Cloud Macro- and Micro-physical Response to Idealized Wildfire Aerosol Forcing

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1. Motivation

Study the subtropical low cloud response and its radiative forcing to idealized wildfire aerosol forcing and the model sensitivity to:

a. Model resolution
b. Atmosphere-ocean coupling
c. Local vs. global wildfire forcing

2. Model and Simulations

Model: US Department of Energy's Energy Exascale Earth System Model (**E3SMv2**):

a. Low resolution configuration (**LR, 100 km**)
b. North American Regionally Refined Model (**NARRM**) configuration (**25km** over NA, 100km global)

Prescribed sea-surface temperature (SST) LR and NARRM Simulations:

a. **Control:** 10–yr run with climatology (2005-14) aerosol and SST forcing (F2010 compset)
b. **10XBB:** same as Control, but forced with climatological biomass burning aerosol mass and number scaled by a factor of 10 globally.

Fully Coupled Atmosphere-Ocean LR simulations:

a. **Control:** 10-year with climatological aerosol forcing
b. **10XBB:** 10 1-year run ensemble with each member initialized from control run model state on Jan 1 of each year and forced with BB aerosols scaled by a factor of 10 globally

Regionally forced prescribed SST LR simulations:

a. **Control:** 10-yr run with climatological aerosol forcing
b. **10xBB-Local:** 10-yr run with BB aerosols scaled by a factor of 10 only over North America

3. E3SMv2.NARRM Response

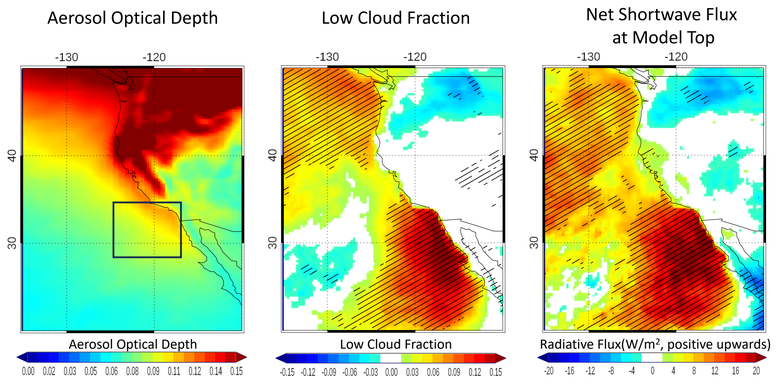

Fig. 1: Difference between **10XBB** and **Control** simulation **NARRM** prescribed SST simulation.

4. E3SMv2.LR Response

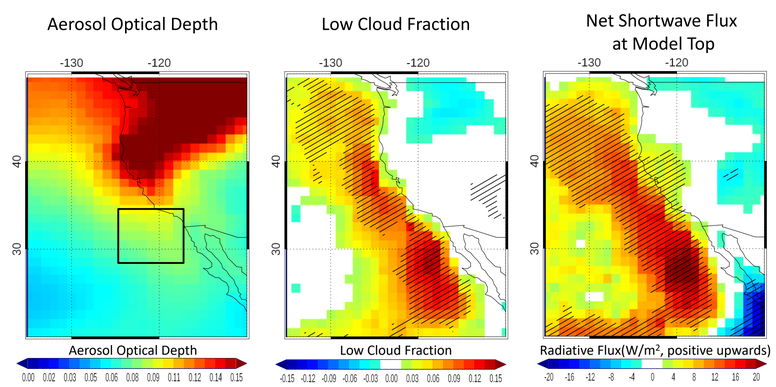

Fig. 2: Difference between **10XBB** and **Control LR** prescribed SST simulation.

5. E3SMv2.LR Coupled Model Response

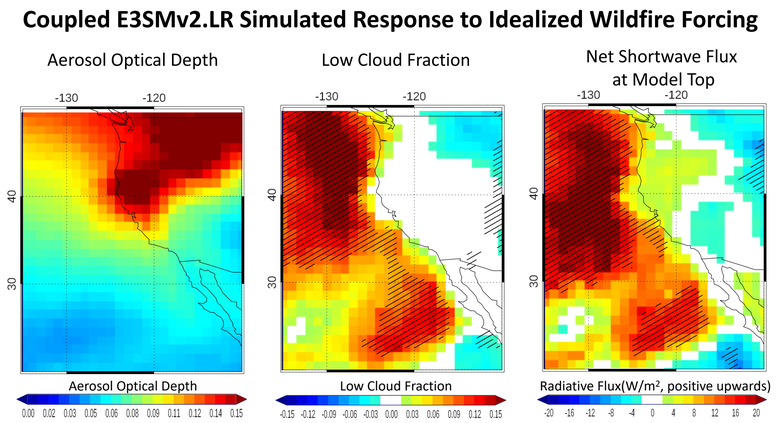

Fig. 3: Difference between **10XBB** coupled model 10 member 1-yr simulation ensemble and **Control** run.

