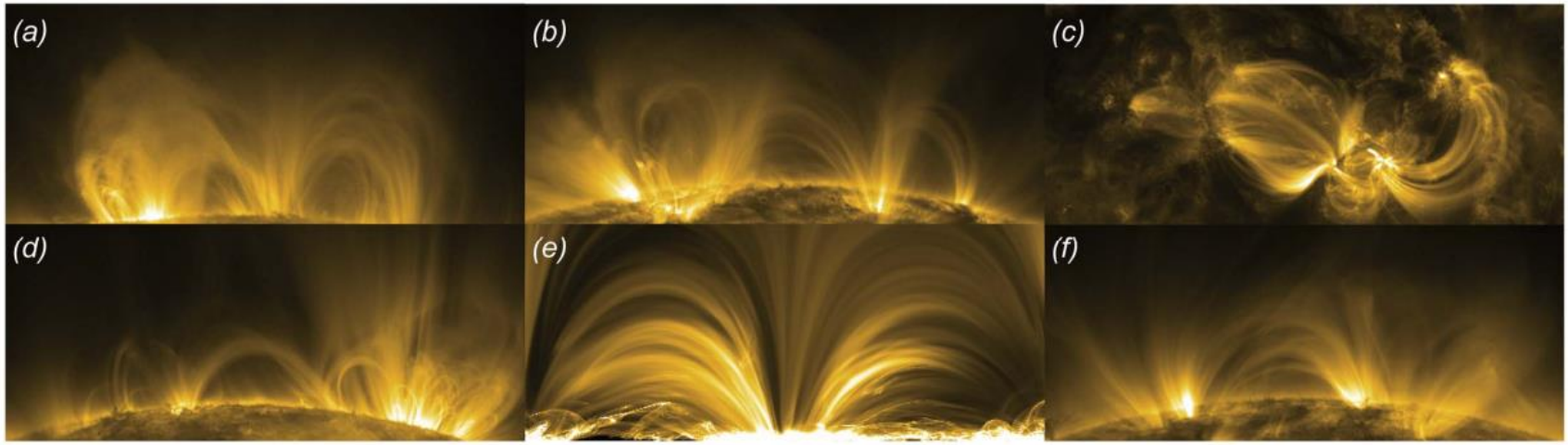
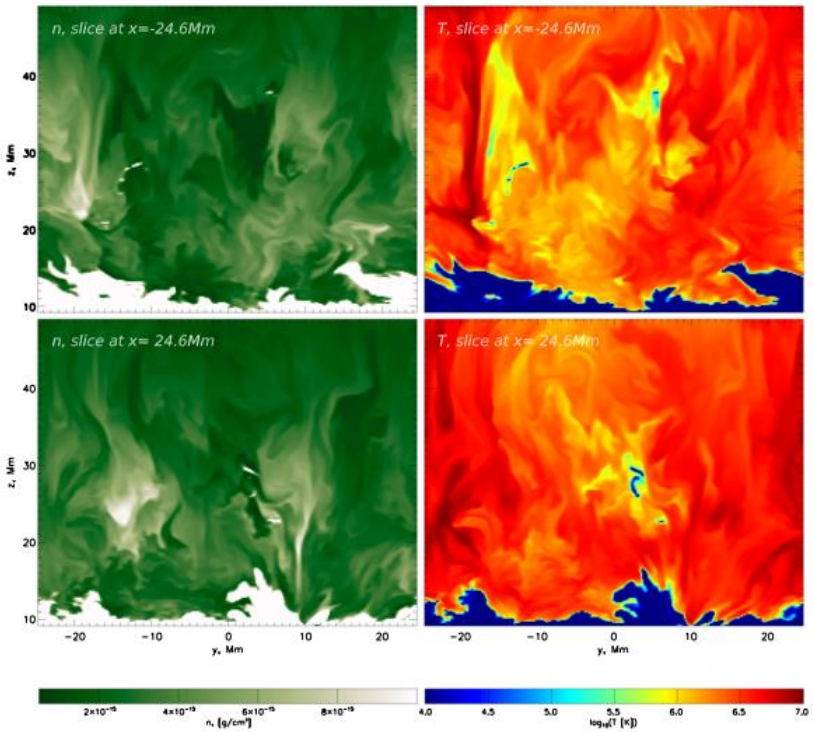
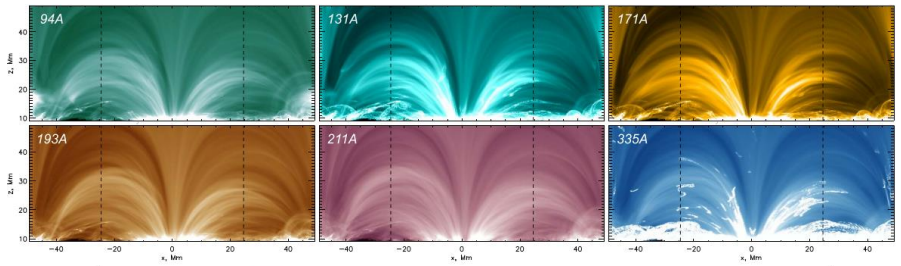
Reconstructing the cross-sectional geometry of a thin closed corona

