Research and modelling center updates
Japan Meteorological Agency/Meteorological Research Institute

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Thanks to S. Hirahara, G. Naresh, K. Ochi, H. Yamaguchi, Y. Kubo

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Configurations of seasonal prediction systems

A JMA/MRI-CPS3 description paper was published **(Hirahara et al. 2023, *J. Meteorol. Soc. Jpn.*)**
https://www.jstage.jst.go.jp/article/jmsj/101/2/101_2023-009/_article/-char/ja

	JMA/MRI-CPS2 (June 2015-Feb. 2022)	JMA/MRI-CPS3 (Feb. 2022-)
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)	←
Ensemble	13 members/5 days x 4 LAF	5 members/day x 11 LAF (Predicted daily SSTs are used in Global EPS)

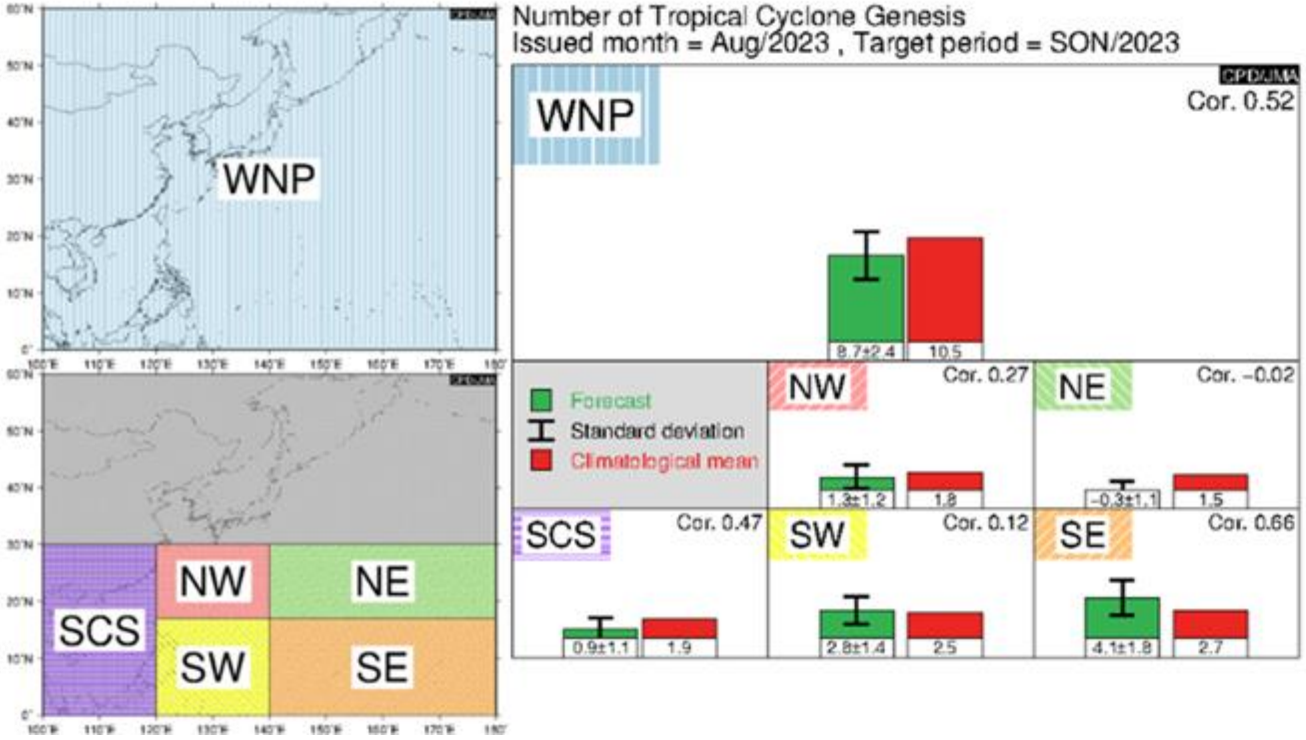
Seasonal prediction (WNP TC prediction)

- TCC has started provision of Seasonal TC Forecast Products for the western North Pacific to support WMO Members in the Asia/Pacific from TCC Web site (https://www.data.jma.go.jp/tcc/tcc/index.html) since 21 May.
- The Products are produced based on JMA/MRI-CPS3.
- Products are password protected. (Application is required for viewing products.)

Seasonal Tropical Cyclone Forecasts (Experimental)

This product is displayed for use by National Meteorological and Hydrological Services (NMHSs). It does not constitute an official forecast for any nation.

Initial month: Aug/2023
Forecast period : SON/2023
Forecast Parameter: Number of Tropical Cyclones



Forecast Parameter

✓ Number of Tropical Cyclones
✓ Tropical Cyclone Frequency
✓ Accumulated Cyclone Energy (ACE)

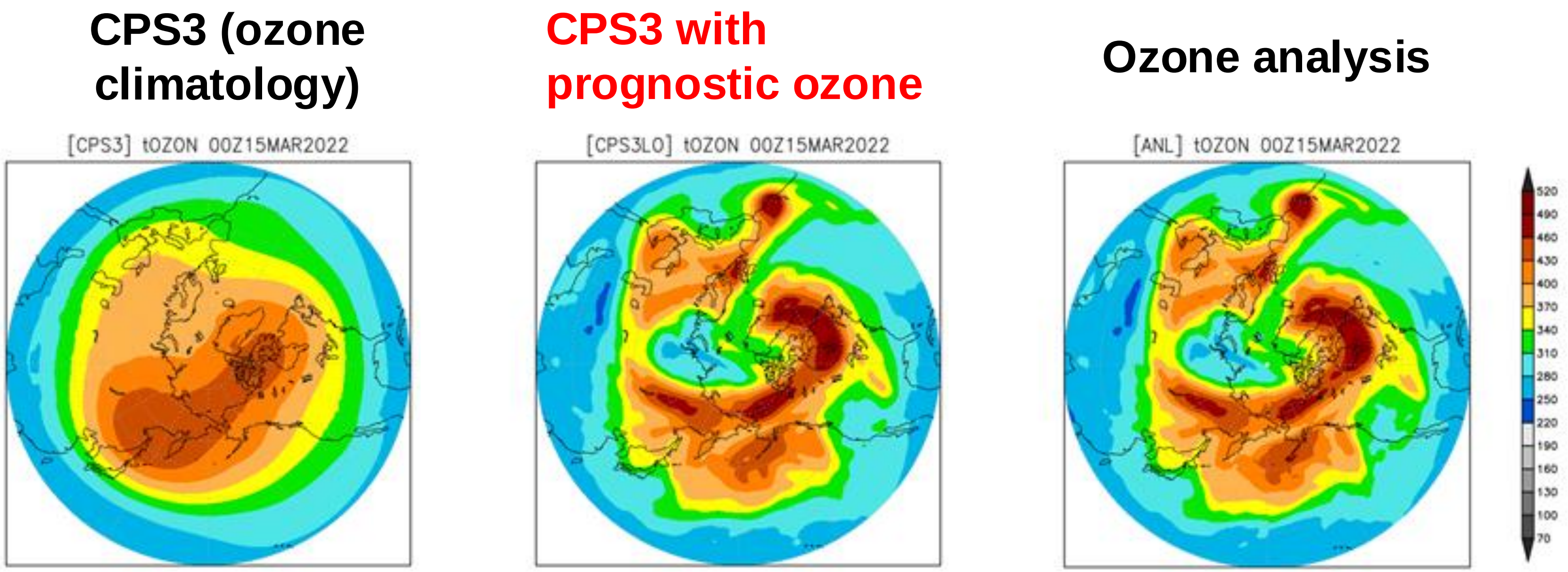
Initial month	Lead time	Target months
May	1-5 month	June-July-August-September-October
	1-3 month	June-July-August
June	1-3 month	July-August-September
July	1-3 month	August-September-October
August	1-3 month	September-October-November

