

**9th Workshop - Solar Influences**  
**on the Magnetosphere, Ionosphere and Atmosphere**  
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**Identification of features in solar ALMA  
images and comparison with solar  
atmospheric models**

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EUROPEAN ARC  
ALMA Regional Centre || Czech



**Astronomical  
Institute**  
of the Czech Academy  
of Sciences

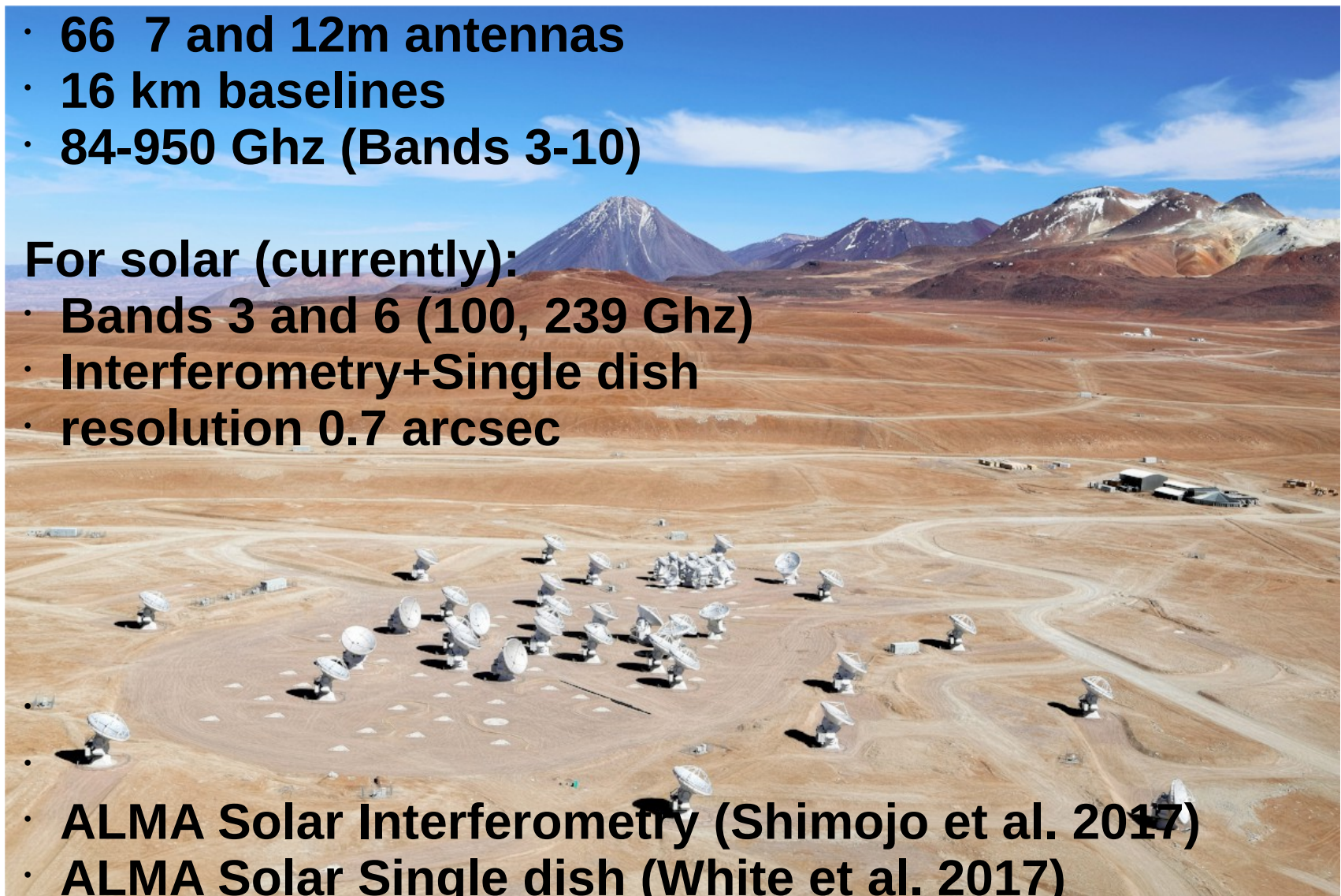
## A word about ALMA...

- 66 7 and 12m antennas
- 16 km baselines
- 84-950 Ghz (Bands 3-10)

**For solar (currently):**

- Bands 3 and 6 (100, 239 Ghz)
- Interferometry+Single dish
- resolution 0.7 arcsec

- ALMA Solar Interferometry (Shimojo et al. 2017)
- ALMA Solar Single dish (White et al. 2017)

