

Sanity checks for TRACMIP ESGF data

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Abstract

This document describes the sanity checks done for the TRACMIP ESGF data. This is in preparation for the corrigendum paper.

The big take-home of the sanity checks

Everything is correctly implemented except for:

- insolation: CALTECH is 3 months out of phase
- q-flux: not zeroed out over land in ECHAM6.3, some smaller deviation in high-latitudes for some models, CAM3 has suspicious kink in aqua4xCO2TRACMIP near 30 deg N
- surface albedo: too strong increase over land in LMDZ5A
- evaporative resistance over land: AM21 does not show expected change in Bowen ratio
- land heat capacity: diurnal cycle of temperature shows that MetUM-CTL and MetUM-ENT did not decrease heat capacity over land; can't check for CALTECH because there is no tasmax/tasmin or 3hr data, might look at Rick's metric of summer warming/winter cooling over land as some kind of indication

Insolation rsdt

Take-home points:

- CALTECH is three months out of phase, but otherwise rsdt seems correct
- there are some smaller differences between models that might have to do with different calendar choices, yet overall rsdt and its changes in landOrbitTRACMIP were implemented properly

Zonal-mean time-mean insolation, and difference from model median

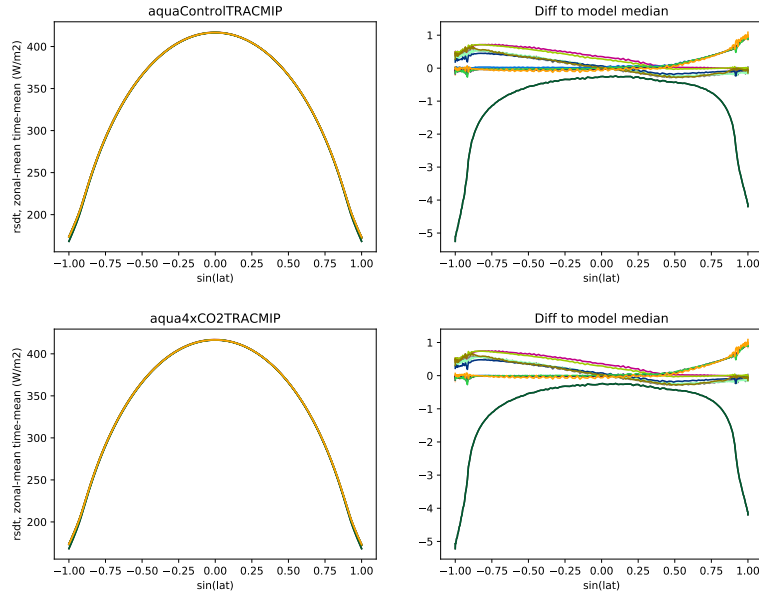


Figure 1: Zonal-mean time-mean rsdt in aquaControlTRACMIP (top) and aqua4xCO2TRACMIP (bottom). Model colors as in 2016 JAMES paper.

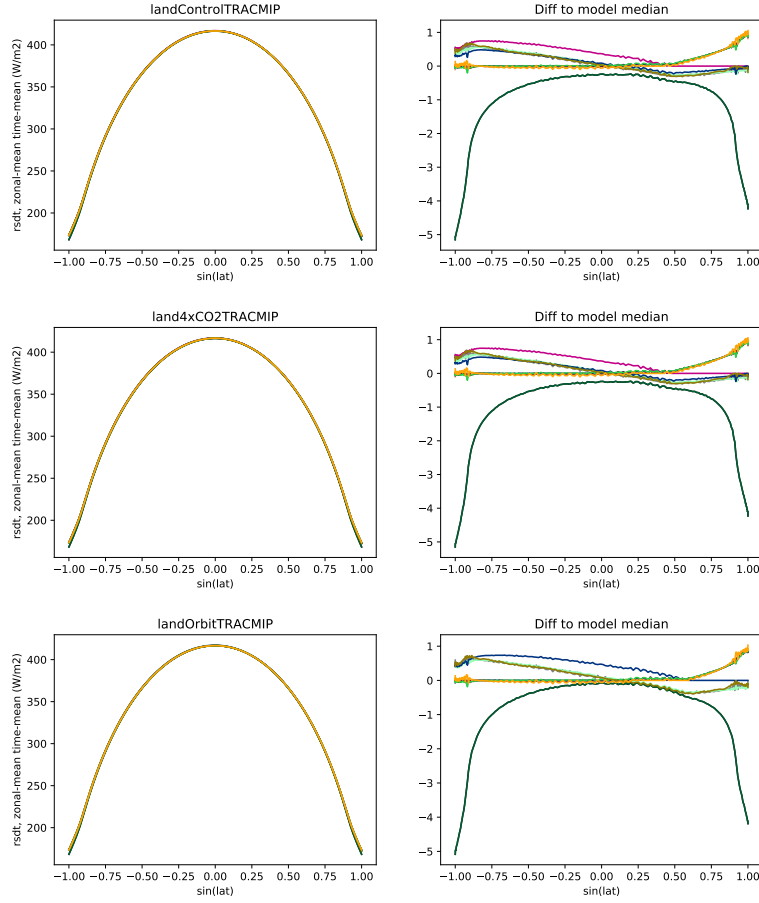


Figure 2: Zonal-mean time-mean rsdt in landControlTRACMIP (top), land4xCO₂TRACMIP (middle) and landOrbitTRACMIP (bottom). Model colors as in 2016 JAMES paper.

Seasonal cycle of zonal-mean insolation, and difference to model median

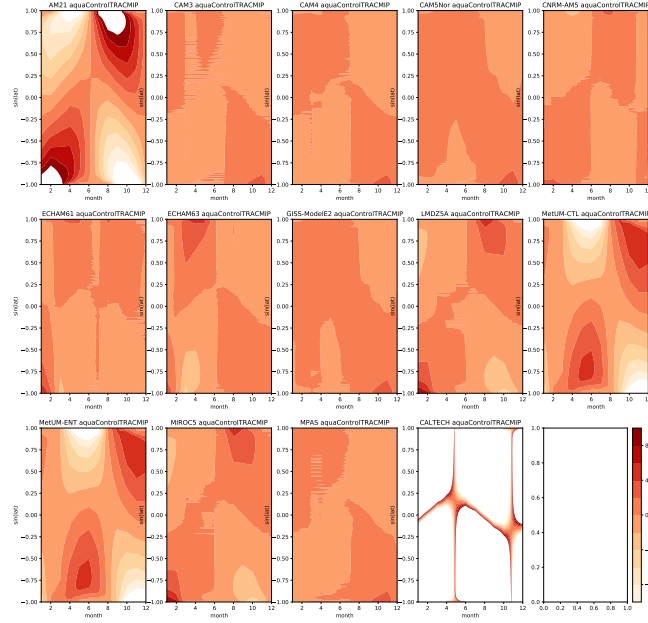
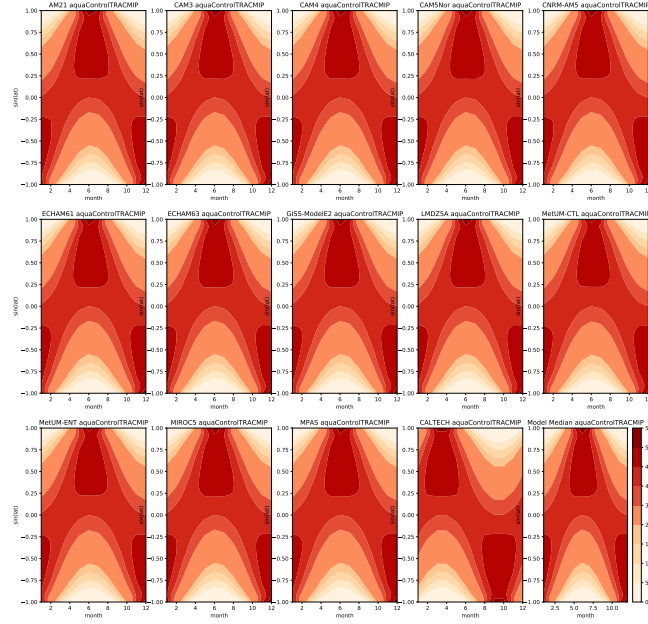


Figure 3: rsdt in aquaControlTRACMIP. Upper plot: full values. Lower plot: difference to model median.

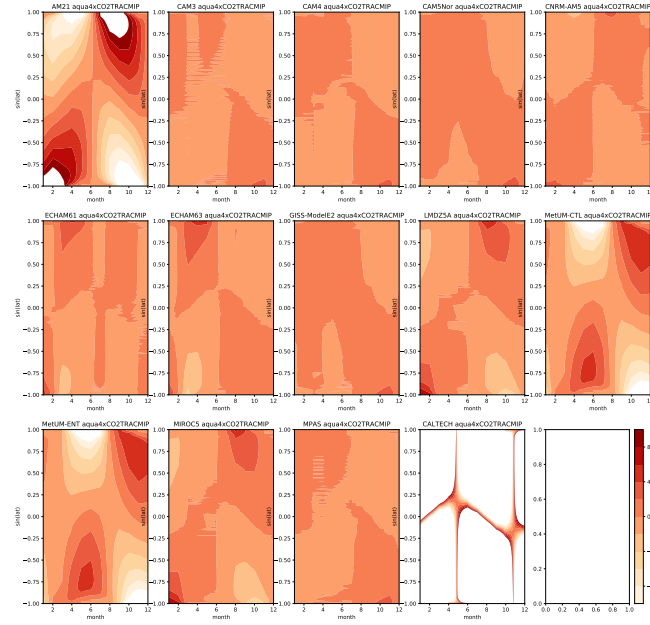
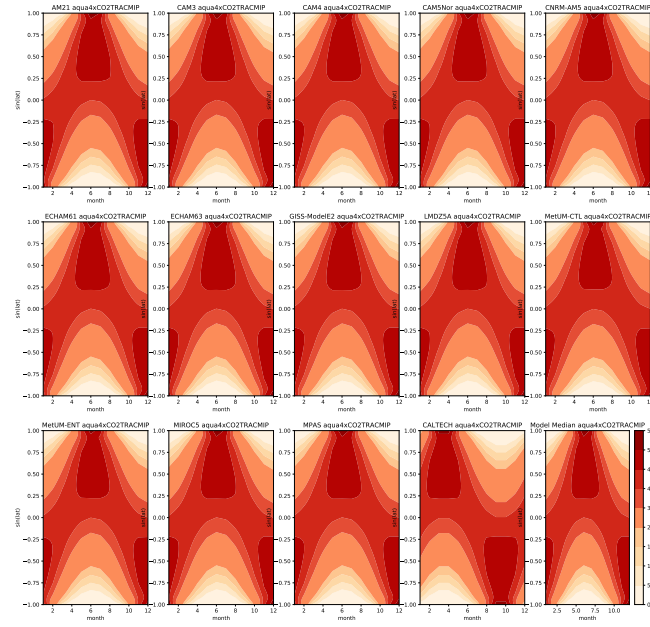


Figure 4: rsdt in aqua4xCO2TRACMIP. Upper plot: full values. Lower plot: difference to model median.

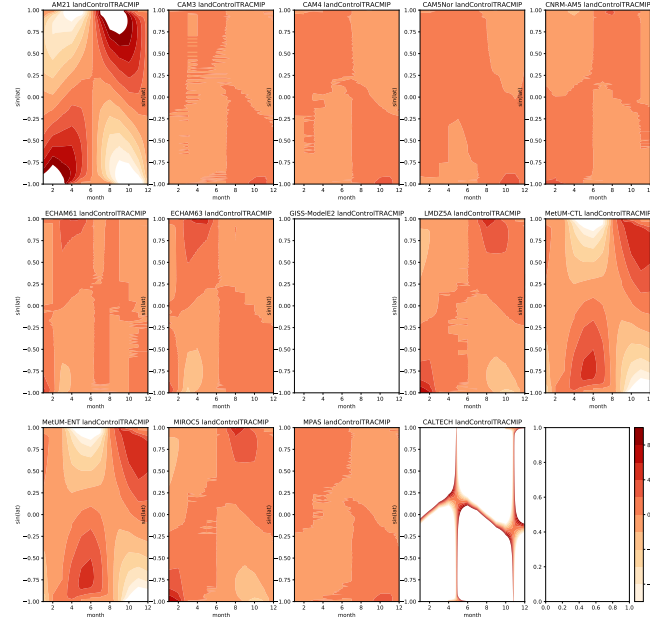
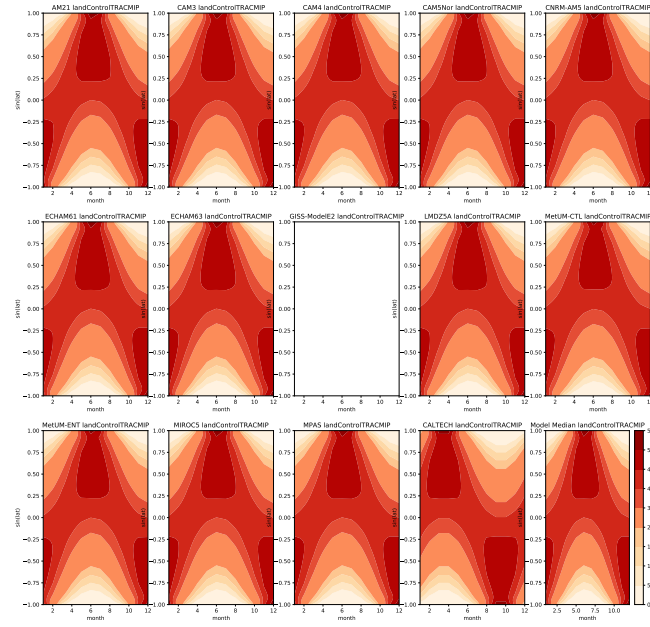


Figure 5: rsdt in landControlTRACMIP. Upper plot: full values. Lower plot: difference to model median.

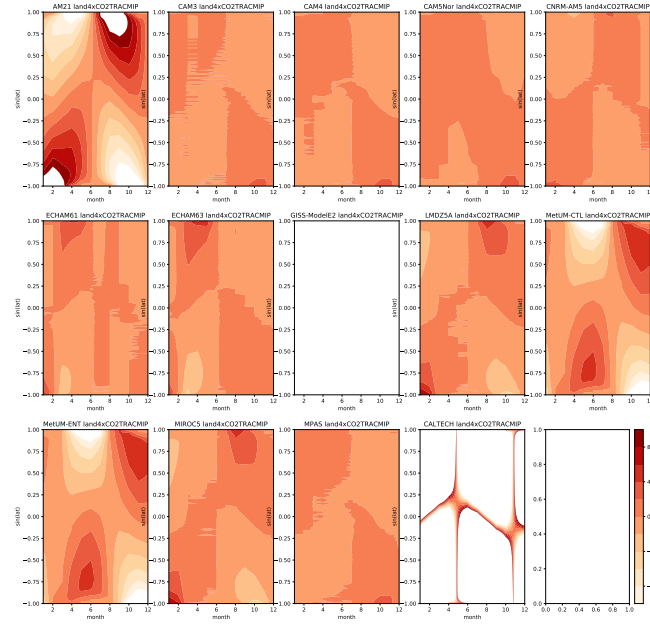
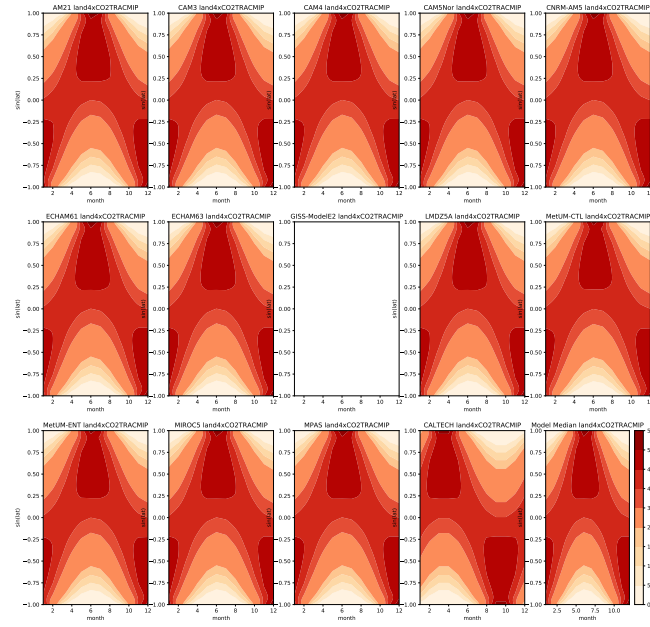


Figure 6: rsdt in land4xCO2TRACMIP. Upper plot: full values. Lower plot: difference to model median.

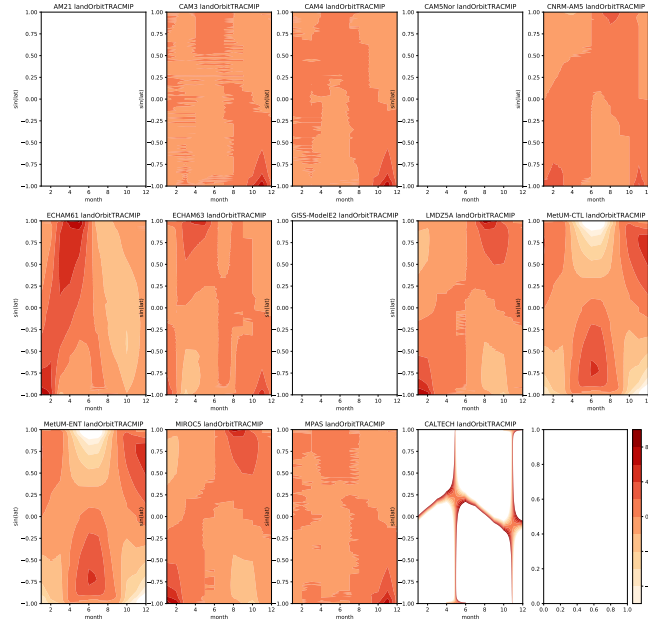
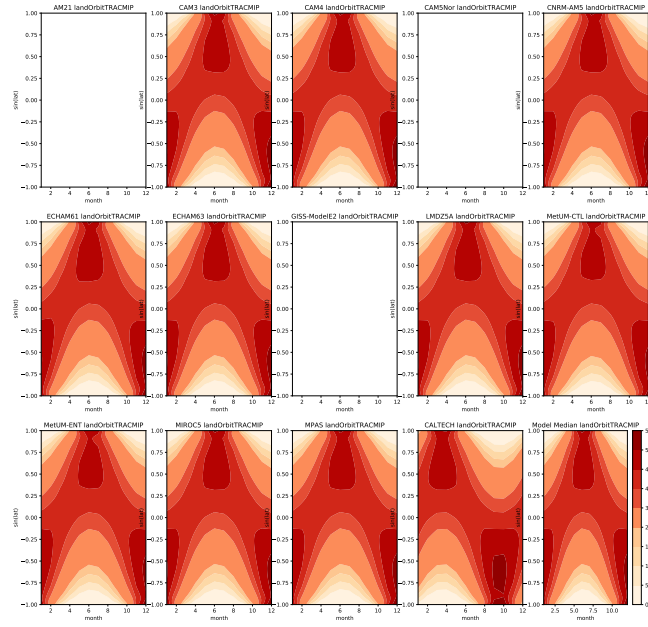


Figure 7: rsdt in landOrbitTRACMIP. Upper plot: full values. Lower plot: difference to model median.

