On Diffusive Fast ULF Wave Radiation Belt Losses During Intense Geomagnetic Storms

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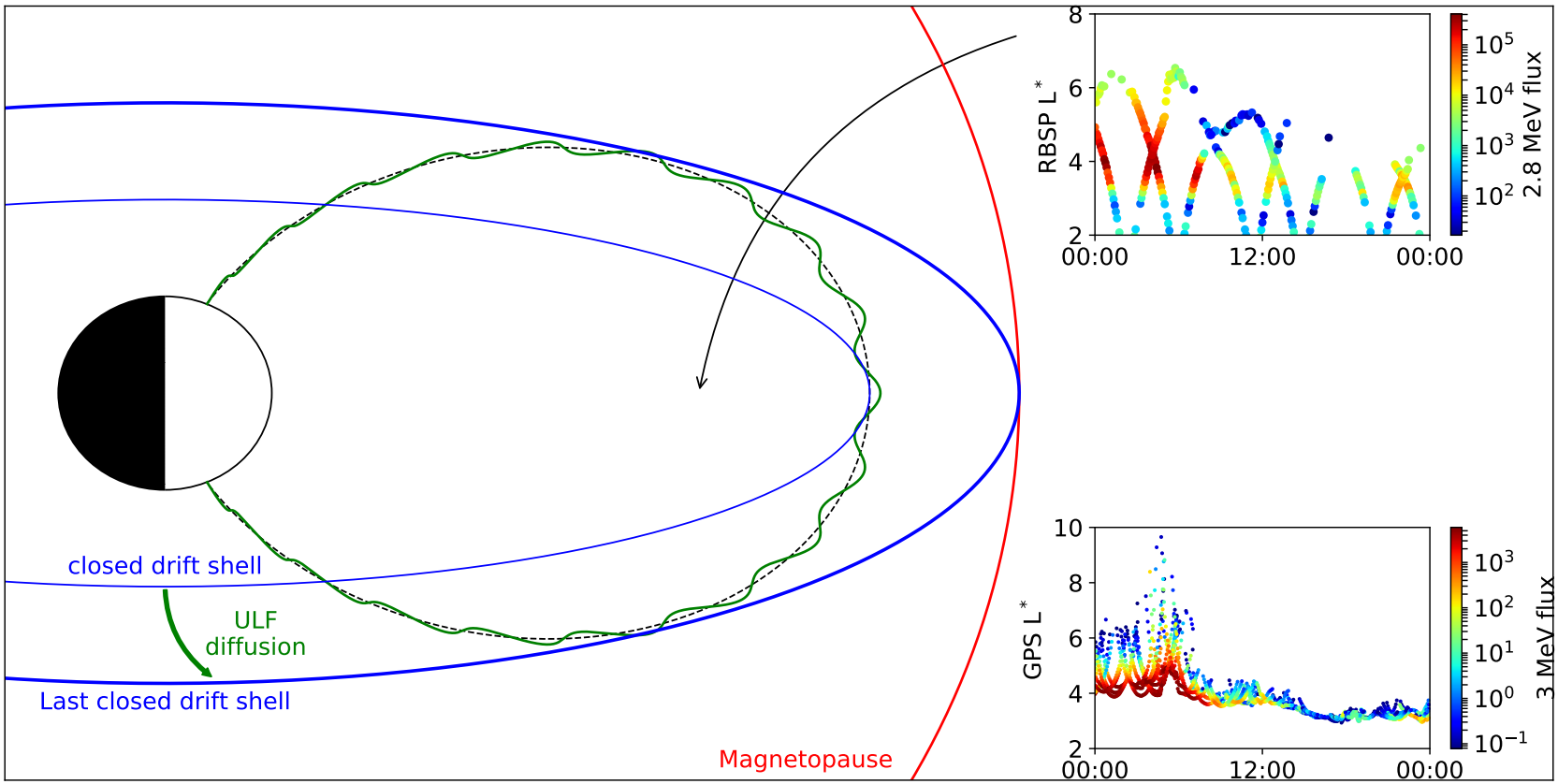
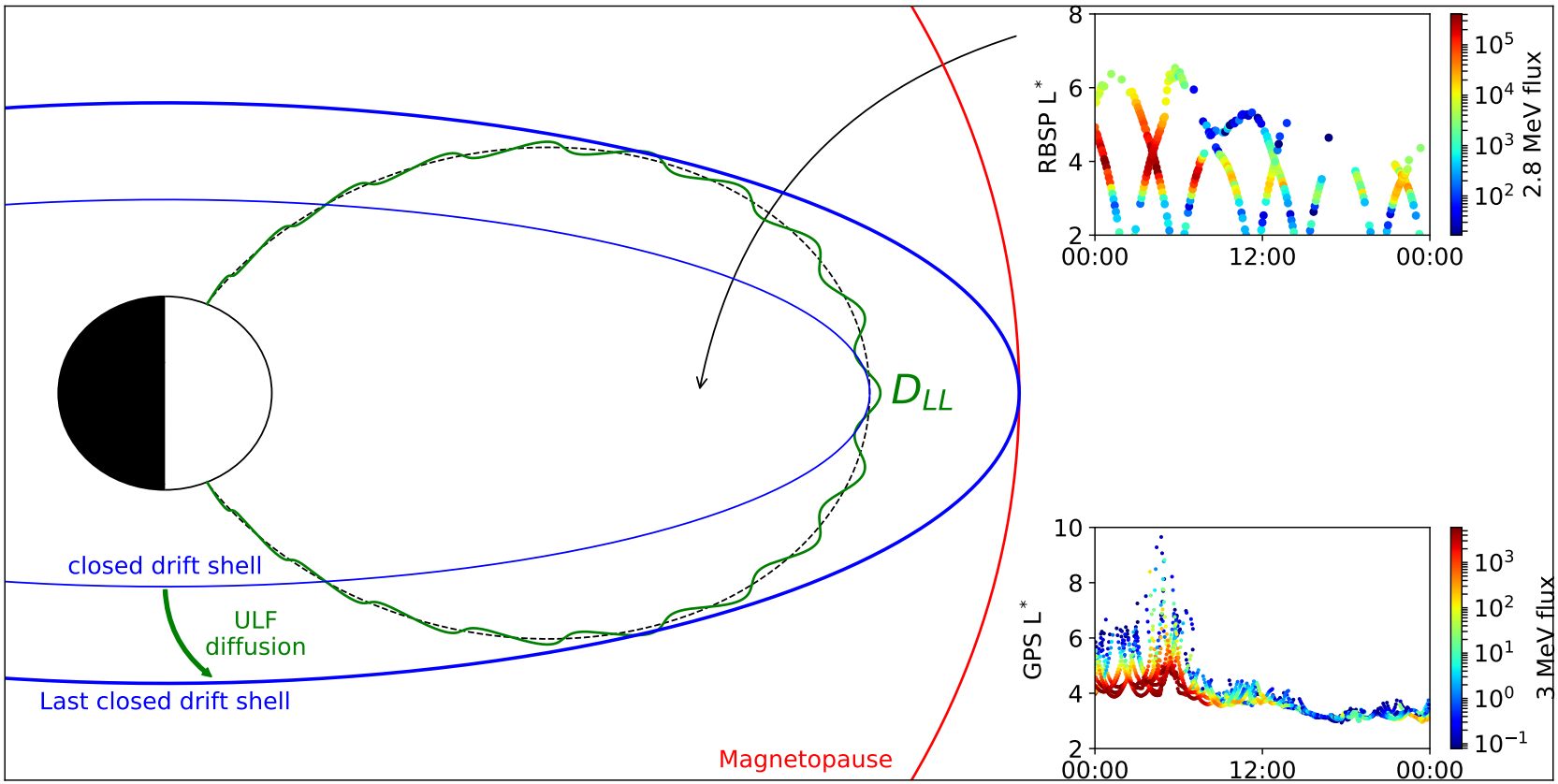
AGU Chapman Conference
4-9 March, 2018, Cascais, Portugal

March 17, 2015 storm



The outer radiation belt depletion happened in ∼4 hours.

