Magnetic Charge Topology (MCT) Analysis of NOAA AR8210, May 1, 1998

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What is Magnetic Charge Topology?

- Method for quantifying the topology of the coronal magnetic field from the observed photospheric field.
- Active region is partitioned into distinct subregions of magnetic flux, each represented by a magnetic monopole.
- Coronal magnetic field is then determined by the locations and strengths of the magnetic monopoles.
- Magnetic reconnection occurs along separator field lines, which are the intersections of separatrix surfaces.

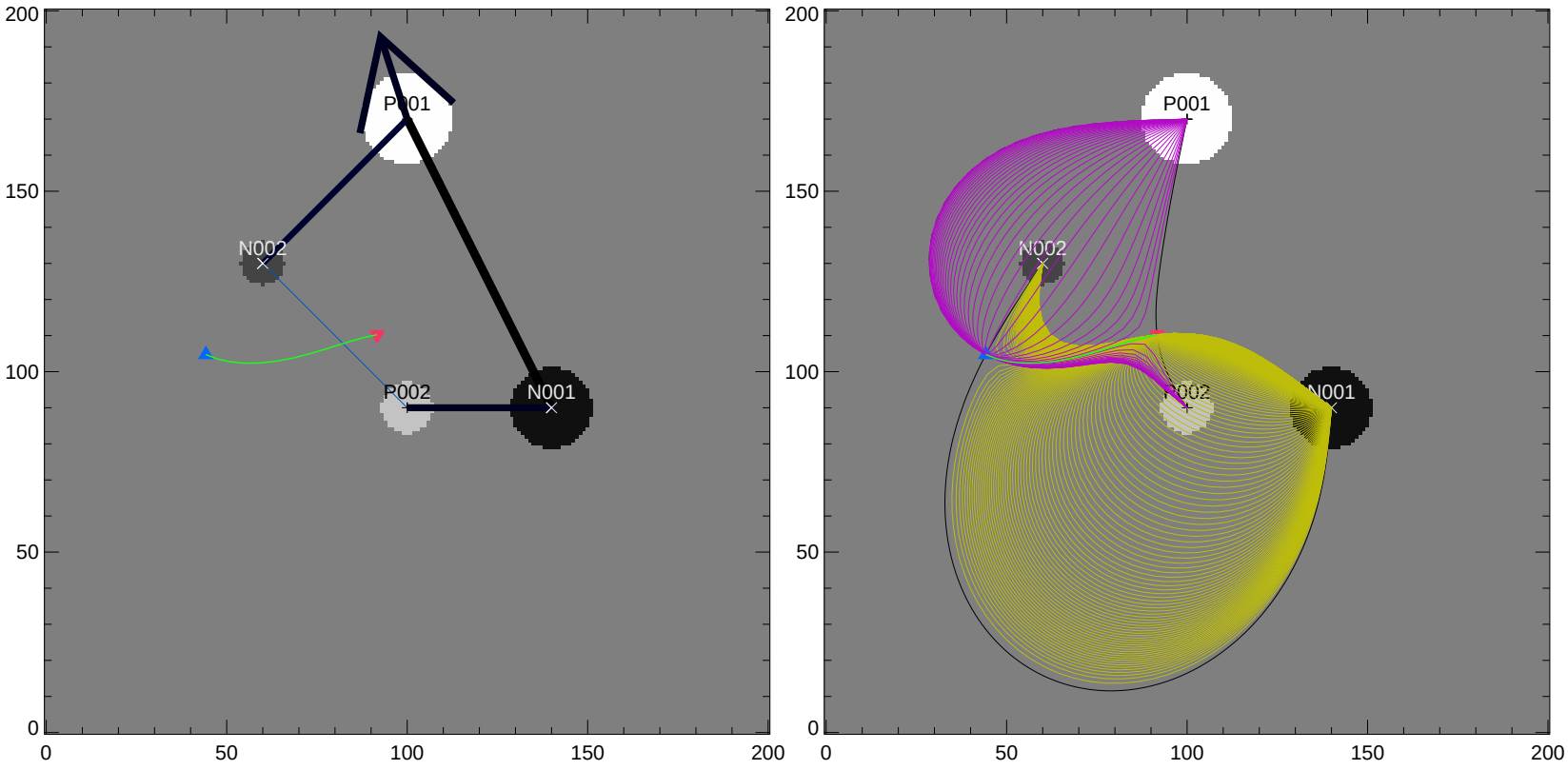

Figure 1: A Simple Example

Why Use Magnetic Charge Topology?

- MCT model has had some initial success predicting the location of flare heating (flare ribbons) as being along separators. (Longcope & Silva, 1998)

- Quantitative description of the topology of the field in the corona.

- Provides an estimate of the rate of flux emergence/submergence and reconnection.

- Provides an estimate of the horizontal velocities.

