PHI: Ground Based Support

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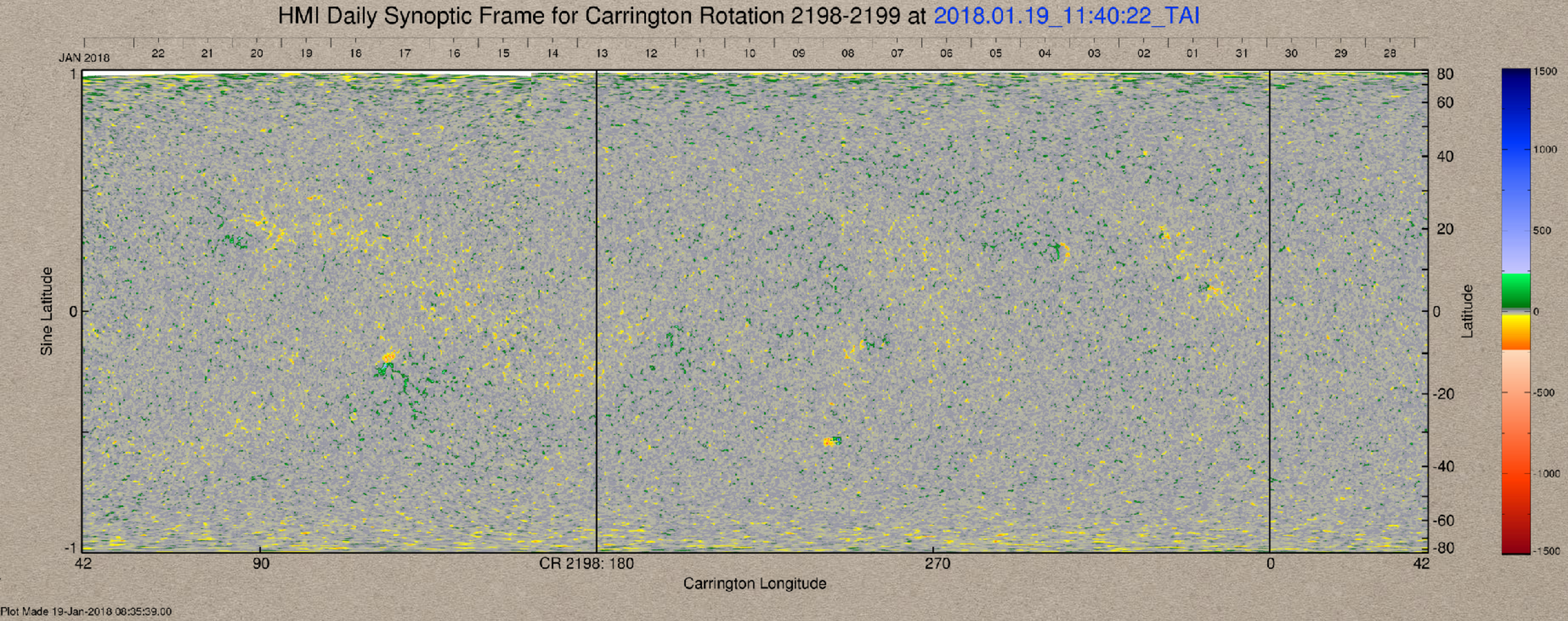
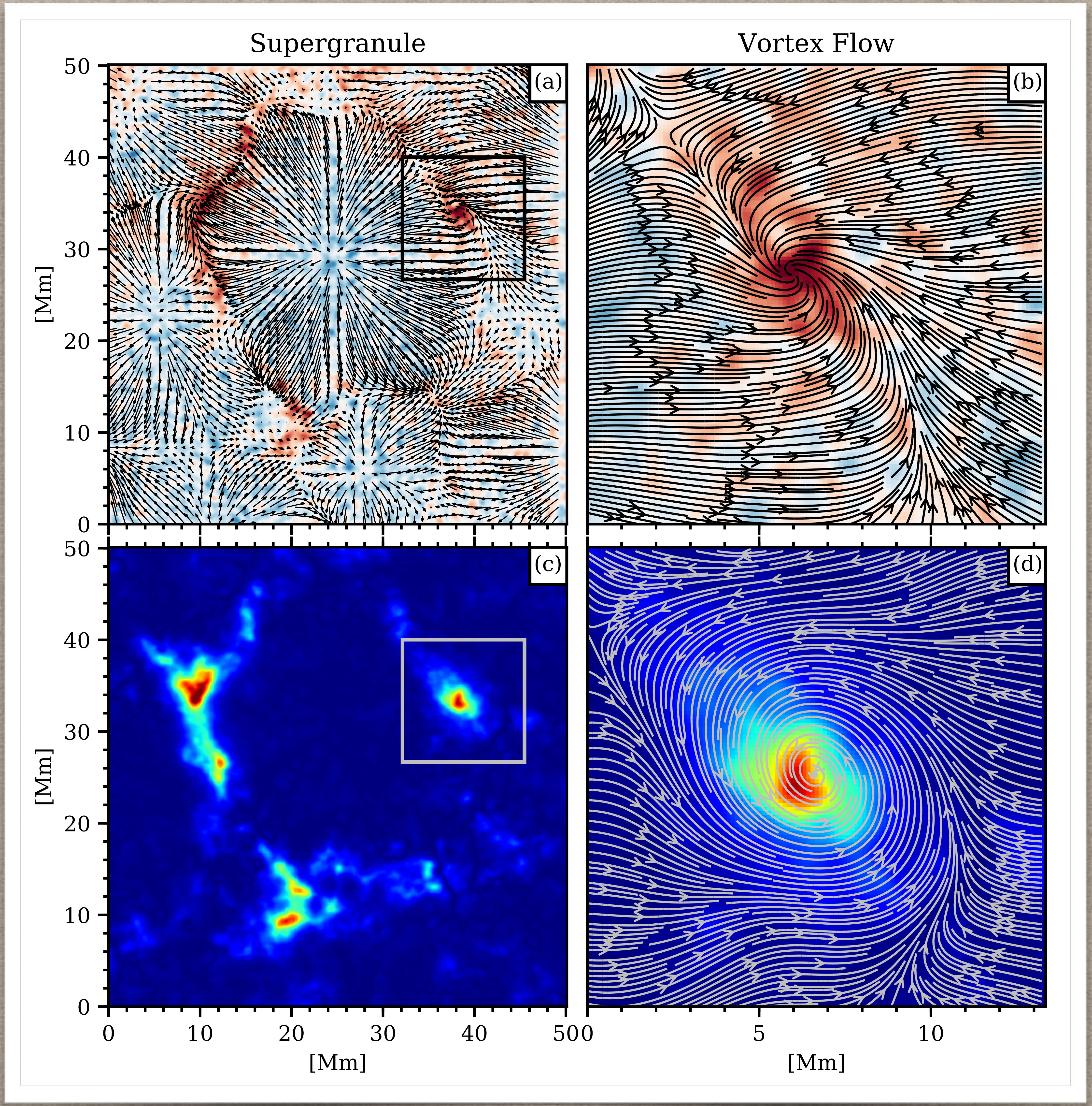
solar orbiter

Faster Synoptic Maps



3D Velocity Vectors

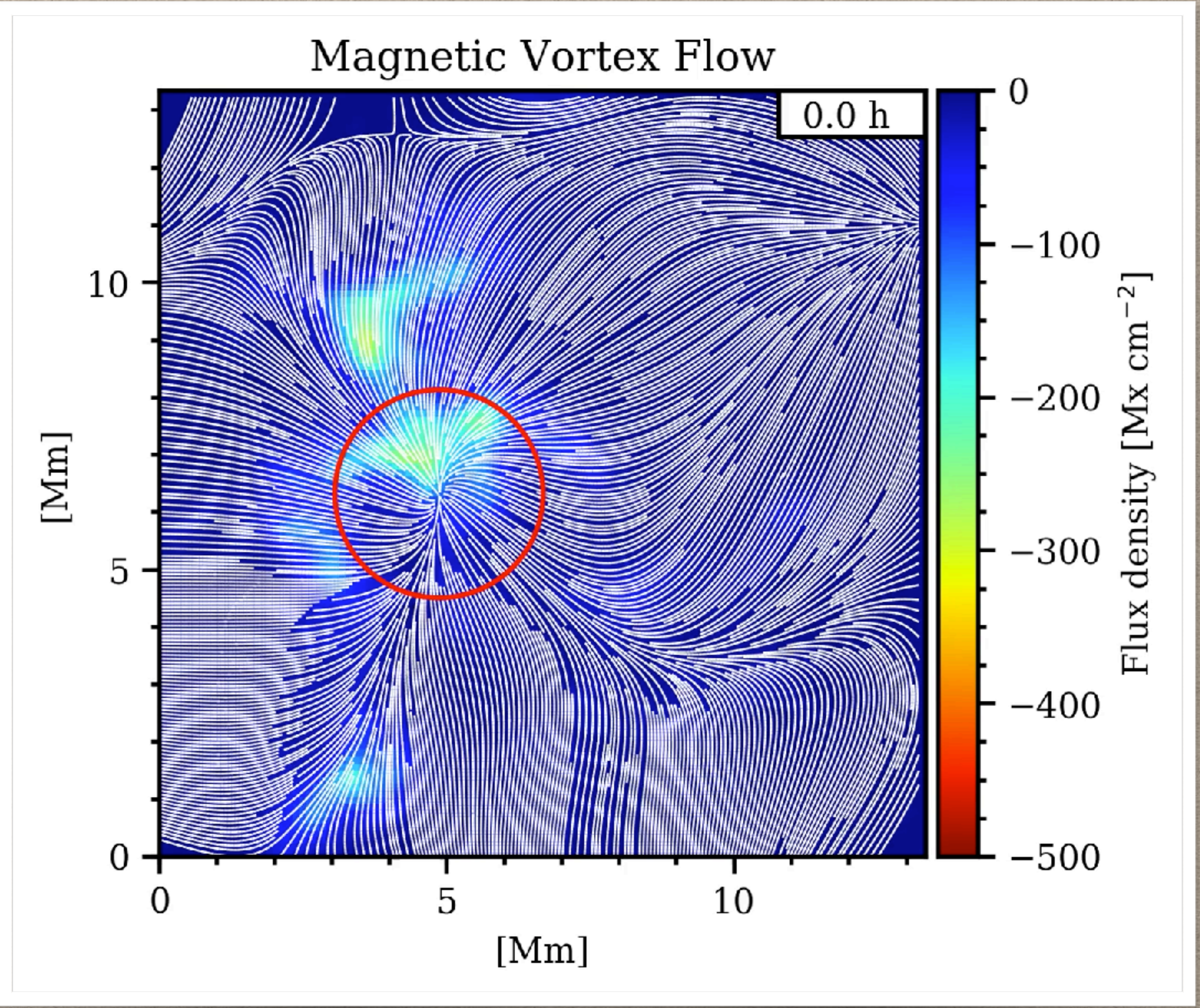
- Combining Doppler maps (LOS-comp.) with feature tracking (horiz. comp.)
- Danger: gas motions ≠ motion of features
  → 3D vector determination usually impossible
- with SO/PHI + GB: stereoscopic feature tracking & stereoscopic Doppler measurements



