

Cornell University

Developing a set of simple metrics to evaluate high-top models for different purposes

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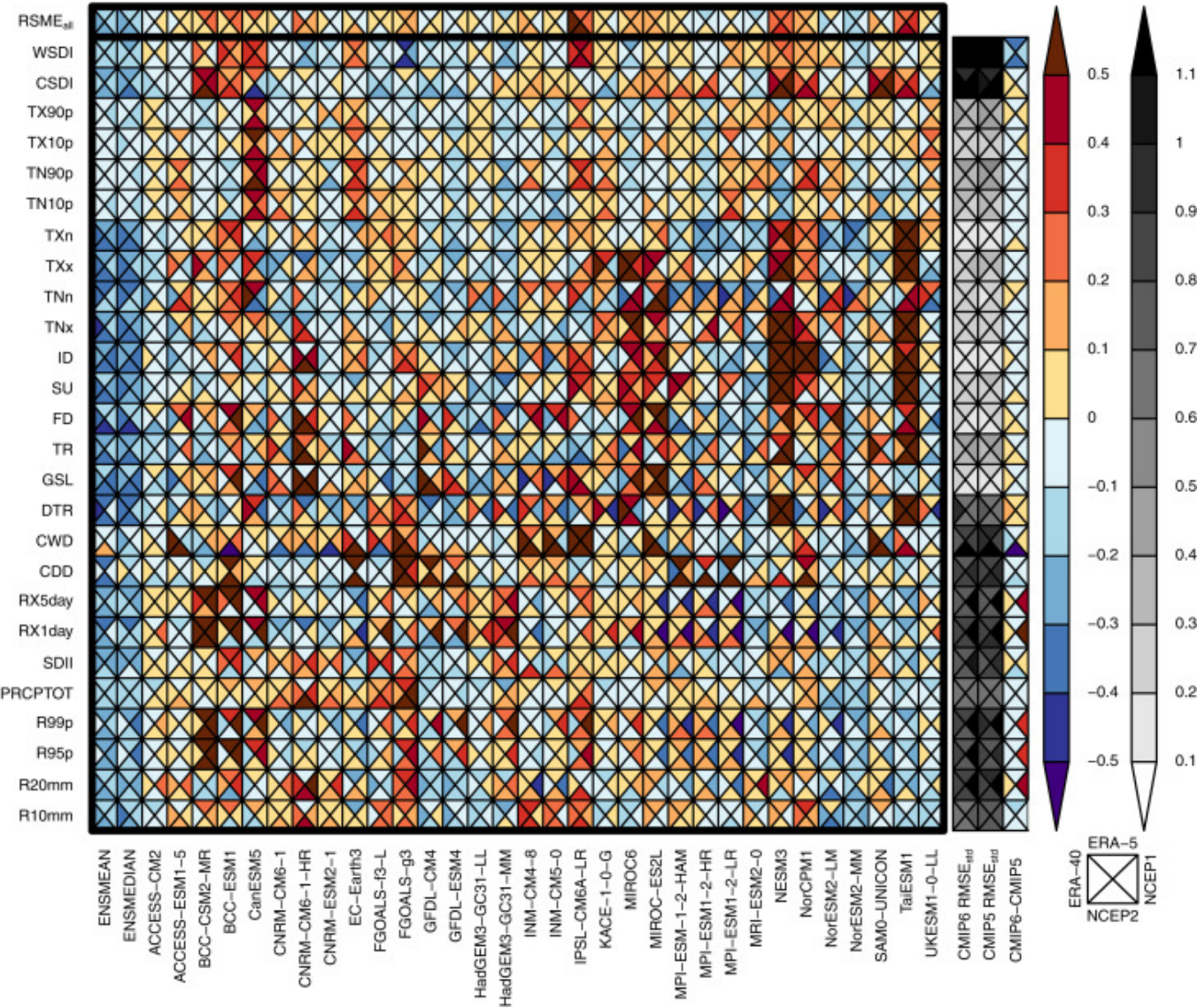
CESM meeting
June 2024

Why “a set of simple metrics”?

- **At a glance, can help determine (relative) skill of different models (or different generations of one model)**
- **Can integrate observations (and/or reanalyses)**
- **David Lawrence asked ;-)**

CMIP6 example

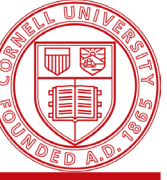
CMIP6 global land 1981–2000



- Plenty of examples in the literature (i.e. [Kim et al., 2020](#))

$$\text{RMSE}_{XY} = \sqrt{\langle (X - Y)^2 \rangle}$$

Can we replicate it for stratospheric variables?



Can we replicate it for stratospheric variables?



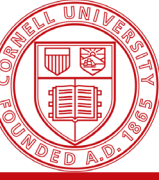
- **What do we pick will depend on the purpose of our evaluation:**
 - **stratospheric dynamics**
 - **stratospheric aerosols**
 - **higher up?**

Can we replicate it for stratospheric variables?



- **What do we pick will depend on the purpose of our evaluation:**
 - **stratospheric dynamics**
 - **stratospheric aerosols**
 - **higher up?**
- **It will also depend on availability of measurements/reanalyses (and other models, possibly!)**
- **Can eventually lead to a new diagnostic package?**

What have we done so far for WACCM



JAMES

Journal of Advances in
Modeling Earth Systems*

Research Article



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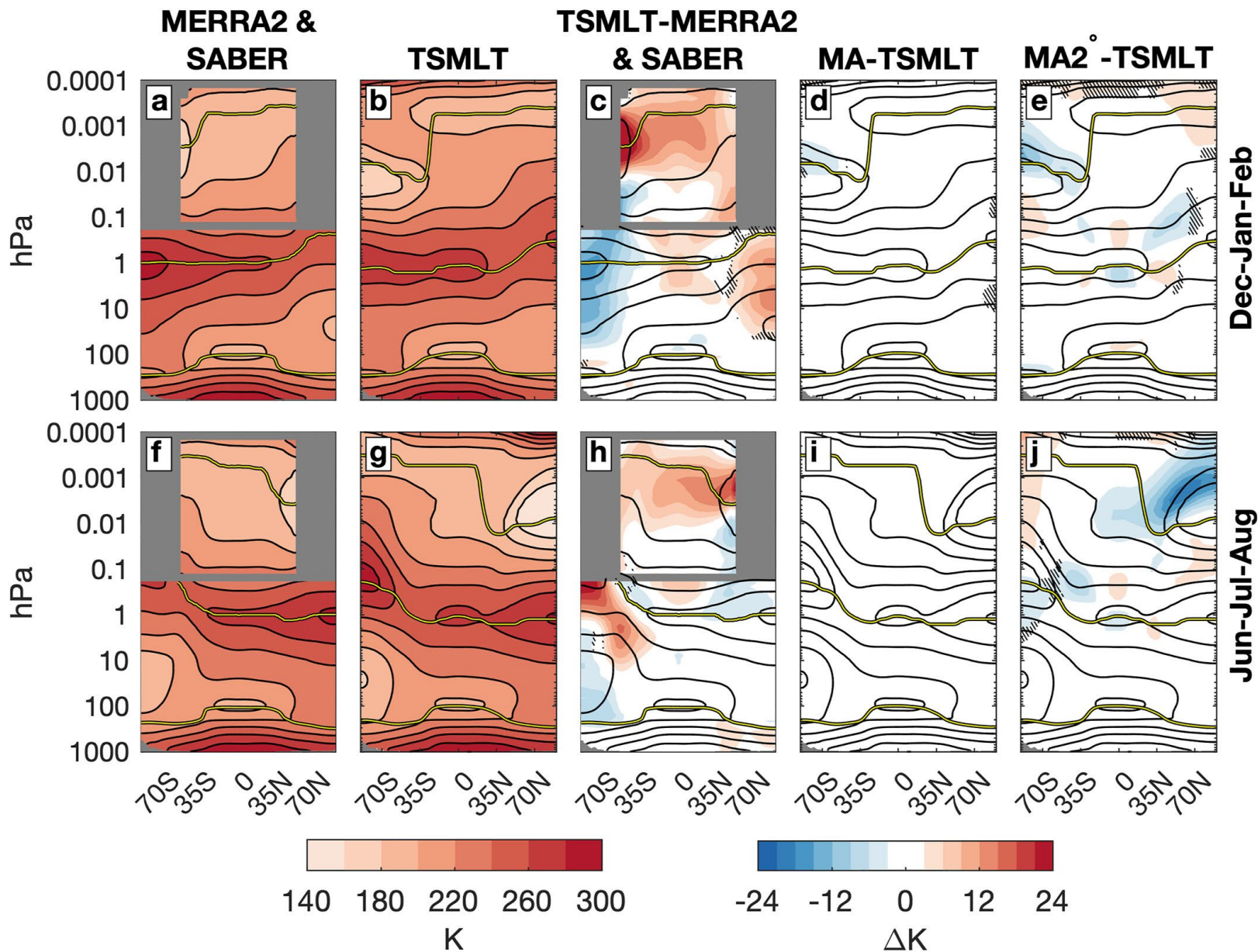