Plans of JMA Seasonal EPS

- New features under development include:
  Atmosphere part:
  - Replacing **initial perturbation** generator: BGM to **SV+LETKF**
  - Enhancing **vertical resolution** of the model: 100 to **128** layers
  - Introducing **prognostic ozone** with linear ozone scheme
  - Improving **snow** parameterization

  Ocean part:
  - Introducing new **time integration scheme** **LFAM3** for the ocean model
  - Increasing horizontal resolution of **global 4DVAR**: 1 to **0.25** degree
- Some of them will be incorporated in the next system **JMA/MRI-CPS4 (scheduled in Japan FY 2025)** and the others are continued to be studied for further future systems.
- CPS4 will take over the role of supporting the issuance of One-month Forecasts from JMA’s GEPS (uncoupled model).

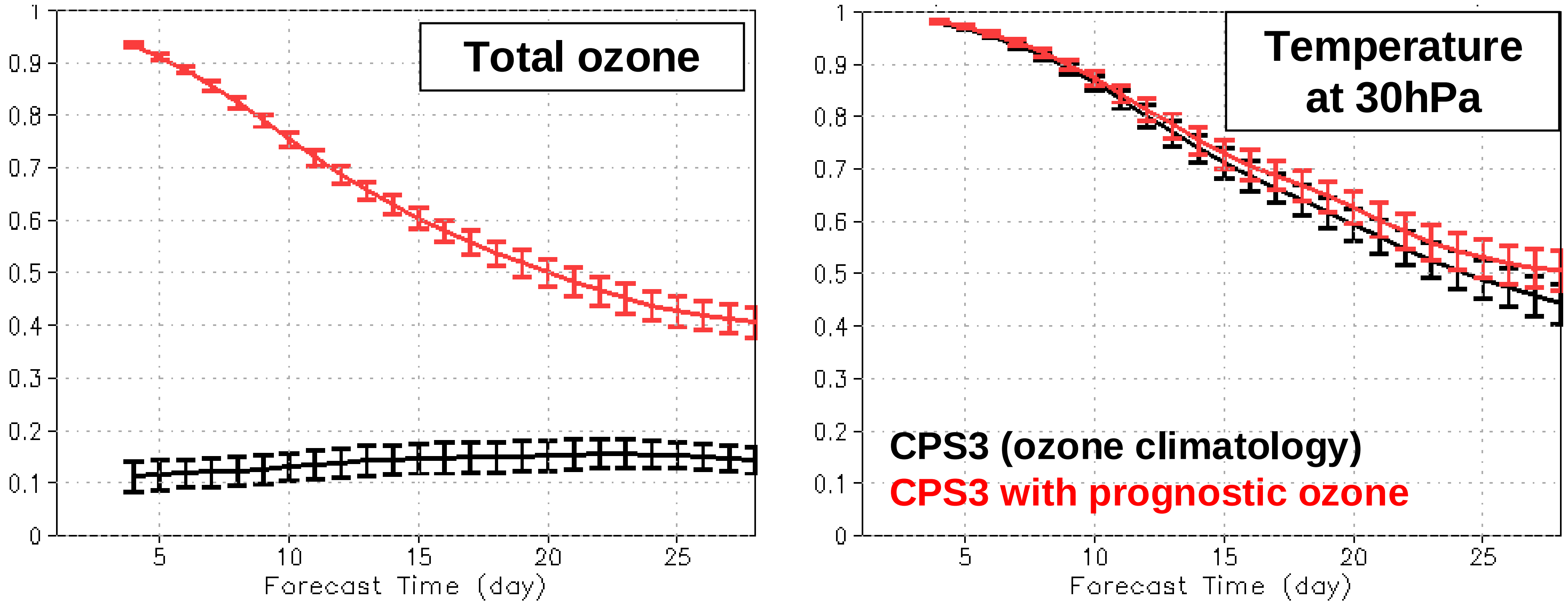
Prognostic ozone



- The simplified linear ozone scheme to represent interactive ozone chemistry can reproduce ozone variation in SSW events.
- Studying benefits to skills of S2S forecasts

