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Possibility for strong northern hemisphere high-latitude cooling under zero and negative emissions

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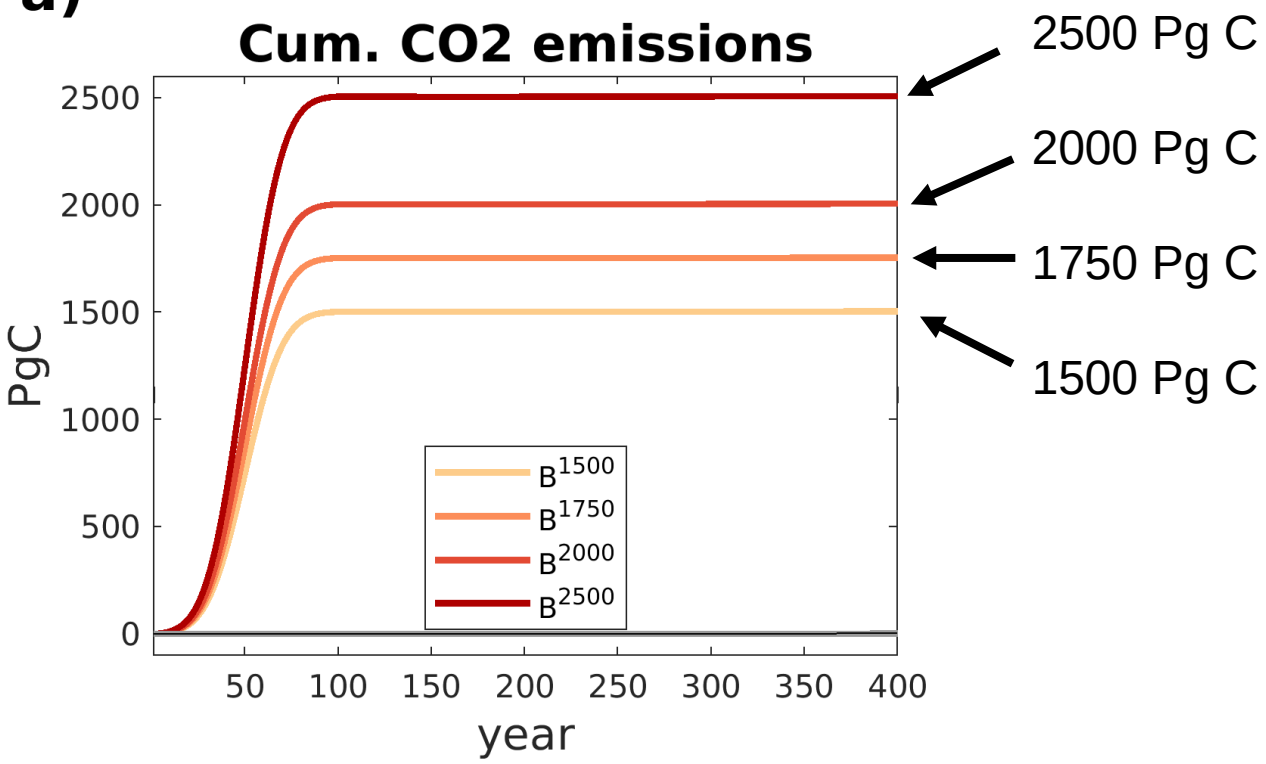
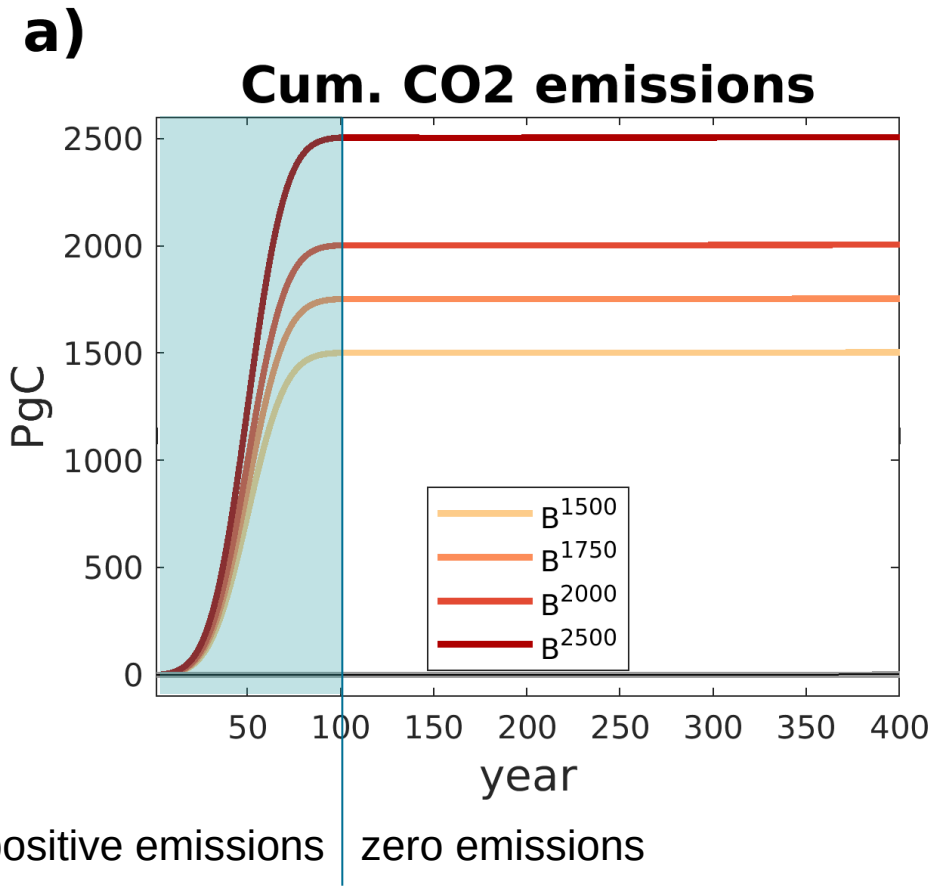
Sharing is encouraged