Climate, Variability, and Climate Sensitivity of “Middle Atmosphere” Chemistry Configurations of the Community Earth System Model Version 2, Whole Atmosphere Community Climate Model Version 6 (CESM2(WACCM6))

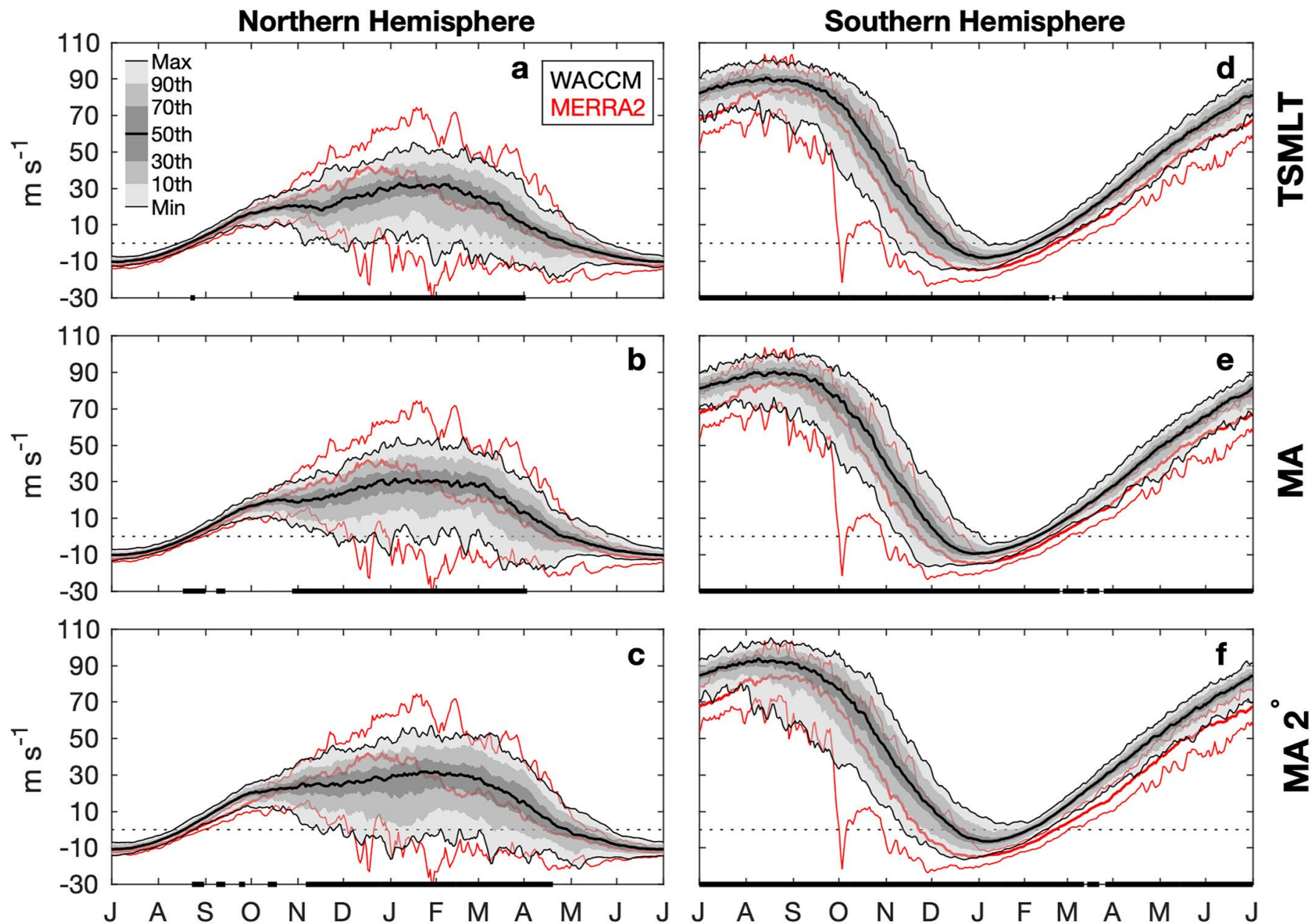
N. A. Davis , D. Vioni, R. R. Garcia, D. E. Kinnison, D. R. Marsh, M. Mills, J. H. Richter, S. Tilmes, C. G. Bardeen, A. Gettelman, A. A. Glanville, D. G. MacMartin, A. K. Smith, F. Vitt

First published: 04 September 2023 | <https://doi.org/10.1029/2022MS003579> | Citations: 4

