The winter North Pacific teleconnection in response to ENSO and the MJO in operational subseasonal forecasting models is too weak

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1. Introduction

● Teleconnection patterns associated with the MJO and ENSO impact weather and climate phenomena in the Pacific-North American region and beyond, and therefore accurately simulating these teleconnections is of importance for seasonal and subseasonal forecasts.

●All 8 subseasonal to seasonal (S2S) forecast models considered simulate a 500-hPa geopotential height response over the Pacific-North America region that is too weak (box 3).

●This overly weak response is associated with overly weak subtropical upper level convergence and a too-weak Rossby wave source in most models, and in several models also with a biased subtropical Pacific jet which affects the propagation of Rossby waves. (box 4,5)

●The net effect is that these models likely under-estimate the impacts associated with the MJO and ENSO over Western North America, and suffer from a reduction in skill from what could be achieved.

2. Methods: S2S hindcasts

model (ensemble members)	years	reforecasts analyzed	vertical levels	model top
CMA - BCC-CPS-S2Sv1 (4)	1999-2014	6 per month	40	0.5hPa
NCEP (4)	1999-2010	9 per month	64	0.02hPa
ECMWF - CY46R1 (11)	2000-2018	4-5 per month	91	0.01hPa
BoM (33)	1981-2013	6 per month	17	10hPa
UKMO (7)	1993-2016	4 per month	85	85km
KMA (3)	1991-2010	4 per month	85	85km
Meteo France - CNRM-CM 6.1(10)	1993-2017	3-5 per month	91	0.01hPa
HMCR (10)	1985-2010	4-5 per month	28	5 hPa

