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Coronal loop footpoints threaded with small-scale mixed polarity surface magnetic fields

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in collaboration with

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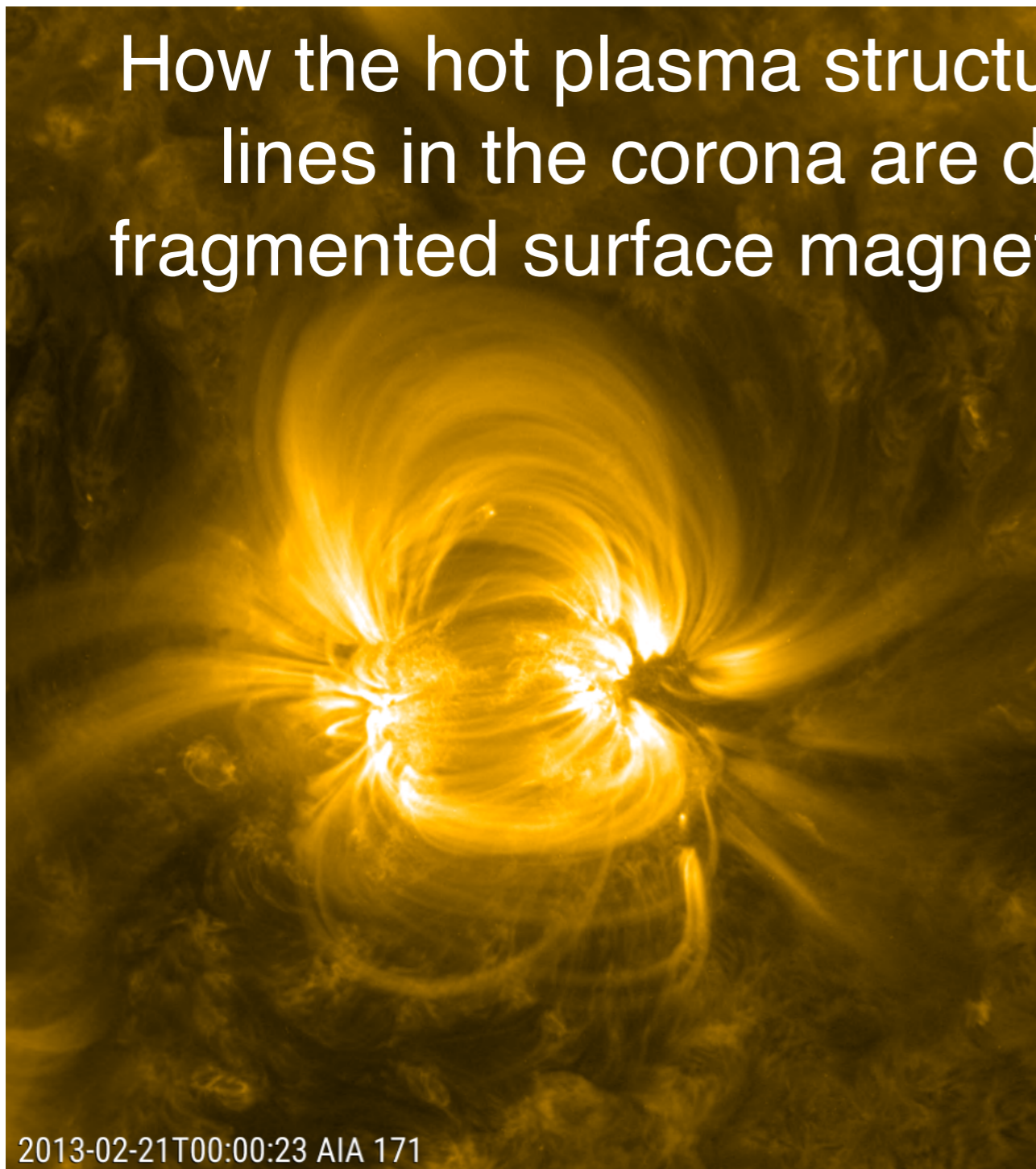
Thanks to Sunrise-II Team

SOLARNET IV Meeting
16-20 January 2017

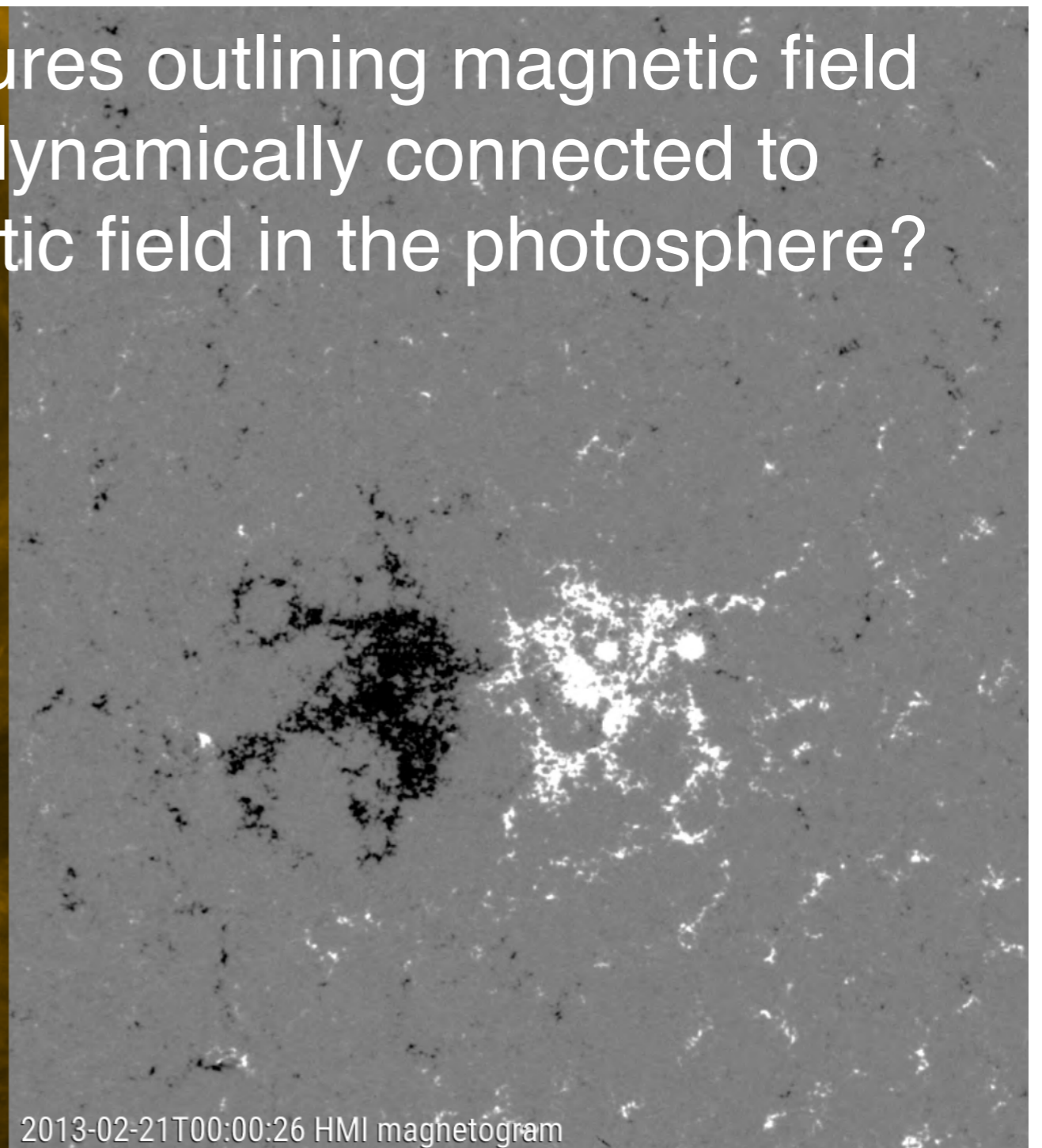
chitta@mps.mpg.de

Scope of this talk

How the hot plasma structures outlining magnetic field lines in the corona are dynamically connected to fragmented surface magnetic field in the photosphere?

