JMA/MRI-CPS3 (planned to be implemented in Q1 2022)

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Yuhei Takaya

Japan Meteorological Agency Meteorological Research Institute

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Configurations of seasonal prediction systems

	JMA/MRI-CPS2 (June 2015-)	JMA/MRI-CPS3 (Jan. 2022-, date TBD)
Atmosphere model JMA global atmospheric model	Version: GSM1011C - SiB Resolution: ~110 km (TL159L60) Model top: 0.1hPa B.C.: CMIP5 RCP4.5 GHG, aerosol climatology (1D), Ozone climatology from MRI-CCM1	Version: GSM2003 – iSiB Resolution: ~55 km (TL319L100) Model top: 0.01hPa BC: CMIP6 SSP2-4.5 GHG, 3D aerosol climatology from aerosol MASINGAR model, Ozone climatology from MRI- CCM2, Volcanic aerosols in stratosphere (off-line)
Ocean model (MRI.COM)	Version: MRI.COM v3.2 Resolution: 1.0° x 0.3-0.5°, L52+BBL	Version: MRI.COM v4.6 0.25° x 0.25° L60
Initial condition	Atmosphere: JRA-55 Land: JRA-55 land analysis Ocean: MOVE/MRI.COM-G2 T, S, SSH 3DVAR Sea ice: no assimilation	Atmosphere: JRA-3Q Land: Land analysis forced by JRA-3Q Ocean: MOVE/MRI.COM-G3 T, S, SSH 4DVAR Sea ice: MOVE/MRI.COM-G3 3DVAR
Initial perturbation	Atmosphere: Bred vector in the tropics and N.H. Ocean: perturbations forced by the bred vectors	Atmosphere: Bred vector in the N.H. and S.H. Ocean: perturbation using ocean obs. errors
Model uncertainty	Stochastic physics (SPPT)	\leftarrow
Ensemble	13 members/5 days x 4 LAF	5 members/day x 11 LAF (Predicted daily SSTs are used in Global EPS)

Seasonal prediction performance | SST biases

JMA/MRI-CPS3





JMA/MRI-CPS2





Improved: Cold bias in

Kurosio Extention region in summer (JJA), warm bias in the northeastern tropical Pacific in winter (DJF).

Degraded:

Global cold bias, cold bias west of Sumatra (JJA)

Seasonal prediction performance | ENSO (NINO3.4 SST)



ENSO prediction starting from spring initials (end of April) are improved.

Seasonal prediction performance | Score cards (all seasons)

Overall skill is improved (yellow indicates statistically significant improvement from JMA/MRI-CPS2).

ACOR (globe)

ACOR (CPS3) init:ALL reg:GLB(90S-90N)

	PSEA	TS	T850	Z500	U850	U200	CHI2	PSI8	PSI2
0–2month	0.364	0.489	0.429	0.409	0.448	0.546	0.790	0.540	0.656
1-3month	0.273	0.401	0.351	0.328	0.377	0.472	0.740	0.471	0.596
2-4month	0.238	0.367	0.324	0.296	0.338	0.436	0.697	0.435	0.562
3-5month	0.231	0.350	0.315	0.296	0.318	0.414	0.655	0.414	0.542
4-6month	0.212	0.338	0.305	0.285	0.296	0.383	0.589	0.383	0.502

RMSE (globe)

RMSE (CPS3) init:ALL reg:GLB(90S-90N)

	PSEA	TS	T850	Z500	U850	U200	CHI2	PSI8	PSI2
0-2month	1.838	0.827	0.806	22.580	1.290	2.989	1.011	1.460	3.592
1-3month	1.919	0.878	0.844	23.594	1.347	3.163	1.096	1.541	3.851
2-4month	1.945	0.893	0.855	23.961	1.375	3.236	1.158	1.575	3.964
3–5month	1.947	0.899	0.857	23.925	1.383	3.269	1.217	1.589	4.017
4–6month	1.956	0.900	0.859	24.002	1.393	3.318	1.305	1.610	4.130

