WIEMIP Climate Overshoot Protocol

WIEMIP will use ScenarioMIP data (embargoed until September 2026) to understand a range of questions related to overshoot and stabilisation dynamics, guided by the following questions which are aligned with WG1 CH9 of the IPCC (Schleussner et al., 2025, concept note):

- Outcomes under warming level stabilisation over time
- Outcomes of overshoot vs non-overshoot at peak
- Long-term outcomes of overshoot including reversible and irreversible effects
- Avoided long-term outcomes of exposure to peak temperatures by global temperature reversal
- Avoided outcomes by limiting overshoot
- Avoided long-term outcomes by limiting peak warming and reversing overshoot
- Outcome dependence on overshoot characteristics, peak, length, integral

The baseline set of simulations will be derived running the UKMO PRIME workflow to generate future climate forcing for land surface models (LSMs) using the ScenarioMIP L, HL, and M scenarios, along with a specifically designed HL counterfactual (HL-CF). PRIME will generate scenarios using the UKESM, GFDL, and IPSL GCM patterns. WIEMIP will also provide forcing data for the rest of the ScenarioMIP scenarios (and counterfactuals) for models that have capacity to run more simulations (potentially including an optional non-ScenarioMIP emissions pathway created for the current set of NDCs and LTSs).

Description of the WIEMIP-CRUJRAv3.5 meteorological data for historical and future

WIEMIP provides a set of meteorological data derived from the CRUJRAv3.5 dataset from GCB-2025 that extends from 1850-2023 (WIEMIP-CRUJRAv3.5). To produce WIEMIP-CRUJRAv3.5, CRUJRAv3.5 is first aggregated to daily from 6-hourly and then downscaled to 6-hourly using the JULES weather generator. The purpose of the JULES weather generator (IMOGEN) (Huntingford et al. 2010) to downscale daily CRUJRAv3.5 to 6-hourly is to ensure consistency across historical and future diurnal distributions.

Daily and monthly sums and global and regional totals of WIEMIP-CRUJRAv3.5 are very similar to CRUJRAv3.5. 1850-1900 in the WIEMIP-CRUJRAv3.5 dataset are recycled 1901-1920 data (i.e., repeating 1901-1920 ~2.5 times).

The data for WIEMIP future runs is produced by the PRIME workflow (Mathison et al., 2025) using ScenarioMIP emissions for the period 2024-2300. In addition, counterfactuals to different overshoot scenarios are provided that hold peak temperature constant. FaIR parameterization #867236 from calibration 1.6.0 (Smith 2026) was used in PRIME to simulate the temperature response to different emissions pathways.

Applying constant 2023 land use and land cover

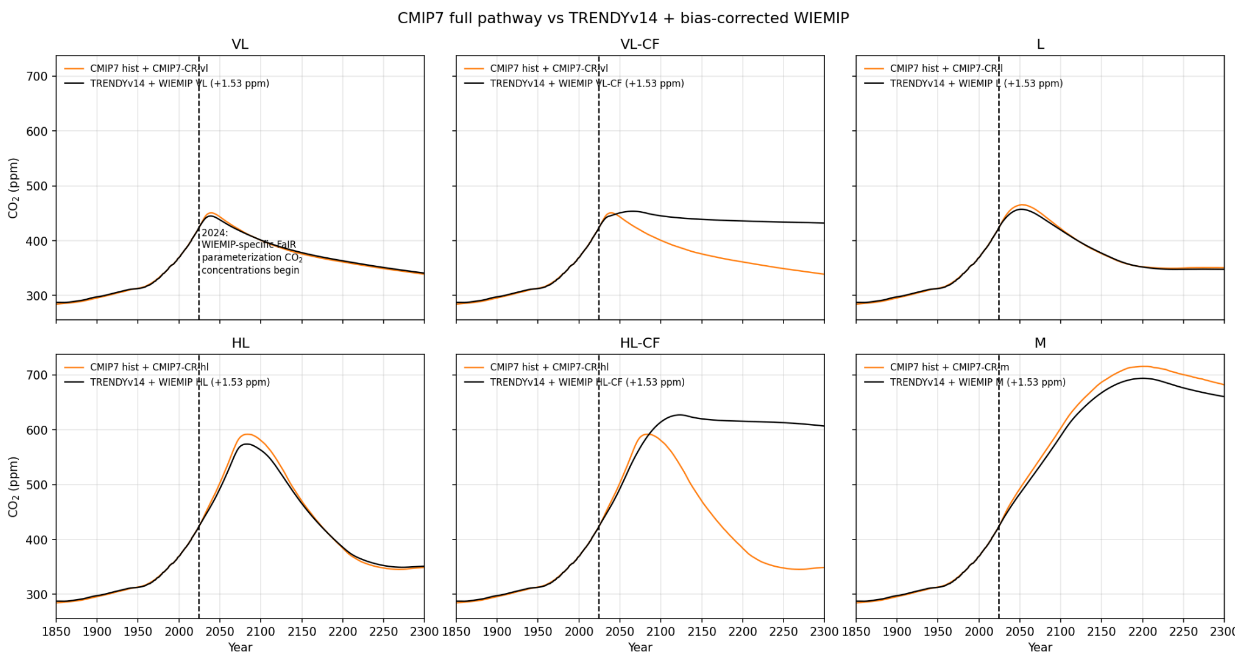
WIEMIP will require models to apply constant land cover (LC) and constant or disabled land use (LU) fixed at 2023 through the historical and future runs. Future LULC scenarios and their extensions to 2300 are not available as of late May, 2026, and may not be available for some time and thus no appealing option exists for specifying future LULC. Though historical LULC datasets are available through CMIP7 or LUH-GCB, switching from transient historical LULC to constant future LULC risks artificial regrowth and/or deforestation. To ameliorate this issue, WIEMIP has decided to require modelers to apply constant LC and constant or disabled LU using 2023 values of LUH-GCB2025. By allowing models to attain an equilibrium LULC state through spinup, historical, and future, the risk of regrowth/deforestation is minimized. In addition, constant LULC will help ensure that WIE responses are not entangled with LULC responses.