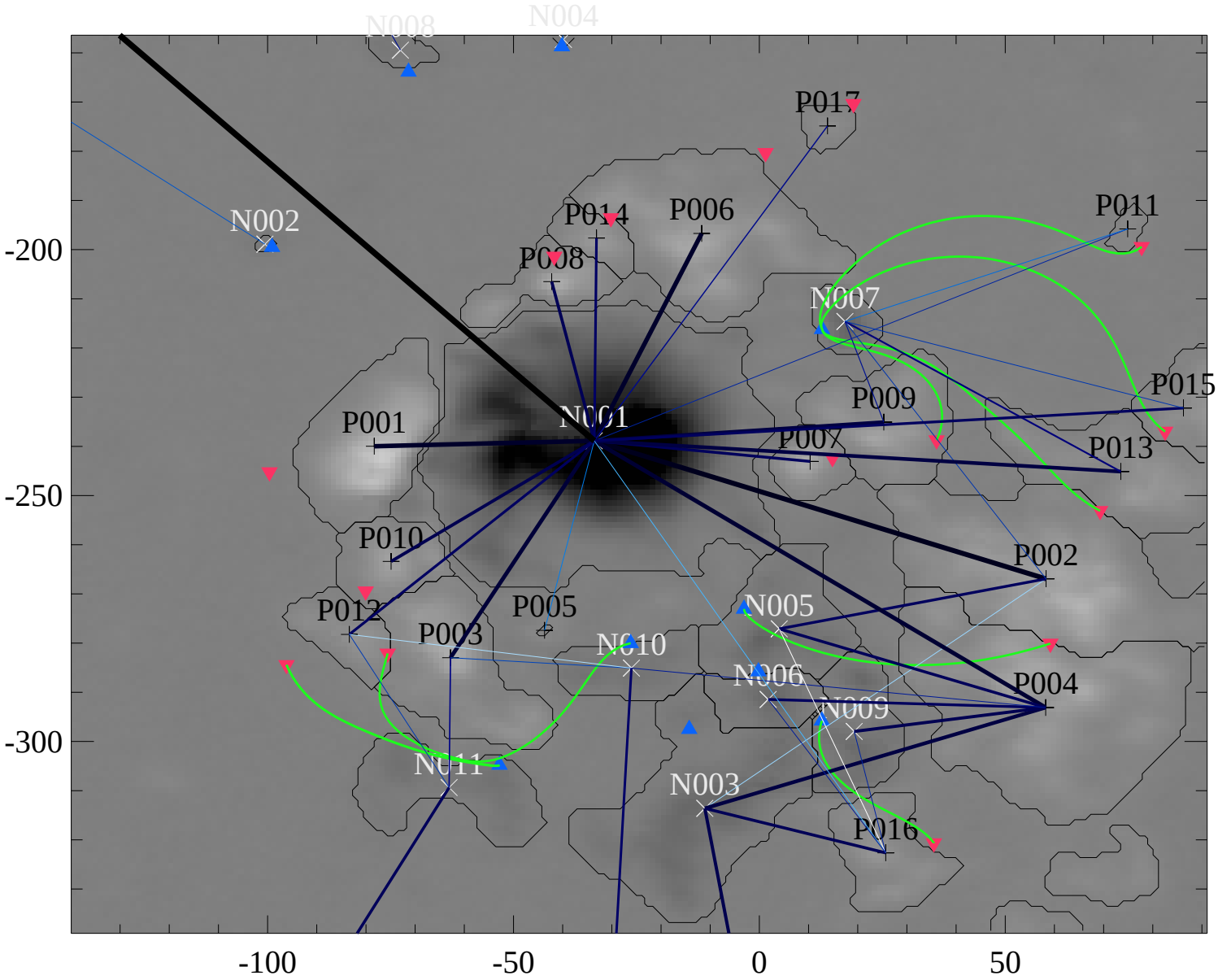

Figure 2: MCT Analysis of NOAA AR8210

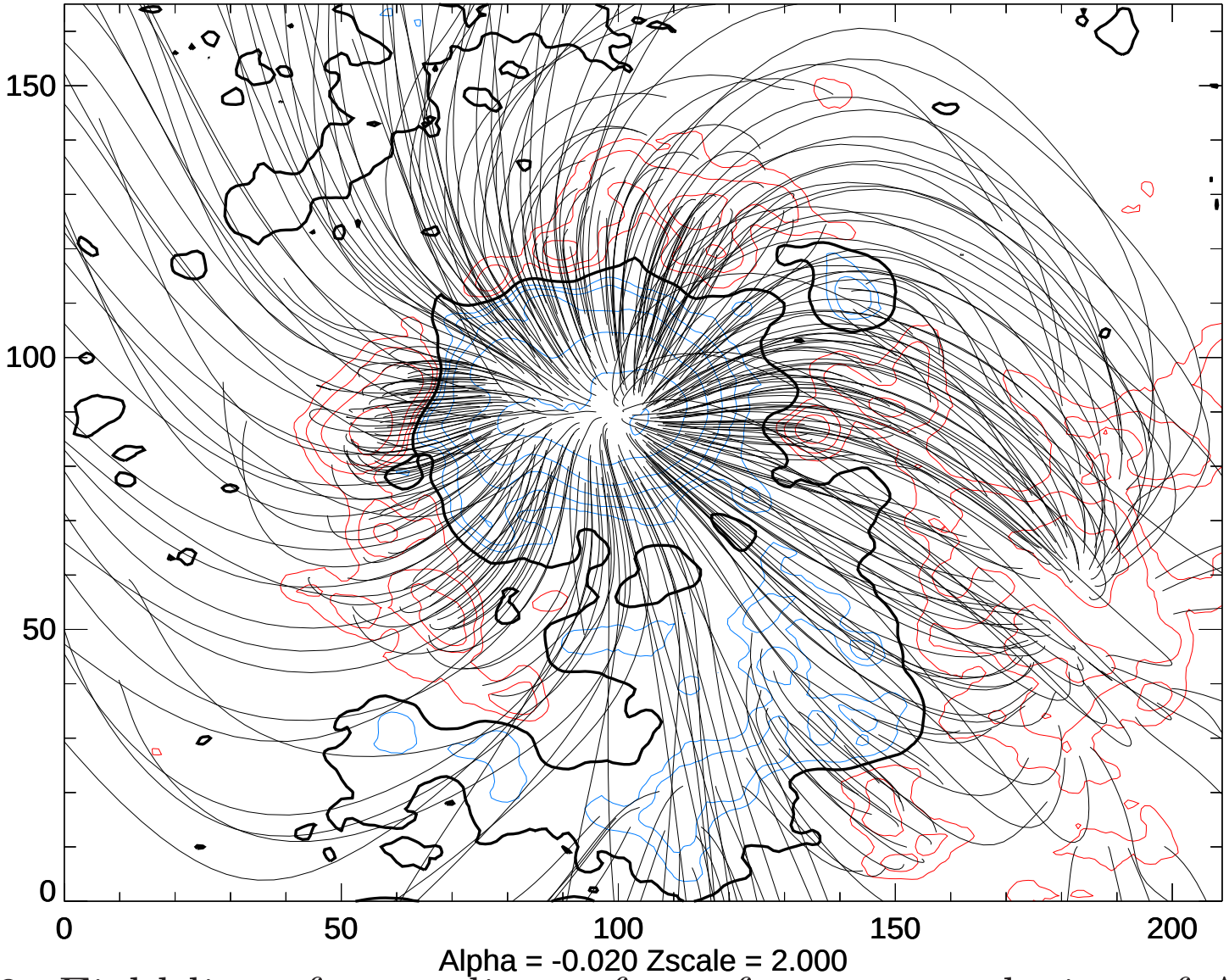

Figure 3: Field lines from a linear force-free extrapolation of AR 8210

Submergence/Emergence & Reconnection

The changes in the N_d domain fluxes ψ_r are related to the changes in the N_s source fluxes Φ_a through the incidence matrix

$$\Delta\Phi_a = \sum_{r=1}^{N_d} M_{ar}\Delta\psi_r \tag{1}$$

In general, the domain flux changes will combine reconnection and submergence/emergence

$$\Delta\psi_r = R_r + S_r \tag{2}$$

Reconnection does not change the source fluxes, so

$$\Delta\Phi_a = \sum_{r=1}^{N_d} M_{ar}S_r \tag{3}$$

But in general, there is no unique solution for the amount of submergence/emergence (i.e., M is not of full rank)

Submergence/Emergence & Reconnection (cont.)

Assume that there is always pair-wise emergence/submergence (as in fluxropes), so that pairs of sources must increase and decrease together. The incidence matrix corresponding to this is of full rank, so can be inverted

$$S_r = \sum_{a=1}^{N_s} [M^{(T)}]^{-1}_{ra} \Delta\Phi_a \tag{4}$$

How are pairs determined? For now: largest change in domain flux. (Anyone have a better suggestion?)

Knowing submergence/emergence, can determine reconnection

$$R_r = \Delta\psi_r - \sum_{a=1}^{N_s} [M^{(T)}]^{-1}_{ra} \Delta\Phi_a \tag{5}$$