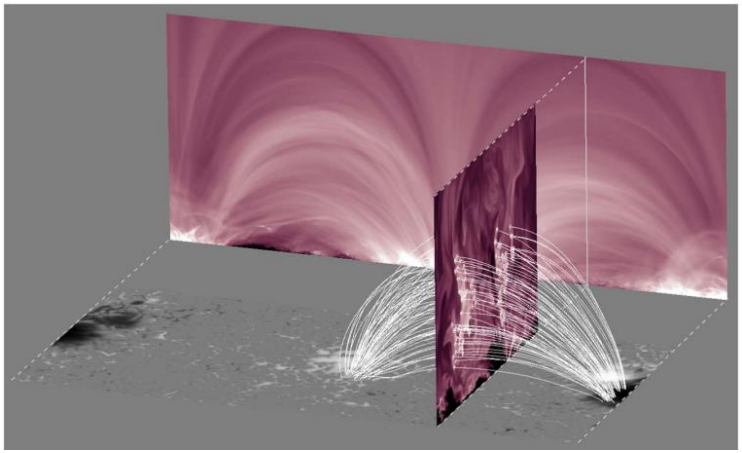
V. Uritsky

Malanushenko et al., ApJ 2022



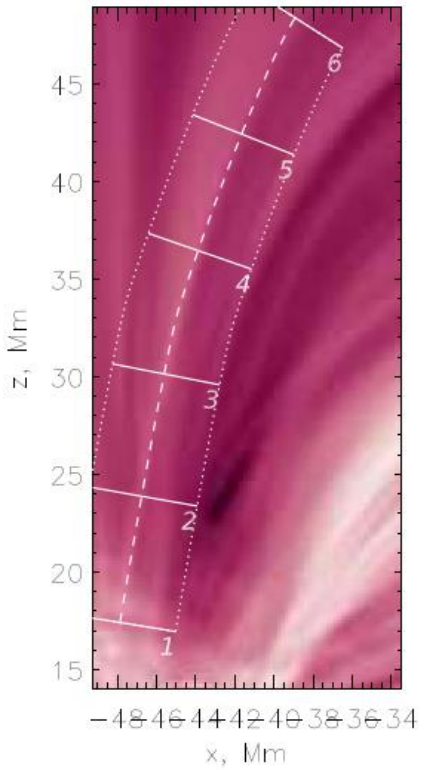


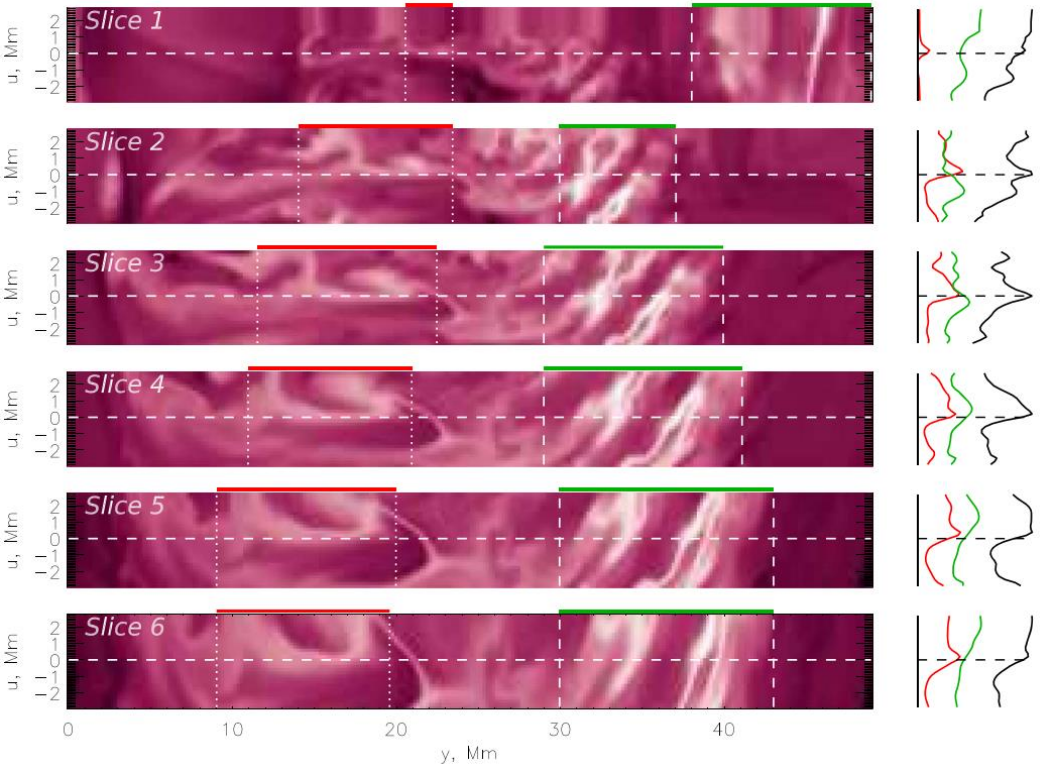


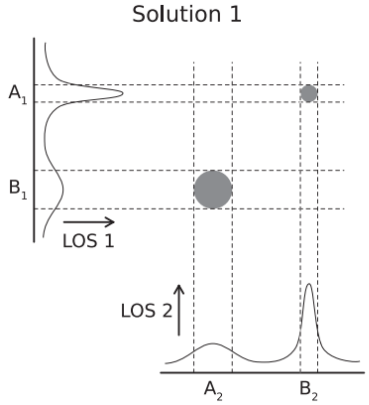


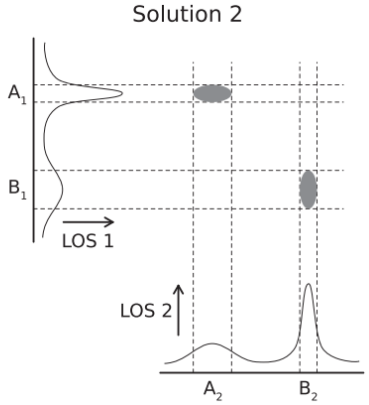
MURaM MHD code (Vogler et al, 2005)

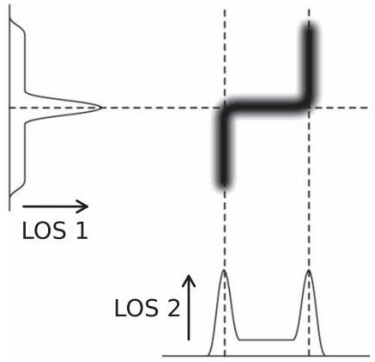
Malanushenko et al., ApJ 2022











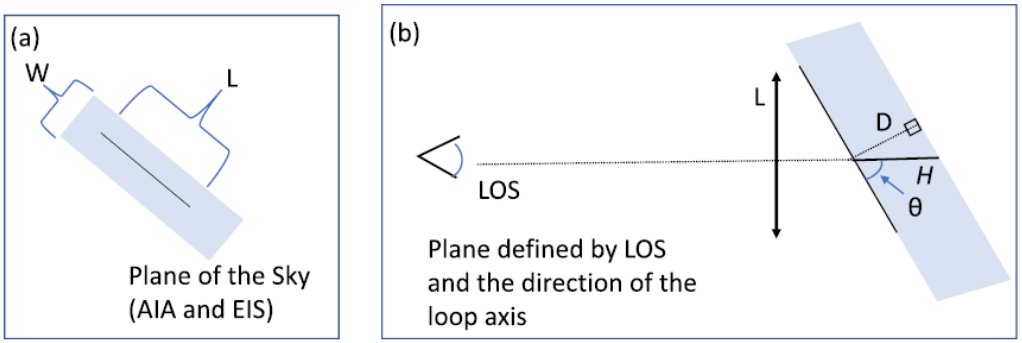


Figure 2. Definition of terms for loop dimensions. W is the width of the loop in the plane of the sky as seen from Earth, H is the loop depth along the LOS, D is the loop dimension perpendicular to the local loop axis and in the plane defined by the axis and the LOS, L is the length of the segment of the loop in the plane of the sky, and θ is the angle between the axis of the loop and the LOS.

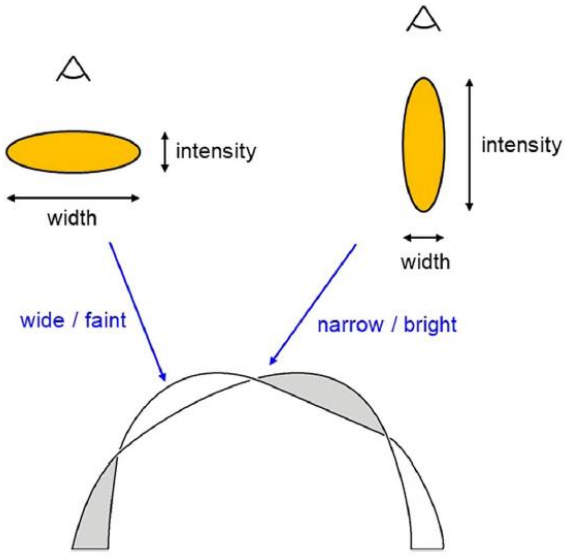
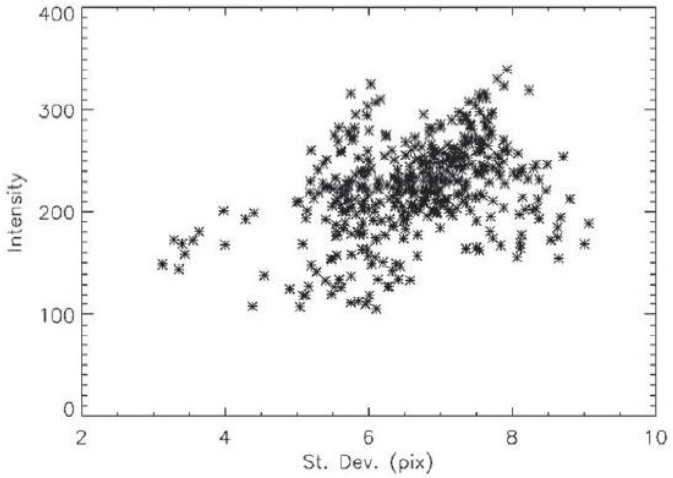
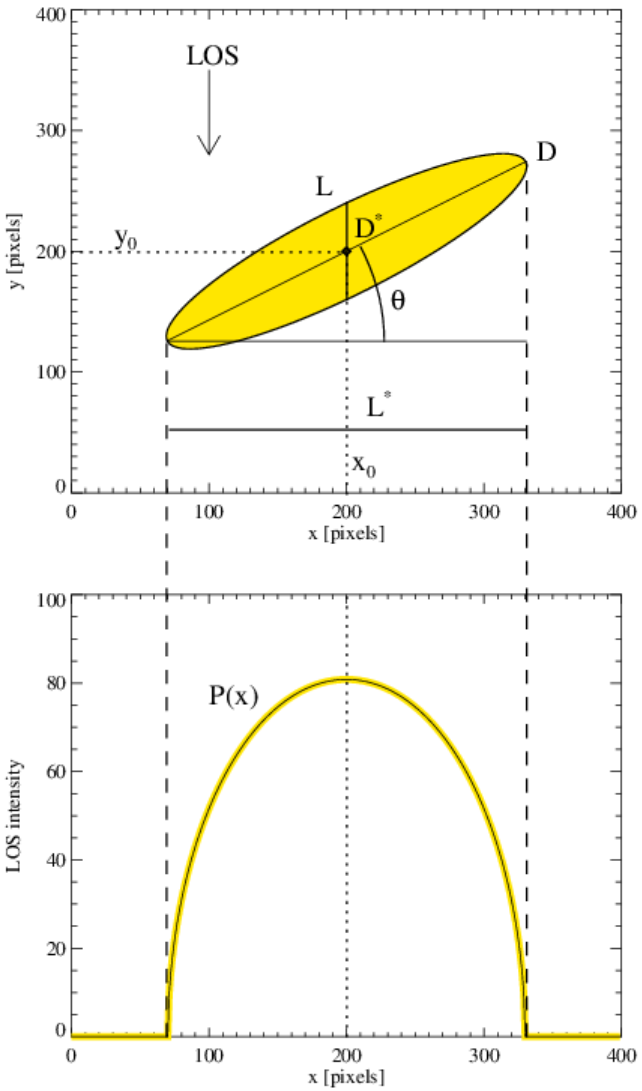


