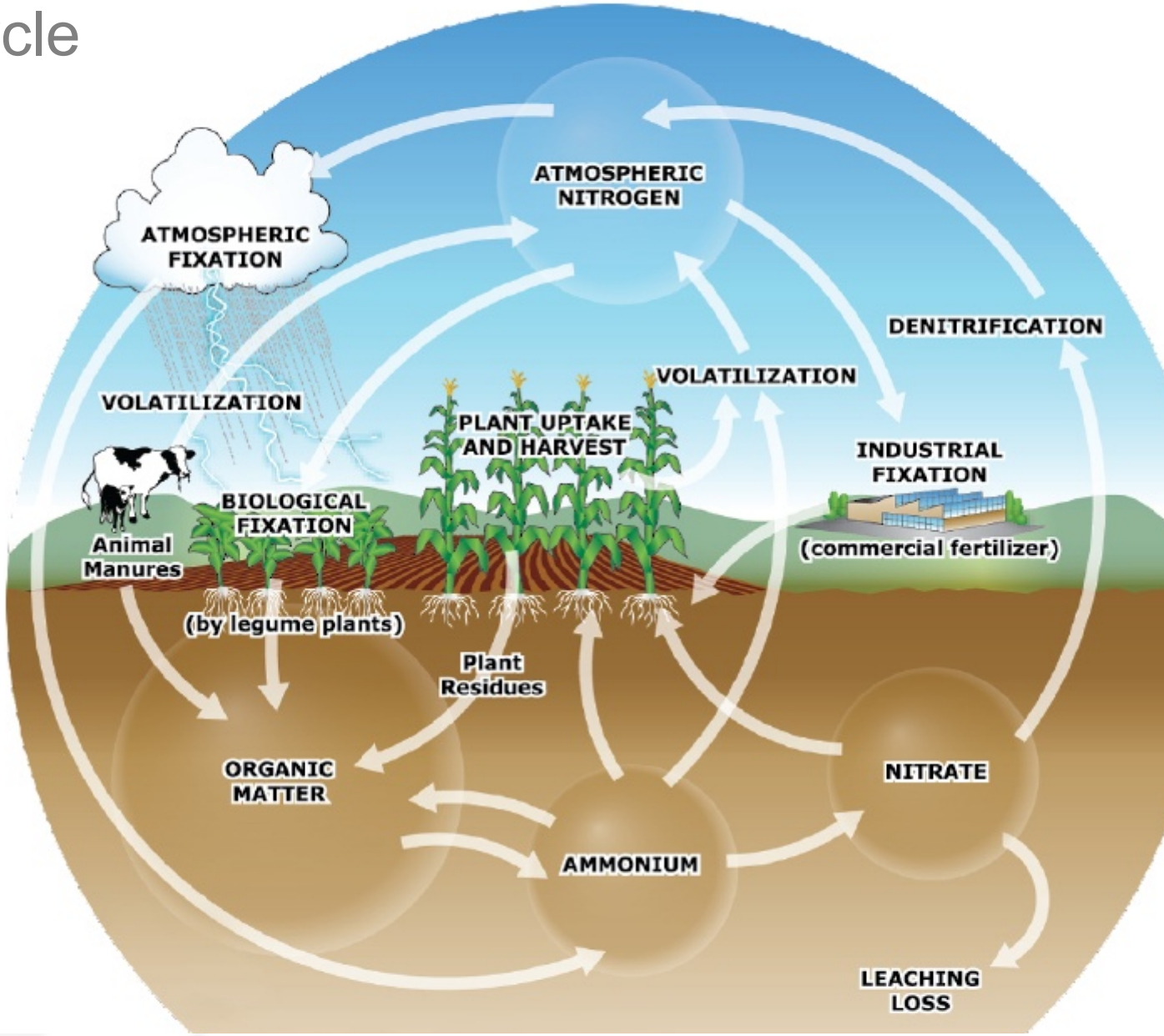
N cycling in ORCHIDEE

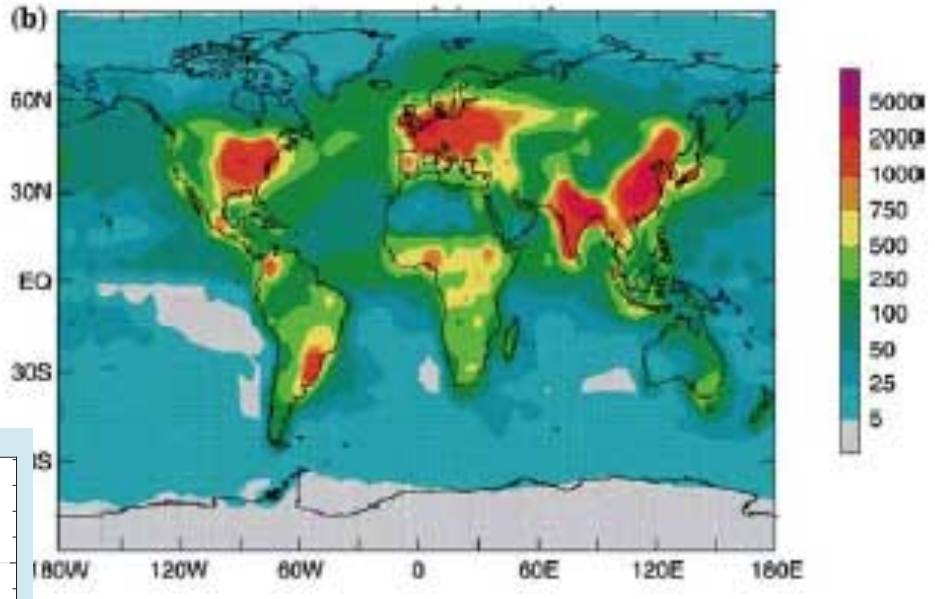
N. Vuichard - LSCE

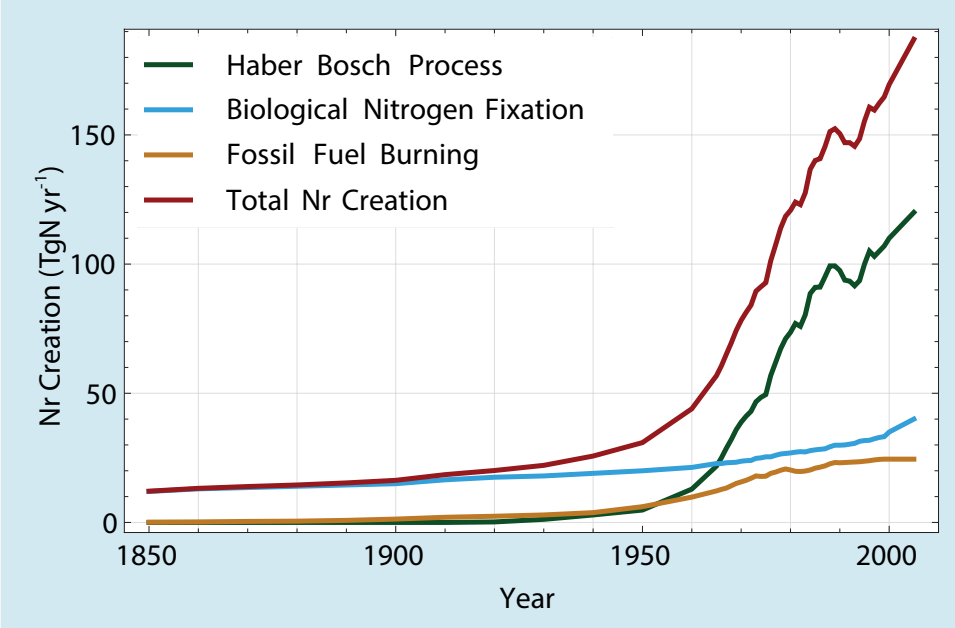
The N cycle


ATMOSPHERIC NITROGEN
ATMOSPHERIC FIXATION
DENITRIFICATION
VOLATILIZATION
VOLATILIZATION
PLANT UPTAKE AND HARVEST
INDUSTRIAL FIXATION
(commercial fertilizer)
BIOLOGICAL FIXATION
