Carbon cycle futures in the PPE-verse

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and the CLM5-PPE working group
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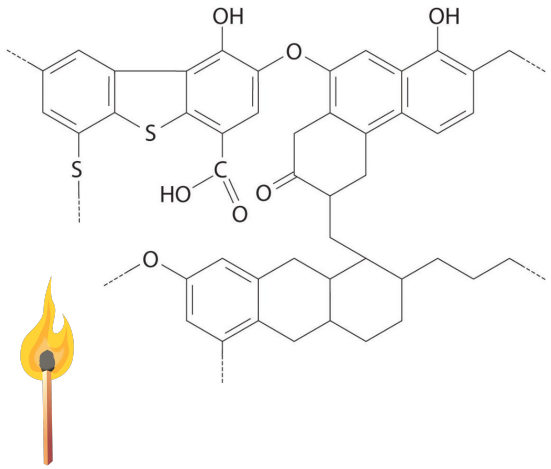
Fossil fuel burning releases energy and CO_2



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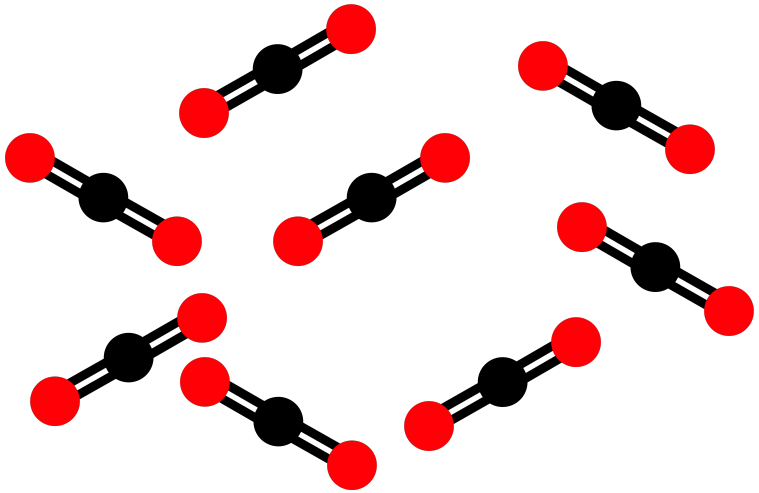
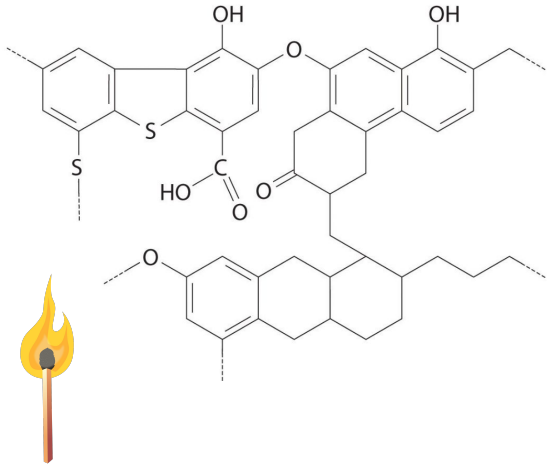
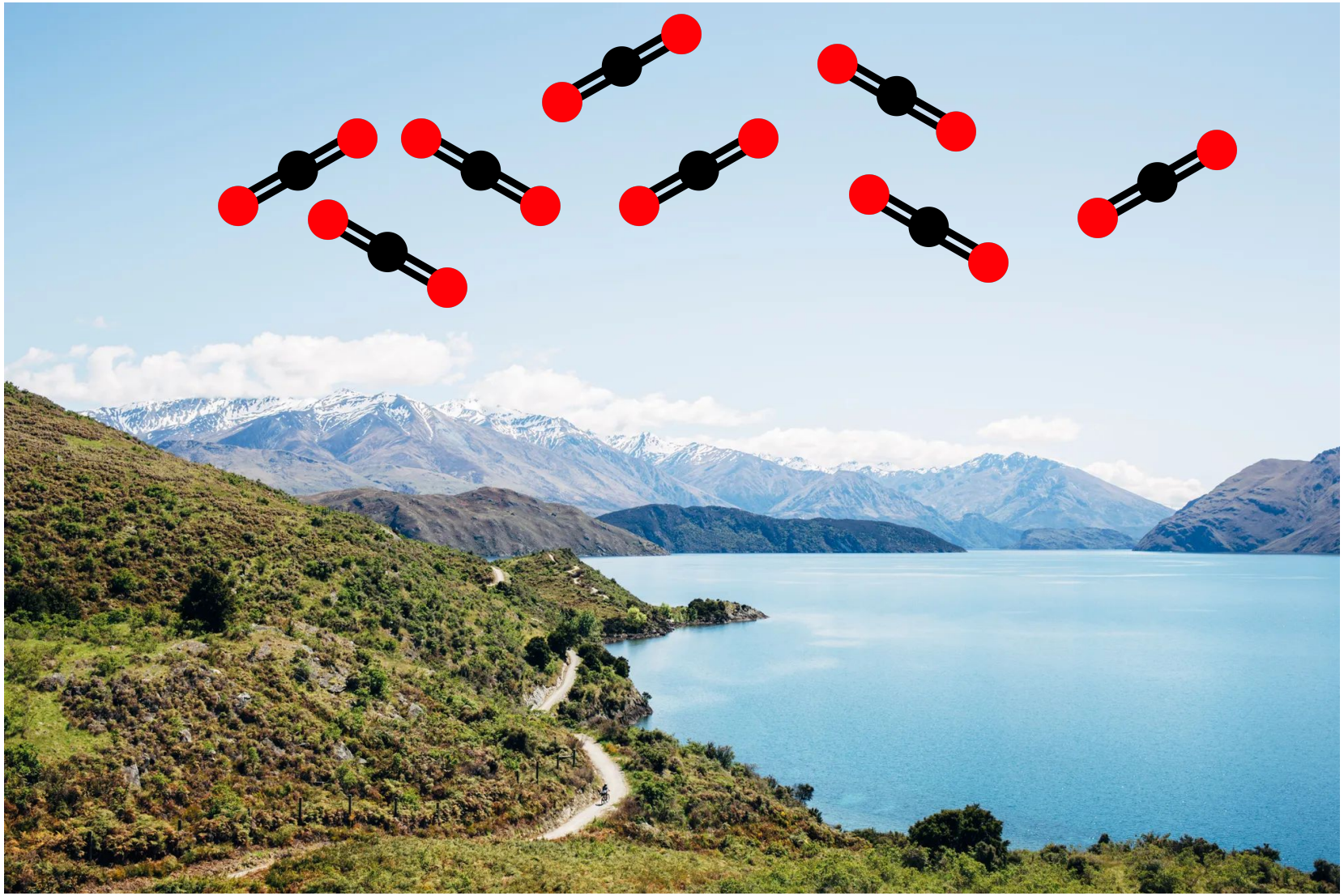




Where did the CO_2 go?

If all the fossil CO_2 stayed in the atmosphere

CO_2 concentration would be ~500 ppm as of 2020



Global Carbon Budget 2021, Friedlingstein et al. 2022

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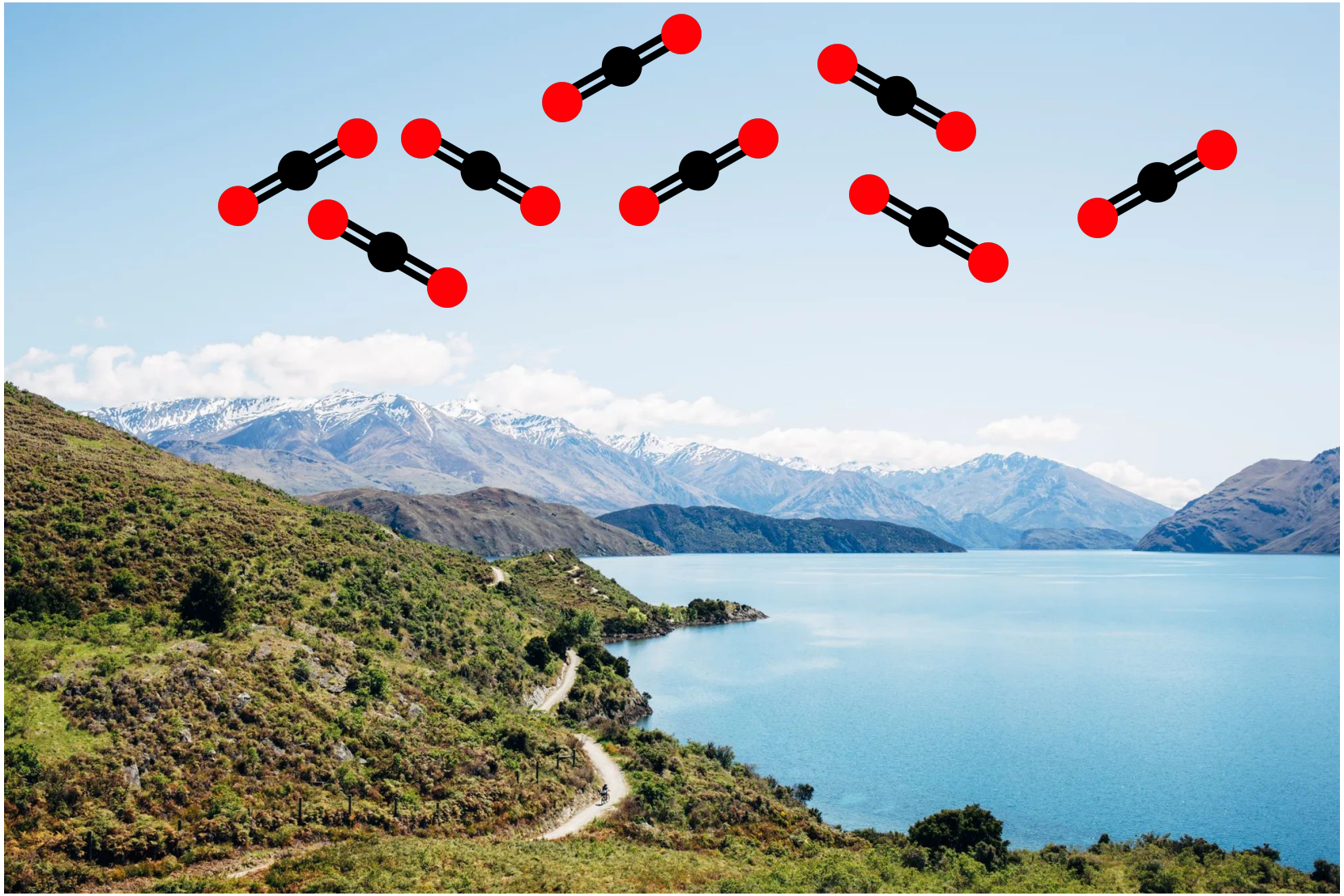

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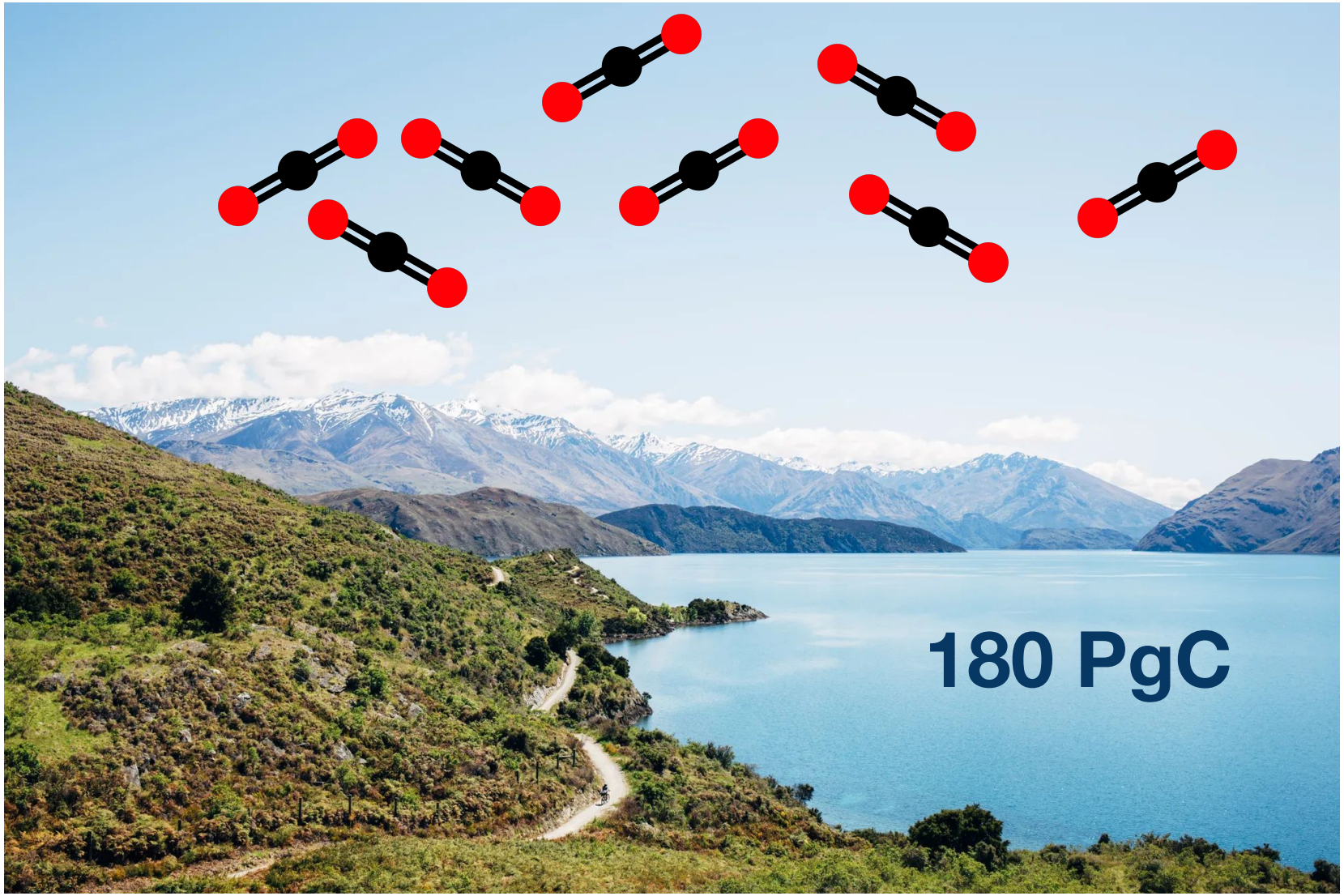

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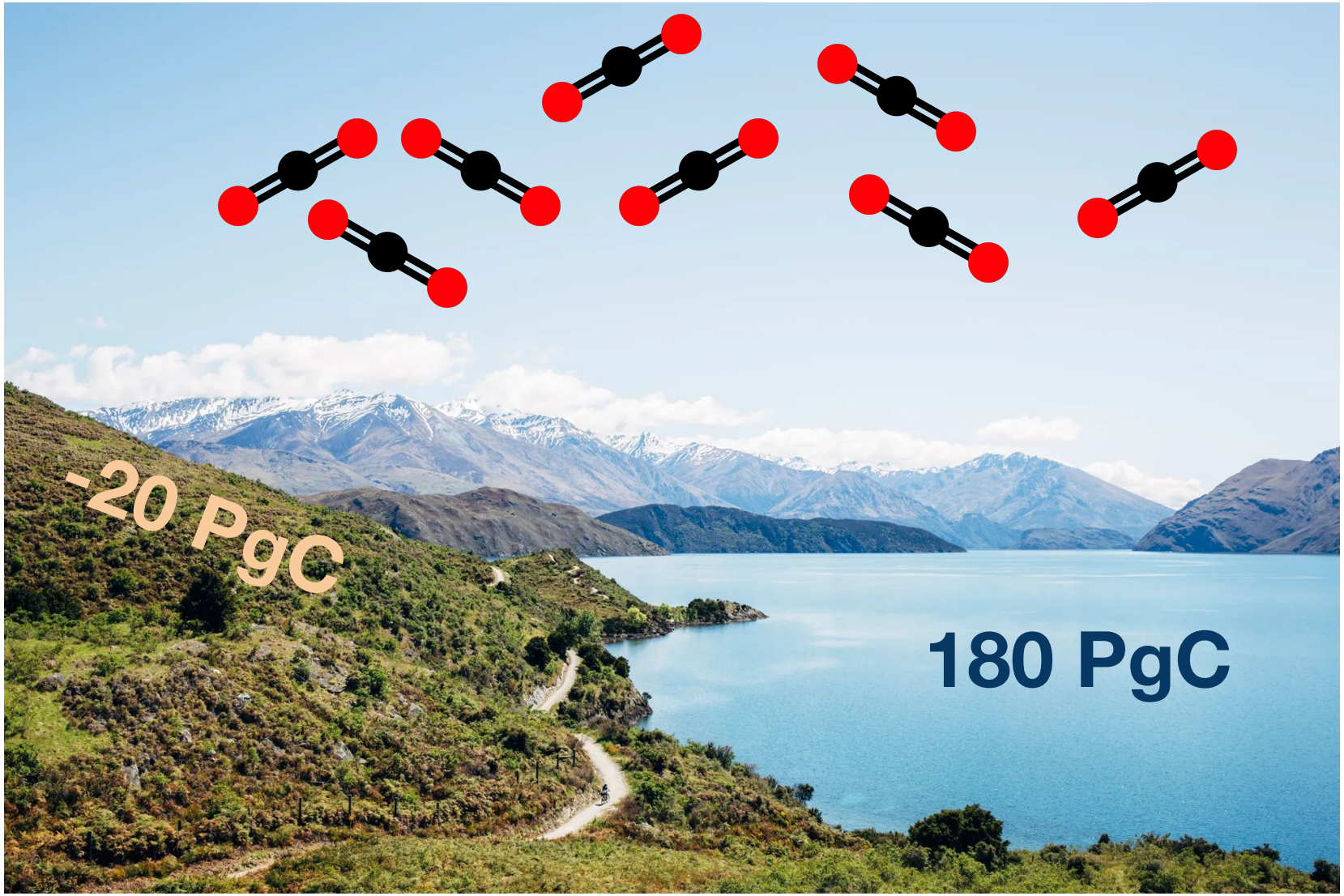

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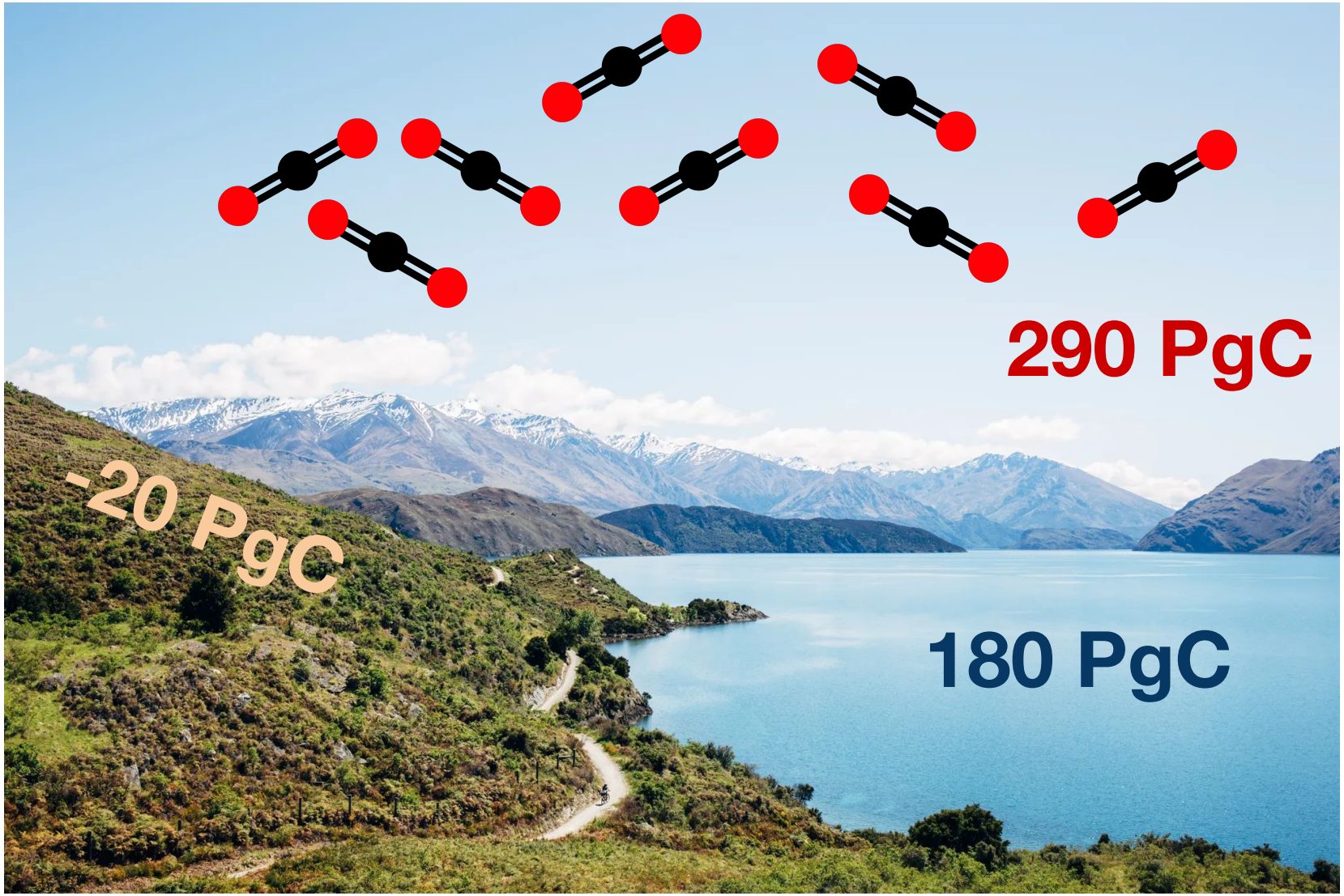

