Cornell University

Recent updates on representing large volcanic eruptions in WACCM

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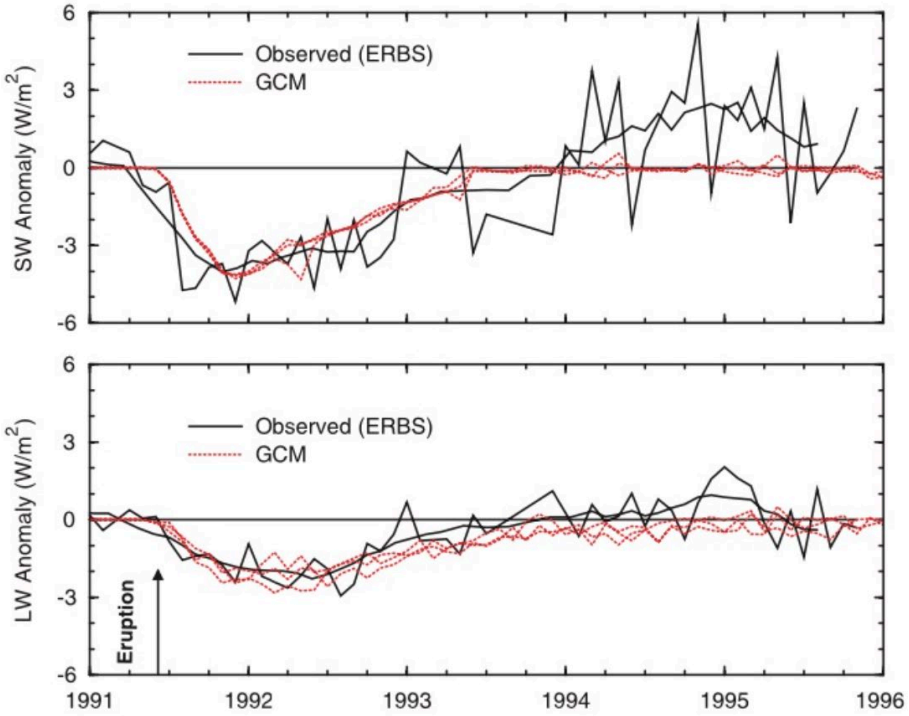
CESM meeting
11 June 2025

Why?

- **Large volcanic eruptions are one of the best "acid tests" for climate models (Hansen, 1992)**



Figures from Soden et al. 2002

Why?

- **Large volcanic eruptions are one of the best "acid tests" for climate models (Hansen, 1992)**

- **They represent one of the best cases of stratospheric-surface coupling, including dynamics, chemistry, microphysics, climate sensitivity**

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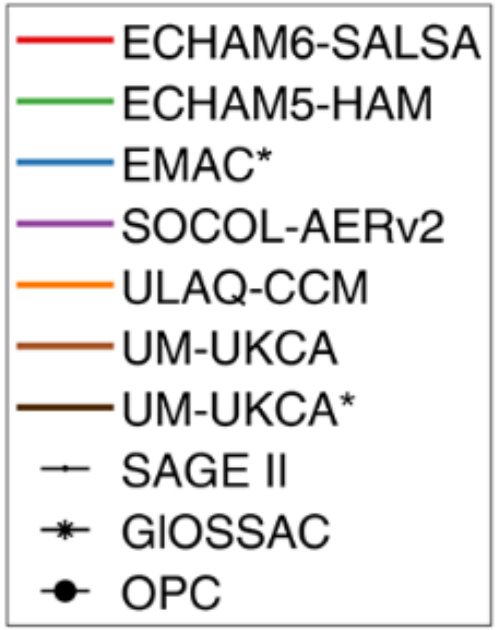
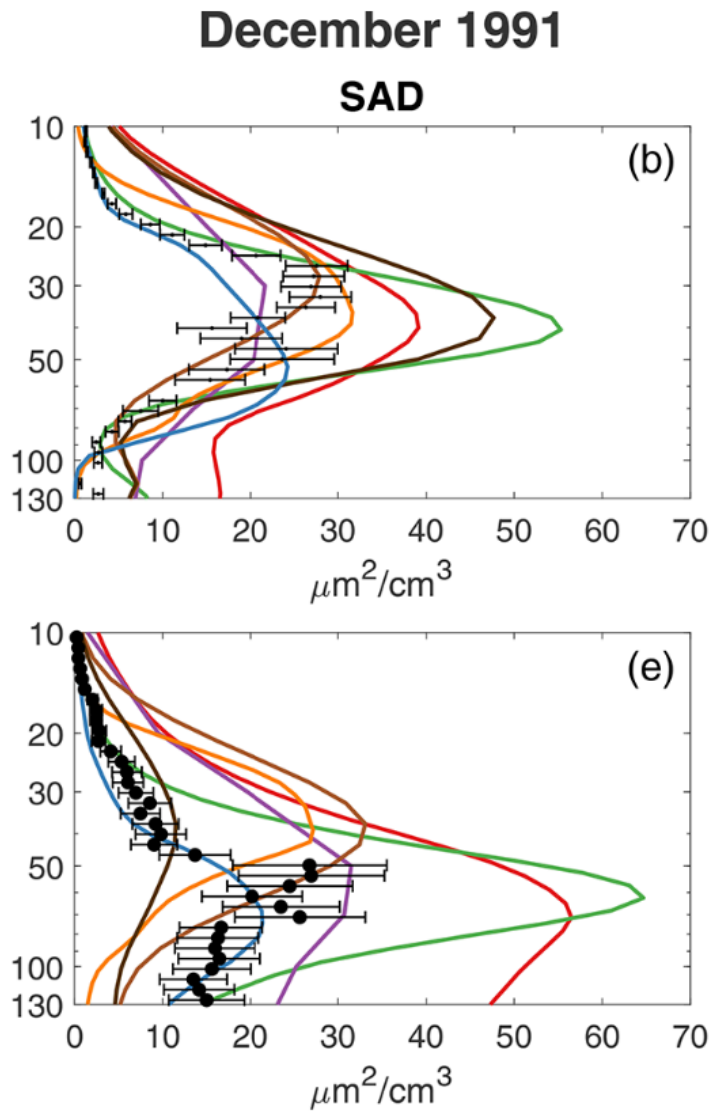
- **They represent one of the best cases of stratospheric-surface coupling, including dynamics, chemistry, microphysics, climate sensitivity**

- **Studying them can provide insight into the potential impacts of climate intervention strategies**

What are the challenges?