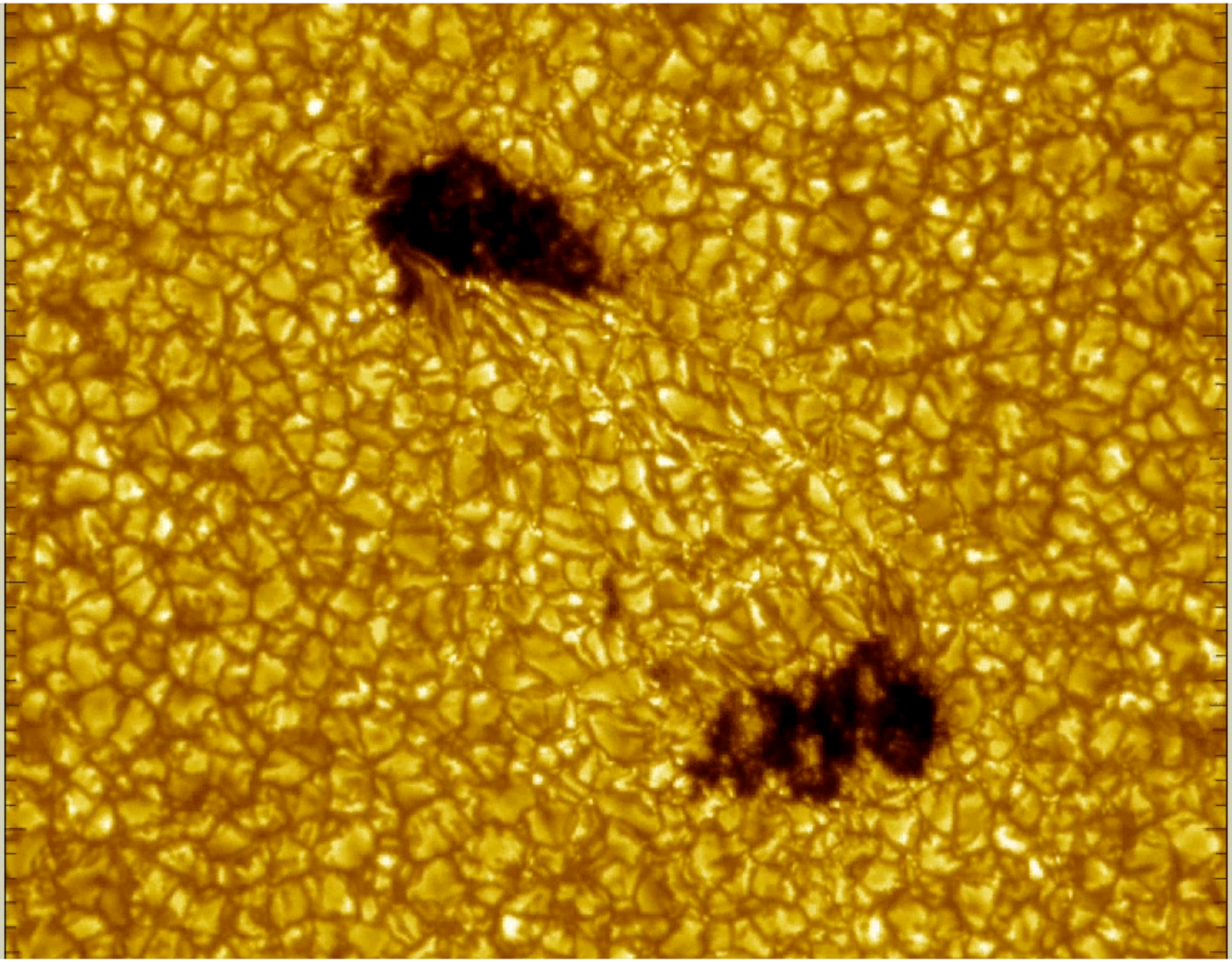
3D Velocity Vectors

Examples for science applications

- Convective motions
  - determination of horizontal component possible
  - granules, LBs, umbral dots, . . .
- Penumbral fine structure
  - direct measurement of the inclination of the Evershed flow
  - understand mass balance & convective nature of filaments



Resolve Azimuth Ambiguity



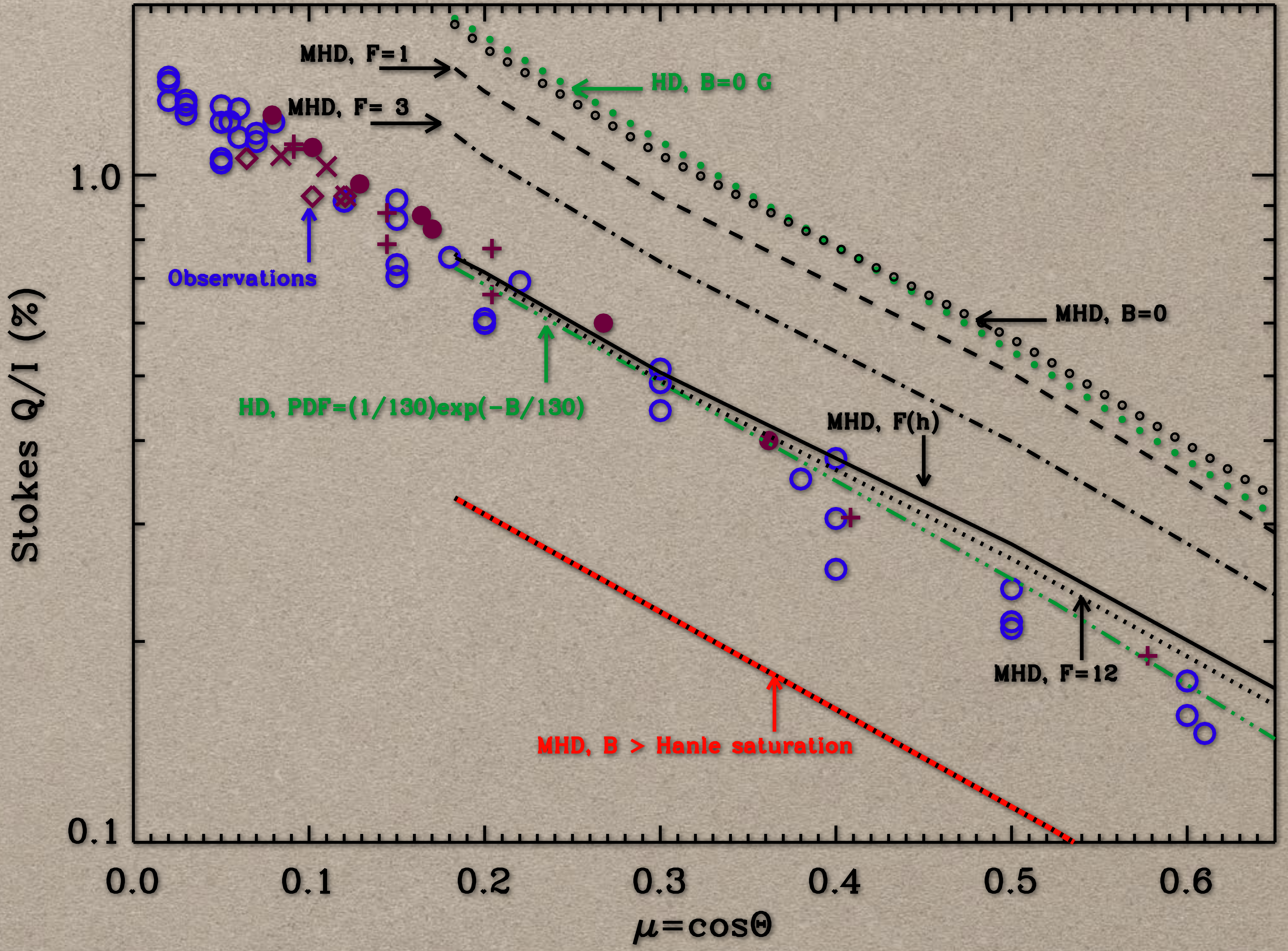
Zeeman-polarimetry intrinsic problem: $2\chi \propto \tan Q/U$

Scattering polarization

Hanle effect (e.g. Sr I 4607 Å)

