2D inversions of weak internetwork spectropolarimetric signals

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Hinode 7
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Internetwork field

Unresolved issues

- weak vs strong field (Orozco Suarez et al. 2008, Stenflo 2010)
- amount of flux (Trujillo Bueno et al. 2004, Pietarila Graham et al. 2009, Danilovic et al. 2010...)
- ratio of transverse vs longitudinal field (Orozco Suarez 2008, Lites et al. 2008, Beck & Rezaei 2009)
- height profile (Shchukina & Trujillo Bueno 2011, 2012)
- predominantly horizontal (Orozco Suarez et al. 2008, Martnez Gonzalez et al. 2008, Ishikawa & Tsuneta 2011, Stenfo 2010)
- origin (Pietarila Graham et al. 2009, Danilovic et al. 2010, Lites 2013)

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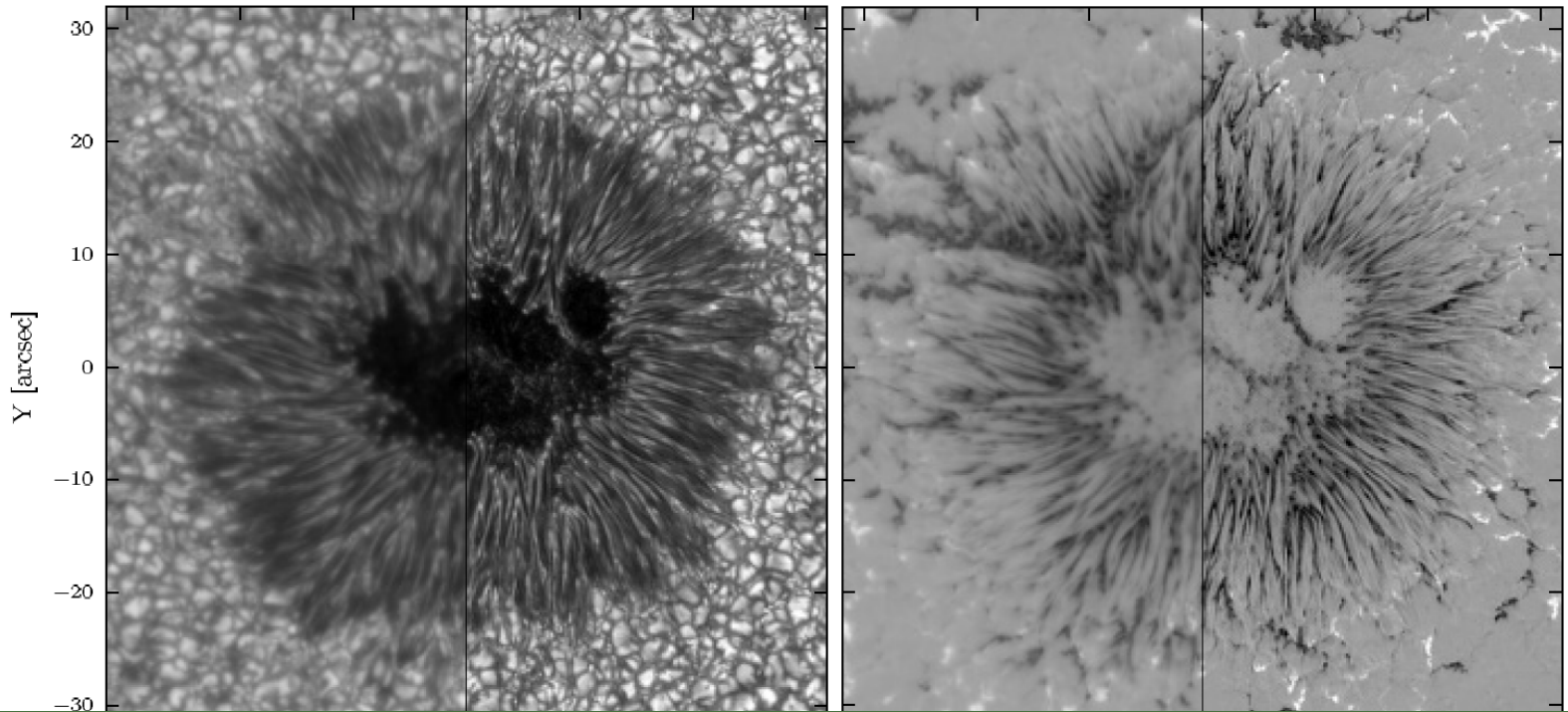
Difficulties: Low signal, high noise lead to biased results retrieved by inversions (Asensio Ramos 2009, Borerro & Kobel 2011,2012)

2D inversions

spatially coupled inversion (van Noort, 2012) - accounts for telescope diffraction PSF, provides self-consistent solution.
Advantage:

- less susceptible to noise - combines information over the whole PSF affected area
- retrieves the information on high spatial frequencies up to the diffraction limit



Simulations of solar surface magneto-convection

Tests were made on 3 types of simulation runs produced with `MURaM` code:

- small dynamo run - $4.86 \times 4.86 \times 1.4$ Mm, hor. spacing 5 km, double the field
- larger dynamo run - $24 \times 24 \times 2$ Mm, hor. spacing 12 km, horizontal field allowed at the bottom boundary
- emergence run - $6 \times 6 \times 1.68$ Mm, hor. spacing 10 km, mean field strength decreases only slightly with height

Simulations are treated in the same way as observations.

General conclusions:

- results sensitive to the node position
- results sensitive to the choice of the PSF
- the code returns correct trend with height