Animal Manures
(by legume plants)
Plant Residues
ORGANIC MATTER
NITRATE
AMMONIUM
LEACHING LOSS

Evolution and distribution of reactive nitrogen

Mean N deposition during the 90's (mgN m^2 yr^{-1})
TM3 Model (Galloway et al., 2004)



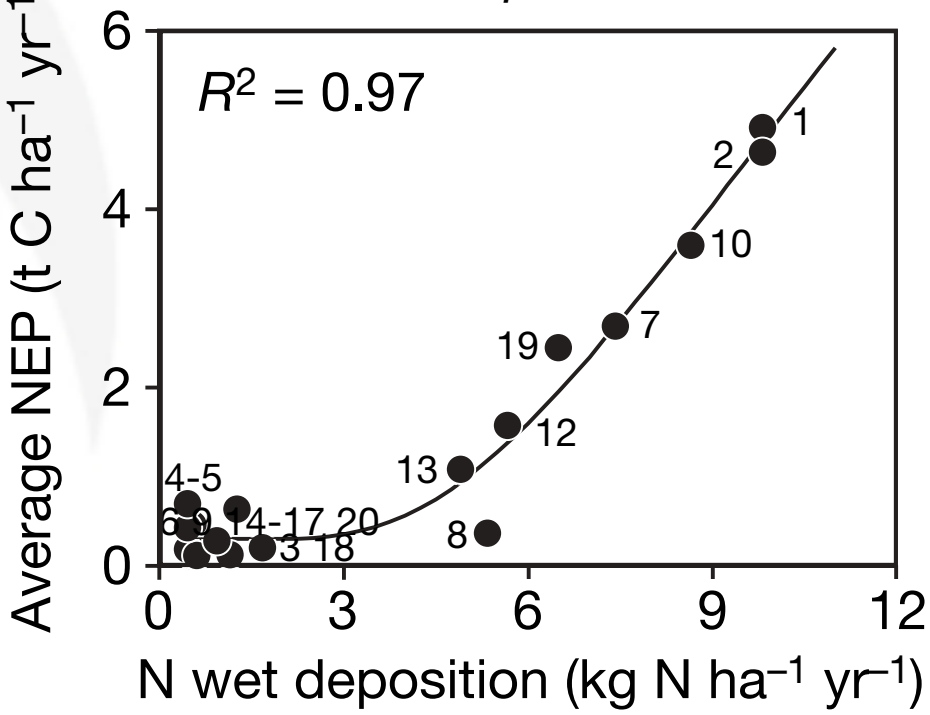


Evolution of reactive nitrogen 1850-2000 by source (IPCC, Chapitre 6, 2014)