Seasonal cycle of zonal-mean insolation: difference between landOrbitTRACMIP and landControlTRACMIP

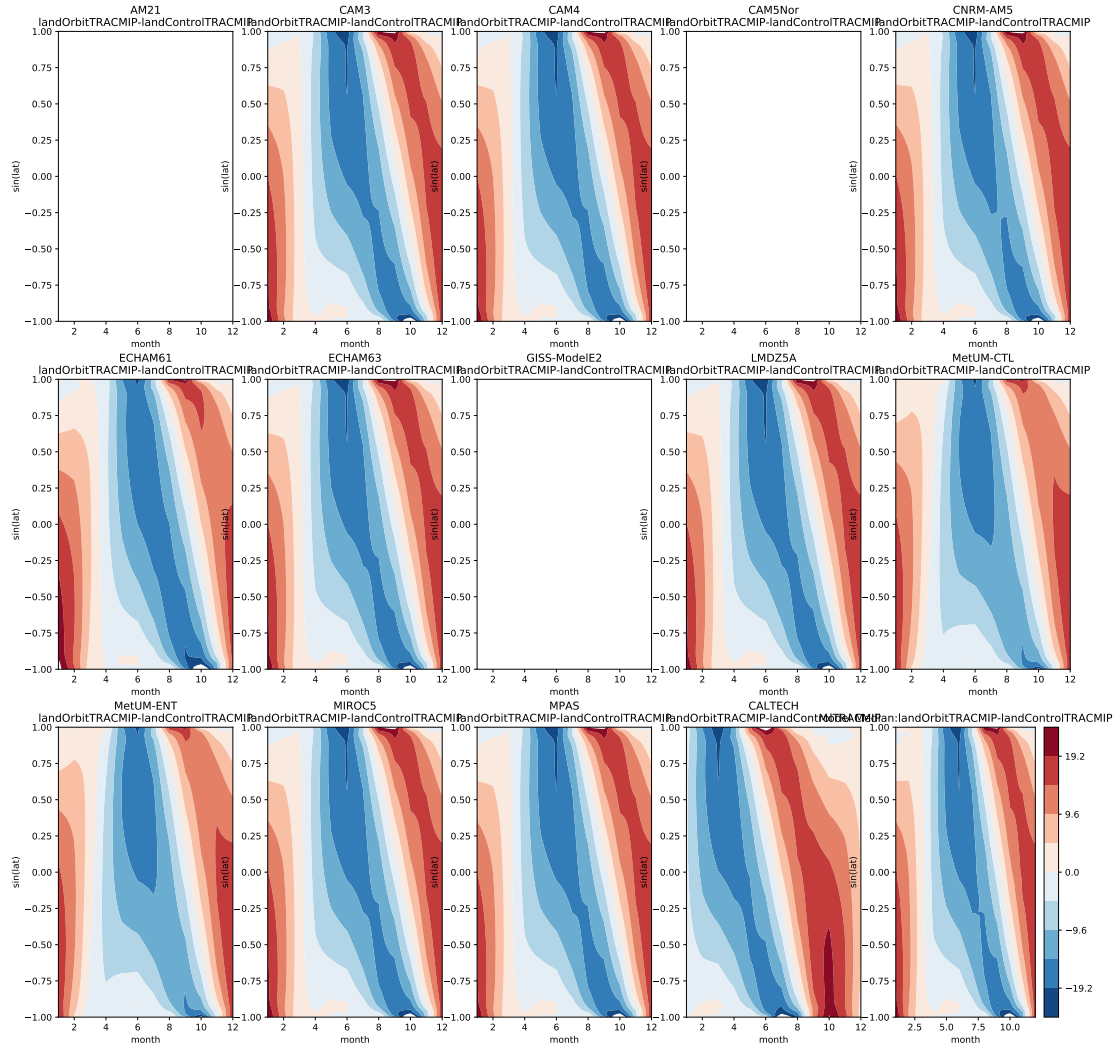


Figure 8: rsdt of landOrbitTRACMIP - landControlTRACMIP.

Ocean heat transport

Ocean heat transport is inferred from the surface energy balance as:

$$qflux = -1 * (rsds - rsus + rlds - rlus - hfss - hfls). \quad (1)$$

Note that for AM2, hfls is not available, but we use $2.5008e6 * evspsbl$ (constant taken from ICON model `hared/mo_physical_constants.f90`). For LMDZ5A, hfls and hfss must be multiplied by -1, as they are directed downward in this model.

Take-home points:

- ECHAM6.3 did not zero out q-flux over land; this can also be seen in the zonal-mean q-flux
- Otherwise, all models seem to be okay
- Apart from the ECHAM6.3 land simulations, the global-mean time-mean inferred q-flux is 0 within typically 0.3 Wm⁻². In ECHAM6.3 land simulations, the global-mean is around -0.6 Wm⁻².

Zonal-mean time-mean ocean heat transport

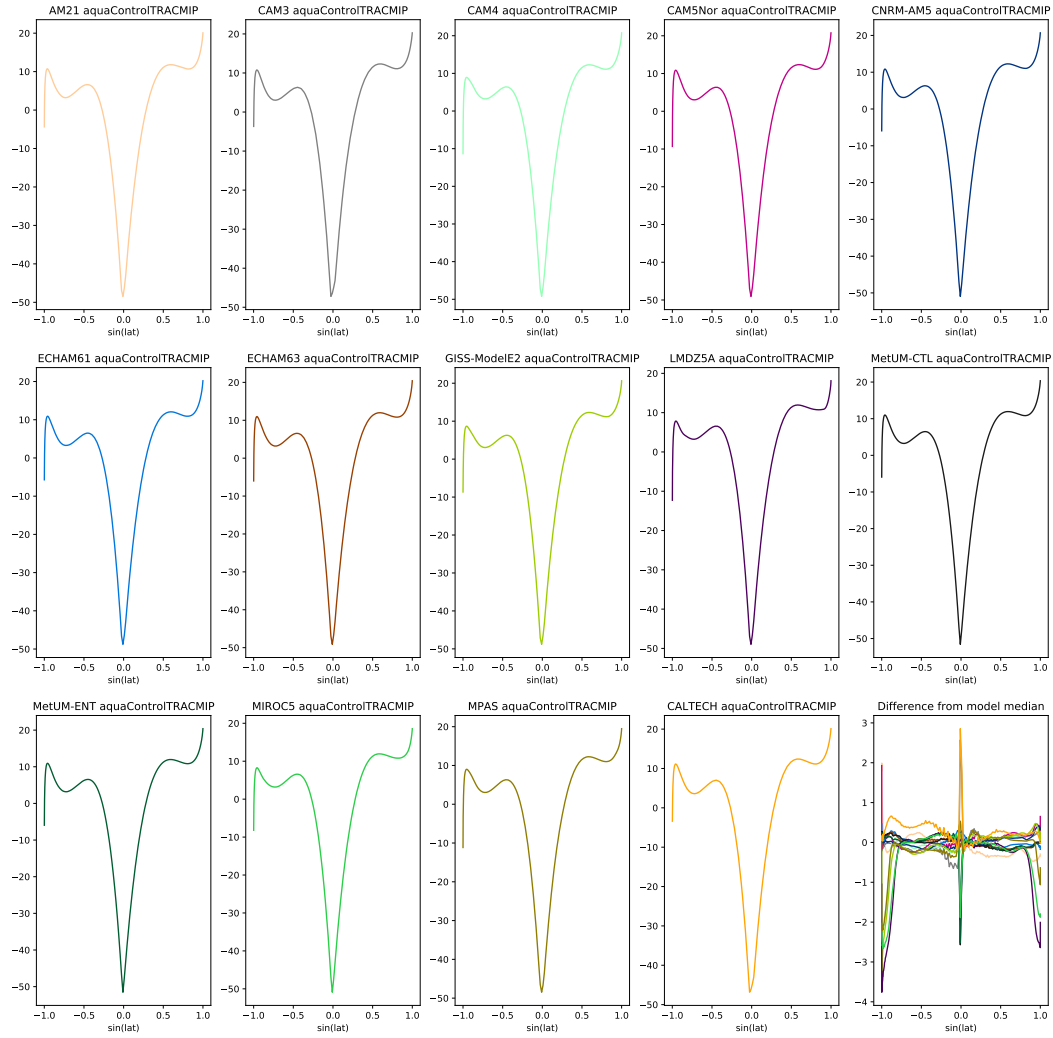


Figure 9: Zonal-mean time-mean ocean heat transport in aquaControlTRACMIP.

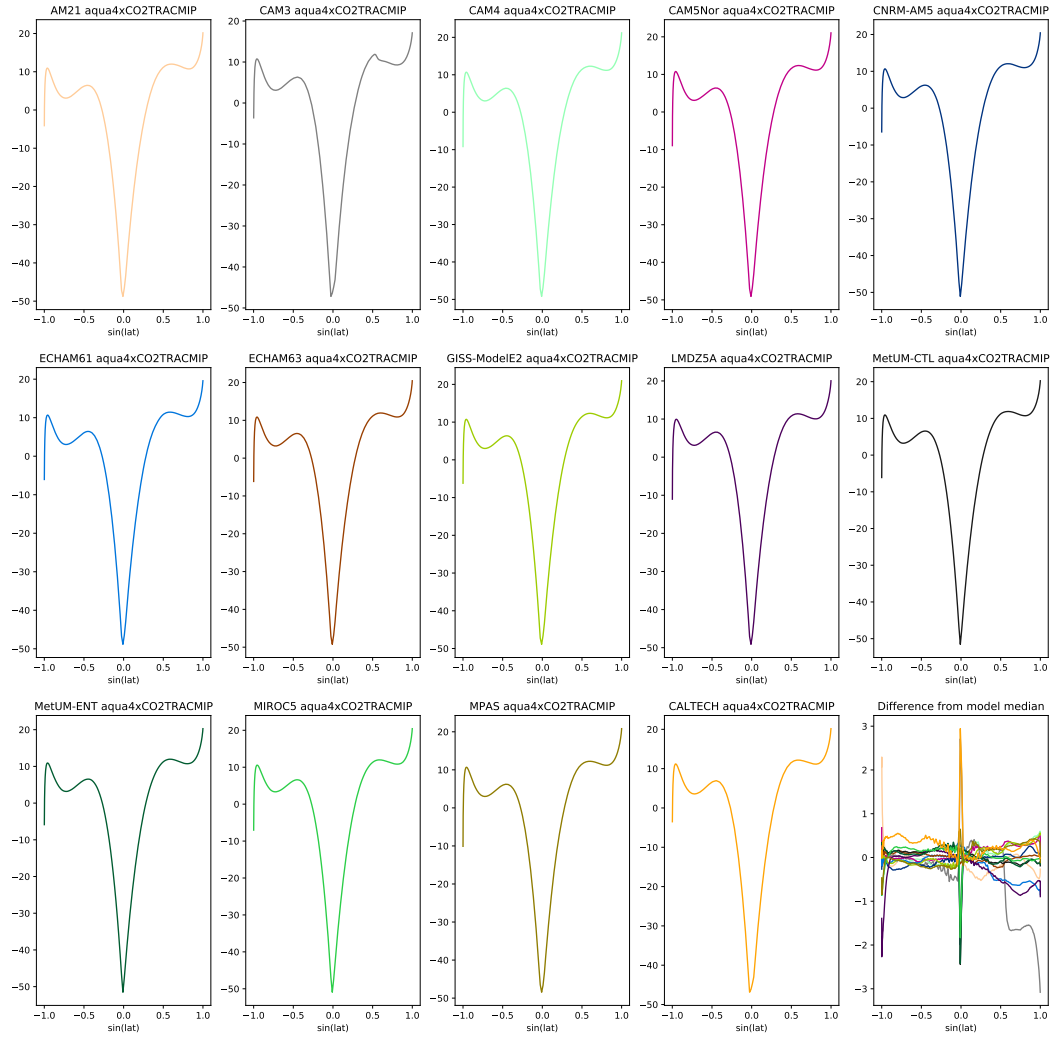


Figure 10: Zonal-mean time-mean ocean heat transport in aqua4xCO2TRACMIP.

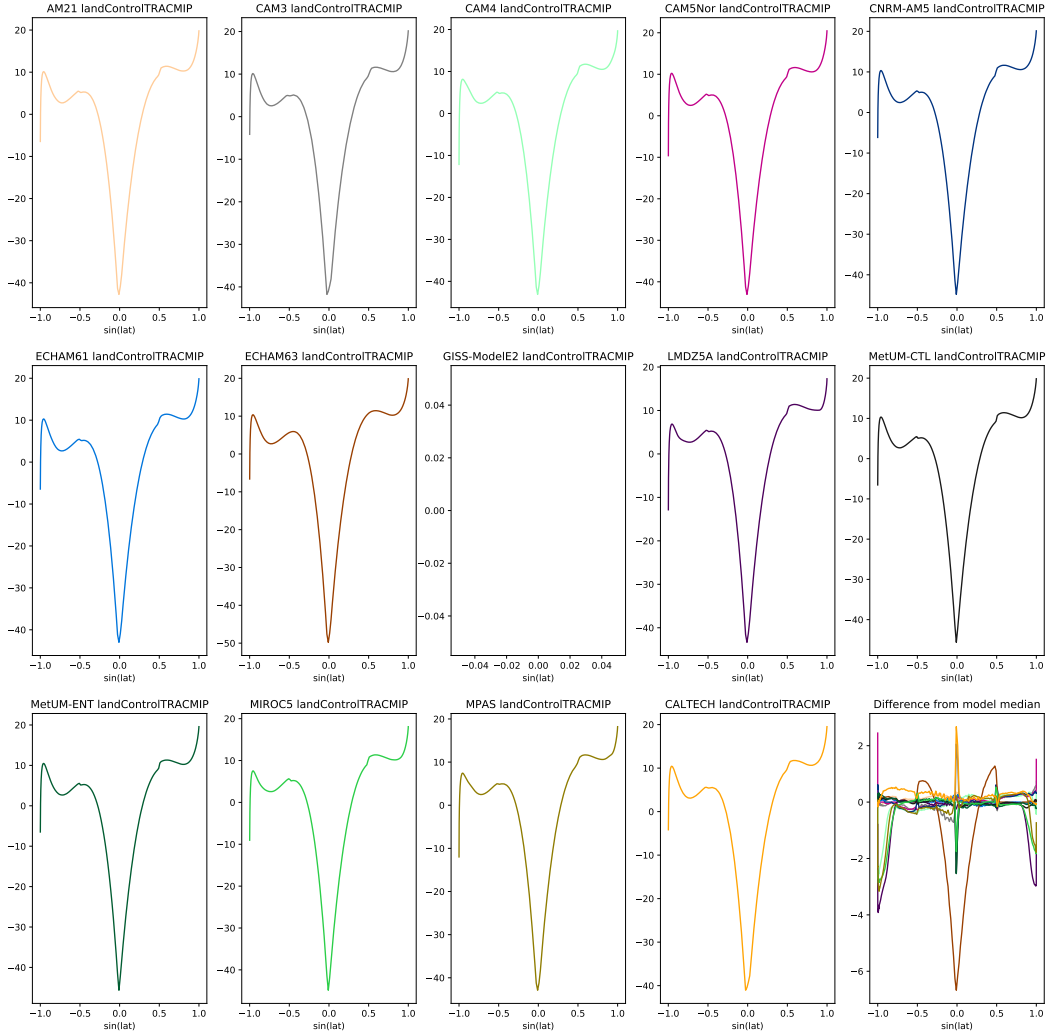


Figure 11: Zonal-mean time-mean ocean heat transport in landControl/TRACMIP.

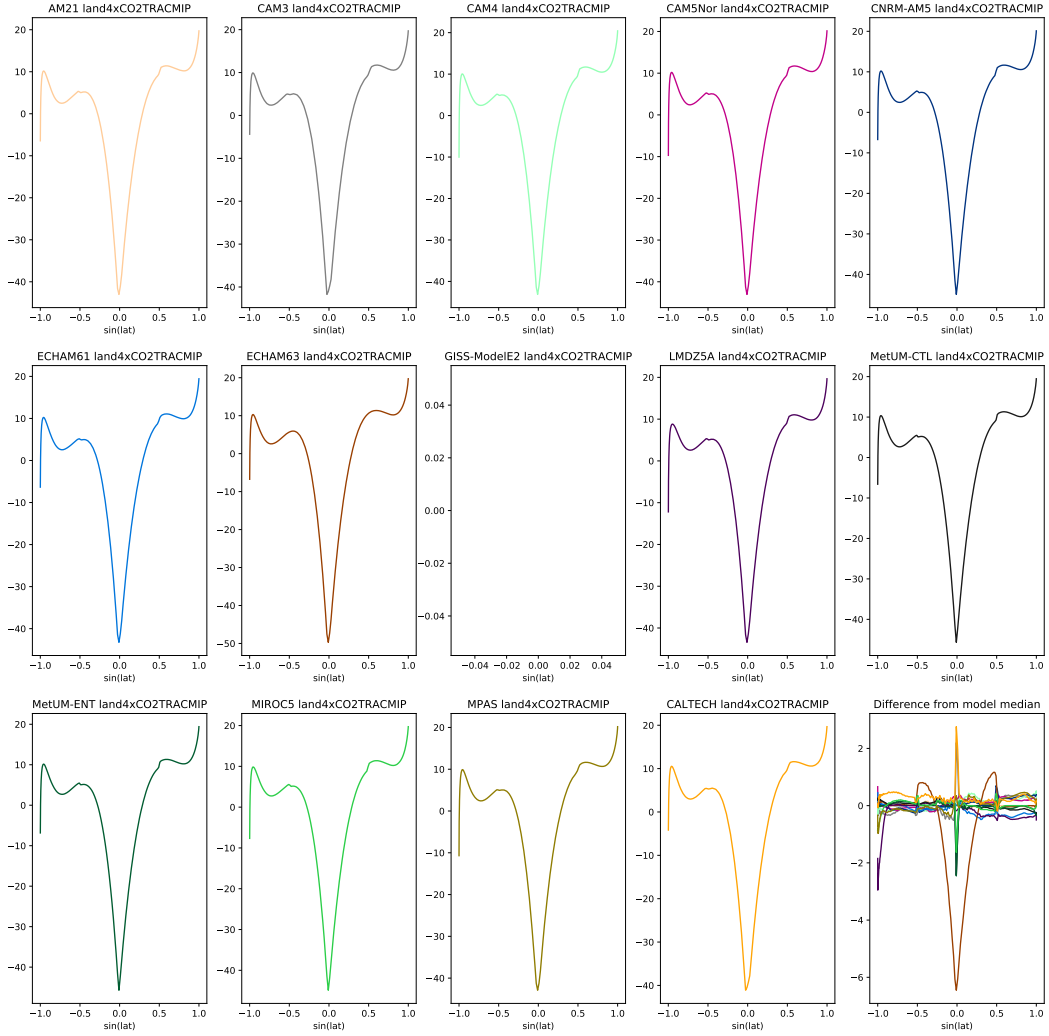


Figure 12: Zonal-mean time-mean ocean heat transport in land4xCO2TRACMIP.

