

An investigation of midlatitude circulation errors in a hierarchy of climate prediction ensembles

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Abstract

The projected response of the atmospheric circulation to changes driven by increasing greenhouse gas concentrations is highly uncertain. One of the primary reasons for this is that the state-of-the-art models we employ to investigate these responses struggle to represent basic features of the midlatitude circulation such as storm tracks, jets and blocking. Biases also have detrimental effects on predictive skill for dynamically driven fields at climate prediction time scales of seasons to decades. Despite this, physical understanding of the controls on these features and the drivers of their biases is still limited. Here we investigate a hierarchy of large ensemble climate reanalysis and hindcast simulations performed by the Norwegian Earth System Model (NorESM). Each ensemble is 30 members and was run from 1985-2010. For the reanalysis runs various data-assimilation strategies were employed. These are: SST only, SST plus hydrographic profiles, SST plus hydrographic profiles plus sea-ice concentration. The assimilation was performed monthly after which the model runs freely. These are compared to both free runs and AMIP-style simulations with ERA-Interim serving as ground truth. We evaluate the North Pacific and North Atlantic jets in winter and summer. We also identify where the observations lie within the predictive distribution of the ensemble. Results show that the North Atlantic jet is too zonal, extends too far into Europe and is shifted northwards. Virtually the entire North Atlantic sector lies outside the predictive distribution of the ensemble and performance actually degrades in the simulations with tighter constraints on the assimilation. By contrast the North Pacific jet is rather better represented in all aspects both with respect to pattern as well as magnitude of the biases. This is likely due to the better-represented teleconnections between the tropical and extratropical Pacific. Comparison of these ensembles with AMIP simulations suggests that the errors in the midlatitude circulation reside in the atmospheric component of the model. We also present results from hindcast simulations where NorCPM was initialized at different times of the year and then run forward 12 months. Implications and causes of the varying behavior among the ensembles are discussed as well as prospects for the future.

An investigation of midlatitude circulation biases in a hierarchy of climate prediction ensembles



