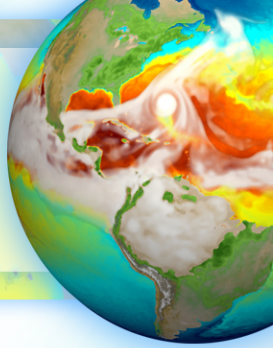
# E3SMv1 DECK Future Projections under the High-Emission SSP5-8.5 Scenario



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**The 2020 ESMD-E3SM PI Meeting**

**10/29/2020**

E3SM Energy Exascale Earth System Model

*This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. LLNL-POST-815834*

U.S. DEPARTMENT OF ENERGY

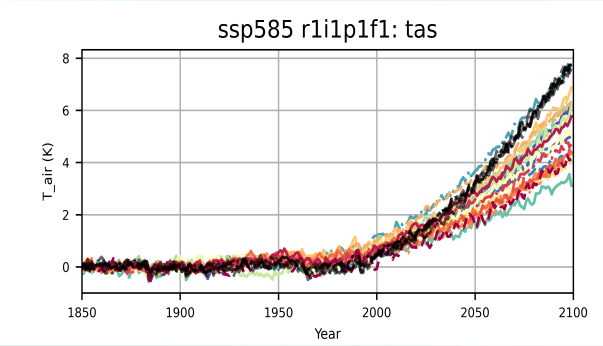
# Scientific Objectives

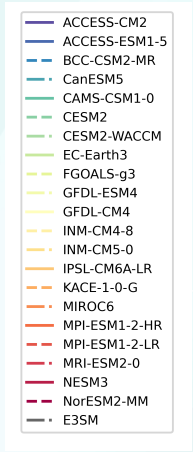
- To document the future climate projected by E3SMv1 under the high-emission scenario.
- To estimate the regional impacts of forcings other than the Greenhouse Gas (GHG) emissions on the future climate projection in E3SMv1, which has a strong aerosol-related effective radiative forcing and a high equilibrium climate sensitivity.
- Hypotheses:
  - The unmasking of aerosol forcing causes the future warming in E3SMv1 being larger than the warming in models with similar climate sensitivity
  - Forcings other than GHG forcing have larger regional impacts over the land than over the ocean
  - Relative to GHG emissions, the impact of other forcings on water cycle over land are different between the last 40 years and the future in E3SMv1 simulations

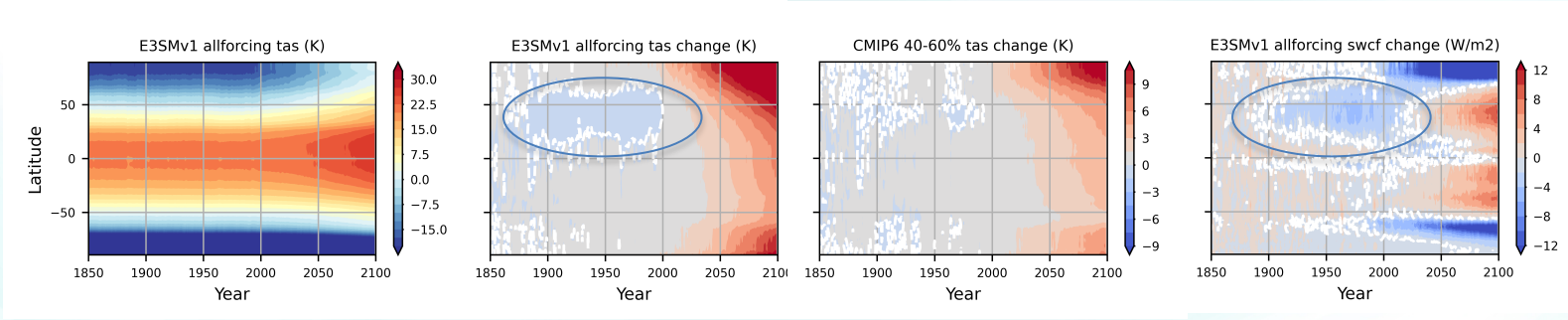
# Simulations

- E3SMv1 DECK future projection simulations under the High-Emission SSP5-8.5 Scenario (five ensemble members)
- Two sets of DAMIP simulations (each has three ensemble members)
  - **DECKv1b_H1_hist-GHG**: DAMIP well-mixed greenhouse-gas-only historical simulations with 1850 tropospheric and stratospheric ozone.
  - **DECKv1b_P1_SSP5-8.5-GHG**: DAMIP well-mixed greenhouse-gas-only future projection simulations with 1850 tropospheric and stratospheric ozone, aerosols and land-use.

