Global synthesis of regional C fluxes

P. Ciais, R. Lauerwald, P. Raymond, S.L. Piao,
G. Peters, P. Canadell, R. Andres, A. Peregon, M. Gloor,
H. Dolman, J. Hartmann, V. Haverd, T. King,
S. Luyssaert, P. Patra, P. Peylin, P. Regnier, R. Valentini

+ Y. Yin, R. Wang, S Peng, T Wang, Y Chao, X Wang
N Mc Bean, F Chevallier

Data sources

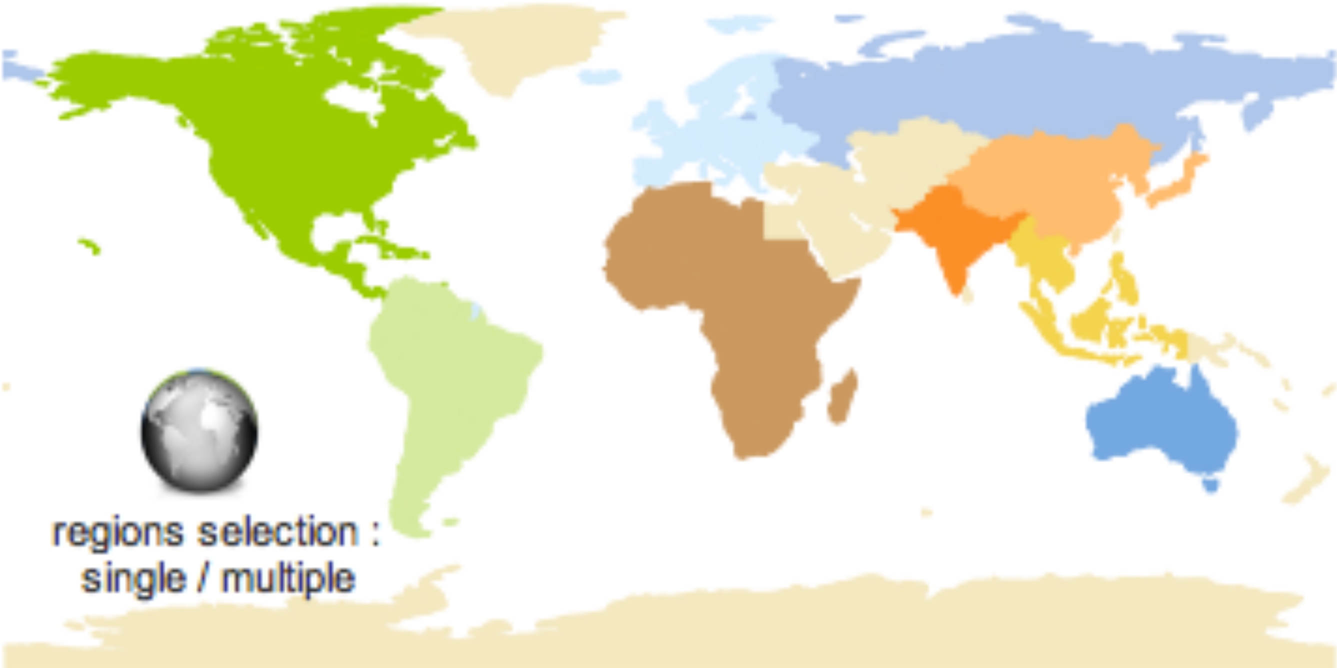
RECCAP synthesis papers Biogeosciences special issue

- N America : King et al. BG submitted
- S America : Gloor et al. BG, 2012
- Africa : Valentini et al. BG 2012
- Europe : Luyssaert et al. BG 2013
- Russia : Dolman et al. BG 2012
- E Asia : Piao et al. BG 2013
- S Asia : Patra et al. BG 2012
- Australia : Haverd et al. BG 2012
- SE Asia : Canadel and Ciais unpublished data

Global datasets collected during or after RECCAP

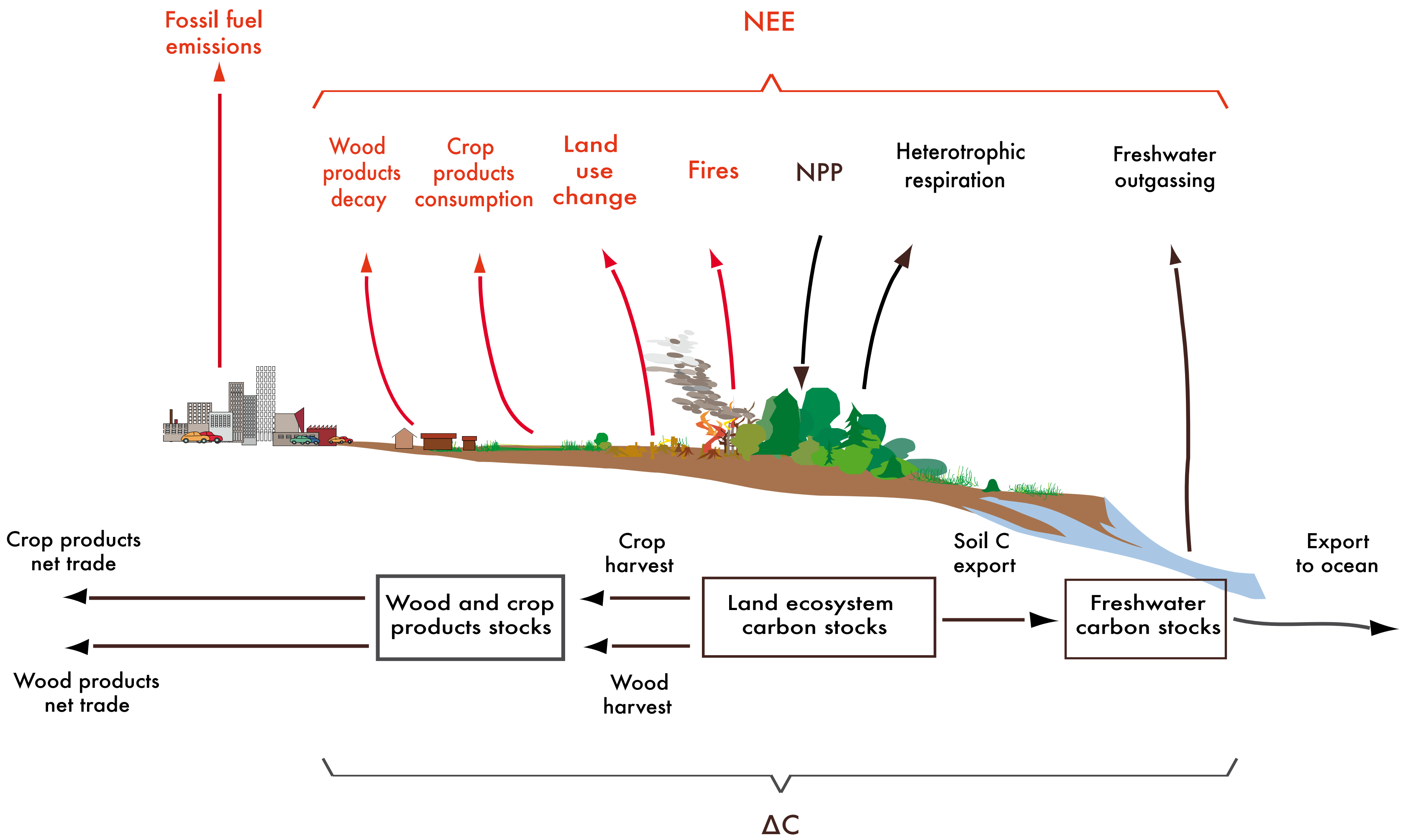
- River and lake outgasing : Raymond et al. 2014 Nature (COSCAT regions)
- DOC, POC, DIC river transport to ocean : Mayorga et al. 2010, Hartmann et al. 2009. Separated lithospheric component of DIC flux by Lauerwald (unpublished data)
- Crop and wood products harvest and trade : Peters et al. BG 2012

