

Understanding chromospheric dynamics

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Danilovic, 2023, AdSpR, 71, 1939

Danilovic et al., 2023, A&A, 670, 50

Skan et al., 2023, A&A, accepted

da Silva Santos et al. 2022, A&A, 661, 17

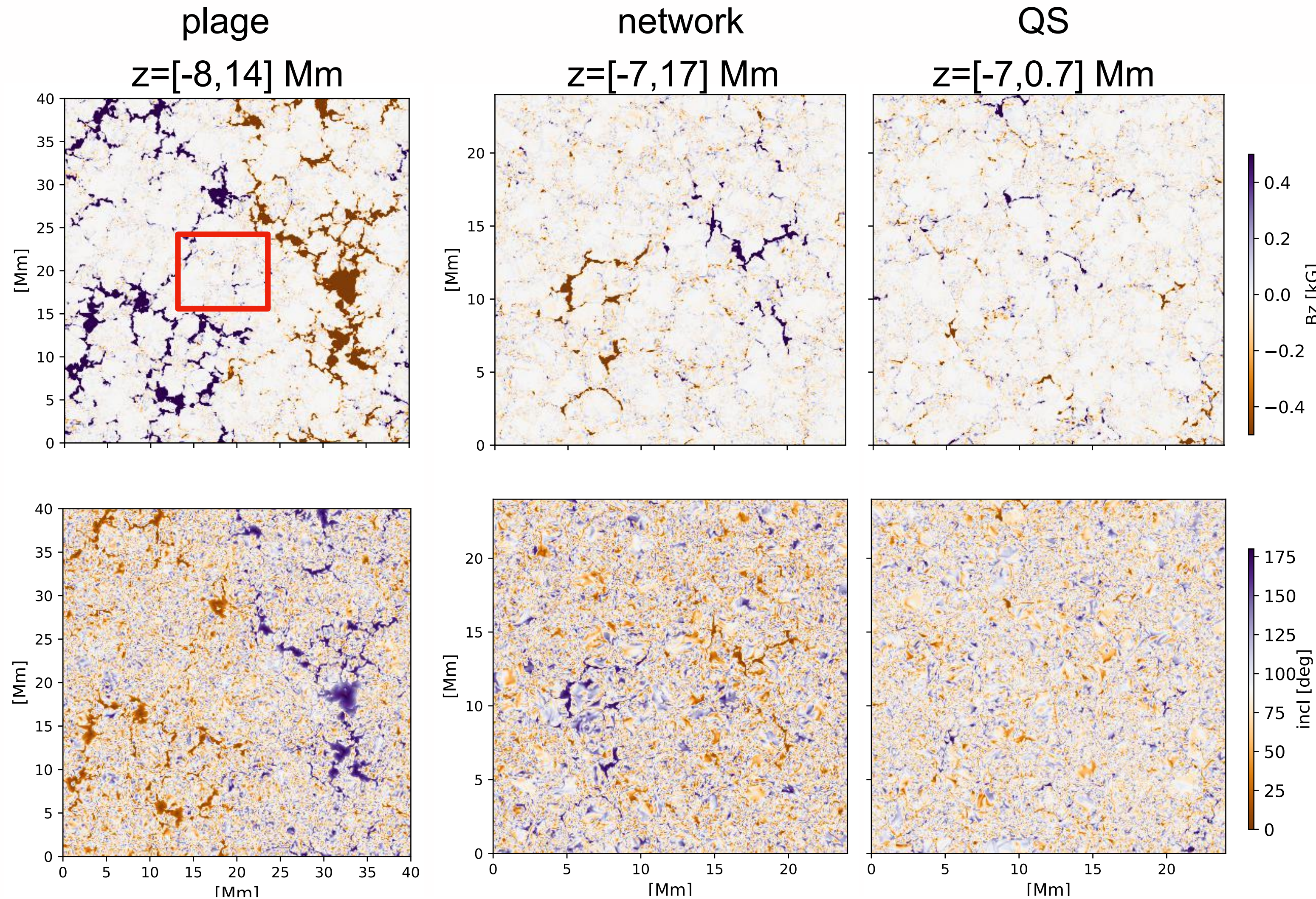
Thanks to:

C. Robustini, M. Skan, J. De la Cruz Rodriguez, J. Leenaarts, M. Rempel, P. Ondratschek, D. Przybylski

Where are they on the scale of MURaM models?

- Comparison of magnetic field

QS: small-scale dynamo (Rempel 2014)
 quantitatively compared with
 Hinode/SP (Danilovic et al. 2016) and
 Gregor/GRIS (Lagg et al. 2016)



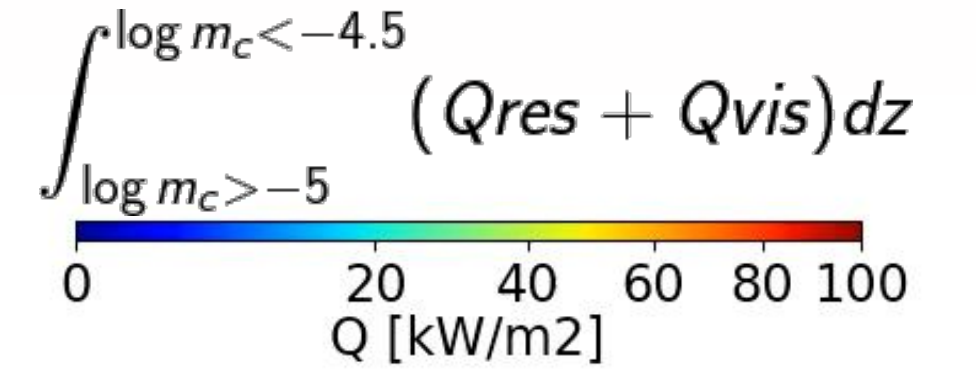
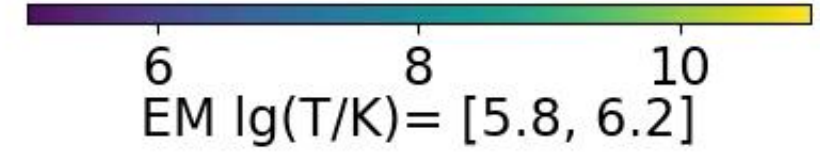
network: with coronal extension
 and chromospheric extension
 non-grey non-local RT
 Non-eq. H ionization
 (Przybylski et al. 2022)

plage: with coronal extension (Rempel 2017)
 grey RT

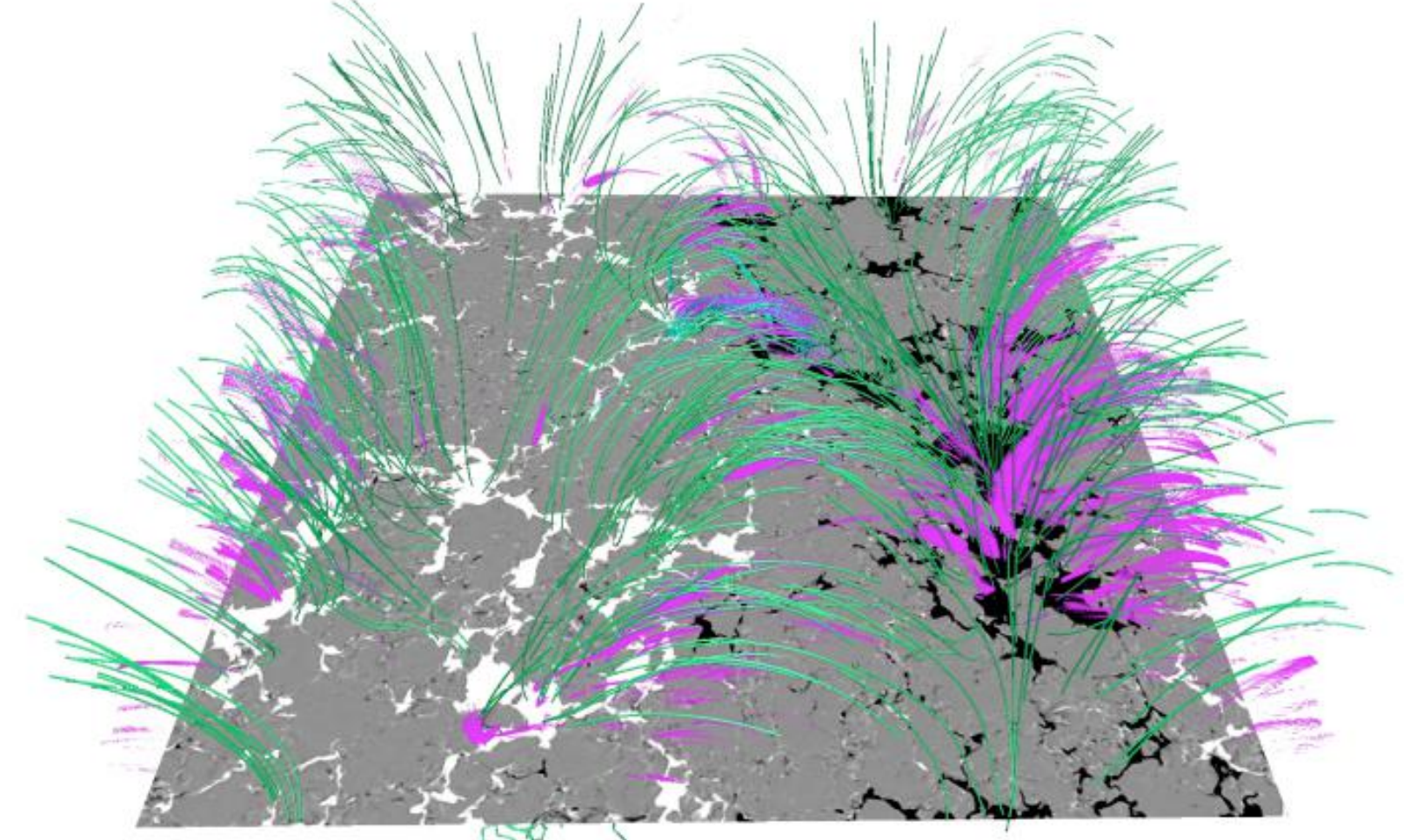
	plage	network	QS
$\langle B \rangle$	187 (94)	115	111
$\langle B_z \rangle$	139 (49)	67	68
$\Delta x, \Delta z$ [km]	39, 21	23, 20	16, 16

Plage model - chromospheric dynamics

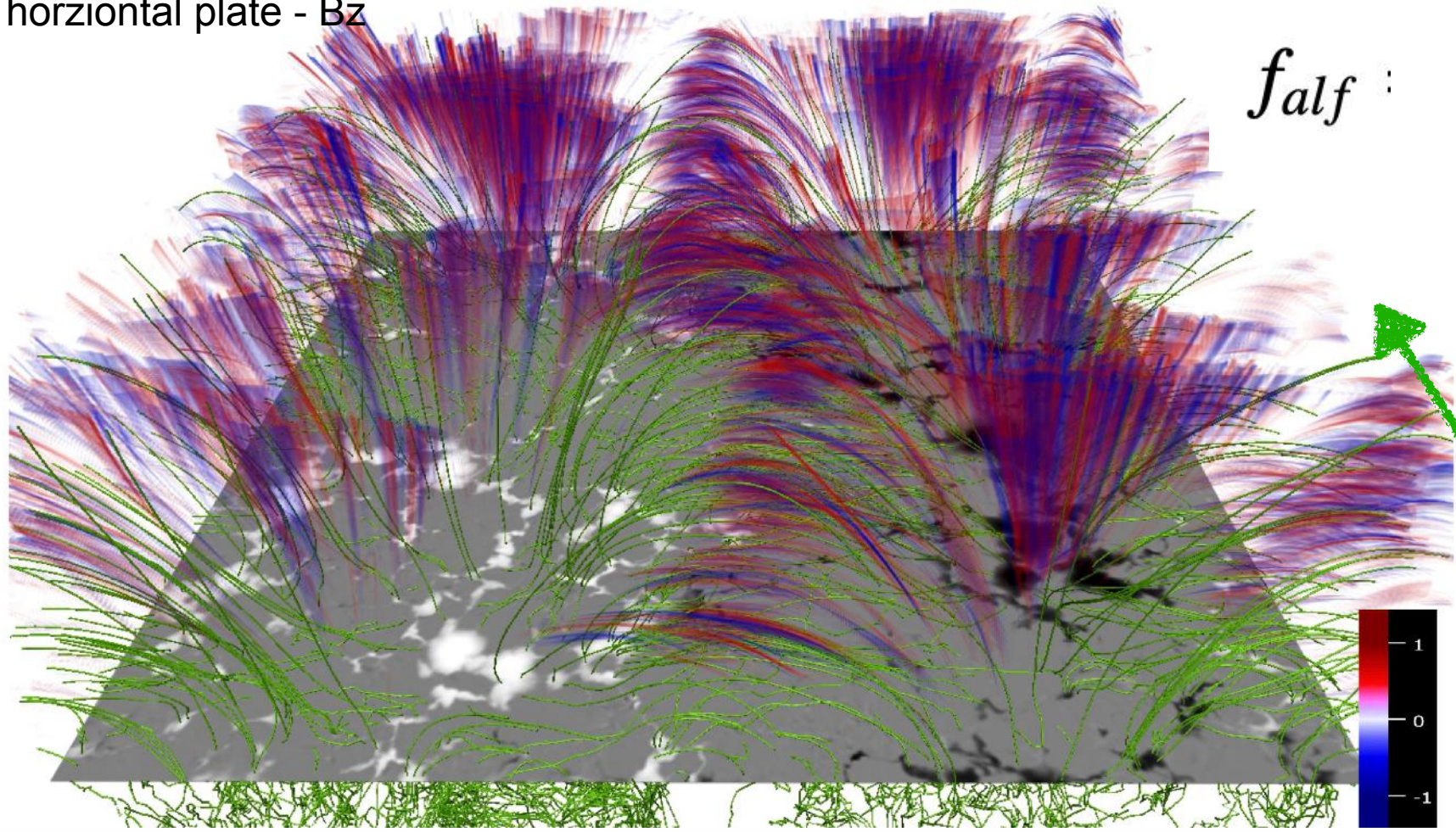
[movie link](#)



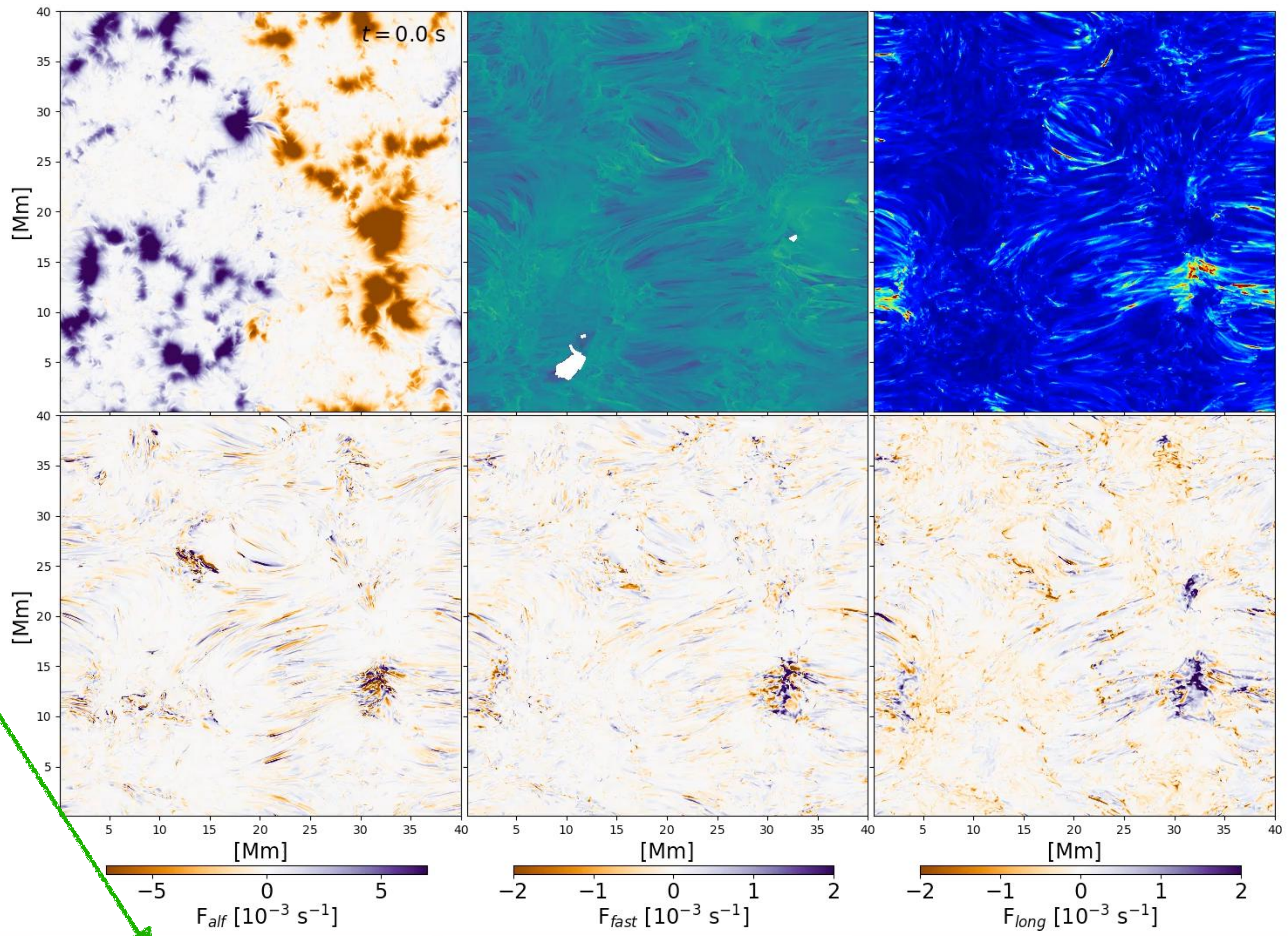
purple - high current density



green - magnetic field lines
horizontal plate - Bz



blue and purple - falf



Right - Wave proxies:
Alfvén, fast and slow magneto-acoustic
(Cally 2017, Khomenko et al. 2018)

