Properties of solar plage from a spatially coupled inversion of Hinode SP data

MAX-PLANCK-GESELLSCHAFT

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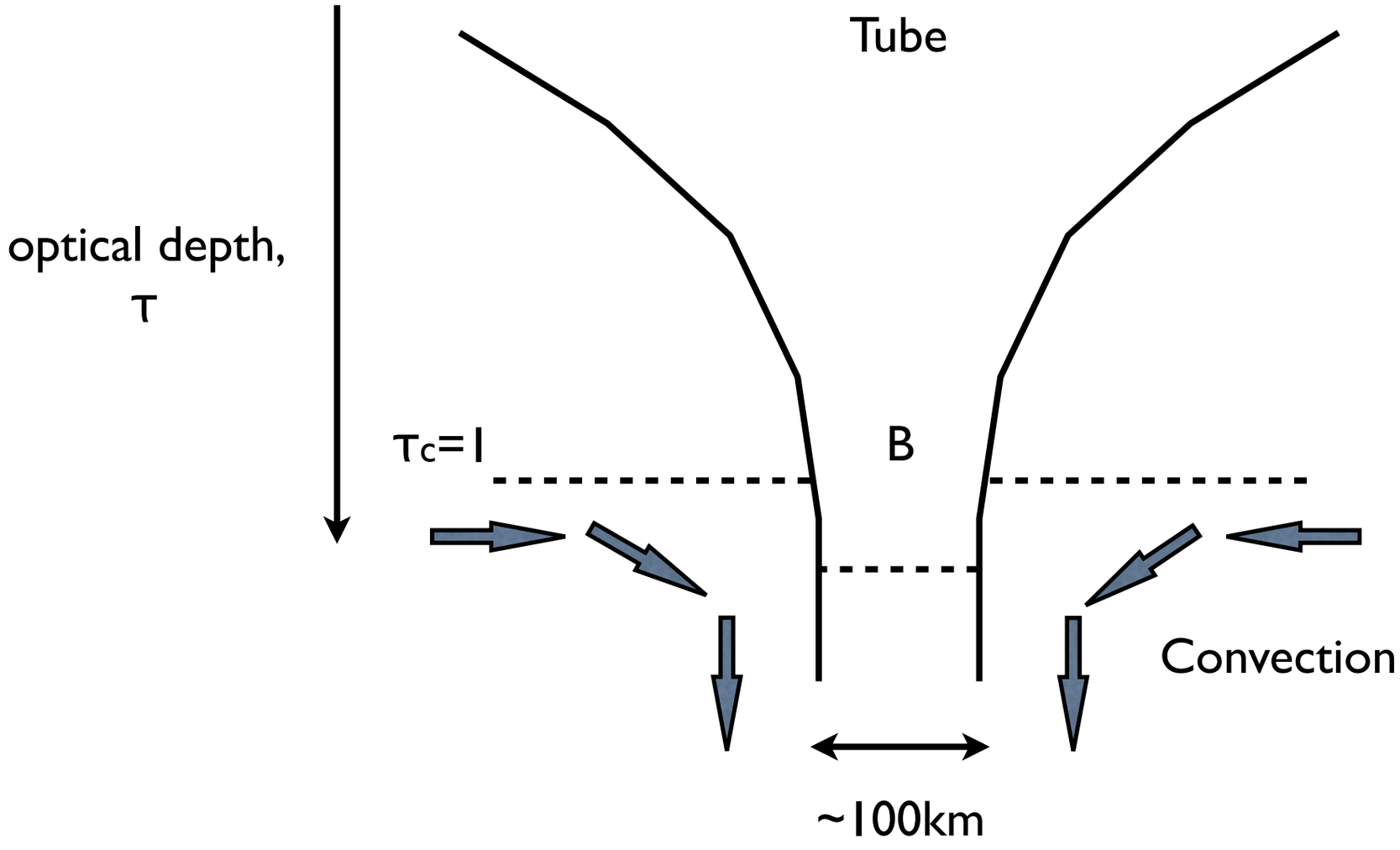
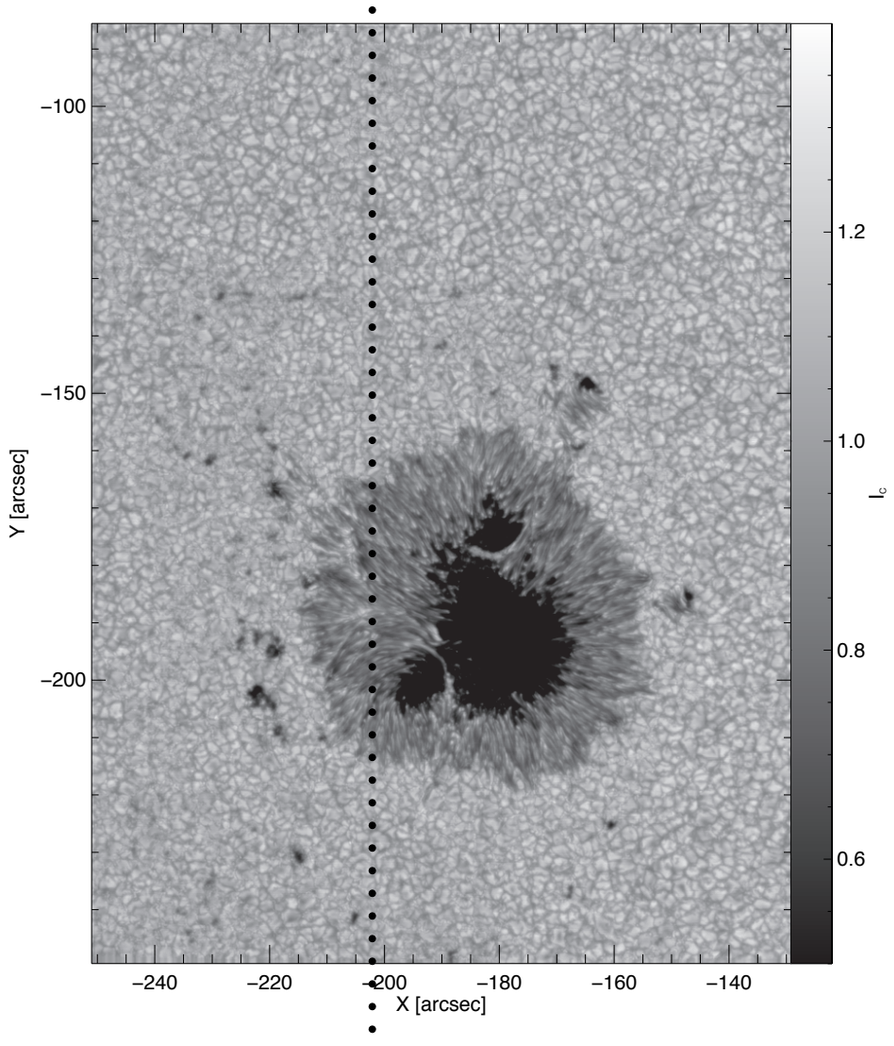
Solar atmosphere & flux tubes

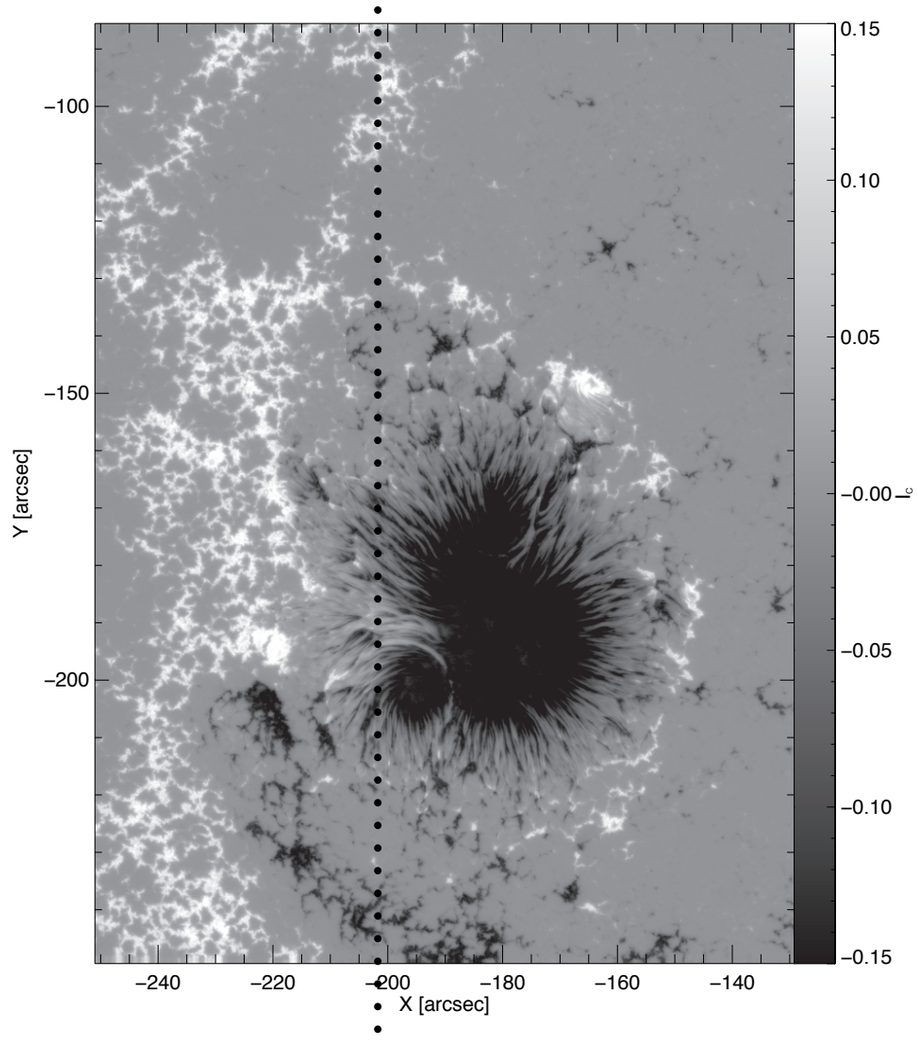


- Magnetic fields arranged in thin kG flux tubes
  - Hot wall effect
- Atmosphere height dependent
  - Magnetic canopies

