

New CMIP7 Forcing Updates Impact Regional but Not Global Earth Radiation Budget Trends

Chongxing Fan^{1*}, David Paynter², Ryan Kramer², Vaishali Naik²

¹Program of Atmospheric and Oceanic Sciences, Princeton University

²Geophysical Fluid Dynamics Laboratory, NOAA

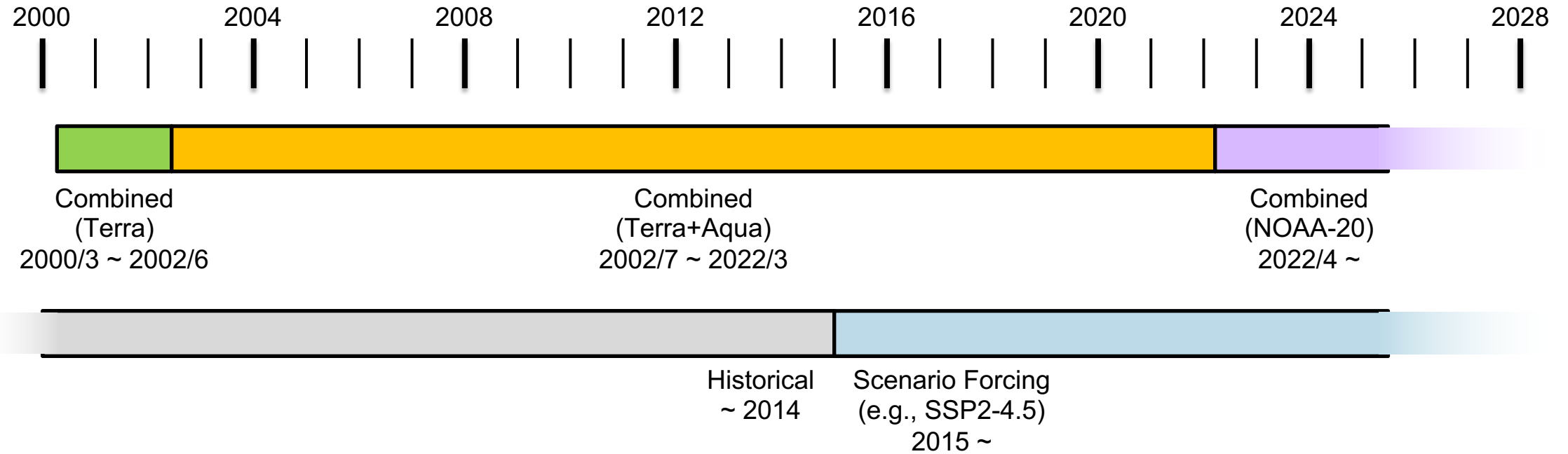
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* cxfan@princeton.edu

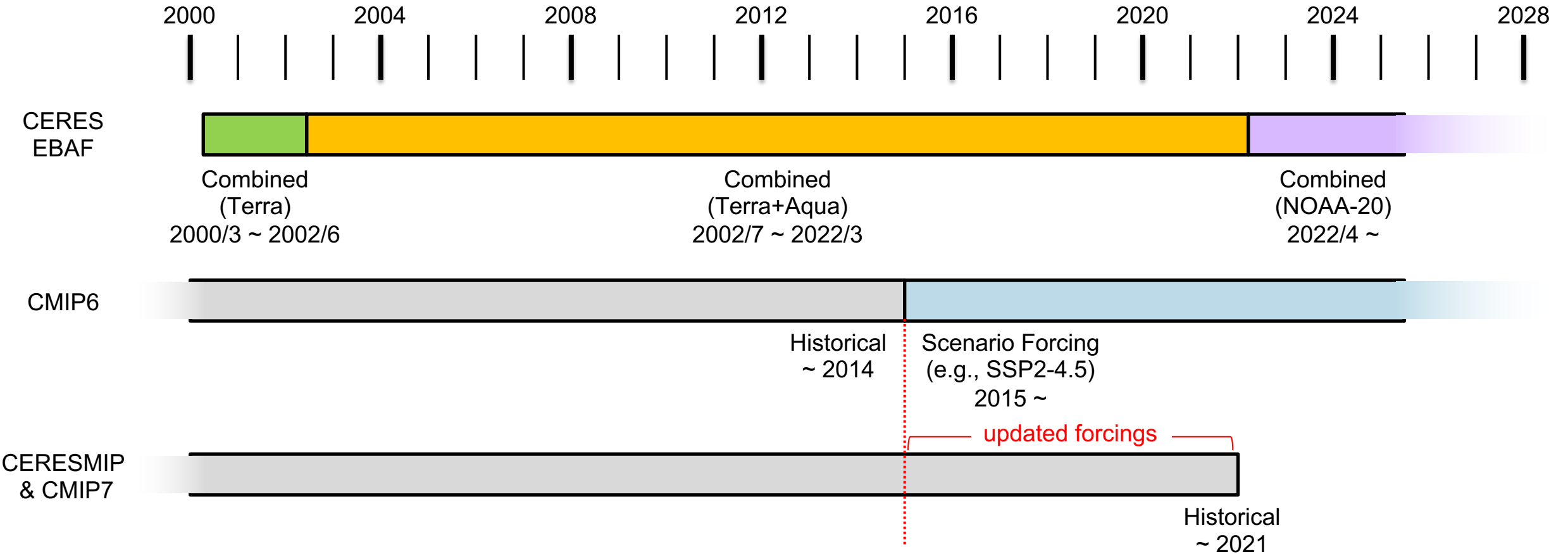
Earth Radiation Budget: CERES vs Model



CMIP7 Forcing Available

Forcing Category	Source ID(s)	DOI / Reference
Anthropogenic SLCF & CO₂	CEDS-CMIP-2025-04-18 CEDS-CMIP-2025-04-18-supplemental	10.5281/zenodo.15127477; 10.5281/zenodo.15001546
Open Biomass Burning	DRES-CMIP-BB4CMIP7-2-0	10.25981/ESGF.input4MIPs.CMIP7/2524040
Land Use	UofMD-landState-3-1-1	10.25981/ESGF.input4MIPs.CMIP7/2521499
GHG Concentrations	CR-CMIP-1-0-0	10.5281/zenodo.14892947
CO₂ Isotopes	ImperialCollege-3-0	10.25981/ESGF.input4MIPs.CMIP7/2583902
Volcanic SO₂ & Aerosols	UOEXETER-CMIP-2-2-1	10.25981/ESGF.input4MIPs.CMIP7/2522673
Ozone Concentrations	FZJ-CMIP-ozone-1-2; FZJ-CMIP-ozone-2-0	10.25981/ESGF.input4MIPs.CMIP7/2584173
Nitrogen Deposition	FZJ-CMIP-nitrogen-1-2	10.25981/ESGF.input4MIPs.CMIP7/2584172
Solar Irradiance	SOLARIS-HEPPA-CMIP-4-6	10.25981/ESGF.input4MIPs.CMIP7/2522675
AMIP SST & Sea-Ice	PCMDI-AMIP-1-1-10	10.25981/ESGF.input4MIPs.CMIP7/2575015
Aerosol Properties	MACv2-SP	Not managed via ESGF (External)
Population Density	PIK-CMIP-1-0-1	N/A

CERES vs Model with Latest Forcing Input



How will the forcing datasets affect simulated Earth radiation budget?