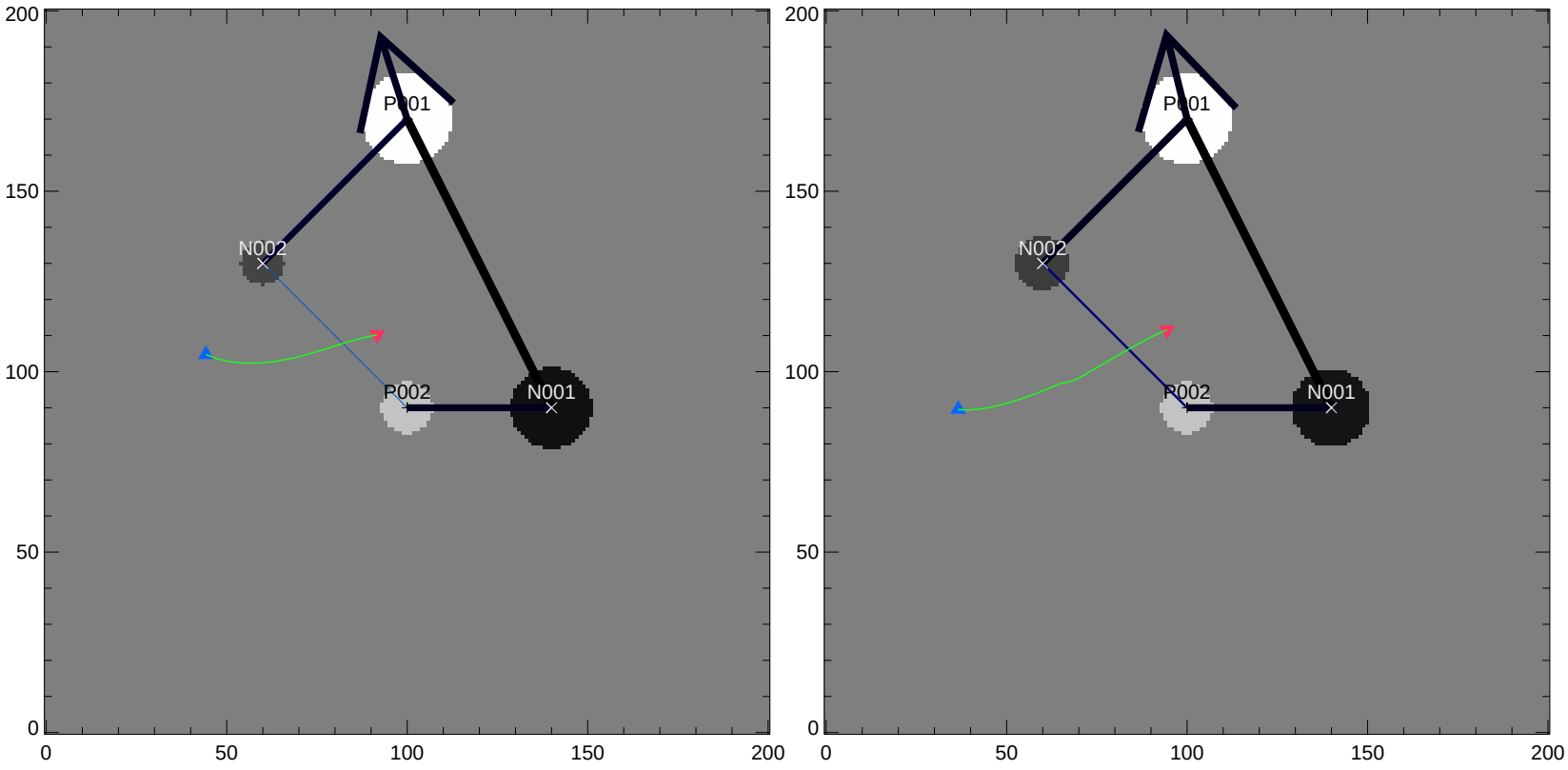

Figure 4: Evolution of the Simple Example

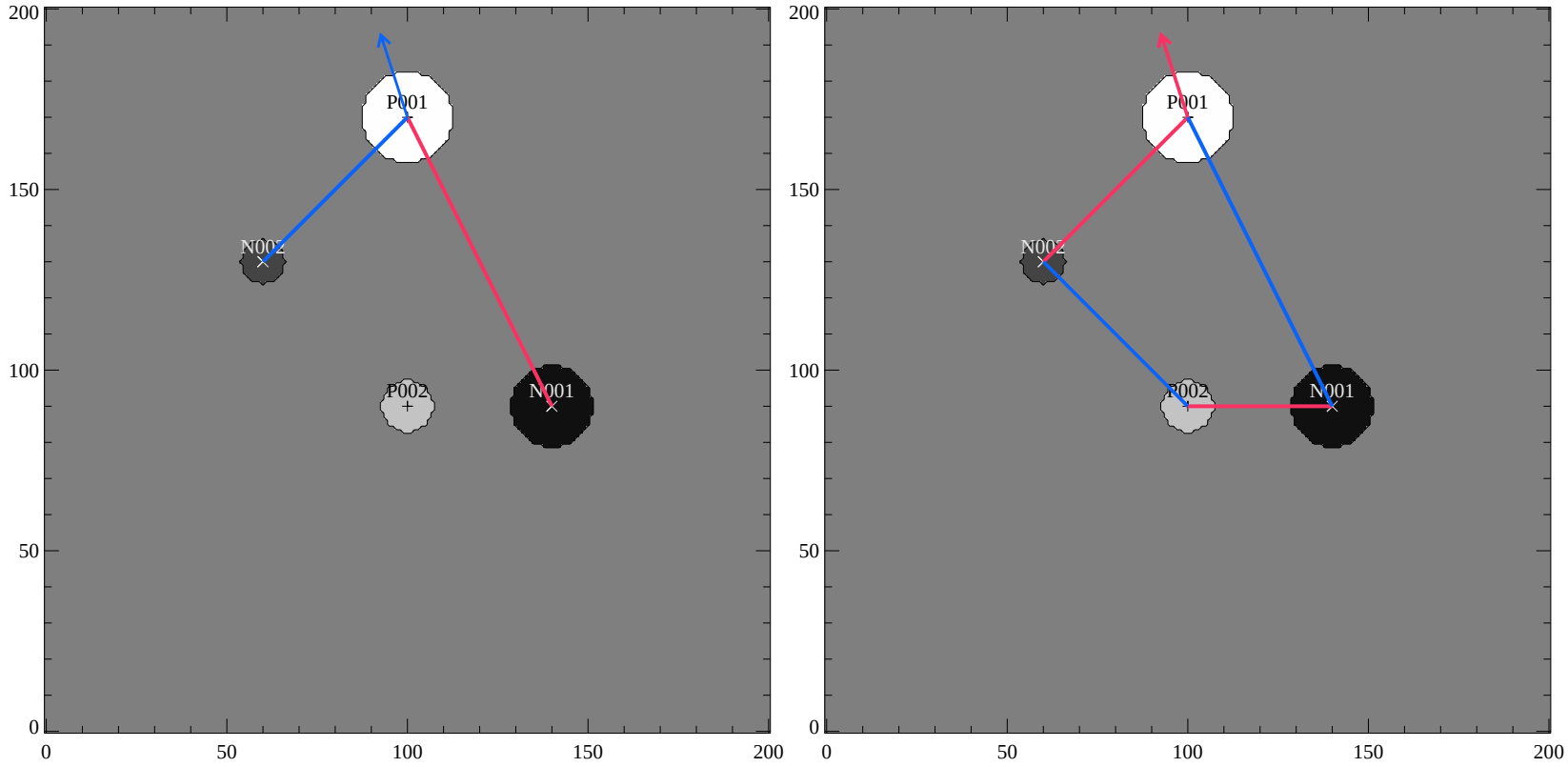

Figure 5: Left: rate of emergence (blue) and submergence (red). Right: