23rd Century Surprises: Long-term Dynamics of the Climate and Carbon Cycles under Mitigated and Unmitigated Global Warming Scenarios

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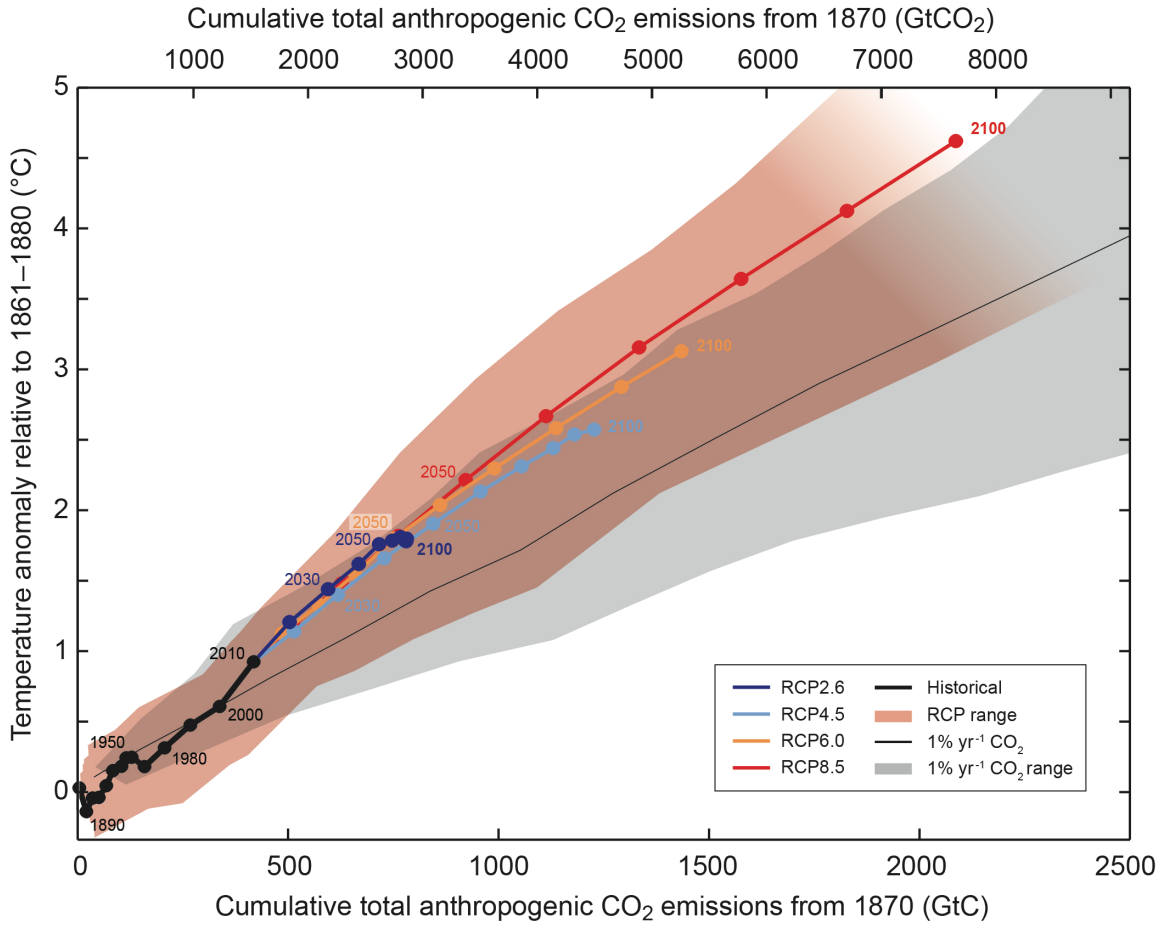
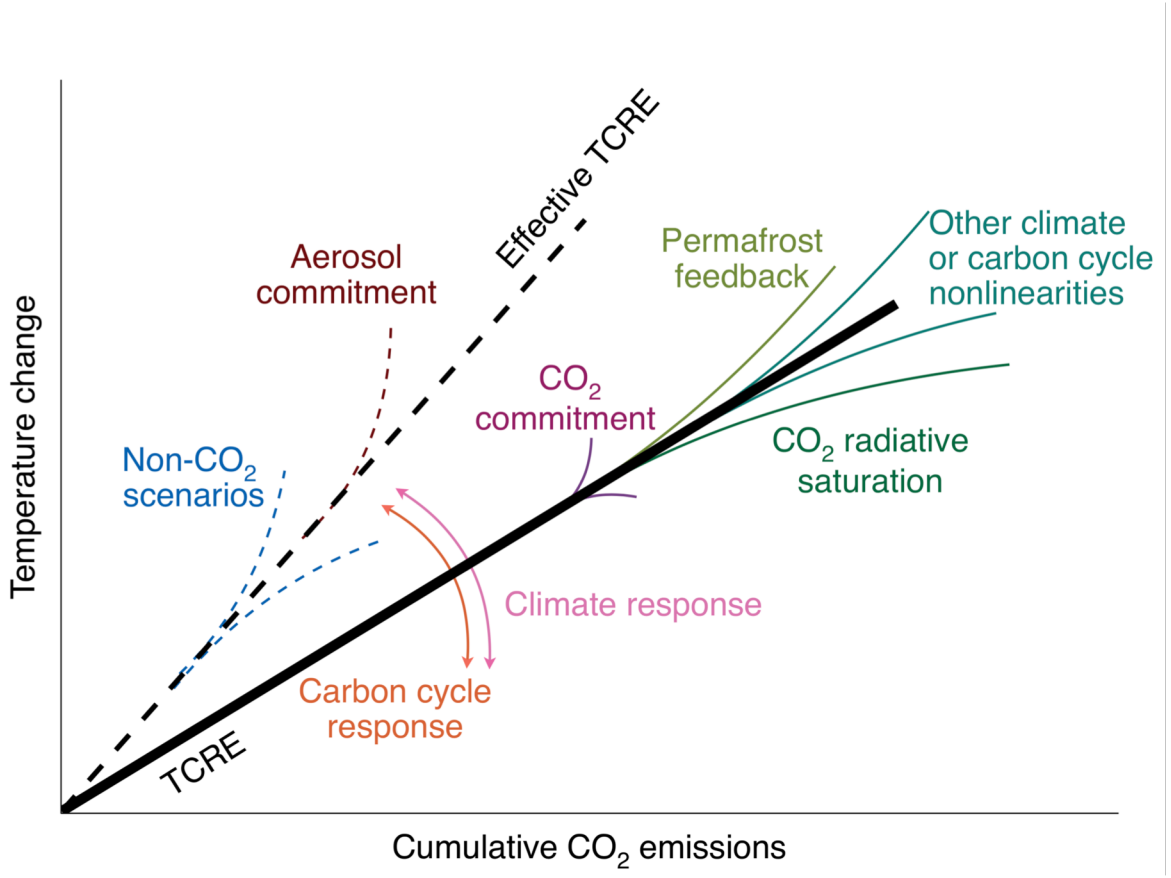
RUBISCO

REDUCING UNCERTAINTIES IN BIOGEOCHEMICAL INTERACTIONS THROUGH SYNTHESIS AND COMPUTATION

Background: what would constitute a surprise?

