Mesogranulation in the Sun

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ABSTRACT

Evidence for structure on the mesogranular scale is investigated in the solar corona using data from the narrow 193Å bandpass images taken with the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). Cross-correlations centered on bright points in quiet sun regions and coronal holes were run for an hour-long limb-subtracted data cube.

1. Introduction

Evidence of intermediate structure on the photosphere between granulation and supergranulation was first discovered by November et al. (1981), who coined the term "mesogranules" after detecting vertical flows at scales between 5000 and 10000 km, lasting roughly two hours. The driving mechanism behind the production of this structure was still uncertain. There is a possible connection between the horizontal size scales of granular structures at the photosphere and the depth at which ionization occurs for H and He. Mesogranulation could be the "missing scale" connected to the second ionization of He. It could also simply be an indicator of "higher spatial harmonics of the primary supergranule cell".

Further investigation of this elusive feature has been carried out over the years…

2. Data

2.1. SDO and AIA

AIA produces 12-second cadence images in ten different passbands, each of which correspond to a different height above the photosphere, and most of which are different ionization states of Fe. (Lemen et al. (2012)). These levels of ionization and strongly dependent on temperature, so AIA samples the "full thermal range of the corona". (source?) The FeXII/XXIV line at 193Å was used for this project, at the "corona and hot flare plasma" region. This particular line was sampled because …? Fe lines are the best emitters at high temperatures, and are much cleaner then those of other elements, which can have more lines in a given passband (source?).

2.2. Data Aquisition

The data was downloaded using `vsoget.pro` (cite Sam here?)

Since the focus of the project was general structure over the solar surface, a relatively "quiet" (i.e. low magnetic activity) data set was chosen. An hour of data at full cadence was downloaded. (include day/time data was taken).

2.3. Data Reduction

First, the limb was subtracted from the data cube, which reduced the original images from 4096×4096 to 2001×2001 square pixels. This new data cube was then aligned to subtract artificial variation between images. An image of the full limb-subtracted disk is shown in figure **??** (with values raised to a power of 0.1 for better visualization of the structures).

A few active regions are visible, as well as some quiet sun areas in the upper right and a coronal hole in the upper left.

2.4. Data Analysis

For simplicity, a few bright points (magnetic BPs? Or just "bright spots"?) were chosen from the region of the data where the coronal hole is located.

A pixel located roughly in the center of each bright point was cross-correlated with every other pixel out to a radius of 50 pixels, or roughly 17500 km. This extends well beyond the proposed maximum diameter of mesogranules at 10,000 km. (commas in big numbers?)

3. Results

Also plotted are the timelag values at which the high correlation values occurred, in the next figure, for a pair of pixel: the one centered at the bright point and another one which was chosen for a very good reason I'm sure. The farther the point is, the longer it takes for the motion to propagate to that point, and therefore the highest cross-correlation value takes place at a higher timelag value.

The previous figures are ambiguous in direction; it is possible that features can be evident by propagating in a particular direction, not necessarily uniformly from the central pixel.

The idea here was to search for distance and timescales that high cc values occur. The distance will reveal the extent of this structure, and the timelag will reveal the timescales at which these structures last.

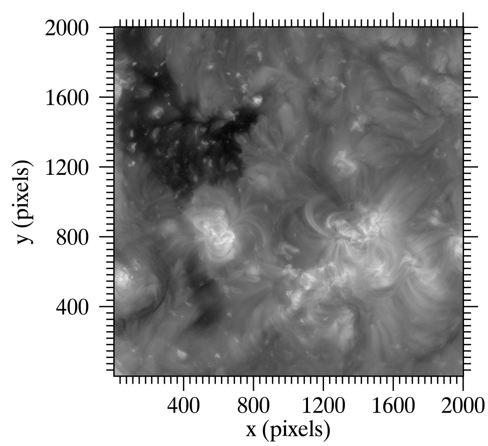

Fig. 1.— Limb-subtracted disk and coronal hole (seen in upper left corner of full disk).