- **Different models, different results**

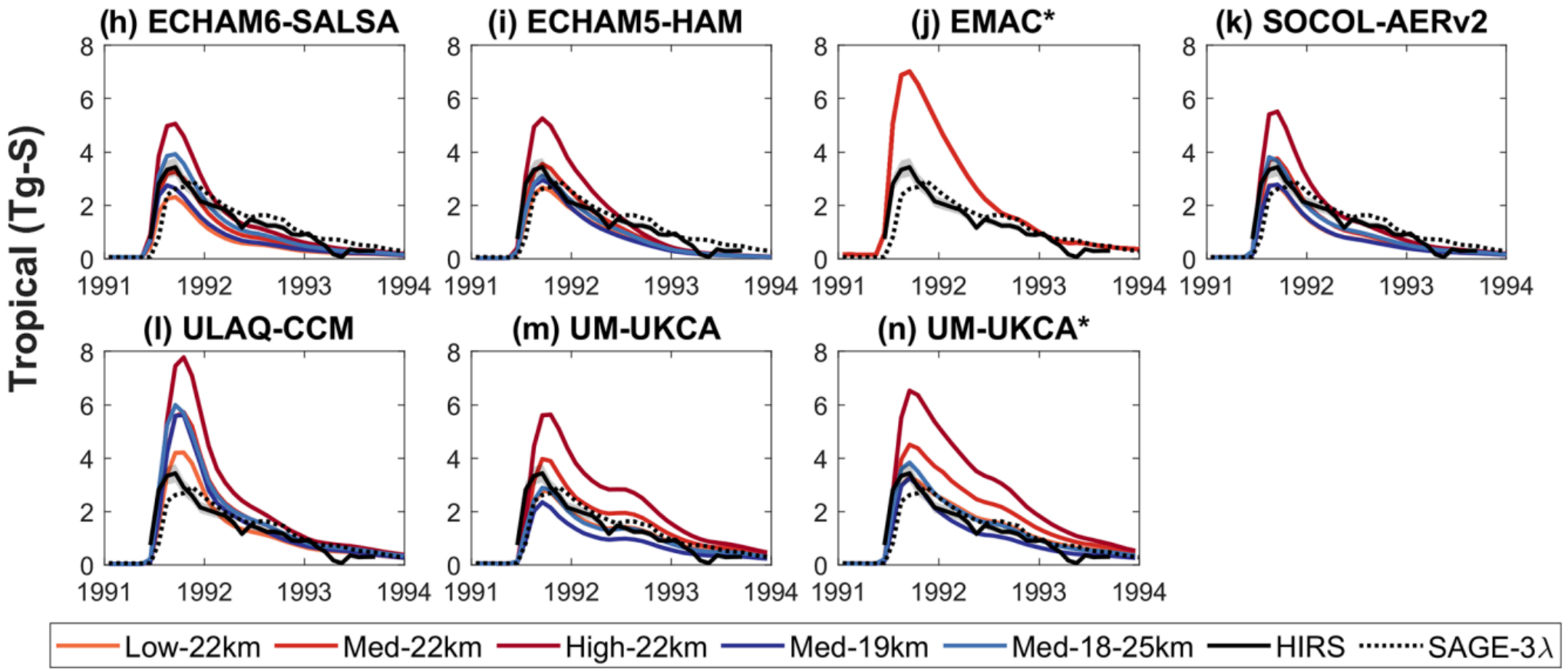




Quaglia et al. (2023)

What are the challenges?

- **Uncertainties over height/magnitude of injection**



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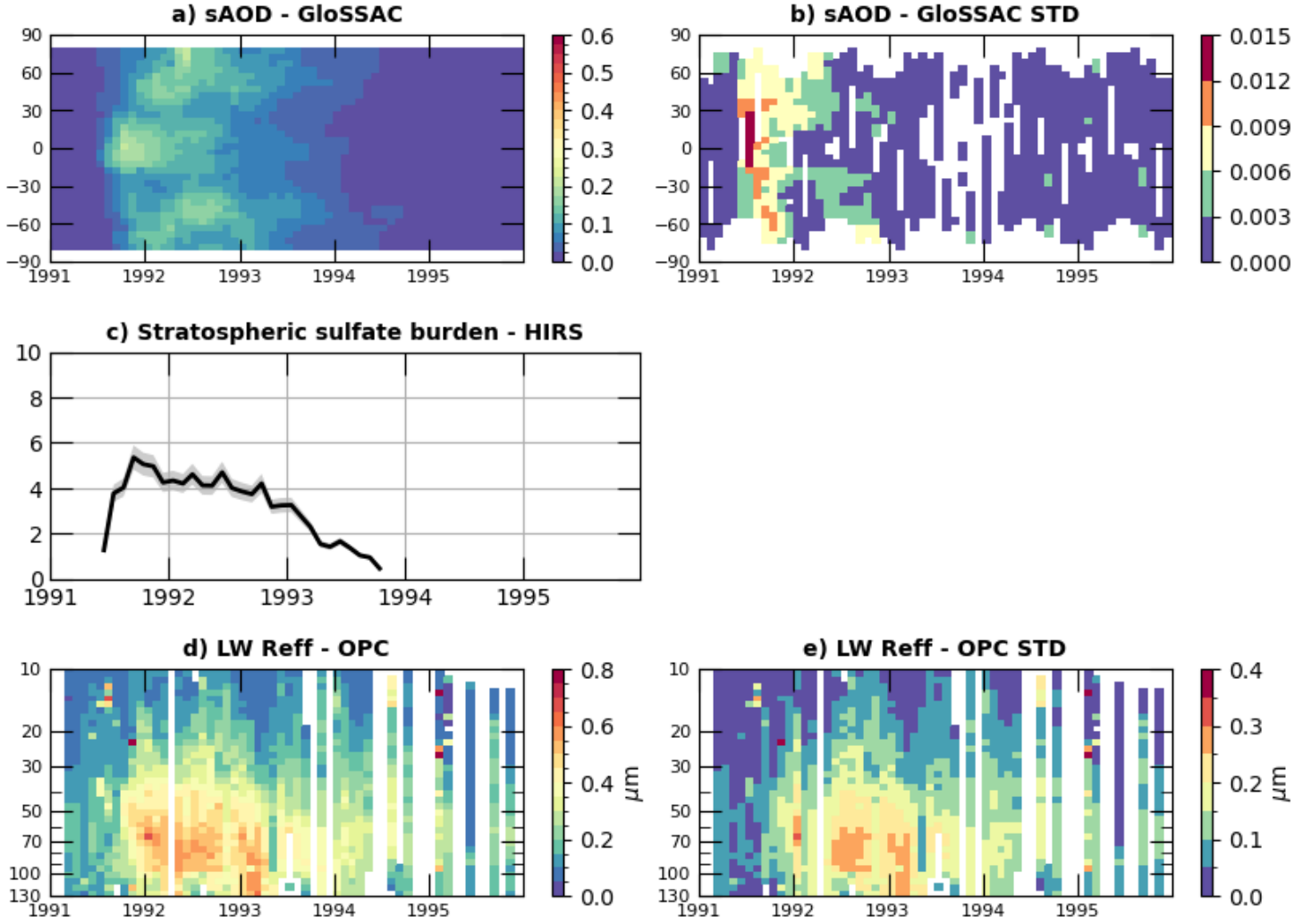
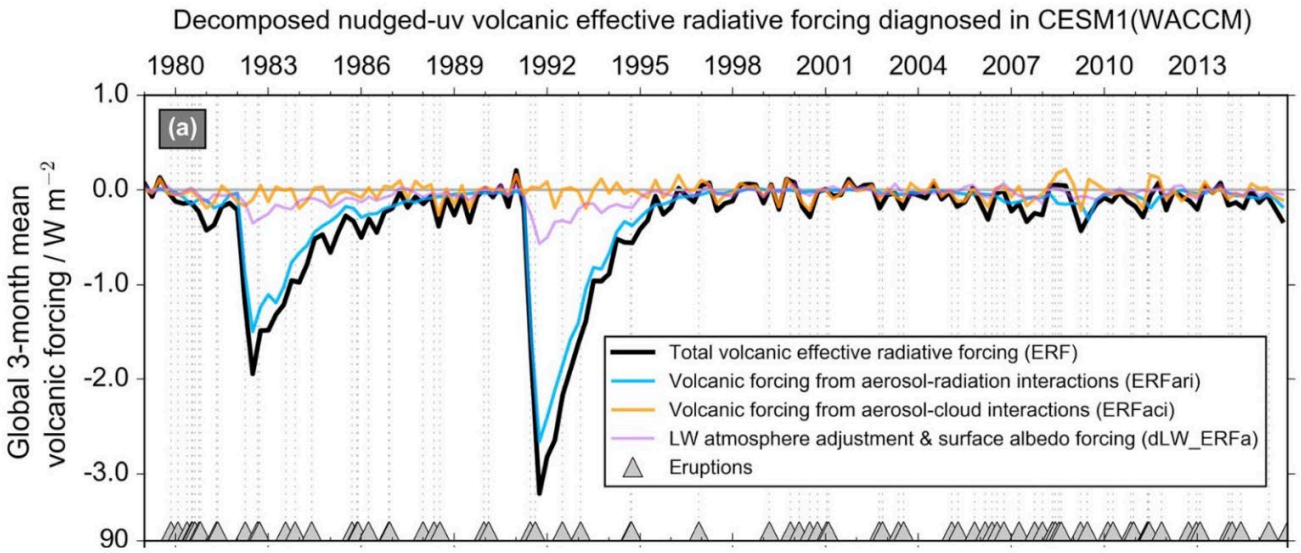
What are the challenges?