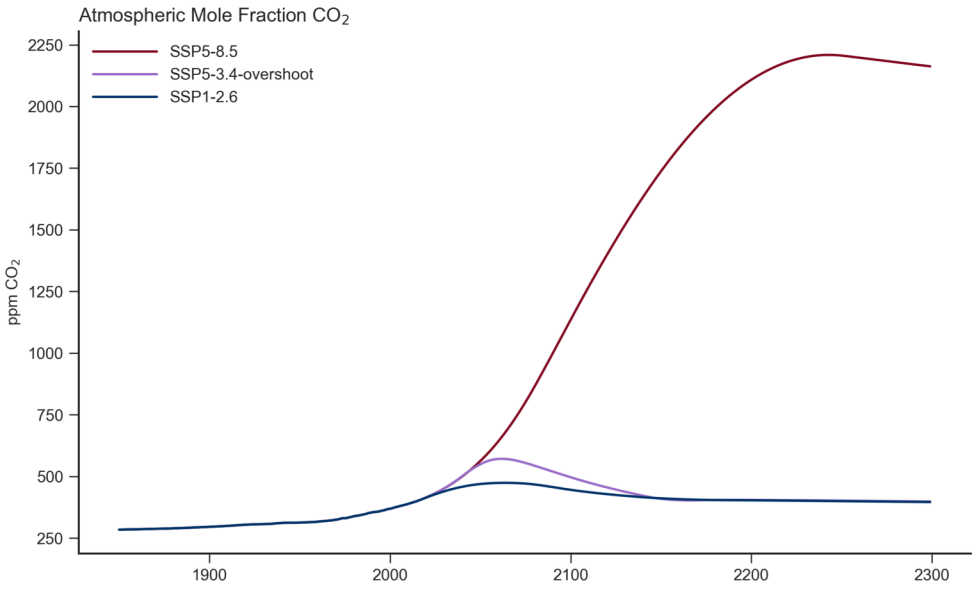


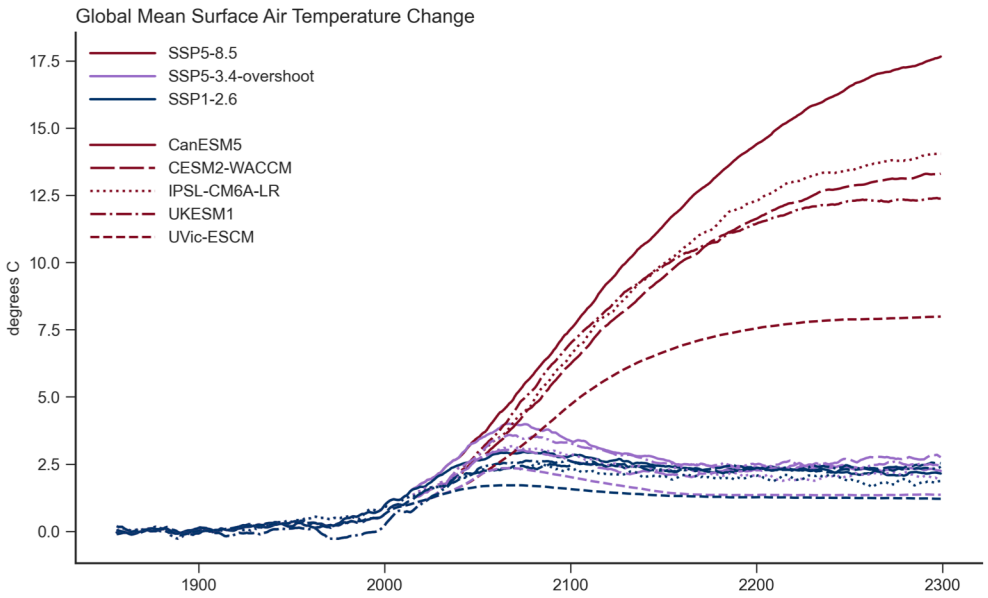
IPCC AR5, fig. SPM10



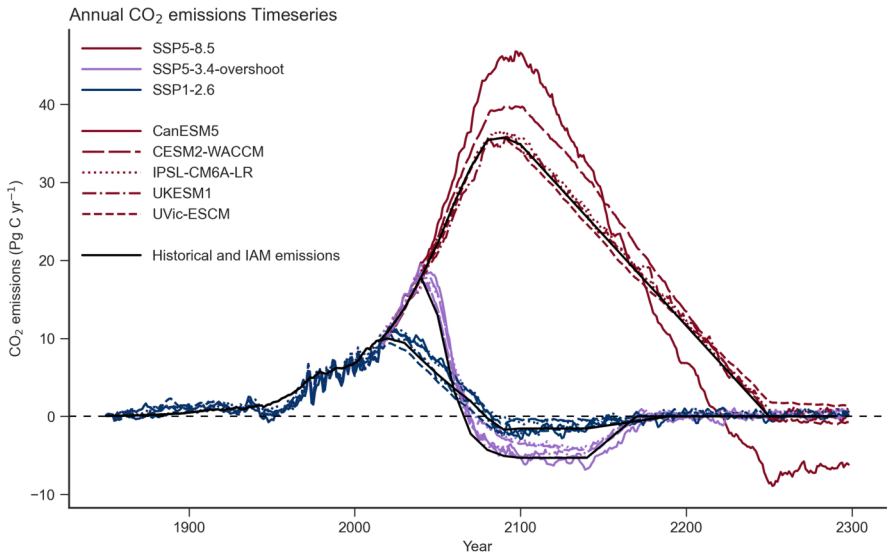
Matthews et al., 2020

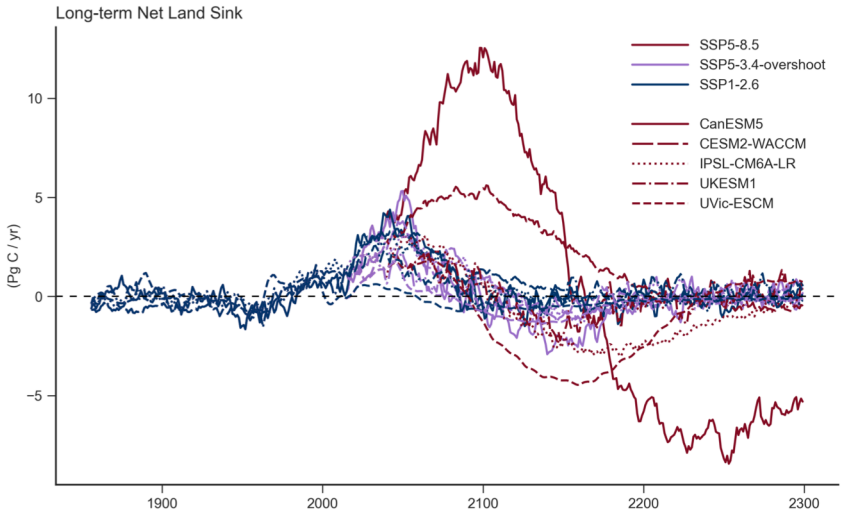
Three different long-term future scenarios: very-high