Magnetic field extrapolation using analytical 3D magnetohydrostatic (MHS) equilibrium solutions

Lilli Nadol

Introduction

Solar atmosphere modelling

Common extrapolation methods utilise photospheric observations as boundary conditions together with the assumption of a fully force-free (f-f) atmosphere. MHS methods can accommodate for the lower non f-f layers and are numerically cheaper than MHD codes.

Inclusion of the transition region

N+W (19) developed a model which transitions from a non-f-f to a f-f description of the magnetic field to mimick the changes in the solar atmosphere.

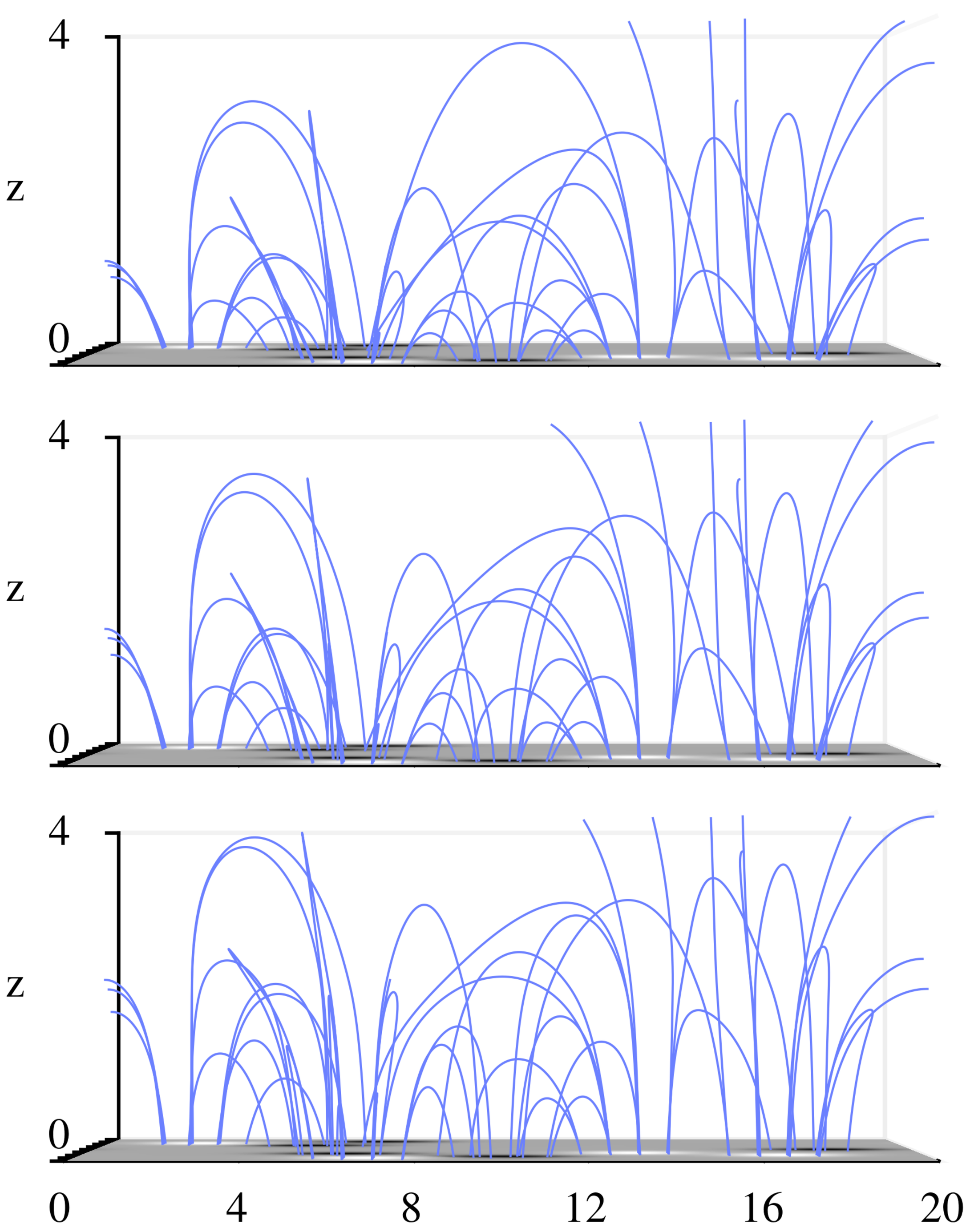
A new "quick-look" tool

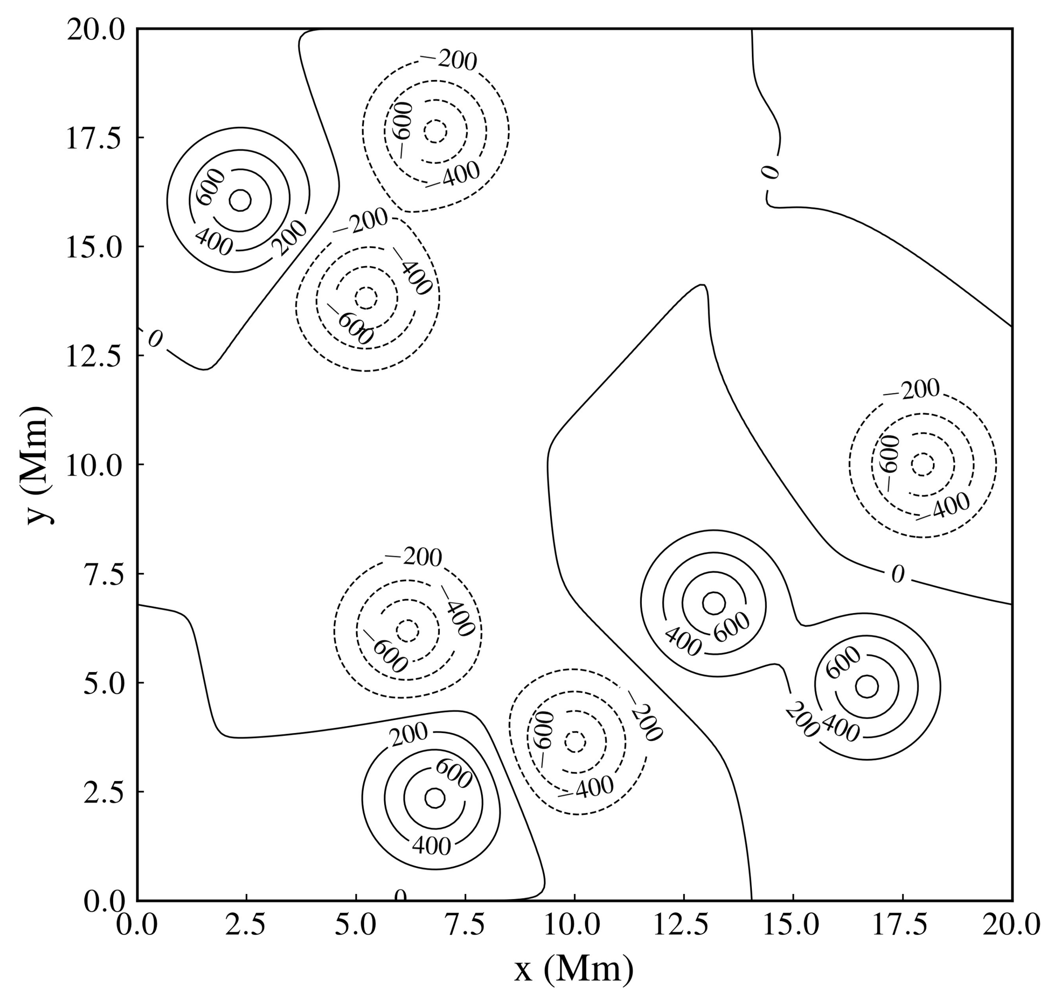
Based on this we developed a computational tool in which an asymptotic solution is used to improve the numerical efficiency. The model is extended by S (78)'s technique to balance flux through the boundary layer to enable the application to observational data.