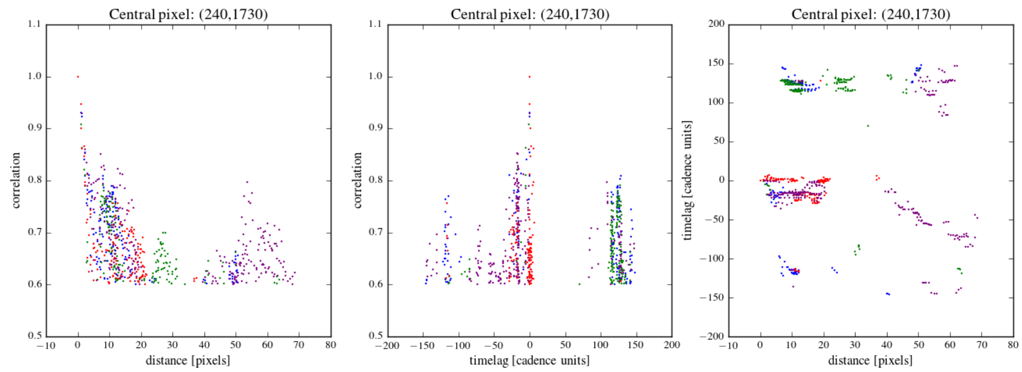

Fig. 2.— Correlation as a function of distance for four bright points from the coronal hole

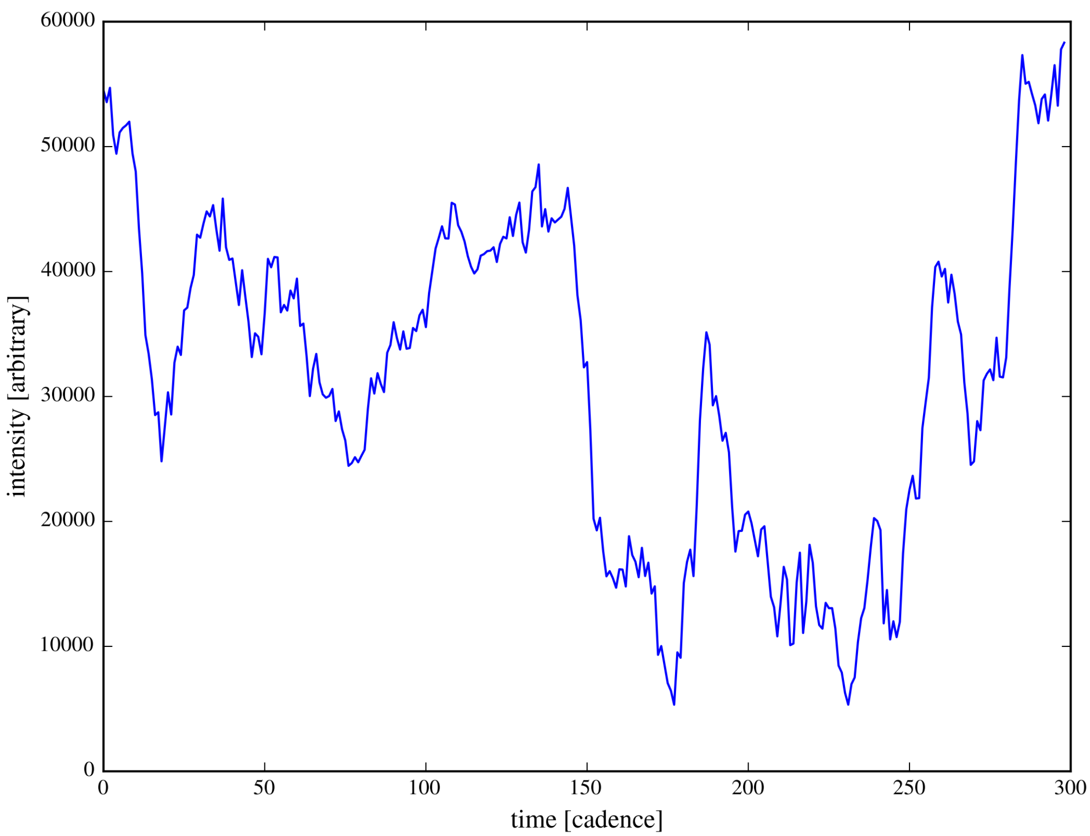

Fig. 3.— lightcurve for one bright point - determined by intensity threshold of 100. There were 441 pixels summed up in every image in the data cube (?).

