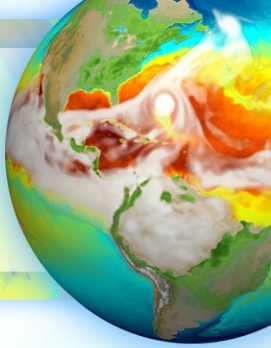


Learning from models that won't

(Trying to)

Chris Golaz and the entire **DOE E3SM Water Cycle Group**

EarthCARE Modeling Workshop
16-18 Feb 2022, online meeting

E3SM Energy Exascale Earth System Model

LLNL-PRES-831687
Work at LLNL was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

U.S. DEPARTMENT OF ENERGY

Caveats

1. This is very much a model builder's perspective.
2. This may be very model specific (E3SMv2).
3. This may be obvious... or not.

ECS and aerosol ERF

- **E3SMv2 is the newest version of DOE's ESM.**
- From E3SMv1 to E3SMv2,

	E3SMv1	E3SMv2
ECS	**5.3 K**	**4.0 K**
Total aerosol ERF	**-1.65 W/m^2**	**-1.53 W/m^2**

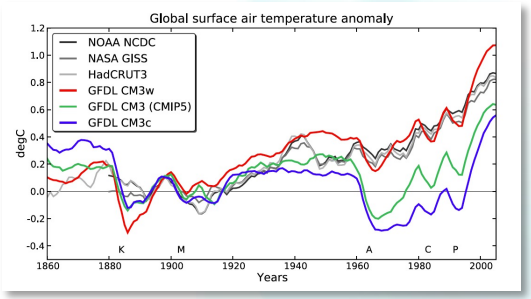
➢ moving in the right direction.

WCRP assessments

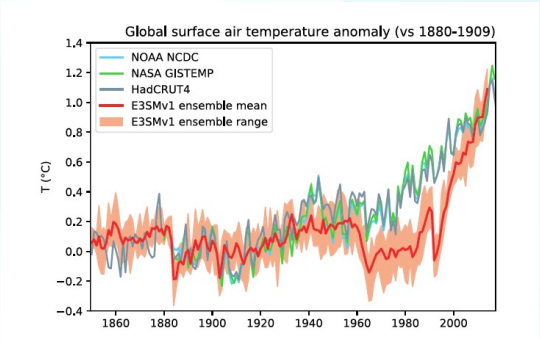
Sherwood et al. (2020)
ECS estimate (66%)
2.6 – 3.9 K (baseline)
2.3 – 4.7 K (robustly)

Bellouin et al. (2020)
Total aerosol ERF
-1.6 to -0.6 W m^{-2} (68%)
-2.0 to -0.4 W m^{-2} (90%)

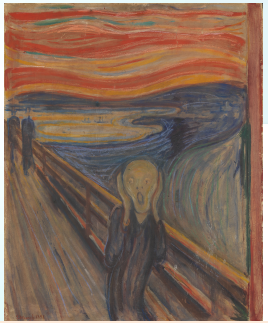
Historical temperature record



Golaz et al. 2013
Suzuki et al. 2013



Golaz et al. 2019



"Not again!!!"

