Rock-N: a potential feedback to the Earth System

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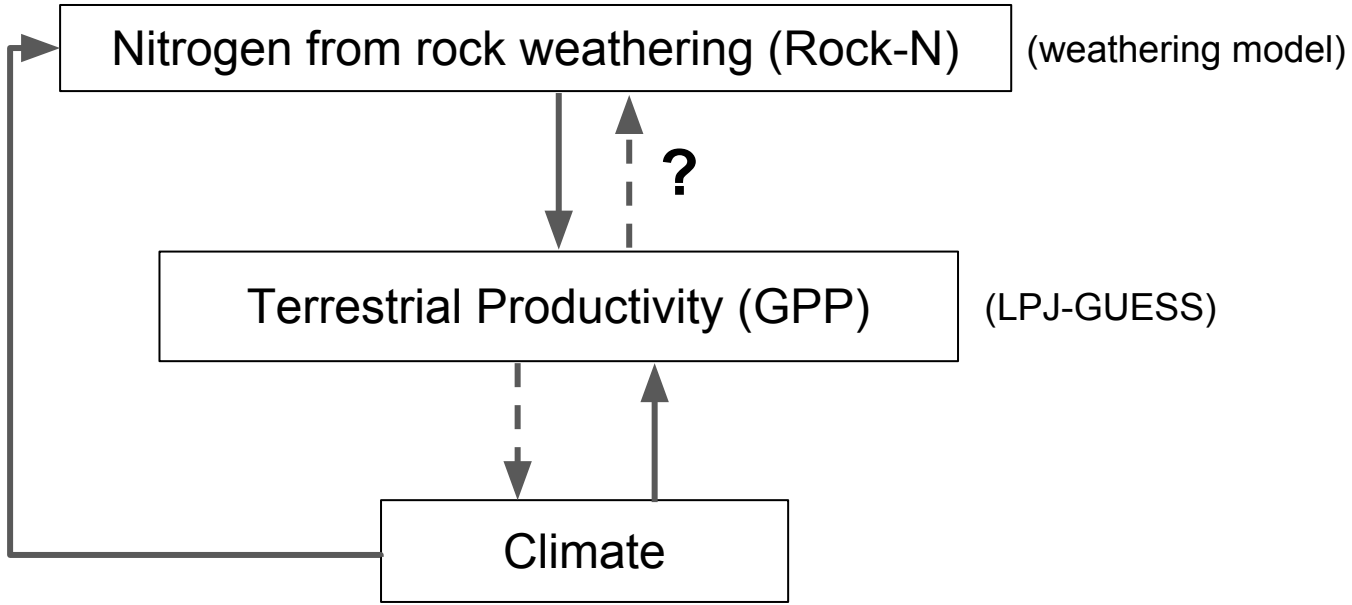
Environmental Quality • Landscape Processes

NSF

Hypothesis



Feedback considered in this study

Feedback not considered in this study

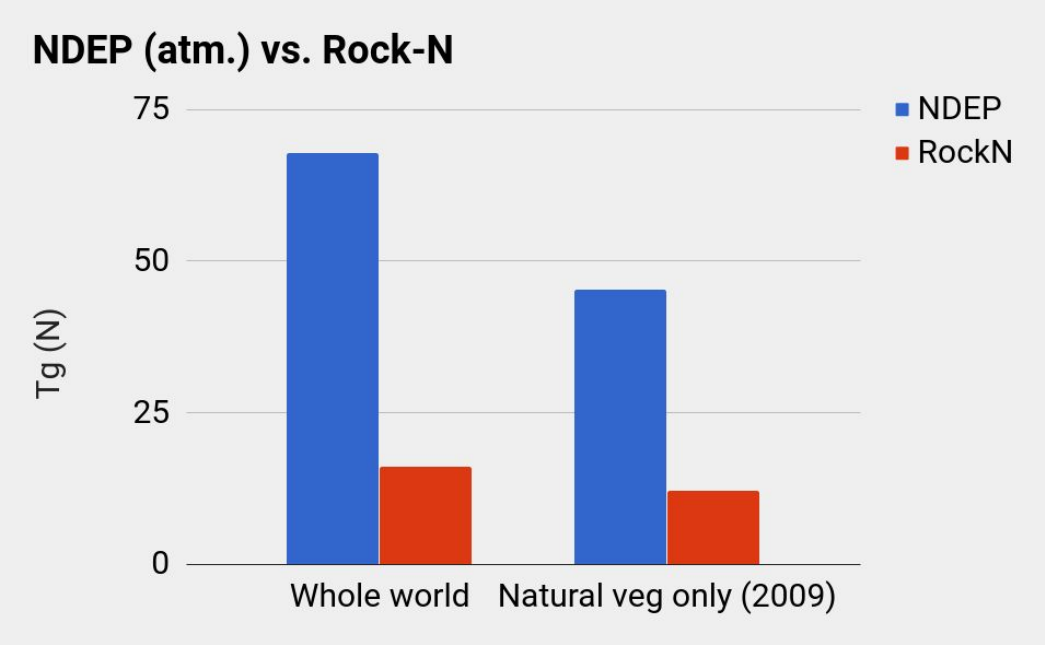
Rock-N weathering - determined by denudation

Which is a function of (see *Houlton et al., in review, Science*):

- Geochemistry - lithological map
- Relief - digital elevation map
- Tectonic uplift - ^{10}Be (cosmogenic radiation)
- Climate - Excess water and Evapotranspiration maps
- Biology - not implemented yet