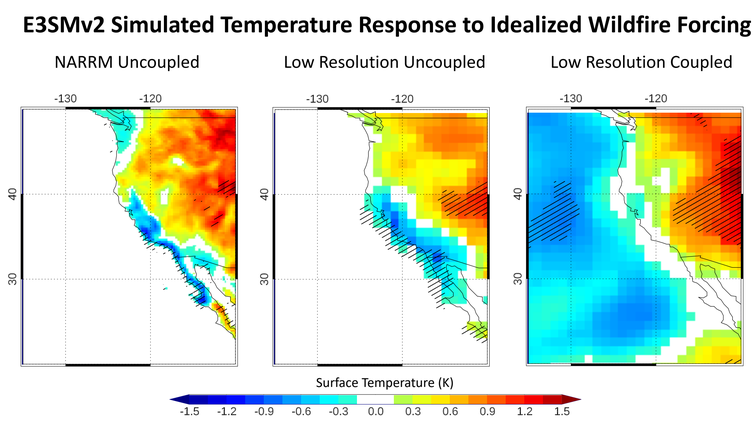

Fig. 4: Difference in surface temperature between **10xBB** and **Control** for different configurations

6. Microphysical Response

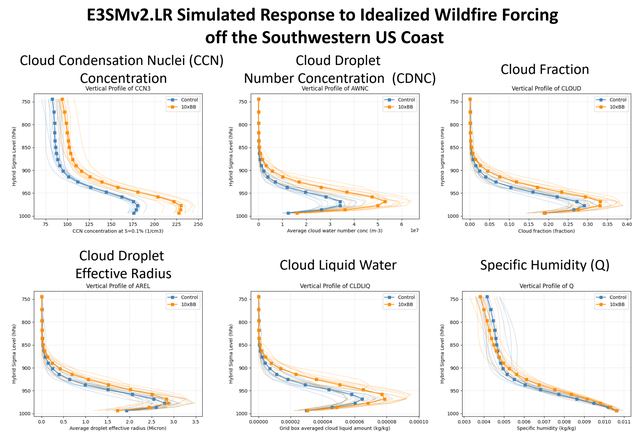

Fig. 5: Difference in cloud microphysical properties between **10XBB** and **Control LR** prescribed SST simulation.

7. Moisture Transport

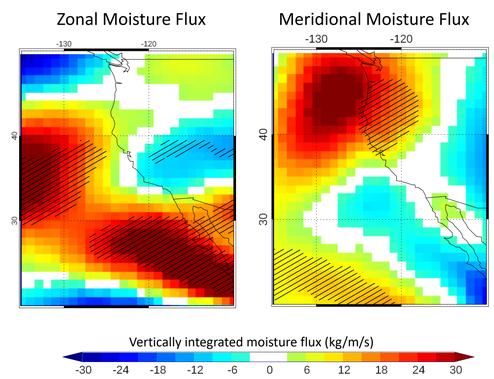

Fig. 6: Difference in zonal and meridional moisture transport between **10xBB** and **Control LR** simulation.

8. Regional Forcing Response

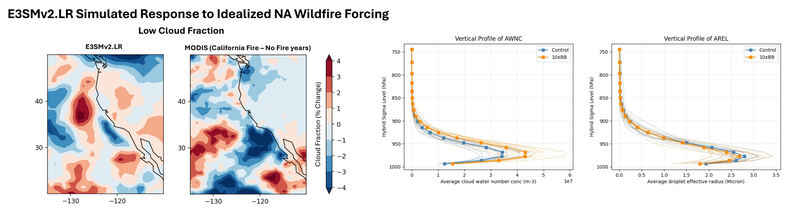

Fig. 7: Difference in cloud fraction and its microphysical properties in **10xBB-Local** and **Control LR**. Also shown is the difference in clouds between strong and weak California fire years in **MODIS** data.

9. Summary and Discussion

- 10x increase in global BB aerosols results in significant increase in cloud off US west coast.
- Increase in resolution results in a stronger cloud and radiative response
- Atmosphere ocean coupling amplifies response due to low-cloud SST feedback.
- CDNC and effective radius both increase, likely due to increased availability of moisture.
- Cloud response is weak in NA-only forcing with an increase in CDNC and a reduction in effective radius suggesting a strong role for larger scale dynamics in global forcing runs.

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