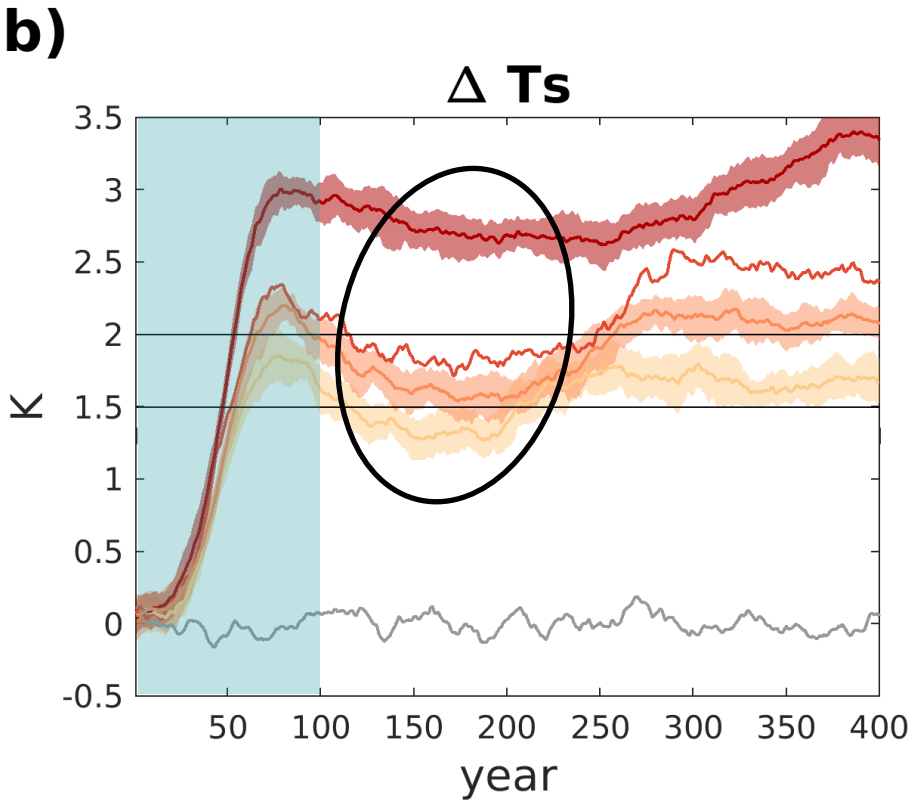
Experimental set-up: NorESM2-LM simulations with CO_2 emissions in the first 100 year and zero emission thereafter following the ZECMIP protocol

a)



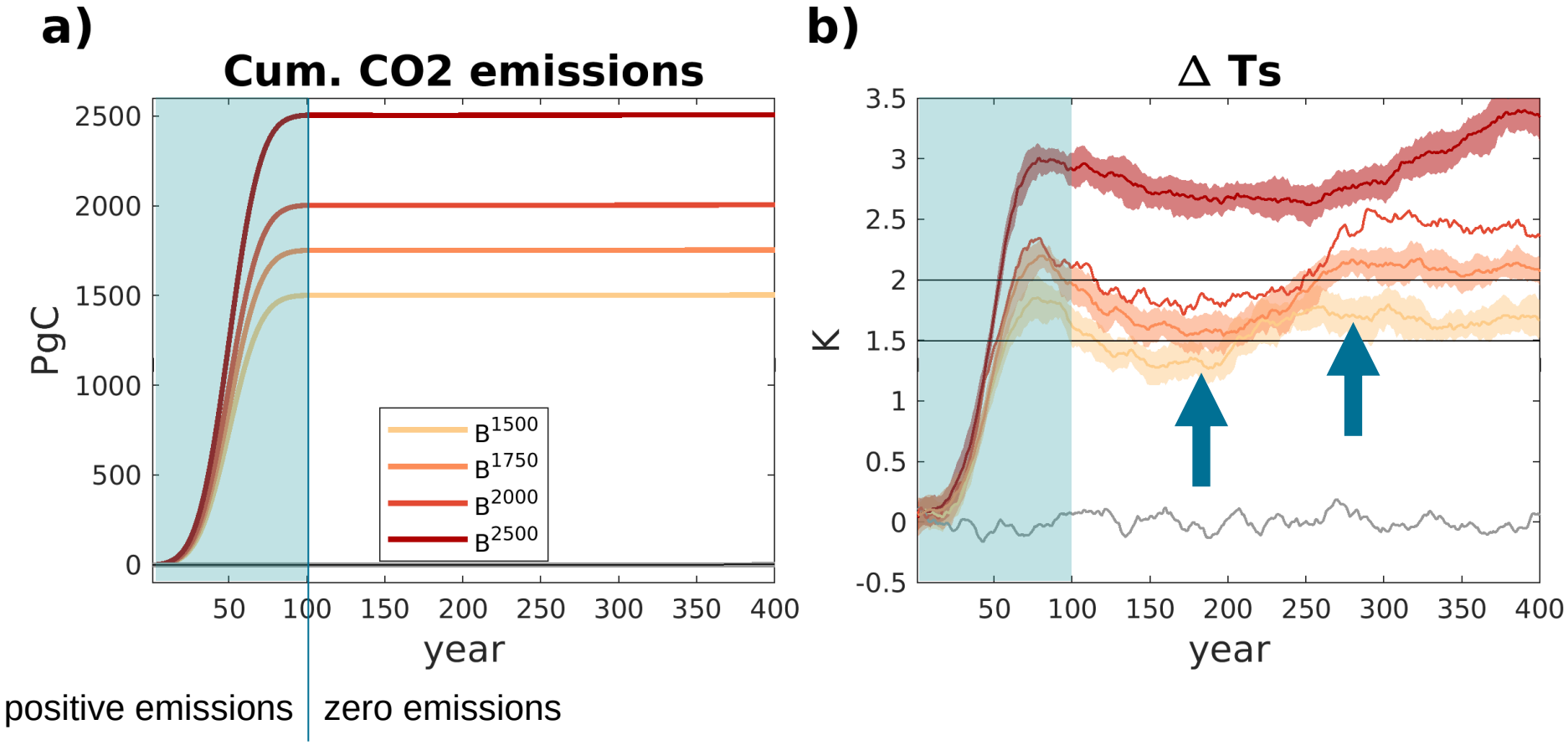
Where do these “warming-cooling-warming” cycles come from?