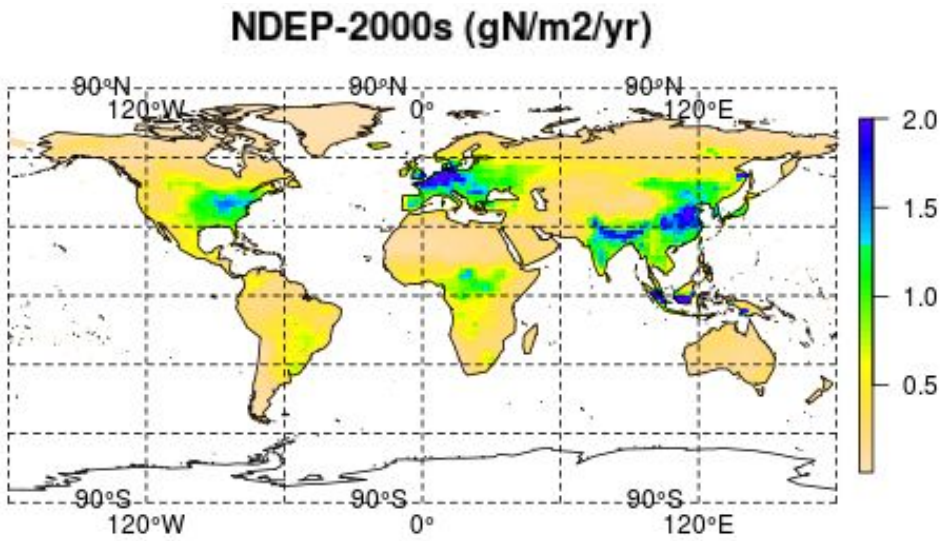
Rock-N & NDEP (atmos. N deposition) global totals

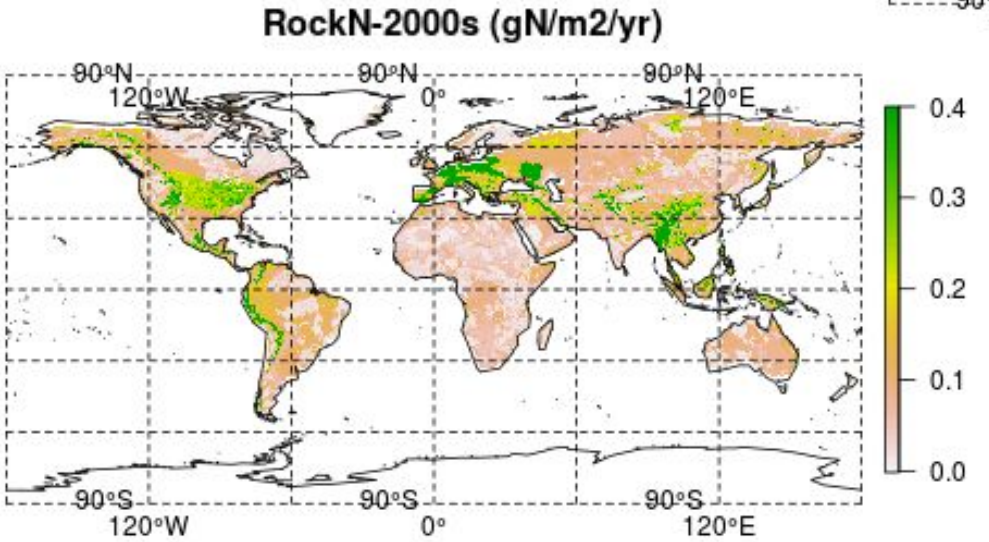
	NDEP	Rock-N
Whole world	67.9 TgN	16.2 TgN
Natural veg (2009)	45.3 TgN	12.2 TgN



For Natural vegetation only, classes masked out: Water, Permanent wetlands, Croplands, Urban and built up, Cropland and natural vegetation mosaic

NDEP & Rock-N distribution (current values)