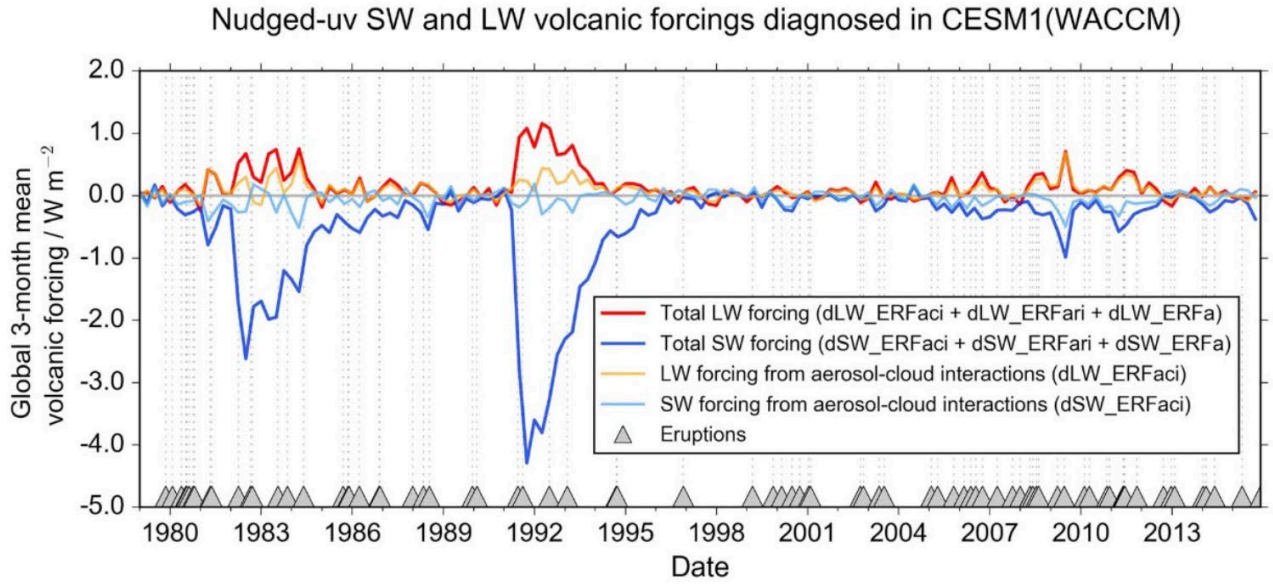
- **Available observations often poor/saturated**



Visioni, Quaglia et al. (in prep.)

What has been done in CESM before?





Volcanic Radiative Forcing From 1979 to 2015

$$\mathrm{ERF} = ERF_{ari} + ERF_{aci} + dLW\_ERF_{a}$$

Figures from Schmidt et al. (2018)

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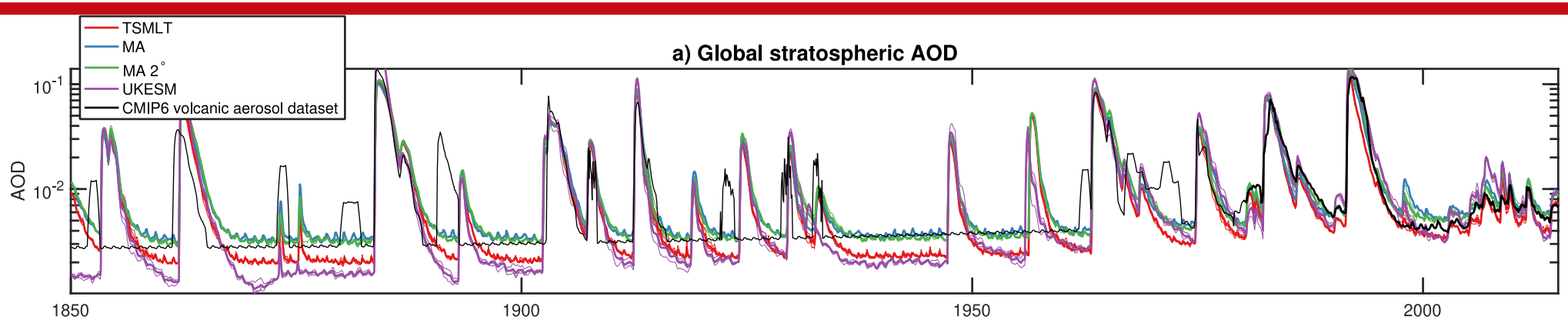
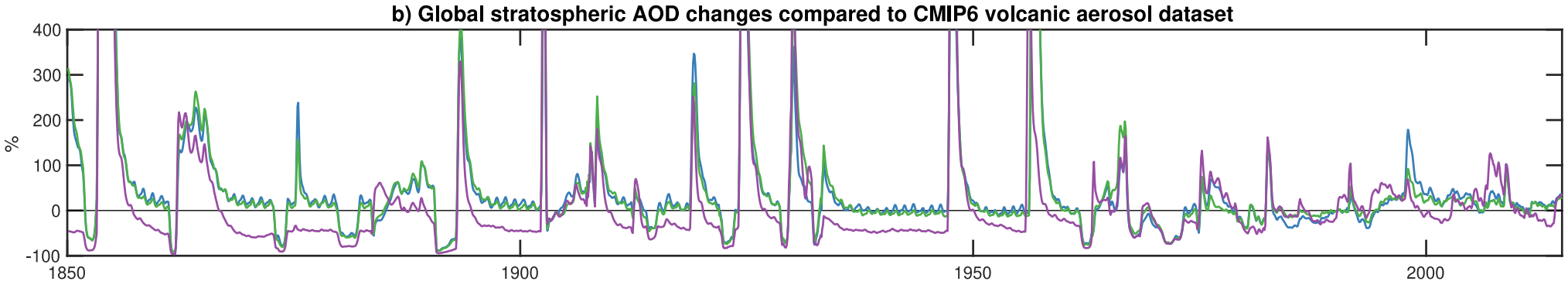
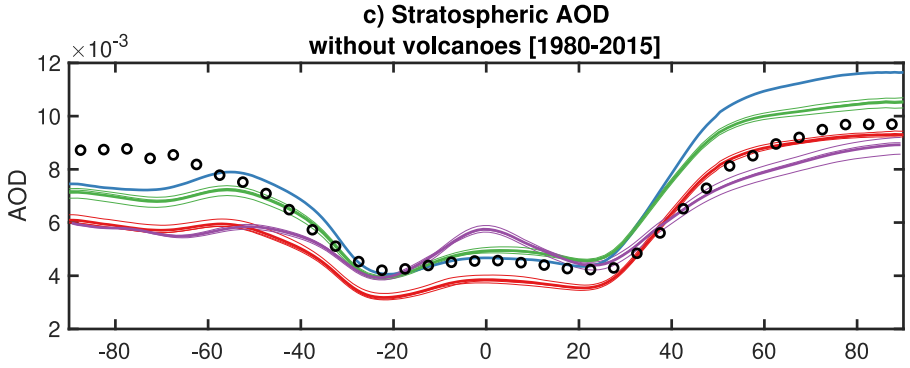
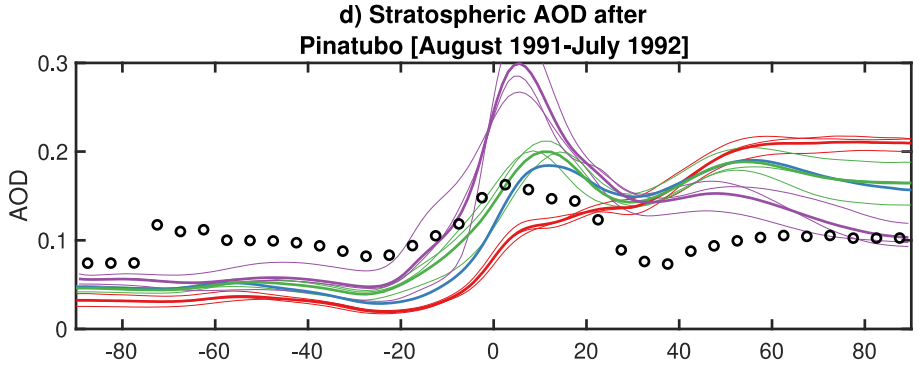