Illustrative example

Boundary condition (BC)

Analytically calculated BC to illustrate differences between a linear f-f and two MHS extrapolations





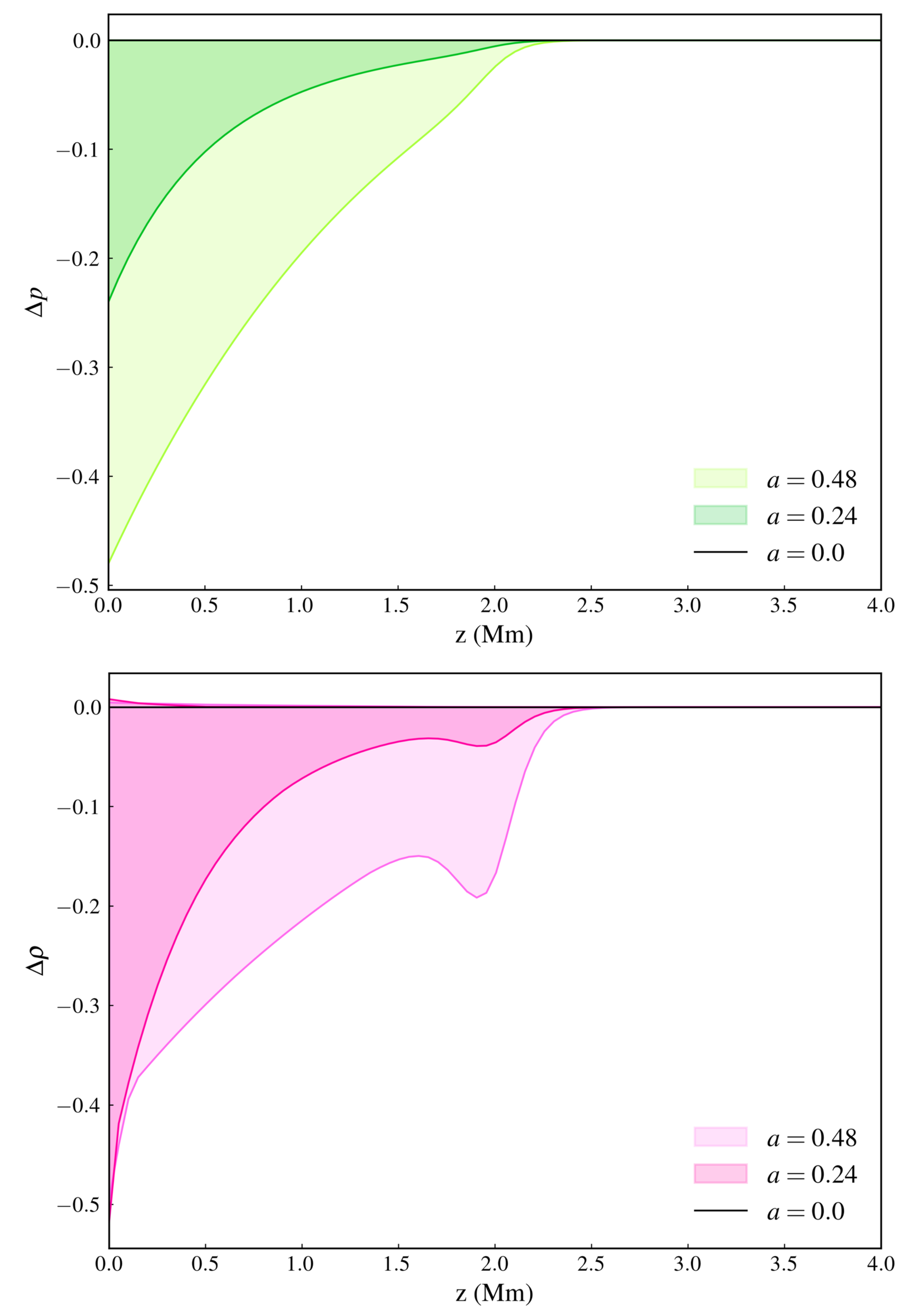
Field lines

Linear f-f field lines (top panel) and MHS solutions (centre and bottom panel): amplitude a of photosperic perpendicular currents is increased from centre to bottom

