

Impact of climate change mitigation on ocean acidification projections

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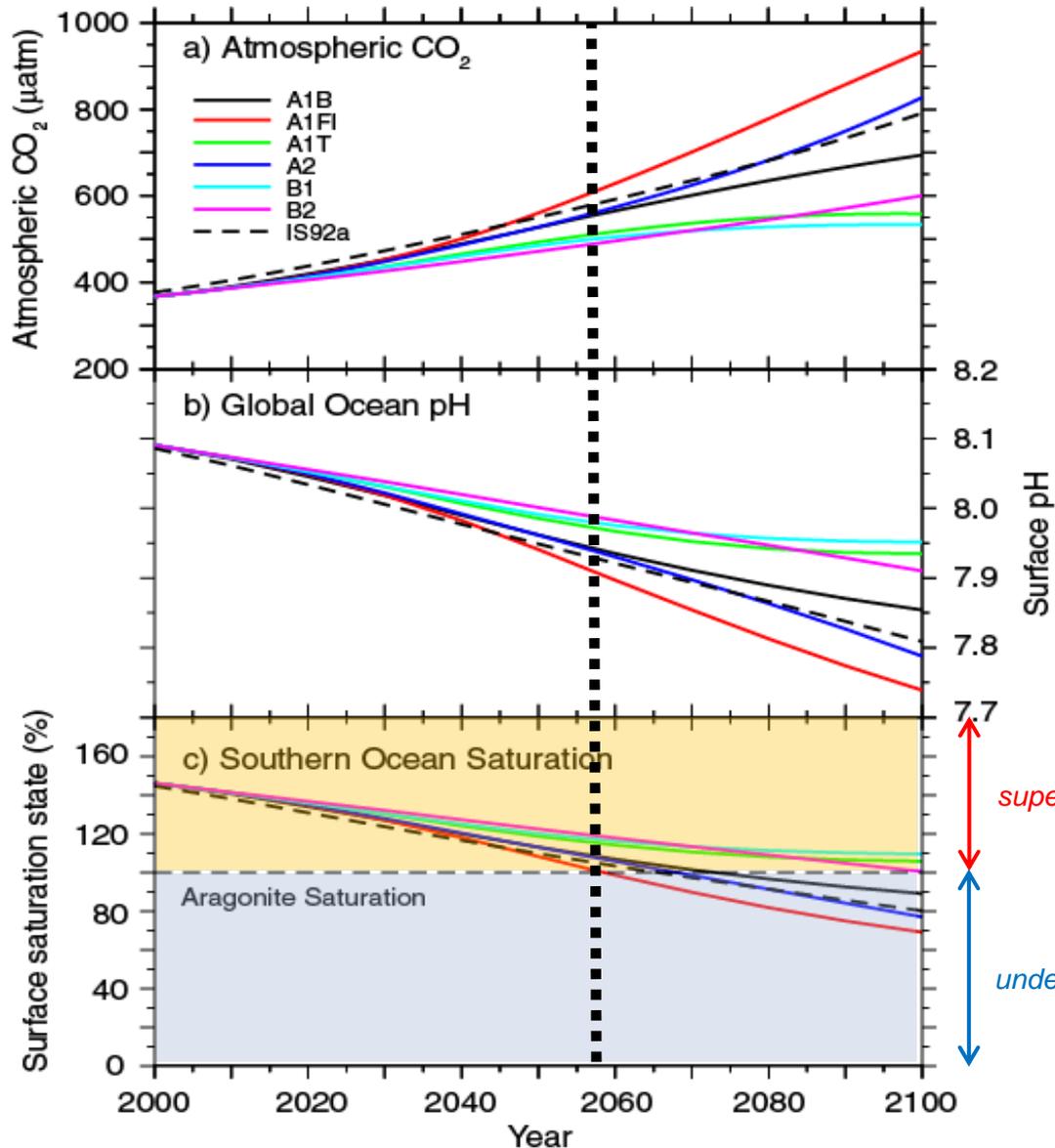
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Projected 21st century changes: SRES “no climate policy”



