Application Laboratory
Innovations from Earth Science

SINTEX-F seasonal prediction system and its application

A brief review of my recent activities

Takeshi Doi

1Application Laboratory (APL)/Research Institute for Value-Added-Information Generation (VAiG)/Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

Acknowledgements:

The SINTEX-F seasonal climate prediction system was run by the Earth Simulator at JAMSTEC. We are grateful to Drs. Wataru Sasaki, Jing-Jia Luo, Sebastian Masson, Andrea Storto, Antonio Navarra, Silvio Gualdi and our European colleagues of INGV/CMCC, L'OCEAN, and MPI for their contributions in developing the prototype prediction system. We also thank Drs. Masami Nonaka and Yushi Morioka for helpful comments and suggestions.

What is seasonal prediction?

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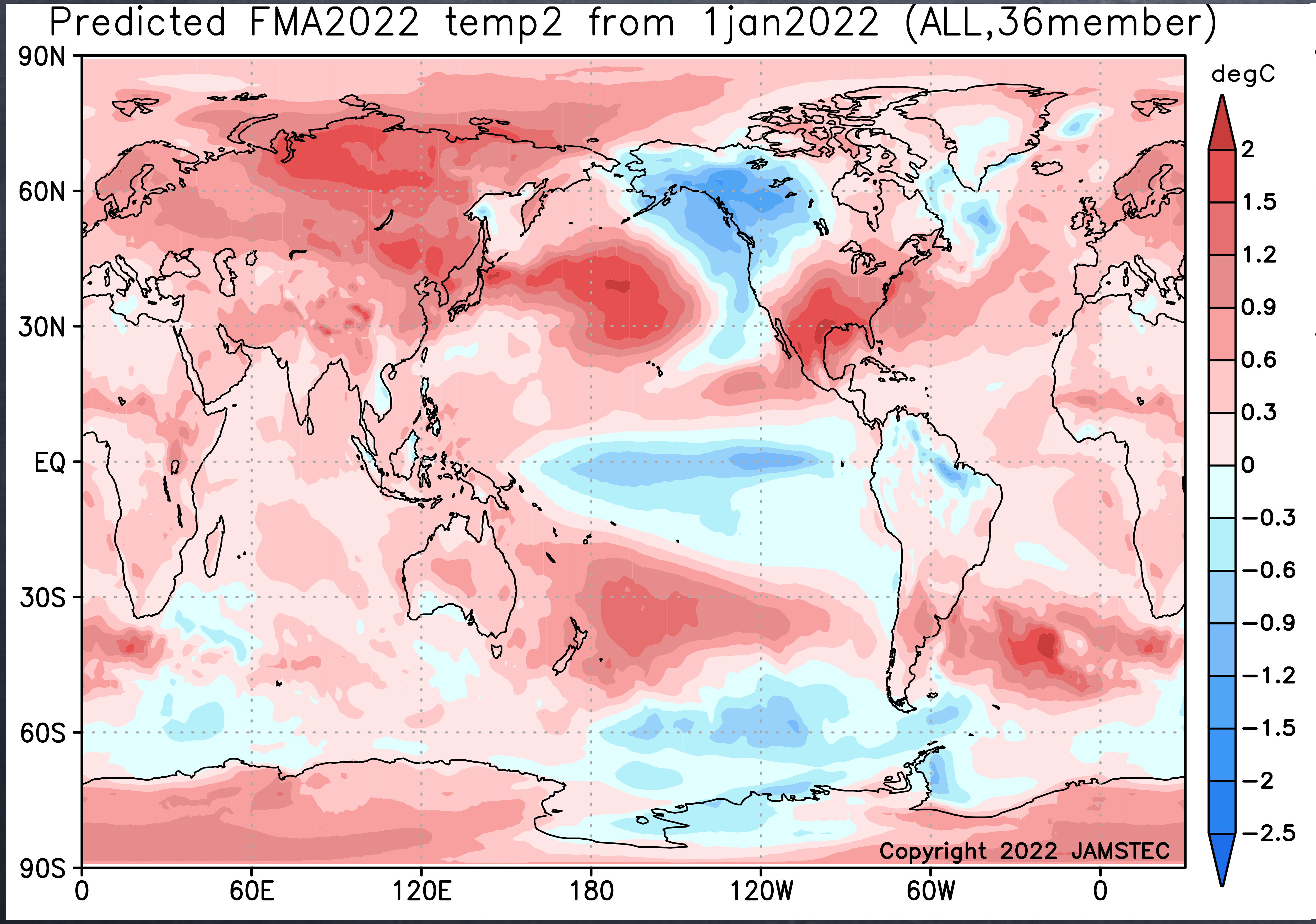

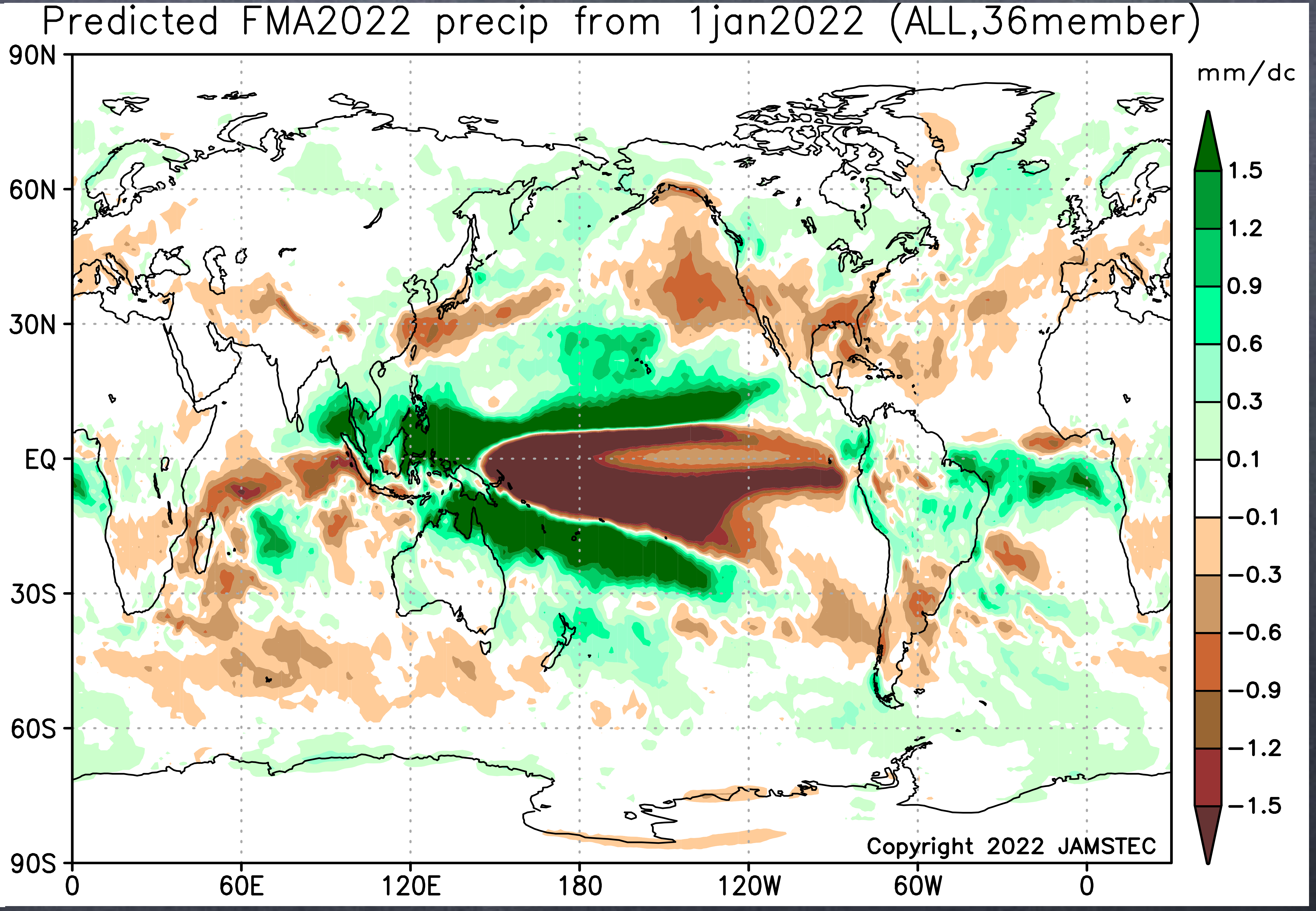

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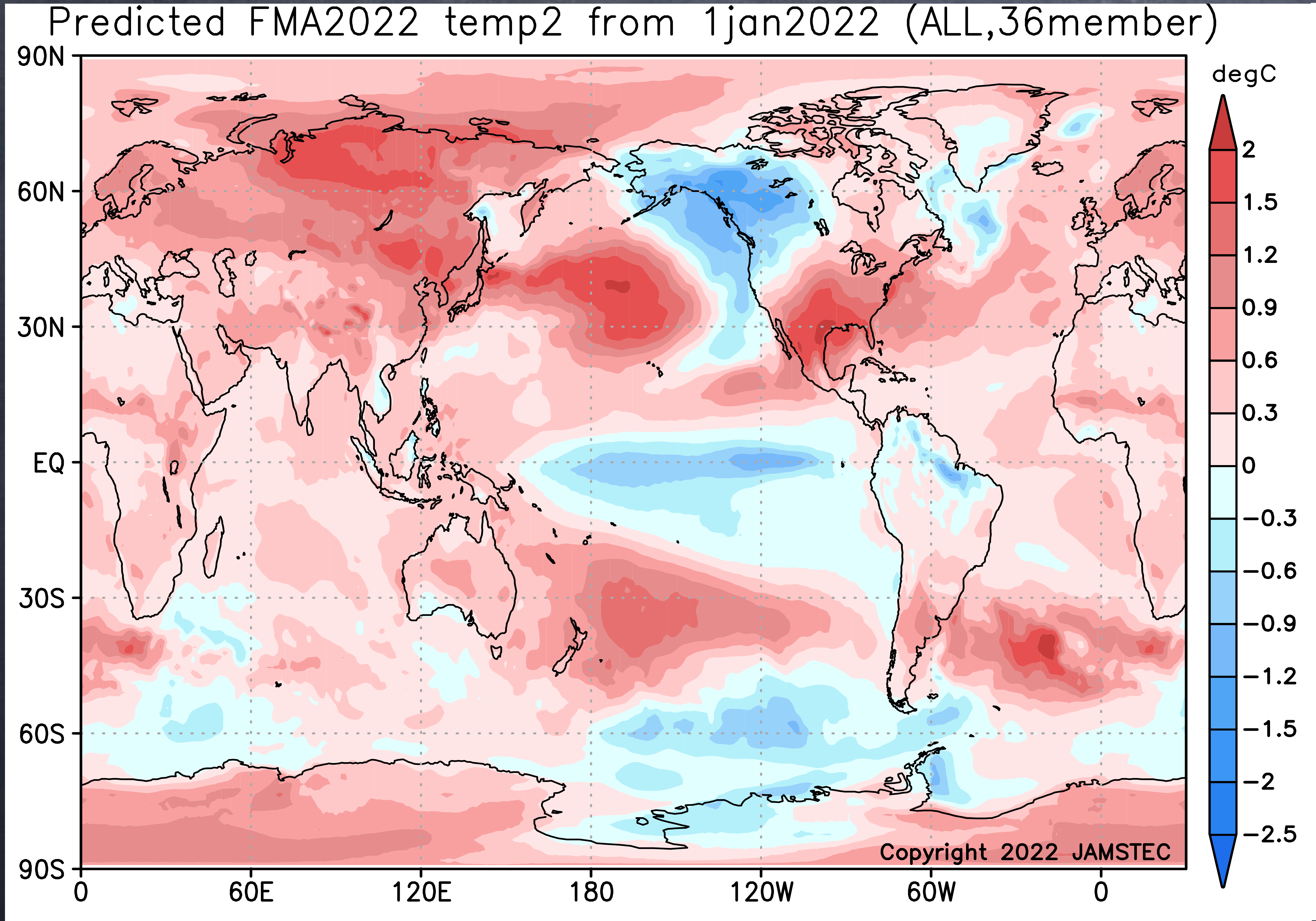
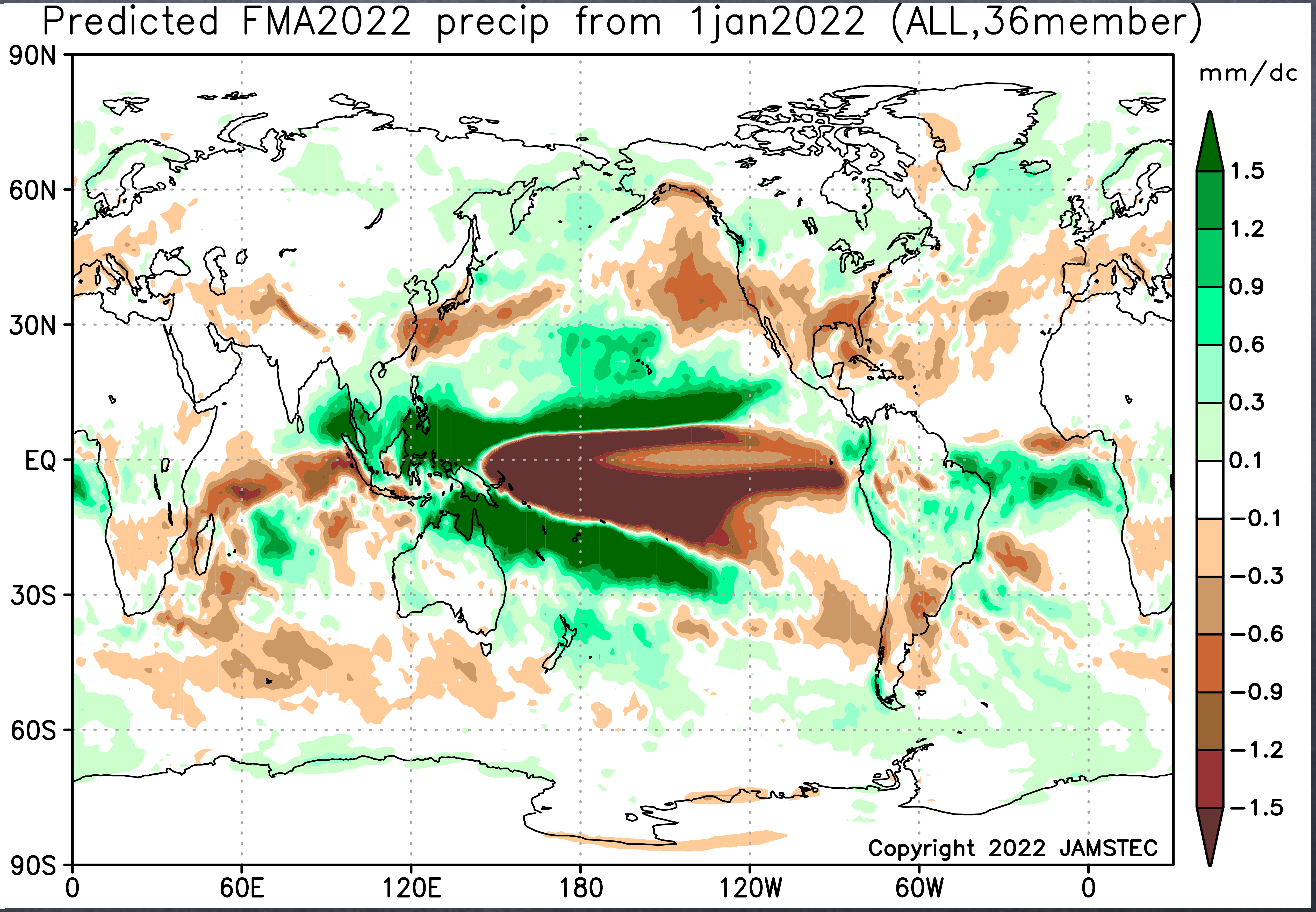
☑ is to provide useful information about the "climate" that can be expected in the coming months/seasons.





