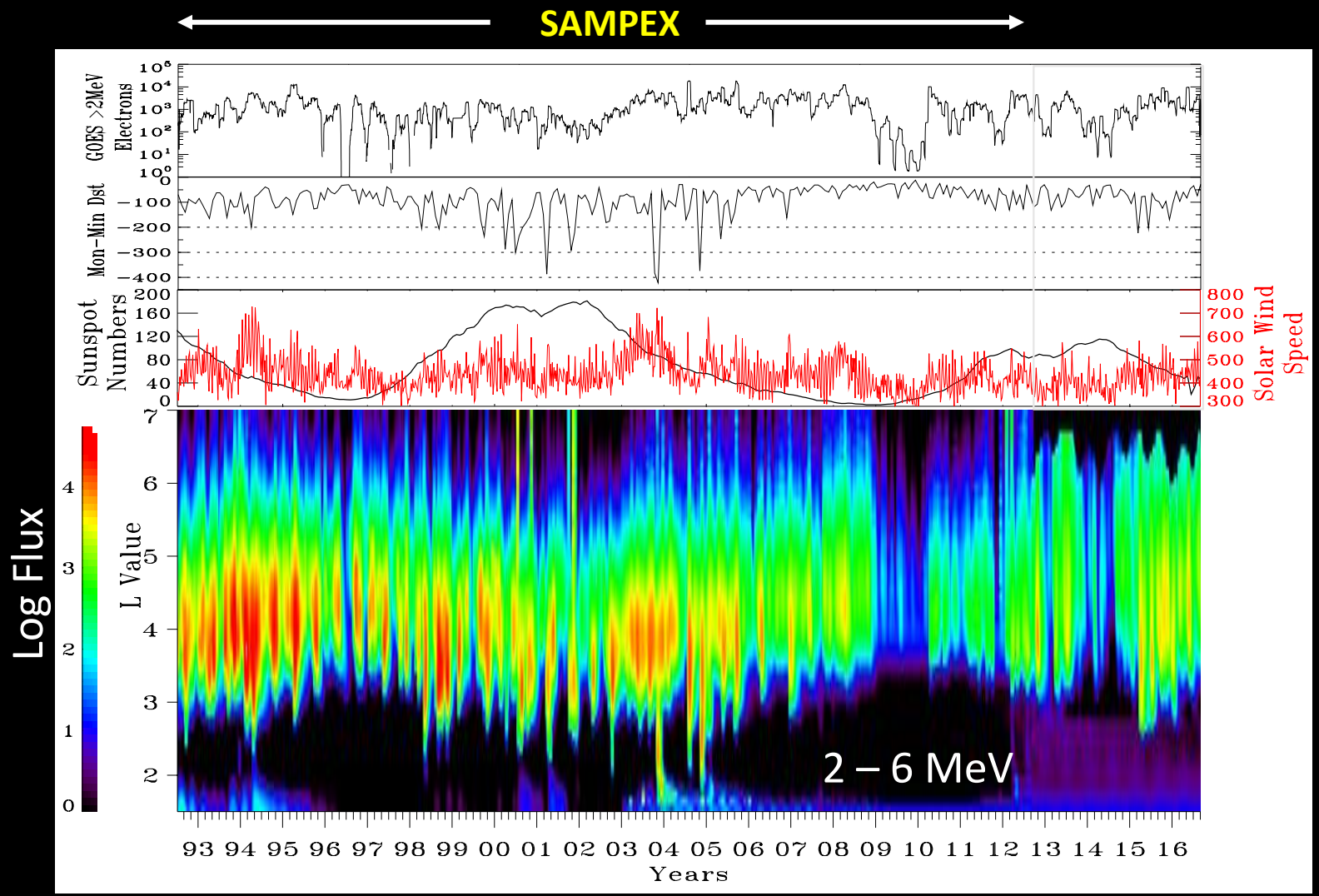


Examining E ~ 2 MeV electron fluxes over the range obtainable from Global Positioning System operational sensors (L > ~4.2)

