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Why does the Signal-to-Noise Paradox Exist in Seasonal Climate Predictability?

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Skillful prediction of seasonal monsoons has been a challenging problem since the 1800s. However, significant progress has been made in Indian summer monsoon rainfall prediction in recent times, with skill scores reaching 0.6 and beyond, surpassing the estimated predictability limits. This phenomenon leads to what is known as the “Signal-to-noise Paradox.” To investigate this paradox, we utilized 52 ensemble member hindcast runs spanning 30 years.

Through the application of ANOVA and Mutual Information methods, we estimate the predictability limit globally. Notably, for the boreal summer rainfall season, the Indian subcontinent exhibited the paradox, among several other regions, while the Equatorial Pacific region, despite demonstrating high prediction skill, does not have the Signal-to-Noise paradox. We employed a novel approach to understand how sub-seasonal variability and their projection in association with predictors are linked to the paradoxical behavior of seasonal prediction skill.

We propose a new method to estimate predictability limits that is free from paradoxical phenomena and shows much higher seasonal predictability. This novel method provides valuable insights into the complex dynamics of monsoon prediction, thereby creating opportunities for expanded research and potential improvements in seasonal forecasting skill in the coming years.