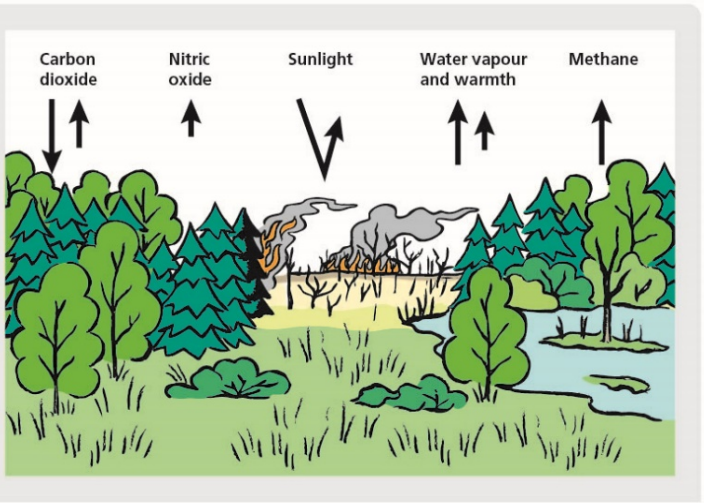
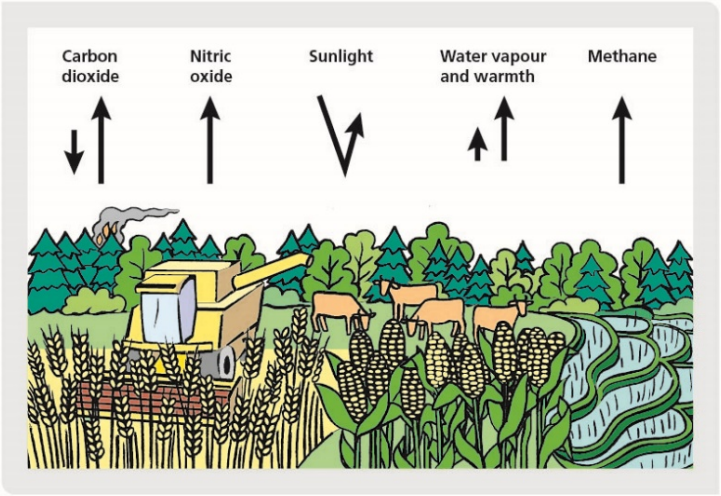
Human Dimensions & DGVMs

Almut Arneth, IMK-IFU, Division of Ecosystem Atmosphere Interactions



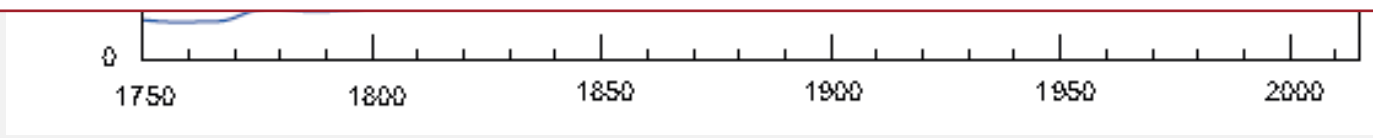


LUC: huge uncertainty in historical C-budget

e.g., definition of LUC, process-representation, LUC hindcasts, model tools applied

