SLAM Meeting
14-Oct-2021

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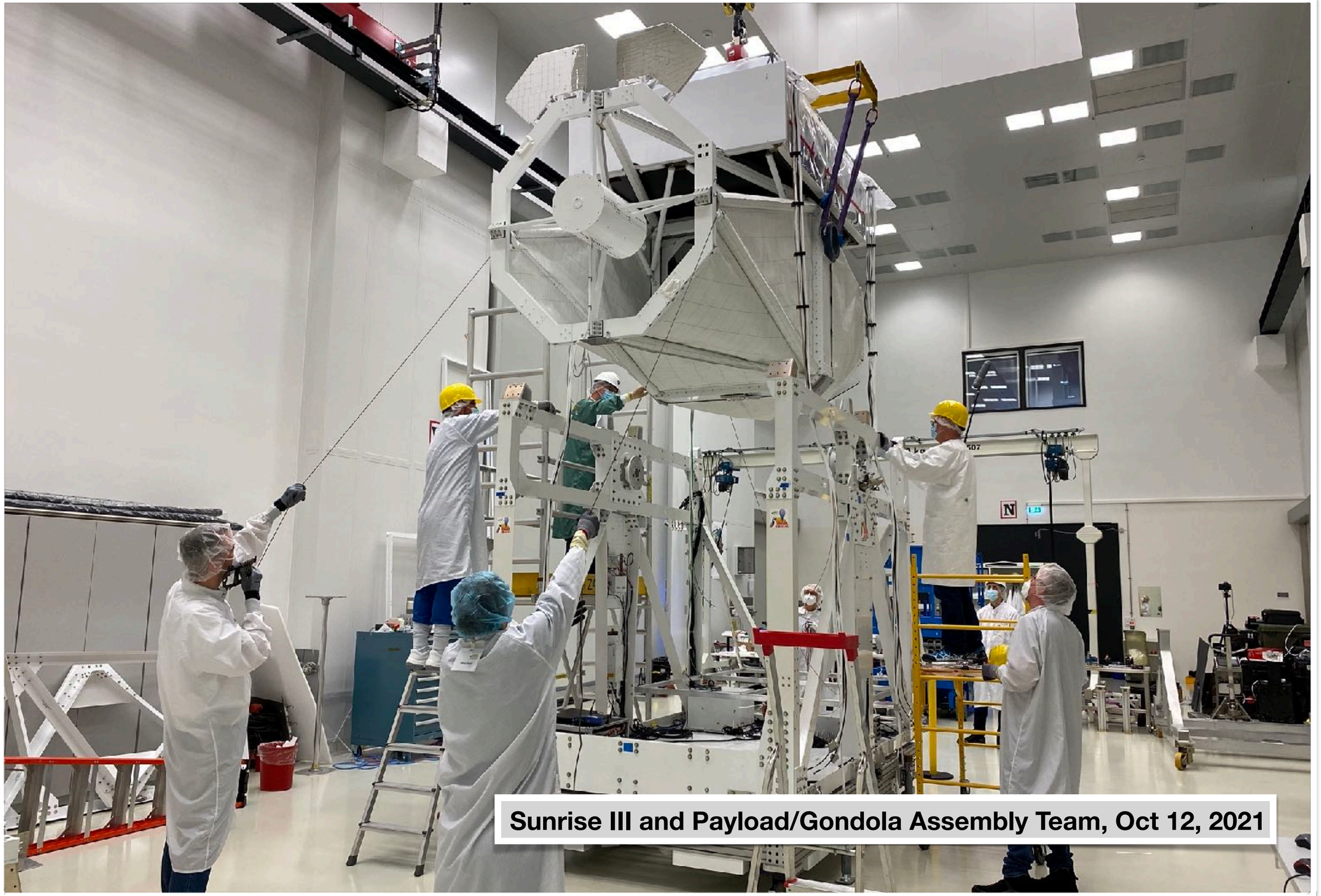
MPS & Aalto University

A quiet talk…



Sunrise III and Payload/Gondola Assembly Team, Oct 12, 2021

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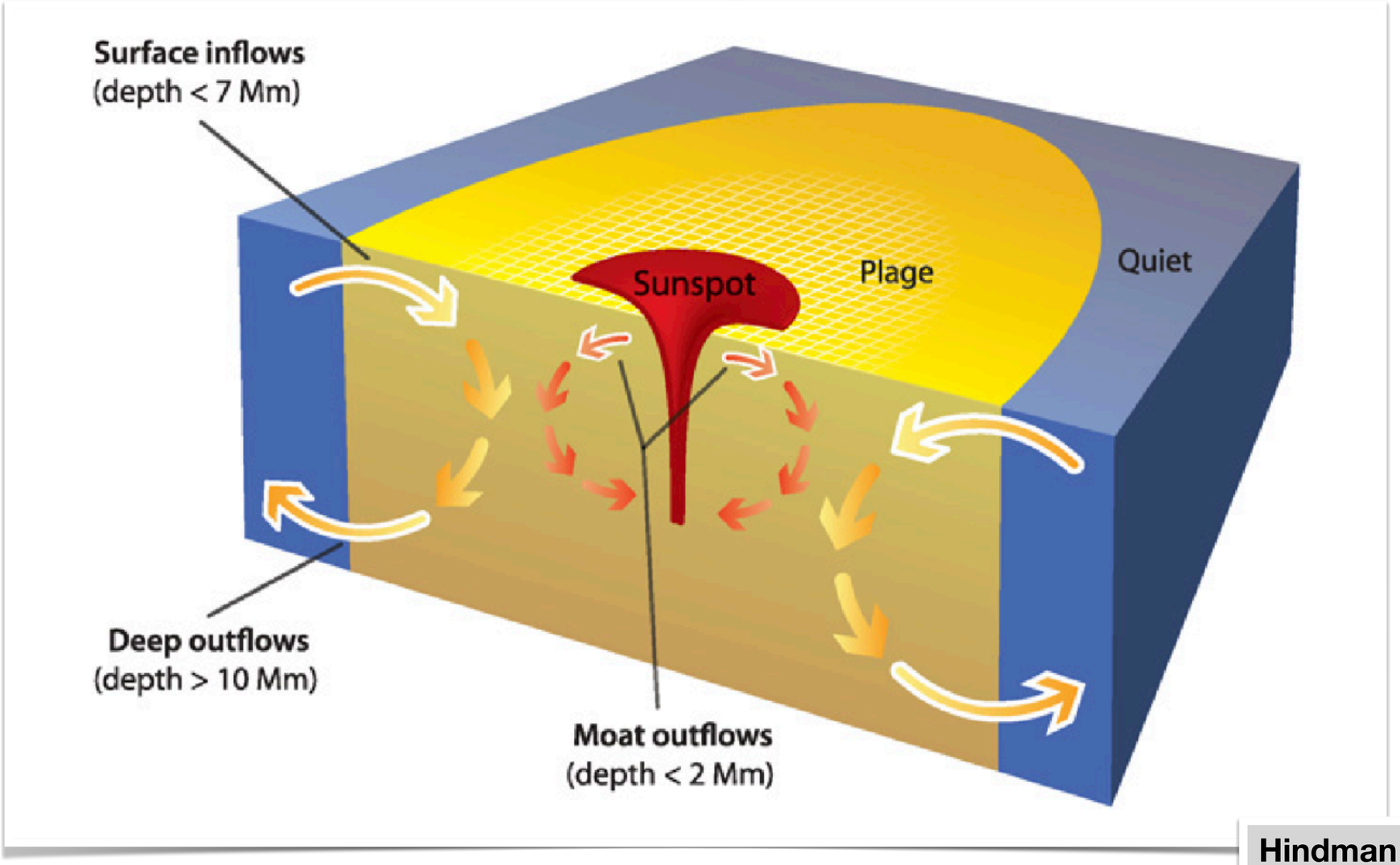
11 years of Quiet Sun

Motivation:

- SDO/HMI in orbit since 2010
- one solar cycle
- Question: Does the very quiet Sun vary with the activity cycle?

(‘waste product’ of joint project with Aalto University)

What is ‘quiet Sun’?

