A high resolution view of solar magnetic fields

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The ever-lasting problem of low S/N

The problem of reconstructing magnetic fields:

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- Spatio-temporal binning (affects all model parameters)
- Filtering of Q,U&V (makes them inconsistent with Stokes I)

Solution: use prior information!

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$$\chi^2 = \frac{1}{N} \sum_{i=1}^{N} \left(\frac{o_i - s_i(\boldsymbol{x})}{\sigma_i} \right)^2 + \sum_{p=1}^{M} \alpha_p \Gamma(\boldsymbol{x})^2$$

Our prior knowledge

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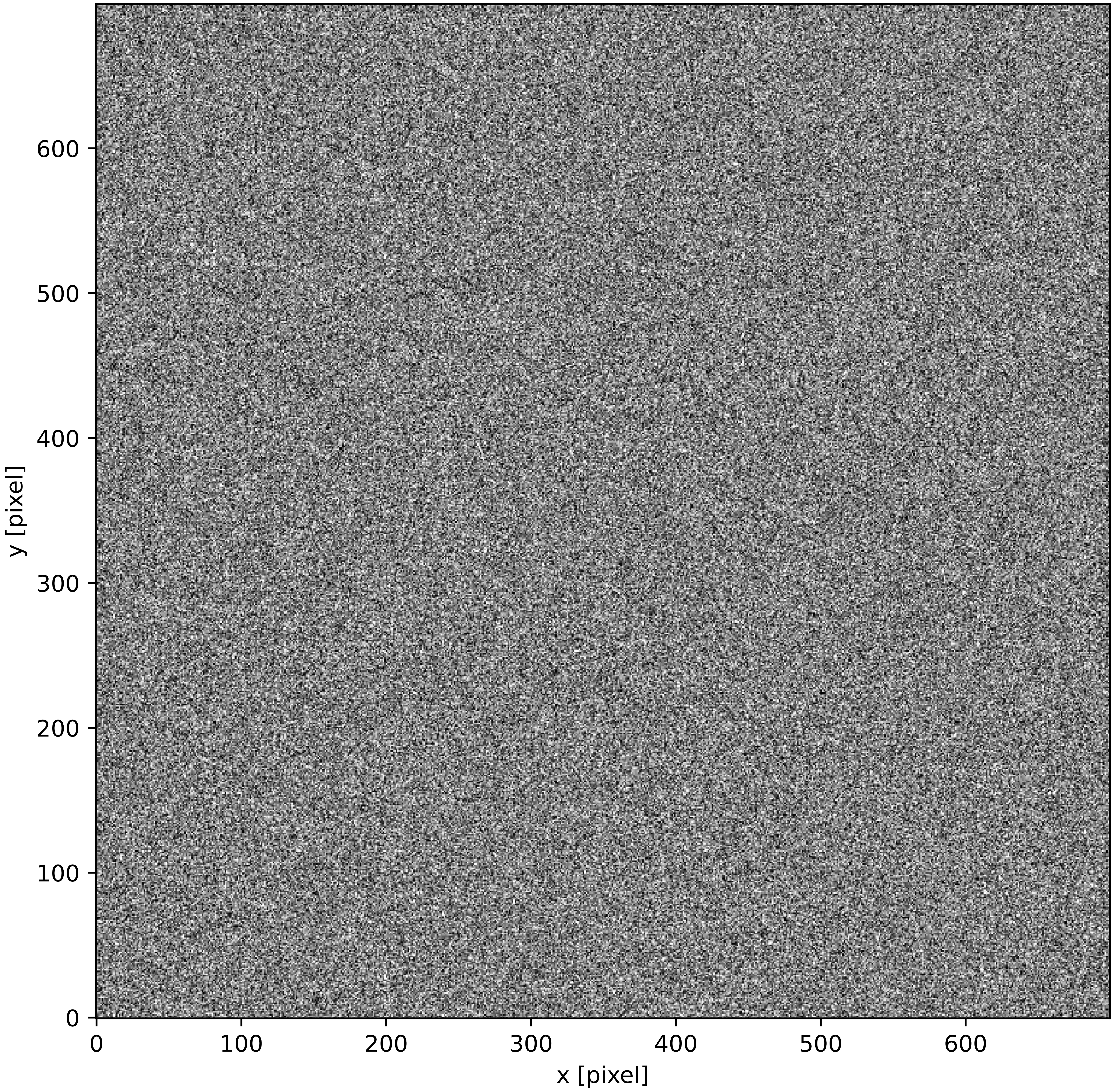
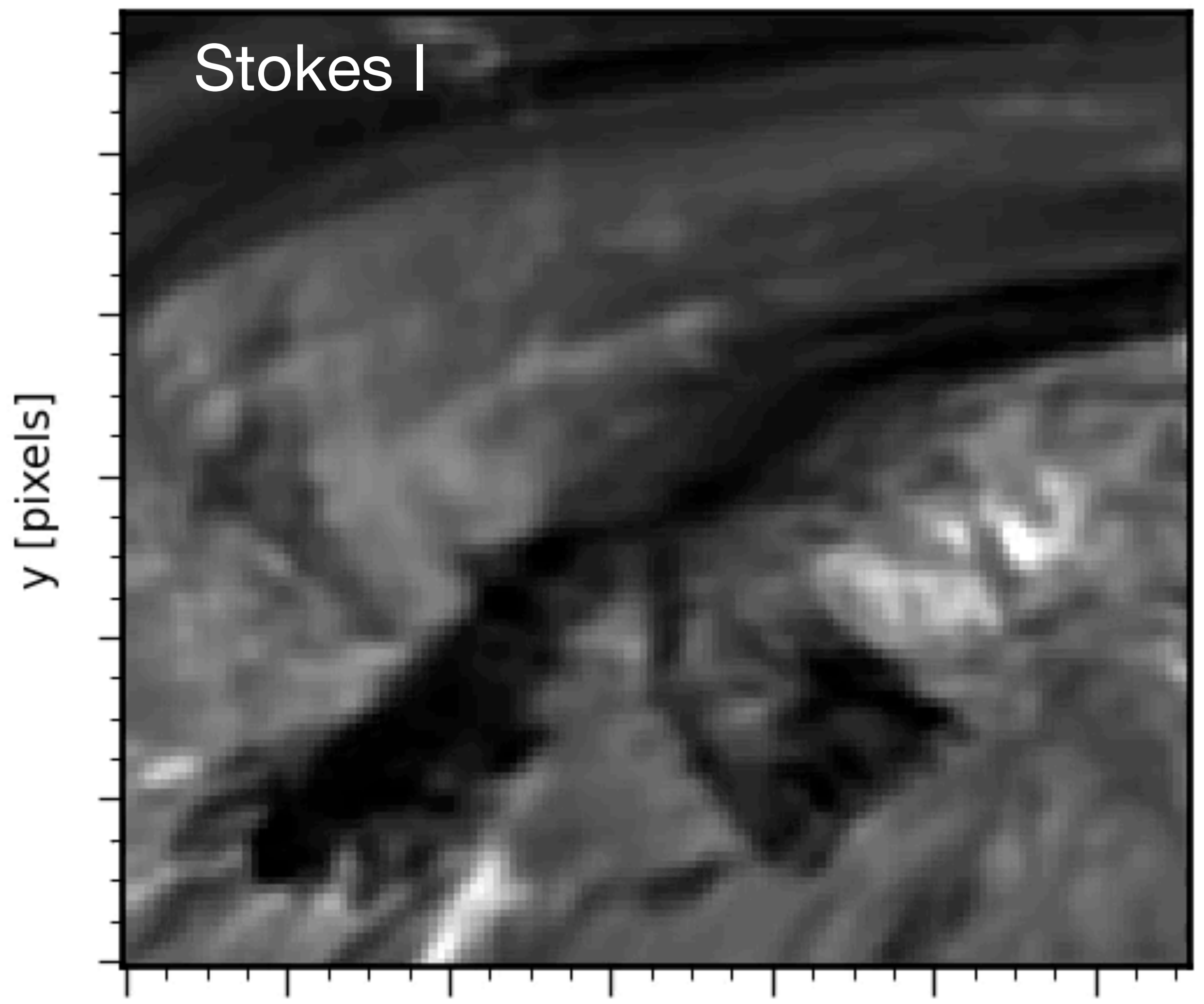


Regularized Weak-Field approximation

A test of the weak-field approximation applied to MiHi $H\alpha$ data



Data courtesy of Michiel van Noort (MPS)

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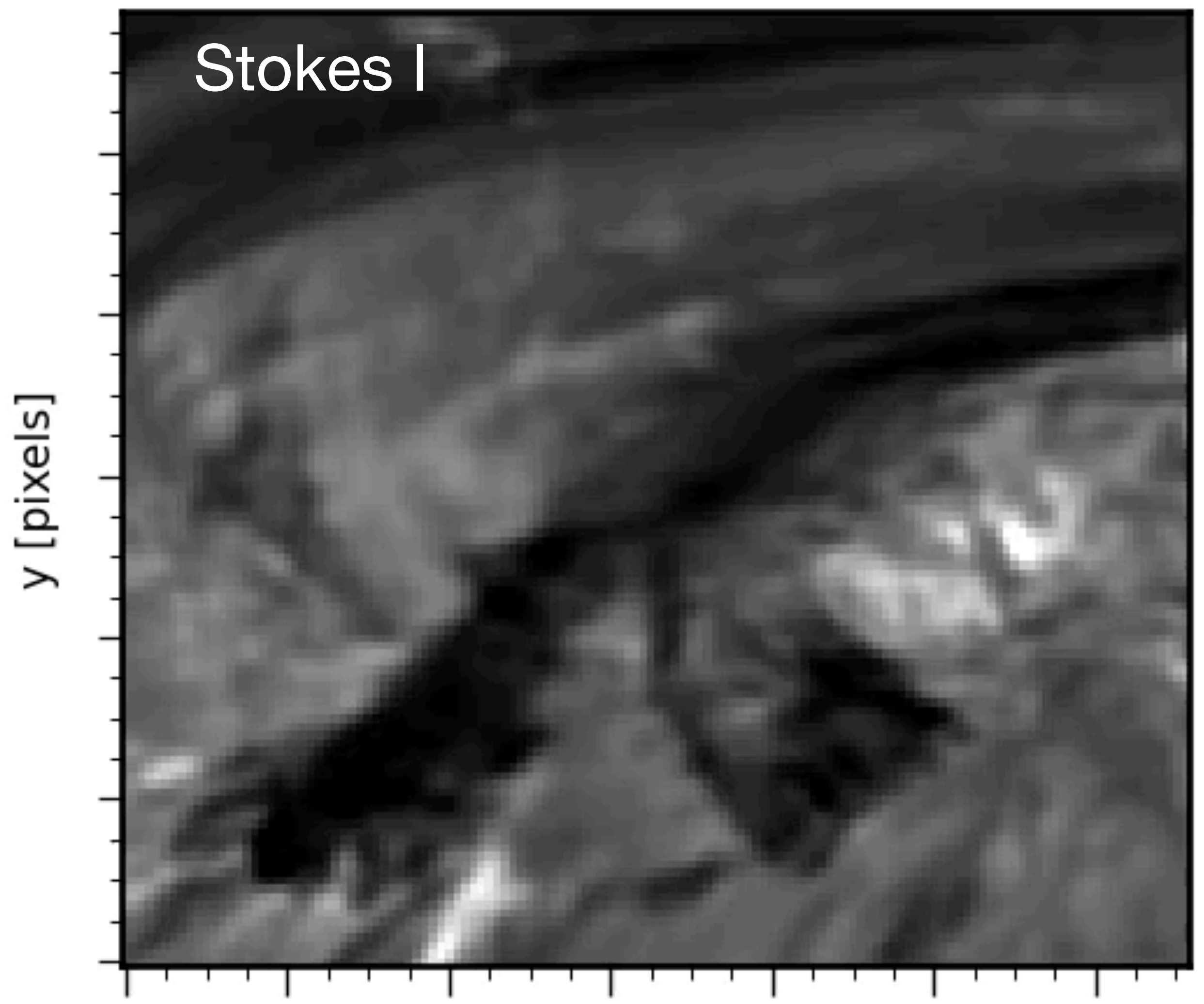

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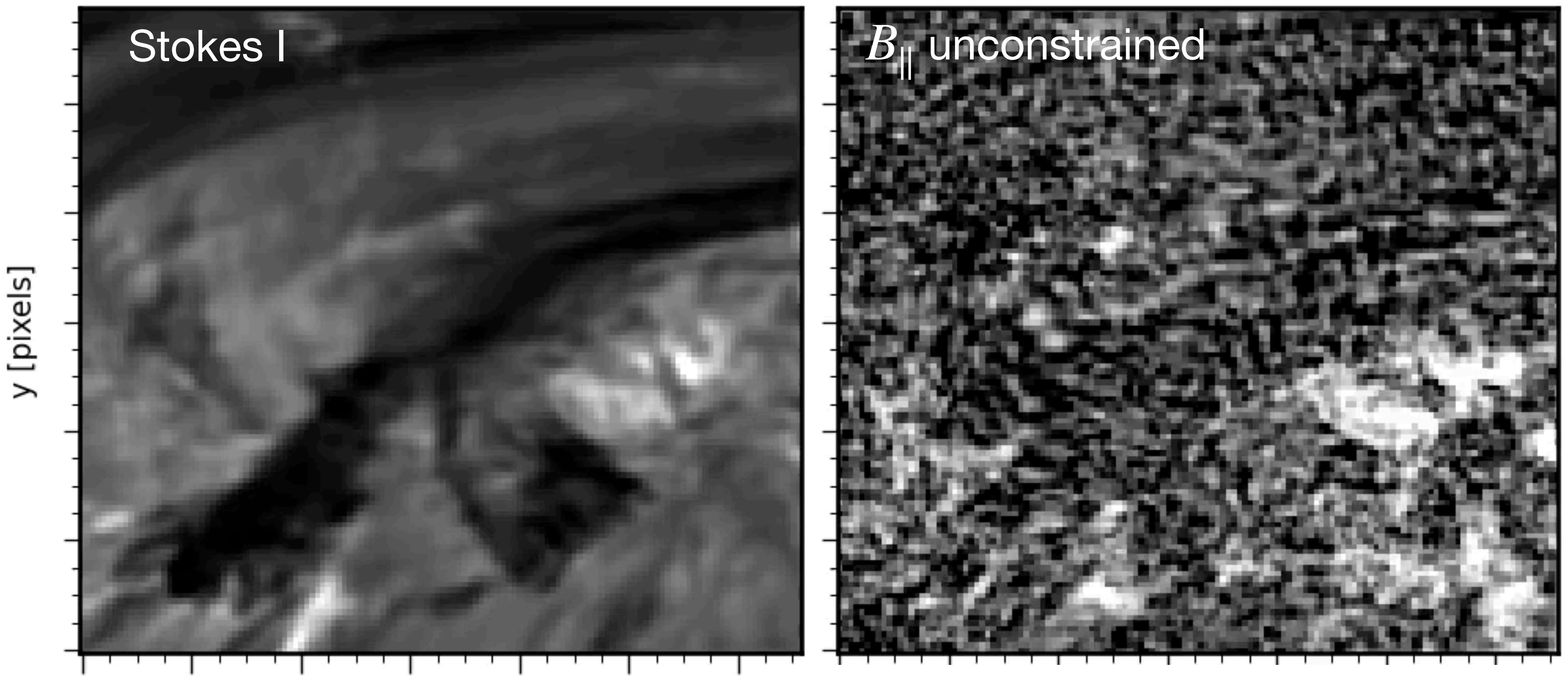

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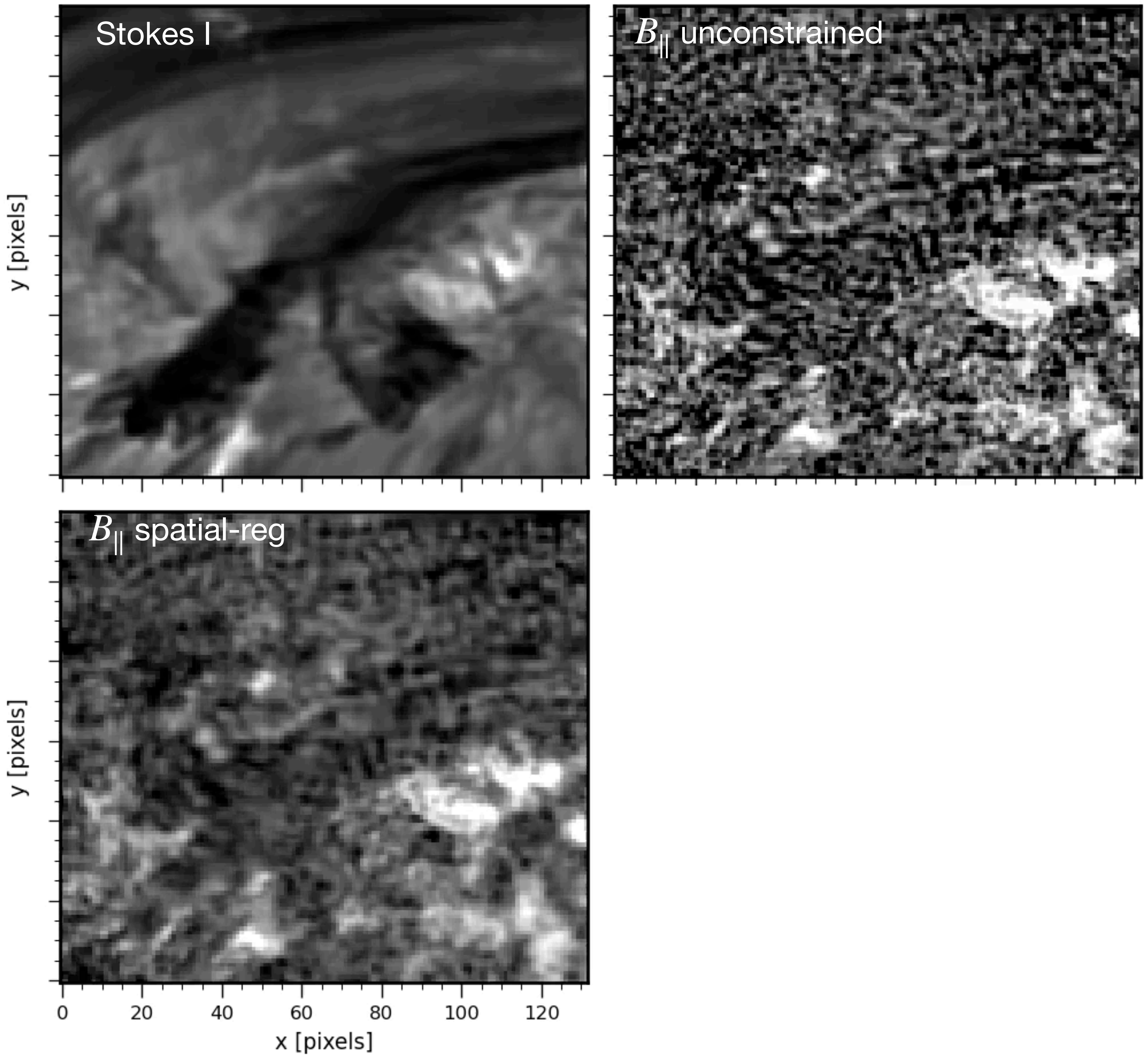

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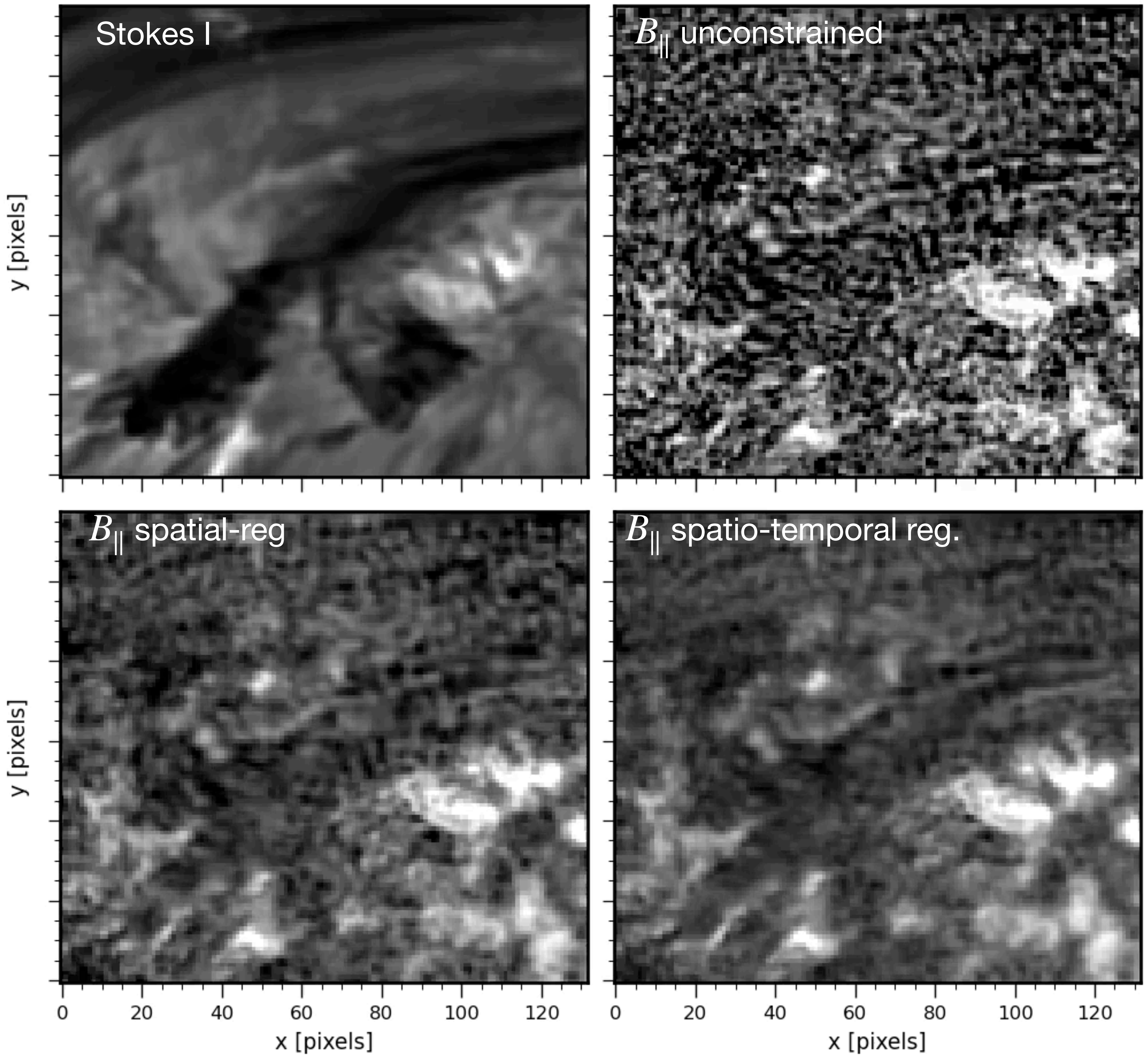

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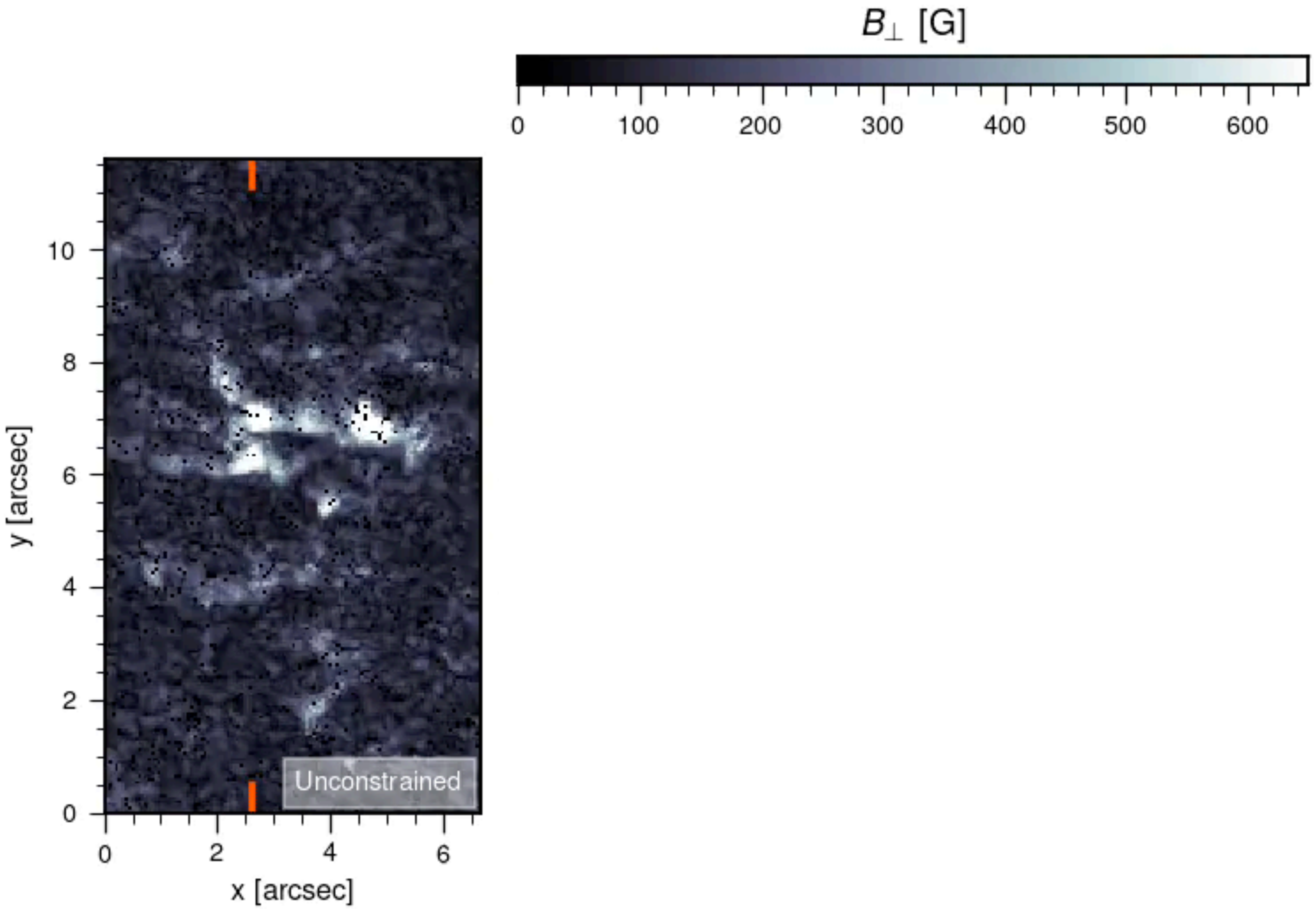
Spatio-temporal regularization in Milne-Eddington inversions



(from de la Cruz Rodríguez & Leenaarts 2024)

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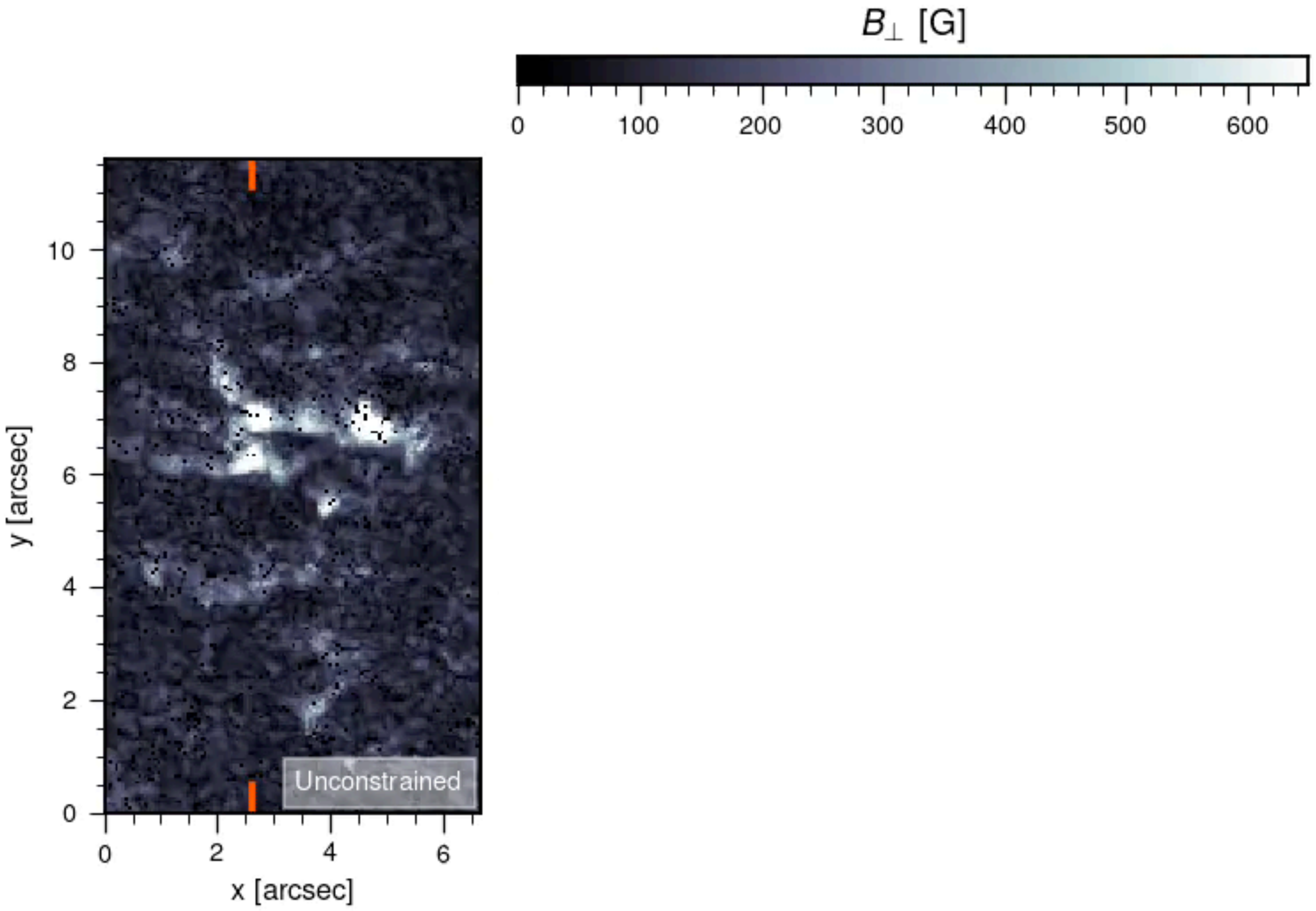