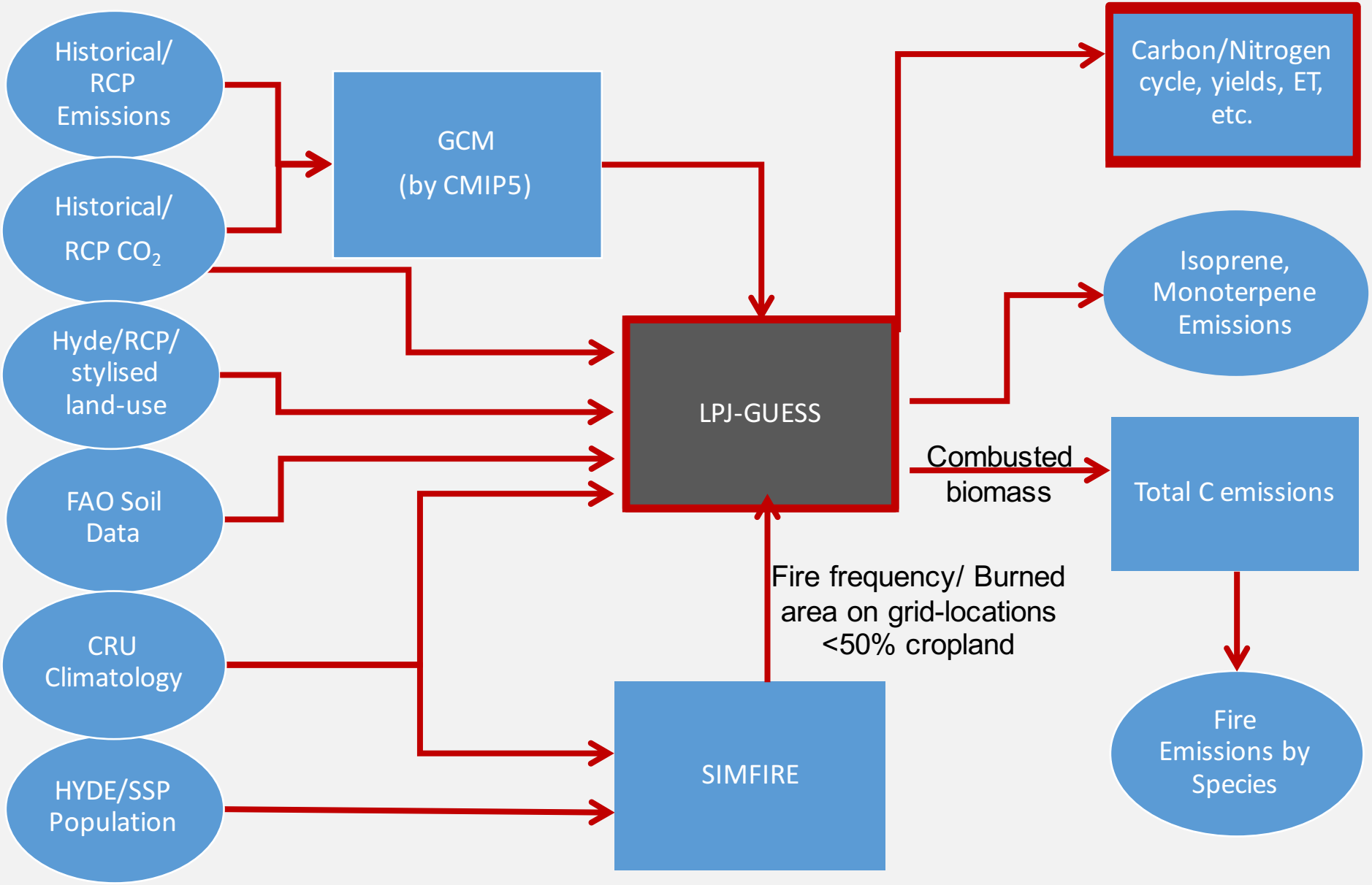
Units of GtC	1750-2014	1850-2005	1870-2014	1870-2015
Emissions				
Fossil fuel combustion and cement production (E_{FF})	405 ± 20	320 ± 15	400 ± 20	410 ± 20*
Land-use change emissions (E_{LUC})	190 ± 65	150 ± 55	145 ± 50	145 ± 50*
Total emissions	590 ± 70	470 ± 55	545 ± 55	555 ± 55*
Partitioning				
Atmospheric growth rate (G_{ATM})	255 ± 5	195 ± 5	230 ± 5	
Ocean sink (S_{OCEAN})	170 ± 20	160 ± 20	155 ± 20	
Residual terrestrial sink (S_{LAND})	165 ± 70	115 ± 60	160 ± 60	

- Residual C sink?
- Future? Land-based mitigation vs. food vs. other ecosystem processes and services?



