Information

Characteristics of Subseasonal data of LC-LRFMME

1. Input data for subseasonal prediction
   WMO LC-LRFMME is downloading the real-time data of GPC Beijing(CMA), ECMWF, Exeter (UKMO), Melbourne(BoM), Montreal(ECCC), Seoul (KMA), Tokyo (JMA) and Washington (NCEP/CPC) from the ECMWF S2S archive (Vitart et al., 2017) and producing MME products on a regular basis (See Table 1).

   The ensemble initialization for the multi-model is described in Figure 1. For availability, we select an optimal issuing date of 'Monday'. Because initialization dates of individual models are slightly different as shown in Figure 1 and Table 1, forecast time ranges of each model for MME are also different as in Table 2.

   To estimate the model's climatological distribution at each forecast start date, the same hindcast start dates (Beijing, ECMWF, Montreal and Washington) or the closest hindcast start dates (Exeter, Melbourne, Seoul and Tokyo) are chosen for the common period 1999 to 2010 as in Table 2.

Table 1. Characteristics of GPC data for subseasonal prediction

GPC name (Center)	Forecast Frequency	Forecast Time range	Forecast Ens. Size	Hindcast Frequency	Hindcast Ens. Size	Hindcast length
Beijing (CMA)	daily	0-60 days	4	daily	4	1994-2014
ECMWF (ECMWF)	2/week (Mon,Thu)	0-46 days	51	2/week (Mon, Thu)	11	past 20 years
Exeter (UKMO)	daily	0-60 days	4	4/month (1,9,17,25)	7	1993-2015
Melbourne (BoM)	2/week (Sun,Thu)	0-62 days	33	6/month (1,6,11,16,21,26)	33	1981-2013
Montreal (ECCC)	weekly (Thu)	0-32 days	21	weekly (Thu)	4	1995-2014
Seoul (KMA)	daily	0-60 days	4	4/month (1,9,17,25)	7	1991-2010
Tokyo (JMA)	weekly (Wed)	0-33 days	50	3/month (10,20,last day)	5	1981-2010
Washington (NCEP)	daily	0-44 days	16	daily	4	1999-2010

* more information : **https://software.ecmwf.int/wiki/display/S2S/Models (https://software.ecmwf.int/wiki/display/S2S/Models)**

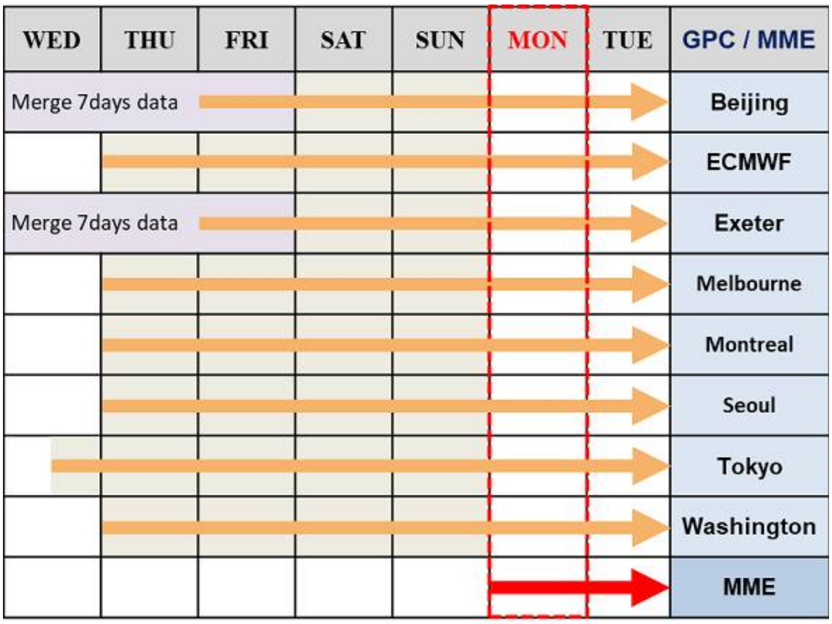

Figure 1. The starting time of subseasonal prediction for 8 GPCs and MME (red box)

Table 2. Participating GPCs in subseasonal MME prediction system

GPC name (Center)	Forecast Init. Date	Forecast Time range	Forecast Ens. Size	Hindcast Init. Date	Hindcast Ens. Size	Common Hind. period

GPC name (Center)	Forecast Init. Date	Forecast Time range	Forecast Ens. Size	Hindcast Init. Date	Hindcast Ens. Size	Common Hind. period
Beijing (CMA)	2 weeks ago Sat - last Fri	4(10)-45(51) days	28 (4*7)	Same date as fcst	4	1999-2010
ECMWF (ECMWF)	last Thu	5-46 days	51	Same date as fcst	11	1999-2010
Exeter (UKMO)	2 weeks ago Sat - last Fri	4(10)-45(51) days	28 (4*7)	Closest date to fcst	7	1999-2010
Melbourne (BoM)	last Thu	5-46 days	33	Closest date to fcst	33	1999-2010
Montreal (ECCC)	last Thu	5-32 days	21	Same date as fcst	4	1999-2010
Seoul (KMA)	2 weeks ago Sat - last Fri	4(10)-45(51) days	28 (4*7)	Closest date to fcst	3	1999-2010
Tokyo (JMA)	last Wed	5-32 days	50	Closest date to fcst	5	1999-2010
Washington (NCEP)	last Thu	5-39 days	16	Same date as fcst	4	1999-2010

* Note: Because the number of daily forecast ensemble of GPC Beijing, GPC Exeter and GPC Seoul system is small (4 members a day), 7-days lagged ensemble members are used (total 28 members). It means that the lead-time of GPC Exeter forecast is relatively longer than others.