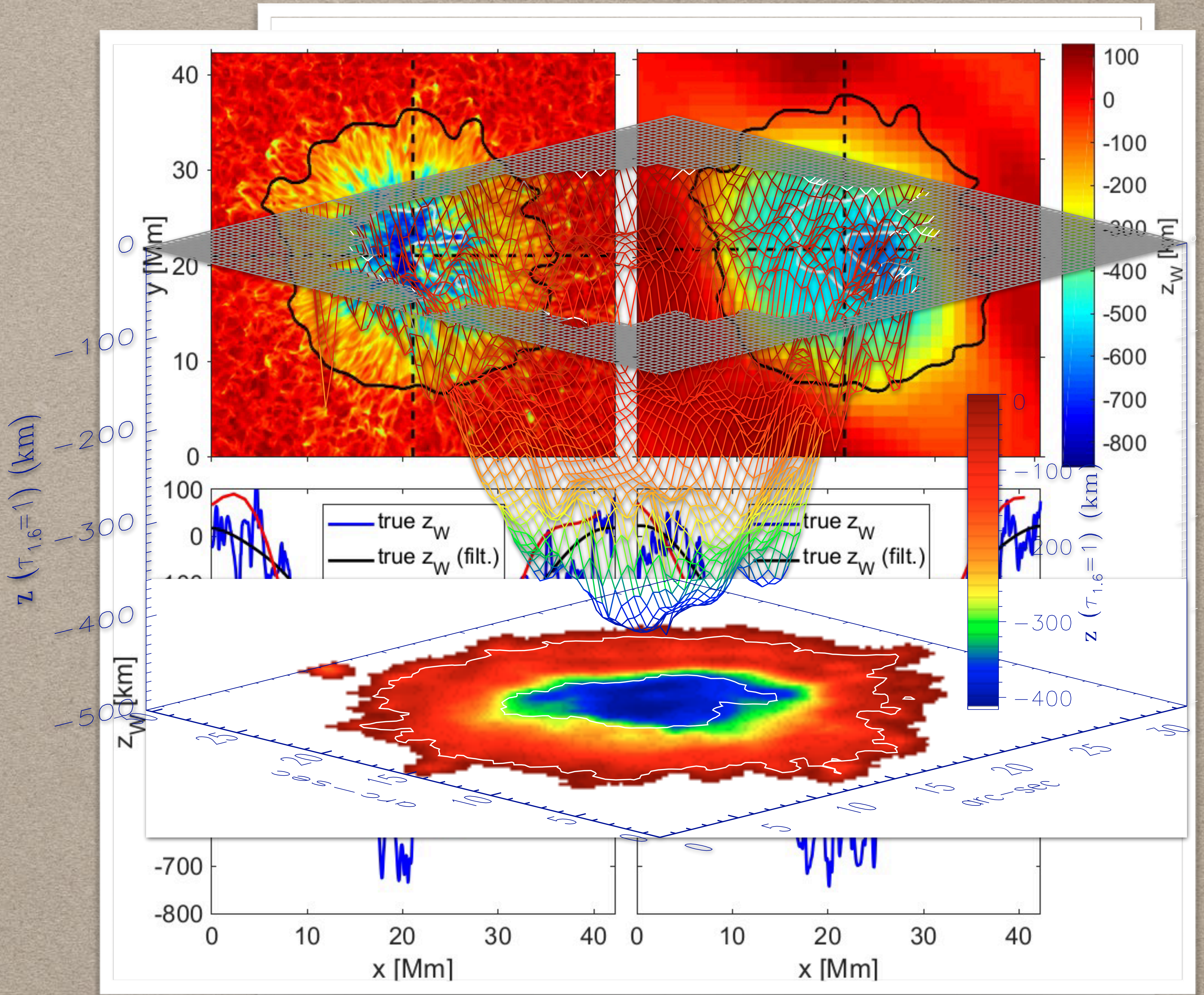
- strongest scattering polarization signals close to limb, where Zeeman signals are weakest
- SO/PHI offers independent “disk-center” measurements
- help to disentangle
  - collisional vs. Hanle depolarization
  - turbulent / non turbulent fields

(Trujillo Bueno et al., 2004)



Geometrical Height Information

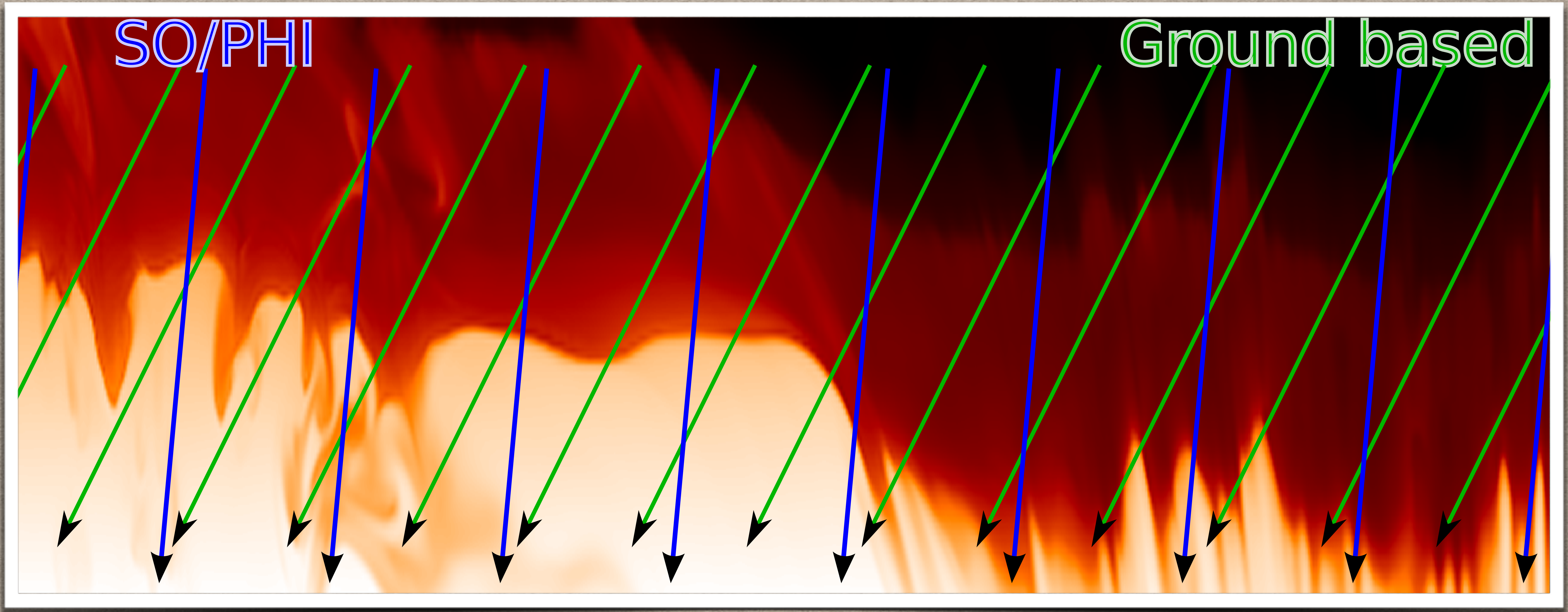
- Triangulation methods (Lites et al., 2004)
- Force-balance methods (Mathew et al. 2004)
- div B = 0 method (Löptien et al., 2018)



Inversion Stereoscopy

Method #1:

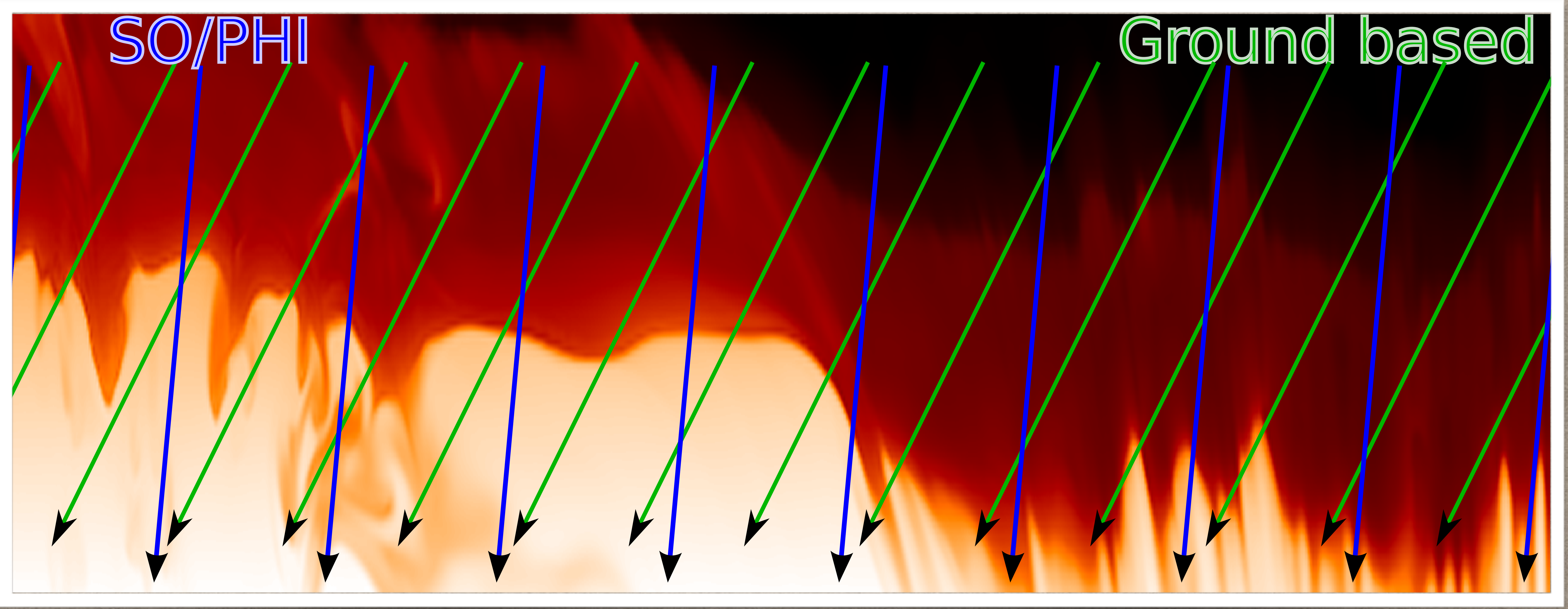
- solveRTE for GB data in2D (logτ)
- convert log τ → z using, e.g., force balance
- tilt this cube to SO/PHI viewing angle
- simulate ME measurement from this cube
- iteratively adjust height for every pixel until best match with SO/PHI ME measurements