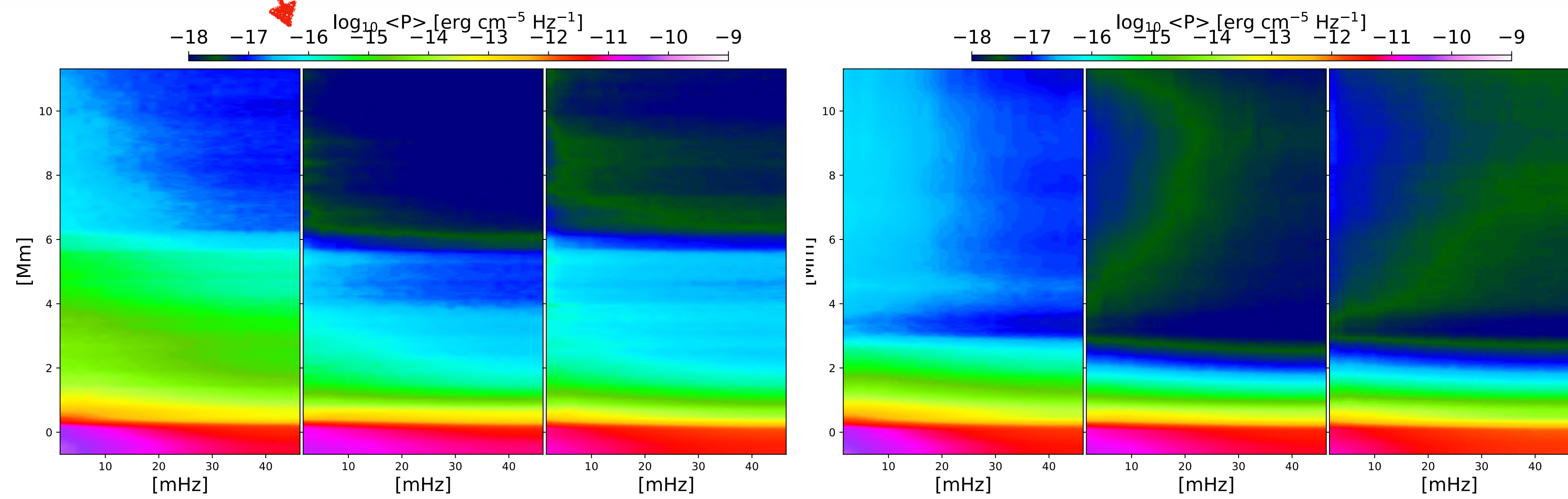
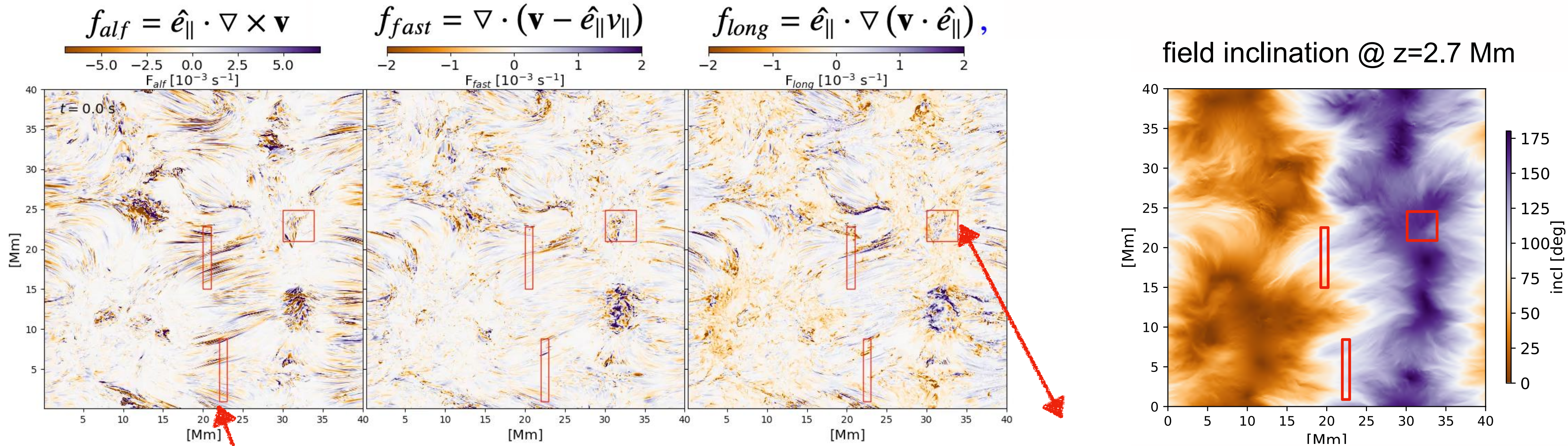
$$f_{alf} = \hat{e}_{\parallel} \cdot \nabla \times \mathbf{v}$$

$$f_{fast} = \nabla \cdot (\mathbf{v} - \hat{e}_{\parallel} v_{\parallel})$$

$$f_{long} = \hat{e}_{\parallel} \cdot \nabla (\mathbf{v} \cdot \hat{e}_{\parallel}),$$

Plage model - chromospheric dynamics

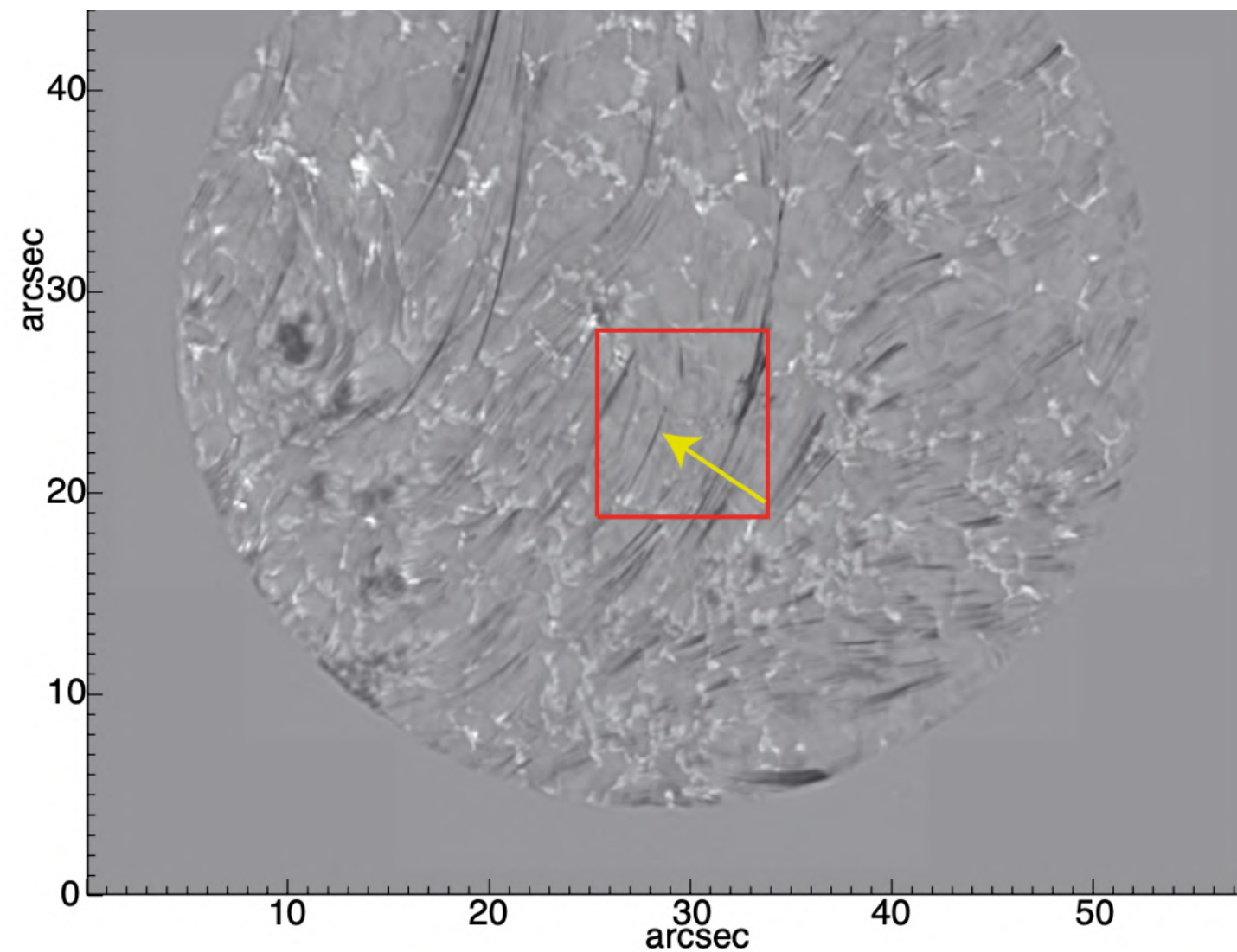
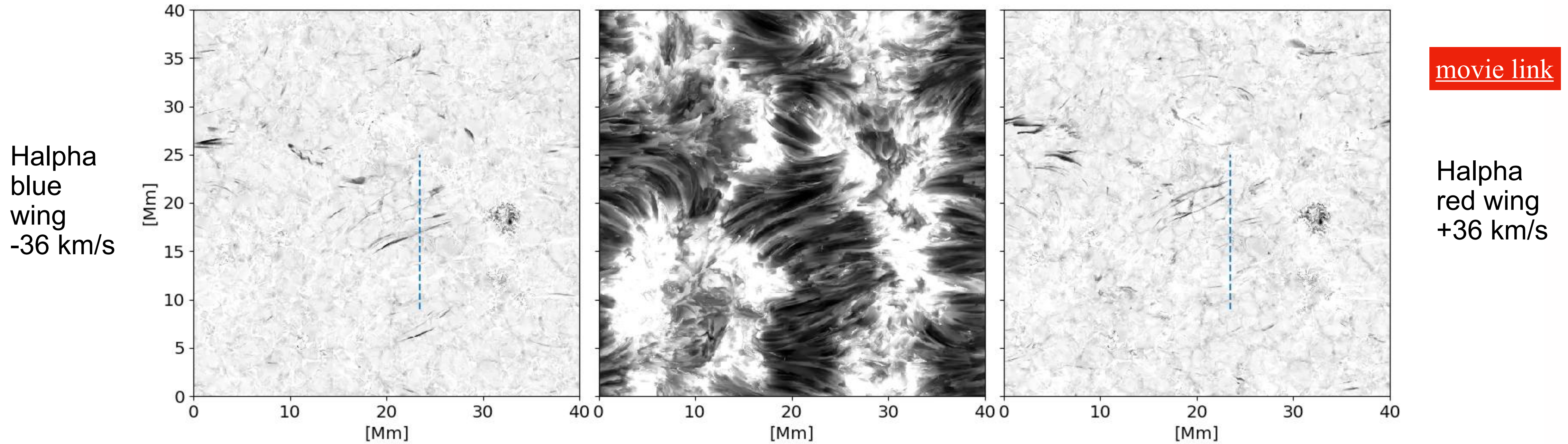
[movie link](#)



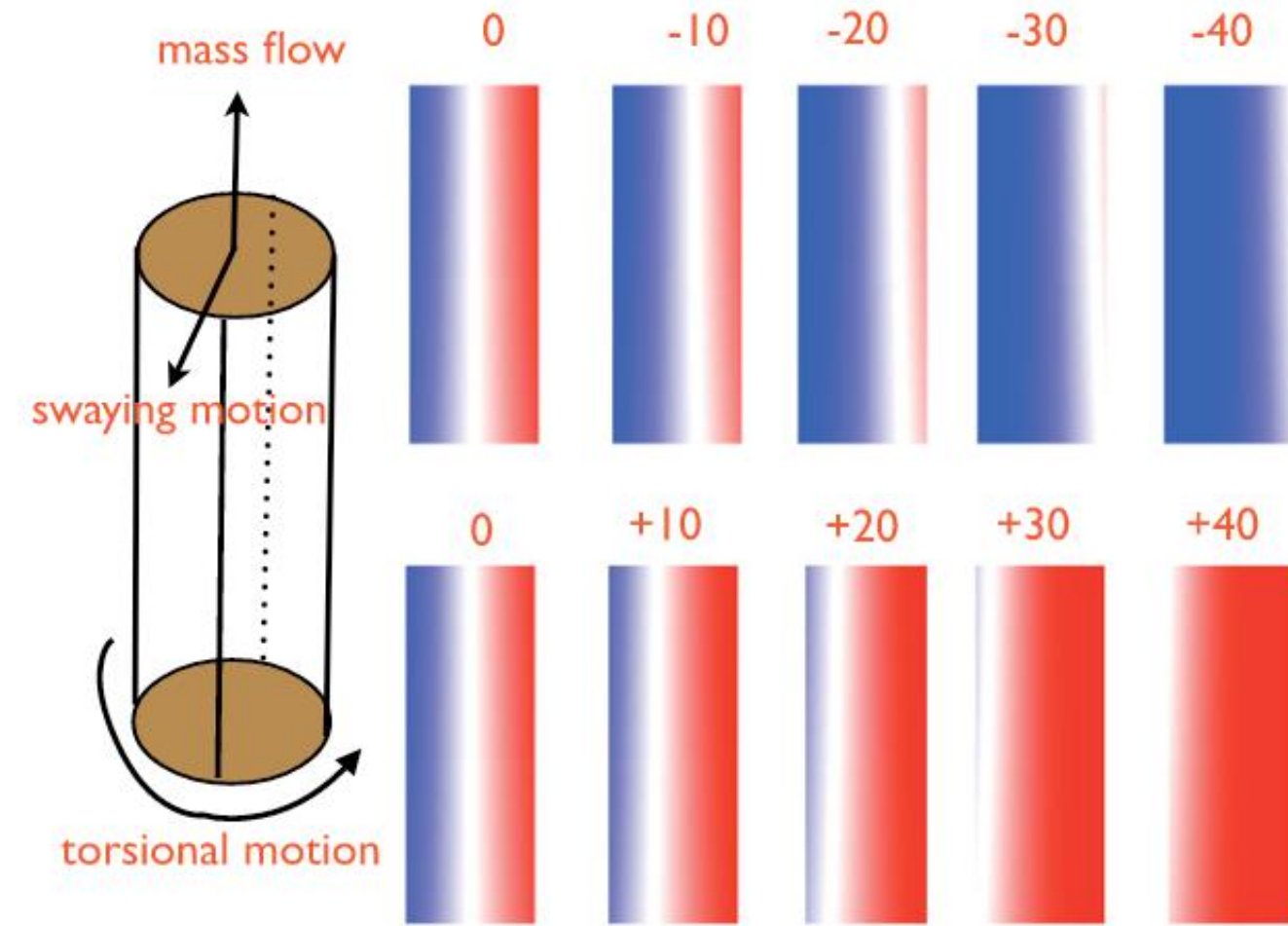
Power spectra of wave proxies averaged over areas with predominantly vertical and horizontal field, shown as a function of height and frequency

