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The Stochastic predictability limits of GCM internal variability and the Stochastic Seasonal to Interannual Prediction System (StocSIPS)

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Over the past ten years, a key advance in our understanding of atmospheric variability is the discovery that between the weather and climate regime lies an intermediate "macroweather" regime, spanning the range of scales from ≈10 days to ≈30 years. Macroweather statistics are characterized by two fundamental symmetries: scaling and the factorization of the joint space-time statistics. In the time domain, the scaling has low intermittency with the additional property that successive fluctuations tend to cancel. In space, on the contrary the scaling has high (multifractal) intermittency corresponding to the existence of different climate zones.
These properties have fundamental implications for macroweather forecasting: a) the temporal scaling implies that the system has a long range memory that can be exploited for forecasting; b) the low temporal intermittency implies that mathematically well-established (Gaussian) forecasting techniques can be used; and c), the statistical factorization property implies that although spatial correlations (including teleconnections) may be large, if long enough time series are available, they are not necessarily useful in improving forecasts. Theoretically, these conditions imply the existence of stochastic predictability limits in our talk, we show that these limits apply to GCM's.
Based on these statistical implications, we developed the Stochastic Seasonal and Interannual Prediction System (StocSIPS) for the prediction of temperature from regional to global scales and from one month to many years horizons. One of the main components of StocSIPS is the separation and prediction of both the internal and externally forced variabilities. In order to test the theoretical assumptions and consequences for predictability and predictions, we use 41 different CMIP5 model outputs from preindustrial control runs that have fixed external forcings: whose variability is purely internally generated. We first show that these statistical assumptions hold with relatively good accuracy and then we performed hindcasts at global and regional scales from monthly to annual time resolutions using StocSIPS. We obtained excellent agreement between the hindcast Mean Square Skill Score (MSSS) and the theoretical stochastic limits.
We also show the application of StocSIPS to the prediction of average global temperature and compare our results with those obtained using multi-model ensemble approaches. StocSIPS has numerous advantages including a) higher MSSS for large time horizons, b) the from convergence to the real – not model – climate, c) much higher computational speed, d) no need for data assimilation, e) no ad hoc post processing and f) no need for downscaling.