

STARA : what is it and what does it do?



The beginning

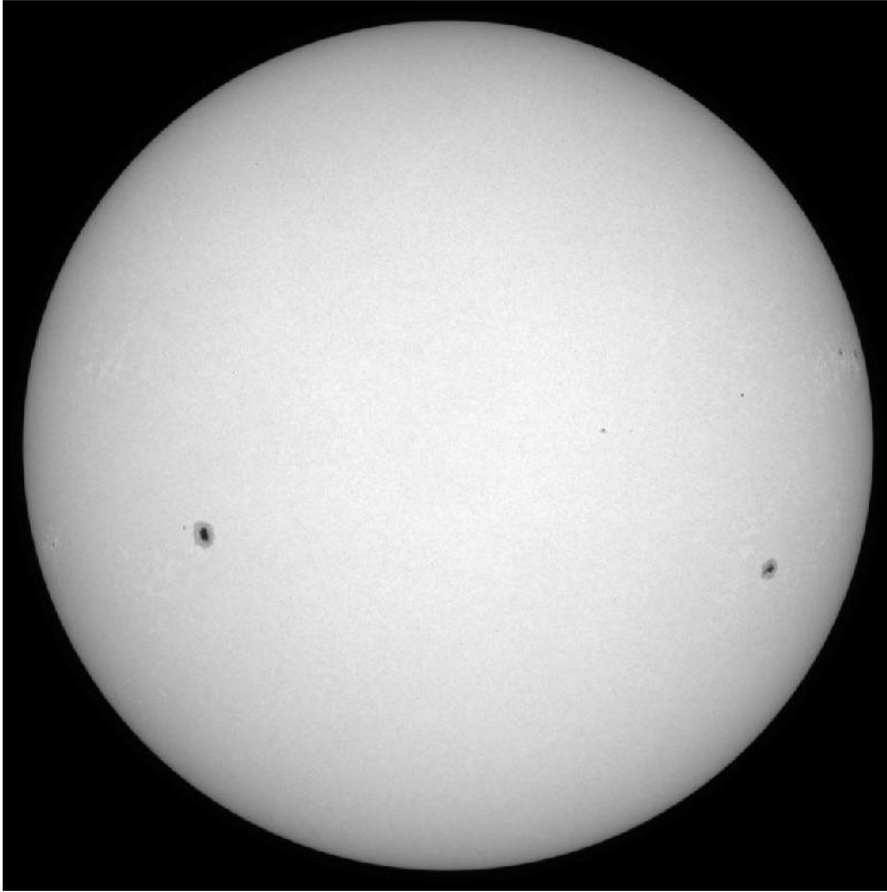
An undergraduate study in 2007

- Can mathematical morphology techniques be used to provide an automated detection mechanism for sunspots?
- Yes.

Image processing tool

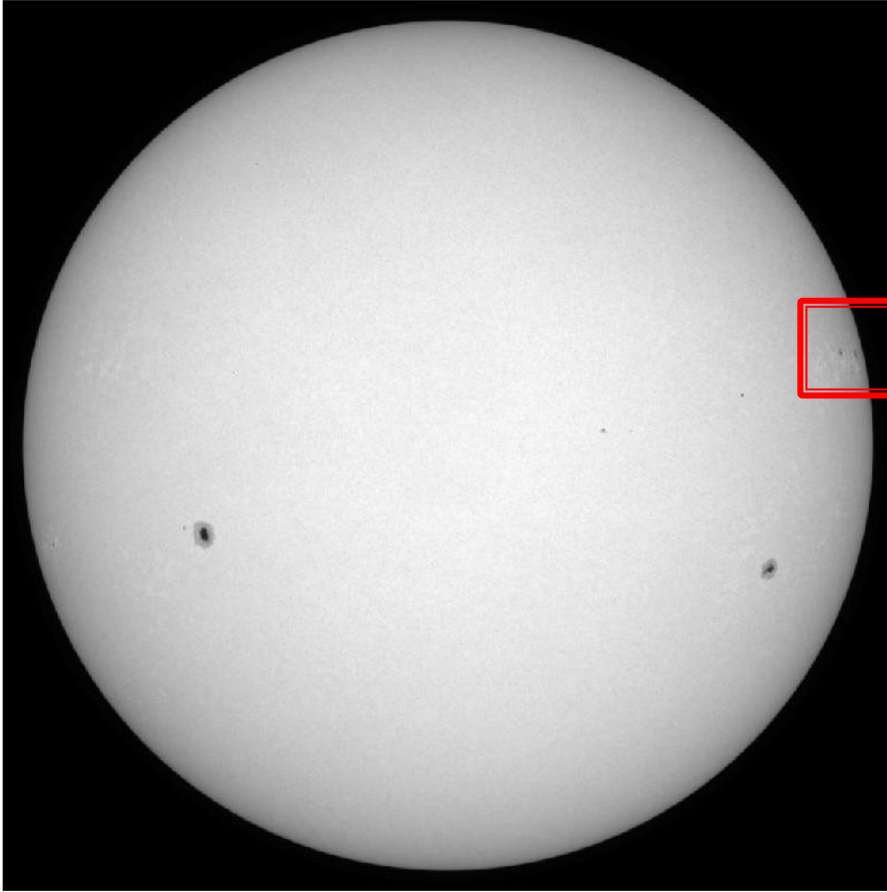
- Study uses MDI data from 1996 – 2011
- Method must be robust and consistent
- STARA – Sunspot Tracking And Recognition Algorithm

Step one – automated detection

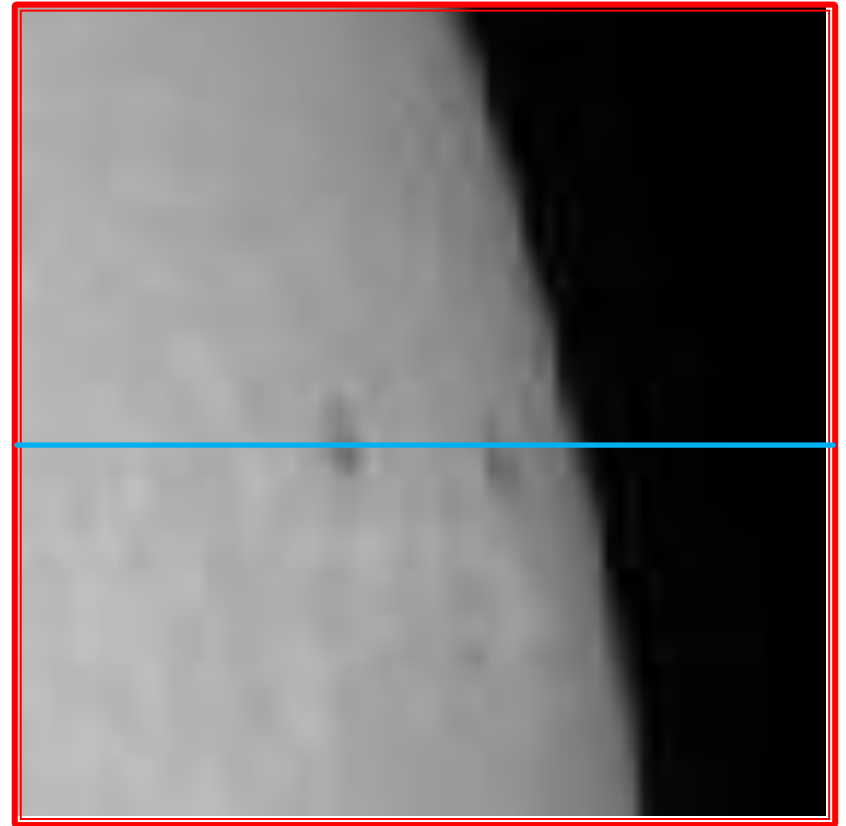
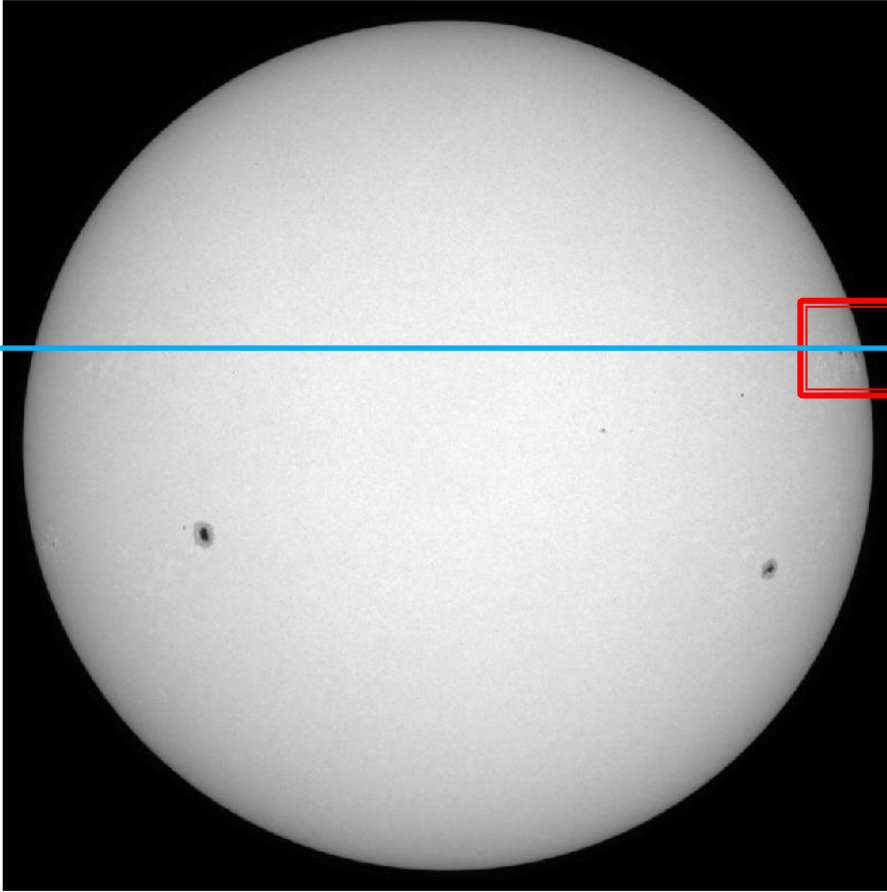


Sunspot Number workshop, Sac Peak, NM.

