

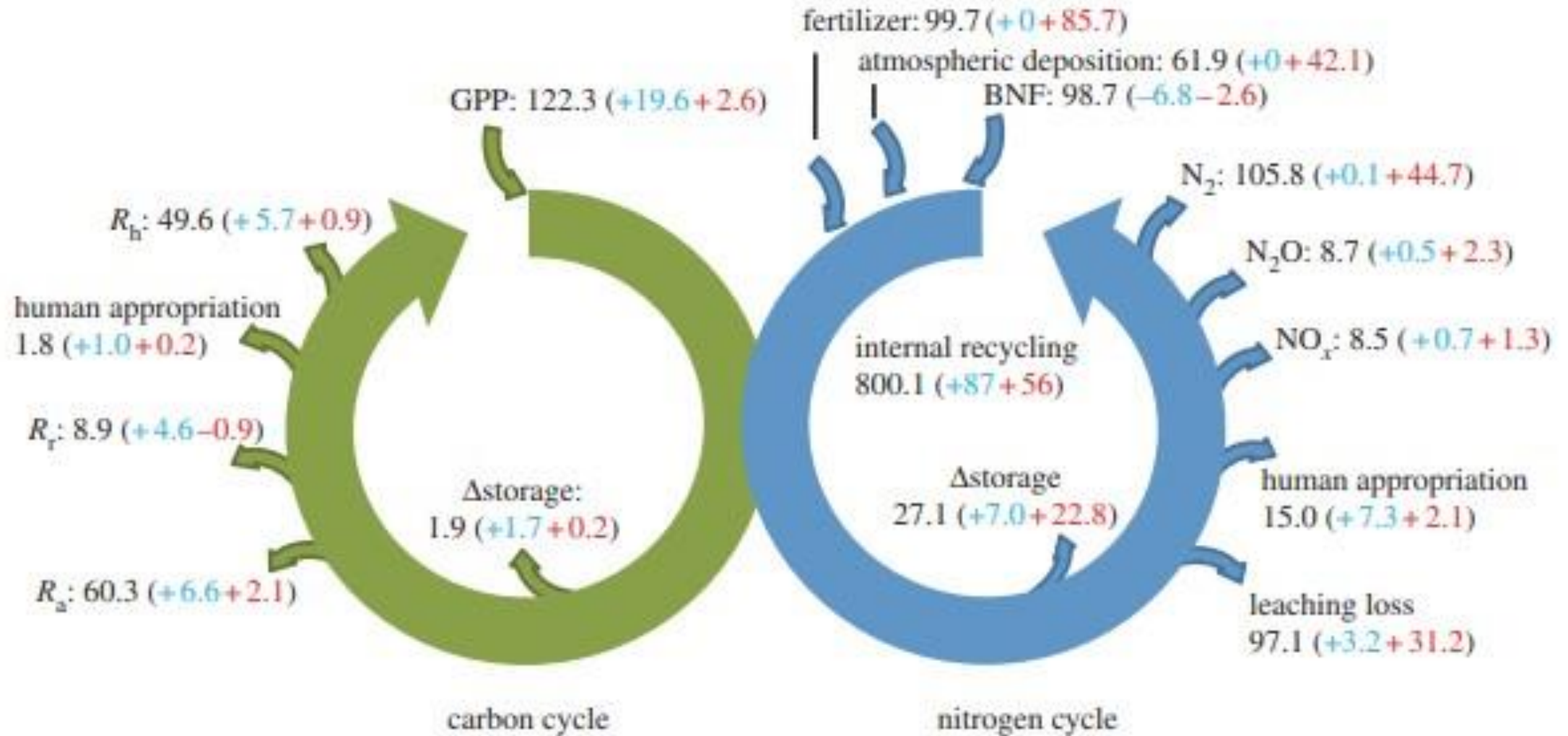


Terrestrial Biological Nitrogen
Fixation:
*What we now know, and what
we still need to find out*