Figure 1. Idealized sketch of a coronal loop corresponding to a twisted flux tube with a noncircular cross section showing how the intensity and width and are anticorrelated. Bottom part adopted from Klimchuk (2000).



The Stochastic Pulse Superposition (SPS) model

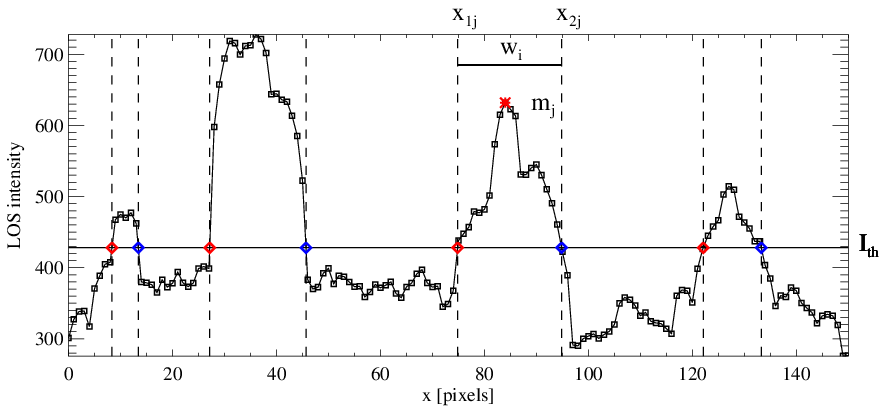


$$L_i^* = \max\{L_i \cos(\theta_i), D_i\}$$
$$D_i^* = \min\{D_i / \cos(\theta_i), L_i\}$$

$$P_i(x) = \begin{cases} D_i^* \sqrt{1 - \left(\frac{x - x_{0i}}{L_i^*/2}\right)^2}, & |x - x_{0i}| < \frac{L_i^*}{2} \\ 0 & \text{otherwise.} \end{cases}$$

$$I(x) = \sum_{i=1}^{N_p} P_i(x)$$

$$f = \frac{\sum_{i=1}^{N_p} \pi L_i D_i / 4}{L_x L_y}$$



Spectral analysis alone is ambiguious

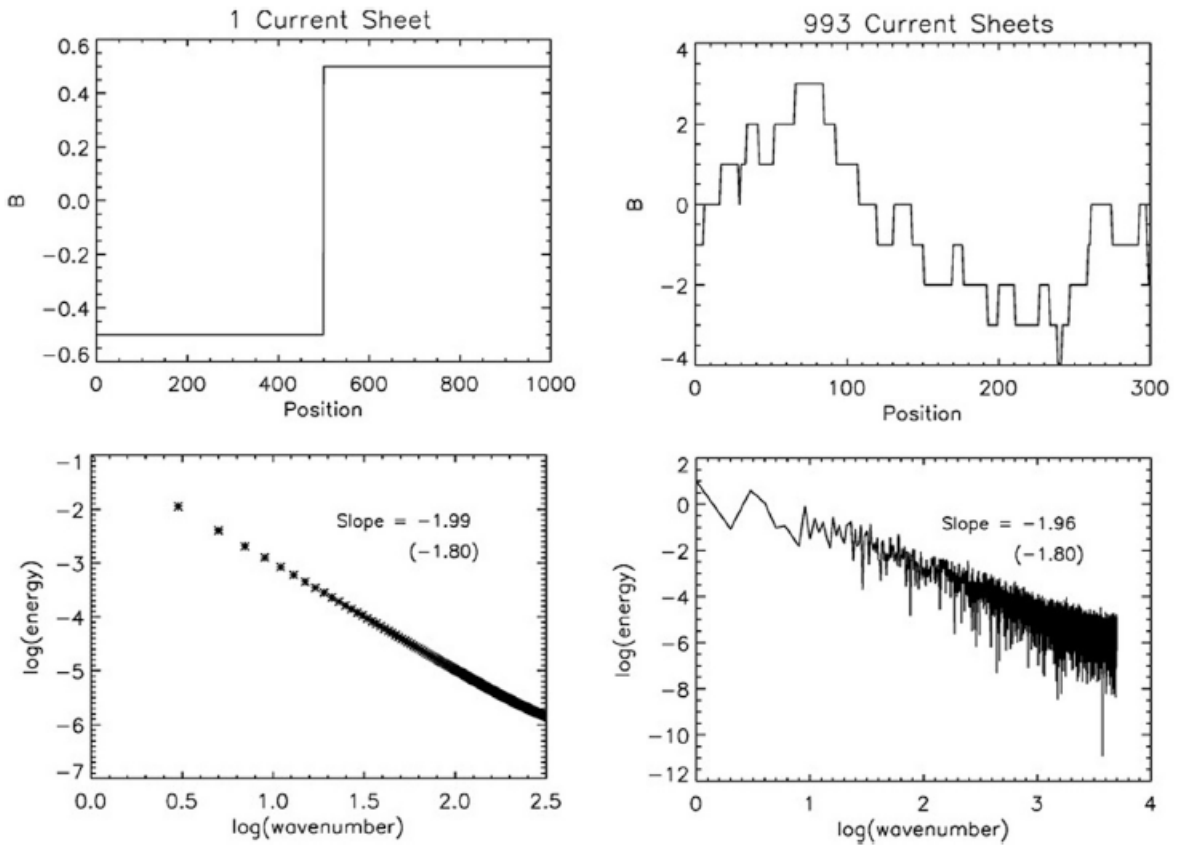


FIGURE 1 | Spatial profile of transverse magnetic field (top) and Fourier power spectrum (bottom) for a single current sheet (left) and 993 currents sheets with random spacing and random sign (right). Only a portion of the profile is shown for the multi-sheet case.

