

A Simple SST Index of Internally-generated  
Atlantic Multi-decadal Variability (iAMV)  
that is Robust to Climate Change

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NCAR/CGD Climate Analysis Section

CVCWG winter meeting, 18 February 2021 (virtual)

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SST anomaly timeseries

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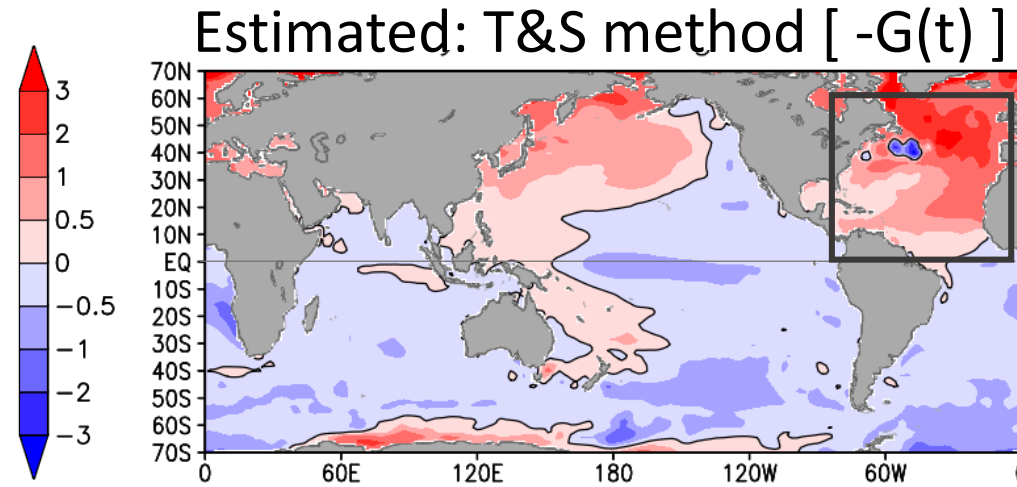
Removal of background climate change:

- Linearly detrend (Enfield et al., 2001)
  - Subtract global-mean SST(t) (Trenberth and Shea, 2006)
- How well does the T&S method work under future climate change?
- Address using 'perfect model' testbeds (i.e., Large Ensembles).

# MPI Grand Ensemble

SST regression maps onto AMV Index  
(20-year running means)

# AMV Internal in the MPI Grand Ensemble: 1950-2020

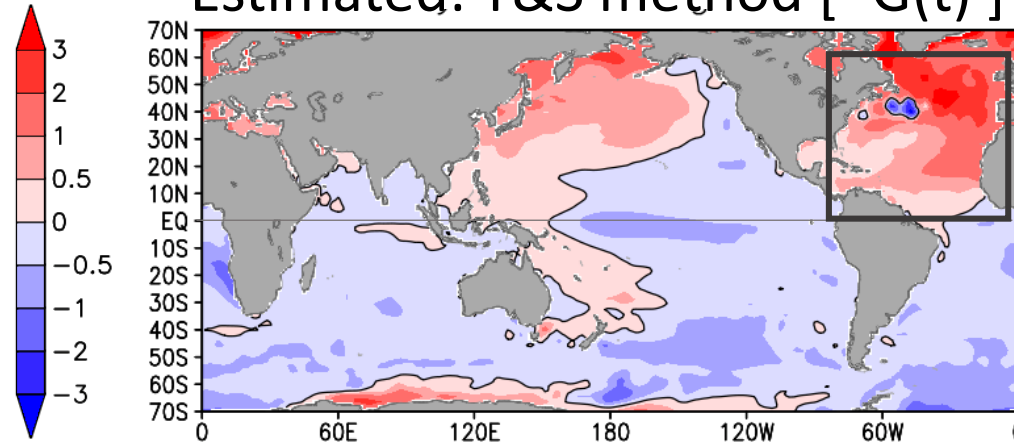


Ensemble mean  
of 40 individual  
member  
regression maps.



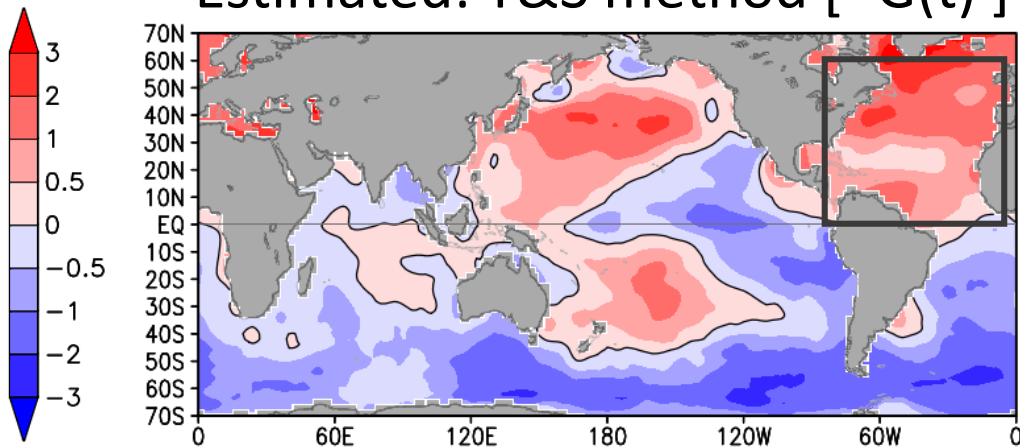
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Estimated: T&S method [ -G(t) ]



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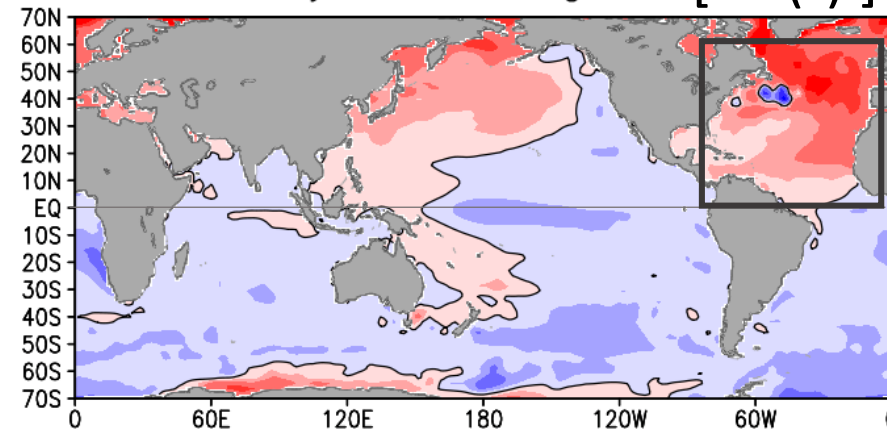
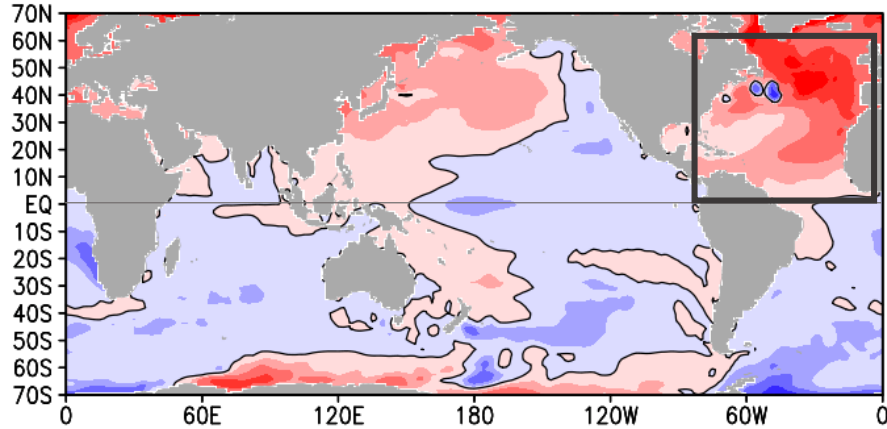
Observations (ERSSTv5)  
Estimated: T&S method [ -G(t) ]



$r = 0.69$

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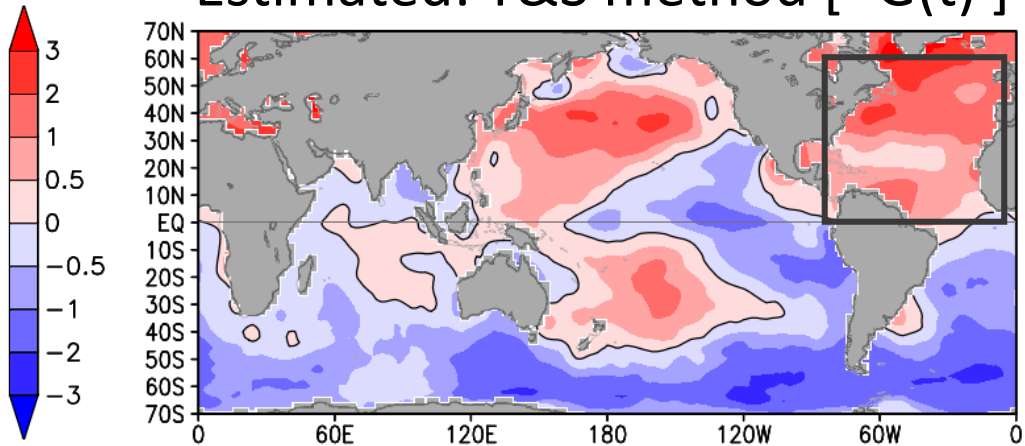
Truth: [ - Ensemble Mean ]  $r = 0.93$  Estimated: T&S method [ -G(t) ]



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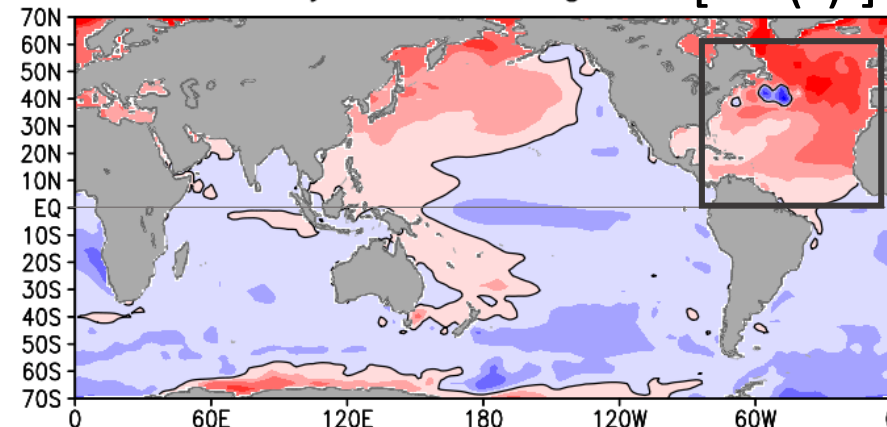
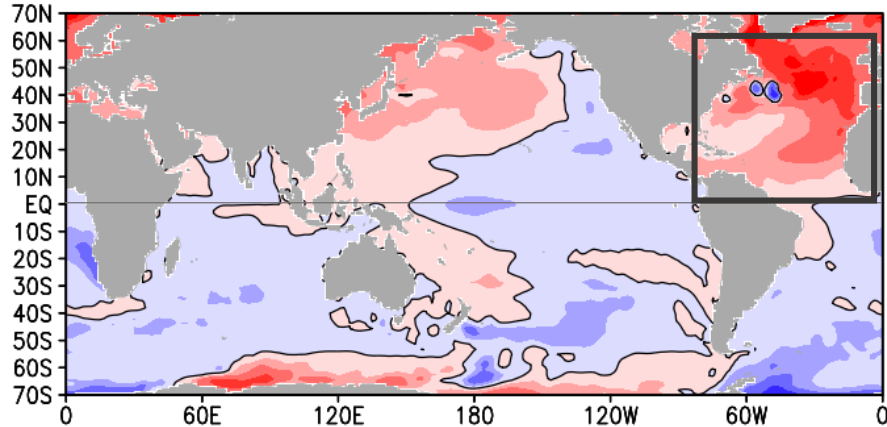
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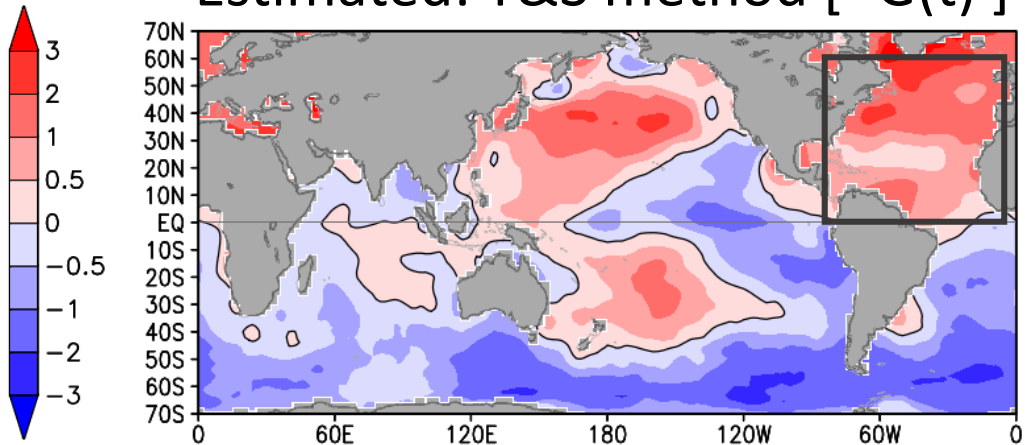
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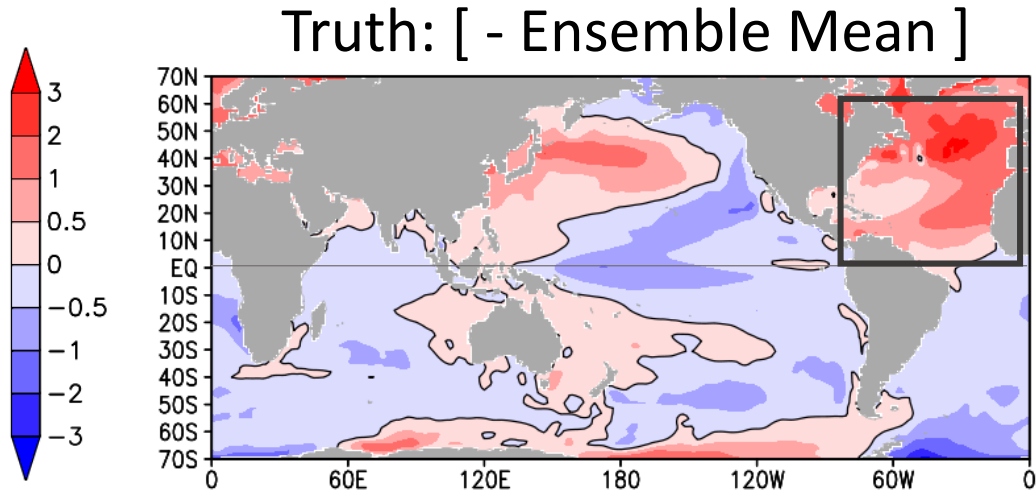