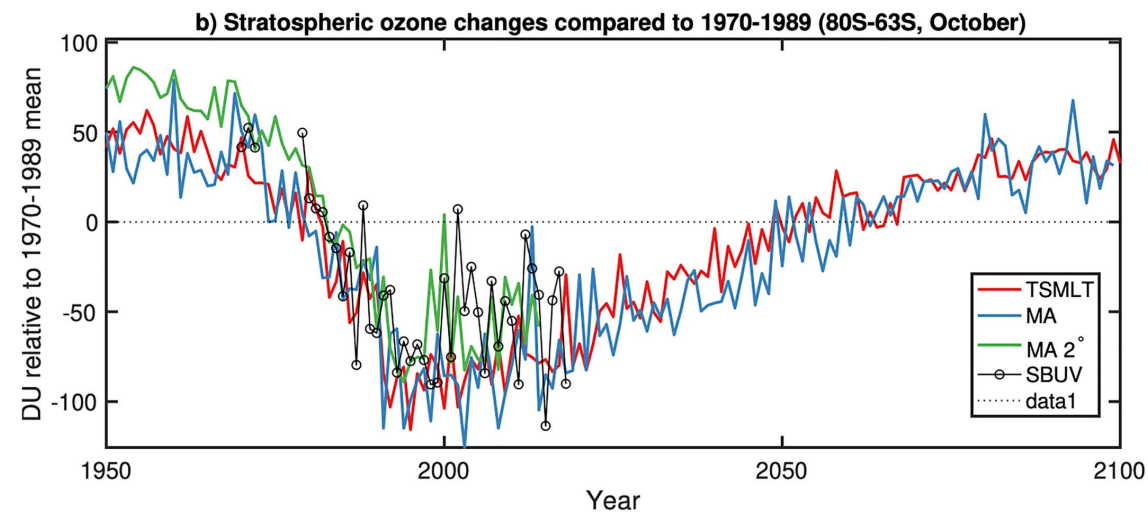
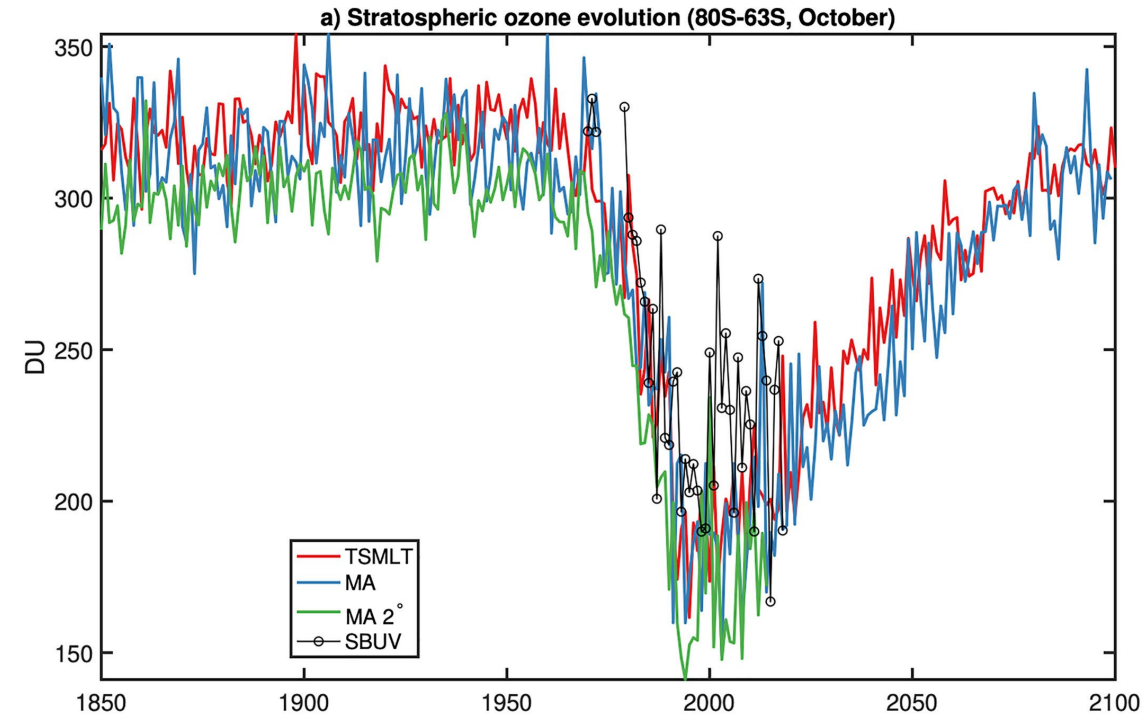
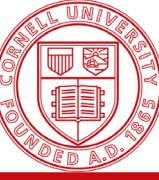
What have we done so far for WACCM



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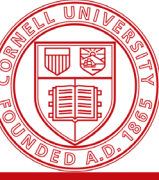


Our case of choice: Pinatubo

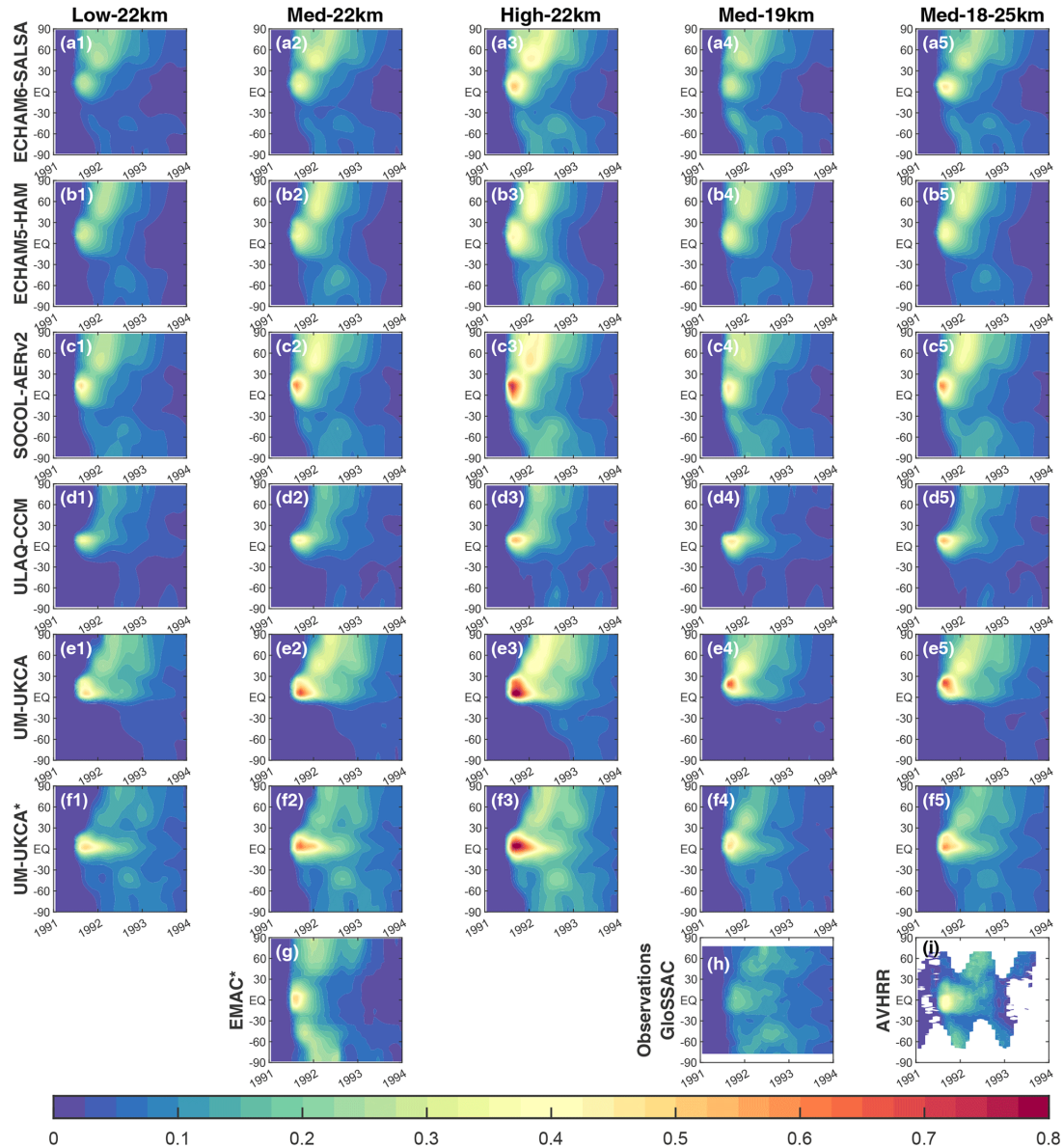
Interactive stratospheric aerosol models' response to different amounts and altitudes of SO₂ injection during the 1991 Pinatubo eruption

