CEDAR
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High-resolution study of the relationship between the Region 2 equatorward boundary and soft electron precipitation

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Introduction

Field-aligned currents (FAC) and electron precipitation are fundamental processes in magnetosphere-ionosphere coupling and auroral formation. The global distribution and current carriers of FACs have been studied extensively, and the electron populations in these systems can be categorized as follows:

- Auroral inverted-V electrons (accelerated to peak energy of 1 keV or more)
- Diffuse auroral electrons (no monoenergetic peak)
- Auroral suprathermal/broadband electrons (characteristic energies < 1 keV; includes Alfvén wave-accelerated electrons)
- Ionospheric electrons (T_e ~ 1 eV or less; sometimes accelerated; often undetected)

This paper addresses the question: What are the properties of the Region 2 (R2) current carriers, particularly near the equatorward boundary?

Methodology: Here we present a multi-instrument study using in-situ measurements of high-resolution magnetic perturbations and soft (< 350 eV) particle fluxes . We focus on the equatorward boundary of the nightside R2 currents (MLAT > 50; MLT > 18 AND MLT < 3) and statistically examine the particle precipitation boundary relative to R2 currents, during different geomagnetic conditions.

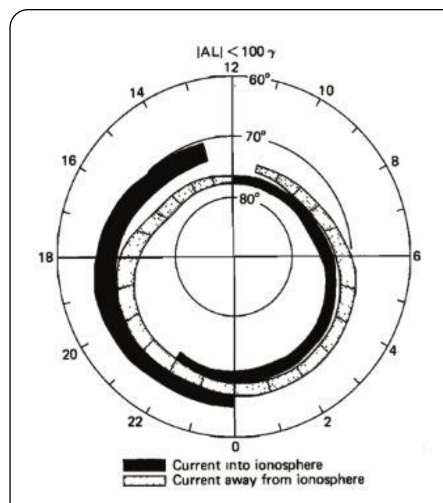


Figure 1 – Distribution and direction of large-scale FAC. (Iijima and Potemra [1976])

Instrumentation

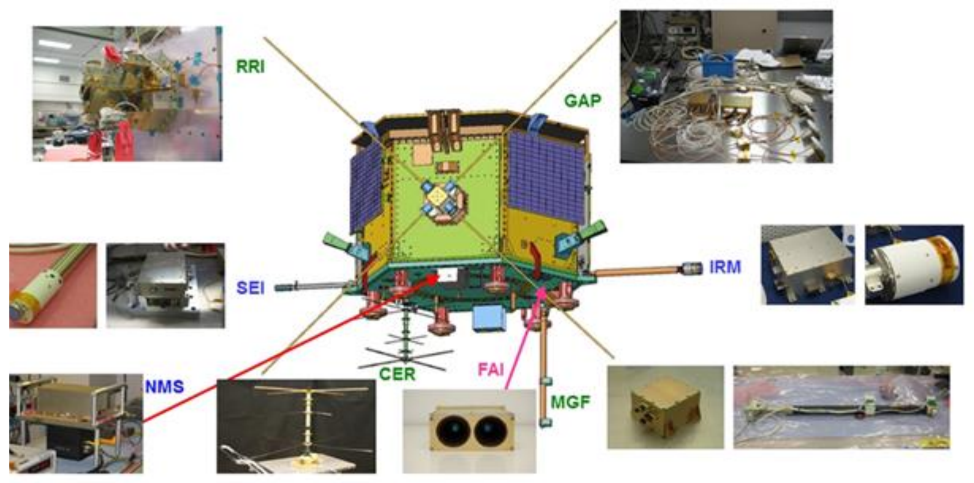


Figure 2 - ePOP instrument payload layout on CASSIOPE (Swarm-E), operating since September 2013 in a polar orbit. (325 x 1500 km, 80.1^0 inclination).

