

Internal variability and surface temperature change

John C. Fyfe

Canadian Centre for Climate
Modelling and Analysis



Environment
Canada

Environnement
Canada

Canada

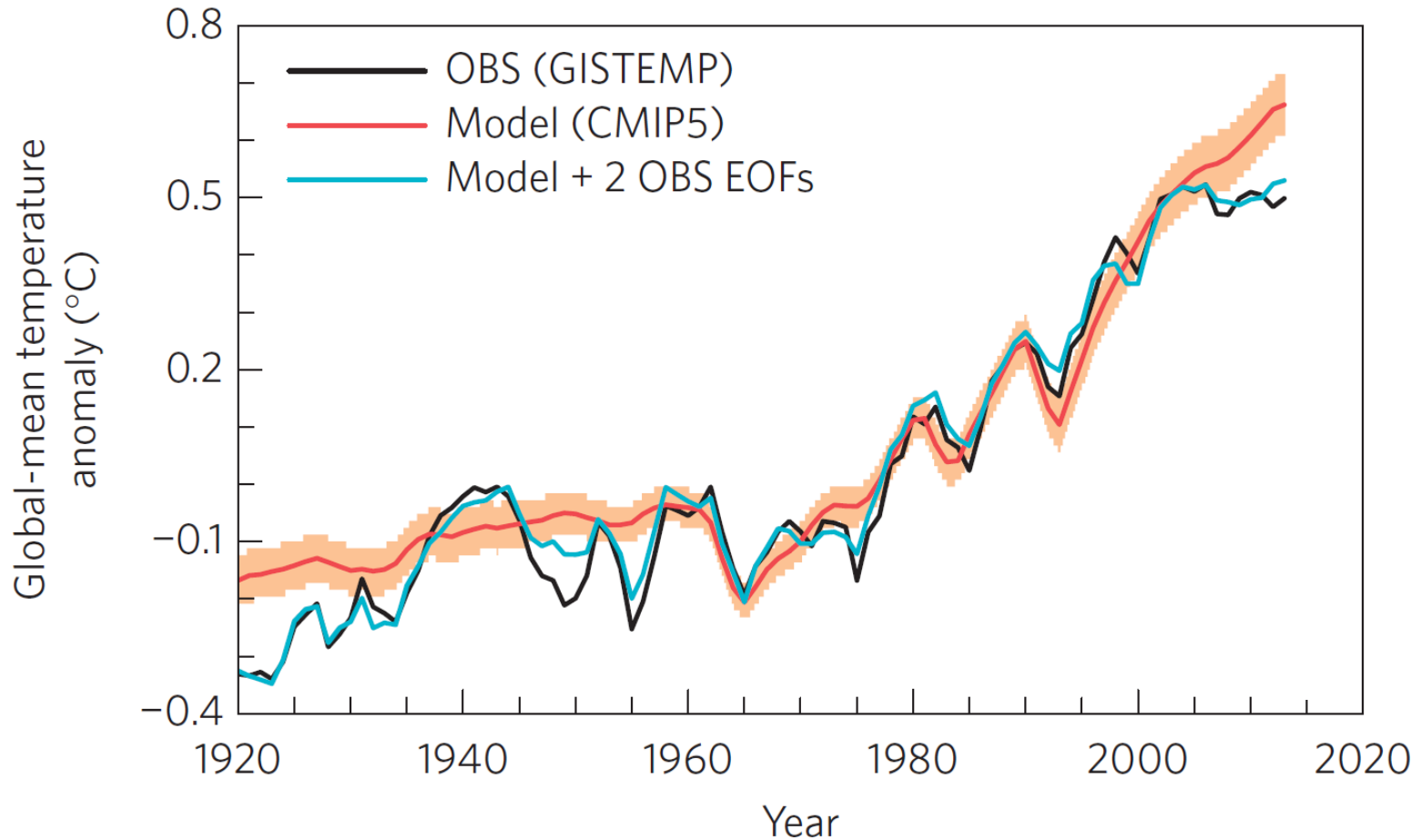
1. Warming slowdowns since 1920

Aiguo Dai, John Fyfe, Shang-Ping Xie and Xingang Dai

2. Cooling North American winters since 2002

Michael Sigmond and John Fyfe

GMST anomalies (annual)

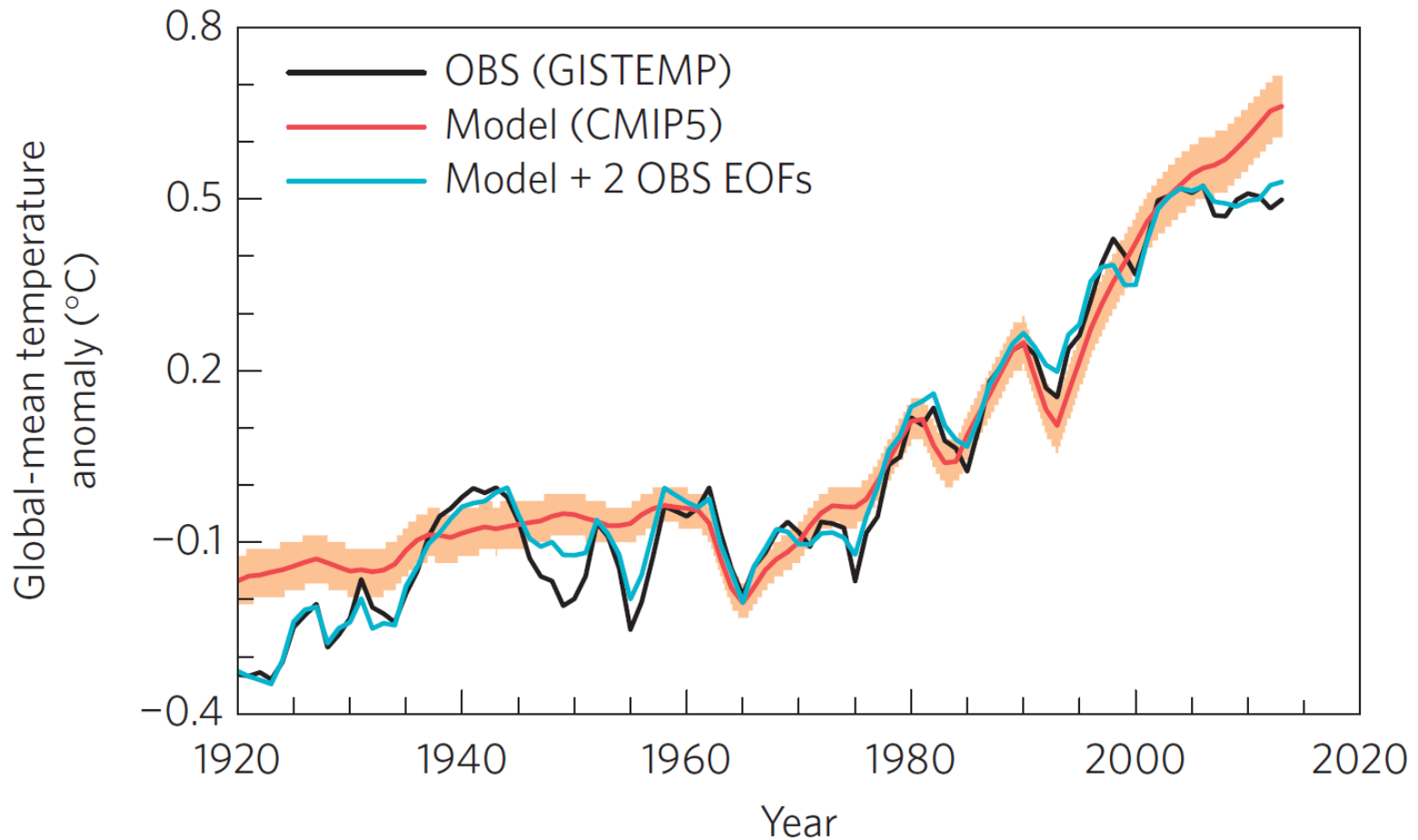


Dai *et al.* (*Nature Clim. Change*, 2015)

