



# The TIPMIP ESM Tier 1 experiment protocol

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## The TIPMIP Earth system model experiment protocol: phase 1

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**TIPMIP ESM Tier 1 experiment protocol:** Experiments run in CO<sub>2</sub>-emission mode

Atmospheric CO<sub>2</sub> concentrations are a prognostic model variable

**GWL=0°C : piControl**

**Time**



# TIPMIP ESM Tier 1 experiment protocol: Experiments run in CO<sub>2</sub>-emission mode

Atmospheric CO<sub>2</sub> concentrations are a prognostic model variable

➡ Positive CO<sub>2</sub> emissions

Using each model TCRE we derive a CO<sub>2</sub> emission rate that gives a 0.2 °C/decade rate of global warming

| Model         | Emissions (PgCyr-1) |
|---------------|---------------------|
| ACCESS-ESM1.5 | 12                  |
| CESM2         | 10.0                |
| CNRM-ESM2     | 11.4                |
| EC-Earth3     | 12.4                |
| GFDL_ESM4     | 13.0                |
| GFDL_ESM2M    | 18.5                |
| IPSL-CM6-ESM  | 9.4                 |
| MIROC_ES2L    | 15.4                |
| NASA-GISS     | 11.4                |
| NorESM2_LM    | 16.8                |
| UKESM1.2      | 8.0                 |