Impacts of prognostic ozone scheme

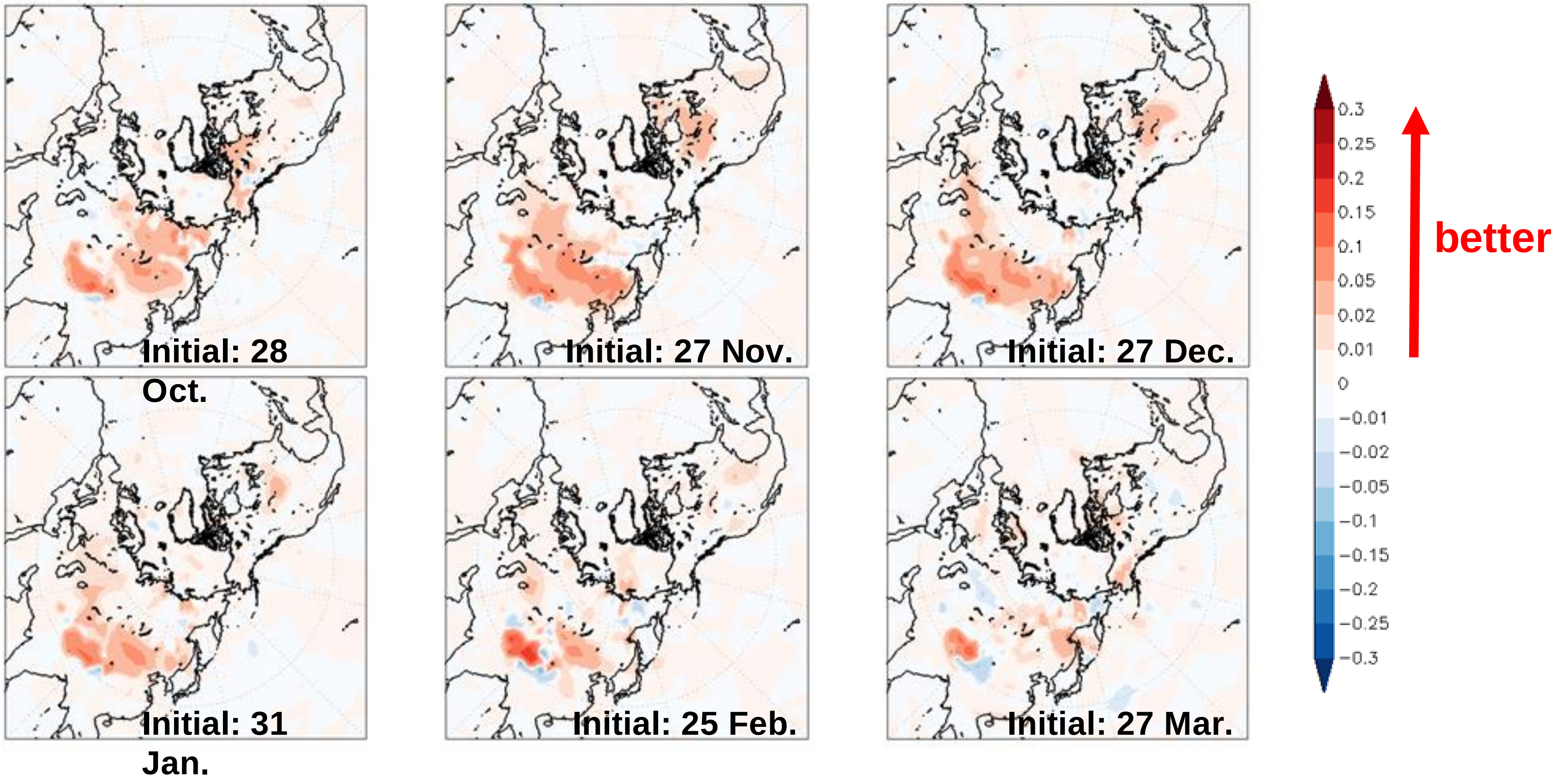
ACC for the globe over the 1991–2020 period



- The prognostic ozone scheme improves forecast skills for ozone and temperature around the stratosphere.

A revised snow scheme for CPS4

Differences in ACC for **2m temperature** for week 1 over the 1991-2020 period

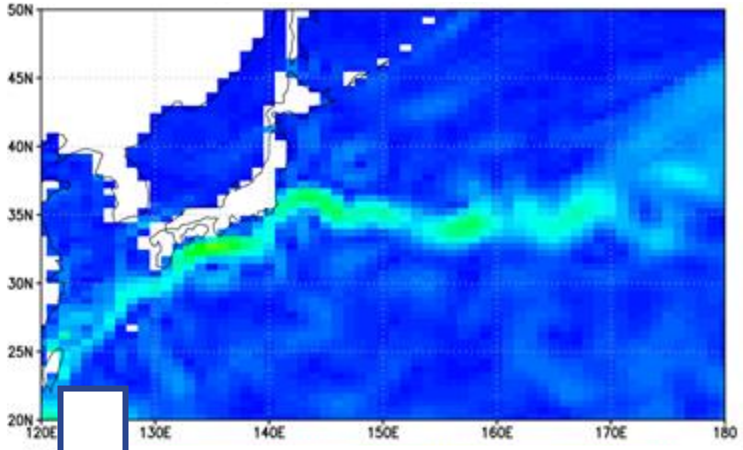


Revised parametrizations for snow cover fraction, snow albedo and snow density reduce systematic biases in snow, leading to improvements in the troposphere.

High-resolution ocean 4DVAR

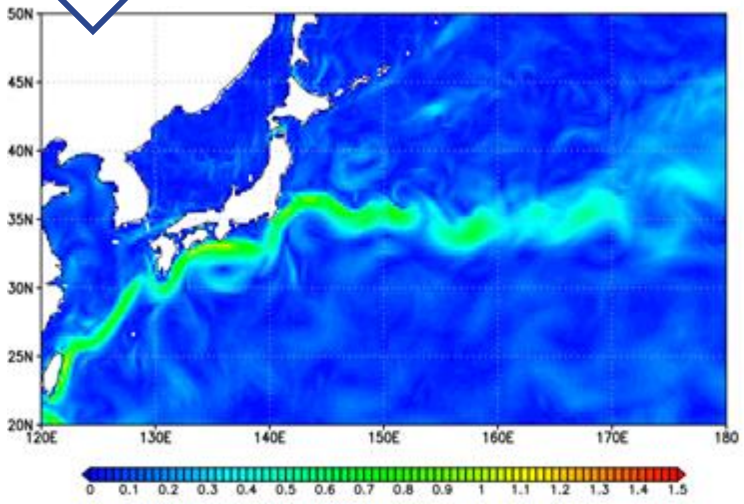
CPS3

G3A-4DVAR (1.0deg)