SOT/SP Observation



Stokes I continuum

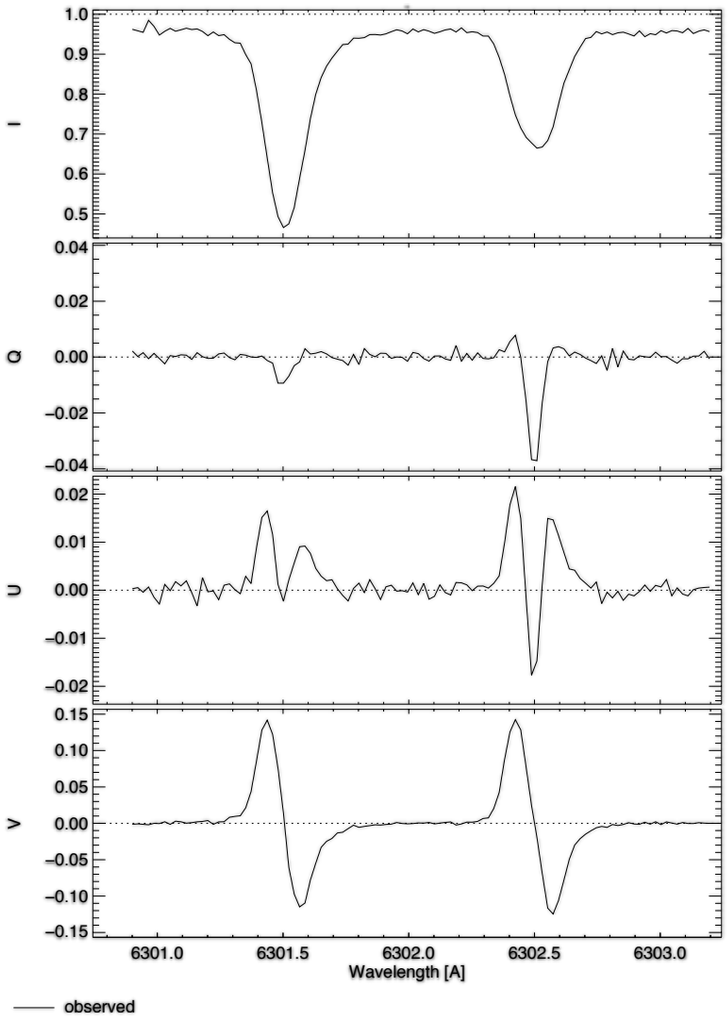


Stokes V

- Normal mode observation
  - 0.16 arcsec
  - Stokes I,Q,U,V
- AR 10953
  - 30th April 2007
  - southern hemisphere, μ=0.97

