Microburst Cumulative Distribution Function

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In this report I discuss the rationale and procedure I used to calculate the coincident microburst cumulative distribution function (CDF). The rationale follows a general idea from Joy et al., 2002 titled “Probabilistic models of the Jovian magnetopause and bow shock locations”. Their argument that we build off here was that a plasma density and velocity measurement made by a spacecraft in orbit around Jupiter can be used to determine the probability that the spacecraft is inside or outside the magnetopause and bow shock boundary surface. When, for example a spacecraft is in a location with negligible plasma velocity, we only know that we are inside the plasmapause boundary and we do not know how far it extends. By building a statistical model of probability of seeing negligible plasma velocity as a function of Jupiter radii (Rj), they created a CDF function. CDF goes to 1 as Rj → 1 and to 0 as Rj → plasmapause. Then they differentiated the CDF to obtain the Probability Density Function of the magnetopause and bow shock stand off distances.

We adopt this analysis in that when AC6-A/B observes a coincident microburst, all we know is the microburst is at least as big as the spacecraft separation. By calculating the fraction of coincident microbursts to all microbursts (observed by one or the other, or both) as a function of separation, we can calculate the microburst CDF and then in theory, differentiate it with respect to separation to get a PDF. In reality this analysis is much more difficult due to a few reasons that including: differentiating between curtains and microbursts at close separations, invalid coincident events with a high cross-correlation (CC) coefficient from to a small window width due to the 10 Hz sampling rate, and a CDF background that arises in part from a high CC coefficient from unrelated microbursts. I address the procedure to calculate the CDF and the issues in the following two sections.

**Cross-Correlation in Space and Time**

The first step to calculate a CDF was to merge the microburst catalogs from both spacecraft into one master catalog and CC all microbursts between the two spacecraft. The code that accomplishes this is in *stats/cross\_correlate\_microbusts.py.* The overall procedure is to load a microburst catalog from AC6-A and AC6-B, and loop over all of the 10 Hz data at times when both AC6-A and B had 10 Hz data at the same time and position. The position requirement is there to identify and ignore high spatial correlations that could be due to curtains (see Blake et al., 2016).

Then for each day the code loops over detections from AC6-A and CCs data with AC6-B data at the same time and position (the data was shifted by the In\_Track\_Lag variable). Then this analysis is done again by looping over AC6-B detections and CC with AC6-A. One of the CC windows was 1 s and the other was 1.2 s with *mode=’*valid’ to give room for clock and Poisson uncertainty. The normalized CC function used here is

CC = max((X-X.mean())\*(Y-Y.mean())/sqrt(len(X)\*len(Y)\*var(X)\*var(Y))

where X and Y are the two arrays to be CCd and var() is the variance. The method that picks out the correct indices given a primary spacecraft (the one for which the detections are currently looped) in space and time is *get\_time\_and\_space\_indicies*(). The space and time max CC coefficient is saved to a new catalog named *AC6\_coincident\_microbursts\_v#.txt* with the center time of the microburst detection, as well as center times for the in-track lag adjusted data. This in-track lag adjusted times are meant for debugging purposes. One of the in-track lag adjusted times will match a microburst time, which indicates which primary spacecraft was looped over. The last data cleaning procedure is to sort the events by time and remove duplicate events.

**Calculate the Microburst CDF**

To make the microburst CDF, I use the *plot\_cdf.py* script to first load the AC6\_coincident\_microburst catalog and then bin the data into cumulative bins in spacecraft separation i.e. a bin from 0 to X spacecraft separation with X varying from 5 km to 100, or 200 km. The microburst detections in each bin were filtered into a set *A*:

* 4 < L < 8
* peak\_std > 2 (i.e. > 2 Poisson std’s above a 10% basline over a 5 s interval). This avoids noisy detections that made it through both the wavelet and burst parameter microburst detectors.
* The temporal\_CC > spatial\_CC + 0.3 to remove curtains.
* Excluded detections made above the US where ground station transmissions cause a lot of microburst-like noise. (-140 < lon < -60 and 15 < lat < 70).
* Excluded the SAA region due to saturation (-116 < lon < 30 and -90 < lat < 0).

Then set *A* was further filtered into set *B* with temporal\_CC > 0.8. The CDF in each cumulative separation bin is len(*B)*/len(*A)*.