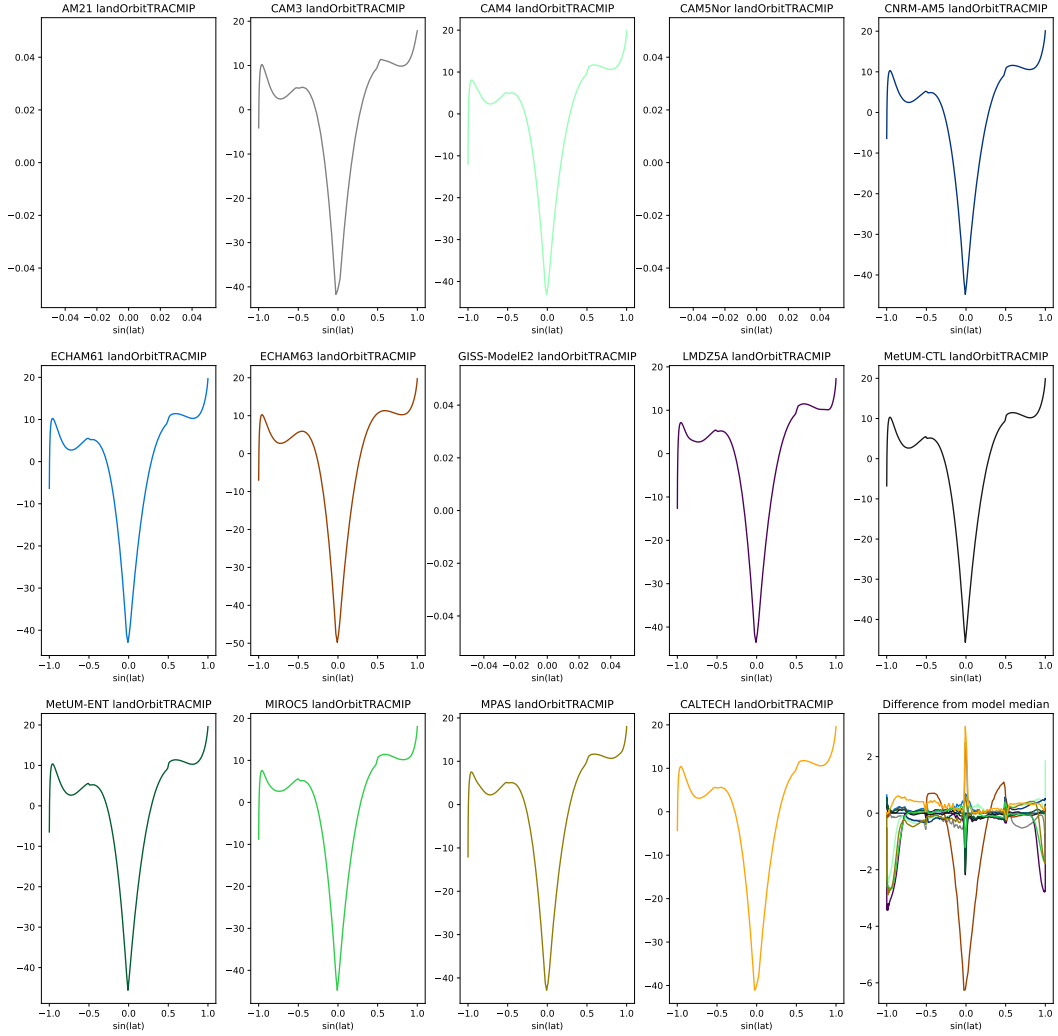


Figure 13: Zonal-mean time-mean ocean heat transport in landOrbitTRACMIP.

Lat-lon time-mean ocean heat transport

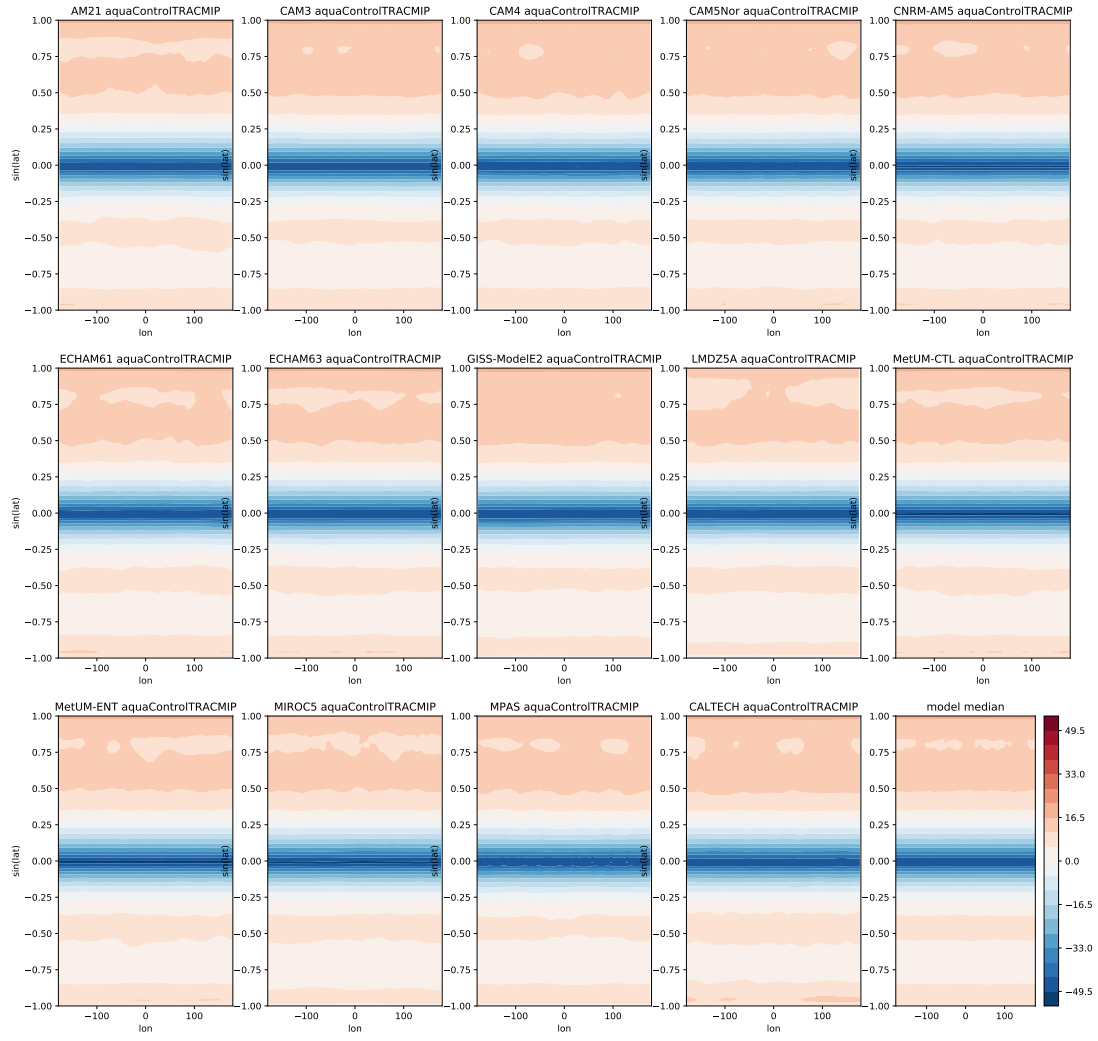


Figure 14: Time-mean ocean heat transport in aquaControlTRACMIP.

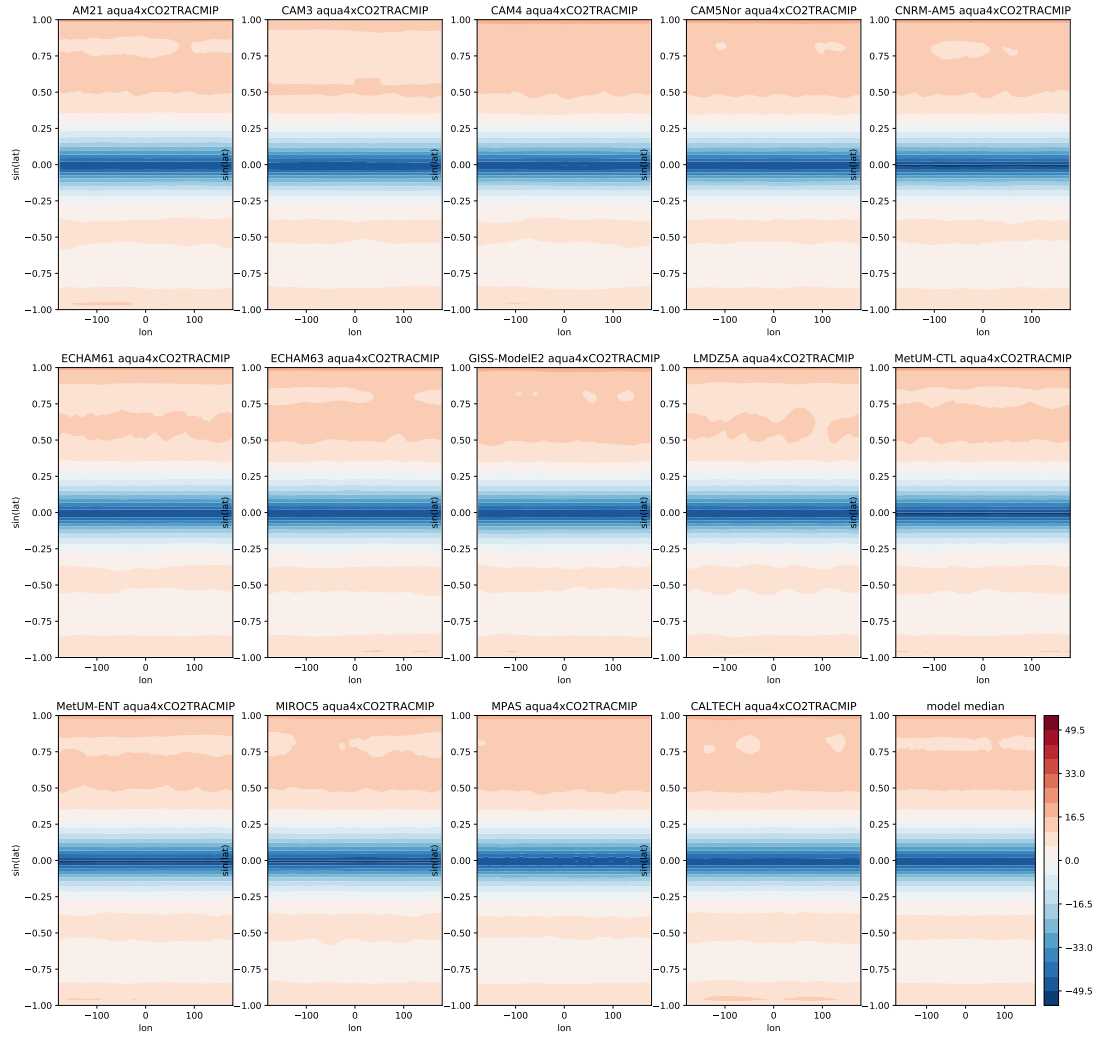


Figure 15: Time-mean ocean heat transport in aqua4xCO2TRACMIP.

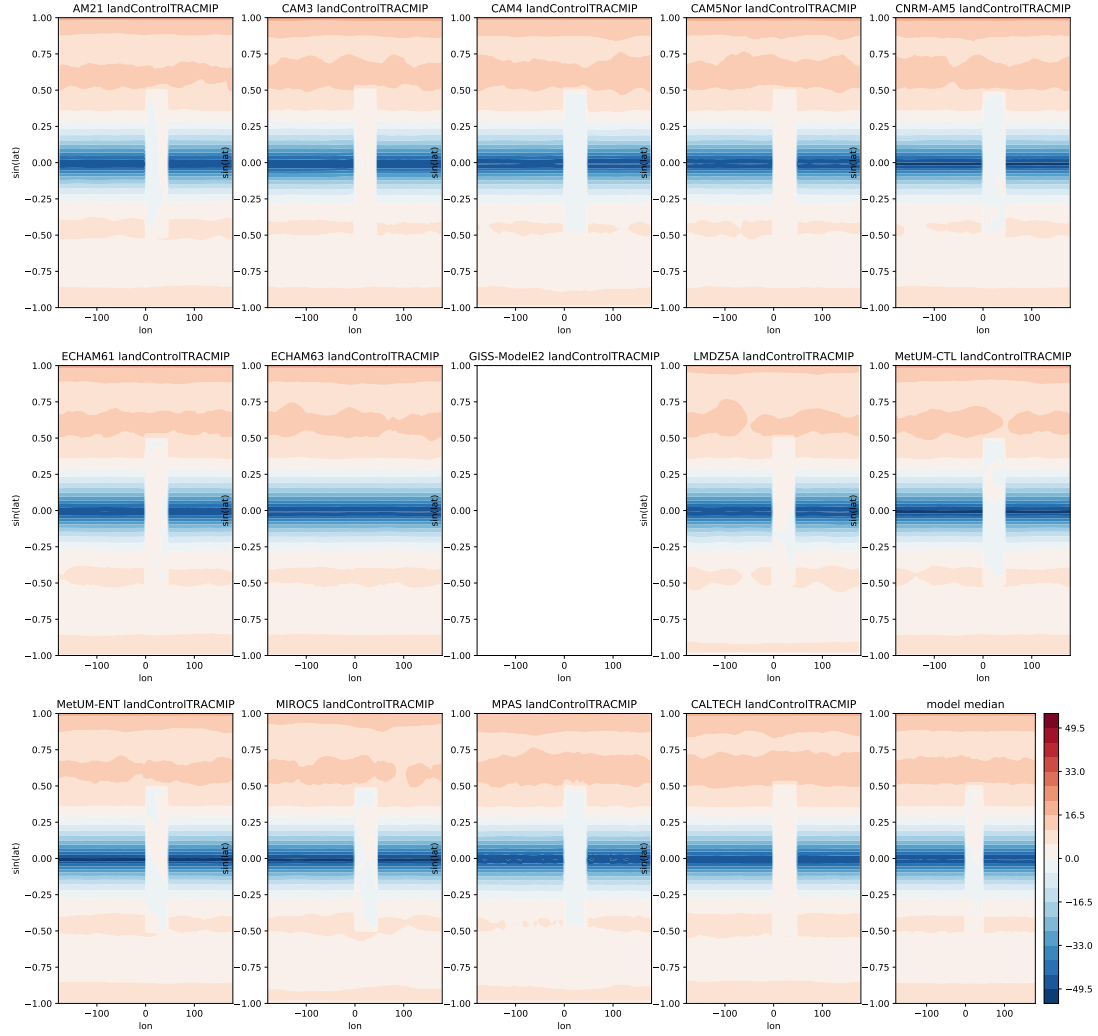


Figure 16: Time-mean ocean heat transport in landControlTRACMIP.

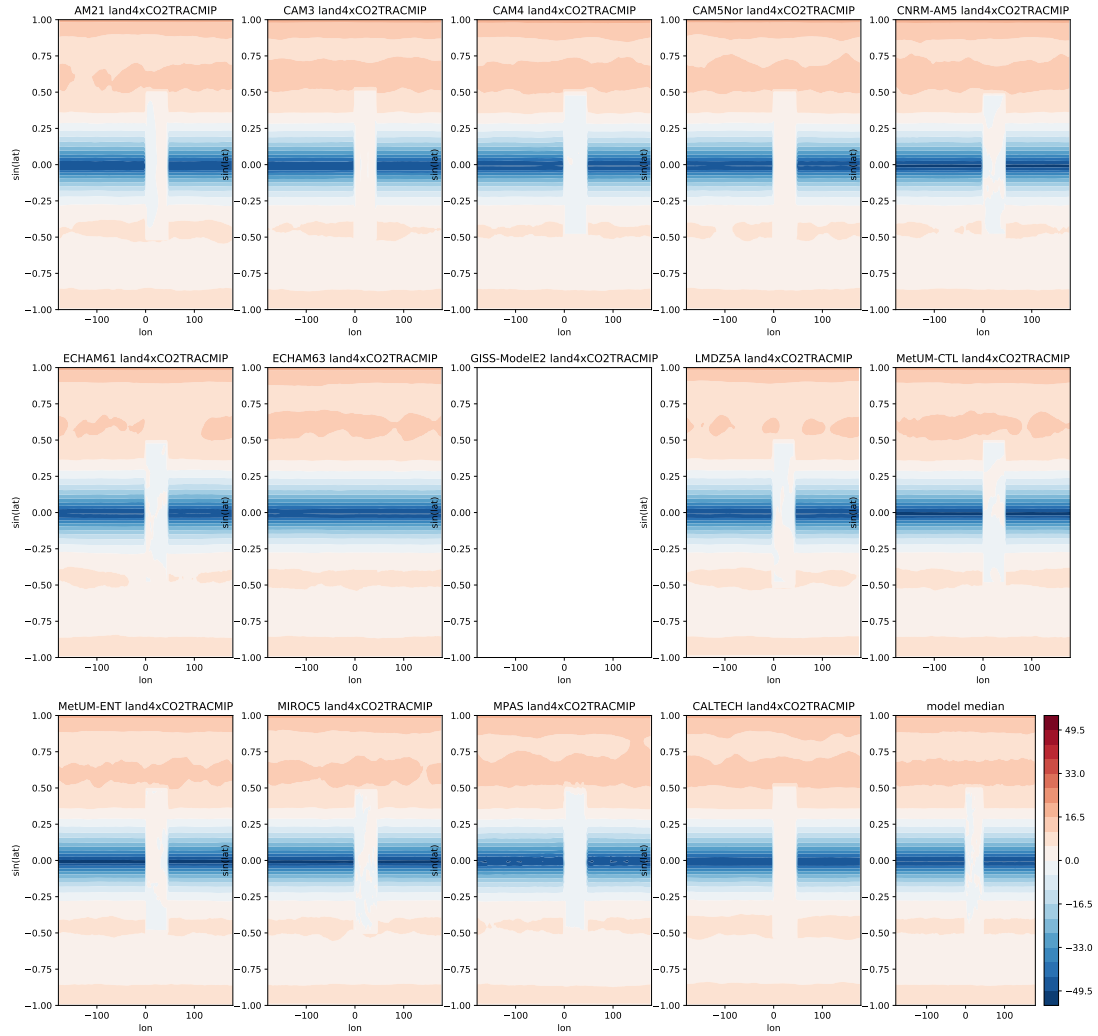


Figure 17: Time-mean ocean heat transport in land4xCO2TRACMIP.