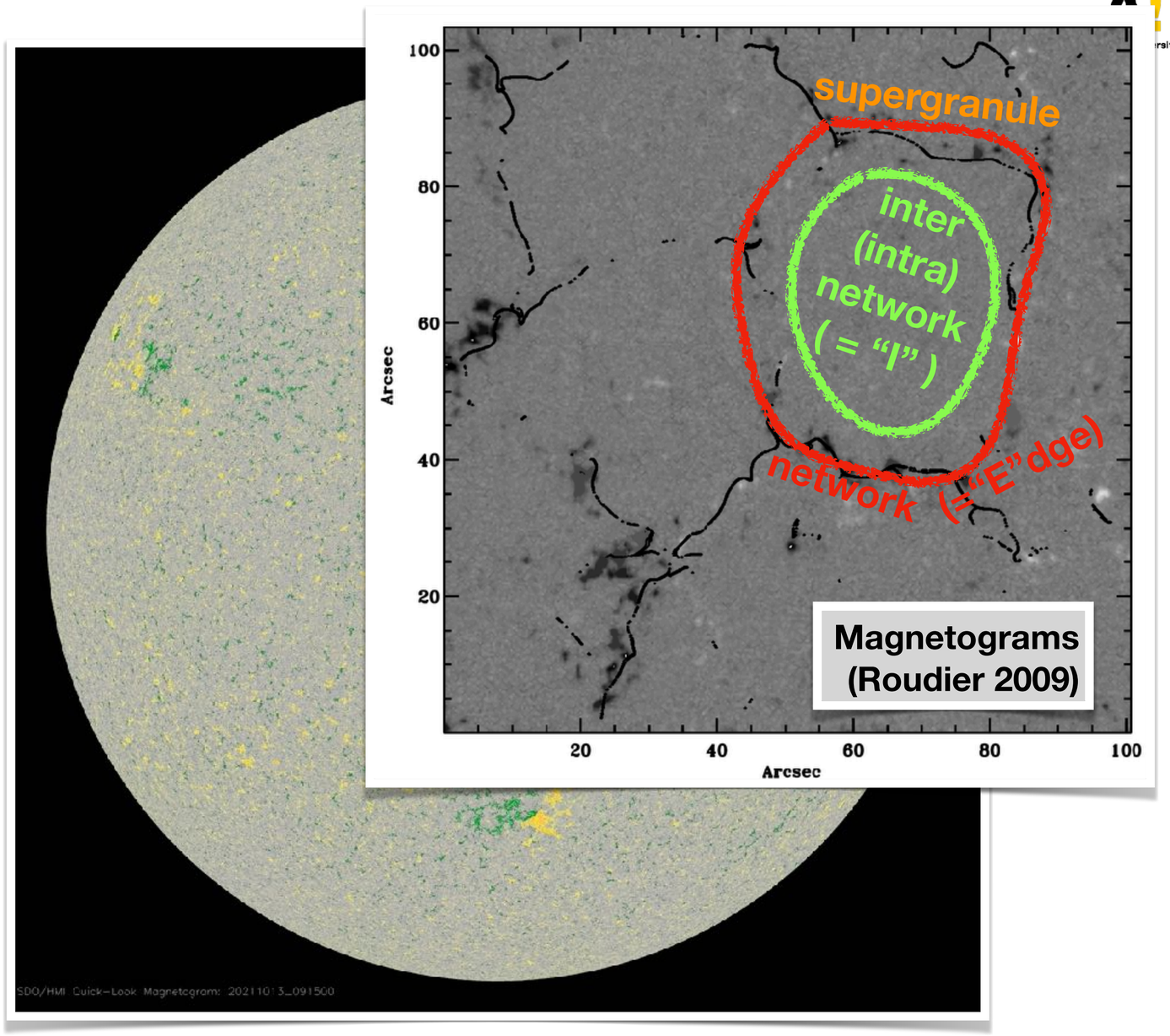


Hindman et al., 2009

What is ‘quiet Sun’?

- Granules
  - 1 Mm, 10’
- Mesogranules
  - 6 Mm, 3-6 h
  - ghost feature?
- Supergranules
  - 30 Mm, 2 days

Quiet Sun =
Network (“E”dges)
+ Internetwork (“I”nterior)
= Supergranular cell



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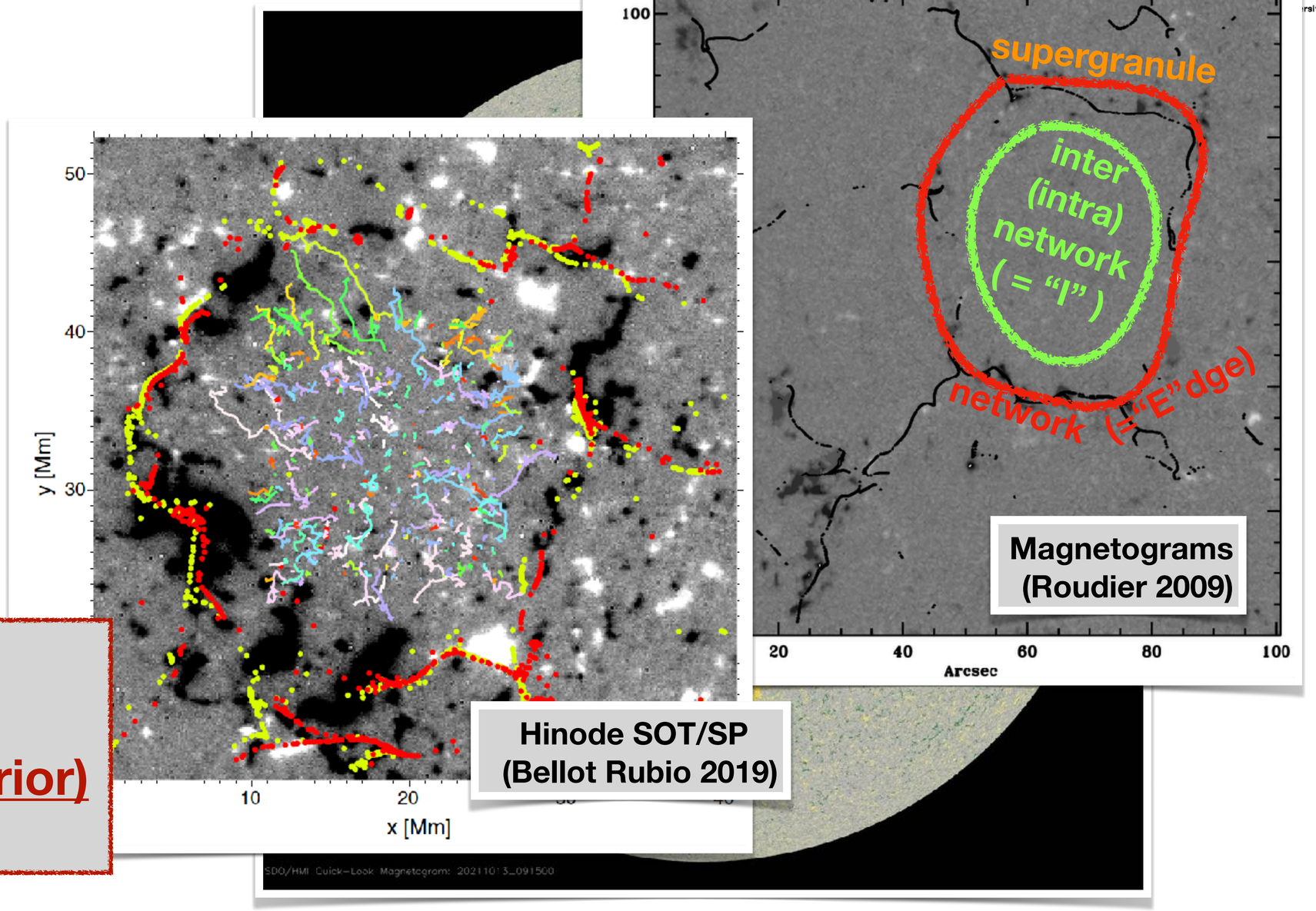
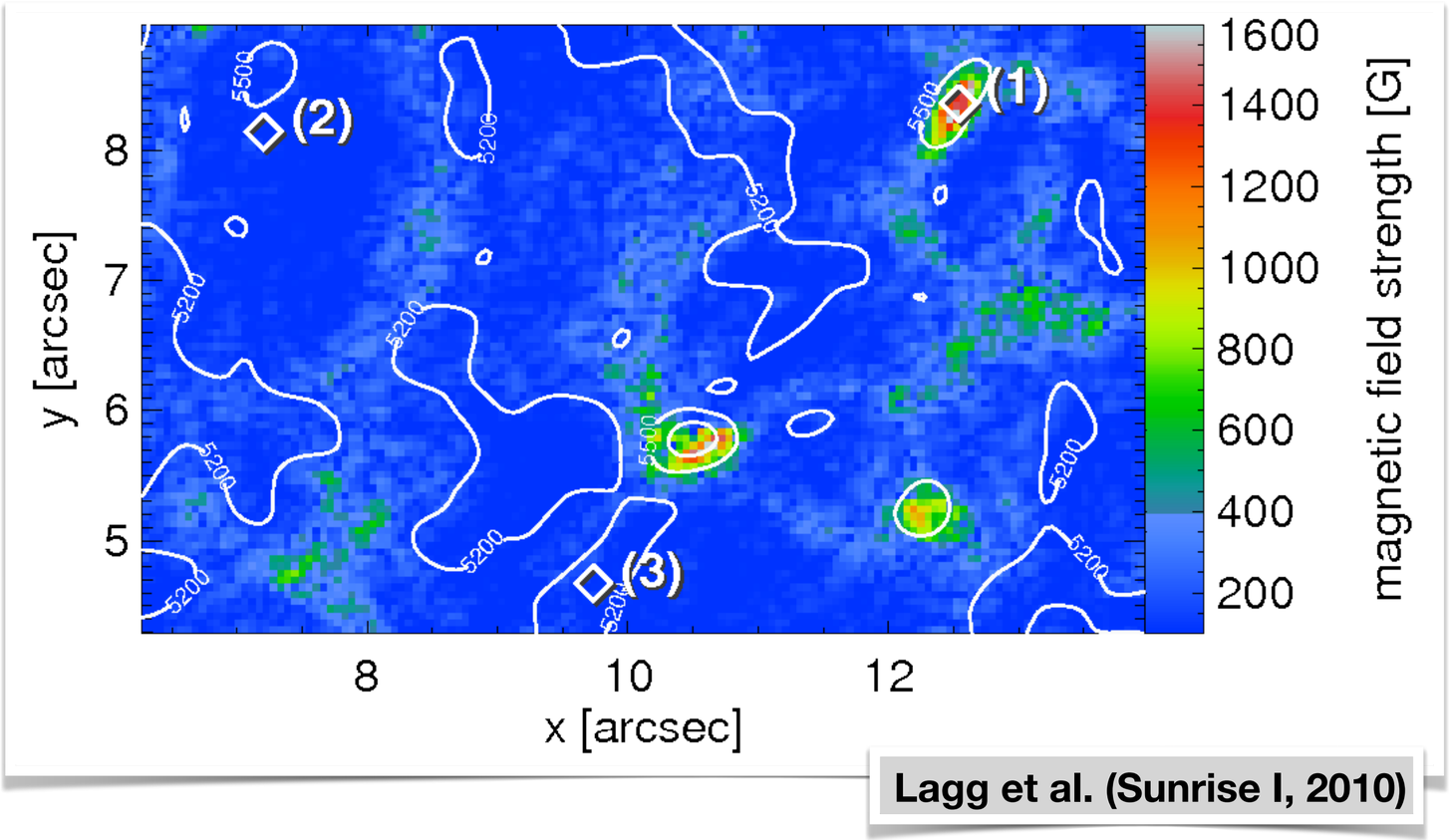