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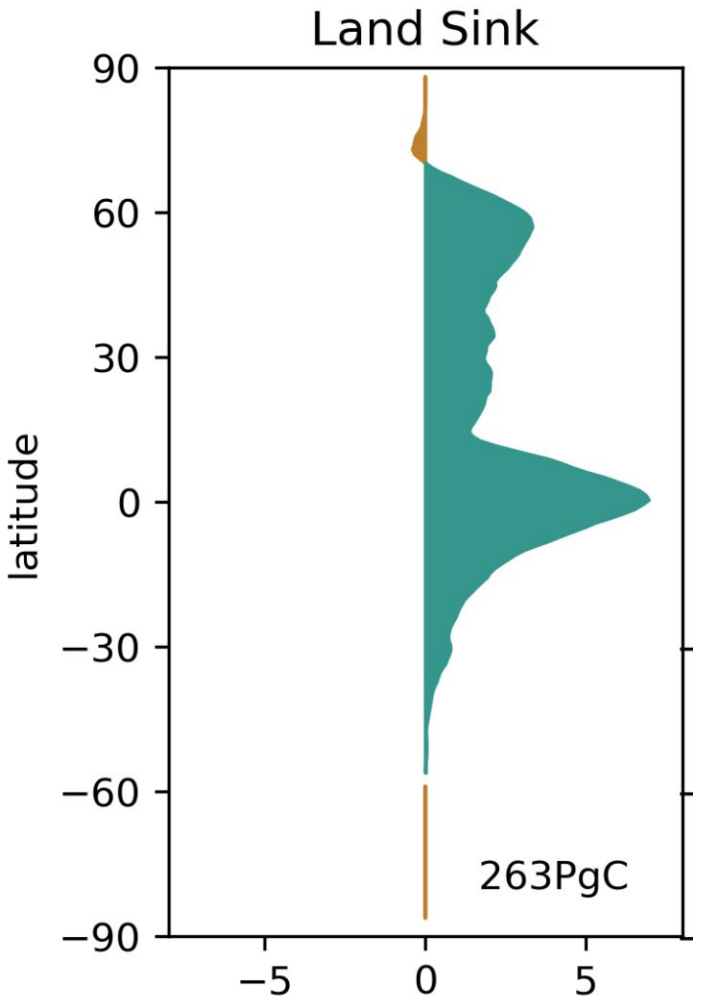
CLM5-TRENDY Land Sink



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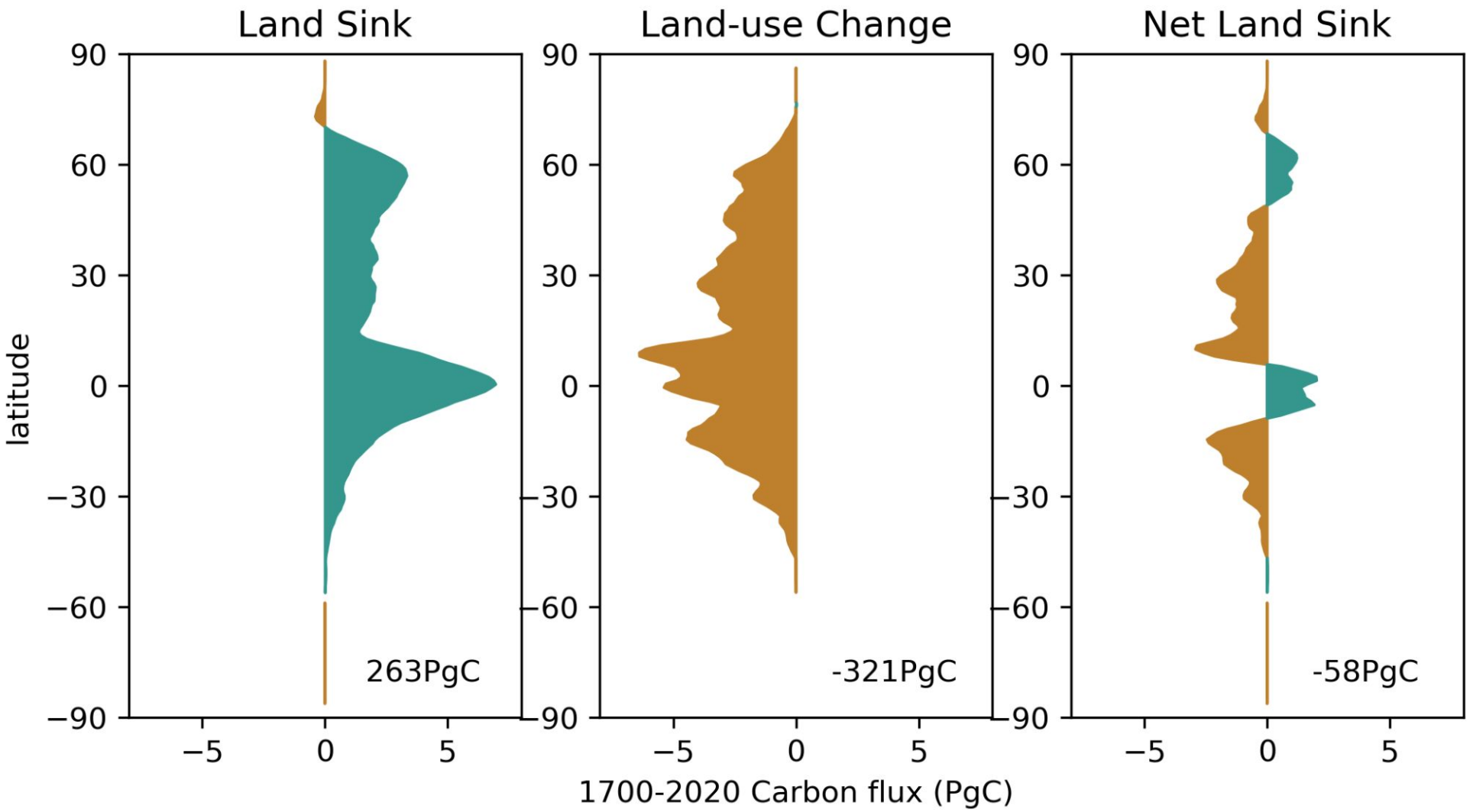
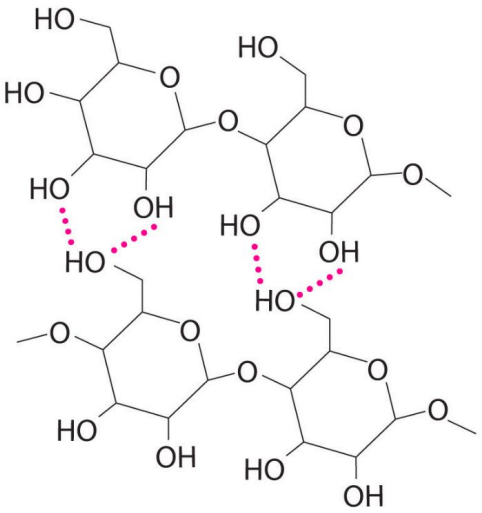


CLM5-TRENDY Land Sink

Carbon on land is more labile than CO_2 in ocean/atmosphere



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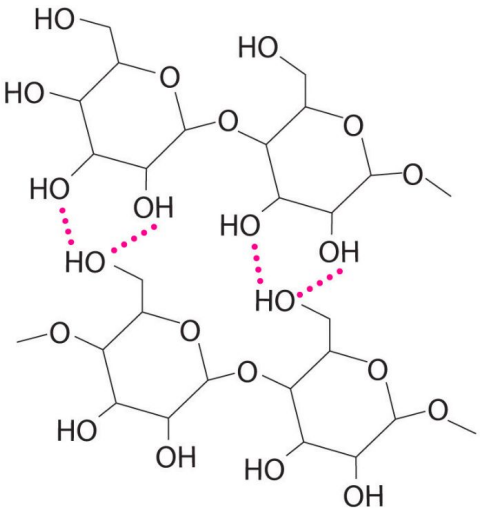

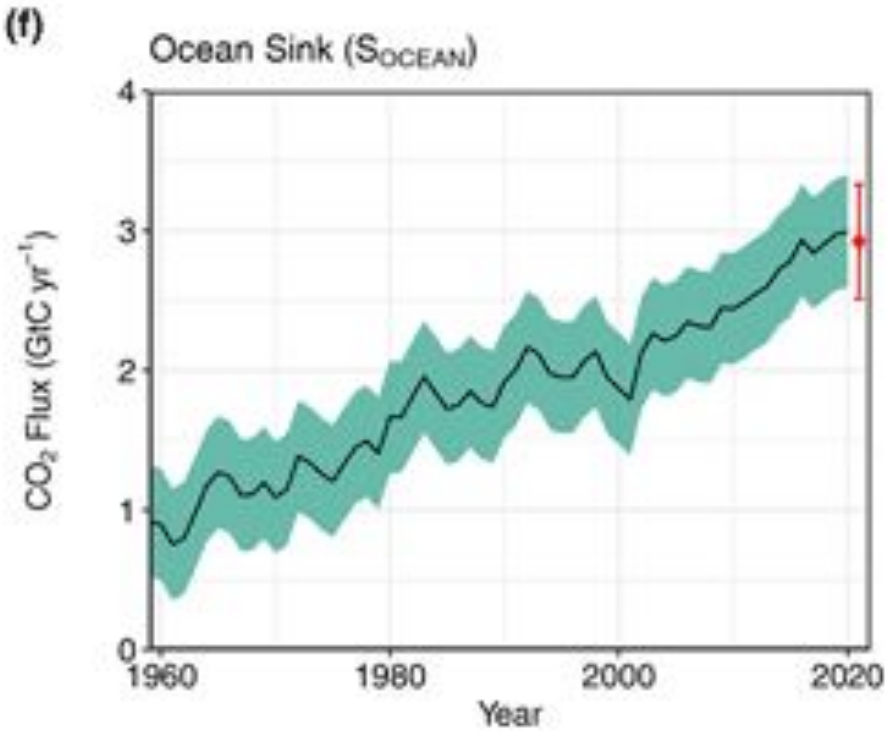

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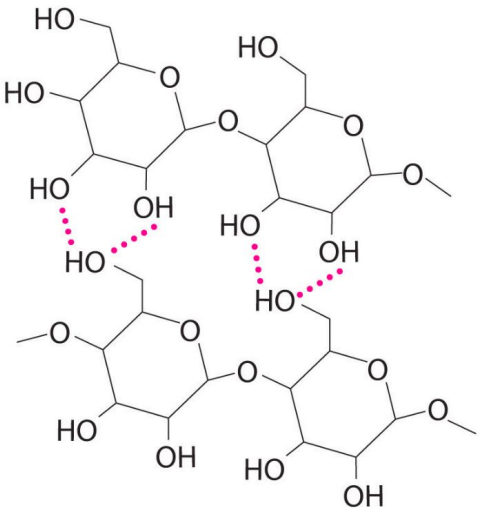

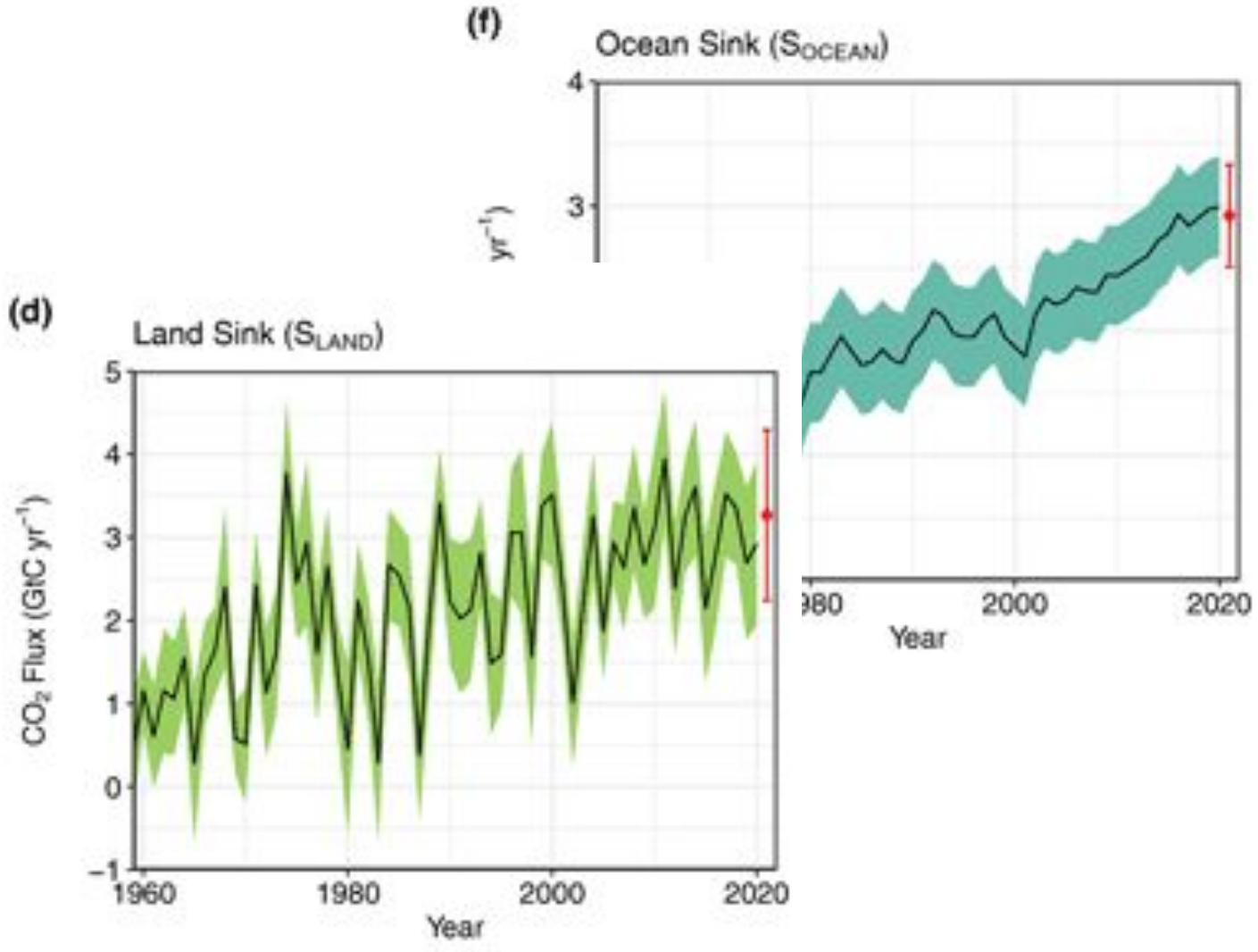

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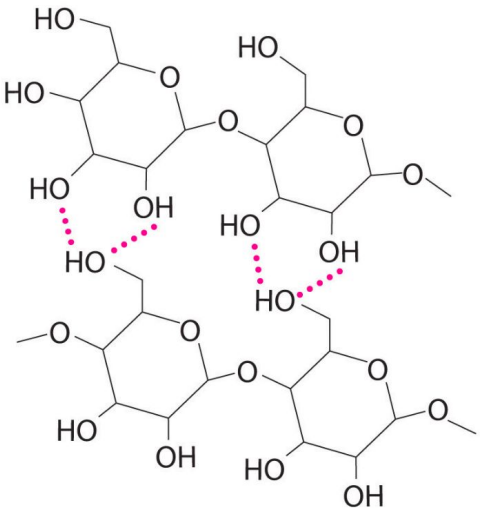
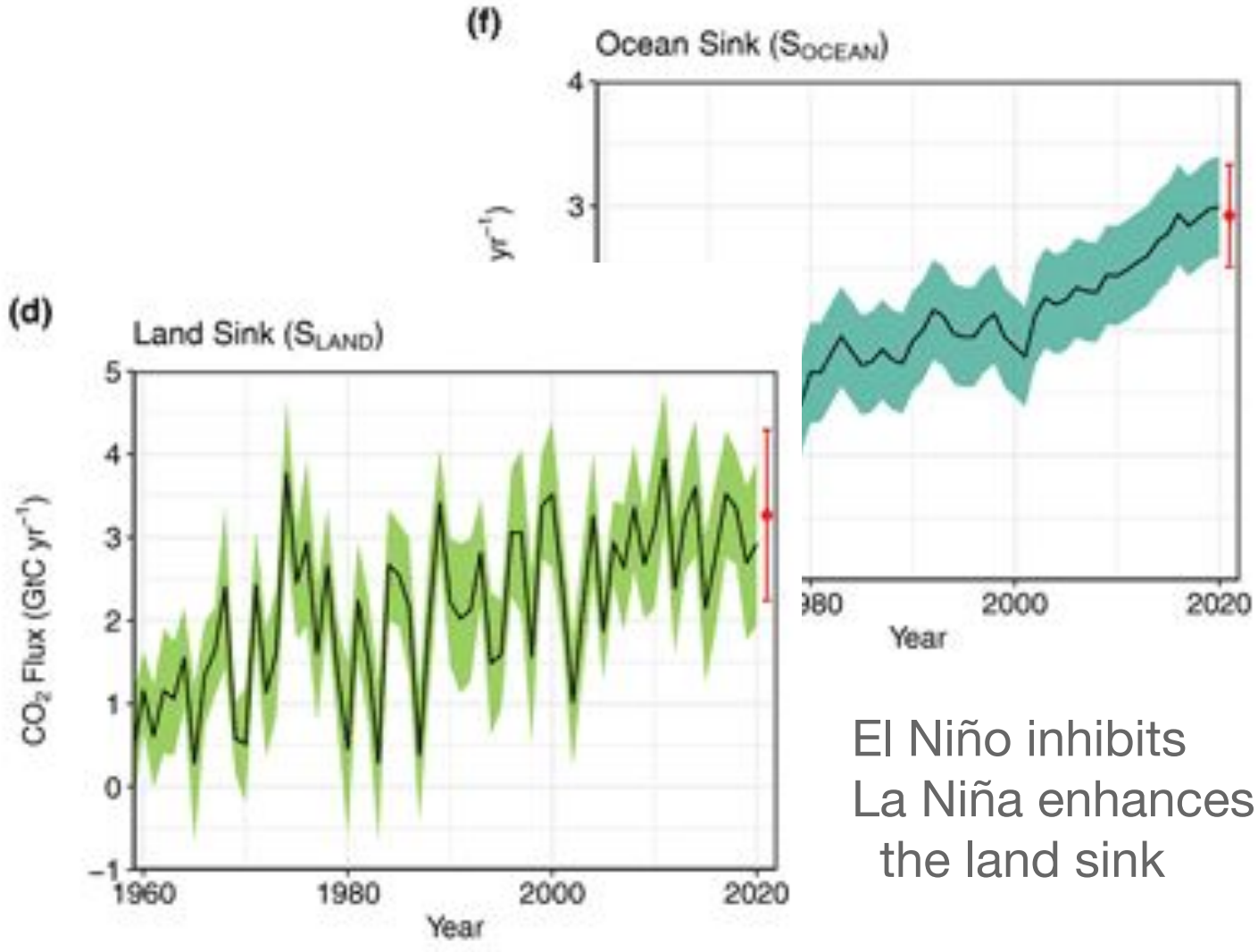


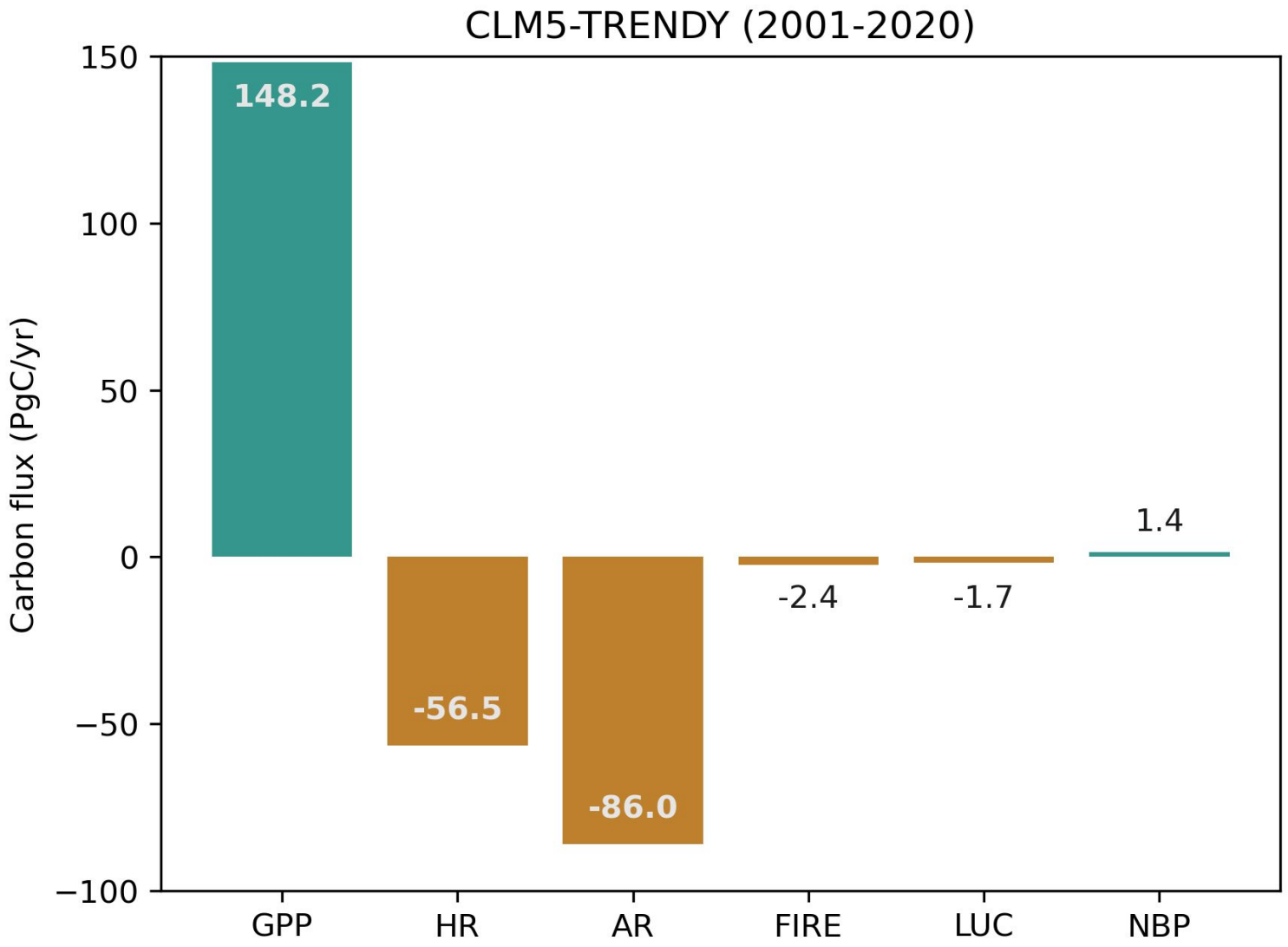


El Niño inhibits
La Niña enhances
the land sink

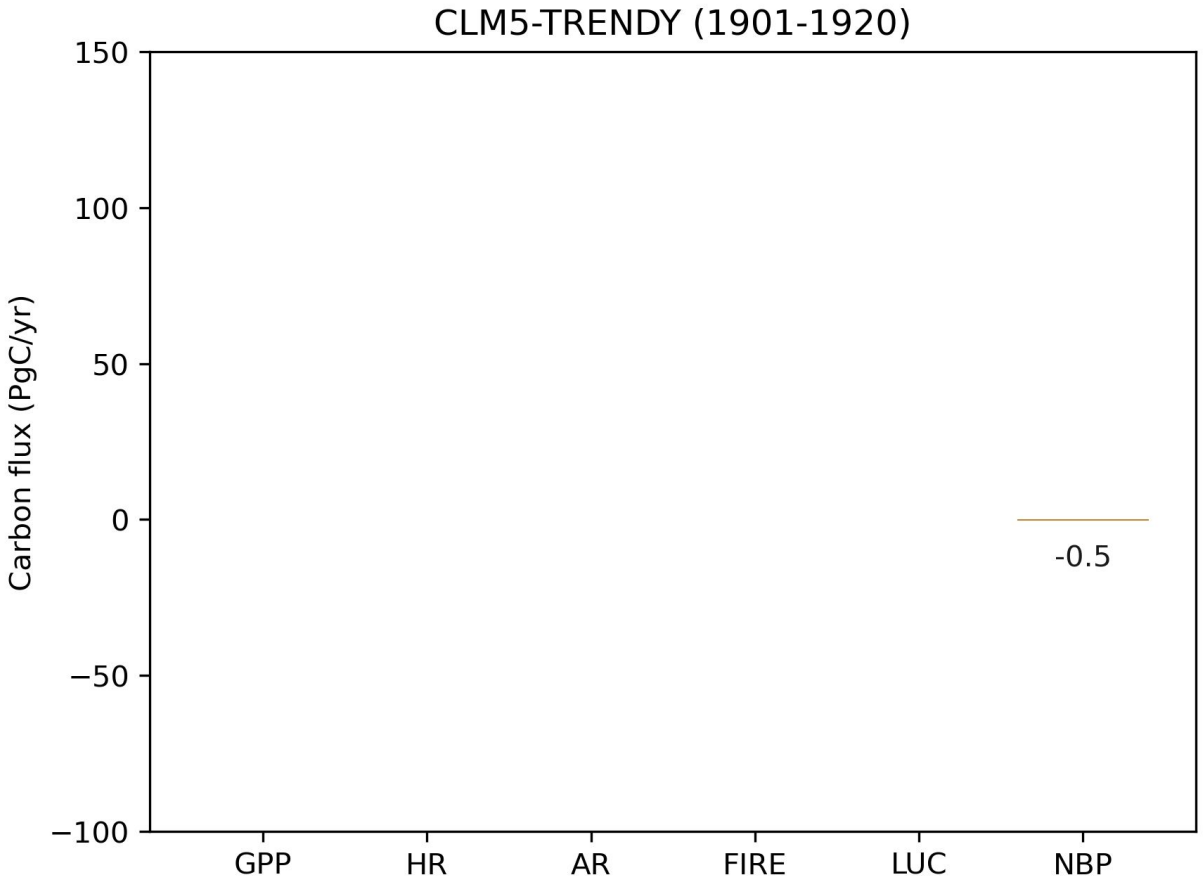
Global Carbon Budget 2021, Friedlingstein et al. 2022