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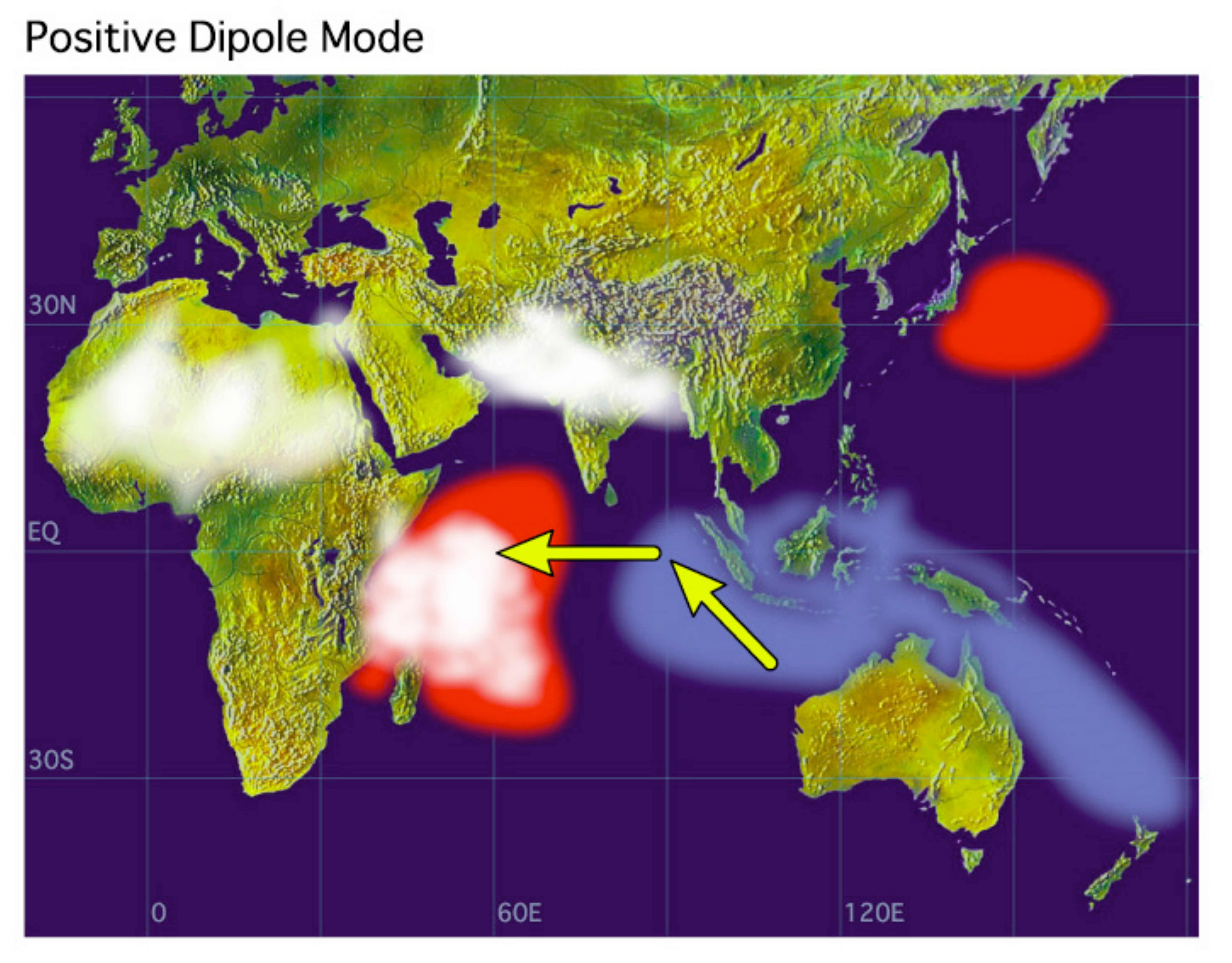
Potential source of predictability	Atmospheric initial conditions	Atmospheric boundary conditions (e.g. SST, sea-ice concentration, soil moisture, stratosphere, etc)

Prediction of the Indian Ocean Dipole Mode (IOD) is crucial for seasonal prediction over the Indian Ocean rim countries, Europe, and East Asia (including Japan)



(Saji et al. 1999; Yamagata et al. 2004)

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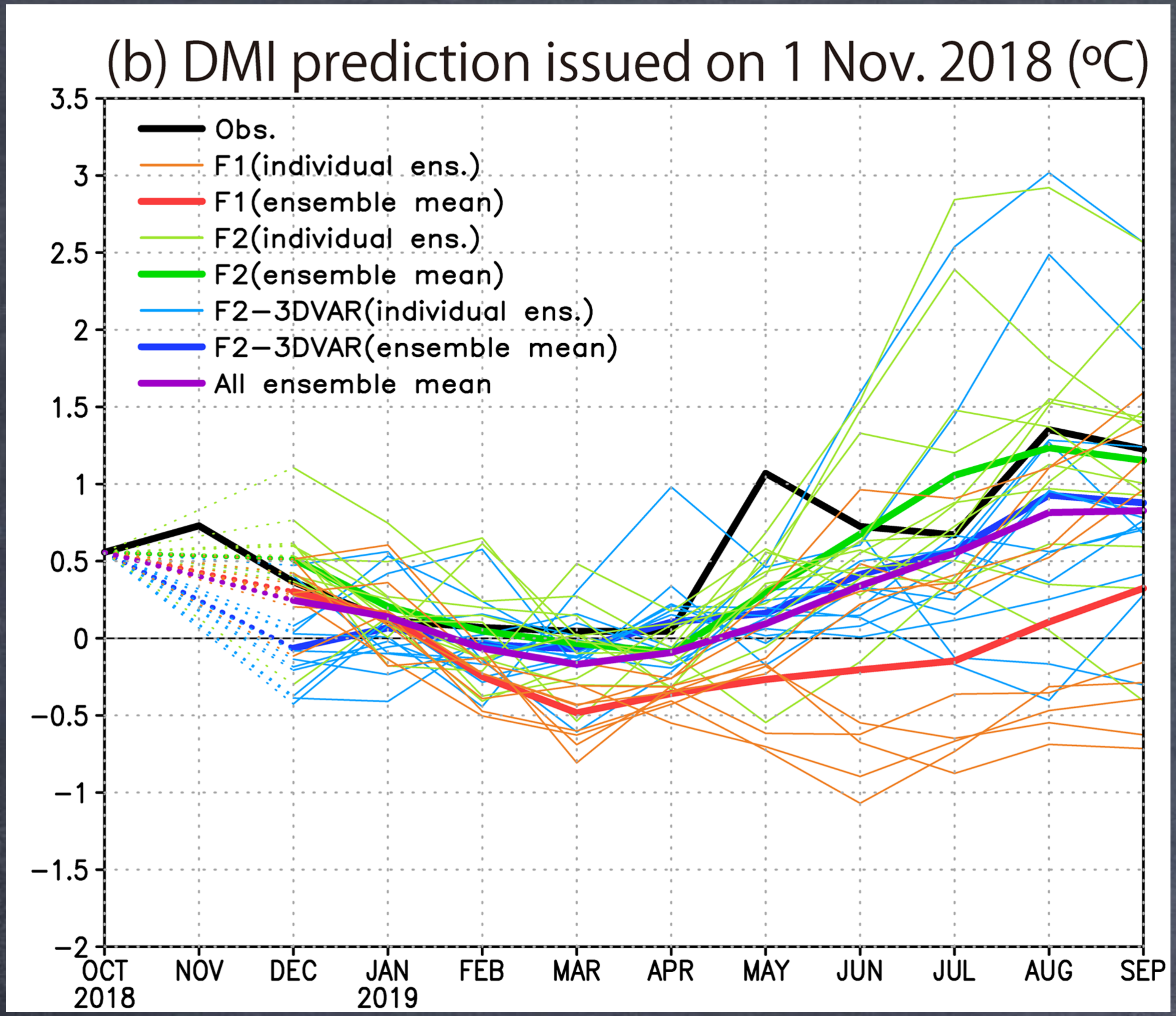
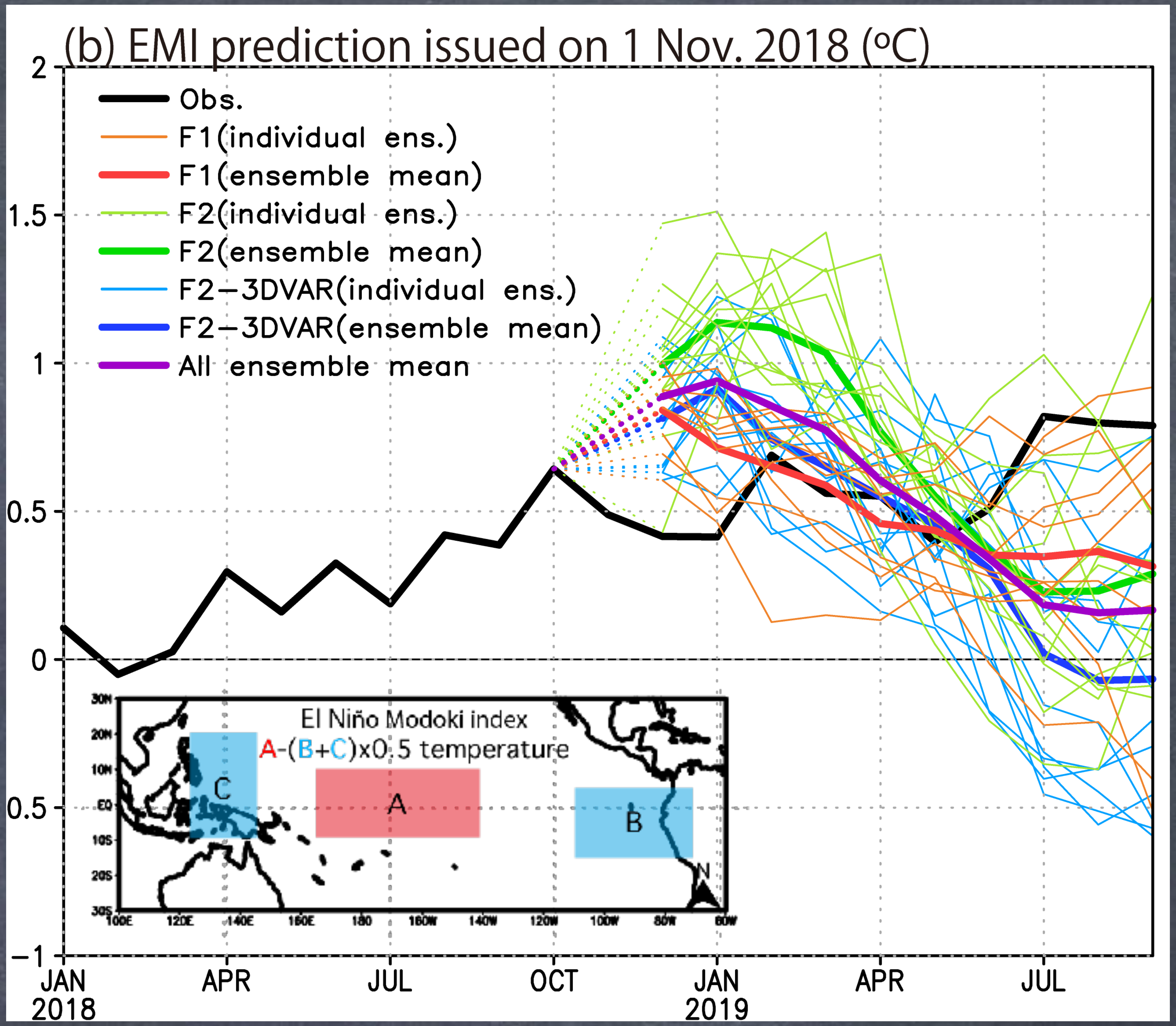
108mem-F2-3DVAR (Doi et al. 2019, JC)	ECHAM5 T106L31	ECHAM5 T106L31	LIM2	108	SST-nudging with 3DVAR ocean assimilation	4-mo lead