Quiet Sun and Solar Activity

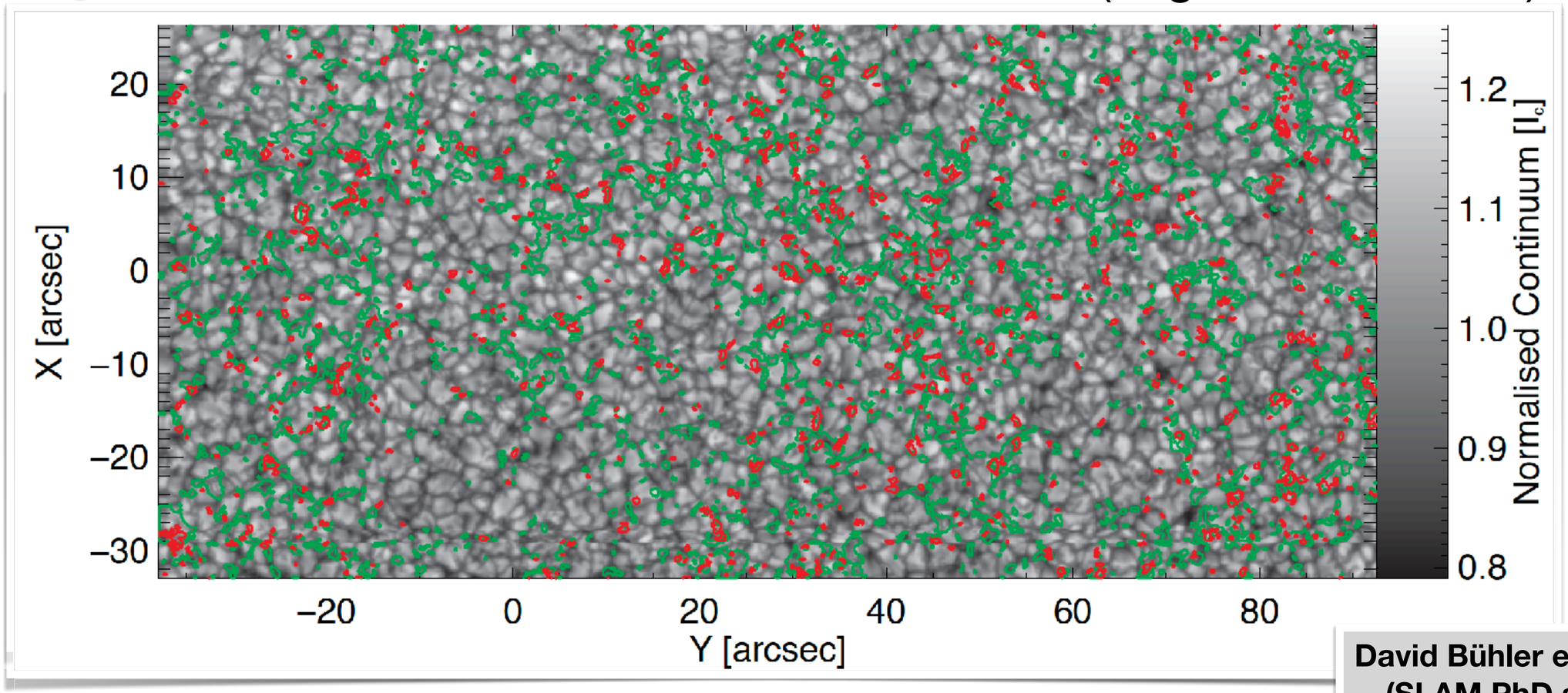
- Quiet = not affected by ARs - so why shall it then vary?
- Quiet Sun is magnetic: kilo-Gauss flux concentrations!
- Where does B come from?
  - small scale dynamo? **—> no 11-yr variation**
  - tangling of large scale flux? **—> 11-yr variation**



Lagg et al. (Sunrise I, 2010)

Previous Studies: hi-res

- Study using high-res Hinode data: 2007 - 2012
- careful consideration of instrumental effects (degradation, focus)



David Bühler et al. 2012 (SLAM PhD student)

Previous Studies: hi-res

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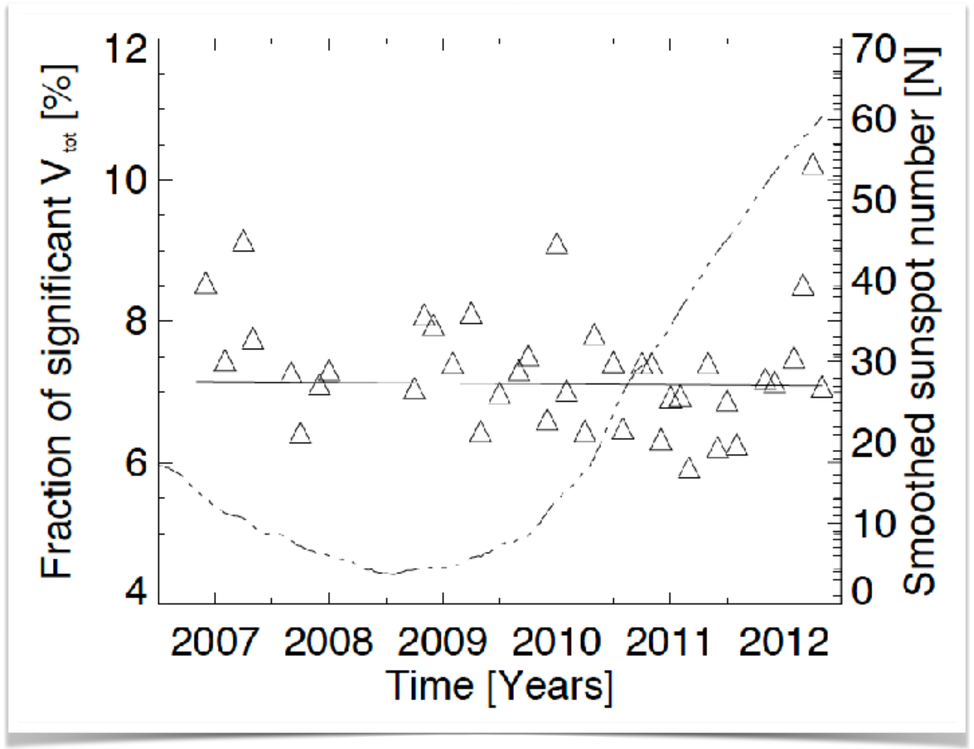
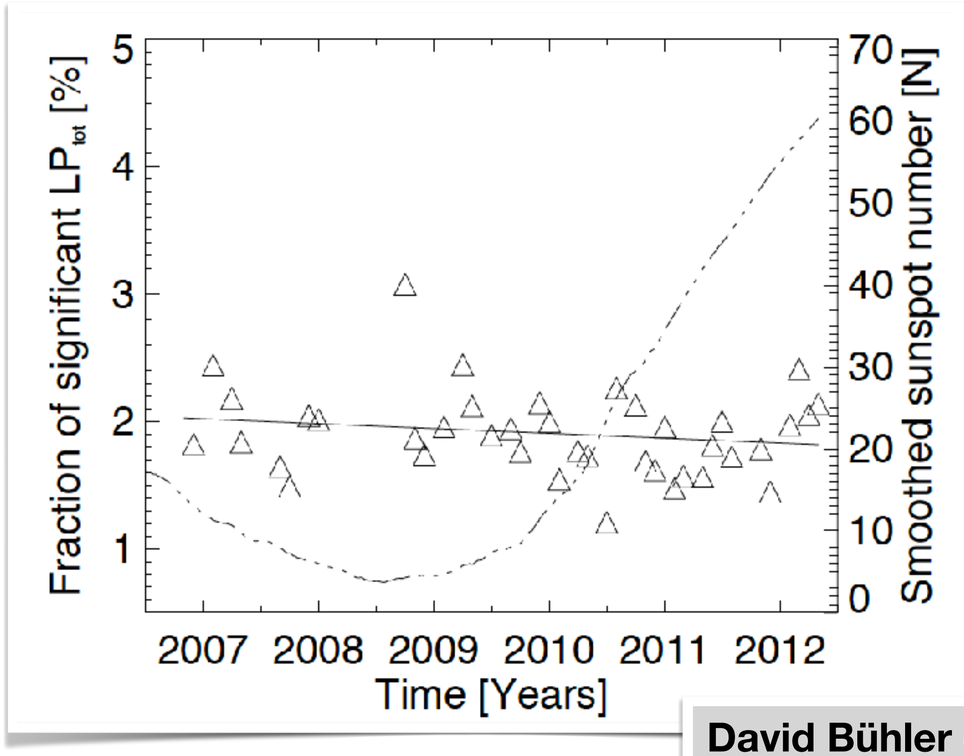
- no variation in vertical & horizontal fields





