

The relationship between plage and sunspot areas

Theodosios Chatzistergos,
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11 September 2023

Data

Year

1600

1700

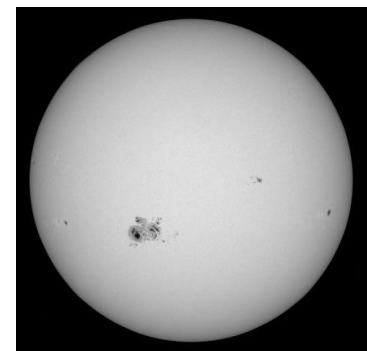
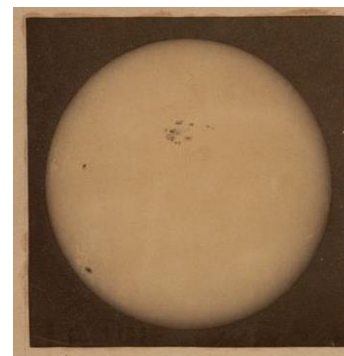
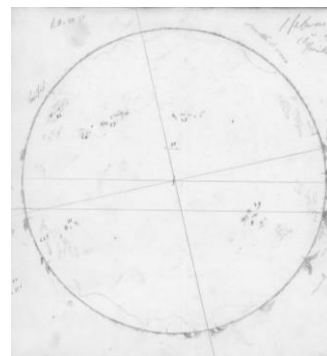
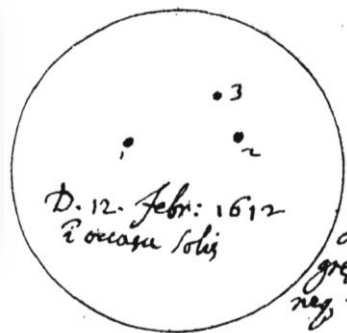
1800

1900

2000

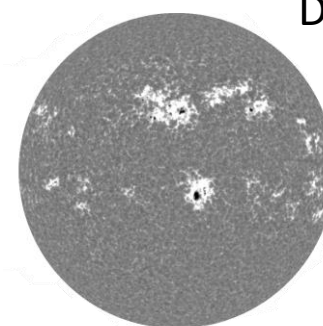
Sunspot

Date	Time	Lat.	Long.	Size	Number	Remarks
Jan 5	10 ^h	0.30	26.00			
10	10.30	0.30	27.25			
15	10.30	0.30	28.50			
20	10.30	0.30	30.00			
25	10.30	0.30	31.50			
30	10.30	0.30	33.00			
1	10.30	0.30	34.50			
2	10.30	0.30	36.00			
3	10.30	0.30	37.50			

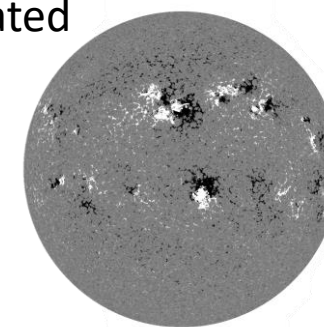


Faculae

Disc-integrated



Ly α
Mg II
Ca II K
F10.7



1600

1700

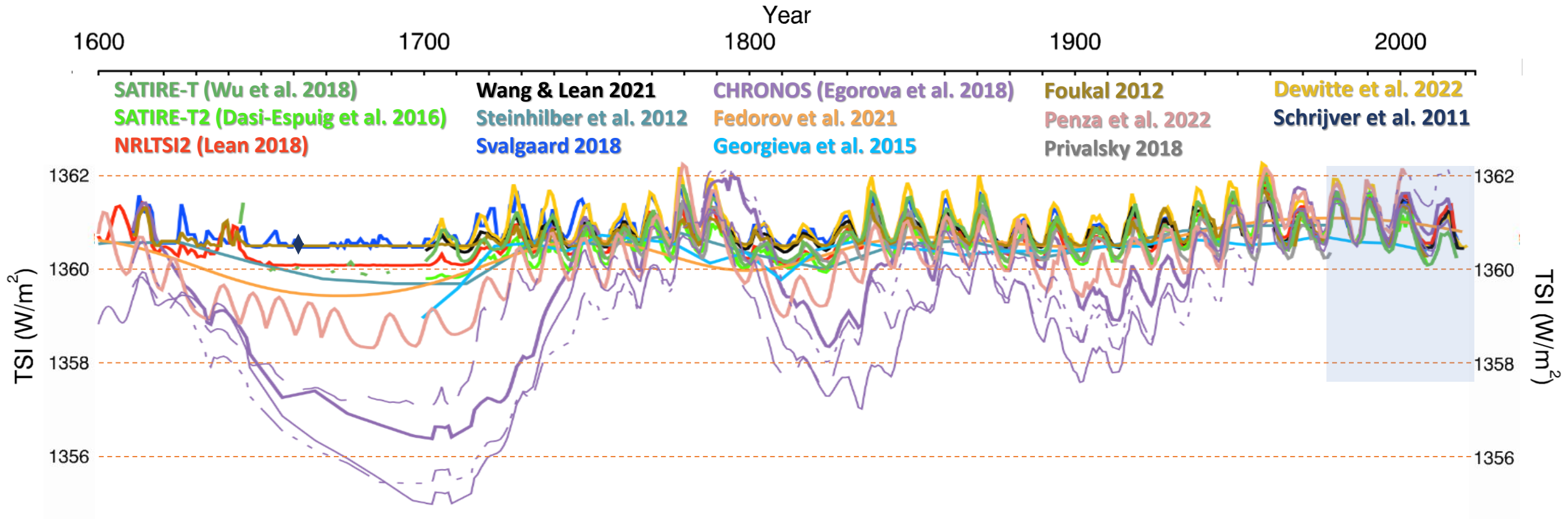
1800

1900

2000

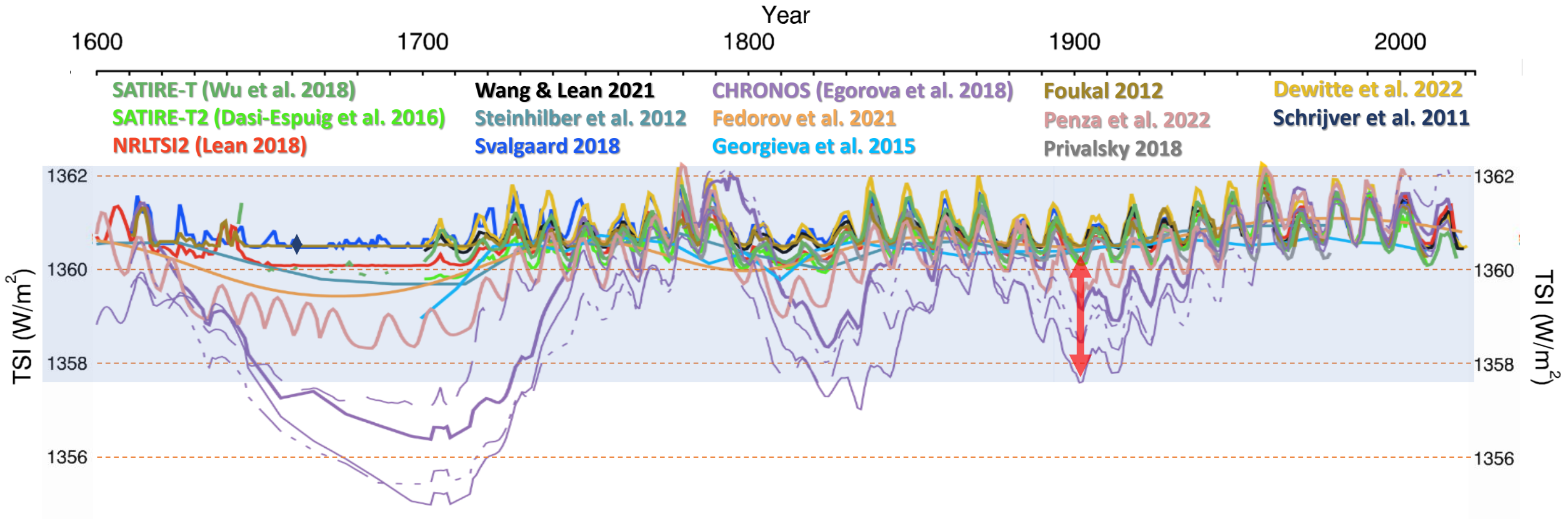
Year

Motivation

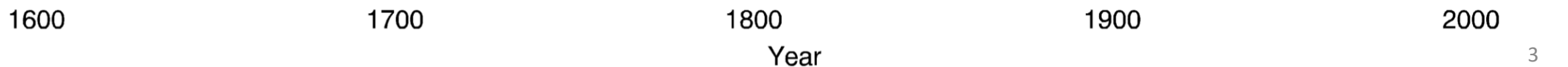


Reconstructions of past irradiance variations rely mostly on sunspot data → large uncertainty in long term trend

