A Statistical Analysis of Interhemispheric Pi1B Seasonal Variations

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Abstract

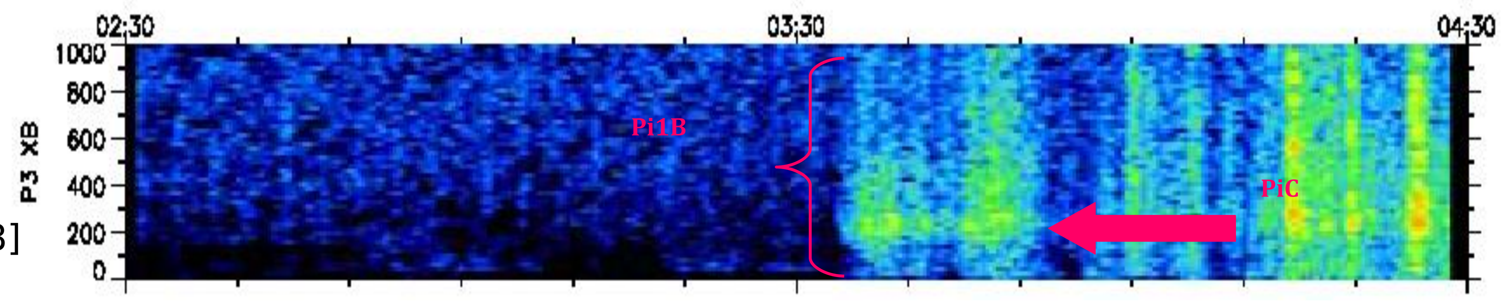
Pi1B magnetic pulsations are 1Hz broadband bursts with periods of between 1-40 seconds that are well-correlated with substorm onset. Lessard, et al. [2006] showed simultaneous observations of Pi1B pulsations in association with substorm onset on the ground and at geosynchronous orbit. Additional, they showed that Pi1B waves that are compressional at geosynchronous orbit must undergo a mode conversation to shear mode waves, and raised the question of whether this makes it possible to use ground-based arrival times to triangulate the source region of substorm onset in the magnetotail. The following study builds off of this question, and is additionally motivated by papers showing interhemispheric differences in substorm evolution [Papitashvili et al., 2002]. Using ground-based 2015 data from South Pole (SPA) and Iqaluit (IQA) in conjunction with Kyoto University's Provisional AE index and SuperMAG magnetic field data, Pi1B waves associated with substorm onset are identified in both hemispheres. Onset time differences (on the order of minutes) are compared between both stations. Particular attention is paid to which hemisphere 'leads' in onset time. The seasonal dependence of these onset time differences will be evaluated over the course of one year. While the current study is still in progress, a preliminary study conducted in 2006 by Hyomin Kim suggested the presence of this seasonal dependence in Pi1B onset times in opposite hemispheres.

Introduction and Motivation

Pi1B: **P**ulsating, **I**rregular, **1**Hz **B**roadband geomagnetic pulsations

Observed to occur near simultaneously with PiC waves between 2300-0200 LMT [Heacock 1967]

Can be observed at geosynchronous orbit in conjunction with substorm onset [Arnoldy et al., 1998]



Lessard et al. [2006]: Looked at substorm associated data from FAST, GOES 9, and various ground-based stations.

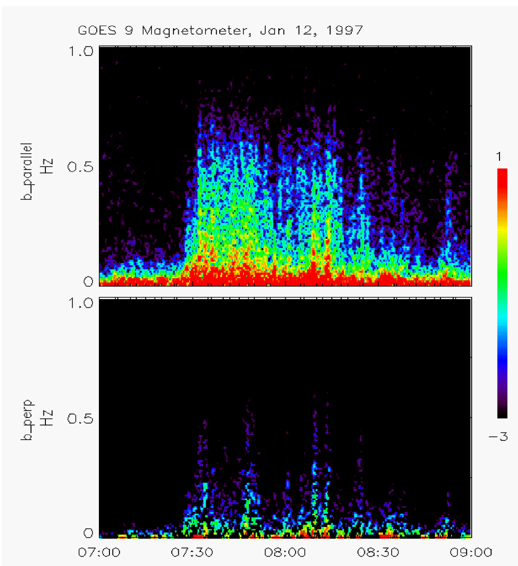
Compressional nature of the Pi1B waves at geosynchronous orbit suggests they are fast-mode waves (could be slow mode waves; unlikely because they would be quickly damped)

However, the same event observed at FAST near-simultaneously was found to be shear-mode

Hypothesis: Compressional, fast-mode waves excited during substorm onset at geosynchronous orbit travel isotropically and slice through the magnetosphere unhindered; as they propagate, these waves become increasingly parallel to the background field and undergo a mode conversion to shear waves, which are guided by the magnetic field lines

Lessard posed the question: can Pi1B onset times be used to triangulate the source region of substorms, if not in the magnetotail then in the ionosphere?