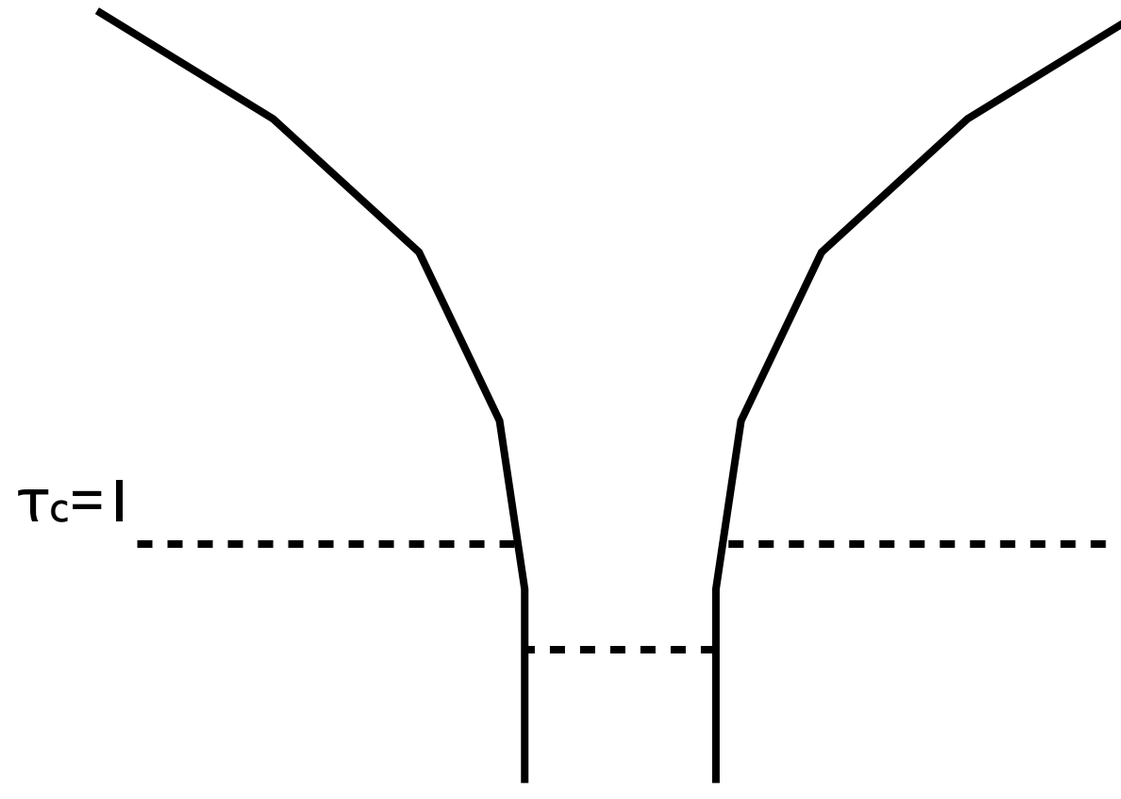
Inversion: SPINOR code

observed spectra



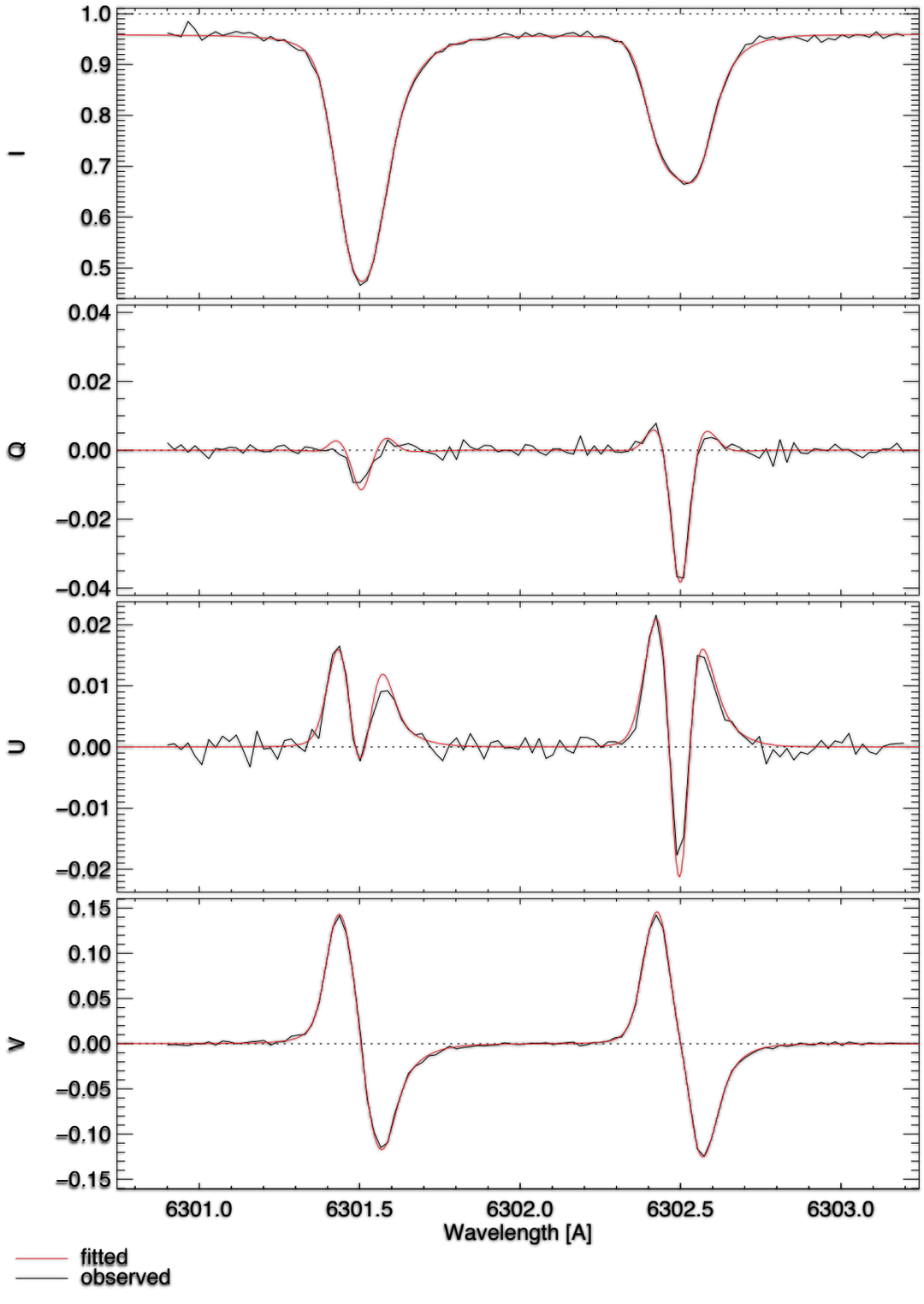
Radiative transfer

Atmosphere:
T, B, γ, ϕ, v, ε

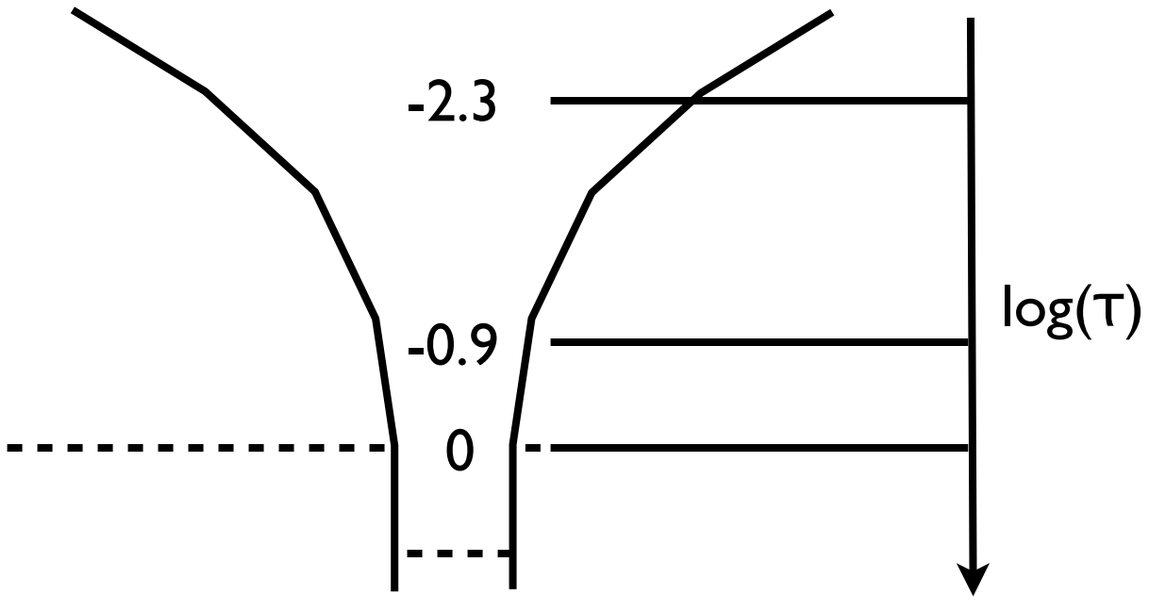


- Hydrostatic equilibrium
- LTE

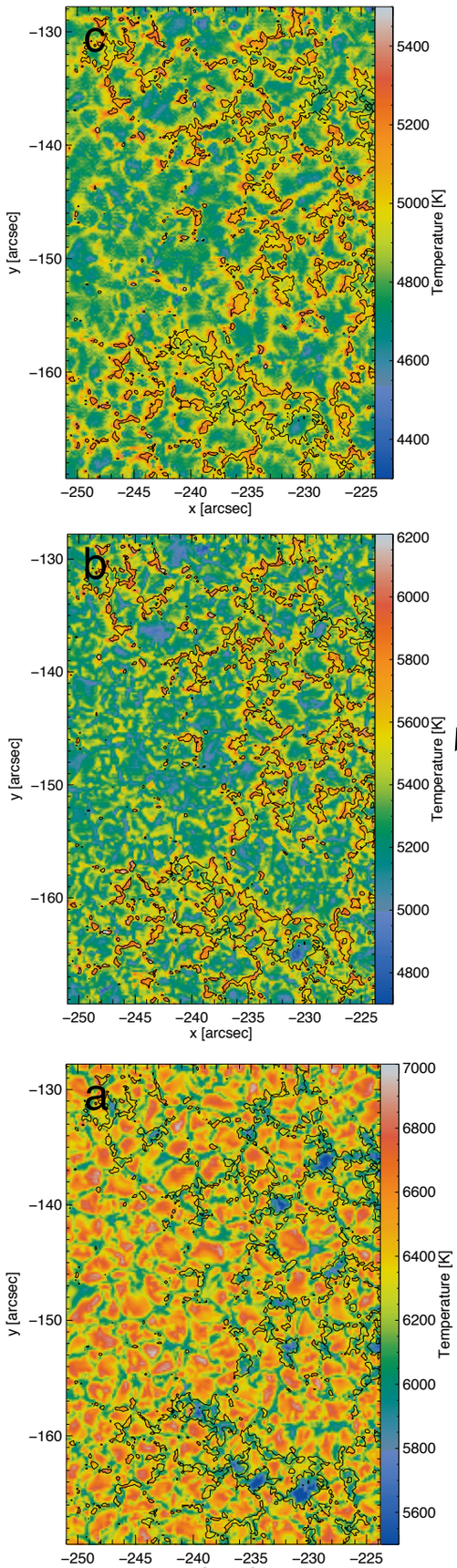
Inversion: SPINOR fit



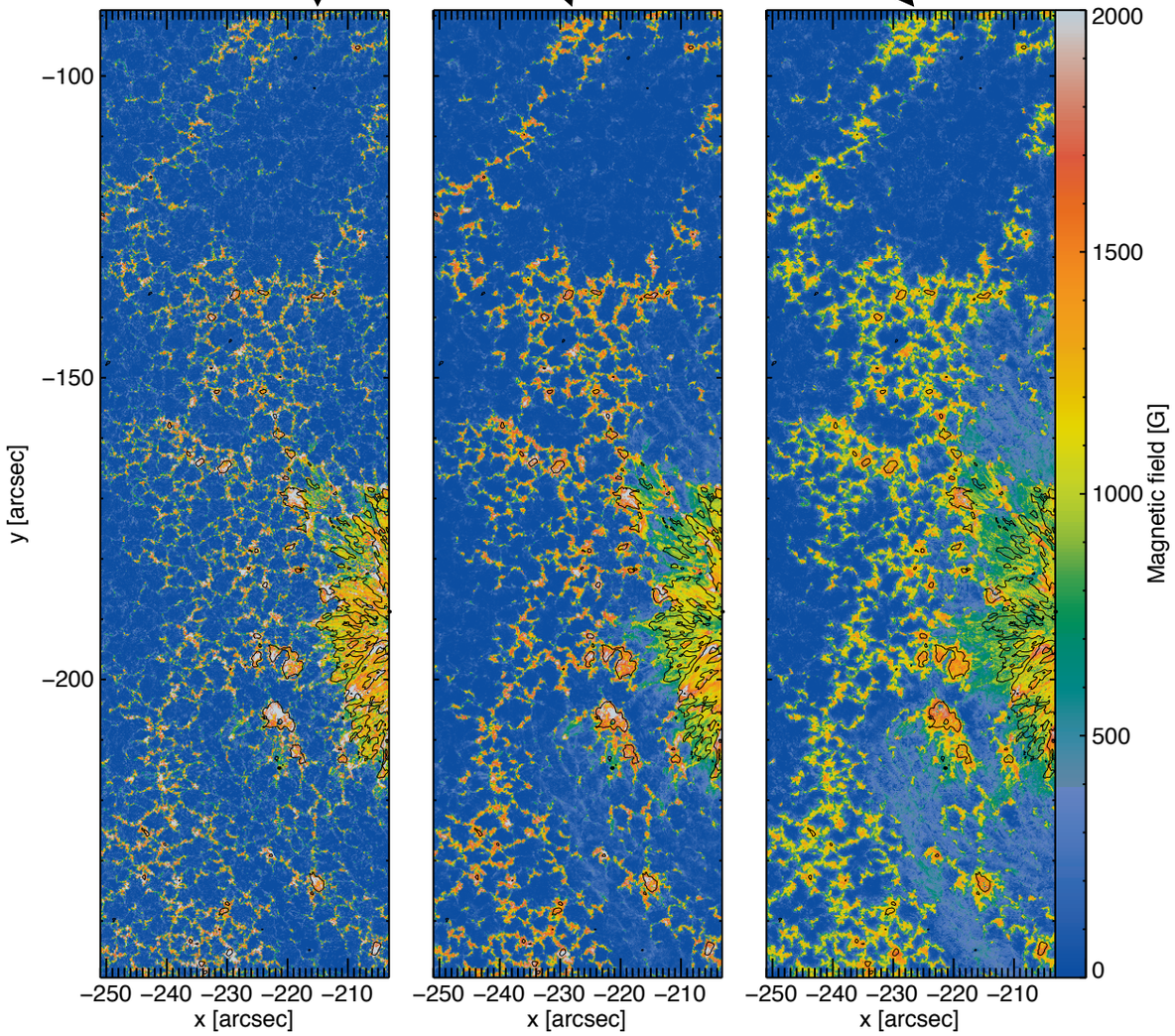
- 2D SPINOR code by van Noort (2012)
- 3 nodes in log(τ): 0, -0.9, -2.3
- 1 component atmosphere
- 18 free parameters
  - T, B, γ, ϕ, v, ε