Ciais et al., 2013, le Queré et al., 2015

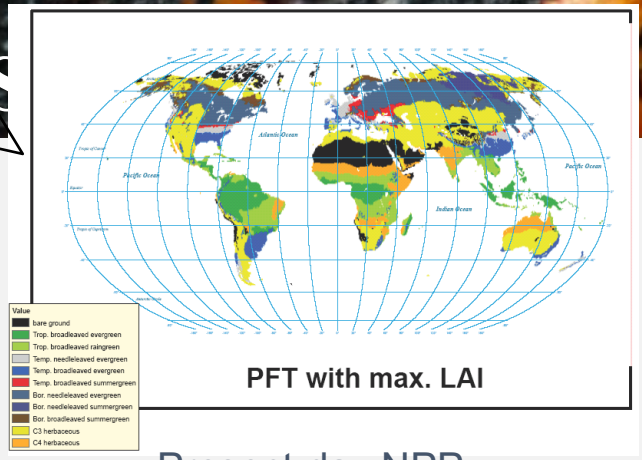
A DGVM

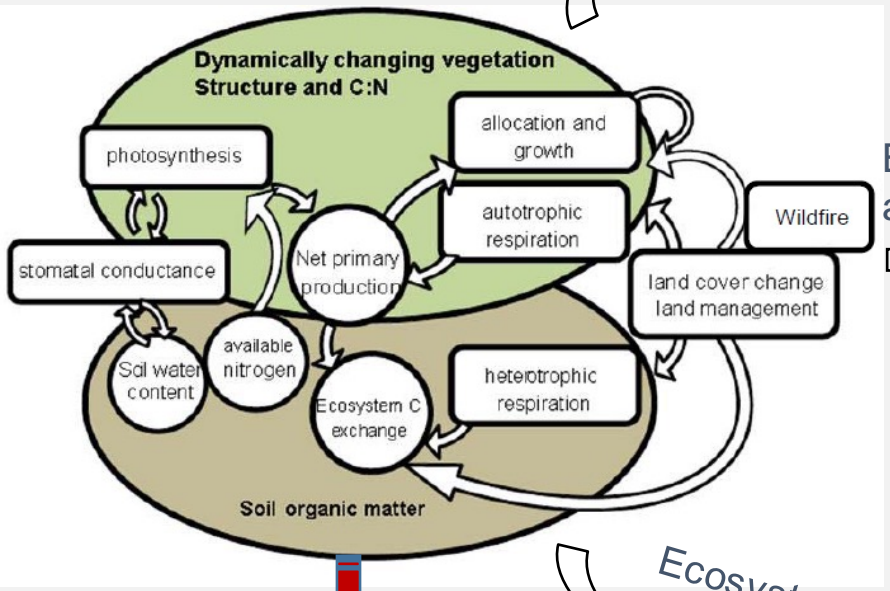

Historical/ RCP Emissions
Historical/ RCP CO_2
Hyde/RCP/ stylised land-use
FAO Soil Data
CRU Climatology
HYDE/SSP Population
GCM (by CMIP5)
LPJ-GUESS
SIMFIRE
Fire frequency/ Burned area on grid-locations <50% cropland
Carbon/Nitrogen cycle, yields, ET, etc.
Isoprene, Monoterpene Emissions
Combusted biomass
Total C emissions
Fire Emissions by Species

The world according to LPJ-GUES

Air T, precip, SW radiation/cloudiness &
N deposition, CO_2 concentration;
land cover change, land-use change