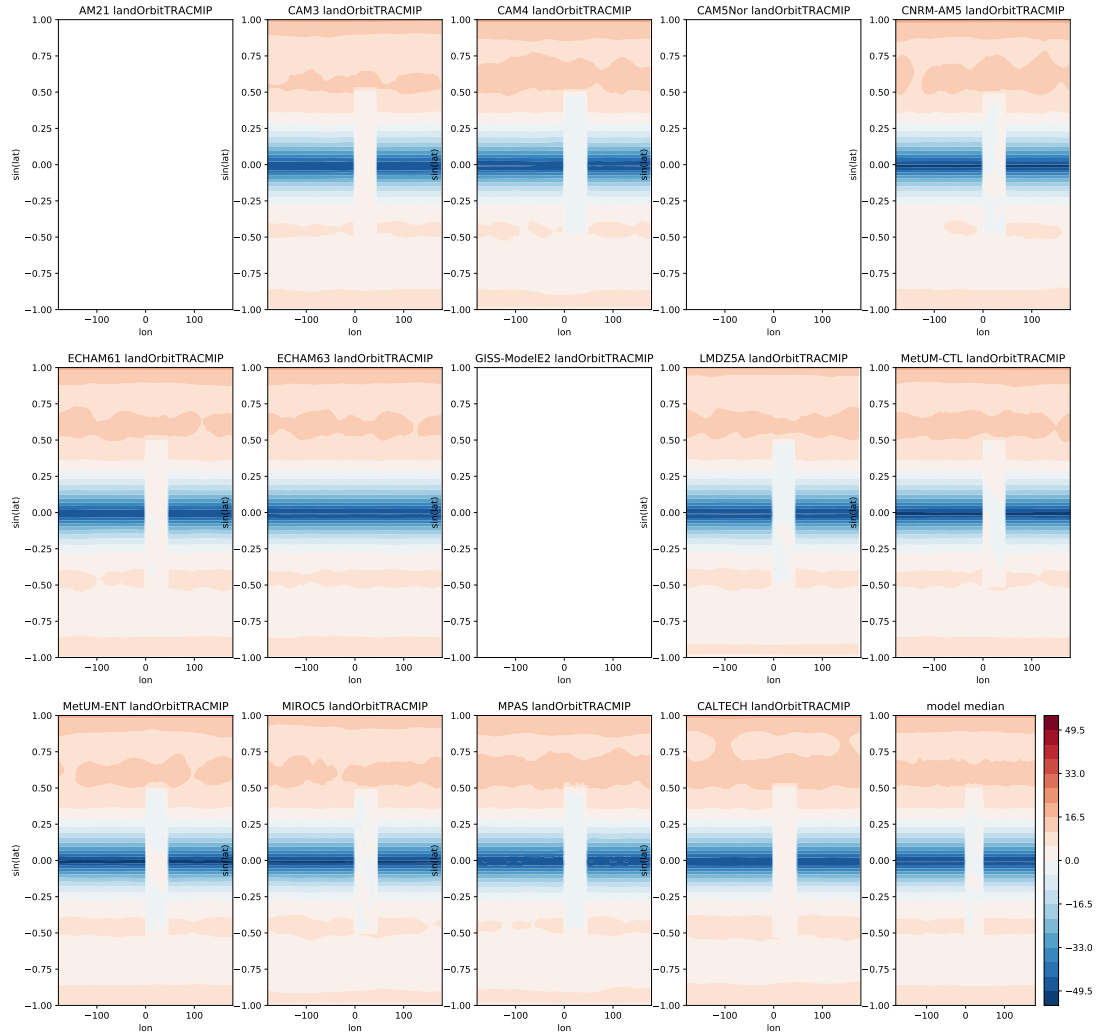


Figure 18: Time-mean ocean heat transport in landOrbitTRACMIP.

Surface albedo over land

Surface albedo over land should be increased by 0.07 compared to the ocean albedo. Surface albedo is diagnosed by $rsus/rsds$.

Take-home points:

- LMDZ5A has too high land albedo increase (by 0.14)
- other models have correct albedo increase over land
- note: CALTECH surface albedo much higher over ocean compared to other models, as this model does not have clouds

Lat-lon time-mean surface albedo

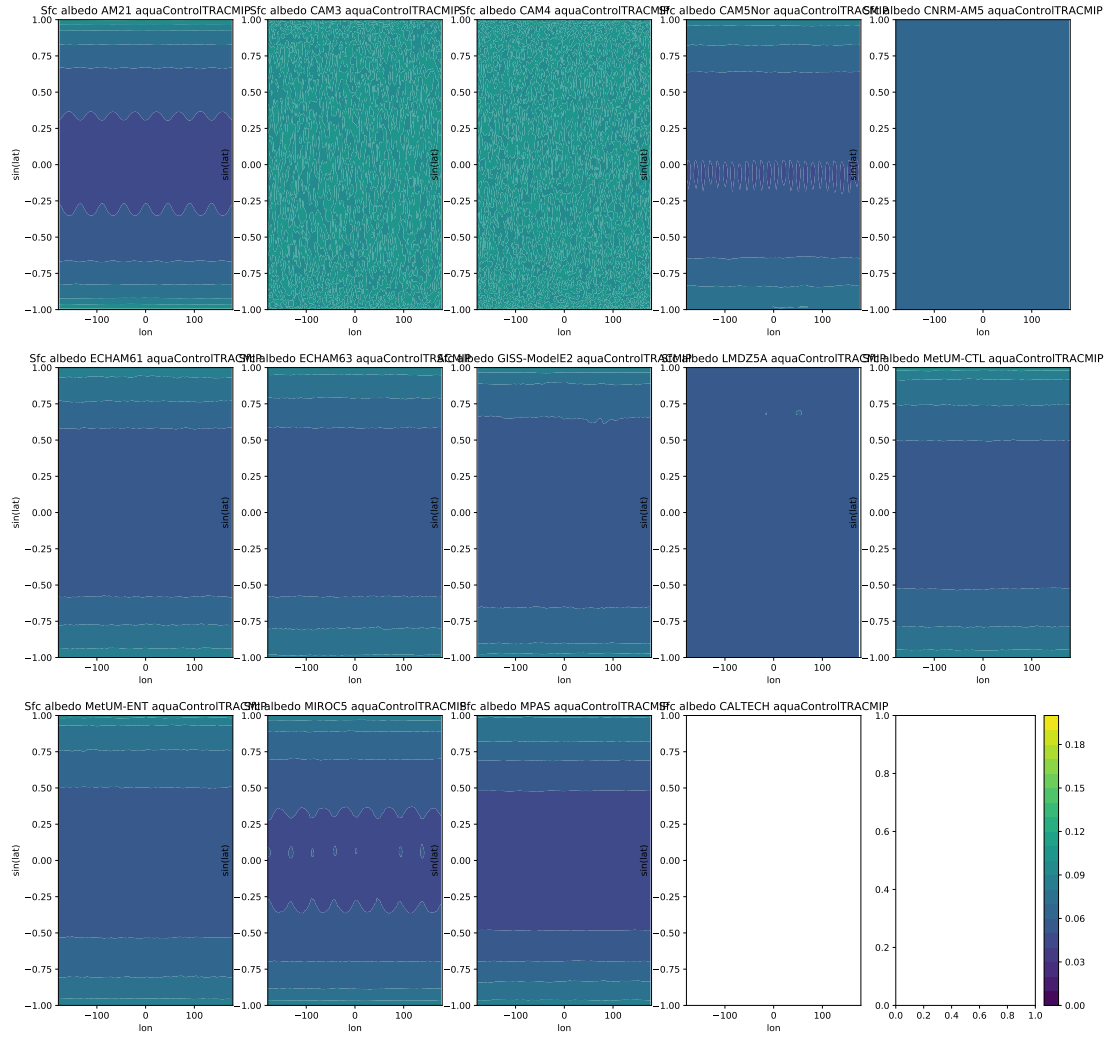


Figure 19: Time-mean surface albedo in aquaControl/TRACMIP.

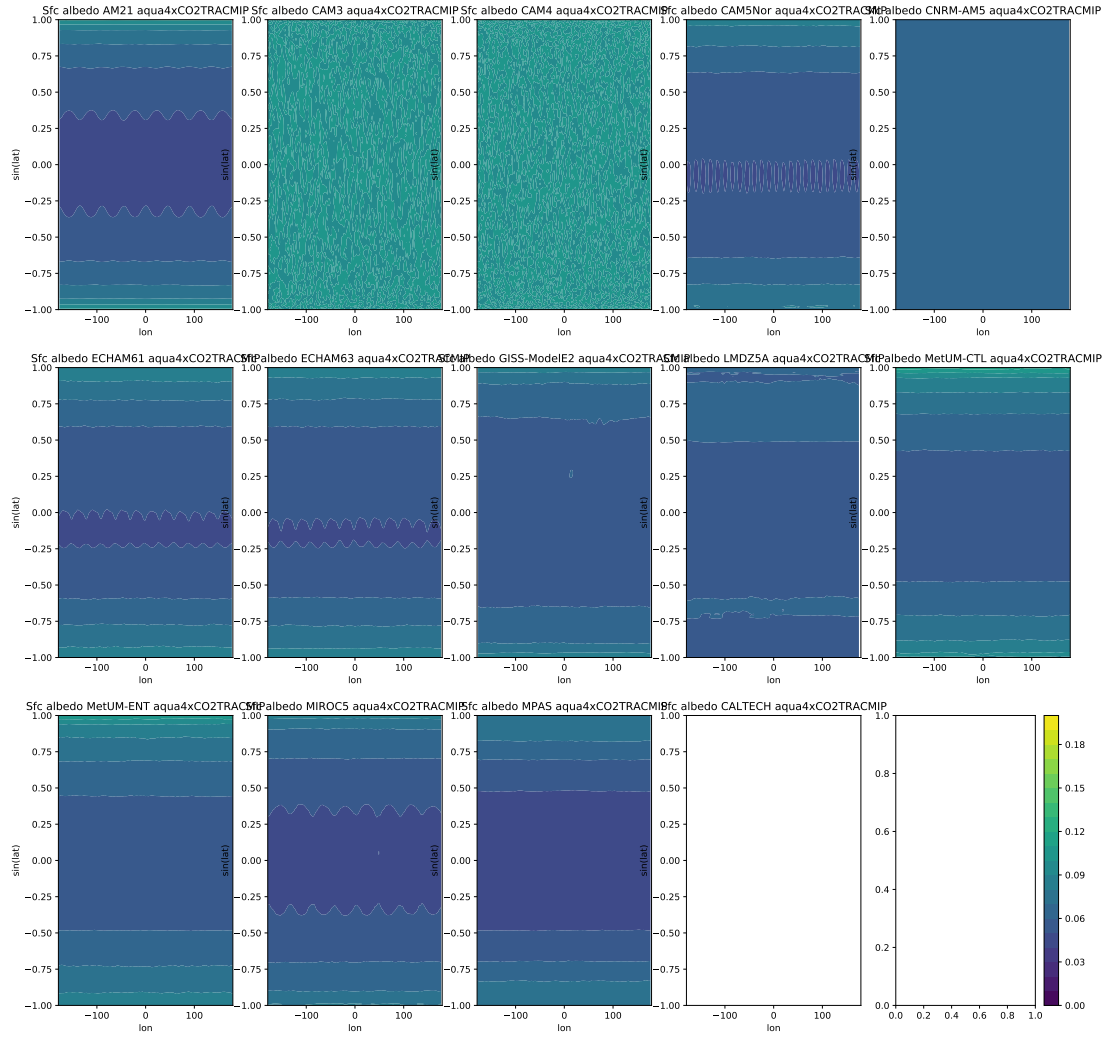


Figure 20: Time-mean surface albedo in aqua4xCO2TRACMIP.

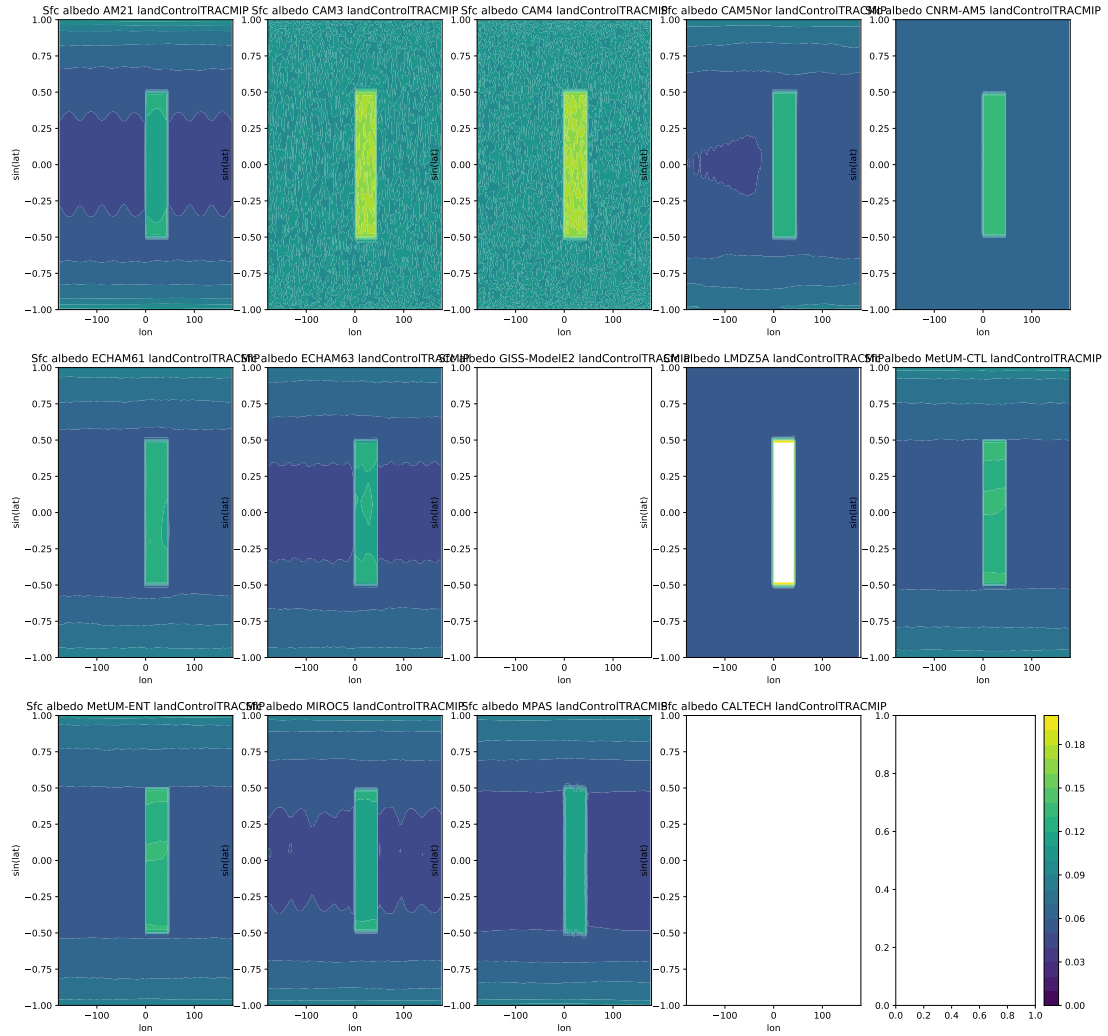


Figure 21: Time-mean surface albedo in landControl/TRACMIP.

