Global Biogeochemical Cycles®

RESEARCH ARTICLE
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Key Points:

- Aircraft observations of atmospheric carbon dioxide concentrations are used to infer the net flux of the northern extratropical growing season net flux
- The observations suggest a larger net flux and shorter growing season than those simulated in Earth system models
- An emergent constraint approach is used to estimate productivity and respiration fluxes

Evaluating Northern Hemisphere Growing Season Net Carbon Flux in Climate Models Using Aircraft Observations

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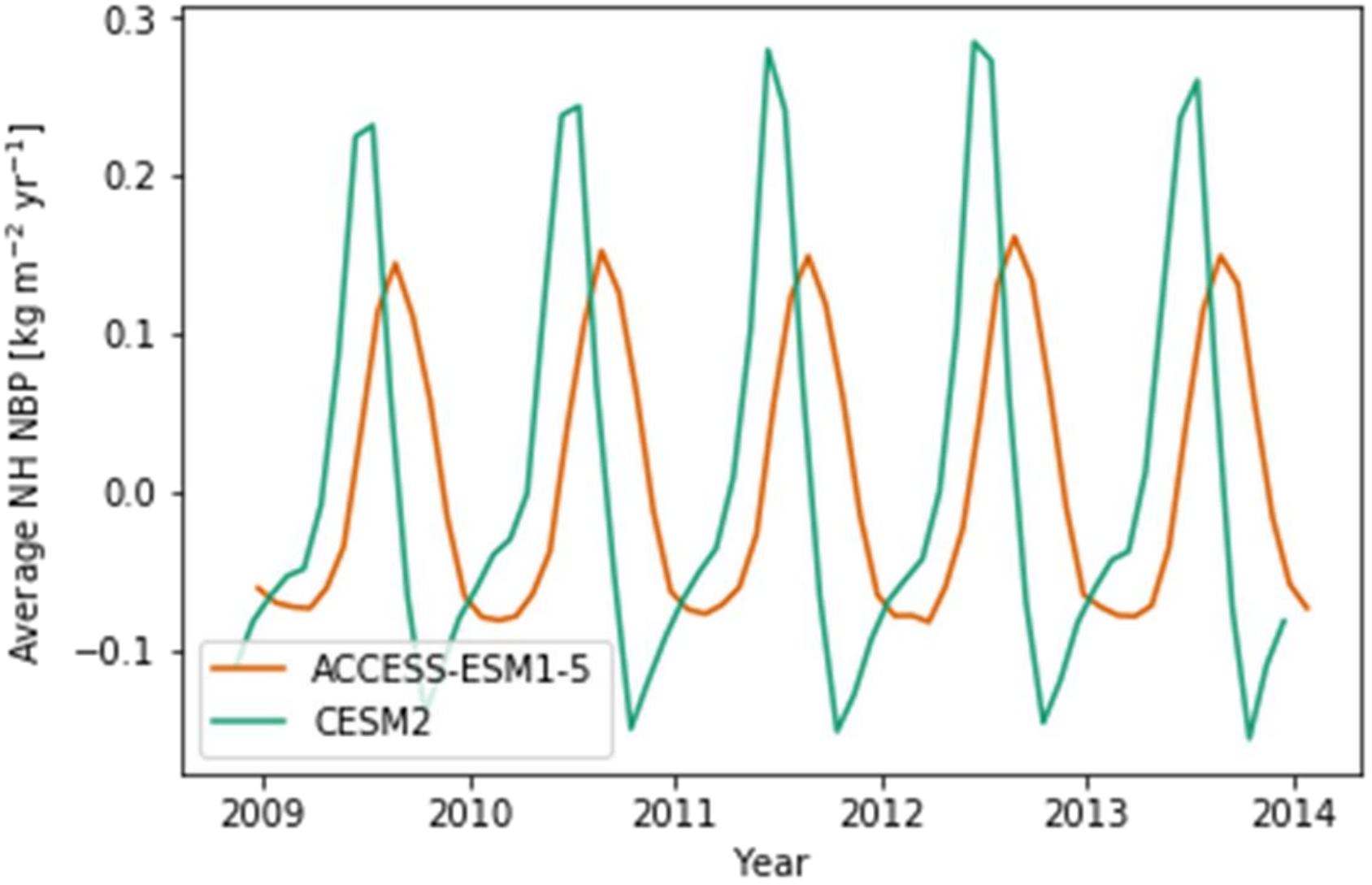
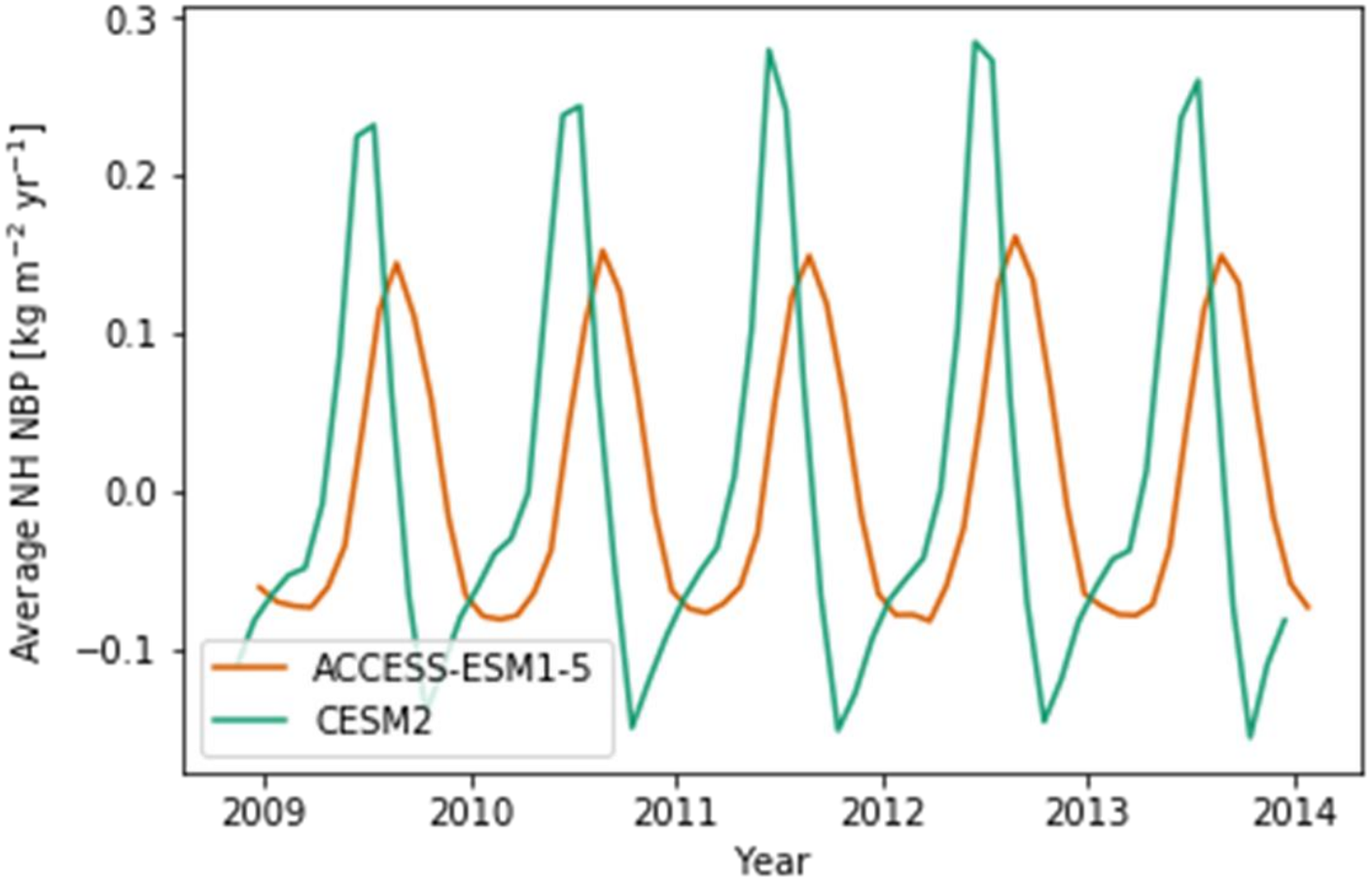


CMIP6 historical data downloaded from Earth System Grid Federation
ACCESS-ESM1-5 (Ziehn et al., 2019) and CESM2 (Danabasoglu et al., 2019)

Models disagree on timing and magnitude of hemispheric land carbon flux.



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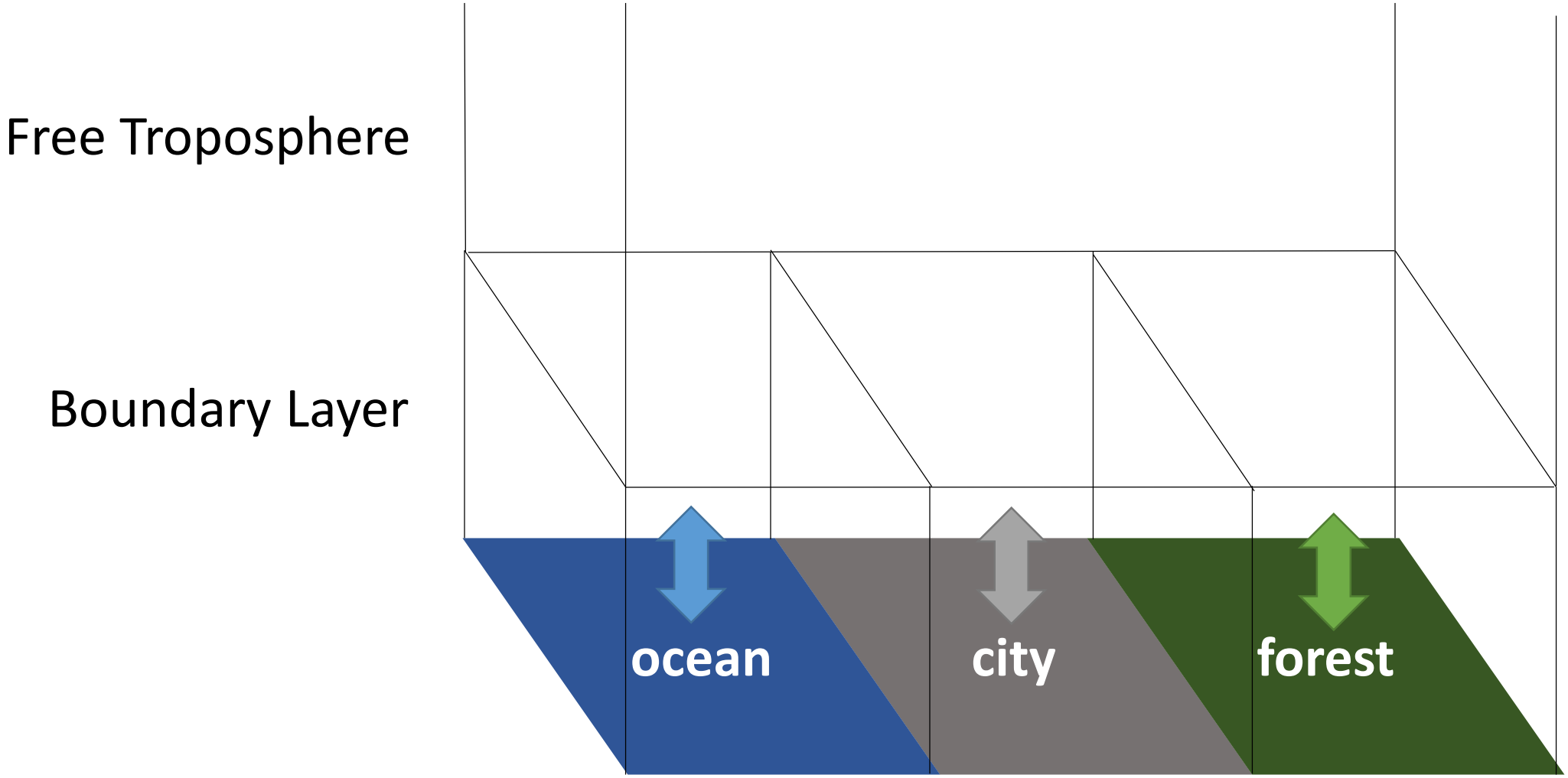
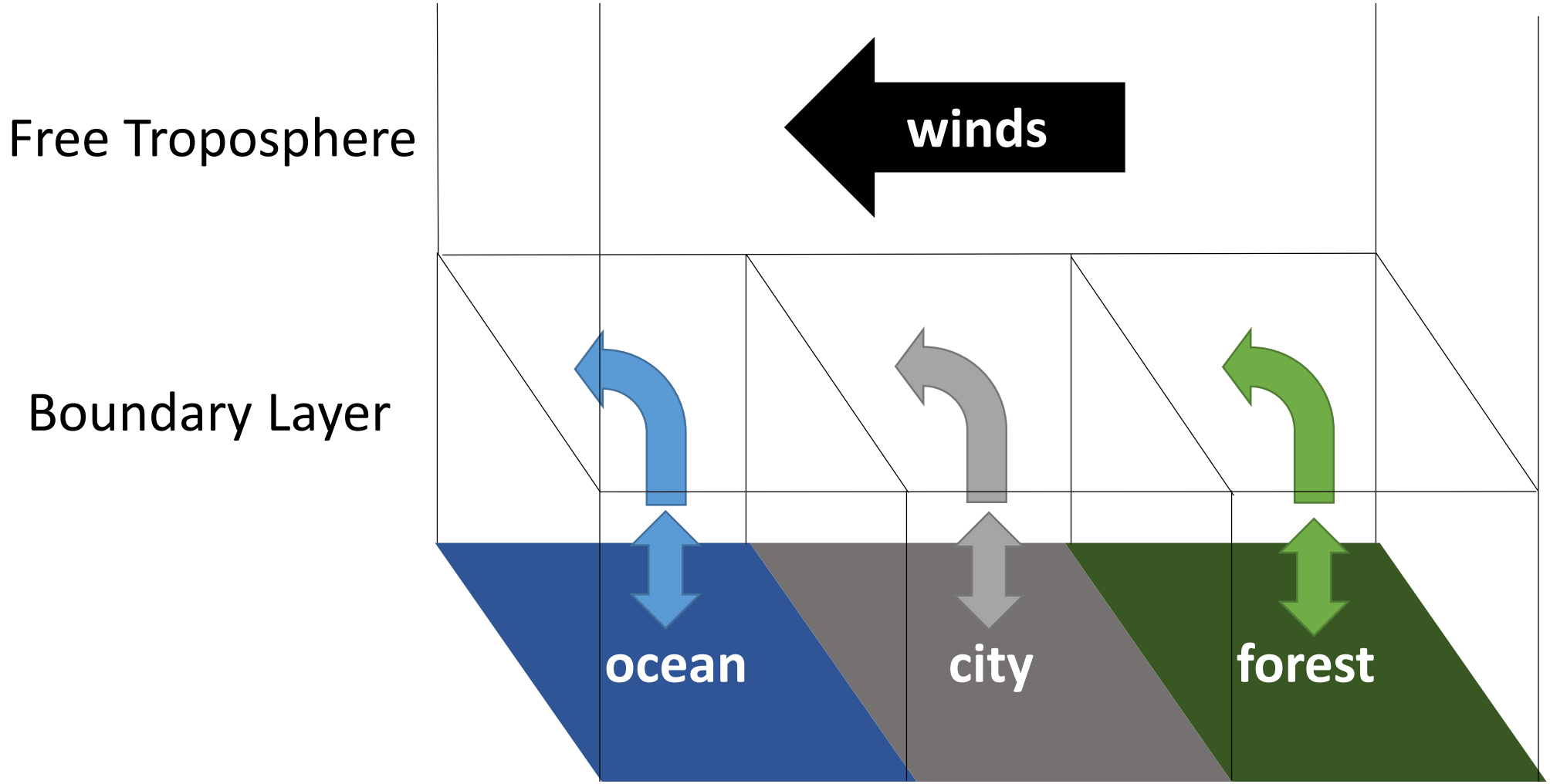
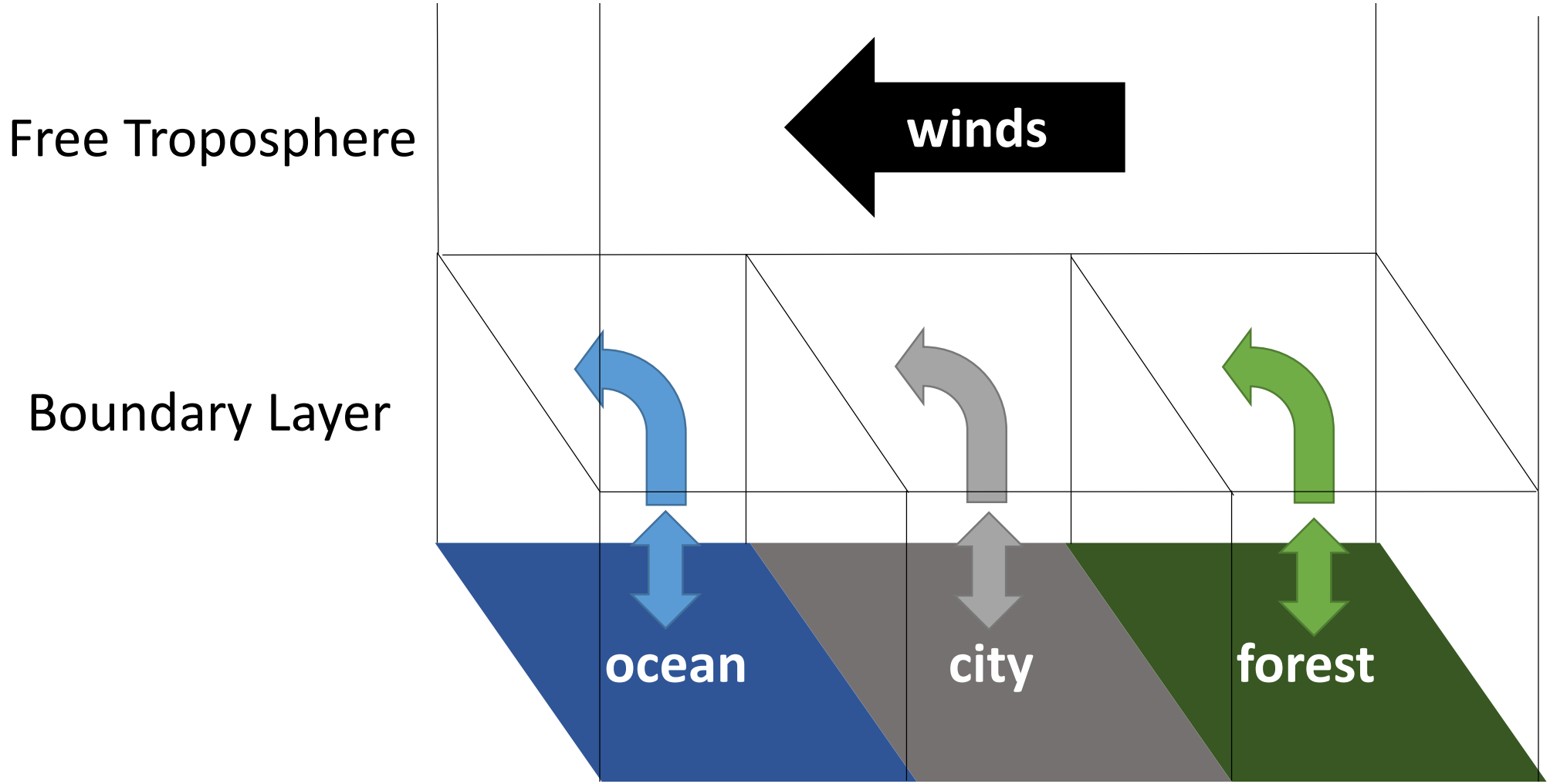
Variation in atmospheric CO_2 can be used to gain knowledge on sources and sinks.



