Effects of ‘natural’ to ‘geoengineered’ nitrogen deposition on the carbon cycle

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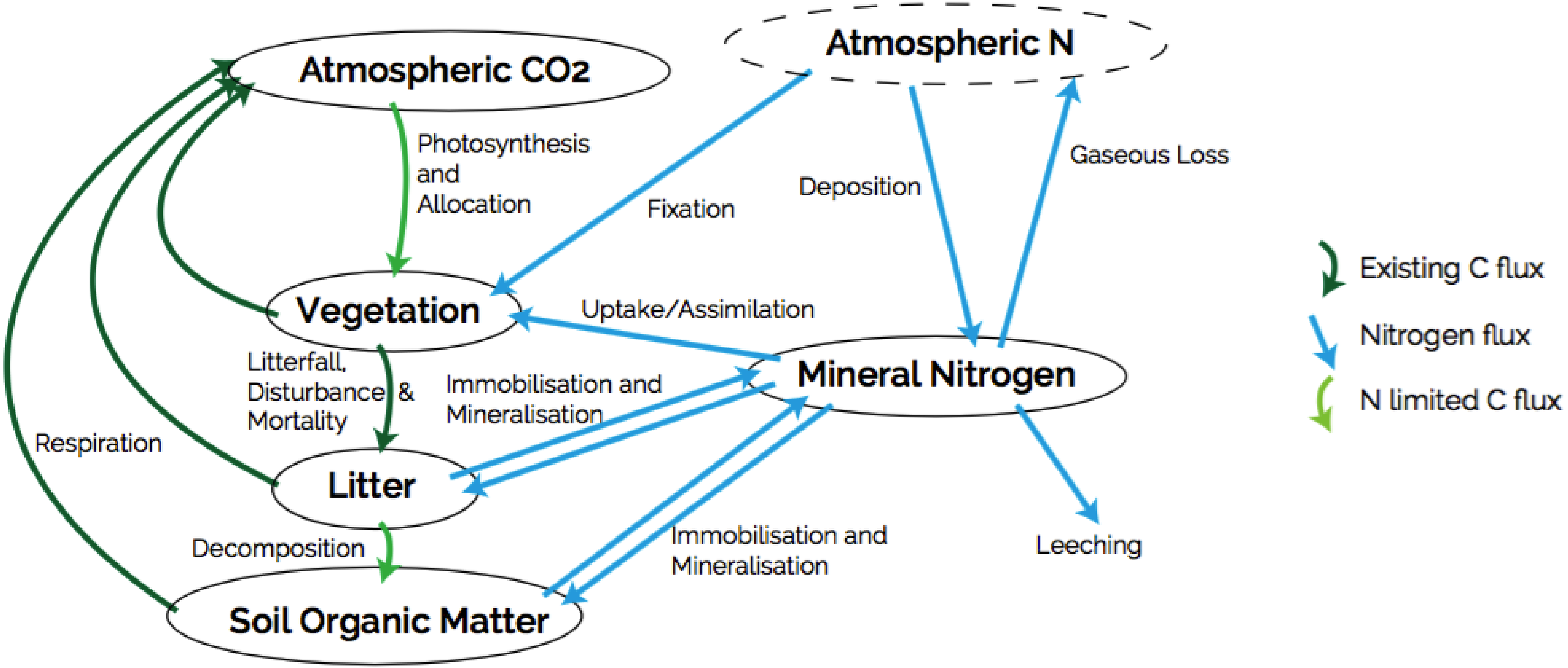
Rationale