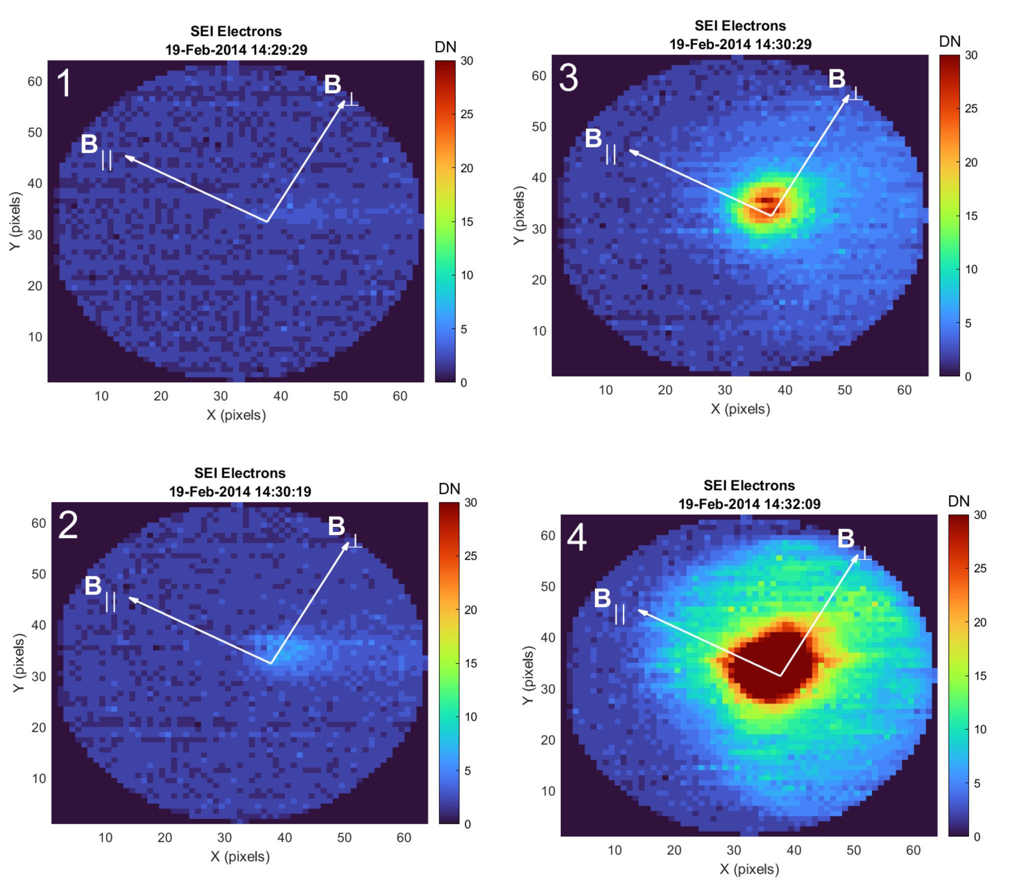
ePOP includes eight plasma instruments but does not include a method to measure high energy particles (> 350 eV). This study uses data obtained between January 2014 – January 2015 from SEI and MGF:

- Suprathermal Electron Imager (SEI) – Records 2D energy-angle images of electron/ion distribution for energy range of 5-350 eV.
- Fluxgate magnetometer (MGF) - Measures the vector magnetic field at a sampling rate of 160 Hz and a resolution of 0.0625 nT.

Note - Due to the limited availability of downlink bandwidth the operation of instruments with high-data rates such as the SEI have been limited to few minutes per day. Therefore, we do not have good coverage of R2/R1 regions in the southern hemisphere.

SEI Image Examples

Figure 3 – Typical SEI flight electron image with parallel and anti-parallel B direction. Energy range of 5-350 eV. (1 –Quiet, 2 – Before the precipitation boundary, 3 – At the boundary, 4 – Higher precipitation.