Ramp-up;  $+X\text{GtCyr}^{-1} \sim 0.2^\circ\text{C/decade}$ : based on TCRE

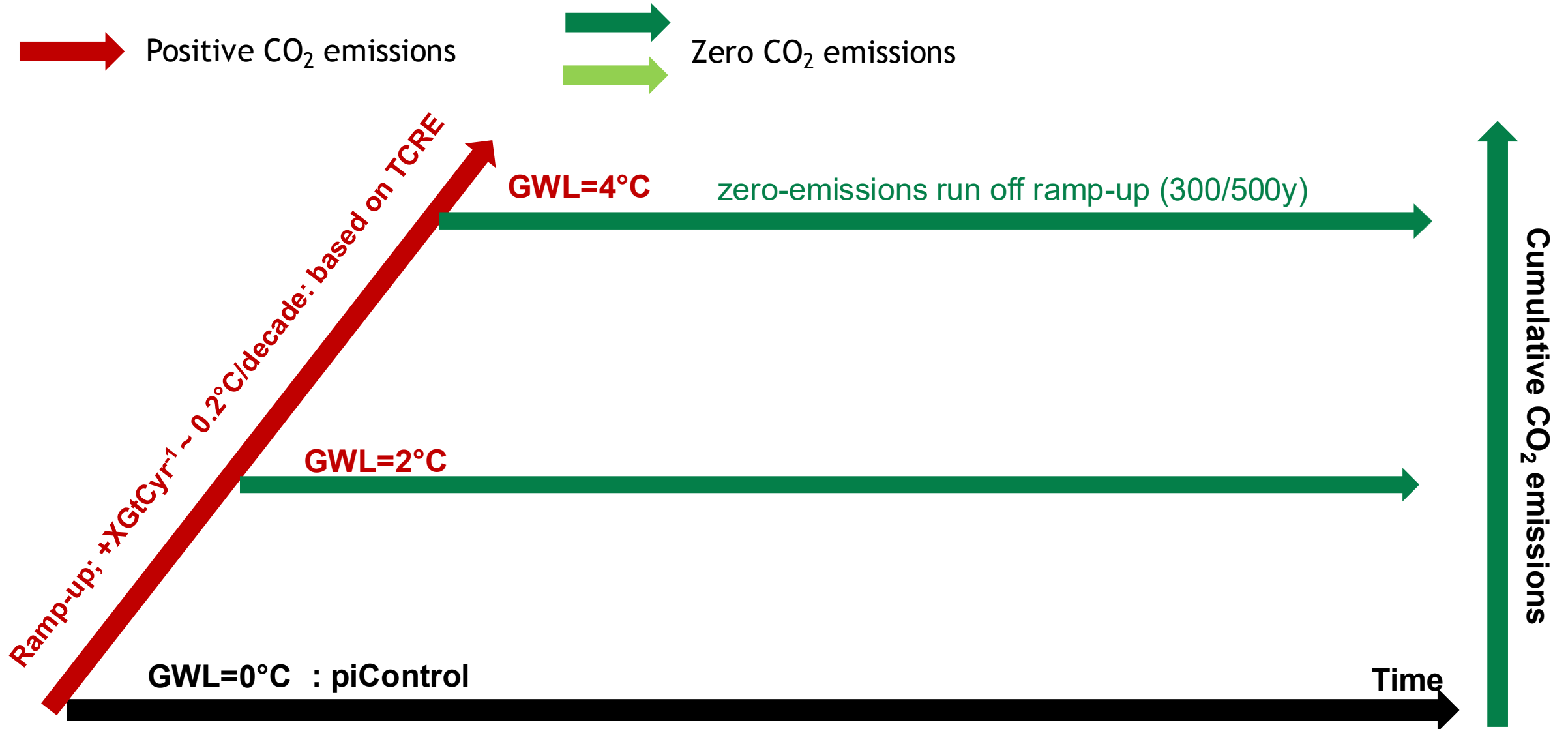
GWL=0°C : piControl

Time

Cumulative CO<sub>2</sub> emissions

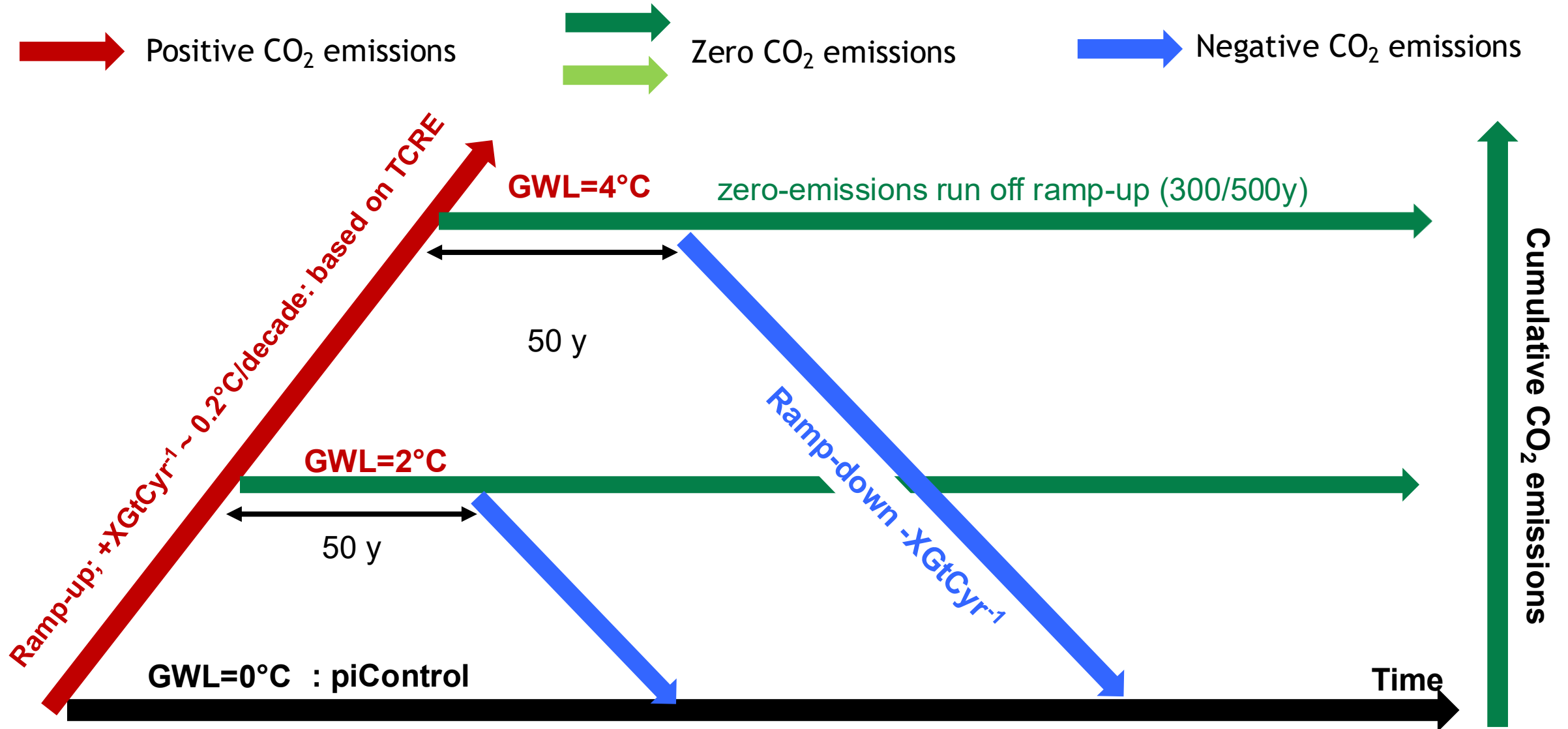
# TIPMIP ESM Tier 1 experiment protocol: Experiments run in CO<sub>2</sub>-emission mode

Atmospheric CO<sub>2</sub> concentrations are a prognostic model variable



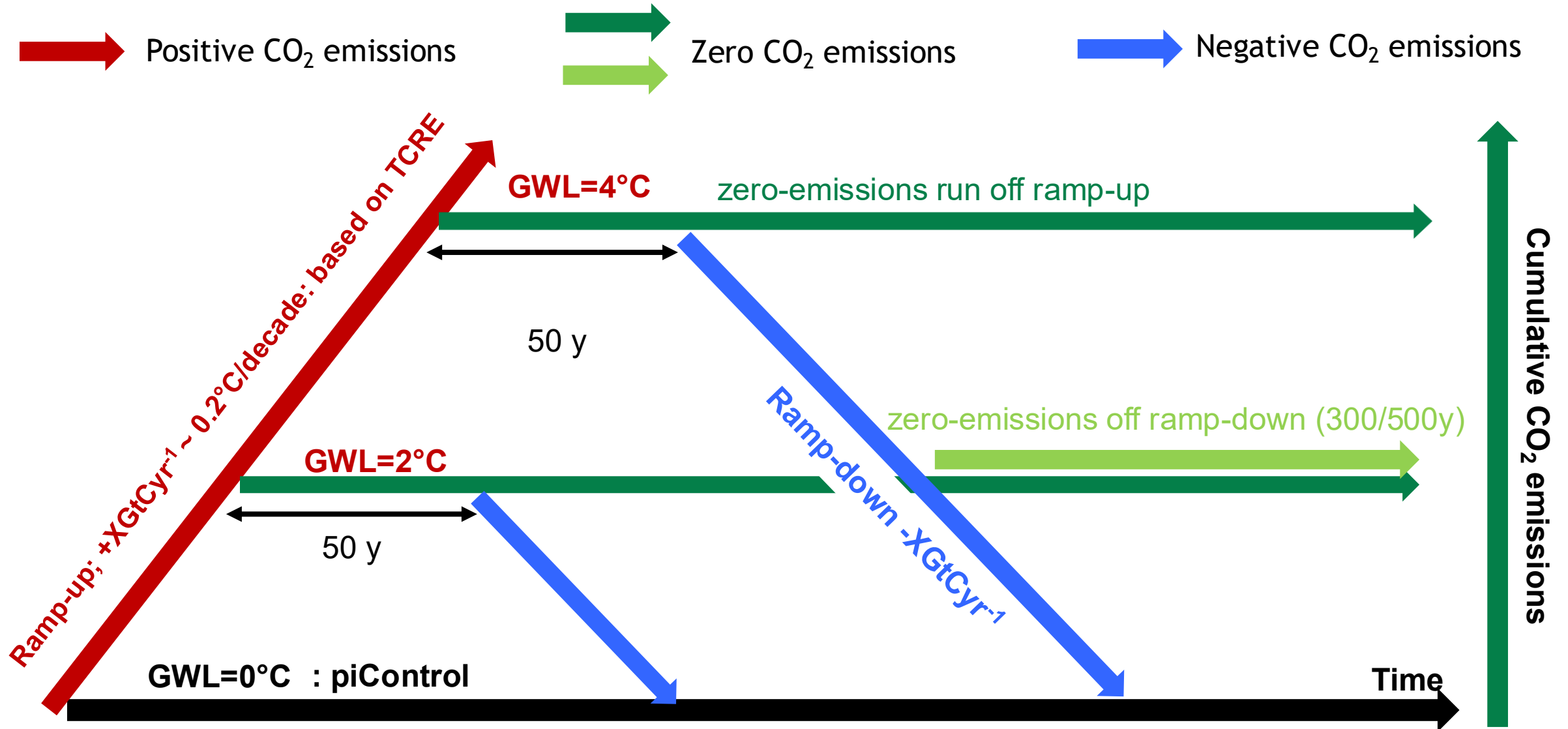
# TIPMIP ESM Tier 1 experiment protocol: Experiments run in CO<sub>2</sub>-emission mode