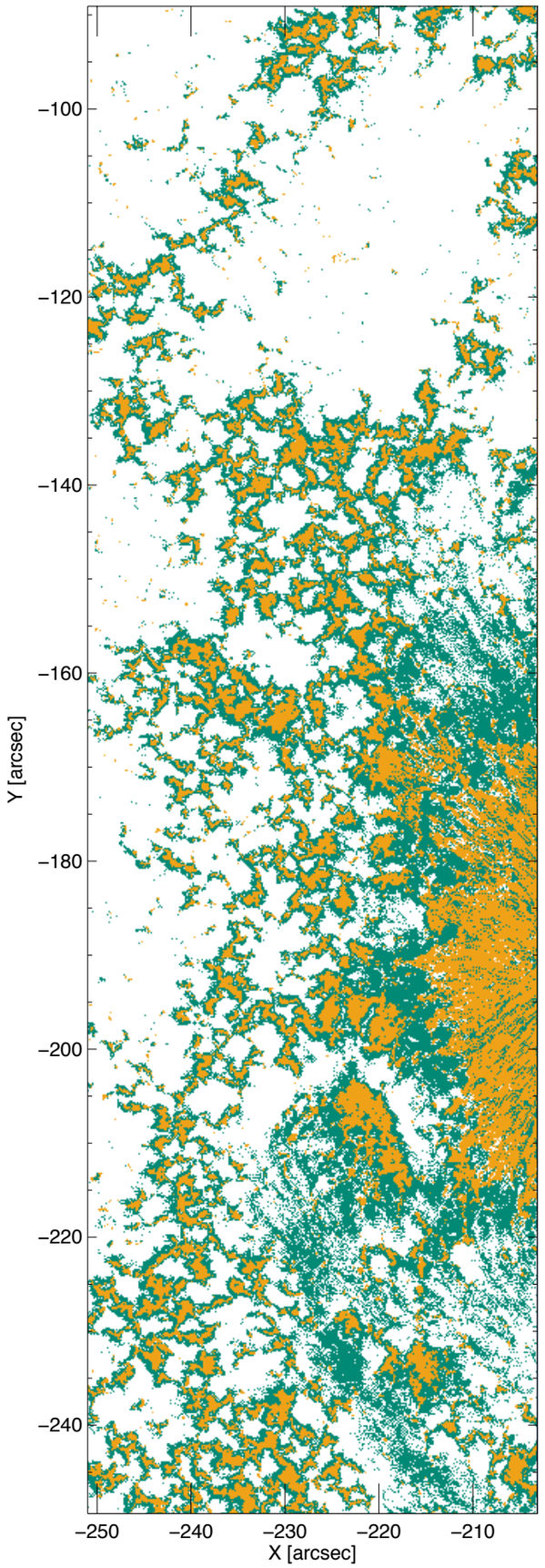
Inversion: results

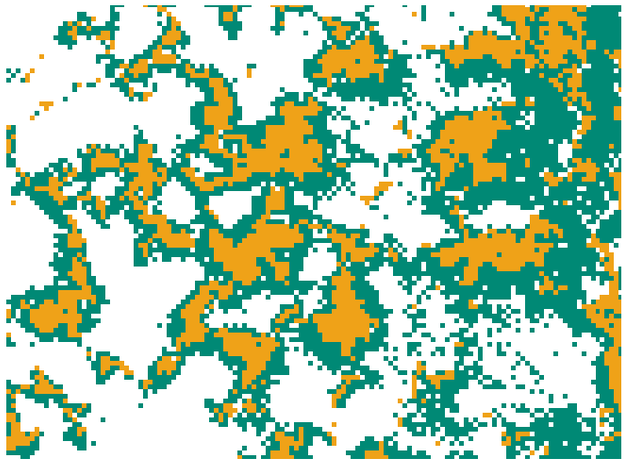


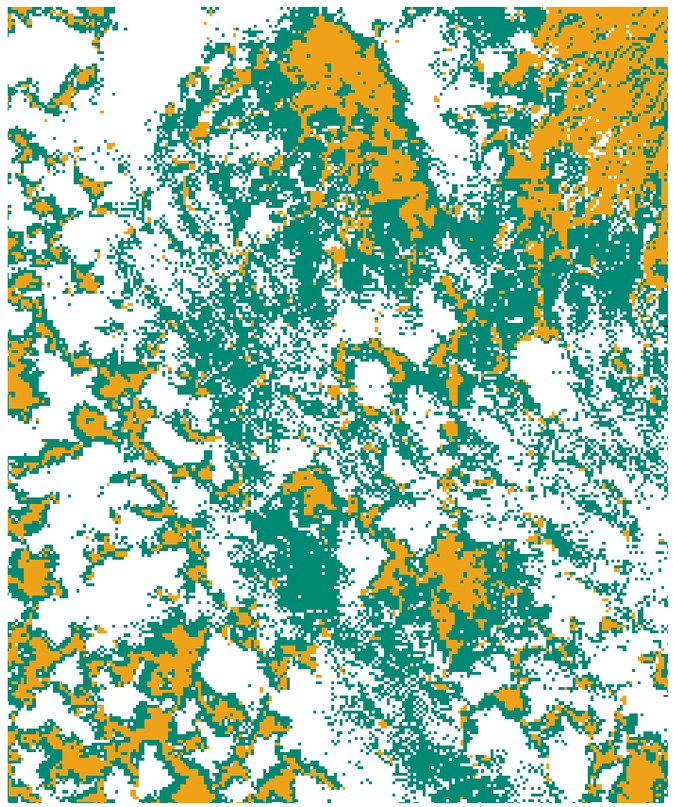
- Magnetic field
- Temperature
- Velocities
- Inclination



Core & Canopy fields

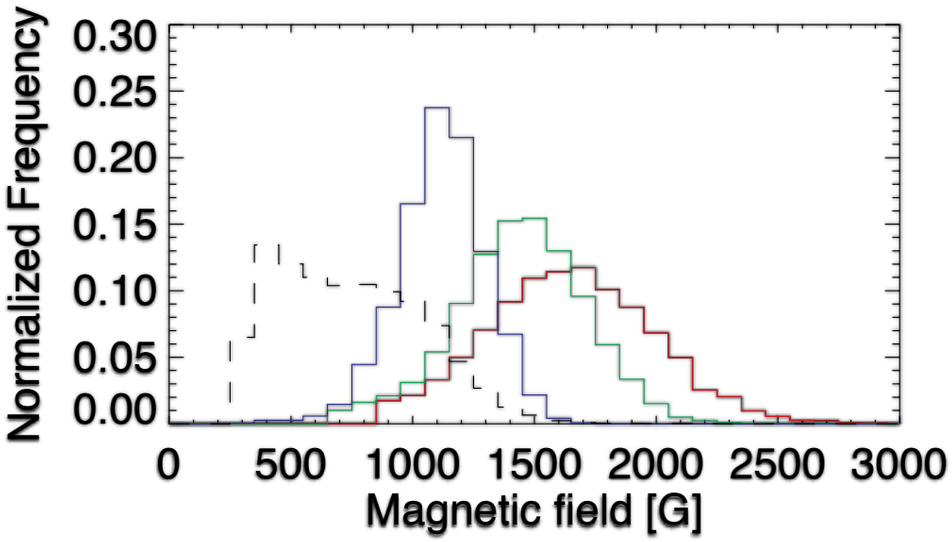


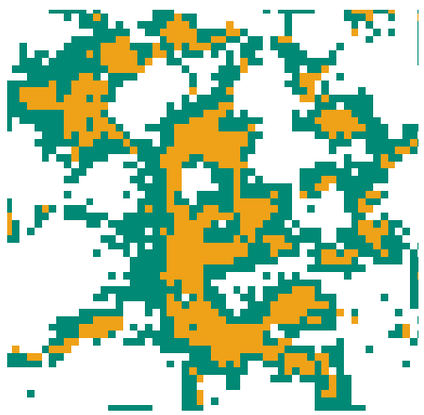




- Core (orange)
- Canopy (green)
- Canopy forms rings around cores
- Filament & sunspot's canopy visible

Magnetic field

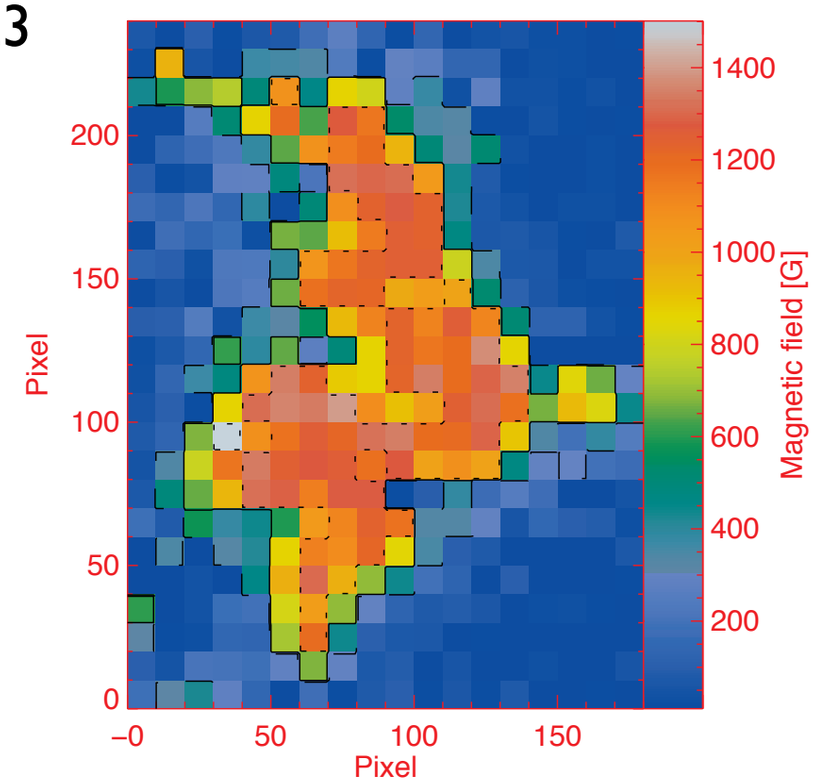




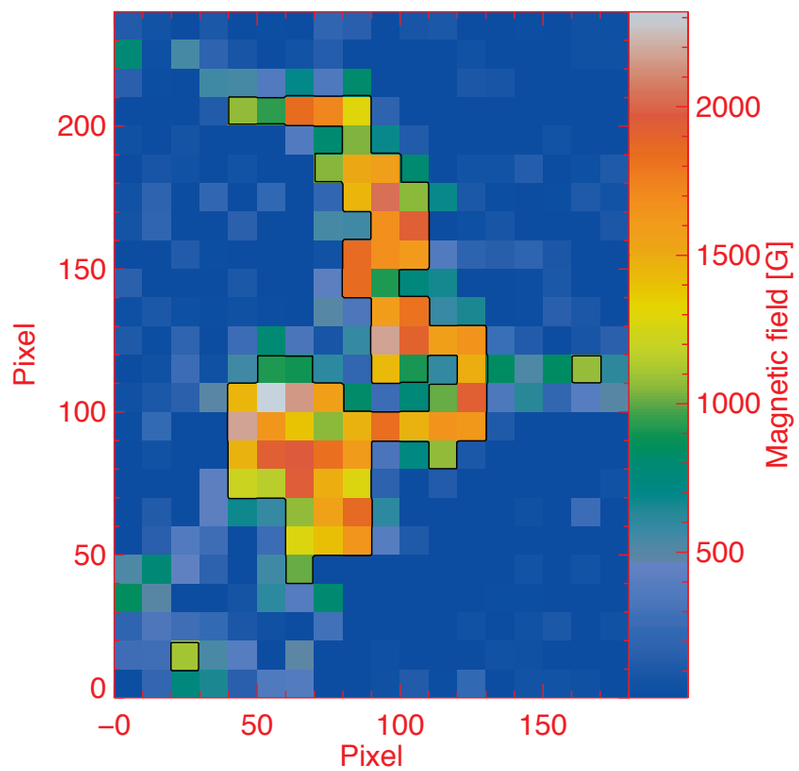
- Core pixels
  - ⟨B⟩ = 1500G at log(τ) = -0.9
    - Magnetic field strength drops with height
- Canopy pixels
  - generally weaker fields

