ROYAL OBSERVATORY OF BELGIUM

LIÈGE université

PhD Project :

Long-term evolution of large-scale magnetic structures on USET images

PhD student : Grégory VANDEN BROECK

ROB Supervisors

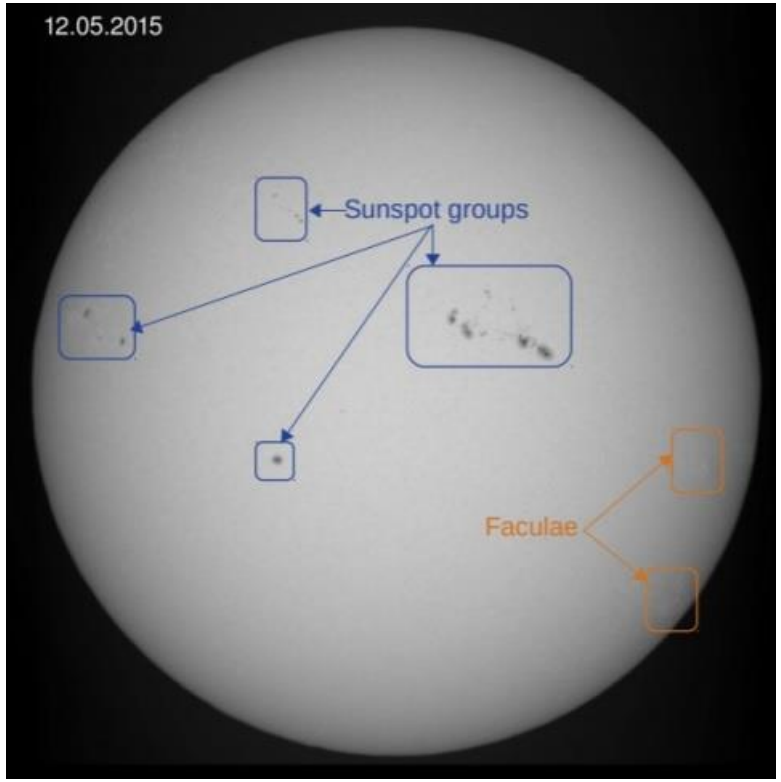
Frédéric CLETTE
Sabrina BECHET

ULiège Supervisor

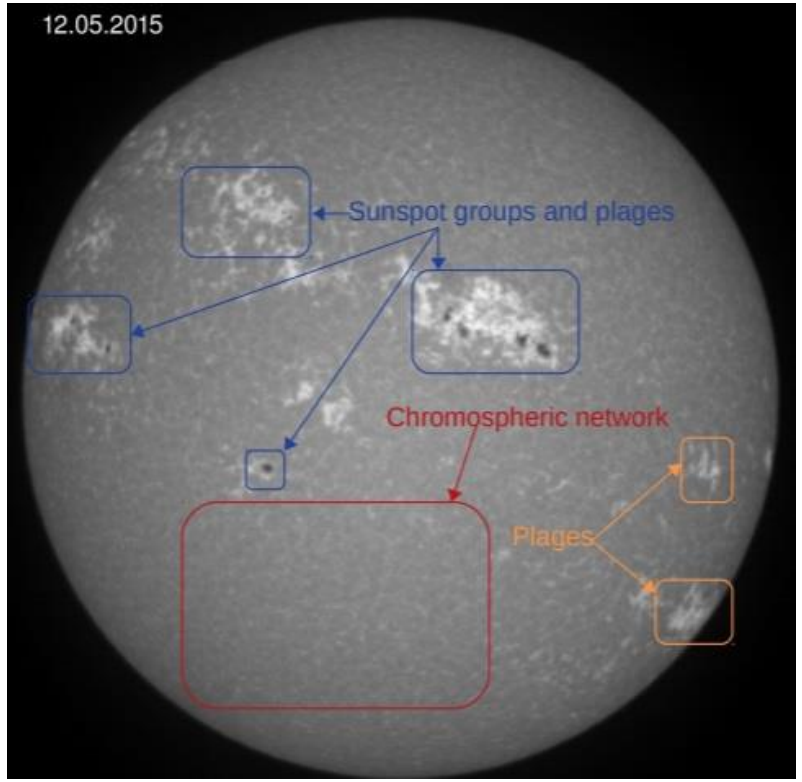
Gregor RAUW

1. Summary

PHOTOSPHERE



CHROMOSPHERE



http://sidc.oma.be/uset/searchForm.php

- Insight in sub-photospheric processes
- Understanding of global solar irradiance evolution
- Deciphering similar mechanisms in other magnetically active stars

2. Objectives

USET

« Uccle Solar Equatorial Table »

http://www.sidc.be/uset/usetpres.php

2. Objectives

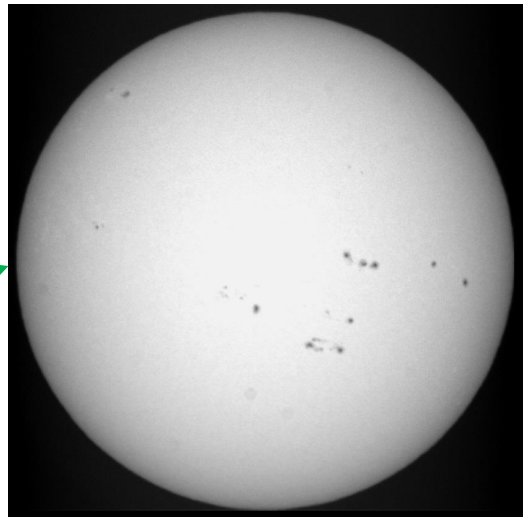
USET

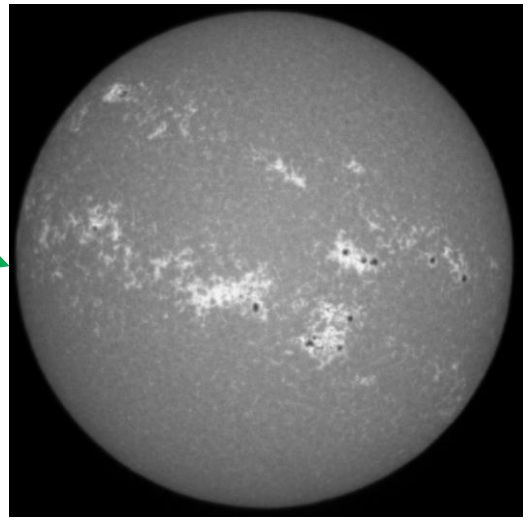
« Uccle Solar Equatorial Table »

http://www.sidc.be/uset/usetpres.php

Photosphere

Chromosphere



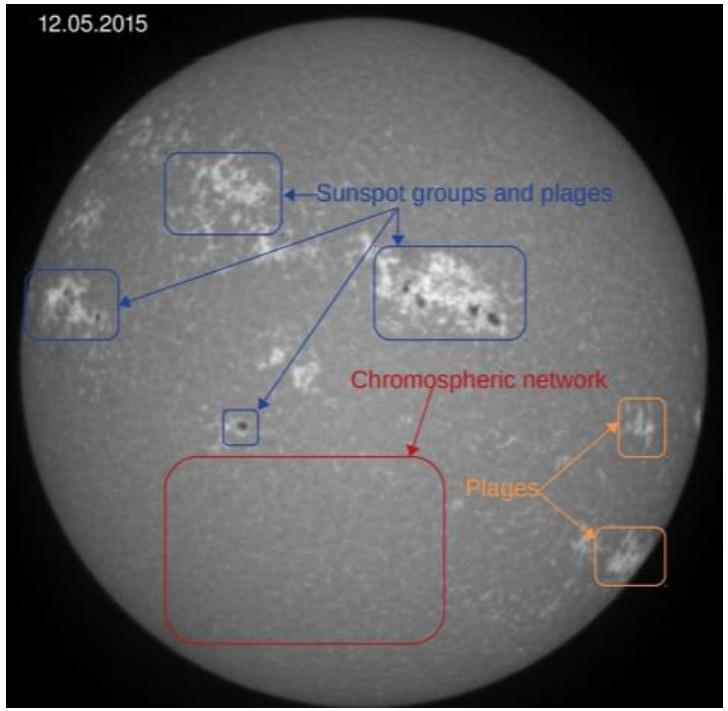


http://sidc.oma.be/uset/searchForm.php

2. Objectives

1) Chromosphere

http://sidc.oma.be/uset/searchForm.php



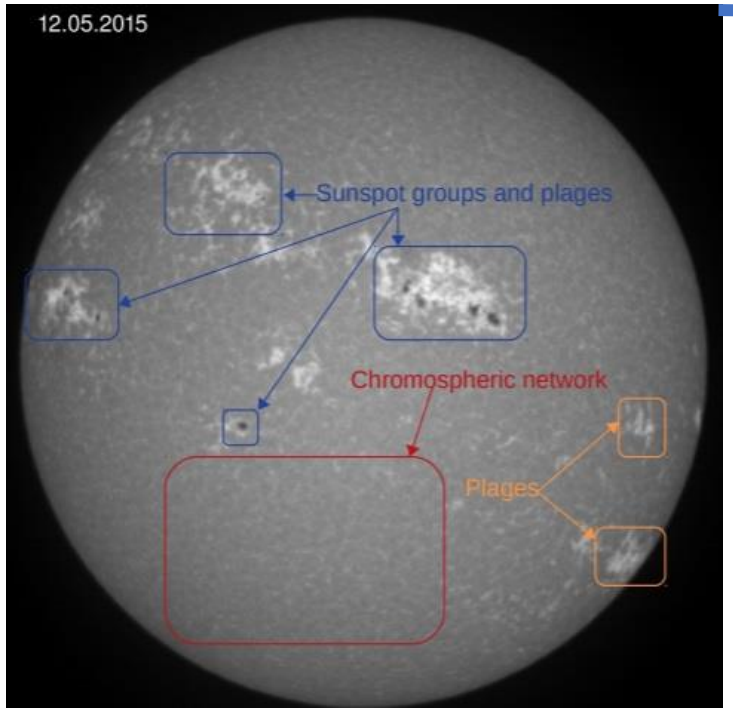
→ Long-term brightness variation

→ Contribution of the magnetic structures

2. Objectives

1) Chromosphere

http://sidc.oma.be/uset/searchForm.php



Global intensities

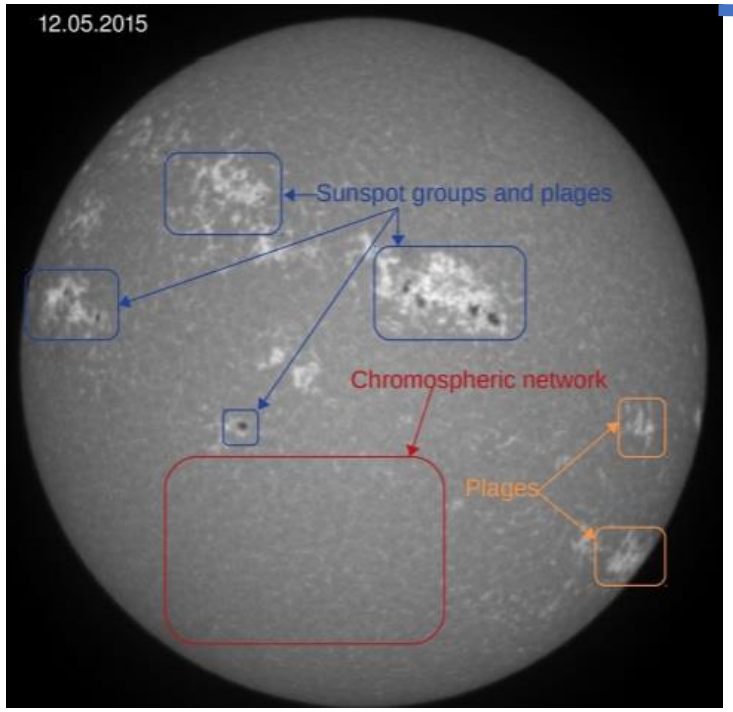
→ Long-term brightness variation

→ Contribution of the magnetic structures

2. Objectives

1) Chromosphere

http://sidc.oma.be/uset/searchForm.php

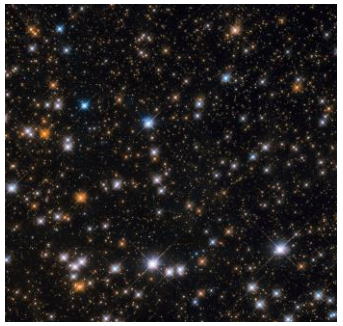


Global intensities

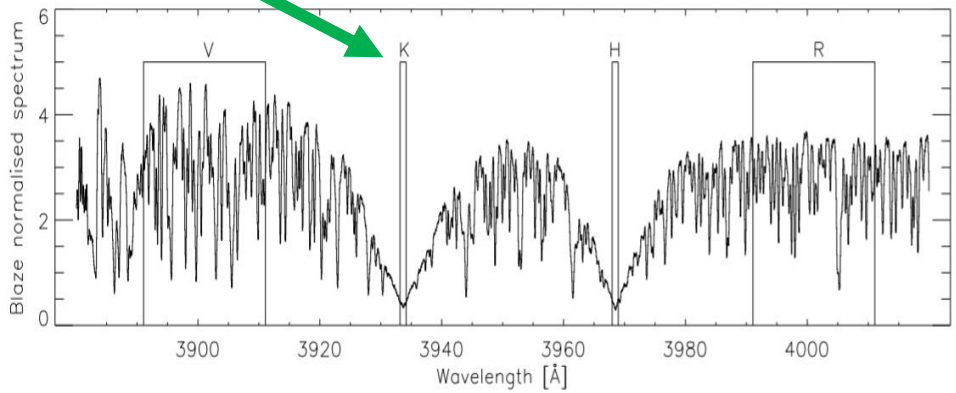
COMPARED TO

Spectral measurements

https://www.nasa.gov/image-feature/goddard/2019/hubble-spots-flock-of-cosmic-ducks