Forcings Used in GFDL AM4 Model

Forcing Category	Source ID(s)	DOI / Reference
Anthropogenic SLCF & CO₂	CEDS-CMIP-2025-04-18 CEDS-CMIP-2025-04-18-supplemental	10.5281/zenodo.15127477; 10.5281/zenodo.15001546
Open Biomass Burning	DRES-CMIP-BB4CMIP7-2-0	10.25981/ESGF.input4MIPs.CMIP7/2524040
Land Use	UofMD-landState-3-1-1	10.25981/ESGF.input4MIPs.CMIP7/2521499
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Aerosol Properties	MACv2-SP	Not managed via ESGF (External)
Population Density	PIK-CMIP-1-0-1	N/A

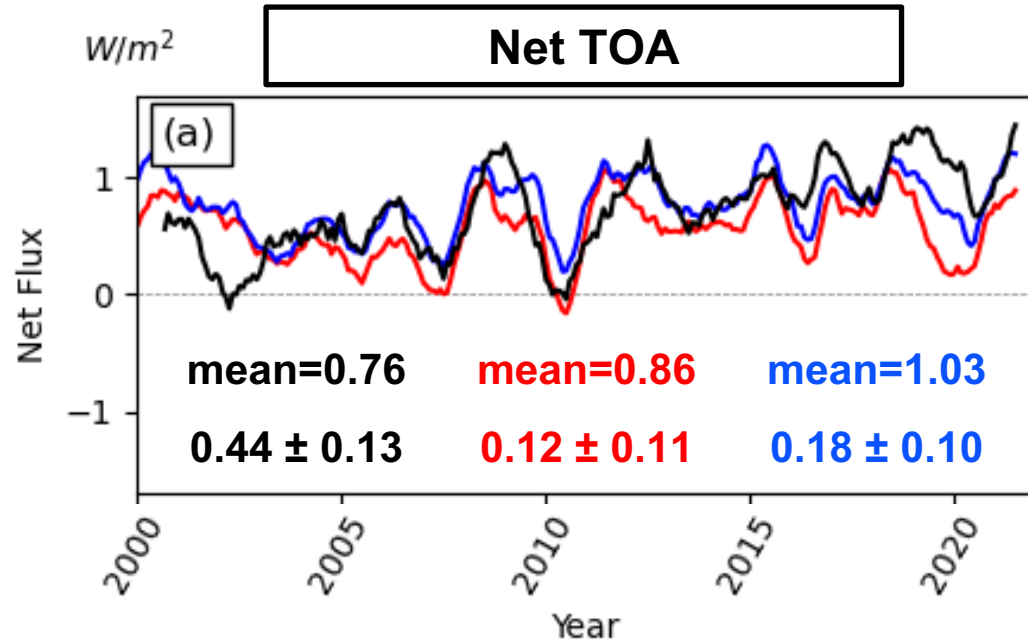
Forcings Used in GFDL AM4 Model

	<i>GFDL AM4 CMIP6^{1,2}</i>	<i>GFDL AM4 CMIP7¹</i>
Anthropogenic short-lived climate forcer (SLCF)	CEDS-2017-05-18 (Hoesly et al., 2018)	CEDS-CMIP-2025-04-18 (Hoesly et al., 2025)
Open biomass burning emissions	VUA-CMIP-BB4CMIP6-1-2 (van Marle et al., 2017)	DRES-CMIP-BB4CMIP7-2-1 (van Marle & van der Werf, 2025)
Greenhouse gas concentrations (GHGs)	UoM-CMIP-1-2-0 (Meinshausen et al., 2017)	CR-CMIP-1-0-0 (Nicholls et al., 2025)
Stratospheric volcanic SO2 emissions and aerosol optical properties	IACETH-SAGE3lambda-3-0-0 (Revell et al., 2017)	UOEXETER-CMIP-2-2-1 (Aubry, 2025)
Solar irradiance	SOLARIS-HEPPA-CMIP-3-2 (Matthes et al., 2016)	SOLARIS-HEPPA-CMIP-4-6 (Funke, 2024)
<i>Sea surface temperature (SST) and sea ice (SI) boundary forcing³</i>	<i>HadISST 2.4.0.0 SST and HadISST 2.2.4.0 SI (Kennedy et al., 2019)</i>	
<i>Ozone forcing⁴</i>	<i>UReading-CCMI-1-0 (Hegglin et al., 2016)</i>	

¹Five ensemble members for each case, simulating from 1979 to 2021 ²Historical forcing (~2014) extended by SSP2-4.5 scenario forcing to 2021

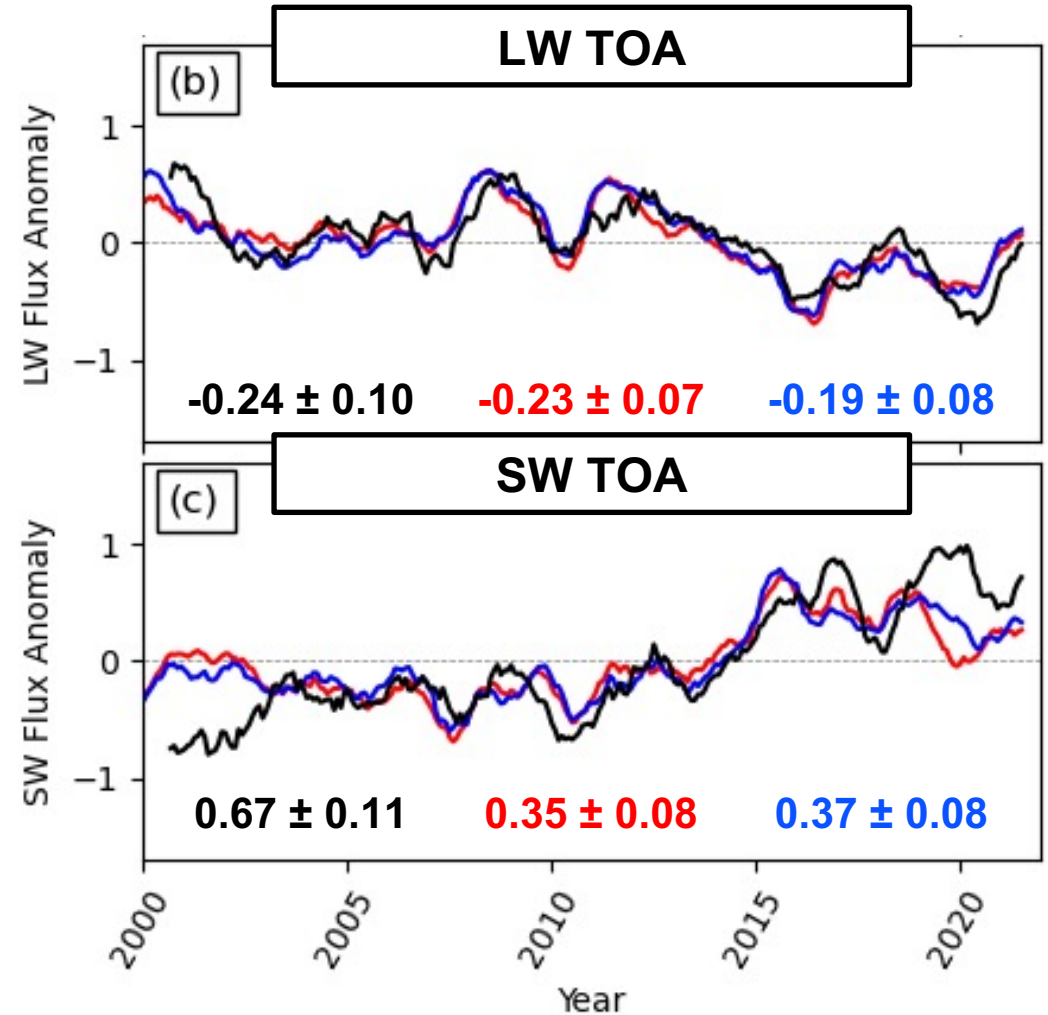
³SST and SI using HadISST 2 instead of PCMDI-AMIP 1.1.10 in our simulations ⁴Ozone forcing not updated in our simulations