Climate change

RCP 8.5 → 8.5 W/m2 (by 2100) → 3.7 °C warming (2100) → **business as usual**

RCP 2.6 → 2.6 W/m2 (by 2100) → 1.0 °C warming (2100) → **aggressive mitigation**

Rock-N & NDEP - changes with climate

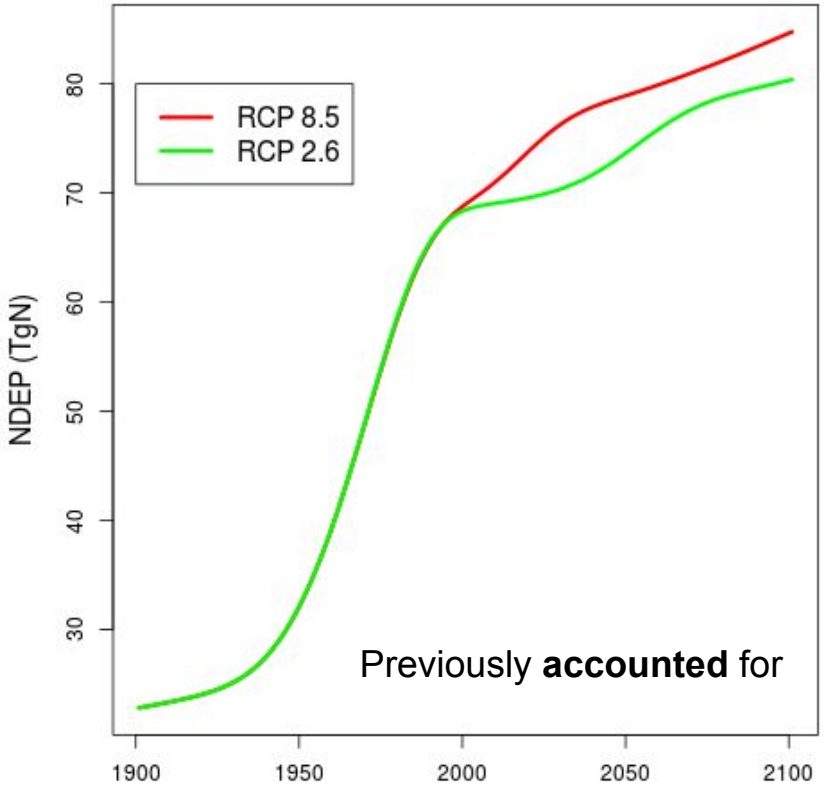
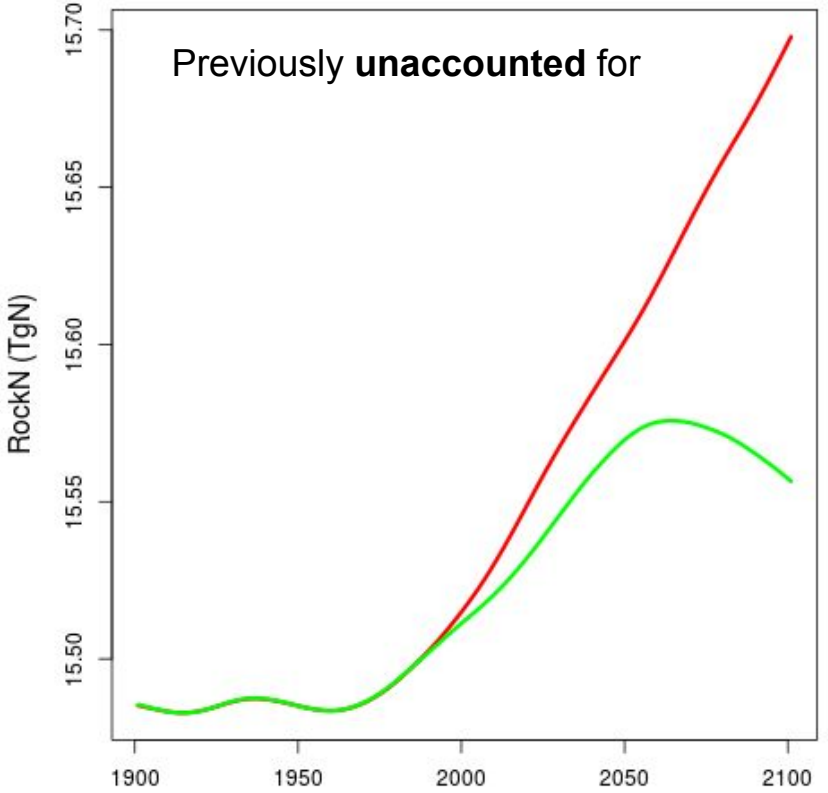


Fig: Atmospheric N deposition with climate



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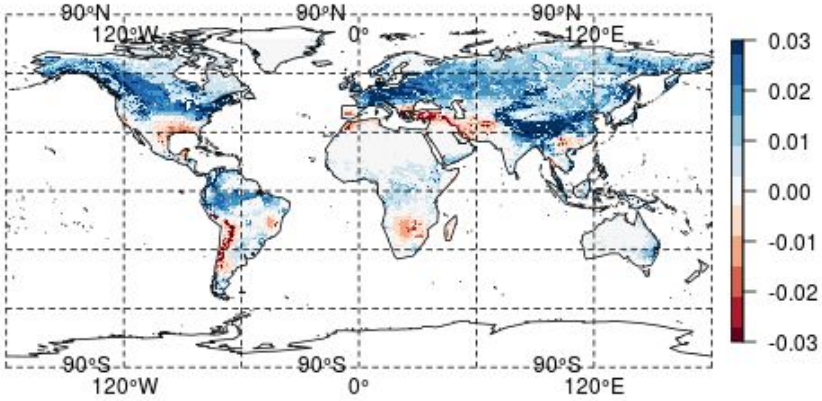
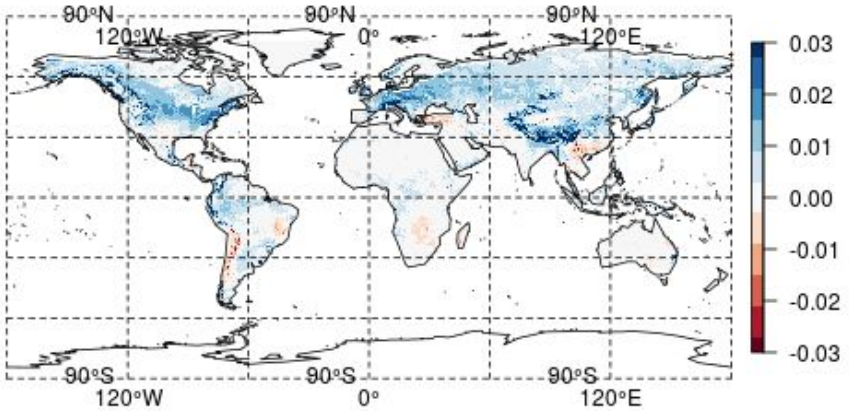
Climate change and Rock-N (spatial change)

Rock-N change: RCP 8.5



Rock-N change: RCP 2.6



Figs: Change of Rock-N from 1901 to 2101 demonstrated by trend values (in kgN/m^2/yr).
BLUE: increase in Rock-N; **RED:** decrease in Rock-N

Gross Primary Productivity (GPP)