Ilaria Quaglia , Claudia Timmreck, Ulrike Niemeier, Daniele Visionsi, Giovanni Pitari, Christina Brodowsky, Christoph Brühl, Sandip S. Dhomse, Henning Franke, Anton Laakso, Graham W. Mann, Eugene Rozanov, and Timofei Sukhodolov

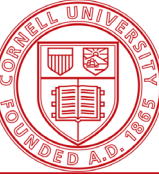
Our case of choice: Pinatubo



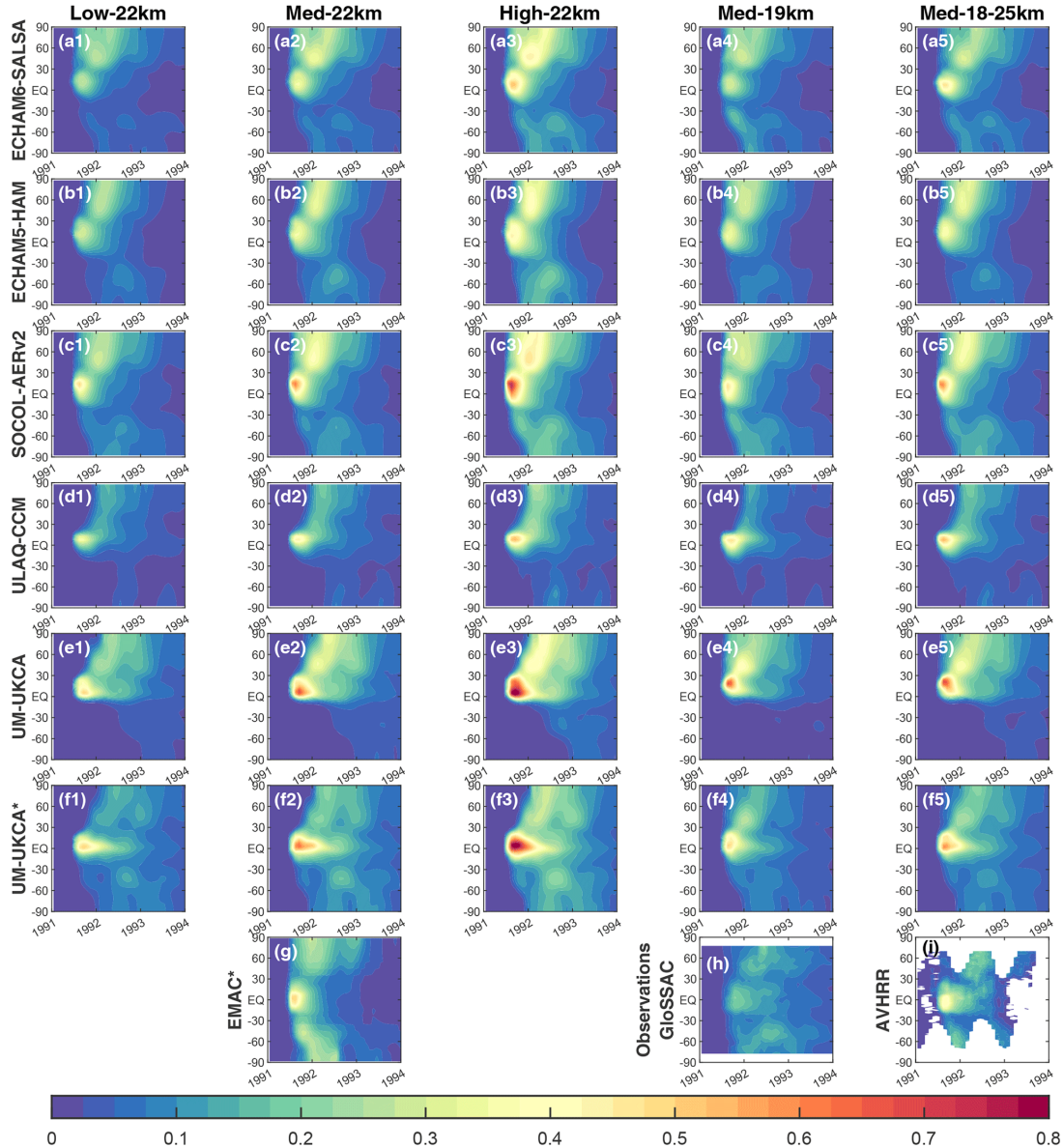
Stratospheric AOD



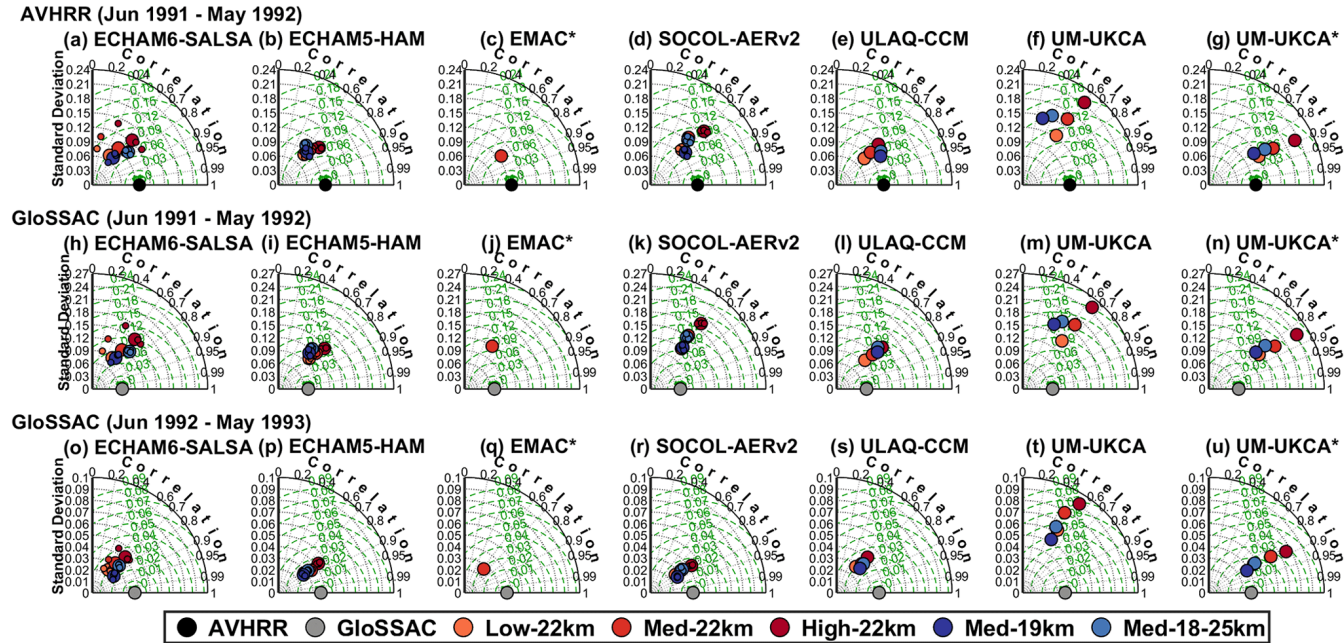
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Stratospheric AOD