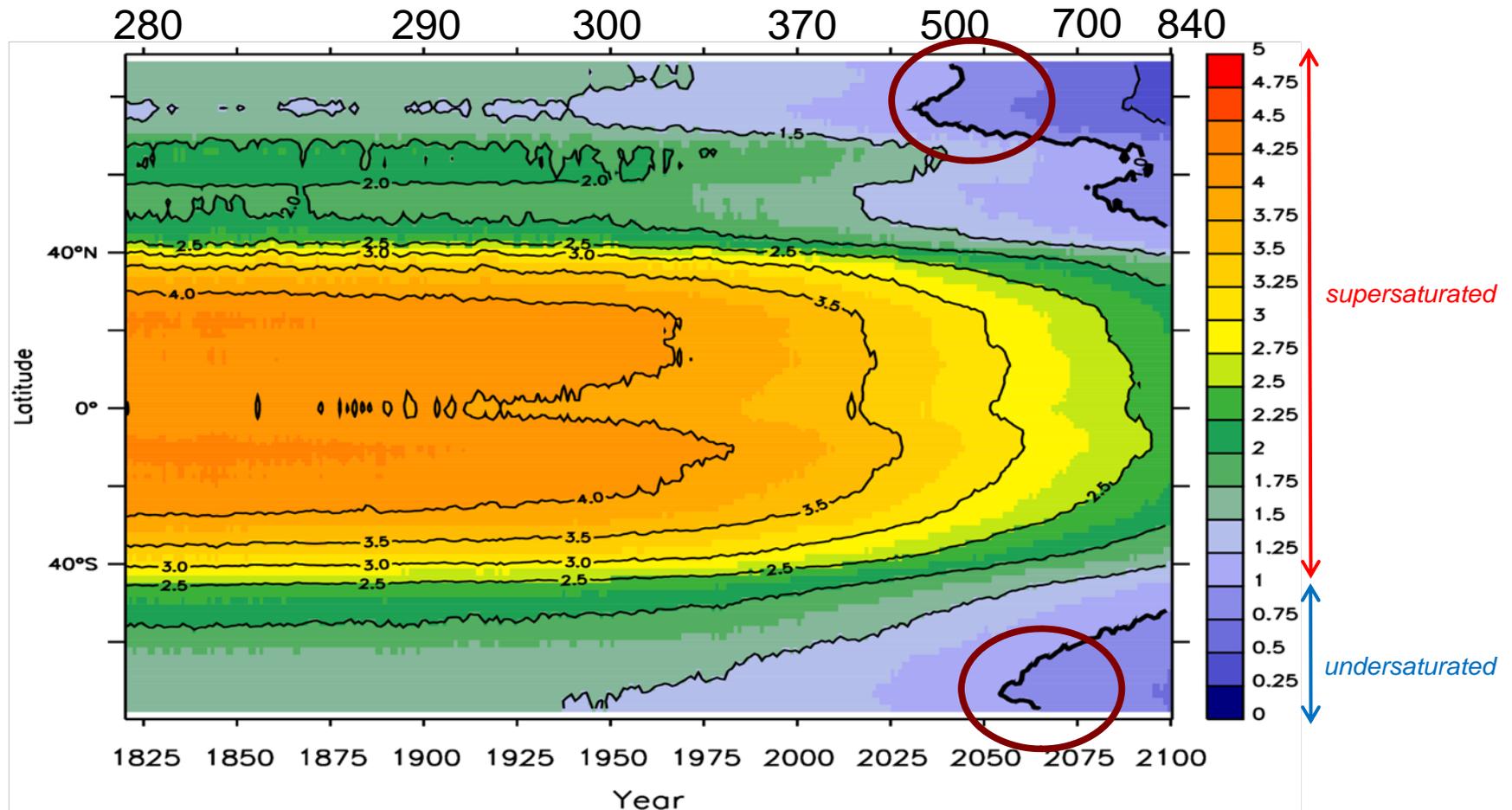
Bern2.5CC EMIC:

- > Year-2100 CO₂ concentrations between 530 and 940 ppm
- > Global mean surface pH drops to values between 7.7 and 8.0
- > undersaturation in Southern Ocean surface waters at ~575 ppm (around 2060)

(adapted from Orr et al., 2005; IPCC 2007)

Projected surface aragonite saturation state (Ω_A):

SRES A2; NCAR CSM1.4



> undersaturation in the Arctic projected at even lower CO₂ (~450 ppm; year 2035)

> other (coastal?) ocean regions might be even more vulnerable (cf. Niki's talk)

Multi-gas scenarios w/wo climate mitigation actions

Bern2.5CC EMIC:

SRES illustrative (6)

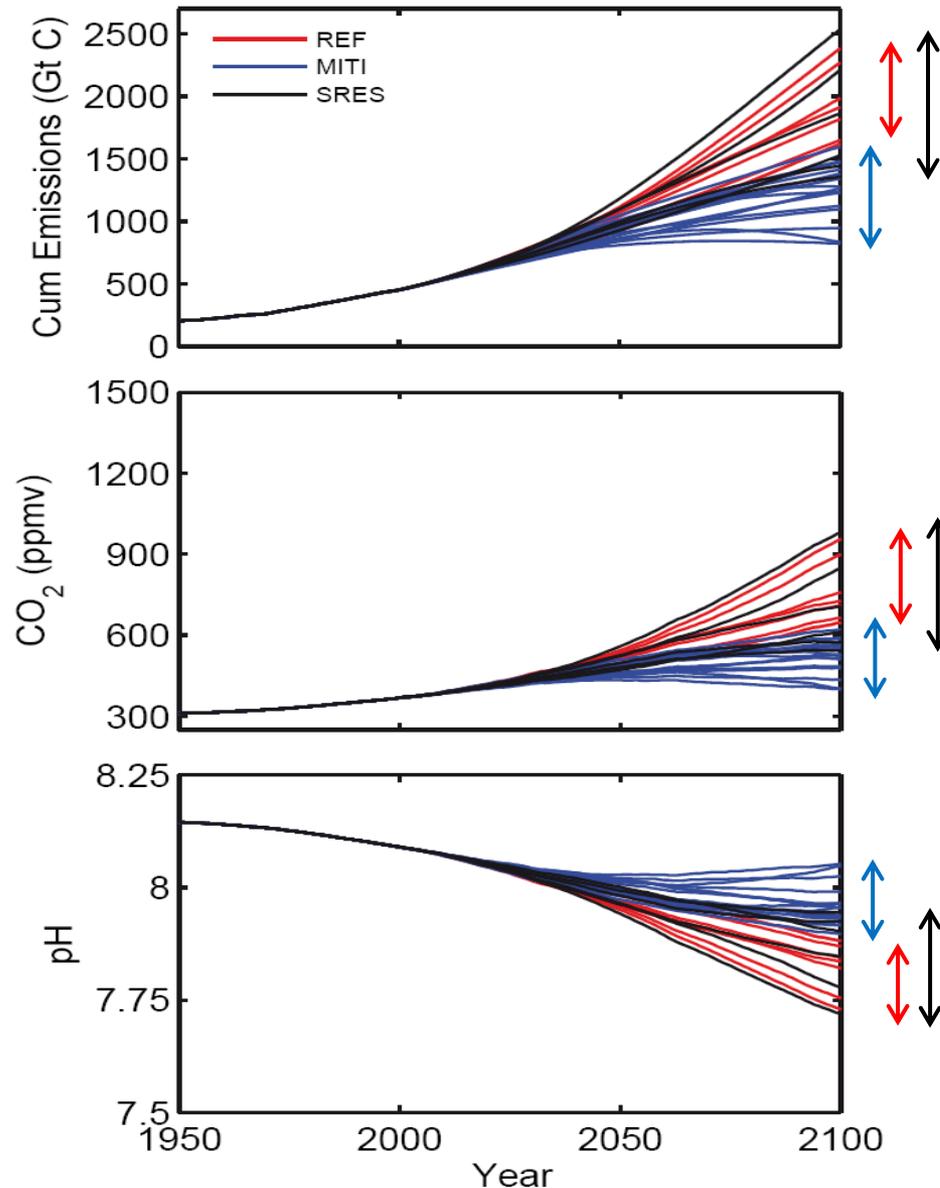
BASELINE (7)