The pIOD occurrence was predicted a few seasons ahead by overcoming the so-called winter predictability barrier, which is related to the success in predicting the El Niño Modoki and its atmospheric connection (Doi et al. 2020a, GRL)

Doi, T., Behera, S. K., & Yamagata, T. (2020). Predictability of the super IOD event in 2019 and its link with El Niño Modoki. Geophysical Research Letters, 47, e2019GL086713. https://doi.org/10.1029/2019GL086713

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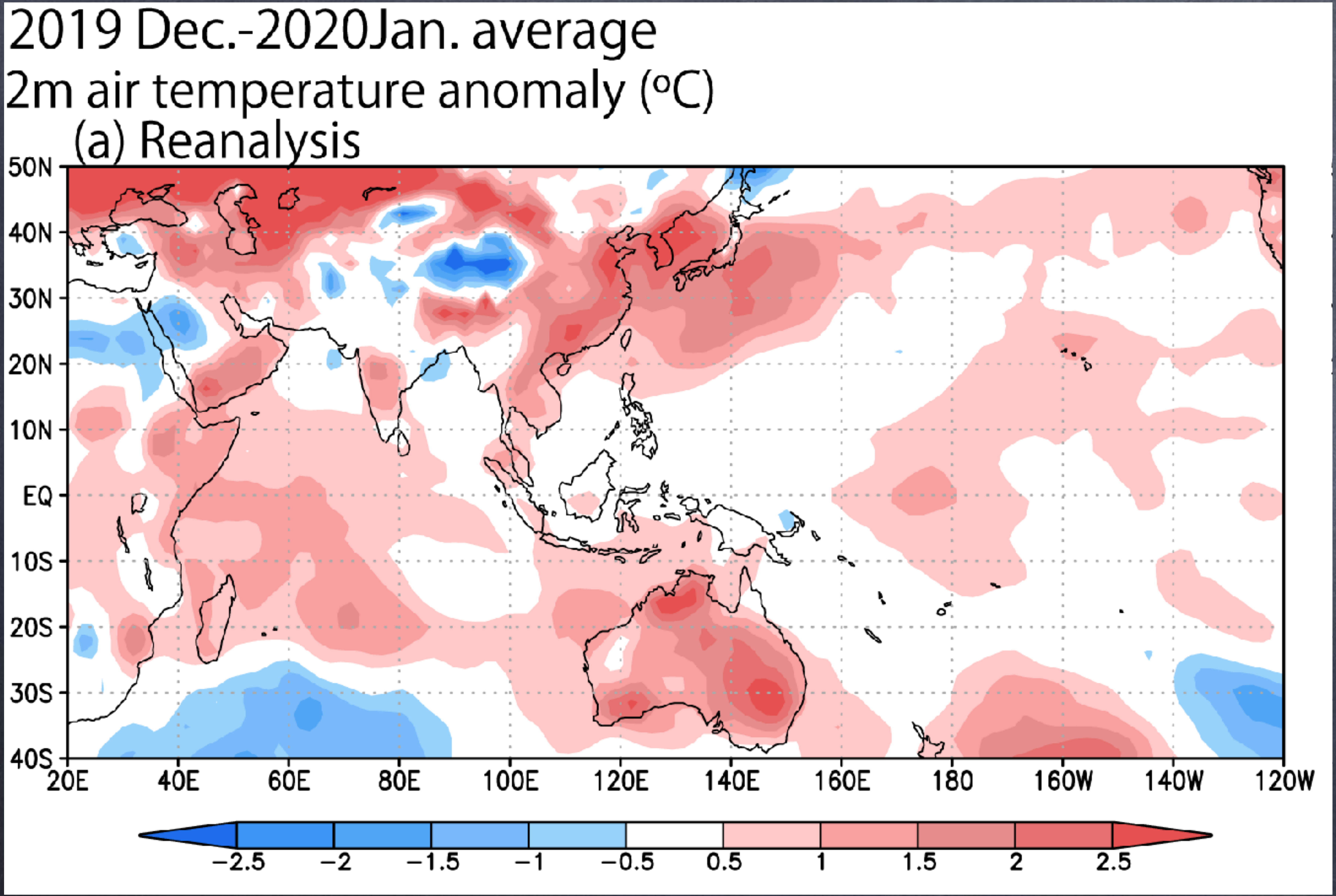

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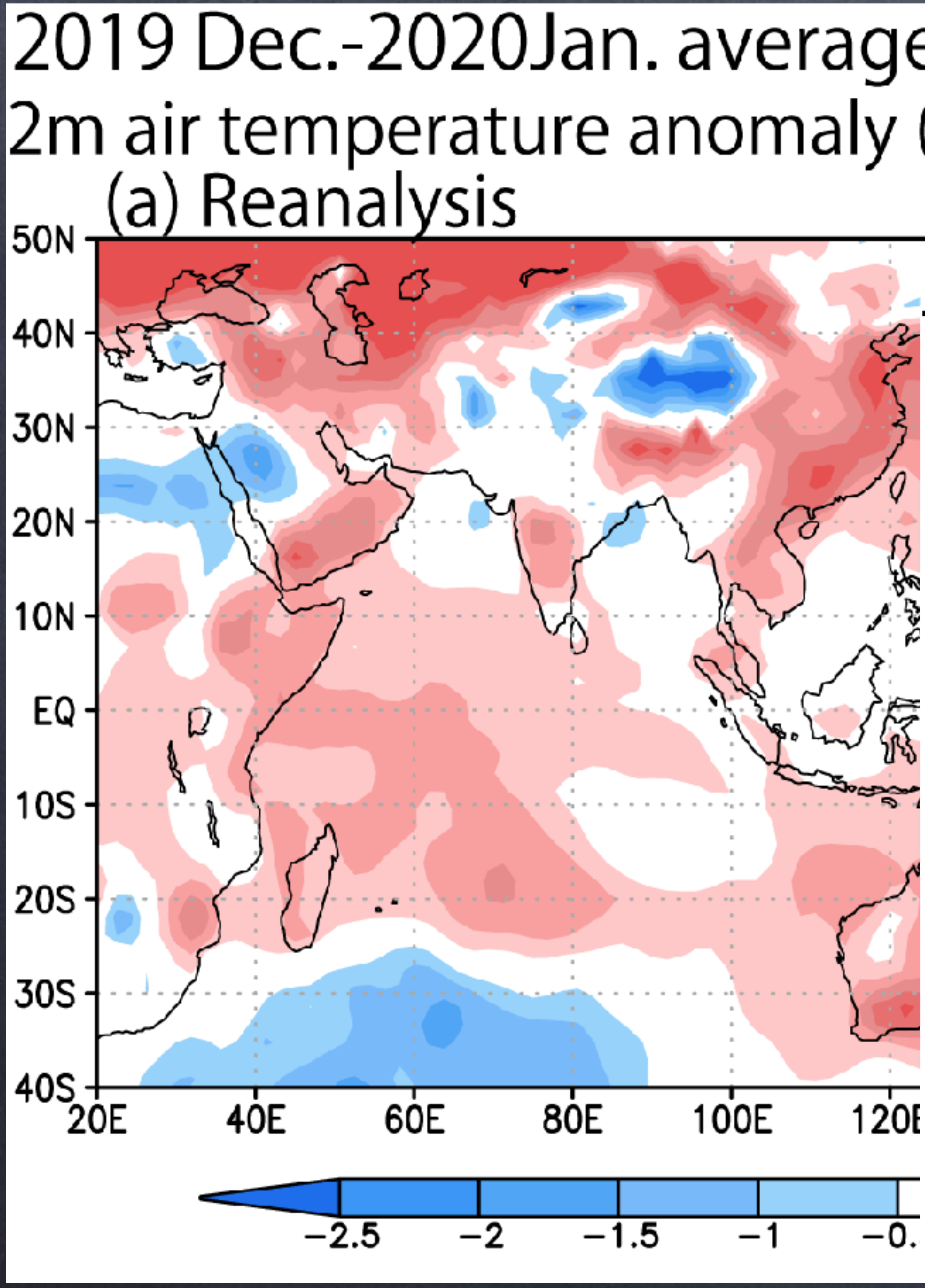