Inversion Stereoscopy

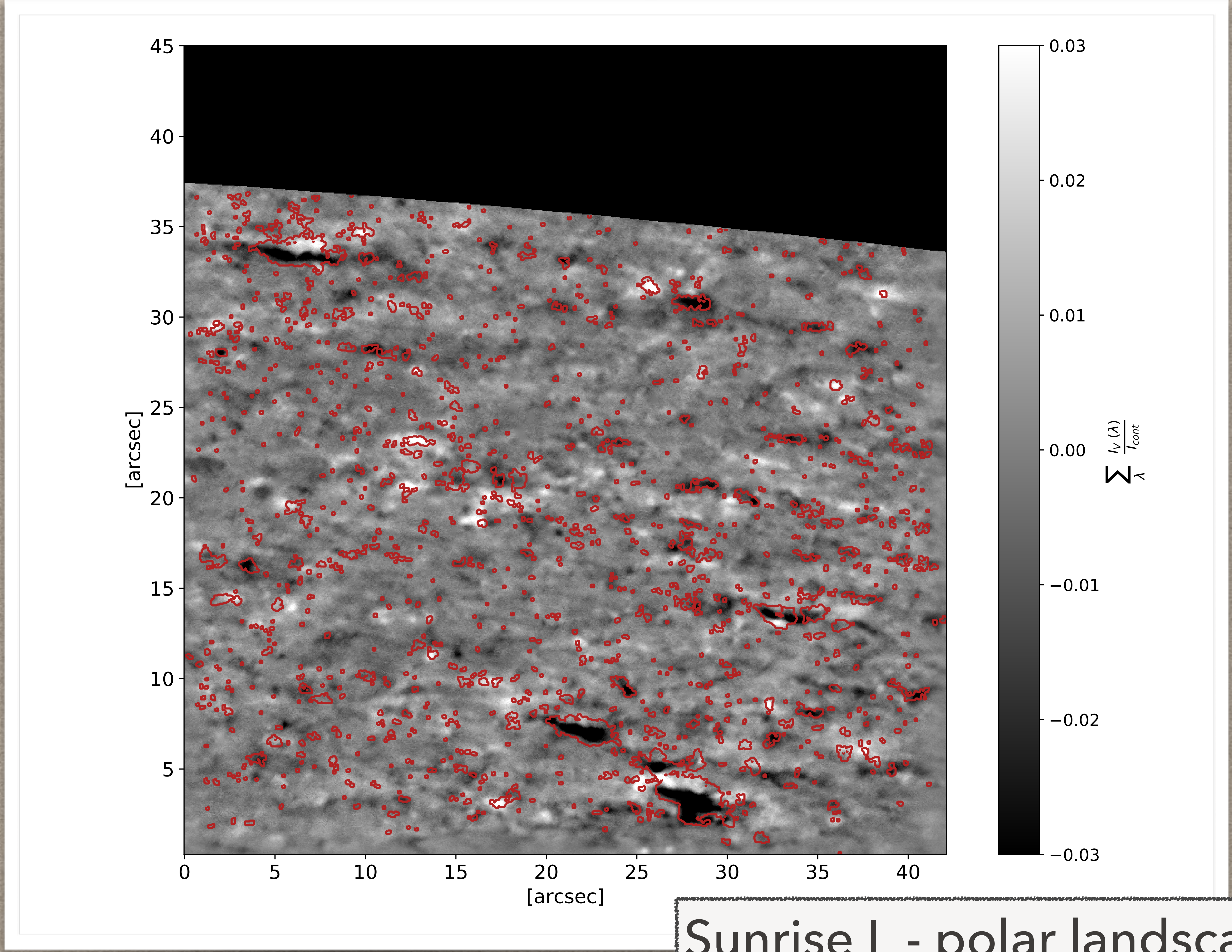
Method #2:

- use raw Stokes vector data (GB and solar Orbiter)
- apply an inversion code solving the RTE on a geometrical height scale (Pastor et al., 2018)



Support Polar Magnetic Field Studies

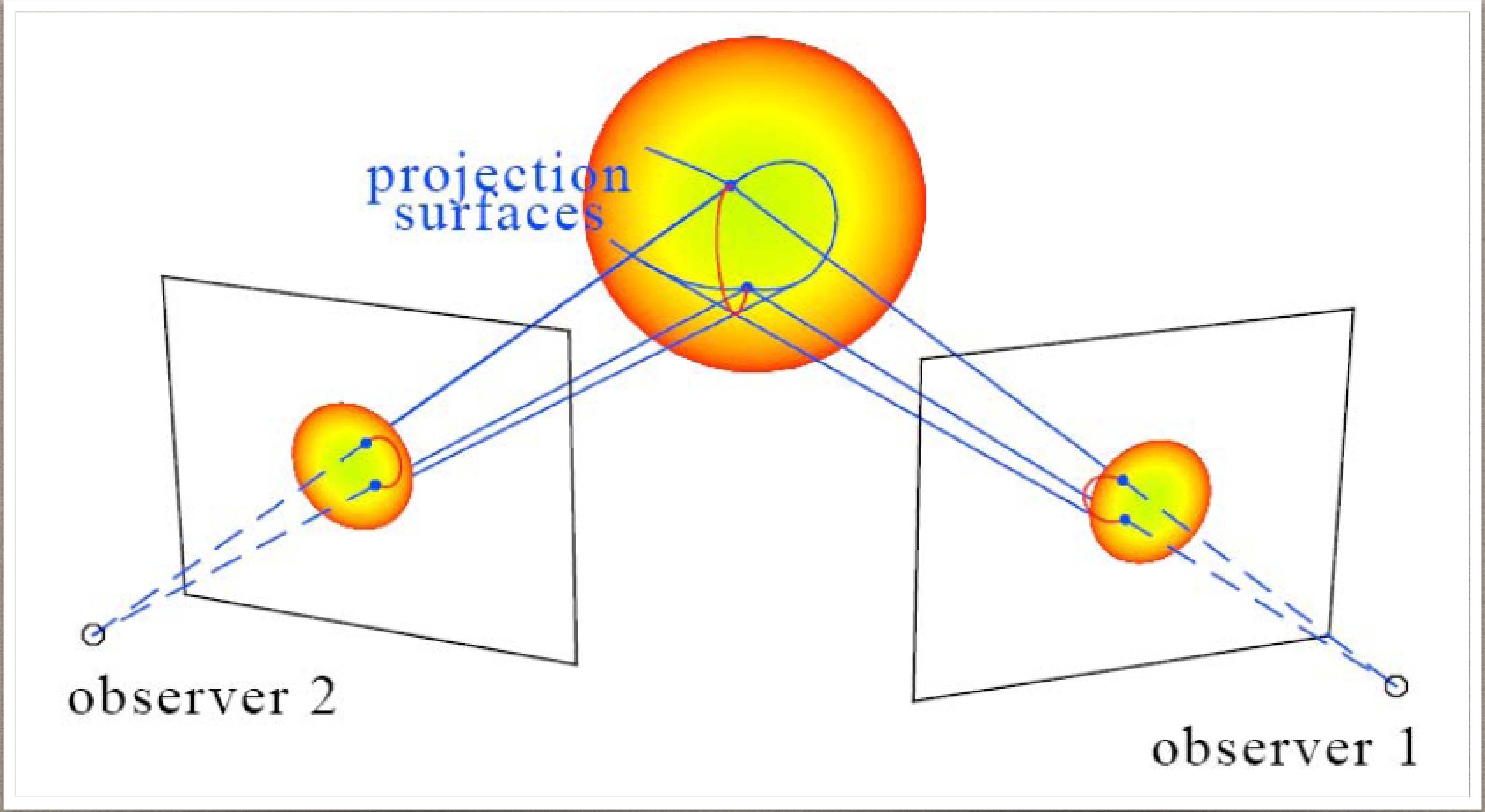
Combine all previously mentioned methods...



Sunrise I - polar landscape (Prabhu, 2018)

SUPPOET FOR CORONOGRAPHIC OBSERVATIONS

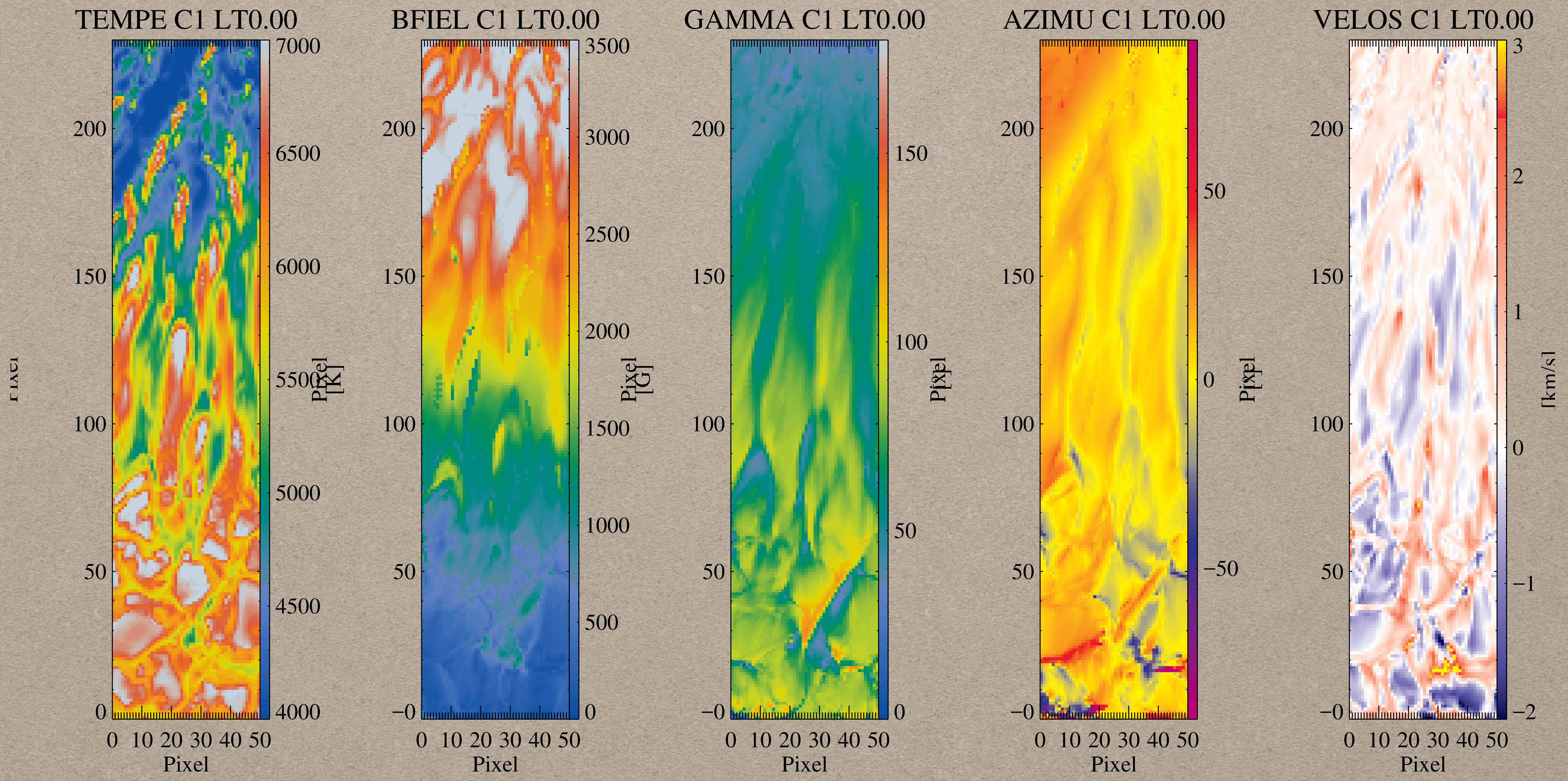
Solar Orbiter & Ground based in quadrature - mutual support