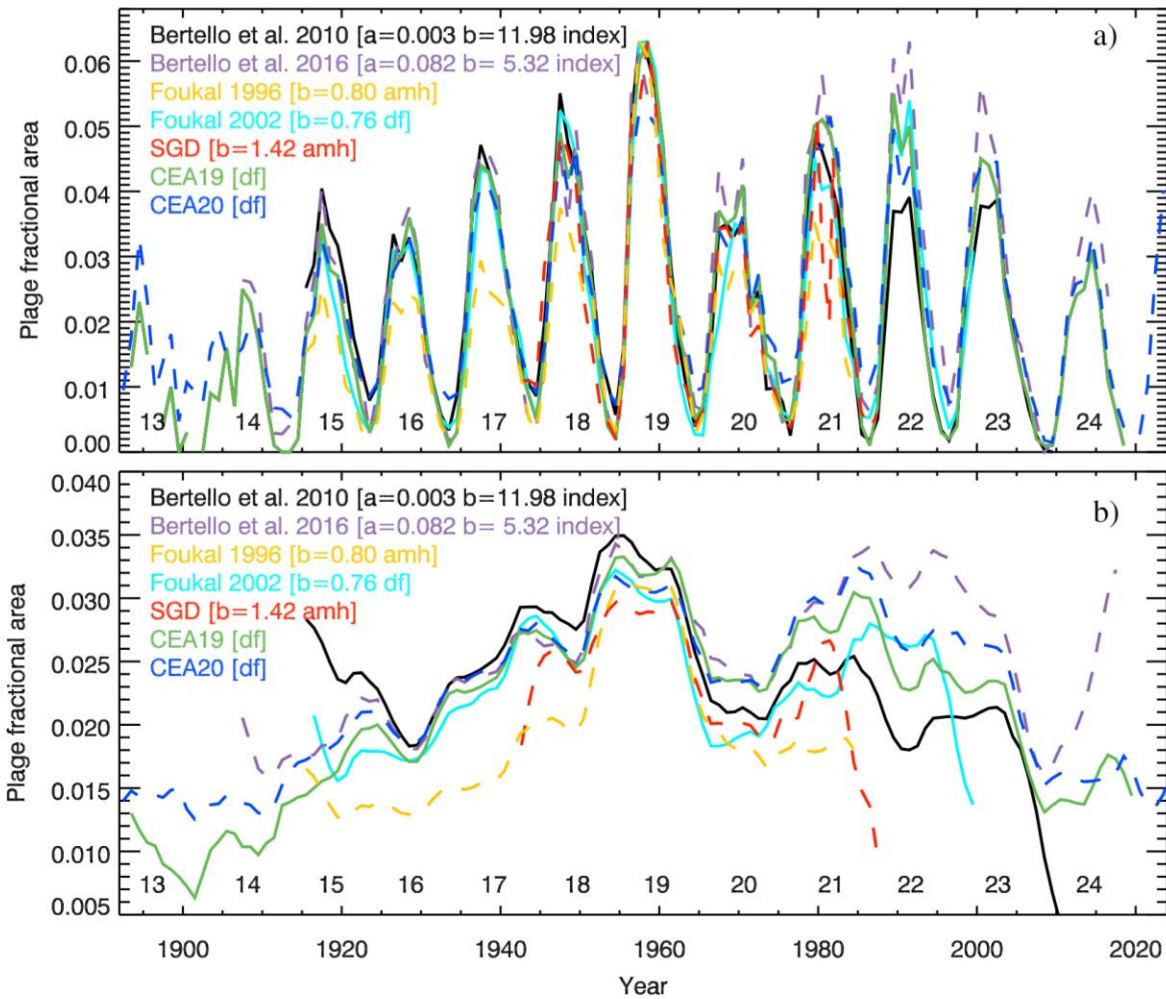
Motivation



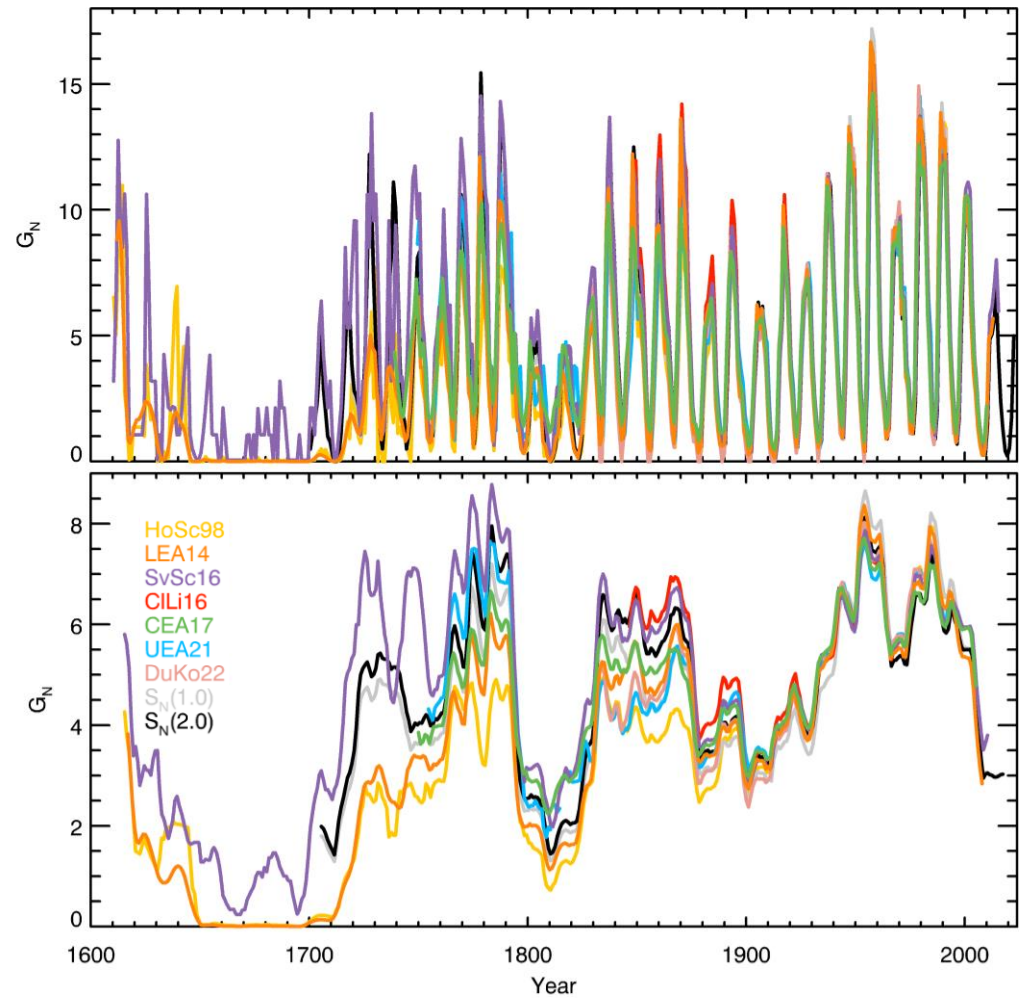
Reconstructions of past irradiance variations rely mostly on sunspot data → large uncertainty in long term trend
Improving relation between plage/sunspots can reduce uncertainty in long term trend of TSI



Published Ca II K plage areas and sunspot number series

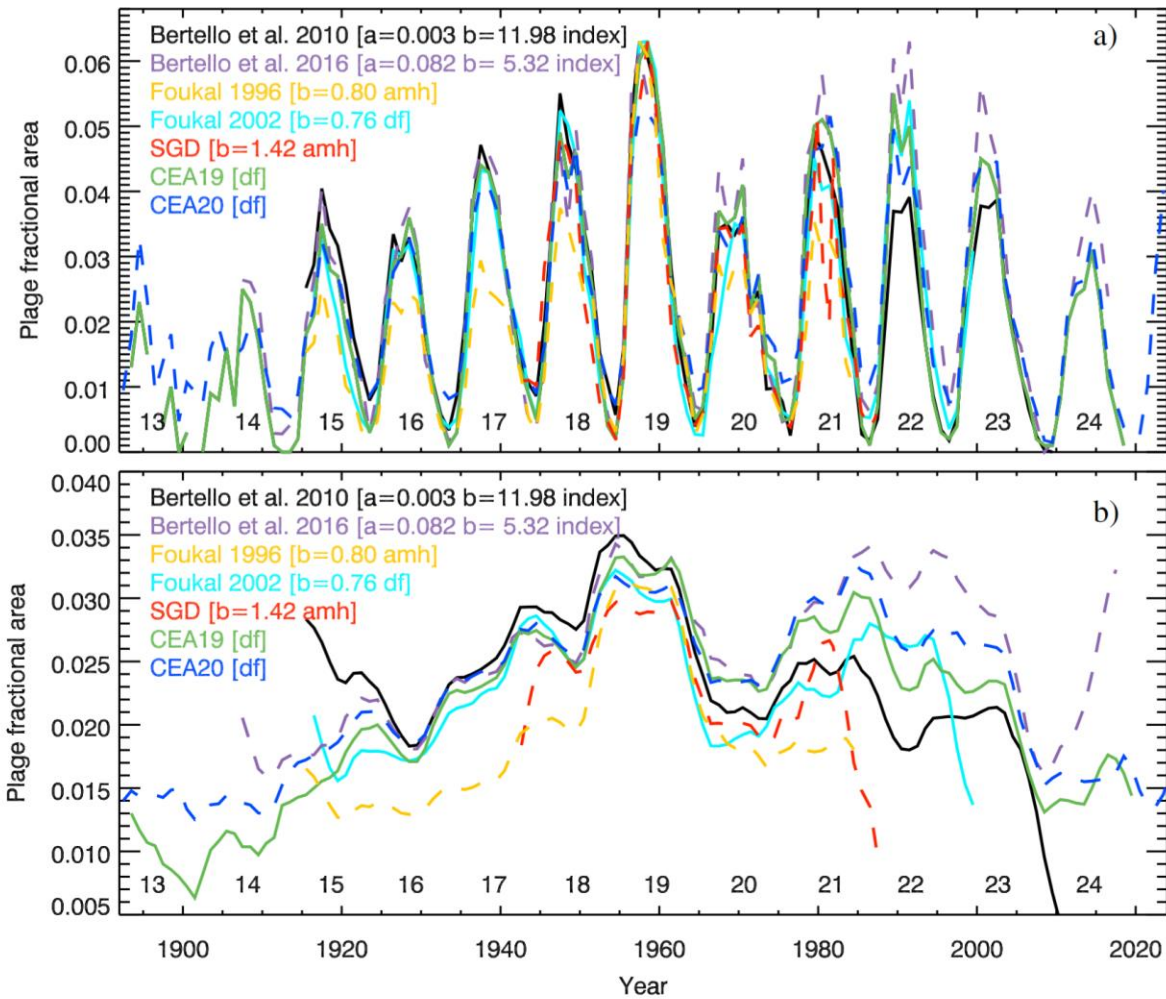


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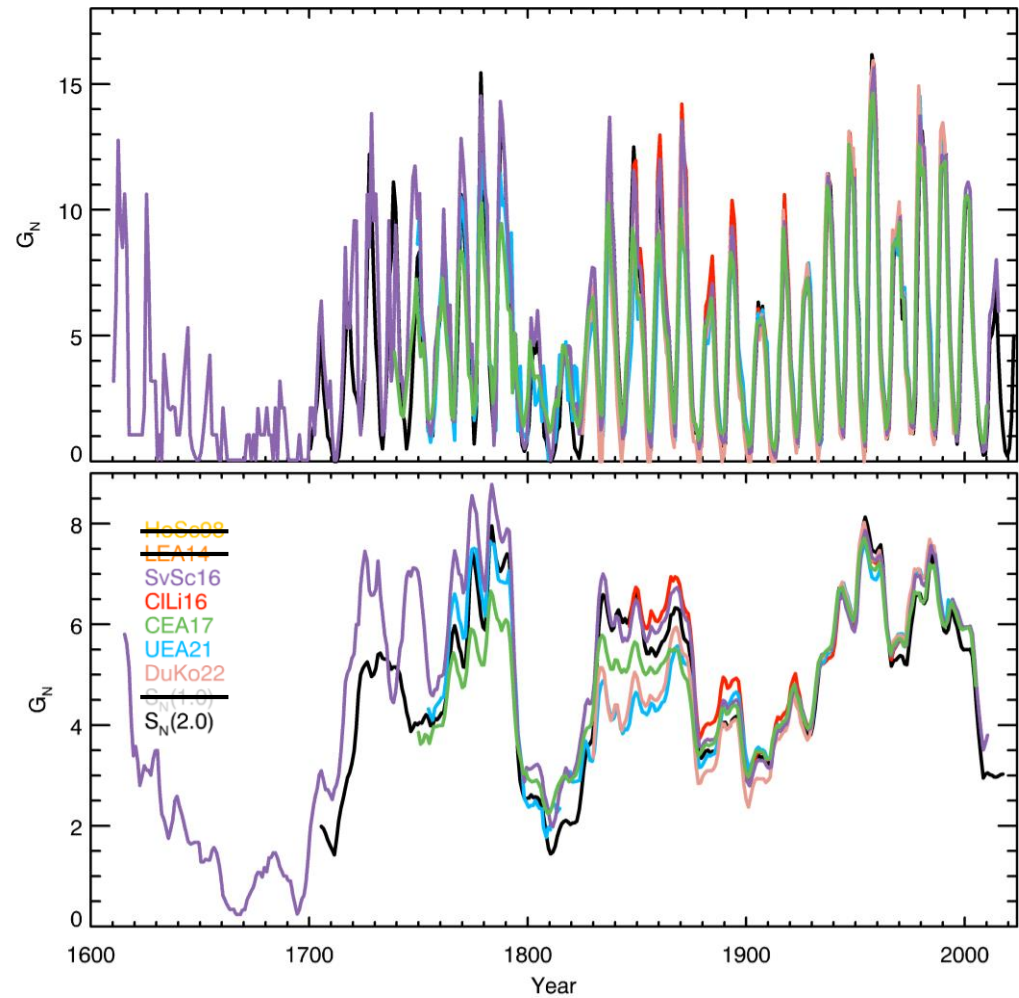


