WMO Lead Centre activities for global sub-seasonal MME prediction

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Introduction

- The forecast on the sub-seasonal to seasonal time-scale is very important information for many management decisions in agriculture and food security, disaster risk reduction, water, and health.
- However, the predictability of long-range forecast is relatively low, compared to the short-range forecast, because there are significant uncertainties arisen from various climate system components and their complex interactions.
- Therefore, there has been a growing recognition that the international exchange of climate prediction information is essential to improve the predictability.

WMO infrastructure for climate prediction information

- **12 WMO-designated Global Producing Centres (GPC) for long-range forecasts**
  - adhering to agreed procedures/standards in delivery of global long-range forecasts (e.g. products, timeliness, verification/validation info, system documentation)
- **2 Lead Centres, facilitating user access to GPC products**
  - Collection/display of forecast products: Lead Centre for Long-range Forecast Multi-Model Ensembles (LC-LRFMME) – jointly operated by KMA/NOAA
  - Collection/display of verification products: Lead Centre for the Standard Verification System for Long-range Forecasts (LC-SVSLRF) – jointly operated by BoM/MSC
- **Products of GPCs and LCs are widely used in NMHSs, RCOFs (Regional Climate Outlook Forum), and RCCs (Regional Climate Centre)**

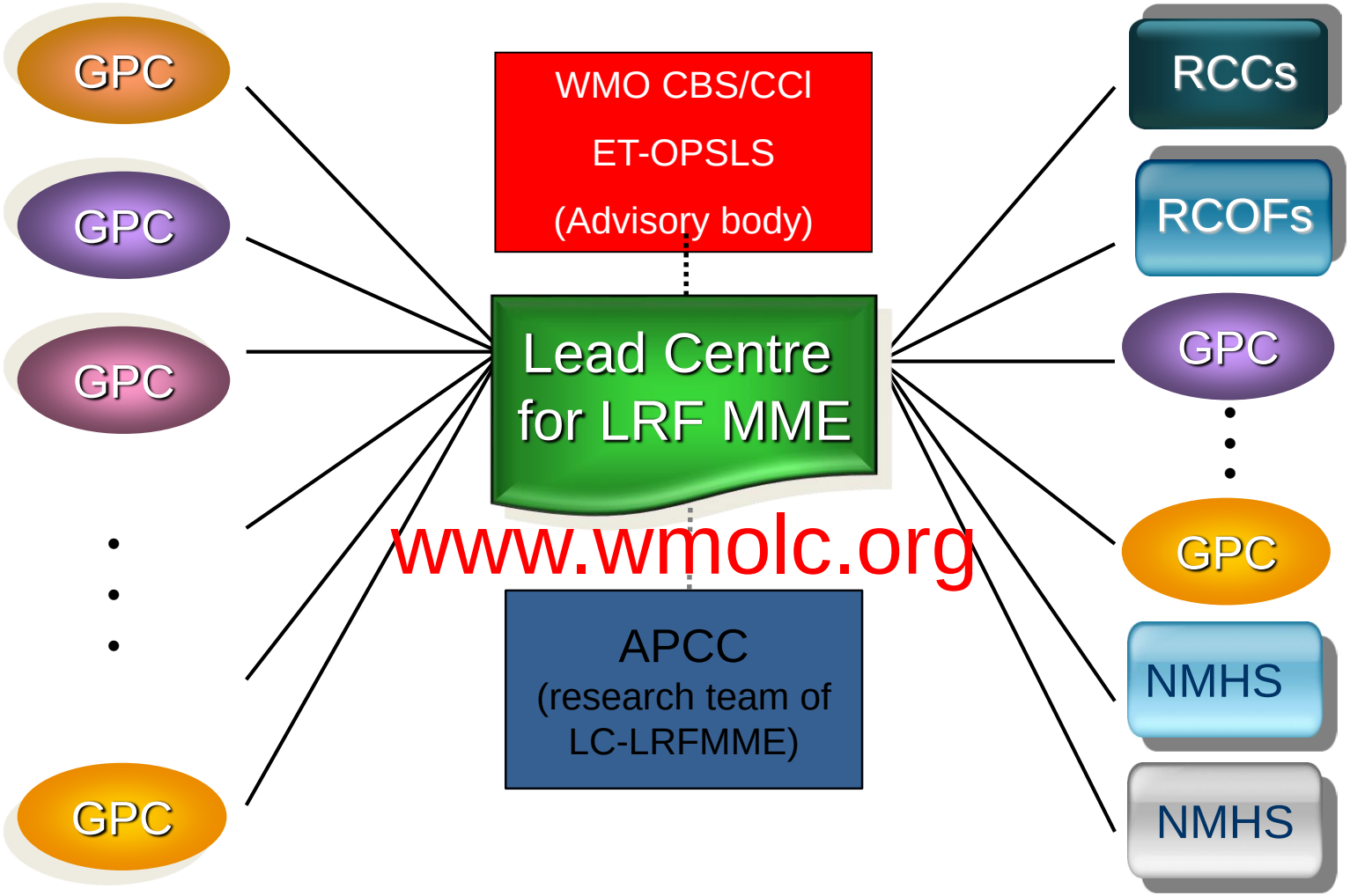
WMO GPCs

❖ **12 GPCs are designated by WMO**

- In 2006, operational centres making global seasonal forecasts were designated as WMO Global Producing Centres (GPCs) for long-range forecast

Links to GPCs:
http://www.wmo.int/pages/prog/wcp/wcasp/clips/producers_forecasts.html

WMO LC-LRFMME



- LC-LRFMME (KMA/NOAA) provides a **conduit** between GPCs and NMHSs, RCCs, RCOFs etc.

Functions of WMO LC-LRFMME

- Collect an agreed set of forecast data from GPCs
- Generate GPCs forecasts in a standard format
- Displays a standardized set of Lead Centre (LC) products
- Redistribute digital forecast data for those GPC's that allow it
- Maintain a repository of documentation for the system configuration of all GPC LRF systems
- Handles requests for the password for the website and data distribution

Global sub-seasonal prediction activities

Background

- The Sixteenth World Meteorological Congress, 2011
  - The Cg-XVI requested the LCLRFMME to explore the possibility of extending its role to include exchange of extended-range predictions.

- The meeting of the CBS Expert Team on Extended and Long-Range Forecasting (ET-ELRF), 2012
  - The meeting recognized the need to coordinate this initiative with activities proposed as part of the WWRP-THORPEX/WCRP research project on sub-seasonal to seasonal prediction (S2S).
  - In response to the above request from Cg-XVI, the meeting prepared a preliminary list of exchange variables and related sub-seasonal forecast products.

Background

- The fifteenth session of CBS (CBS-15), 2012
  - CBS-15 recommended a phased approach, starting with development of links with the S2S database enabling the LC-LRFMME to generate and display a range of products, and while this pilot exchange is developing, to accelerate the availability of extended-range products to WMO Members.

- The extraordinary meeting of the Implementation Coordination Team of the Open Programme Area Group (OPAG) for the DPFS (ICT-DPFS), 2013
  - The meeting set up a Task Team (TT3) under the CBS ET-OPSLS to scope the implementation of real-time sub-seasonal forecasts, and to establish the necessary links with the WWRP-THORPEX/WCRP research project (S2S).
    - **Task Team 3**: Scoping implementation of sub-seasonal forecasts
    - **Members**: Suhee Park, Richard Graham, Alberto Arribas (changed to Craig MacLachlan), Laura Ferranti, Yuhei Takaya

Development of the pilot real-time MME system

- There is the very wide diversity among sub-seasonal modeling systems (in forecast issue time and frequency, hindcast frequency, ensemble size etc). So, development of multi-model products will be a considerable technical challenge.

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- Although the multi-model approach had shown forecast skill benefits in the seasonal range and that some studies show benefit for medium-range forecasts, there was no guarantee that similar benefits would carry into the sub-seasonal range.

➢ Phase approach was selected.

- ✓ The pilot real-time activities with a small group of volunteering centres will be performed within Joint CBS-CCl Expert Team on Operational Predictions from Sub-seasonal to Longer-Time Scales (ET-OPSLS)

Plan for the pilot real-time MME service

❖ Operational service

- The LC-LRFMME provides MME forecasts and its verification results through website (www.wmolc.org).
- Expected products are summarized in Table.

Products/ variables	Covering periods	Charts	Verification scores
· Accumulated prec · Average 2m temp	Weeks 1,2,3,4, 3-4,1-4	Probabilistic maps · terciles	Reliability diagrams / ROC
MJO Need: · OLR · U850 · U200	32 days	· Hendon and Wheeler Diagram · Hovmoller	Temporal correlation and RMSE
Velocity Potential	Weeks 1,2,3,4, 3-4,1-4	Velocity potential anomaly (Ensemble mean for each period)	correlation

Plan for the pilot real-time MME service

❖ Data exchange

- **Variables to exchange**: The recommendation for minimum variables is SST, T2m, precipitation, u200, v200, u850, OLR. This list may be augmented following the need to developing specific products.

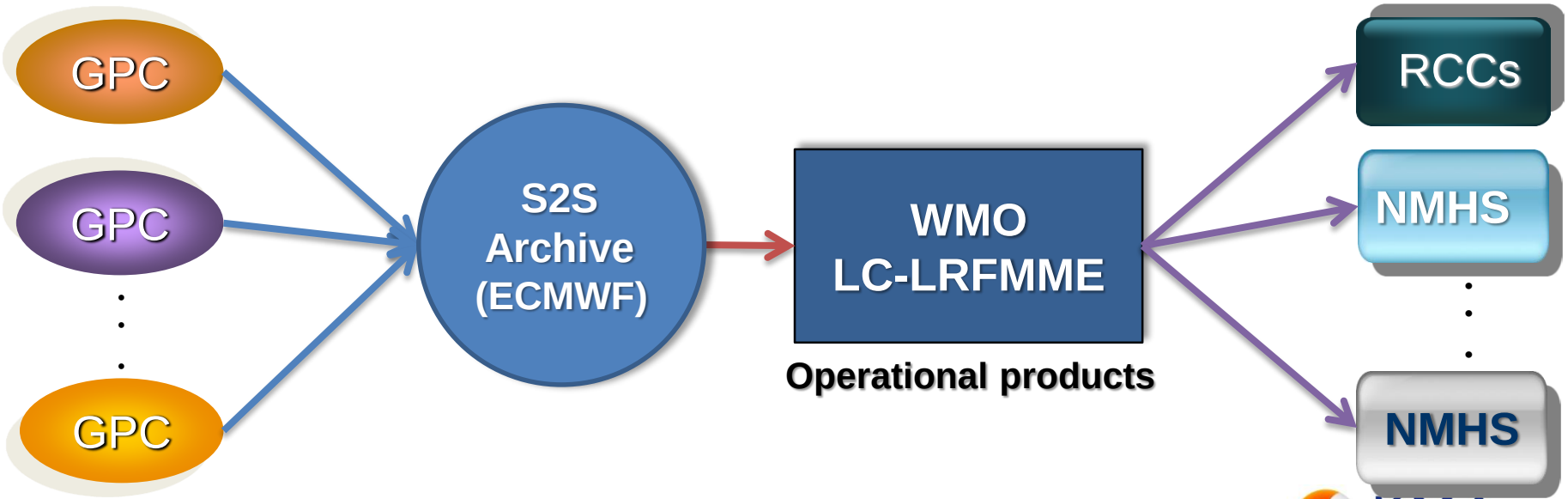
- **Frequency of model output to exchange**: Exchange of daily model output is recommended. Exchange of daily data will provide the freedom to develop products for different time averages, for example, weekly means, monthly mean, average over week 3-4. Data should also be exchanged for the individual members in the ensemble so that probability forecasts can be developed.