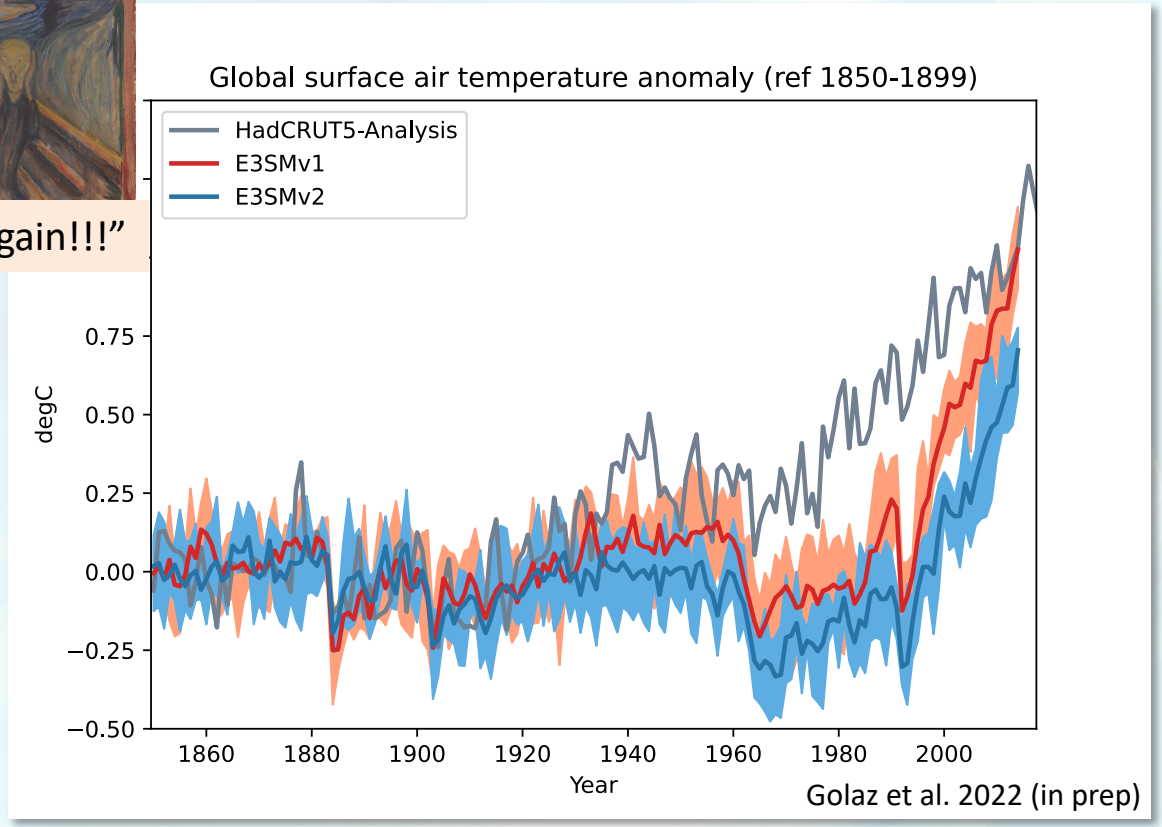
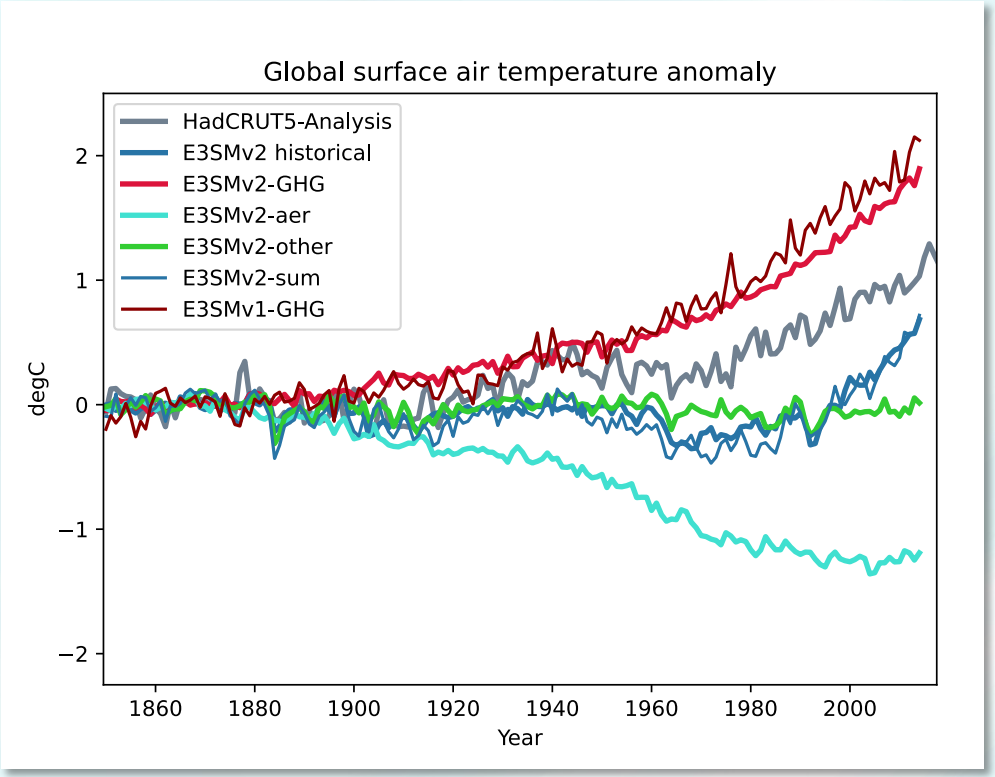


Image credit: wikipedia.org

Single forcing ensemble

Single-forcing decomposition
- GHG
- Aerosol related
- Everything else (other)

Fully coupled simulations (1850-2014), 5 members for each forcing.