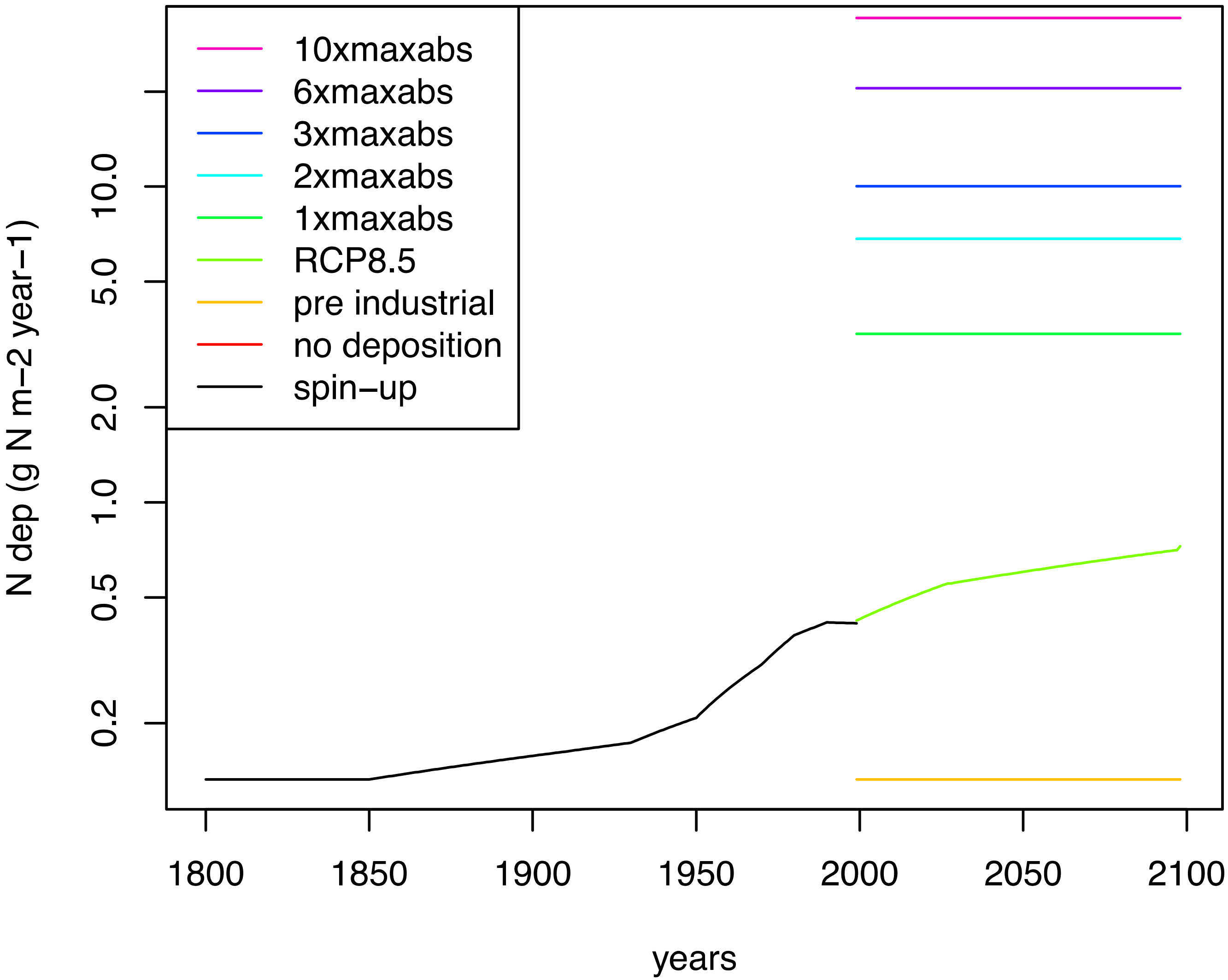
- Carbon sequestration by terrestrial biosphere under climate change
- Effect of Nitrogen limitation/fertilisation
- Limits?
- Potential to help mitigation efforts via ‘geoengineering’ (deliberate changes to perturb the climate)?

JULES-CN

- JULES-CN is a version of JULES with a Nitrogen as well as a Carbon cycle.