Fertilising effect of N on ecosystem production

- C sink increases with N deposition level

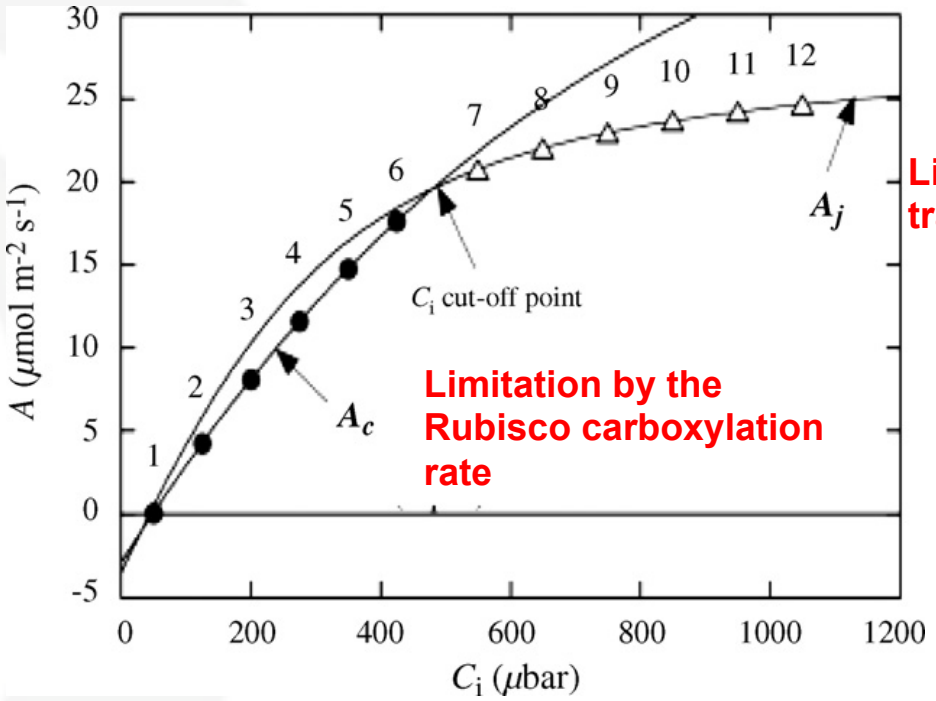
C budget as a function of N deposition over 20 sites of temperate and boreal forests



Magnani et al., 2007

Fertilising effect of the increase of $[CO2]_{atm}$

- GPP increases with $[CO_2]$



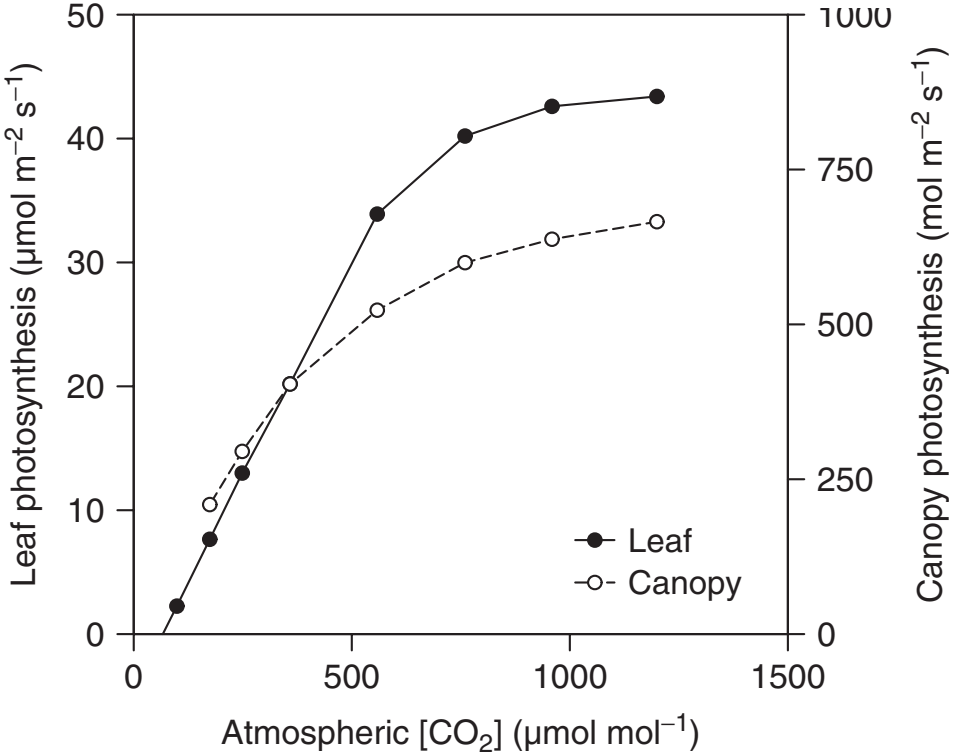
From Yin et al., 2009

FACE experiments

- Free Air CO2 Enrichment Experiment
  - Enrichment from 475 ppm up to 600 ppm
  - More than a dozen of experimental sites
  - Up to 20 years of observation (Duke Forest)

FACE site @ Duke University (USA)