SPS control parameters and diagnostics

"Under the hood"

"The dashboard"

Size distribution

$$p(L) = \begin{cases} c\,L^{-\alpha}, & L \in [L_{\min}, L_{\max}] \\ 0 & \text{otherwise.} \end{cases}$$

$$c = \frac{1-\alpha}{L_{\max}^{1-\alpha} - L_{\min}^{1-\alpha}}$$

Ansisotropy scaling

$$D(L) = \frac{D_{\min}}{L_{\min}^{\gamma}} L^{\gamma} \qquad a = L/D \propto L^{1-\gamma}$$

Spectral analysis

$$E(k) = |\tilde{I}(k)|^2 \quad \Rightarrow \quad E(k) \propto k^{-\beta}$$

Intermittency analysis

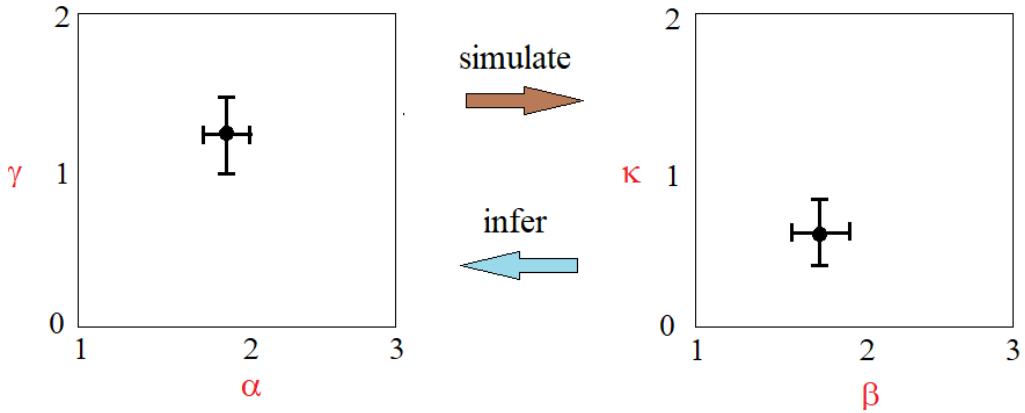
$$\delta I(x,r) = I(x+r) - I(x)$$

$$S_q(r) = \langle |\delta I(x,r)|^q \rangle_{x \in [0, L_x]} \quad \Rightarrow \quad S_q(r) \propto r^{\zeta(q)}$$

$$F(r) = \frac{S_4(r)}{[S_1(r)]^4} \propto r^{-\kappa}$$

Peak analysis

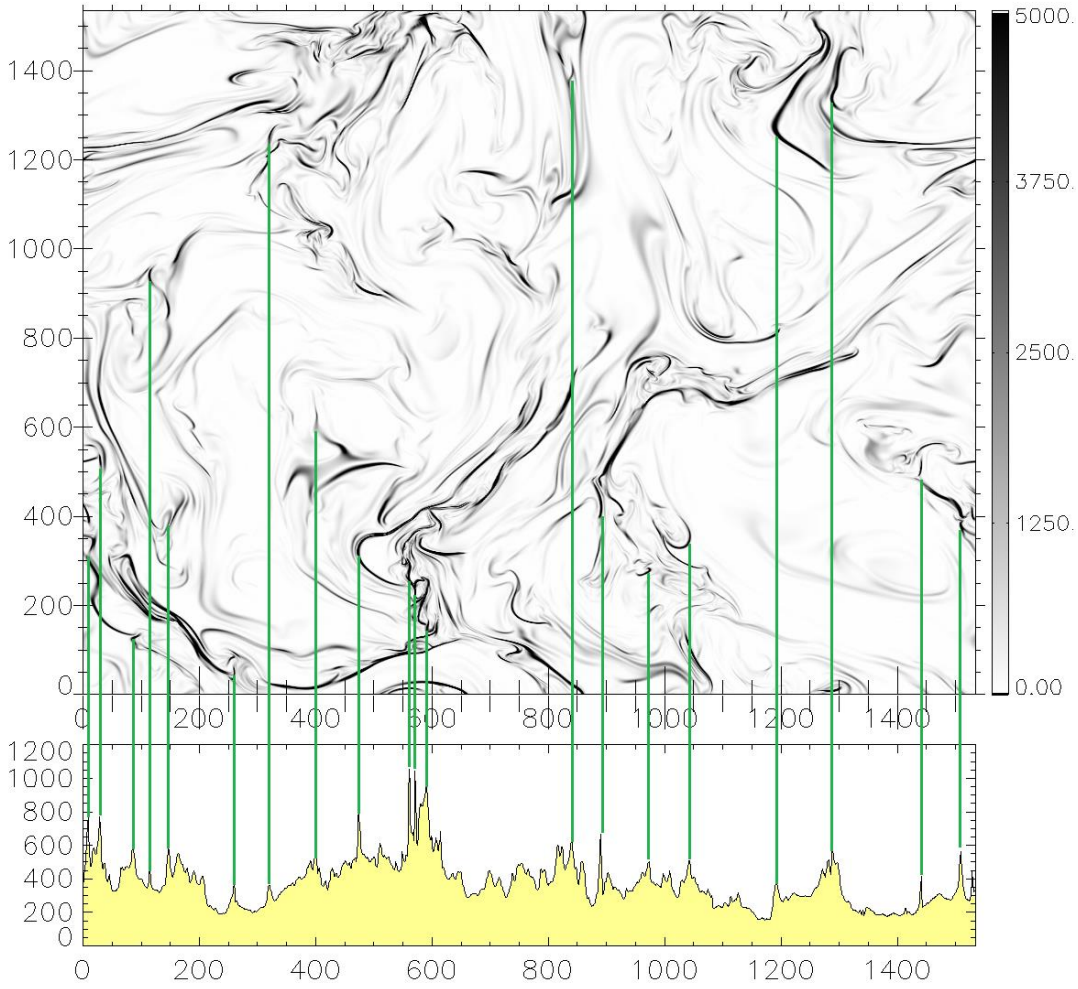
$$p(w) \propto \exp(-w/w_c) \quad \Rightarrow \quad m \propto w^{\xi}$$