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✓ T&S method works well for the period 1950-2020.

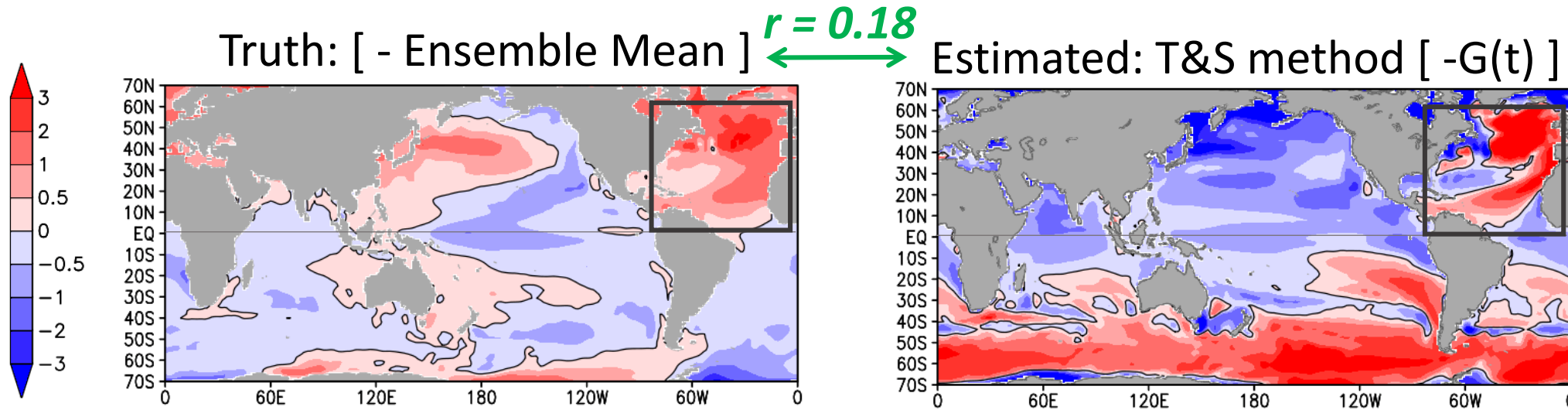
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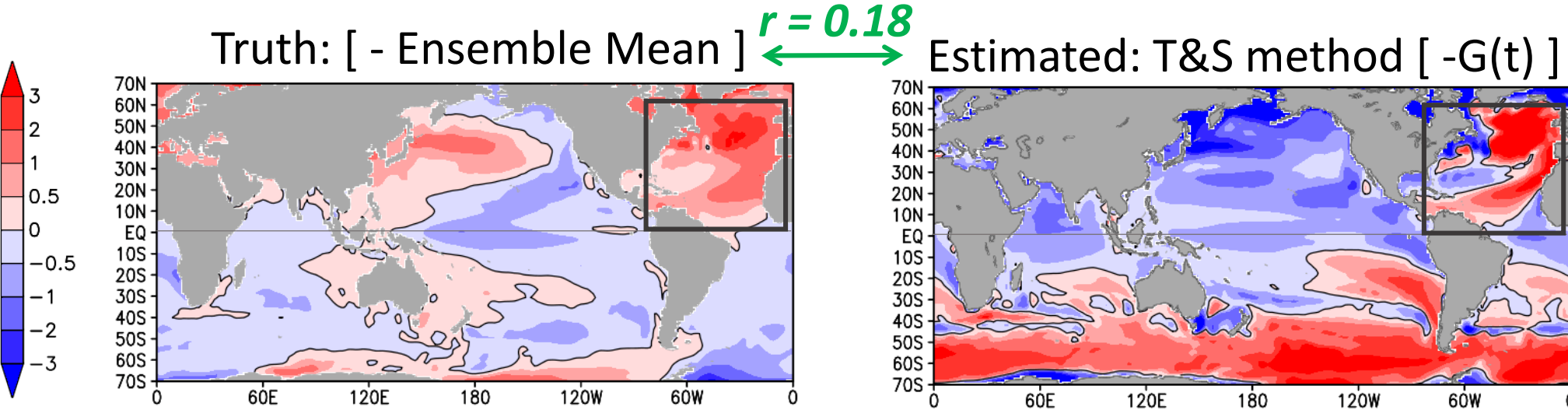
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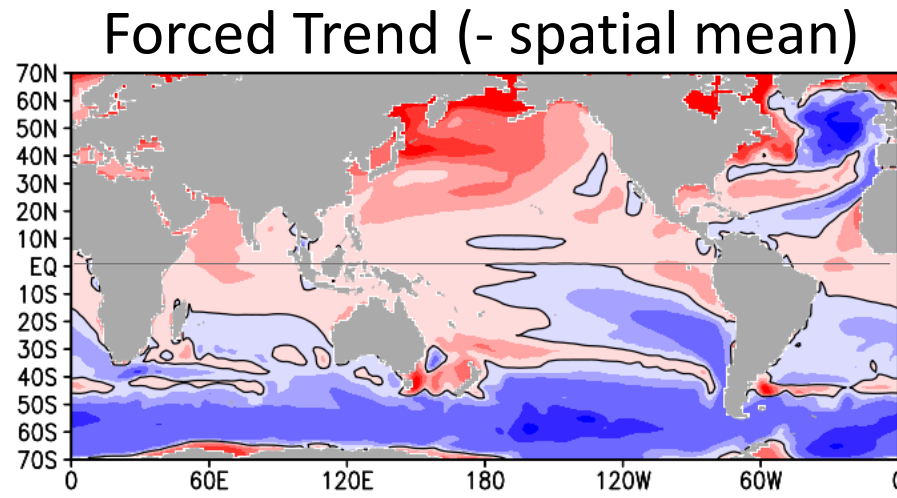
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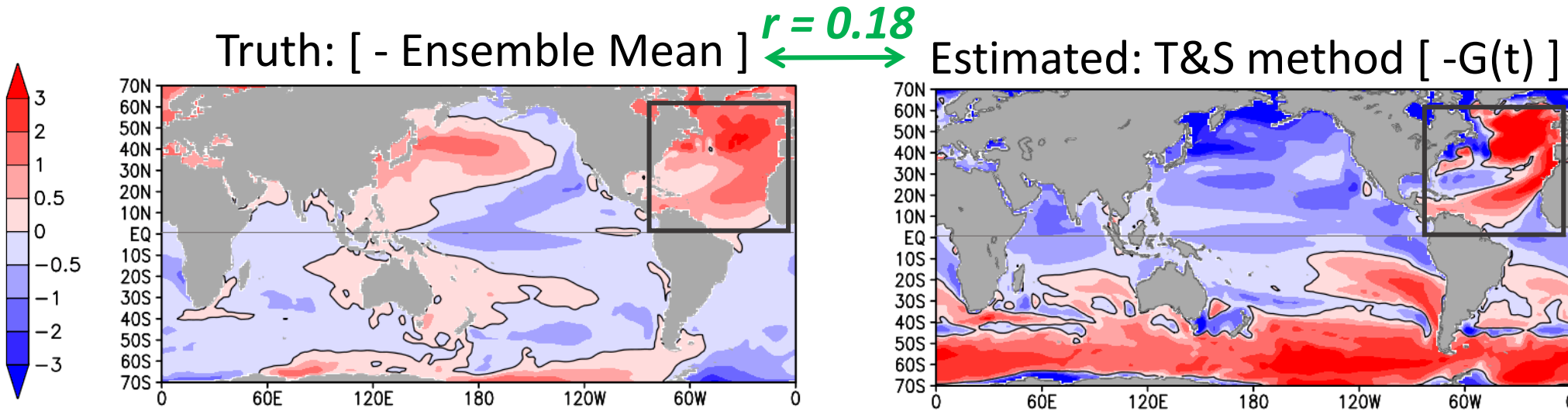


Ensemble mean of 40 individual member regression maps.

$r = -0.92$



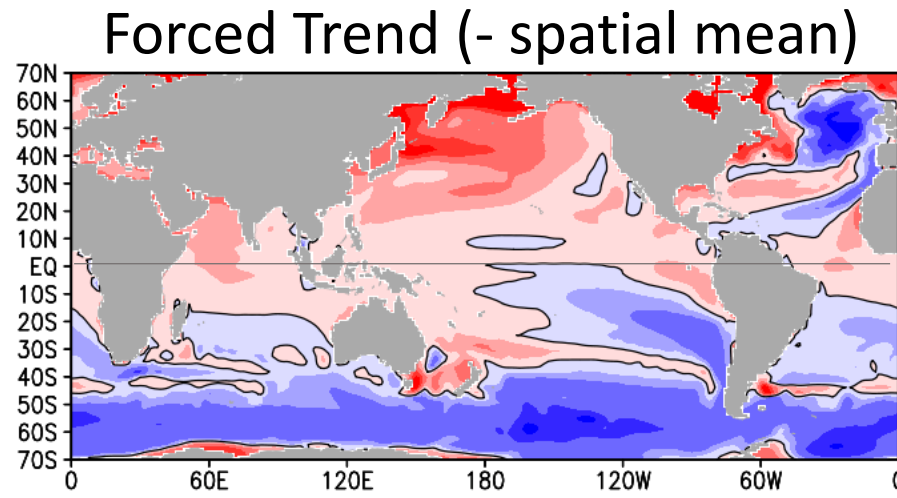
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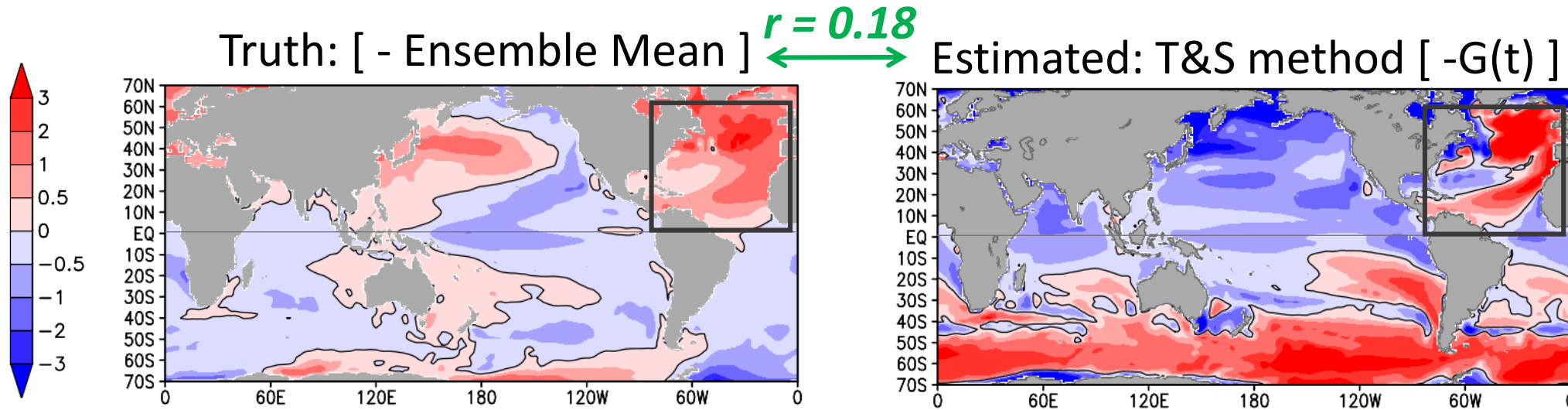
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T&S method aliases the pattern of the forced trend onto the AMV pattern.