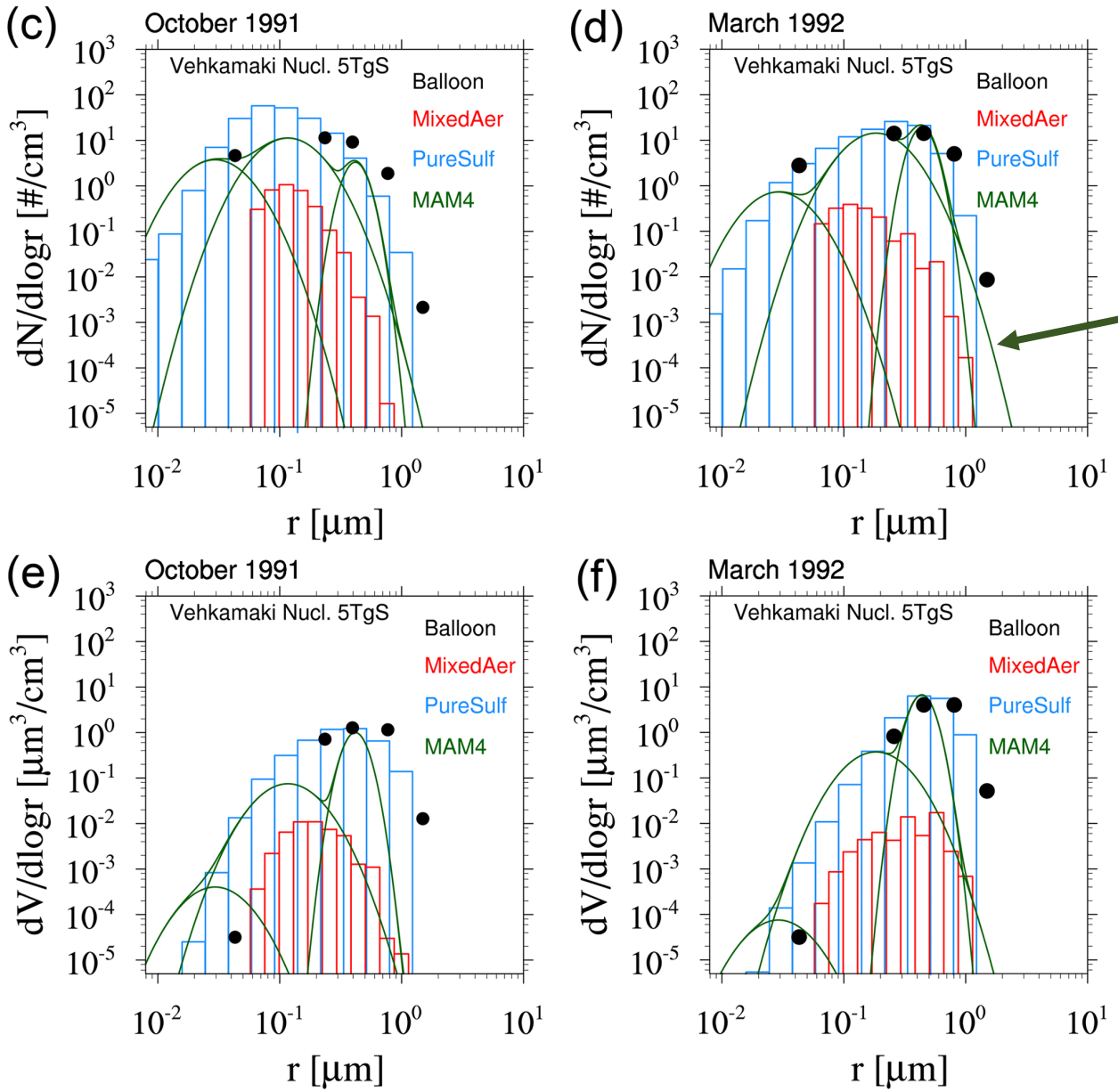






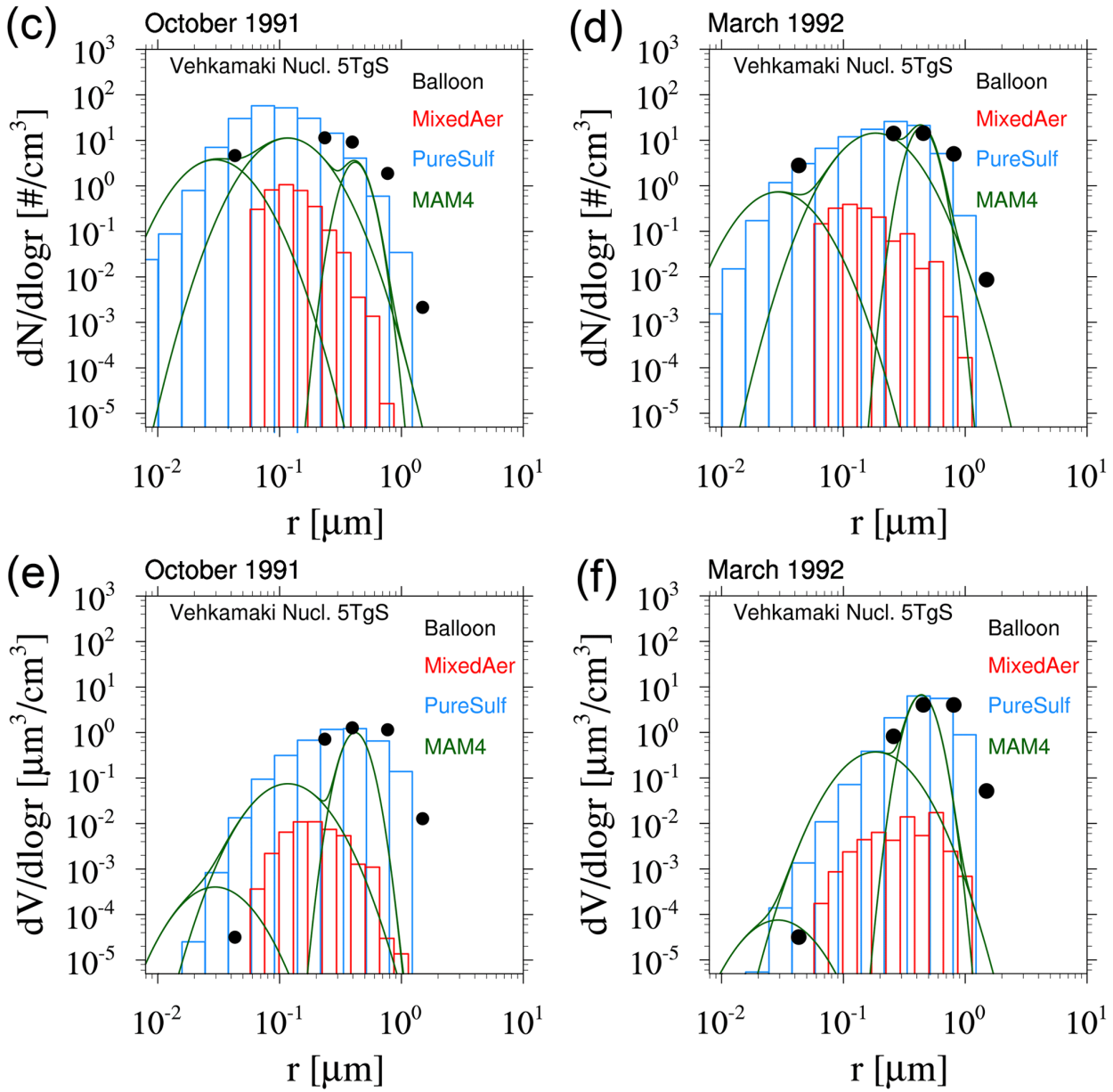
from Davis, Visioni et al. (2023), updated. Thanks to Thomas Aubrey for UKESM data

The importance of microphysics



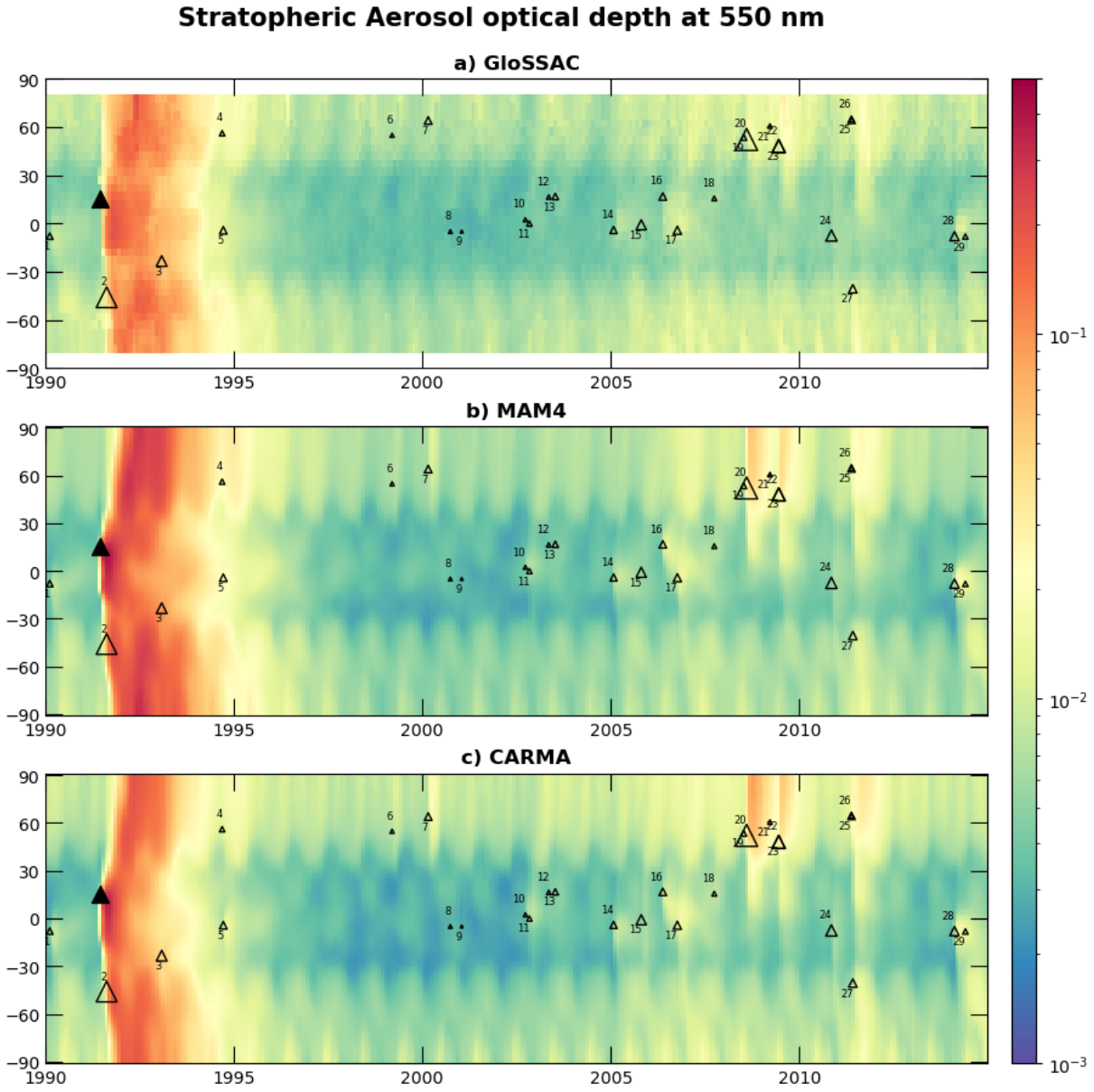
- **Normally simulations done with MAM4**

The importance of microphysics



- **Normally simulations done with MAM4**
- **New inclusion in CESM2 of CARMA (sectional microphysics) may improve accuracy of simulations**

New simulations of historical period in MAM4/CARMA



- First simulations of historical period (1980-2014) in CARMA (AMIP-style) x3, 2°
- Includes 29 “small-to-moderate” volcanic eruptions with stratospheric SO_2 of different magnitude
- 15k vs 2k pe-h/yr

Quaglia, Tilmes, Visioni et al. (in prep.)

