Title: Using the Chandra Source-Finding Algorithm to Automatically Identify Solar X-ray Bright Points

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Abstract

This poster details a technique of bright point identification that is used to find sources in Chandra X-ray data. The algorithm, part of a program called LEXTRCT, searches for regions of a given size that are above a minimum signal to noise ratio. The algorithm allows selected pixels to be excluded from the source-finding, thus allowing exclusion of saturated pixels (from flares and/or active regions). For Chandra data the noise is determined by photon counting statistics, whereas solar telescopes typically integrate a flux. Thus the calculated signal-to-noise ratio is incorrect, but we find we can scale the number to get reasonable results. For example, Nakakubo and Hara (1998) find 297 bright points in a September 11, 1996 Yohkoh image; with judicious selection of signal-to-noise ratio, our algorithm finds 300 sources. To further assess the efficacy of the algorithm, we analyze a SOHO/EIT image (195 Angstroms) and compare results with those published in the literature (McIntosh and Gurman, 2005). Finally, we analyze three sets of data from Hinode, representing different parts of the decline to minimum of the solar cycle.

Using a Chandra Source-Finding Algorithm to Automatically Identify Solar X-ray Bright Points

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Abstract

This paper describes adapting a method that is used to find point sources in Chandra X-ray telescope data for use in finding solar X-ray bright points. The algorithm allows selected pixels to be excluded from the source finding; thus, excluding saturated pixels (from flares and/or active regions). For Chandra data the noise is determined by photon-counting statistics, whereas solar telescopes typically integrate a flux. Thus, the calculated signal-to-noise ratio is incorrect, but we find we can scale the number to get reasonable results. We compare our source finding to previous Yohkoh results and find a similar number of bright points. Finally, we analyze three sets of data from Hinode, representing different parts of the decline to minimum of the solar cycle. Although these preliminary results are based on a very small sample, we see no dependence on the solar cycle.

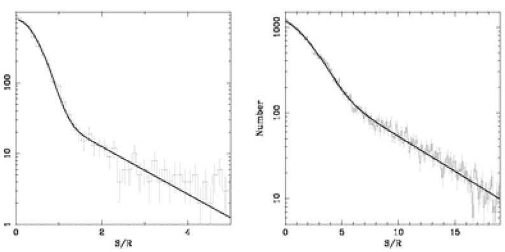
Analysis

We exclude data that are greater than 95% of a solar radius from sun center. In addition, we exclude from analysis, data on the disk that are saturated. The analysis package used in astrophysics data analysis is called lextract, the Low Energy (X-ray) Telescope Data Analysis Package and may be found here:
LEXTRCT: http://wwwastro.msfc.nasa.gov/qdp/lextrct/lextrct.html

Source-Finding Component: Computes Fixed-Size, Best-Fit Gaussian to Every Pixel
Background Is Locally Constant
S/N = Number of counts in Gaussian/Uncertainty
A Source = Local Maximum with S/N Above Threshold
Scale Size = Approximate Size of Bright Points — Yohkoh = 5 arcsec, Hinode = 7 arcsec

Errors and Signal to Noise

We use the lextrct default, square root of DN. Background subtraction yields negative values in the data, these are flagged and not considered in the analysis. To determine signal-to-noise threshold, we construct a histogram of the data in a region of quiet Sun. The break between components (Gaussian and power-law) gives a lower bound on the threshold. Examples are shown below.

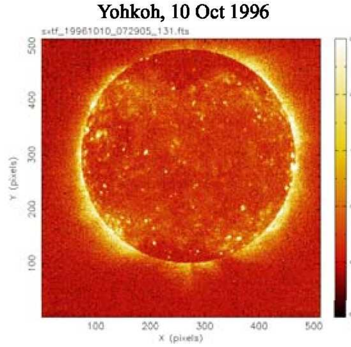


Left: A histogram of the S/N for a region of the quiet Sun using Yohkoh data from 1996-Oct-10.
Right: A histogram of the S/N for a region of the quiet Sun using Hinode data from 2006-Oct-24.