rate of reconnection - increasing domain flux in blue; decreasing domain flux in red.

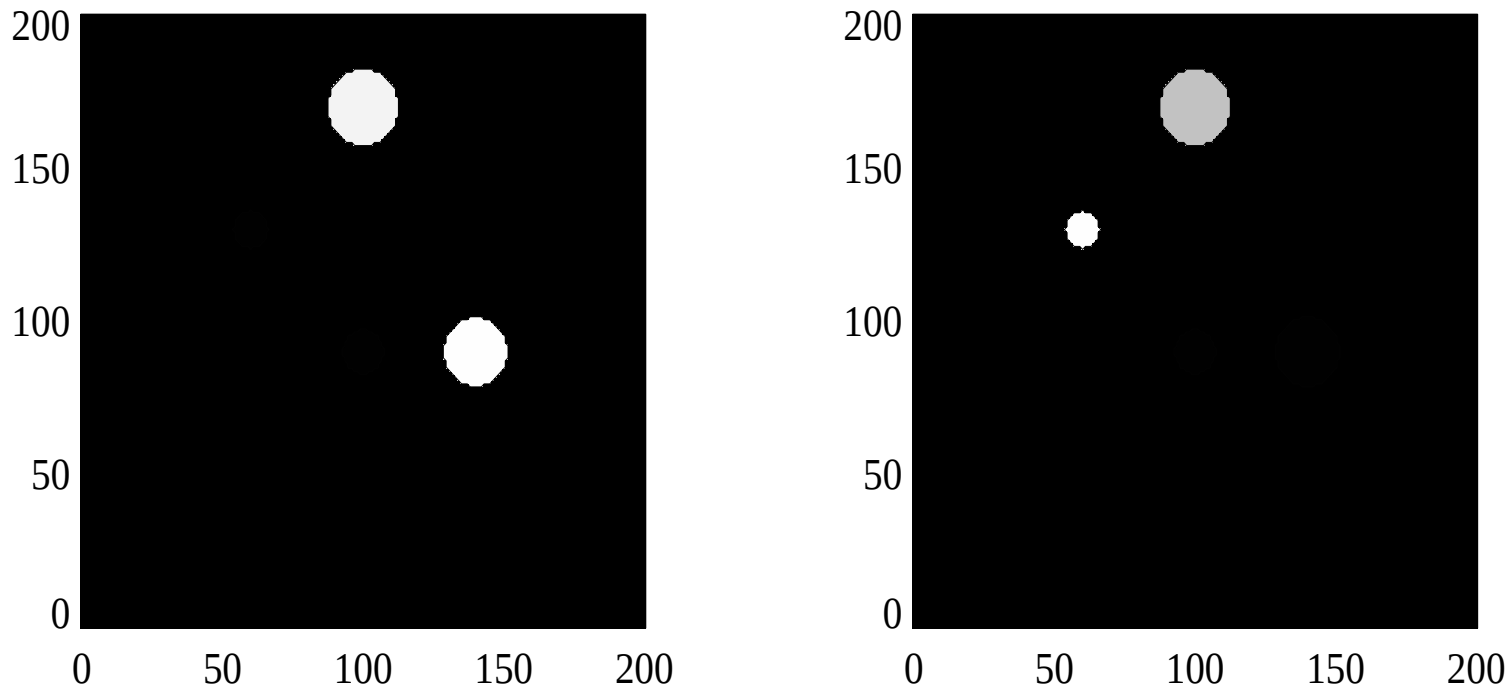

Figure 6: Rate of submergence (left) and emergence (right)

