Korea Meteorological
Administration

Status and Plan of Seasonal Forecasting Services in KMA

Dong-Joon Kim, Jiseon Bak

and all other CPD/KMA staffs

Climate Prediction Division/KMA

2017 EASCOF

The Fifth Session of East Asian winter Climate Outlook Forum

8 – 10 November 2017, Tokyo, Japan

Contents

Korea Meteorological Administration

Operational Long-range Forecast

- and Modeling System - in KMA

Long-range Forecast products

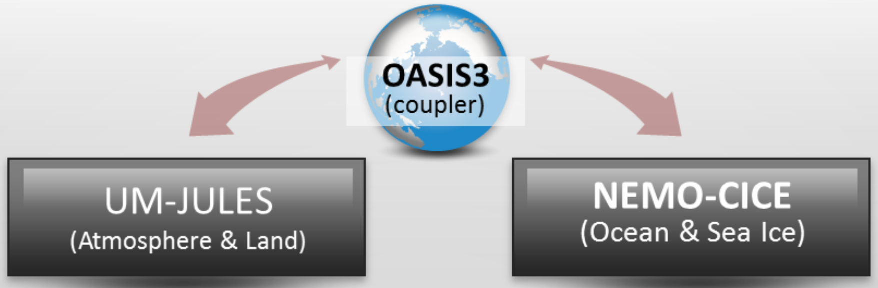
Forecast Type: Tercile Probability Forecast

Products	Date of issue / interval	Contents
1-month Outlook	• Every Thursday • Outlook for the 1-month after the next 2-week	• Weekly mean temperature and precipitation
3-month Outlook	• Every 23rd • Outlook for the next three months • Special : Feb., May., Aug., Nov.	• Monthly mean temperature and precipitation • El Niño/La Niña update • Asian dust : February • Typhoon : May / August
6-month Outlook	• 23rd in Feb., May., Aug., Nov. • Outlook for the season after next season	• Seasonal mean temperature and precipitation • El Niño/La Niña update
1-year forecast	• 23rd December • Outlook for the next year	• Annual mean temperature and precipitation

✓ ***Asian dust outlook*** : Frequency and density of Asian dust expected to affect Korea during upcoming Spring.

✓ ***Typhoon outlook*** : Number of Typhoon expected to affect Korea during upcoming Summer and Fall.

GloSea5: Global Seasonal forecasting system



	Atmosphere	Ocean & Sea Ice
Model	UM (UM 8.6, JULES 8.6)	NEMO-CICE (NEMO 3.4, CICE 4.1)
Horizontal res.	N216 (0.83° x 0.56°)	ORCA tri-polar grid at 0.25°
Vertical res.	85 levels (~85km)	75 levels

Global Coupled Configuration Package / current version : GC2.0

- **UM** (Met Office Unified Model) for Atmosphere : GA6.0
- **JULES** (Joint UK Land Environment Simulator) for Land Surface : GL6.0
- **NEMO** (Nucleus for European Modeling of the Ocean) for Ocean : GO5.0
- **CICE** (Los Alamos National Laboratory) for Sea-ice : GSI6.0
- **OASIS** (CERFACS) for coupling between component models

GloSea5: Joint Seasonal Forecasting System

December 2014 ~ Present

Recent Progress (1)

: Assessment of KMA-UKMO Ensemble **(Merged Ensemble)**

GloSea5: Hindcast Ensemble Size

※ 2017.03~

HCST year	KMA	UKMO	Merged Ensemble
1991	●●●		
1992	●●●		
1993	●●●	●●●●●●●	●●●●●●●●●●
…	…	…	…
2010	●●●	●●●●●●●	●●●●●●●●●●
2011		●●●●●●●	
2012		●●●●●●●	
2013		●●●●●●●	
2014		●●●●●●●	
2015		●●●●●●●	
Total	20years	23years	18years

Assessment Design

- Common Hindcast Period : 18 years (1993-2010)
- Experiments 1 : 6 member ensemble (3 KMA members + 3 UKMO members)
  - ▶ Period : May 2016 ~ Feb 2017 (40 cases)
- Experiments 2 : 10 member ensemble (3 KMA members + 7 UKMO members)
  - ▶ Period : Mar 2017 ~ Aug. 2017 (17 cases)

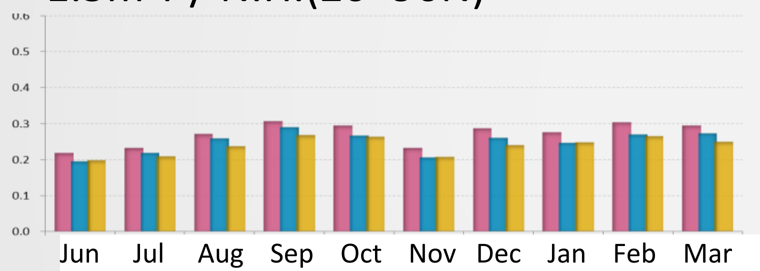
Verification : 1.5m Temperature and Precipitation

- **Correlation coeff.** between each ensemble mean and reanalysis data
  - Reanalysis data : ERA-interim (1.5m T) and JRA55 (precip.) reanalysis
  - HCST: temporal corr. coeff. / FCST: spatial corr. coeff.