positive emissions | zero emissions

Difference between minimum SAT and "recovered" SAT



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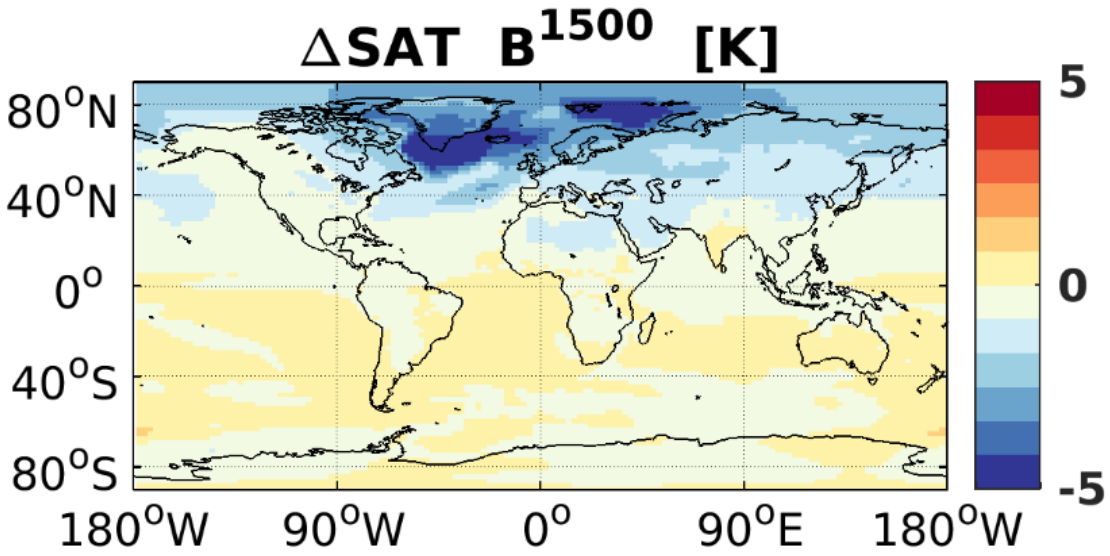