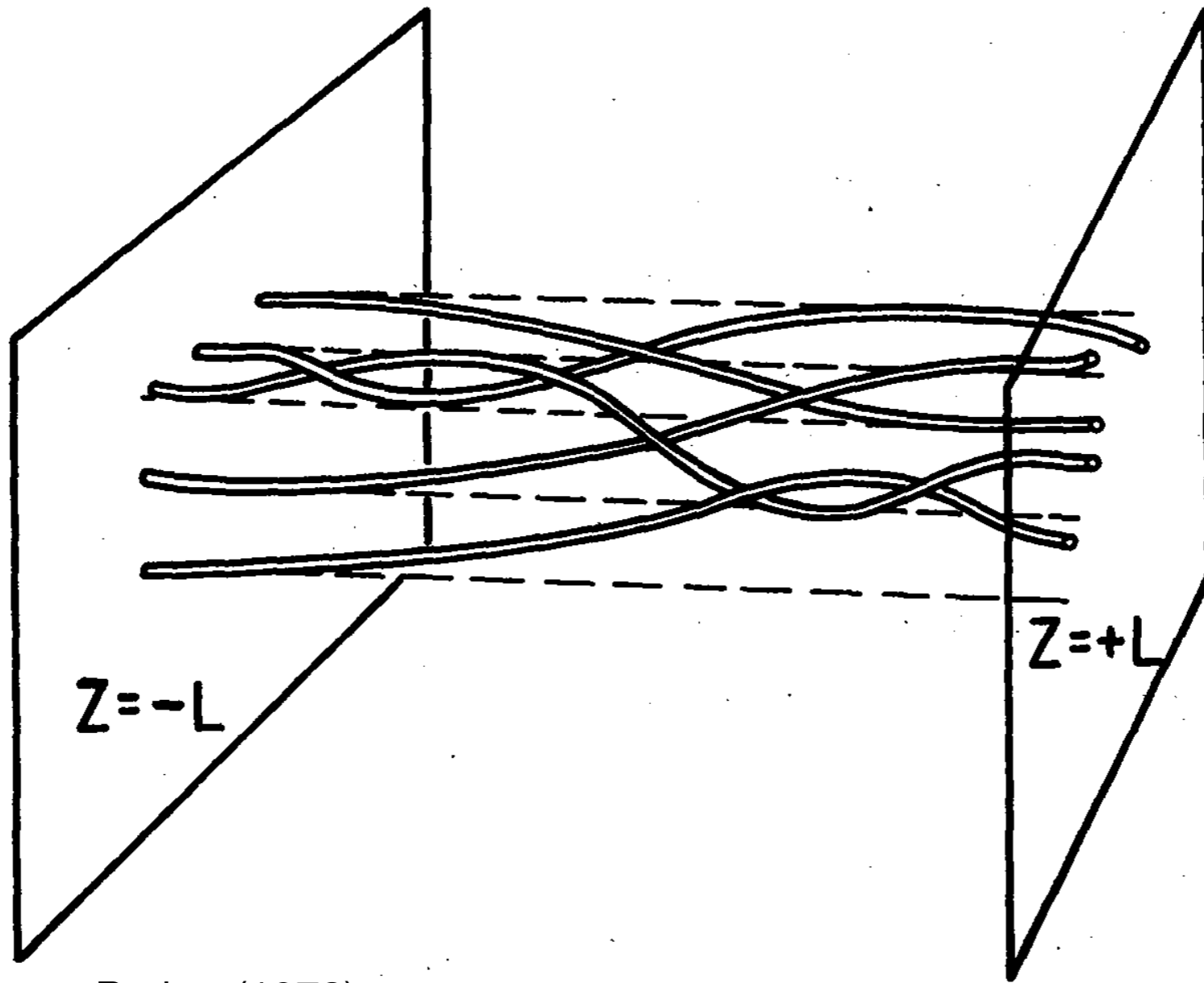


2013-02-21T00:00:23 AIA 171



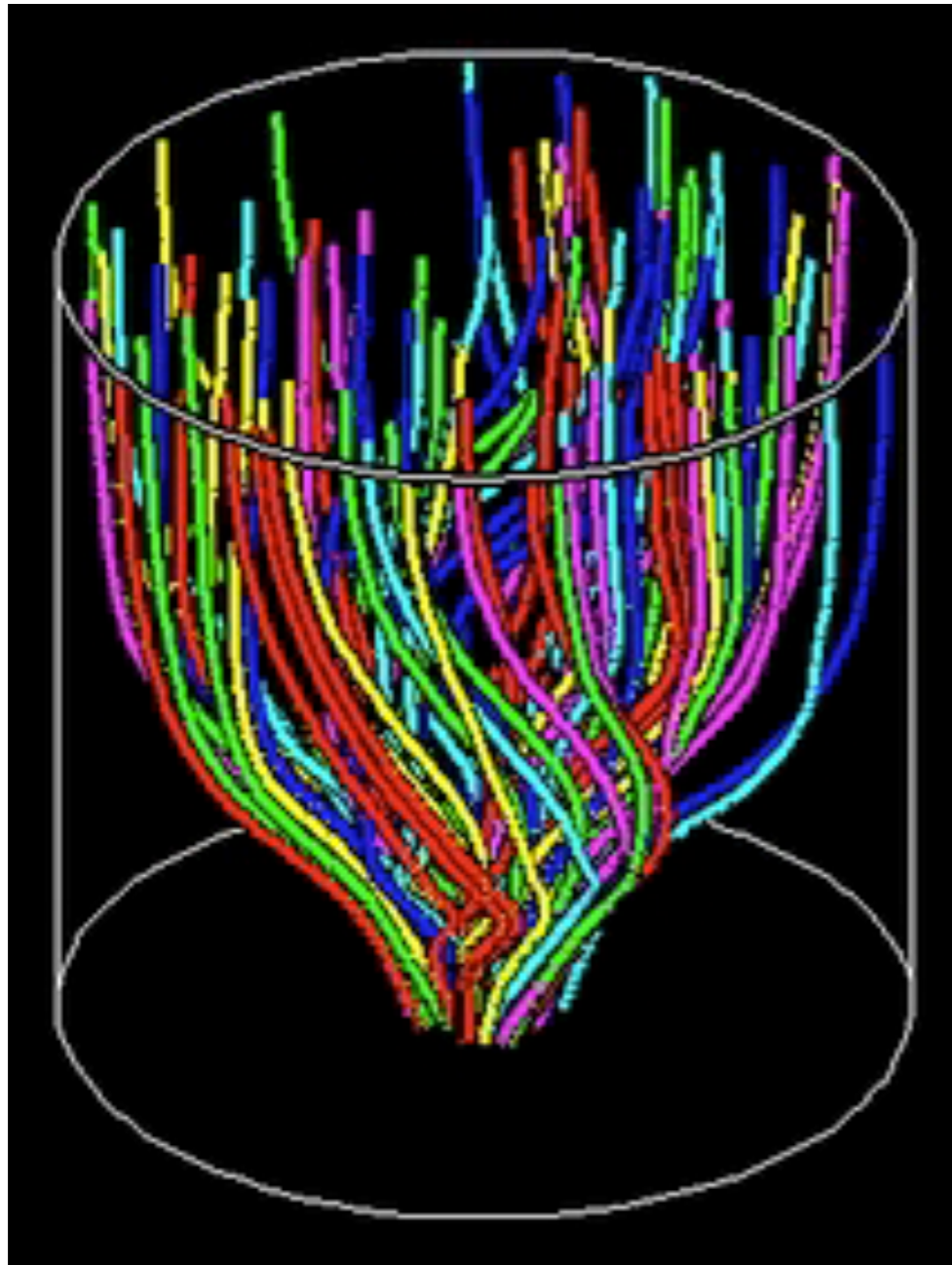
2013-02-21T00:00:26 HMI magnetogram

Numerical models of coronal loops

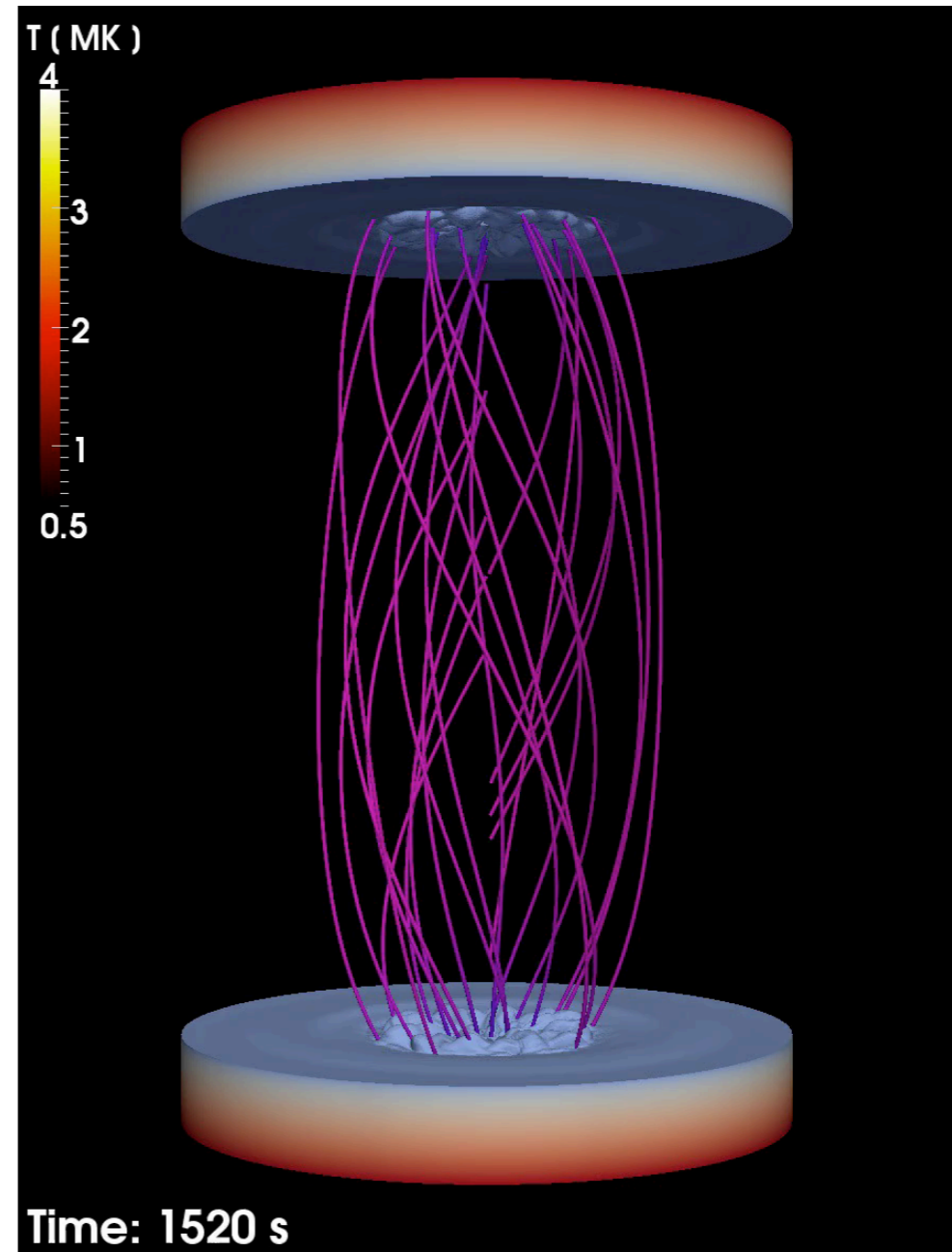


Parker (1972)