Ca II K



Mittag, et al. 2016, A&A, 591, A89

→ Long-term brightness variation

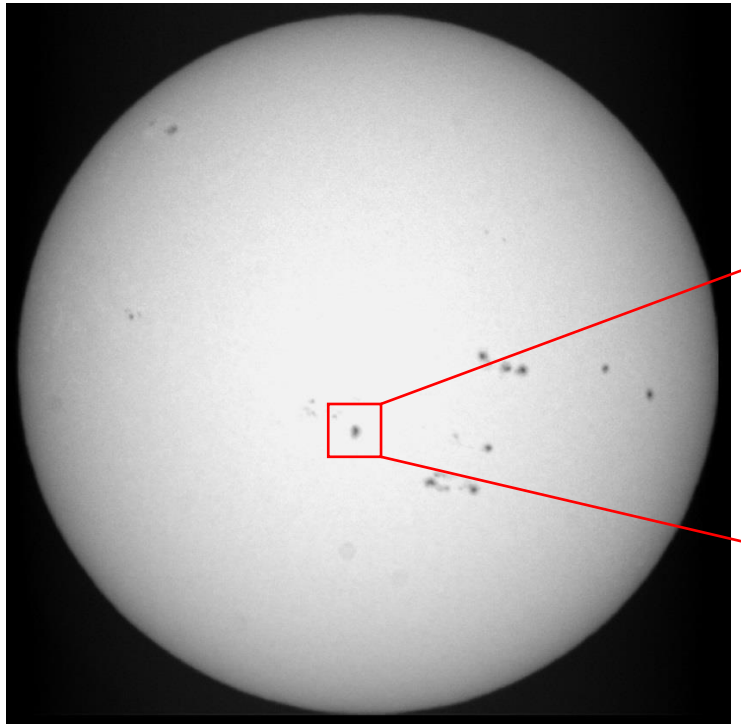
→ Contribution of the magnetic structures

→ « Sun seen as a star »

2. Objectives

2) Photosphere

Sunspot proper motion



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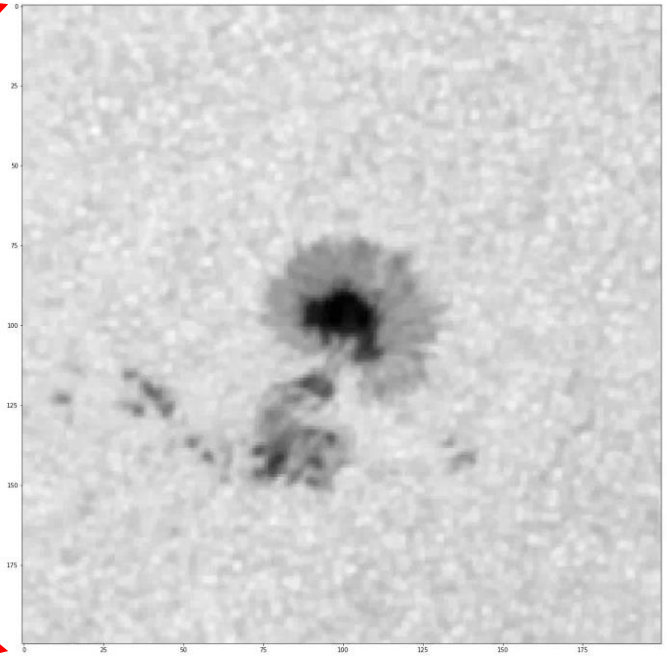
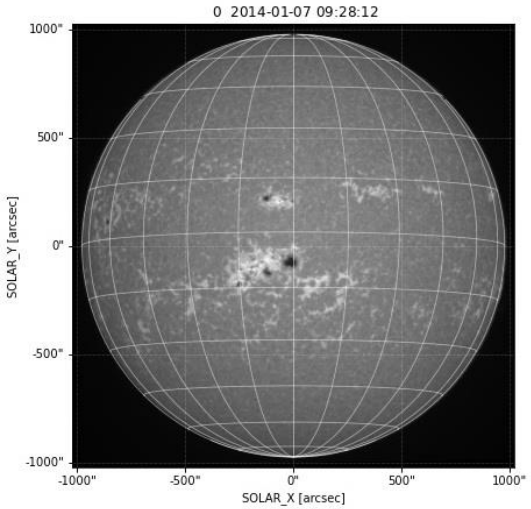


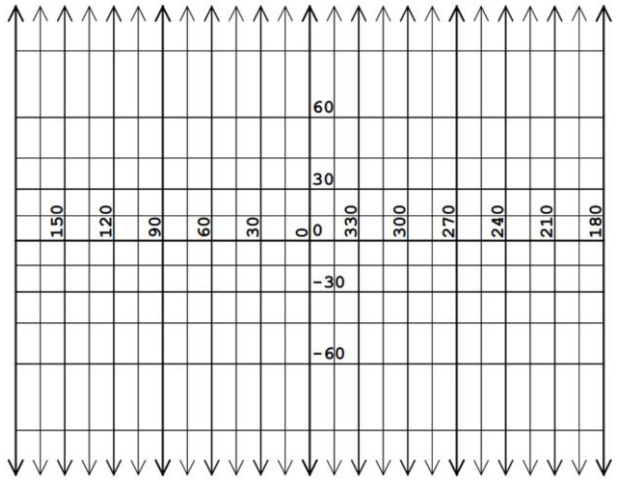
Suivi d'un groupe pendant deux jours (28.03.2014 -> 29.03.2014).
Source images : HMI (satellite SDO)

3. Progress and results

1) Construction of synoptic maps – Solar projection

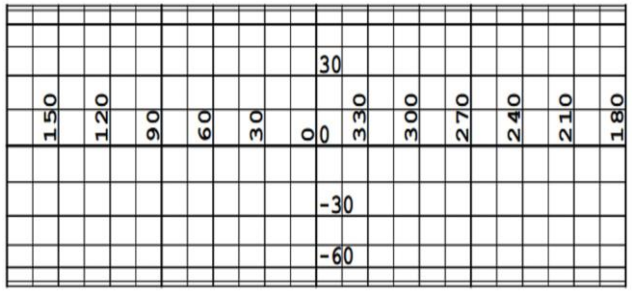


Mercator



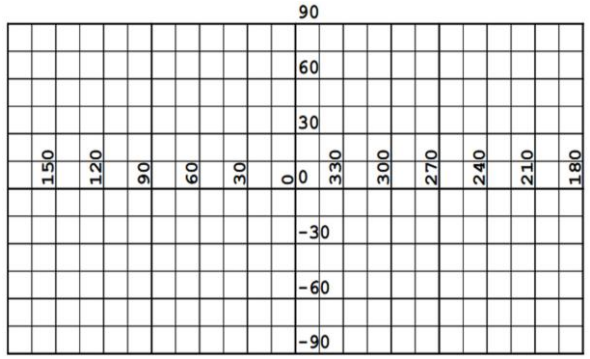
Calabretta, M. R. & Greisen, E. W. 2018, *A&A*, **395**, 1077

Cyclindrical equal area



Calabretta, M. R. & Greisen, E. W. 2018, *A&A*, **395**, 1077

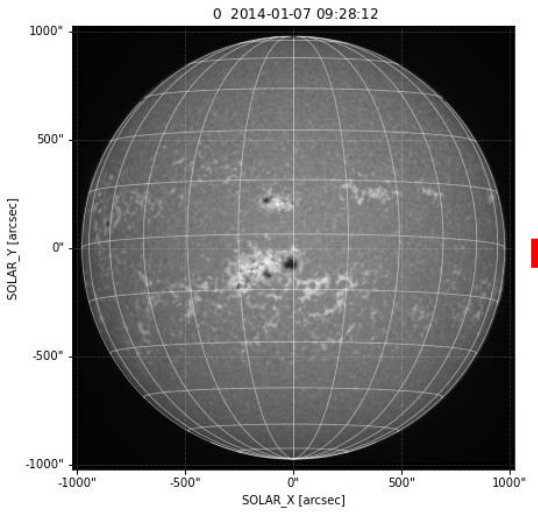
Plate carrée



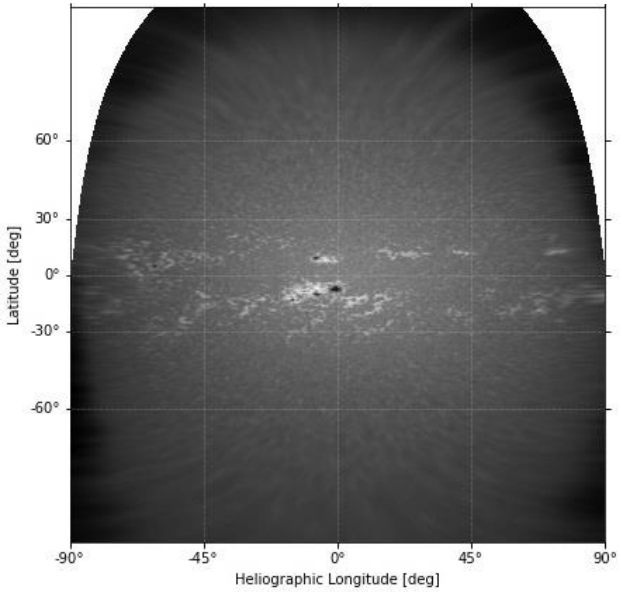
Calabretta, M. R. & Greisen, E. W. 2018, *A&A*, **395**, 1077

3. Progress and results

1) Construction of synoptic maps – Solar projection



Mercator



Cyclindrical equal area

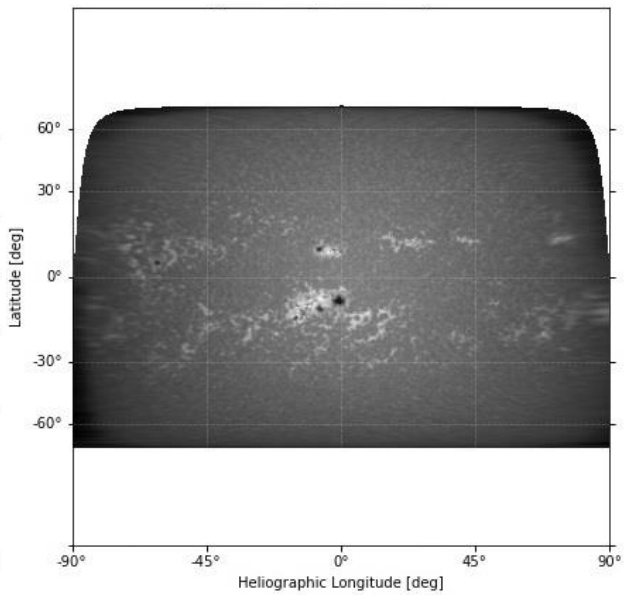
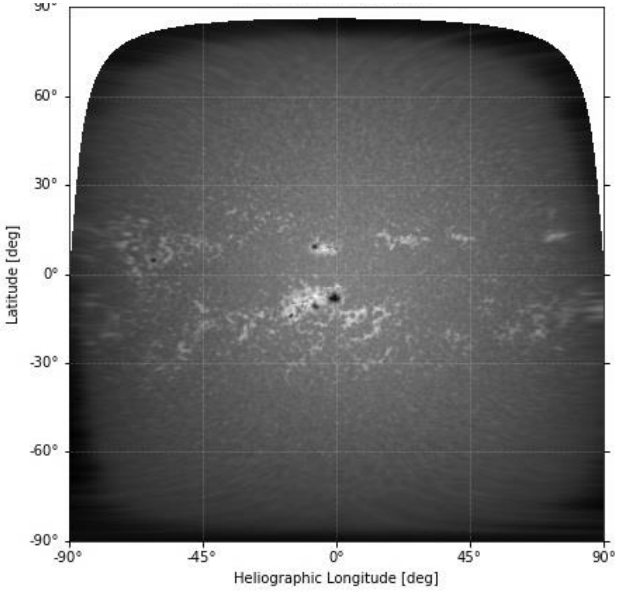