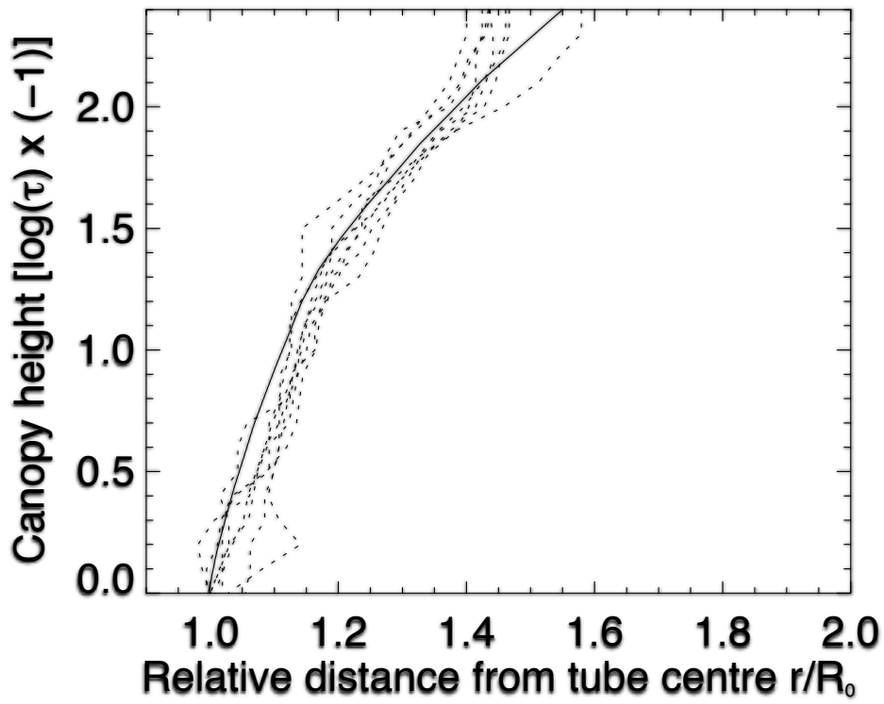
Expansion of magnetic features

log(τ)=-2.3



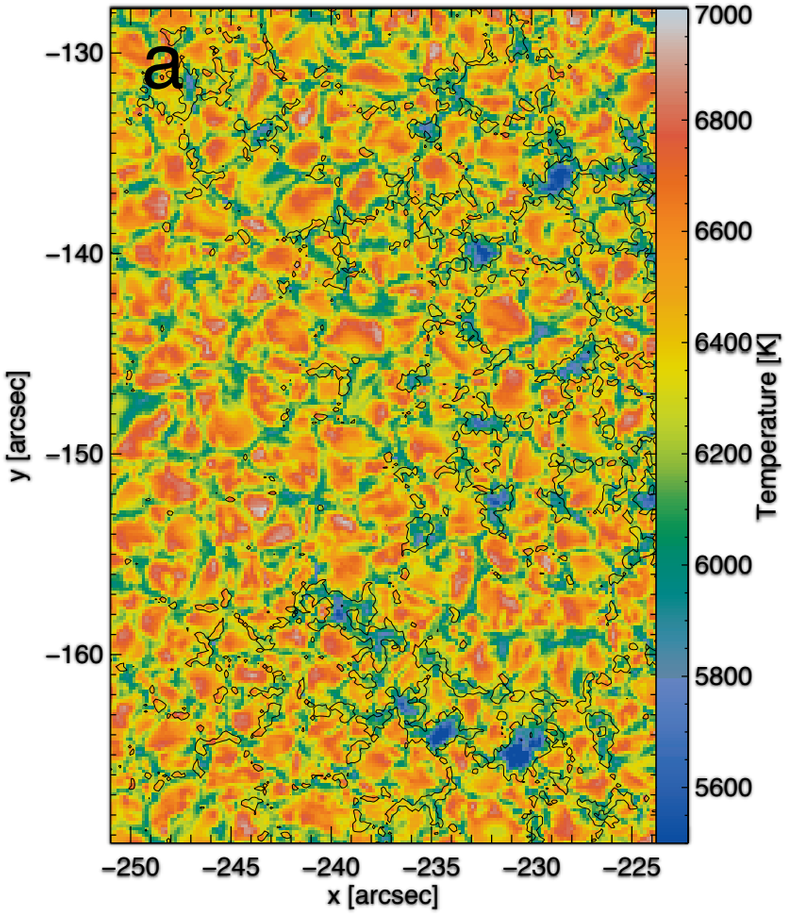
log(τ)=0

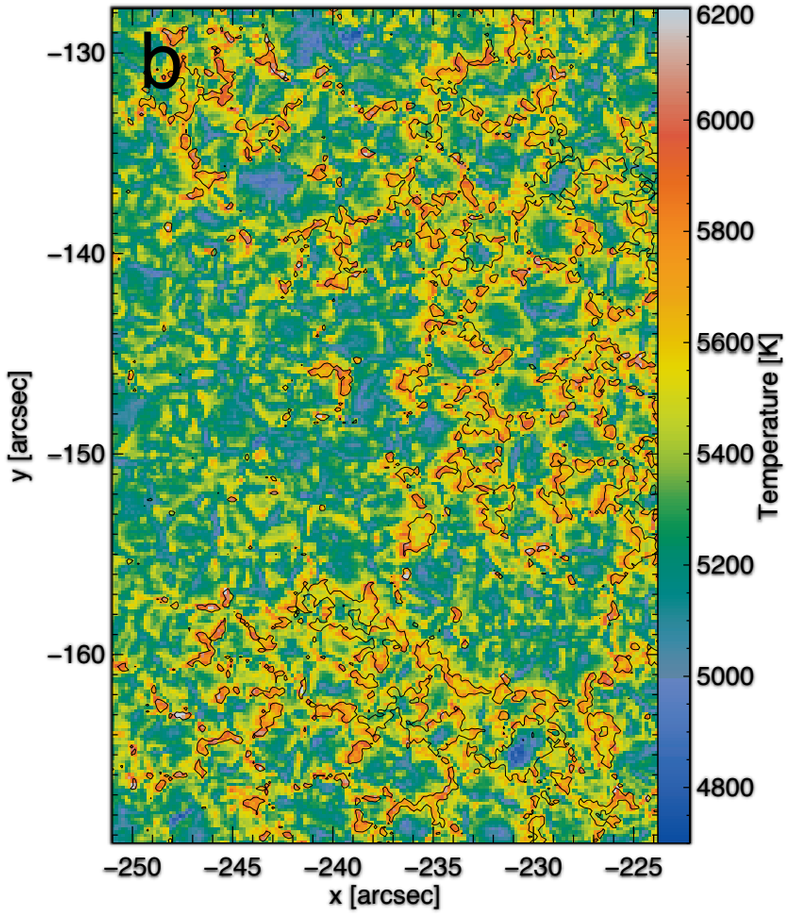


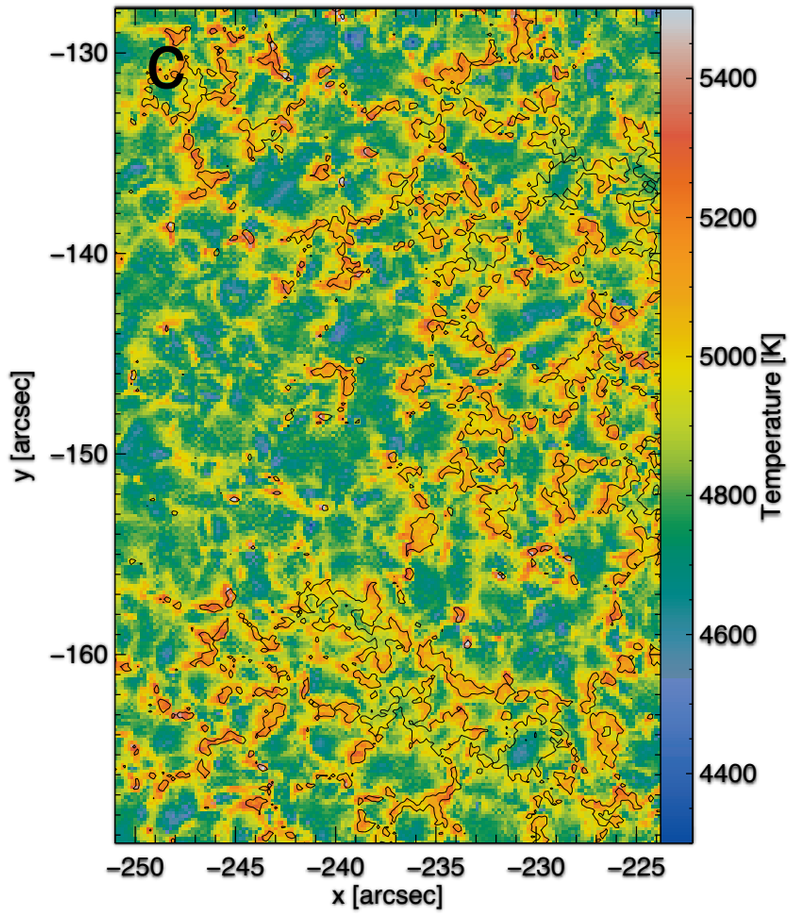


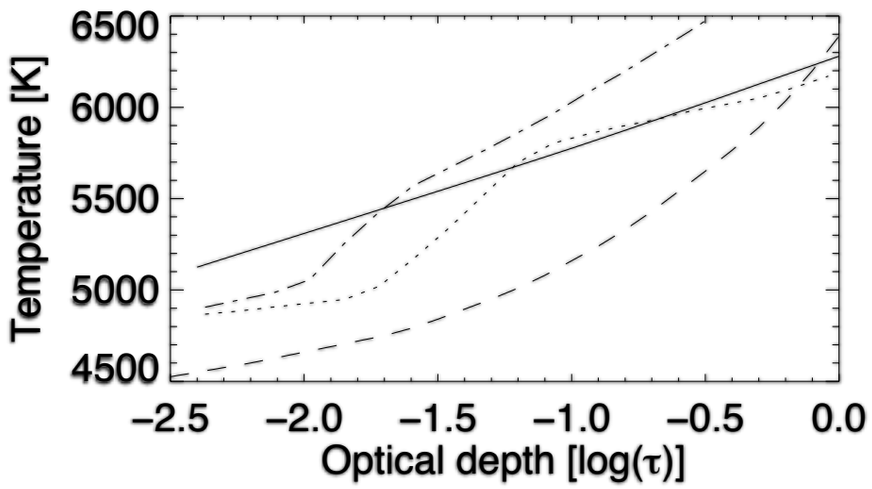
- Selected 7 isolated features
- Expansion of features similar to zeroth order flux tube model