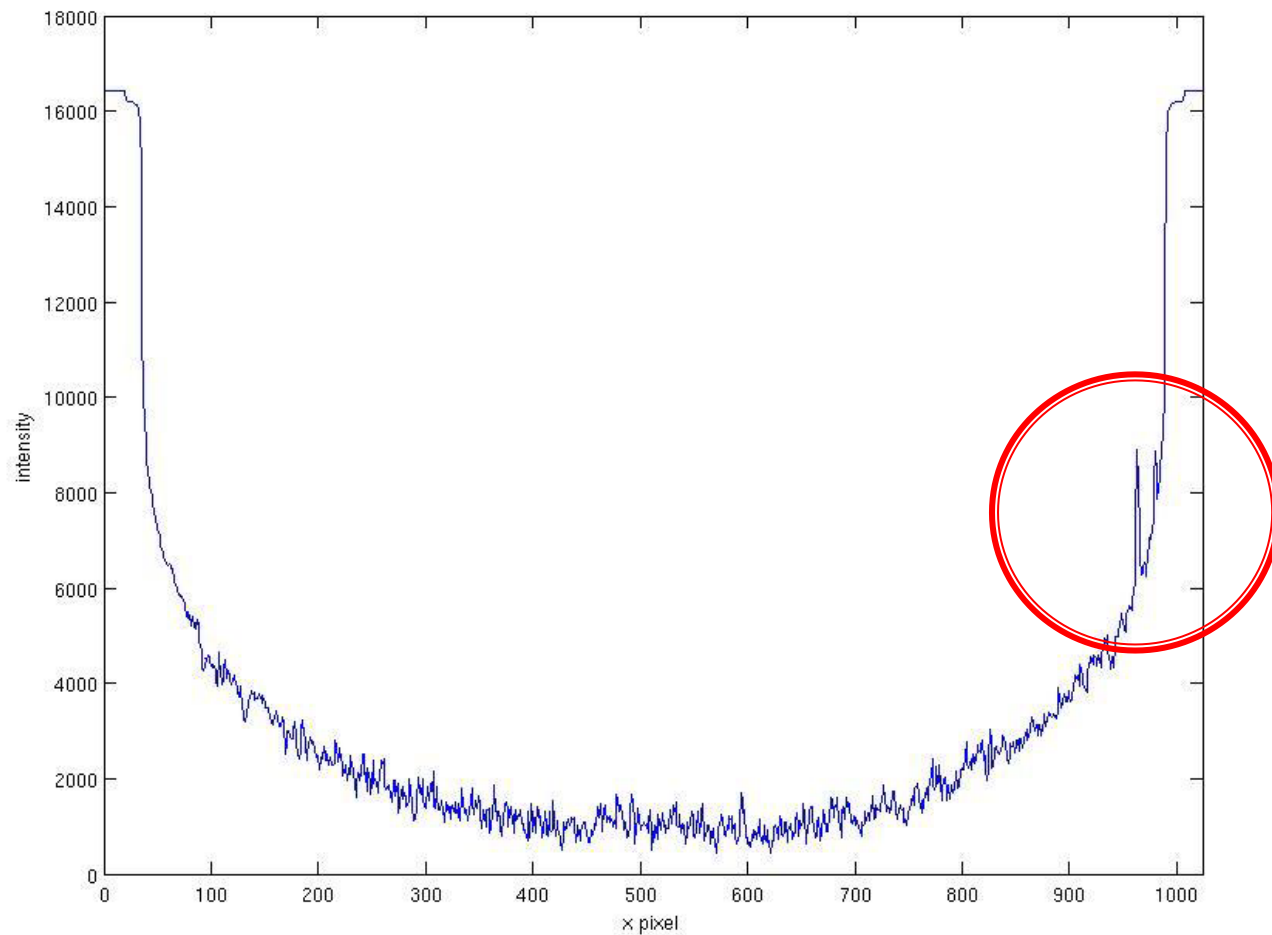
Step one – automated detection



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Step one – automated detection

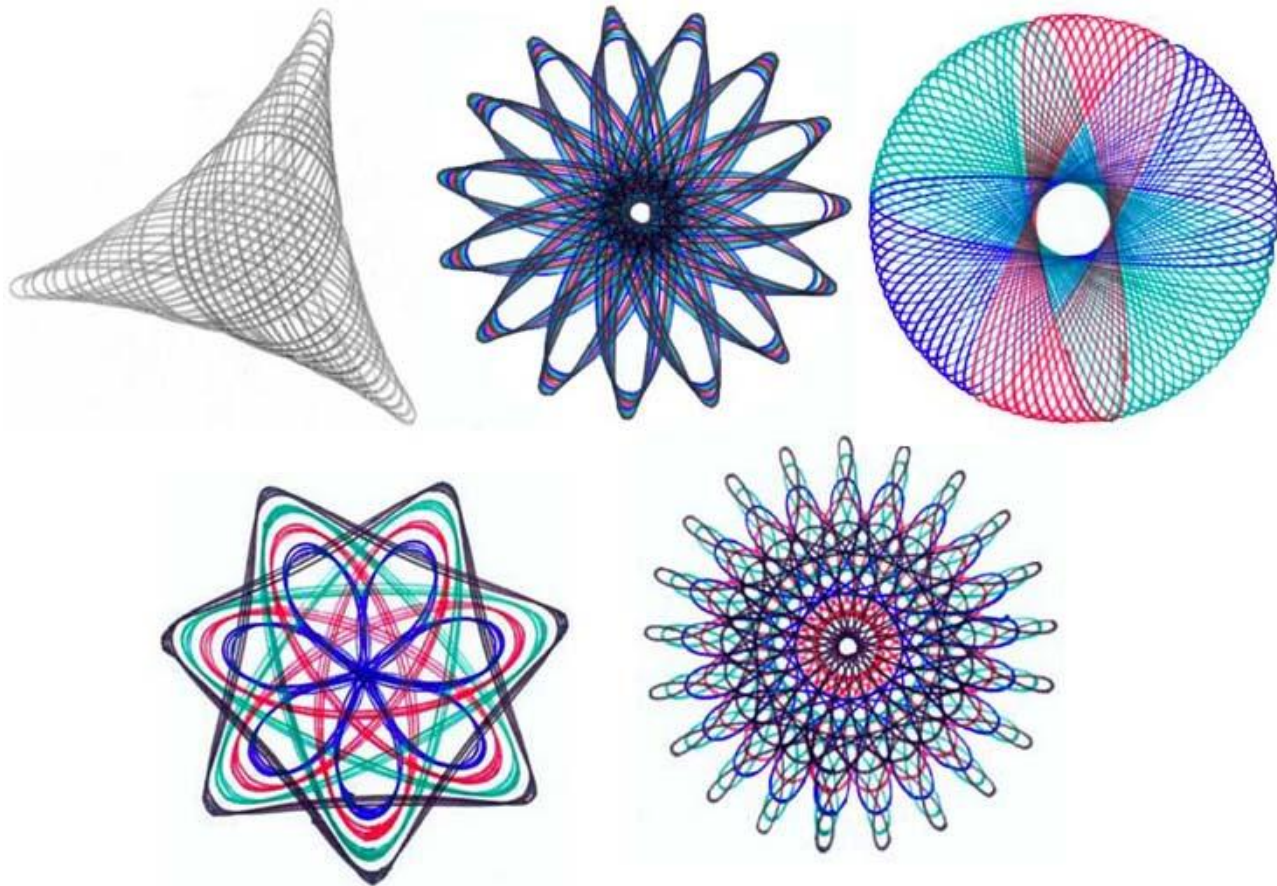


Sunspot Number workshop, Sac Peak, NM.