Signals from carbon sources and sinks are mixed in the free troposphere.



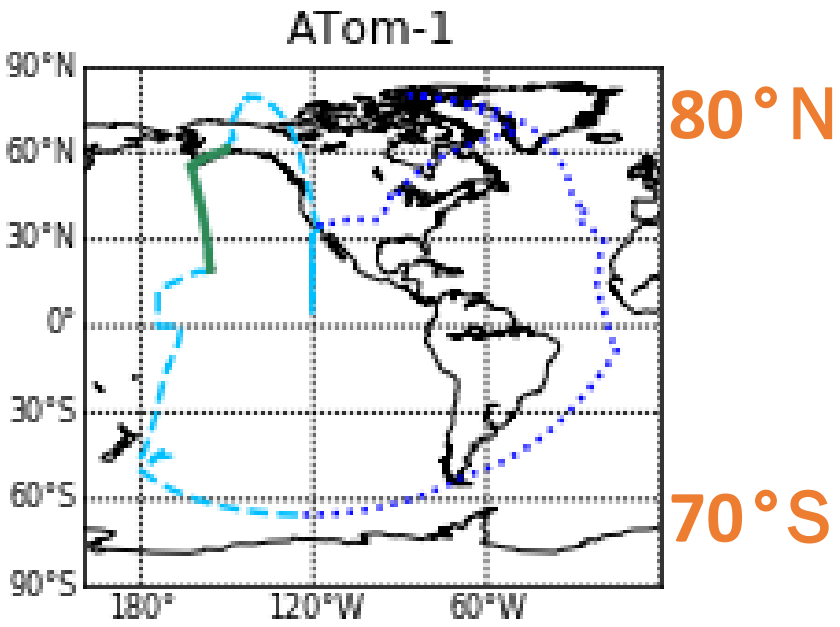
Inverse models rely on simulating atmospheric transport, introducing uncertainty to flux estimates.

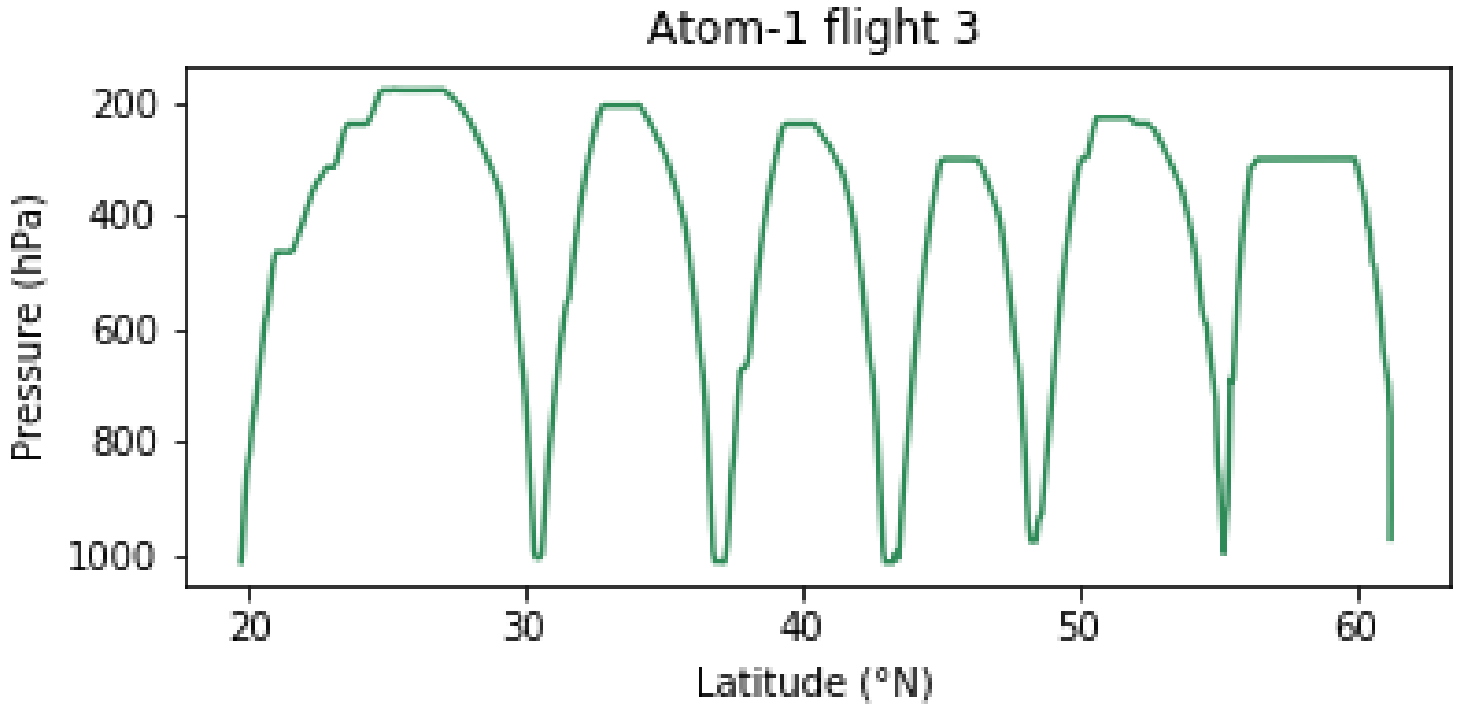


HIPPO and ATom

Photo credit:
https://espo.nasa.gov/atom/image/Landing_in_Thule

Air flight campaigns over the Pacific and Atlantic provide constraints on atmospheric CO_2.





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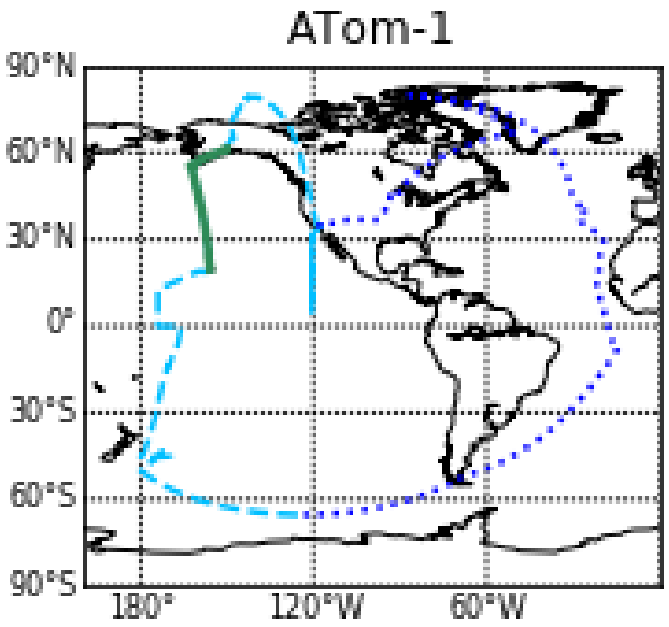