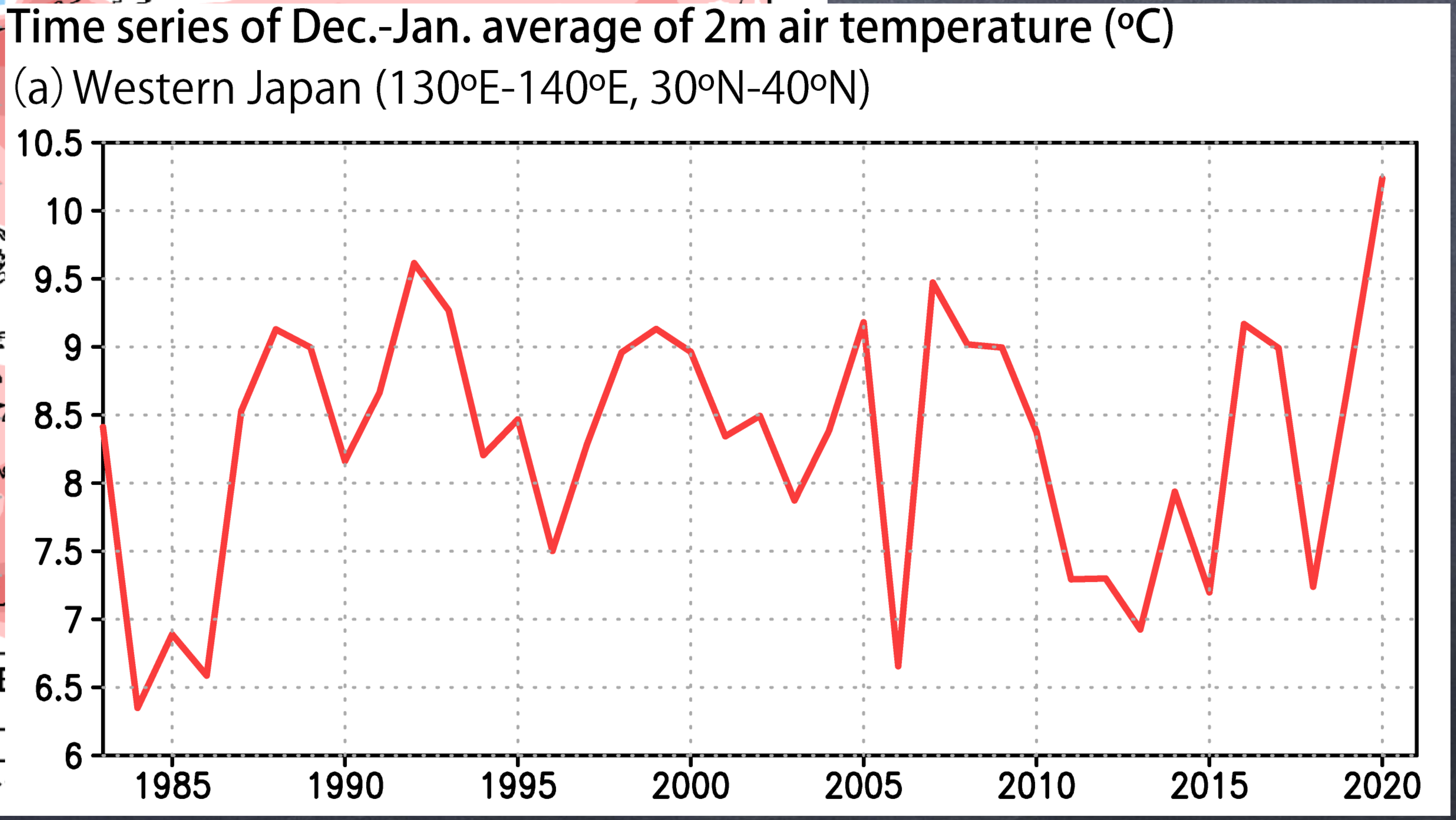

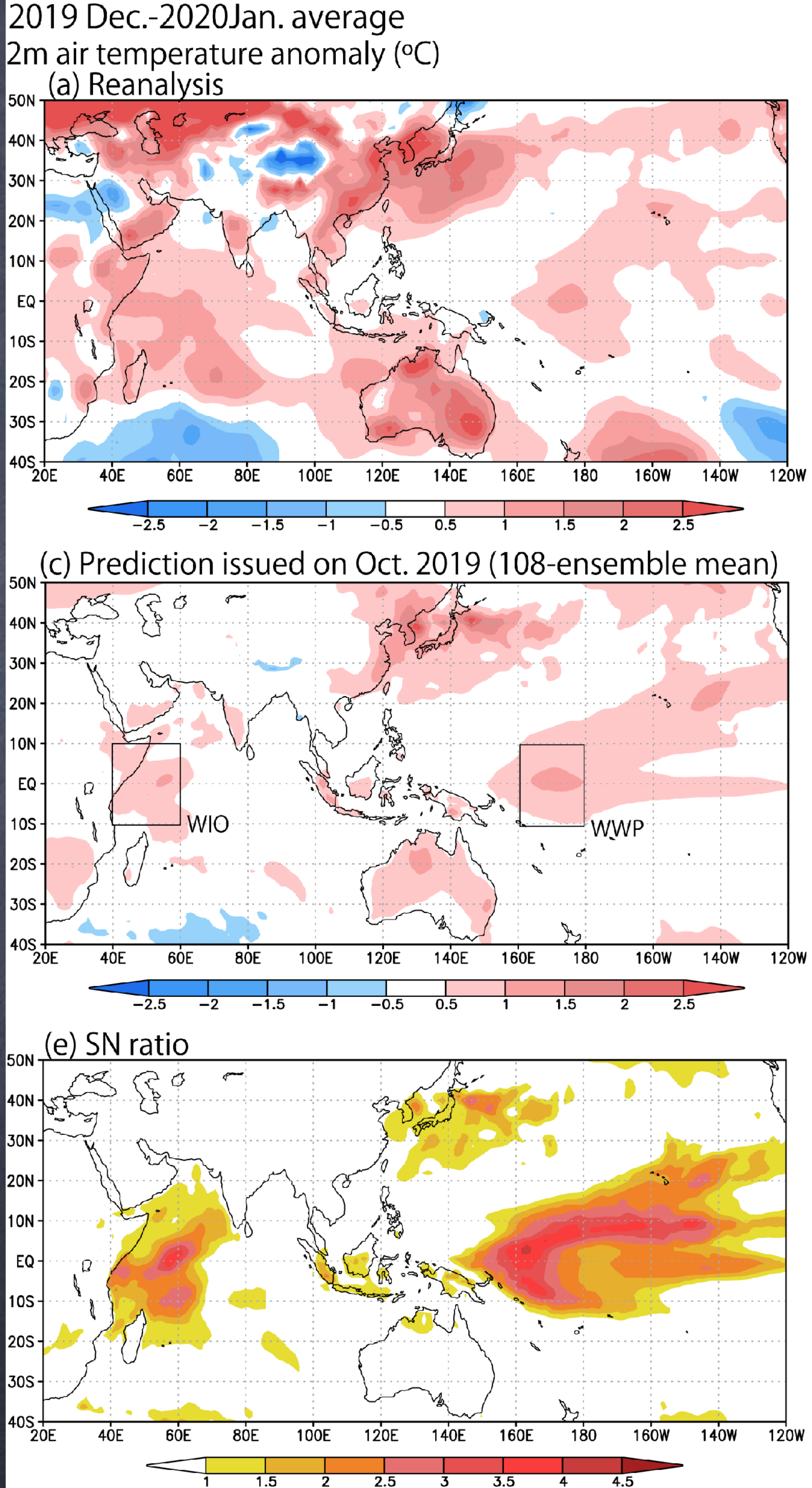
2019 Dec.-2020Jan. average
2m air temperature anomaly (ºC)
(a) Reanalysis
50N 40N 30N 20N 10N EQ 10S 20S 30S 40S
20E 40E 60E 80E 100E 120E 140E 160E 180 160W 140W 120W
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(c) Prediction issued on Oct. 2019 (108-ensemble mean)
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(e) SN ratio
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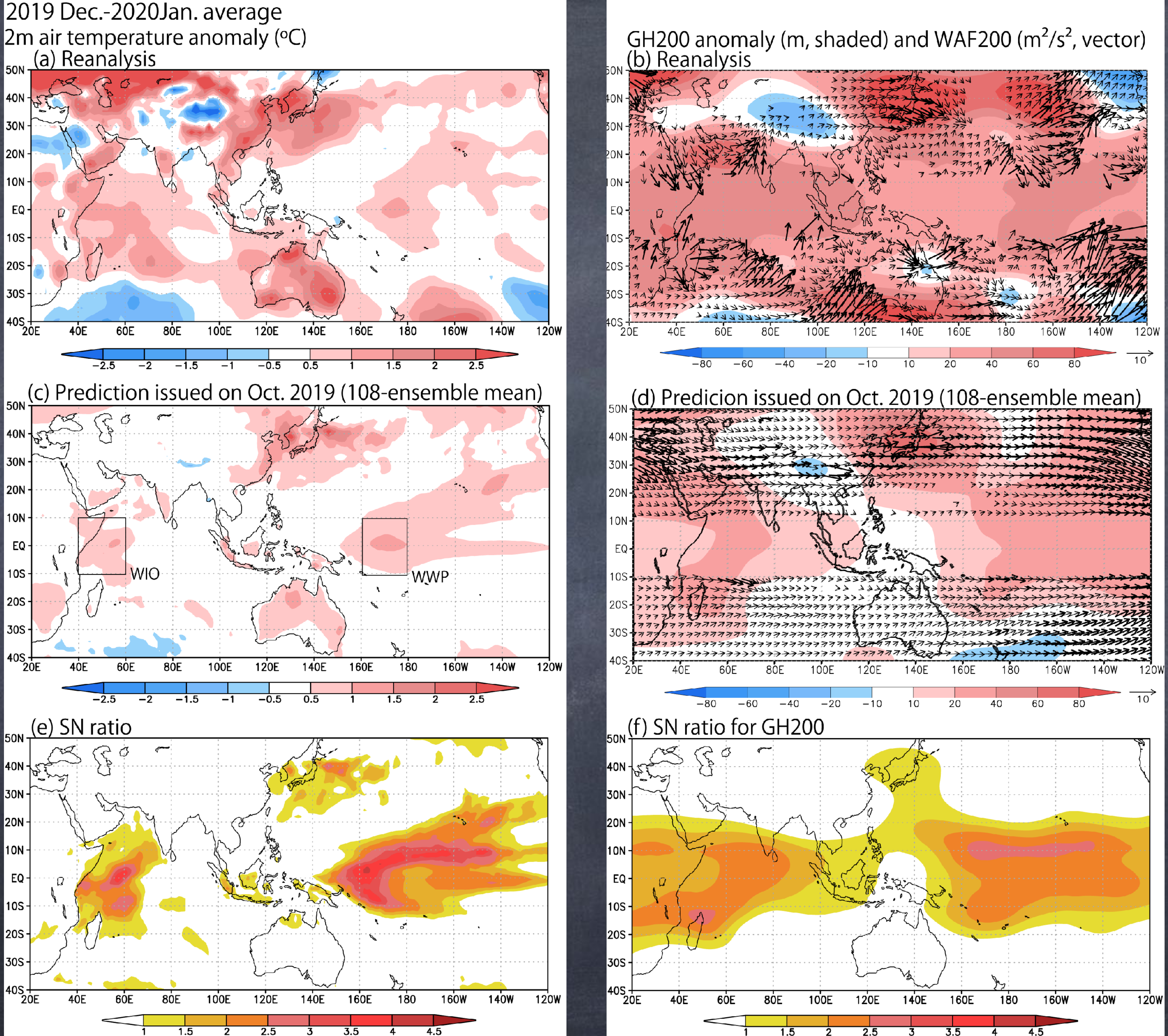
1 1.5 2 2.5 3 3.5 4 4.5


2019 Dec.-2020Jan. average
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(a) Reanalysis
GH200 anomaly (m, shaded) and WAF200 (m²/s², vector)
(b) Reanalysis
(c) Prediction issued on Oct. 2019 (108-ensemble mean)
WIO
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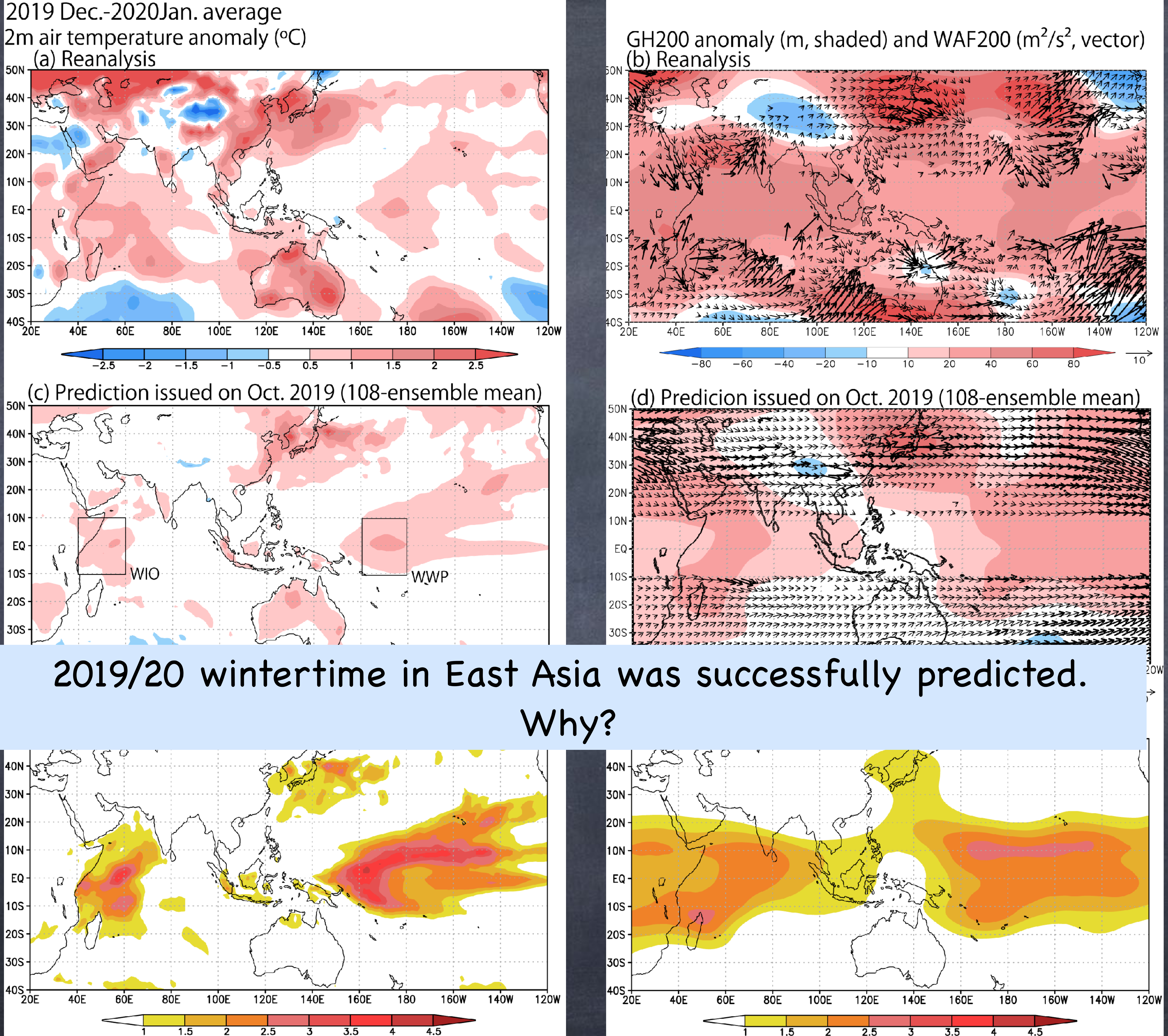
(e) SN ratio
(f) SN ratio for GH200



2019/20 wintertime in East Asia was successfully predicted.
Why?

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- The anomalies among the ensemble members (defined as deviations from the ensemble mean) may provide useful insights into possible precursors and teleconnection patterns related to a climate event [Ma et al., 2017; Ogata et al., 2019; Doi et al., 2020].

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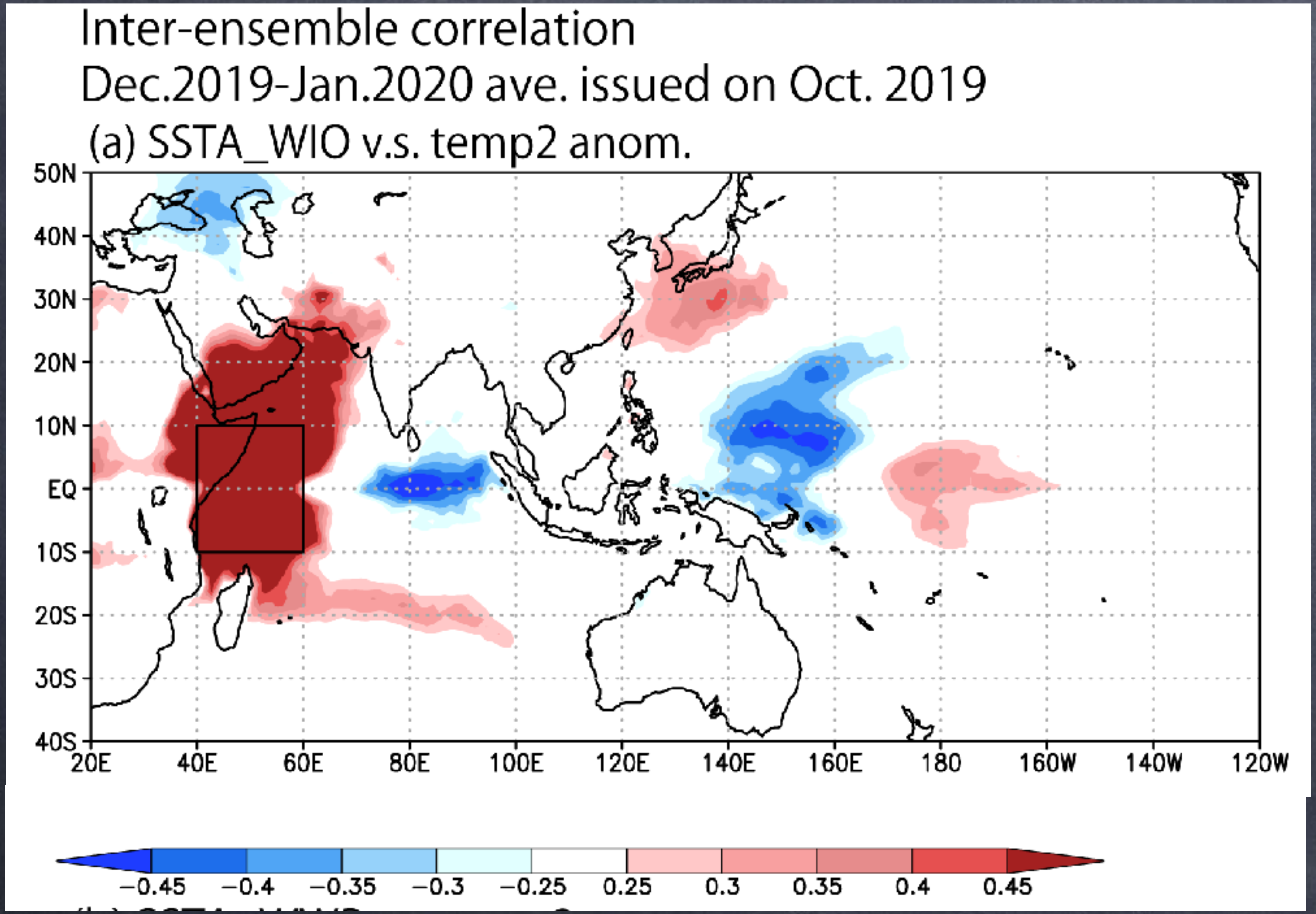
Co-variability of ensemble members may suggest a possible teleconnection from the western tropical Indian Ocean to Japan



