Defining Internal Atlantic Multidecadal Variability in a Changing Climate: Insights from Large Ensembles

Clara Deser & Adam S. Phillips
Climate Analysis Section (NCAR)

CESM Tutorial
August 9, 2022

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Deser and Phillips (*Geophys. Res. Lett*. 2021 & 2022 submitted)

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NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

Automated tool for analyzing leading modes of variability in models and observations.

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

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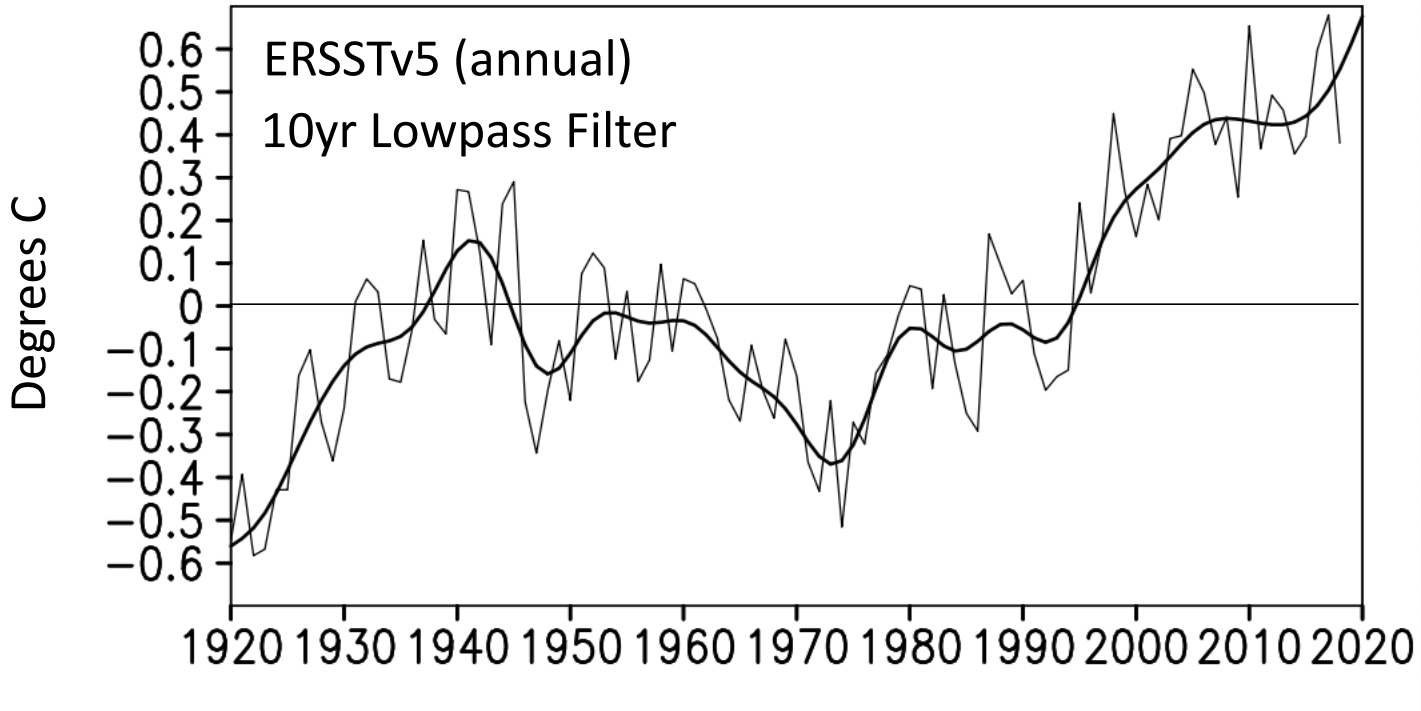
e.g., ENSO, Pacific Decadal Variability, Atlantic Multidecadal Variability.

What is Atlantic Multidecadal Variability?

North Atlantic (0-60N) SST anomalies

(Enfield et al. 2001)



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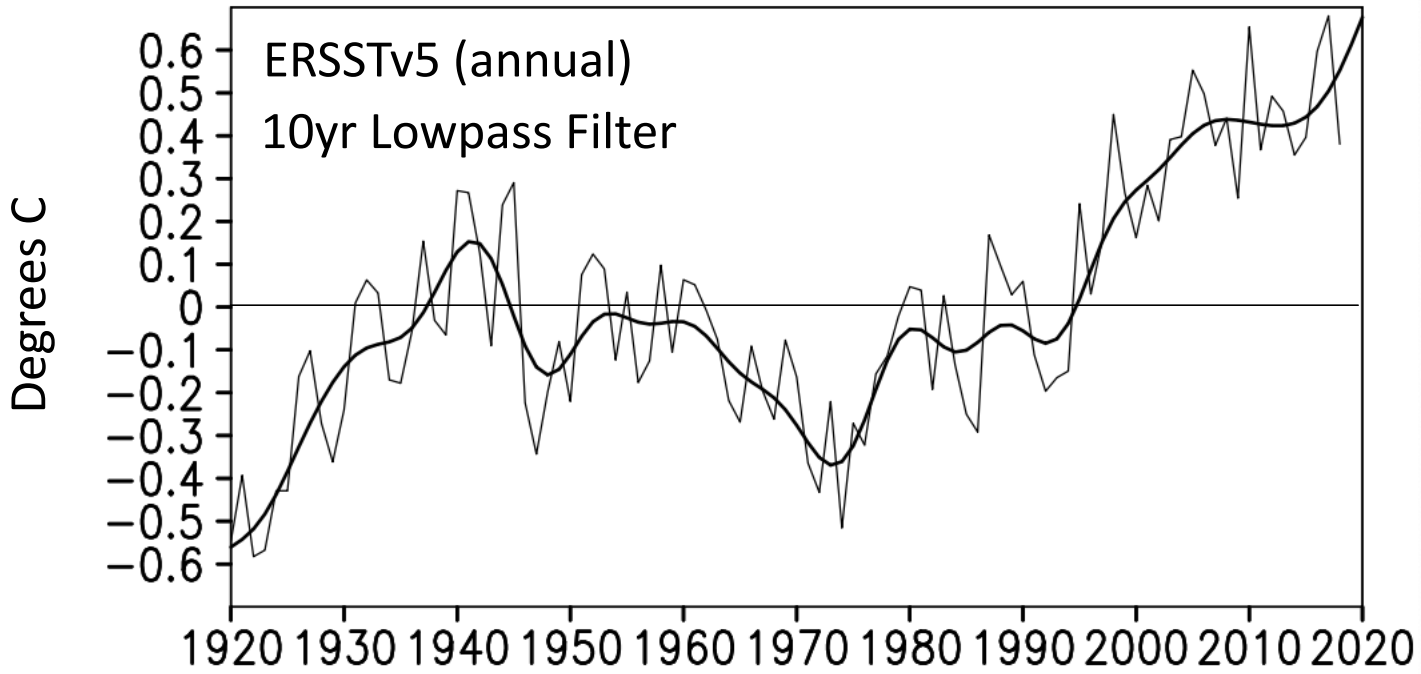

- Need to remove the global warming signal to isolate the internal component of AMV.

What is Atlantic Multidecadal Variability?

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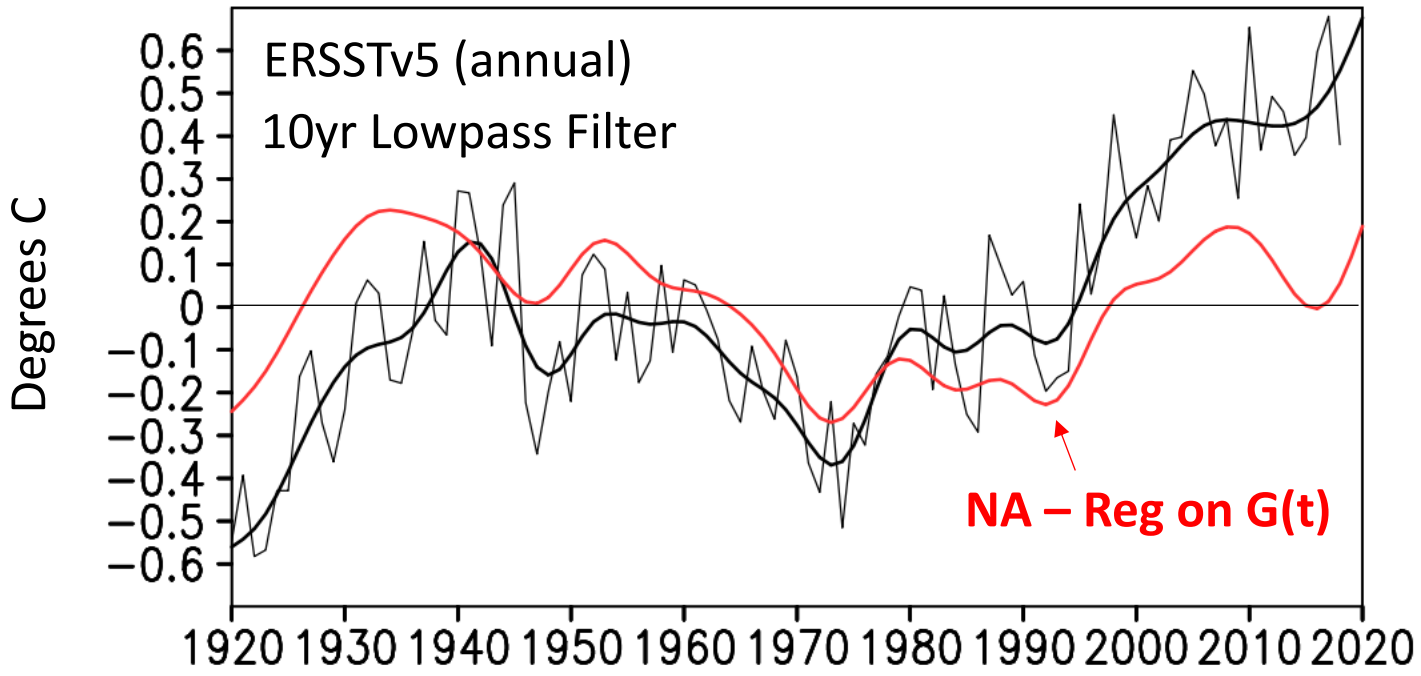

Subtract the component that is linearly related to global mean SST.

Internal Component

What is Atlantic Multidecadal Variability?

