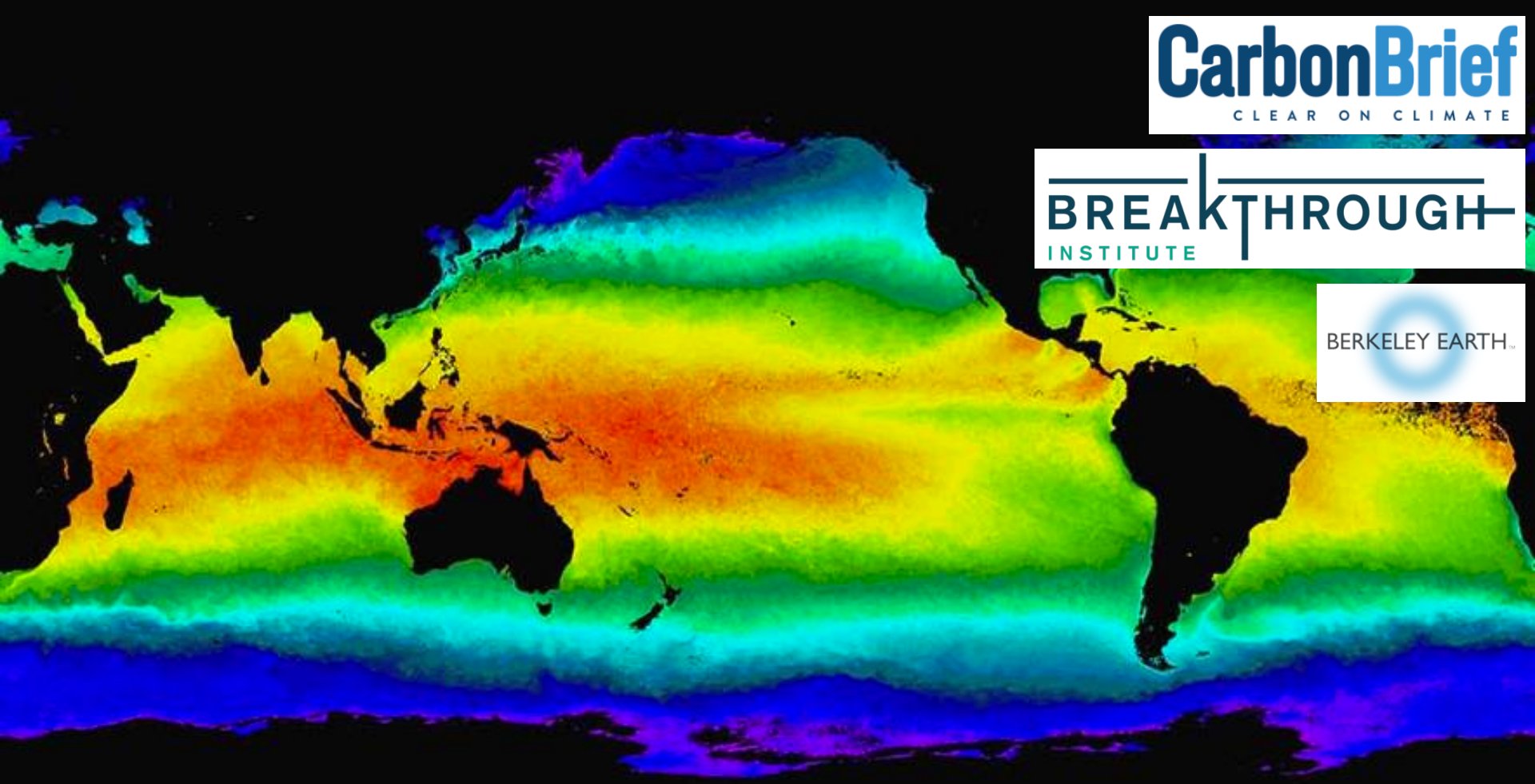


The role of carbon cycle feedback uncertainty in future concentration and warming outcomes