Atmospheric CO<sub>2</sub> concentrations are a prognostic model variable



# TIPMIP ESM Tier 1 experiment protocol: Experiments run in CO<sub>2</sub>-emission mode

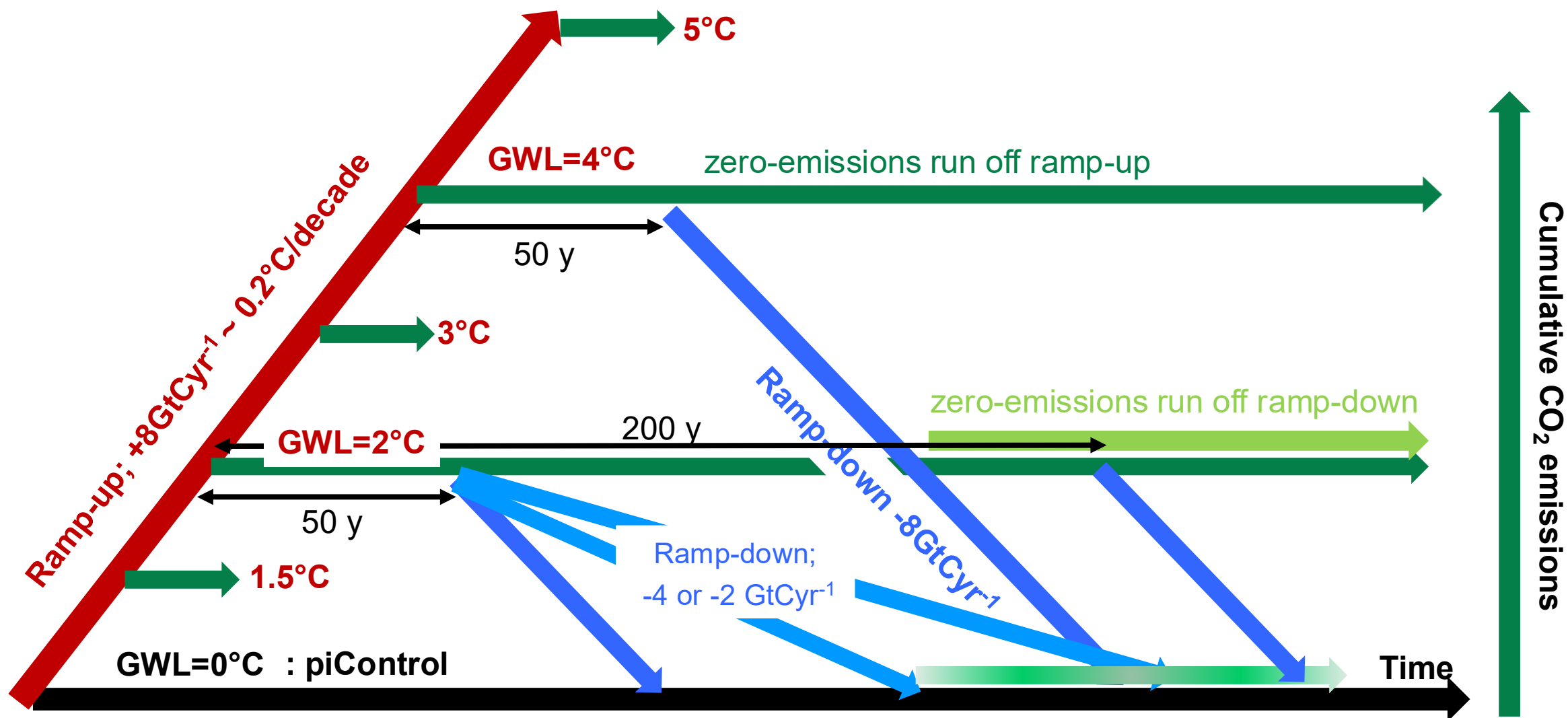
Atmospheric CO<sub>2</sub> concentrations are a prognostic model variable



The TIPMIP protocol is a subset of the TerraFIRMA protocol.

