# JMA's New Seasonal Ensemble Prediction System: JMA/MRI-CPS2

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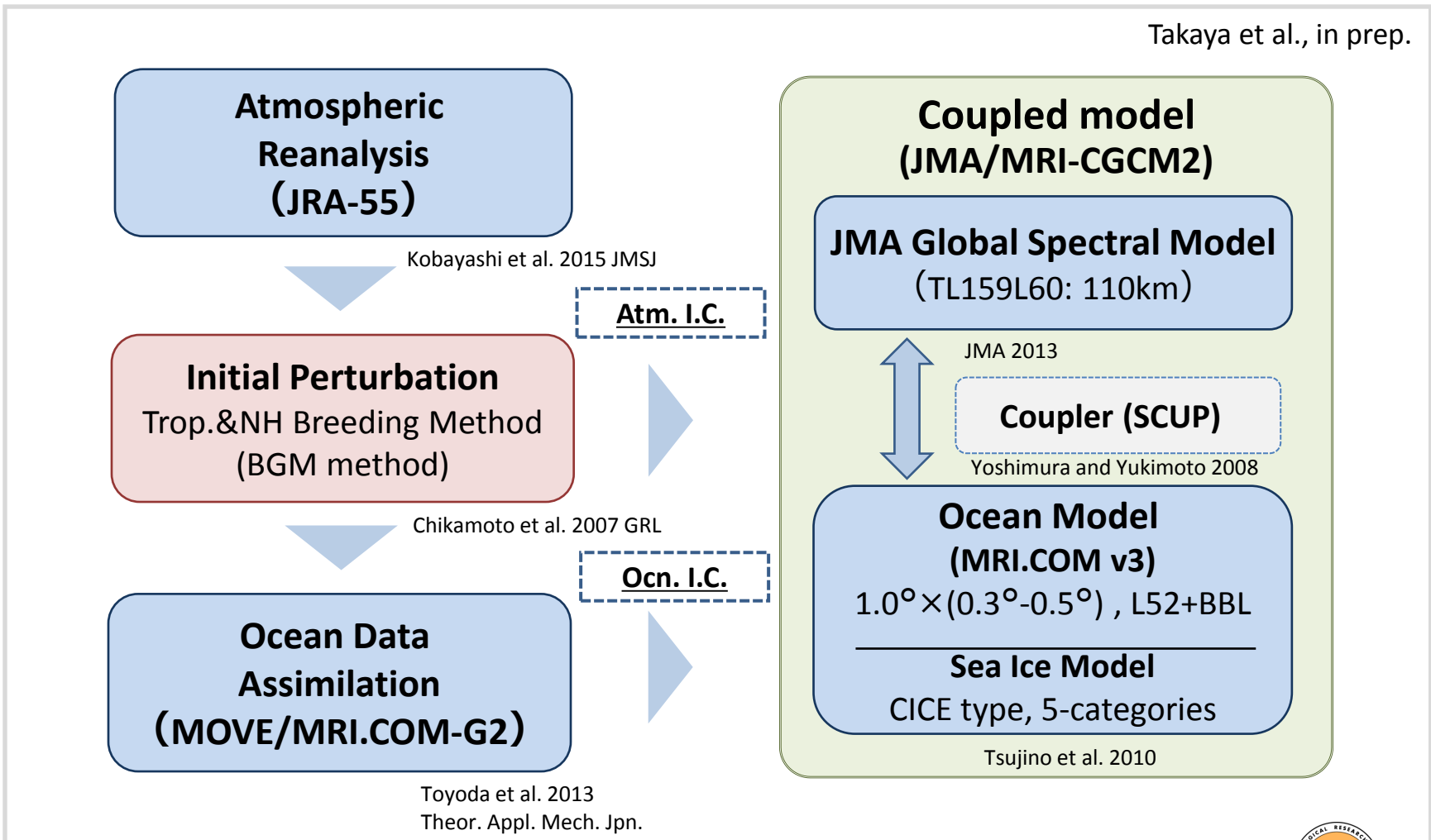**Meteorological Research Institute, Japan Meteorological Agency**
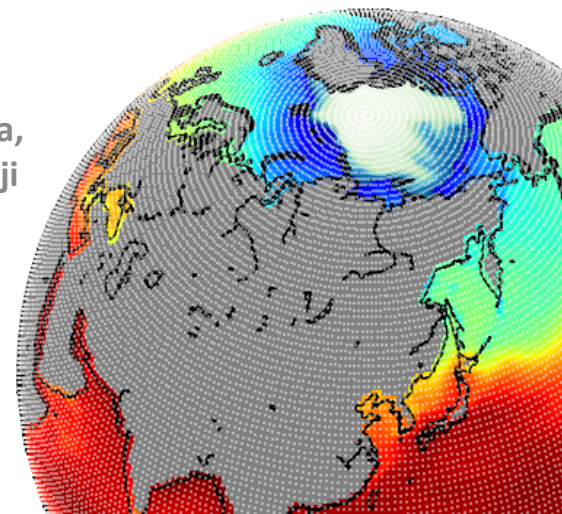
Outline

- Configuration of JMA's Seasonal EPS
- Evaluation of prediction skill
  - 3-month forecast
  - ENSO prediction
- Newly introduced sources of predictability
  - Sea ice
  - Land initialization
  - Greenhouse gases
- East Asian Winter Monsoon

System components of JMA/MRI-CPS2

JMA/MRI-CPS2（Coupled Prediction System 2）   *Upgraded in June 2015*

Takaya et al., in prep.

Atmospheric Reanalysis（JRA-55）

Kobayashi et al. 2015 JMSJ

Atm. I.C.

Initial Perturbation
Trop.&NH Breeding Method
(BGM method)

Chikamoto et al. 2007 GRL

Ocn. I.C.

Ocean Data Assimilation（MOVE/MRI.COM-G2）

Toyoda et al. 2013
Theor. Appl. Mech. Jpn.

Coupled model (JMA/MRI-CGCM2)

JMA Global Spectral Model（TL159L60: 110km）

JMA 2013

Coupler (SCUP)

Yoshimura and Yukimoto 2008

Ocean Model (MRI.COM v3)
$1.0° \times (0.3°\text{-}0.5°)$, L52+BBL

Sea Ice Model
CICE type, 5-categories

Tsujino et al. 2010

Configuration of JMA's seasonal EPS

	JMA/MRI-CPS1 (Previous)	JMA/MRI-CPS2 (since June 2015)
Atmosphere (JMA-AGCM)	*TL95L40*, ~180km, Up to *0.4hPa*	*TL159L60* , ~110km, up to *0.1hPa* *Stochastic tendency perturbation* *GHG forcing* from RCP4.5 scenario
Ocean (MRI.COM) (Tsujino et al 2010)	1.0° (lon) x *0.3-1 °* (lat) *L50* 75°S-75°N Ocean *Sea-ice climatology*	1.0° (lon) x *0.3-0.5 °* (lat) *L52+BBL* *Global ocean with tri-polar grid* *Sea-ice model*
Coupler (Scup) (Yoshimura and Yukimoto 2008)	1-hour coupling interval *Momentum and heat flux adjustments*	1-hour coupling interval *No flux adjustment*
Initial Condition	Atmosphere: *JRA-25* Land: *Climatology* *with ERA-15 forcing* Ocean: *MOVE/MRI.COM-G* T, S&SSH (Usui et al. 2006) *Sea-ice climatology*	Atmosphere: *JRA-55* Land: *JRA-55 land analysis* Ocean: *MOVE/MRI.COM-G2* T, S & SSH *Sea-ice model*
Ensemble Size	51 (*9* BGMs, *6* days with 5-day LAF)	51 (*13* BGMs, *4* days with 5-day LAF)