Clette et al. 2023

Published Ca II K plage areas and sunspot number series



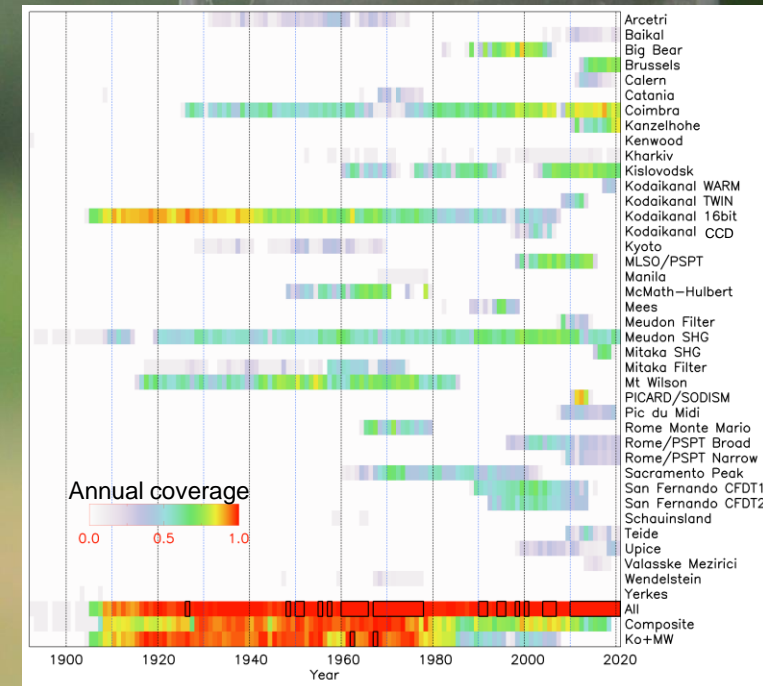
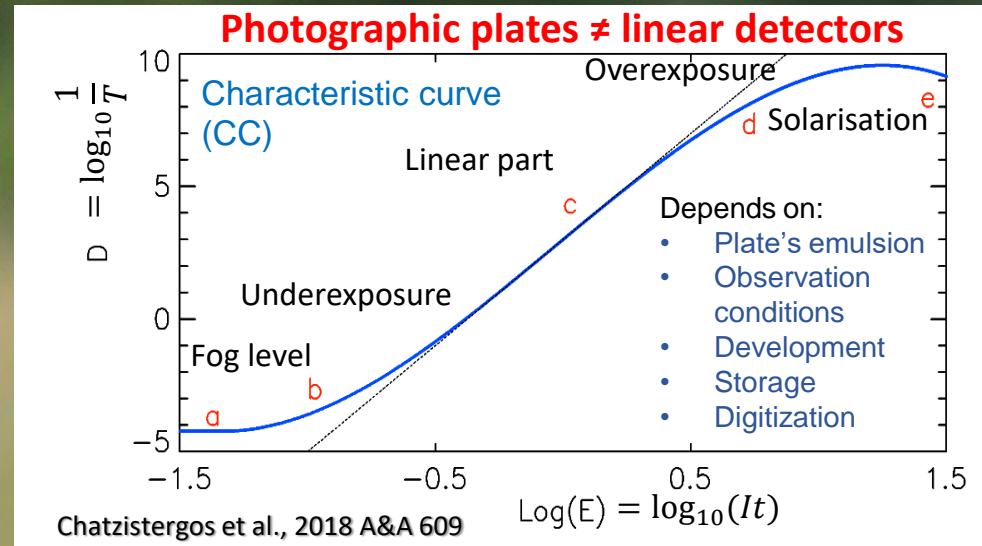
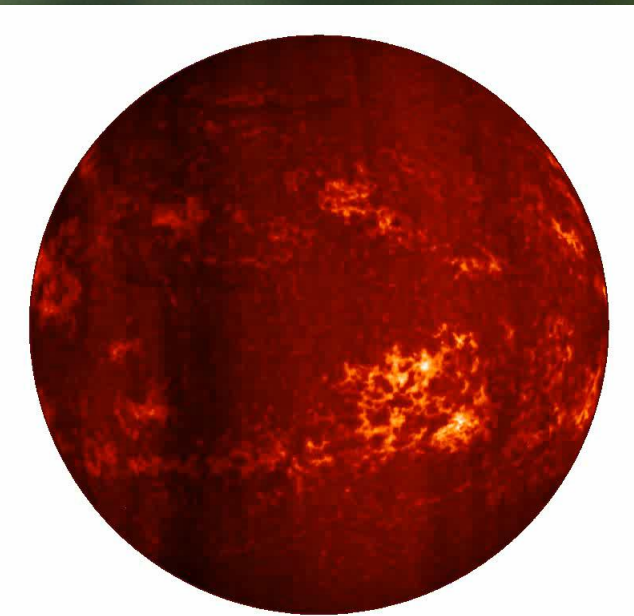
Chatzistergos et al. 2023



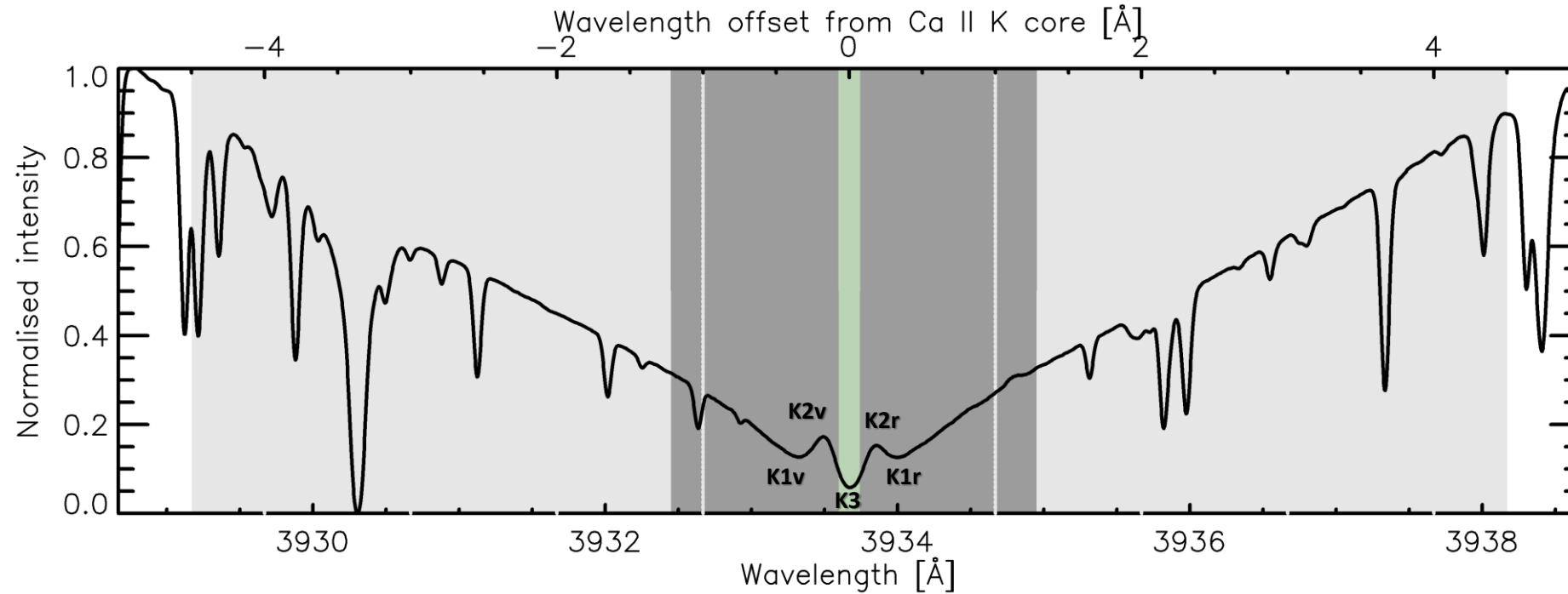
Clette et al. 2023

Ca II K observations

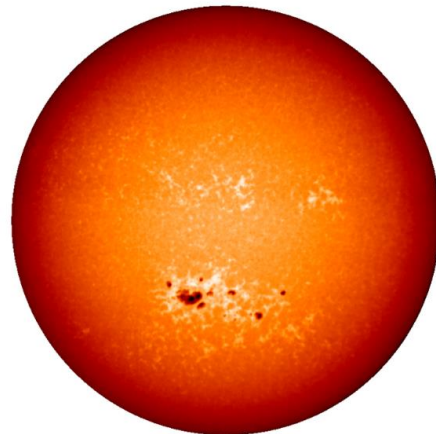
- 1) Varying accuracy of processing techniques
- 2) Lack of photometric calibration
- 3) Use of different dataset or inaccurate cross-calibration