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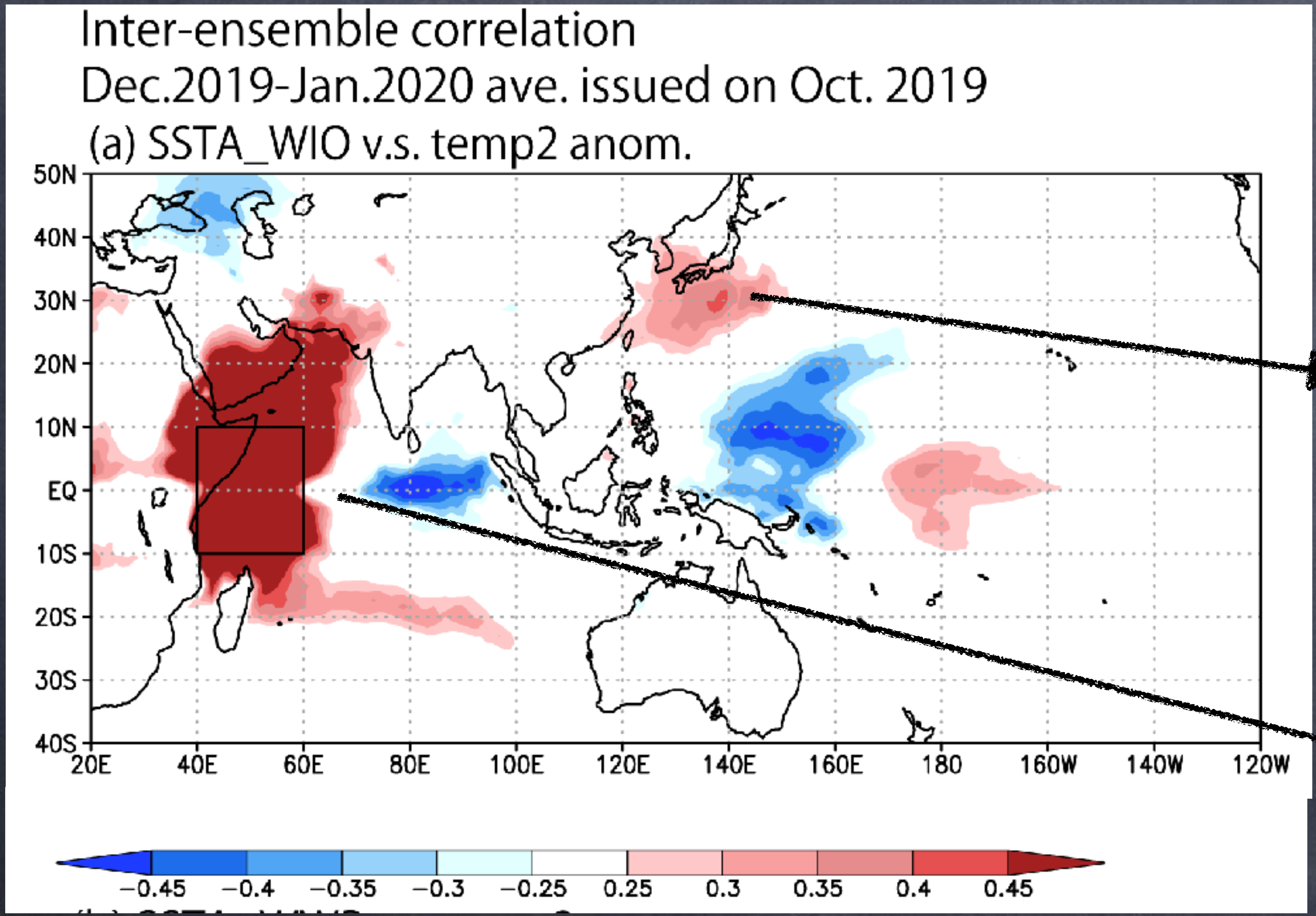
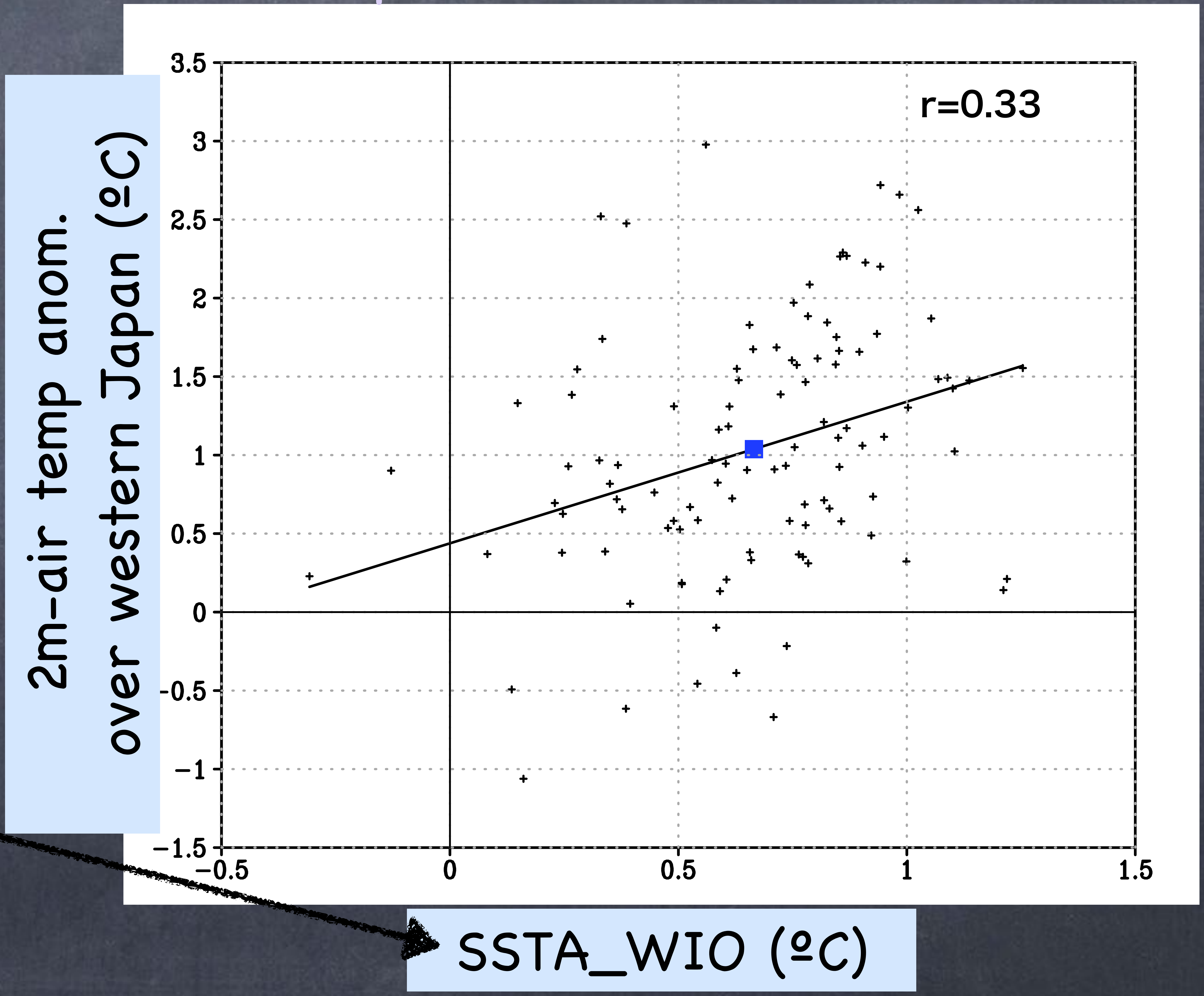
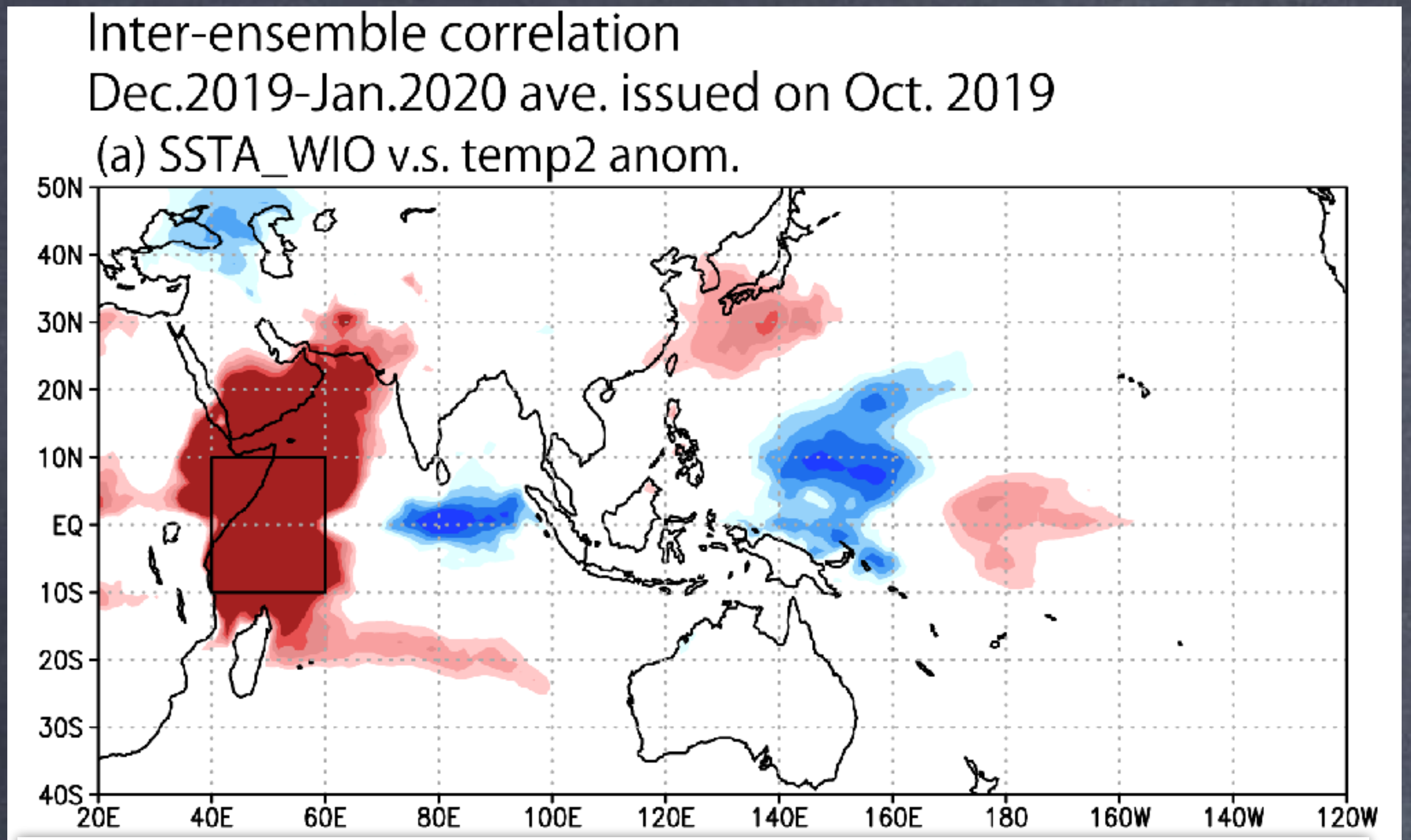
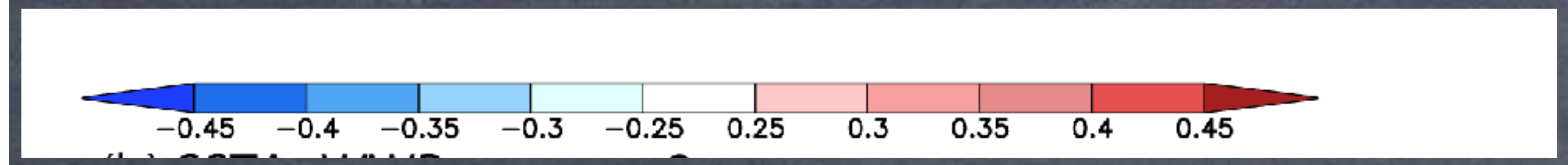