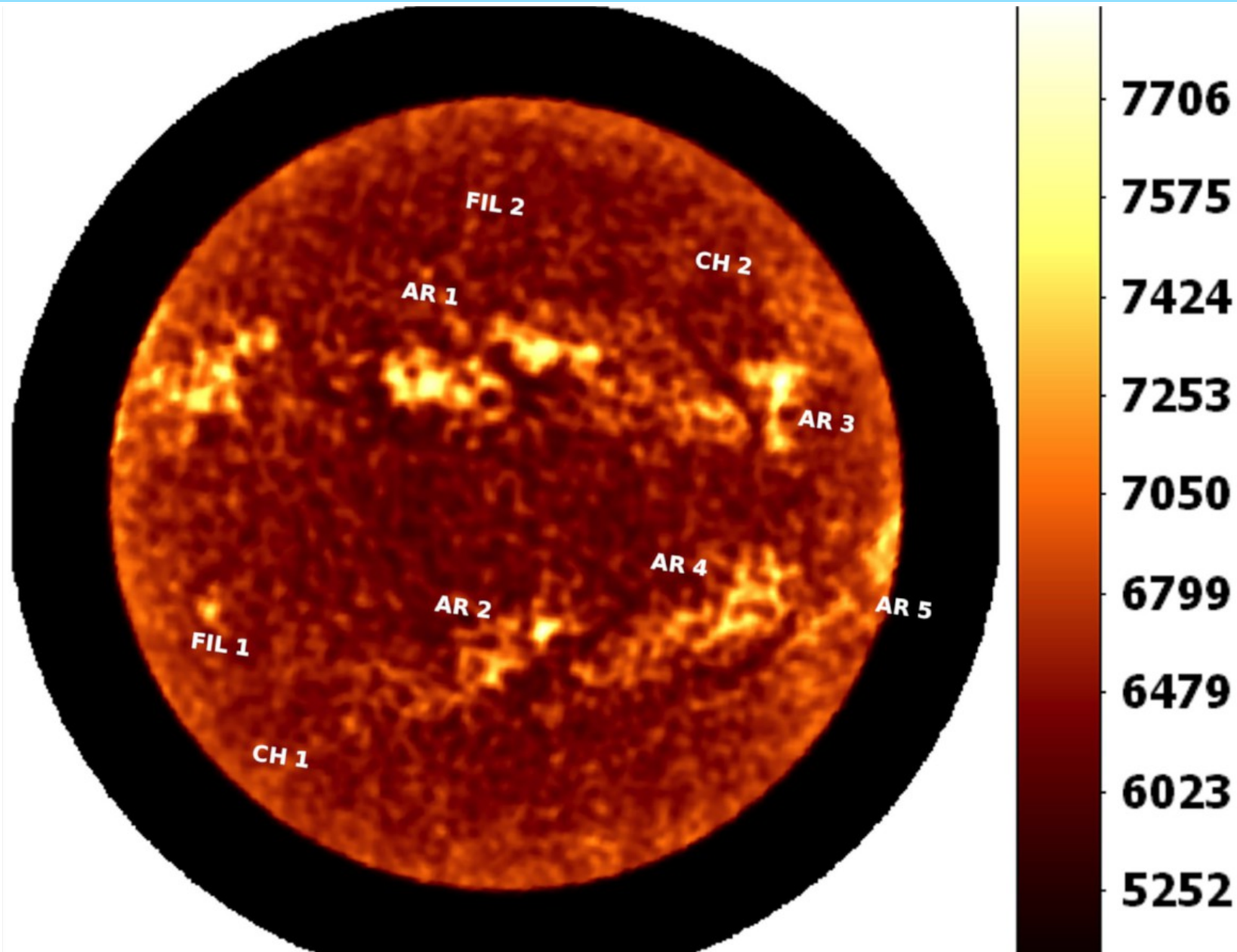




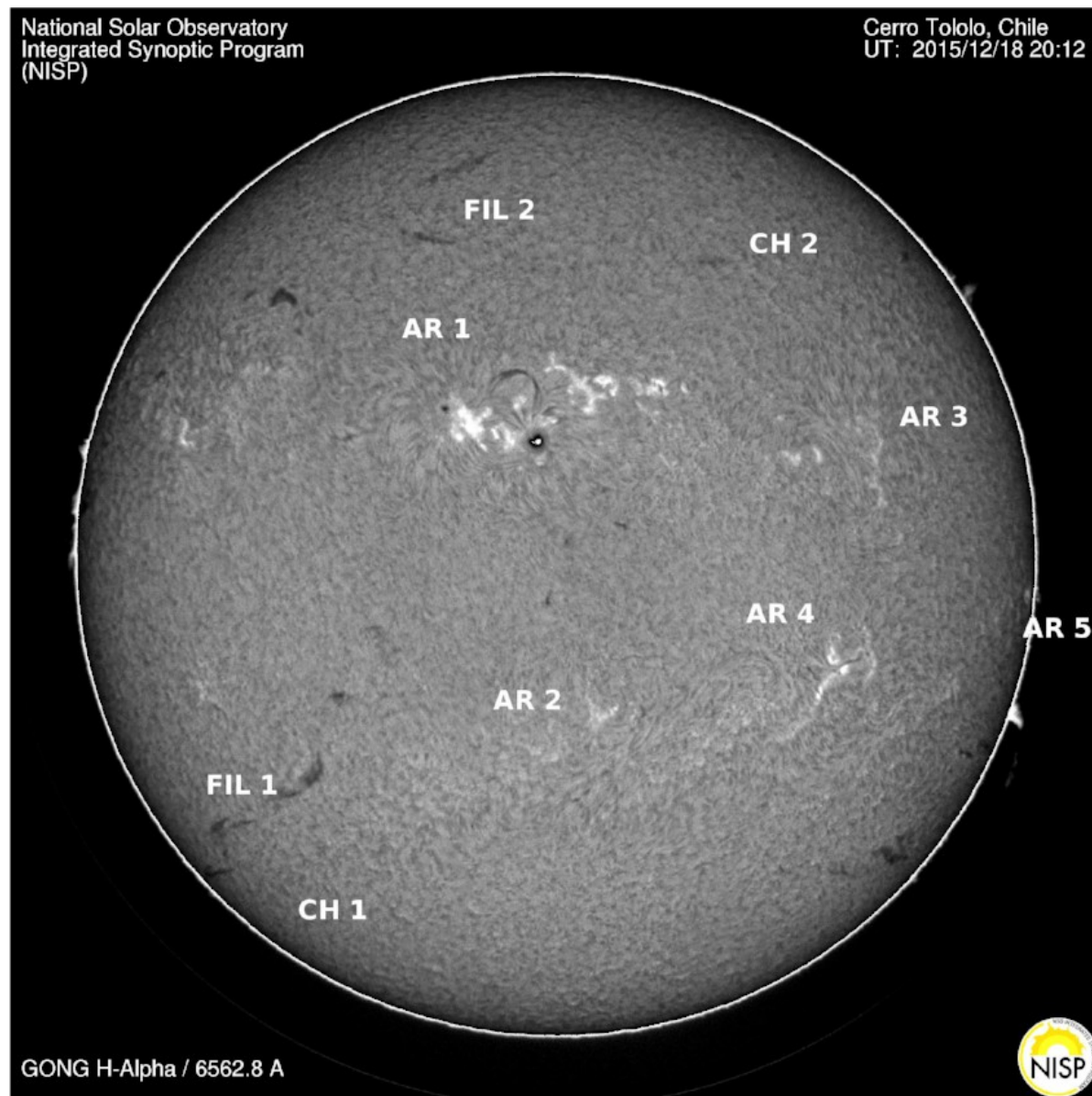
# Finally... ALMA image of the Sun



# ALMA, Single dish, 1.2 mm, 2015-Dec-18

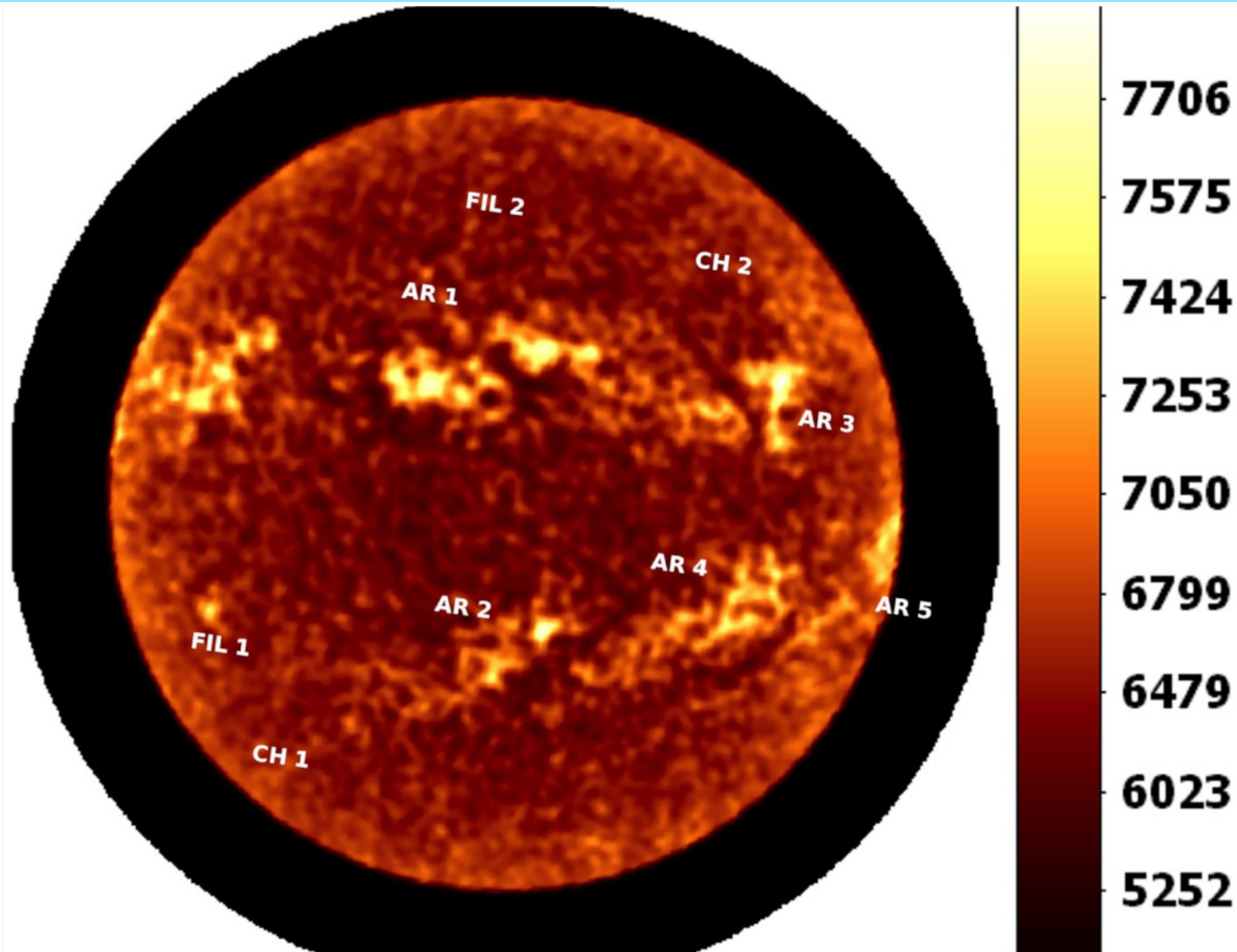


# H-alpha, NSO, NISP, Cerro Tololo

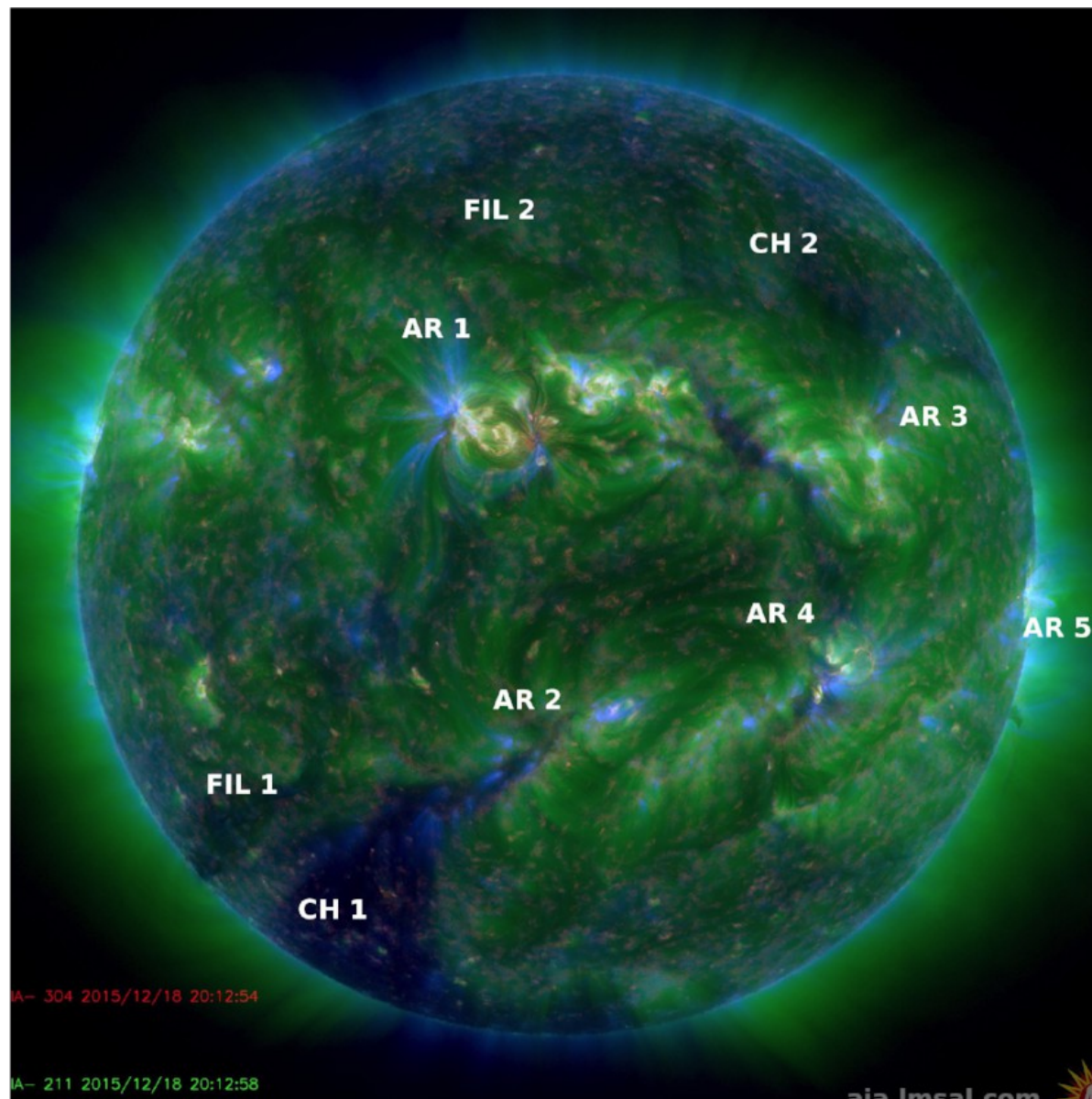




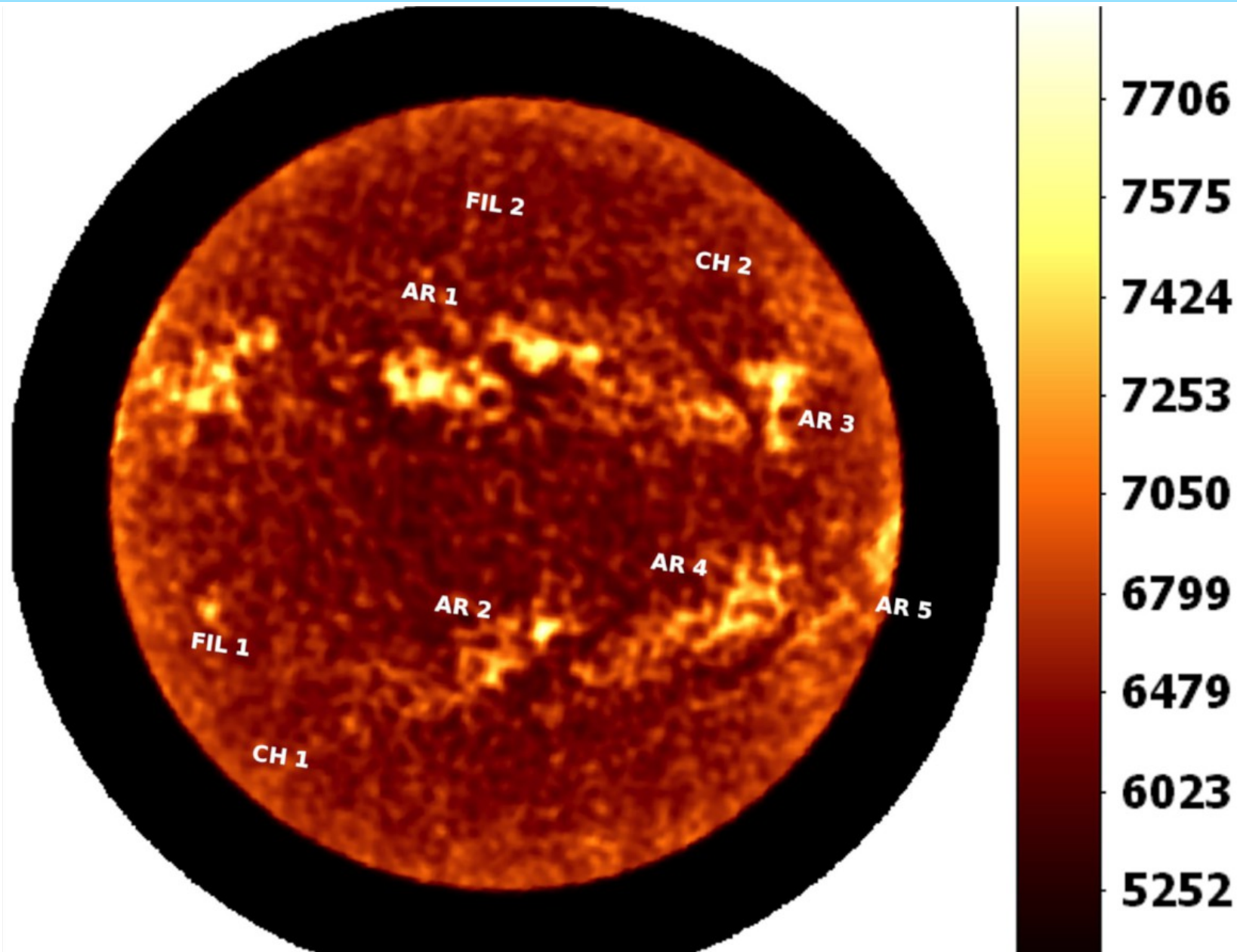
# ALMA, Single dish, 1.2 mm, 2015-Dec-18