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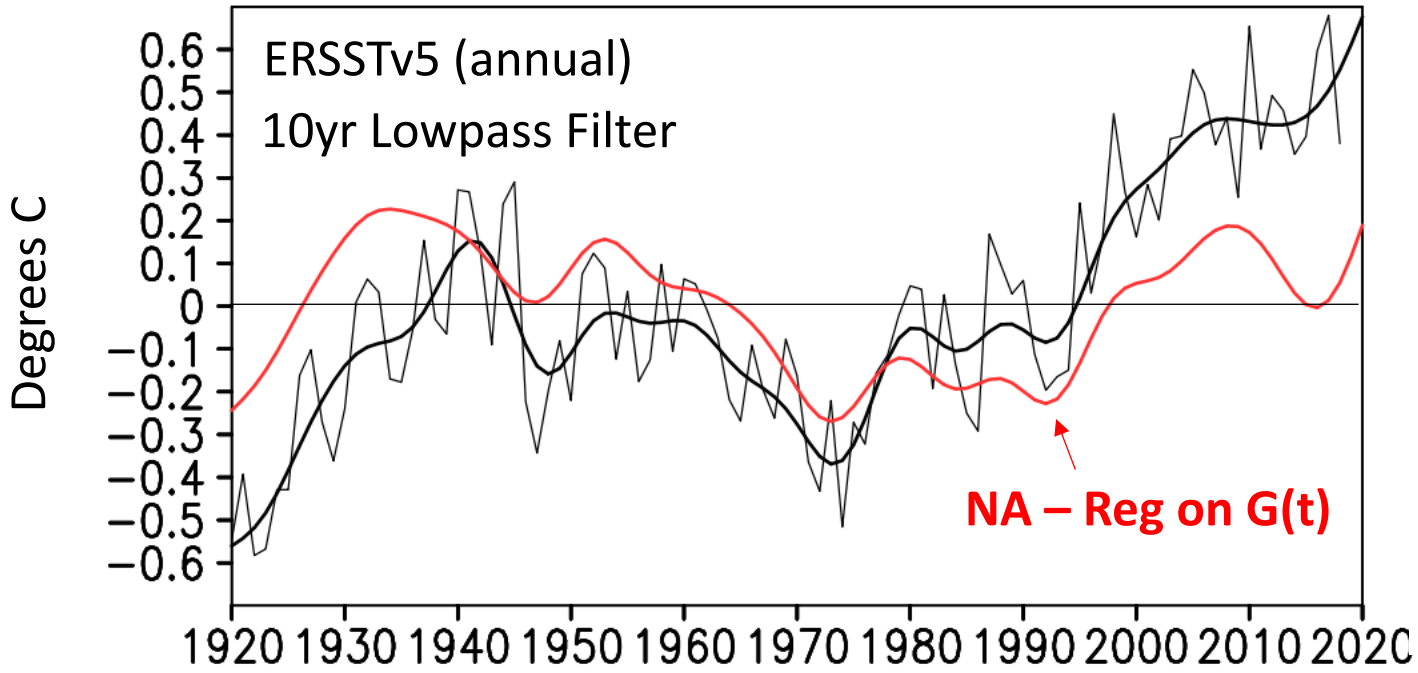
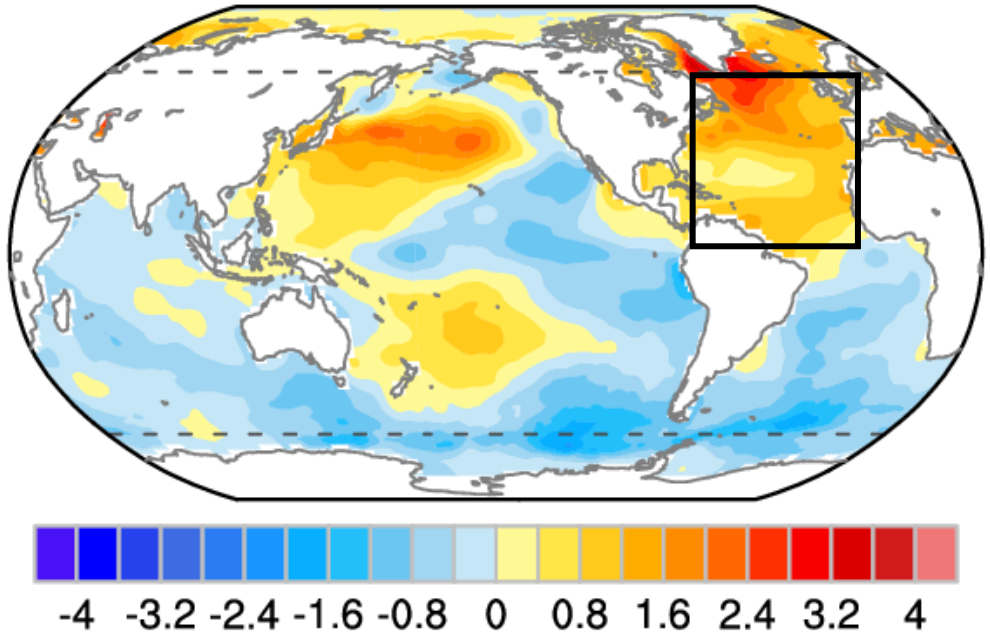
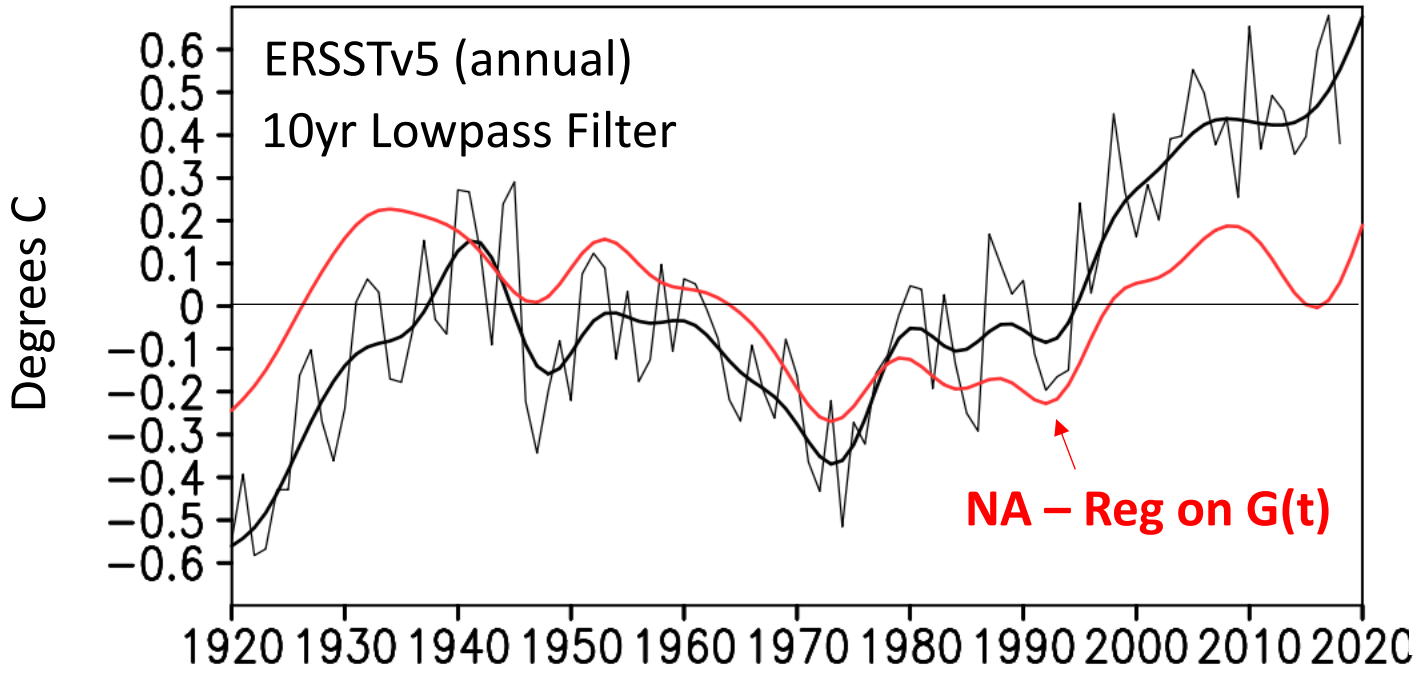


Regression on AMV Index



After removing component that is linearly related to global mean SST.

Does this procedure really isolate the internal component of AMV?



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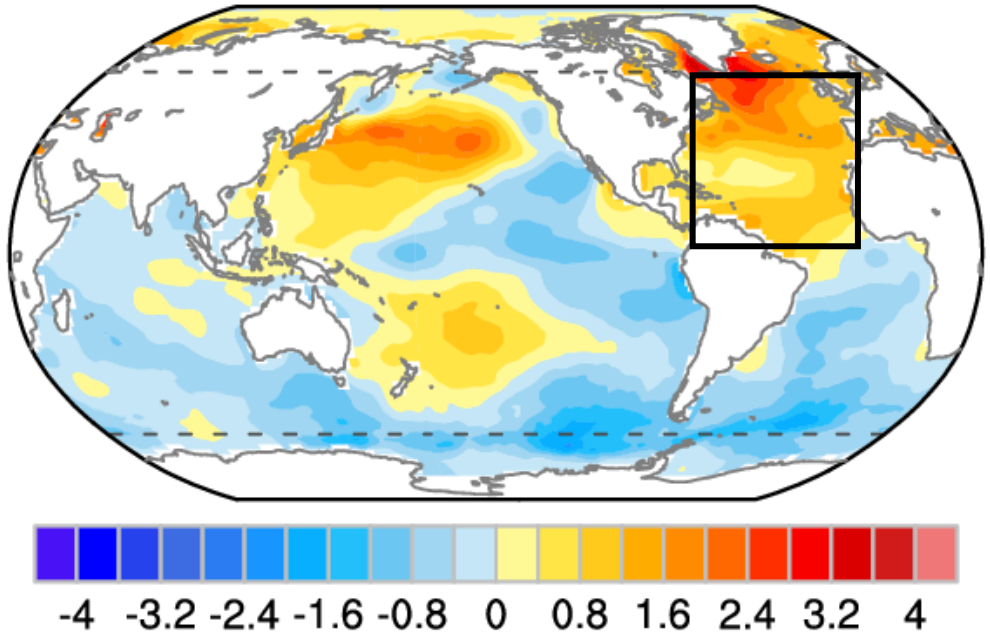

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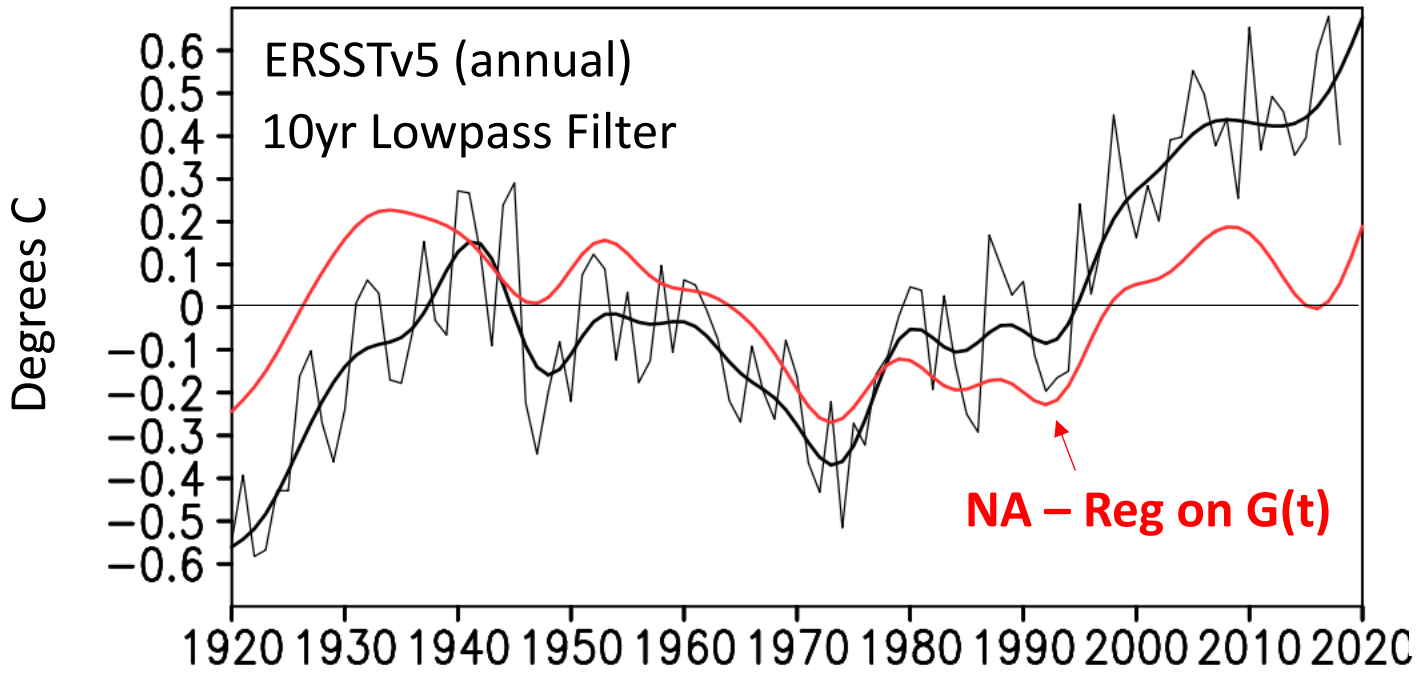
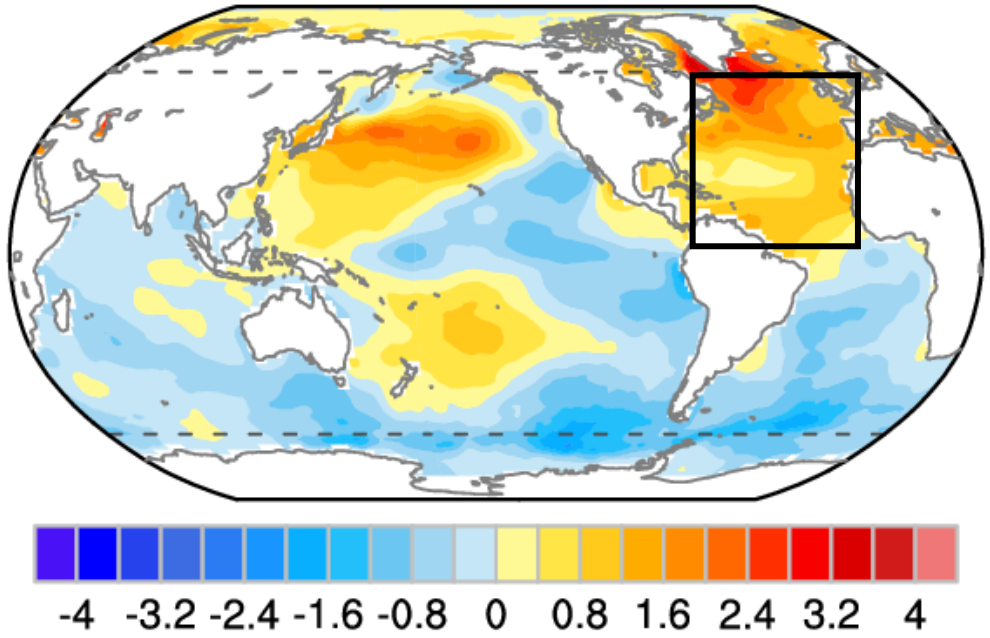


Test with model Large Ensembles, where the true internal variability is known *a priori*.