CMIP6 vs CMIP7: TOA Fluxes

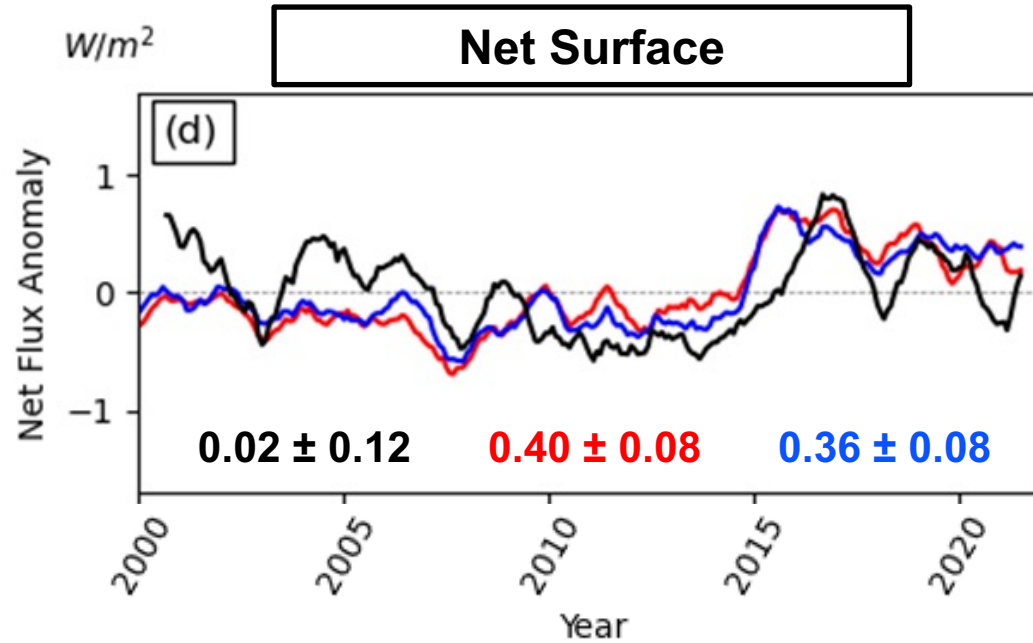


— CERES EBAF Ed4.2.1
 — GFDL AM4 CMIP6
 — GFDL AM4 CMIP7

2001~2021 trend included ($W/m^2/decade$)

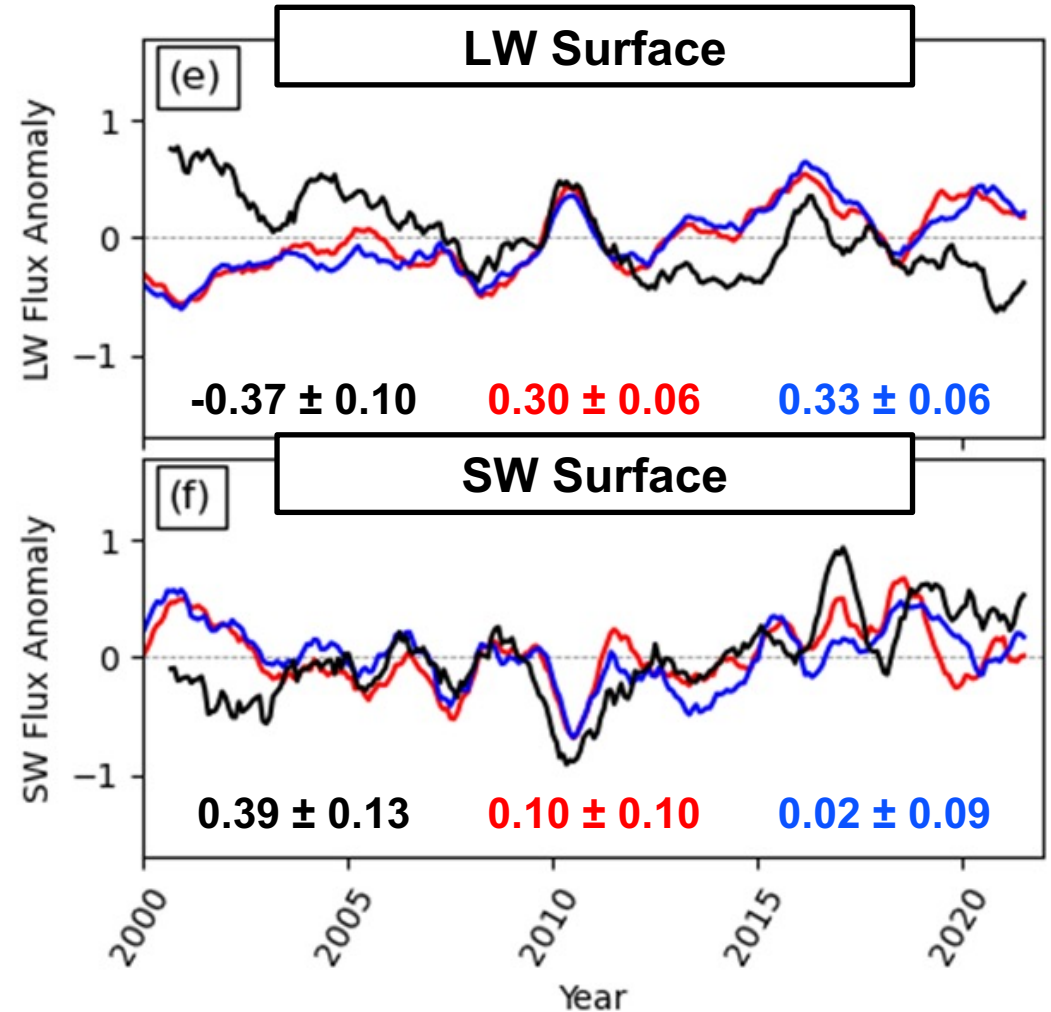


CMIP6 vs CMIP7: Surface Fluxes

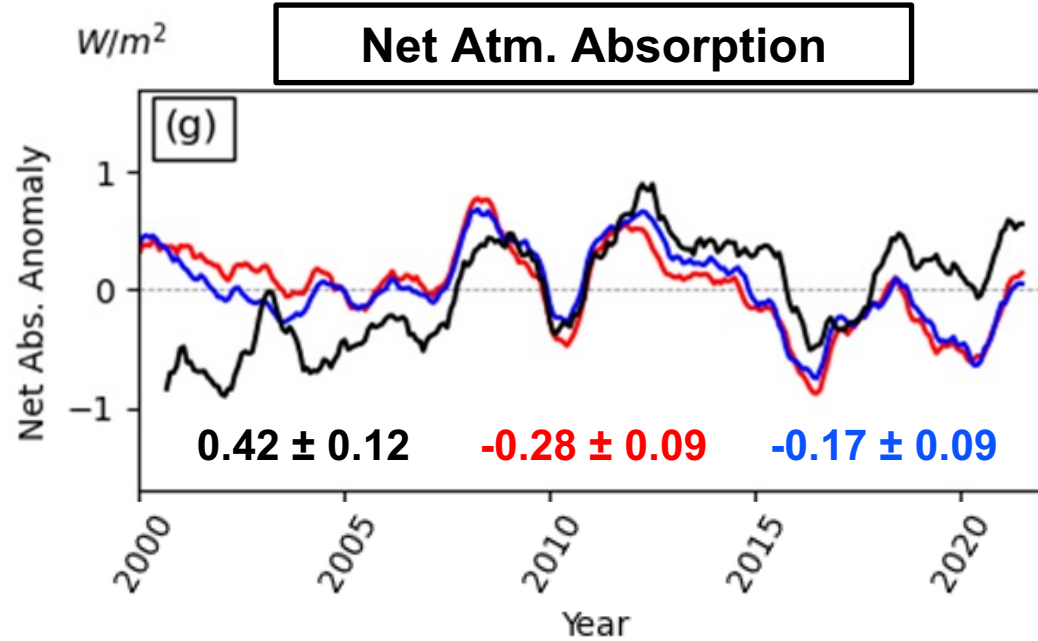


- CERES EBAF Ed4.2.1
- GFDL AM4 CMIP6
- GFDL AM4 CMIP7

2001~2021 trend included ($W/m^2/decade$)