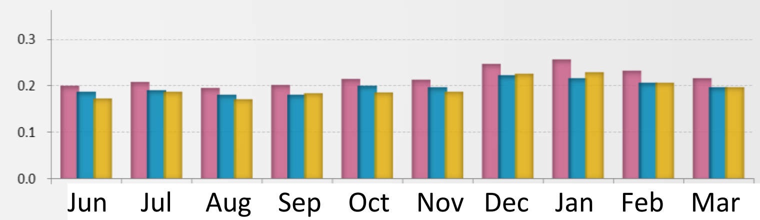
HCST / Jun.~Mar. (1993-2010)

Merged
KMA
UKMO

1.5m T / N.H.(20~90N)

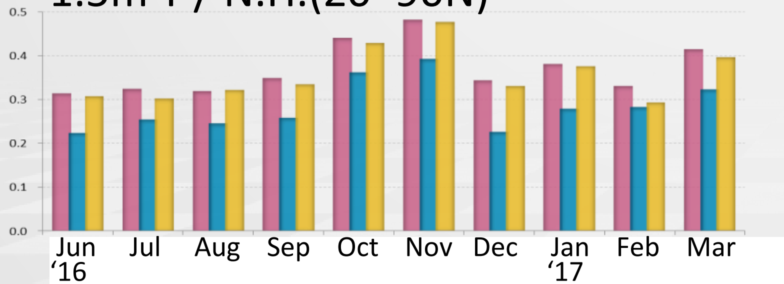


Precip. / Tropics(20S~20N)

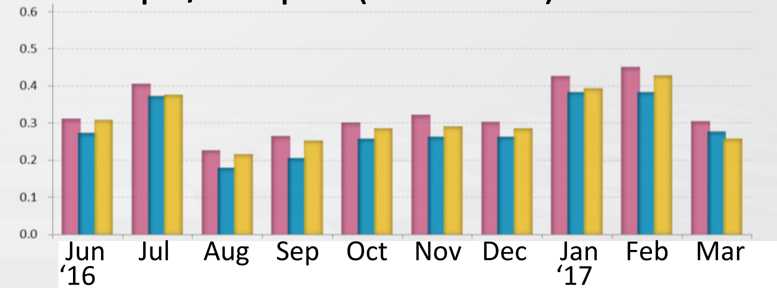


FCST / 2016.06~2017.03

1.5m T / N.H.(20~90N)



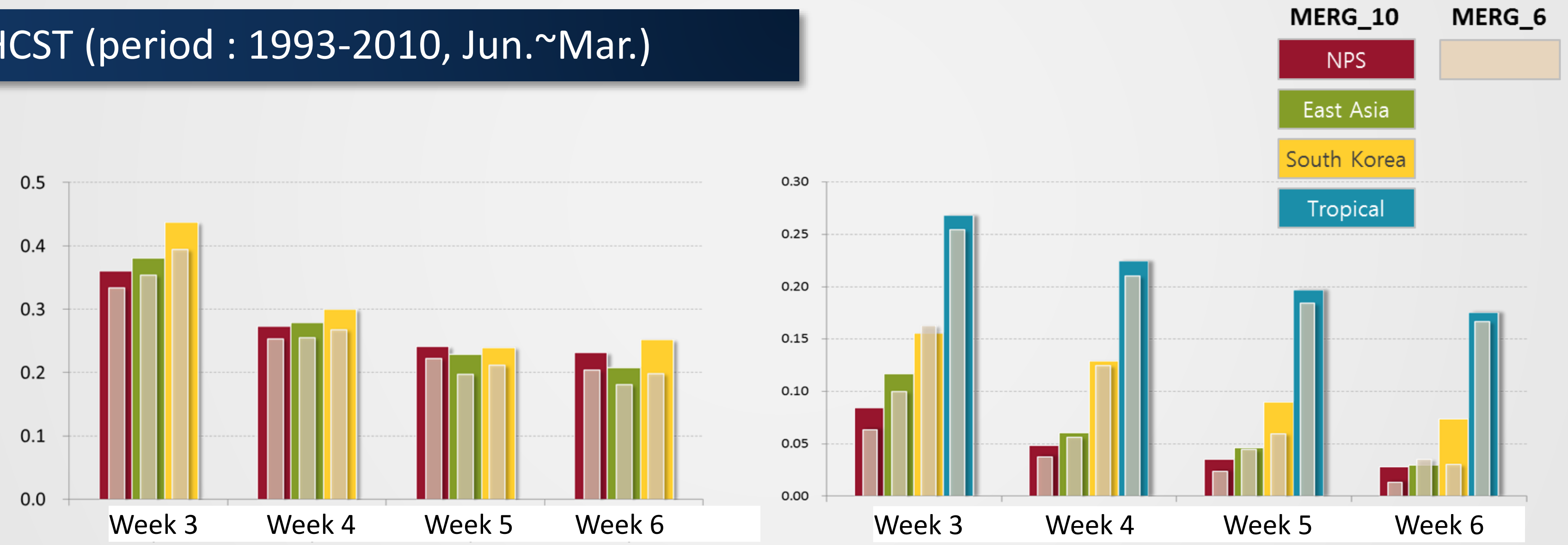
Precip. / Tropics(20S~20N)



Verification : Sensitivity to the Ensemble Size

- 6 member ensemble (3 KMA + 3 UKMO) vs. 10 member ensemble (3 KMA + 7 UKMO)
  - Correlation coefficient between merged ensemble hindcast and reanalysis data

HCST (period : 1993-2010, Jun.~Mar.)