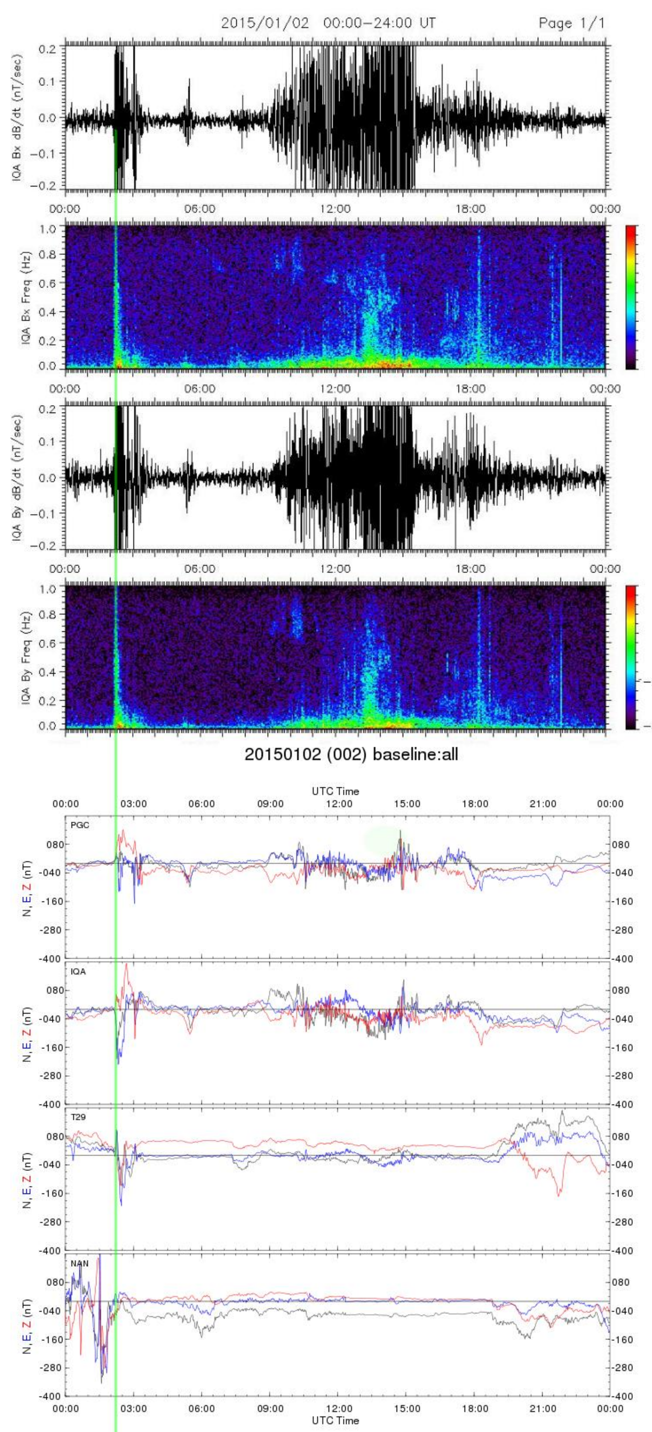
Motivated by this question, Hyomin Kim began a statistical study of interhemispheric Pi1b onset times. He used 1995/1996 data from conjugate stations IQA and SPA, but there was not enough data. This study has the same goal.