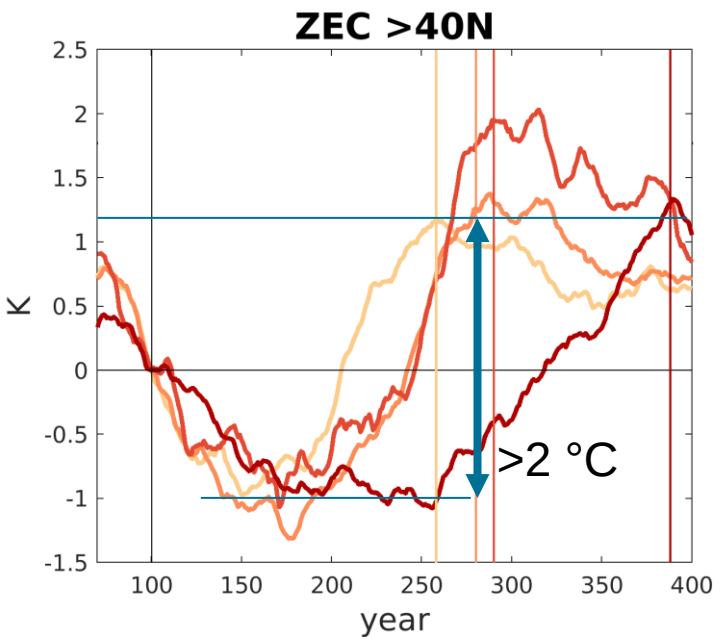

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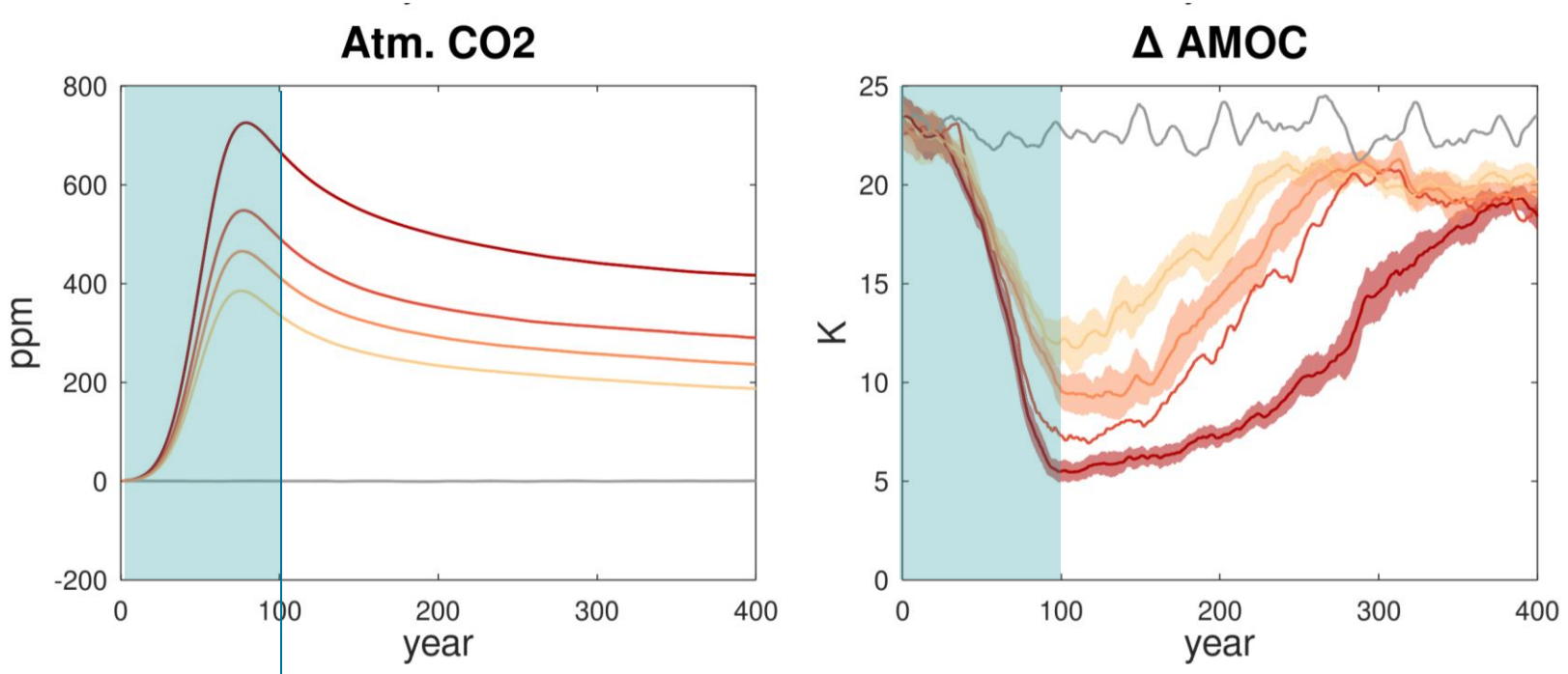
Difference between minimum SAT and “recovered” SAT



positive emissions | zero emissions

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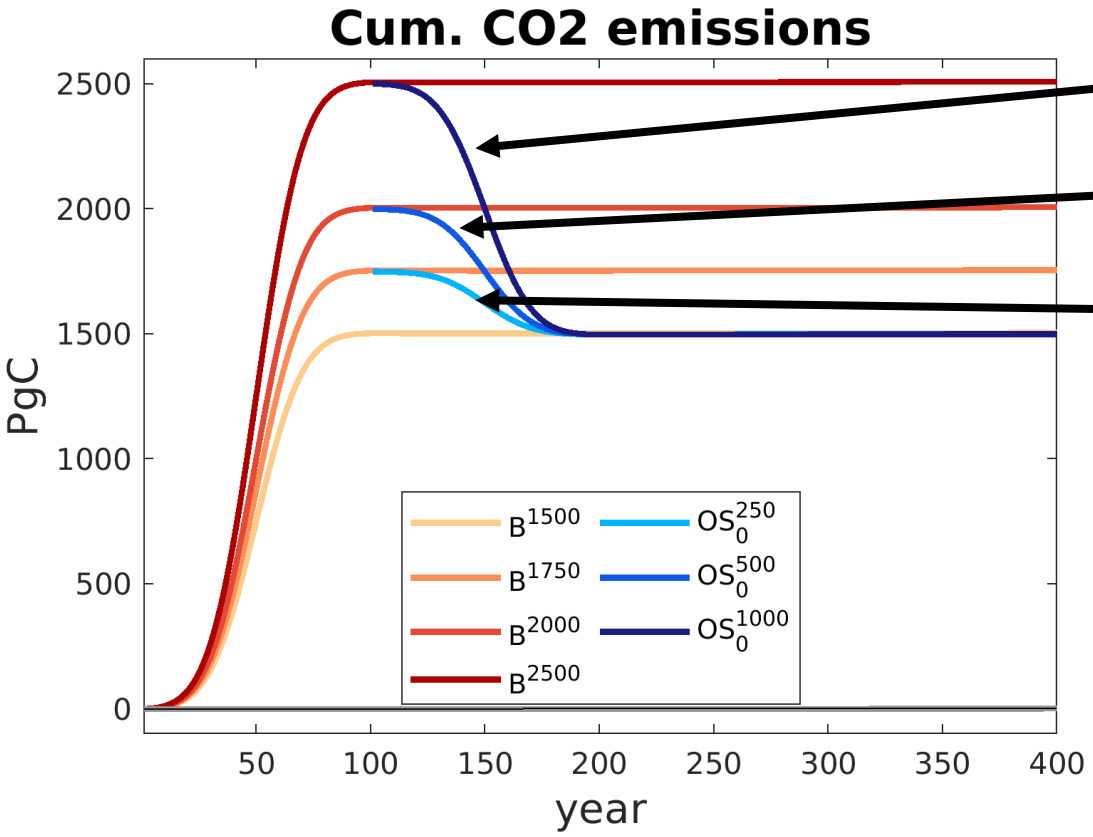
Experimental set-up: complement simulations with negative emission phases



