Update on JULES-ECOSSE-FUN

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July 2014

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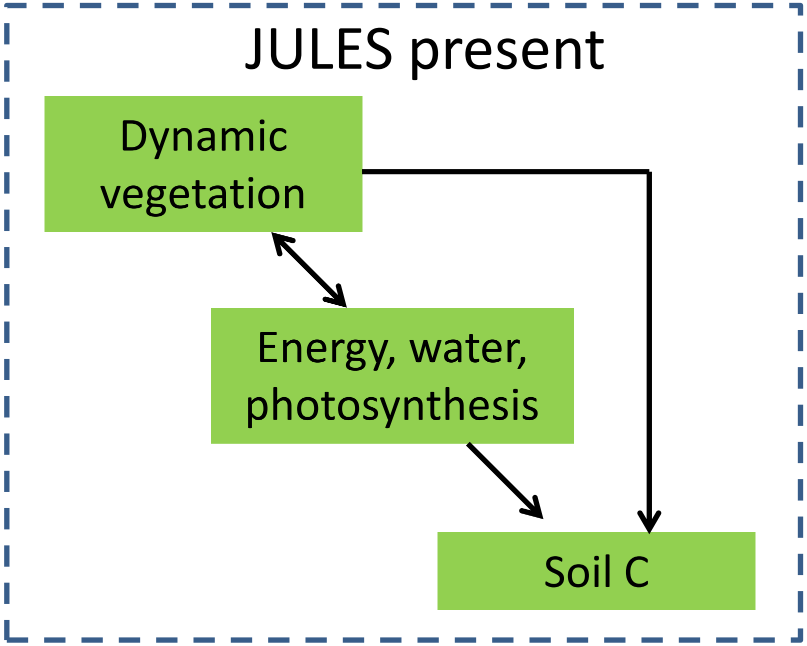
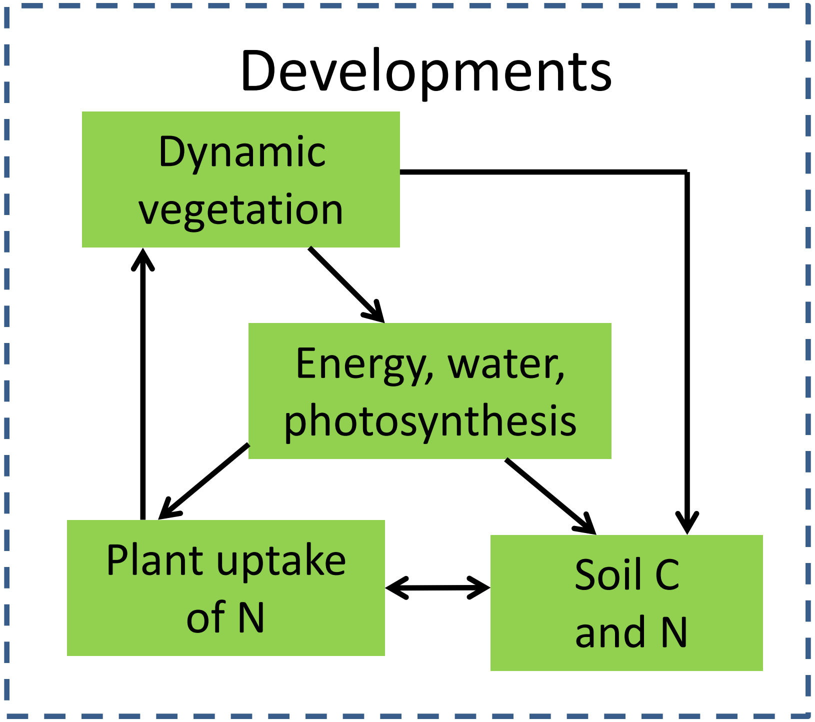
Adding terrestrial N-cycle processes



- No representation of soil N and effects on plants
- No layering of soil C



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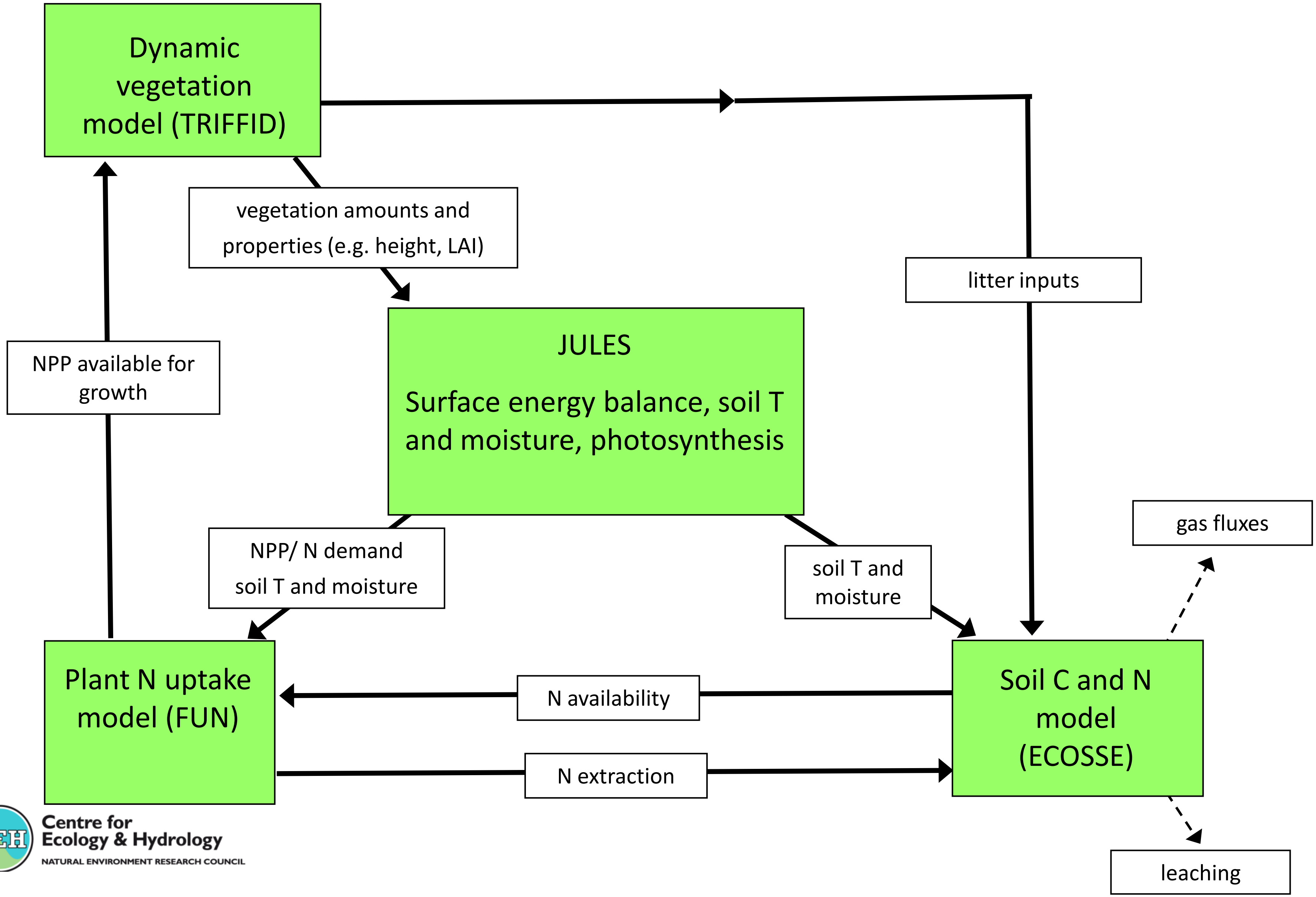
Main connections in JULES-N



