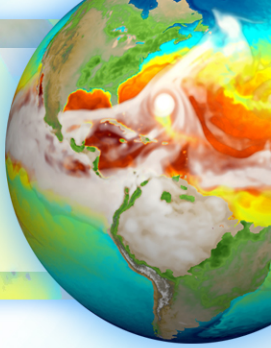
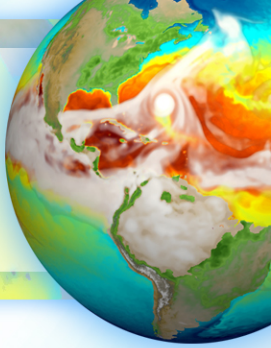
v1 High-Res Atm Evaluation



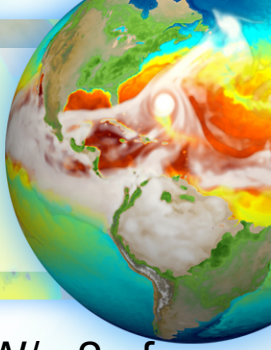
Peter Caldwell

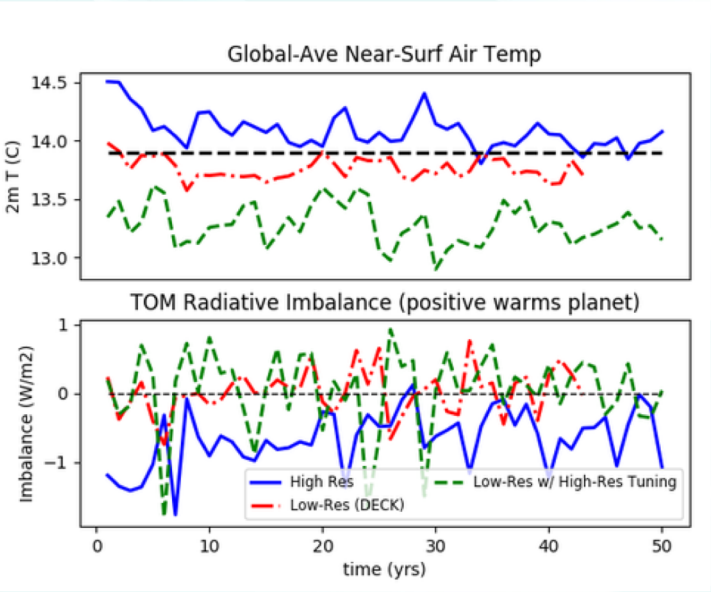
3/21/19

Part 1: Large-Scale Evaluation



Top-of-Atmosphere (TOA) Energy Balance





- The planetary system is still losing ~0.5 W/m2 of heat after 50 yrs ☹
  - Initial conditions which bring us more quickly into balance would be useful
  - This bias is probably not big enough to get our paper rejected
- Consistent with this, surface air temperature is a bit warm
  - But is decreasing towards 20th C average
  - Radiative imbalance is due mainly to LW clearsky, which is sensitive to surface T (not shown)
- Coarsening resolution (green line) cools the planet, resulting in near-zero rad imbalance

Overall Skill

- High-Res RMSE is better than DECK and CMIP5 in ~all atm variables!
  - despite High-Res using 1950 forcings while others use forcings for obs time period
  - perhaps because High-Res has only 50 yrs to drift from obs?