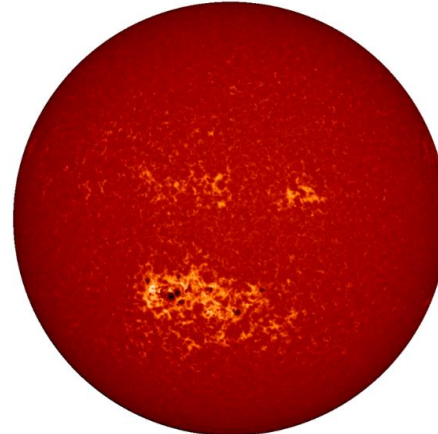
Differences between archives



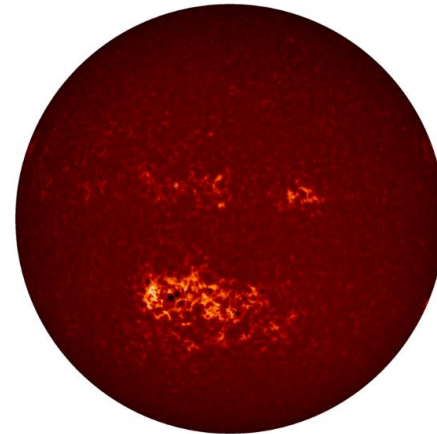
San Fernando
9 \AA



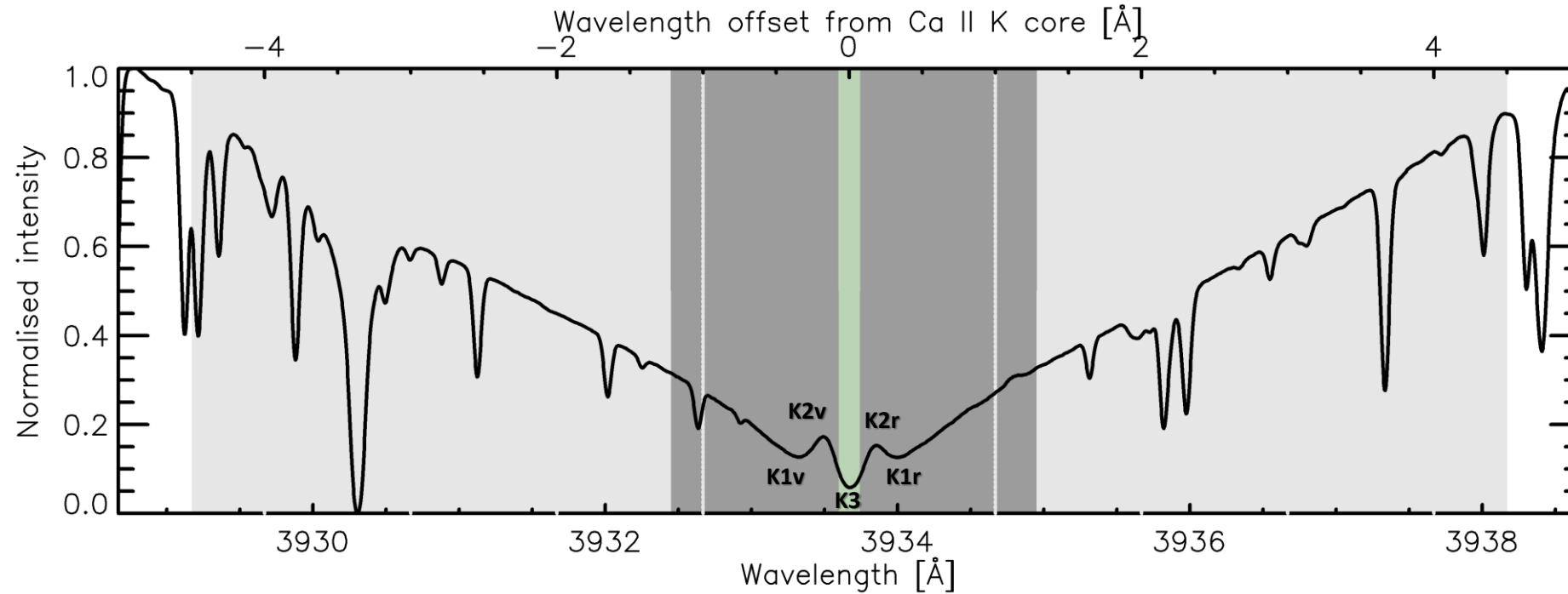
Rome/PSPT
2.5 \AA



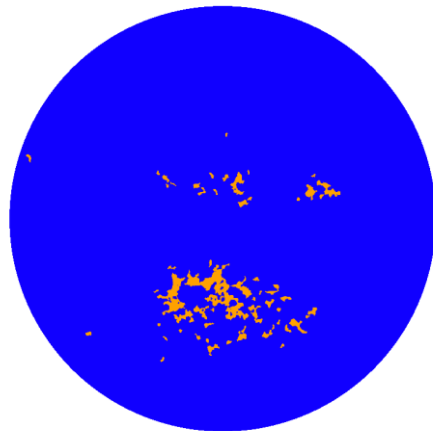
Meudon K3
0.15 \AA



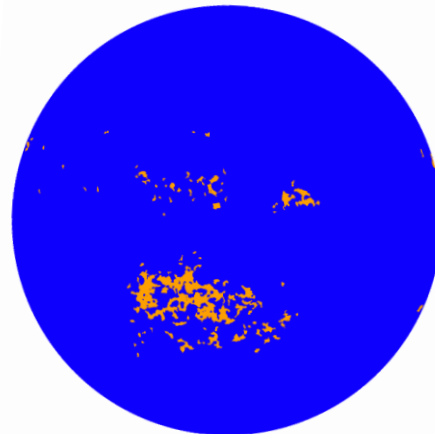
Differences between archives



San Fernando
9 \AA



Rome/PSPT
2.5 \AA



Meudon K3
0.15 \AA

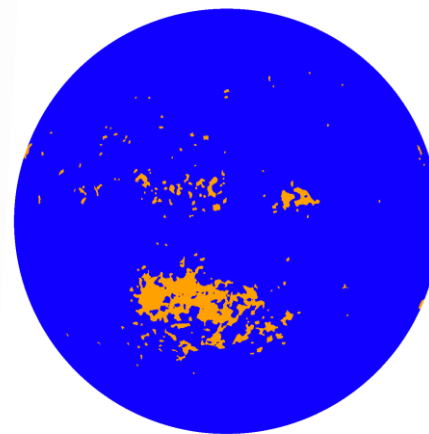
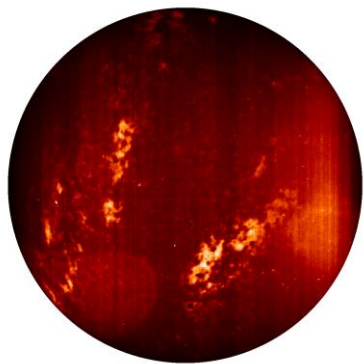


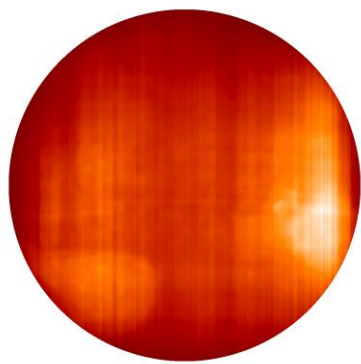
Image processing

Automatic process to:

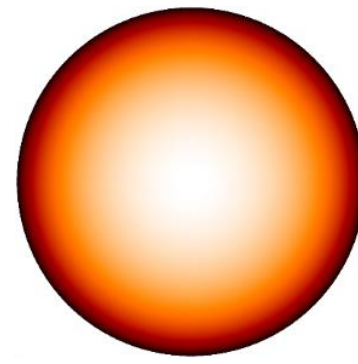
- Photometrically calibrate images
- Compensate for instrumental and physical effects



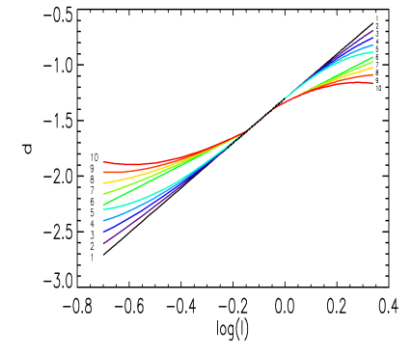
Kyoto
17/04/1956



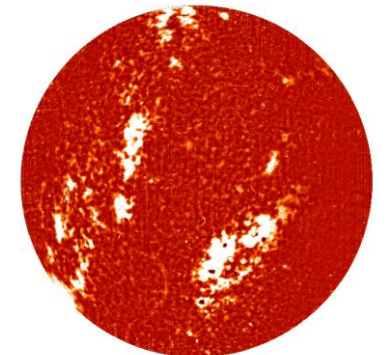
Artefacts map
(instrumental +
physical effects)



CLV
(physical effects)



Calibration curve



Calibrated image

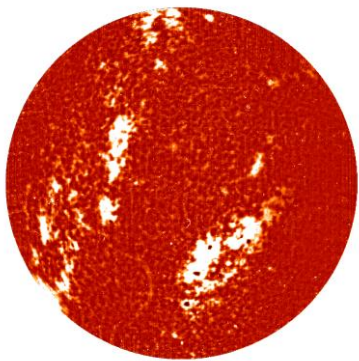
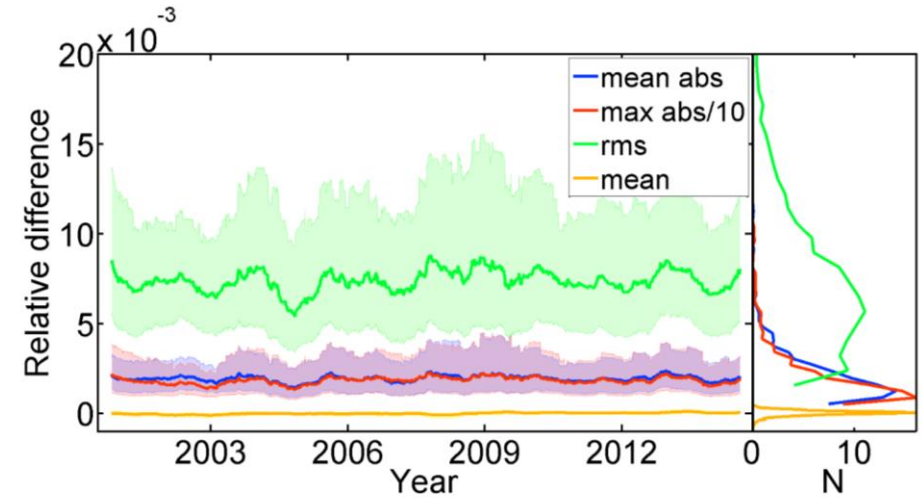
Image processing

Automatic process to:

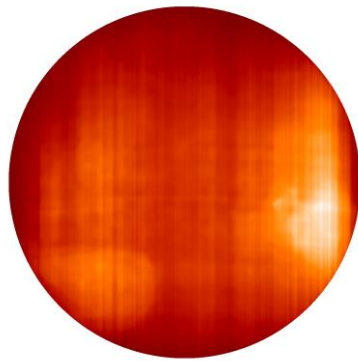
- Photometrically calibrate images
- Compensate for instrumental and physical effects

Evaluated method's accuracy with synthetic data

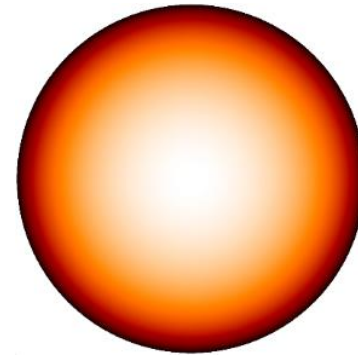
- Performs better than all other methods in the literature



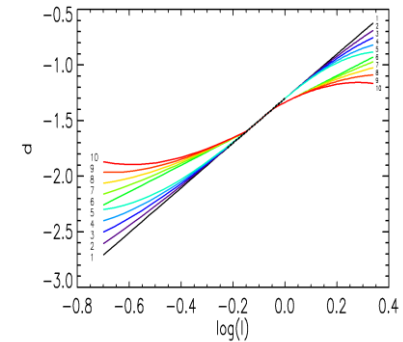
Kyoto
17/04/1956



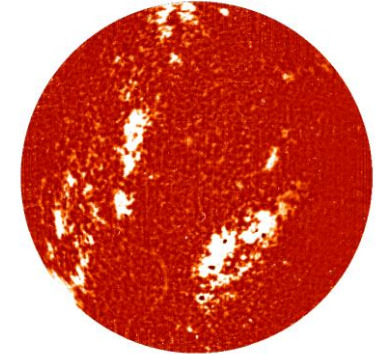
Artefacts map
(instrumental +
physical effects)



CLV
(physical effects)



Calibration curve



Calibrated image

Image processing

Automatic process to:

- Photometrically calibrate images
- Compensate for instrumental and physical effects