Time series: 61 snapshot that cover 635 s

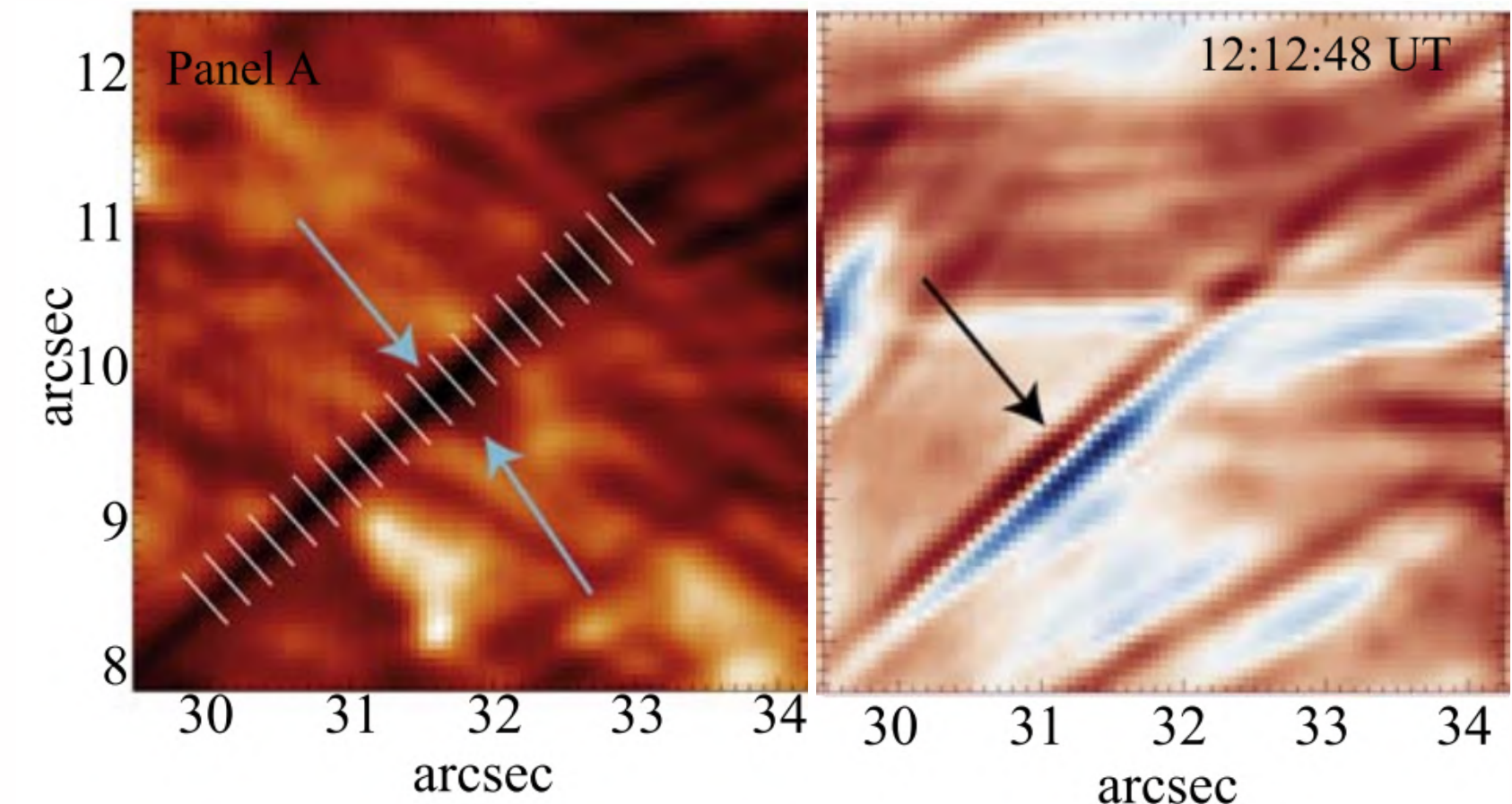
Rapid Blue- and Red-shifted Excursions (RBEs/RREs) signatures of Alfvénic waves



Shetye et al. 2016

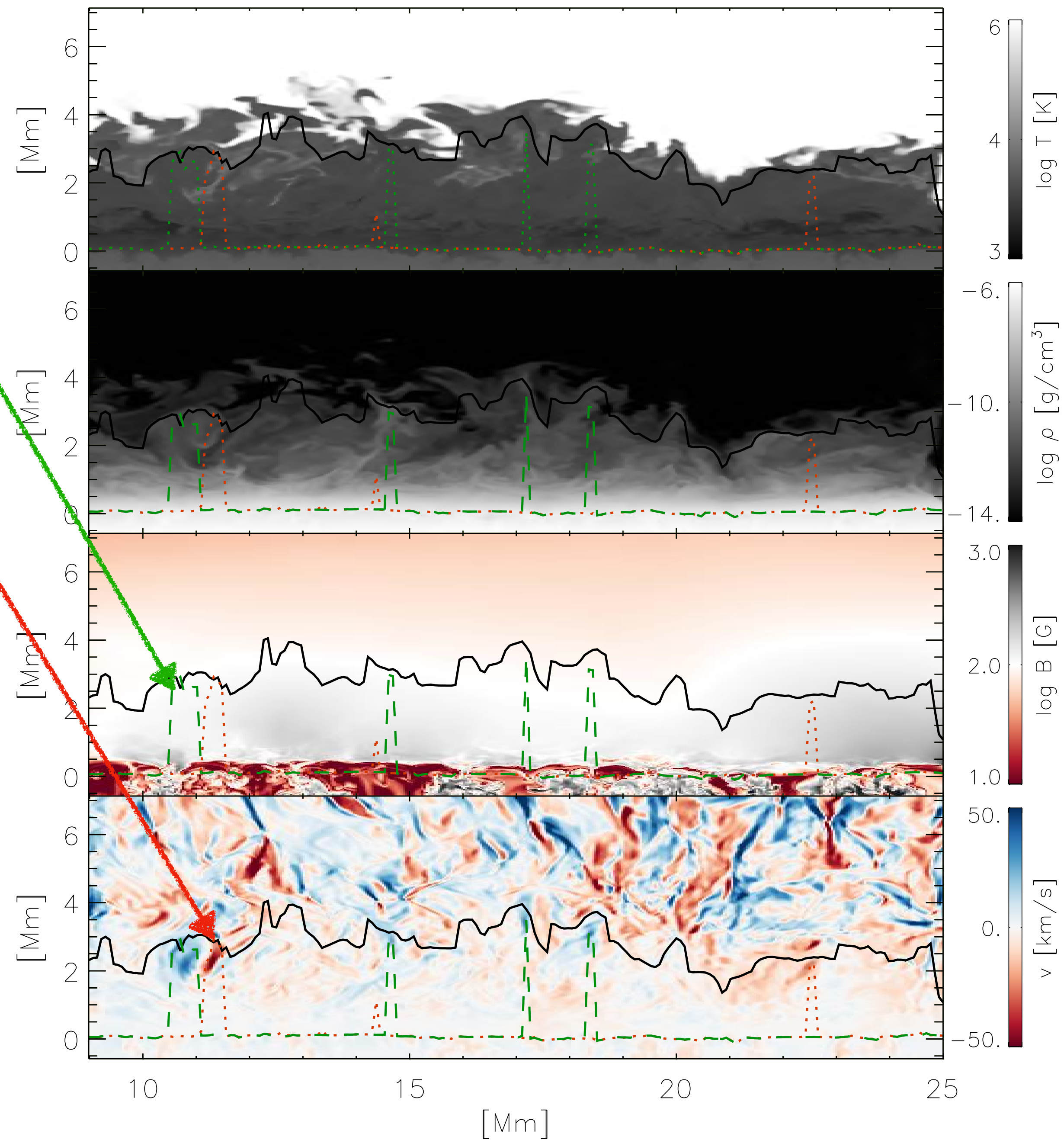
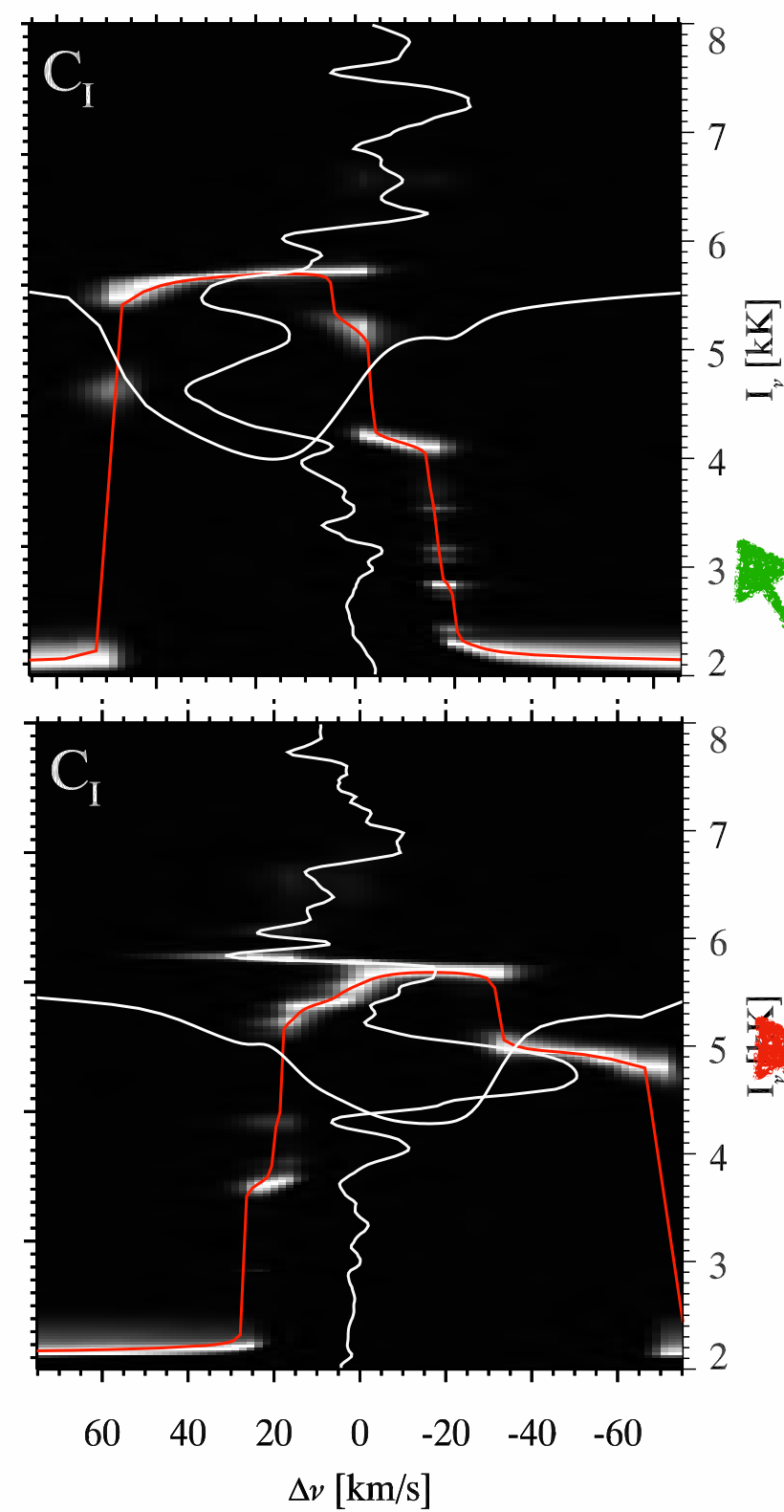
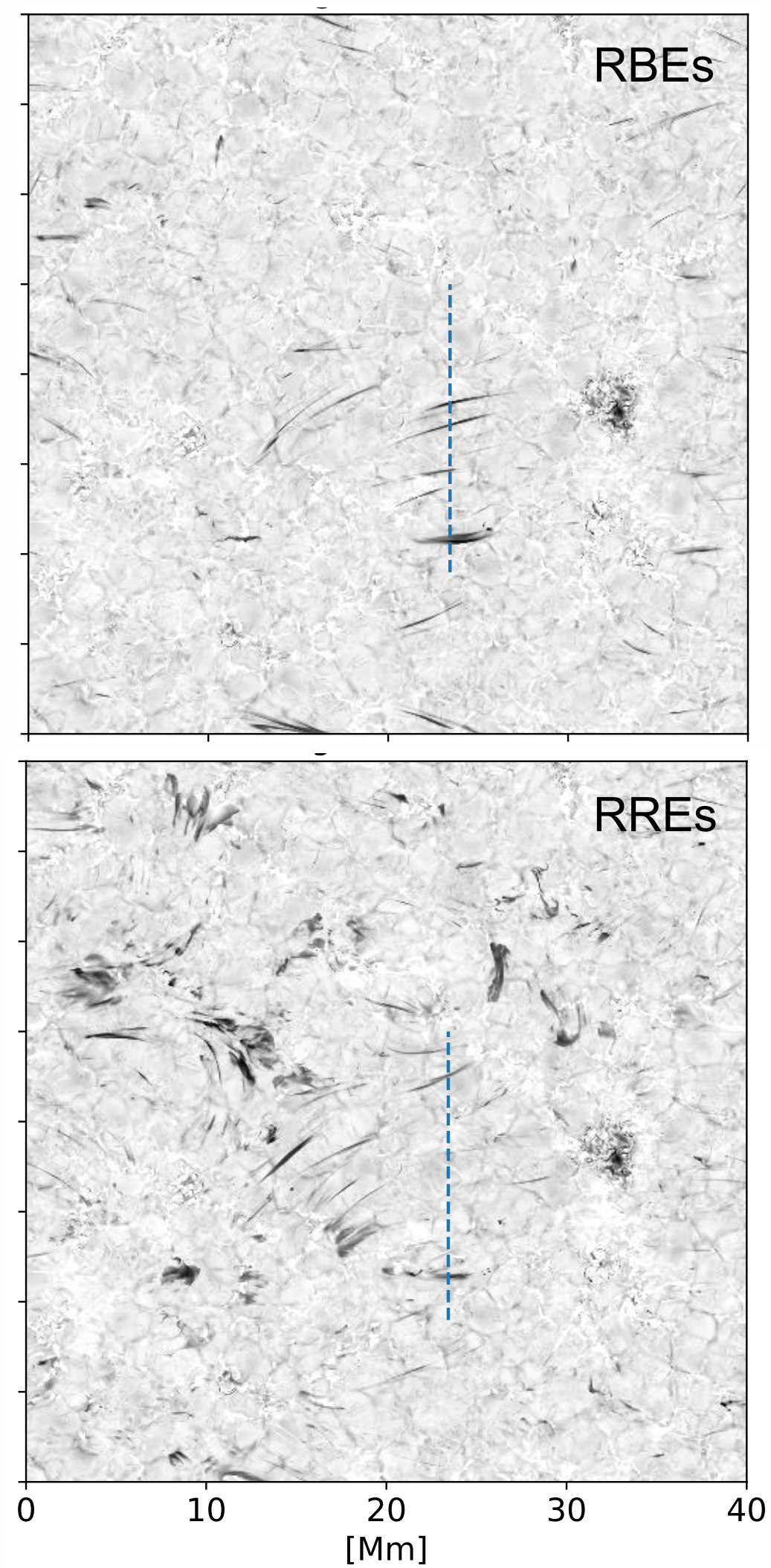