# The annual surface air temperature changes

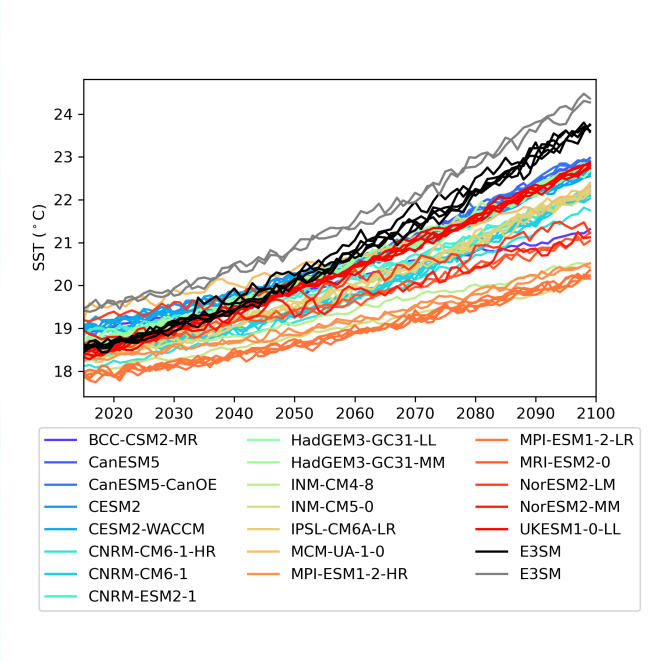


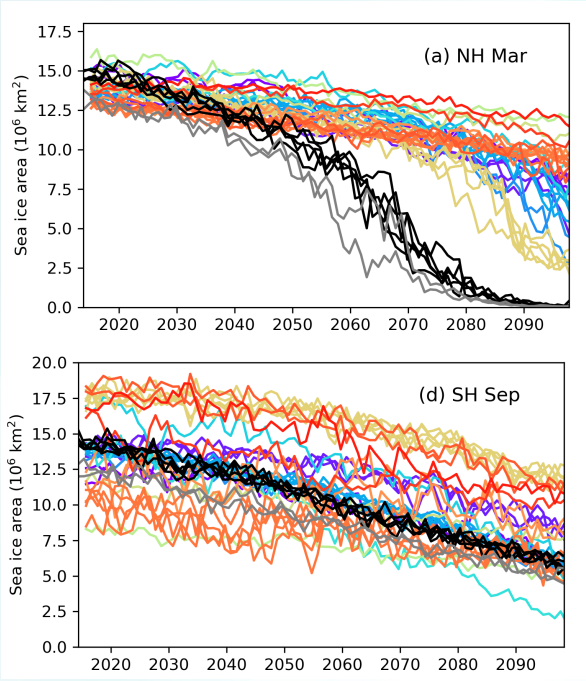




Surface air temperature shows a NH cooling in the historical runs and a rapid warming in the future runs

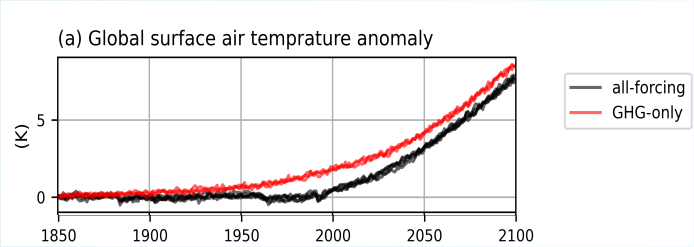
# SST and sea ice in the future simulations

