Simultaneous Observation Of A Strong Electron Microburst At The Equator And In the Ionosphere

Forrest Mozer[1], Oleksiy V. Agapitov[1], J Bernard Blake[2], and Ivan Vasko[1]

[1] *Space Science Laboratory, University of California, Berkeley, Berkeley, CA*

[2] *Aerospace Corporation Santa Monica, Santa Monica, CA, United States*

Acknowledgements

- US Air Force Space and Missile Systems Center Developmental Planning Directorate (SMC/XR)
- The Aerospace Corporation Space Sciences Applications Laboratory (SSAL)
- The Aerospace Corporation PICOSAT Team

Chorus and electron microburst precipitations

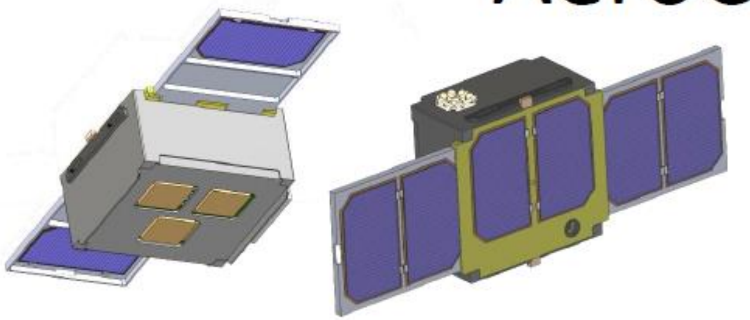
- **Chorus type whistler waves**
  - structured e/m whistler emissions generated in a vicinity of the equator with f from 0.1-0.45 and 0.5- 0.9 f_{ce}
  - time scale from 0.05-0.5 s
  - spatial scale 600-800 km at L~4-5
- **Microbursts**
  - 10 KeV – >1 MeV electrons bursty precipitations
  - time scale ~0.1-0.2 s
  - from ~10-100 km spatial scale (Crew et al., 17; Shumko et al., 18), which corresponds to ~100-1000 km near the equator

Connection of MB to Chorus is discussed from 60s:

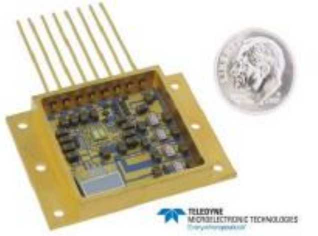
Anderson+ 1966, Datta+1996, Dietrich+2010, Hikishima+2010, Imhof+1992, Johnston+2010, Kurita+2016, Lee+2005, O'Brien+ 2003, Oliven&Gurnett1968, Omura&Zhao 2013, Parks 1967, Roeder+1985, Rosenberg+1977, 1981, 1990, Siren+1980, Thorne+2005, Tsurutani+2013 and many more

Kersten+2011, Breneman+ 2017, Crew+ 2016 , Mozer+2018, Shumko+2018(under review)

AeroCube-6*



Dosimeter Payload:



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- AeroCube-6 is two 0.5U cubesats
- Science goal: measure spatial scales of radiation in LEO
- Launched June 19th
- 620 x 720 km x 98°
- Payload: 3 dosimeters on each satellite
- Including 3 new variants that have never flown before
- Nominal sample rate is 1 Hz
- Dosimeters A1 and B1 can burst at 10 Hz
- Using differential drag technique to modify spacecraft in-track separation

S/C	ID#	Dosimeter	Measures
A	A1	Thin Window Low LET Variant	>50 keV electrons & >600 keV protons
	A2	Thin Window High LET Variant	>600 keV protons
	A3	Standard Teledyne	>1 MeV electrons & >10 MeV protons
B	B1	Thin Window Low LET Variant	>50 keV electrons & >600 keV protons
	B2	Thin Window High LET Variant	>600 keV protons
	B3	High LET Variant	>10 MeV protons