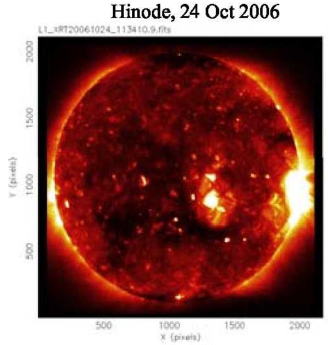
DATA

Source	Exp (sec)	Filter	Thresh S/N	Sigma (arcsec)	Num Brt Pts
Yohkoh SXT 1996-10-10T07:20:35	1.0	AlMg	1.5	7	198
Hinode 2006-10-24T11:34:10	4.1	Al poly Open	10	5	251
Hinode 2007-01-26T00:03:20	4.1	Al poly Open	10	5	184
Hinode 2009-02-06T18:19:09	5.8	Al poly Open	10	5	302

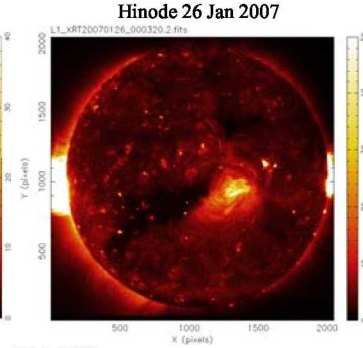
Yohkoh, 10 Oct 1996



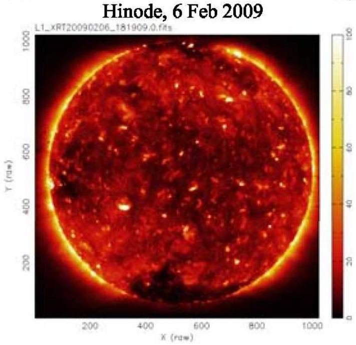
Hinode, 24 Oct 2006



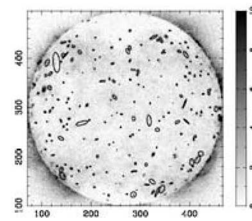
Hinode 26 Jan 2007



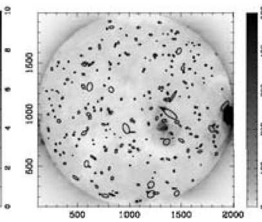
Hinode, 6 Feb 2009



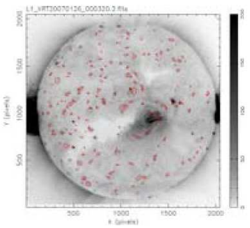
Results of Applying the *lextrct* Source-Finding Algorithm to Solar X-Ray Data



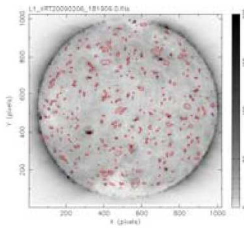
Yohkoh, 10 Oct 1996



Hinode, 24 Oct 2006



Hinode 26 Jan 2007



Hinode, 6 Feb 2009

Discussion and Conclusions

Using an algorithm designed for finding astrophysical sources in data from the Chandra X-ray observatory, we examined four sets of solar data to find bright points. Our results are consistent with those reported in the literature. Comparing three sets of data from Hinode with one from Yohkoh, we find more bright points in the Hinode data, because of the greater dynamic range of Hinode and the nearly three times better angular resolution. We note that there are fewer bright points in the 2007 Hinode data, contrary to what one might expect from (possibly apparent) solar cycle dependence or instrumental differences. However, the 2007 value is only 2-sigma low. We obviously need more statistics to resolve this issue. Since the source-finding method has proven reliable and successful, our future work will include calculating the correct statistics to allow for setting a threshold independent of source parameters. We will then catalogue bright points found in Hinode data with at least the following parameters: position, size, orientation.

References and Acknowledgements

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