emissions (SSP5-8.5), late mitigation and overshoot (SSP5-3.4-os), or early mitigation and stabilization (SSP1-2.6)

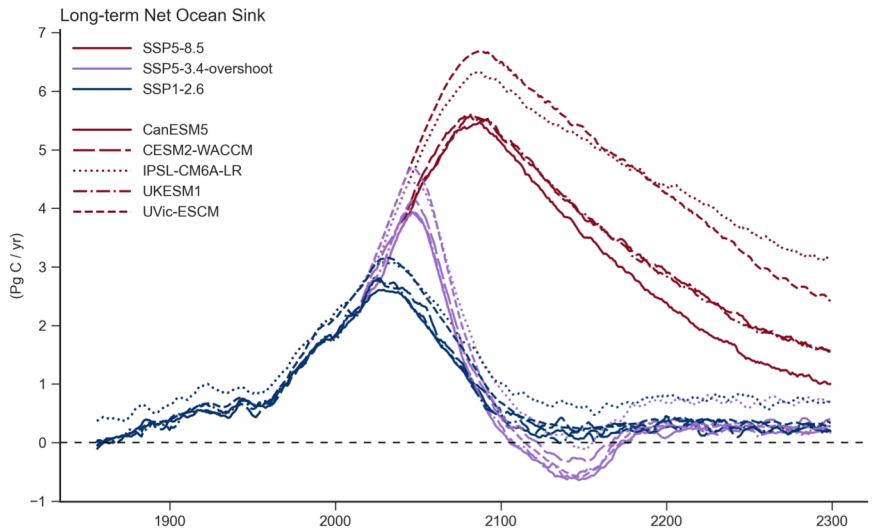




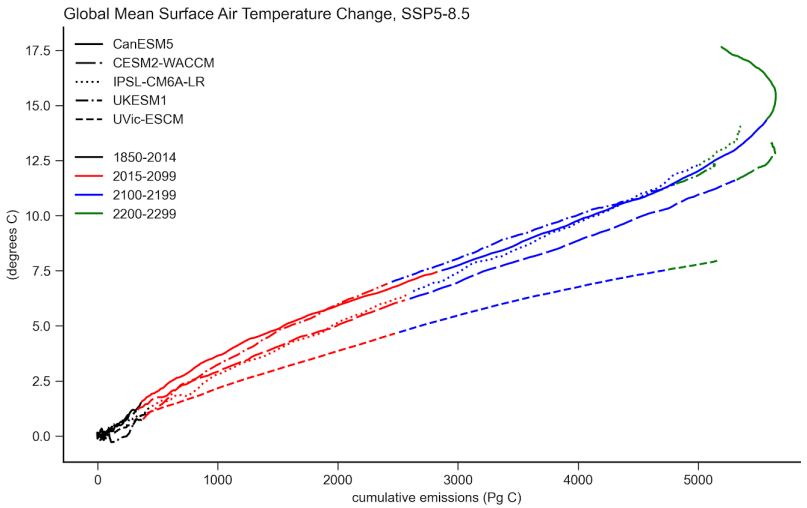
Emissions mainly drive sinks (and sources), particularly in the ocean