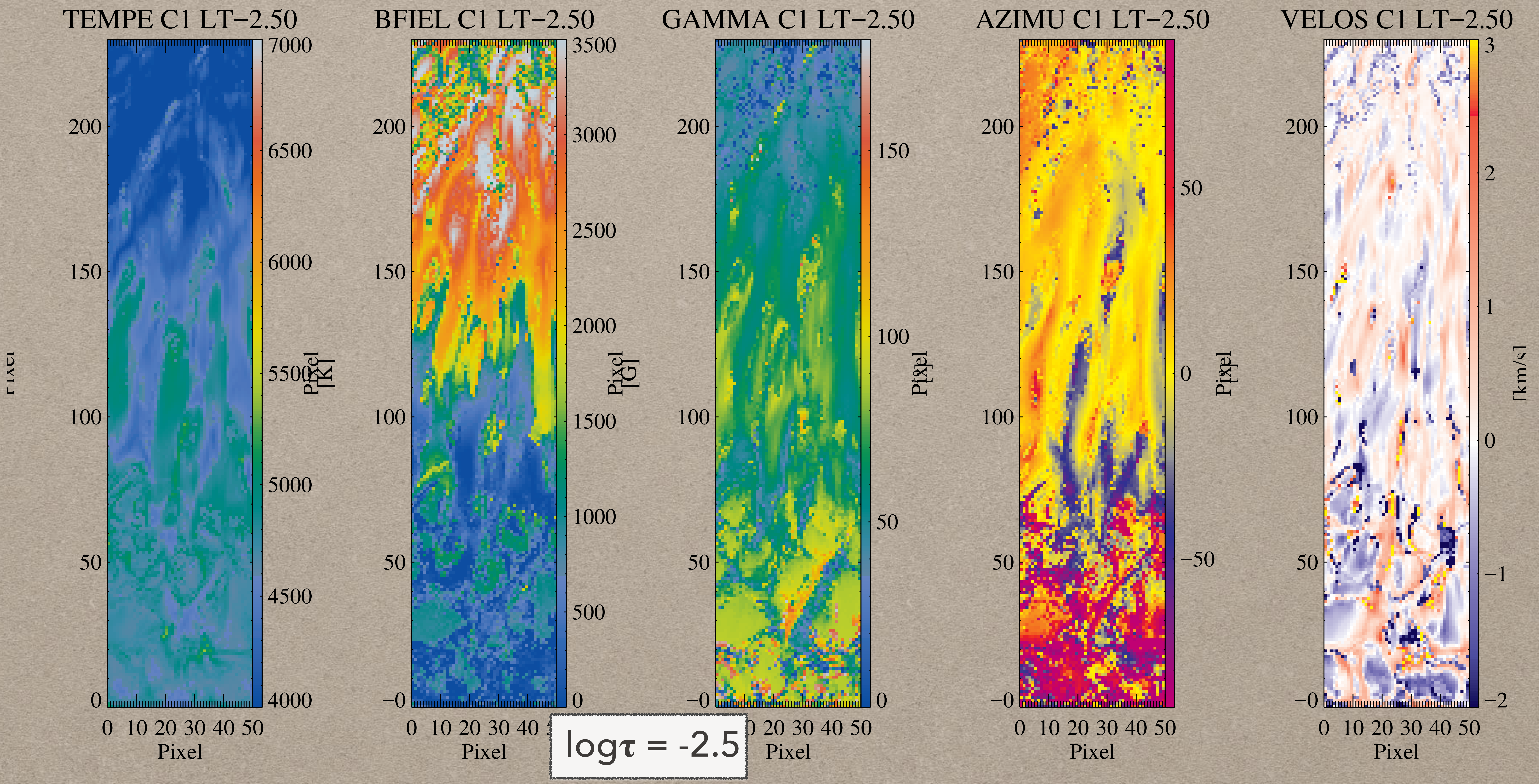
Uncertainties in Magnetograms

VERTICAL GRADIENTS

1-NODE (ME-TYPE) INVERSIONS



3-NODE (HEIGHT-DEPENDENT) INVERSIONS



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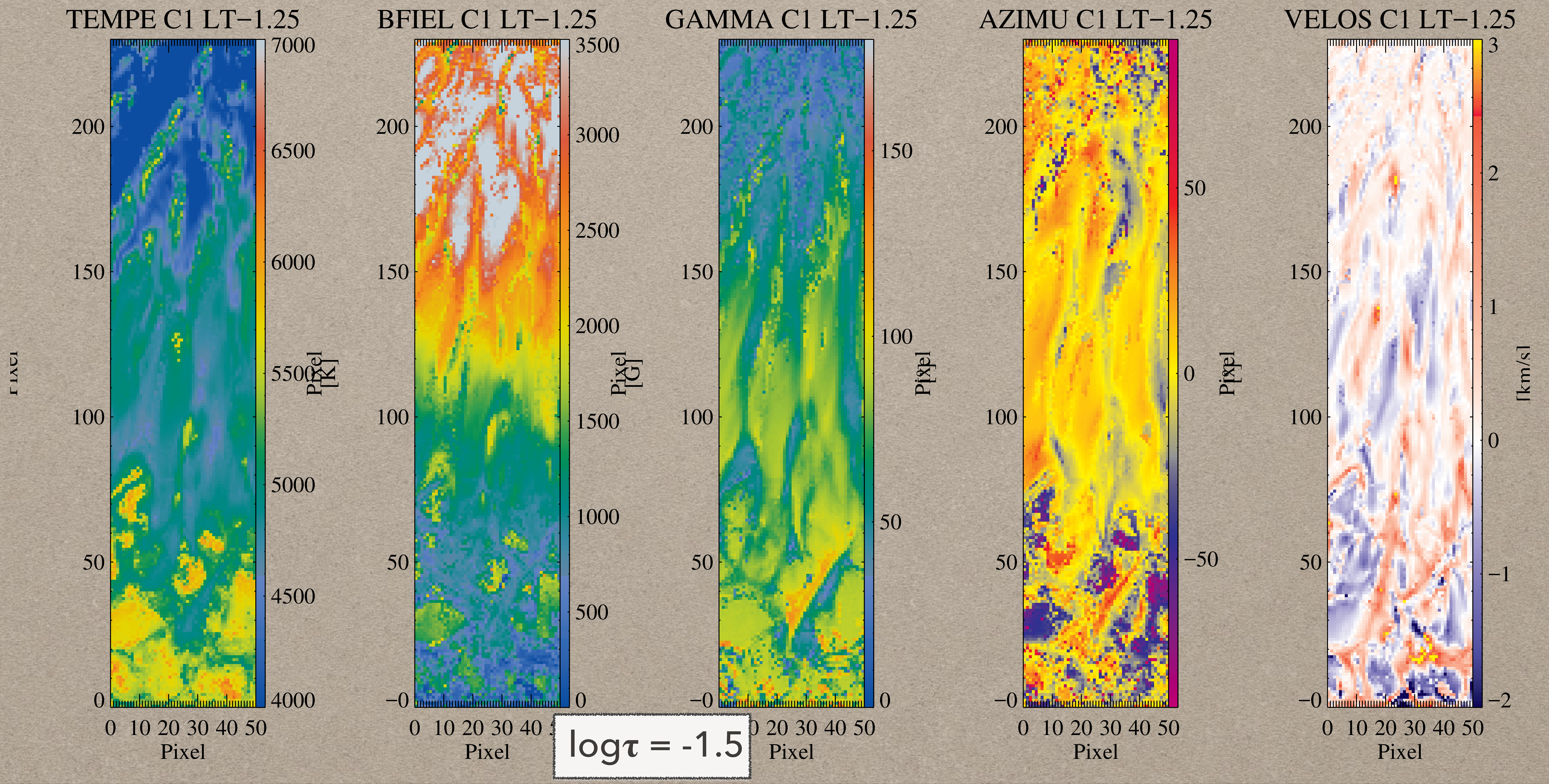

