

Global carbon budget variations in emission-driven Earth system model predictions



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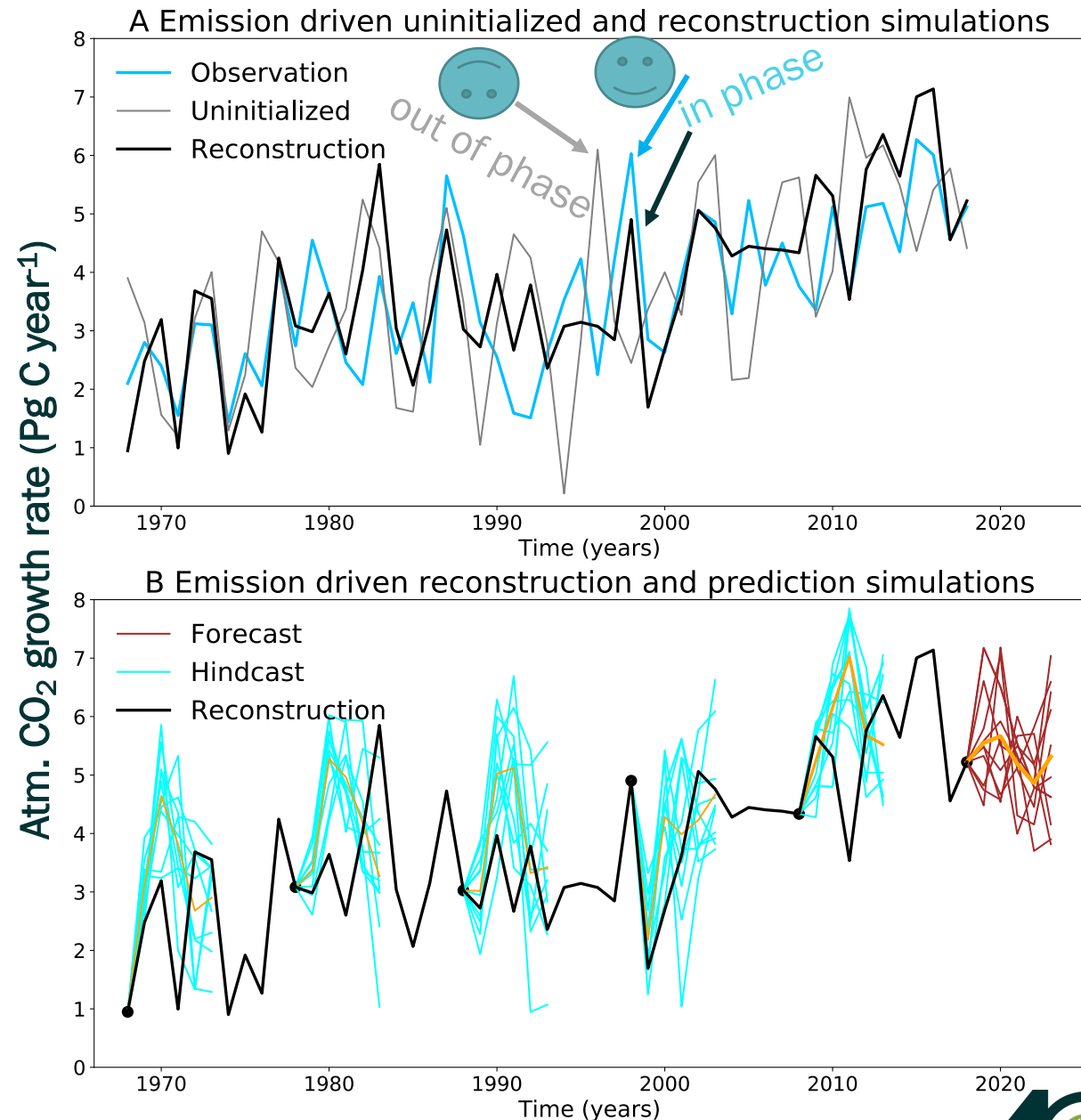
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Prediction system

Model: MPI-ESM1-2-LR

Ensemble size: 10 members

- **Uninitialized:** freely evolving simulations
- **Reconstruction:** Variations of the global carbon budget are **reconstructed with nudging** ERA40&ERA-interim T, vor, div, log P, ORAS4 ocean T&S, and NSIDC sea-ice into the ESM.
- **Predictions:** including hindcasts and forecasts **initiated** from the reconstructed states.