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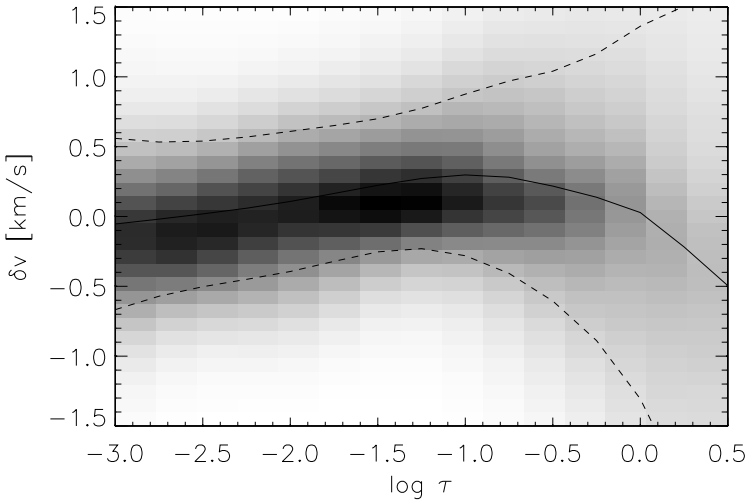
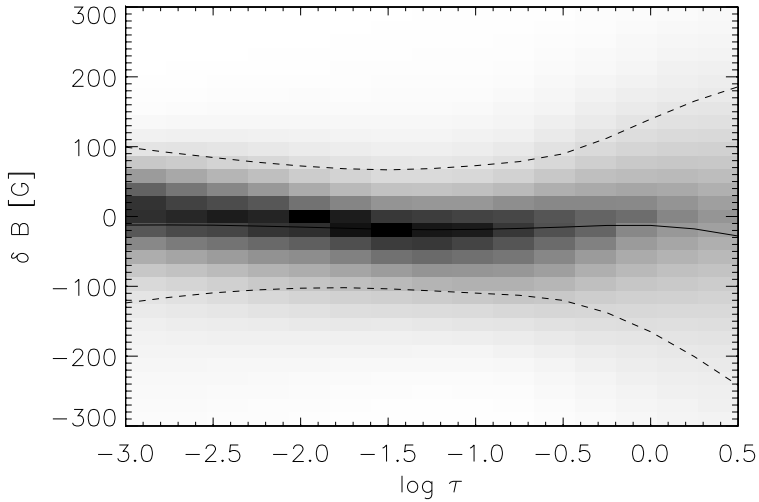
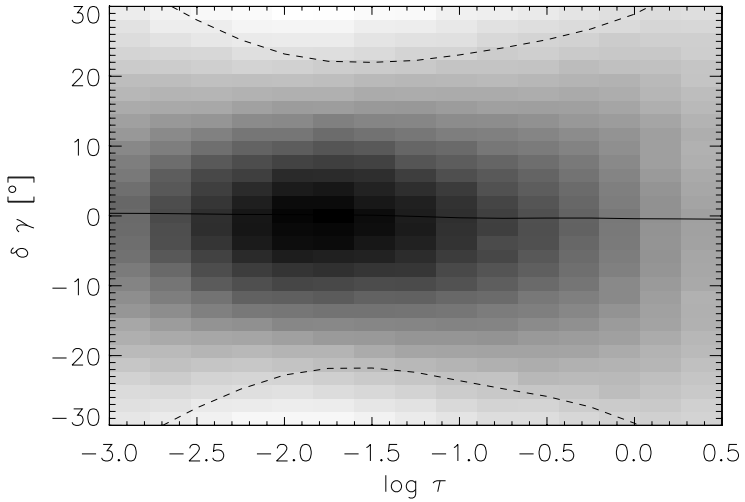
Simulations - inversion results

inversion errors as a function of height - difference between the original @ const optical depth (without spatial frequencies above the diffraction limit of the telescope) and the inversion results