T Davies-Barnard

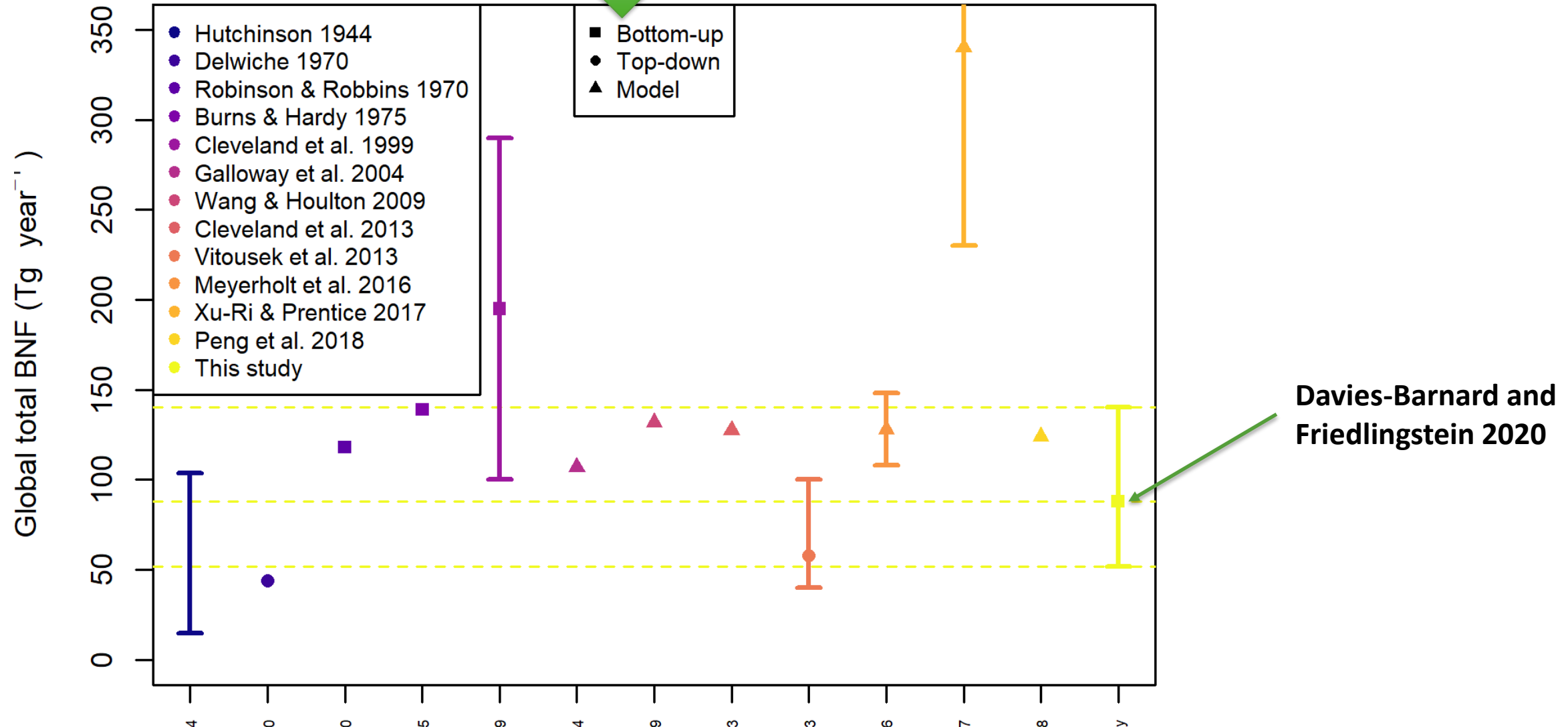
Pierre Friedlingstein, Sönke Zaehle, Johannes Meyerholt

Biological Nitrogen Fixation (BNF)