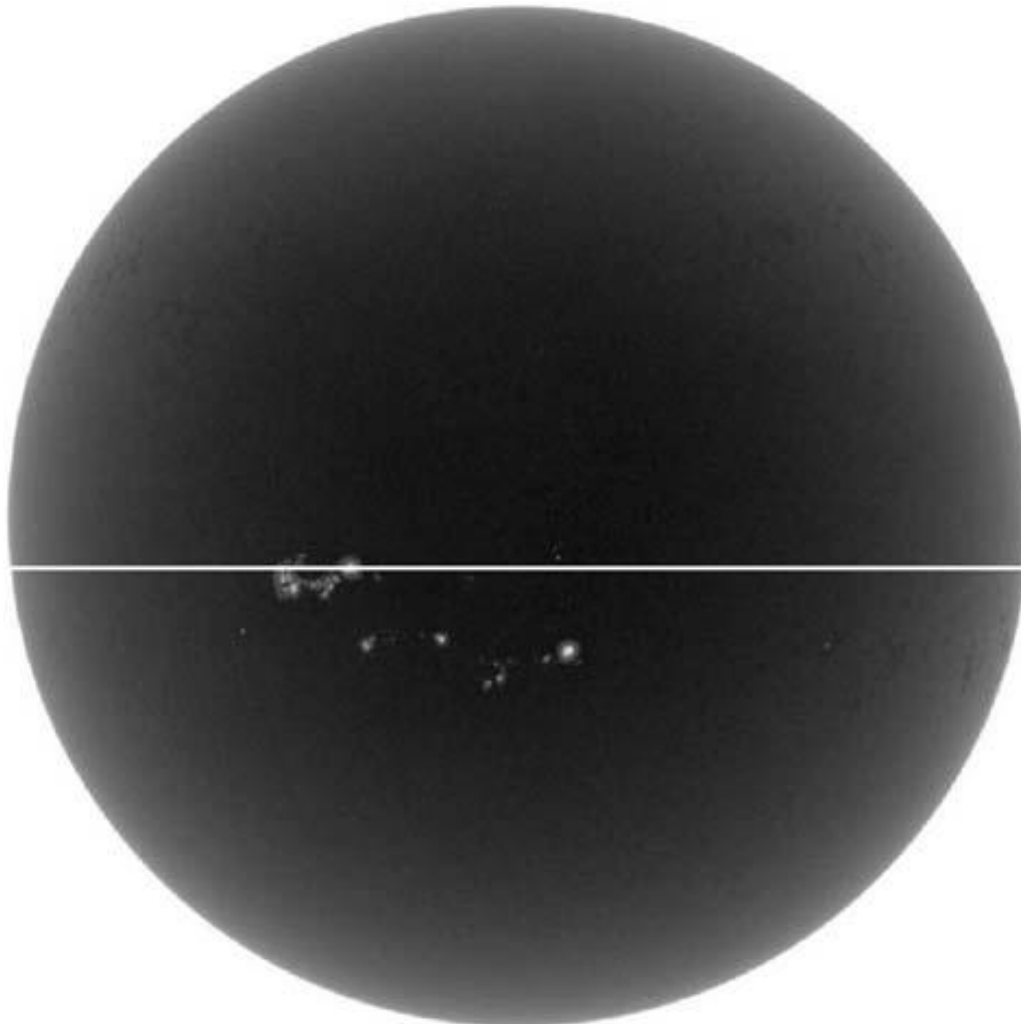
Step one – Automated detection



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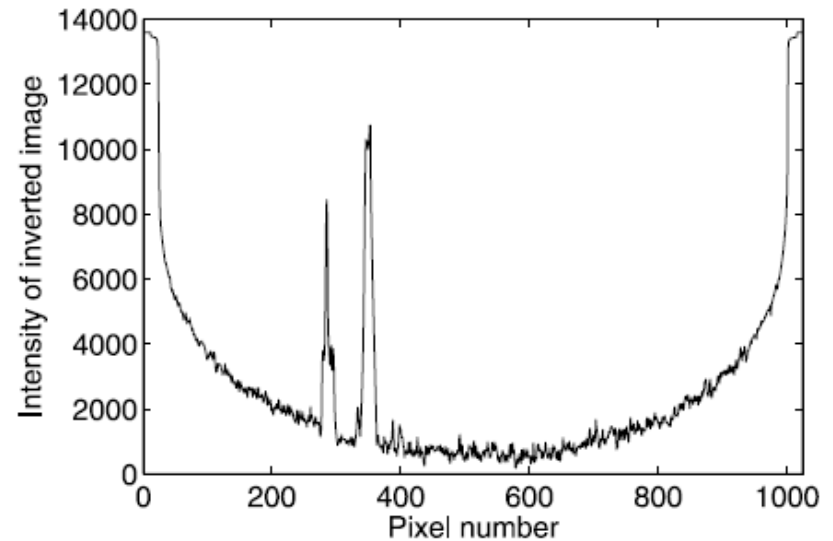
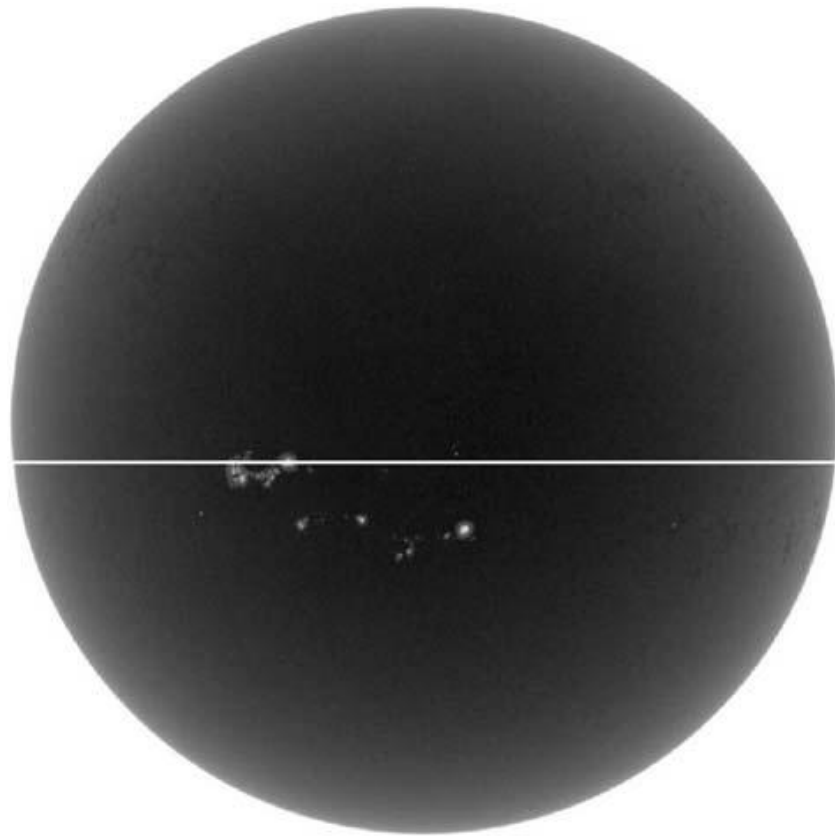


Detecting sunspots - STARA

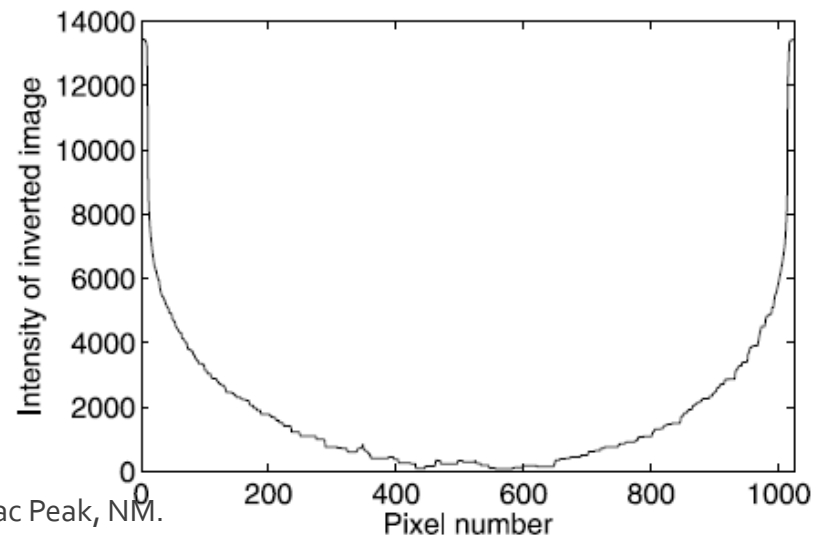
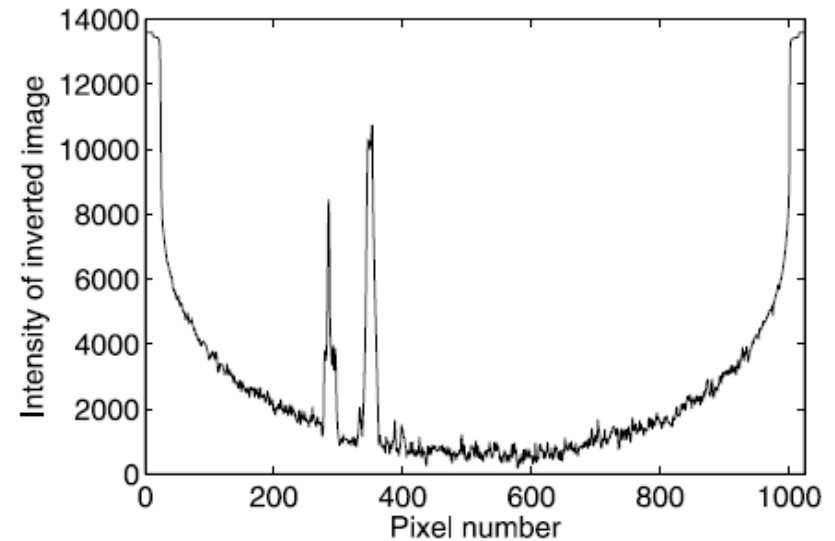
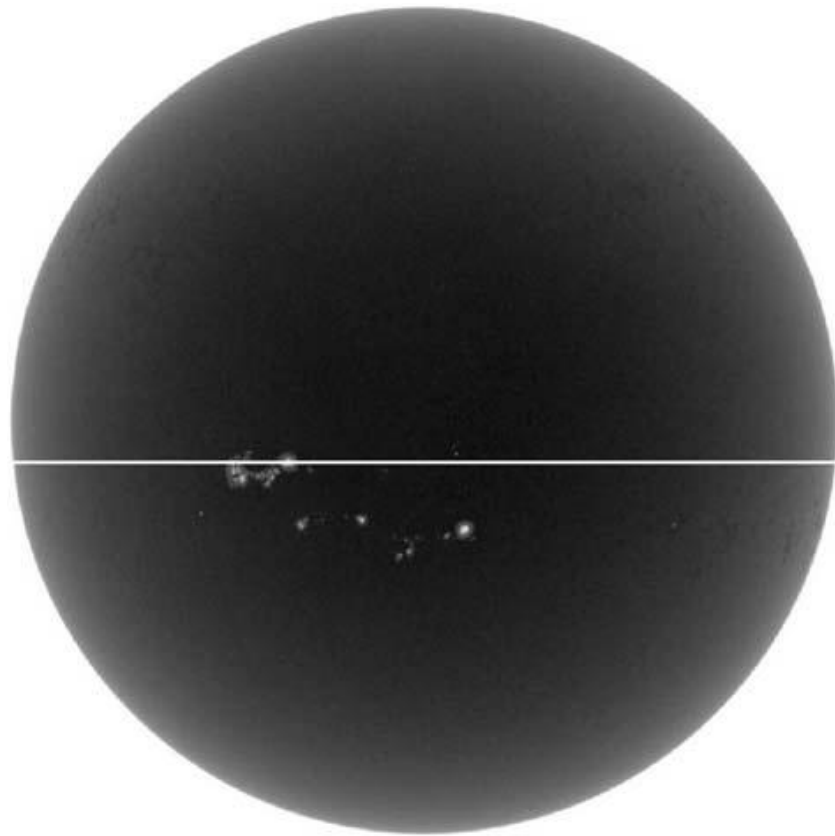


Sunspot Number workshop, Sac Peak, NM.