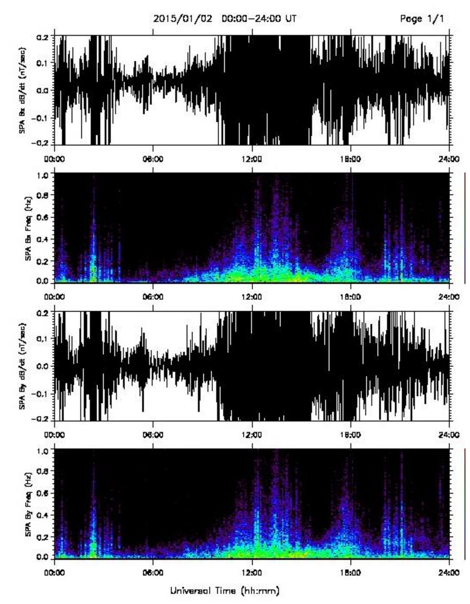


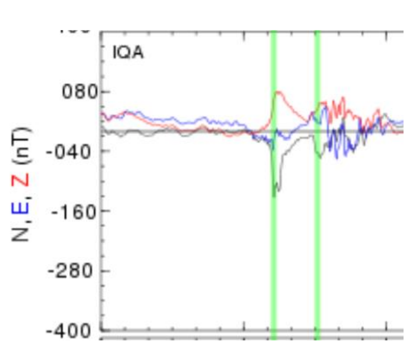
Identification process, current status, and substorms

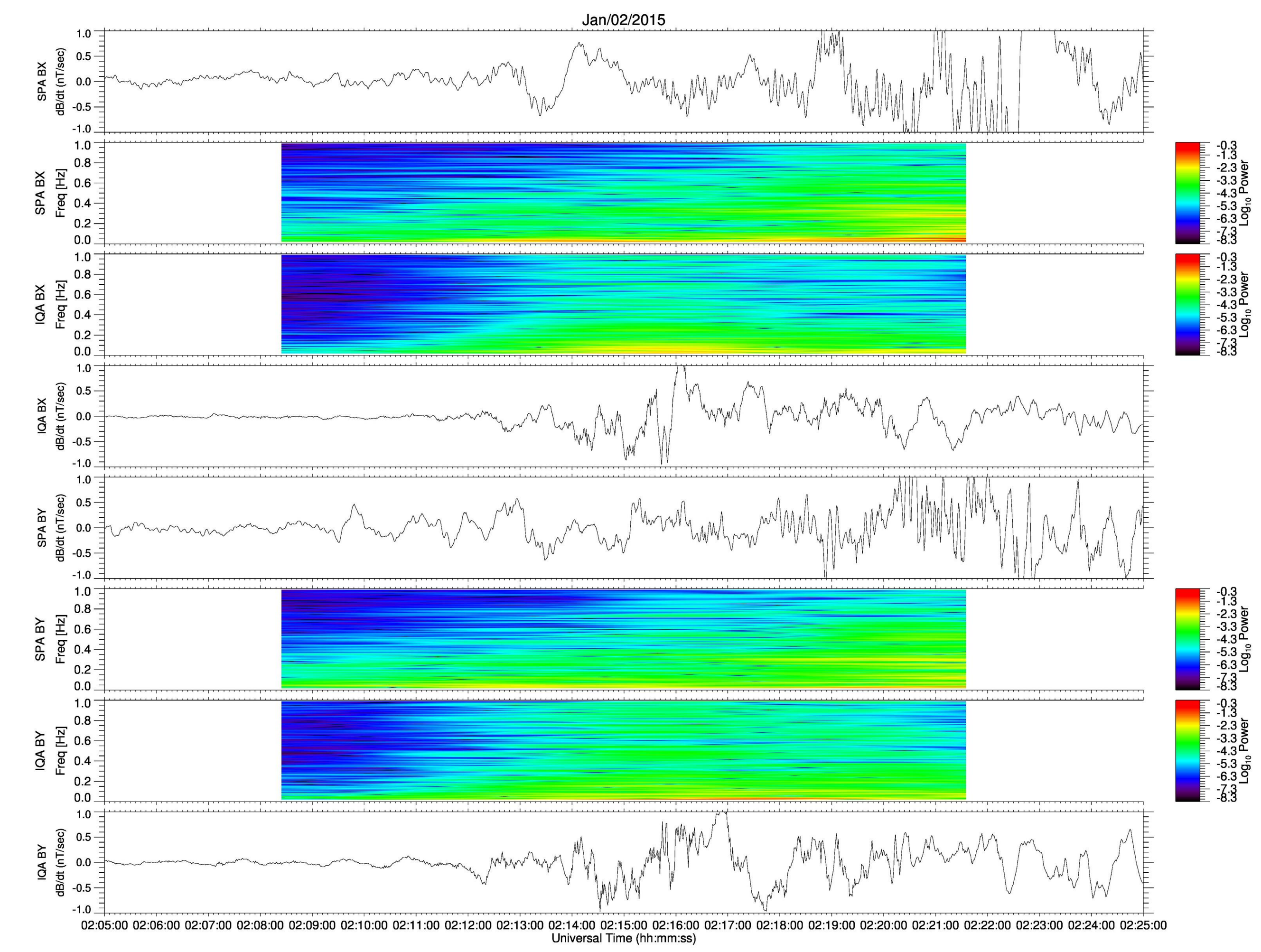
This study uses 2015 ULF data from South Pole Antarctica (SPA) and Iqaluit (IQA)

