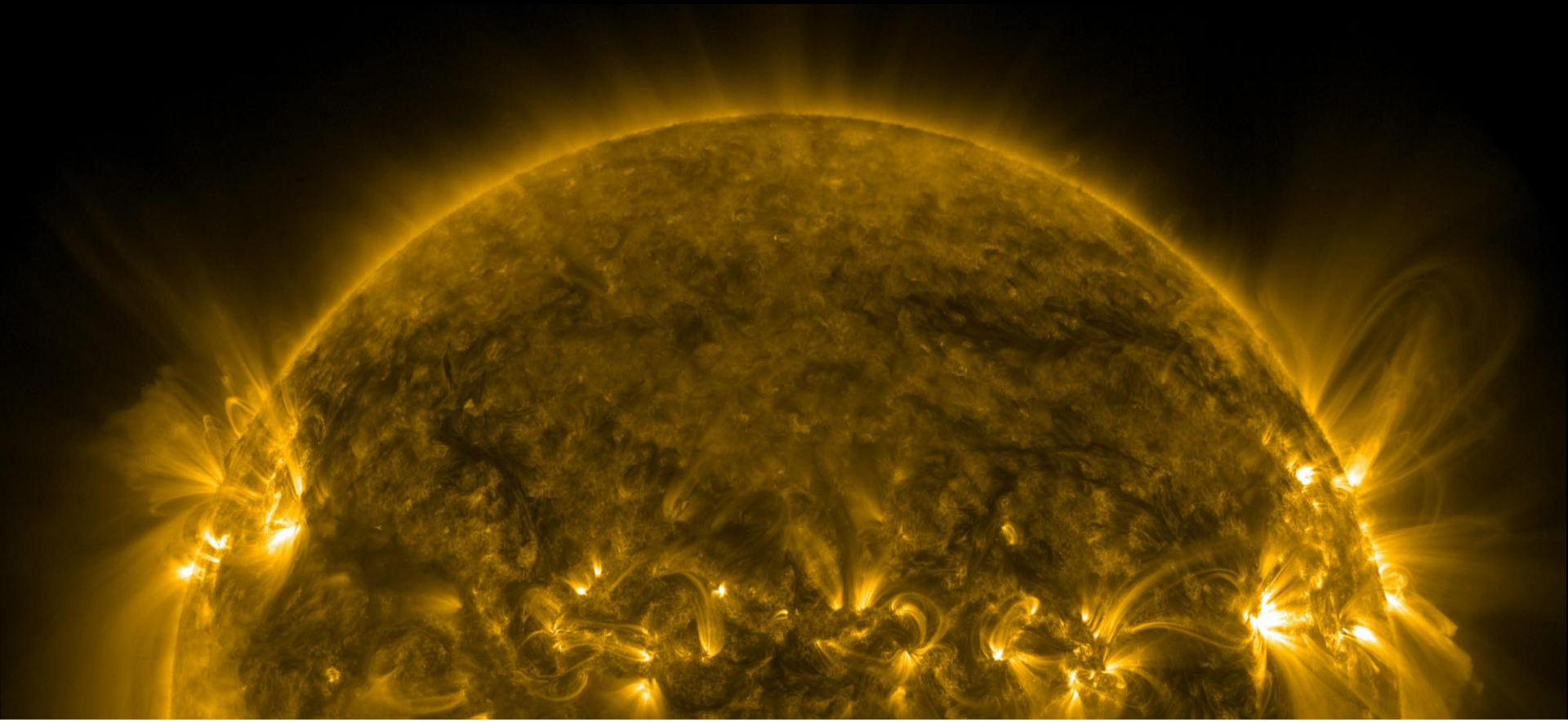
Measuring sunspots from space



Fraser T. Watson
NSO, Tucson

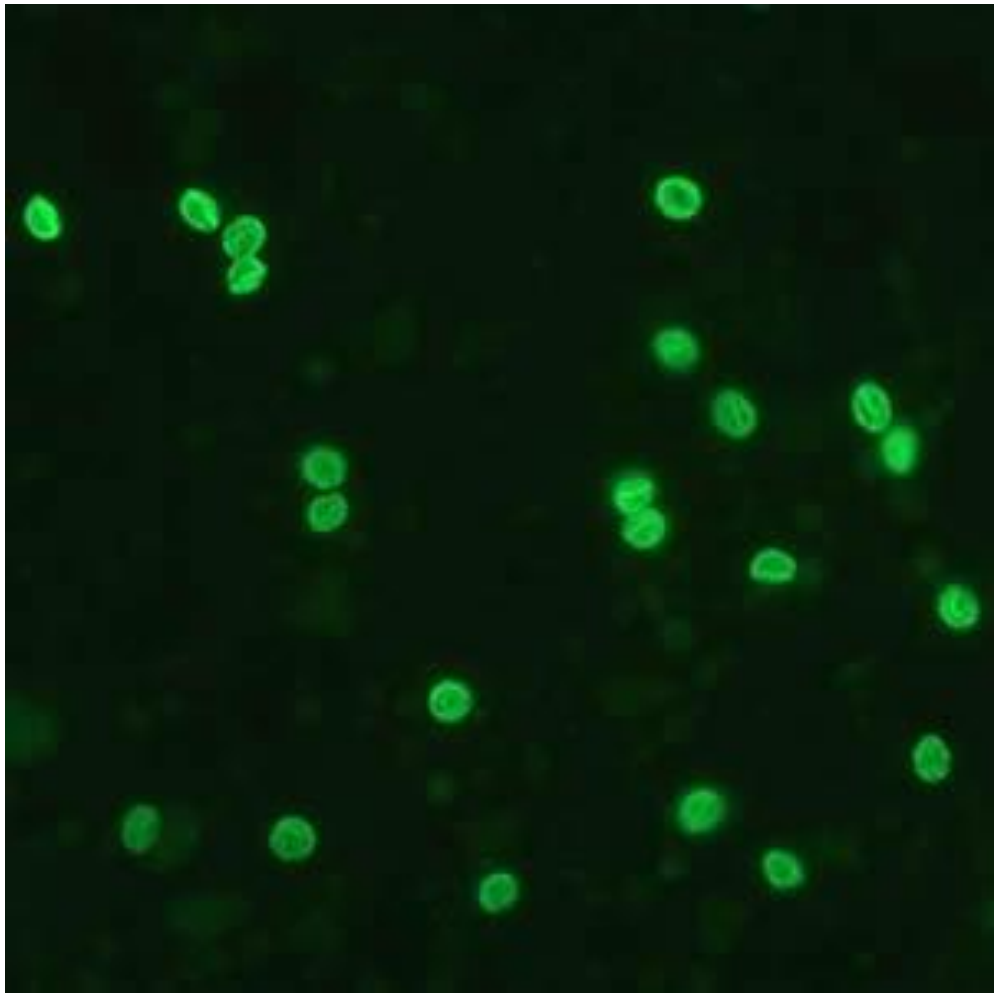
Motivation

- Sunspot catalogues created from drawings or at the eyepiece have been used in great detail.
- What other tools are available?

Motivation

- Similar fields that rely on images?

Motivation



Automated image processing

- Minimal human intervention.
- Looking with the same ‘brain’, although perhaps not the same ‘eyes’.


STOP

Automated image processing

I am NOT saying that this should be a replacement.

c.f. question at the end of Frédéric's presentation

Automated image processing

I am suggesting that this could be a useful addition to methods already well established.

STARA

Sunspot Tracking And Recognition Algorithm

Allows fast and efficient detection of sunspots and spot umbrae in digitised data.

Automated method allows consistency in detections.

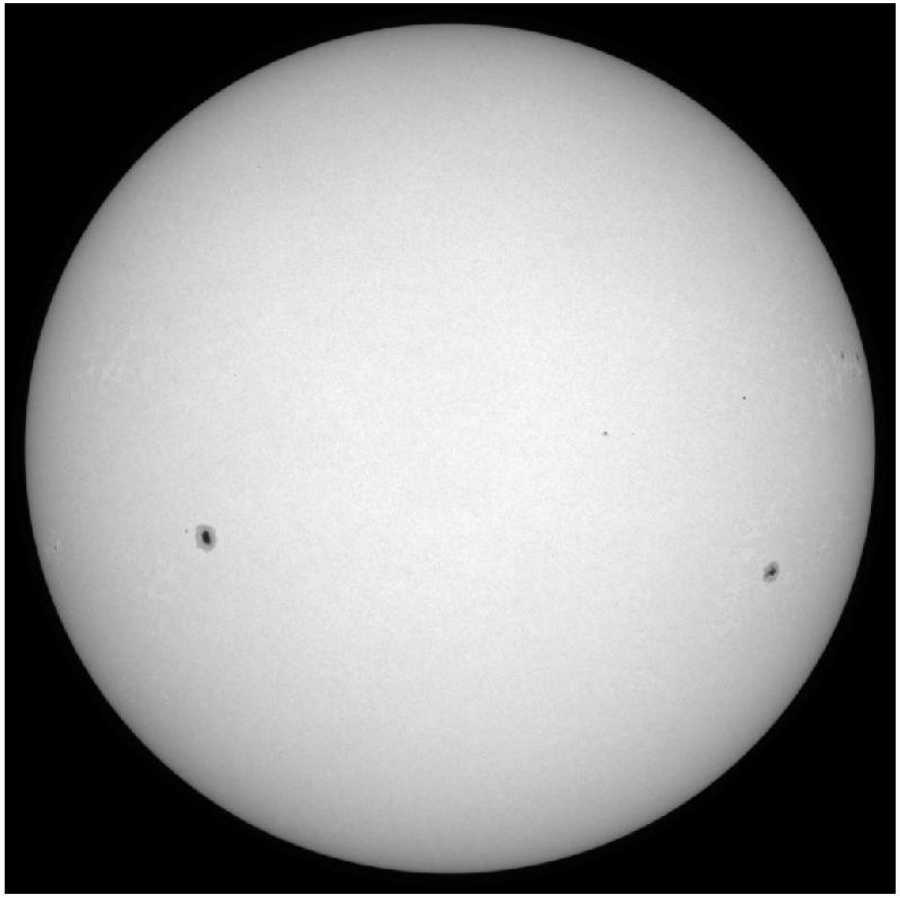
I currently use SOHO/MDI and SDO/HMI

A warning

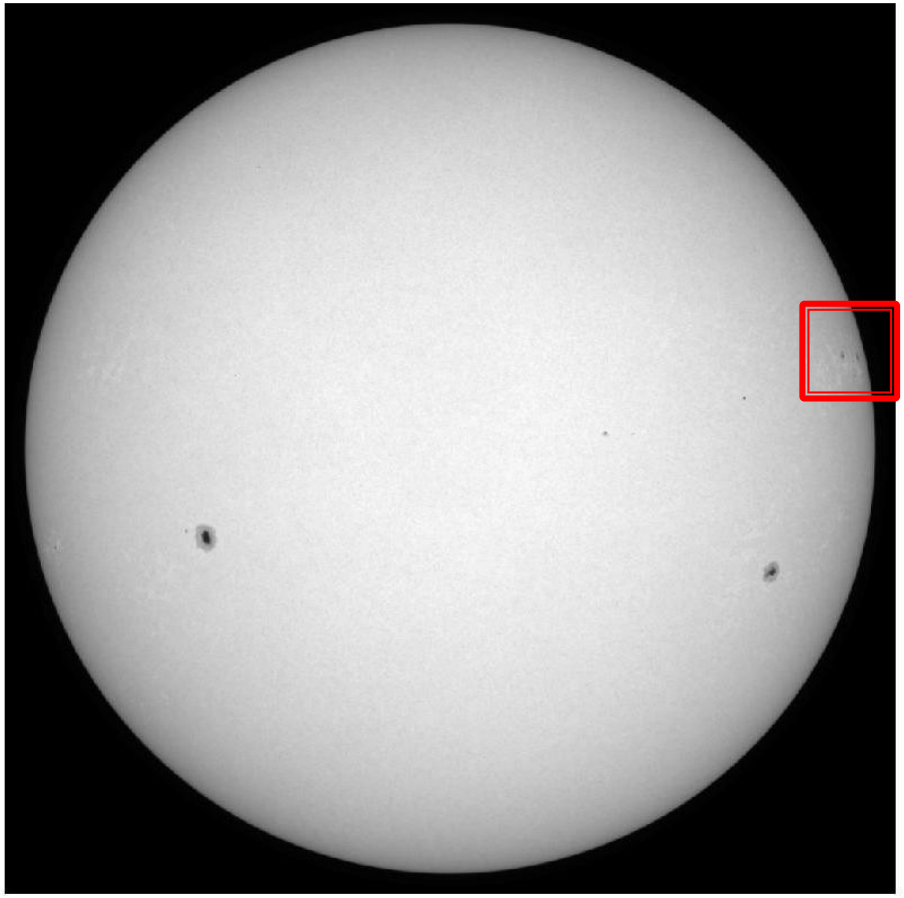
"Be careful with MDI data"