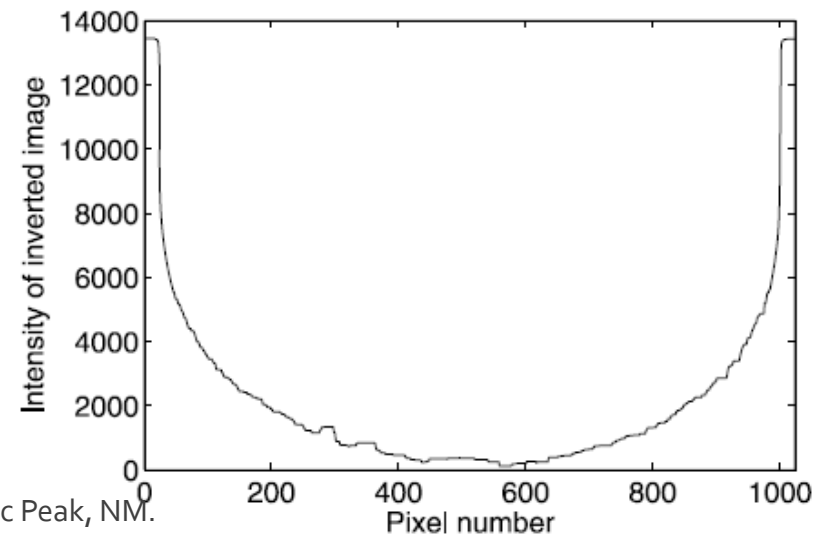
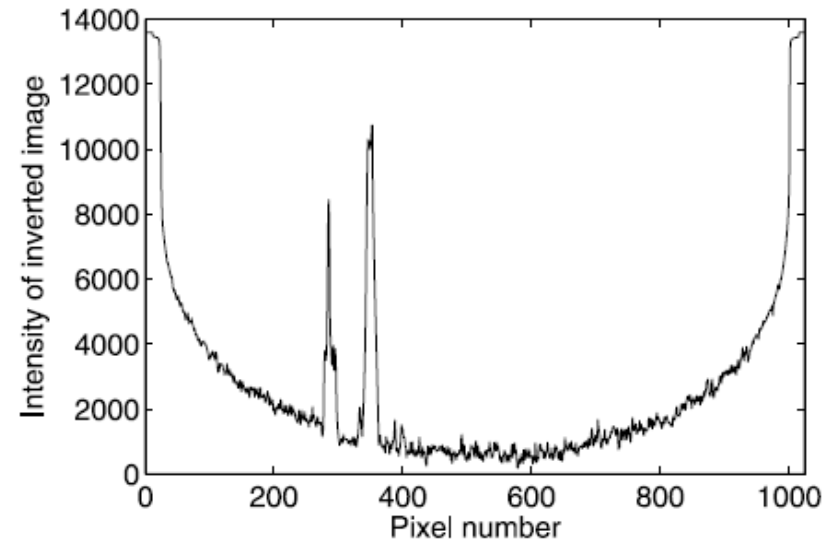
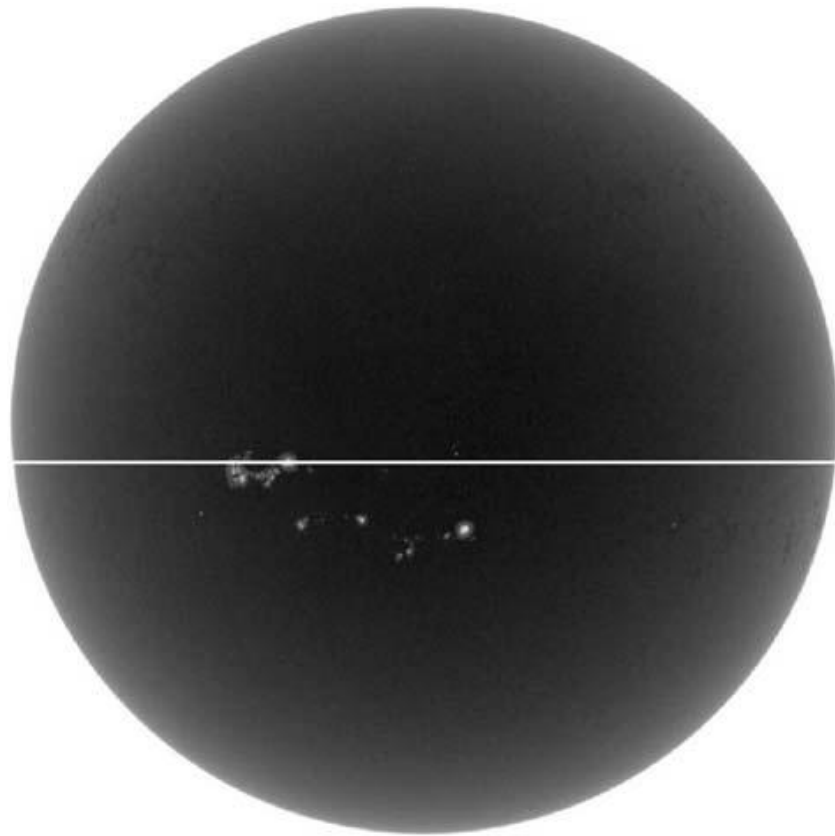
Detecting sunspots - STARA



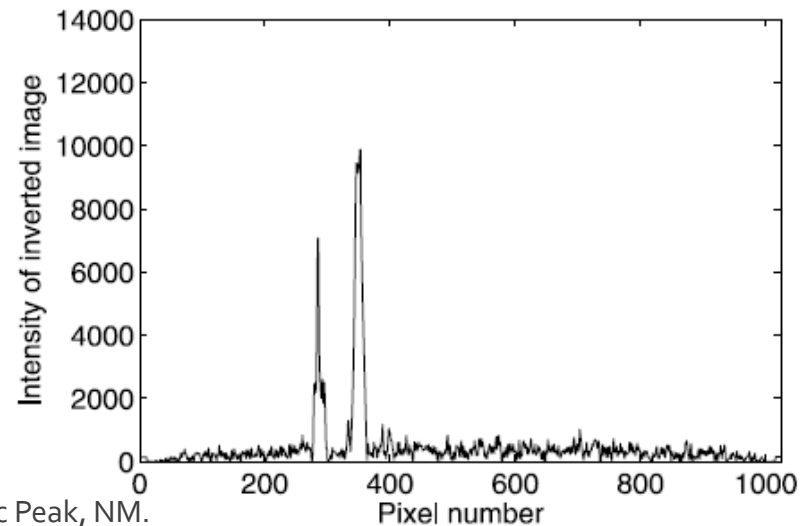
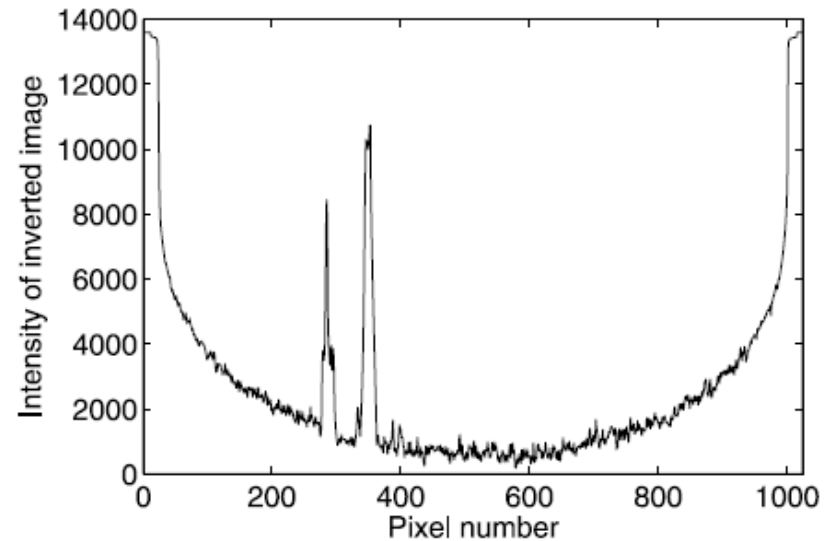
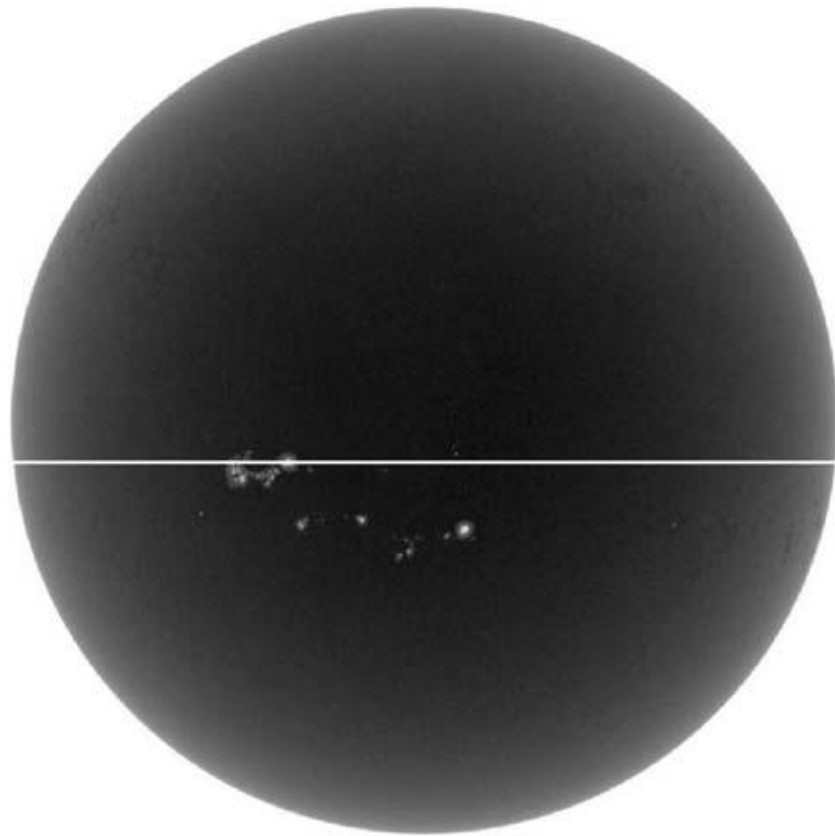
Detecting sunspots - STARA