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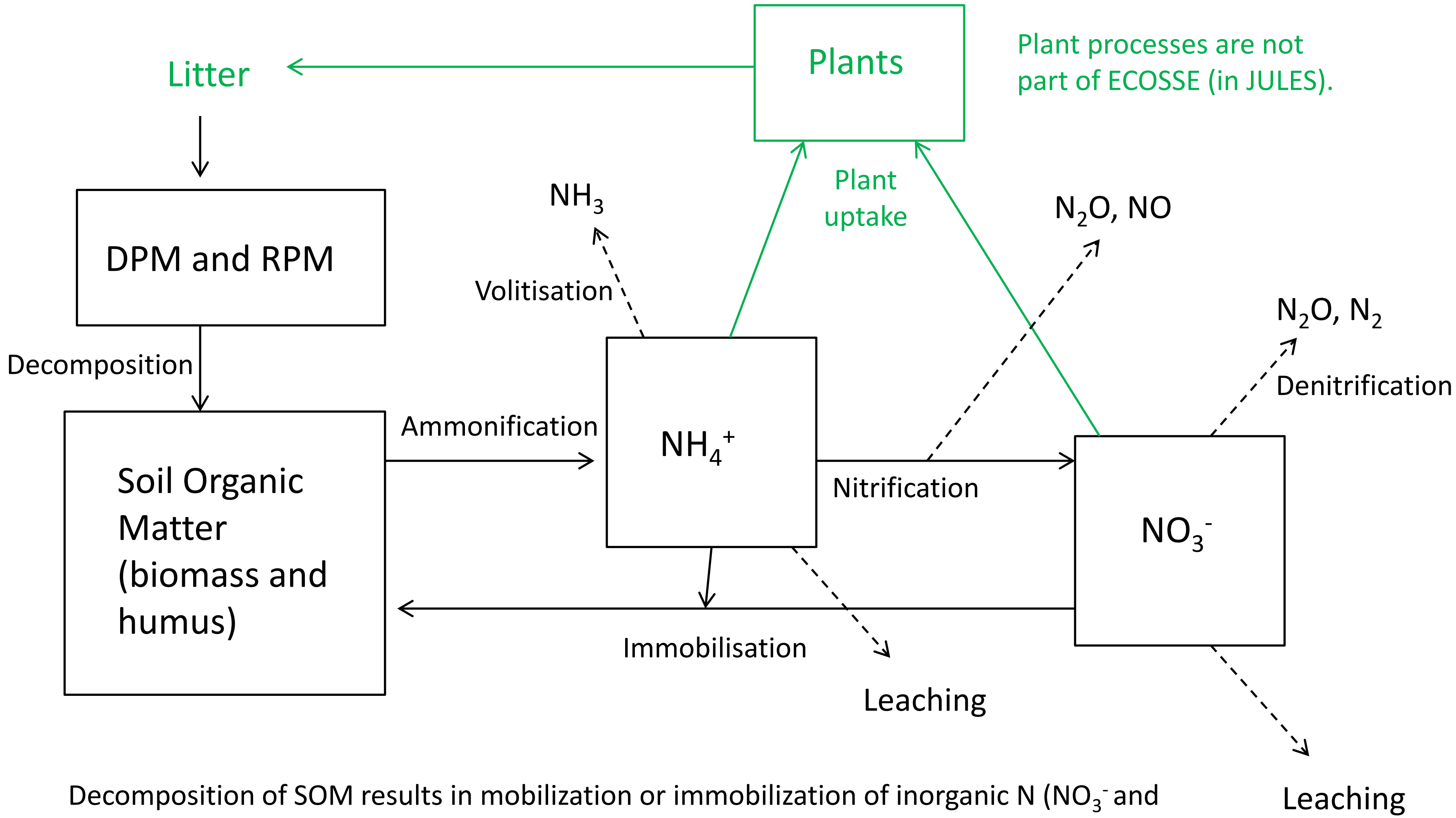
Schematic of N in ECOSSE



Decomposition of SOM results in mobilization or immobilization of inorganic N (NO_3^- and NH_4^+) to maintain C:N.

If insufficient N, decomposition is slowed and produces relatively more CO_2.

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Overview of FUN

Fixation and Uptake of Nitrogen (FUN), Fisher et al, 2011, GBC.

- N_demand = C_demand x plant N:C

- If passive uptake (via transpiration) is insufficient, plants spend C (NPP) acquiring N via 3 mechanisms:
  - active uptake
  - fixation
  - retranslocation.

- Each process has a cost (kg C $[\text{kg N}]^{-1}$) and plants optimise C expenditure.

- Uptake is in inverse proportion to cost (kgC/kgN).

- When N is limiting, NPP available for growth is reduced.

Runs

Four types of runs will be described (briefly):

- US forest sites (mainly Duke Forest)
- 10 global benchmarking sites
- Duke and ORNL FACE runs
- Global runs

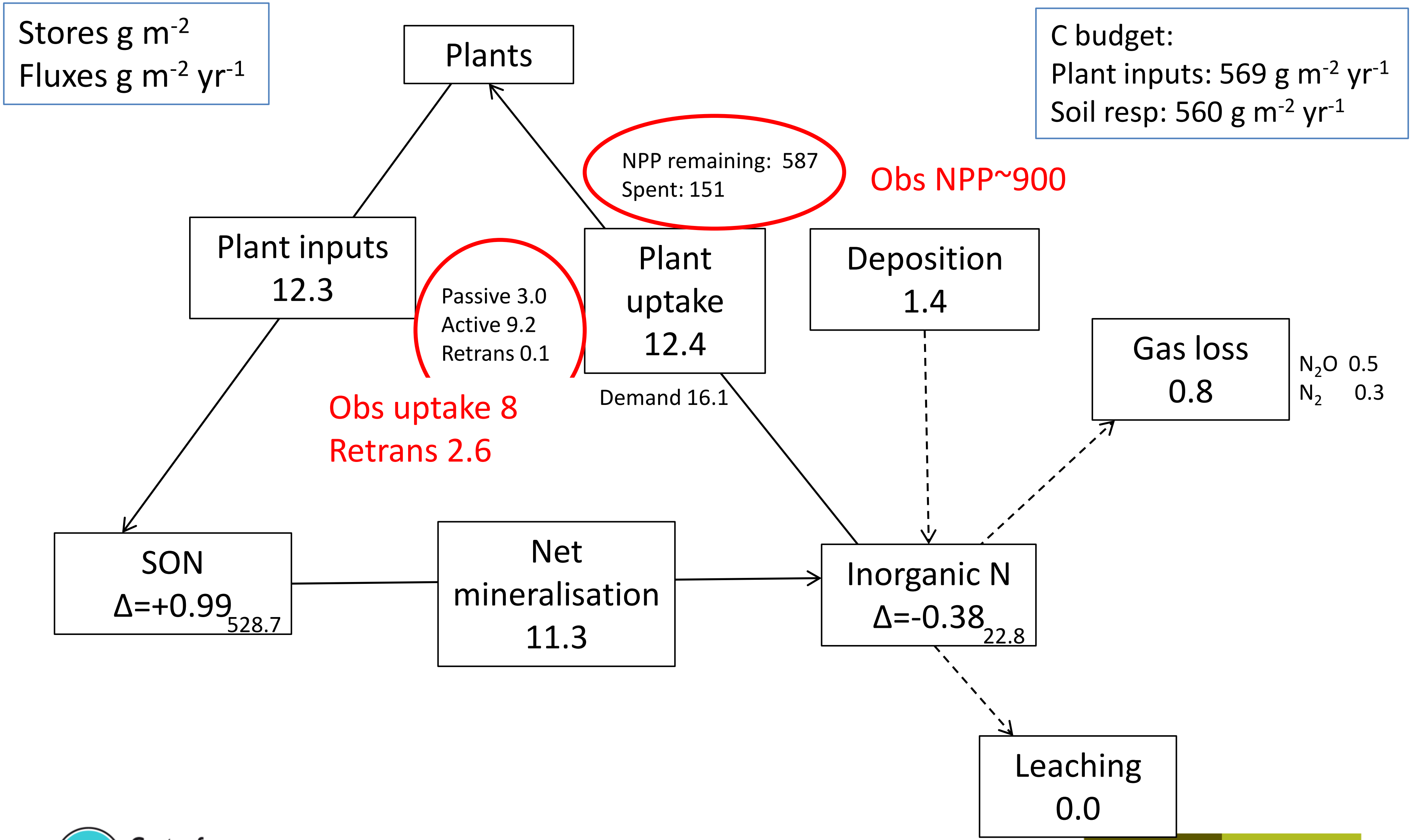
The focus is on vegetation growth and the N budget.
4 soil layers for ‘physics’ and ECOSSE
ECOSSE called every timestep (30 mins)
Phenology and TRIFFID called once a day