Zero emission (ZE) runs at GWL = 1.5, 2, 3, 4, 5K. Ramp-down -8, -4, -2 GtC/yr, start 50 and 200y into ZE runs

Zero emission runs off ramp-downs at GWL=2K, 0K (PI) for analysis of reversibility



Apart from increasing CO<sub>2</sub> emissions  
everything else is held at pre-industrial values

CMORized UKESM1.2 data available to download from JASMIN see:

[gws-access.jasmin.ac.uk/public/ukesm/TerraFIRMA/index.html](https://gws-access.jasmin.ac.uk/public/ukesm/TerraFIRMA/index.html)

TIPMIP runs and TIPMIP diagnostic list has been CMORized

| Experiment                        | variant                  | start date | end date   | # years | # variables | # files |
|-----------------------------------|--------------------------|------------|------------|---------|-------------|---------|
| esm_piControl                     | <a href="#">r1i1p1f1</a> | 2100-01-01 | 2899-12-30 | 800     | 544         | 8230    |
| esm_hist                          | <a href="#">r1i1p1f1</a> | 1850-01-01 | 2014-12-30 | 165     | 545         | 1660    |
| esm_hist                          | <a href="#">r2i1p1f1</a> | 1850-01-01 | 2014-12-30 | 165     | 545         | 1660    |
| esm_hist                          | <a href="#">r3i1p1f1</a> | 1850-01-01 | 2014-12-30 | 165     | 539         | 1642    |
| esm_hist                          | <a href="#">r4i1p1f1</a> | 1850-01-01 | 2014-12-30 | 165     | 16          | 32      |
| esm_ssp245                        | <a href="#">r1i1p1f1</a> | 2015-01-01 | 2025-12-30 | 11      | 545         | 1074    |
| esm-up2p0                         | <a href="#">r1i1p1f1</a> | 1850-01-01 | 2139-12-30 | 290     | 539         | 2828    |
| esm-up2p0                         | <a href="#">r2i1p1f1</a> | 1850-01-01 | 2139-12-30 | 290     | 16          | 48      |
| esm-up2p0                         | <a href="#">r3i1p1f1</a> | 1850-01-01 | 2139-12-30 | 290     | 16          | 48      |
| esm-up2p0                         | <a href="#">r4i1p1f1</a> | 1850-01-01 | 2139-12-30 | 290     | 16          | 48      |
| esm-up2p0-gwl2p0                  | <a href="#">r1i1p1f1</a> | 1944-01-01 | 2444-12-30 | 501     | 539         | 10625   |
| esm-up2p0-gwl2p0-50y-dn1p0        | <a href="#">r1i1p1f1</a> | 1994-01-01 | 2053-12-30 | 60      | 539         | 1354    |
| esm-up2p0-gwl2p0-50y-dn2p0        | <a href="#">r1i1p1f1</a> | 1994-01-01 | 2127-12-30 | 134     | 545         | 5256    |
| esm-up2p0-gwl3p0                  | <a href="#">r1i1p1f1</a> | 1992-01-01 | 2349-12-30 | 358     | 545         | 24360   |
| esm-up2p0-gwl3p0-50y-dn2p0        | <a href="#">r1i1p1f1</a> | 2044-01-01 | 2126-12-30 | 83      | 542         | 5477    |
| esm-up2p0-gwl4p0                  | <a href="#">r1i1p1f1</a> | 2044-01-01 | 2544-12-30 | 501     | 545         | 22833   |
| esm-up2p0-gwl4p0-50y-dn1p0        | <a href="#">r1i1p1f1</a> | 2096-01-01 | 2406-12-30 | 311     | 539         | 9431    |
| esm-up2p0-gwl4p0-50y-dn2p0        | <a href="#">r1i1p1f1</a> | 2095-01-01 | 2343-12-30 | 248     | 542         | 10927   |
| esm-up2p0-gwl4p0-50y-dn2p0-gwl2p0 | <a href="#">r1i1p1f1</a> | 2233-01-01 | 2394-12-30 | 162     | 538         | 10175   |

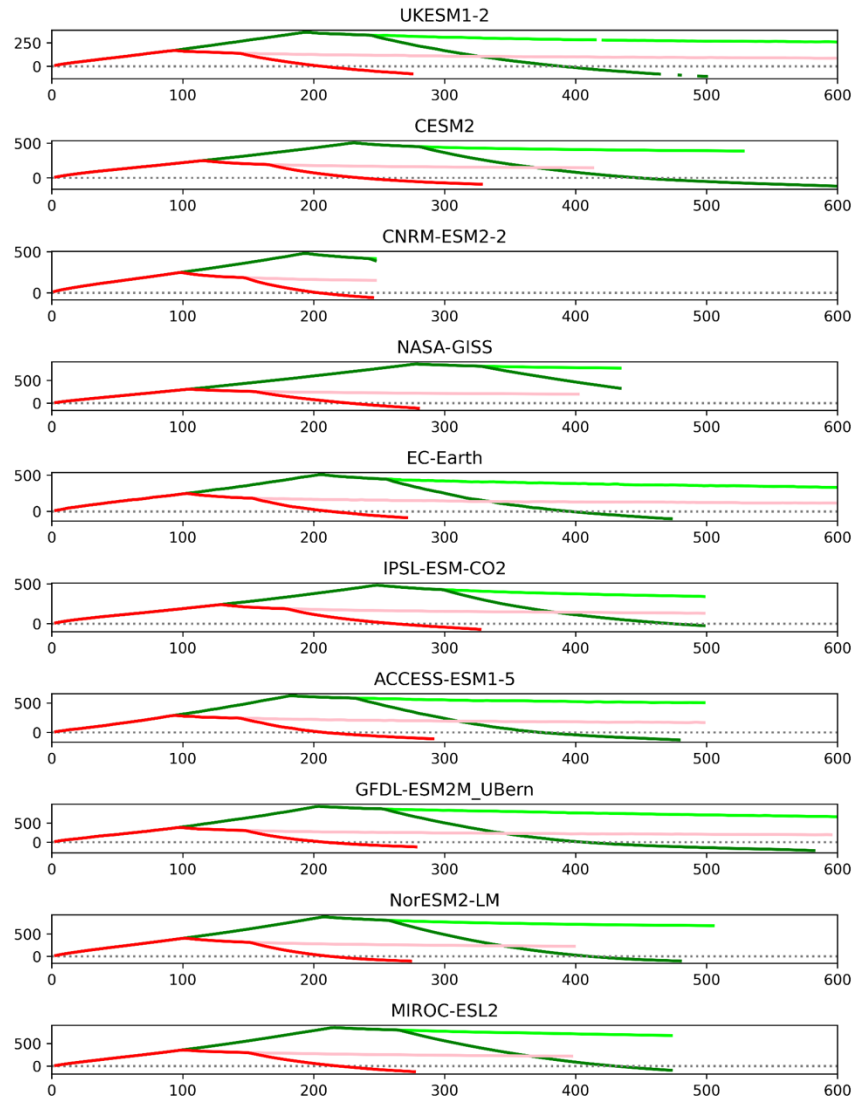
The last experiment, zero-emission run at GWL=2K branched from ramp-down from GWL=4K is being rerun