March 17, 2015 storm



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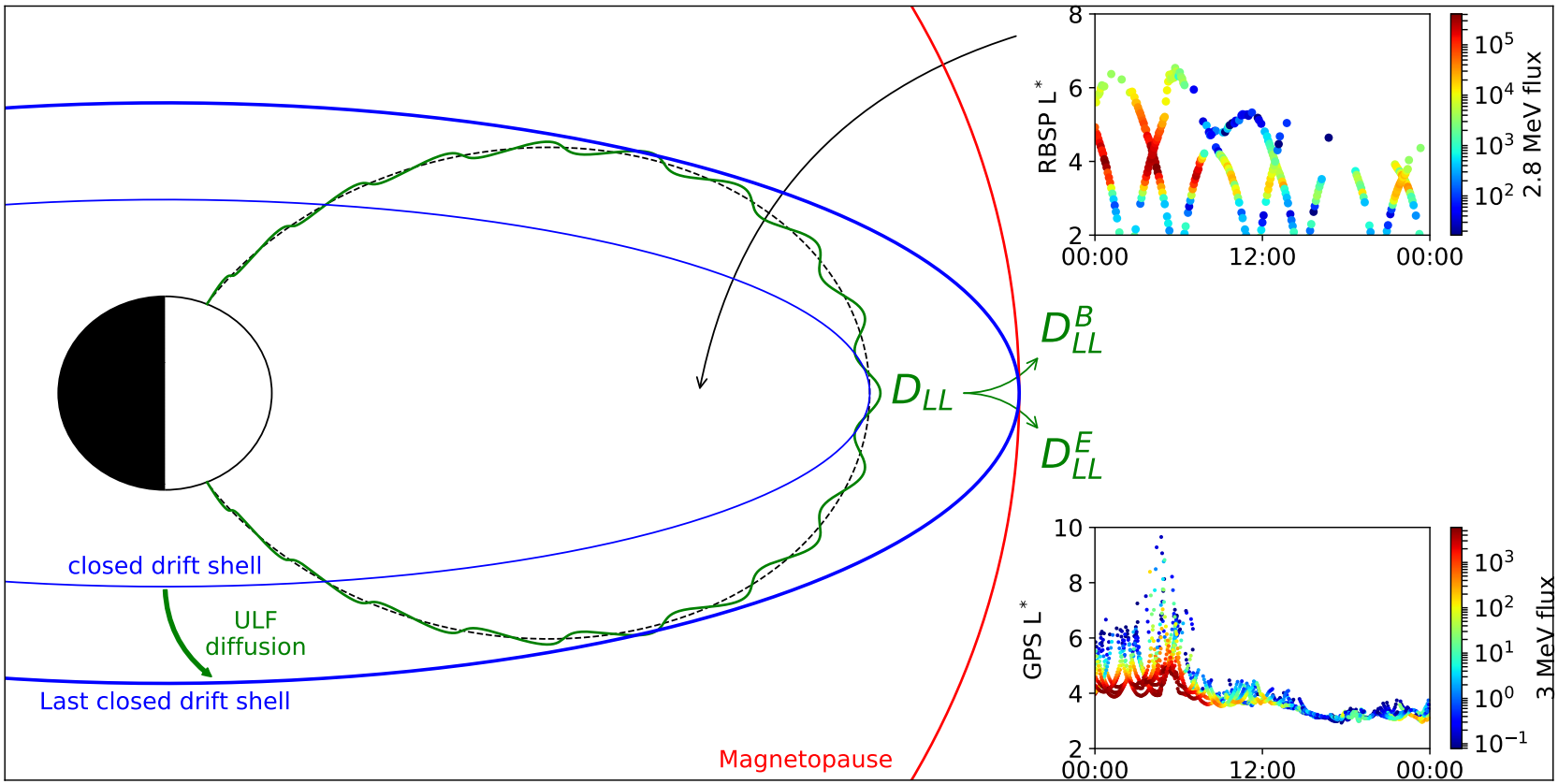
- Determine diffusion coefficients

March 17, 2015 storm



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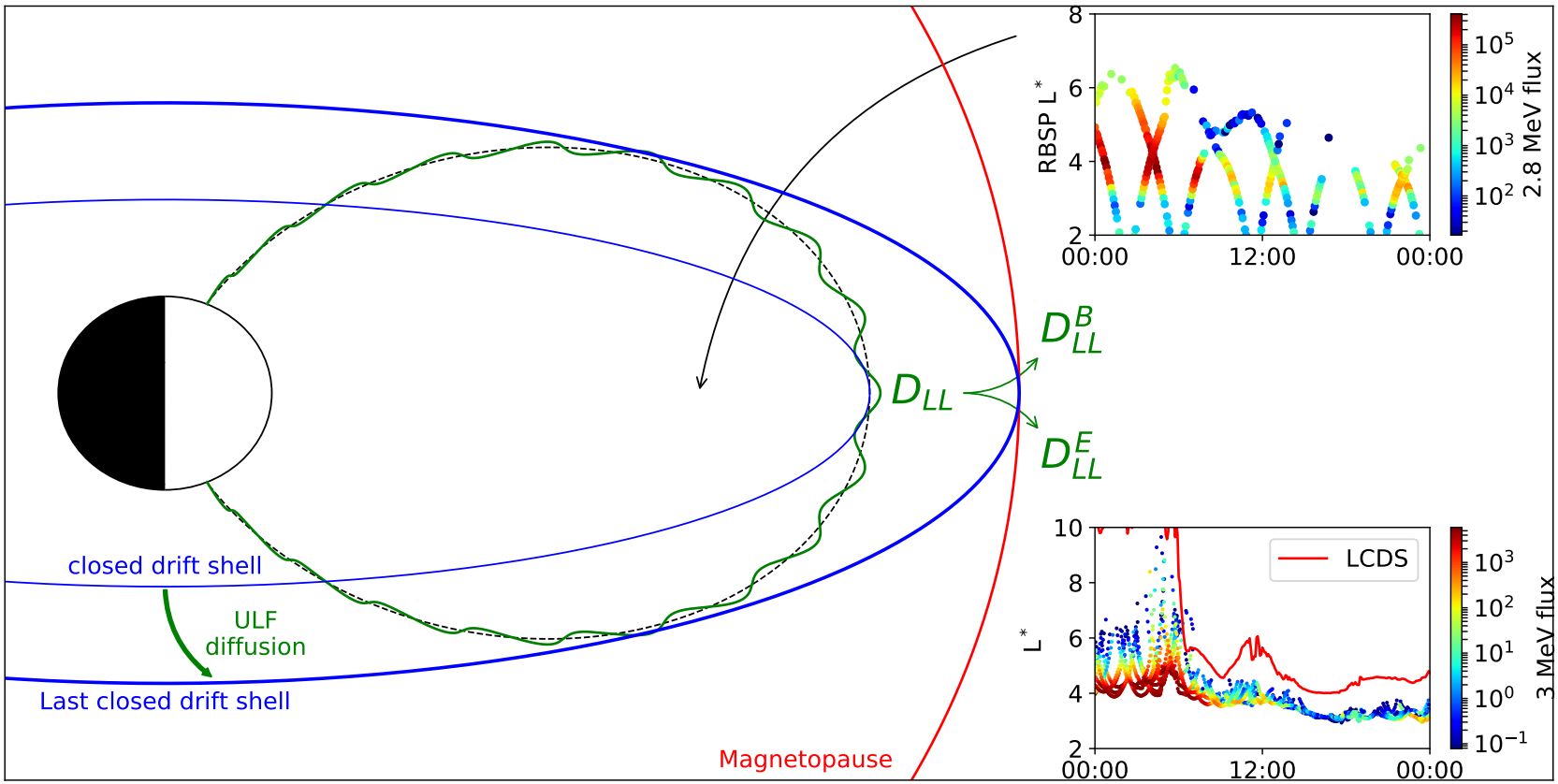
- Determine diffusion coefficients
- Compare D_{LL}^{E} and D_{LL}^{B}

March 17, 2015 storm



The outer radiation belt depletion happened in ~4 hours.