- Gary Chapman

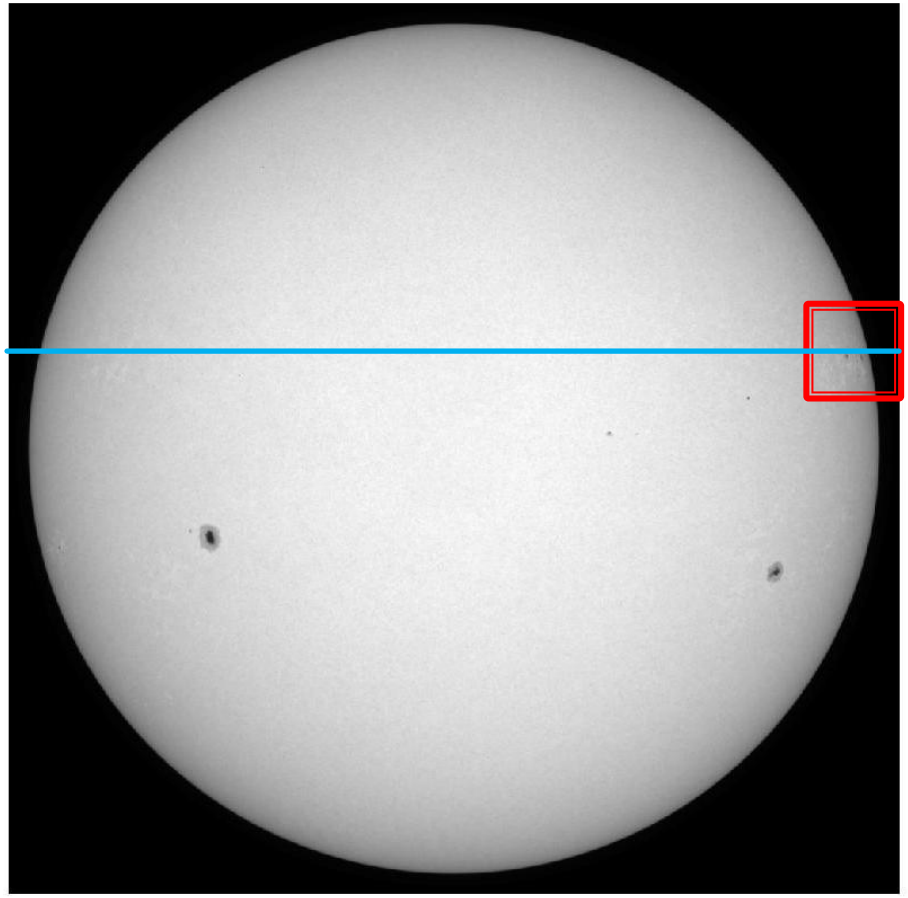
Step one – automated detection

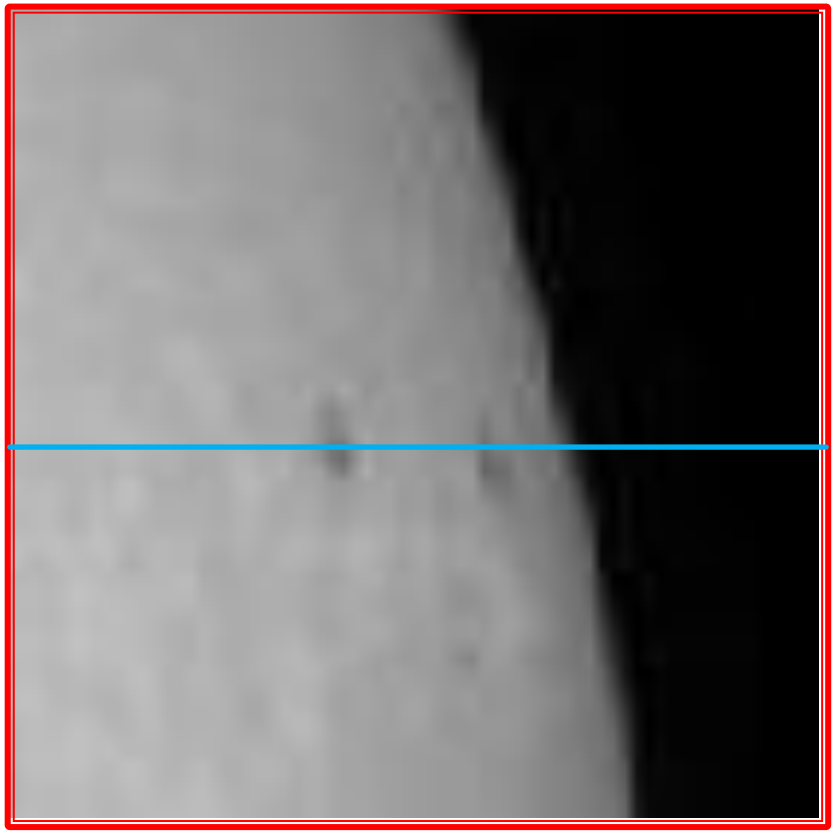


Step one – automated detection

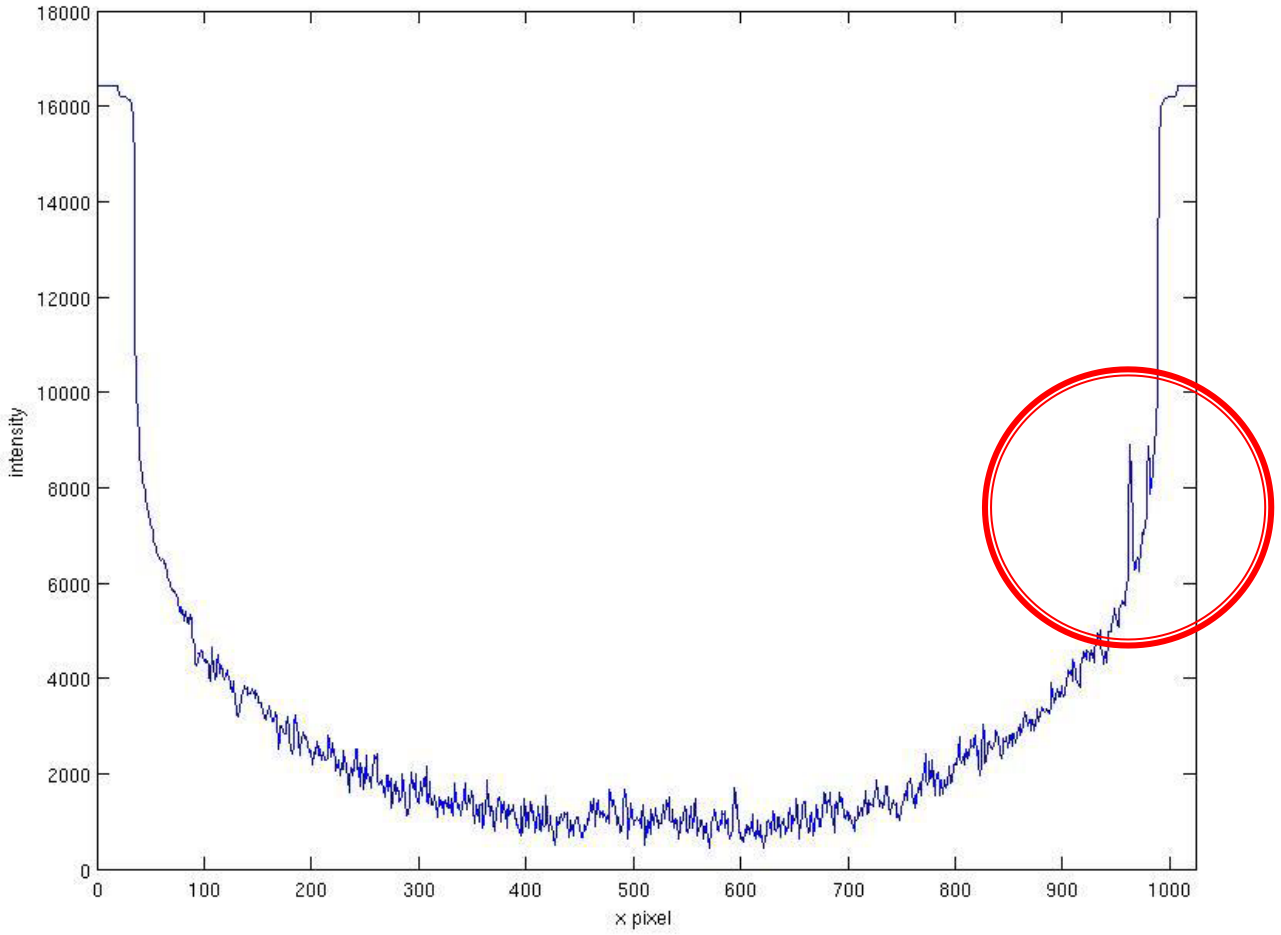


Step one – automated detection



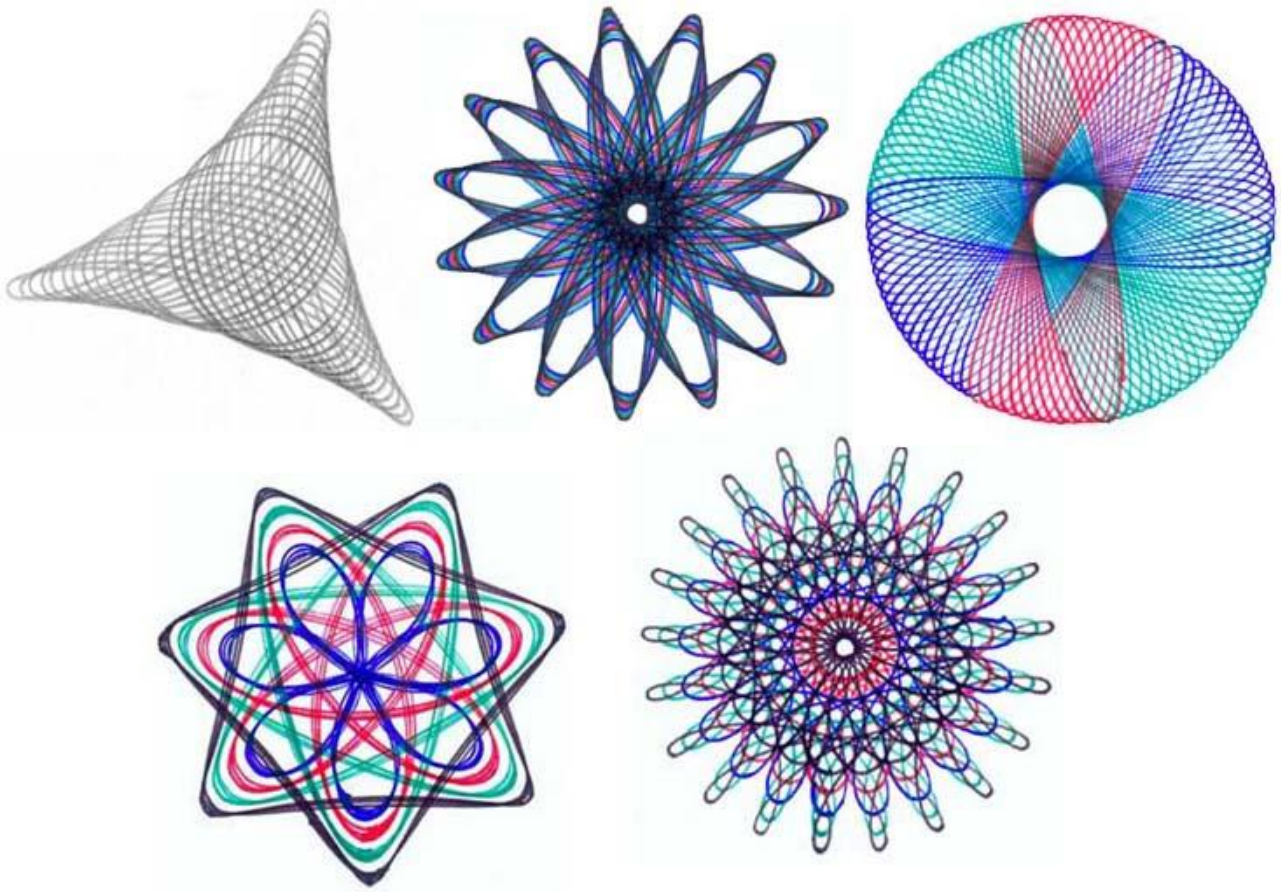


Step one – automated detection

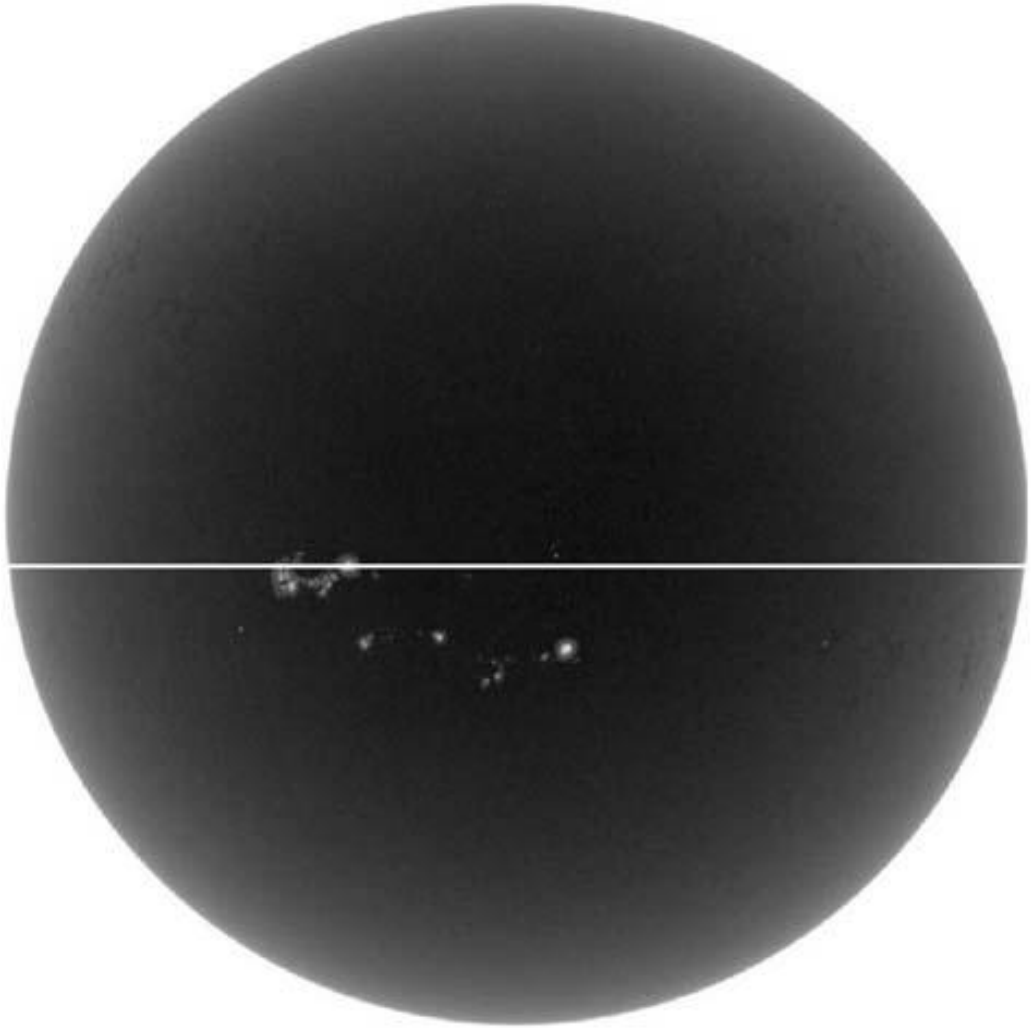


Step one – Automated detection