The approach

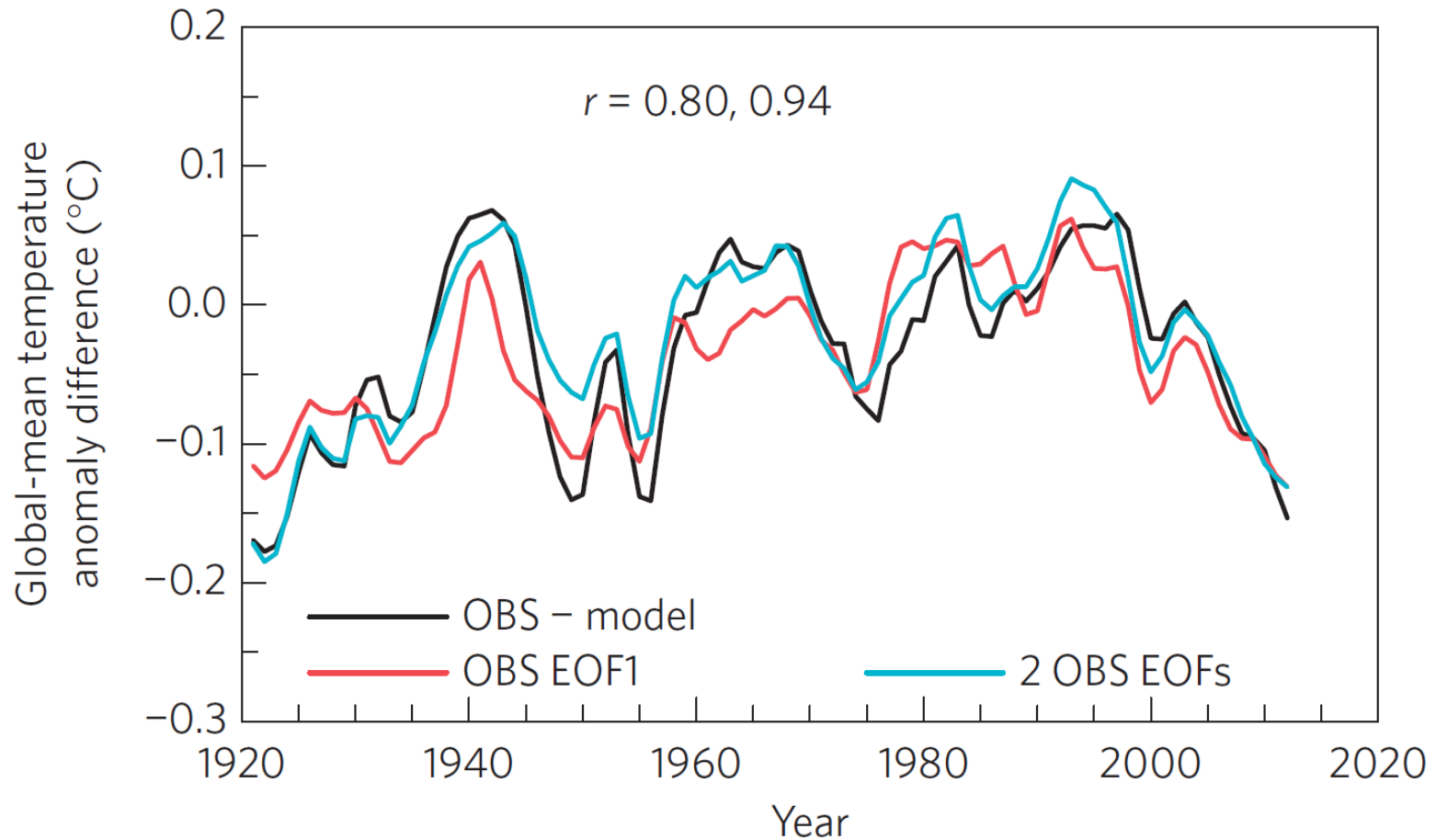
2. Remove CMIP5 GMST from OBS ST
3. 3-year means and EOF expansion
4. Compute OBS GMST (residual)
5. Add back CMIP5 GMST (total)

GMST anomalies (total)