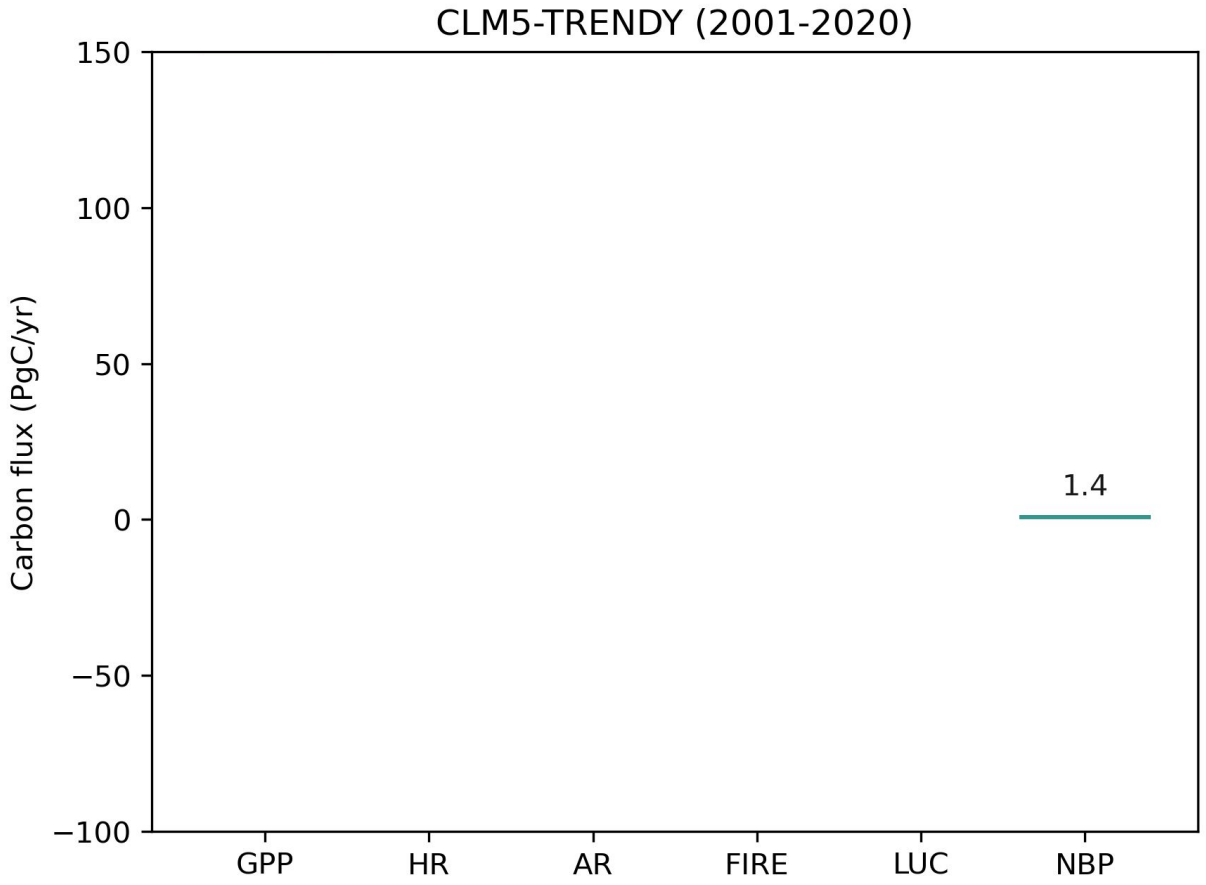
Why is NBP so hard to project?

NBP is a small residual of five component fluxes, each with lots of complexity



Why did NBP switch from negative to positive over the 20th century?





+1.9 PgC/yr

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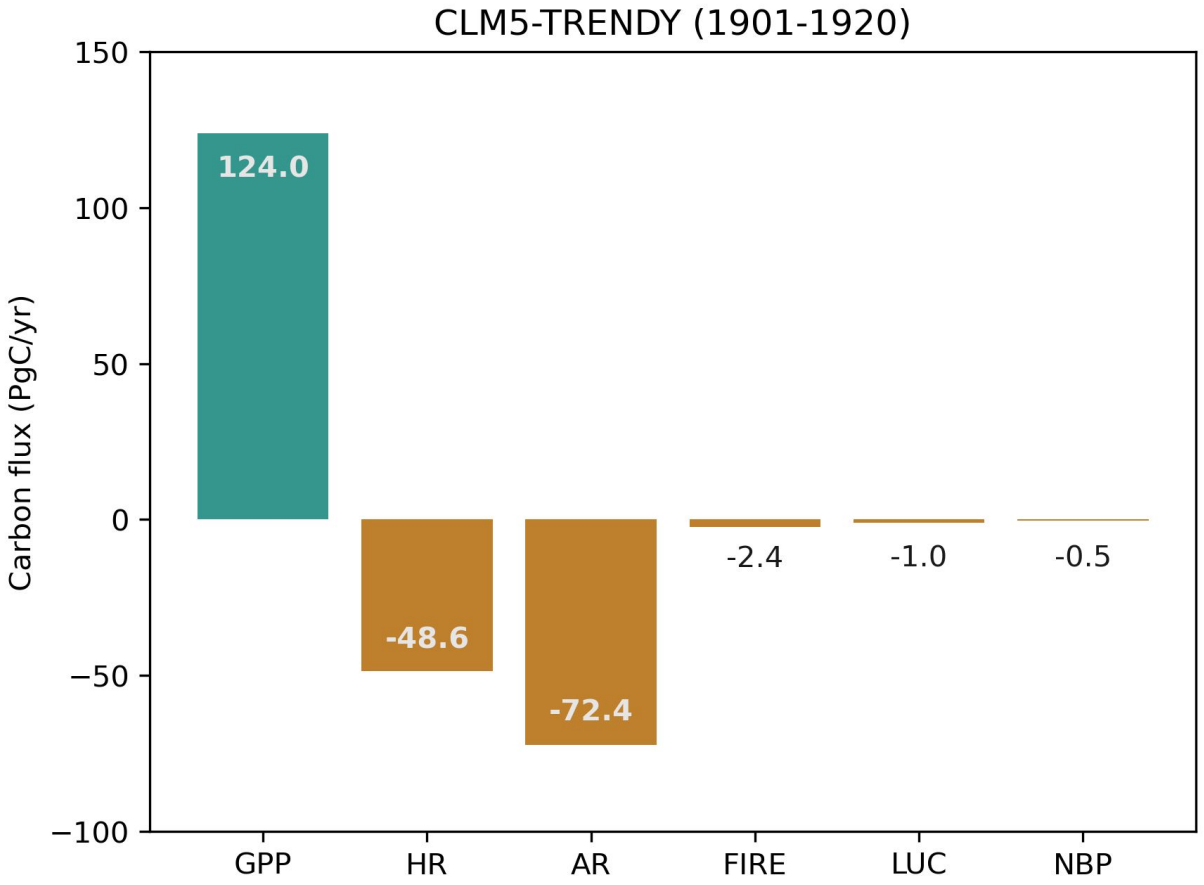

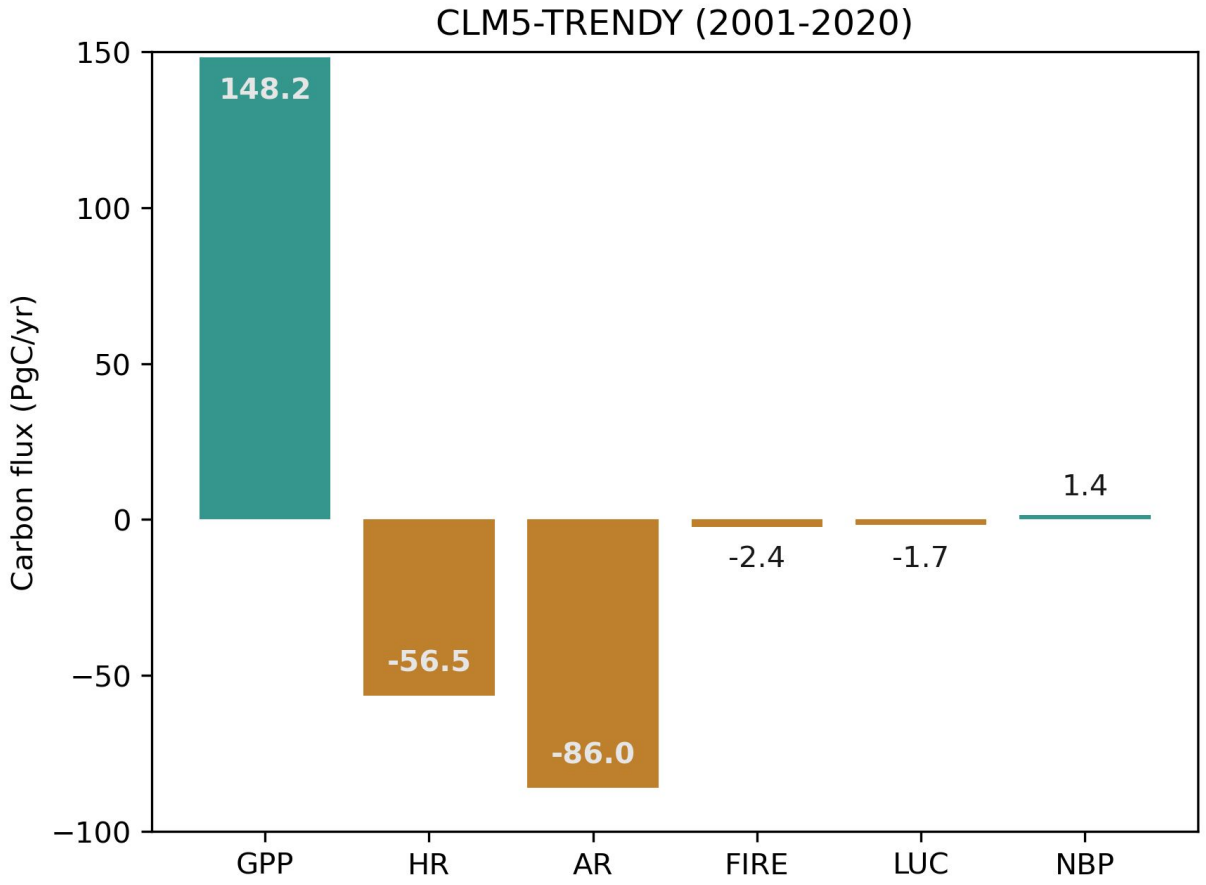

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Will human activity enhance or inhibit the land sink?

Pros:

- CO_2 fertilization
- Nitrogen deposition

Cons:

- Deforestation / disturbance

Will human activity enhance or inhibit the land sink?

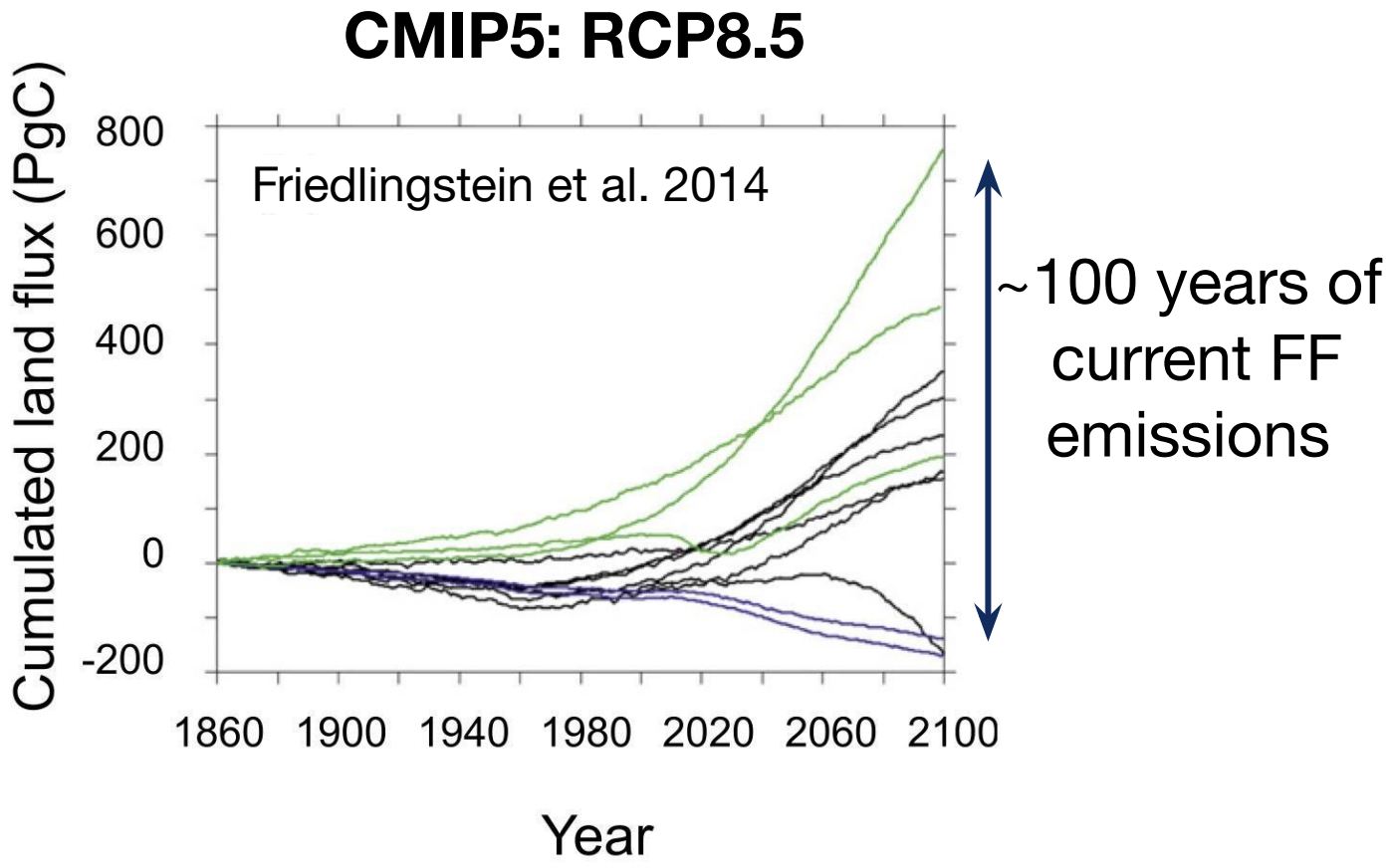
Pros:

- CO_2 fertilization
- Nitrogen deposition
- Extend growing seasons
- …

Cons:

- Deforestation / disturbance
- Increased aridity / water stress
- Increased soil respiration
- Increased fire
- …

Multi-model ensembles show wide range in the land carbon sink



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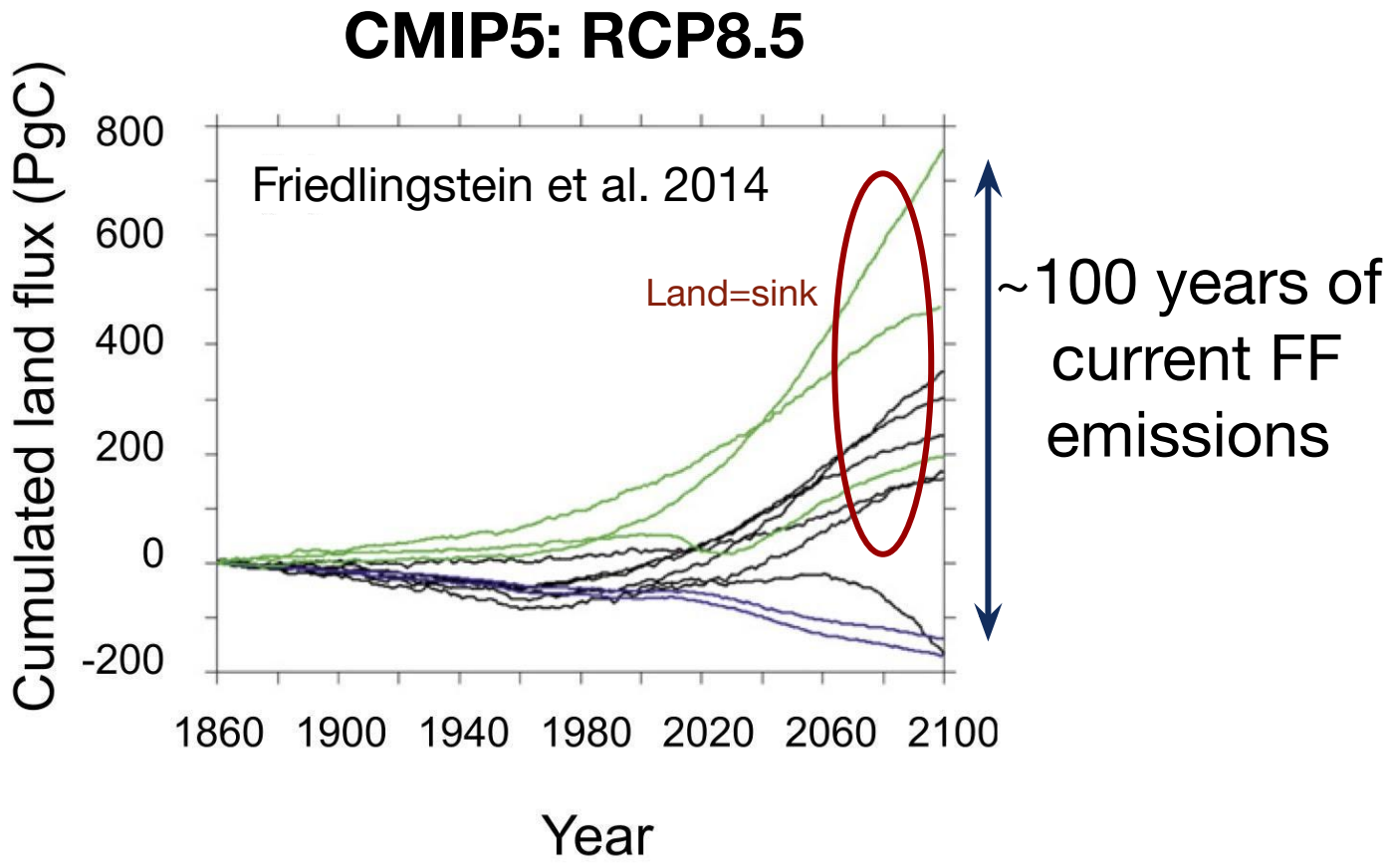

