Questions

1/ Crops

- What is the impact of different management practices on the ability of the agriculture for carbon mitigation

-In particular what is the real potential of first generation of biofuel for carbon mitigation.

-What are the solutions to solve the trade off between increasing food demand and potential negative effect of climate change on agriculture

-What was the evolution of crops during the 20th century and is impact on the global carbon cycle.

Management practices

- Management of harvest residues
- Tillage
- Mineral / N - fertilization
- Irrigation
- Improvement of cultivar species
- Intercropping
- Plant breeding
- Pesticides application
- Machinery
- …

Bondeau, et al, 2007; Ciais, et al 2010

The management of harvest residues has the largest impact, followed by **tillage** and by **N-fertilizer additions**

- **⊿C** the change in the input of non-harvested biomass returned to the soil
- **NBP** (net biome productivity), equaling for croplands the soil C balance, by convention a>0 sign corresponds to an **ecosystem sink**
- **Reversal date years** = the year at which the arable soils stop loosing C after intensification of agriculture, and begin to gain C thereafter

Table 1 Summary of the ORCHIDEE-STICS ensemble of the European C balance simulations, integrated from 1901 to 2000

		Input of carbon to the soil ($t C ha^{-1} yr^{-1}$)			Arable soil carbon density ($t C ha^{-1}$)			NBP* ($t C ha^{-1} yr^{-1}$)	
	Simulation parameters	INIT 1901	1991–2000	ΔI	INIT 1901	1991–2000	ΔC	1991–2000	Reversal date years
CNT (control)	Mineral N fertilizers increase from 1951 to 2000† Harvest index increase from 1981 to 2000† Tillage intensity is moderate from to 1951 to 2000‡	3.51	3.80	0.29	56.2	55.3	−0.9	0.16	1965
S1-HI	Residues are left in the field between 1951 and 2000	3.51	5.95	2.43	56.2	78.7	22.5	0.72	1957
S1-LO	100% residues exported between 1951 and 2000	3.51	2.37	−1.14	56.2	39.7	−16.5	−0.23	None
S2-HI	Manure ($2 t ha^{-1}$) remains applied between 1951 and 2000 with mineral fertilizers	3.51	4.30	0.79	56.2	62.8	6.6	0.17	None
S2-LO	Manure between 1951 and 2000 but no mineral fertilizers Harvest index fixed at ancestral value from 1951 to 2000	3.51	3.54	0.03	56.2	54.1	−2.1	−0.006	None
S3-HI	No tillage between 1951 and 2000§	3.51	3.80	0.29	56.2	60.9	4.7	0.20	1957
S3-LO	Intensive tillage, with intensity increased¶	3.51	3.80	0.29	56.2	49.3	−6.9	0.13	1971

Some key output variables are the change in the input of non-harvested biomass returned to the soil, net soil C balance (NBP), and the reversal date (the year at which the arable soils stop loosing C after intensification of agriculture, and begin to gain C thereafter). Arable land is defined as the area that is arable by year 2000.

*NBP is defined over the period 1991–2000; by convention a > 0 sign corresponds to an ecosystem sink.

†See Gervois *et al*. (2008) for details of the simulation parameters.

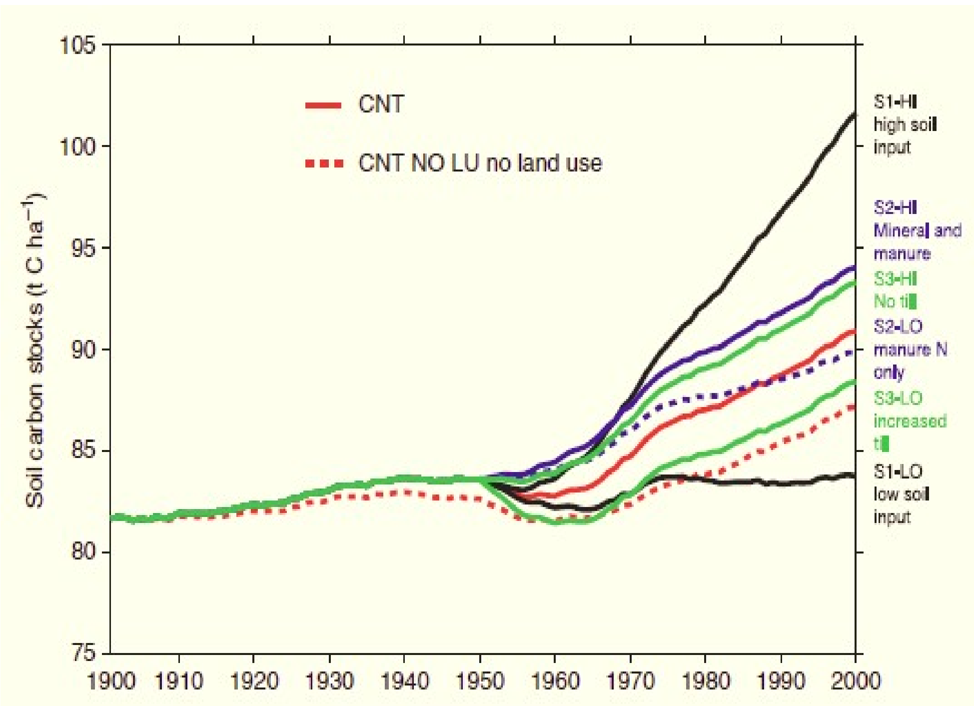
‡From 1901 to 2000, a 10% reduction in mean residence time of arable soil carbon is assumed.