Van Allen Probes: The Whole Iceberg

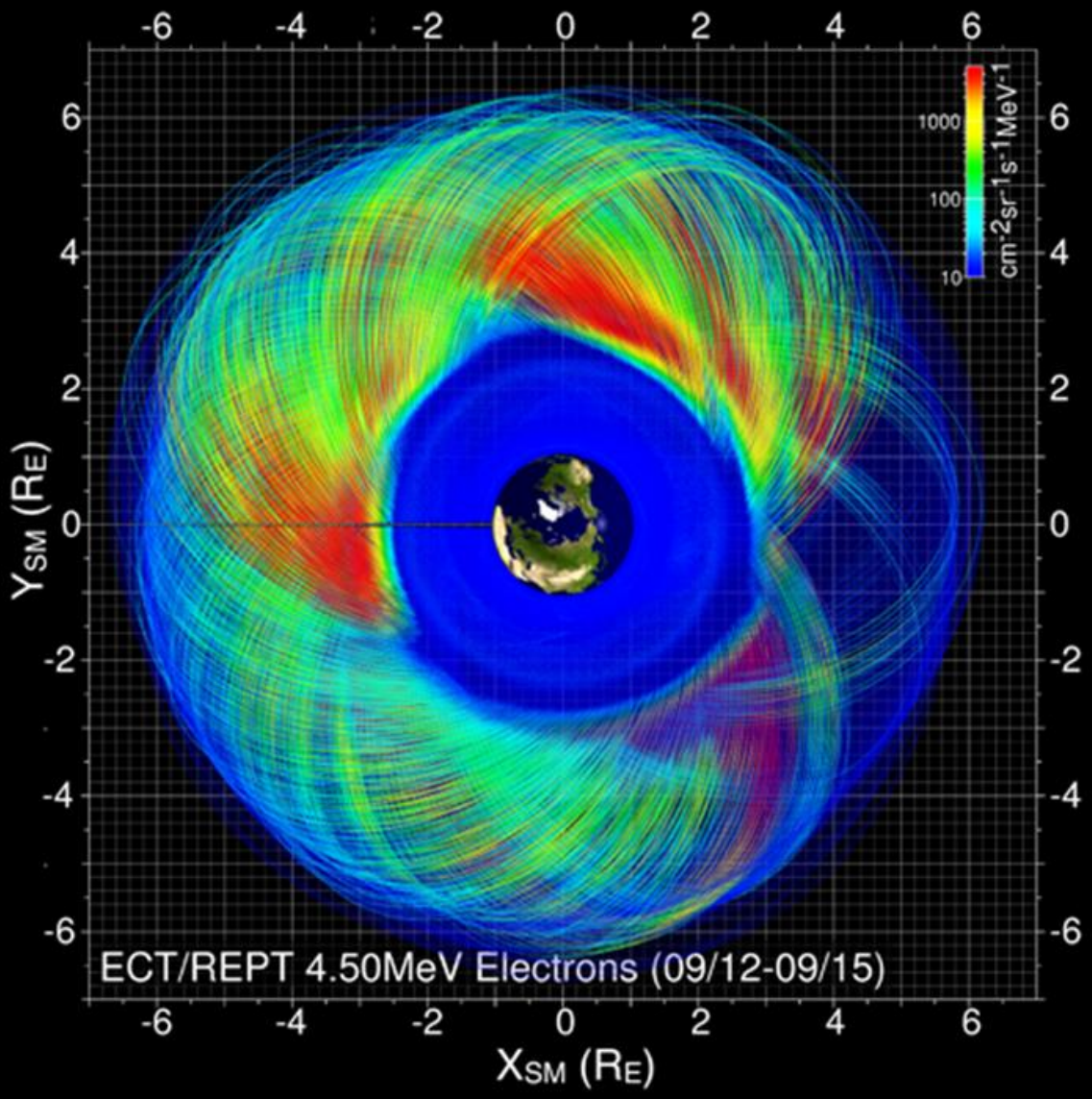


Measuring the full range of radial distances in the radiation belts for relatively fine differential energy slices has been a key contribution of the Van Allen Probes mission.