# SDO/AIA, 17.1, 30.4, 21.1 nm

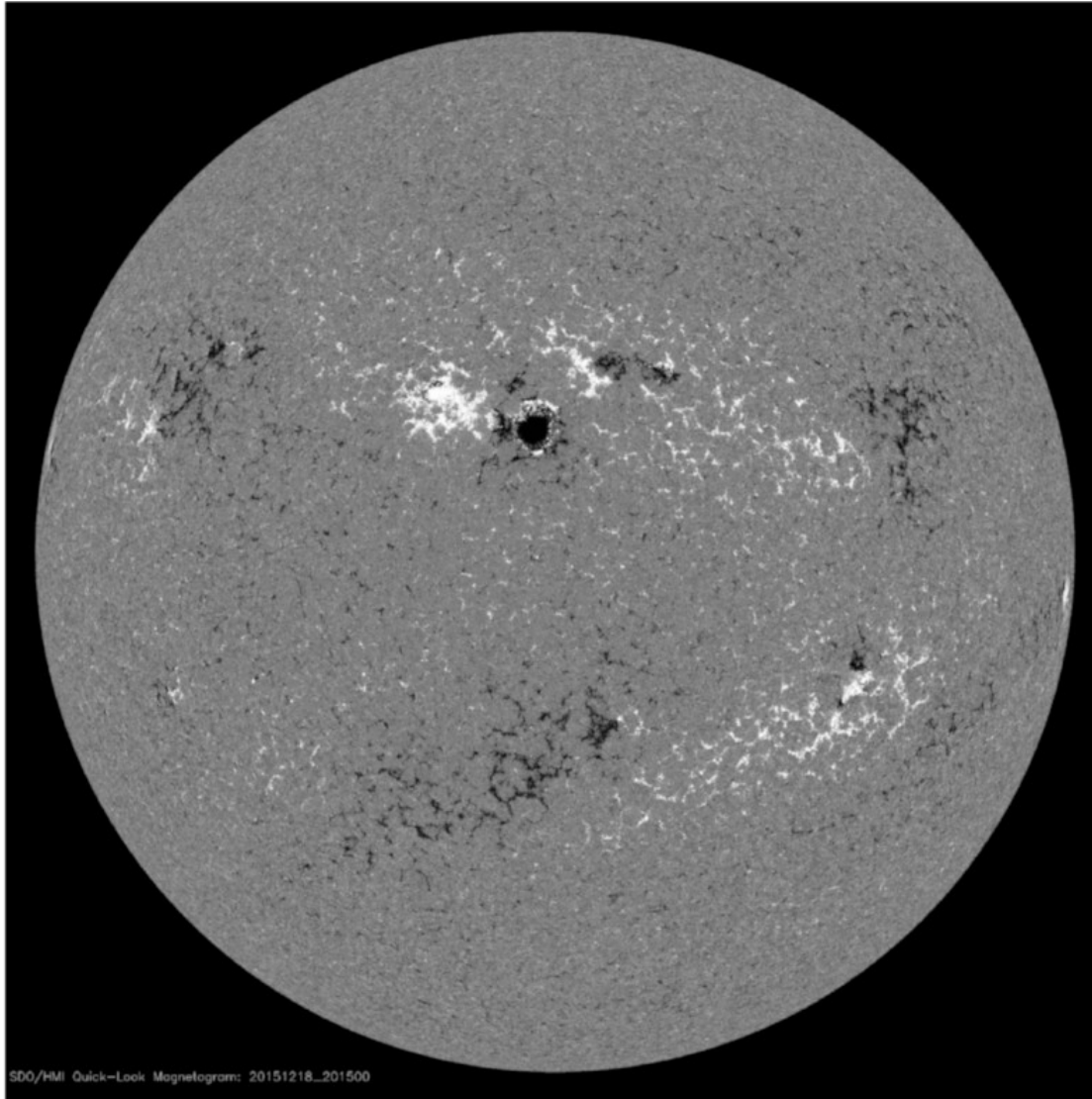


# ALMA, Single dish, 1.2 mm, 2015-Dec-18





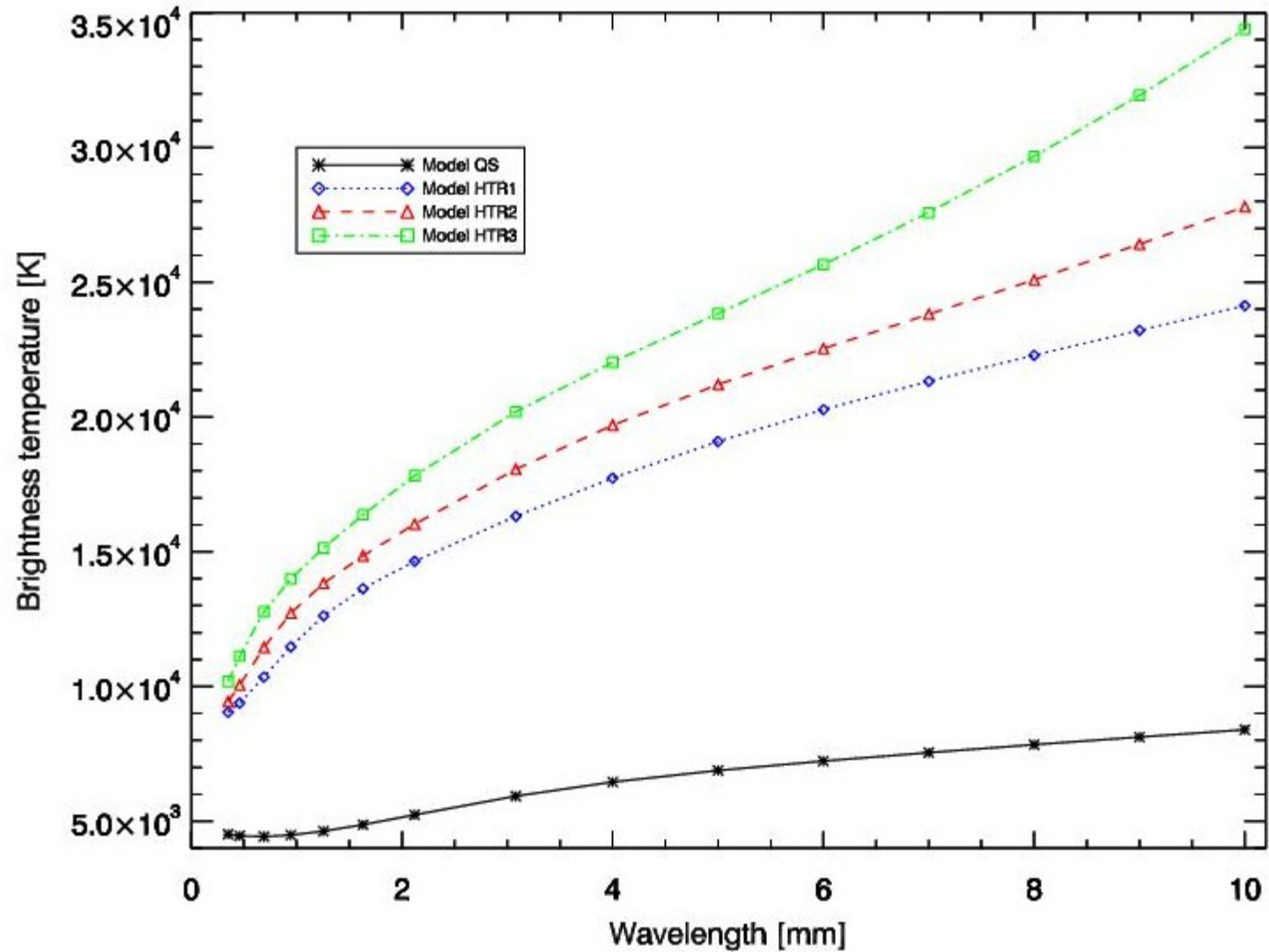
# SDO/HMI mangnetogram



# Models of the solar atmosphere

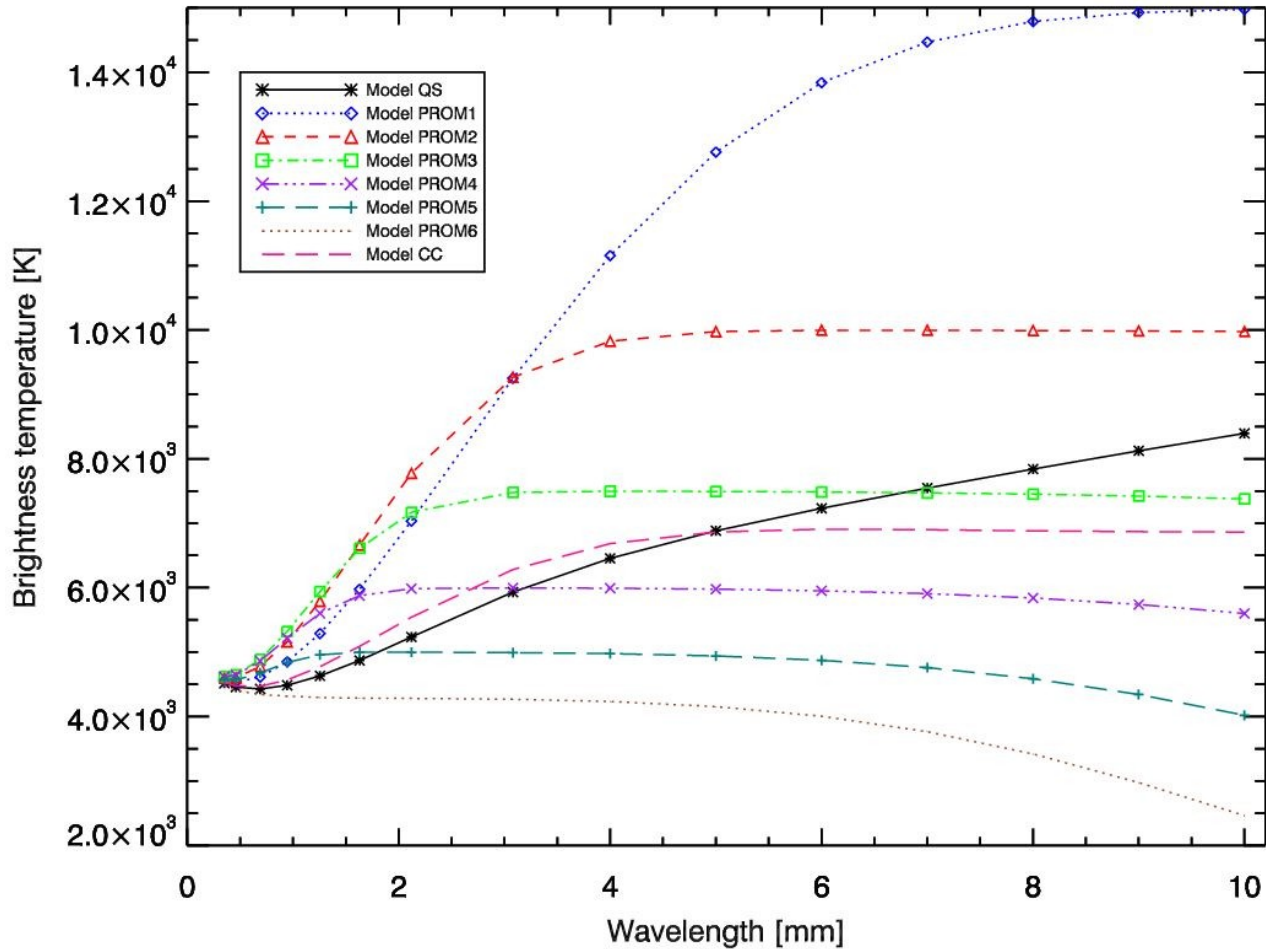
- FAL models (Fontenla et al., 1993); Baumbach-Allen coronal model
- agree reasonably well with radio observations (Bastian et al., 1996)
- $T_e = 1.2 \times 10^6$  K at high altitudes (Benz et al., 1997)
- FAL model A: good approximation of coronal holes → Quiet Sun (QS)
- model parameters (T,n) changed for specific structures
  
- thermal bremsstrahlung considered as the relevant radiation mechanism
- gyromagnetic (cyclotron) radiation does not contribute significantly