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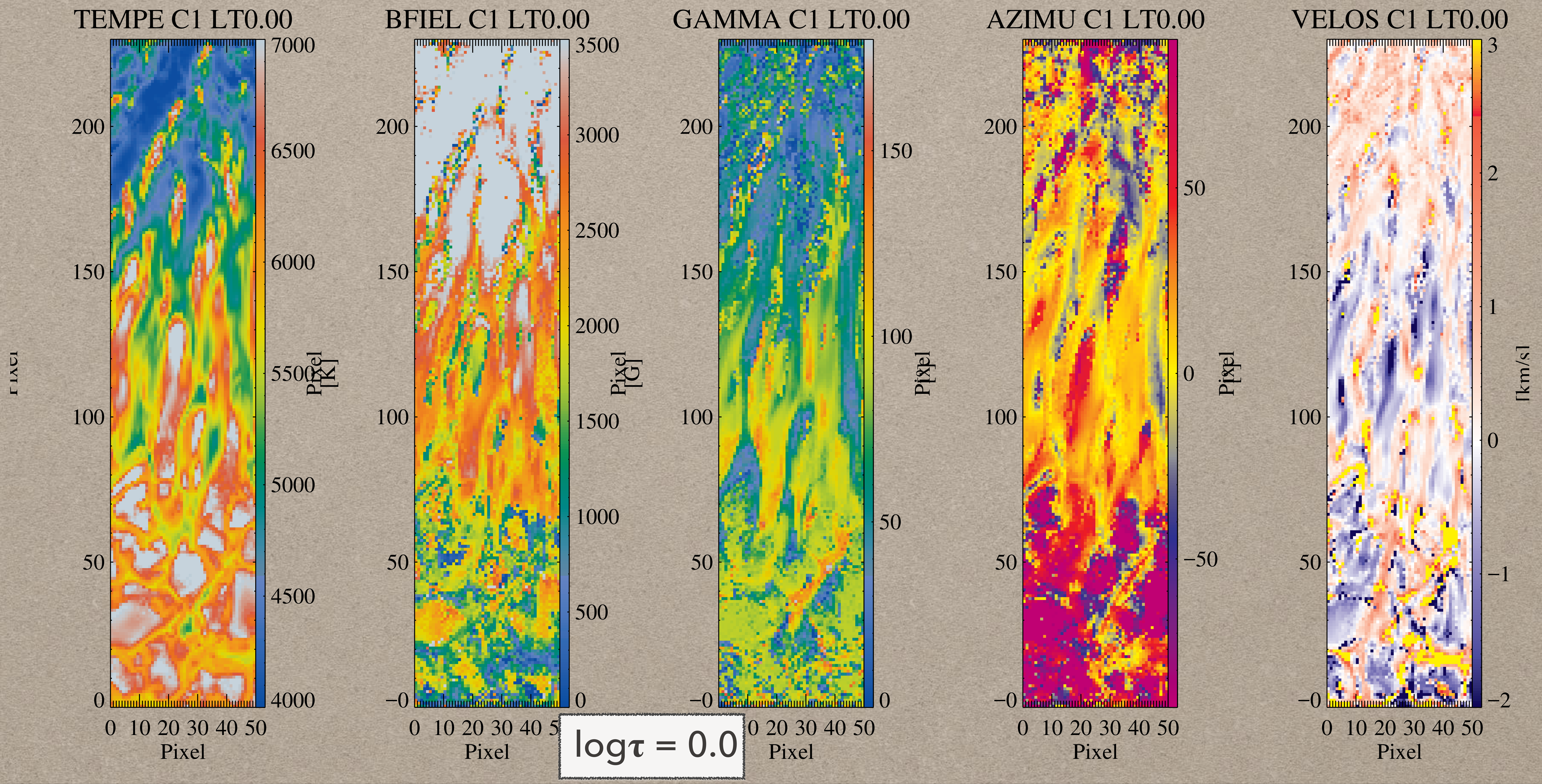

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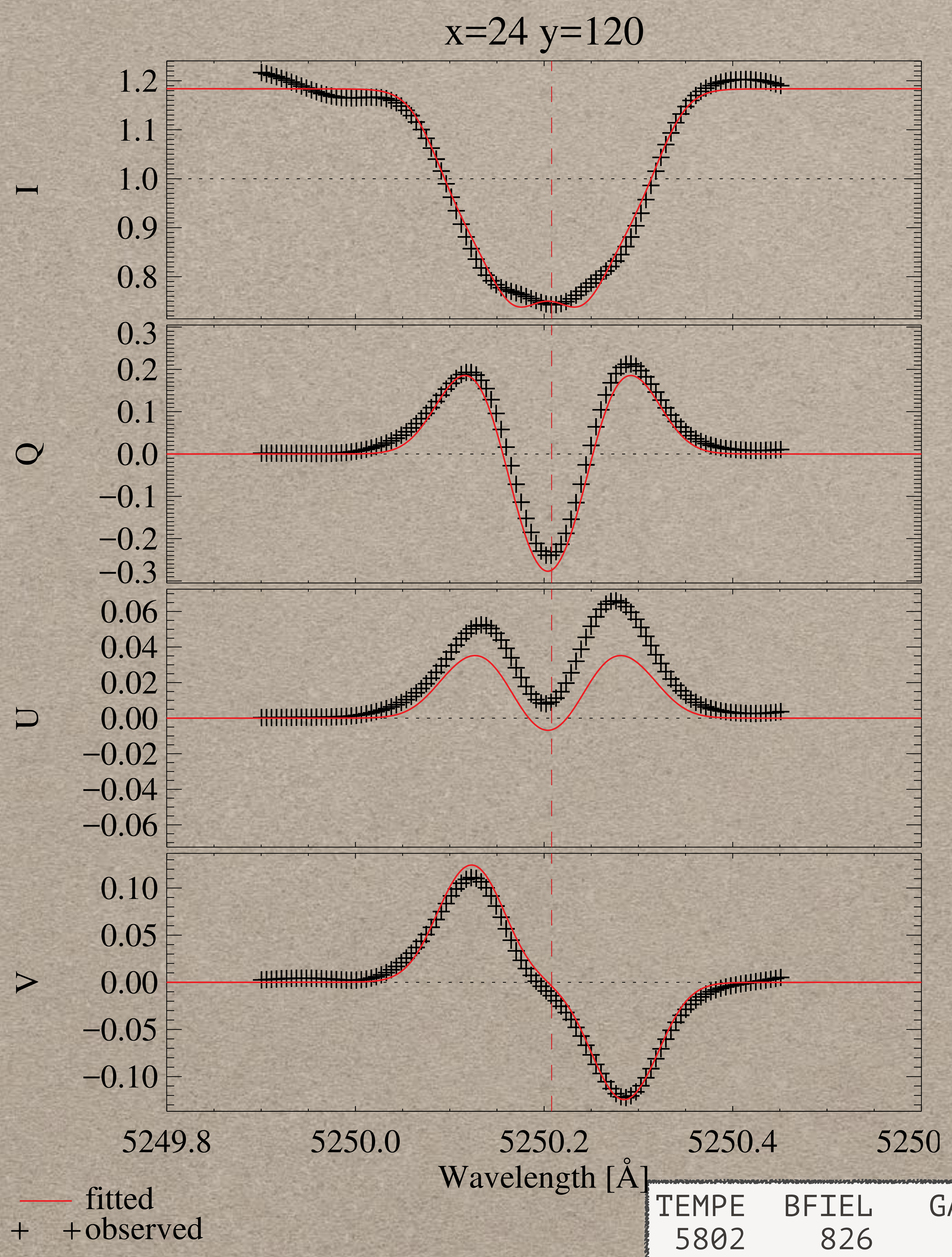
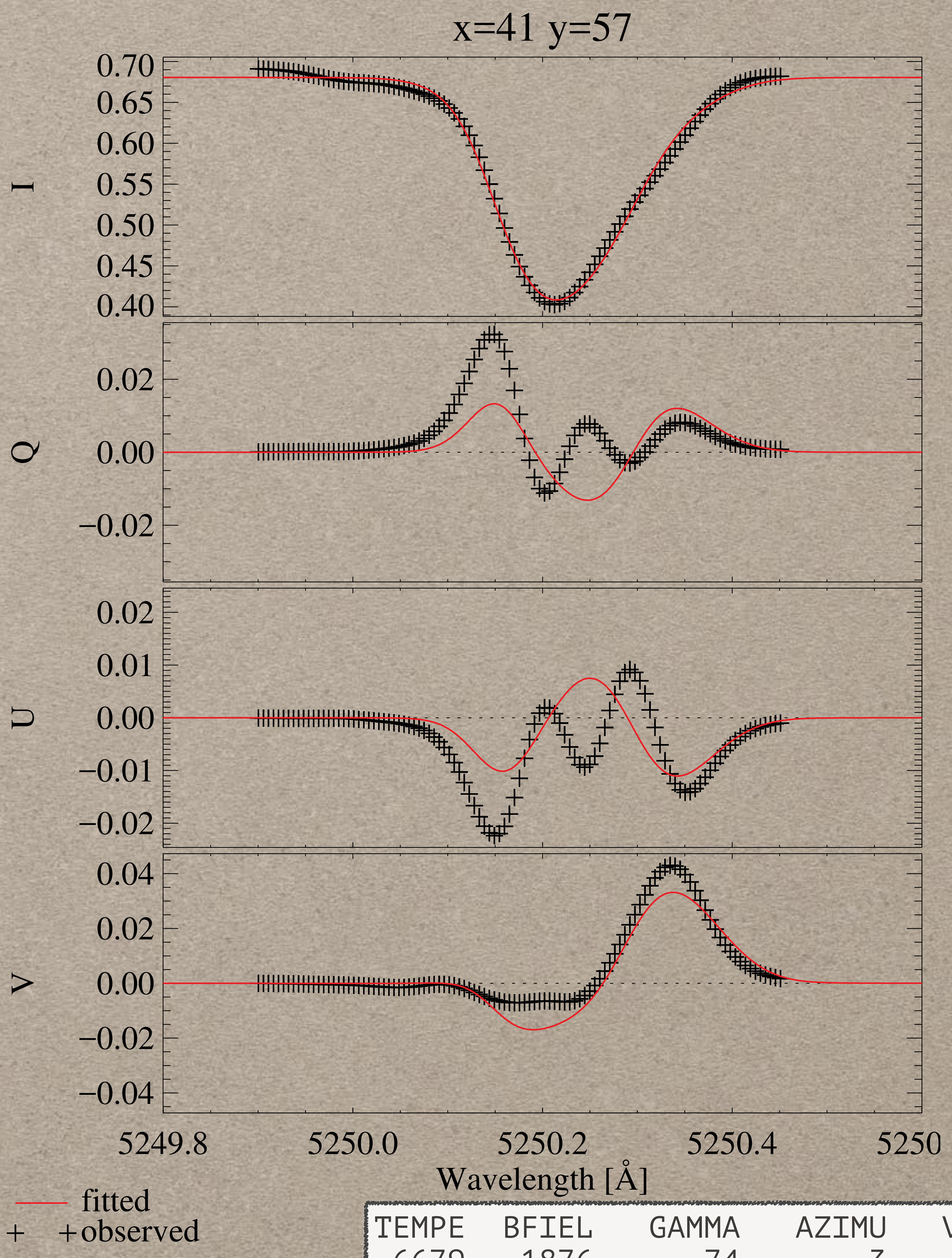
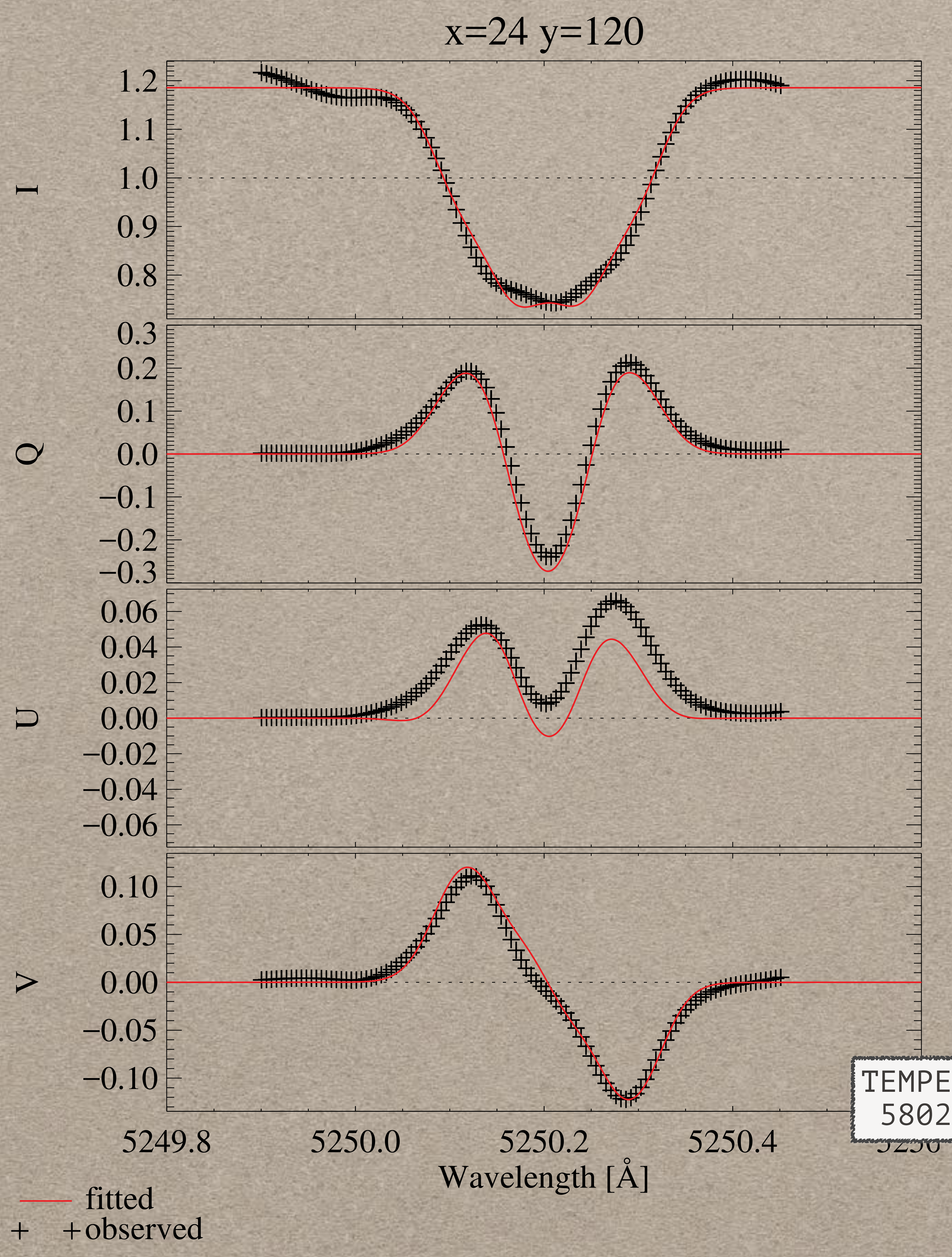