Scatter plot of ensemble members







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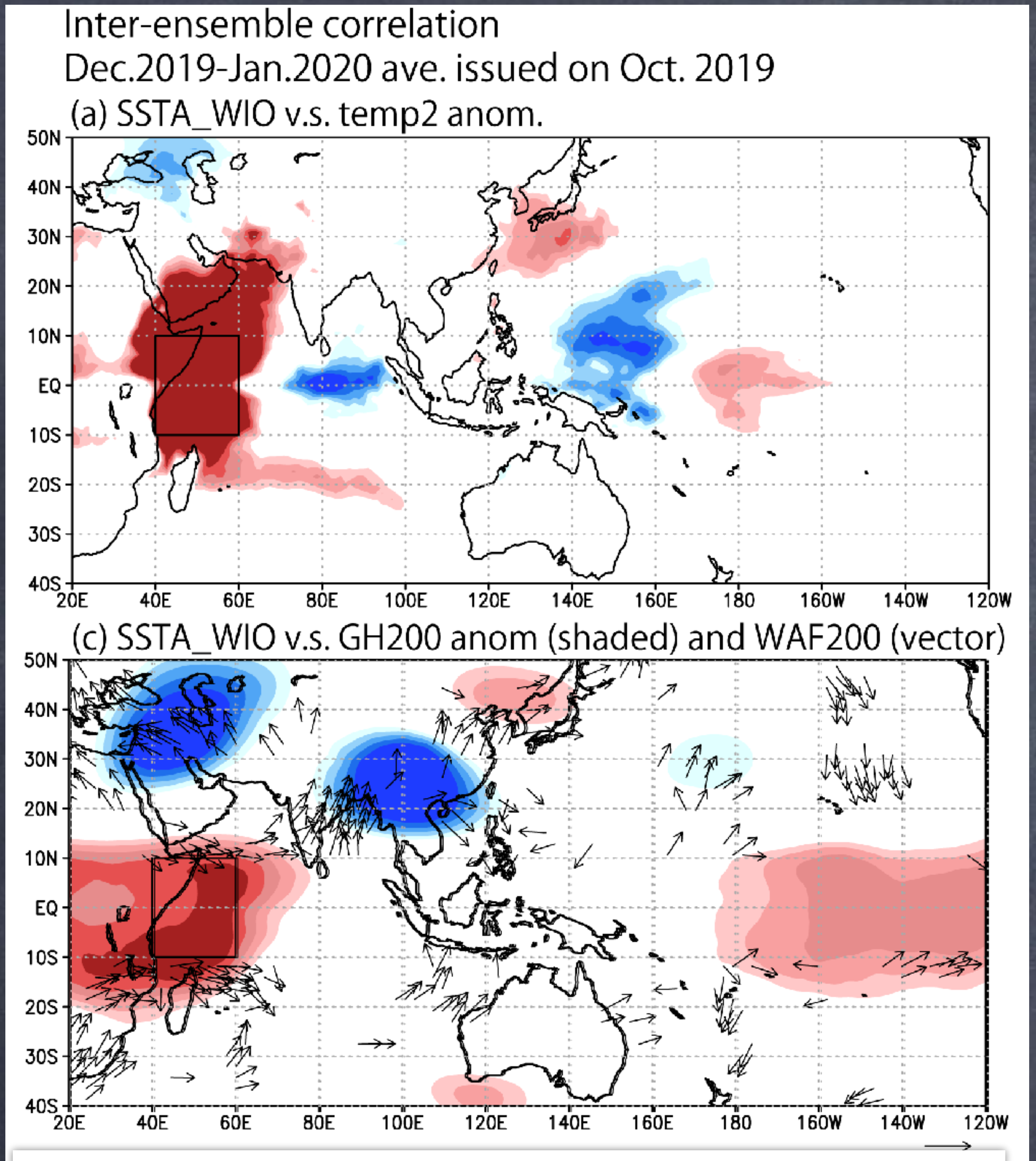

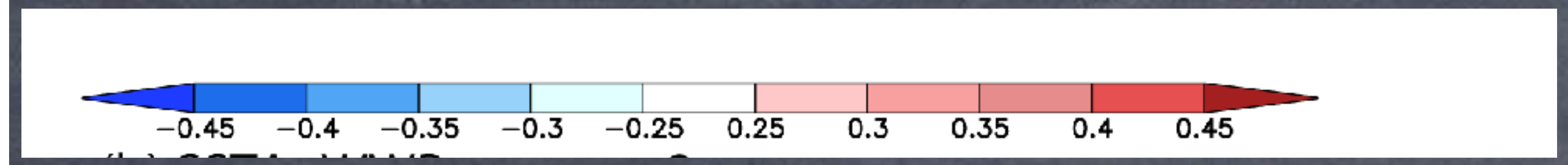

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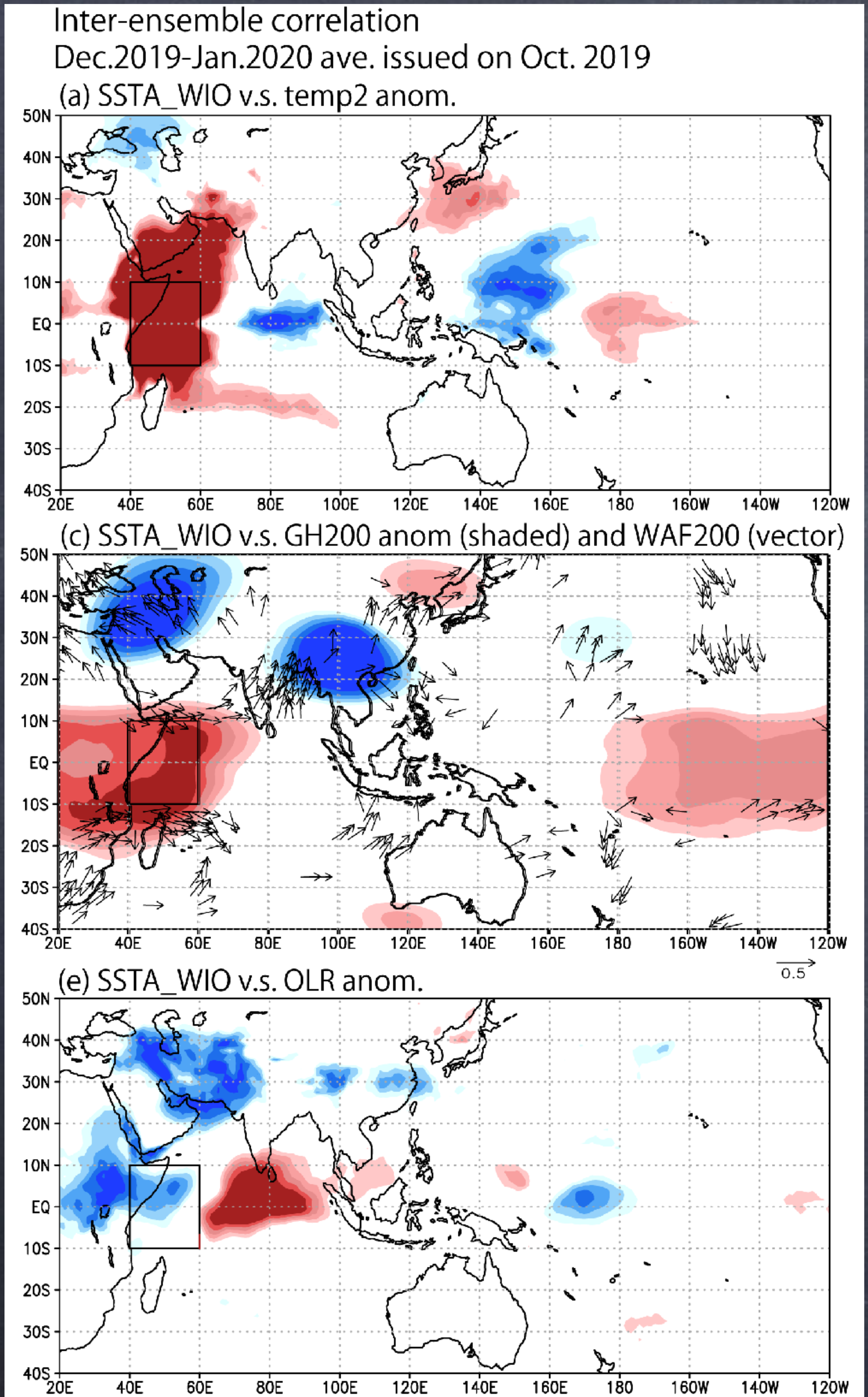

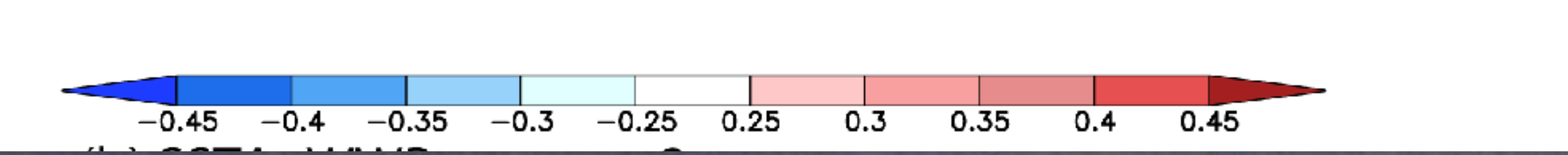

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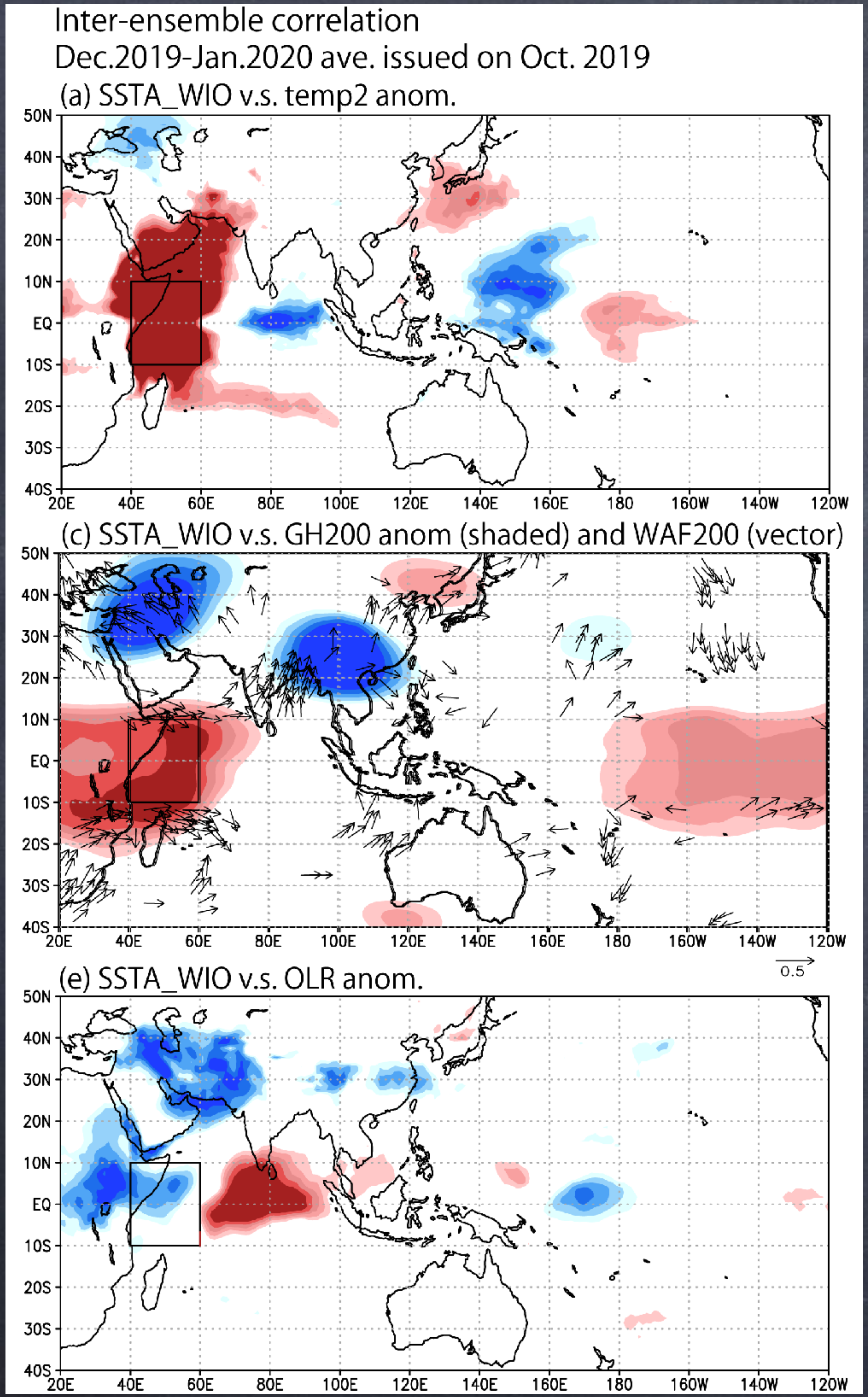