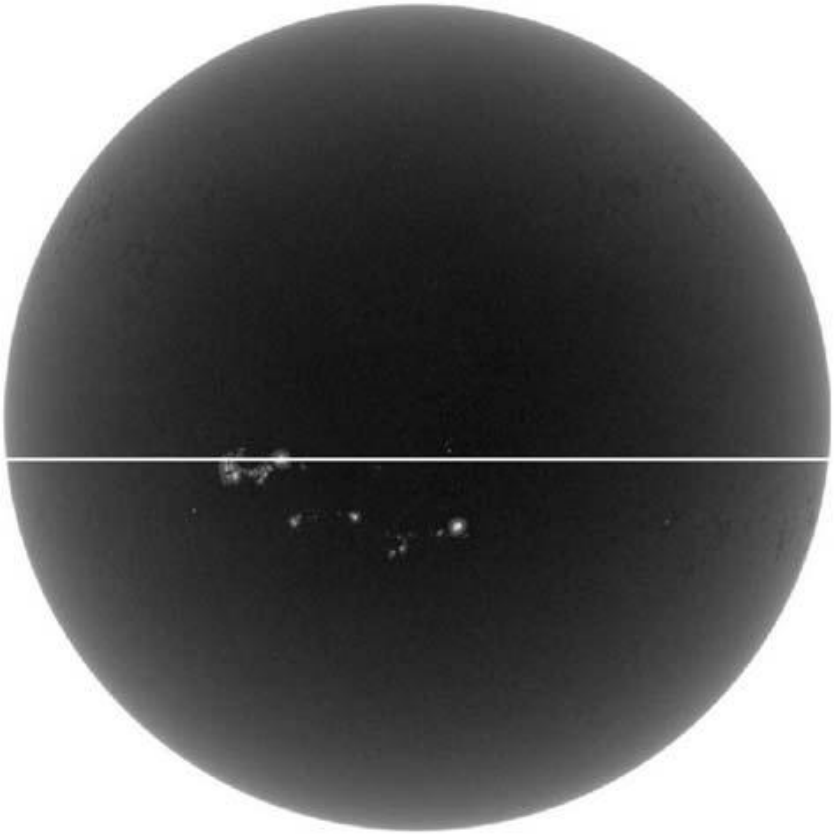
Step one – Automated detection

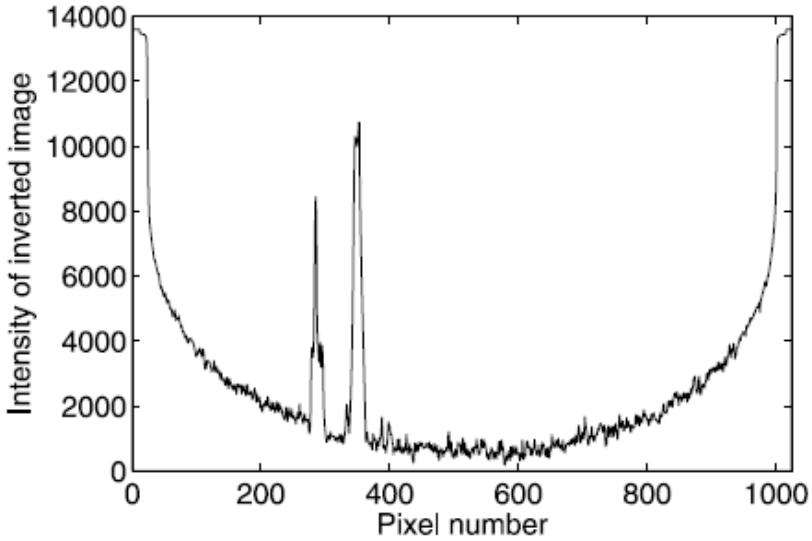


Detecting sunspots - STARA

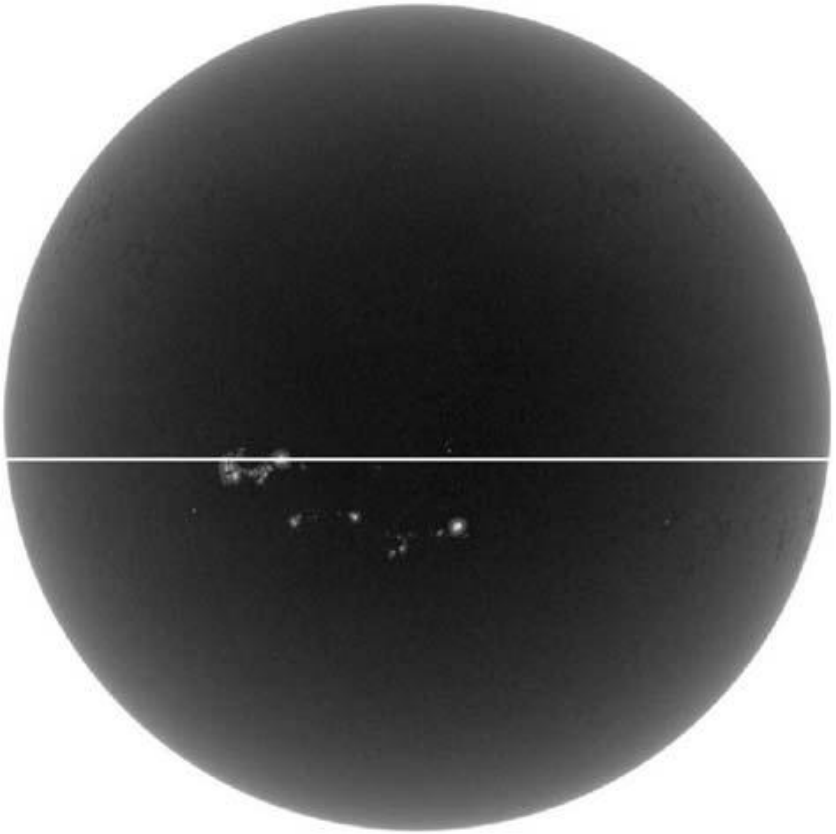


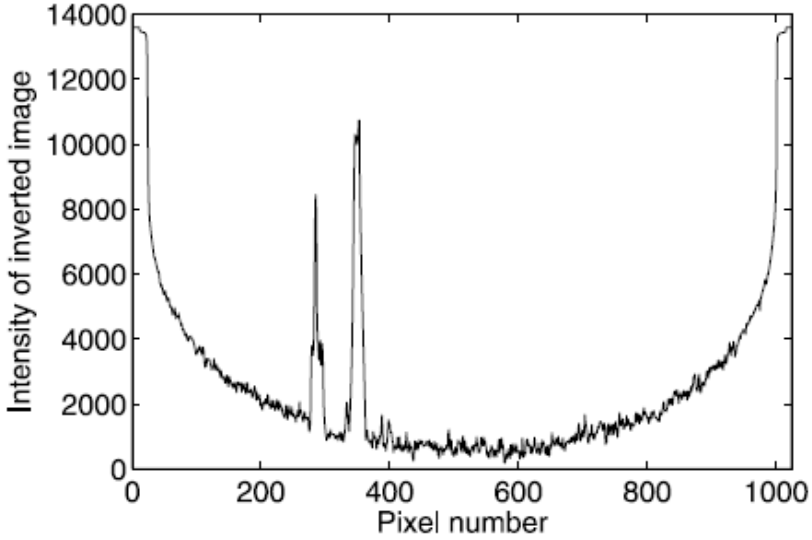
Detecting sunspots - STARA

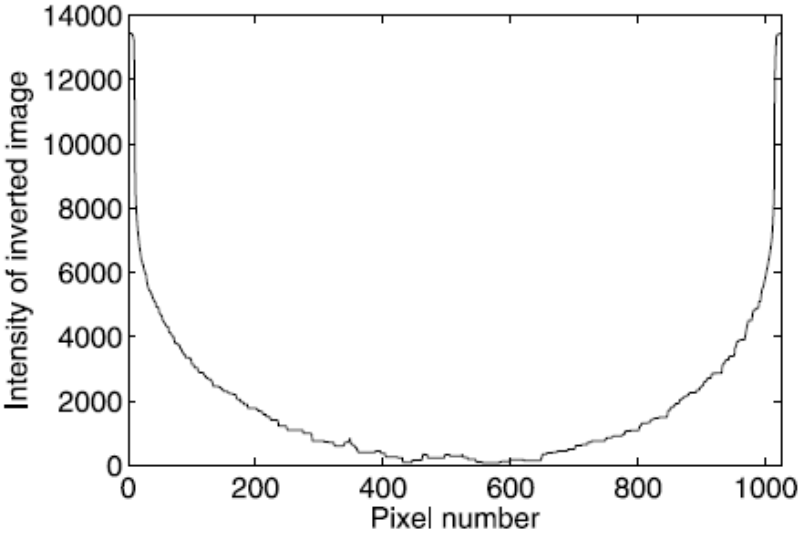




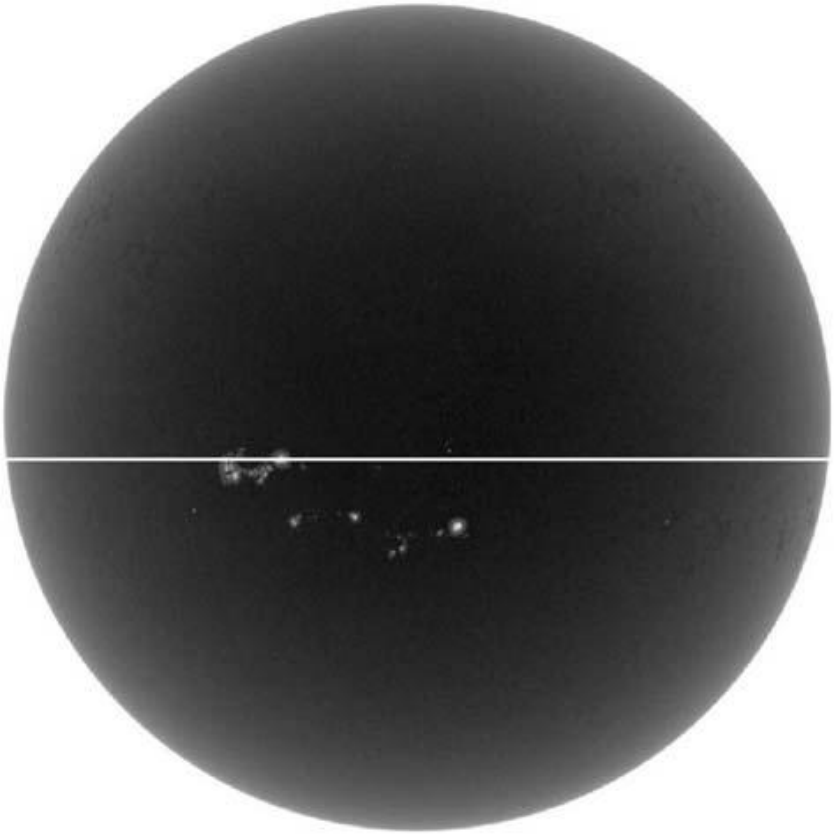
Detecting sunspots - STARA

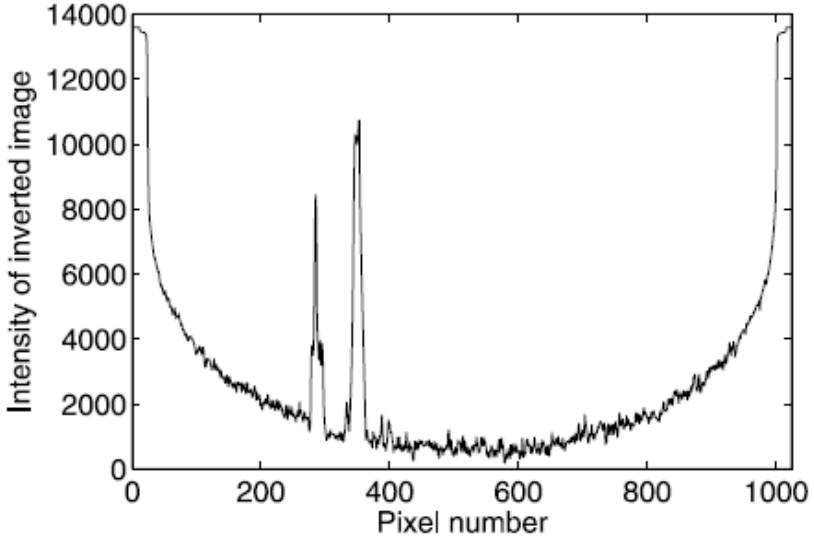