# 11 ESMs have run the experiment protocol (preliminary results from 10 shown below)

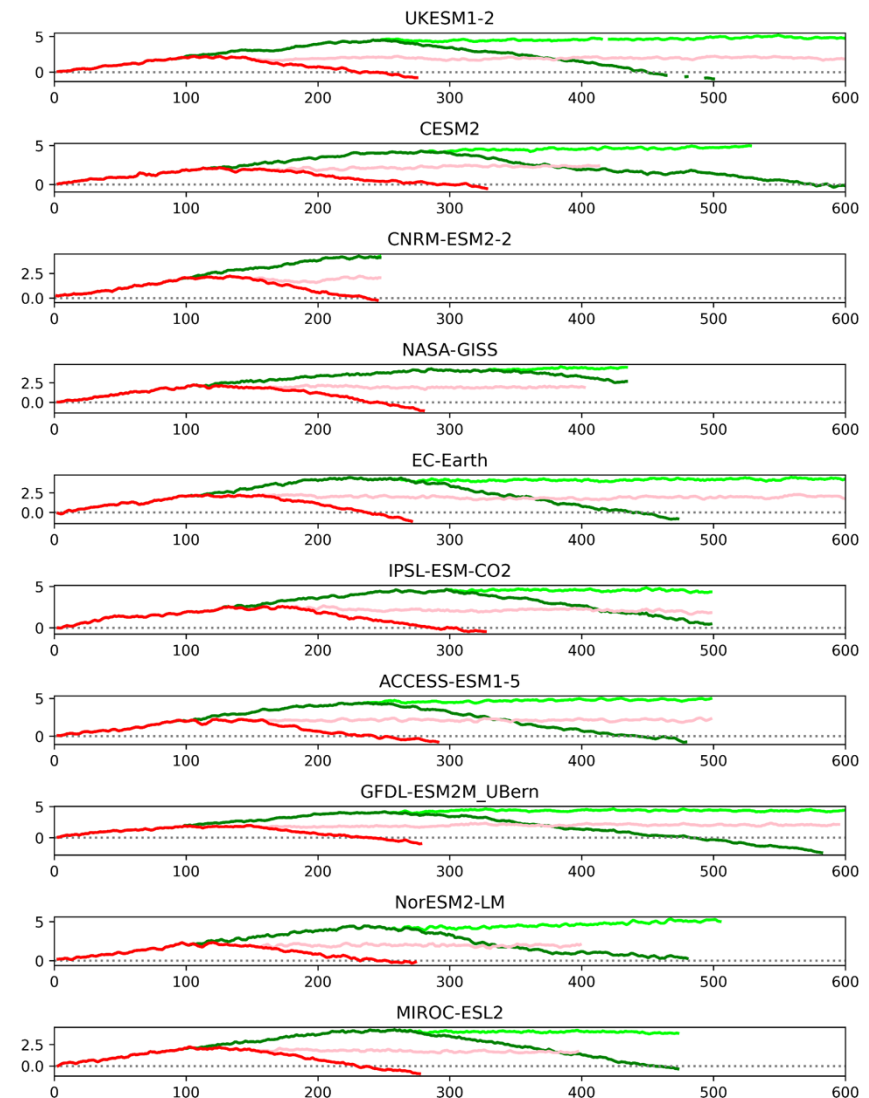
Results for ramp-up  $\rightarrow$  zero emission  $\rightarrow$  ramp-down to both  $\text{GWL} = 2^\circ\text{C}$  (red/pink) and  $4^\circ\text{C}$  (green)

Ramp up positive emission =  $+\text{XGtCyr}^{-1}$  ramp down negative emission =  $-\text{XGtCyr}^{-1}$