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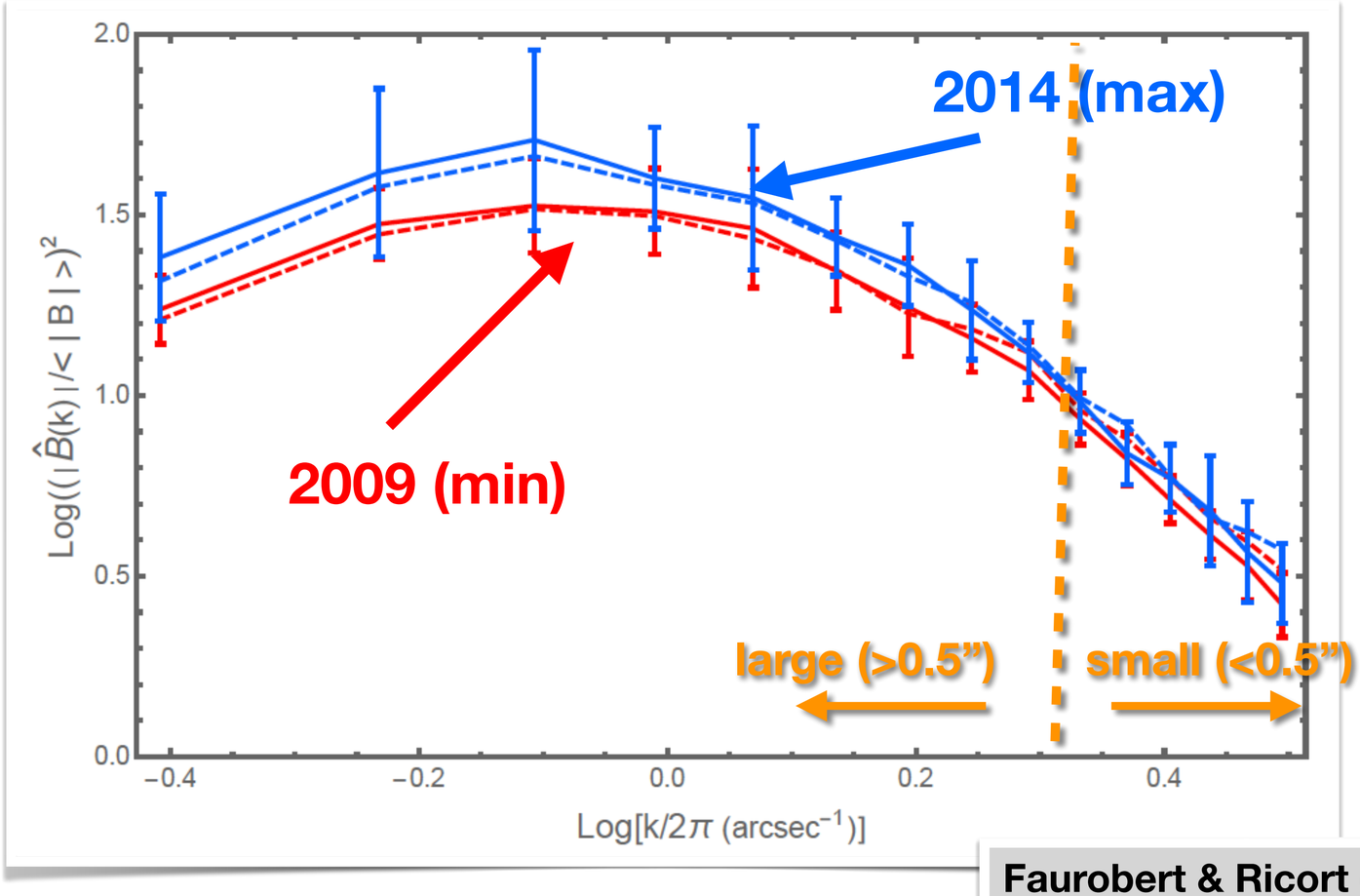
Previous Studies: hi-res

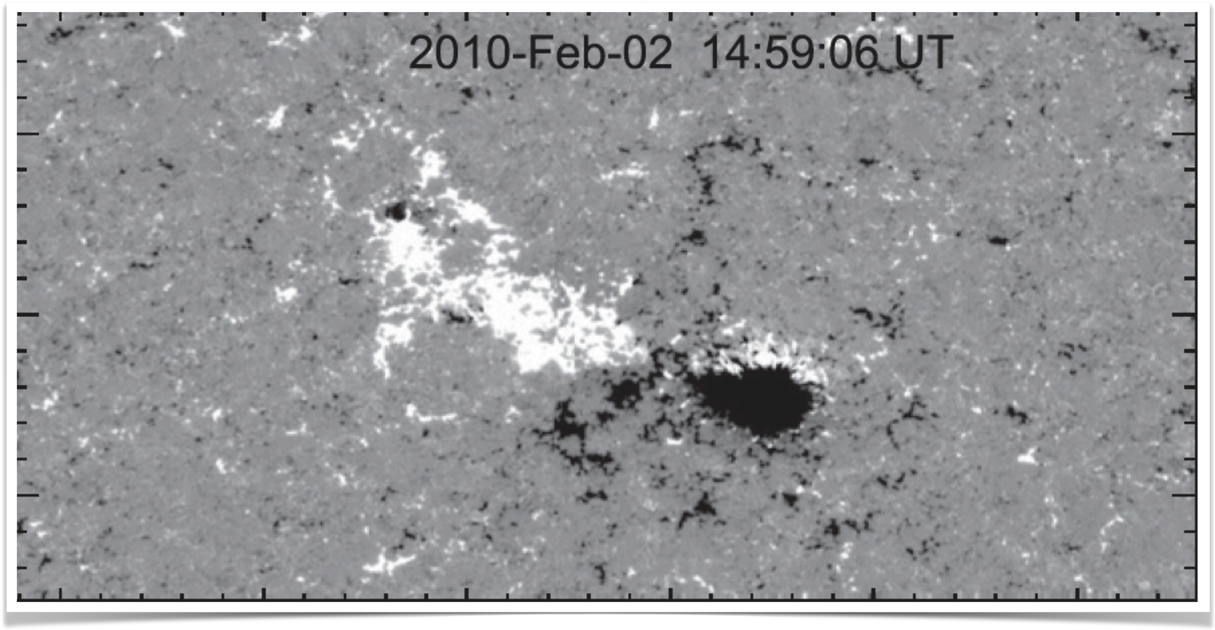
- equator to pole spectral analysis of the spatial fluctuations in magnetic flux density (2008 - 2016)
- only internetwork regions of quiet Sun
- no significant solar cycle dependency for all scales at equator