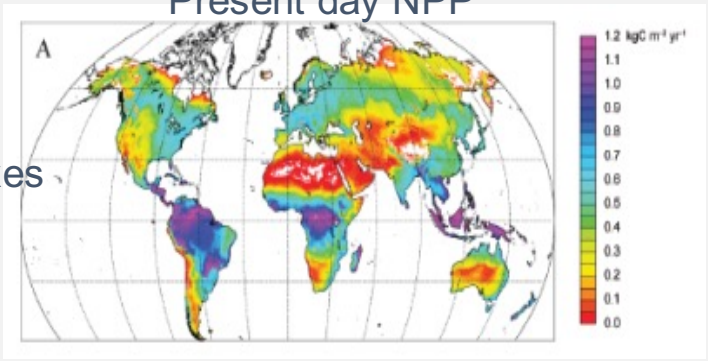
Vegetation distribution





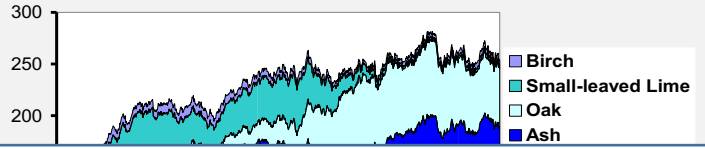
Biosphere-atmosphere fluxes

Present day NPP



Ecosystem respons
to environ

Vegetation composition (growth, ecosystem fluxes..) through time

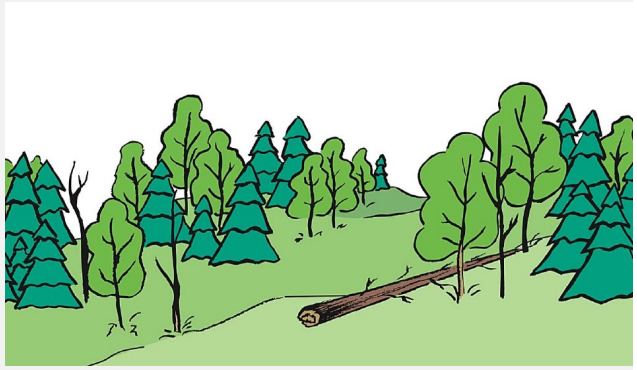


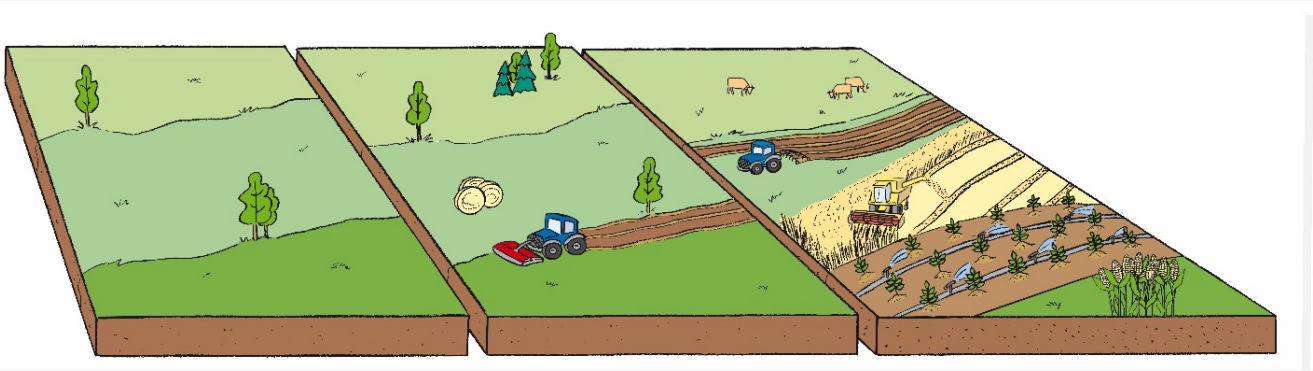
- Soil and vegetation C and N pools and fluxes
- Crop yields
- BVOC emissions
- Emissions from wildfire
- etc.

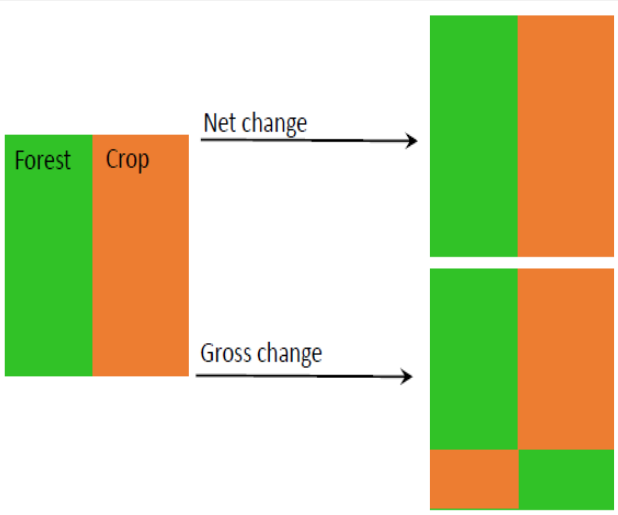
Dynamic: → responding to changes in climate, atmospheric composition, LUC

Current developments

- C:N coupling in natural vegetation, pastures and crops
- Gross transitions (e.g., shifting cultivation)
- Crop management: harvest, fertiliser, tillage, irrigation, multi-cropping….
- Forest management (clear-felling, selective logging, planted PFTs