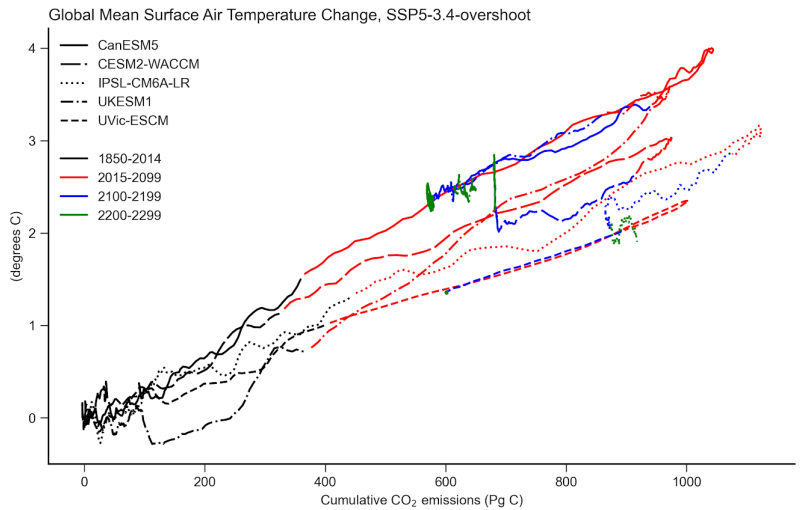


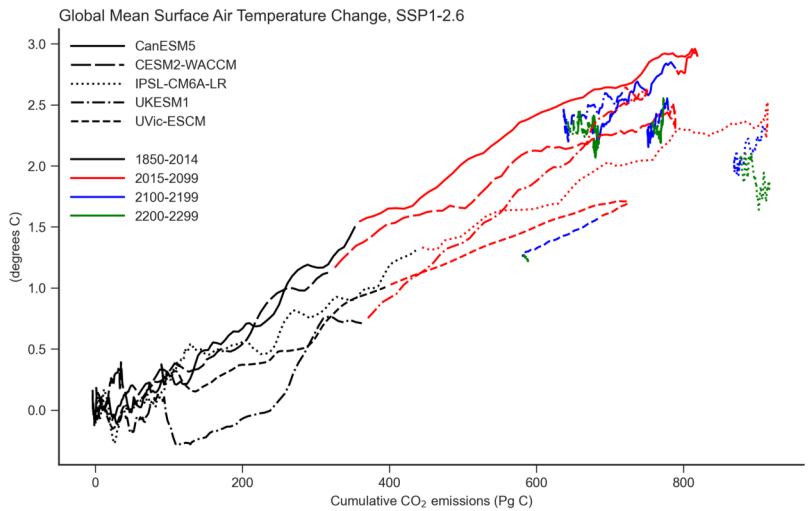




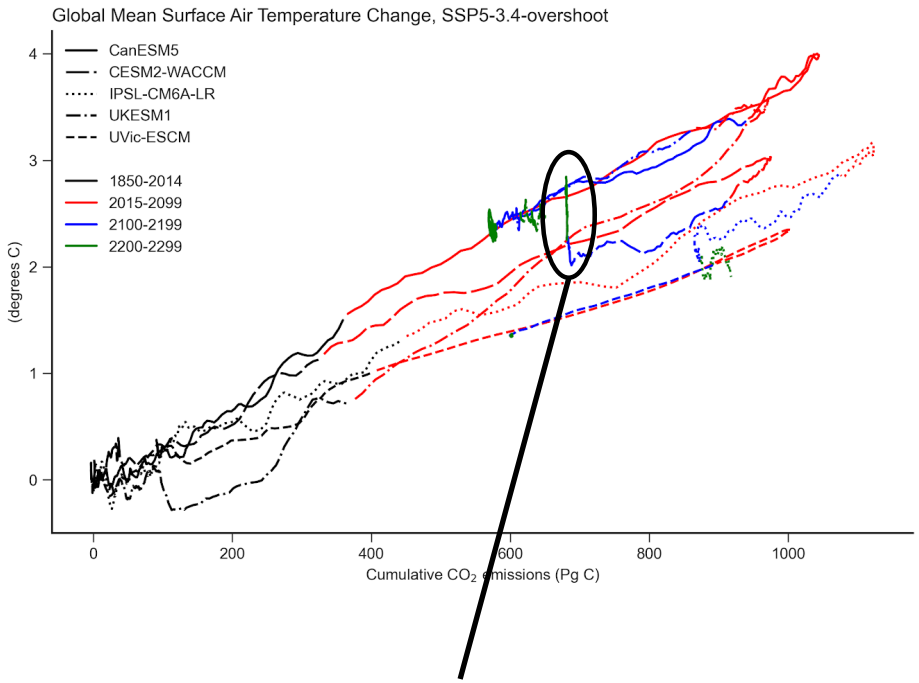
Temperature vs Cumulative Emissions plots for three scenarios: linearity (mostly) holds



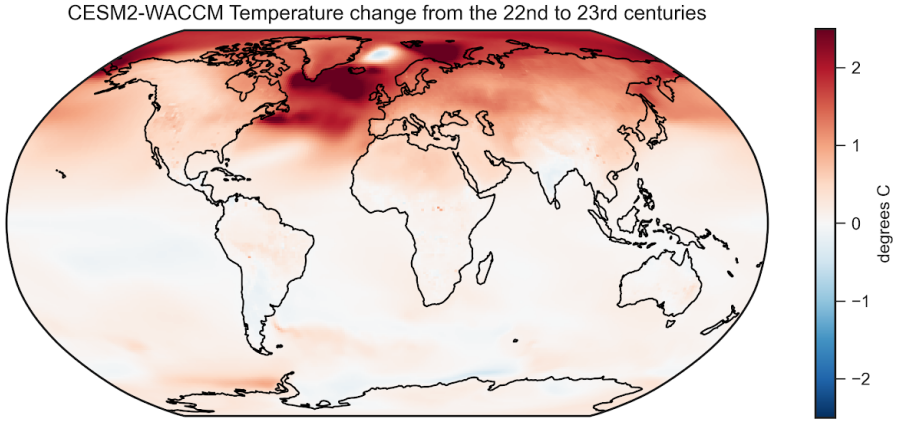


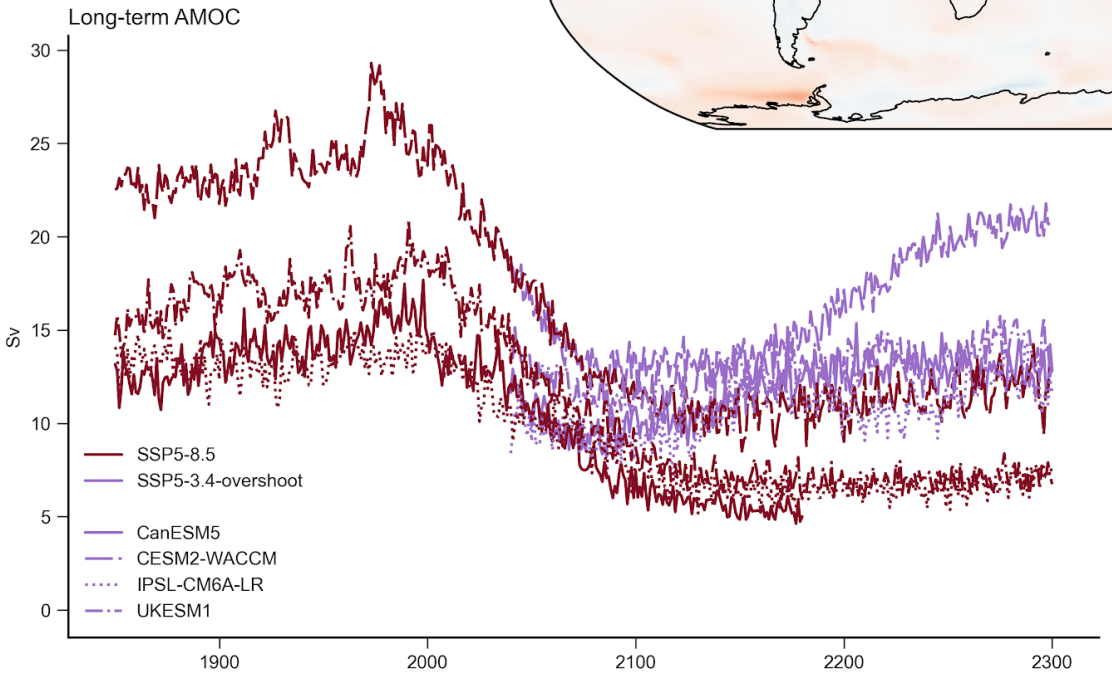


Why the nonlinearity in CESM2 T-CE plot in SSP5-3.4-os?