- **Forecast length**: Forecast length will be determined by the longest common period over which operational monthly prediction systems at different GPCs are run.

- **Exchange of full fields**: It is recommended that exchange of data should be for full fields. This exchange then needs to be accompanied by the exchange of relevant hindcast data such that forecast anomalies and tercile (or quintile) boundaries for probabilistic forecasts can be computed.

Establish working links with the S2S data center

- The meeting of the S2S steering group, 2014
  - It was agreed to make use of the S2S research archive of sub-seasonal forecasts to develop a real-time multi-model display at the LC-LRFMME.
    - The operational centers participating in the S2S project send their real-time forecasts to ECMWF, ECMWF allows LC-LRFMME access to an agreed subset of the data for use in preparing a display of real-time forecast on their website. This approach to the data flow would have the advantage that the operational centers would need to send their data only once for both S2S and CBS.



Volunteering Centres and related data

❖ Volunteering Centres (until May 2015) and exchanged data

- These five Centres had agreed to the data transfer from the S2S archive of ECMWF to LC-LRFMME without 3-week delay.
- 5 Centres: GPC ECMWF, Exeter (Met Office), Seoul (KMA), Tokyo (JMA), Washington (NCEP)
  - ✓ Next year, LC will seek additional volunteers among available Centres.

❖ Exchange data

- Variables: SST, T2M, PREC, OLR, U850, U200, V200
- Horizontal resolution: 1.5˚x1.5˚
- Frequency of model output: daily model output
- Data types: full fields of forecast data with relevant hindcast (reforecast)

✓ Currently available data at S2S archive

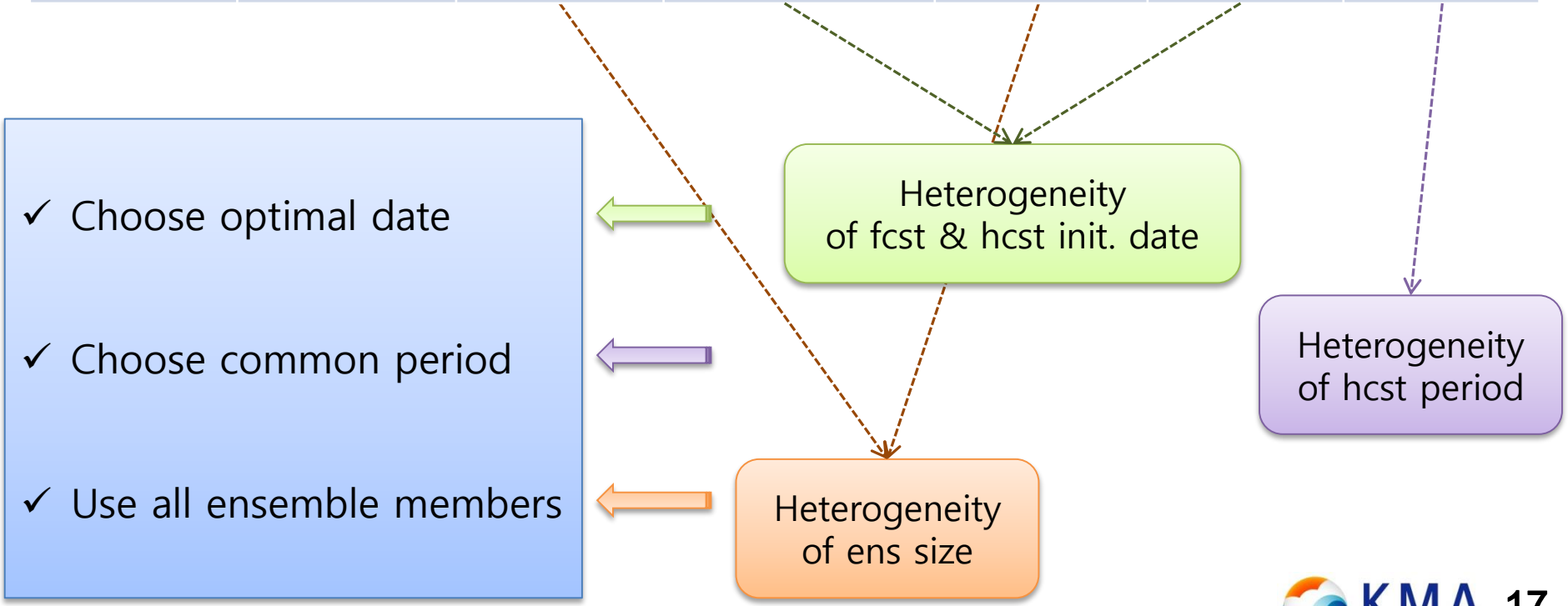
GPC	Time range	Ens. Size	Frequency
ECMWF	0-46 days	51	2/week (Mon, Thu)
Washington	0-44 days	16	Daily
Tokyo	0-34 days	25	2/week (Tue, Wed)

Operational setup

Operational setup 1: Issuing timing and data

❖ List of GPCs and their configurations

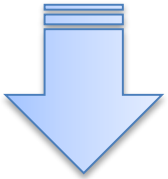
GPC	Time range	Forecast Ens. Size	Forecast Frequency	Hindcast Ens. Size	Hindcast Frequency	Hindcast length
ECMWF	0-46 days	51	2/week (Mon, Thu)	11	2/week (Mon, Thu)	Past 20 years
Washington	0-44 days	16	Daily	4	Daily	1999-2010
Tokyo	0-34 days	25	2/week (Tue, Wed)	5	3/month (10/20/last day)	1981-2010



Operational setup 1: Issuing timing and data

❖ Inputs of sub-seasonal MME prediction

GPC	Forecast Init. date	Forecast Time range	Forecast Ens. Size	Hindcast Init. Date	Hiindcast Ens. Size	Hindcast length
ECMWF	Mon	3-30 days	51	Same date with fcst	11	1999-2010
Washington	Tue	2-29 days	16	Same date with fcst	4	1999-2010
Tokyo	Tue	2-29 days	25	Closest date to fcst	5	1999-2010



Sub-seasonal MME prediction

- Issuing date
  - Every Wednesdays
- Forecast period
  - Four weeks (Thu~Wed cycle)
- Common reference period
  - 1999-2000

Operational setup 2: Estimation of forecast probability

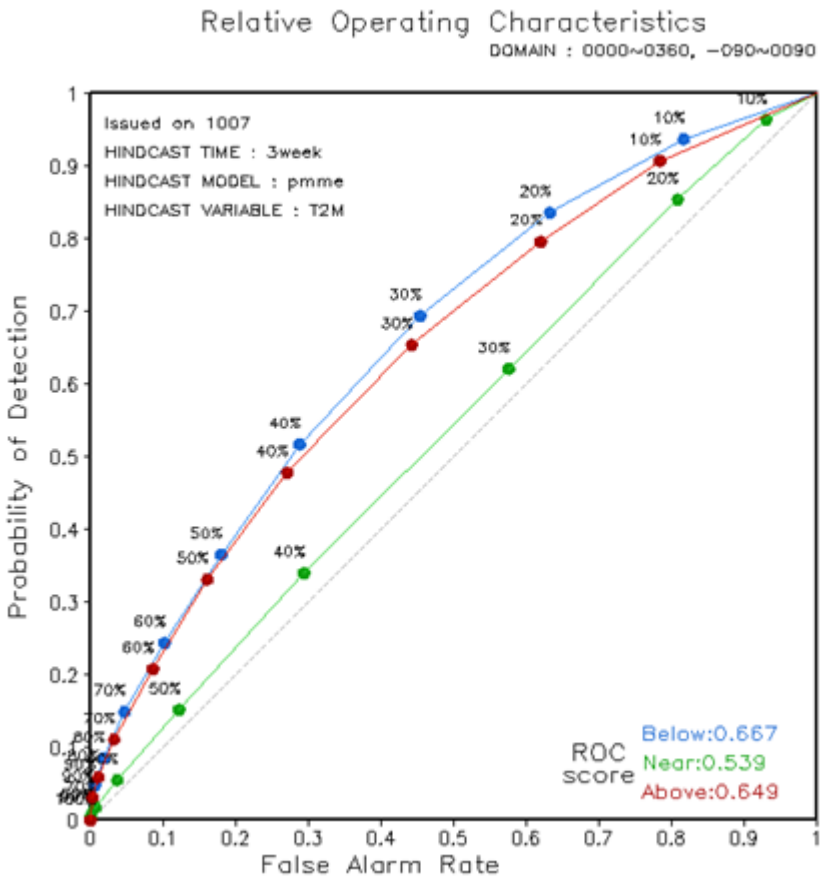
❖ Parametric vs Non-parametric estimation of tercile probability

- Parametric estimation: Distribution fitting method
  - When defining tercile boundaries, an theoretical distribution is assumed
    - ✓ 2-m air temperature: Normal distribution
    - ✓ Precipitation: Gamma distribution
  - Forecast probabilities are calculated with a distribution of forecast ensemble
  - This method can minimize sampling issues

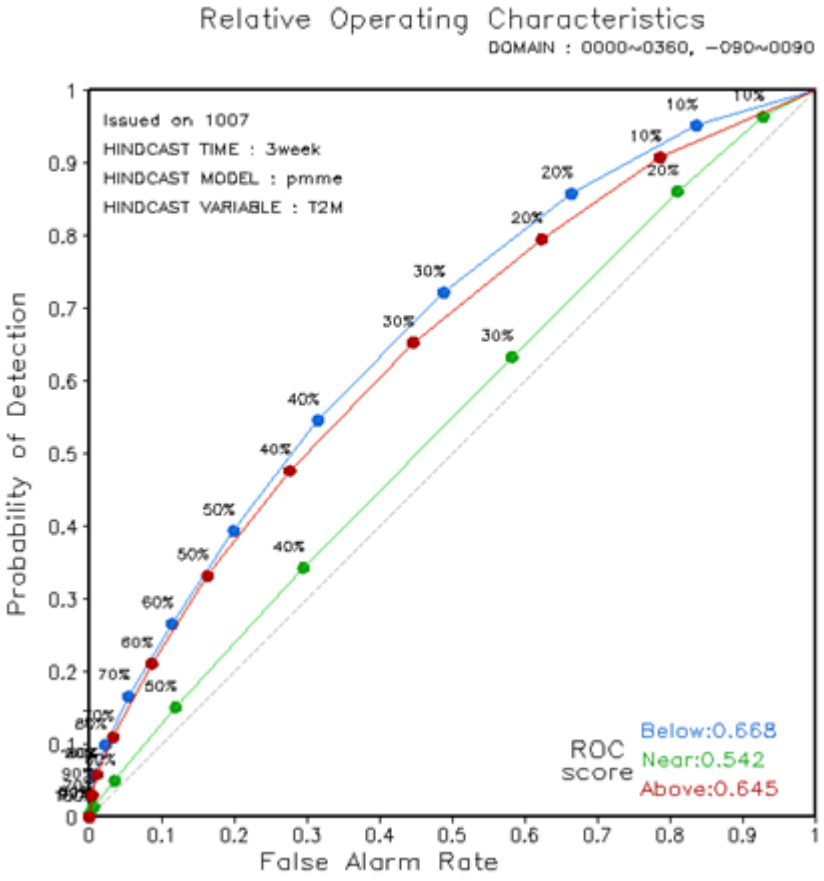
- Non-parametric estimation: Ranking & counting method
  - When defining tercile boundaries, hindcast data are ranked
    - ✓ Redistribute with ascending order and find values of 1/3 and 2/3 boundaries
  - Forecast probabilities are calculated with counting the number of forecast ensemble
  - This method is free of distribution property and easy to understand