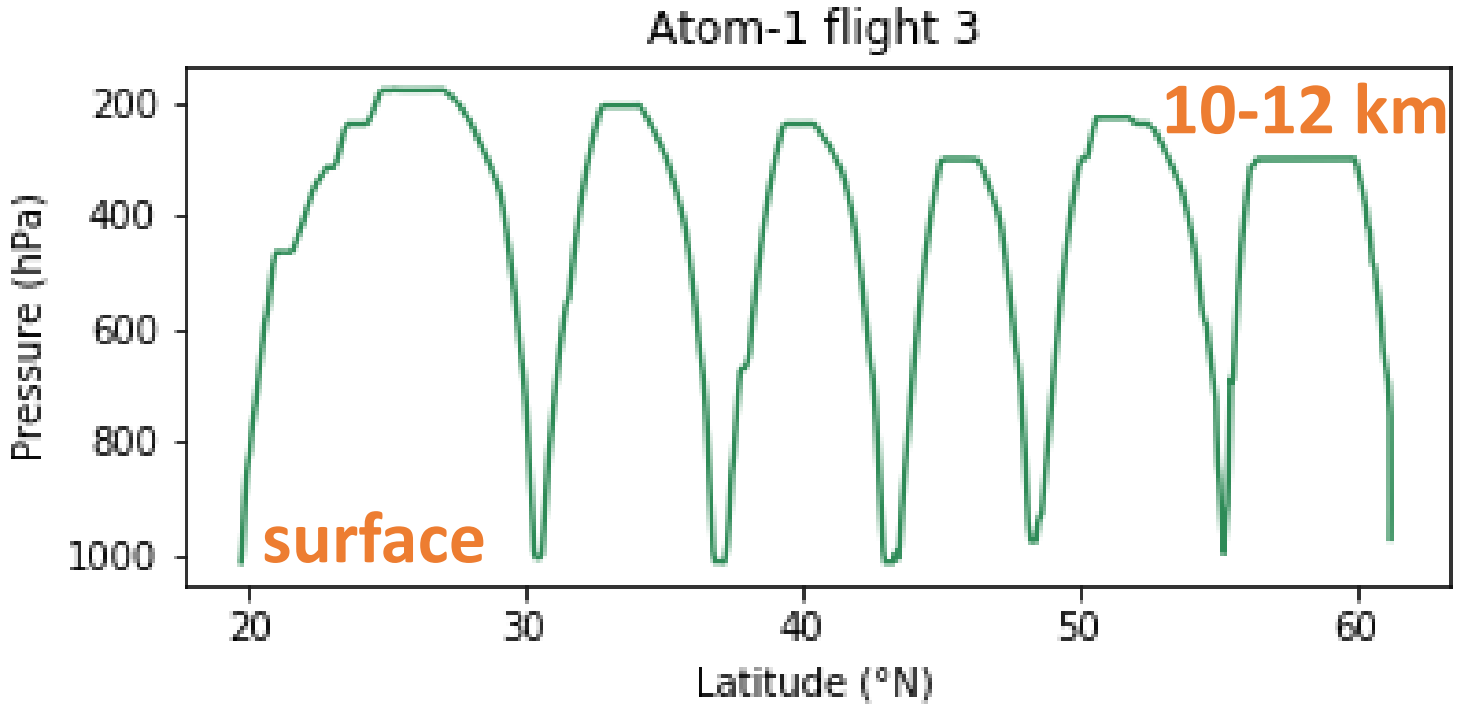

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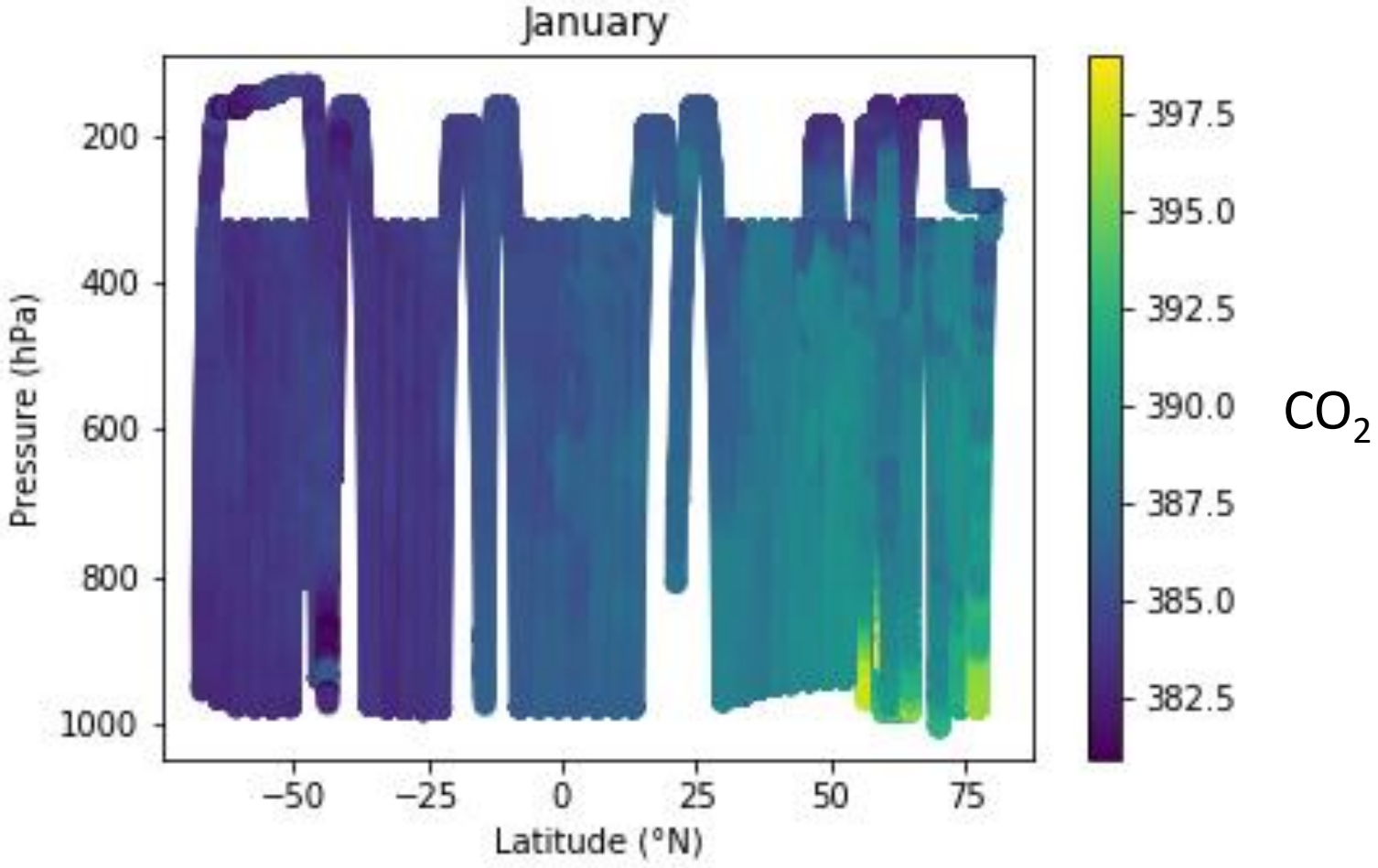
Air flight campaigns provide knowledge on the vertical structure of atmospheric CO_2.



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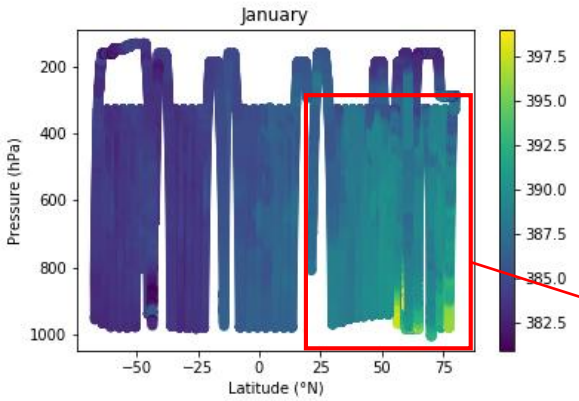
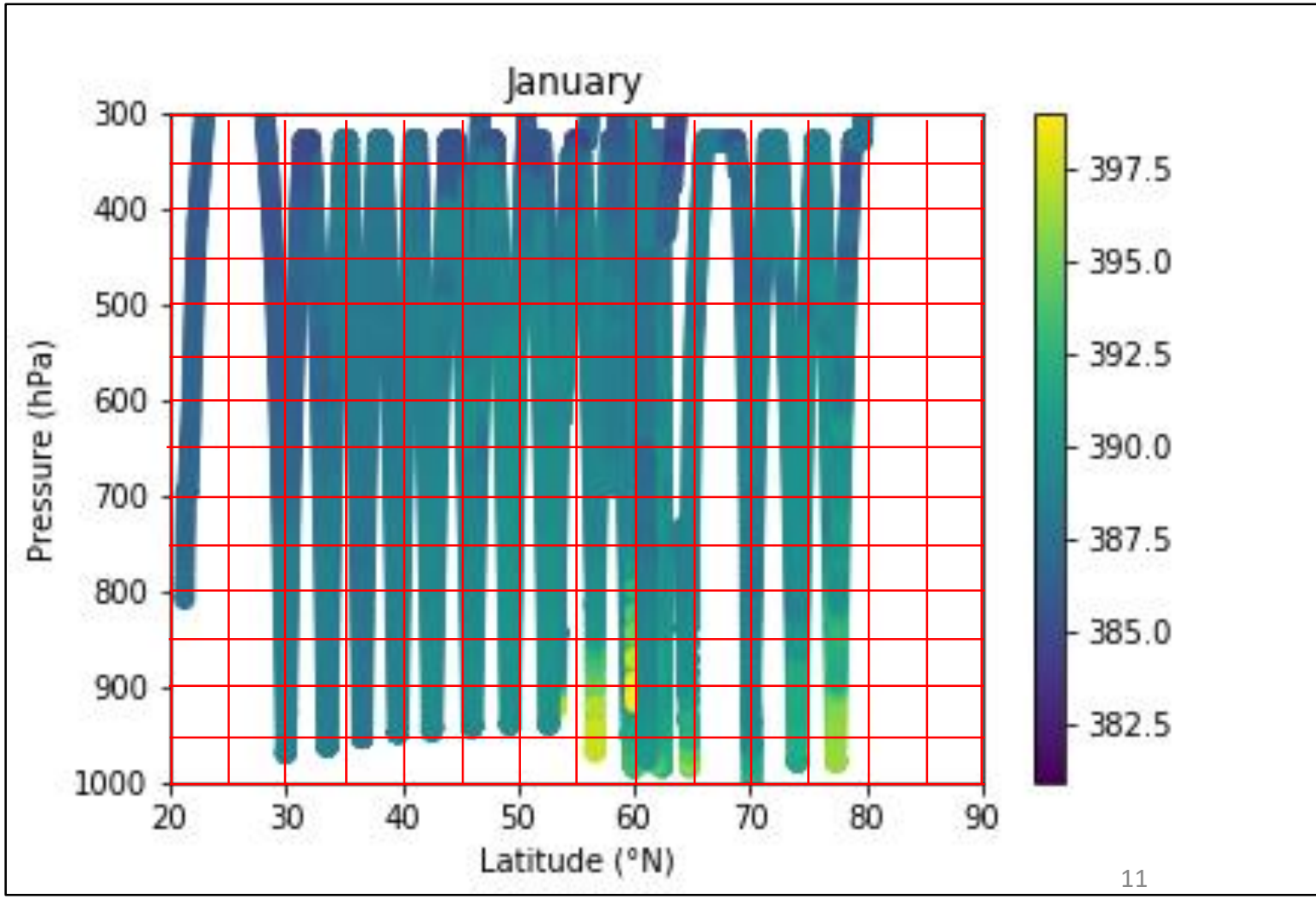
Data are filtered, detrended, binned, fit by a second-order harmonic, and averaged in the Northern Hemisphere.





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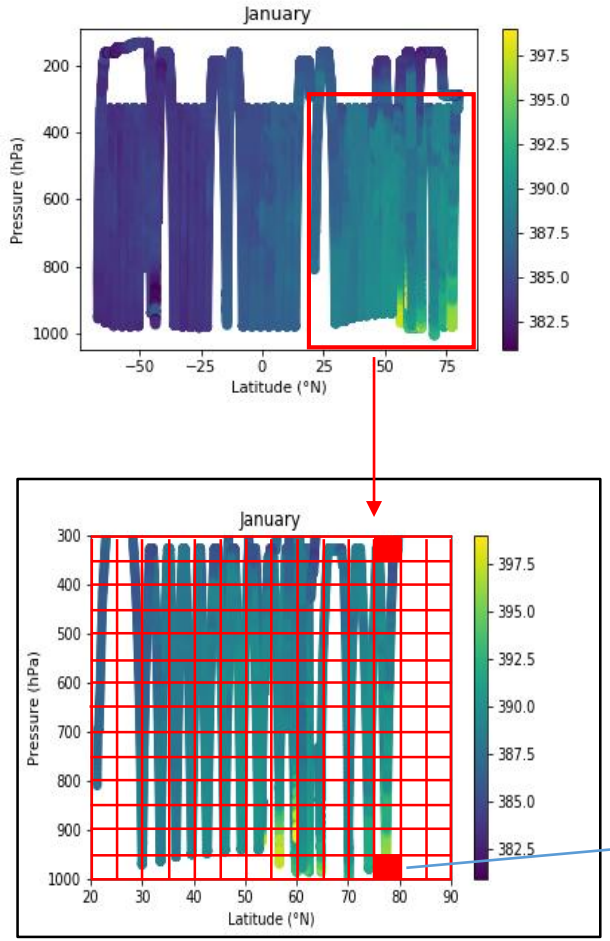
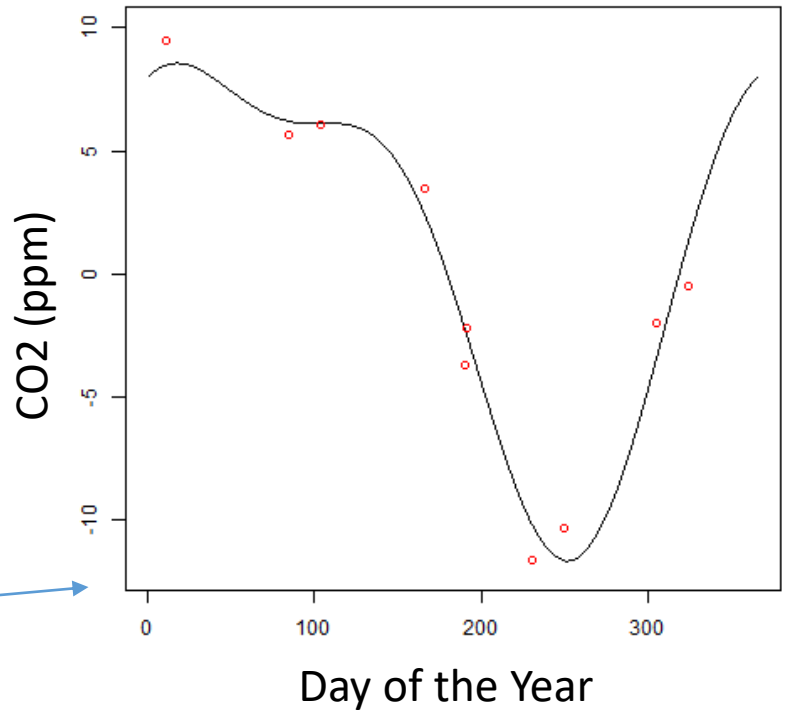


Latitude 75°N - 80°N
Pressure 1000 hPa – 950 hPa



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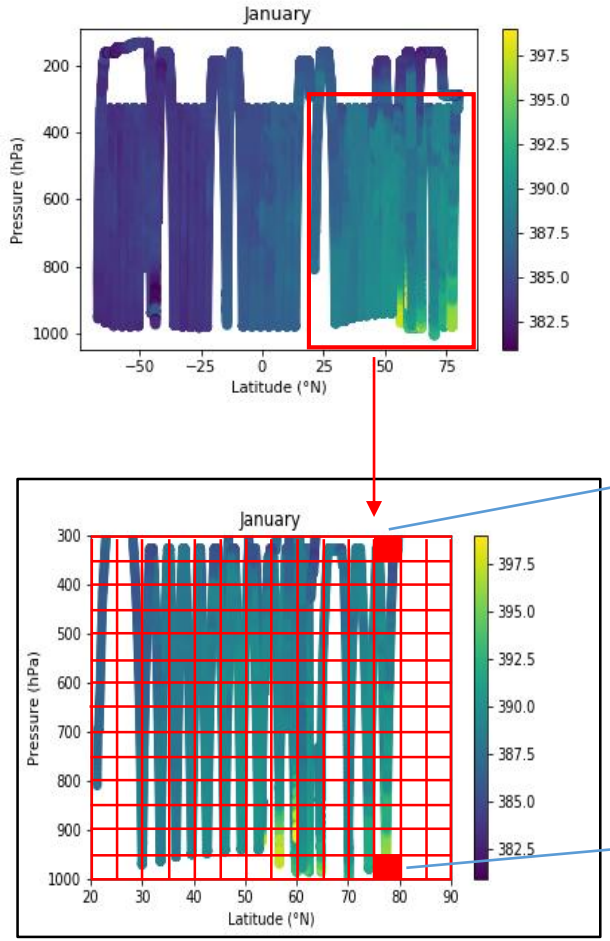