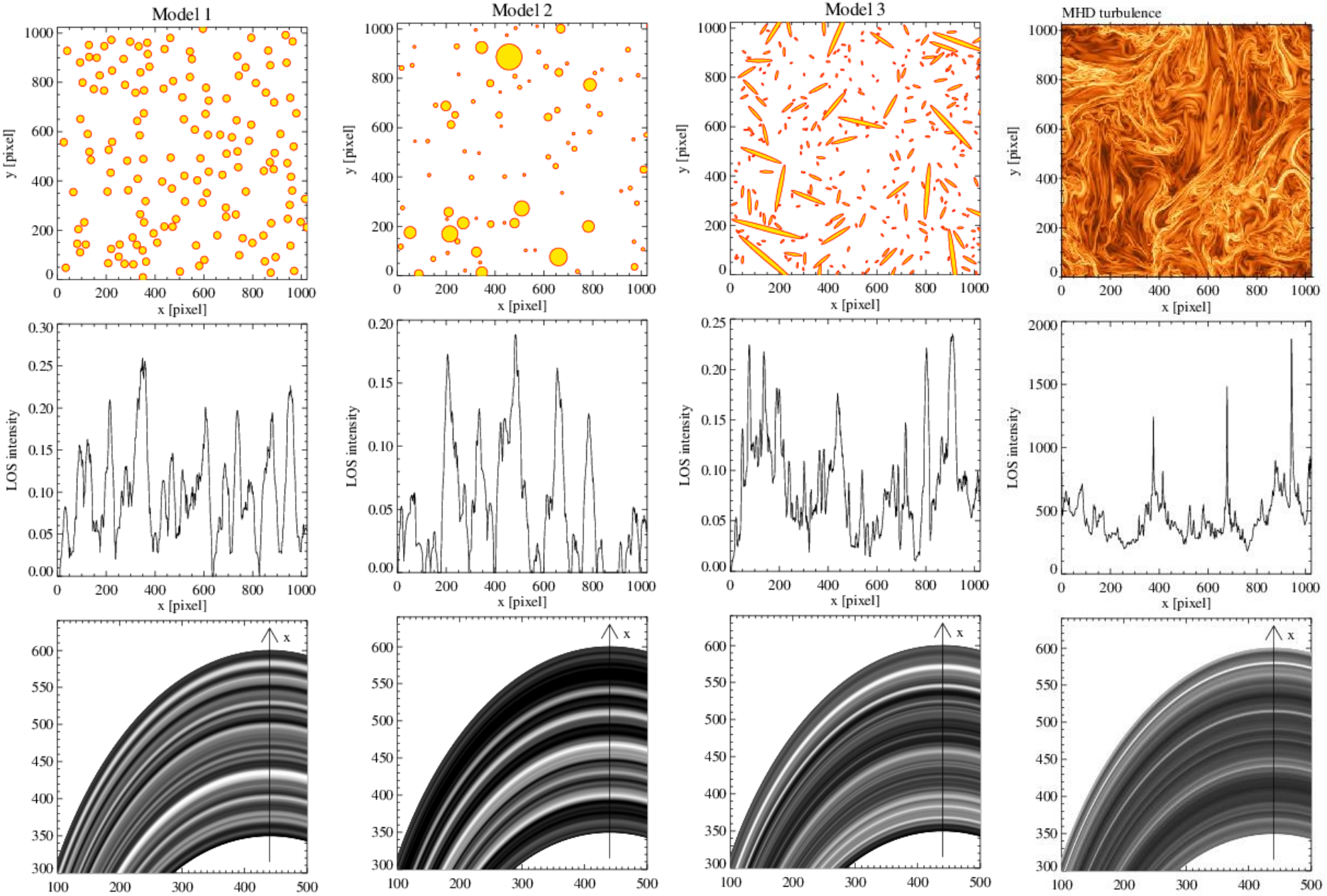
Auxiliary model: 3D incompressible MHD turbulence

Structures in magnetohydrodynamic turbulence: Detection and scaling

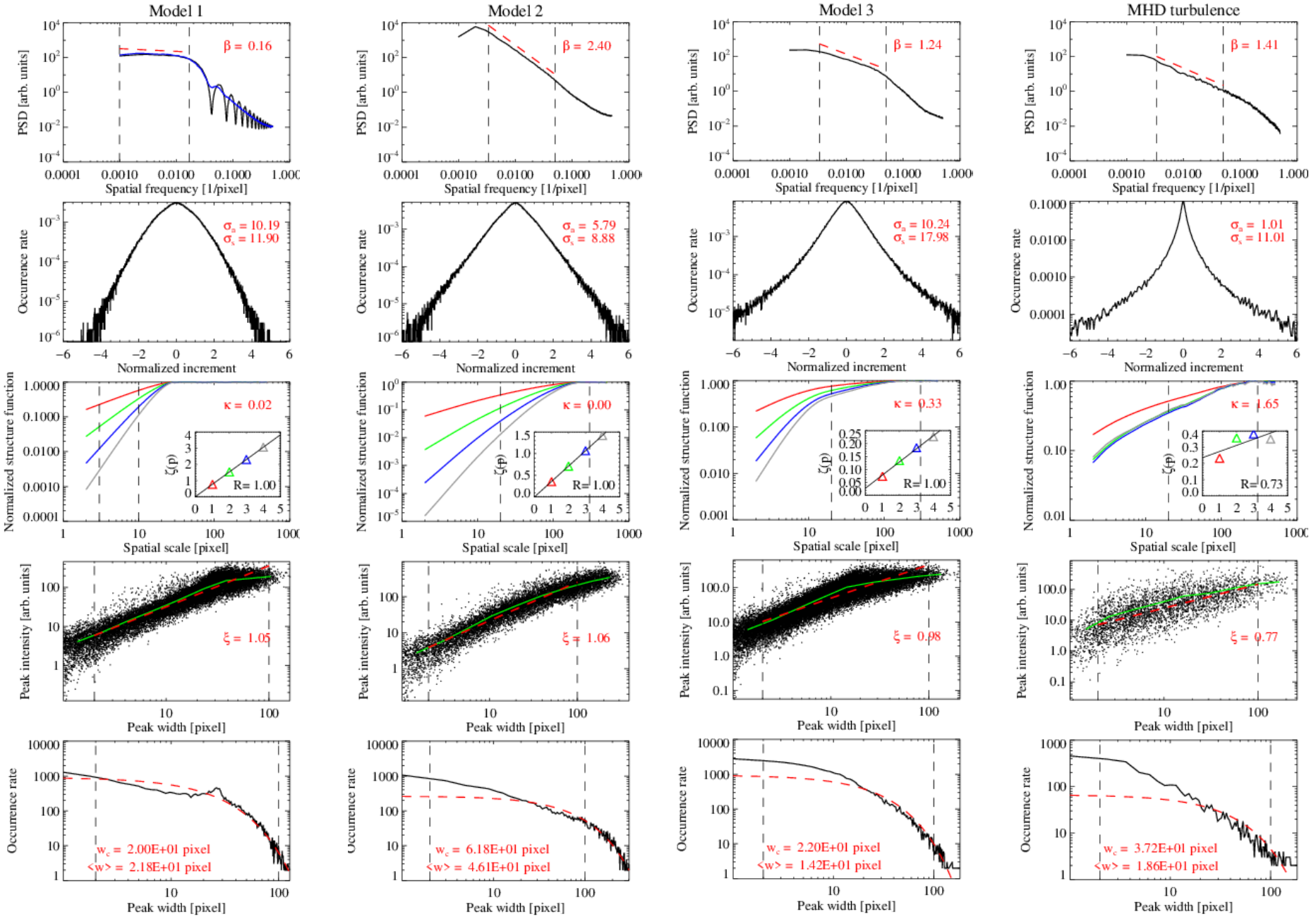
V. M. Uritsky, A. Pouquet, D. Rosenberg, P. D. Mininni, and E. F. Donovan
Phys. Rev. E **82**, 056326 – Published 30 November 2010