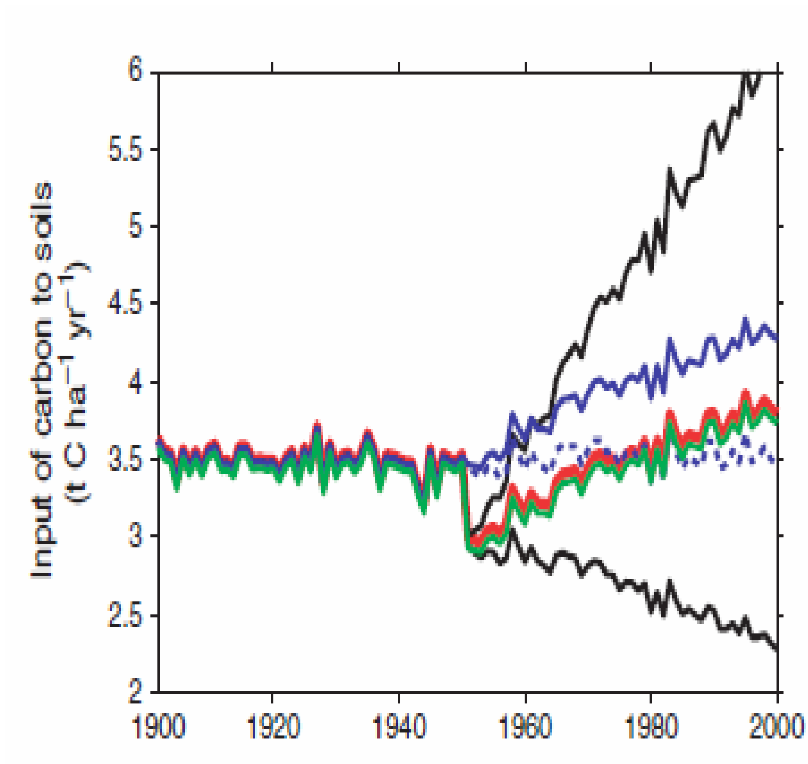
§From 1951 to 2000 no reduction in mean residence time of soil carbon, compared with 10% before.

¶From 1951 to 2000 a 20% reduction in mean residence time of soil carbon, compared with 10% before.

(Ciais, et al 2010)

- In particular what is the real potential of first generation of biofuel for carbon mitigation.





(Ciais, et al 2010)

- What are the solutions to solve the trade off between increasing food demand and potential negative effect of climate change on agriculture

Four strategies

- Halting agricultural expansion
- Closing ‘yield gaps’ on underperforming lands
- Increasing cropping efficiency
- Shifting diets and reducing waste

All four strategies are needed to meet our global food production and environmental goals; no single strategy is sufficient.

Adding them together, they increase global food availability by 100–180%, meeting projected demands while lowering greenhouse gas emissions, biodiversity losses, water use and water pollution.

(Foley, et al 2011)

Specific land use, agricultural and food system tactics must be developed and deployed. Fortunately, many such tactics already exist, including:

precision agriculture, drip irrigation, organic soil remedies, buffer strips and wetland restoration, new crop varieties that reduce needs for water and fertilizer, perennial grains and tree-cropping systems, and paying farmers for environmental services.

However, deploying these tactics effectively around the world requires numerous economic and governance challenges to be overcome. For example,

reforming global trade policies, including eliminating price-distorting subsidies and tariffs, will be vital to achieving our strategies.