From a C-cycle perspective

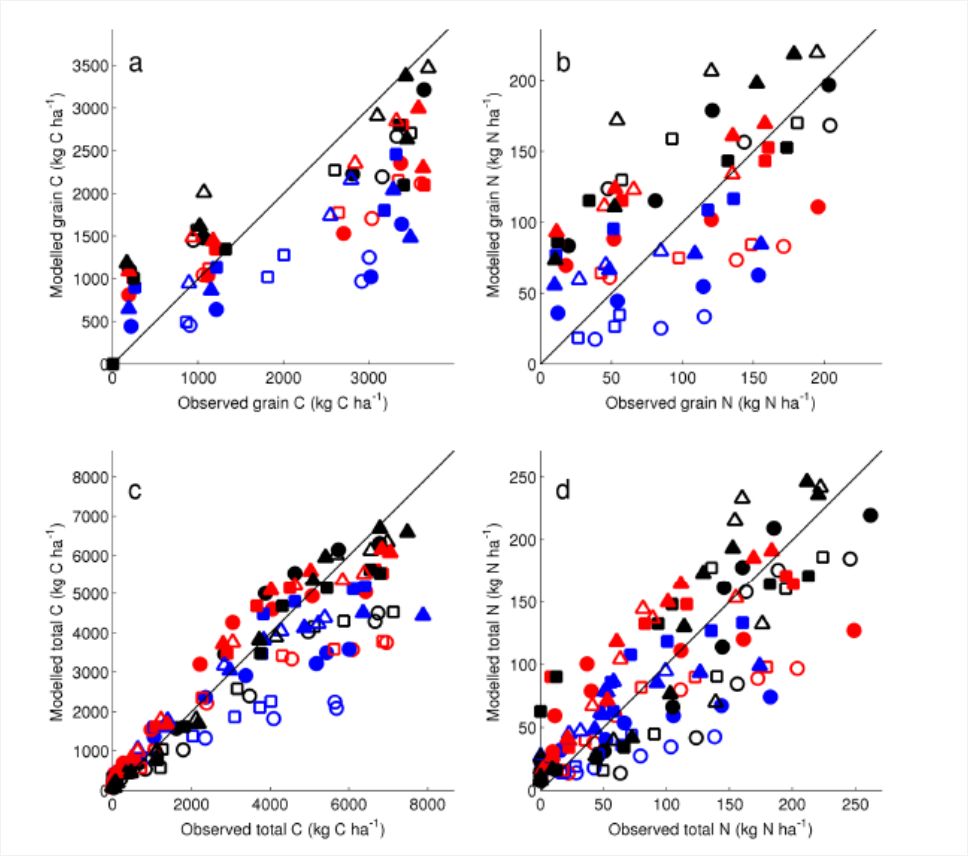
I removed this Figure, since not yet submitted/published. If interested to discuss the work, please contact me directly.

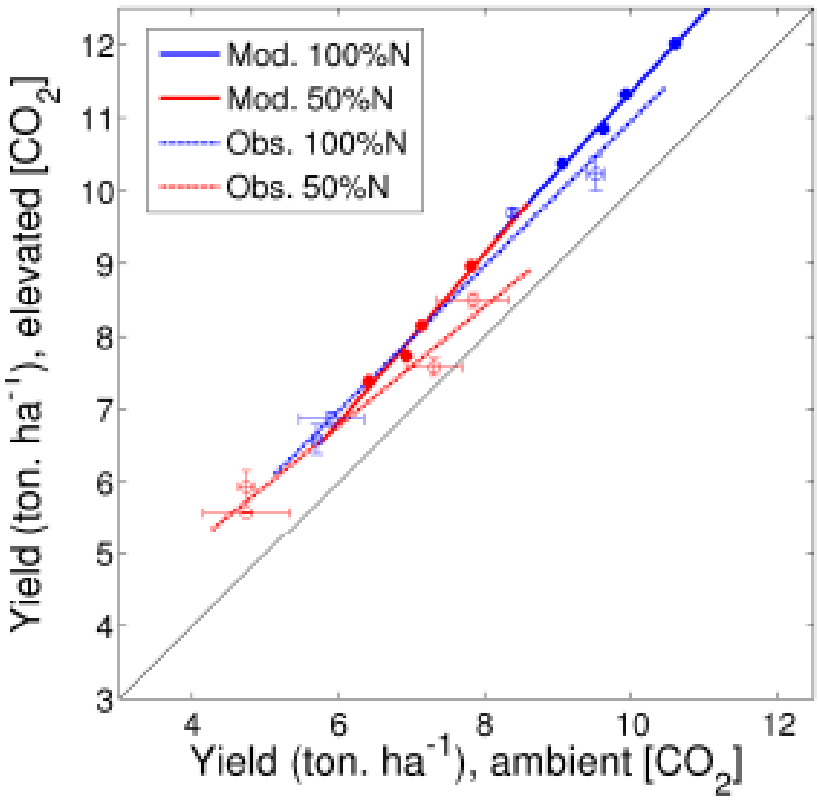
Land management: substantially larger historical F_{LULCC} (double?)

→ Must balance the generally well constrained C-budget: $F_{RL} = E_{Anth} + F_{LULCC} - (Gr_{Atm} - U_{ocean})$
→ Much larger residual sink. Can we fit this into our process understanding?
→ Implications for reforestation potential (and land management)

Arneth et al., in prep.