Numerical models of coronal loops

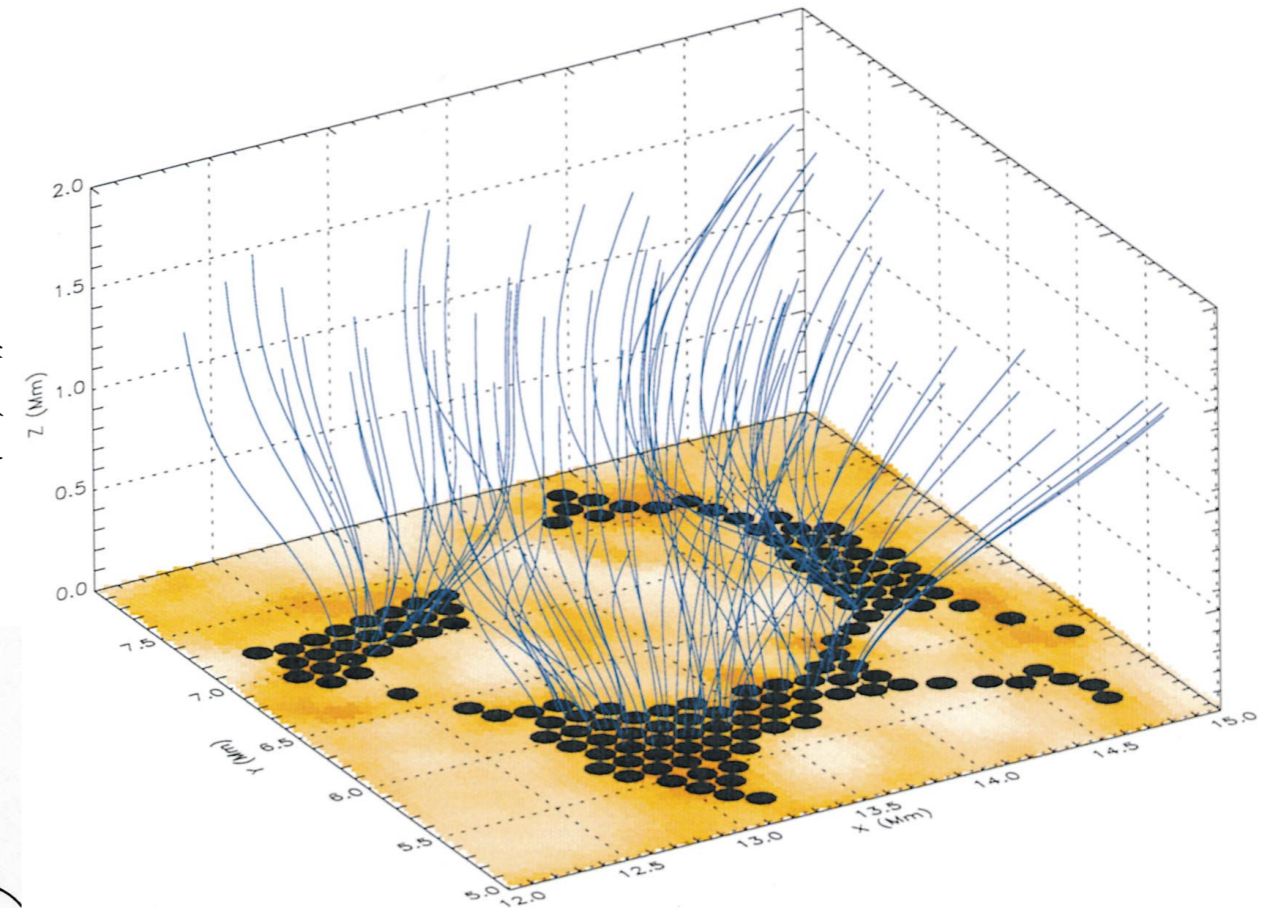
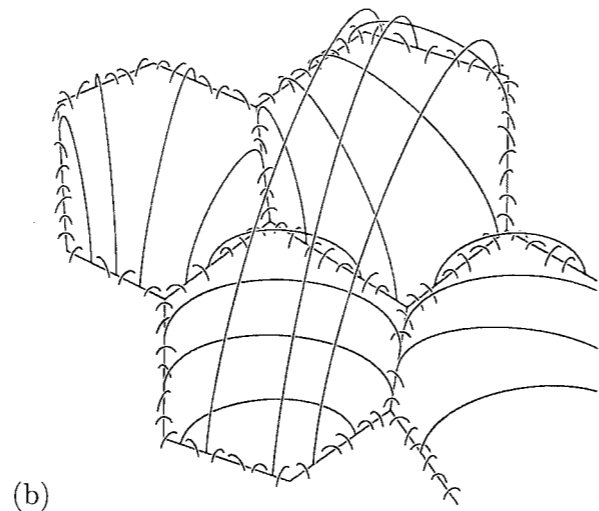
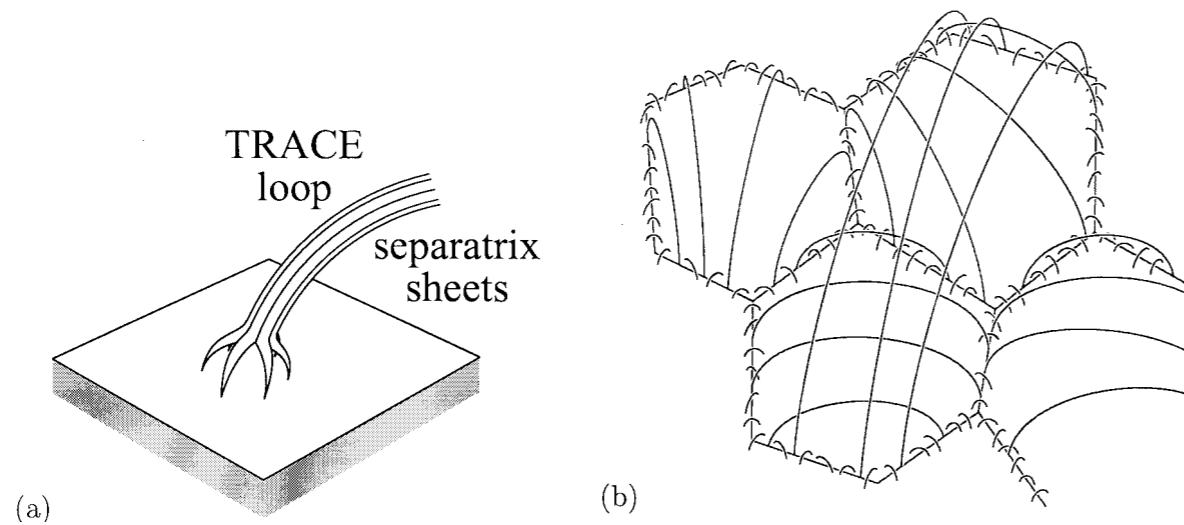


van Ballegooijen et al. (2011)

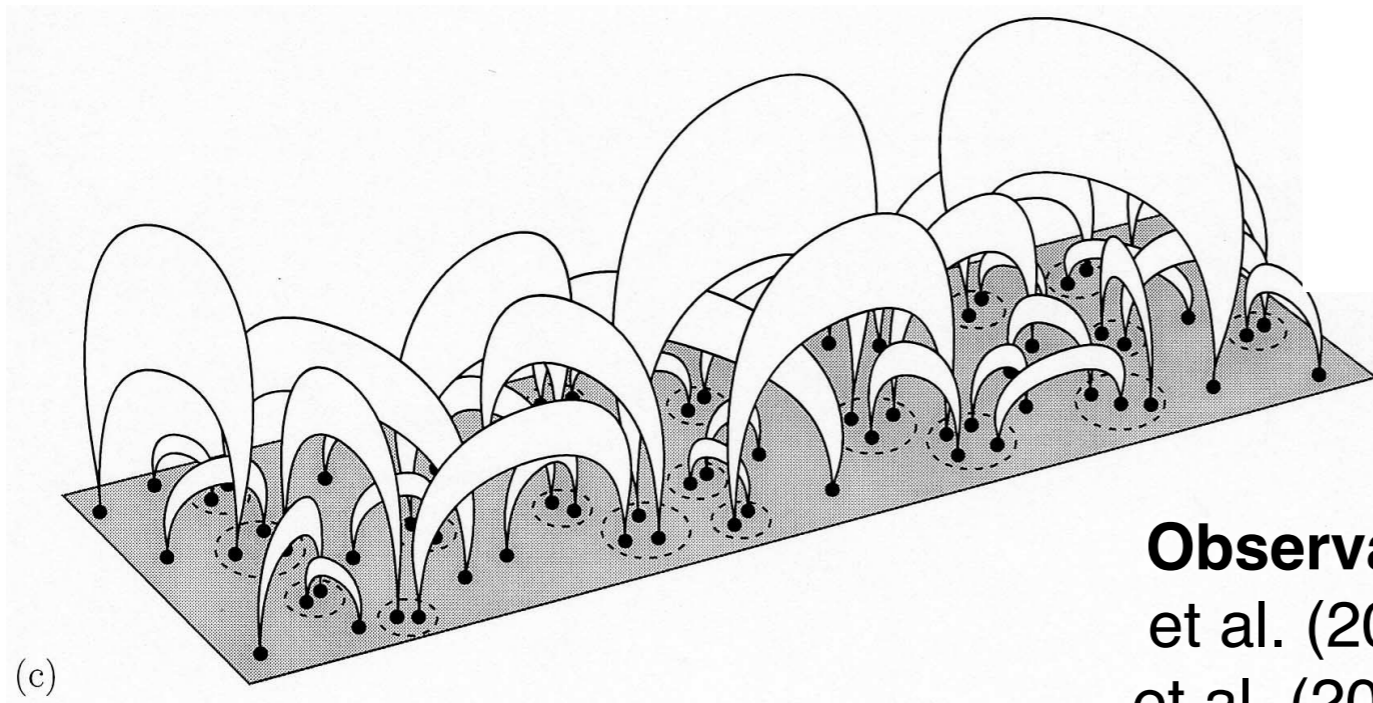


Reale et al. (2016)

Numerical models of coronal loops



van Ballegooijen et al. (1998)



Flux-tube tectonics model of Priest et al. (2002)