* re-forecast: 10 member ensemble (5 BGMs, twice a month, 1979-2014)

Operational ensemble method

Previous system
(JMA/MRI-CPS1)

New operational system
(JMA/MRI-CPS2)
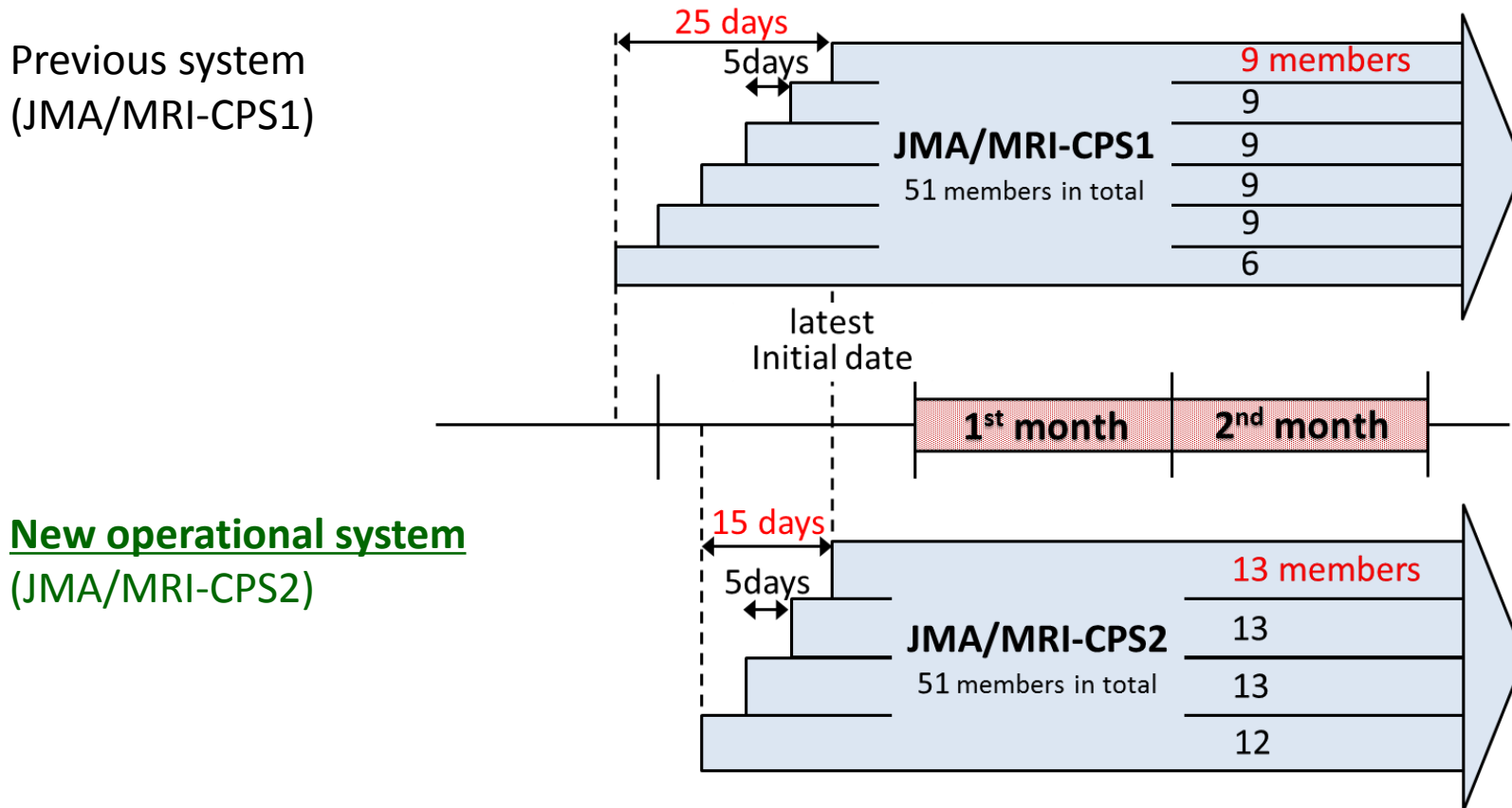
The number of ensembles per initial date has been increased from 9 to 13.
- Production of combined 51-member ensemble predictions starting from later initial dates compared to the previous system
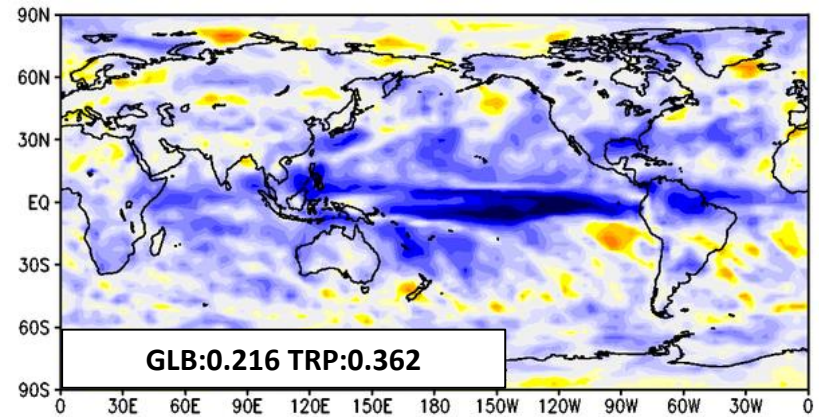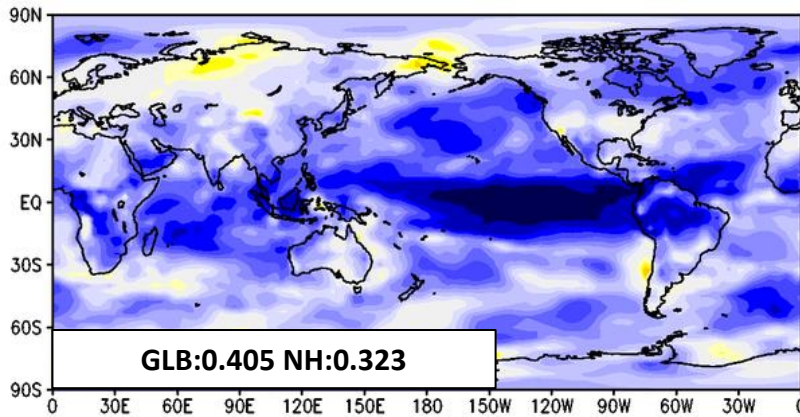   - ➔ The forecast lead time is shortened.