Regression on AMV Index



After removing component that is linearly related to global mean SST.

“Initial-condition” Large Ensemble Simulations with Global Earth System Models

nature climate change

30 March 2020

PERSPECTIVE

https://doi.org/10.1038/s41558-020-0731-2

Check for updates

Insights from Earth system model initial-condition large ensembles and future prospects

C. Deser[1,2]✉, F. Lehner[1,2], K. B. Rodgers[2,3,4], T. Ault[2,5], T. L. Delworth[2,6], P. N. DiNezio[2,7], A. Fiore[2,8], C. Frankignoul[2,9], J. C. Fyfe[2,10], D. E. Horton[2,11], J. E. Kay[2,12,13], R. Knutti[2,14], N. S. Lovenduski[2,12,15], J. Marotzke[2,16], K. A. McKinnon[2,17], S. Minobe[2,18], J. Randerson[2,19], J. A. Screen[2,20], I. R. Simpson[1,2] and M. Ting[2,8]

“Initial-condition” Large Ensemble Simulations with Global Earth System Models

Many (30-100) simulations with the same model under the same radiative forcing scenario, but different initial conditions.

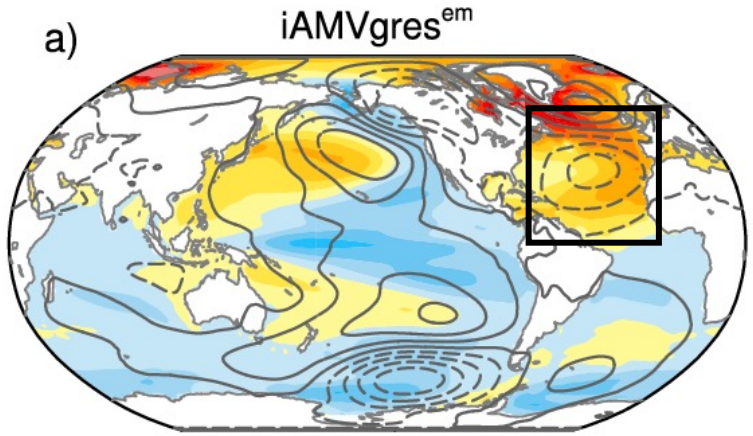
- **Each simulation has its own random sequence of internal variability, superimposed upon a common forced response (estimated by the ensemble-mean).**

- **Isolate the internal variability in each simulation by subtracting the ensemble-mean at each time step.**

7 Model Large Ensembles
(30-100 simulations each; 420 total)

Analysis Period: 1950-2020
(similar results for 2030-2100)

Regression on AMV Index after removing component that is linearly related to global mean SST.



SST shaded, SLP contoured

7 model Large Ensembles
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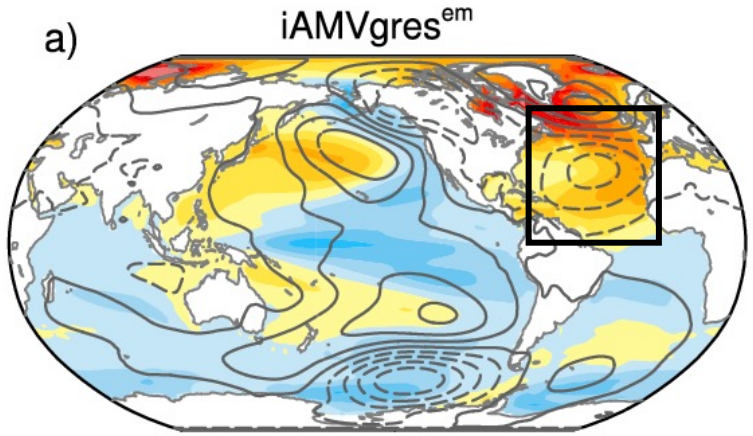

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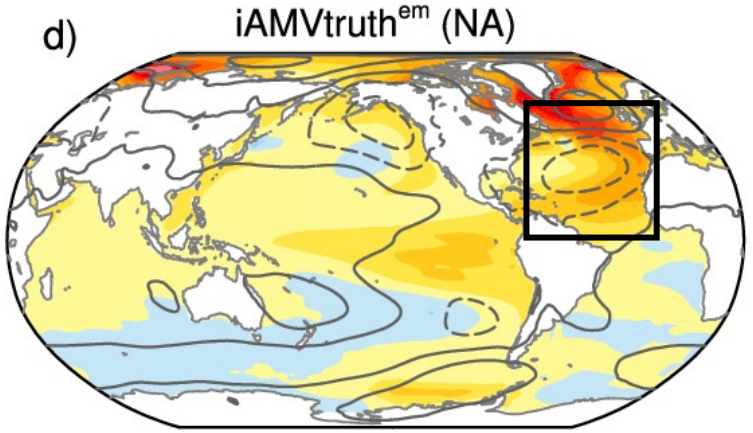

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Regression on AMV Index: **True internal variability.**

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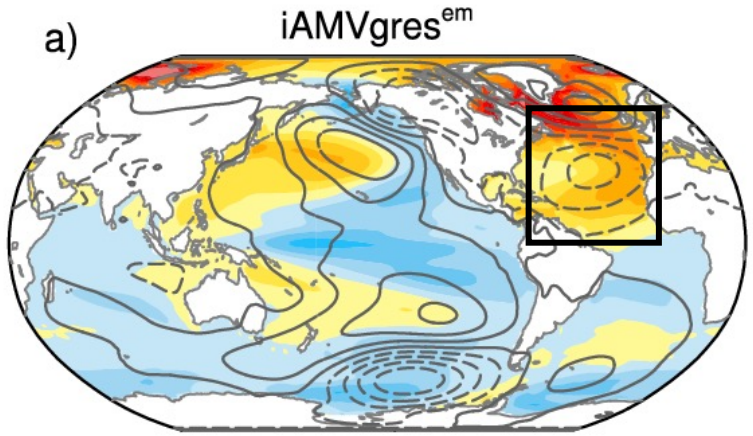

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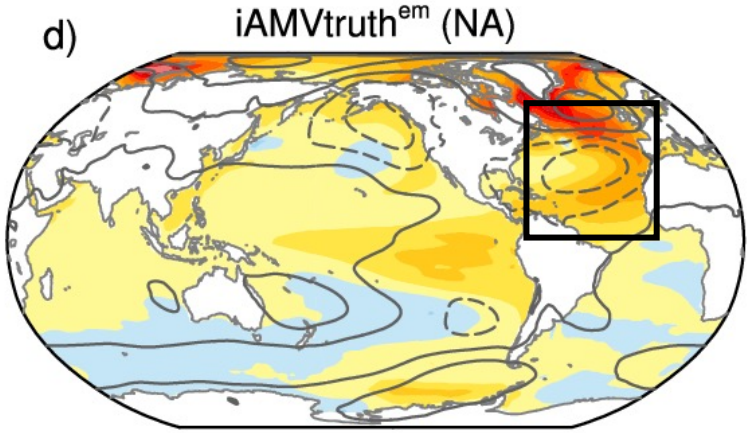

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G(t) = forced G(t) + internal G(t)

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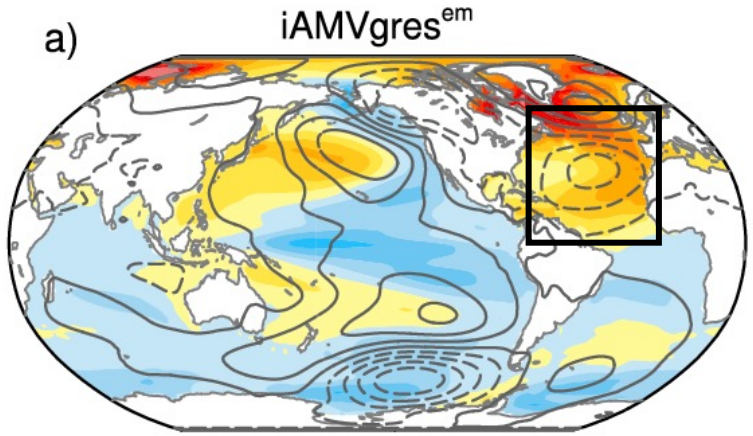

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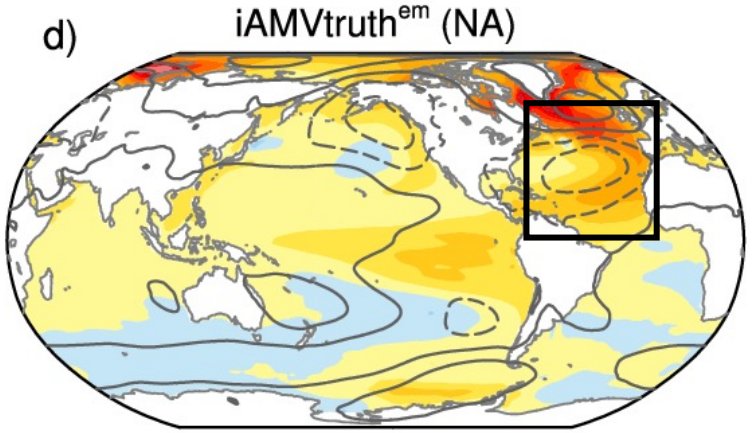

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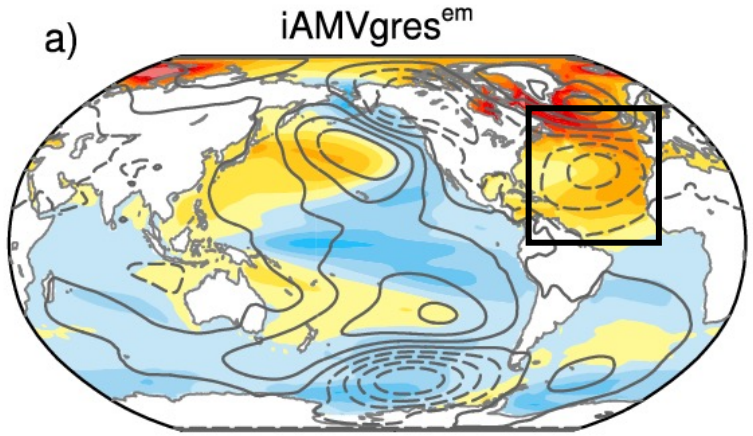

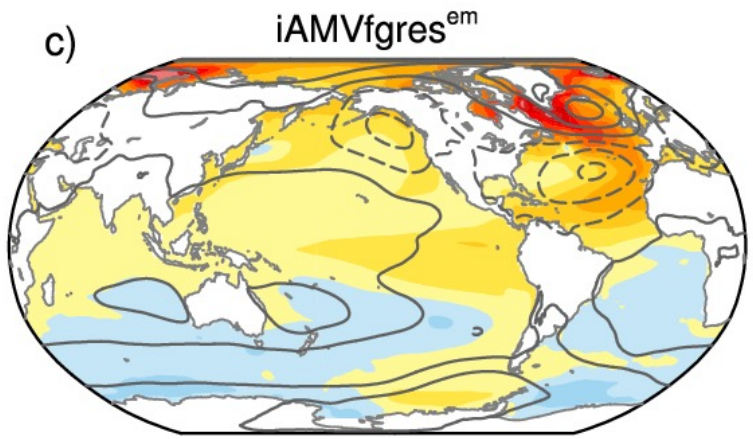

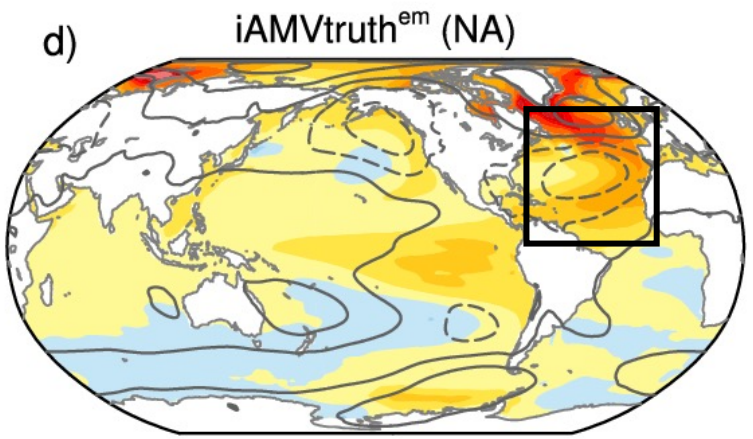

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Regression on AMV Index after removing component that is linearly related to global mean SST.

