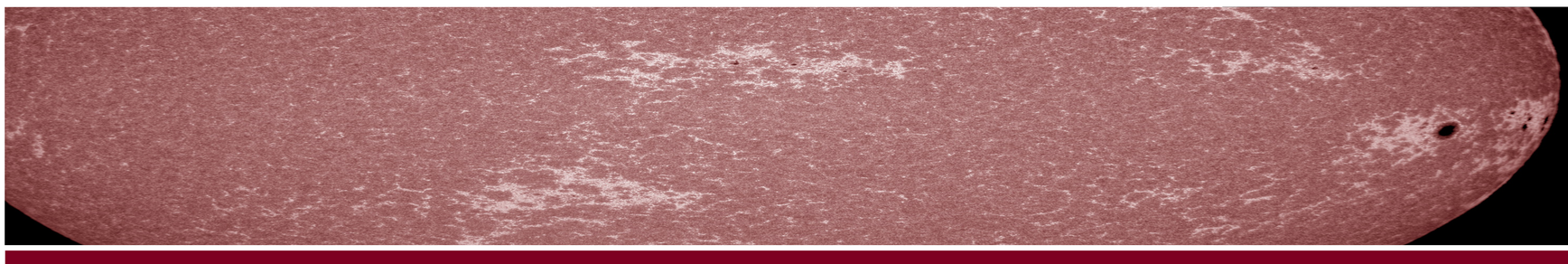

Detection and Characterisation of the Solar UV Network

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When viewed at UV wavelengths (1600 and 1700 Angstroms) there is a network like structure visible upon the solar disk, appearing prominently in active regions but also forming the boundary between granulation cells. The availability of high resolution data from the Solar Dynamic Observatory (SDO) satellite allows us to examine this network in great detail. As such, this work uses several image processing techniques in an attempt to quantify what percentage of the solar disk this 'network' makes up, with current results suggesting that about 30% of the disk is network. Further analysis of these results reveals a monthly fluctuation in the covering percentage and a correlation with the F10.7 flux. Our ongoing work tries to discern whether this variation and correlation has a component related to the network or is simply from the presence of active regions within the detection methods.

I: Background Removal

Figure 1: Left) Grayscale of the original image taken at 1600Å. Centre) Tophat created background. Right) Image with background removed.

- Images were first converted to grayscale for ease of analysis.
- To account for limb darkening a background intensity was removed from each image analysed.
- A Tophat filter was found to be the most effective method for creating and removing a background (Figure 1).
- A disc shaped filter of radius 60 pixels was used.
- This method was applied to all images before further work was done.

II: Network Detection – Mathematical Morphology

- Detection method based on the shape and connectivity of objects[1].
- A structuring element is used to define areas of importance in the analysed image. The origin pixel is shown in white and the neighbouring pixels in black in Figure 2.

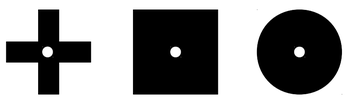

Figure 2: Examples of differently shaped structuring elements.

- An image processing technique known as 'dilation' is applied to the image causing features to 'grow'. A 3 by 3 cross was found to be the most effective structuring element.

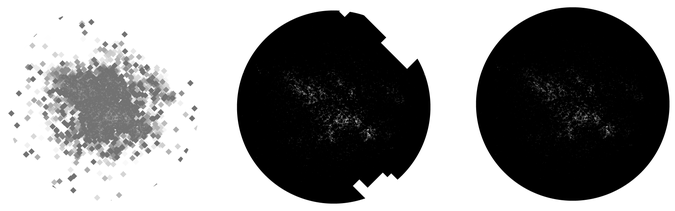

Figure 3: Left) After 50 iterations of the dilation. Centre) After 500 iterations of the dilation. Right) After 1000 iterations of the dilation.

- After many iterations only the desired features, the network in this case, are left.
- This method suggested a covering percentage of around 10% for the test images used.

III: Network Detection – Concentric Thresholds

- The analysed image was split into three concentric sections.
- A different threshold was used on each section to determine whether a pixel should be designated as network or not.
- With the data normalised the thresholds were set at values of 0.1, 0.09 and 0.08 for the inner, middle and outer sections respectively.

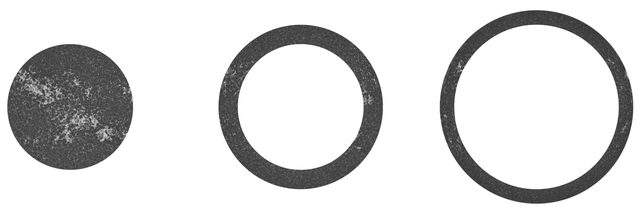

Figure 4: The inner, middle and outer concentric sections.

- A value of about 30% was found for the covering fraction of the network using this method.

IV: Long Term Evolution of Network

- Using the concentric thresholding method the time behaviour of the network was investigated.
- One image a day was taken and analysed from January 2011 to January 2015.

