Probing solar polar magnetic fields: a spatially-coupled approach with disambiguation

Đ. Mijović[1], I. Milić[2], and R. Centeno[3]

[1] Faculty of Mathematics, University of Belgrade, Studentski Trg 16-20, 11000 Belgrade, Serbia
[2] Institute for Solar Physics, Georges Khöler Allee 401a, 79110 Freiburg, Germany
[3] High Altitude Observatory, Center Green Drive 3090, CO 80301 Boulder, United States of America

contact e-mail: *djordje.mijovic@matf.bg.ac.rs*

In the solar polar regions, the inclined limb geometry and limited spatial resolution of spectropolarimetric instruments introduce significant biases in the retrieval of vector magnetic fields. Near the limb, the Zeeman linear signals, proportional to the square of the transversal magnetic field, contain information on the radial component of the field, which is crucial for studying so-called open polar flux. Furthermore, resolving 180° ambiguity becomes crucial, as it directly influences the inference of the open flux.

In this study, we synthesize full Stokes profiles $\{I, Q, U, V\}$ from a 3D MHD atmosphere model (polar geometry effects are included) and apply spatial degradation to mimic the effects of the telescope's PSF. We perform both traditional pixel-to-pixel inversion and the spatially-coupled approach. By comparing (i) the *ground truth* magnetic field vector ($\boldsymbol{B}$) and line-of-sight (los) velocity (v_{los}) from the original atmosphere, with the results of different inversion approaches (traditional pixel-to-pixel inversion and spatially-coupled inversion) we investigate the improvements in recovering underlying magnetic field structures. After quantifying these improvements, we address the inherent 180° ambiguity in transverse azimuth. To resolve it, we apply a robust minimum energy disambiguation procedure to the ambiguous magnetic field inferred by different inversion approaches.

Our results indicate that combining spatially-coupled inversion and minimum energy disambiguation yields more accurate and reliable reconstructions of photospheric magnetic structures and line-of-sight velocities in polar regions. These improvements are most pronounced within particular ranges of $|\boldsymbol{B}|$ and v_{los}. Intervals differ for various cases we examined.