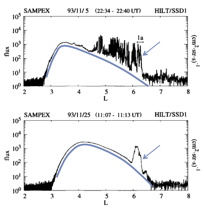
# Rapid Enhanced Precipitation of Radiation Belt Electrons: Microbursts and Precipitation Bands


L. W. Blum and X. Li

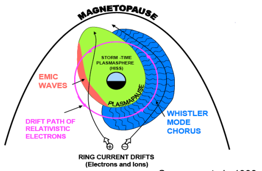
LASP, University of Colorado, Boulder, CO, U.S.A.
Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, U.S.A.
lauren.blum@colorado.edu


## Background

- Radiation belt dynamics are controlled by a balance of acceleration and loss mechanisms
  - In order to fully understand source processes, we must understand loss
  - One main loss mechanism is precipitation into the atmosphere via pitch angle scattering by waves (e.g. EMIC, Hiss, Chorus)
- Rapid enhancements of MeV electron fluxes are measured by low earth orbit satellites on timescales ranging from <1 second to minutes
- Microbursts: <1 second bursts of electron precipitation
  - Occurrences peak from midnight – dawn, becoming more enhanced during active times
  - Pitch angle scattering by large amplitude Whistler mode waves or Chorus at high latitudes or higher order resonance is believed to be one cause of MeV bursts (Lorentzen et al., 2001)
- Precipitation Bands: broader bands of precipitation, typically a few degrees in latitude, lasting seconds - minutes
  - Occur most often on the afternoon and nightside, and are often seen in conjugate locations, persisting multiple orbits (Blake et al., 1996)
  - Potential source mechanisms include EMIC or electrostatic waves (Vampola, 1977; Thorne and Kennel, 1971)




Nakamura et al., 2000




Summers et al., 1998

Goal: to investigate the distributions of these rapid enhancements in MeV electron precipitation to help understand their source mechanisms and contributions to radiation belt losses

## SAMPEX HILT Data

- We use 100 msec count rates from the HILT instrument on SAMPEX, in an 82° inclination orbit of ~500-600 km altitude
  - HILT: an array of 16 solid state detectors grouped into 4 rows of 4 detectors - SSD1, SSD2, SSD3, SSD4
  - Sensitive to >1 MeV electrons
  - ~60° field of view, geometric factor = ~15 cm² str per SSD row

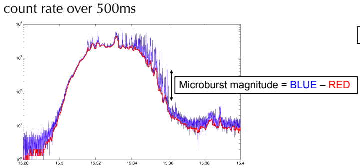
- Microburst detection criteria:

$$\frac{N - N_{ave}}{\sqrt{1 + N_{ave}}} > 10$$

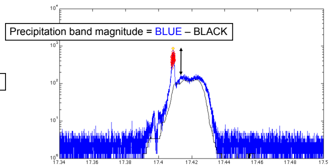
(O'Brien et al., 2003)

$N$ = 100ms count rate, and $N_{ave}$ = average count rate over 500ms

- Precipitation Band detection criteria:
  - $N_{100}$ > 4x baseline for ≥ 5 seconds
  - 10 second linear correlation coefficient between $N_{100}$ and baseline <0.955



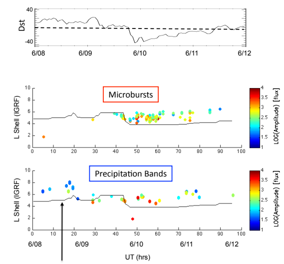

BLUE: 100 ms count rate
RED: Baseline - 10th percentile of 3 sec bins

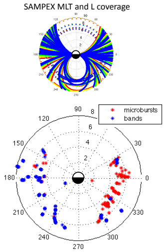



BLUE: 100 ms count rate
RED: Band detections
BLACK: Baseline - 10th percentile of 20 sec bins