Sekse et al. 2013

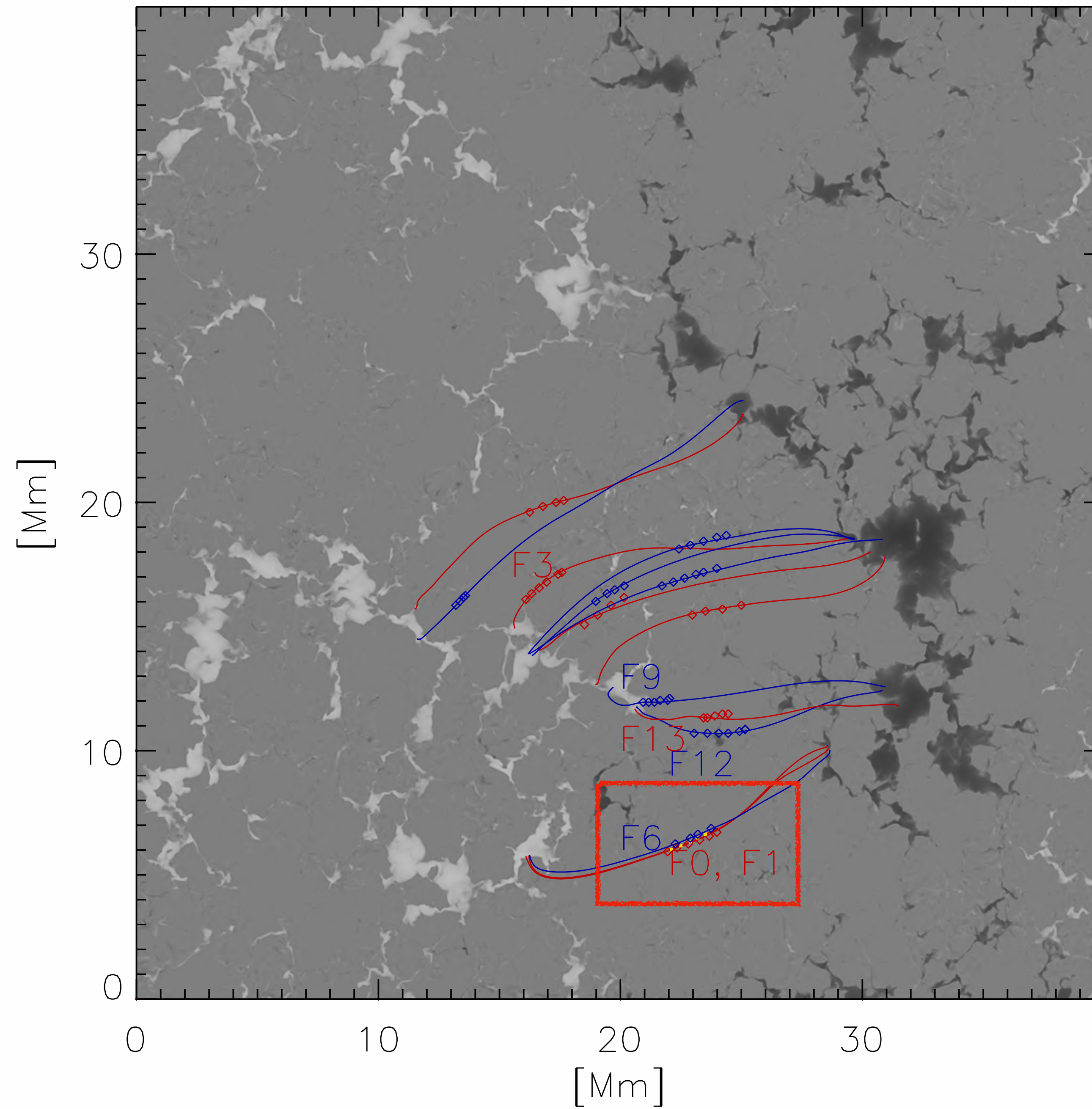


Shetye et al. 2021

Rapid Blue- and Red-shifted Excursions (RBEs/RREs) signatures of Alfvénic waves



Source and nature of synthetic RBEs and RREs

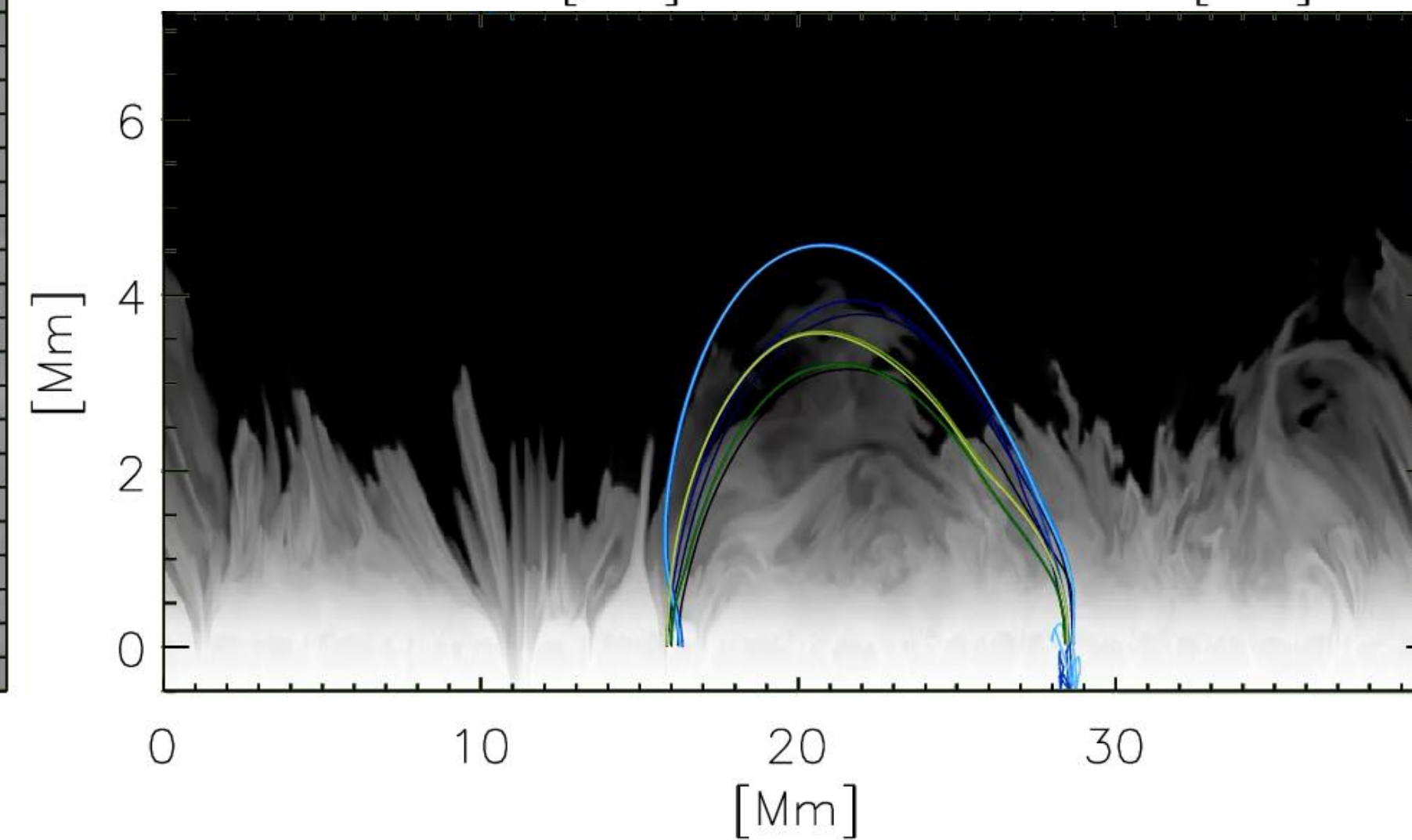
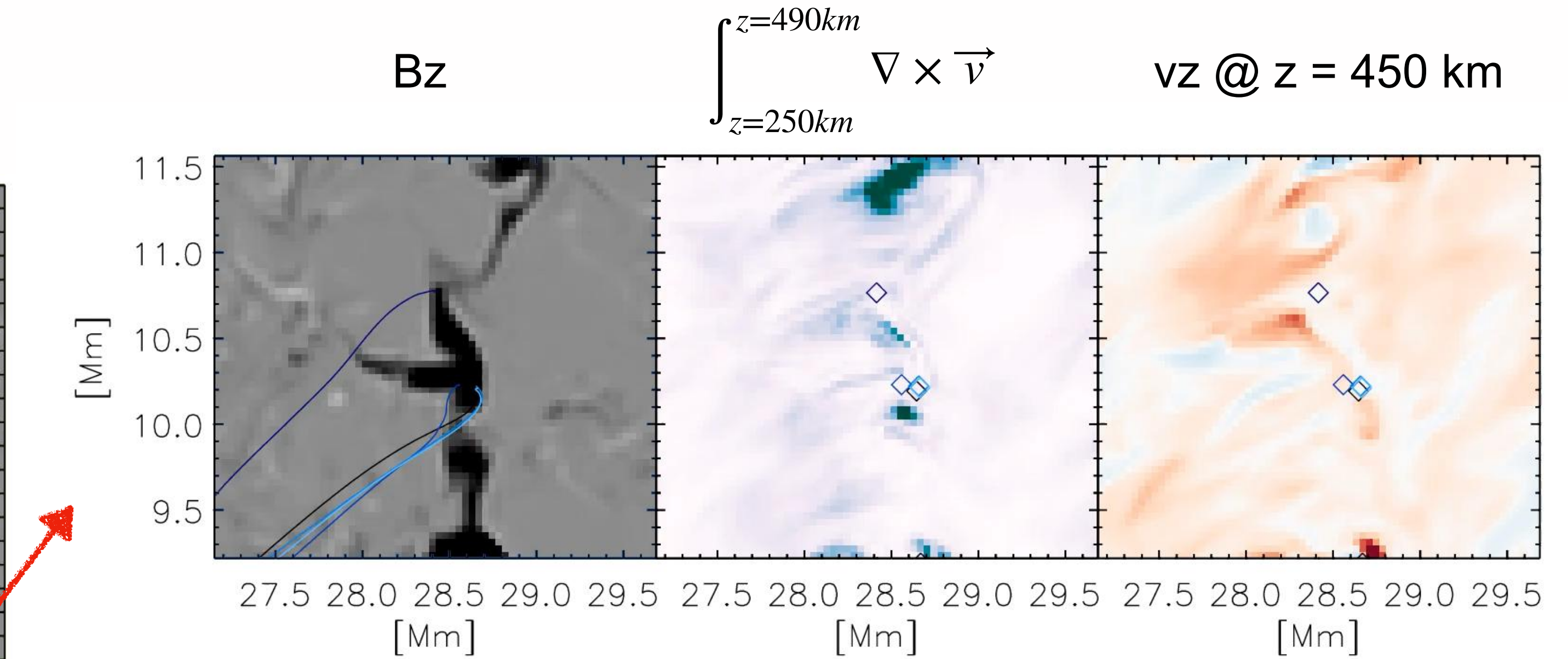
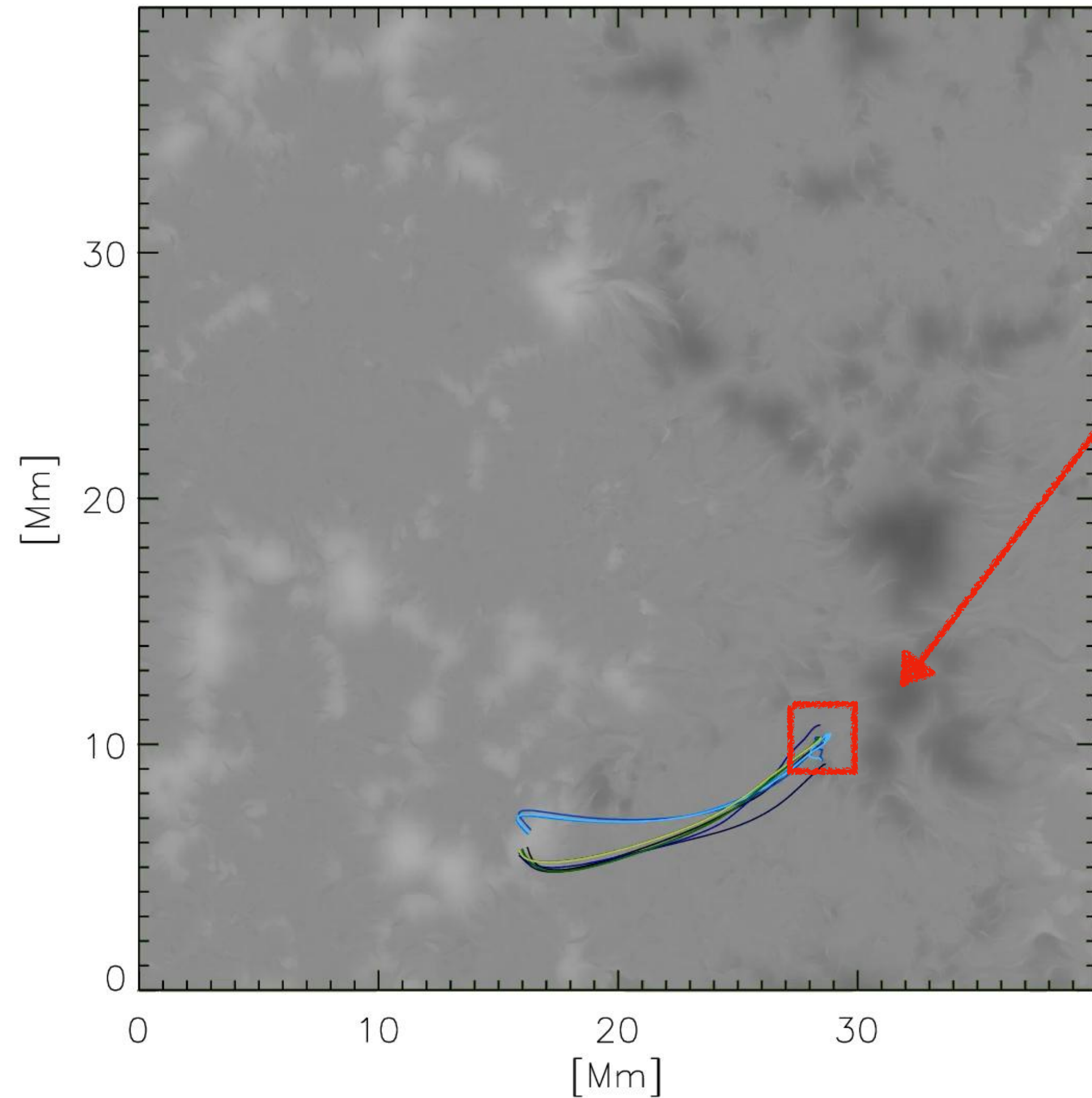


Source and nature of synthetic RBEs and RREs

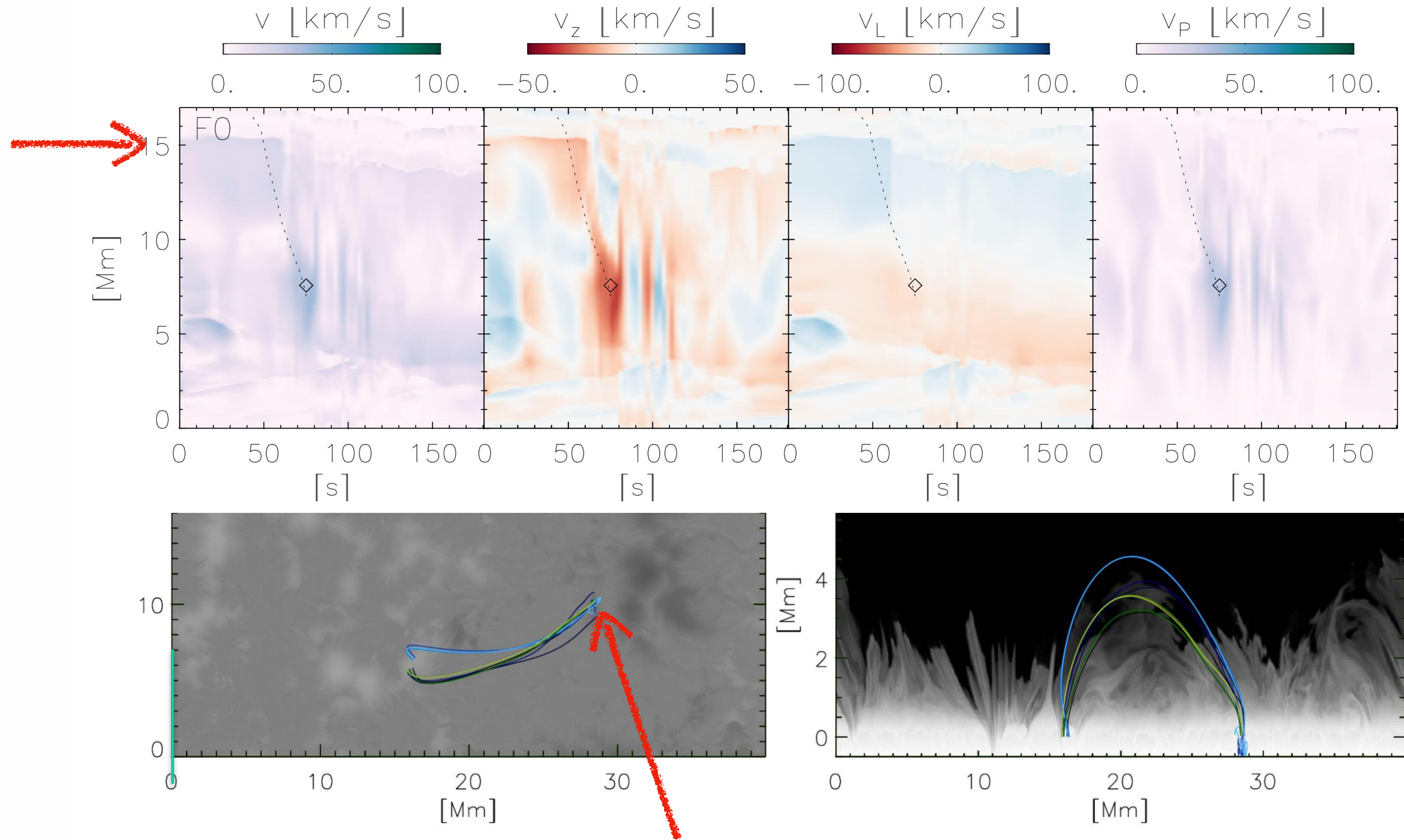
[movie link](#)