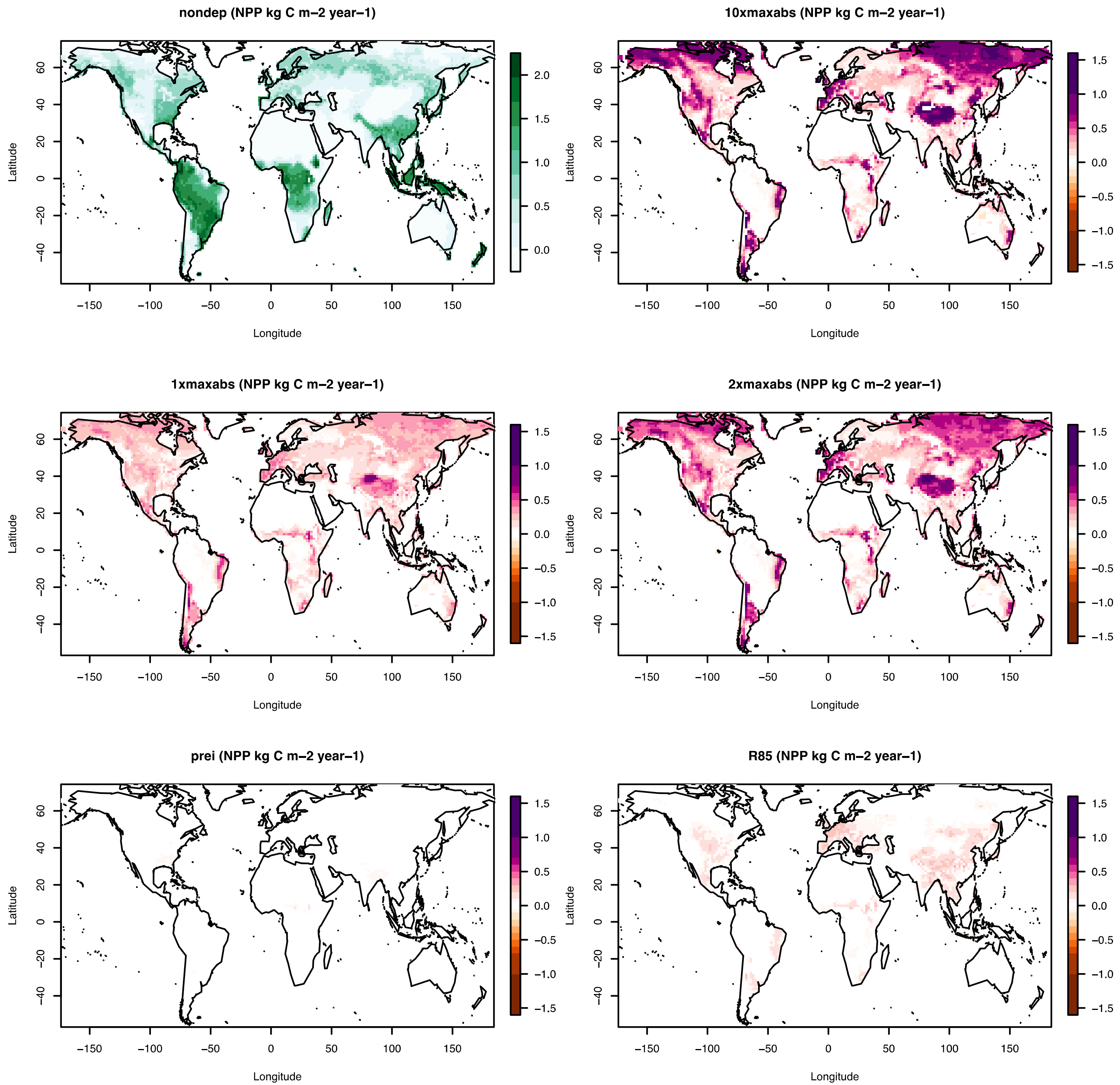
Simulations



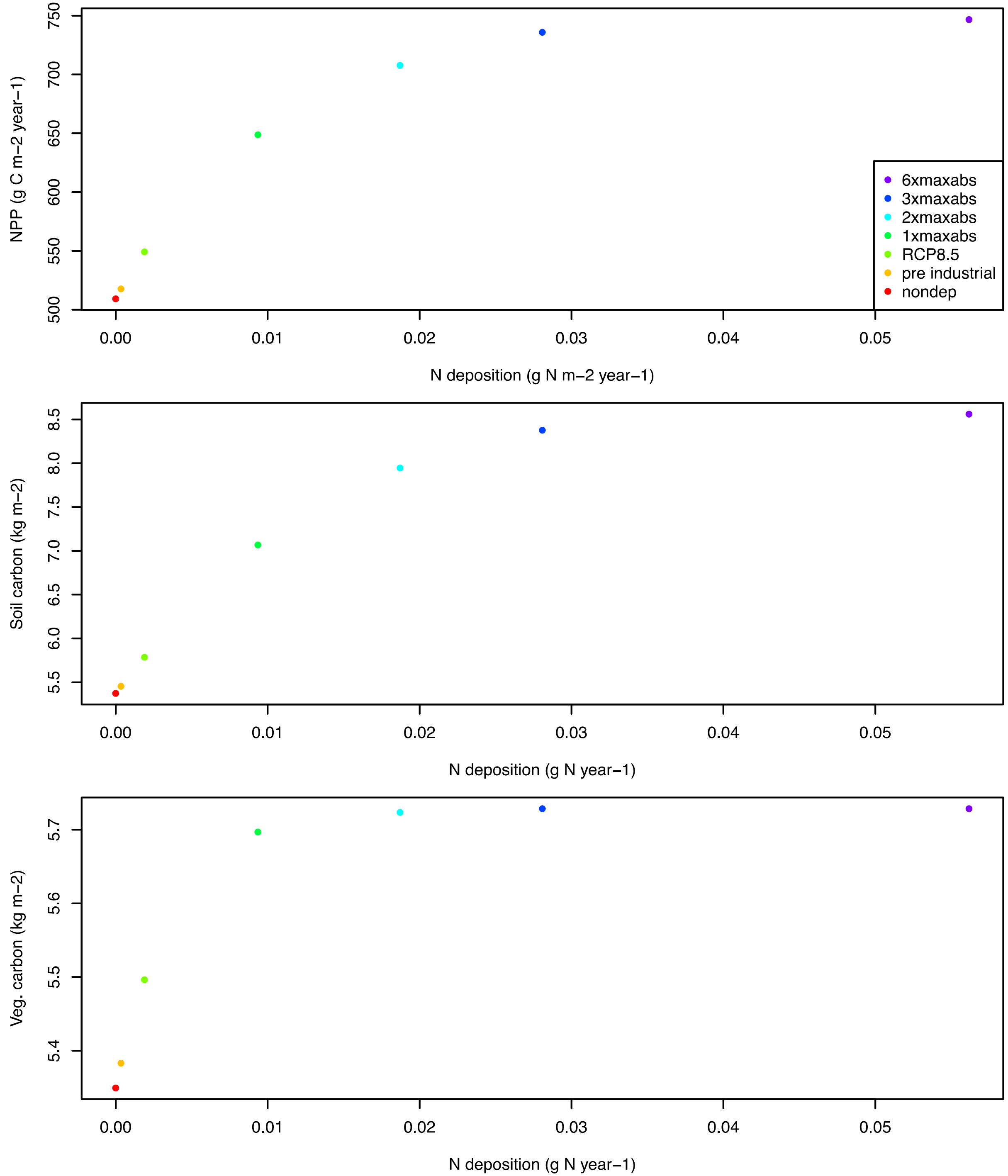
Main sims:
Climate: RCP8.5
CO2: RCP8.5
LUC: fixed 2005
TRIFFID: on
Competition: off
Nitrogen: on
1xmaxabs = max of 2000 N dep across globe

Spin-up: CRU, 600 years at PI, transient to 2005

NPP

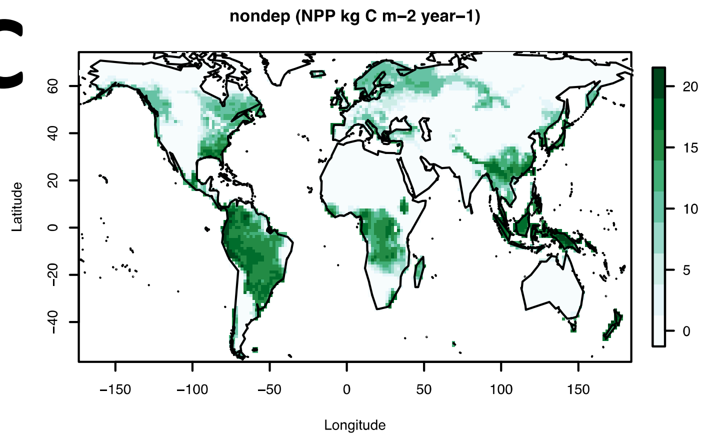

nondep (NPP kg C m−2 year−1)
10xmaxabs (NPP kg C m−2 year−1)
1xmaxabs (NPP kg C m−2 year−1)
2xmaxabs (NPP kg C m−2 year−1)
prei (NPP kg C m−2 year−1)
R85 (NPP kg C m−2 year−1)
Latitude
-40 -20 0 20 40 60
Longitude
−150 −100 −50 0 50 100 150
0.0 0.5 1.0 1.5 2.0
−1.5 −1.0 −0.5 0.0 0.5 1.0 1.5