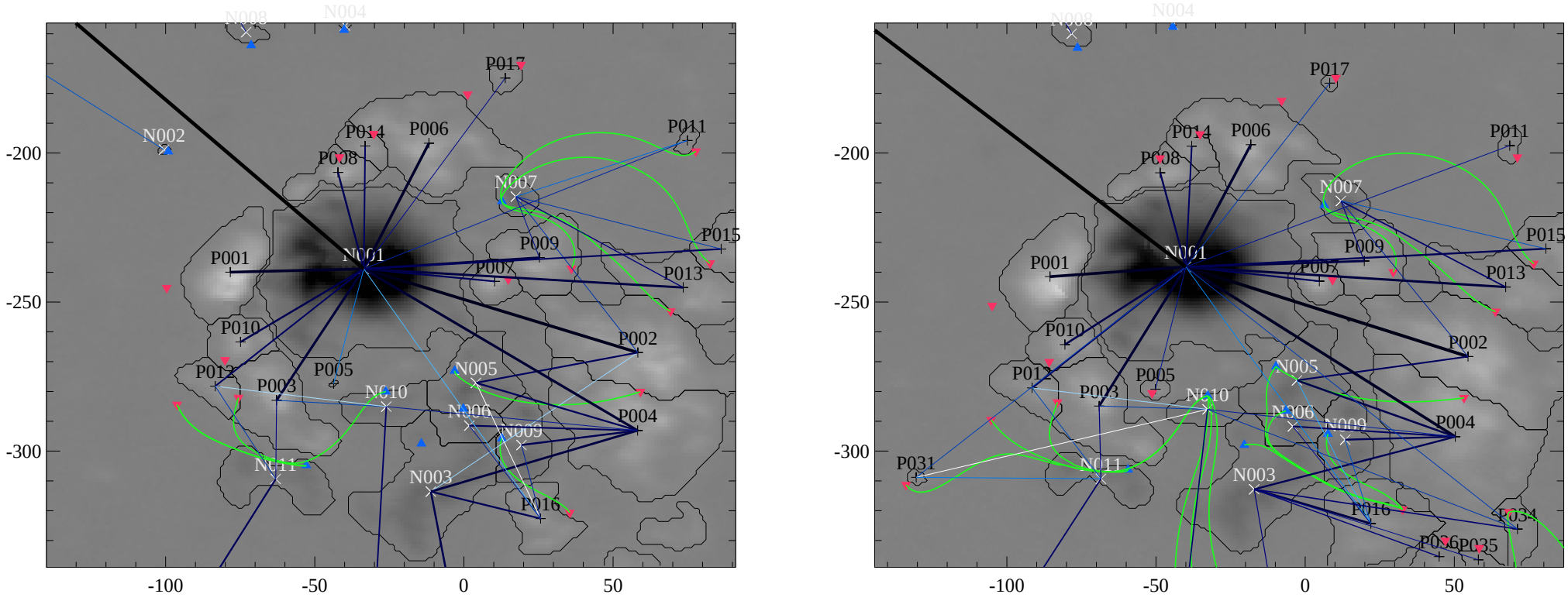

Figure 7: Evolution of AR8210

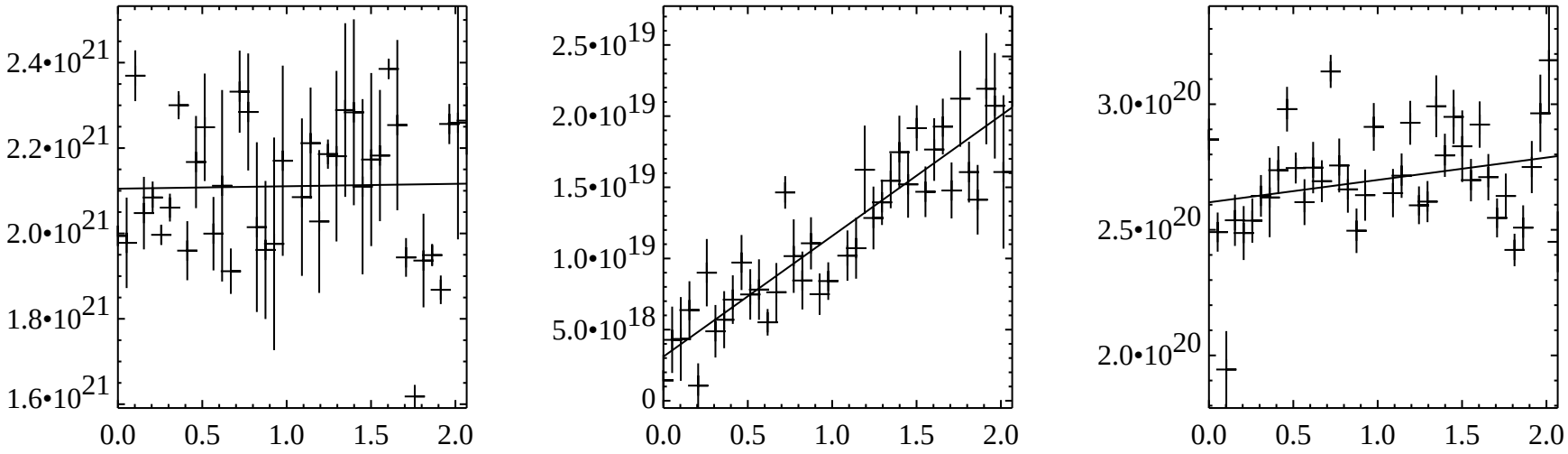

Figure 8: Flux as a function of time for selected sources