Evaluated method's accuracy with synthetic data

- Performs better than all other methods in the literature

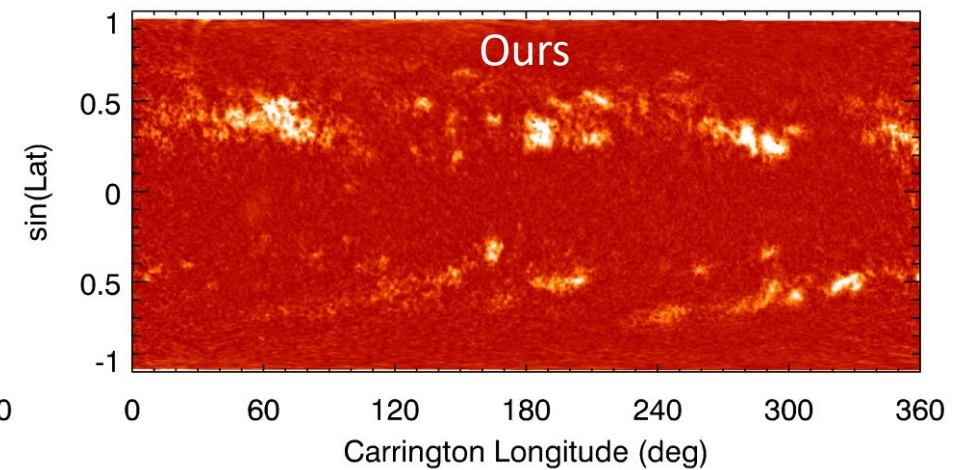
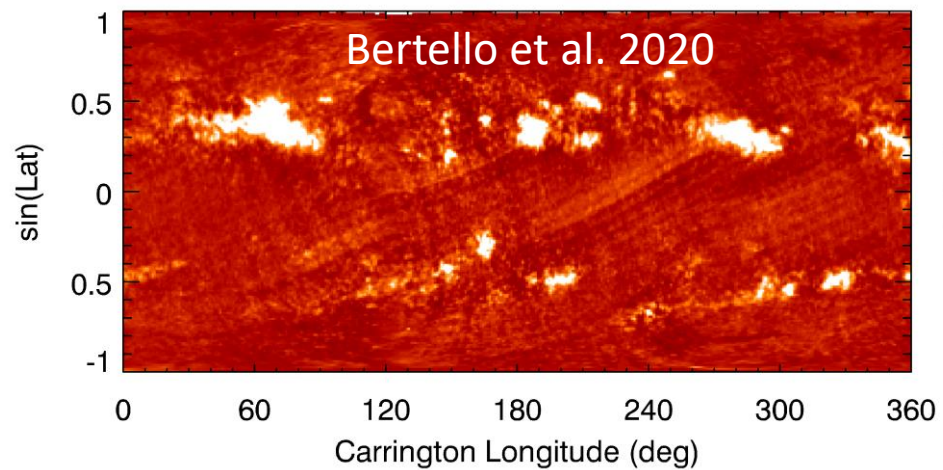
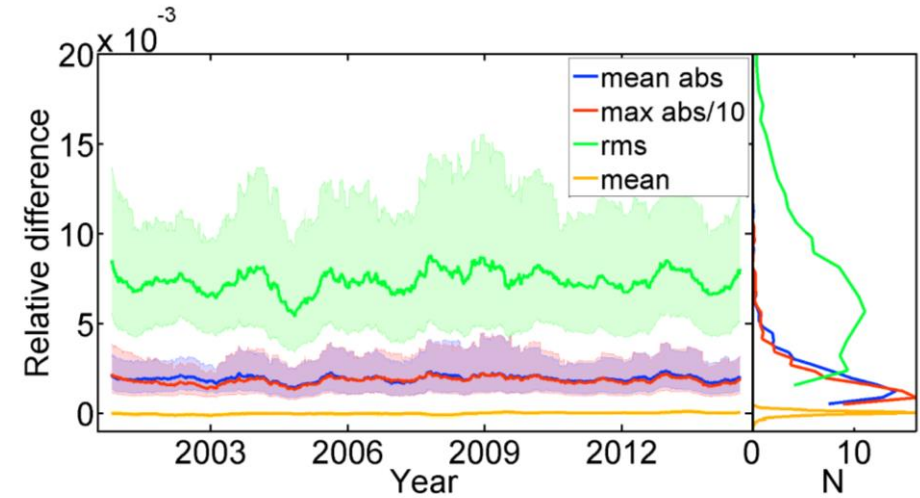


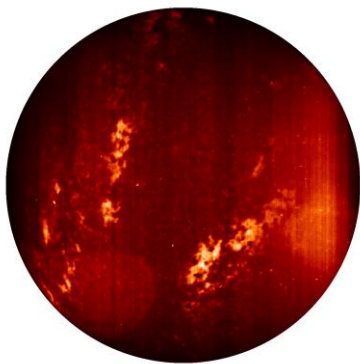
Image processing

Automatic process to:

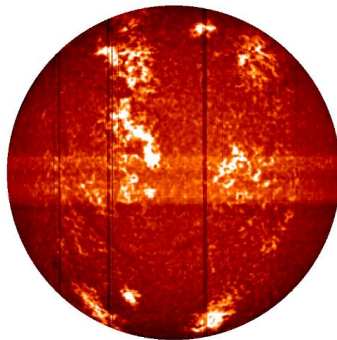
- Photometrically calibrate images
- Compensate for instrumental and physical effects

Evaluated method's accuracy with synthetic data

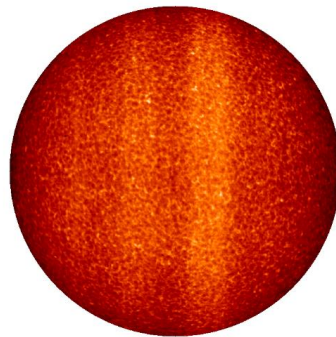
- Performs better than all other methods in the literature
- Works consistently with quite diverse data



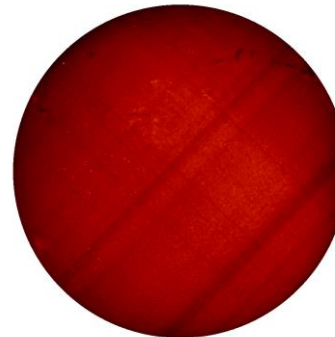
Kyoto Ca II K
17/04/1956



Arcetri Ca II K
16/05/1957



Kodaikanal Ca II K
23/09/1913



Kodaikanal H α
04/08/1965

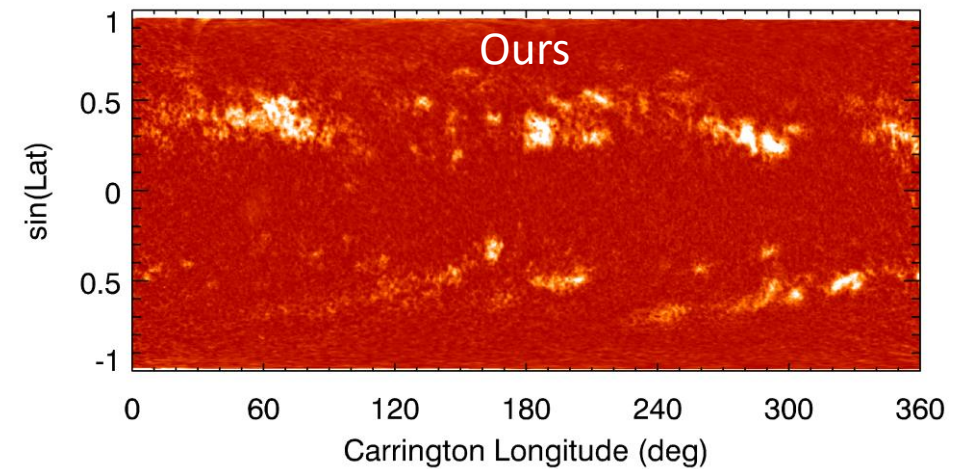
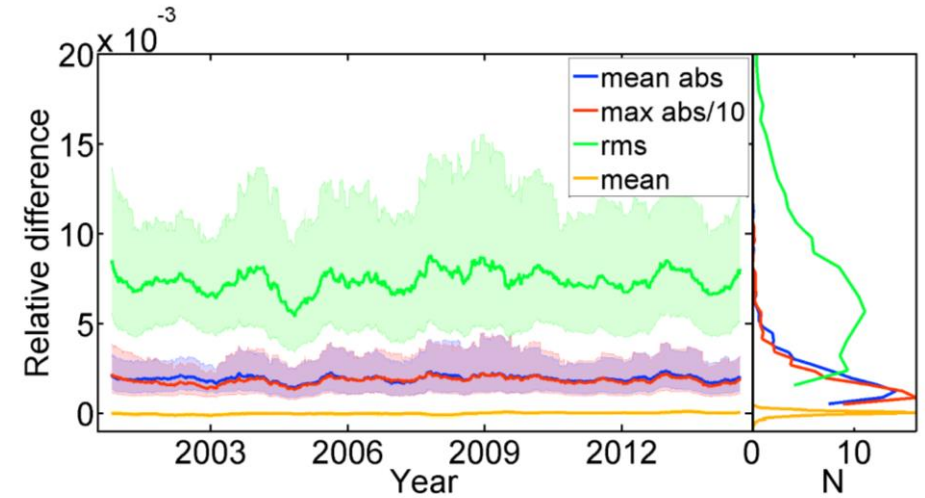


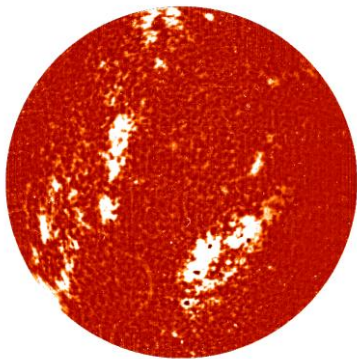
Image processing

Automatic process to:

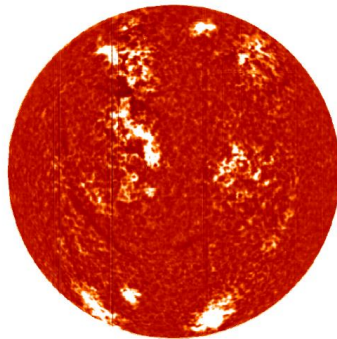
- Photometrically calibrate images
- Compensate for instrumental and physical effects

Evaluated method's accuracy with synthetic data

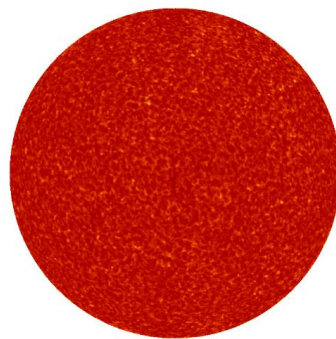
- Performs better than all other methods in the literature
- Works consistently with quite diverse data



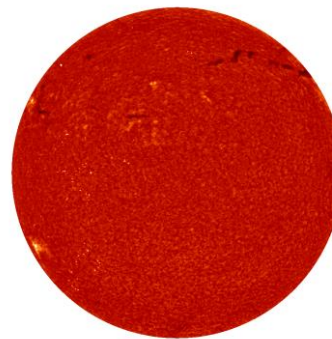
Kyoto Ca II K
17/04/1956



Arcetri Ca II K
16/05/1957



Kodaikanal Ca II K
23/09/1913



Kodaikanal H α
04/08/1965

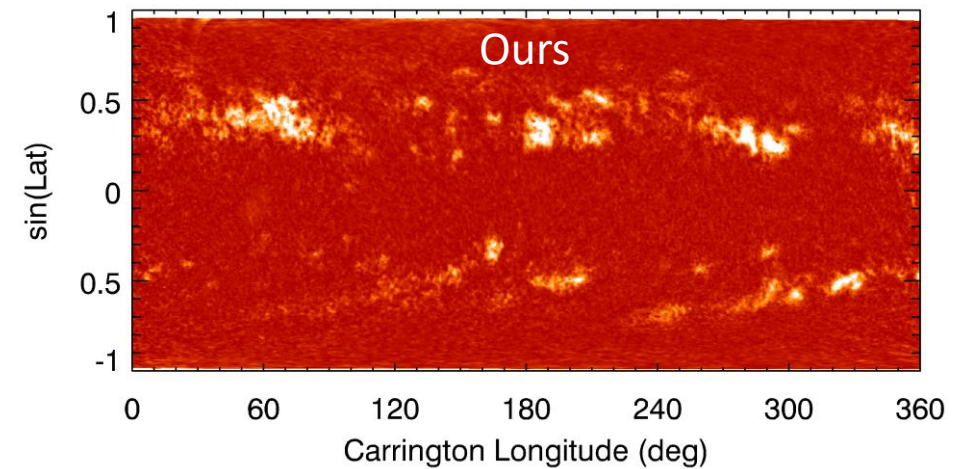
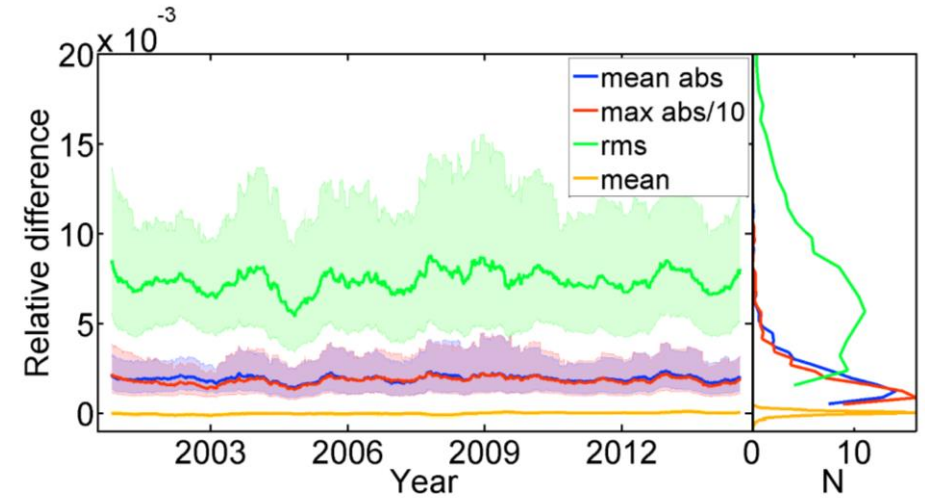