1000 Pg C

500 Pg C

250 Pg C

applied immediately or…

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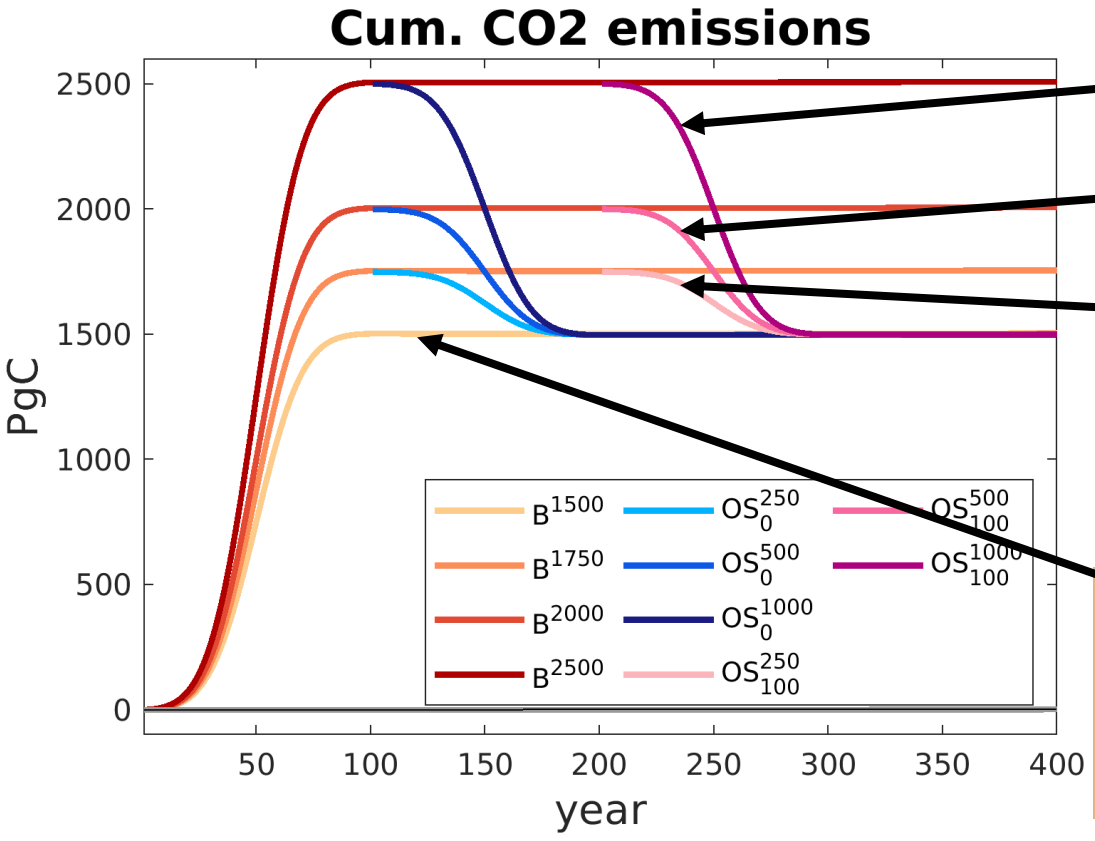
Experimental set-up: complement simulations with negative emission phases



1000 Pg C

500 Pg C

250 Pg C

…or after 100 years of zero emissions

This is our reference simulation, all overshoots have the same final carbon budget (1500 Pg C)