Reccap regions

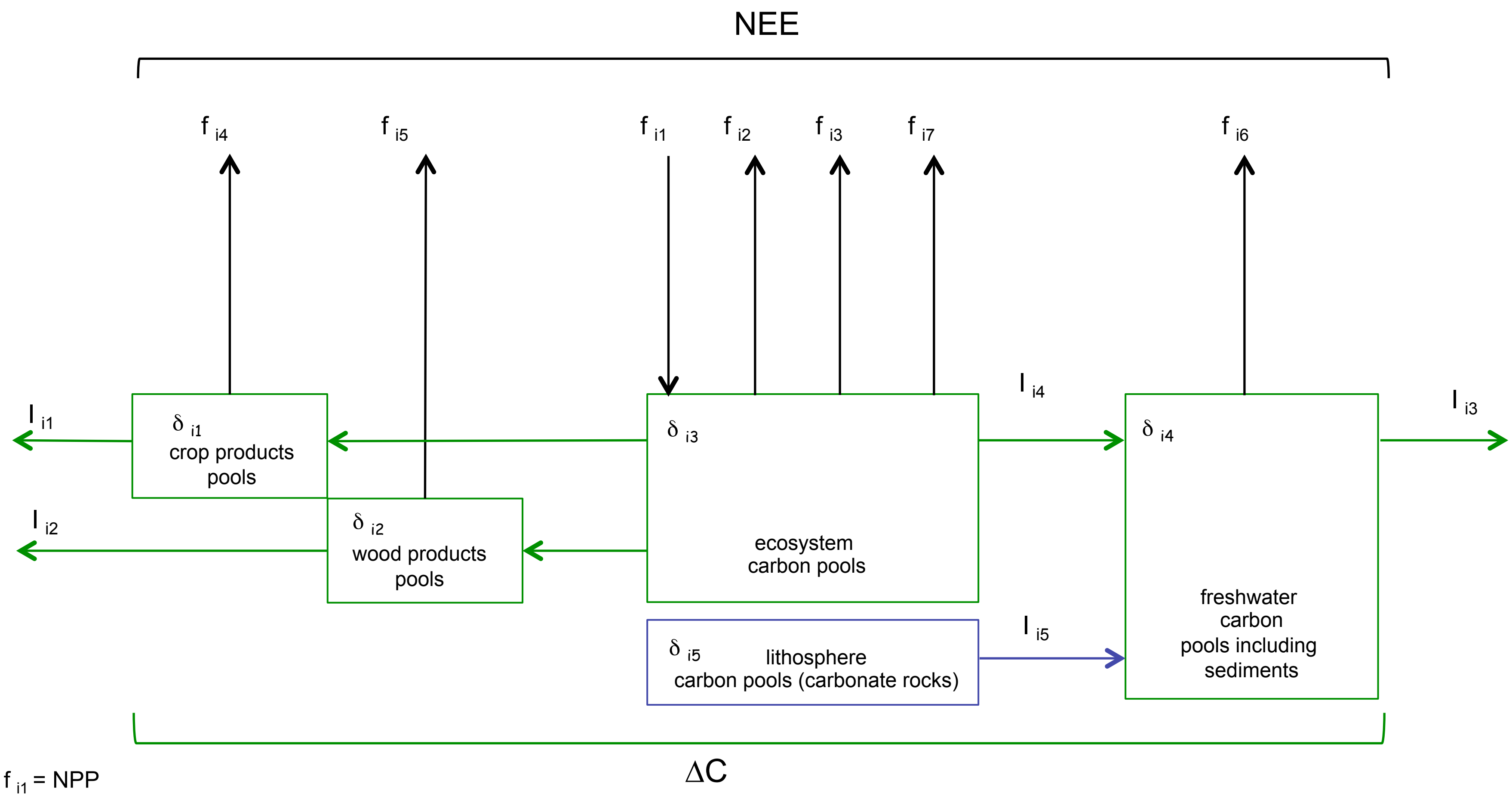


tan color = no data available

Carbon budget of a RECCAP region



Terrestrial carbon budget of each RECCAP region

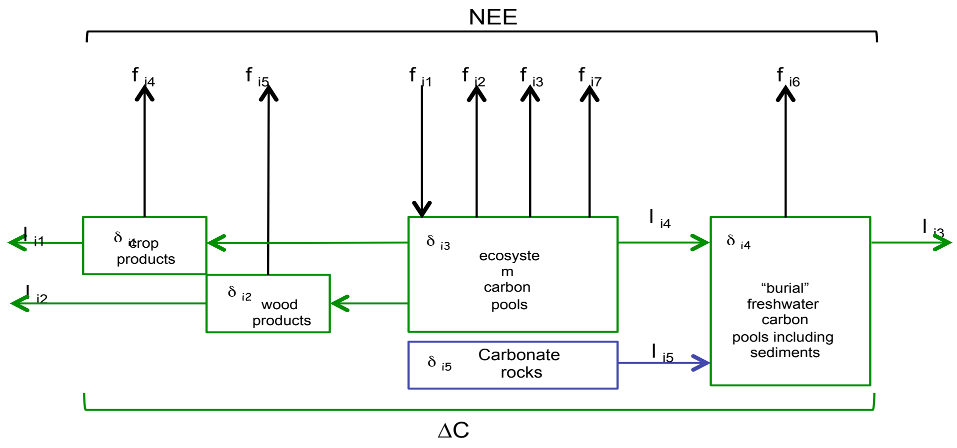


f_{i1} = NPP
f_{i2} = fire emissions
f_{i3} = net land use change flux
f_{i4} = crop product consumption
f_{i5} = wood product decay
f_{i6} = rivers and lakes outgassing
f_{i7} = soil heterotrophic respiration

δ_{i1} = change in crop product pools
δ_{i2} = change in wood product pools
δ_{i3} = change in ecosystem pool
δ_{i4} = change in freshwater and sediment carbon pools
δ_{i5} = change in bedrock carbon pools