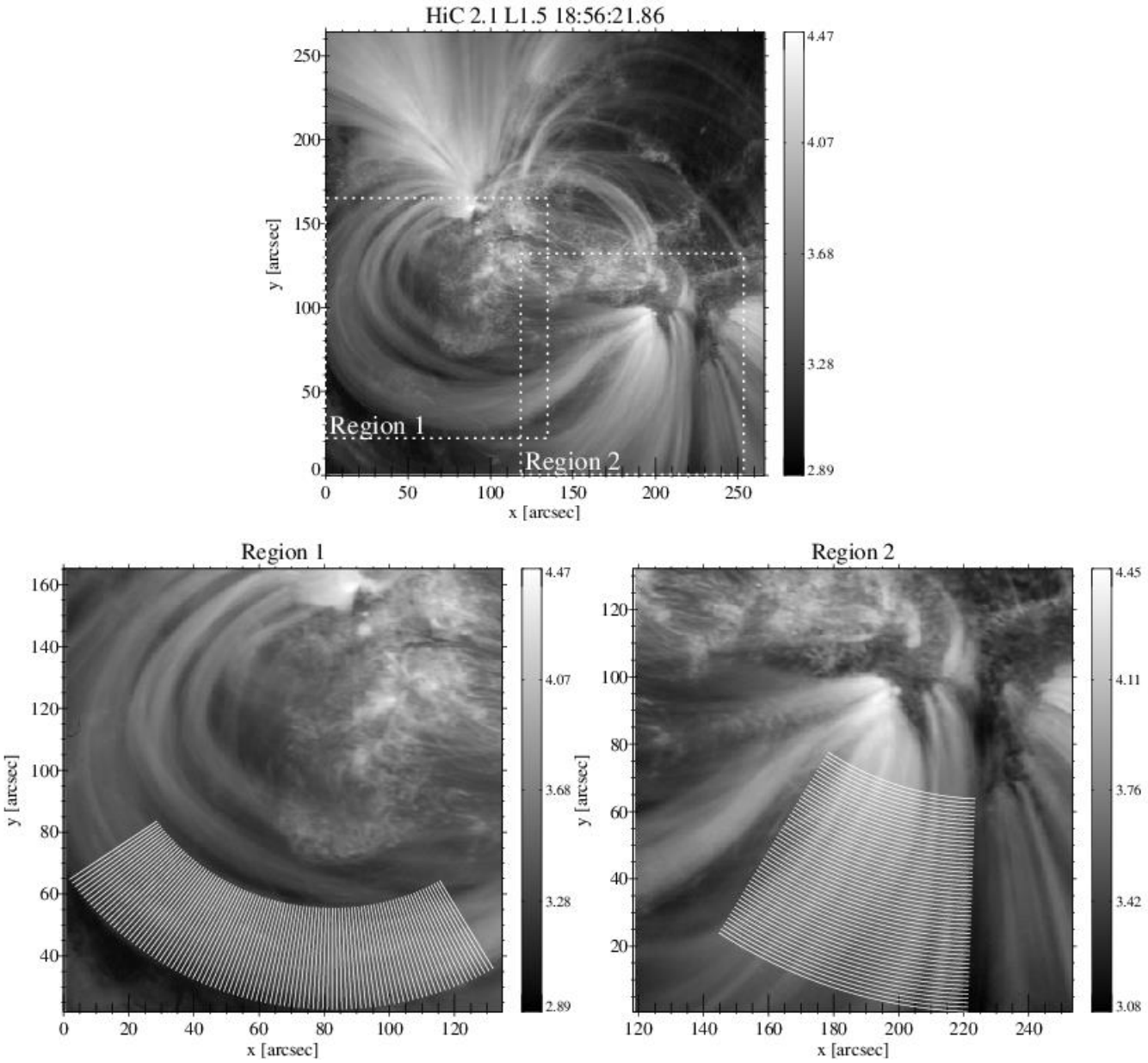
Four paradigmatic models compared



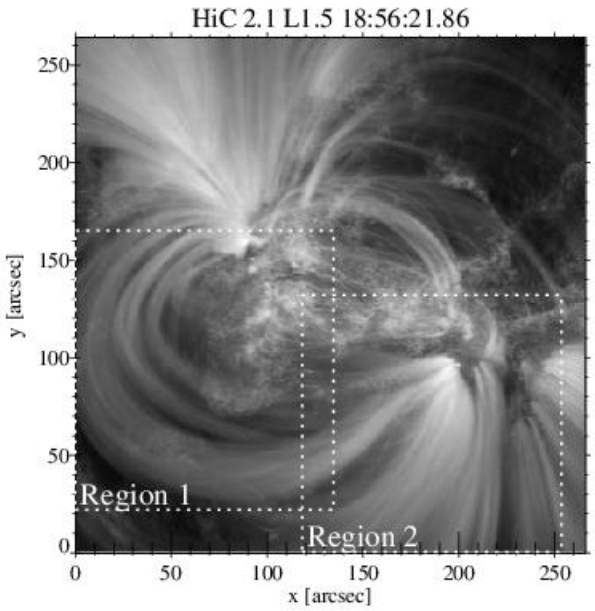
Statistical diagnostics

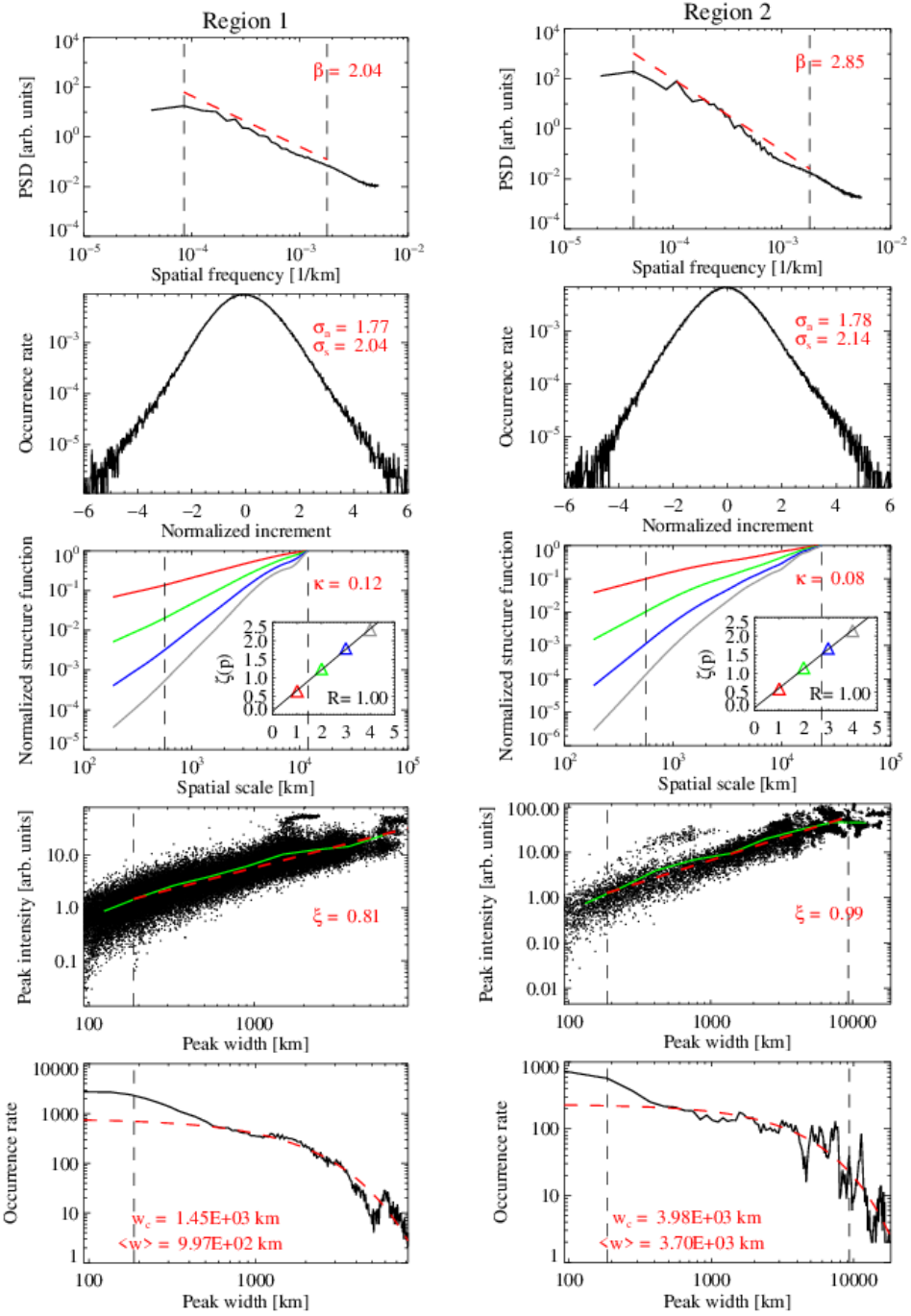


HiC 2.1 images (36 frames, 100 (50) slits for R1 (R2))