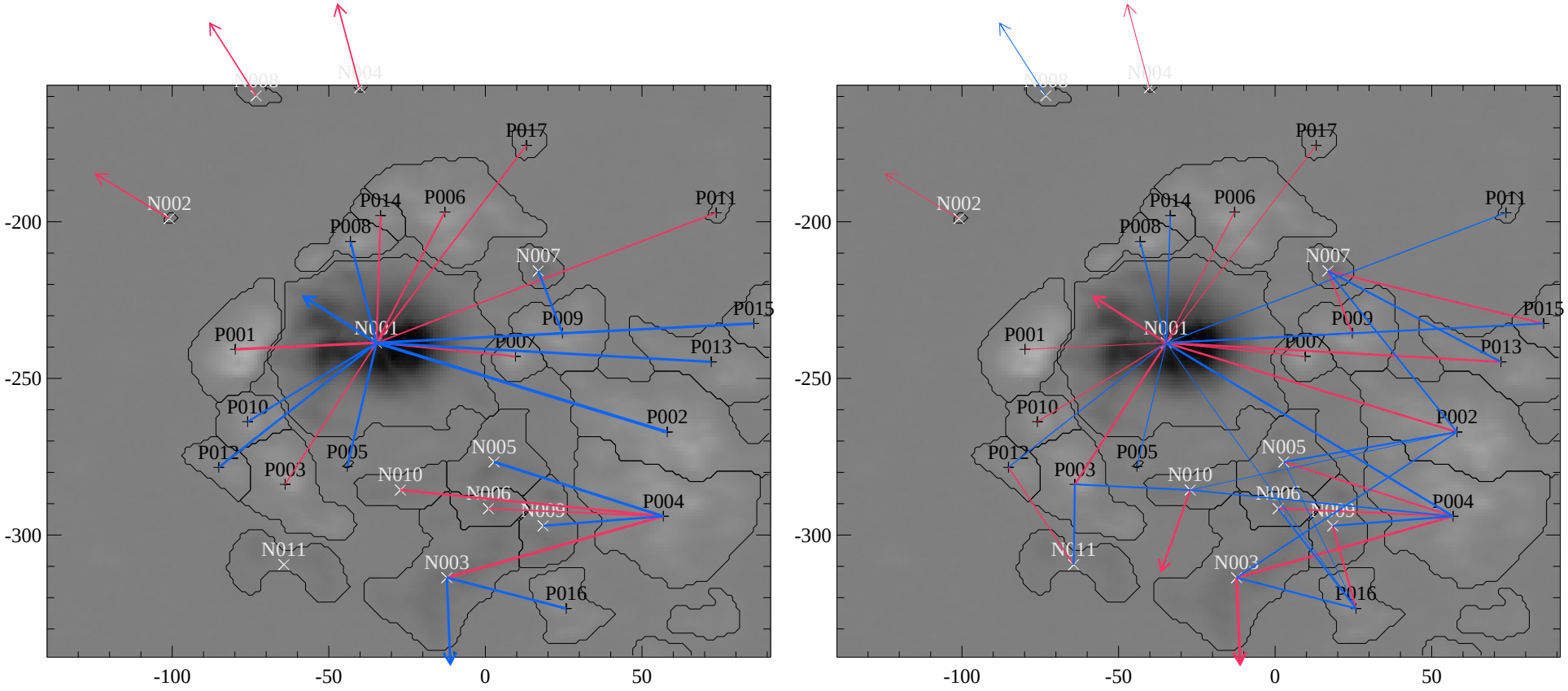

Figure 9: Left: rate of emergence (blue) and submergence (red). Right: rate of reconnection - increasing domain flux in blue; decreasing domain flux in red.