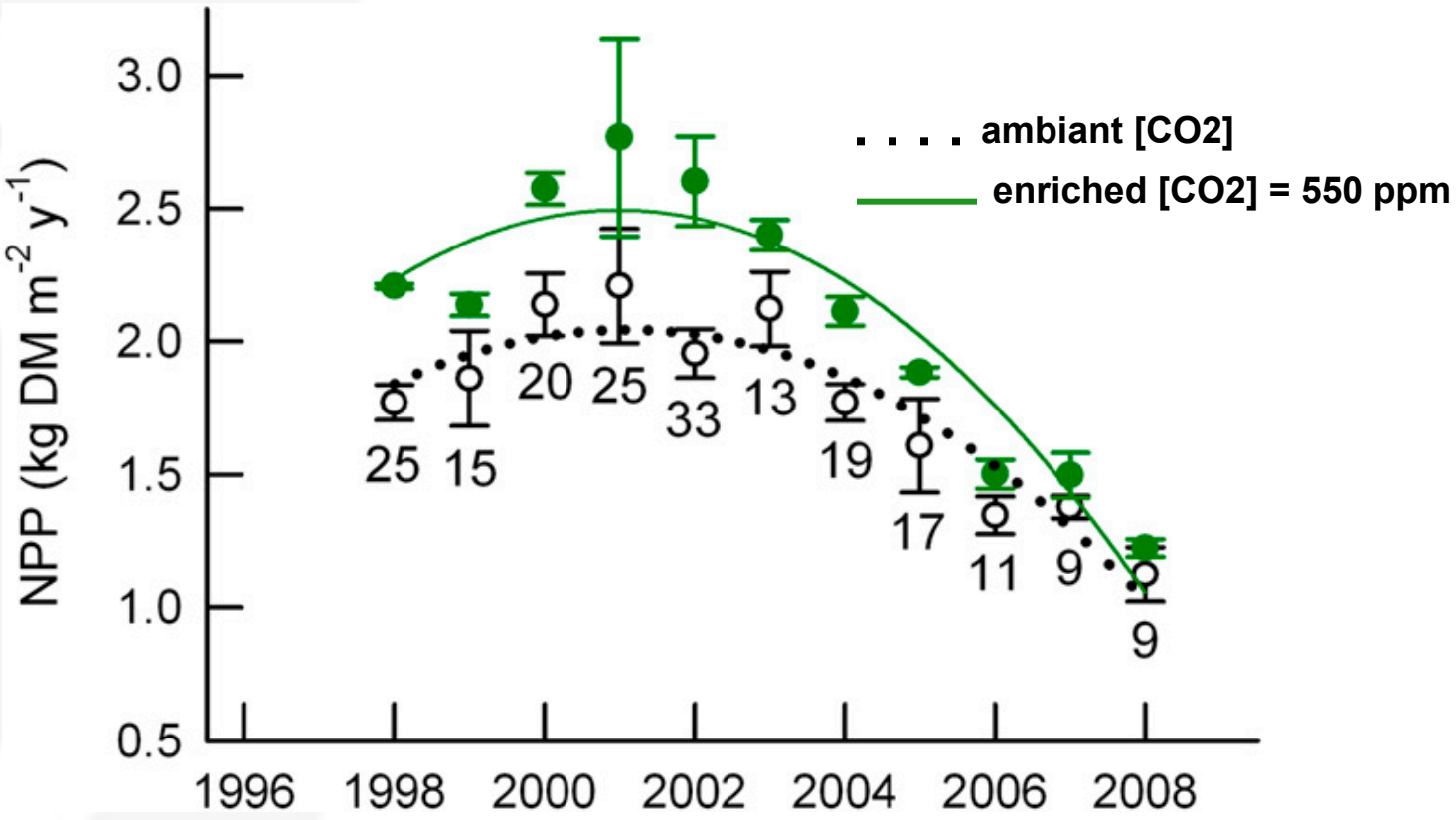
C assimilated by lead as function of [CO_2] at Oak Ridge



From Medlyn et al., 2011

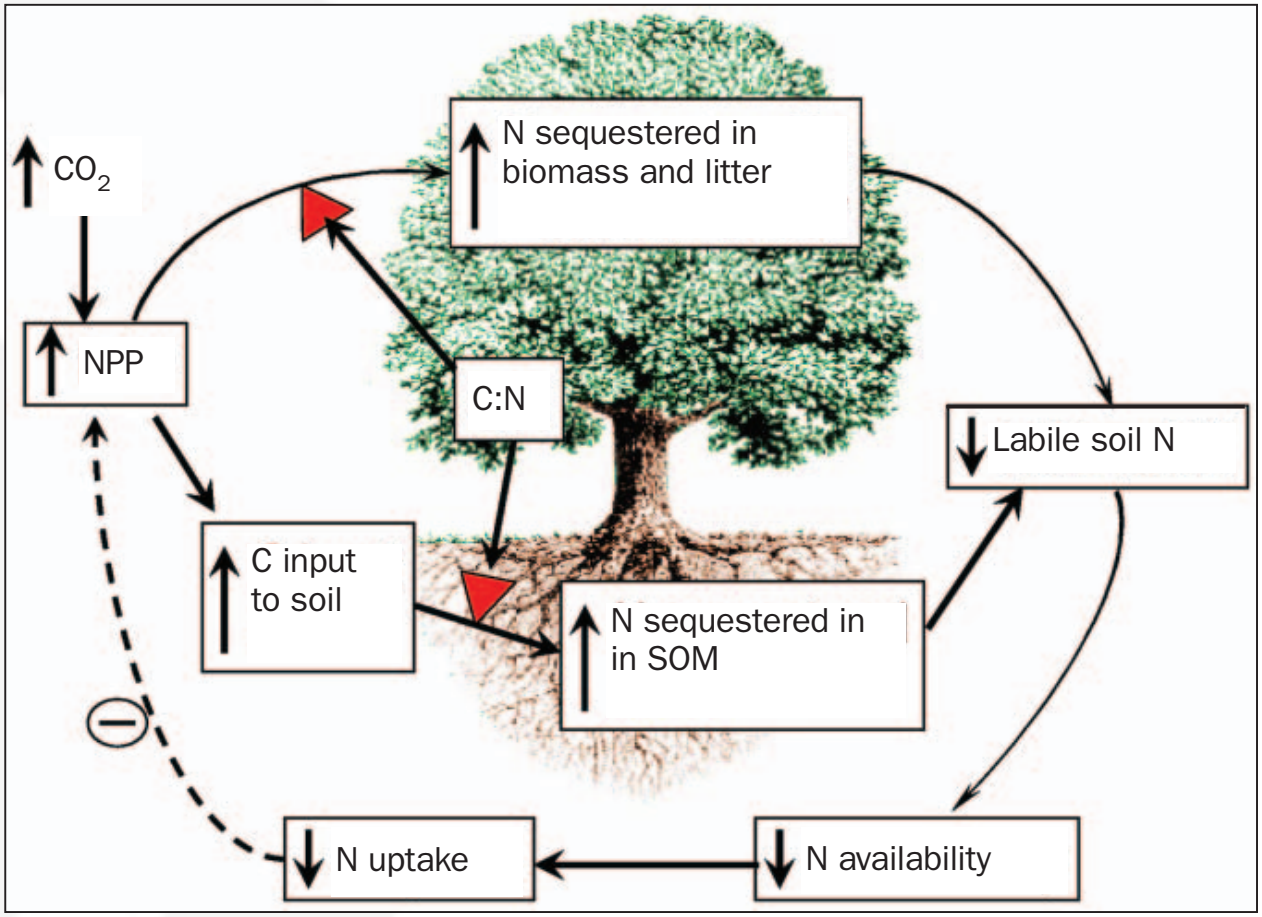
CO2 fertilising effect limited with N-availability