Steeping of field lines occurs below $z = 2$ Mm with increasing a

Pressure and density

Range of pressure and density variations for the linear f-f solution ($a = 0$) and the MHS solutions ($a = 0.24, 0.48$)



Application to SDO-HMI LOS magnetogram

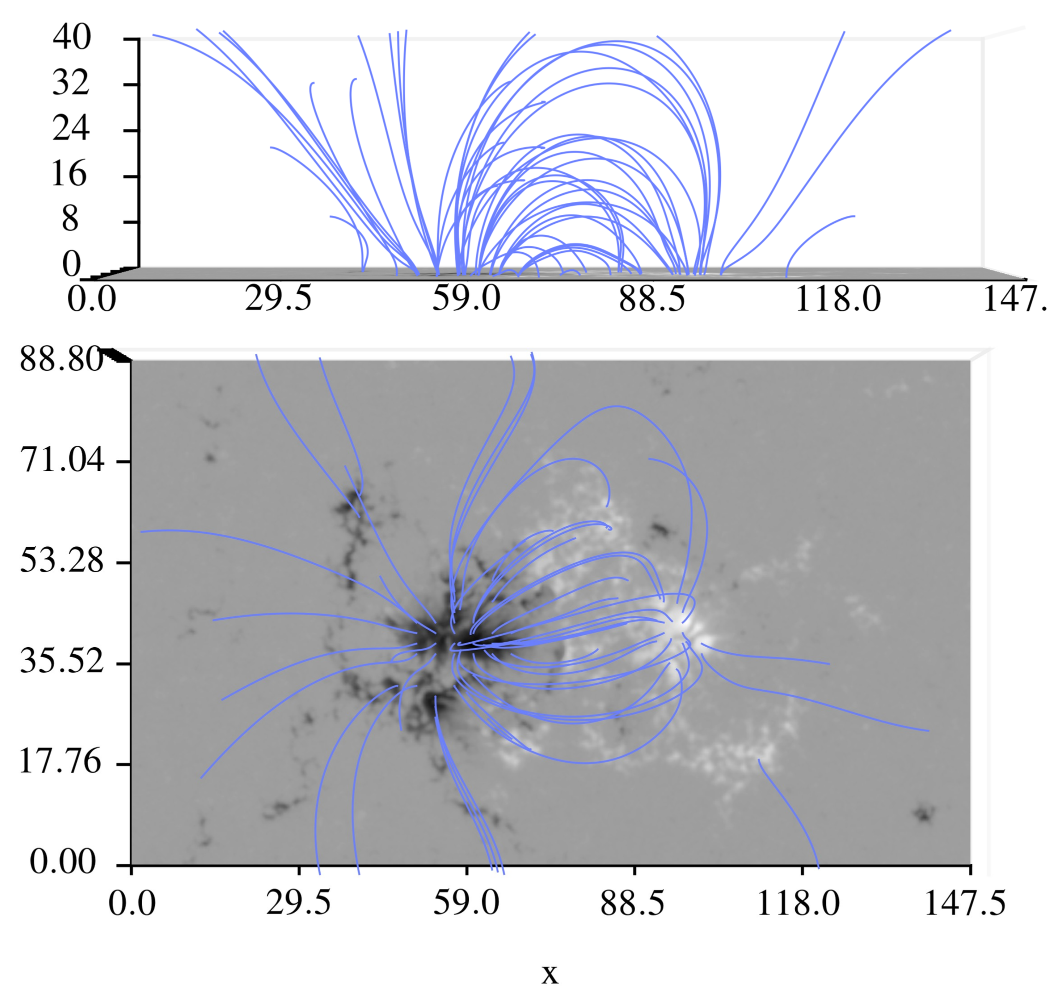
Observational BC

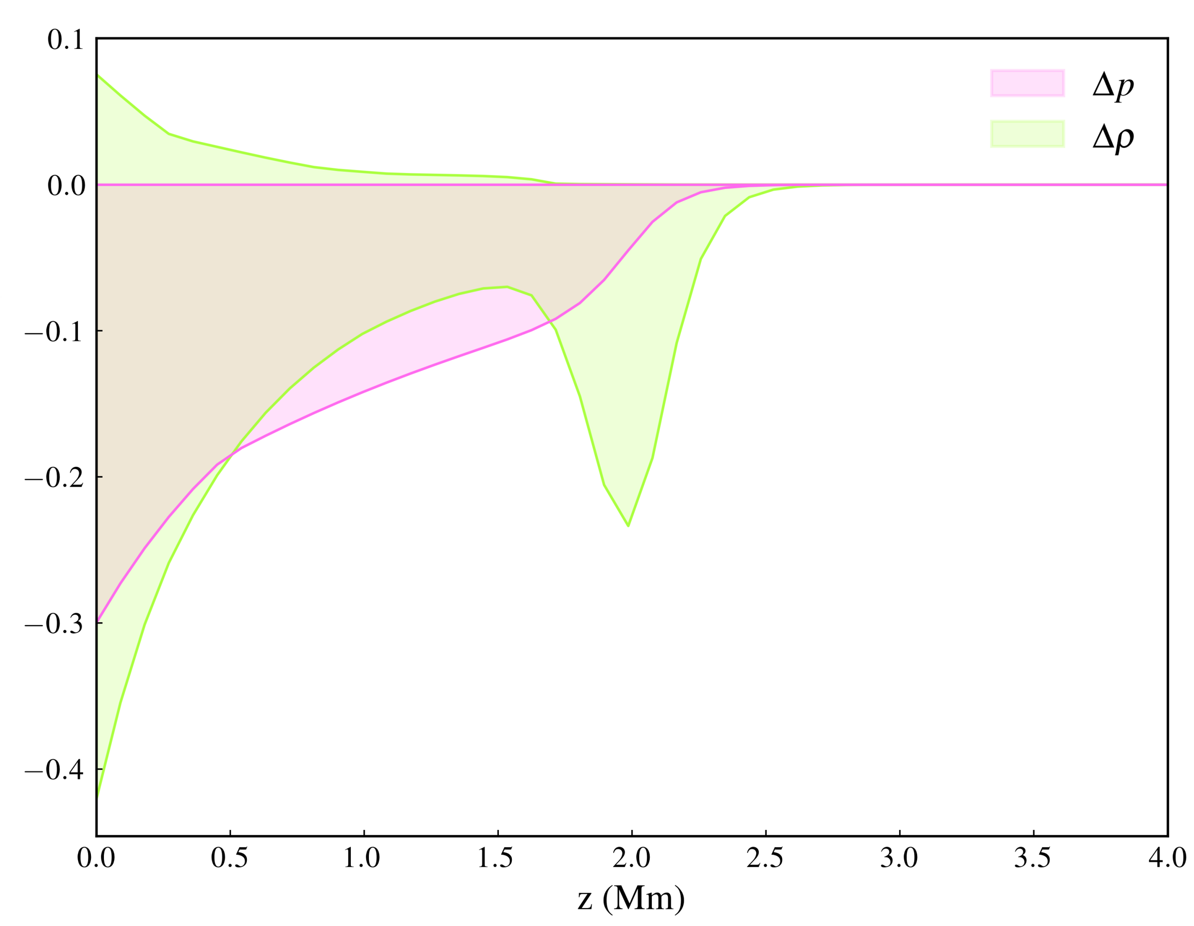
Cut-out of full disk line-of-sight magnetogram observed by HMI (SDO) on 2013-06-13 at 7:30 UT

Results

Extrapolated field lines represent overall connectivity successful

Variations in pressure and density shown with height z





Summary and outlook

First applications of N+W (19) to observational data (SDO, Solar Orbiter)

Further investigations required for parameter optimisation

Currenlty working on comparison to other extrapolation methods with ISSI

N+W (19): T. Neukirch & T. Wiegelmann, *Sol. Phys.* **294**, 171 (2019).
S (87): N. Seehafer, *Sol. Phys.* **58**, 215-223 (1987).

INTERNATIONAL SPACE SCIENCE INSTITUTE
University of St Andrews