3. North Pacific teleconnection for ENSO and the MJO is too weak in all models

EN-LN response of Z500hPa in week 6 for December initializations

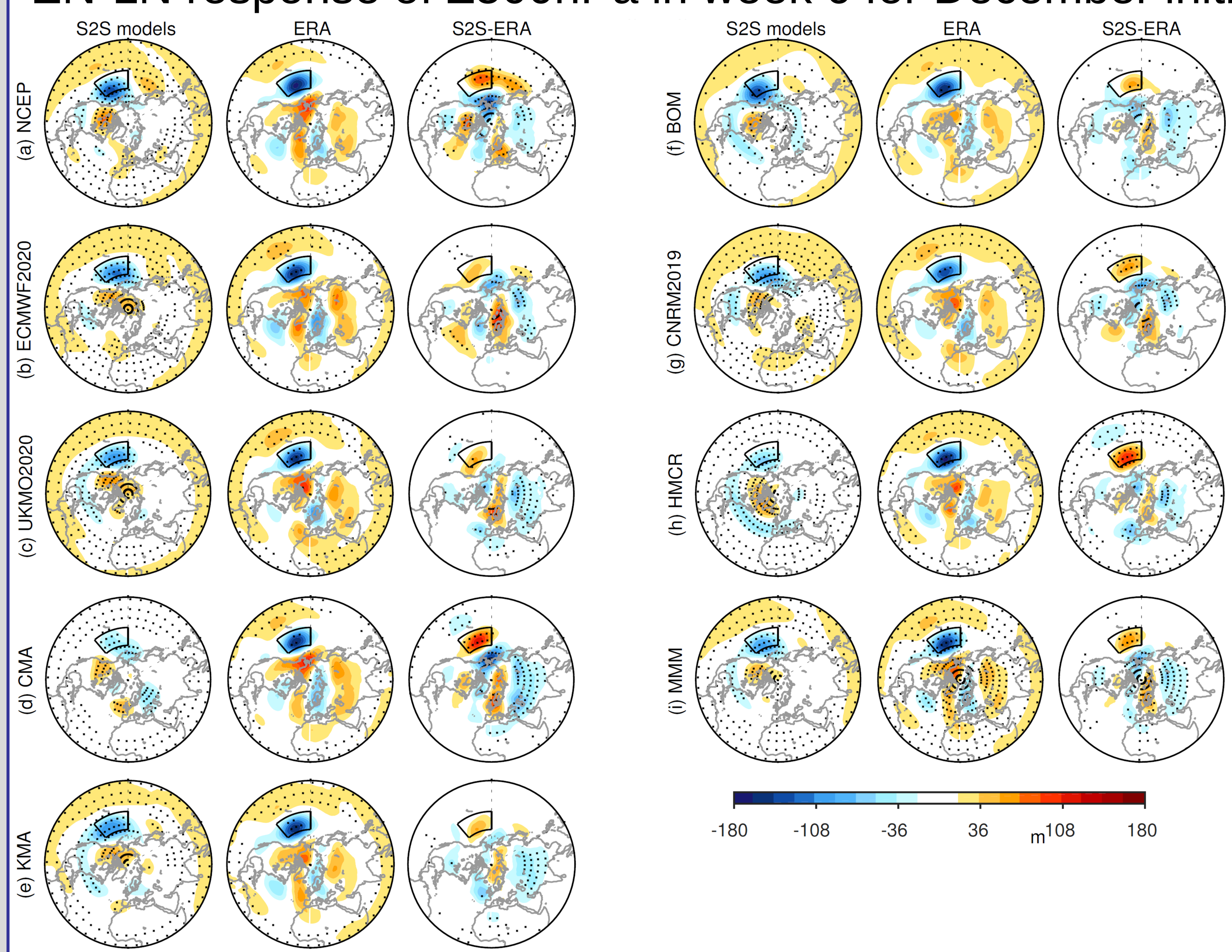

Fig. 1. Response to ENSO in the sixth week after initialization in the December hindcast ensemble for the S2S models. For each model, the left column is for the responses in the S2S models, the middle column is for ERA-I subsampled to match the specific dates included in each composite for each model, and the right column is the difference between the model and reanalysis responses (i.e. the bias). Statistical significance at the 95% confidence level are denoted with dots.