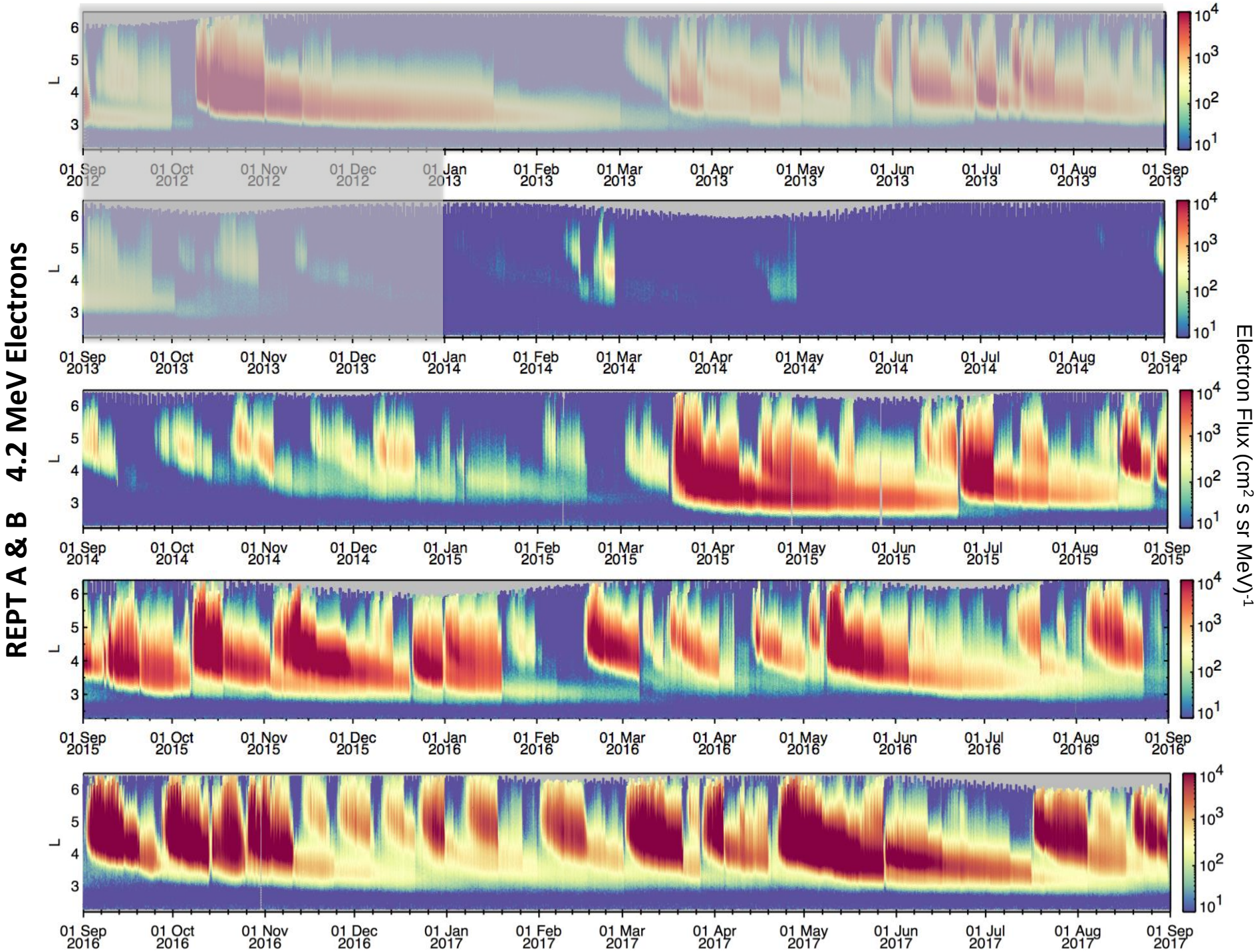


Courtesy: Xinlin Li

Van Allen REPT Data: 3 Years



Ukhorskiy et al., 2016


REPT A & B 4.2 MeV Electrons
L
6
5
4
3
01 Sep 2012
01 Oct 2012
01 Nov 2012
01 Dec 2012
01 Jan 2013
01 Feb 2013
01 Mar 2013
01 Apr 2013
01 May 2013
01 Jun 2013
01 Jul 2013
01 Aug 2013
01 Sep 2013
01 Sep 2013
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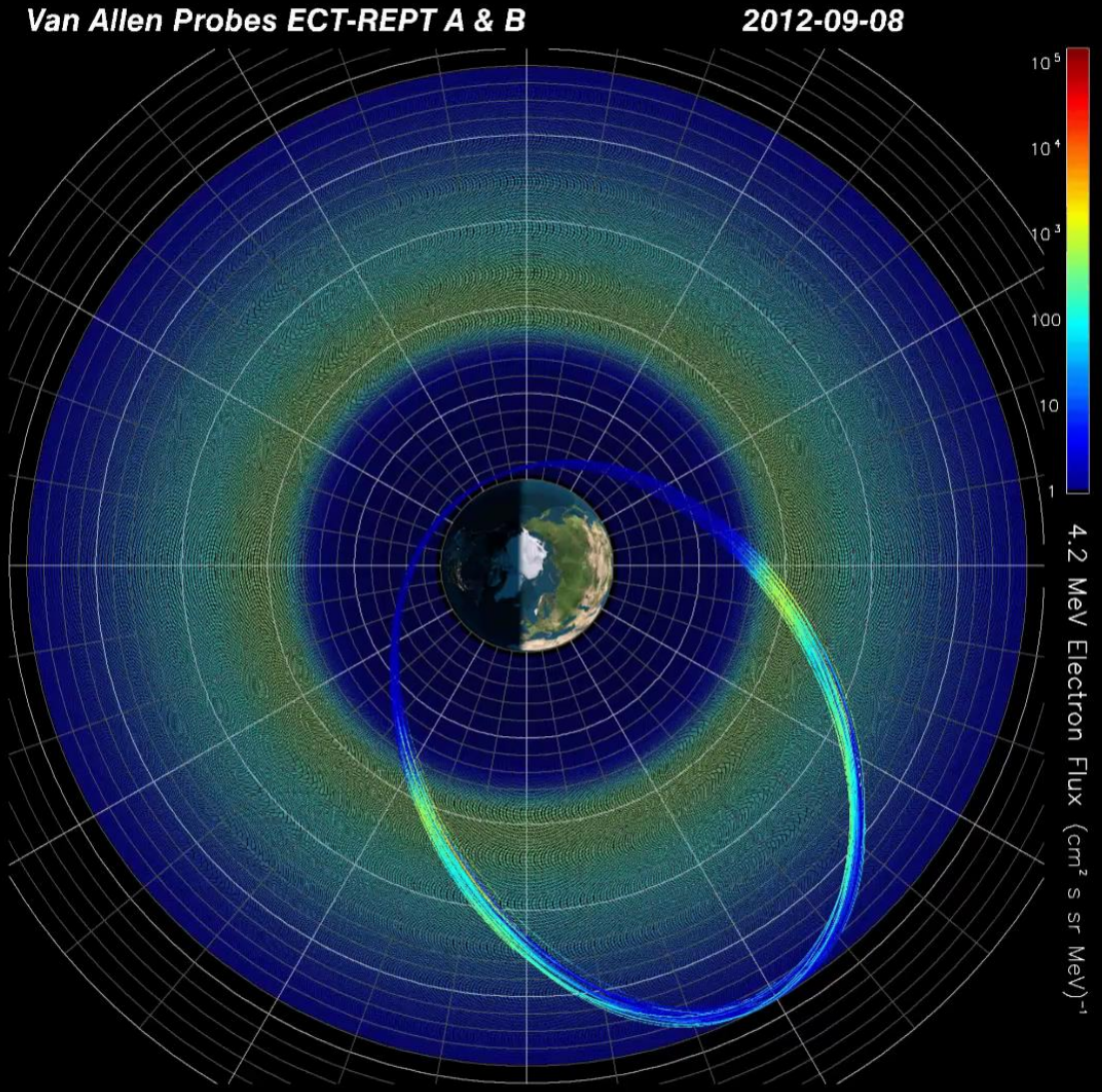
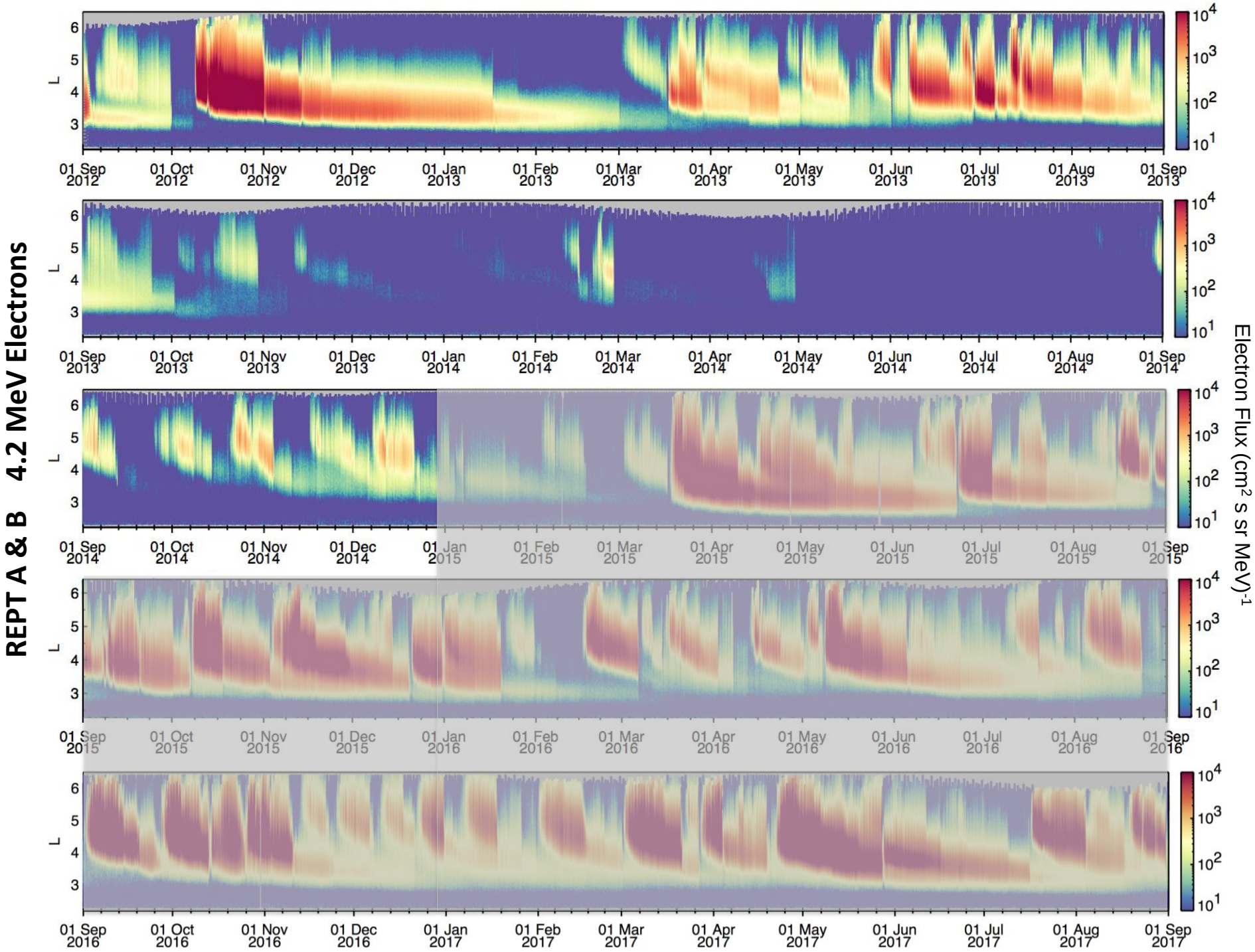
01 Apr 2017
01 May 2017
01 Jun 2017
01 Jul 2017
01 Aug 2017
01 Sep 2017
10^4
10^3
10^2
10^1
Electron Flux (cm^2 s sr MeV)$^{-1}$