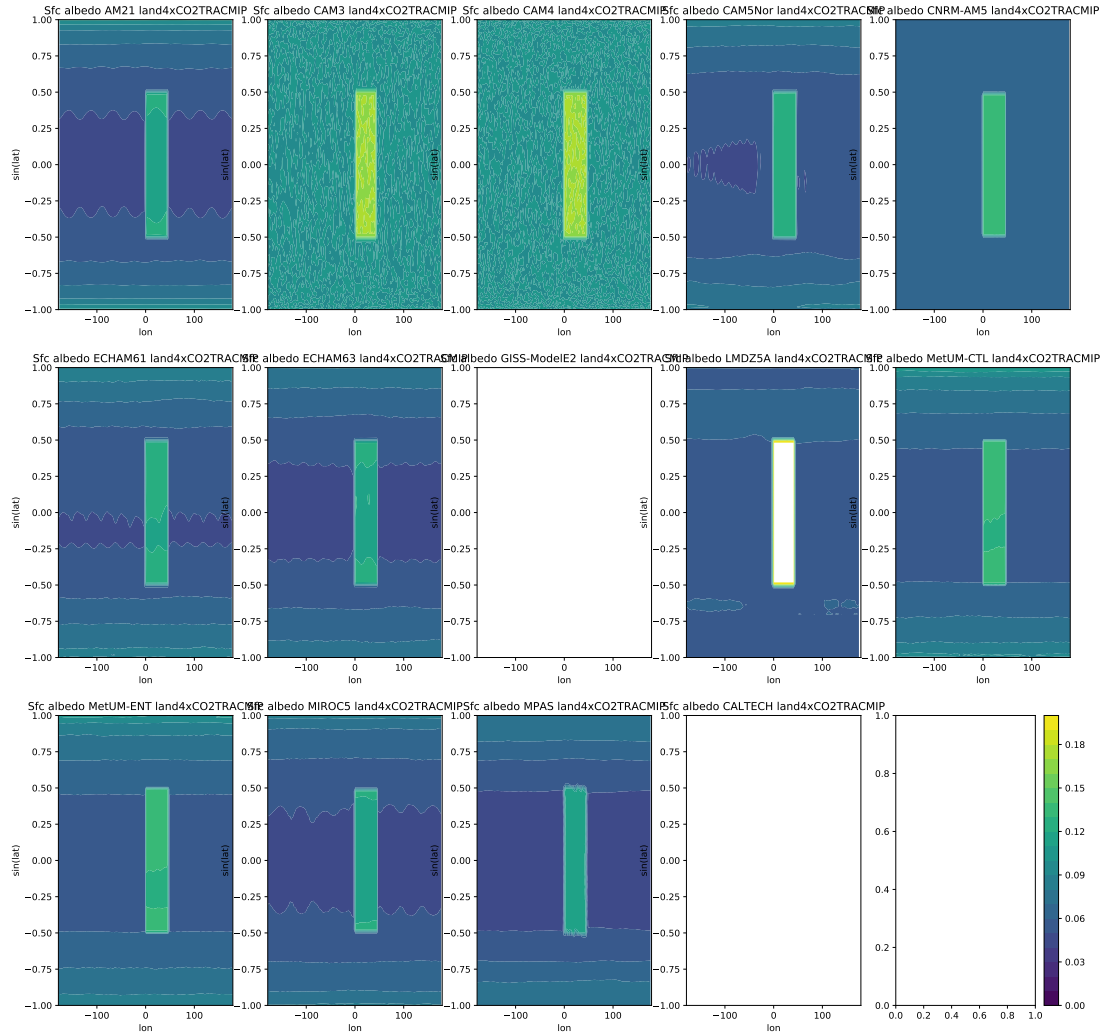


Figure 22: Time-mean surface albedo in land4xCO2TRACMIP.

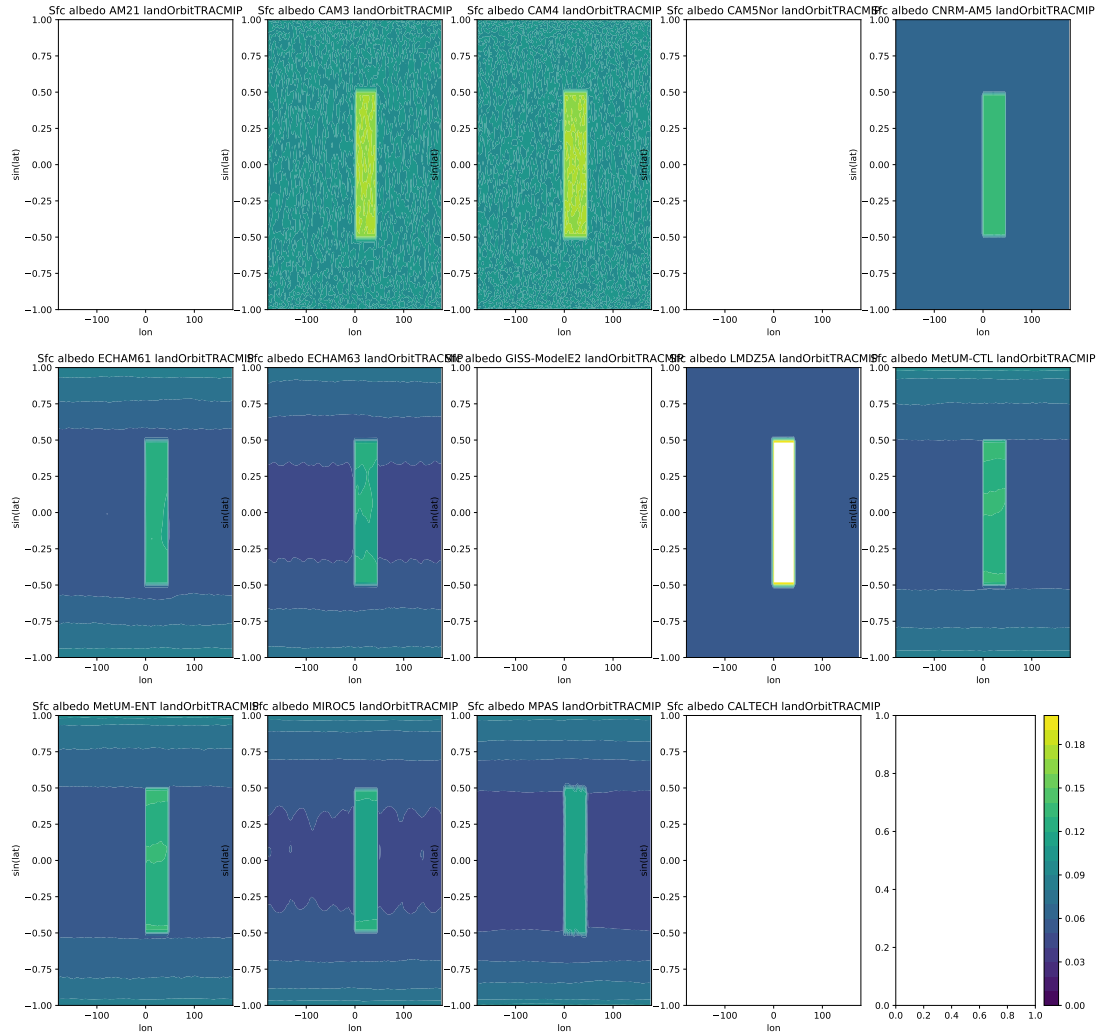


Figure 23: Time-mean surface albedo in landOrbitTRACMIP.

Lat-lon time-mean difference between landControlTRACMIP and aquaControlTRACMIP

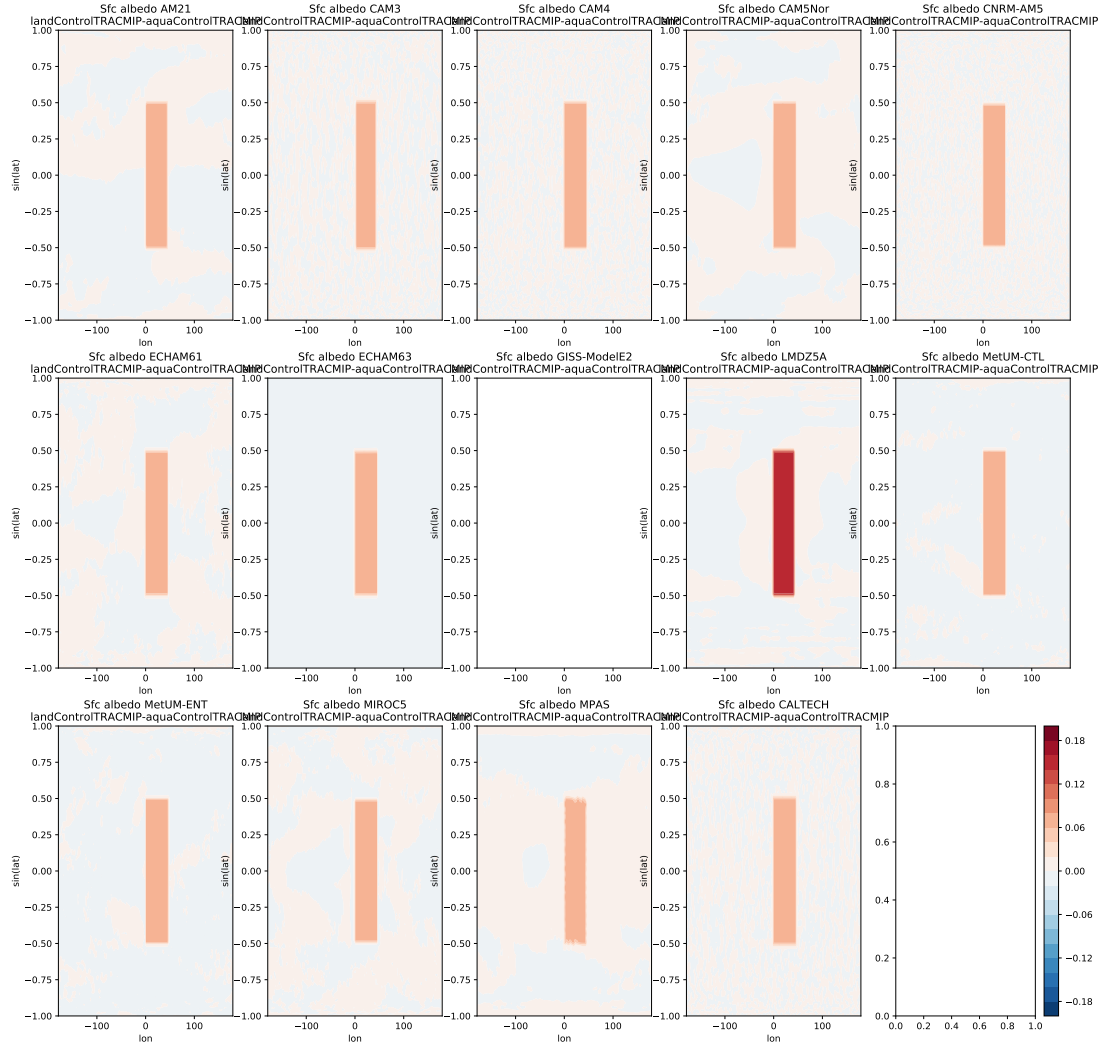


Figure 24: Time-mean surface albedo in landControlTRACMIP-aquaControlTRACMIP.

Special look at CALTECH

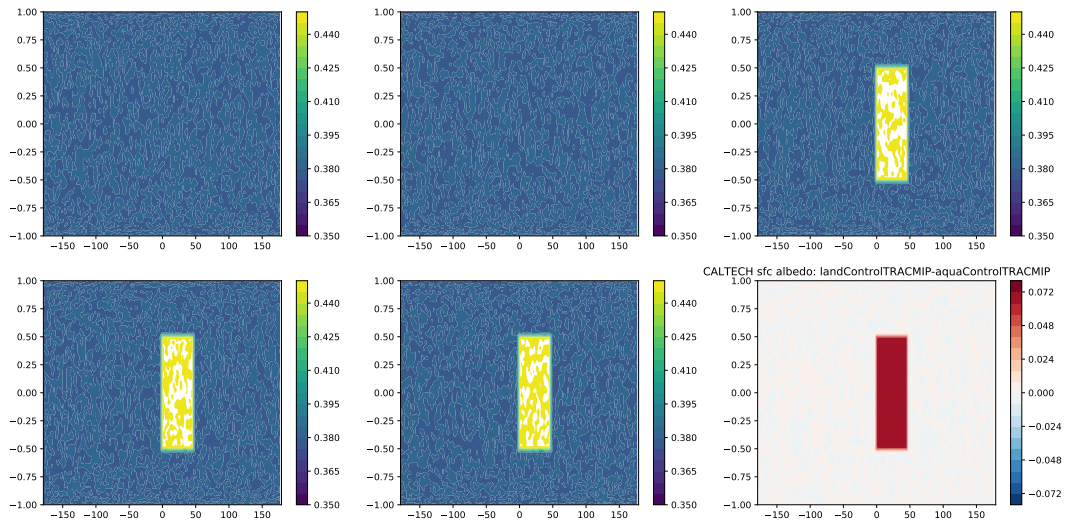


Figure 25: Time-mean surface albedo in all CALTECH simulations.

Evaporative resistance over land: Bowen ratio

Bowen ratio calculated from hfss and hfls. Note that for LMDZ5A, hfss and hfls need to be multiplied by -1. For AM21 we need to use evspsbl for hfls (see section on q-flux).

Take-home points:

- AM21 does not show expected increase in Bowen ratio over land
- other models have correctly implemented evaporative resistance

Lat-lon time-mean Bowen ratio

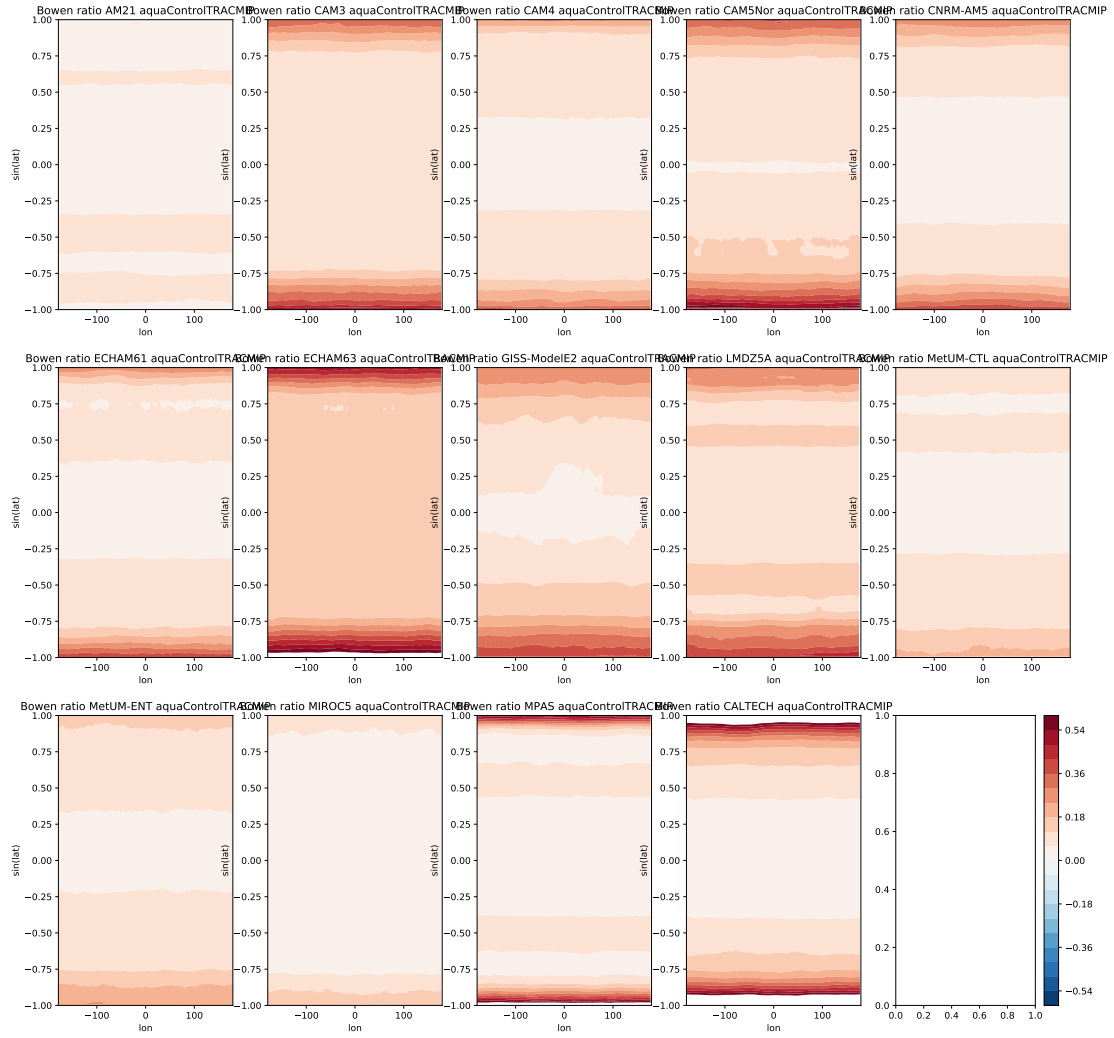


Figure 26: Time-mean Bowen ratio in aquaControl/TRACMIP.

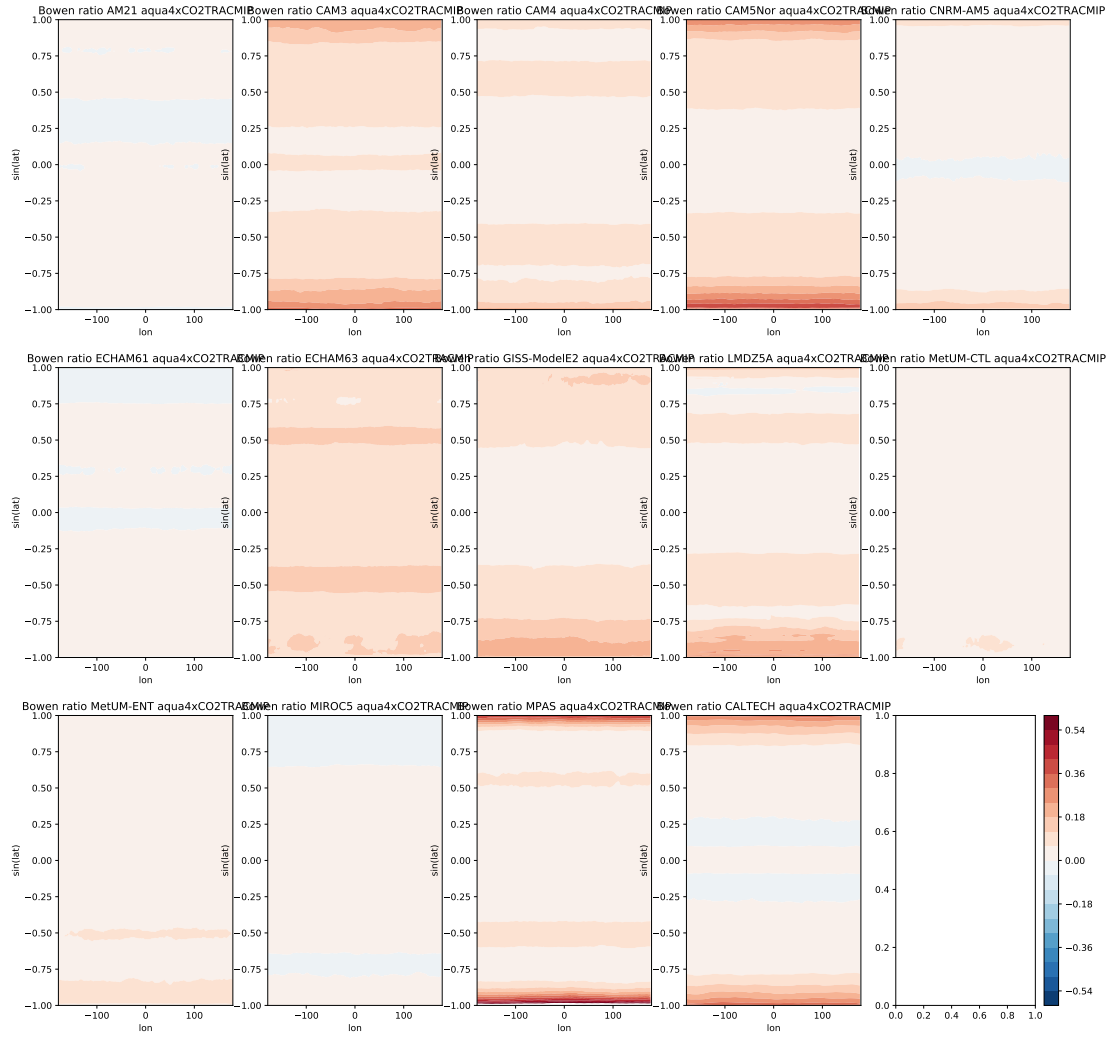


Figure 27: Time-mean Bowen ratio in aqua4xCO2TRACMIP.