Plate carrée

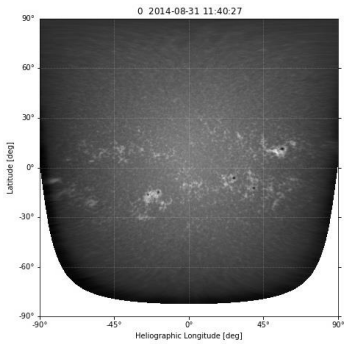


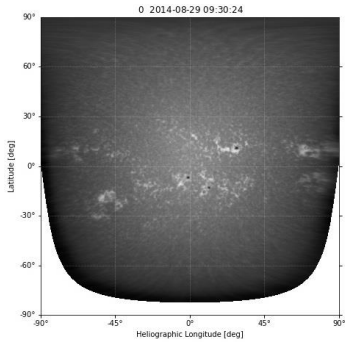
Plages flattened

Surface of plages better reproduced

3. Progress and results

1) Construction of synoptic maps – Image assembling





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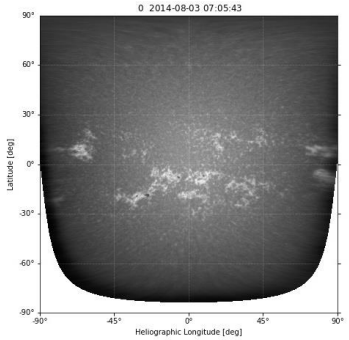
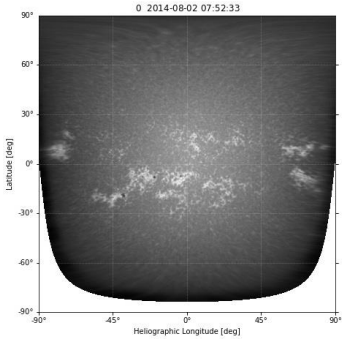
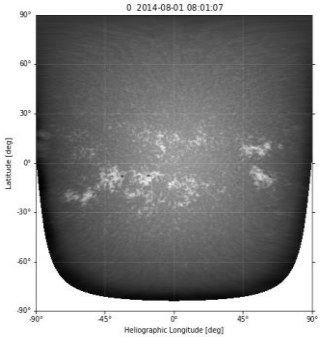
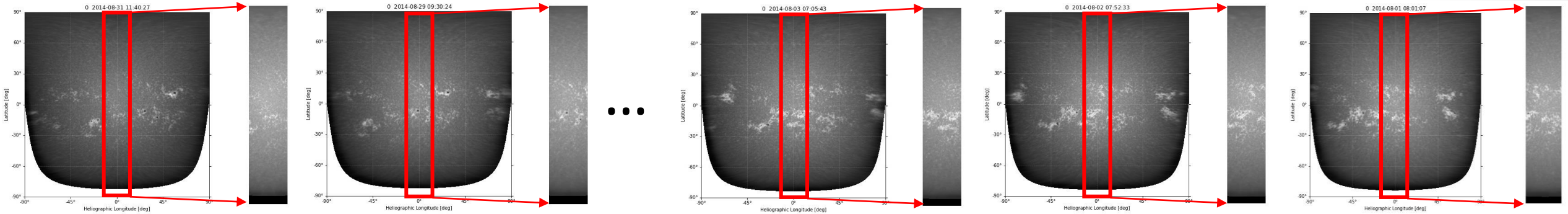






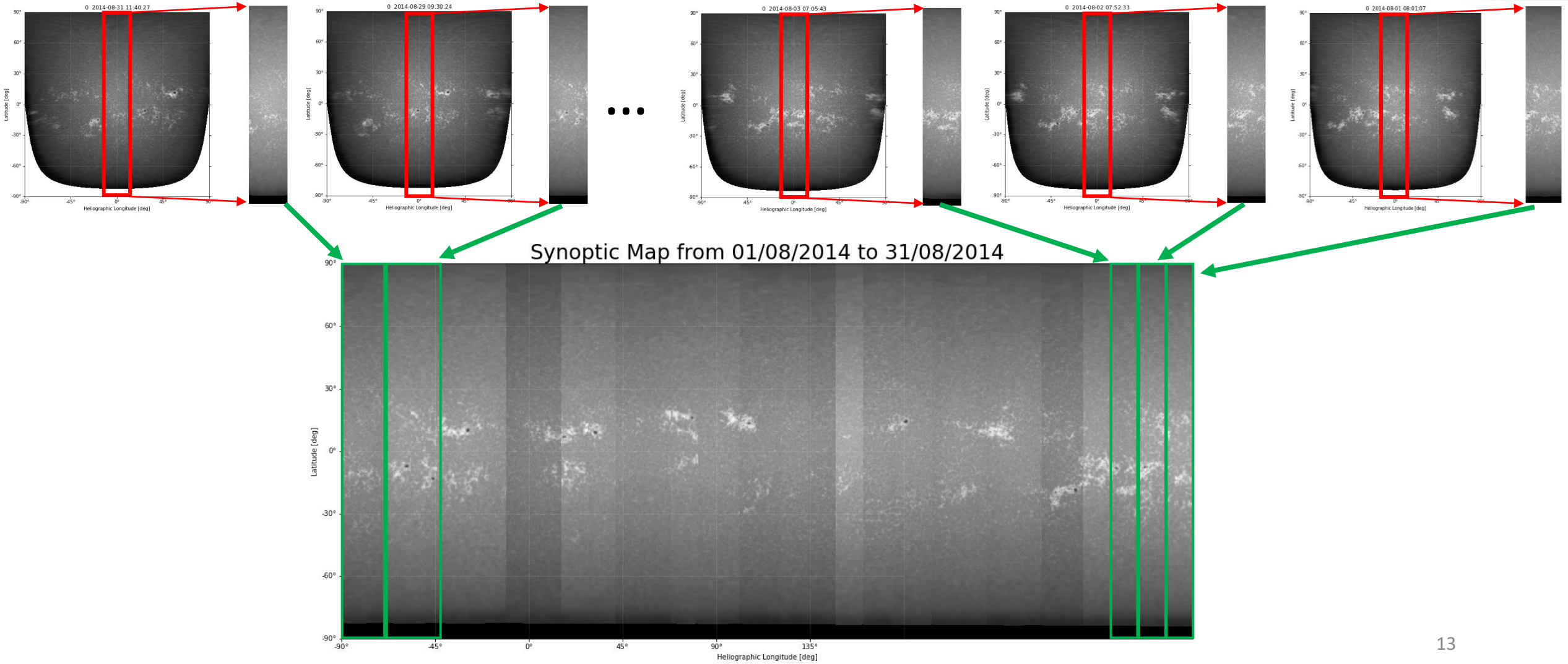
3. Progress and results

1) Construction of synoptic maps – Image assembling



3. Progress and results

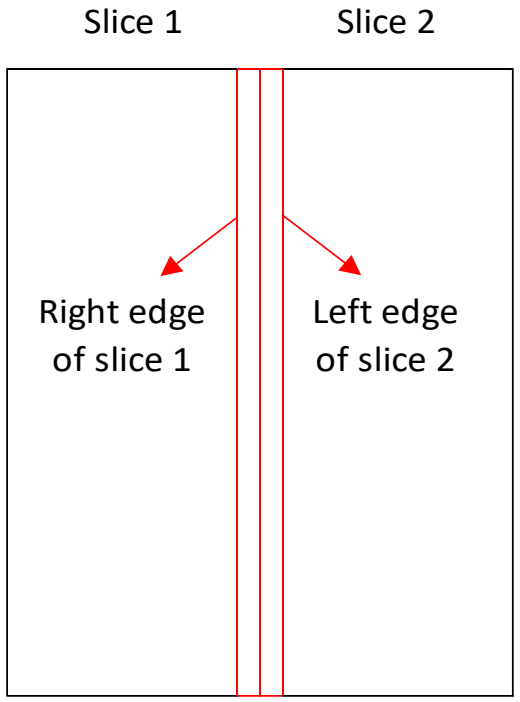
1) Construction of synoptic maps – Image assembling



3. Progress and results

1) Construction of synoptic maps - Normalization

Assumption

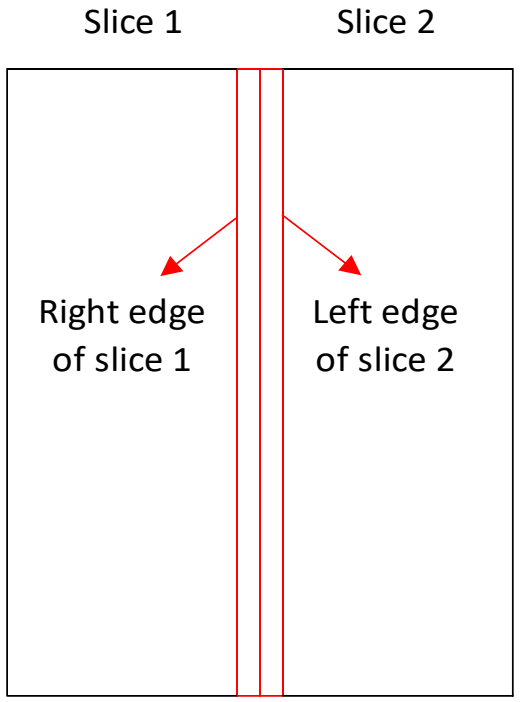


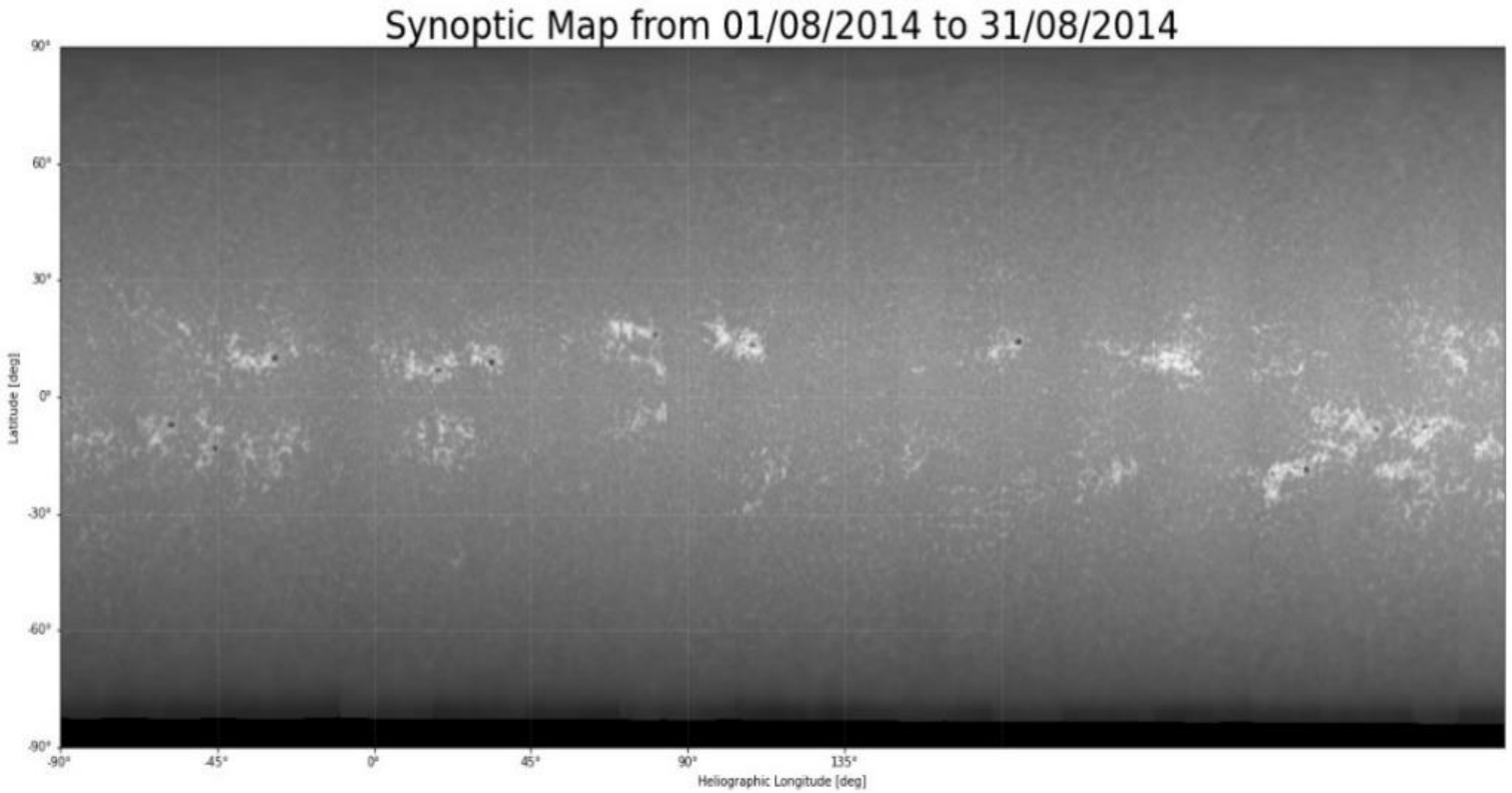
$$\frac{\text{Intensity of right edge of slice 1}}{\text{Intensity of left edge of slice 2}} = \text{Factor of normalization}$$