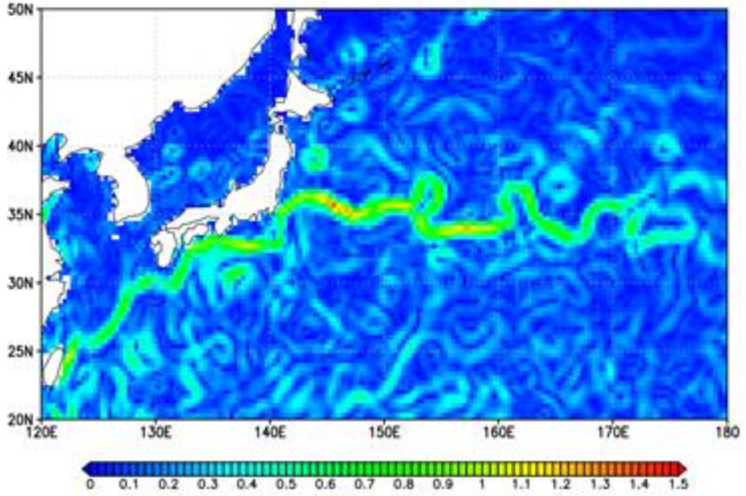


Downscaling

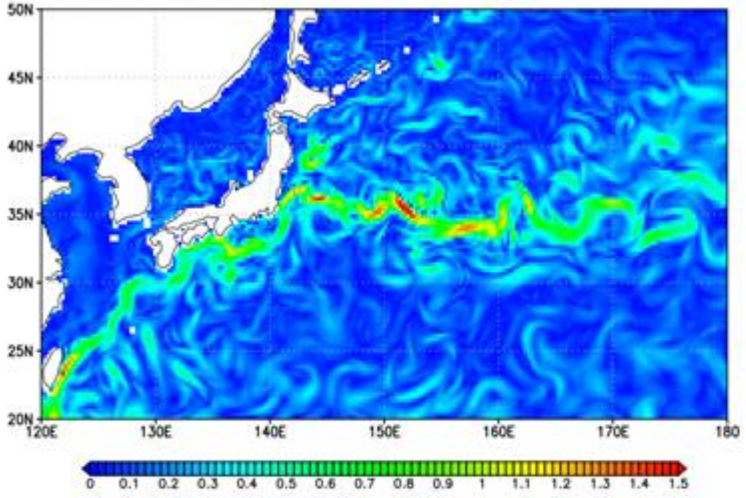
G3F-IAU (0.25deg)



OSCAR Surface Current Analysis (1/3deg)



TEST-4DVAR (0.25deg)



- Currently using the combination of low resolution 4D-Var (1.0x0.3-0.5deg.) and high-resolution IAU (0.25deg.)
- Only large-scale features such as mainstream of the Kuroshio are resolved by the current 4D-Var system.
- Finer resolution (0.25deg) Ocean 4DVAR is currently under development (but is not targeted on CPS4)

Tropospheric and Stratospheric Boreal Winter Jet Response to Eddying Ocean in a Seasonal Forecast System

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Hirahara, S., Ishikawa, I., Fujii, Y., Nakano, H., Tsujino, H., Adachi, Y., & Naoe, H. (2024). Tropospheric and stratospheric boreal winter jet response to eddying ocean in a seasonal forecast system. Journal of Geophysical Research: Atmospheres, 129, e2023JD040444. https://doi.org/10.1029/2023JD040444

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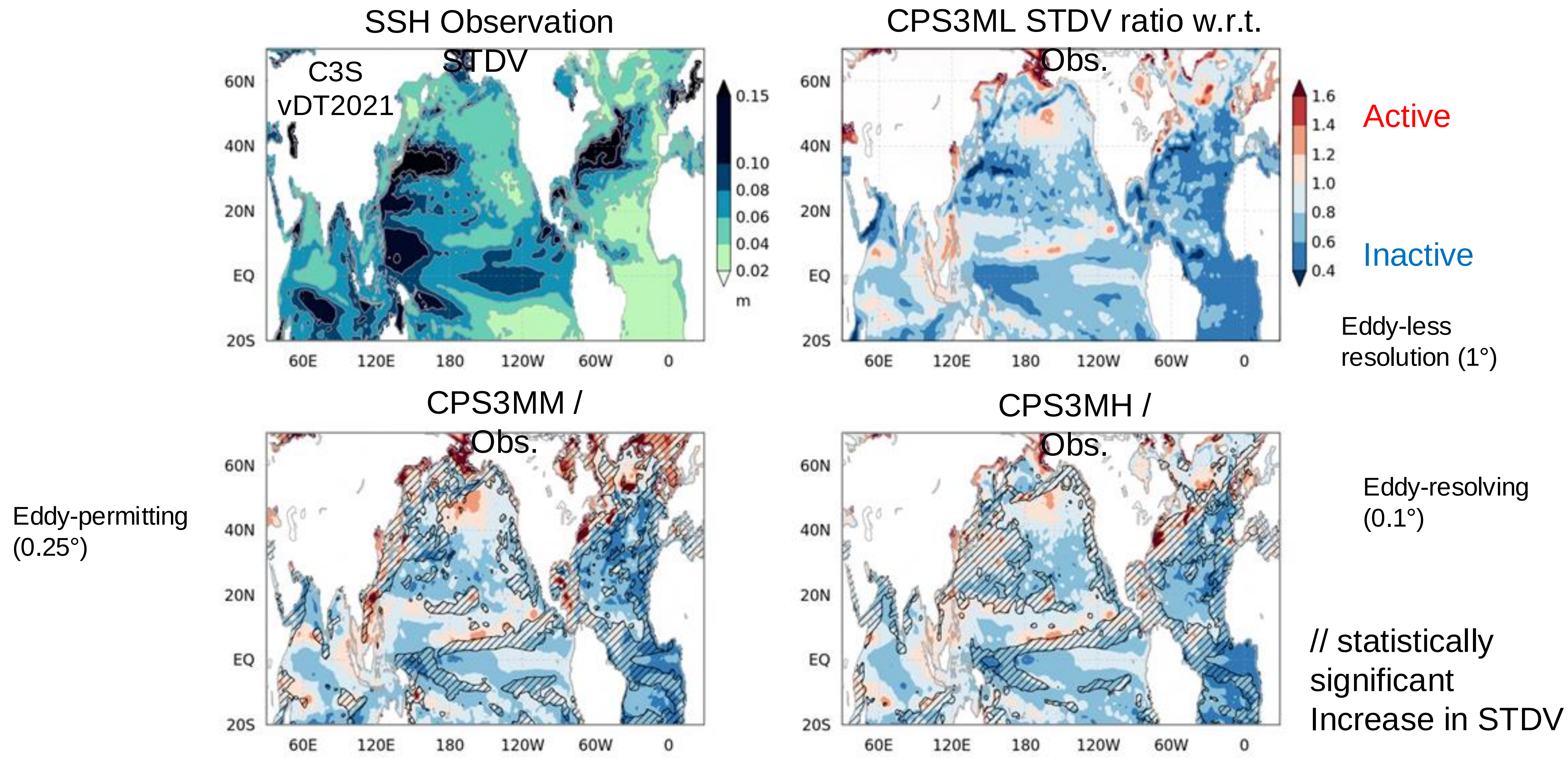
Increased variability of 5-day mean SSH(DJF, 1991-2020)