# Active regions vs quiet Sun

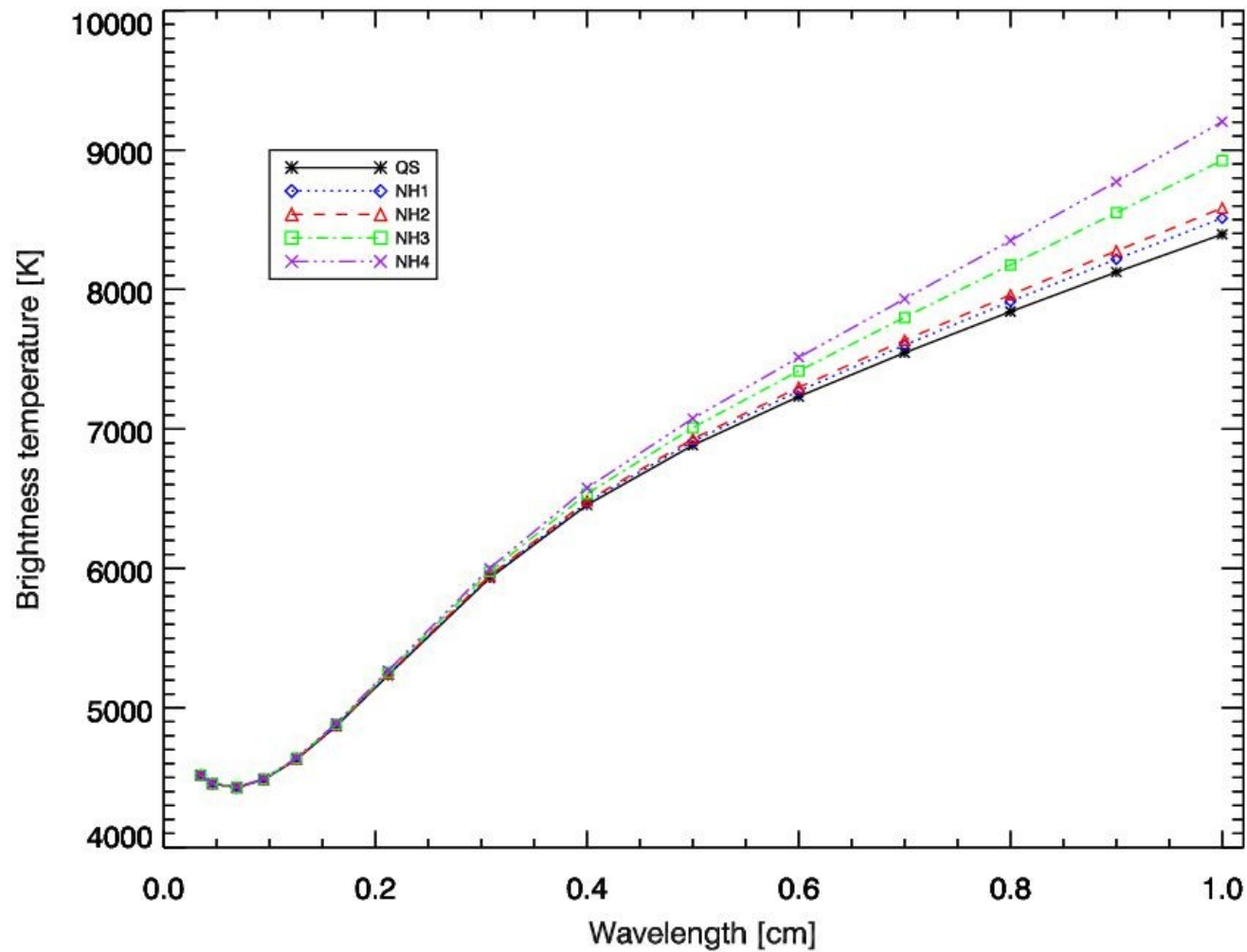




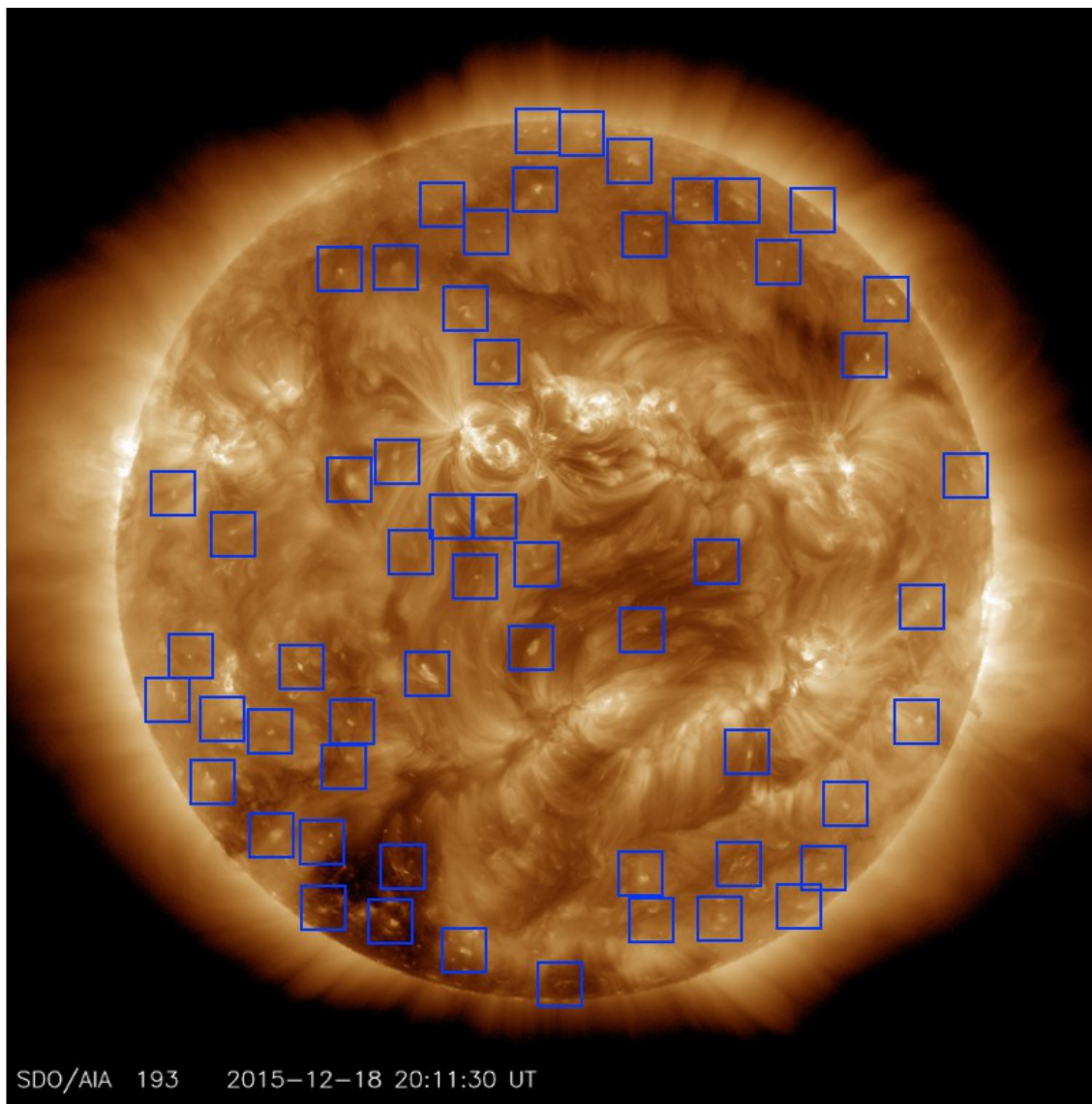
# Prominences vs quiet Sun



# Coronal holes vs quiet Sun

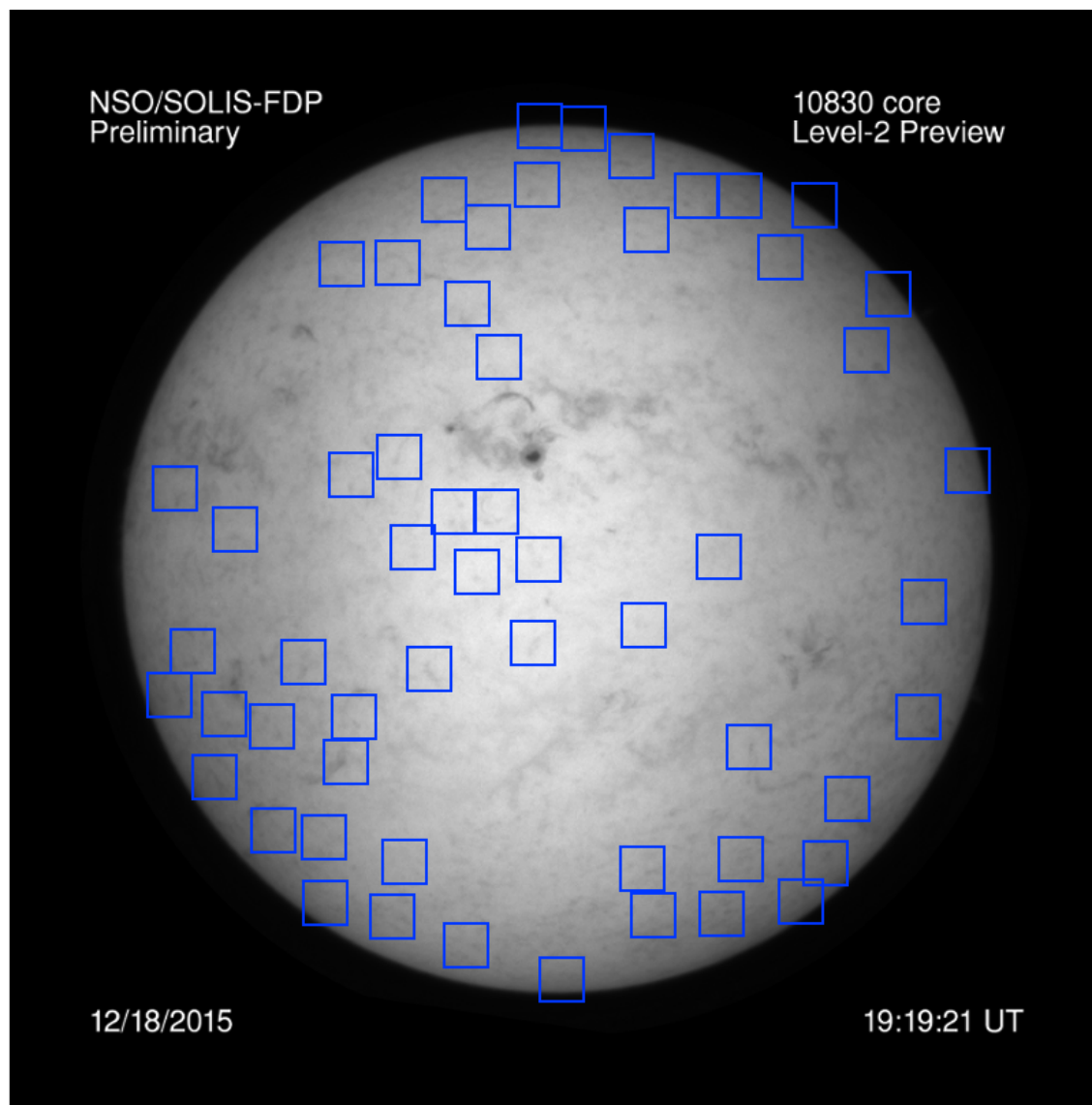


# Coronal bright points, SDO/AIA, 19.3 nm

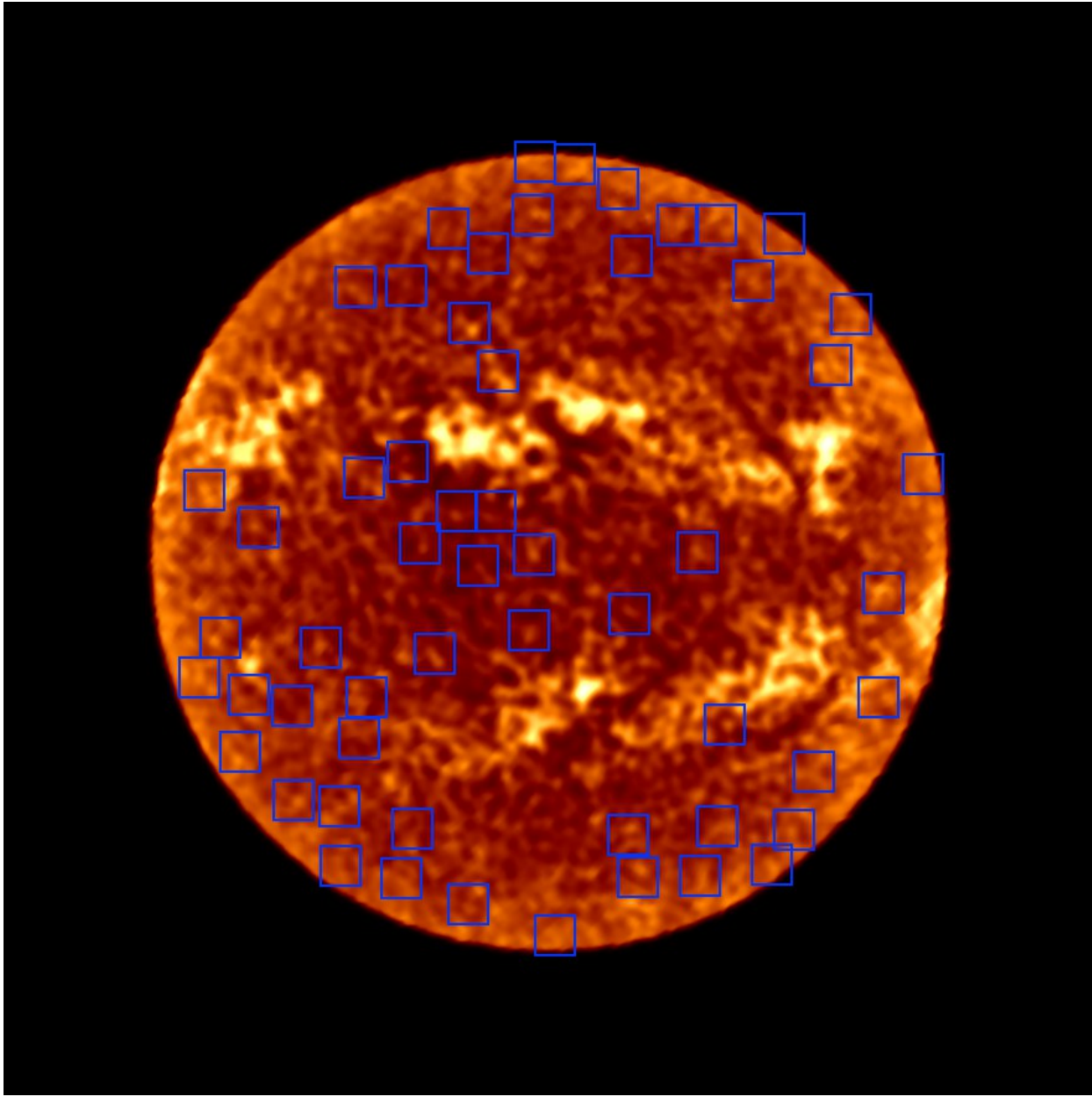




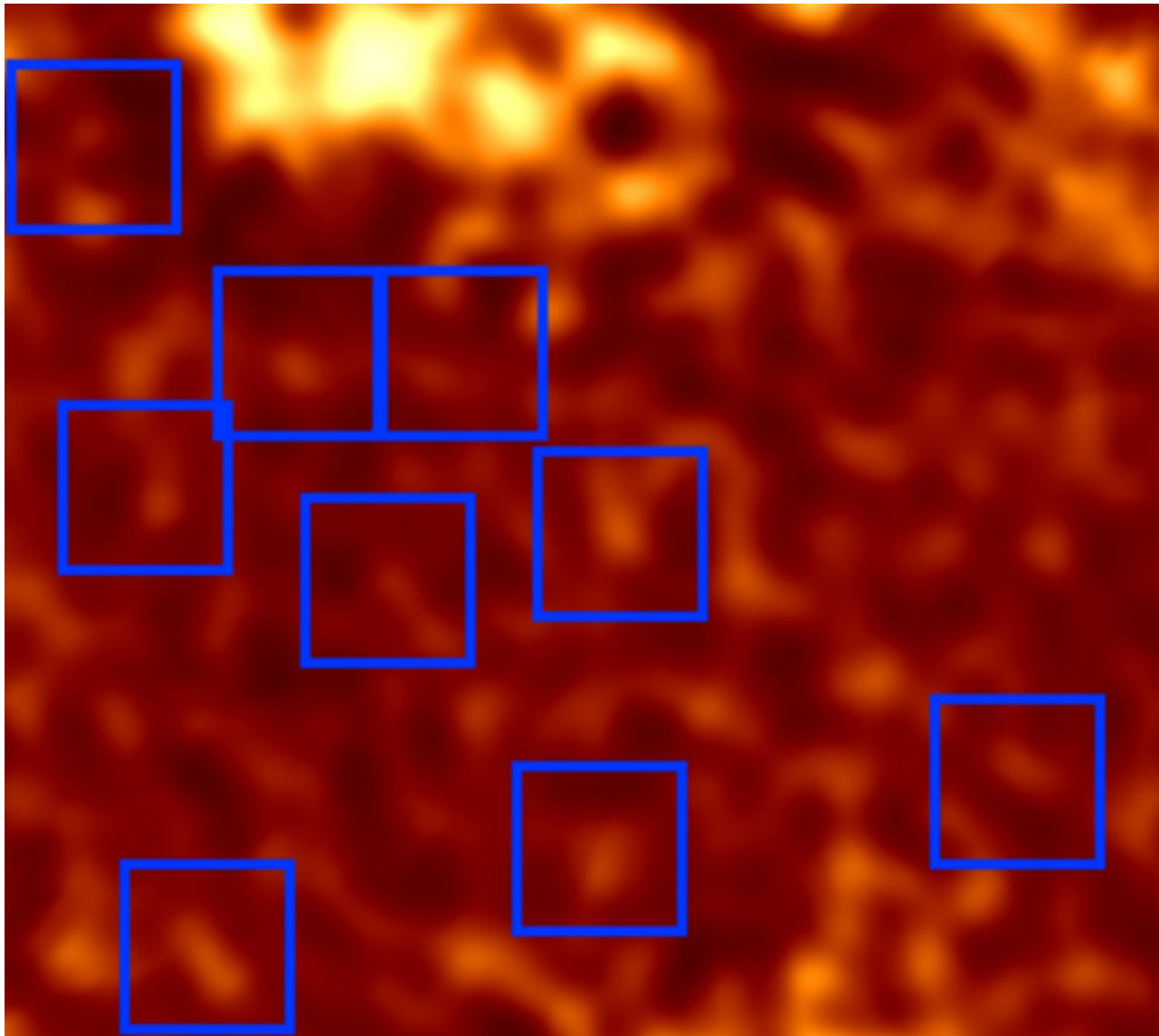
# Dark points, He 1083 nm, NSO/SOLIS



# ALMA, Band 6, 1.2 mm, 248 GHz

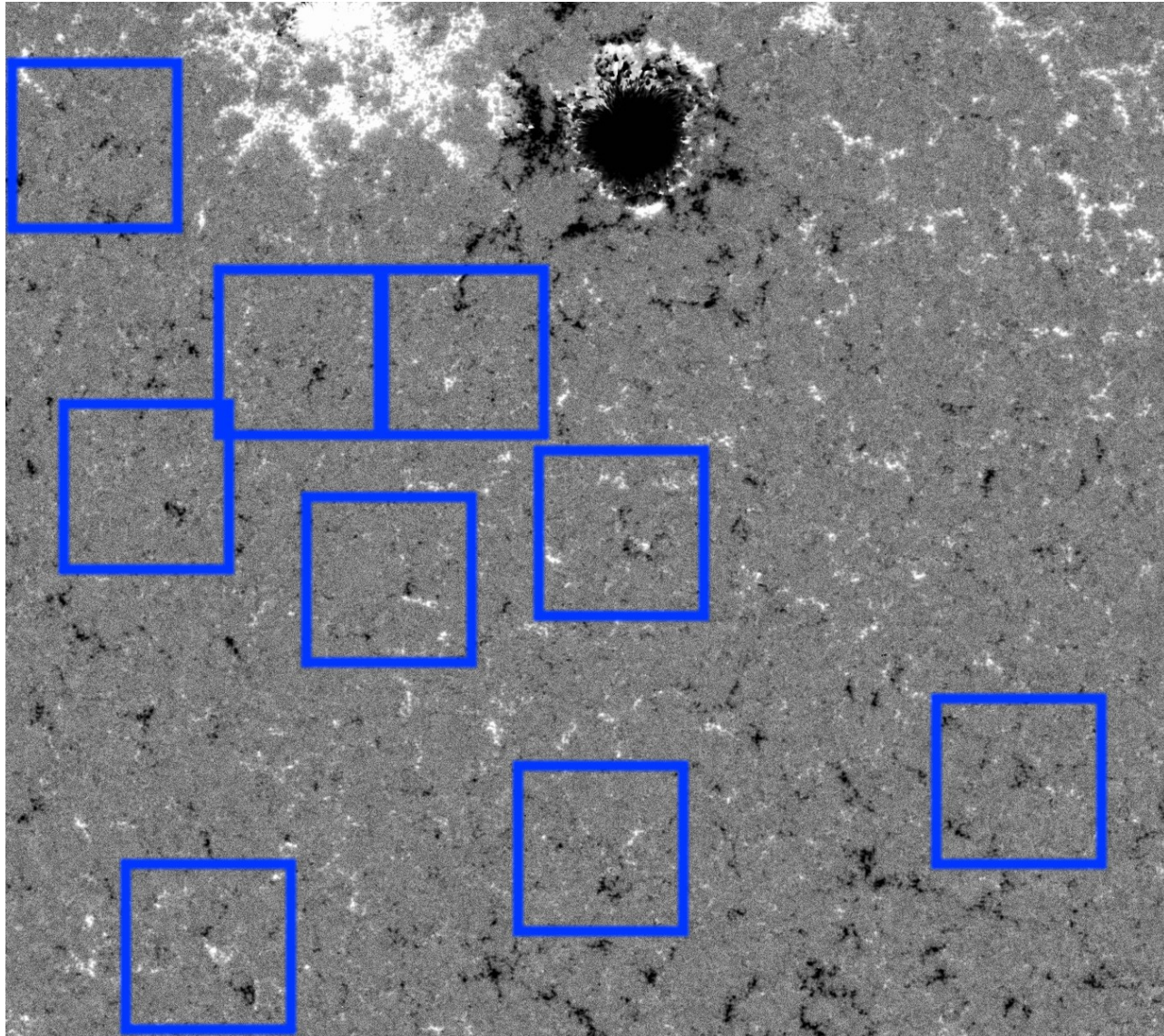