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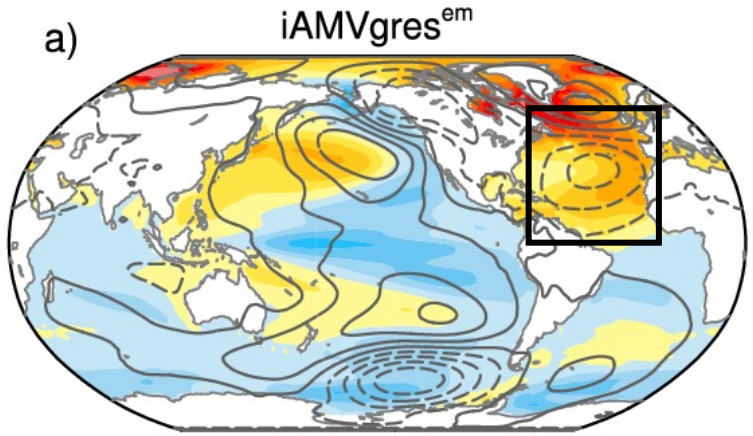
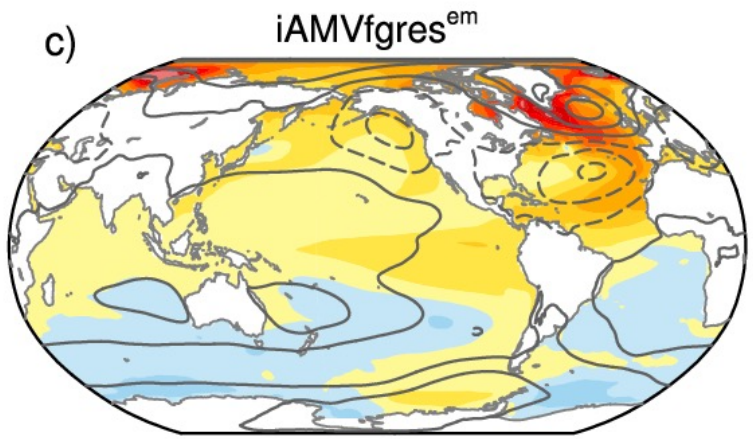
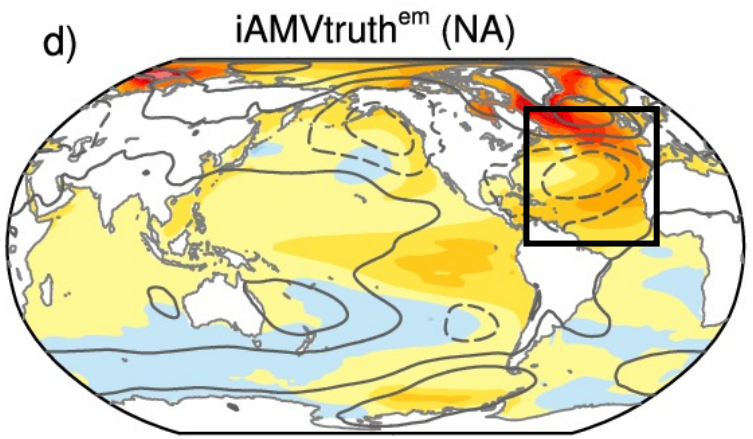
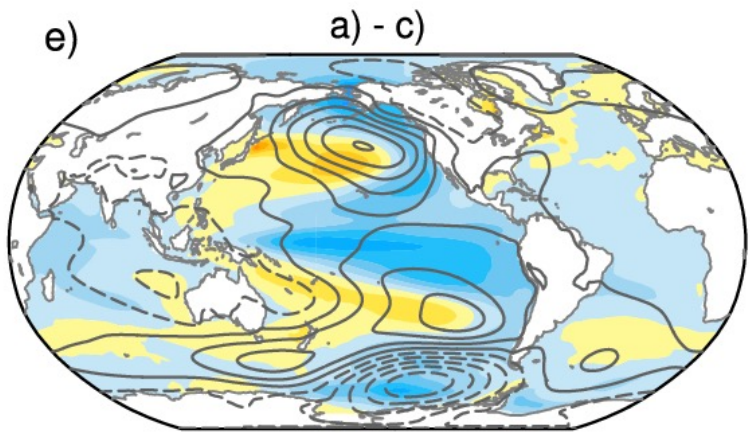
Difference (spurious influence from internal G)









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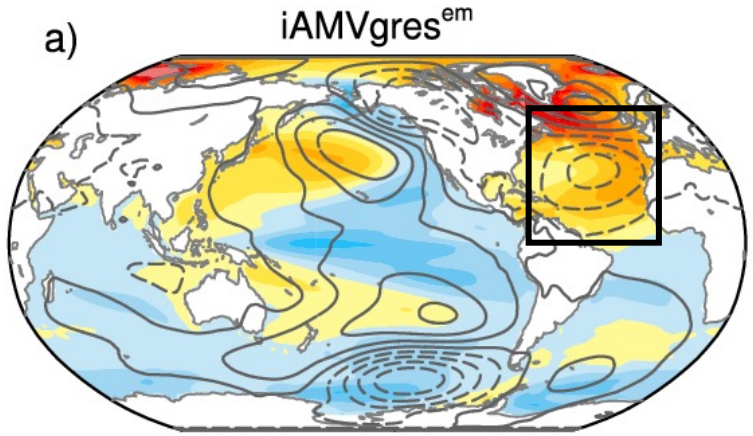

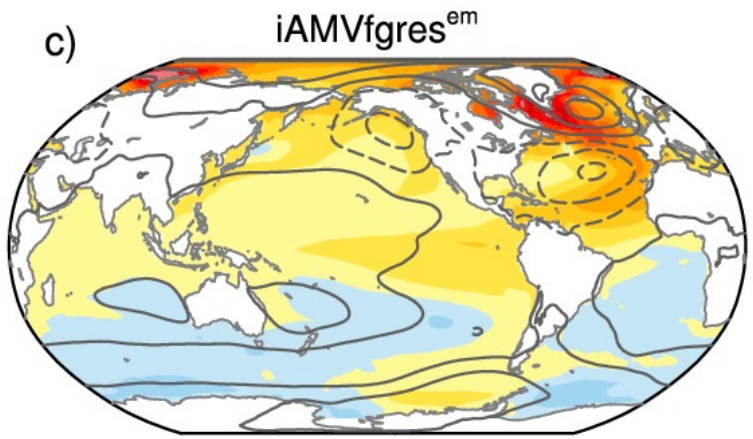

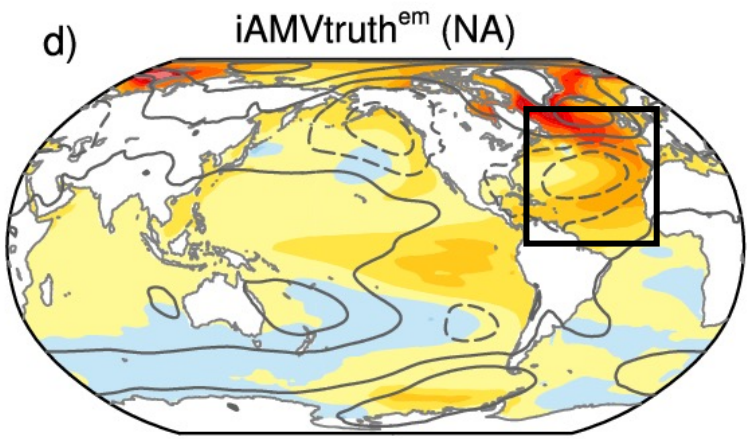

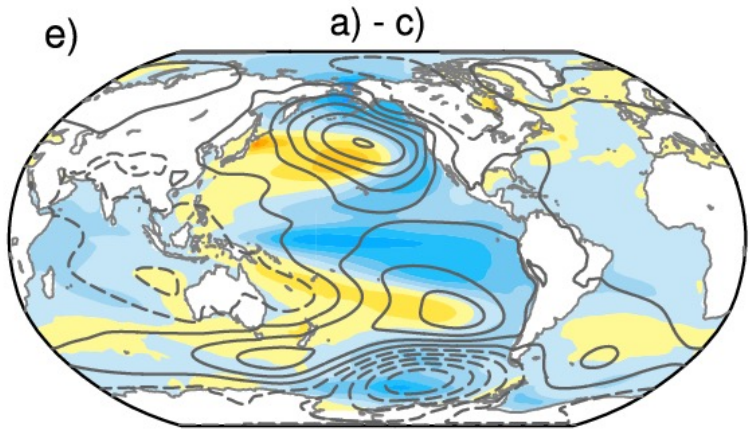

7 model Large Ensembles (420 simulations)

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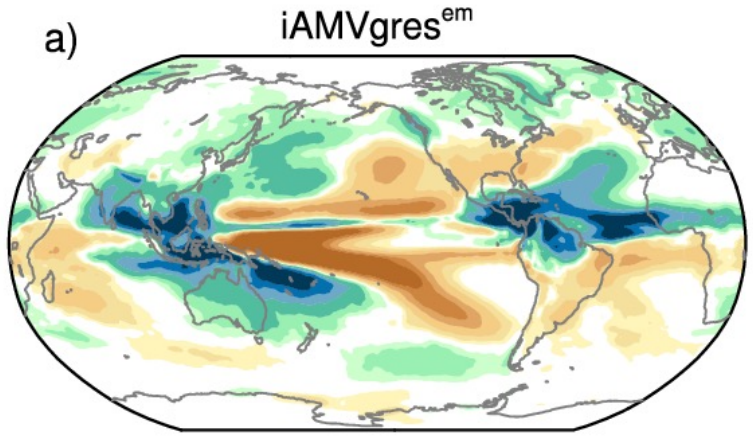
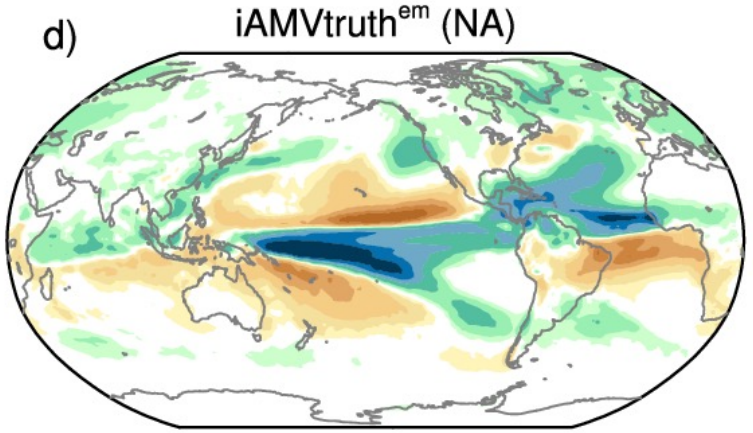
0.94 pattern correlation with PDV

Regression on AMV Index after removing component that is linearly related to global mean SST.