Anomaly correlation of the seasonal EPS
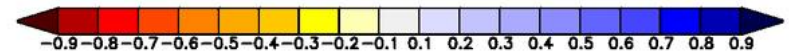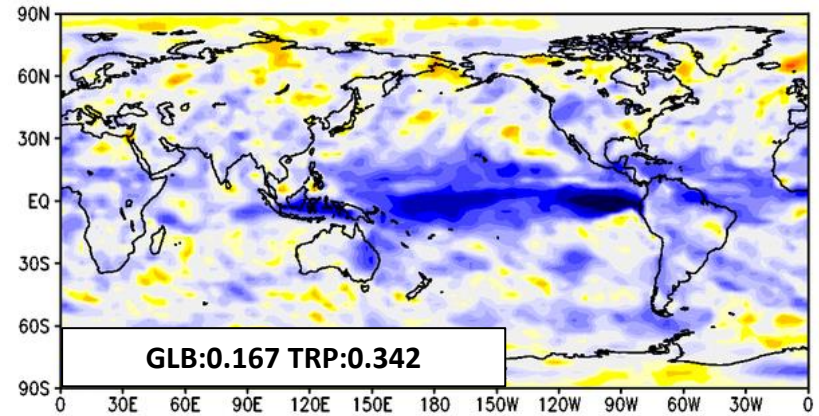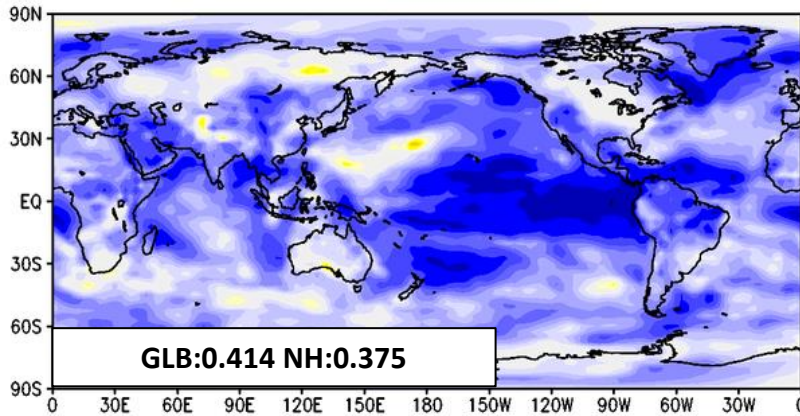
NH: 20N-90N,0E-360E
TRP: 20S-20N,0E-360E

2m temperature

Precipitation

DJF (Initial: Nov.)

GLB:0.405 NH:0.323

GLB:0.216 TRP:0.362

JJA (Initial: May)

GLB:0.414 NH:0.375

GLB:0.167 TRP:0.342

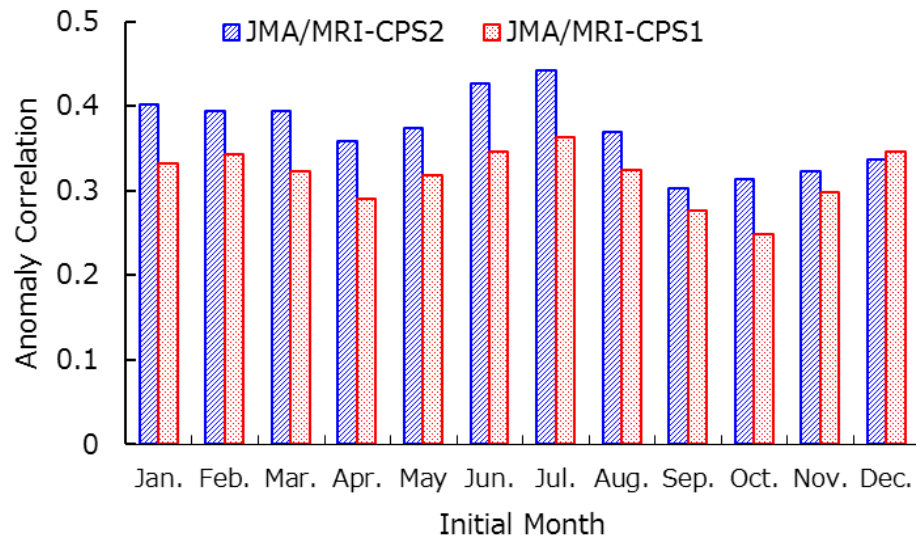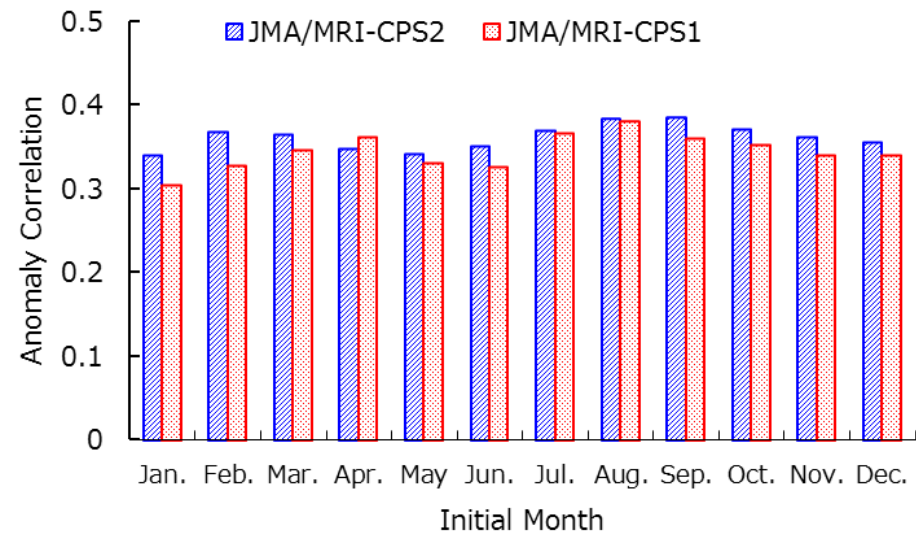-0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Improved ACC for 3-month forecast