REPT – The Space Weather Movie




REPT A & B 4.2 MeV Electrons
L
6
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01 Sep 2012
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01 Mar 2013
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01 May 2017
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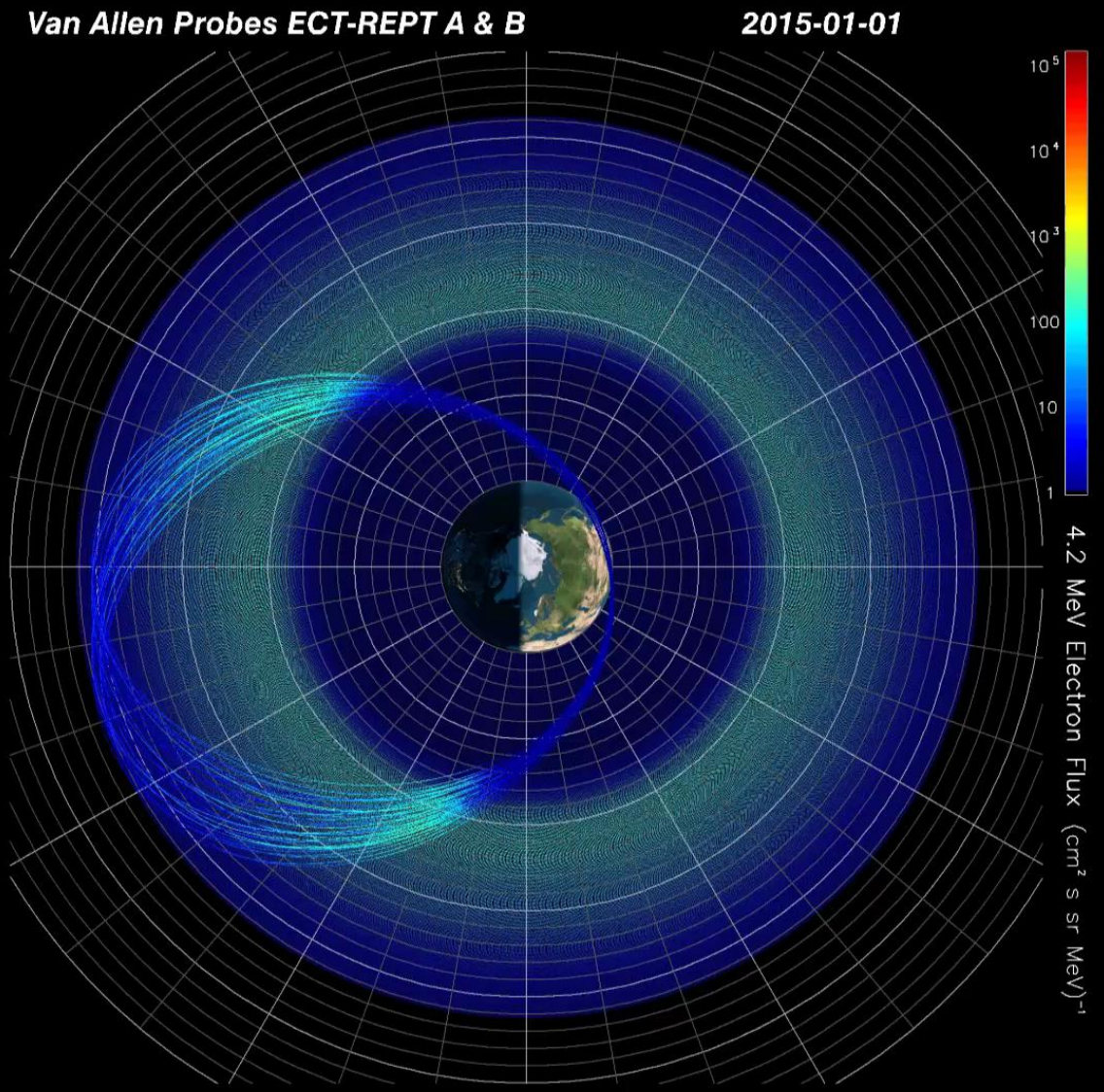
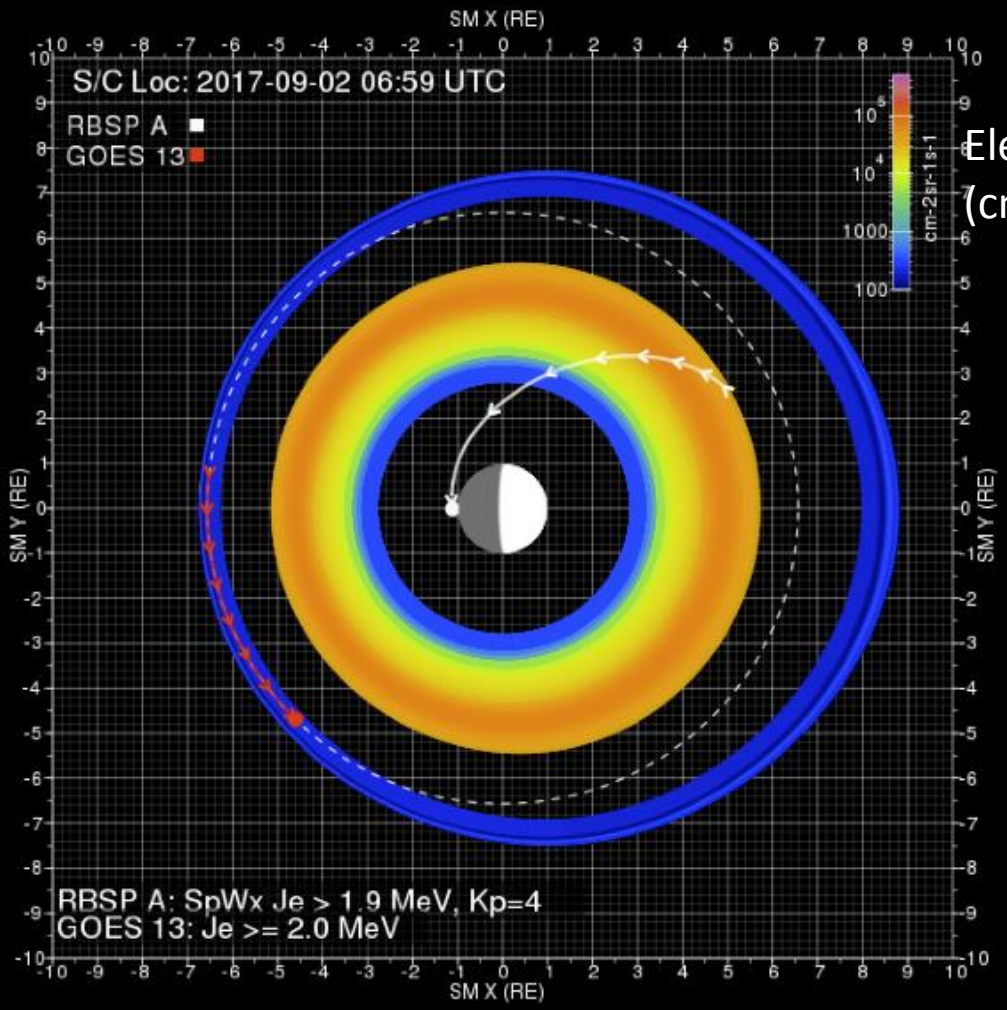
01 Jul 2017
01 Aug 2017
01 Sep 2017
10^4
10^3
10^2
10^1
Electron Flux (cm^2 s sr MeV)$^{-1}$