1. US forest runs (mainly Duke Forest)

Duke Forest (FACE, NT), ORNL FACE (BT), Harvard Forest (BT), Morgan Monroe (BT)

Prescribed frac (no competition).
Watch Forcing Data.
Spin up over 1901-1950, main run 1951-2001.
Annual N deposition from ACCMIP multi-model mean, scaled to local obs (where available).
No fixation was allowed.

N budget for Duke Forest, 2001



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set1/r55_duke_r820_ec_nz4_fun_toc2kg

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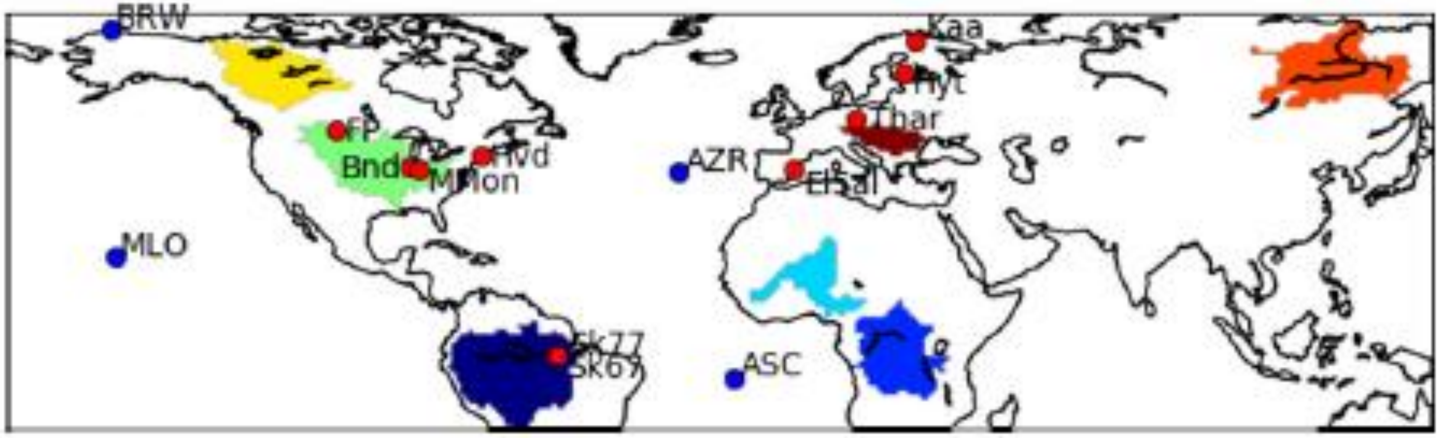
Summary of US forest runs

- Most attention has been paid to Duke Forest (good obs and I started there!).
- Duke NPP rather low despite high N uptake.
  Active uptake dominant, little retranslocation.
- At other sites passive uptake dominant, little retranslocation.
- NPP is generally rather low, but can possibly be “tuned” back up.

2. Runs at the benchmarking sites

Looking at the 10 sites used in the JULES benchmarking paper – these cover a range of climate/biome types.



Blyth et al., 2011, GMD

Name	Obs veg
Kaamanen	wetl
Hyytiala	ENT
Tharandt	ENT
Harvard Forest	DBT
Morgan Monroe State Forest	DBT
Fort Peck	grass
Bondville	crops
El Saler	ENT
Santarem km77	grass
Santarem km67	DBT

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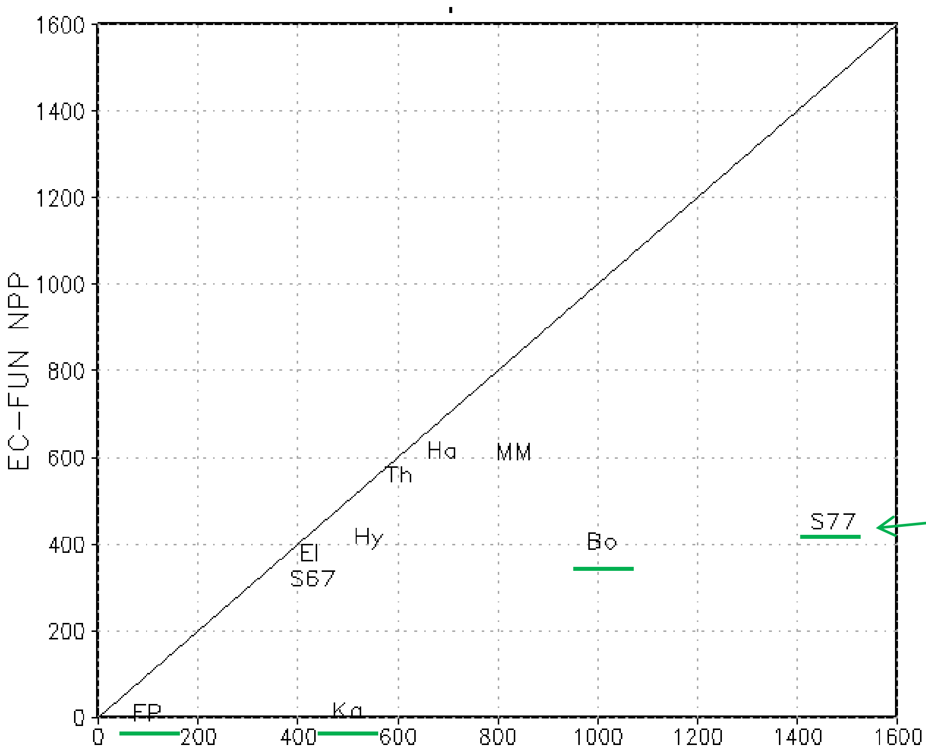
Comparison of JULES and J-EC-FUN.