*Also known as CubeRad, which refers to the dosimeter payload

paul.obrien@aero.org
Space Sciences/SSAL/PSL

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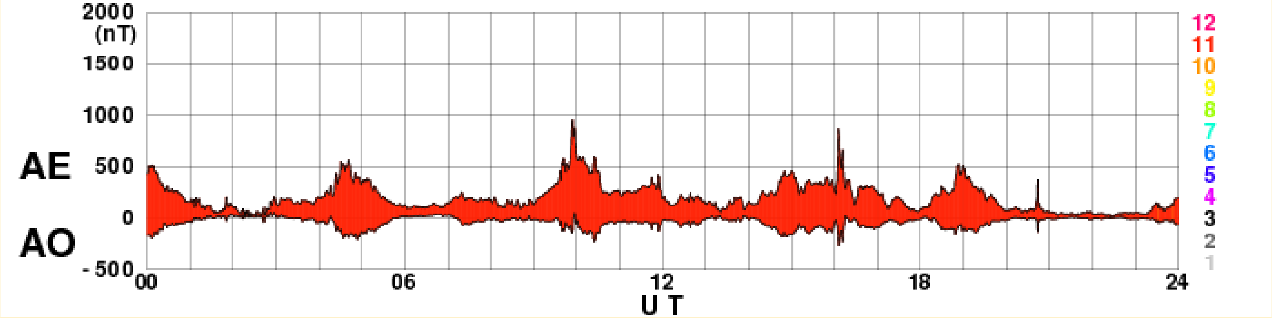
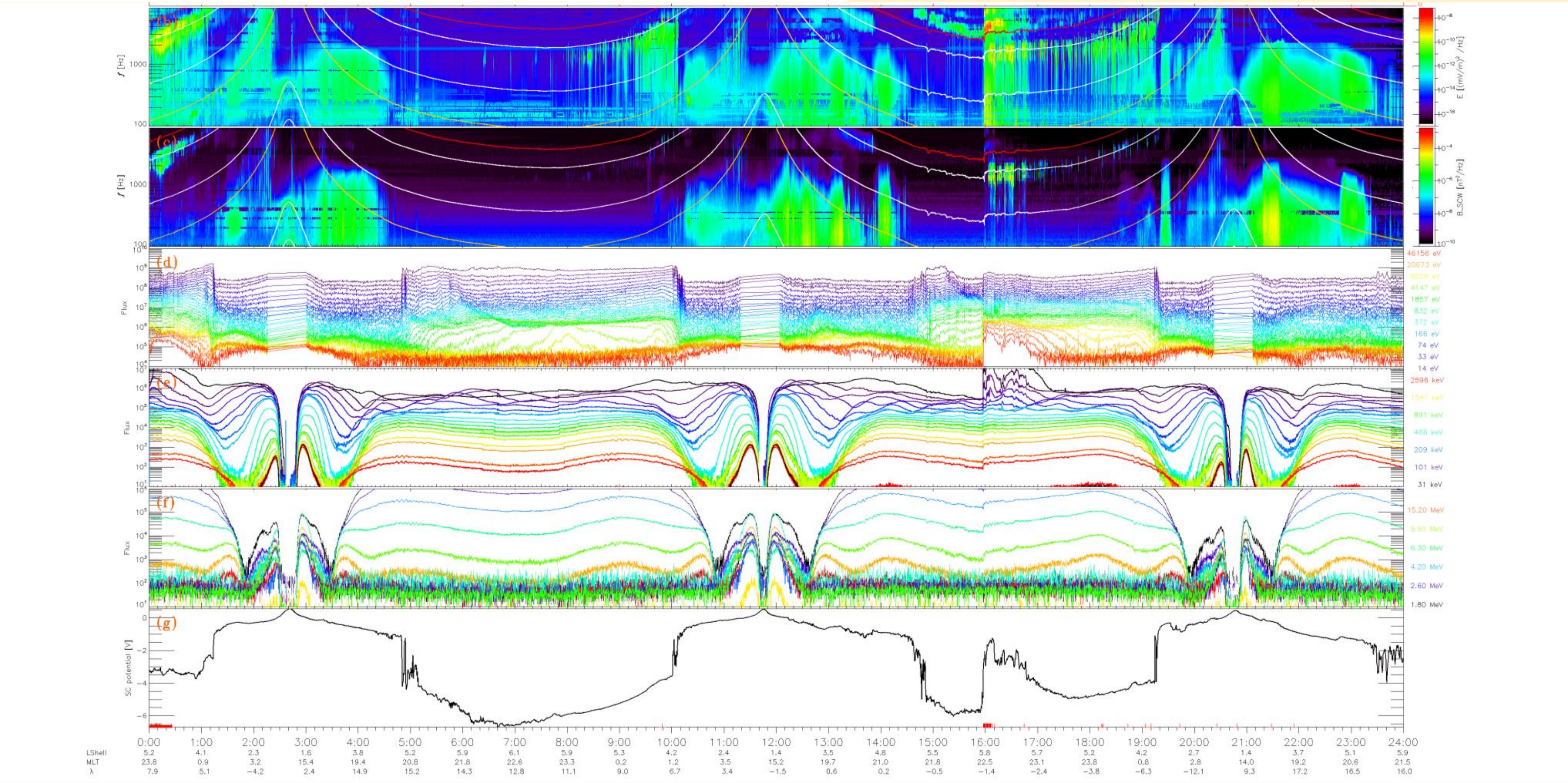
Chorus and electron microburst precipitations