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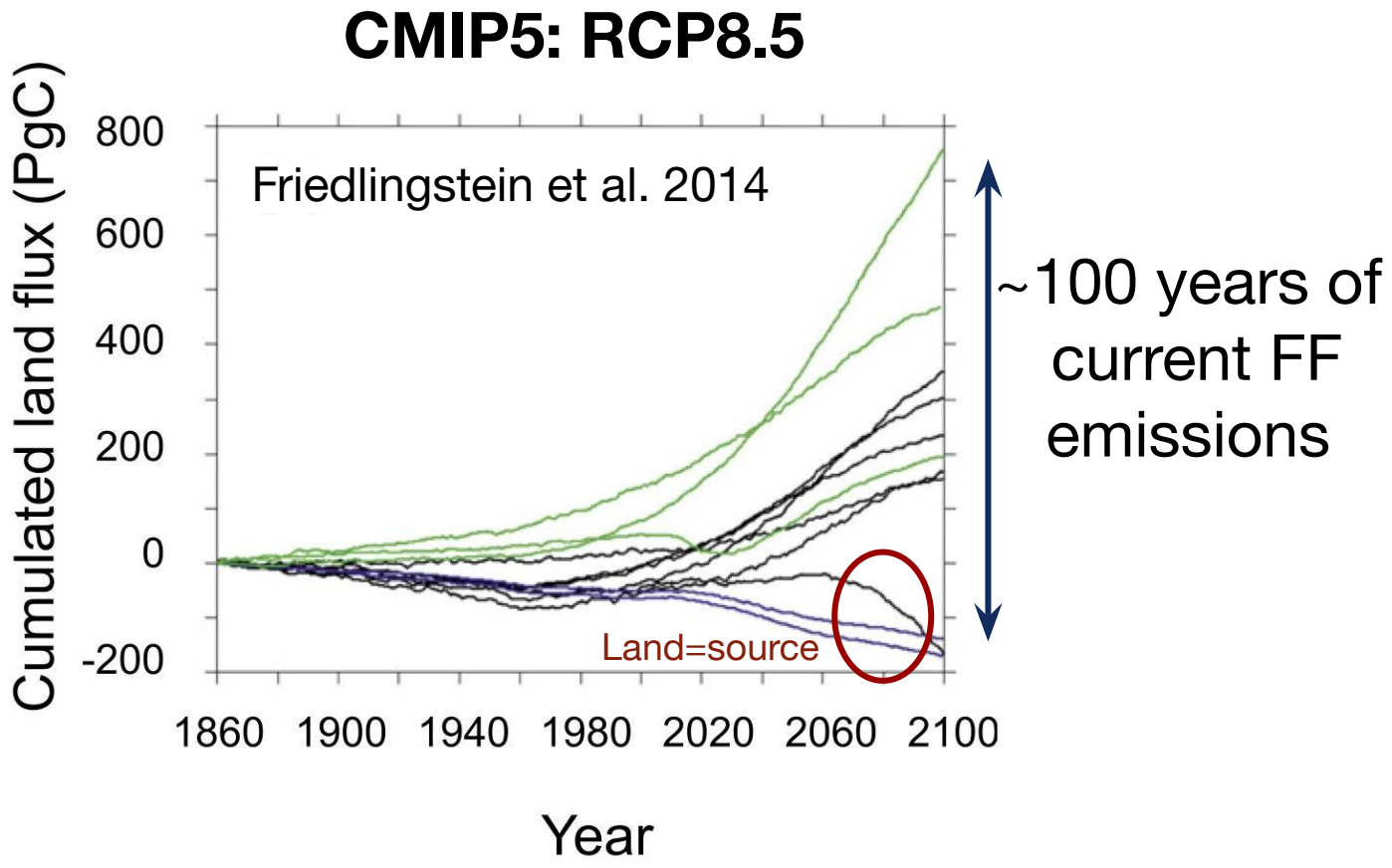
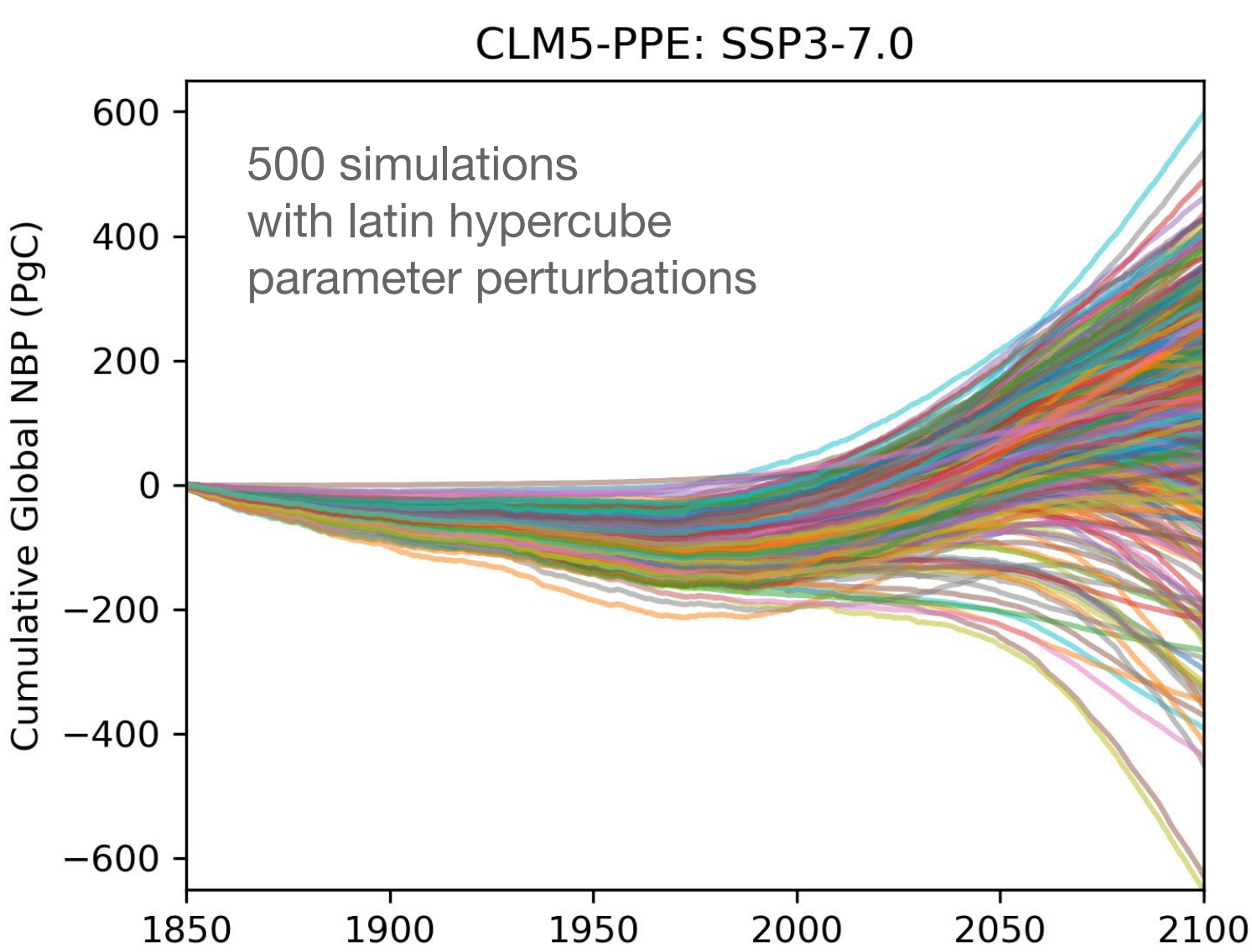
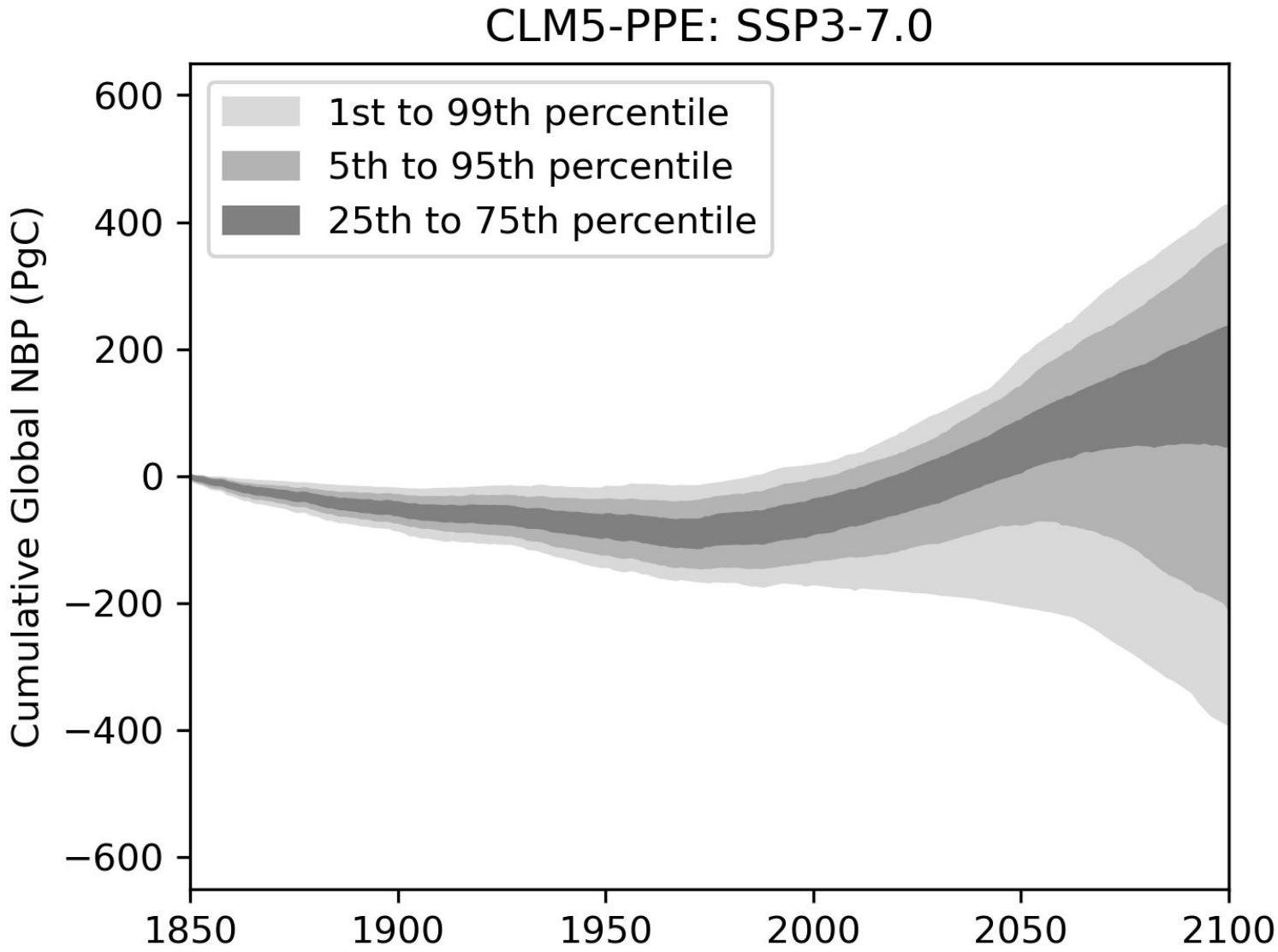


Spread from one model (varying parameters) is of similar magnitude

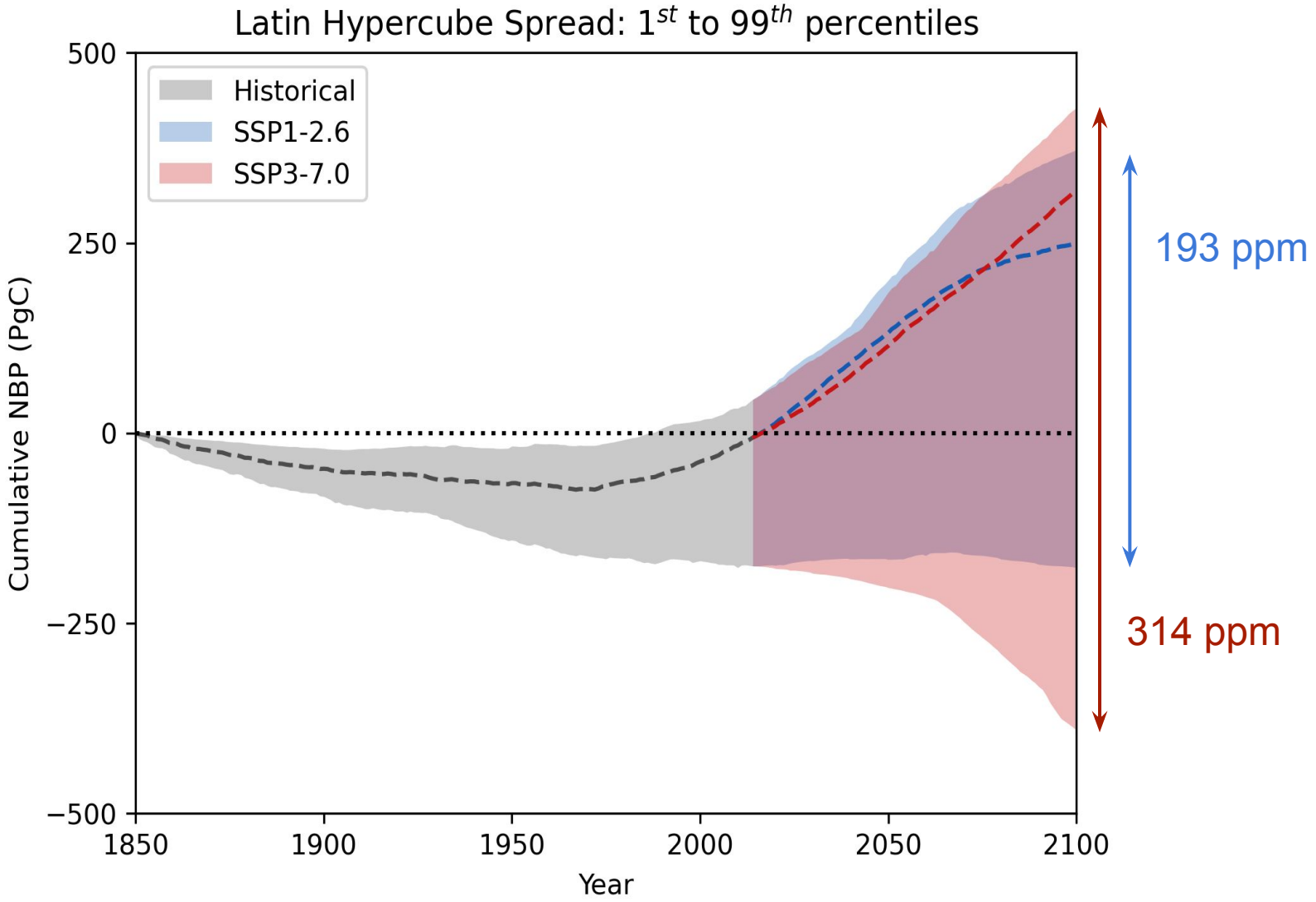


Establishing quantiles is quite a bit trickier

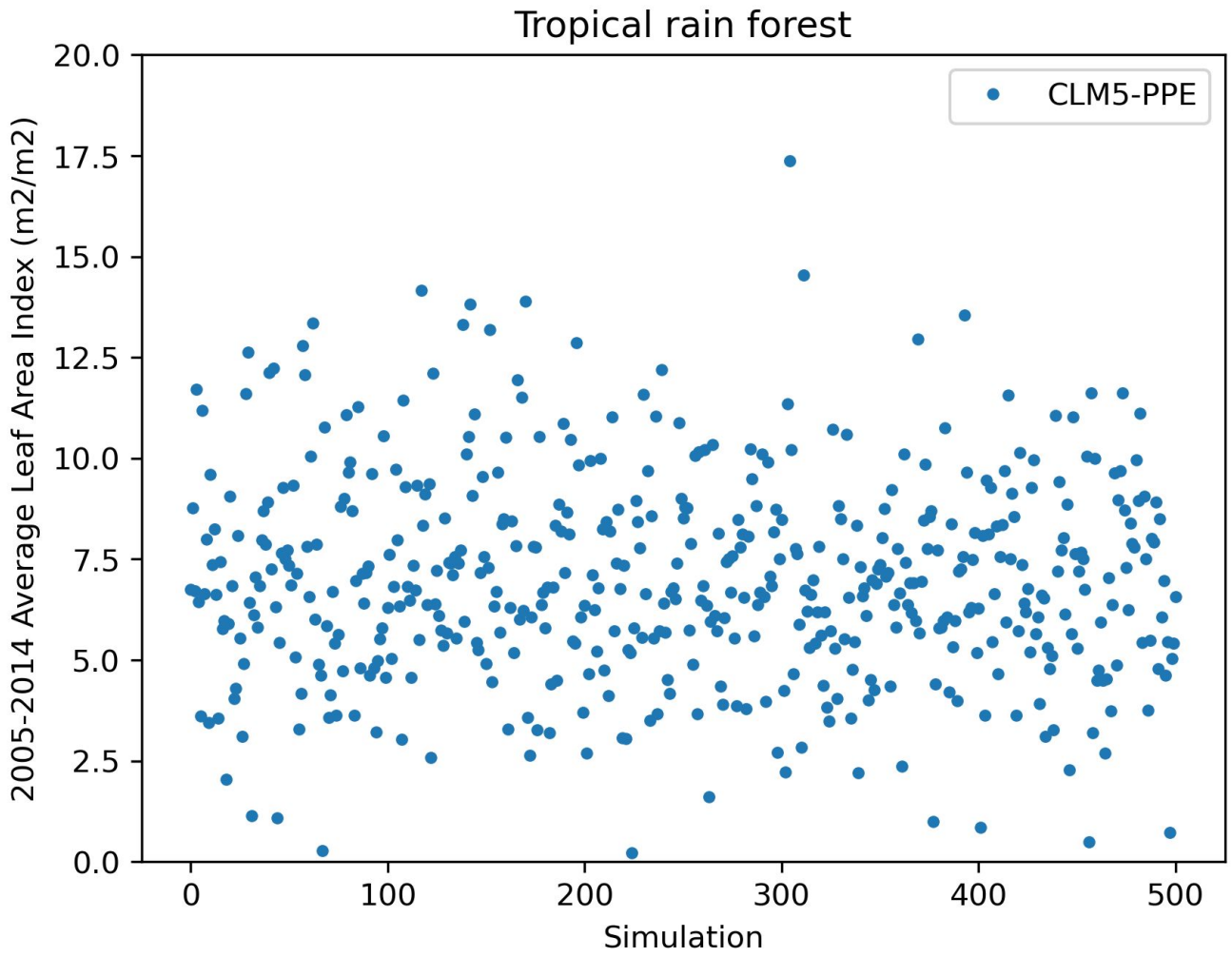


this assumes that all 500 simulations are equally likely

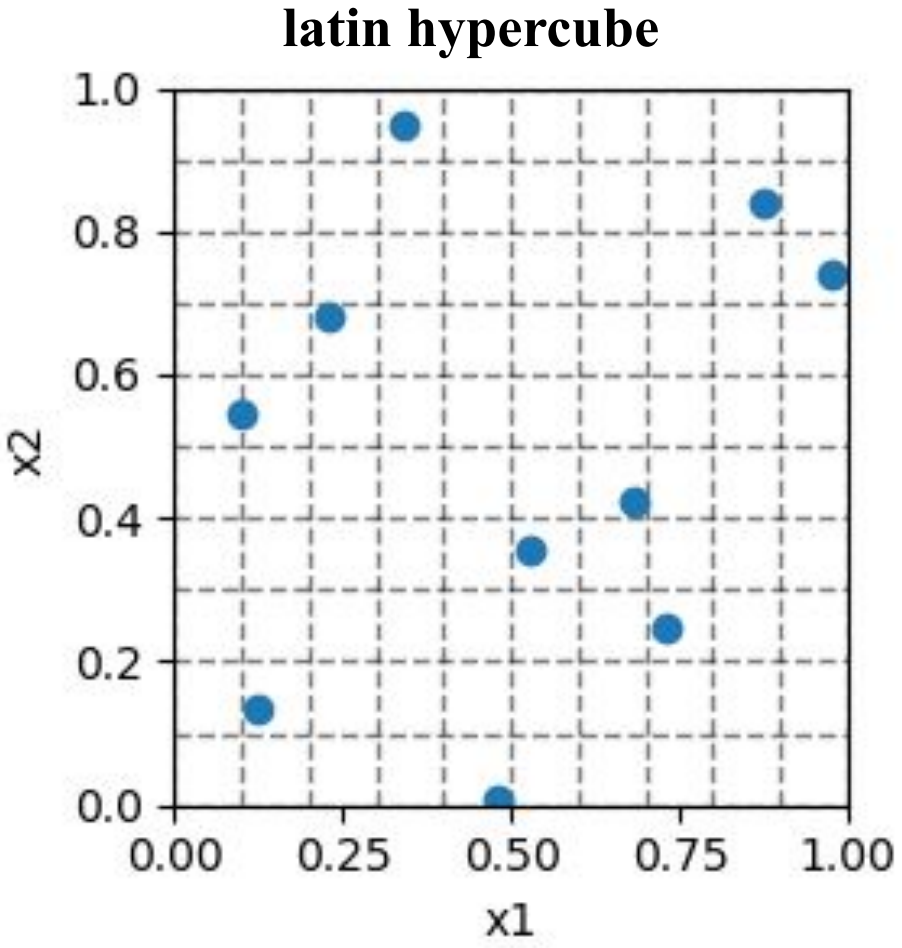
Parametric uncertainty is larger than scenario uncertainty