MJO phases 4/5 minus 1/8; Z500 in week 3 for NDJF initializations

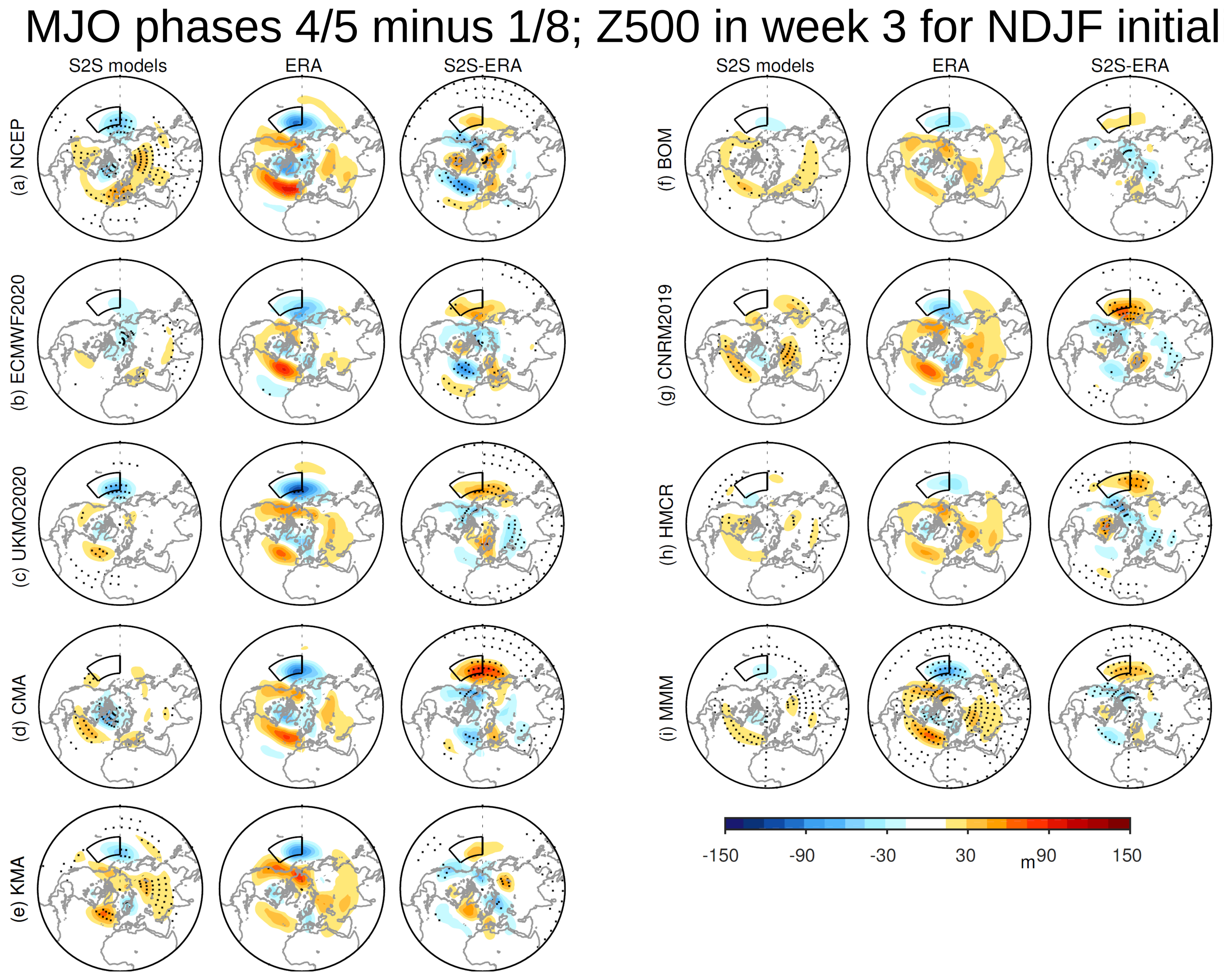

Fig. 2. As in Figure 1 but for week 3 following November through February initializations during MJO phases 4/5 as compared to MJO phases 8/1.

Less than 3% of individual ensemble members simulate a response as strong as that observed.