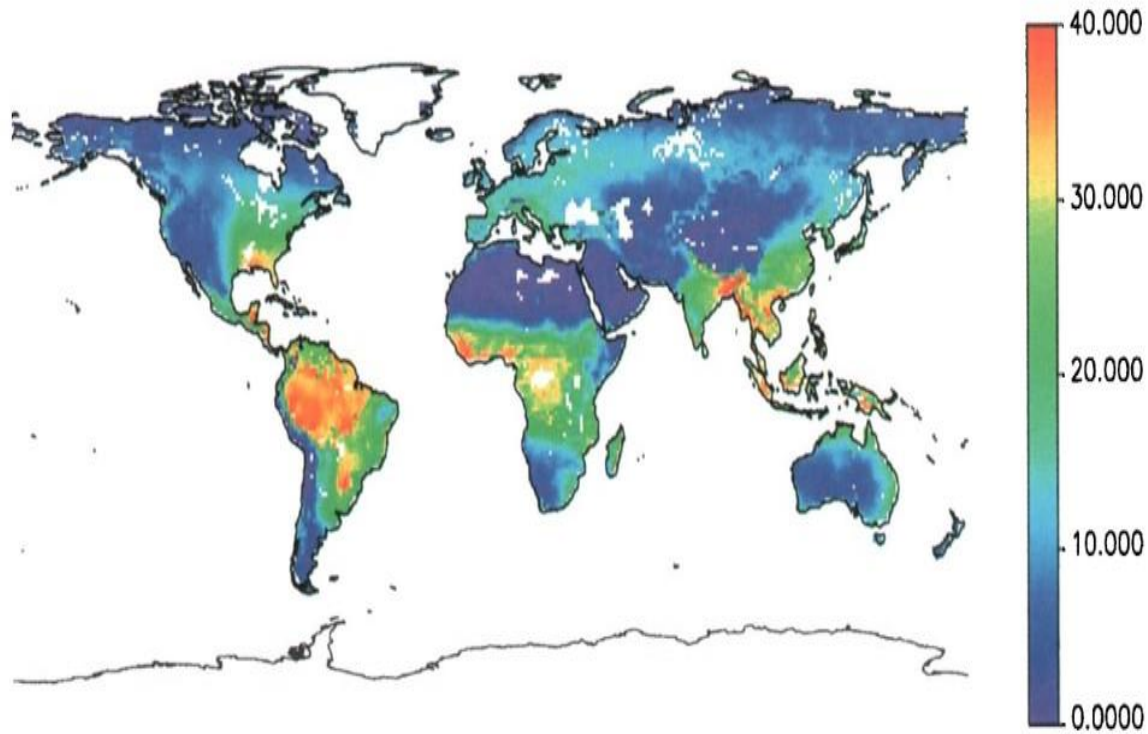
Better Understanding of global total BNF