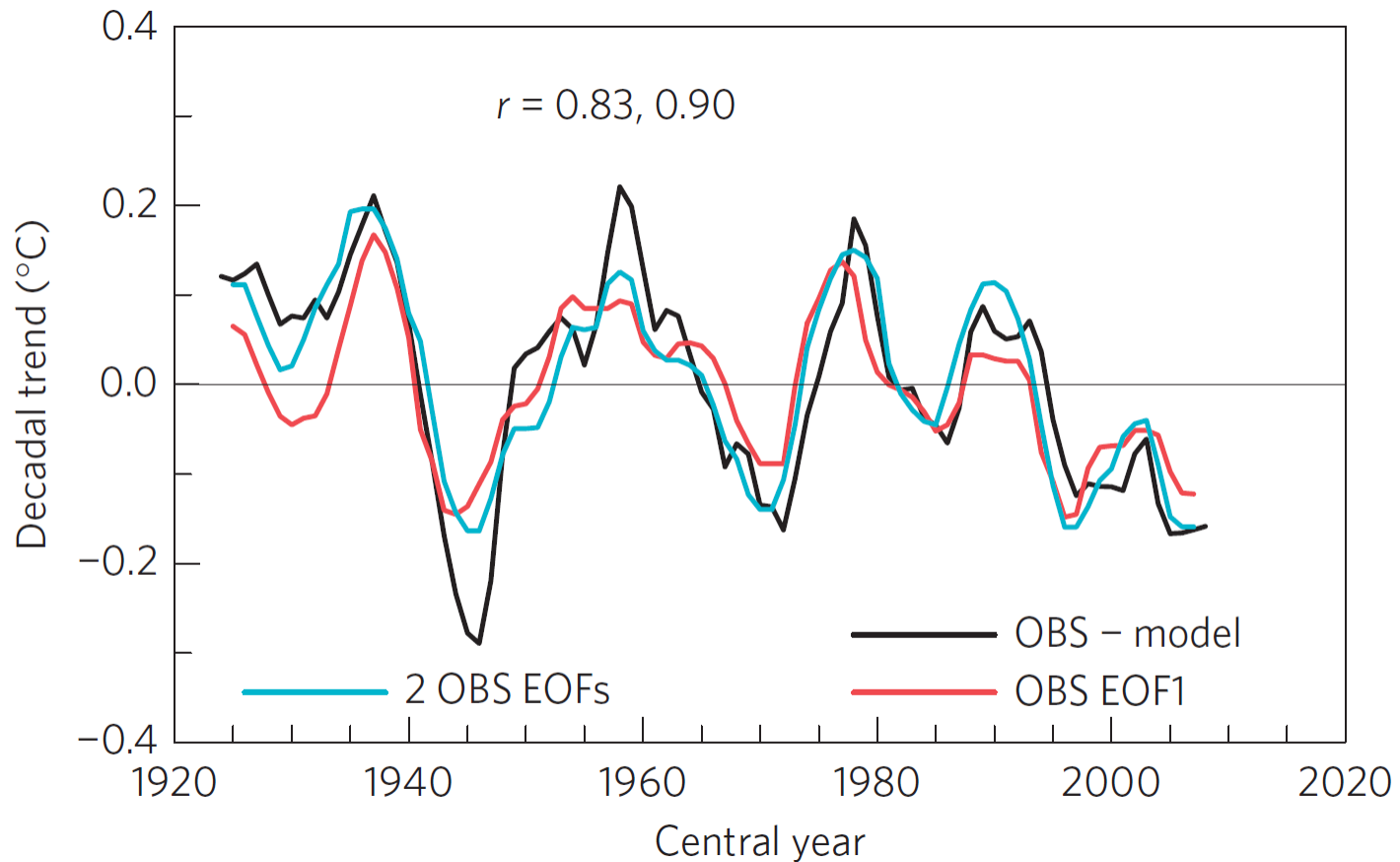
Dai *et al.* (*Nature Clim. Change*, 2015)

GMST anomalies (residual)



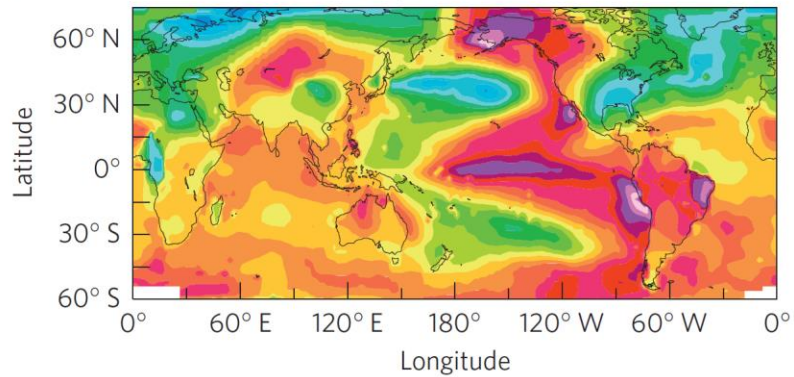
Dai *et al.* (*Nature Clim. Change*, 2015)

GMST decadal trends (residual)

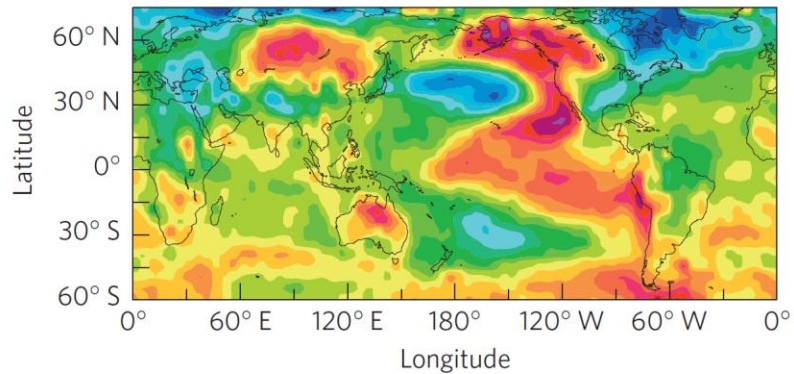


Dai *et al.* (*Nature Clim. Change*, 2015)

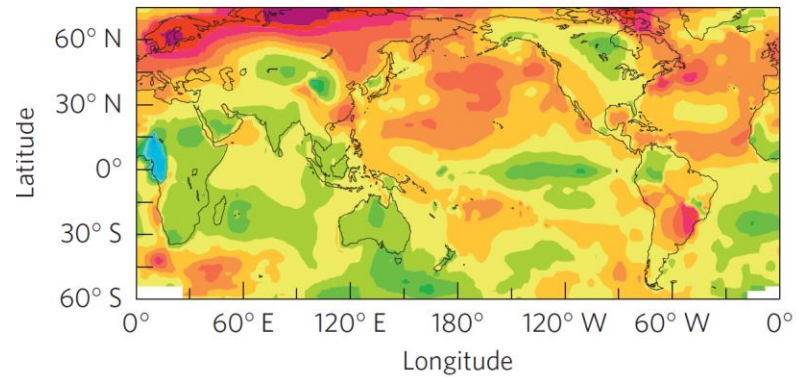
EOF1



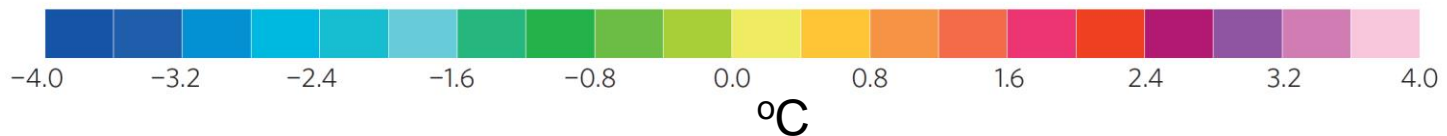
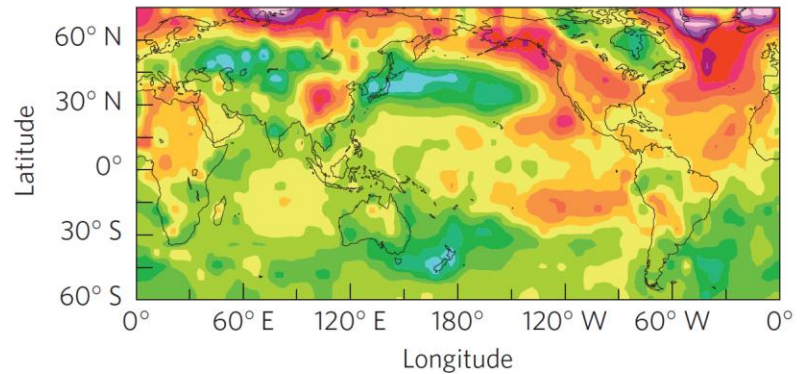
IPO: $r = 0.81$