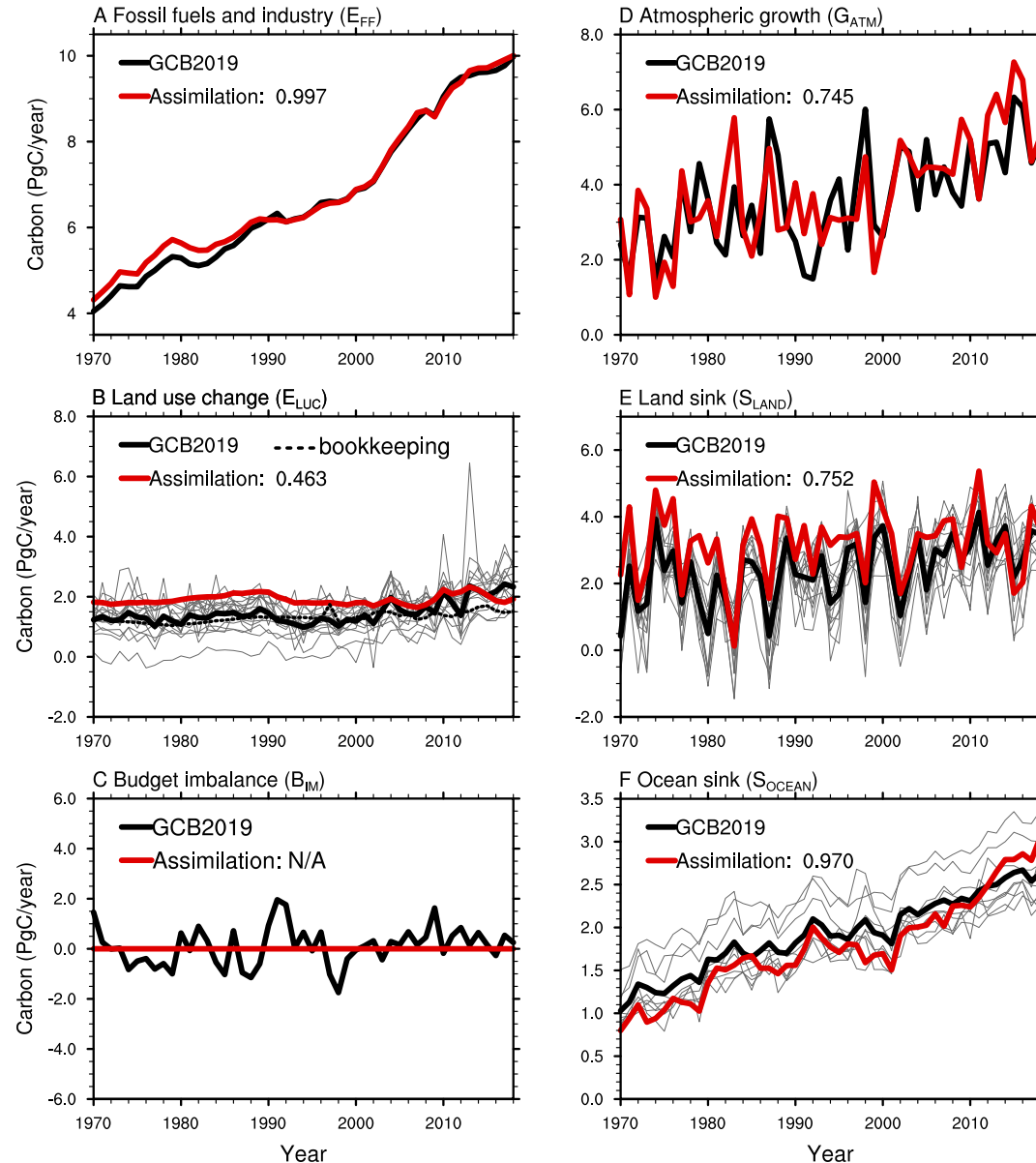
Observation is from NOAA-ESRL data (Dlugokencky et al. 2019)