2. Output data for subseasonal prediction
   a. Digital products
      i. Only SCM forecast data
      ii. Lead time : 6 weeks (42 days)
      iii. Spatial resolution : 1.5° x 1.5°
      iv. Variable
         - Sea Surface Temperature (SST)
         - 2m Temperature (T2M)
         - Mean Sea Level Pressure (MSLP)
         - Total Precipitation (PREC)
         - Outgoing Longwave Radiation (OLR)
         - Geopotential Height at 500 hPa (Z500)
         - Zonal wind at 850 hPa (U850)
         - Meridional wind at 850 hPa (V850)
         - Zonal wind at 200 hPa (U200)
         - Meridional wind at 200 hPa (V200)

   b. Graphical products shown in Table 3

Table 3. The variables and covering periods of graphical products for subseasonal prediction

	Products/Variable	Covering Periods	Charts	Verification scores
Probabilistic MME	▪ Precipitation ▪ 2m Temperature	▪ Weeks 1, 2, 3, 4, 5, 6, 3-4, 5-6, 3-6	▪ Probabilistic maps	▪ ROC Curve ▪ ROC Score map ▪ Reliability Diagram
Deterministic MME	▪ Precipitation ▪ 2m Temperature ▪ Mean Sea Level Pressure ▪ Mean Sea Level Pressure ▪ Geopotential Height at 500hPa ▪ 850hPa Wind ▪ 200hPa Wind ▪ 200hPa Velocity Potential ▪ 200hPa Stream Function	▪ Weeks 1, 2, 3, 4, 5, 6, 3-4, 5-6, 3-6	▪ Each variable anomaly map	▪ Pattern Correlation Coefficient ▪ Root Mean Square Error ▪ Time Correlation Coefficient
Intraseasonal Oscillations	▪ MJO Need: OLR, U850, U200 ▪ BSISO Need: OLR, U850 ▪ Outgoing Longwave Radiation	▪ 42 days	▪ Hendon and Wheeler Diagram ▪ Hovmöller diagram	▪ Root Mean Square Error ▪ Correlation Coefficient

MME Prediction

1. Deterministic MME
   DMME forecast is constructed with the simple composite mean (SCM), which is simple averaged MME where the contribution of each single-model is equally weighted (Krishnamurti et al., 2000)

$$\mathrm{M} = \frac{1}{N}\sum_{i=1}^{N}(F_i - \bar{F}_i)$$

Where M is a multi-model ensemble anomaly, N is number of models, F_i is the forecast from i-th model, $\bar{F}_i$ is the mean of i-th hindcast during training period.

2. Probabilistic MME

PMME are issued in the form of tercile-based categorical probabilies (tercile probabilities), that is, the probability of the below-normal (BN), near-normal (NN), and above-normal (AN) categories with respect to climatology. Gaussian and gamma approximation were applied for 2m temperature and precipitation respectively.

$$\mathrm{P}(\mathrm{E_j}) = \frac{1}{\mathrm{N}}\sum_{\mathrm{i=1}}^{\mathrm{N}}(\mathrm{P}(\mathrm{E_j}|\mathrm{mdl_i}))$$

Where P is forecast probability, E_j is j-th event (i.e., either above-normal (AN), near-normal (NN) or below-normal (BN)), mdl_i is the i-th model, and N is the number of models. $P\ (E_j \mid mdl_i)$ is a forecast probability of the event conditioned on the i-th model (i.e., the i-th model forecast of j-th event) (Min et al., 2009).

Intraseasonal Oscillation (ISO)

1. Madden-Julian Oscillation (MJO)

The MJO index follows closely that developed by Wheeler and Hendon (2004; hereafter WH2004). The data input into this index are latitudinally-averaged (15°S-15°N) fields of zonal winds at the 850 hPa and 200 hPa levels, and outgoing longwave radiation (OLR). After some pre-processing, these fields are projected onto a pair of observationally-derived global structures of the MJO, giving a pair of numbers to measure its state each day, called the Real-time Multivariate MJO (RMM) indices (RMM1 and RMM2).

For more information, see **http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml)**.

2. Boreal Summer Intraseasonal Oscillation (BSISO)

The BSISO index developed by Lee et al. (2013) is adapted. This index is similar to the RMM indices of Wheeler and Hendon (2004), except that the focus is on the intraseasonal variability that is specific to the Asian monsoon region (10.5°S-40.5°N, 39°E-160.5°E). Two propagating modes, each comprising a pair of multivariated EOF, are respectively called BSISO1 and BSISO2. BSISO1 captures the canonical northward-propagating BSISO component and BSISO2 captures the higher-frequency pre-monsoon and onset component. Compared to the MJO monitoring and prediction activity, which uses only latitudinal-averaged data, the BSISO indices require latitude-longitude grids of outgoing longwave radiation and 850-hPa zonal wind.

For more information, see **http://www.apcc21.org/eng/service/bsiso/fore/japcc030601.jsp. (http://www.apcc21.org/eng/service/bsiso/fore/japcc030601.jsp)**

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