3. Progress and results

1) Construction of synoptic maps - Normalization

Assumption





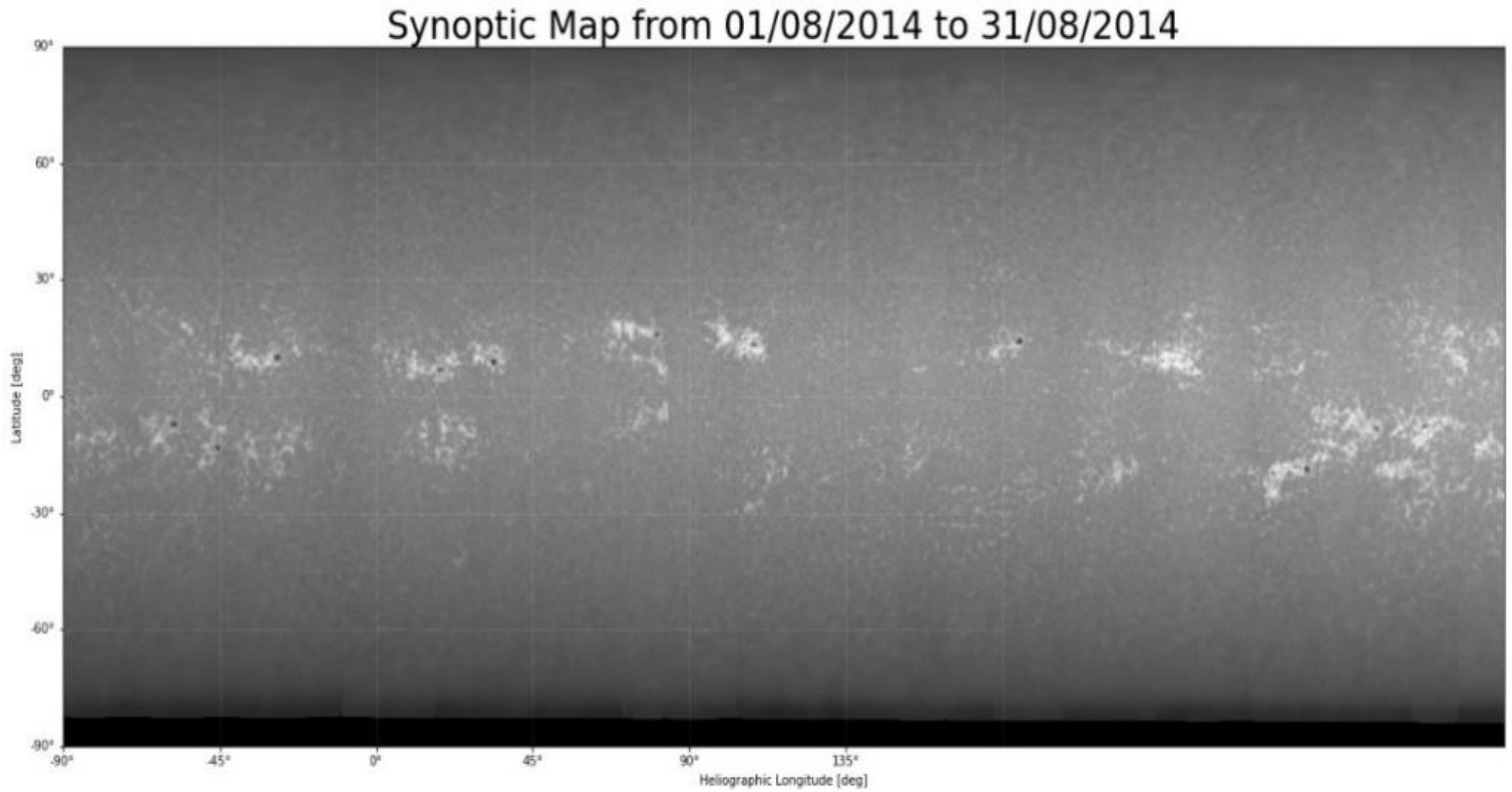
$$\frac{\text{Intensity of right edge of slice 1}}{\text{Intensity of left edge of slice 2}} = \text{Factor of normalization}$$

3. Progress and results

1) Construction of synoptic maps - Normalization

Drawbacks

- **Differential rotation → Assumption not completely correct**
- Centre-to-limb variation in intensity
- More precise to use the whole image to normalize



3. Progress and results

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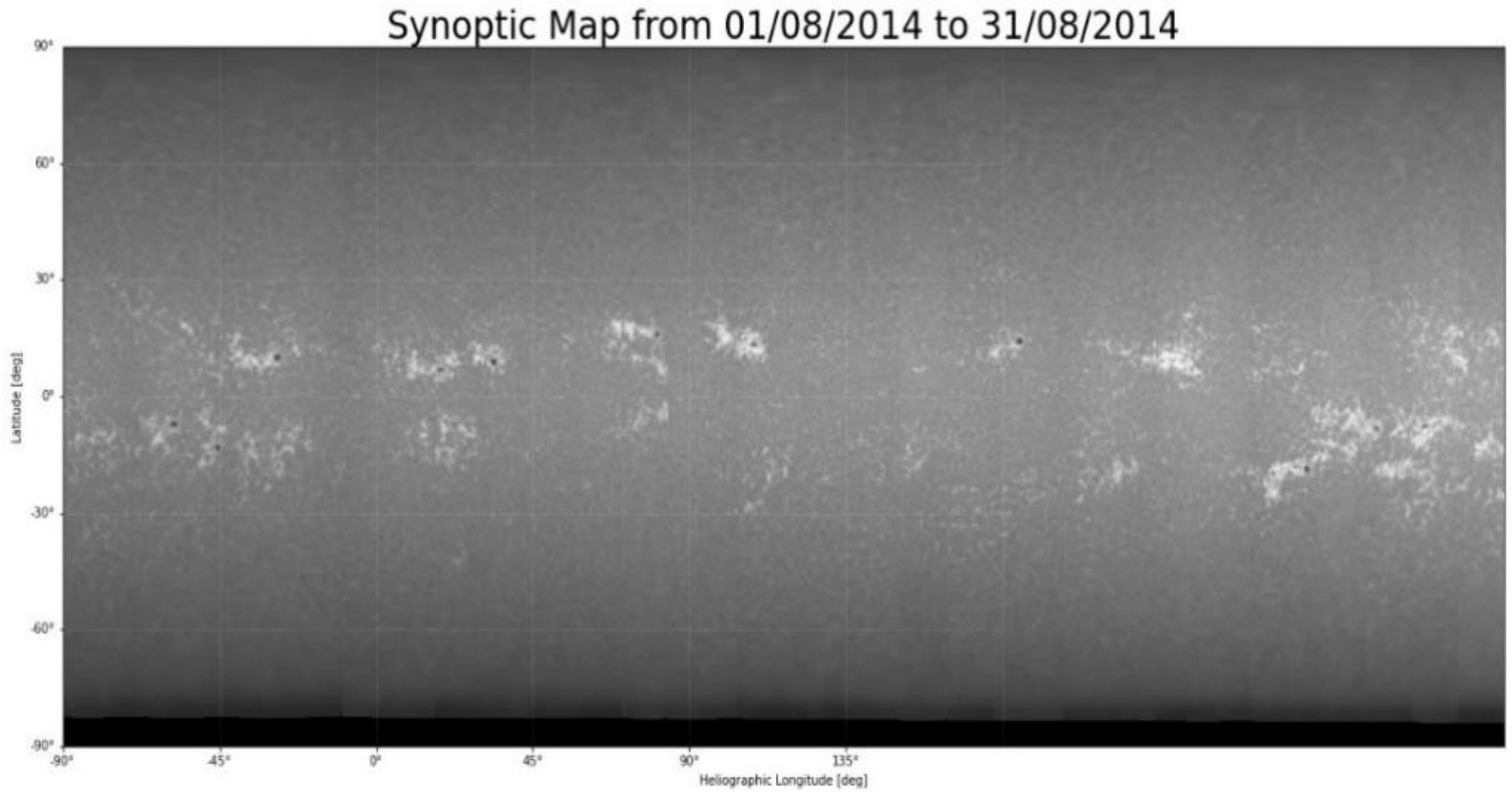

3. Progress and results

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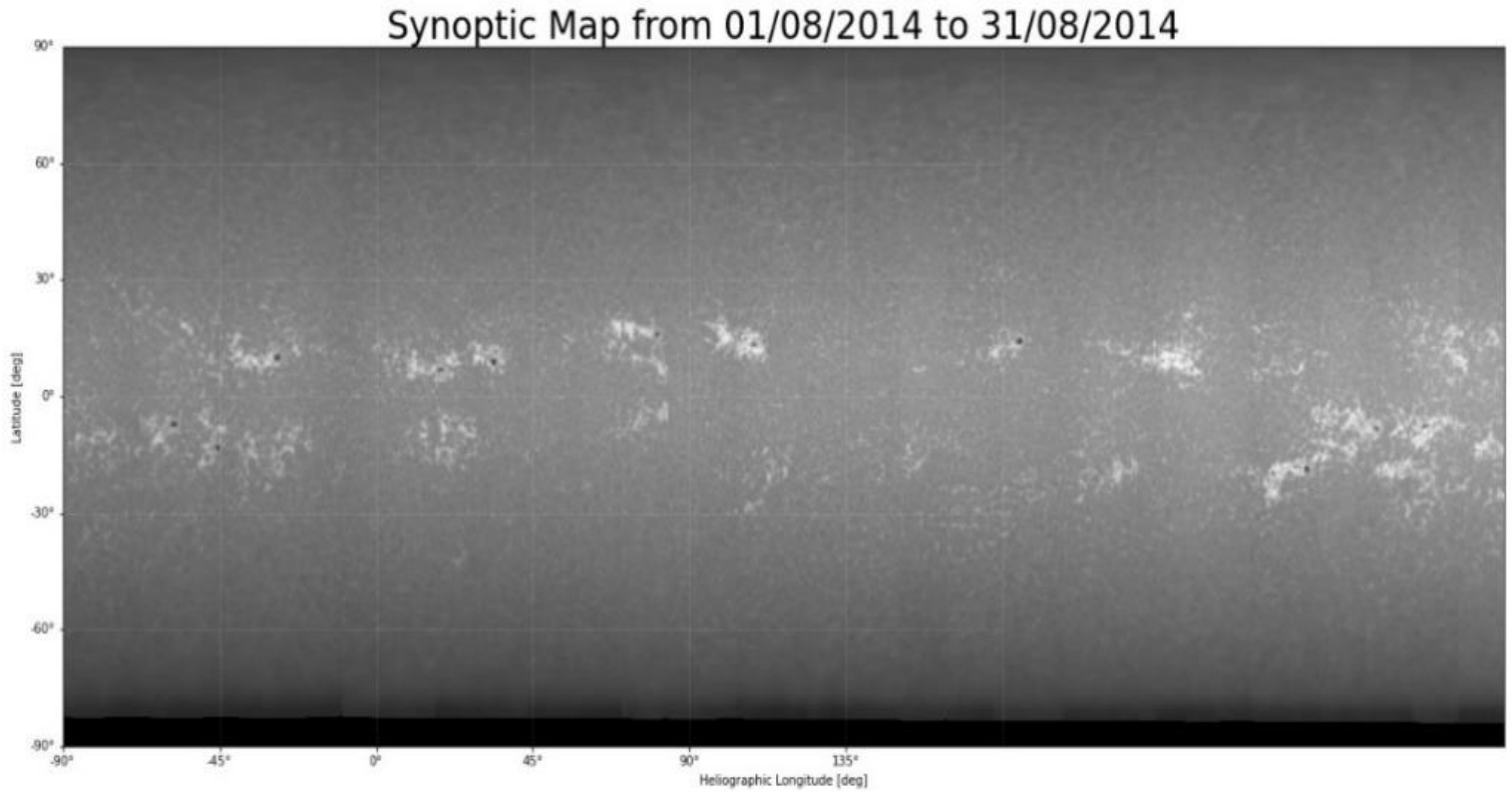