REPT – 2015 to 2017



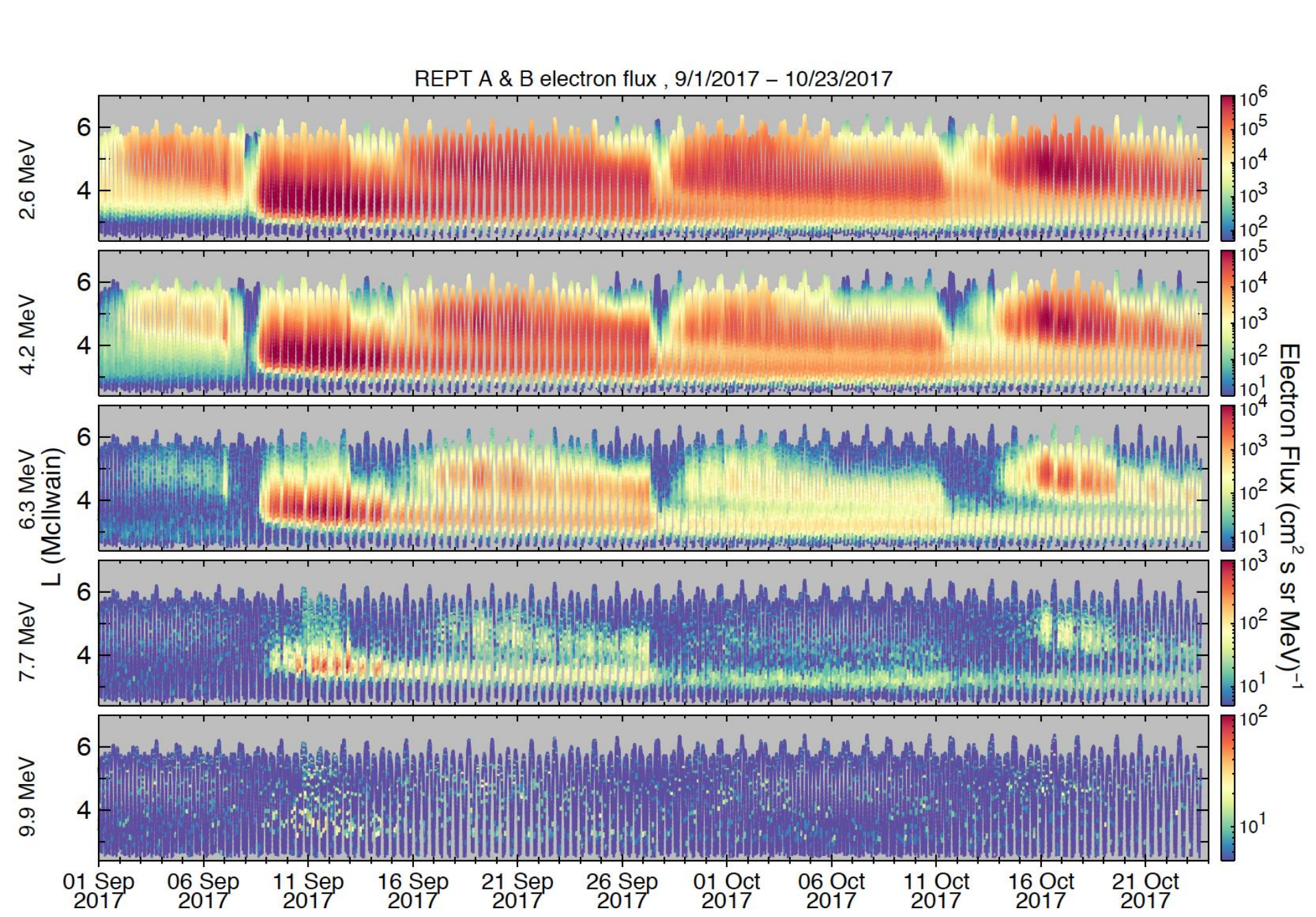
SWPC Experimental Test Product >2 MeV Electrons NASA Van Allen Probe Inside GEO and GOES