Precipitation

7 model Large Ensembles (420 simulations)



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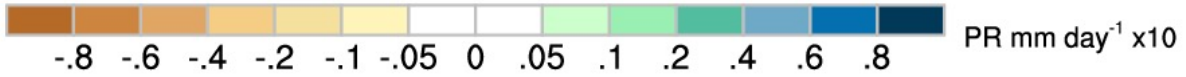
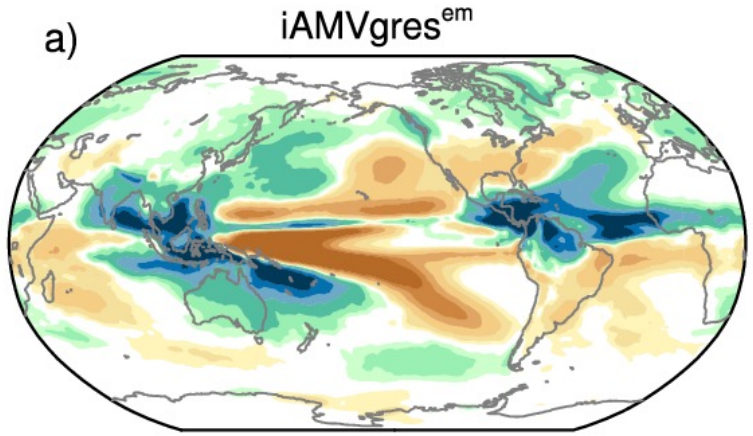
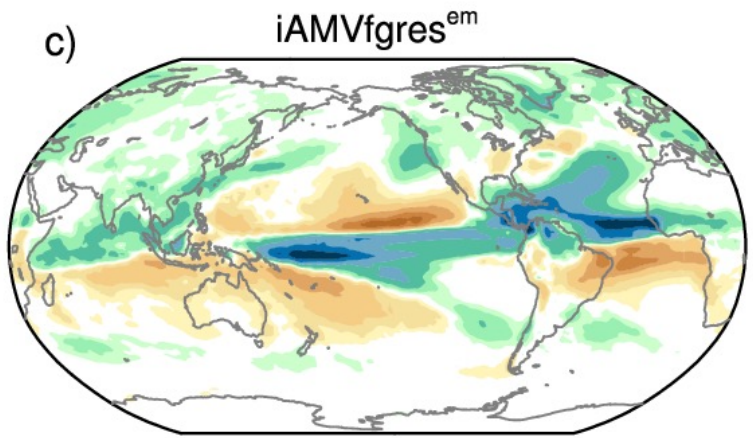
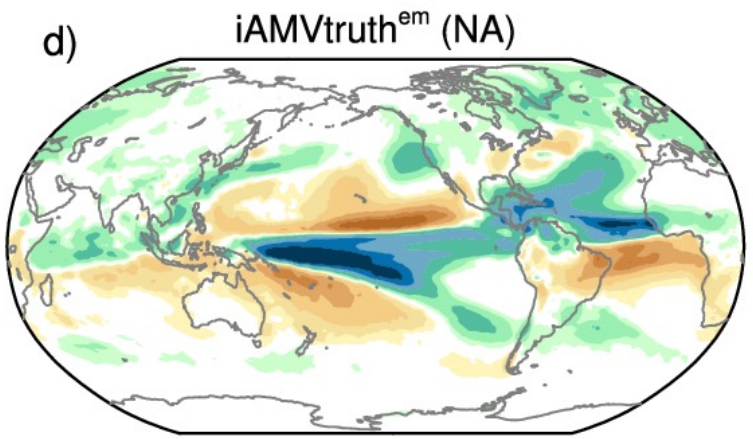


Regression on AMV Index after removing component that is linearly related to global mean SST.

As in a), but after removing component that is linearly related to the **forced component** of global mean SST.







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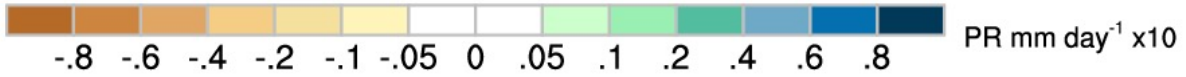

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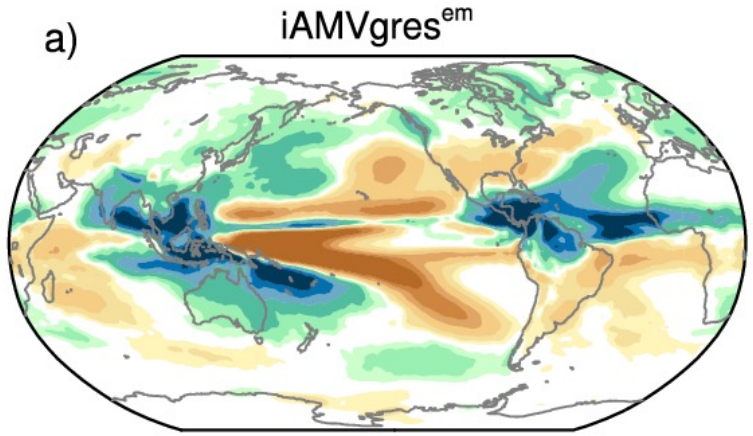
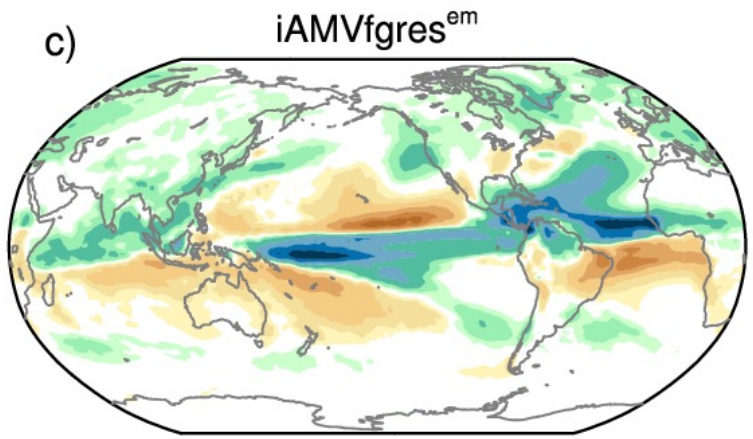
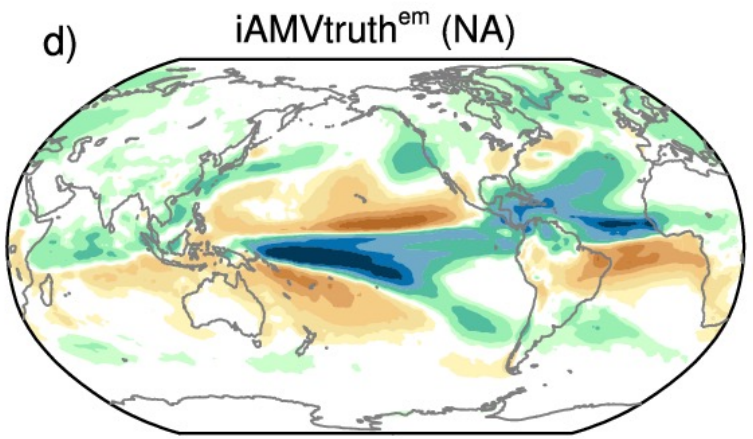
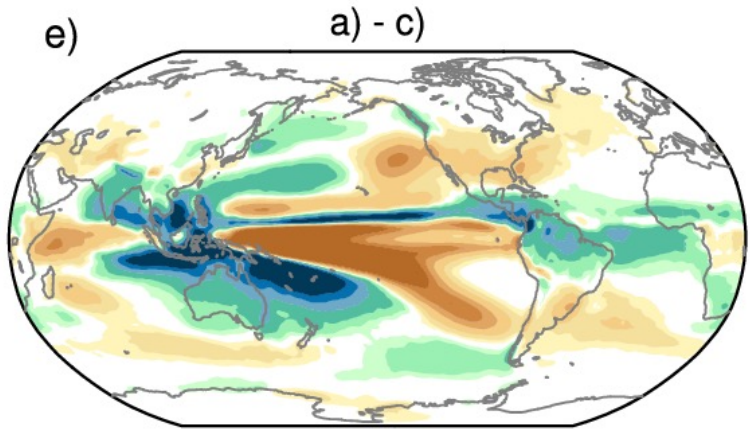
Difference (spurious influence from internal G)









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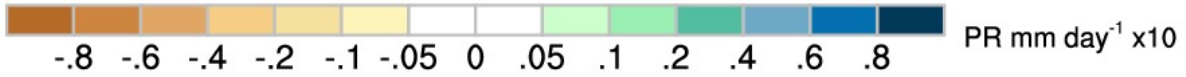
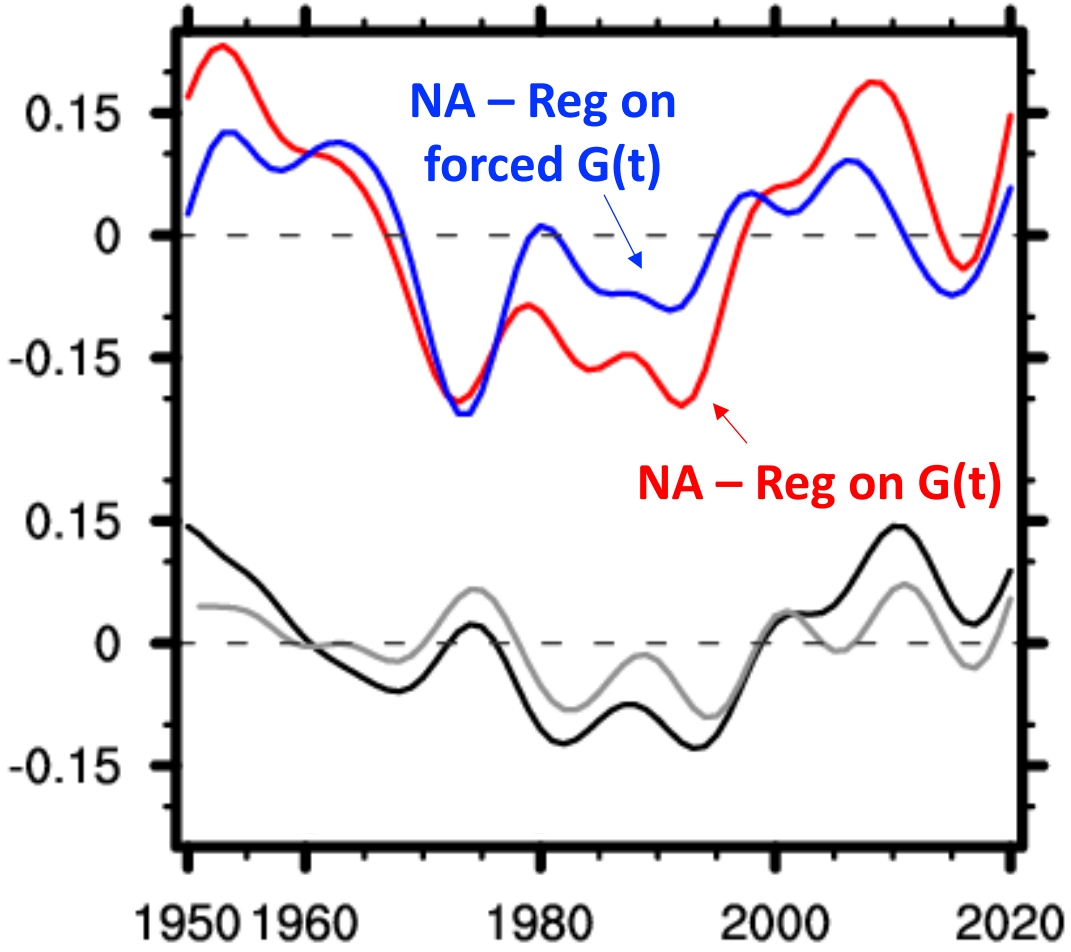