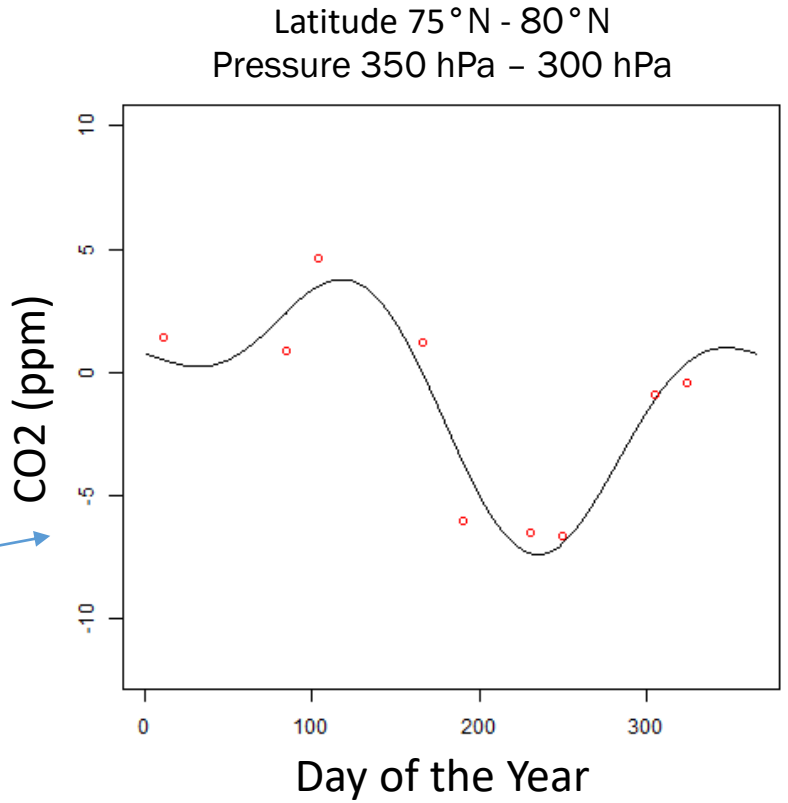

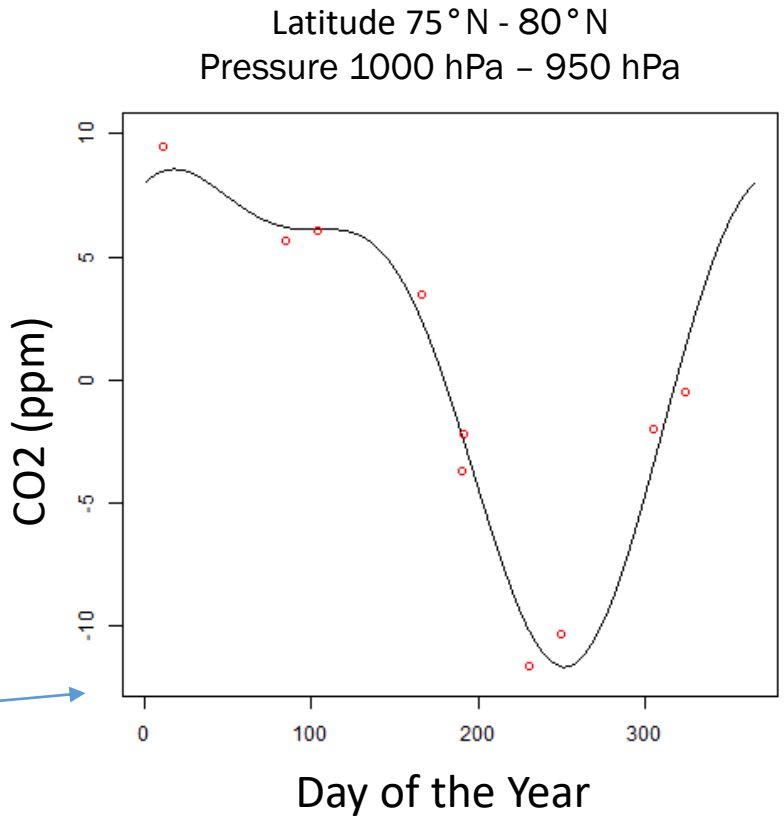

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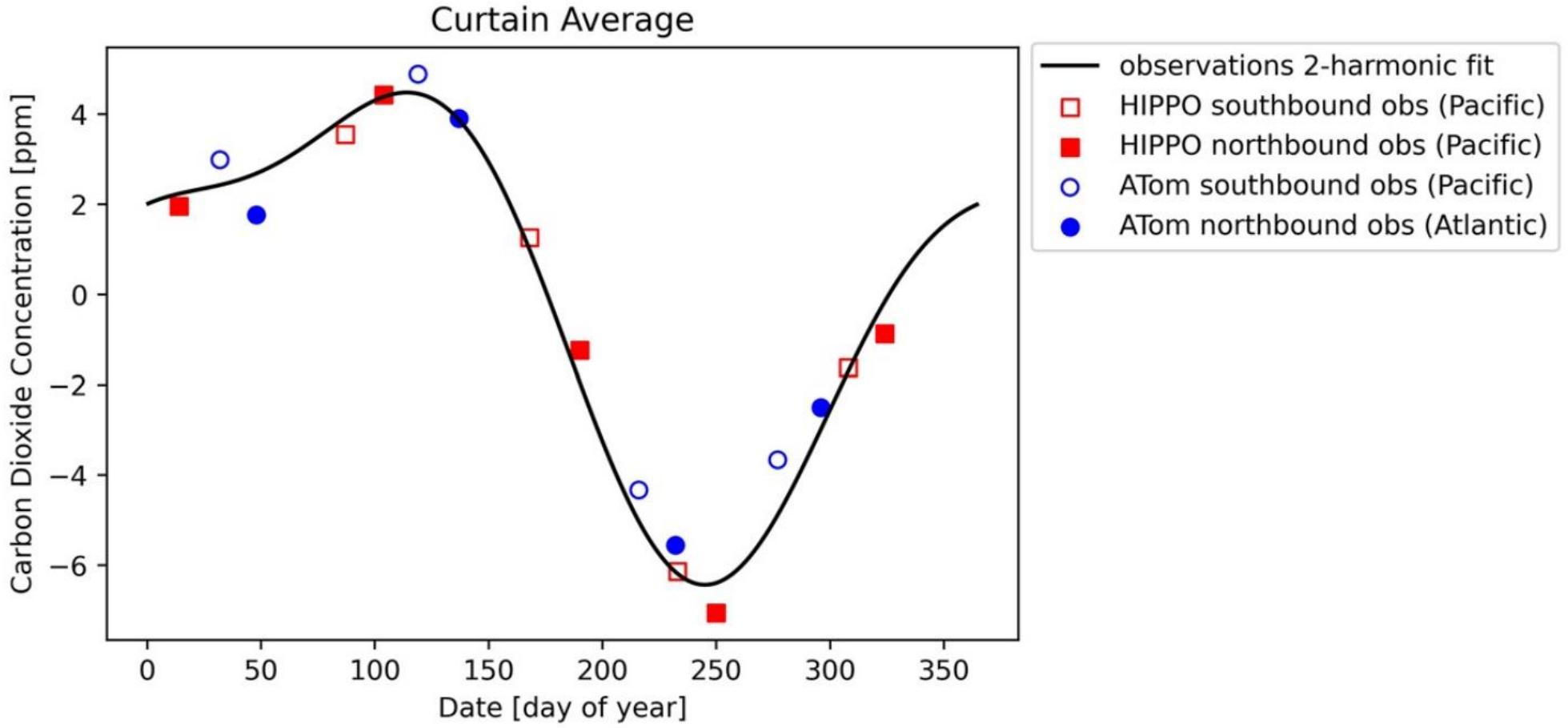
Fitting a second-order harmonic allows for the calculation of the mass of carbon in the NH atmosphere at every day over a seasonal cycle.



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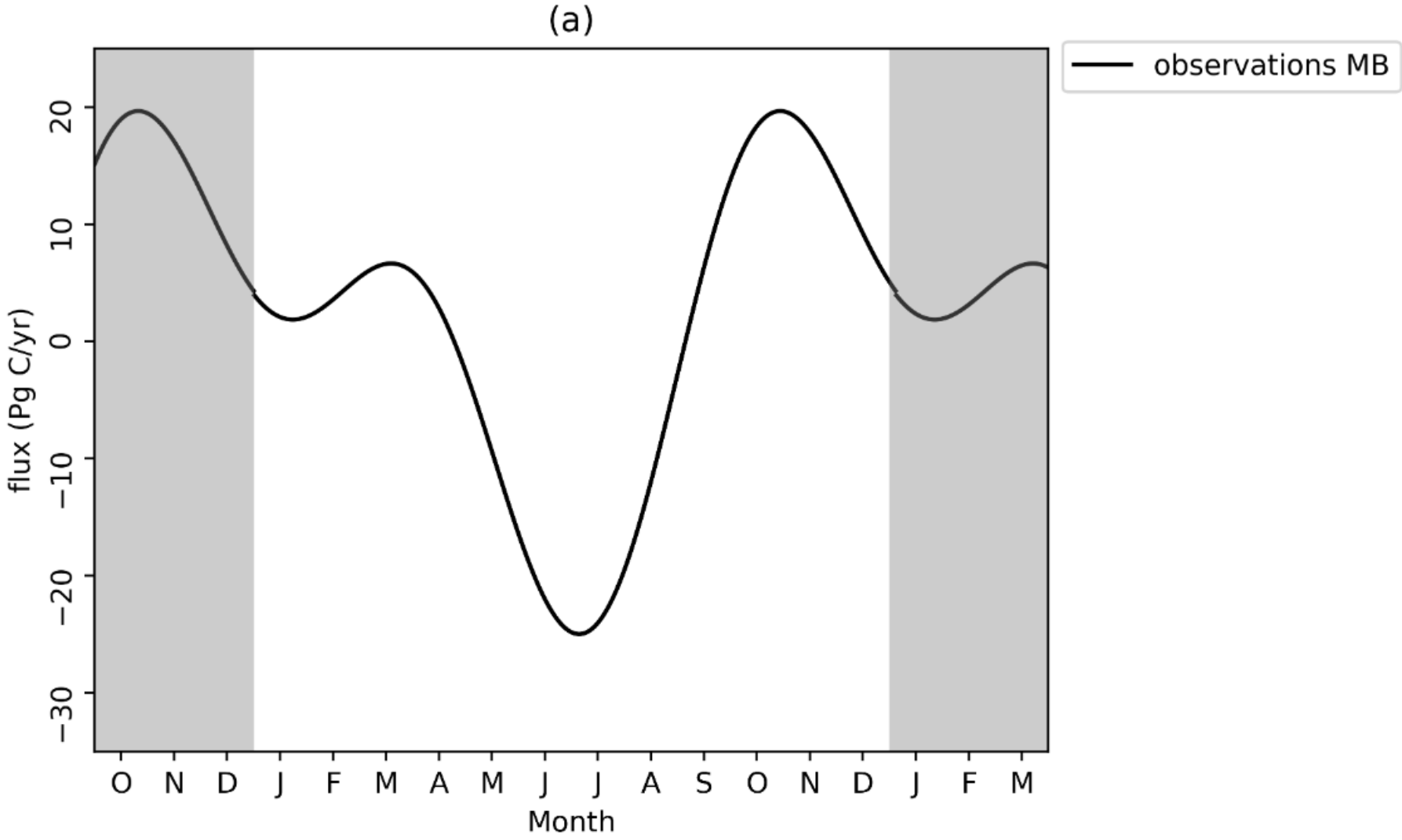
The derivative of the curtain average gives the flux.



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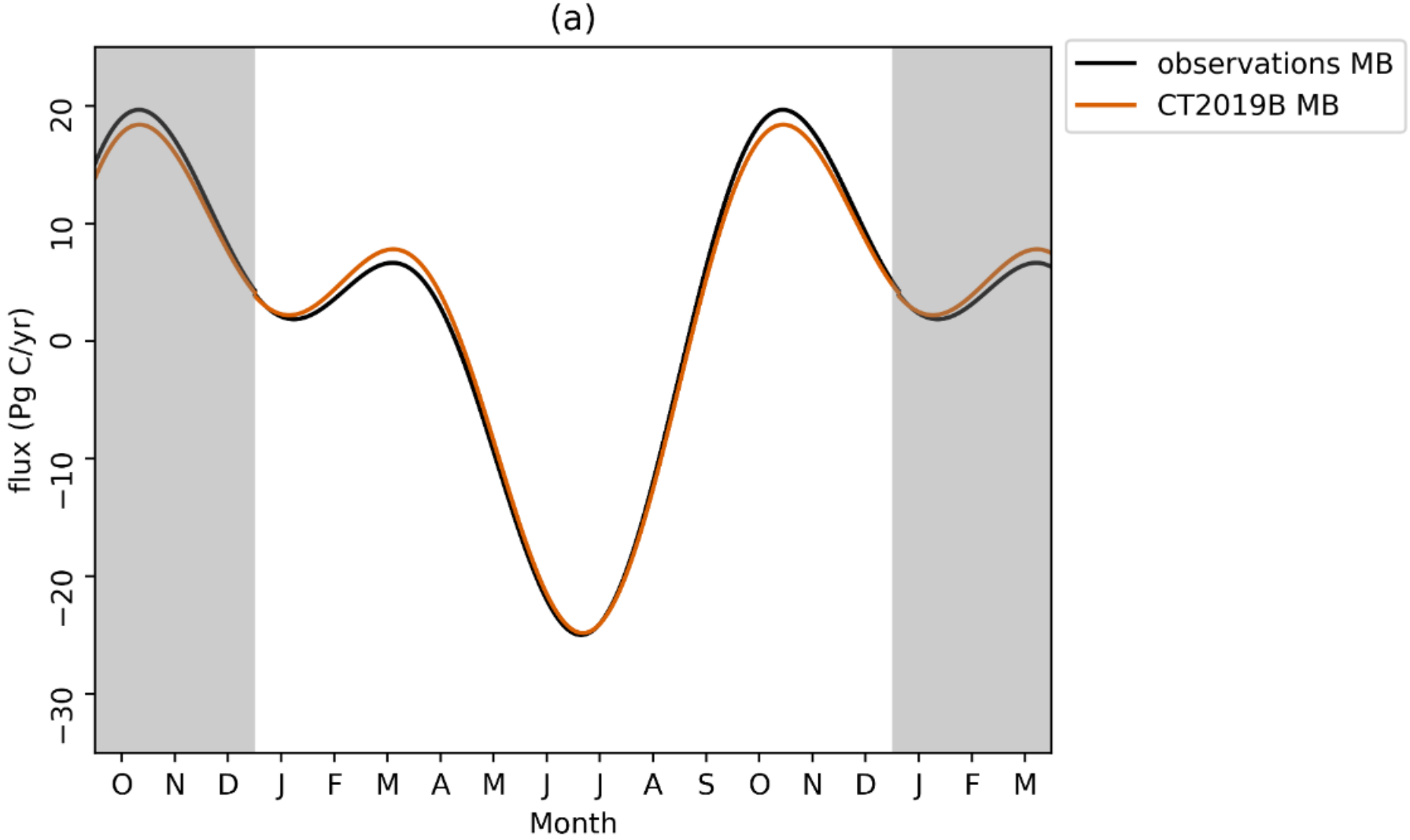
Inverse models are used to account for atmospheric mixing and local influences.