3. Progress and results

1) Construction of synoptic maps - Normalization

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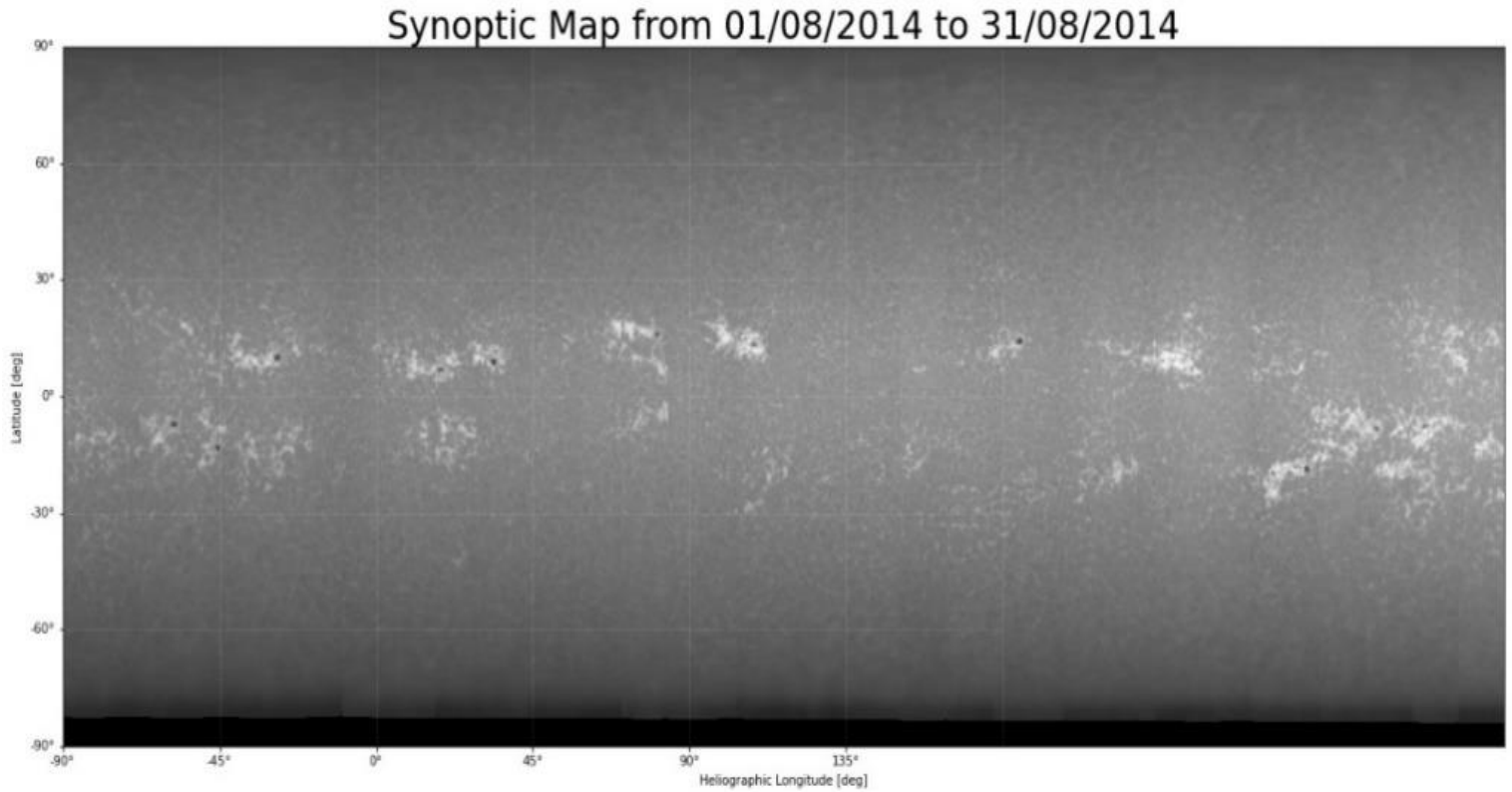
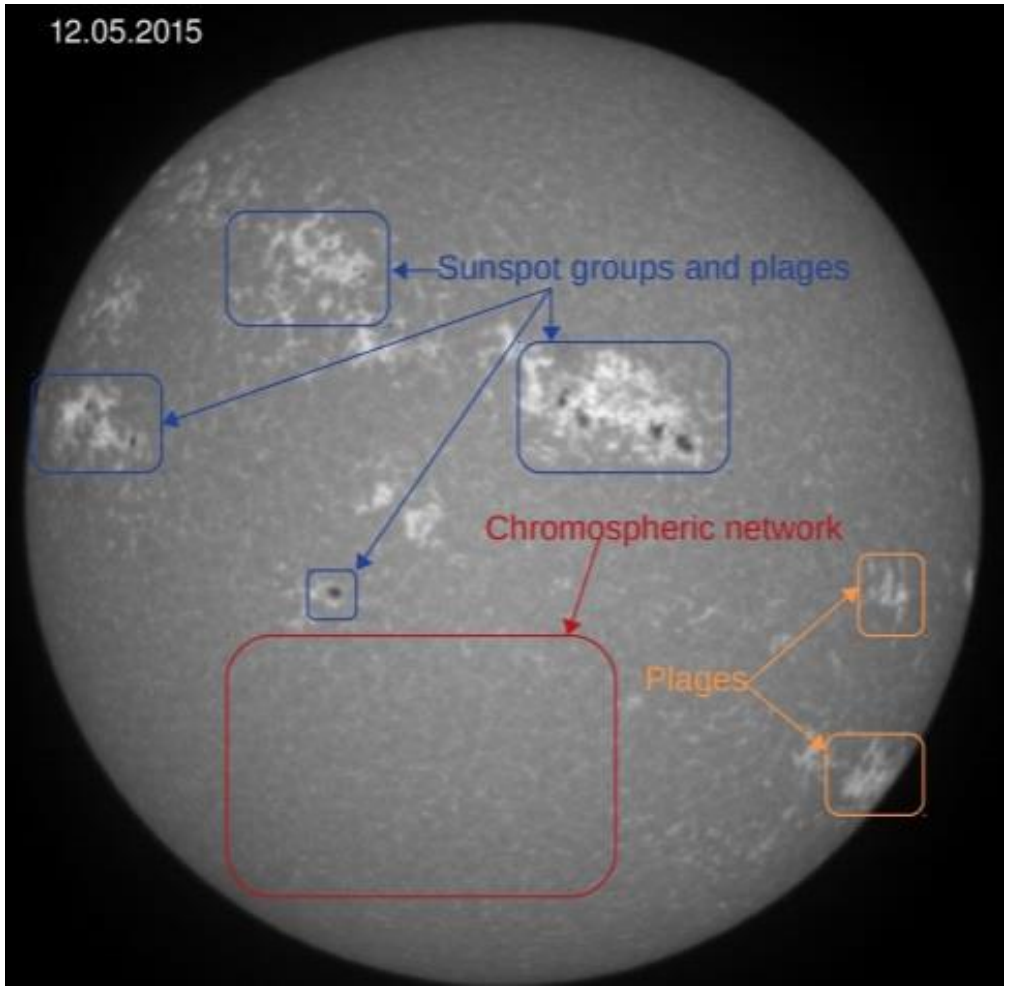


Test of another way to normalize

3. Progress and results

2) Chromospheric structures segmentation



http://sidc.oma.be/uset/searchForm.php

Our plan :

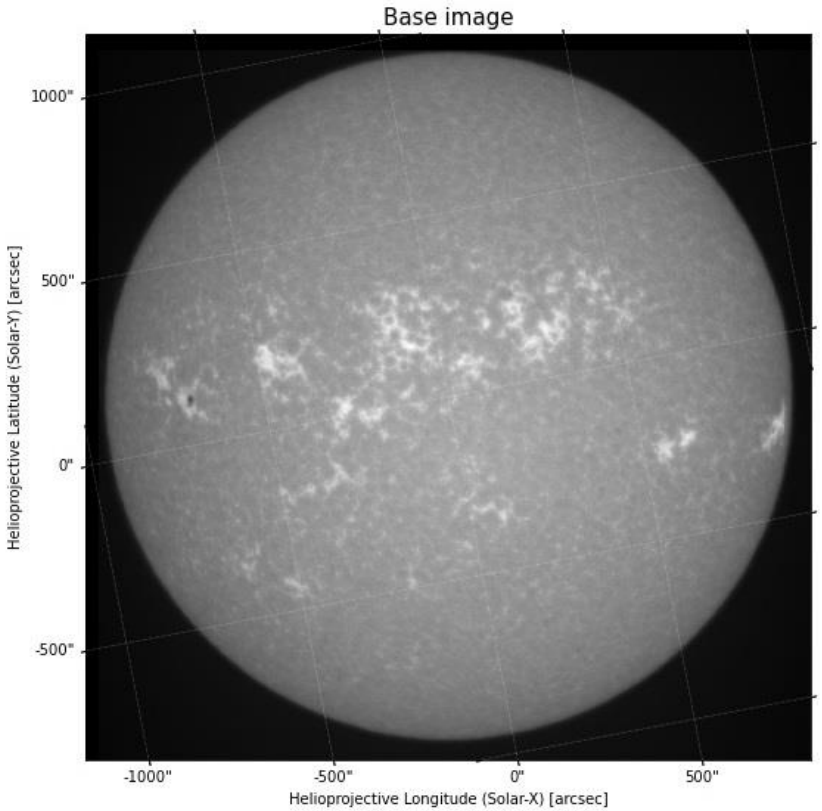
Study the long-term brightness variation of the chromosphere in the Ca II K line

Our goal :

Reach a better understanding of the different contributions of those structures

3. Progress and results

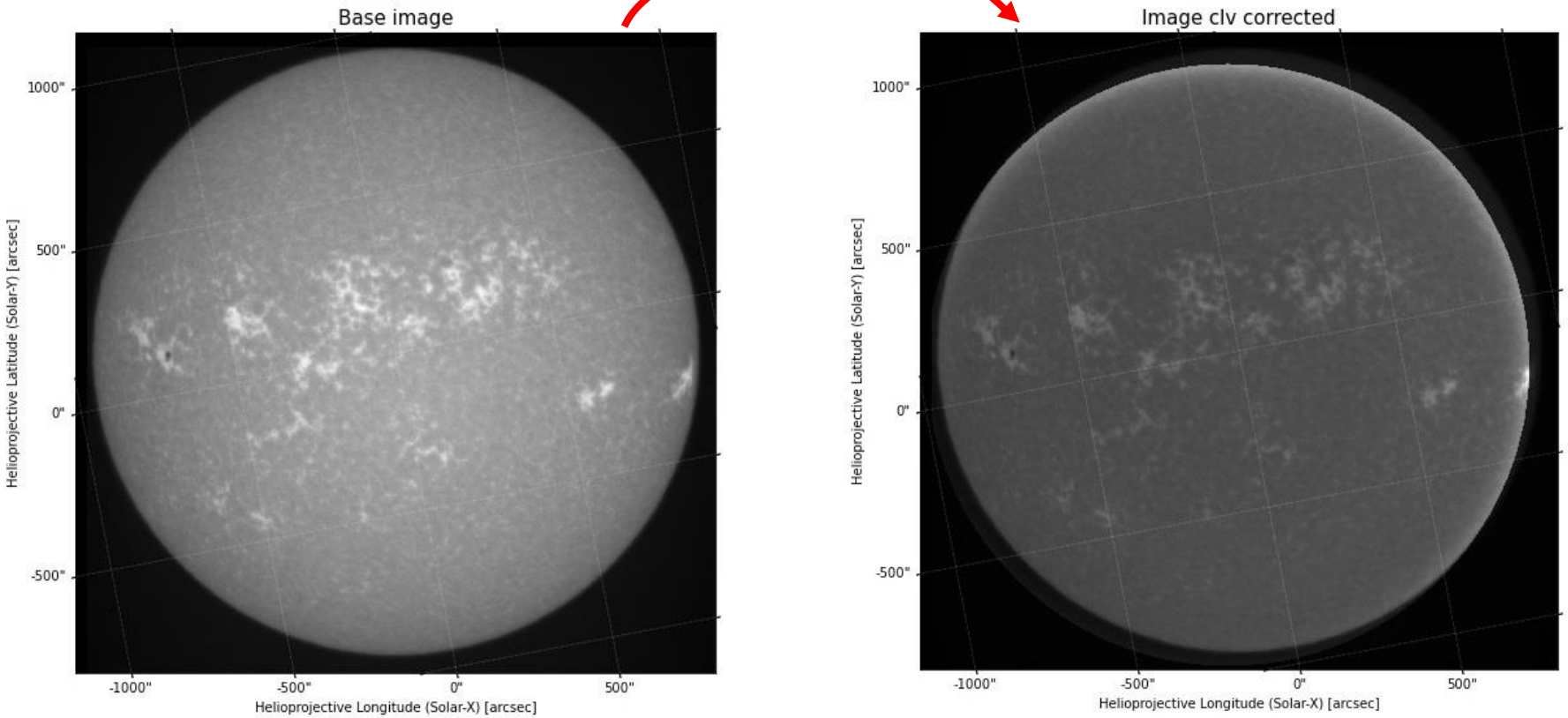
2) Chromospheric structures segmentation – CLV correction



3. Progress and results

2) Chromospheric structures segmentation – CLV correction

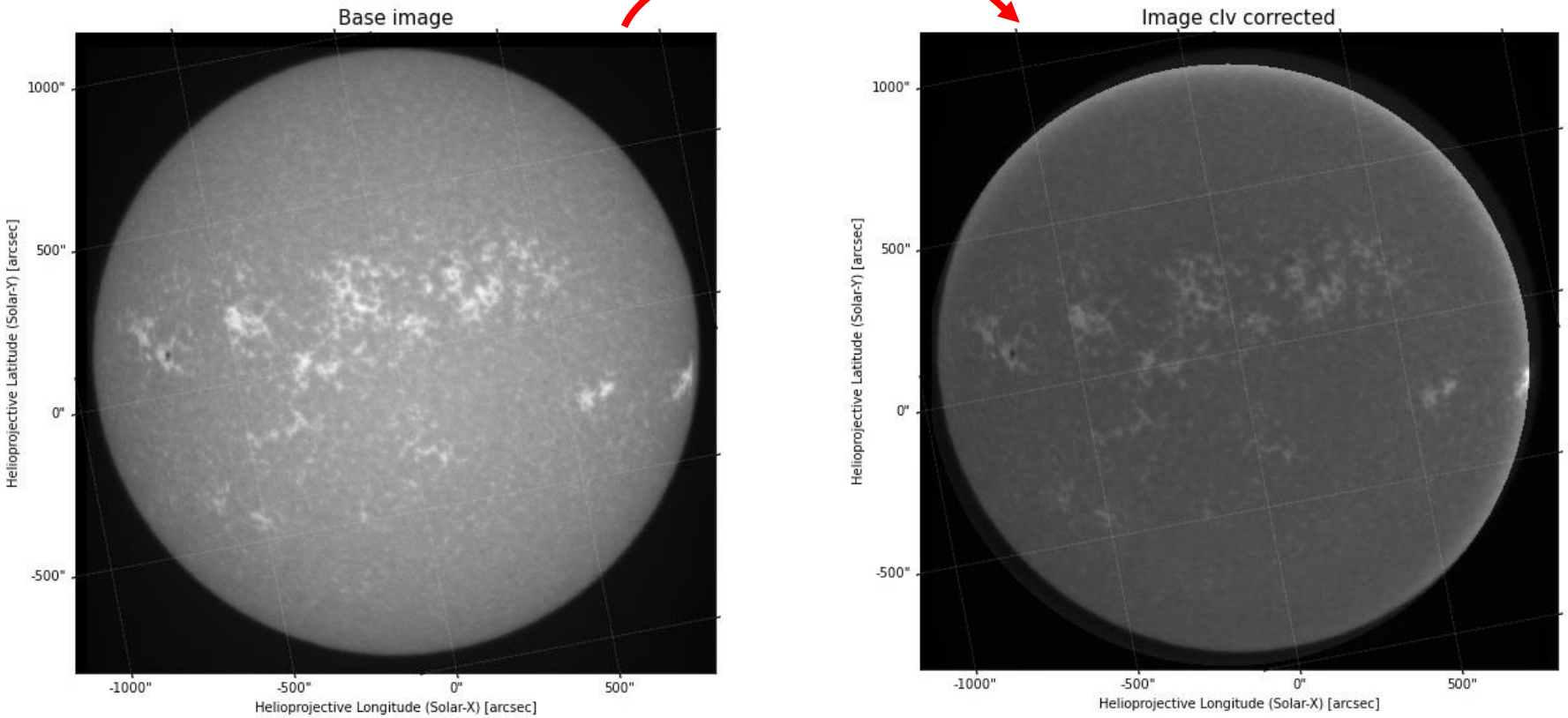
CLV correction



3. Progress and results

2) Chromospheric structures segmentation – CLV correction

CLV correction



Problem :