Golaz et al. 2022 (in prep)

Composite configurations

- Treating single-forcing simulations as linear perturbations from the piControl, we can recompose them with alternate strengths:

$$\psi_{\text{all}} = \psi_{\text{piControl}} + \alpha_{\text{GHG}}\left(\psi_{\text{GHG}} - \psi_{\text{piControl}}\right) + \alpha_{\text{aer}}\left(\psi_{\text{aer}} - \psi_{\text{piControl}}\right) + \left(\psi_{\text{other}} - \psi_{\text{piControl}}\right)$$

Baseline | Modulate GHG response | Modulate aerosol response | Keep the rest unchanged

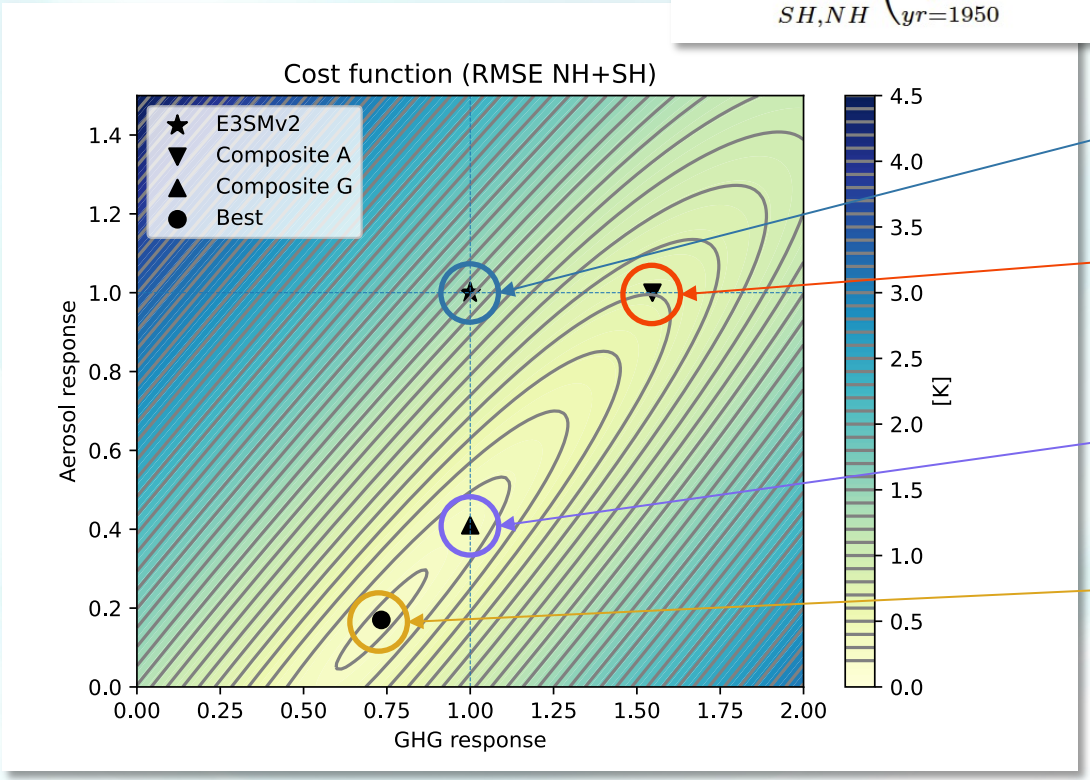
- Modulate strength of GHG response (proxy for TCR/ECS) and aerosol related to create alternate **composite configurations**.

- Applicable to any field; linear approximation holds well.

Inspired from Neelin et al. (2010)

Looking for an optimum

$$F = \sum_{SH,NH} \left(\sum_{yr=1950}^{2014} (\bar{T}_{\text{model}} - \bar{T}_{\text{obs}})^2 \right)^{1/2}$$



Weaker aerosol-related impact

Weaker GHG impact
(proxy for TCR/ECS)