Before CRESCENDO



Better Understanding of BNF spatial distribution

Cleveland et al. 1999



Davies-Barnard and Friedlingstein 2020

All BNF by biome

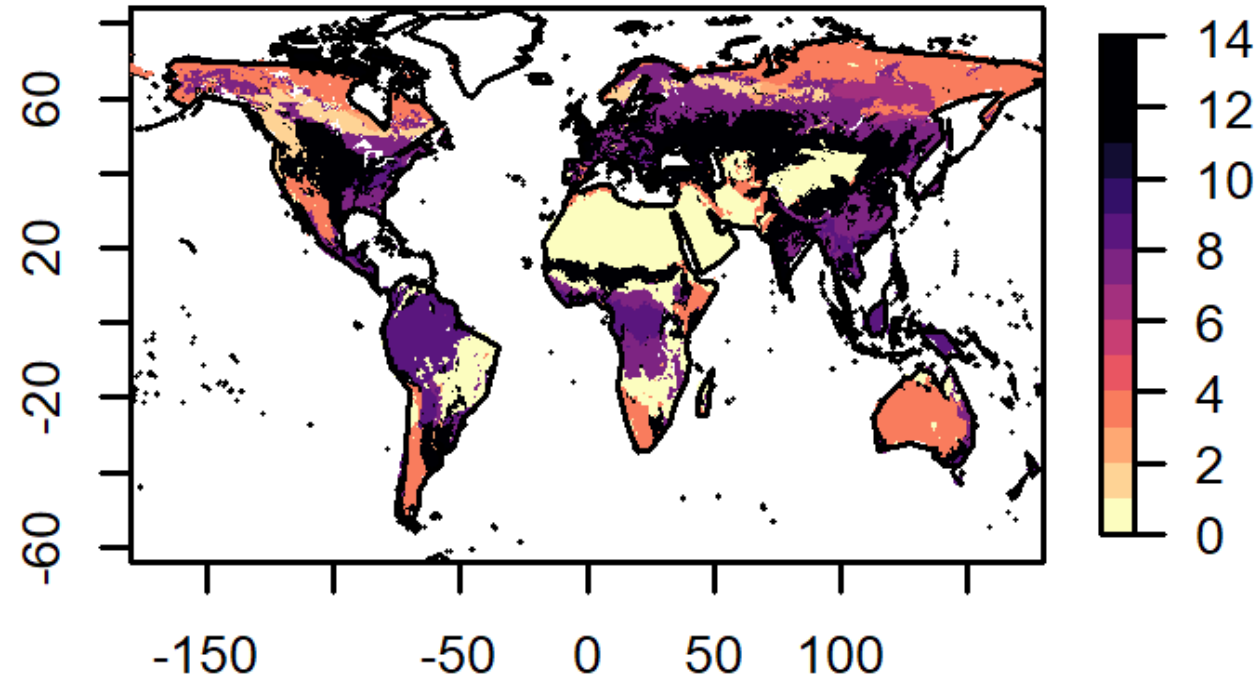
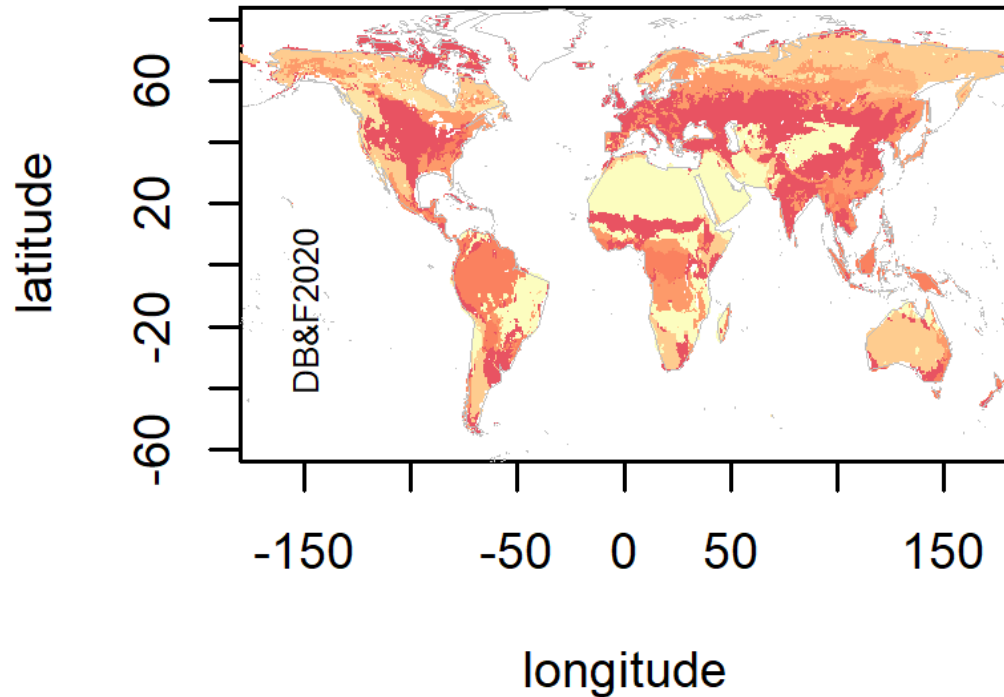


Plate 2. Mapped potential annual BNF by natural ecosystems based on the relationship between the central estimates of BNF ($N_{\text{fixation}} = 0.234(ET) - 0.172$) and ecosystem ET. Values are $\text{kg N ha}^{-1} \text{ yr}^{-1}$. White areas represent regions where modeled ET values are unavailable.