Each model must ensure that there are no spikes in fluxes or jumps in pools/stocks at the start of each simulation phase. For example, abruptly applying 2023 LULC at the start of the historical run may lead to artificial changes in the fluxes and stocks. Therefore, WIEMIP recommends a "'land use" spinup phase to allow models to reach equilibrium before forcing with transient climate, CO_2, nitrogen deposition, and so forth. The treatment of wood harvest and other land use types must be specific to each model to ensure equilibrium and prevent runaway deforestation or regrowth.

Treatment of the CO_2 driver

WIEMIP will include counterfactual simulations for which CO_2 pathways are not available through input4MIPs. One of the purposes of the counterfactual simulation is to understand the impacts of coming down from overshoot versus staying at a certain global warming level (GWL). WIEMIP will use bias-corrected FaIR-generated CO_2 concentrations for all future simulations to ensure uniform CO_2 concentrations across scenarios and their counterfactuals. To bias-correct, WIEMIP will use historical TRENDY CO_2 concentrations from TRENDYv14. The historical CO_2 concentrations are available up to 2024 (2024 [CO_2]=422.77ppm), so the first value of the FaIR generated [CO_2] is bias corrected to match 422.77ppm. The WIEMIP CO_2 pathways differ from the official CMIP7 future CO_2 concentrations (see figure below), but are essential for intercomparability of counterfactual and other runs.

Figure 1: WIEMIP future CO_2 concentrations. The plot shows historical and future CMIP7 [CO_2], TRENDYv14 historical CO_2 concentrations, and bias-corrected future WIEMIP concentrations.



Simulation protocol

- **Spinup run**
    - Models should spin up using their standard method to achieve a pre-industrial (PI) equilibrium state with 2023 LULC. Spin up using recycled meteorology data

from the first 20 years of WIEMIP-CRUJRAv3.5 (1850-1869). Fix LULC at the 2023 state using LUH2-GCB2025. Apply 2023 nitrogen fertilisation rates from the LUH2-GCB2025 driver. Use a PI CO_2 concentration of 287.43 ppm (taken from TRENDYv14 historical CO_2 at 1850). All other drivers (population, nitrogen deposition, ozone) should be held at 1850 values.

- **Control run (1851-2023)**
  - The control run is a continuation from the spin-up and used to quantify any residual drifts or trends in model output (analogous to TRENDY S0). It should use the same forcing (fixed CO_2, fixed 2023 land-use, recycled 20-year climate, fixed nitrogen deposition, fixed ozone) as the spin-up. Models should output variables for the control run as detailed in the variable request, though focusing on first priority carbon stocks and fluxes is acceptable. The control run should extend at least as long as the historical simulation (174 years).
- **Historical run (1851-2023)**
  - Use WIEMIP-CRUJRAv3.5 meteorology data and historical global annual CO_2 concentrations. CO_2 concentrations are from TRENDYv14. Use constant 2023 LULC from LUH2-GCB2025 and apply 2023 LUH2 nitrogen fertilisation. See section “Constant 2023 land use and land cover” for details on how constant LULC should be applied. Other drivers (nitrogen deposition, population, and ozone) should vary through time. If a non-meteorology driver does not extend to 2023, the last available year of the driver should be repeated. This run is similar to the GCB TRENDY S2 simulation but with 2023 instead of 1700 land cover and nitrogen fertiliser values.
- **Future runs (2024-2300) (required: L, HL, HL-CF, and M)**
  - Use the provided future climate datasets and future annual global CO_2 concentrations. All other drivers (nitrogen deposition, population, and ozone) should be held at their last available historical year (e.g., 2023 or 2022) for the duration of the future simulations.

Note: If a driver is not mentioned above, the choice of driver is up to the modeler (e.g., lightning). However, we ask that each ancillary driver is held constant during the spinup run, transient during the historical run, and constant once the historical record ends (in the same way as other non-meteorological drivers are handled in the protocol).