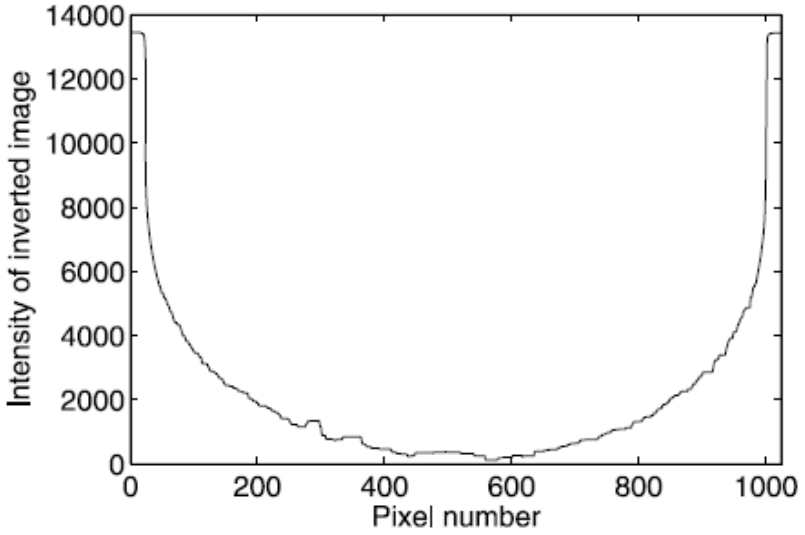




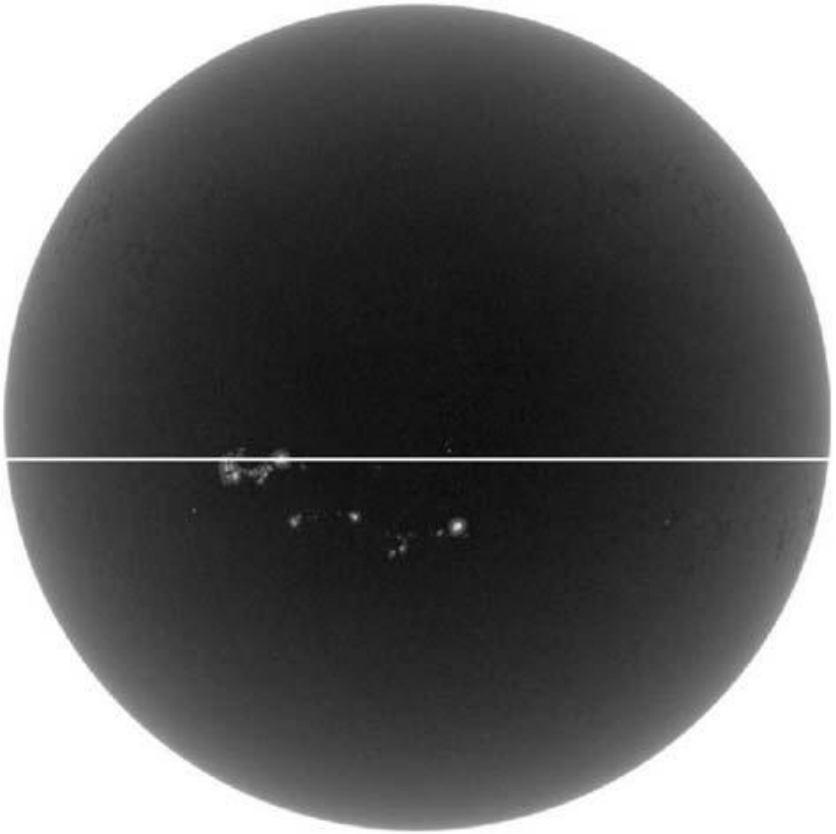
Detecting sunspots - STARA

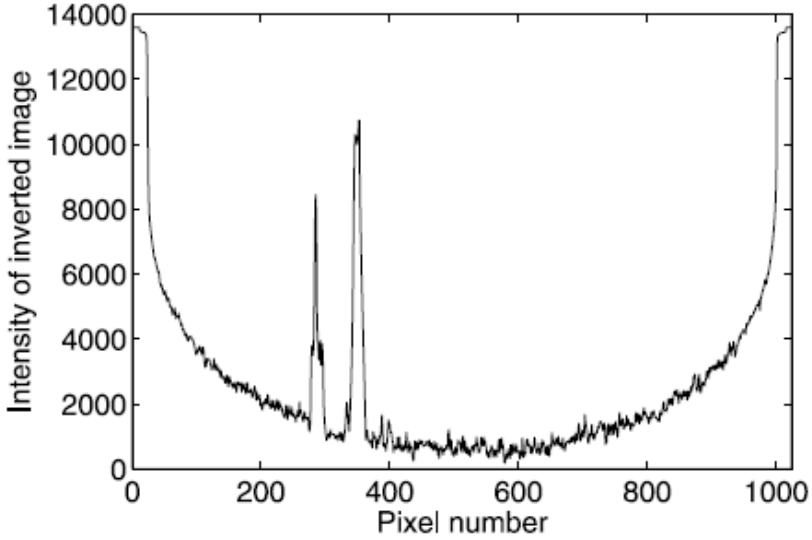


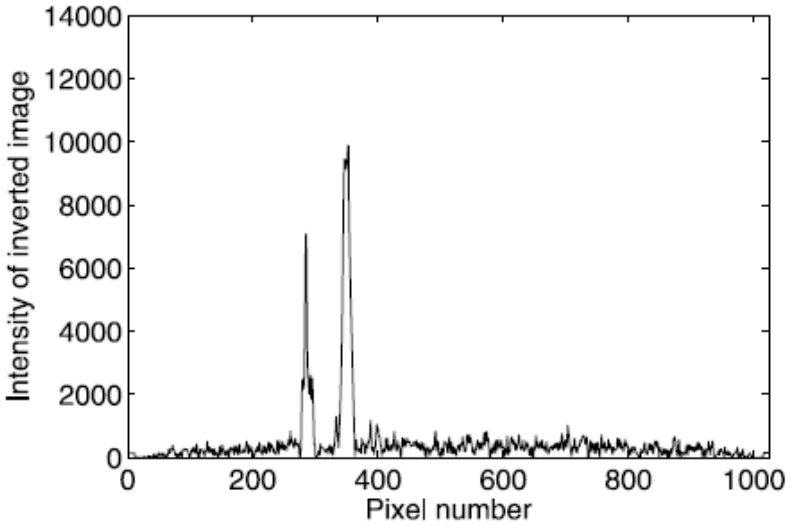




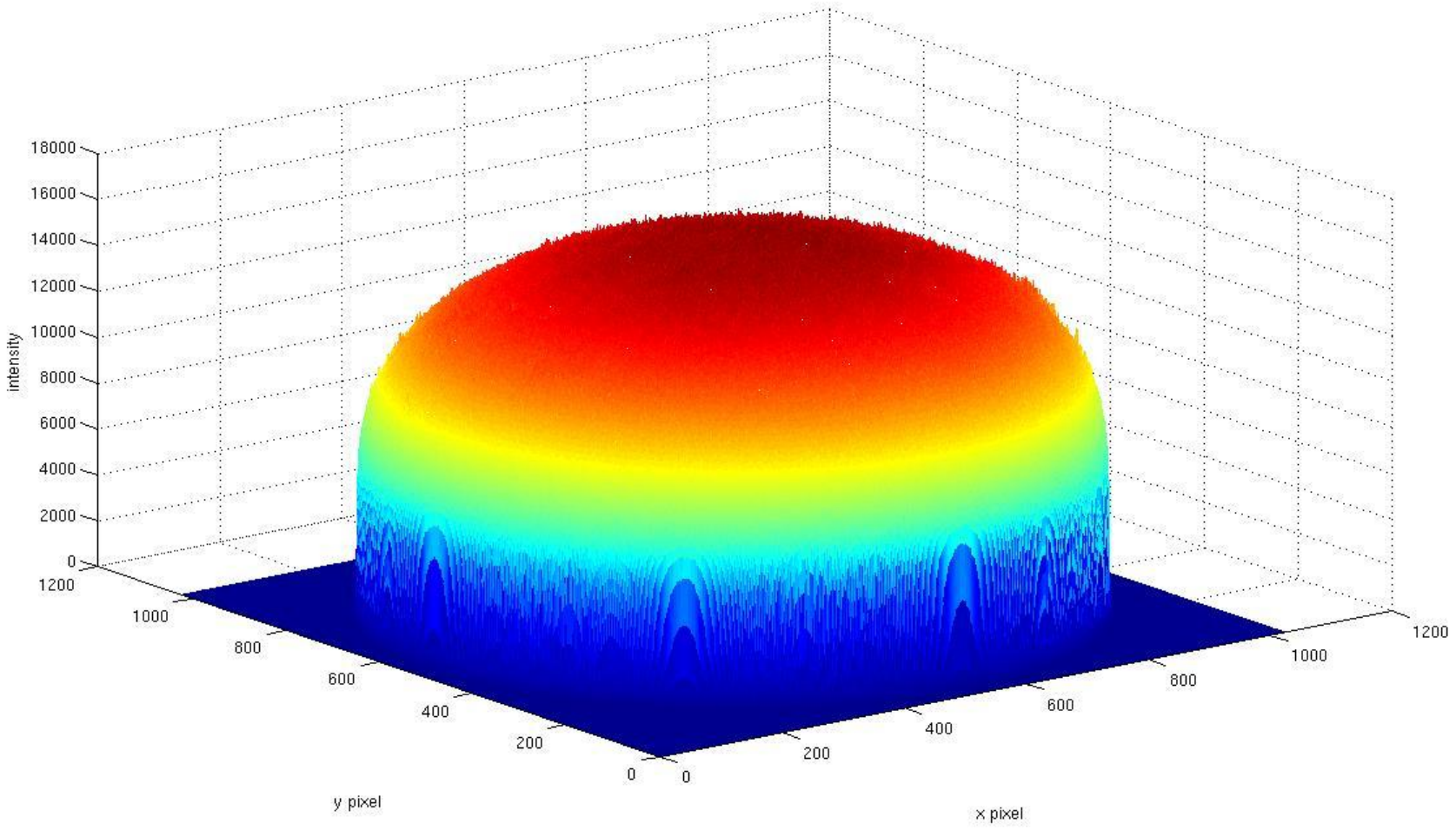
Detecting sunspots - STARA



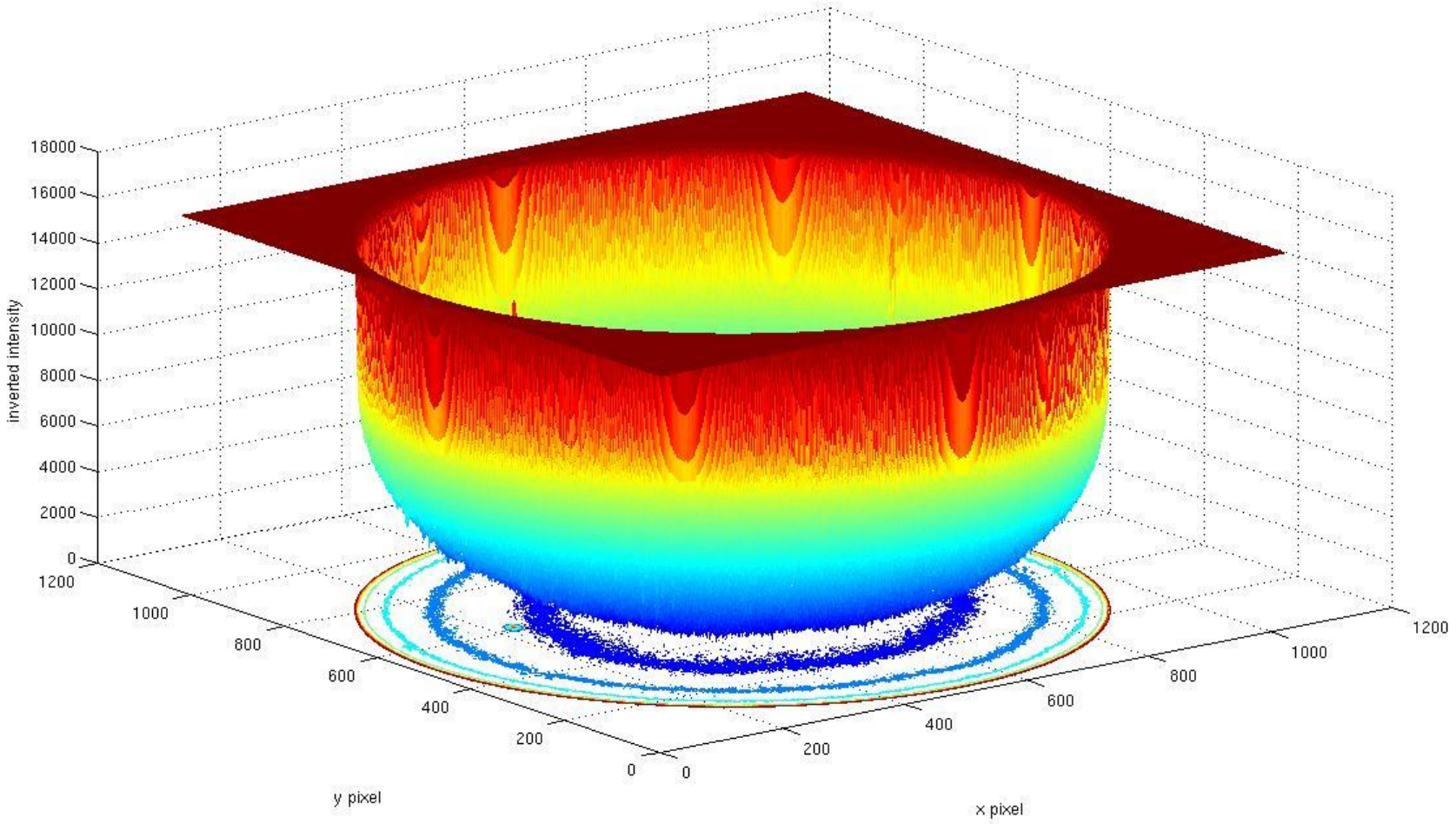




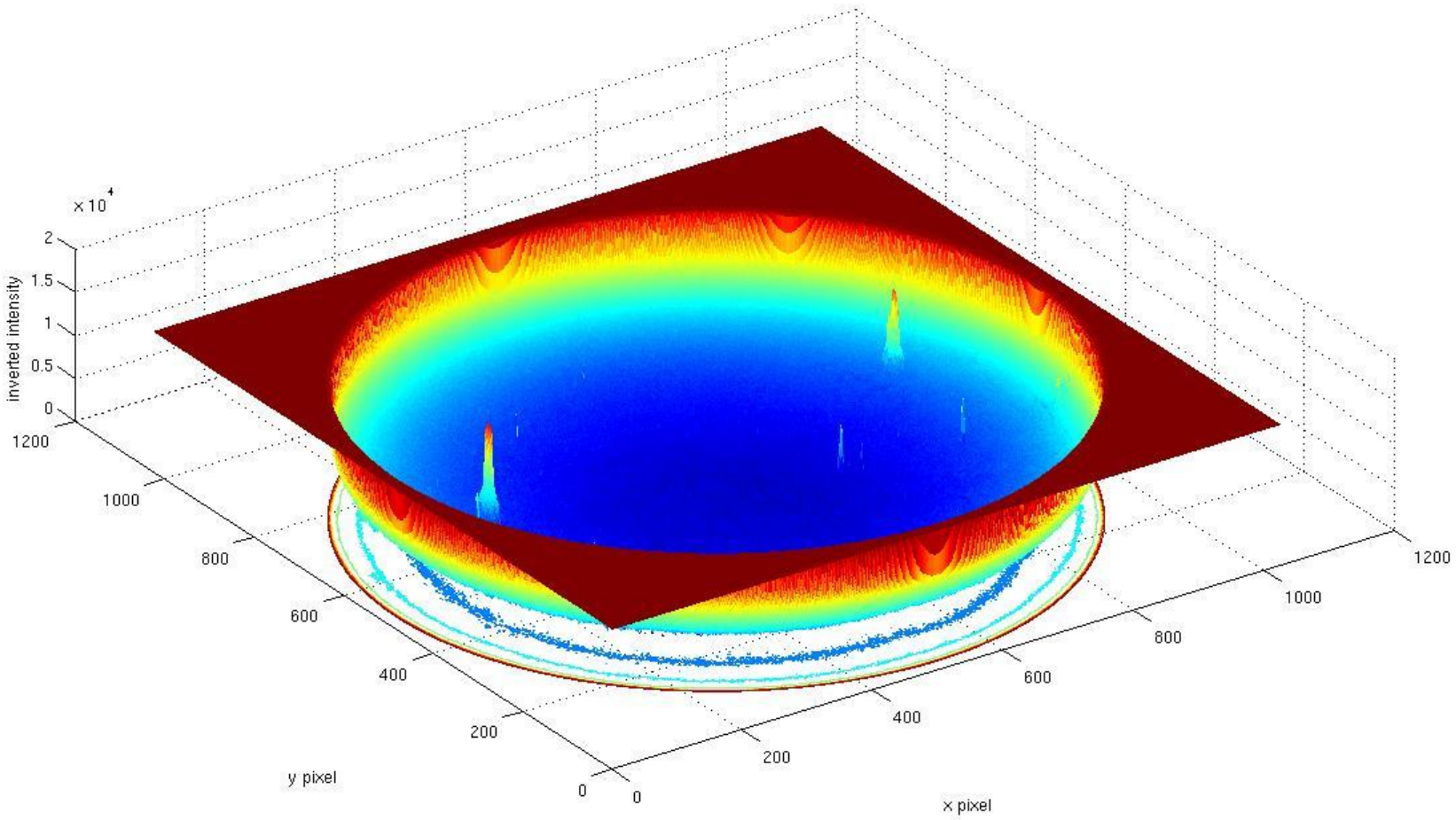
Detecting sunspots - STARA