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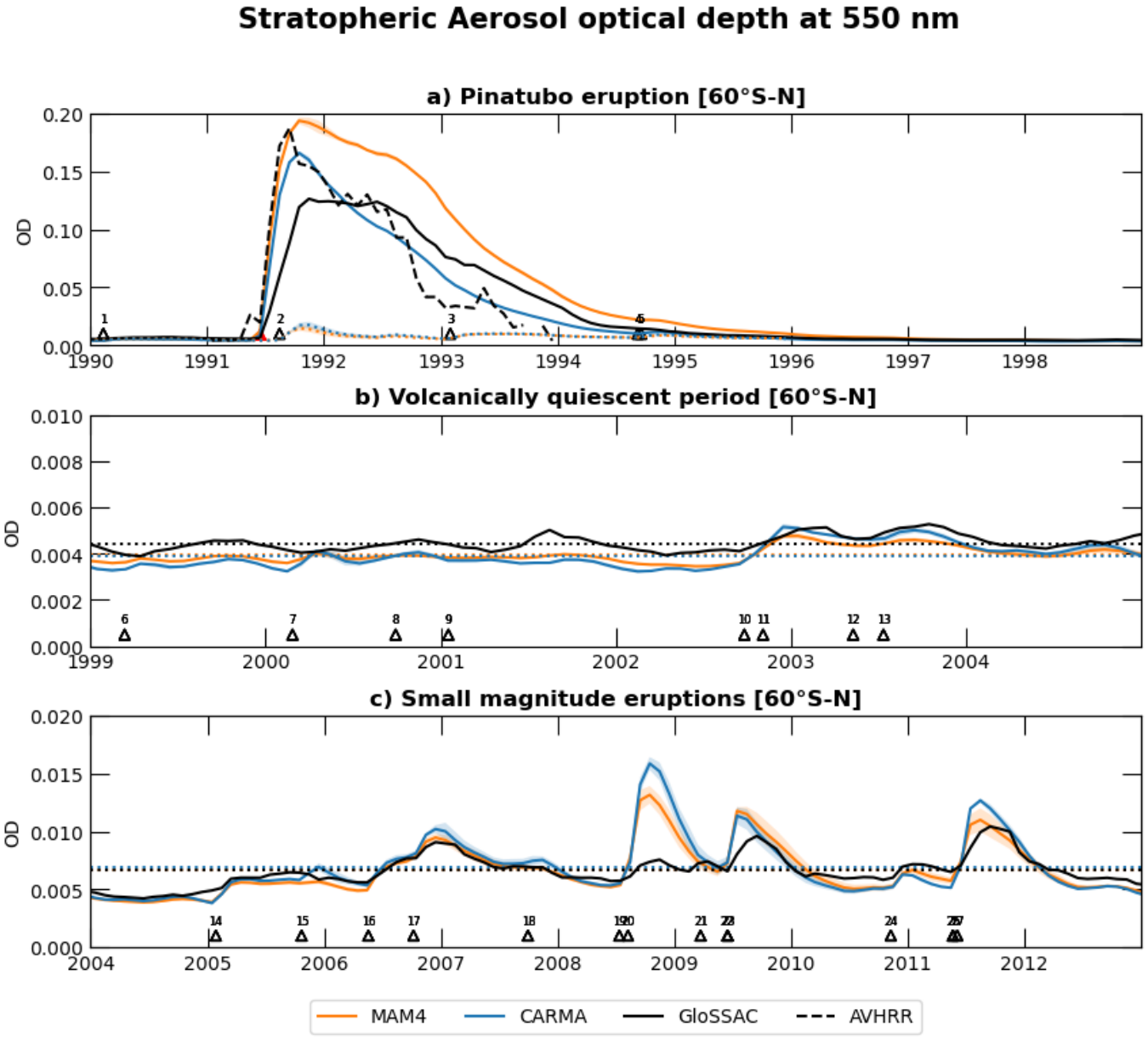

- We look at quiescent vs Pinatubo vs "small" volcanic eruptions periods
- Indications that small volcanic eruptions reduce r_{eff} rather than increase already in the literature

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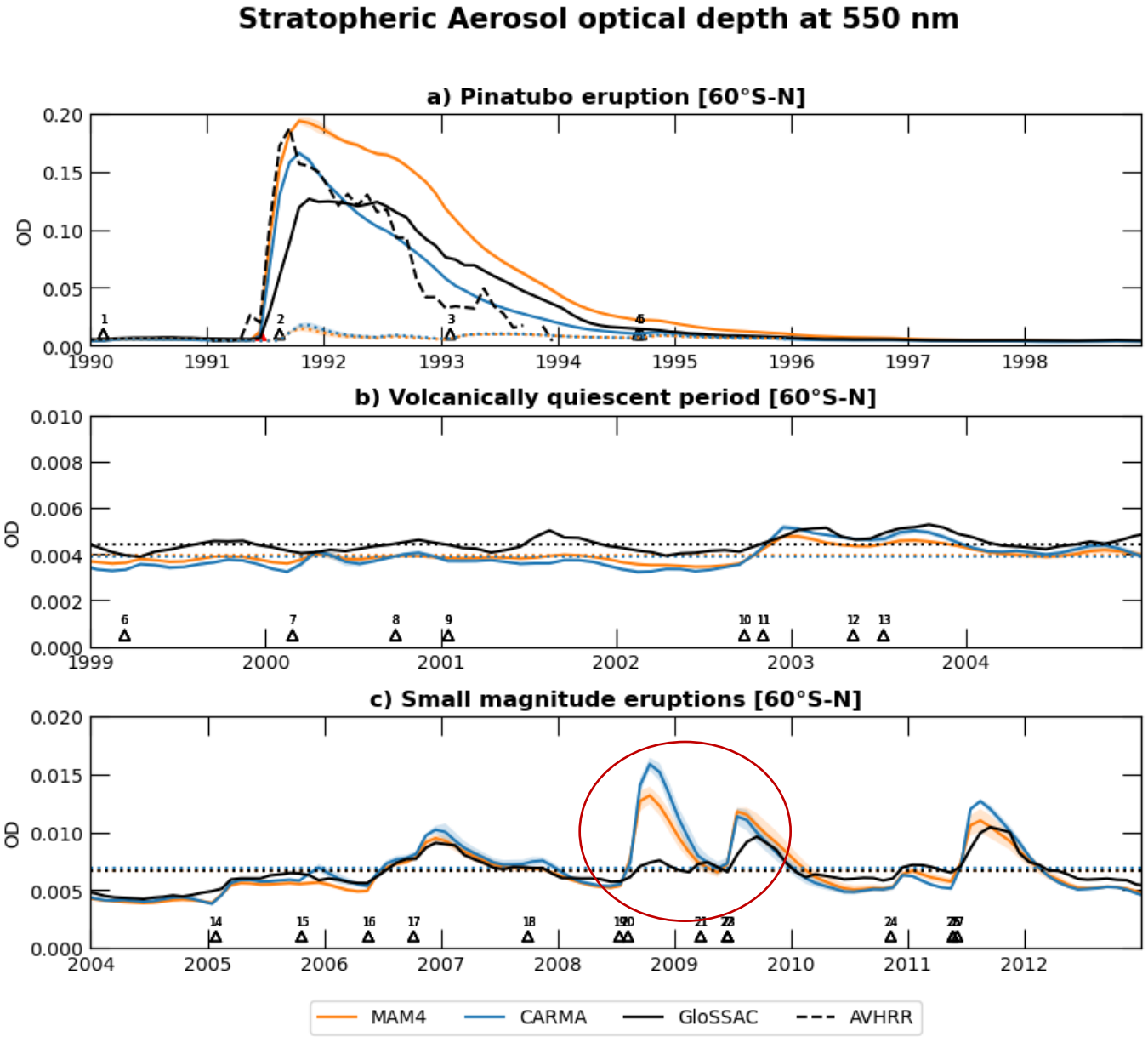

