Climate Prediction System of KMA: Current Status and Plans

Pil-Hun Chang, Yu-Kyung Hyun, Johan Lee and Yoon-Jae Kim

(National Institute of Meteorological Sciences, Korea Meteorological Administration, Jeju, Korea)
yukyung.hyun@gmail.com (Yu-Kyung Hyun)

Abstract

Climate prediction system (GloSea5) operated at KMA is described in this paper, and its probabilistic reliability is quantitatively assessed using ensemble re-forecasts (20-year hindcast). The reliability for 2 m temperature generally reveals 'good' in boreal summer, and it is comparable to those from other operational centers. Also, the impact of ensemble size and hindcast periods on the reliability is examined. The preliminary results imply that reliability increases as the ensemble size becomes large, and that forecasts are more reliable when hindcast periods are longer in case of the same ensemble size.

1 Introduction

GloSea5 (Global Seasonal Forecasting system version 5) of U. K. Met Office (UKMO) was implemented to the KMA and started producing operational forecasts in 2014. Recently, the KMA updated initialization process for ocean and land surface models. In October 2018, global ocean data assimilation system started operation, and soil moisture and temperature initialization were upgraded by using JULES reanalyzes forced by JRA-55. In addition to initialization, the KMA has a plan to enhance ensemble member and to expand hindcast periods from 20- to 25-year in 2020.

There have been lots of studies on the assessment of sub-seasonal and seasonal forecasts of GloSea5, however, they were mostly done by deterministic verification. In this study, we describe GloSea5 and then quantitatively assess its probabilistic forecasts based on five categories of reliability [1]. Also, we try to examine how operational forecast system can be reliable. Regarding this, some preliminary results about impacts of ensemble size and hindcast periods are addressed.

2 Description of GloSea5

In section 2, we briefly introduce coupled models, initialization and ensemble prediction system of GloSea5. As details of GloSea5 are described in [2], only its essential features are presented here.

2.1 Models

GloSea5 is the 5th version of UKMO ensemble prediction system for monthly and seasonal forecasting based on the latest version of the HadGEM3. The system, operated at KMA, consists of UM version 8.6 (Met Office Unified Model) for atmosphere, NEMO (Nucleus for European Modelling of the Ocean) version 3.4 for ocean, CICE (Los Alamos sea-ice model) version 4.1 for sea ice, and JULES (Joint UK Land Environment Simulator) version 8.6 for land surface components. The model resolutions are N216L85 for atmosphere and ORCA025L75 for ocean.

2.2 Ensemble prediction system

GloSea5 uses time-lagged ensemble approach, which possibly represents uncertainty of initial condition. Also, stochastic physics scheme, SKEB2 is applied to represent model uncertainty.

GloSea5 has two component of forecast and hindcast suites. Atmosphere and ocean models are initialized by UM based KMA-NWP and ocean data assimilation system, which is based on the UKMO FOAM system, respectively. Hindcast ensembles are initialized by ERA-interim reanalysis and ORA reanalysis, which is forced by ERA-interim.

GloSea5 produces sub-seasonal and seasonal products. Forecast suite has four ensemble members; two members are run out to 75 days, and the other two members are run out to 240 days. For sub-seasonal product, four ensemble members from the last seven days, namely total of 28 members are combined to form a lagged ensemble. For seasonal product, two members from the last three weeks, total of 42 members, are combined. Hindcast suite consists of three ensemble members, which are initiated on 1st, 9th, 17th and 25th of each month for 20-year (1991-2010). Hindcast set is used to correct forecast bias.

3 Assessment of seasonal probability prediction

3.1 Data and Methods

In section 3, we assess probabilistic reliability of hindcast (i.e. reforecast) ensembles of GloSea5, operated at KMA, which are then compared with those estimated from UKMO GloSea5 and ECMWF System 4. Here, we analyze ensembles initialized on May and November to estimate reliability in JJA and DJF. Table 1 shows information of hindcast data obtained from each operational center. Although UKMO increased hindcast ensemble member from three to seven lately, but only three members are adopted here. Also, System 4 uses 51 members, but only 15 ensemble members are adopted. Note that additional ensembles initiated on 17th and 25th in previous month (i.e., April and October) and 1st in the next month (i.e., June and November) are used to estimate reliability of KMA and UKMO. It is however likely that additional ensembles are not much contribute to improve reliability (not shown).

A reliability diagram was used, which is a tool for the reliability by comparing forecast probabilities with the corresponding observed frequency. In order to quantify the reliability, here we adopt a method proposed by [1], in which the reliability is categorized to five levels (Table. 2).

3.2 Results

Figure. 1 shows the reliability categories for 2 m temperature in DJF and JJA over 21 land regions for re-forecast of each operational center. Since limited ensembles are used in the estimation, reliability of ECMWF is worse than [1]. It is likely that reliability of KMA is comparable to those of other centers. It appears in results of all centers that reliability of seasonal forecasts in JJA is more useful than those in DJF. Also, reliability in high latitude regions of northern Asia and Europe is poorer than other regions.

