Project SolMAG

Data-Driven Modelling of Erupting Solar Active Regions

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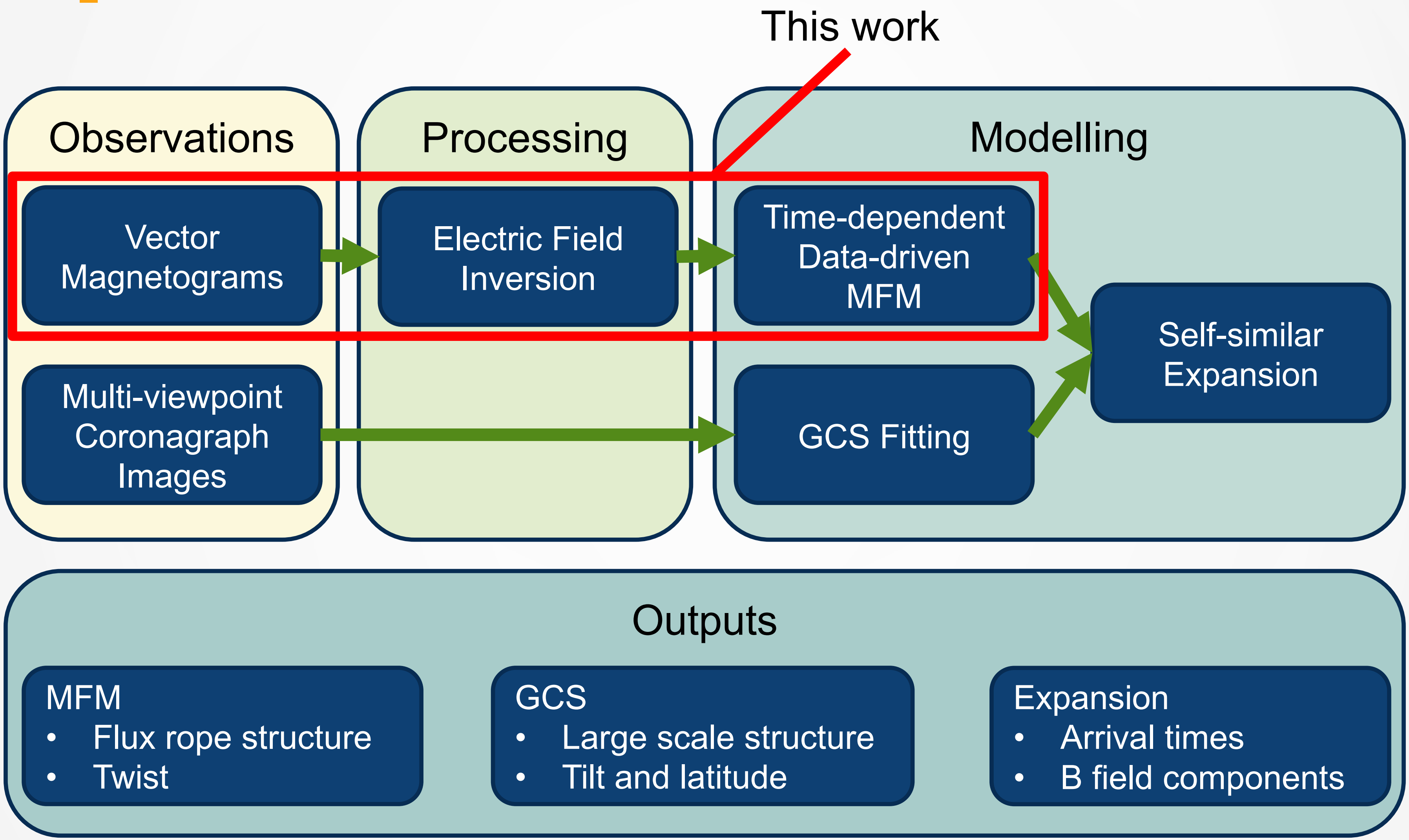
Modelling Pipeline



Electric Field Inversion

- Based on the PTD part of the PDFI method of Kazachenko et al. (2014) and on ad-hoc assumptions (below) – for further details see Lumme et al. (2017).
- *E* decomposed into inductive and non-inductive components.