# Close-up, ALMA, 1.2 mm





# Close-up, SDO/HMI

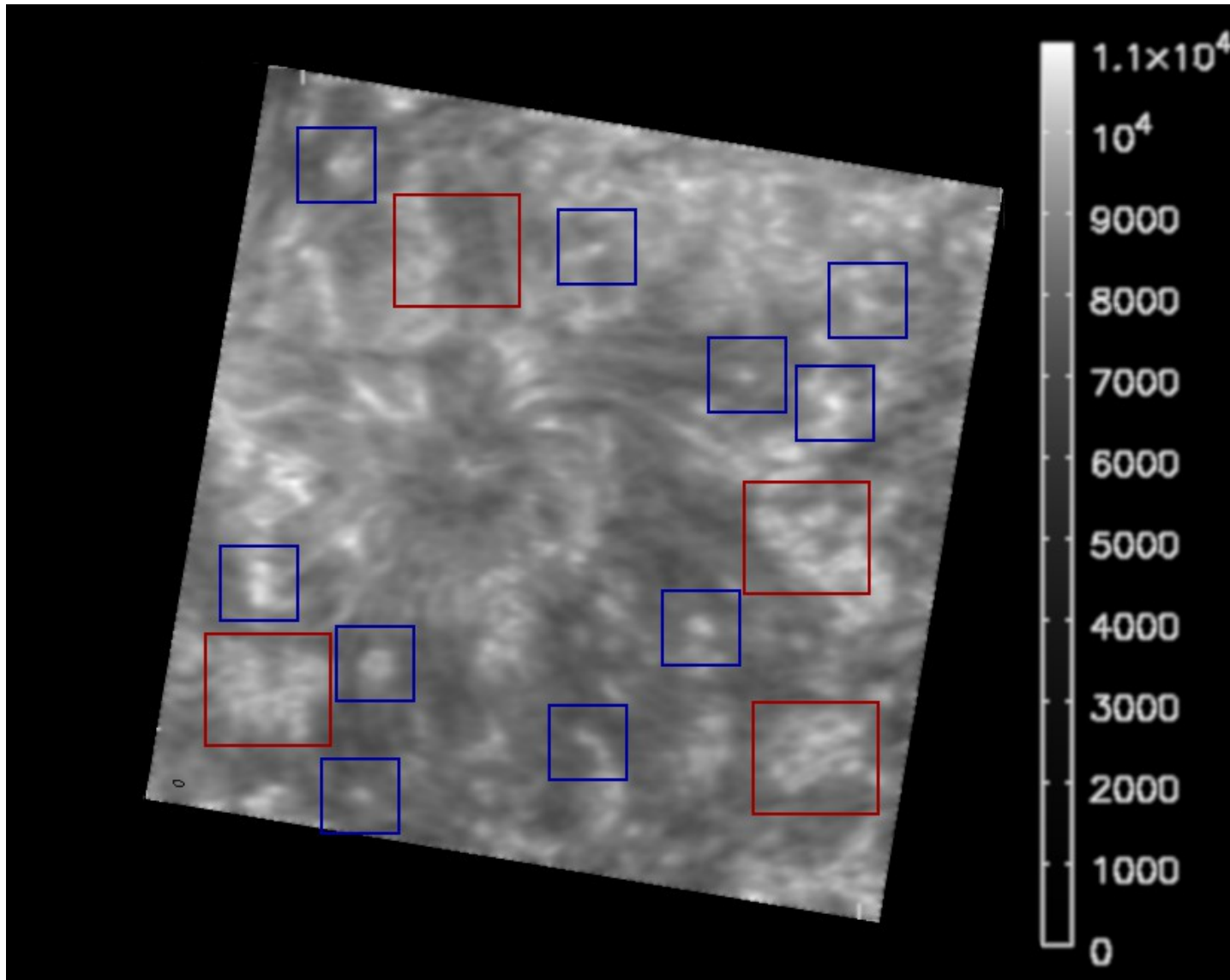


# ALMA solar interferometry

- Sun is a very difficult target for interferometry
- Very dynamic
- Limited use of Earth rotation synthesis
- Big (0.5 deg, ALMA FoV at 240 GHz is 26 arcsec)
- Fills the beam with structures on wide range of scales
- Needs a lot of baselines