- **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)


REPT A & B electron flux , 9/1/2017 – 10/23/2017
2.6 MeV
4.2 MeV
6.3 MeV
7.7 MeV
9.9 MeV
L (McIlwain)
6
4
Electron Flux (cm^2 s sr MeV)$^{-1}$
01 Sep 2017
06 Sep 2017
11 Sep 2017
16 Sep 2017
21 Sep 2017
26 Sep 2017
01 Oct 2017
06 Oct 2017
11 Oct 2017
16 Oct 2017
21 Oct 2017

Conclusions

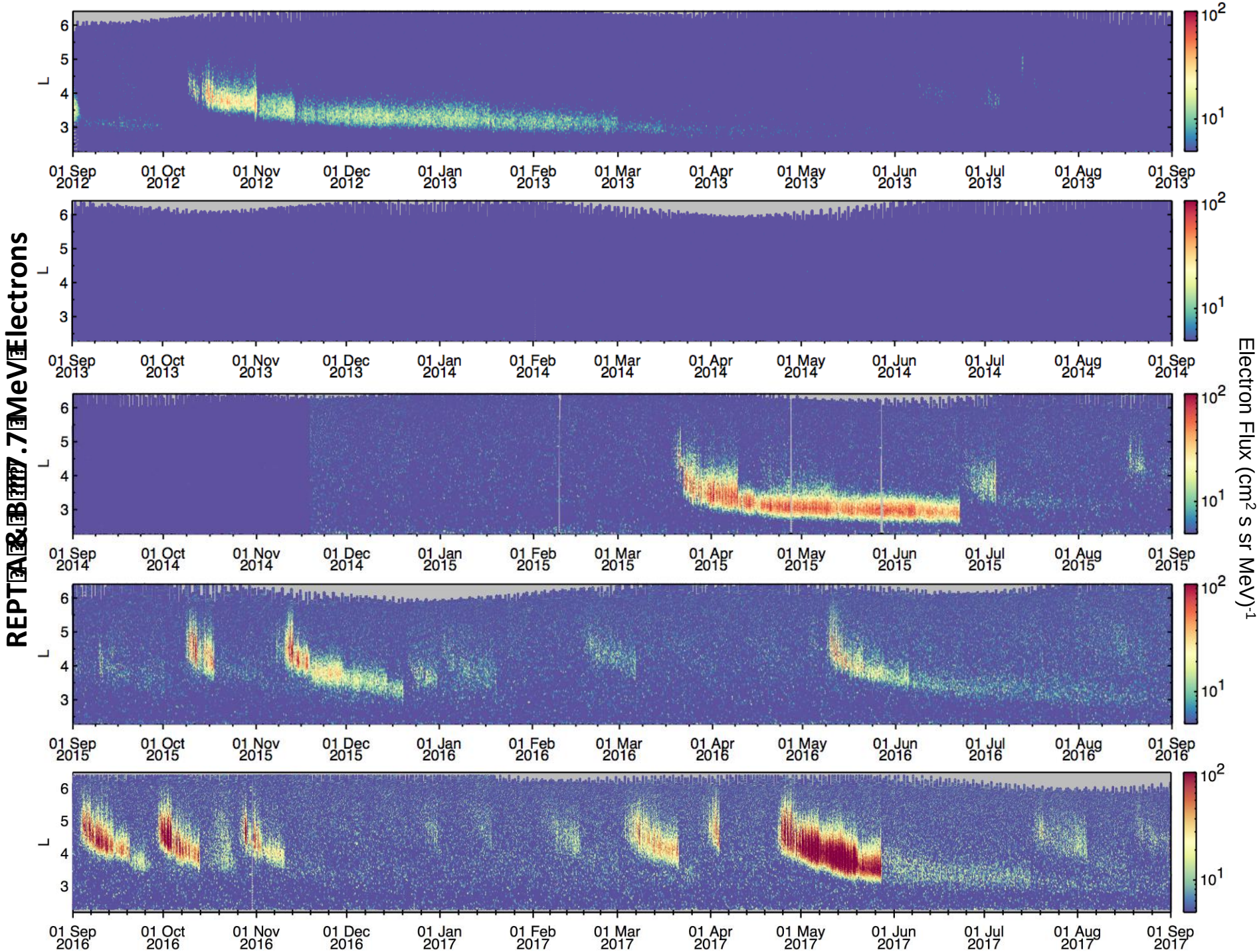
- Results from the Van Allen Probes mission demonstrate remarkable, previously unobserved features about radiation belt structure, acceleration, transport, and rapid loss.

- 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?