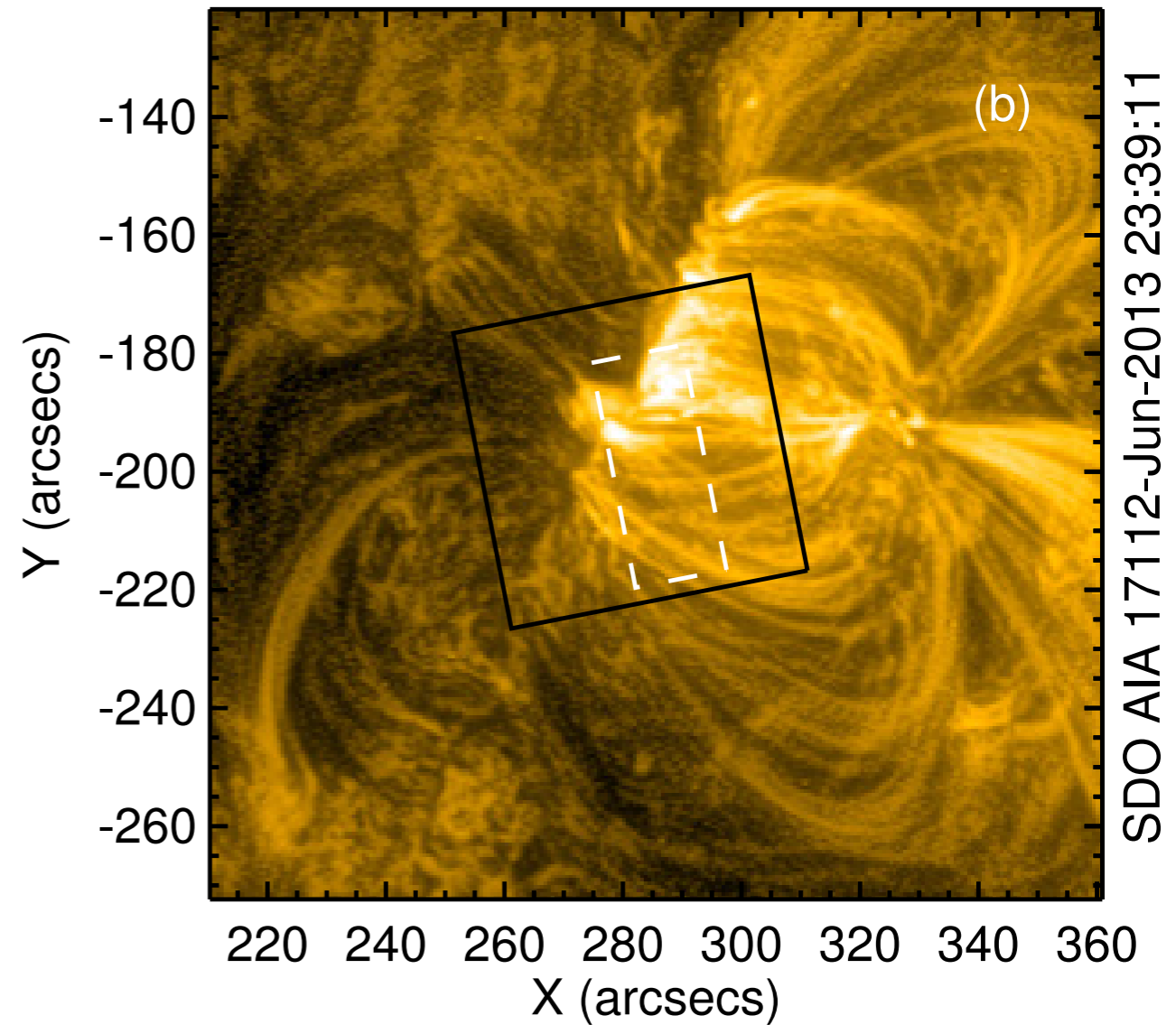
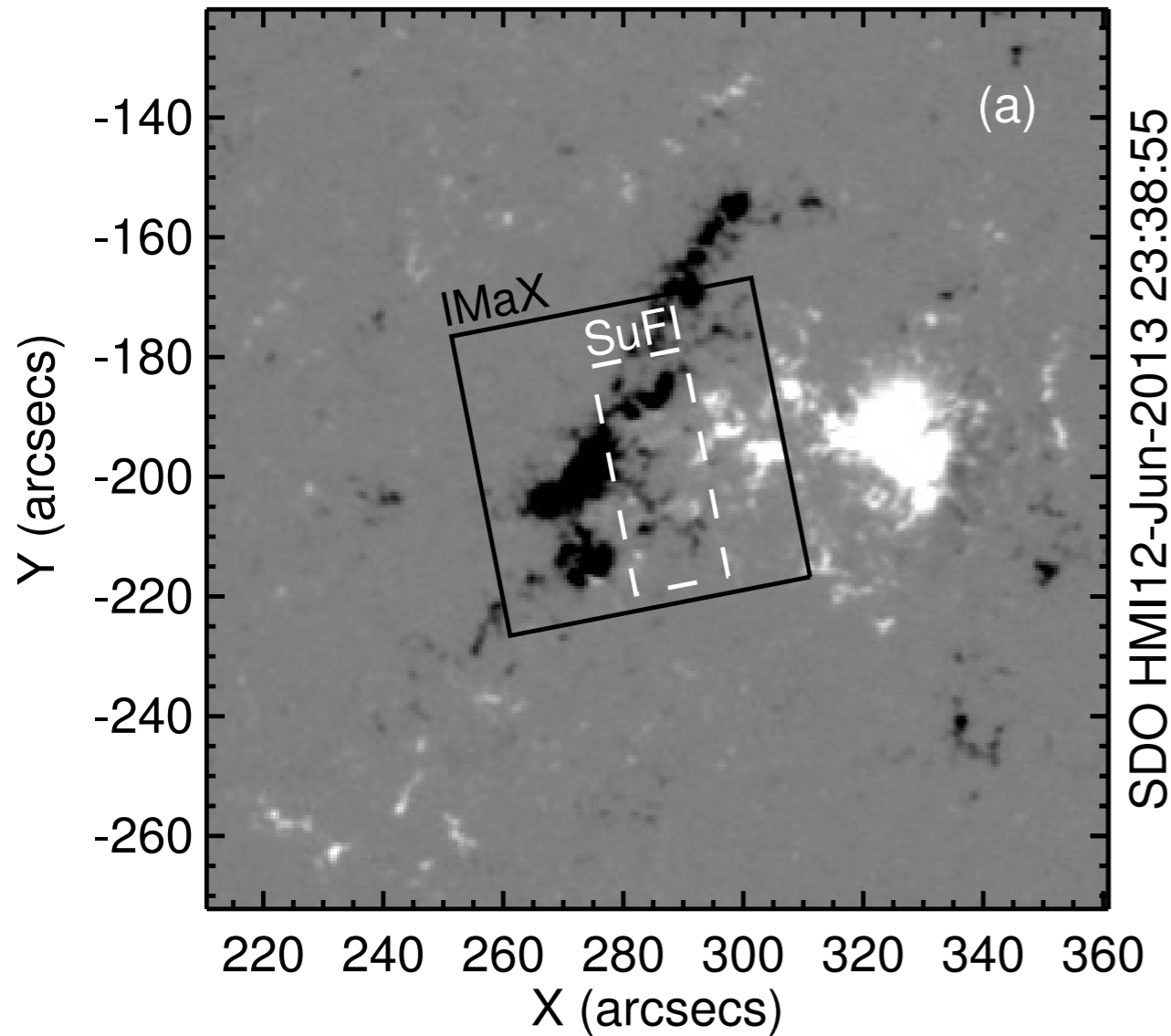
Observations: Porter et al. (1994); De Pontieu et al. (2003); Aschwanden & Title (2004); Peter et al. (2013); Régnier et al. (2014); Wang (2016)

A more detailed picture of coronal loop footpoints with Sunrise Observations

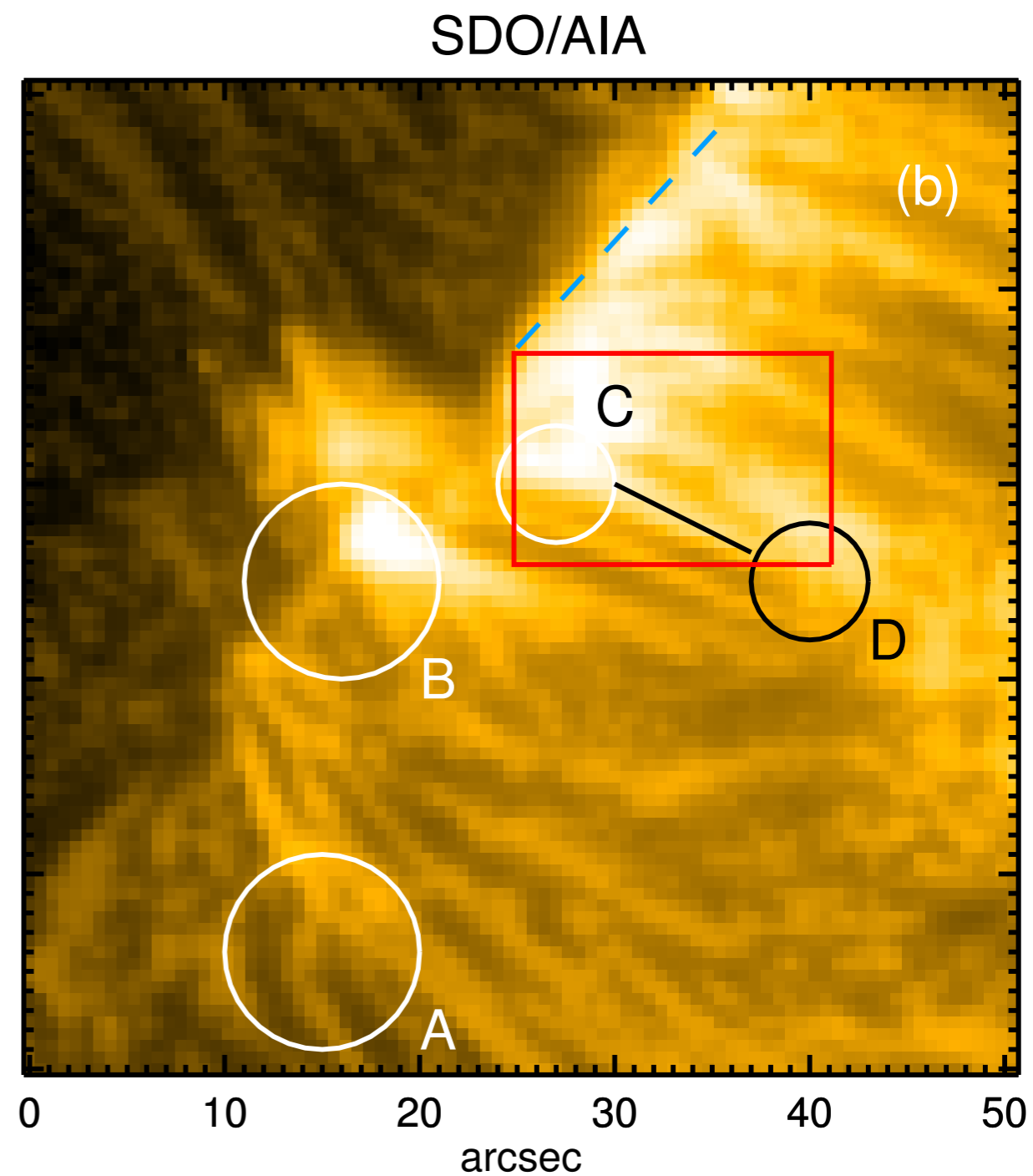
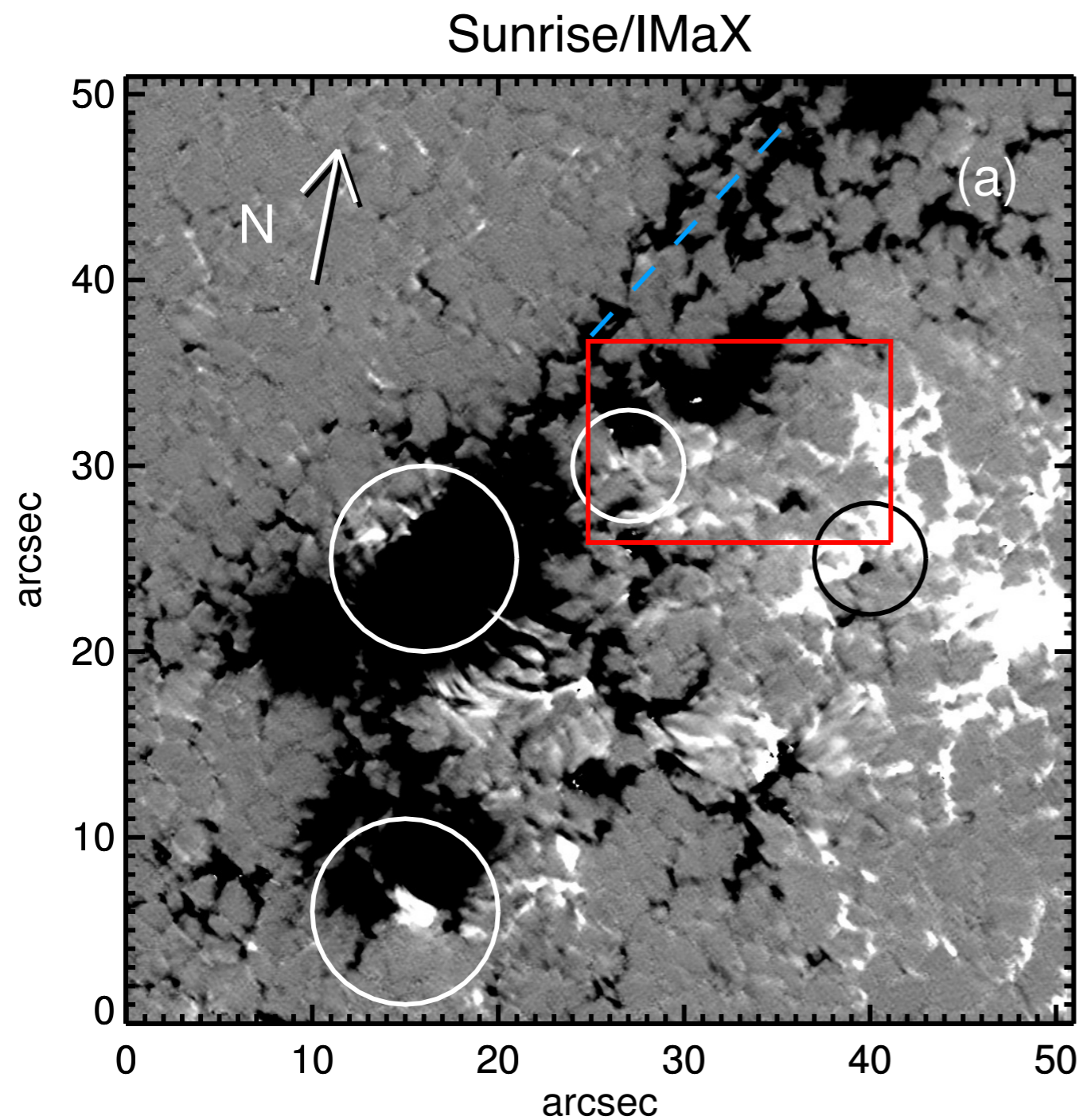