(Foley, et al 2011)

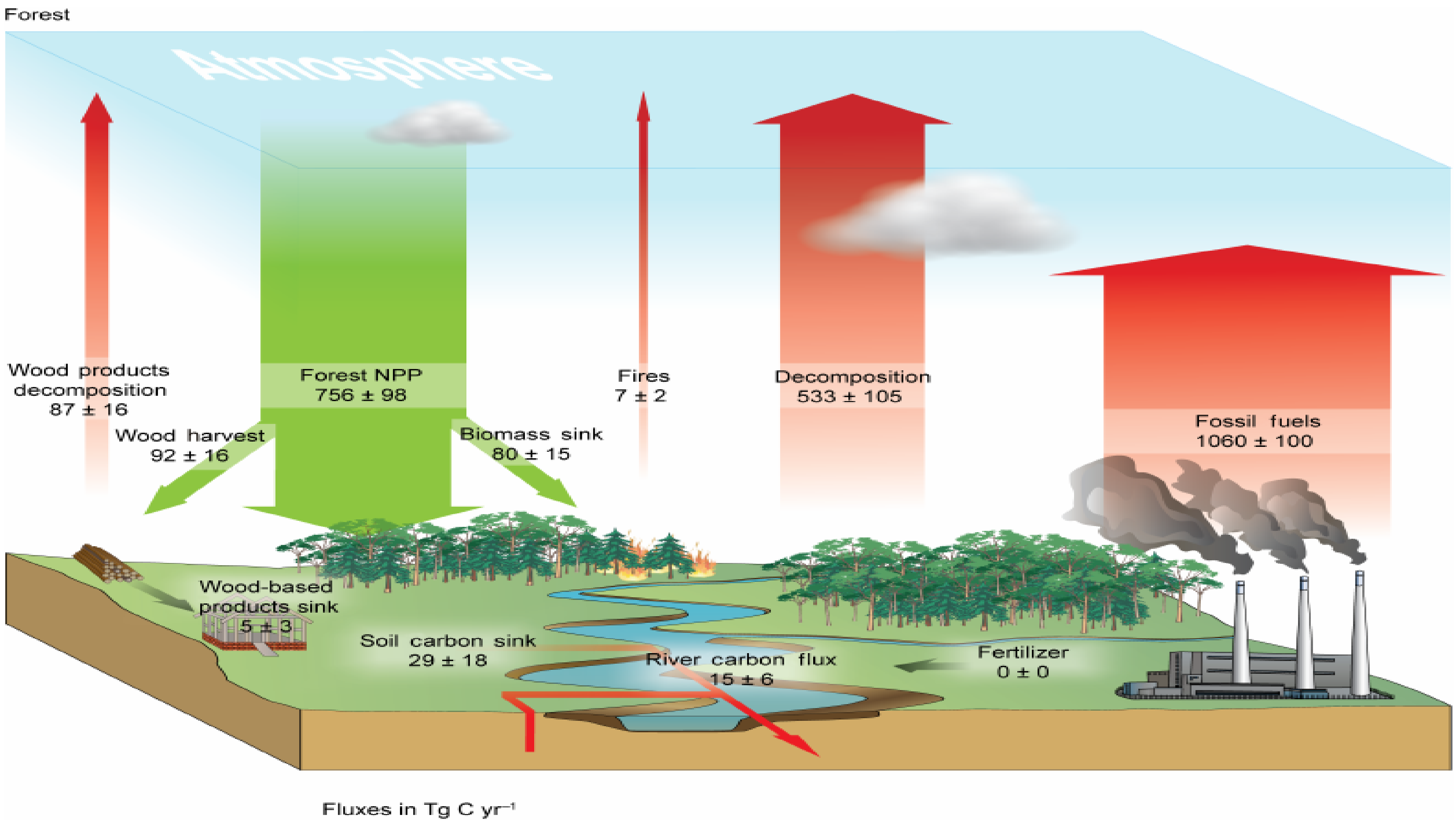
- What was the evolution of crops during the 20th century and is impact on the global carbon cycle.

Global simulations indicate due to agriculture, a 24% (respectively 10%) reduction in global vegetation (respectively soil) carbon, and 6–9 PgC of yearly harvested biomass in the 1990s.

LPJmL simulates a net carbon source until the 1970s (due to land use), and a small sink (mostly due to changing climate and CO2) after 1970, in contrast to simulations of the potential natural vegetation showing the land biosphere to be an increasing carbon sink during the 20th century, 2/ Disturbances:

- What are the most important forest disturbances with regards to the carbon cycle?