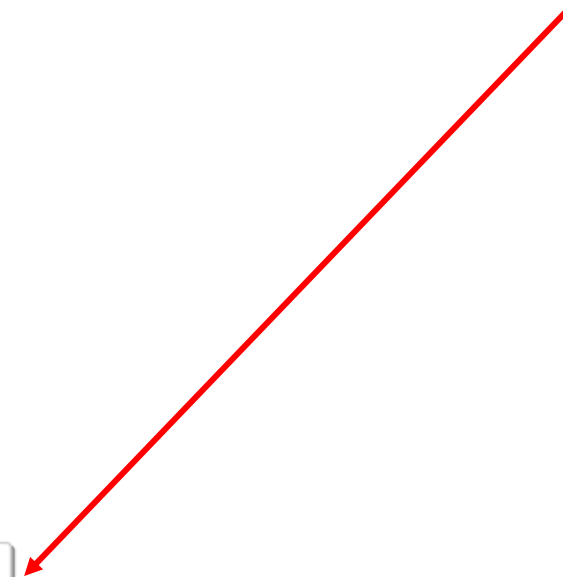
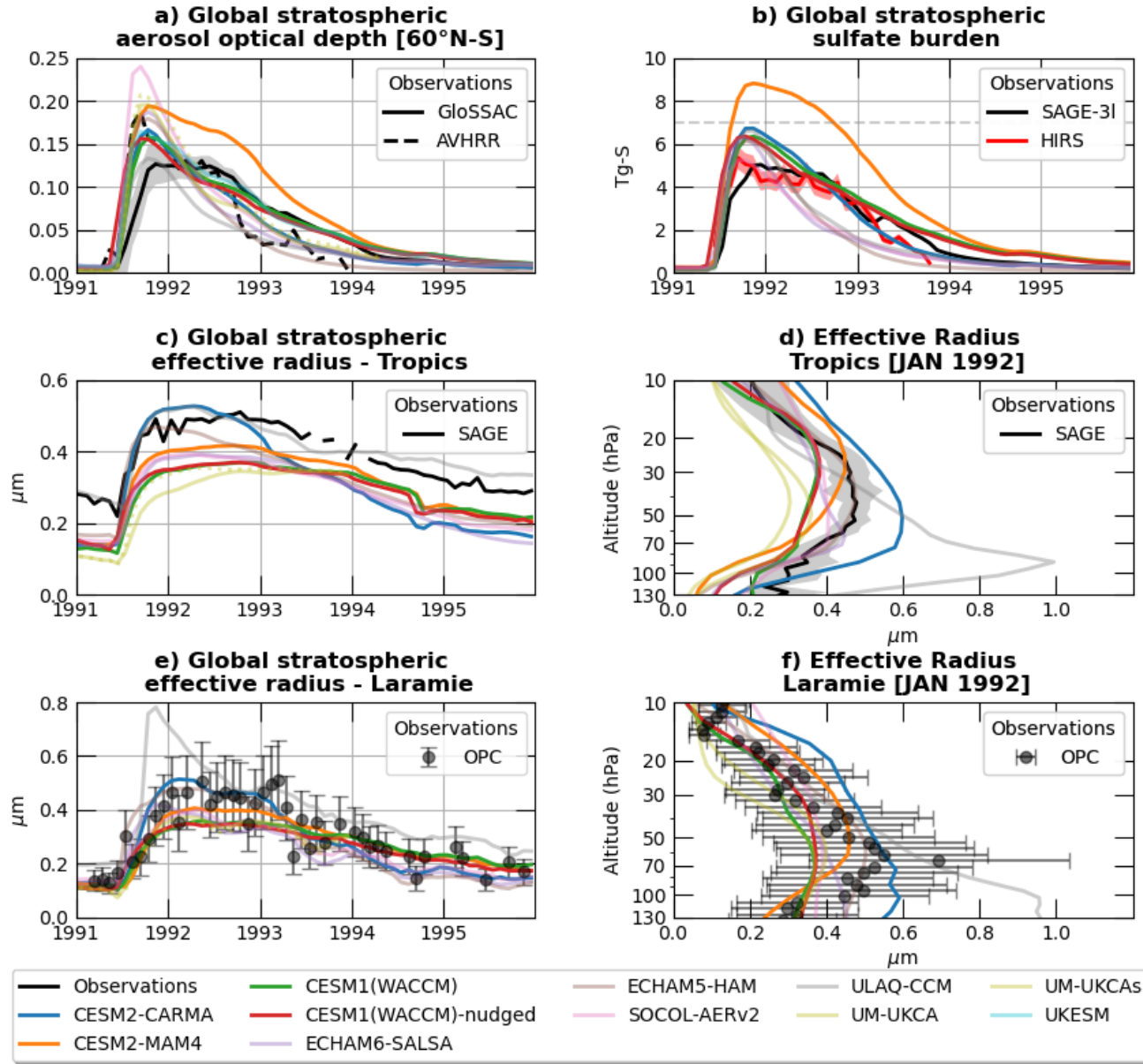


Global Stratospheric AOD



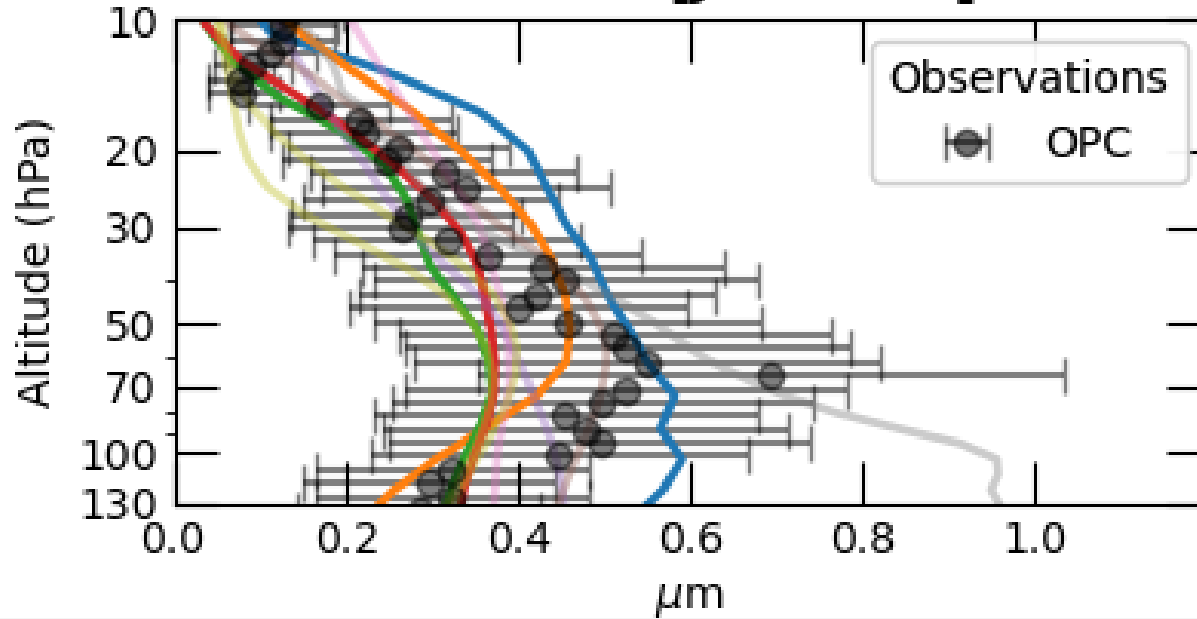
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Adding CESM1 and 2
 Not exactly the same
 simulation protocol, but
 what can we do...