NPP over 11 years at FACE Site of Oak Ridge



Norby et al., 2010

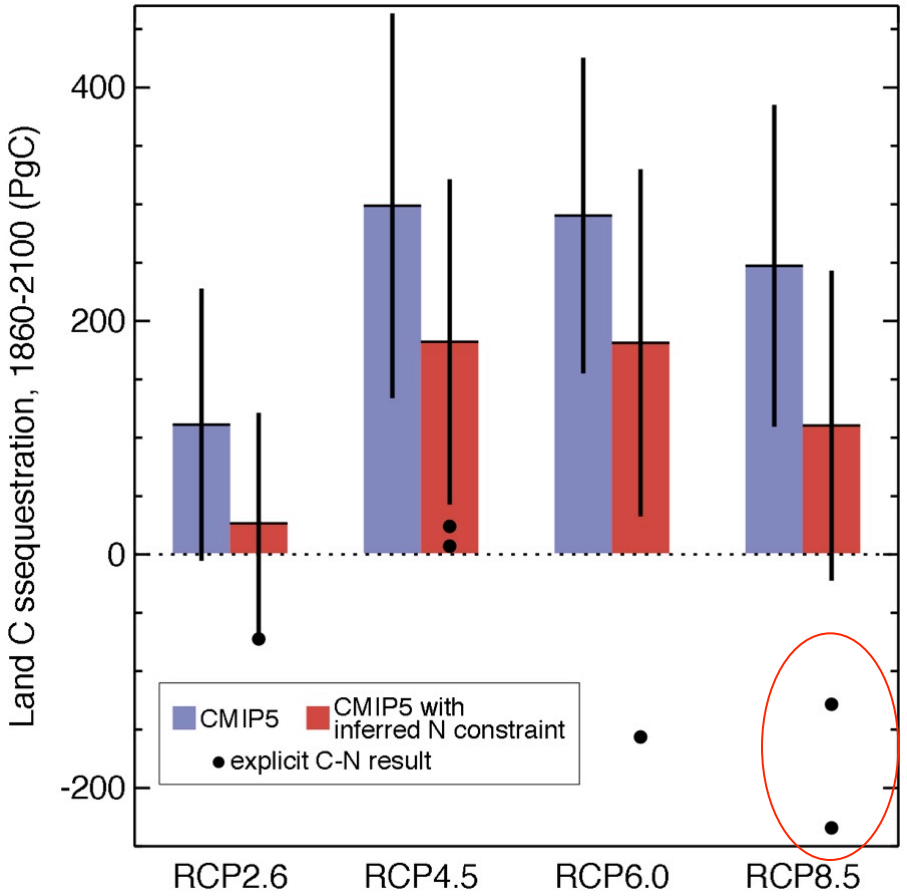
Some processes



From Luo et al., 2004

Impact on CMIP5 projections

- Carbon sink in terrestrial ecosystems (1860-2100)