ACOR (NH)

ACOR (CPS3) init:ALL reg:NH(20N-90N)

	PSEA	TS	T850	Z500	U850	U200	CHI2	PSI8	PSI2
0-2month	0.301	0.496	0.386	0.353	0.247	0.411	0.795	0.512	0.644
1-3month	0.202	0.402	0.296	0.266	0.159	0.328	0.751	0.444	0.593
2-4month	0.173	0.367	0.266	0.231	0.124	0.289	0.714	0.408	0.560
3-5month	0.165	0.349	0.262	0.236	0.124	0.275	0.675	0.385	0.539
4-6month	0.167	0.348	0.263	0.242	0.137	0.263	0.613	0.364	0.502

RMSE (NH)

RMSE (CPS3) init:ALL reg:NH(20N-90N)

	PSEA	TS	T850	Z500	U850	U200	CHI2	PSI8	PSI2
0-2month	2.185	1.143	1.085	28.094	1.431	3.406	0.829	1.638	4.037
1–3month	2.273	1.213	1.137	29.253	1.478	3.562	0.891	1.716	4.297
2-4month	2.299	1.231	1.151	29.700	1.499	3.631	0.936	1.755	4.421
3–5month	2.302	1.238	1.151	29.621	1.493	3.646	0.980	1.768	4.481
4–6month	2.286	1.233	1.147	29.484	1.483	3.655	1.046	1.773	4.587

No statistically significant degradation.

Some highlights | Eddy-permitting ocean

Tropical Instability Wave (TIW): SST averaged during 22-26 Dec. 1999



Sharp coastal upwelling, stronger TIW, which potentially better represents north-south heat exchange.

* Analysis from a historical SST analysis produced by European Space Agency (ESA) Climate Change Initiative (CCI) Programme (Prof. Chris Merchant, Reading Univ.)

Some highlights | Atmospheric blocking

Blocking frequency is better represented in JMA/MRI-CPS3, in particular, in the Atlantic sector.



Results for hindcasts during day 4-27.

Some highlights | Cumulus convection

Cumulus convection scheme (Entrainment depending on relative humidity and cumulus closure)

CTL TEST Radar/lidar obs. 200 200 300 300 **Cloud fraction** 400 400 500 500 600 600 700 700 800 800 900 900 100 1000 100 21|an 23|an 25|an 27|an 29|an 31|an 02Feb04Feb06Feb08Feb 21|an 23|an 25|an 27|an 29|an 31|an 02Feb04Feb06Feb08Feb 21|an 23|an 25|an 27|an 29|an 31|an 02Feb04Feb06Feb08Feb

Single-column simulation of TWP-ICE case (May et al. 2008) using boundary forcing (Lin et al. 2012) (FT=24-45hr).

Entrainmanet rate ϵ :

$$\epsilon(i,z) = \epsilon'(i)f(\overline{RH}(z)), \quad \text{Komori et al.(2020, WGNE Blue Book)}$$
$$f(\overline{RH}(z)) = \left(\frac{RH_c - \overline{RH}(z)}{\overline{RH}(z)}\right) \times \left(\frac{\overline{q_s}(z)}{\overline{q_s}(z_B)}\right) \quad RH_c = 1.1$$

Adjustment of the closure and entrainment led to weakening of convection in mid-tropospheric dry conditions, improving the MJO prediction (next slide).

0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Some highlights | MJO

MJO prediction skill (bivariate RMSE and correlation of RMM index, NDJFMA)



Some highlights | Mixed phase clouds

Previous studies suggested that biases of clouds and radiation fluxes over the Southern Ocean are related to deficiency of model representation of mixed phase clouds (supercooled liquid water clouds; e.g., Bodas-Salcedo et al. 2016).