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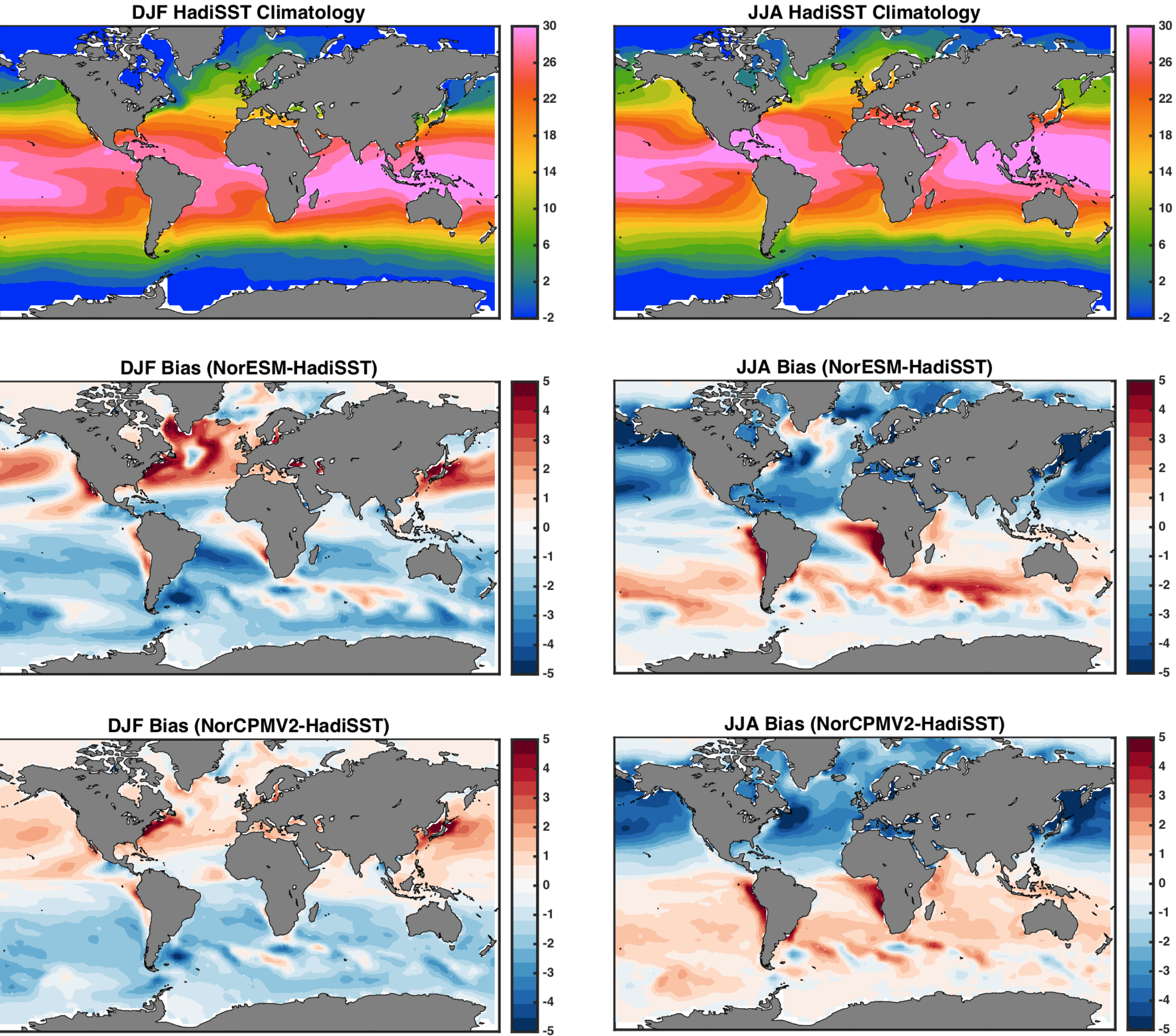
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We investigate circulation biases in large ensembles of climate reanalysis and hindcast (not shown) simulations performed by the Norwegian Earth System Model (NorESM). Biases have detrimental effects on predictive skill for dynamically driven fields at climate prediction time scales of seasons to decades. They also contribute to the large uncertainty in the circulation response to external forcing. We aim to better understand their physical drivers.