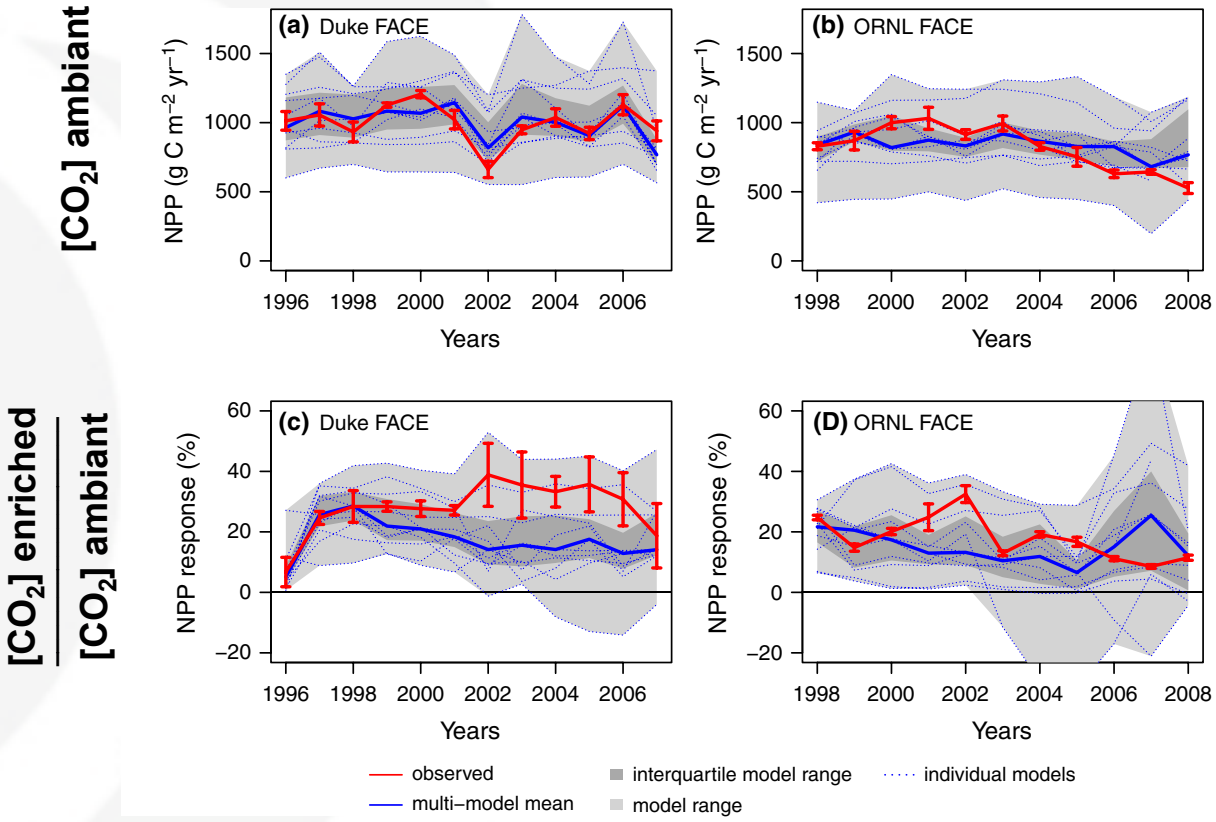


Two models couple C and N in CMIP5

IPCC, WGI, Chapitre 6, 2014

Vegetation model with C and N coupled

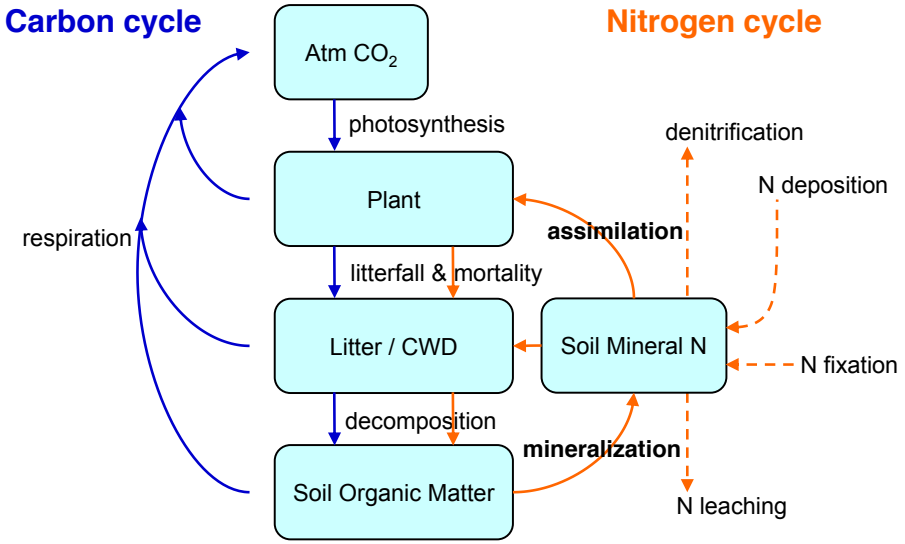
- Intercomparison of 12 models AT 2 FACE sites



Zaehle et al., 2014

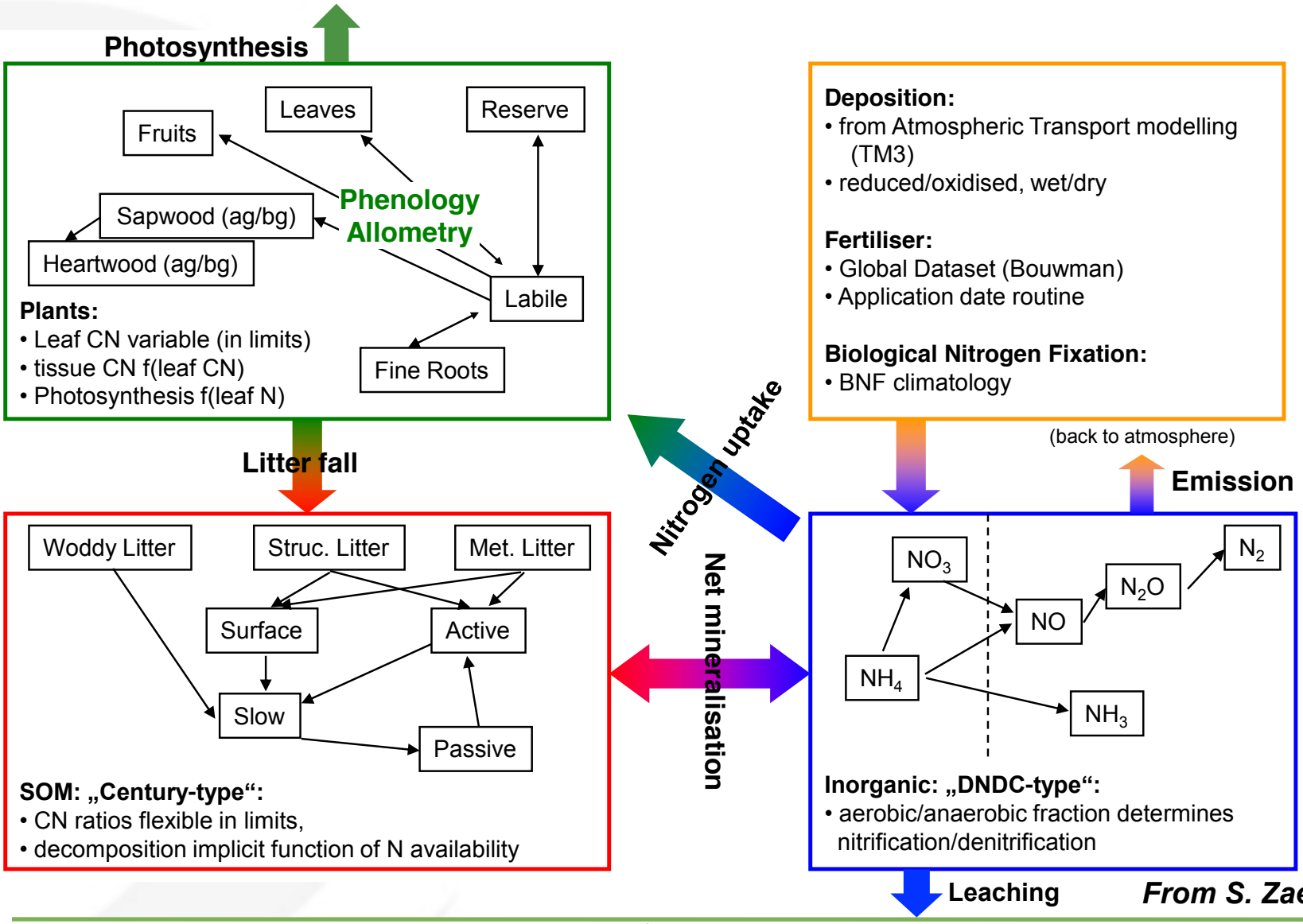
Coupling between C and N cycles in ORCHIDEE