TEMPE	BFIEL	GAMMA	AZIMU	VELOS
5802	826	105	-16	+1.13



TEMPE	BFIEL	GAMMA	AZIMU	VELOS
6679	1876	74	3	-0.22

3-node (Height-Dependent) inversions



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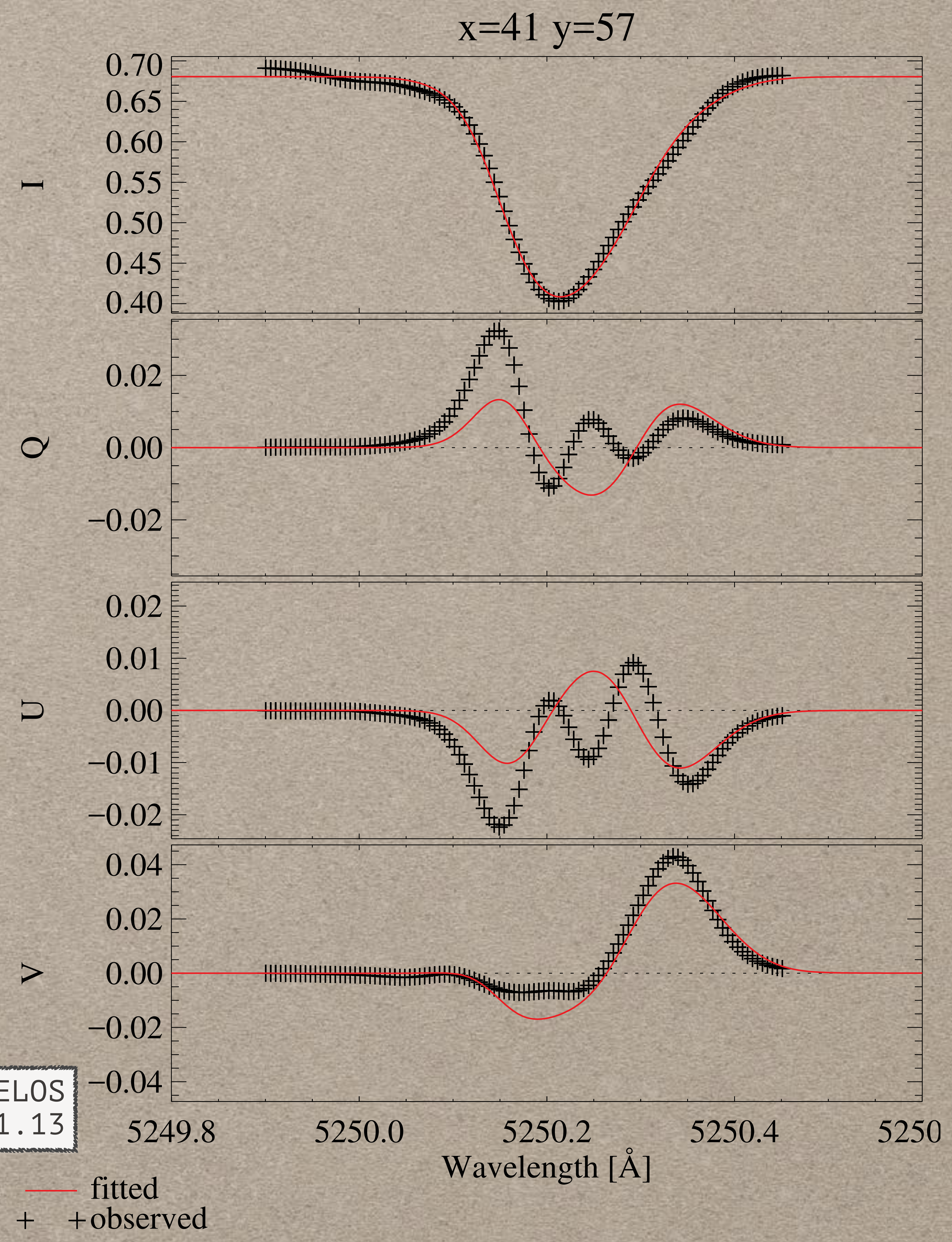
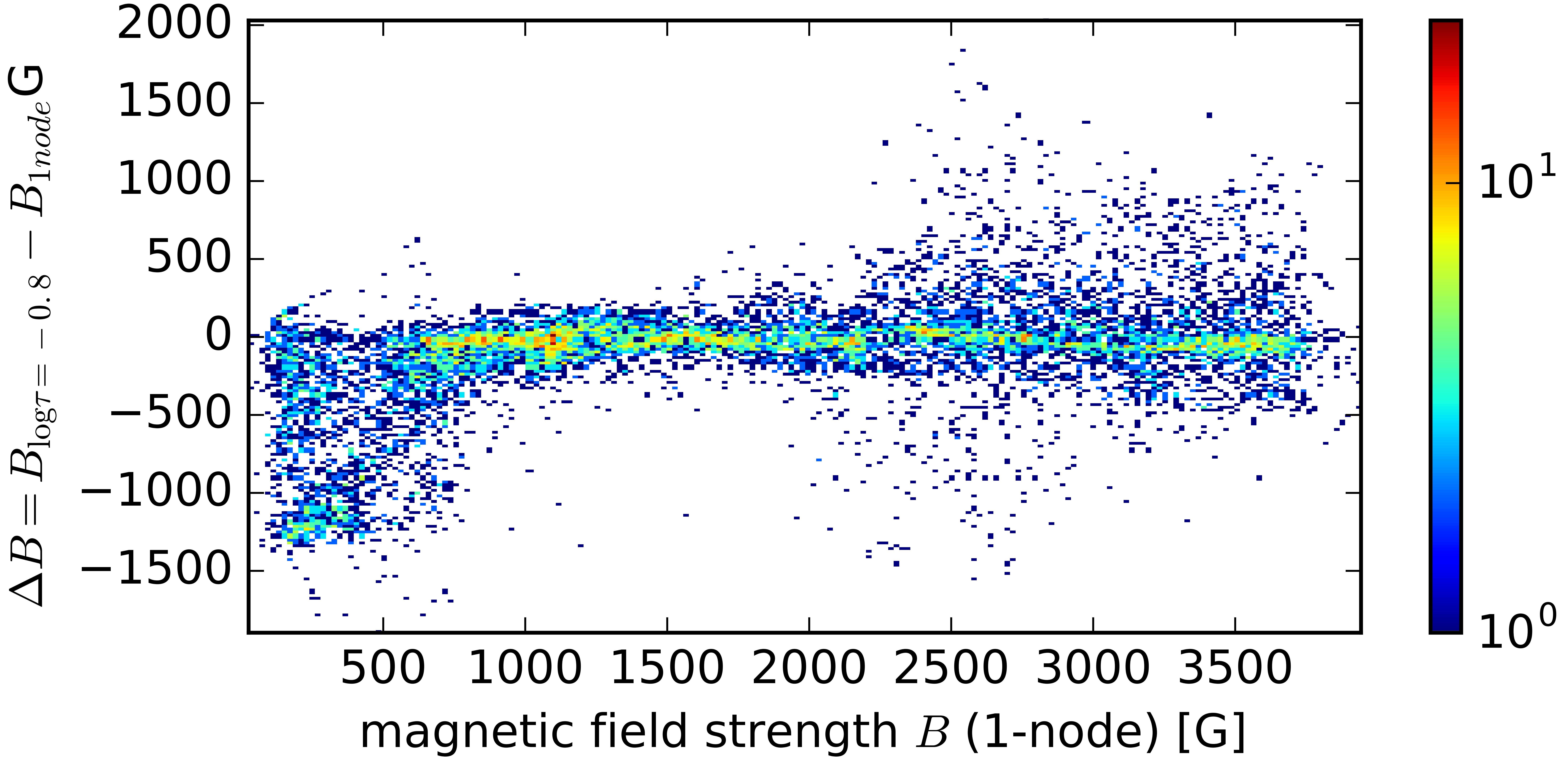