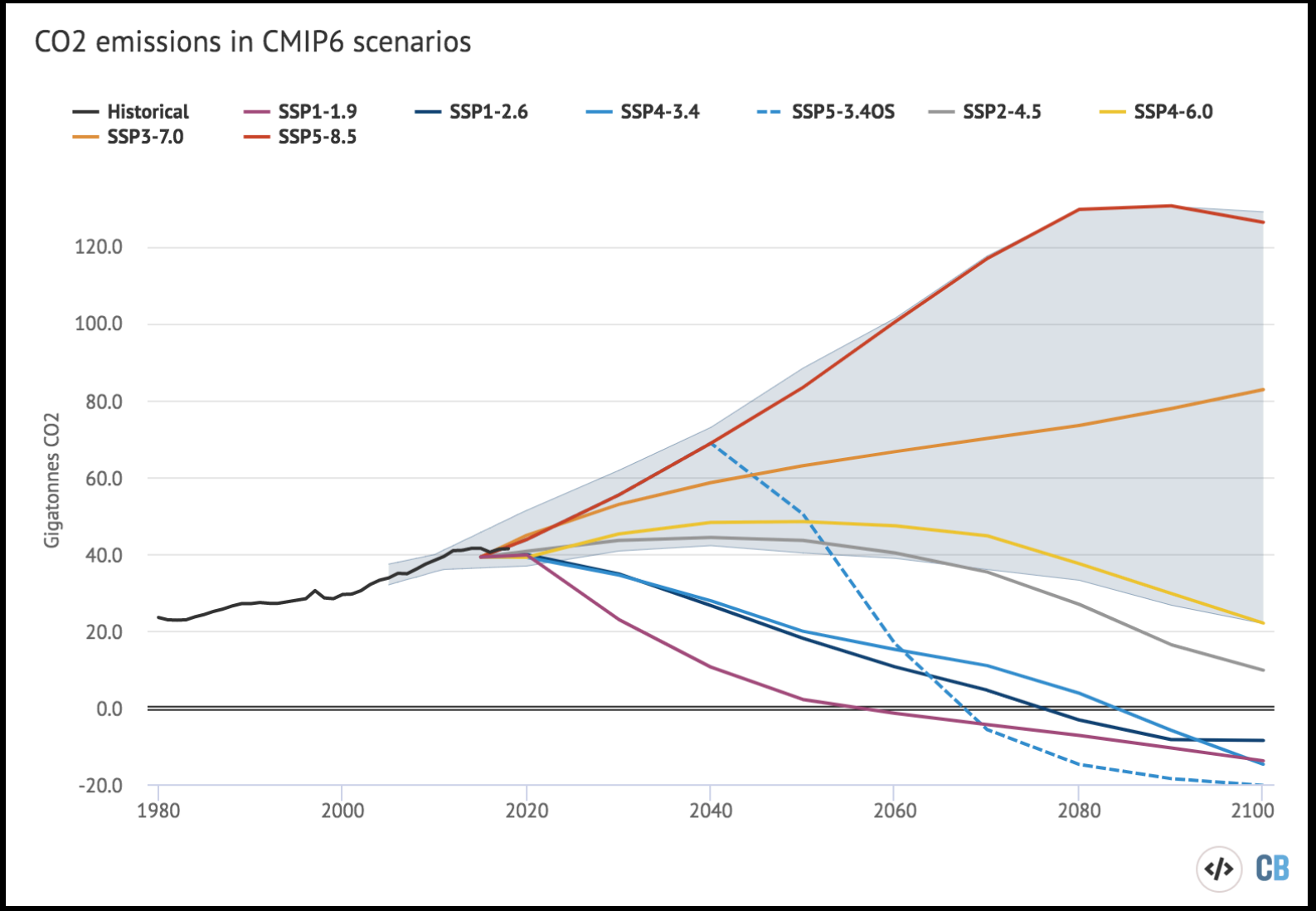
Zeke Hausfather

Presented to NASA CMS

June 17th, 2020

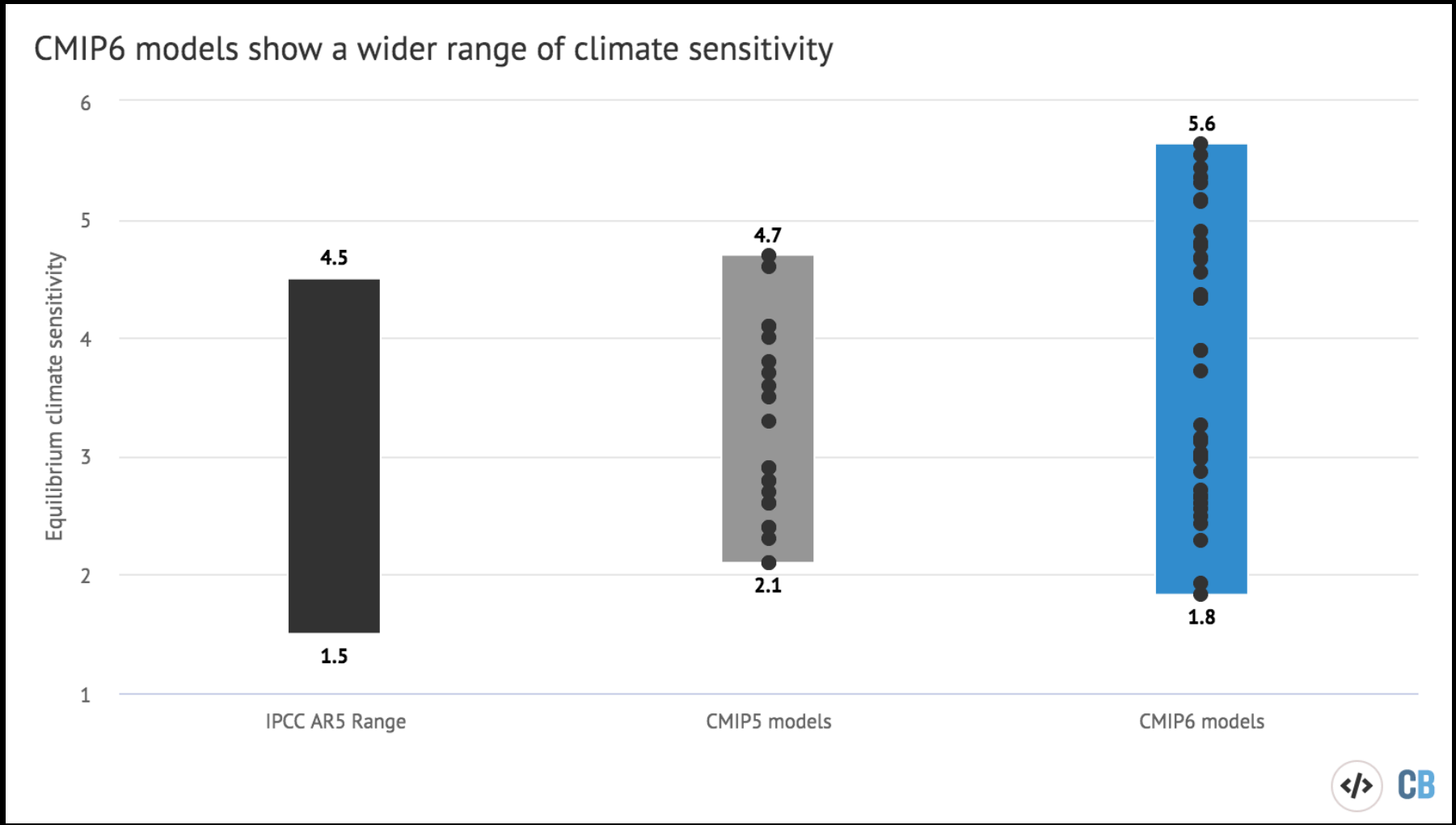