MITIGATION (14)

> *Integrated Assessment Models (a.o. EMF-21):*

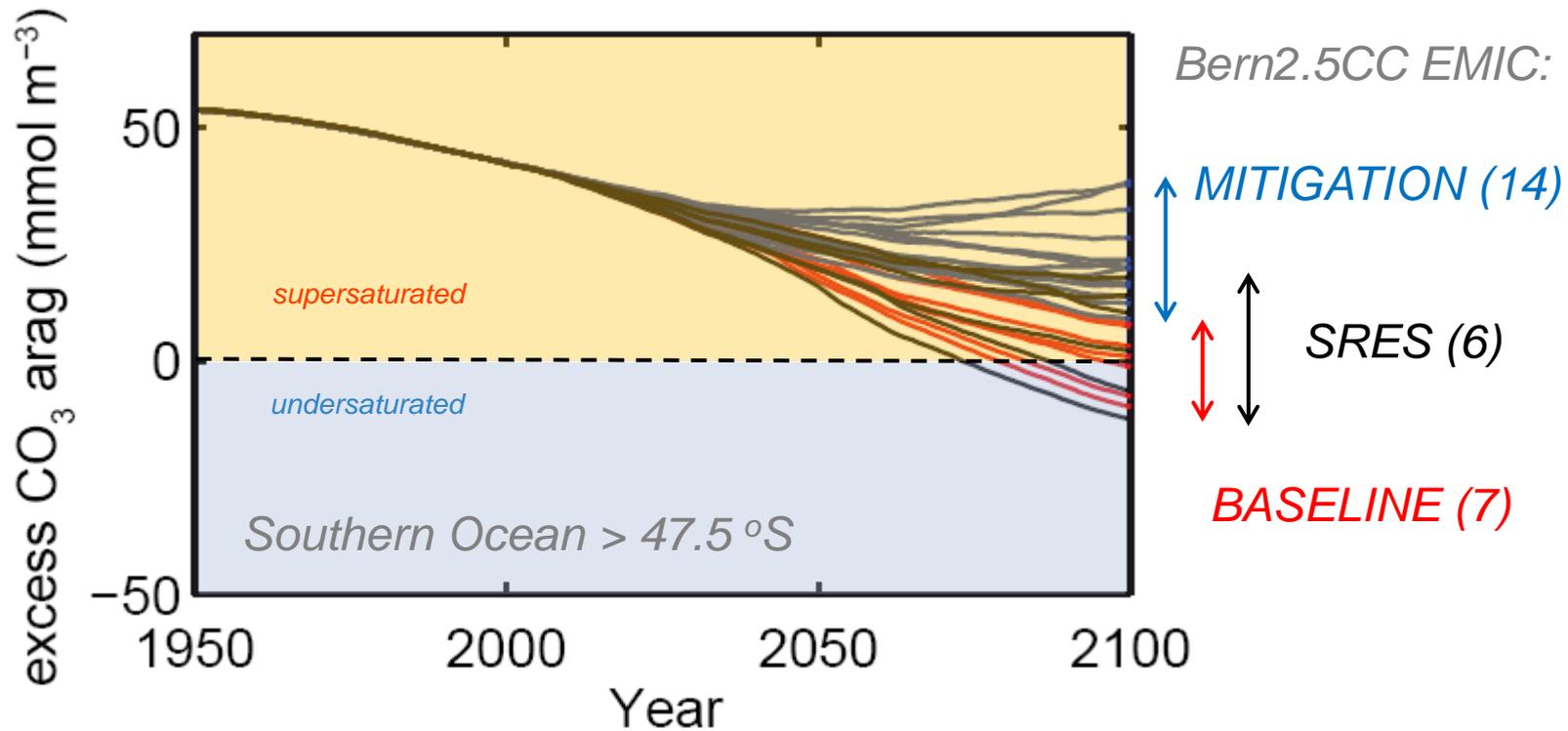
- AIM
- EPPA
- IMAGE
- IPAC
- MESSAGE
- MiniCAM