- *using LPJ-GUESS*

GPP - changes with climate

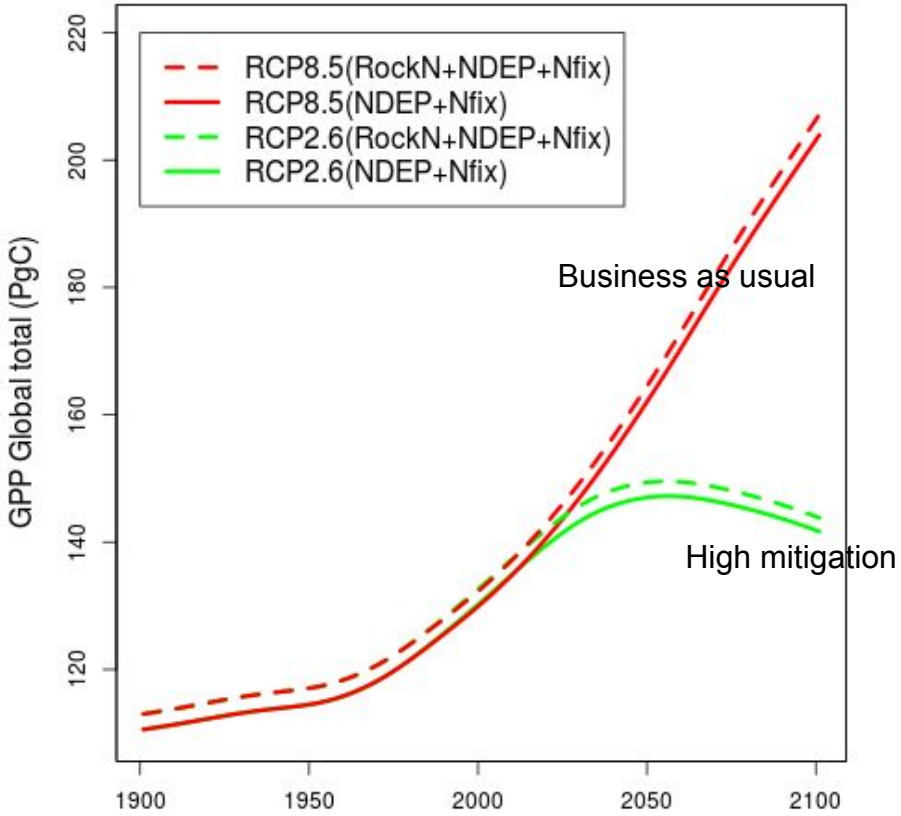


Fig: GPP (global total) changes with climate

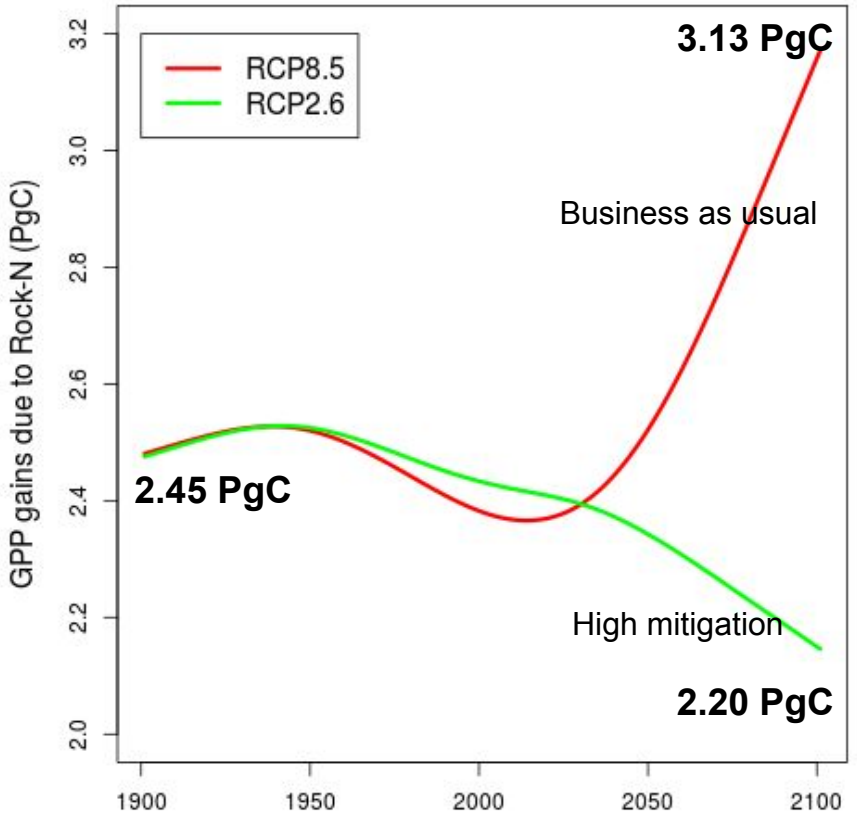
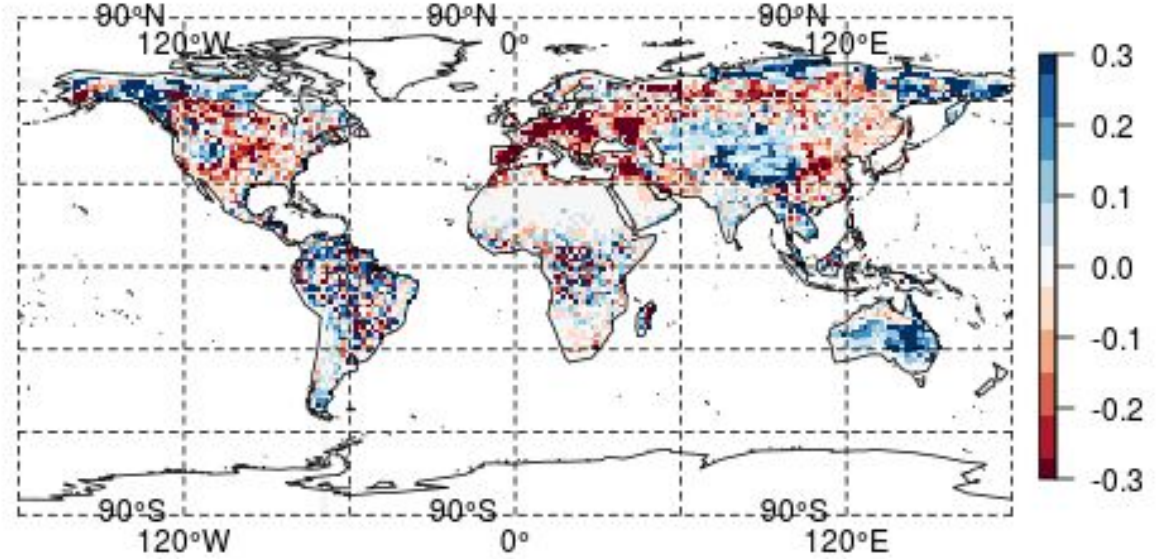