AE index and Van Allen Probe B overview on December 11, 2016



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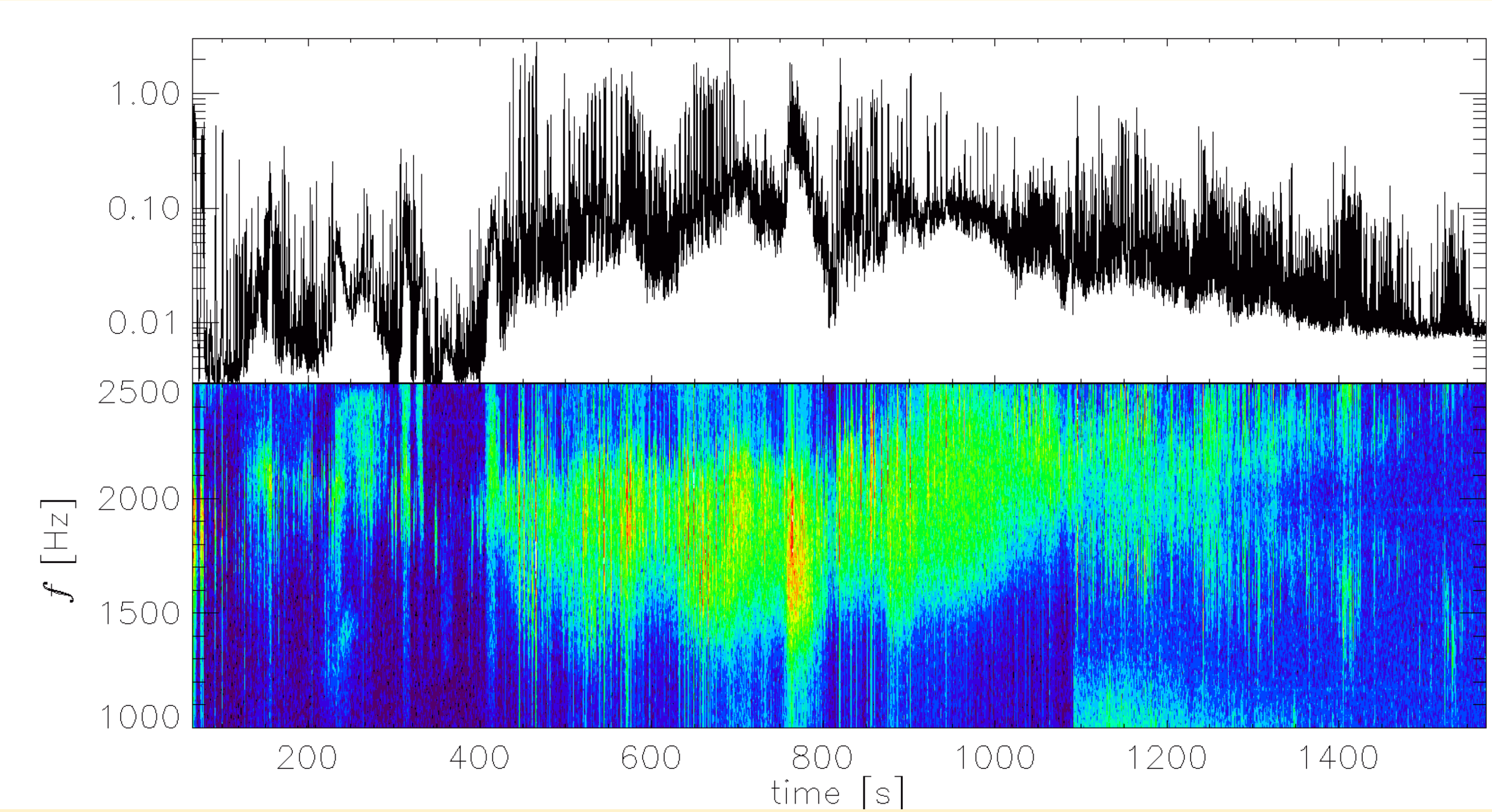