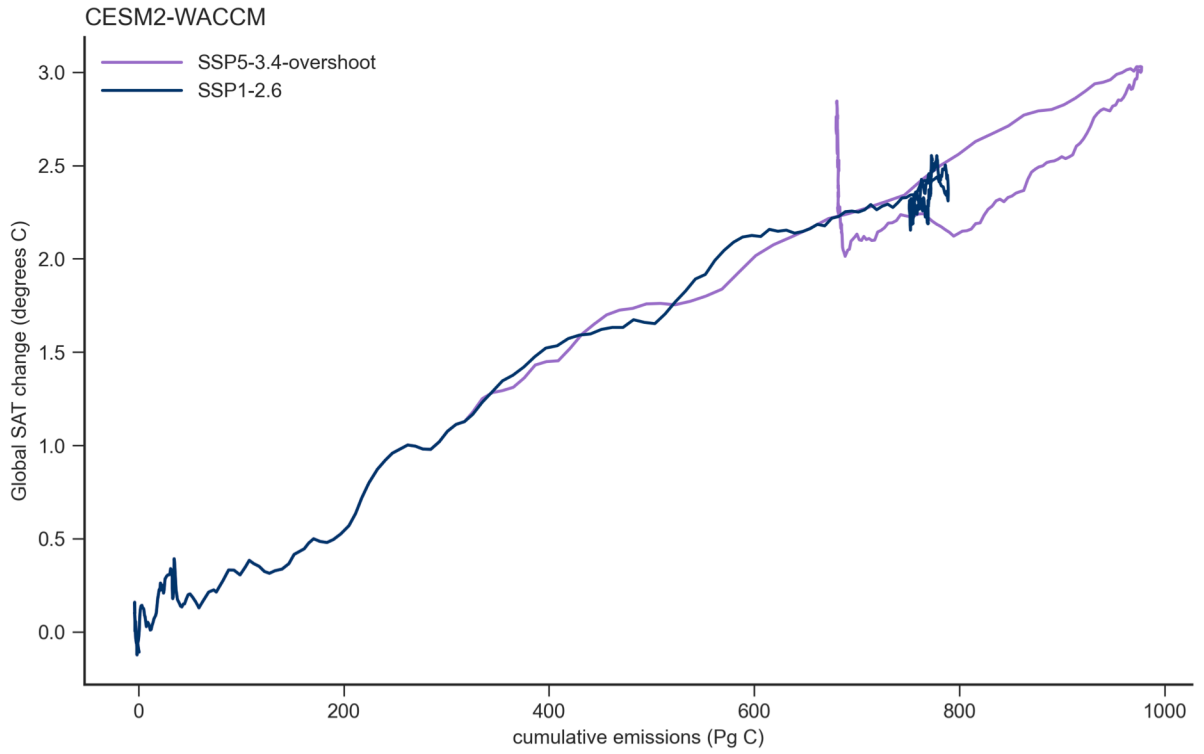


CESM2 23rd-century warming

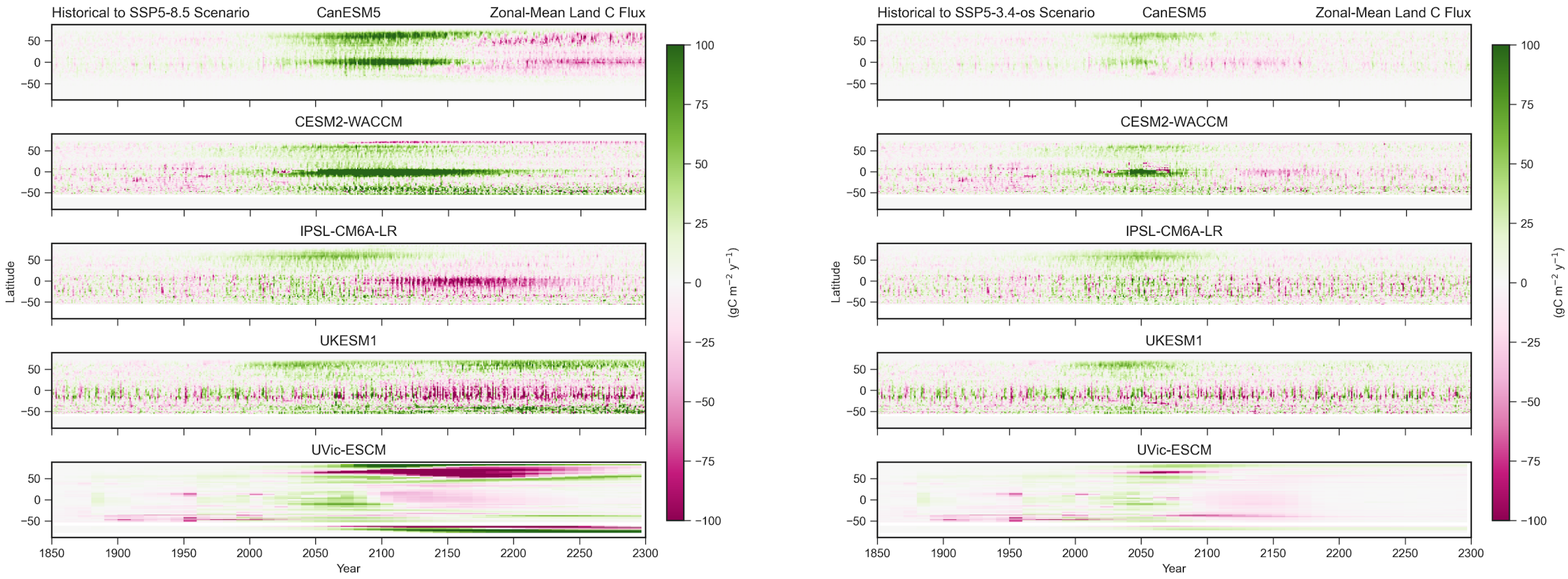




CESM2-WACCM 33rd century rebound in temperature only seems to happen in SSP5-4.3-os, not SSP1-2.6