These stations were chosen because they are good magnetic conjugates within the closed field lines and have good availability of data across a full year





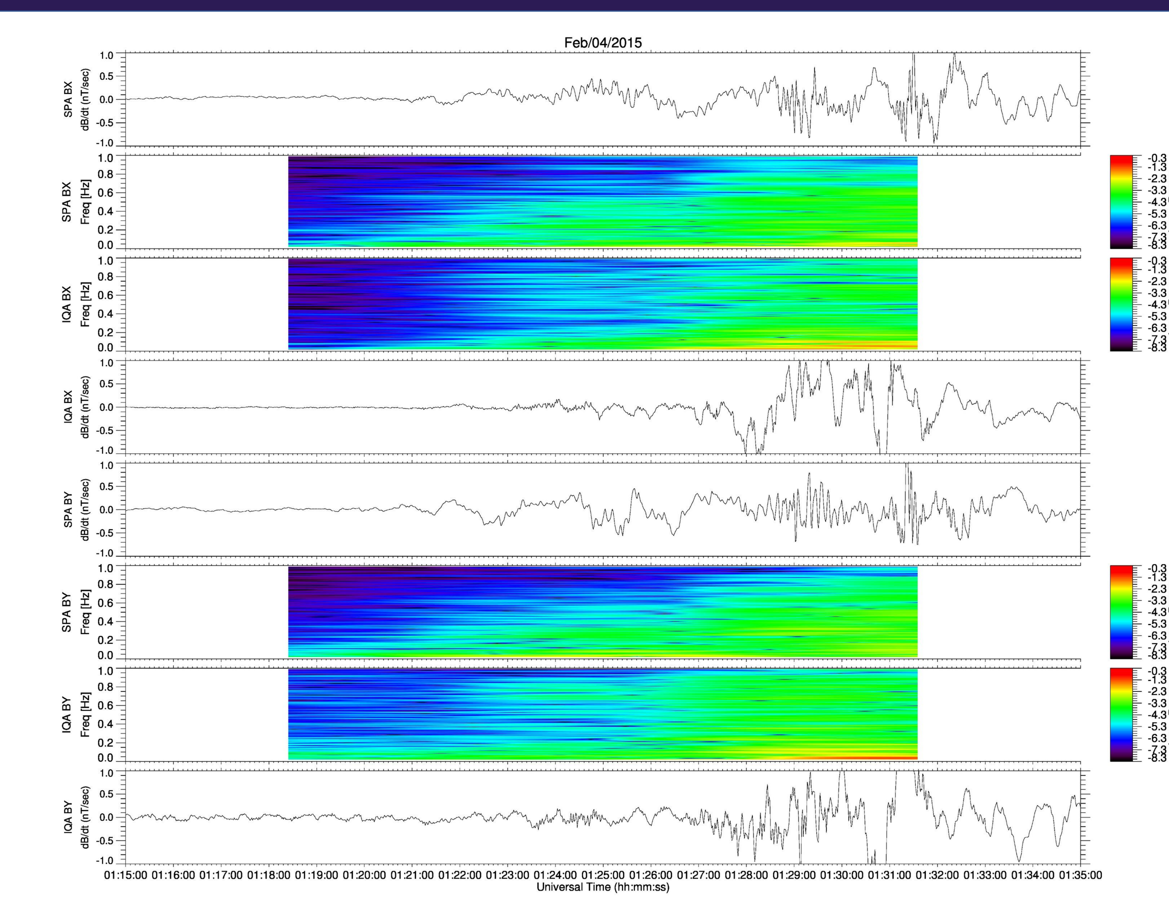




Substorms can be identified by a negative bay in the northern component of the B-field using SuperMAG fluxgate data. By first identifying potential Pi1B events, it's relatively straightforward to confirm substorm onset around the same time.