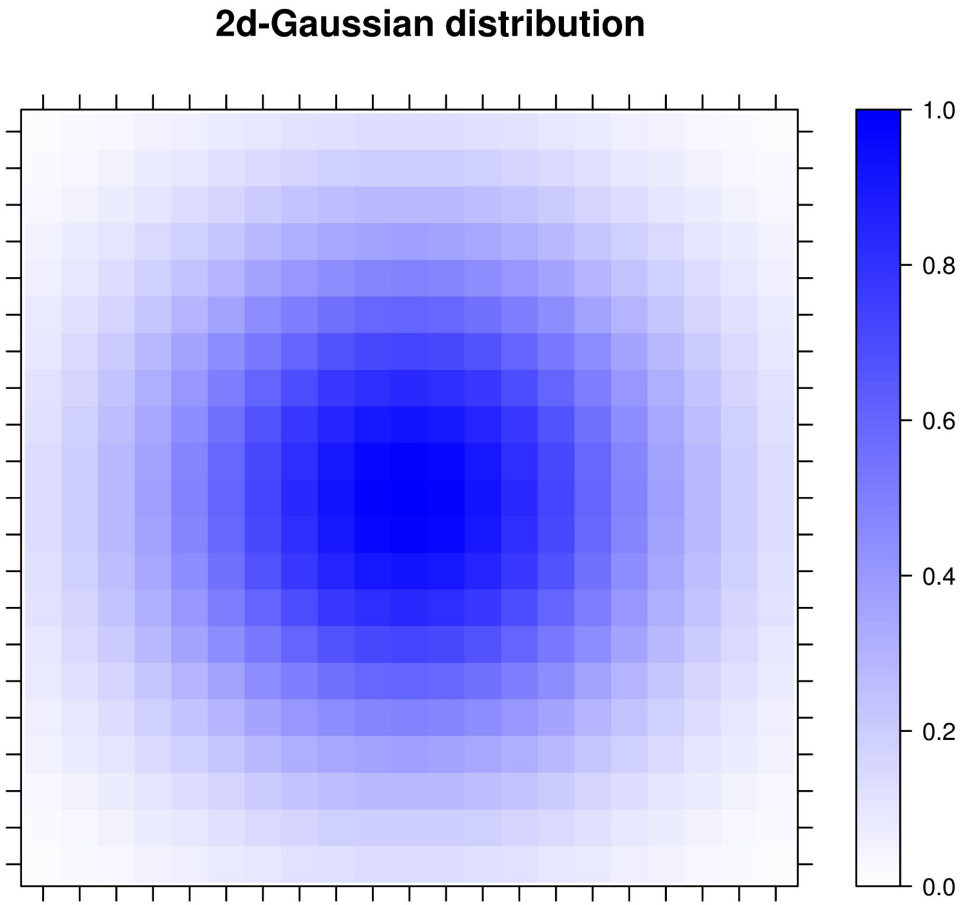


Many of these simulations seem unlikely



Parameter sampling paradigms





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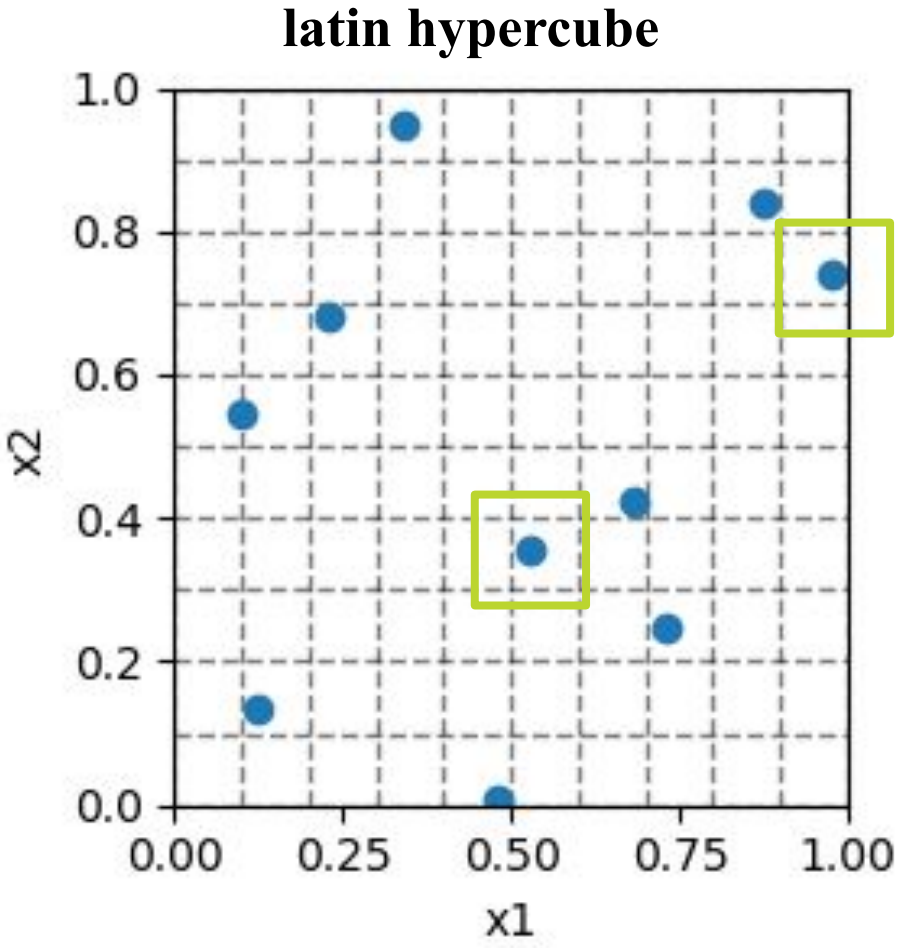
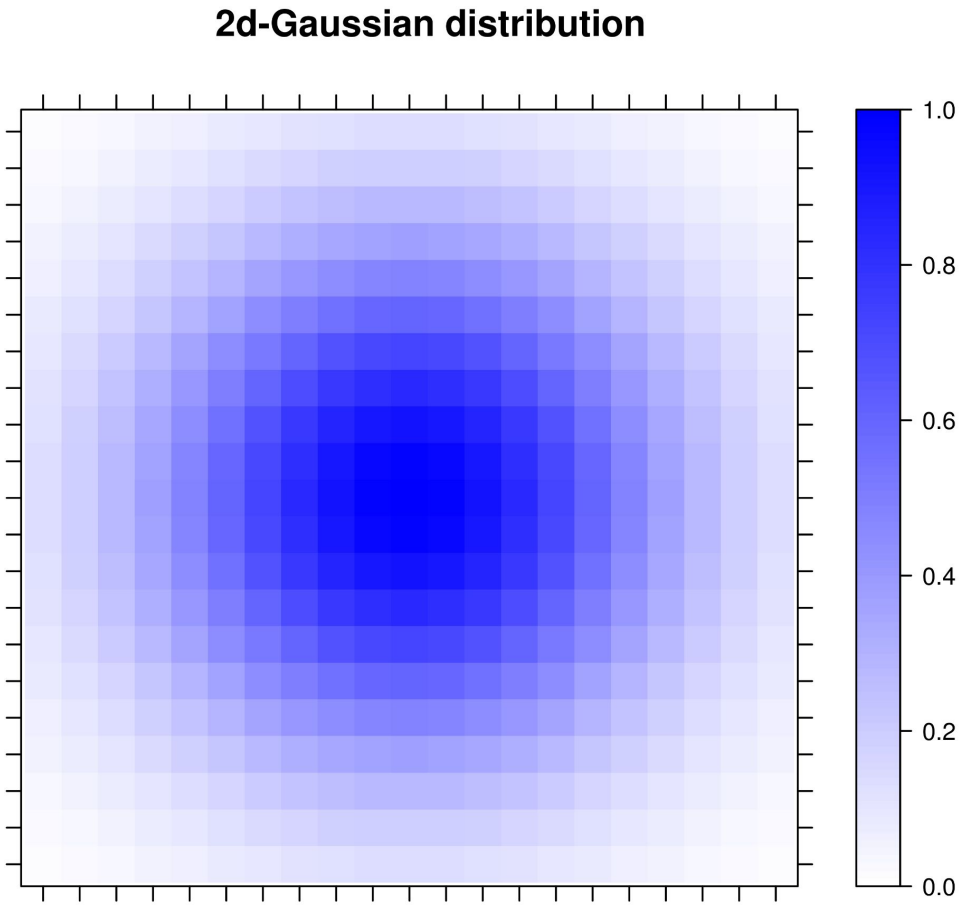
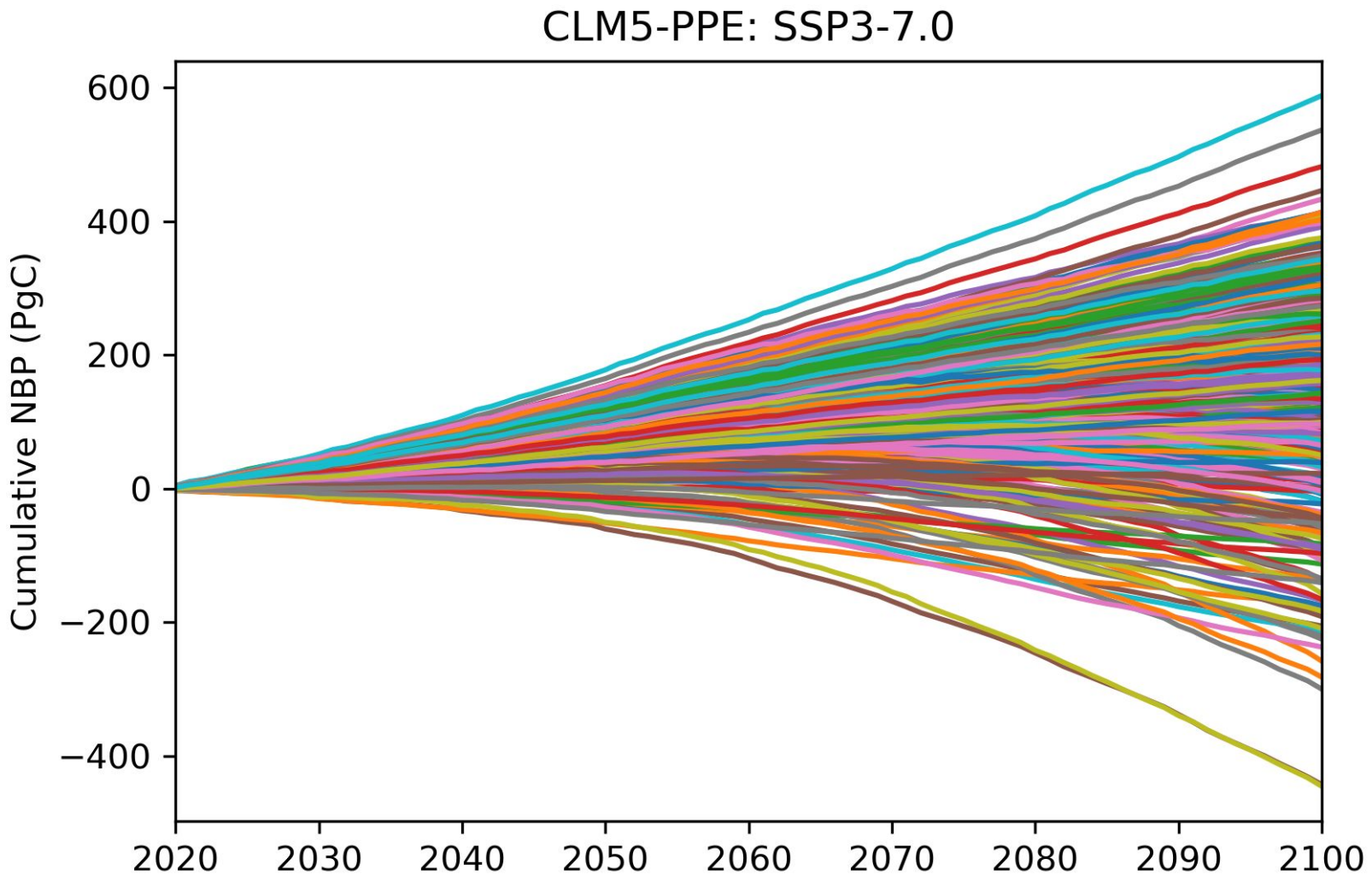
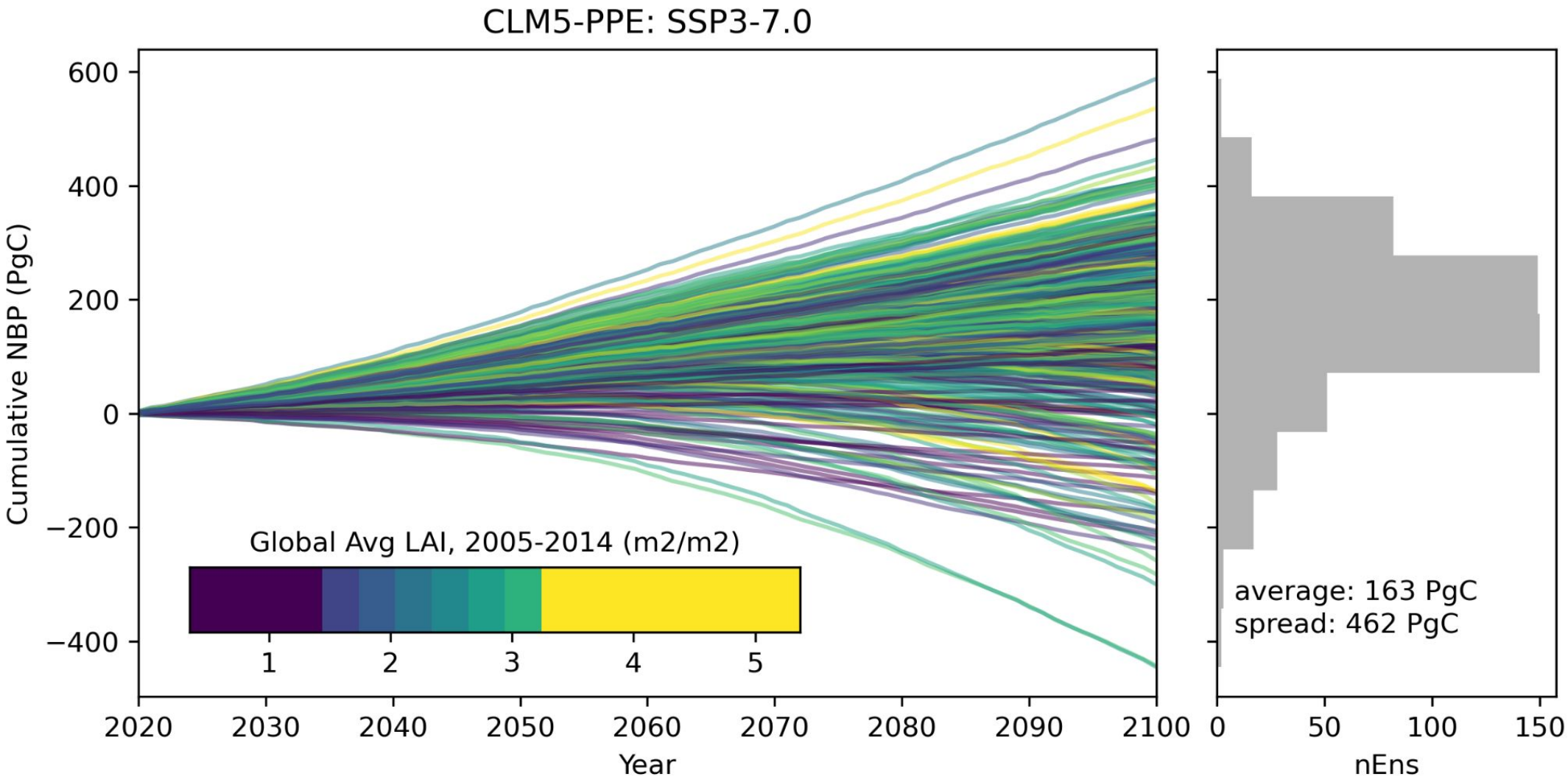




Can we use observations to better estimate uncertainty?



Do global mean LAI observations constrain uncertainty?



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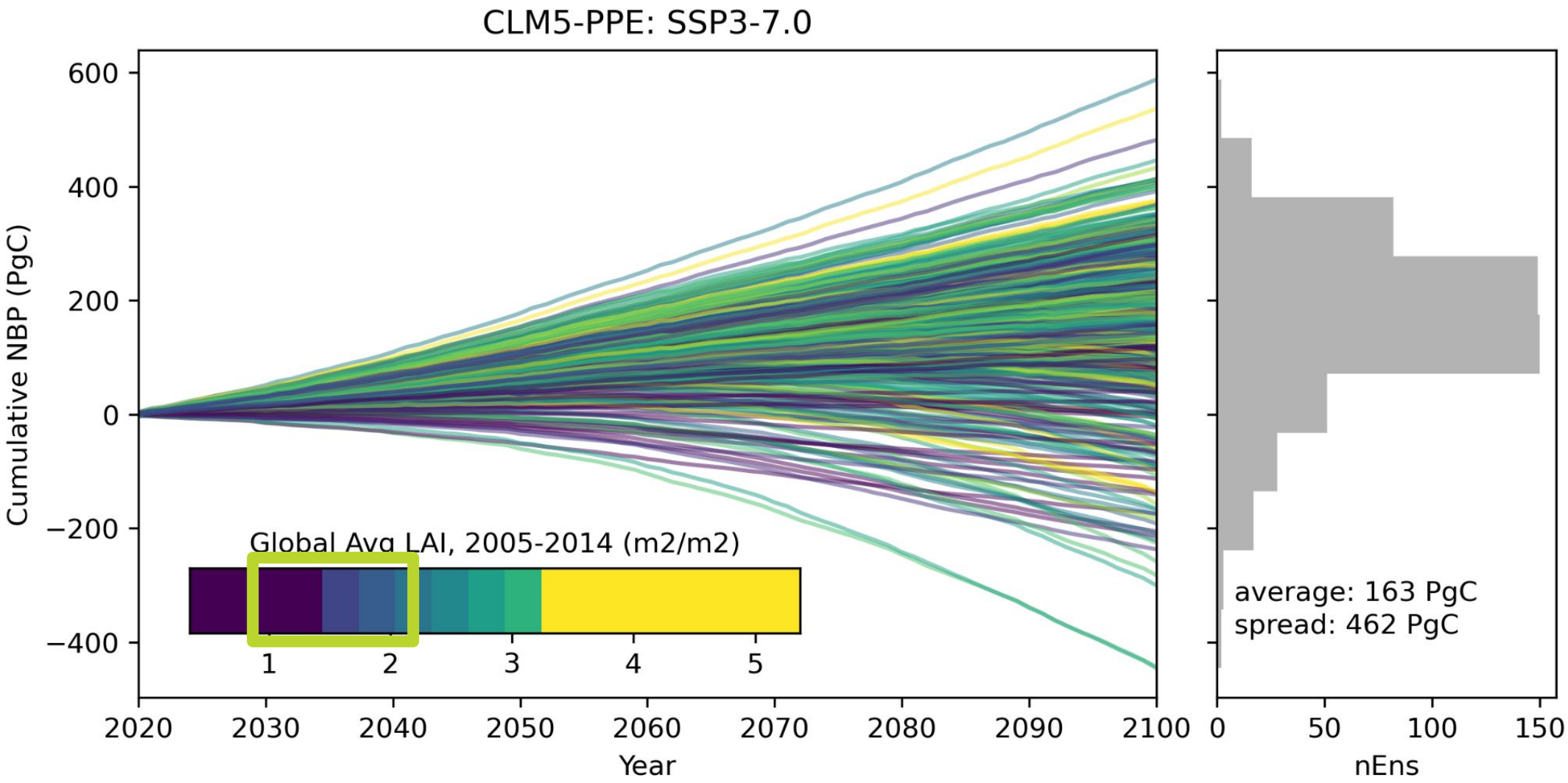
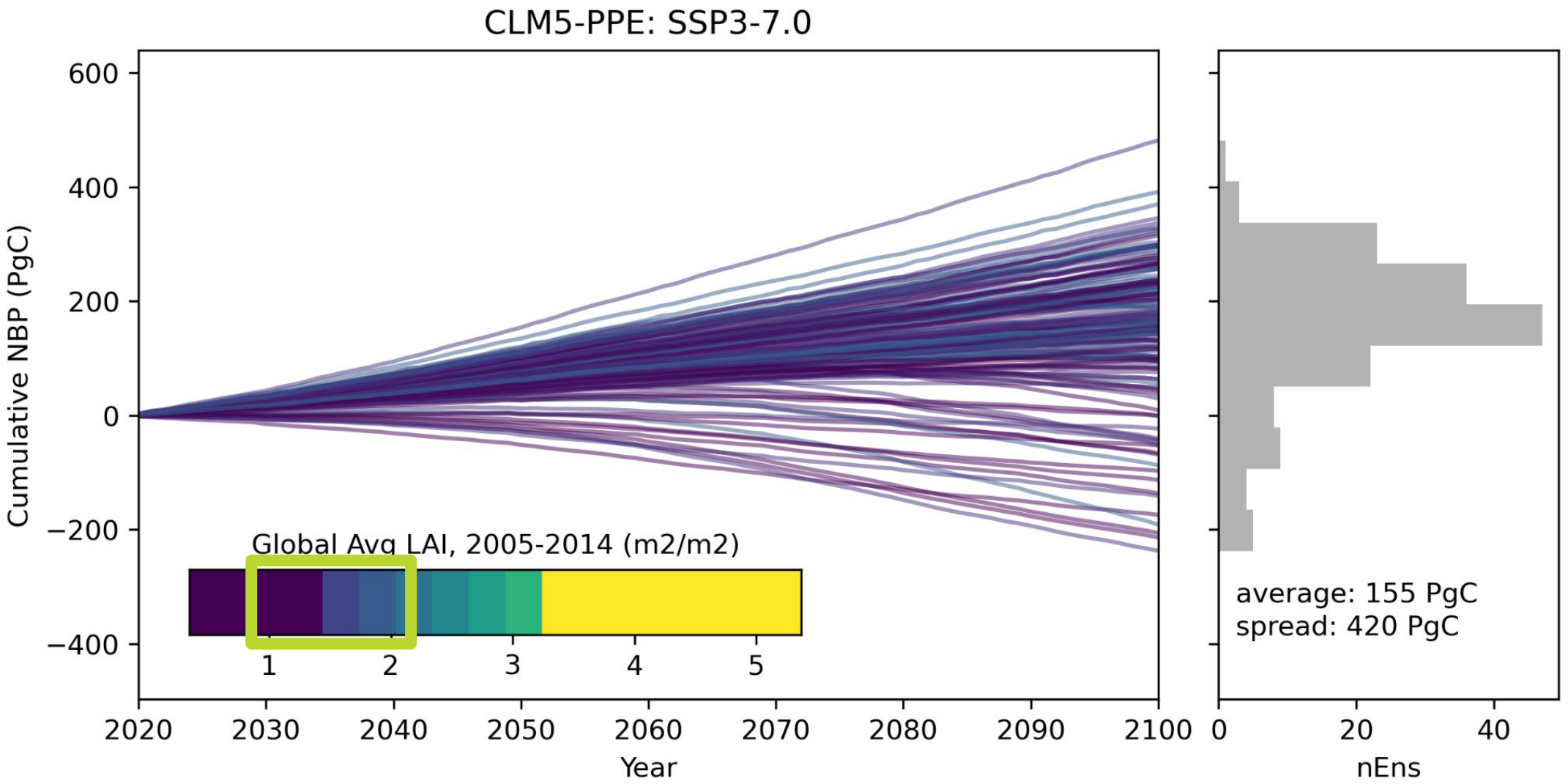
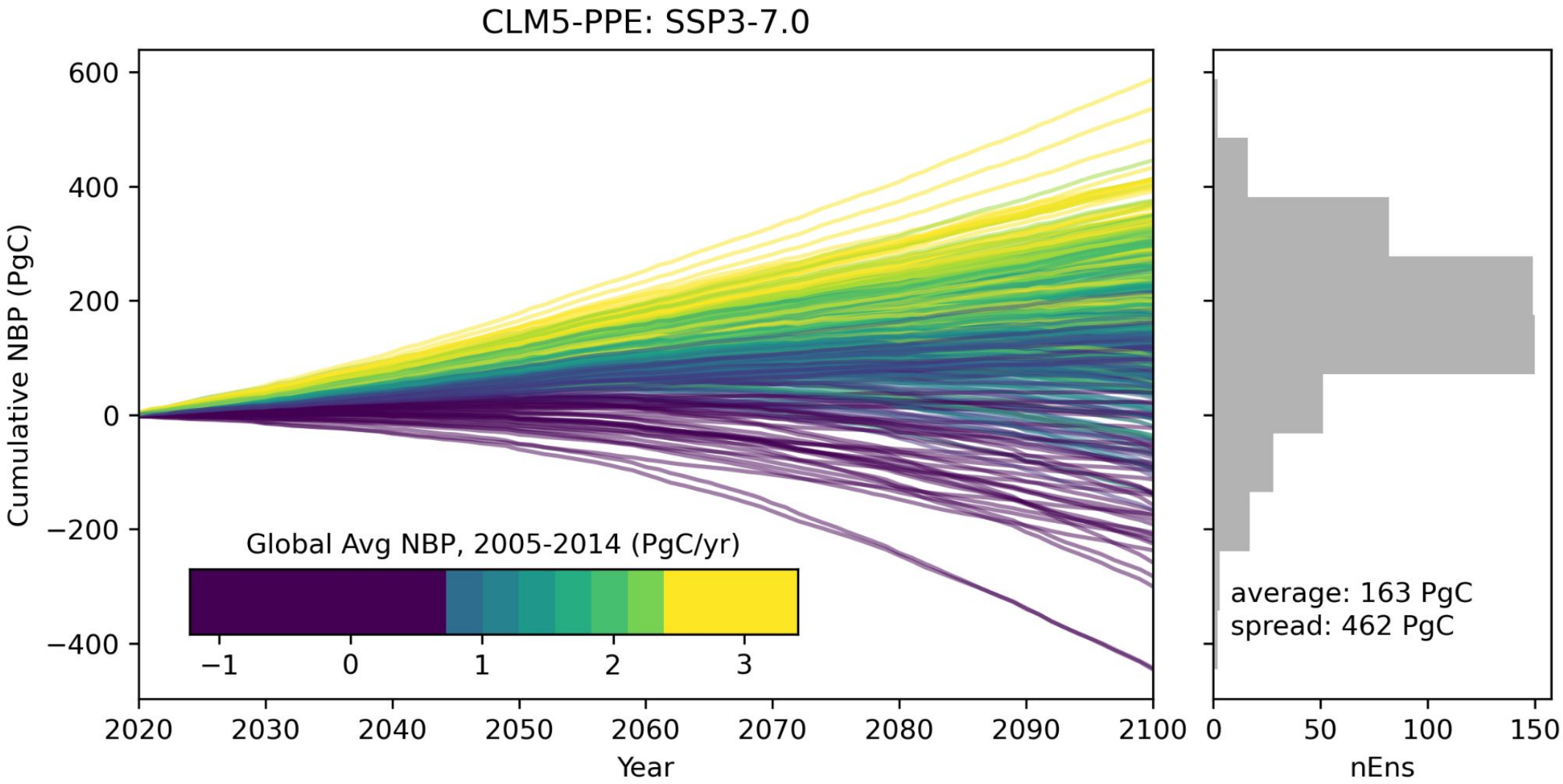