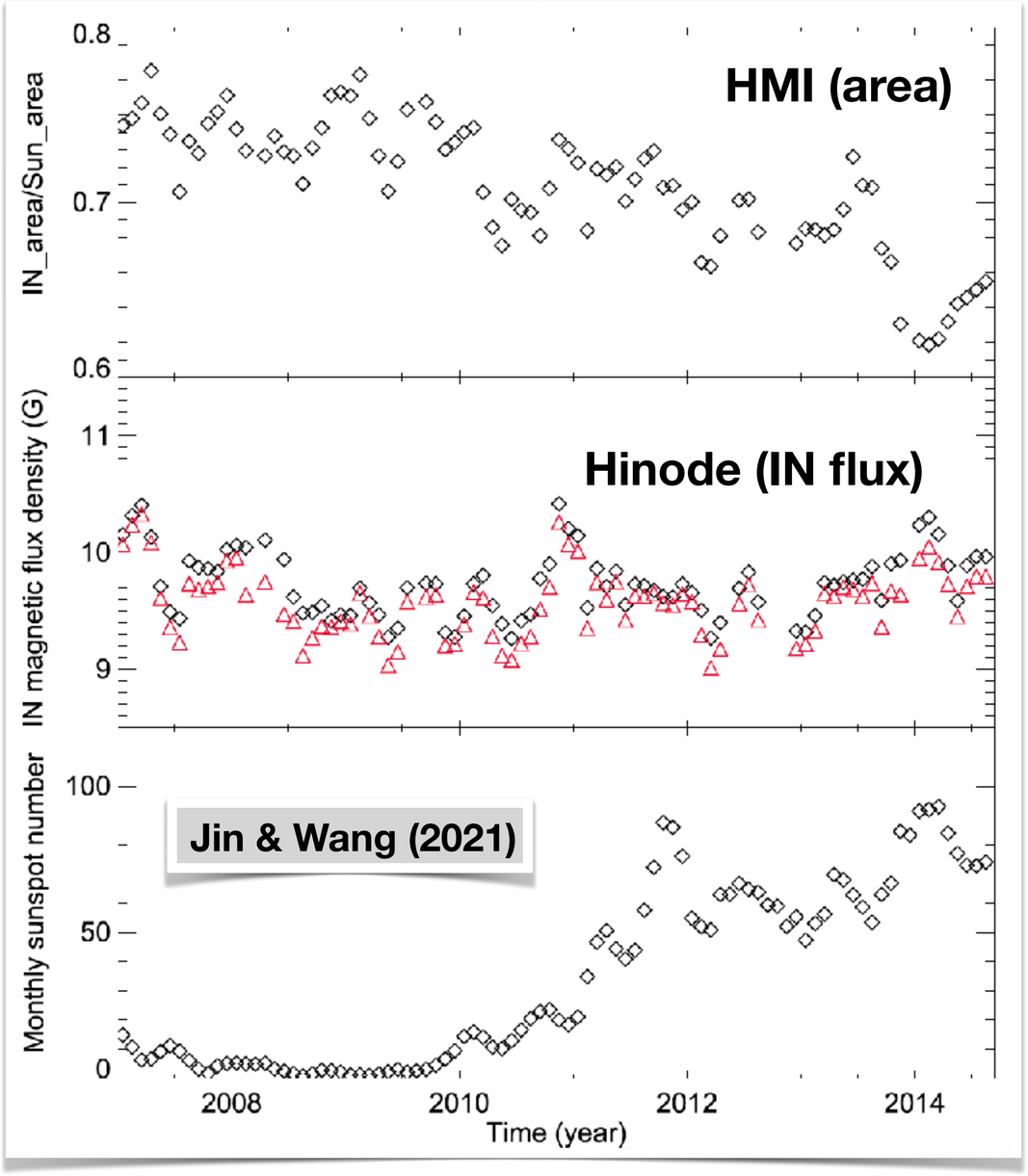


Faurobert & Ricort (2021)

Previous studies: Hinode + HMI

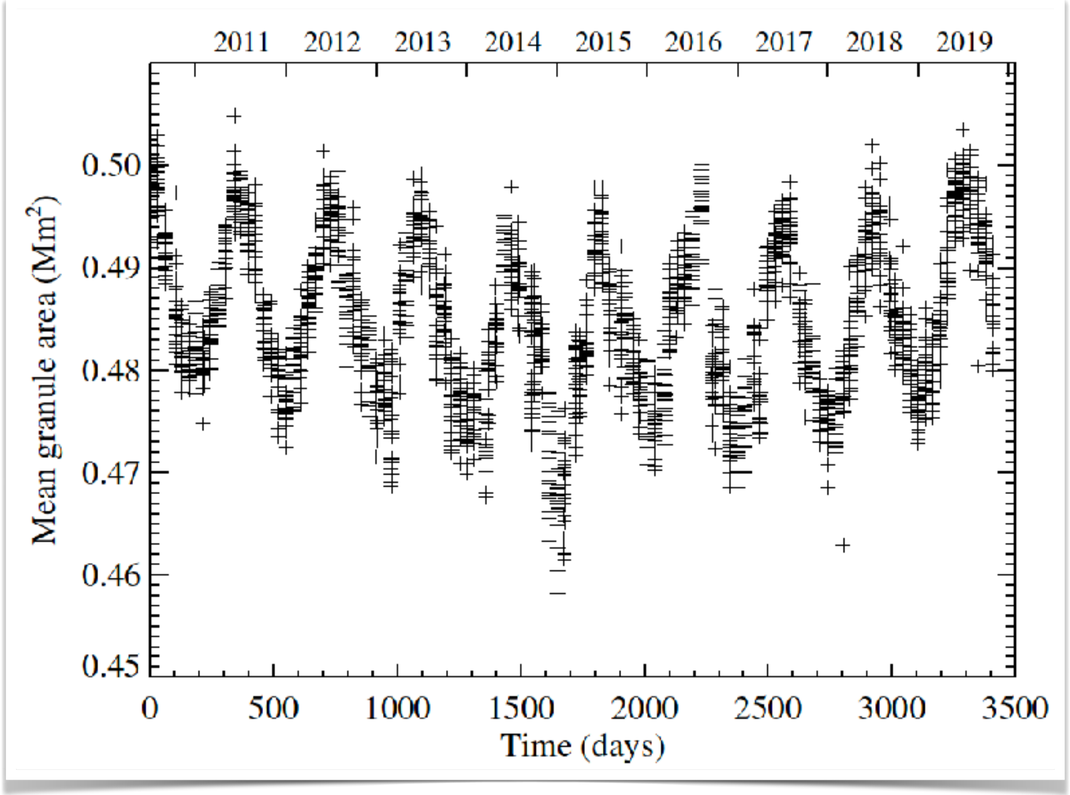
- based on masking of SOT/SP maps
- decrease of internetwork area form 2007 to 2014
- no variation of internetwork magnetic flux density

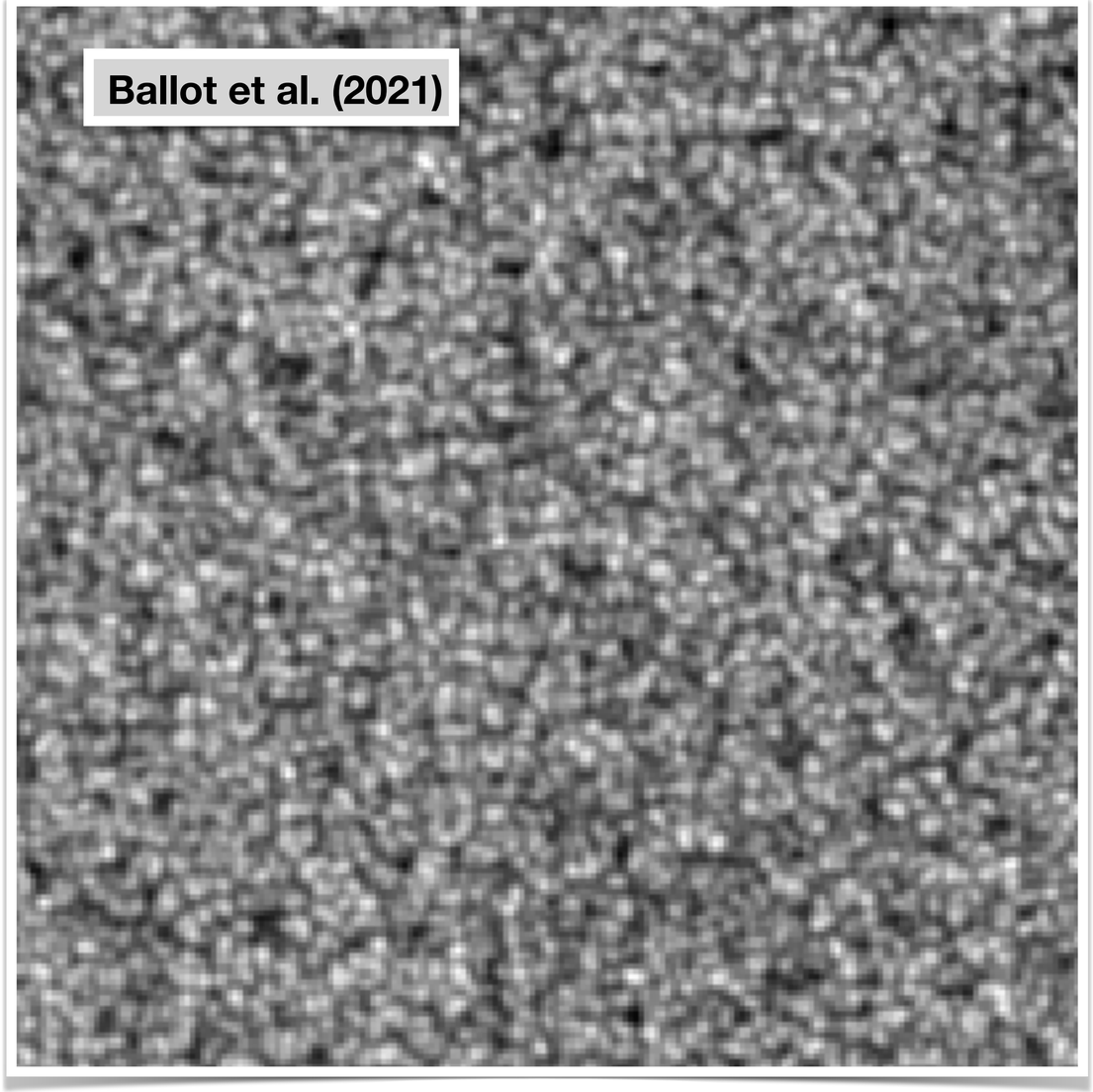




Previous studies: Hinode + HMI

- investigation of granular size (HMI data: deconvolution - thresholding)
- measurement at disk center, network and internetwork (“E” and “I”)
- 2% smaller granules during solar maximum