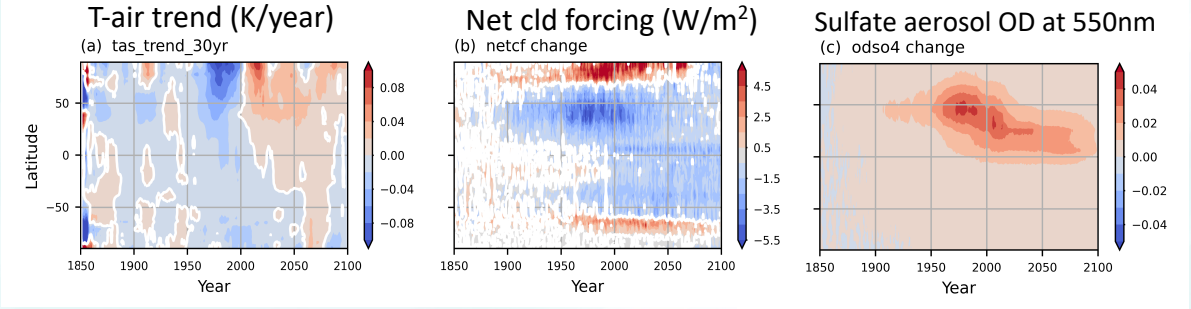


# The regional impacts of GHG emissions vs. other forcings in the atmosphere

*There is a sign that the reduced aerosol forcing causes all-forcing simulations warm more rapidly that GHG-only simulations*

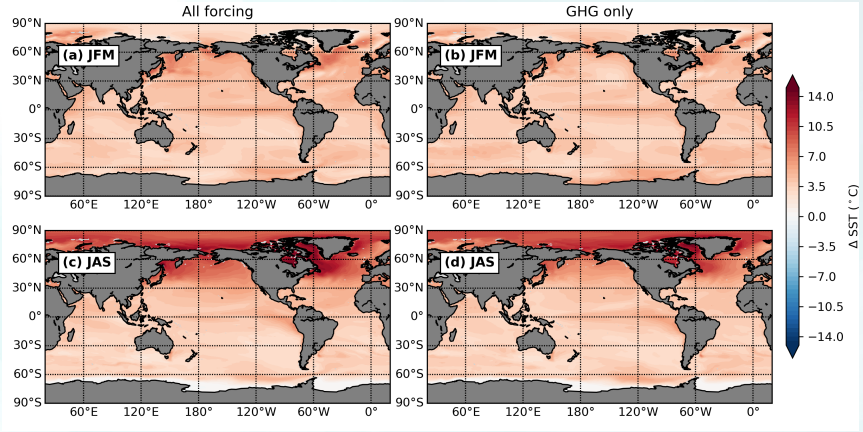


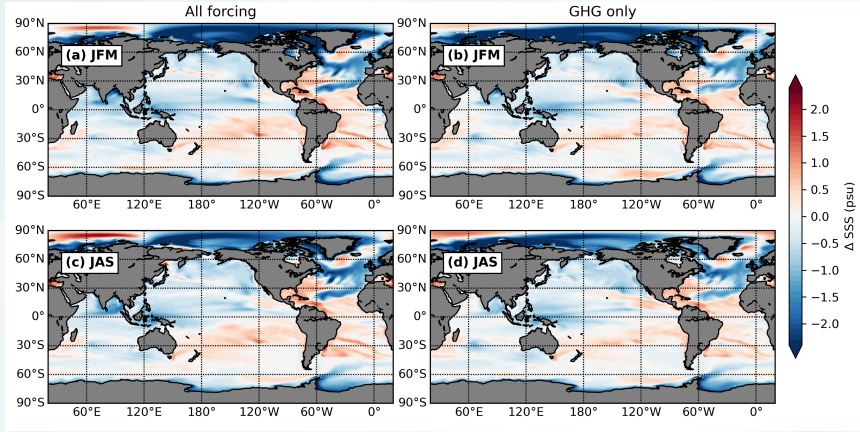

**All-forcing simulations vs. GHG-only simulations**

# The regional impacts of GHG emissions vs. other forcings over the ocean

*The patterns of the oceanic climate change in all-forcing simulations and GHG-only simulations are similar*