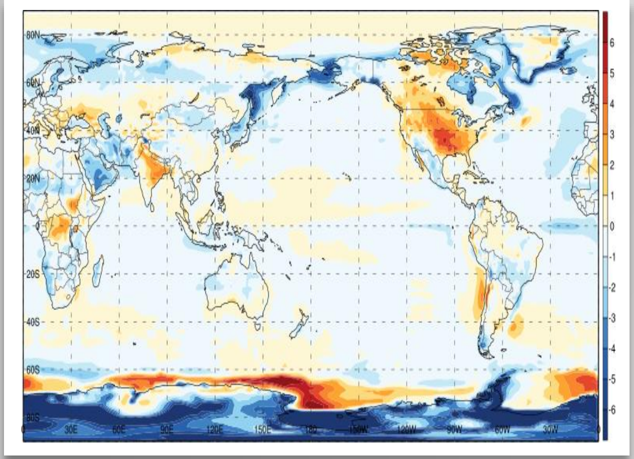


1.5m T / N.H.(20~90N)

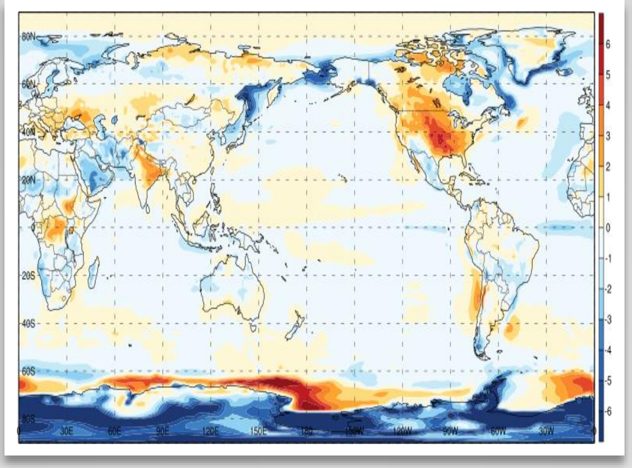
Precip. / Tropics(20S~20N)

Temperature bias from reanalysis / June (1-month run)

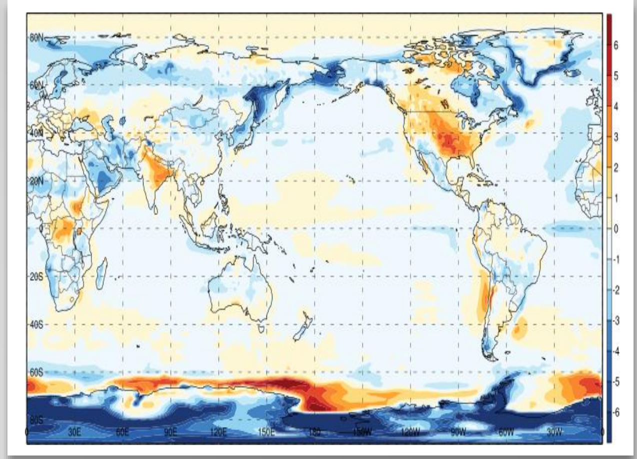
MERG



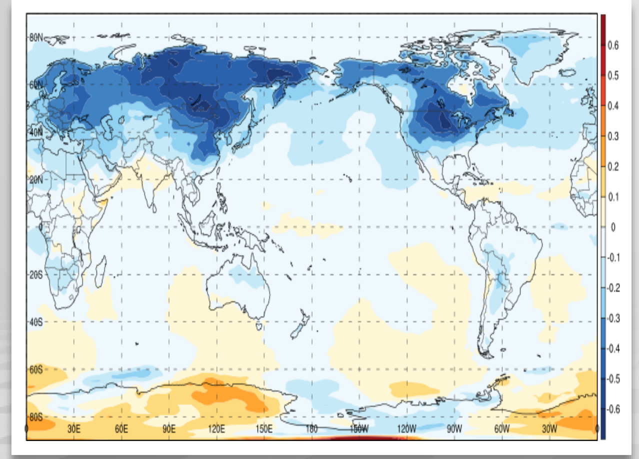
KMA



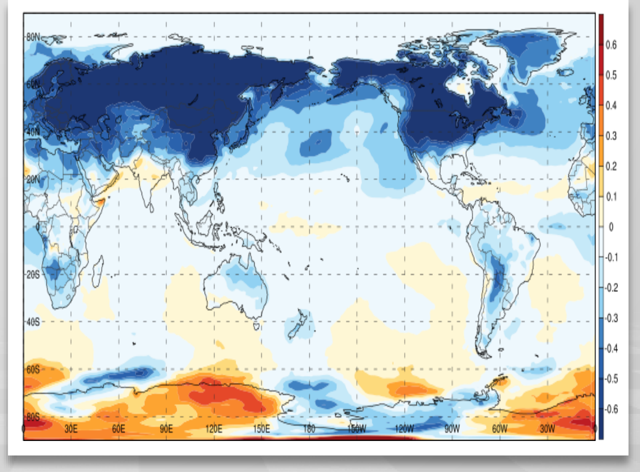
UKMO



MERG-KMA



UKMO-KMA



➔ **Note** : UK Met Office uses climatological mean value of soil moisture variables for hindcast.