NH: 20N-90N, 0E-360E
TRP: 20S-20N, 0E-360E
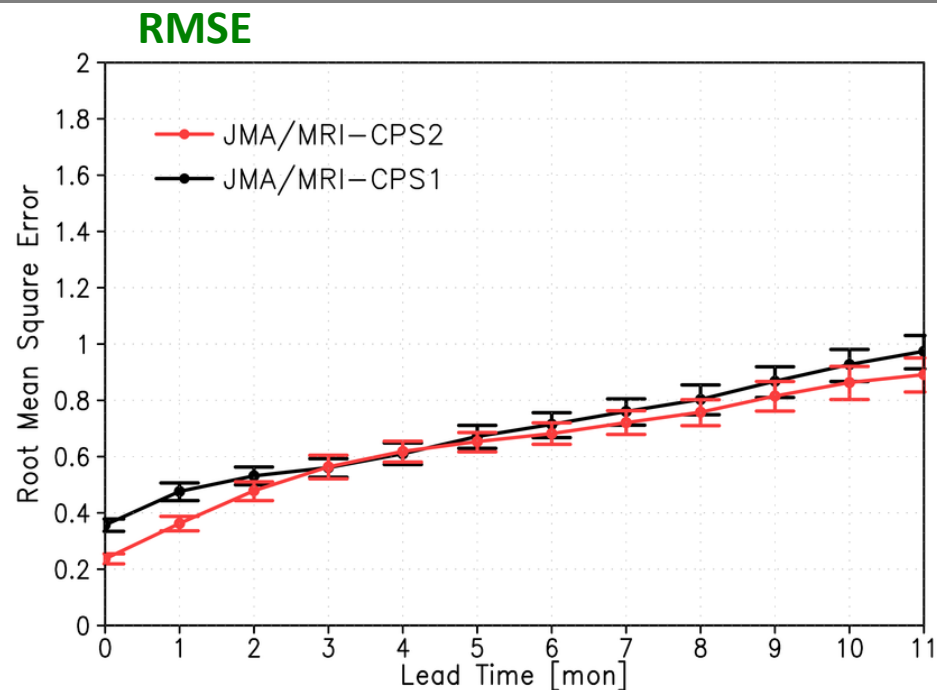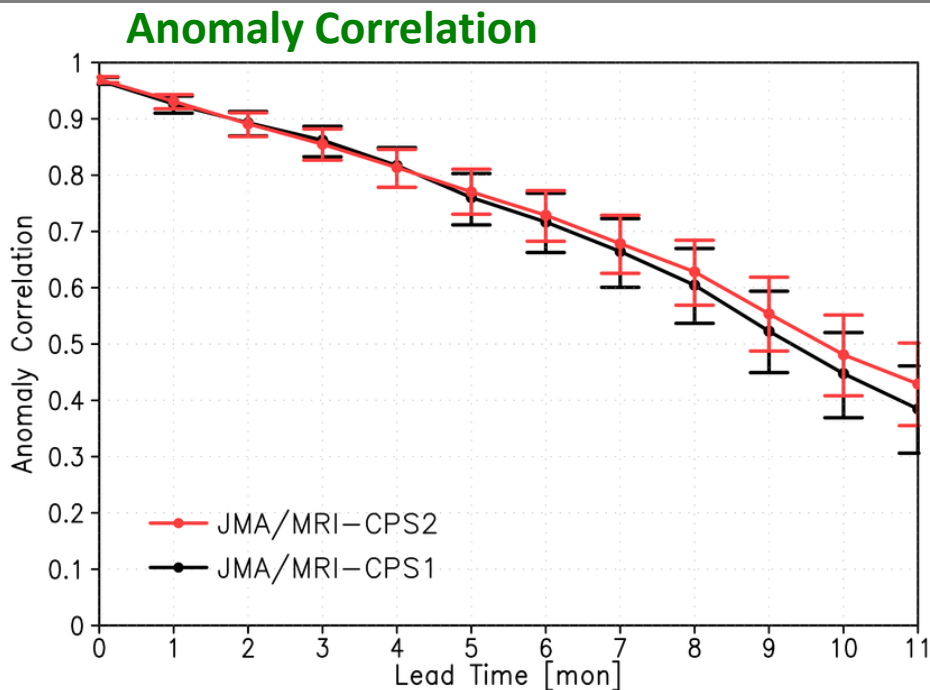

2-m Temperature averaged in NH

Precipitation averaged in TRP

☐ For 3-month forecast, anomaly correlation coefficient of 2m temperature (NH) and precipitation (TRP) is greater than the previous system in almost all initial months.

NINO3 SST prediction skill

Anomaly Correlation

RMSE

☐ Improvement of ACC in longer lead time
☐ Improvement of ACC over the spring barrier (not shown)

NINO.3 : 150W-90W, 5S-5N

Newly introduced sources of predictability

- Dynamical sea ice simulation

- Land initialization with JRA-55

- Fully covered stratosphere (Top: 0.1 hPa)

- Global ocean domain

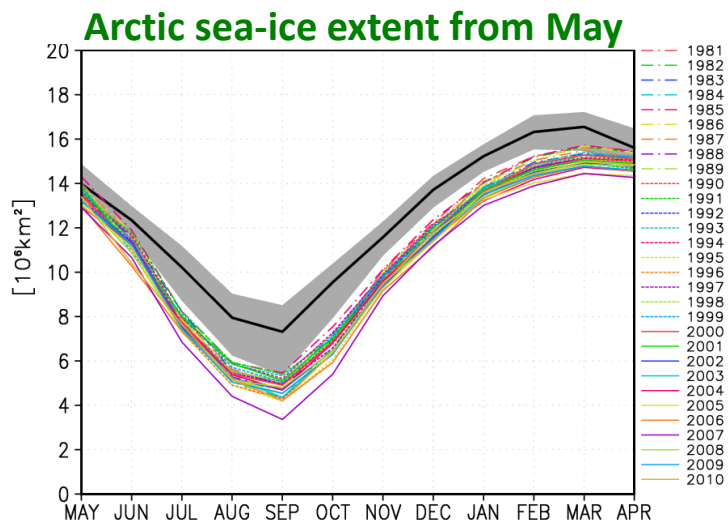- Realistic concentration of GHGs (6 gases prescribed with RCP4.5 scenario)

The new system is capable of incorporating a full range of potential sources of the predictability.
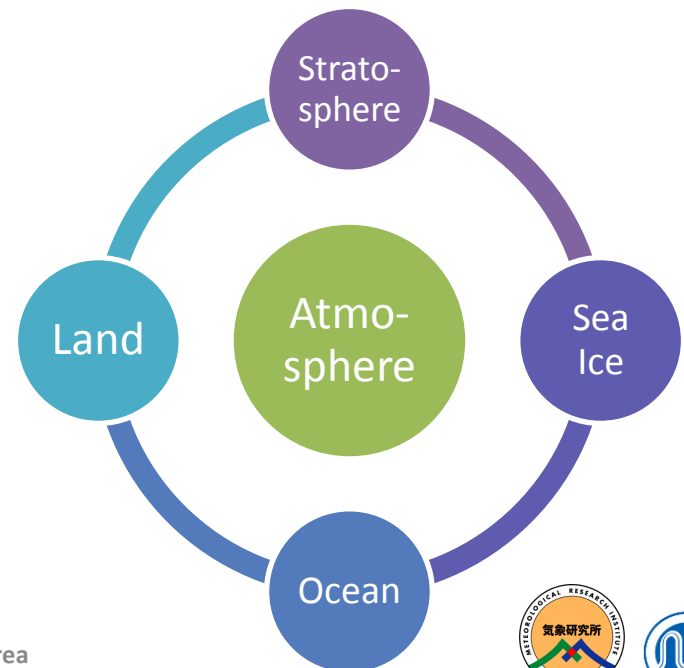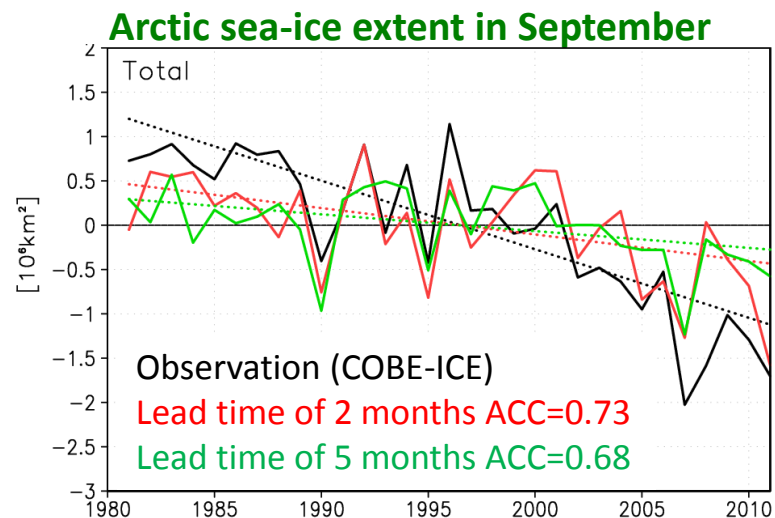
Sea-ice model

- **Interactive sea-ice model**
  - Thermodynamic model (sea-ice production / melting)
  - Dynamic model (momentum equation)