> *Scenarios based on wide range of modeling approaches and socio-economic assumptions*



(VanVuuren et al., 2008; Plattner et al., in prep.)

Projected impact on 21st century ocean acidification



- > no Southern Ocean surface undersaturation occurring in mitigation scenarios
- > ...but what about other relevant uncertainties besides emission pathways?

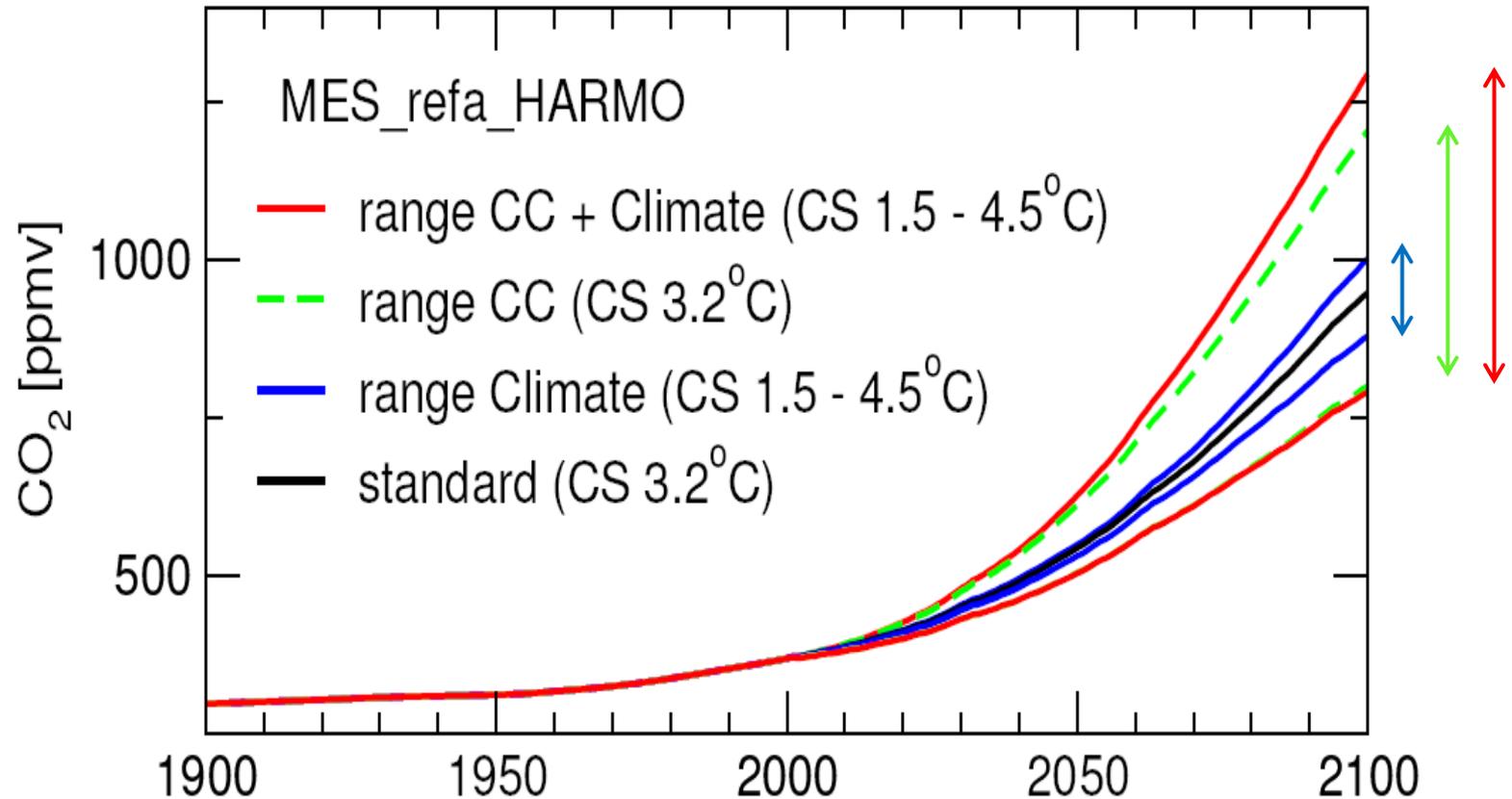
Uncertainties in projected CO₂ concentrations