EOF4

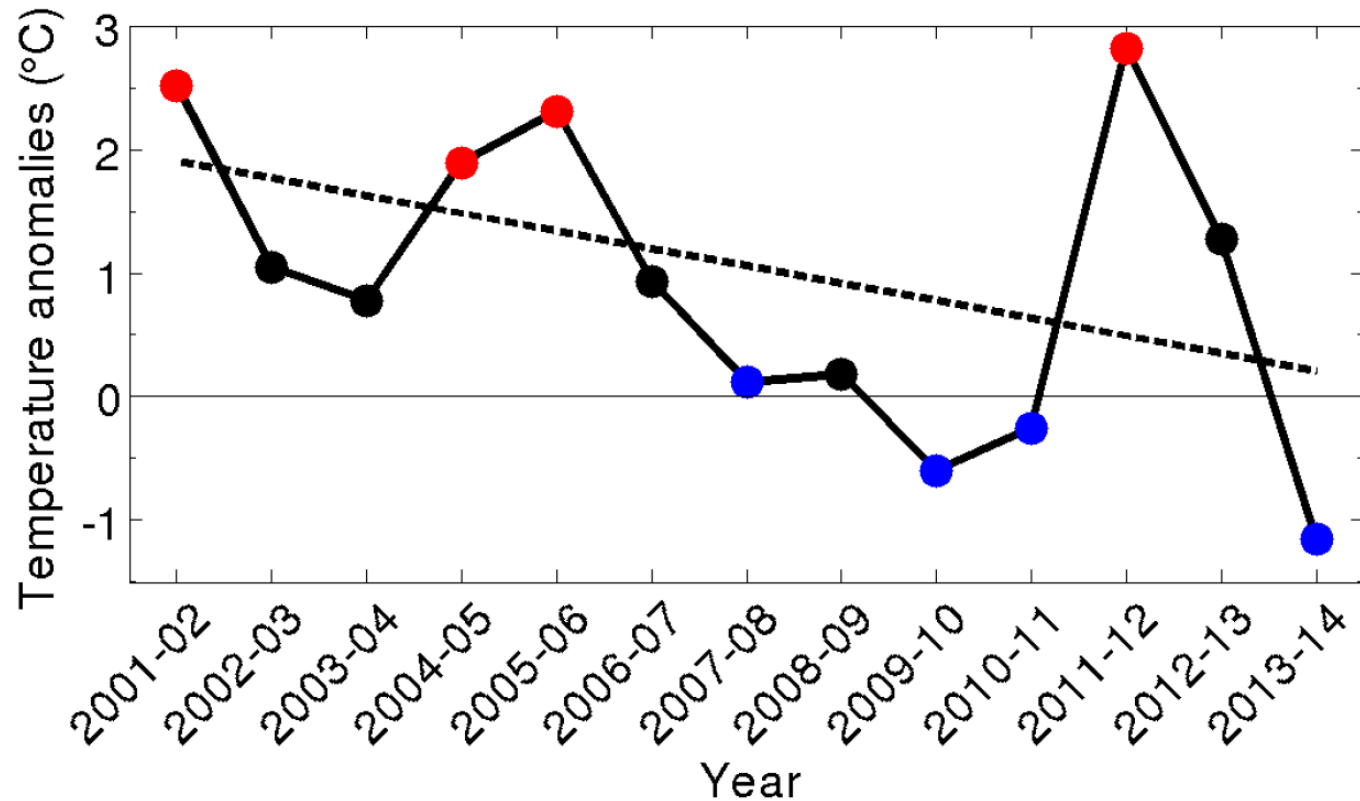


AMO: $r = 0.33$



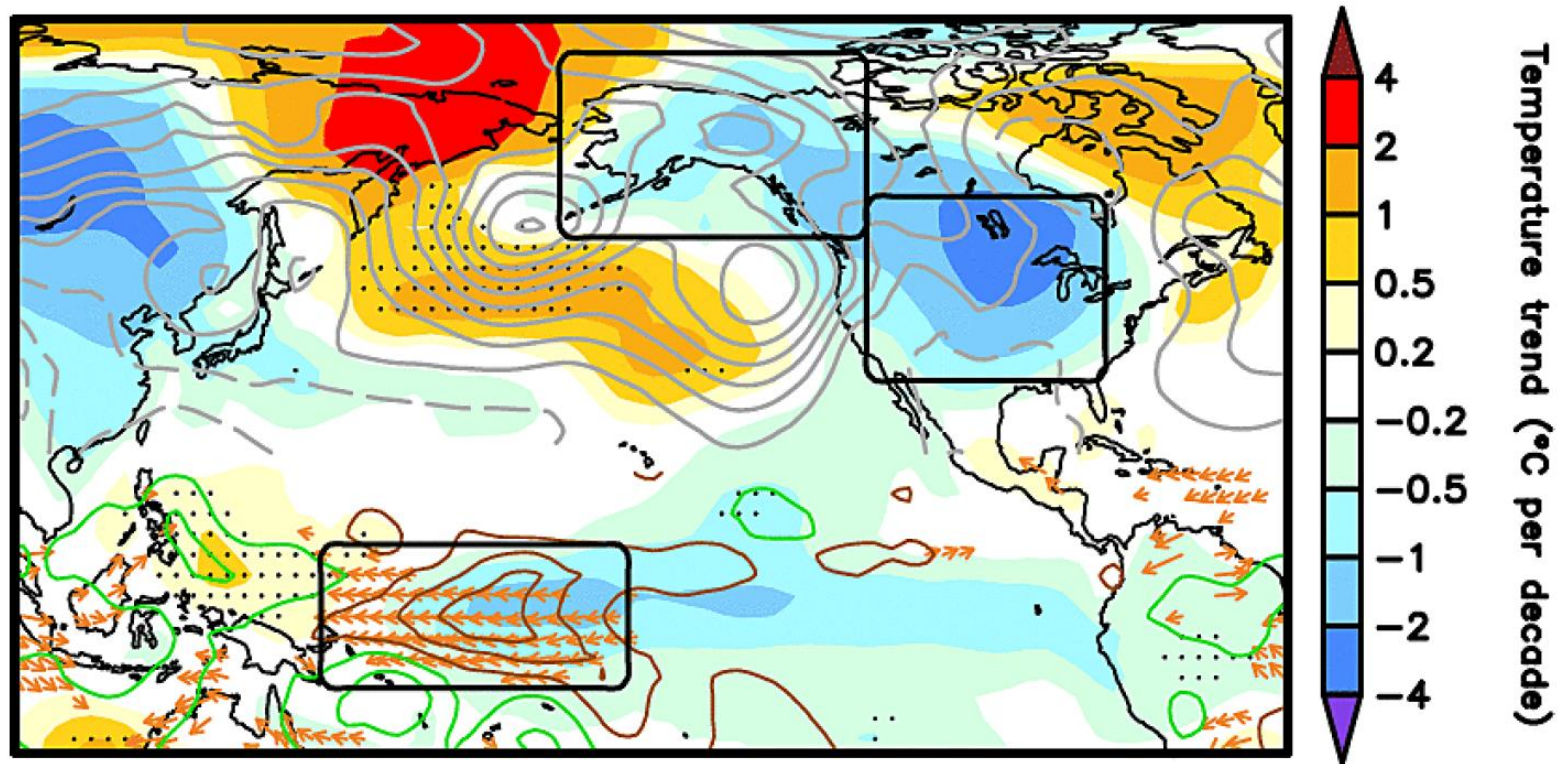
Dai *et al.* (*Nature Clim. Change*, 2015)