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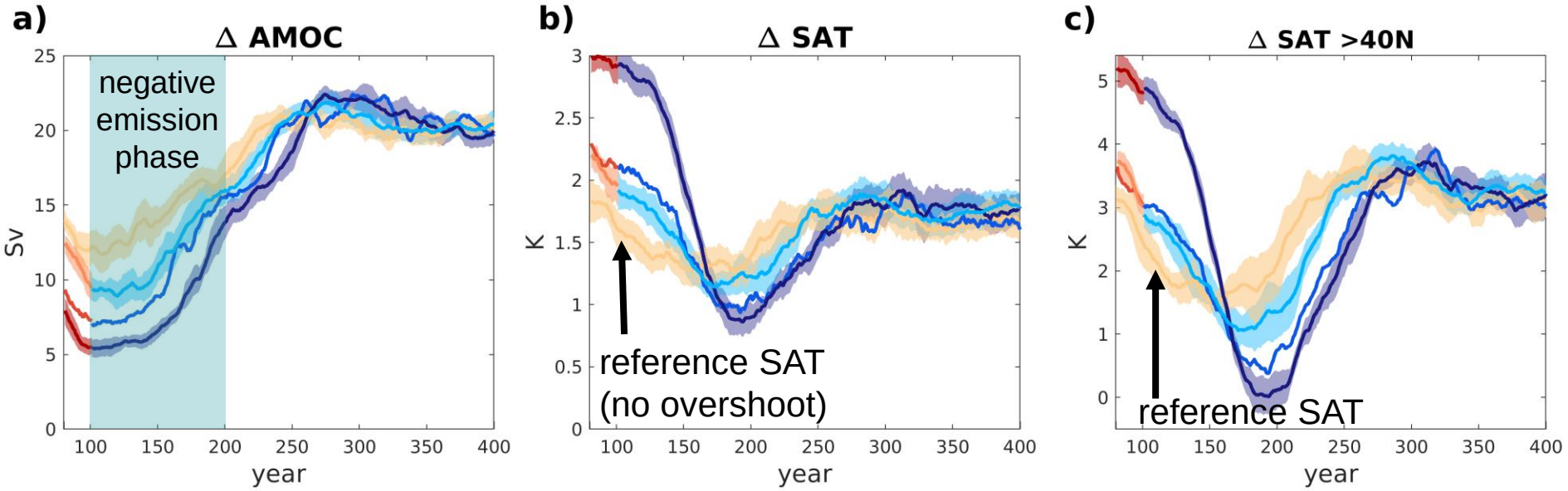
If negative emissions are applied in a state of reduced AMOC…



- the radiative forcing is brought back towards the reference level quickly, but AMOC remains in a reduced state for much longer
- reduced northward heat transport in combination with reduced radiative forcing cool the norther hemisphere below the reference level -> **amplification of warming-cooling-warming cycles**

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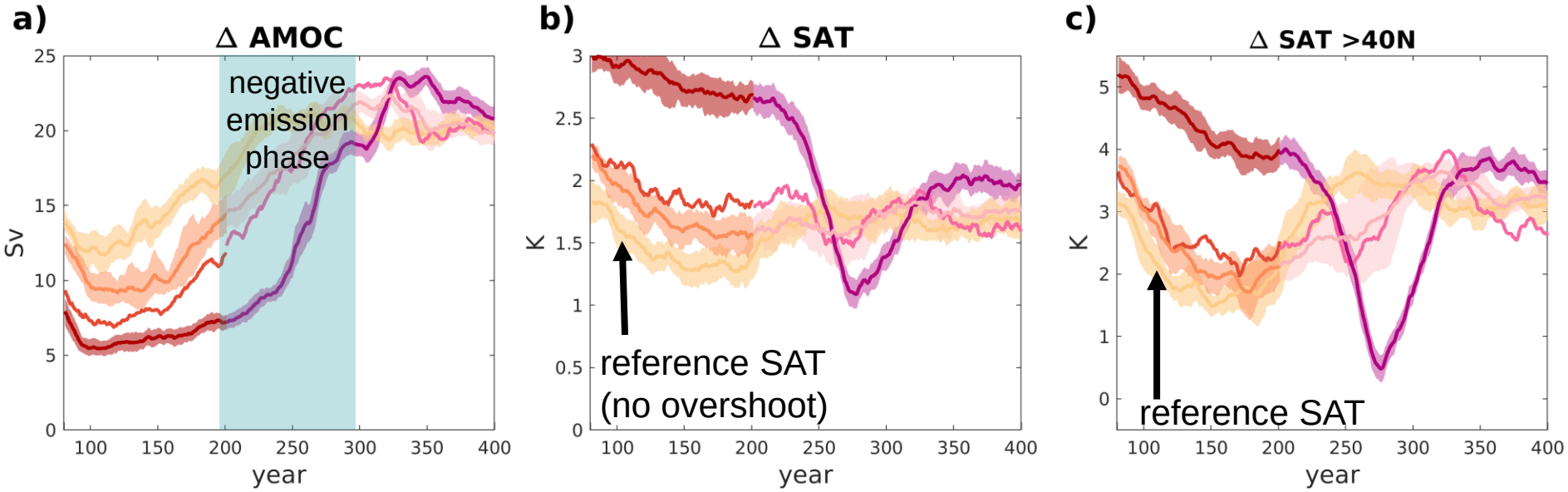

- the timing of negative emission matters: If AMOC has partly recovered, negative emissions mitigate the resulting SAT increase and **warming-cooling-warming cycles are not amplified**

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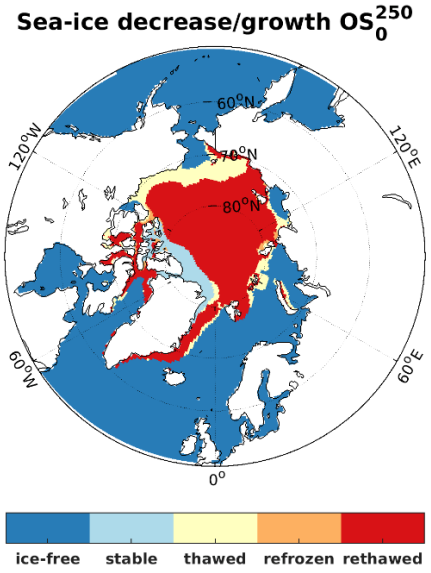
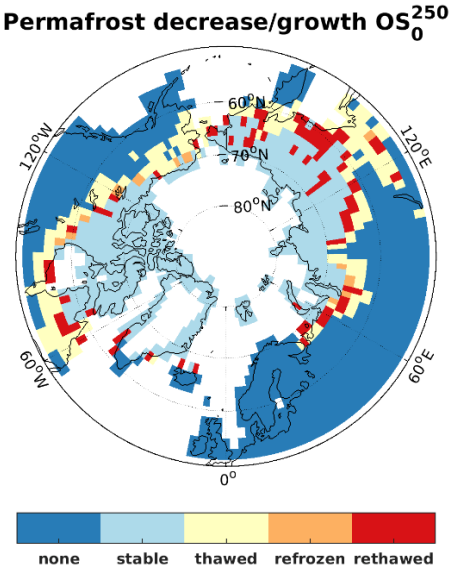
Impacts of these warming-cooling-warming cycles?