III

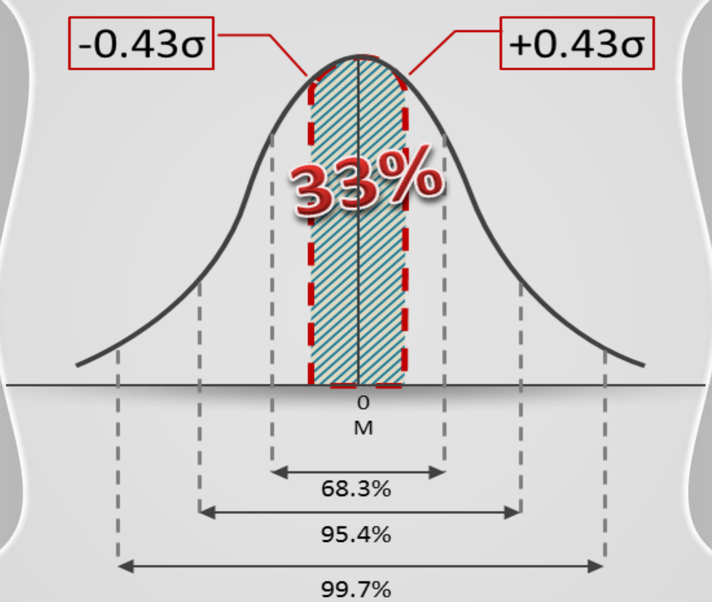
Recent Progress (2)

: **Quantile-based method** for
tercile categorization of precipitation

KMA's Current Tercile Categorization (As-Is)

Temperature

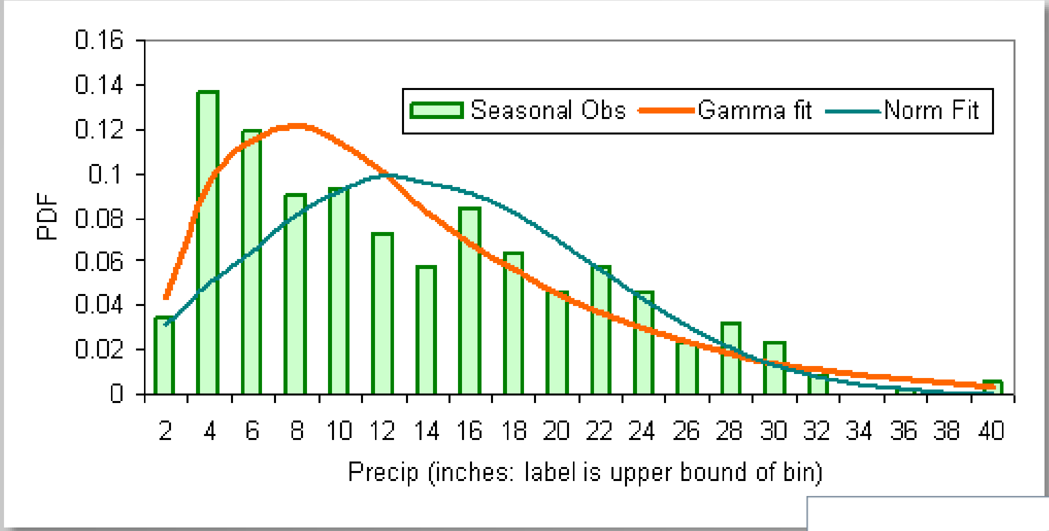
Approximation	Normal Dist.
Normal category	Mean±0.43σ
Unit	℃
Extreme values	-



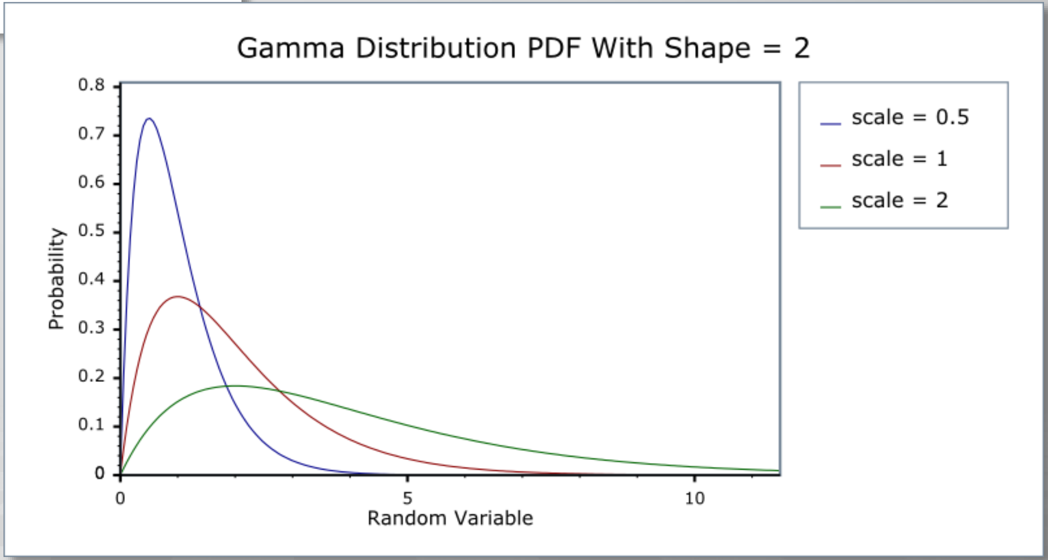
Precipitation

Approximation	Normal Dist.
Normal category	100±0.43σ
Unit	%
Extreme values	Eliminate values > ±3σ