Operational setup 2: Estimation of forecast probability

❖ Comparison between parametric & non-parametric : ROC Curve – T2m



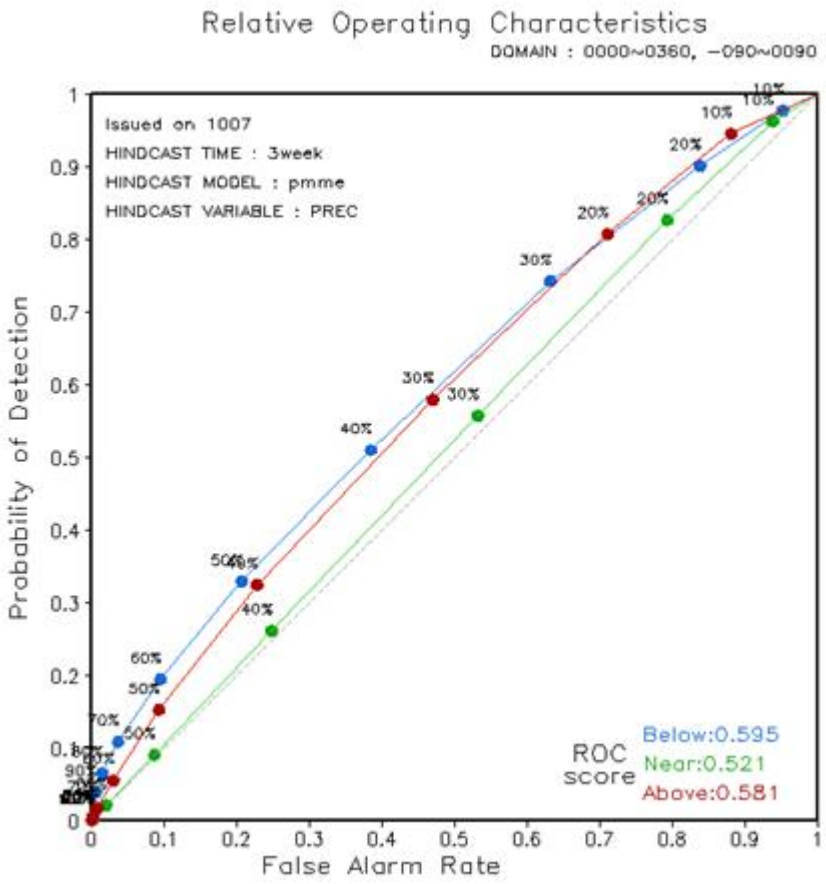
< Parametric (Gaussian Fitting)>



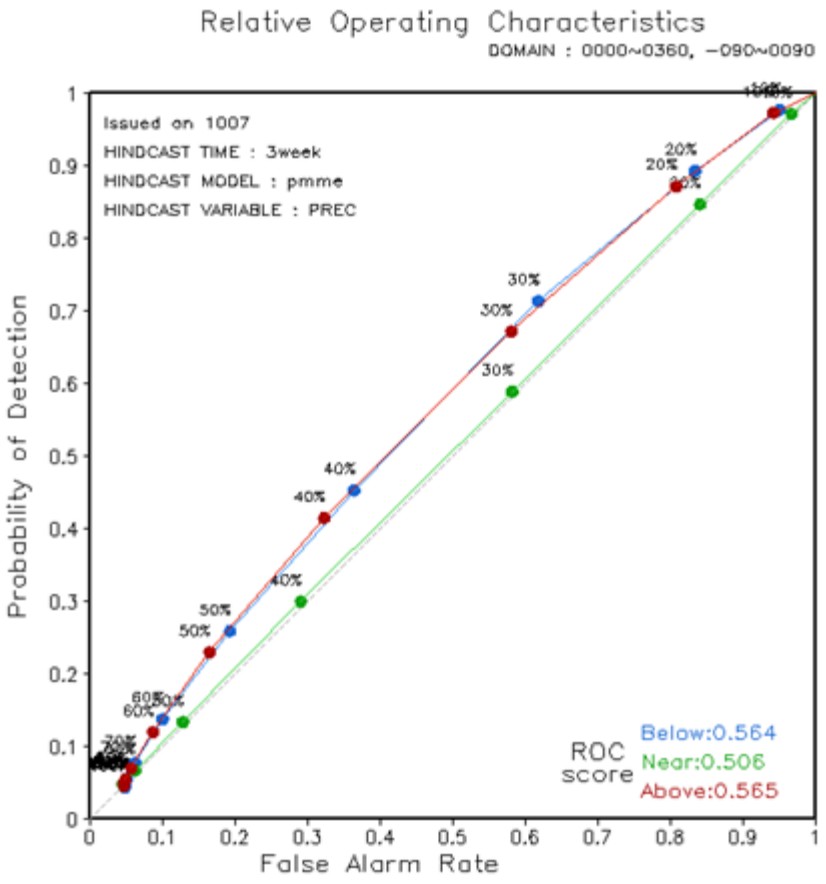
<Non-parametric (Ranking & counting) >

Operational setup 2: Estimation of forecast probability

❖ Comparison between parametric & non-parametric : ROC Curve – Precip



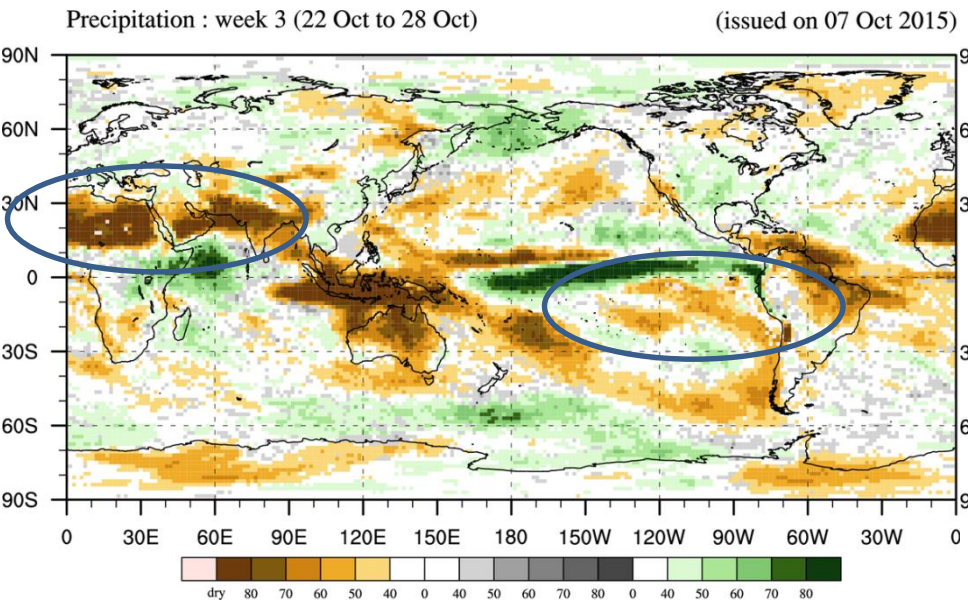
< Parametric (Gamma Fitting)>



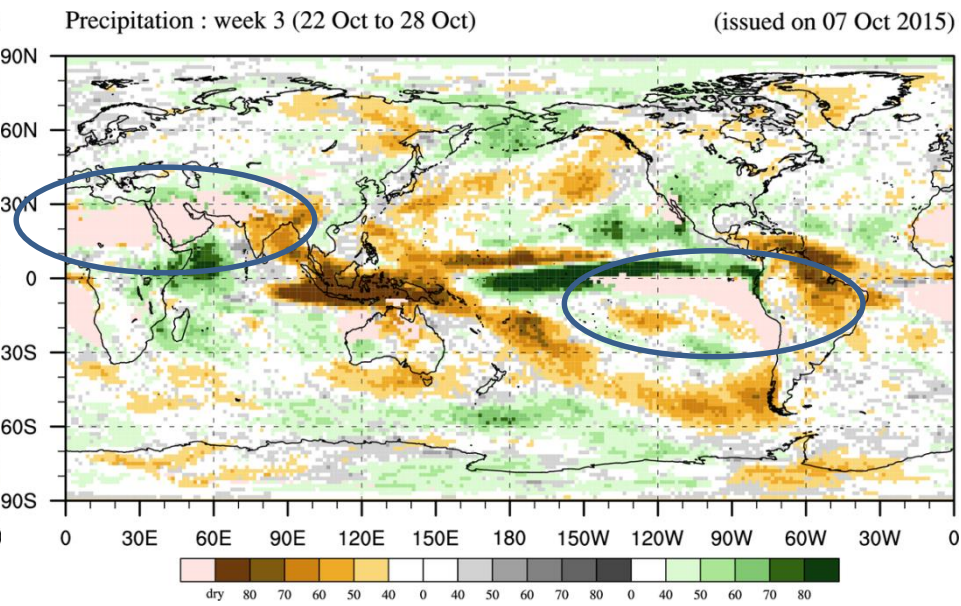
<Non-parametric (Ranking & counting) >

Operational setup 2: Estimation of forecast probability

❖ Forecast map of precipitation.