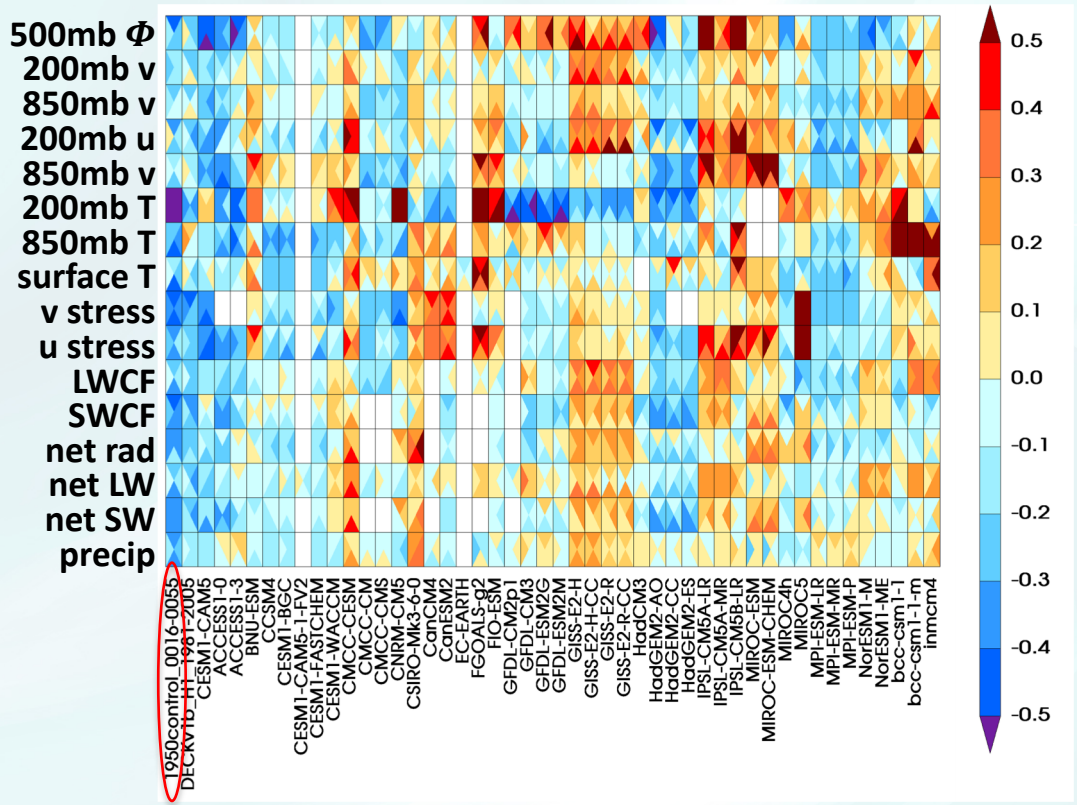
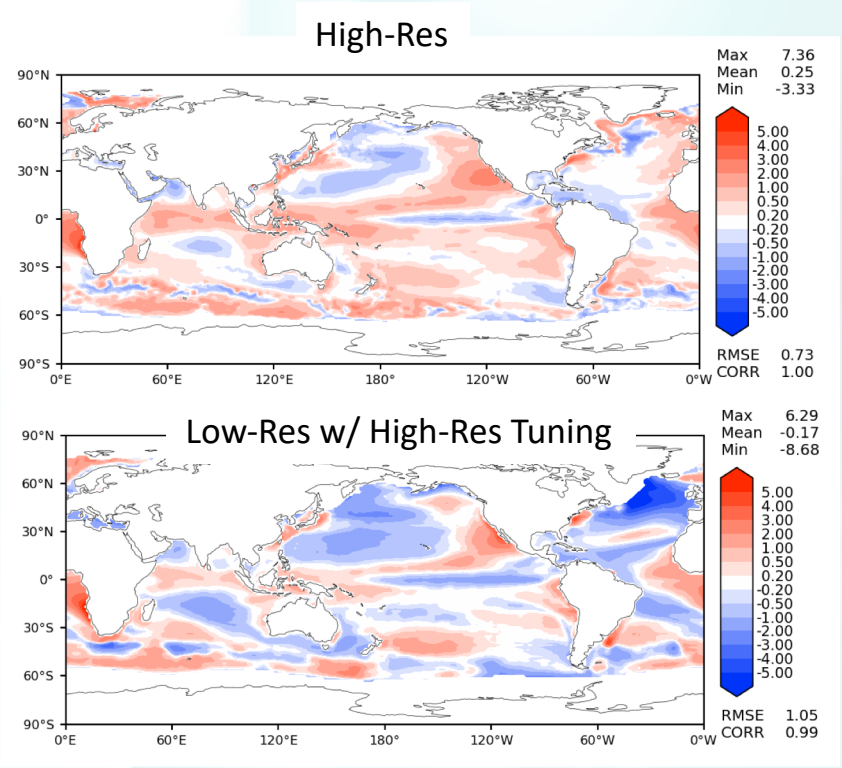


Fig: Model ranking for global RMSE of variables on y axis. CMIP5 and Low-Res DECK results are 1981-2005 results from HIST runs. Plot courtesy Qi Tang.