Characteristics of Precipitation Data

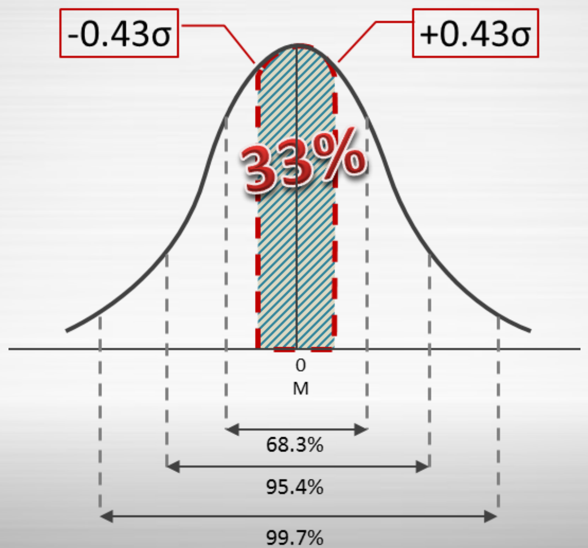


- Usually precipitation distribution cannot be approximated by a normal distribution



Quantile-based method (for precip.)

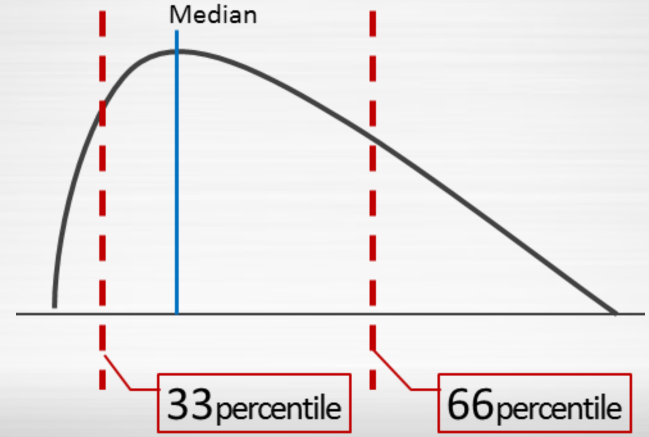
As-Is



Unit : Percentage ratio (%)

Approximation	**Normal Dist.**
Central value	**Clim. Mean**
Normal range	**Mean±0.43σ**

To-Be

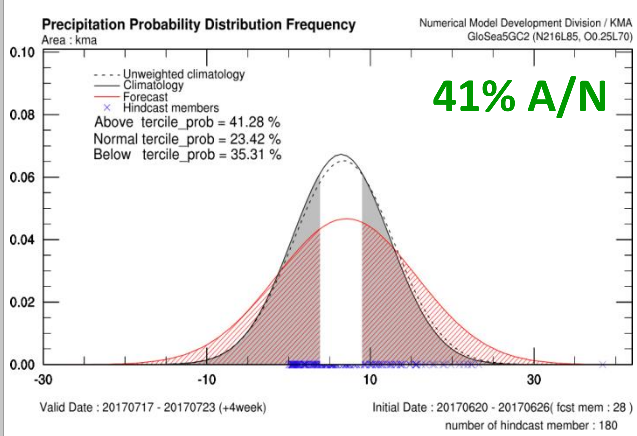


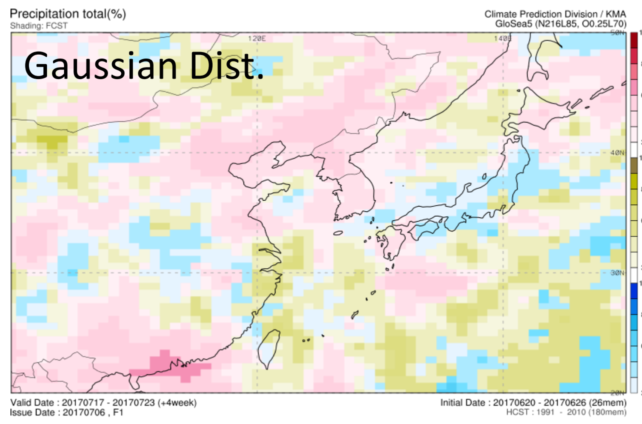
Unit : Precipitation amount (mm)

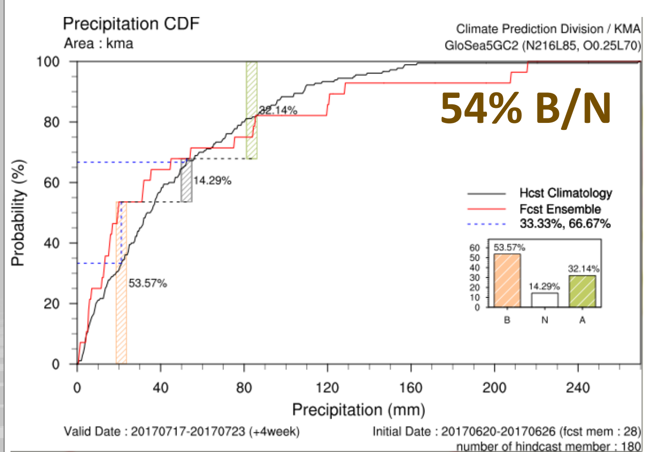
Approximation	**Quantile Dist.**
Central value	**Median value**
Normal range	**33~66% range**

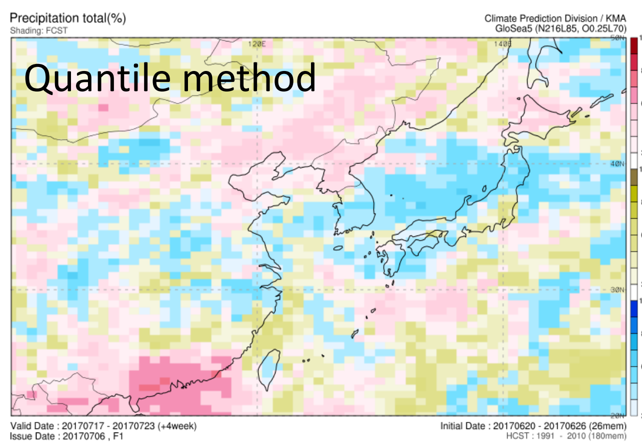
Sensitivity test / Use of CDF (Cumulative Dist. Func.)