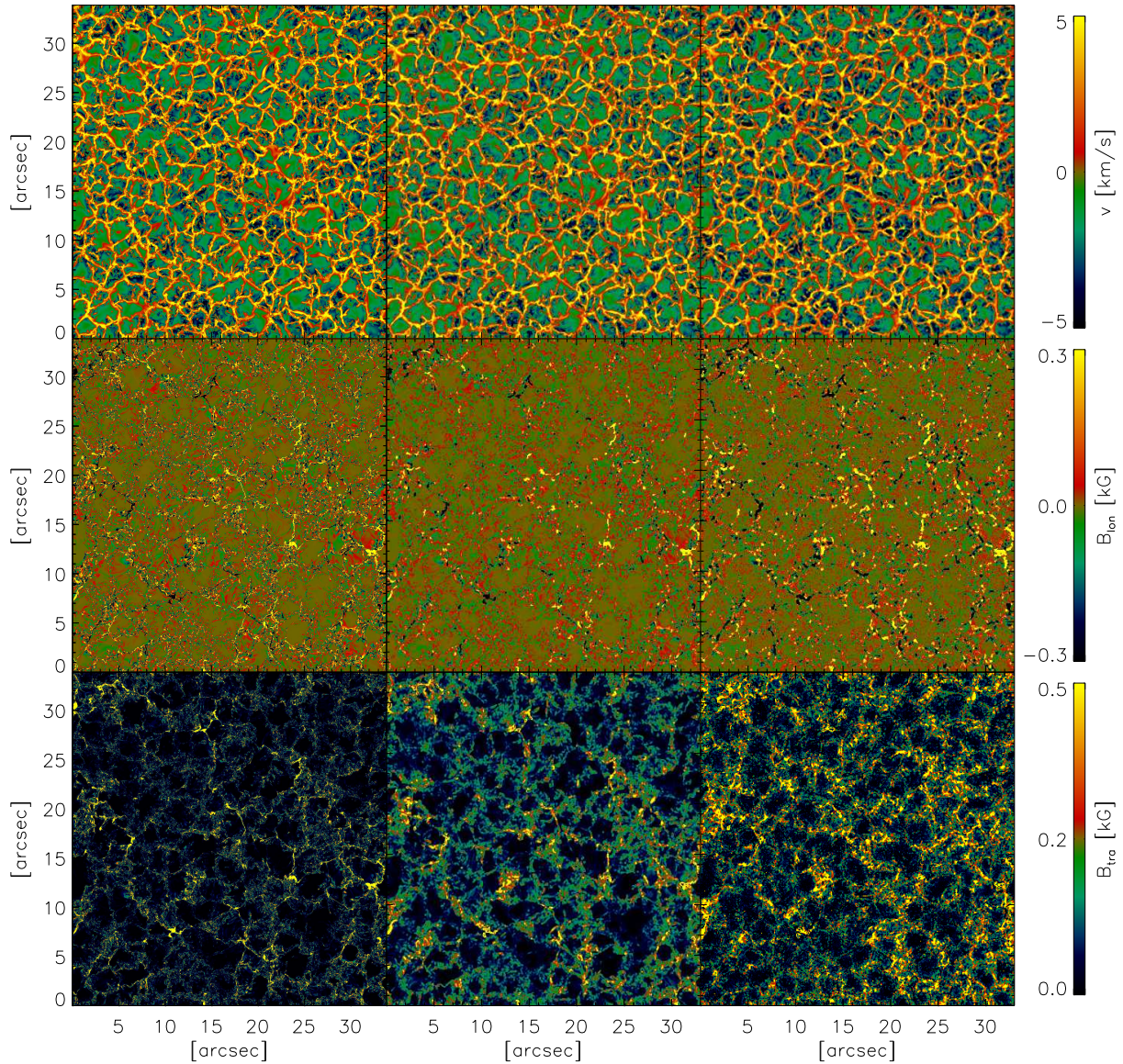


Simulations - inversion results

left column - original maps

middle column - Four. filtered original maps

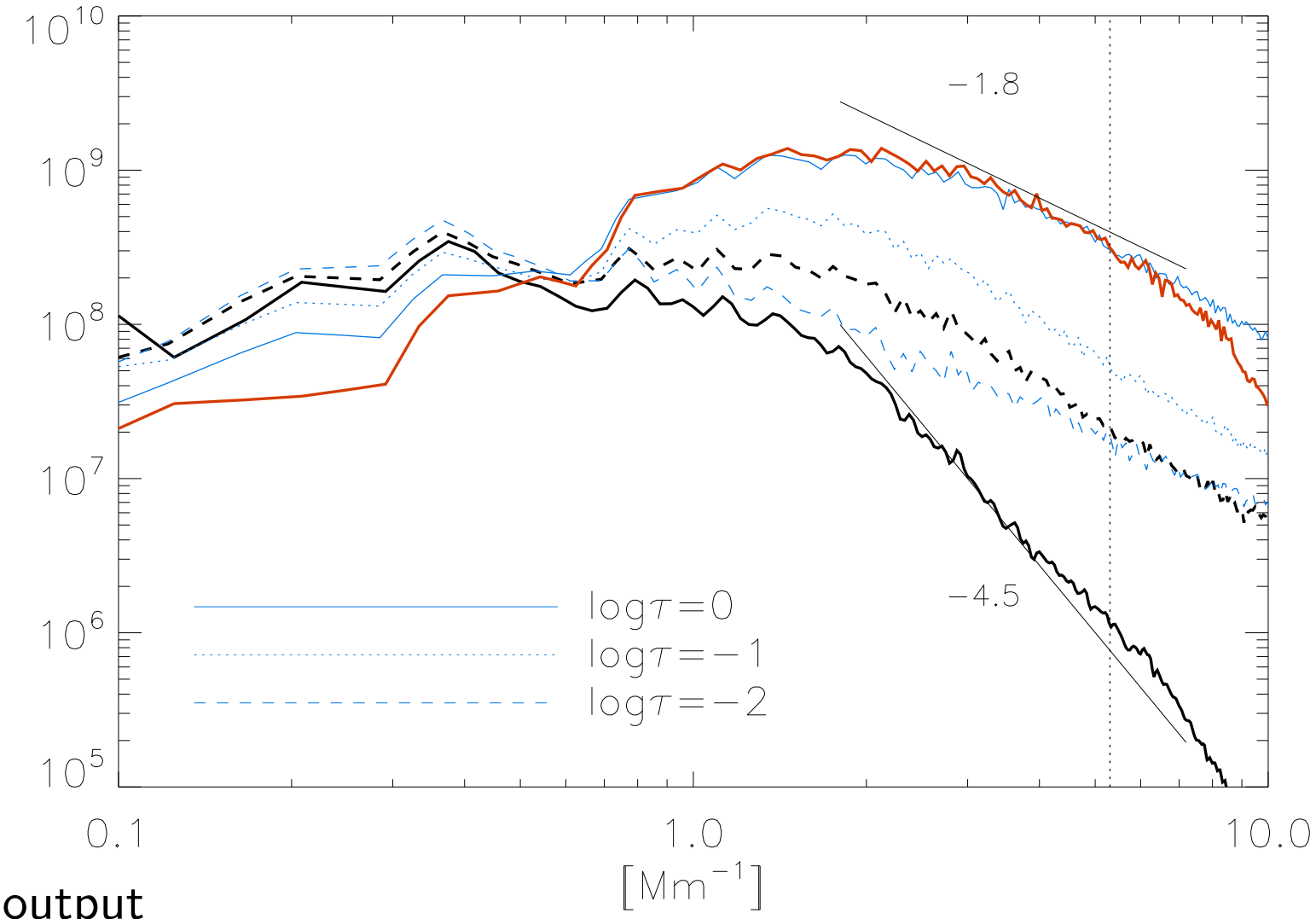
right column - inversion results



maps @ $\tau = 1$

Simulations - inversion results

velocity power spectra



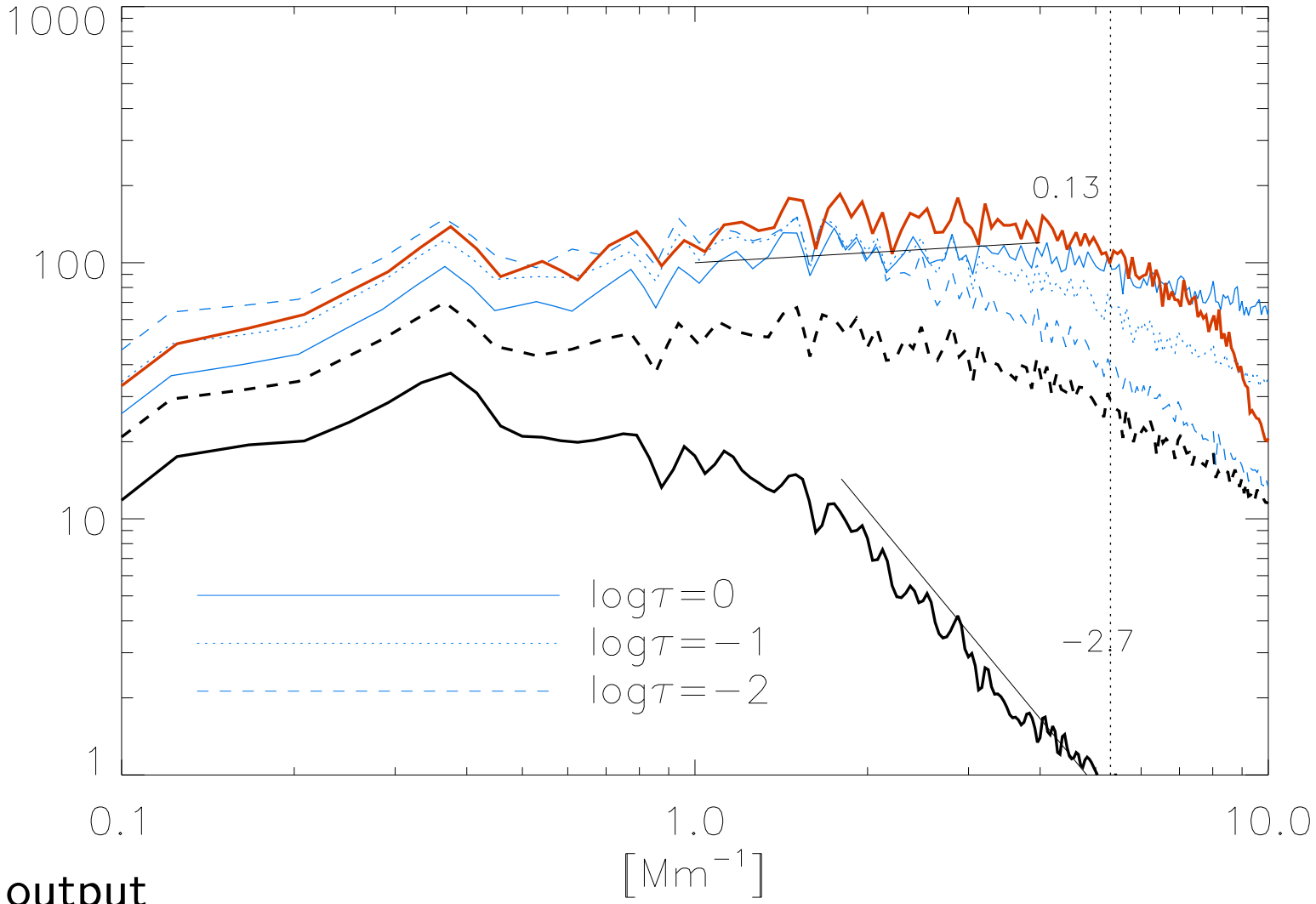
original

inversion