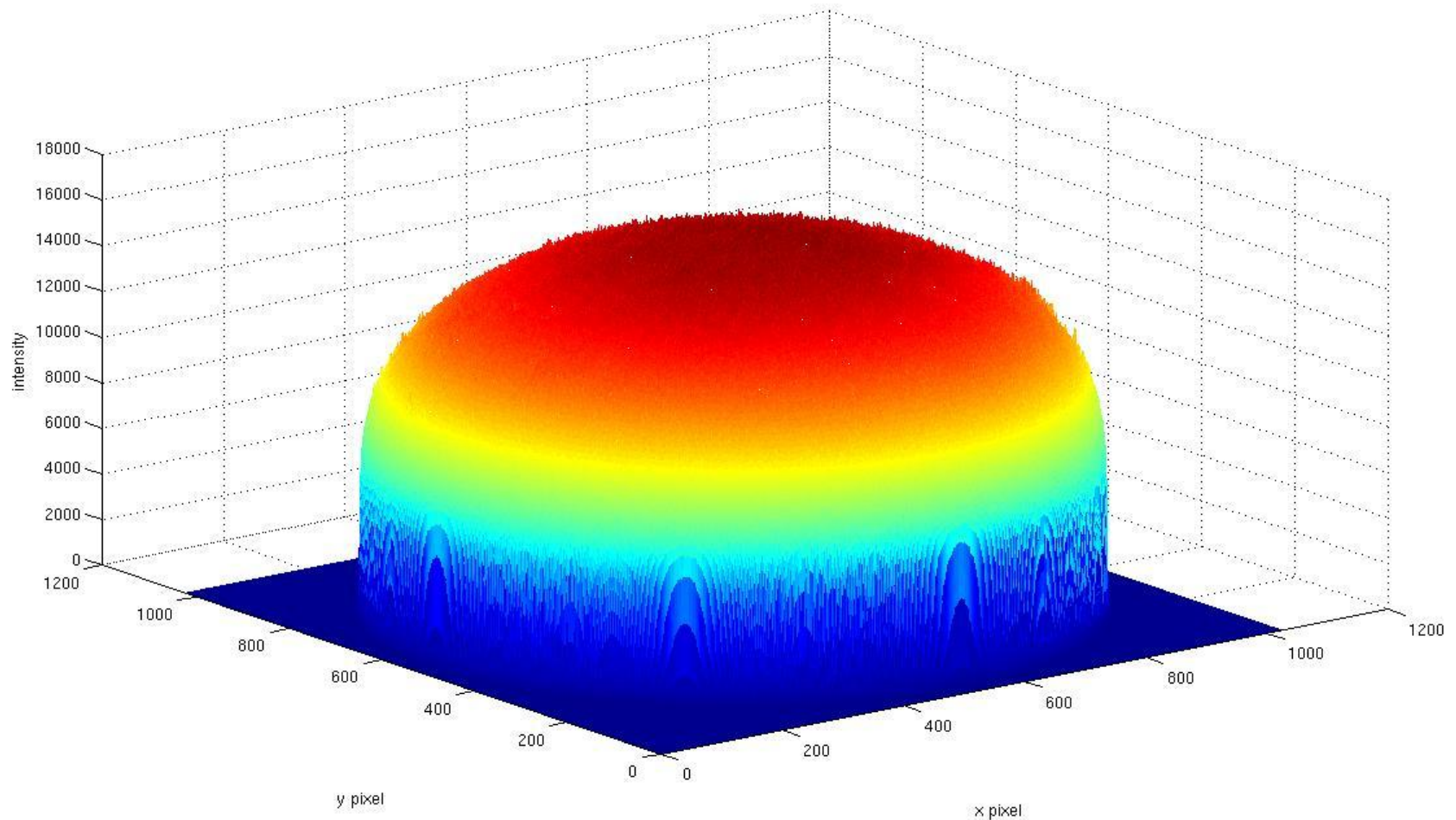
Detecting sunspots - STARA



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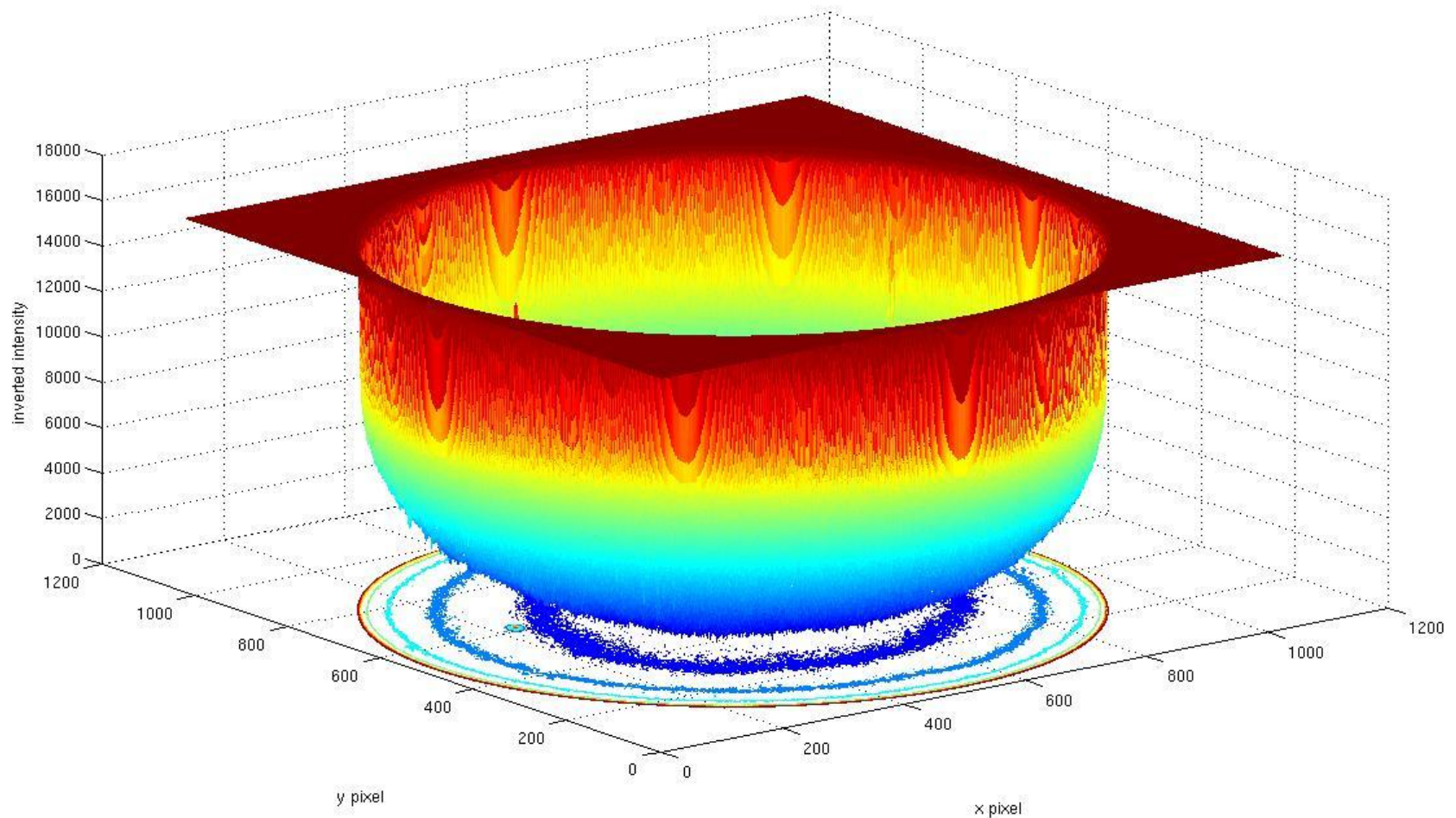