Three main uncertainties in future warming

Emissions



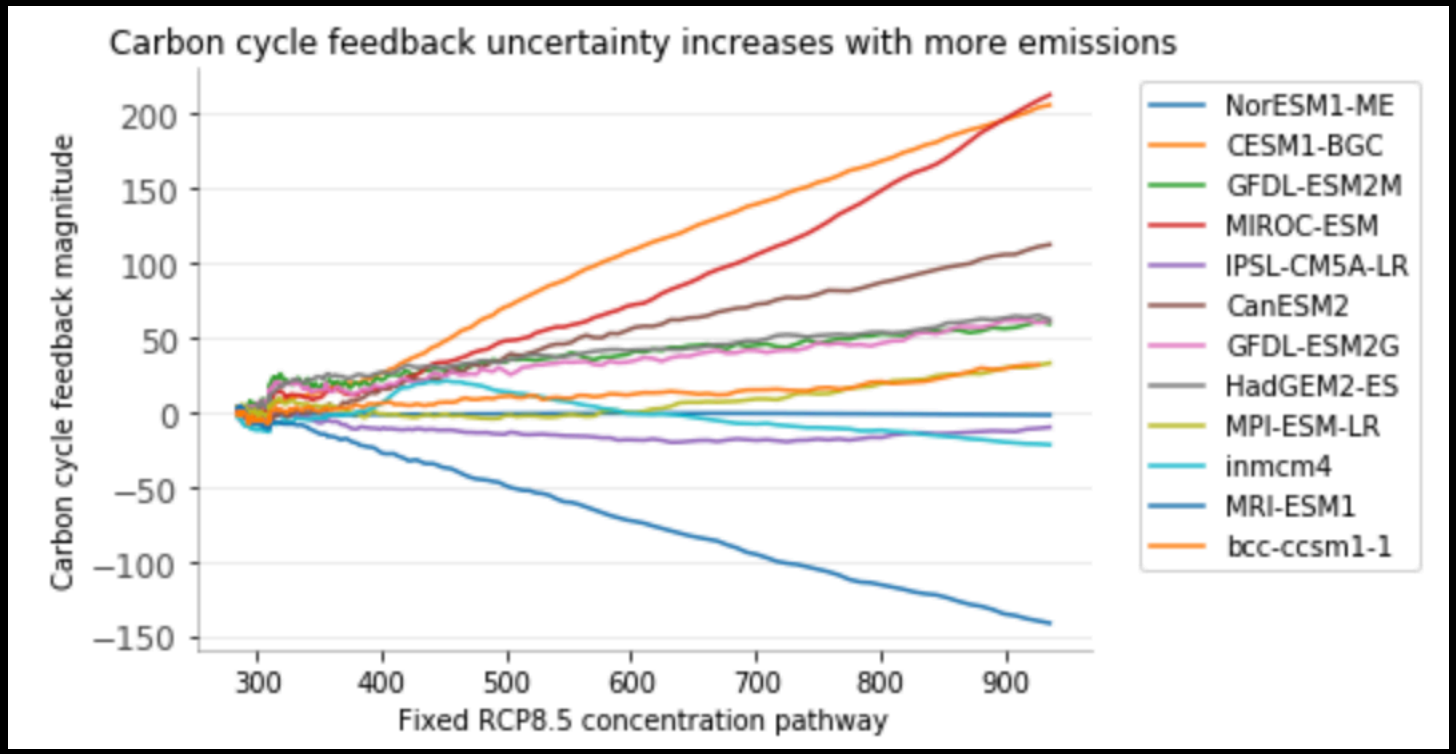
Three main uncertainties in future warming