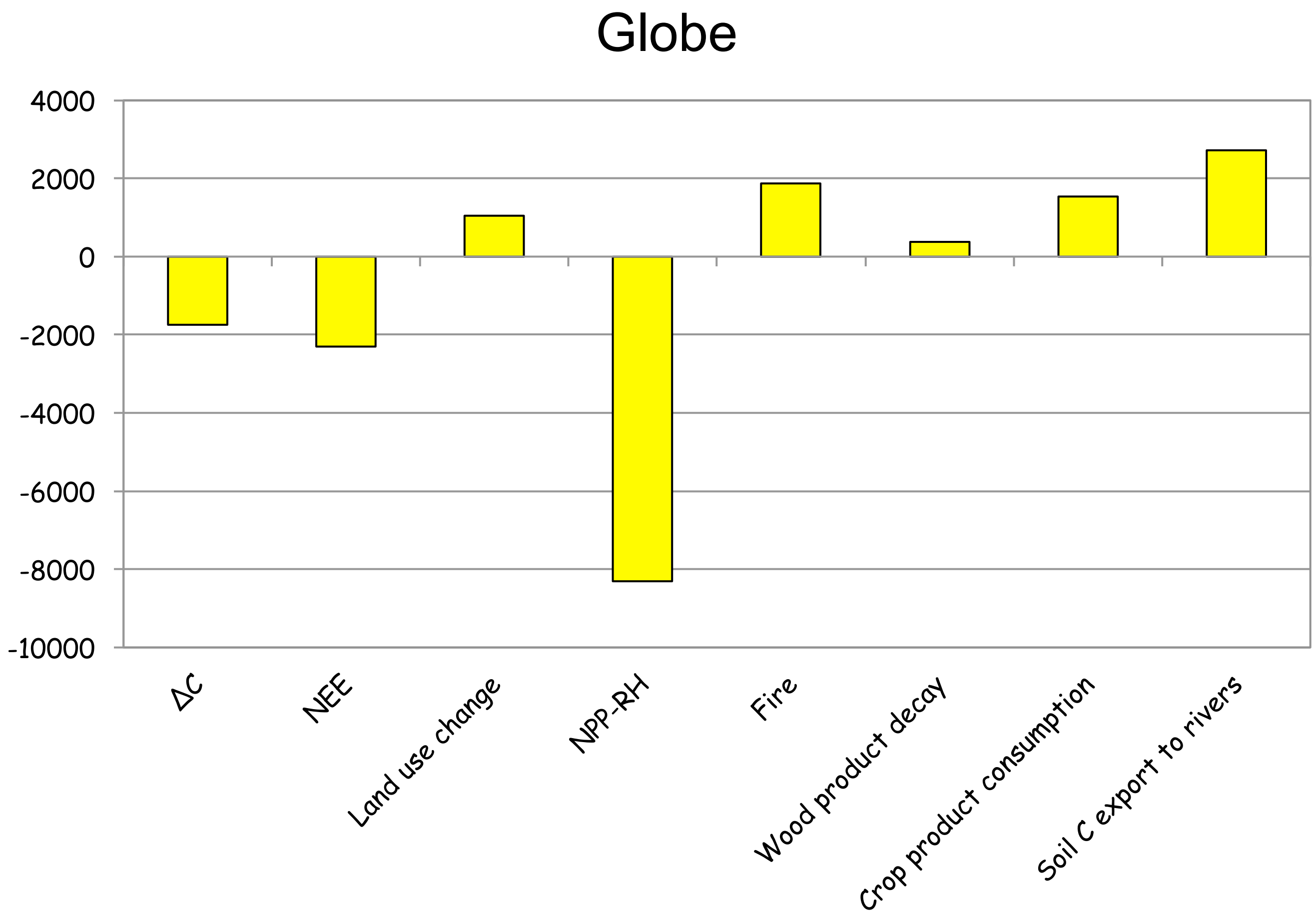
I_{i1} = net export of crop products
I_{i2} = net export of wood products
I_{i3} = export by rivers to ocean (DOC, POC, DIC)
I_{i4} = soil carbon export to rivers headstreams
I_{i5} = export of carbonate DIC to rivers headstreams

Data synthesis strategy - sequential steps

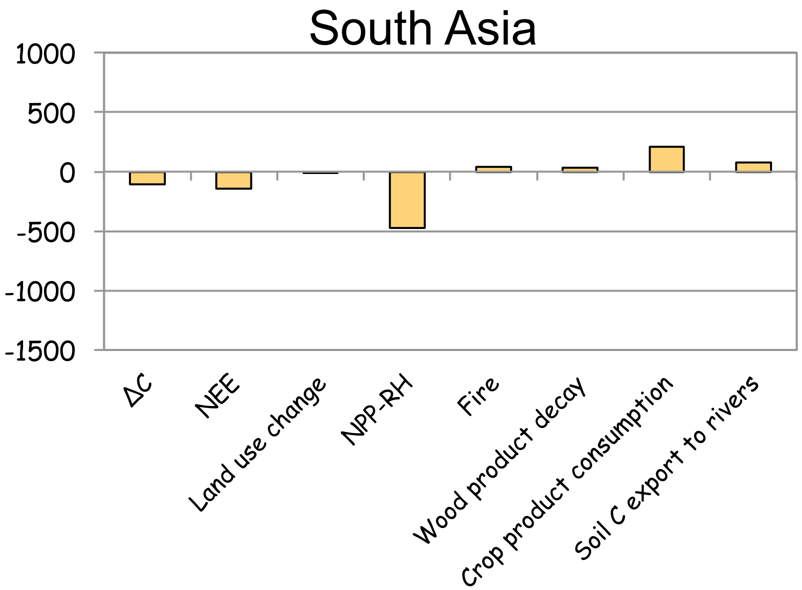


1. Collect ΔC from inventory approaches (empirical models) from RECCAP publications.
   Note that ΔC includes LUC
2. Calculate export fluxes from harmonized global datasets :
   Peters et al. 2012 for crop and wood products trade
   Mayorga et al. 2010 and Hartmann et all. 2009 for river export to the ocean
   separated DIC from carbonate rocks (Lauerwald et al. pers. com.)
3. Outgassing from Raymond et al. Nature 2014 includes rivers and lakes
4. Calculate Soil C export to rivers = outgassing + burial + river-to-ocean – DIC from carbs
5. NEE = ΔC + ∑ exports
6. Calculate soil hetetrotrophic respiration (SHR) as a residual :
   SHR = NPP - NEE wood & crop product consumption – fire – LUC - outgassing