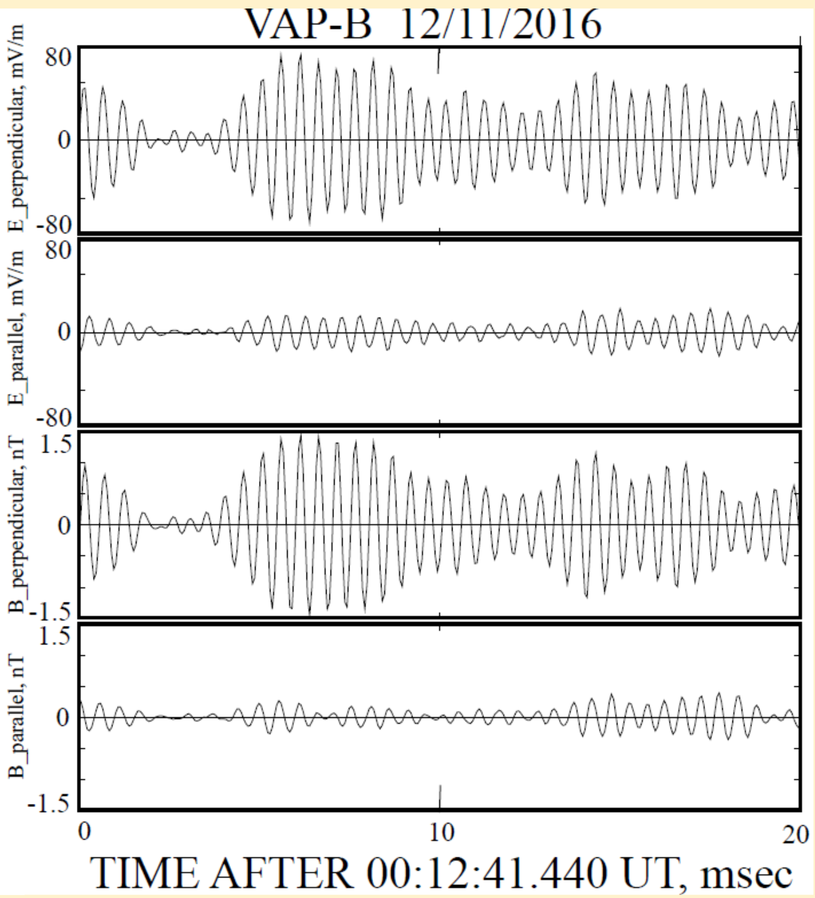
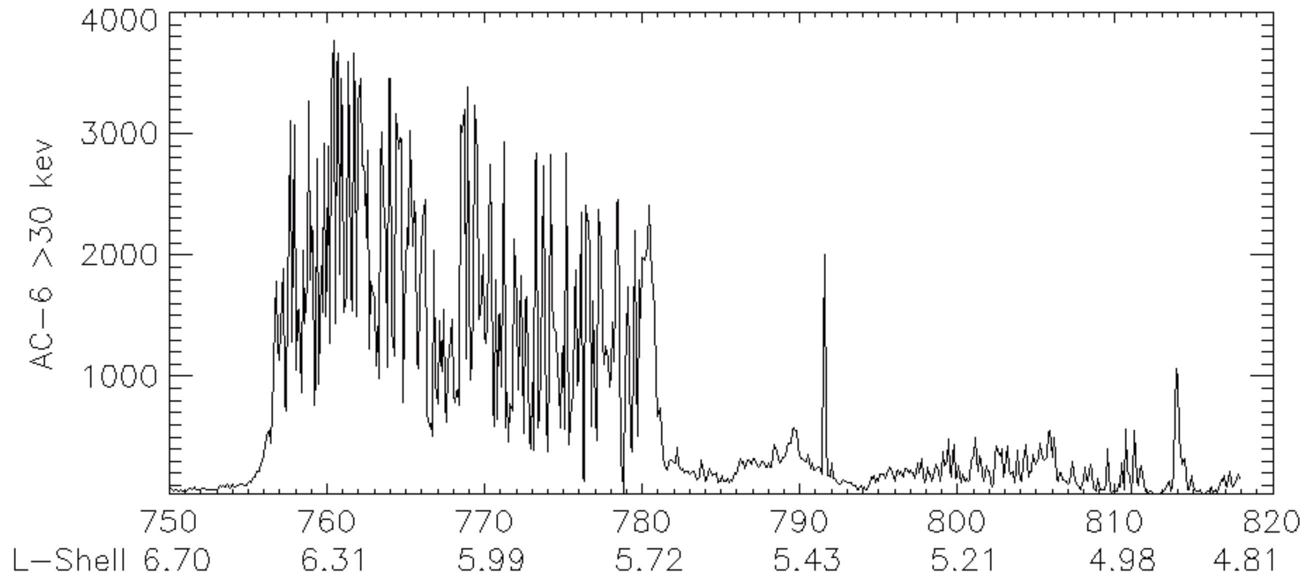
Chorus waves on December 11, 2016