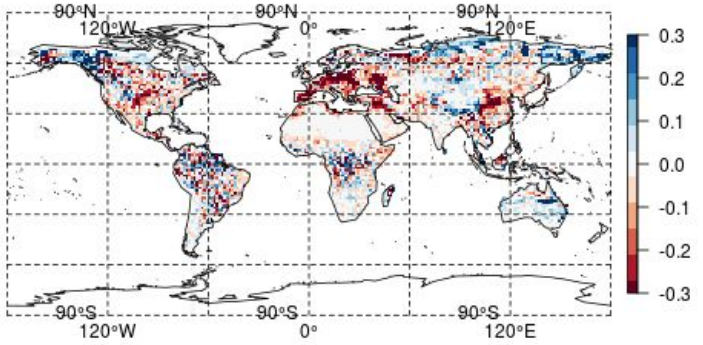
Fig: Δ GPP (global total) only due to Rock-N

GPP gains only due to Rock-N (ΔGPP)



ΔGPP: RCP 8.5

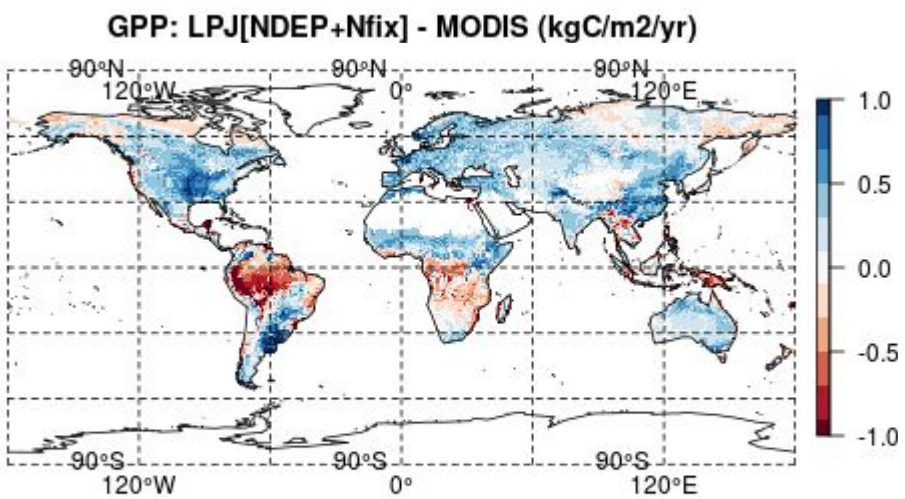
ΔGPP: RCP 2.6

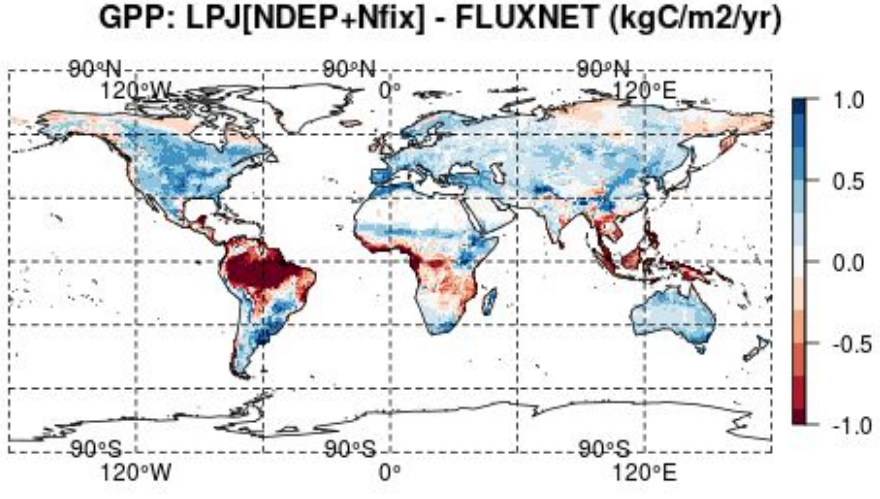


Figs: Trend 1901-2101 (gC/m2/yr)

GPP: difference with observation

“All models are wrong” - George Box





RED: Pixels (areas) where LPJ-GUESS is underperforming with respect to observation

HYPOTHESIS: On addition of Rock-N total **RED** area (model underperformance) will reduce.