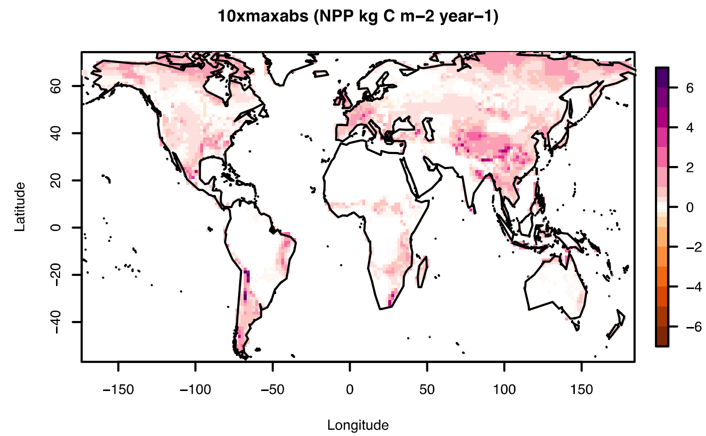
Global



NPP (g C m−2 year−1)
750
700
650
600
550
500
0.00
0.01
0.02
0.03
0.04
0.05
N deposition (g N m−2 year−1)
6xmaxabs
3xmaxabs
2xmaxabs
1xmaxabs
RCP8.5
pre industrial
nondep
Soil carbon (kg m−2)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
N deposition (g N year−1)
Veg. carbon (kg m−2)
5.7
5.6
5.5
5.4
N deposition (g N year−1)

Veg C


nondep (NPP kg C m−2 year−1)
Latitude
Longitude
-150 -100 -50 0 50 100 150
-40 -20 0 20 40 60
0 5 10 15 20


10xmaxabs (NPP kg C m−2 year−1)
Latitude
Longitude
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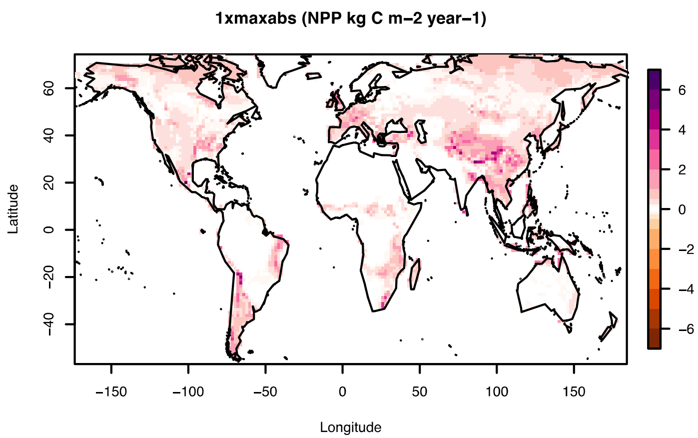
-40 -20 0 20 40 60
−6 −4 −2 0 2 4 6


1xmaxabs (NPP kg C m−2 year−1)
Latitude
Longitude
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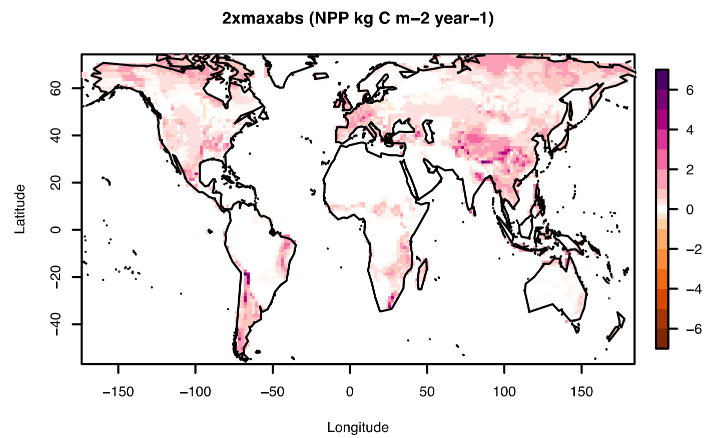
-40 -20 0 20 40 60
−6 −4 −2 0 2 4 6