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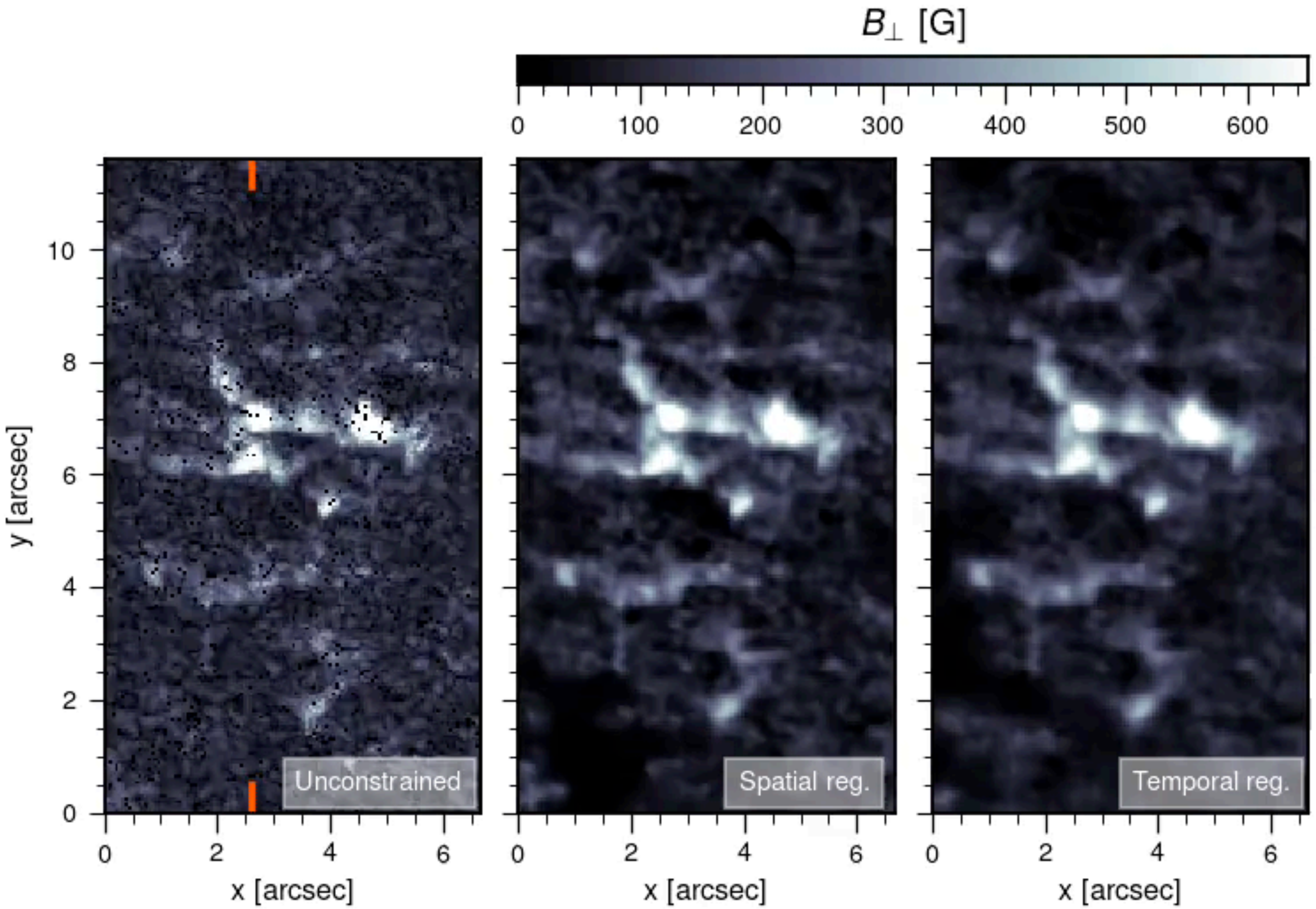

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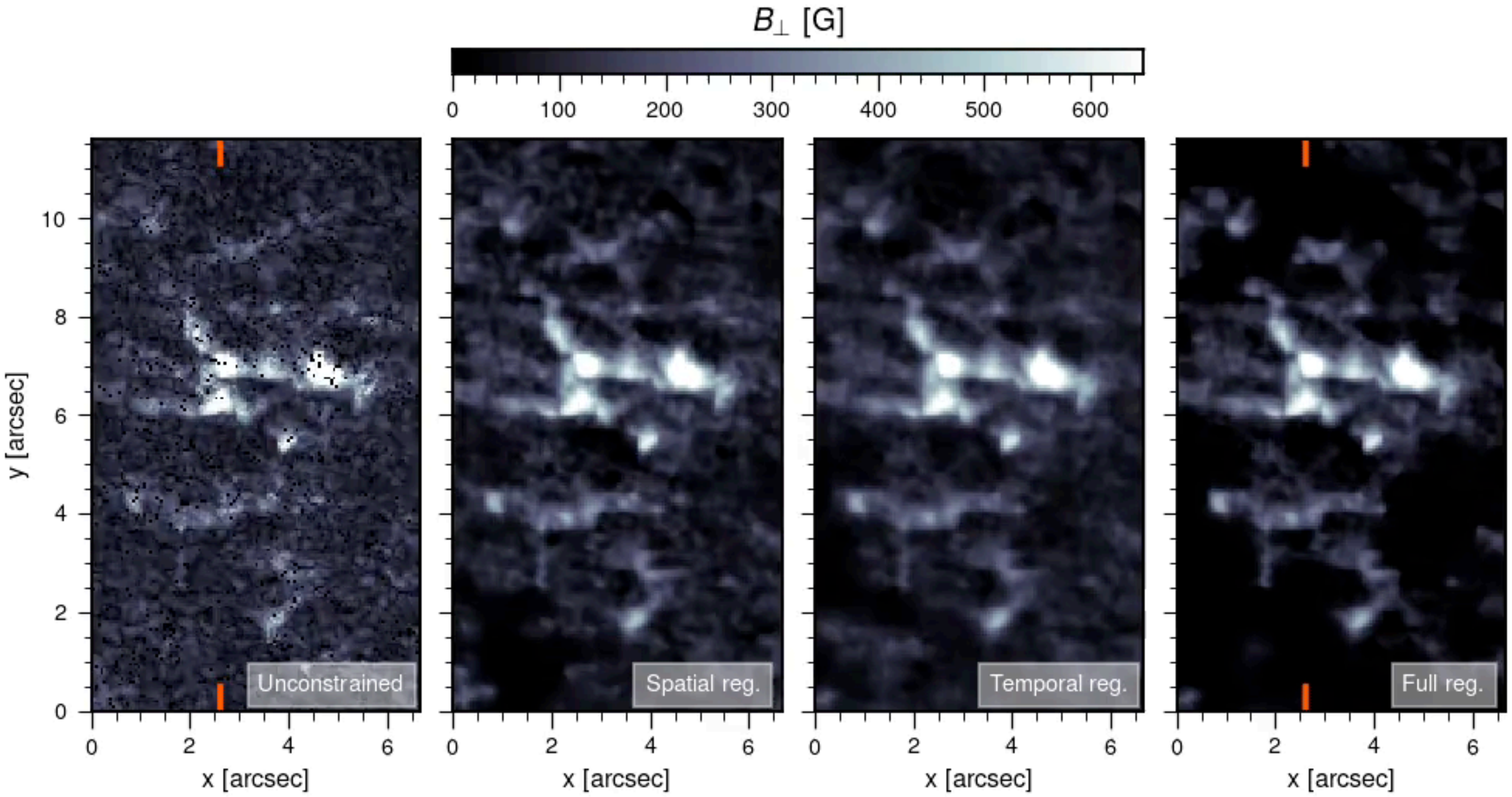

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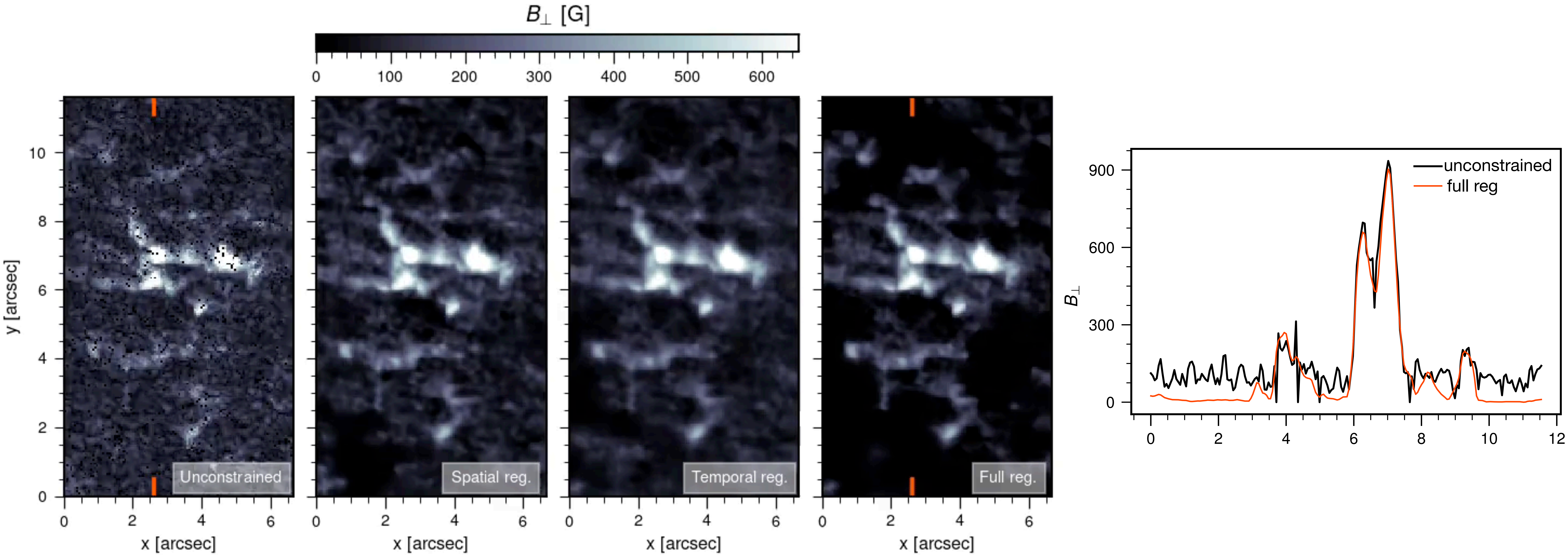

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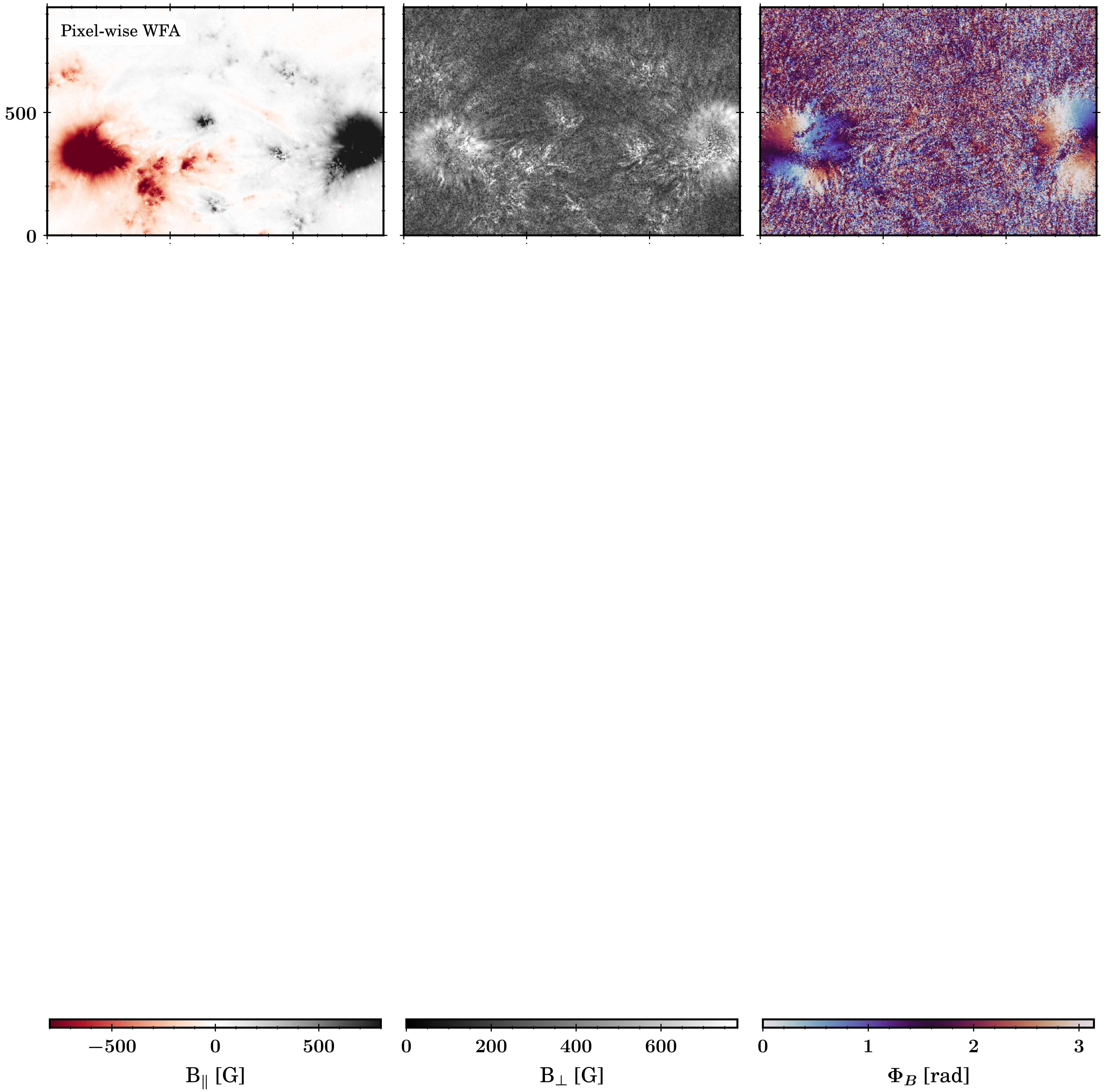
Reconstruction with physics-informed neural networks



No regularization

Diaz Baso et al. (2025)

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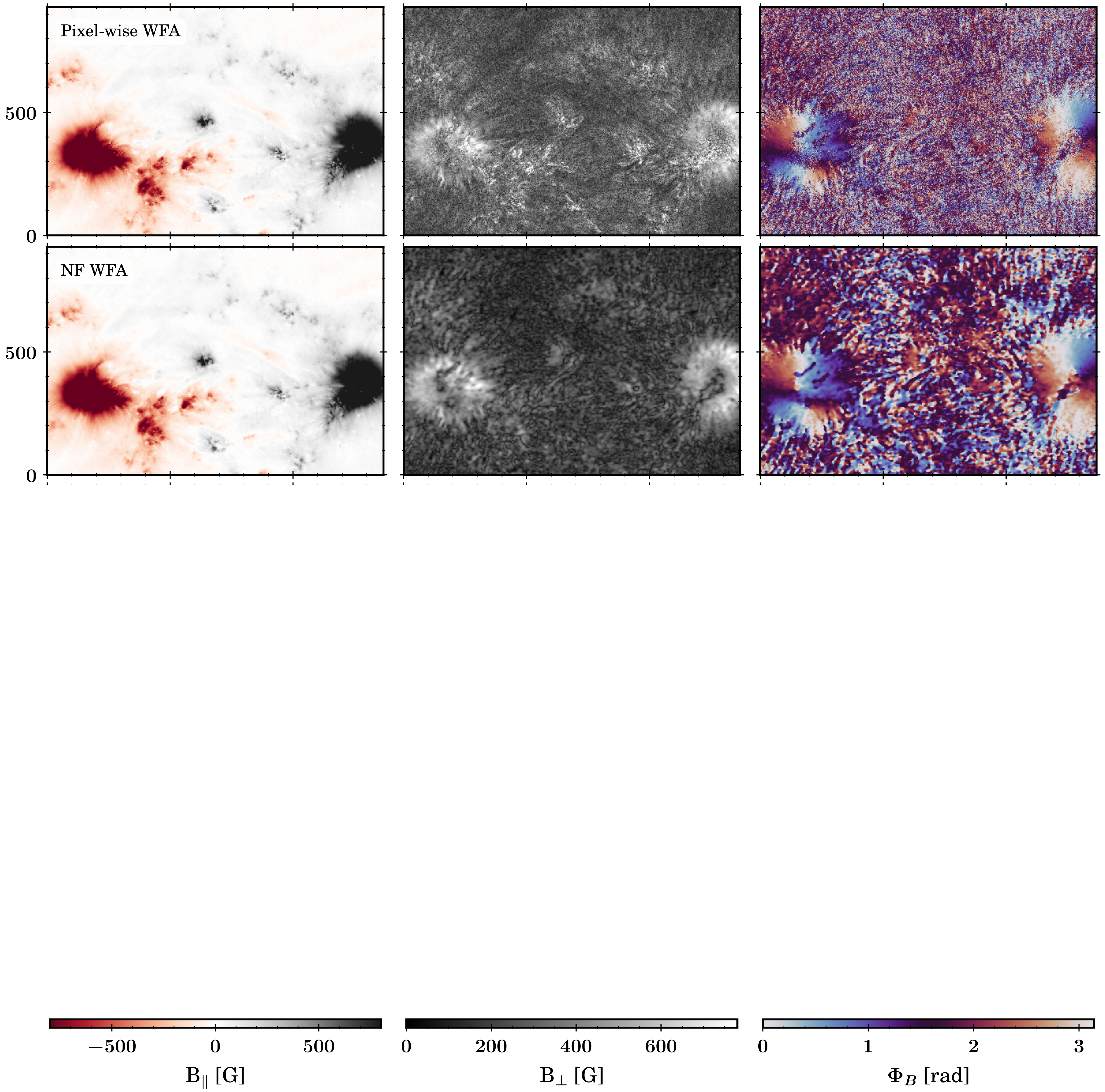

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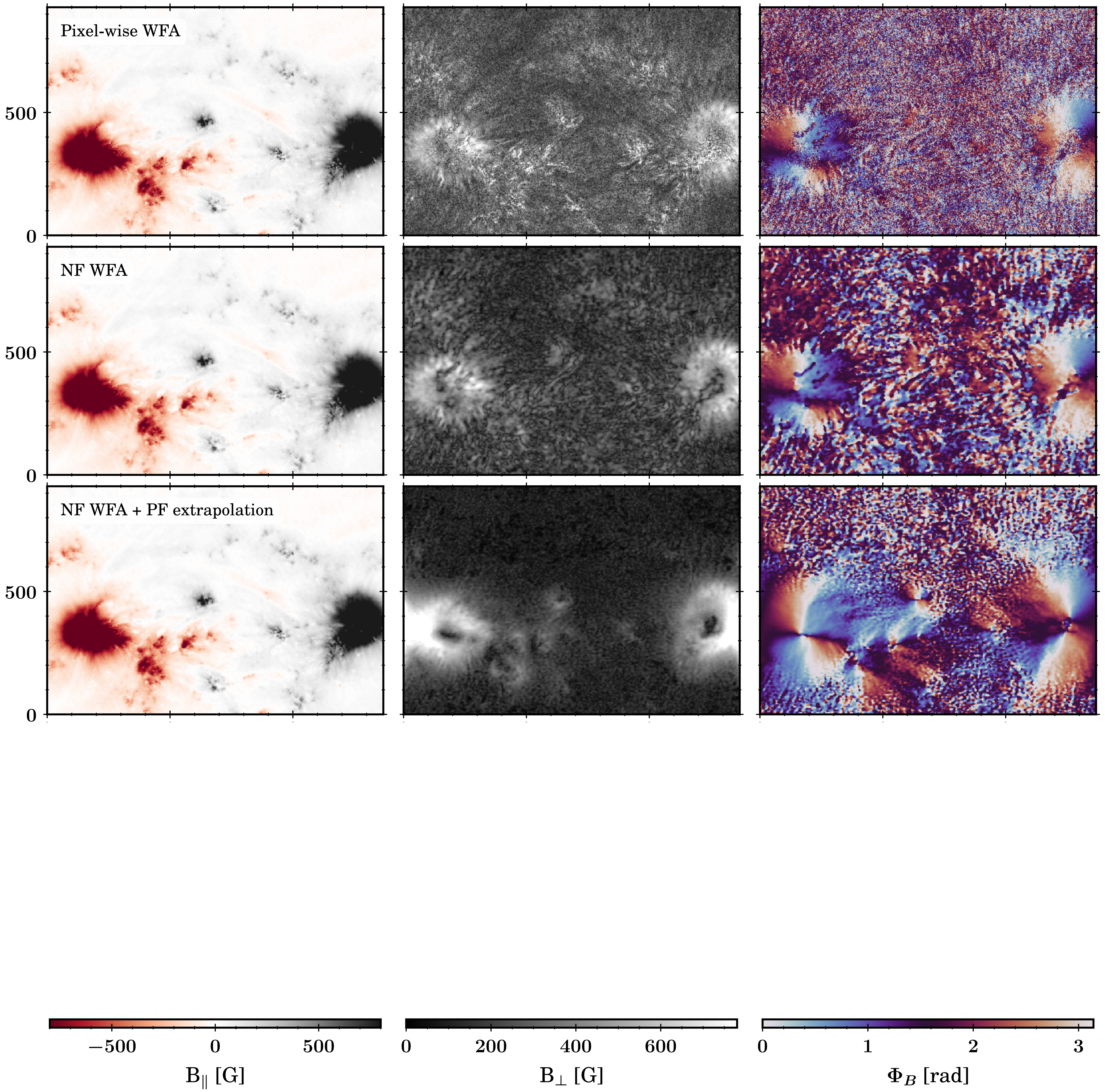

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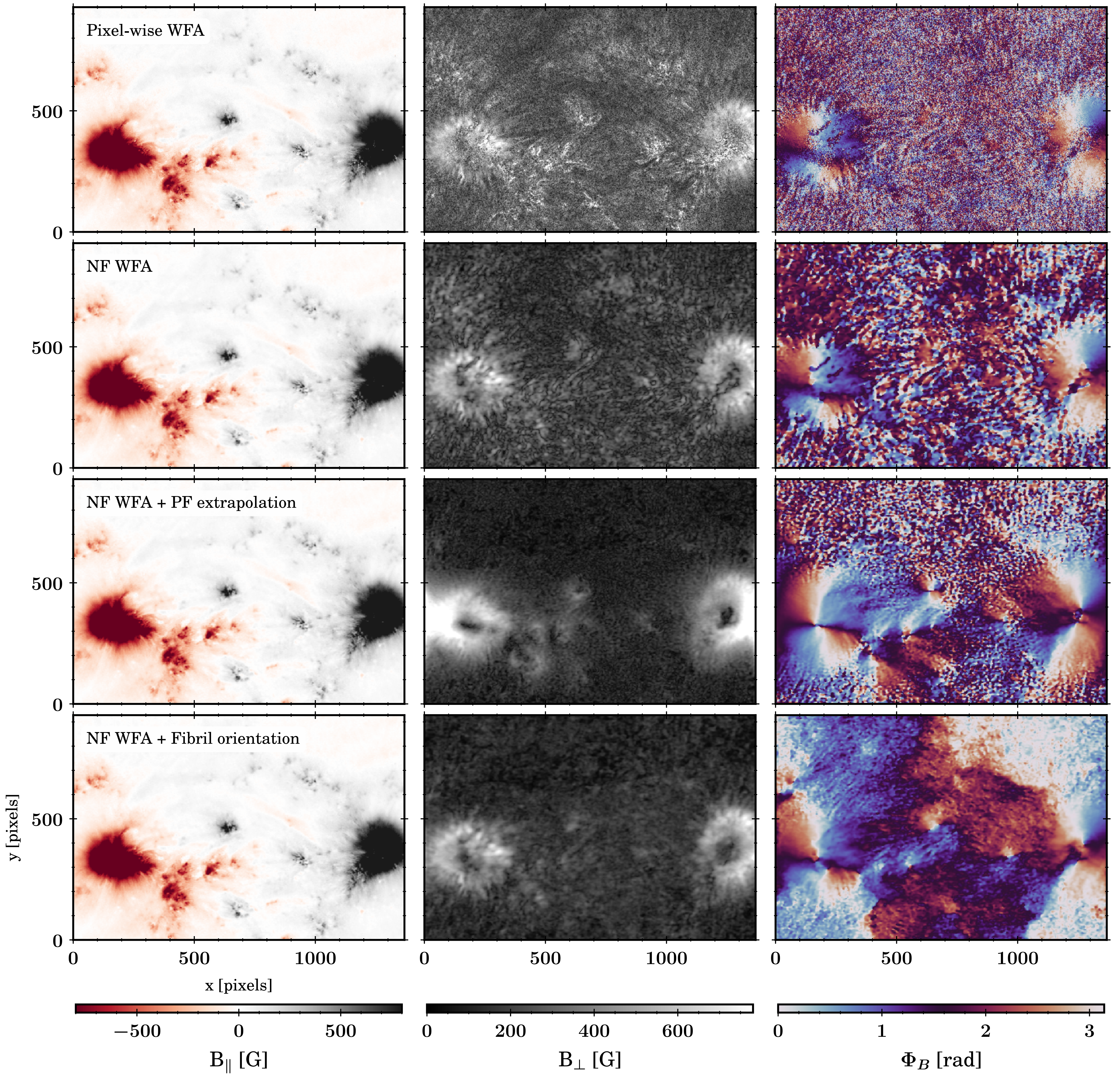

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Solution forced to be close to a potential field-extrapolation