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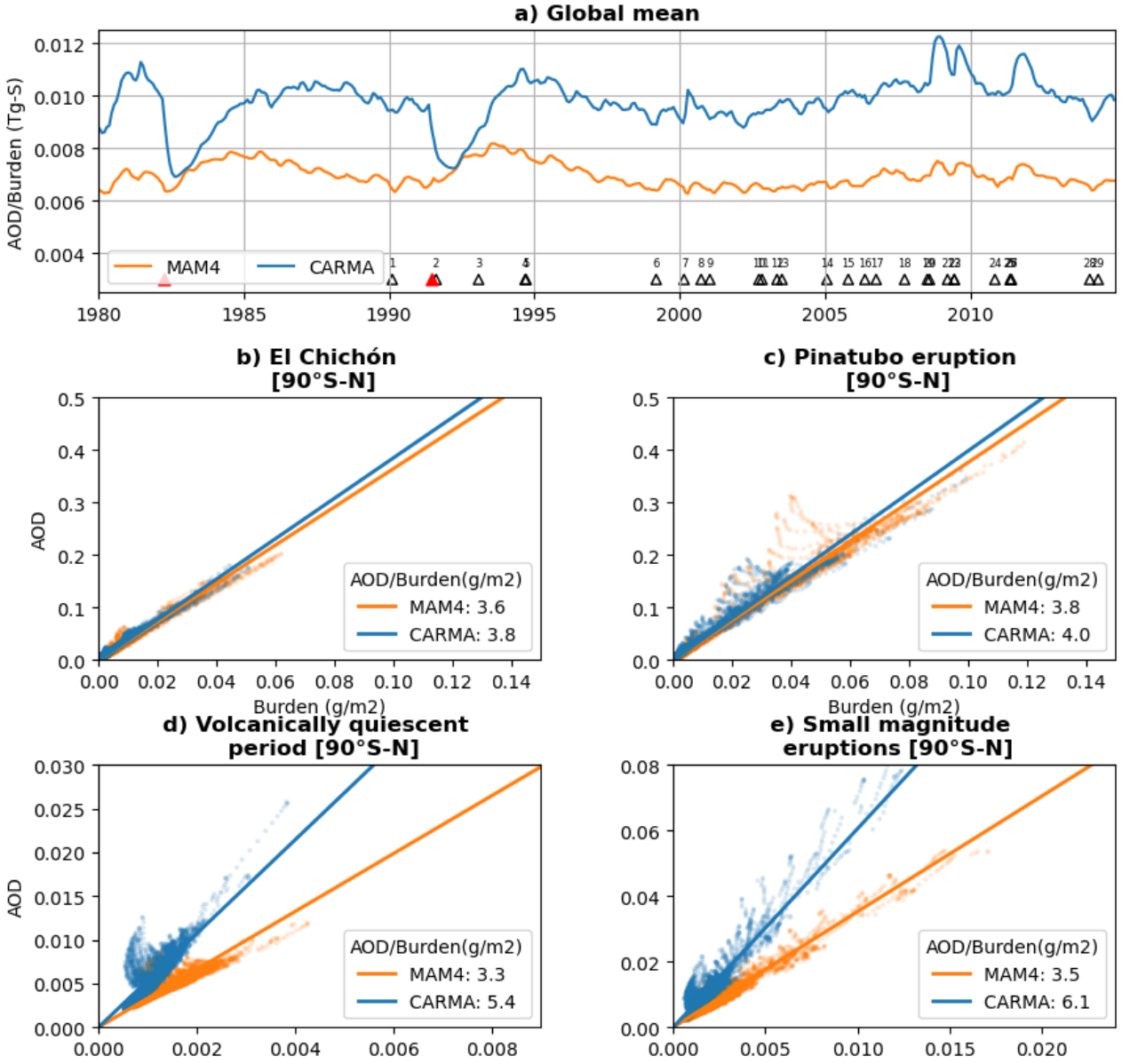

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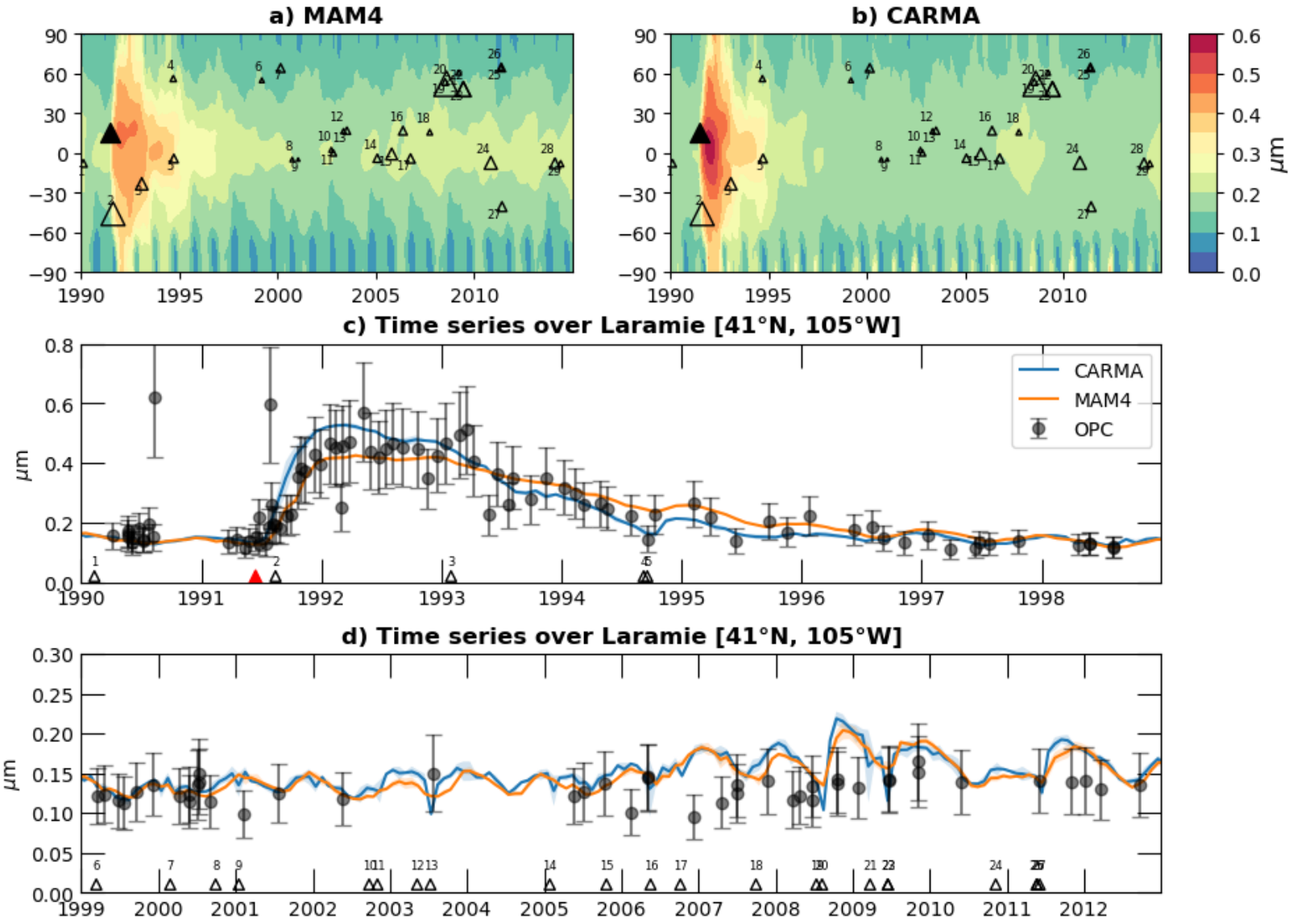