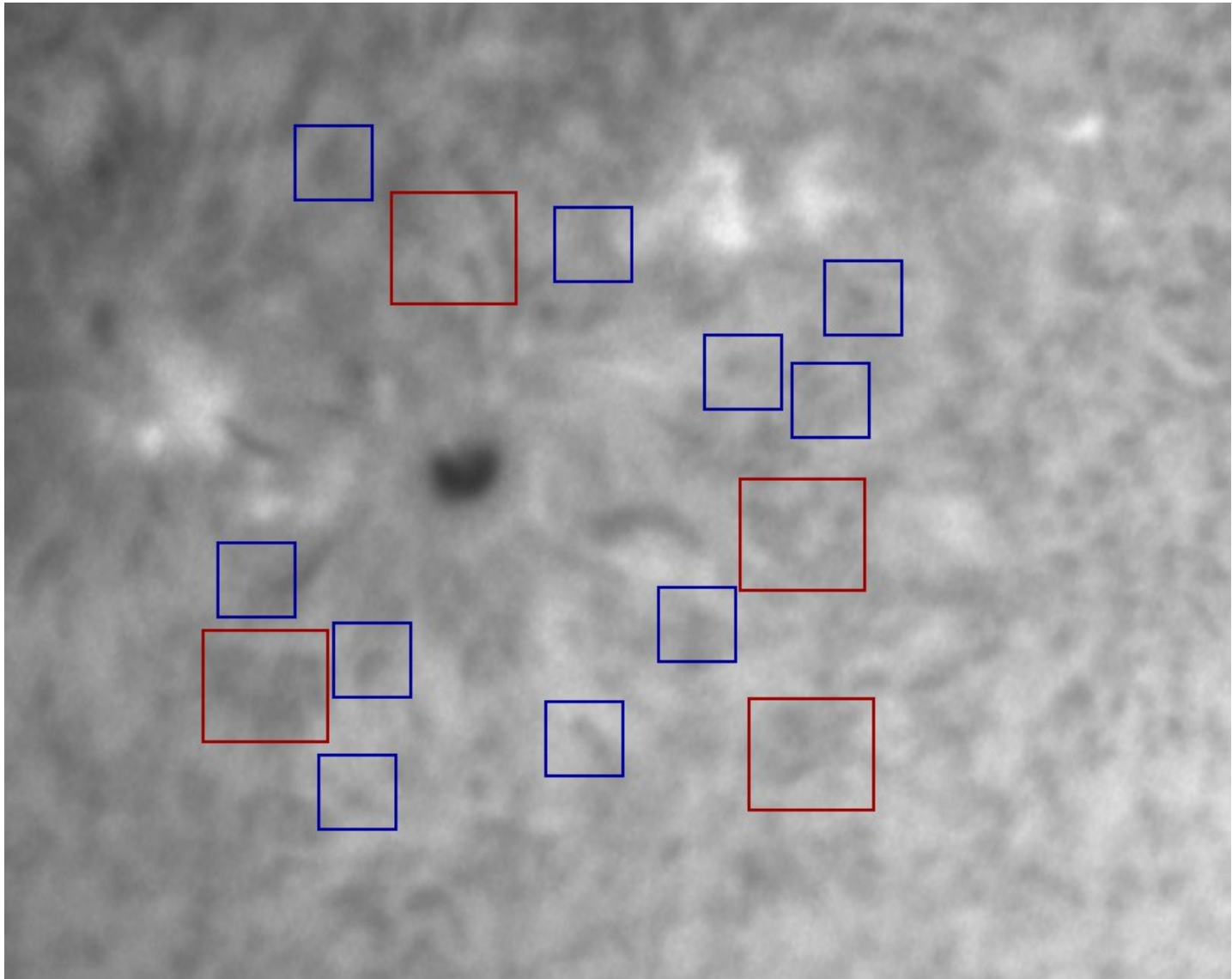


# ALMA, interferometric, Sunspot, 3 mm



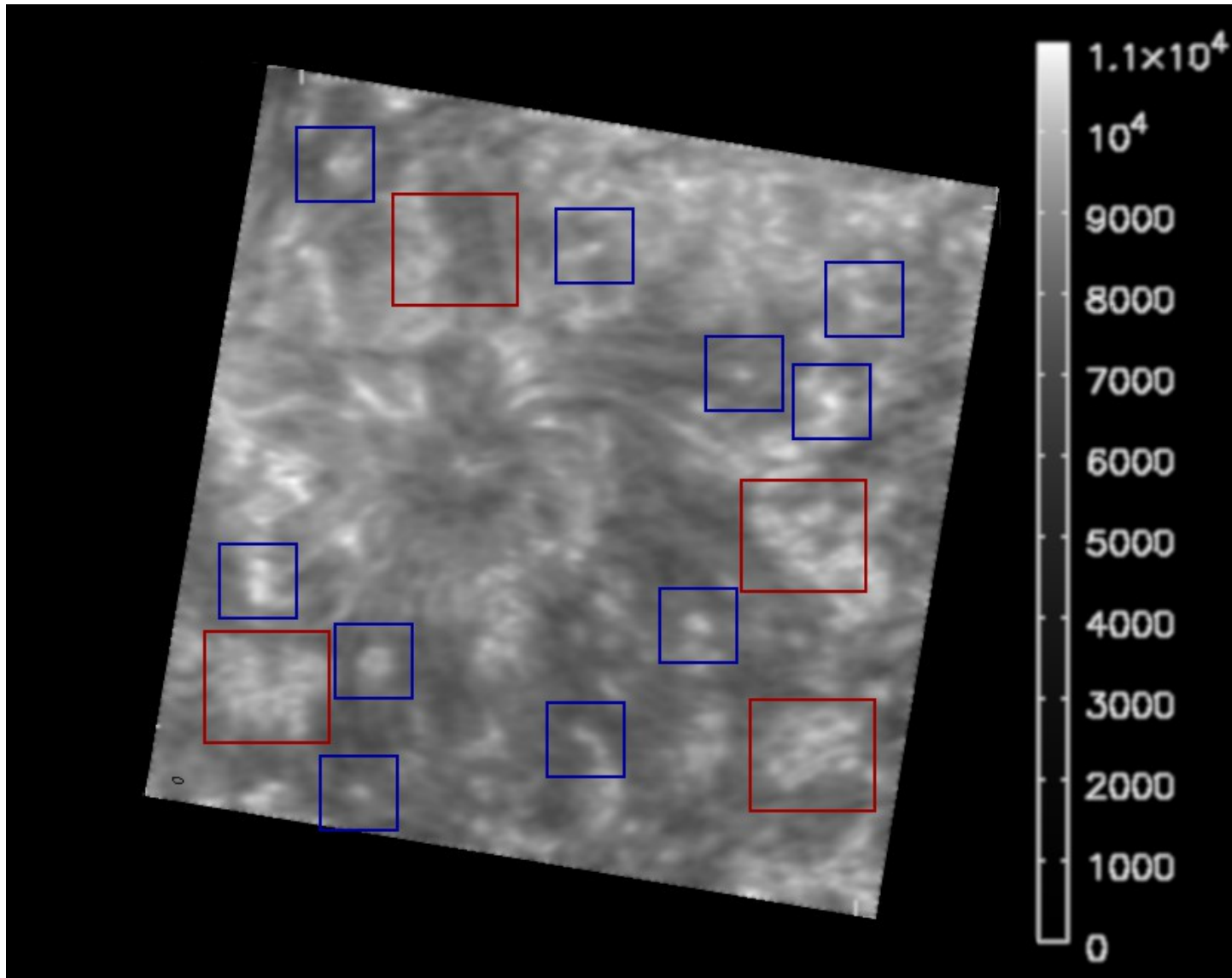


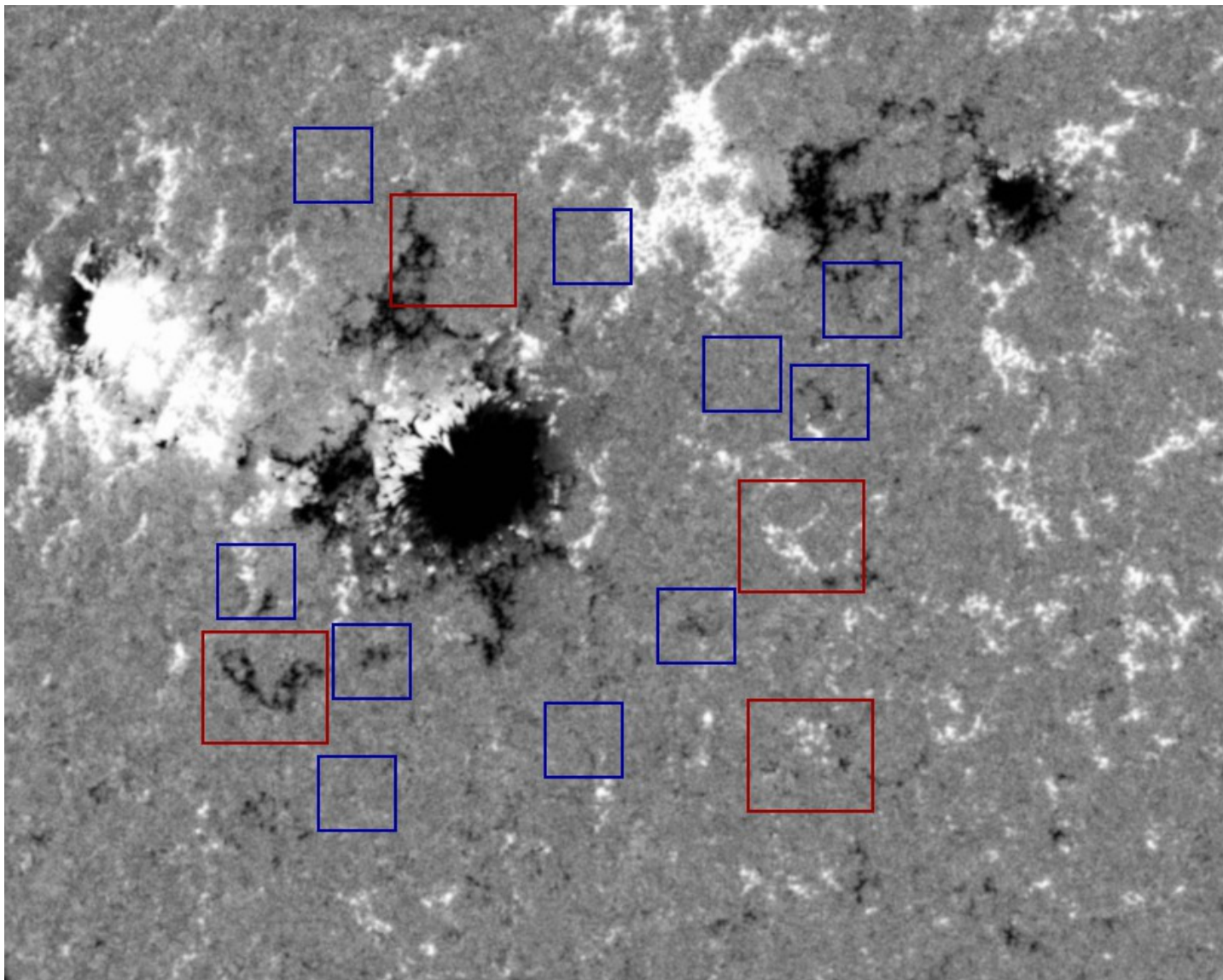
# NSO/SOLIS, H-alpha



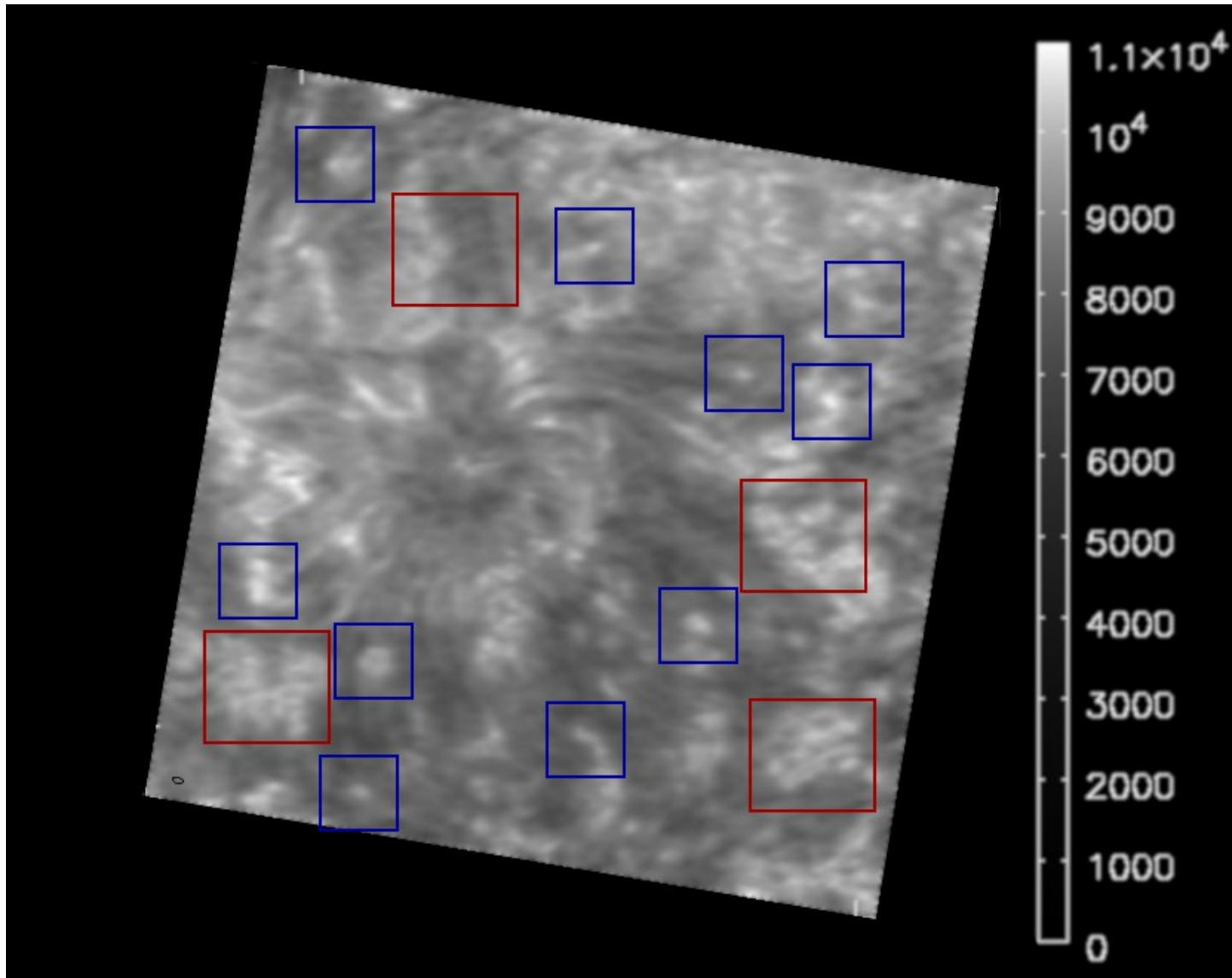


# ALMA, interferometric, Sunspot, 3 mm

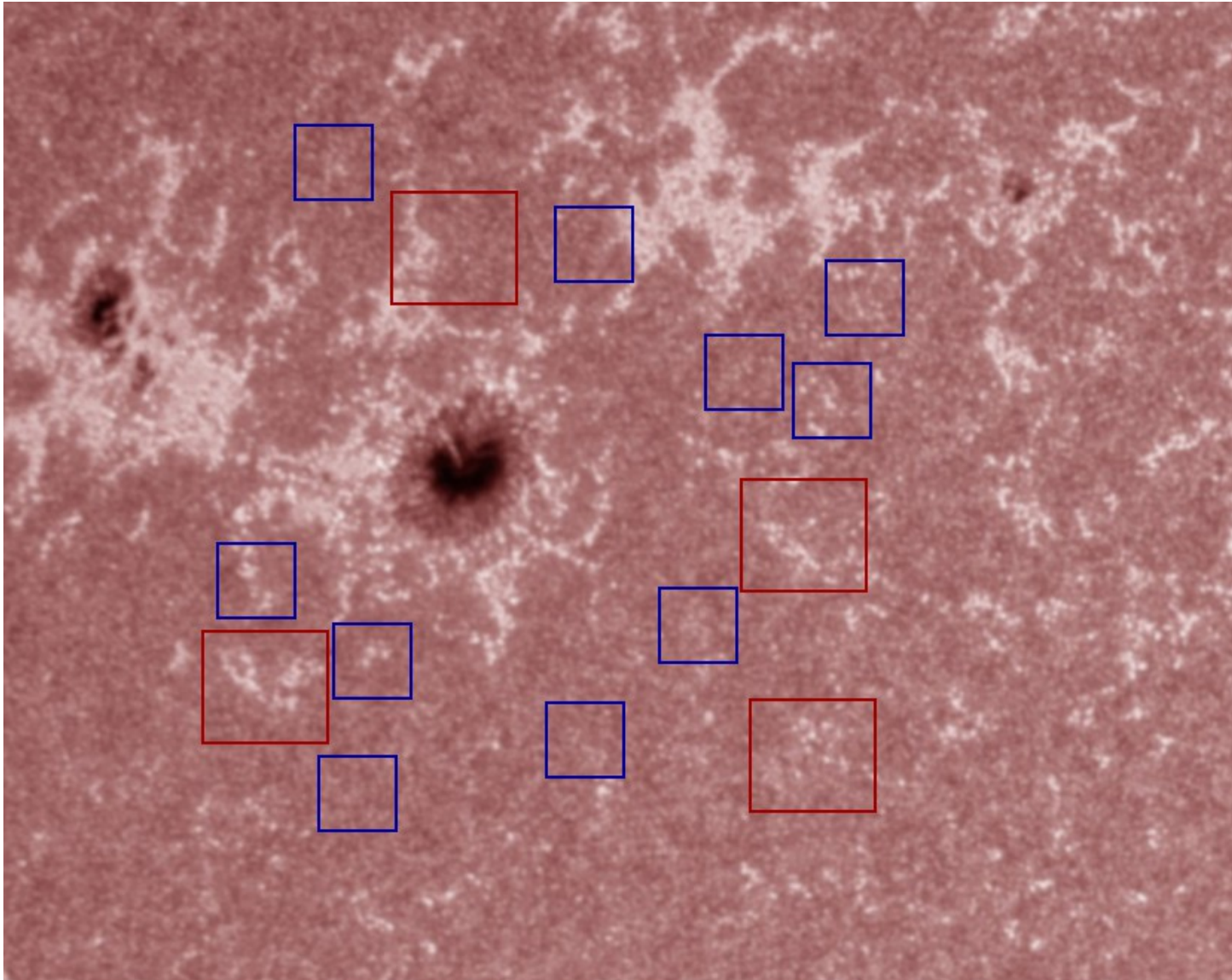




# ALMA, interferometric, Sunspot, 3 mm

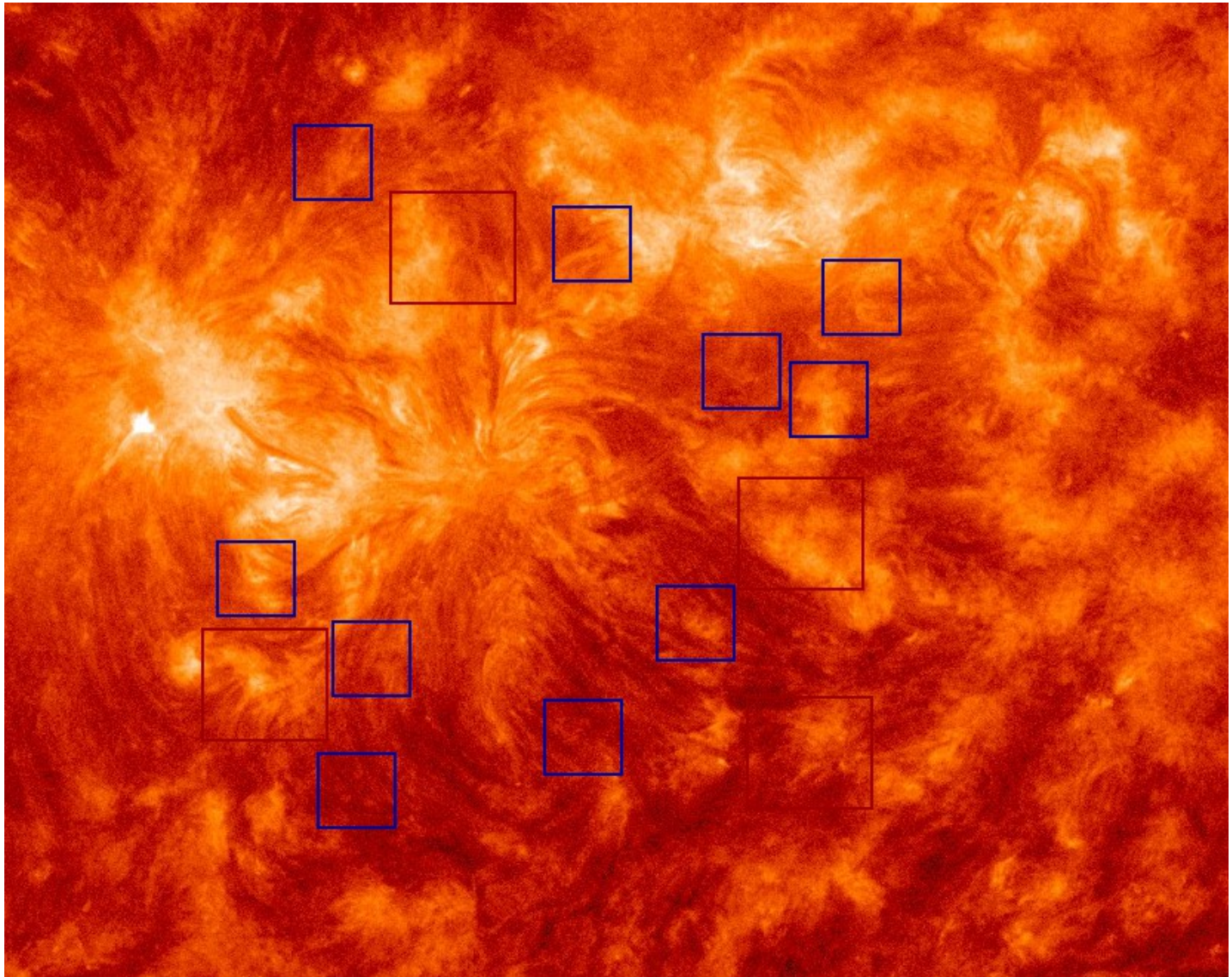


# SDO/AIA 170 nm





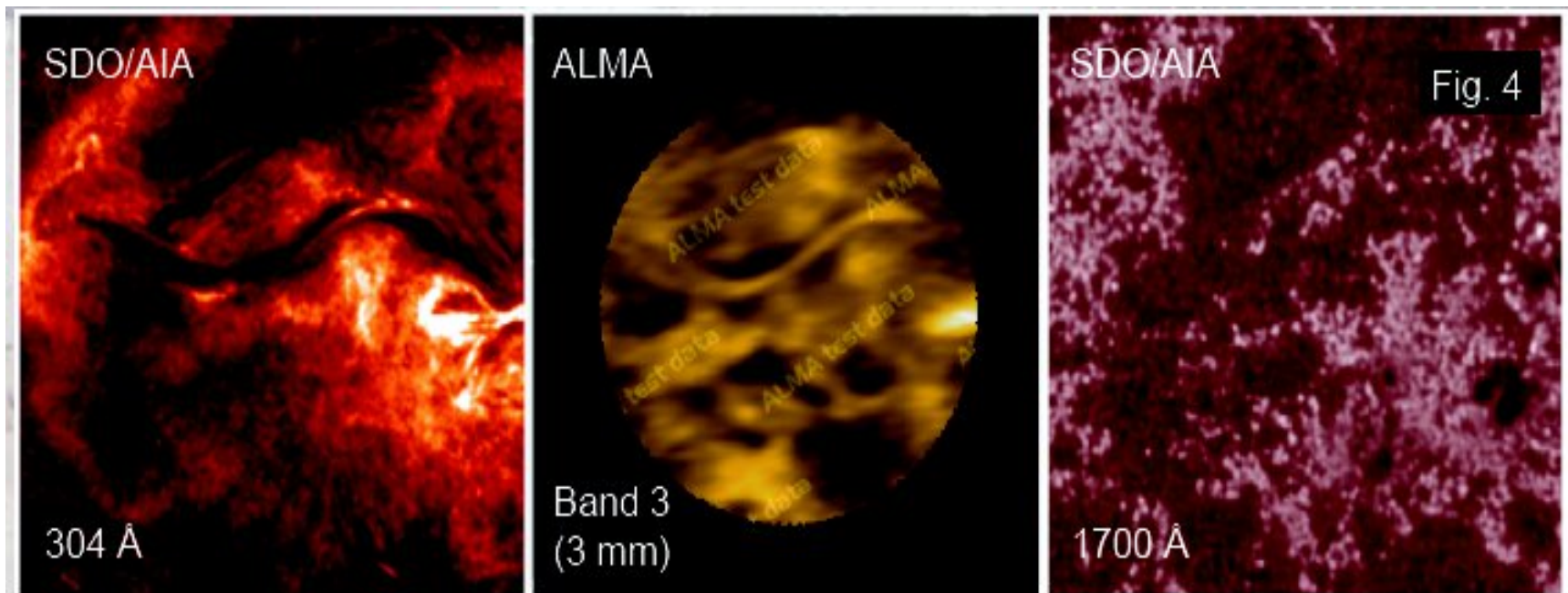
# SDO/AIA 30.4 nm



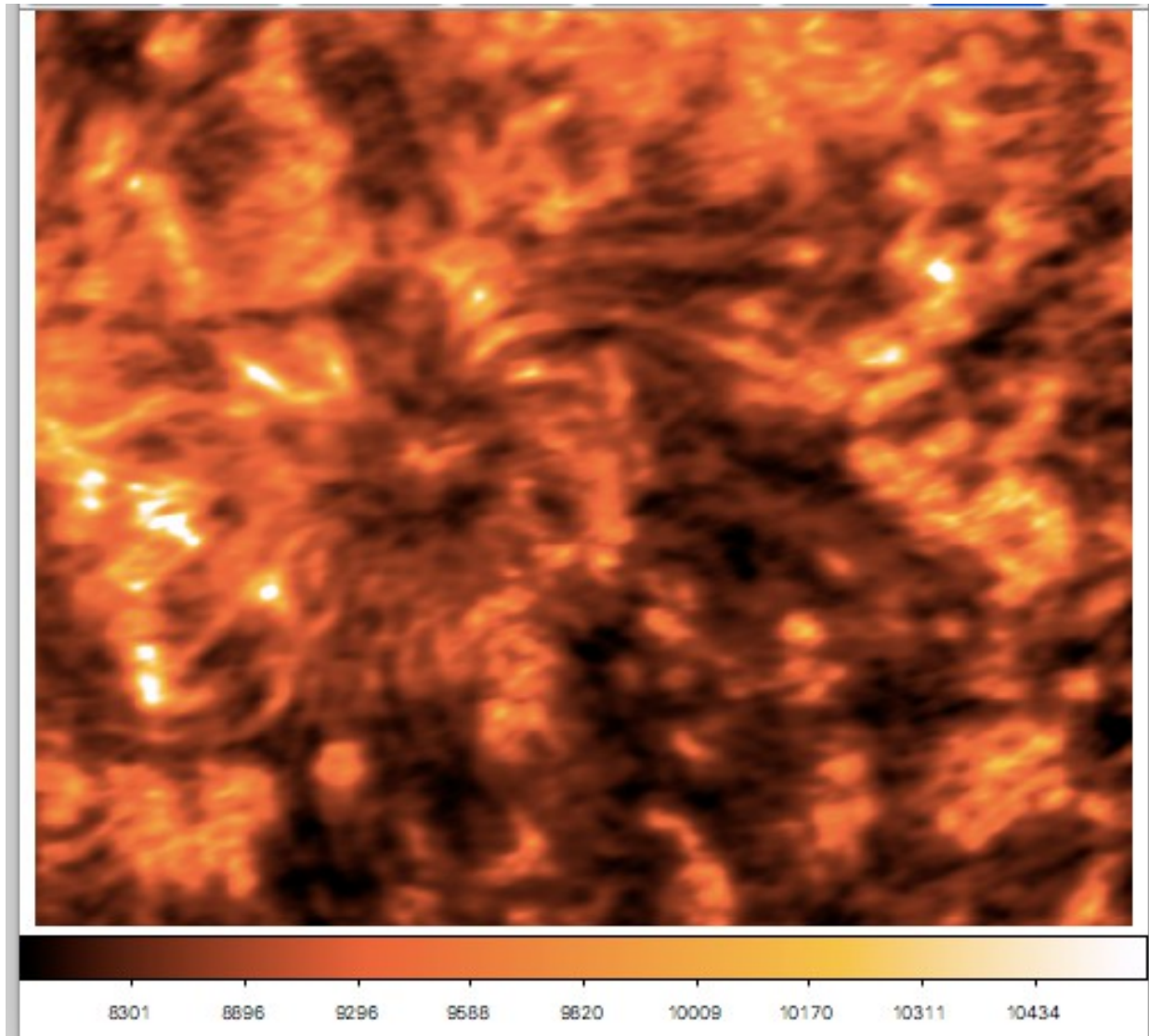