Do global mean LAI observations constrain uncertainty? (no)



Historical NBP is the best constraint on future NBP



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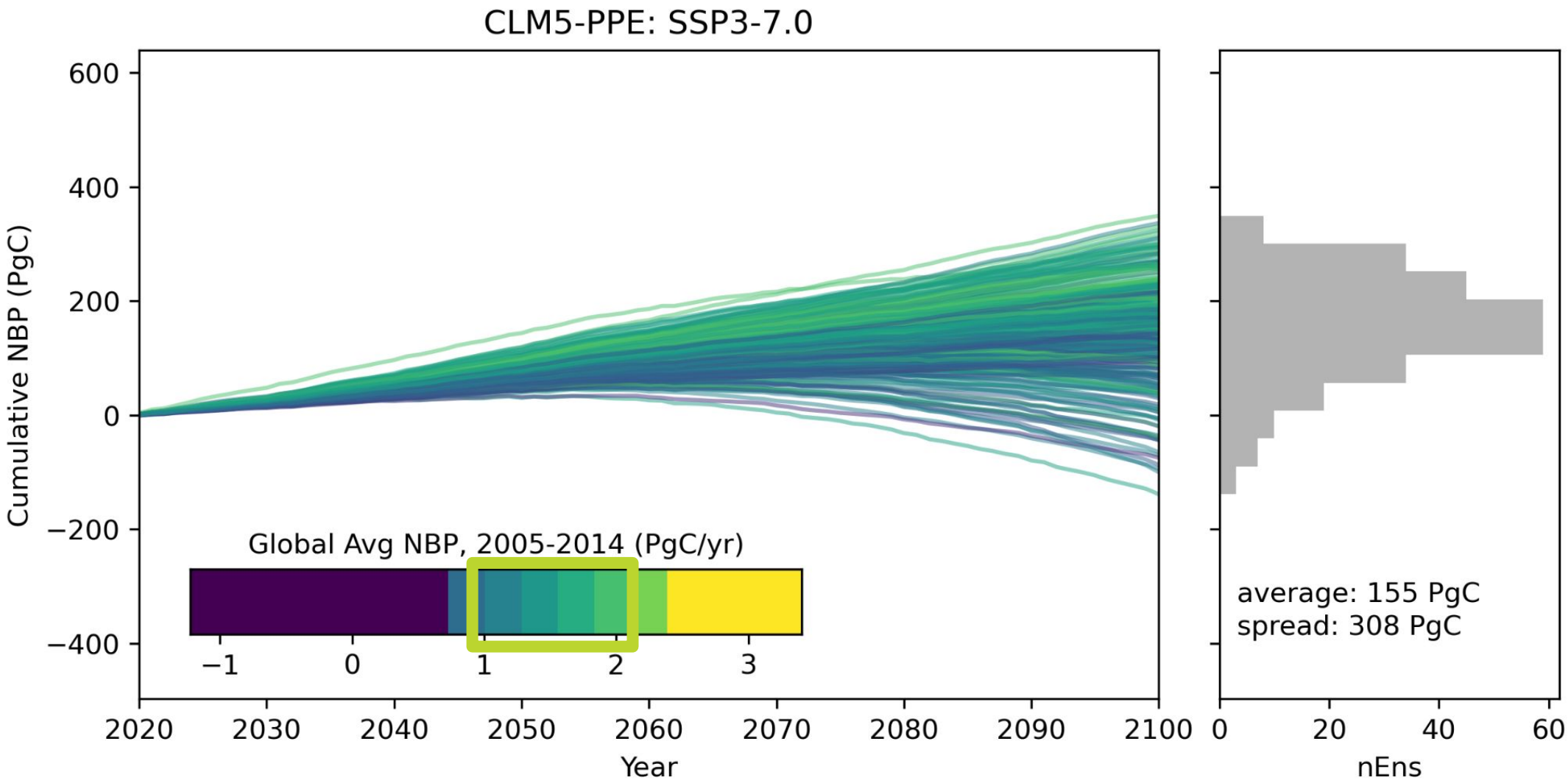
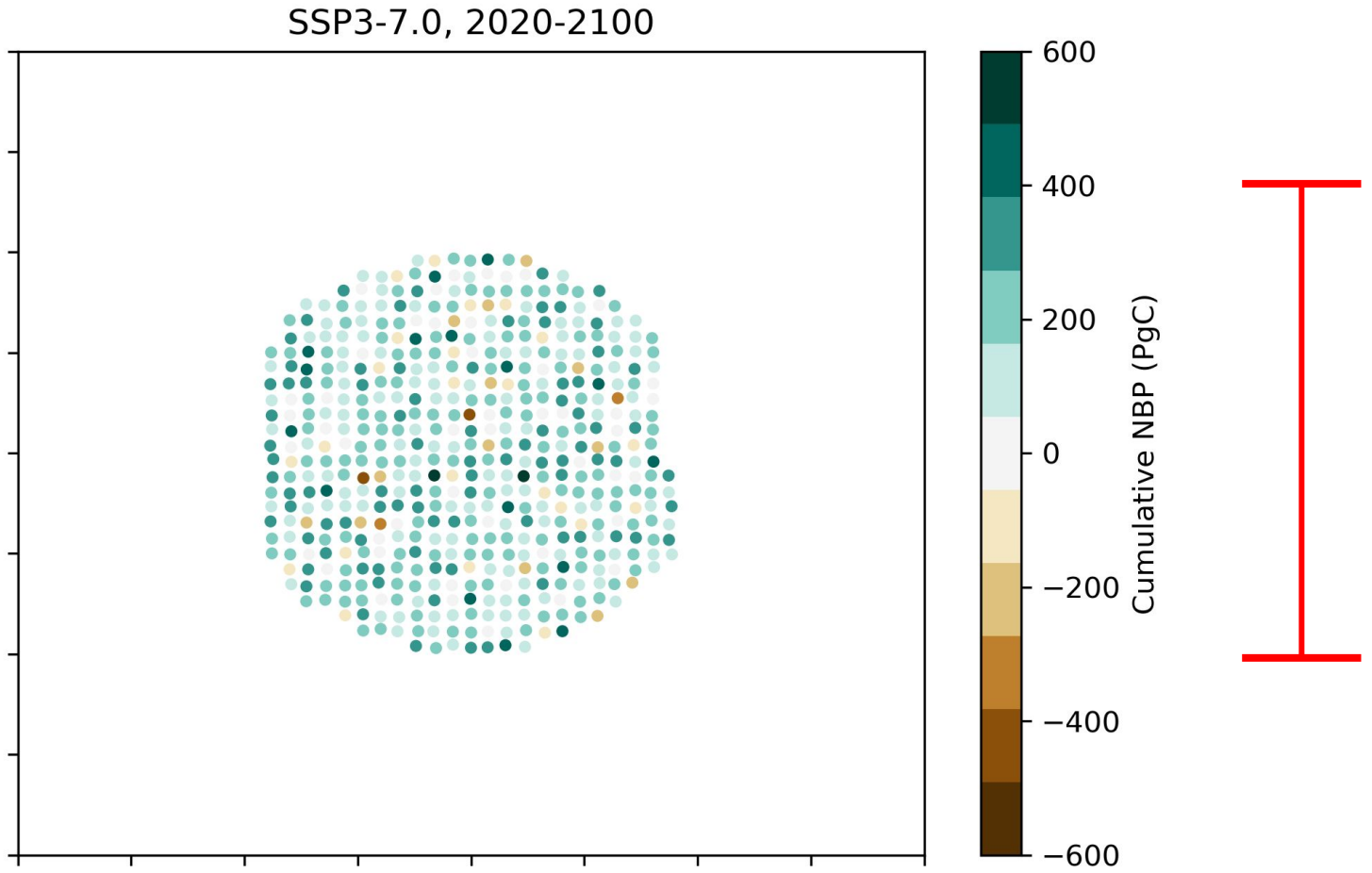


What makes for effective constraints?

Here are our 500 simulations, without any constraints



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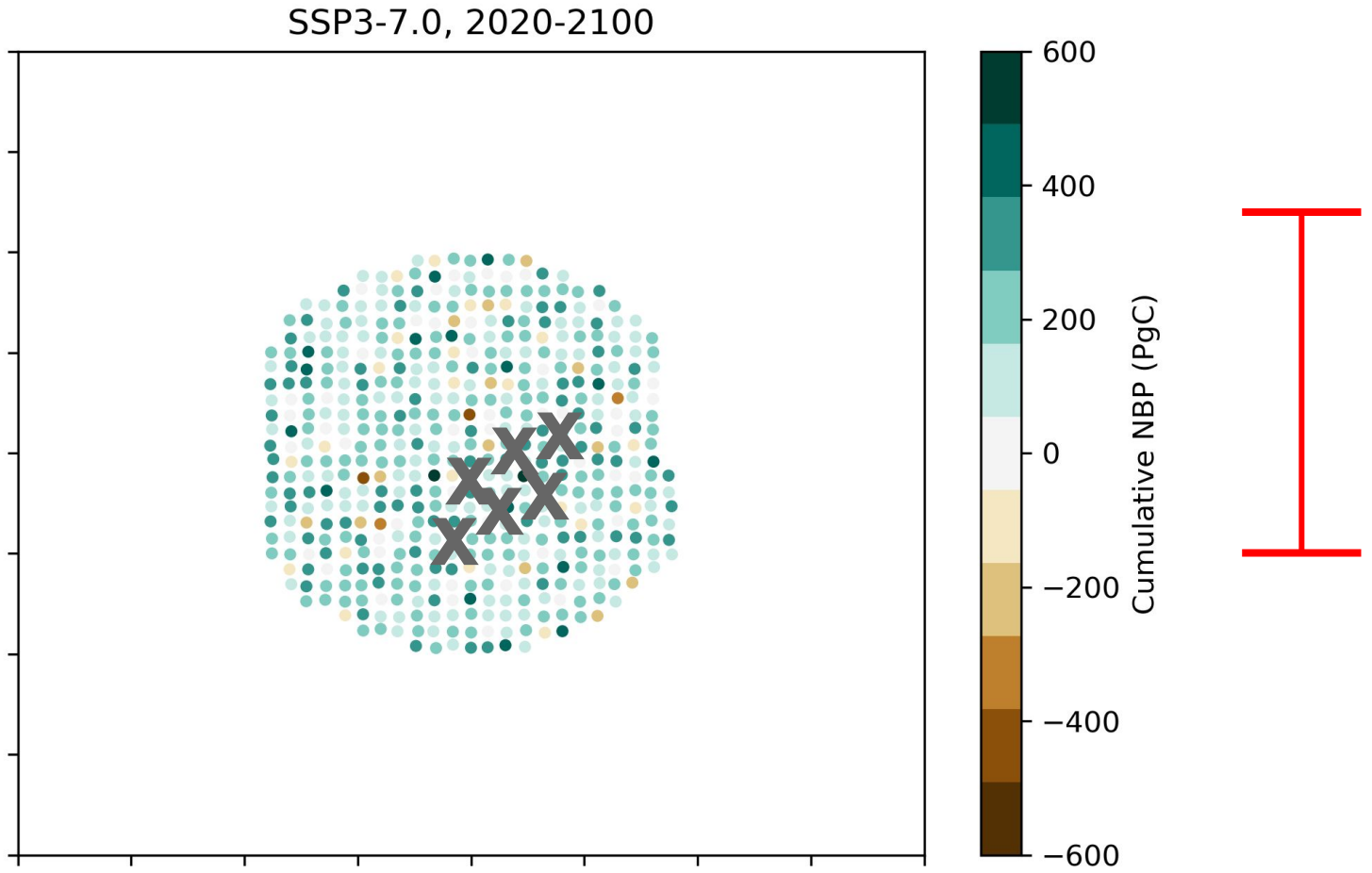

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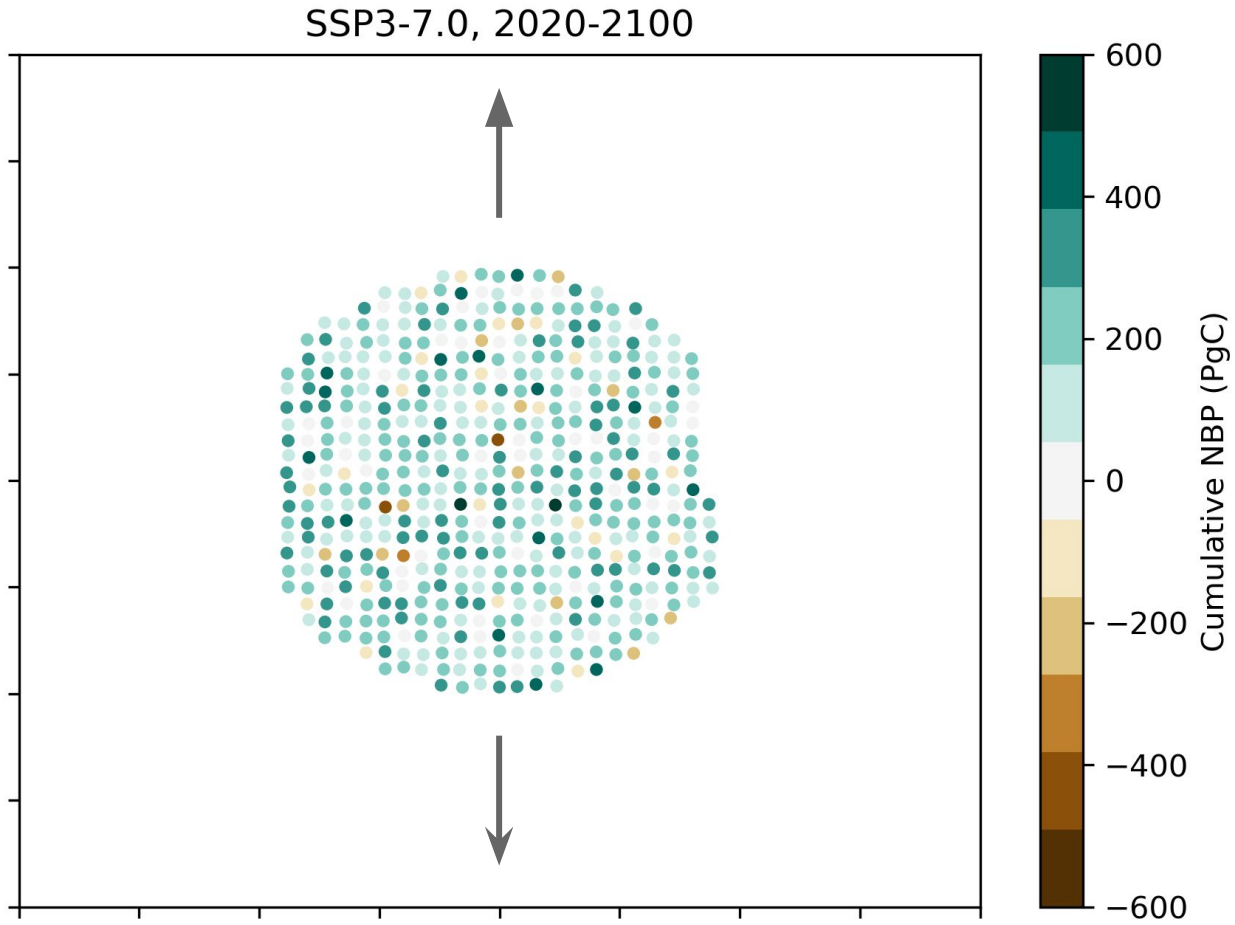
explanatory variable (observable)



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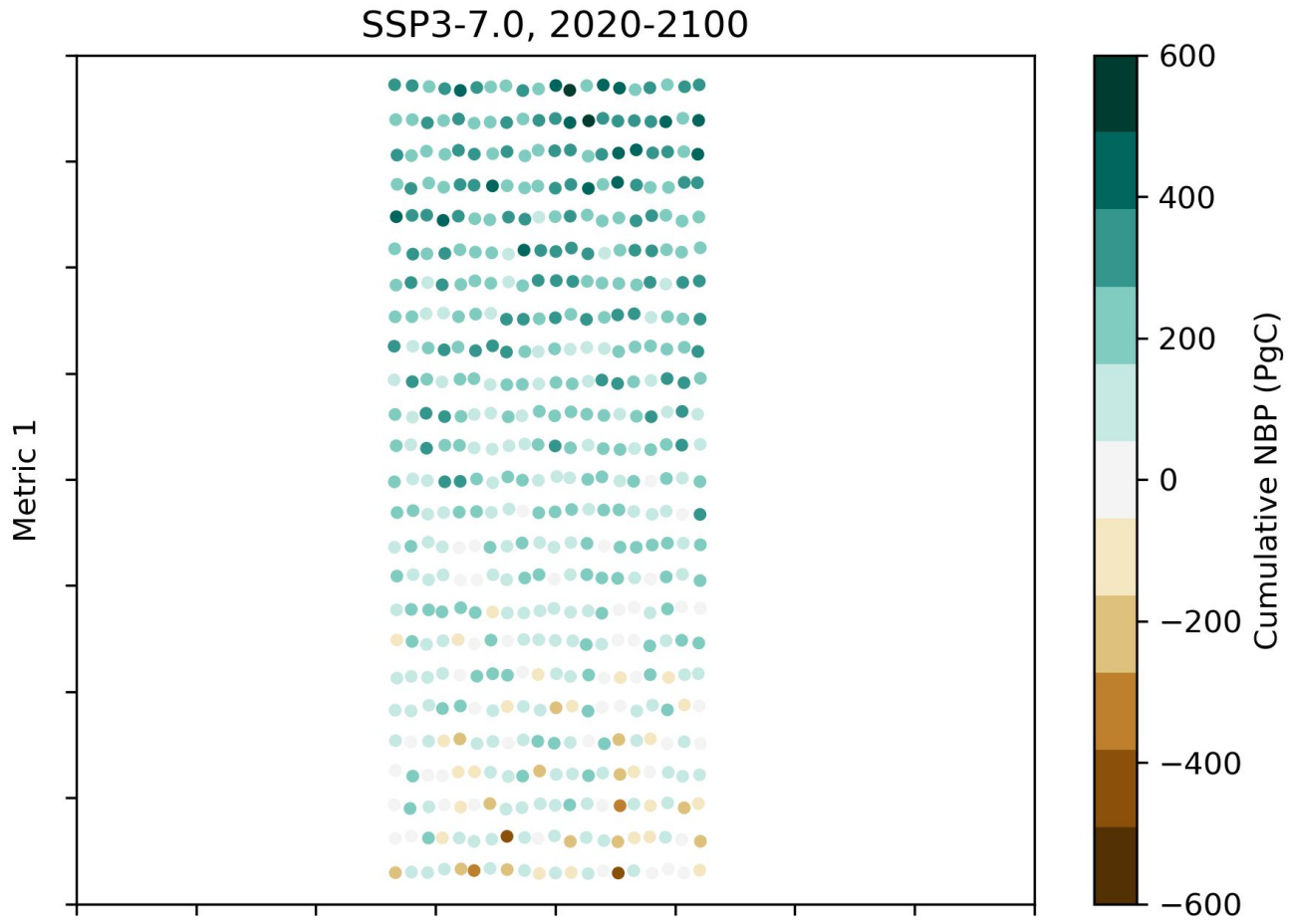