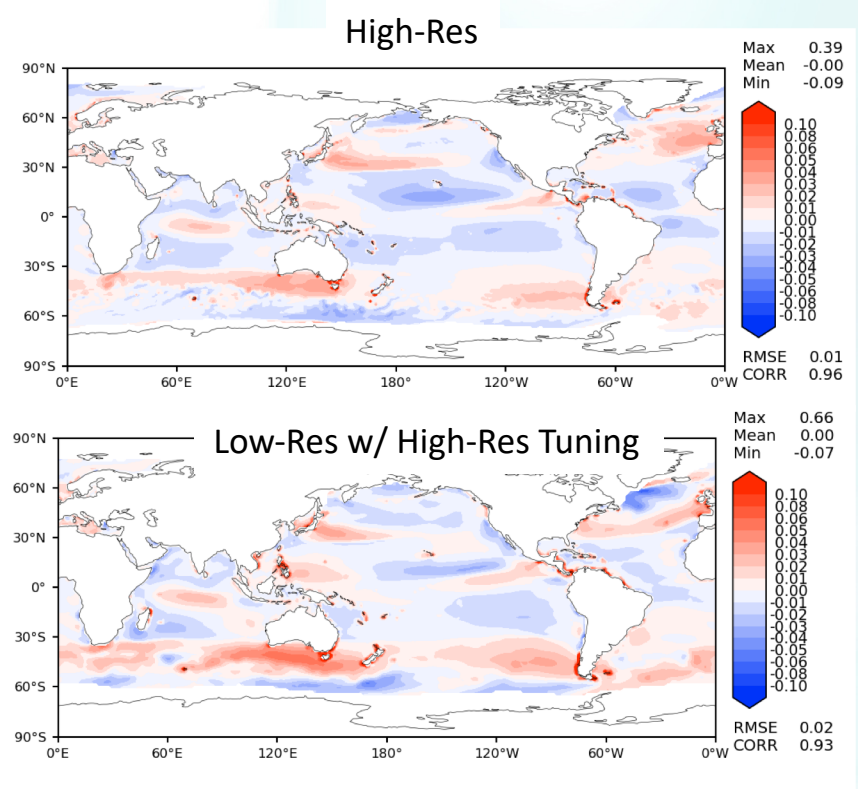
SST



- High-Res is warmer
  - as seen in previous slide
  - = great improvement over Labrador Sea!
- Warming in subtropical E oceans reflects lack of stratocumulus
- Hints of double ITCZ are seen in equatorial Pacific dipole
- Other features due to… discussion needed

Fig: SST bias relative to HADISST-PI for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

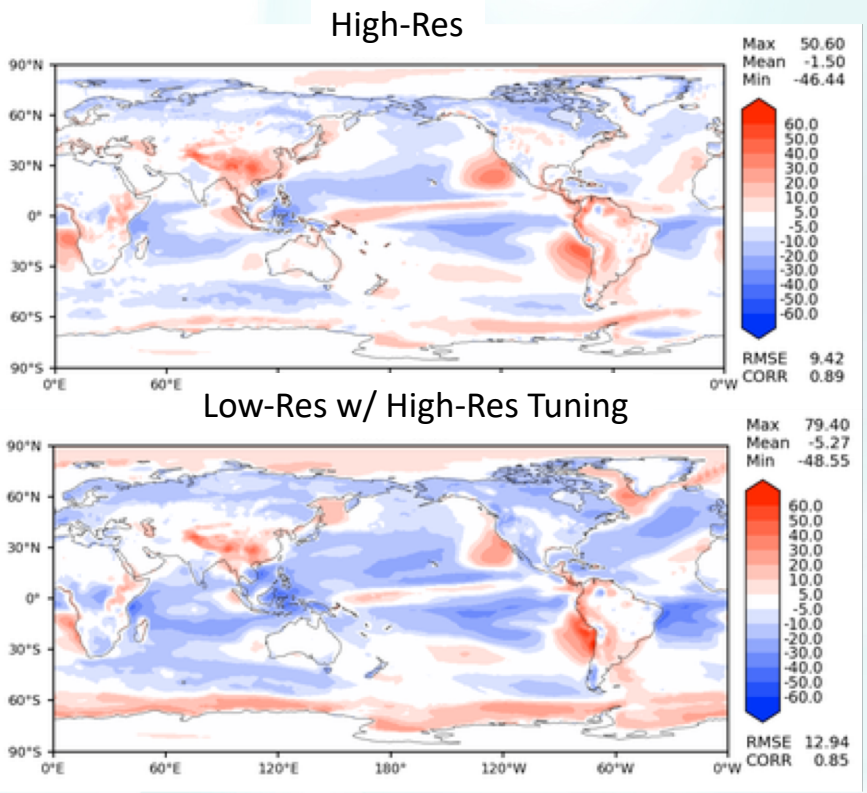
Wind Stress



- Resolution improves long-standing S Ocean bias
- Bias near Labrador Sea is also greatly improved