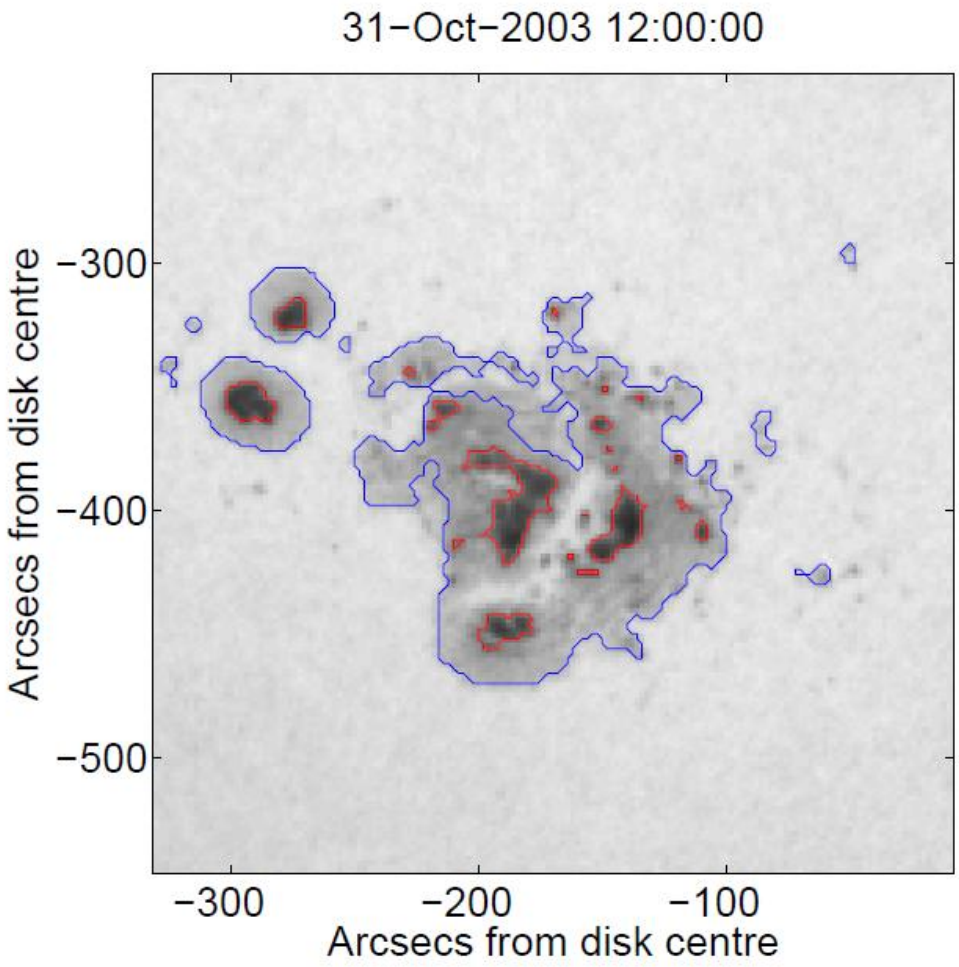
Detecting sunspots - STARA



Detecting sunspots - STARA



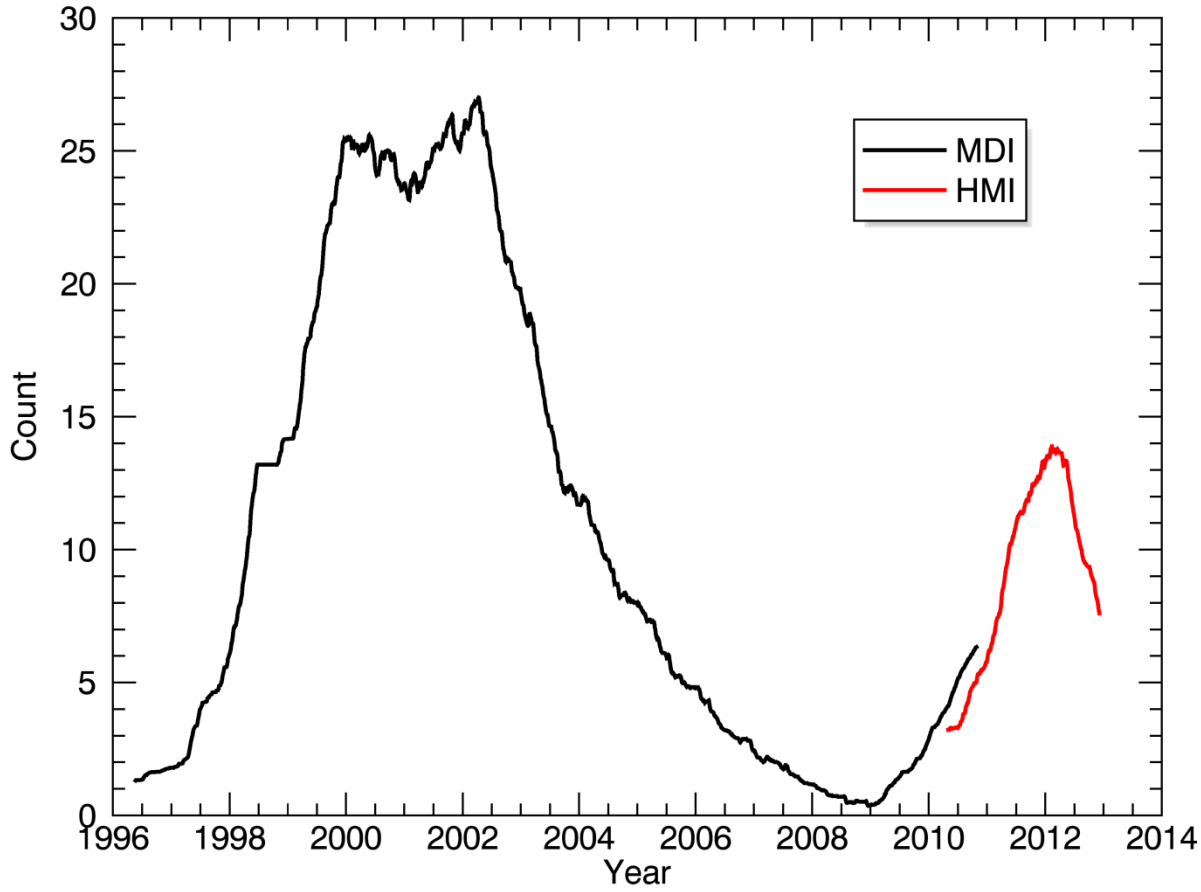
Detecting sunspots - STARA



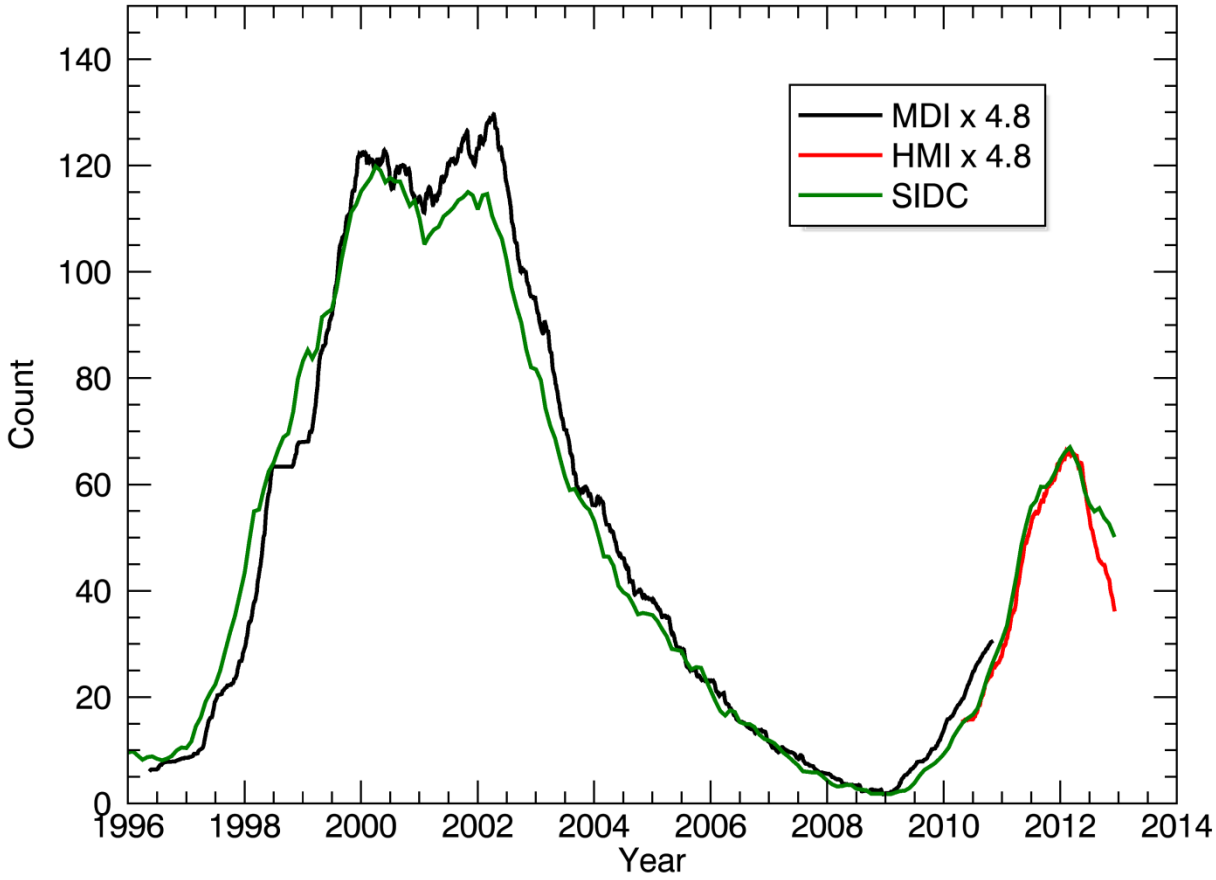
Analysis

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

Sunspot count



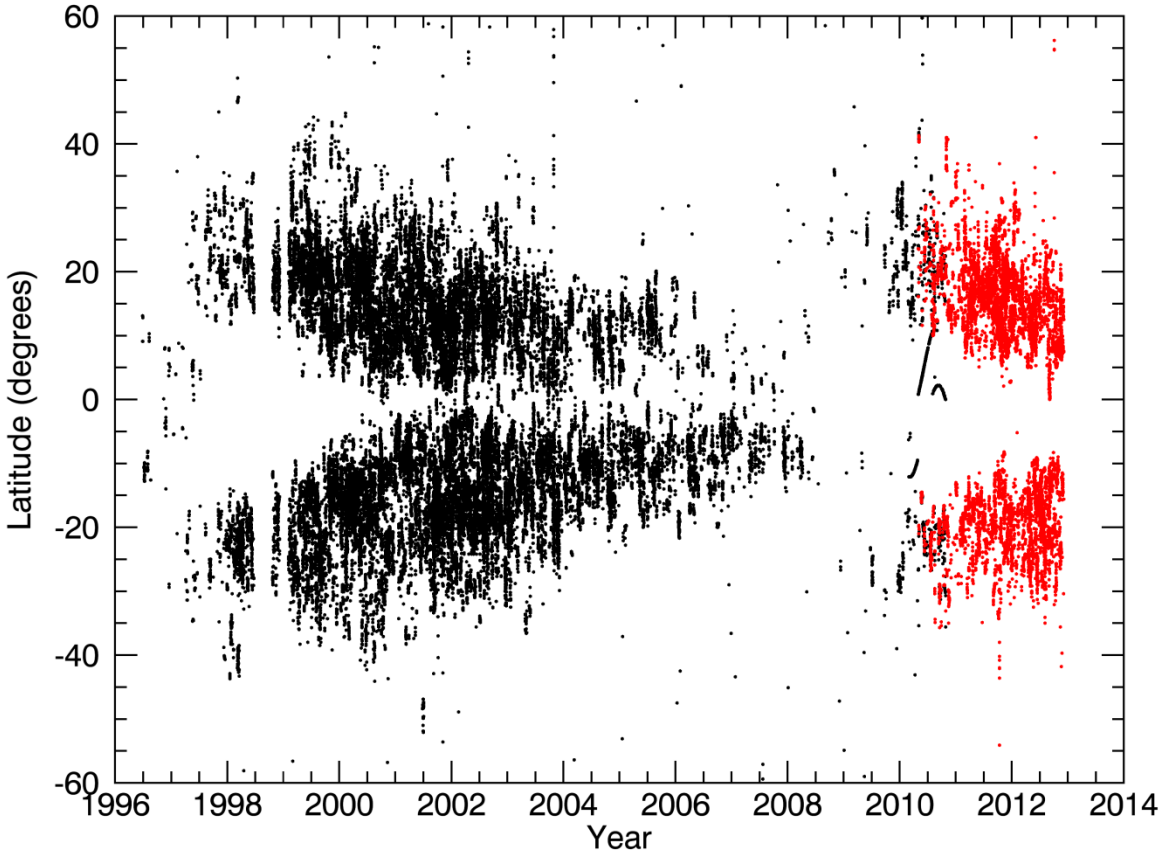
Sunspot count



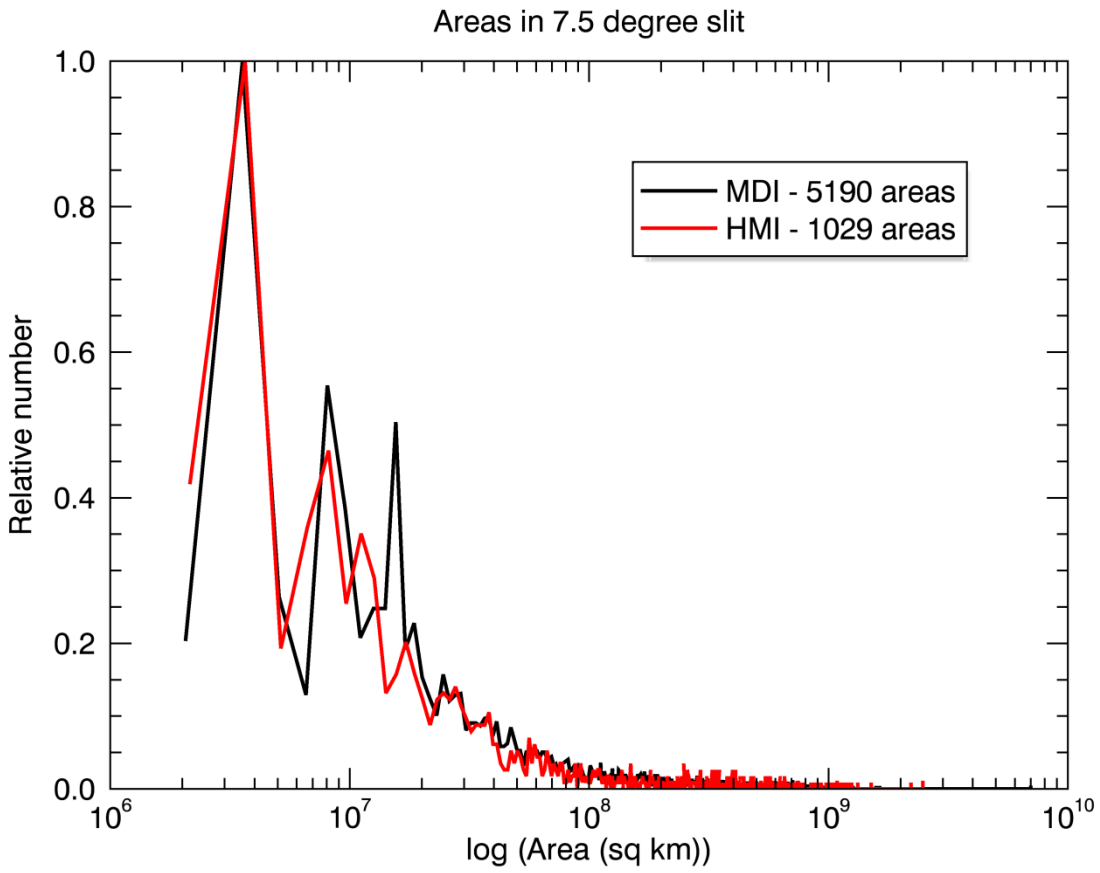