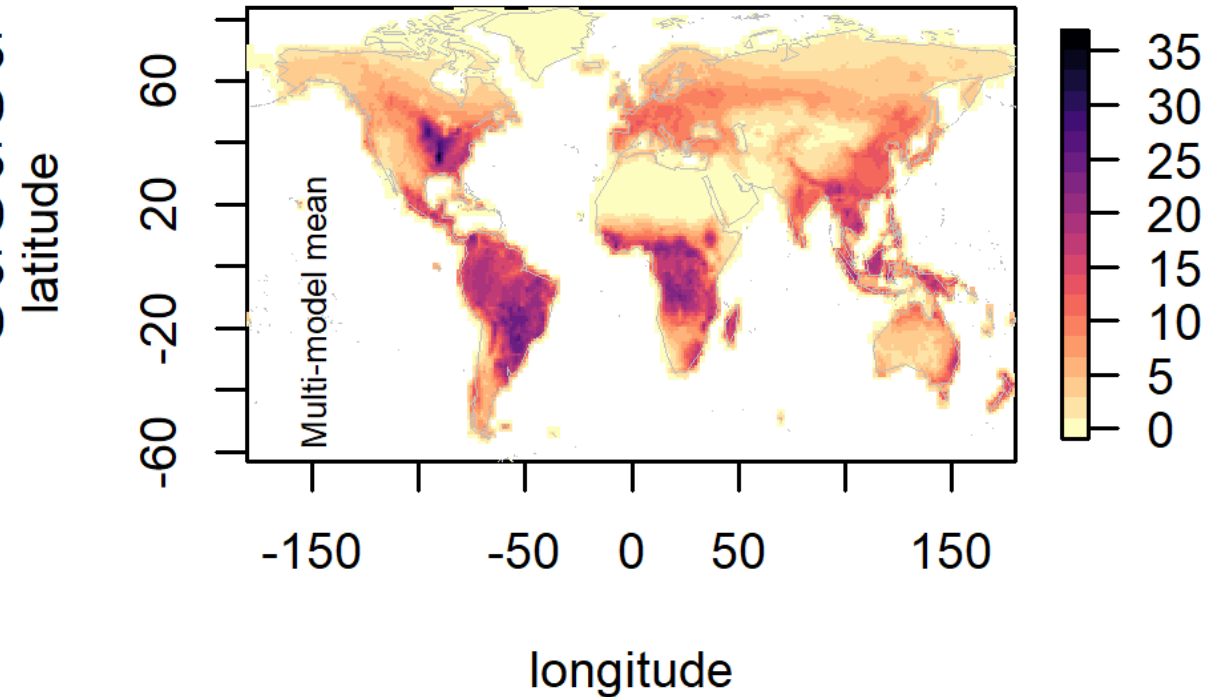
longitude

BNF from upscaled observations & models

Davies-Barnard and Friedlingstein (2020)