Arctic sea-ice extent from May

Color: Individual forecast
Black and Grey: Observed climatology (COBE-ICE) (Grey) minimum and maximum

Arctic sea-ice extent in September

Observation (COBE-ICE)
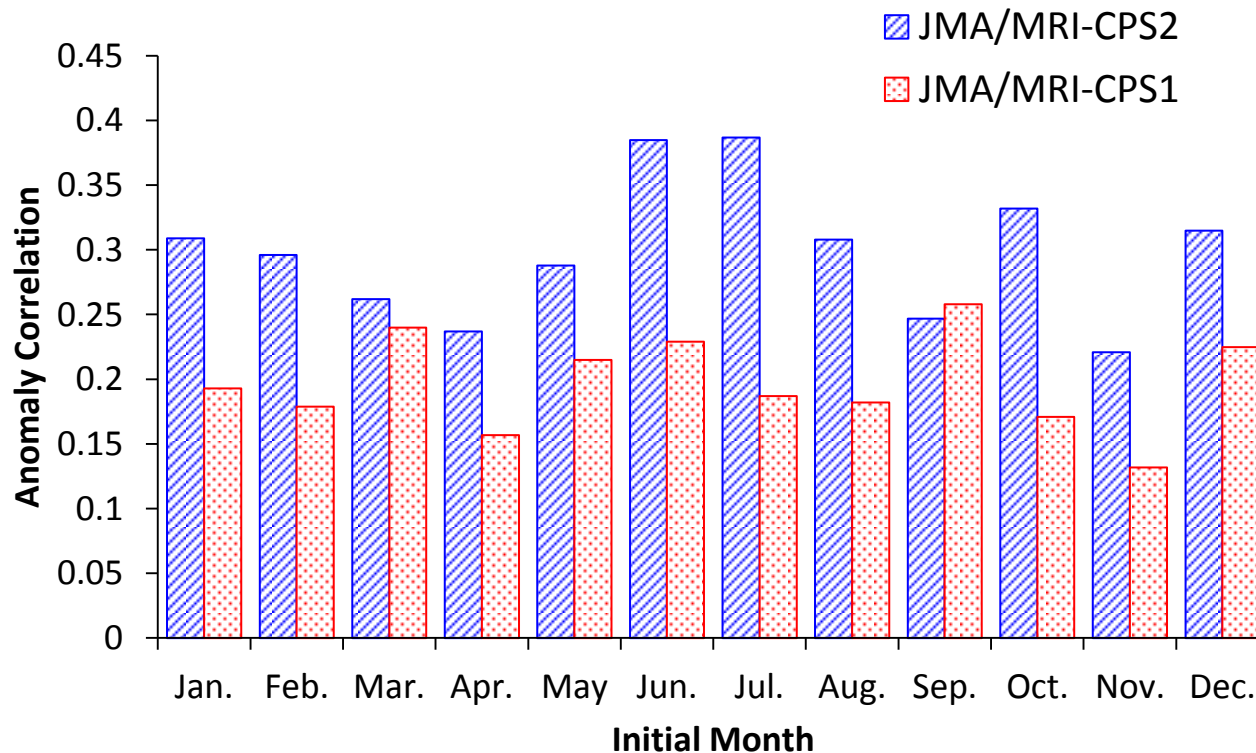Lead time of 2 months ACC=0.73
Lead time of 5 months ACC=0.68

Sea-ice simulation represents:
☐ Seasonal variation of Arctic sea ice.
☐ Interannual variability and reduction trend of Arctic sea-ice extent.

2-m temperature over the Arctic region

Anomaly Correlation of 2-m Temperature over the Arctic region (60N-90N)

Lead time: 1 month
Target: 3-month mean

- ☐ Prediction skill of 2-m temperature over the Arctic area is improved in almost all initial month.
- ☐ It is suggested that sea-ice model contributes to improvement of 2-m temperature.

Impact of land initialization

- **JMA/MRI-CPS1**   Climatology with ERA-15 forcing

- **JMA/MRI-CPS2**   JRA-55 land analysis : Land A

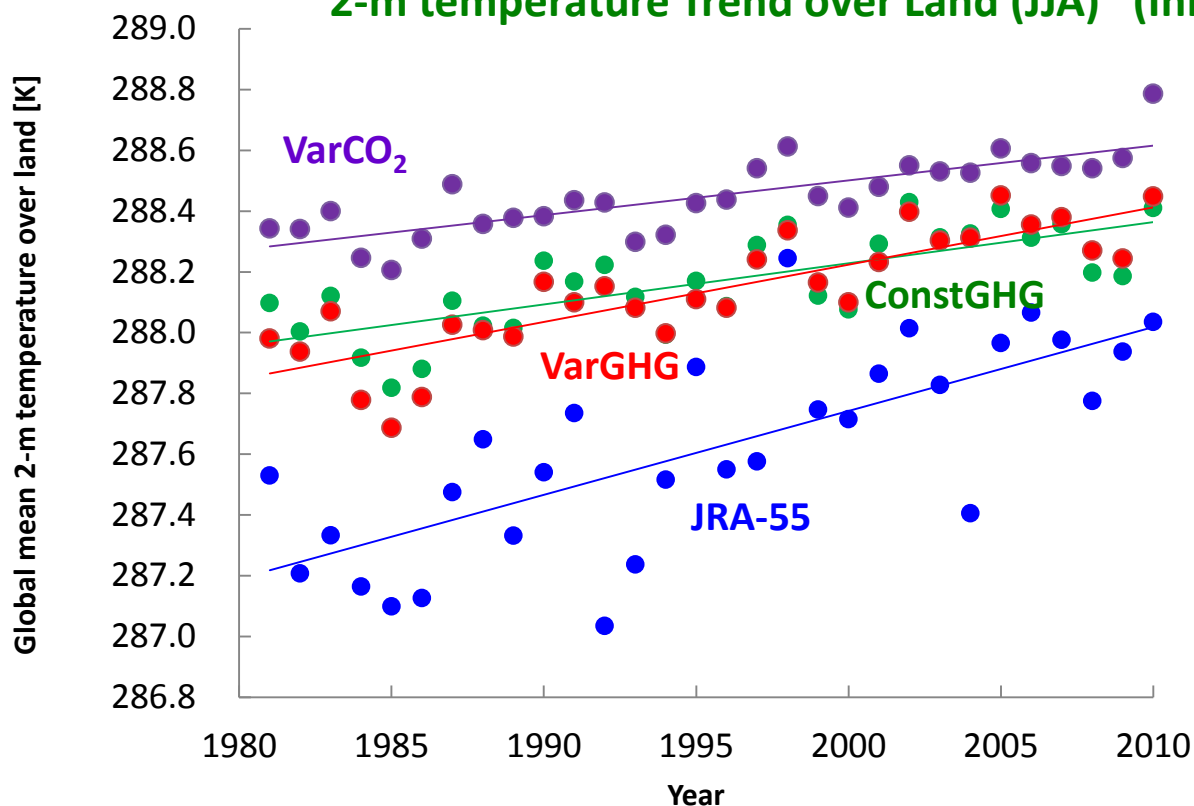 – Additional experiment: Climatology (1981-2010) of JRA-55 land analysis (Land C)