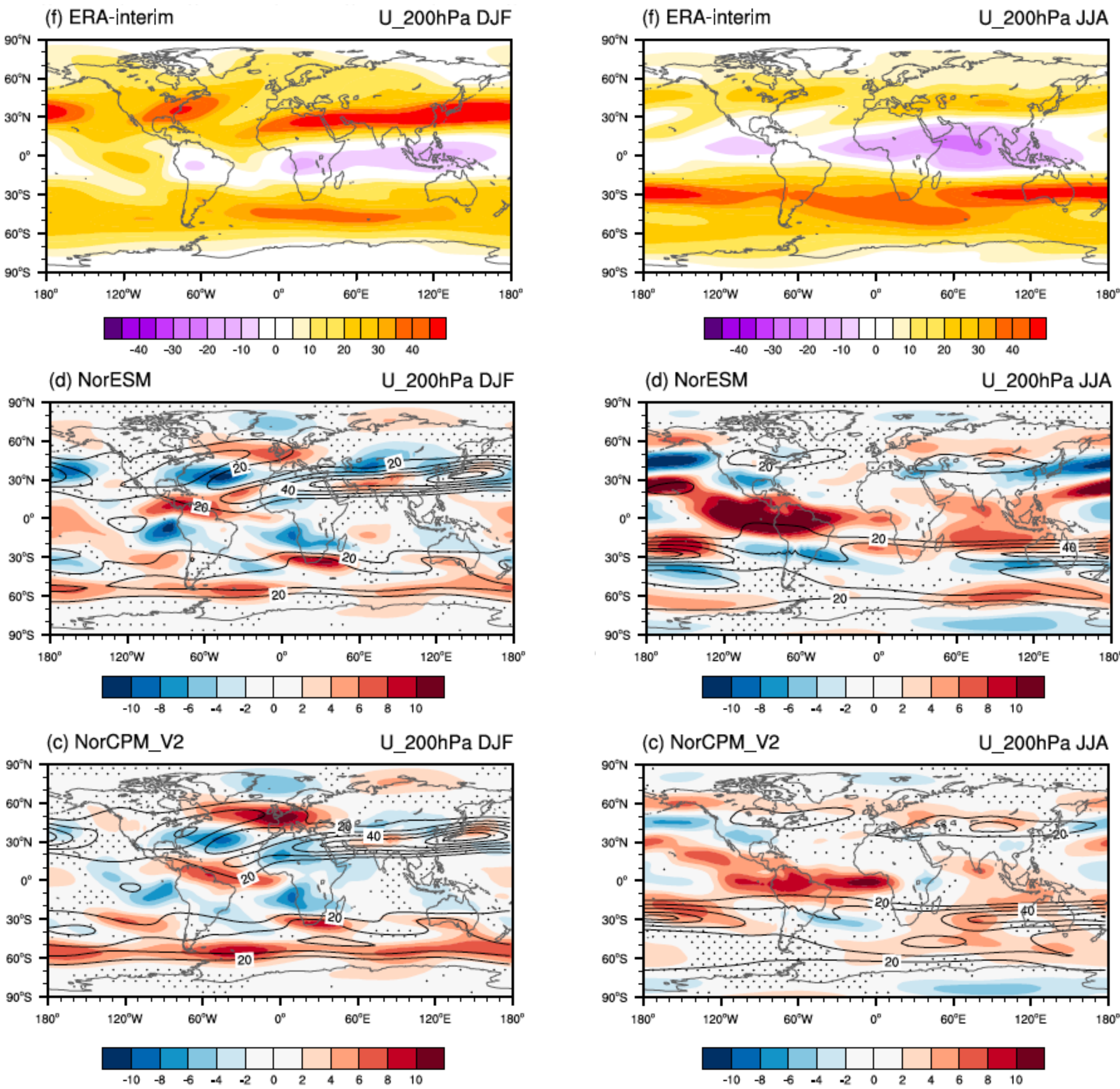
5 Key takeaways:

- Key features of midlatitude circulation in ERA-I generally not covered by the ensemble spread (30 members)
- Largest improvements over North Pacific
- Large SST biases persist (>25%); pattern suggests too weak atmosphere-ocean interactions
- Biases are asymmetric in time and space; largest in summer(winter) over North Pacific(North Atlantic)
- However, NAO variability is reasonably well reproduced; though with large spread

Winter(left) and summer(right) SST biases improve with assimilation but indicate strong dynamical feedbacks from the atmosphere



Biases in winter(left) and summer (right) upper level winds show some improvement over North Pacific/Tropics but little change over North Atlantic