Reconstruction of global carbon budget

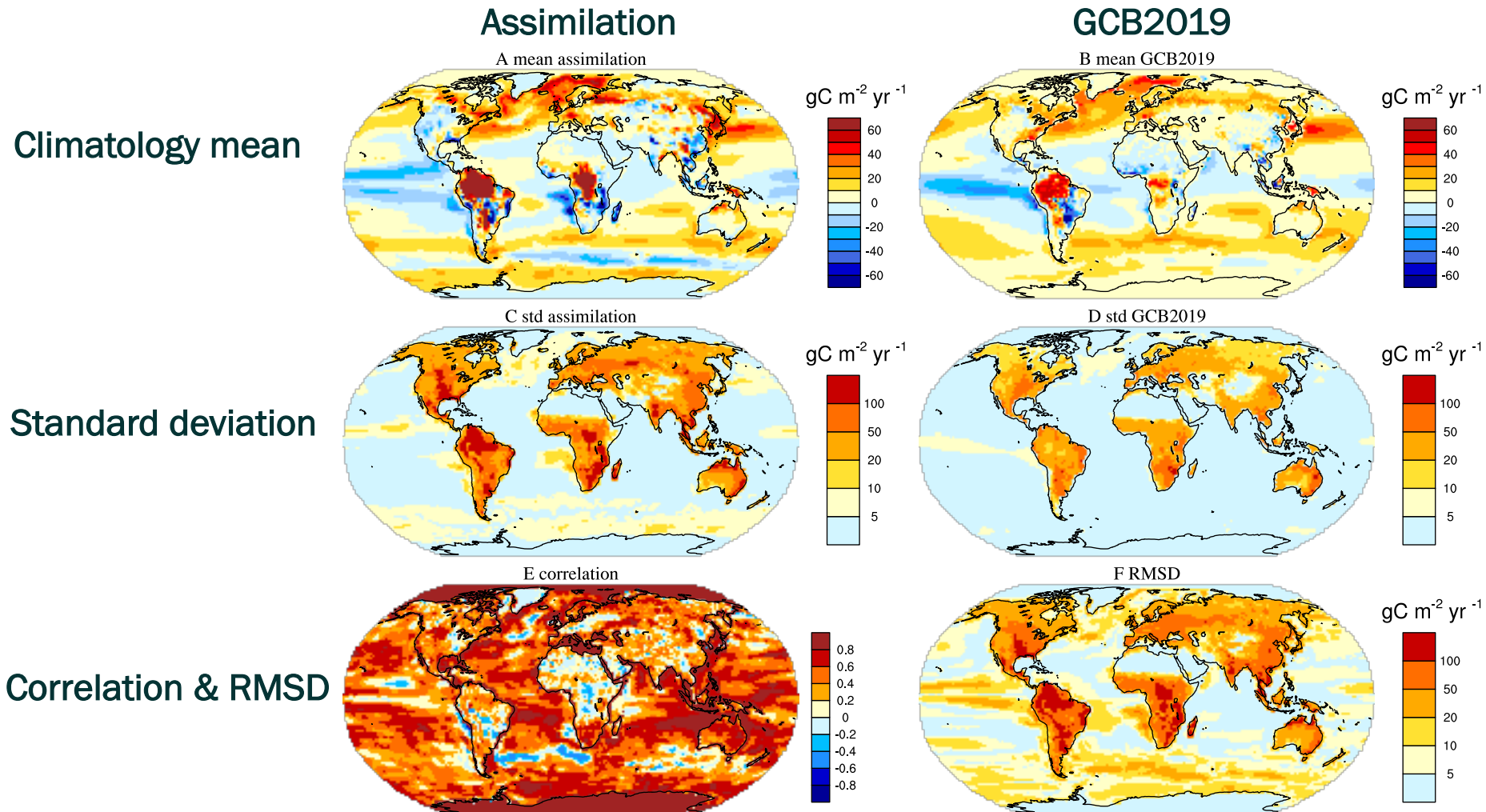
- ❖ The evolution of global carbon budget is well reconstructed by MPI-ESM assimilation within a closed Earth system.

The reference data is from Global Carbon Project (GCB2019, Friedlingstein et al. 2019).