4. Biases in tropical convection response to ENSO

EN-LN response of omega at 500hPa in week 6 for December initializations

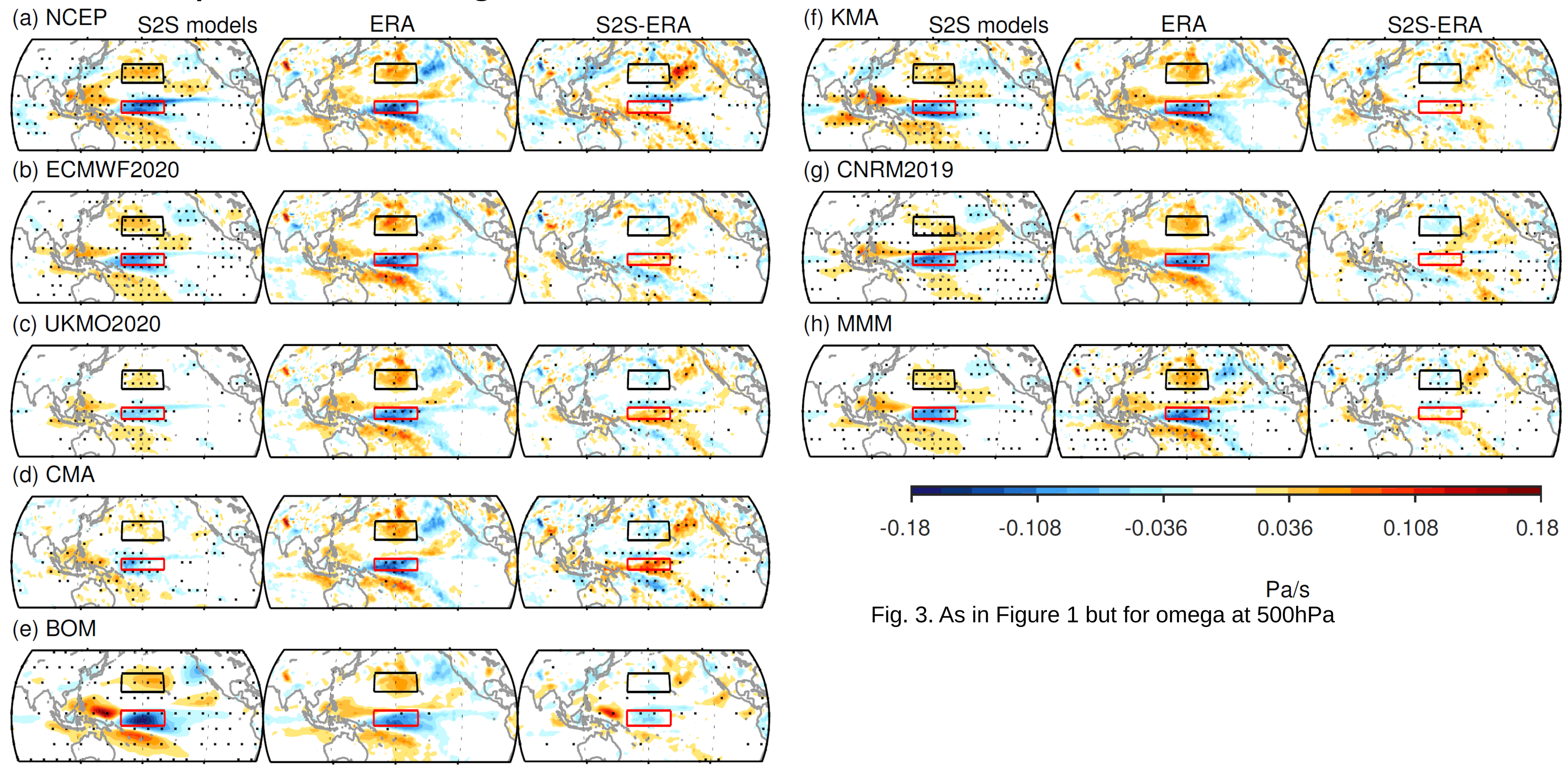

Fig. 3. As in Figure 1 but for omega at 500hPa

- All models simulate enhanced upwelling in the tropical Central Pacific and subsidence over the subtropical North Pacific, however the magnitude is often not correct.
- BoM, KMA, and NCEP all simulate stronger tropical upwelling and subtropical subsidence than observed, while other models simulate too-weak of a response especially in subtropics. However even these three relatively successful models struggle to simulate the upper level subtropical convergence as strongly as observed.
- Biases even worse for the MJO (see paper).