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**f) Effective Radius
Laramie [JAN 1992]**



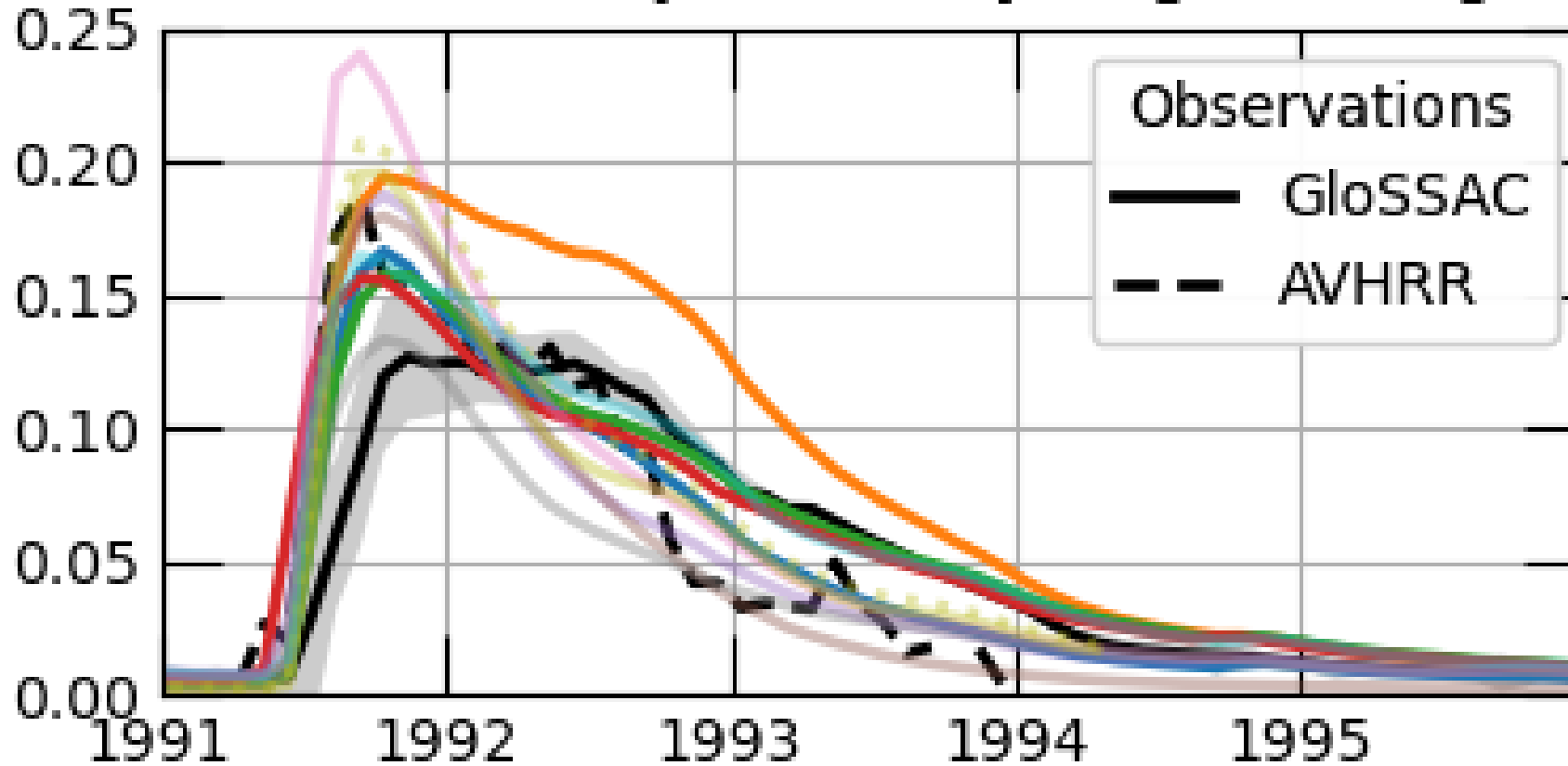
$$WRMSE = \sqrt{\frac{\sum_i (X_{\{model,i\}} - X_{\{observations,i\}})^2 \cdot \omega_i}{N}}$$

$$\omega_i = \frac{1}{\sigma_{\{obs,i\}}^2}$$

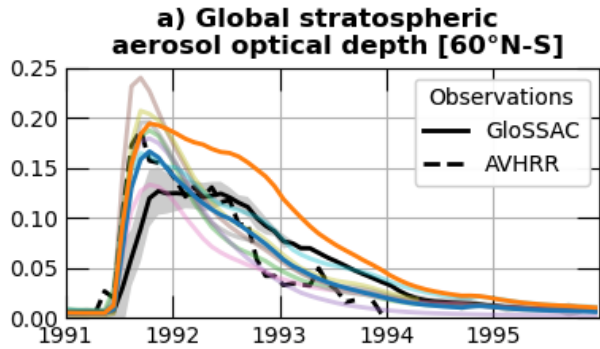


Our case of choice: Pinatubo

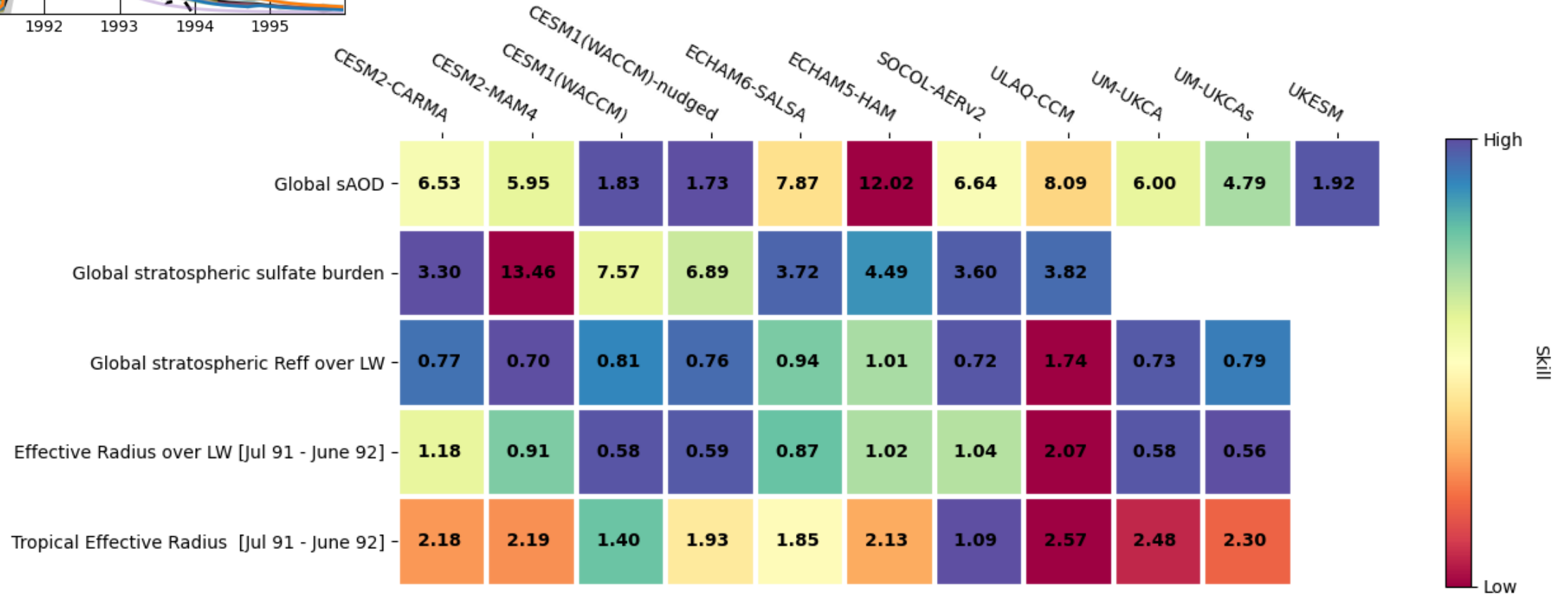
a) Global stratospheric aerosol optical depth [60°N-S]