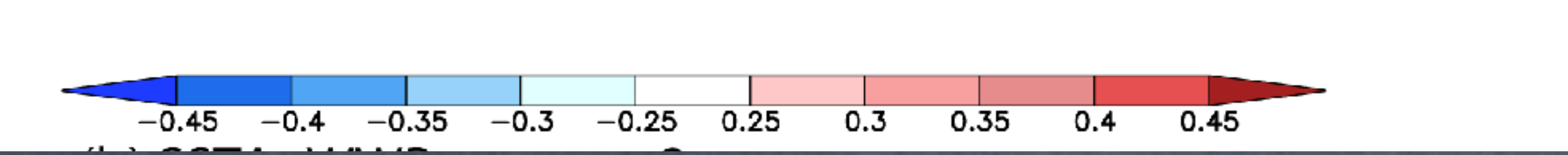

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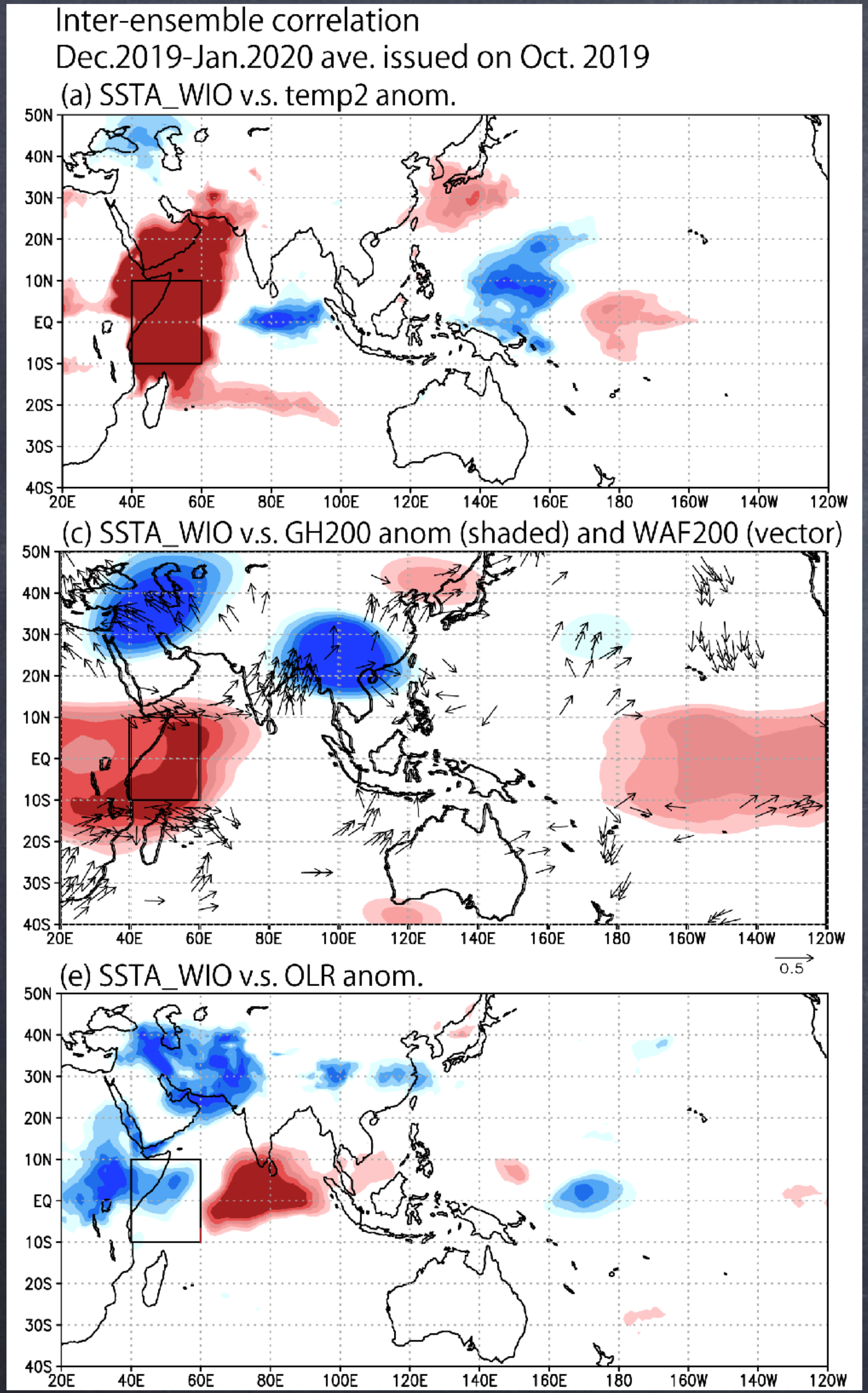

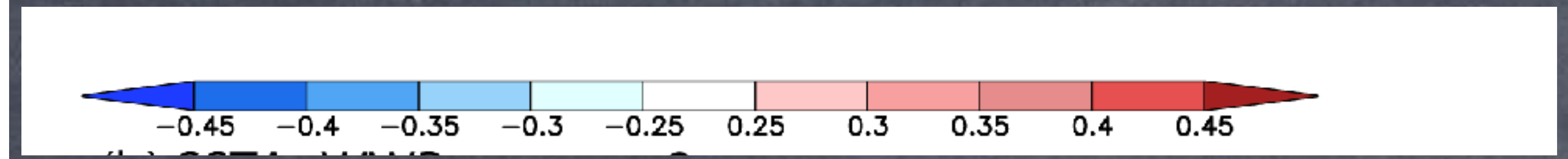

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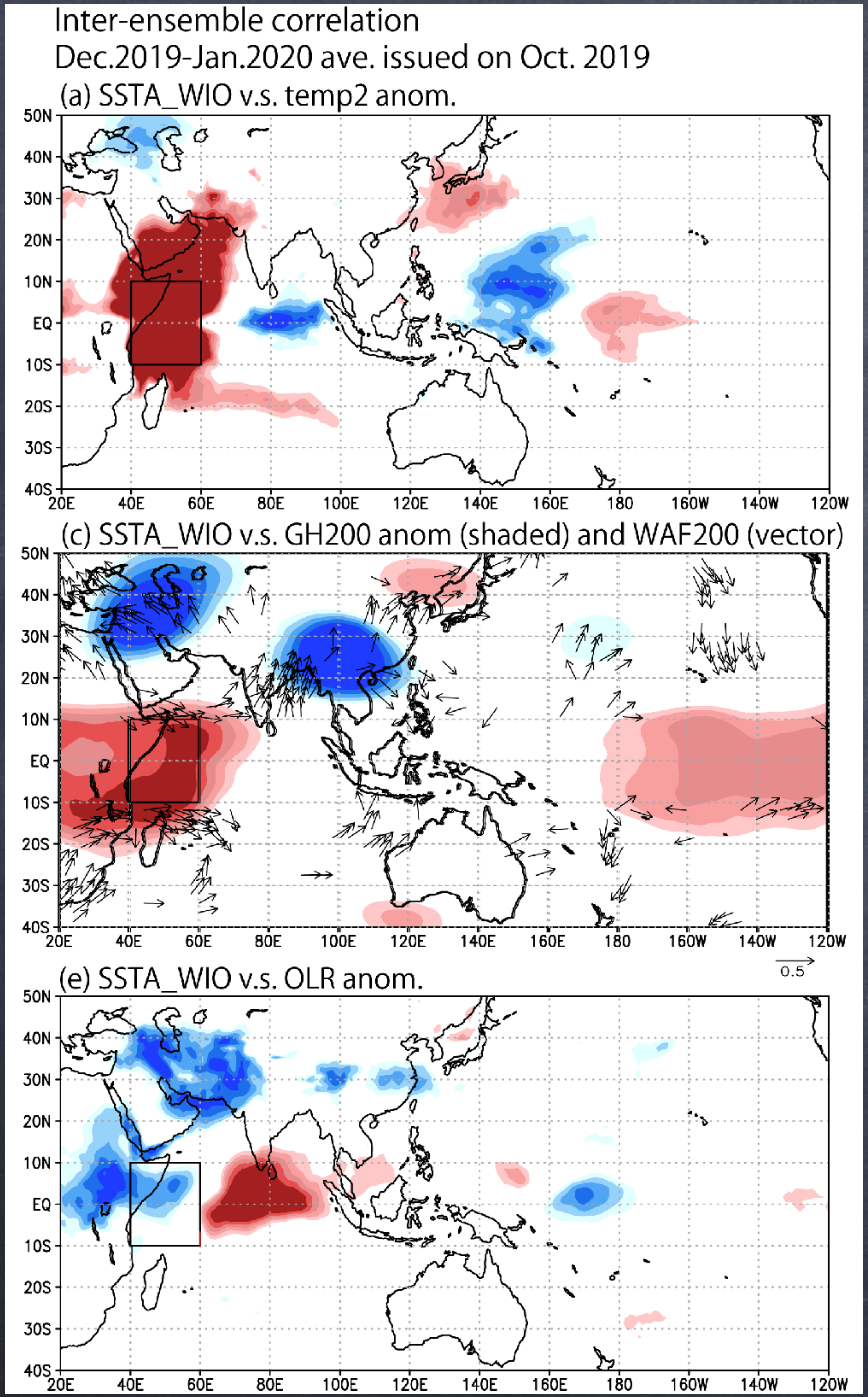

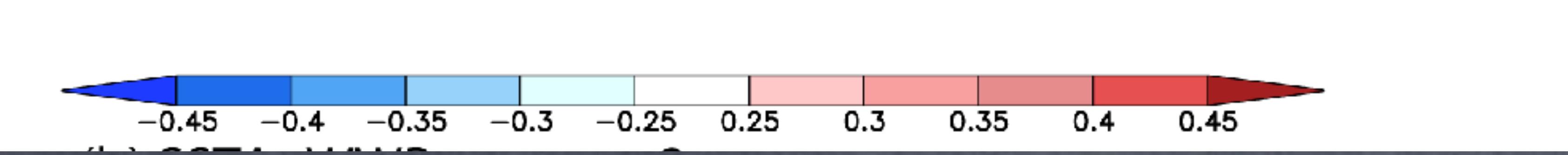

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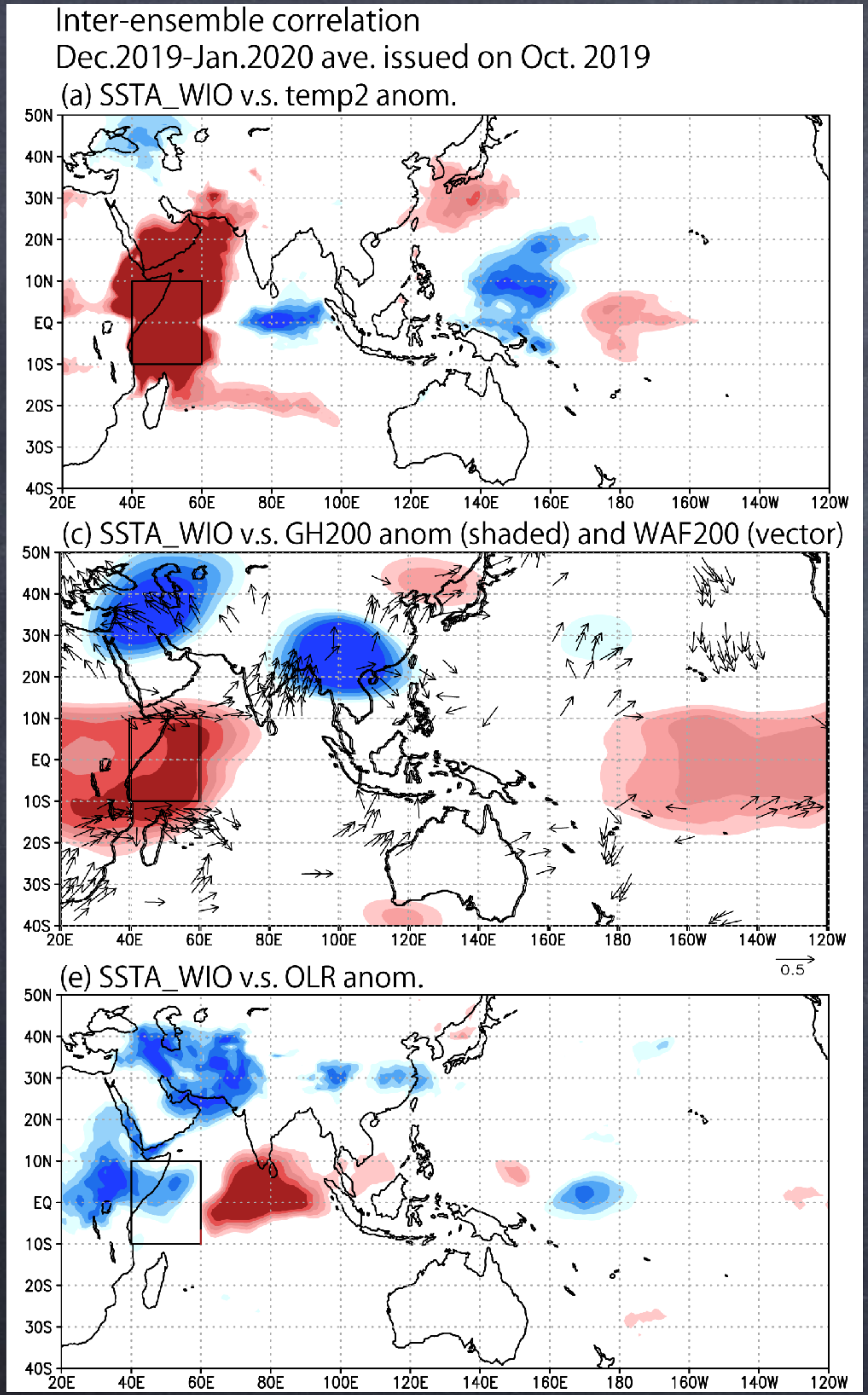

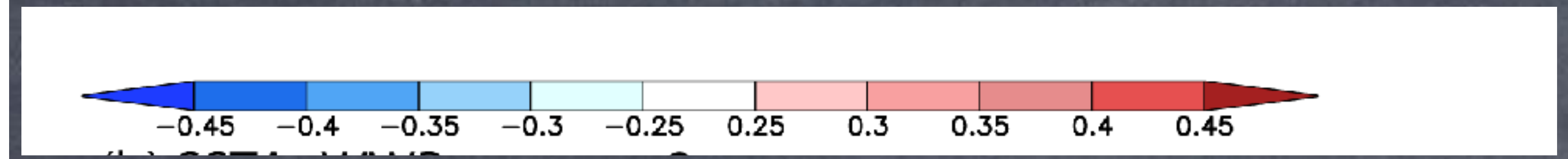

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A zonal dipole is also seen in the correlation maps for the temperature and the OLR anomalies in the tropical Indian Ocean, confirming the link with the super IOD of 2019.