Fig: Wind stress magnitude bias relative to ERA-Interim for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

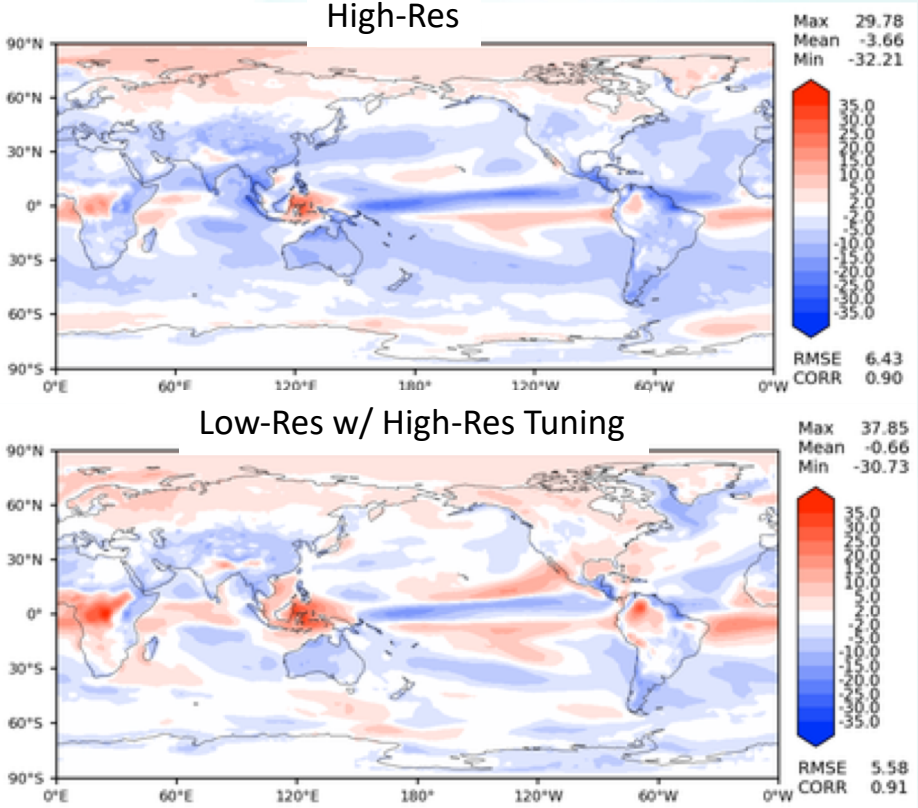
Shortwave Cloud Forcing (SWCF) Bias



- Major net TOA radiative biases are due to SWCF (not shown)
- SWCF biases are typical:
  - stratocumulus not bright enough
  - other regions too bright in order for global-ave to match obs
- Biases improve at high res (check RMSE!)

Fig: SWCF bias relative to CERES-EBAF4.0 for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