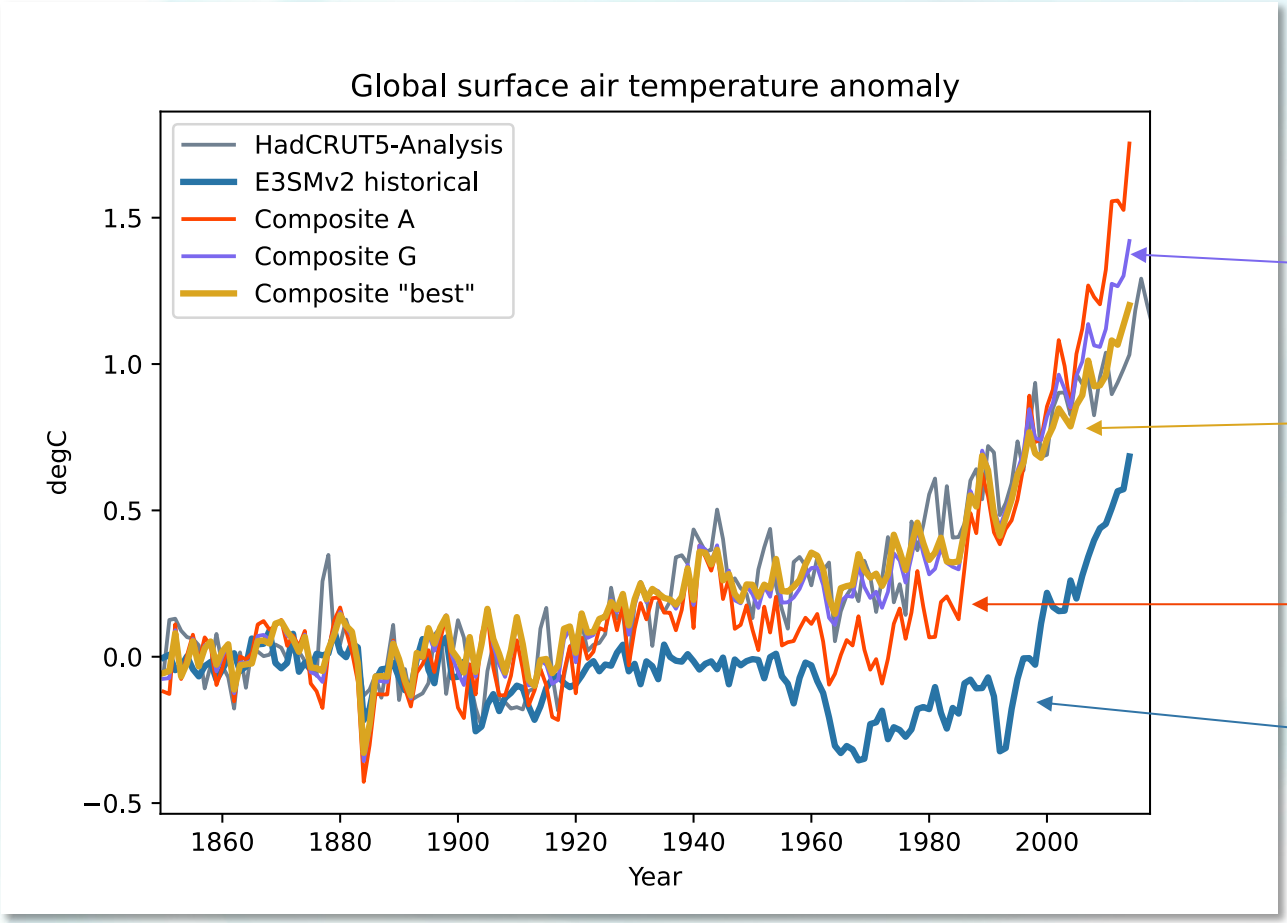
E3SMv2

holding aerosol, adjusting GHG response

holding GHG, adjusting aerosol response

best

Golaz et al. 2022 (in prep)



holding GHG, adjusting aerosol response

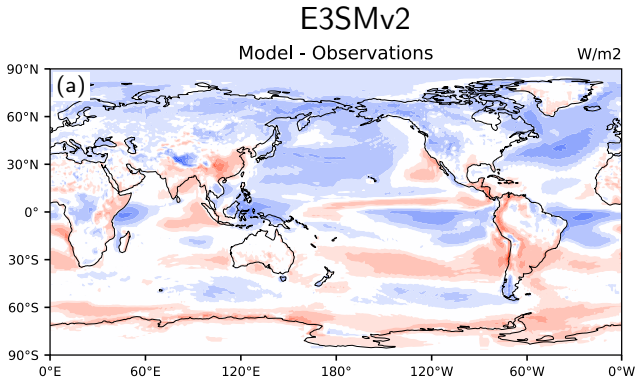
best

holding aerosol, adjusting GHG response

E3SMv2

Golaz et al. 2022 (in prep)