- Determine diffusion coefficients
- Compare D_{LL}^{E} and D_{LL}^{B}
- Define the outer boundar

Obtaining diffusion coefficients

From direct measurements

In-situ $\mathbf{B}$ and $\mathbf{E}$

ULF power spectrum density (PSD)

$$D_{LL}^{B} \propto L^{8}\langle \mathrm{PSD}\left(B_{\parallel}\right) f^{2}\rangle,$$
$$D_{LL}^{E} \propto L^{6}\langle \mathrm{PSD}\left(E_{\phi}\right)\rangle$$

Fei et.al. [2006] for $m = 1$

From statistics

Position (L-shell) and magnetic disturbances (K_p-index)

$$D_{LL}^{B} = g\left(L, K_p\right),$$
$$D_{LL}^{E} = h\left(L, K_p\right),$$

where g and h are *Ozeke et.al.* [2014] statistics.

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Questions to answer:

- How do two approaches compare?
- Is the diffusion energy independent?

GOES-13 D_{LL}^{B}

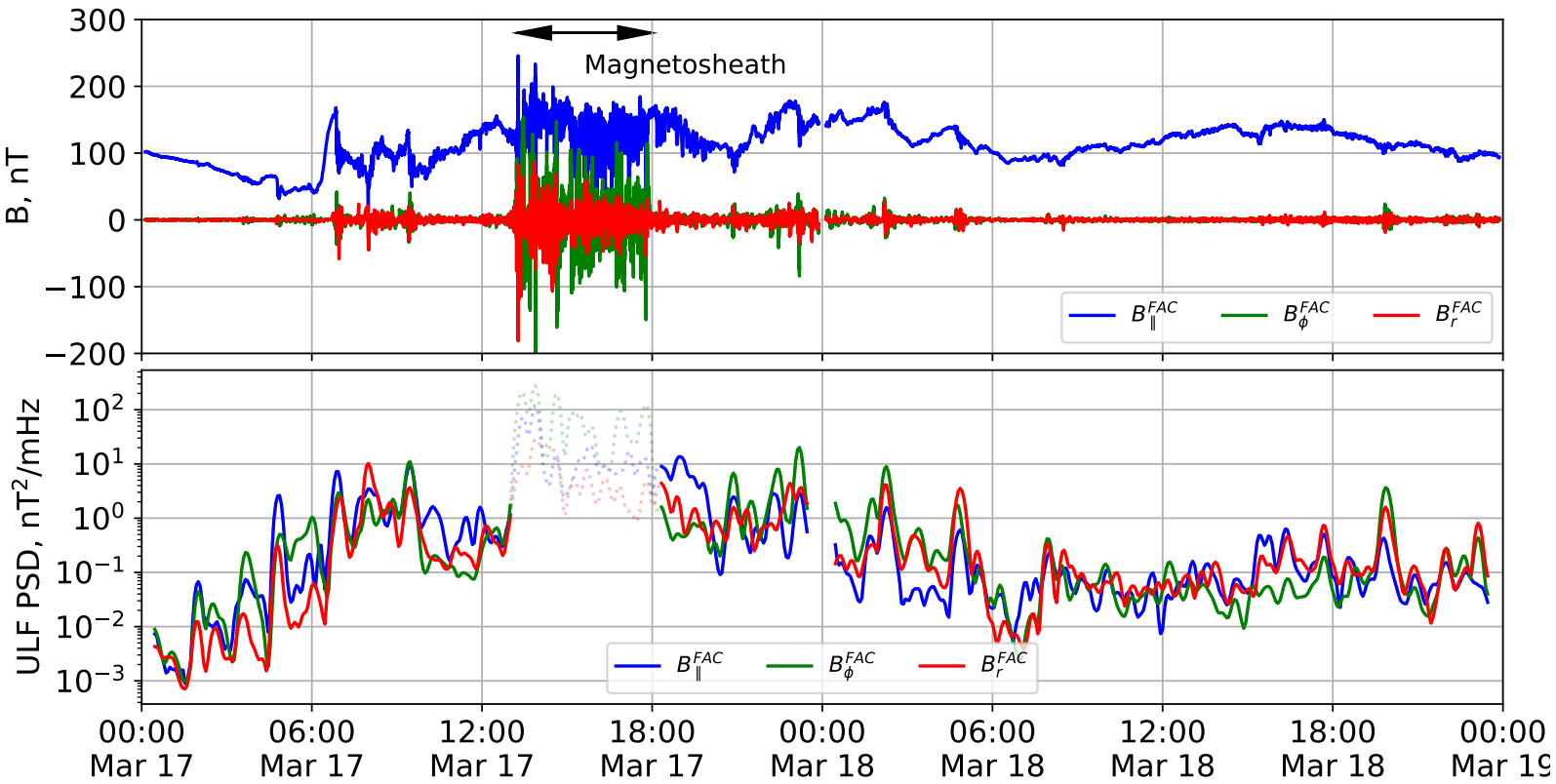
$\mathbf{B}$

$\Downarrow$

ULF PSD

$\Downarrow$

D_{LL}^{B}



To obtain D_{LL}^{B} we are interested in $\mathrm{PSD}\left(B_{\|}\right)$.

In-situ vs. Statistics?