Climate Sensitivity

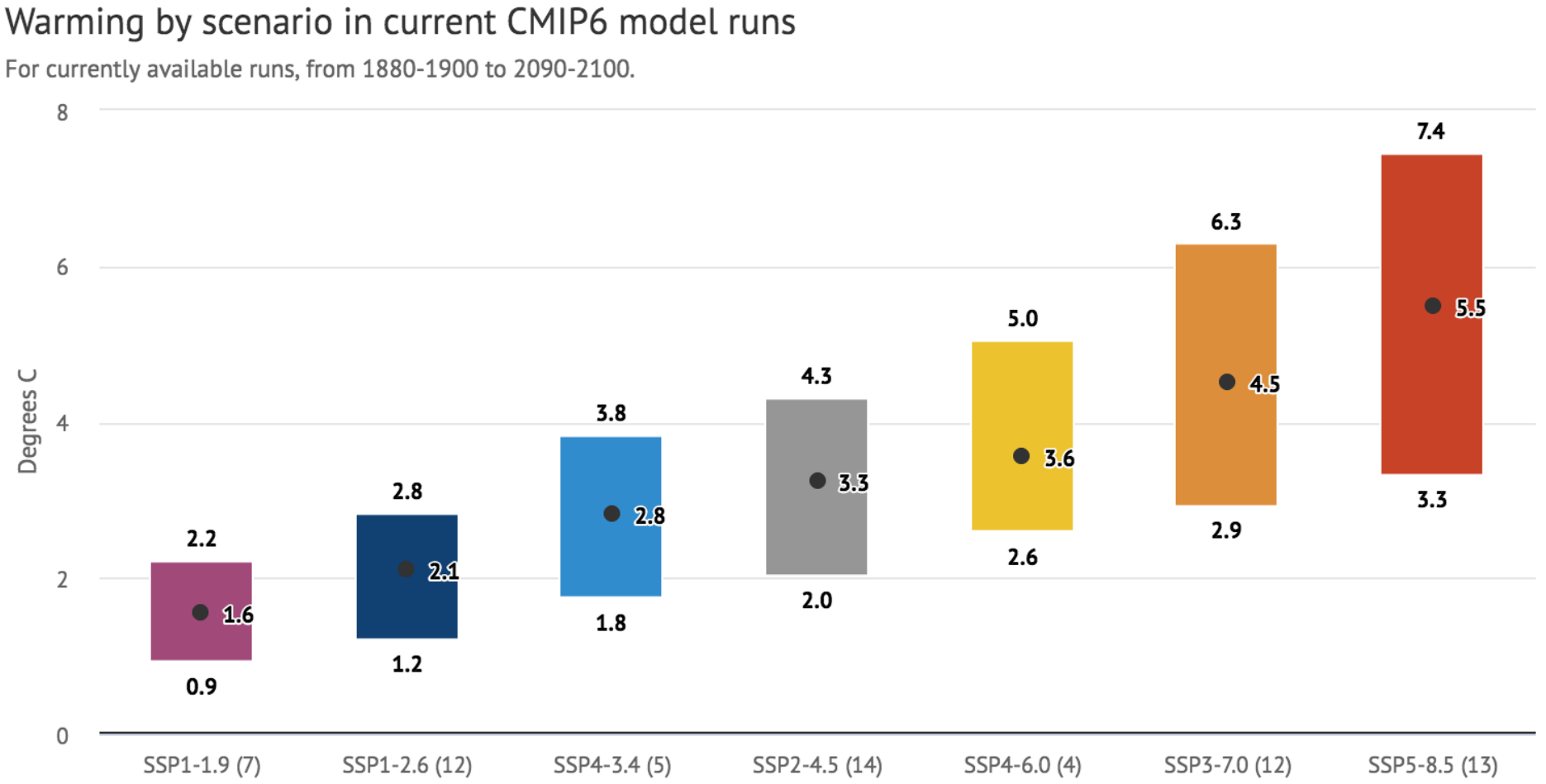


Three main uncertainties in future warming

Carbon cycle feedbacks



Standard future warming projections ignore carbon cycle feedback uncertainties



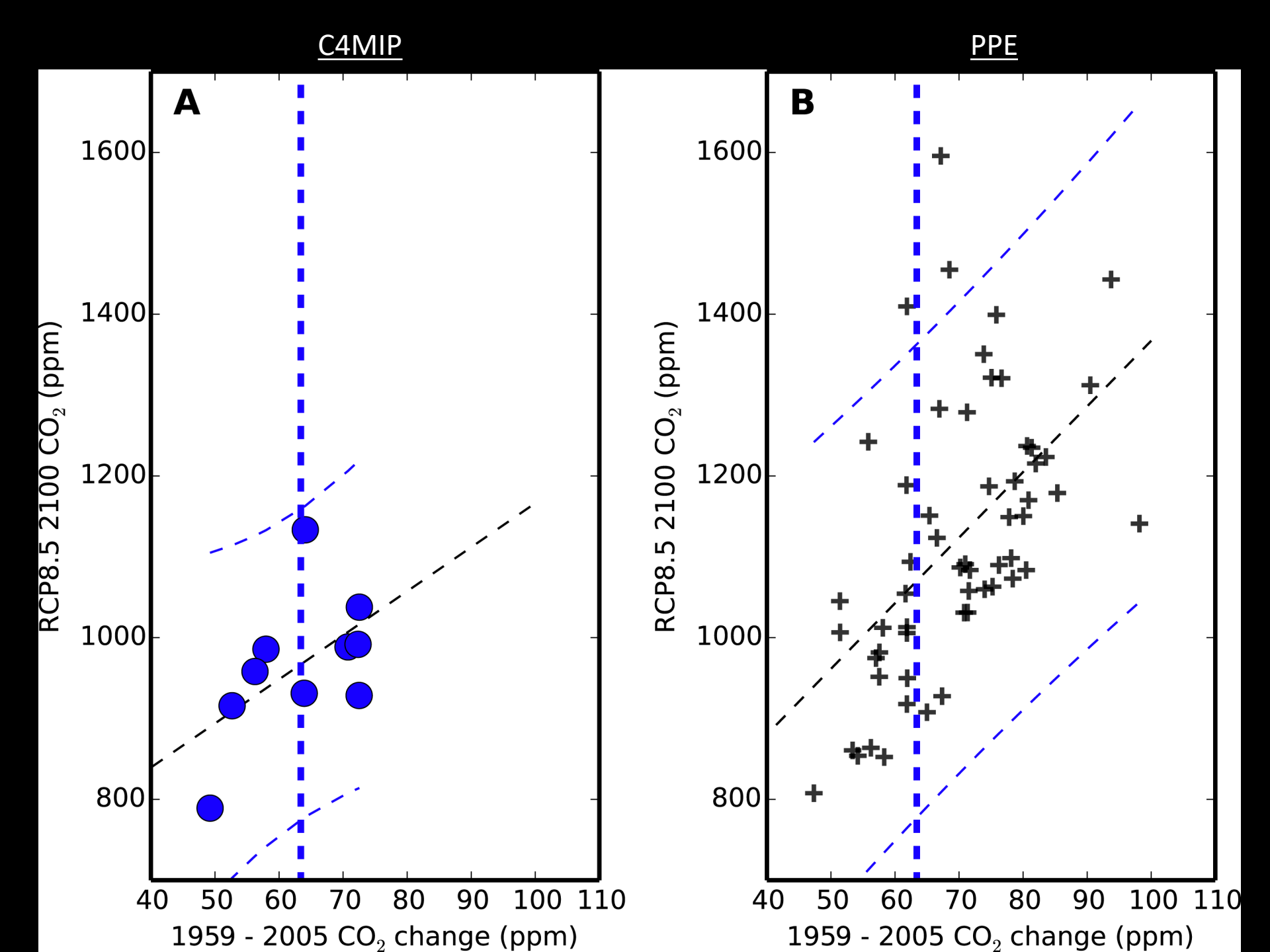
Carbon cycle feedbacks in CMIP

- MAGICC used to translate emission scenarios into fixed concentrations/forcings.
- MAGICC uses results of prior C4MIP efforts to provide a best-estimate of carbon cycle feedbacks.
- These estimates both lag current models and exclude large uncertainties.