Observations

North Atlantic (0-60N) SST anomalies

ERSSTv5 (annual) 10yr Lowpass Filter



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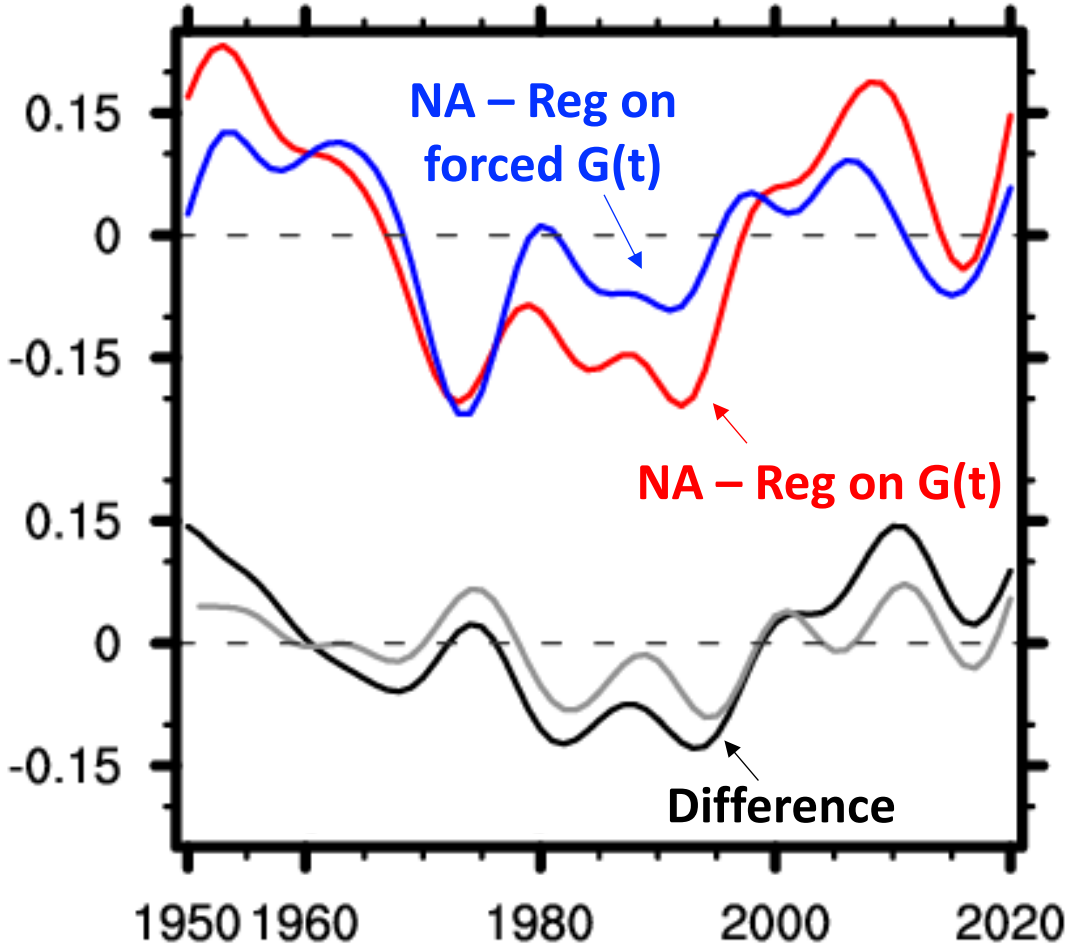

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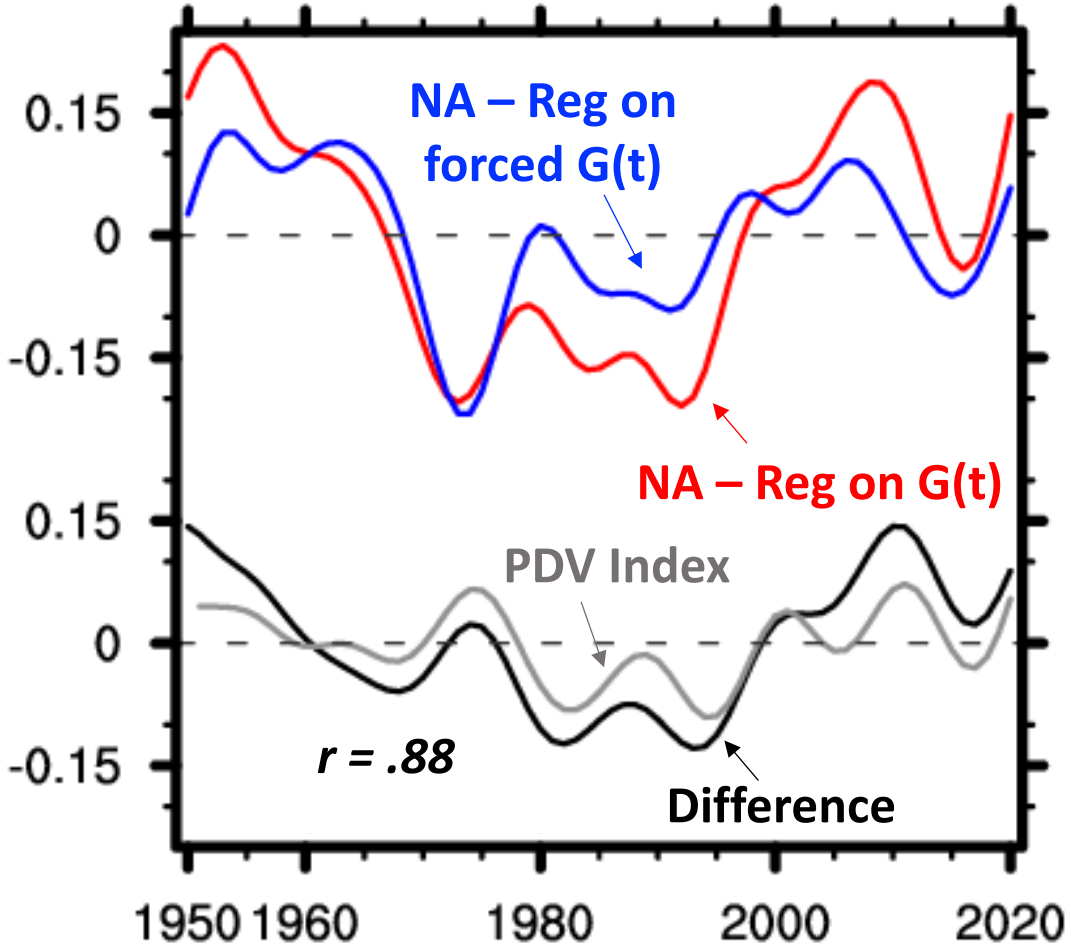
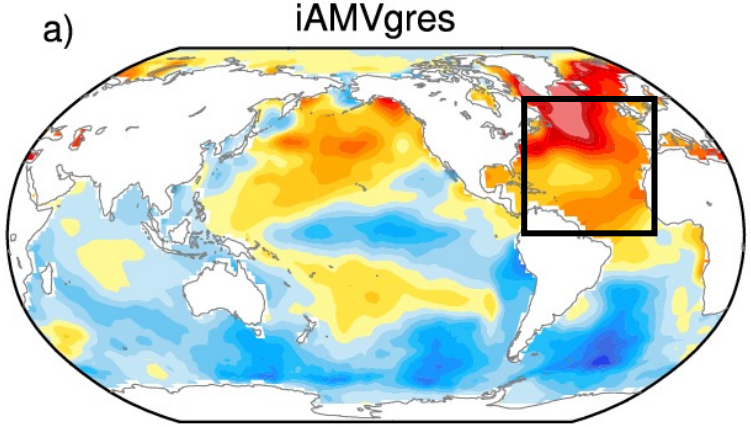
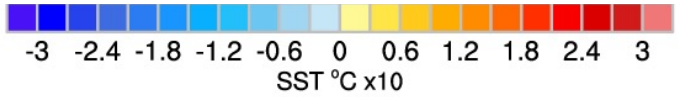


Regression on AMV Index after removing component that is linearly related to global mean SST.



Observed SST (ERSSTv5) 1900-2022



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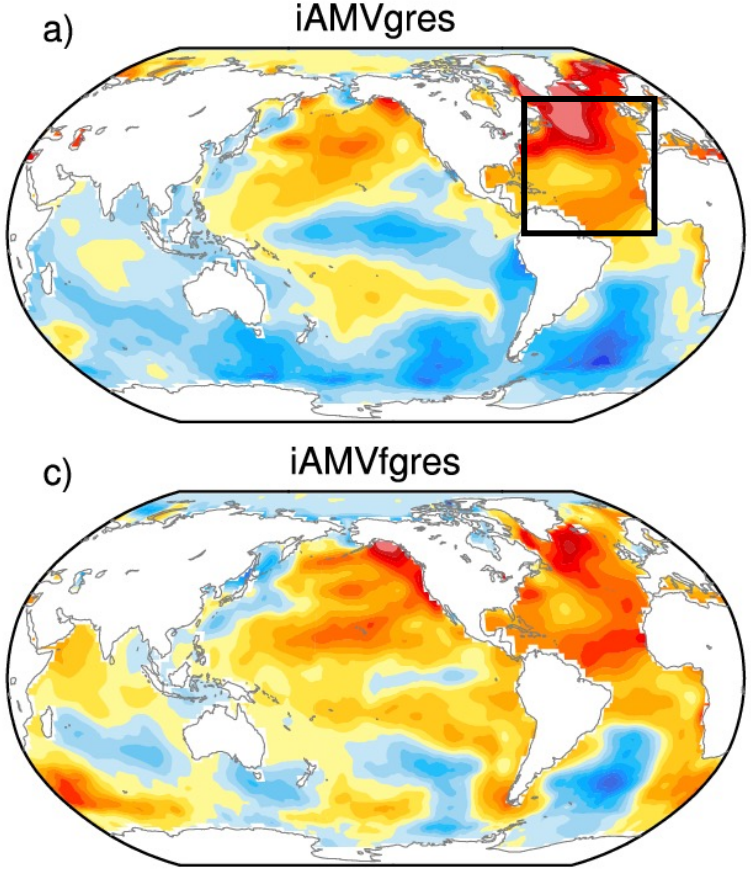
As in a), but after removing component that is linearly related to the **forced component** of global mean SST.