sp_ prep-like output

Simulations - inversion results

B_{los} power spectra



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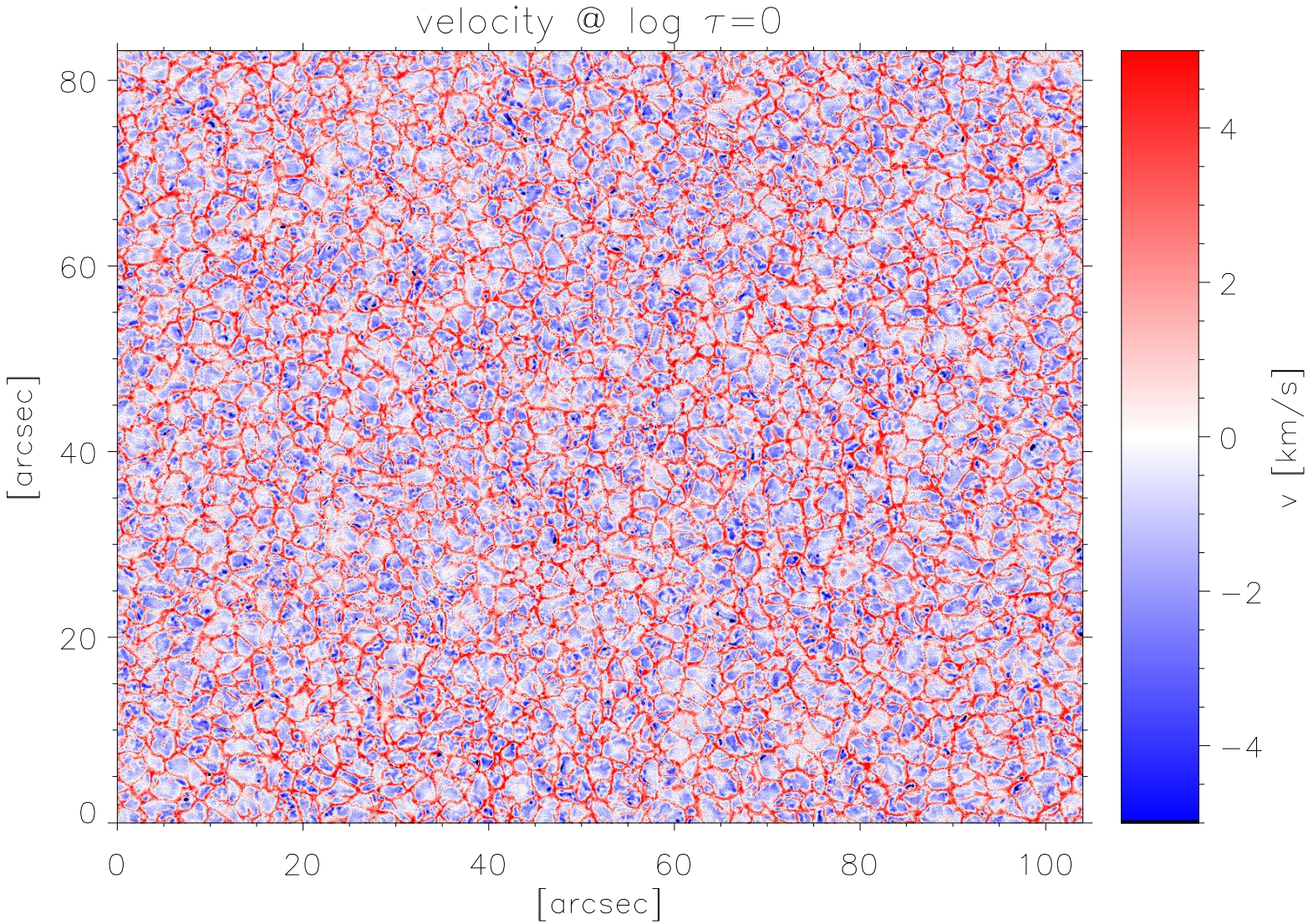
Hinode/SP data - inversion results

data set taken on March 10th 2007 (Orozco Suarez et al 2007,Lites et al.2008)



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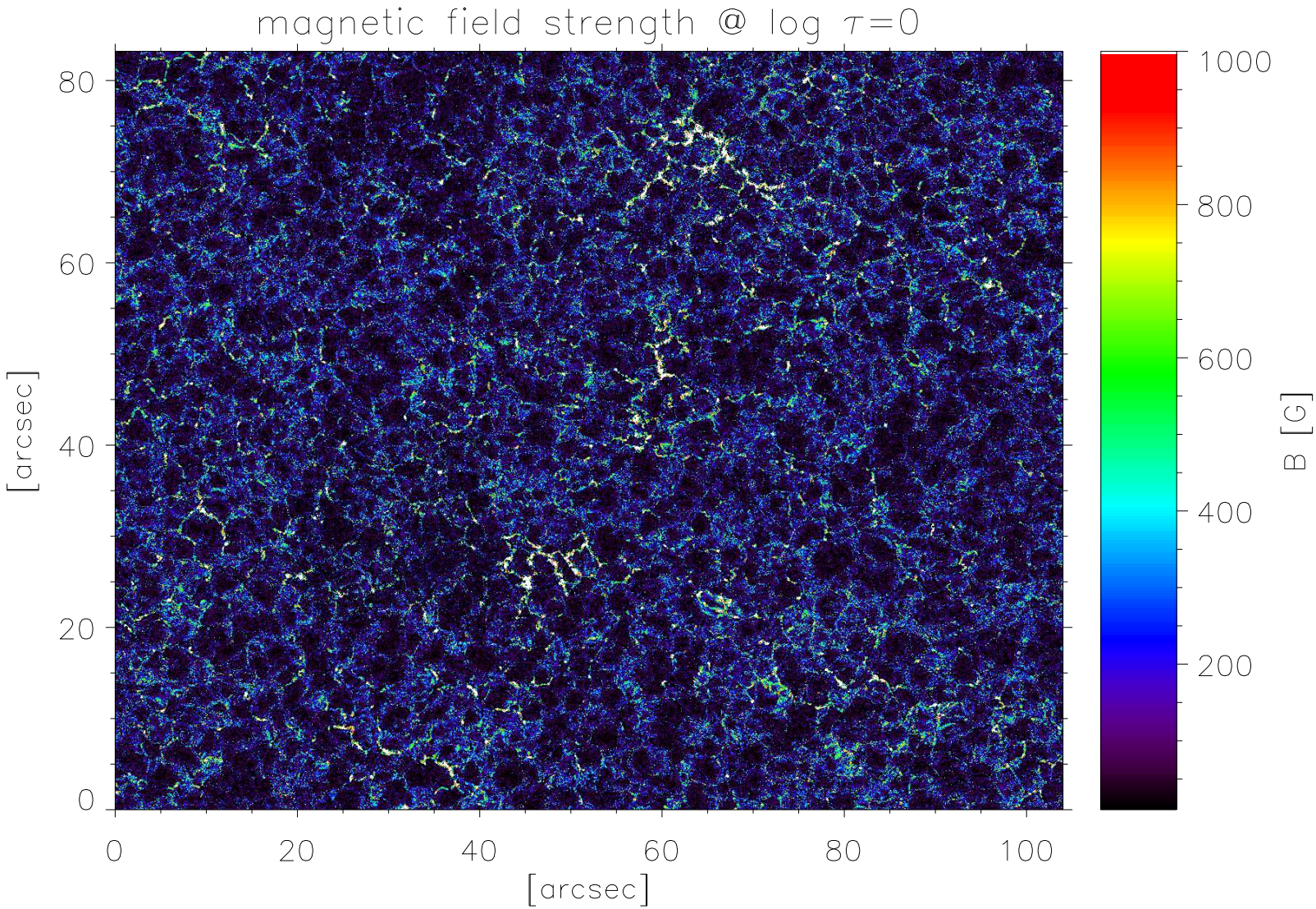