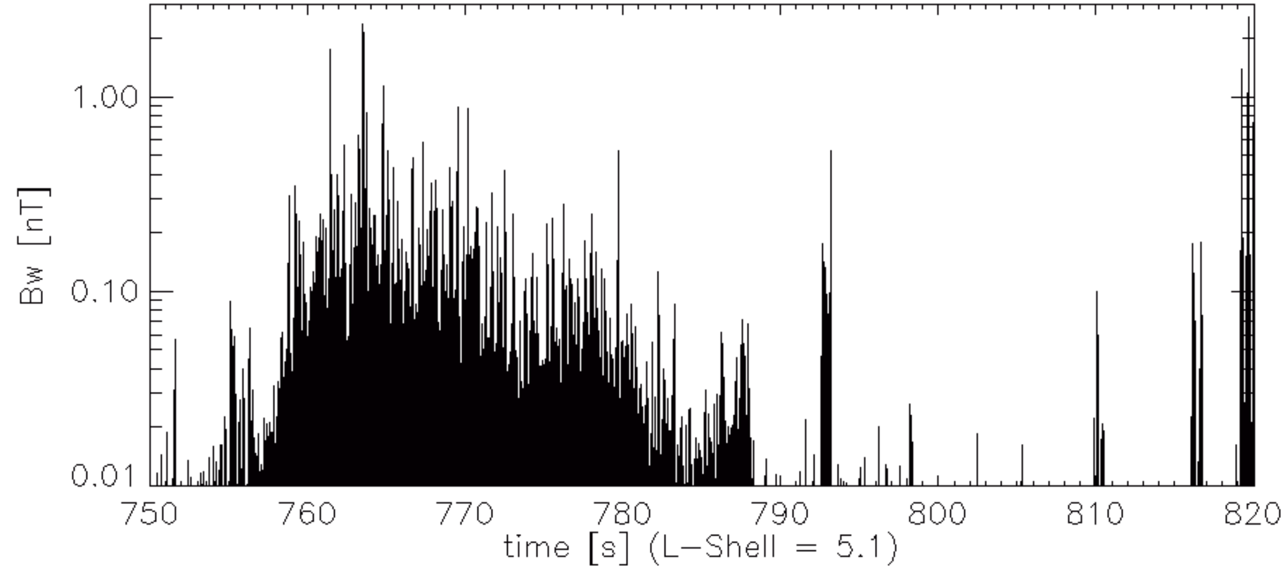




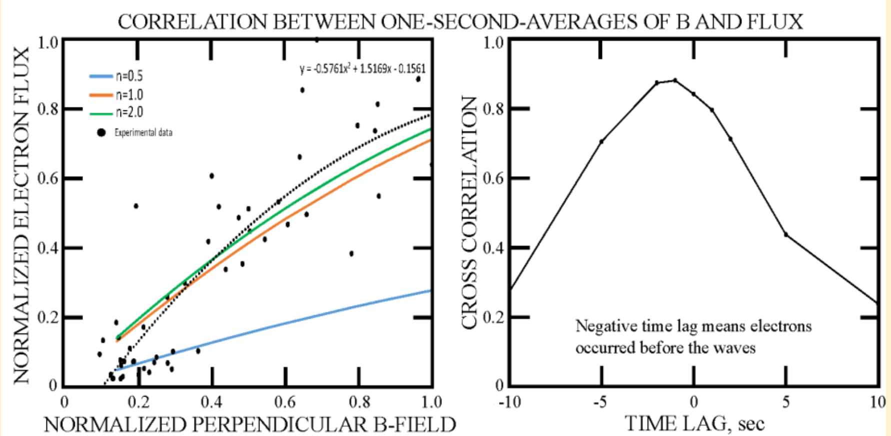
On December 11, 2016, at 00:12:30 UT, Van Allen Probe B was located at 6 Re geocentric altitude near midnight. The chorus amplitude and the power spectrum captured aboard the Van Allen Probe B on December 11, 2016

Microbursts associated with chorus





On December 11, 2016, at 00:12:30 UT, Van Allen Probe B was located at ~5.5 Re geocentric altitude near midnight on a magnetic field line whose foot point, at an altitude of 100 km, was located at 67.4º latitude and 345.5º longitude. At the same time, the AC6-B satellite was in the ionosphere on a field line whose 100 km foot point was at 62.3º latitude and 347.7º longitude. The separation of the foot points at 100 km over the event was about 600 ± 100 km. AC6-B measured electrons >35 keV that were in the local loss cone while Van Allen Probe-B observed chorus waves.