A coefficient of rain transform in a 500-m layer below the cloud top, $-25^{\circ}C \le T \le -5^{\circ}C$ is reduced. The cloud droplet effective radius is also used in a radiation scheme.



Some highlights | Sea ice assimilation

The excessive bias of the sea ice area in the old analysis was alleviated in the new system by sea ice assimilation.

MOVE/MRI.COM-G3A

MOVE/MRI.COM-G2



Some highlights | Sea ice prediction

The model representation of sea ice is also improved in the new system.

Sea ice area in the N. H. in the prediction starting from 30 June

JMA/MRI-CPS3 bias

JMA/MRI-CPS2 bias

NH SealceArea(x10⁶ km²) CPS3(initial=0630), red:ensmean, gray:member black:MGDSST, diff:ensmean-MGDSST

-2

1995

2000



2005

2010

2015

2020

NH SealceArea(x10 $\rm km^2$) CPS2(initial=0630), red:ensmean, gray:member black:MGDSST, diff:ensmean-MGDSST



Some highlights | Subseasonal prediction skill

Subseasonal prediction skill is overall greatly improved from the previous system.

Correlation skill for 28-day mean of T850 Anomaly Correlation for 30 years (1991-2020) Initial : JJA, 28day mean : day 03-30 90N Summer (JJA) 30N EC 305 90S -3ÓE 6ÔE 90E 120E 150E 180 15⁰W 120W 9Ó₩ 6ÓV зóу анналу синан вызво сонтосской Anomaly Correlation for 30 years (1991-2020) Initial : DJF, 28day mean : day 03-30 901 60 Winter (DJF) 30 60 90S -30F 60E 90E 120E 150E 180 0.3 0.6 0.7 0.8

Anomaly Correlation for 30 years (1991—2020) Initial : JJA, 28day mean : day 03—30



Diff. of JMA/MRI-CPS3 and JMA/MRI-CPS2

⁹⁰⁵0 30e 60e 90e 120e 150e 180 150w 120w 90w 60w 30w 6 Anomaly Correlation for 30 years (1991–2020)

Initial : DJF, 28day mean : day 03-30



Thank you for your kind attention.

Climatology of sea ice content during SON (predictions from the end of July)



Some highlights in model development (subseasonal prediction skill)

<CPS3(5mem) : JRA-3Q> Z500 anamaly (with bias-carrection) Anamaly Correlation for 30 years (1991–2020) Initial : JJA, 28day mean : day 03–30



<CPS3(5mem) : JRA-3Q> - <CPS2(5mem) : JRA-3Q> Z500 anomaly (with bias-correction) Anomaly Correlation for 30 years (1991-2020) Initial : JJA, 28day mean : day 03-30



⁵ d. 30F 60F 90F 120F 150F 180 150W 120W 90W 60W 30W <CPS3(5mem) : JRA-3Q> - <CPS2(5mem) : JRA-3Q> Z500 anomaly (with bias-correction) Anomaly Correlation for 30 years (1991-2020) Initial : DJF, 28day mean : day 03-30



Some highlights (improvement of monthly forecast skill of ASM)



<CPS3(5mem) : JRA-3Q> U850 anamaly (with bias-correction) Anomaly Correlation for 30 years (1991-2020) Initial : JJA, 28day mean : day 03-30



<CPS3(5mem) : GPCP1DD_v1.3> - <CPS2(5mem) : GPCP1DD_v1.3> RAIN anomaly (with bias-correction) Anomaly Correlation for 23 years (1998-2020) Initial : JJA, 28day mean : day 03-30



<CPS3(5mem) : JRA-3Q> - <CPS2(5mem) : JRA-3Q> U850 anomaly (with bias-correction) Anomaly Correlation for 30 years (1991-2020) Initial : JJA, 28day mean : day 03-30



0.3-0.25-0.2-0.15-0.1-0.05-0.02-0.01 0 0.01 0.02 0.05 0.1 0.15 0.2 0.25 0.3