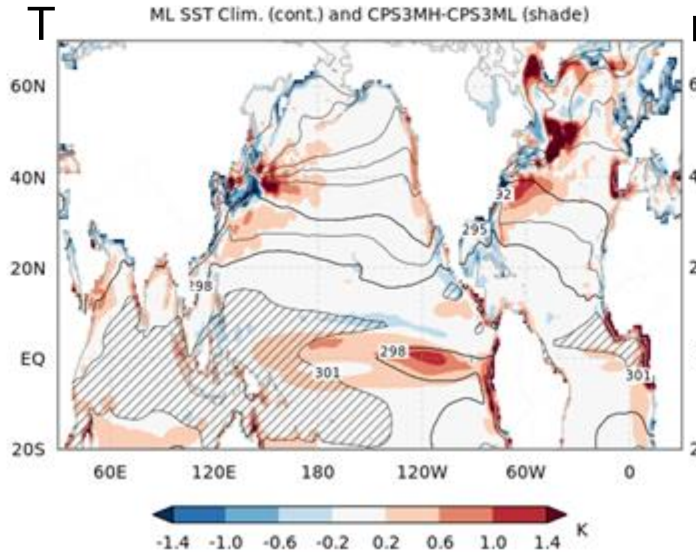


- Interannual variations in SSH intensify with ocean model rersolution (Iovino et al., 2016 GMD)
- Large changes are found in the western boundary currents and in the tropical Pacific

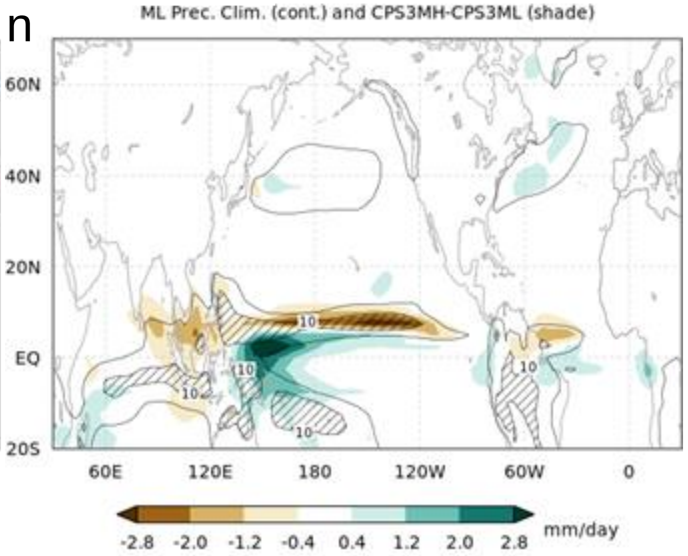
Hirahara et al. *JGR Atmos*. 2023

Ocean res. impacts on SST, Prec. and the polar stratosphere (DJF)

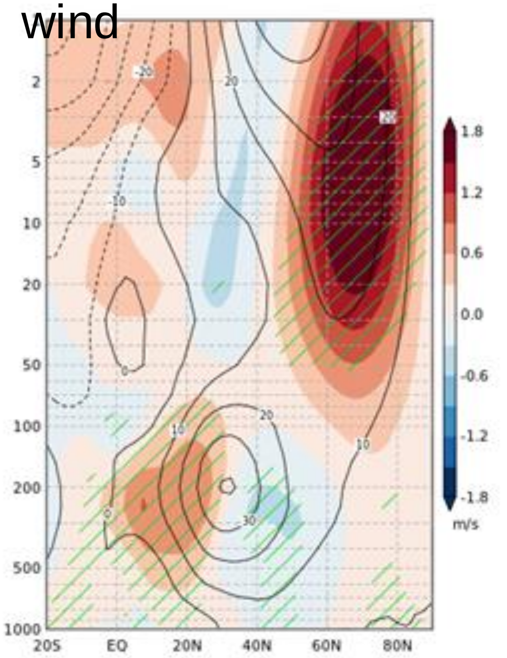
SST



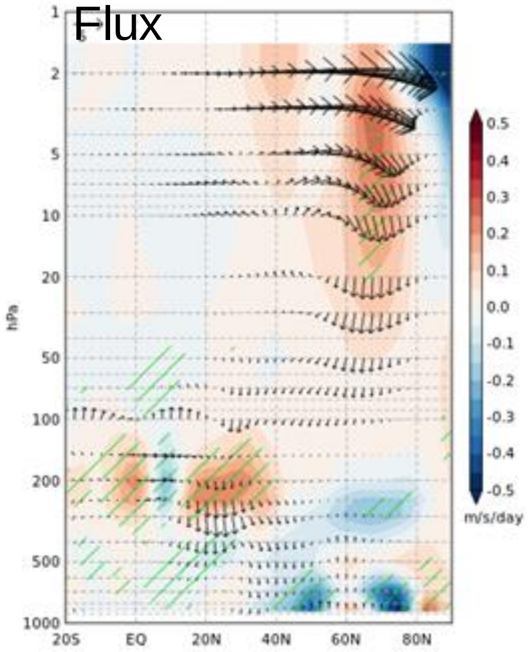
Precipitation



Zonal wind



EP Flux



High resolution impacts based on CPS3MH (0.5° Atmos. – 0.1° Ocean) – CPS3ML (0.5° Atmos. – 1° Ocean)

- Better-resolved eddies improve the cold tong bias in the Tropical Pacific
- Eastward warm-pool expansion and increased precipitation in the western tropical Pacific, **reduced double-ITCZ bias**
  - **Warmer SST and increased precipitation in the mid-latitude ocean frontal zone**, too
- Equatorward displacement of ITCZ leads to the southward shift of the subtropical jet
- Tropical changes modulate stational waves at mid- and high-latitudes, enhancing the stratospheric polar vortex through a reduced reduction in the upward wave momentum flux

Hirahara et al. *JGR Atmos*. 2023

The causality analysis between snow and surface air temperature toward a better understanding of climate feedbacks in numerical models

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Acknowledgements: Drs. K. Komatsu, N. Ganeshi, T. Toyoda, H. Hasumi

Komatsu, K. K., Y. Takaya, T. Toyoda, and H. Hasumi, (2023): A submonthly scale causal relation between snow cover and surface air temperature over the autumnal Eurasian continent. *J. Climate*, 36, 4863–4877.