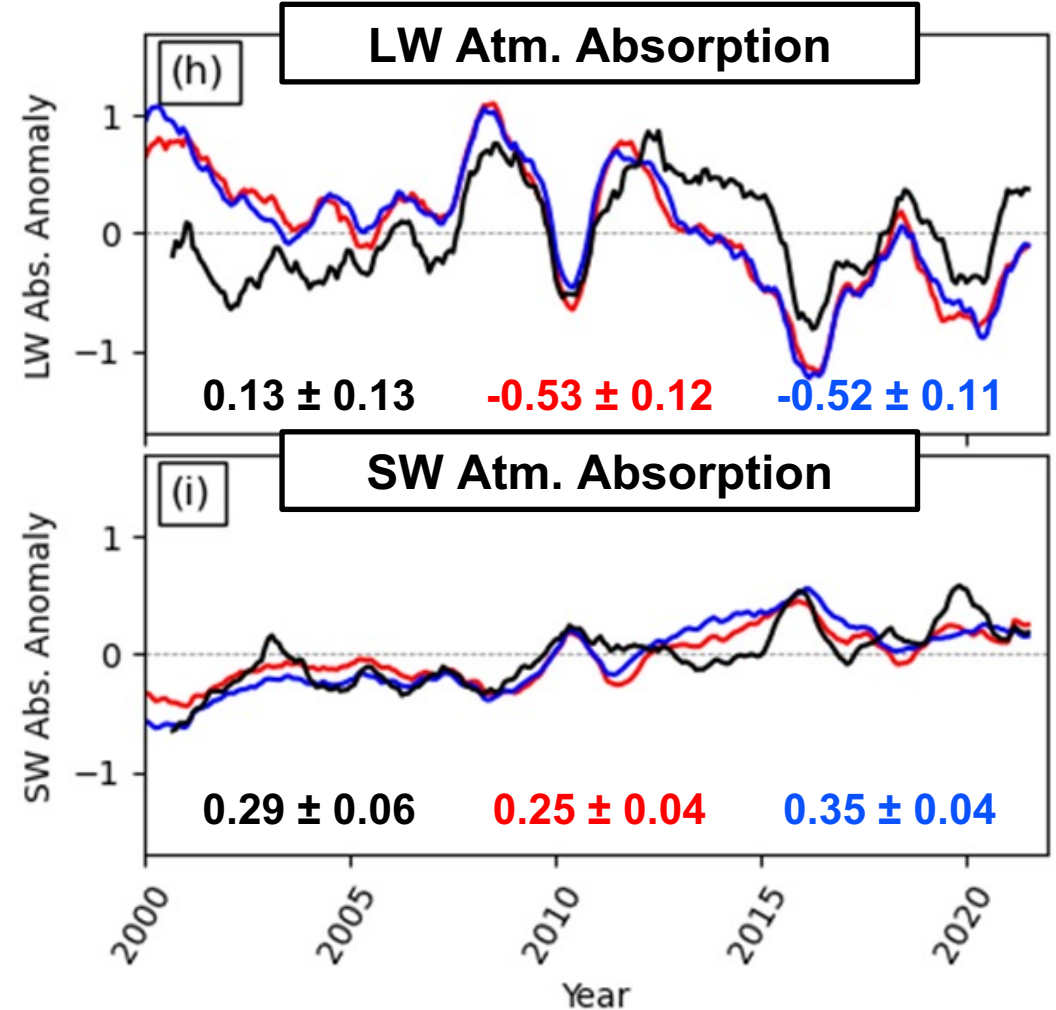


CMIP6 vs CMIP7: Atmospheric Abs.

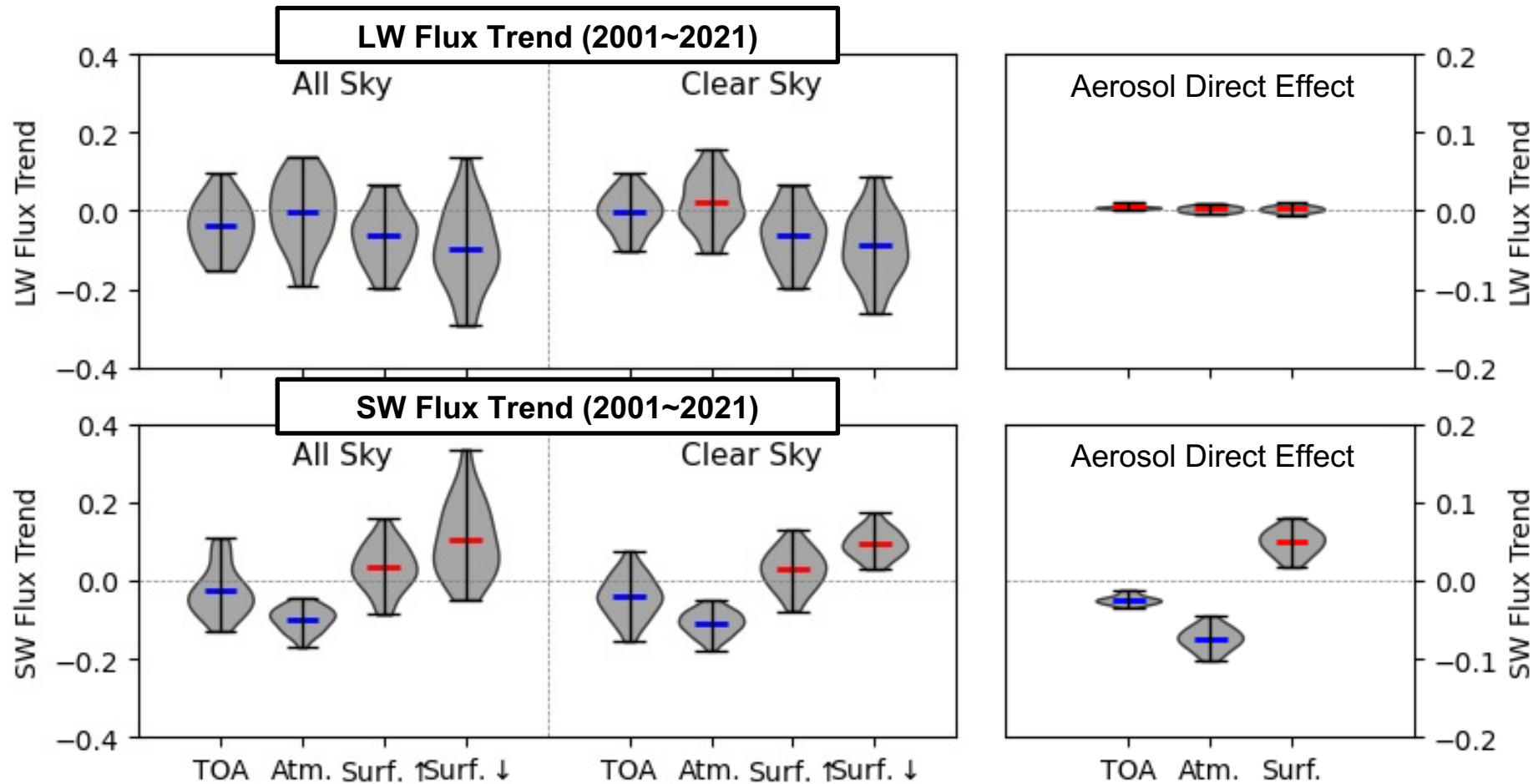


- CERES EBAF Ed4.2.1
- GFDL AM4 CMIP6
- GFDL AM4 CMIP7

2001~2021 trend included ($W/m^2/decade$)