Initial date: **2017. 6. 26.**
Target date: **2017. 7. 17~7. 23. (+4weeks)**

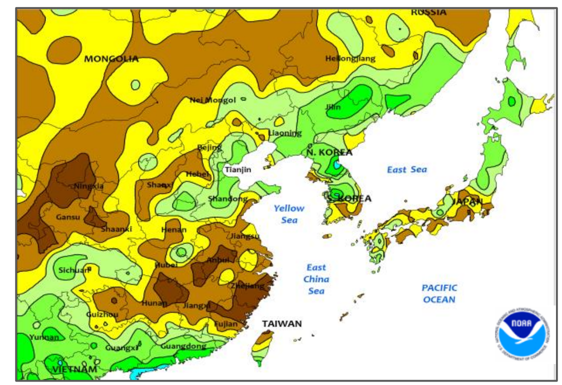


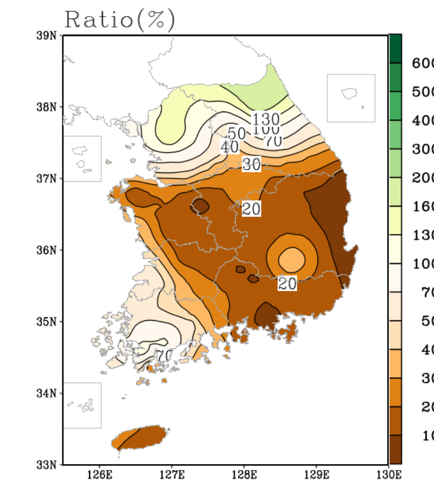






Observation





44% of clim. avg.

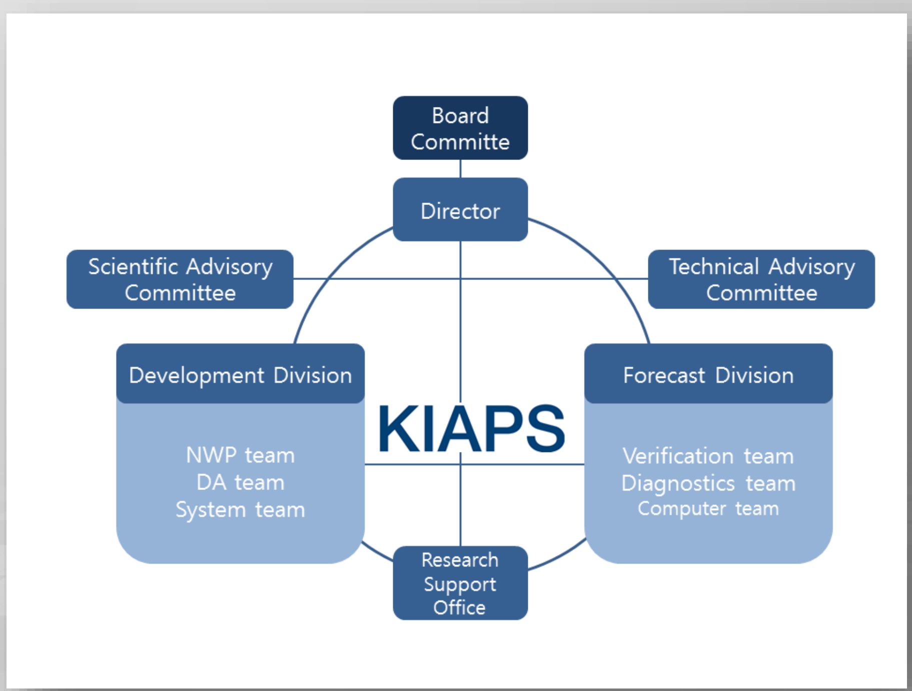
Korea Meteorological Administration

Next-generation Global Model Development Project :

Korea Institute of Atmospheric Prediction Systems (KIAPS) / 2011~2019

Project Overview

- Purpose : Development of a **next-generation operational global model** for KMA
  - Global model (KIAPS Integrated Model, KIM) as well as its observation preprocessing and D.A. system
- Development period : **2011 ~ 2019**
- Budget : ~ 85 million USD (~ 10 million USD / year)
- Development Group : Korea Institute of Atmospheric Prediction Systems (KIAPS)
  - number of staffs : 58