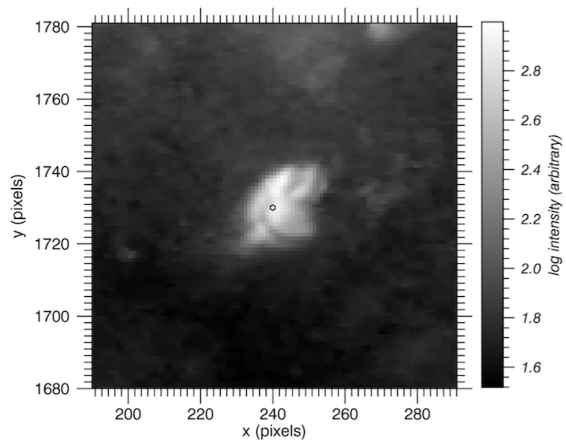

Fig. 4.— First bright point at (240,1730), which occupies an area of about 50 million km^2 (at this height).

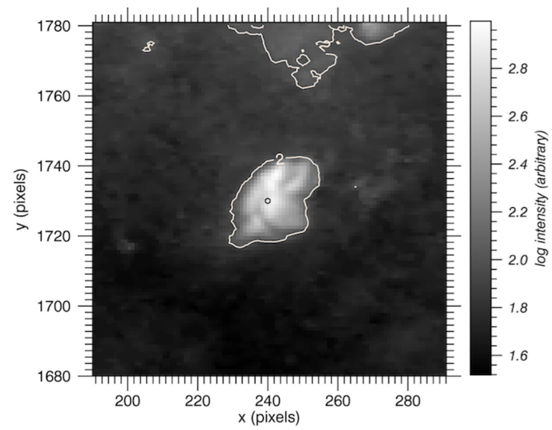

Fig. 5.— Contour around intensity threshold.

Why does intensity reveal anything about a possible mesogranular structure? Or any structure for that matter? Supergranules exist with diameters of about 30,000 km and last for roughly two days. Granules have diameters of about 1,000 km and last for about 12–20 minutes. With only an hour of data, we wouldn't be able to find anything beyond granule size, unless the timelag values don't actually correspond to the timescales that these structures last. Flux tubes in the photosphere are passively moved around until they eventually fall into the intergranular lanes between supergranules, where they appear as bright points: low density regions with reduced opacity where the hotter, brighter interior of the sun becomes visible.

For mesogranulation, we expect a timelag of about 3–5 minutes. WHY?

4. Analysis

5. Conclusions

REFERENCES

Lemen, J. R., Title, A. M., Akin, D. J., et al. 2012, Sol. Phys., 275, 17

November, L. J., Toomre, J., Gebbie, K. B., & Simon, G. W. 1981, 245, L123

This preprint was prepared with the AAS LaTeX macros v5.2.