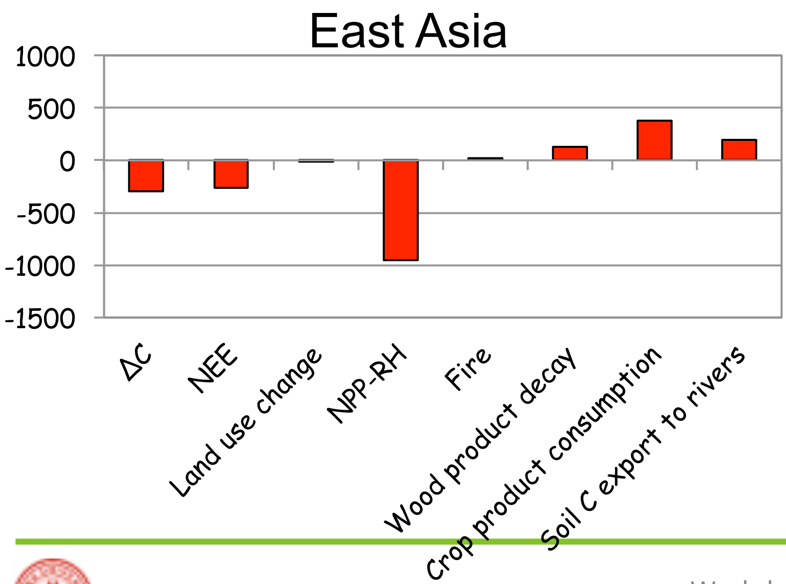
Global NEE components

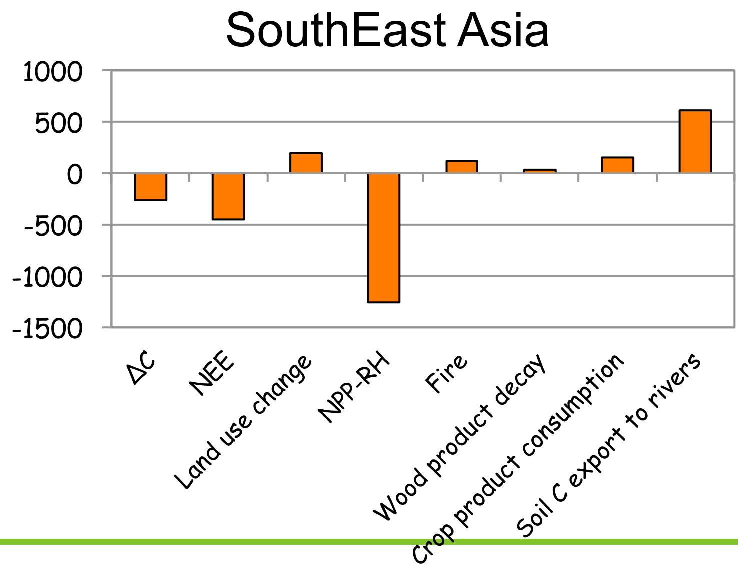


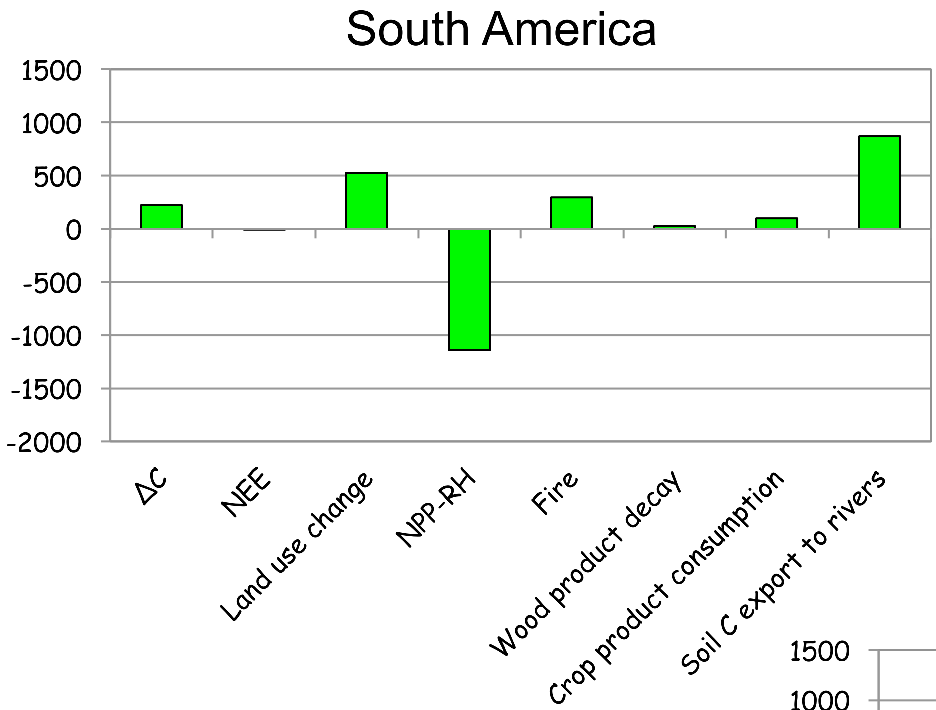
ΔC is usually smaller than NEE because of net export. It can be larger only if imported wood and food products oxidized in the region offset river C export to ocean



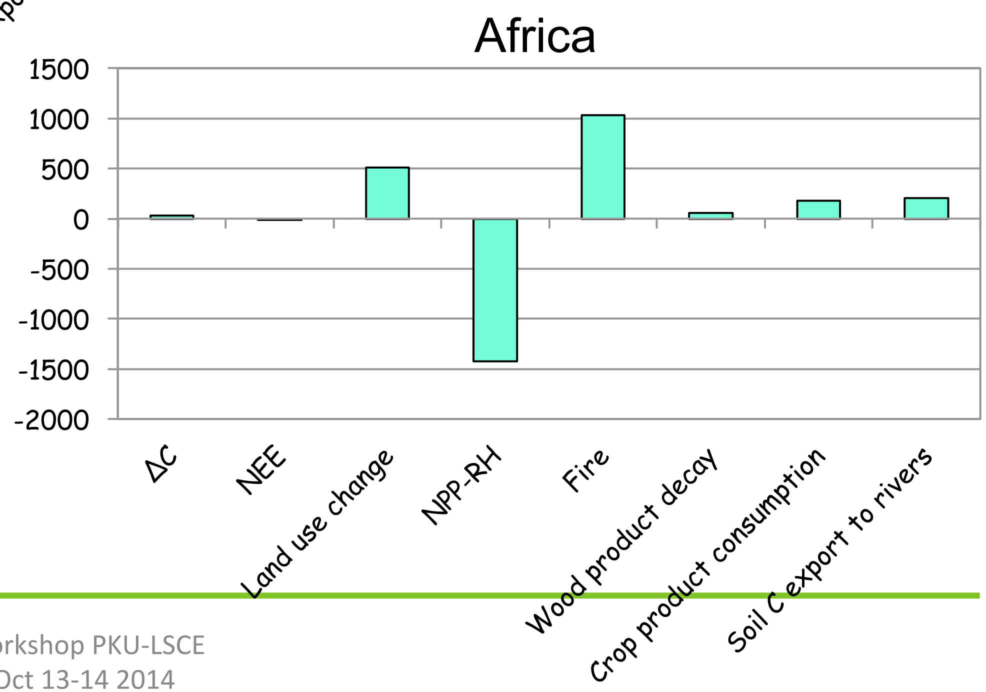
note NEE < ΔC in East Asia
due to crop imports