## Global mean atmospheric $\text{CO}_2$



## Global mean near-surface air temperature

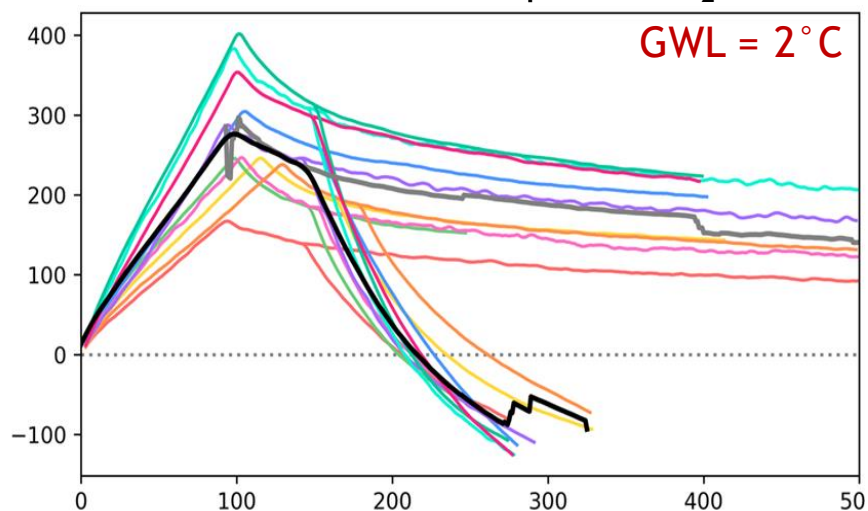


# Global mean atmospheric CO<sub>2</sub> and near-surface air temperature

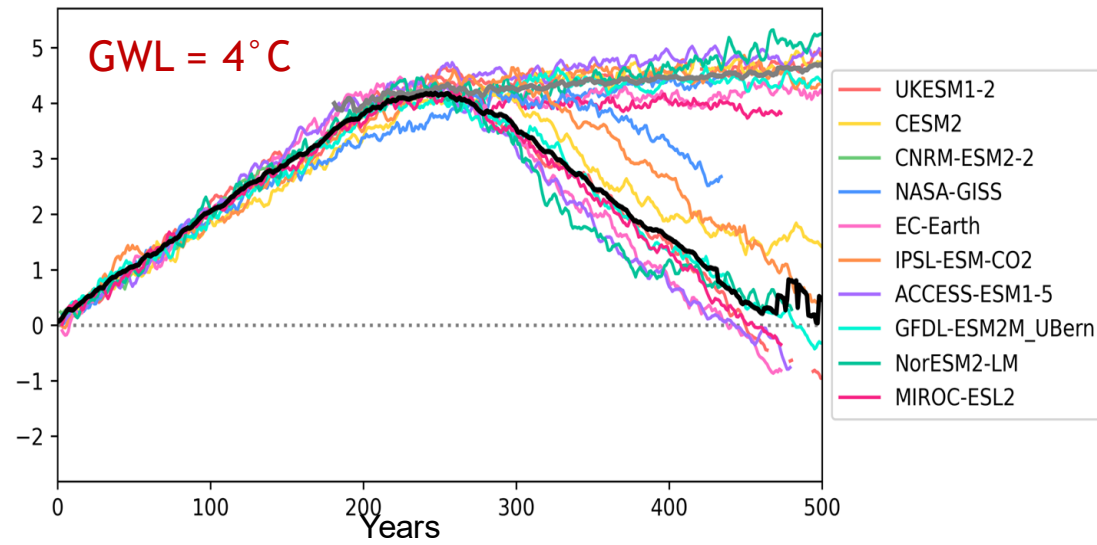
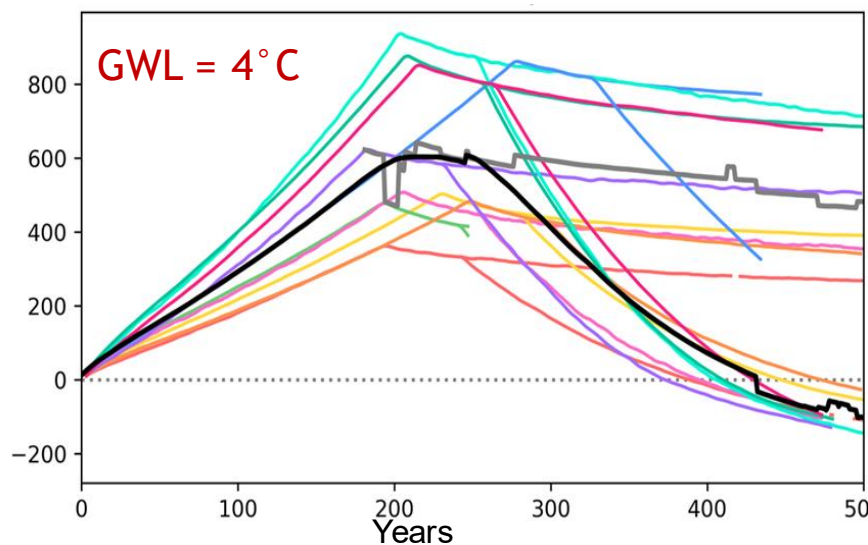
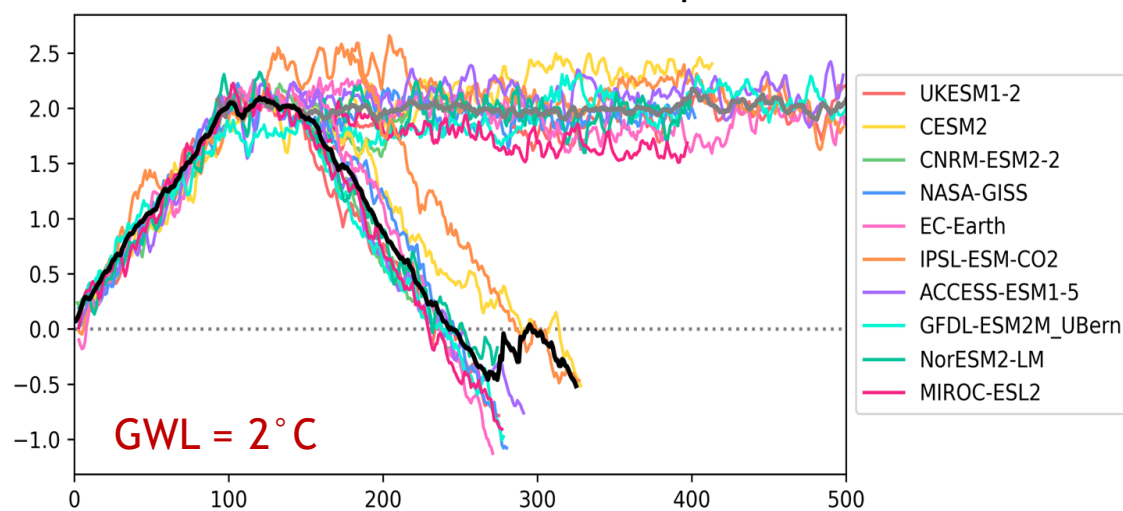
GMSAT well constrained in the ramp-up, and fairly well in the ramp-down