$D_{LL}\left(f\right) \stackrel{?}{=} const$

GOES-13 D_{LL}^{B}

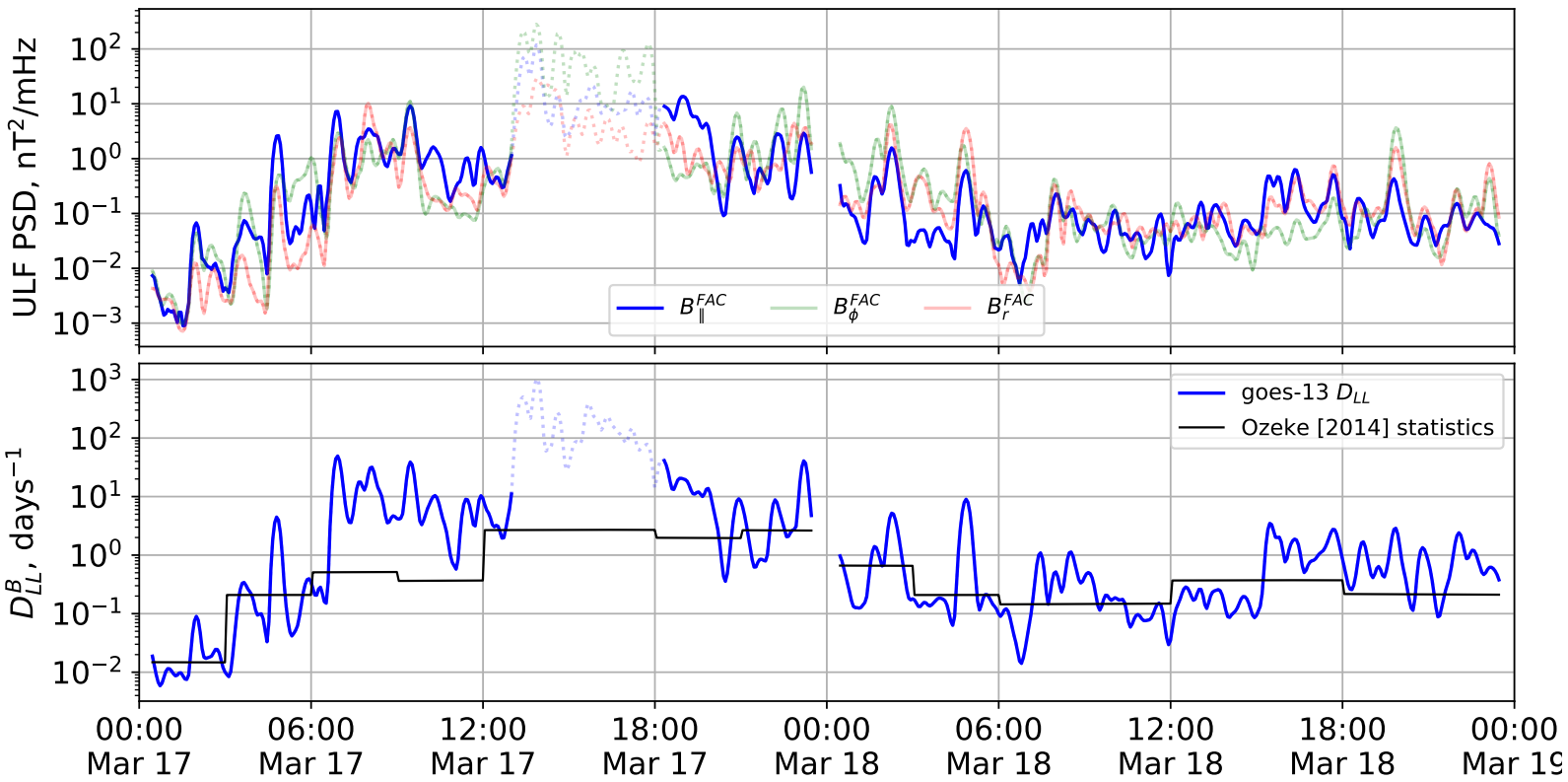
B

⇓

ULF PSD

⇓

D_{LL}^{B}

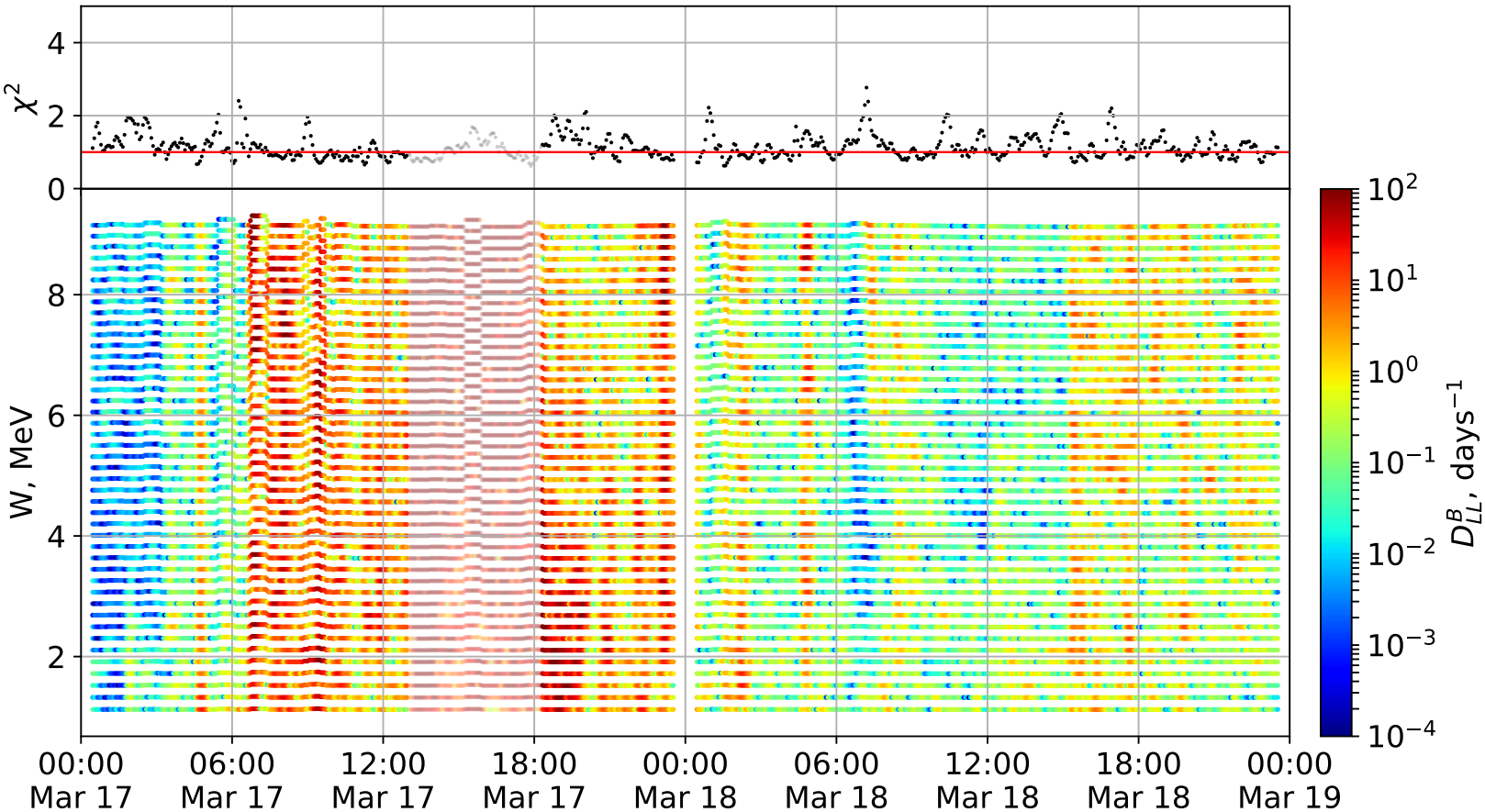


Is the assumption about PSD $(B_{\parallel}) \propto f^{-2}$ correct in storm time?

In-situ $\neq$ Statistics!