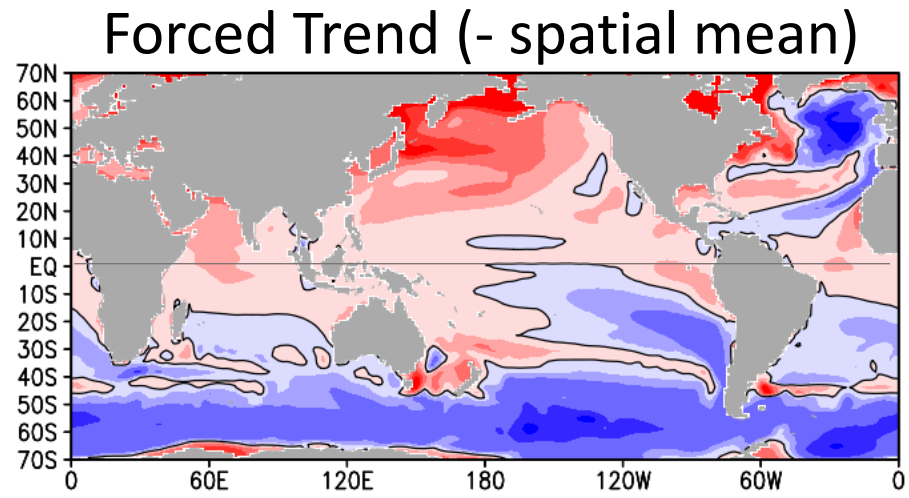
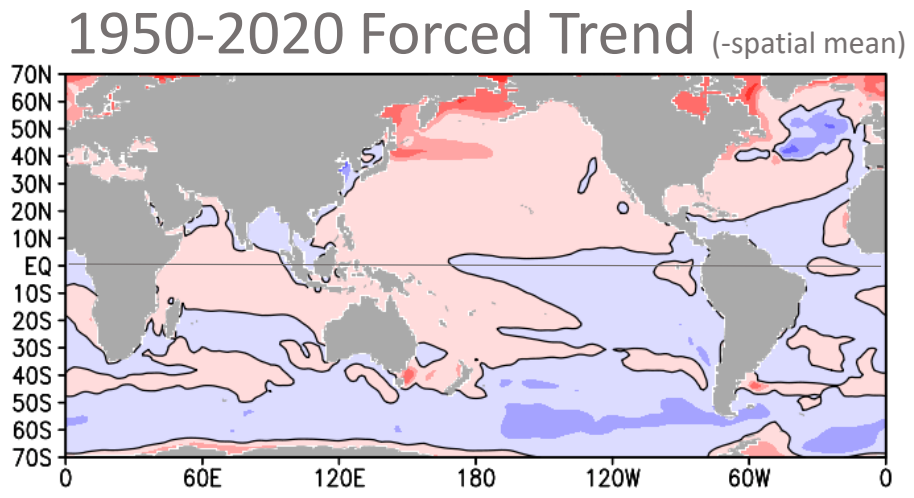


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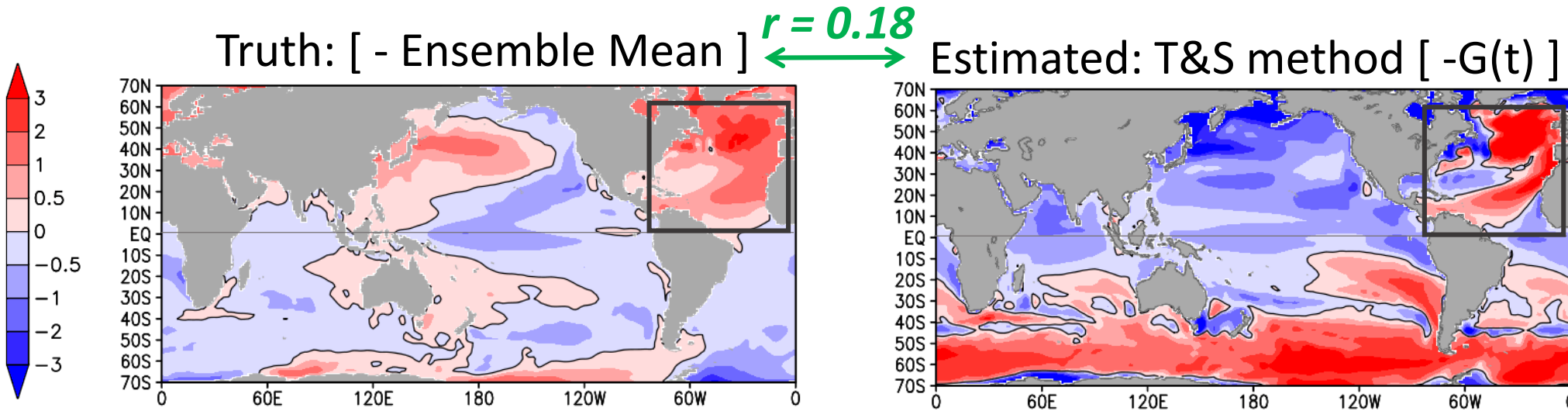


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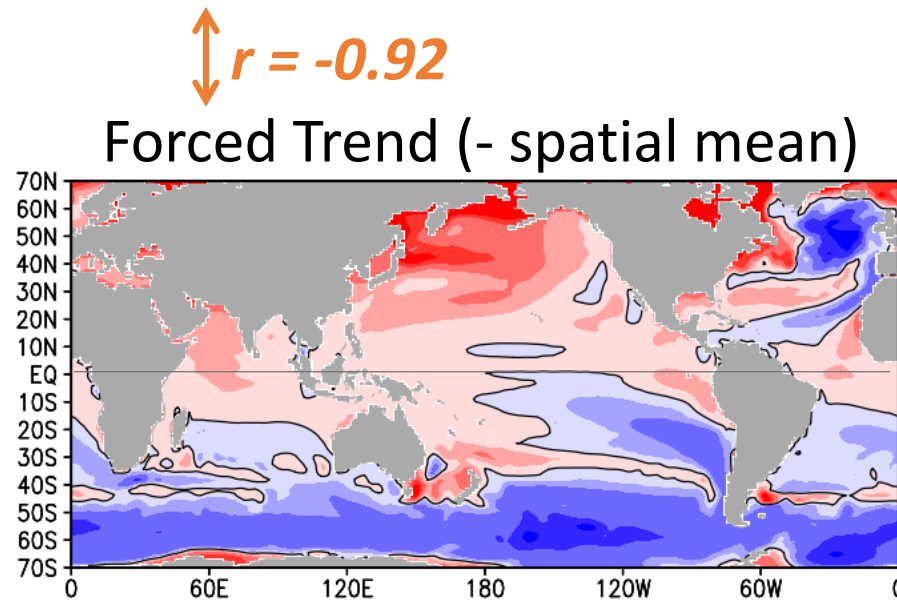


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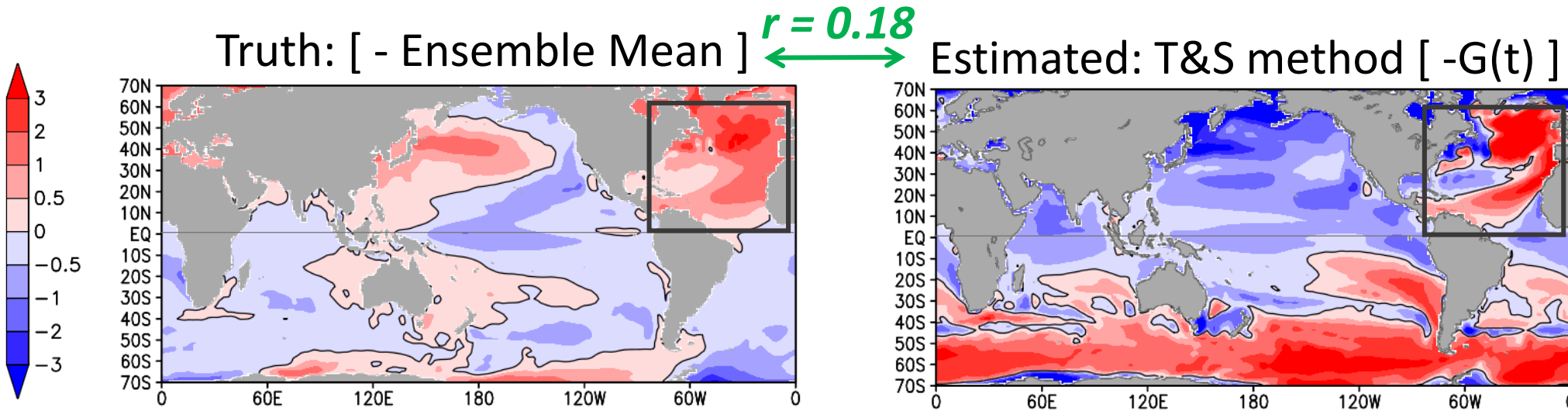


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Is there a better approach?



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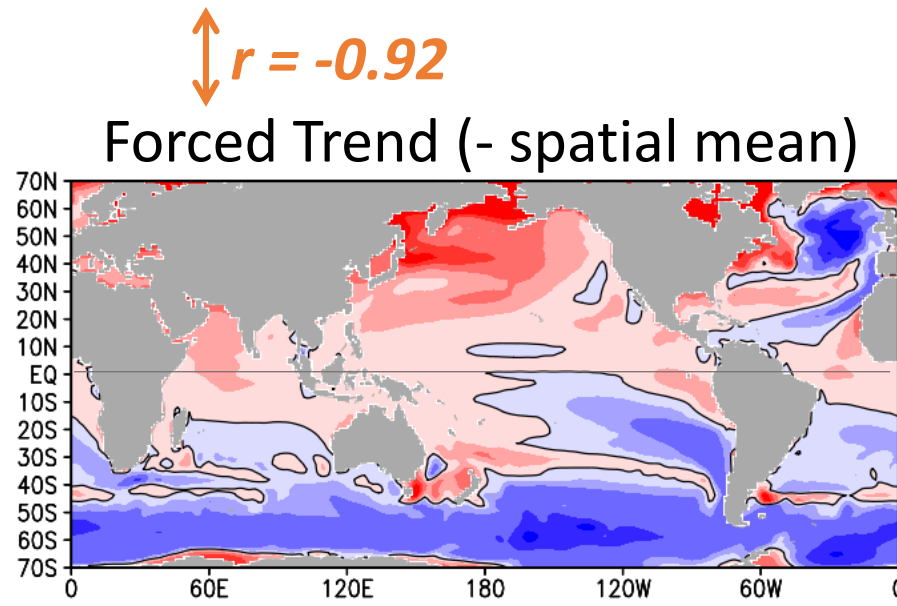