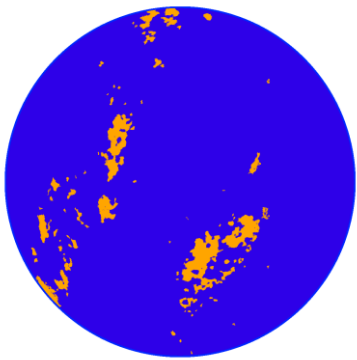
Image processing

Automatic process to:

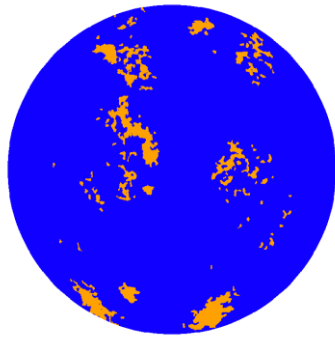
- Photometrically calibrate images
- Compensate for instrumental and physical effects
- Segment images to isolate plage regions

Evaluated method's accuracy with synthetic data

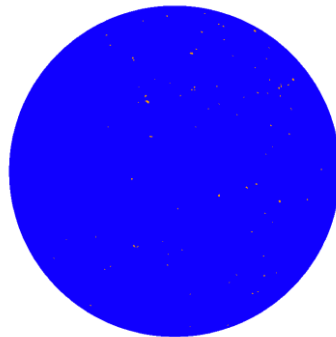
- Performs better than all other methods in the literature
- Works consistently with quite diverse data



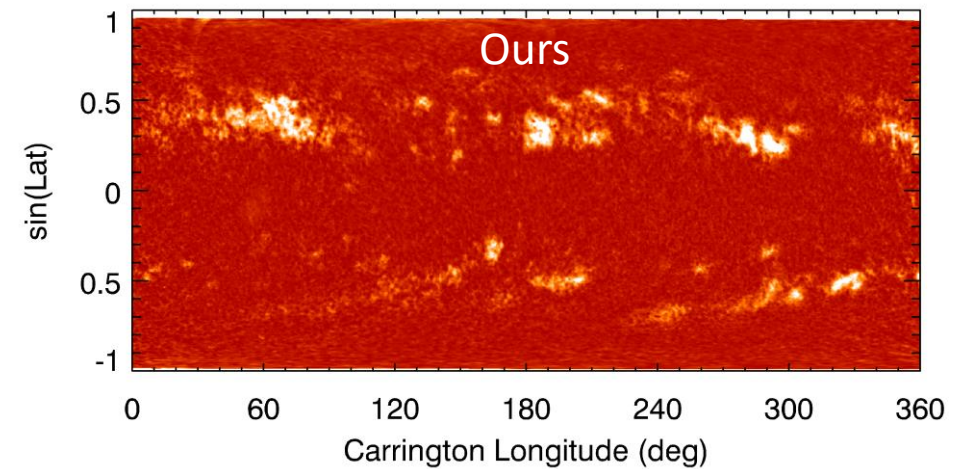
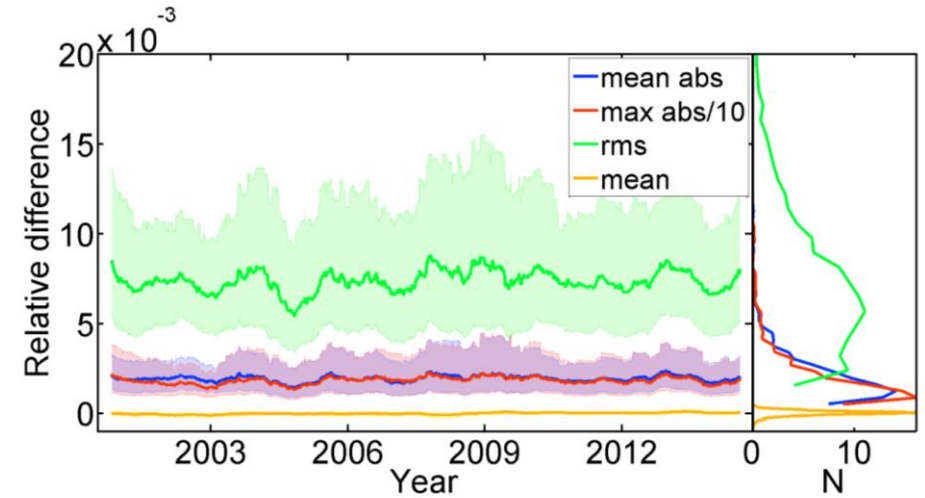
Kyoto Ca II K
17/04/1956



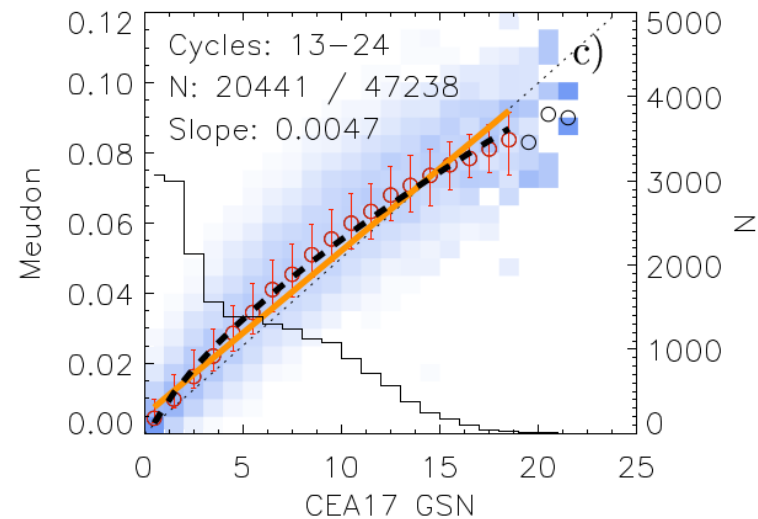
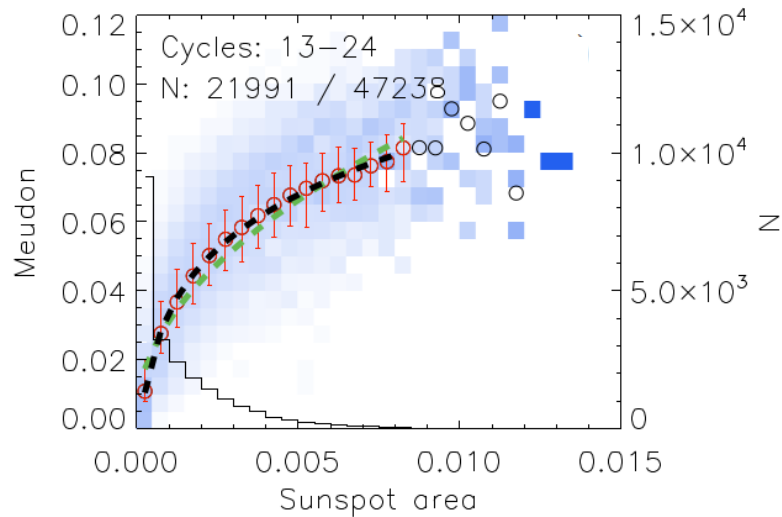
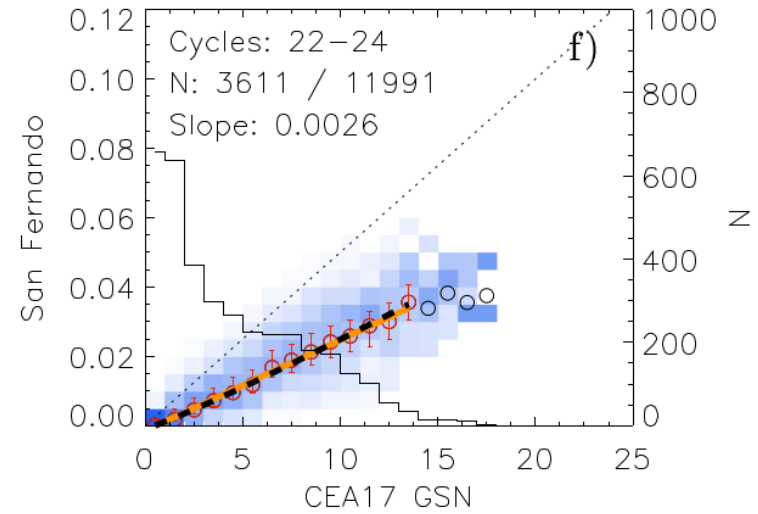
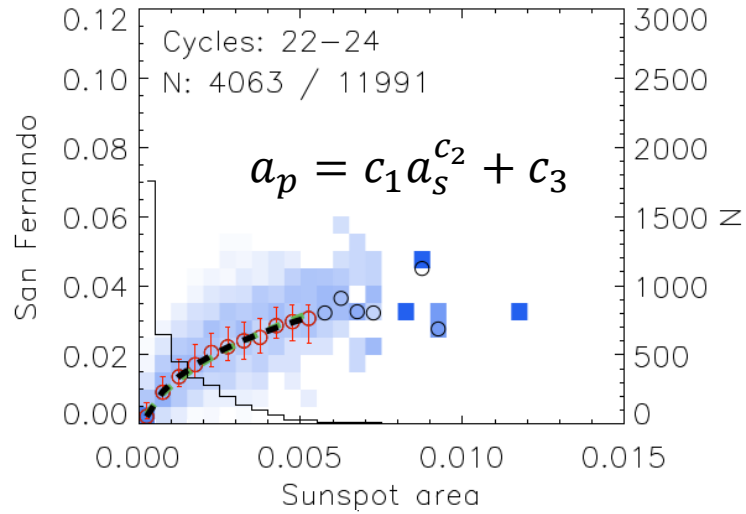
Arcetri Ca II K
16/05/1957