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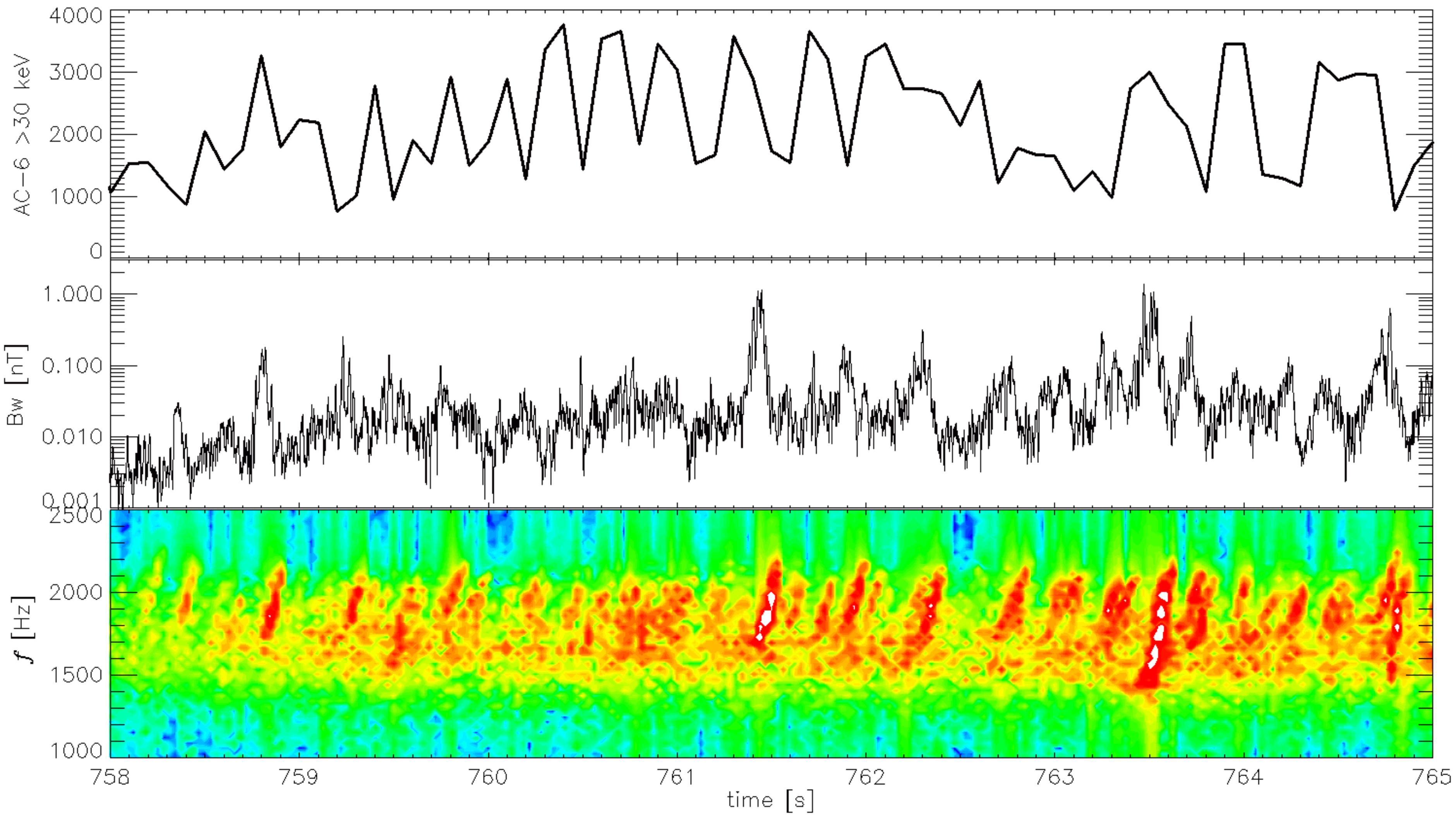