IMaX + SuFI covering solar lower atmosphere

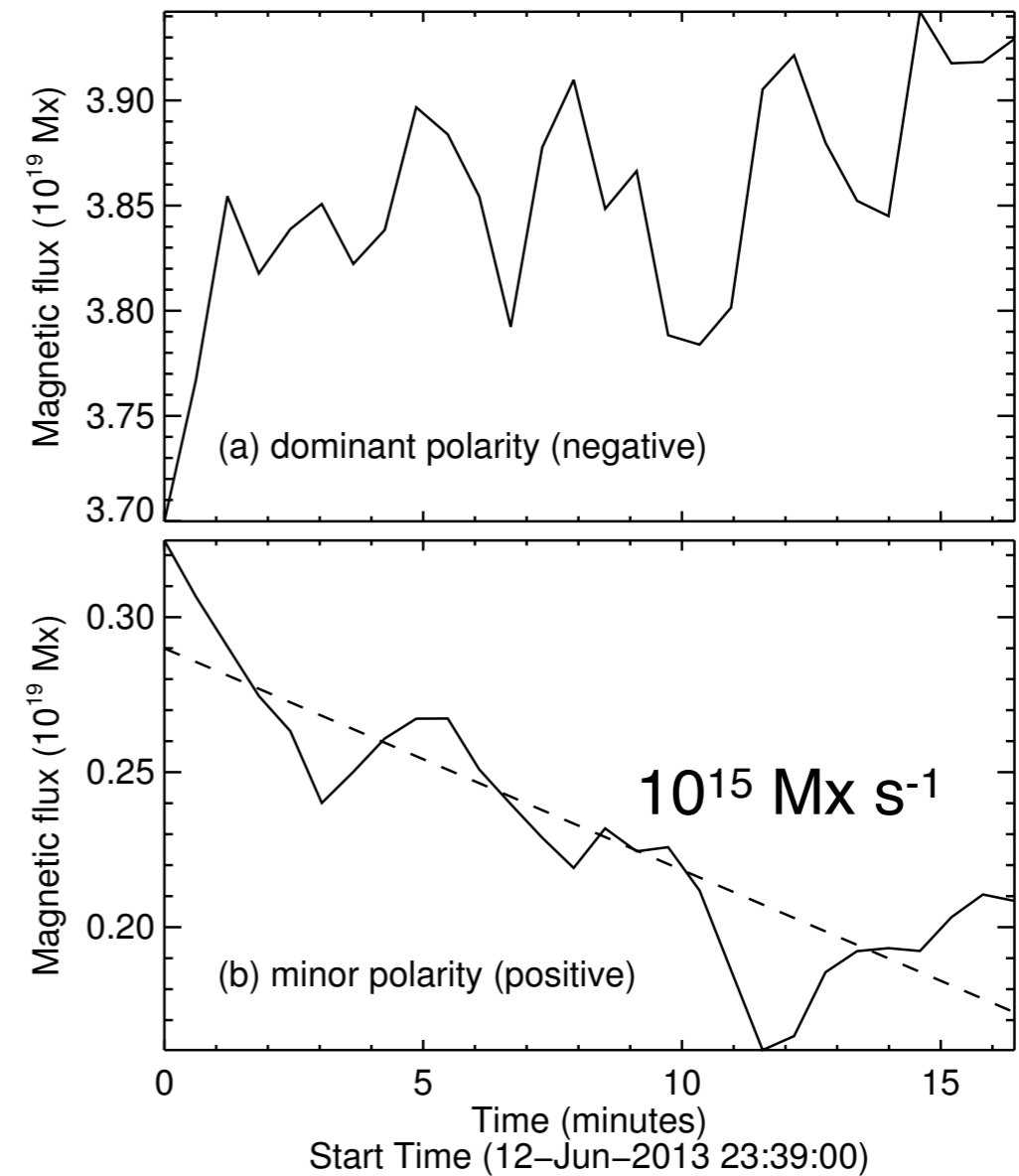
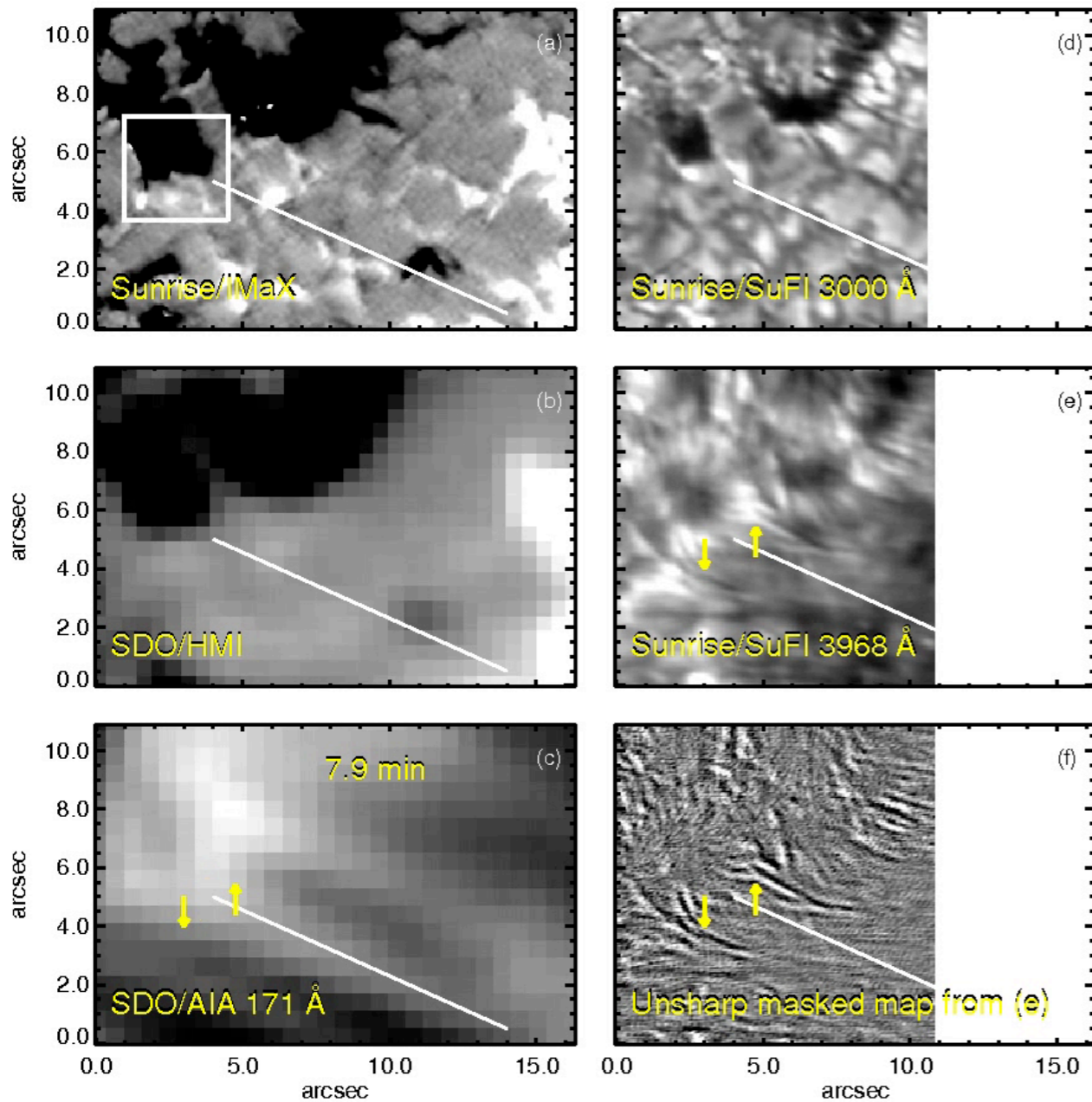
Sunrise observations — context