Solution forced to be close to fibril orientation in Stokes I

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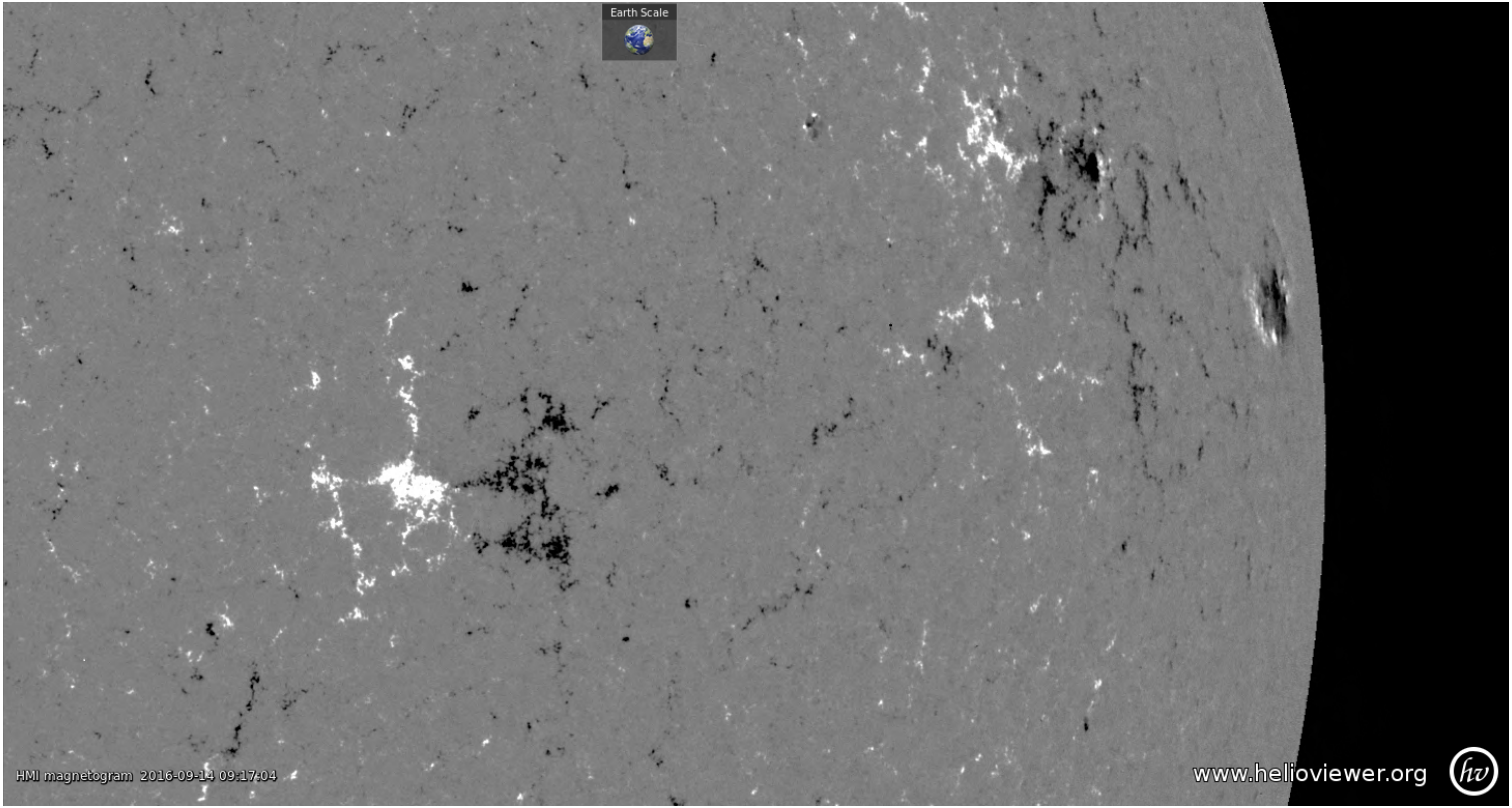
Magnetic fields in solar plage



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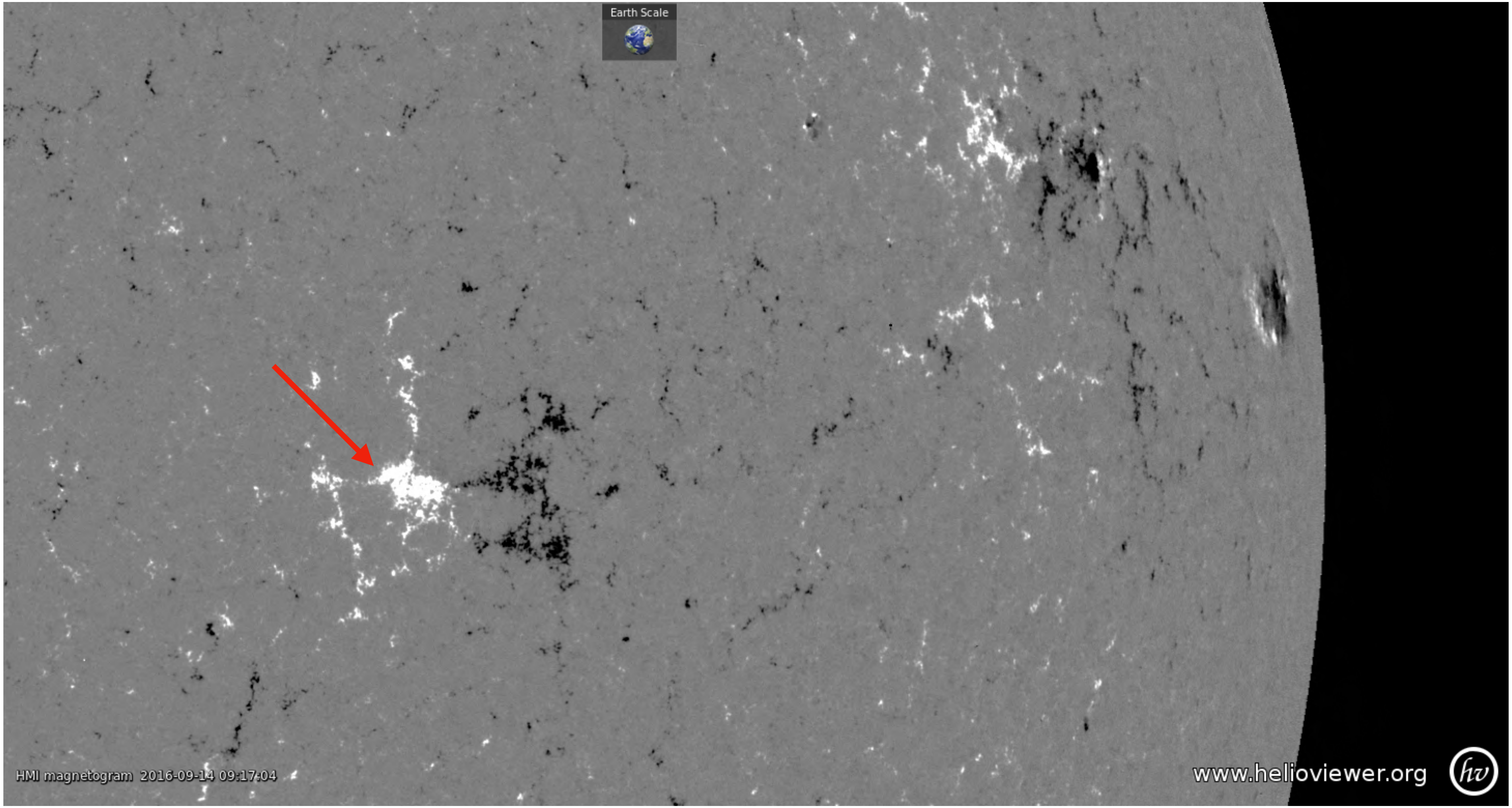

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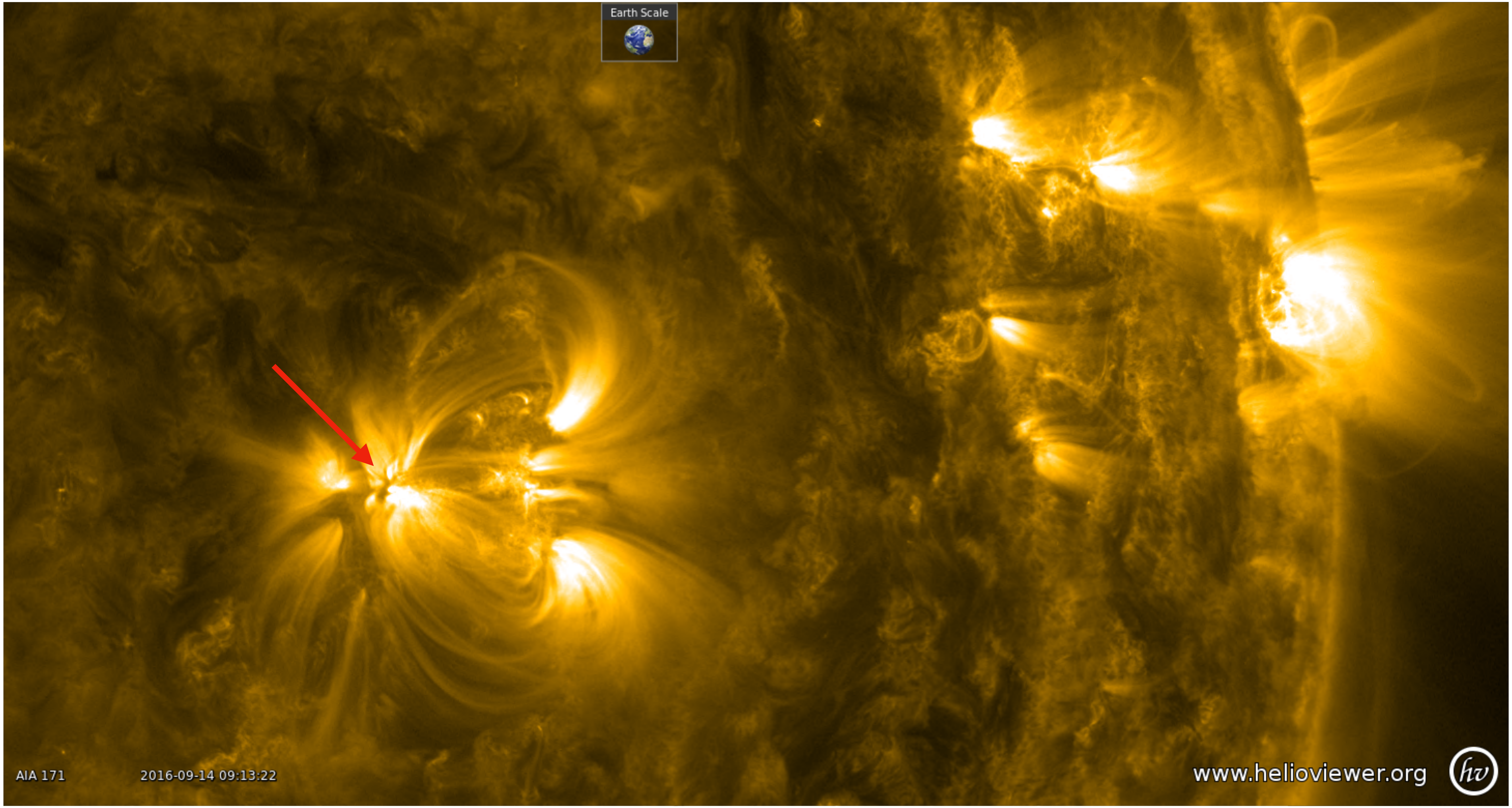

Plage photospheres

An explanation for the Stokes *V* asymmetry in solar faculae

J. Sánchez Almeida, M. Collados, and J. C. del Toro Iniesta

Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain

Received May 19, accepted June 2, 1988

Summary: The asymmetry in the Stokes *V* profile observed in solar faculae can be explained by assuming that the magnetic field increases with height while downflow speed decreases. The MHD compatibility of such a solution is briefly discussed together with an observational test for that possibility.

Key Words: The Sun: faculae - magnetic fields - Stokes profiles - line asymmetries

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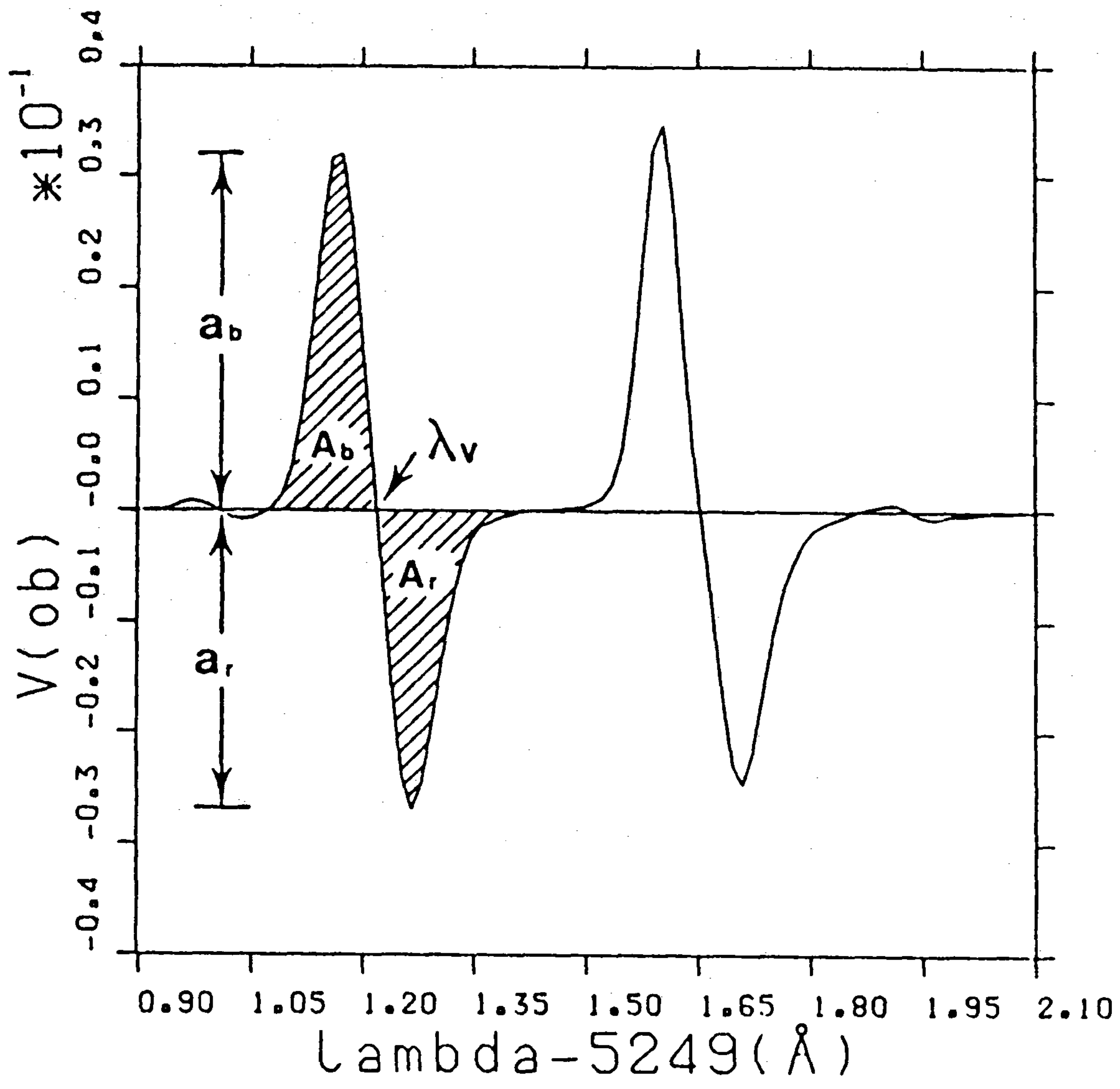
It seems well established that the Stokes *V* profile (circular polarization versus wavelength) of lines observed in solar faculae show several asymmetric features (Stenflo et al.,1984). Figure



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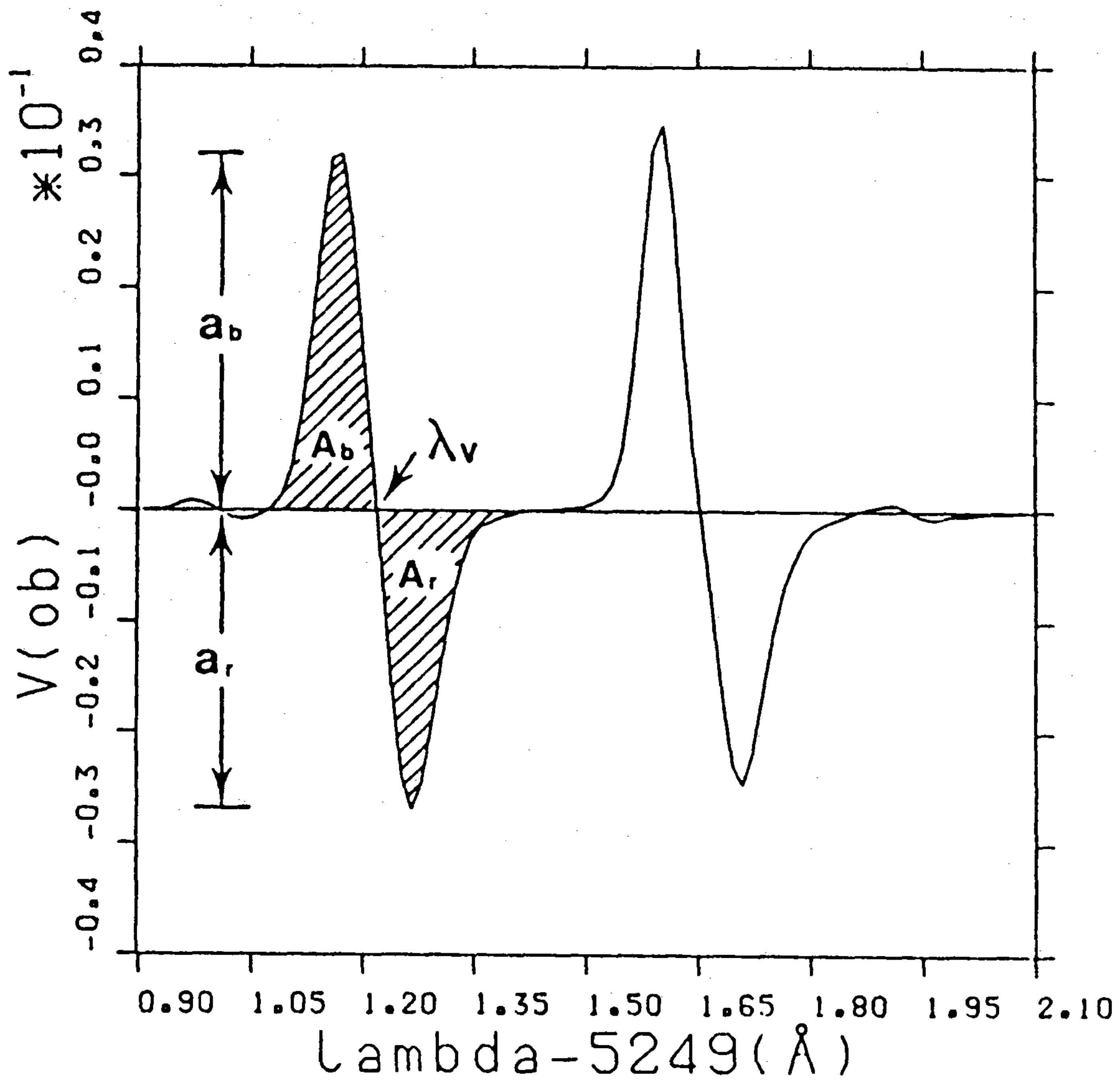

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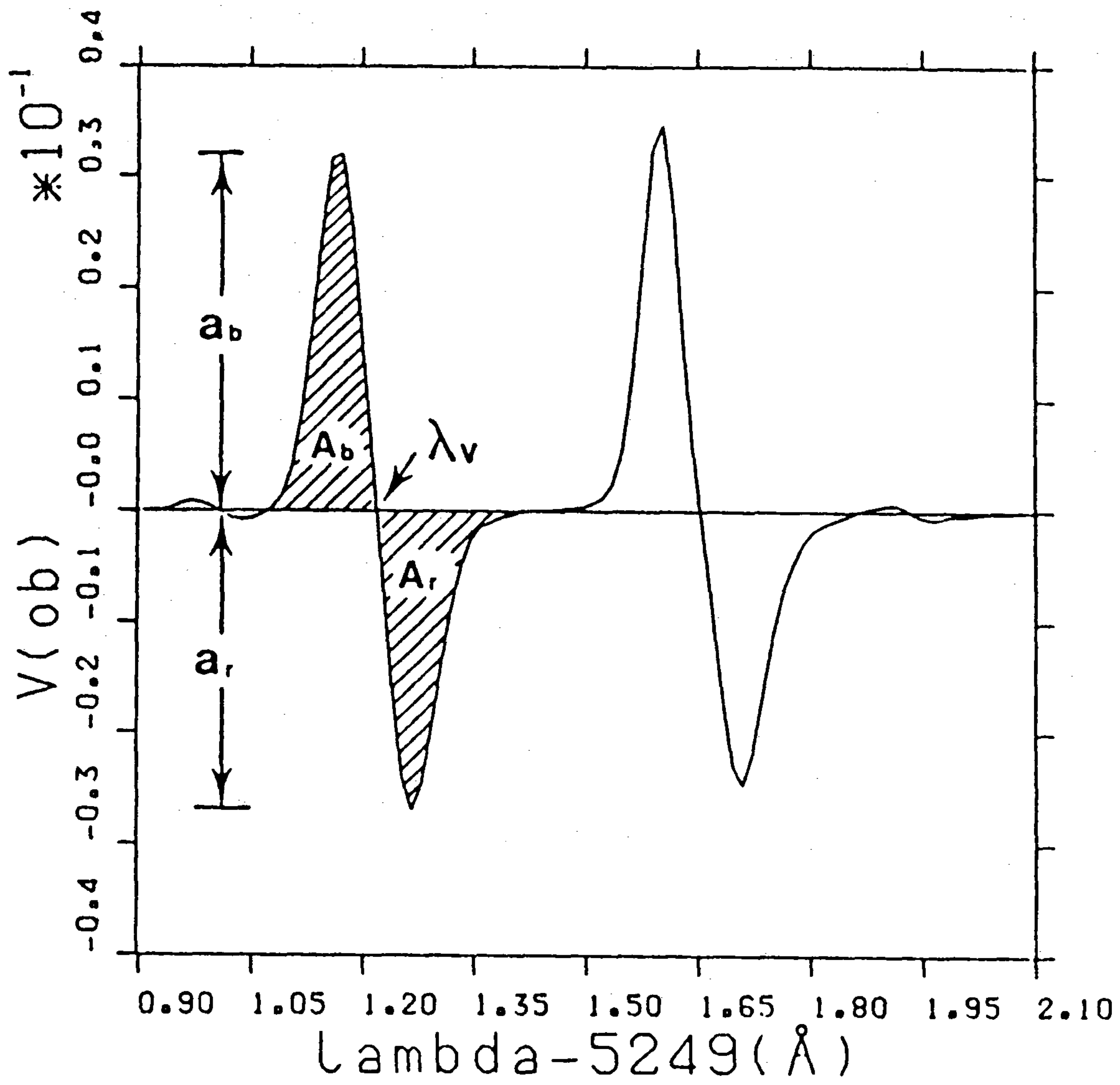

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Early observational indications of the canopy effect imprinted in the Stokes V profiles!

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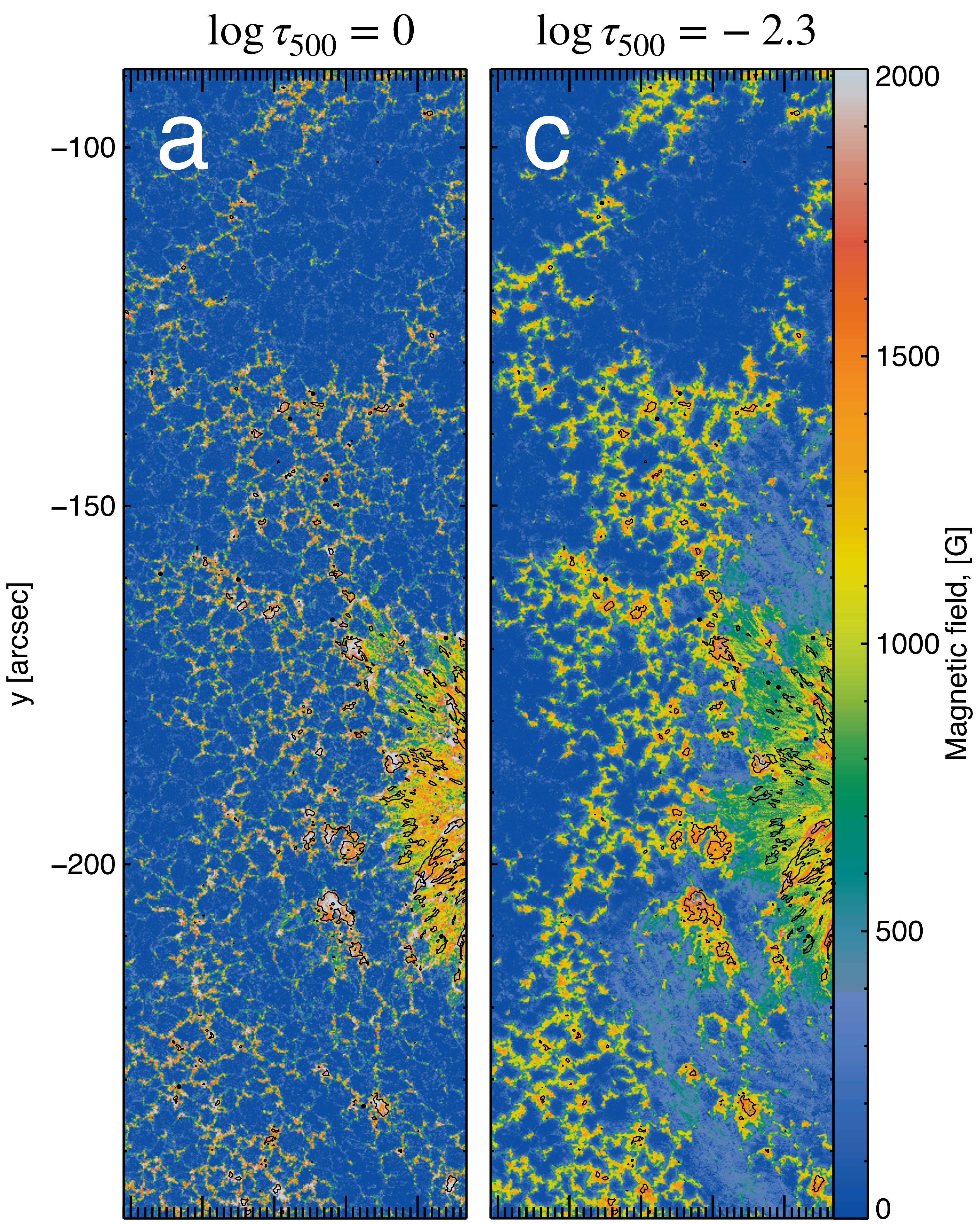

Buhler et al. (2015)

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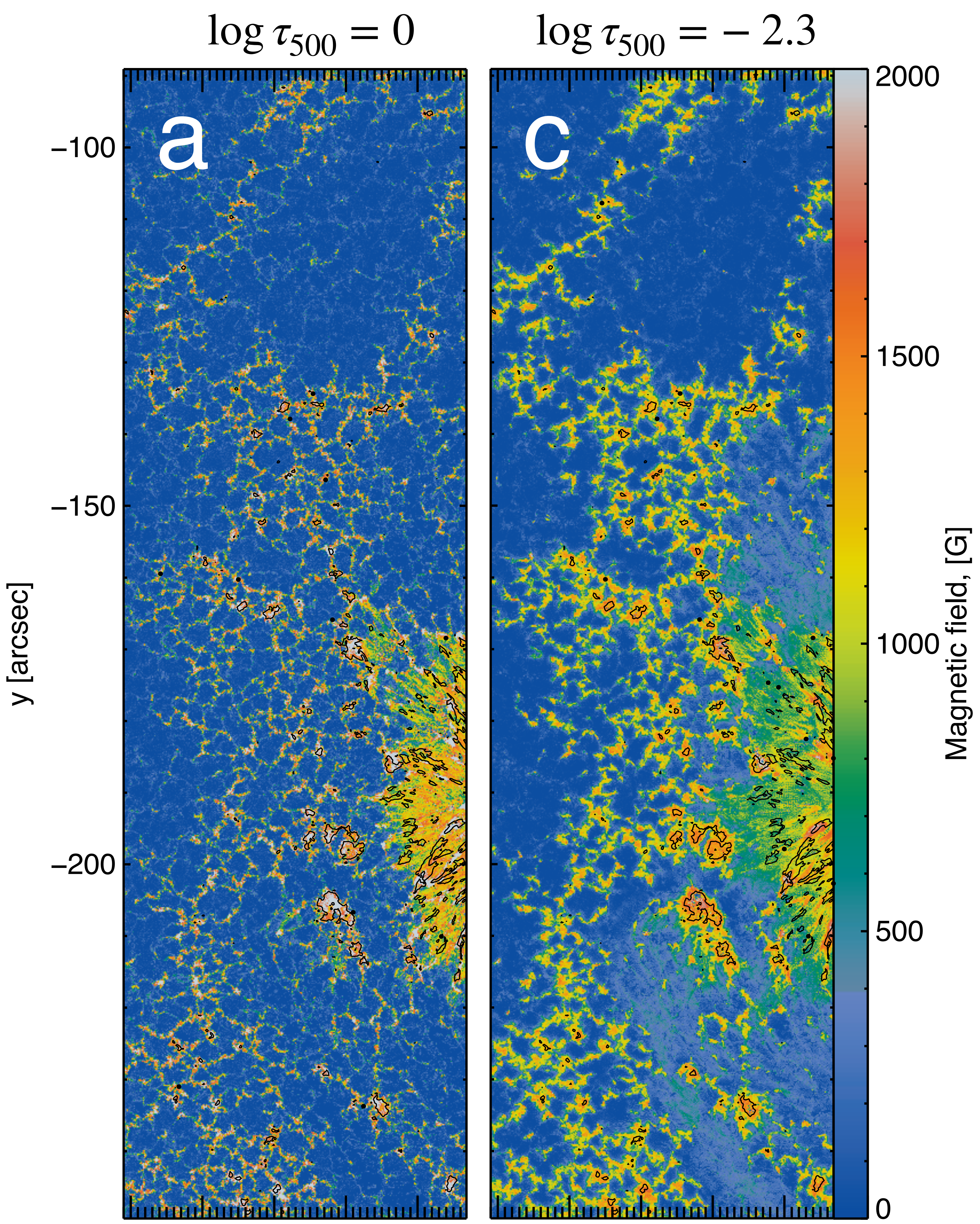