Takaya, Y, K. K. Komatsu, N. Ganeshi, T. Toyoda, H. Hasumi (2024): A sub-monthly timescale causality between snow cover and surface air temperature in the Northern Hemisphere inferred by Liang–Kleeman information flow analysis, *Clim. Dyn*.

Purpose of this study

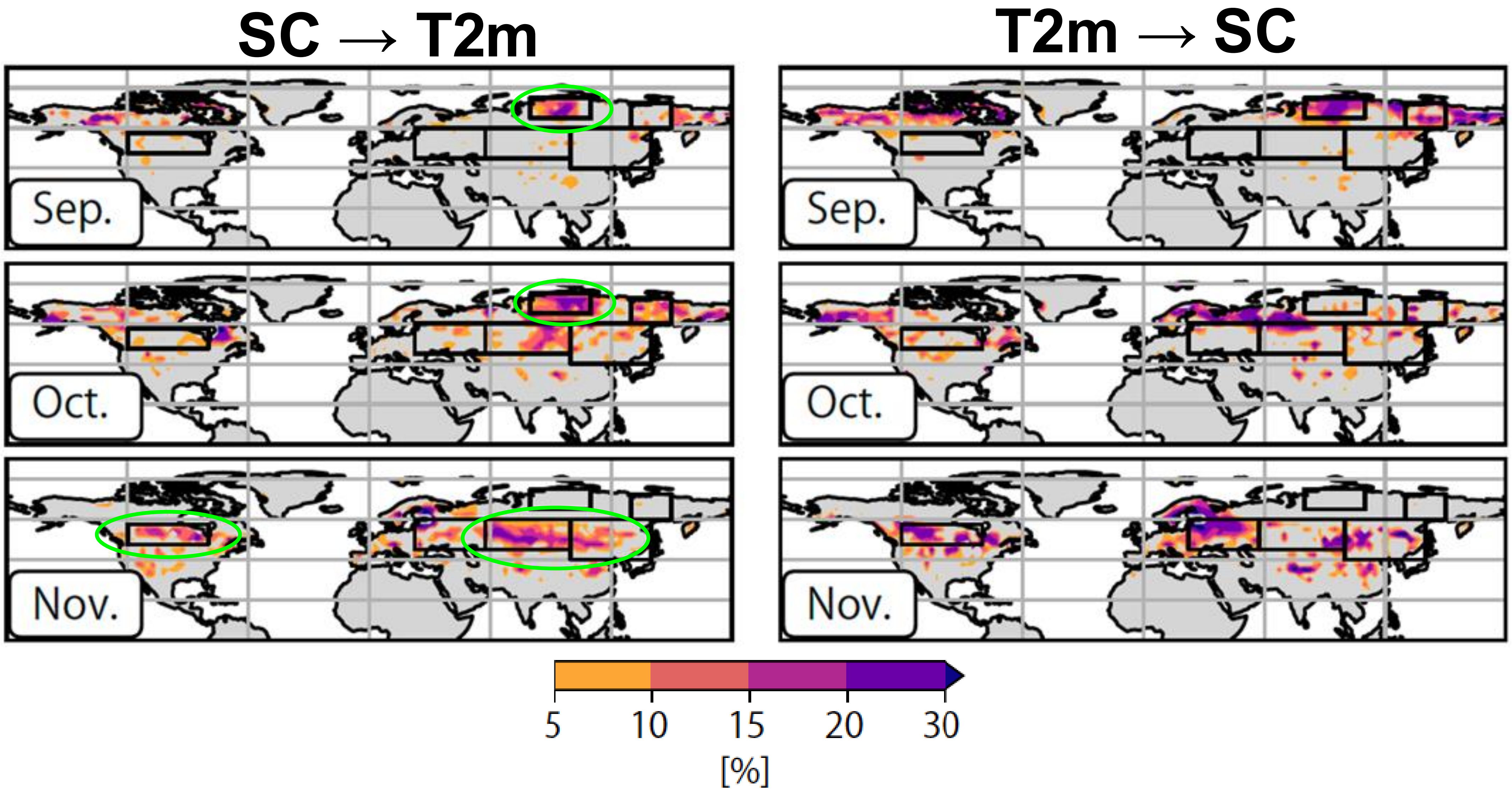
Previous studies

Assessed snow impacts using statistical analysis (correlation/regression) or model sensitivity experiments

This study (Takaya et al. 2024, *Clim. Dyn.*)

- Evaluating the snow impacts using a simplified transfer entropy analysis (Liang-Kleeman information flow)
- Diagnosing models' representation of snow-SAT interaction
- Underpinning the predictability originated from the snow condition in S2S models

T2m-SC Liang-Kleeman information flow (MERRA-2)