Limb correction complexity

Solution :

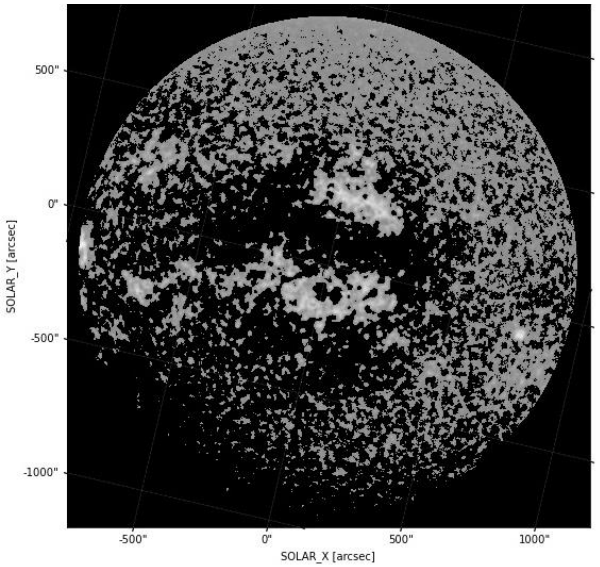
Considering pixels within $0.98R$

3. Progress and results

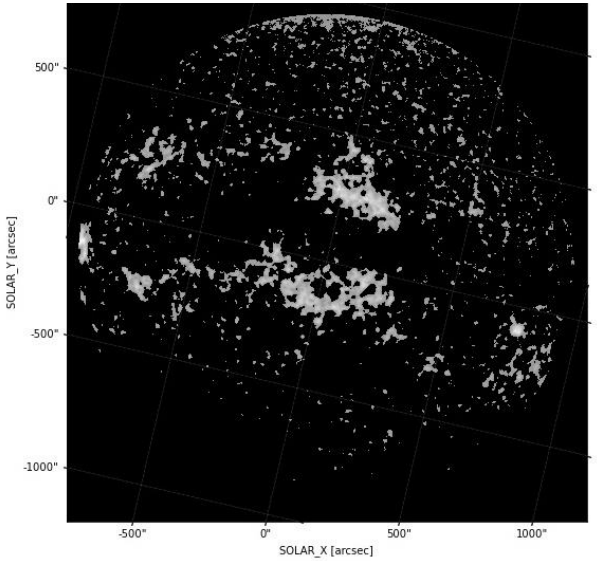
2) Chromospheric structures segmentation – Thresholding

Threshold → Considering the intensities of pixels within $0.98R$

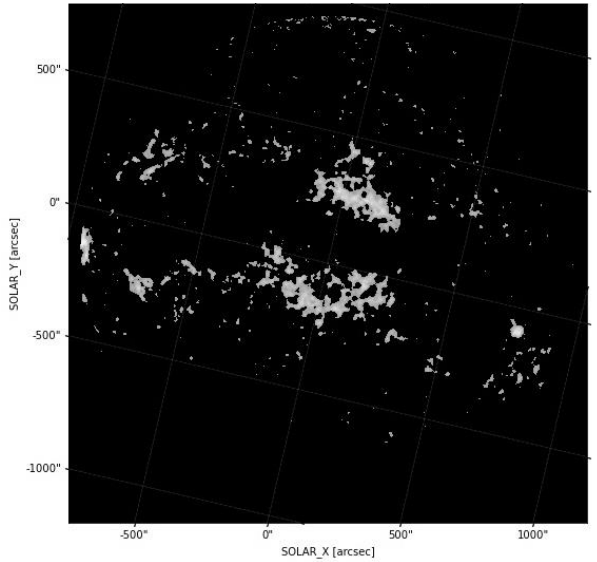
Mean



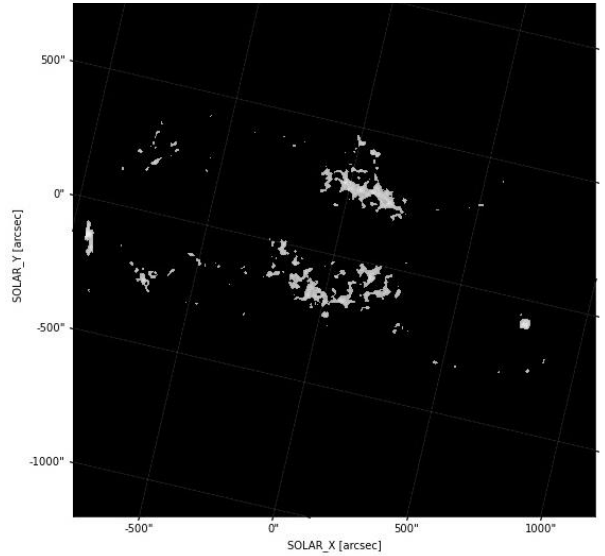
90th percentile



95th percentile



98th percentile



3. Progress and results

2) Chromospheric structures segmentation – Thresholding

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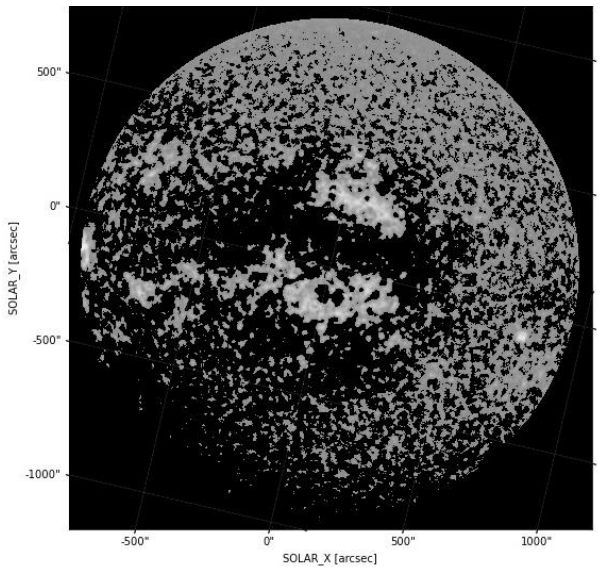
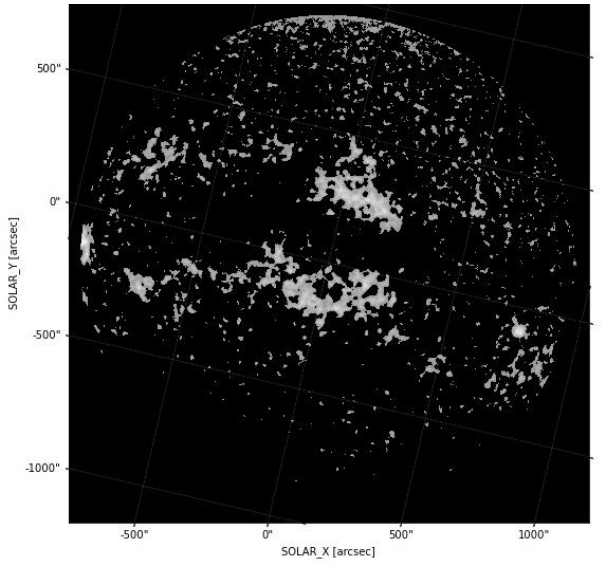
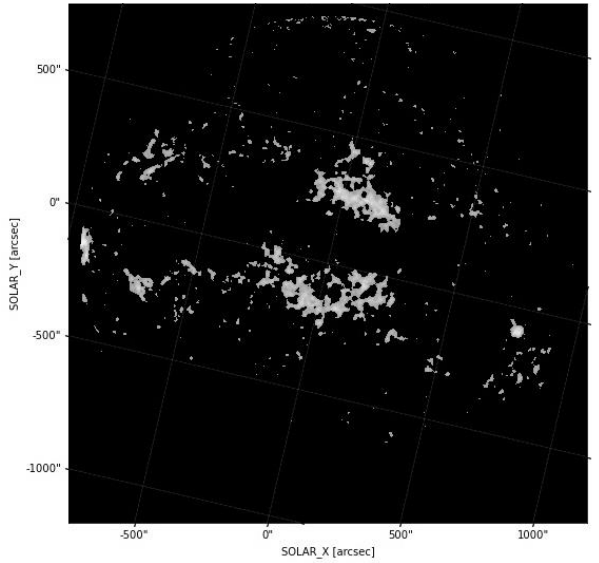
Mean



