Correlating Type II and III Radio Bursts with Solar Energetic Particle Events

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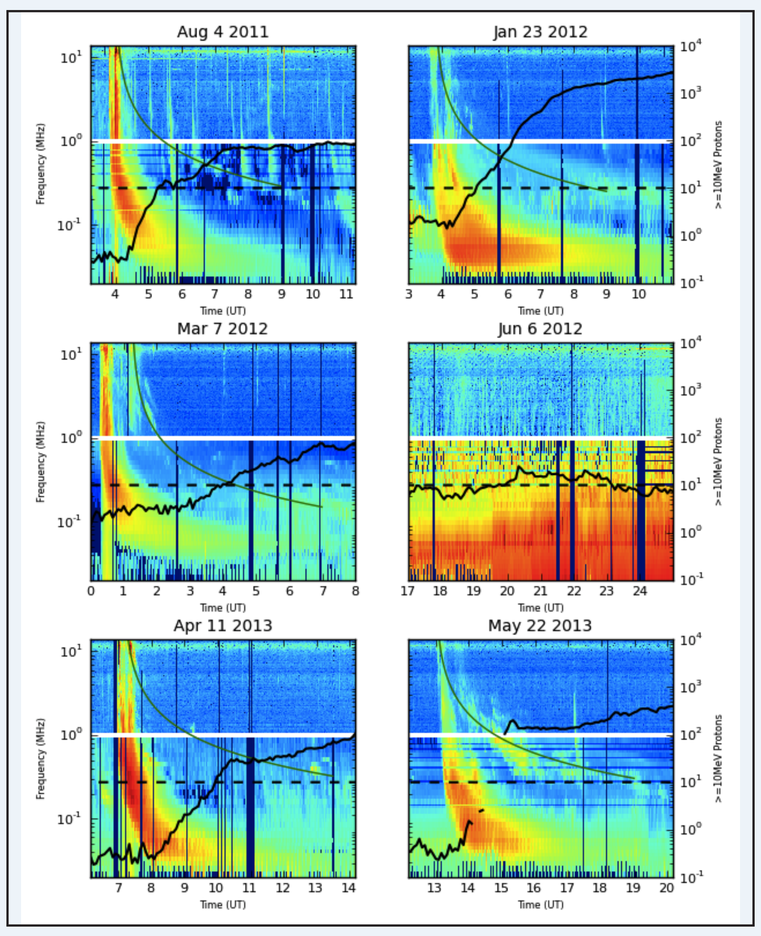
Summary

We analyzed the Wind/WAVES radio and GOES integral proton flux observations for the 123 DH type II radio bursts occurring from Jan 2010-May 2013, as listed in the *Type II and IV burst lists* from NASA Wind/WAVES (http://www-lep.gsfc.nasa.gov/waves/data_products.html).
Our main result is that the intensities of type III radio bursts associated with DH type II bursts are highly correlated with the peak proton flux of solar energetic particle events.

Solar Radio Bursts



We extracted the properties of DH type II radio bursts and their accompanying type III bursts using the NASA Wind/WAVES RAD1 and RAD2 observations. The above plots show examples of the radio observations with an overlay of the GOES > 10 MeV proton flux.

GOES Observations

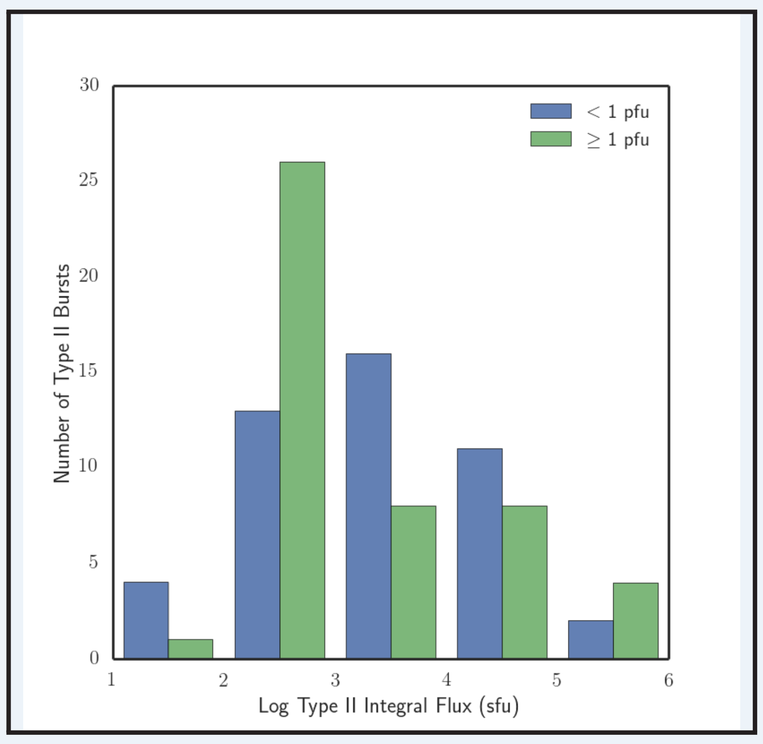
The Geostationary Operational Environmental Satellites (GOES) proton flux observations were analyzed for the time period of each of the 123 DH type II radio bursts. We found the peak time, peak flux, and spectral energy shape following each burst. All type II bursts are associated with a rise in proton flux level, but ~ 20% of these fit the NOAA definition of a solar energetic particle event (SEP events correspond to > 10 MeV flux above 10 pfu). In total, 26 SEP events occurred during this time period.