Different CO<sub>2</sub> emissions (and GMCO<sub>2</sub>) needed for common GMSAT evolution in ramp-up

## Global mean atmospheric CO<sub>2</sub>

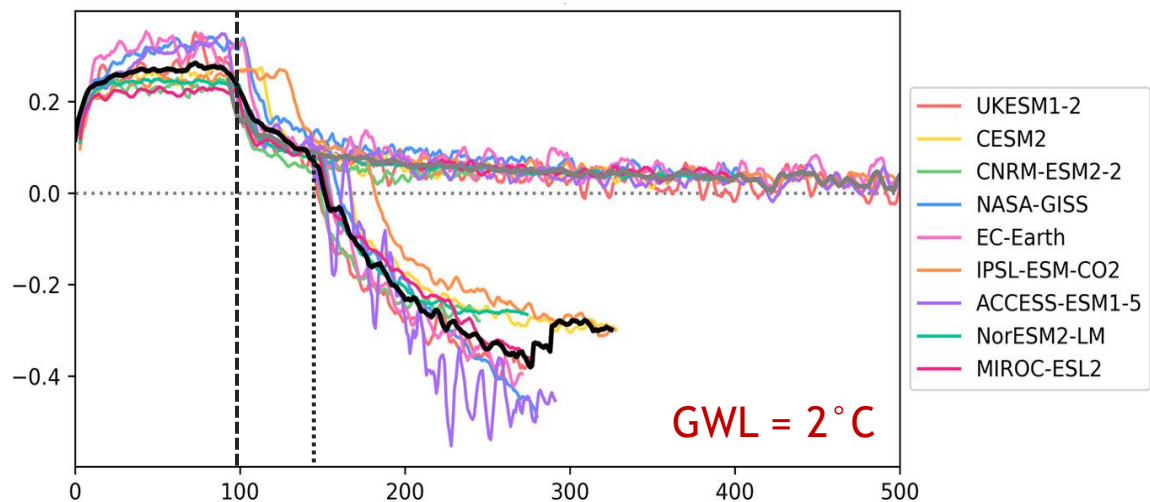


## Global mean near-surface air temperature

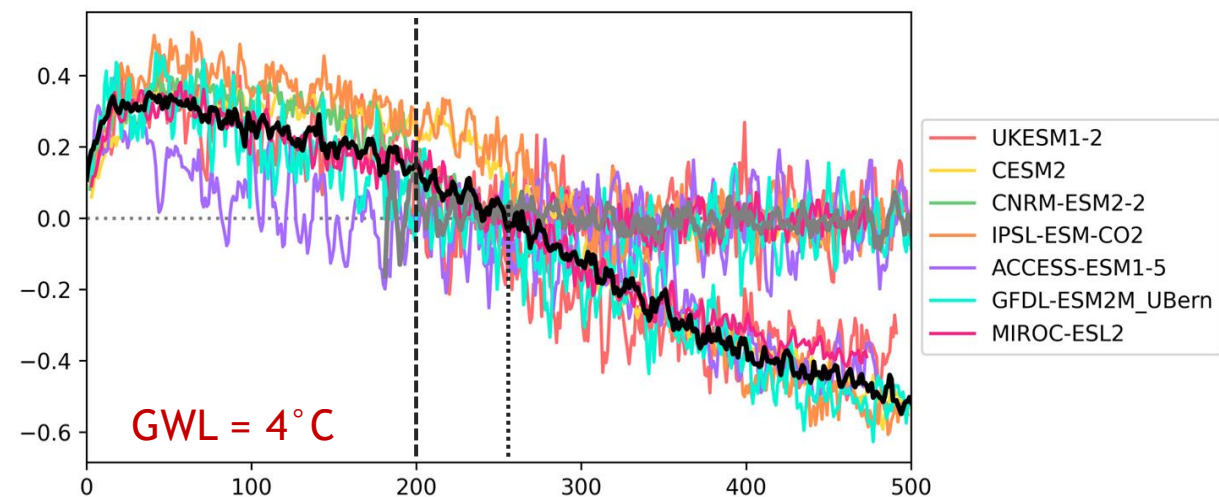
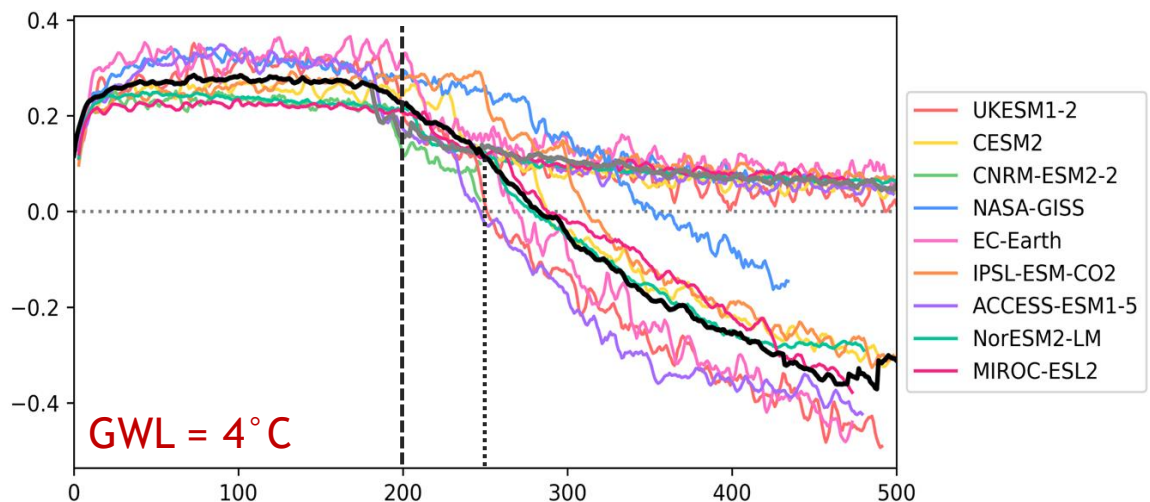
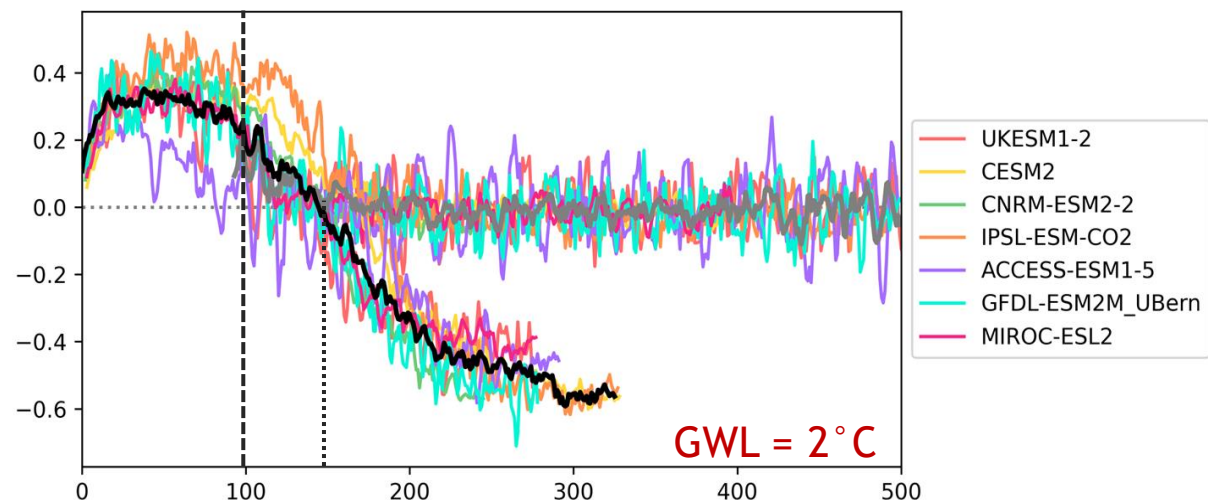