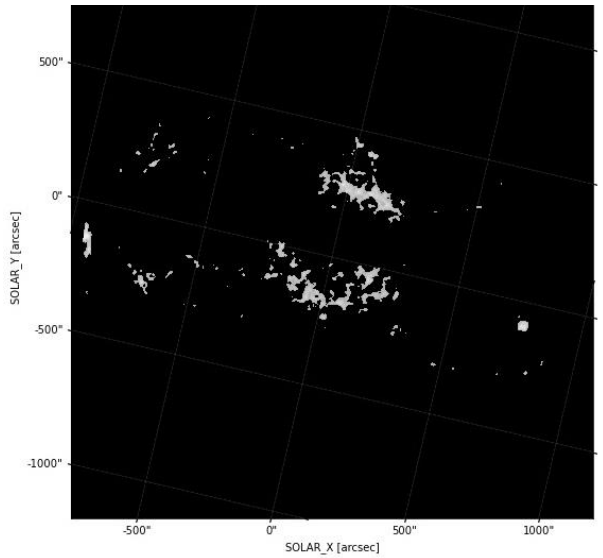
90th percentile



95th percentile



98th percentile



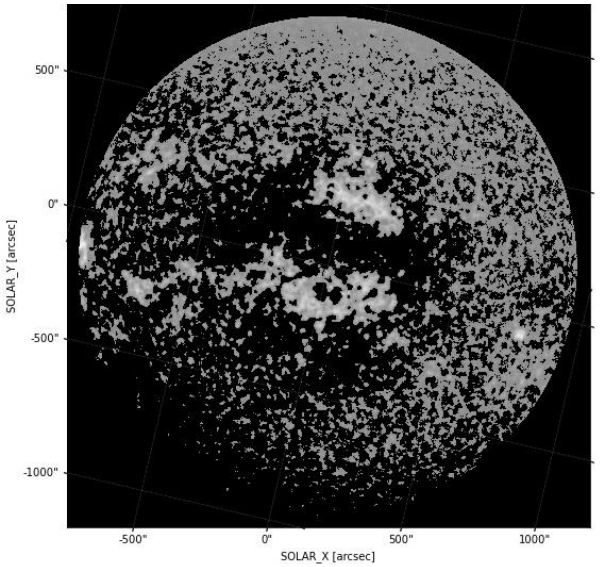
Too many pixels kept

3. Progress and results

2) Chromospheric structures segmentation – Thresholding

Threshold → Considering the intensities of pixels within $0.98R$

Mean



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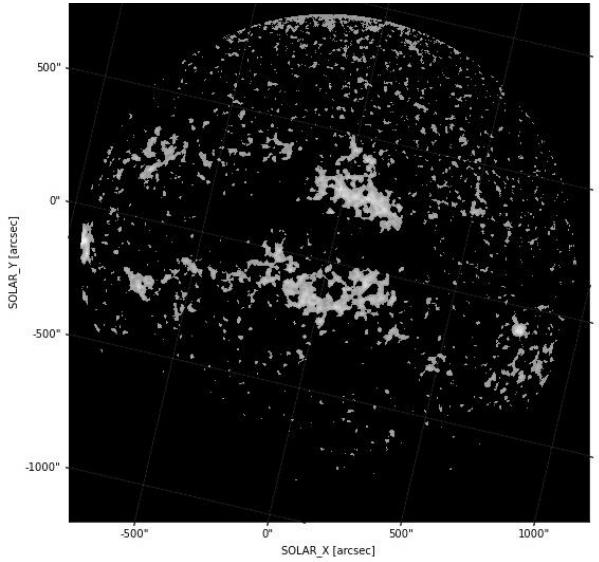
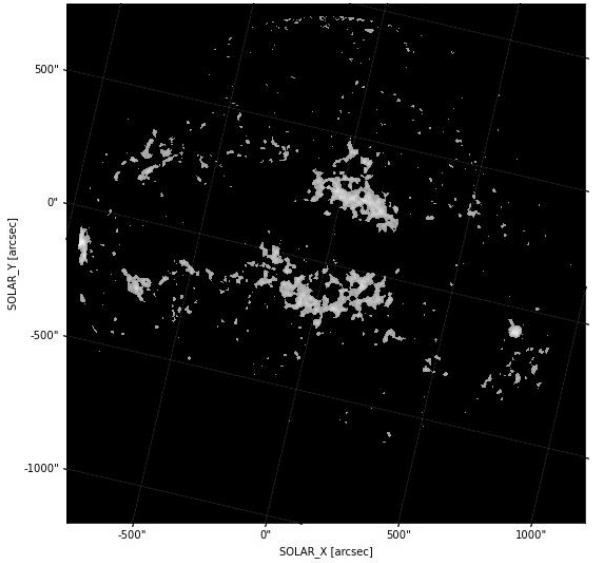
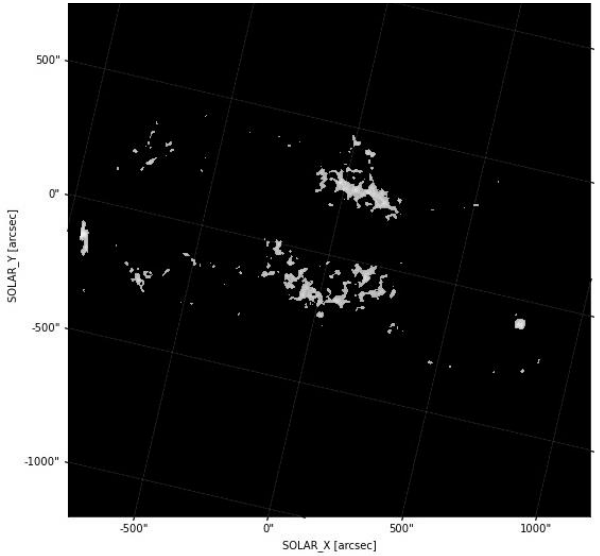


95th percentile



98th percentile



Too many pixels kept

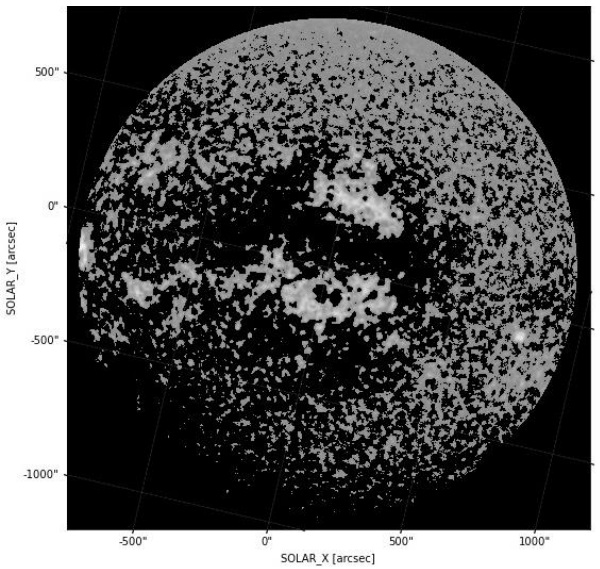
Some pixels forgotten

3. Progress and results

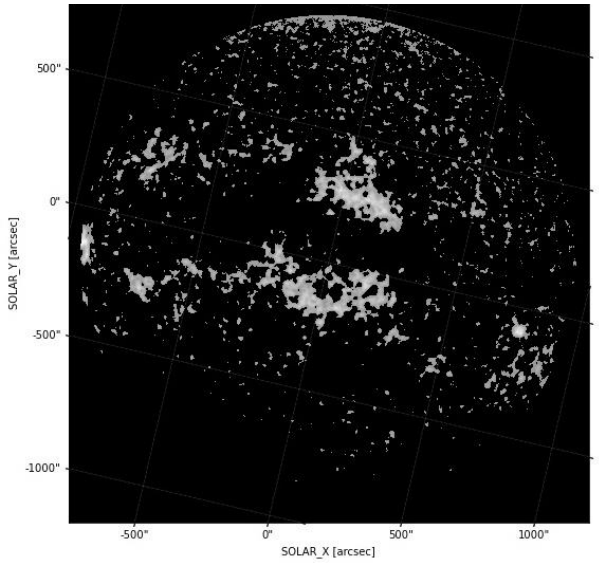
2) Chromospheric structures segmentation – Thresholding

Threshold → Considering the intensities of pixels within $0.98R$

Mean

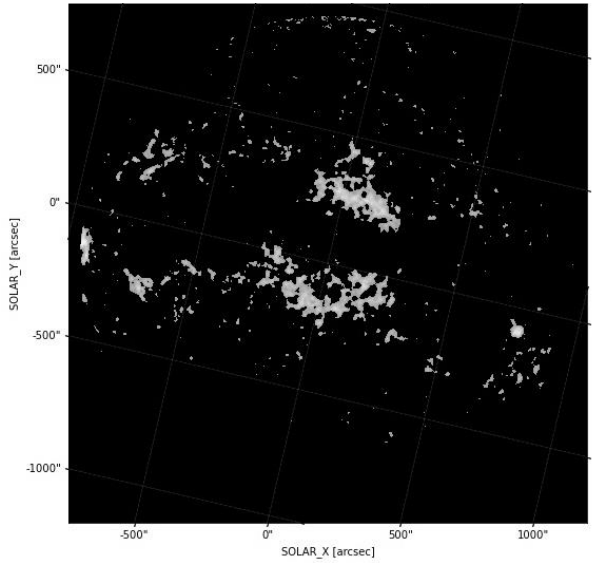


90th percentile



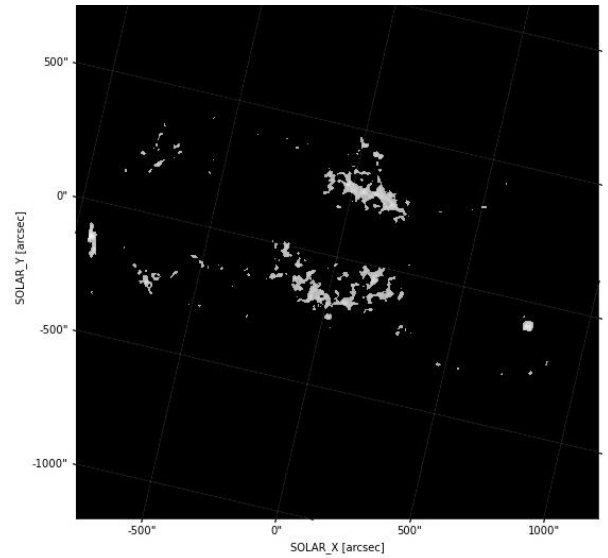
Too many pixels kept

95th percentile



Threshold chosen

98th percentile

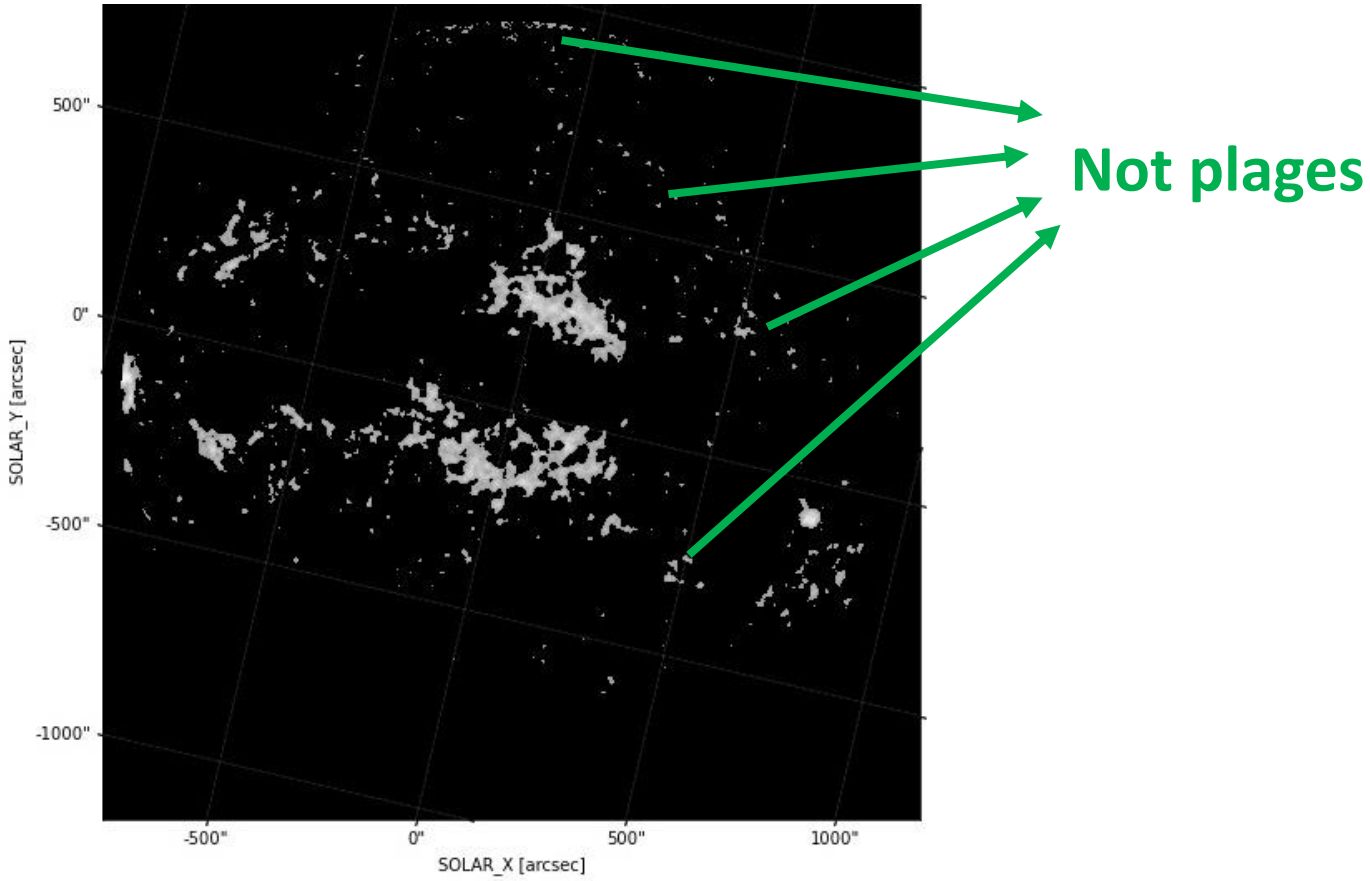


Some pixels forgotten

3. Progress and results

2) Chromospheric structures segmentation – « Single » pixels

95th percentile

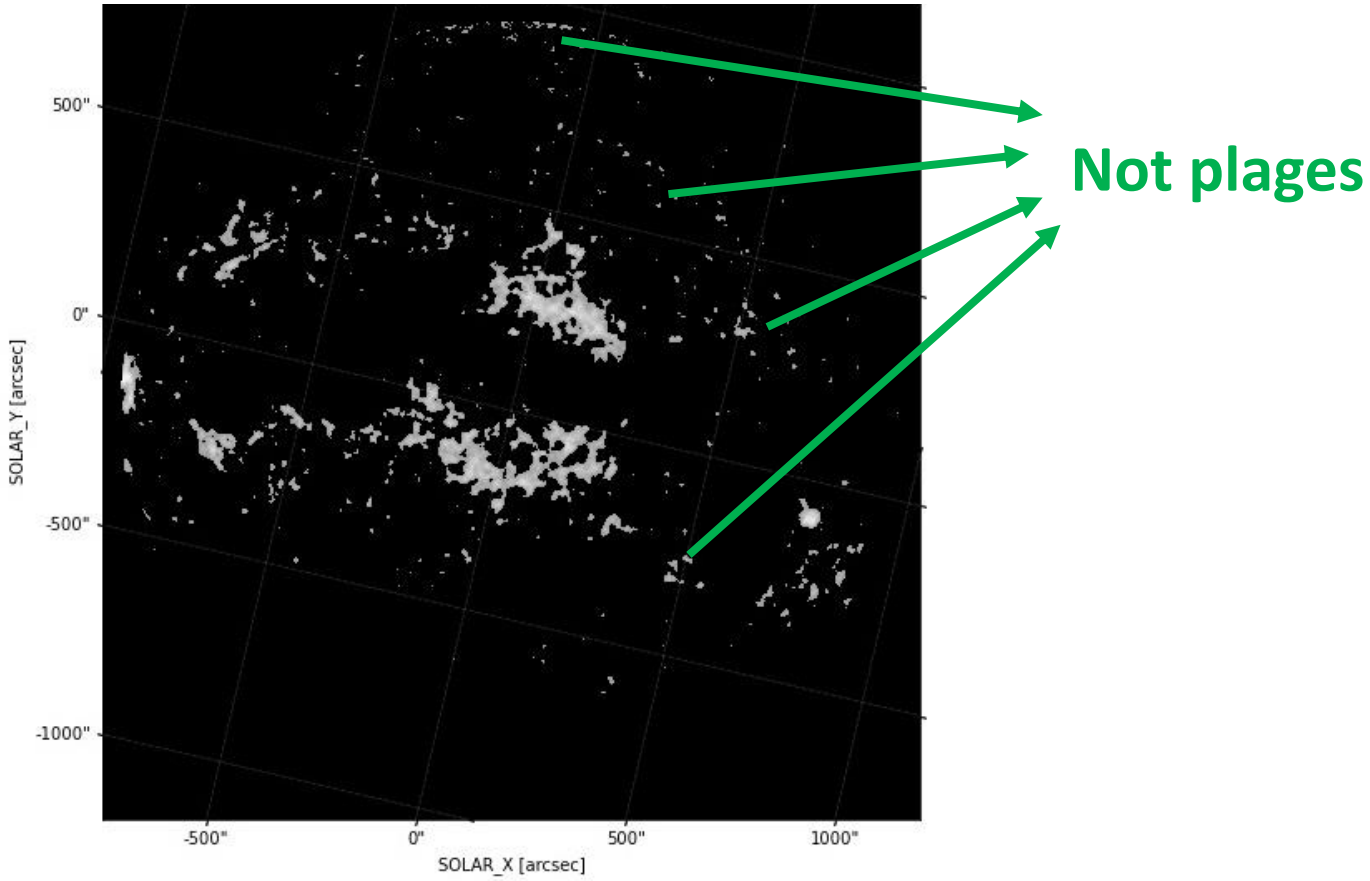


Not plages

3. Progress and results

2) Chromospheric structures segmentation – « Single » pixels

95th percentile



Not plages

Solution :