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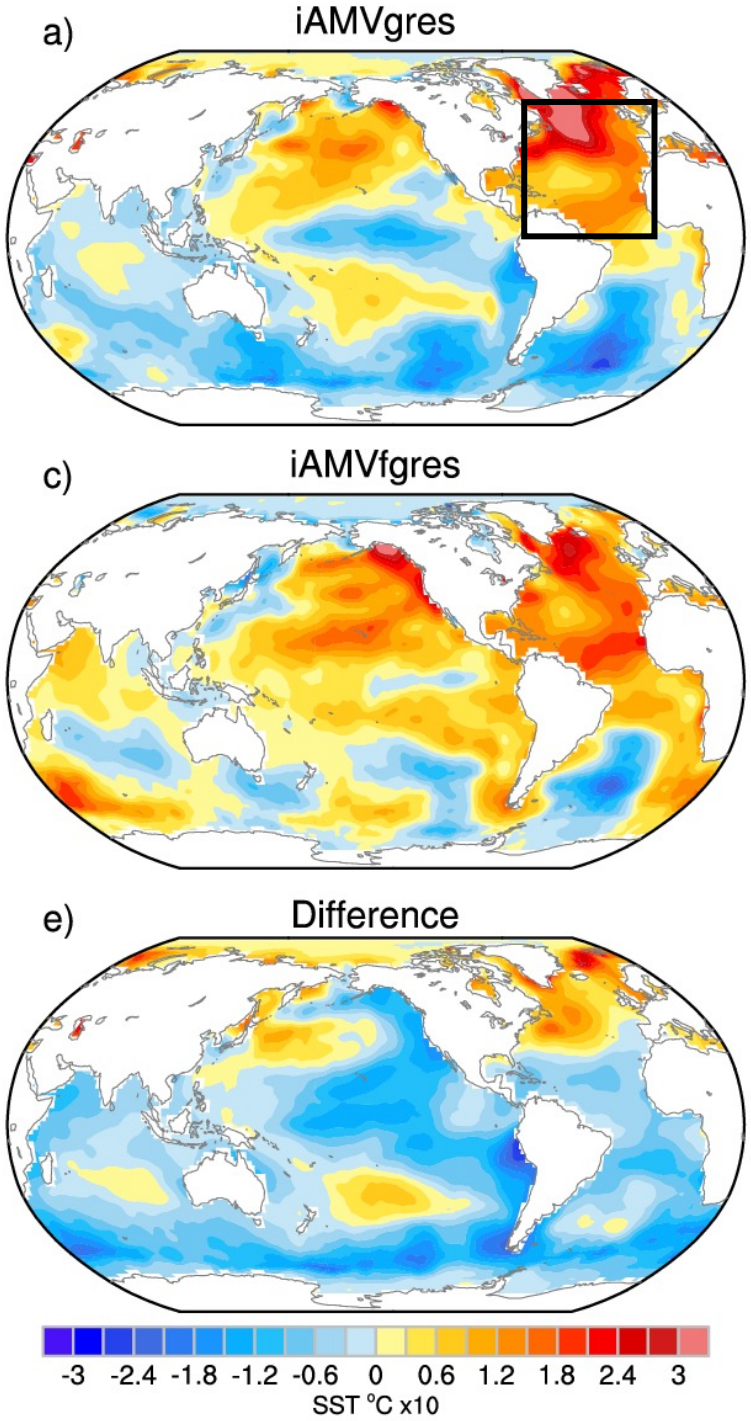
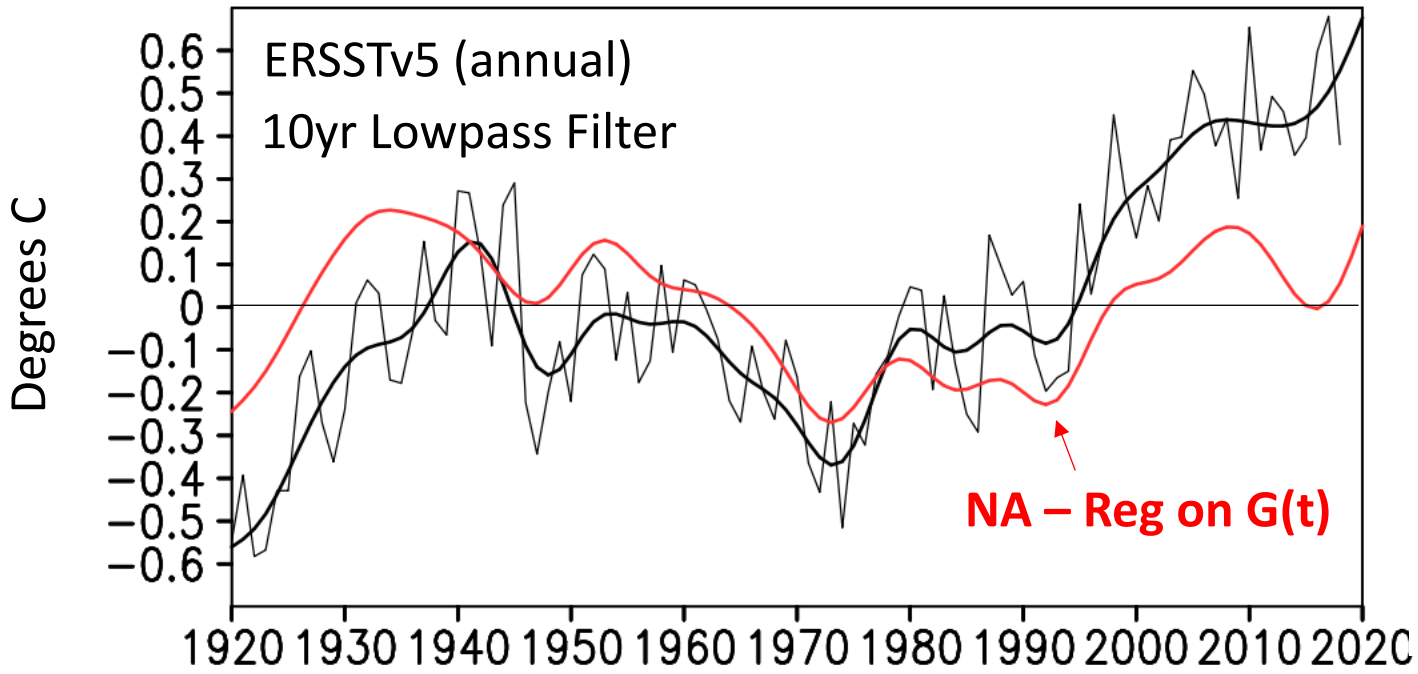


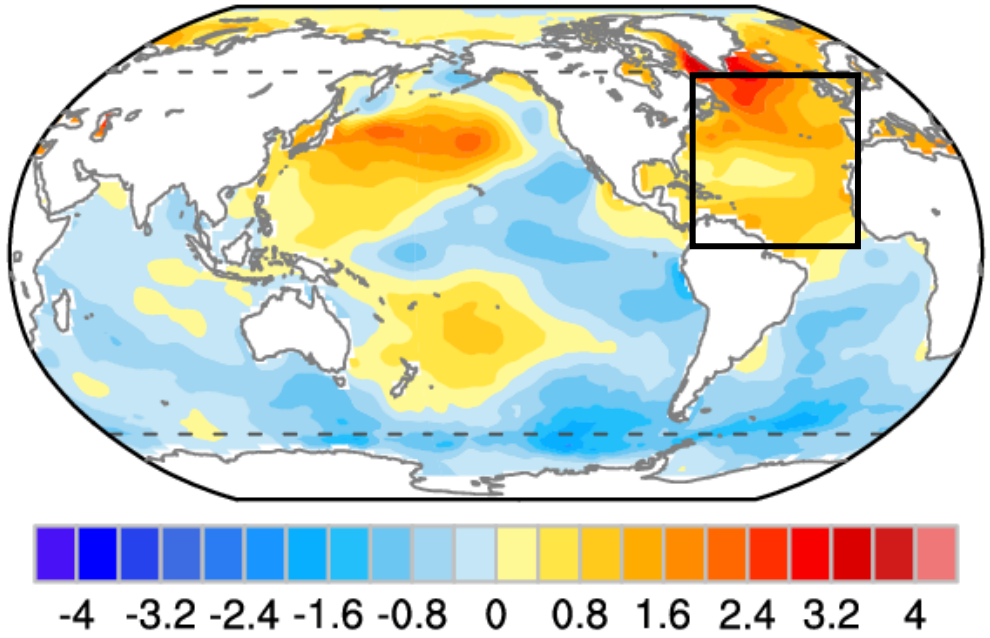
Observed SST (ERSSTv5) 1900-2022

Conclusions

Does this procedure really isolate the internal component of AMV?



Regression on AMV Index



After removing component that is linearly related to global mean SST.

Test with model Large Ensembles, where the true internal variability is known *a priori*.

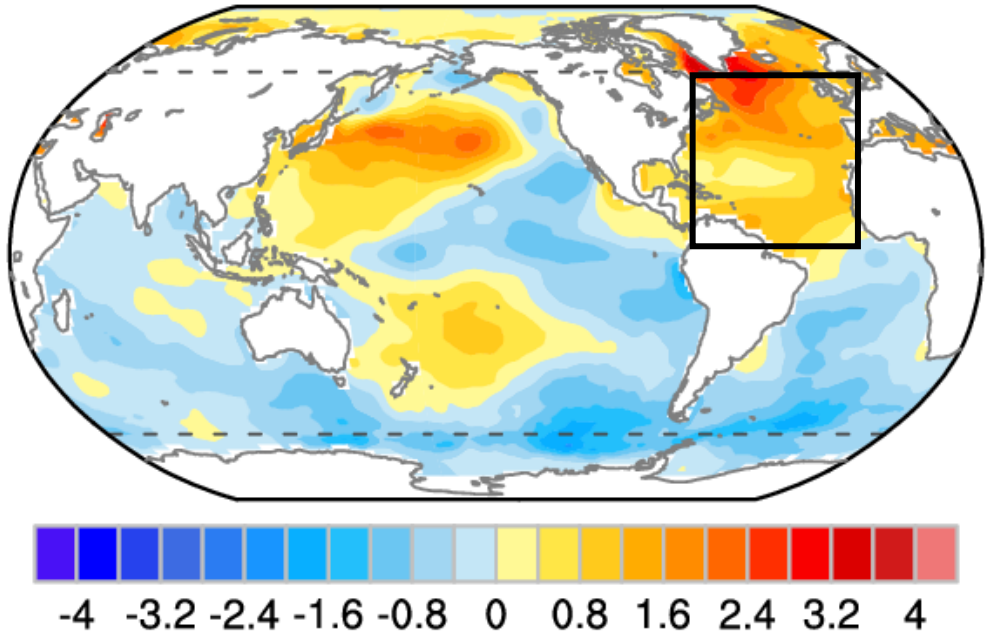
Does this procedure really isolate the internal component of AMV?

No, it introduces a spurious negative PDV by virtue of removing variability associated with the internal component of global-mean SST.

Deser and Phillips, 2022
(submitted to *Geophys. Res. Lett.*)

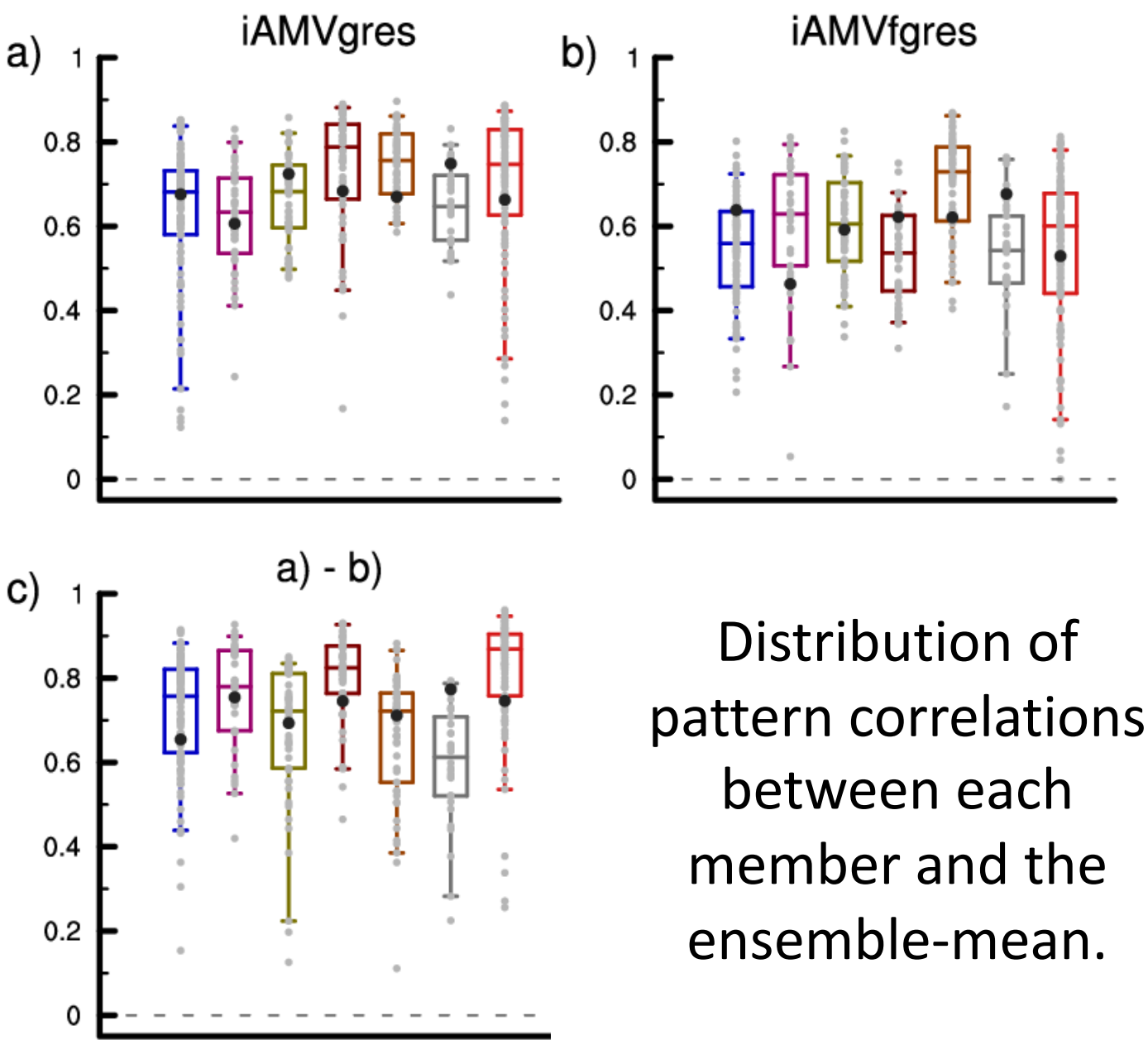
Test with model Large Ensembles, where the true internal variability is known *a priori*.

Regression on AMV Index



After removing component that is linearly related to global mean SST.