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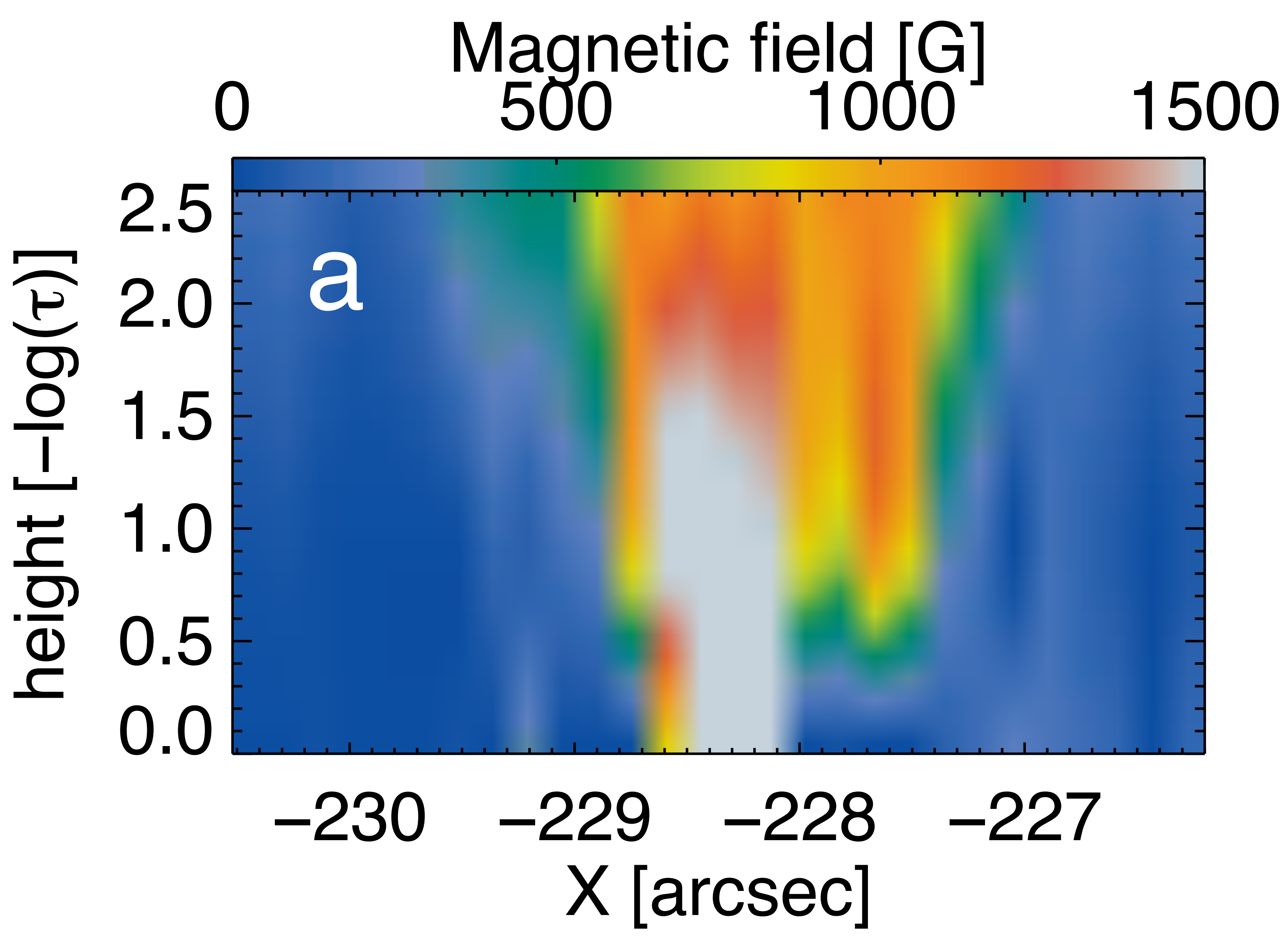

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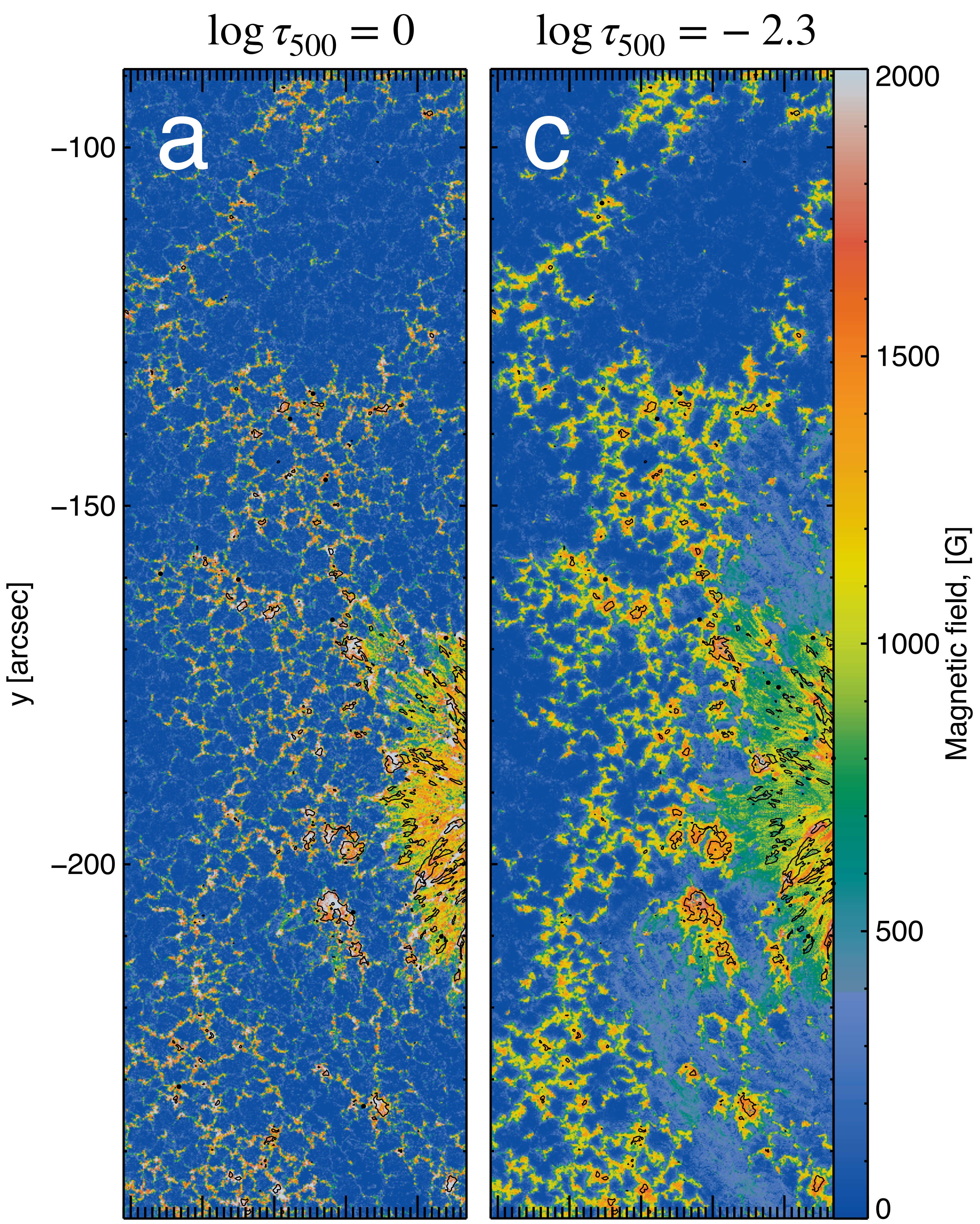

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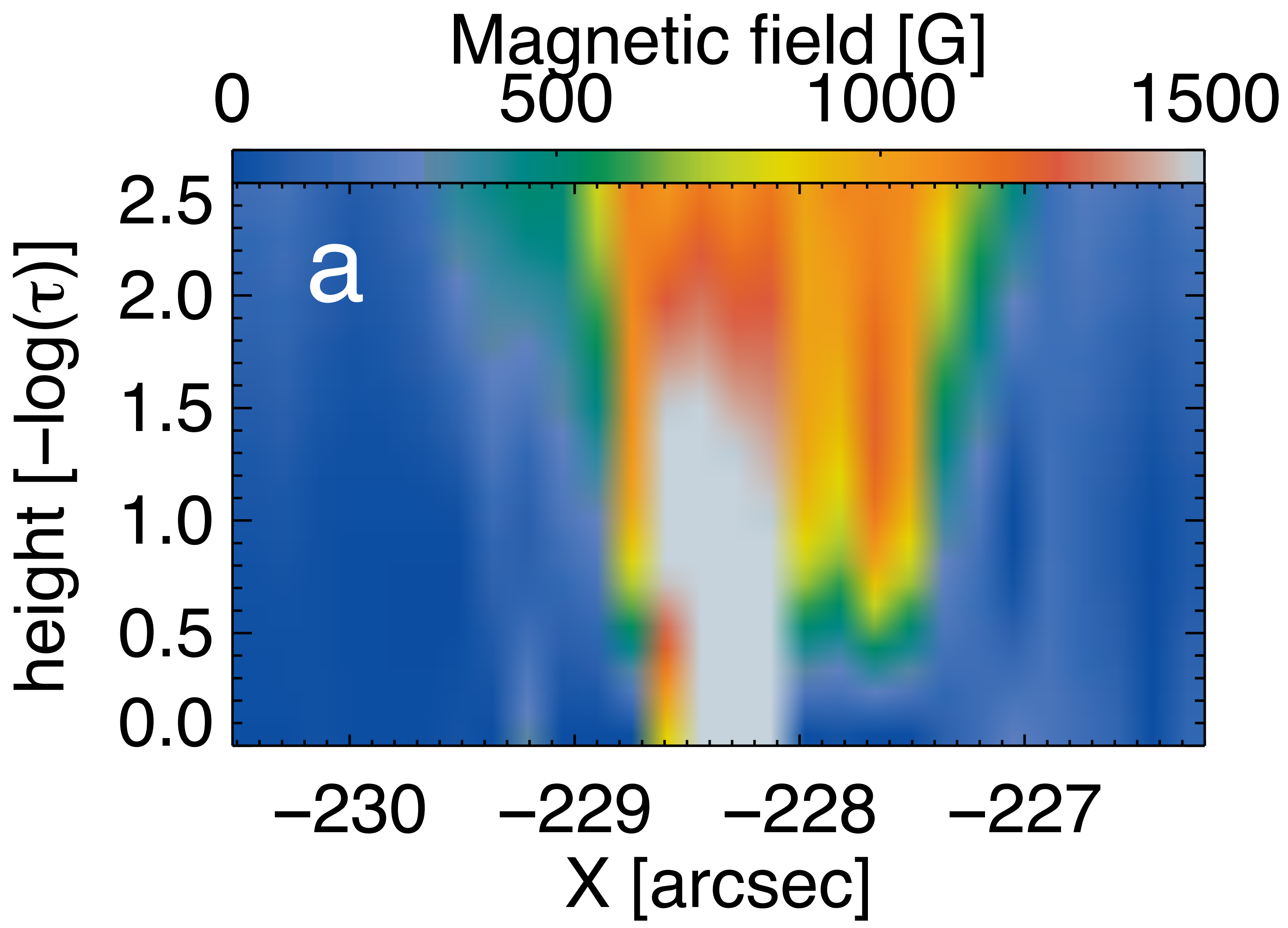
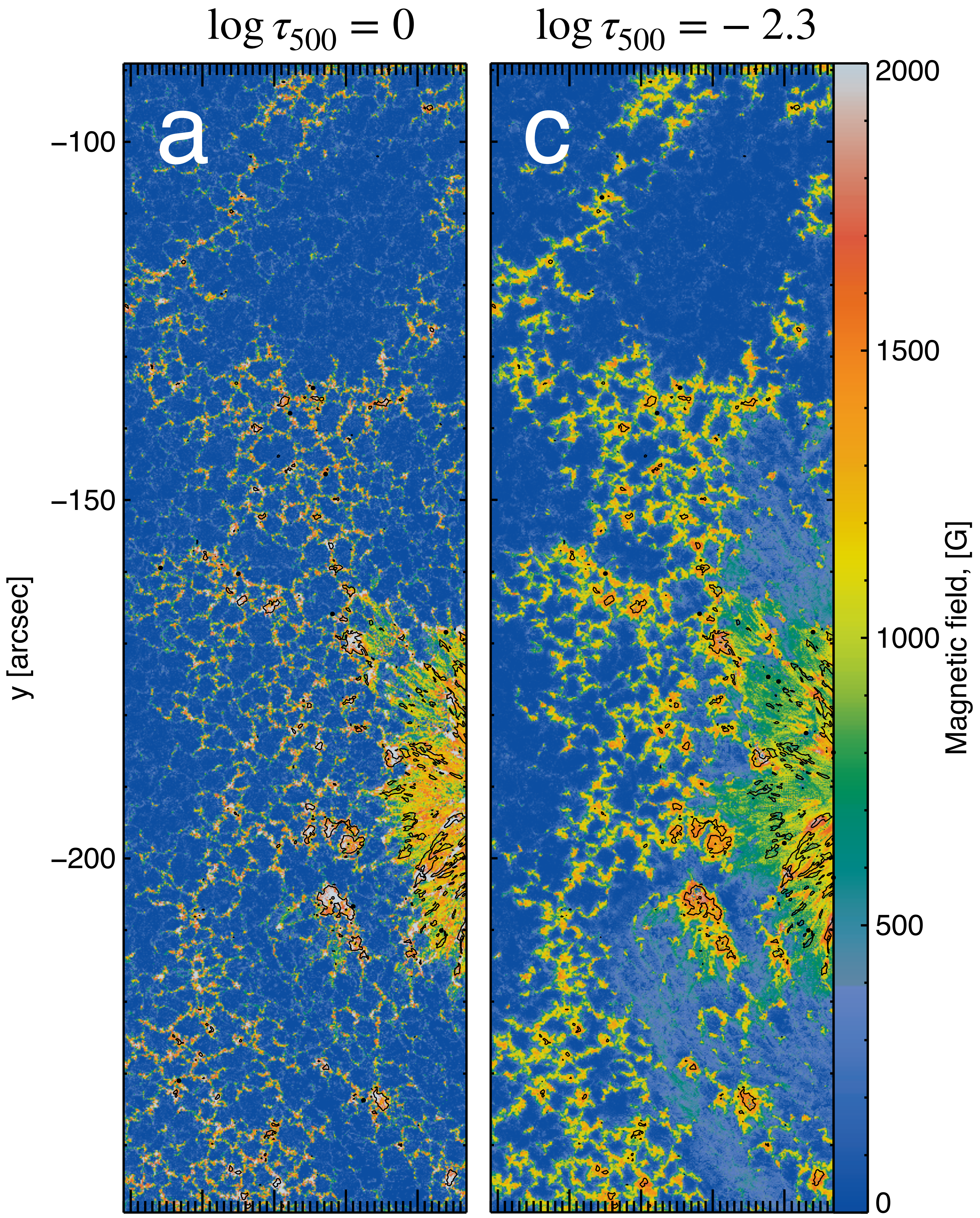


Buhler et al. (2015)

- The magnetic field is confined to inter granular lanes

Plage photospheres



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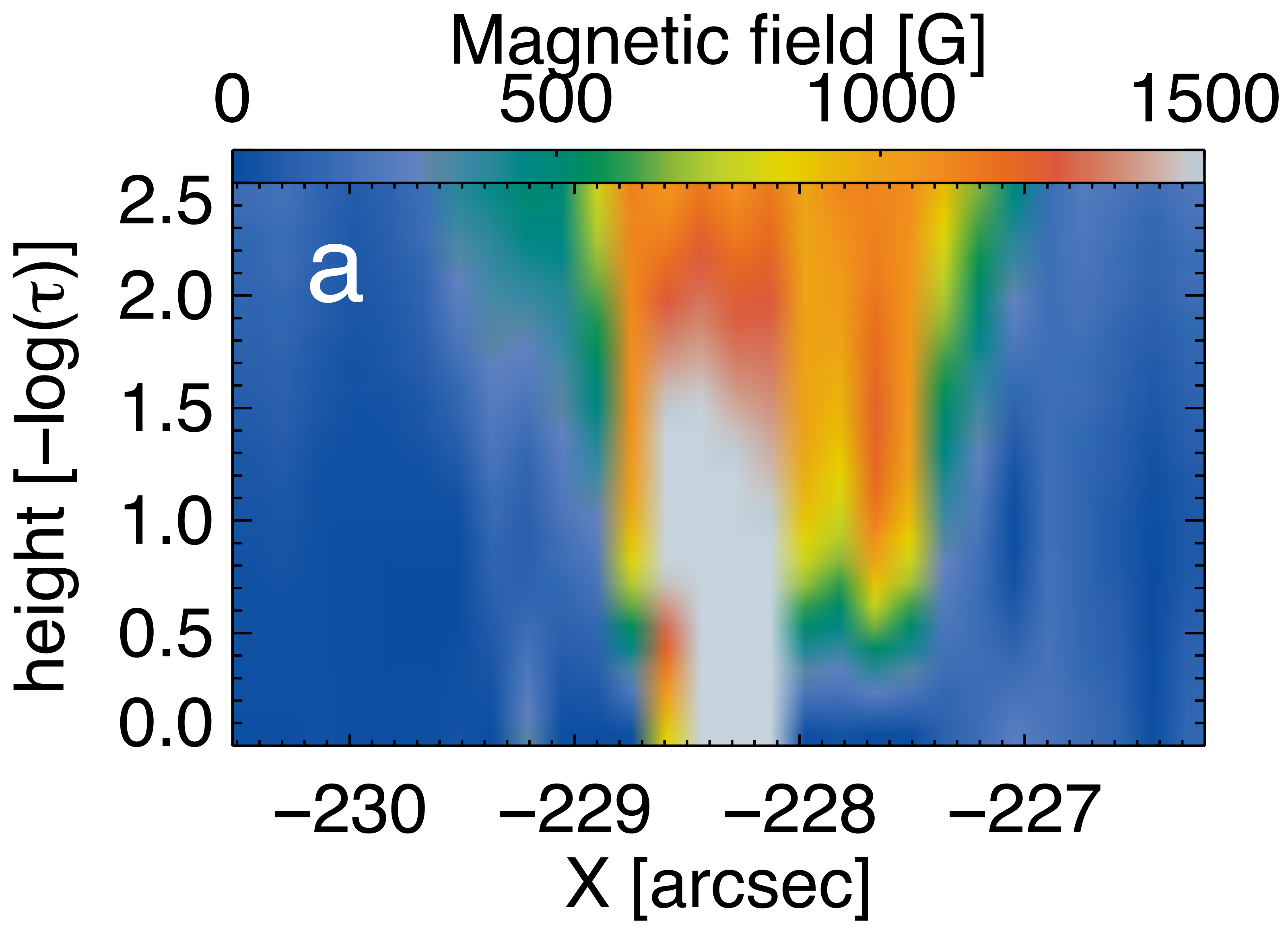

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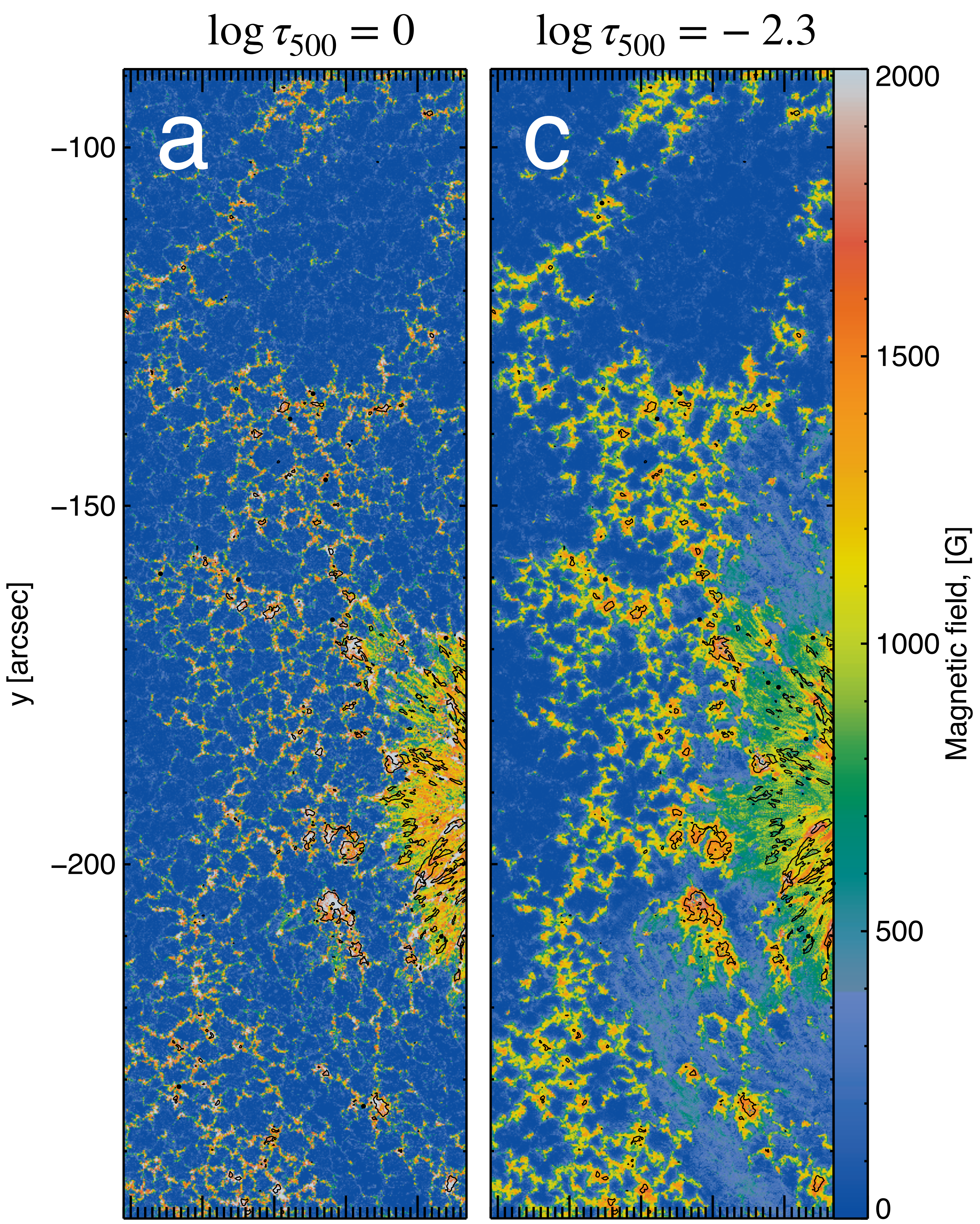

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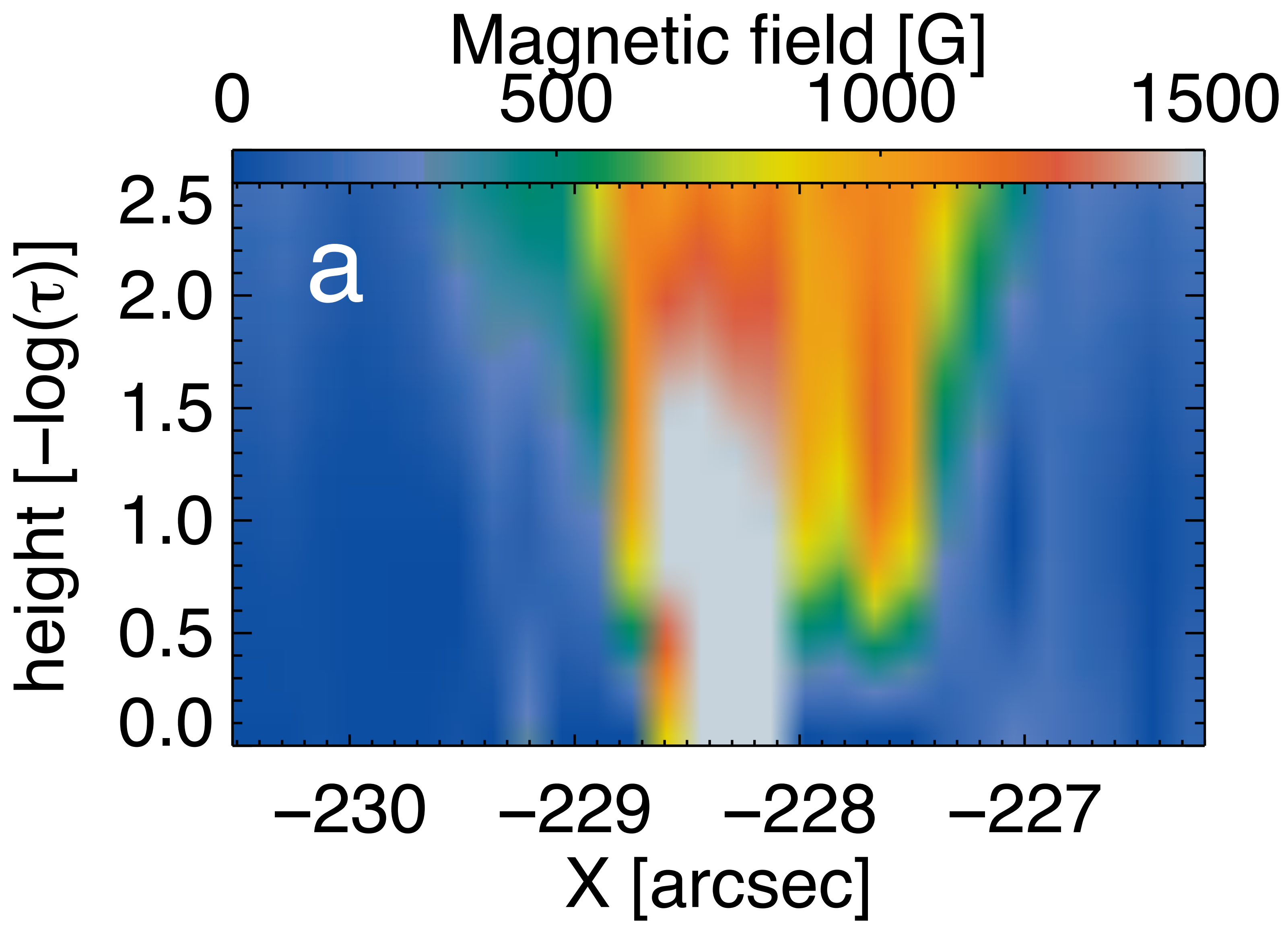

Buhler et al. (2015)

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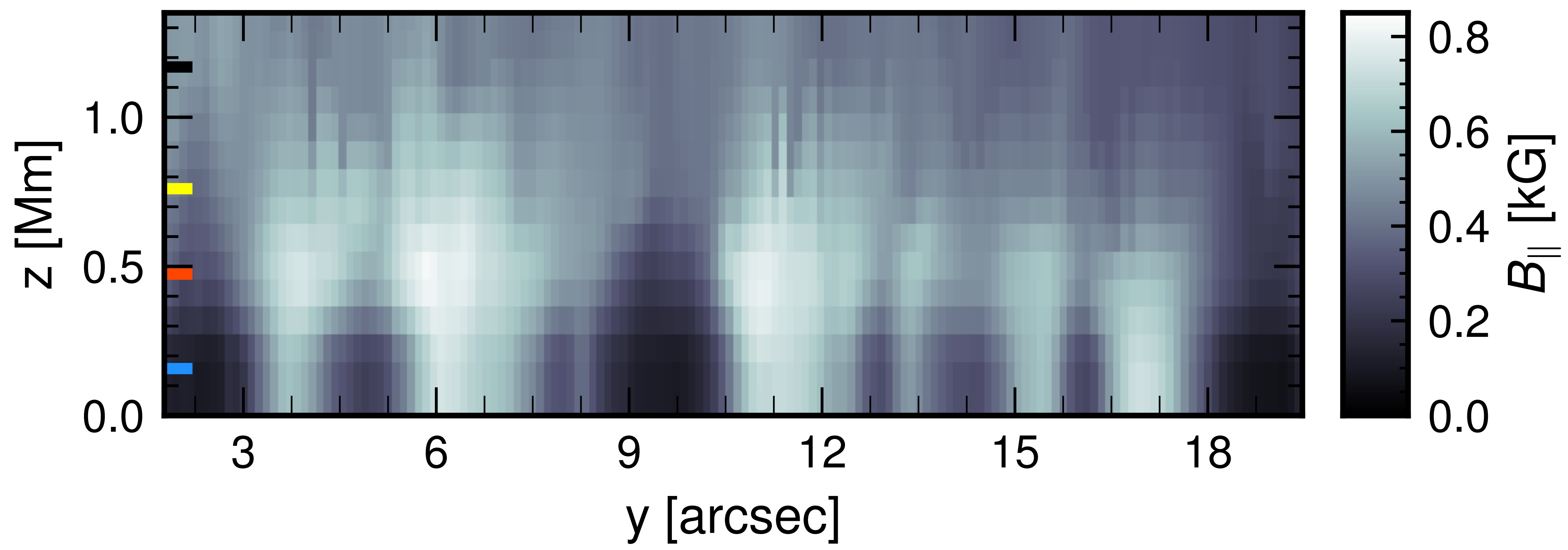
- Gas pressure drops with height and the field can expand horizontally
- Flux emergence can occur inside plage (Chitta et al. 2019)