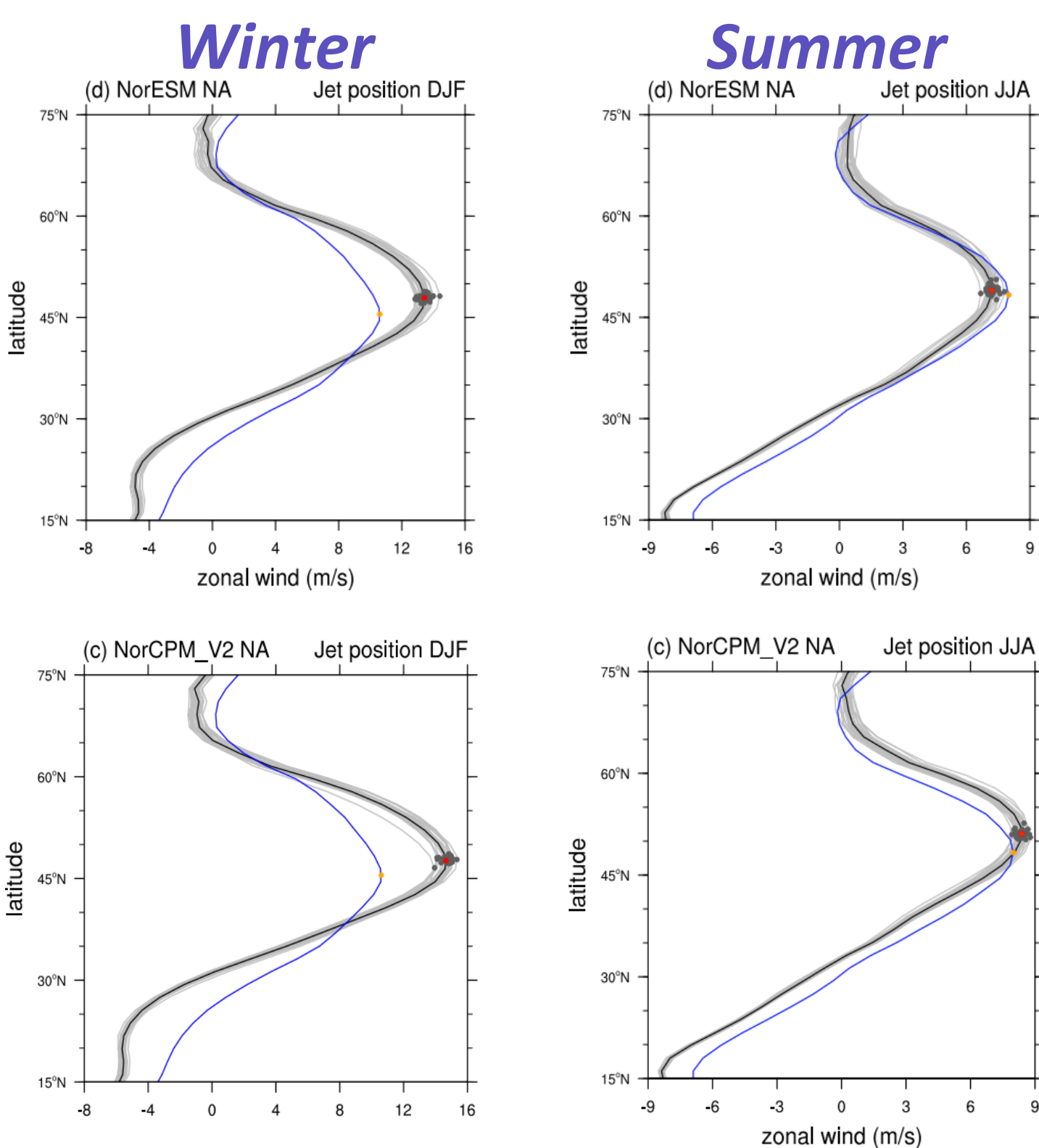
“Reanalysis” simulations (monthly assimilation):

- NorCPM V0*: anomaly assimilation SST (HadI)
- NorCPM V1*: anomaly assimilation SST (HadI), temperature, salinity (EN4)
- NorCPM V2*: full field assimilation SST + SIC (HadI), temperature, salinity (EN4) [SHOWN HERE]
- NorESM: free run, no assimilation [SHOWN HERE]
- NorESM AMIP: 1985-2008 atmosphere only, only 5 ensemble members