Anomaly Correlation of 2-m Temperature over land (Lead Time: 0 month)
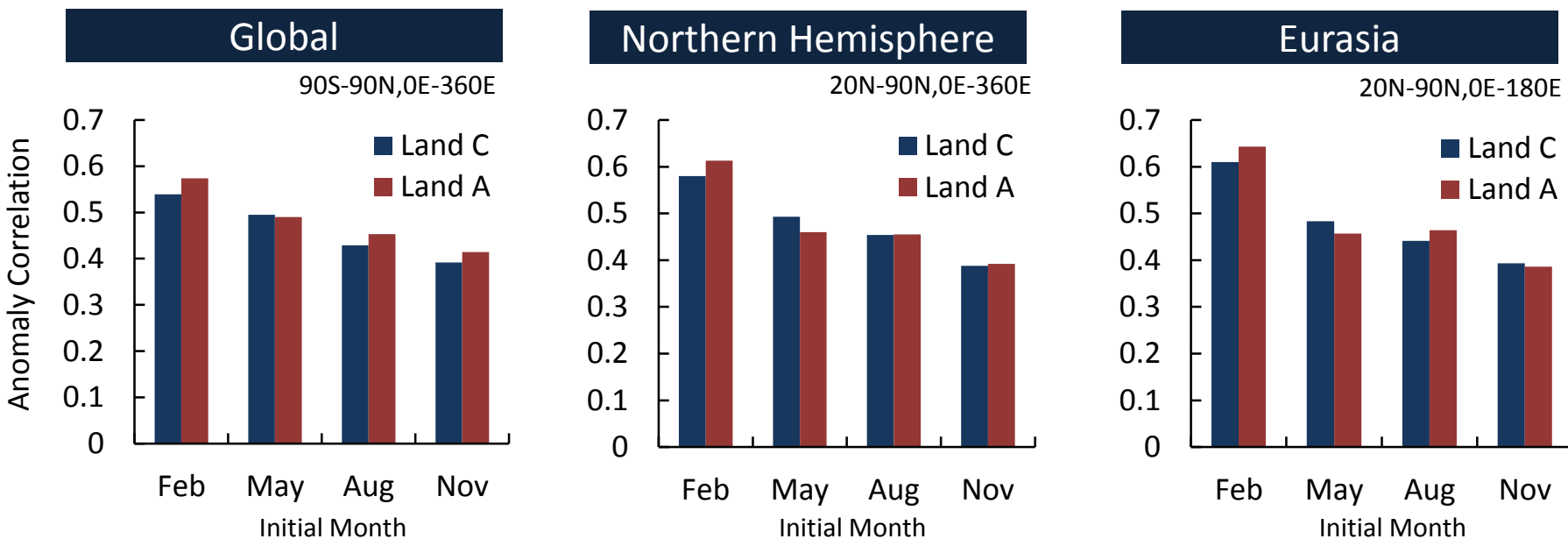
Improvement of GHG forcing

- **JMA/MRI-CPS1** CO_2 trend

- **JMA/MRI-CPS2**   RCP 4.5 scenario

2-m temperature Trend over Land (JJA)   (Initial: May)

VarCO$_2$
- JMA/MRI-CPS1
- CO$_2$ Trend

VarGHG
- JMA/MRI-CPS2
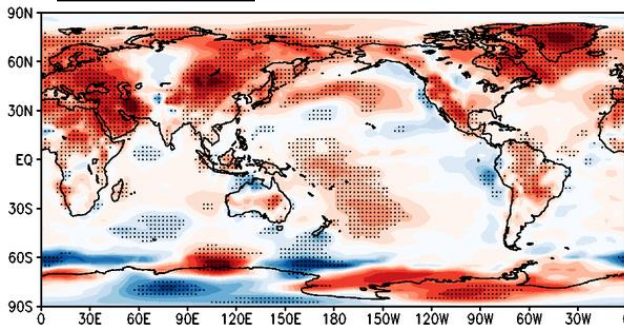- CO$_2$, CH$_4$, N$_2$O, CHC-11, CHF-12, HCFC-22 (GHGs) Trend
     (RCP 4.5 scenario)

ConstGHG
(Additional experiment)
- JMA/MRI-CPS2
- Constant GHGs

Linear trend of 2-m temperature over land: JMA/MRI-CPS1 < ConstGHG < VarGHG < JRA-55

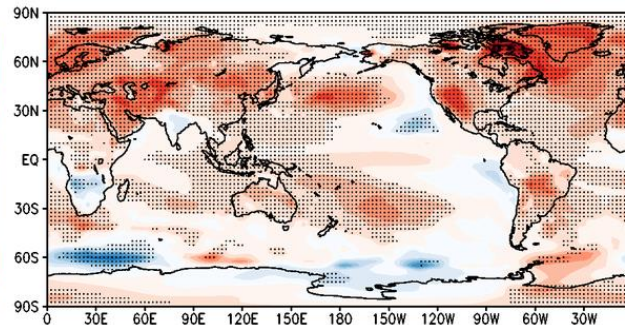# 2-m temperature linear trend

Spatial maps of 2-m temperature linear trend from 1981 to 2010
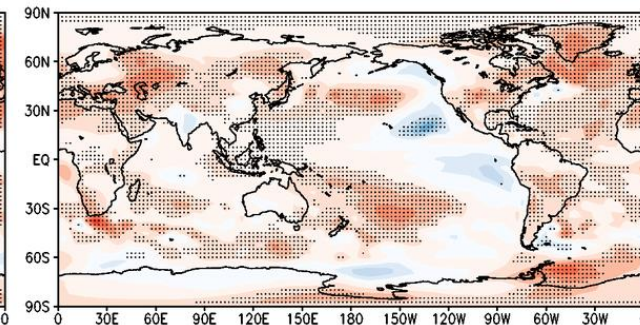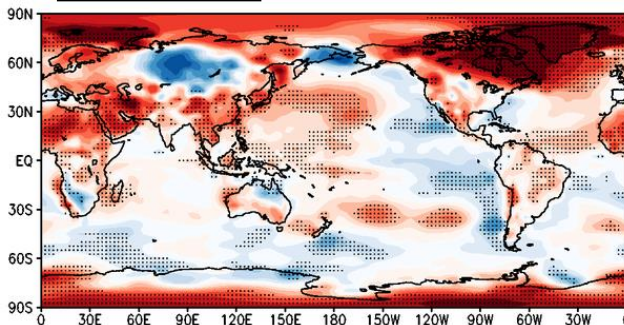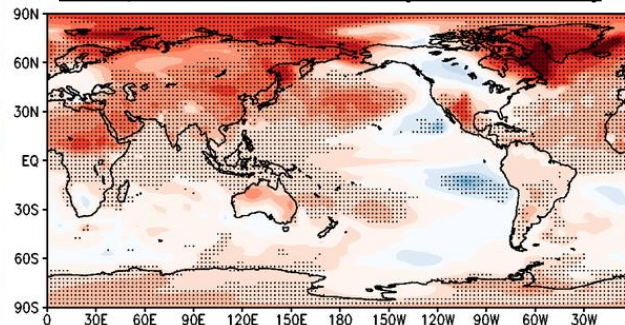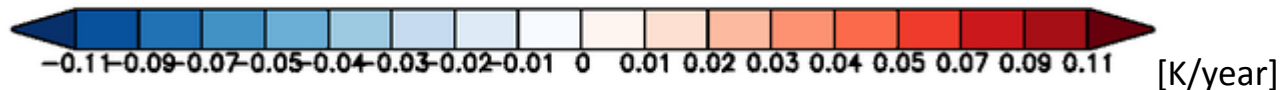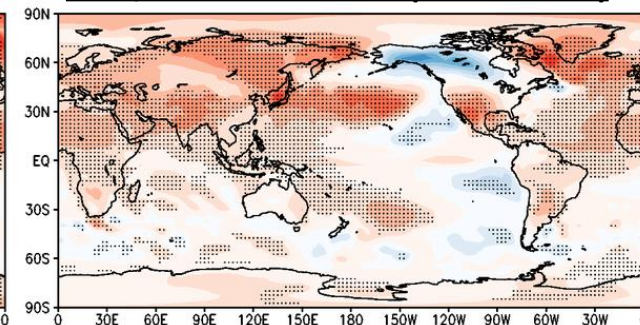
East Asian Winter Monsoon
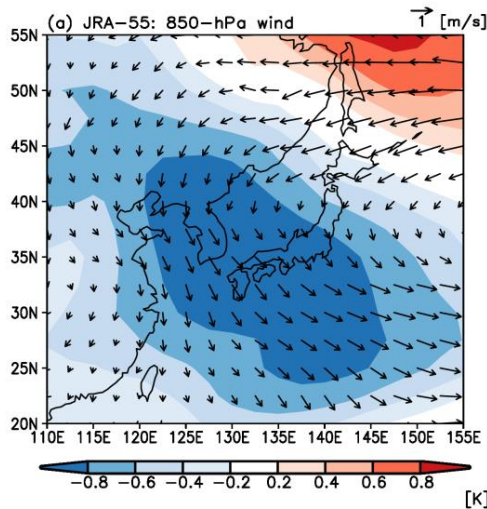
JRA-55