Previous Studies: summary

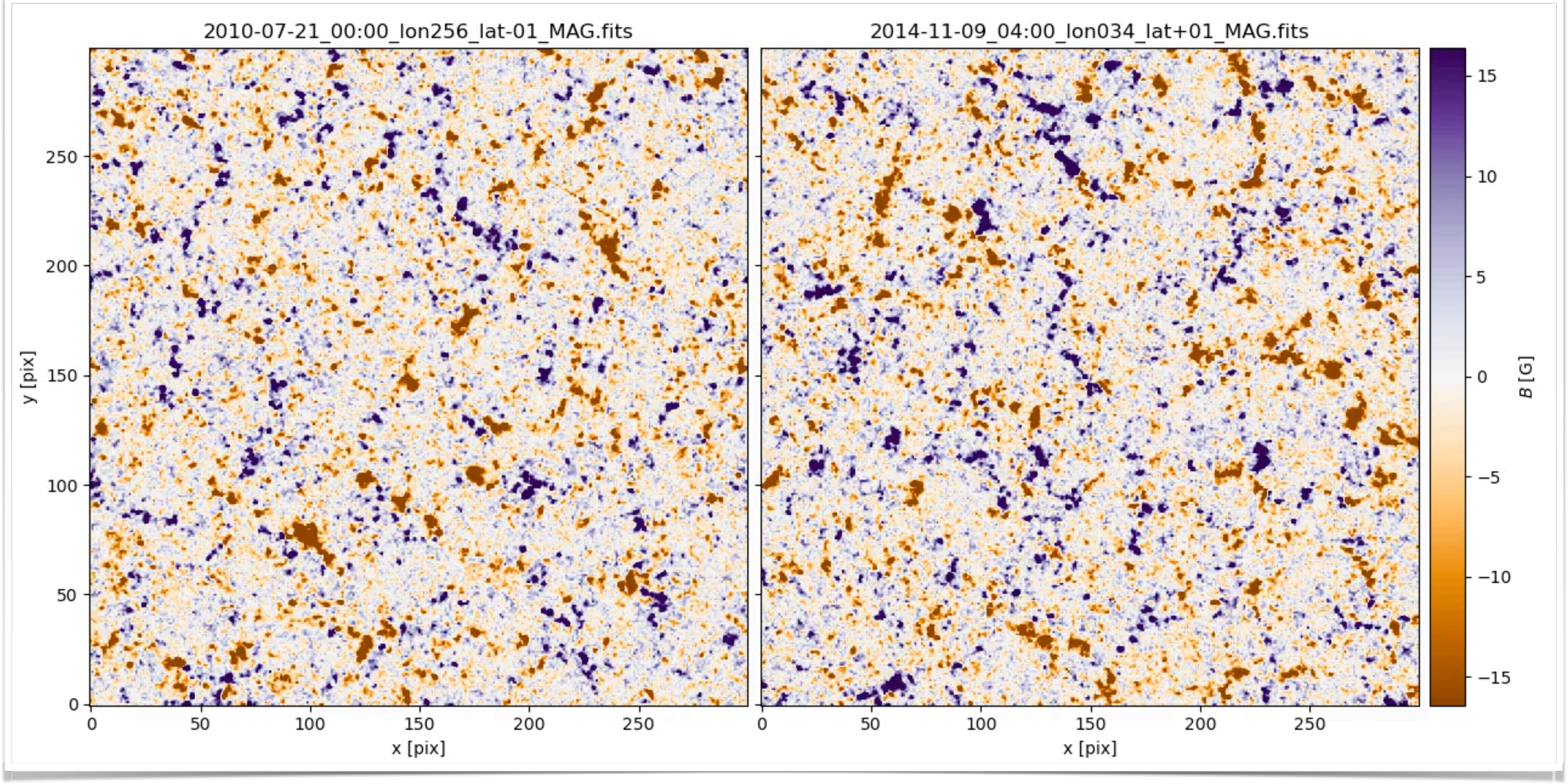
Observational facts:

- internetwork: no change with solar activity level
- network area larger at solar maximum
  2 explanations:
  - smaller super granulation?
  - ‘thicker’ network at super granular boundaries?
- granular size: smaller at solar maximum
  2 explanations:
  - smaller granules everywhere?
  - “E”:”I” (network : internetwork) ratio?
    (granules are smaller on network)

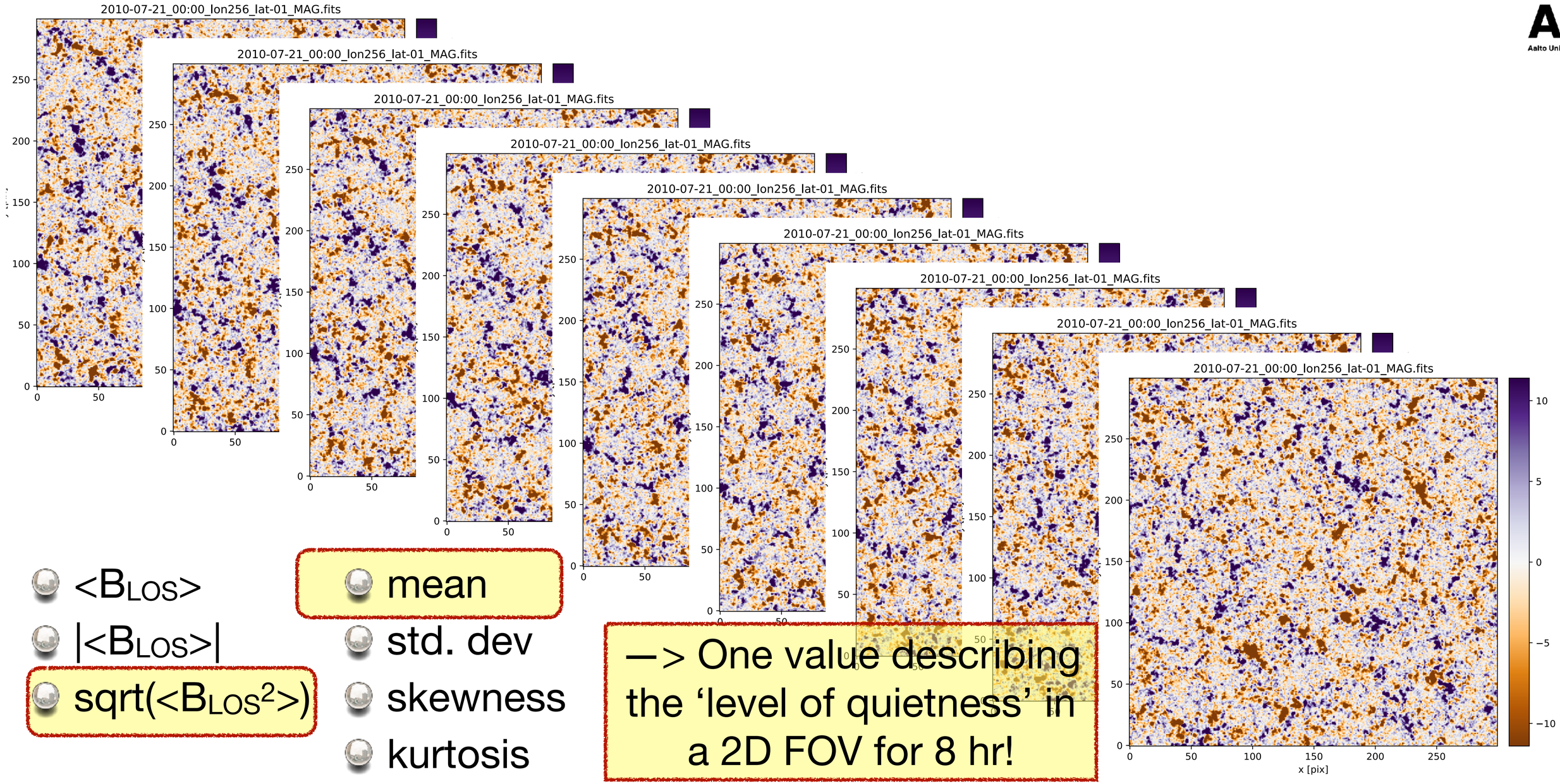
New Study: selection & temporal evolution

Quiet Sun at disk center:

@solar minimum **@solar maximum**



compute statistics over 8hr 2D map



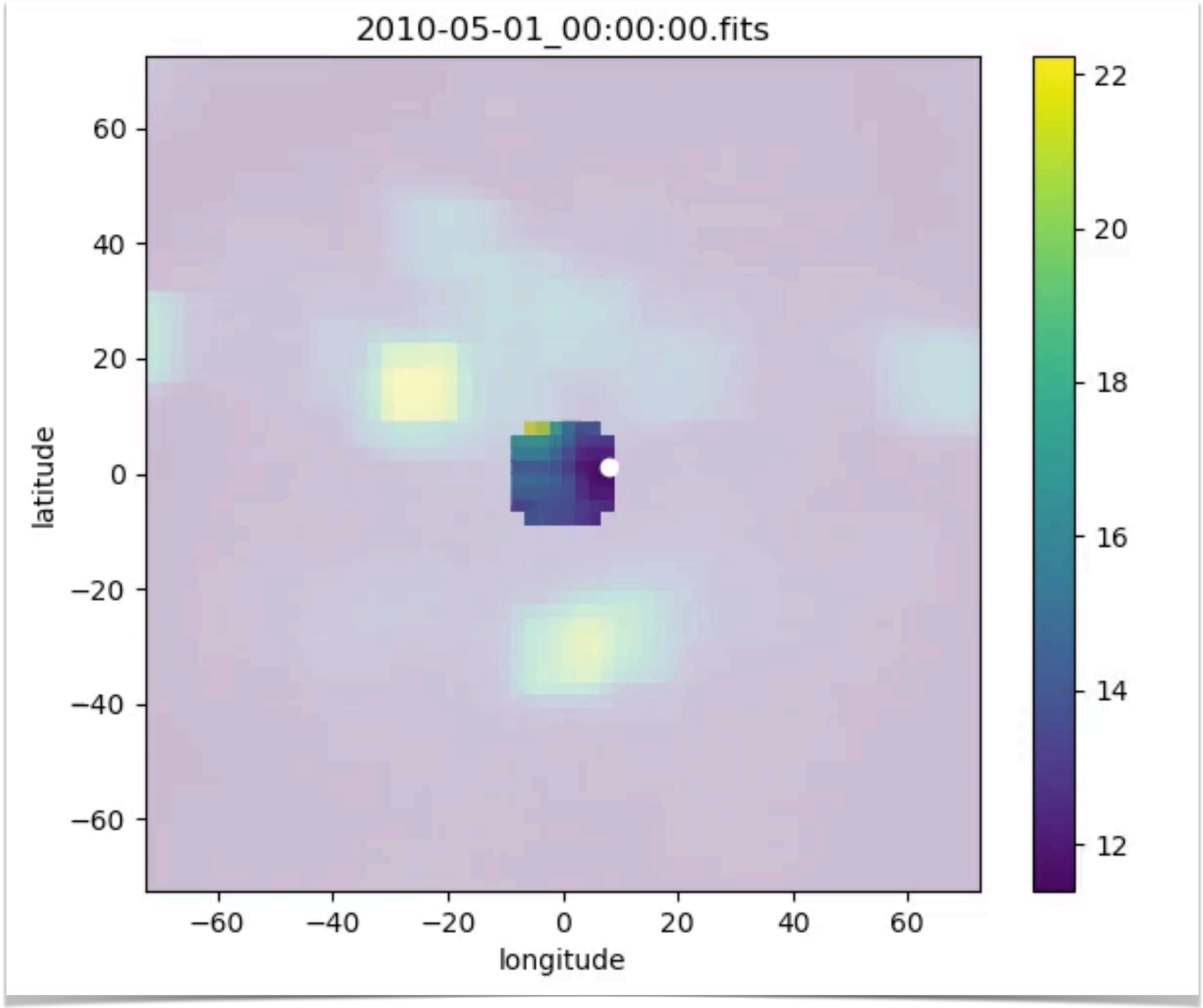
- $\langle B_{LOS} \rangle$
- $|\langle B_{LOS} \rangle|$
- $\mathrm{sqrt}(\langle B_{LOS}^2 \rangle)$

- mean
- std. dev
- skewness
- kurtosis

—> One value describing the ‘level of quietness’ in a 2D FOV for 8 hr!

New Study: quiet-region selection

- background: 8-hr averages of B_{RMS} for a 15 deg
- define a circle at lat/lon (here: disk center)
- select only most quiet patch
- do this for all data (2010-2021) in 4hr chunks
- select only the 10% most quiet patches every month
- Result: statistics of most quiet 3D cubes over 40 frames (=12hr) for:
  - internetwork “I” (10”)
  - network + internetwork E=G (150”)

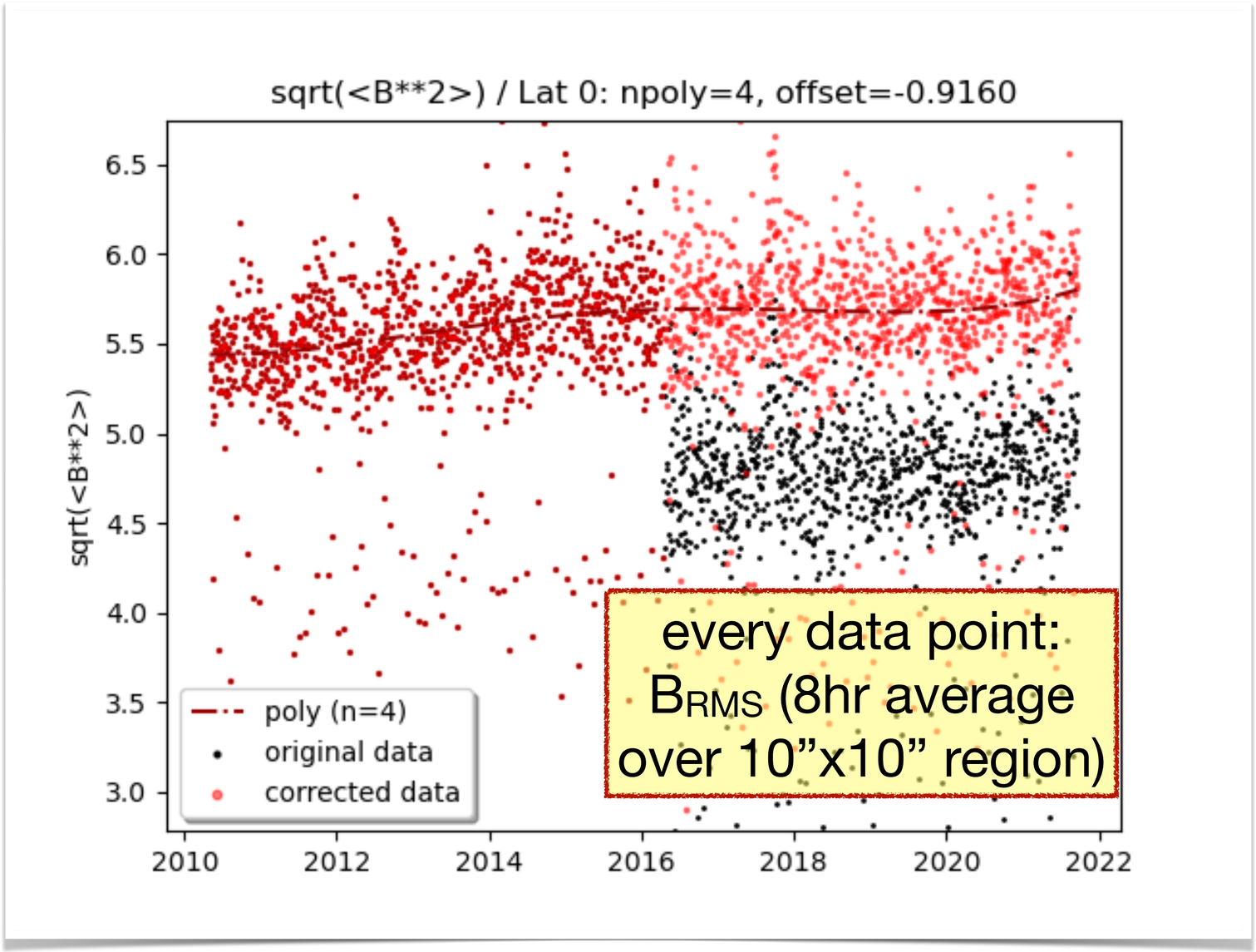


Internetwork cubes: HMI issue…

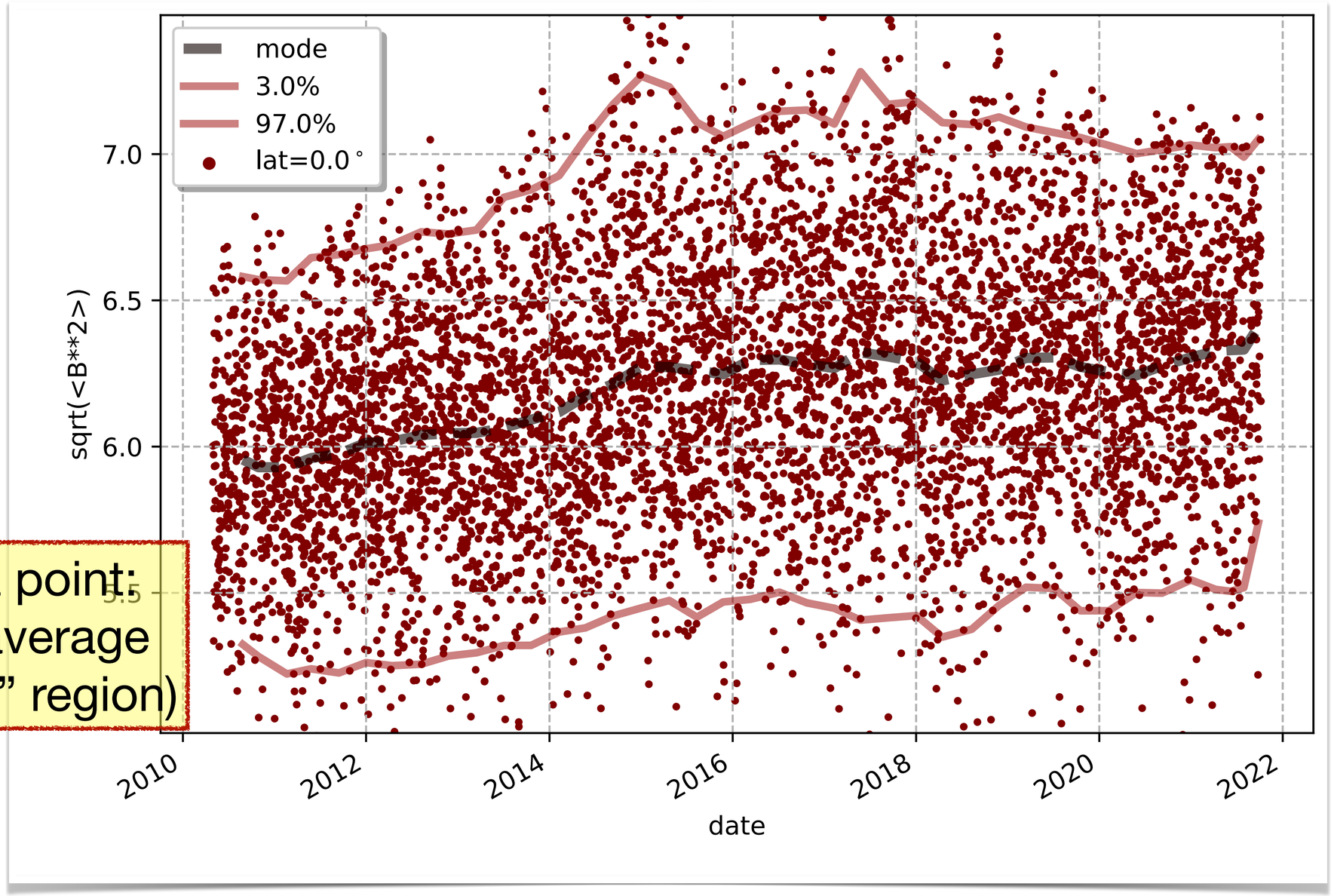
HMI observing mode change (April 2016):