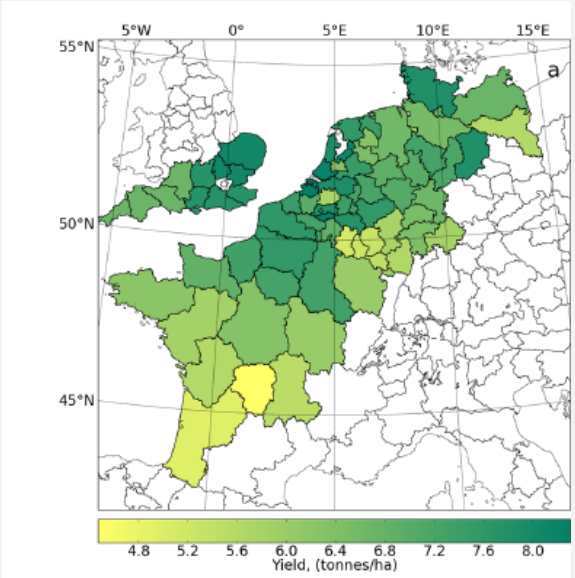
From a yield perspective

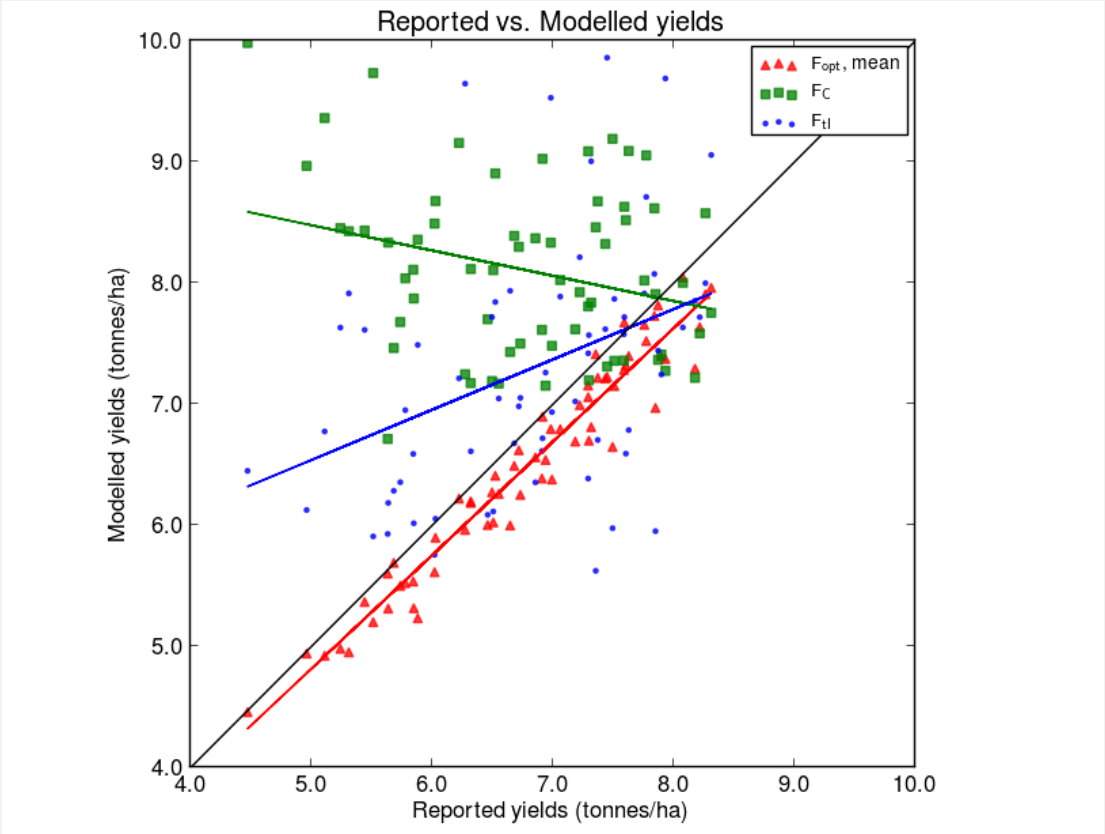




Coupled CN dynamics in modelled crops improve yield response to enhanced CO_2