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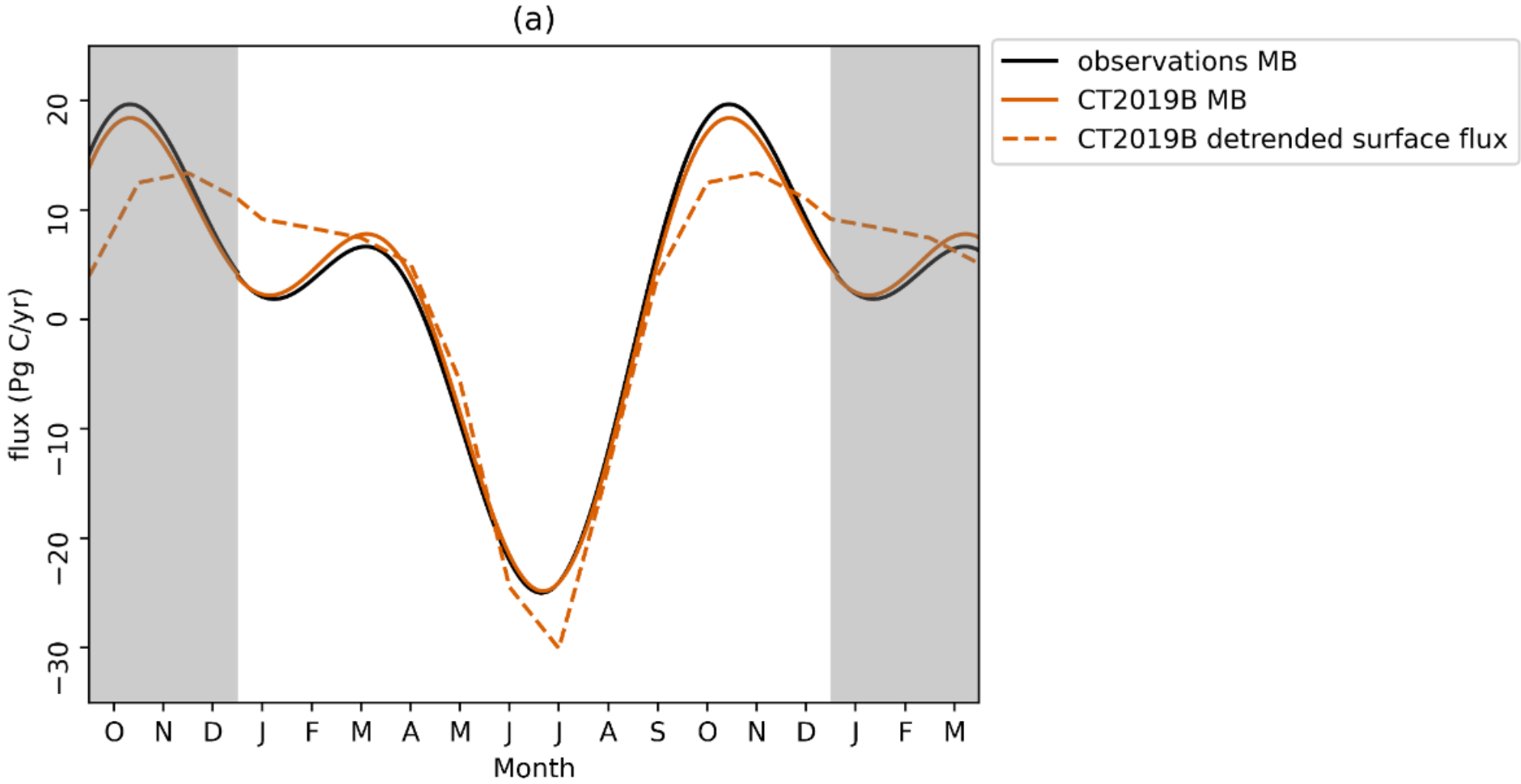

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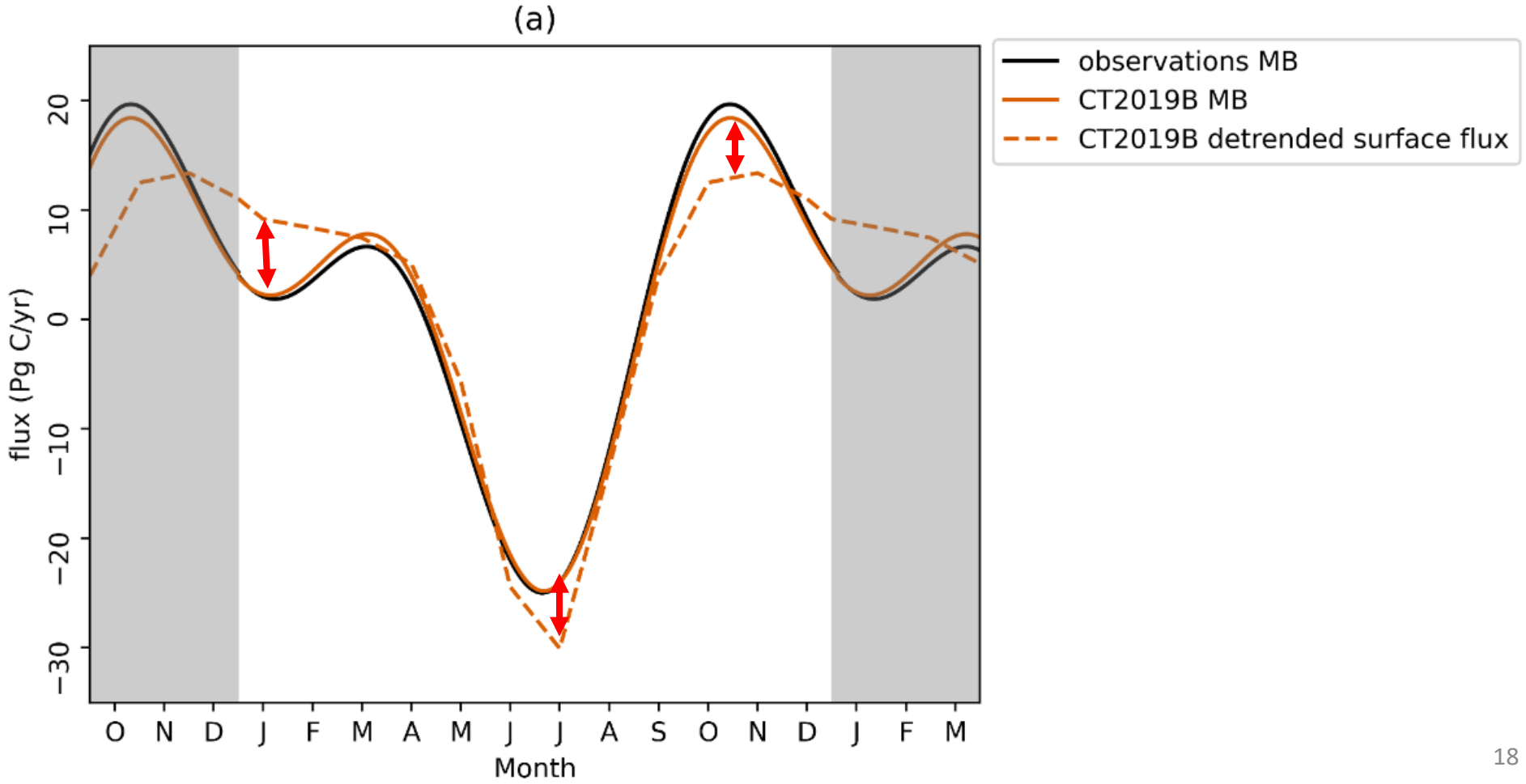

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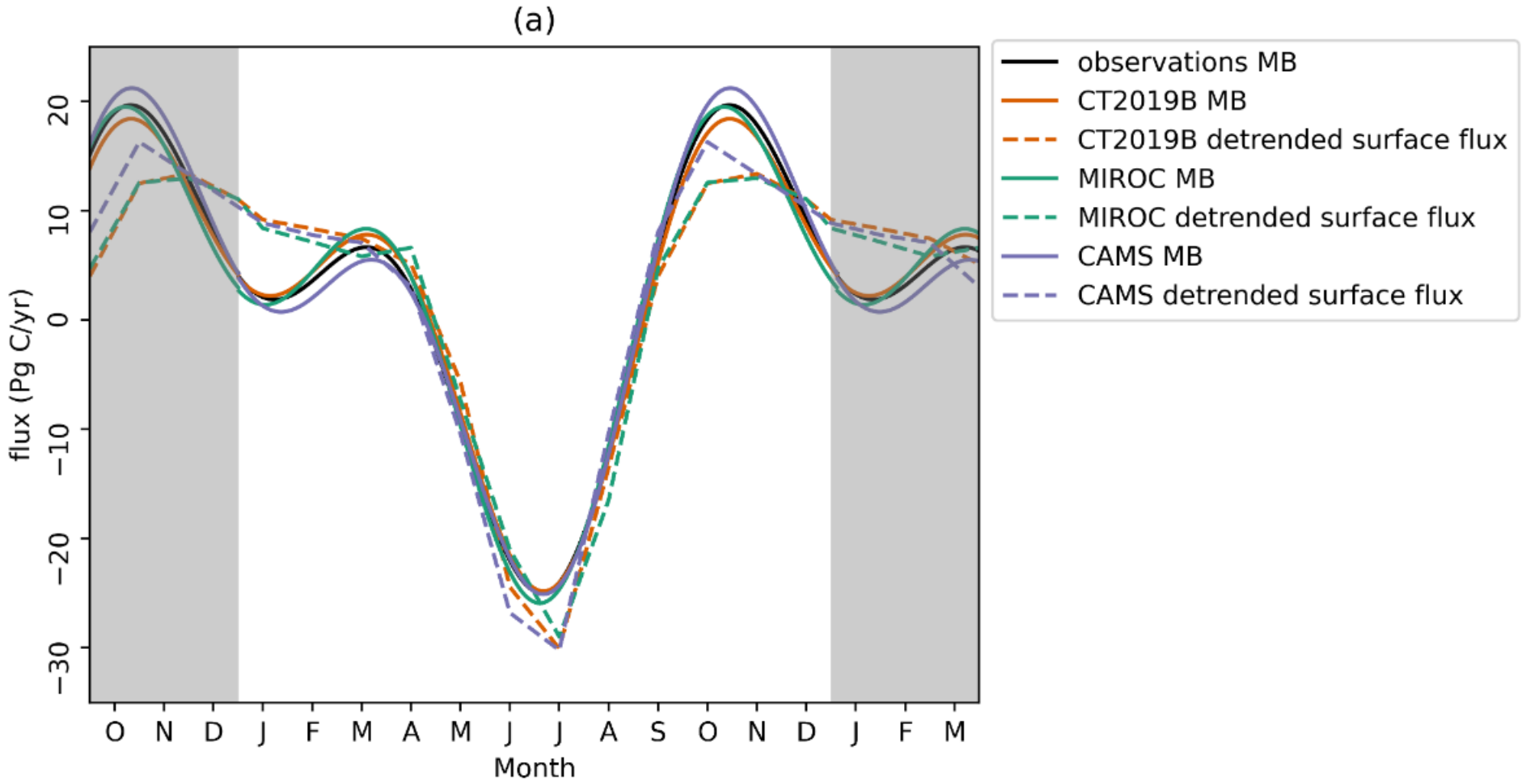
Inverse models agree at the hemispheric scale.



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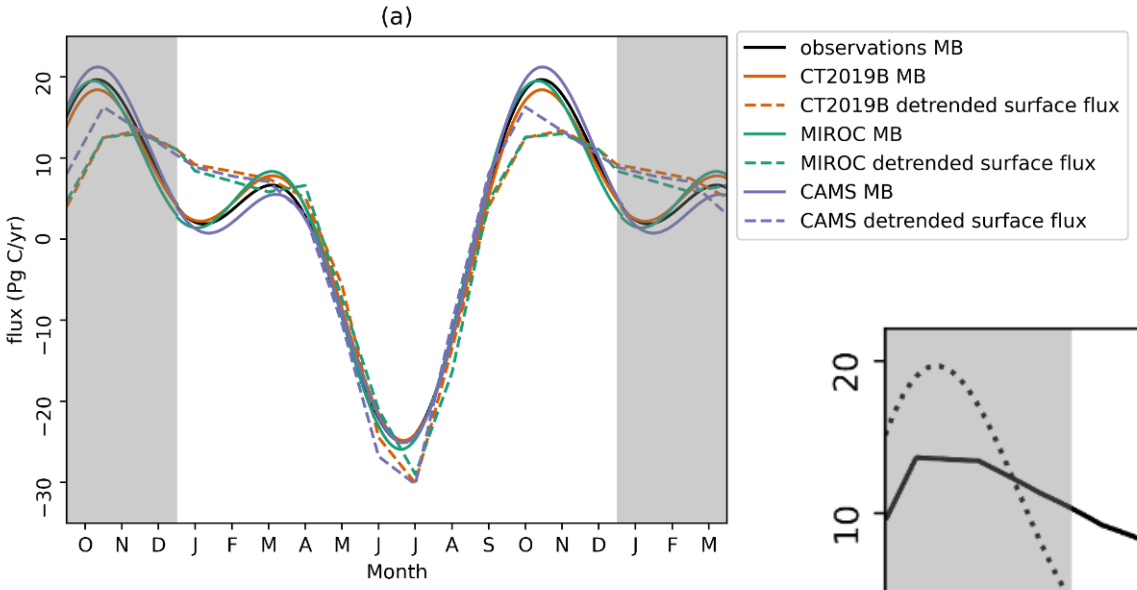