* 1985-2010, 30 members, NorCPM ME, monthly assimilation

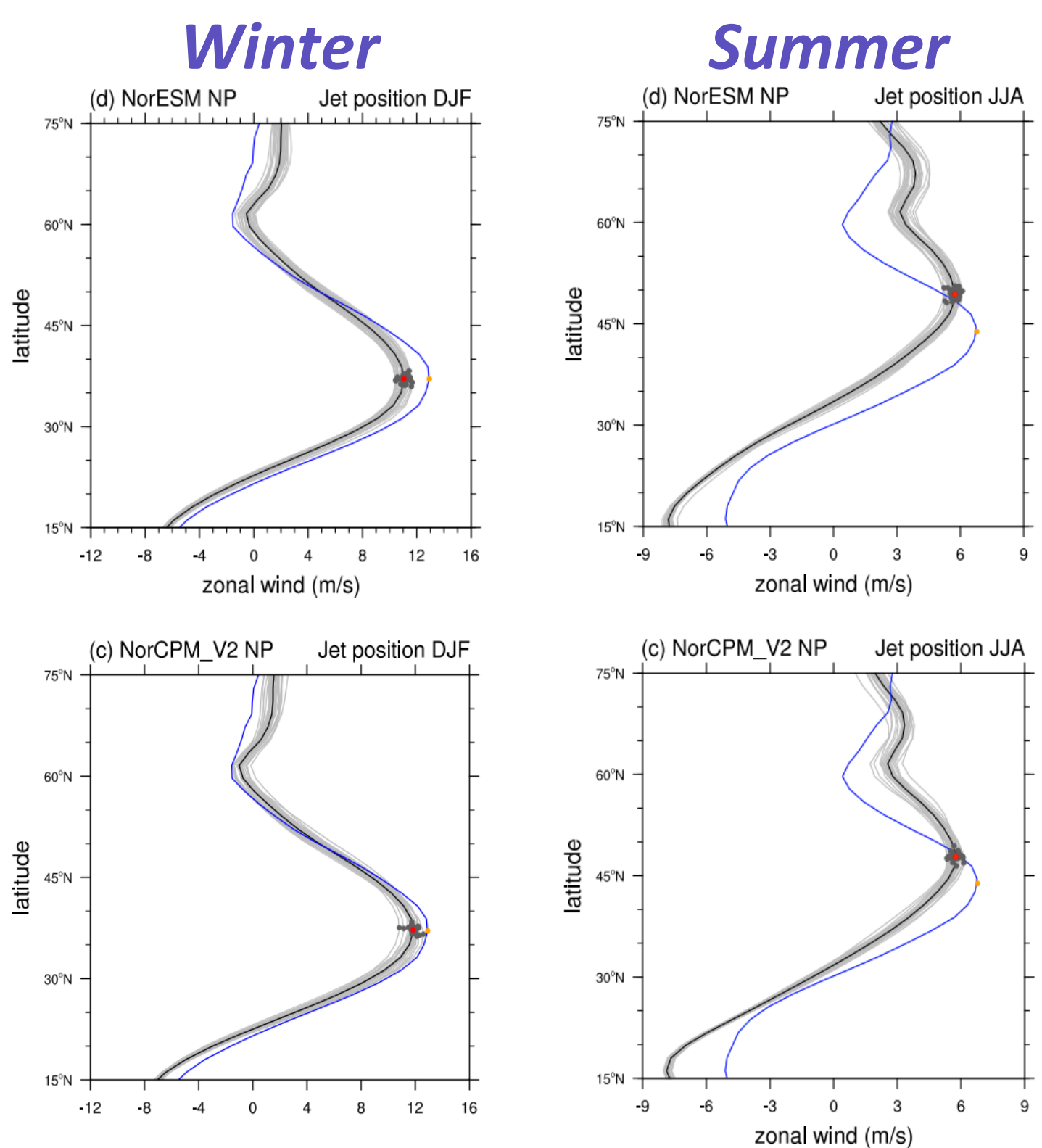
Eddy driven jet biases in North Atlantic (60W-0)

- Winter jet too strong/poleward; ERA-I not covered by the spread
- Summer jet much better; ERA-I mostly covered by the spread
- Both seasons are degraded by data assimilation