< Parametric (Gamma Fitting)>

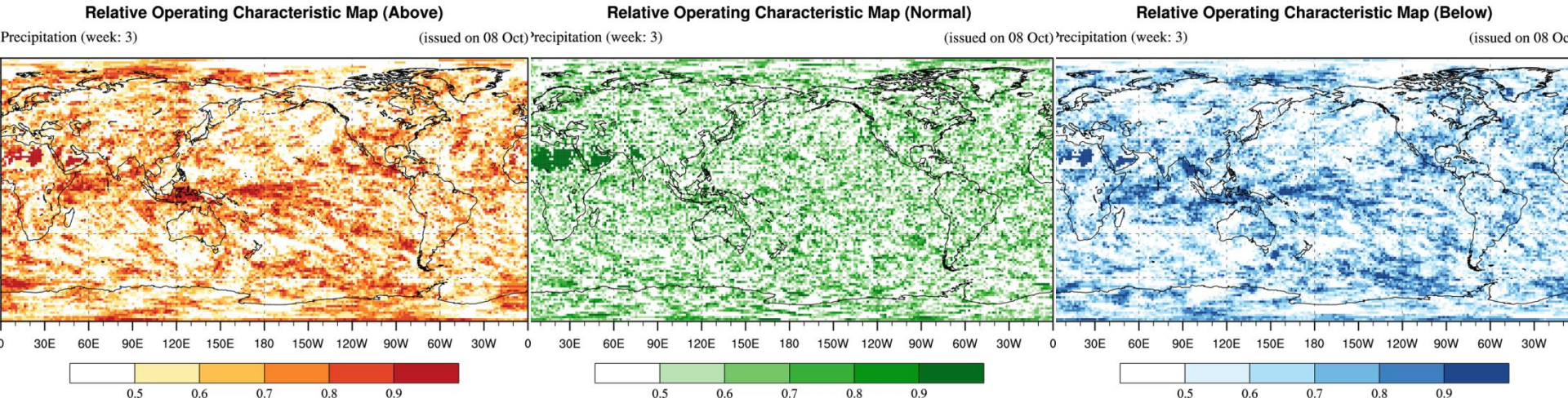


<Non-parametric (Ranking & counting) >

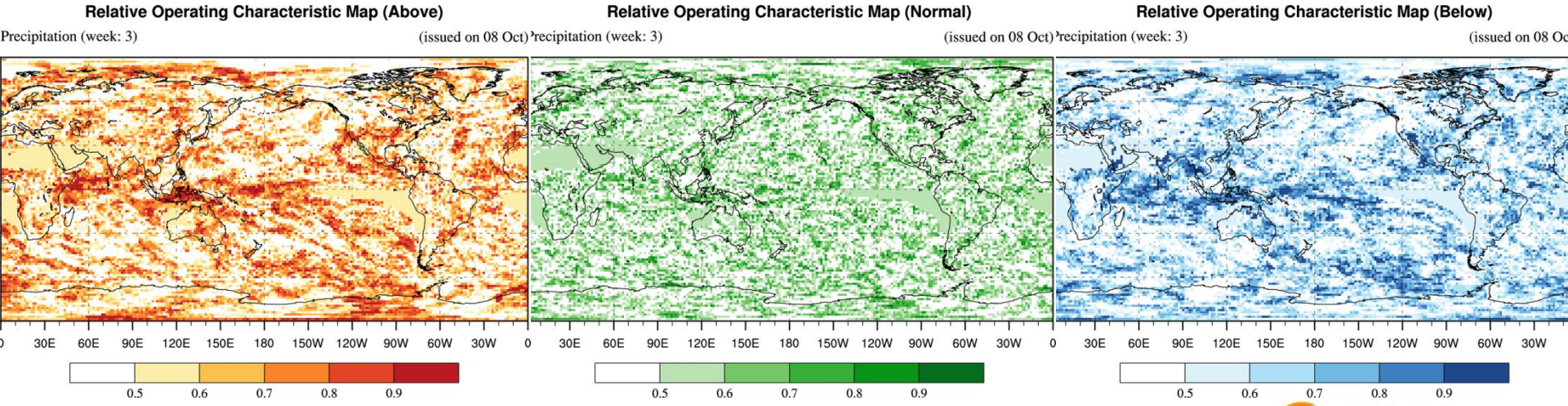
Operational setup 2: Estimation of forecast probability

❖ Hindcast - ROC Map – Precipitation (3 week)

< Parametric (Gamma Fitting)>

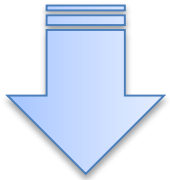


<Non-parametric (Ranking & counting) >



Operational setup 2: Estimation of forecast probability

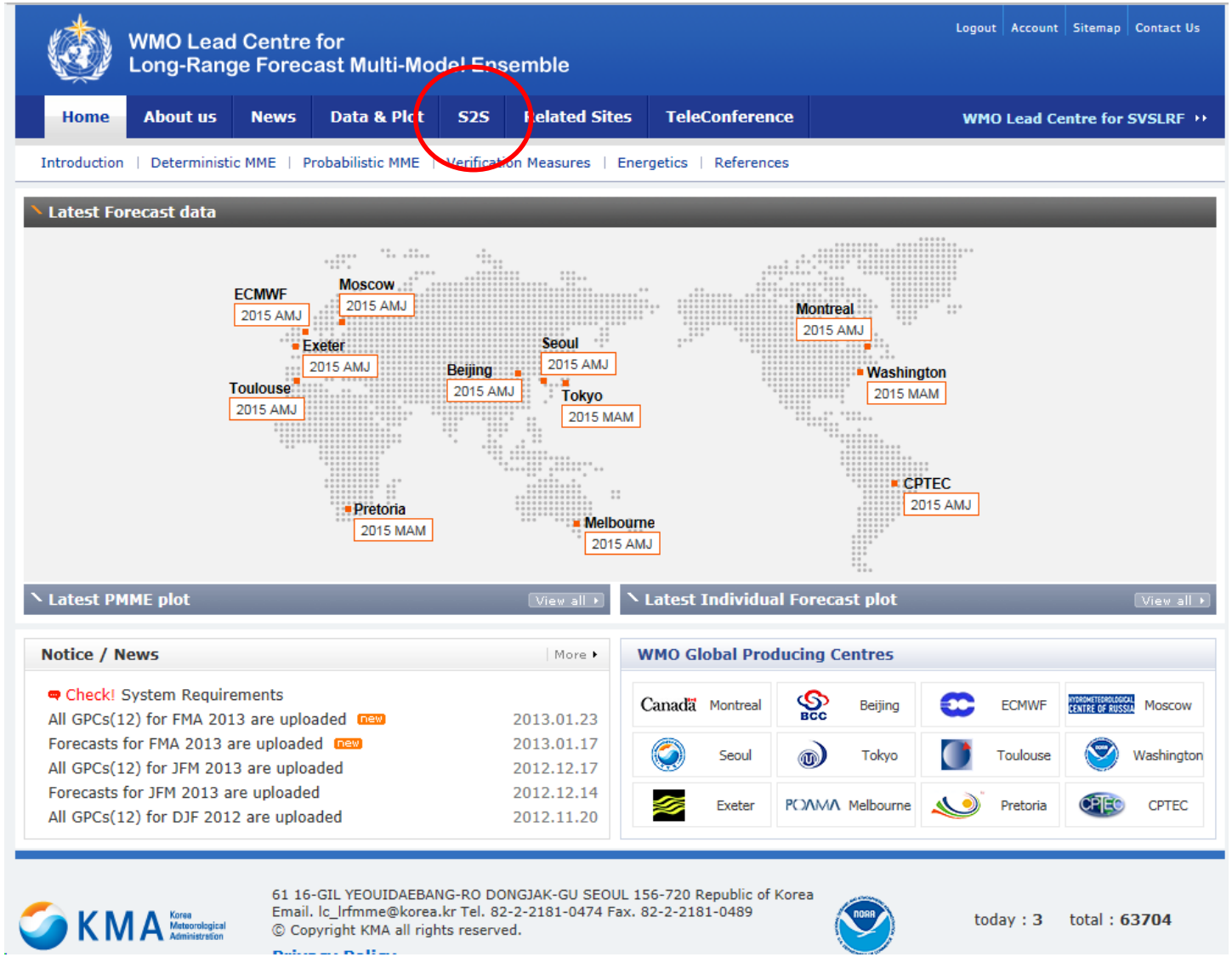
❖ Overall, parametric method seems to be more accurate and useful than non-parametric method in estimation of forecast probability



Sub-seasonal MME prediction

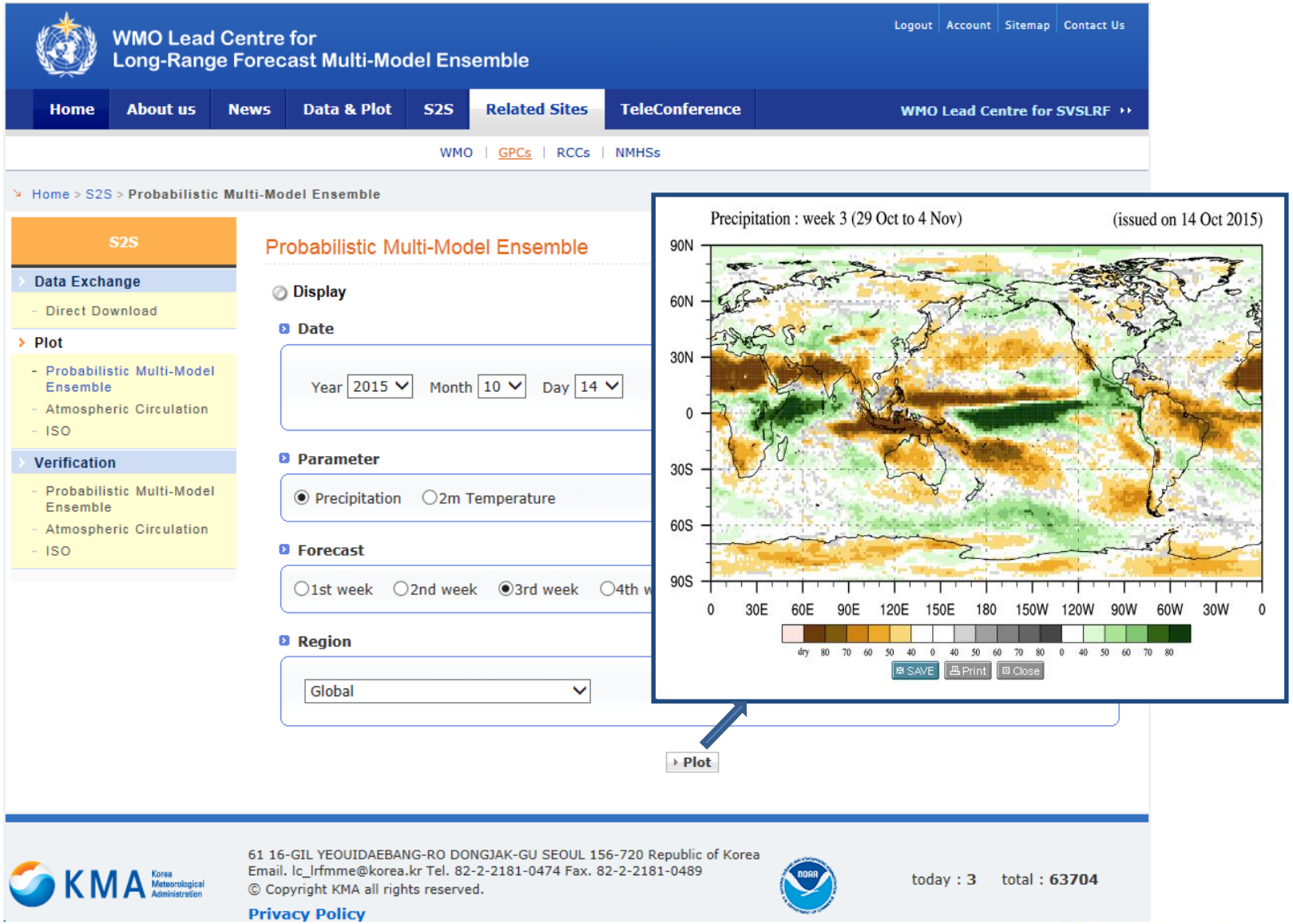
- Tercile probability forecast
  - T2m: Gaussian fitting
  - Precip.: Gamma fitting