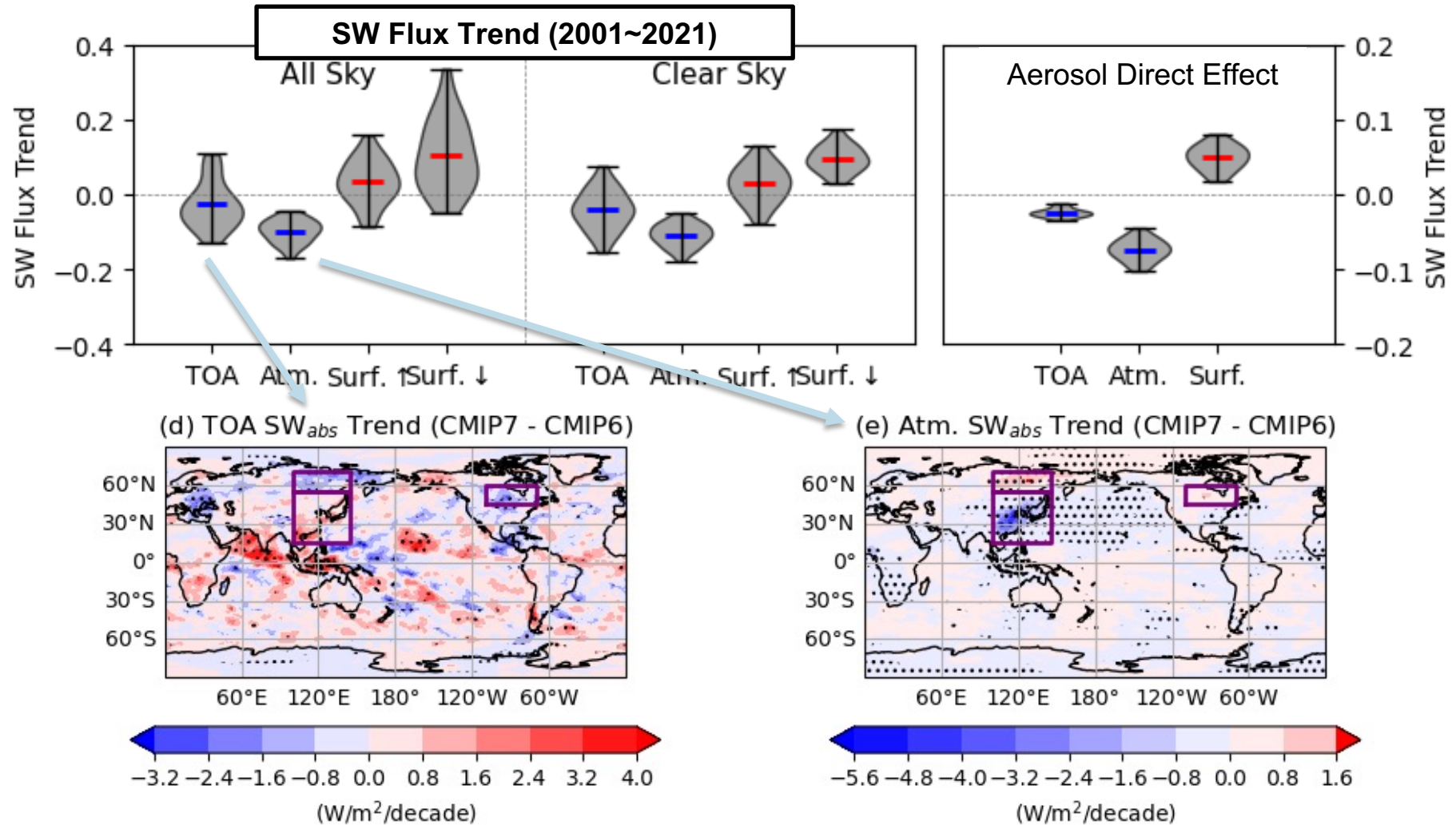
Trend Difference between CMIP6 and CMIP7



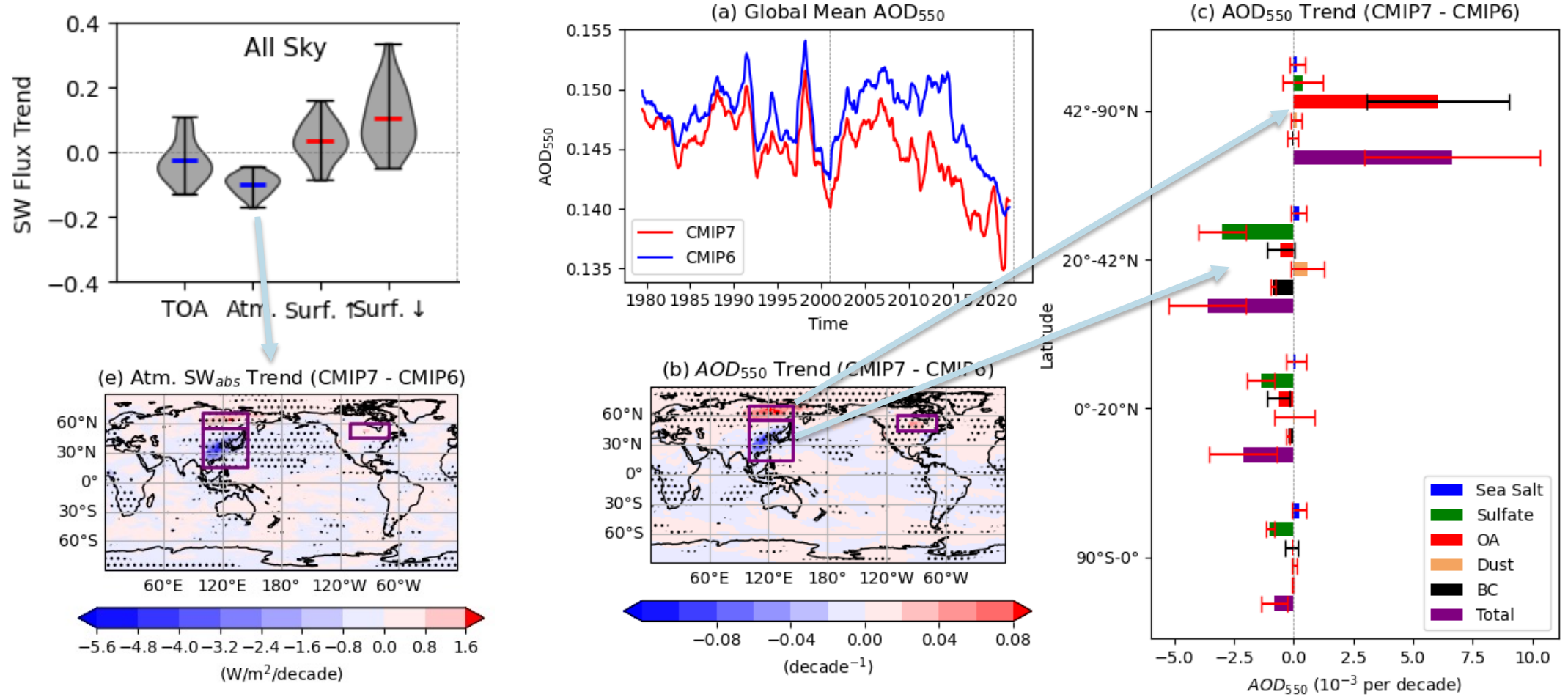
5 ensemble members for each case => 25 pairs to calculate trend differences that are visualized as violins