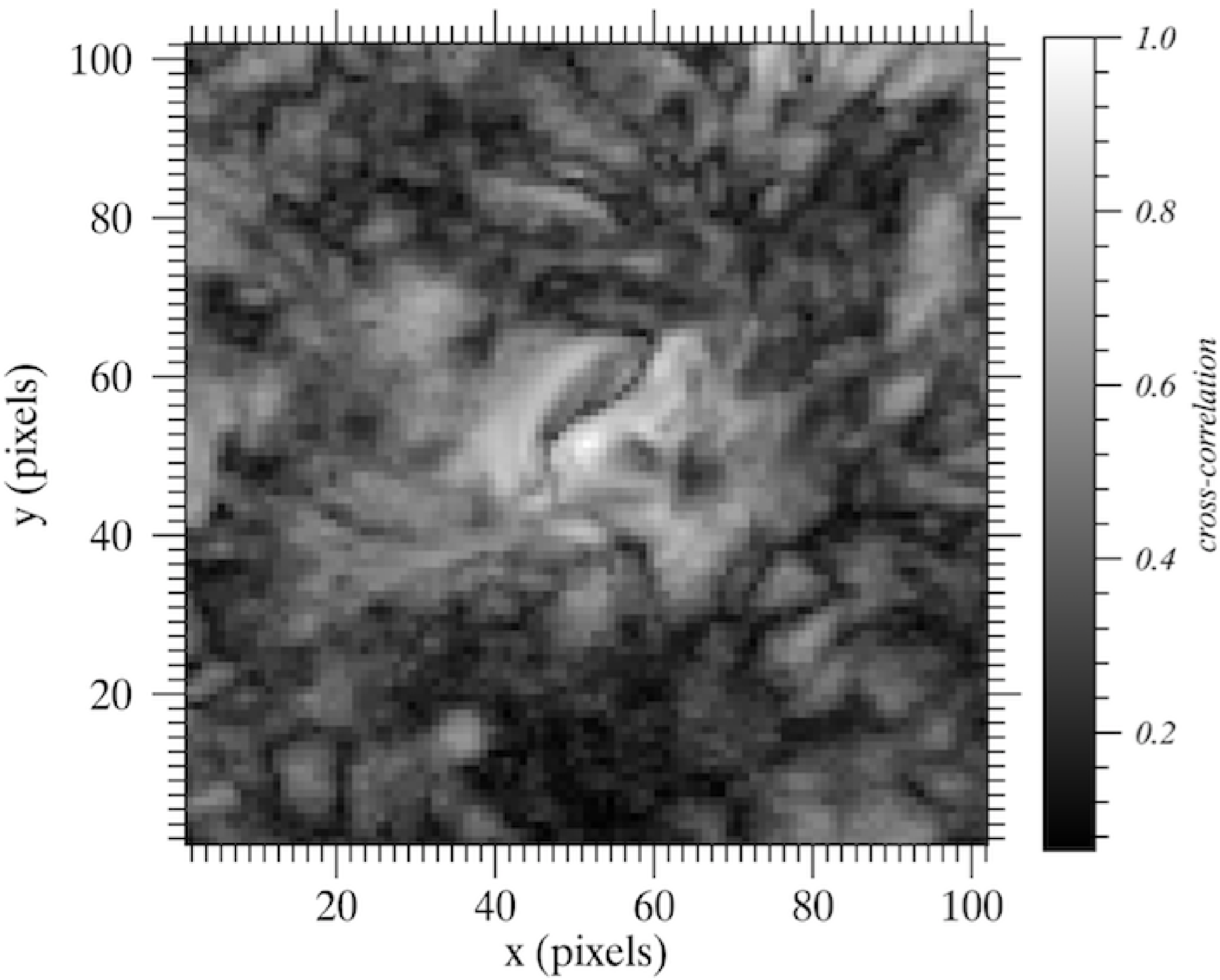

Fig. 6.— Cross-correlation image

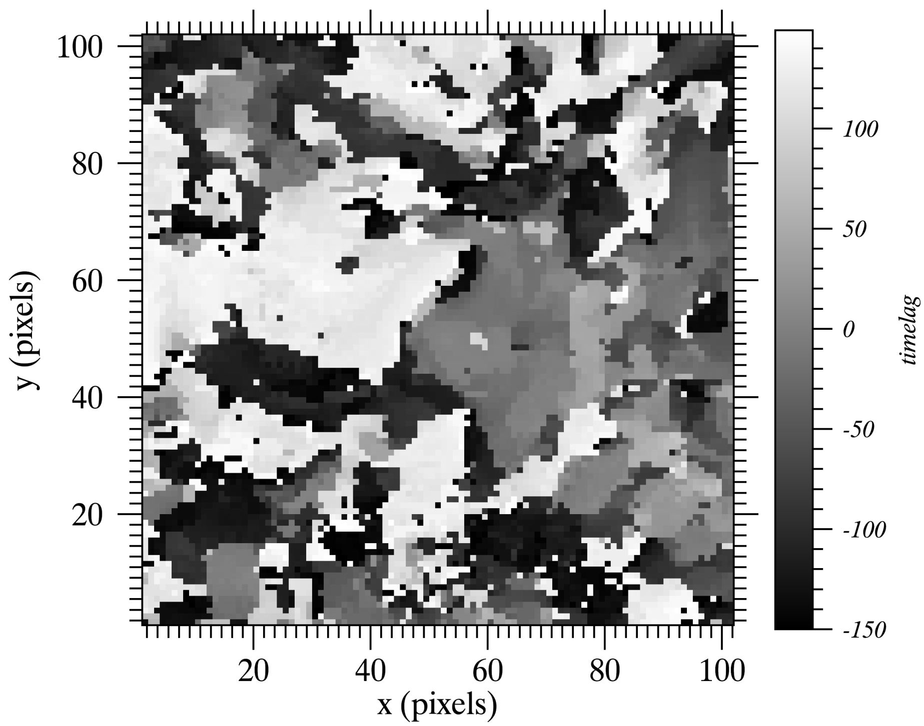

Fig. 7.— Timelag image

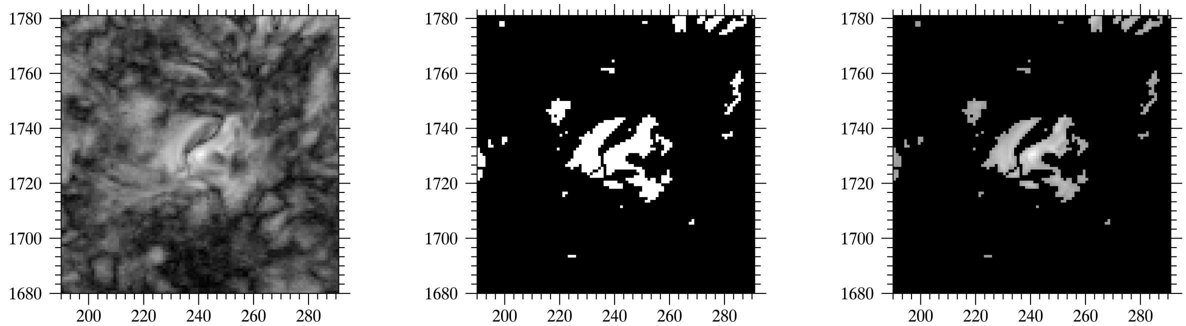

Fig. 8.— Left: cross-correlation image of the BP; middle: “mask” with each cross-correlation pixel greater than the threshold (0.6) set