Operational setup 3: Structure of website



http://www.wmolc.org

Operational setup 3: Structure of website

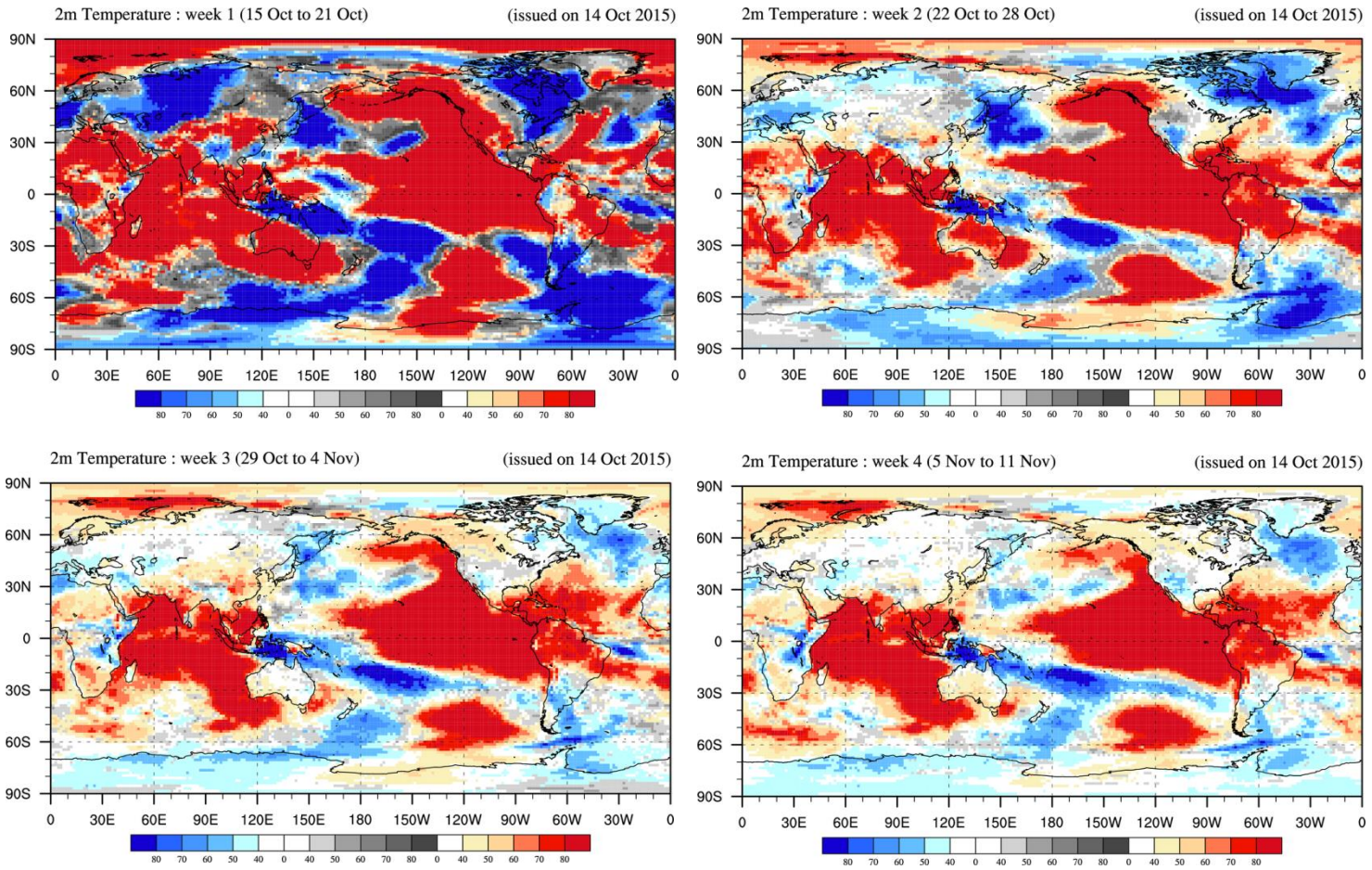


http://www.wmolc.org

Products: Prediction

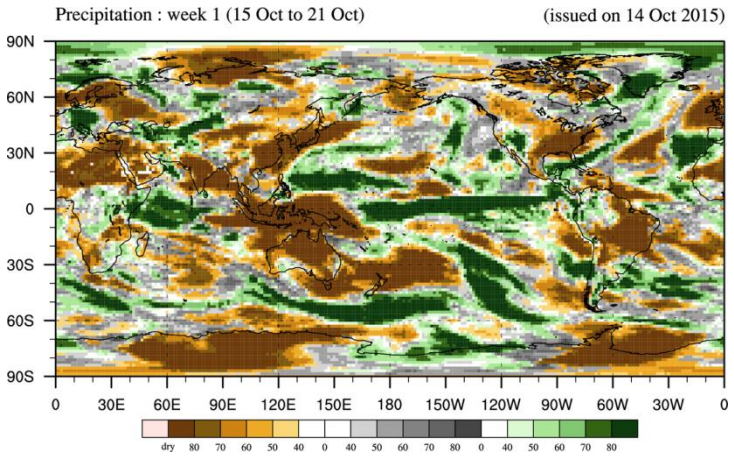
Products : Probabilistic MME – T2m

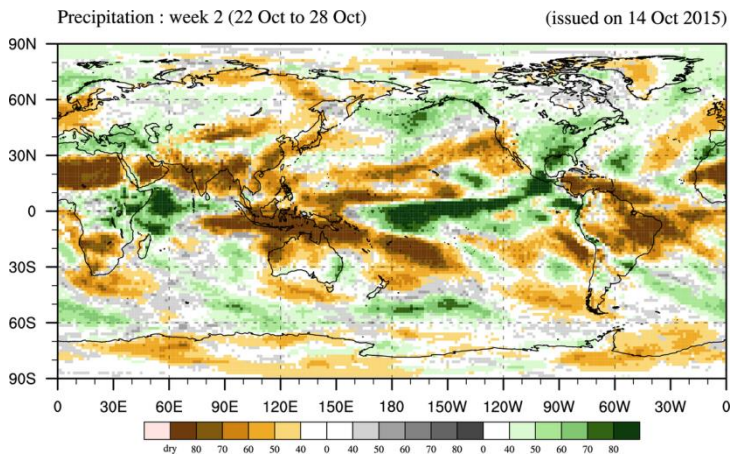
- Probabilistic prediction map of 2m air temperature
  - Tercile probabilistic forecast using parametric method (Gaussian fitting)

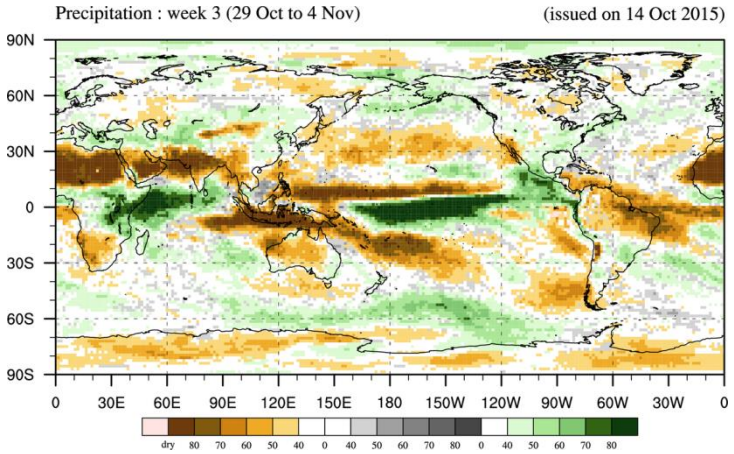


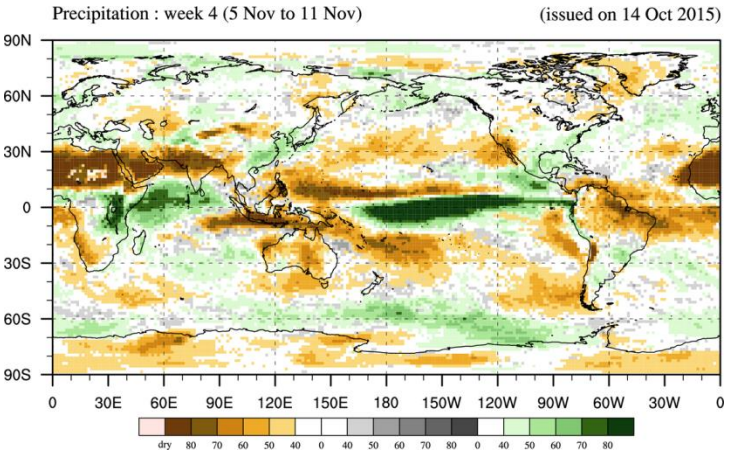
Products : Probabilistic MME - Precipitation

- Probabilistic prediction map of precipitation
  - Tercile probabilistic forecast using parametric method (Gamma fitting)