Olin et al., ESD2015; Olin et al., BG 2015



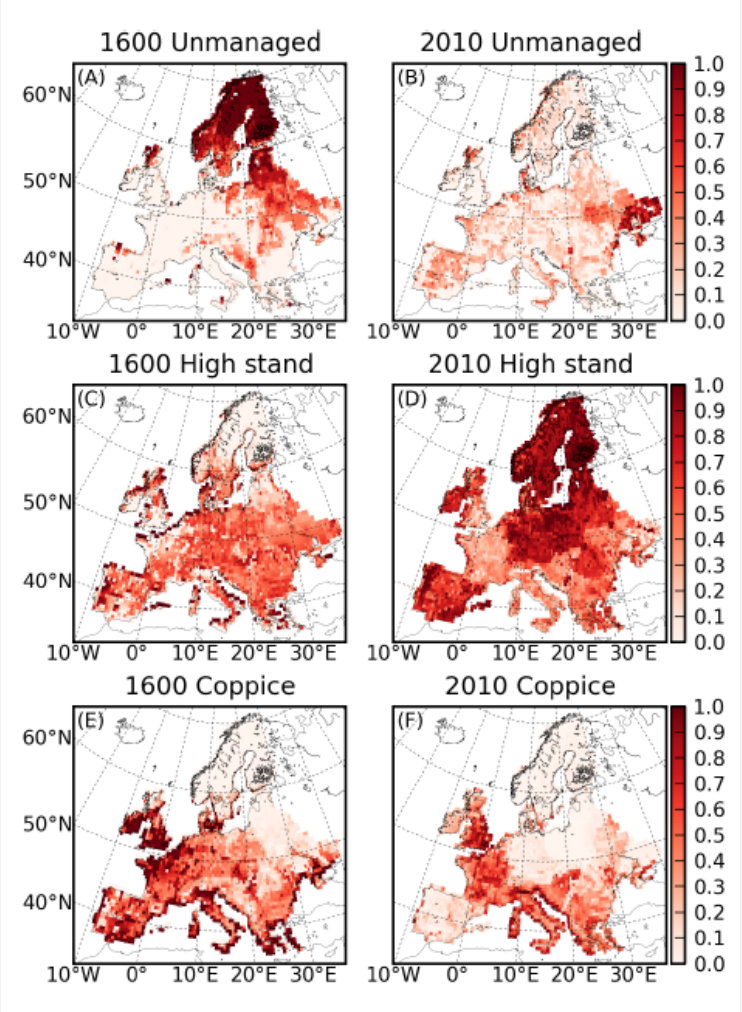


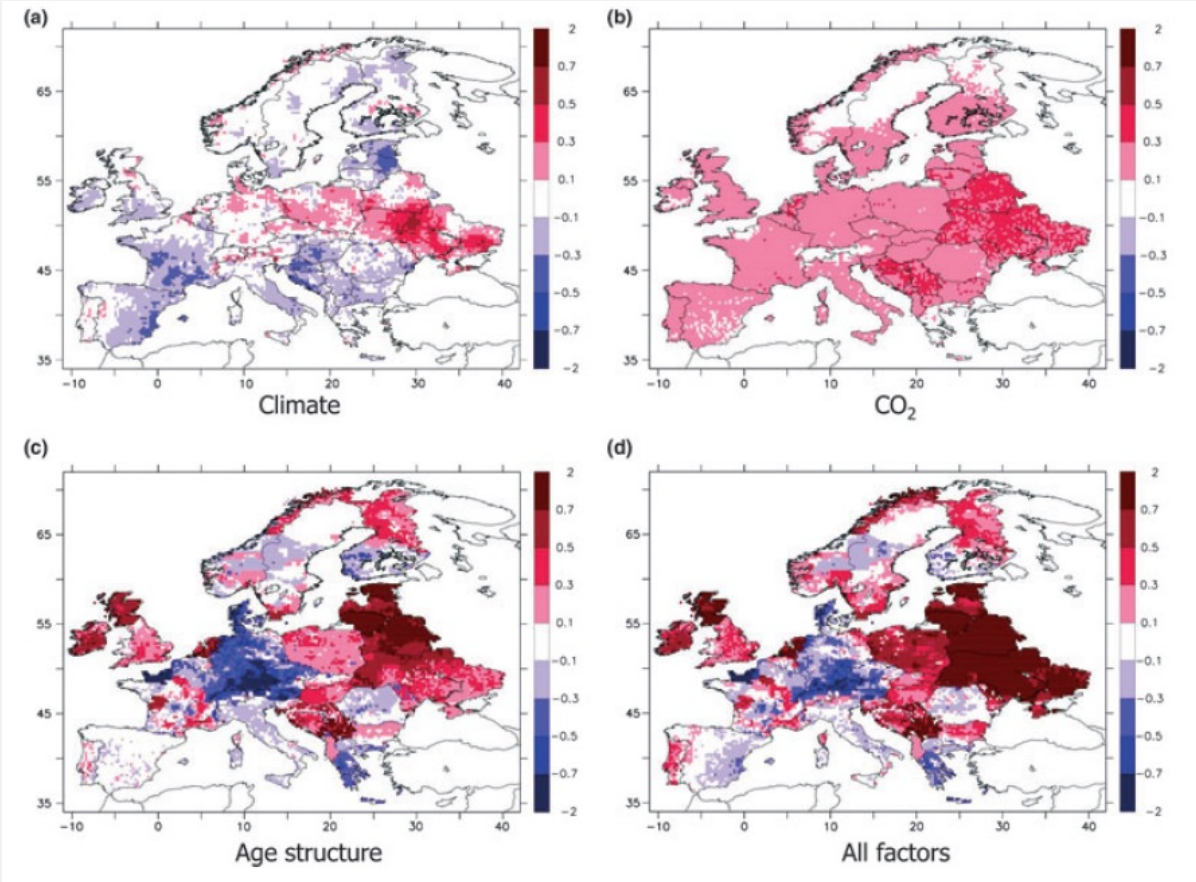
N is essential for getting yields correct (now, that's a surprise…)