inductive

$$E = E_I - \nabla\psi \qquad \nabla \times E_I = -\frac{\partial \boldsymbol{B}}{\partial t}$$

non-inductive

- B_z is almost exactly reproduced in the eventual simulations.
- In this work the non-inductive component is approximated by the "Omega assumption":

$$\nabla_h^2\psi = -\nabla_h \cdot \boldsymbol{E}_h = -\Omega B_z$$

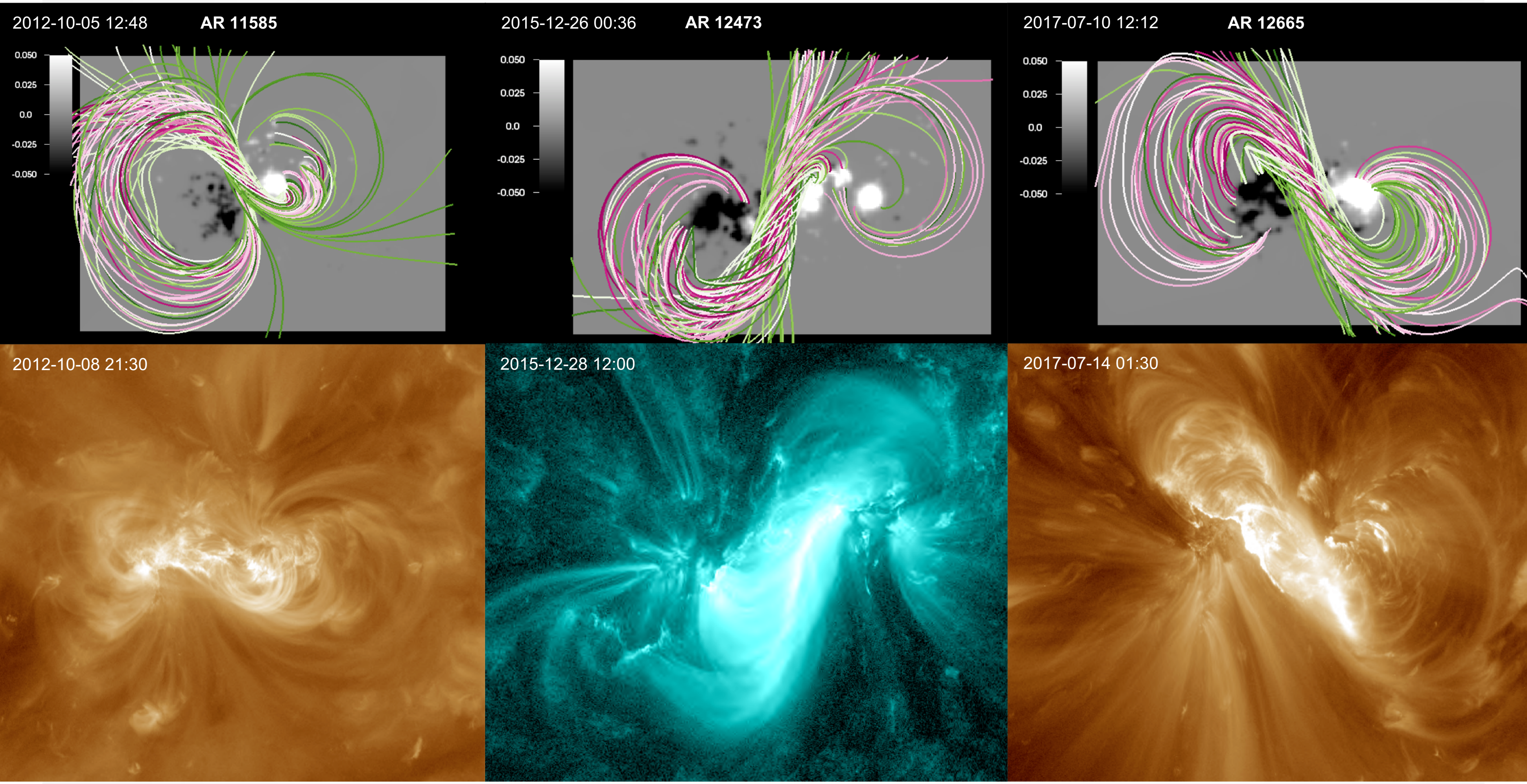
"uniform vortical motions" (Cheung & DeRosa (2012))

Magnetofrictional Modelling

$$\frac{\partial \boldsymbol{B}}{\partial t} = -\nabla \times \boldsymbol{E} \qquad \boldsymbol{E} = -\boldsymbol{V} \times \boldsymbol{B} + \mu_0 \eta \boldsymbol{J} \qquad \boldsymbol{V} \propto \frac{1}{\nu} \frac{\boldsymbol{J} \times \boldsymbol{B}}{B^2}$$

- The system is driven towards a minimum energy state where **J** x **B** = 0.
- Gradual buildup of currents allowed, permitting time-dependence.
- The constant competition between the relaxation and the photospheric driving is controlled by the frictional coefficient ν.
- Requires the observed horizontal electric field as a crucial input for the lower boundary condition.

Results & EUV Comparison



Summary & Conclusions

- Time-dependent data-driven MFM produced flux ropes with handedness consistent with in-situ observations.
- Eruptions always prior to observed eruption time.
- Magnetic field structure visually consistent with EUV observations.
- Some field lines are attracted to the boundary, this problem is under investigation but believed to be related to excessive helicity injection.

- Future work:
  - Try different assumptions for the non-inductive component.

Note that this talk has been cut down to facilitate not being presented. You are welcome to contact the authors for more information at daniel.price@helsinki.fi