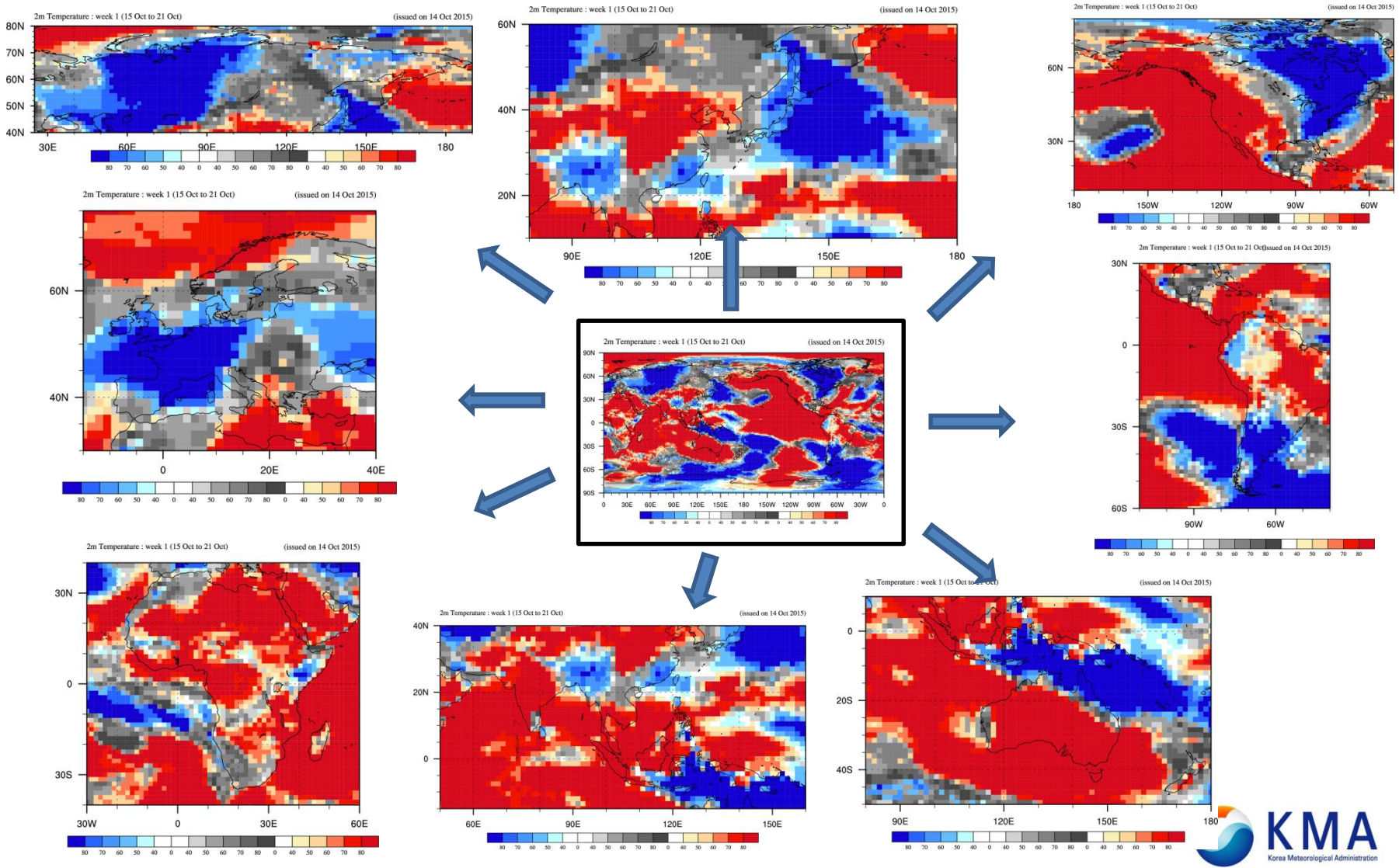






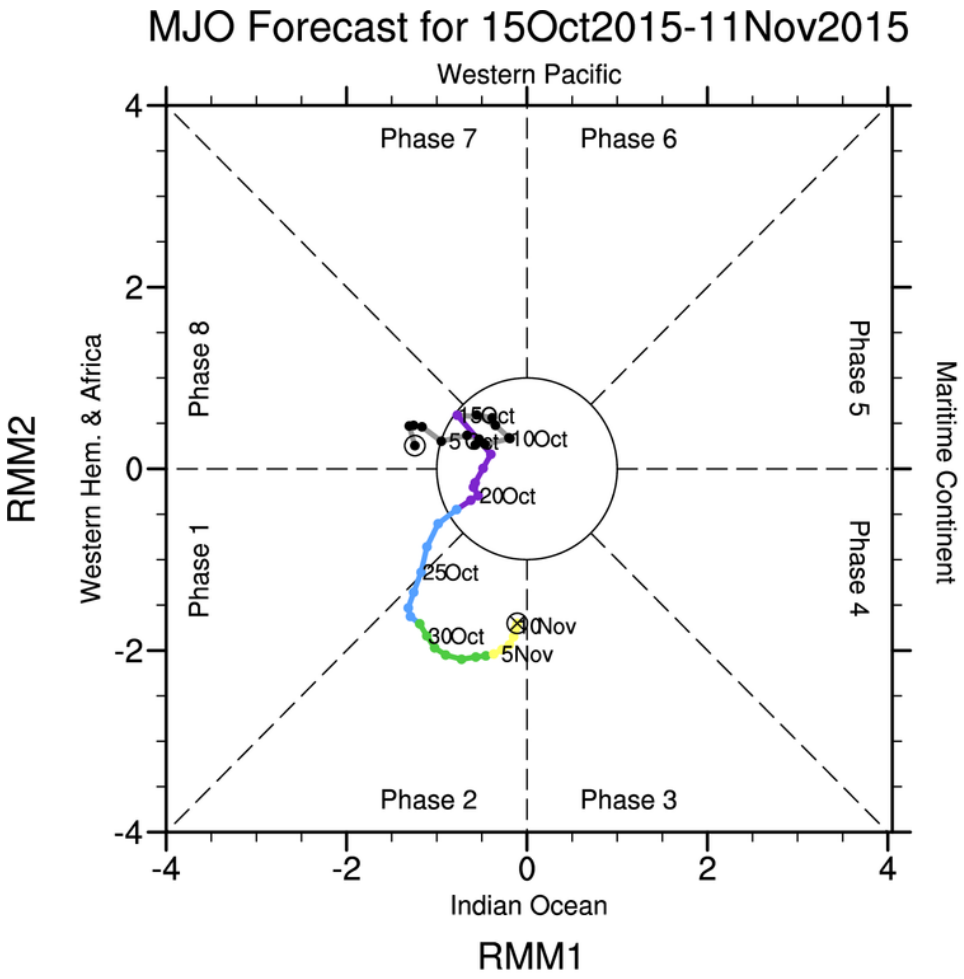
Products : Prediction map over various regions

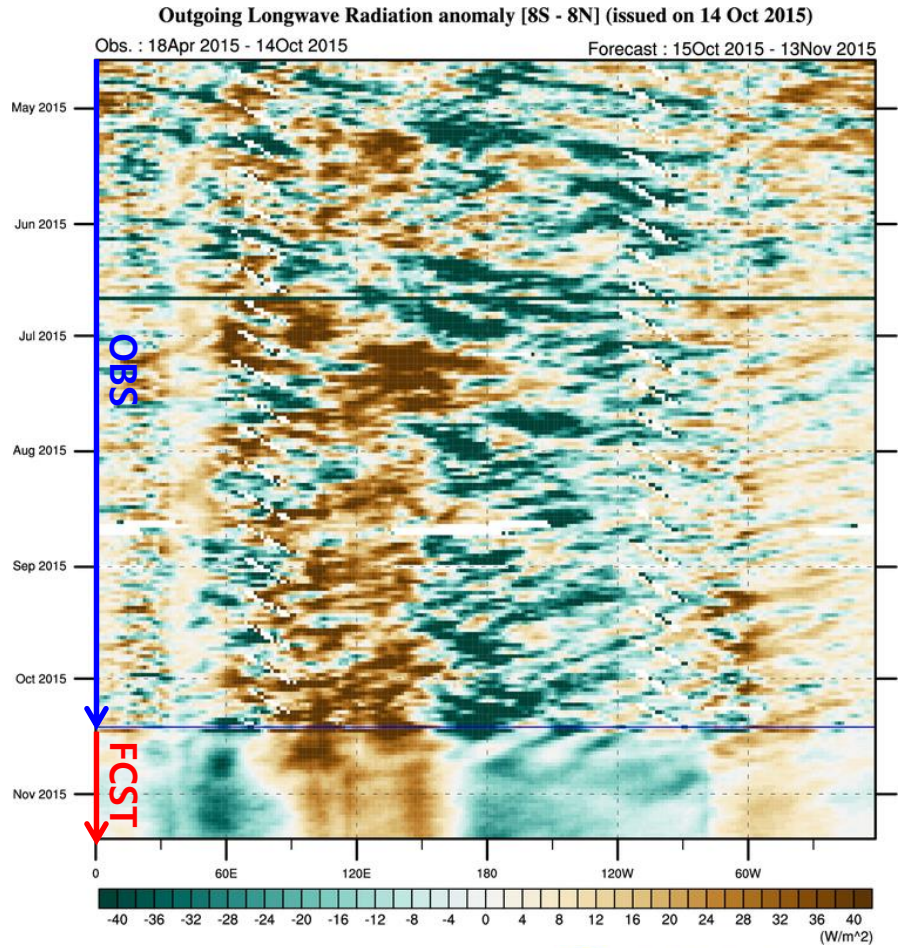
❖ Probabilistic prediction maps over 8 regions are provided



Products : MJO

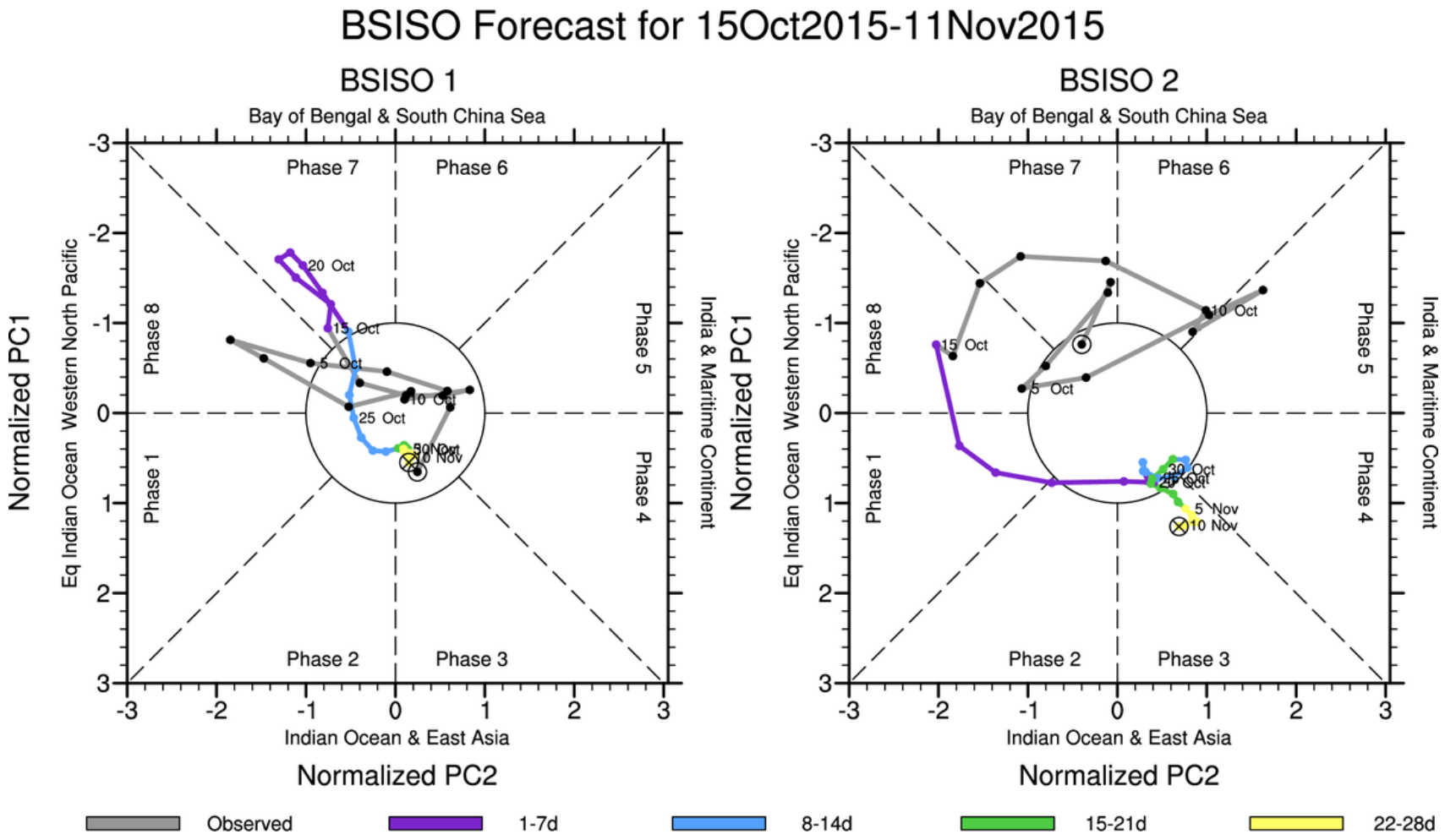
- ❖ MJO diagram of ensemble mean
- ❖ OLR Hovmoller diagram of ensemble mean anomaly





Products : BSISO

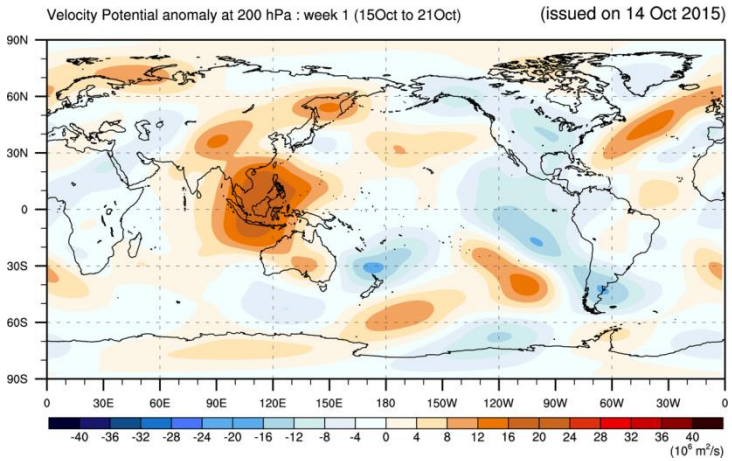
❖ Boreal Summer Intra-Seasonal Oscillation (BSISO) diagram of ensemble mean