Step three - analysis

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

Locations


60
40
20
0
-20
-40
-60
Latitude (degrees)
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

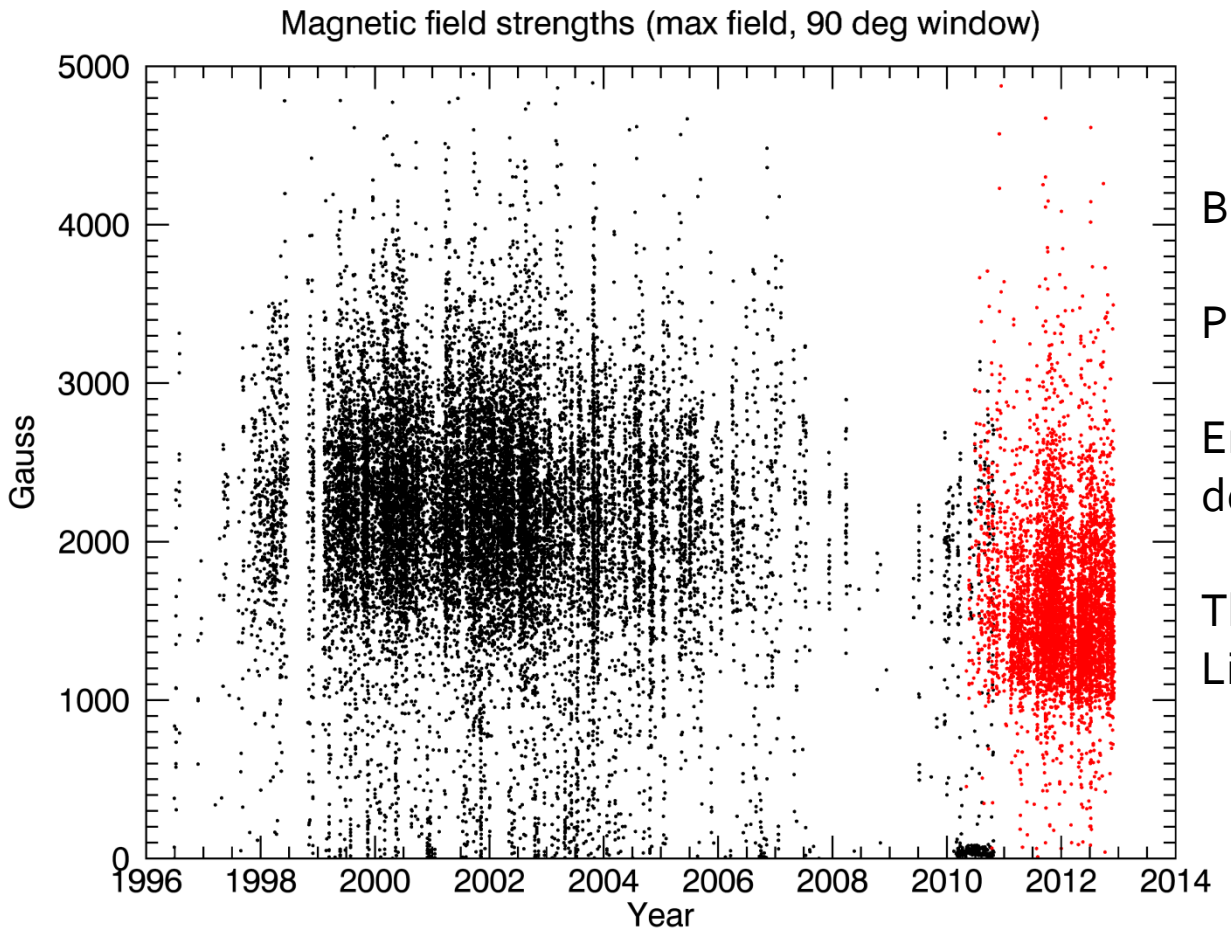
Areas


Areas in 7.5 degree slit
MDI - 5190 areas
HMI - 1029 areas
Relative number
log (Area (sq km))
1.0
0.8
0.6
0.4
0.2
0.0
10^6
10^7
10^8
10^9
10^10