red: positive ensemble mean changes blue: negative ensemble mean changes

Dipole: East Asia and East Siberia



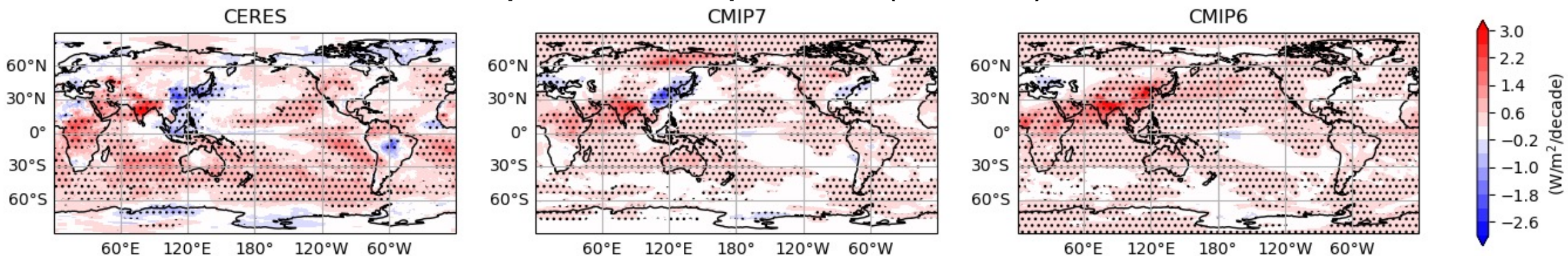
Flux Trend Changes Attributed to Aerosols



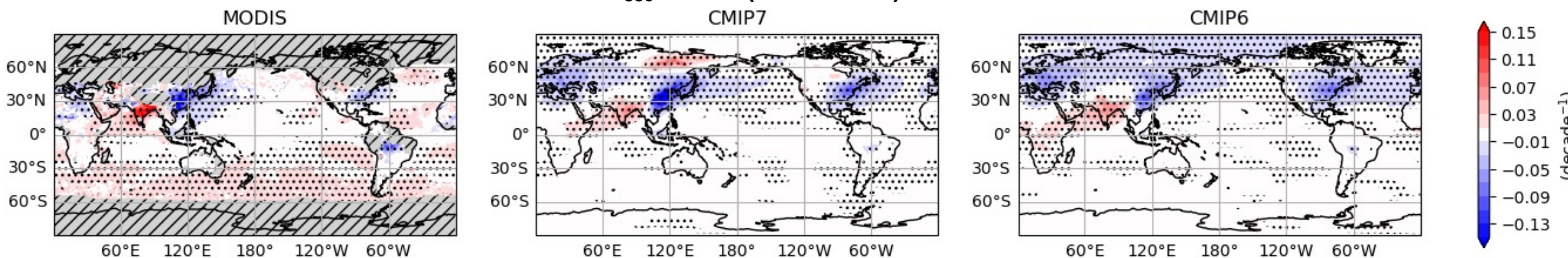
These trend differences vanish when aerosol forcing is fixed at 1850 level

Regional Comparison to CERES and MODIS

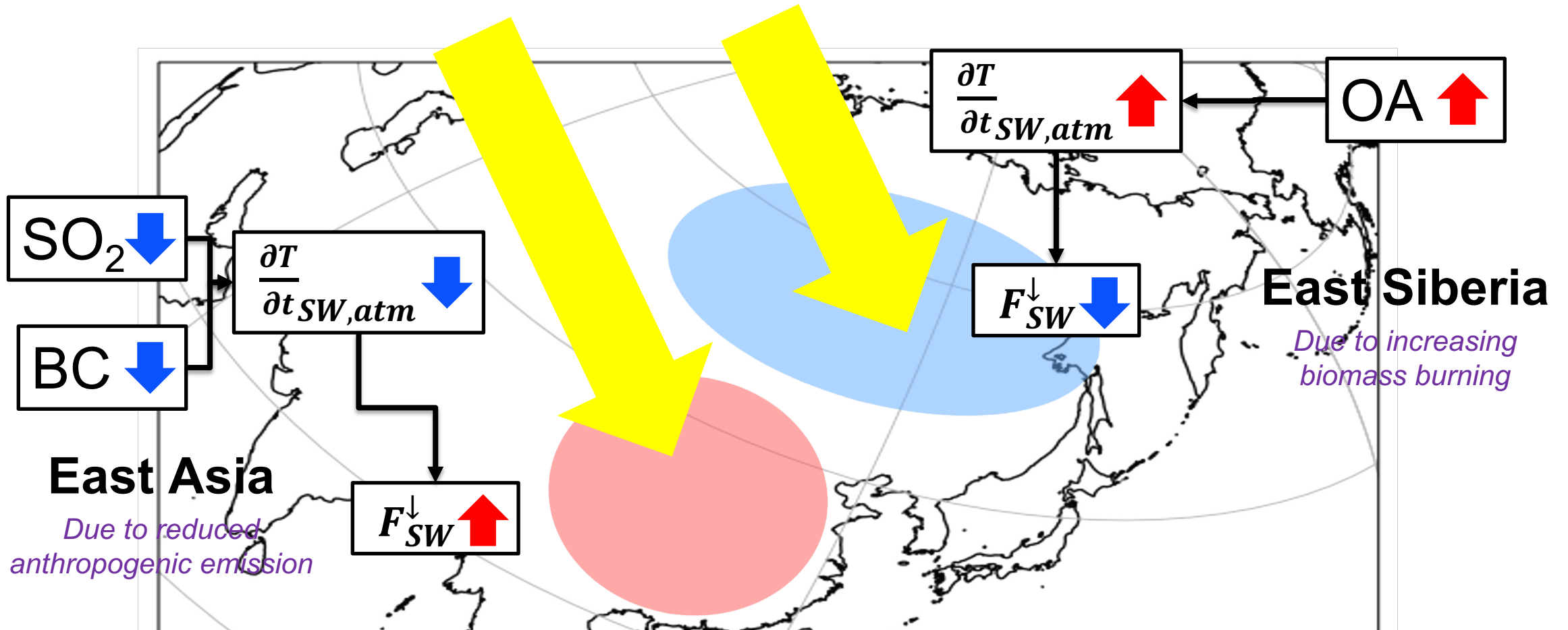
Atmospheric SW Absorption Trend (2001~2021)



AOD₅₅₀ Trend (2002~2021)