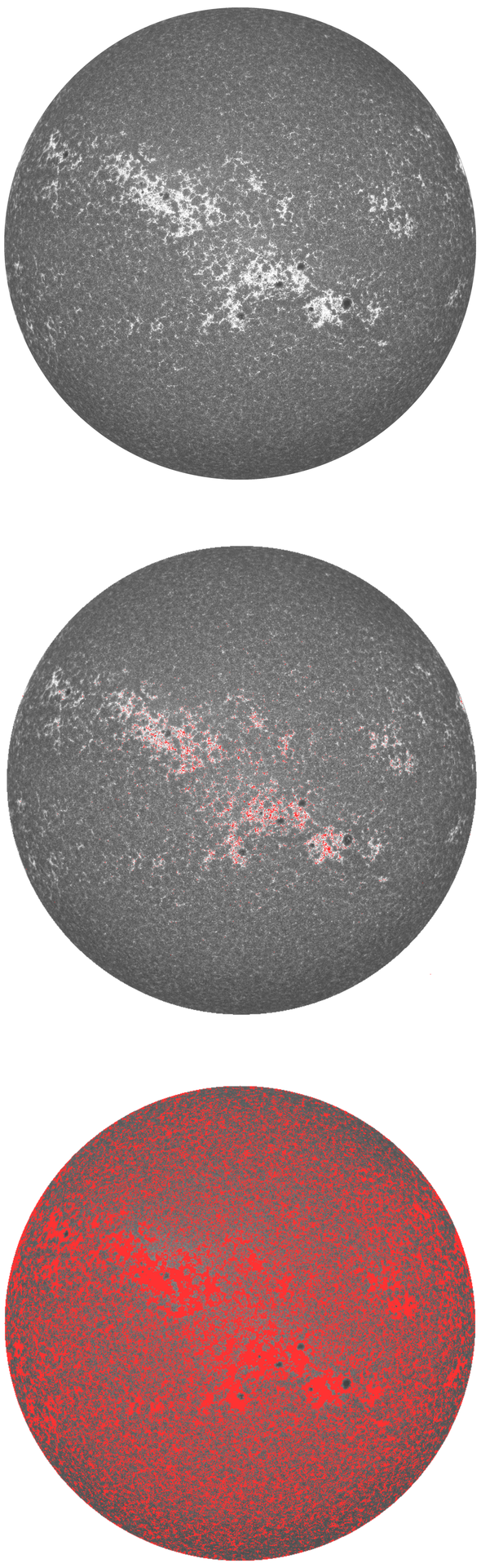

Figure 5: Top) Original image taken at 1600A. Centre) Network detected by morphology highlighted in red. Bottom) Network detected by concentric thresholding highlighted in red.

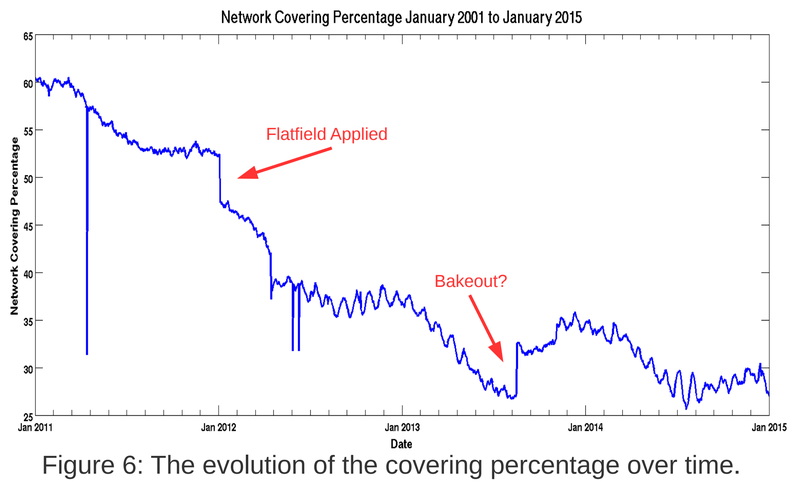

Figure 6: The evolution of the covering percentage over time.

- Disparities in the detected covering percentage were immediately evident which seem to align with the application of flat-fields and a possible bakeout[2].
- A monthly fluctuation is also present which may be caused by the rotation of active regions across the surface.
- When compared to the F10.7 radio flux[3] a strong correlation is observed.

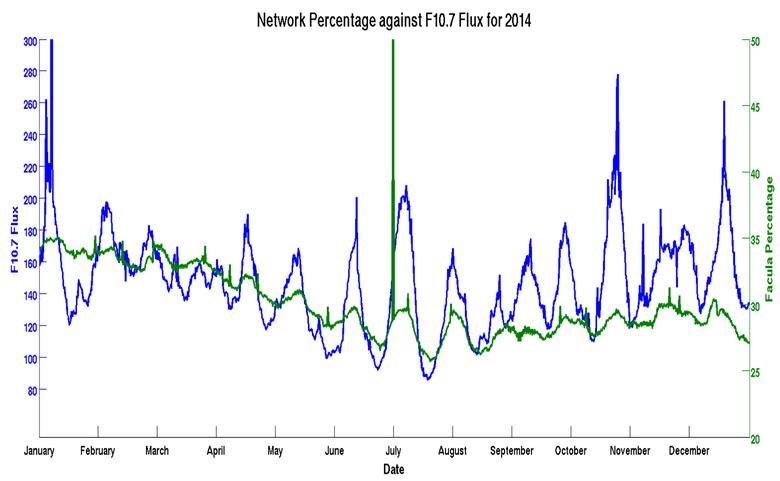

Figure 7: The covering percentage for 2014 plotted against the F10.7 radio flux.

V: Future Work

- We are currently working on fine tuning the detection methods and investigating others.
- We are also developing a method of removing the active regions from the current detections using Singular Spectrum Analysis.
- With the active regions removed we can investigate how the network behaves over the quiet Sun and whether the same patterns are observed.

VI: References

[1] R. Gonzalez, R. Woods, 2001, *Digital Image Processing*, Second Edition, Prentice Hall

[2] SDO/AIA Data Archive

[3] L. Svalgaard, 2015, *TSI-F10.7-MF-SSN-Solar Activity*, leif.org/research/