An important step for realistic numerical simulations of solar active regions would be to attempt to predict the short-term evolution of the solar photosphere for space weather modeling through data assimilation. Satellite and ground-based observations are however limited to the Sun’s surface and may not be directly related to state variables in physical models: we must then extrapolate or reconstruct. Our objective is to identify which method is best suited to generate synthetic observations of plasma motions for data assimilation processes.

**Results – Synthetic Data**

![Figure 4](image1.png)

**Figure 4:** Horizontal velocity fields computed by (a) the Stein & Nordlund (2012) magnetoconvection simulation resampled at the SDO/HMI spatial resolution (reference field), (b) the DeepVel neural network trained using results from the Stein & Nordlund (2012) numerical simulation, (c) Local Correlation Tracking (LCT: November & Simon (1988)) and (d) Fourier-based Local Correlation Tracking (FLCT: Fisher & Welsch (2008)). The vertical component of the velocity field computed by the Stein & Nordlund (2012) simulation is displayed in the background. Inside a granule, plasma rises (positive vertical velocities) and the horizontal velocity vectors diverge. In the intergranular network, plasma sinks back into the star’s interior (negative vertical velocities) and horizontal velocity vectors converge. (e) Kinetic energy spectra $E(k)$ as a function of the wave number $k$ (which is inversely proportional to the spatial scale). The reference vector field and the velocity field inferred using DeepVel are in agreement at supergranular scales (SG: order of 10 Mm or larger), mesogranular scales (MG: between 1 Mm and 10 Mm) and granular scales (G: 1 Mm or less).

**Results – SDO/HMI Data**

![Figure 5](image2.png)

**Figure 5:** (a) Continuum intensity measured by SDO/HMI on 2010-10-08. (b) Horizontal velocity fields computed by (b) the DeepVel neural network trained using results from the Stein & Nordlund (2012) numerical simulation, (c) LCT and (d) FLCT. The continuum intensity measured by SDO/HMI is displayed as background. Inside a granule, the ascending plasma is hotter (higher intensity at the photosphere) and the horizontal velocity vectors diverge. In the intergranular network, the sinking plasma is colder (lower intensity) and the horizontal velocity vectors converge. (e) The kinetic energy spectra $E(k)$ as a function of the wavenumber $k$ (which is inversely proportional to the spatial scale) shows that only DeepVel can reproduce the variations expected at mesogranular scales (MG: between 1 Mm and 10 Mm) and granular scales (G: 1 Mm or less).

**Conclusion**

- Comparison: Velocity fields inferred by the DeepVel convolutional neural network capture the properties of solar granulation at spatial and temporal scales that are compatible with observations recorded by SDO/HMI.
- Future: Use the inferred velocity fields as synthetic observations in data assimilation processes by incorporating them in a MHD model of solar active regions.

**References**