[movie link](#)

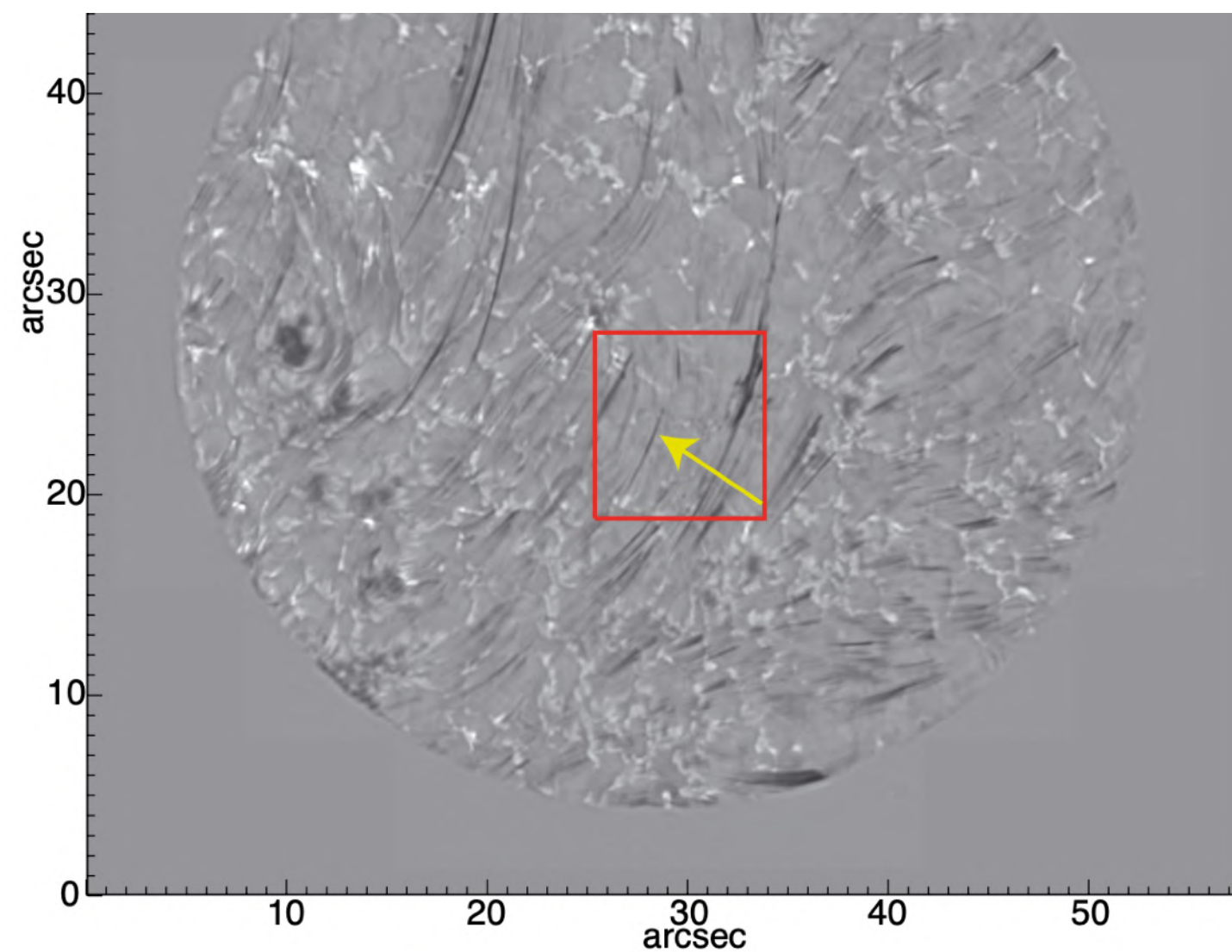
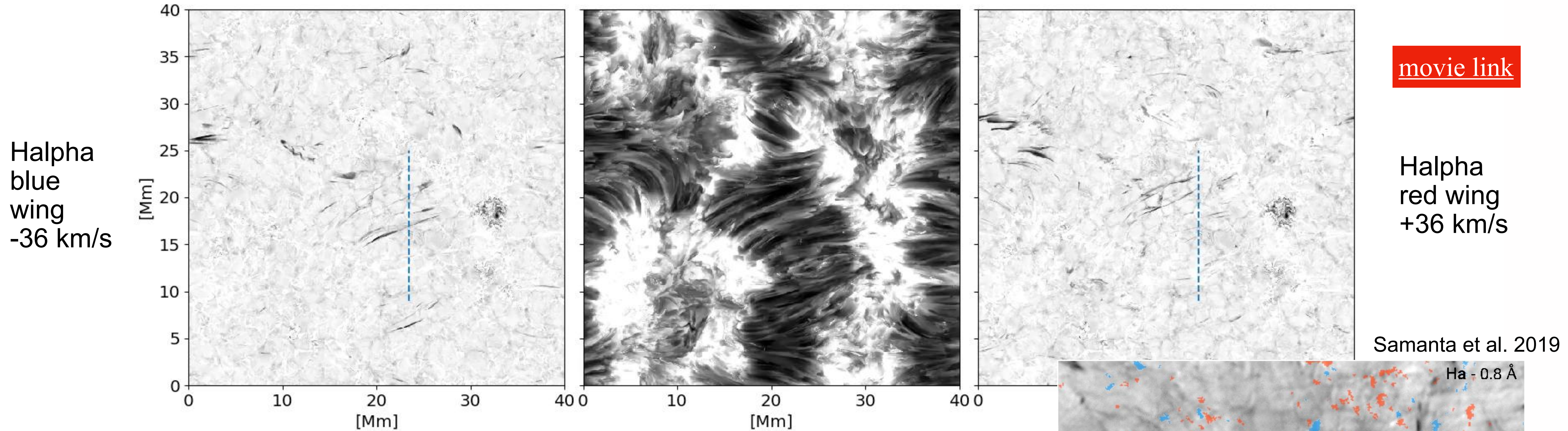
F0 – blue lines and F1 – green lines - RREs



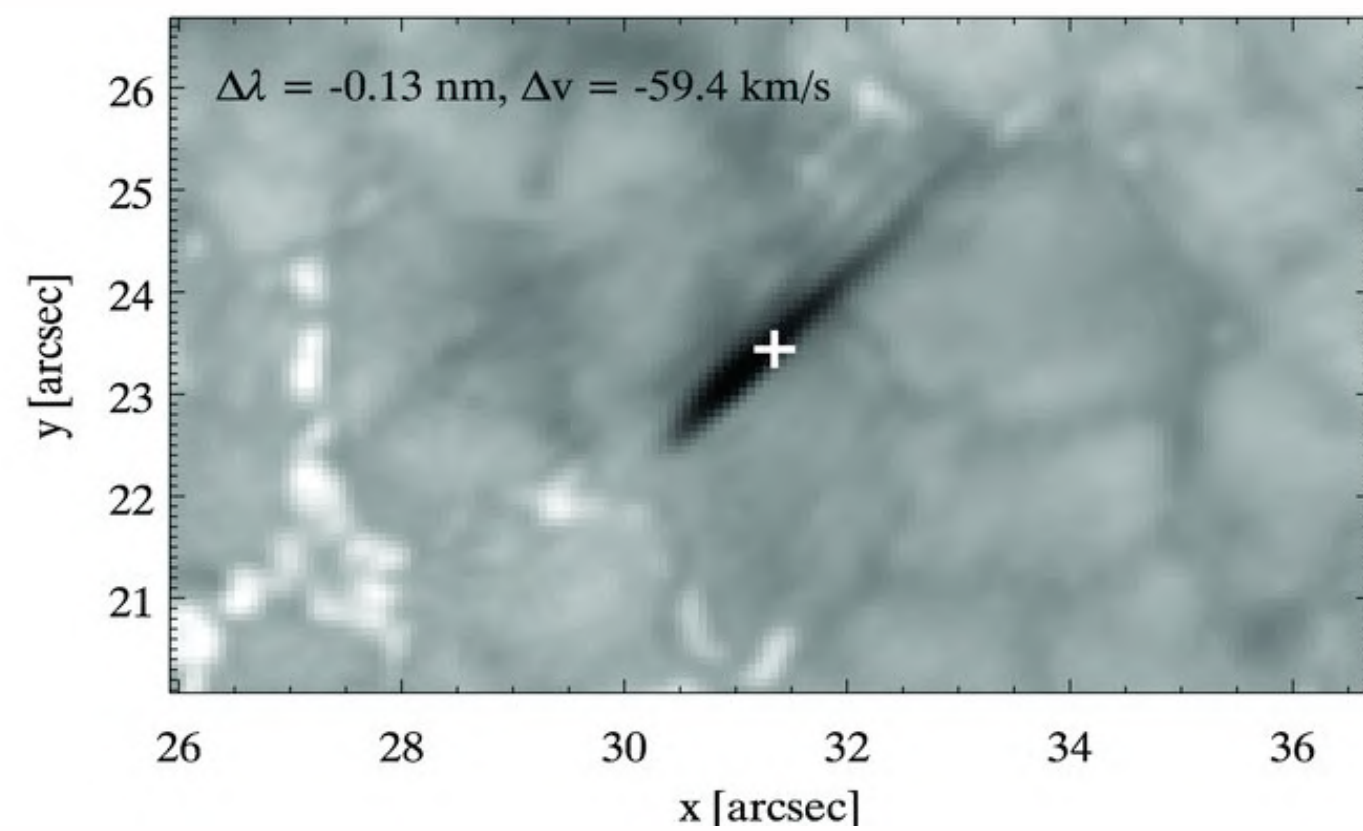
Source and nature of synthetic RBEs and RREs



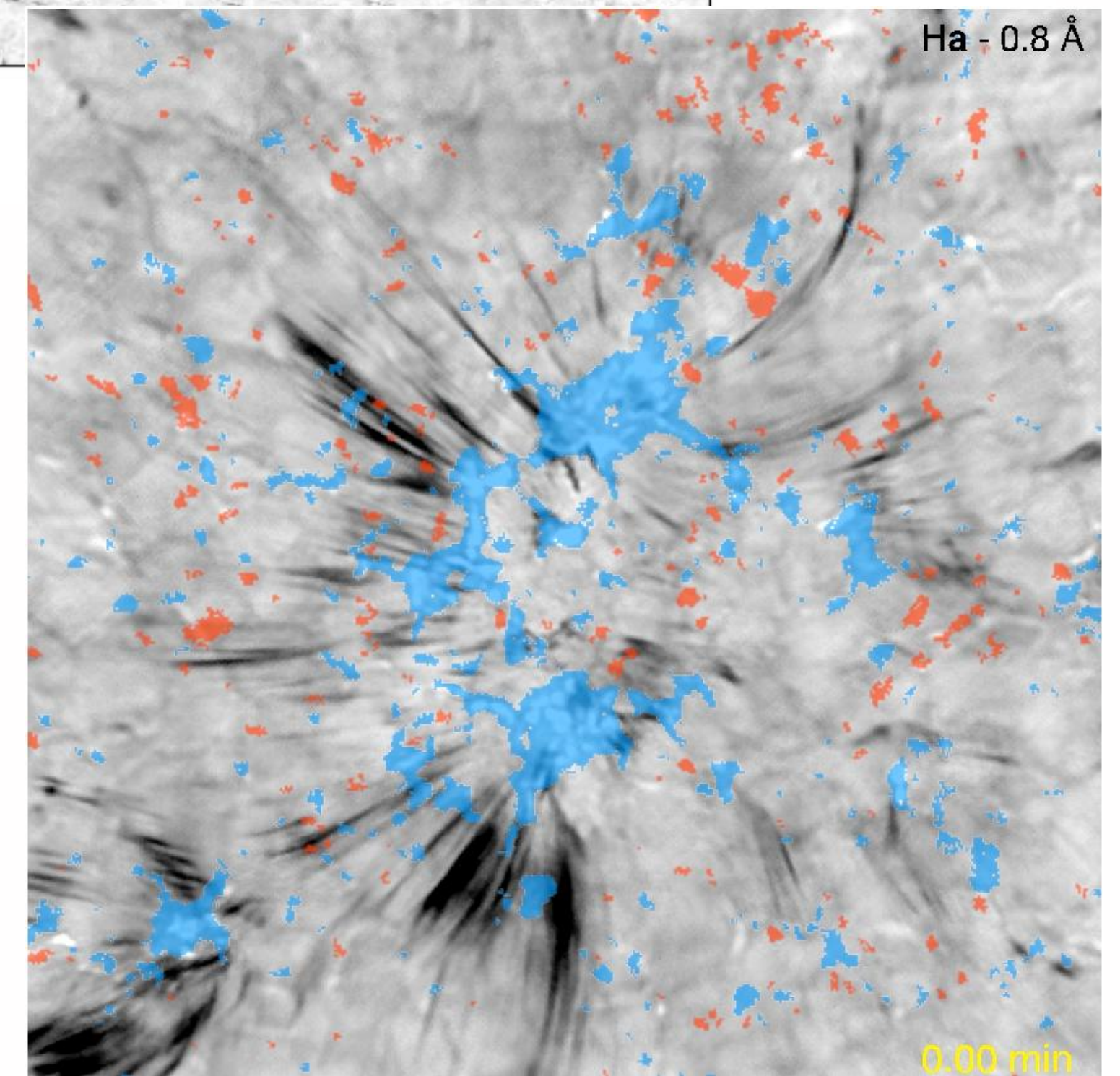
Synthetic RBEs and RREs resemble a subclass of observed RBE and RREs



Shetye et al. 2016



Roupe van der Voort et al. 2008



Footpoint motion - chromospheric dynamics not always clear from photospheric motion

$$\int (Q_{res} + Q_{vis})$$

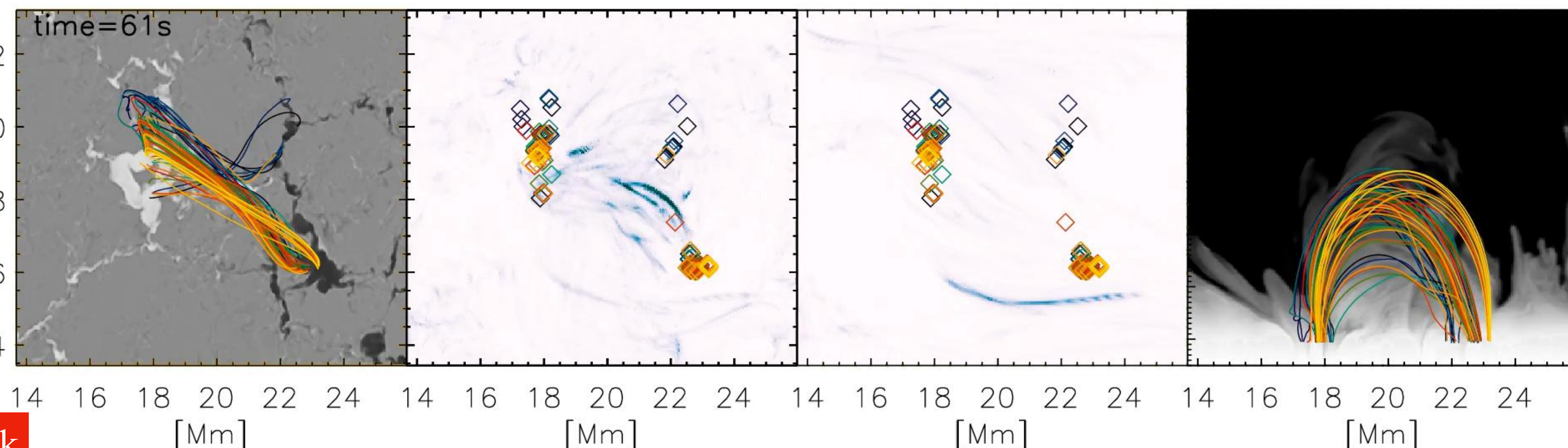
Moa Skan's talk later!