Temperature





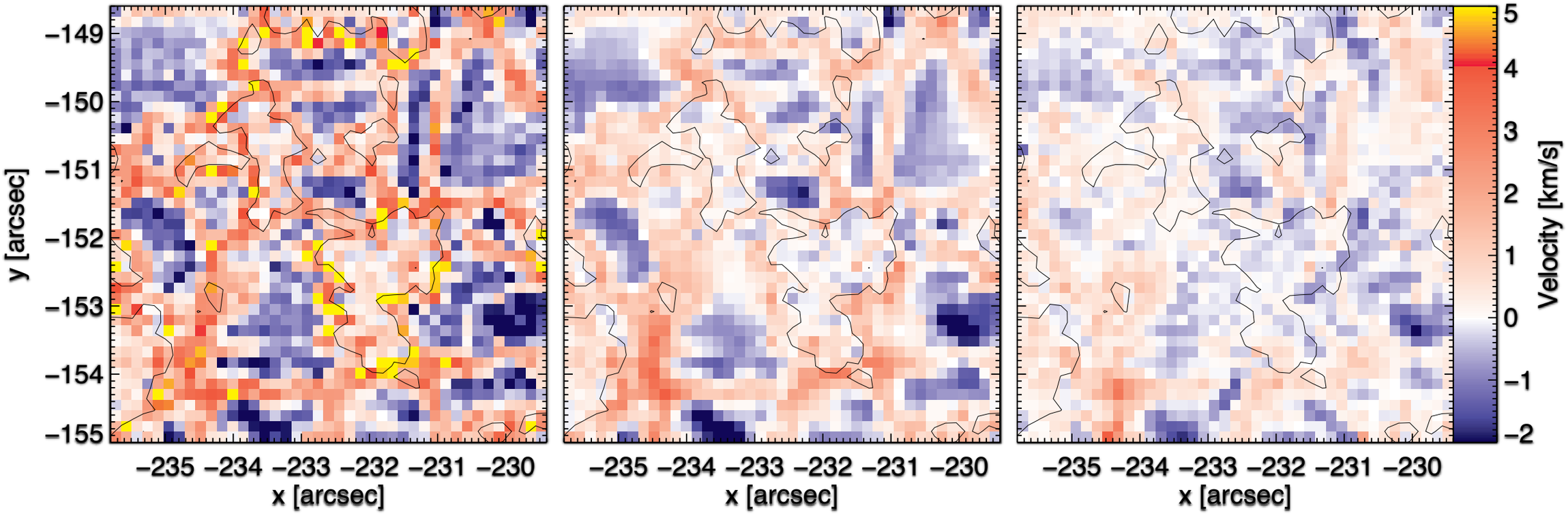


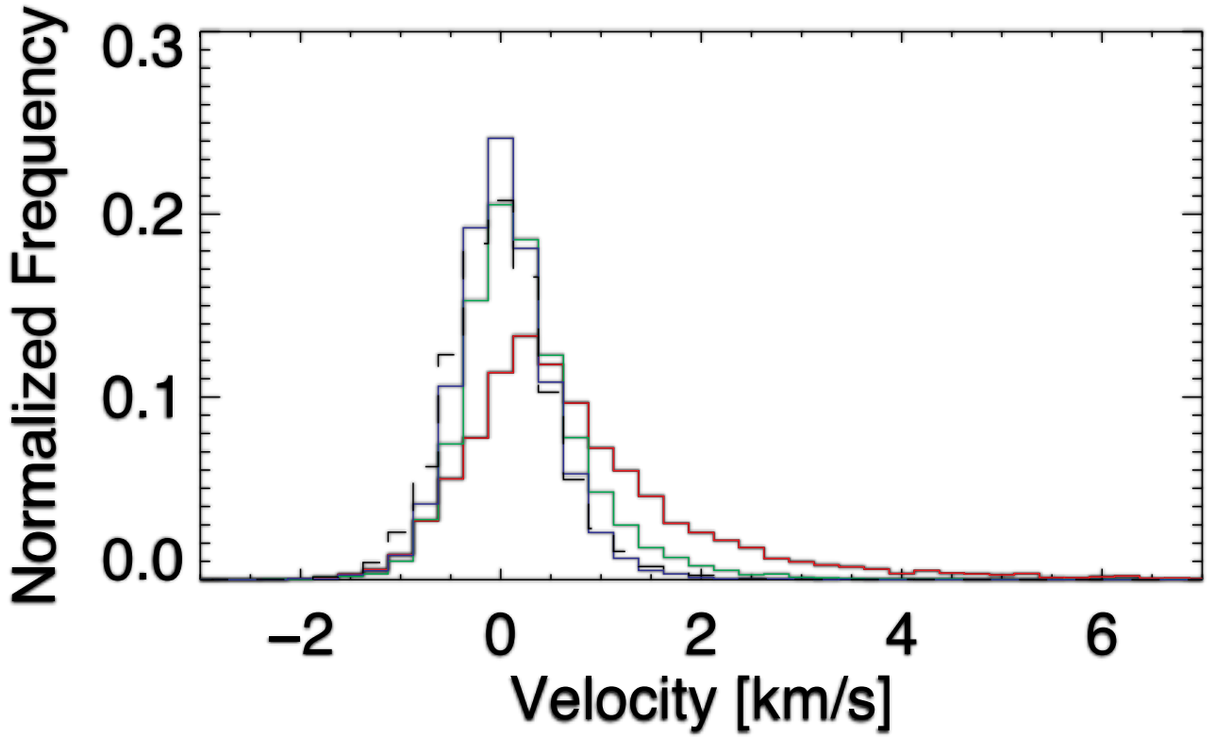


- Network model from Solanki (1986)
- Plage model from Solanki & Brigljevic (1992)
- HSRASP model from Gingerich et al. (1971), Spruit (1974)

- Plage hotter than quiet Sun in higher layers
- Core pixels have similar temperature stratification as plage flux tube model

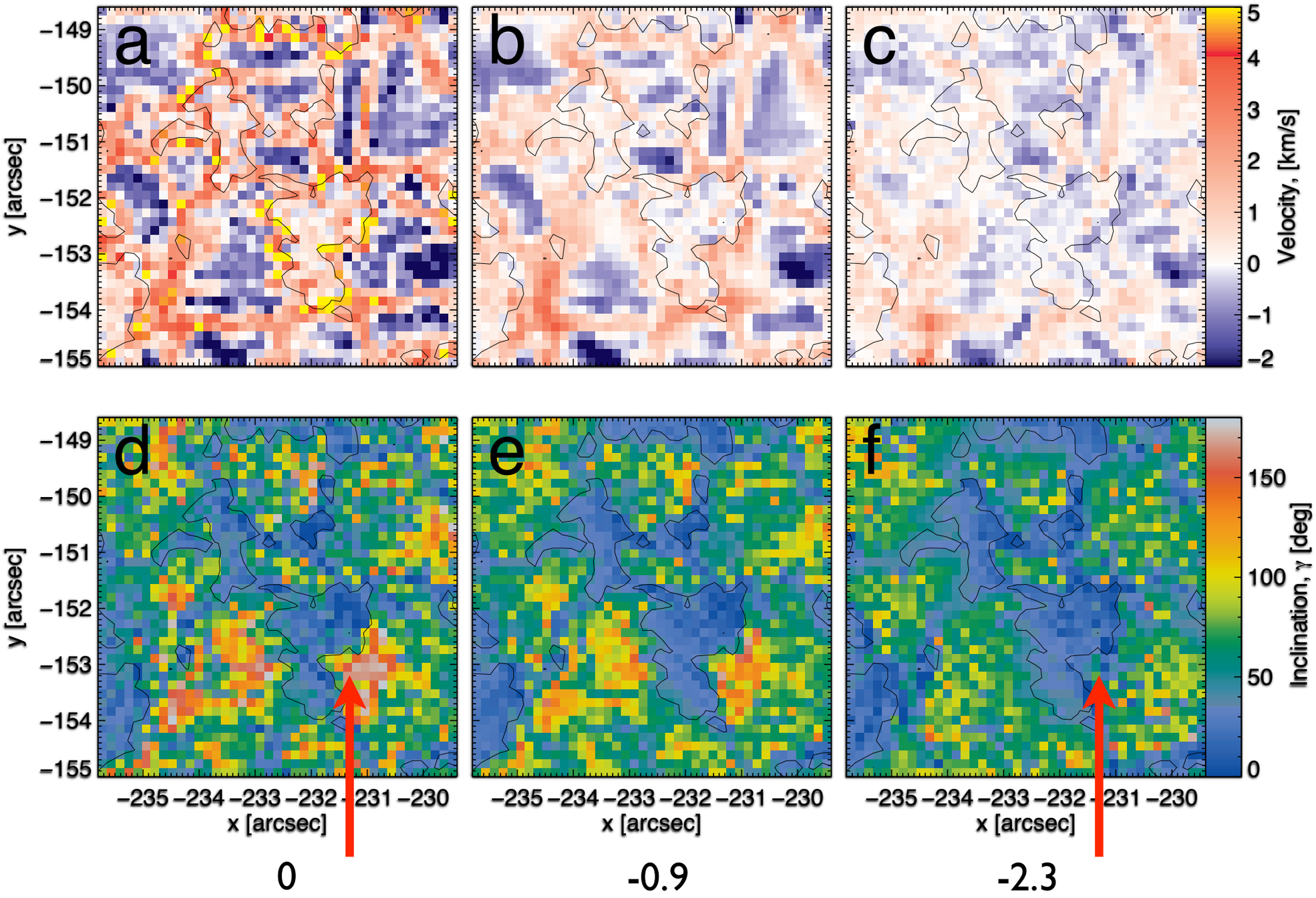
Line-of-sight Velocity





- Weak flows within magnetic features
  - $\langle v \rangle$ = 0.37km/s at log(τ)=-0.9
- magnetic features surrounded by downflows
  - typically 1-3km/s
  - up to 8km/s at log(τ)=0

