

Long-Term Sunspot Activity Forecasting Using Artificial Neural Networks

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Abstract

This study presents a long-term forecast of sunspot activity up to the year 2250 using a multi-window ensemble approach based on artificial neural networks. The proposed architecture employs a large-scale ensemble of Multilayer Perceptrons (MLPs), consisting of approximately 80 independent models trained across diverse temporal lag windows and multiple experimental runs. Although precise point forecasting over such an extended horizon is inherently constrained by chaotic dynamics, the collective behavior of the ensemble yields significant structural insights. While the grand ensemble mean (the white trajectory) remains bounded within a stable regime, individual model trajectories exhibit progressively higher maximums in each subsequent solar cycle. This divergence and the expanding envelope of peak amplitudes suggest an underlying structural tendency indicating a general future increase in solar activity and maximum cycle intensities.