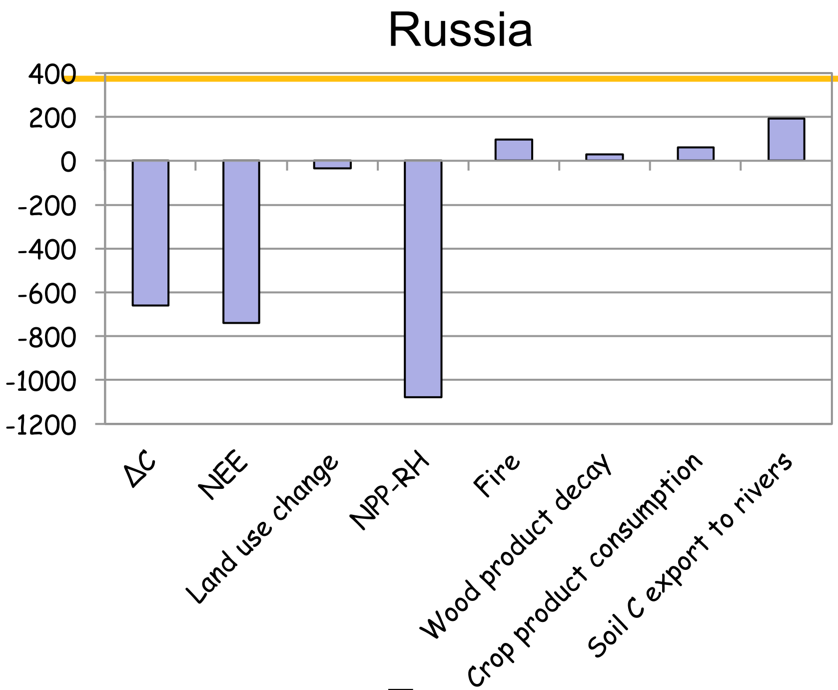






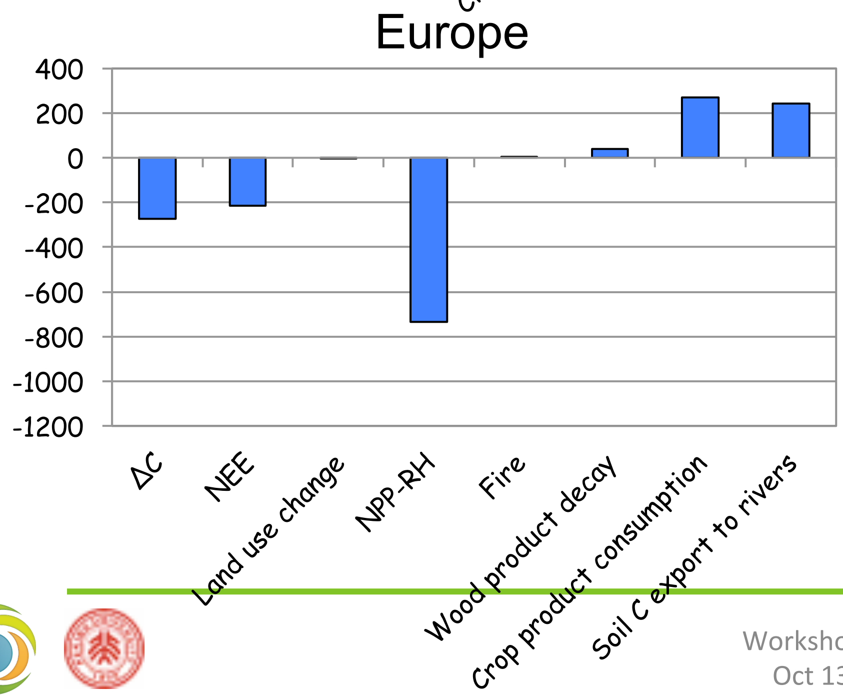
ΔC > 0 is carbon loss
but NEE ≈ 0 because of crop exports
and large river C export

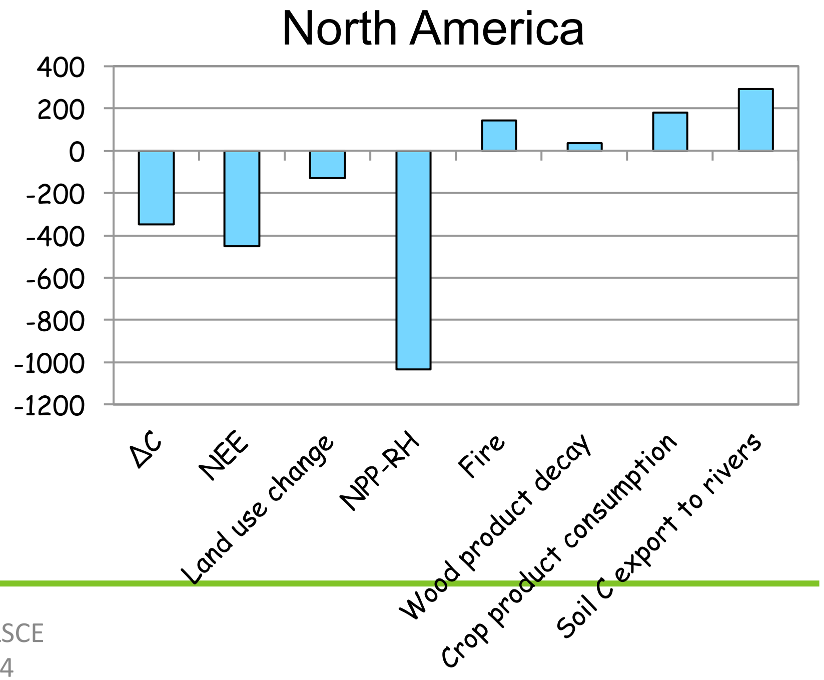


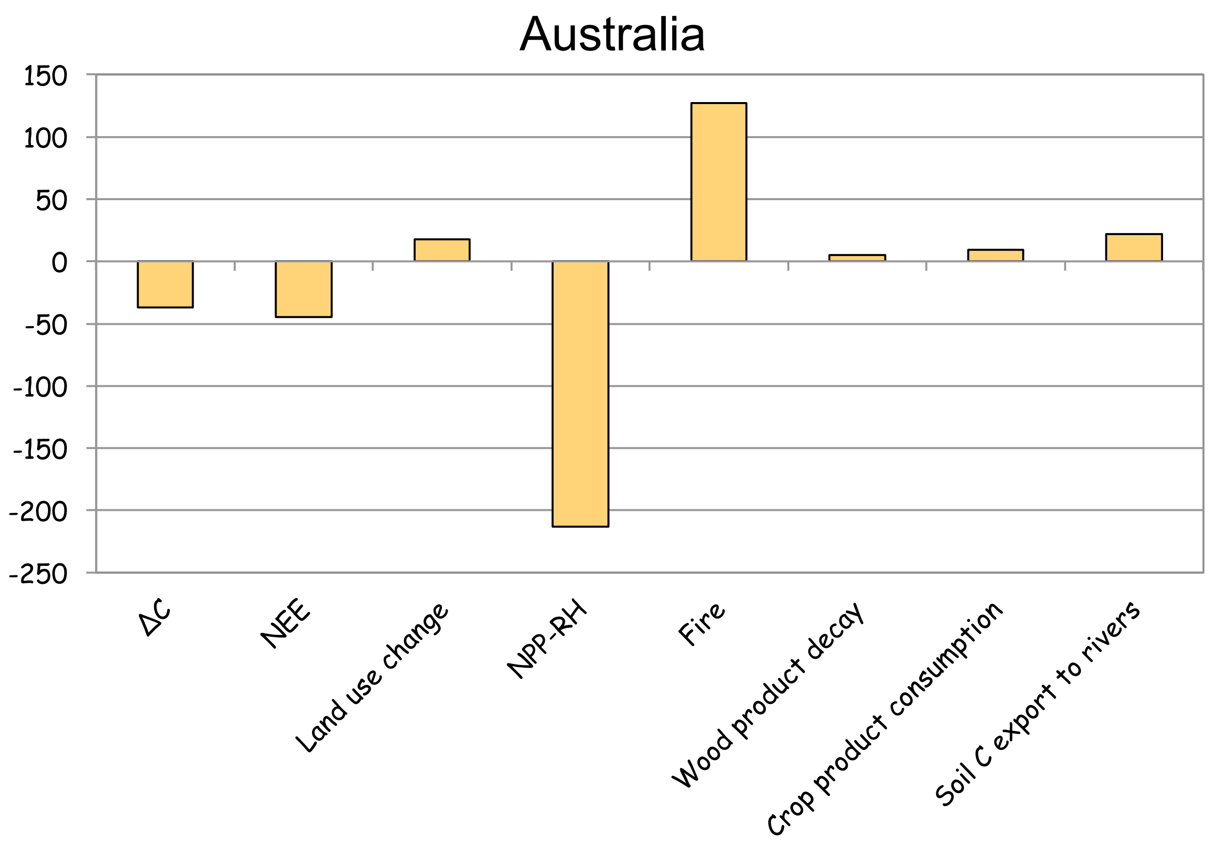


These regions have rather large C pools accumulation

in Europe NEE < ΔC because of crop imports






Australia
150
100
50
0
-50
-100
-150
-200
-250
ΔC
NEE
Land use change
NPP-RH
Fire
Wood product decay
Crop product consumption
Soil C export to rivers