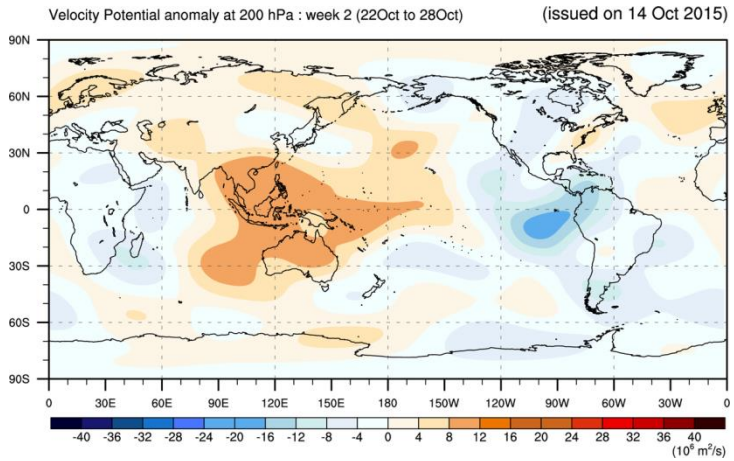


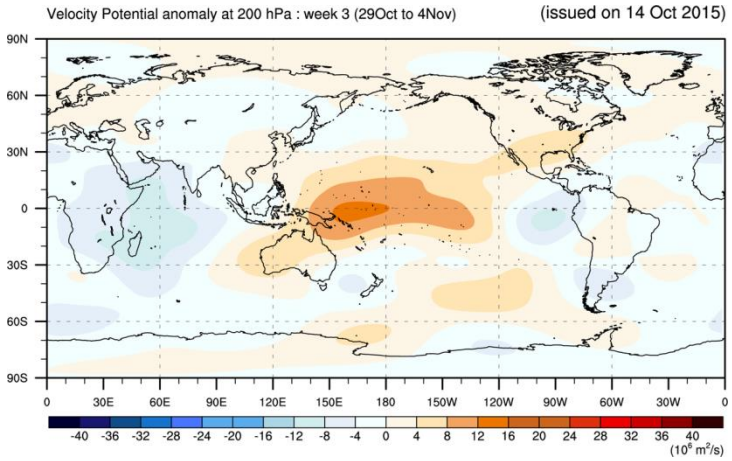
Products : Circulation – Velocity Potential

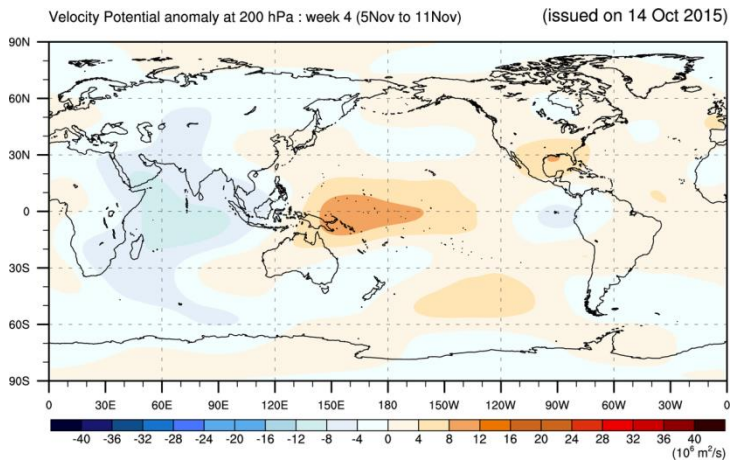
❖ Ensemble mean anomaly map of velocity Potential at 200hPa

(also, stream function map in website)







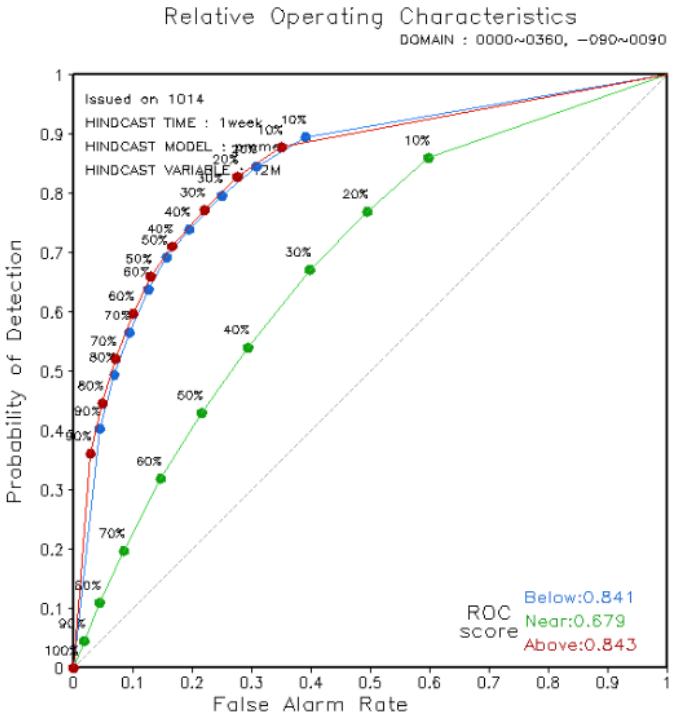


Products: Verification

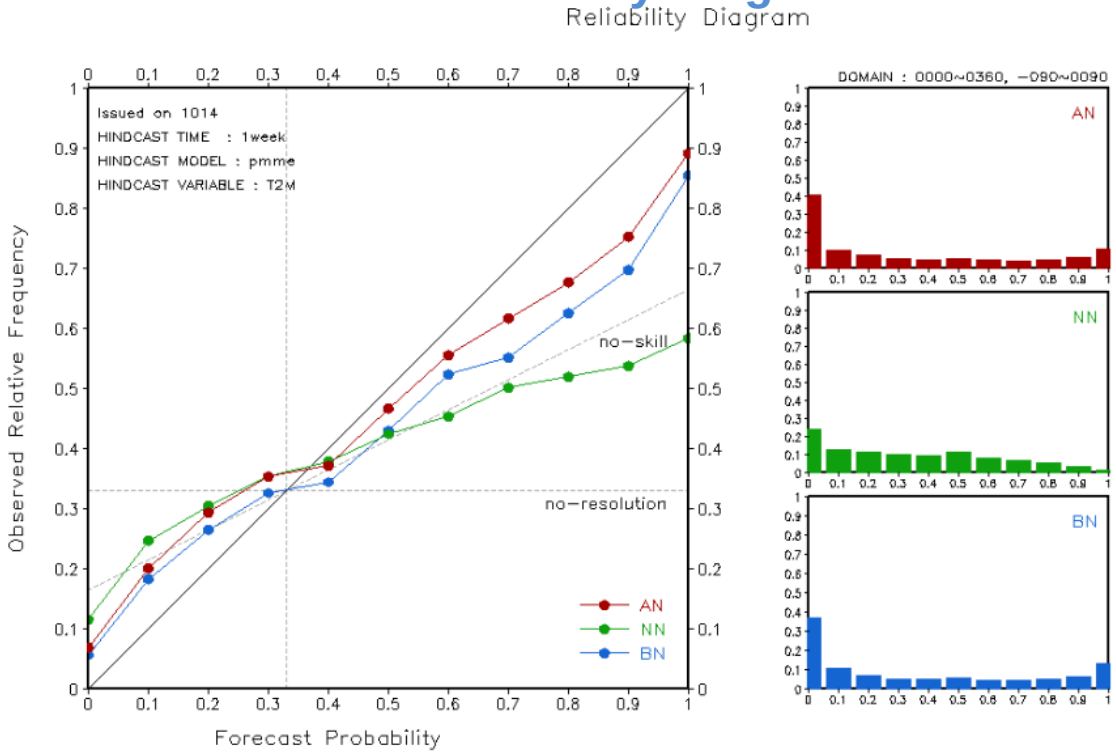
Products: Verification

- Verification for sub-seasonal MME products
  - Probabilistic verification: ROC curve , Reliability Diagram