- Work of Sönke Zaehle (2007- 2010)
  - Based on a so-called O-CN version (Zaehle et al., 2010a,b)
  - Main focus: C flux responses to N-availability
- An ongoing work of merge into the trunk of ORCHIDEE
  - Code “checking” and writing (N. Vuichard): Jan-Sept. 2014
  - Testing phaseDébut de la phase de test : This fall
  - Starting point for the version coupling C, N and P (P-imbalance ERC project)



From S. Zaehle

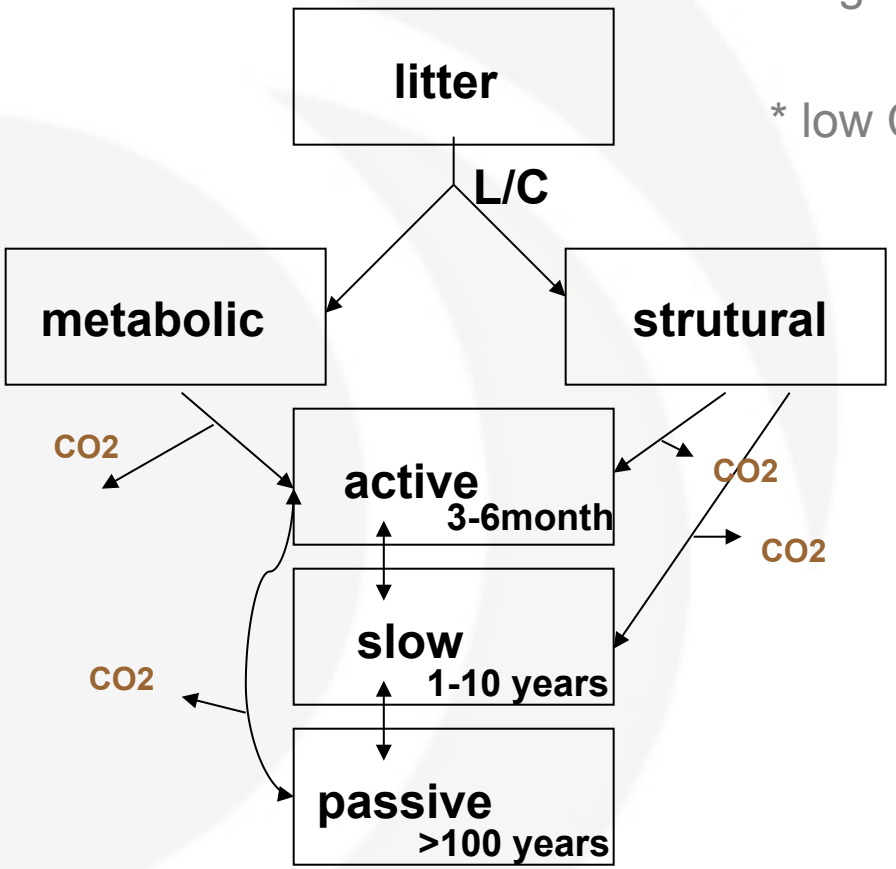
N cycle in ORCHIDEE

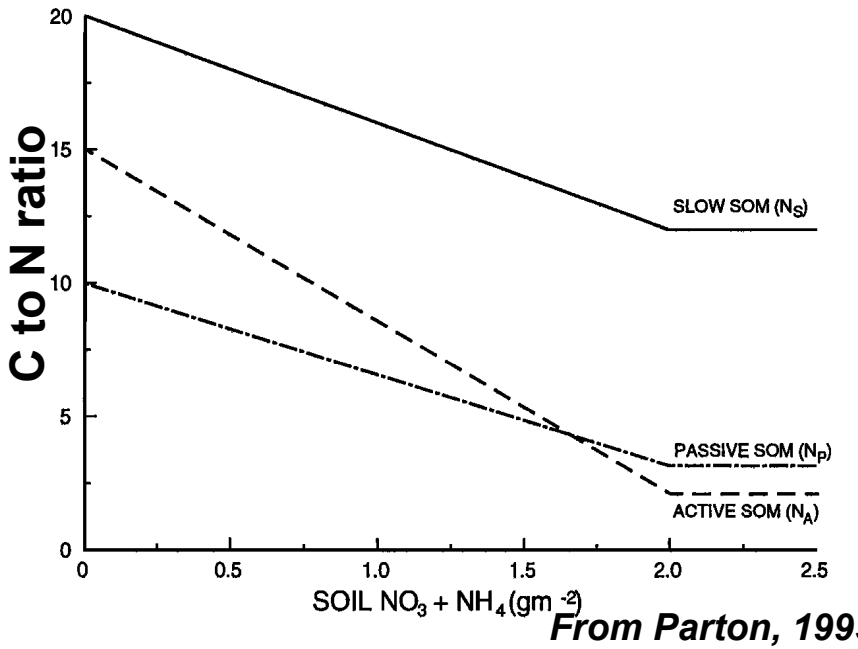


Soil organic matter dynamics

- Based on the Century model (Parton et al., 1993)

  * high C:N ratio of metabolic residue
    => N immobilisation
  * low C:N ratio of strtuctural residue
    => N mineralisation