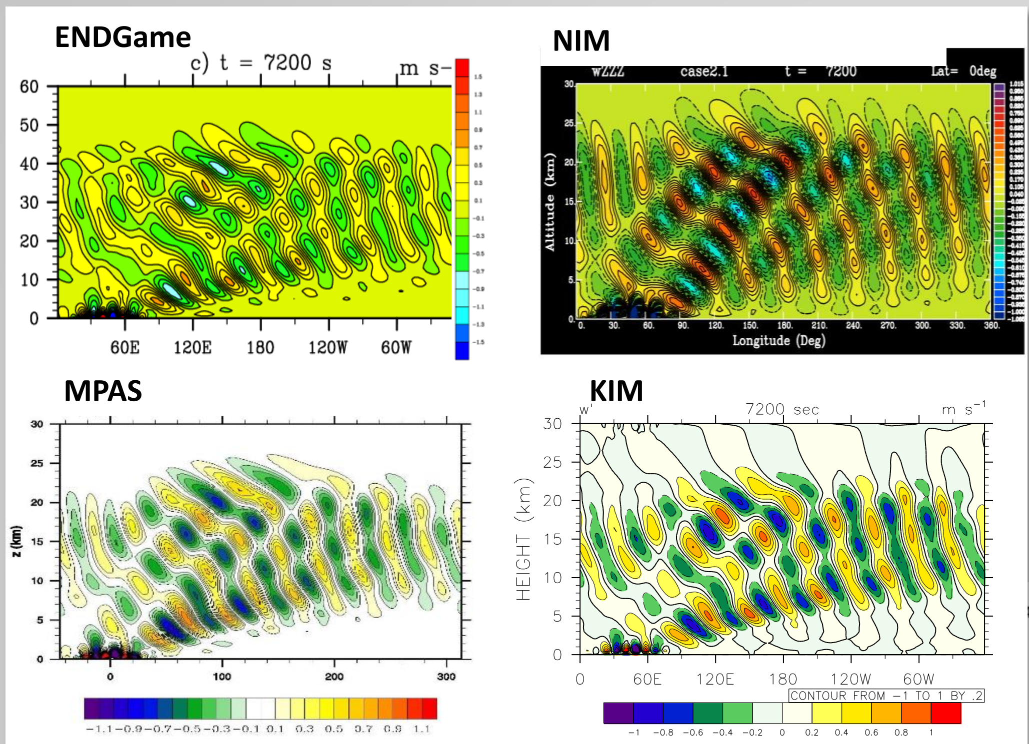
KIM development : Dynamical Core

"The first fully functional non-hydrostatic spectral element global dynamic core over cubed sphere grid" *Joseph Klemp (NCAR)*

❖ **KIM**(KIAPS Integrated Model) : Hydrostatic/Non-hydrostatic system with spectral element method over cubed sphere grid

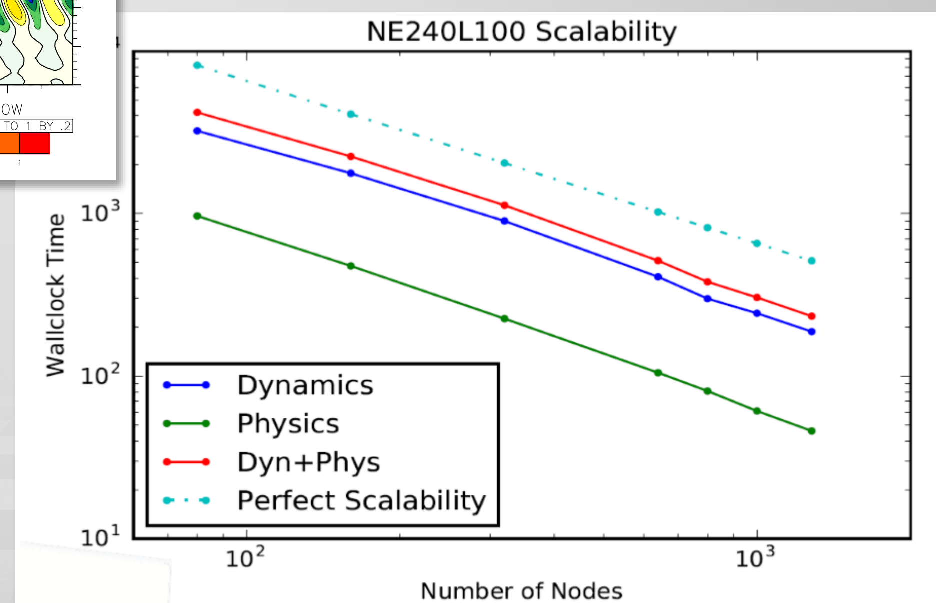
	KIM-SH (High Order Method Modeling Environment model; NCAR's CAM-SE)	**KIM-SW** (KIAPS Integrated Model – Spectral element method, WRF-Type)
Spherical grid	Cubed-sphere (Equiangular gnomonic projection)	
Horizontal approximation	Spectral Element	
Vertical approximation	Finite Element	Finite Difference
Temporal approximation	Fully Explicit Leapfrog, first-order due to Robert-Asselin filter	Split-explicit RK3, second-order for nonlinear equation
Equation	**Hydrostatic** (Full variables)	**Non-hydrostatic** (Perturbation variables)
Explicit spatial diffusion	4^{th} order linear horizontal diffusion	6^{th} order time-split explicit diffusion

KIM development : Dynamical Core



Dry simulation (Orographic gravity wave)

DCMIP (Dynamical Core Model Intercomparison Project)



➔ High Scalability

KIM development : Physics package (KIM3.0 / Apr. 2017)