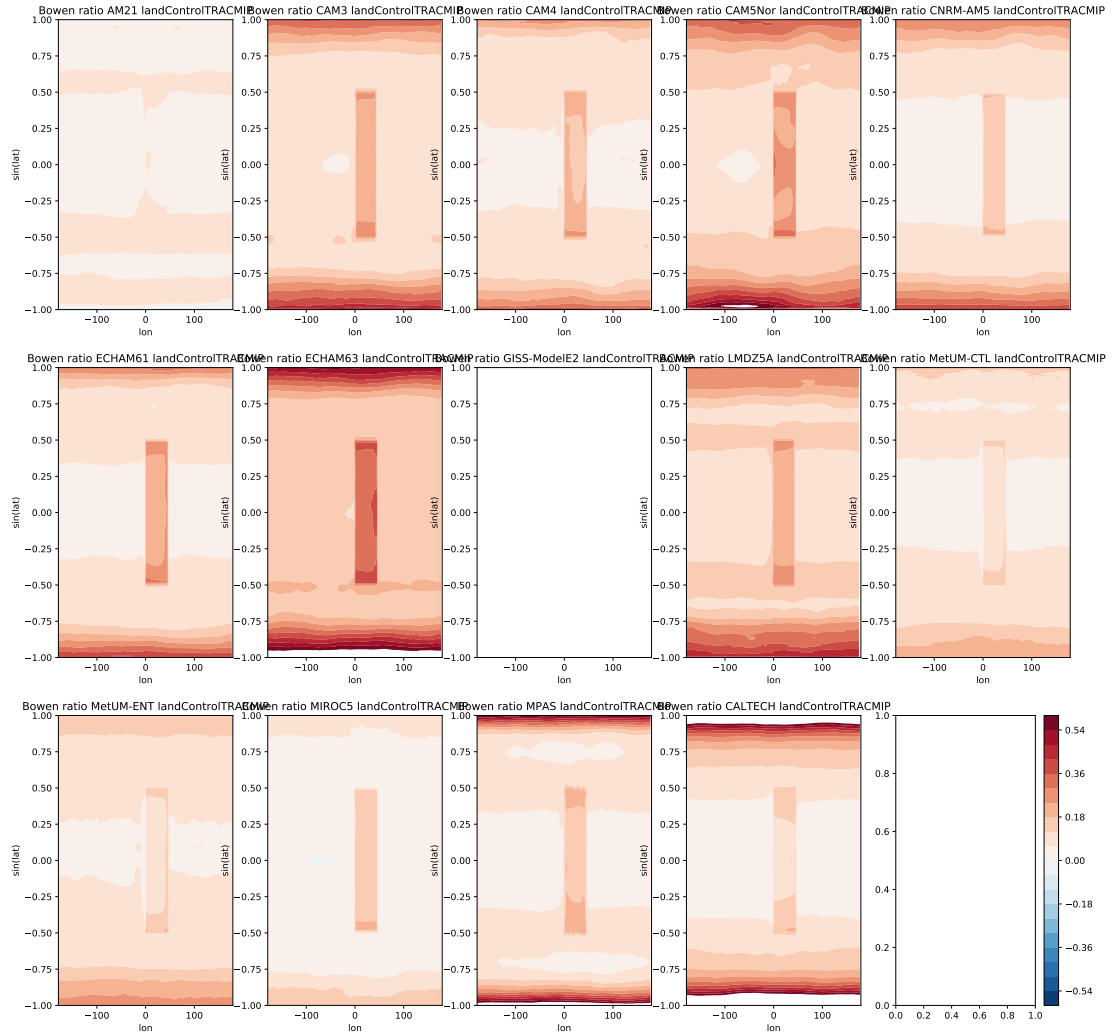


Figure 28: Time-mean Bowen ratio in landControl/TRACMIP.

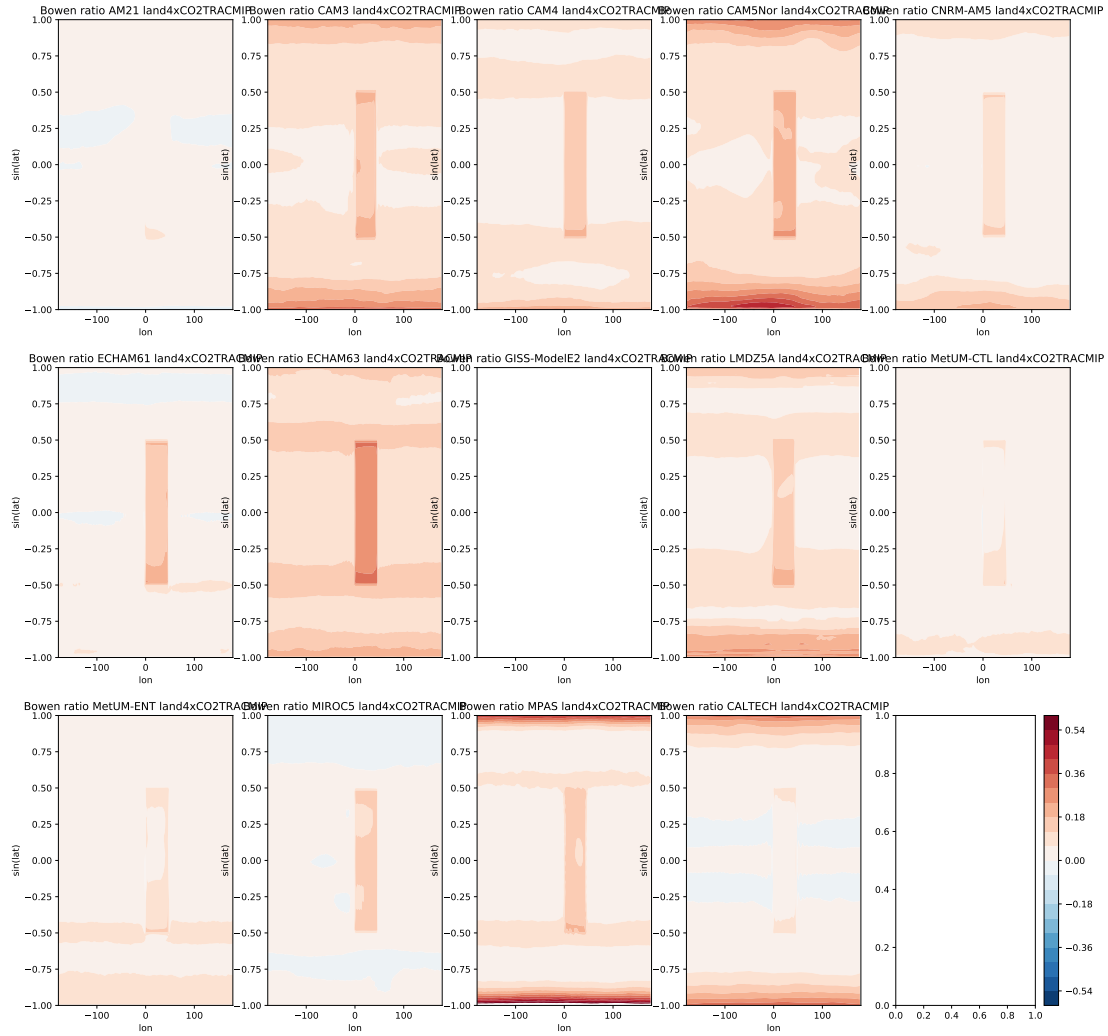


Figure 29: Time-mean Bowen ratio in land4xCO2TRACMIP.

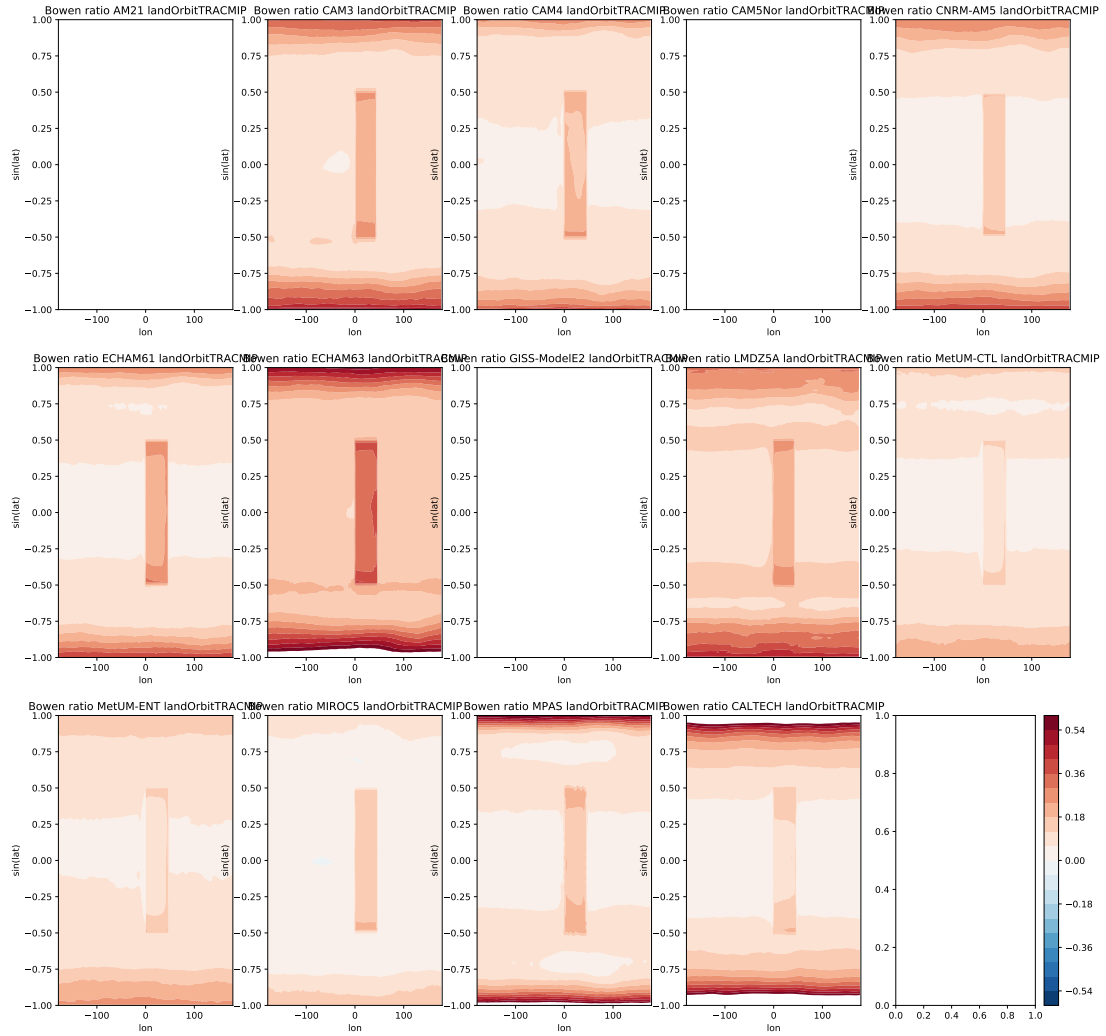


Figure 30: Time-mean Bowen ratio in landOrbitTRACMIP.

Diurnal cycle over land: land heat capacity

The shallow slab ocean over land should lead to a much stronger diurnal cycle of ts or tas. This has been checked. For most models, this has been done by looking at 3hr data for ts or tas. For some models, 3hr data was not available, and so daily data for tasmax and tasmin, and the difference thereof, was used.

Take-home points:

- MetUM-CTL and MetUM-ENT did not properly implement the reduced heat capacity
- for CALTECH we can't check because there is no tasmax/tasmin or 3hr data
- all other models have the increased diurnal cycle (at least for one of the analysis options taken here)

Lat-lon diurnal cycle diagnosed based on 3hr ts

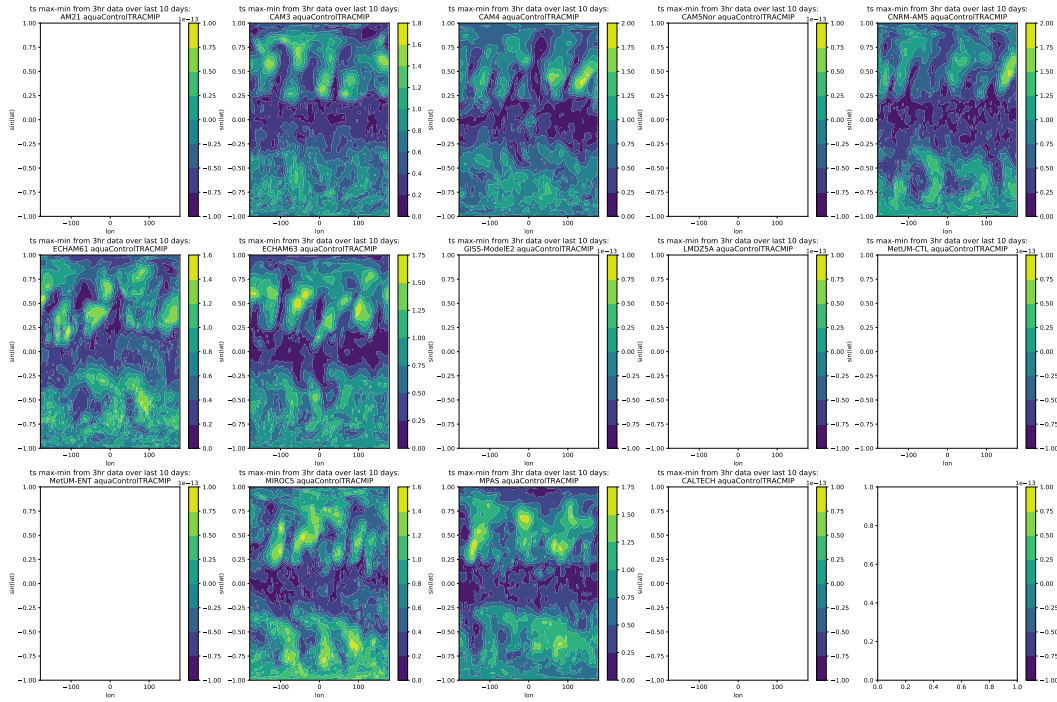


Figure 31: Diurnal cycle from 3hr ts data in aquaControlTRACMIP.

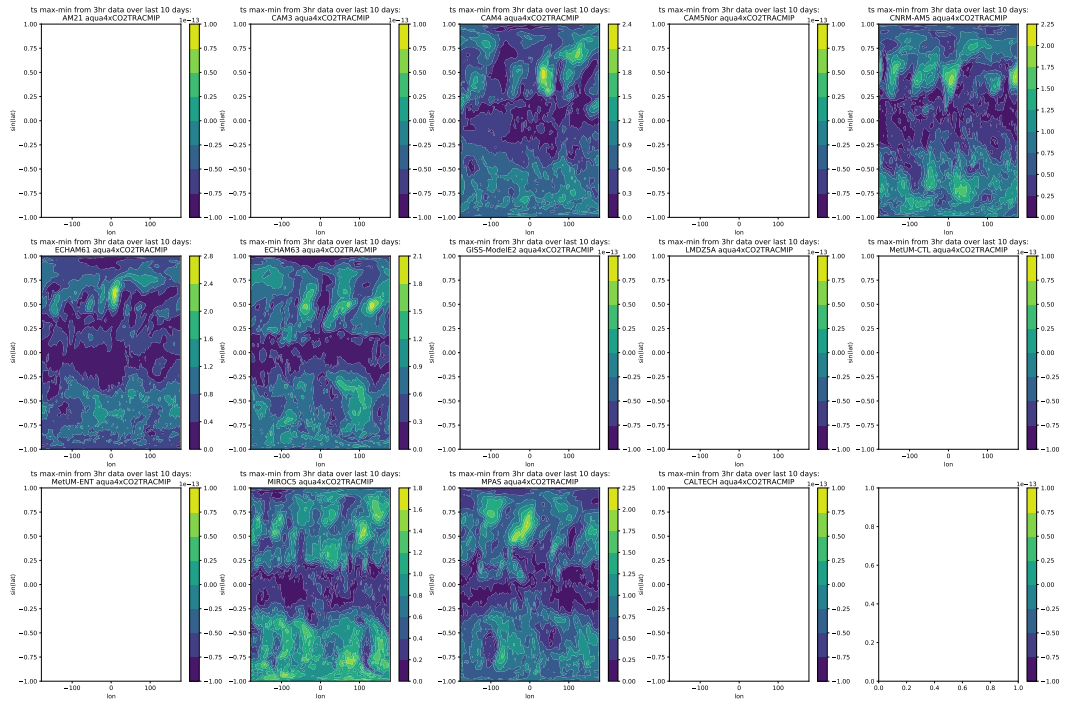


Figure 32: Diurnal cycle from 3hr ts data in aqua4xCO2TRACMIP.