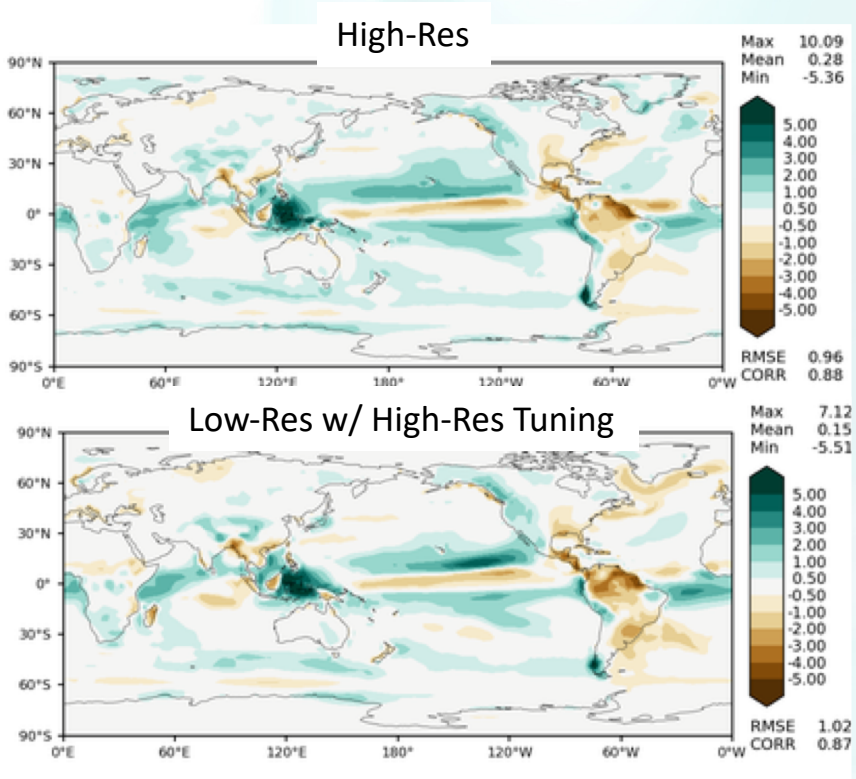
Longwave Cloud Forcing (LWCF)



- High clouds generally don't trap enough radiation in high-res model
  - this is somewhat improved in low-res model
- Double ITCZ stands out

Fig: SWCF bias relative to CERES-EBAF4.0 for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

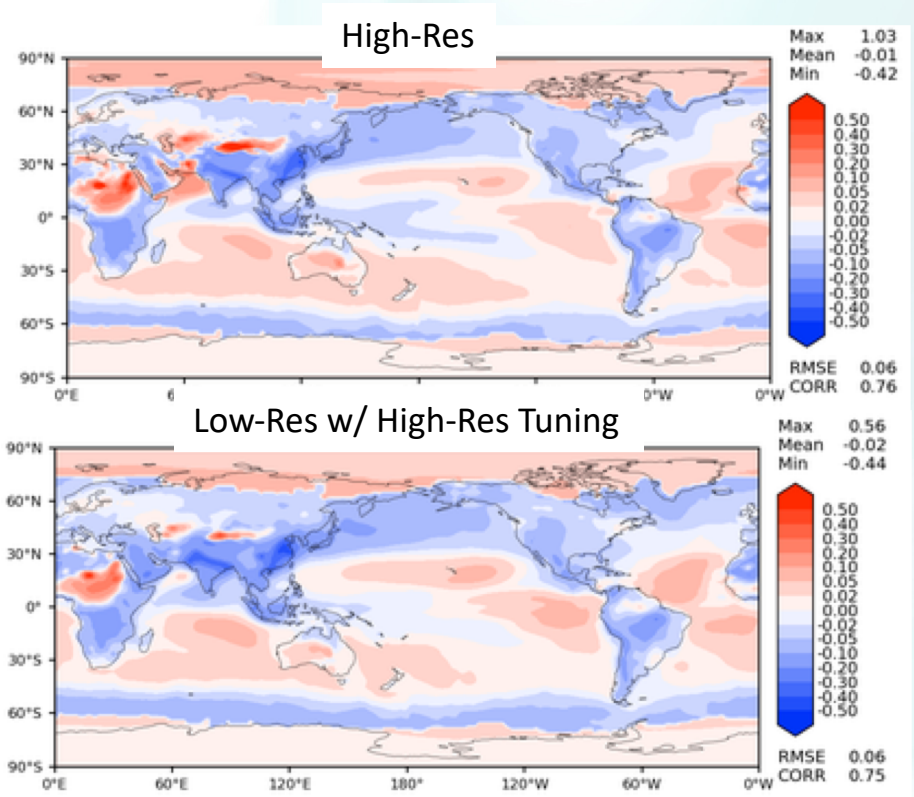
Precip



- High-Res doesn't solve E3SM's precip problems:
  - Double ITCZ
  - Dry Amazon
  - Wet Maritime Continent
- High-Res does better in mountainous regions, but this doesn't show up in coarse-res bias plots

Fig: Precip bias relative to GPCP for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

Aerosol Optical Depth (AOD)



- Asian aerosol bias worsens at high res.
- Otherwise, simulations look fairly comparable.