Global budget

Globe	Fossil fuel CO2 emissions	2000-2009	7900	400	Propagated	source
Globe	ΔC	2000-2009 (inconsistent)	-1733	568	Propagated	gain
Globe	NEE	2000-2009 (inconsistent)	-2307	595	Propagated	sink
Globe	Land use change	2000-2009 (inconsistent)	1055	189	Propagated	source
Globe	NPP	2000-2009 (inconsistent)	-55983	5058	Propagated	sink
Globe	Soil Heterotrophic Respiration	2000-2009 (inconsistent)	47675	5115	Propagated	source
Globe	NPP-RH	2000-2009 (inconsistent)	-8308			
Globe	Fire	2000-2009 (inconsistent)	1878	236	Propagated	source
Globe	Wood product decay	2004	385	77	Propagated	source
Globe	Wood export	2004	5	38	Propagated	lateral
Globe	Crop product consumption	2004	1542	120	Propagated	source
Globe	Crop export	2004	46	29	Propagated	lateral
Globe	Soil C export to rivers	undefined	2716	426	Propagated	lateral
Globe	Bedrock C export to rivers	undefined	70		Hartmann et al., 2009	lateral
Globe	Freshwater outgasing	2000s	2112	479	Propagated	source
Globe	River export to ocean	undefined	613	92	Propagated	lateral

$TgC\ yr^{-1}$

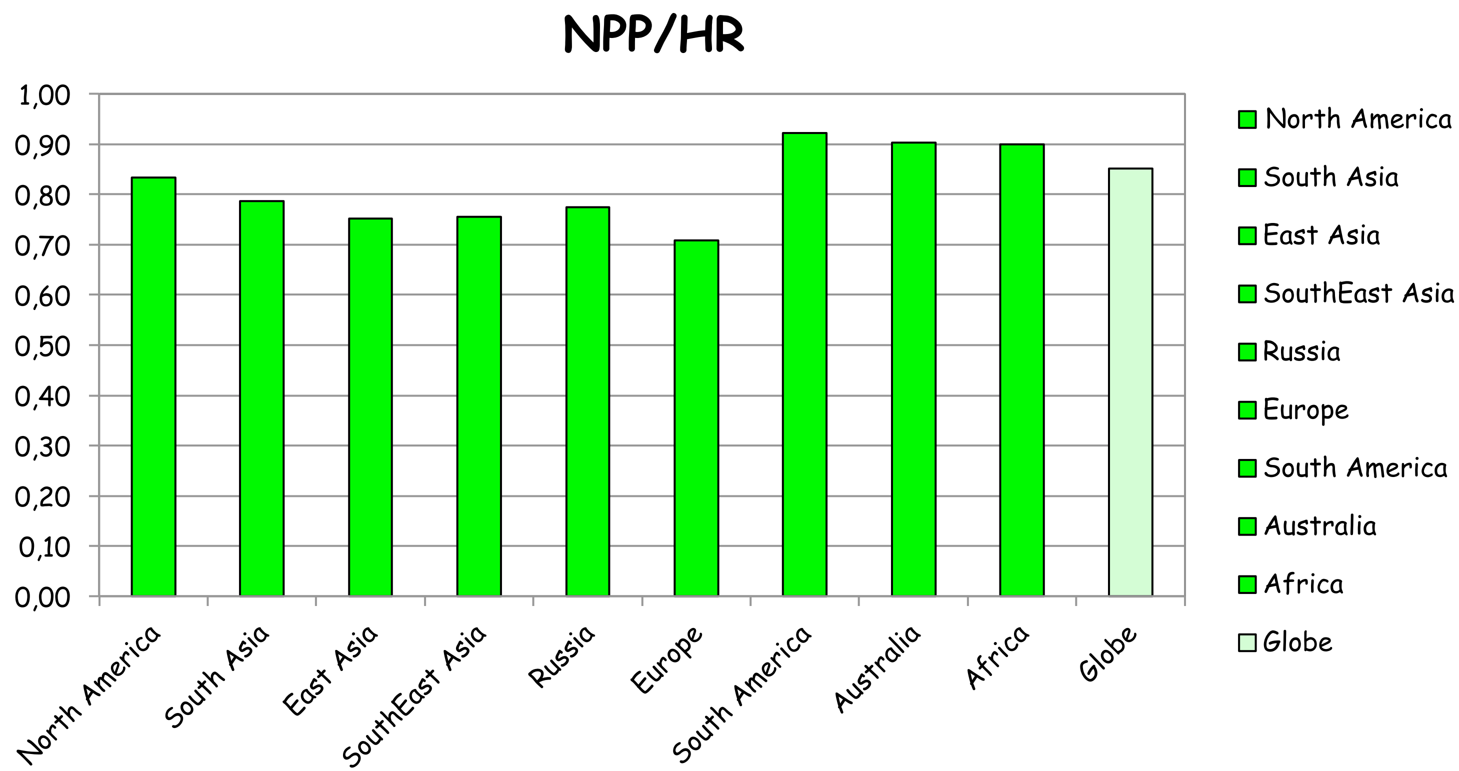
NEE - rivers in 2000-2009 $= 1.7 \pm 0.6\ Pg\ C\ y^{-1}$