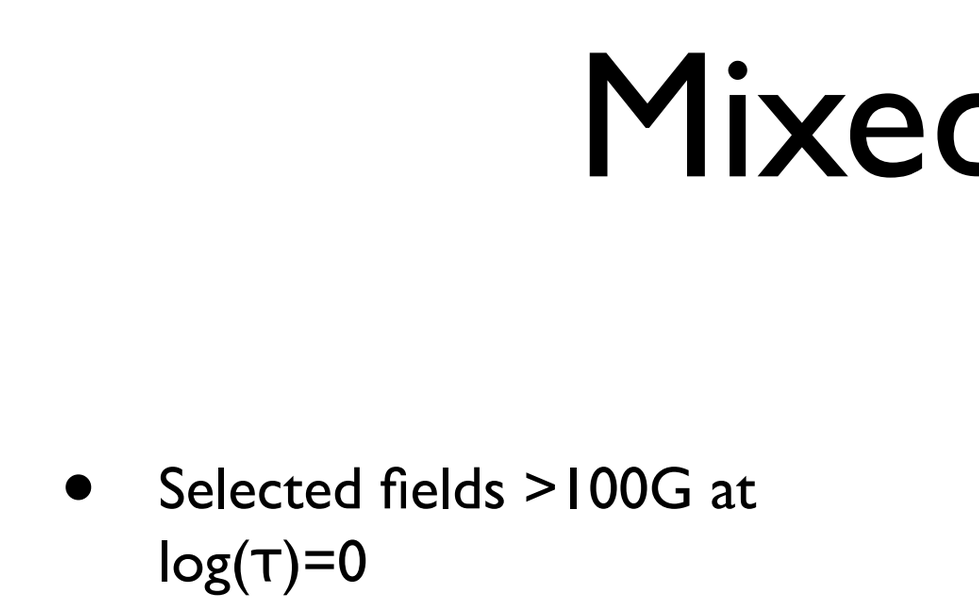
Mixed polarity fields

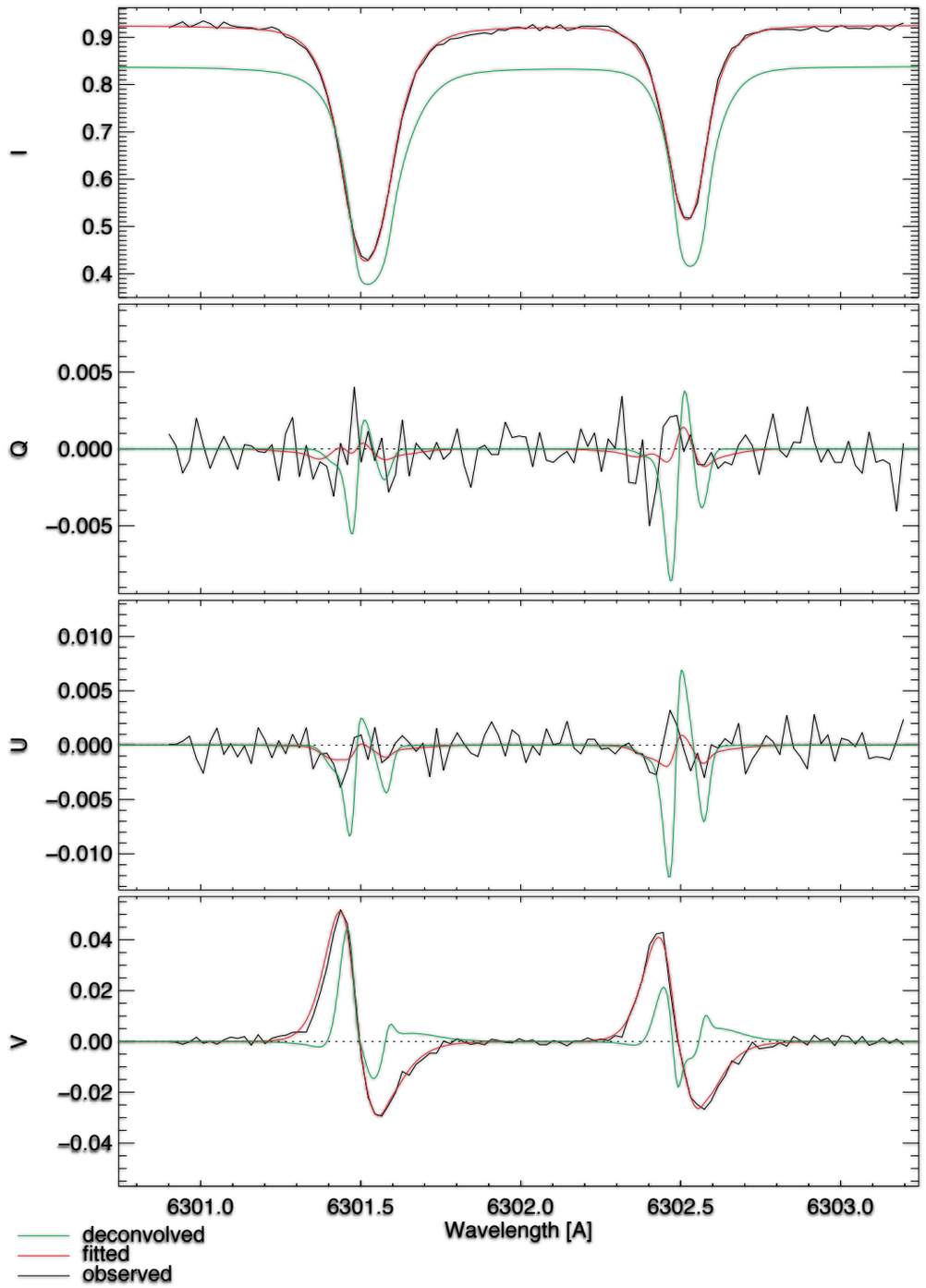


- Opposite polarity fields hidden below canopy of main feature
- Fields are weak
  - <200G at log(τ)=0

Mixed polarities

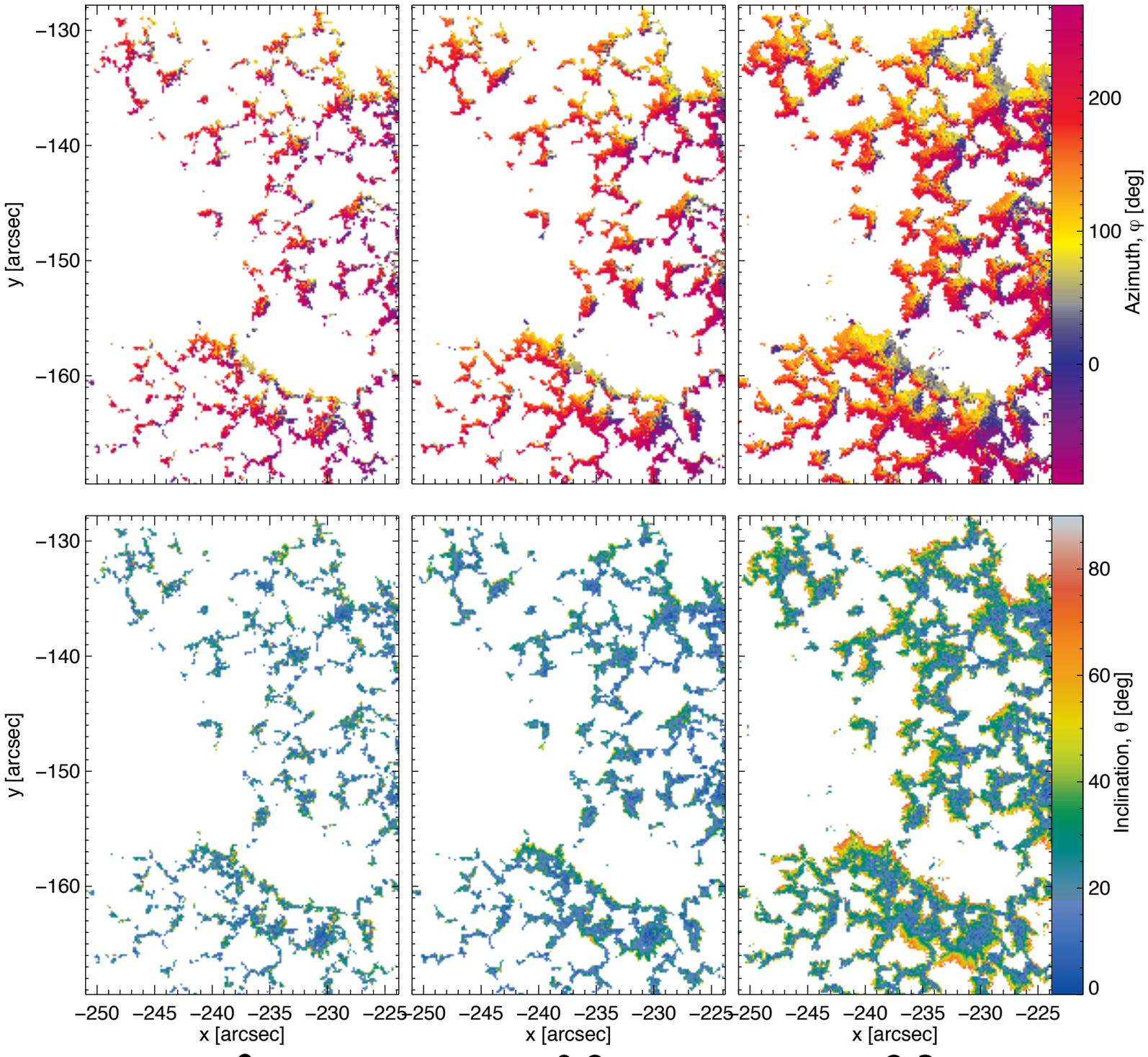
- Selected fields >100G at log(τ)=0
- Opposite polarities located in downflow regions





