On the Magnetic-Field Diagnostics Potential of SDO/HMI

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Objectives

How representative of the actual magnetic field in the solar atmosphere can we expect inversions of HMI Stokes filtergrams to be?

How large is the error of the inverted magnetic field (strength and inclination) and the inverted vertical velocity?

How do these errors depend on

- uncertainties of HMI filter response function
- settings (stop criteria and weights) of HMI magnetic field pipeline routine (VFISV)
- noise level
- limited spatial resolution of HMI

Method

☑ Three 3D MHD snapshots of the solar atmosphere

- one representative of a sunspot region (MURaM code)
- one representative of a plage region (MURaM code)
- one representative of a network region (CO⁵BOLD code)

☑ Calculate Stokes profiles for Fe I 6173Å

☑ Multiply Stokes profiles with HMI filter response functions and integrate

☑ Invert filtergrams using standard HMI pipeline process (VFISV)

☑ Compare inversions to actual physical parameters in model atmosphere

MURaM sunspot simulation:

- fully compressible MHD
- 1536 x 1024 x 256 cells (48 km x 48 km x 32 km)
  (but only 600 x 600 subfield used for this analysis)
- line synthesis: SIR
- average field strength at log(τ) = -1: **935 G**

MURaM plage simulation:

- fully compressible MHD
- 288 x 288 x 100 cells (21 km x 21 km x 14 km)
- line synthesis: LILIA
- average field strength at log(τ) = -1: **265 G**

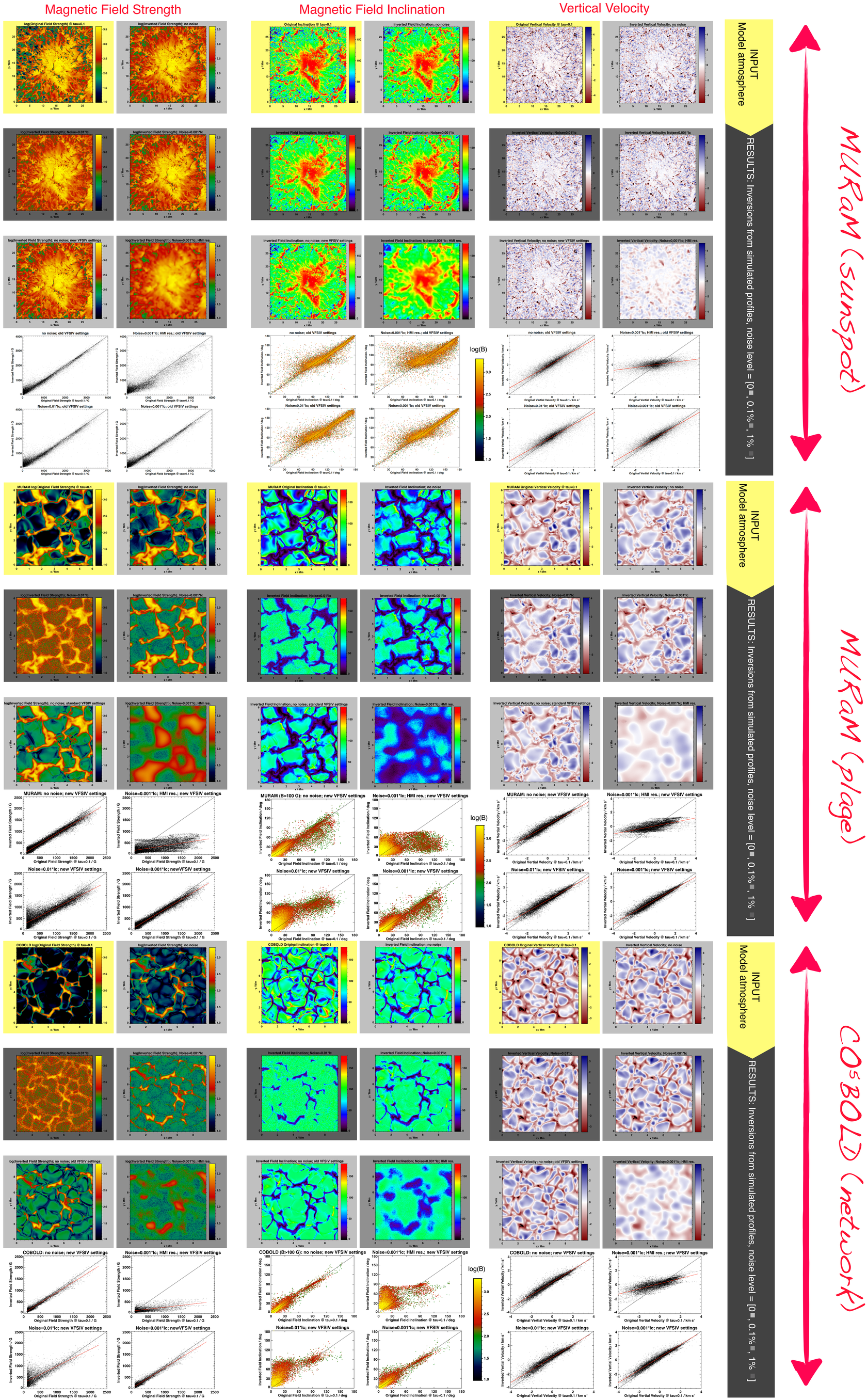
CO⁵BOLD simulation:

- fully compressible MHD
- 240 x 240 x 120 cells (40 km x 40 km x 20 km)
- line synthesis: SIR
- average field strength at log(τ) = -1: **73 G**

Results

Summary or key findings:

- inversions of field strength up to noise level of 0.1% I_c (which is representative of the noise level of HMI Stokes filtergrams) good, at least for stronger fields
- inversions for weak fields problematic: with typical HMI noise levels, VFISV interprets pure noise as a hecto-Gauss horizontal field
- inversions of vertical velocity rather robust against noise
- inversions not sensitive to uncertainties in filter response function
- tuning of VFISV settings ("new", optimized settings for MHD simulations as compared to the standard, "old" settings used in HMI pipeline) yields slightly better results for weak fields; for sunspot simulation standard settings slightly better
- HMI resolution not adequate to study magnetic fine scale structure of solar atmosphere, but for active regions the inversions yield very good results, in particular considering the limited spectral resolution of HMI

RMS errors (comparing physical parameters at log(τ)=-1 of pixels with B>100G with inversions using "new", optimized VFISV settings)**:**

	Field Strength [G]			Field Inclination [deg]			Vertical Velocity [m/s]		
	no noise	0.1% I_c	1% I_c	no noise	0.1% I_c	1% I_c	no noise	0.1% I_c	1% I_c
MURam sunspot	185	186	229	14	14	15	530	530	560
MURaM plage	106	108	218	12	13	19	370	370	420
CO⁵BOLD	77	81	226	8	21	17	320	320	380