Accounting for carbon cycle feedback uncertainties

Two readily available modeling efforts:

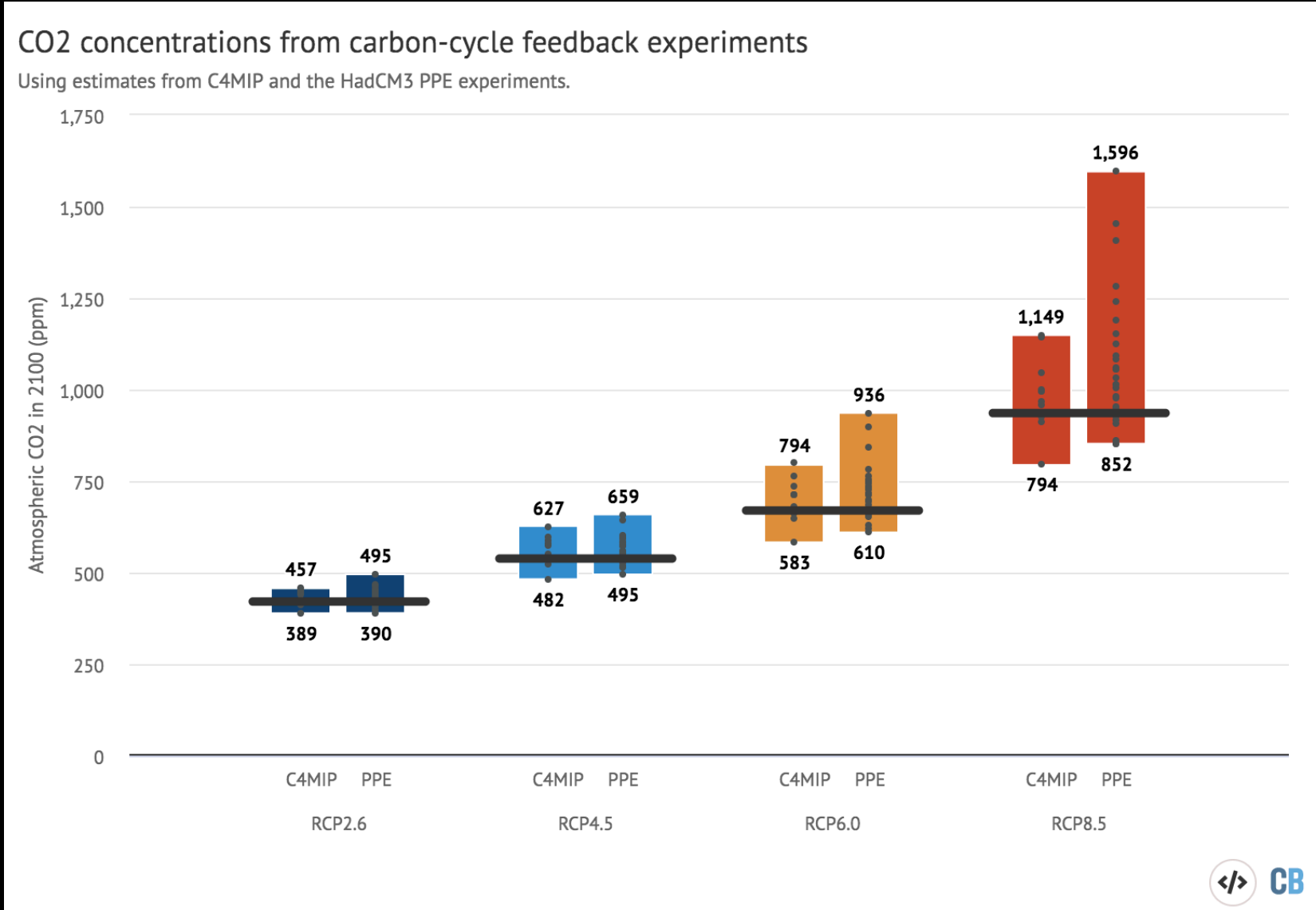
- C4MIP
  - multiple models participating, but an ensemble of opportunity with one estimate per model.
- PPE
  - one climate model (HadCM3C) with a wide range of possible parameters for the land and ocean biogeochemical processes
  - Constrained analysis to select only those variants (27 out of 57) that matched historical observations.