$D_{LL}(f) \stackrel{?}{=} const$

GOES-13 $D_{LL}^{B}\left(W\right)$

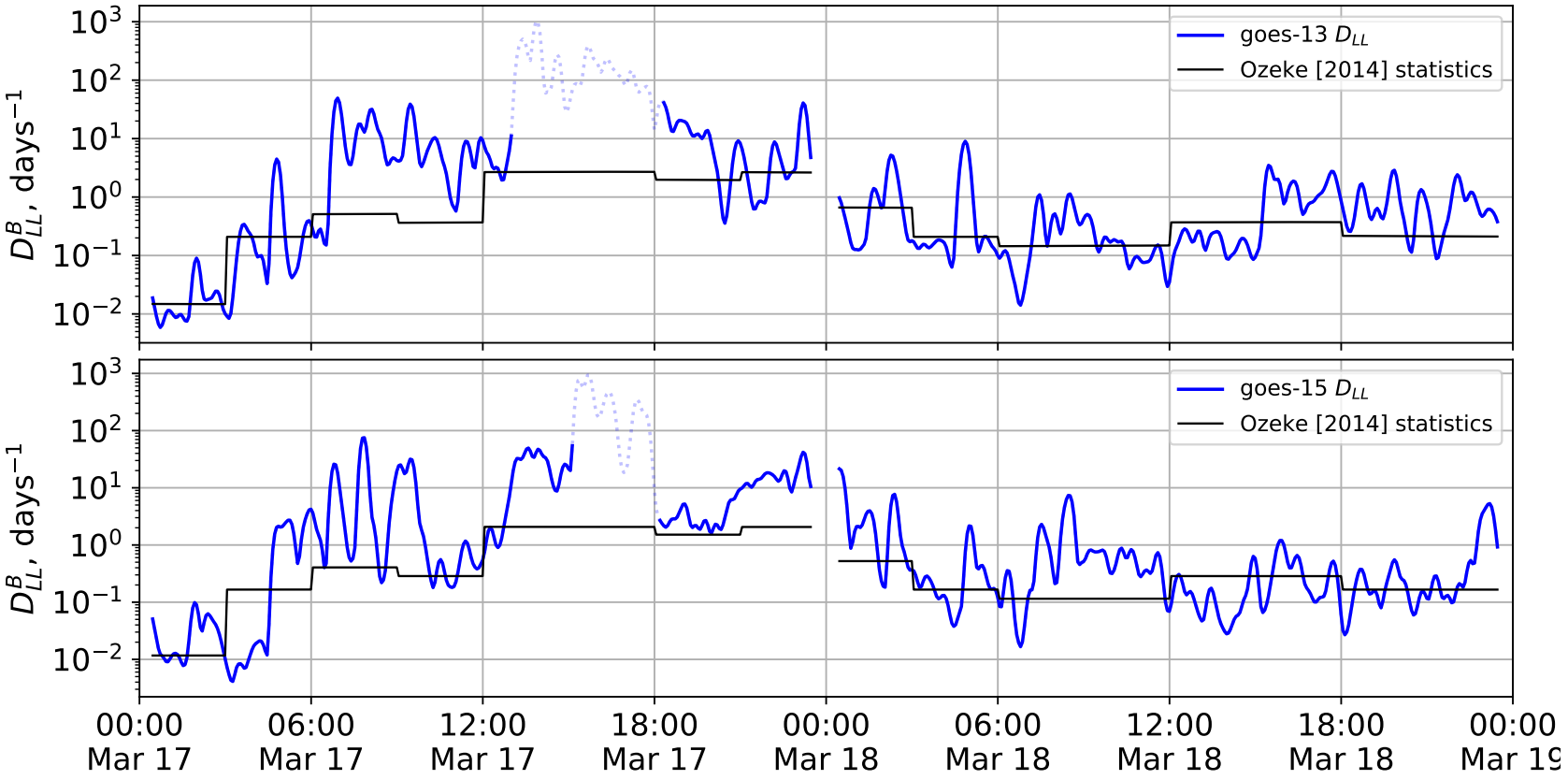


D_{LL}^{B} seems constant for all energies (frequencies).

In-situ $\neq$ Statistics!

$D_{LL}\left(f\right) = const$!

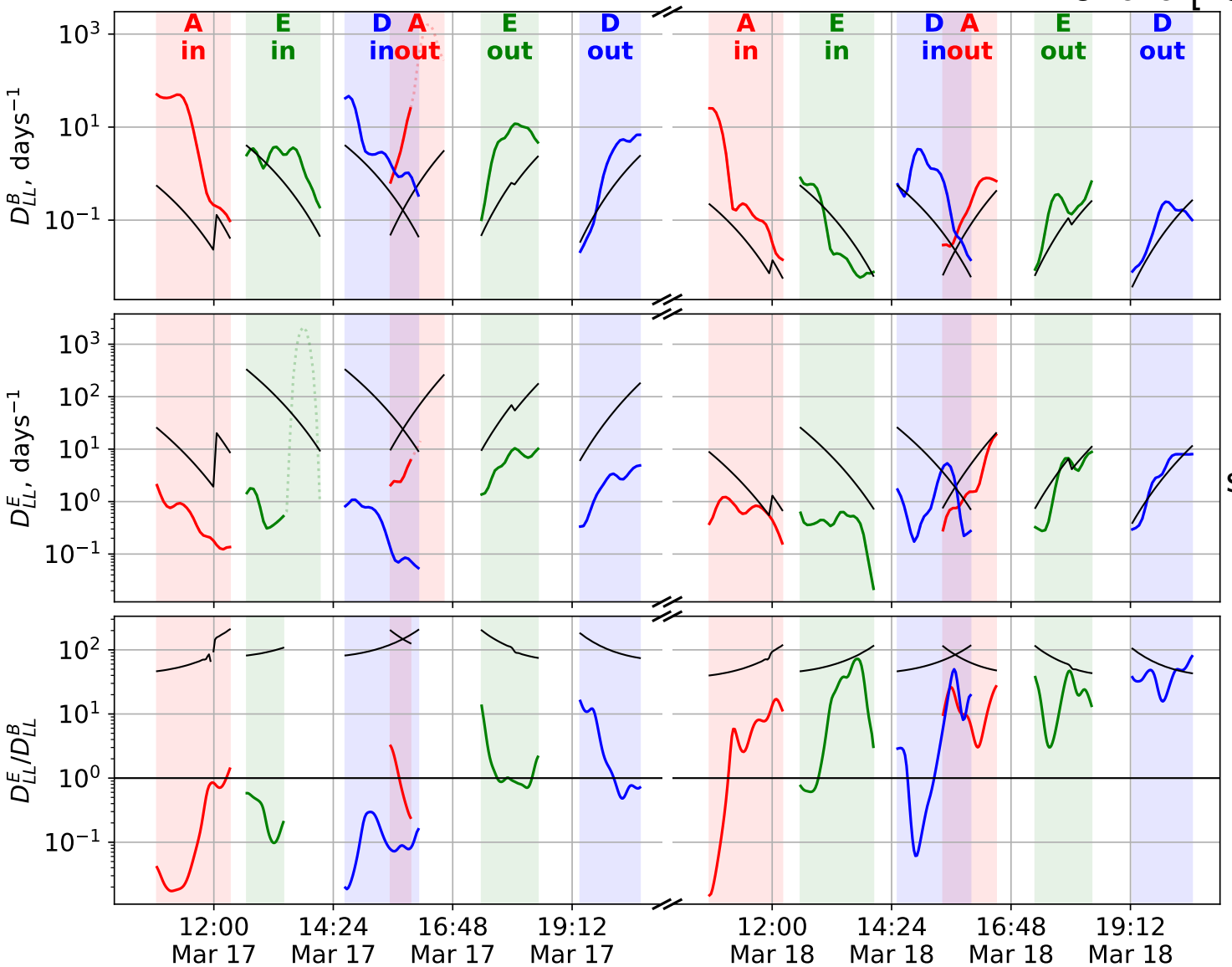
GOES D_{LL}^B



Calculated D_{LL}^B for GOES satellites are quite close to statistics.
However strong discrepancies are during the main phase.