top view

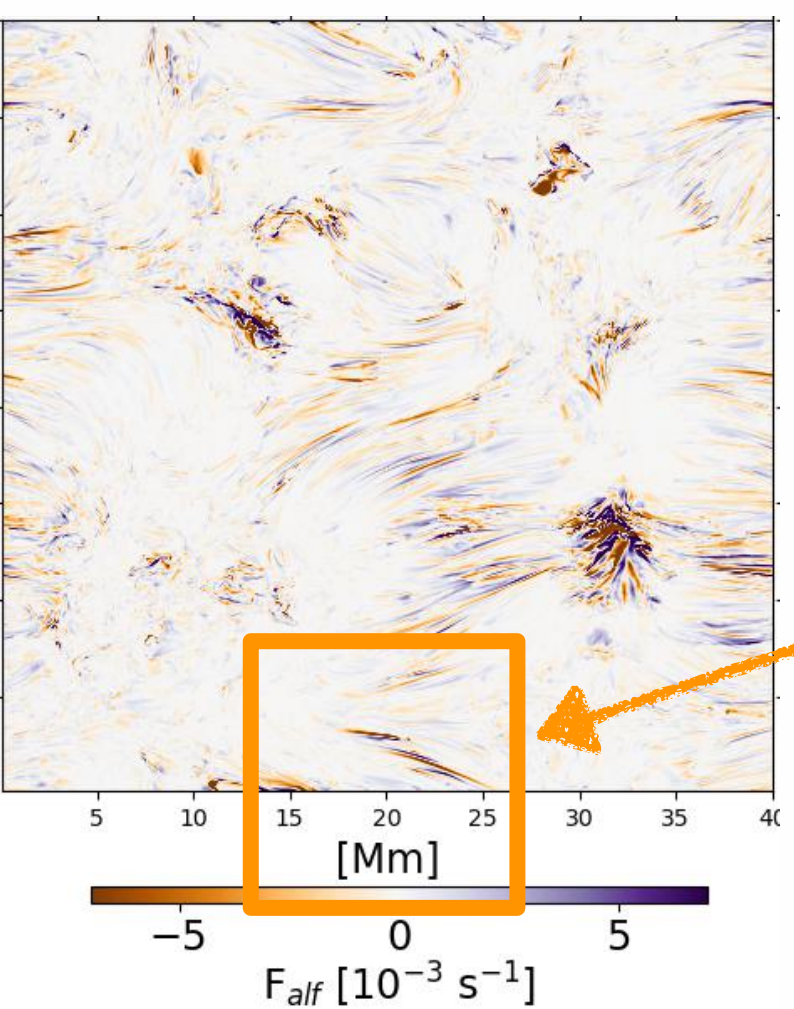
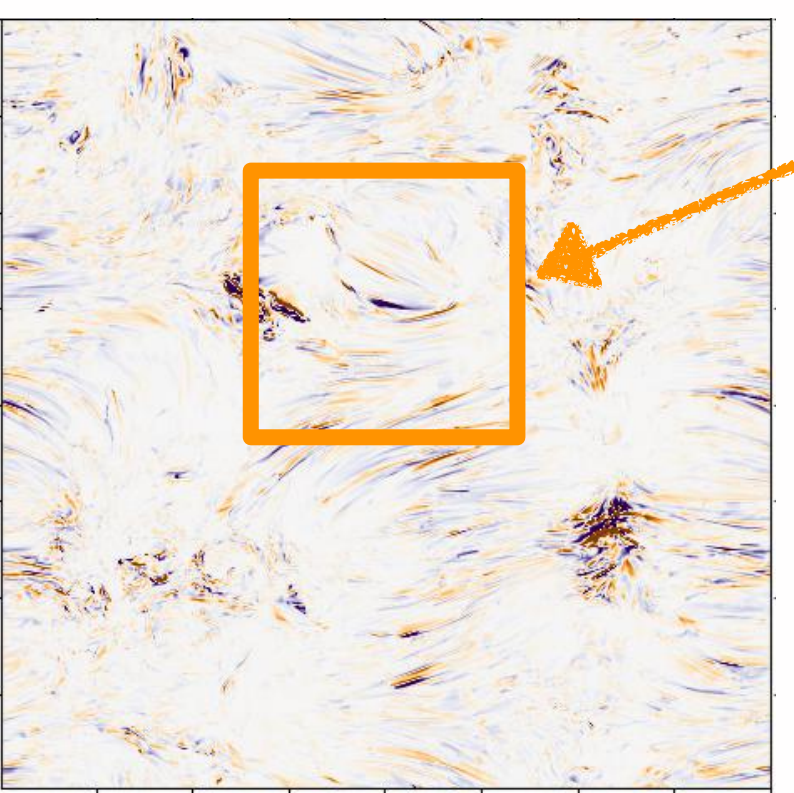
@ [0.6-3.8] Mm

@ [2.7-7] Mm

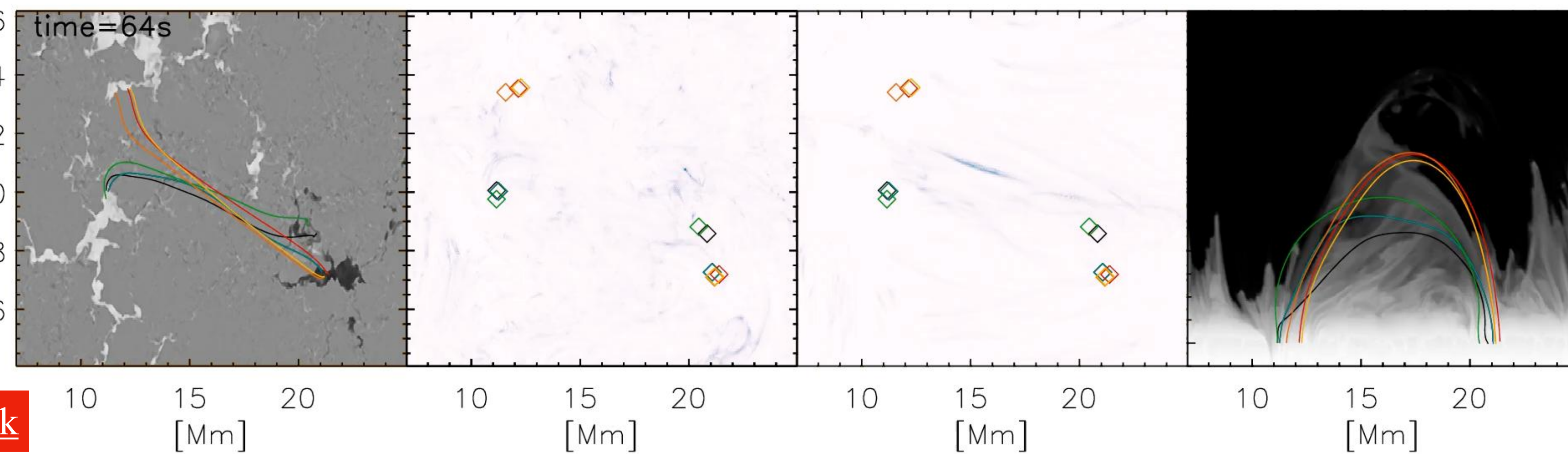
side view



[movie link](#)

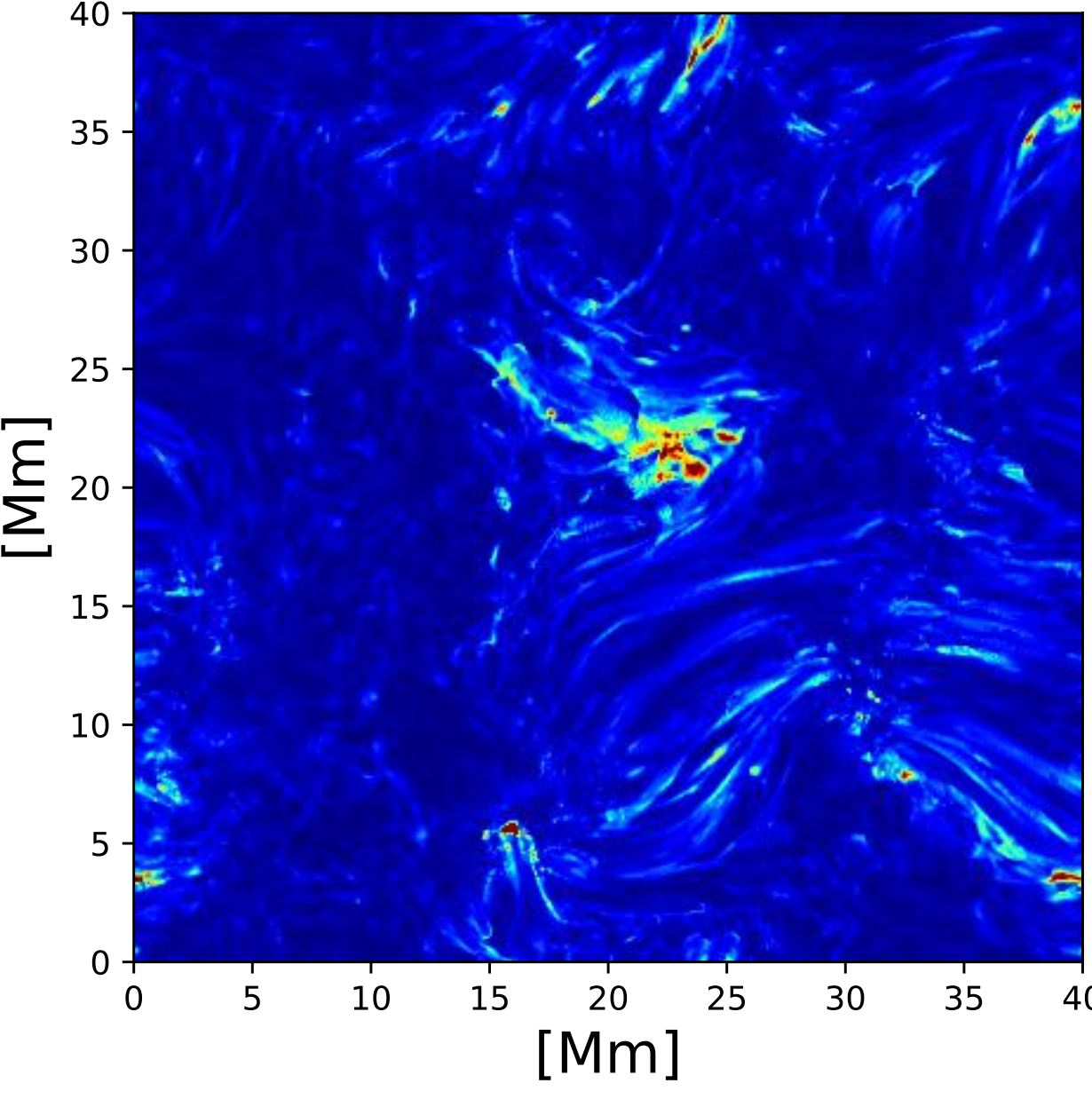
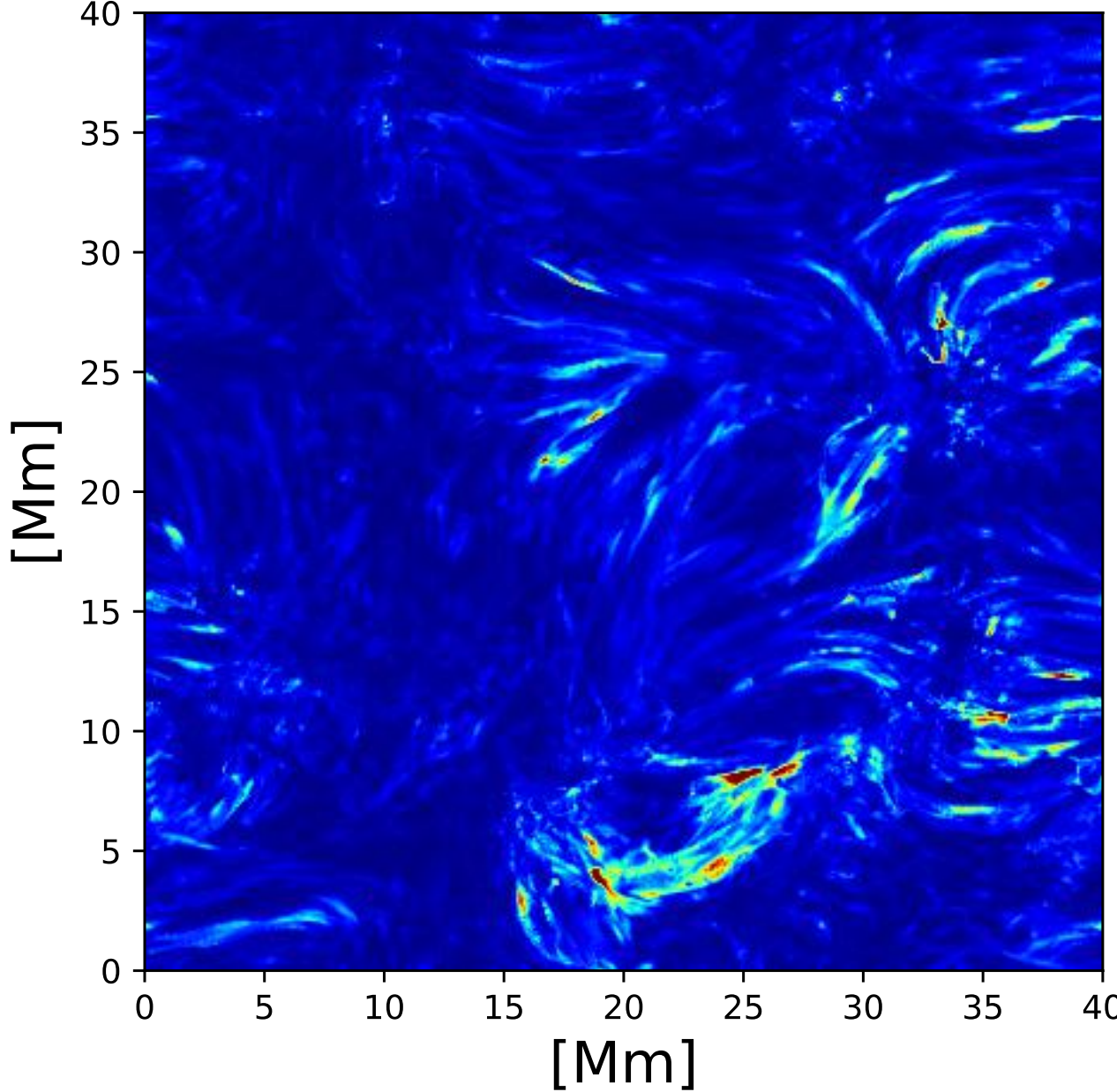
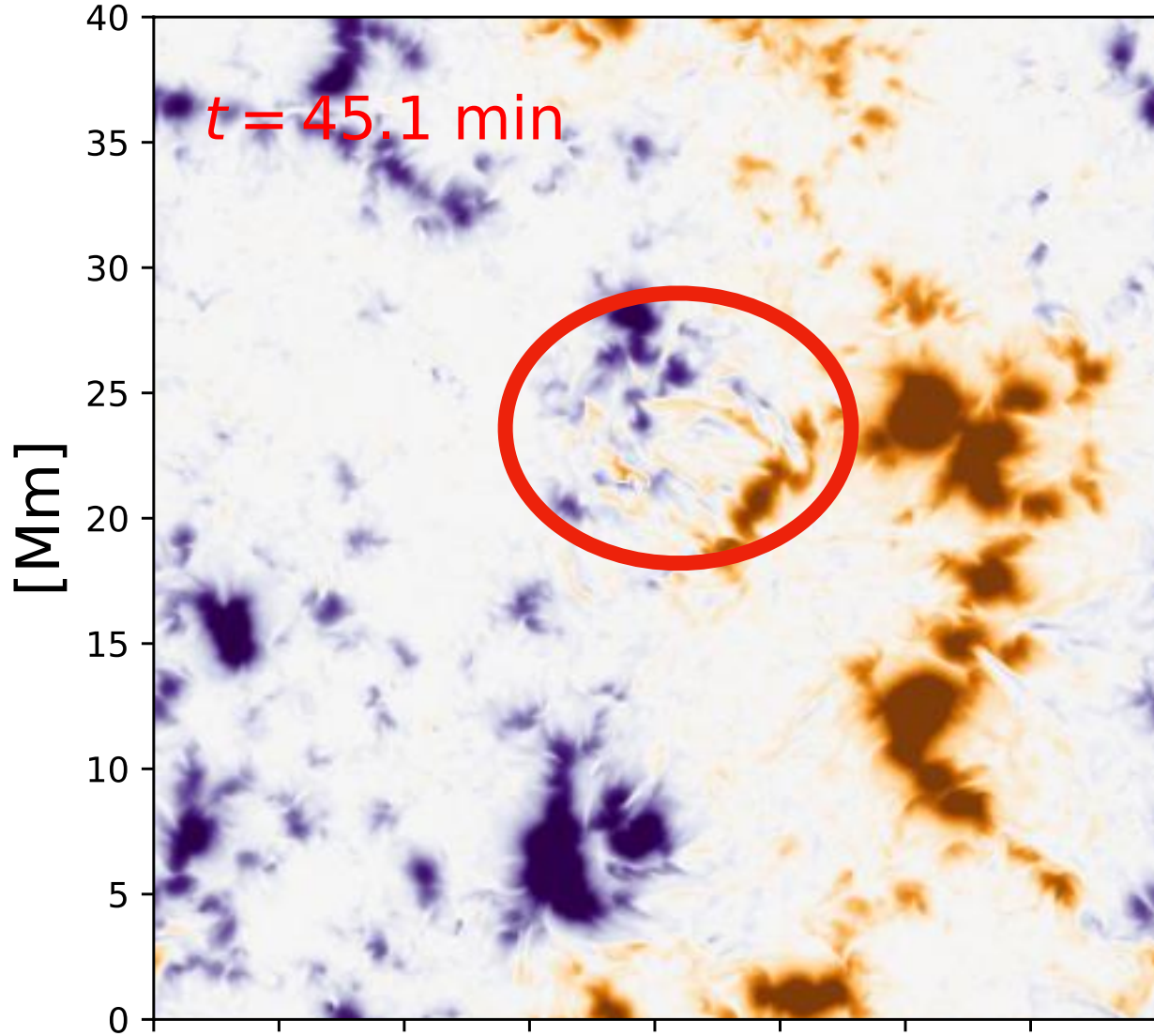
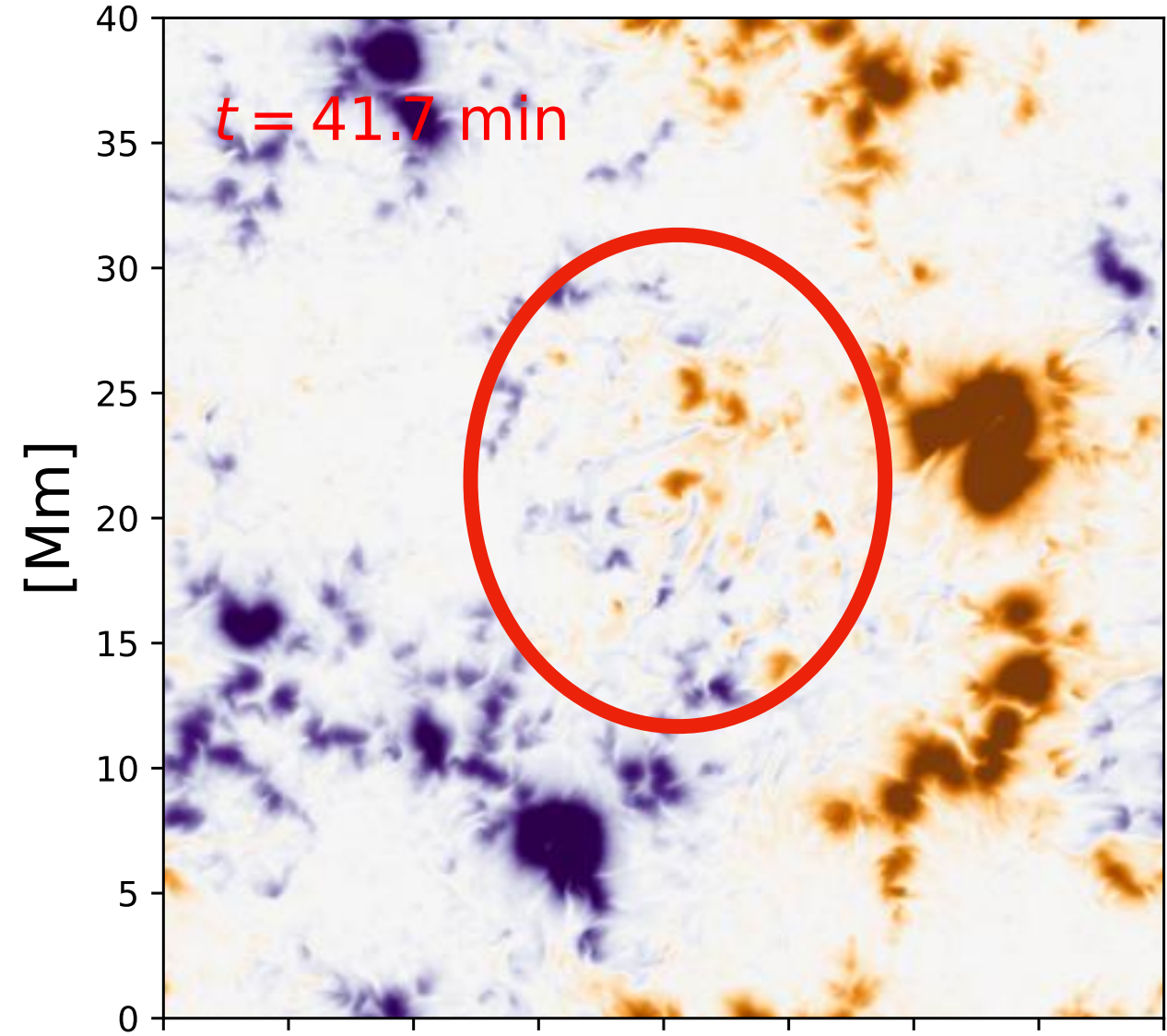