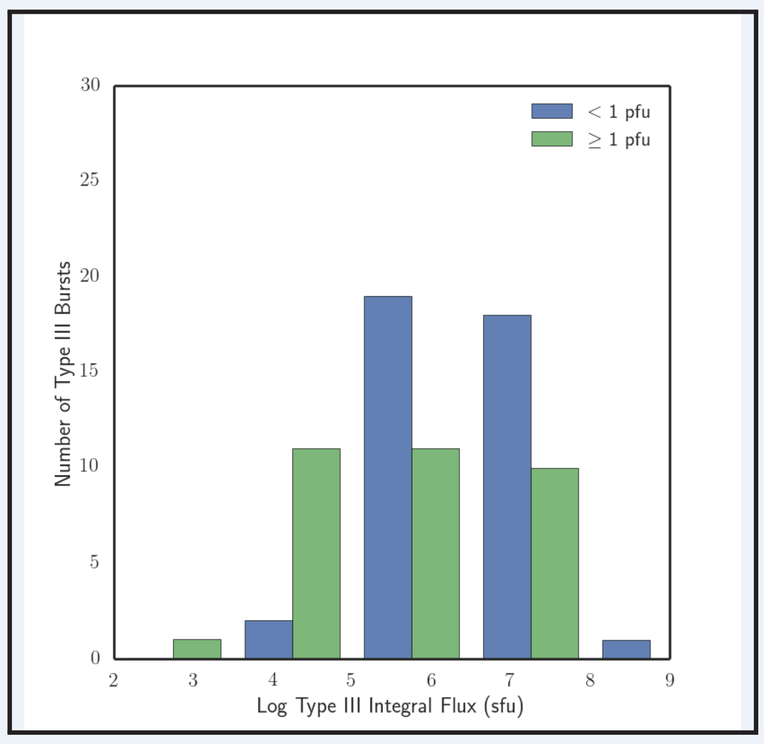
Acknowledgements

KL gratefully acknowledges funding through NSF and the University of Colorado as part of the LASP 2013 Research Experience for Undergraduates Program in Solar and Space Physics.
This work has been submitted to JGR.

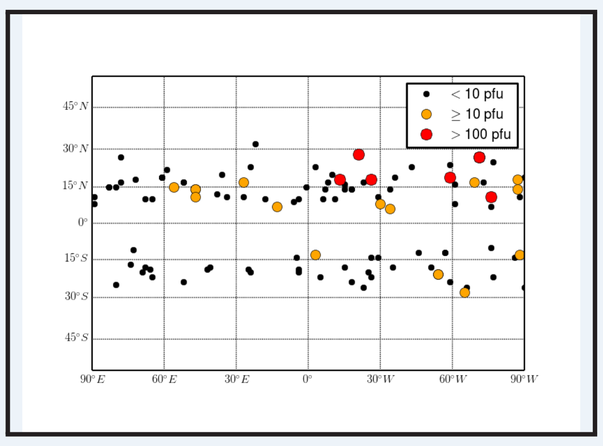
Statistics of Solar Radio Bursts

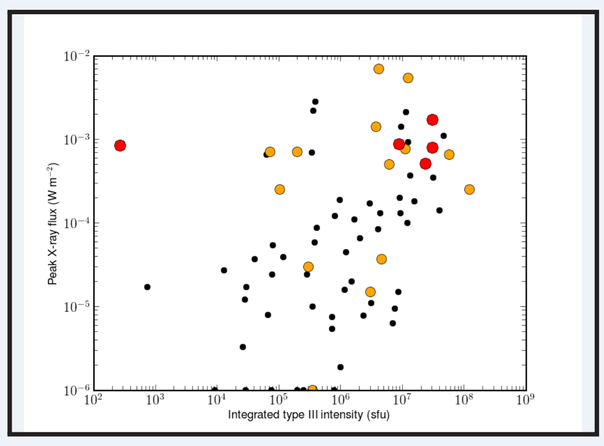
All of the type II radio bursts are associated with increases in the proton flux level. The rise in proton flux following a burst ranges from a factor of 1.8 to > 5000 times the median background flux level. Of the 123 type II bursts from Jan 2010-May 2013, 59% are also associated with a type III burst. However, 92% of the SEP events occur along with both a type II and a type III burst. Below we show the distribution of integrated burst intensity for low proton flux and high proton flux levels. The greatest separation in these distributions is seen for type III bursts, where higher peak proton flux more often corresponds with higher integrated type III burst flux.





The flare location, from the NOAA SWPC Weekly reports, shows no trends in the location of bright radio bursts or proton flux (bottom left, size of the circle indicates brightness of proton peak flux). There is only a weak trend between peak proton flux and X-ray flare brightness (bottom right).





Radio Burst Intensity and Peak Proton Flux

A principal component analysis showed that the variables accounting for the most variance in the radio data are: type III integrated intensity, type III duration, type II peak intensity, and Langmuir wave peak intensity. These parameters make up principal component 1 (C1; plotted on the x-axis).

Results of our logistic regression analysis between C1 and peak proton flux are shown below (SEP events are in red). Using just the radio parameters, our probability of detection (POD) is 0.65 (15/23) with a false alarm rate (FAR) of 0.17 (3/18). Further, we find that our classifications have a percentage correct of 0.88 (83/94). Our results show that there is excellent potential in using the space-observed radio observations in forecasting the peak intensity of SEP events.

Statistics of Logistic Regression Analysis

POD = 0.65

FAR = 0.17

Percent Correct = 0.88