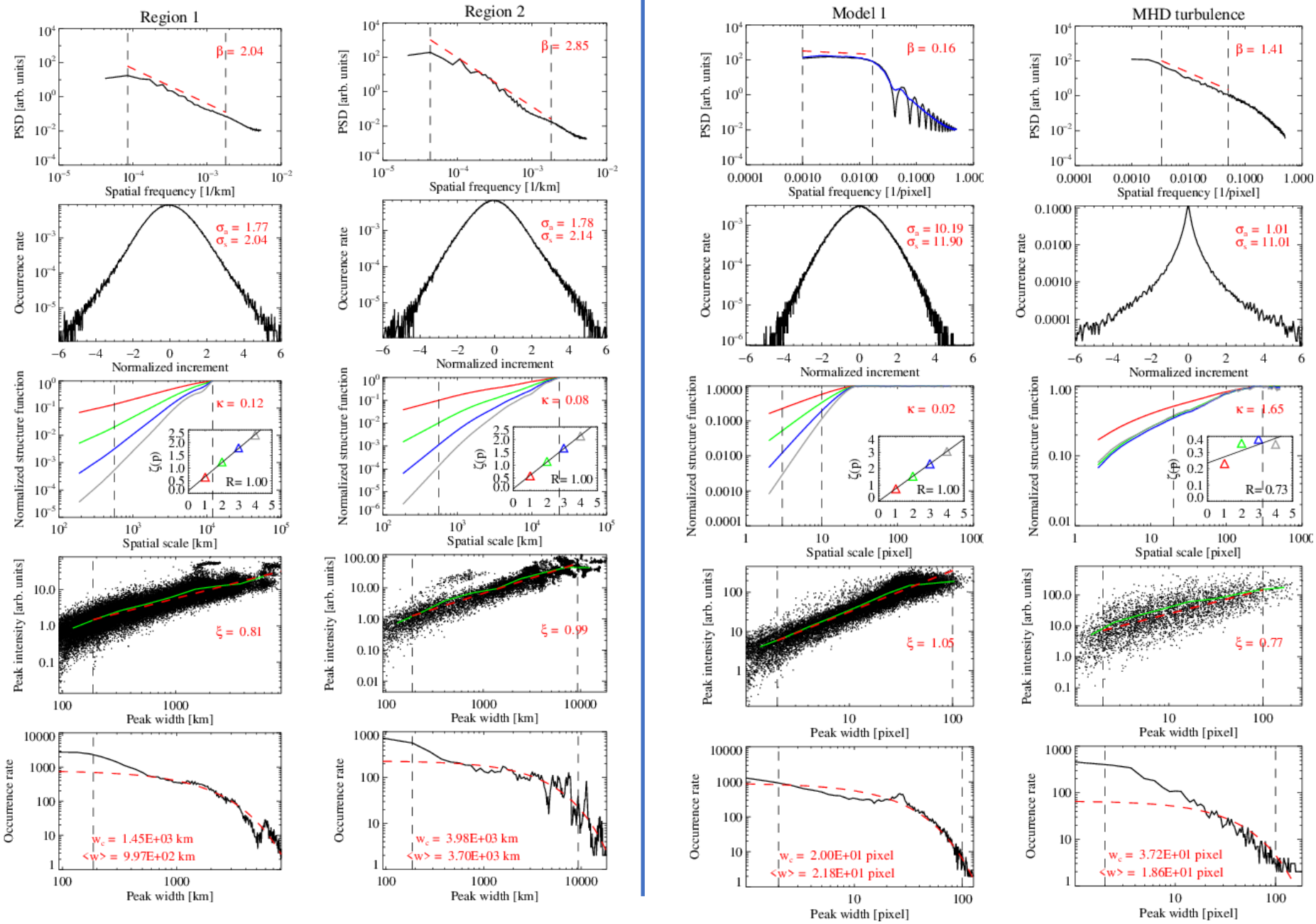


HiC statistics

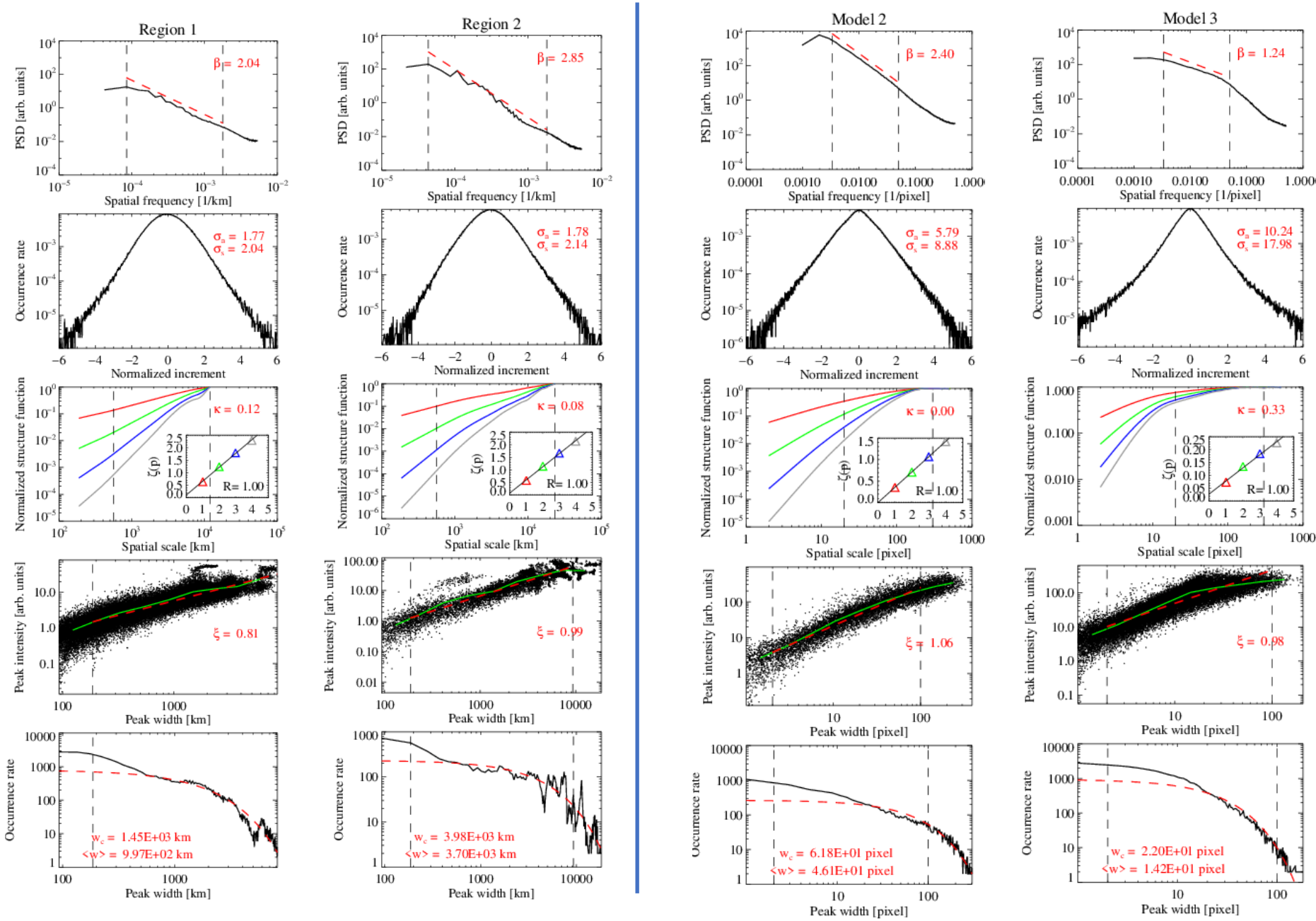




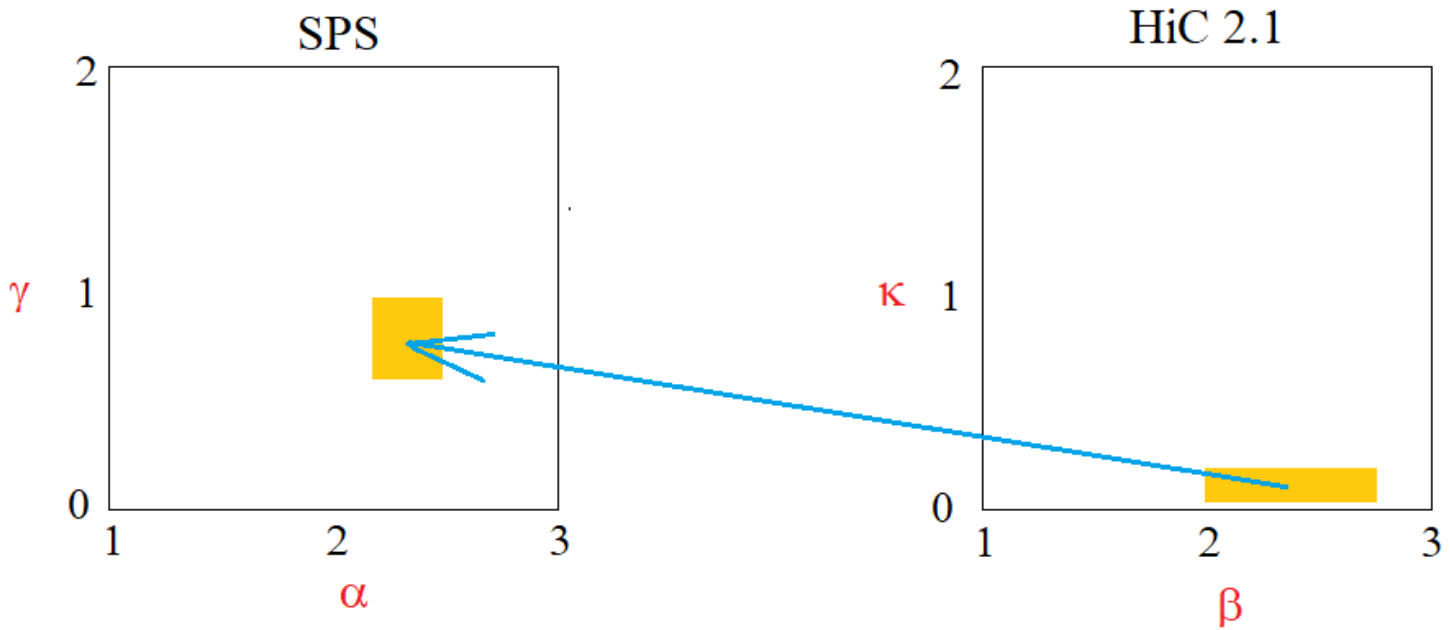
HiC loops vs models: Model 1 and MHD turbulence ruled out



HiC loops vs models: Models 2 and 3 confirmed



HiC vs models mapping & summary

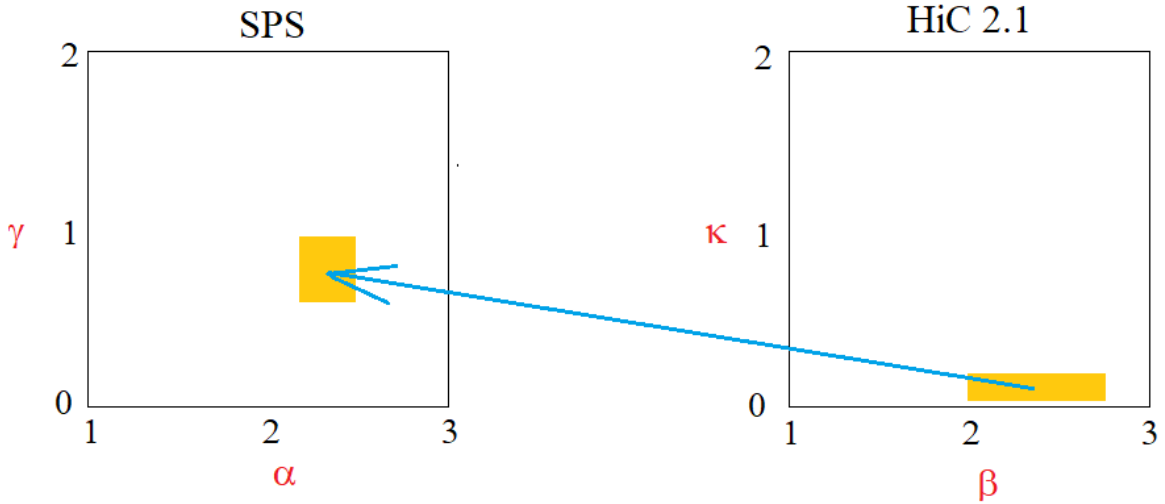


- power-law size distribution
- sligtly anisotropic at large scales
- possibly irregular shapes

Inferring the loop geometry:

Quisi-circular clusters of bright transient strands / sheets

TBD.



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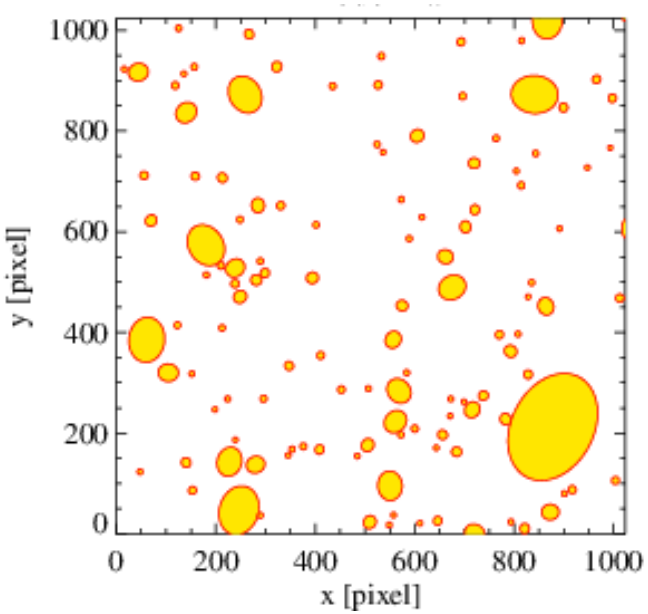

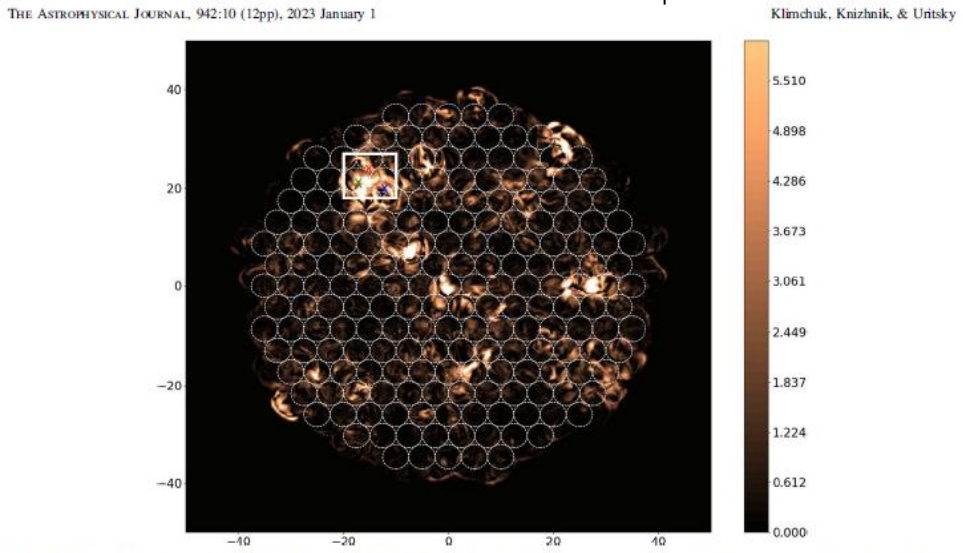

Figure 8. Map of 193 Å emissivity from Figure 6 overlaid with the projected locations of the vortex driver cells at the "photospheric" boundaries. The cluster of brightenings near position (−17, 22) is shown close-up in Figure 10.

Uritsky et al., PRE 2010