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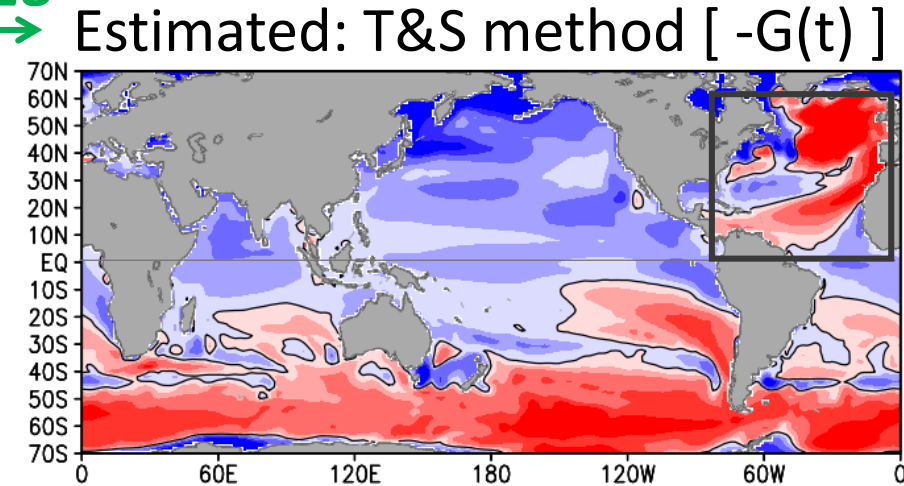
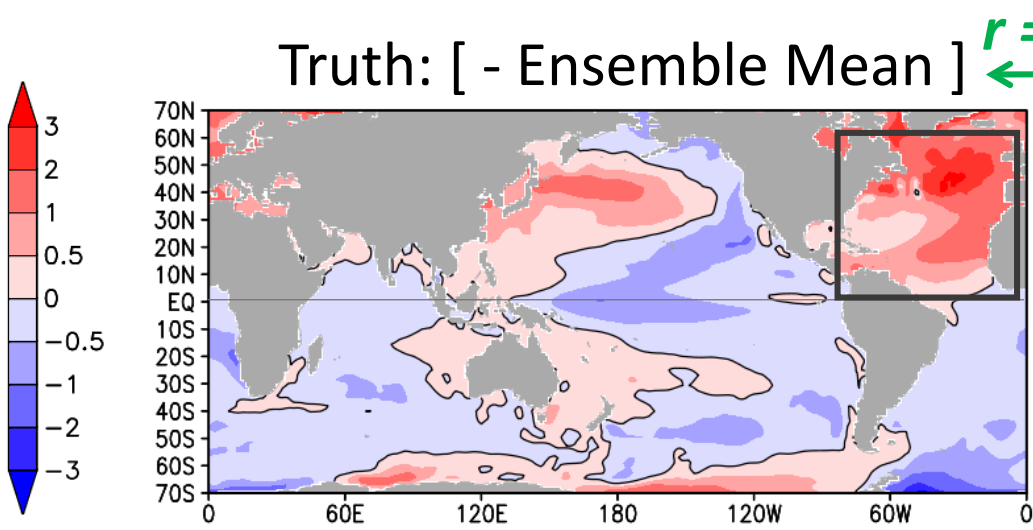
Is there a better approach?

Remove the *pattern* associated with G(t)

(Zhang et al., 2019; Qin et al. 2020)



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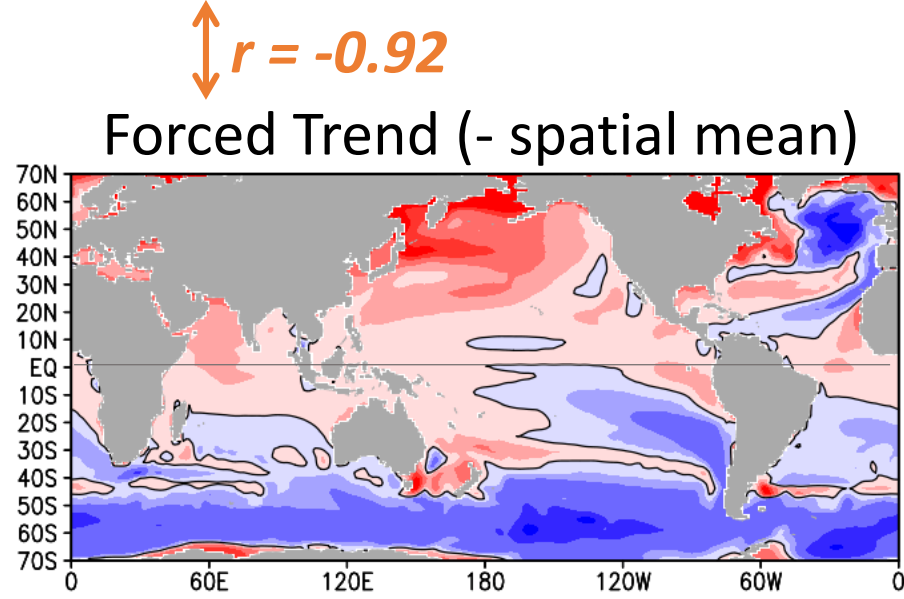
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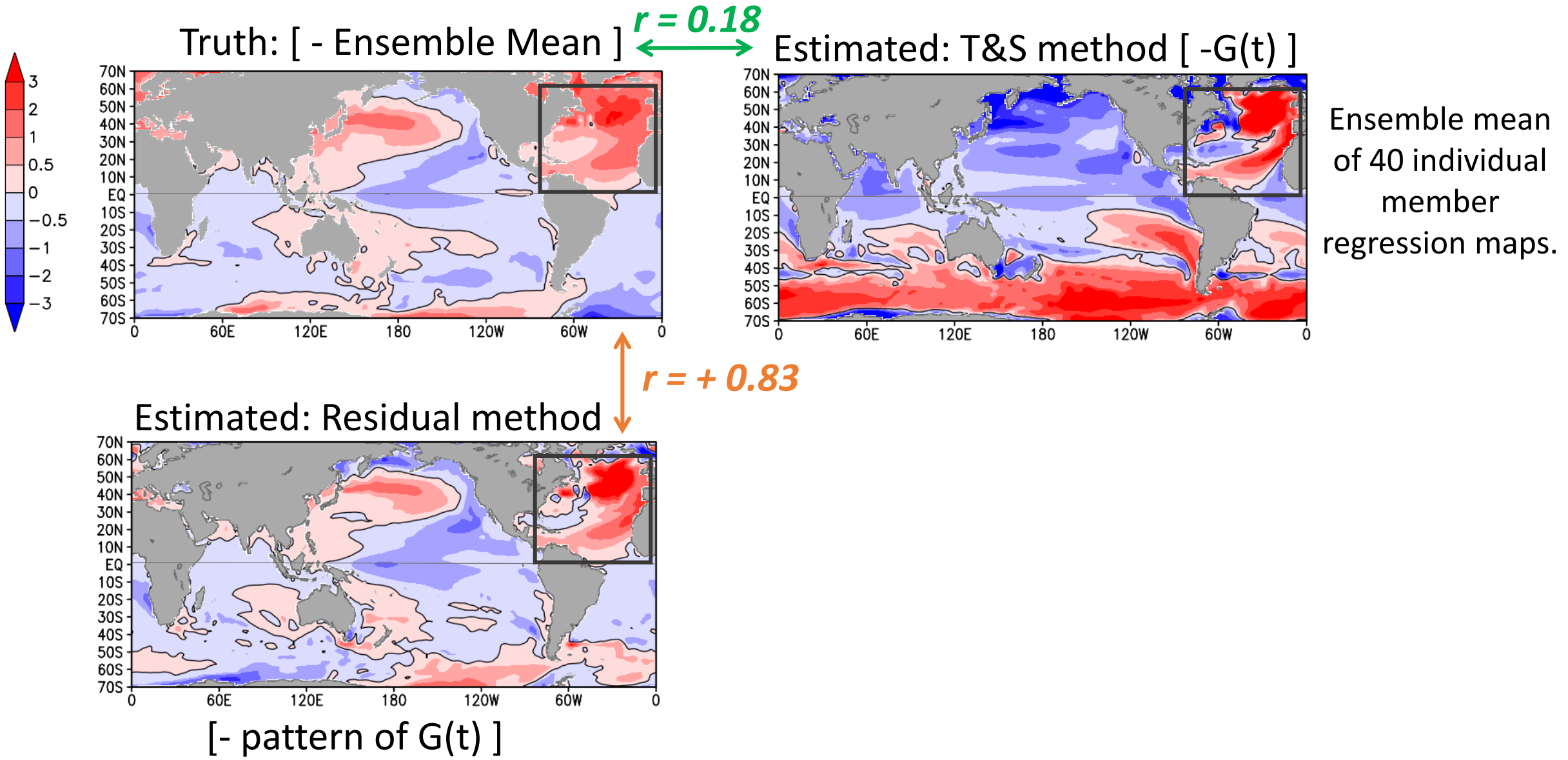
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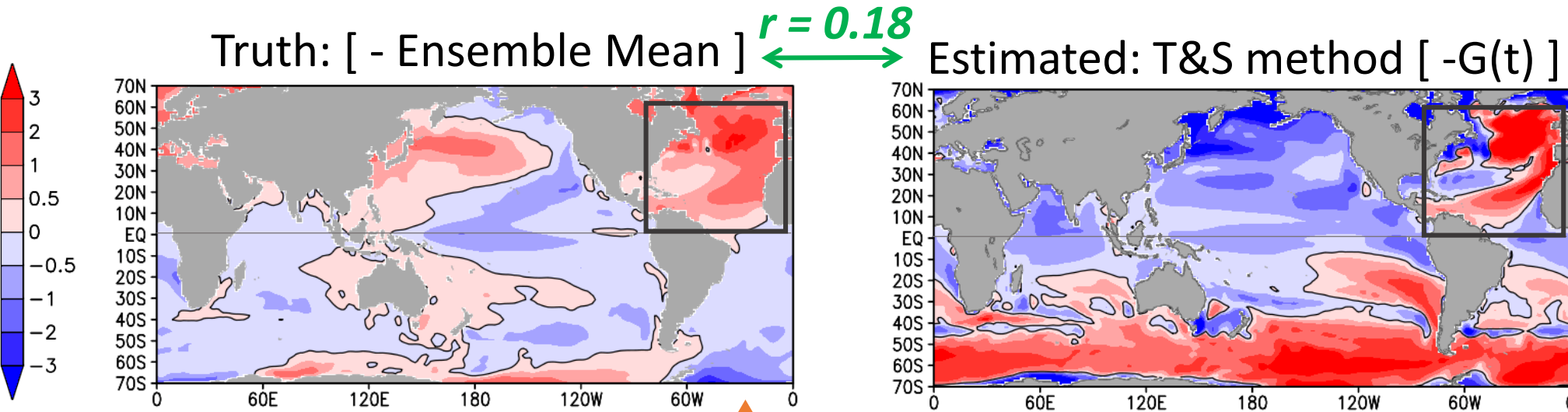
“Residual method”