2xmaxabs (NPP kg C m−2 year−1)
Latitude
Longitude
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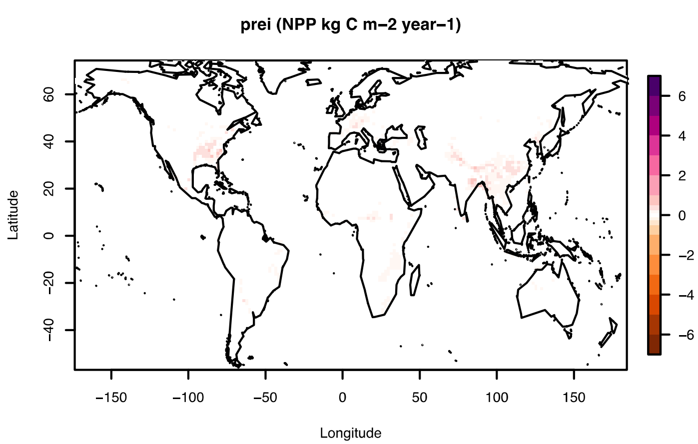
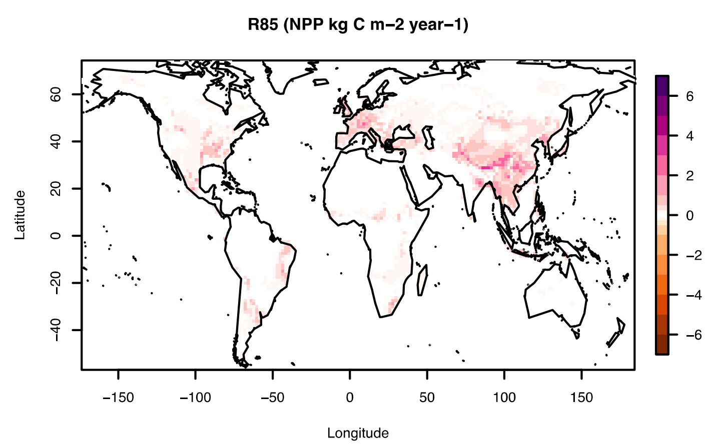
-40 -20 0 20 40 60
−6 −4 −2 0 2 4 6


prei (NPP kg C m−2 year−1)
Latitude
Longitude
-150 -100 -50 0 50 100 150
-40 -20 0 20 40 60
−6 −4 −2 0 2 4 6


R85 (NPP kg C m−2 year−1)
Latitude
Longitude
-150 -100 -50 0 50 100 150
-40 -20 0 20 40 60
−6 −4 −2 0 2 4 6

Veg Carbon effects



- Up to 1.15 K cooling from N deposition
  - (using HadGEM2ES TRCE) from difference between no N dep and 10x (saturated)
  - 546 Pg extra carbon storage at 2100 (soil and veg combined).
- But, this would require at global fertilisation of up to 35g N m^{-2} $year^{-1}$.
  - Less in the tropics, most in the high latitudes.
- The effect is much smaller for single regions, e.g.
  - Europe 9.7×10^{-08} K
  - N. America 1.2×10^{-07} K

Drawbacks and Considerations



- Nitrogen fertilisation generally reduces biodiversity
- Quantities needed to fertilise are ~ x10 what you'd usually put on say a lawn (~3g N vs ~30g N m^{-2})
- Most of the areas that would benefit most from N fertilisation are currently low productivity, high latitude, and inaccessible.

Potential development to nitrogen scheme



- Accounting for mycorrhizal fungi
  - Mycorrhizal fungi are symbiotic fungi living on plant roots
  - AM fungi (mostly sub-tropical) don't increase production of N as CO2 increases
  - ECM fungi increase production with CO2 increases
- Limitation via root uptake
  - currently only considers supply and demand
  - potential for including root biomass giving increased realism and control of nitrogen limit

Contribute to the JULES Community

- Help improve the JULES-CN profile and user experience
  - create configurations of JULES-CN for open use
  - maintain accurate and up-to-date user guides
  - publish model description and analysis papers on JULES-CN and subsequent development in a timely fashion



Thank you for your attention

I’d be glad to answer any questions