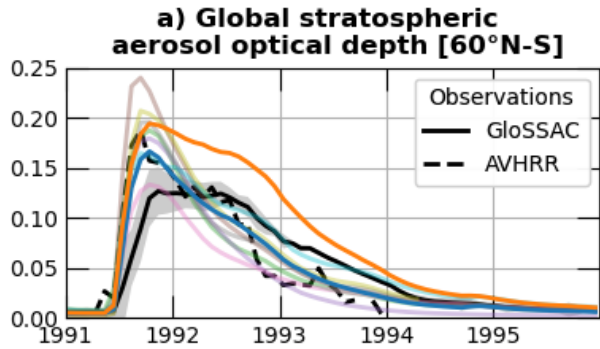
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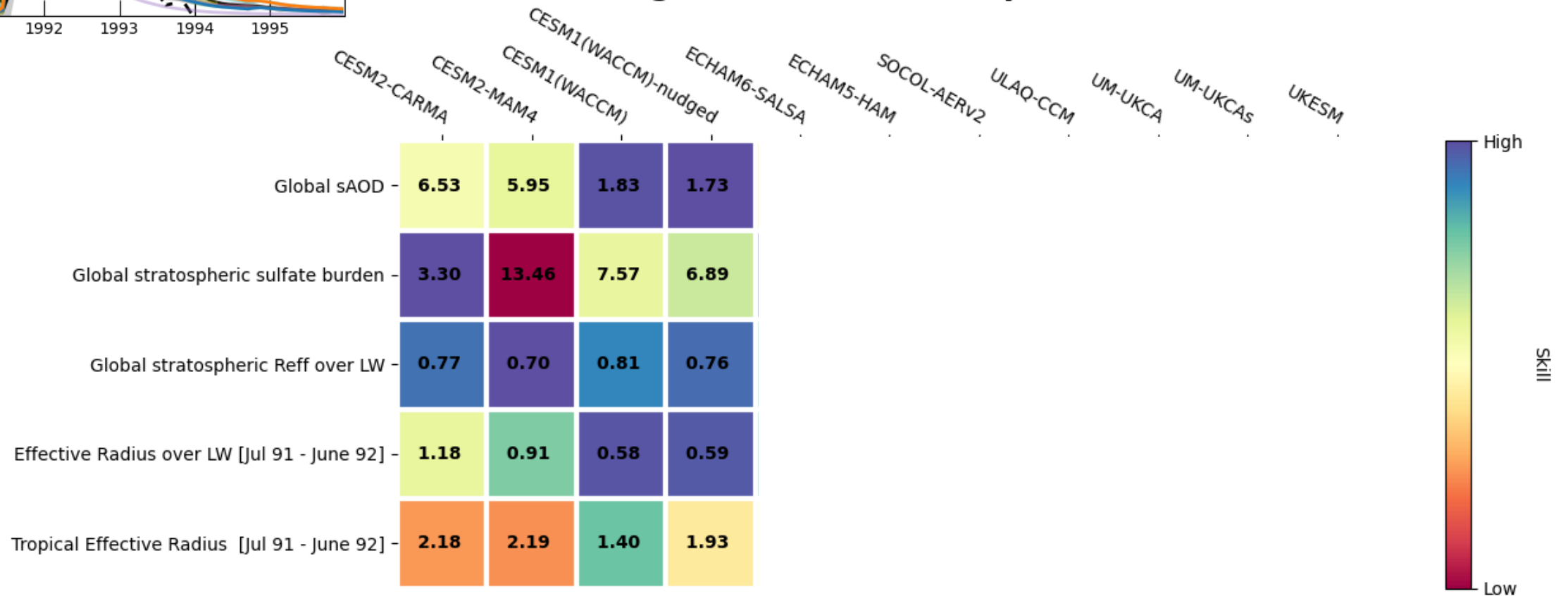
Weighted Root Mean Square Error