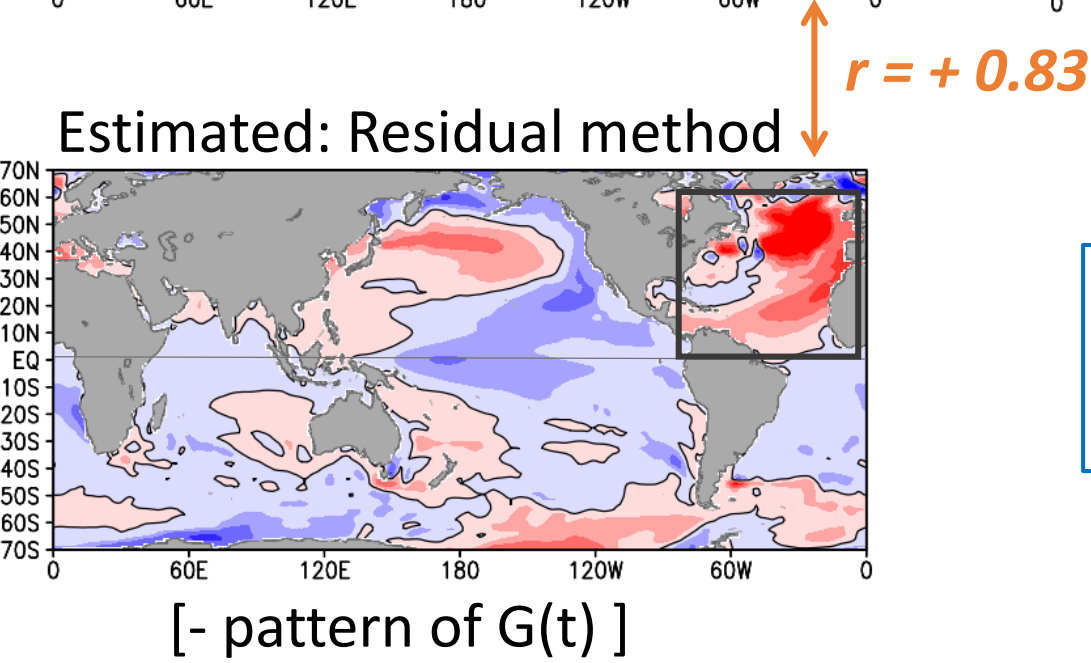
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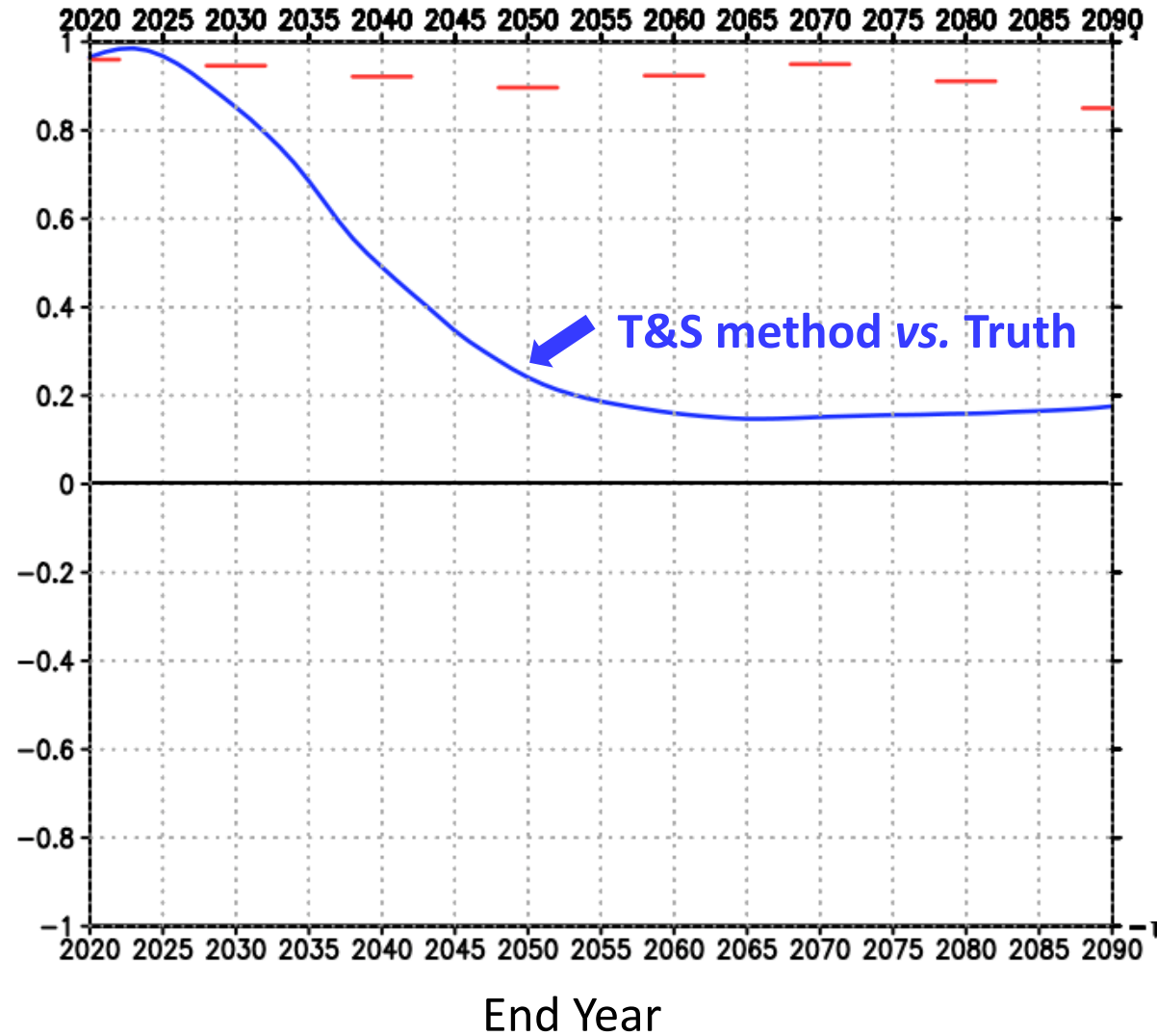
When does the T&S method start to fail?

# **AMV Internal in the MPI Grand Ensemble**

Cumulative Pattern Correlations (since 1950)

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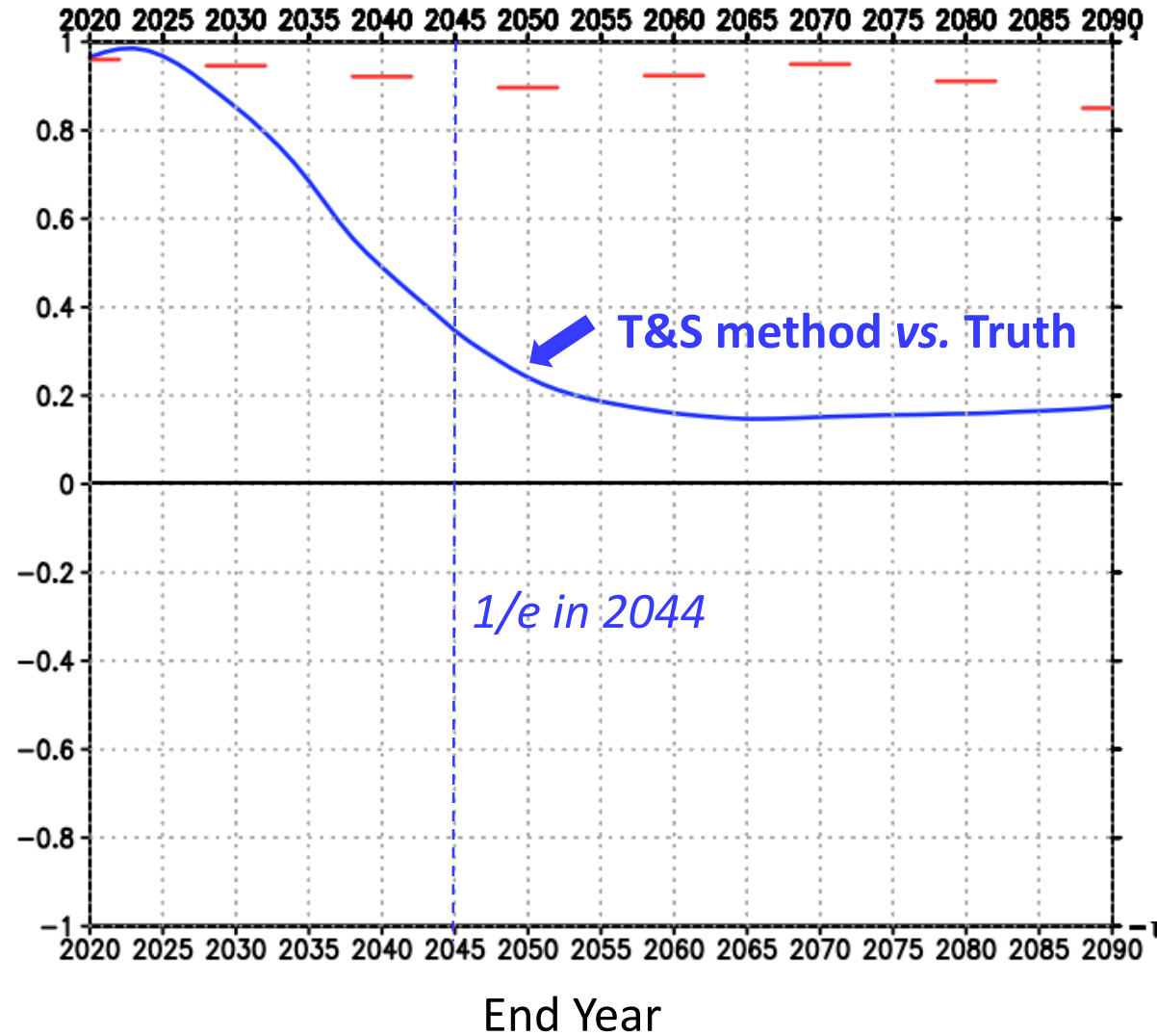
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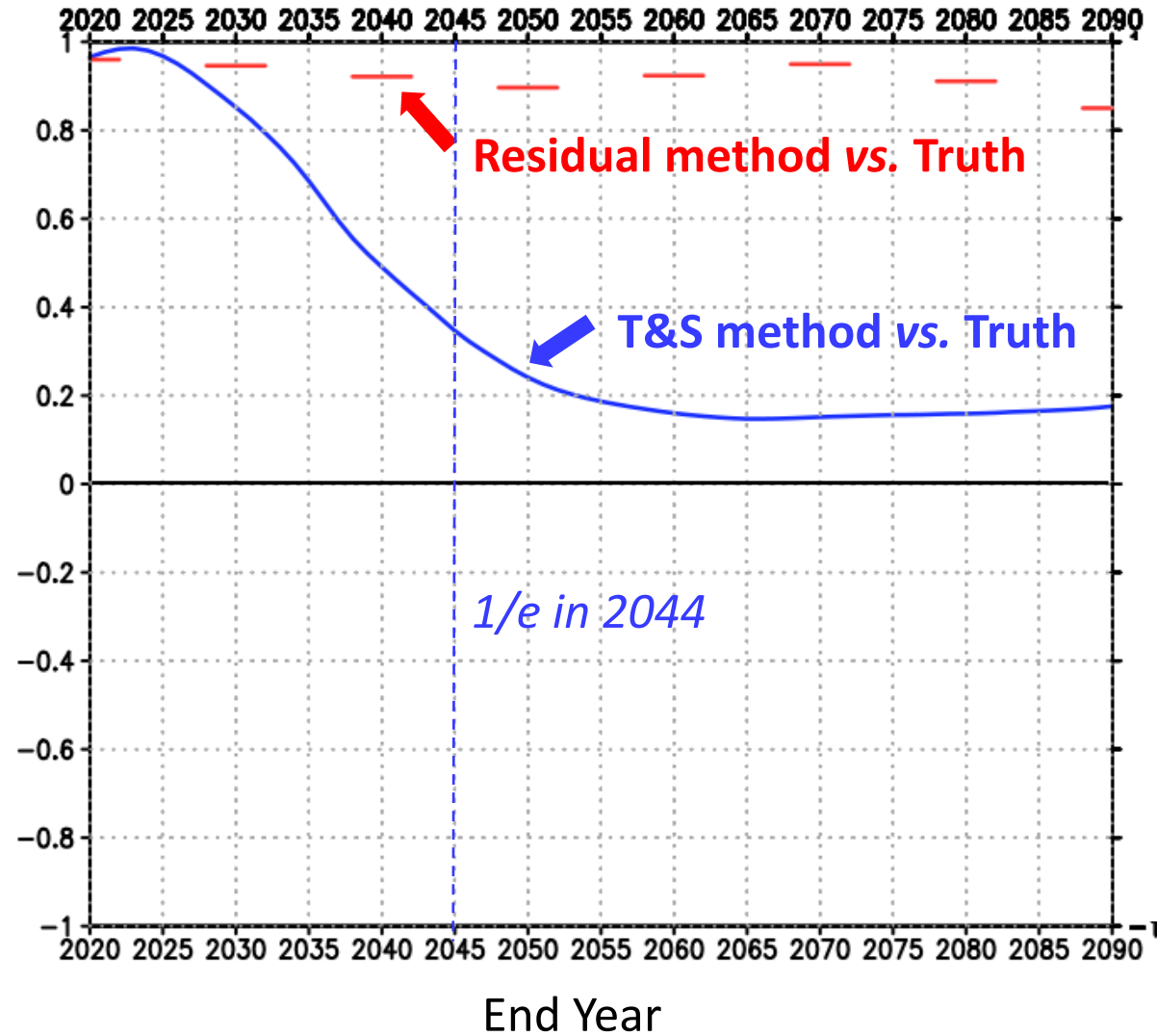
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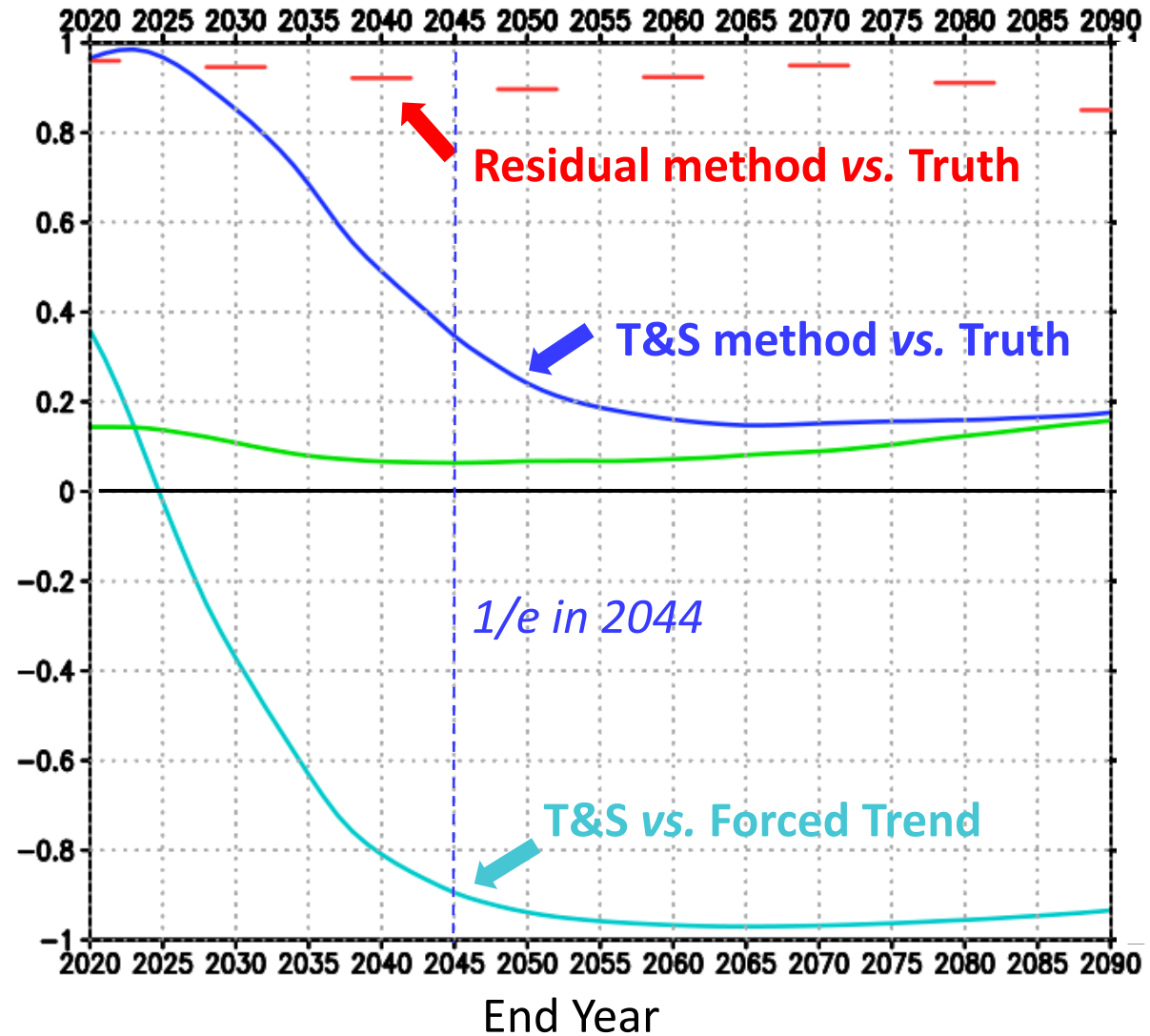
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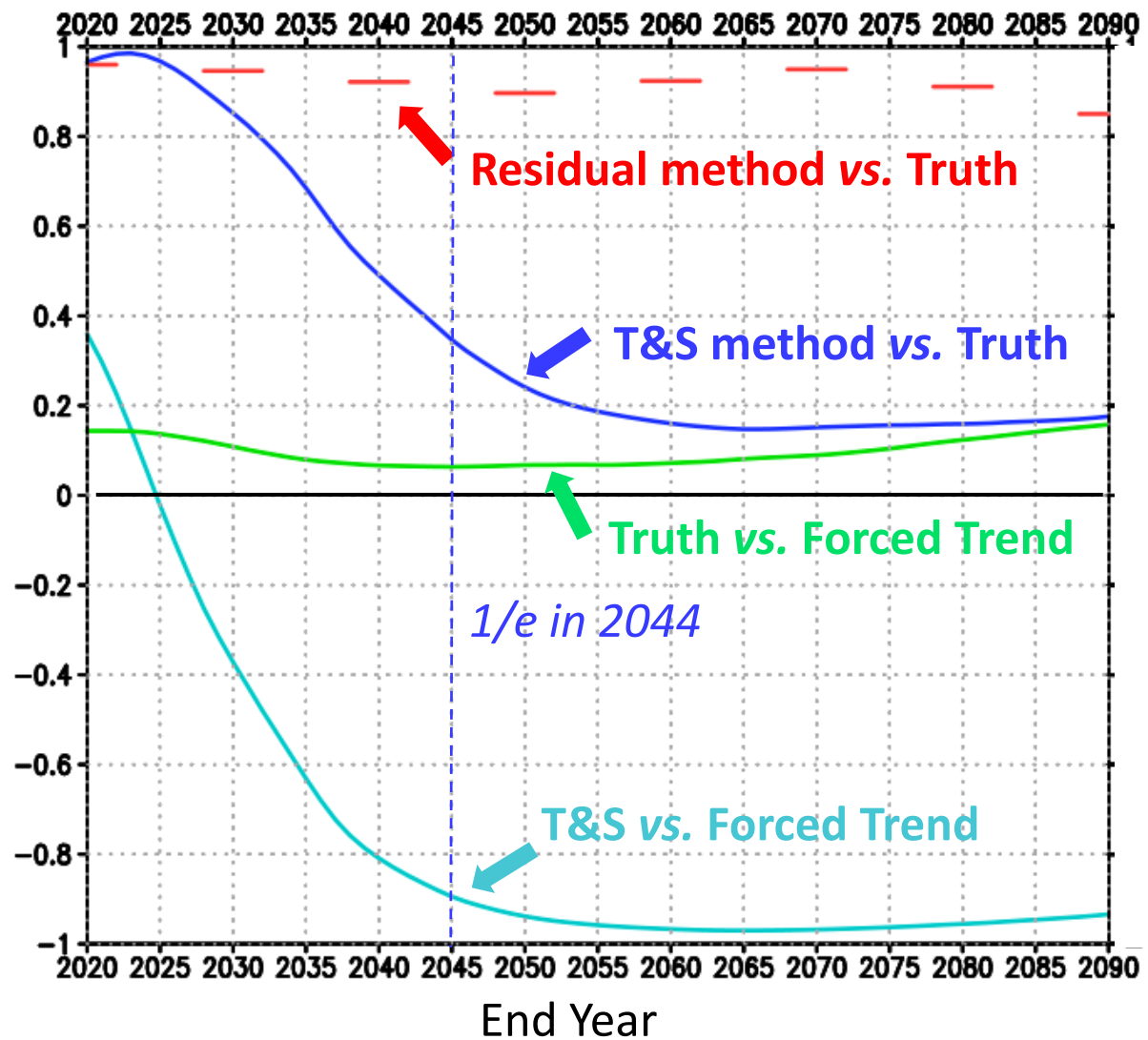
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# Other Model Large Ensembles