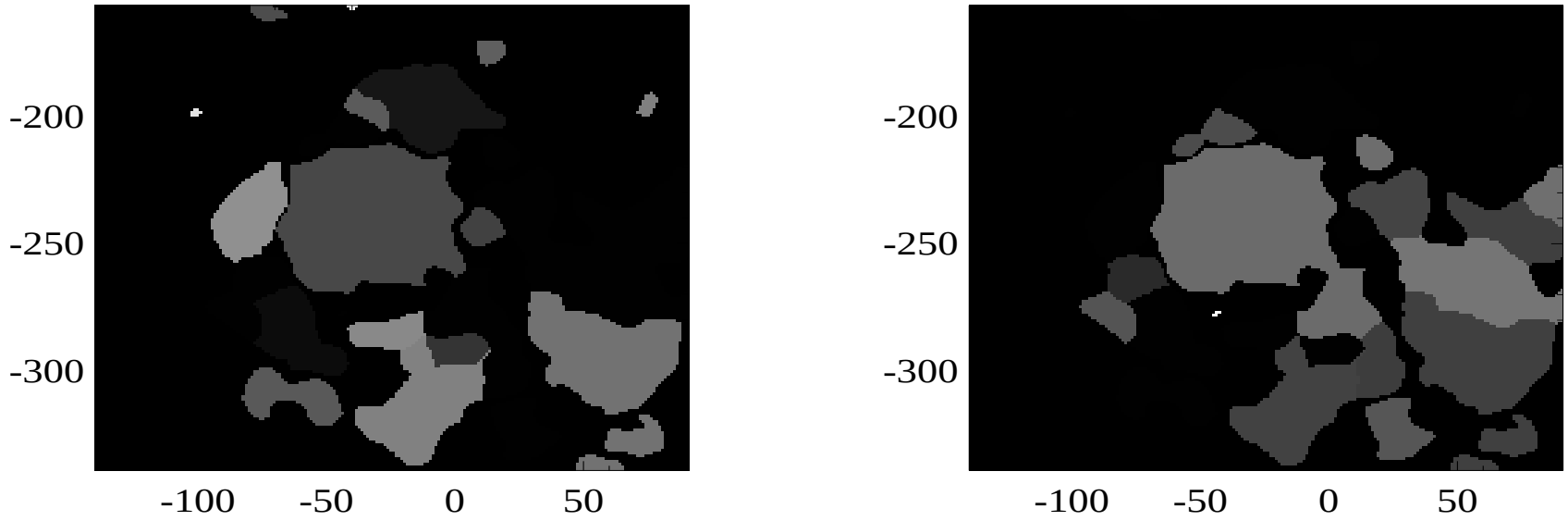

Figure 10: Rate of submergence (left) and emergence (right)

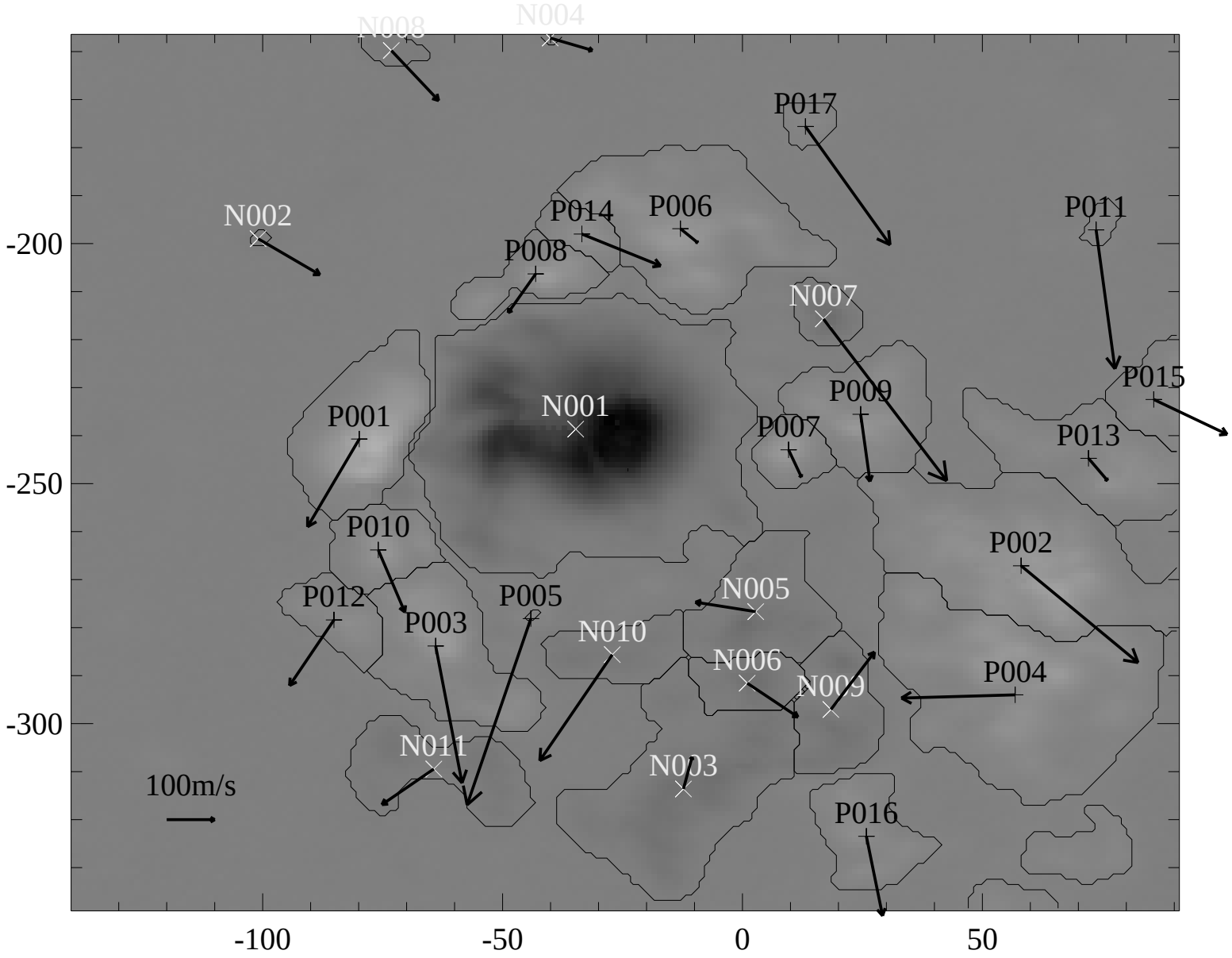

Figure 11: Horizontal velocities

Summary

- What can one get out of MCT?
  - Quantitative measures of coronal topology
  - Estimate of rates of flux emergence and reconnection
  - Estimate of the horizontal velocities