1-node vs. 3-node Inversions



DKIST SUCs …

… REQUESTING SOLAR ORBITER SUPPORT

DKIST SUCs

SUC 13: The multi-scale nature of vorticity in the solar atmosphere	
PI:	Eamon Scullion, Northumbria University, UK
Science:	Vortex motions are present in a wide variety of phenomena and across a range of temporal and spatial scales in the lower solar atmosphere. Understanding the nature of vorticity, at different spatial scales, could also lead to new insights into the transport of mechanical energy and its dissipation in the solar atmosphere.
SolO support:	PHI velocity maps, determine 3D-velocities of vortices
DKIST-Obs:	Hi-res, hi-cadence images in various photospheric and chromospheric channels (VTF + VBI)

Understanding the nature of vorticity, at different spatial scales, could also lead to new insights into the transport of mechanical energy and its dissipation in the solar atmosphere.

DKIST SUCs

SUC 20: Long Term High Resolution Observations of the Sun's Polar Fields	
PI:	Gordon Petrie, National Solar Observatory
Science:	The Sun's polar fields play a leading role in organizing the large-scale structure of the solar atmosphere and in determining the strength of the interplanetary magnetic field. Accurate measurements of the polar field are essential for understanding the solar cycle and predicting its strength.
SolO support:	PHI polar landscape measurements
DKIST-Obs:	Tiled scan of the polar crown with ViSP Tiled scan of the polar chromosphere/corona with DL-NIRSP Tiled scan of the polar corona (off-limb) with Cryo-NIRSPi-res

DKIST SUCs

SUC 60: Coronal helium abundance from joint DKIST and Solar Orbiter observations	
PI:	Vincenzo Andretta, INAF/Osservatorio Astronomico di Capodimonte
Science:	The helium abundance relative to hydrogen from in-situ measurements of the fast and slow solar wind has long been known to be depleted. Measurements of the helium abundance in the corona will allow for identification of the source regions of the slow wind streams with different helium abundance.
SolO support:	Solar Orbiter in conjunction or opposition, remote sensing & in-situ instruments (already defined as SOOP: L_FULL_HRES_MCAD_Coronal_He_Abundance)
DKIST-Obs:	Cryo-NIRSP in various wavelength bands

SUC 61: DKIST and Solar Orbiter observations for understanding the creation of upflowing plasma on the Sun.	
PI:	Louise Harra , UCL-MSSL
Science:	The project aims to explore the physical processes that create upflowing plasma that constitutes part of the solar wind. DKIST will provide photospheric and chromospheric magnetic fields, providing a 3-D view of the magnetic structure. This will permit constraining of models and detailed understanding of the processes creating the upflow.
SolO support:	PHI magnetic field maps and in-situ experiments in quadrature. SOOPs: L_BOTH_HRES_LCAD_CH_Boundary_Expansion L_SMALL_HRES_HCAD_SlowWindConnection L_SMALL_HRES_HCAD_Fast_Wind L_SMALL_HRES_HCAD_SlowWindConnection R_SMALL_HRES_MCAD_PolarObservations
DKIST-Obs:	VTF, VBI, ViSP, NIRSP in photospheric& chromospheric lines

SUC 62: Are quiet-Sun internetwork fields turbulent? The Zeeman view	
PI:	Luis Bellot Rubio, Instituto de Astrofisica de Andalucia - CSIC
Science:	The main goal of this SUC is to investigate the magnetism of the solar internetwork by means of the Zeeman effect. 1. Determine the vector magnetic field in the internetwork reliably, using all four Stokes parameters of visible and infrared spectral lines 2. Study the magnetism of the quiet-Sun internetwork over most of the solar surface 3. Determine whether or not internetwork fields are "turbulent", as assumed to explain spatially and temporally unresolved Hanle measurements 4. Assess the compatibility of the Zeeman and Hanle views of the quiet Sun
SolO support:	PHI magnetic field maps (stereoscopy)
DKIST-Obs:	Ultra-deep spectropol. observations of the solar internetwork at different heliocentric angles with VISP, DL-NIRSP and VTF.

SUC 64: FIP fractionation as tracer of solar wind source regions from joint DKIST and Solar Orbiter observations.	
PI:	Susanna Parenti, Institut d'Astrophysique Spatiale, France
Science:	The plasma composition and FIP fractionation are considered a good tracer for discriminating the wind source regions and the plasma propagation in the heliosphere. This project is to provide strong constraints to the identification of the winds sources by using joint measures of the plasma parameters (i.e. the FIP effect and flows) and magnetic field properties (from DKIST) in different solar regions.
SolO support:	FIP maps at different temperatures (SPICE), high-res context of the observed area (EUI) and vector magnetic field (PHI). SOOPs: L_SMALL_MRES_MCAD_Ballistic-connection; L_SMALL_MRES_MCAD_Connection_Mosaic; L_SMALL_HRES_HCAD_Fast_Wind; L_SMALL_HRES_HCAD_SlowWindConnection; R_SMALL_HRES_LCAD_Composition_vs_Height.
DKIST-Obs:	VBI-Blue

DKIST SUCs

SUC 88: Properties of the solar wind source regions	
PI:	Daniele Spadaro, INAF-Osservatorio Astrofisico di Catania, Italy
Science:	The magnetic field topology detected by DKIST can be related to the solar wind properties (plasma density, helium abundance, plasma outflow velocity) measured by the Solar Orbiter instruments Metis and EUI (FSI) in the innner heliosphere. The influence of the magnetic flux divergence (directly determined by DKIST and indirectly by Metis) on the wind expansion velocity in the source regions can be investigated.
SolO support:	PHI in perihelion & conjunction SOOPs L_BOTH_HRES_LCAD_CH_Boundary_Expansion, L_FULL_HRES_LCAD_MagnFieldConfig
DKIST-Obs:	Cryo-NIRSP in various wavelength bands

SUC 89: Tracking the evolution of Corona Mass Ejections plasma	
PI:	Daniele Spadaro, INAF-Osservatorio Astrofisico di Catania, Italy
Science:	Tracking the evolution of the coronal mass ejections plasma from the solar surface through the inner and outer corona, possibly through regions of the solar wind probed by PSP. SO science questions are Q1: What drives the solar wind and where does the heliospheric magnetic field originate? and Q2: How do solar transients drive heliospheric variability?
SolO support:	Solar Orbiter orbital quadrature, the existing Solar Orbiter SOOPs: L_FULL_HRES_HCAD_Coronal_Dynamics, L_FULL_LRES_MCAD_Coronal_Synoptic
DKIST-Obs:	VBI-blue

DKIST SUCs

SUC 115: Temperature, density and composition of the solar corona and the solar wind from joint DKIST and Solar Orbiter observations	
PI:	Andrzej Fludra, STFC Rutherford Appleton Laboratory
Science:	Temperature and density, combined with a solar wind model, will be used to calculate the ionization fractions of elements along the open magnetic field lines, and to compare them with line intensities observed by SPICE and ion fractions measured by Solar Orbiter SWA/HIS. We will also derive outflow velocity maps and FIP maps of elements observed by SPICE and compare them to in-situ abundance measurements. This study will provide constraints on the fast solar wind models and locate the sources of the fast solar wind.
SolO support:	Solar Orbiter preferably from higher ecliptic latitude >20 degrees. Full field of view to include the coronal hole. SOOPS: L_SMALL_HRES_HCAD_Fast_Wind, R_SMALL_HRES_LCAD_Composition_vs_Height, R_SMALL_HRES_MCAD_PolarObservations
DKIST-Obs:	Cryo-NIRSP