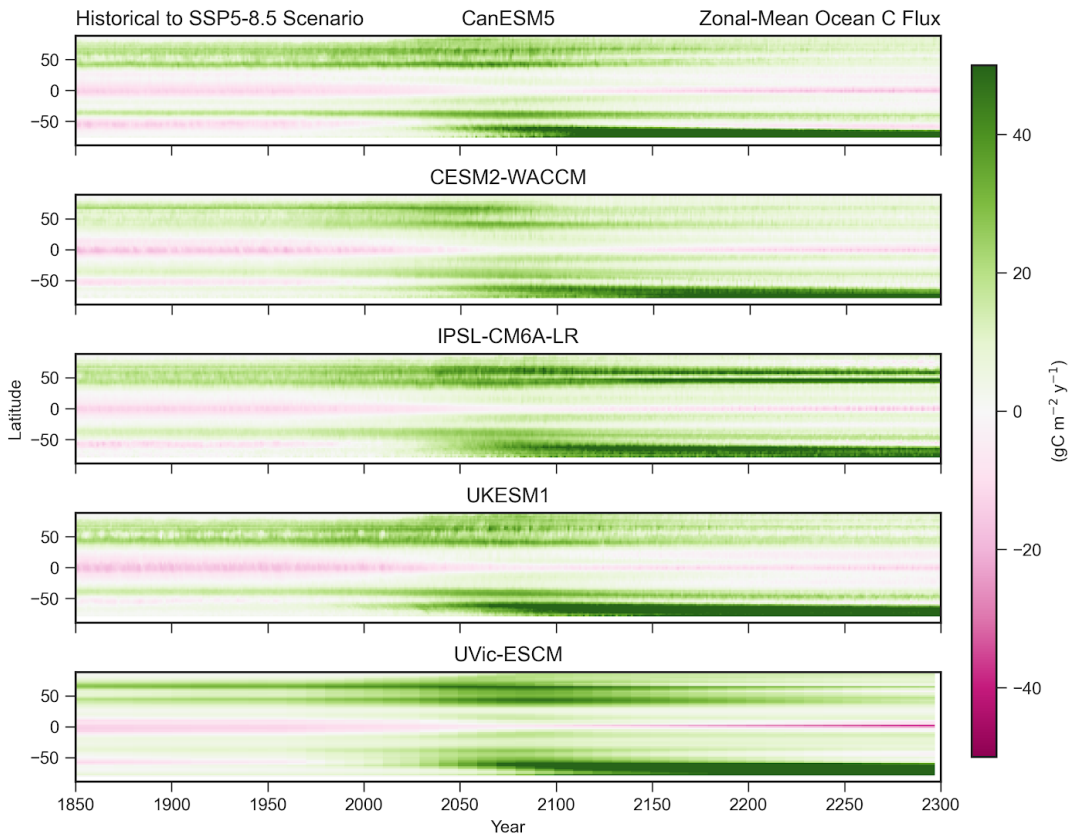


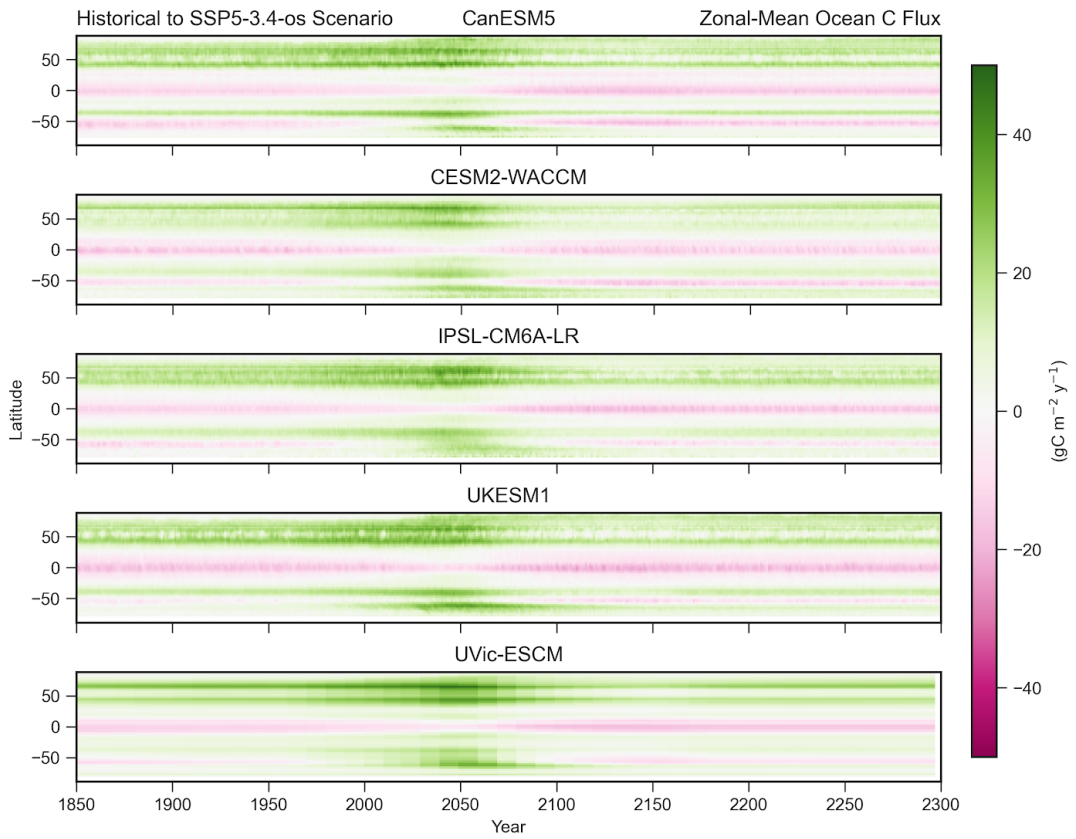
Where actually does the carbon go?—Land



Land models just completely disagree on spatial and temporal patterns of carbon fluxes, particularly in high-warming scenario