(30 members of each)

CMIP5 Multi-Model Large Ensemble Archive

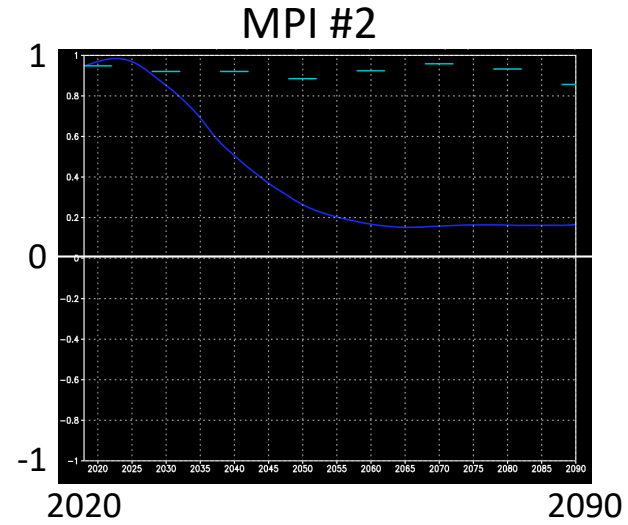
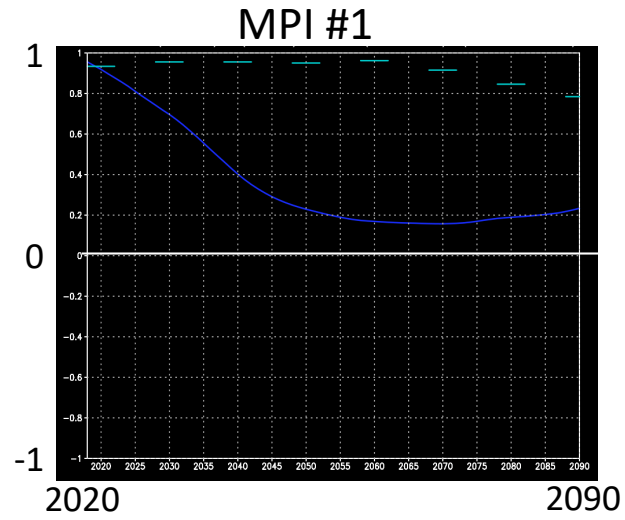
Deser et al (2020, *Nature Climate Change*)

US CLIVAR WG on LEs

# Cumulative Pattern Correlations (since 1950)

Residual method vs. Truth

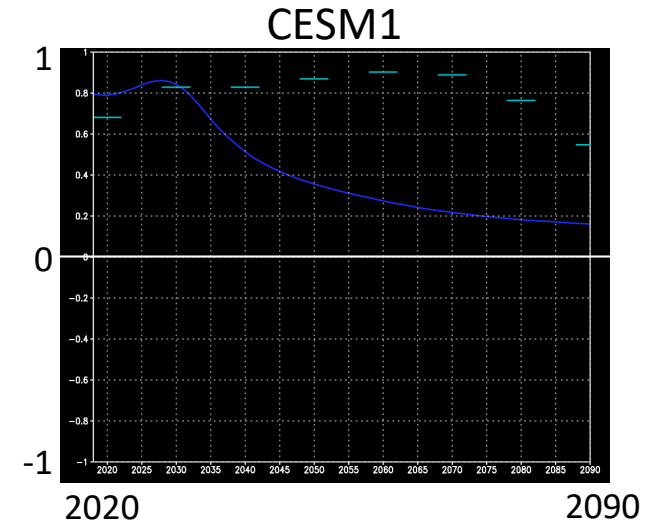
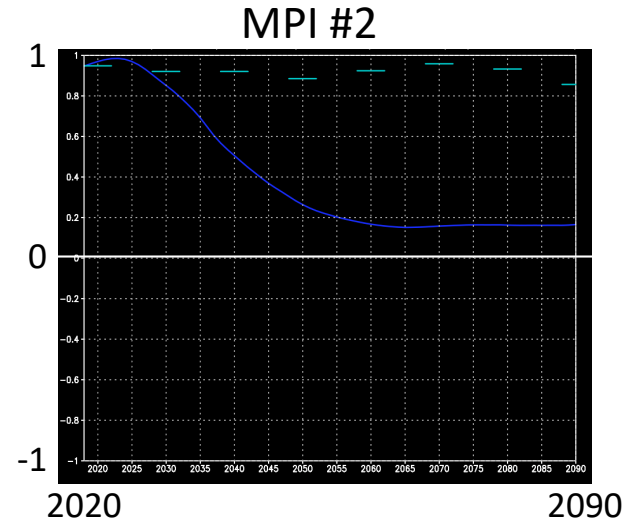
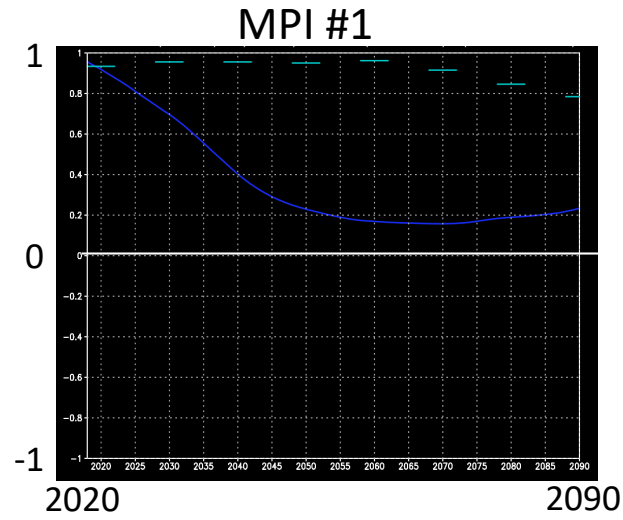
T&S method vs. Truth