equal to 1, and the rest set equal to 0; right: multiplication of the first two.

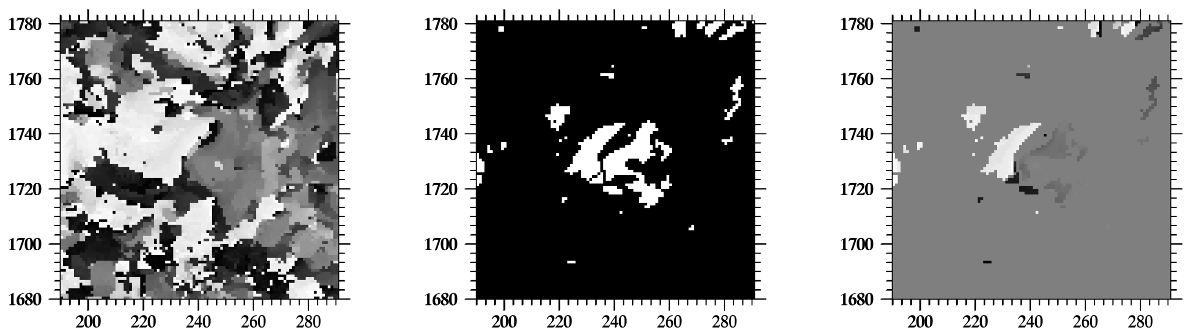

Fig. 9.— Left: timelag image of the BP, showing the time (still in “cadence” units, where each unit is 12 seconds apart); middle: same mask as in Fig. 8; right: multiplication of the first two.