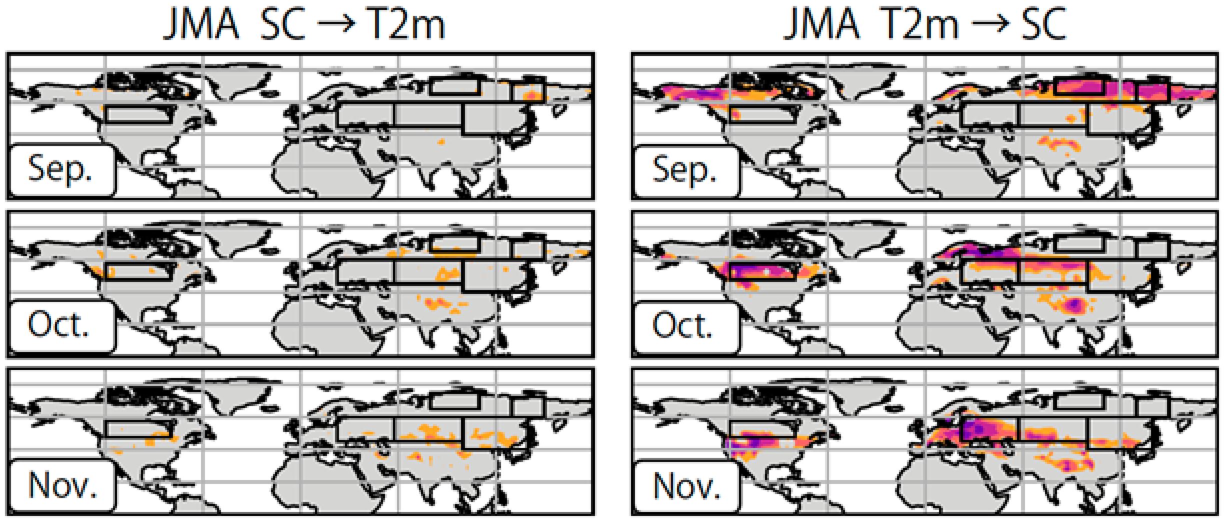


Information flow was computed using four consecutive weeks.

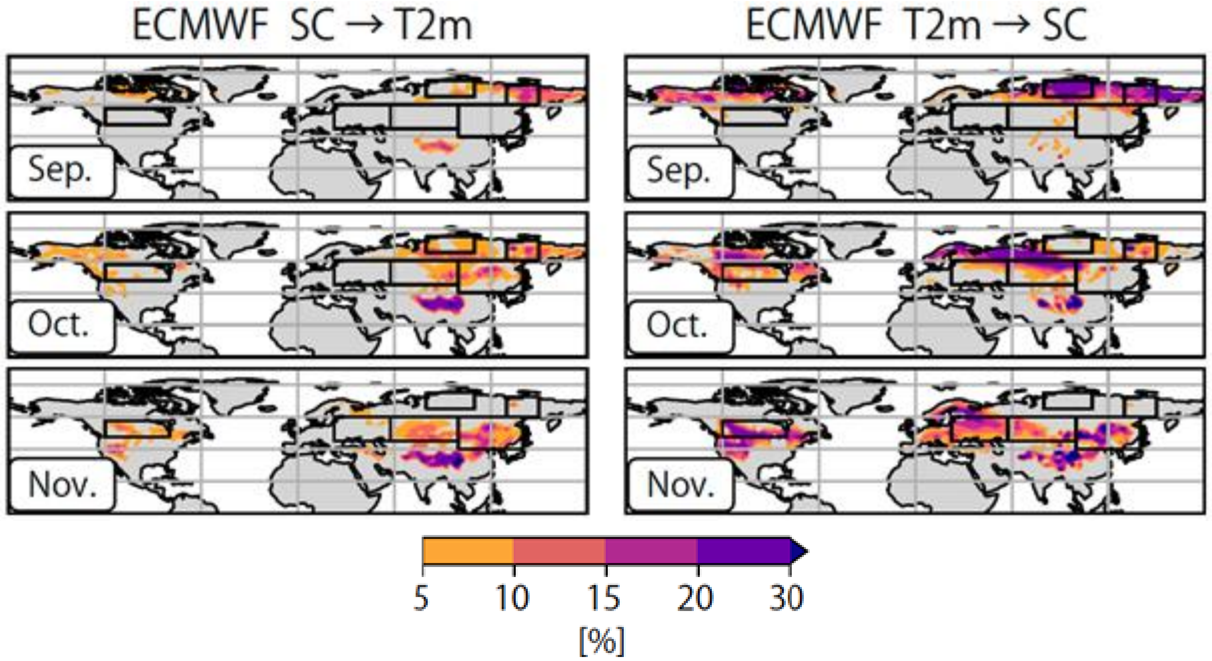
Takaya et al. (2024)

T2m-SC Liang-Kleeman information flow (S2S model)