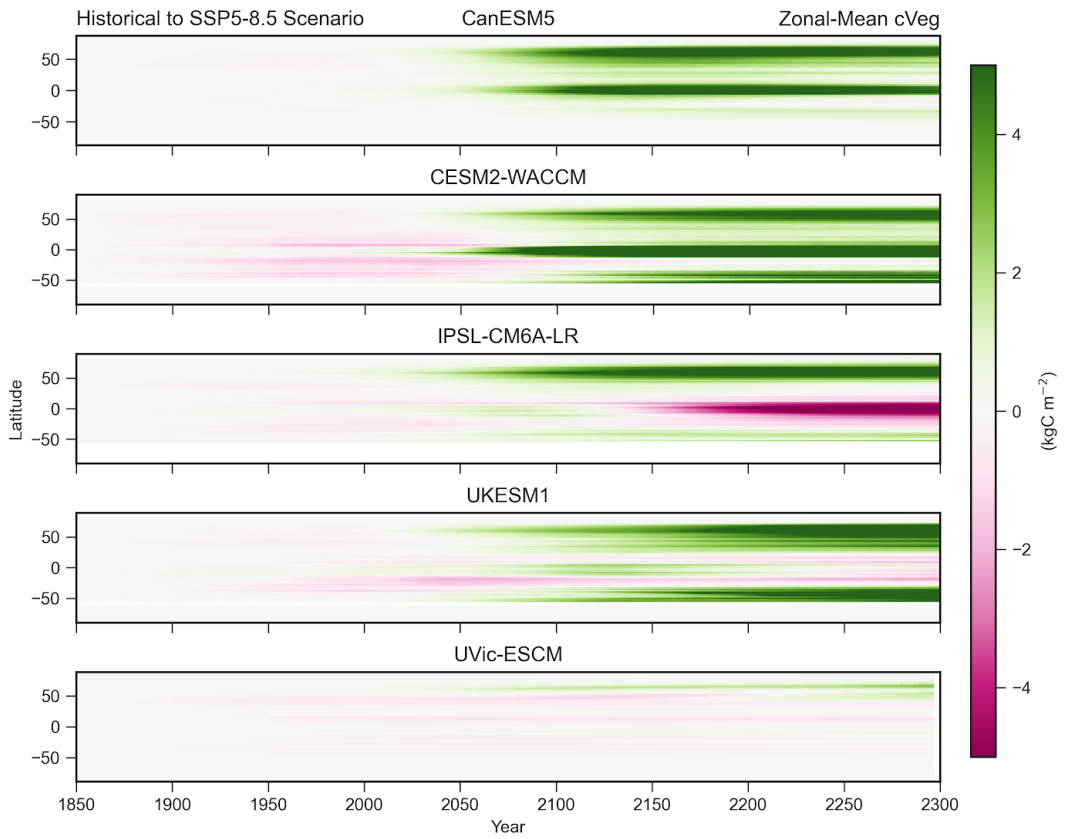
Where actually does the carbon go?—Ocean

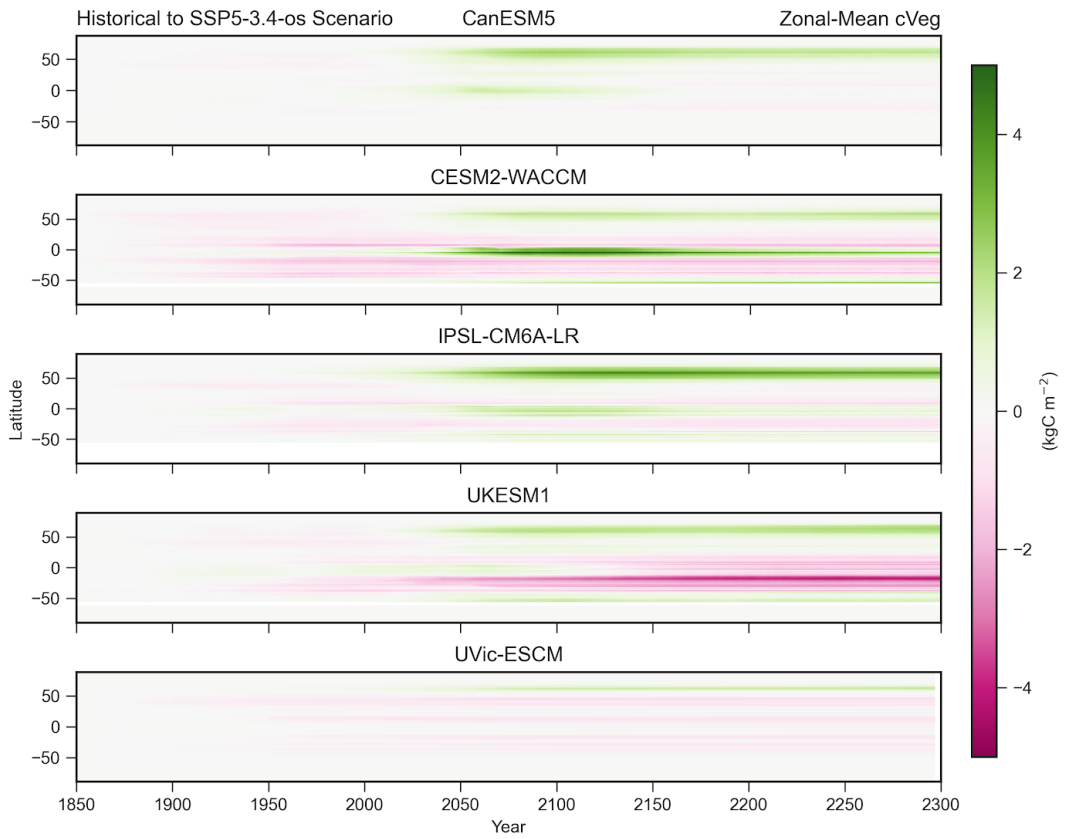




Ocean models show qualitative agreement on patterns, even when ensemble spread is wide.