Central North American winters



Sigmond & Fyfe (*in prep.*)

Winter trends (2002-2014)

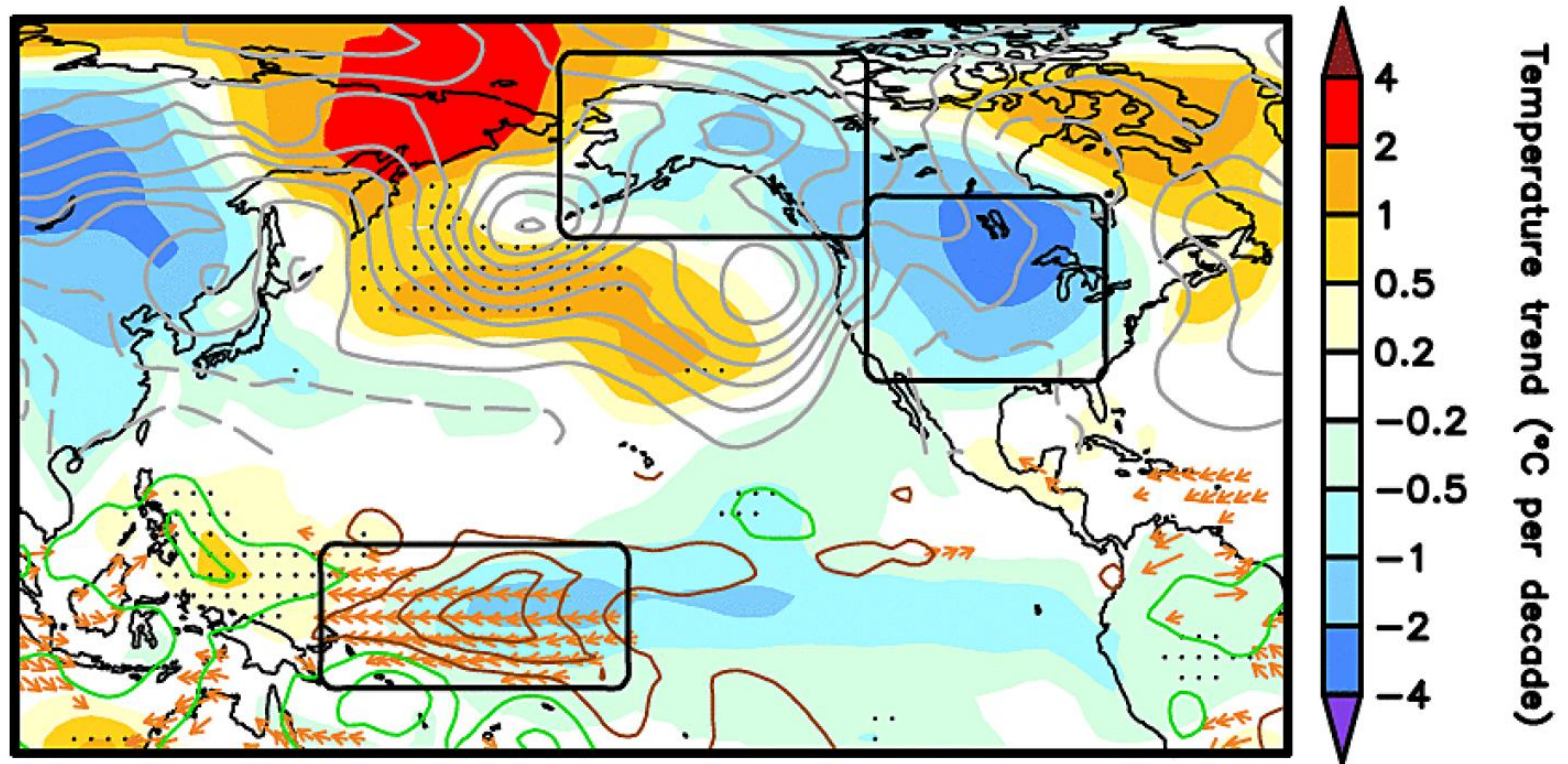


Sigmond & Fyfe (*in prep.*)

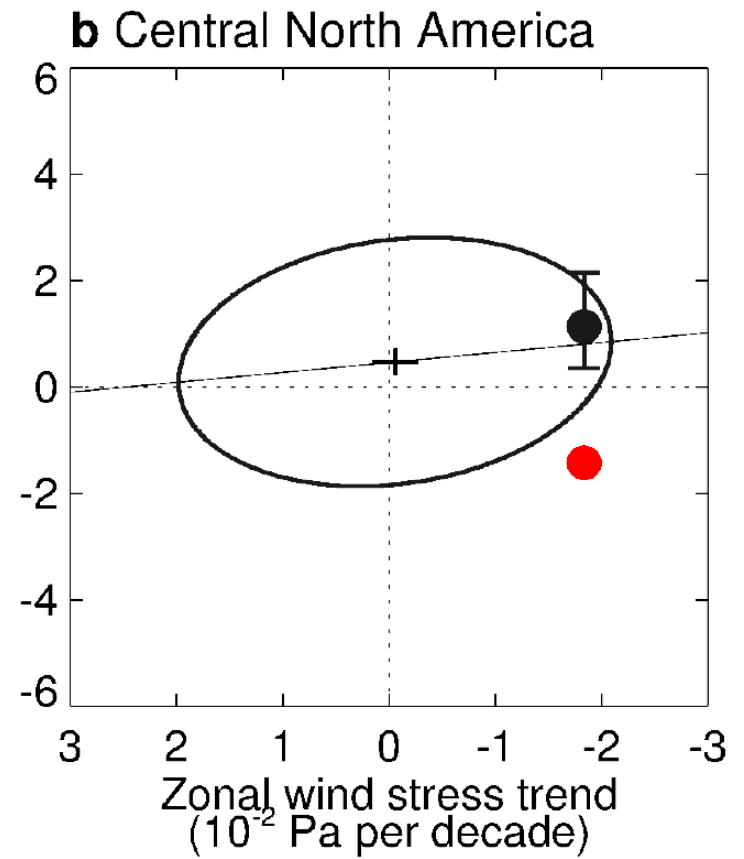
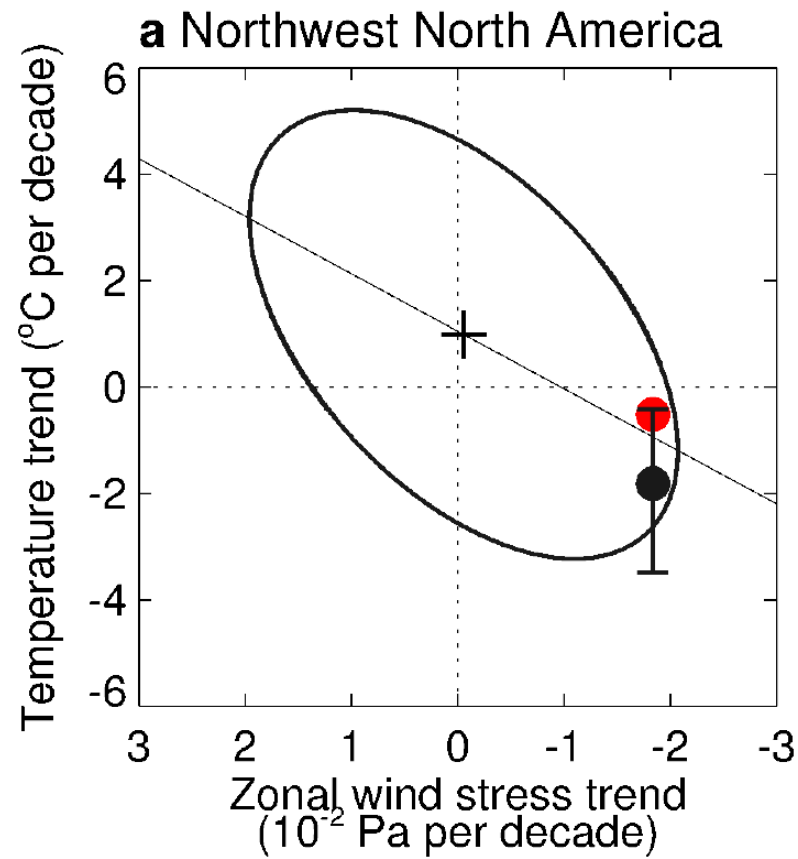
Everything but the kitchen sink