NPP from JULES and J-E-F.

With
N model



No N model

Forest sites typically spending 10-25% (ave 18%) of NPP on N.

Grasses spending ave 78%: their low C:N results in a large demand for N.

Site	Kaa	Hyy	Tha	Harv	MMSF	FortP	Bondv	El Sa	San77	San67
Obs veg	wetl	ENT	ENT	DBT	DBT	grass	crop	ENT	grass	DBT

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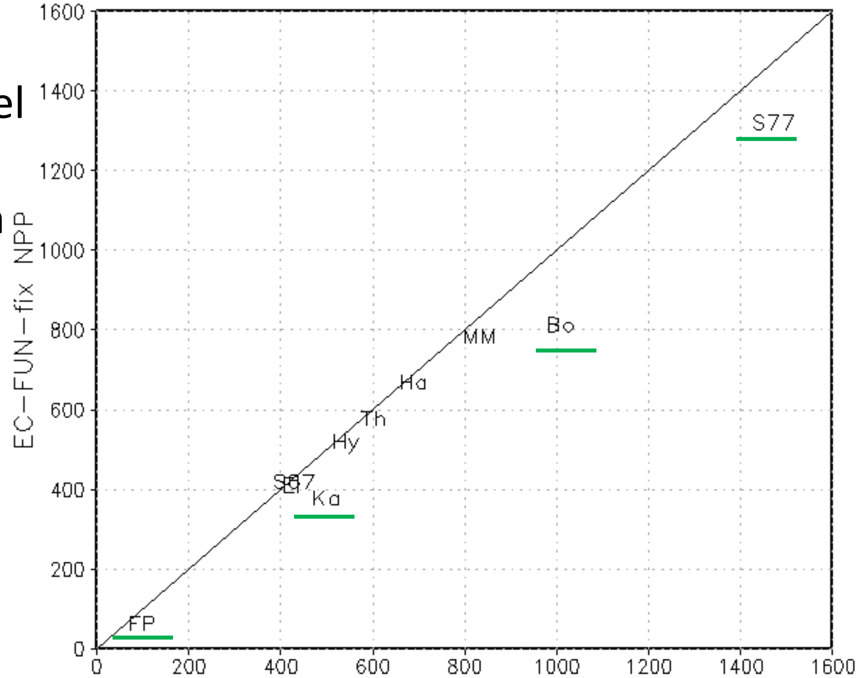
Effect of fixation

NPP from with/out fixation.

N model with fixation

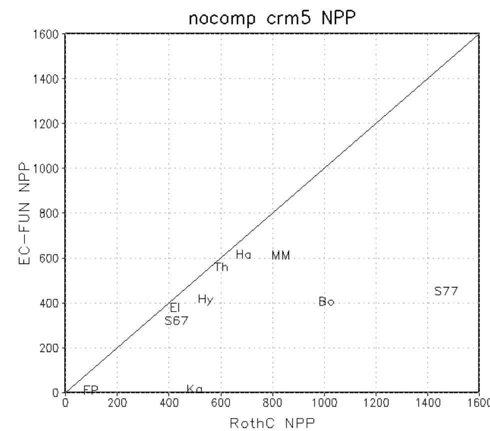


No N model

JULES-EC-FUN with fixation produces NPP that is broadly similar to that of the no-N model, largely by improving grasses.

22% of NPP is spent on N (was 78%). Fixation is 18% of uptake (28% for grasses).

compare previously (no fixation)



Site	Kaa	Hyy	Tha	Harv	MMSF	FortP	Bondv	El Sa	San77	San67
Obs veg	wetl	ENT	ENT	DBT	DBT	grass	crop	ENT	grass	DBT

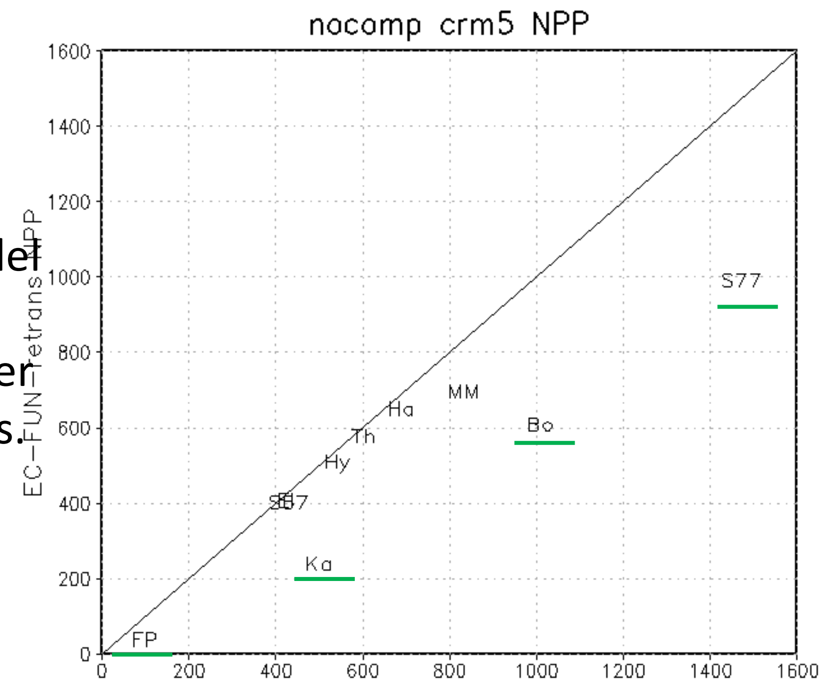
Cheaper retranslocation

The default parameters give insignificant retranslocation.

Reducing the cost by a factor of 10 gives retranslocation of 7% on average (as fraction of total uptake).

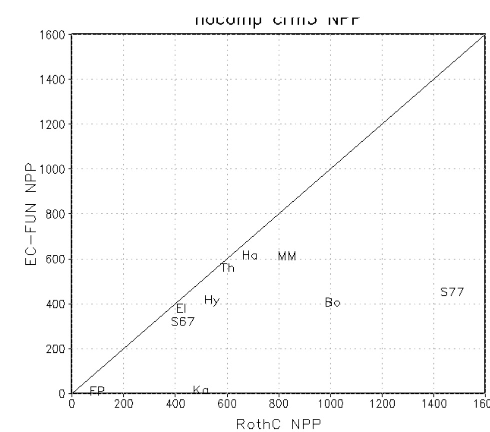
In general we need to recalibrate FUN to work on a shorter timestep and with ECOSSE-calculated soil N.

N model with cheaper retrans.



No-N model

compare previously



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Site	Kaa	Hyy	Tha	Harv	MMSF	FortP	Bondv	El Sa	San77	San67
Obs veg	wetl	ENT	ENT	DBT	DBT	grass	crop	ENT	grass	DBT

Benchmark sites: summary

Broadly reasonable NPP and N uptake for mid-latitude forests without fixation of N, but high demand for N from grasses results in a major reduction in NPP at those sites.

