Solar Activity Modeling: from Subgranular Dynamical Scales to the Solar Cycles

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The dynamical effects of solar magnetoconvection span a wide range spatial and temporal scales that extend from the interior to the corona and from fast turbulent motions to global magnetic activity. To study the solar activity on short temporal scales (minutes to hours), we use 3D radiative MHD simulations that allow us to investigate complex turbulent interactions that drive various phenomena, such as plasma eruptions, spontaneous formation of magnetic structures, funnel-like structures and magnetic loops in the corona, and others. In particular, we focus on multi-scale processes of energy exchange across layers of the solar interior and atmosphere, which contribute to coronal heating and eruptive dynamics. For modeling global-scale activity, we use a data assimilation approach that has demonstrated great potential for building reliable long-term forecasts of solar activity. In particular, it has been shown that the Ensemble Kalman Filter (EKF) method applied to the Parker-Kosovichev-Russell magnetic dynamo model is capable of predicting solar activity on the solar rotation cycle ahead in time, as well as estimating the properties of the next cycle a few years before it begins. In this presentation, we use the available magnetodynamic data, we discuss development of the methodology and forecast quality criteria (including forecast uncertainties and sources of errors). We demonstrate the influence of observational limitations on prediction accuracy, and we present the EKF predictions of the upcoming Solar Cycle 25 (based on both the supercycle number and observed magnetic fields) and discuss the uncertainties and potential of the data assimilation approach for modeling and forecasting solar activity.


Reference:


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