But: needs gridded information on fertiliser amount (minimum: annual totals) – and type (mineral vs. manure)

Olin et al., ESD2015; Olin et al., BG 2015

Forest management





Even forest age is an important factor for C-fluxes → species, rotation length, clear-cut vs. selective logging etc. ?

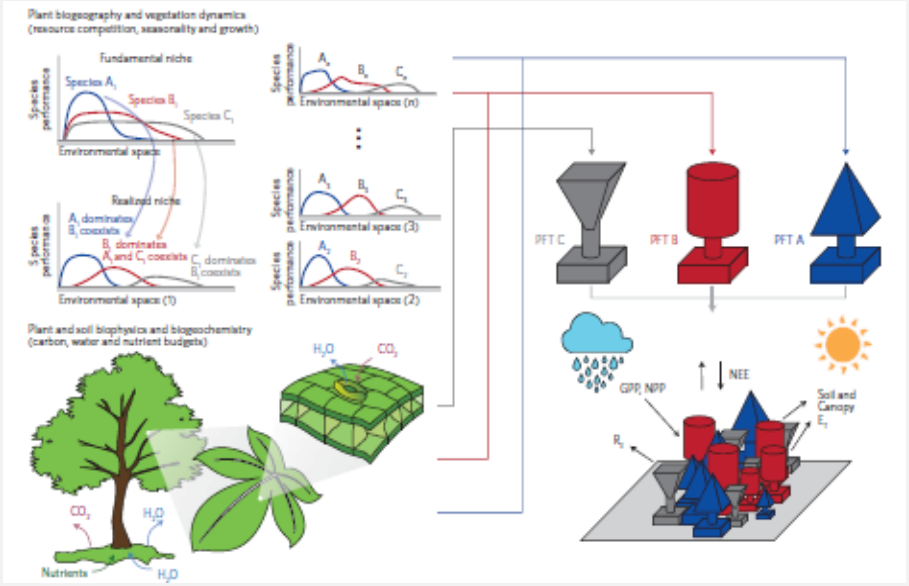
McGrath et al., BGS 2015; Belassen et al., GCB 2014

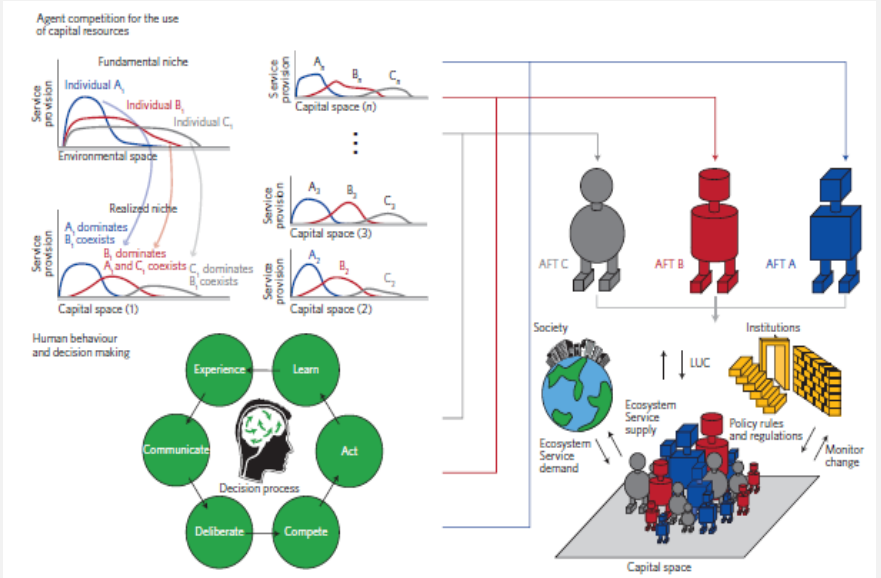
Open issues

1) The “how to” of LUC in DGVMs still poorly understood

2) Requires information beyond crop area changes

3) Forest and pasture area and management – should become a focus of LU models – need foresters and pastoralists as (globally operating) agents, not “only” farmers





Arneth et al., Nature CC, 2014

With input from/thanks to:

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Etc!