C4MIP
PPE
A
B
1600
1400
1200
1000
800
RCP8.5 2100 CO_2 (ppm)
40
50
60
70
80
90
100
110
1959 - 2005 CO_2 change (ppm)

Limited emissions scenarios available

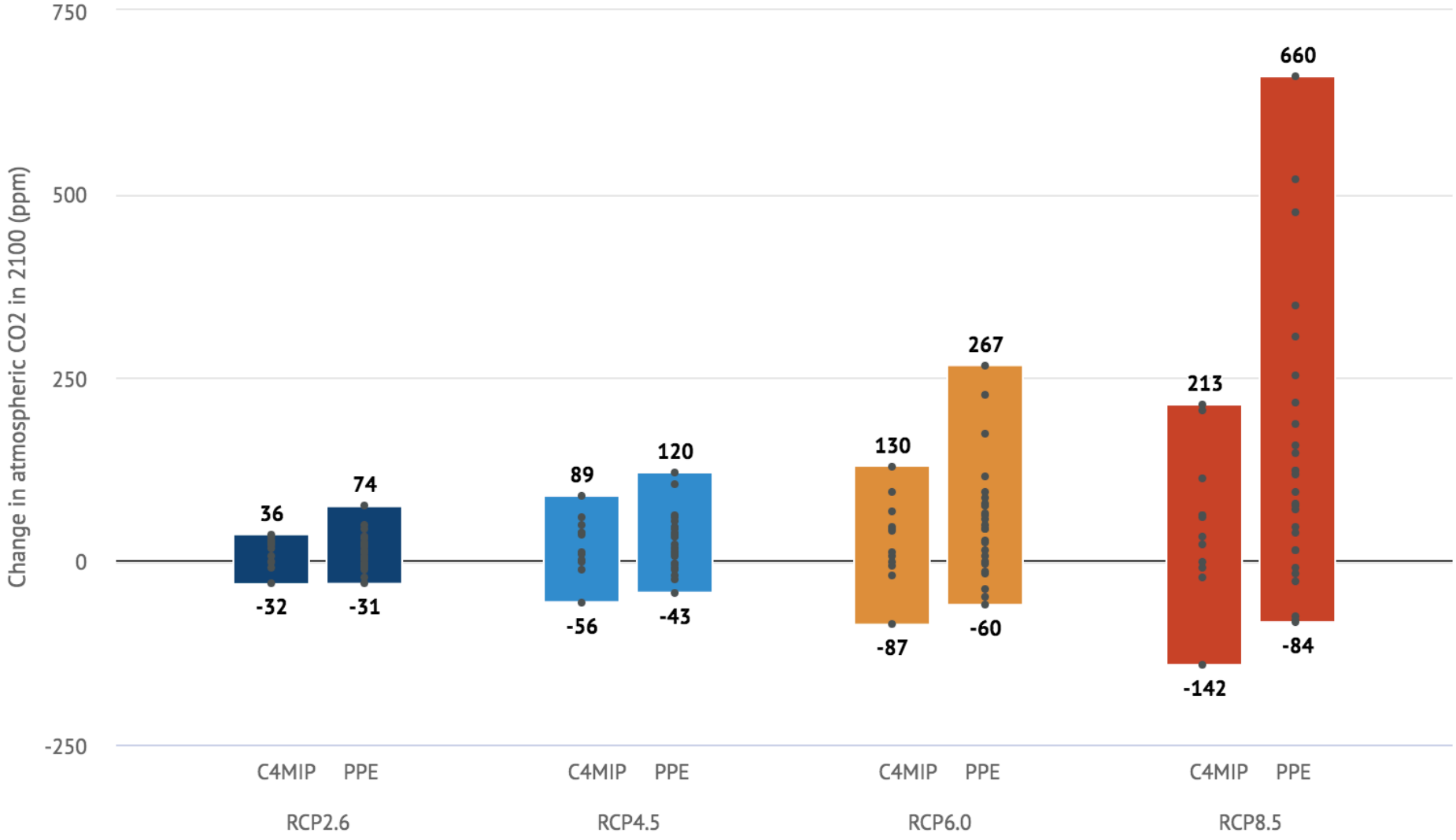
- C4MIP runs only done for RCP8.5 (which is problematic).
- PPE runs done for RCP2.6, RCP8.5, and SRES A1B.

Estimating carbon cycle feedback uncertainties by scenario



Change in CO2 concentrations when including carbon-cycle feedback uncertainties

Using estimates from C4MIP and the HadCM3 PPE experiments.