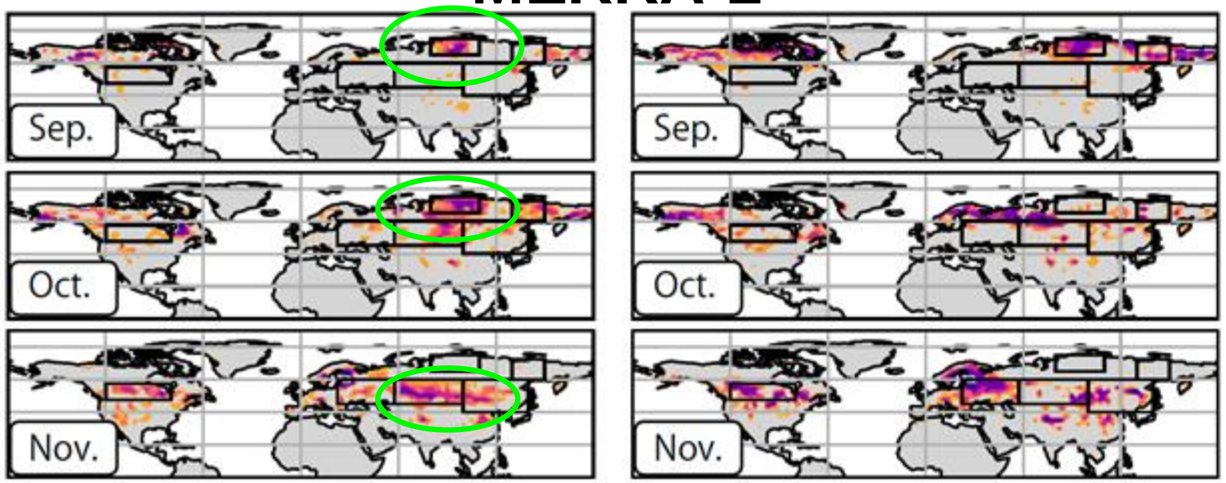
JMA



ECMWF

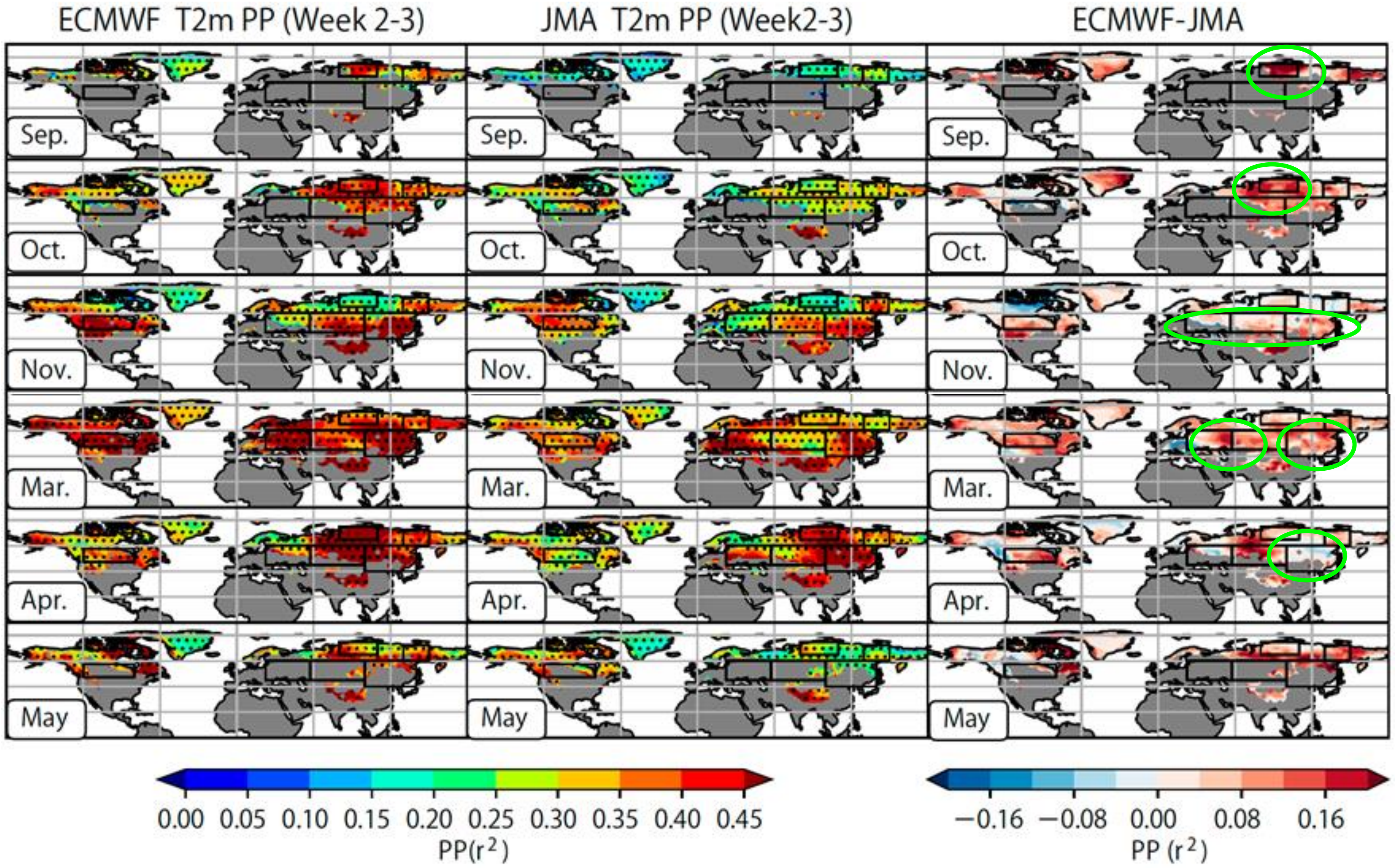


MERRA-2



Takaya et al. (2024)

Impacts on the potential predictability of SAT



The potential predictability over the cold spots tends to be lower in the JMA model than in the ECMWF model (Except for East Asia in April)

Strong SC effect on SAT
→ High SAT potential predictability

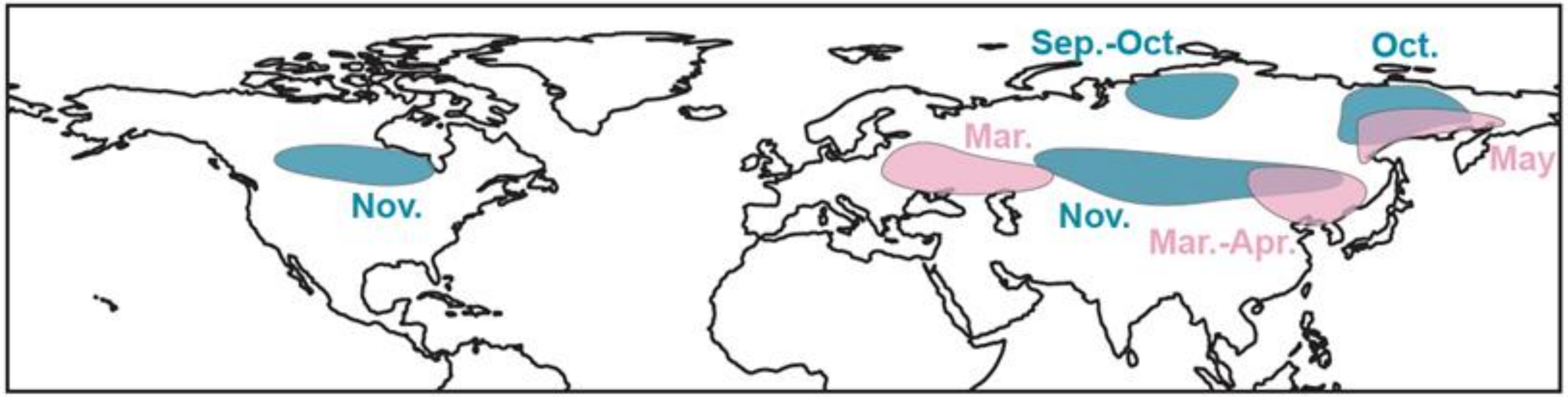
Weak SC effect on SAT
→ Low SAT potential predictability

Takaya et al. (2024)

Summary

- This study investigated the sub-monthly causal relationship between observed snow cover (SC) and surface air temperature (SAT) in the Northern Hemisphere.
- Evaluation of S2S models revealed the shortcomings of the model in representing snow influence on SAT.
- The diagnostics of this study are useful for advancing our understanding of S2S predictability and contributing to the future improvement of S2S prediction.

‘Cold spots’ identified by Liang-Kleeman information flow analysis



Takaya et al. (2024) A sub-monthly timescale causality between snow cover and surface air temperature in the Northern Hemisphere inferred by Liang–Kleeman information flow analysis, *Clim. Dyn*