## Event Study

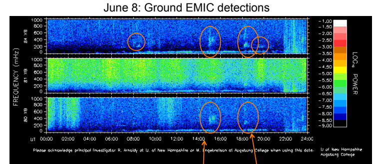
- Compare precipitation bands measured by SAMPEX/HILT to EMIC wave distributions for disturbance event
  - Small storm June 8-11 2001: GEM Plasmasphere Magnetosphere Interactions (PMI) focus group challenge event



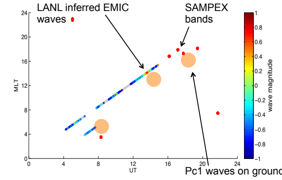

$L_{pp} = -1.57 \cdot \log_{10}(Dst_{min,\,24hr}) + 6.3$ (O'Brien and Moldwin '03)

June 8: Ground EMIC detections



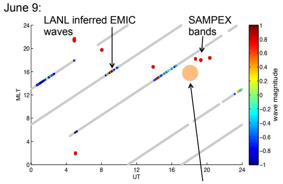

(Courtesy of Mark Engebretson) ~noon LT Pc1 activity

June 8:




- LANL plasma conditions used to infer EMIC growth (Blum et al., 2012)

June 9:

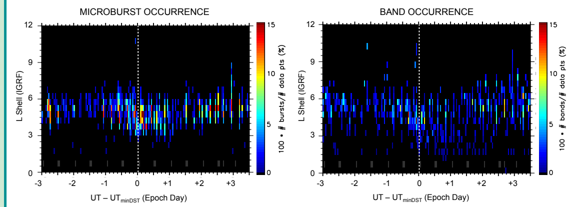



- LANL measurements, ground EMICs, and precipitation bands are compared across UT and MLT for June 8th and 9th

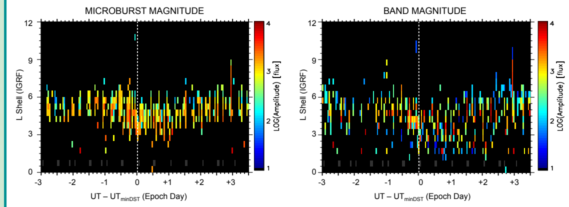
- A correspondence between EMIC waves (measured and inferred) and precipitation band occurrence
- Next Steps:
  - Compare to in-situ GOES EMIC measurements
  - Map precipitation bands to plasmapause location measured by IMAGE
  - Investigate energy spectrum of precipitation bands

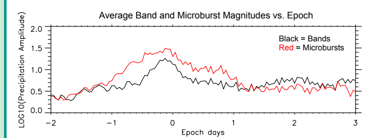
## Statistical Comparison

- Large, isolated storms in 2001 investigated: 14 storms total, $Dst_{min}$ from ~ -60 to -300 nT (ave = -140nT)
- Storms superposed at minimum Dst = 0 epoch




- Occurrences peak in the main phase of storms, but persist into the recovery
- Precipitation bands occur at a wider range of L shells than microbursts, particularly in the recovery phase of storms




- Microburst magnitudes peak in the main phase (consistent with O'Brien et al. 2004 GRL), while bands remain relatively larger throughout recovery

## Summary

- Using SAMPEX HILT data we investigate the magnitudes and distributions of rapid precipitation enhancements at LEO on a variety of timescales – from <1 sec precipitation (microbursts) to longer duration (precipitation bands)
- For the storms investigated:
  - Microbursts occur primarily on the morning side, from ~2-12 MLT, while band occurrences show a strong enhancement around dusk/midnight, from ~15-24 MLT
  - Microbursts are confined to L shells outside the plasmasphere, while bands occur at a wider range of radial distances, often around and within the plasmapause
  - A correspondence exists between precipitation band locations and EMIC wave activity
- Next steps:
  - Further investigate precipitation distributions across various storm types: CME vs. CIR, storms causing radiation belt depletions vs. enhancements
  - Quantify the relative loss due to microbursts versus precipitation bands across storm type and phase -> investigate how much loss occurs when, and due to what processes