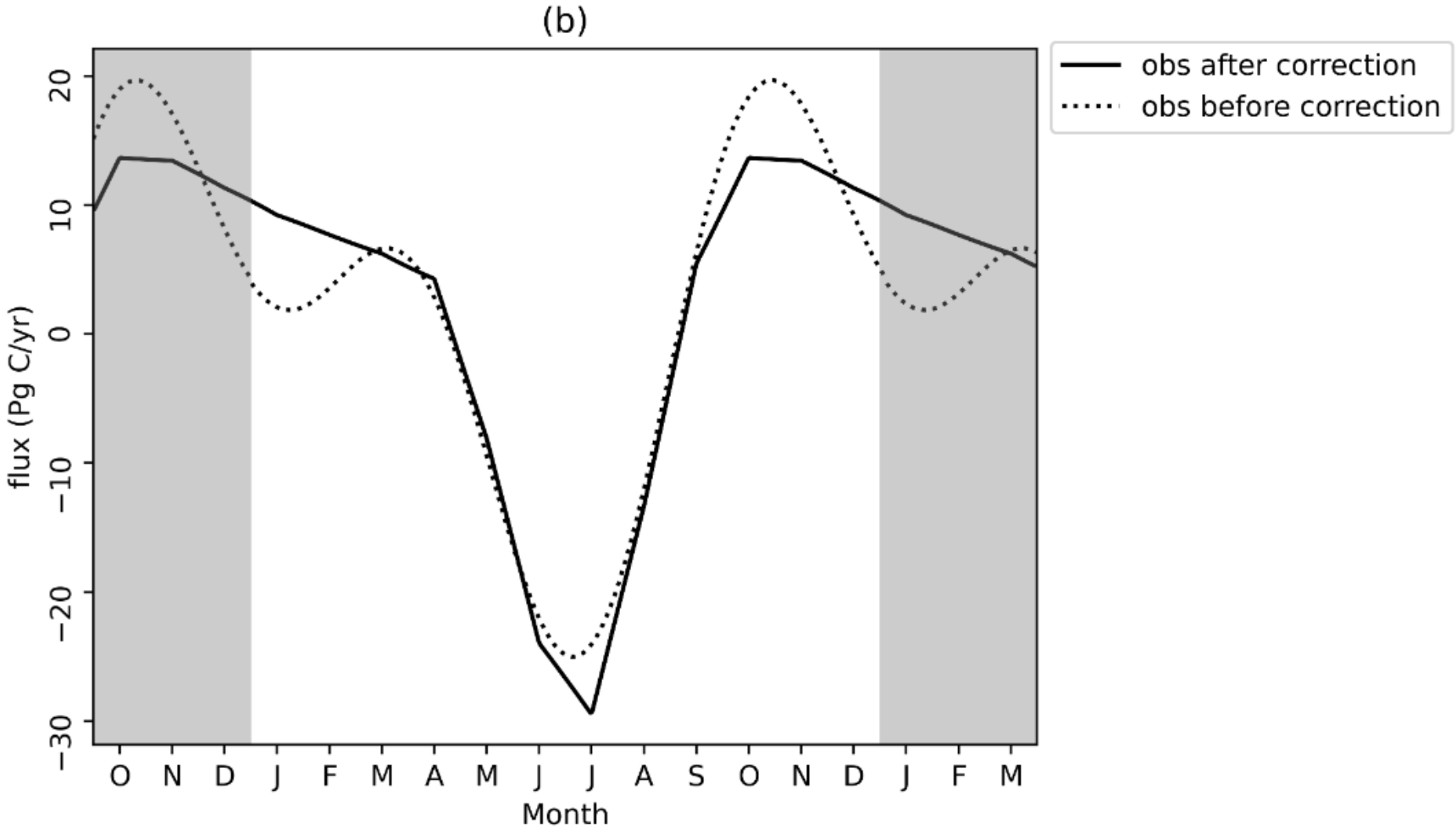

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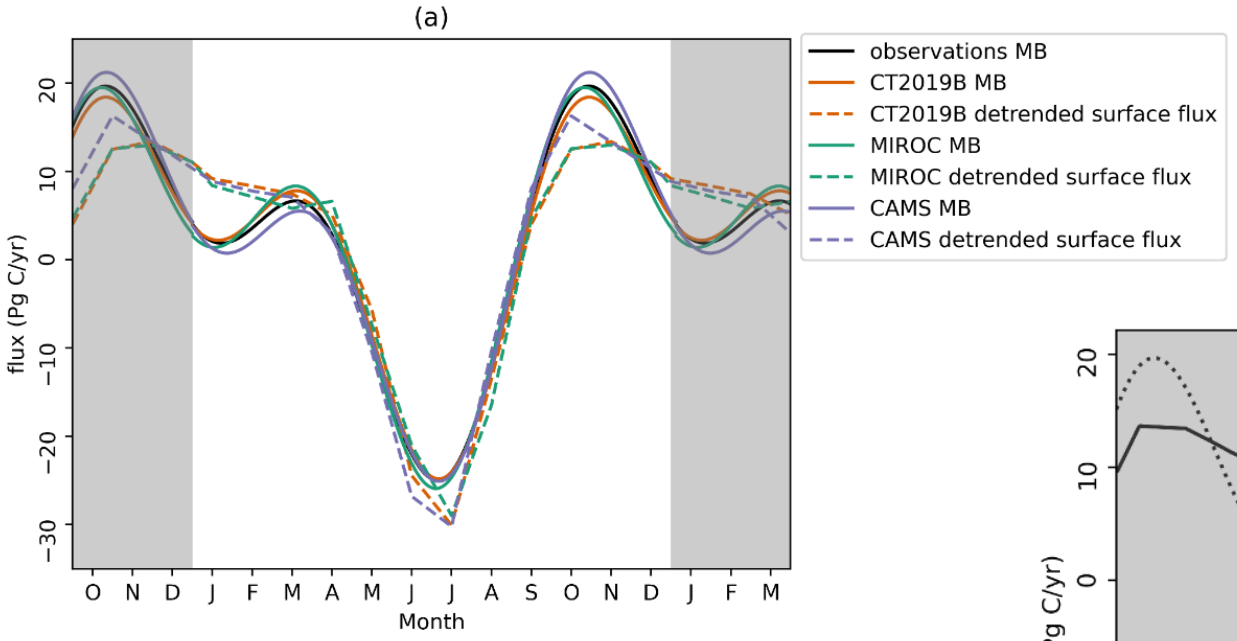
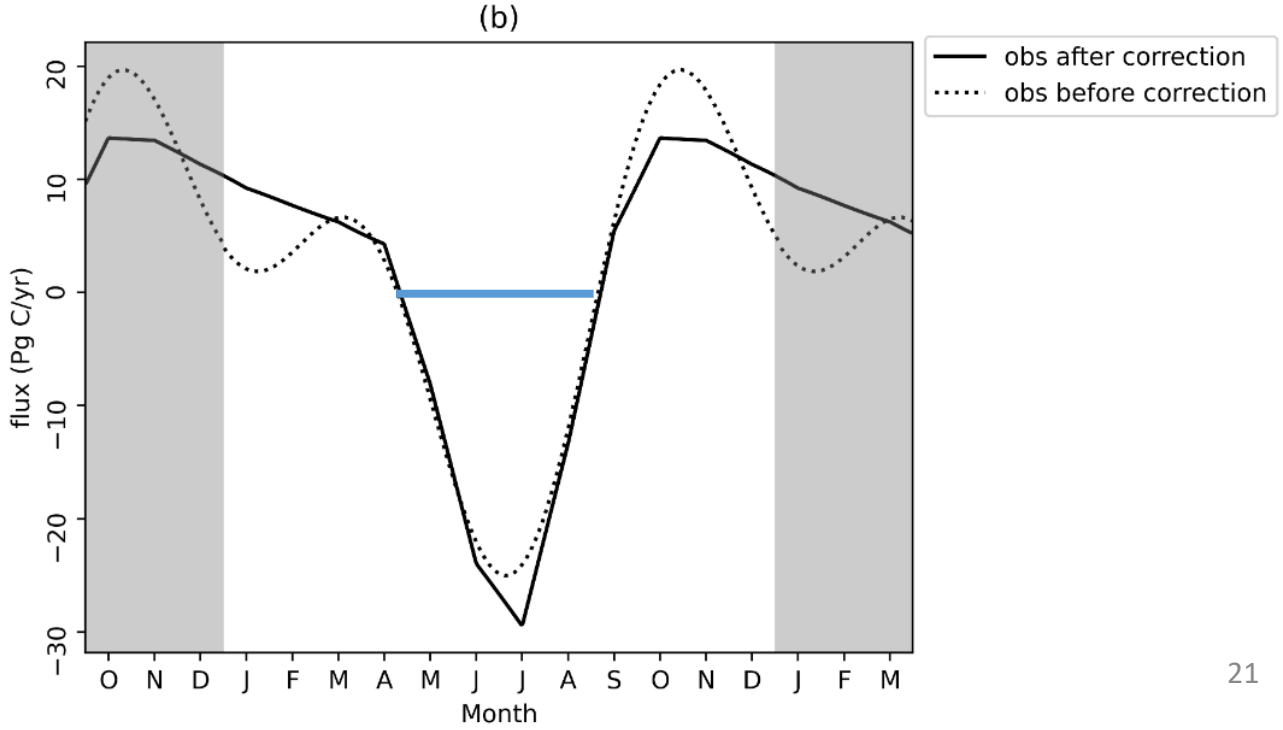
Inferred Northern hemisphere growing season net flux from atmospheric CO_2 from HIPPO and ATom aircraft campaigns is 5.7 ± 0.3 PgC/yr





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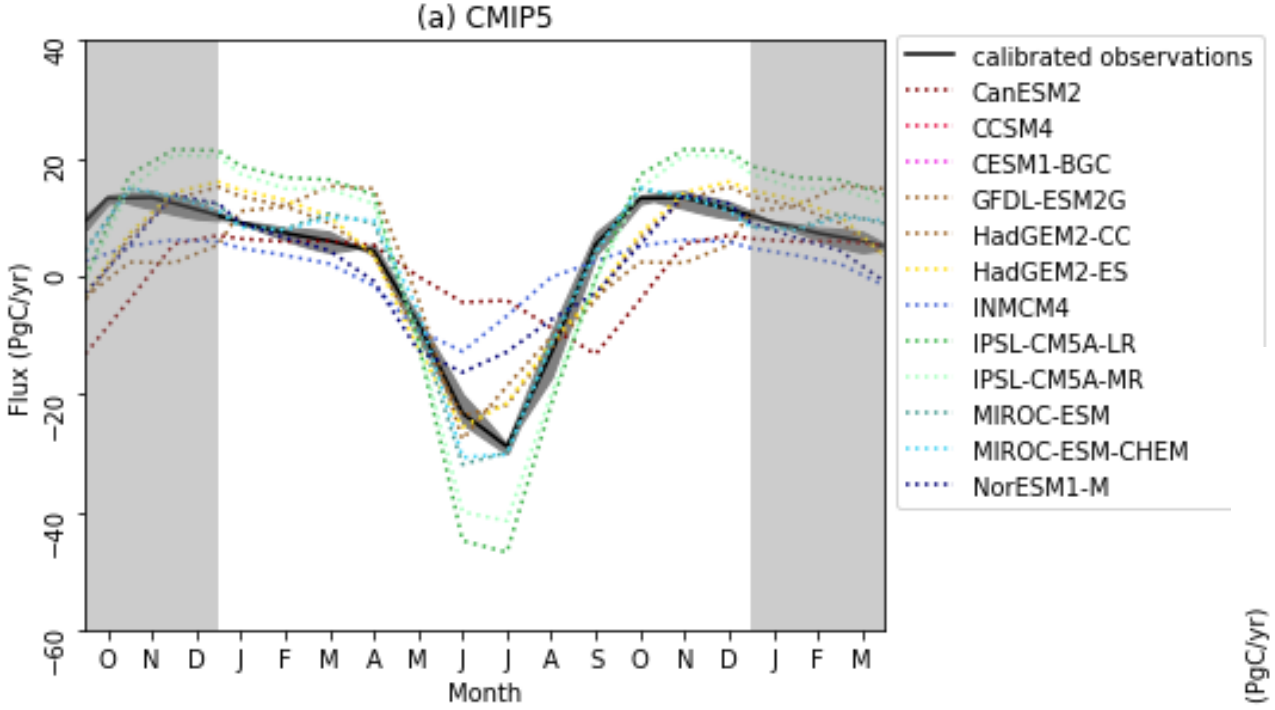
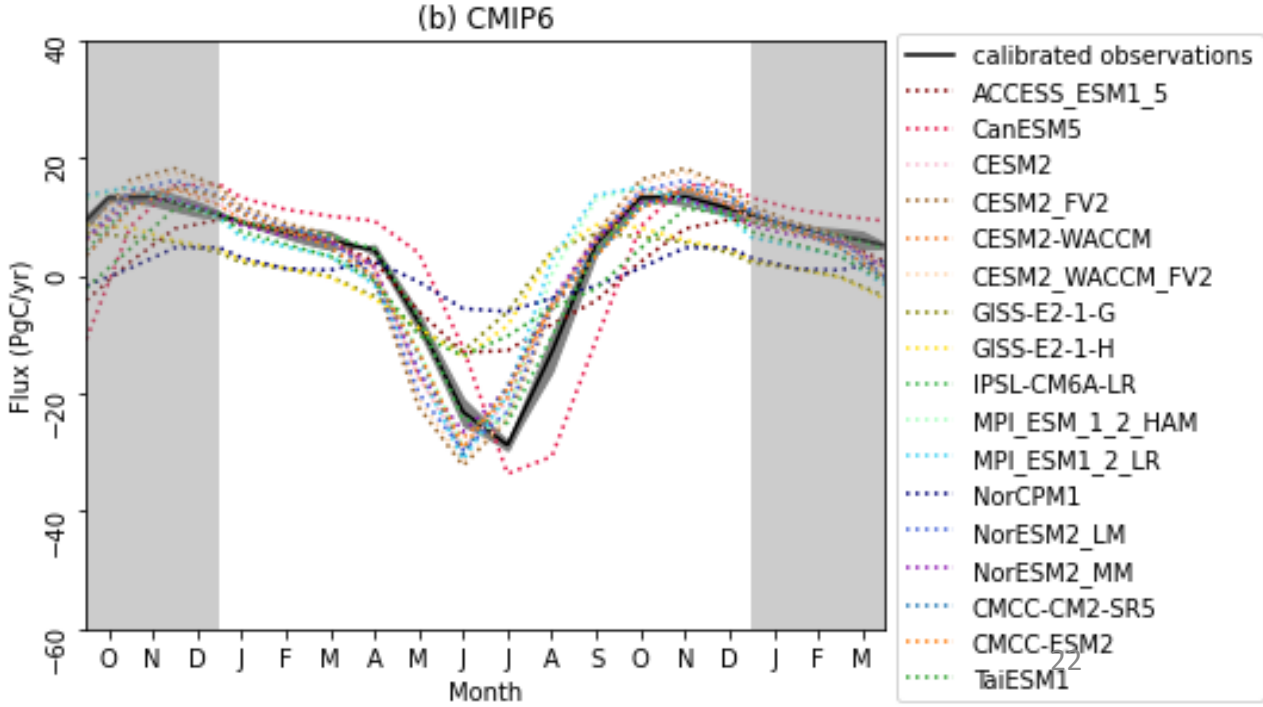
Both CMIP5 and CMIP6 models disagree on the timing and magnitude of the flux.





