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Uncertainties and coupled error covariances in the CERA-20C, ECMWF's first coupled reanalysis ensemble

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ECMWF has produced its first ensemble ocean-atmosphere coupled reanalysis, the 20th century Coupled ECMWF ReAnalysis (CERA-20C), with 10 ensemble members at 3-hour resolution. Here the analysis uncertainties (ensemble spread) of lower atmospheric variables and sea surface temperature (SST), and their correlations, are quantified on diurnal, seasonal and longer timescales.

The 2-m air temperature (T2m) spread is always larger than the SST spread at high-frequencies, but smaller on monthly timescales, except in deep convection areas, indicating increasing SST control at longer timescales. Spatially the T2m-SST ensemble correlations are the strongest where ocean mixed layers are shallow and can respond to atmospheric variability. Where atmospheric convection is strong with a deep precipitating boundary layer, T2m-SST correlations are greatly reduced.

As the 20th-century progresses more observations become available, and ensemble spreads decline at all variability timescales. The T2m-SST correlations increase through the 20th-century, except in the tropics. As winds become better constrained over the oceans with less spread, T2m-SST become more correlated. In the tropics, strong ENSO-related inter-annual variability is found in the correlations, as atmospheric convection centres move.

These ensemble spreads have been used to provide background errors for the assimilation throughout the reanalysis, have implications for the weights given to observations, and are a general measure of the uncertainties in the analysed product. Although cross boundary covariances are not currently used, they offer considerable potential for strengthening the ocean-atmosphere coupling in future reanalyses.