1. 100-member initial condition ensemble
2. 10-member pacemaker ensemble with observed tropical surface wind
3. AGCM ensemble with prescribed tropical Pacific SSTs

Winter trends (2002-2014)



Sigmond & Fyfe (*in prep.*)



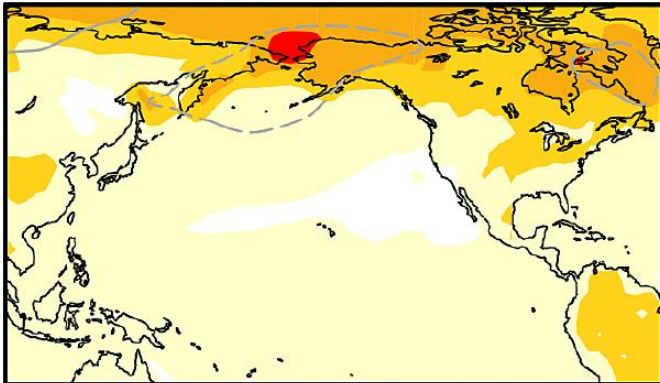
Sigmond & Fyfe (*in prep.*)

Temperature trends associated
with observed trades trend

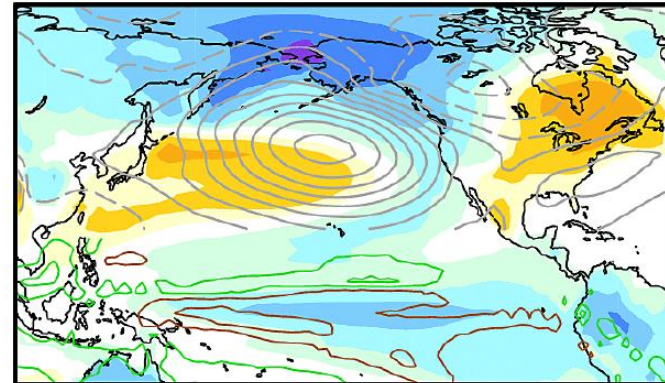
$$\Delta \vec{T}_i \approx \vec{\beta} \Delta \tau_i$$

$$\rightarrow \Delta \vec{T}^\tau = \vec{\beta} \Delta \tau^{obs}$$

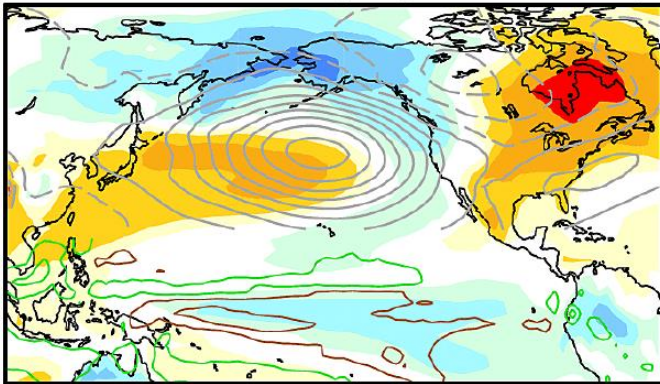
a Forced (large ensemble)



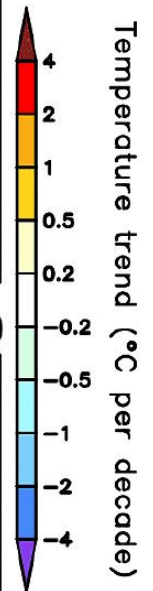
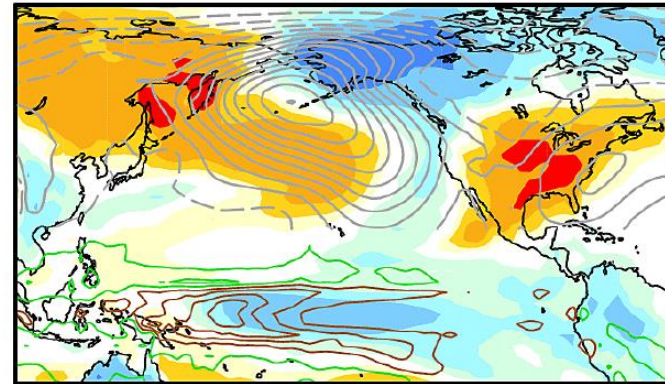
b Wind (large ensemble)



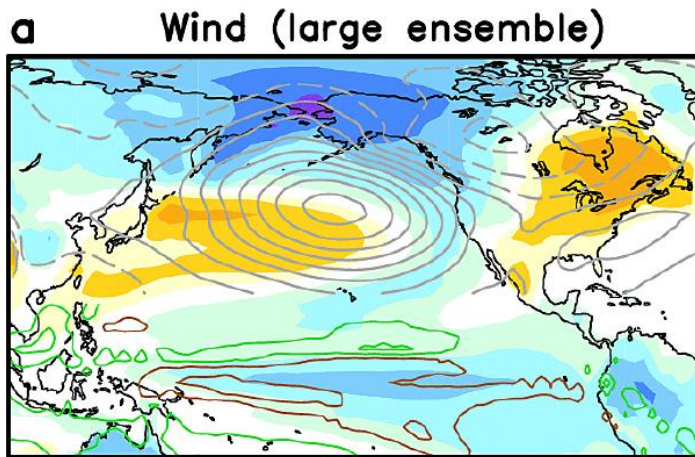
c Forced+Wind (large ensemble)