NEE - rivers in 1850 $= 1.9 \pm 0.6$

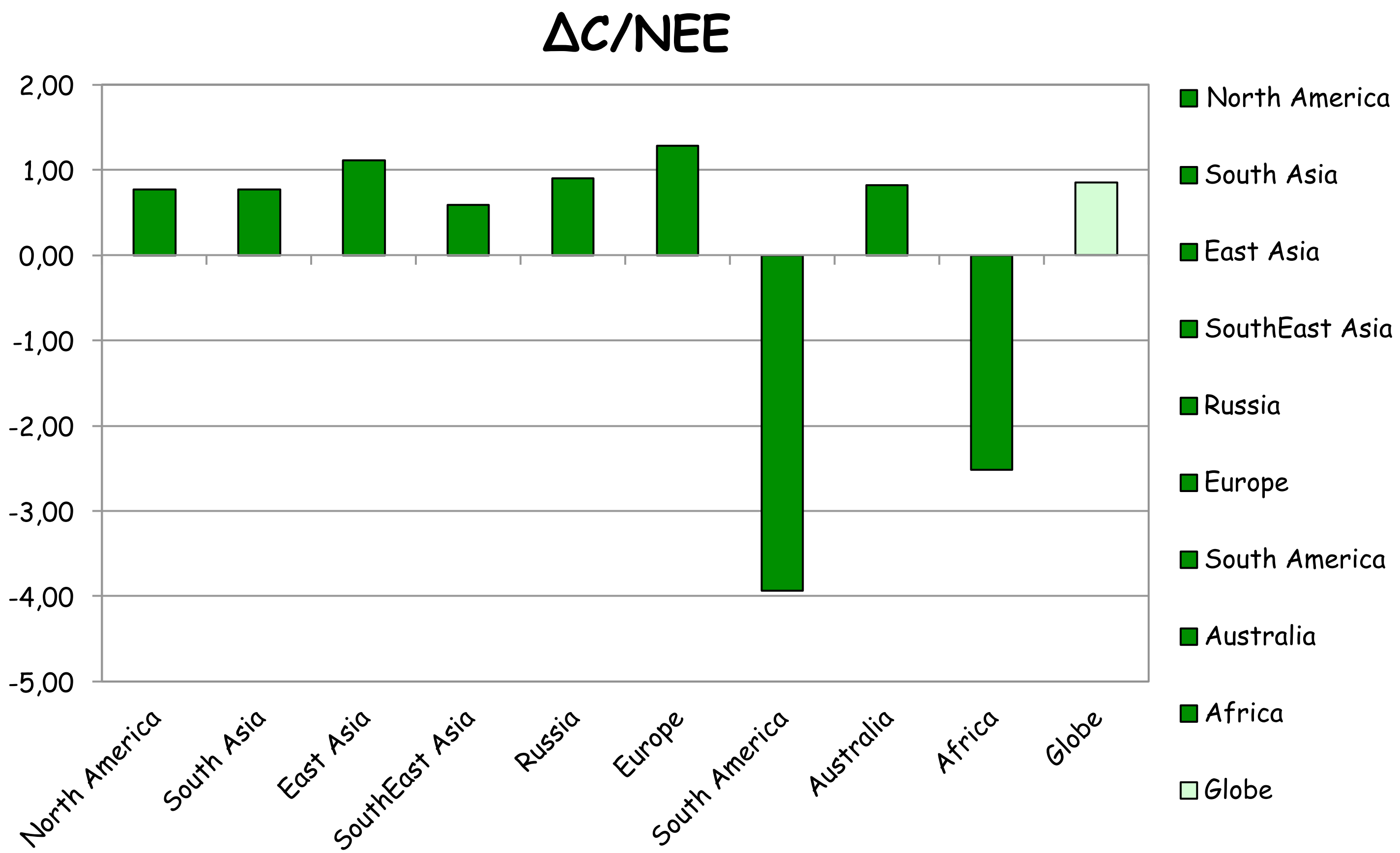
GCP $E_{LUC} + S_{LAND}$ $= 1.4 \pm 0.9$