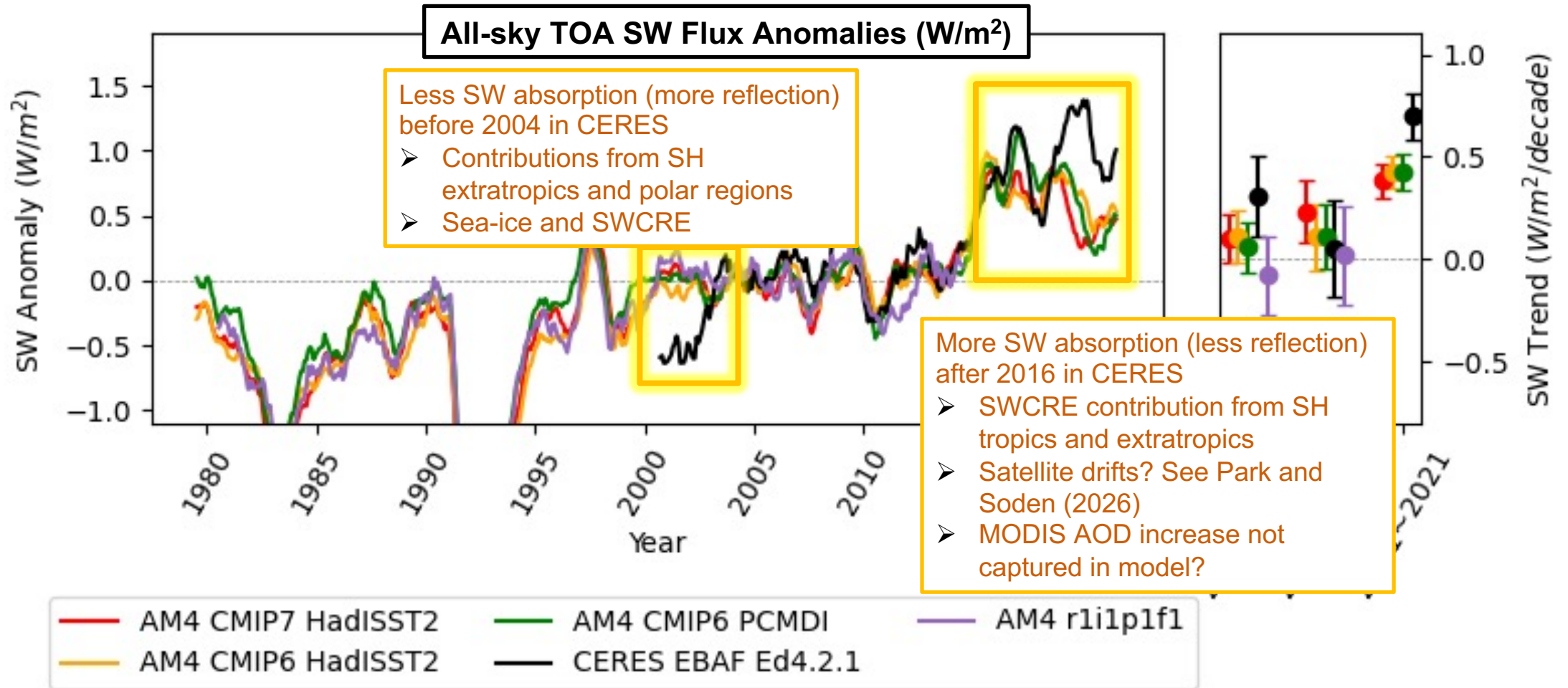


Summary: Impact of CMIP7 Forcing Updates

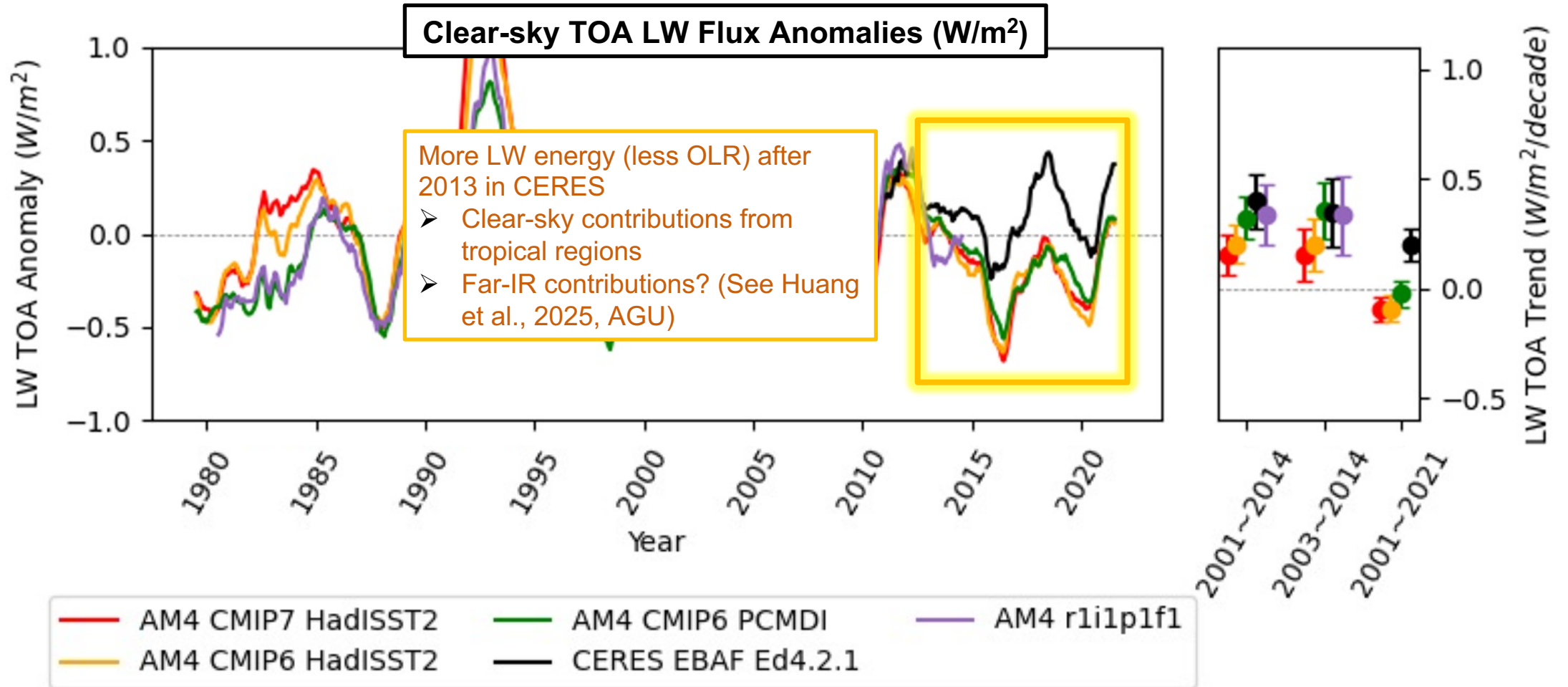


While the forcing updates do not modify global mean TOA radiation budget, it slightly redistributes the SW radiation partition between atmosphere and surface.