EN-LN response of divergence at 200hPa in week 6 for December initializations

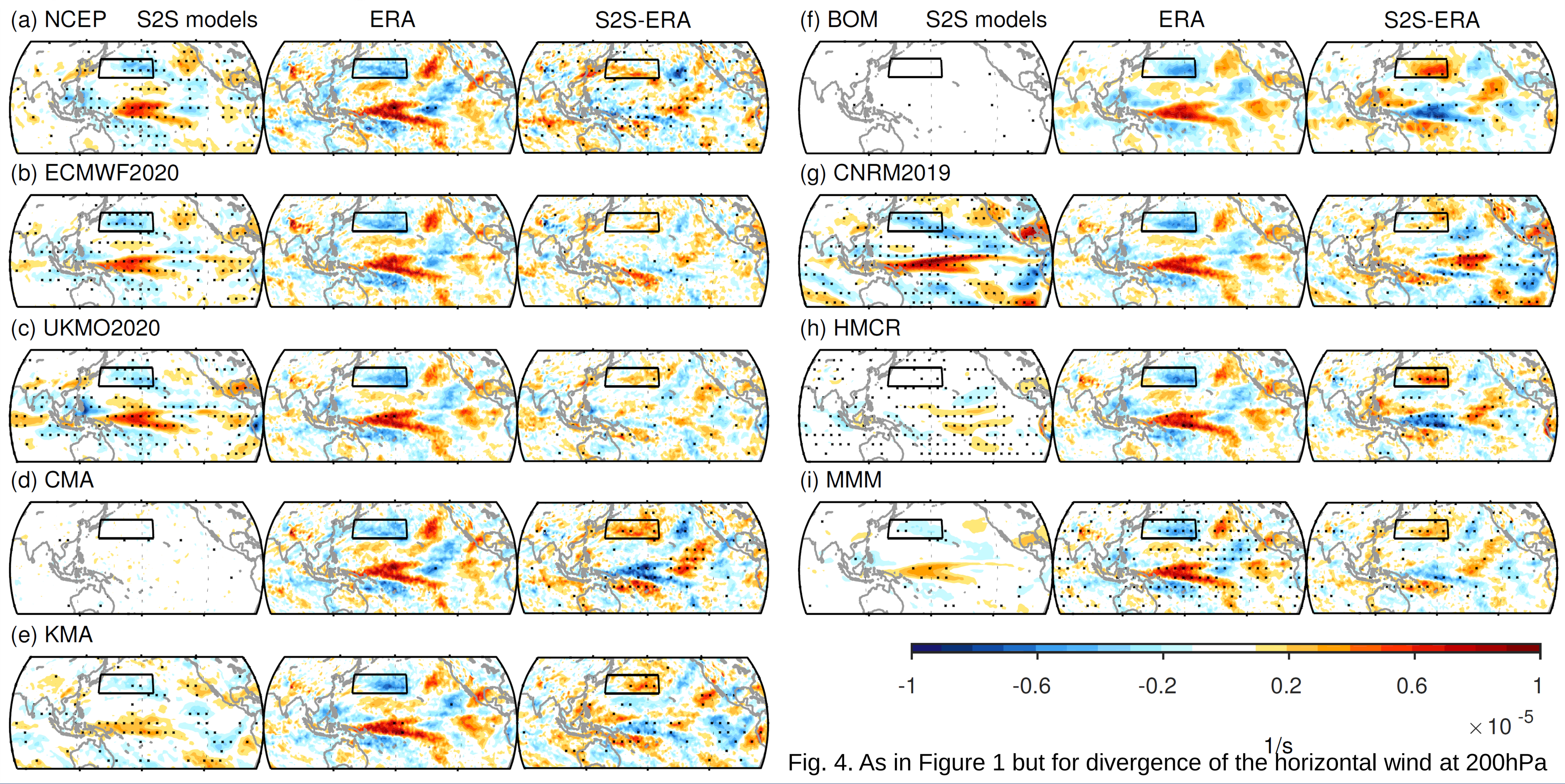

Fig. 4. As in Figure 1 but for divergence of the horizontal wind at 200hPa

5. Mean state bias in East Pacific jet

U200hPa climatology in week 6 for December initializations

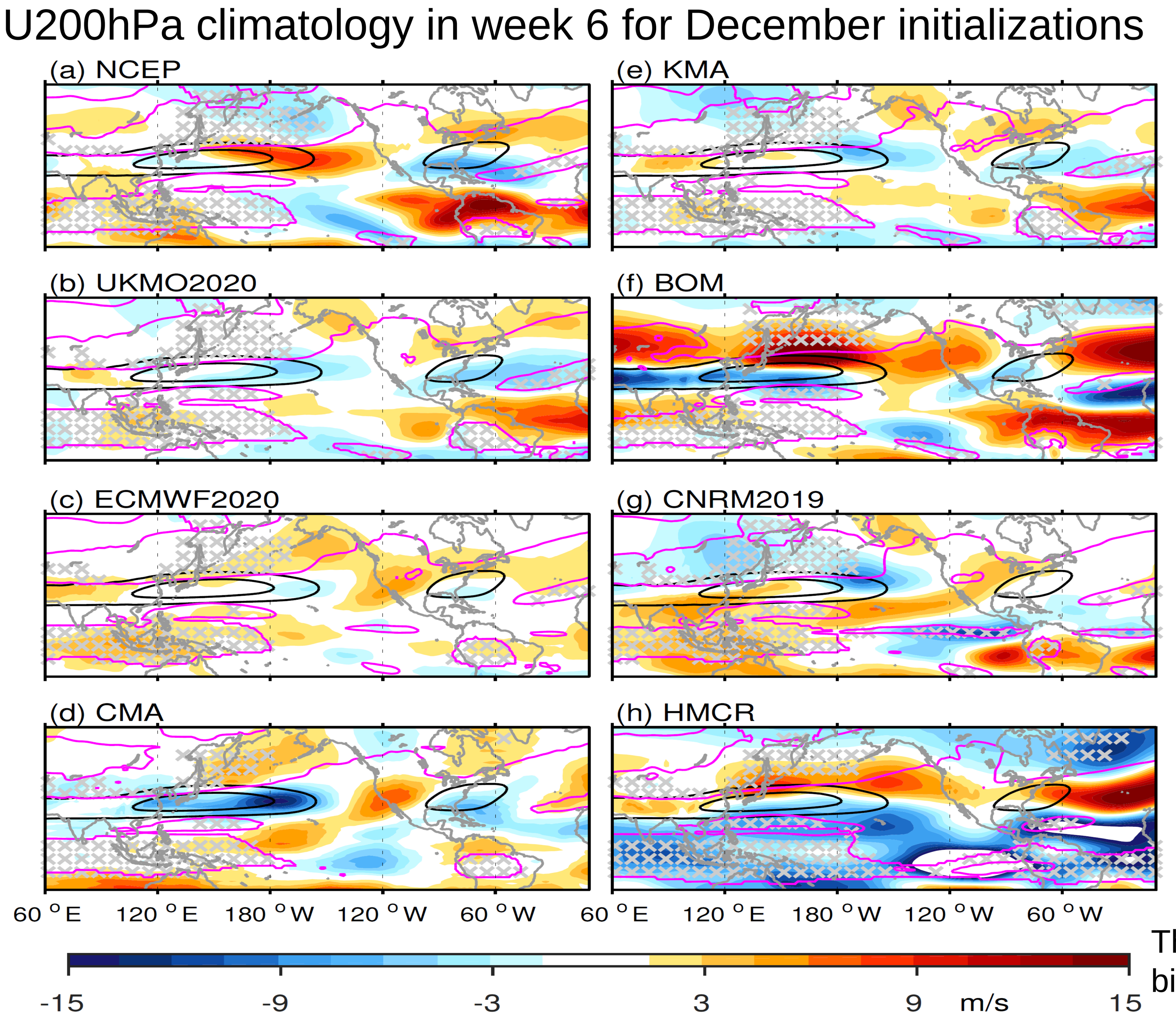

Fig. 5. Biases in U 200hPa in week 6 (color contours), the 40m/s and 60m/s isotachs for the corresponding dates in ERA-i (black contours), and the climatological region of forbidden propagation for linear stationary Rossby waves (gray stippling).

Three classes of biases:

1. NCEP, HMCR, and BoM suffer from an eastward extended jet. Consistent with this, the region of forbidden linear wave propagation on the poleward flank of the jet (Ks undefined) extends further eastward for NCEP and BoM, however for HMCR wind biases elsewhere overwhelm this effect. This leads to a North Pacific low that extends too close to North America (consistent NCEP, BoM panels in Figure 1).
2. CNRM and CMA suffer from a jet that does not extend far enough eastward and that is equatorward shifted. An equatorward shift, in isolation, leads to a too-strong teleconnection, thus we suspect that these models have compensating biases.
3. UKMO, ECMWF, and KMA have the smallest biases among the models, however all three suffer from a jet that does not extend far enough eastward. This leads to a North Pacific low too weak near the midlatitude West Coast of North America and too strong over Alaska.

Overall, while the U200hPa biases differ across models, they lead to biases in the location of the wavetrain.

For more information

Garfinkel C.I., W. Chen, Y. Li, C. Schwartz, P. Yadav, D.I.V. Domeisen (2023), The winter North Pacific teleconnection in response to ENSO and the MJO in operational subseasonal forecasting models is too weak, J. Climate, doi: 10.1175/JCLI-D-22-0179.1.