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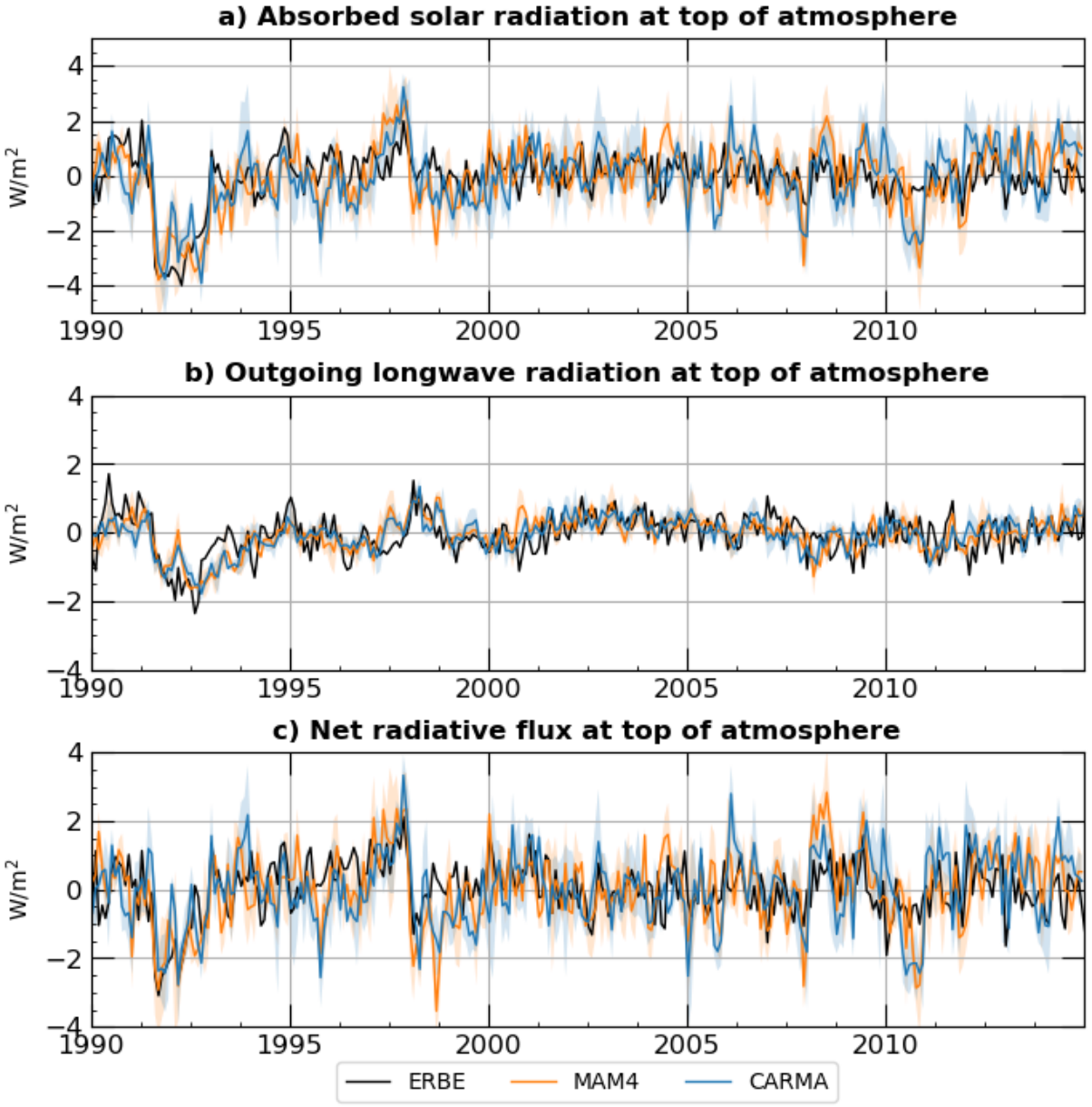

- **Good match in the TOA RF in both cases**
- **Further analyses with double radiation call show higher direct aerosol forcing in MAM than CARMA**

Conclusions

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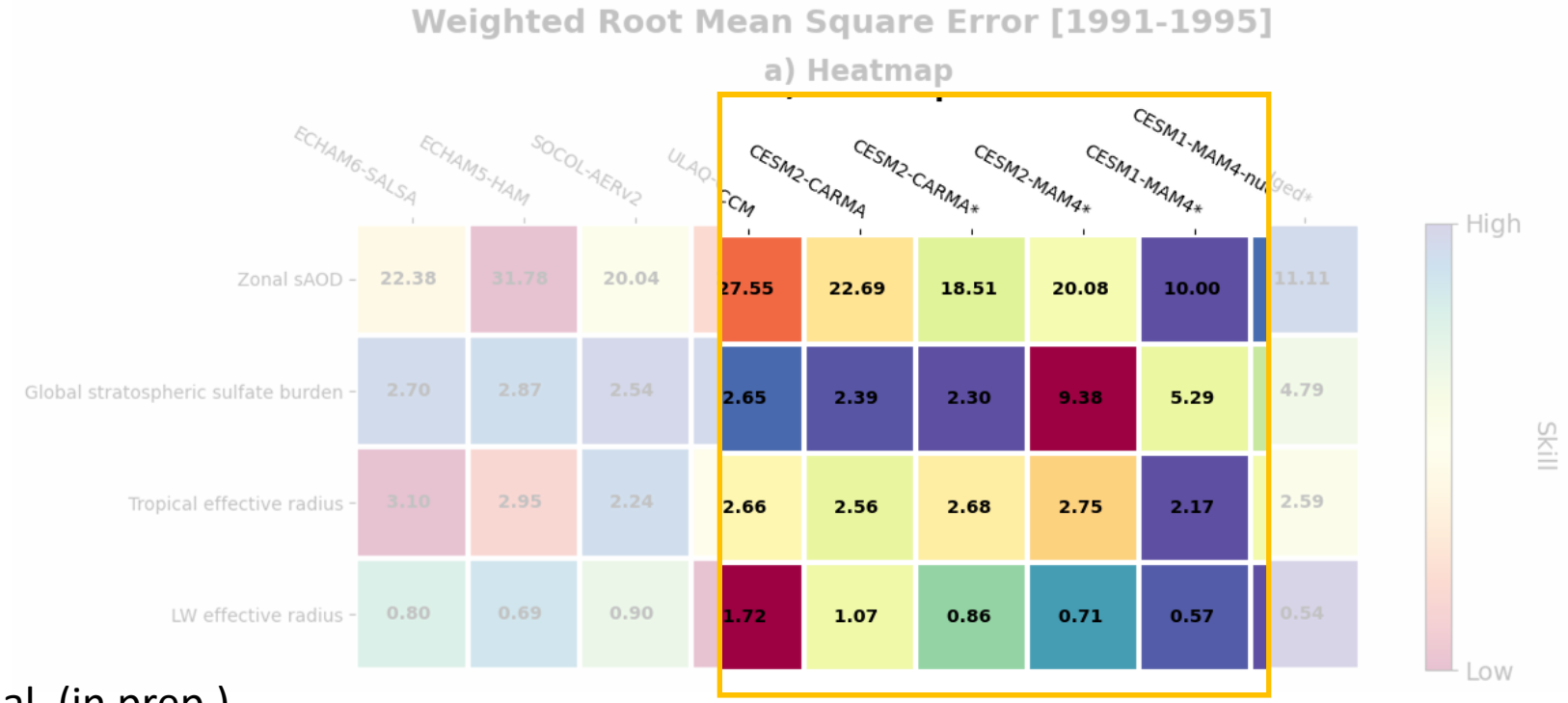

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Conclusions

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- Some indications that it performs marginally “better” over a set of metrics

- Next steps will hopefully include understanding impact on Stratospheric Aerosol Injection (SAI) simulations