Step three - analysis

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

Umbral magnetic field strengths



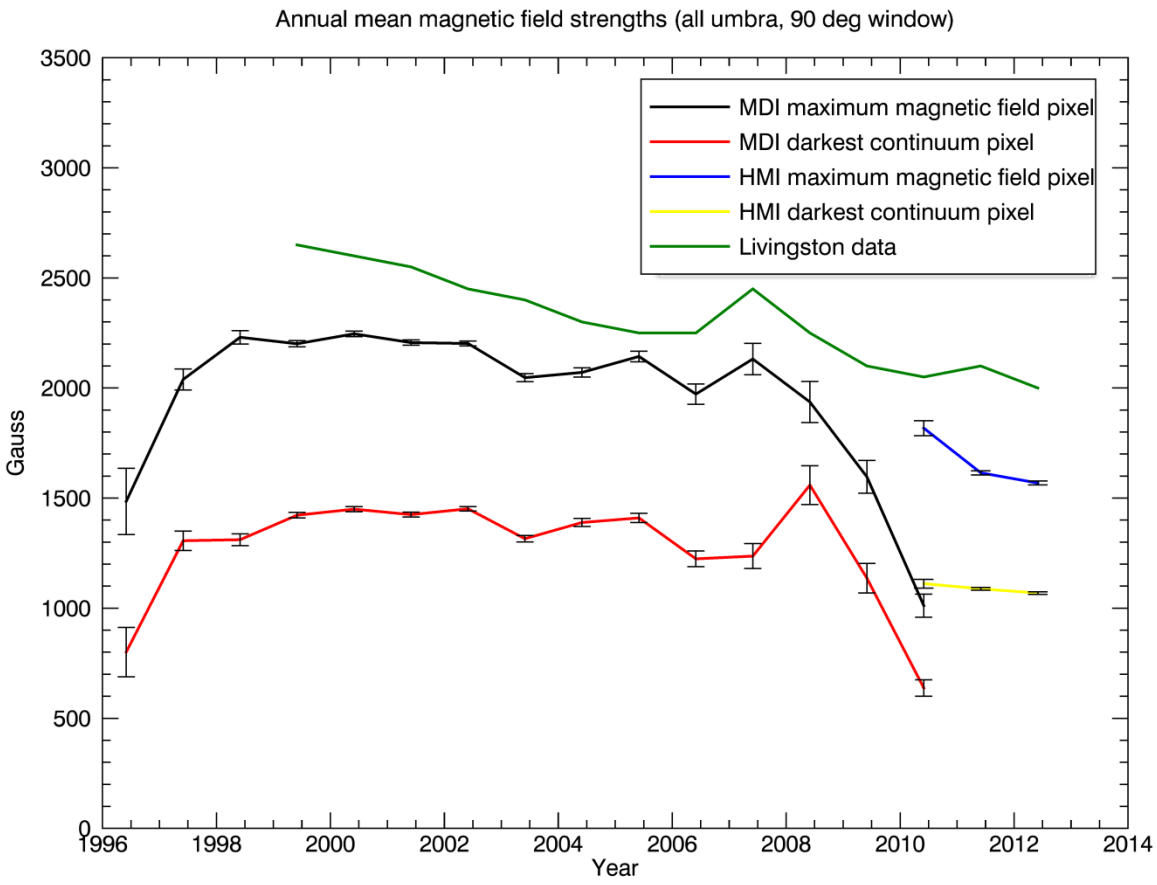
Bin the data by year.

Plot the mean of each bin.

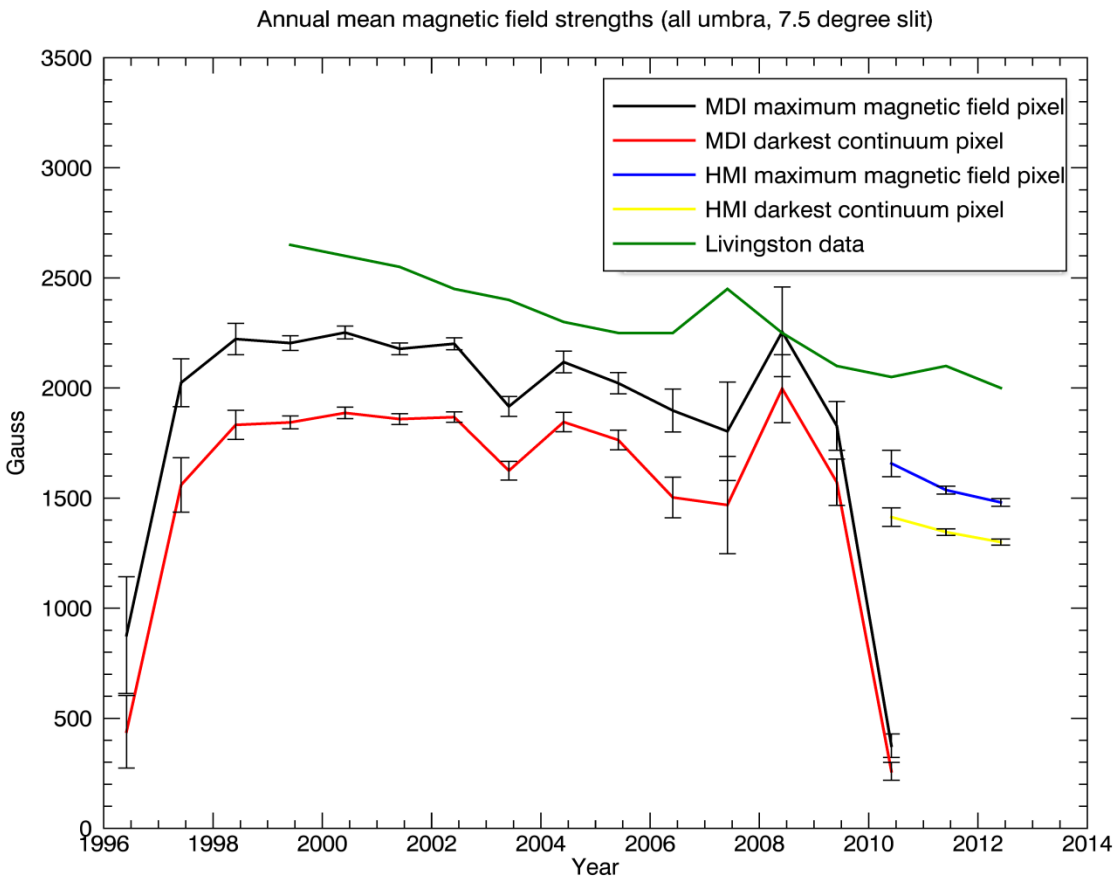
Error given by the standard deviation on the mean.

This is the method used by Livingston and Penn.