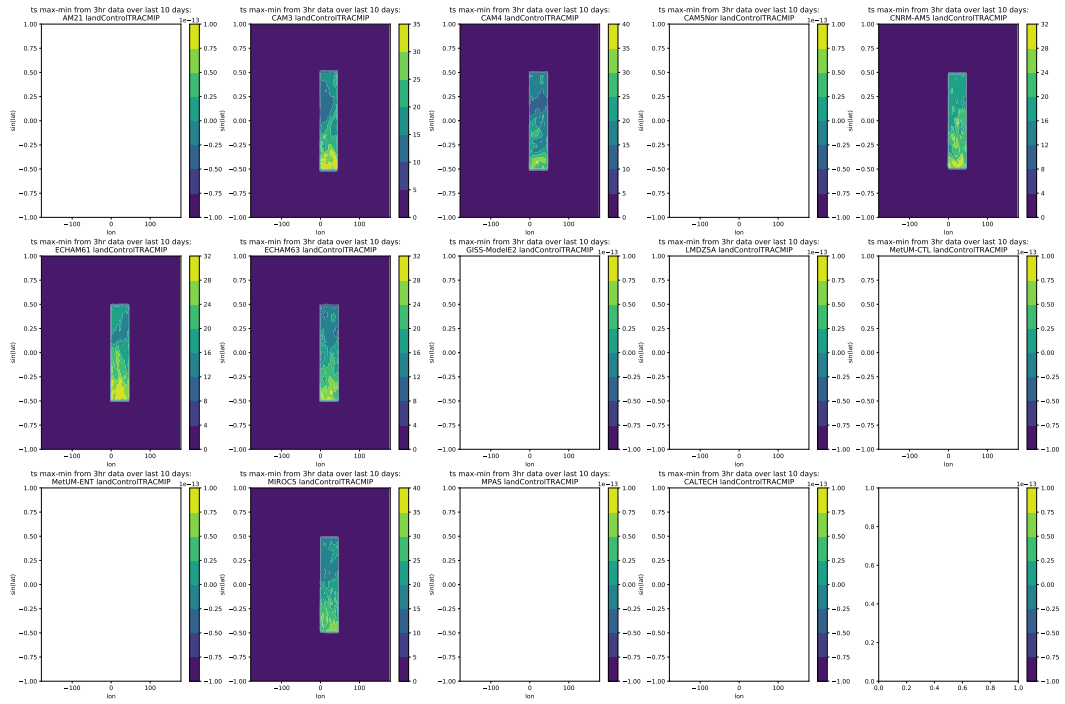


Figure 33: Diurnal cycle from 3hr ts data in landControlTRACMP.

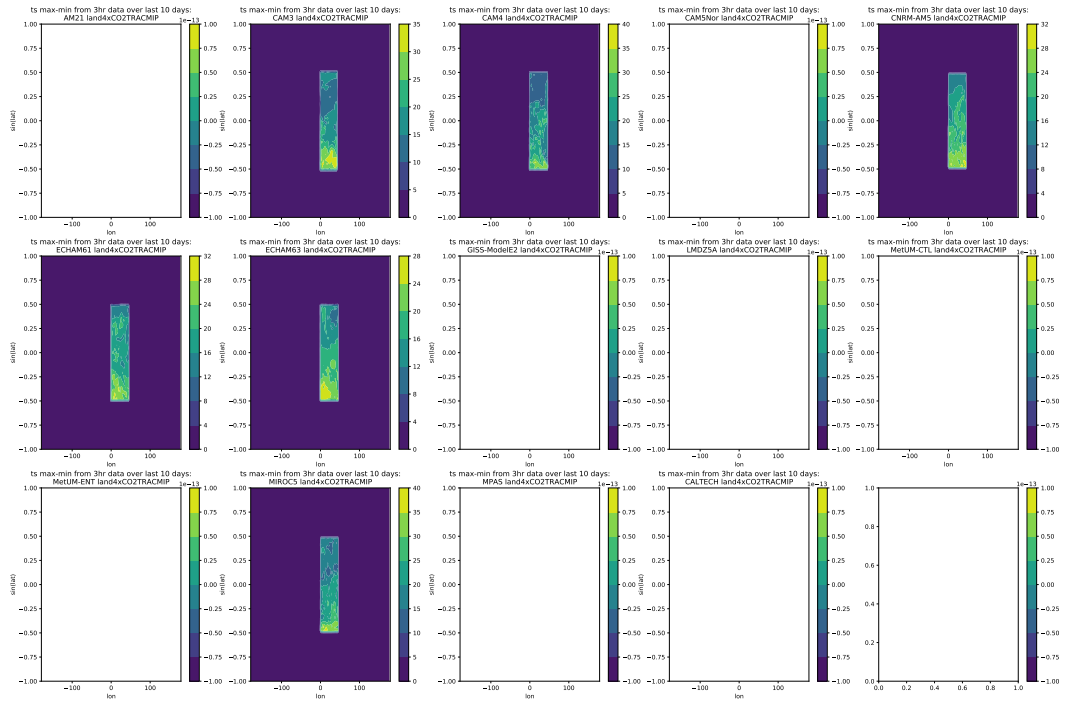


Figure 34: Diurnal cycle from 3hr ts data in land4xCO2TRACMIP.

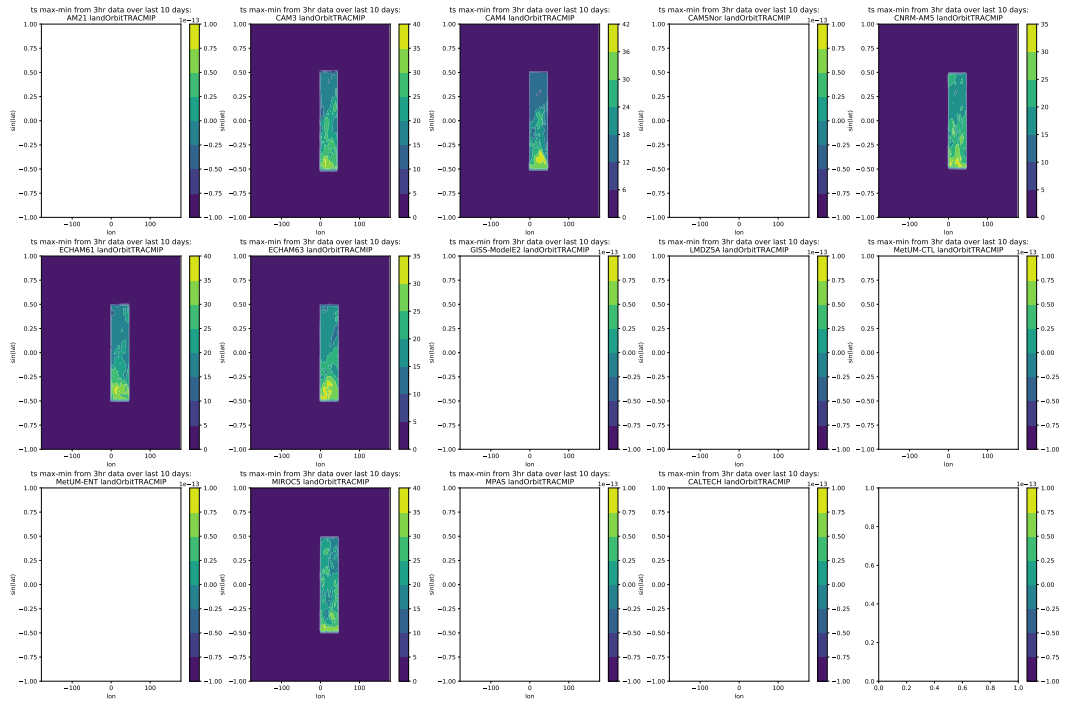


Figure 35: Diurnal cycle from 3hr ts data in landOrbitTRACMIP.

Lat-lon diurnal cycle diagnosed based on 3hr tas

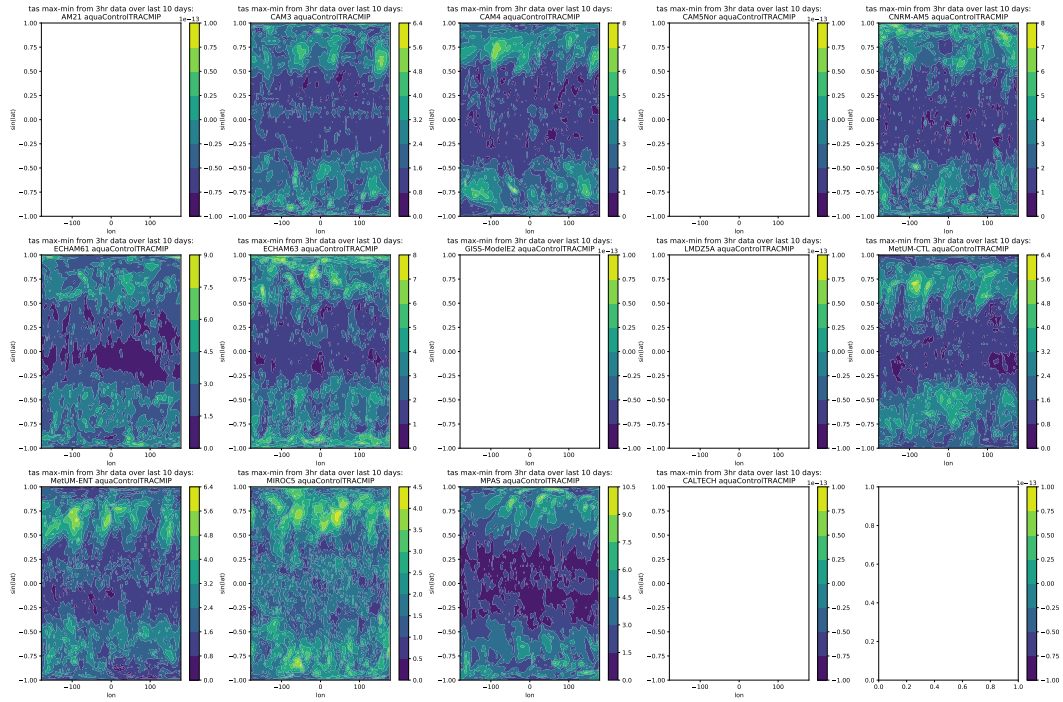


Figure 36: Diurnal cycle from 3hr tas data in aquaControlTRACMIP.

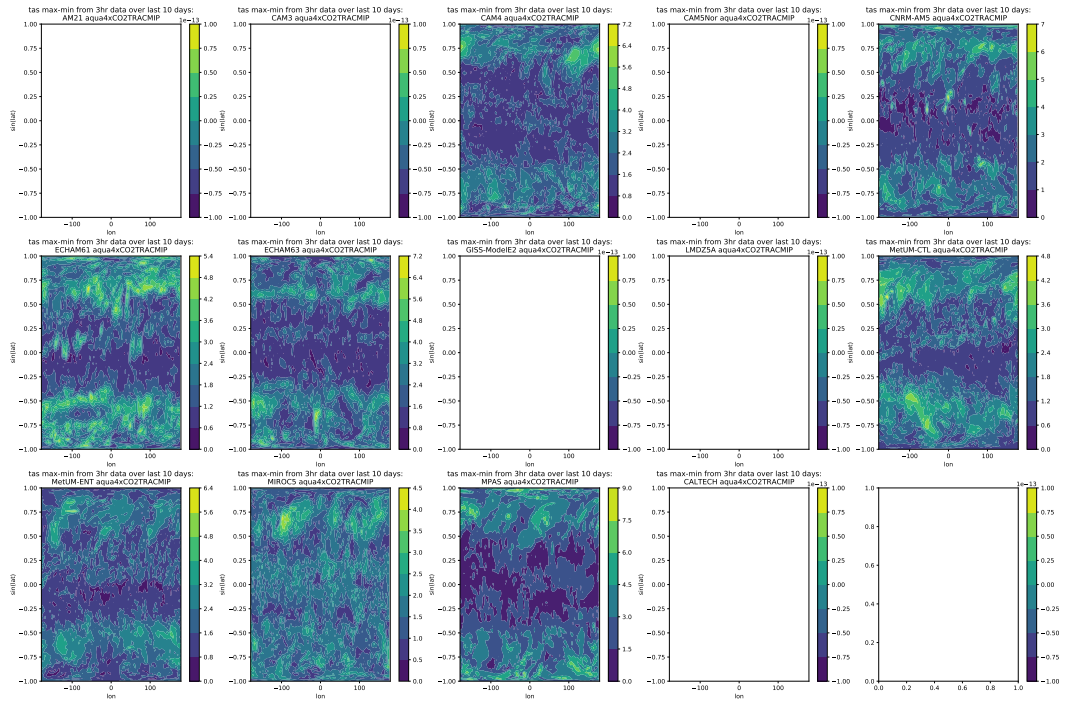


Figure 37: Diurnal cycle from 3hr tas data in aqua4xCO2TRACMIP.

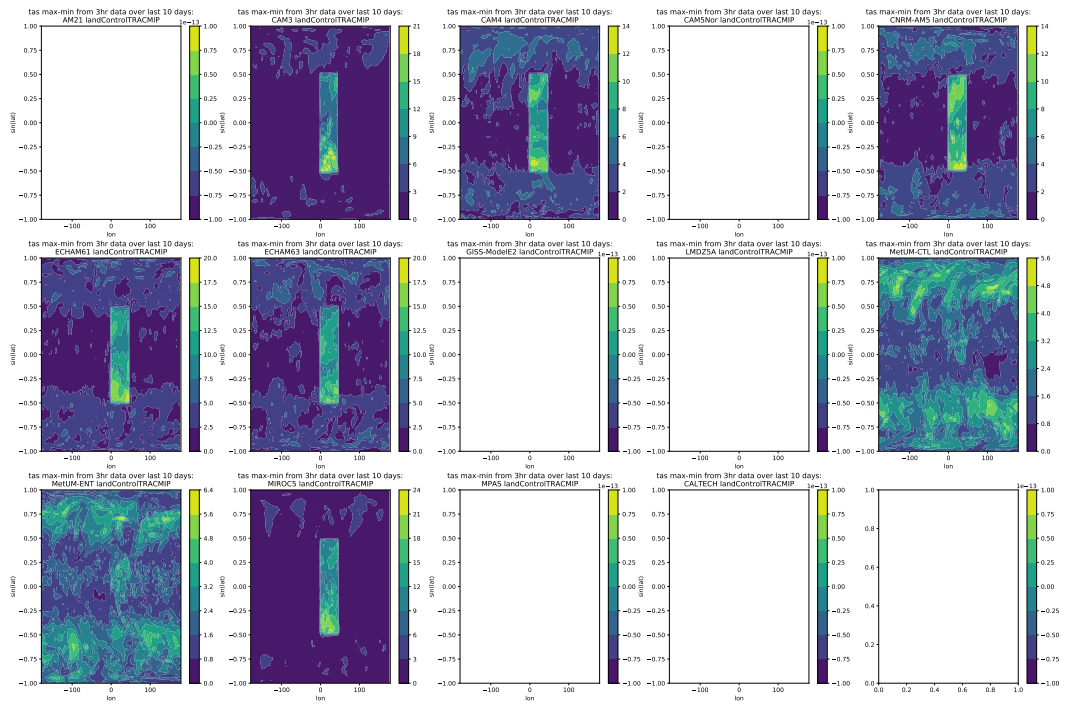


Figure 38: Diurnal cycle from 3hr tas data in landControlTRACMIP.

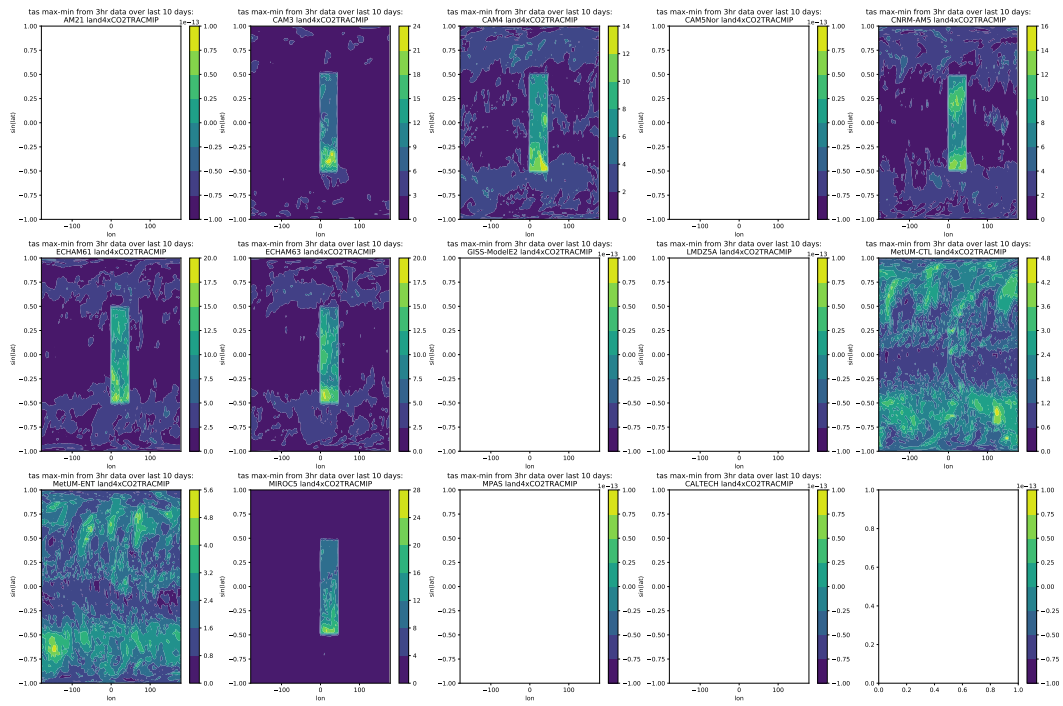


Figure 39: Diurnal cycle from 3hr tas data in land4xCO2TRACMIP.

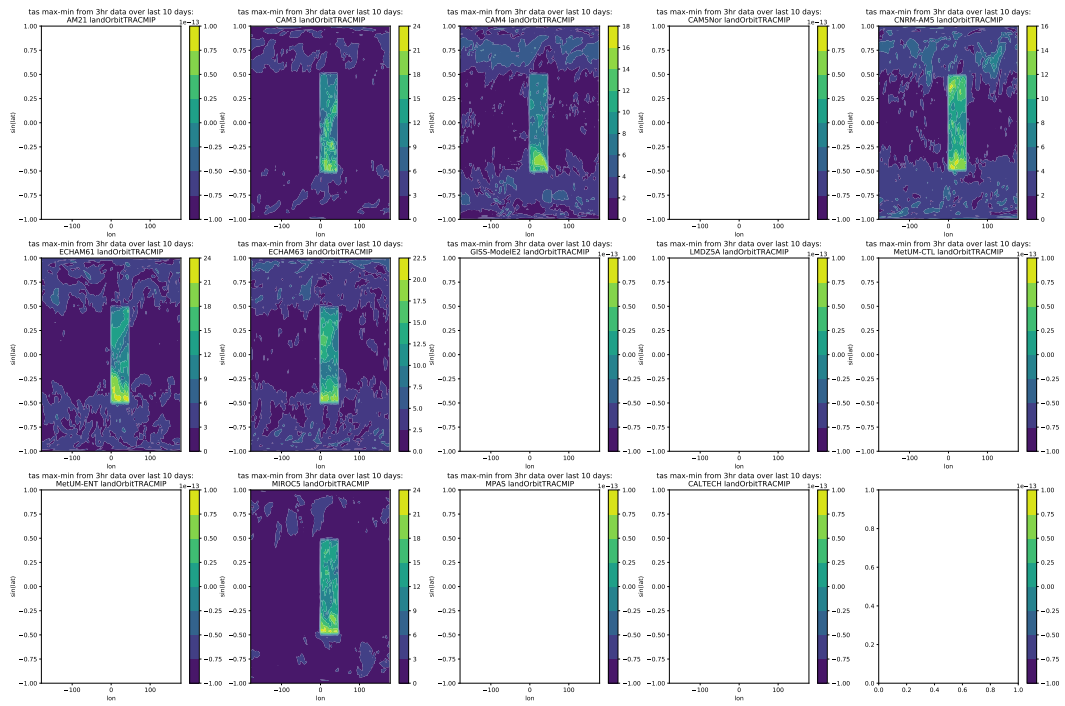


Figure 40: Diurnal cycle from 3hr tas data in landOrbitTRACMP.