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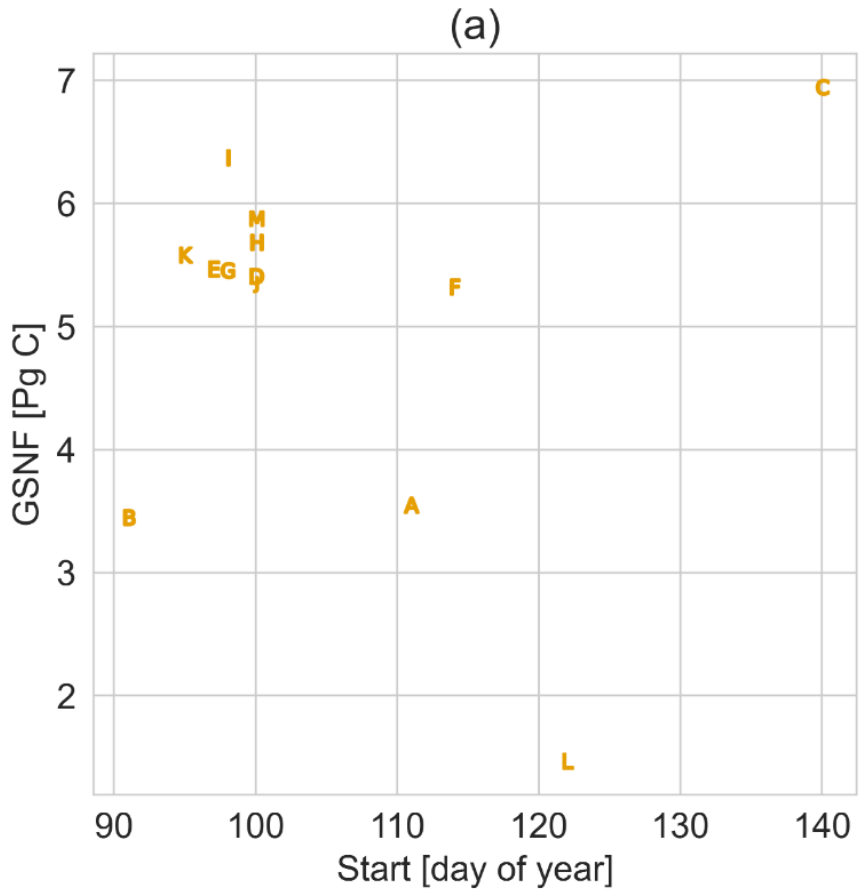

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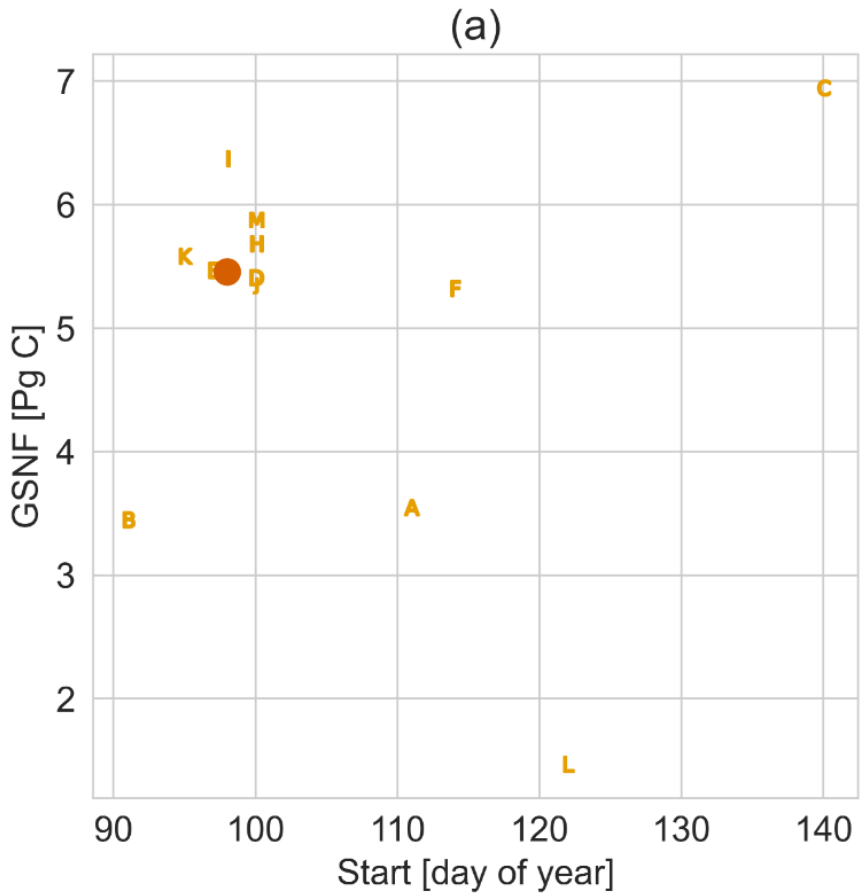

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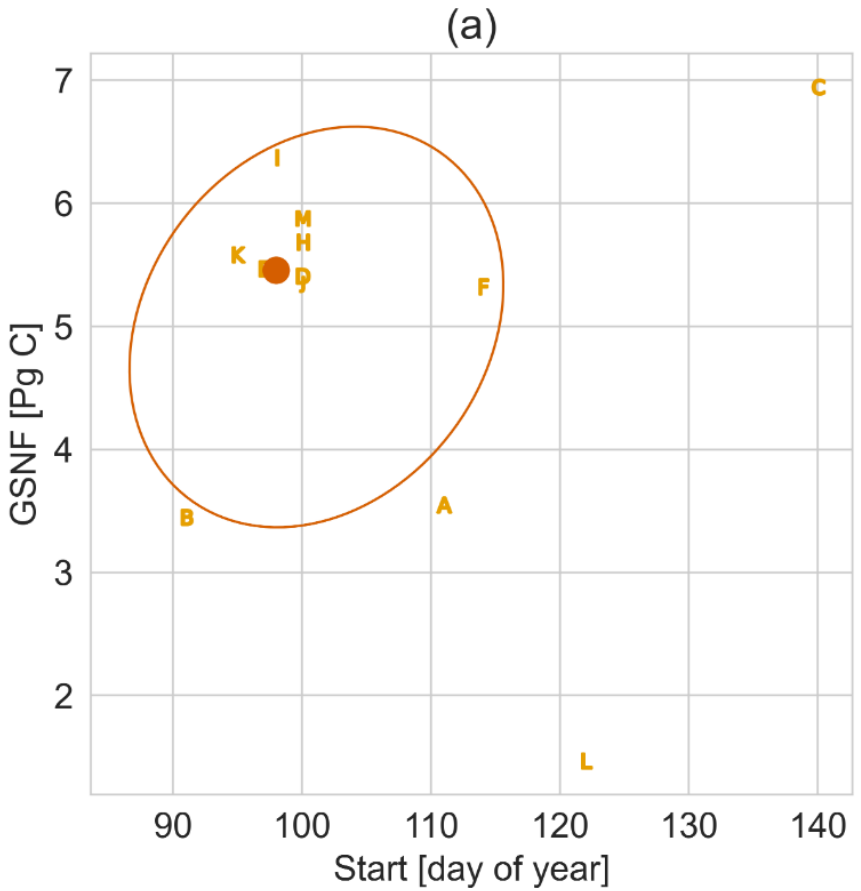

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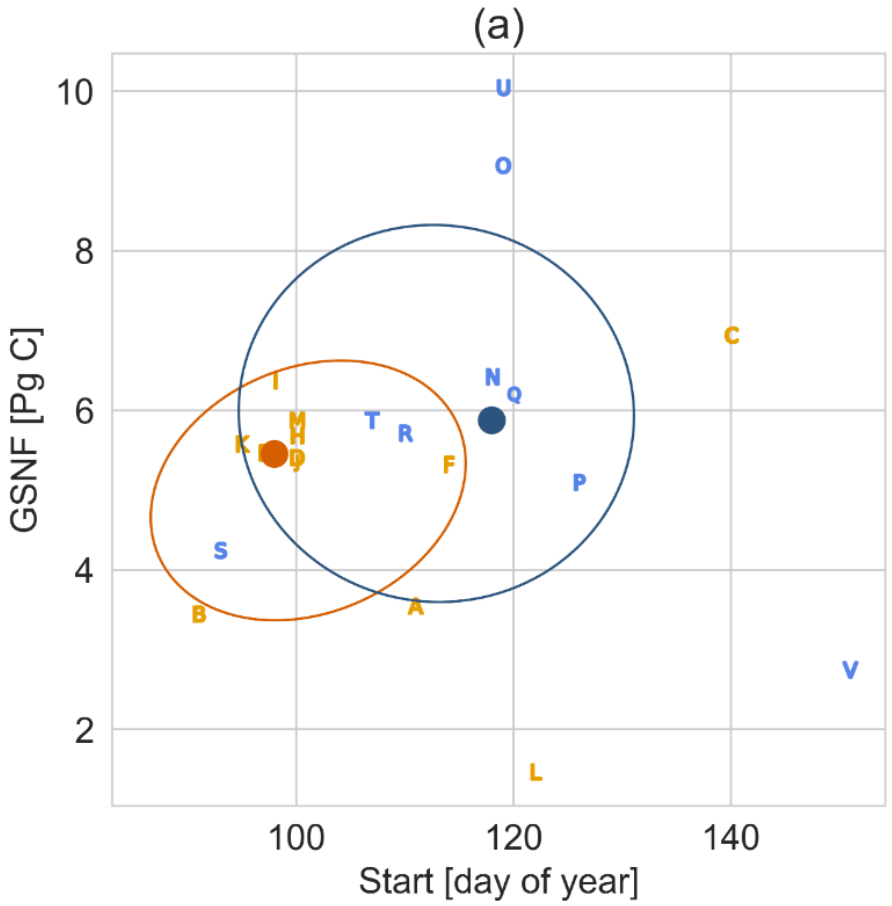
CMIP6 models have a decreased spread compared to CMIP5 models.



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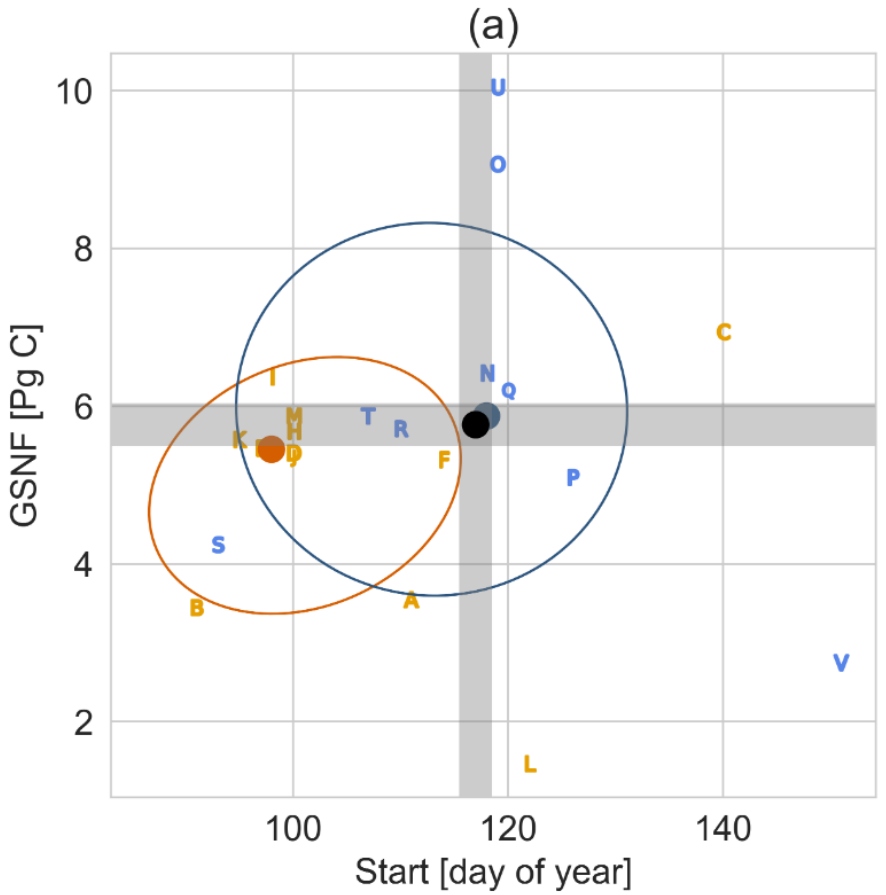
Observations suggest a later start to the growing season and larger flux than simulated in CMIP6 models.



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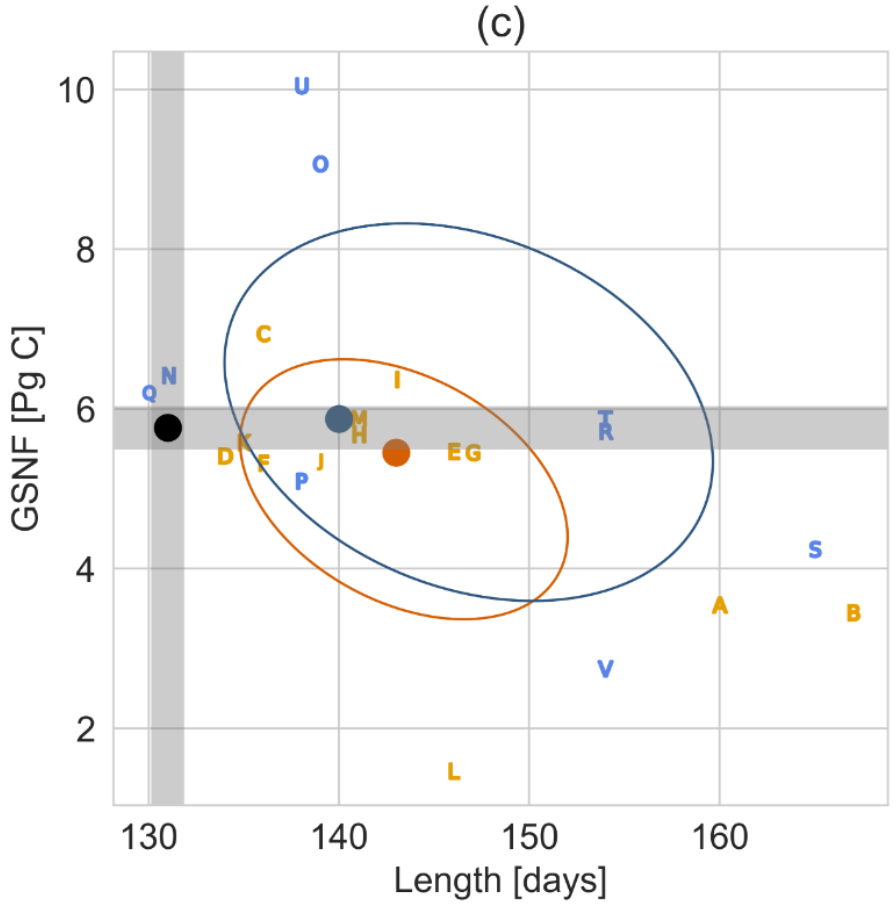
Observations suggest a shorter growing season than is simulated by models.