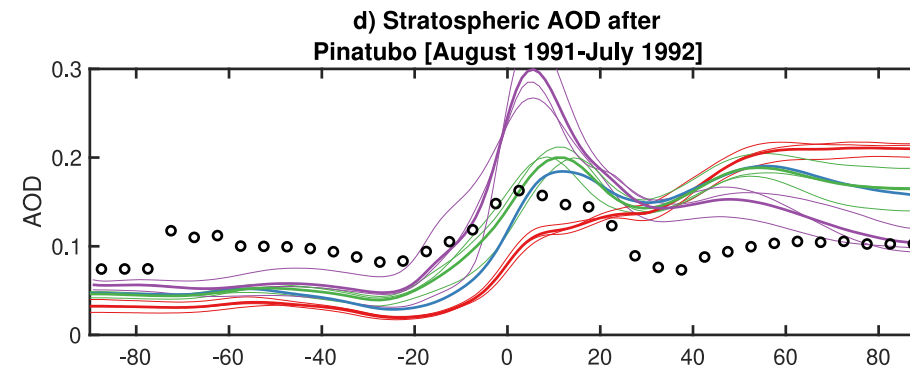
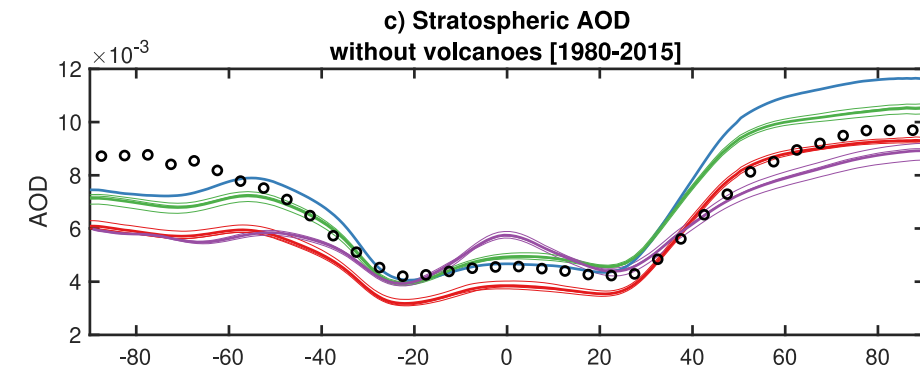
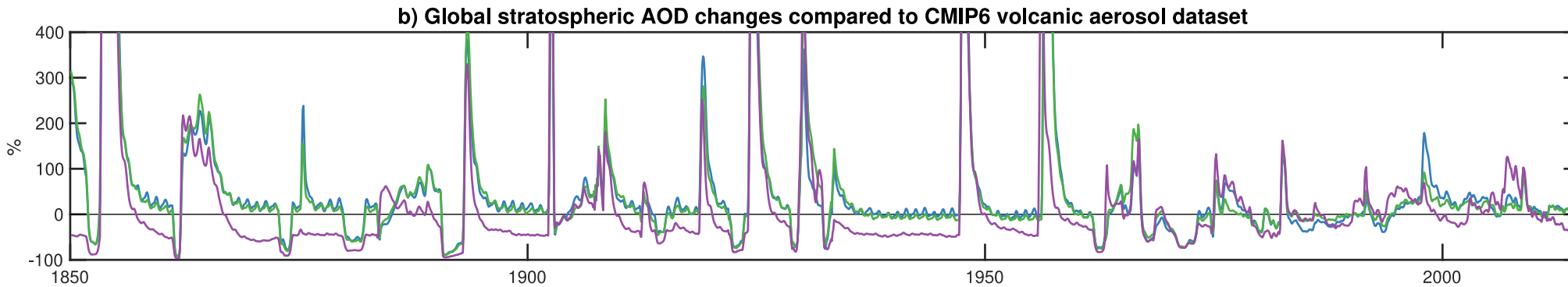
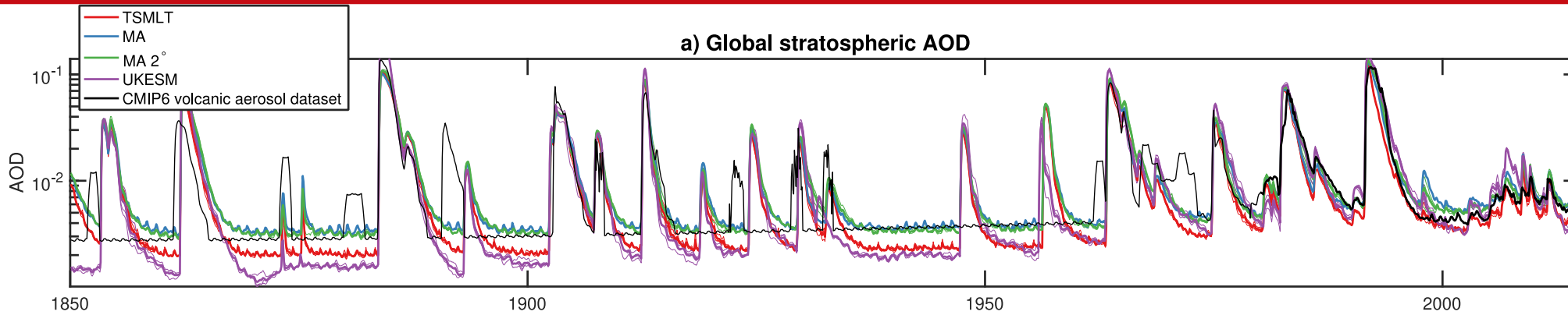
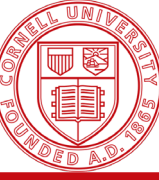
Our case of choice: Pinatubo



Weighted Root Mean Square Error

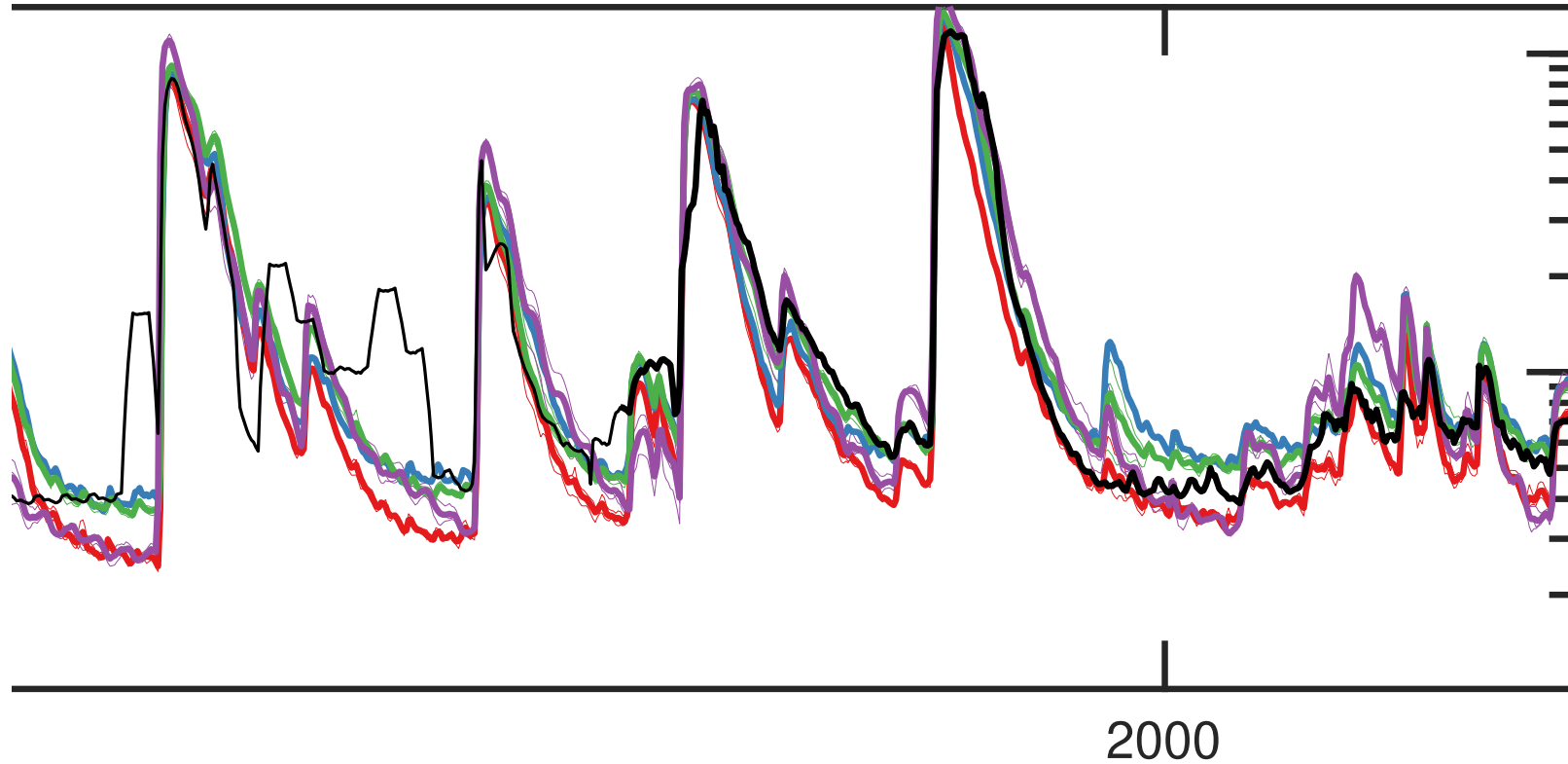
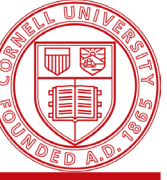


Can we expand this to CMIP6?



from Davis et al. (2023), updated. Thanks to Thomas Aubrey for UKESM data

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Conclusions

- **We've come up with “simple” metrics to evaluate models skills for at least one stratospheric feature (volcanic aerosols)**
- **They might allow for a quick comparison across models versions and inter-model differences**
- **Can we expand this to other metrics for stratospheric/high atmospheric values of interest?
Chime in with what you think!**