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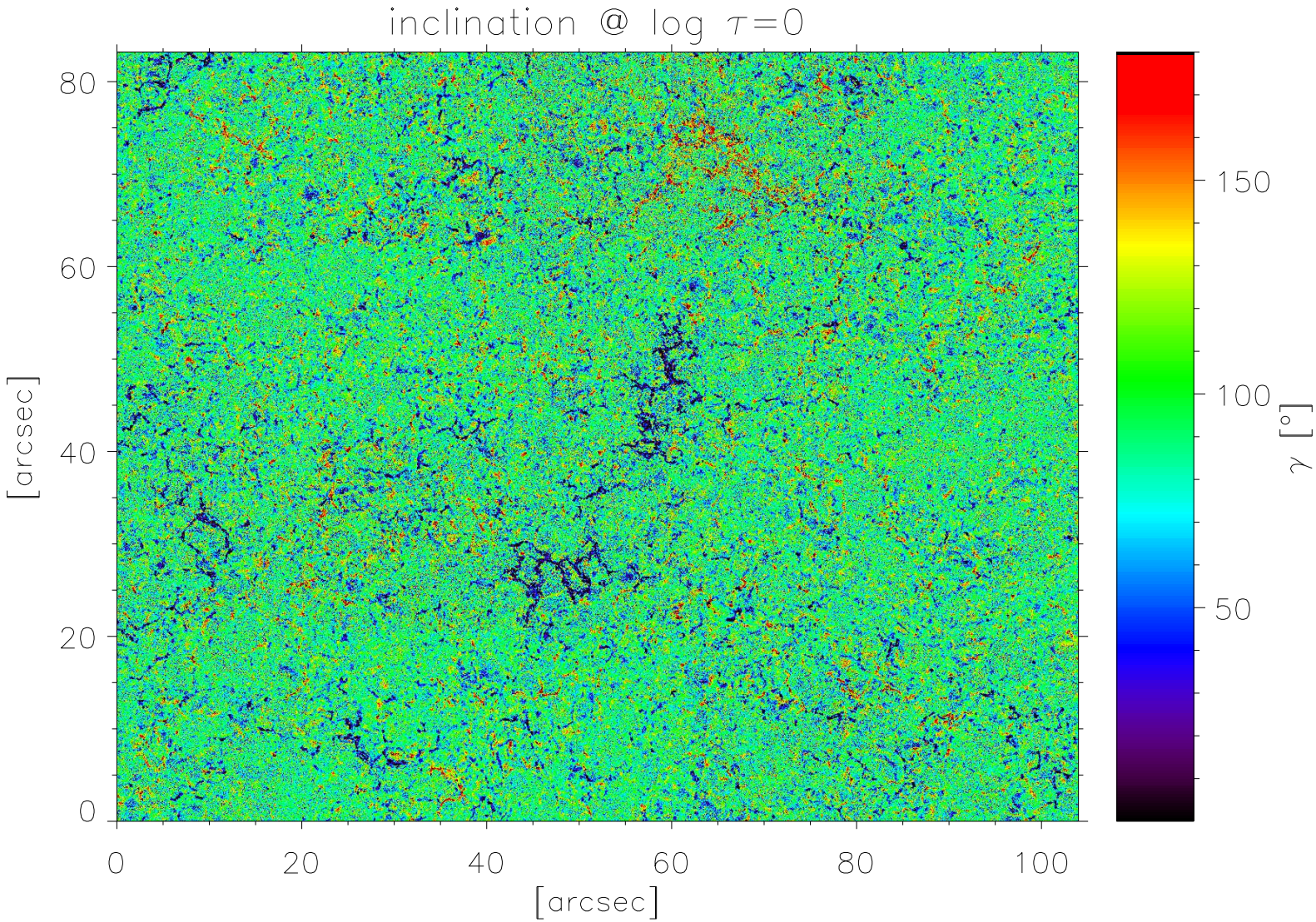
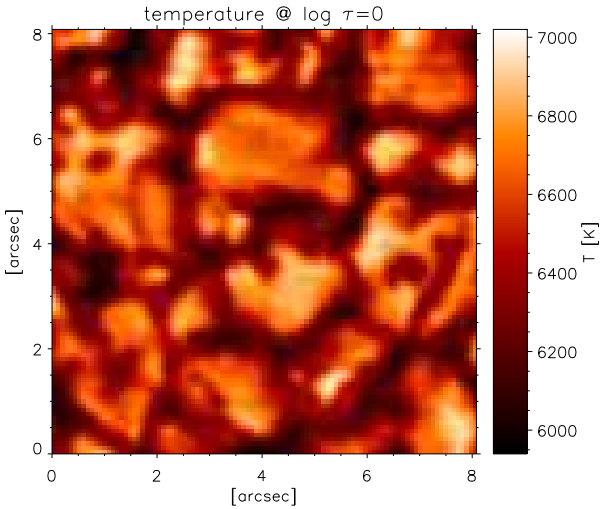
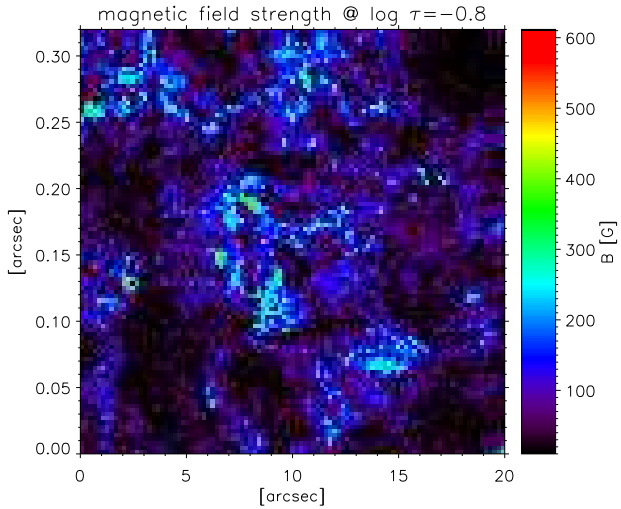
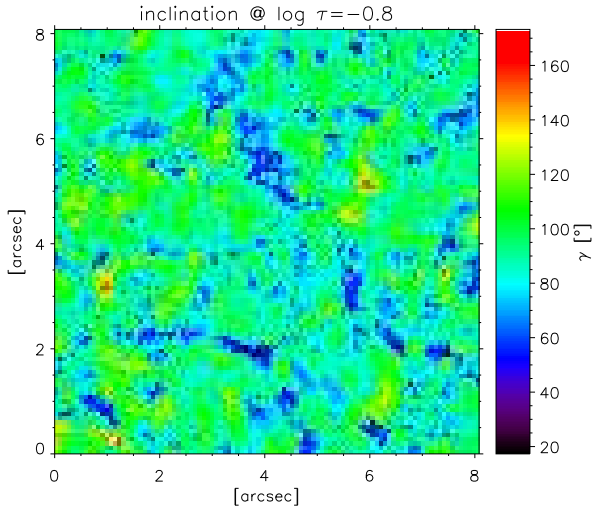