GPP: Rock-N decreasing model-observation disagreement

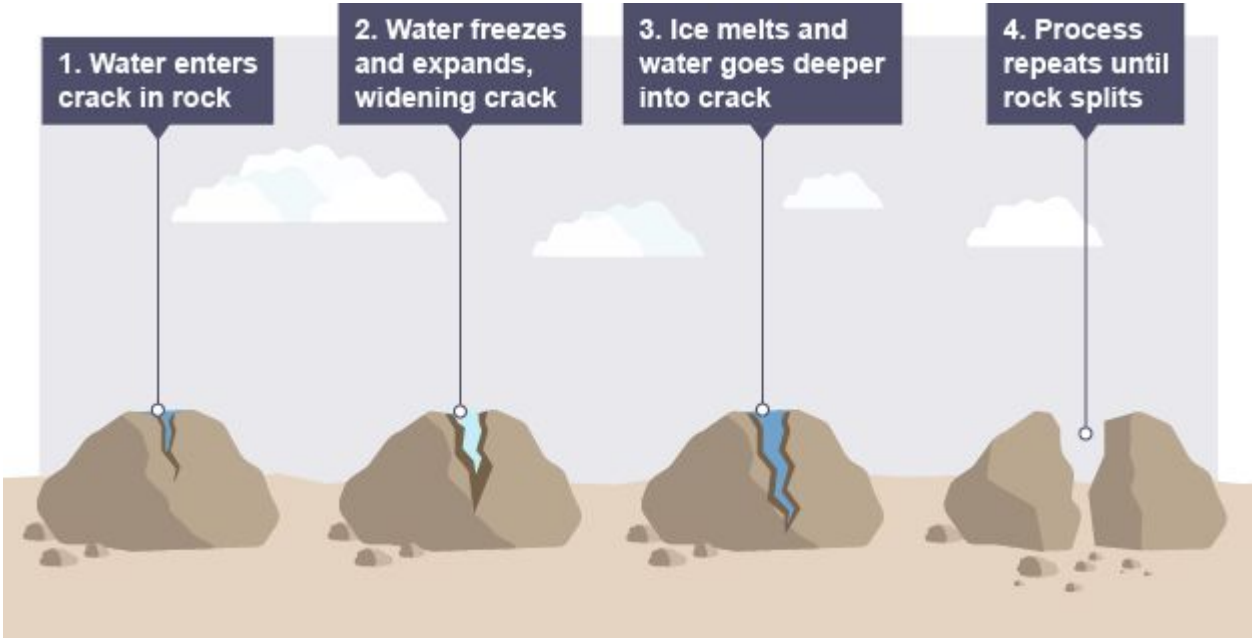
Simulations	FLUXNET	MODIS
LPJ [NDEP + Nfix]	35.15	30.27
LPJ [RockN + NDEP + Nfix]	33.47	28.78
Decrease	**1.68**	**1.49**

Table: % of area (vegetated ice free land) where simulated GPP is less than observed GPP

Scope for improvement

1. Compute an upper bound for ΔGPP

2. Permafrost: freeze-thaw weathering



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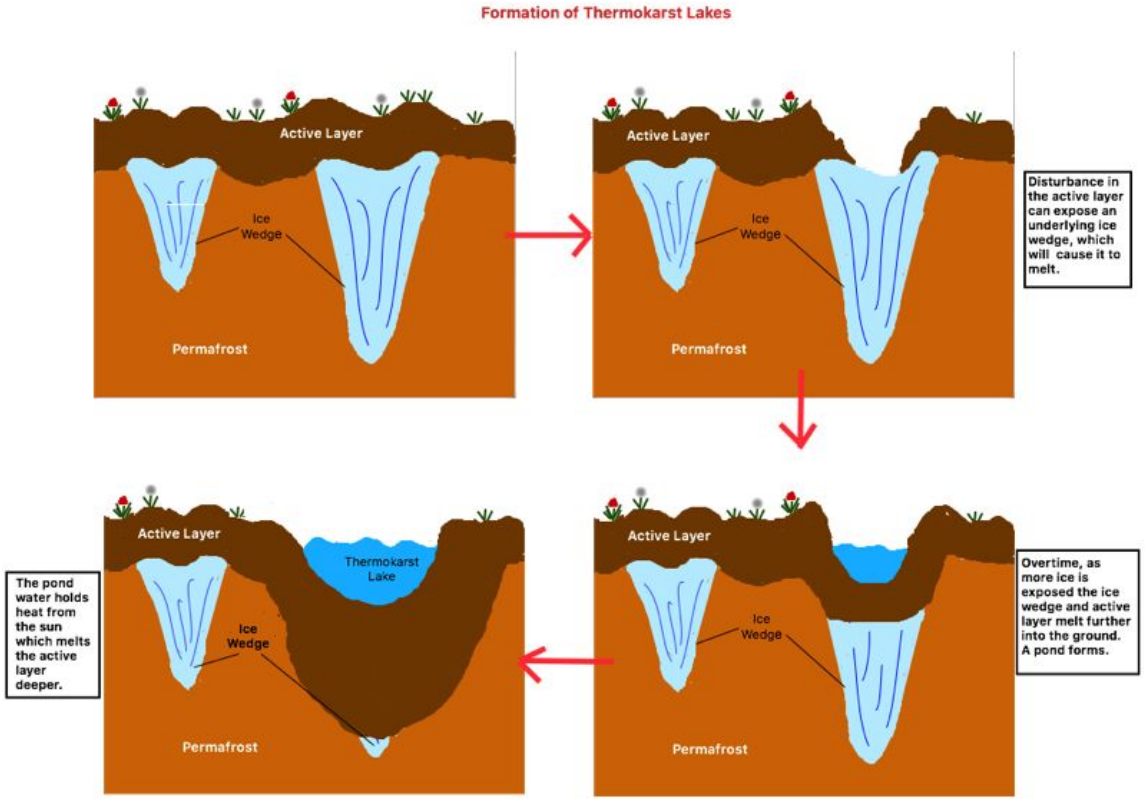
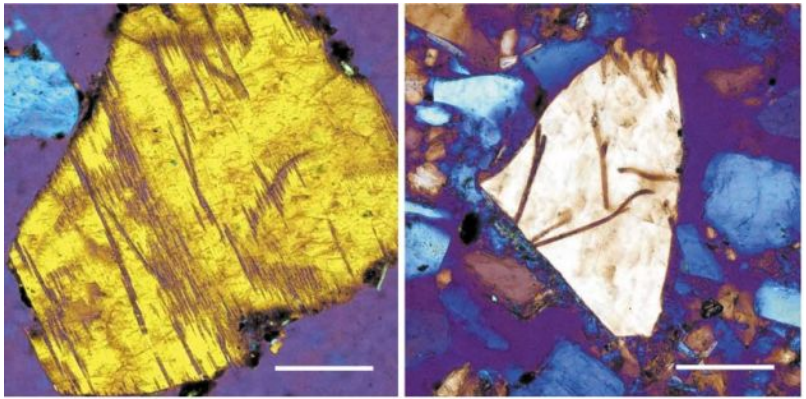
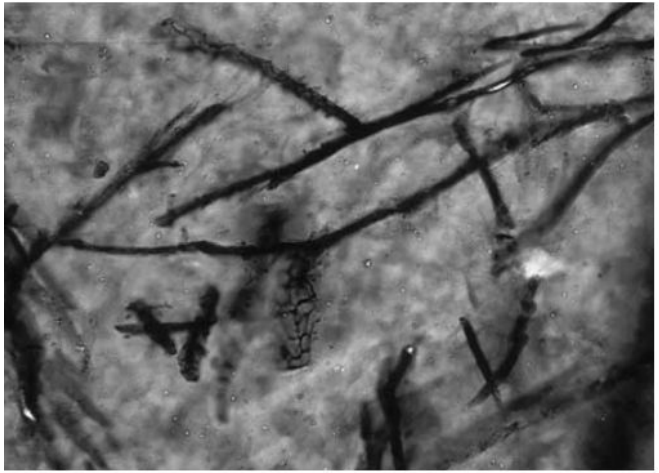