Using the size of supergranulation

3. Progress and results

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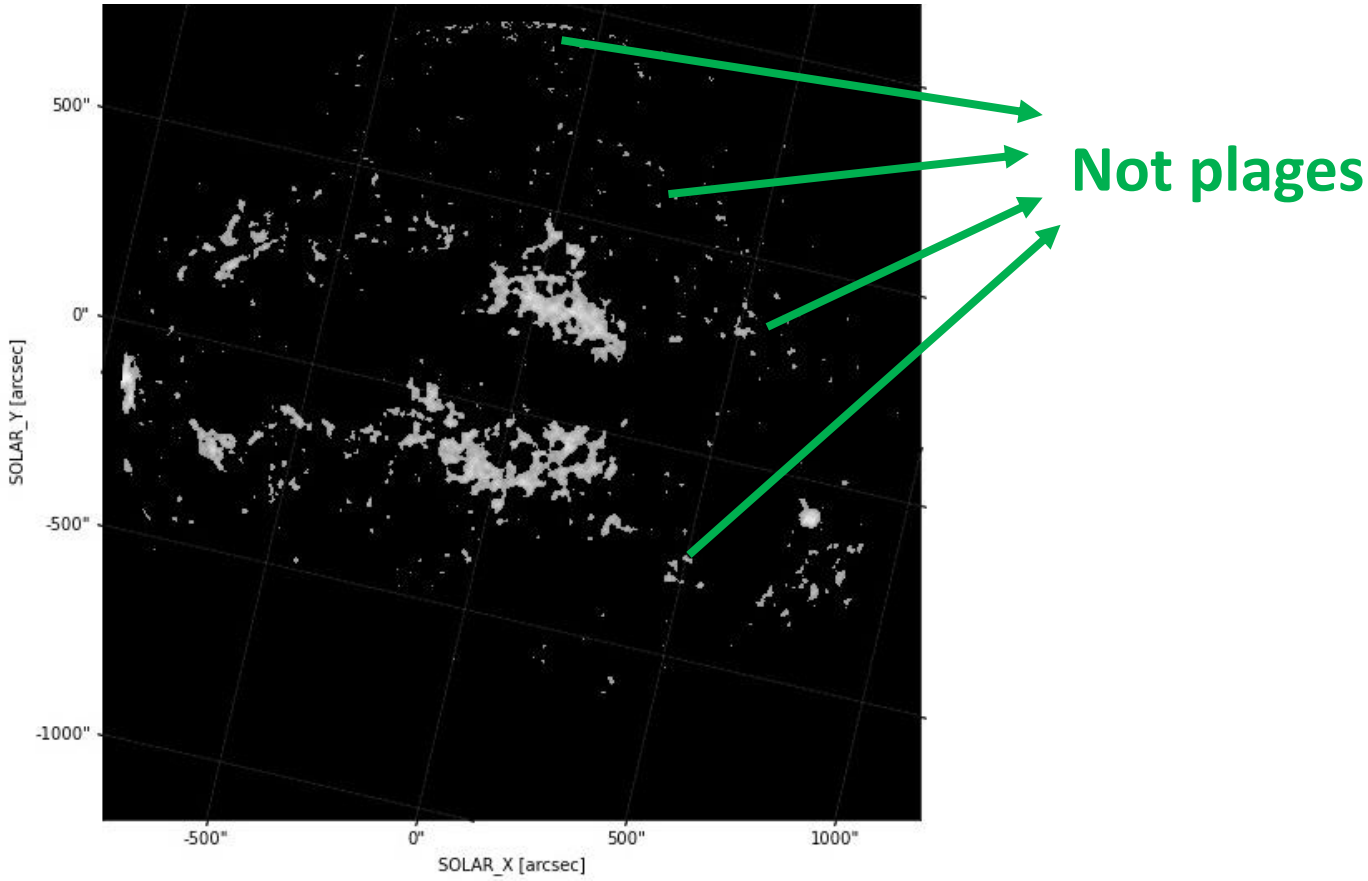
95th percentile

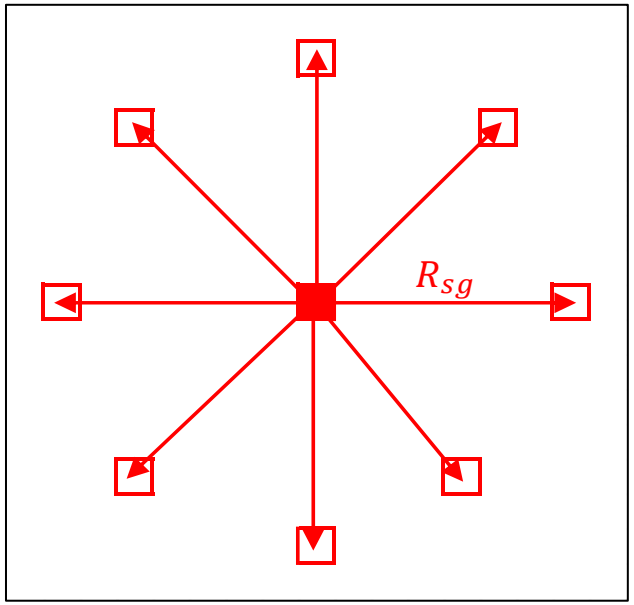


Not plages

Solution :

Using the size of supergranulation

R_{sg} = Supergranular cell radius



3. Progress and results

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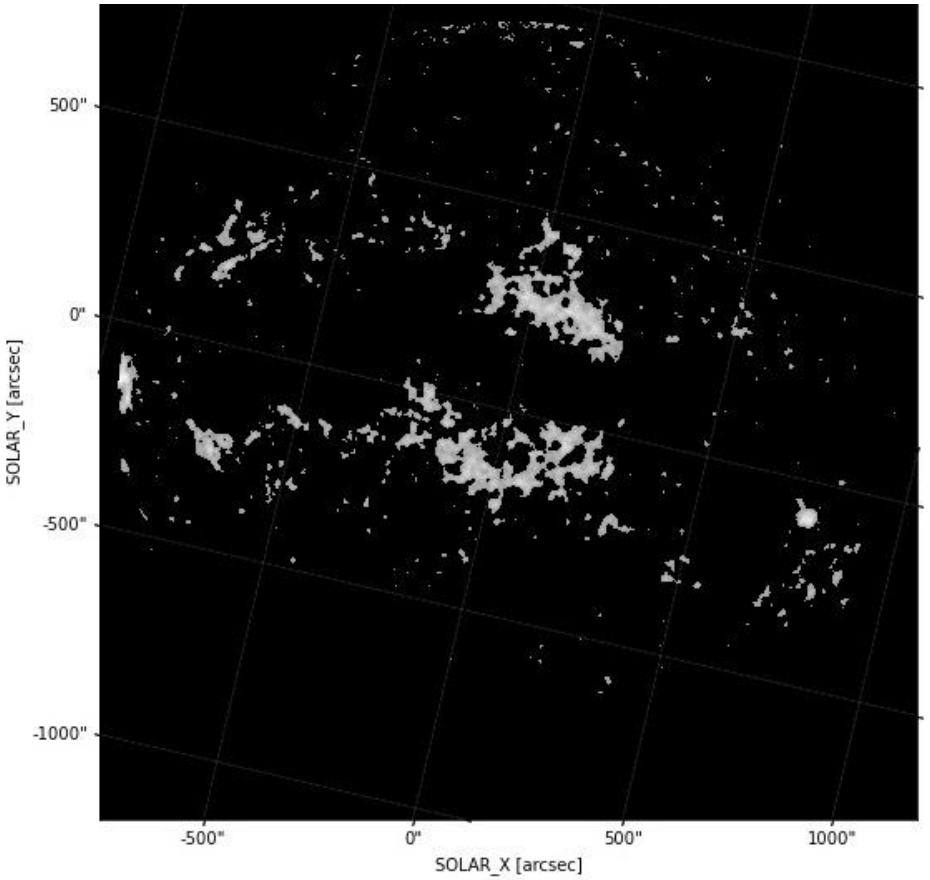
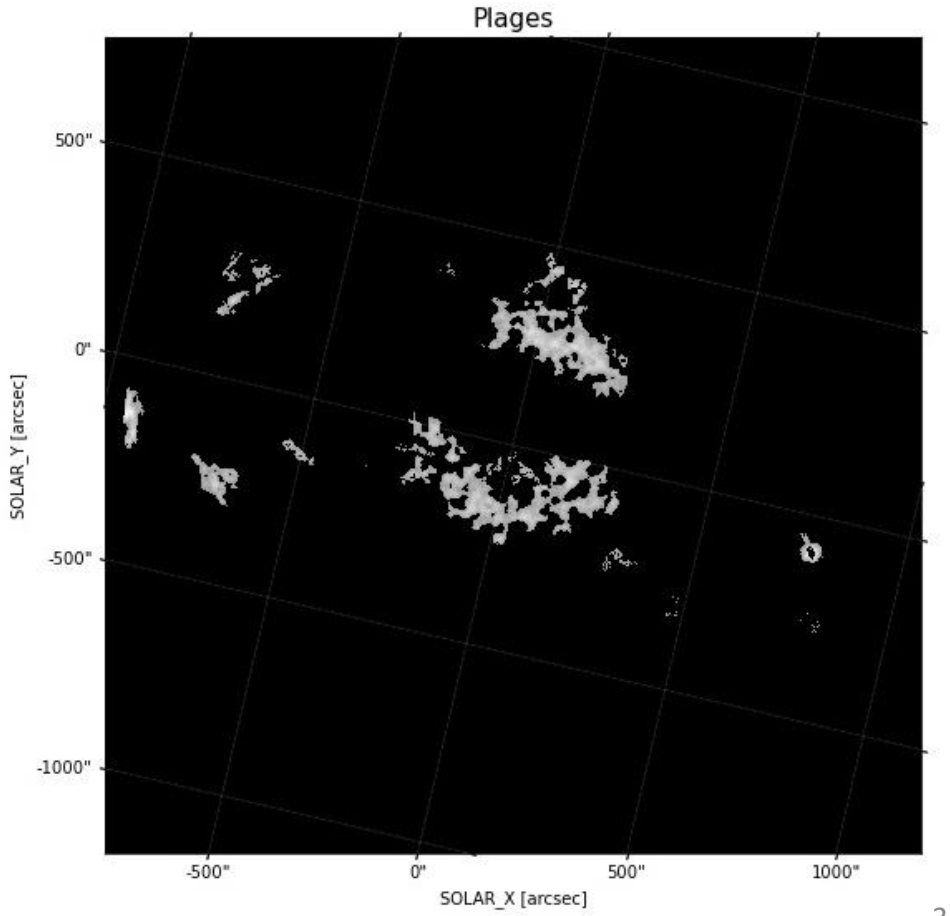
95th percentile



FINAL

RESULT



4. Next steps

Synoptic maps and the Sun seen as a star	Chromospheric structures segmentation

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Synoptic maps and the Sun seen as a star	Chromospheric structures segmentation
- Inclination effect on the observed Ca II K emission at a given time - Study the brightness variation as seen from any viewing angle during a solar cycle	

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Synoptic maps and the Sun seen as a star	Chromospheric structures segmentation
- Inclination effect on the observed Ca II K emission at a given time - Study the brightness variation as seen from any viewing angle during a solar cycle	- Contribution of chromospheric structures to the long-term brightness variation - Run algorithm for images during a solar cycle - Plot the intensity variation of structures as a function of time + comparison with solar irradiance variation - Study the specific contribution of plages

5. Other activities

- FRIA Grants → Final grading : A-
  → Application not funded due to the strong competition in the field

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- USET observations

Thank you for your attention !