THEMIS D_{LL}^B and D_{LL}^E

Th A data Th E data
Th B data
Ozeke [2014]

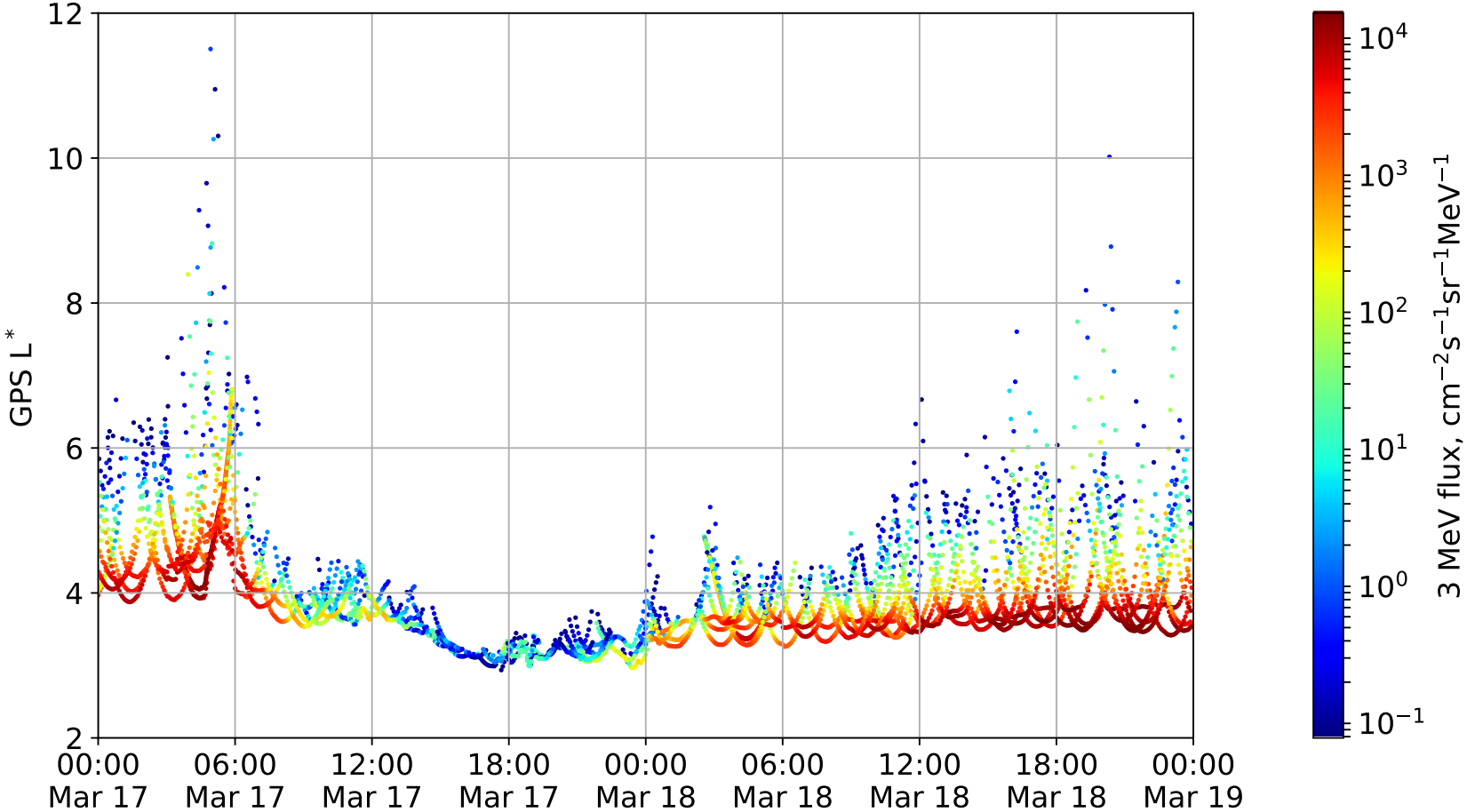


D_{LL}^B is larger than expected

D_{LL}^E is smaller than expected

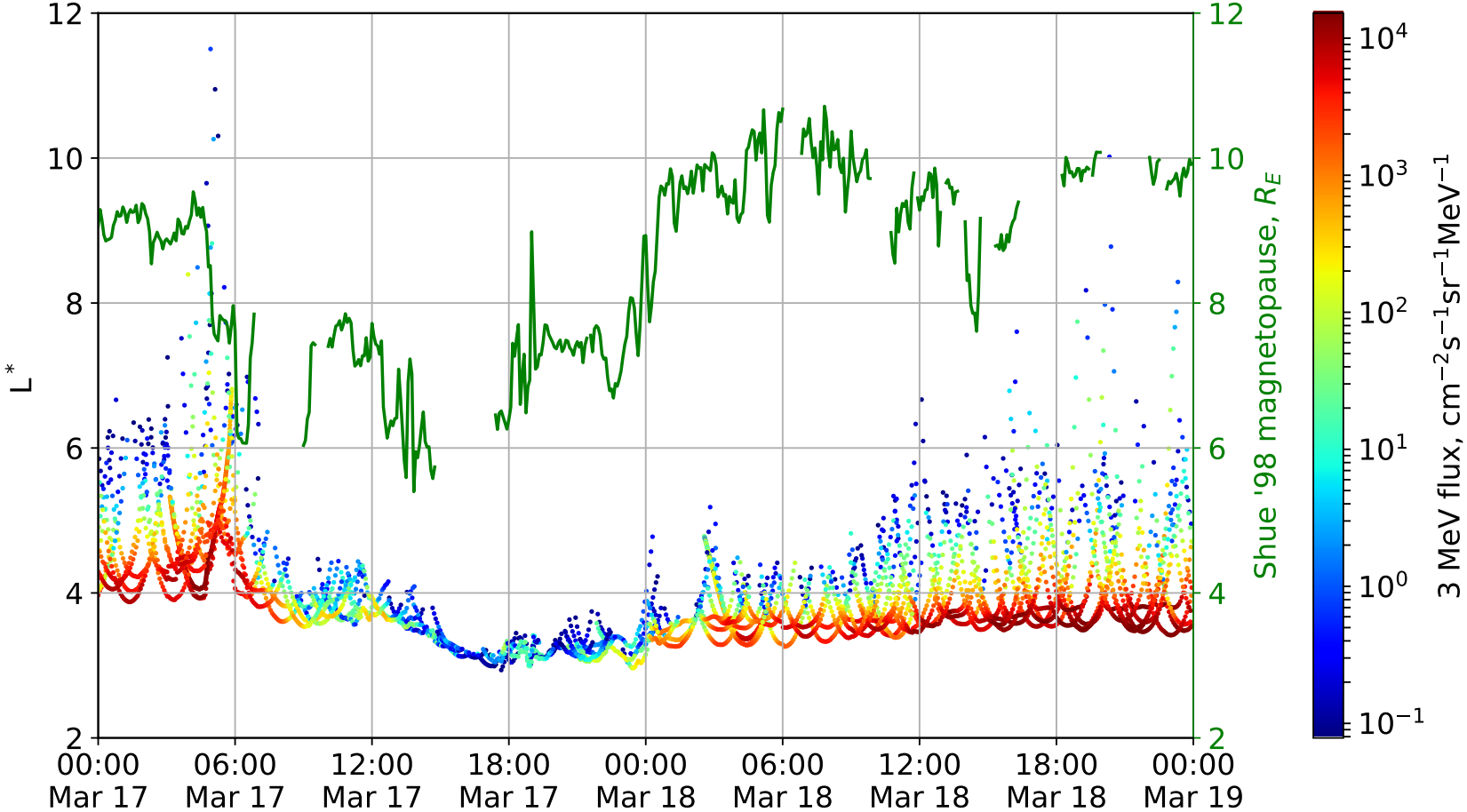
$D_{LL}^B > D_{LL}^E$ in the main phase

GPS Flux



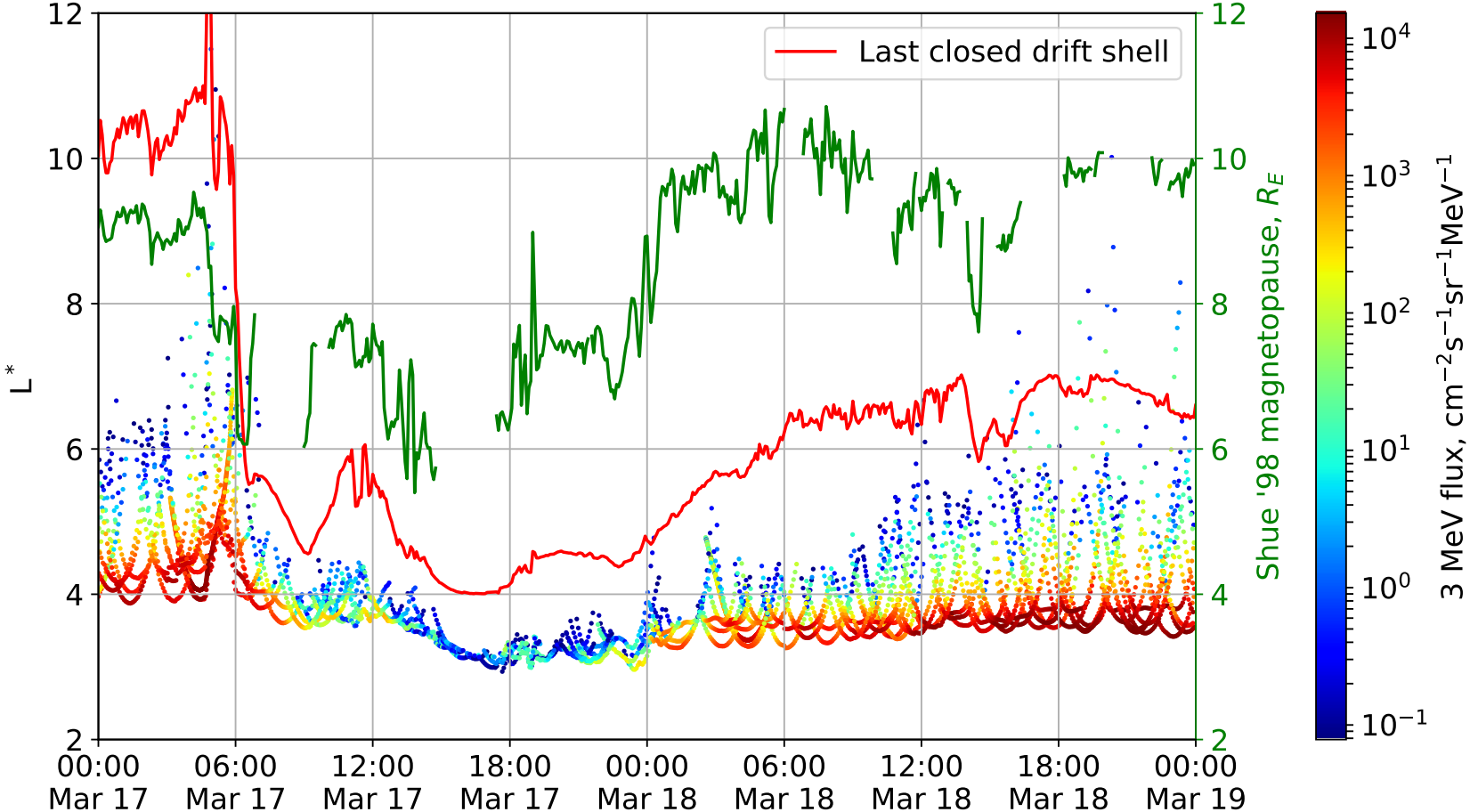
