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Web Seminar

Multi-scale deep learning for estimating horizontal velocity fields on the solar surface

Ryohtaroh T. Ishikawa

National Astronomical Observatory of Japan, Tokyo, Japan

The dynamics on the solar surface is governed by turbulent convection termed as granulation and supergranulation. It is important to derive three-dimensional velocity vectors to know the nature of the turbulent convection. The line-of-sight component of the velocity can be obtained by observing the Doppler shifts, but it is difficult to obtain the velocity component perpendicular to the line-of-sight which corresponds to the horizontal velocity. We develop a convolutional neural network model to infer the horizontal velocity fields.

The model is based on a multi-scale deep learning architecture that consists of multiple convolutional kernels with various sizes of the receptive fields and performs convolution for both the spatial and temporal axes. The network is trained with data from three different numerical simulations of turbulent convection. We also newly introduce a coherence spectrum to assess the horizontal velocity fields thus derived at each spatial scale. The multi-scale deep learning method successfully predicts the horizontal velocities for each convection simulation in terms of the global correlation coefficient. However, the coherence spectrum reveals the strong dependence of the correlation coefficients on the spatial scales. Although the coherence spectra are higher than 0.9 for large-scale structures, they drastically decrease to less than 0.3 for small-scale structures, wherein the global correlation coefficient is about 0.95. These results imply that the accuracy for the small-scale structures is not guaranteed only by the global correlation coefficient. To improve the accuracy on small scales, it may be worth improving the loss function to

enhance the small-scale structures and to utilize other physical quantities as input data related to the non-linear cascade of convective eddies.