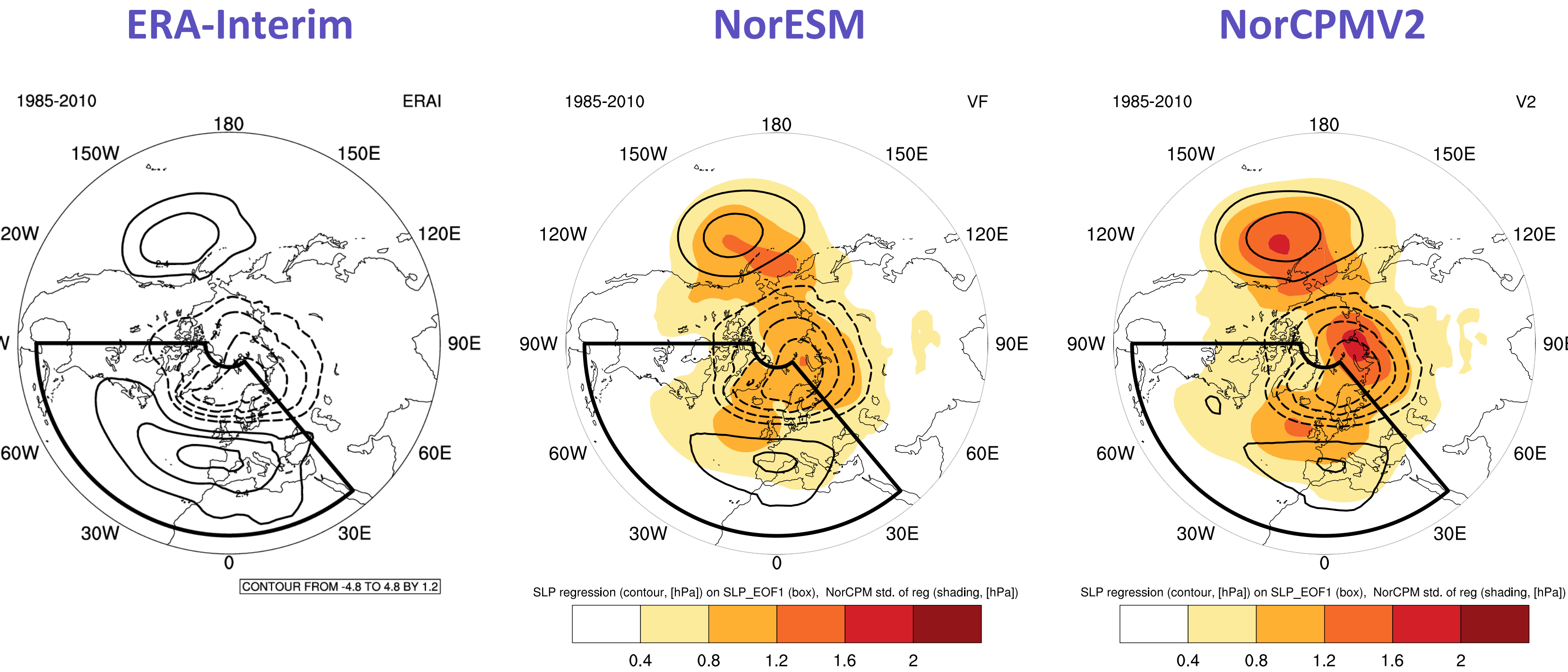


Eddy driven jet biases in North Pacific (135E-125W)

- Winter jet includes ERA-Interim through part of the jet core, but is too weak.
- Summer jet is poorly reproduced in both latitude, speed and width.
- Data assimilation appears to improve the simulation in both seasons



Despite large jet biases NAO is reproduced reasonably well



NAO calculated as the first EOF of DJF SLP in the black boxes of each panel. Contours (black lines) show SLP regressed onto the first EOF (contour interval +/- 1.2 hPa). Shading shows the uncertainty across all 30 members of each ensemble in the right two panels.



Please consider submitting an abstract to our EGU2019 session: “Biases in weather and climate models: understanding drivers, paths to improvement and implications for the future” (QR Code at left)



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