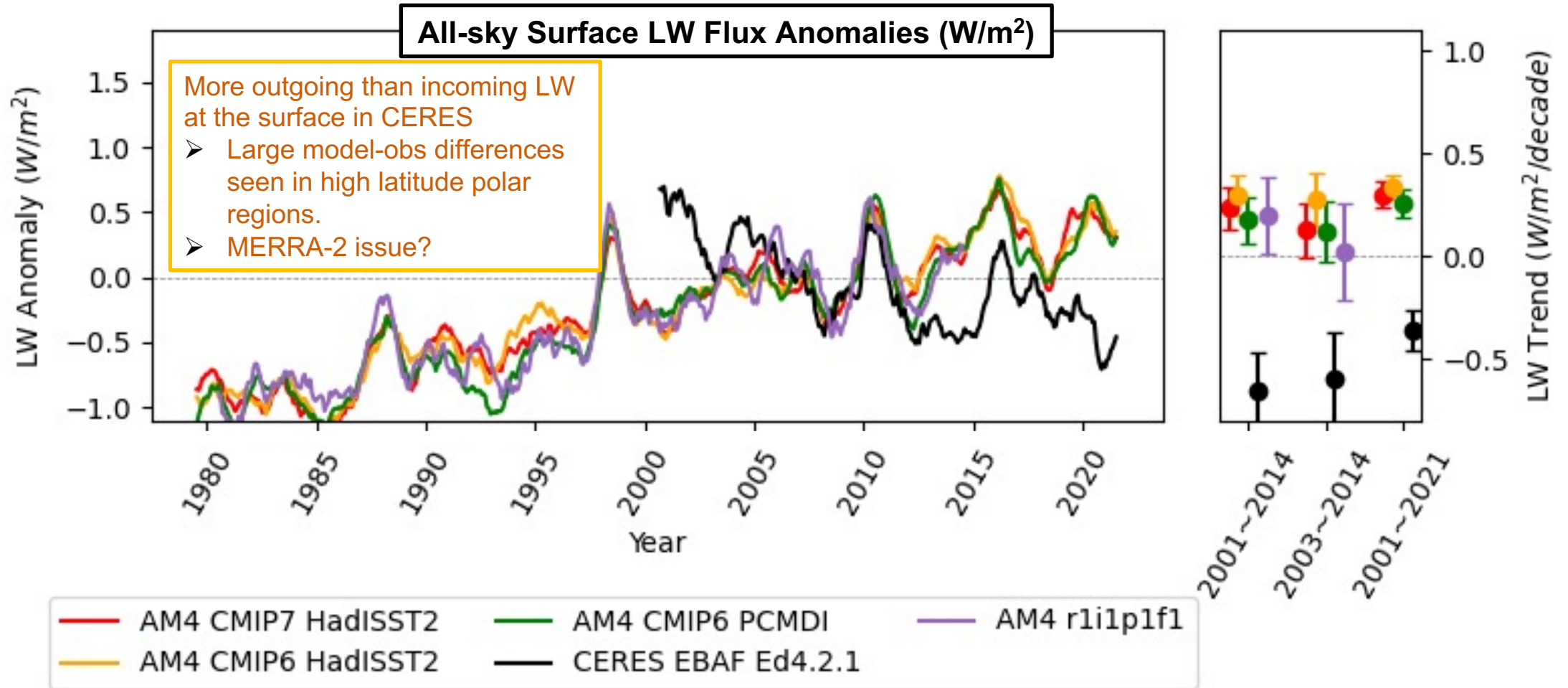
CERES vs Model TOA SW Bias Persists



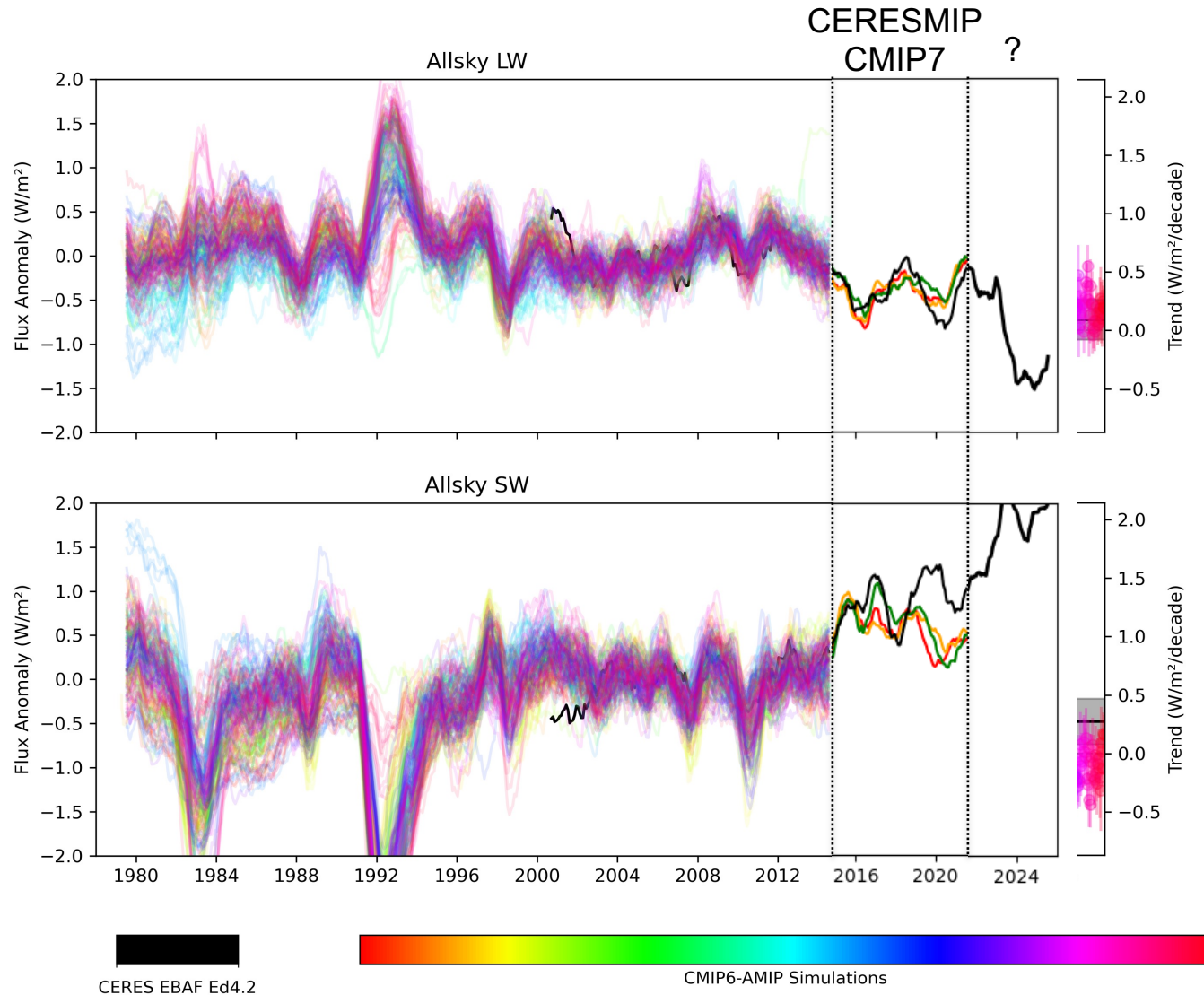
CERES vs Model TOA LW Clear-Sky Issue



CERES vs Model Surface LW Issue



Outlook: CERESMIP/CMIP7 and beyond



Thank you!

- CMIP7 forcing update minimally impacts global TOA radiation trends but reveals pronounced regional shifts in atmospheric solar absorption.
- Updated aerosol forcing drives reduced atmospheric solar absorption over East Asia and increased absorption over Siberia.
- Routine forcing evaluation and updates are necessary to resolve regional inconsistencies between model simulations and observations.

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- Dr. John Dunne and Dr. Fabien Paulot for reviewing our write-up
- CMIP Forcings Task Team for preparing and providing the CMIP7 forcing datasets
- Dr. Jing Feng, Dr. Eric Stofferahn, and Dr. Pu Lin for processing the CMIP7 forcing datasets specifically for GFDL models
- GFDL computational resources for supporting this work
- CIMES grant (NA23OAR4320198) from National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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- Atmospheric and Oceanic Sciences program from Princeton University



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