Heterotrophic respiration efficiency ε

regions will less intensively managed ecosystems have a higher ε

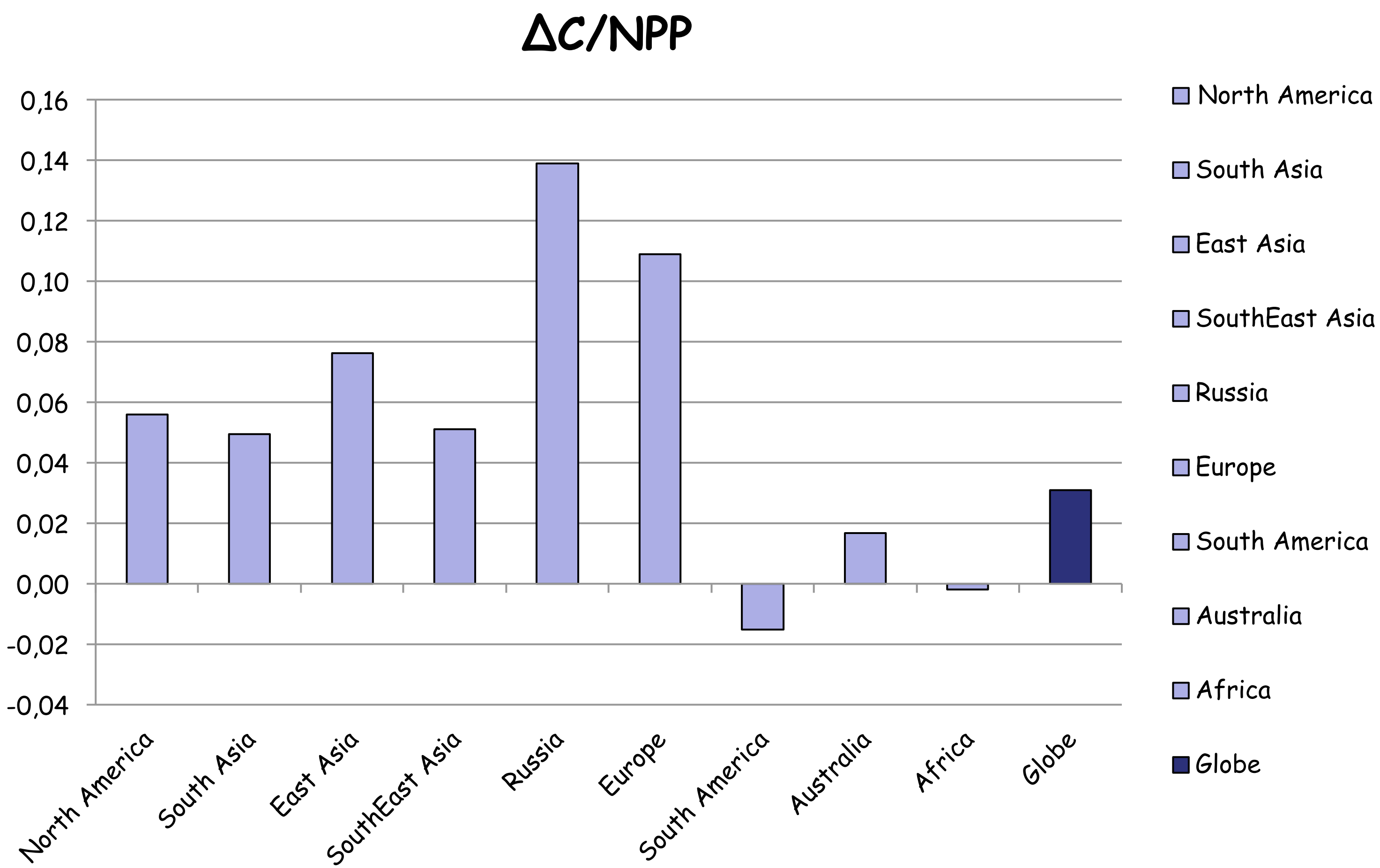


Carbon storage efficiency of NEE



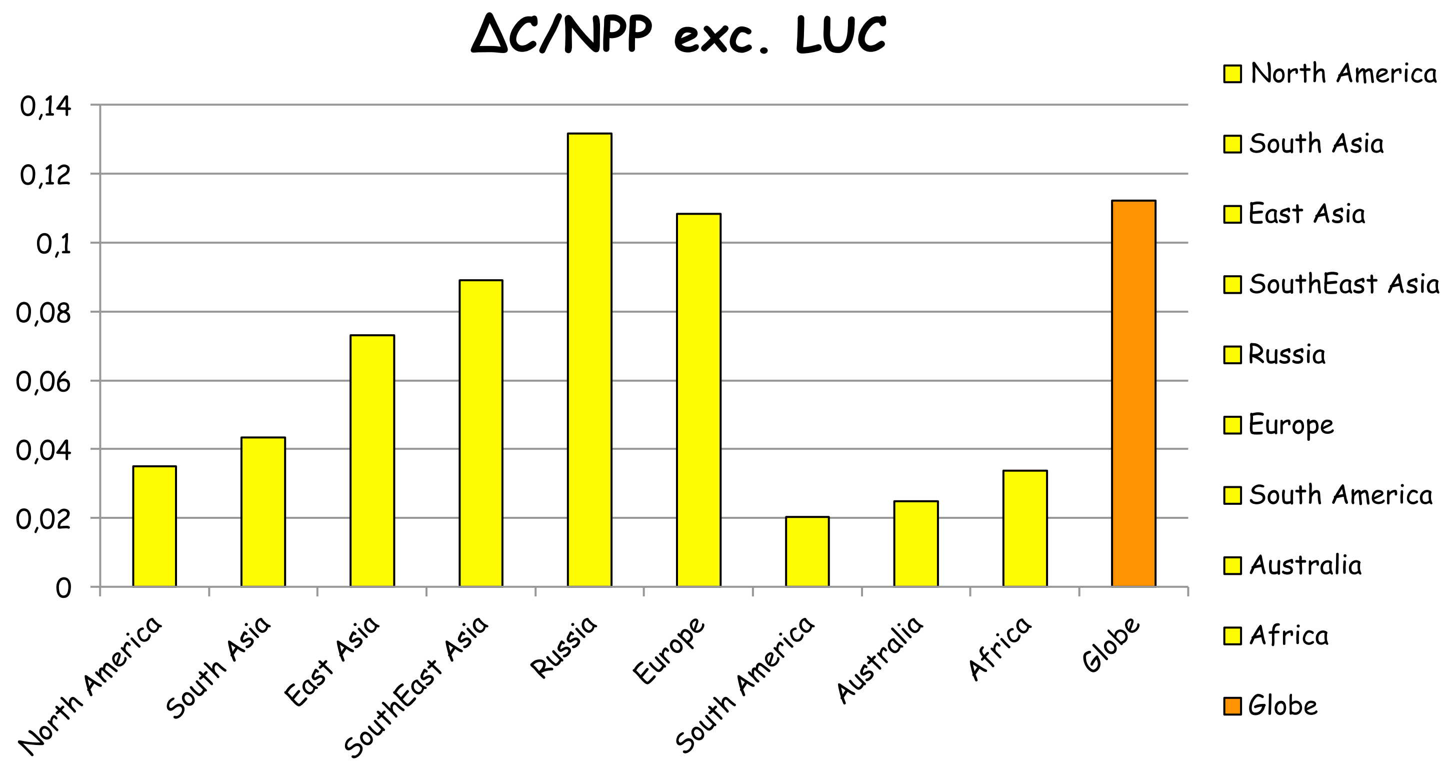
S America value divided by 10

Carbon storage efficiency of NPP

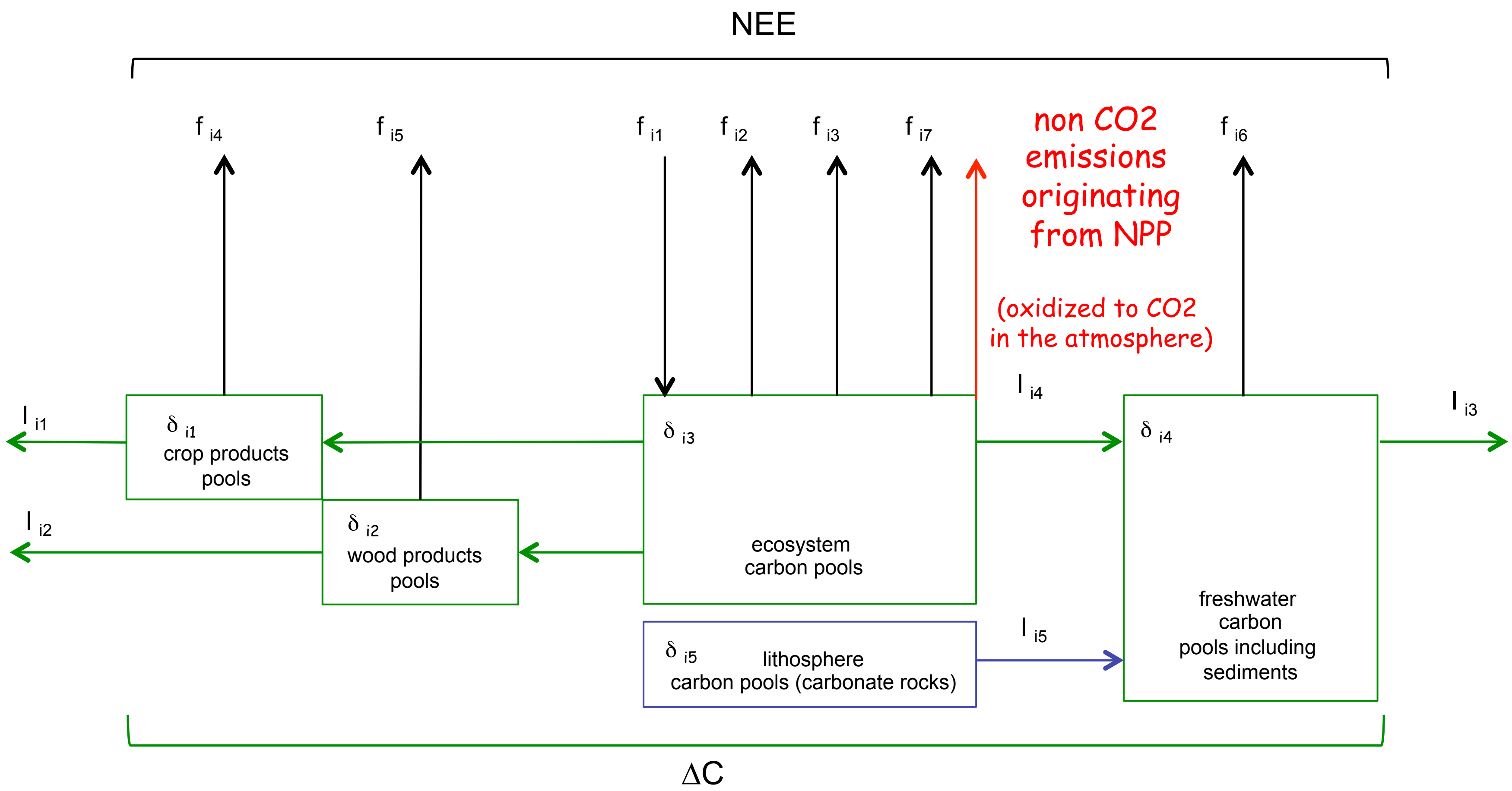


Carbon storage efficiency of NPP

excluding land use change



Missing component



Global biogenic emissions of CH_4 = 178-383 Tg C yr-1
Global BVOC oxidation into CO = ? 200 Tg C yr-1

Conclusions - help needed

Near Future work – next week ☺

- Complete grasslands ΔC in Africa and S America from DGVMs
- Include NEE losses from non-CO2 carbon gases (CH4, CO)
- Include sediment burial of C
- Include NEE losses from BC emissions in wildfires (small)
- Fuel wood harvest and emissions : in equilibrium ?

Future work

- Separate ΔC into forest, grassland, cropland, peatland, wetland
- Soil and biomass ΔC attribution

- Compare NEE with inversions and CCDAS
- Peat ΔC from drainage and fuel use
- Wetland ΔC