CMIP6 models multi-model mean for equivalent time period

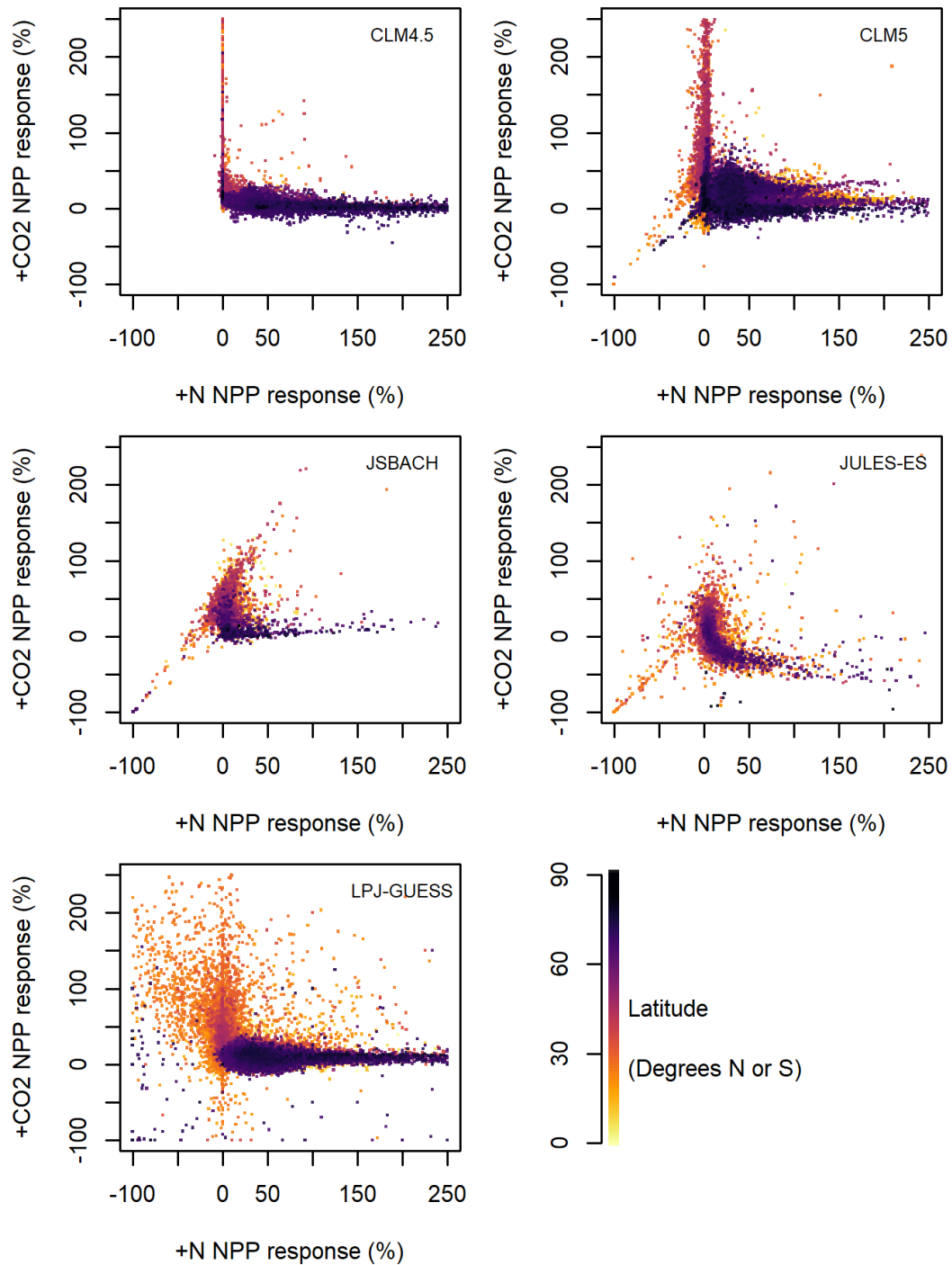


(Davies-Barnard et al. in prep)

CRESCENDO Models' BNF is better than average

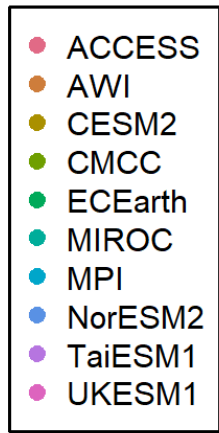
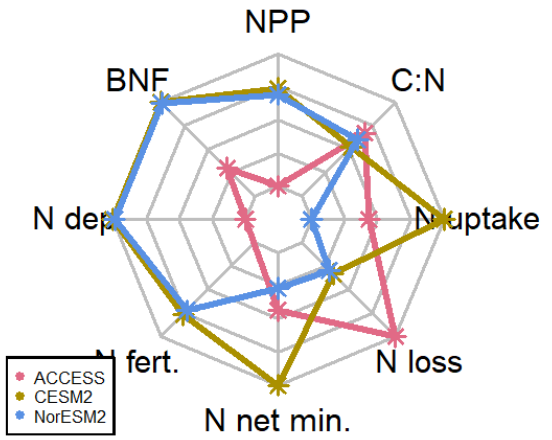
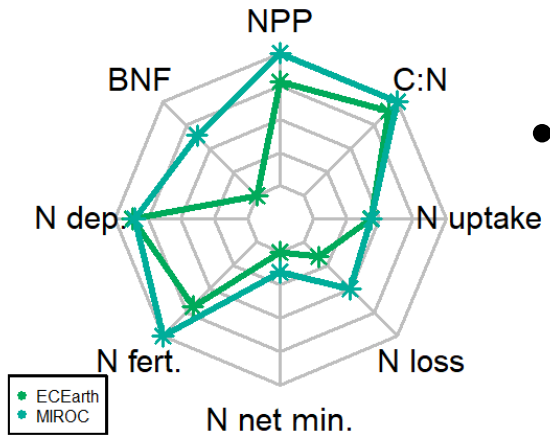
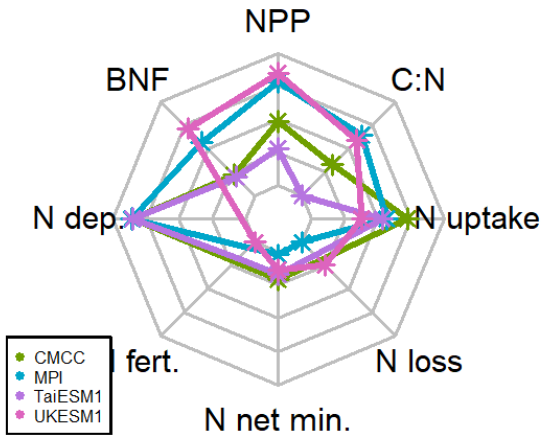
Benchmark	[-]	88.2										
Download Data	Period Mean (original grids)	Model Period Mean (intersect)	Benchmark Period Mean (intersect)	Model Period Mean (complete)	Benchmark Period Mean (complete)	Bias [kg ha ⁻¹ yr ⁻¹]	Bias Score [1]	Uncertainty Bias Score [1]	Overall Score [1]			
ACCESS-ESM1-5	[-]	208.	200.	88.0	7.15	0.238	9.10	0.370	0.508	0.439		
AWI-ESM-1-1-LR	[-]	106.	101.	83.0	5.02	5.25	1.52	0.470	0.659	0.564		
CESM2	[-]	88.1	82.1	88.0	5.78	0.278	-0.164	0.557	0.756	0.657		
CESM2-FV2	[-]	94.6	86.4	88.1	7.33	0.0731	0.358	0.550	0.744	0.647		
CESM2-WACCM-FV2	[-]	99.6	91.0	88.1	7.57	0.0731	0.741	0.543	0.738	0.641		
CMCC-CM2-SR5	[-]	94.7	88.7	87.6	5.89	0.605	0.437	0.522	0.753	0.637		
EC-Earth3-Veg	[-]	42.4	41.1	88.3	1.63	0.00	-3.68	0.503	0.671	0.587		
MIROC-ES2L	[-]	129.	115.	88.2	11.8	0.0366	2.62	0.518	0.715	0.616		
MPI-ESM-1-2-HAM	[-]	136.	128.	83.7	7.67	4.49	3.62	0.465	0.646	0.556		
MPI-ESM1-2-LR	[-]	132.	123.	83.7	8.06	4.49	3.20	0.461	0.639	0.550		
NorESM2-LM	[-]	44.4	40.5	88.2	3.48	0.00	-3.42	0.494	0.680	0.587		
NorESM2-MM	[-]	46.8	43.5	88.2	3.14	0.00	-3.35	0.490	0.678	0.584		
TaiESM1	[-]	111.	104.	88.2	6.52	0.00	1.51	0.493	0.709	0.601		
UKESM1-0-LL	[-]	109.	101.	87.9	8.03	0.320	1.56	0.453	0.640	0.546		