Detecting sunspots - STARA



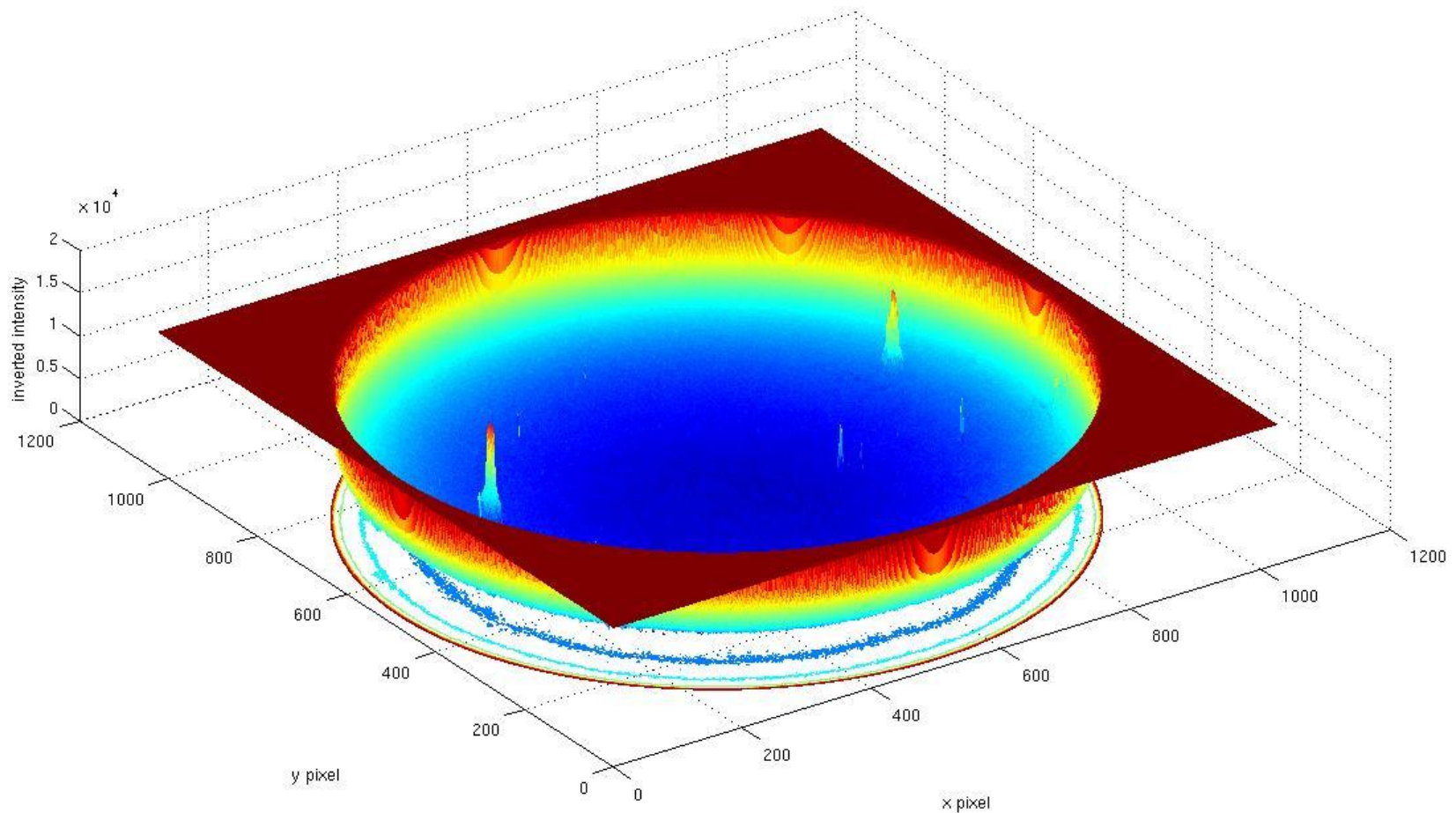
Sunspot Number workshop, Sac Peak, NM.

Detecting sunspots - STARA



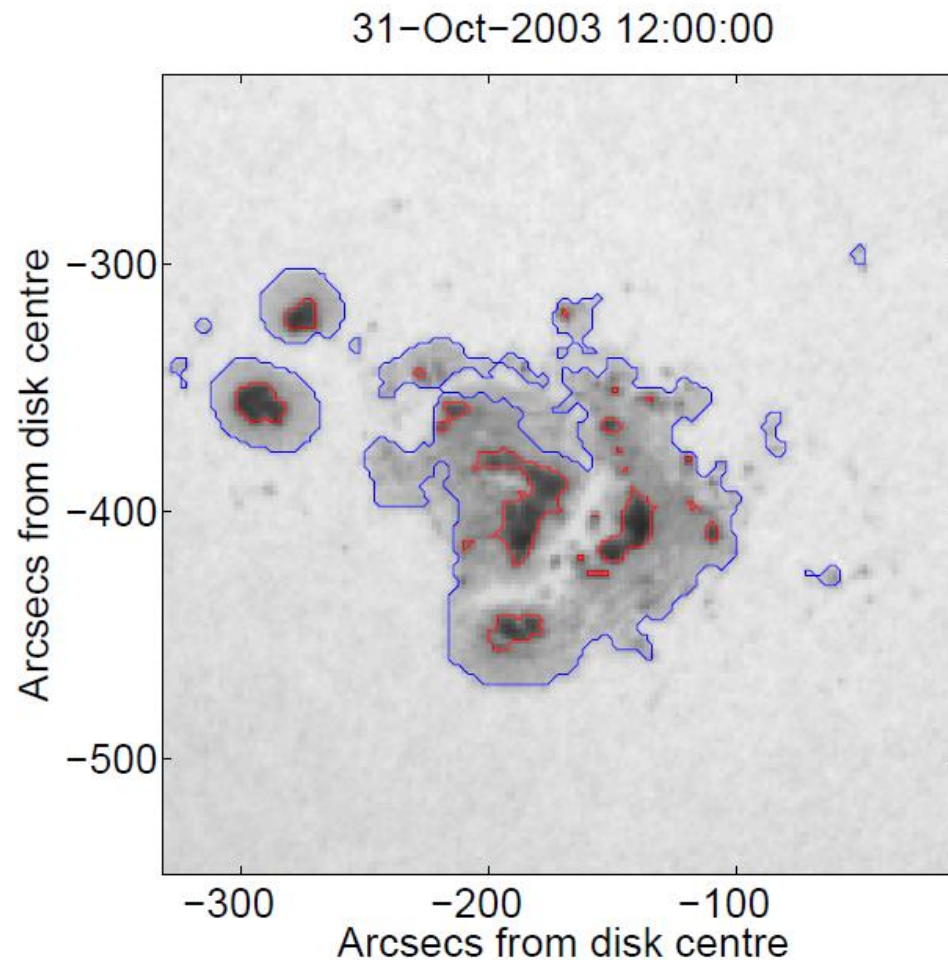
Sunspot Number workshop, Sac Peak, NM.

Detecting sunspots - STARA



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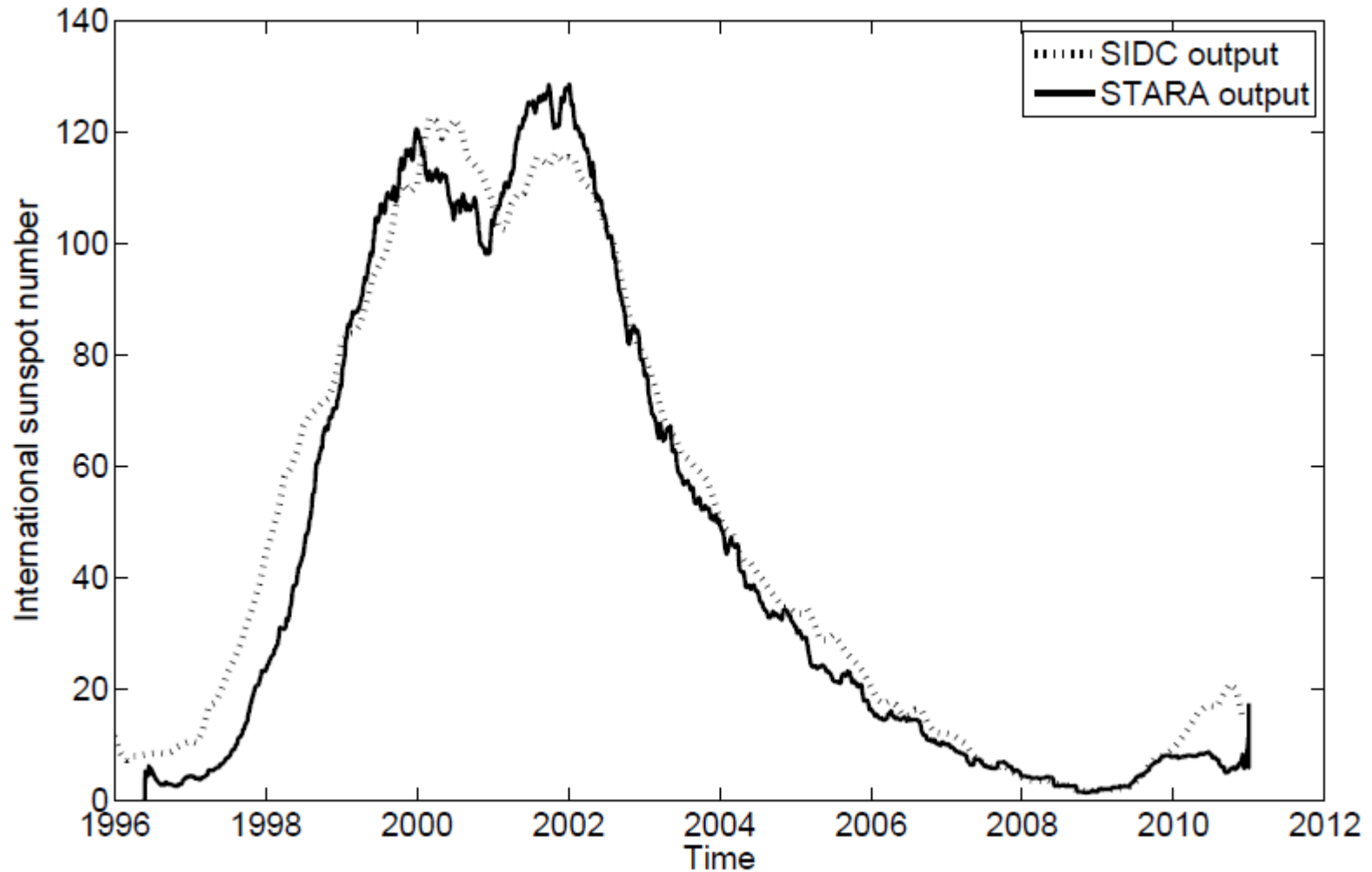
Detecting sunspots - STARA