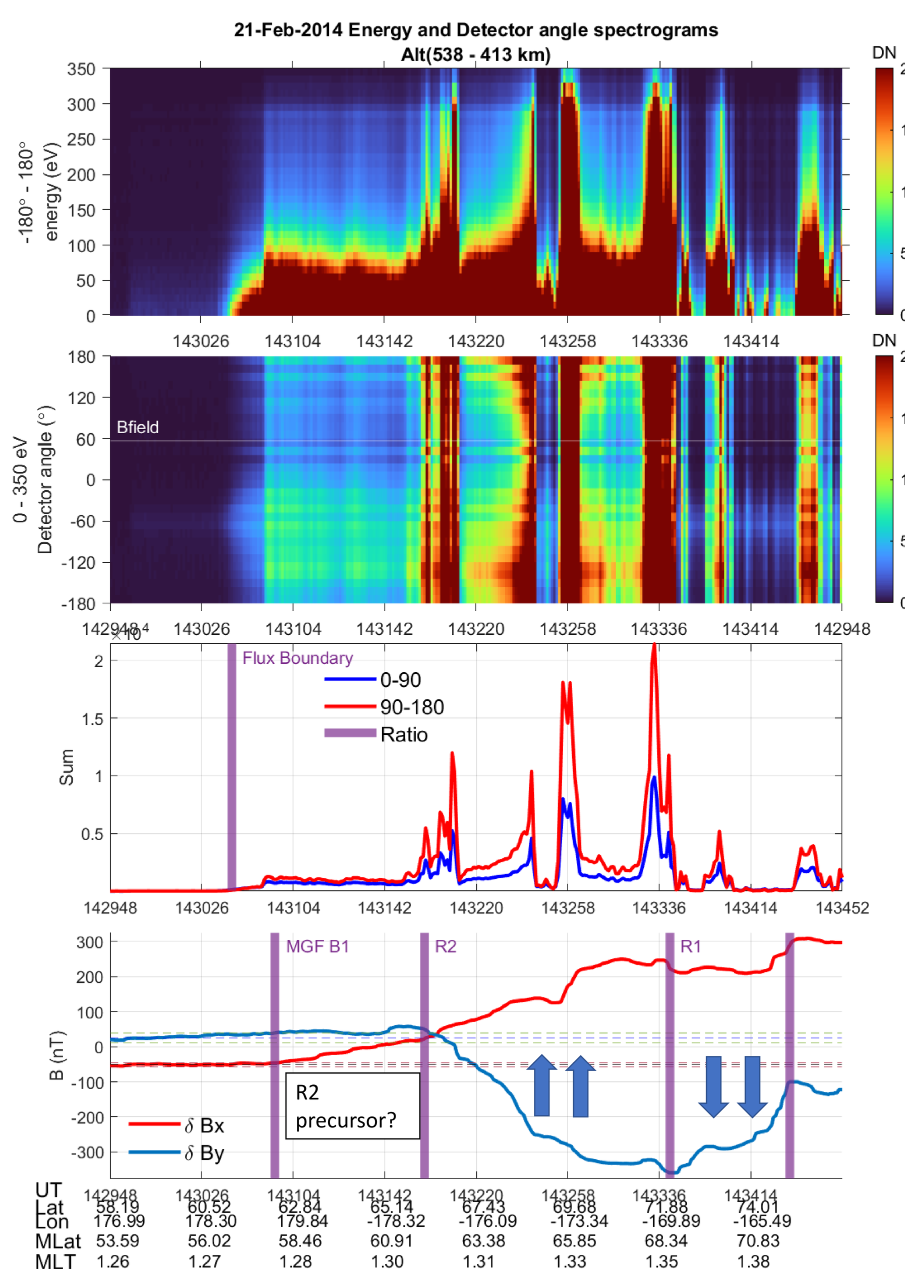


Energy increases with radius to a maximum of 350 eV.

Boundary selection criteria –

- **MGF –** 4σ deviation from the mean of the quiet magnetic field.
- **SEI –** 2σ deviation from the mean of the quiet region.