CO2 vs N response



- **Most gridcells N *OR* CO₂ responsive**
- **High latitudes more N responsive in most models**

Changes in NPP and N over SSP370



- **3 groups of N models**
 - **NPP increases approximately proportional to BNF**
 - **NPP increases bigger than BNF**
 - **increases sustained mainly by flexible C:N ratios**
 - **NPP increases are smaller than BNF**

(Some of) What's still to do...

- Models are getting BNF wrong (to a greater or lesser degree)
- Models are working within fundamentally different systems of NPP to Nitrogen relationships, and we don't know which (if any) are correct
- It's unclear whether the CO₂/N response dichotomy is true in the real world, or why it's happening in models

Thanks for listening!

Some of the above will be in a forthcoming paper.

The BNF data can be found in: Davies-Barnard, T., & Friedlingstein, P. (2020). *The Global Distribution of Biological Nitrogen Fixation in Terrestrial Natural Ecosystems*. *Global Biogeochemical Cycles*, 34(3), e2019GB006387.
<https://doi.org/10.1029/2019GB006387>

BNF will be in iLamb (when we finish finessing the details)

My current job is under threat of being axed because of the UK government's 50% reduction in Official Development Assistance. There's a petition, link is on twitter. If you know of any job opportunities, do get in touch. My email is t.davies-barnard@exeter.ac.uk

References

Davies-Barnard, T., Meyerholt, J., Zaehle, S., Friedlingstein, P., Brovkin, V., Fan, Y., et al. (2020). Nitrogen Cycling in CMIP6 Land Surface Models: Progress and Limitations. *Biogeosciences Discussions*, 1–32. <https://doi.org/10.5194/bg-2019-513>

Davies-Barnard, T., & Friedlingstein, P. (2020). The Global Distribution of Biological Nitrogen Fixation in Terrestrial Natural Ecosystems. *Global Biogeochemical Cycles*, 34(3), e2019GB006387. <https://doi.org/10.1029/2019GB006387>

Meyerholt, J., Zaehle, S., & Smith, M. J. (2016). Variability of projected terrestrial biosphere responses to elevated levels of atmospheric CO₂ due to uncertainty in biological nitrogen fixation. *Biogeosciences*, 13(5), 1491–1518. <https://doi.org/10.5194/bg-13-1491-2016>

Zaehle, S. (2013). Terrestrial nitrogen–carbon cycle interactions at the global scale. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 368(1621), 20130125. <https://doi.org/10.1098/rstb.2013.0125>