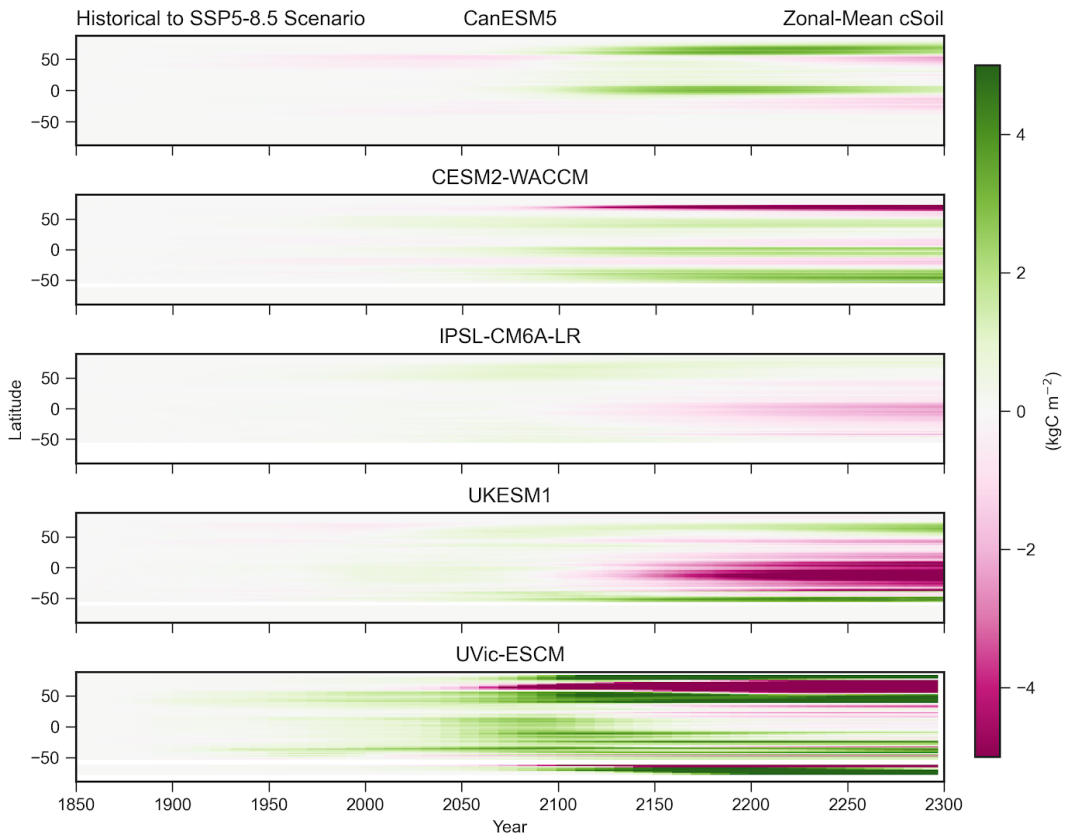
Where actually does the carbon go?—Veg

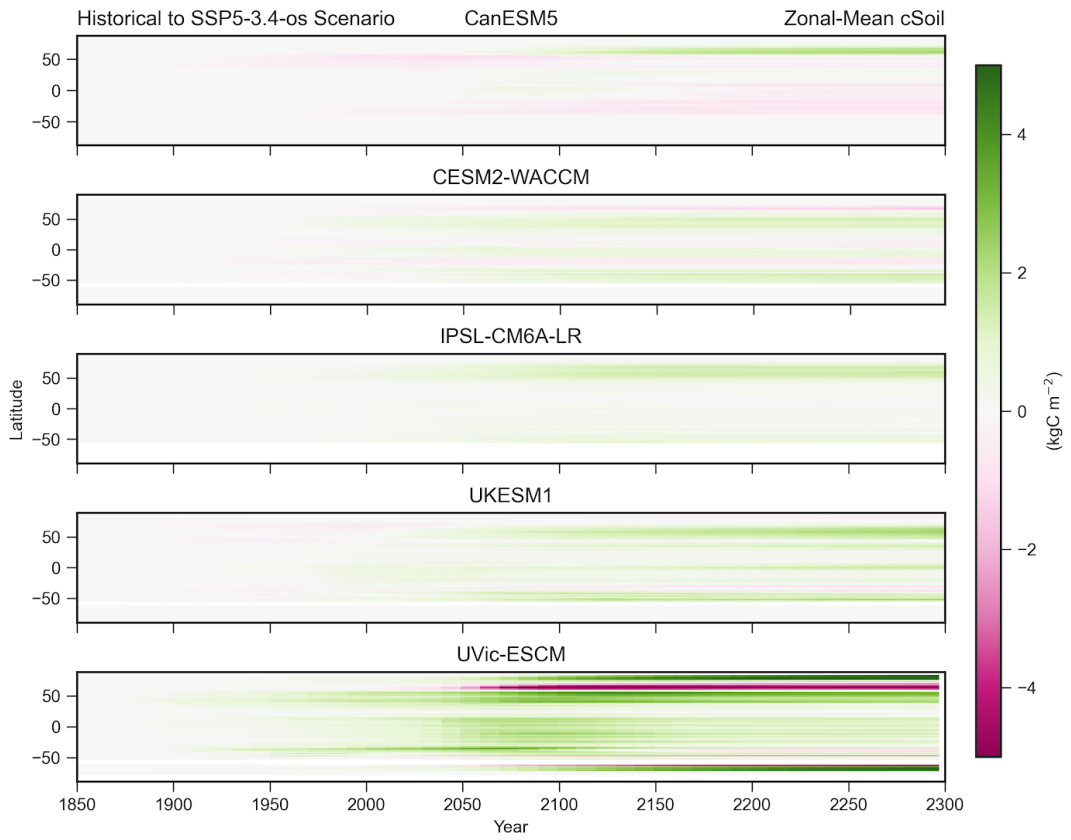




Splitting land model response into vegetation versus soils makes qualitative disagreement even more apparent…

Where actually does the carbon go?—Soils





Splitting land model response into vegetation versus soils makes qualitative disagreement even more apparent…

What do we learn from all this?

- Linearity of T-CE paradigm mostly holds through wide range of emissions
  - Possible wildcard of AMOC, which mitigates warming during the collapse phase, may lead to reëmergence of warming during recovery phase?
- We can expect sink-to-source transitions in strong overshoot scenarios on both land and ocean, and possibly in high-emission scenarios on land, but for very different reasons.
- Land carbon cycles disagree in just about every possible way
  - Which zonal bands are most active
  - Signs and strengths of veg vs soil responses
  - Timing and century-to-century continuity of patterns
- Ocean carbon cycles agree quite well in patterns, though ensemble spread still widens after 2100