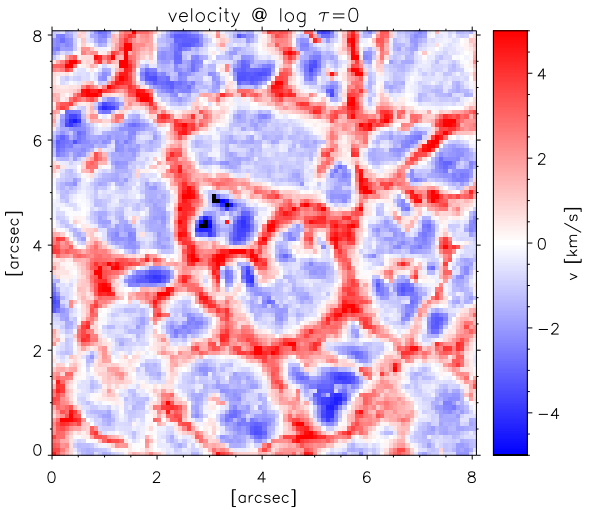
Hinode/SP data - inversion results - zoom in

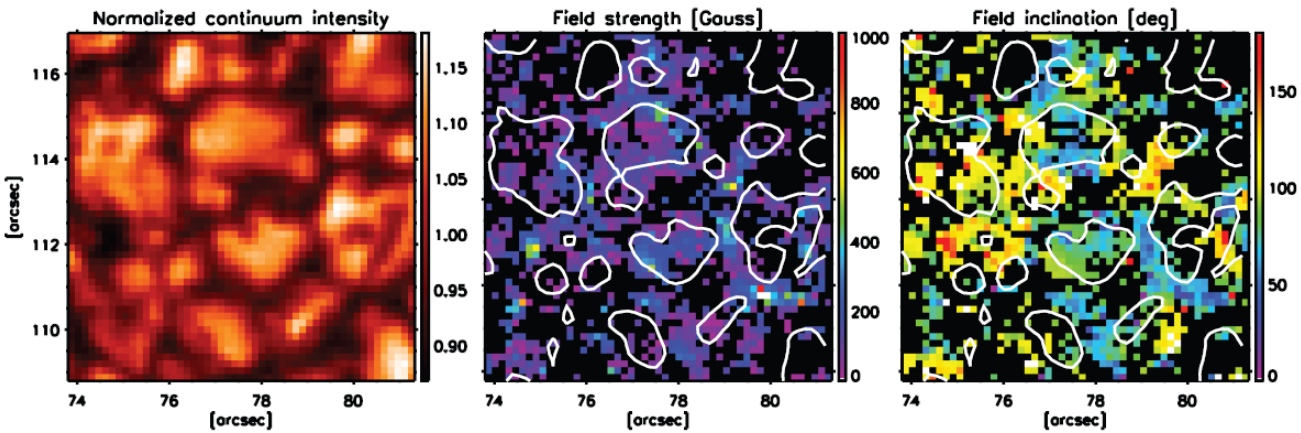
comparison with ME inversions (Orozco Suarez et al 2007) and Bayesian analysis reuslts (Asensio Ramos 2009)











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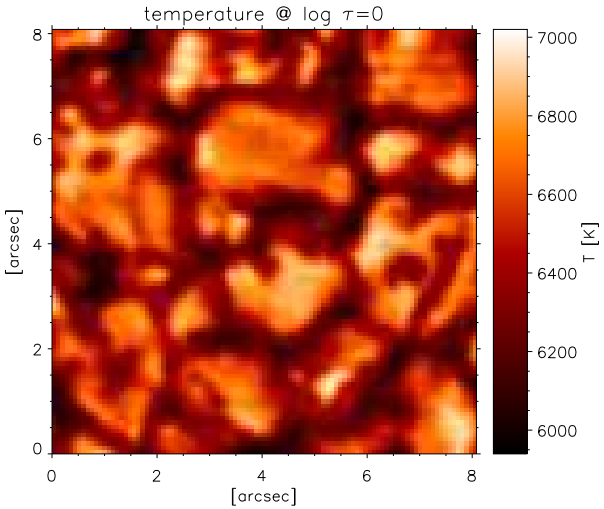
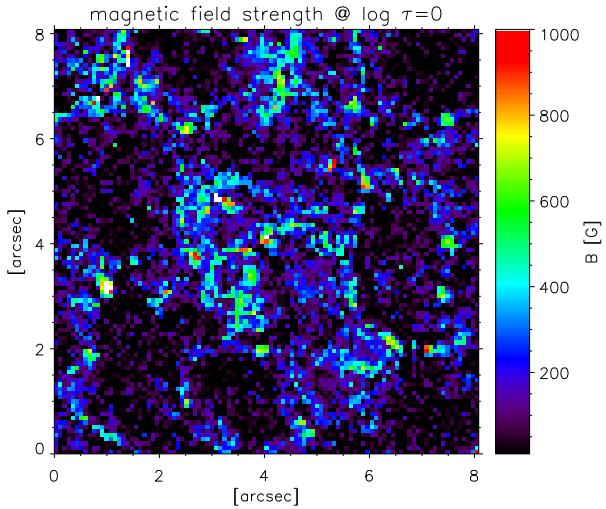
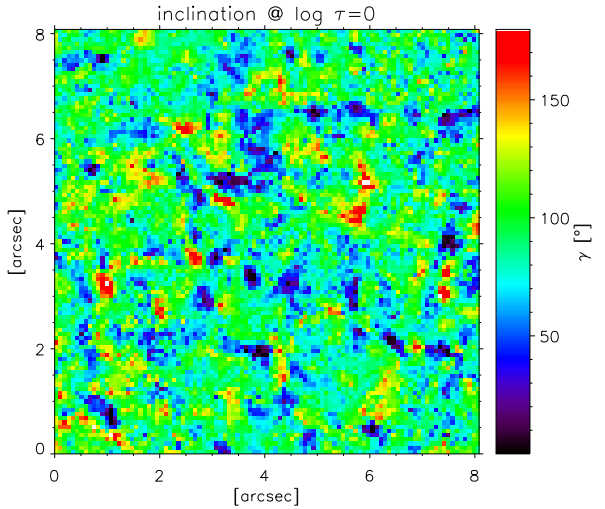
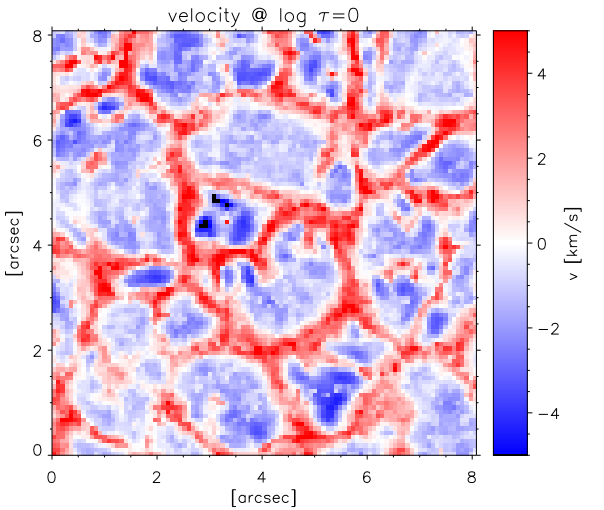
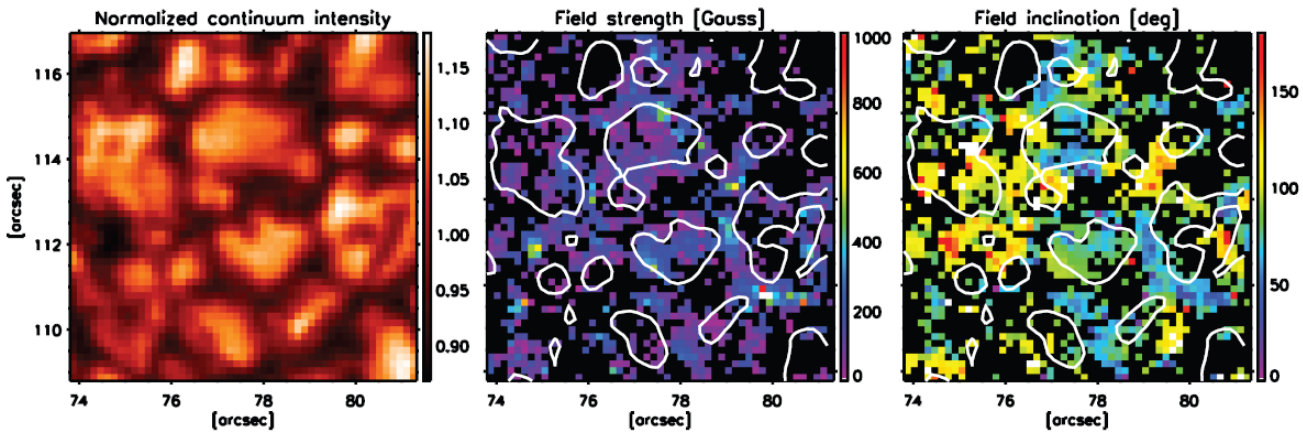