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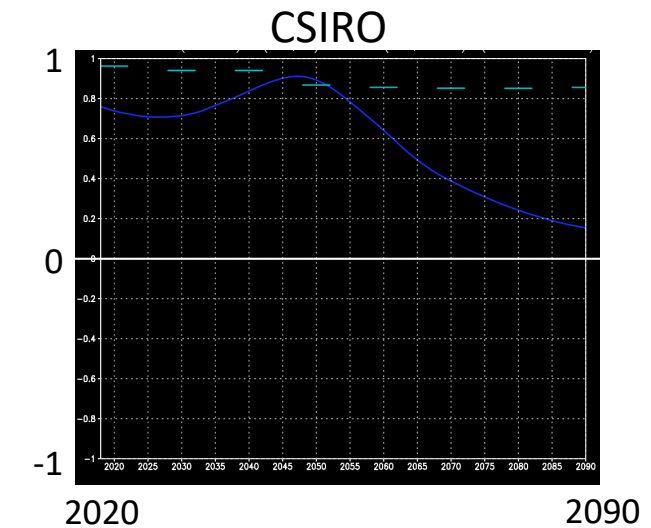
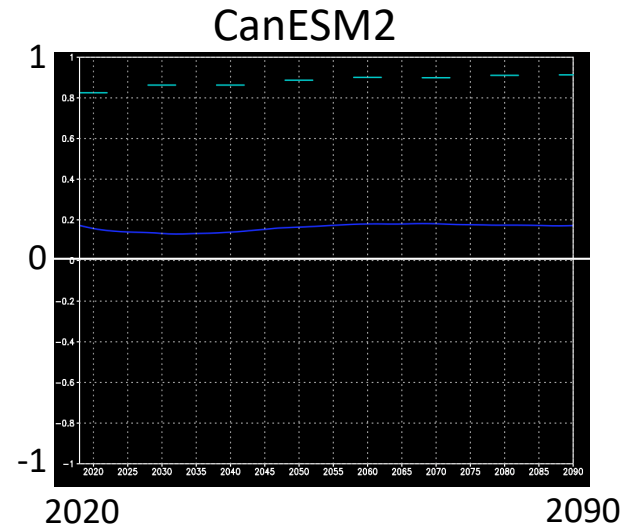
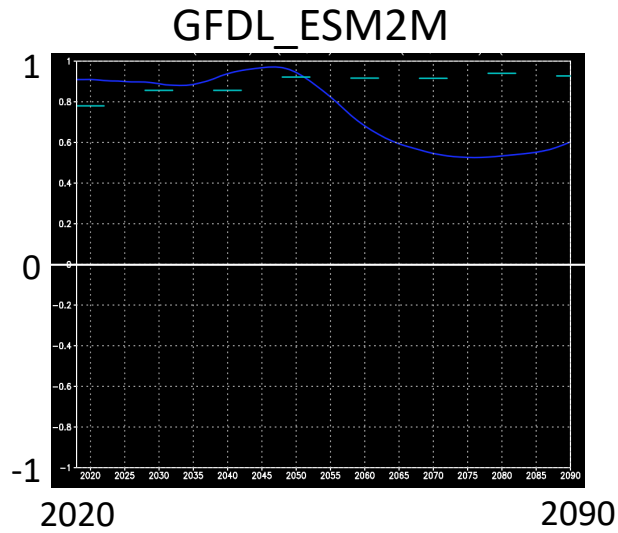
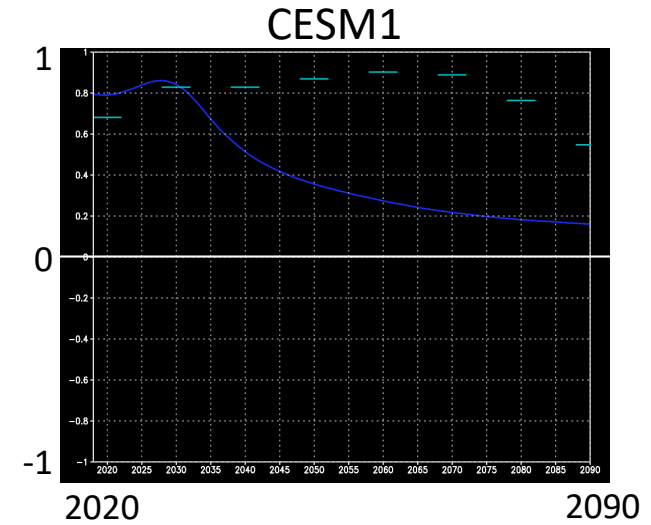
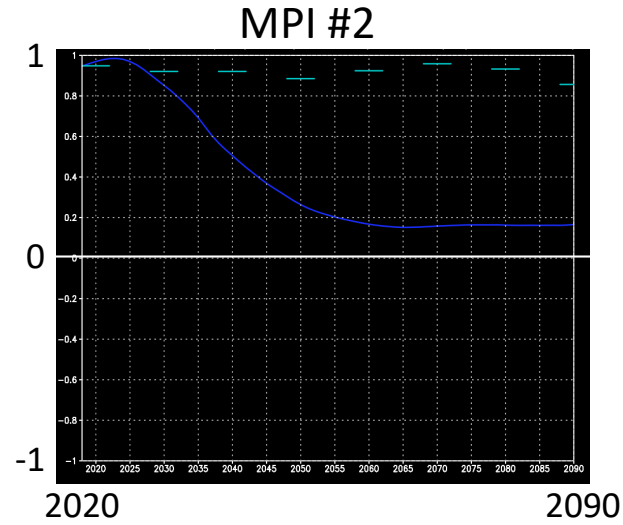
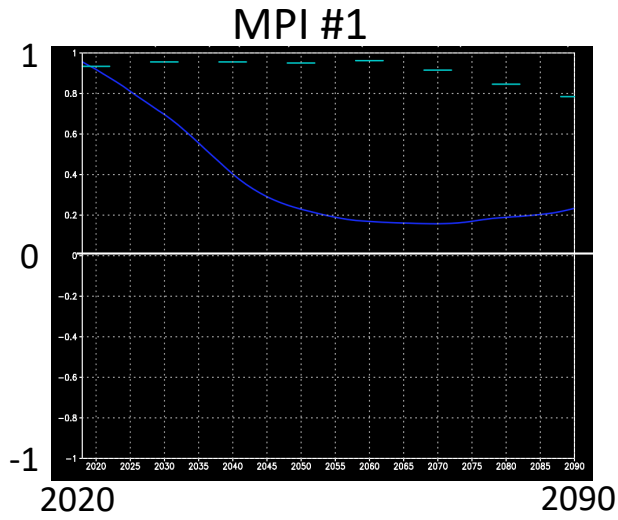
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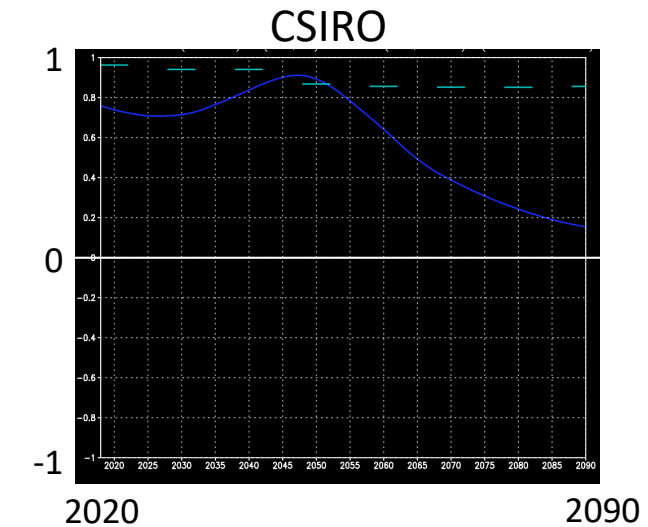
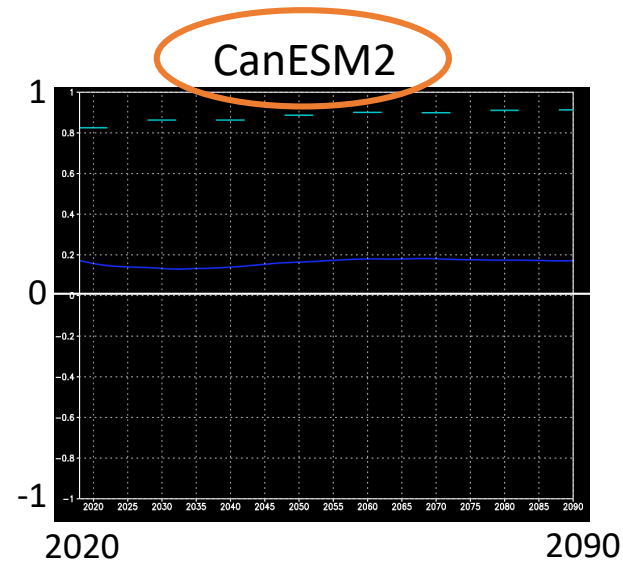
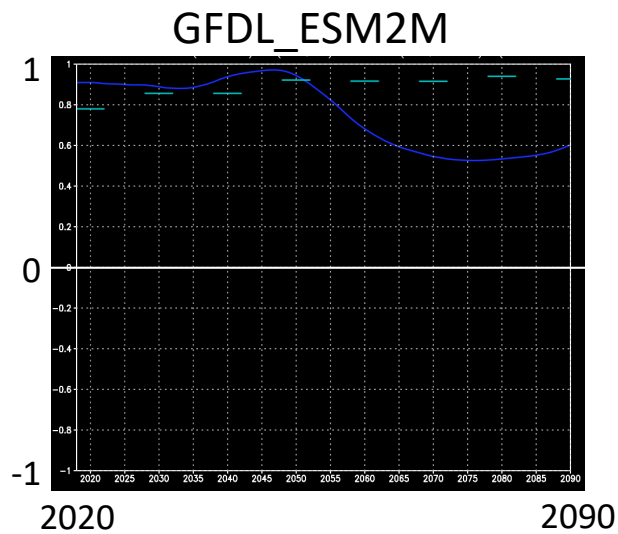
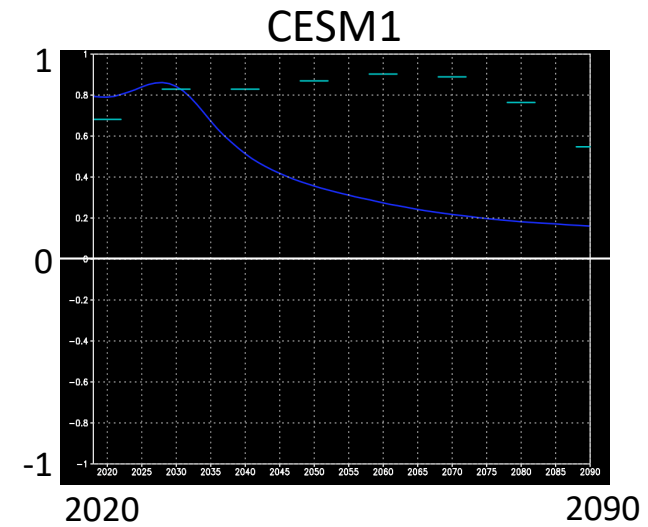
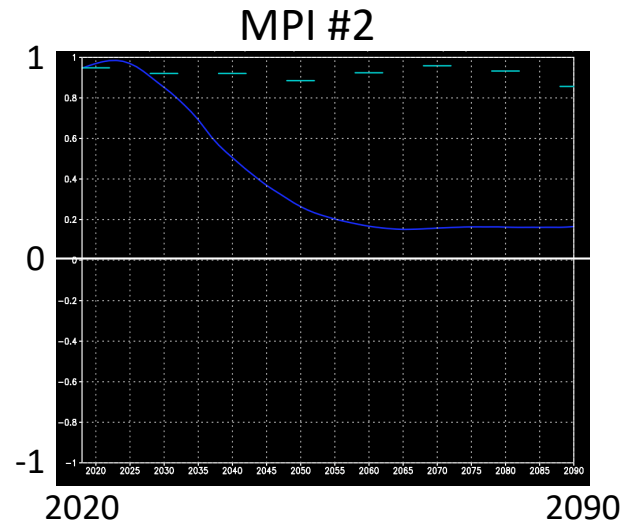
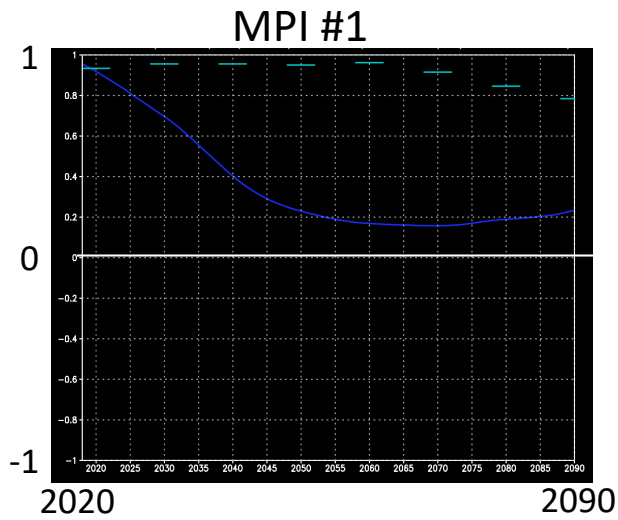