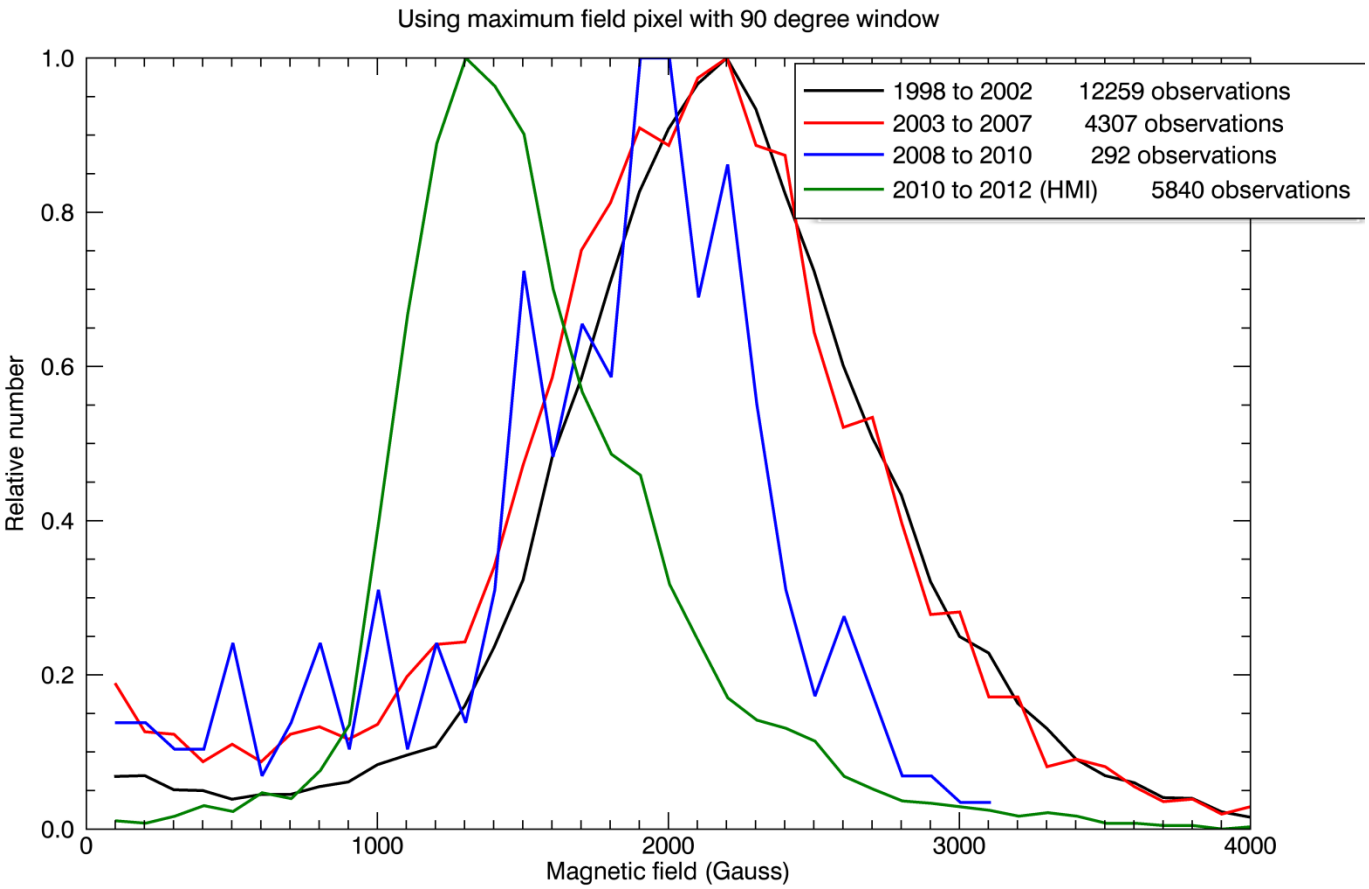
Umbral magnetic field strengths



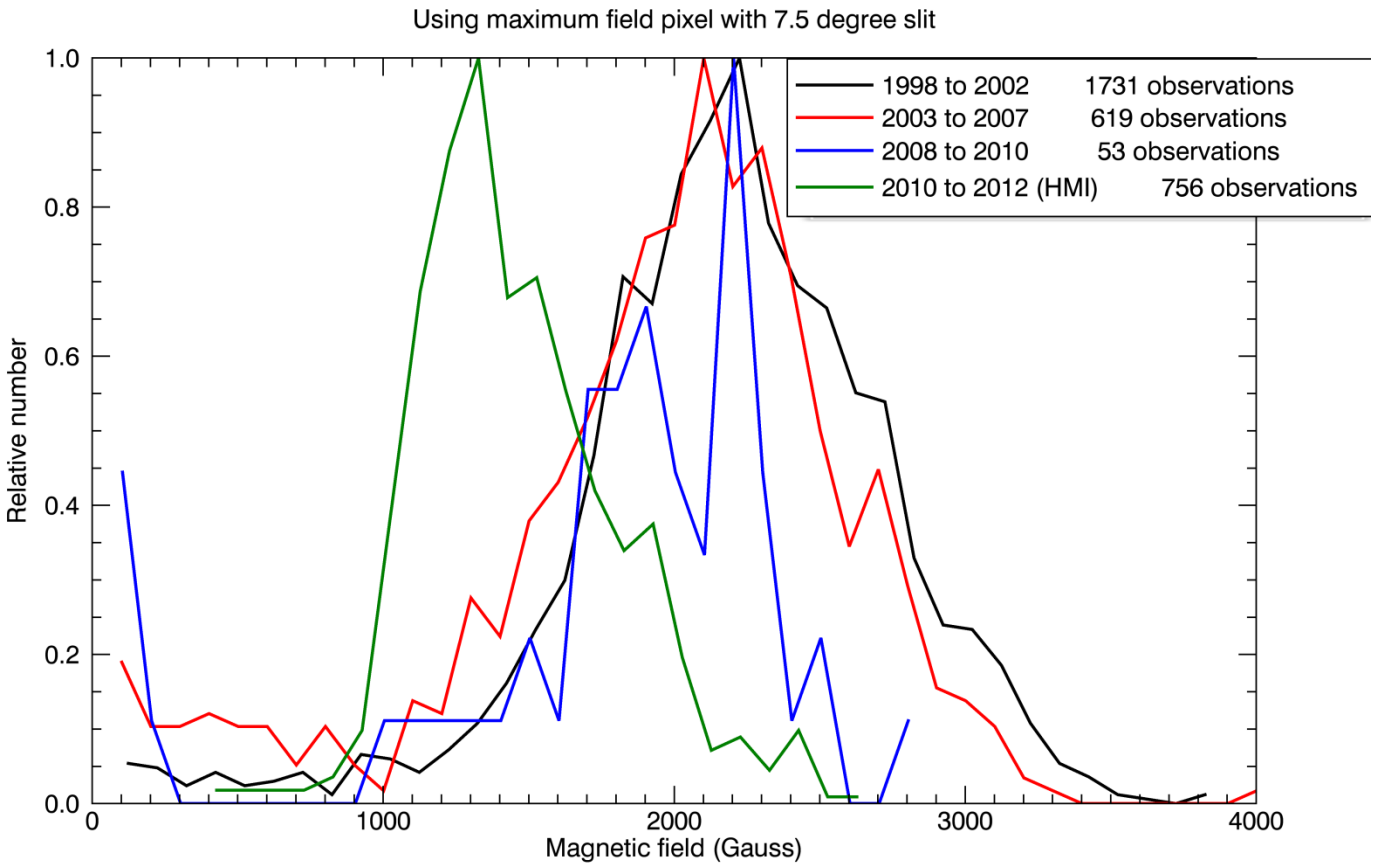
Umbral magnetic field strengths



Umbral magnetic field strengths



Umbral magnetic field strengths



Catalogue information

- Location (including hemispheric)
- Area (both projected and fractional, umbra and penumbra separated)
- Magnetic fields (mean, max, min)
- Sunspot count

- Easily trained with new datasets :
  Kodaikanal – Ravindra et. al. 2012
  Kanzelhohe daily observations

All suggestions are welcome.

www.nso.edu/staff/fwatson/STARA

Catalogue information

Why

www.nso.edu/staff/fwatson/STARA

Catalogue information

Why not

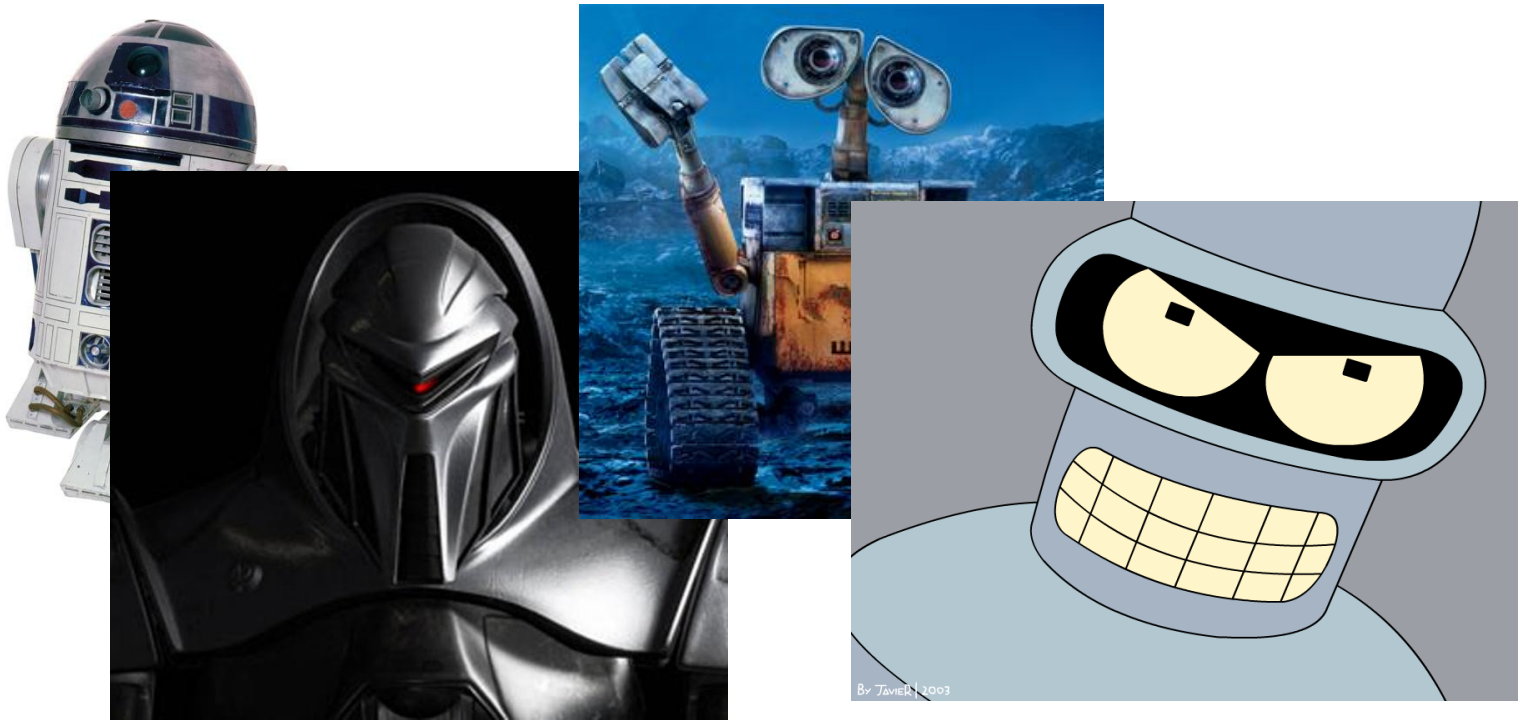
www.nso.edu/staff/fwatson/STARA

Catalogue information

Why not let

www.nso.edu/staff/fwatson/STARA

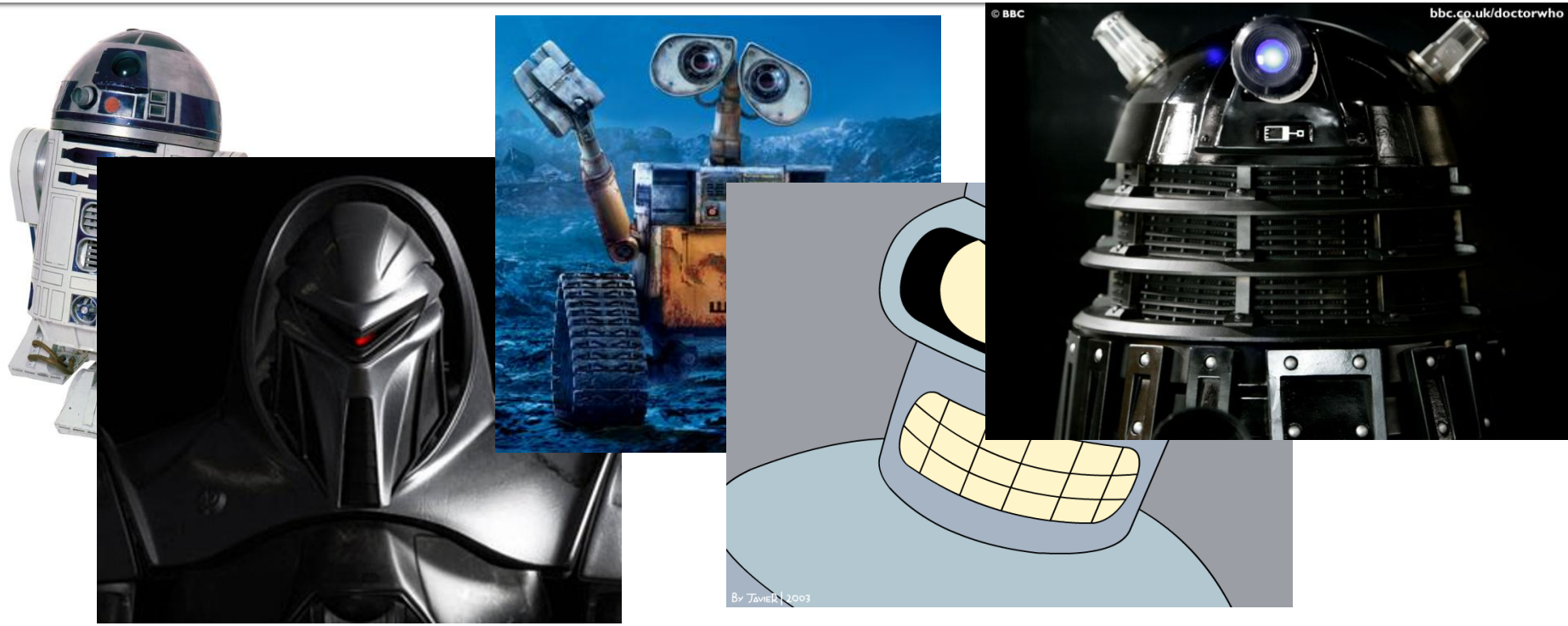
Catalogue information



Why not let machines

www.nso.edu/staff/fwatson/STARA

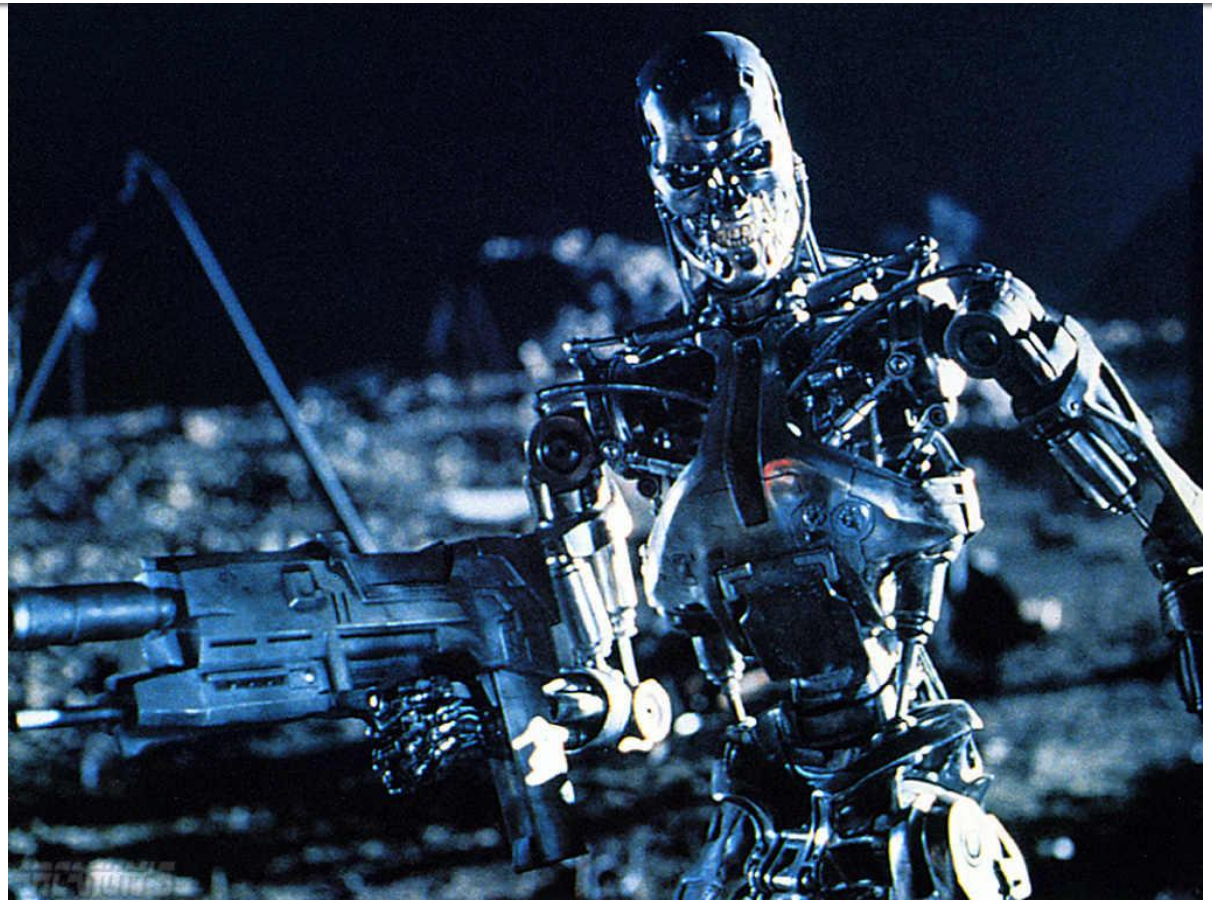
Catalogue information



Why not let machines try?

www.nso.edu/staff/fwatson/STARA

Catalogue information



www.nso.edu/staff/fwatson/STARA

References

- Watson, Fletcher and Marshall, Astronomy & Astrophysics, Volume 533, id.A14, 7 pp, 2011
- Watson, Fletcher, Dalla and Marshall, Solar Physics, Volume 260, Issue 1, pp.5-19, 2009