MPI-ESM-LR simulations v.s. GCB2019

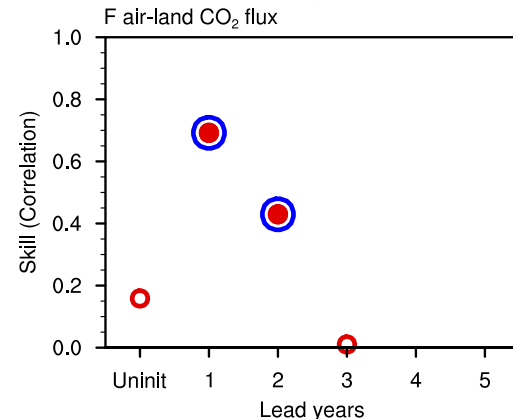
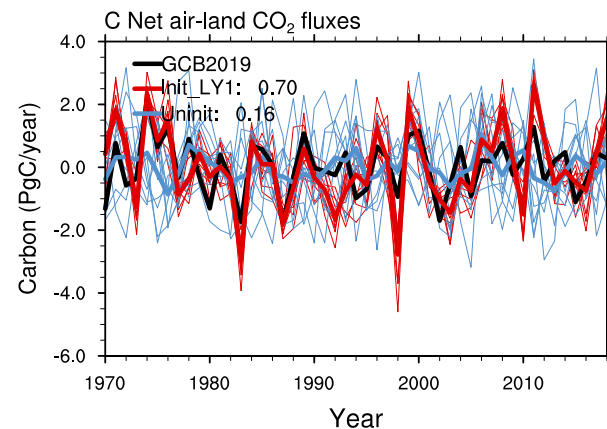
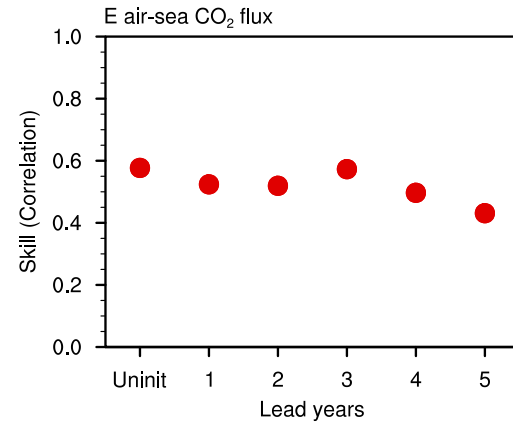
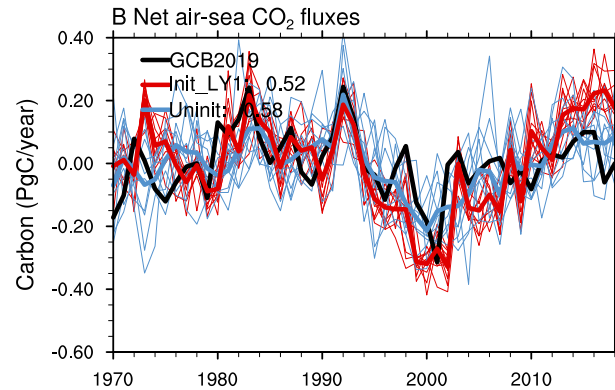
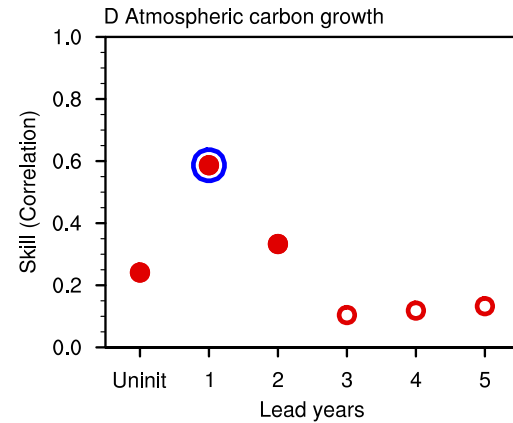
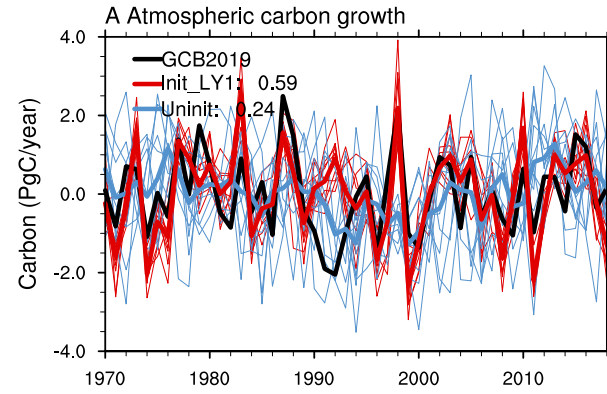


Air-land and air-sea CO₂ fluxes: Assimilation v.s. GCB2019



The assimilation show higher amplitude of CO₂ fluxes than GCB2019, but they are highly correlated.

