Assessment of sub-seasonal forecast skill over the Northern Hemisphere in operational ensemble forecasts

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The predictability of numerical weather prediction (NWP) over the Northern Hemisphere is traditionally up to ~10 days (e.g., Lorenz 1982). However, some studies showed that low-frequency atmospheric variabilities (e.g., Madden-Julian oscillation) could be predictable beyond the limit of the lead time (e.g., Miyakawa et al. 2014). In this study, we assessed the forecast skill of weekly mean atmospheric variability in winter (DJF) of 1999-2010 over the Northern Hemisphere on sub-seasonal timescales using operational ensemble reforecast data from three operational NWP centers (ECCC (Canada), ECMWF (Europe), and NCEP (US)). These data are provided by the sub-seasonal to seasonal (S2S) prediction project database (Vitart et al., 2017) and are available at the ECMWF data portal. The ERA5 data were used for the verification of the reforecast.

The correlation skills of weekly mean geopotential height anomaly at 500 hPa (Z500) at each grid for the ECMWF ensemble mean forecast are > 0.6 on medium-range timescales (1- and 2-week forecasts) (Fig. 1). In the 3-week forecast, the correlation skill decreases to < 0.5 in the north of 40ºN. In particular, it drops significantly over the northern coast of Greenland. On the other hand, the skill is higher over the North Pacific to the Chukchi sea than that at the same latitude. Although the correlation skill becomes < 0.2 over most of the area in the 4- to 6-week forecasts, the skill of > 0.3 appears over North Pacific to North America and the East Siberian Sea in the 4- and 5-week forecasts. ECCC and NCEP also show similar results (not shown), suggesting that the weekly mean atmospheric variability over North America is predictable on S2S timescales. The predicted and analyzed Z500 anomalies at (55ºN, 115ºW), where the correlation skill is the highest in the north of 40ºN in the 4-week forecast, are shown in Fig. 2. The grid also corresponds to one of the centers of action in the Pacific–North American (PNA) pattern (Wallace and Gutzler 1982). On medium-range timescales, the relationship between predicted and analyzed Z500 anomalies is almost linear (correlation coefficient > 0.7). On S2S timescales, the correlation coefficient drops gradually from 0.47 (3-week forecast) to 0.09 (6-week forecast). However, the correlation coefficient for the predictions during strong El Niño or La Niña events is higher than that for all predictions, except for the El Niño event in the 4-week forecast. Besides, the average of predicted and analyzed Z500 anomalies is positive (negative) during El Niño (La Niña) event. These results indicate that the positive (negative) PNA pattern associated with strong El Niño (La Niña) is predicted well even on S2S timescales. NCEP shows almost similar results to ECMWF, as with the correlation skill. On the other hand, the difference in correlation coefficient between all predictions and predictions during the El Niño or La Niña events does not appear in the ECCC forecast. Air-sea interactions might be one of the reasons for this difference. Namely, the ECMWF and NCEP systems use atmosphere-ocean coupled models, while the ECCC system does not. The air-sea interaction in the coupled models, as well as atmospheric teleconnection, can enhance sub-seasonal predictability.
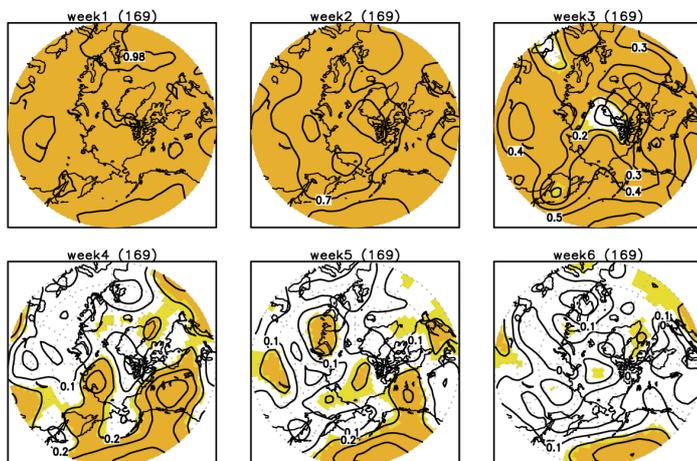

Figure 1. Correlation skill of weekly mean Z500 anomaly at each grid for the ECMWF ensemble mean forecast in winter of 1999 to 2010 (contour). Right (heavy) yellow shading indicates 95% (99%) significance level.
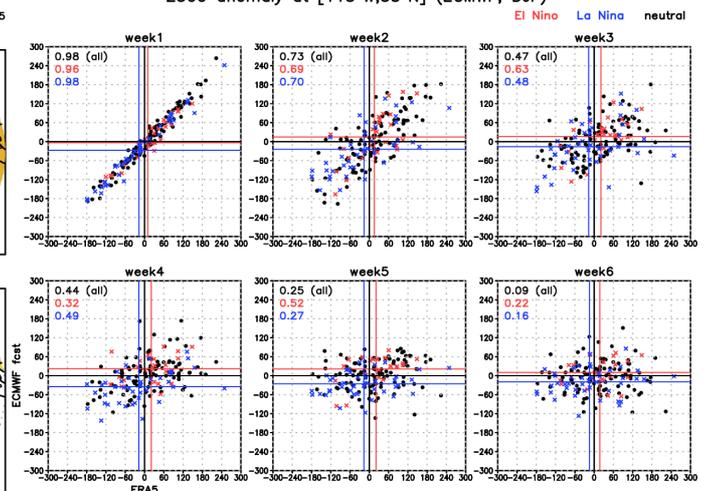
Figure 2. Scatter diagram of weekly mean Z500 anomaly at [115ºW, 55ºN] between ERA5 and ECMWF ensemble mean forecast in DJF from 1998 to 2010. El Nino (La Nina) years is described by red (blue) symbols, and red (blue) lines indicate the average of Z500 anomaly in El Niño (La Niña) years. Correlation coefficient for individual forecasts is shown on the upper-left corner of each panel.

References

Lorenz, E., Atmospheric predictability experiments with a large numerical model, Tellus 34, 505–513, 1982.

Miyakawa. T., M. Satoh, H. Miura, H. Tomita, H. Yashiro, A.T. Noda, Y. Yamada, C. Kodama, M. Kimoto., and K. Yoneyama, Madden–Julian Oscillation prediction skill of a new-generation global model demonstrated using a supercomputer, Nat. Commun., 5(3769), 2014.

Vitart, F.A., et al., The Sub-seasonal to Seasonal Prediction (S2S) Project Database. Bull. Amer. Met. Soc., 98, 163-173, 2017.

Wallace, J.M., and D.S. Gutzler, Teleconnections in the geopotential height field during the Northern Hemisphere winter, Mon. Wea. Rev., 109, 784–812, 1982.