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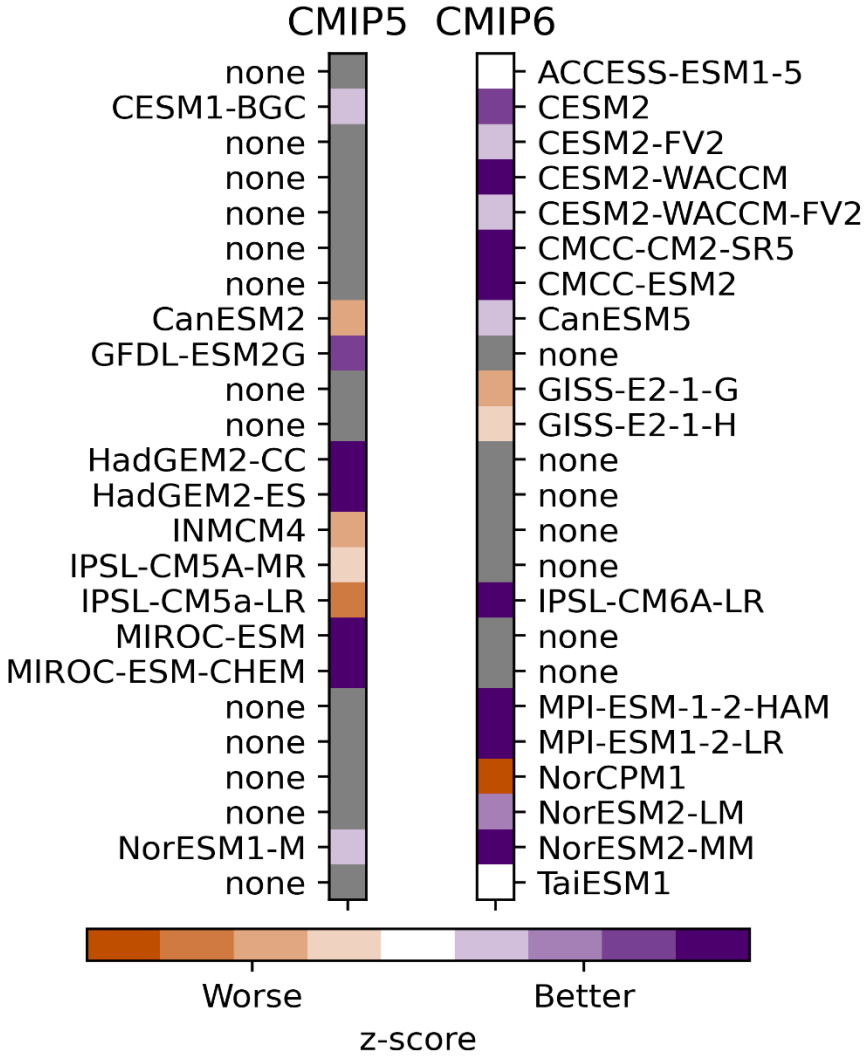
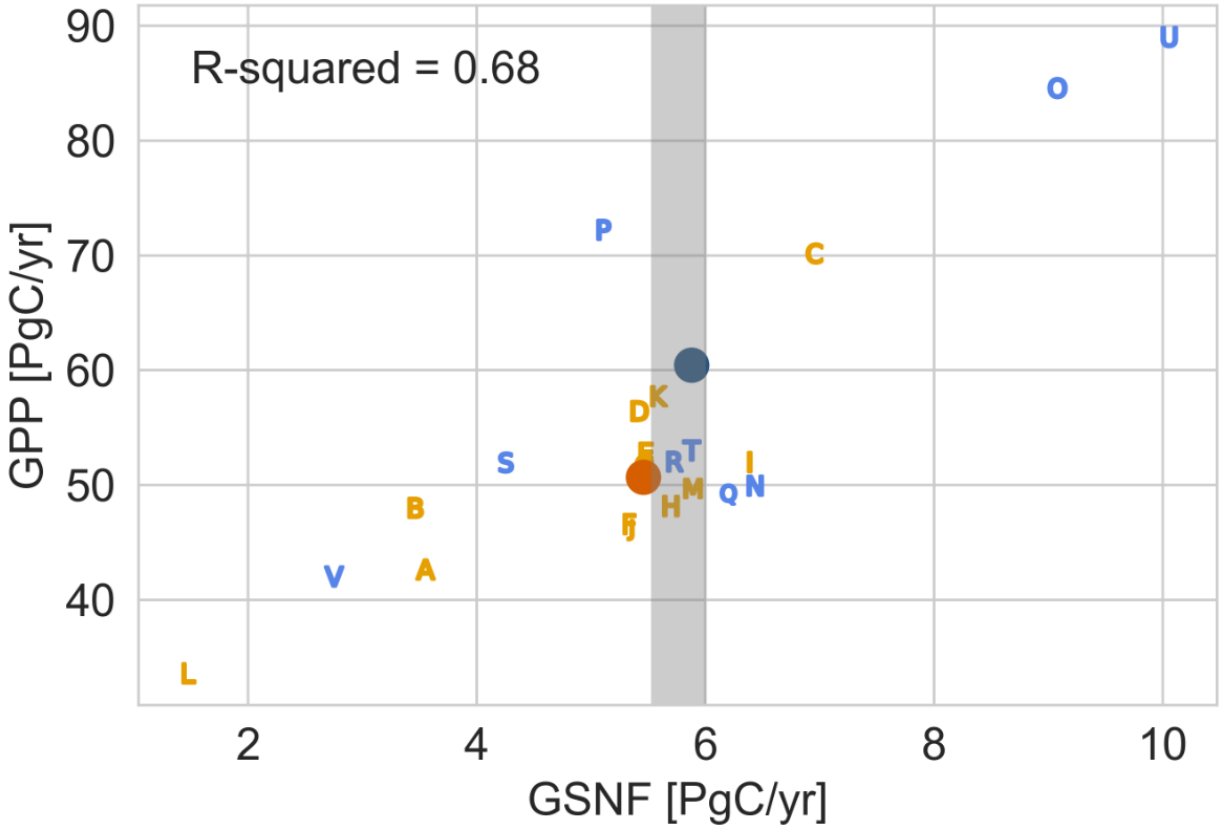
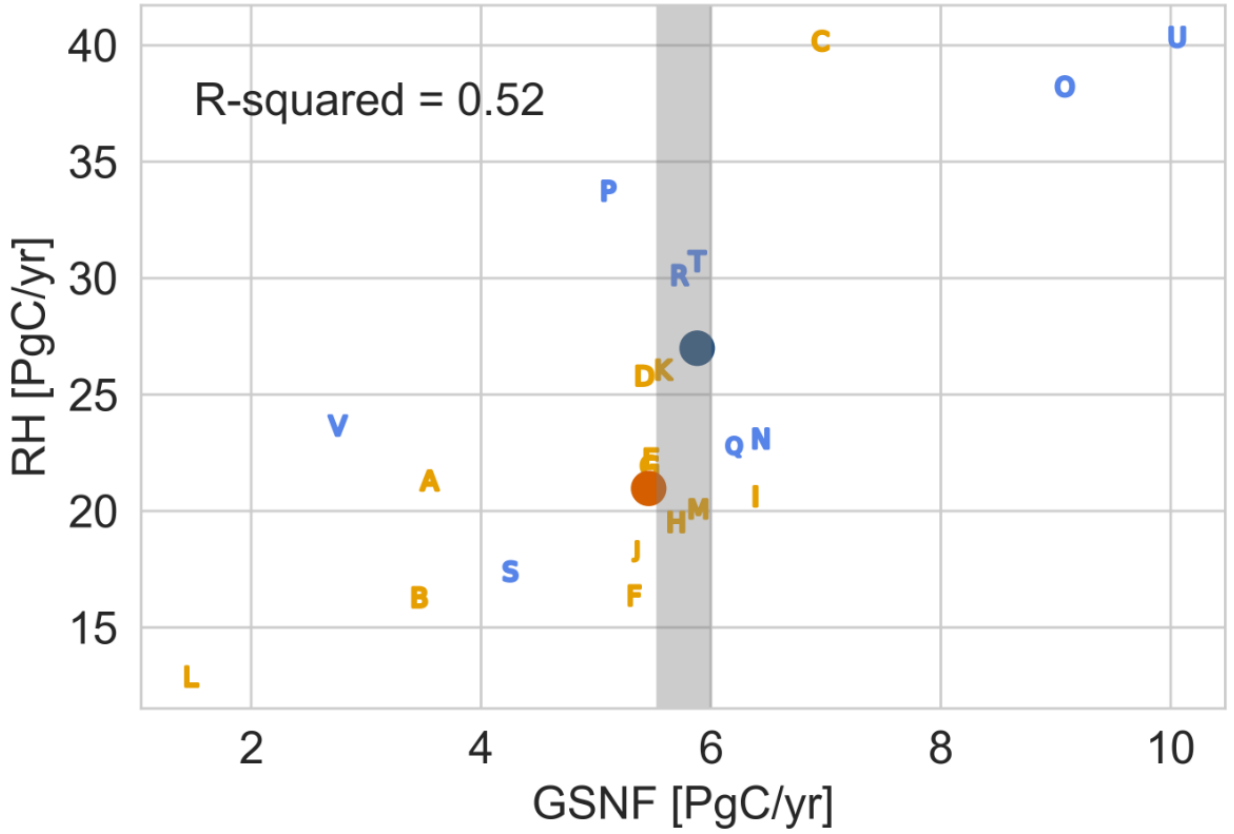
All modeling centers with models in both generations showed improvement in CMIP6.

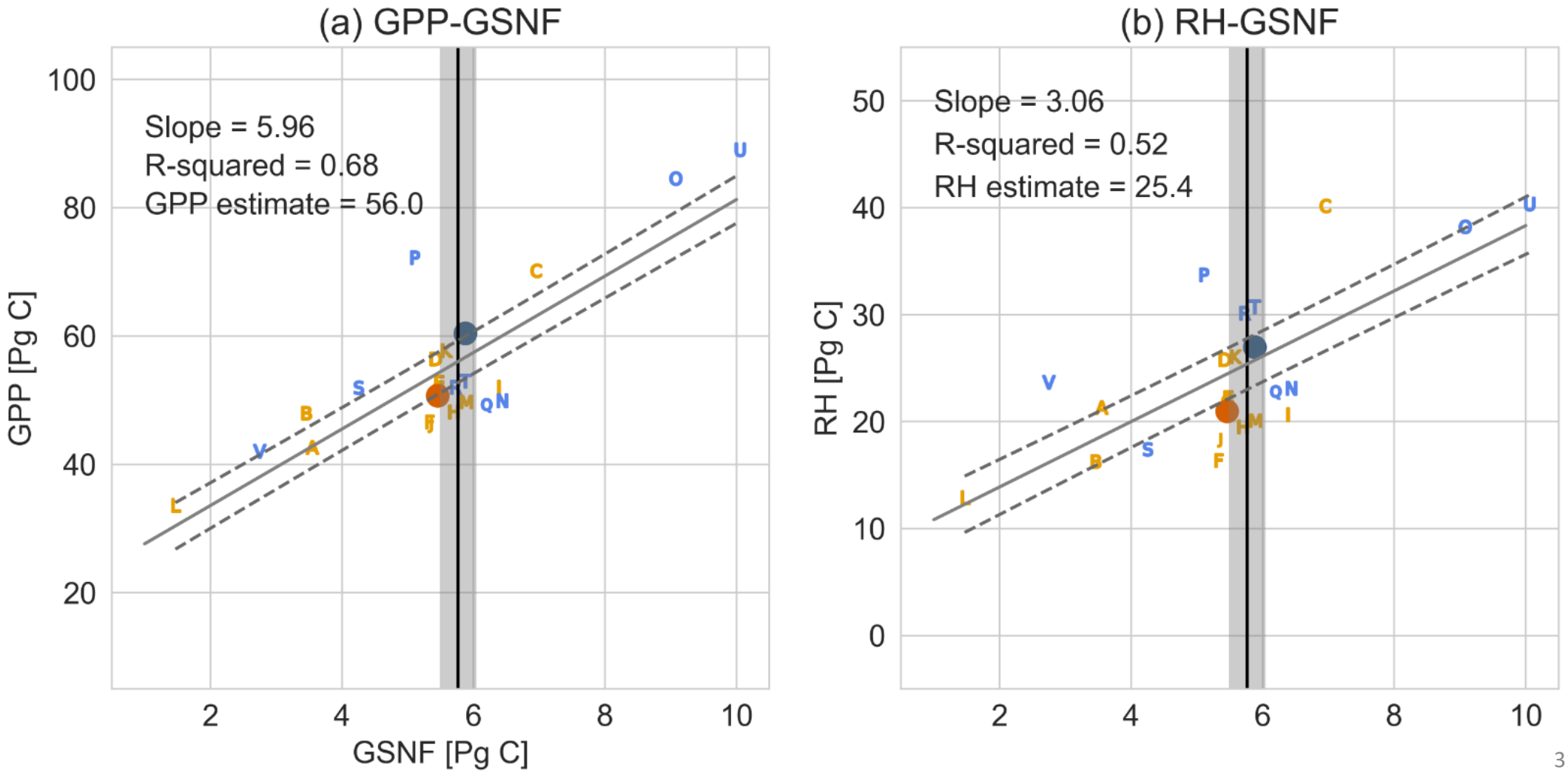


GSNF is well correlated with GPP and RH.





Estimated GPP is consistent with upper end of upscaled flux-tower estimates.



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