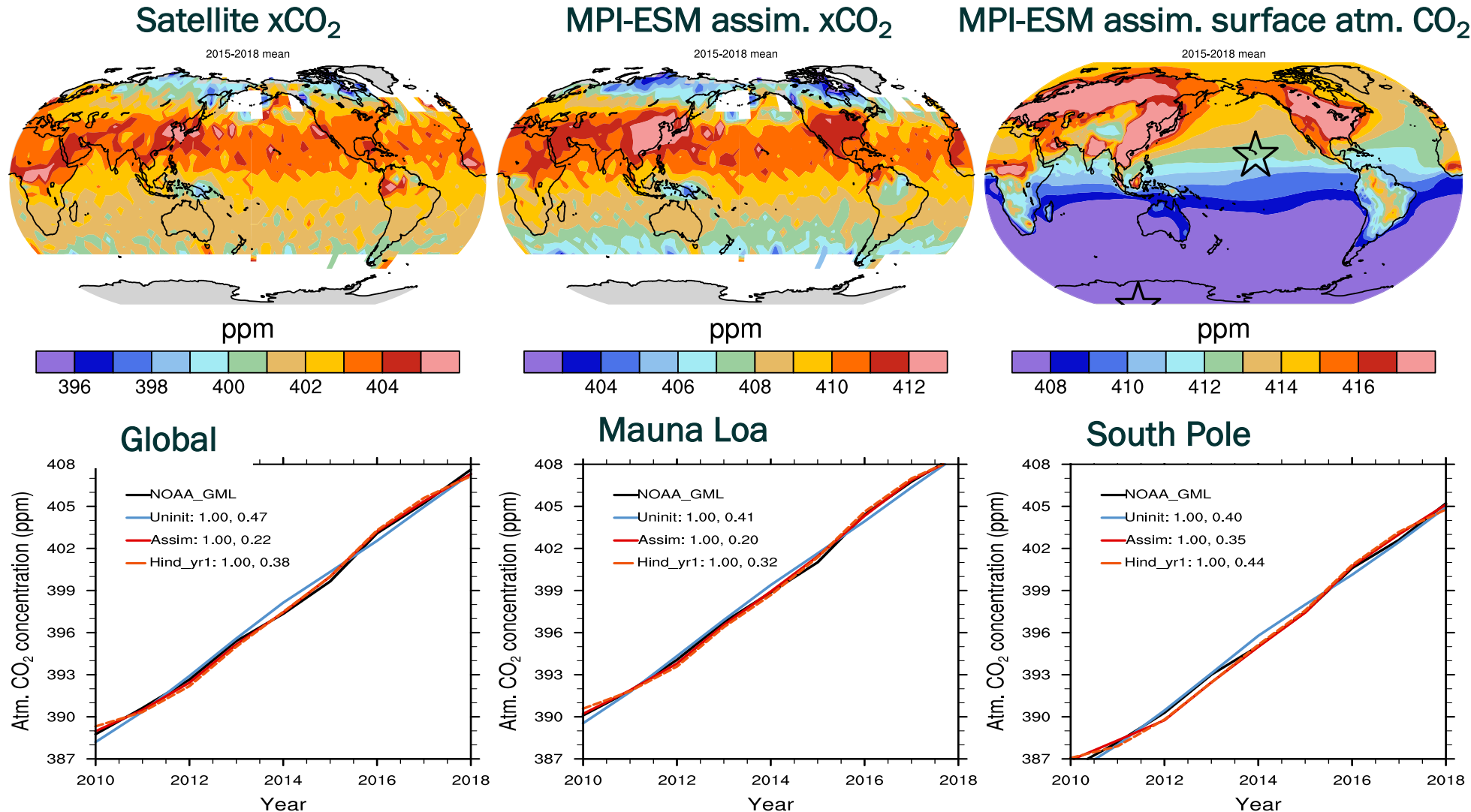
Predictive skill of atmospheric carbon growth and CO₂ fluxes



Retrospective predictions show high confidence to predict the next year global carbon budget hence support the Global Carbon Project.

Linear trends are removed from the time series. The filled red circles on top of the open red circles show that the predictive skill is significant at 95% confidence level and the additional larger blue circles indicate improved significant predictive skill due to initialization in comparison to the uninitialized simulations.

Atm. CO₂ in MPI-ESM simulations v.s. satellite and in-situ data



- In general, the model simulated atm. CO₂ show consistent spatial distribution and temporal evolution as observations.
- Note the modeled atm. CO₂ is several ppm higher, the mean and trend bias in the time series panels are corrected.

Satellite xCO₂ (Reuter et al., 2013; 2020), the conversion from modeled CO₂ to xCO₂ is according to Gier et al. (2020)

Summary

- ❑ The evolution of global carbon budget is well reconstructed by MPI-ESM assimilation within a closed Earth system.
- ❑ Retrospective predictions show high confidence to predict the next year global carbon budget hence support the Global Carbon Project.
- ❑ For the first time, our emission-driven predictions enables prognostic atmospheric CO₂, hence reconstructing and predicting the variations.
- ❑ The Earth system prediction provides an additional line for assessing and predicting the global carbon budget.

Thanks for your attention!