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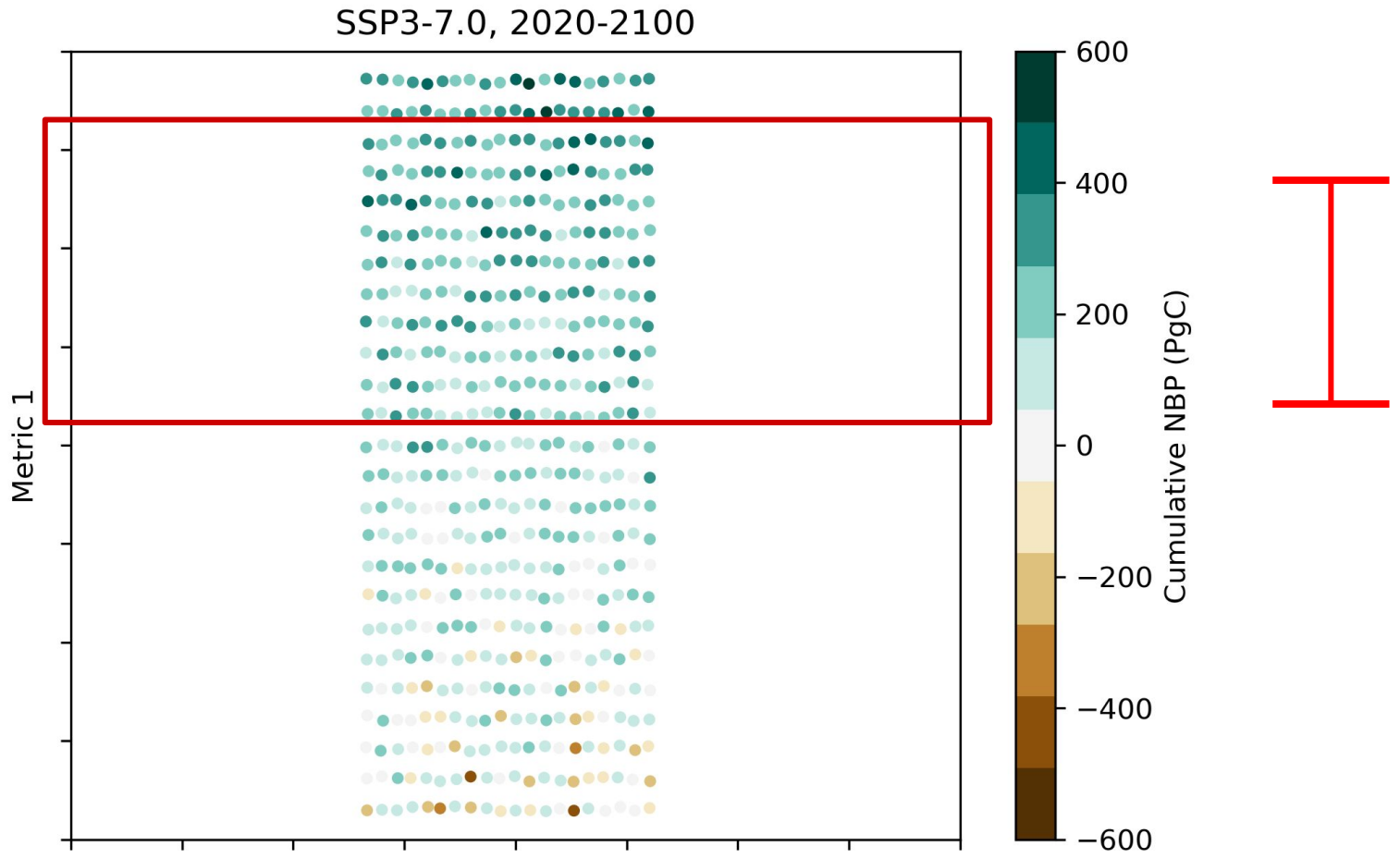

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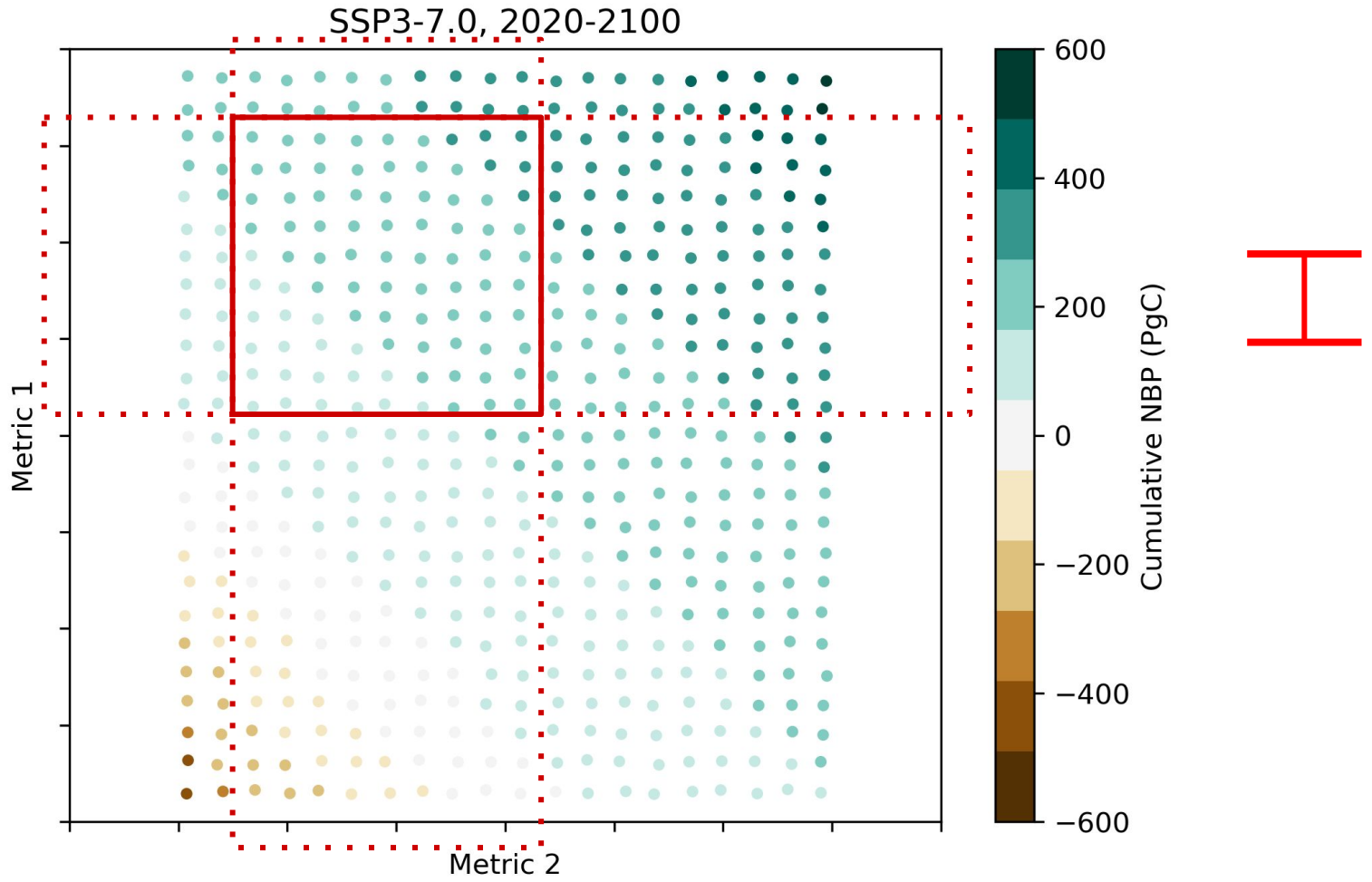
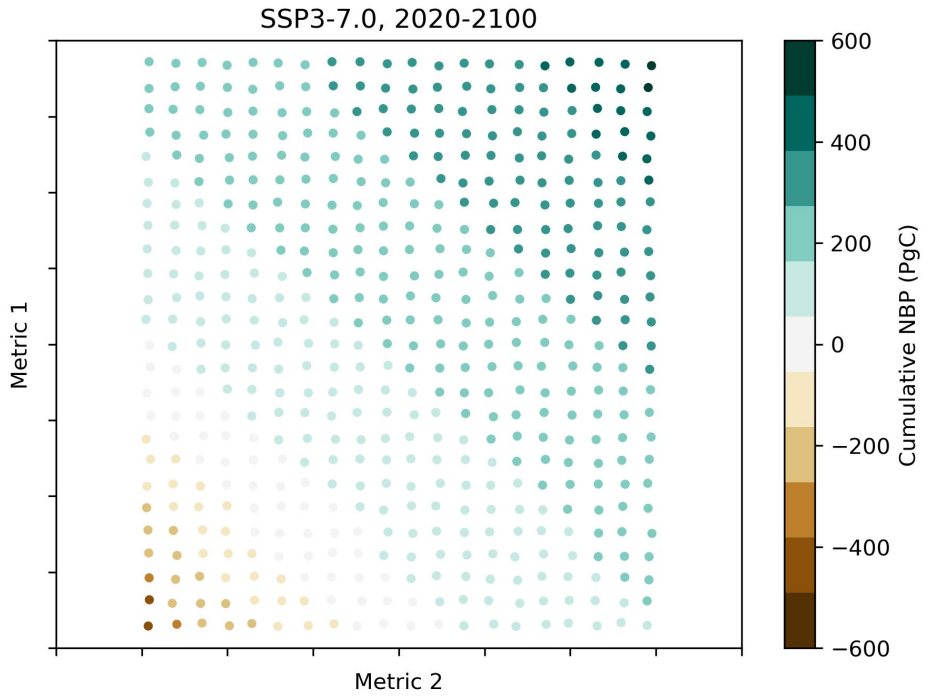
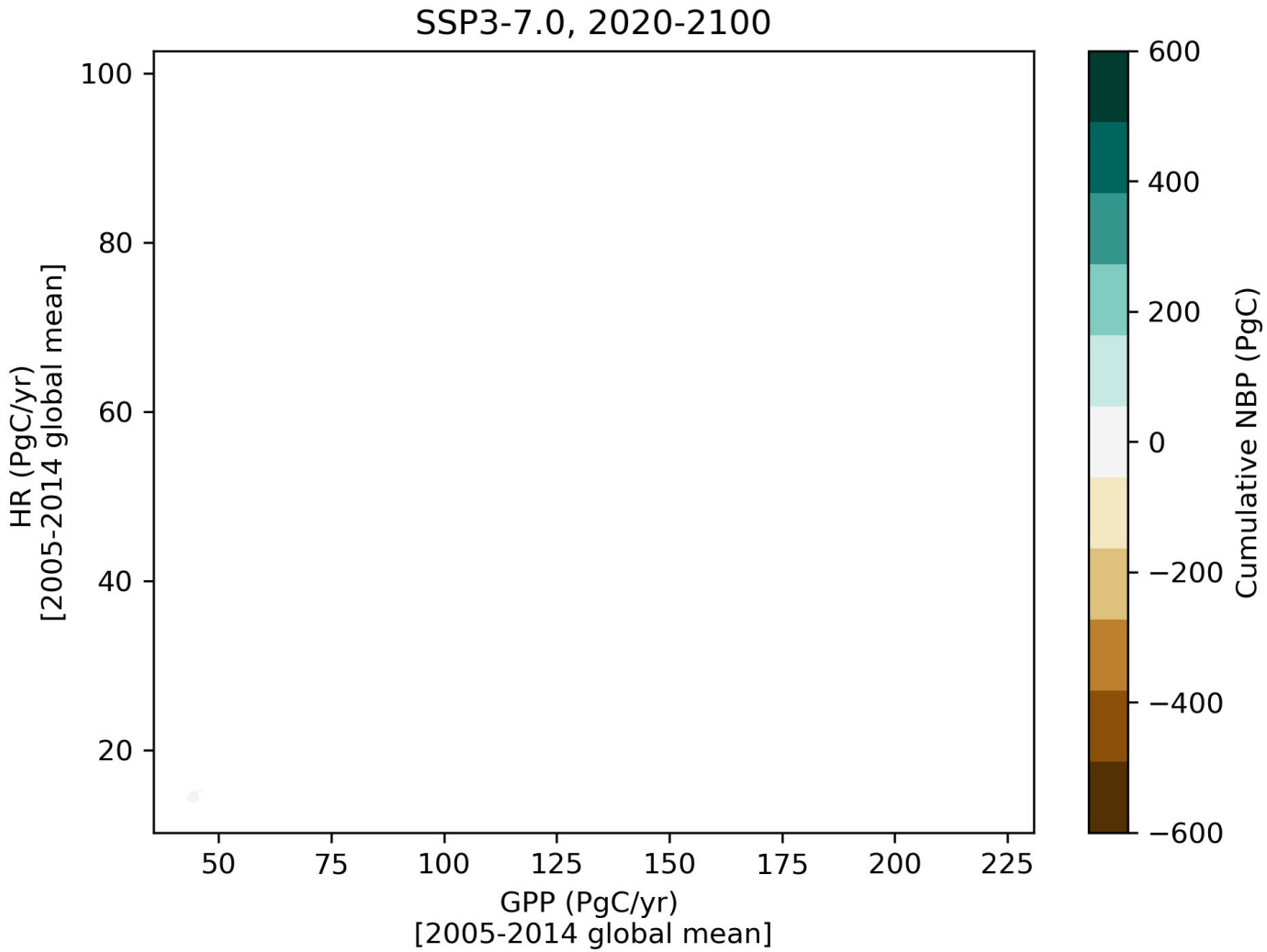


Take home message from this?

Ideally the observational metrics are correlated with future NBP, but not correlated with each other



A more typical example



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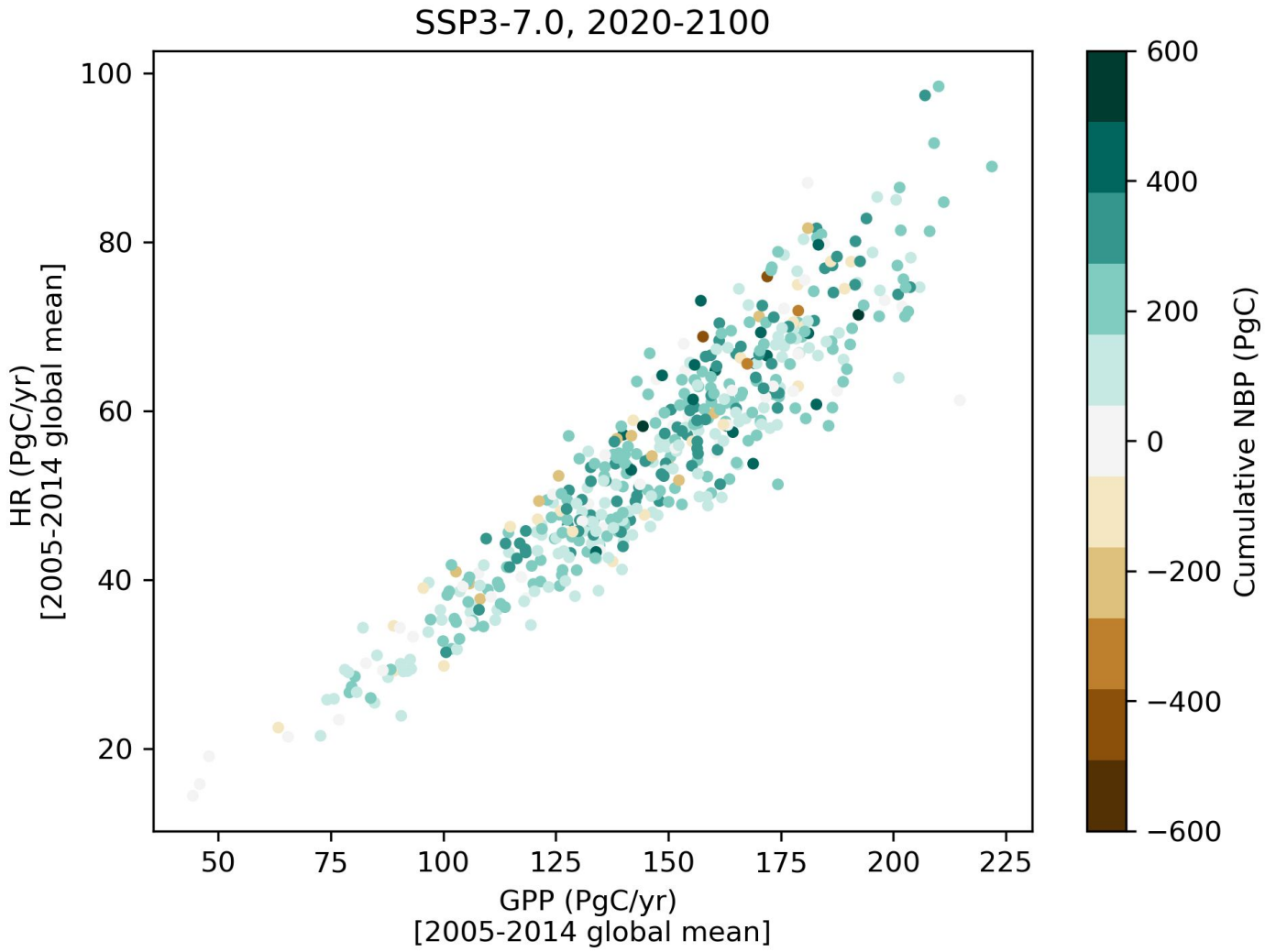

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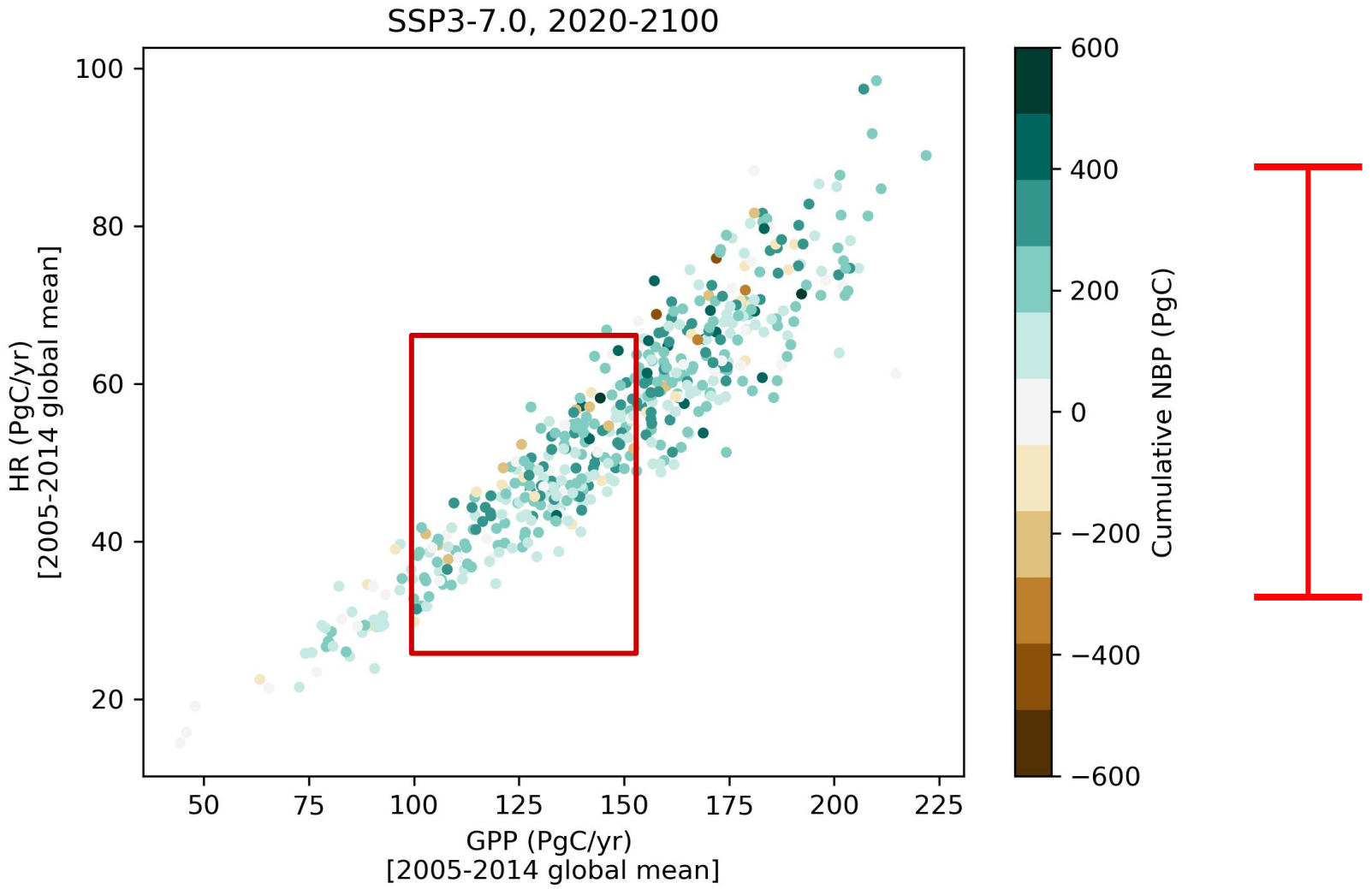
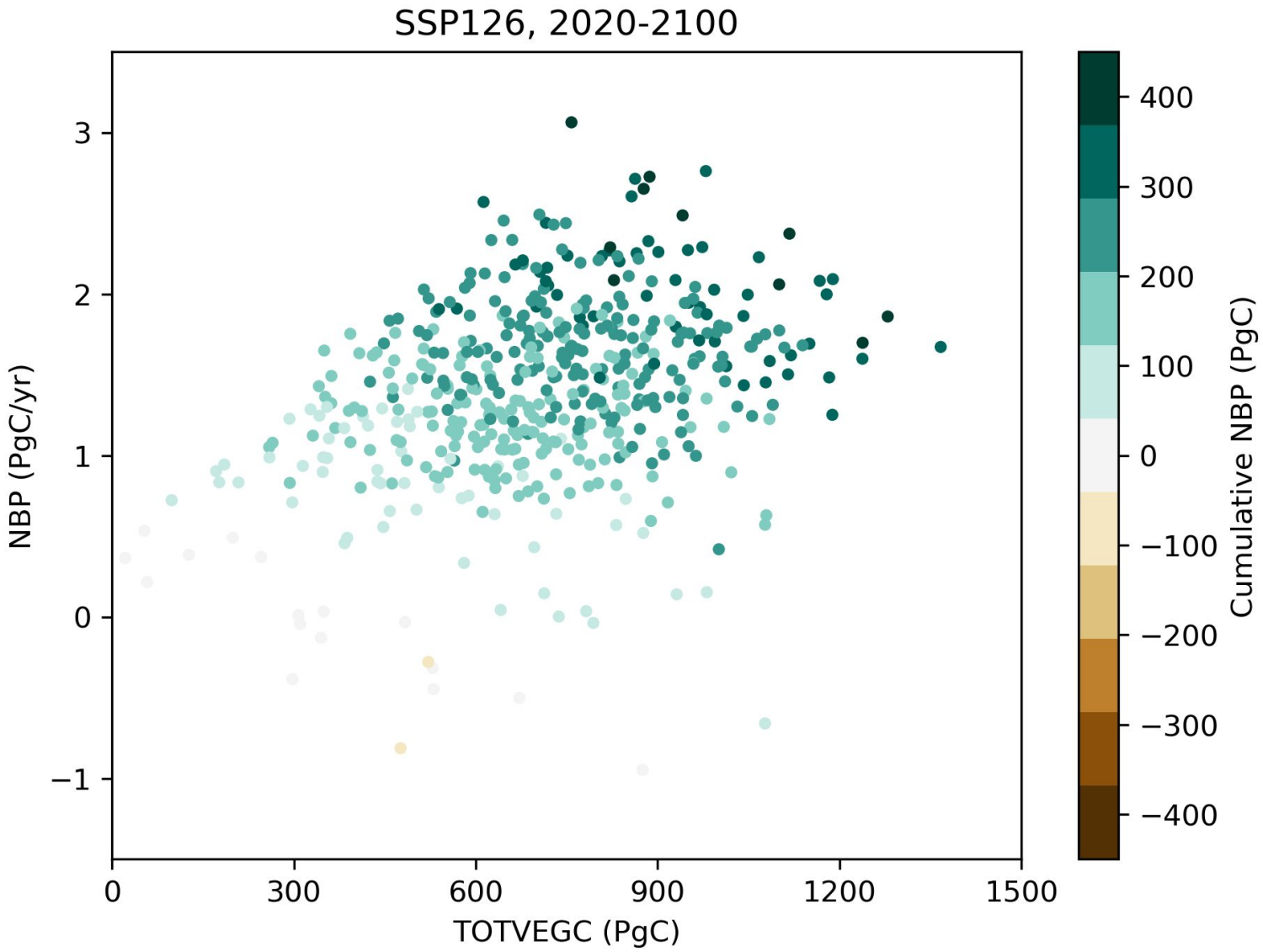