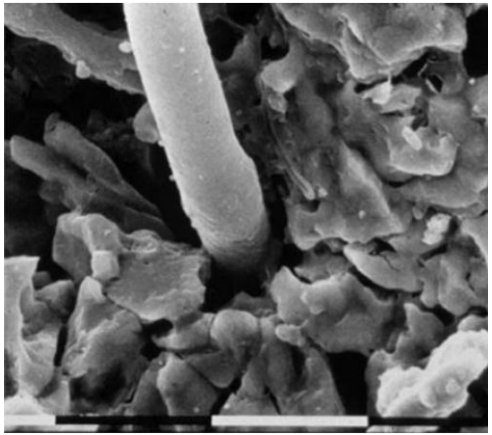
3. Mycorrhizae: active Rock-N uptake



Thin-section micrograph
of feldspar grain
Landwert et al., 2001



Thin-section micrograph
of feldspar grain
Sholl et al., 2008



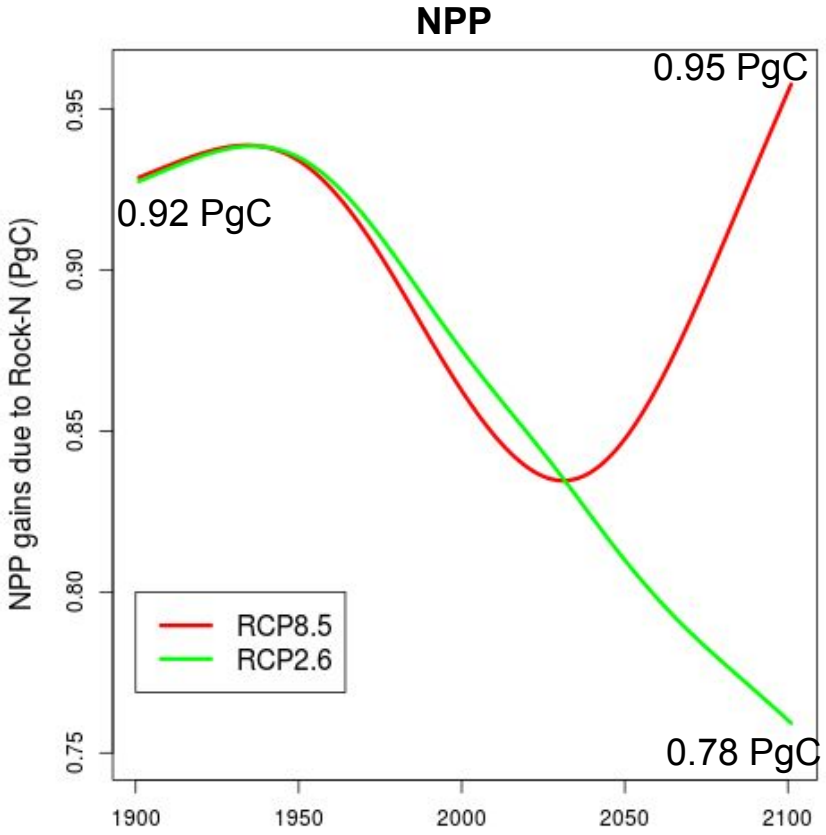
Scanning electron
micrograph
Sholl et al., 2008