Allowing fixation of N and/or cheaper retranslocation returns NPP at most sites to values broadly similar to those of the standard (no N) model.

Suggests that it might be possible to “tune” the model to give reasonable results.

3. Runs for FACE sites: response to eCO_2

- Duke Forest (pine) and ORNL (sweetgum) FACE sites.
  - Duke: Aug1996-2007 +200ppm CO_2
  - ORNL: 1998-2008 +152ppm CO_2

- Run JULES with prescribed land frac (no competition).
  - Initial state is a ‘close-to-equilibrium” state using WFD inputs.

- The setup broadly mimics that of Zaehle et al. (2014, New Phyt.).

- Also some equivalent eCO_2 runs with standard JULES (no N model).

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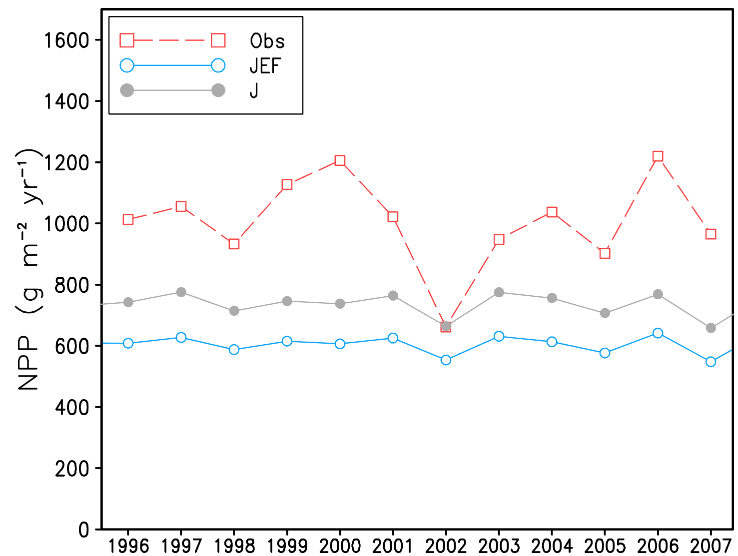
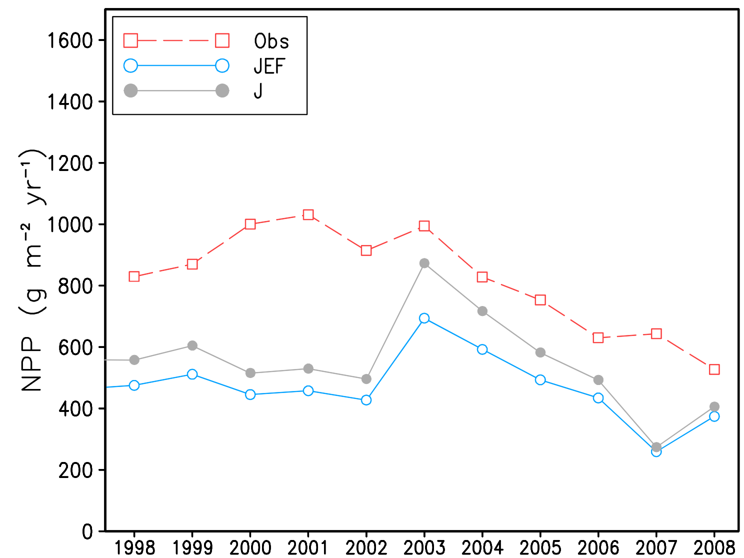
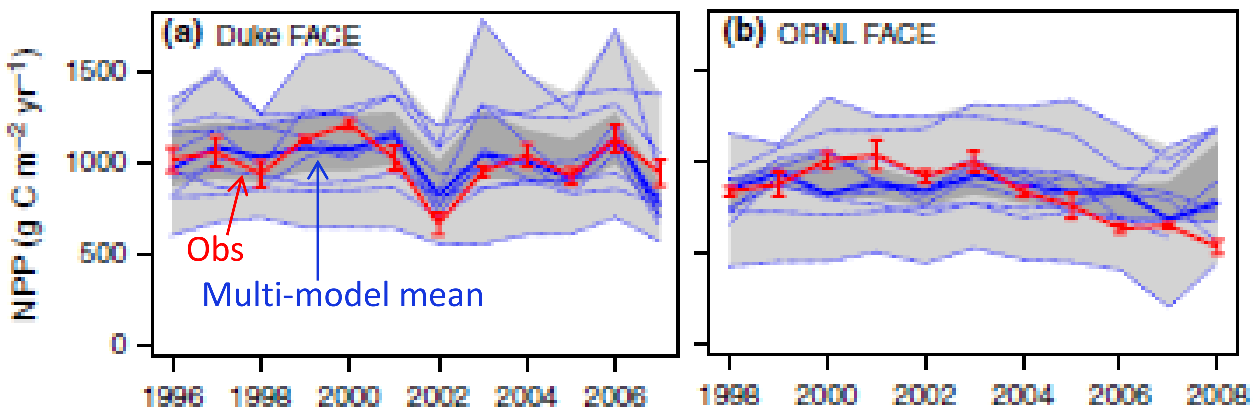
FACE runs: NPP with ambient CO_2





JULES NPP is too low, J-EF even lower.

Results from Zaehle et al. (2014)



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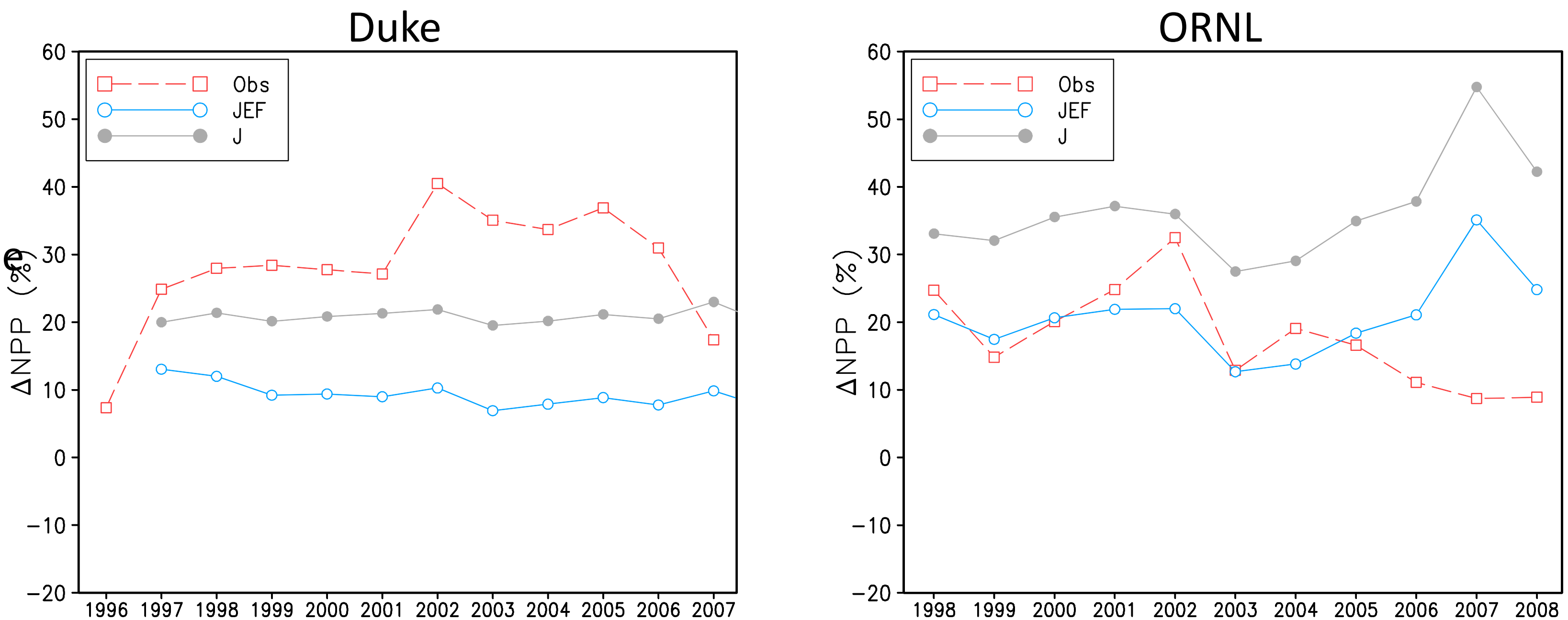
FACE runs: NPP response