Kodaikanal Ca II K
23/09/1913

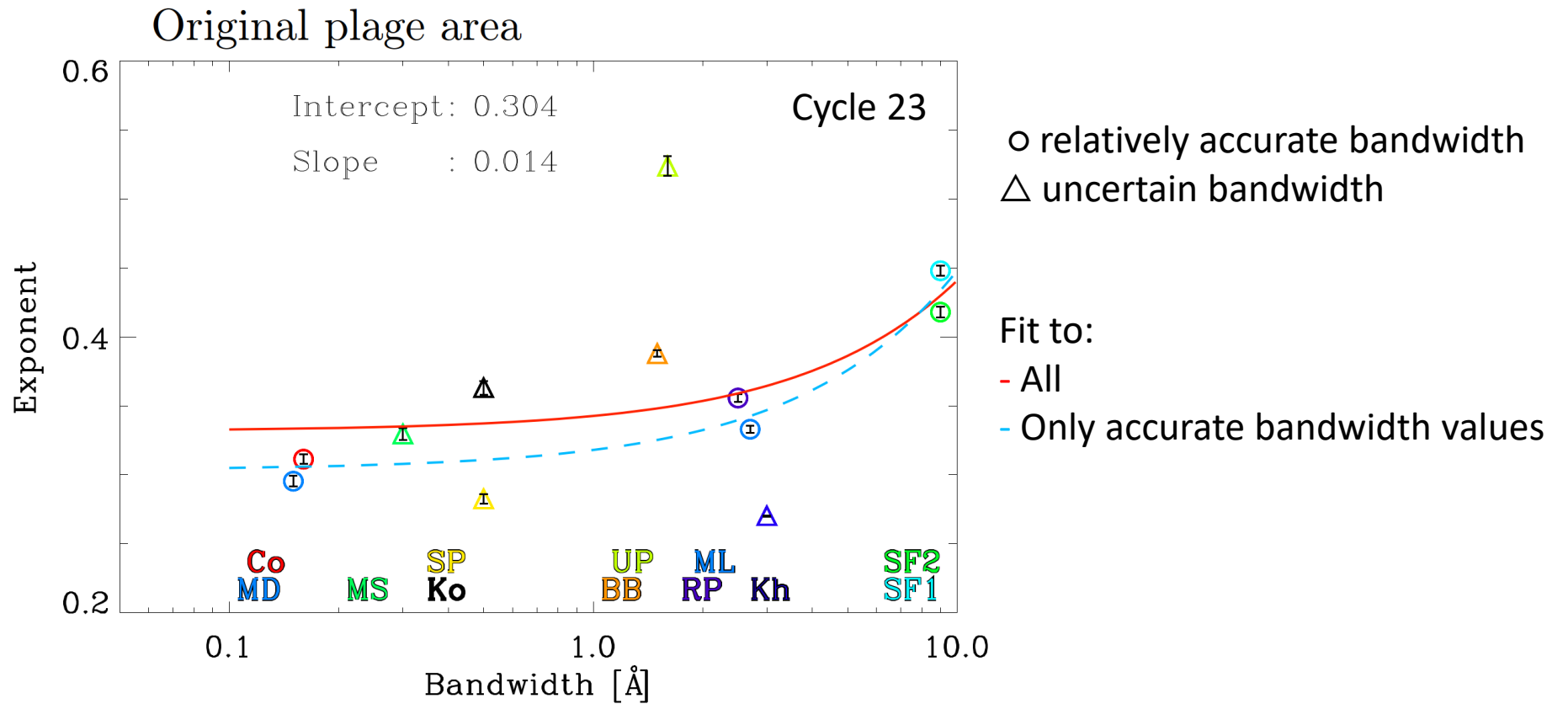


Relation between plage and sunspot data



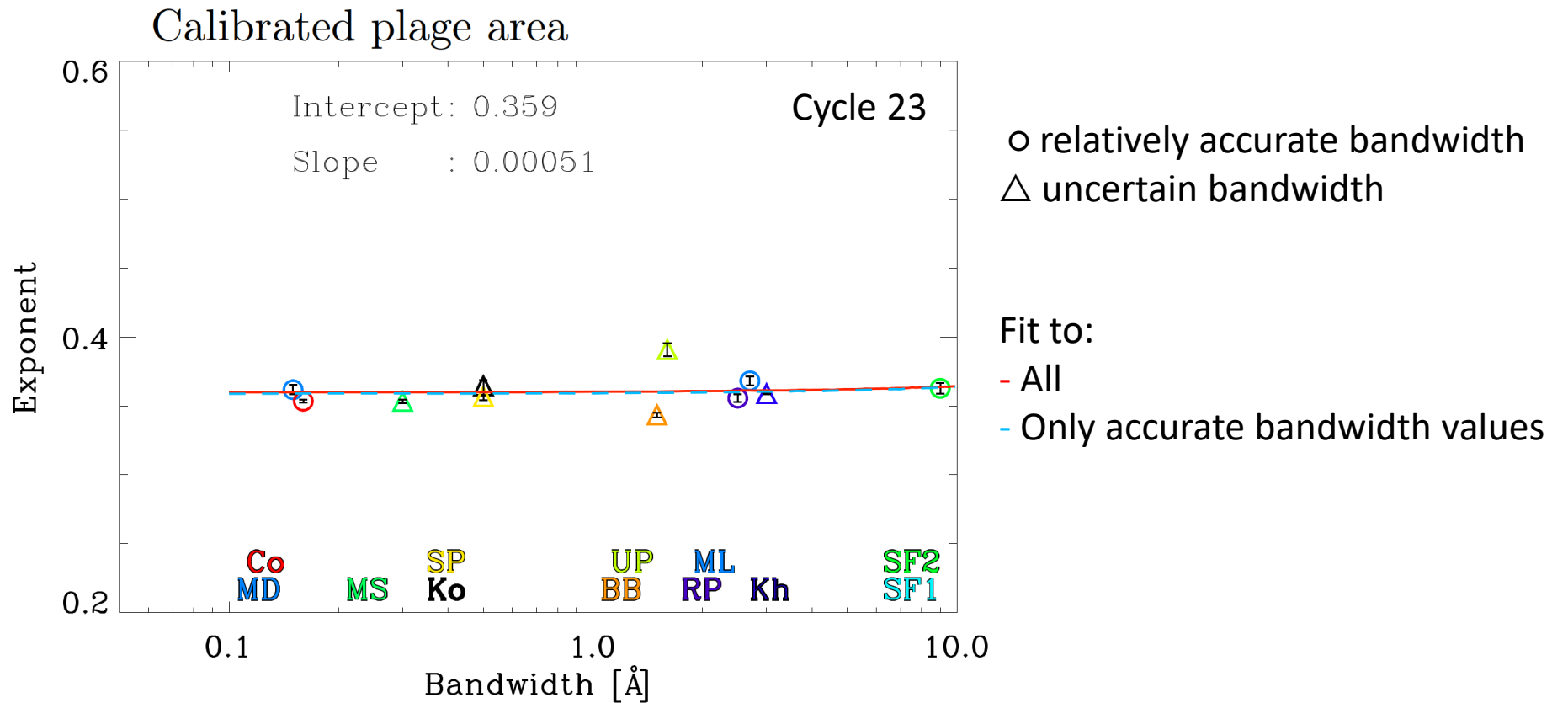
Dependence of relation on bandwidth

$$a_p = c_1 a_s^{c_2} + c_3$$

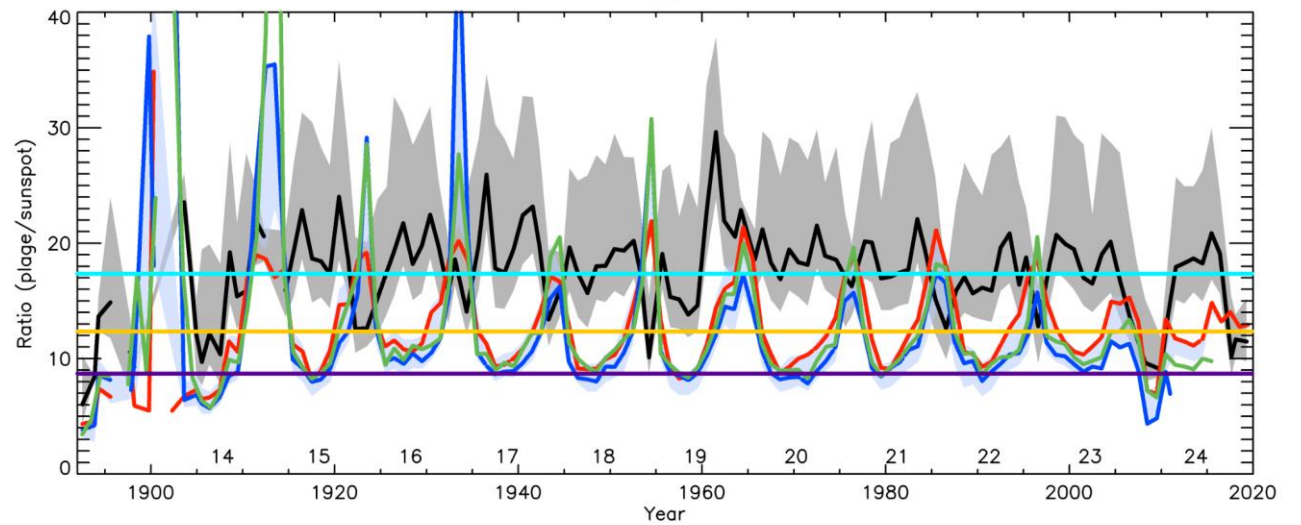
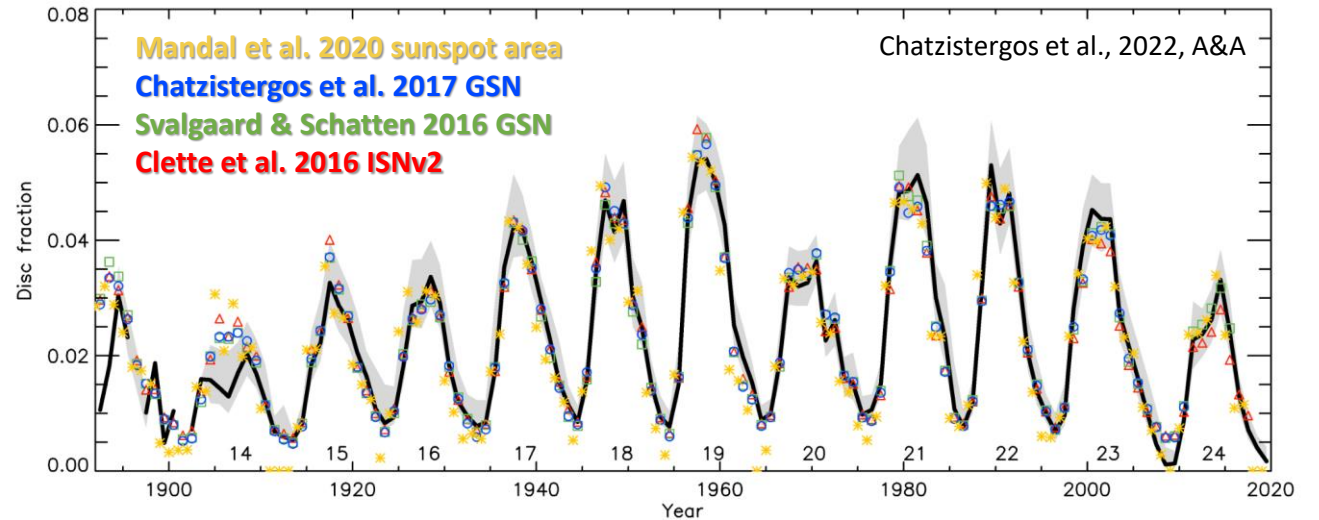
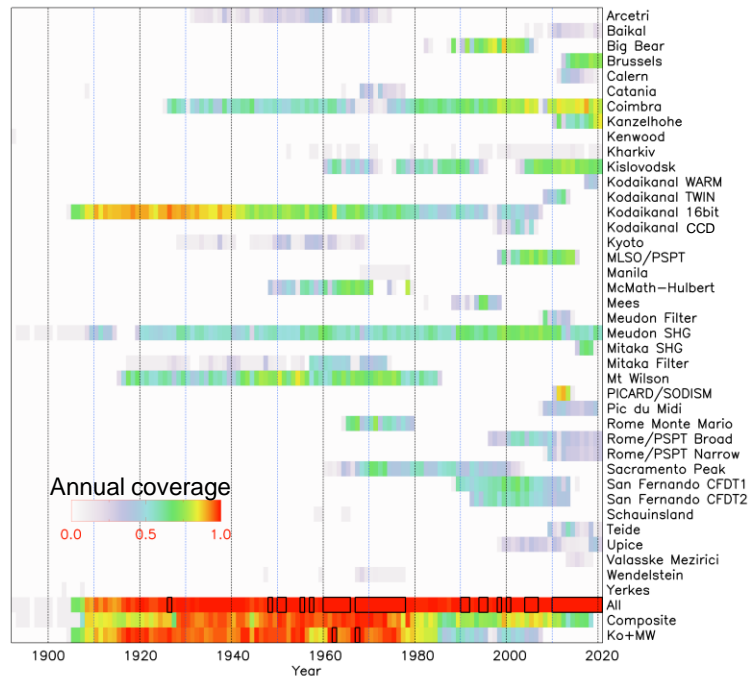