Sunrise observations — context

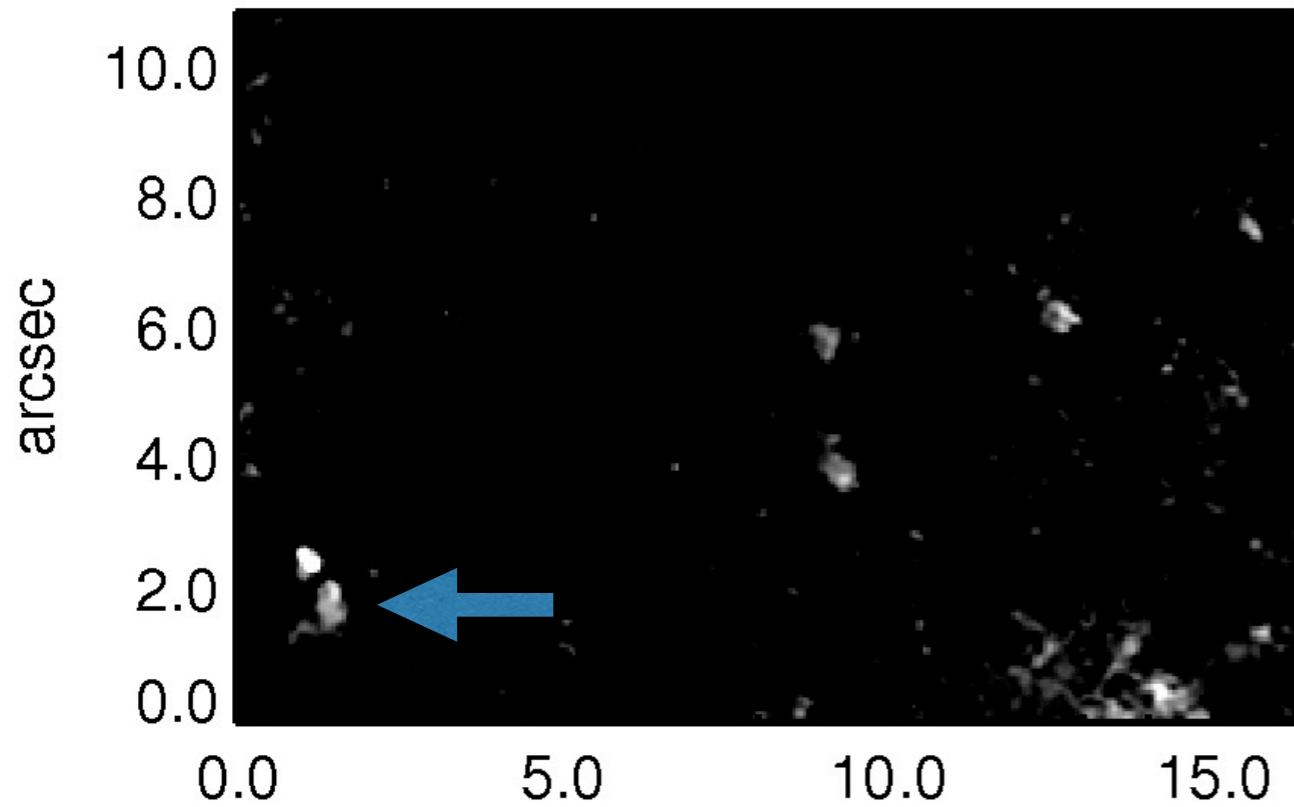


Magnetic connection: photosphere to corona

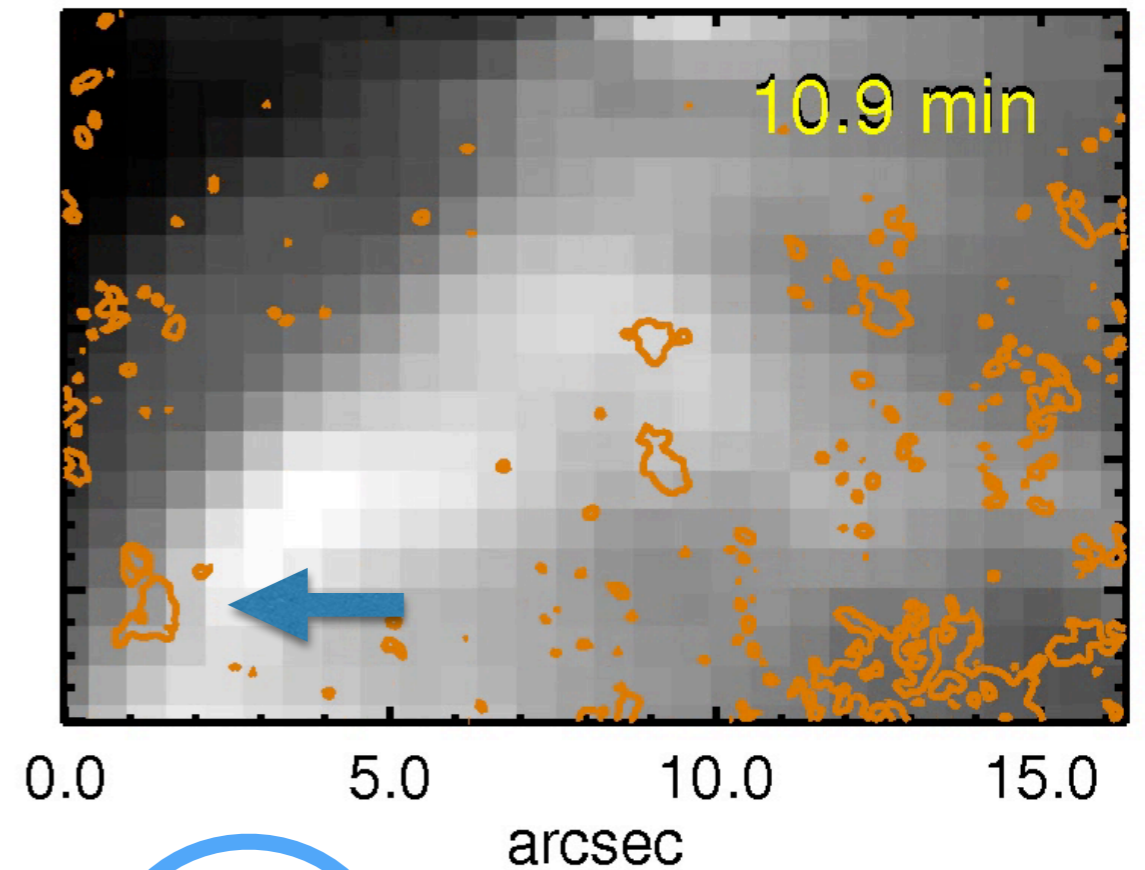


Magnetic connection: photosphere to corona

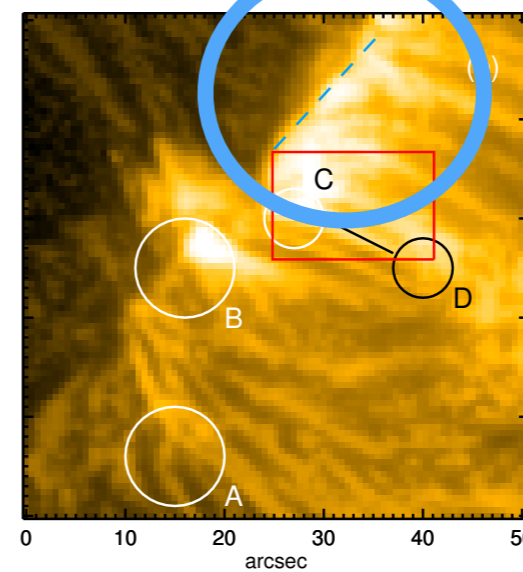
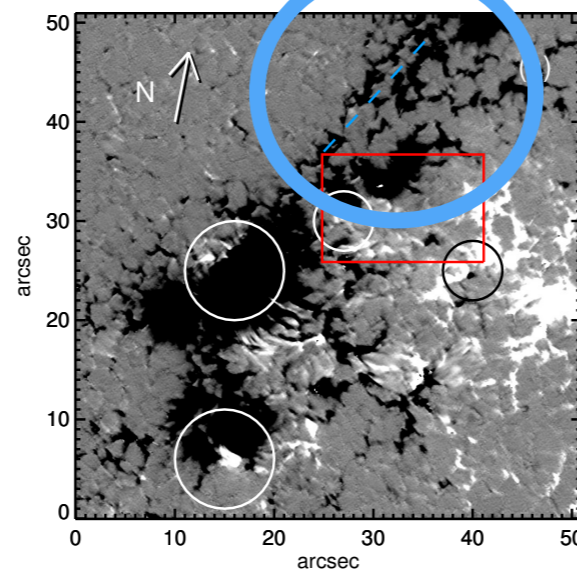
Sunrise/IMaX