Combined data from GPS satellites can resolve the exact dropout pattern.

GPS Flux



Shue magnetopause in L potentially represents the outer boundary

GPS Flux

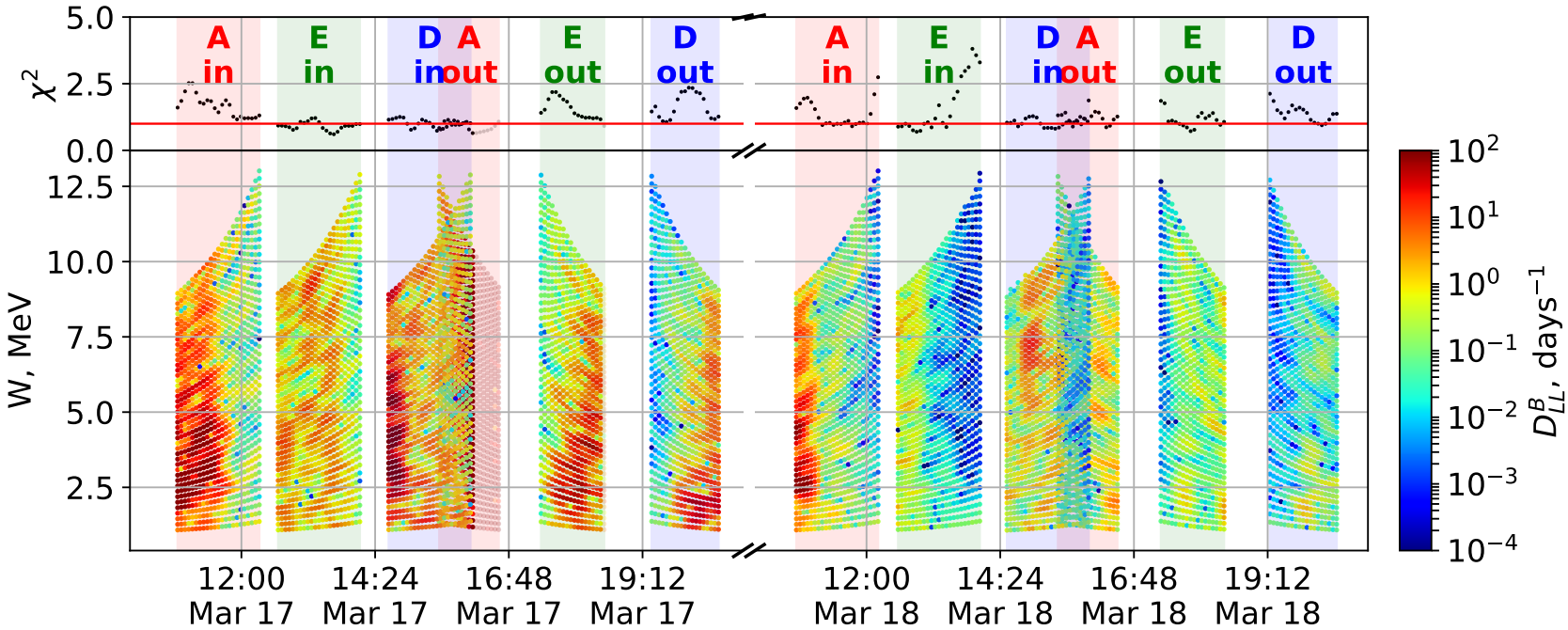


Dynamics of the Last Closed Drift Shell in L^* follows the loss patterns closer than the Shue magnetopause in L.