Approach: modify key parameters in the carbon cycle–climate model

- *Climate sensitivity*, i.e. sensitivity of climate to a change in forcing (often expressed in terms of ΔT for a doubling of CO₂)
 - > vary between **1.5 to 4.5°C** (IPCC AR4 likely range)
 - *Carbon cycle processes*: slow vs. fast removal of excess CO₂
 - > Ocean carbon cycle: - high/low **vertical diffusivity**
 - > Land carbon cycle: - **CO₂ fertilization** on/off
 - T-dependence of **soil respiration** on/off
- Results in **low- to high-end estimates** of projected atmospheric CO₂ and climate change for a given emission scenario

Uncertainties in projected CO₂ concentrations

Bern2.5CC EMIC: Illustrative case

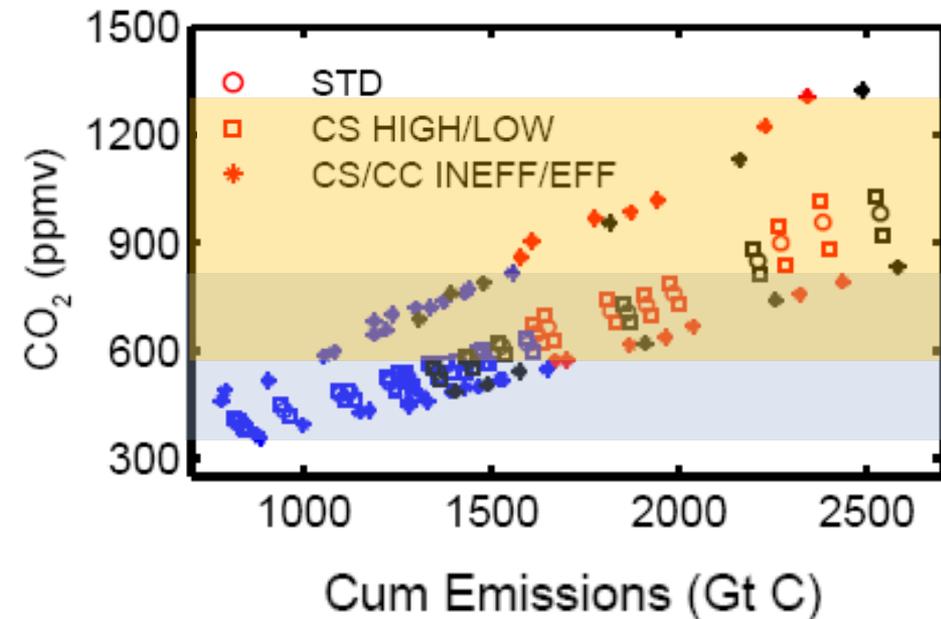
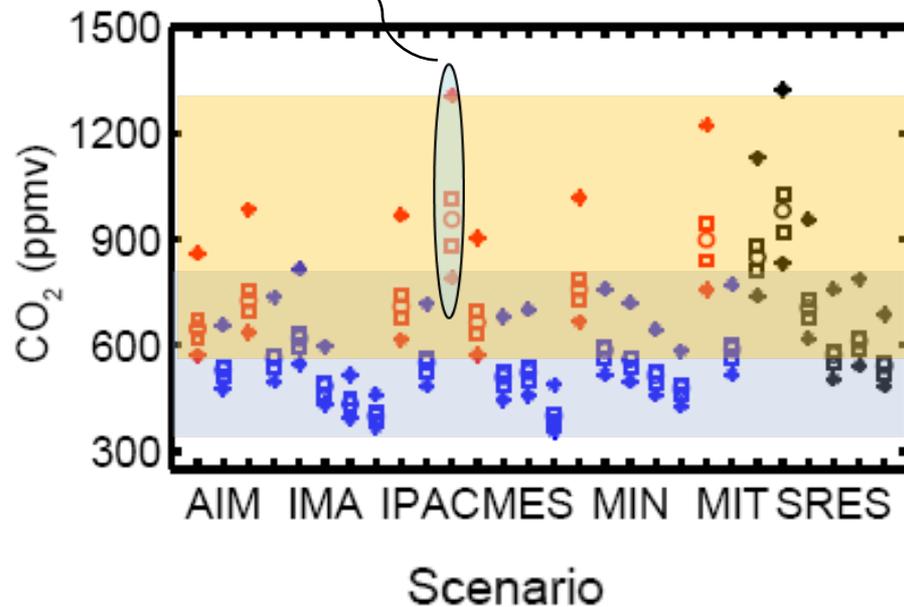