[movie link](#)



How do properties of emerging flux affect chromospheric dynamics?

- Less flux over a larger area vs. more flux over a smaller area

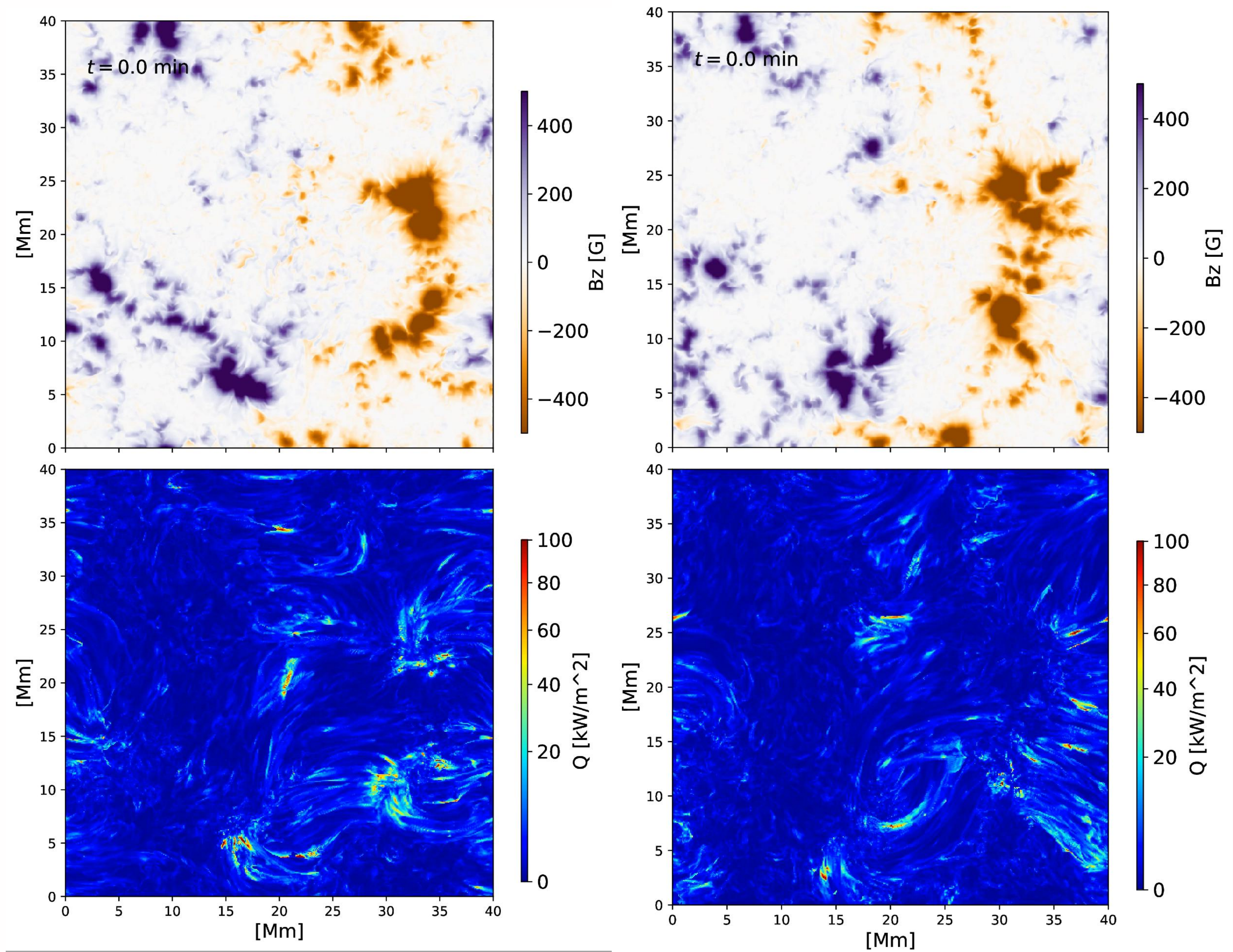


$$\int_{\log m_c > -5}^{\log m_c < -4.5} (Q_{res} + Q_{vis}) dz$$

How do properties of emerging flux affect chromospheric dynamics?

- Less flux over a larger area vs. more flux over a smaller area

[movie link](#)



[movie link](#)

The run on the right is partially analyzed in
 da Silva Santos et al. 2022
 and MUSE papers
 De Pontieu et al. 2022
 Cheung et al. 2022

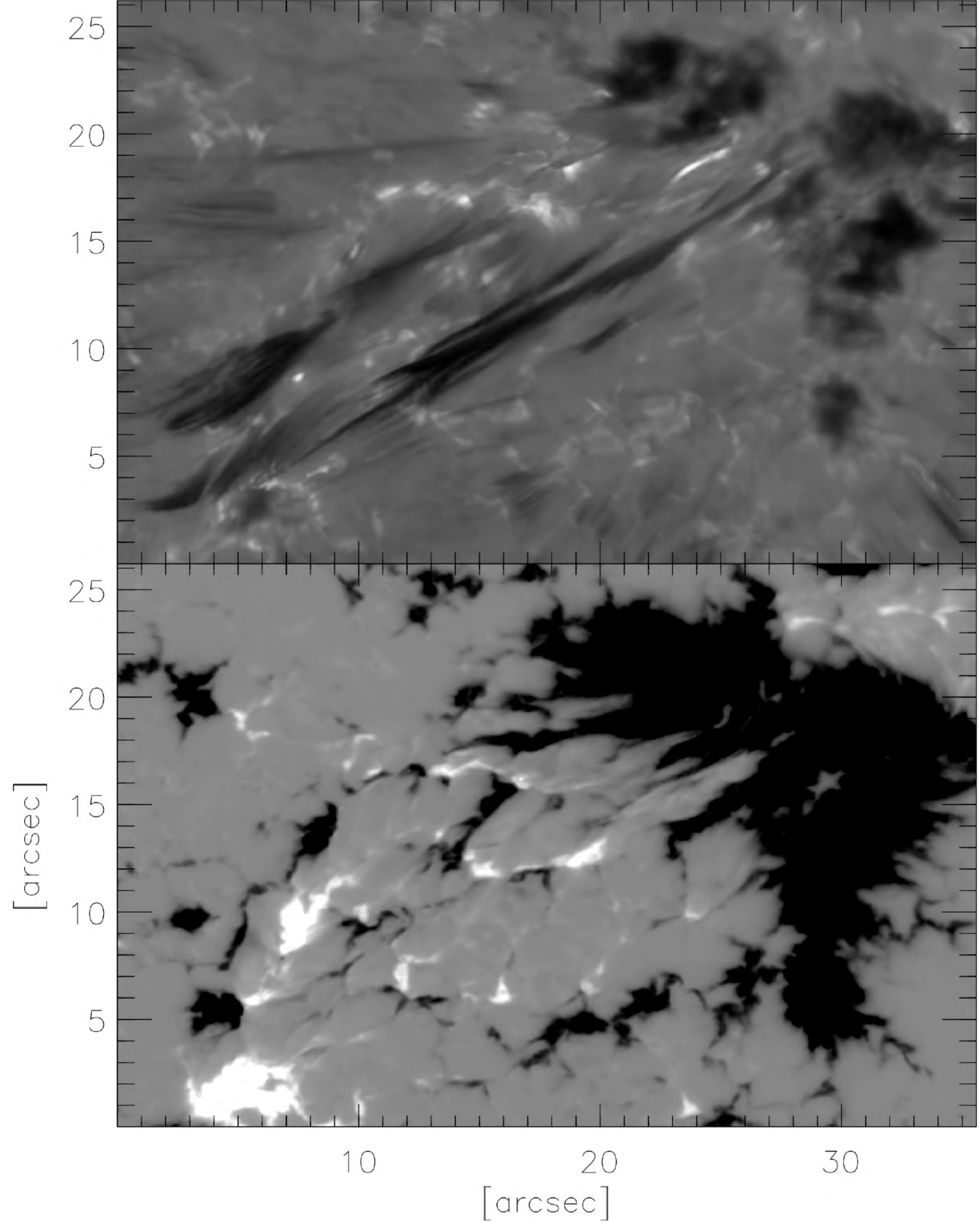
$$\int_{\log m_c > -5}^{\log m_c < -4.5} (Q_{res} + Q_{vis}) dz$$

Recreating chromospheric dynamics - A plage fan-shaped jet

SST observations:
H α -34 km/s

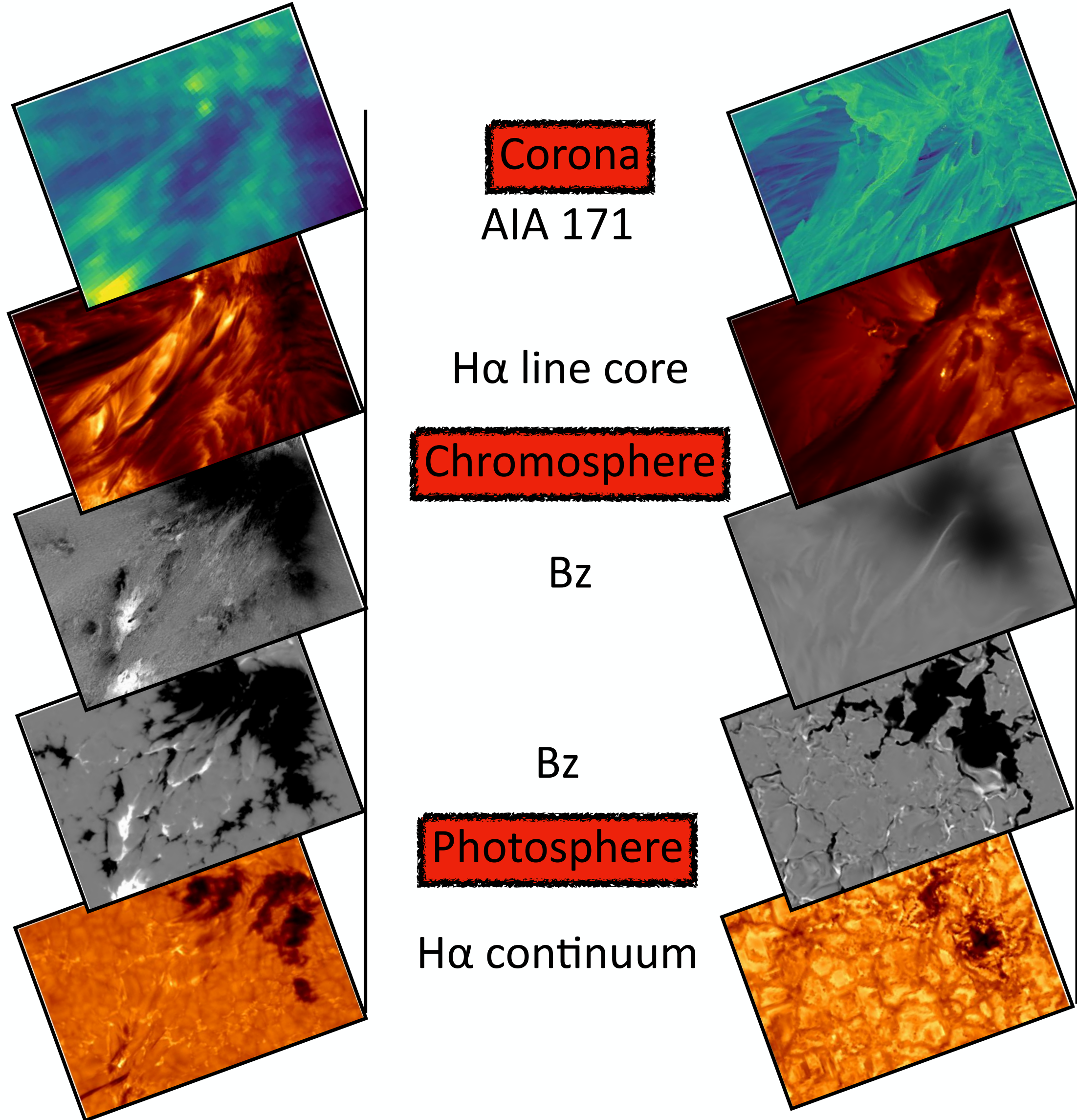
[movie link](#)