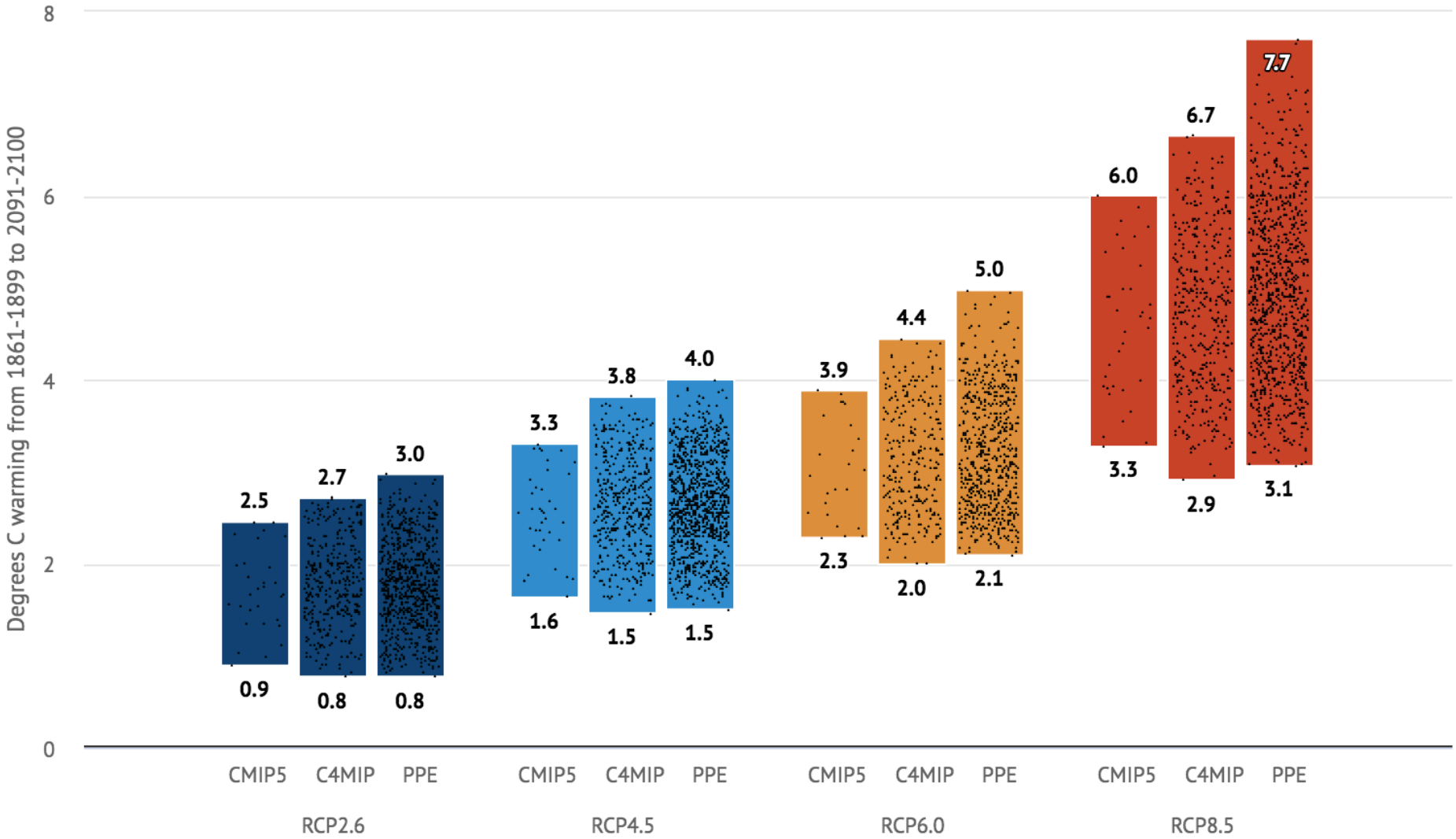


Estimating impacts on future warming

- Used the range of carbon cycle feedback estimates from C4MIP and the PPE.
- Perturbed each CMIP5 2100 model warming estimate using the difference from prescribed RCP concentrations and model TCR.

Warming estimates based on carbon-cycle feedback experiments

CMIP5 global mean temperature changes with carbon-cycle feedback uncertainty based on C4MIP and the HadCM3 PPE experiments.



Results

- Under the highest estimate of carbon cycle feedbacks in the literature, a more current-policy RCP6.0 world could yield concentrations consistent with a worst-case RCP8.5 scenario.
- Including carbon cycle feedback uncertainties could result in up to 25% more warming than in the main IPCC projections.
- Uncertainties are highly non-symmetric; much more risk on the high-end in current estimates.
- Current models (CMIP5 C4MIP, PPE) still miss important factors permafrost thaw, nitrogen cycle changes and dynamic vegetation.