	Scheme	Updated	Reference
Radiation	Revised RAD (RRTMK)	• unified RRTMG • reduced MCICA • updated ancillaries (aerosol, GMAO ozone, reflectivity, emissivity, snow albedo) • Improved two-stream approximation for shortwave radiation • Scale-awareness for sub-grid hydrometeors	Iacono et al. 2008 **Beak 2017**
Land surface	Revised LSM	• 3-layer sea-ice model • frozen processes (z0, conductivity over snow cover, flux over sea-ice) • USGS to IGBP for land data • soil moisture initialization • consistent diffusivity in LSM and RAD • Heterogeneous land-surface parametrization • Roughness length considering snow	Ek et al. 2003 **Koo et al. 2016**
Ocean surface layer	Diurnal SST OSH	• SST warming effect • Considering salinity effect	Kim and Hong 2010 **Lee and Hong 2017**
Boundary layer	Scale-aware non-local PBL	• top-down mixing • updated background diffusion & heating rate • minimum Richardson number changed • scale-aware (ShingHong PBL) • Considering dissipative heating	Hong et al. 2006 **Shin and Hong 2015** **Lee et al. 2016**
Gravity wave drag	Sub-grid orographic GWD	• flow blocking drag • orographic anisotropy • updated efficiency/intermittency factor	Hong et al., 2008 **Choi and Hong 2015**
	Non-orographic GWD	• Source-based spectral nonorographic GWD	**Choi et al. 2017**
Deep convection	Scale-aware mass-flux CPS	• revised autoconversion & entrainment rate • moisture-based trigger threshold • scale-aware / aerosol-aware	Han and Pan 2011 Lim et al. 2014 **Han et al. 2016** **Kwon and Hong 2016**
Shallow convection	Adjustment SCV	• improved eddy diffusivity profile (2.5) • Considering diffusion of cloud water contents	Hong et al. 2013
Microphysics	WSM5 MPS	• effective radius	**Hong et al. 2004** **Bae et al. 2016**
Cloudiness	Prognostic CLD	• revised CPS condensate • consistency (cloud-MPS-CPS-RAD) • reduced high cloud fraction at high latitude	**Park et al. 2016**

KIM development : Major Progresses so far

- Major components of KIM are mostly developed by KIAPS scientists
  - dynamical core, physics, data assimilation and model framework
- **Non-hydrostatic dynamic core and data assimilation system over cubed sphere system** are implemented at KIAPS, will be adopted to US/NWS and UK Met Office
- Physics suite of KIM has many updates with special emphasis **on scale-aware** and inter-scheme consistency
- Flexible model framework – operable on both **CPU & GPU platform**, **KIM-IO**, **coupler capability** are also developed in KIAPS

WMO LC-LRFMME

WMO Lead Centre for
Long-Range Forecast Multi-Model Ensemble

13 WMO GPCs for LRF

WMO Global Producing Centres

- **Beijing:** China Meteorological Administration (CMA) / Bejing Climate Center (BCC)
- **CPTEC:** Center for Weather Forecasting and Climate Research / National Institute for Space Research (INPE), Brazil
- **ECMWF:** European Centre for Medium-Range Weather Forecasts
- **Exeter:** Met Office, United Kingdom
- **Melbourne:** Bureau of Meteorology (BOM), Australia
- **Montreal:** Meteorological Service of Canada (MSC)
- **Moscow:** Hydrometeorological Centre of Russia
- **Offenbach:** Deutscher Wetterdienst Wetter und Klima aus einer Hand **(Aug. 2017 ~)**
- **Pretoria:** South African Weather Services (SAWS)
- **Seoul:** Korea Meteorological Administration (KMA)
- **Tokyo:** Japan Meteorological Agency (JMA) / Tokyo Climate Center (TCC)
- **Toulouse:** Météo-France
- **Washington:** Climate Prediction Center (CPC) / National Oceanic and Atmospheric Administration (NOAA), United States of America

Summary of data provided by the GPCs

Information on the data configuration supplied by the 13GPCs

GPC	Beijing	CPTEC	ECMWF	Exeter	Melbourne	Montreal	Moscow	Offenbach	Pretoria	Seoul	Tokyo	Toulouse	Washington
Forecast system	1-tier	2-tier	1-tier	1-tier	1-tier	1-tier	2-tier	1-tier	1-tier	1-tier	1-tier	1-tier	1-tier
Forecast													
Ensemble size	24	15	41	42	33	20	10	30	40	42	51	41	40
Hindcast													
Period	1991-2010	1979-2001	1981-2010	1993-2015	1981-2011	1981-2010	1986-2010	1981-2010	1981-2001	1991-2010	1981-2010	1979-2007	1982-2010
Ensemble size	24	10	15	28	99	20	10	15	10	12	10	11	20
Digital data	◎	◎	×	×	◎	◎	◎	◎	◎	◎	×	×	◎

An "×" indicates that data is not currently available in LC-LRFMME, because of GPC's data Policy

LC-LRFMME Plan : contribution to S2S project

Pilot real-time MME service for sub-seasonal forecasts

- WMO Cg-XVI(2011) requested LC-LRFMME to expand its role to include exchange of extended-range predictions.
- In 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.

* S2S : Sub-seasonal to Seasonal Prediction Project

ECMWF: European Centre for Medium-Range Weather Forecasts

LC-LRFMME Plan : contribution to S2S project

Pilot real-time MME service for sub-seasonal forecasts

- The LC-LRFMME is planning to provide MME forecasts and its verification results through website after IPET-OPSLS and GPCs agree (2018~)

※ **IPET-OPSLS:** Inter-Programme Expert Team on Operational Predictions from Sub-seasonal to Longer-time Scales

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

Korea Meteorological Administration

Thank you

2017 EASCOF

The Fifth Session of East Asian winter Climate Outlook Forum

8 – 10 November 2017, Tokyo, Japan