Plage chromospheres



Morosin et al. (2020)

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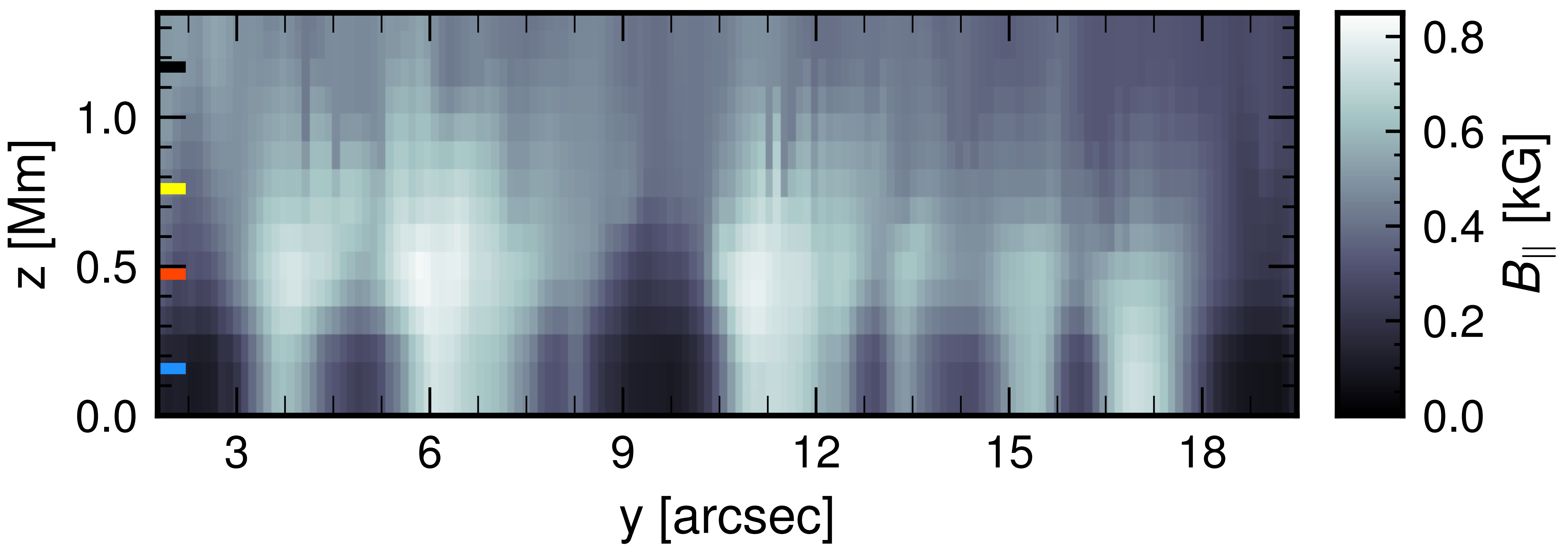

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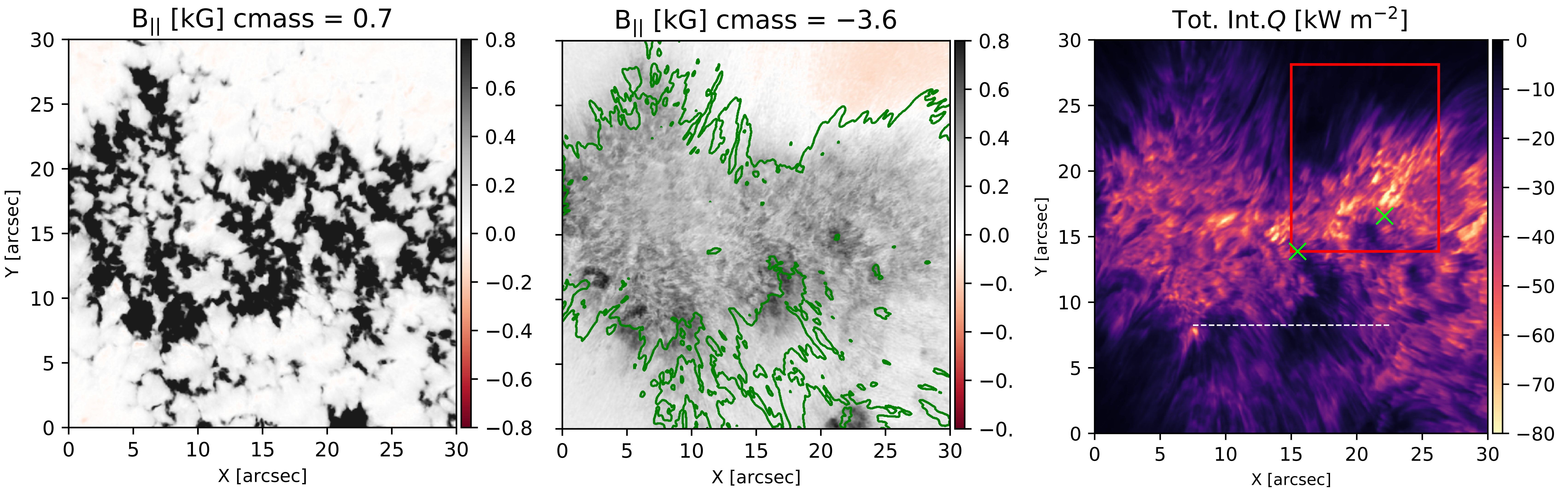

Morosin et al. (2022)

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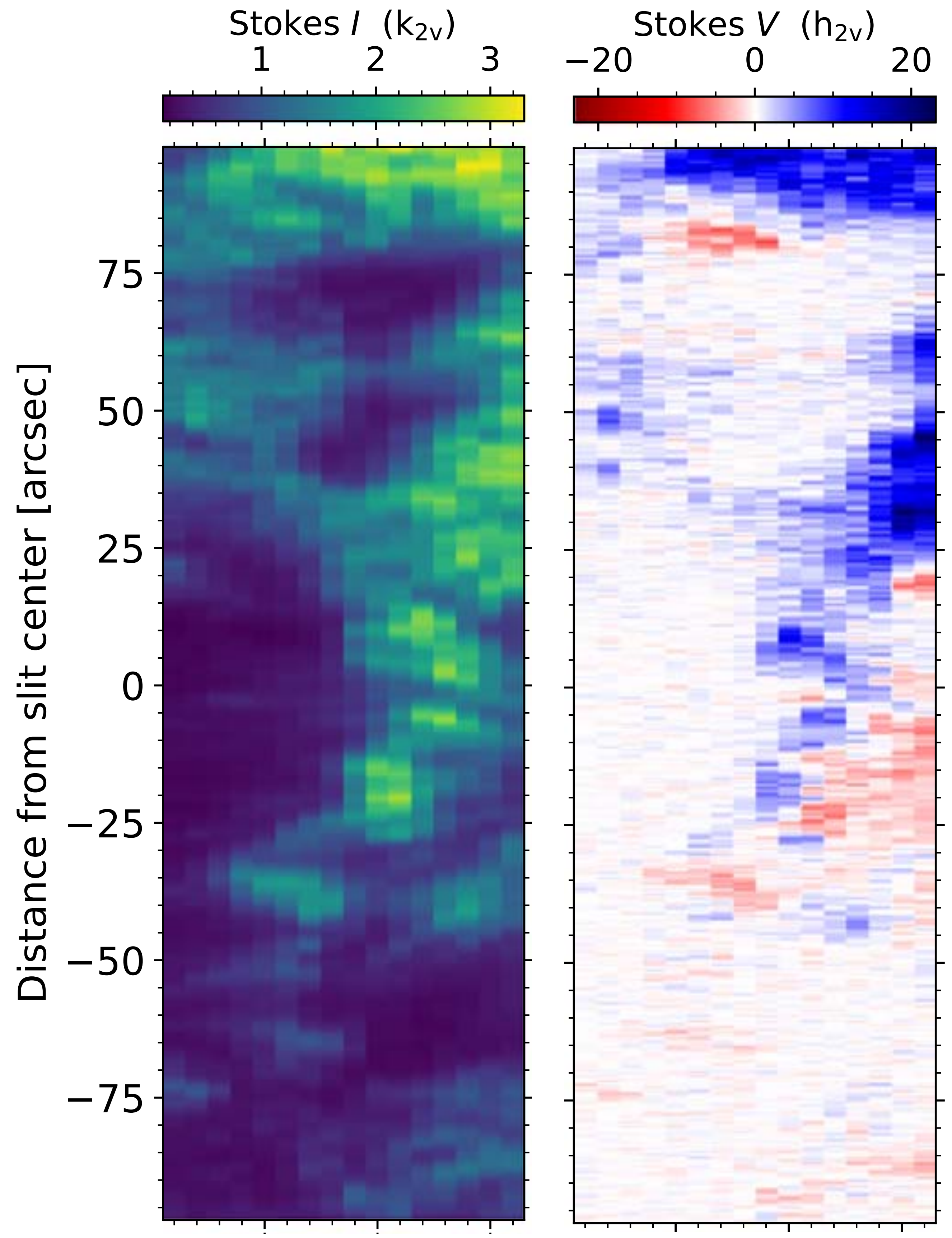
Based on Clasp-2 data



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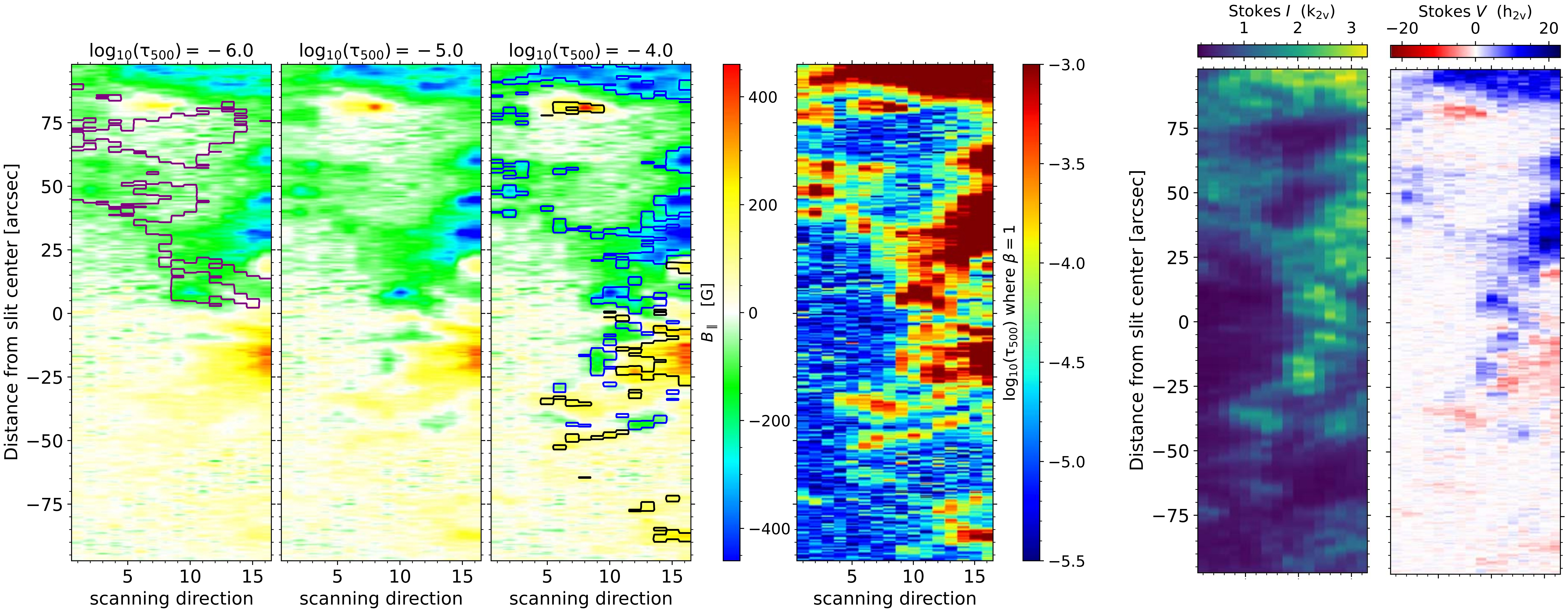

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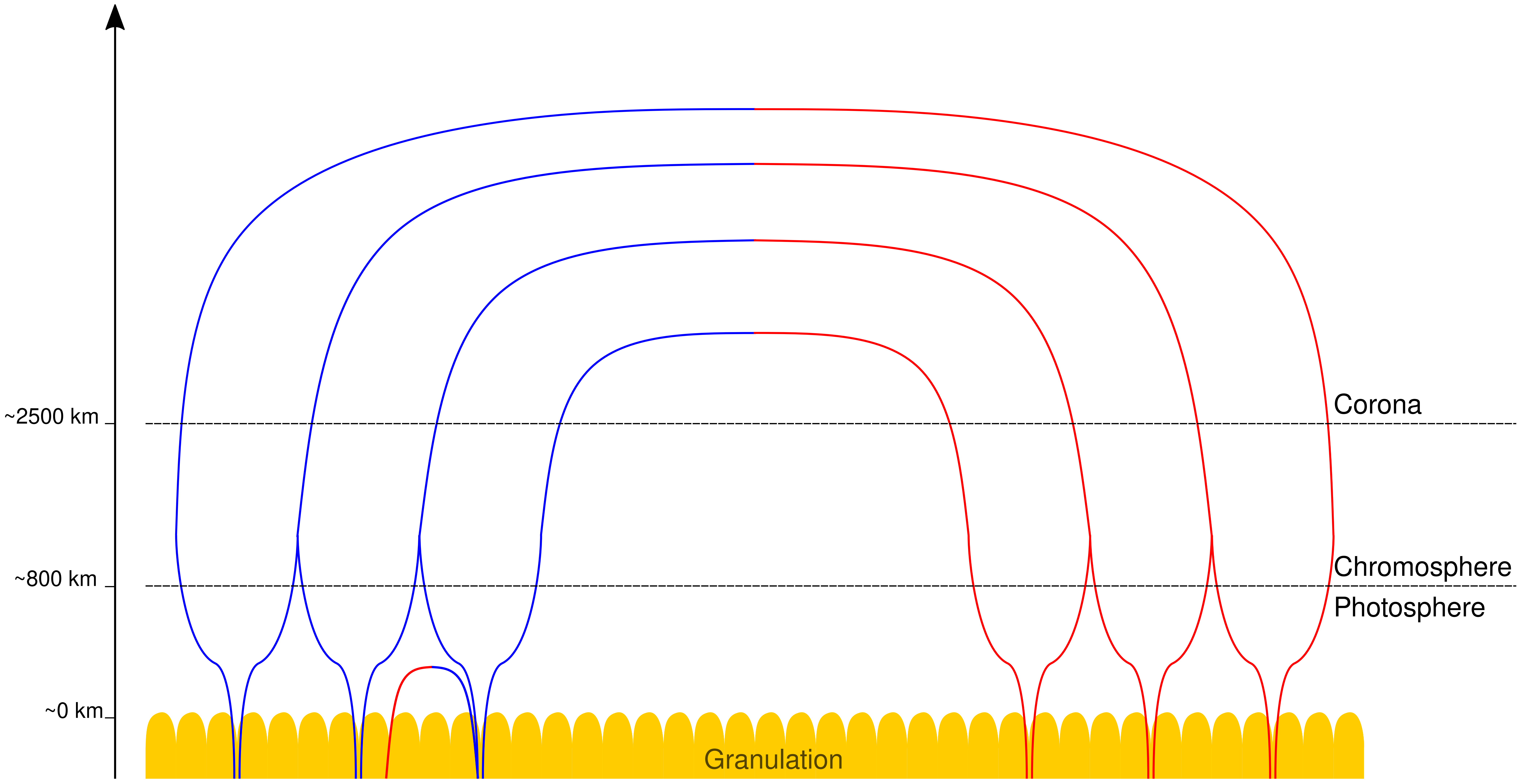
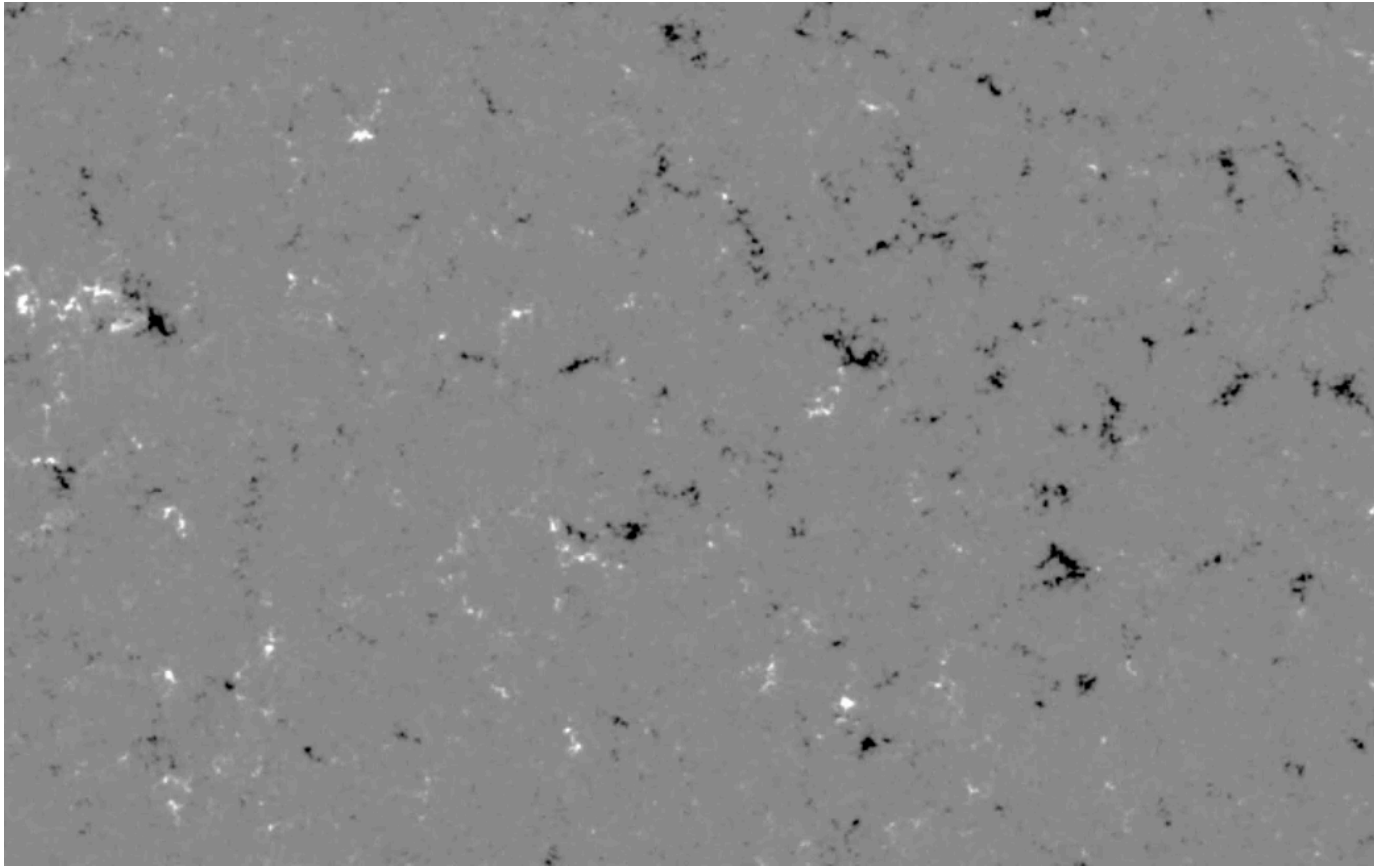


de la Cruz Rodriguez & van Noort in prep.

Emerging-flux regions



SDO/HMI magnetogram

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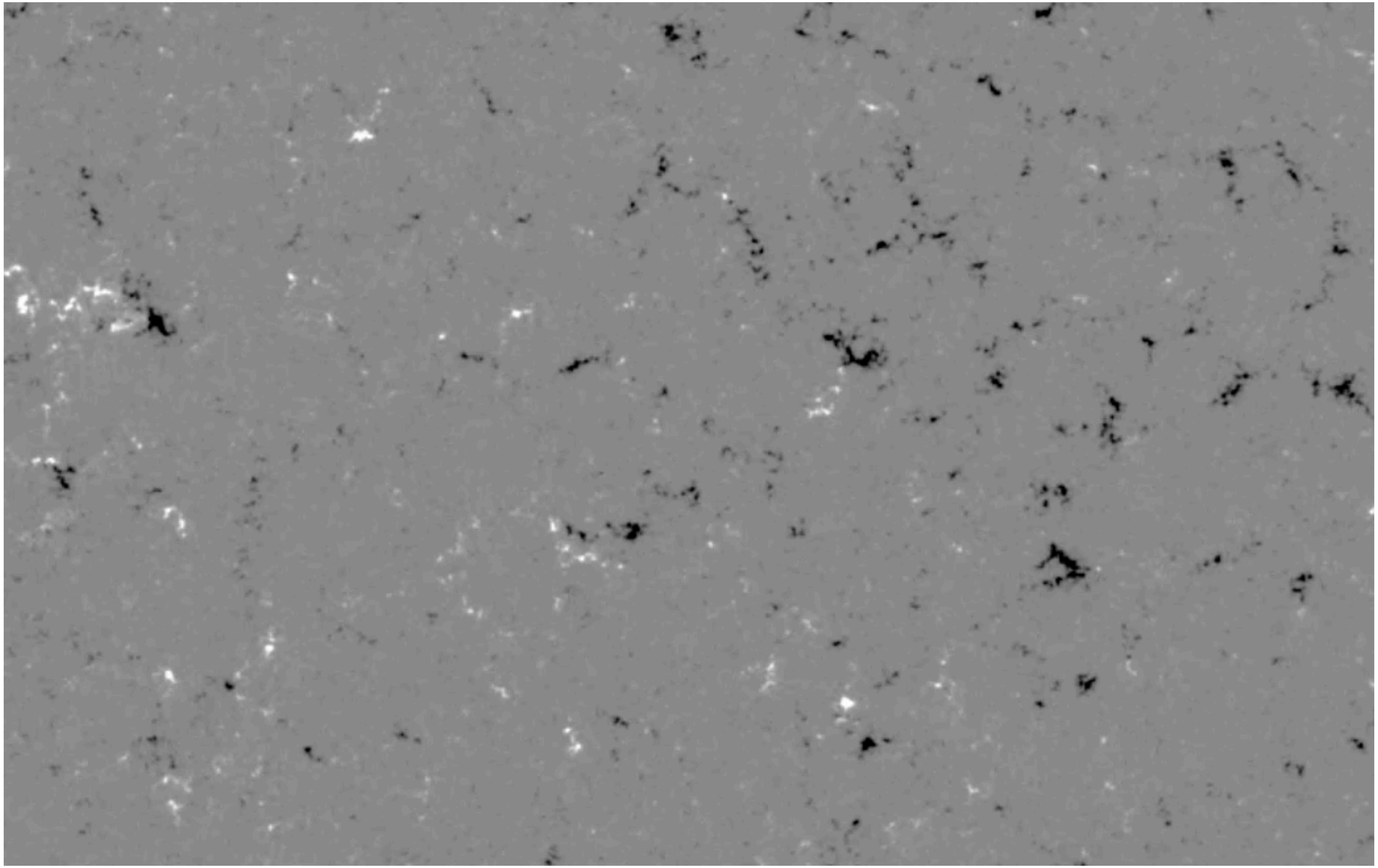

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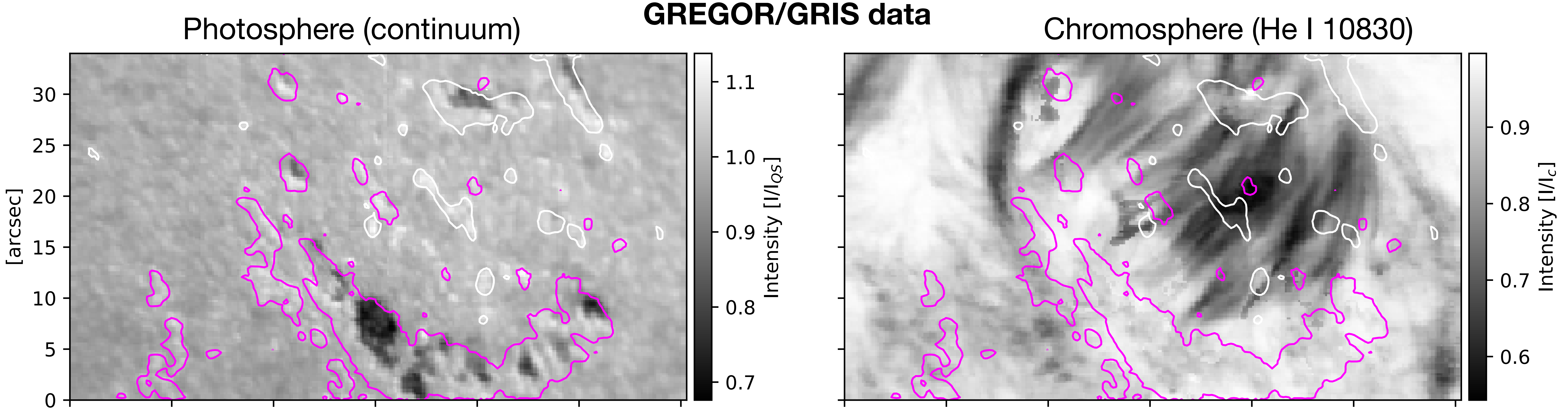
GREGOR/GRIS data



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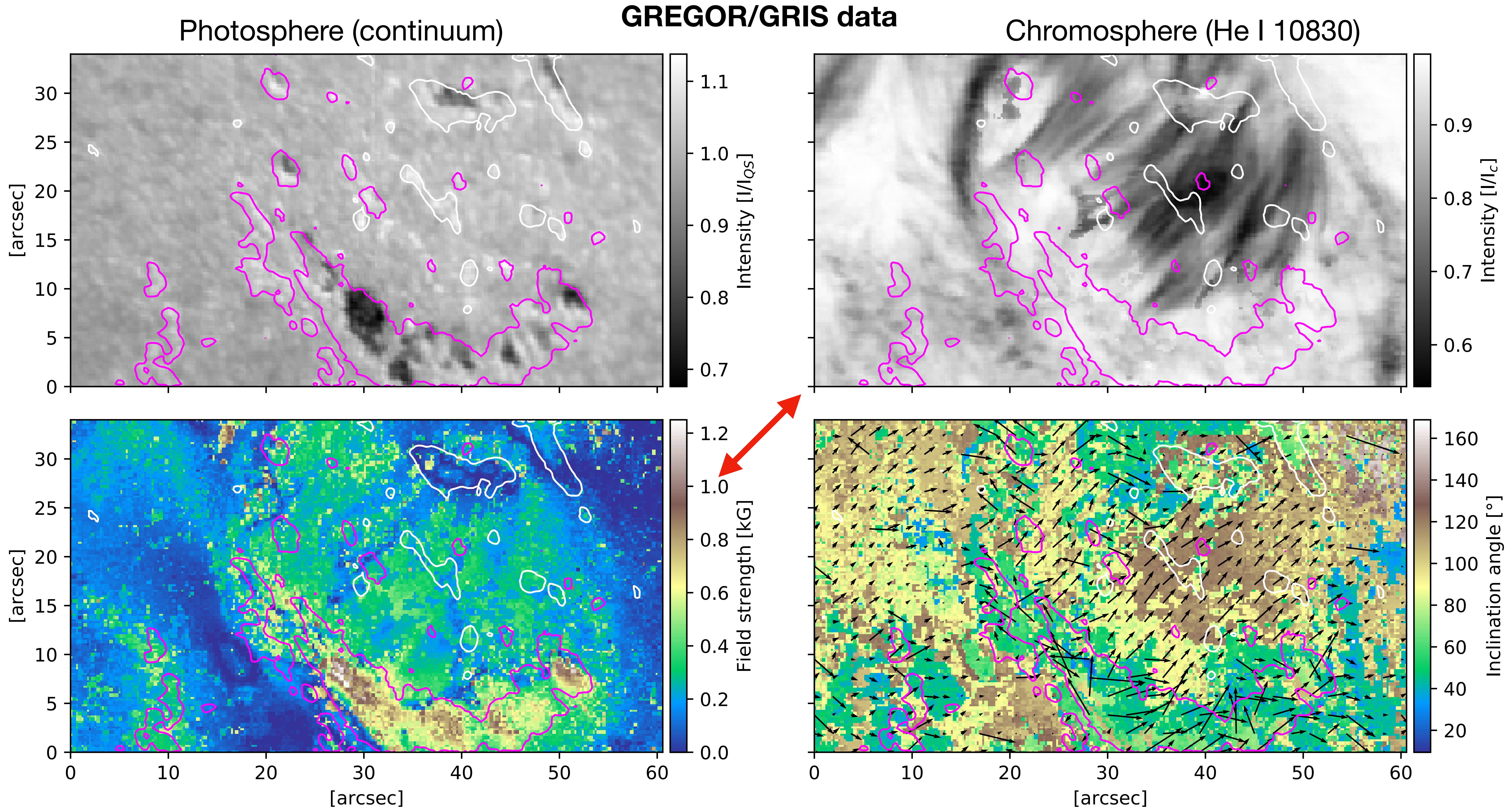