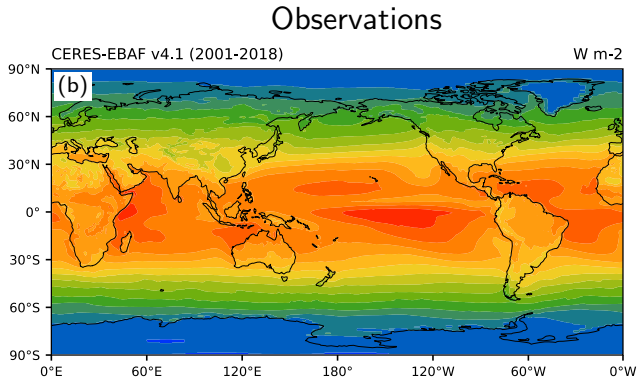
Impact on TOA net shortwave



Max 77.28
Mean -1.88
Min -56.24

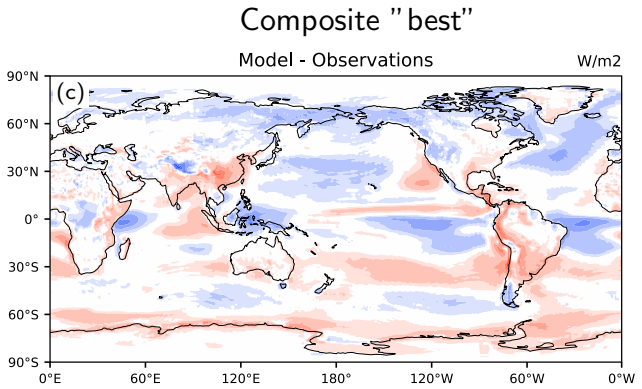
75.0
50.0
40.0
30.0
20.0
10.0
5.0
-5.0
-10.0
-20.0
-30.0
-40.0
-50.0
-75.0

RMSE 10.38
CORR 0.99



Max 362.61
Mean 241.24
Min 49.12

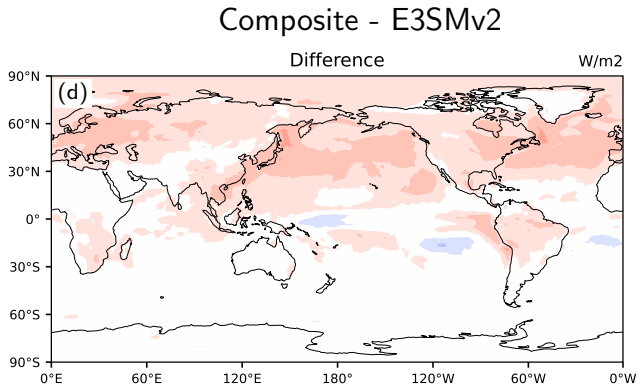
350.0
325.0
300.0
275.0
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0



Max 79.25
Mean 0.11
Min -57.35

75.0
50.0
40.0
30.0
20.0
10.0
5.0
-5.0
-10.0
-20.0
-30.0
-40.0
-50.0
-75.0

RMSE 9.69
CORR 0.99



Max 13.43
Mean 1.99
Min -5.51

30.0
25.0
20.0
15.0
10.0
5.0
2.0
-2.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0

RMSE 3.02
CORR 1.00

Golaz et al. 2022 (in prep)

Summary

- **E3SMv2 improves upon v1 in many aspects** (not discussed)
  - Twice as fast. Better clouds and precipitation.

Sherwood et al. (2020)
ECS estimate (66%)
2.6 – 3.9 K (baseline)
2.3 – 4.7 K (robustly)

Bellouin et al. (2020)
Total aerosol ERF
-1.6 to -0.6 W m^{-2} (68%)
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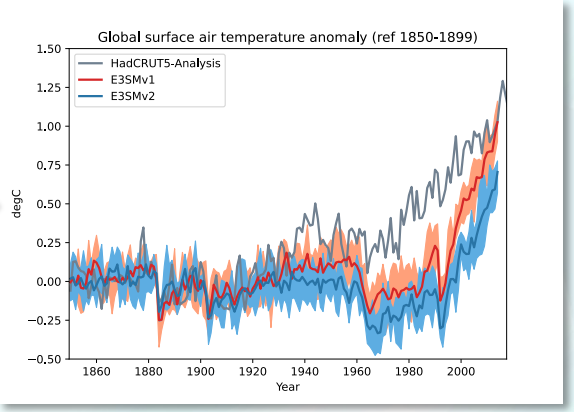

- **ECS = 4.0 K** ✅
- Total aerosol **ERF = -1.52 W/m2** ✅
- **Historical temperature record** ❌
- Correcting E3SMv2 might require reducing **aerosol ERF 60% to 80% (-0.6 to -0.3 W/m^2)**