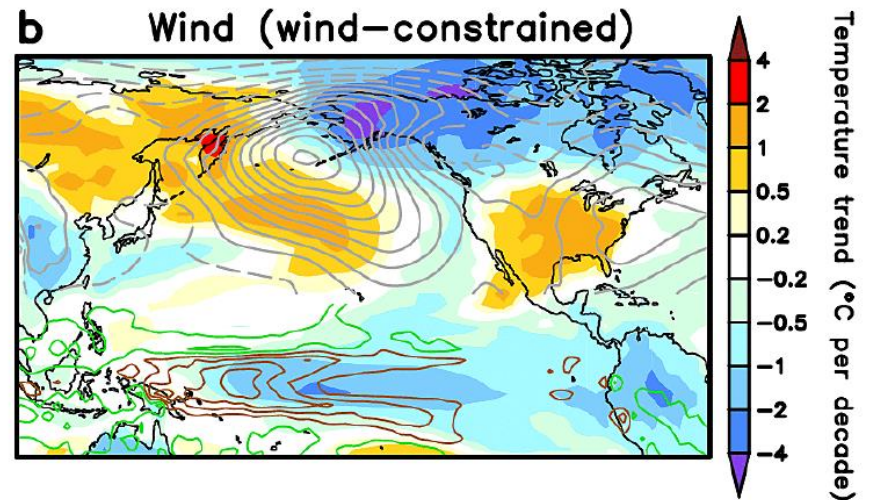
d Forced+Wind (wind-constrained)



Large ensemble

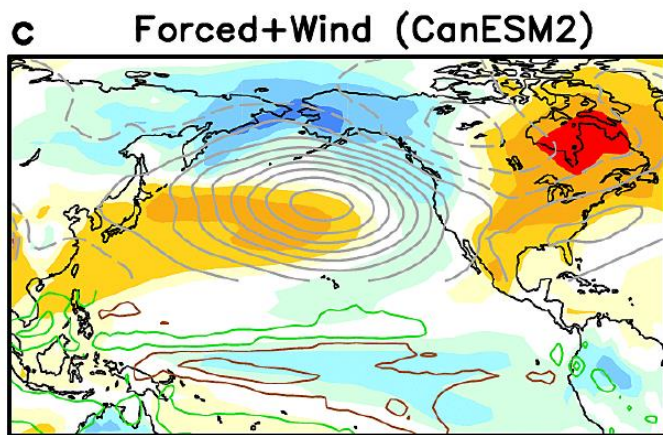
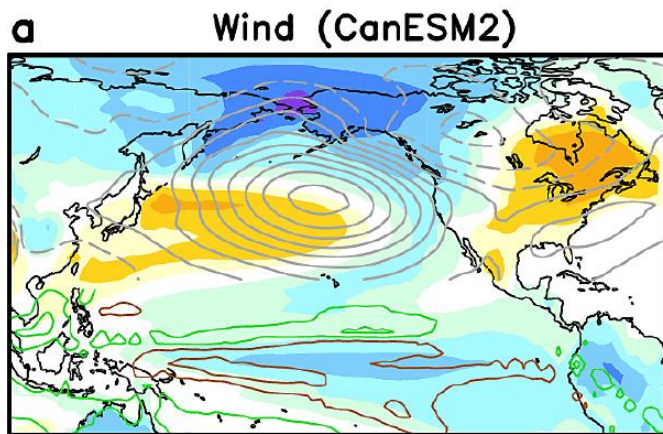


Pacemaker

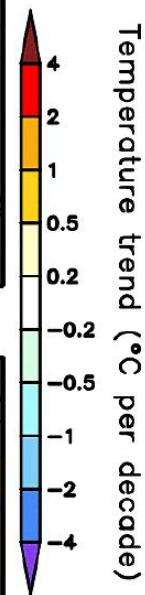
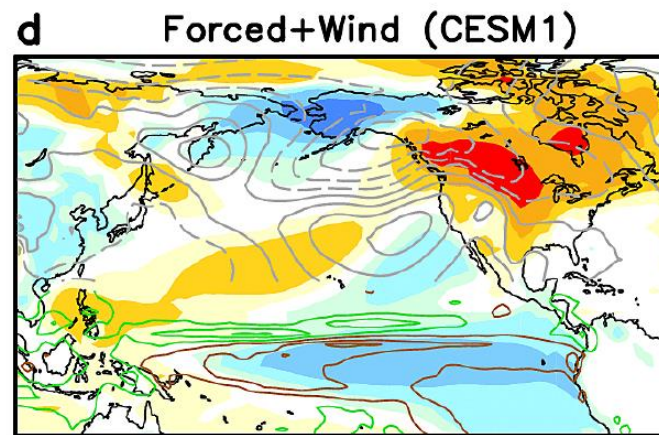
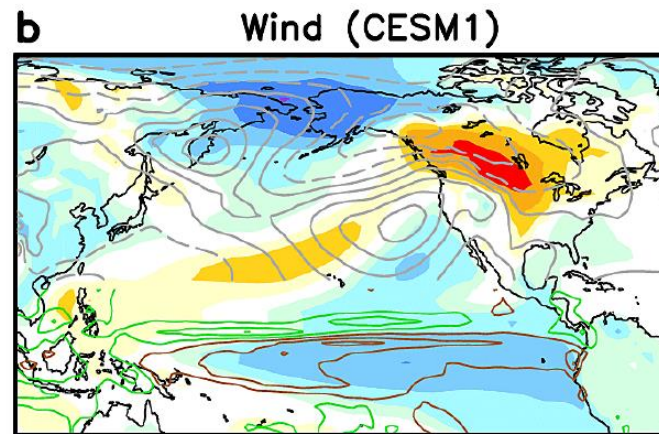


Sigmond & Fyfe (*in prep.*)

CanESM2 LE



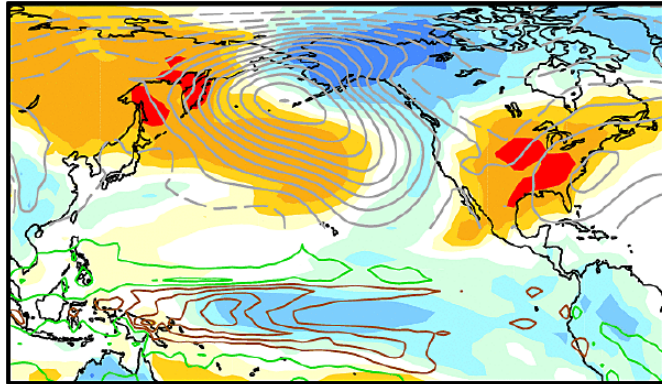
CESM1 LE



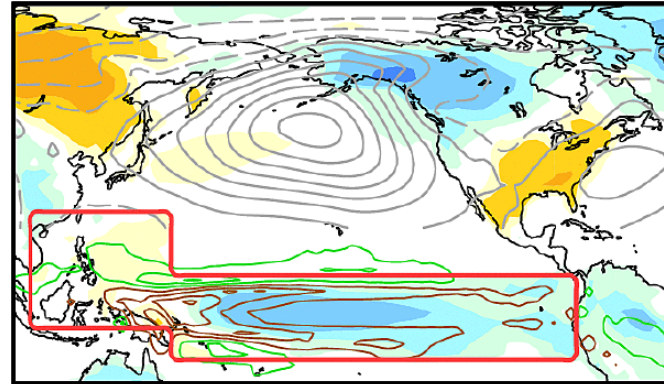
Sigmond & Fyfe (*in prep.*)