In addition, we examine forecast reliability depending on the initiated date of ensembles. In consequence, reliability estimated by ensembles initiated on 17th and 25th April and 1st and 9th May reveals poorer performance, comparing to ensembles initiated on 1st, 9th, 17th, 25th May, and 9th, 17th, 25th May and 1st June. It is found that reliability of forecast ensembles initiated later date is slightly more useful.

Since System 4 has many ensemble members and relatively long hindcast periods, it is good to examine the impact of ensemble size on the reliability. It is clearly seen that reliability of probability forecasts increases as the number of ensemble member increases. Especially, ensemble size reaches to 1,530, Categories of 5 - 3 distribute over whole region, except for northern Asia. It is also suggested that reliability with longer hindcast period becomes higher, although ensemble size is the same.

Table 1. Summary of hindcast data obtained from three operational centers. Note that 'ENS size' means total ensembles used to estimate reliability shown in Figure. 1

	KMA	UKMO	ECMWF
System	GloSea5		System4
HCST Period	1991-2010	1993-2015	1981-2010
No. ENS member	3	3	15
No. initial date/mon.	4	4	1
No. total initial date	7	7	1
ENS size	420	483	450

Table 2. Five categorization of reliability.

Category	Reliability	Description
5	Perfect	The uncertainty range of the reliability slop includes the perfect slop and falls into the skilful BSS area
4	Still very useful	The uncertainty range of the reliability line at minimum slope ≥ 5
3	Marginally useful	The slope of the reliability line ≥ 0 and not includes the perfect line
2	Not useful	The slope of the reliability line cannot be distinguished within its uncertainties from 0
1	Dangerously useless	The reliability line < 0

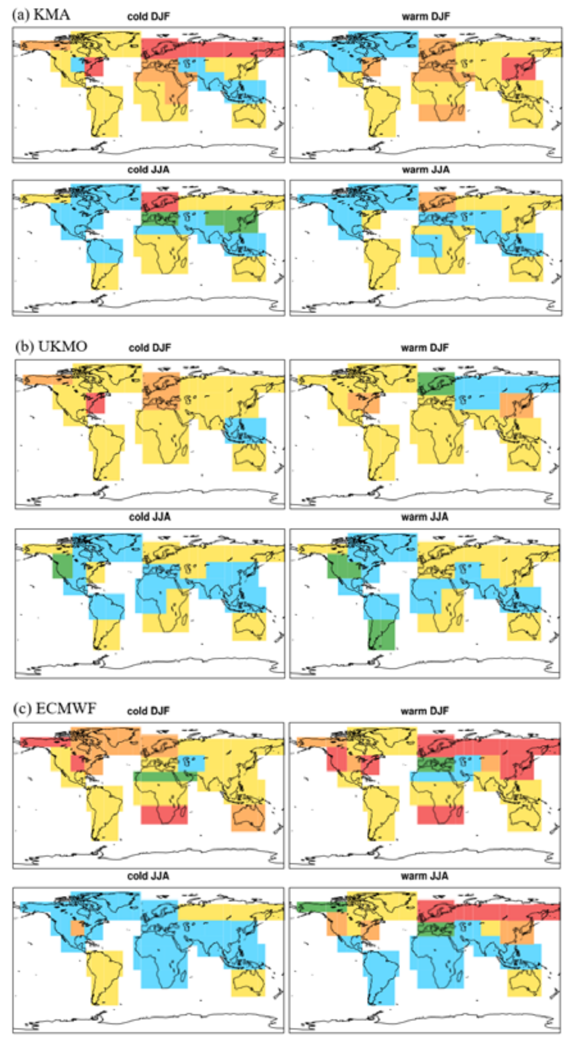

Figure 1. Reliability map of 2 m temperature from (a) KMA, (b) UKMO, and (c) ECMWF on cold DJF, warm DJF, cold JJA and warm JJA. Also, green, blue, yellow, orange, and red coloured boxes are the region categorized as 5, 4, 3, 2 and 1, respectively (see, Table 2).

Acknowledgements

This work was funded by the program "Development of Climate Prediction System" under Grand (1365003084). Pil-Hun Chang is partly supported by UM partnership. The authors are grateful for Dr. C. MacLachlan for his kind cooperation on implementation of GloSea5 to the KMA.

References

[1] Weisheimer A and Palmer TN, "On the reliability of seasonal climate forecasts," J. R. Soc. Interface 11: 20131162, 2014.

[2] MacLachlan C and Coauthors, "Global seasonal forecast system version 5 (GloSea5): a high resolution seasonal forecast system," Q. J. R. Meteorol. Soc., Vol. 141, No. 689, pp. 1072-1084, 2015.