JMA/MRI-CPS2

1st mode of multivariate EOF analysis for 5 variables (200hPa zonal and meridional wind, 850hPa zonal and meridional wind, 850hPa temperature) at 20N-55N, 110E-155E in DJF

(Left)   JRA-55
(Right)   JMA/MRI-CPS2
                Initial: Nov. (1-month lead)

(top)   Shade: 850hPa temperature
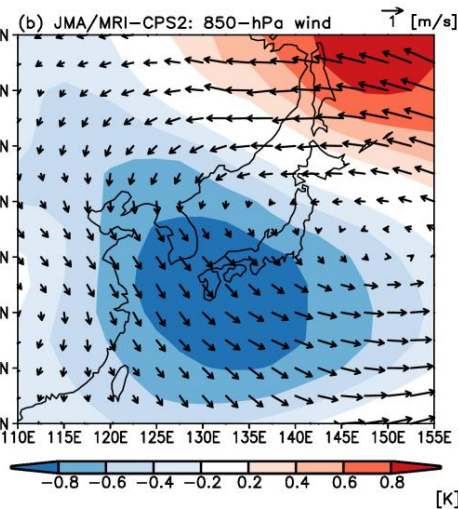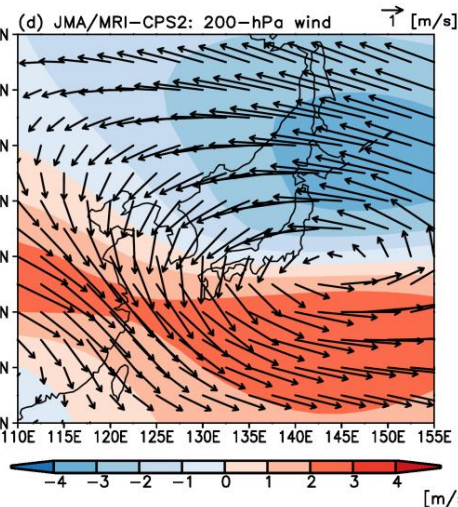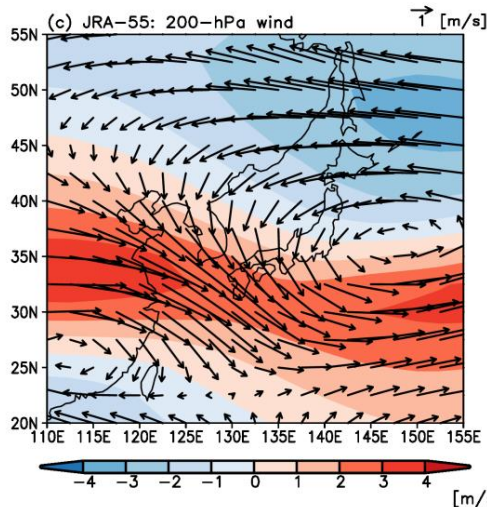   Vector: 850hPa horizontal wind
(bottom) Shade: 200hPa zonal wind
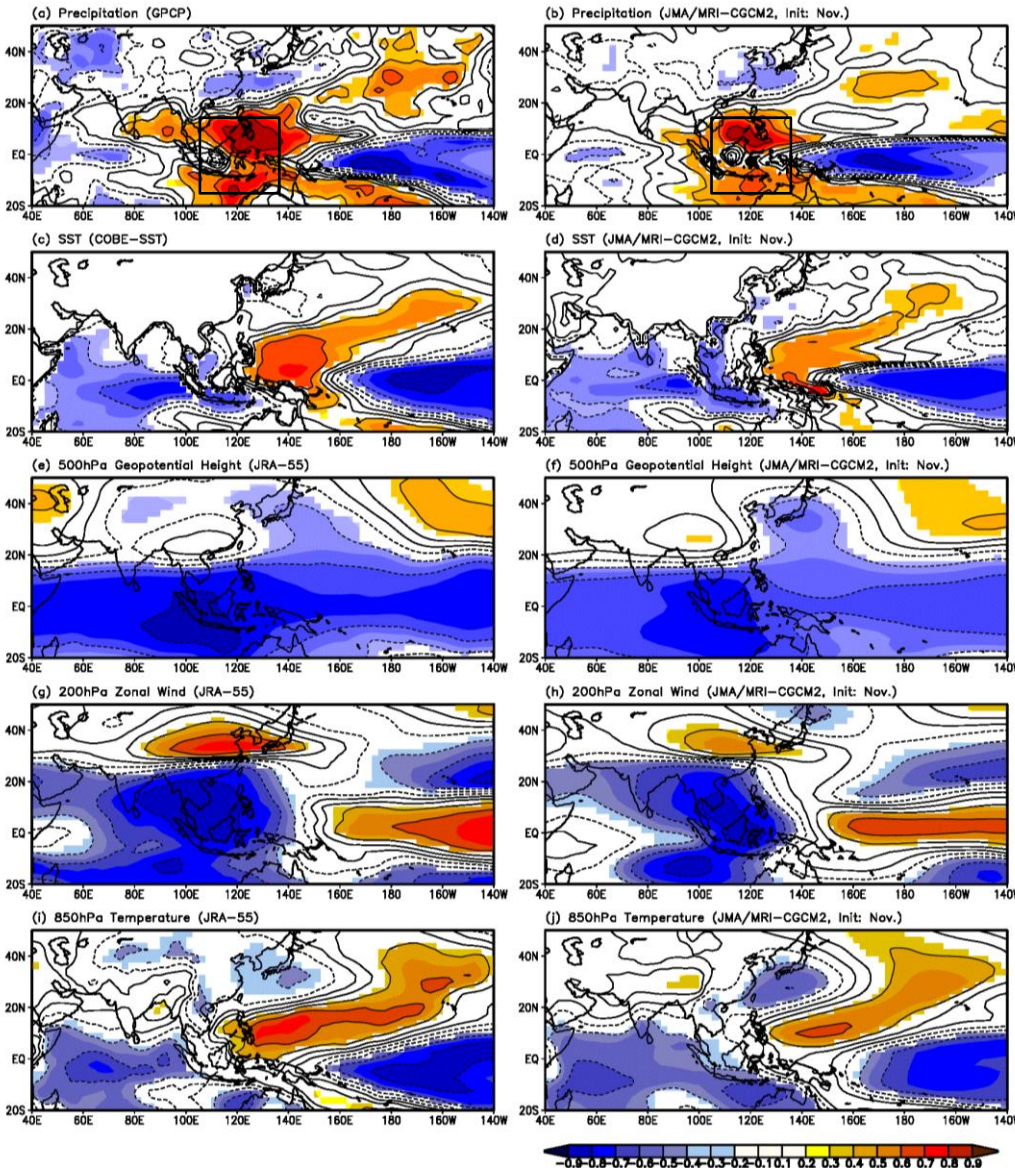   Vector: 200hPa horizontal wind