Fig: 550 nm AOD bias relative to AERONET-composite for High-Res (yrs 16-55) and Low-Res w/ High-Res tuning (yrs 31-50)

Warm Pole Problem Revisited

- Our 1st high-res run had a very warm surface in Arctic winter (left panel)
  - due to excessive supercooled liquid
  - unclear why the low-res model – which also had this bug – didn't warm (right panel)
- Our current run fixes this by reverting the CNT ice nucleation scheme to Meyers
  - This fix does an acceptable but not perfect job

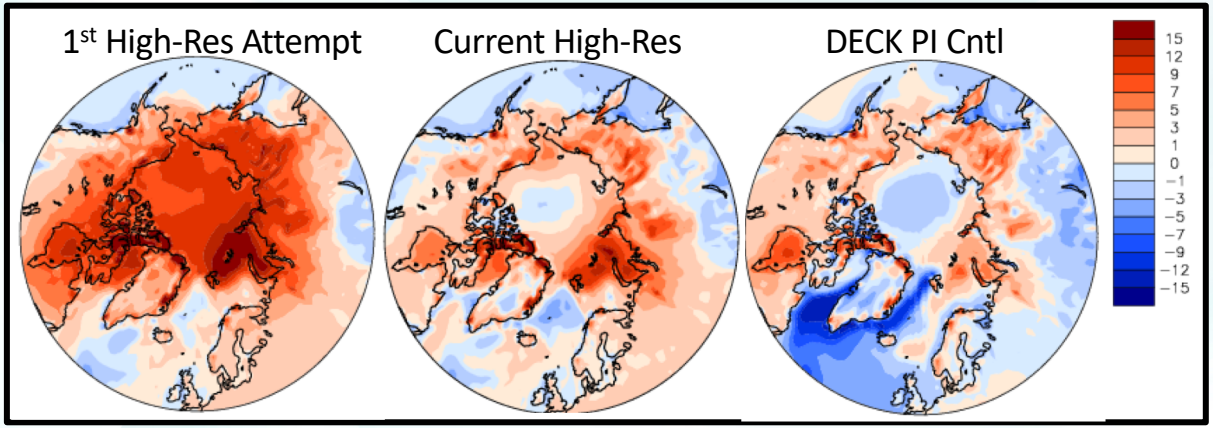
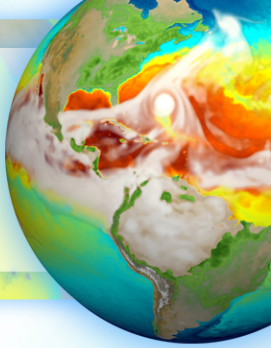


Fig: DJF Surface temperature bias (relative to ERA-Interim)

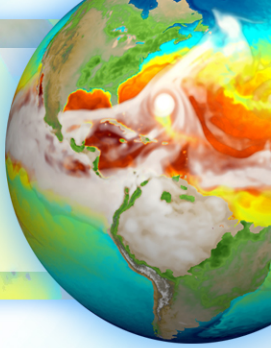
- v2 should apply a more appropriate fix

Part 2: High-Resolution Features



- Tropical cyclones (looking for help)
- Blocking (looking for help)
- Orographic Precip (wouldn't mind help)
- Low Clouds/Topography/SST coupling (Klein et al)
- Other ideas?

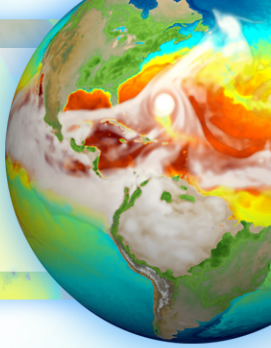
Part 3: Climate + Aerosol Sensitivity



- Perform 5-10 yr F1850 simulation
  - need to finalize CMIP6 F1850 compset first! (Qi is doing this)
- Perform 5-10 yr F1850+4K SST simulation
- Perform 5-10 yr F2010 simulation with F1850 SST
  - need to finalize CMIP6 F2010 compset (Qi is doing this)
- Compute Cess sensitivity $\lambda = \frac{-(F1850{+}4K - F1850\ RESTOM)}{(F1850{+}4K - F1850\ TS)}$
- Compute Total Adjusted Forcing:

  TAF=(RESTOM from F2010 w/ 1850 SST) – (F1850 RESTOM)

Summary/Conclusions:



- The 50 yr High-res simulation looks good!
  - perhaps because its biases are still developing
- It is a bit further out of balance than we'd like
- Help is desired for high-res features analysis
- Sensitivity analysis is ongoing