Upgrade of the JMA's Seasonal Ensemble Prediction System

The wide-ranging February 2022 upgrade of JMA's Seasonal Ensemble Prediction System improved sub-seasonal and seasonal forecasts, including operational three-month predictions, warm/cold season outlooks and El Niño outlooks. The latest system, JMA/MRI-CPS3 (the Japan Meteorological Agency/Meteorological Research Institute-Coupled Prediction System version 3), is an atmosphere/ocean/land/sea ice-coupled prediction system featuring a variety of changes in its initialization and the forecast model used.

Major CPS3 updates

- In addition to a newer version of the operational atmospheric model, a wide range of improvements have also been implemented for physical parameterization, including cumulus convection, cloud and gravity waves. The horizontal (approx. from 110 to 55 km) and vertical (from 60 to 100 levels) resolutions have also been increased.
- Atmospheric conditions are now initialized using JMA's Global Analysis (GA), in which atmospheric conditions are updated with a shorter time delay.
- A different land-sea mask from GA and a unique lake scheme are implemented. To avoid initial shock, offline surface simulation for the period to date is run separately and used for forecasts.
- Ocean and sea ice conditions are initialized with MOVE/MRI.COM-G3 (the Multivariate Ocean Variational Estimation/Meteorological Research Institute Community Ocean Model - Global version 3) – a global ocean 4DVAR analysis system downscaled to eddy-permitting resolution (0.25 x 0.25° in longitude and latitude).
- The ensemble size and forecast run frequency have been changed from 13 ensemble members every five days to 5 ensemble members every day. Grid data resolution has also been enhanced from 2.5 to 1.25 degrees.
- Perturbed atmospheric conditions are now determined for each initial time using BGM. Ocean perturbations are calculated using 4DVAR minimization history, by which daily analysis error covariance can be approximated.

Performance

To assess forecast performance, a set of hindcasts (re-forecasts) was carried out covering the 30-year period from 1991 to 2020. This is similar to real-time operation except for a smaller ensemble size of 10 per month using JRA-3Q (Japanese Reanalysis for Three Quarters of a century) data to initialize atmospheric/land/ocean conditions.

The results demonstrate a wide range of improvements in the upgraded version over the previous CPS2. Figure 1 shows the reduction of zonally averaged temperature errors for

three-month average forecasts. Madden-Julian Oscillation (MJO) prediction skill with CPS3 also exhibits significant enhancement (Figure 2). Such skillful representation of the MJO contributes to better representation of tropical atmospheric circulation and ocean current drivers, including downward radiation and surface wind. These atmospheric forcing, in addition to the upgraded ocean model and related initialization, help to improve SST prediction in the NINO.3 area with lead times of up to seven months (Figure 3).

Other verification scores and products for seasonal forecasting are available on the TCC website at https://ds.data.jma.go.jp/tcc/tcc/products/model/index.html.

The gridded datasets used for operational forecasting are also available exclusively to registered NMHSs. To register, contact TCC at tcc@met.kishou.go.jp

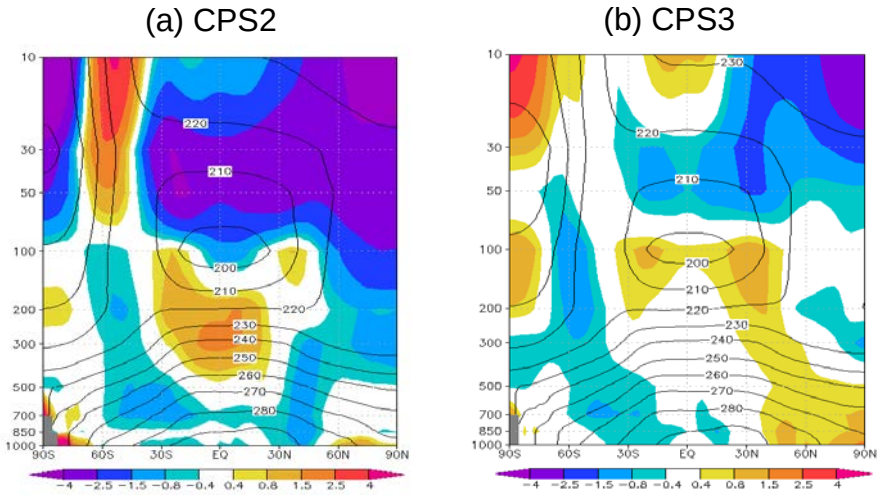

Figure 1: Climatological zonal mean of temperature (contours) and related mean errors (shading) in three-month summer forecasts (June – July – August) with (a) CPS2 and (b) CPS3. The contour interval is 10 K.