Summary

☑In this study, we have explored the potential source of the unusually warm 2019-2020 winter in East Asia by analyzing the co-variability of inter-member anomalies in the 108-members ensemble of the SINTEX-F prediction system.

☑We have found a possible teleconnection pattern related to the meander of the subtropical jet, which was excited by the atmospheric processes due to the abnormally warm SST in the western Indian Ocean.

☑The anomalous SST is due to the long-lasting super IOD in 2019.

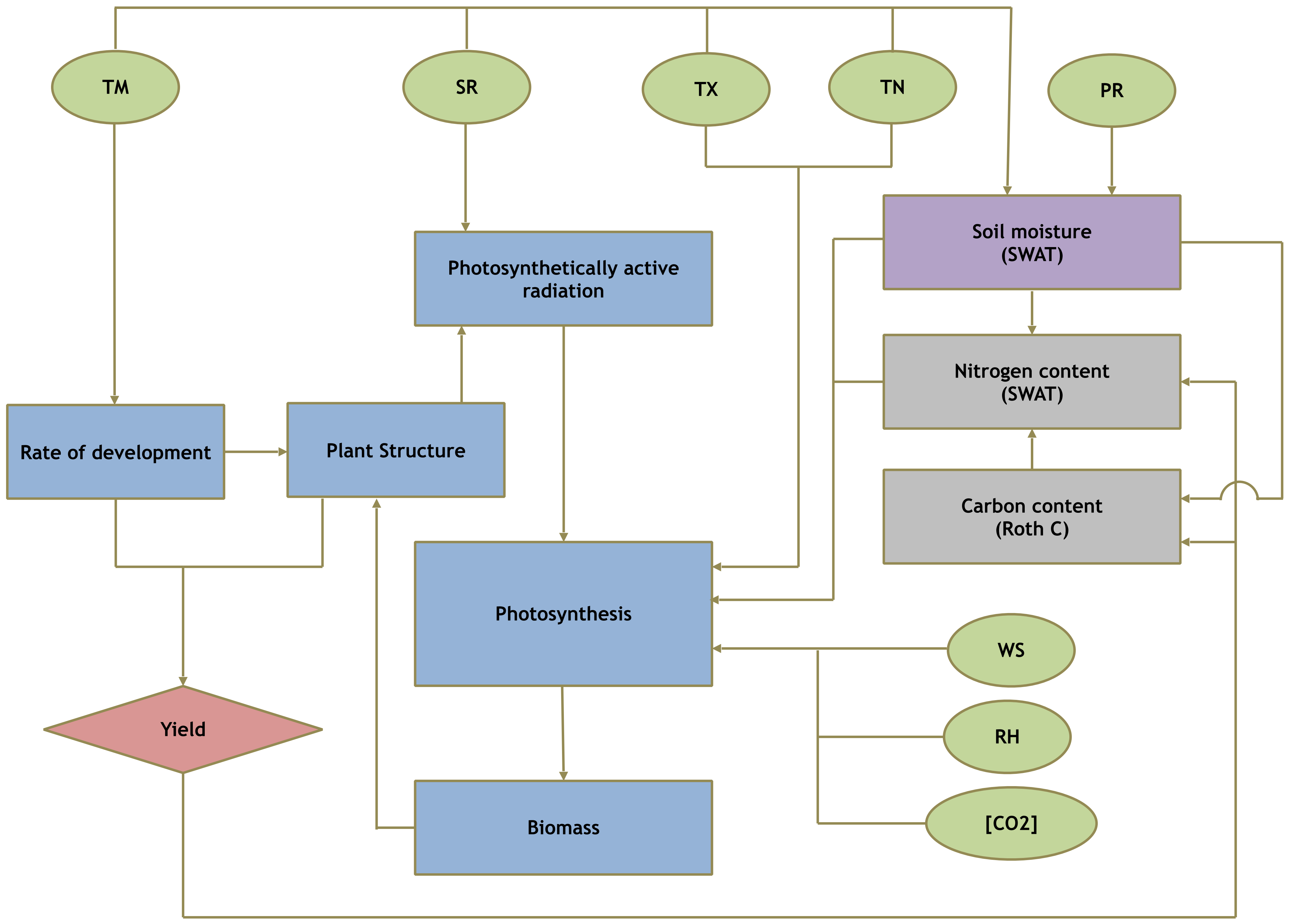
☑For the present purpose, the ensemble prediction system with 108-members has an advantage in finding possible teleconnection patterns influencing the mid-latitude climate with the large stochastic internal variability.

Doi, T., Behera, S. K., & Yamagata, T. (2020). Wintertime impacts of the 2019 super IOD on East Asia. Geophysical Research Letters, 47, e2020GL089456.

Application Ex. 1

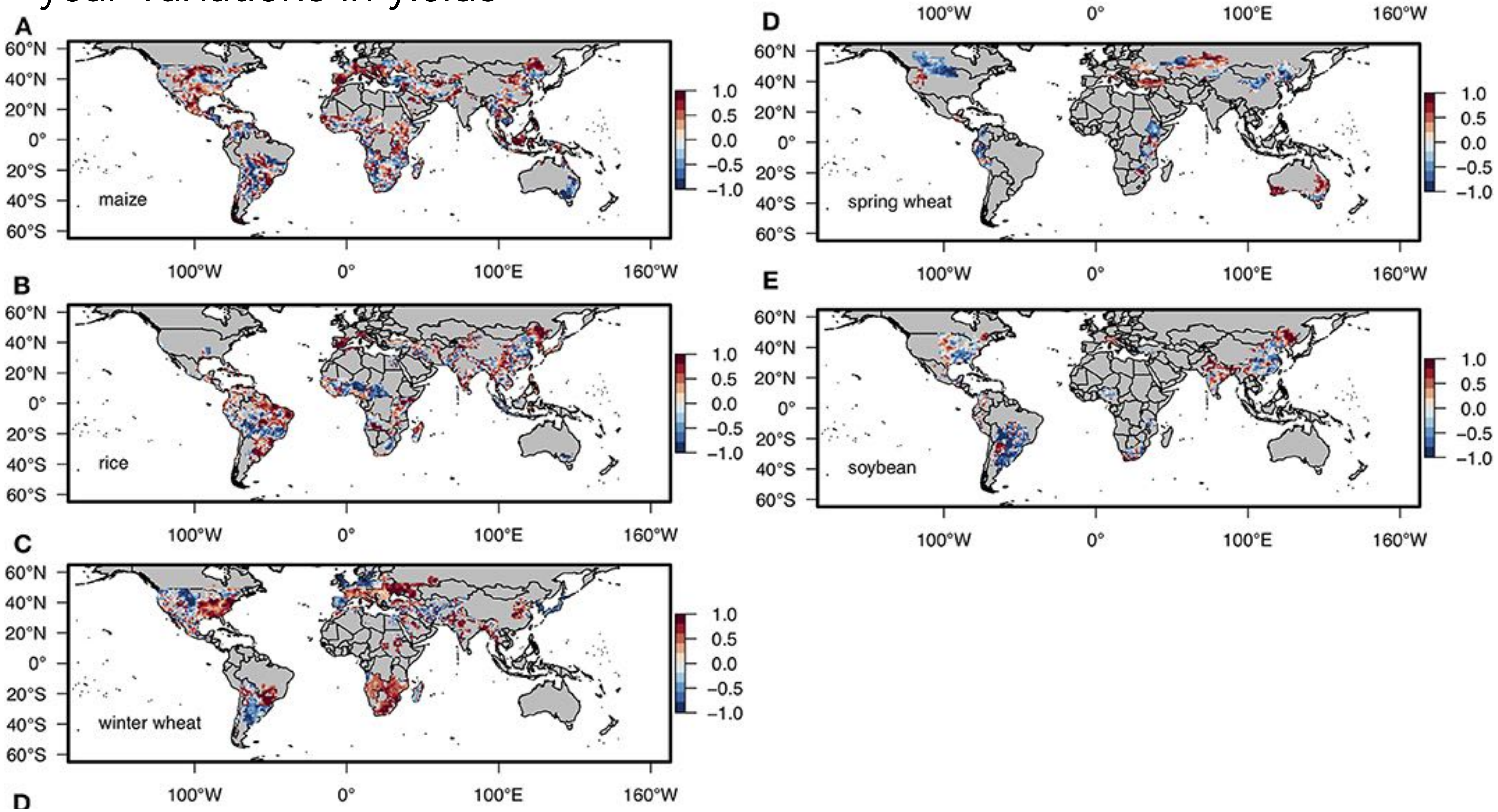
An eco-physiological process-based crop model “PRYSBI2” (developed by NARO) with SINTEX-F2 to predict worldwide yields for four major crops

PRYSBI2 (Sakurai et al. 2014)



The daily outputs from the SINTEX-F2 seasonal prediction system were used as the inputs to the crop model

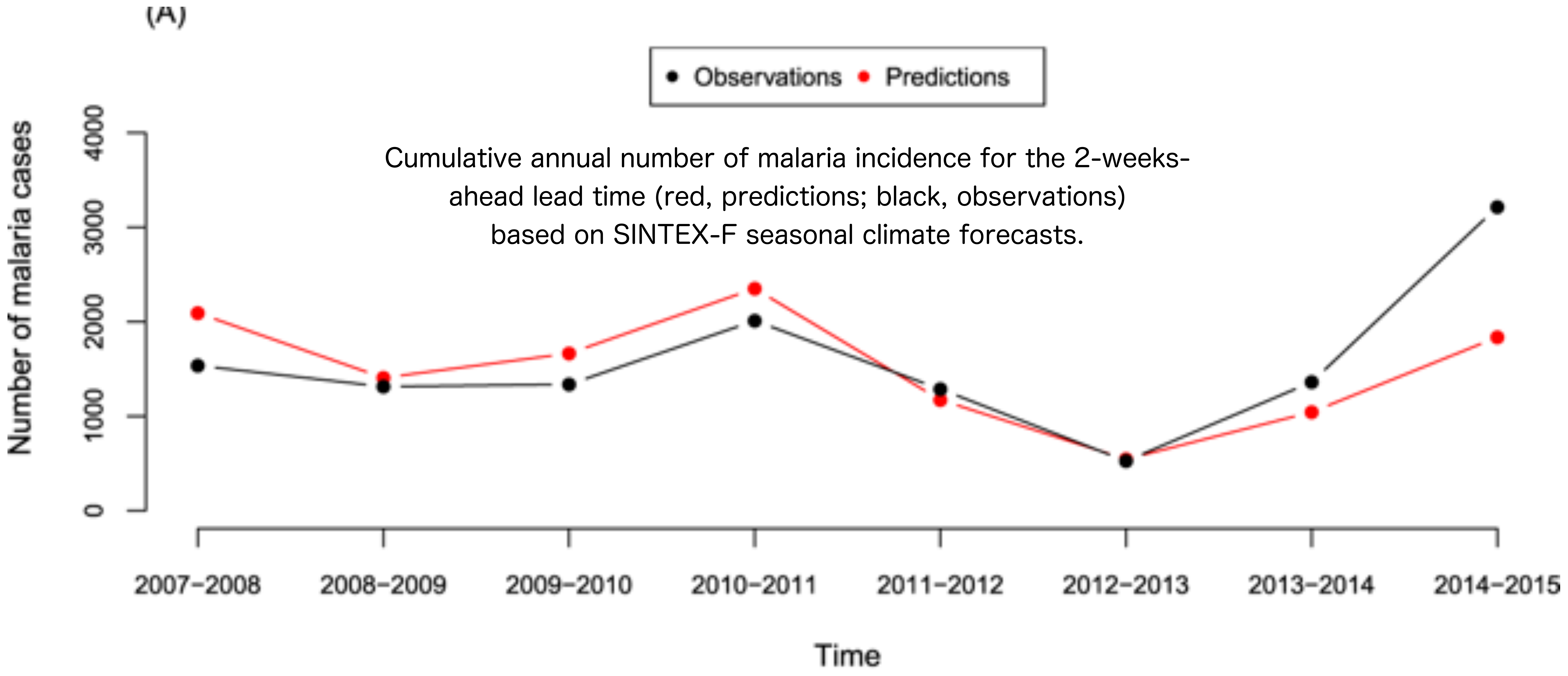
Anomaly correlation scores for a 3-months lead prediction of year-to-year variations in yields



Doi, T., G. Sakurai, and T. Iizumi. 2020. Seasonal Predictability of Four Major Crop Yields Worldwide by a Hybrid System of Dynamical Climate Prediction and Eco-Physiological Crop-Growth Simulation. Frontiers in Sustainable Food Systems. 4: https://doi.org/10.3389/fsufs.2020.00084

Application Ex. 2

Malaria predictions in South Africa based on our seasonal climate forecasts: A time series distributed lag nonlinear model



Kim, Y., and Coauthors (2019), Malaria predictions based on seasonal climate forecasts in South Africa: A time series distributed lag nonlinear model, Scientific Reports, Article No. 17882