REPTAD Electrons
Electron Flux (cm² s sr MeV)⁻¹
L
01 Sep 2012
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01 Mar 2013
01 Apr 2013
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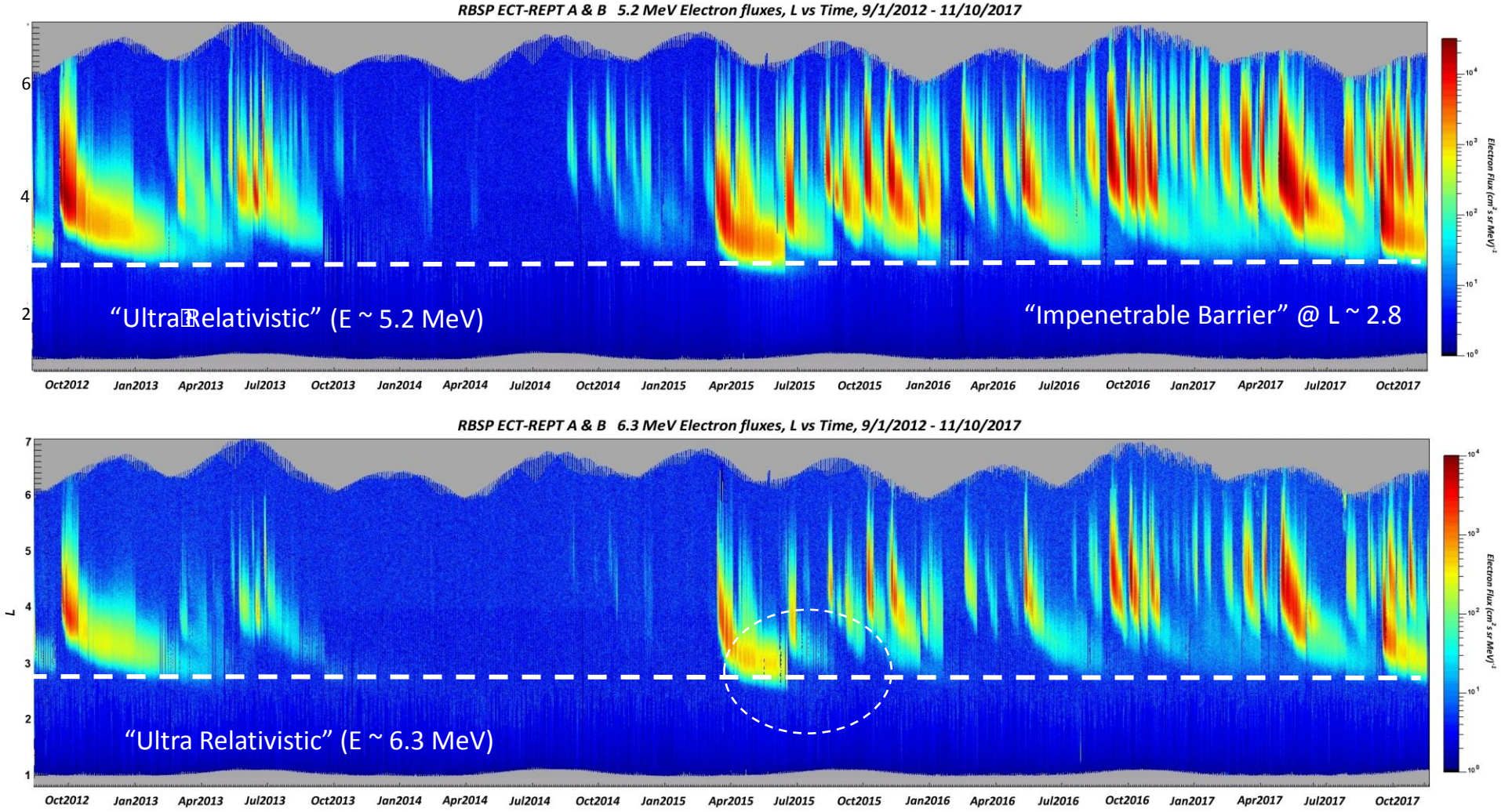
RBSP ECT-REPT A & B 5.2 MeV Electron fluxes, L vs Time, 9/1/2012 - 11/10/2017
6
4
2
"Ultra Relativistic" (E ~ 5.2 MeV)
"Impenetrable Barrier" @ L ~ 2.8
Oct2012
Jan2013
Apr2013
Jul2013
Oct2013
Jan2014
Apr2014
Jul2014
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Apr2015
Jul2015
Oct2015
Jan2016
Apr2016
Jul2016
Oct2016
Jan2017
Apr2017
Jul2017
Oct2017
Electron Flux (cm² s sr MeV)⁻¹
RBSP ECT-REPT A & B 6.3 MeV Electron fluxes, L vs Time, 9/1/2012 - 11/10/2017
L
7
6
5
4
3
2
1
"Ultra Relativistic" (E ~ 6.3 MeV)
Oct2012
Jan2013
Apr2013
Jul2013
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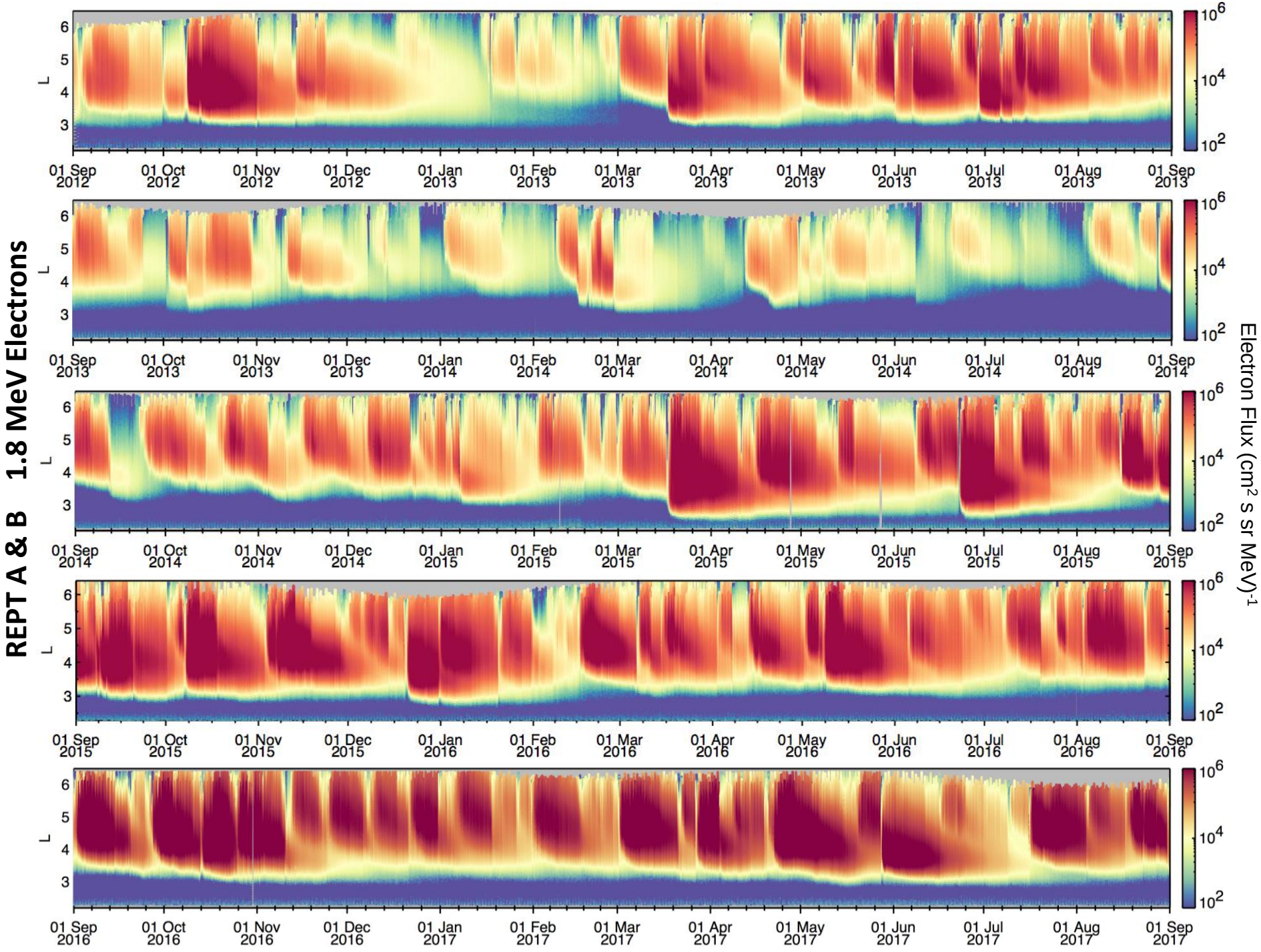
Apr2017
Jul2017
Oct2017
Electron Flux (cm² s sr MeV)⁻¹