ROC Curve and Score

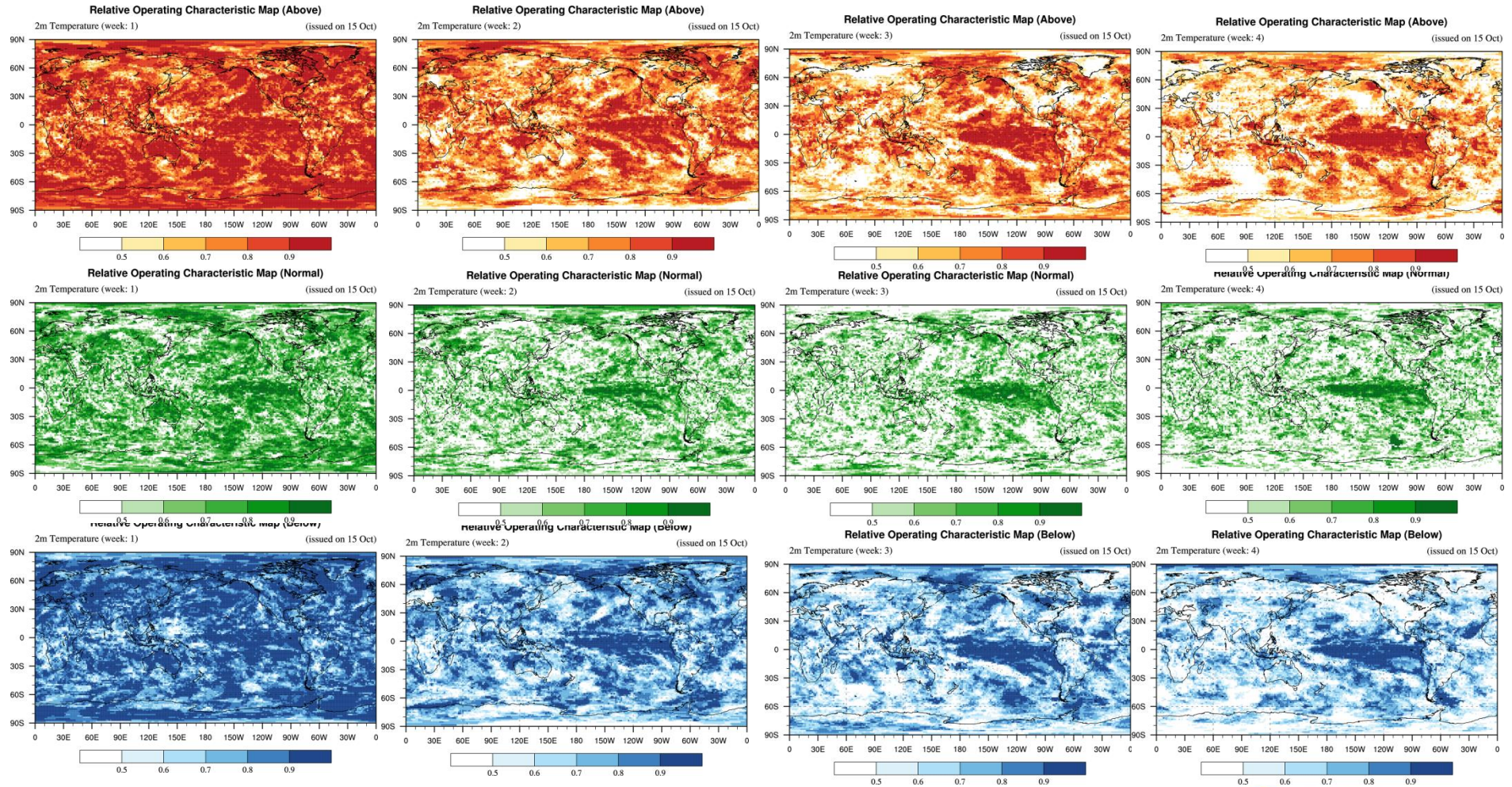


Reliability Diagram



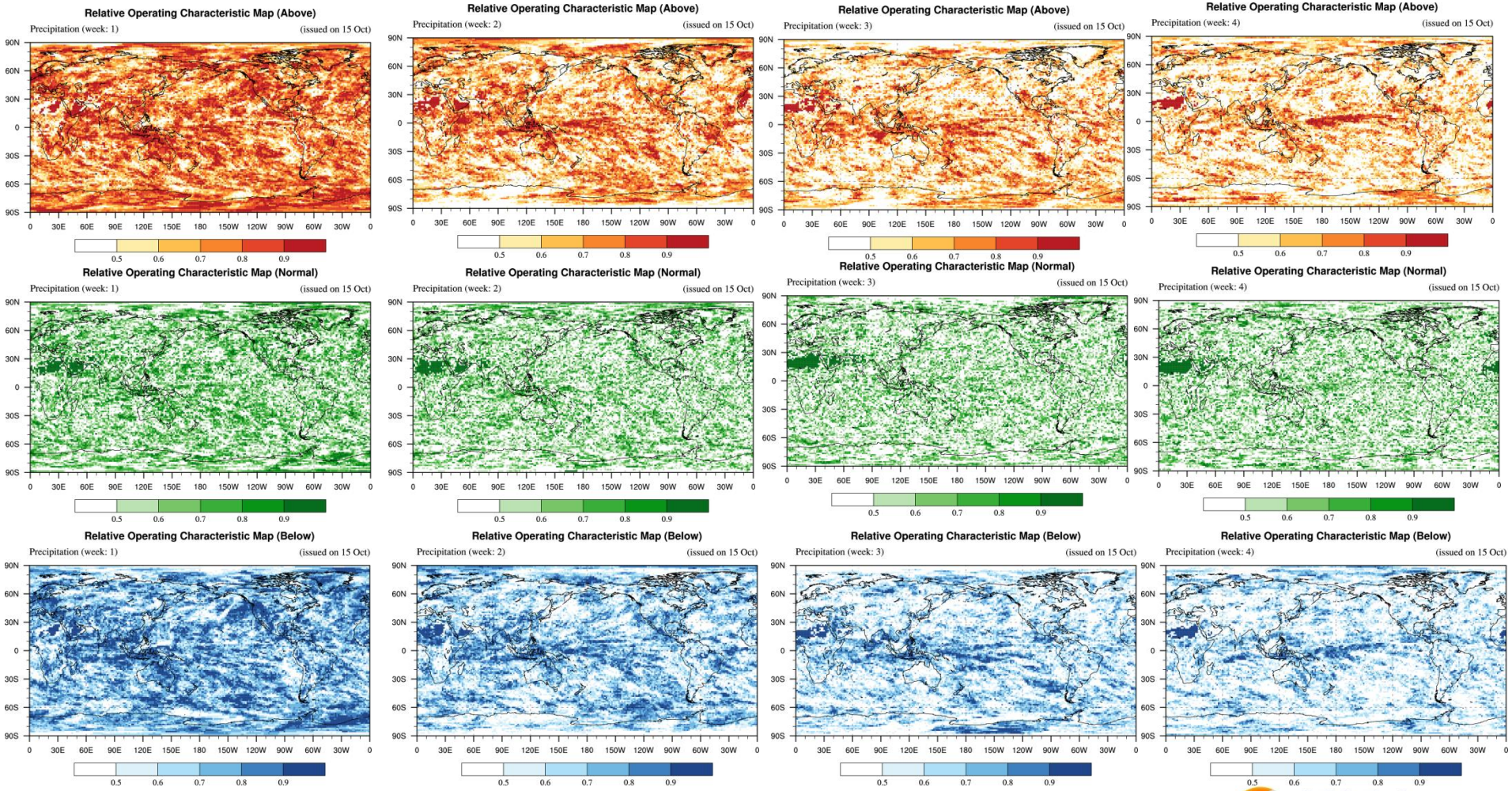
Products: Verification

- Verification for sub-seasonal MME products
  - Probabilistic verification: ROC score map - T2m



Products: Verification

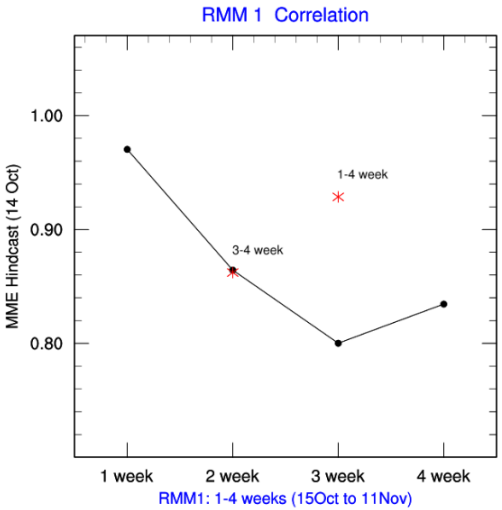
- Verification for sub-seasonal MME products
  - Probabilistic verification: ROC score map - Precipitation

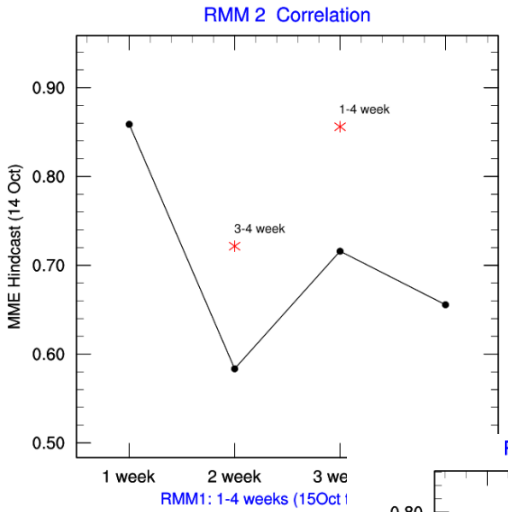


Products: Verification

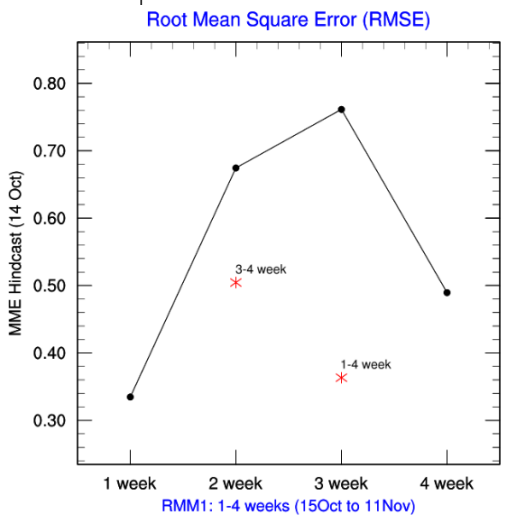
- Verification for sub-seasonal MME products
  - Deterministic verification: ACC, RMSE - MJO

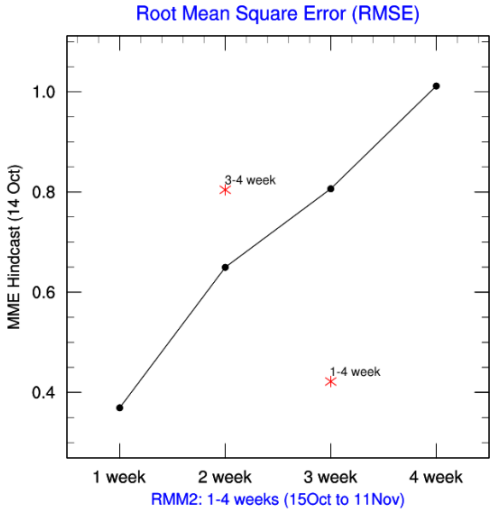
Anomaly Correlation Coefficient (ACC)





Root Mean Square Error (RMSE)

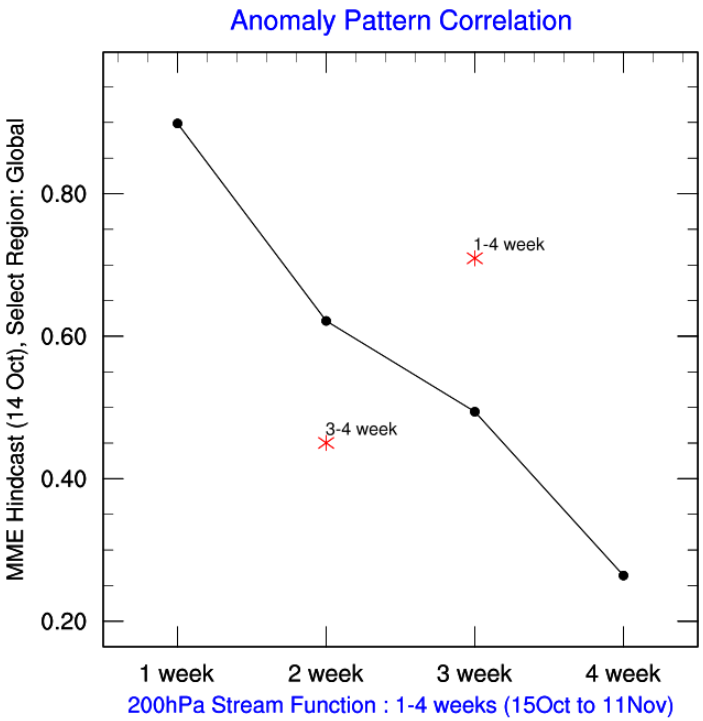




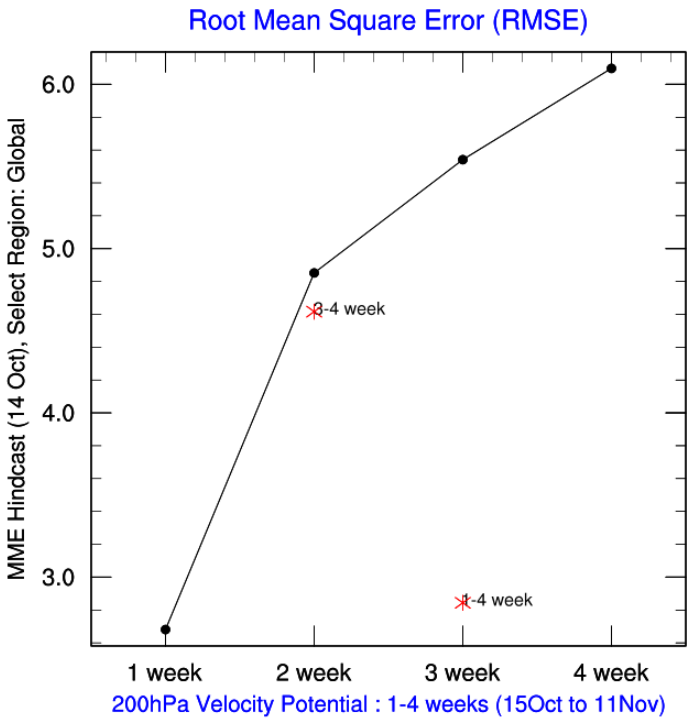
Products: Verification

- Verification for sub-seasonal MME products
  - Deterministic verification: ACC, RMSE – Velocity Potential

Anomaly Correlation Coefficient (ACC)



Root Mean Square Error (RMSE)



Summary and future plans

Summary and future plans

- The pilot real-time sub-seasonal MME activities with a small group of volunteering centres are started within Joint CBS-CCl ET-OPSLS and this activities is expected to accelerate the availability of sub-seasonal forecast data to WMO Members.

- Initial contents of sub-seasonal MME forecast are consist of traditional extended-range forecast products and MJO related products.

- Close collaboration with the S2S project is required
  - Data exchanges: S2S Data Archive (ECMWF)
  - Development of verification: The S2S sub-project, *Verification*

Milestone

- May 2015: Five participants in informal exchange agreed
- May 2015: Establish working links with the S2S data center
  - Start to download the exchange data from ECMWF
- October 2015: Develop proto-type of pilot display on LC-LRFMME website
- December 2015 : Reviewed by WMO CBS/CCL ET-OPSLS (Task Team 3) & S2S members
- 2016: Start to provide a pilot real-time service (expert only)
- 2017: Operational service (after ET-OPSLS and GPCs are agreed)

Thank you very much!