A better set of constraints…



Future Sink~
1995-2014 NBP
1995-2014 TOTVEGC

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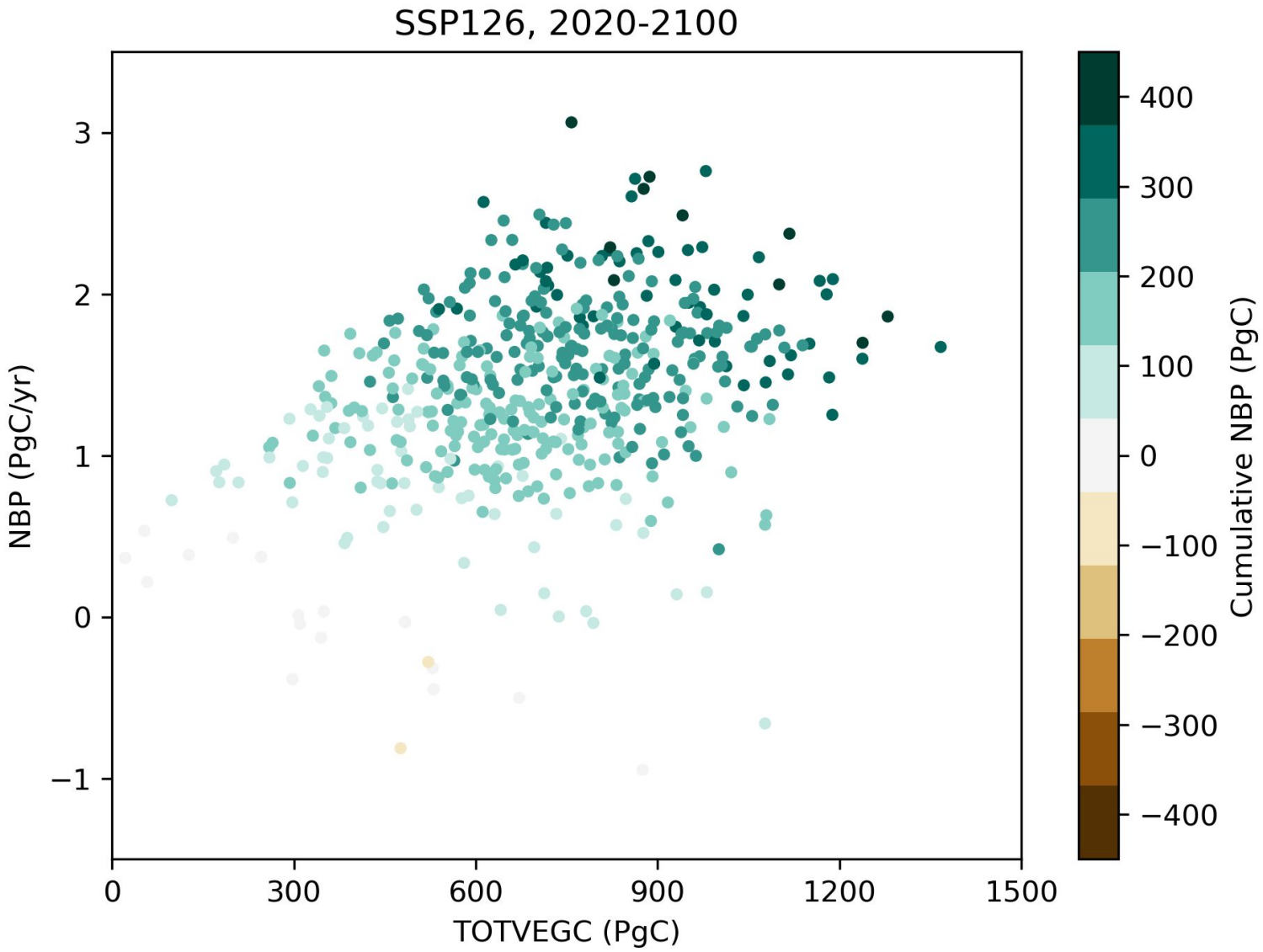


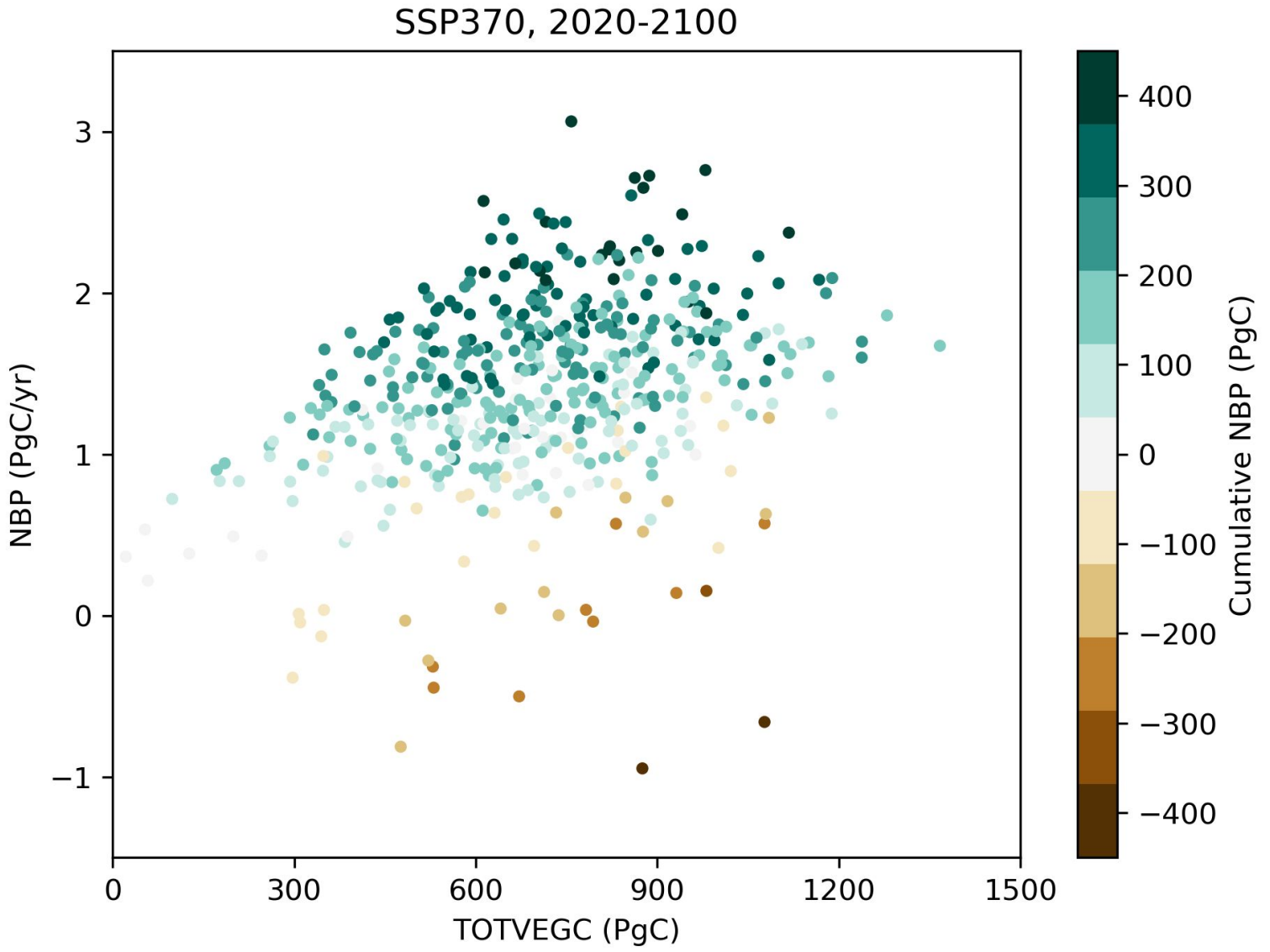
Future Sink~
1995-2014 NBP
1995-2014 TOTVEGC

multi-linear regression coefficients:
NBP: 95 PgC/PgC/yr
TVC: .14 PgC/PgC

R^2: 0.79

Also works for SSP3-7.0

Future Sink~
1995-2014 NBP
1995-2014 TOTVEGC

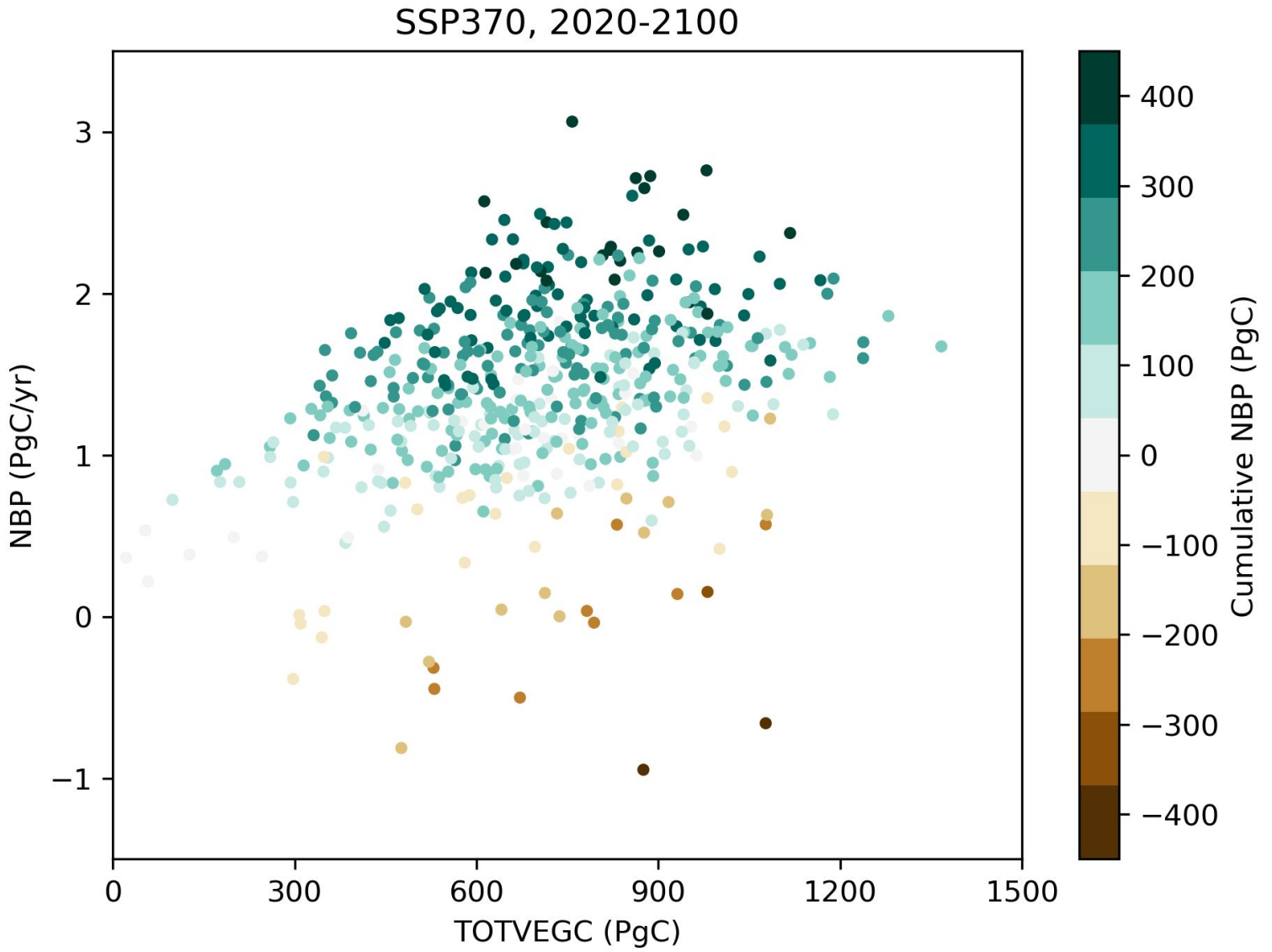


But with different relationships…

Future Sink~
1995-2014 NBP
1995-2014 TOTVEGC

multi-linear regression coefficients:
NBP: 227 PgC/PgC/yr
TVC: -.14 PgC/PgC

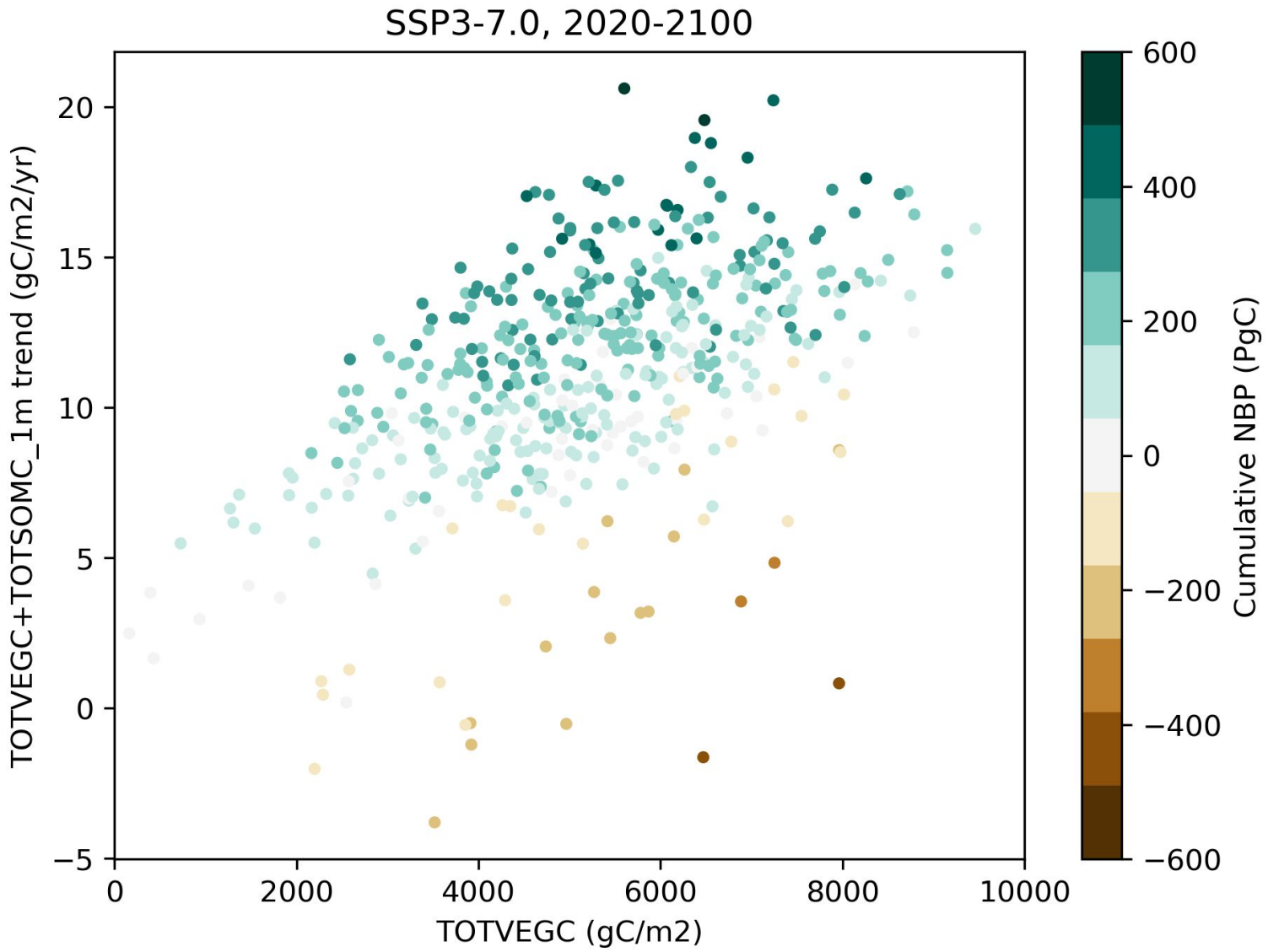
R^2: 0.73



NBP is difficult to measure…

But I've found that the:
TOTVEGC+TOTSOMC_1m **trend**

is an effective stand-in



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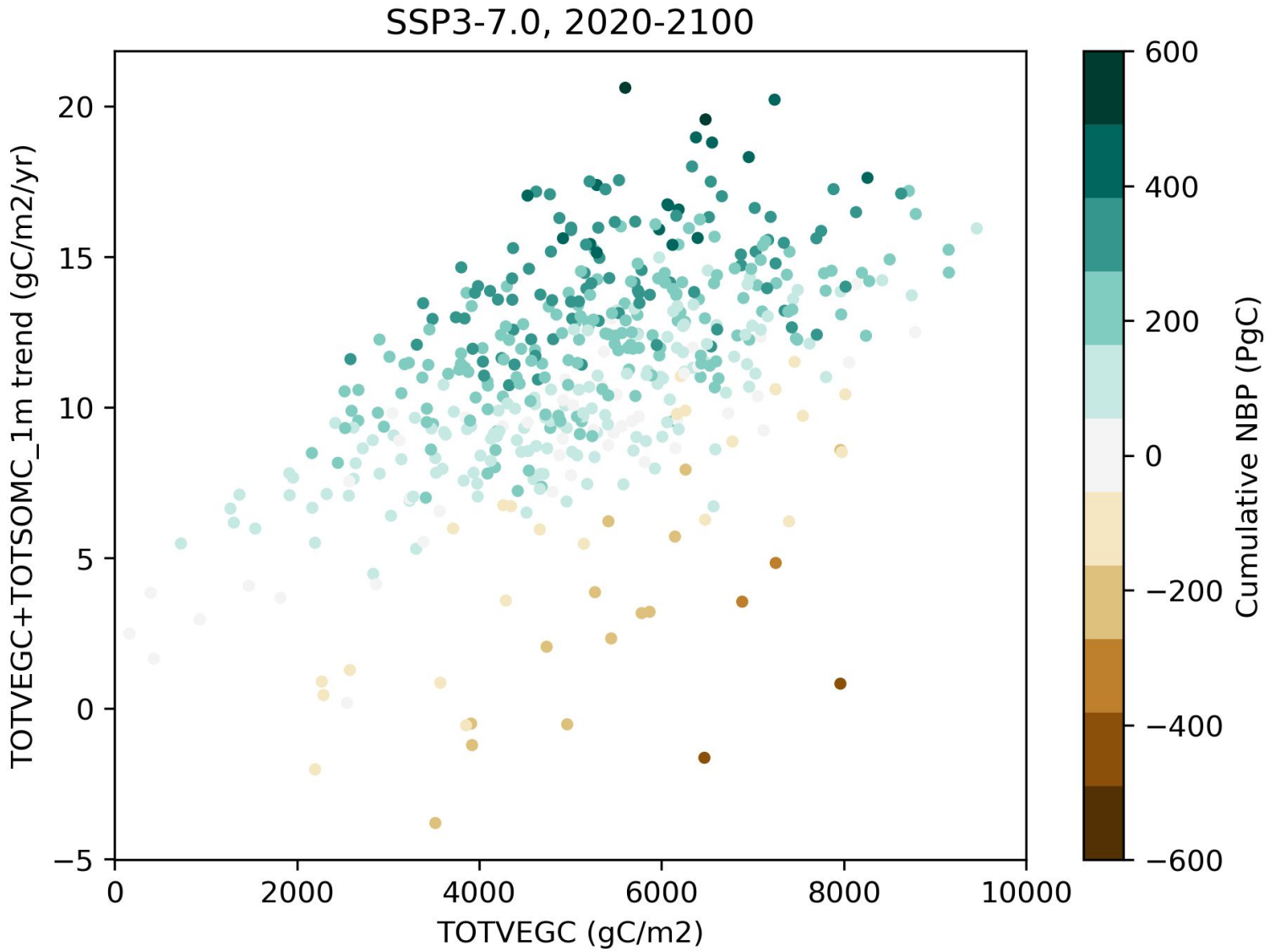
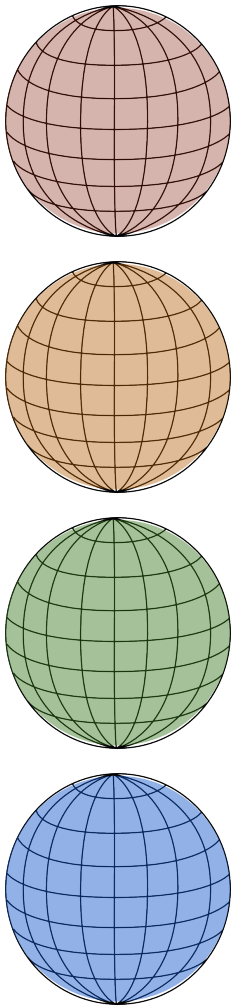
ΔTOTECOSYSC=NBP



Conclusions



- The CLM5-PPE shows a wide spread in carbon cycle futures
  - comparable in size to multi-model spread
  - larger than scenario uncertainty
- Leaf area index is not a very discerning constraint on future NBP
- Past NBP ***is*** a nice constraint on future NBP
- Trends in carbon pools tend to be more informative than the gross carbon fluxes

Diagnostics website:

webext.cgd.ucar.edu/I2000/PPEn11_OAAT/

djk2120@ucar.edu