Lat-lon daily tasmax - tasmin

The last 10 days are used. Plotted is the 10-day mean of (tasmax-tasmin).

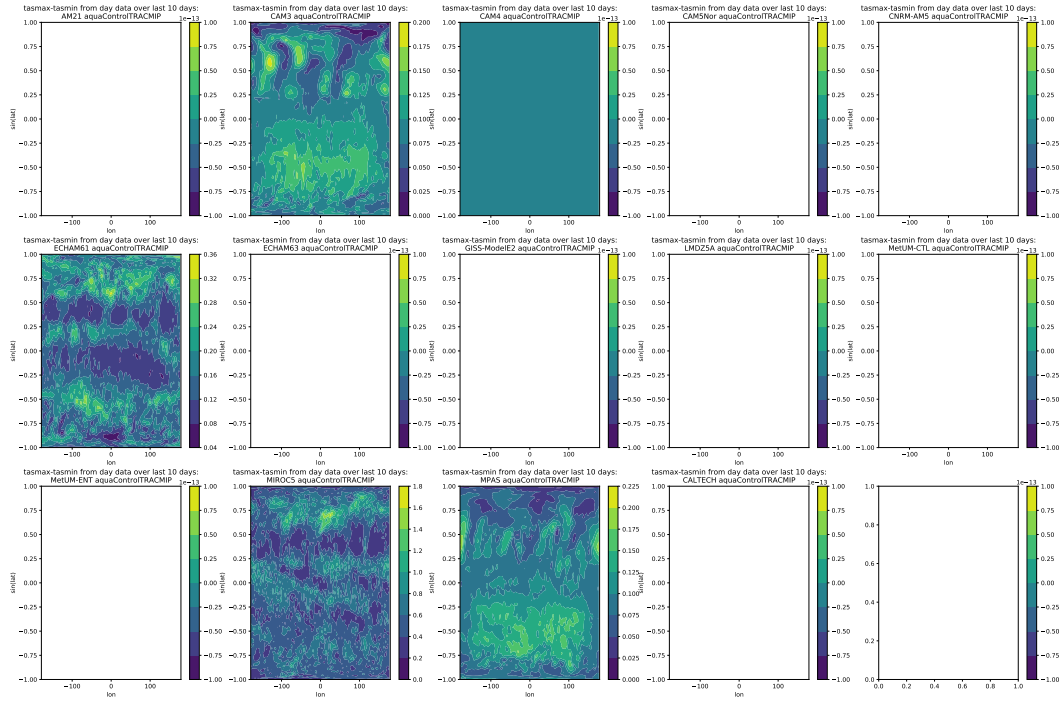


Figure 41: tasmax-tasmin from day data in aquaControlTRACMIP.

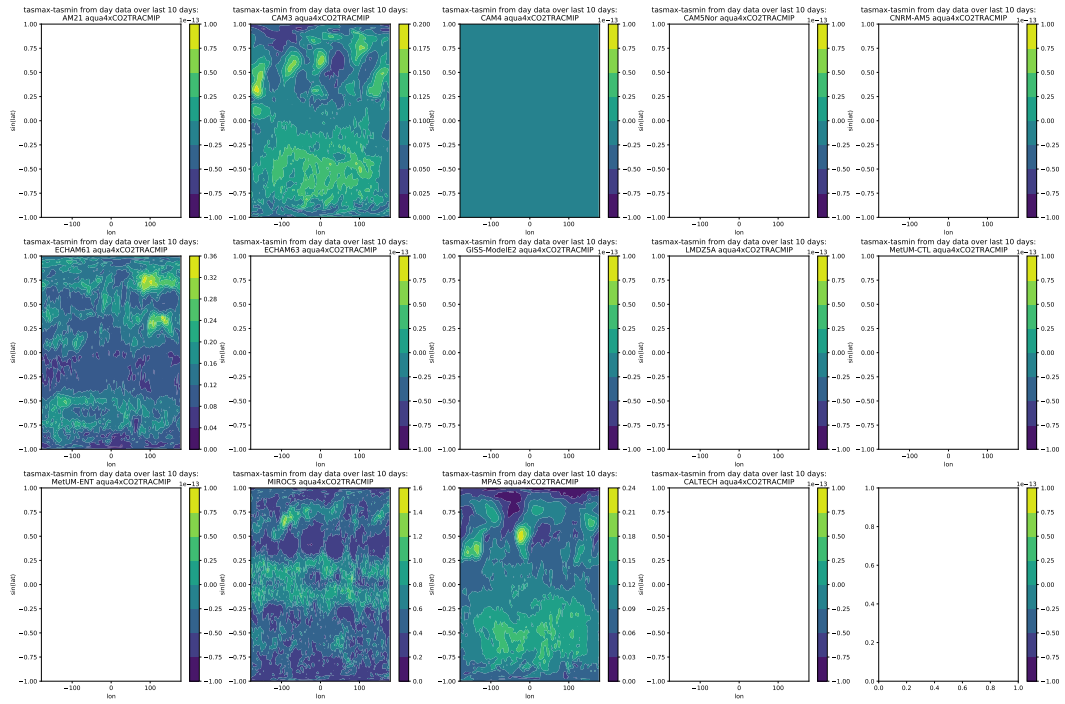


Figure 42: tsmx-tasmin from day data in aqua4xCO2TRACMIP.

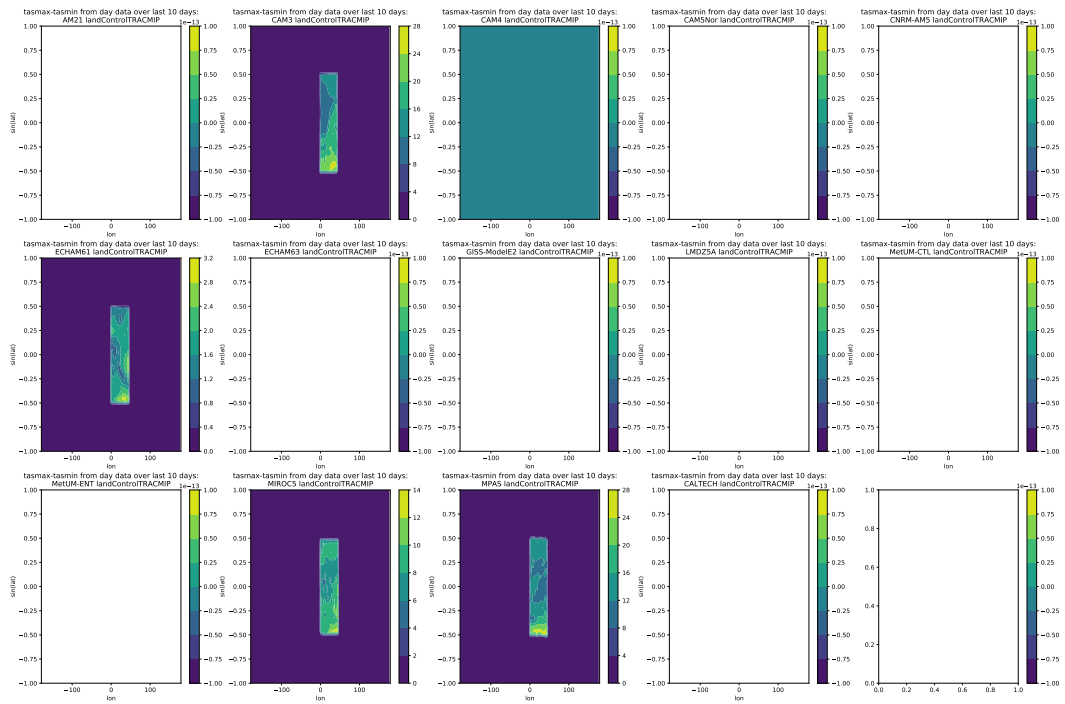


Figure 43: tsmx-tasmin from day data in landControlTRACMIP.

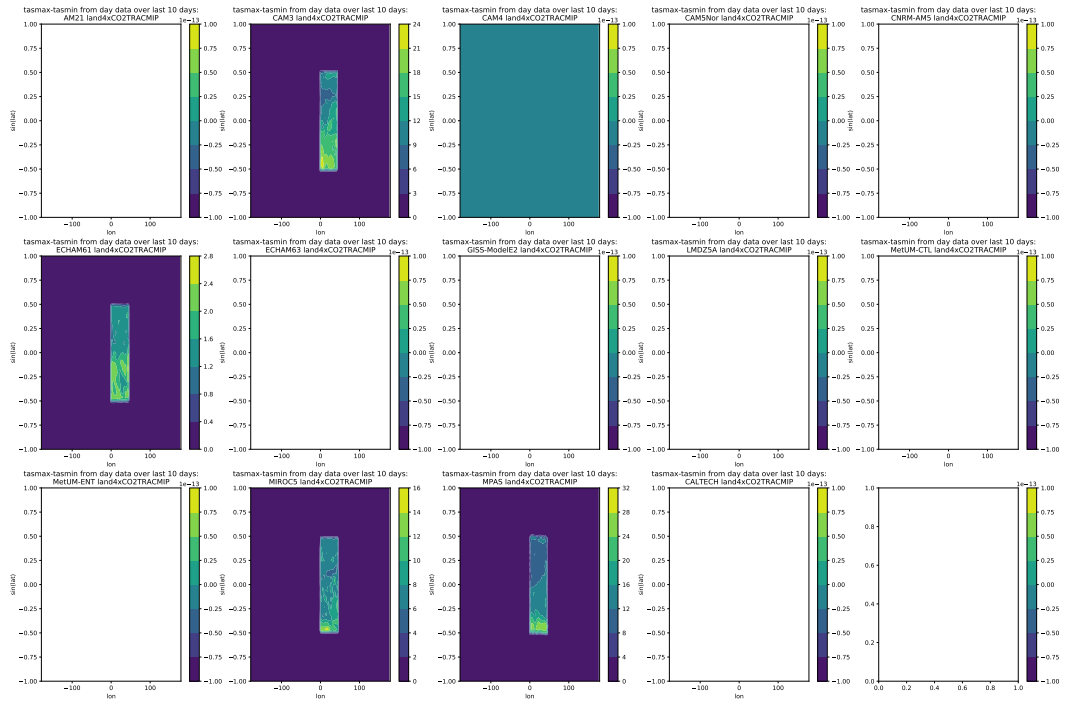


Figure 44: tsmmax-tasmin from day data in land4xCO2TRACMIP.

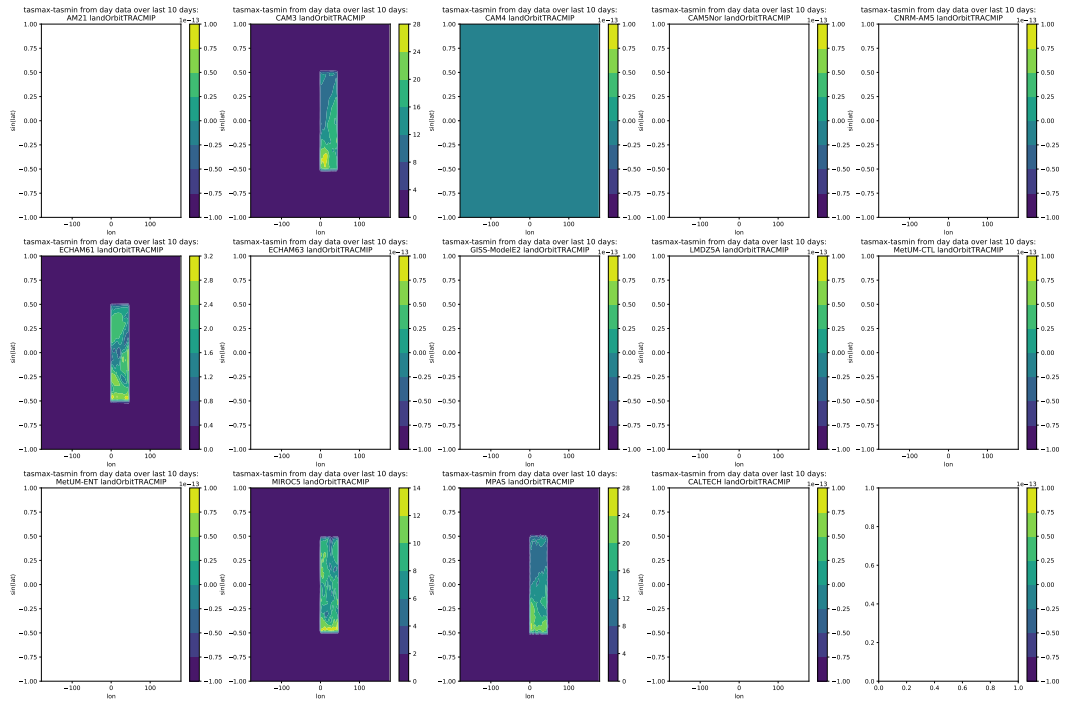


Figure 45: tasmx-tasmin from day data in landOrbitTRACMIP.

Custom analysis for AM21

There is no tasmax/tasmin data for AM21 landControlTRACMIP on ESGF, and no 3hr ts or tas data. There is no 3hr data because that data was found to only contain less than a year of timesteps, and so it was not cmorized. Yet, we have copied the last timesteps of the AM21 landControlTRACMIP 3hr ts data from the UMiami server

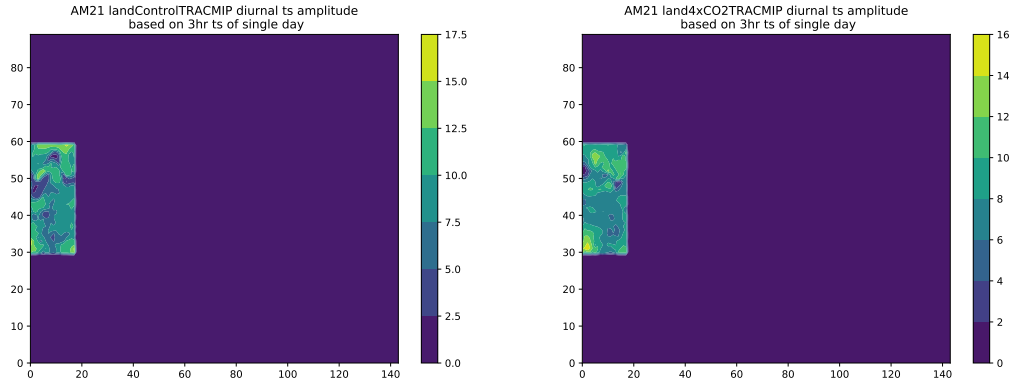


Figure 46: Diurnal ts cycle for AM21 based on some 3hr data.

Custom analysis for LMDZ5A

The UMiami server has daily tasmin and tasmax for LMDZ5A, but they were inadvertently not included in the cmorizing and hence are not on ESGF.

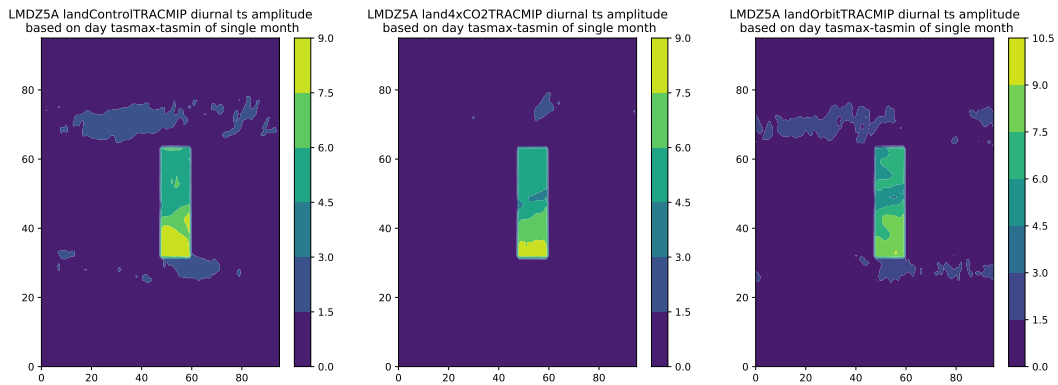


Figure 47: Mean of day tasmax-tasmin for LMDZ5A from some day data.

Custom analysis for CAM5Nor

The UMiami server has daily tasmin and tasmax for CAM5Nor LandControlTRACMIP and Land4xCO2TRACMIP, but tasmin was inadvertently not included in the cmorizing and hence is not on ESGF.

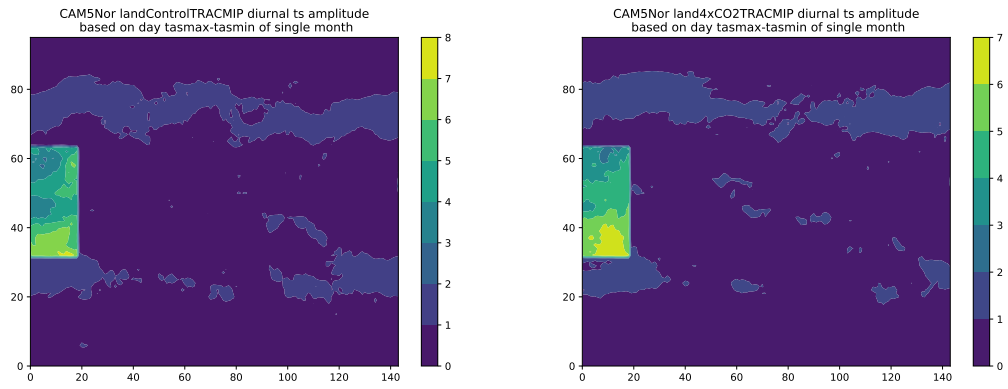


Figure 48: Mean of day tasmax-tasmin for CAM5Nor from some day data.