Example #1 -



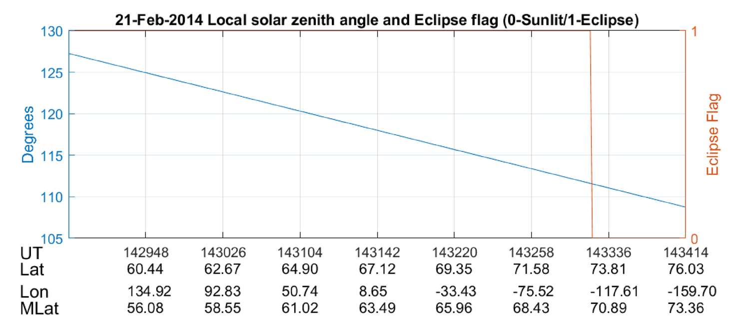


Figure 5 – Solar eclipse flag and the solar zenith angle of the spacecraft

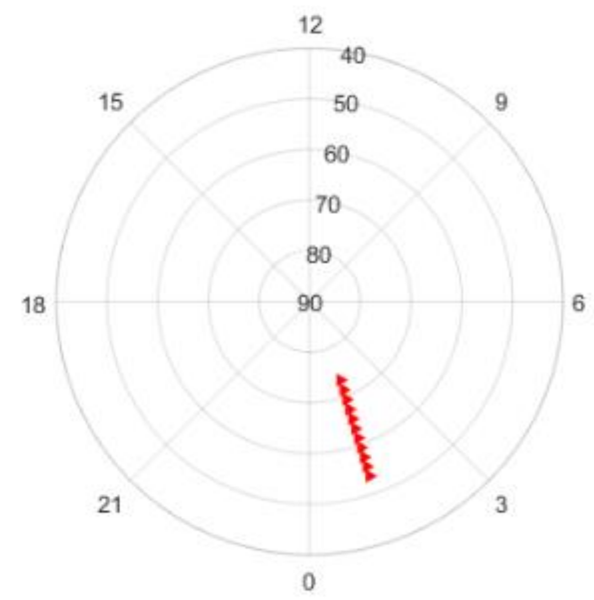
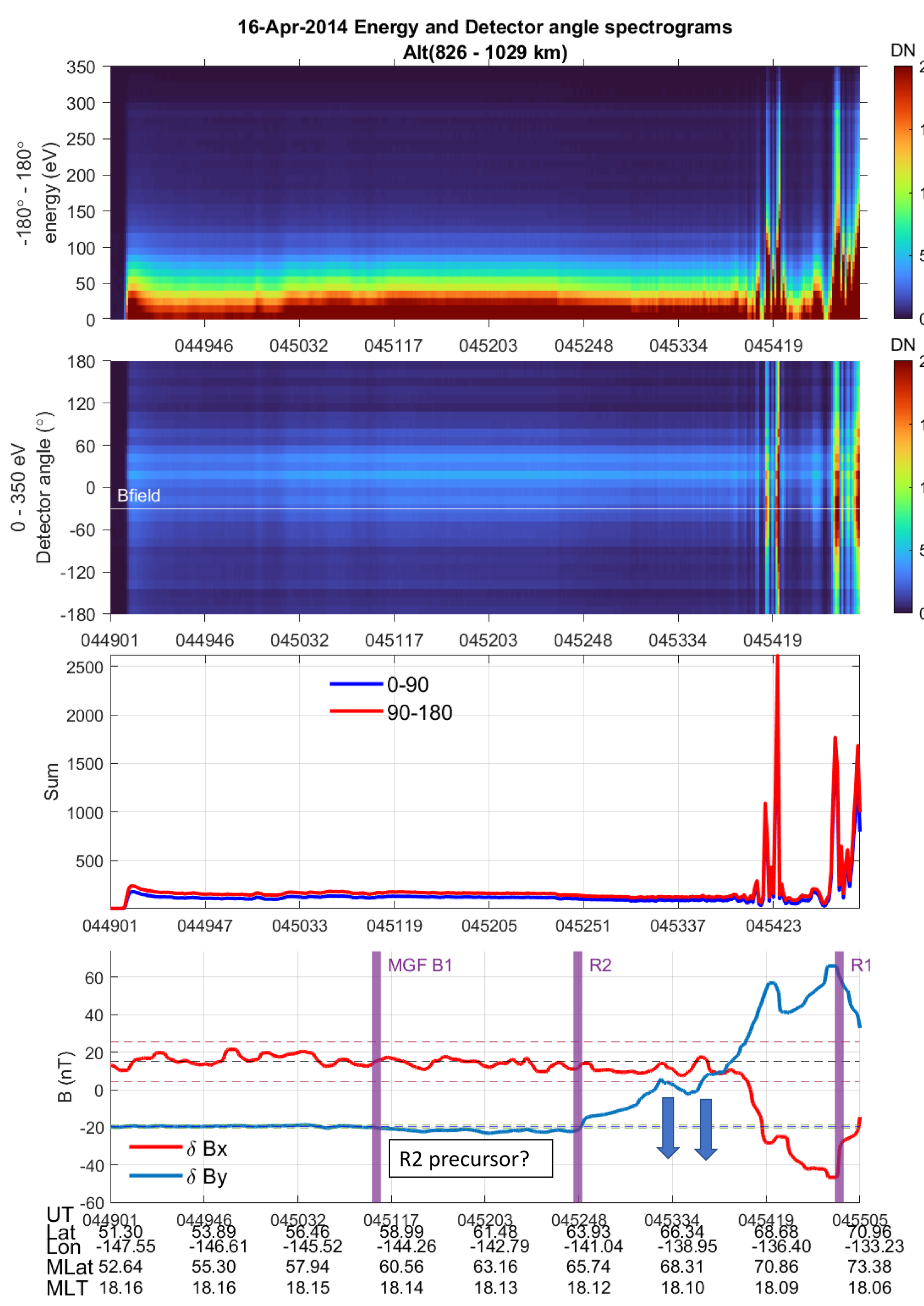