REPT A & B 1.8 MeV Electrons
L
6
5
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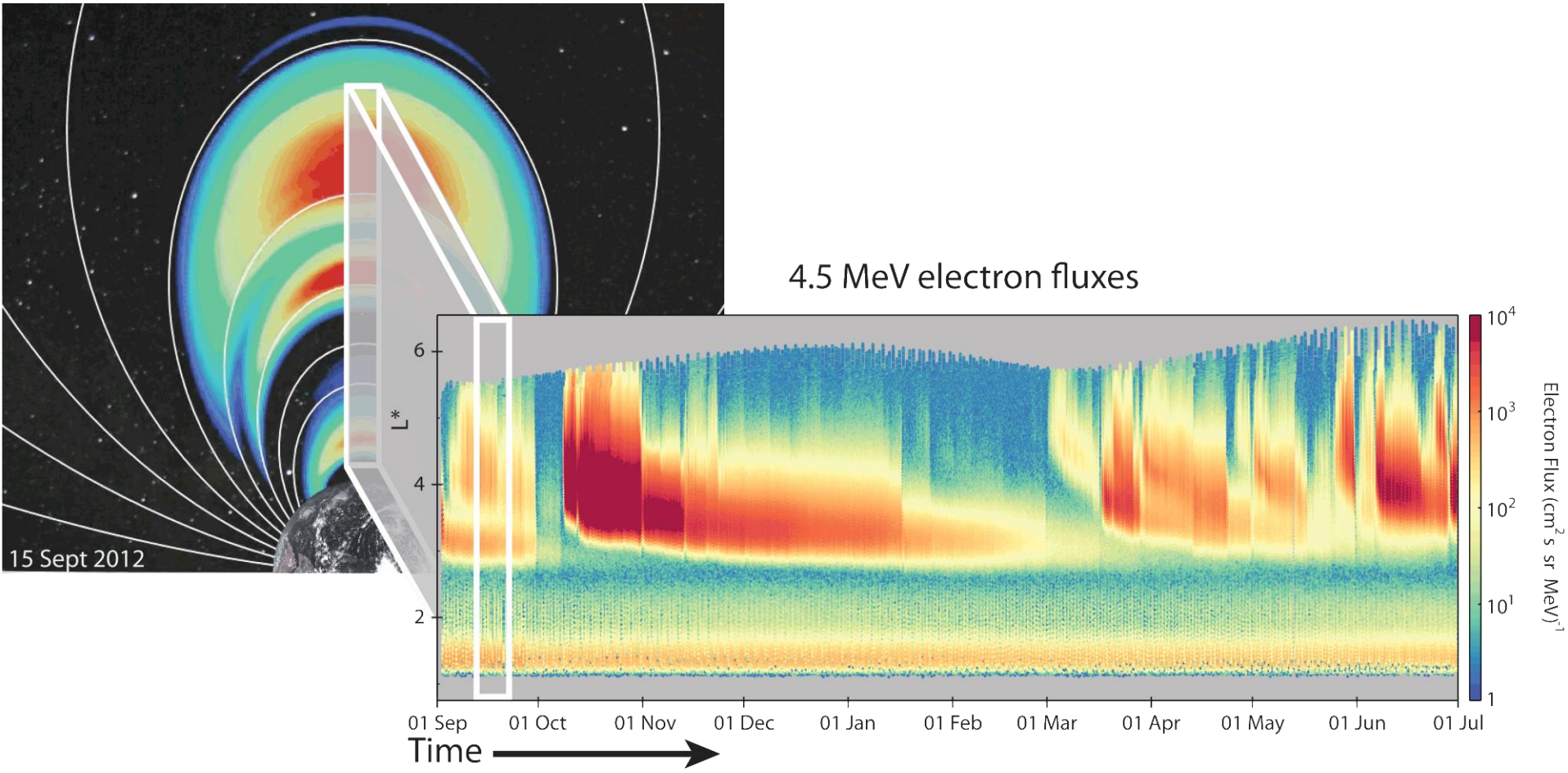
01 Sep 2017
10^6
10^4
10^2
Electron Flux (cm^2 s sr MeV)$^{-1}$

Van Allen Probes Observations:

Acceleration, Remanence, and Sudden Loss



[D. N. Baker, ***American Scientist***, Sept.2014]