Yadav et al. (2019)

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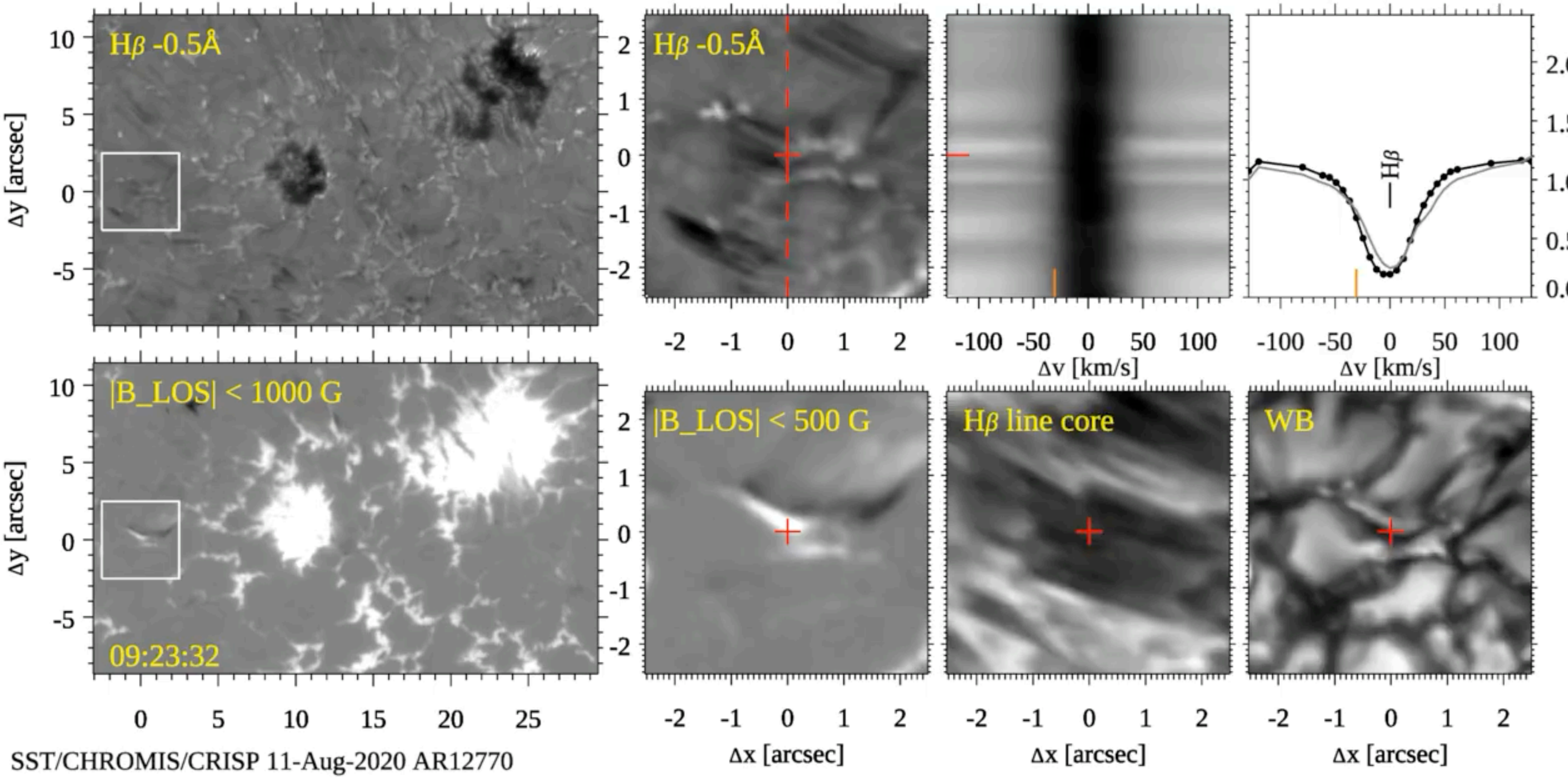

Rouppe van der Voort et al. (2024)

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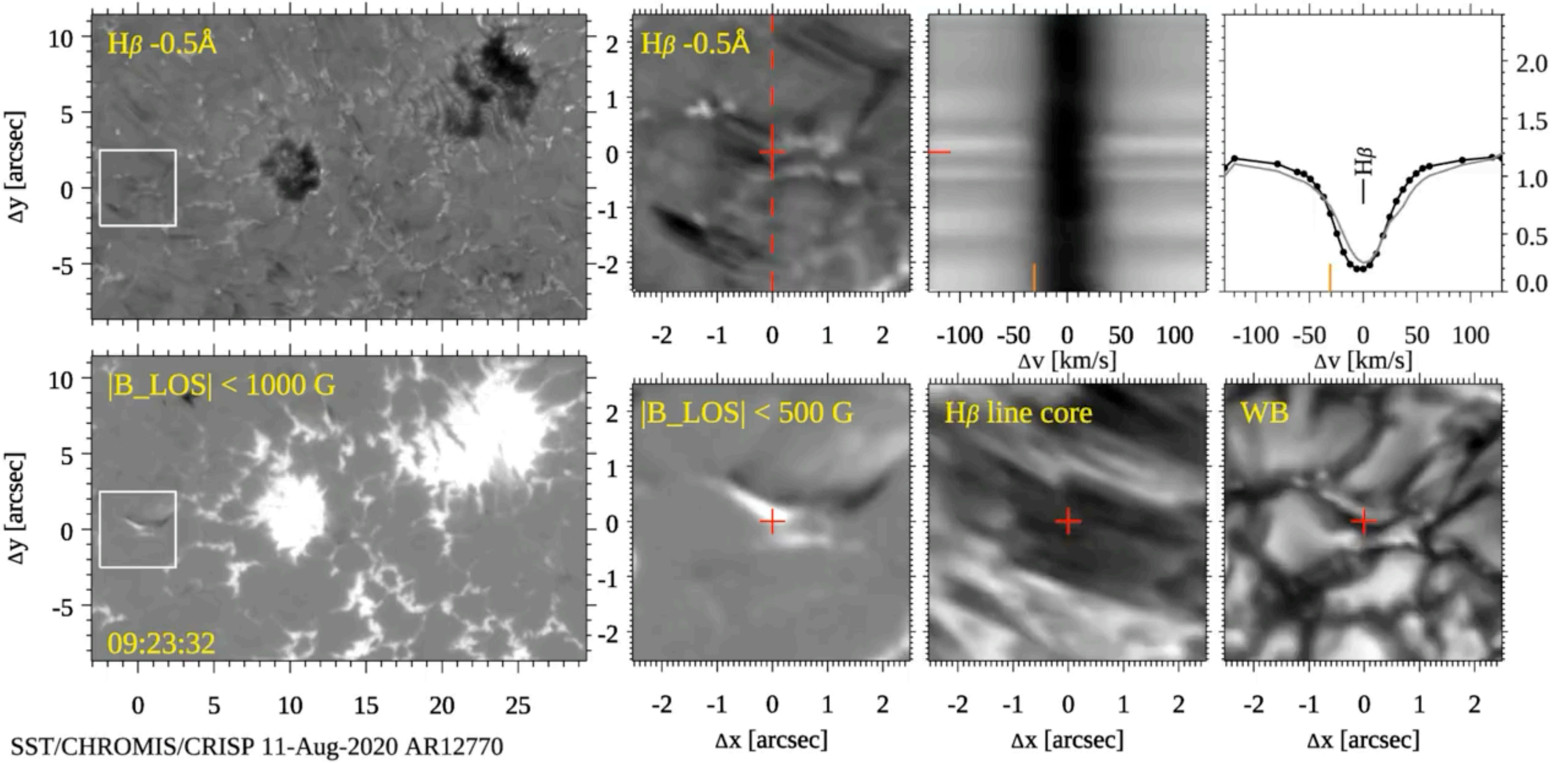

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Hansteen et al. (2019)

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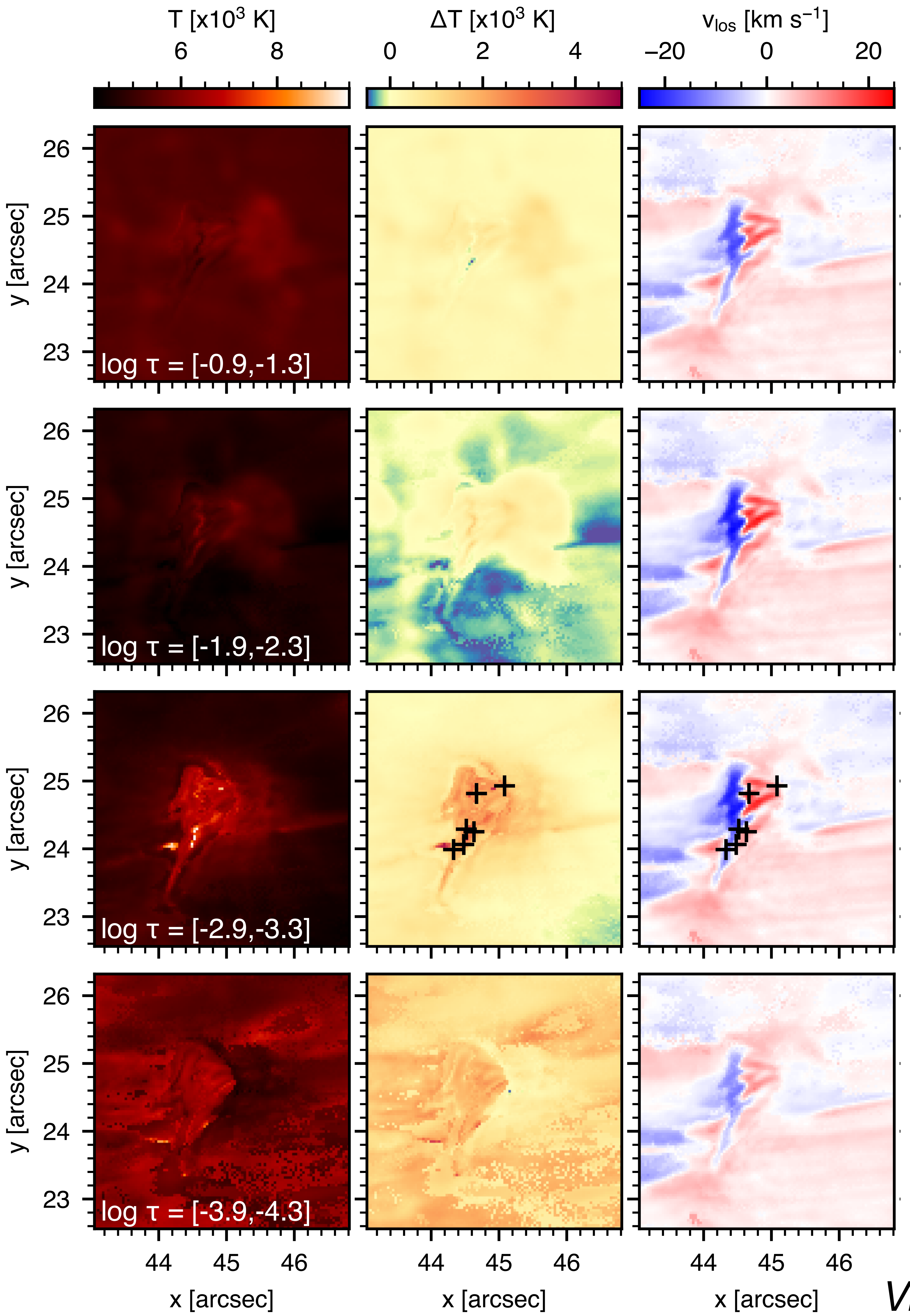

Vissers et al. (2020)

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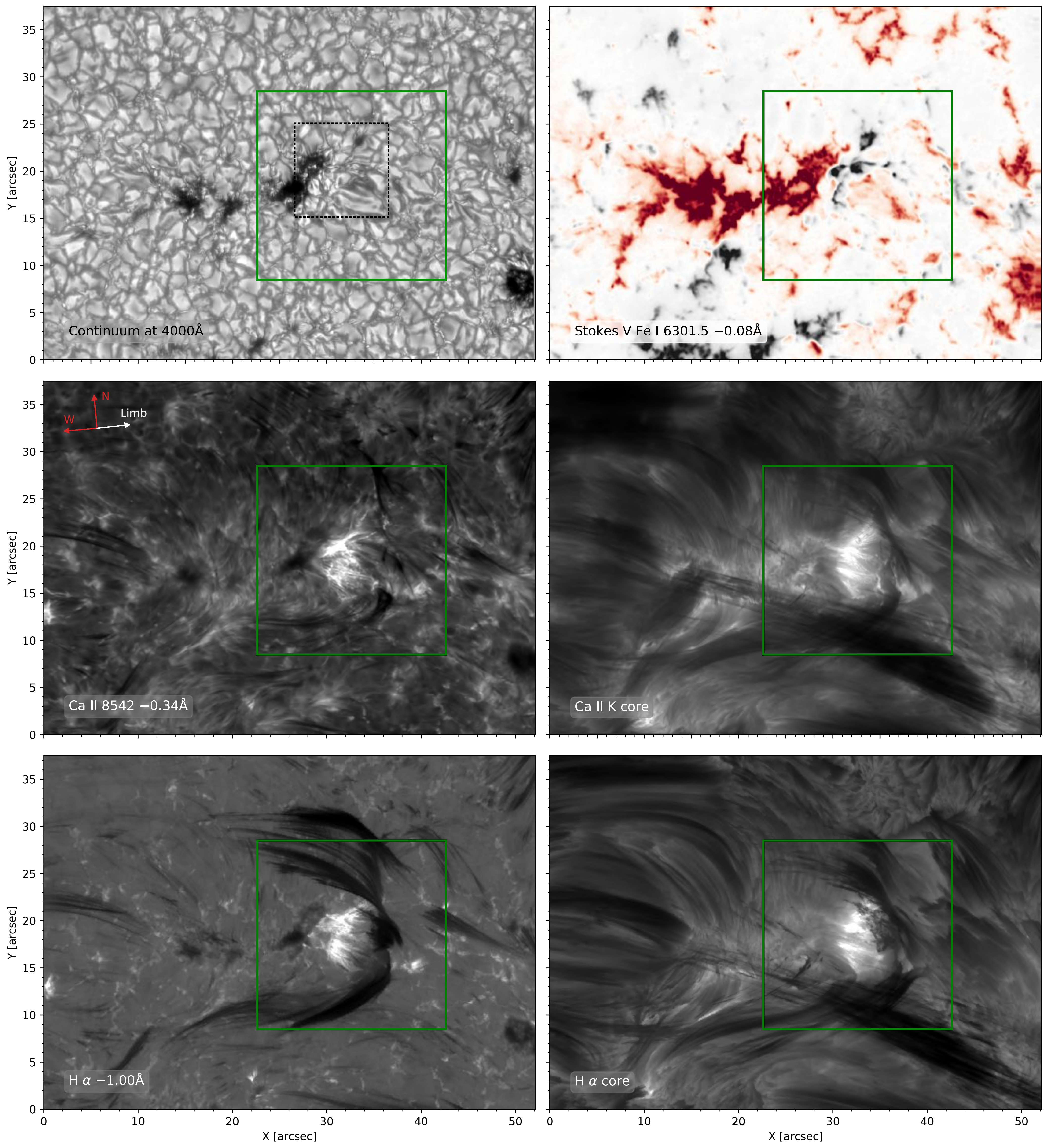

Díaz Baso et al. (2021)

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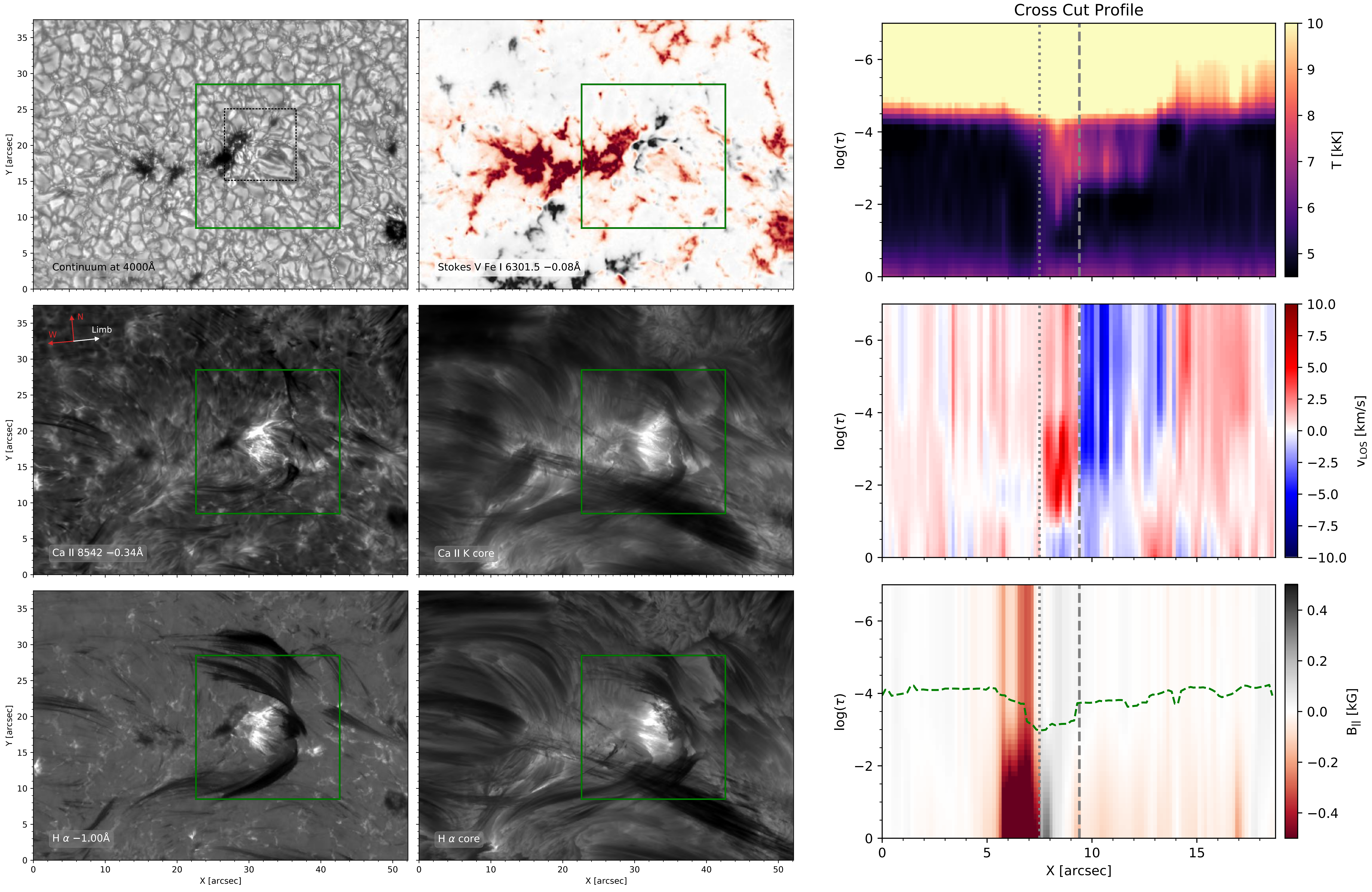

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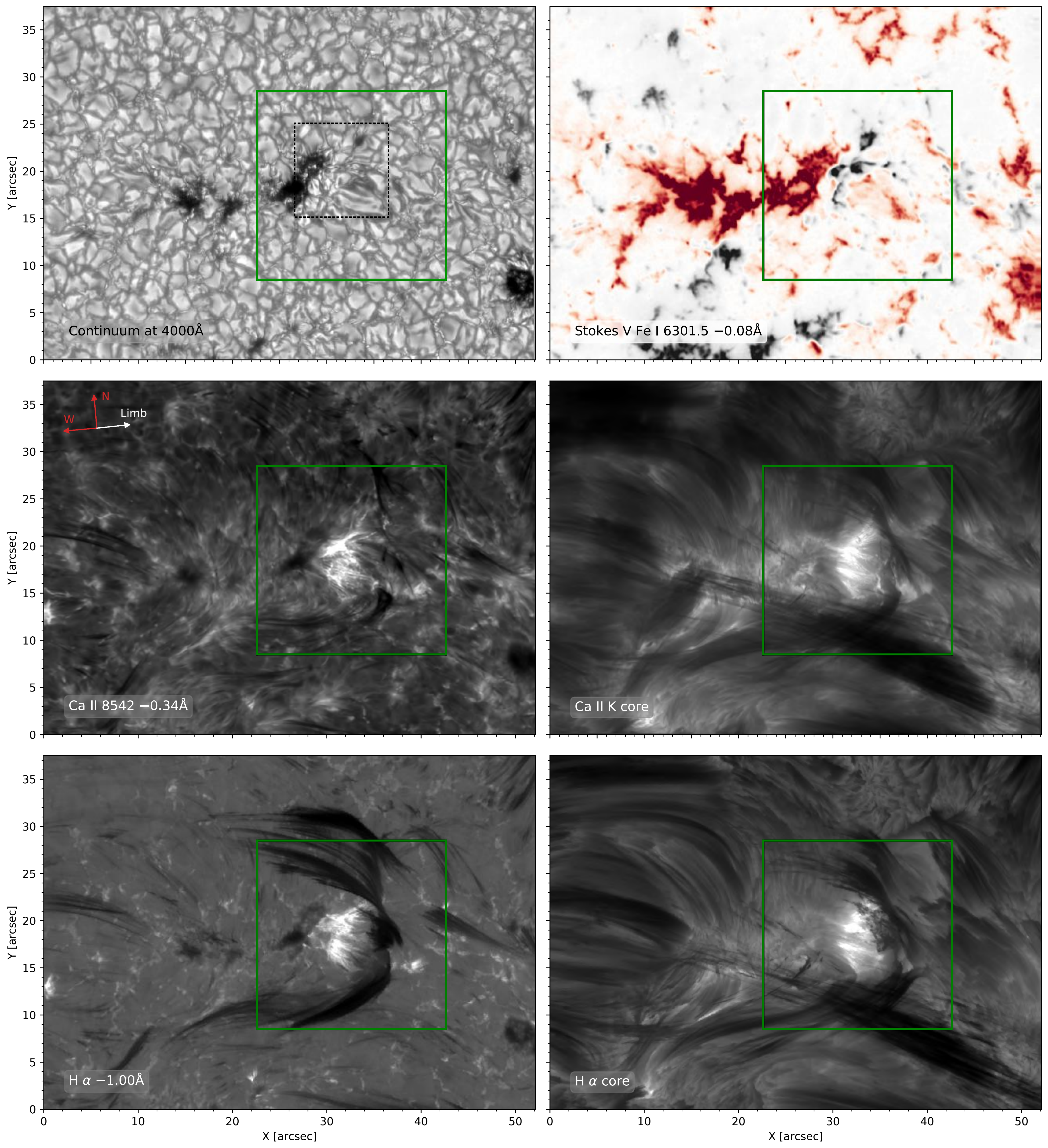