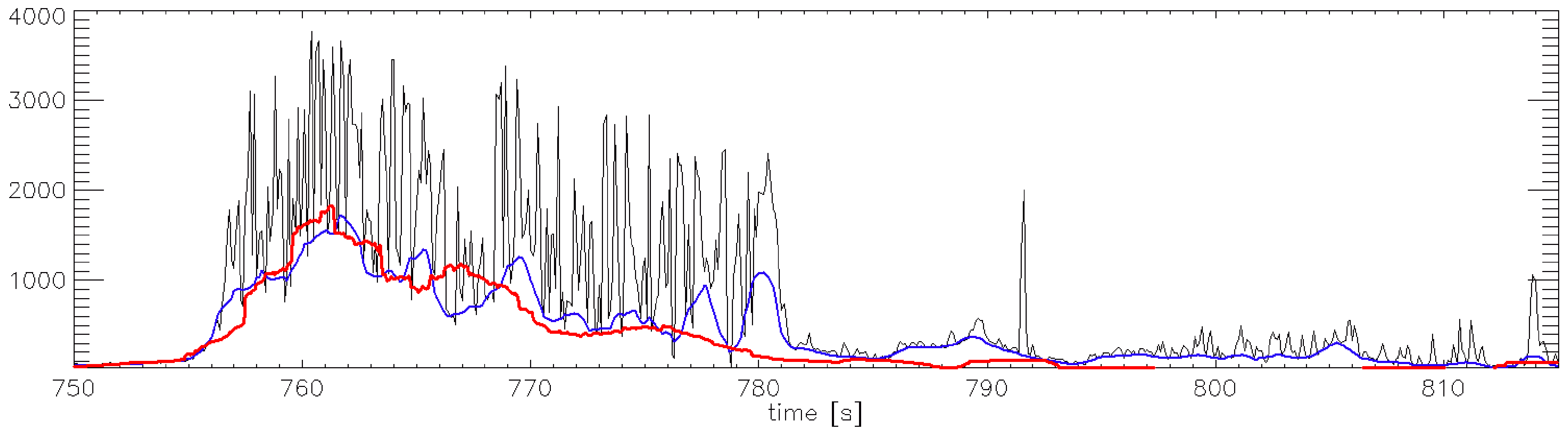
Chorus and MBs