The following mode are extracted both in the analysis (27%) and re-forecast (26%):
☐ Negative pattern of 850hPa temperature corresponding to northwesterly wind
☐ Cyclonic circulation, equatorward shift and intensification of westerly jet

cf. Wang et al. 2010, Journal of Climate

East Asian Winter Monsoon

(a) Precipitation (GPCP)
(b) Precipitation (JMA/MRI-CGCM2, Init: Nov.)
(c) SST (COBE-SST)
(d) SST (JMA/MRI-CGCM2, Init: Nov.)
(e) 500hPa Geopotential Height (JRA-55)
(f) 500hPa Geopotential Height (JMA/MRI-CGCM2, Init: Nov.)
(g) 200hPa Zonal Wind (JRA-55)
(h) 200hPa Zonal Wind (JMA/MRI-CGCM2, Init: Nov.)
(i) 850hPa Temperature (JRA-55)
(j) 850hPa Temperature (JMA/MRI-CGCM2, Init: Nov.)

DJF correlation between the MC Rain (15S-15N, 105E-135E) and Precip., SST, Z500, U200 and T850

(Left)   GPCP v2.2, COBE-SST, JRA-55
(Right) JMA/MRI-CPS2
               Initial: Nov. (1-month lead)

Contour interval: 0.1
Shade: above the 95% confidence level

Precipitation near the Maritime Continent correlates with
☐ SST spatial pattern similar to La Niña
☐ Mid-tropospheric trough around Japan
☐ Intensification of westerly jet near 35N
☐ Cold temperature of lower troposphere around East Asia

This correspondence to MV-EOF suggests that 1st mode is induced by convective activity near the Maritime Continent.

2015/2016 DJF (Initial: Oct.2015)

Spatial maps of prediction for this winter (DJF2015-2016, Initial: Oct.)

Initial: Oct. 2015   Ensemble Member: 51   Climatology: 1981-2010
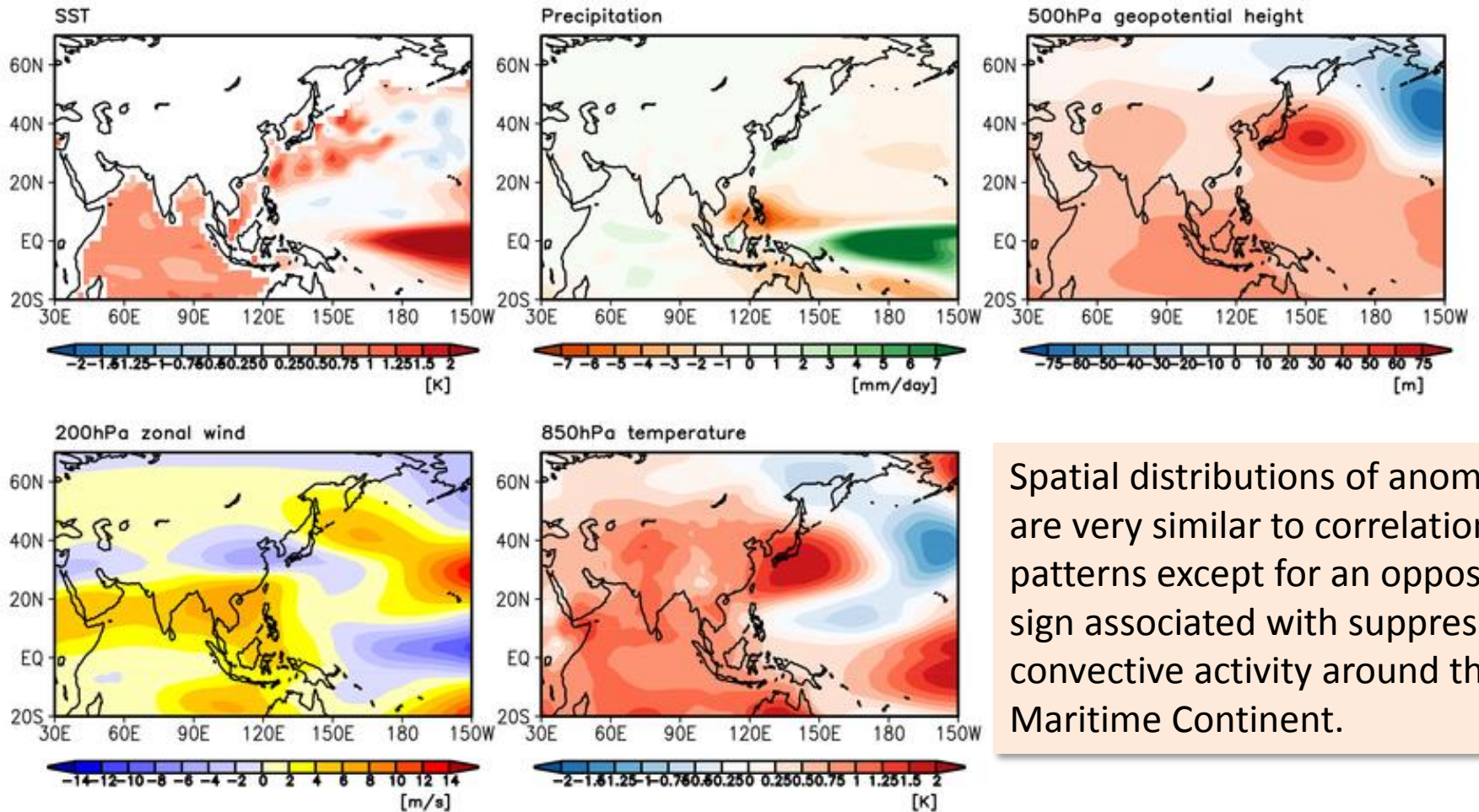
Spatial distributions of anomaly are very similar to correlation patterns except for an opposite sign associated with suppressed convective activity around the Maritime Continent.

Summary

- The new operational system JMA/MRI-CPS2 includes:
  - Enhanced horizontal / vertical resolution
  - New initial conditions for atmosphere, land surface, and ocean
  - Newly introduced sources of predictability
    - sea ice, stratosphere, global ocean, GHGs, …

- The improvement in JMA/MRI-CPS2 is as follows:
  - ENSO prediction skill
  - 3-month forecast (2-m temperature, precipitation, …)
  - Sea-ice interannual variability and declining trend
  - Warming trend of 2-m temperature over land
  - East Asian Winter Monsoon representation

Thank you for your kind attention.