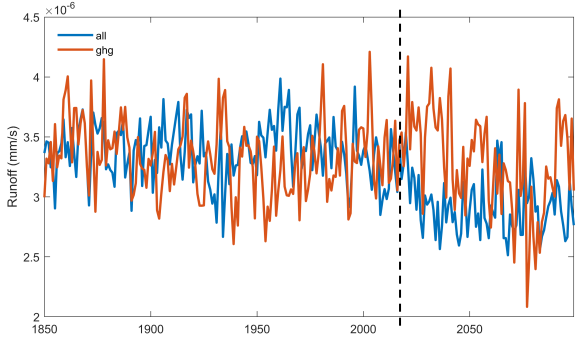

The changes in sea surface temperature (SST) between the time period of 2070 – 2099 and the period of 1985-2014 for Jan-Feb-Mar and Jul-Aug-Sep from E3SMv1 all forcing simulation and GHG-only simulation



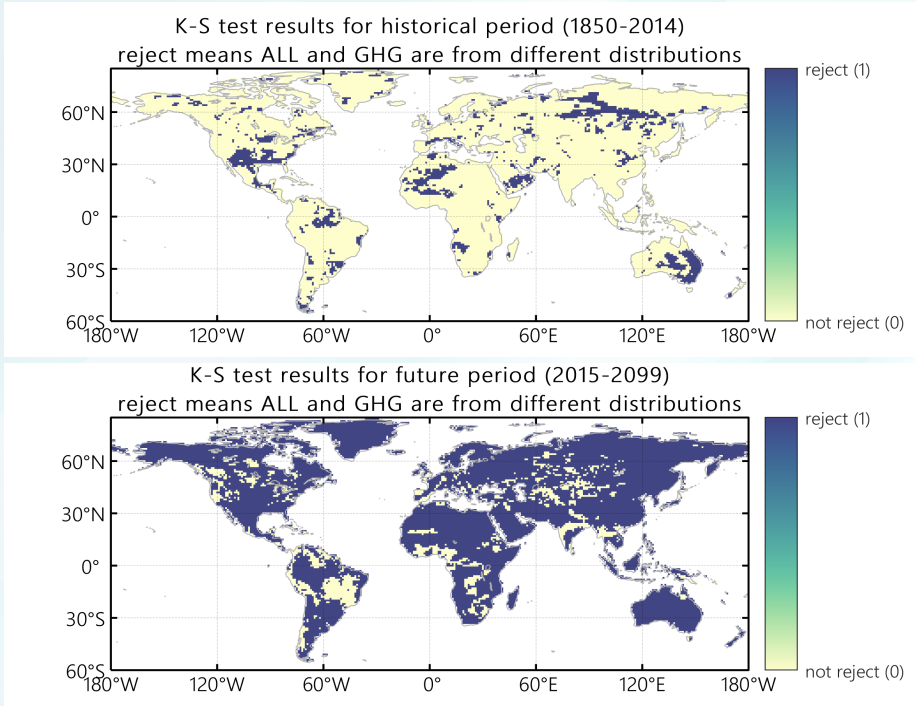

Same as the left figure except for changes in sea surface salinity (SSS)

# The regional impacts of GHG emissions vs. other forcings over the land

*As for the runoffs, the difference btw all-forcing and GHG-only is notably larger in the future simulations.*




An example of the timeseries of the runoff from E3SMv1




Kolmogorov–Smirnov (K-S) tests for the time series of runoff

# Summary

- E3SMv1 is one of the strongest warming models among CMIP6 models between 2050-2099 under the High-Emission SSP5-8.5 Scenario.
- The time evolution of the zonal mean near surface air temperature shows that E3SMv1 has a strong cooling at the Northern Hemisphere between 1900 and 2000, which is consistent with the peak aerosol optical depth.
- Changes in SST, SSS, mixed layer depth (no shown here) from all-forcing and GHG-only runs suggest that forcings other than GHG have little impact on the oceanic mean climate.
- Runoff analyses: Basin-based analyses found the time series of runoff from all-forcings are more different from GHG-only in the future simulations than in the historical simulations, indicating forcings other than GHG emissions have increased impacts over the land in the future climate projected by E3SMv1.