# CSV Data Release – Filament, 100 Ghz (Band 3)

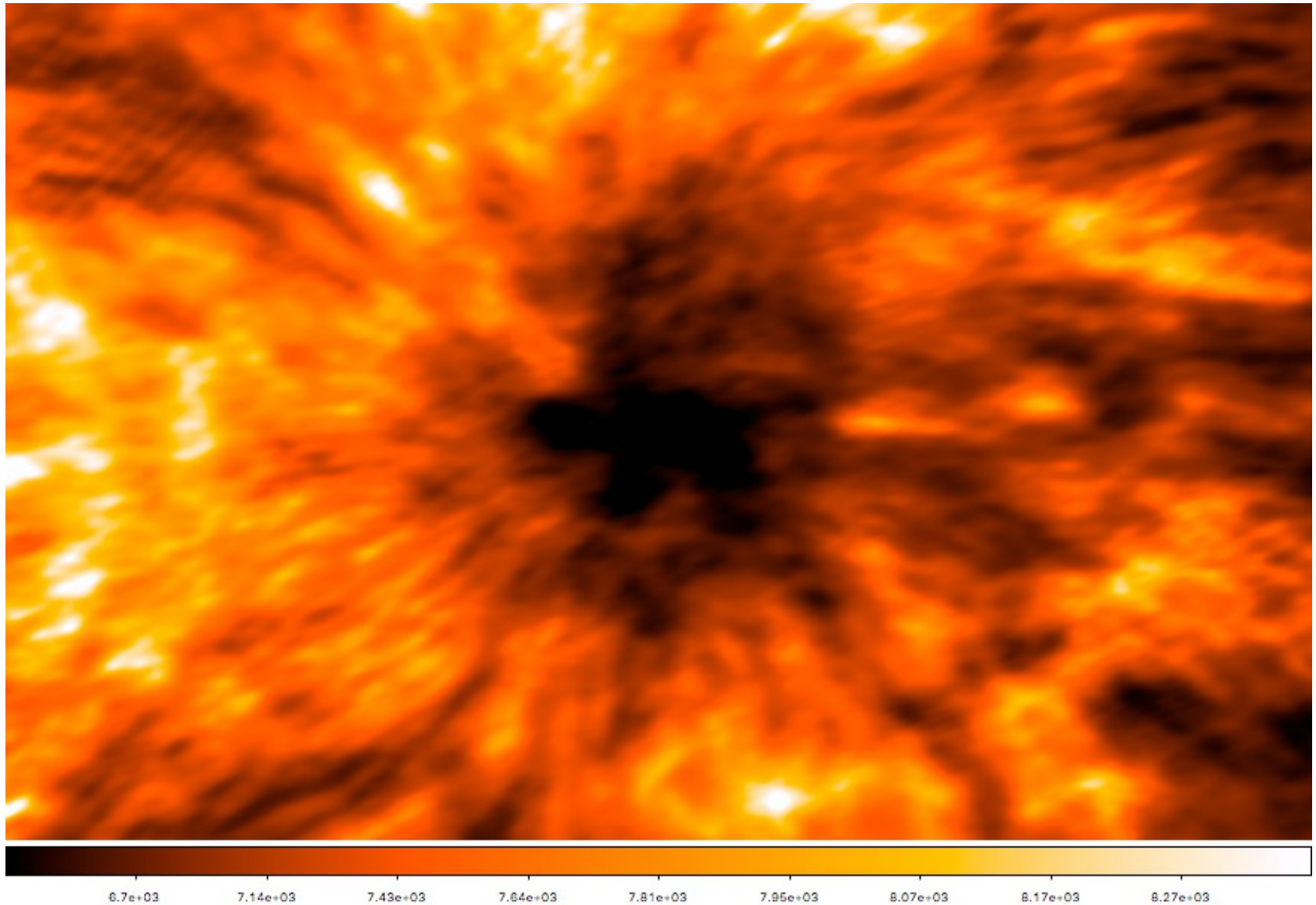


# CSV Data Release – Sunpot, 100 Ghz (Band 3)

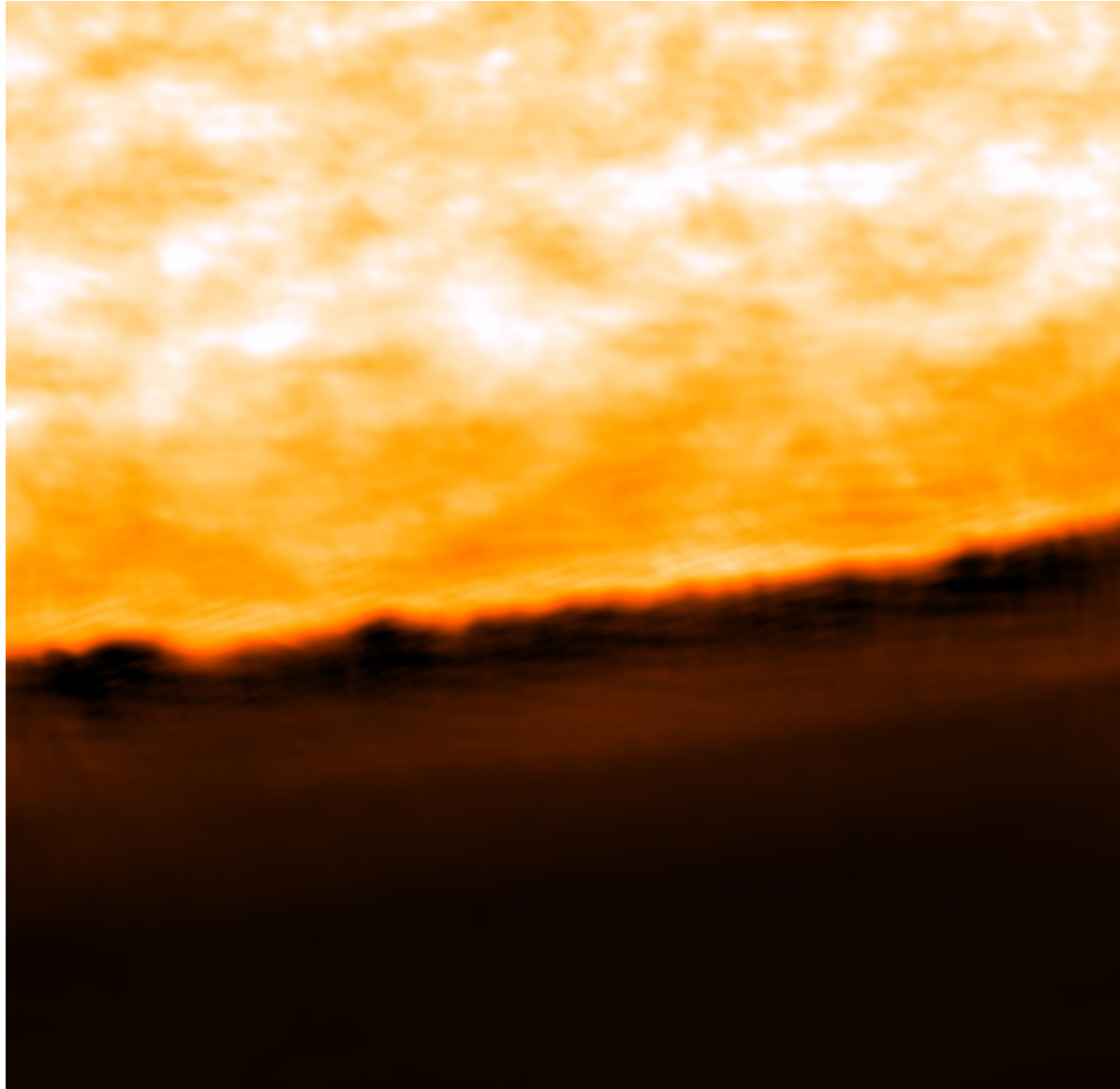




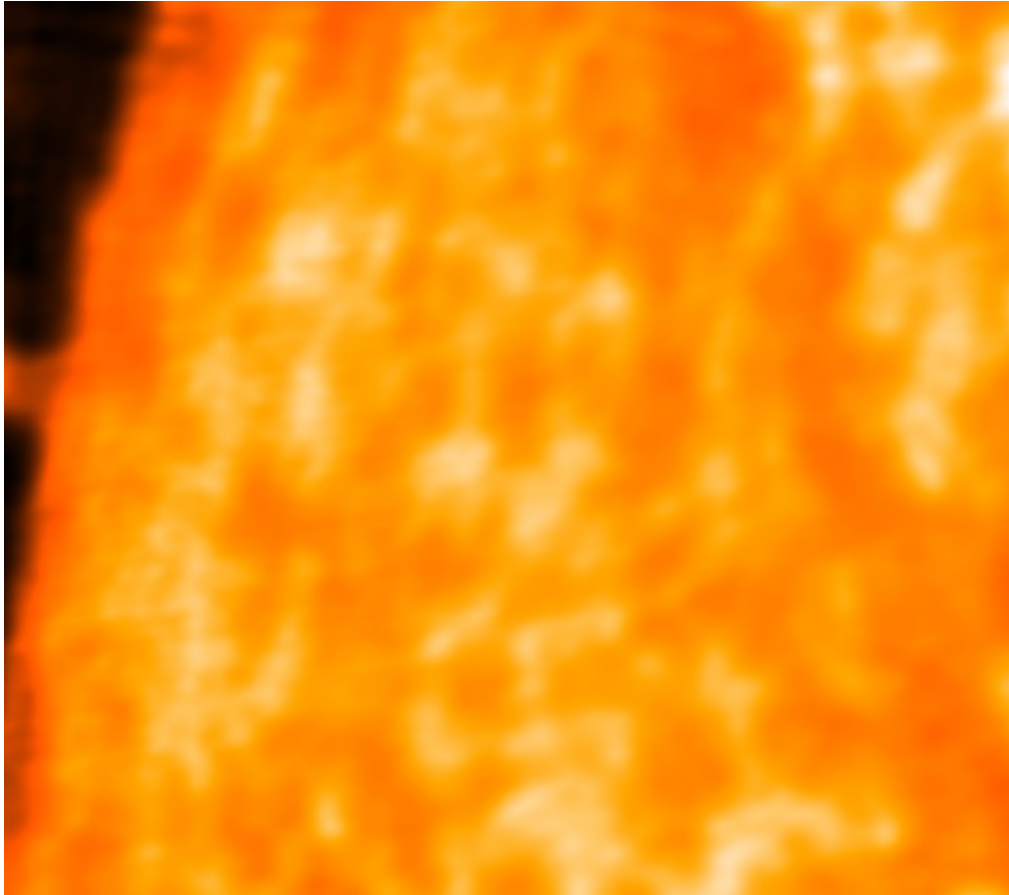
# CSV Data Release – Sunpot, 239 Ghz (Band 6)



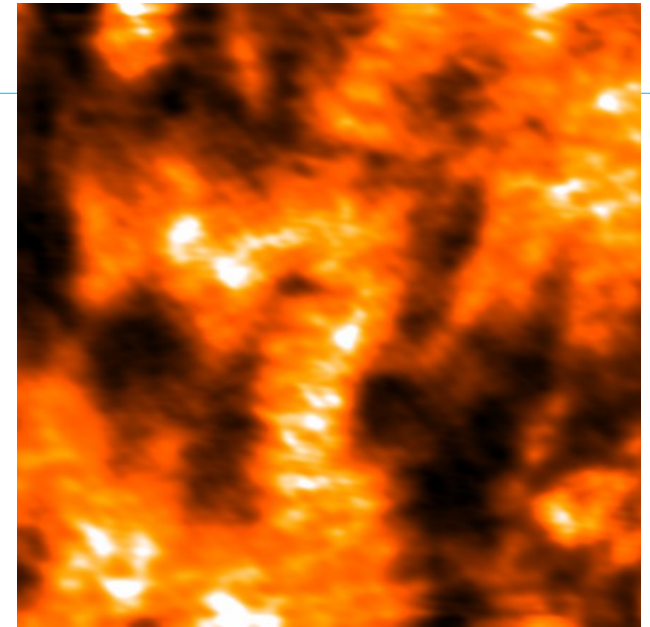
# CSV Data Release – South pole, 239 GHz



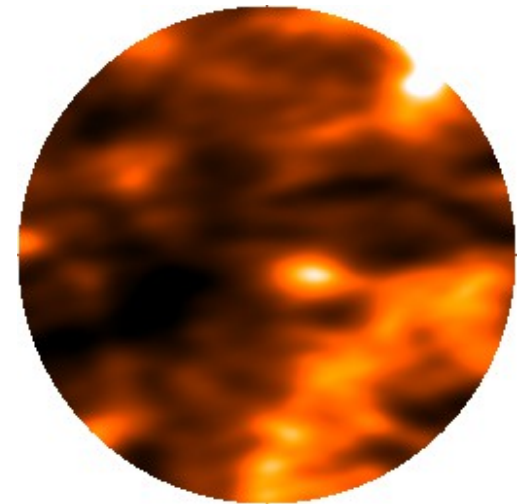
# CSV Data Release



100 GHz, prominence, small mosaic



100 GHz, AR, small mosaic



100 GHz, AR, single pointing

# Conclusions

- INT image reconstruction → correct
- pointing and overlapping (coalignment) of ALMA images with other images → successful, TP & INT
- ARs → bright in B6 & B3
- Sunspot umbra → dark in B6 → bright in B3
- filaments (on disc) and CHs are not discernible against the QS background
- large-scale elongated dark structures in B6 → inversion lines of the magnetic field
- coronal bright points → He 1083 dark points → ALMA B6 (TP) bright points; strongly correlated with magnetograms
- small bright ALMA B3 (INT) structures → H $\alpha$  dark points → magnetograms → UV continuum



## Acknowledgments

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