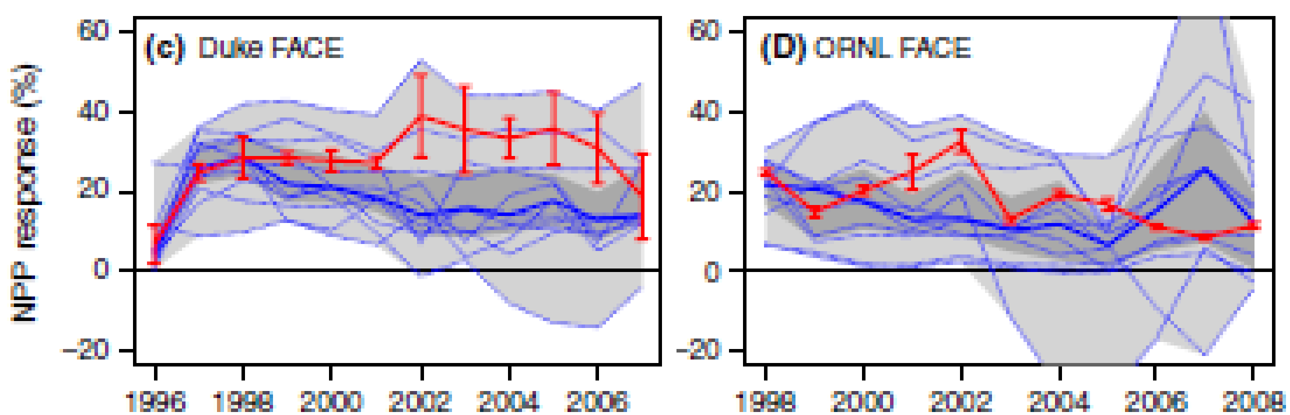
NPP response (%)



Results from Zaehle et al. (2014)

Obs

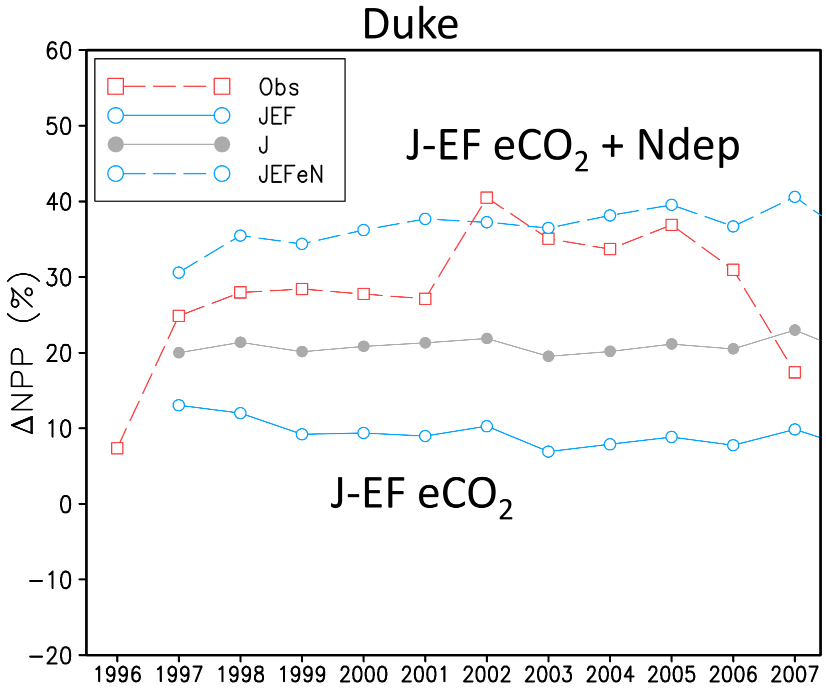
Multi-model mean

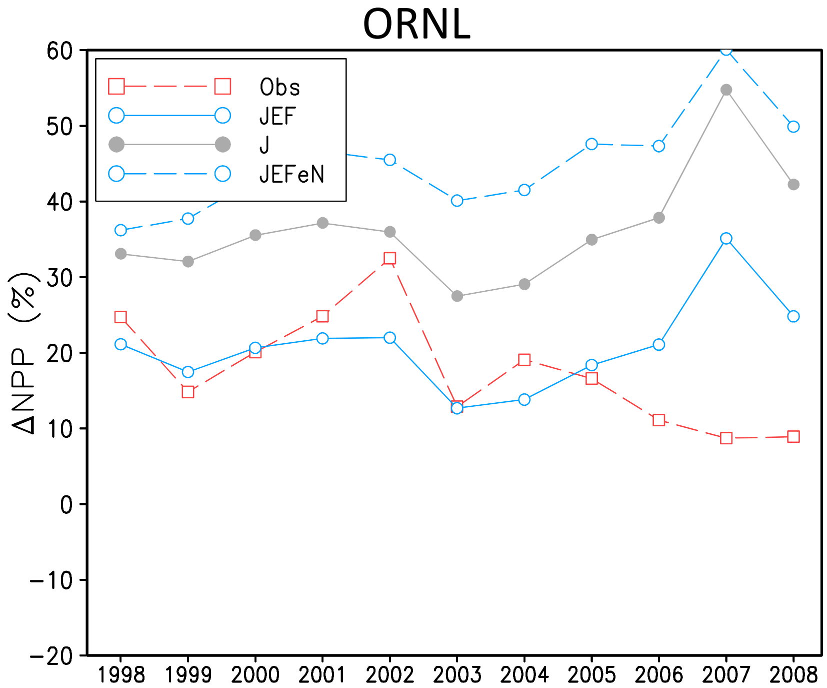


FACE runs: NPP response with N fert.