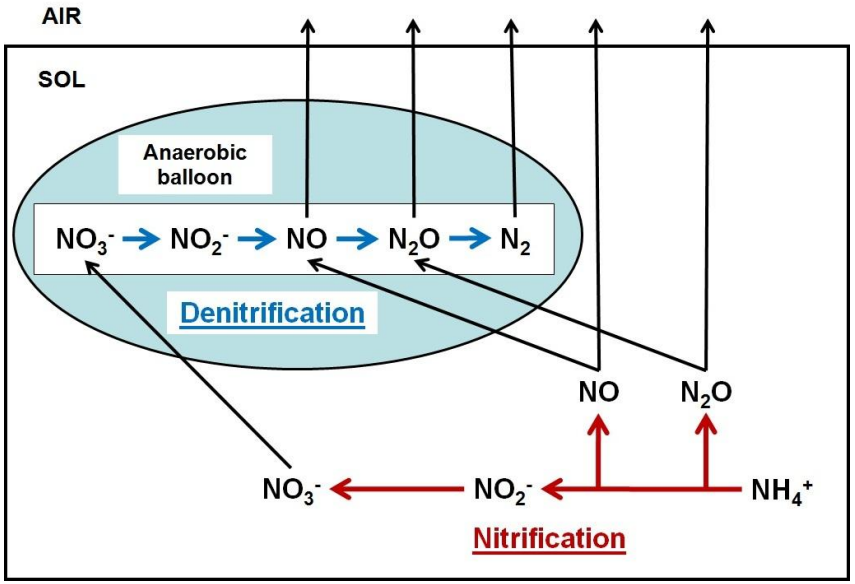




From Parton, 1993

Mineral soil N dynamics

- Based on the DNDC model (Li et al., 1992, 2000).
- It accounts for:
  - Sorption of NH4 onto clay surfaces
  - pH-dependent dissociation of NH_4 to NH_3
  - Nitrification: oxydation of NH_4 to NO_3 (NO_x and N_2O are by-products, f(temp, pH))
  - Denitrification: series of reduction reactions from NO_3 to NO_x, N_2O, and N_2. *f*(temp, pH, denitrifier microbial population)
  - Emissions of NH_3, NO, N_2O, N_2
  - Leaching of NH_4 and NO_3

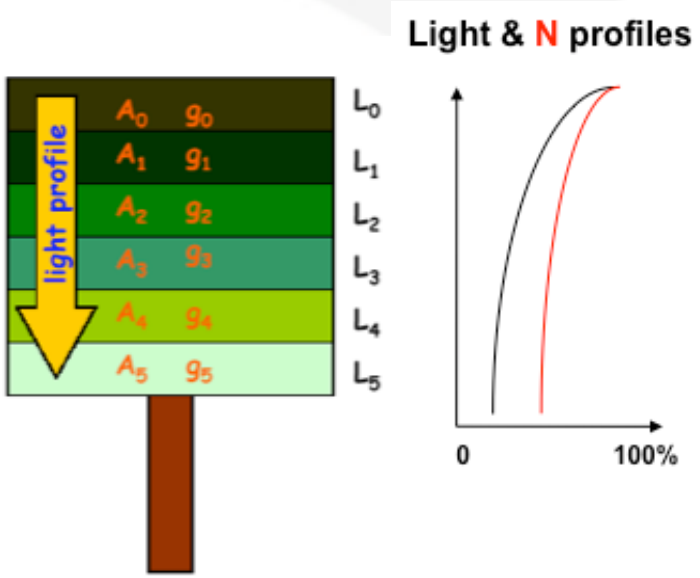


From Prieur, 2012

Photosynthesis

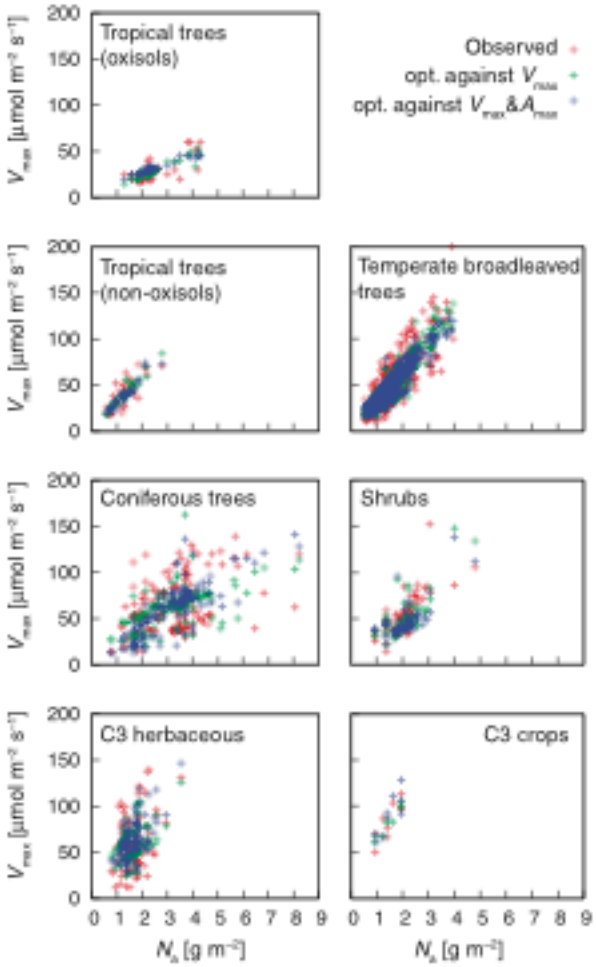
- Based mainly on the work of Kattge et al. (2009)

  => Vmax vs. Leaf N content



$$N_L = \frac{k_N \times N_{leaf}}{1 - exp^{-k_N \times LAI_{Lc}}} \times exp^{-k_N \times LAI_{Lc}}$$

With k_N values around 0.1-0.2 (Carrswell et al., 2000; Dewar et al. 2012)



References

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