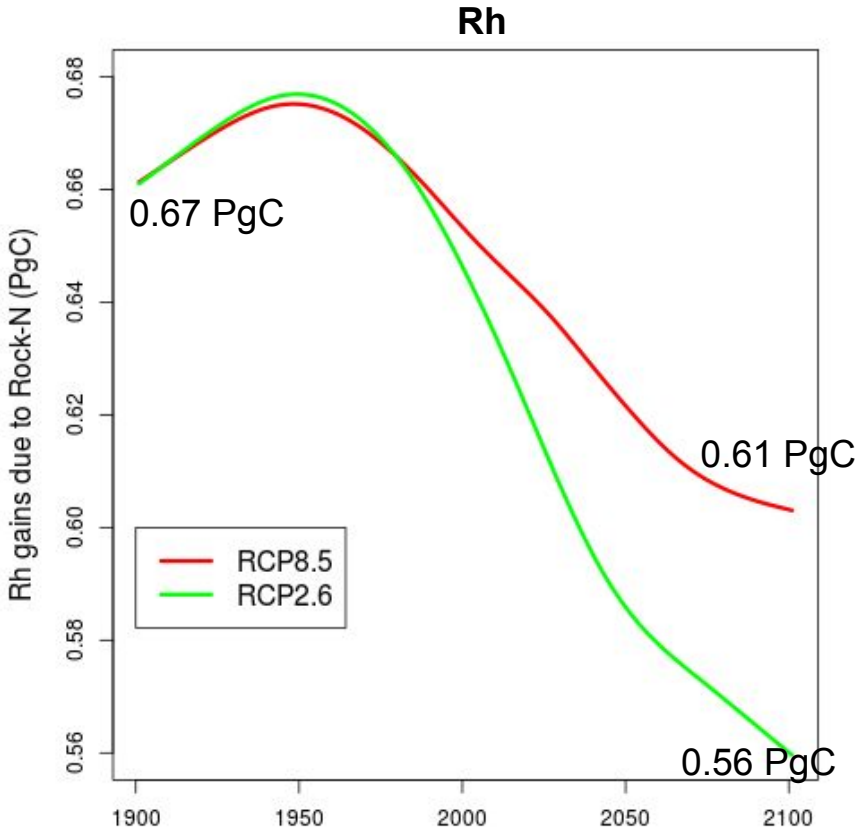
Summary

- Nitrogen from rock weathering (Rock-N) accounts for a significant increase in terrestrial productivity.
- The increase in productivity shown here is probably a conservative estimate.
- The high latitudes are probably not as Nitrogen limited as previously thought.
- Increase in productivity due to Rock-N has the potential to act as a negative feedback.

Other Carbon cycle values

Impact of Rock-N: other C-cycle values





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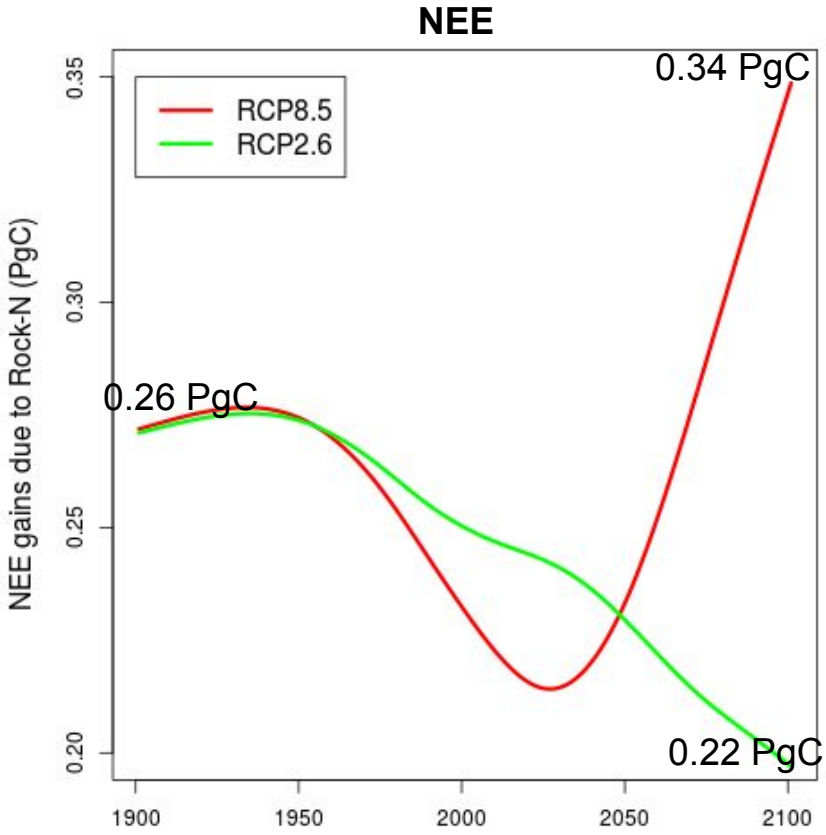

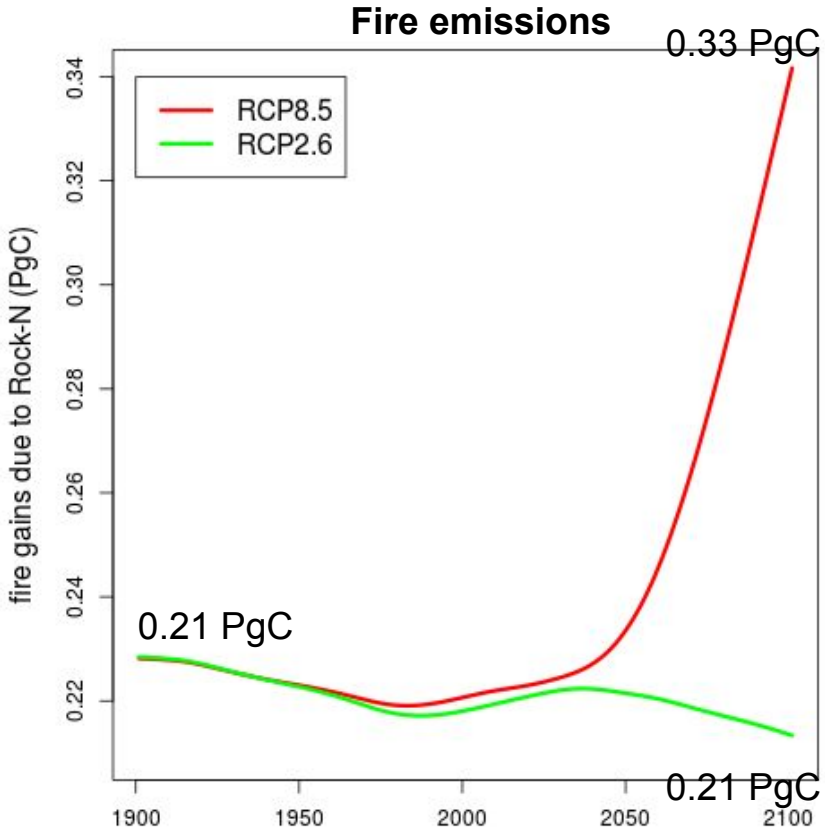

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