J-EF eCO_2 + extra N deposition (10g m^{-2} yr^{-1})

NPP response (%)





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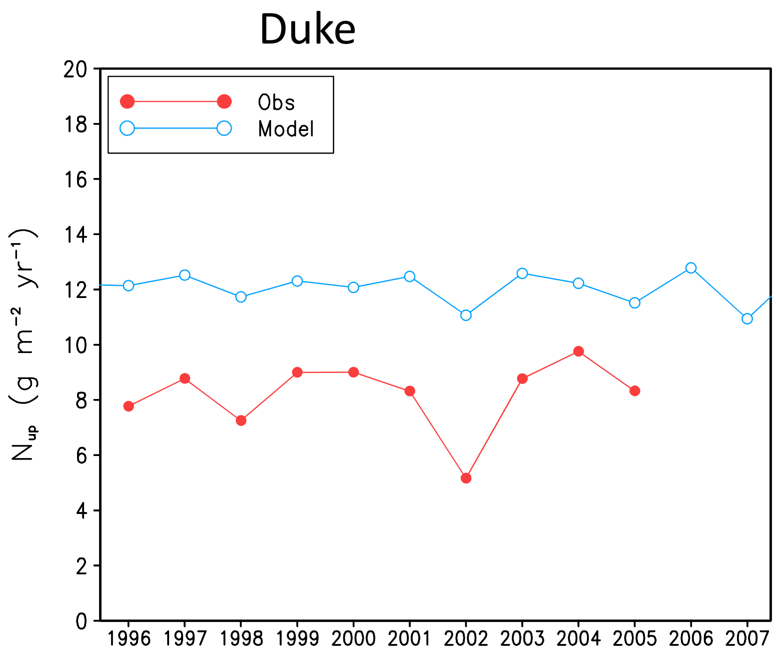
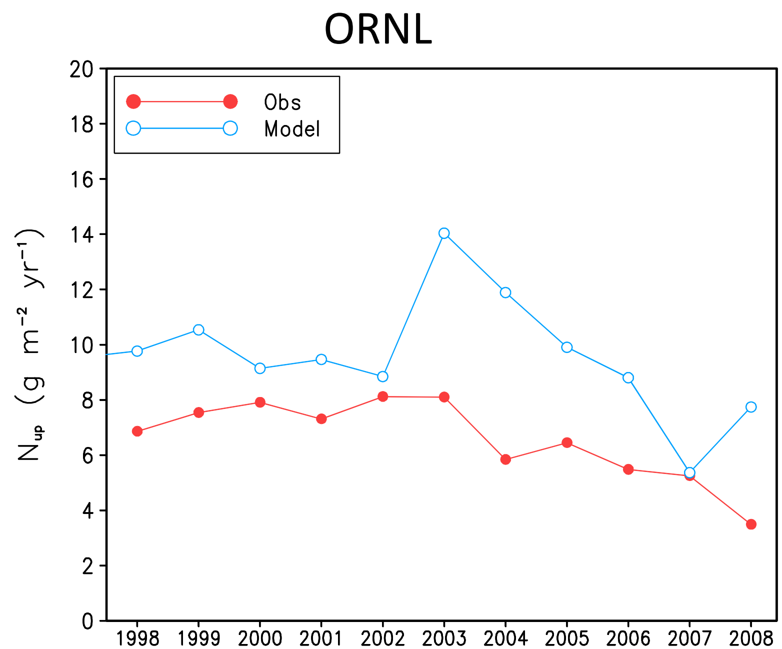
FACE runs: N uptake ambient

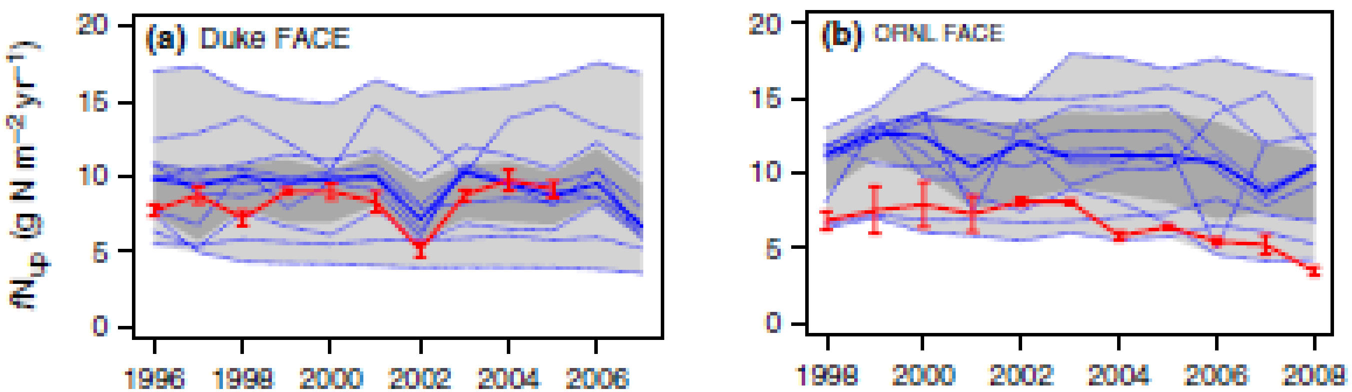




Results from Zaehle et al. (2014)

Obs

Multi-model mean



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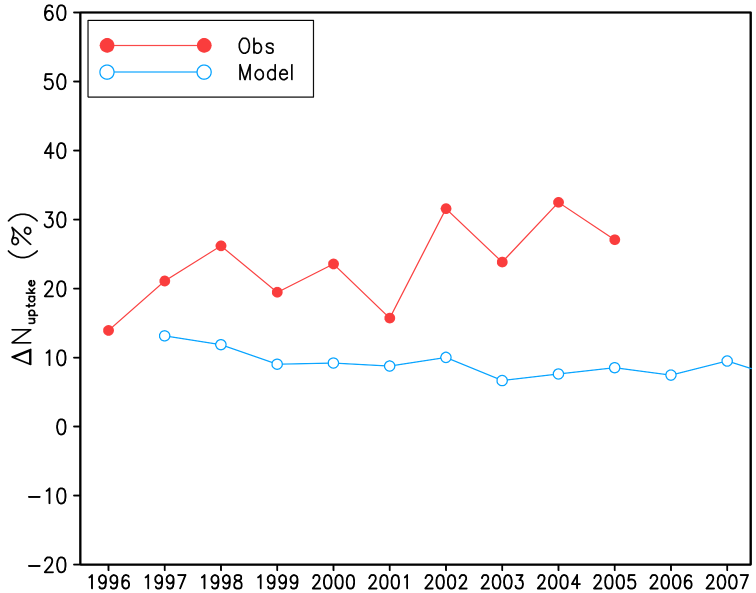
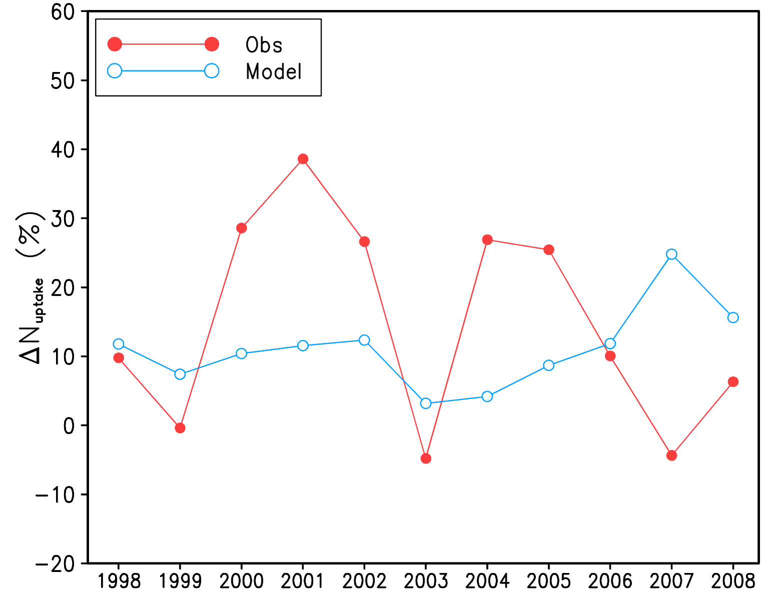
FACE runs: N uptake response