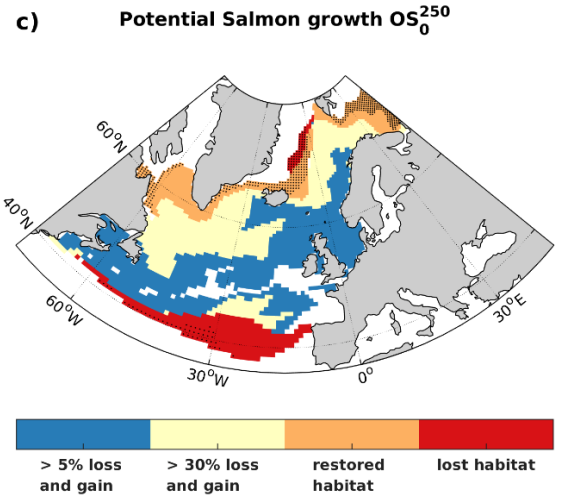
a)



b)



c)



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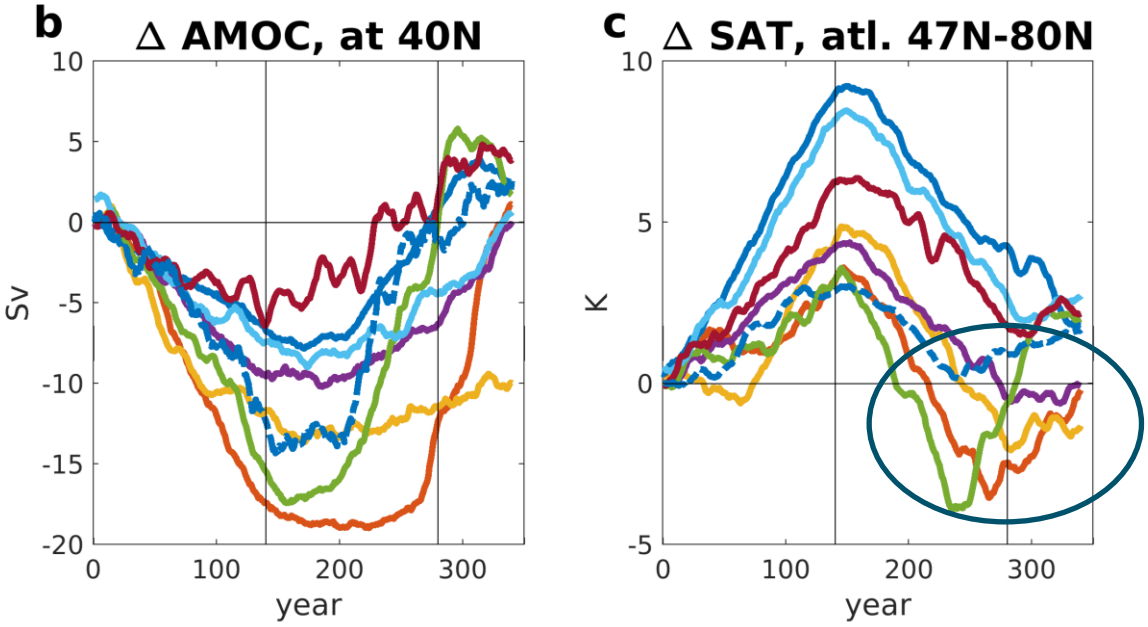
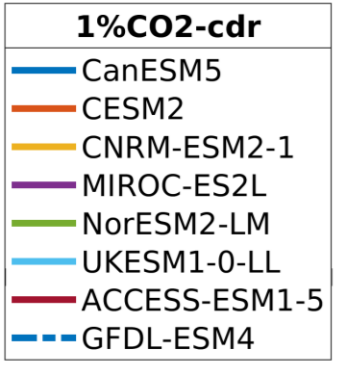
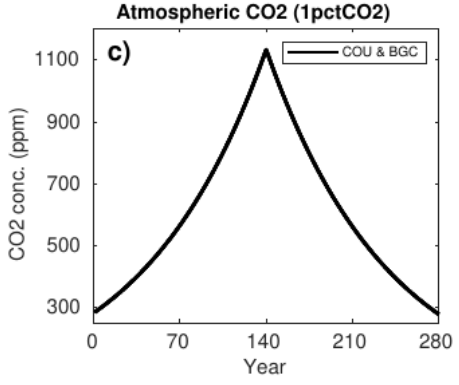
What so other ESMs say?