Figure 6 – Location of the SC visualized using polar plot relative to Magnetic latitude and MLT

Figure 4 – Panel 1 SEI energy spectrogram (5 – 350 eV); Panel 2 – SEI detector angle spectrogram with direction of B; Panel 3 – Downgoing and Upgoing Suprathermal electron flux; Panel 4 – Along-track (δBx) and cross-track (δBy) magnetic perturbations from MGF. An equatorward "precursor" to R2 is evident δBy.

Example #2 -



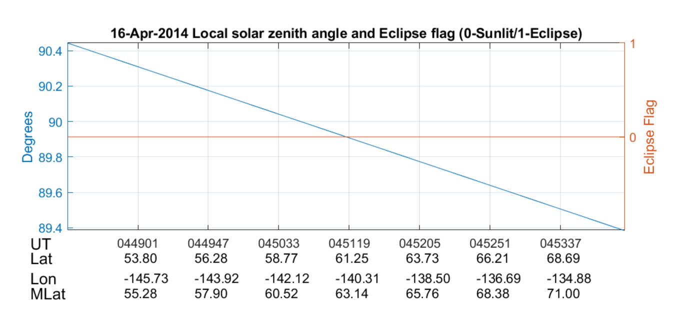


Figure 8 – Solar eclipse flag and the solar zenith angle of the spacecraft

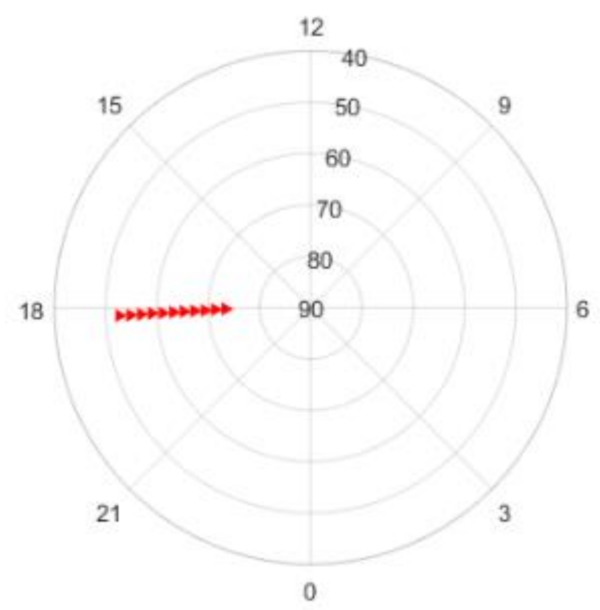
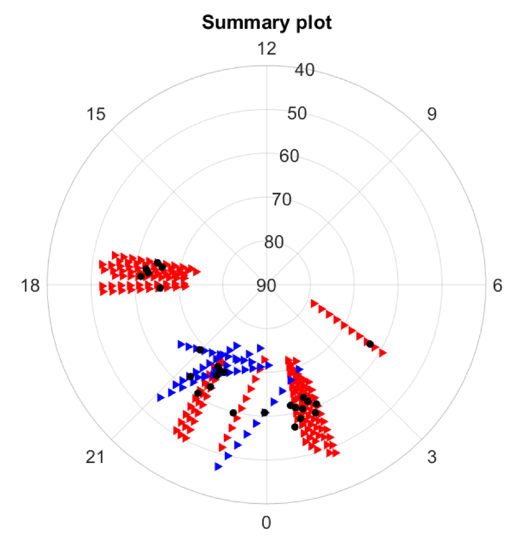


Figure 9 – Location of the SC visualized using polar plot relative to Magnetic latitude and MLT

Figure 7 – Same as Figure 4 for a dusk-side pass. Photoelectrons dominate in the sunlit sub-auroral region. Again, an equatorward precursor to R2 is evident in δBy.



