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## Progress in ensemble forecasting and verification methodologies at ECMWF

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This talk focusses on progress in ensemble forecasting methodology (Part I) and ensemble verification methodology (Part II).

Operational ECMWF ensemble forecasts are global predictions from days to months ahead. At all forecast ranges, model uncertainties are represented stochastically with the Stochastically Perturbed Parametrization Tendency scheme (SPPT). Recently, considerable progress has been made in developing the Stochastically Perturbed Parametrization scheme (SPP). The SPP scheme offers improved physical consistency by naturally preserving the local conservation properties for energy and moisture of the unperturbed version of the corresponding parametrization. In contrast, the SPPT scheme lacks such local conservation properties, mainly because the scheme does not perturb fluxes at the surface and at the top of the atmosphere consistently with the tendency perturbations in the column.

NWP research and development relies on scoring rules to judge whether or not a change to the forecast systems results in better ensemble forecasts. A new tool will be presented that can improve the understanding of score differences between sets of forecasts for a widely used proper score, the Continuous Ranked Probability Score (CRPS). An analytical expression has been derived for the CRPS when a homogeneous Gaussian (hoG) forecast-observation distribution is considered. This leads to an approximation of the CRPS when actual verification data are considered, which deviate from a homogeneous Gaussian distribution. The hoG approximation of the CRPS permits a useful decomposition of score differences. The methodology will be illustrated with verification data for medium-range weather forecasts.