CDRMIP simulations (1% CO_2 ramp-up/ramp-down)







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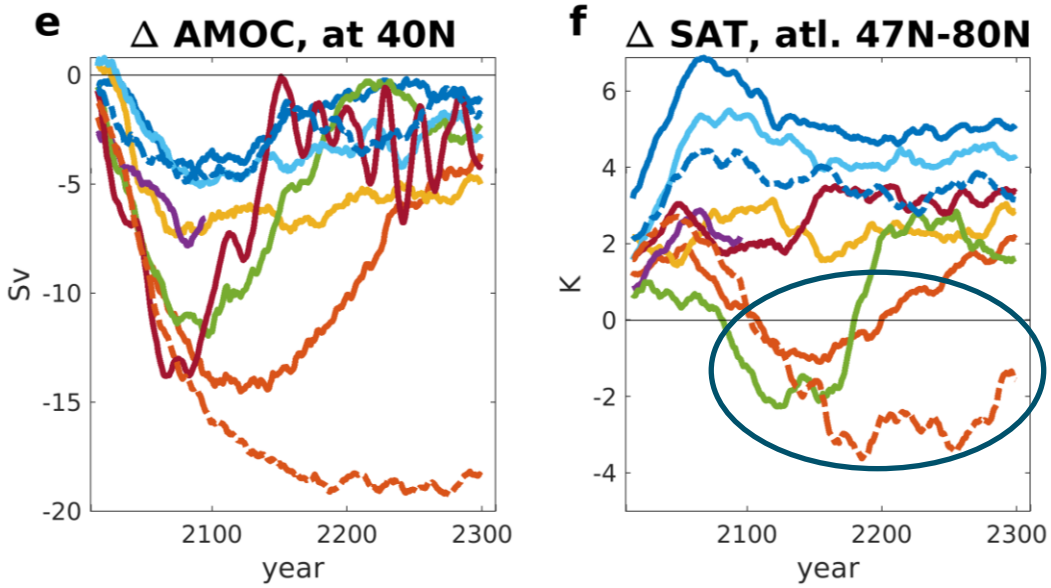
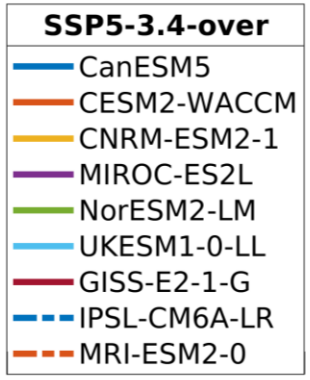
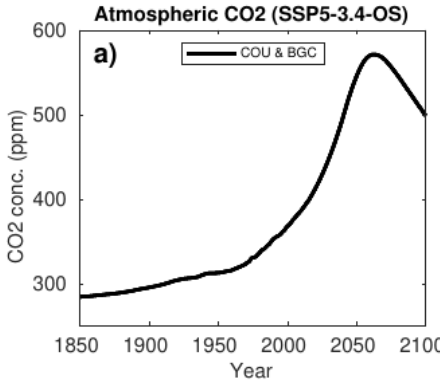
What so other ESMs say?

ScenarioMIP overshoot simulations (SSP5-3.4-OS)







Discussion and conclusions:

- Northern hemisphere warming-cooling-warming cycles appears to be a robust feature of ESMs that show a strong AMOC decline
- These cycles would be amplified under large scale CO_2 removal
- We do not know the true sensitivity of AMOC to global warming, IF it is very sensitive the cooling effect of AMOC decline needs to be considered

Why would we care?

- An amplified cooling effect would come with consequences for marine and terrestrial ecosystems and climate change adaptation.
- There are potential trade-offs between the global north and south: avoid NH cooling would imply delaying negative emission at the cost of delaying temperature reduction in the south.

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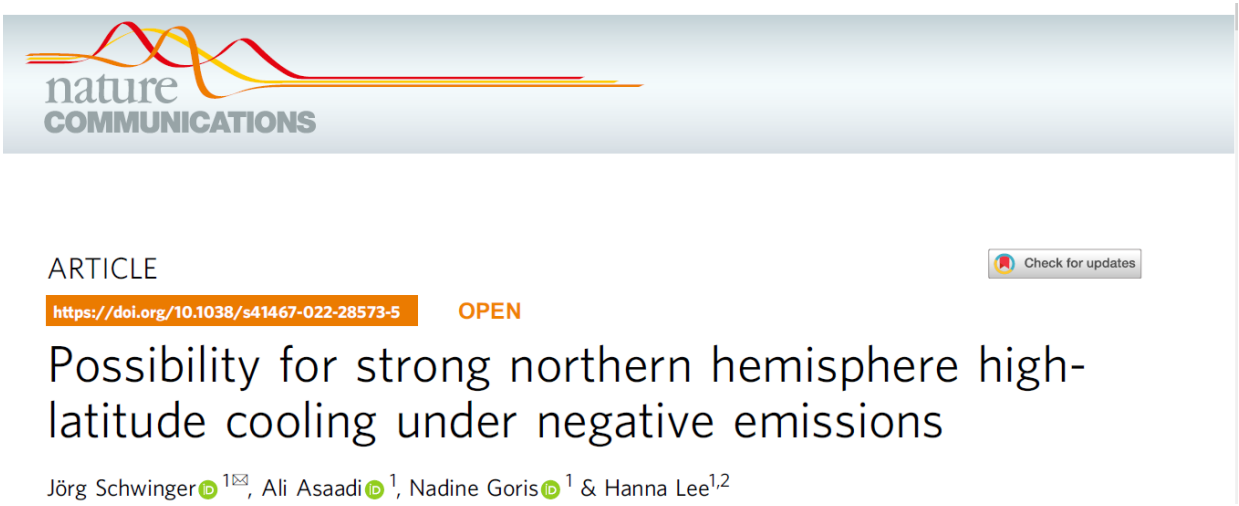
Thank you for listening!



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