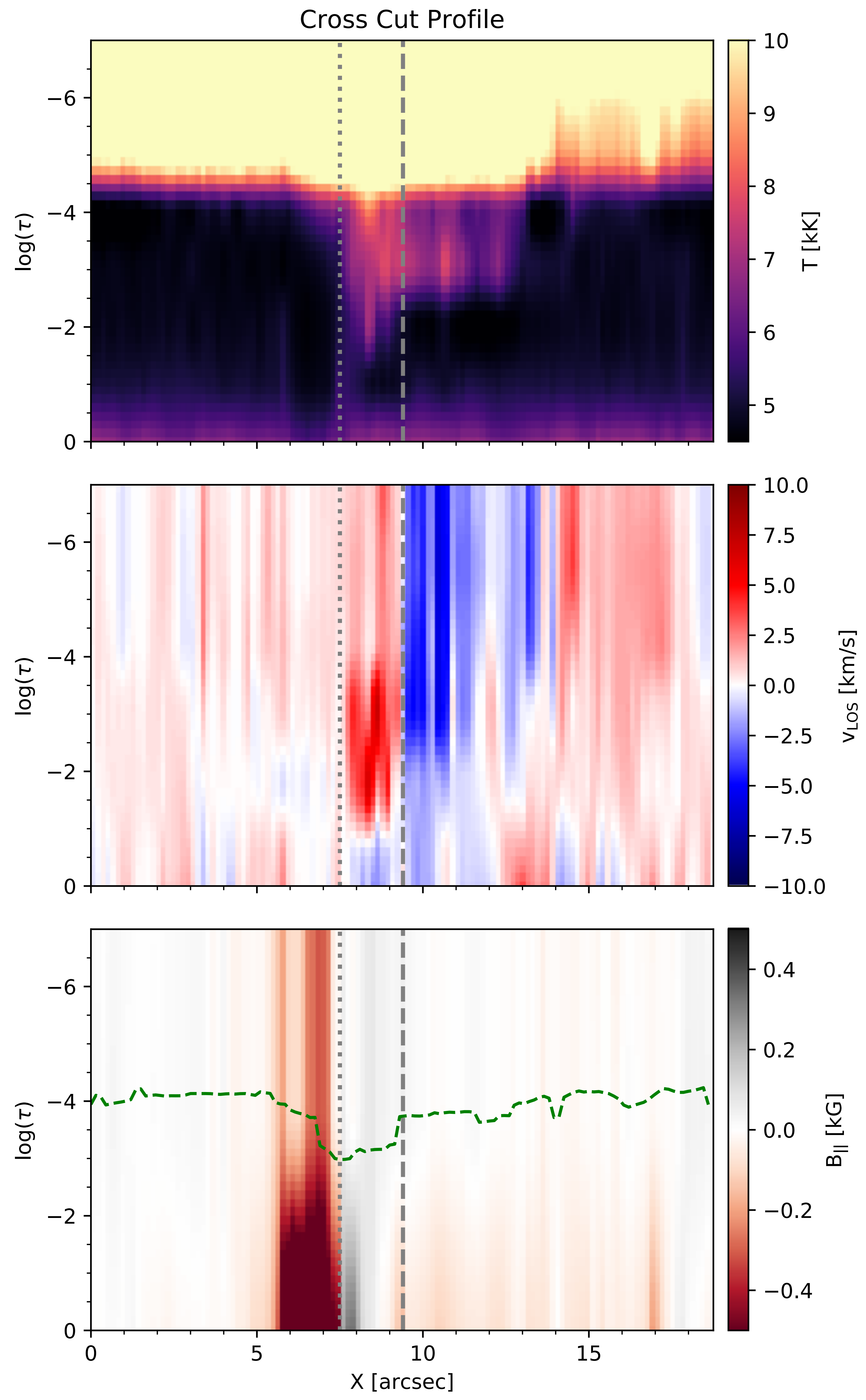

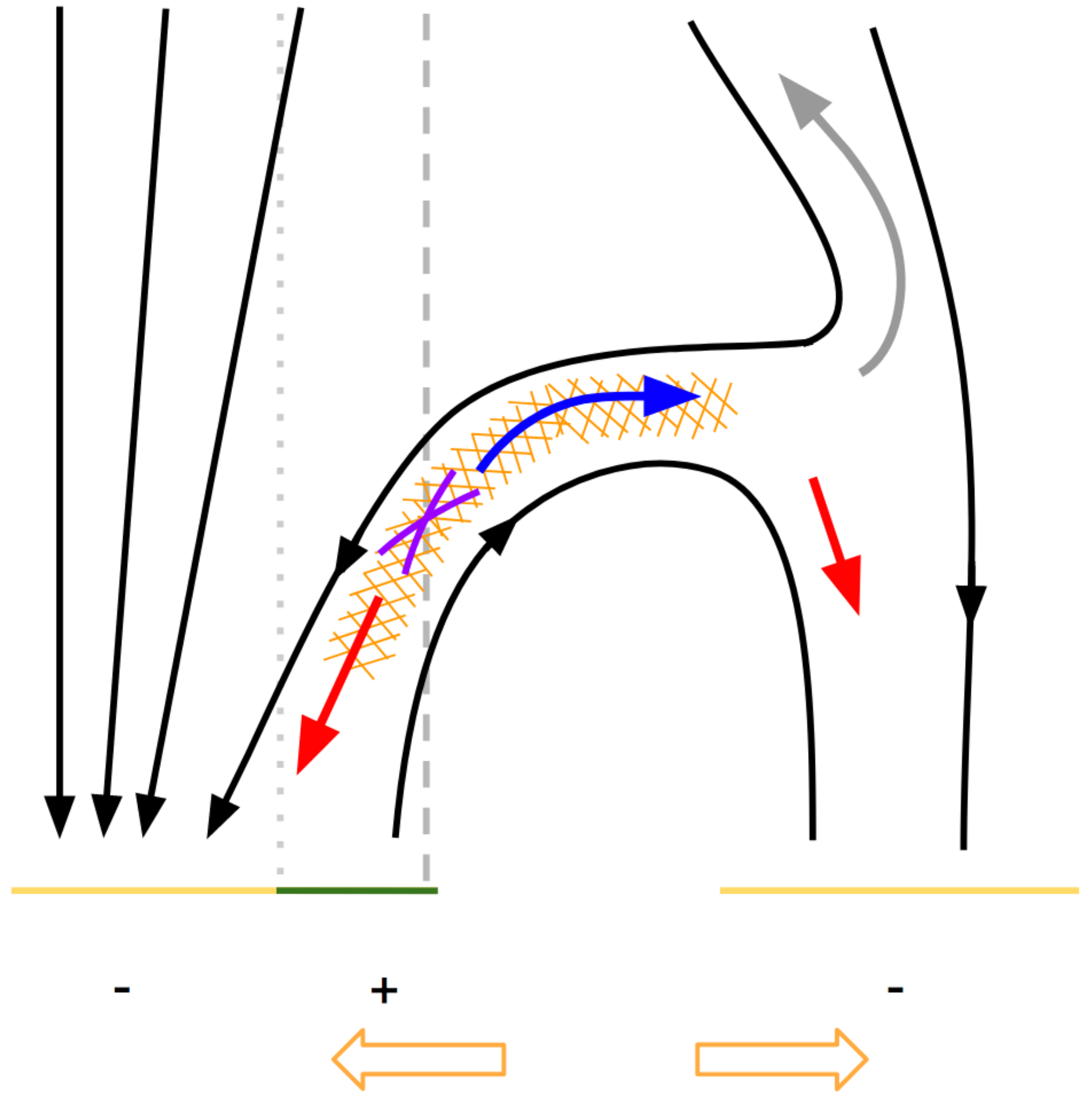

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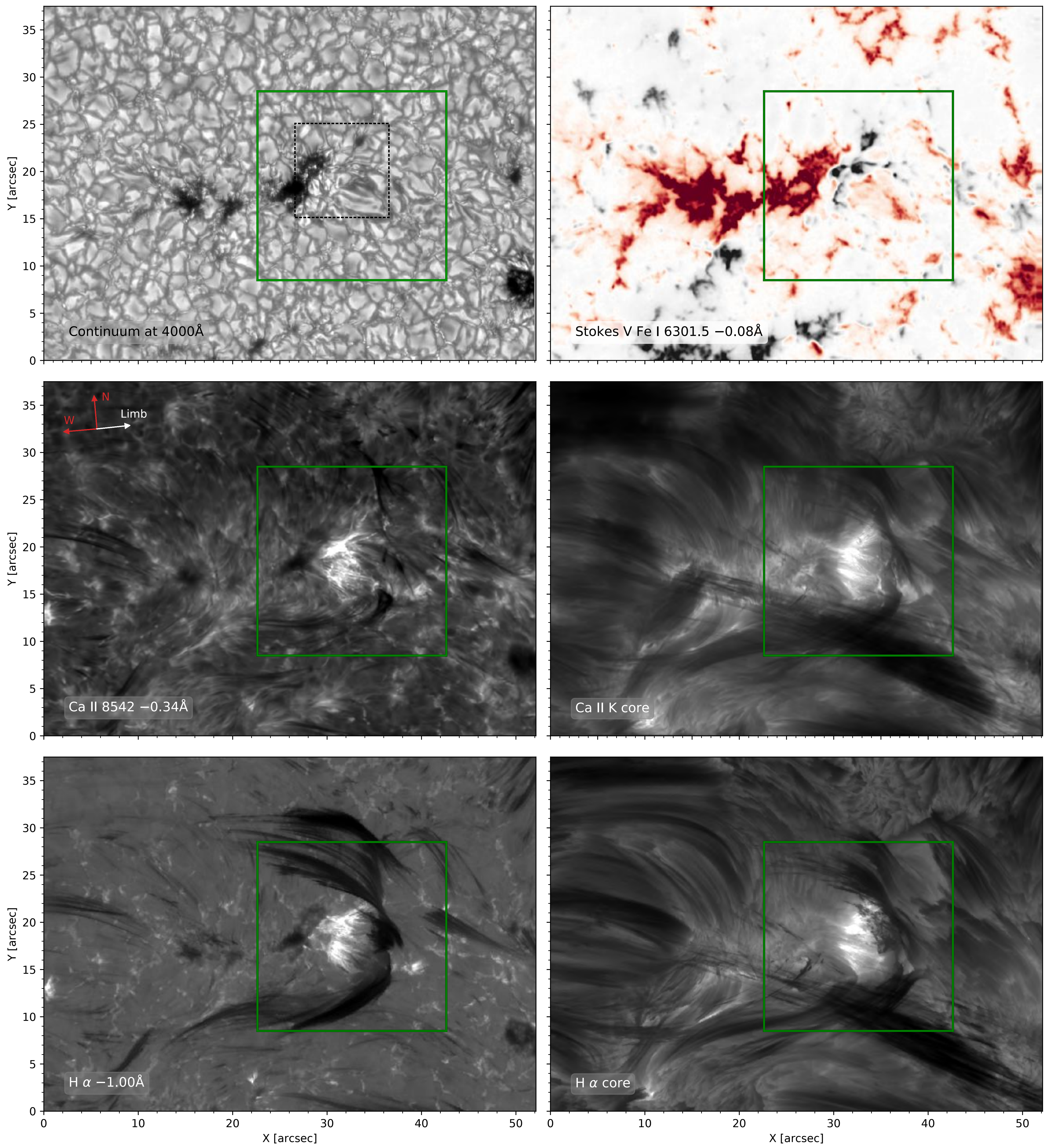
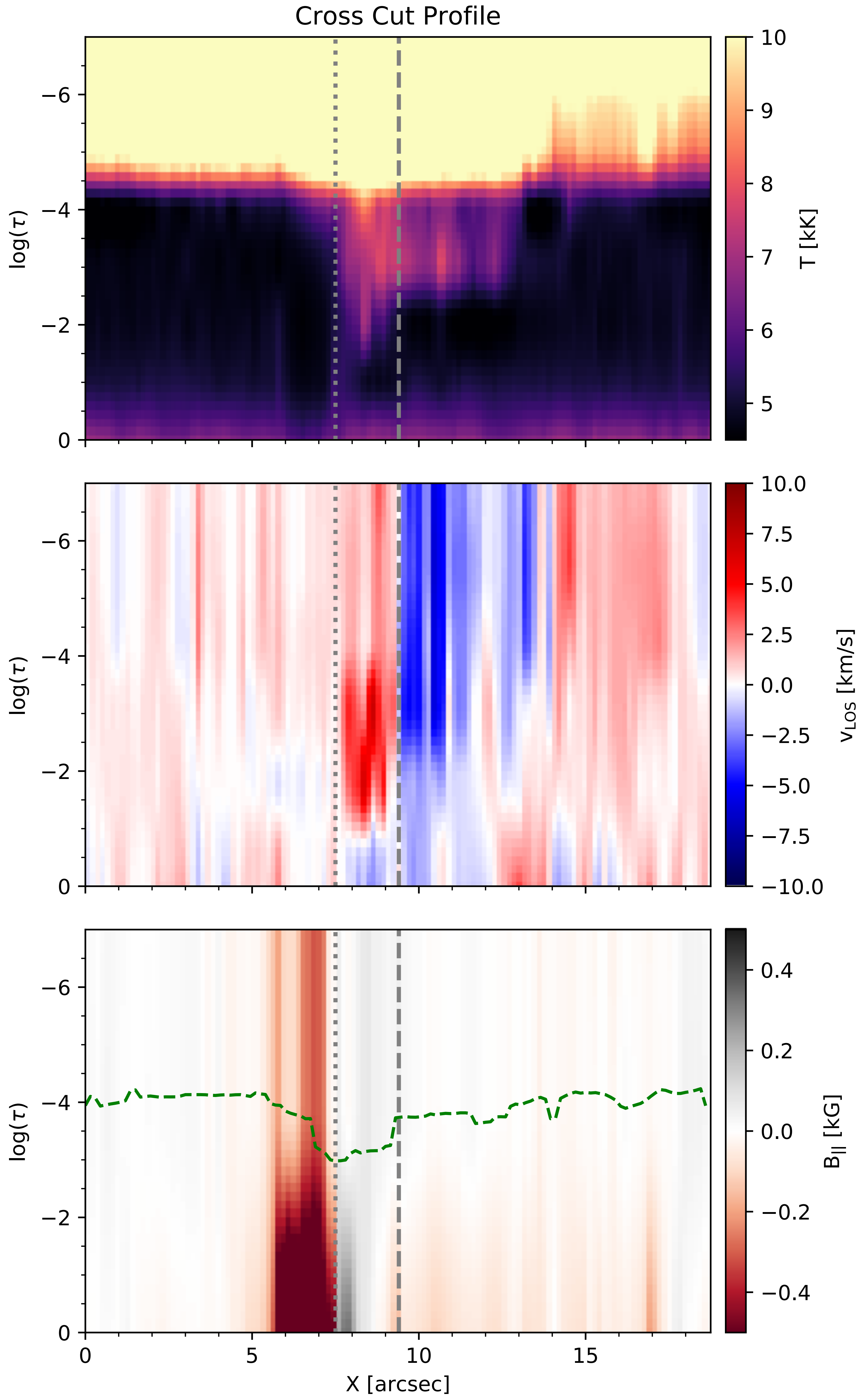
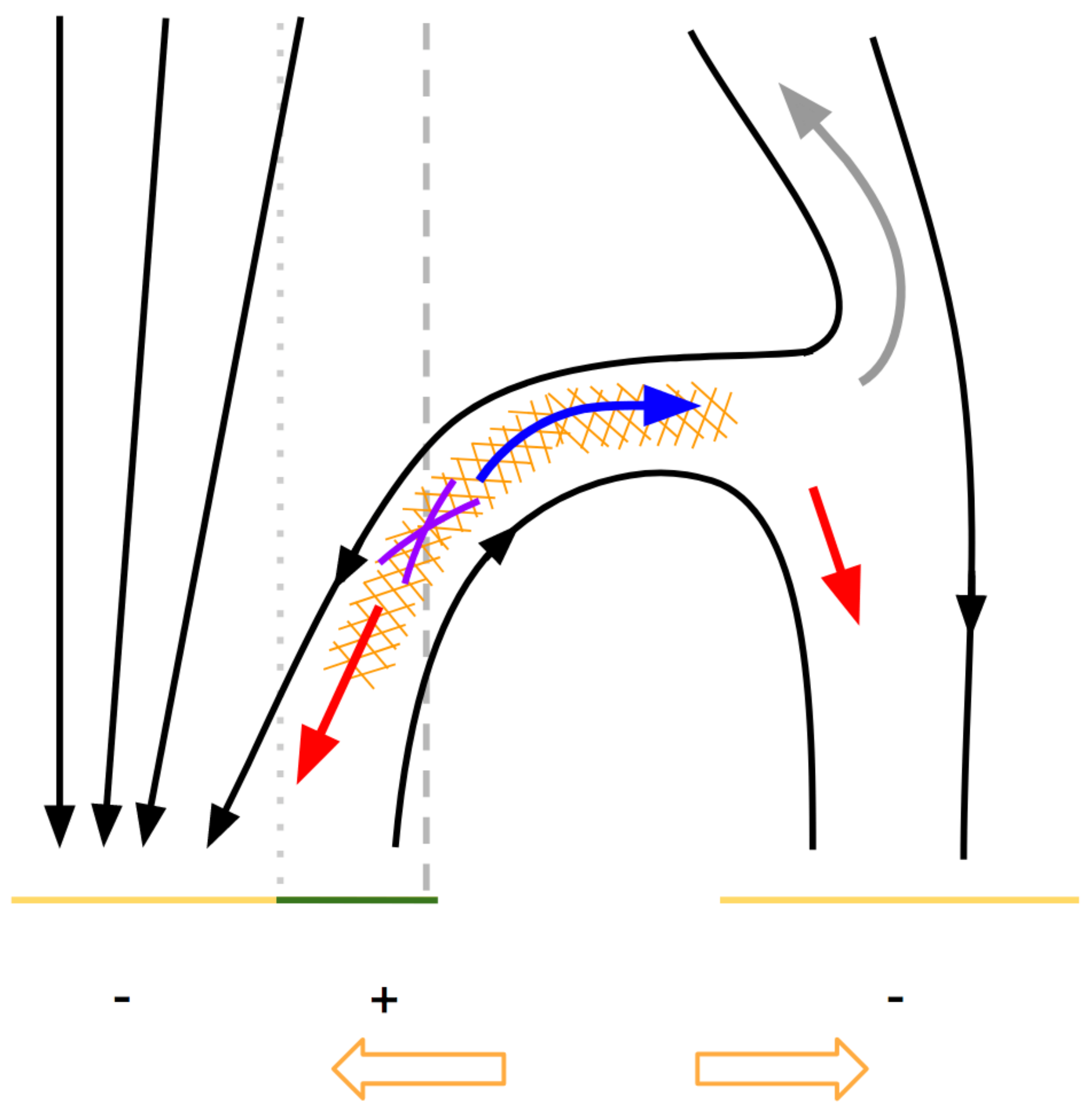
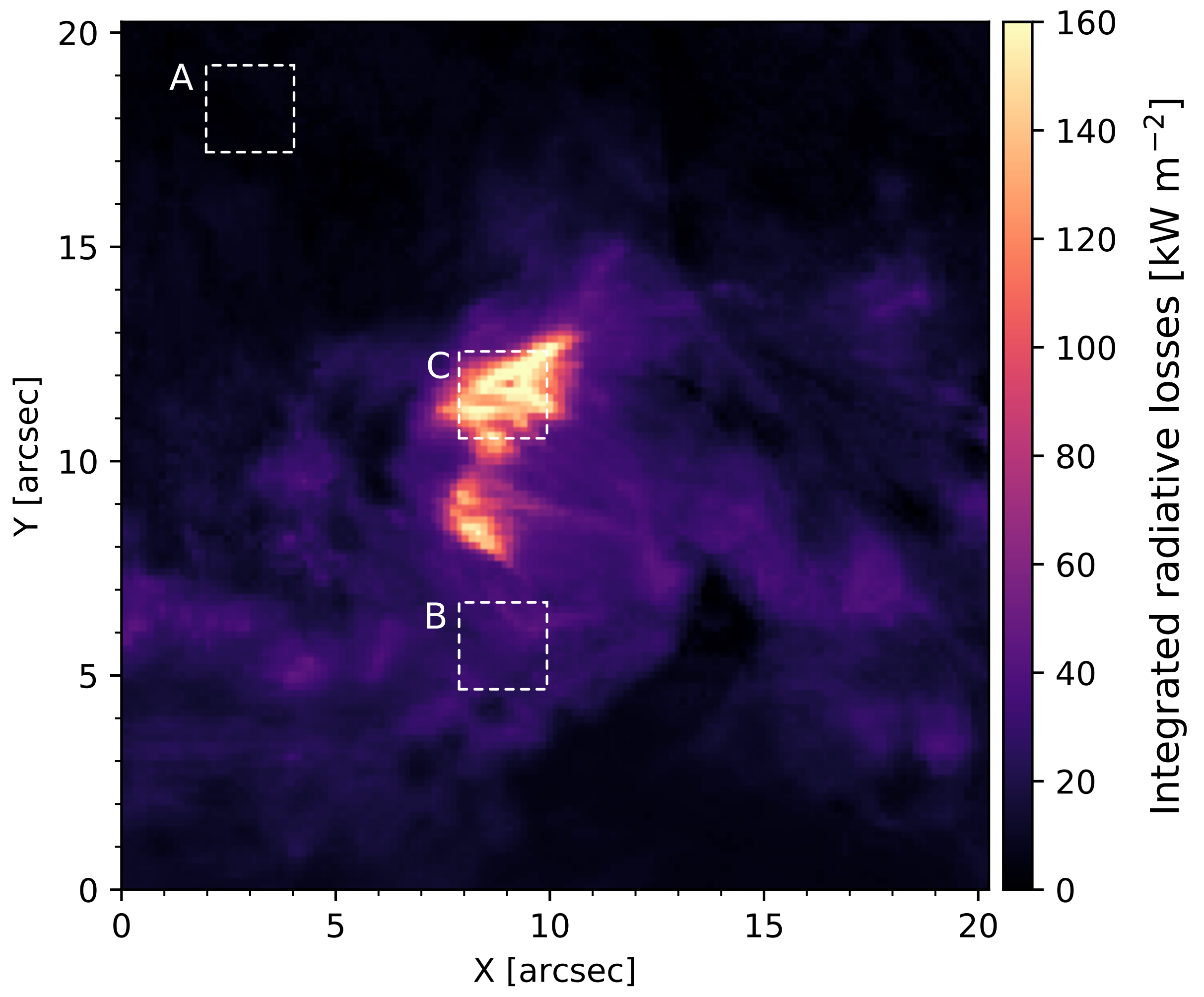


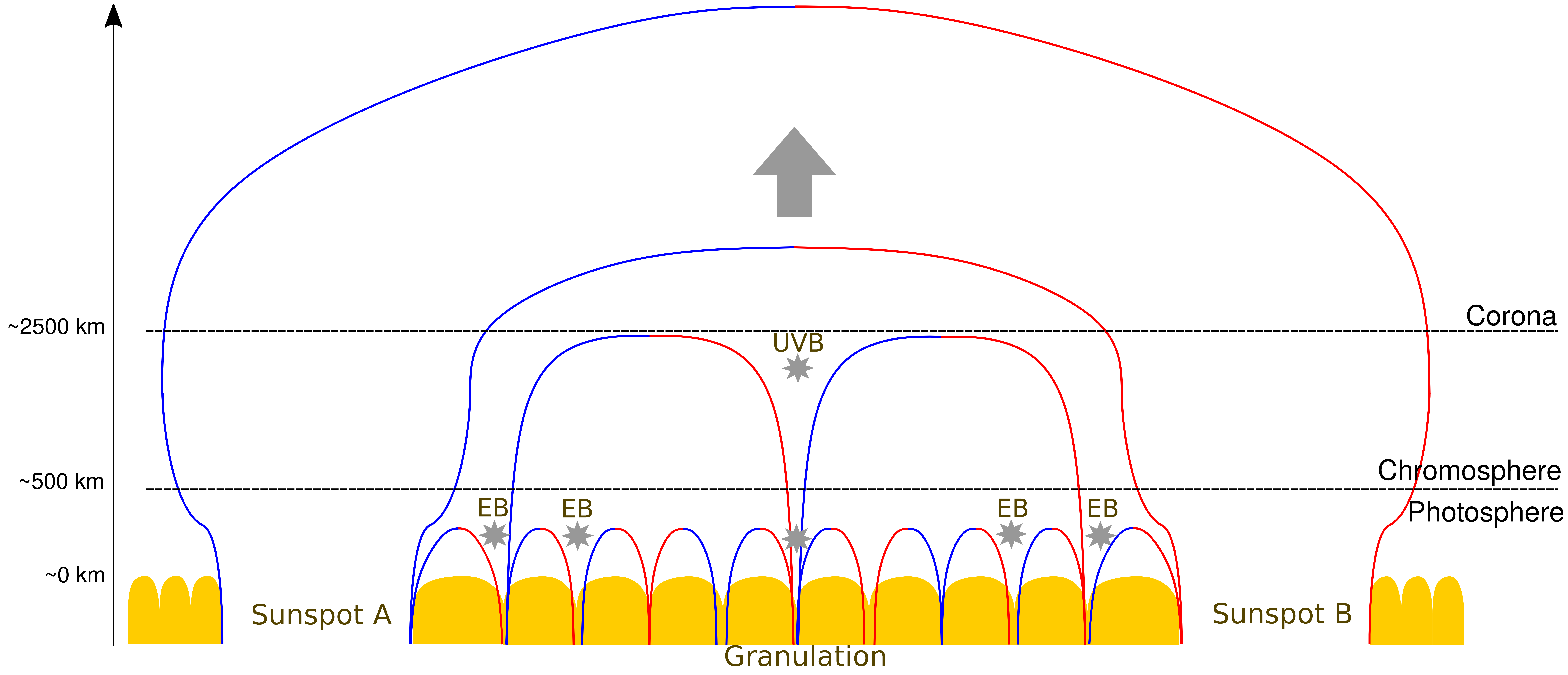






Díaz Baso et al. (2021)

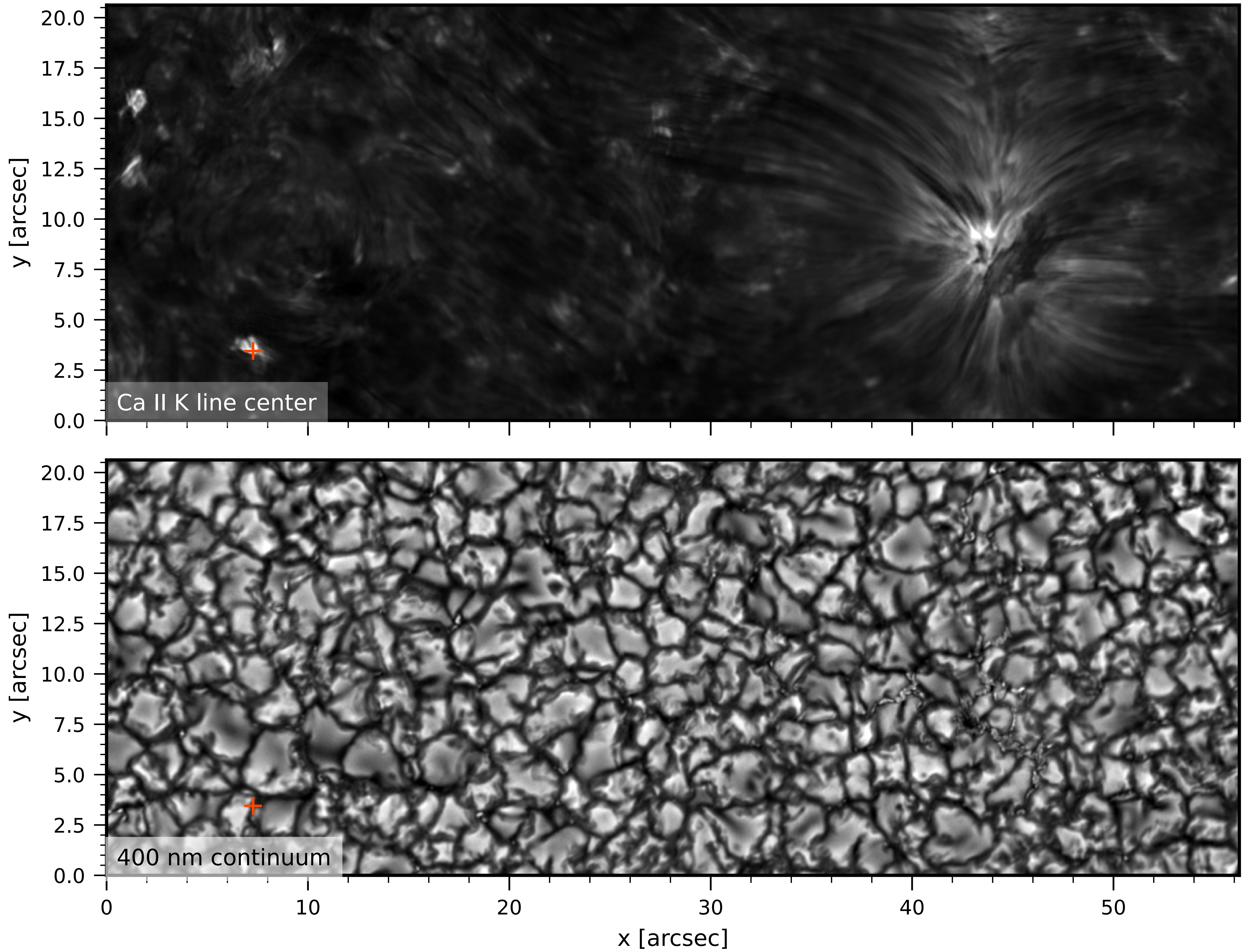
Emerging-flux regions



de la Cruz Rodriguez & van Noort in prep.

Magnetic fields in the quiet-Sun

SST/CHROMIS & CRISP data



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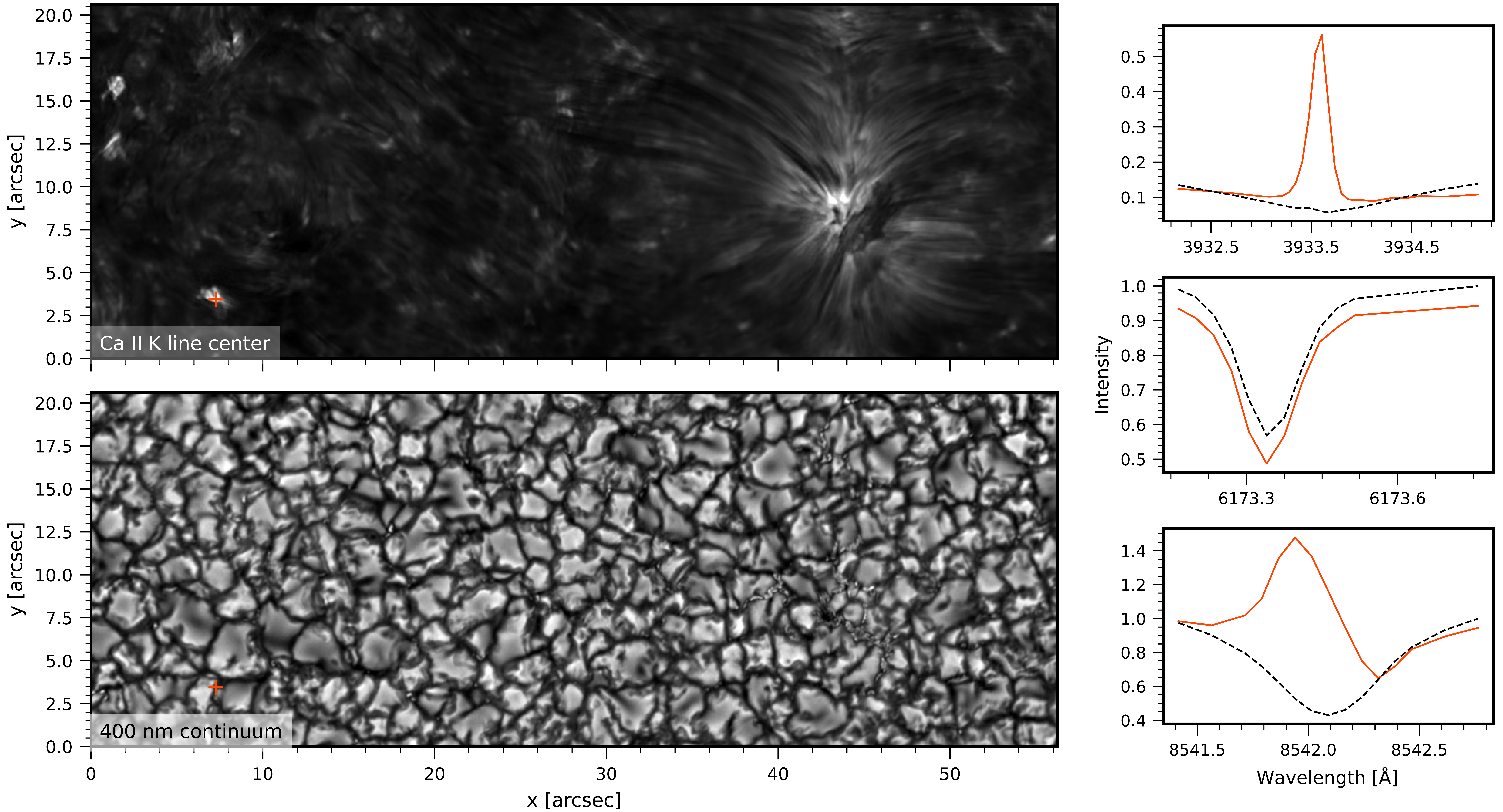