> Resulting projected atmospheric CO₂ varies substantially for different settings, i.e. uncertainties are large, in particular on long time scales.

Uncertainty ranges of projected 21st century changes

Bern2.5CC EMIC: Projected year-2100 atmospheric CO₂ concentrations

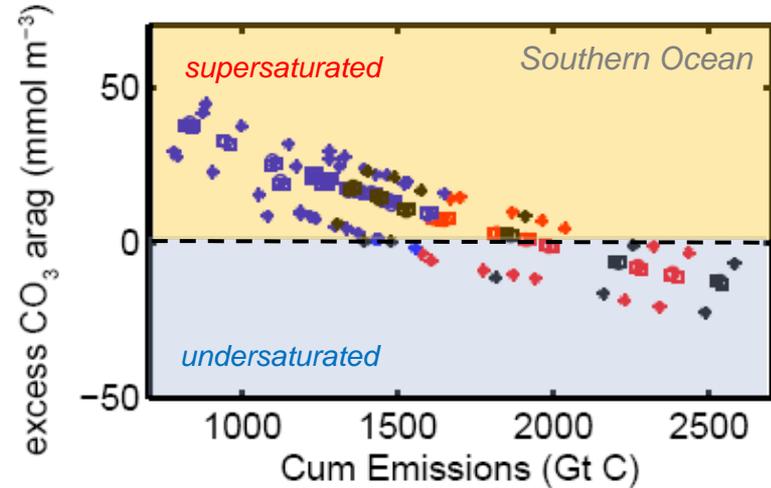
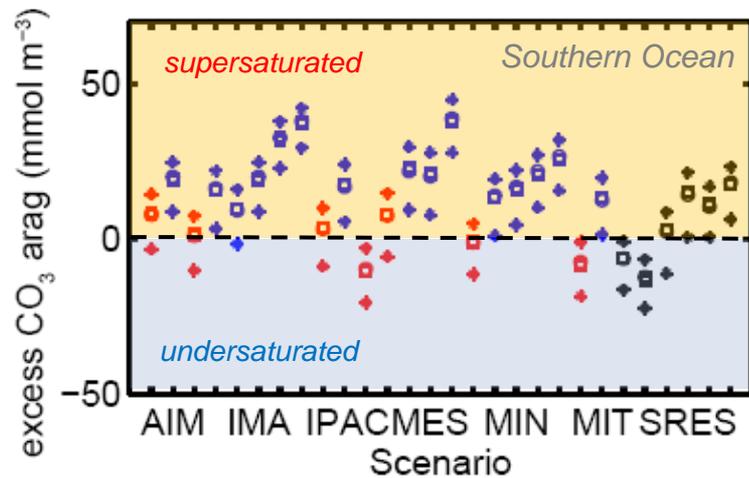
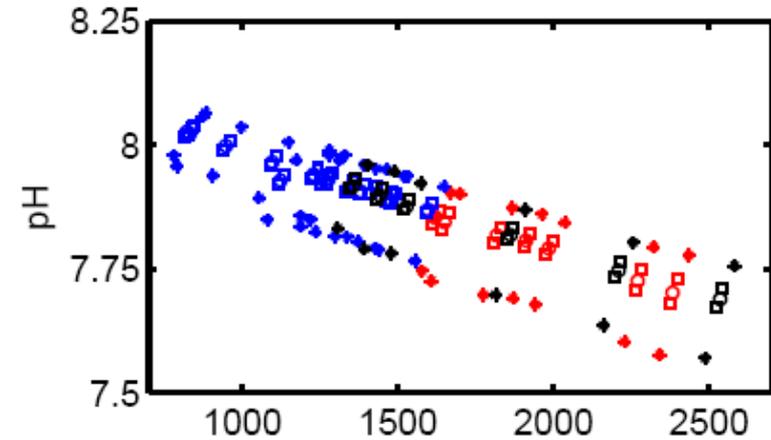
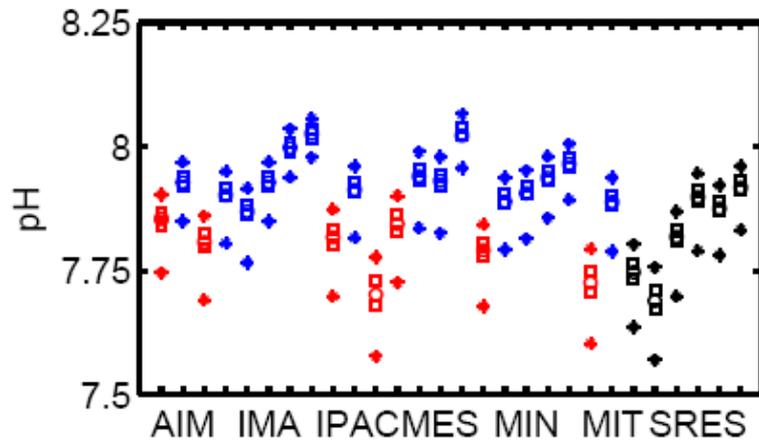
MES_refa_HARMO



- > *Best CO₂ estimates and ranges for mitigation << for baseline scenarios*
- > *overall good scaling with total cumulated emissions, despite non-linearities; upper bound is more uncertain than lower bound*

Uncertainty ranges of projected 21st century changes

Bern2.5CC EMIC: Projected year-2100 ocean acidification



Conclusions and Outlook

- New sets of *multi-gas scenarios explicitly accounting for carbon mitigation* actions will allow us to more reliably project future CO₂ levels, climate and ocean acidification.
- Ocean acidification *is projected to continue, w/wo currently feasible climate change mitigation* actions reducing CO₂ emissions; yet climate change mitigation is *beneficial and also mitigates OA* (especially on long time scales).
- Surface ocean undersaturation with regard to aragonite is *projected to occur within years to decades* (Arctic, Southern Ocean, coastal systems?), but is subject to *large uncertainties*.
- *Uncertainties* associated with *future emission pathways, current and future carbon cycle functioning, and climate sensitivity* are substantially affecting CO₂ and climate change projections and thus also the magnitude and distribution of OA.
- Preventing ocean acidification provides an other good reason, besides climate change, to quickly *reduce carbon emissions*.

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