Blos photosphere



Observations

Simulations



Corona
AIA 171

H α line core

Chromosphere

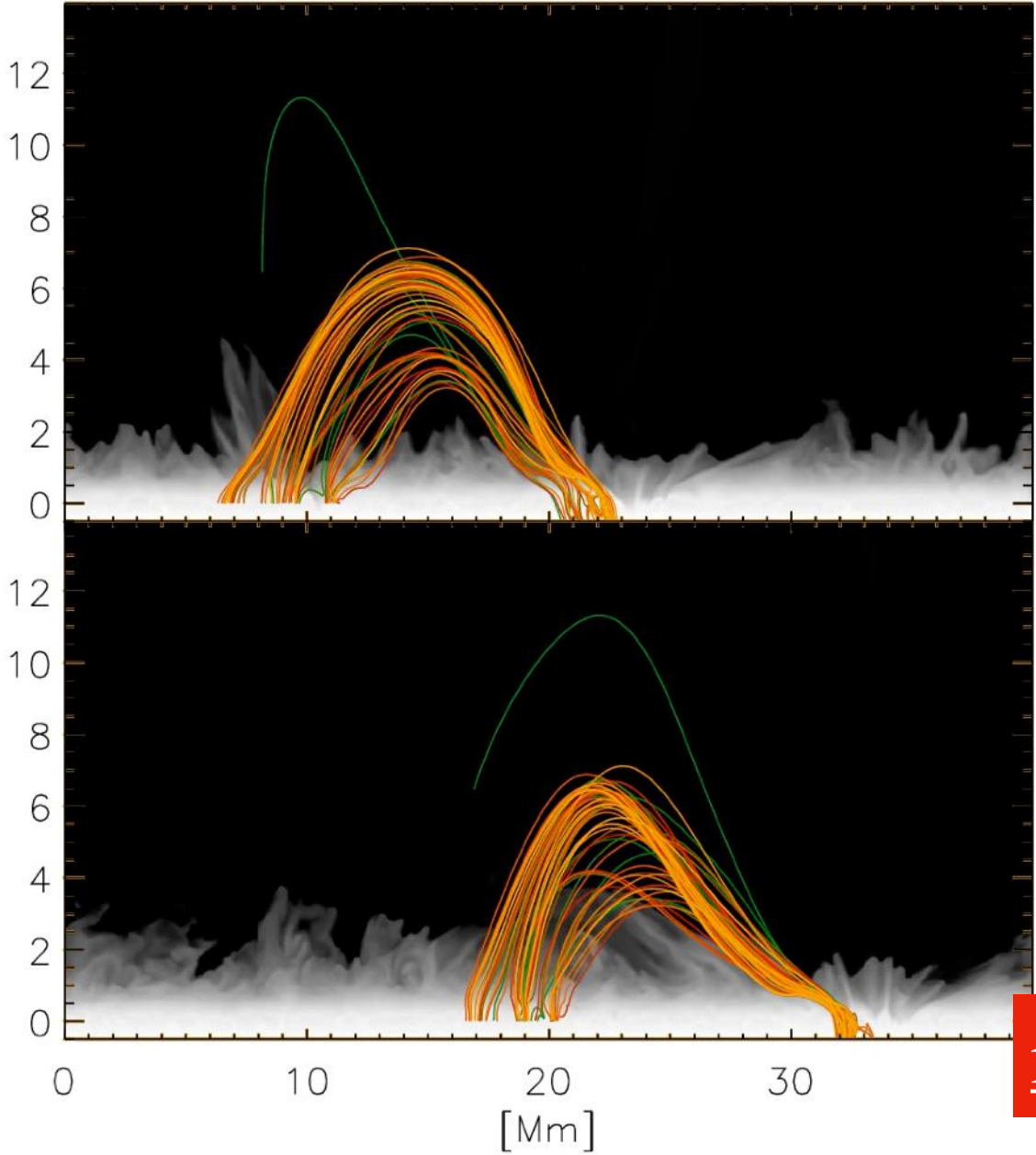
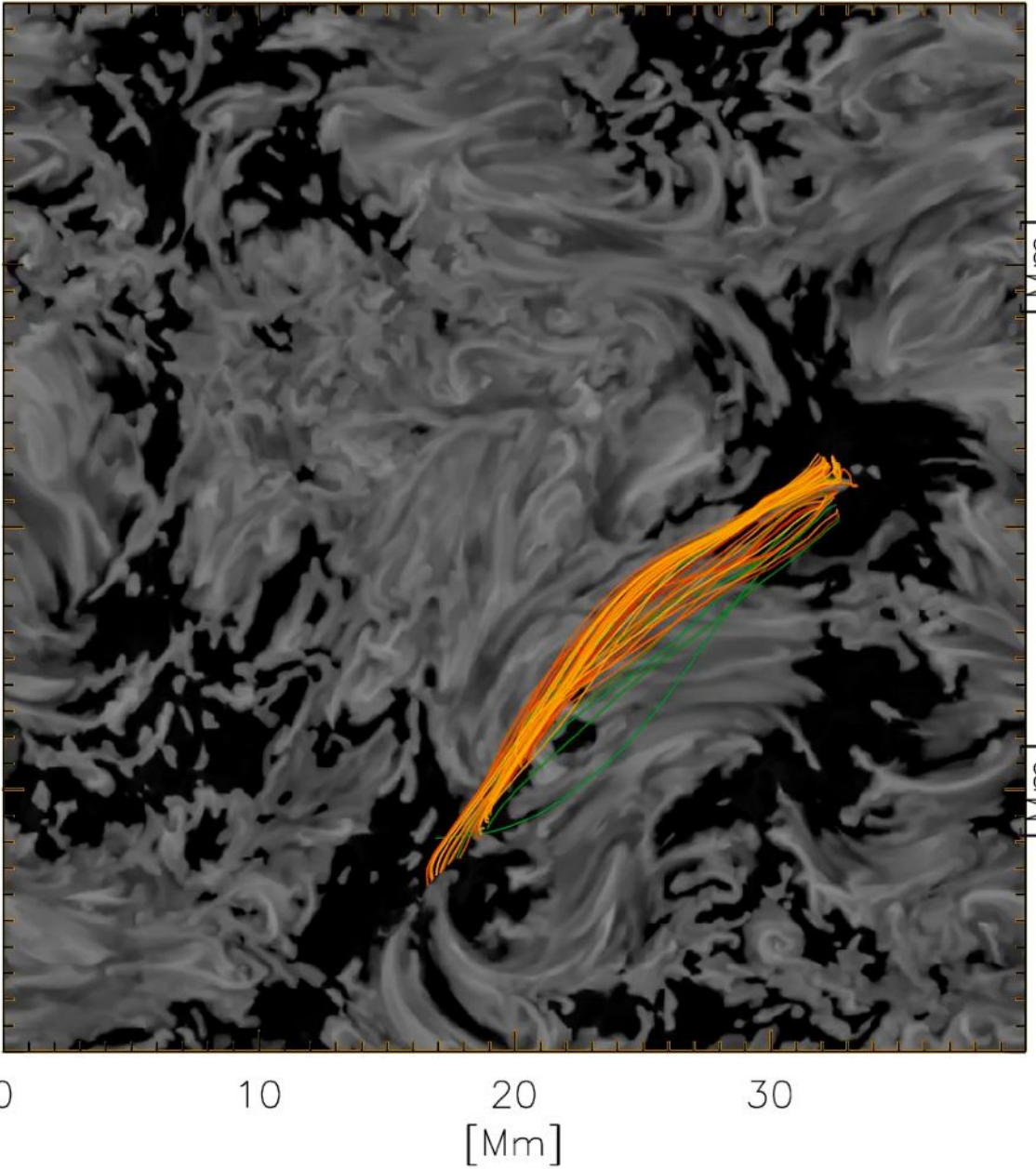
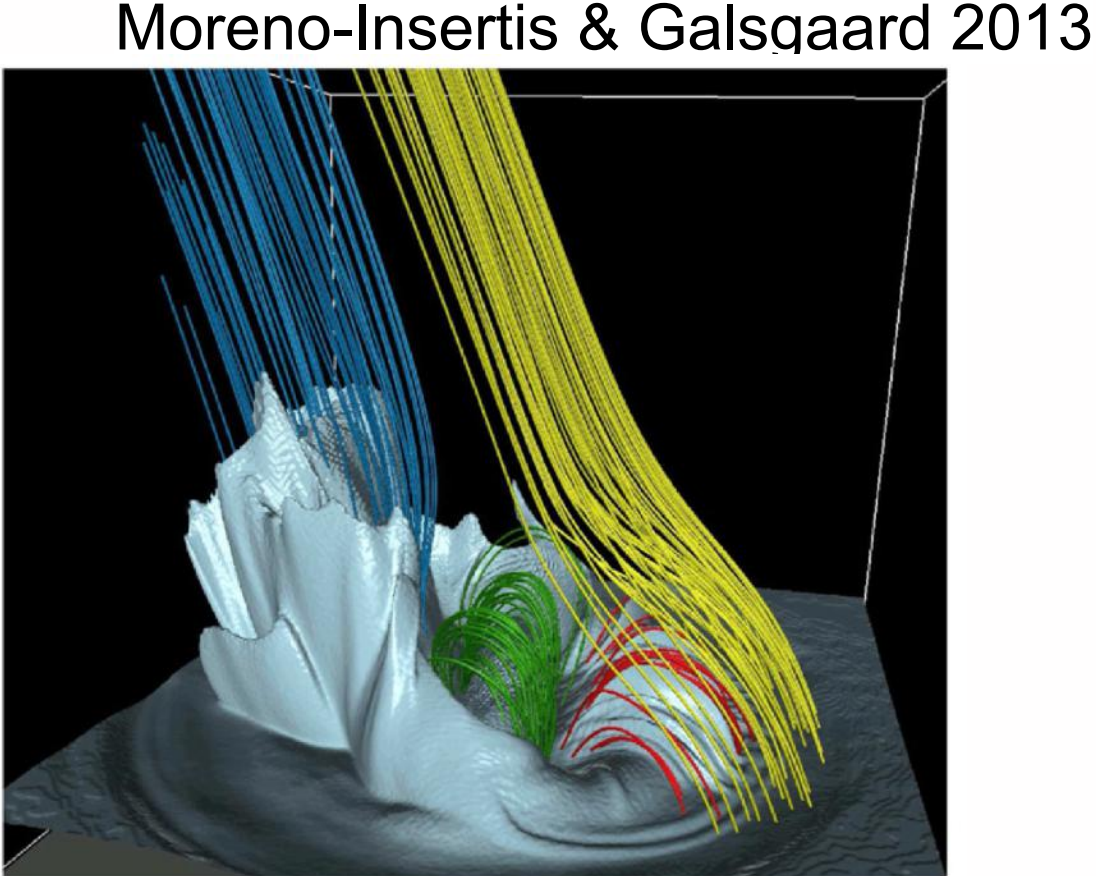
Bz

Bz

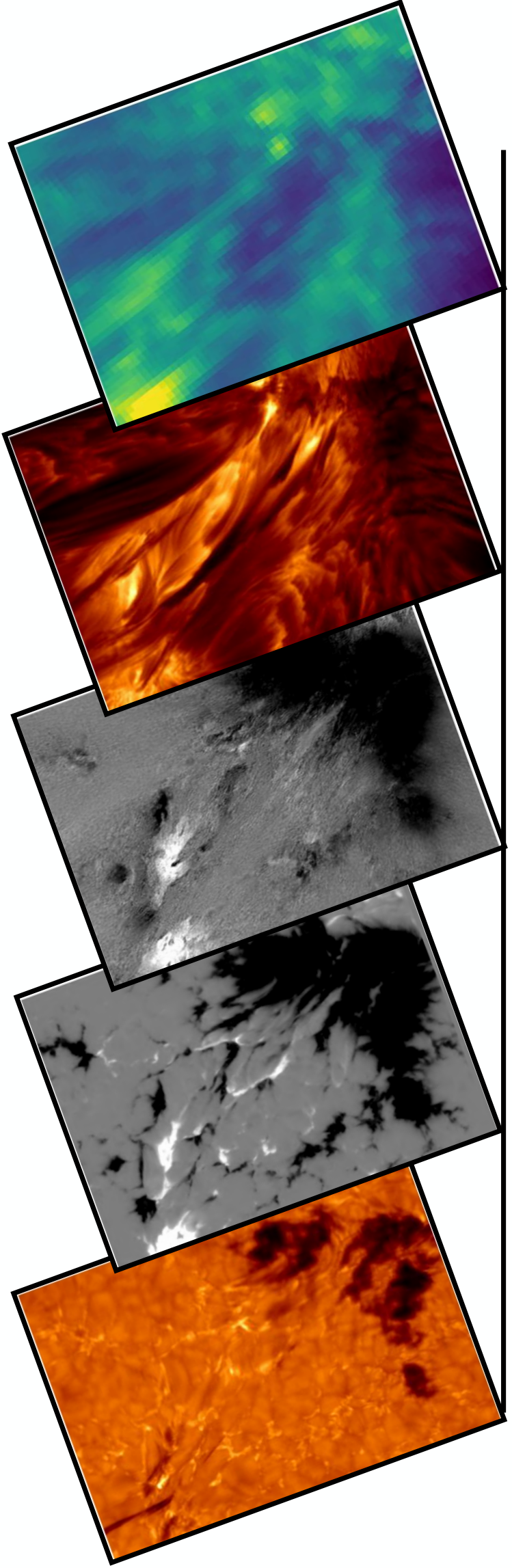
Photosphere

H α continuum

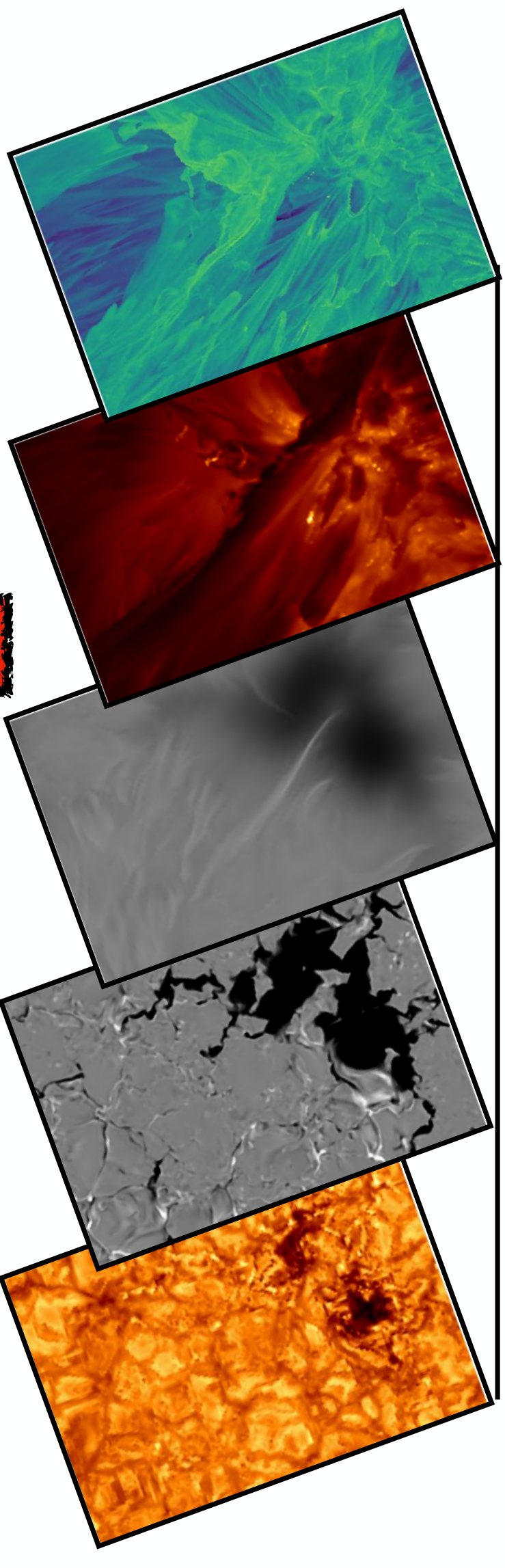
Recreating chromospheric dynamics - A plage fan-shaped jet



Observations



Simulations



Corona
AIA 171

$H\alpha$ line core

Chromosphere

Bz

Bz

Photosphere

$H\alpha$ continuum

Understanding chromospheric dynamics



Summary

- The models show very dynamic chromosphere
- Signatures of both: dissipation in current sheets and different types of MHD waves are present
- The models reproduce a subclass of RBEs and RREs
- For recreating more specific observational features the field configuration has to be recreated

Questions

- What determines the width of the synthetic and observed RBEs and RREs?
- What do we miss for reproducing 'classic' RBEs and RREs?
- How do we characterize the photospheric motions that lead to the observed chromospheric dynamics?