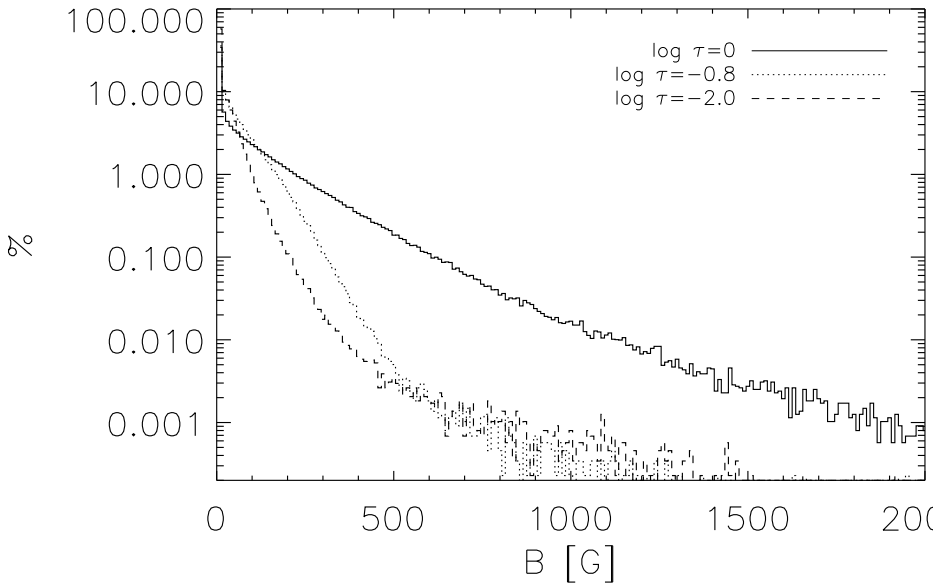


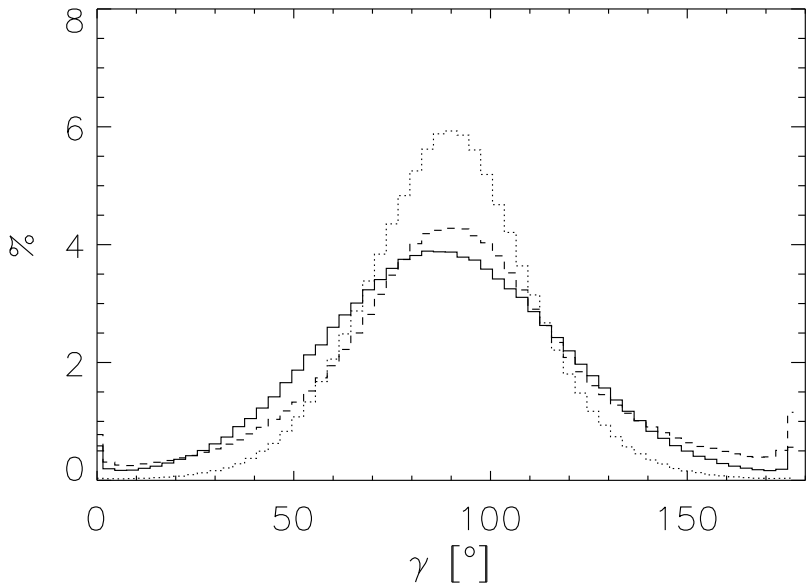




Hinode/SP data - inversion results - distributions

network exclusion - areas with $|B^L_{app}| > 100$ G + 2 arcsec surroundings (Lites 2013)