# Cumulative Pattern Correlations (since 1950)

Residual method vs. Truth

T&S method vs. Truth



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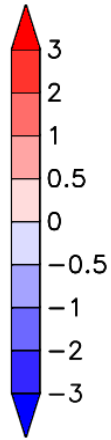
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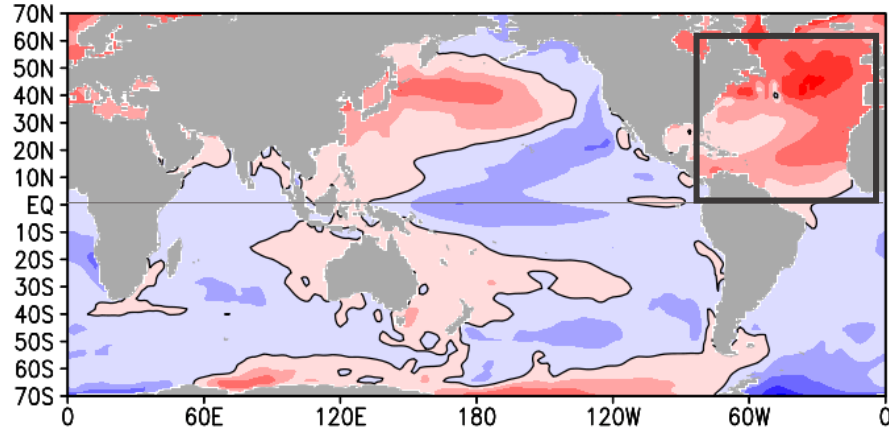
- Subtracting global-mean SST(t) (i.e., Trenberth & Shea method) works well under current and near-term climate change in most CMIP5 model Large Ensembles, but fails thereafter due to aliasing of the global warming pattern.
- Removing the global warming pattern via spatial regression onto GSST(t) (i.e., Zhang et al. 2019; residual method) yields robust results ( $r > 0.8$ ) throughout the 21st century.

Extra

# AMV Internal in the MPI Grand Ensemble: 1950-2100

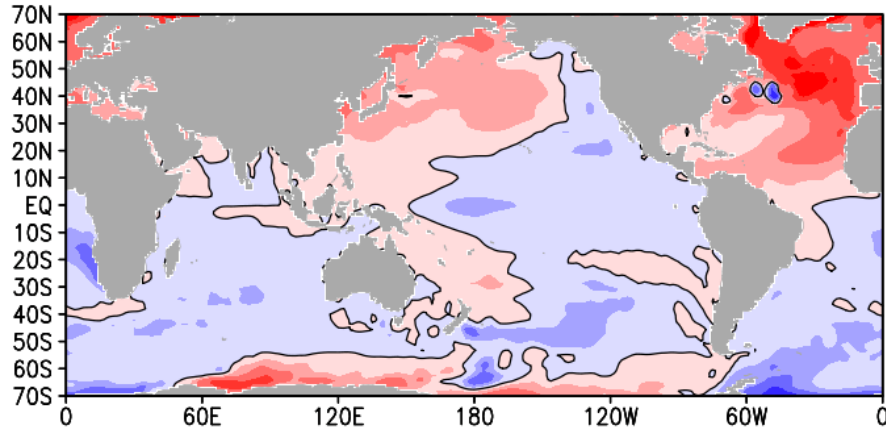


Truth: [ - Ensemble Mean ]



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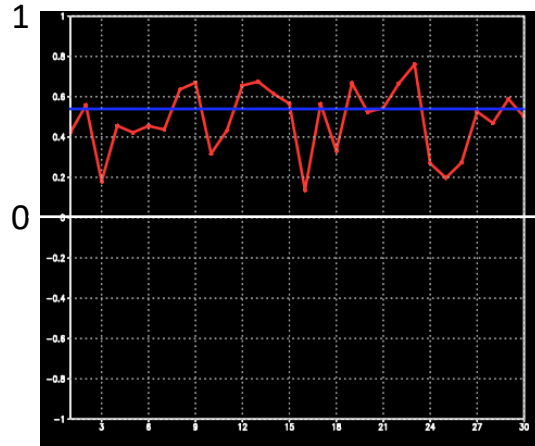


1950-2020

# AMV (Residual Method) Pattern Correlations with EM (1950-2020)

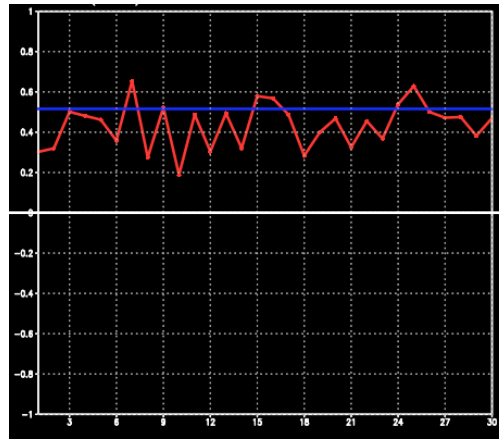
(ERSSTV5)  
20-yr running  
mean annual SST

MPI (1-30)

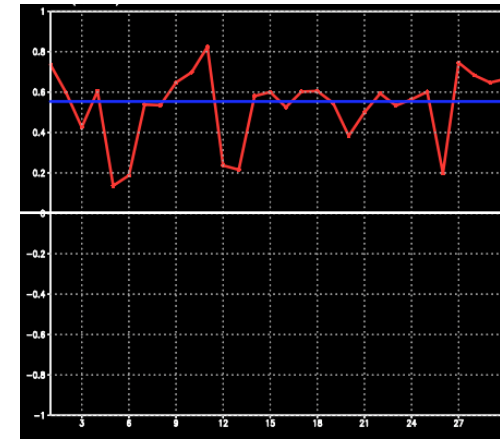


Ensemble Member

MPI (41-70)

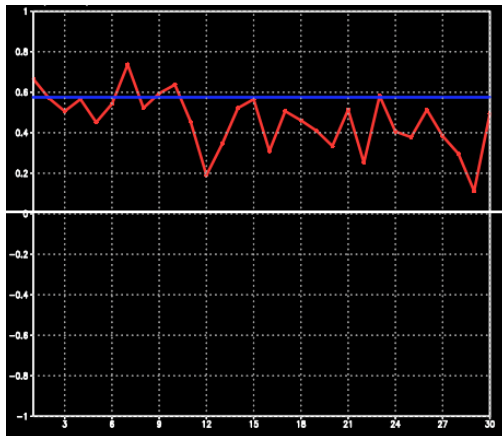


CESM1 (1-30)

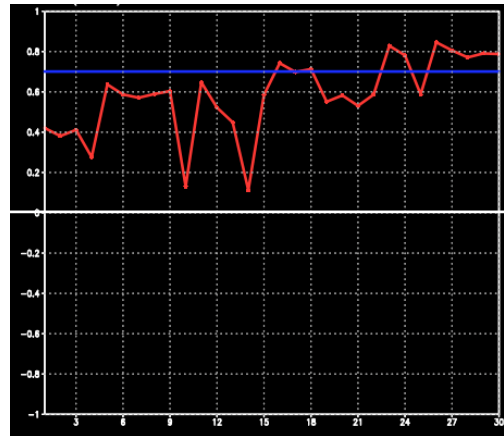


$r(\text{obs, EM})$   
 $r(i, \text{EM})$

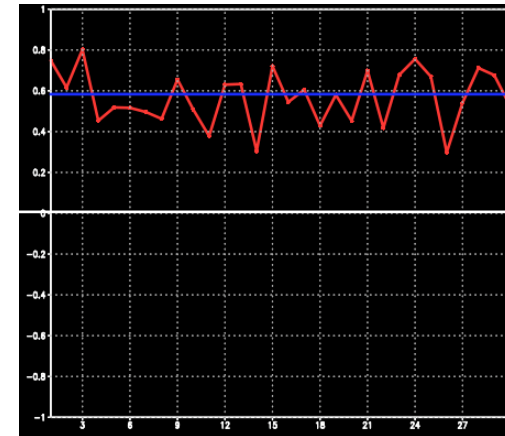
GFDL\_ESM2M (1-30)



CanESM2 (1-30)

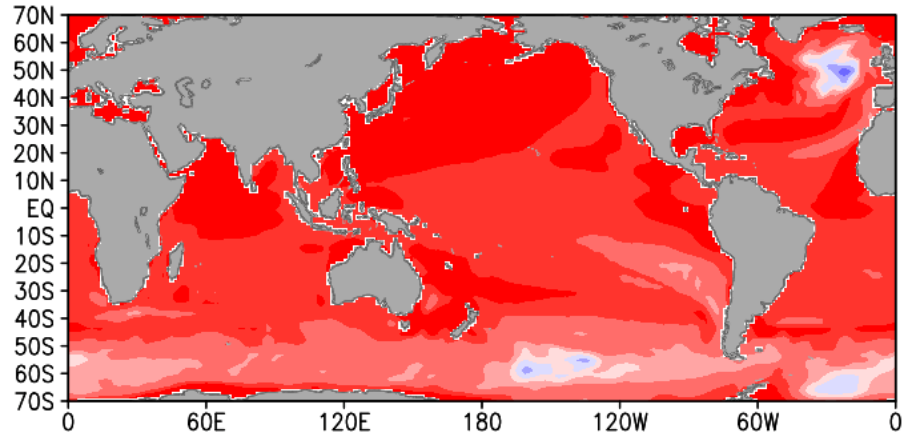


CSIRO (1-30)

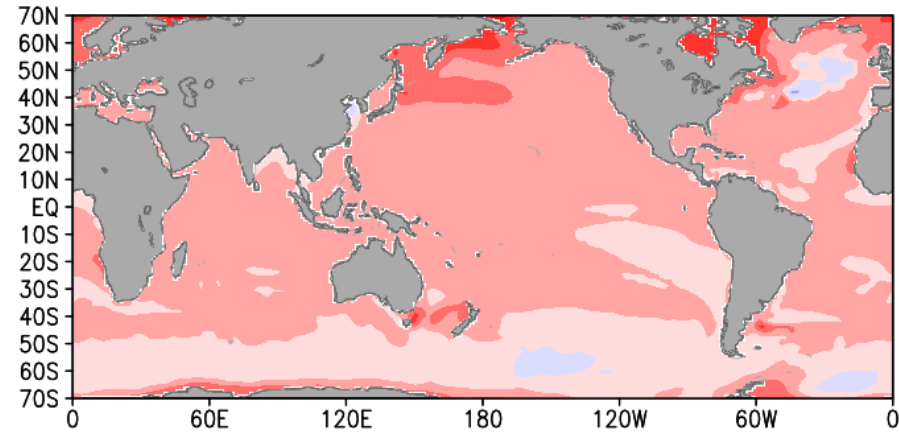


➤  $r(\text{obs, EM})$  lies within 5<sup>th</sup>-95<sup>th</sup> % spread of model  $r(i, \text{EM})$  for all models

# MPI Grand Ensemble: Forced SST Trend



Forced SST\* trend 1955–2095



Forced SST\* trend 1955–2015