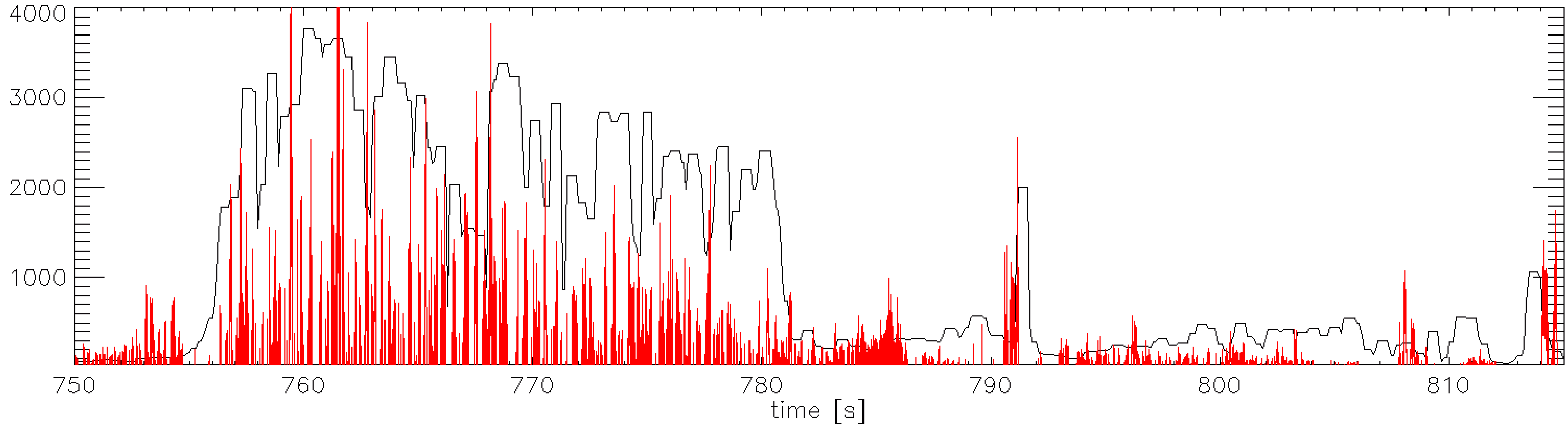
Example of the rapid flux variations observed in the precipitating electrons (panel a) and in the chorus wave amplitude at the equator (panel b). Panel c presents the wavelet spectrum of the chorus magnetic field.

QL approach



The observed electron flux versus time (black curve) along with the fluxes expected from the quasi-linear diffusion (the red line). The blue curve represents the base line of the flux without microbursts. We restrict our estimates to parallel chorus waves (because the observed waves had wave normal angles <10º, as seen by the ratio of the magnetic fields in the two bottom panels of Figure 3) and we compute the quasi-linear pitch angle diffusion coefficient following *Summers* [2005]. The chorus properties are adopted from the Van Allen Probe measurements presented, e.g., in Figure 3. We have verified that the magnetic field power spectral density of the chorus waves is well-fitted by the expression $I_B(f) = A\,\exp[-(f - f_0)^2/\delta f^2]$, where $f_0 = 1780$ Hz, $\delta f = 230$ Hz and the frequency range is $|f - f_0| < 2\delta f$. The parameter, A, is related to the root mean square (RMS) chorus wave intensity B_w^2 by the standard relations [e.g., *Summers*, 2005].

NL approach



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Conclusions

A conjunction event between bursty electron precipitation observed by AC6 at low altitudes for a few tens of seconds and chorus waves observed by the Van Allen Probes at the equator is presented.

The equatorial electron fluxes measured by the MAGEIS instrument and the root mean square chorus wave intensity to evaluate the flux of precipitating electrons, using quasi-linear theory. The predicted precipitating flux agrees with the base line of flux measured by AC6.

The MBs well correspond to the chorus temporal and amplitude structure and provide the significant contribution to the precipitation, which is not explained by the QL approximation but requires the NL approach to wave-particle interaction