- 2 cameras combined
- 135 s cadence reduced to 90 s
- Stokes V: 17% lower noise

—> correction needed!

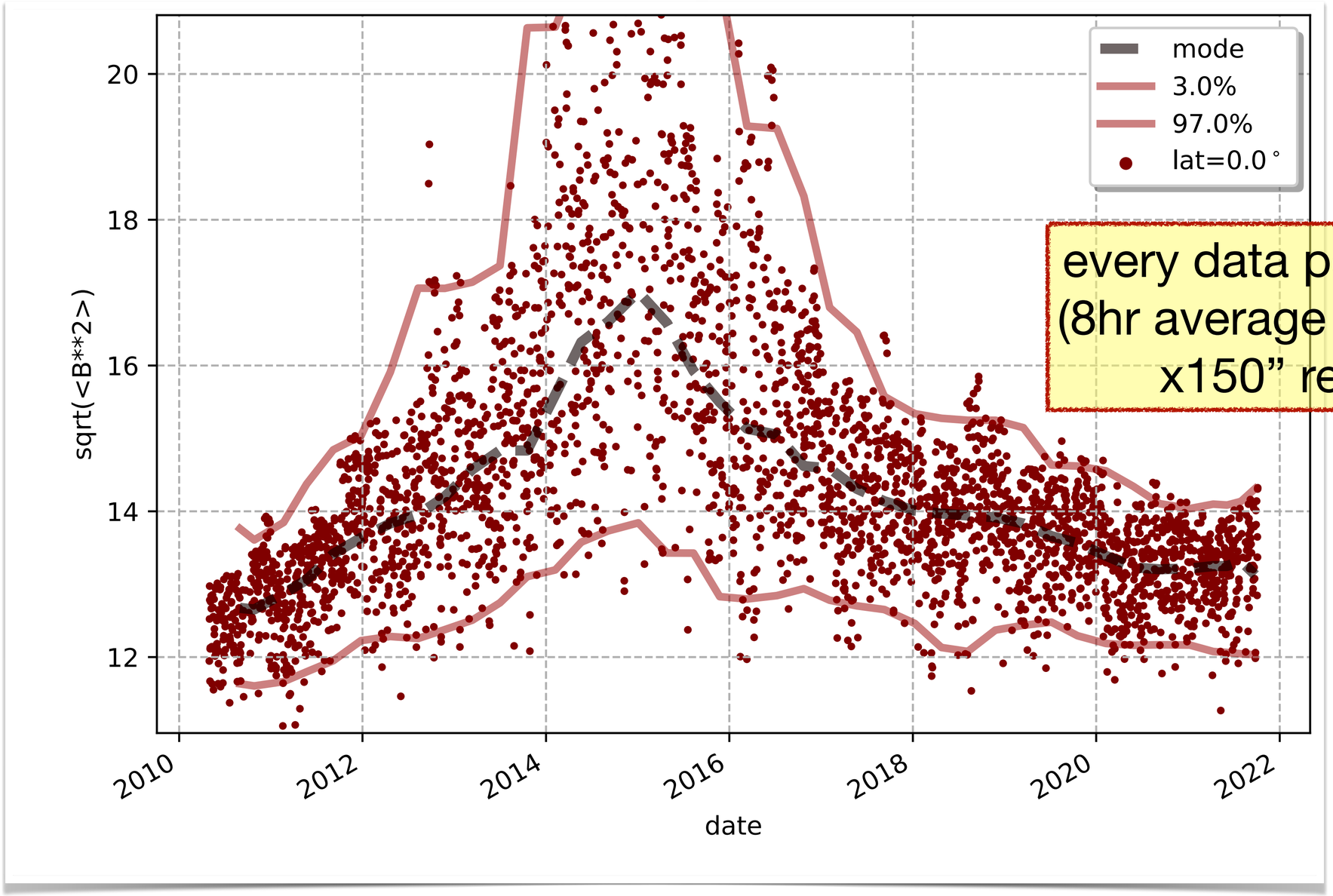


Solar Cycle: Internetwork



every data point: B_{RMS} (8hr average over 10”x10” region)

Solar Cycle: Internetwork + Network



every data point: B_{RMS} (8hr average over 150” x150” region)

Results

Internetwork

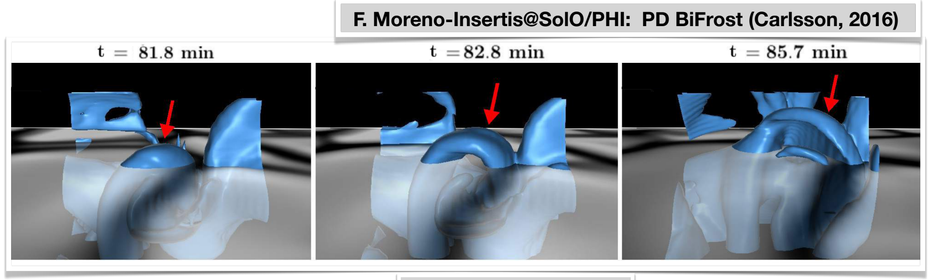
- no solar cycle dependence (despite extremely low noise)
  - still below detection threshold?

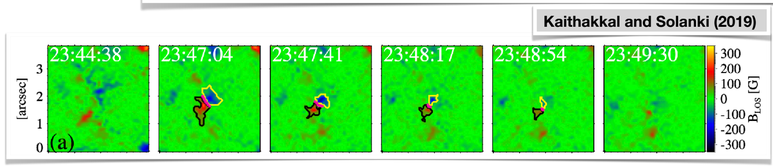
Network + internetwork

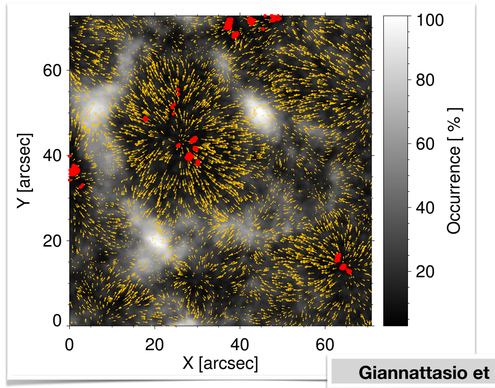
- clear solar cycle dependence of B_{RMS}
- quiet-regions selection ensures that this is not an effect of AR

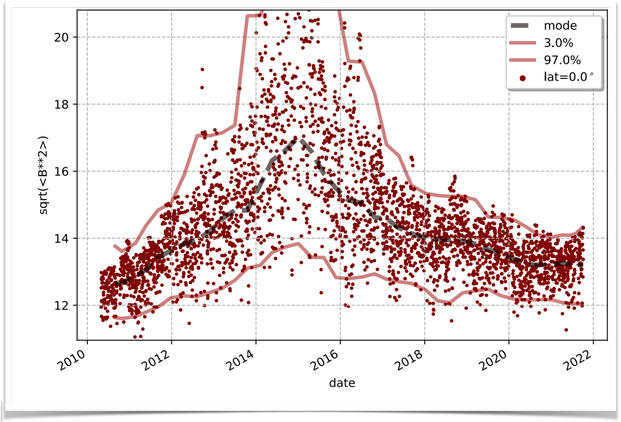
Possible Conclusion?

- small-scale flux emergence in every granule in tiny magnetic tubes or flux sheets: “recycled” flux
- most of the emerged flux: removed by flux cancellation / submergence
- a small fraction: expelled (advected) towards “E”dge —> forms network (coherent hG/kG fields) —> “E”dge: smaller granules, increased downdraft
- “E”dge (network) fields: everywhere on the Sun —> expelled fields from “I”nterior is major (only?) source!
- “E”dge fields vary with solar cycle —> more flux expelled from “I” to “E” —> stronger small-scale flux emergence









Is the small-scale dynamo more efficient at solar maximum? (Why should it be?)

Is it flux tangling from large-scale fields (stronger at solmax) near the surface?