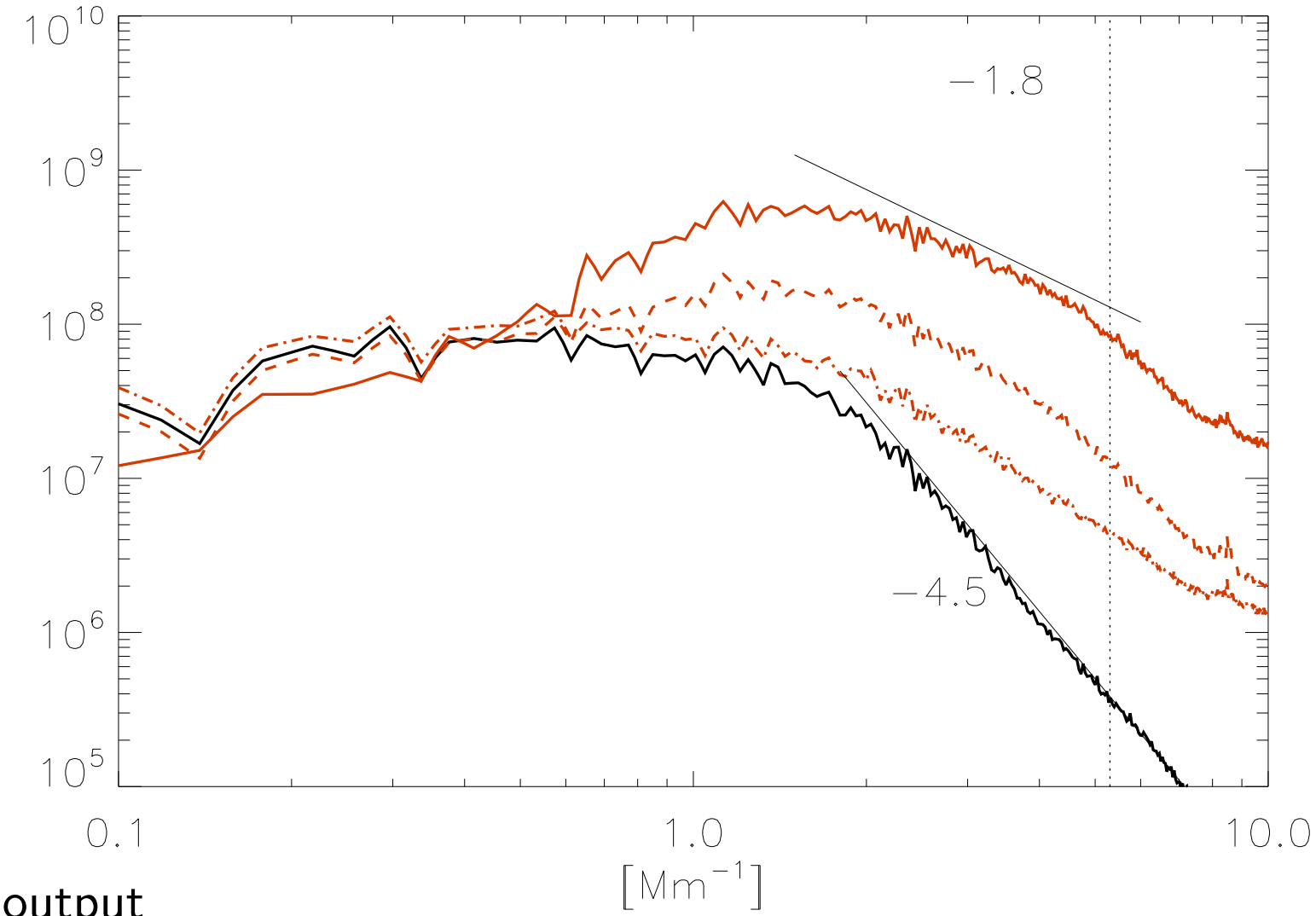




	$\langle B \rangle$	$\langle \mid B_L \mid \rangle$	$\langle B_T \rangle$
$\log \tau = 0$	134 G	74 G	94 G
$\log \tau = -0.8$	67 G	28 G	56 G
$\log \tau = -2.0$	43 G	24 G	31 G

Hinode/SP data - inversion results - power spectra

velocity power spectra



inversion

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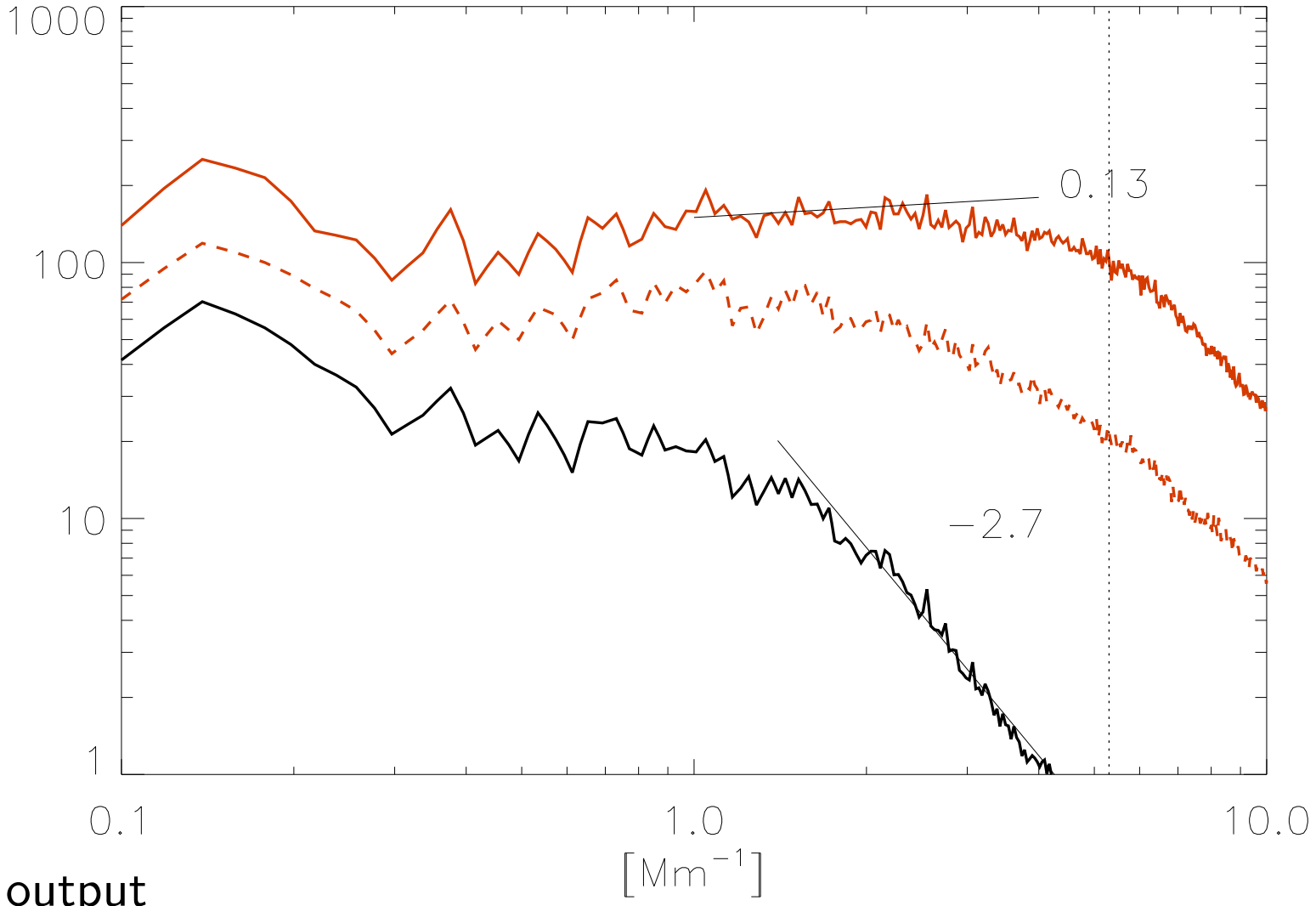
B_{los} power spectra



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Summary

The test on MHD simulations gave us confidence to conclude that the results might not be far from the truth. So, the 2D inversion revealed following facts about the IN fields:

- the field distribution decreases monotonically with the field strength
- the inclination distribution peaks at 90^o
- $\langle B \rangle = 134\ G, \langle \mid B_L \mid \rangle = 74\ G, \langle B_T \rangle = 94\ G$ @ $log\tau = 0$
- the slope of B_{los} power spectra is positive.

Things to do:

- see how different focus steps from optimal SP focus influence result
- analyse maps taken at different heliocentric angles
- compare kinetic and magnetic power spectra

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Thank you!