Analysis

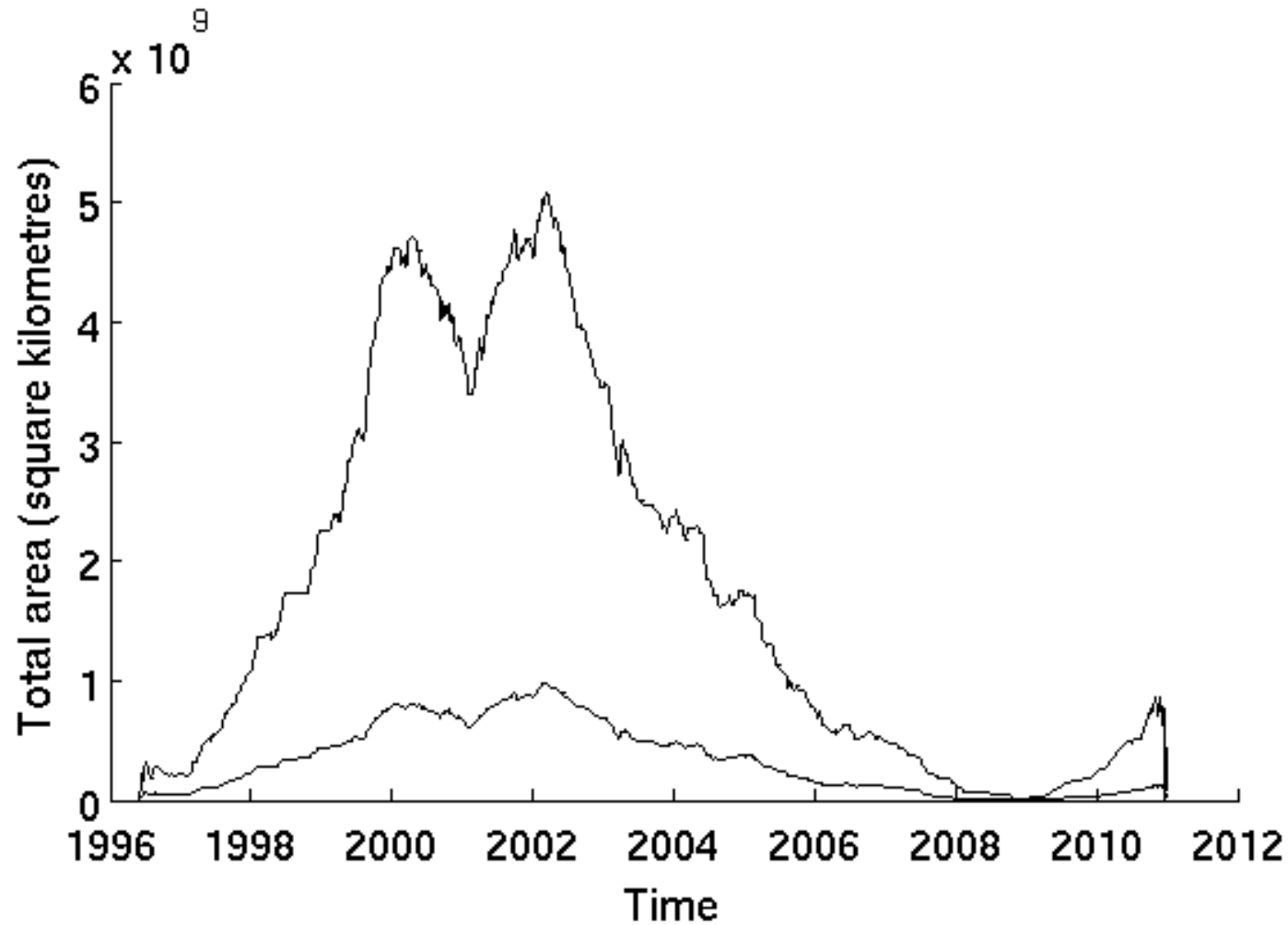
- **Sunspot number**
- Locations
- Umbral magnetic field strengths

Sunspot number



Sunspot Number workshop, Sac Peak, NM.