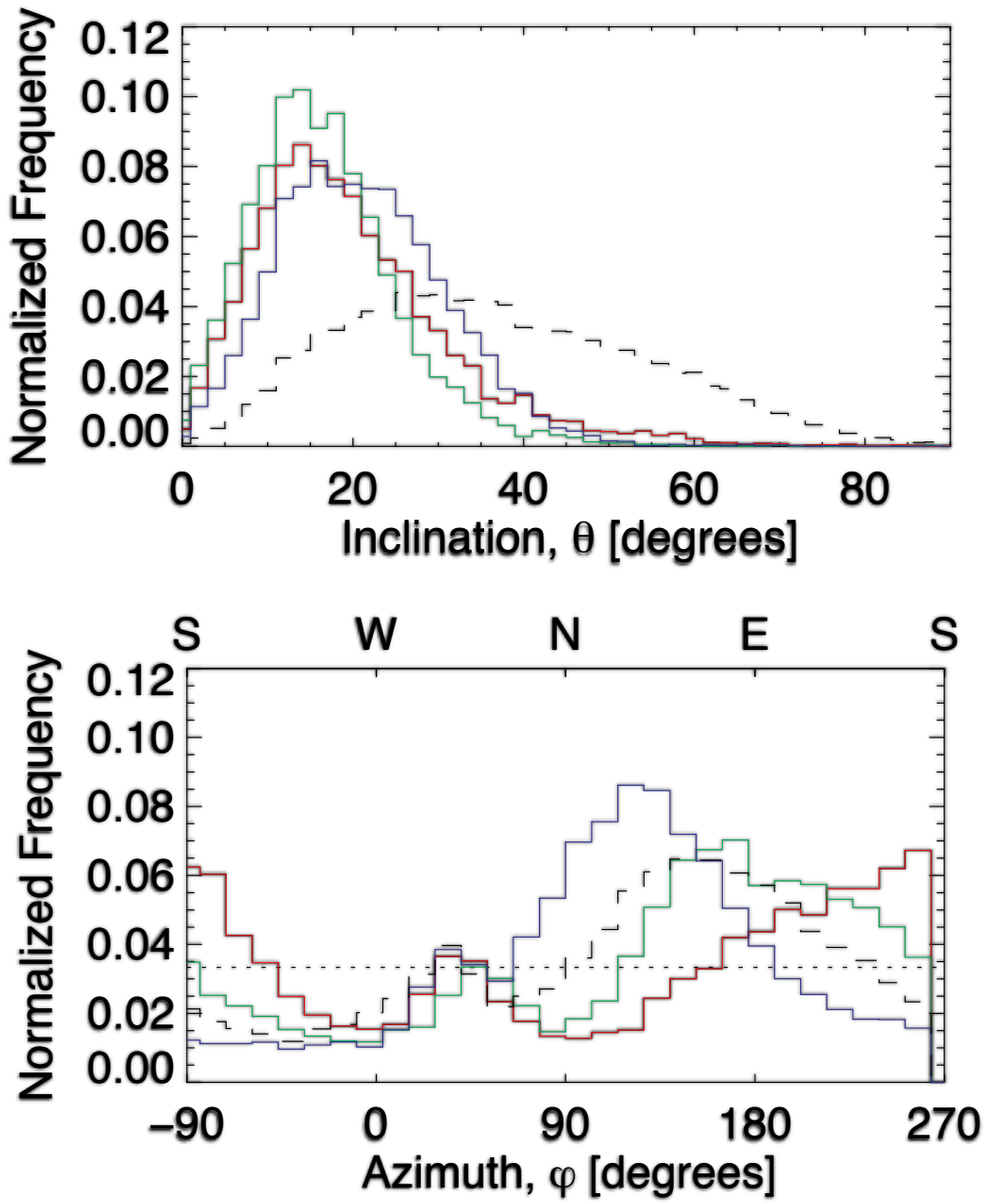
Mixed polarity spectrum

Inclination & Azimuth



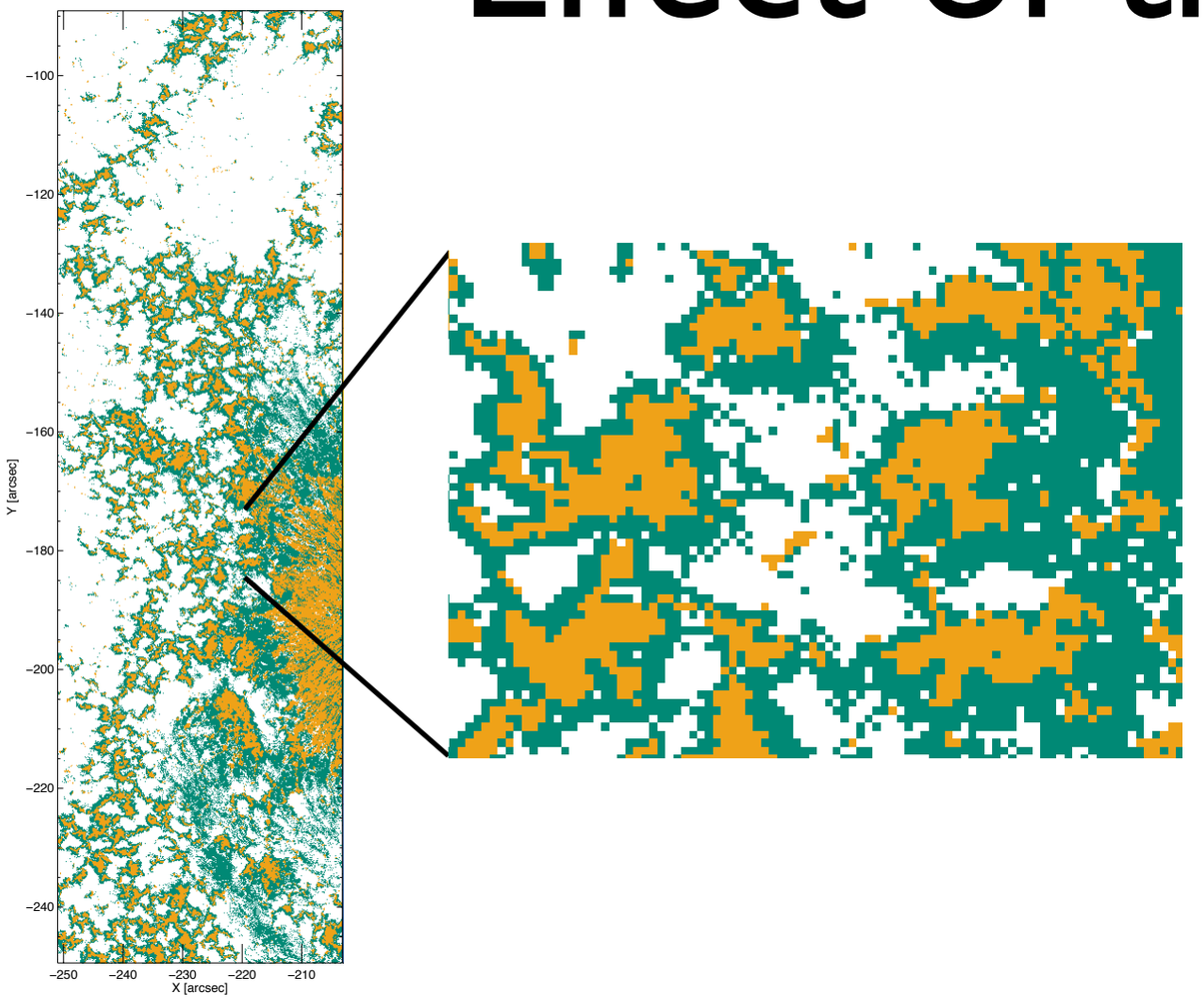
- ‘Azimuth centres’
- Fields are vertical at centre,
- but more horizontal at edges of features

Inclination & Azimuth

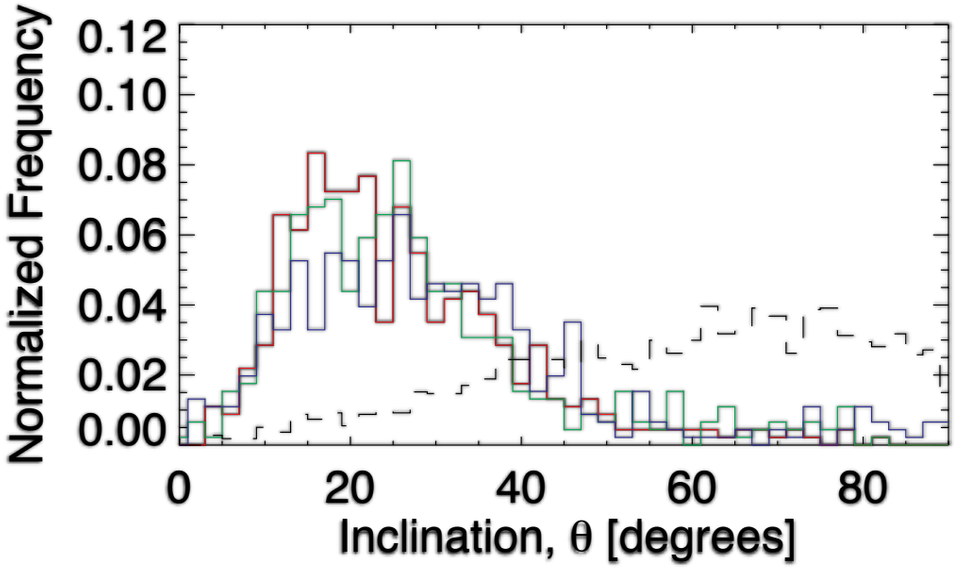


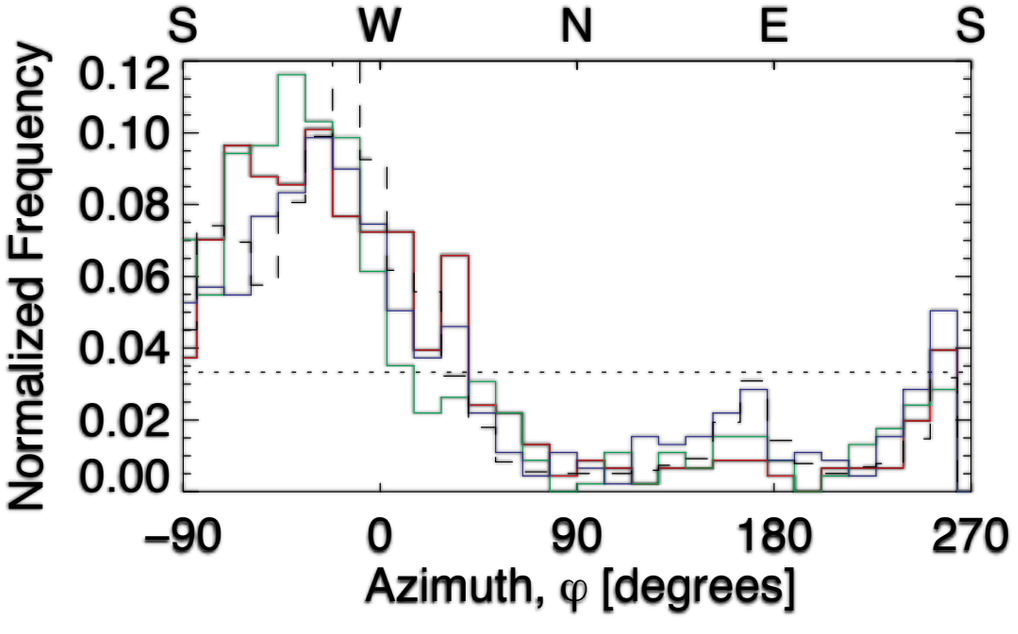
- Core pixels
  - $\langle\theta\rangle$ = 18.4° at log(τ)=-0.9
  - generally vertical in all layers
  - Azimuth changes with height
- Canopy pixels
  - $\langle\theta\rangle$ = 39.1°

Effect of the sunspot



- Mean core inclinations 10° larger
- Azimuth not isotropic
- Deformed canopy
- Effects seen up to 7” away from outer penumbral boundary





Summary

- Inversion able to retrieve typical B, θ and v values for plage features
- Magnetic features expansion is similar to thin flux tube model
- Magnetic features are surrounded by downflows
- Within the downflows small patches of opposite polarity can be observed
- Sunspot affects orientation of magnetic fields up to 7” away