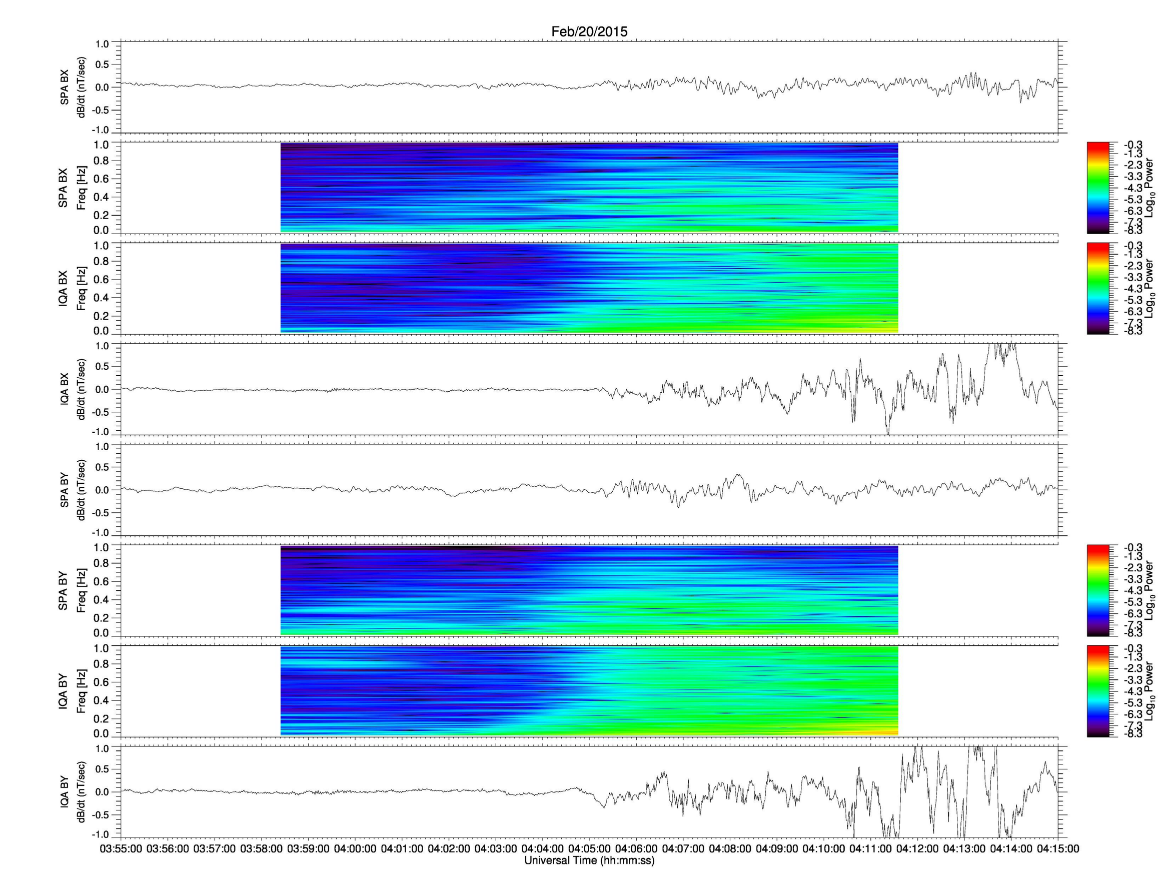
Identifying Pi1B waves themselves can be trickier. They must be broadband and short-lived, but these are not hard qualifiers.

The first qualifier I impose is time. Magnetic midnight is around 0340 UT at South Pole, and the Pi1B waves we're interested in occur around magnetic midnight. To this end I only look at events between ~0000 and ~0700 UT.



All identification is done visually

Pi1B waves are picked out using spectrographs of ULF searchcoil dB/dT data, but because of smearing effects, it is important to look at the time series data



Quicklook passthroughs of the data identified an average of 14 events per month (near-simultaneous in both hemispheres), which gives us good statistical significance

I am currently identifying onset-time differences in Q1 2015 data

References

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