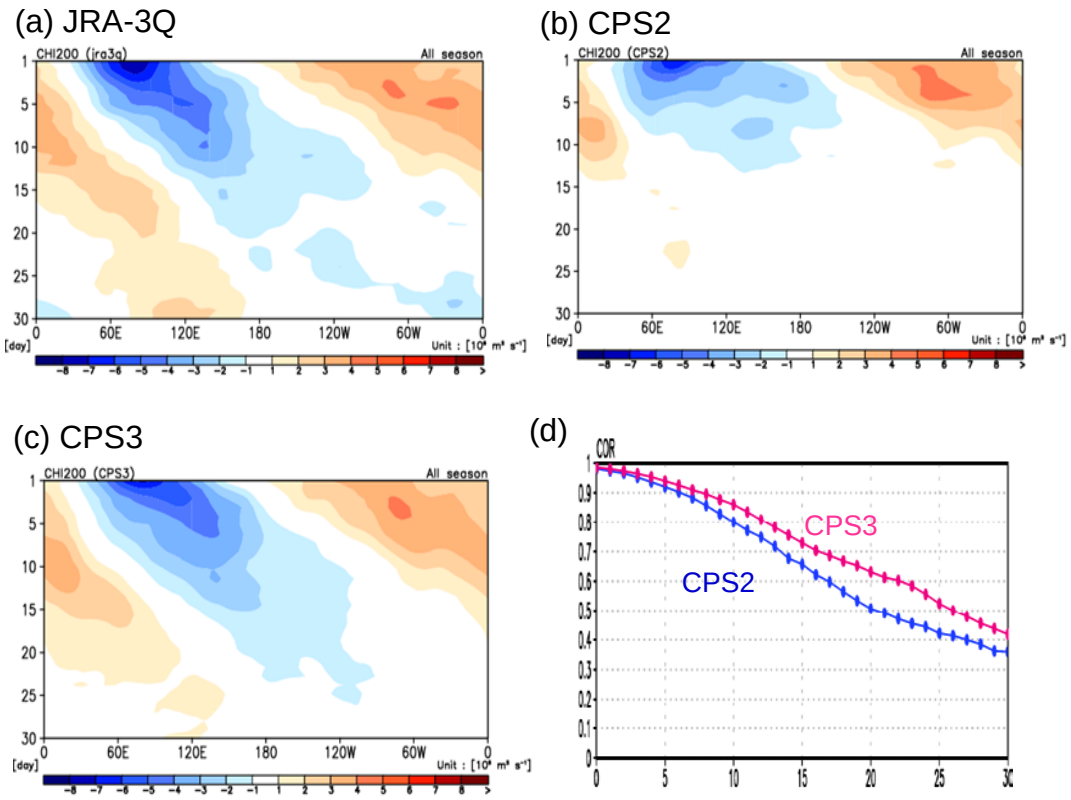

Figure 2: Composite time-longitude diagrams (5°N – 5°S) for anomalous velocity potential at 200 hPa associated with MJO propagation from the Indian Ocean (Phase 3): (a) JRA-3Q reanalysis, and forecasts with (b) CPS2 and (c) CPS3. MJO index correlation coefficients between CPS2 and CPS3 along the forecast lead time (days) are shown in (d). All data are sampled from 30-year hindcast dataset.

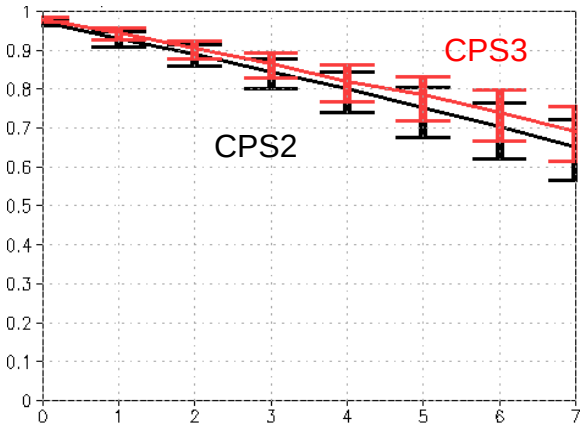

Figure 3: Anomaly correlations of NINO.3 SSTs as a function of lead time (months). The black and red lines indicate CPS2 and CPS3, respectively. Scores are based on the 10-member ensemble mean over the hindcast period.