N uptake response (%)

Duke



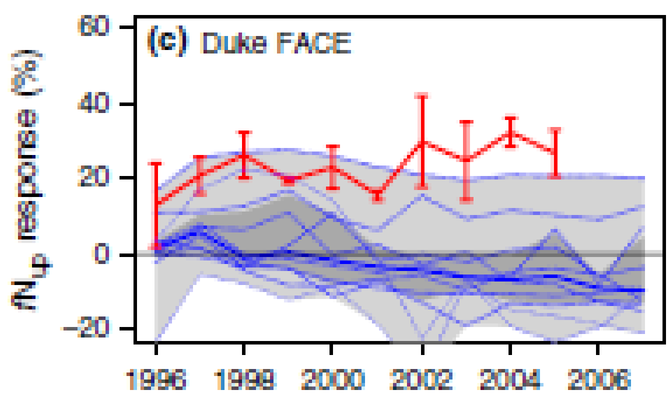
ORNL

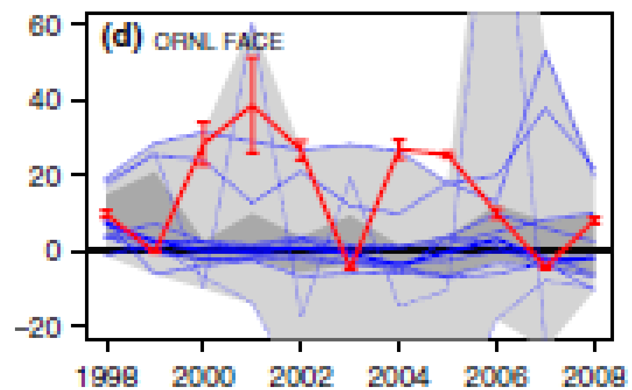


Results from Zaehle et al. (2014)

Obs

Multi-model mean





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FACE runs: summary

Preliminary results for Duke Forest and ORNL:

• Baseline NPP is low and N uptake is high relative to obs.

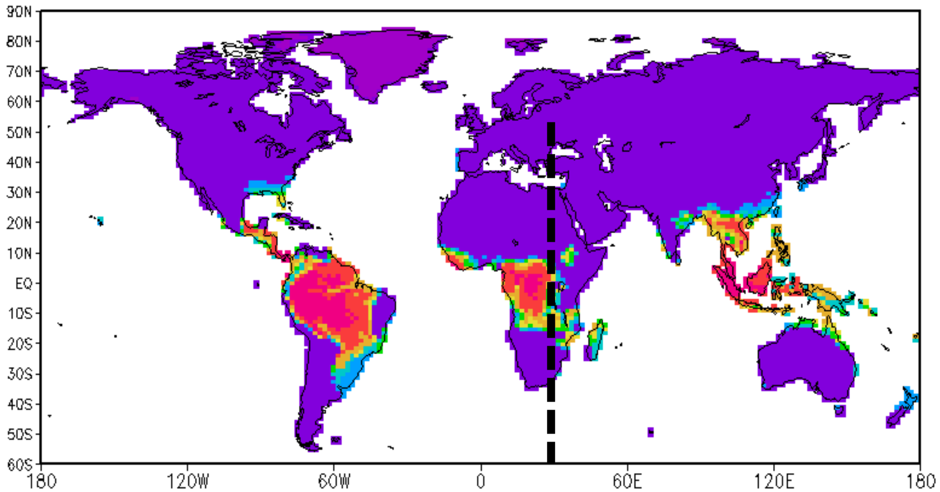
NPP at or below bottom end of ensemble; partly because of expenditure on N but baseline JULES (no N model) is also low.
N uptake at high end (Duke) or middle (ORNL) of ensemble.
NUE at or below bottom end of ensemble.

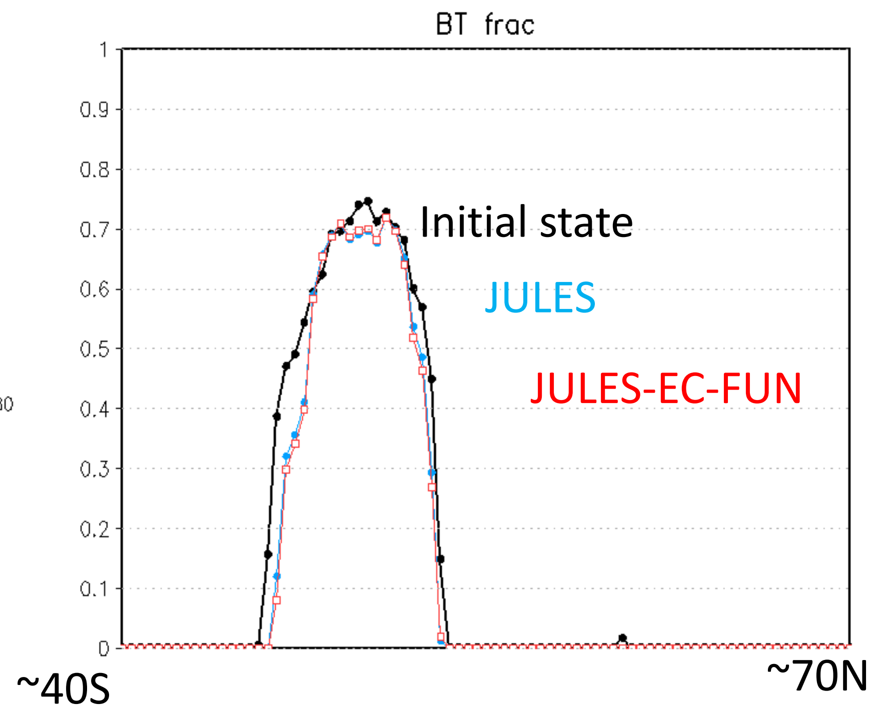
• For what it's worth....results generally compare reasonably with the (large range of the) multi-model ensemble (not NUE).

Global runs

Comparing JULES, JULES-ECCOSE-FUN and another JULES N scheme (Andy Wiltshire).
Using the TRENDY data/protocol.
CRU-NCEP meteorology at N96 (HadGEM2-ES), “pre-industrial” spin up.
Allowing fixation and cheaper retranslocation.

My current focus is on a transect near 20°E
Broad evolution of veg frac in JULES and JULES-ECOSSE-FUN is similar so far (after ~1000yrs).





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Recap

- Runs at US forest sites
  Largely looked at Duke, where Nuptake is high, NPP low with current parameters.

- Runs at benchmarking sites
  Grasses struggling in initial runs.
  Fixation and/or cheaper retranslocation give results more similar to standard JULES.

- Runs at FACE sites
  Broadly reasonable response to eCO_2 (but room for improvement!).

- Global runs
  Spin up of transect at 20°E looks OK (so far).

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