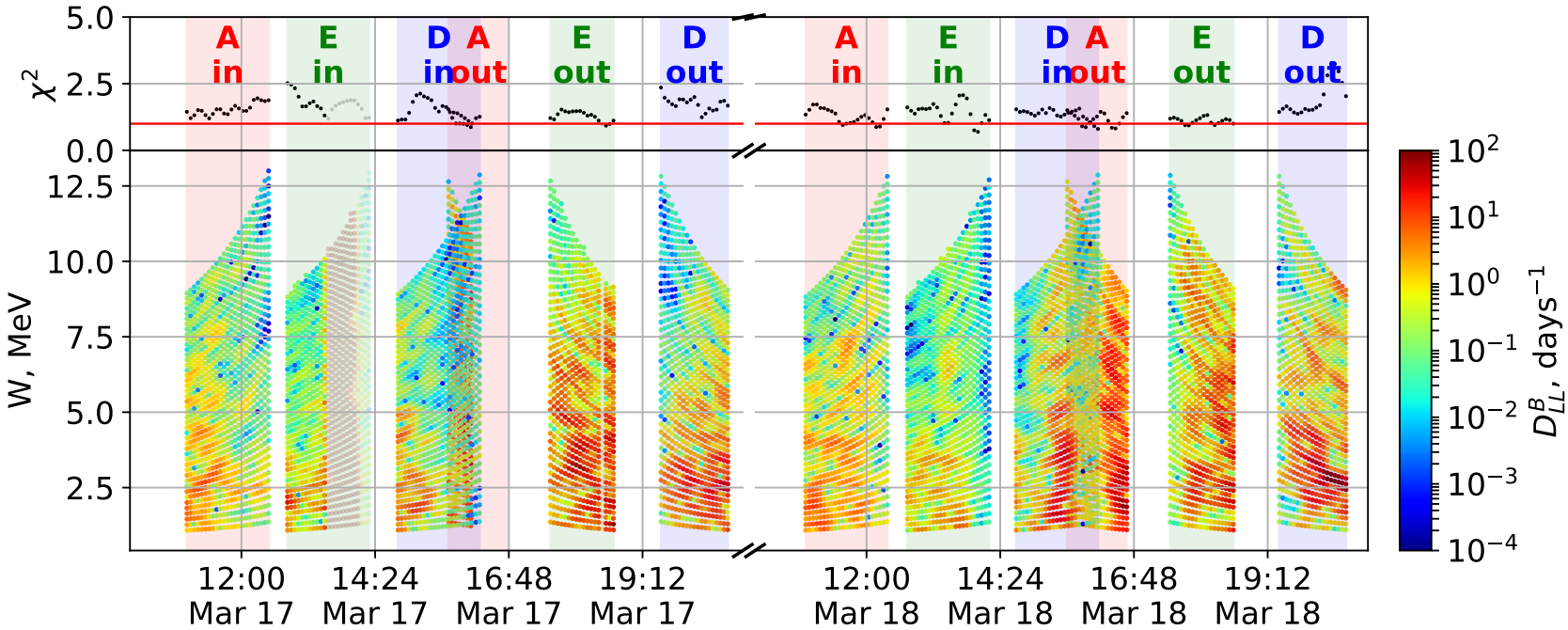
Conclusion

1. Hour time scale losses can be resolved by GPS electron flux measurements.
2. ULF wave transport induced by magnetic field dominates over electrically induced one during the main phase of a storm.
3. Measured diffusion coefficients differ from statistics in as much as 100 times.
4. Observed $D_{LL} \approx 10\,\mathrm{days}^{-1}$ creates a powerful transport mechanism for RB electrons.
5. Observed loss is strongly correlated with the last closed drift shell dynamics.
6. Results imply existence of the fast ULF wave transport to the proximal LCDS.

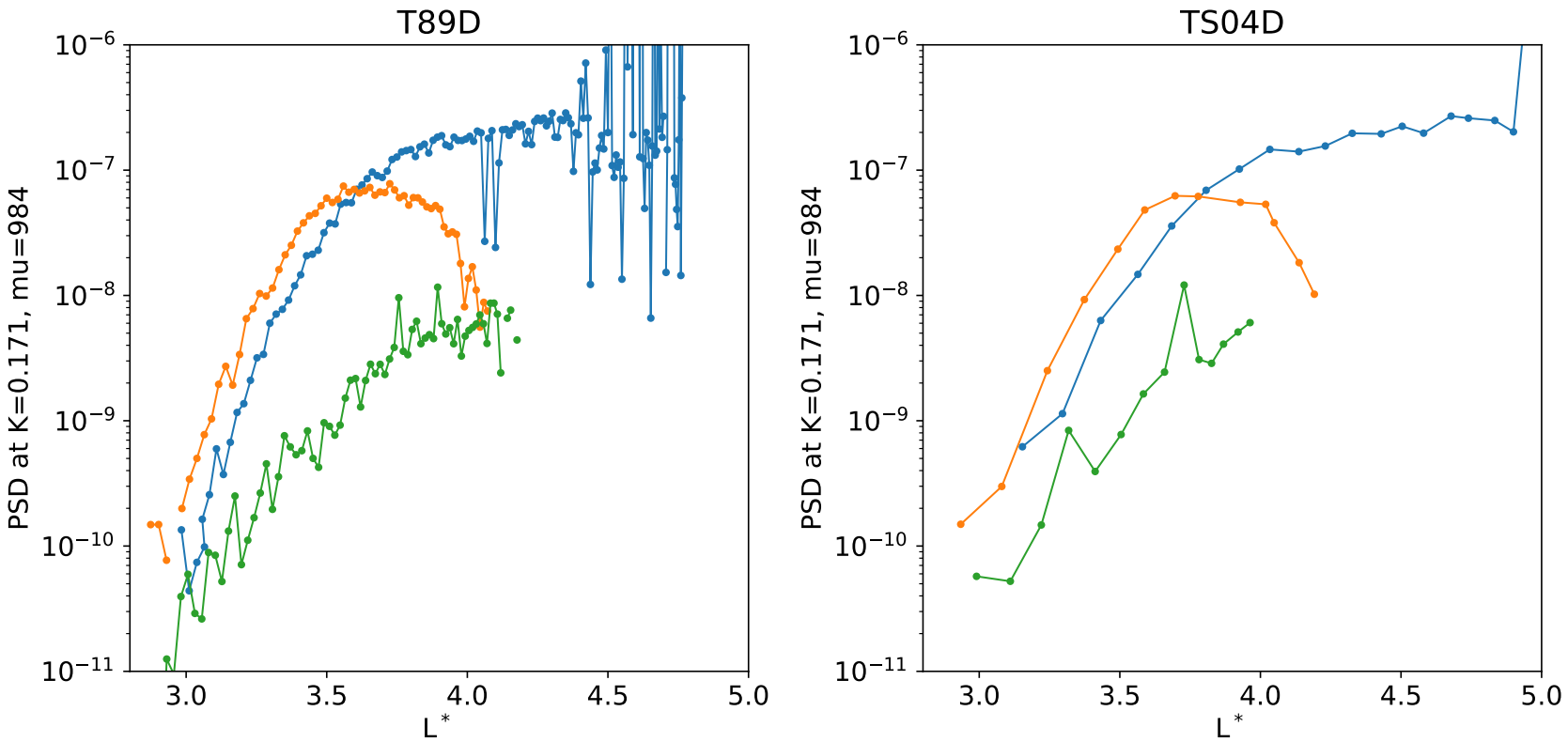
Themis $D_{LL}^{B}(W)$



Themis $D_{LL}^{E}(W)$



Phase Space Density



Calculation of the Phase Space Density was performed using LANLGeoMag library for two magnetosphere models $T89D$ and $TS04D$.