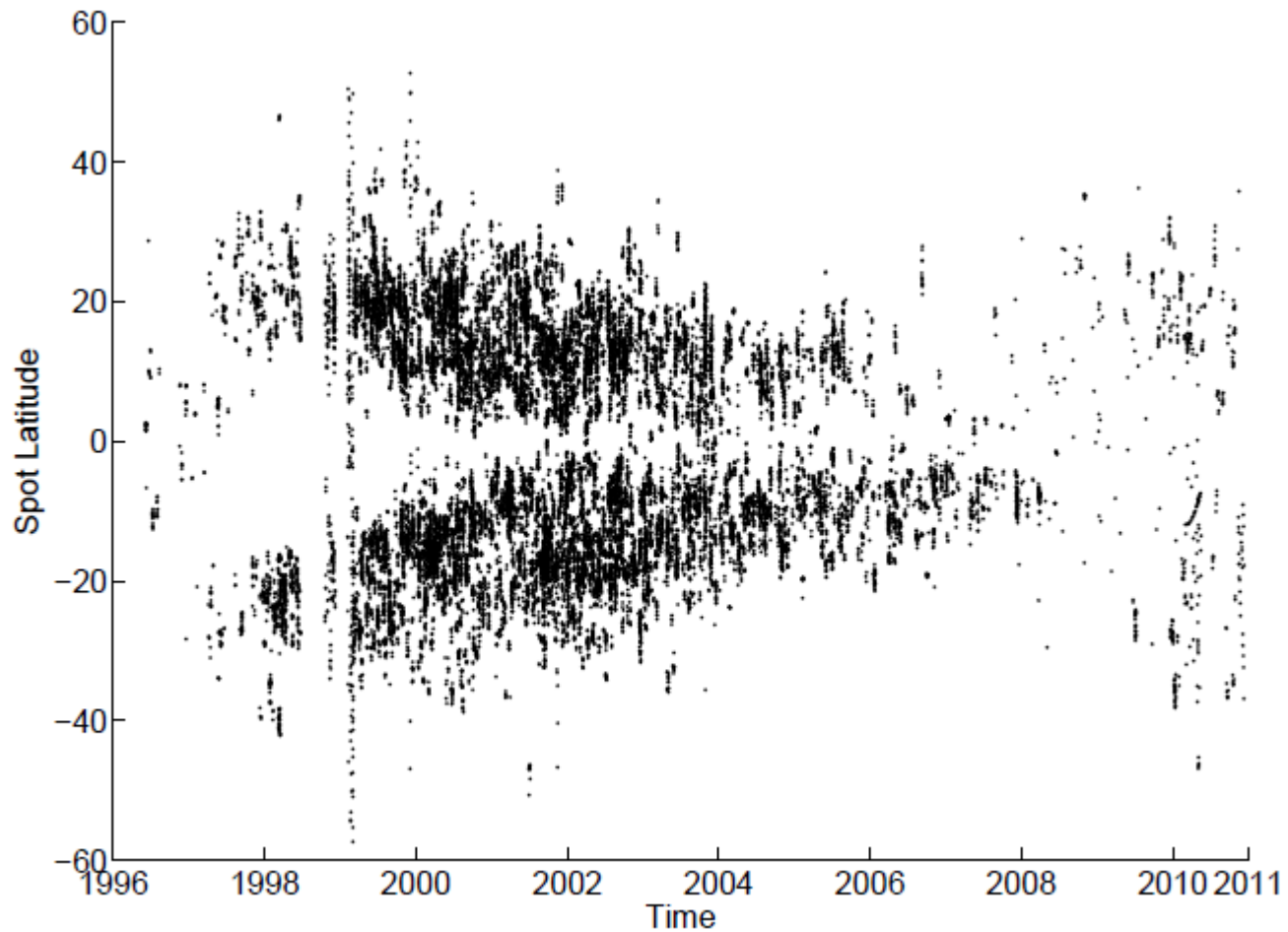
Total spot area



Step three - analysis

- Sunspot number
- **Locations**
- Umbral magnetic field strengths

Locations

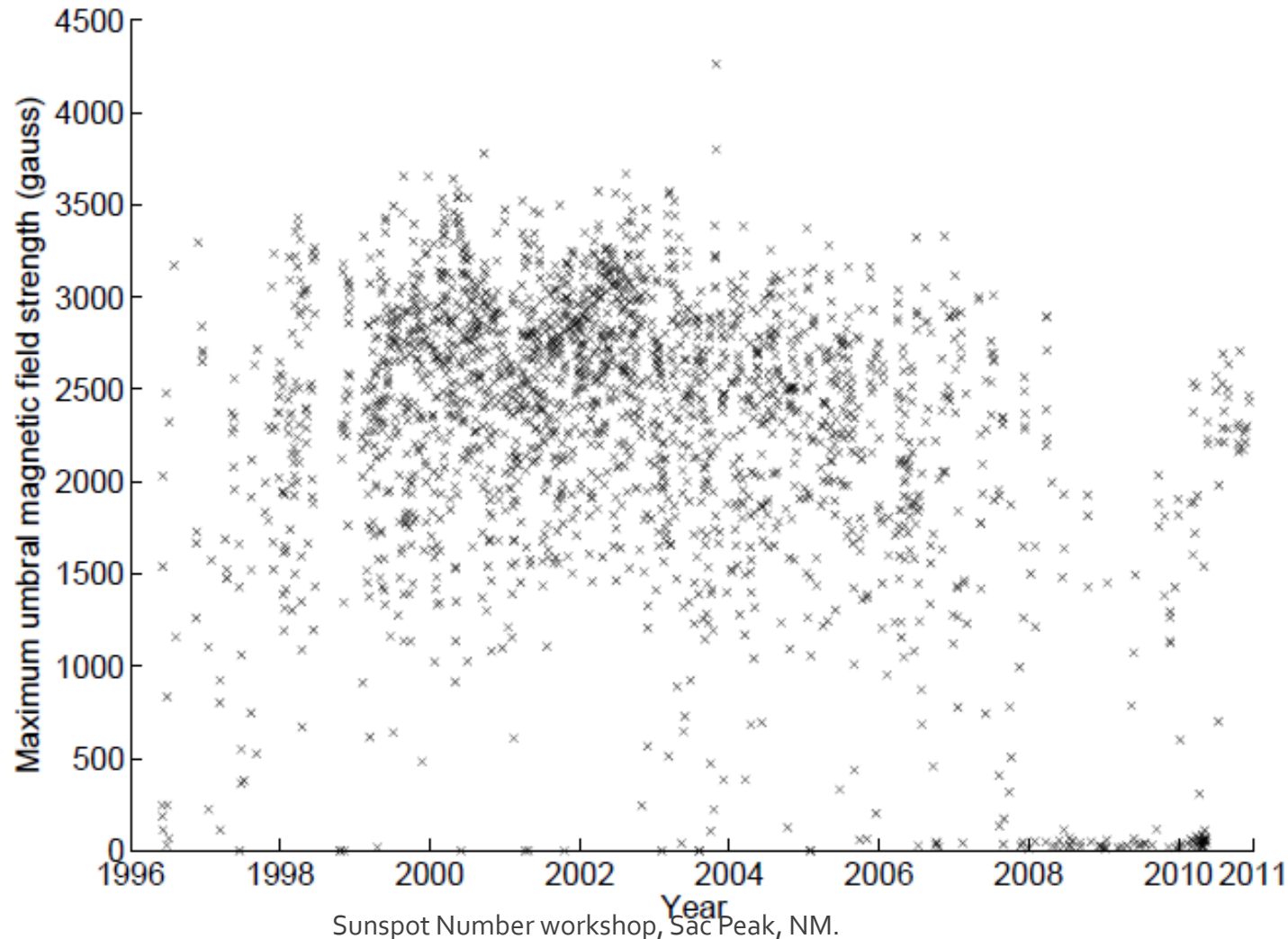


Sunspot Number workshop, Sac Peak, NM.

Step three - analysis

- Sunspot number
- Locations
- **Umbral magnetic field strengths**

Umbral magnetic field strengths



Umbral magnetic field strengths

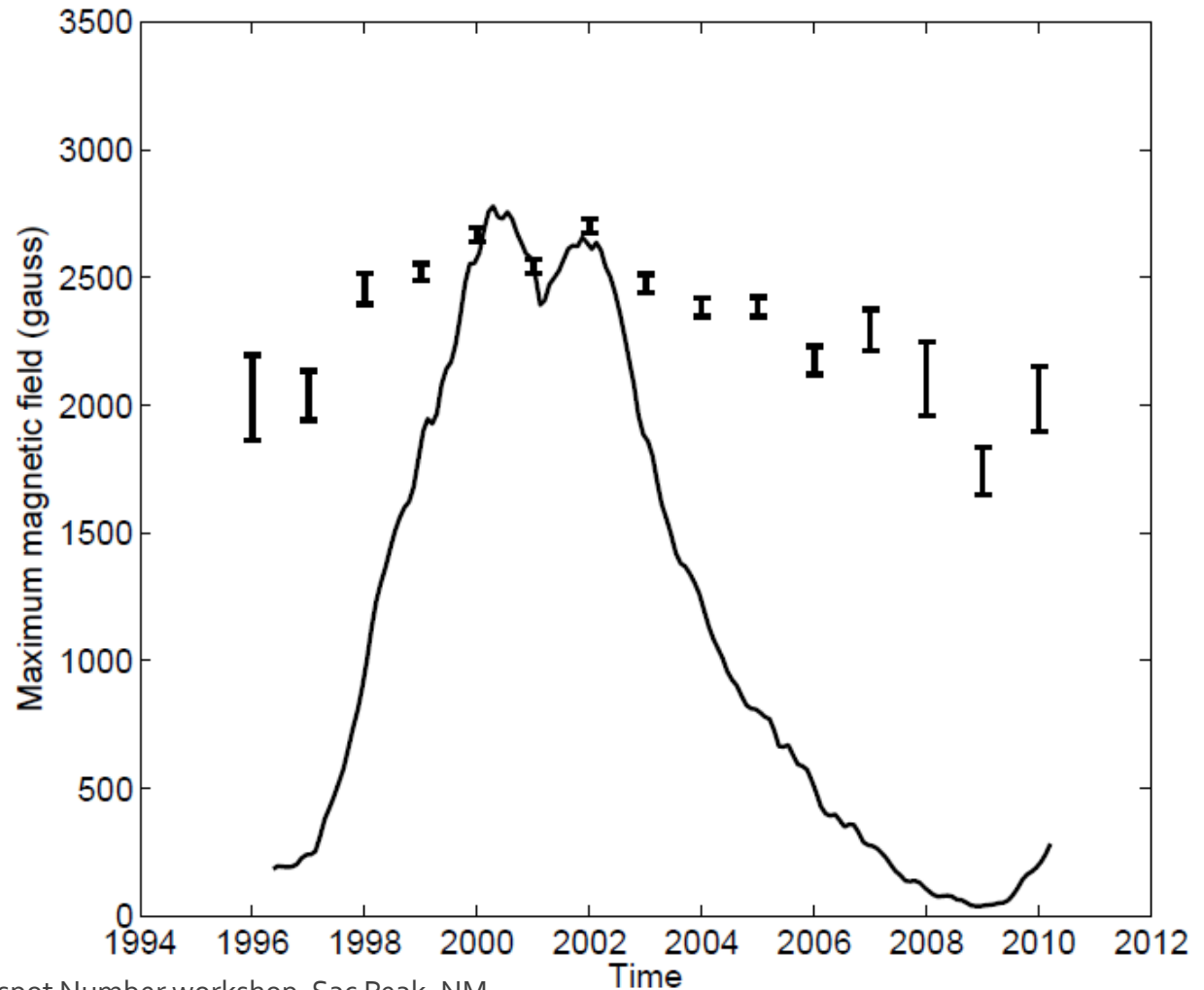
Bin the data by year.

Plot the mean of each bin.

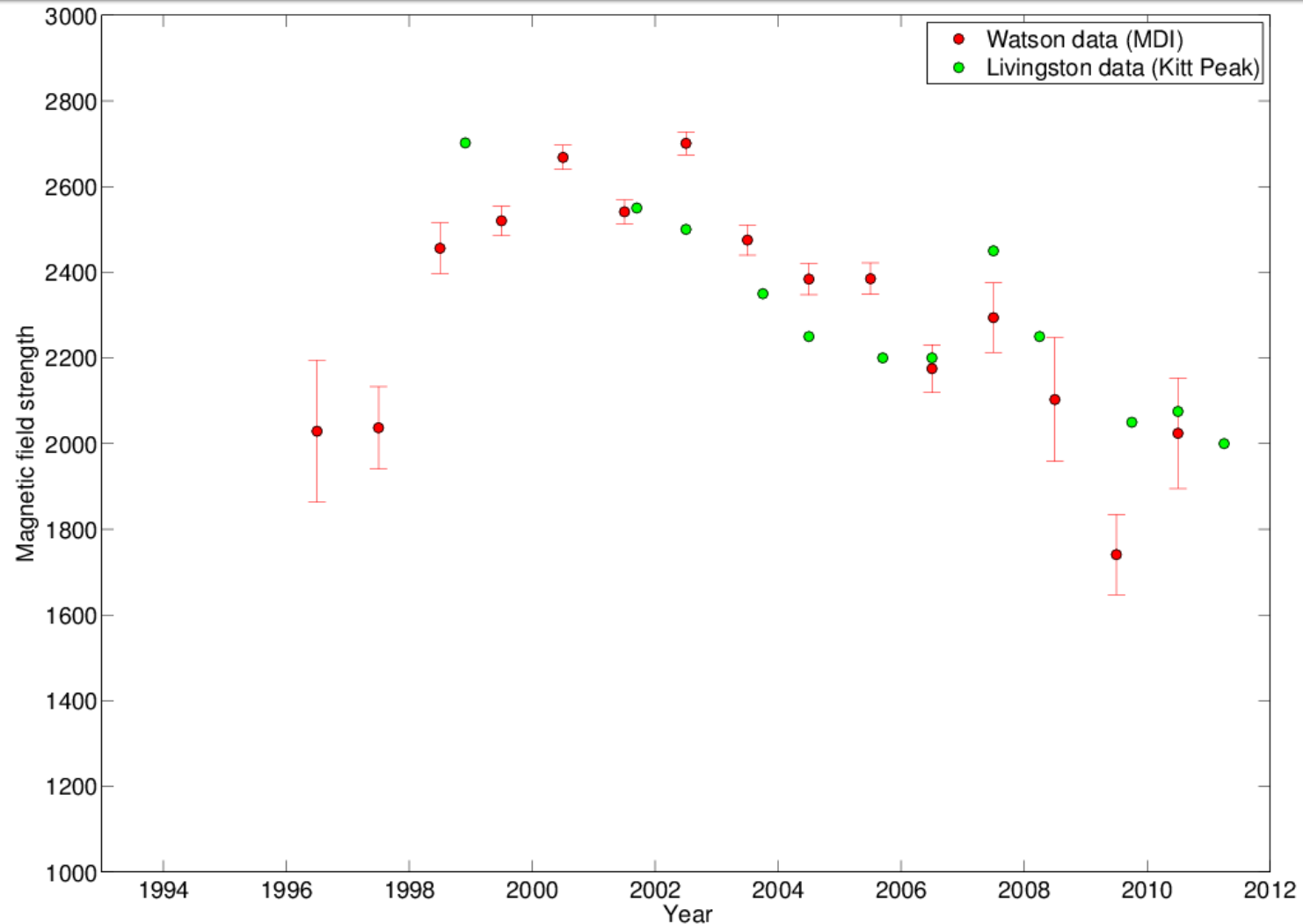
Error given by the standard deviation on the mean.

This is the method used by Livingston and Penn.

The International Sunspot Number is included to give an indication of the solar cycle.



Umbral magnetic field strengths



Sunspot Number workshop, Sac Peak, NM.

HMI tests