AGCM with pacemaker SSTs

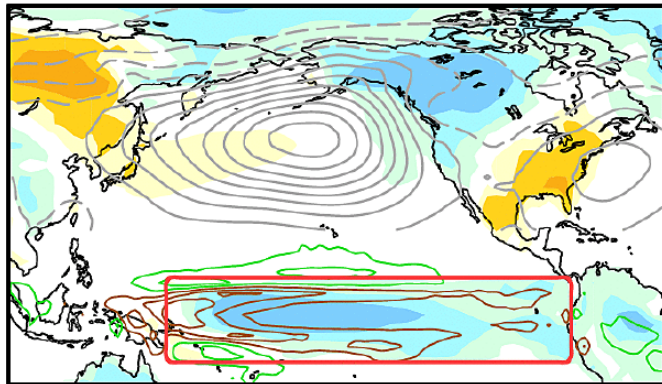
a Forced+Wind (wind-constrained)



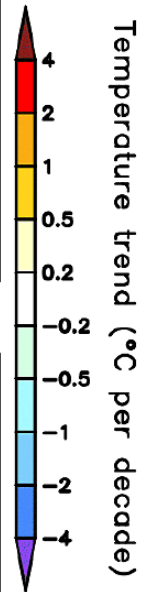
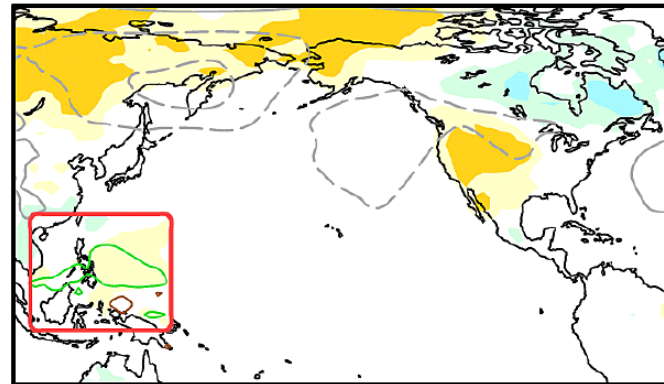
b AGCM



c AGCM

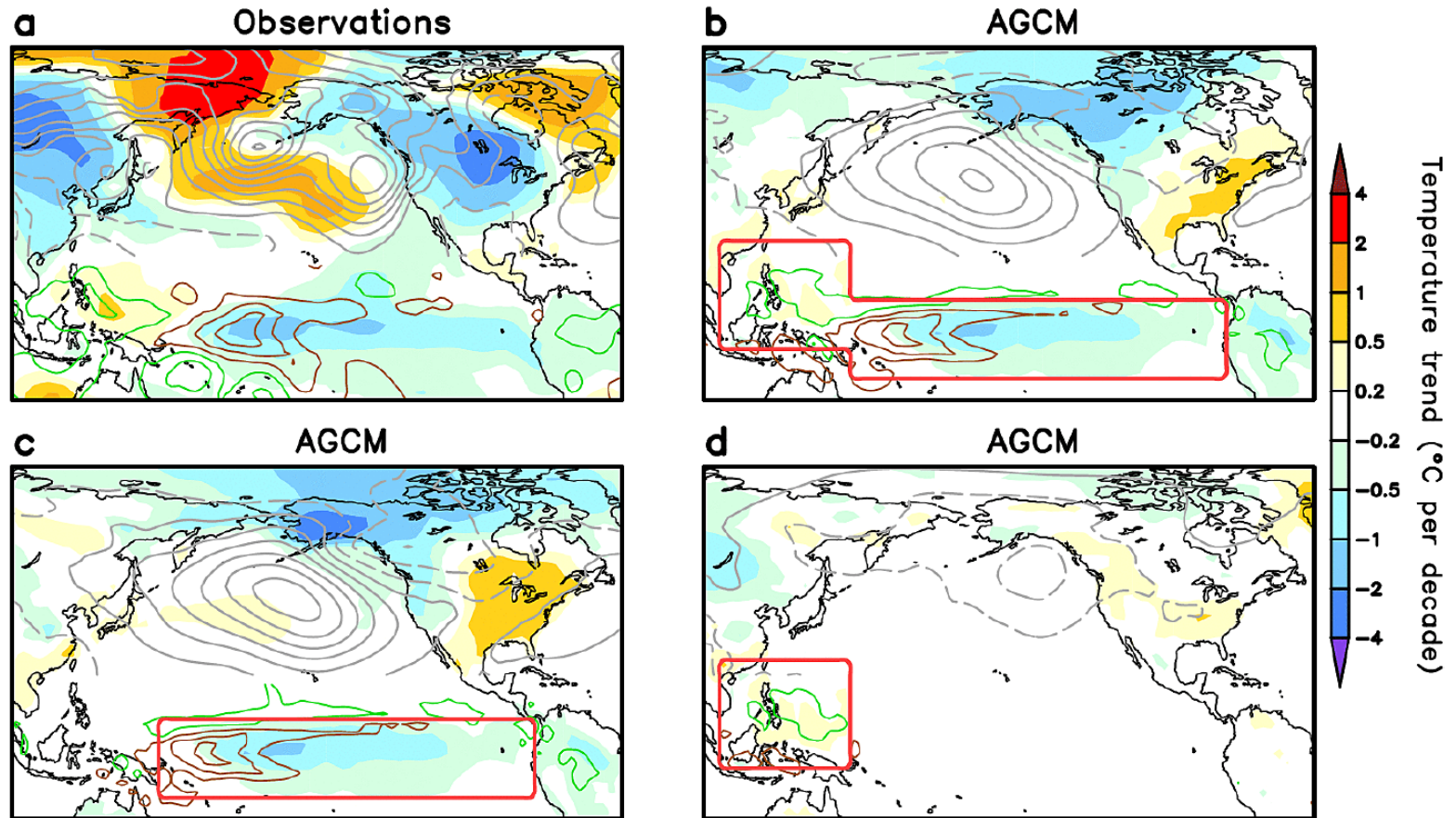


d AGCM



Sigmond & Fyfe (*in prep.*)

AGCM with observed SSTs



Sigmond & Fyfe (*in prep.*)

Summary

1. Recent warming slowdown, and others since 1920, primarily due to the IPO
2. Recent cold central North American winters not linked to the tropical Pacific

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