Dependence of relation on bandwidth

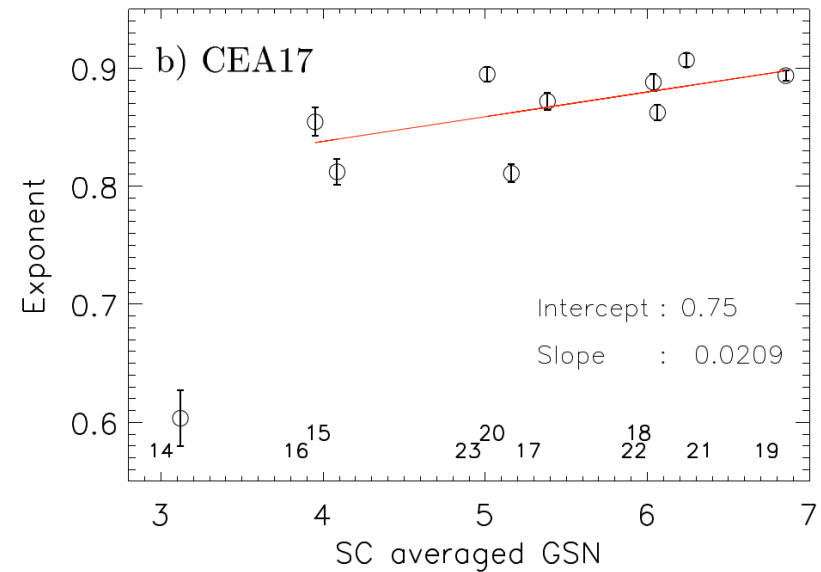
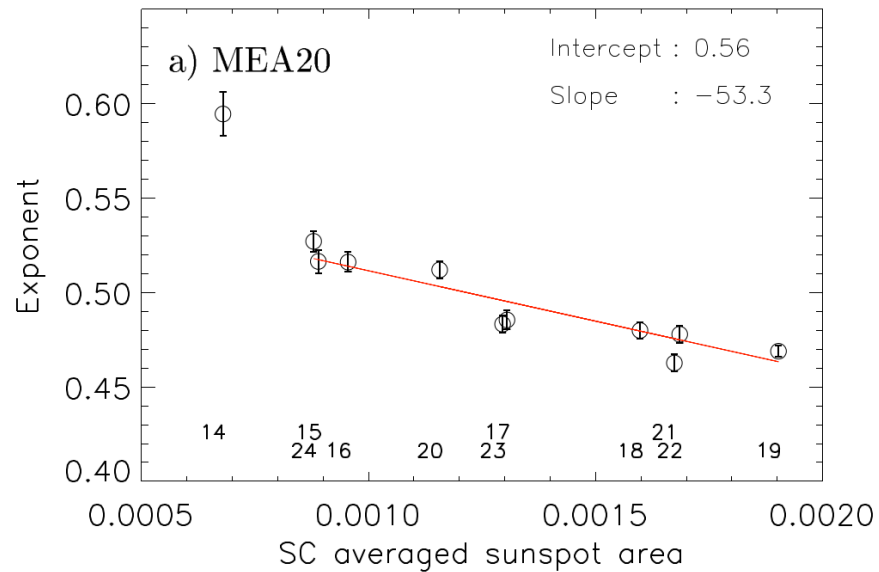
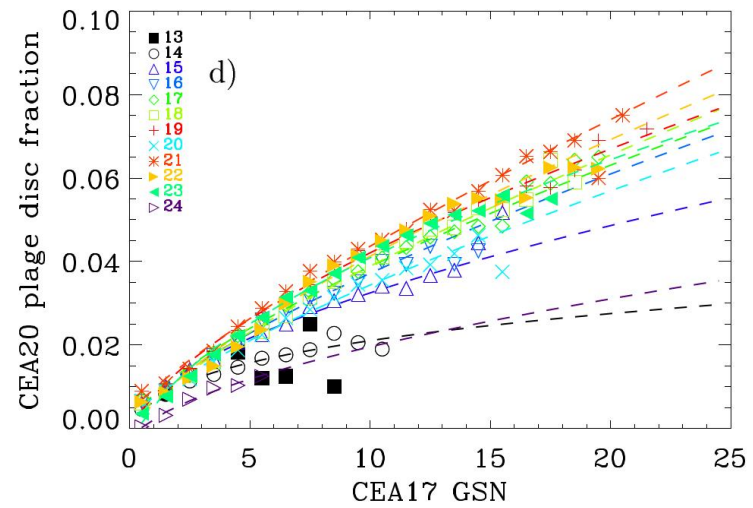
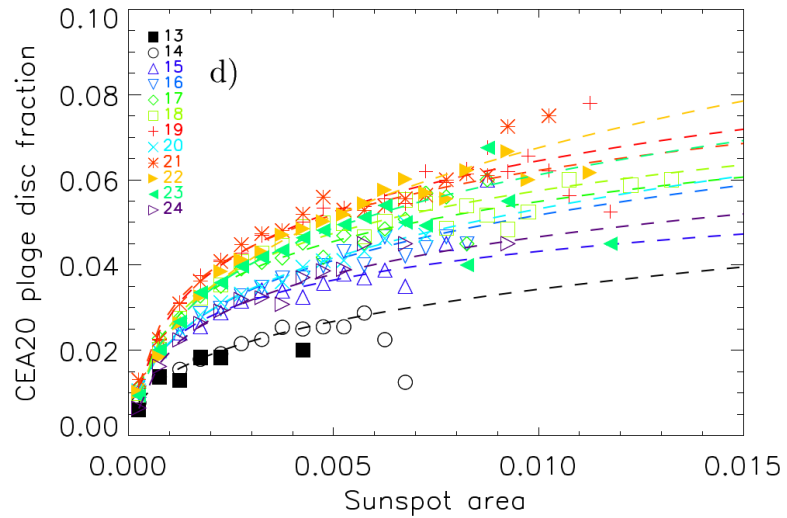
$$a_p = c_1 a_s^{c_2} + c_3$$



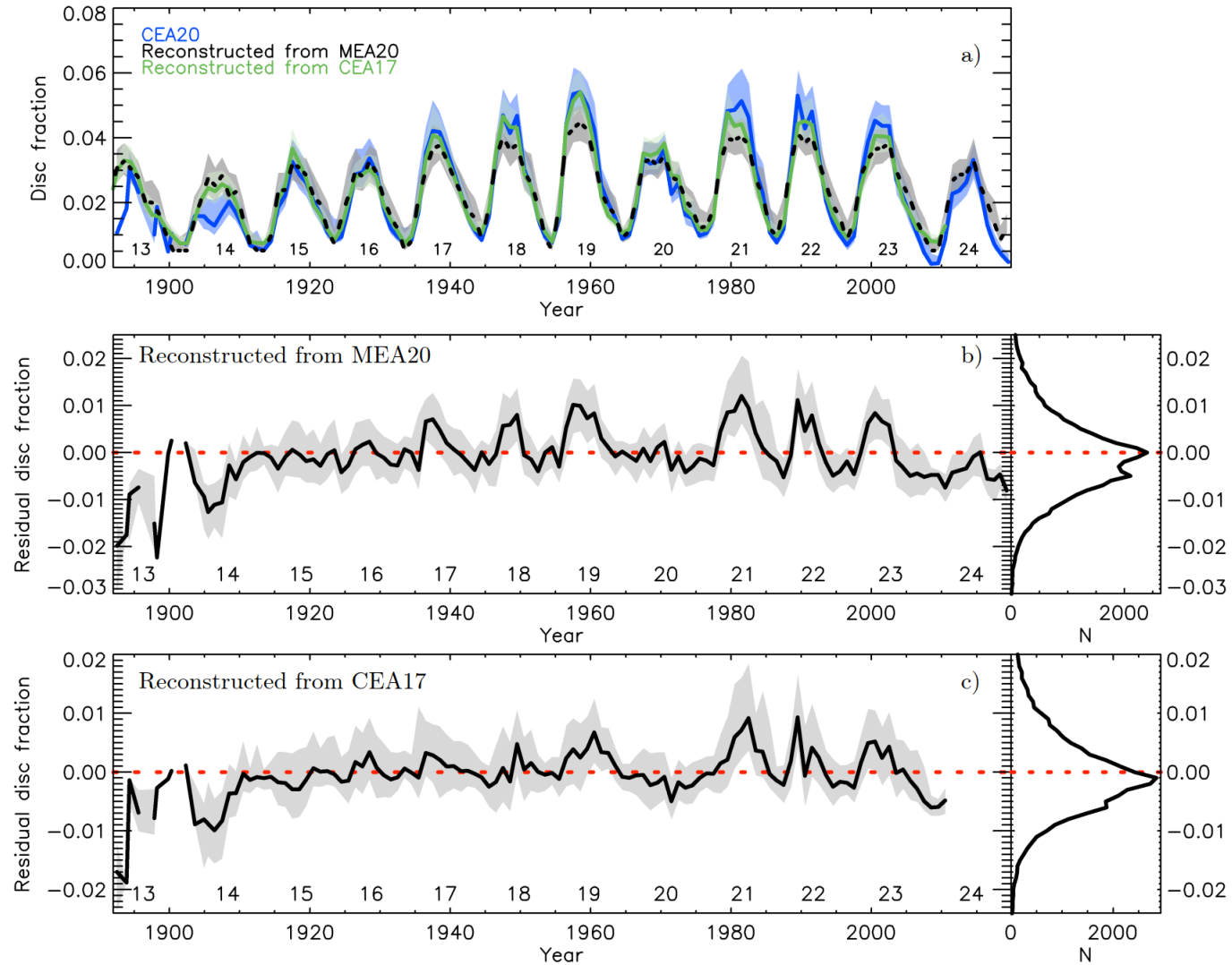
Plage area composite



Dependence of relation on cycle strength



Reconstructing plage areas from sunspots



Summary

- ▶ Ca II K observations are an extremely valuable, but largely unexplored, resource for irradiance studies
- ▶ We performed a comprehensive analysis of Ca II K observations
 - ▶ Produced the first plage area composite from 38 archives
 - ▶ Scrutinised the relationship between plage and sunspot areas
 - ▶ Depends on bandwidth of observations
 - ▶ Hints for dependence on activity level



Thank You