Fires, storms and pests



16TgCyr^{-1} out of 685 TgCyr^{-1} (the sum of wood harvest, fires and heterotrophic respiration) is due to natural disturbances such as fires, storms and pests. (Luyssaert et al, 2010)

Natural disturbances in the European forests
(19th and 20th centuries)

Storms	53%
Fires	16%
Biotic factors	16%
Snow	3%
Other abiotic causes	5%
No cause or a combination of causes	7%

(Schelhaas et al, 2003)

- Are these disturbances similar in all biomes?

Table 2. Combustion Efficiencies for Fuels Affected by Fires[a]

Biome Type	C_w	C_l	C_{cwd}	C_{lit}	M
1	0.3	0.9	0.9	0.9	0.1
2	0.5	0.9	0.5	0.7	0.5
3	0.5	0.8	0.5	0.9	0.2
4	0.3	0.8	0.5	0.8	0.9
5	0.3	0.8	0.4	0.4	0.36
6	0.5	0.75	0.01	0.2	0.03
7	0.5	0.75	0.01	0.2	0.001
8	0.6	0.9	0.6	0.9	0.9

a Subscripts indicate w: wood, l: leaves, lit: litter, cwd: coarse woody debris.
M is the percentage of trees (wood biomass) affected by fires.

Biome types are: (1) broad leaf evergreen trees, (2) broad leaf deciduous trees, (3) mixed trees, (4) needleleaf evergreen trees, (5) high latitude deciduous trees, (6) grass with 10–40% trees, (7) grass with >10% trees, (8) shrubs.

(Mouillot et al, 2006)

- How important are disturbances for the global forest carbon cycle?

16TgCyr^{-1} out of 685 TgCyr^{-1} (the sum of wood harvest, fires and heterotrophic respiration) is due to natural disturbances such as fires, storms and pests.

(Luyssaert et al, 2010)

3/ Forest sink

- Which are the different methods to estimate the forest sink?

- What is the uncertainty and scale(s) associated with each method?

- What are the strengths and weaknesses of each method?

approaches		scale	uncertainty	strenths	weaknesses
stock-change	The stock change approach involves estimating C stocks at two or more points in time, then taking the difference between the stock estimates as the rate of change over the time period.	**For boreal and temperate biomes,** following the guidance from IPCC for estimating and reporting country-level greenhouse gas inventories	Generally, estimates for temperate and boreal forests have lower uncertainty than estimates for intact or tropical regrowth forests because they are based on unbiased statistical sample surveys of all vegetation types and conditions. Also, estimates of above-ground biomass C stocks and changes in C stocks have lower uncertainty and more consistent results even with different estimation approaches, while there remains greater uncertainty and inconsistency in both data and methods for estimating dead wood, litter, soil, and harvested wood C stocks and changes in these stocks	lower uncertainty	need the repeated national-scale forest inventories
default	The IPCC default approach commences with a single forest inventory and then adds C gains from forest growth and losses from harvest, fires and decomposition	**For boreal and temperate biomes**, following the guidance from IPCC for estimating and reporting country-level greenhouse gas inventories		For C stock gains and losses without confounding estimates through C transfers between land-use categories.	need the repeated national-scale forest inventories
flow	Fluxes were estimated from measured C stock changes on permanent sample plots, which is nearly equivalent to forest-atmosphere C exchange except for river transport and deposition of C	**For most tropical areas** which lack the repeated national-scale forest inventories, not affected by land use or change		solve the problem that lack of inventories	high uncertainty, no consider of land use change
tier 2	Multiply region-specific estimates of C density or change in C density times the associated areas represented by the region-specific estimates	**For most tropical areas** which lack the repeated national-scale forest inventories, not affected by land use or change		solve the problem that lack of inventories	high uncertainty, no consider of land use change
bookkeeping	The bookkeeping approach keeps track of ecosystem C emissions and harvested wood products from deforestation and logging, and ecosystem C uptake on regrowing forests	**For tropical regrowth forests,** which lack sufficient ground-based data		Based on a literature review of regrowth rates and knowledge of forest areas and conditions; solve the problem that lack of sufficient ground-based data	
empirical modeling	The empirical modeling methods were used to combine data from soil surveys and field studies for developing the soil C estimates.	**In almost every region**		To evaluate forest soil C change over time is particularly challenging	

Thank you for your attention!