Global mean CO<sub>2</sub> flux into the ocean and land expressed as a fraction of the prescribed ramp-up emission rate for each model

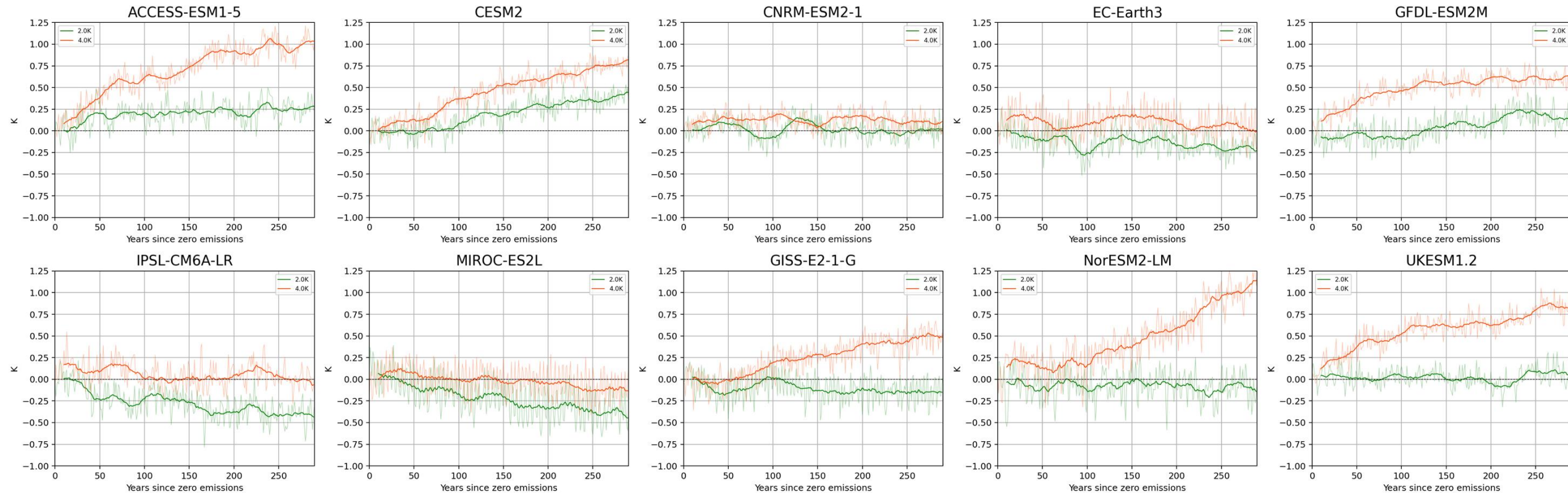
Atmosphere to ocean flux



Atmosphere to land flux



# Global mean surface air temperature in zero-emission runs as $\text{GWL} = 2^\circ\text{C}$ and $4^\circ\text{C}$ for 10 ESMs following the TIPMIP protocol



In all models  $\text{ZEC}(\text{GWL}=4\text{K})$  is greater than  $\text{ZEC}(\text{GWL}=2\text{K})$

A number of model's (~8) data (following the TIPMIP diagnostic request) will be published on the ESGF over the coming month, following CMIP6plus standards.

Within the TIPMIP collaboration a number of multi-model analysis papers are being worked on. People are invited to add potential papers into this list.

[\[TIPMIP-INTERNAL\] TIPMIP papers - Google Sheets](#)