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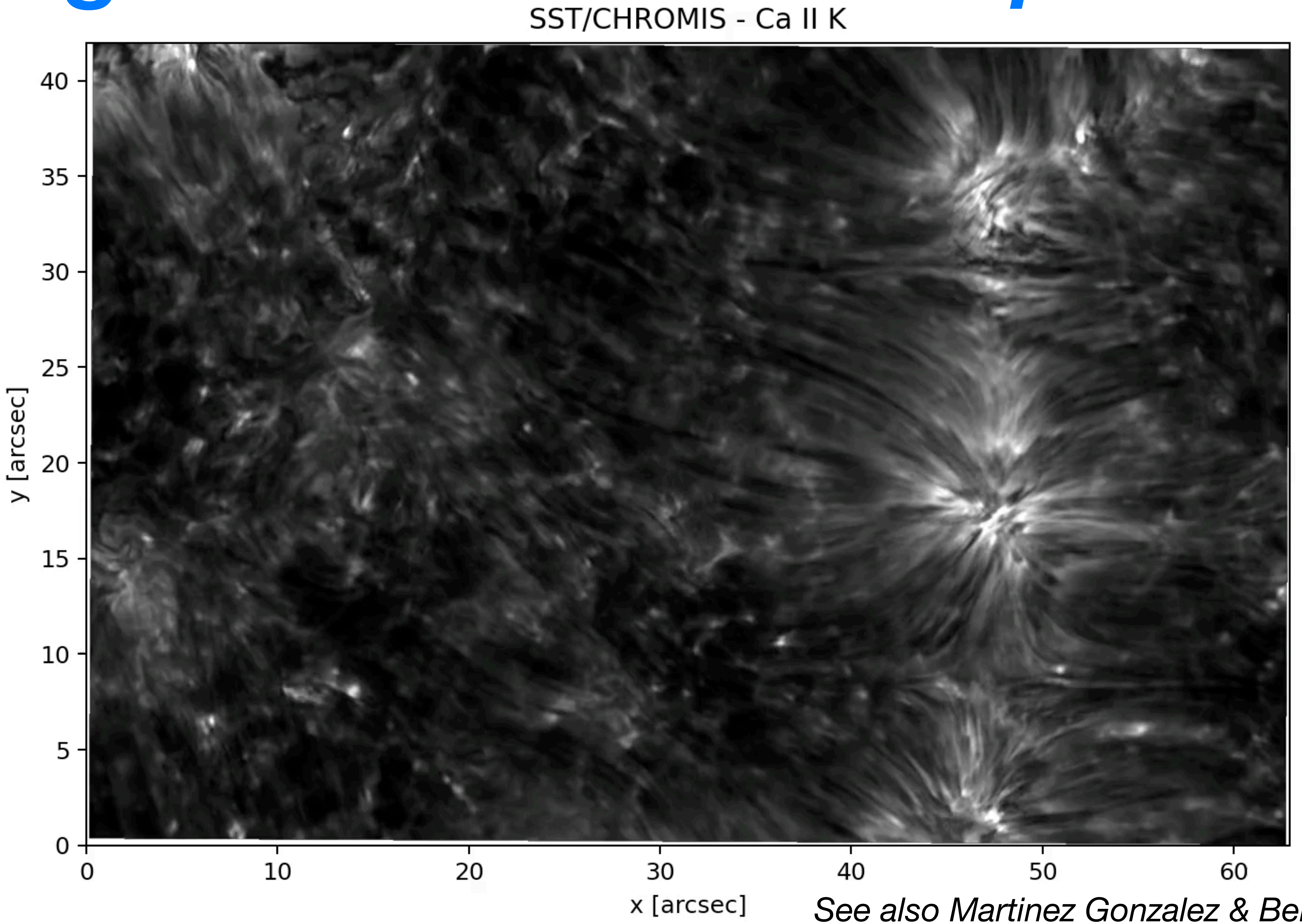

See also Martinez Gonzalez & Bellot Rubio (2009)

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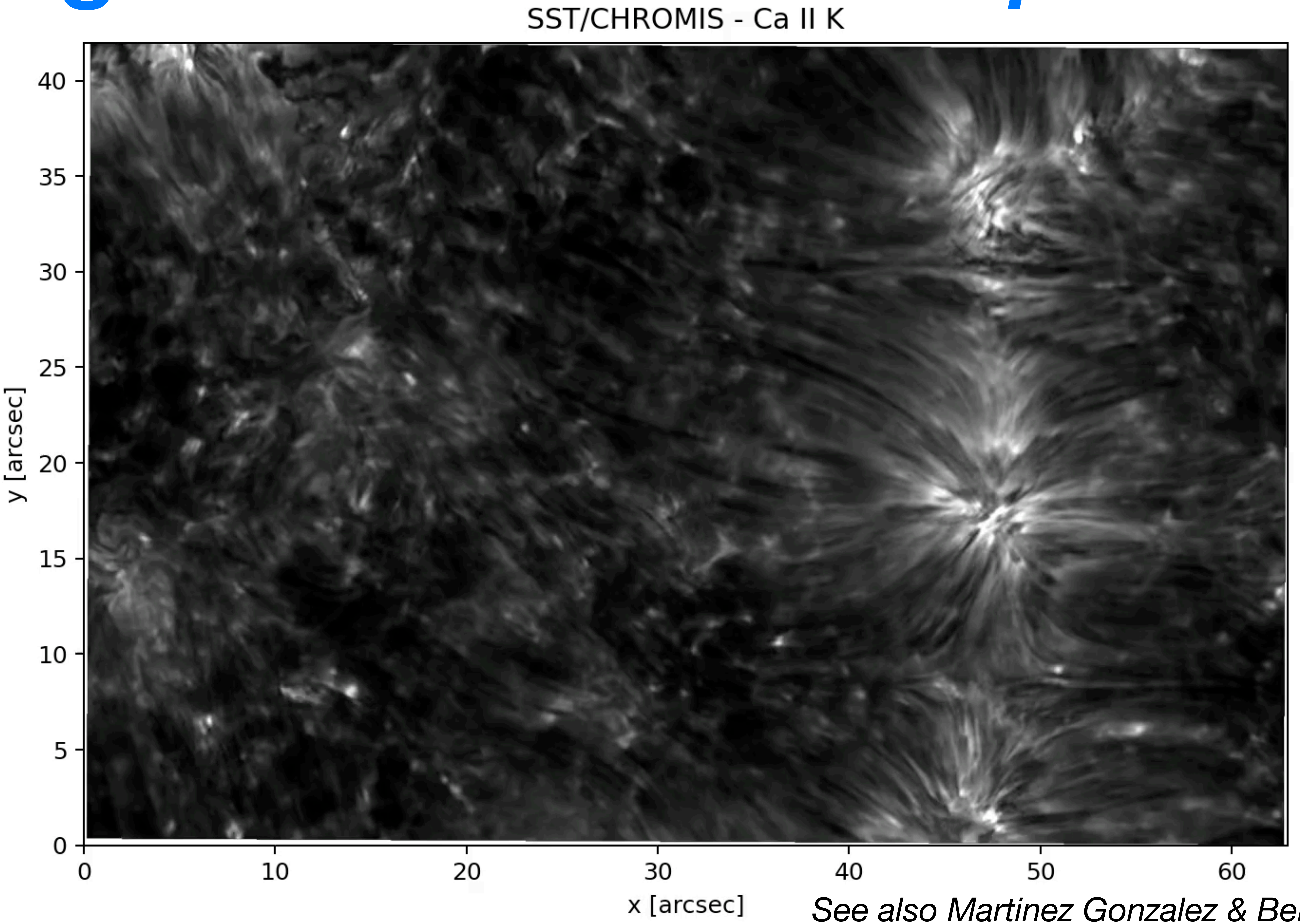

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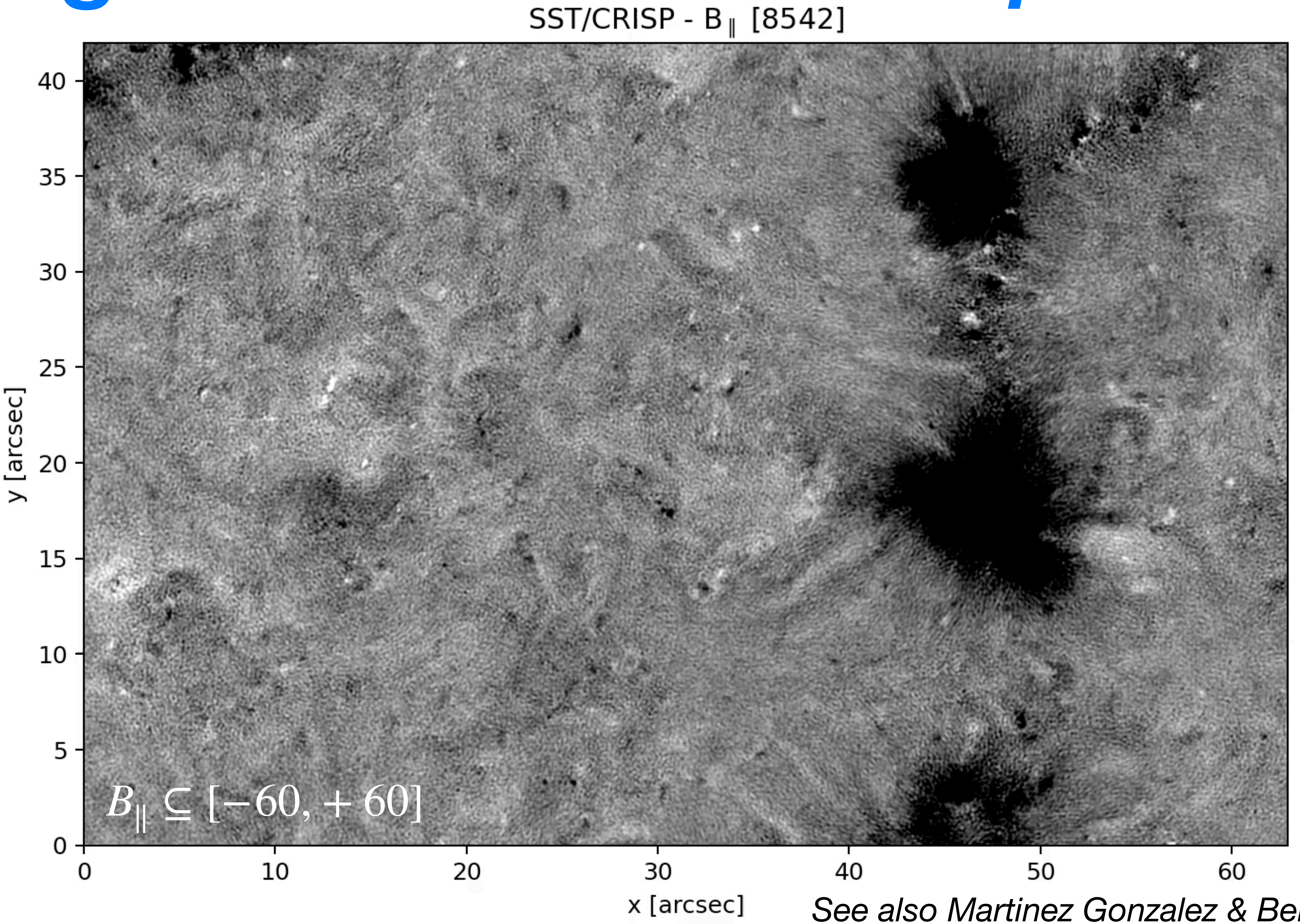

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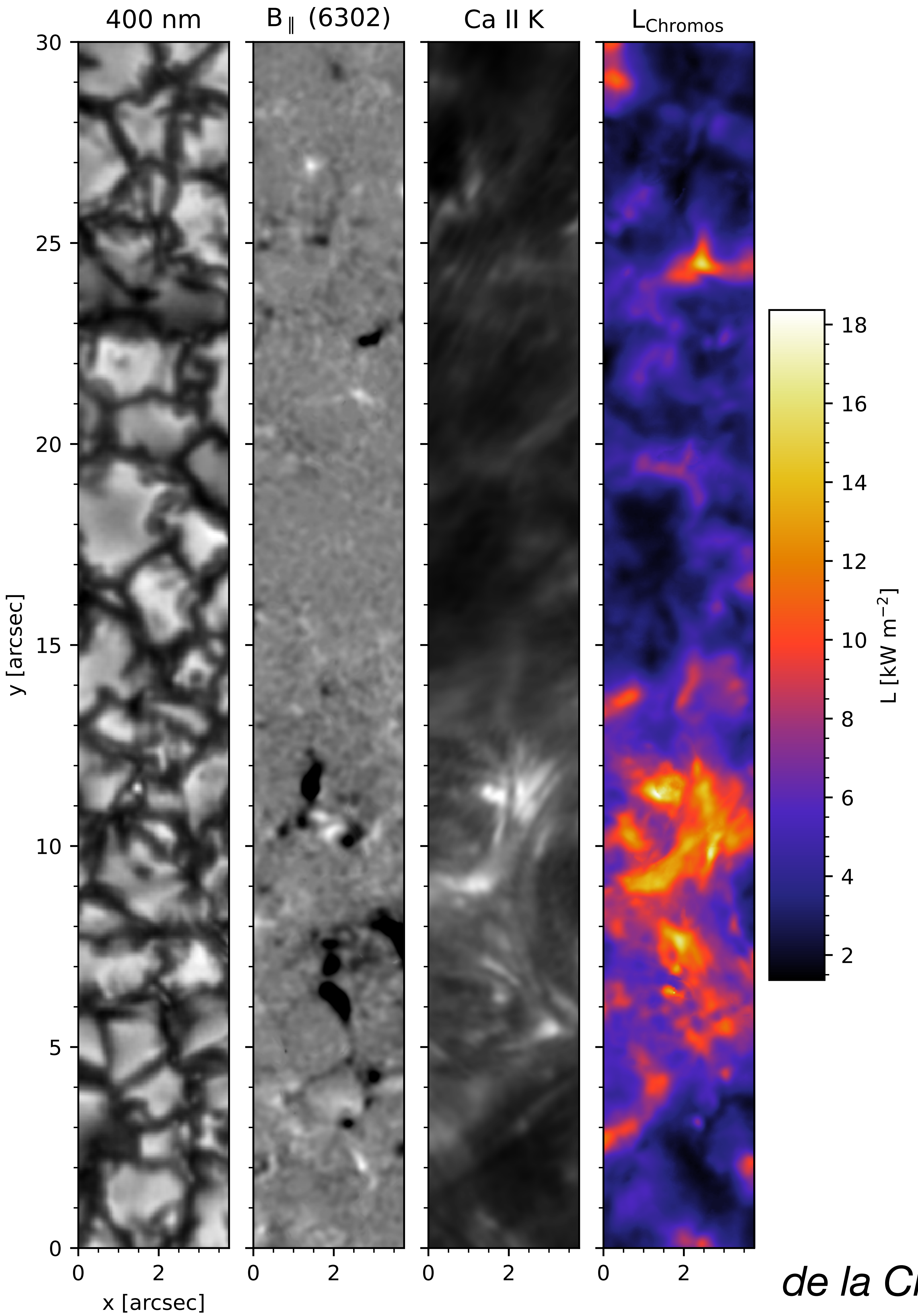

de la Cruz Rodriguez & Leenaarts in prep.

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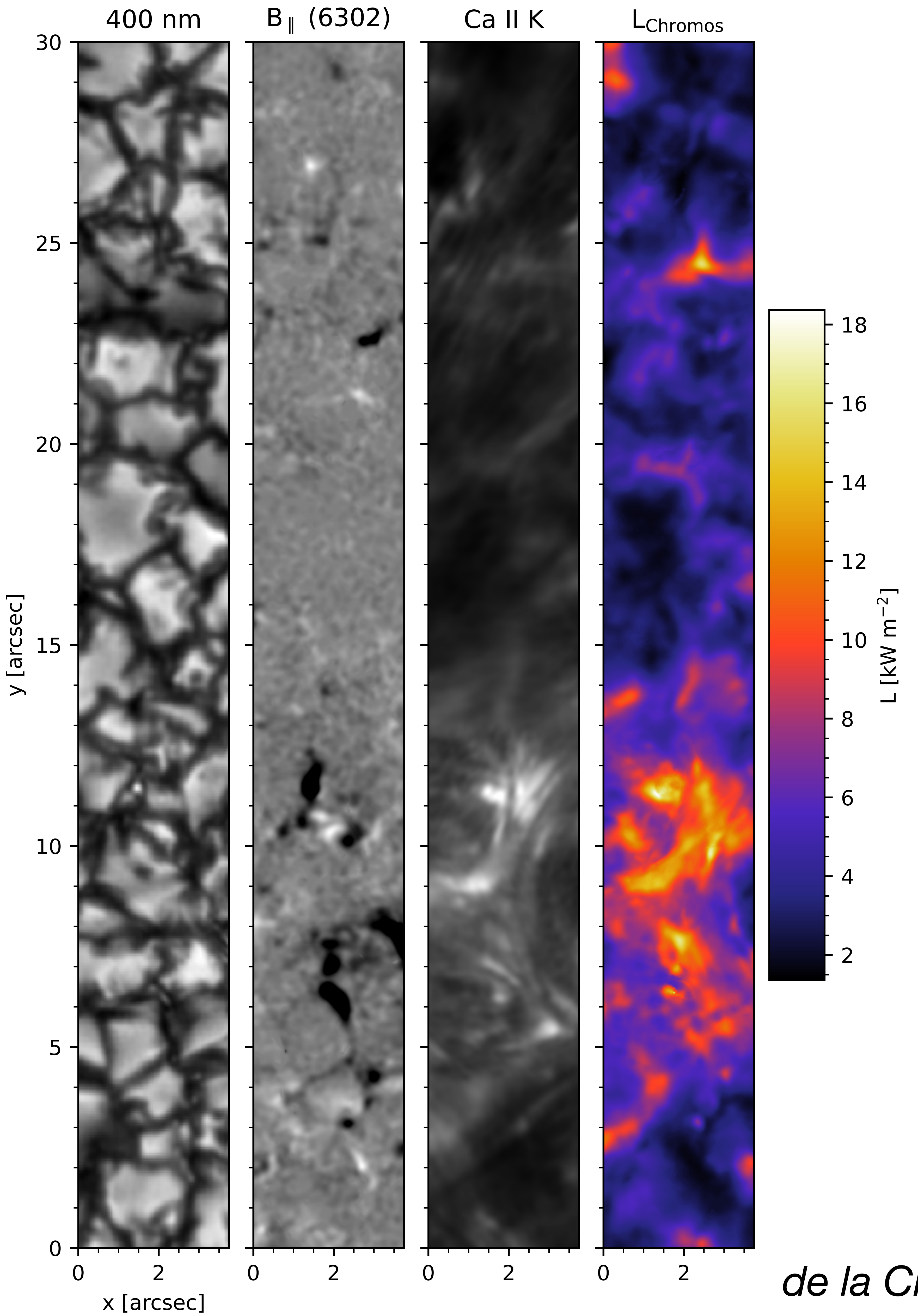

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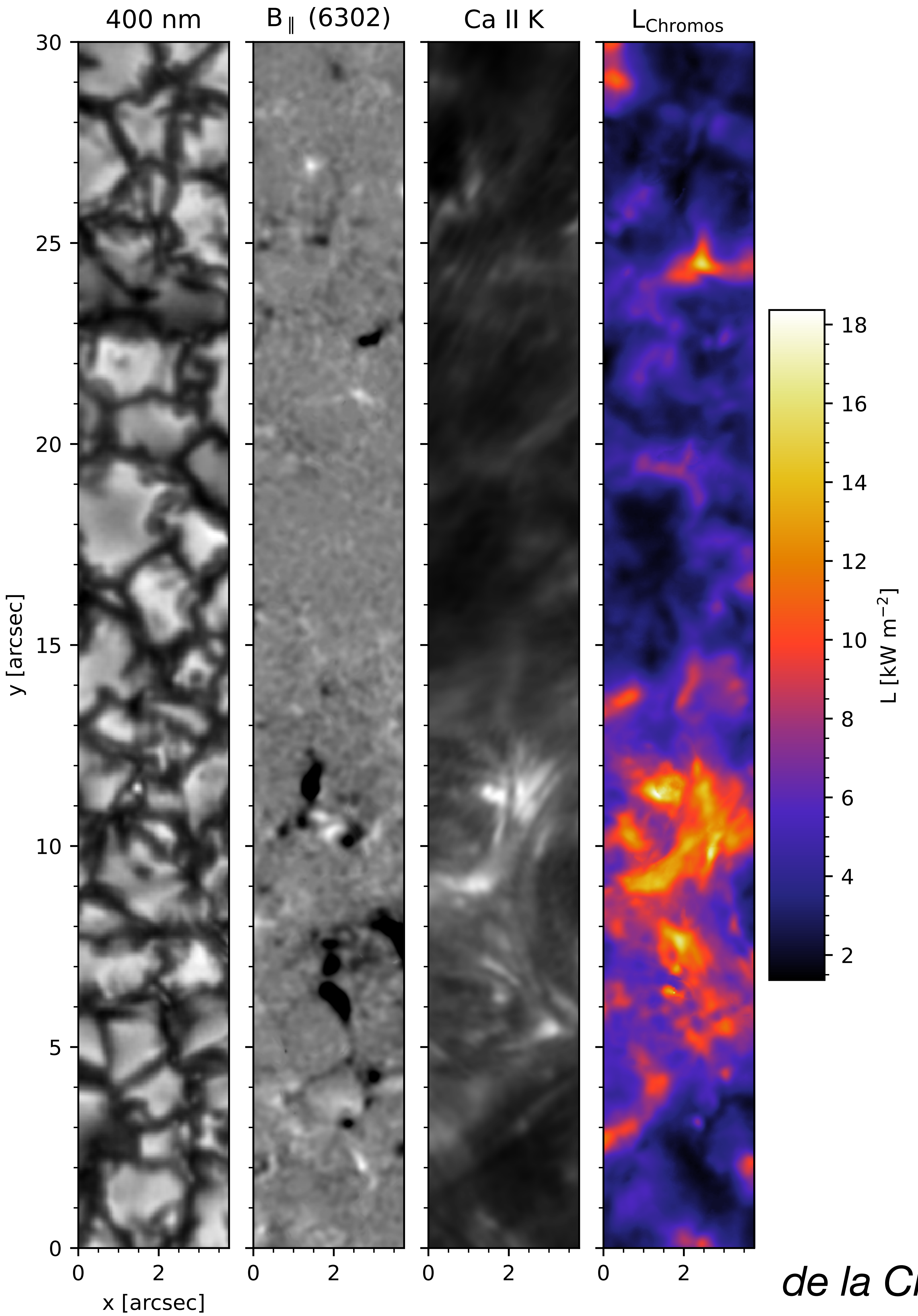
de la Cruz Rodriguez & Leenaarts in prep.

Magnetic fields in the quiet-Sun



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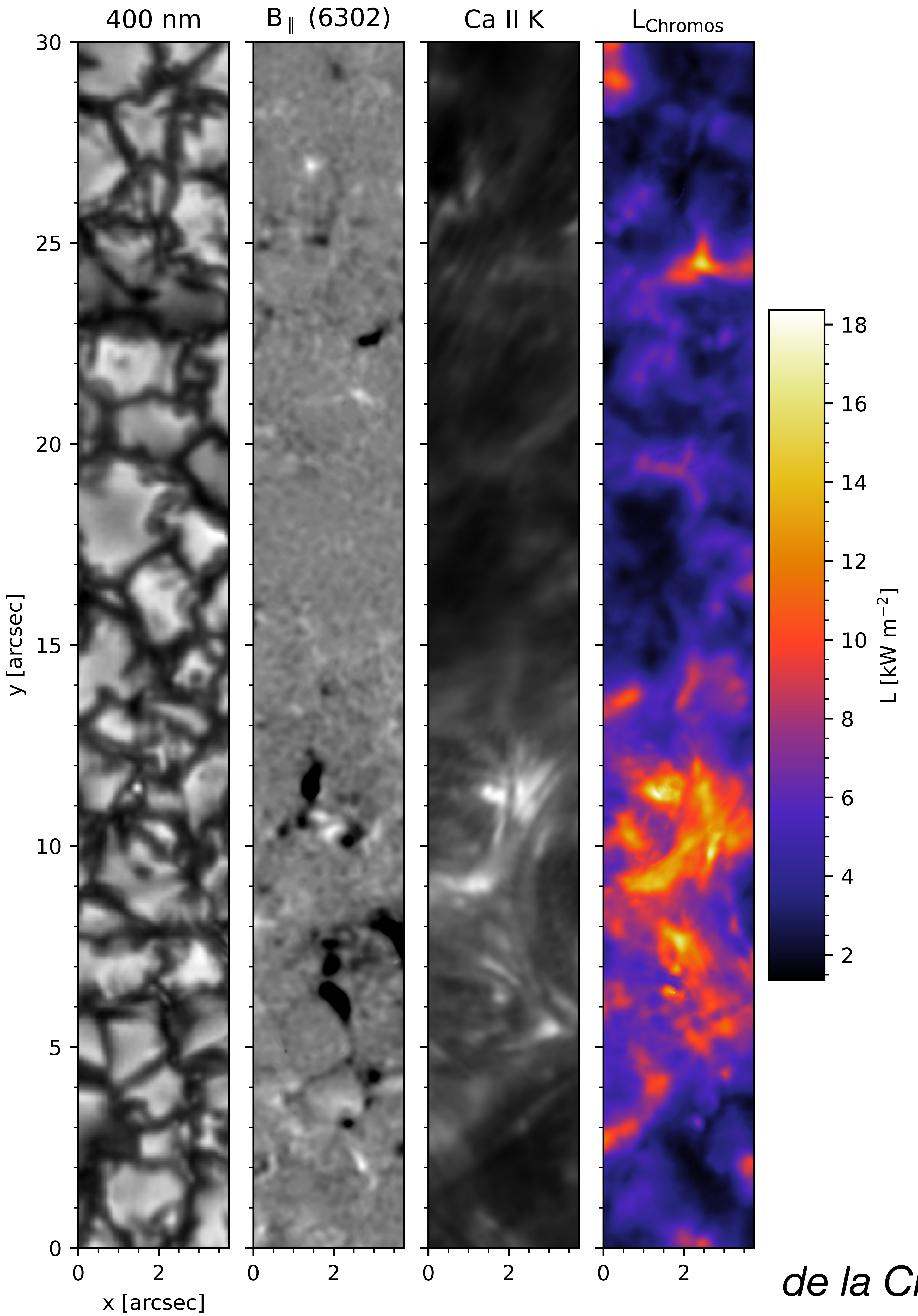
de la Cruz Rodriguez & Leenaarts in prep.

Magnetic fields in the quiet-Sun



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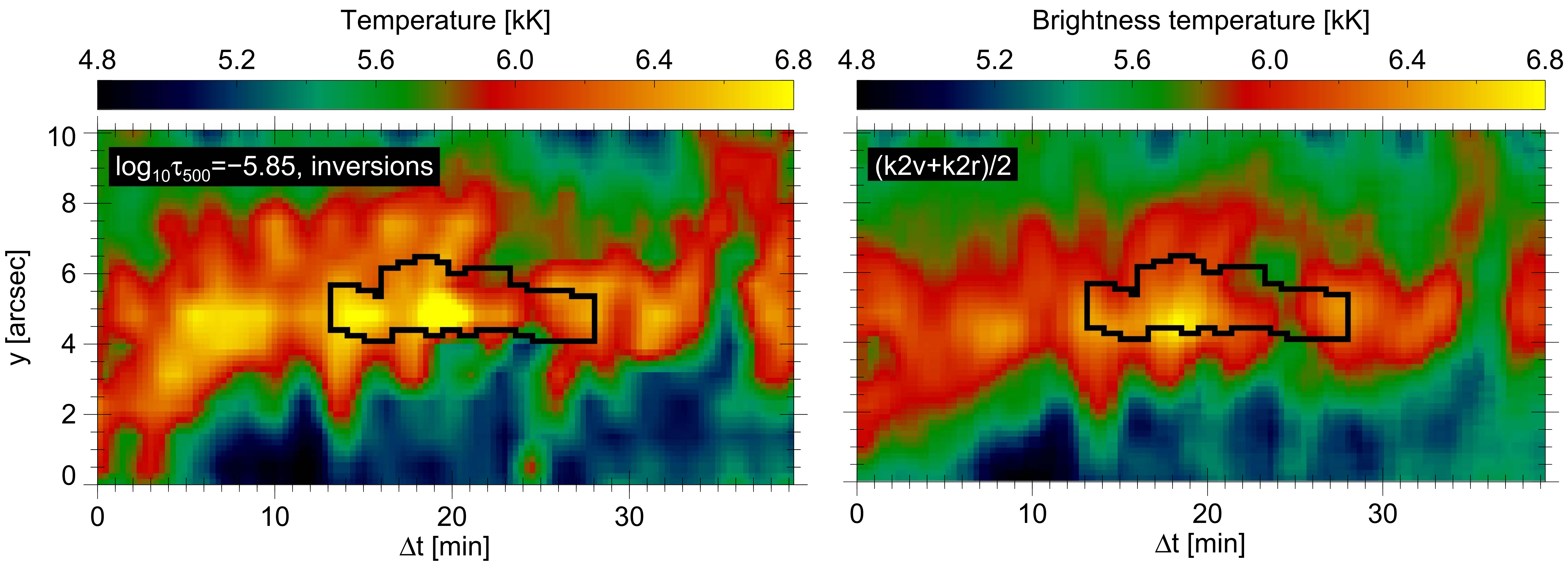

Gosic et al. (2018)

Conclusions

This project has been funded by the European Union through the European Research Council (ERC) under the Horizon Europe program (MAGHEAT, grant agreement 101088184).

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SST public archive: https://dubshen.astro.su.se/sst_archive/

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