Extra Slides



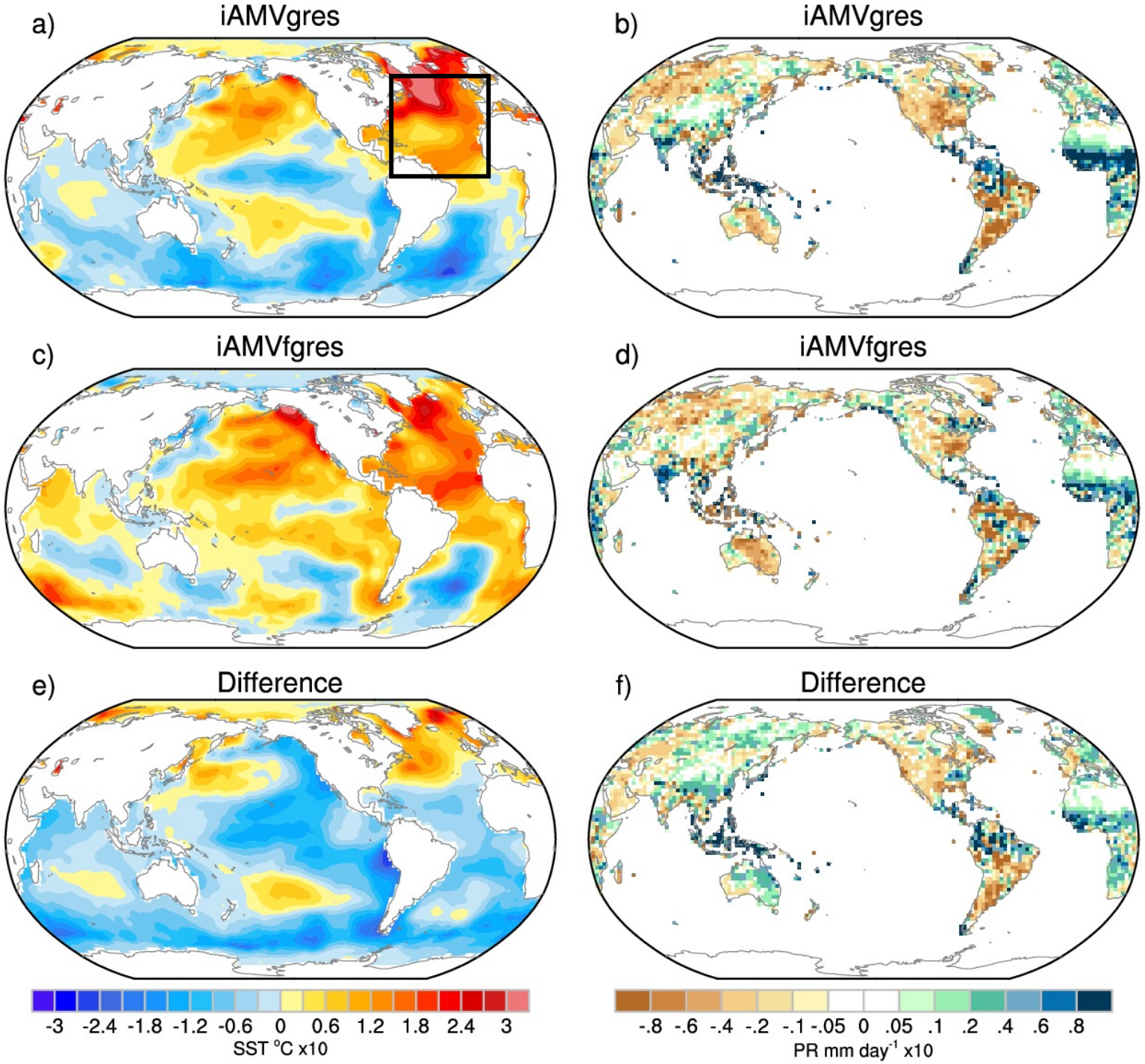
Distribution of pattern correlations between each member and the ensemble-mean.

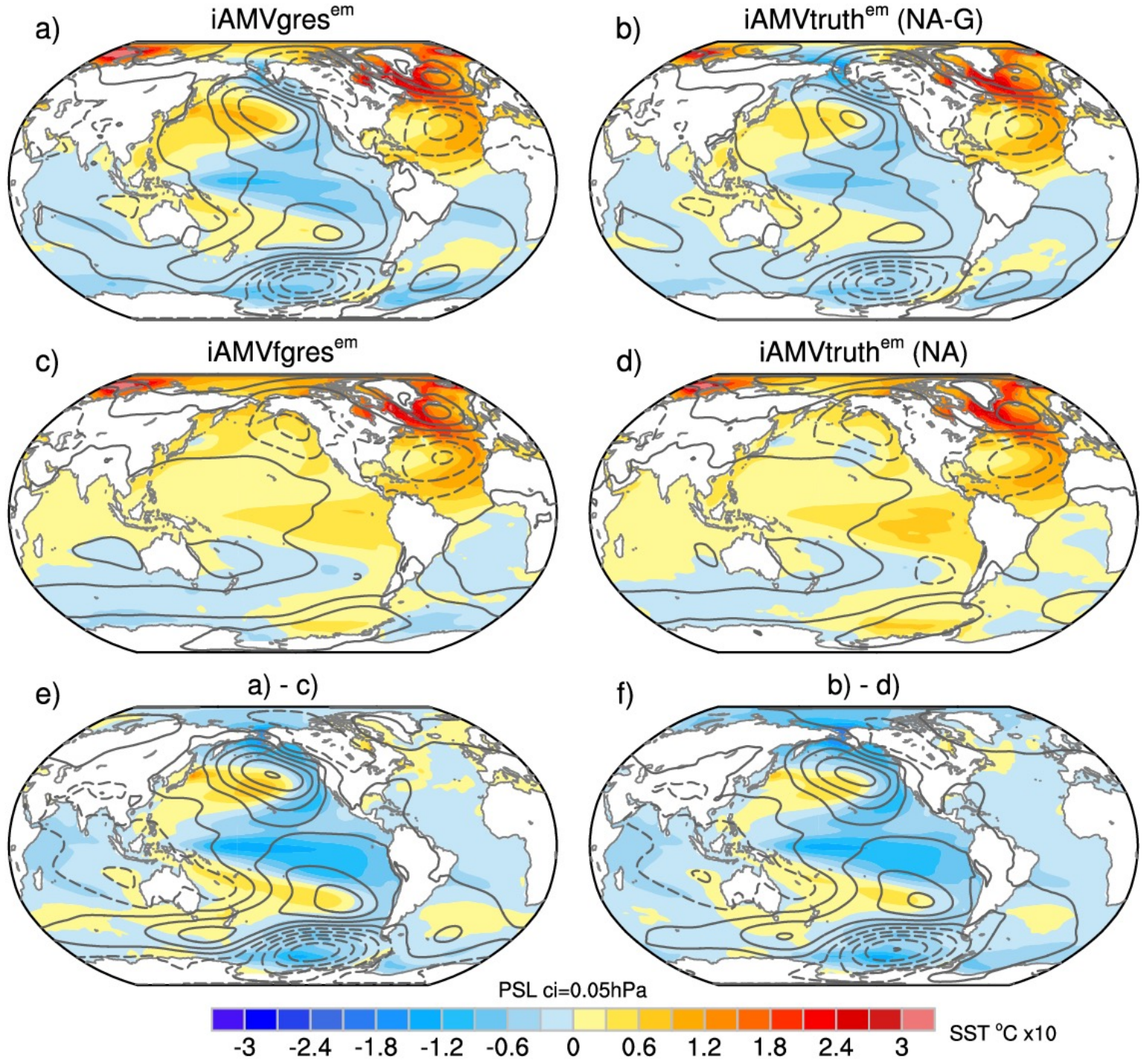
Observed SST and Precipitation 1900-2022

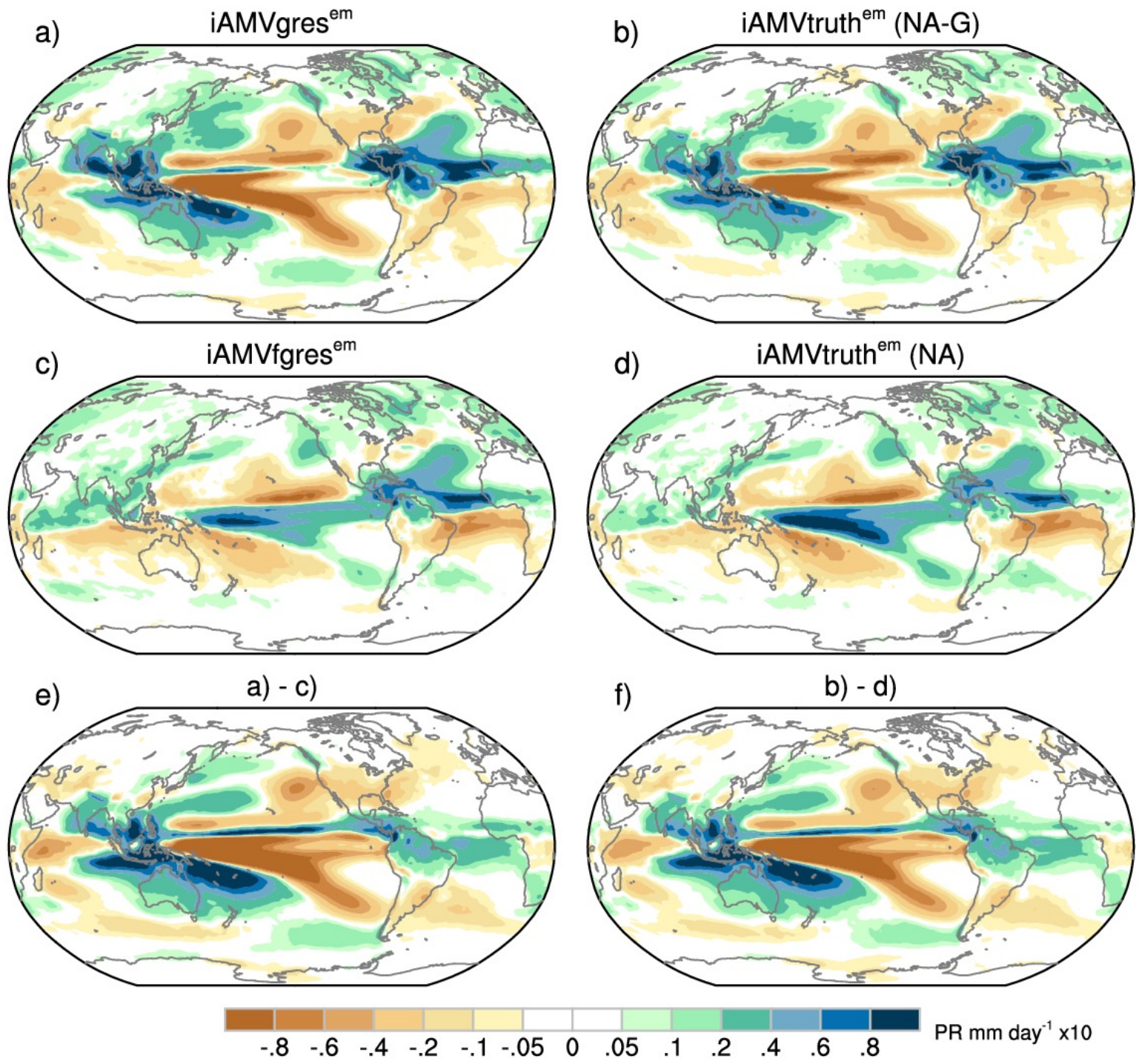
Regression on AMV Index after removing component that is linearly related to global mean SST.

As in a), but after removing component that is linearly related to the **forced component** of global mean SST.

Difference (spurious influence from internal G)




a)
iAMVgres^em
b)
iAMVtruth^em (NA-G)
c)
iAMVfgres^em
d)
iAMVtruth^em (NA)
e)
a) - c)
f)
b) - d)
PSL ci=0.05hPa
-3
-2.4
-1.8
-1.2
-0.6
0
0.6
1.2
1.8
2.4
3
SST °C x10


a)
iAMVgres^em
b)
iAMVtruth^em (NA-G)
c)
iAMVfgres^em
d)
iAMVtruth^em (NA)
e)
a) - c)
f)
b) - d)
-.8 -.6 -.4 -.2 -.1 -.05 0 .05 .1 .2 .4 .6 .8
PR mm day^-1 x10