Overview of 26 auroral zone traversals. Red: Northern hemisphere; Blue: Southern hemisphere.

Out of 26 cases, 15 show a clear flux boundary, and 19 cases show evidence of a precursor to R2.

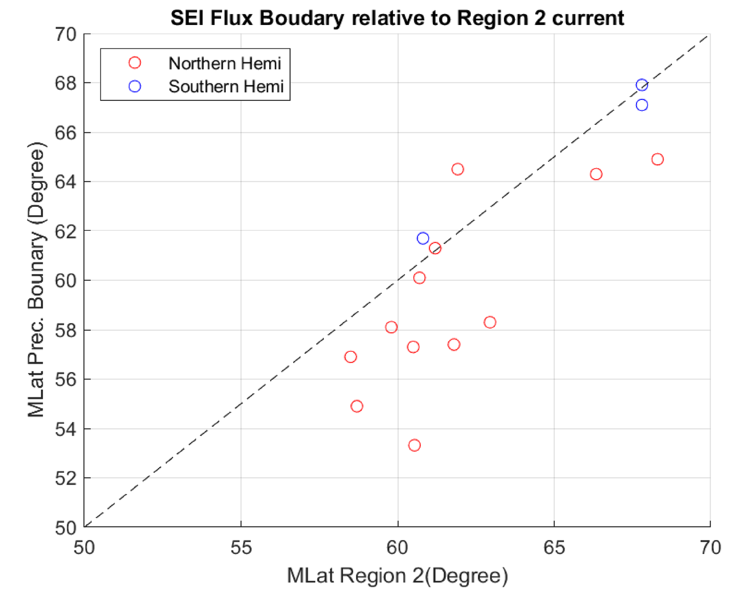


Figure 10 – Suprathermal electron flux boundary boundary relative to R2 equatorward boundary

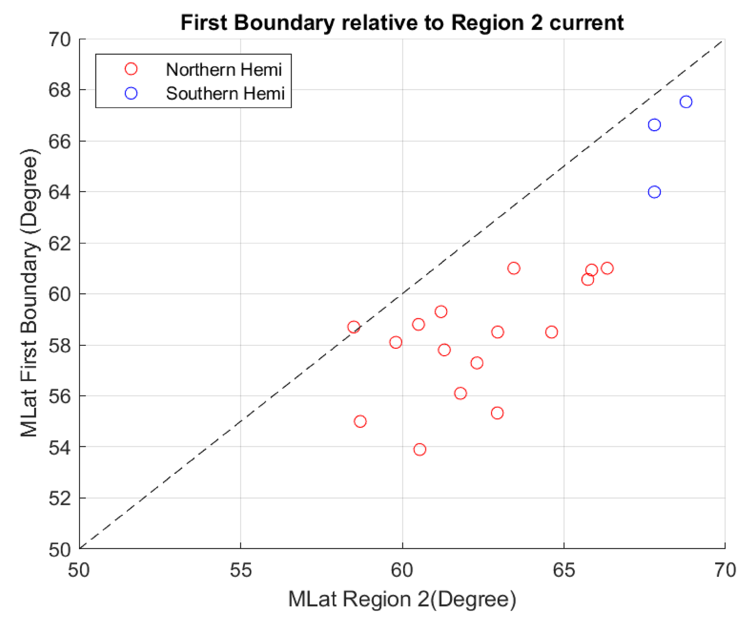


Figure 11 – MGF first deflection point relative to R2 boundary

Conclusion and future work

- Suprathermal electron fluxes in the 5-50 eV range are seen equatorward of the R2 boundary in 15 out of 25 traversals.
- The flux is narrow in pitch angle close to the boundary. (9 Cases)
- These fluxes are consistent with a weak "precursor" current seen by the MGF instrument equatorward of R2.
- **Question: Has this precursor region been reported in literature?**

References

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Acknowledgements

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