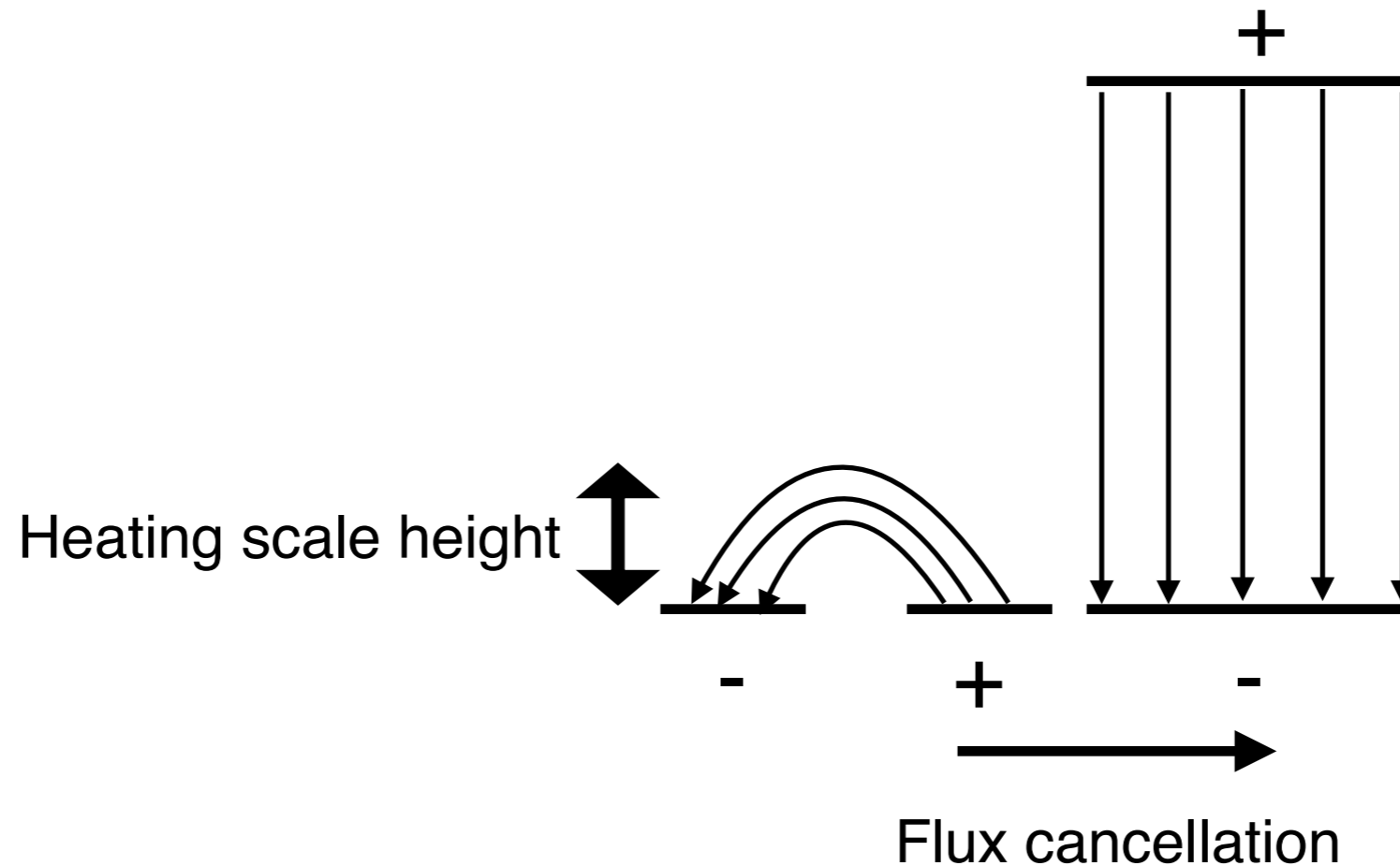
SDO/AIA



arcsec

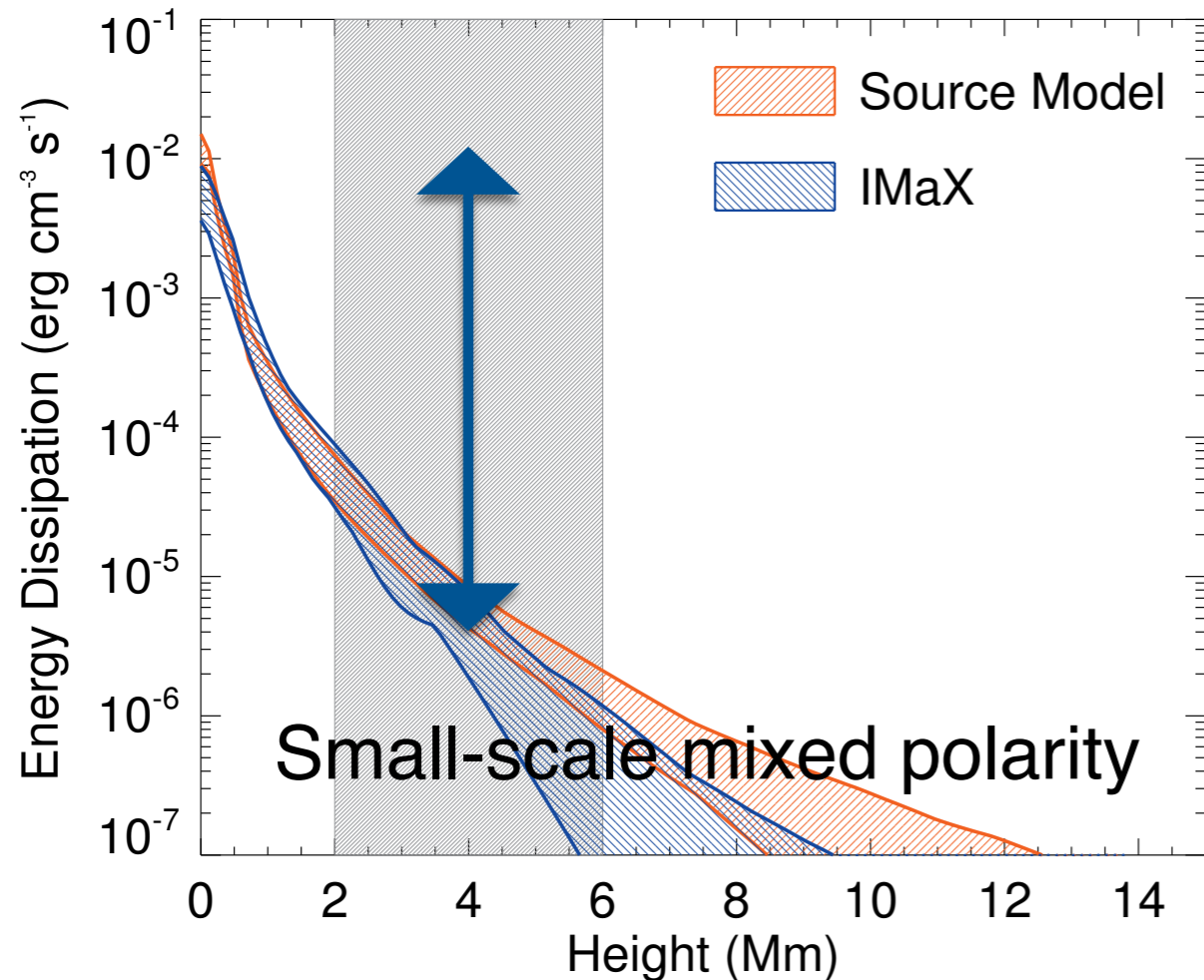


A cartoon of the observed scenario

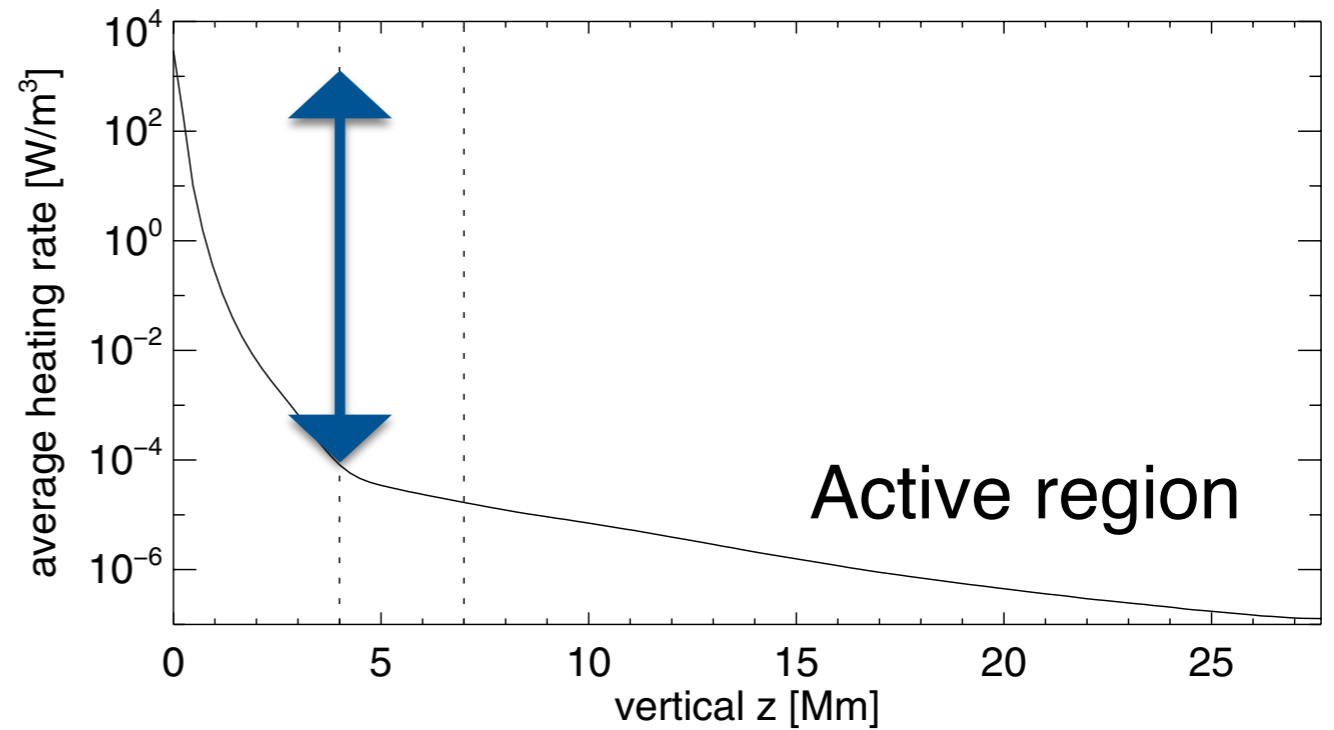


Heating scale height : Magnetic energy decay with height :
close down of magnetic loops

Interpretation of heating scale height



Nonlinear force-free field model (Chitta et al. 2014)

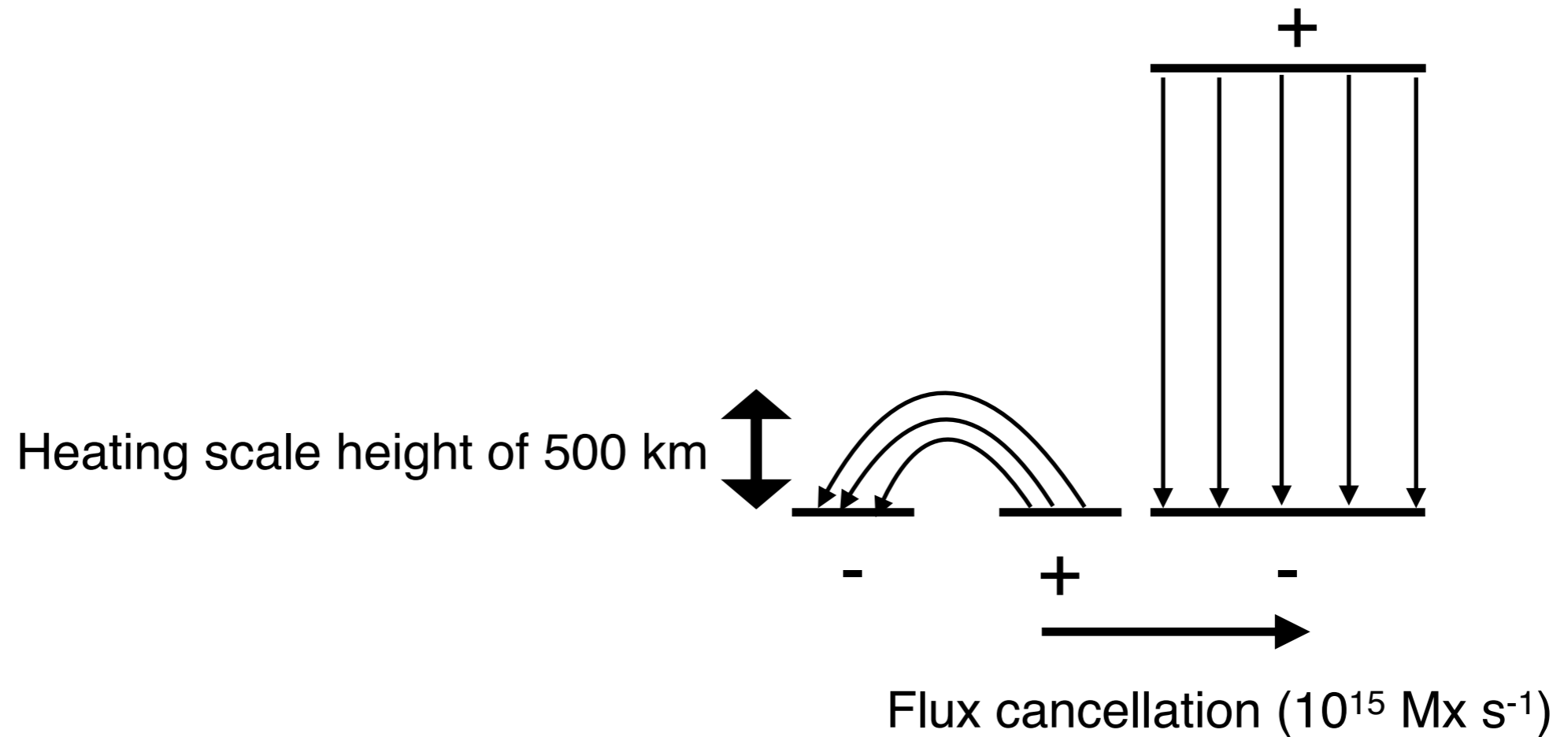


3D MHD model (Bingert & Peter 2011)

