SESSION: (A2) Modelling issues in S2S prediction

(A2-04)

Sufficient resolution for S2S predictions

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Subseasonal to Seasonal (S2S) predictions are inherently probabilistic. They are about predicting the probability distributions of future states given initial conditions and external forcing. The question is whether one needs ultra-high-resolution models to represent such distributions, or whether lower resolution models with a suitable combination of deterministic plus stochastic parameterizations of small-scale feedbacks are sufficient for this purpose. From a computational viewpoint, lower resolution models are obviously more attractive, especially for generating large forecast ensembles to pin down the forecast probability distribution. On the other hand one could argue that ultra-high resolution is necessary, given the existence of coherent structures at every scale and the absence of a spectral energy gap, to adequately capture multi-scale interactions and the statistics of extreme values i.e. the tails of the generally non-Gaussian probability distributions.

Comparisons of the probability distributions of daily anomalies in long global atmospheric GCM runs made at ECMWF and NCAR at resolutions ranging from T95 (about 130 km) to T2047 (about 6.5 km) are, however, revealing in this regard. The distributions are indeed non-Gaussian, but to an excellent approximation differ only in their widths but not their shapes at the different resolutions. This remarkable result is argued to be consistent with the stochastically generated skewed (SGS) nature of the distributions, and that beyond T511 (about 25 km) the main impact of higher resolution is merely to enhance the effectively stochastic forcing of the large-scale eddies by small-scale fluxes. This suggests that a resolution of about T511, utilizing a suitable combination of deterministic and stochastic parameterizations to accurately represent variances and energy spectra, should be sufficient for S2S predictions. Indeed we have recently confirmed in a large ensemble forecast experiment performed with the NCEP/GFS model (80-member 15-day forecasts at T254 resolution for 100 forecast cases) that adding stochastic parameterizations to the model not only increases the ensemble spread but also unambiguously reduces the error of the ensemble mean forecast. This increases both the deterministic and probabilistic skill of the forecasts at Day 15, and makes it indistinguishable from that of the much higher resolution operational GFS forecasts. The increase of ensemble spread through the additional stochastic forcing is not surprising, but the unambiguous reduction of the ensemble mean error is. It results from a multiplicative (state-dependent) noise-induced modification of the deterministic forecast evolution operator, as will be described in the talk