4–6 orders of magnitude drop in the heating rate

Heating scale height \approx 500 km

A cartoon of the observed scenario



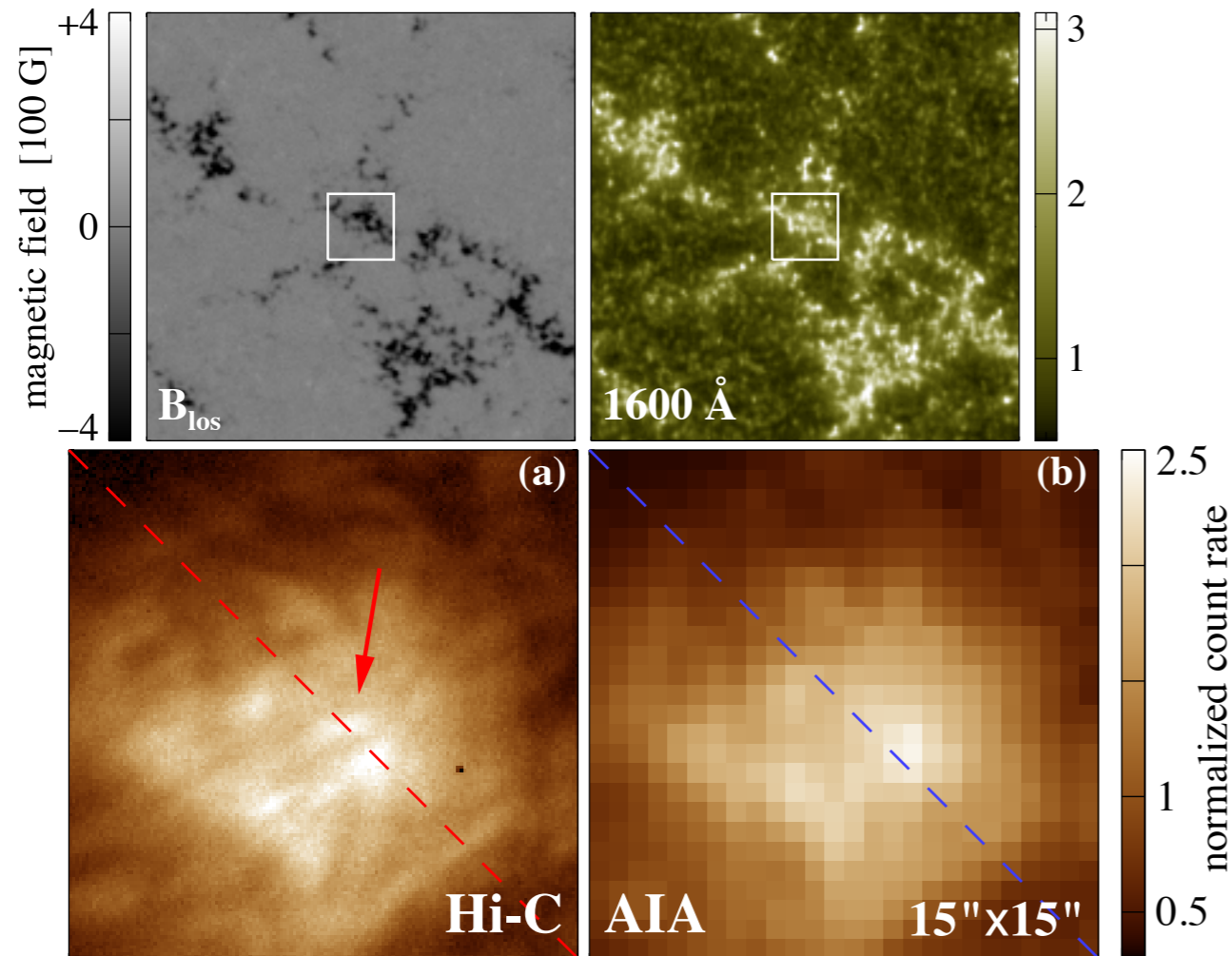
Average magnetic energy flux $\approx 10^9 \text{ erg cm}^{-2} \text{ s}^{-1}$

Photospheric Poynting flux due to convective motions

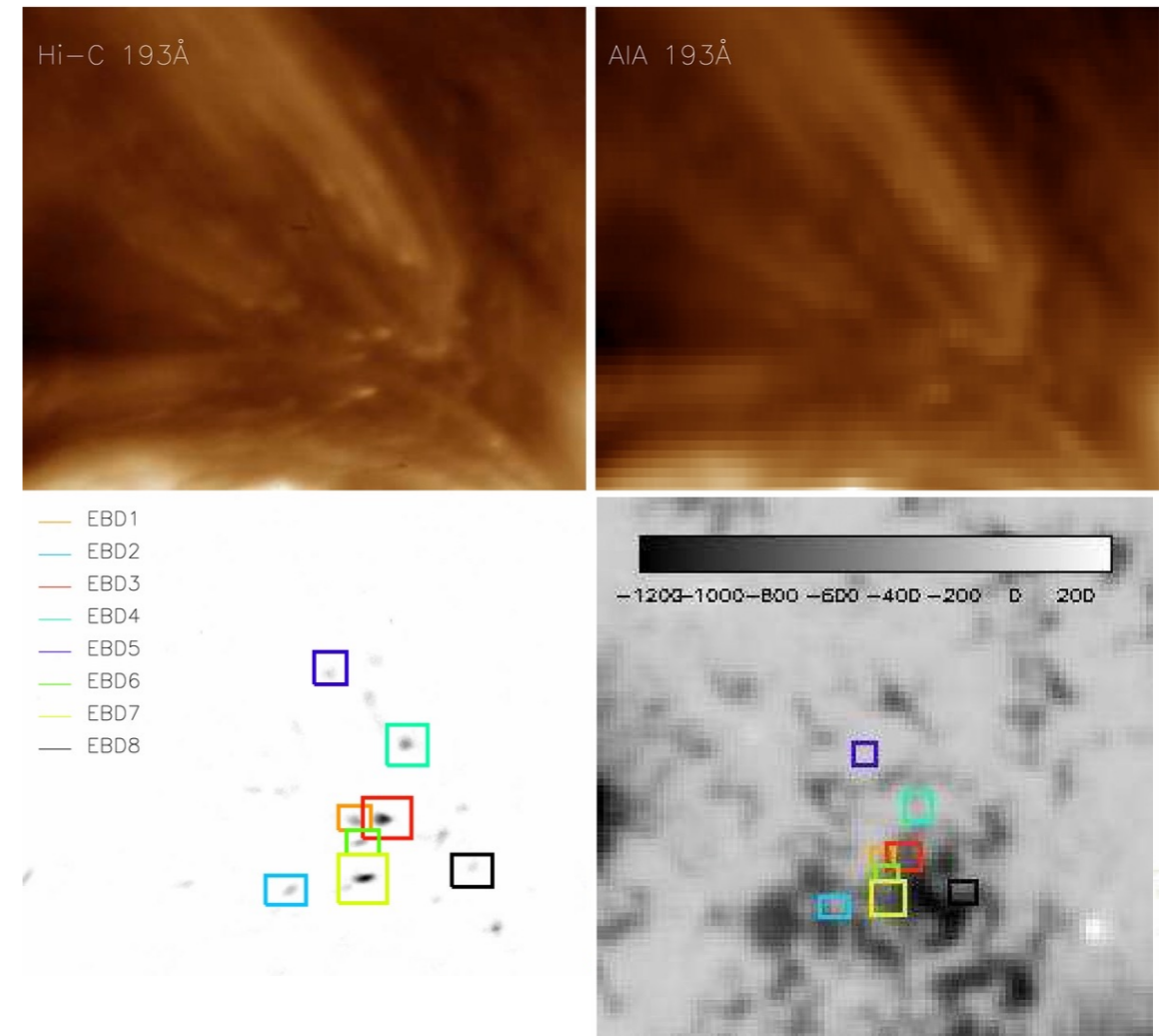
$\approx 5 \times 10^7 \text{ erg cm}^{-2} \text{ s}^{-1}$

(e.g. Welsch 2015)

Indirect evidence for the mixed polarity?

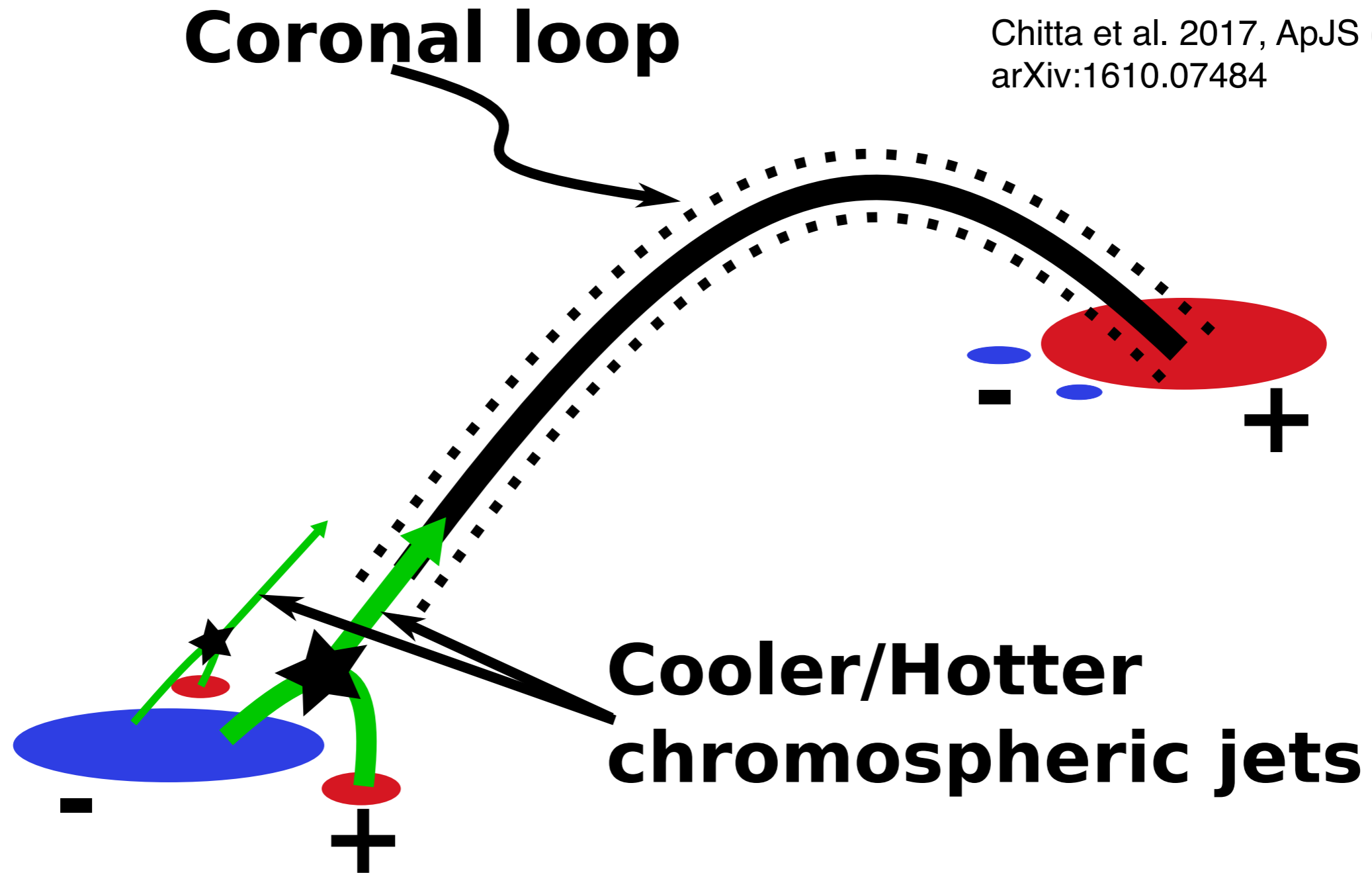


Peter et al. (2013)



Régnier et al. (2014)

Illustration of a coronal loop



Conclusions

- Sunrise observations revealed presence of small-scale mixed polarity field at coronal loop footpoints
- A flux cancellation rate of 10^{15} Mx s⁻¹ can provide a large reservoir of magnetic energy at the base of coronal loops

Question

- At what stage of active region evolution do this small-scale mixed polarity field will govern coronal dynamics?