Peatland Carbon Stocks and Fluxes:

monitoring, measurements and modelling

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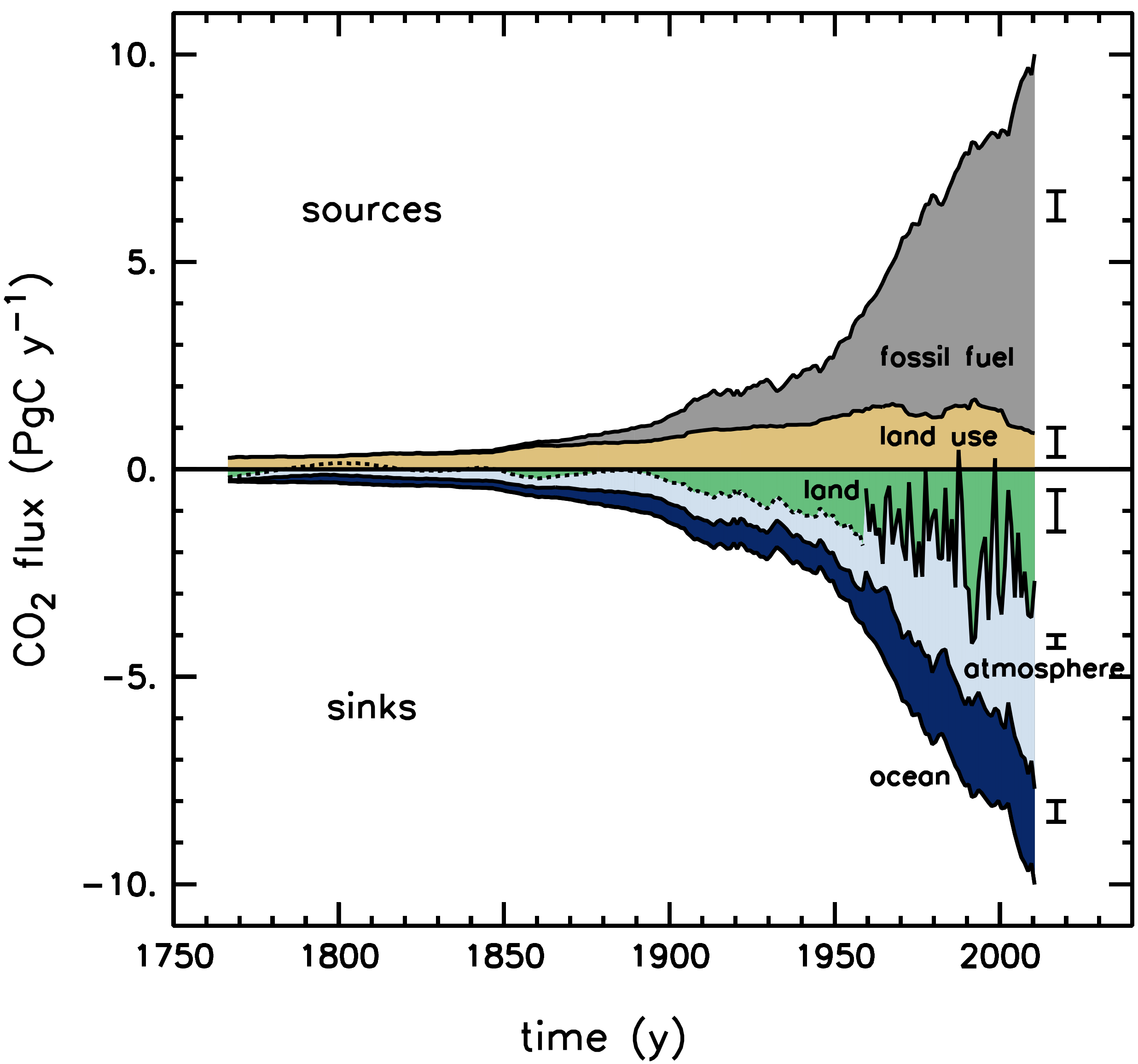
South Africa:
"…quantify with more precision the location, activity and interannual **variability…** ."
EU:
"…estimates around carbon storage, sequestration and emissions, and their **uncertainties…** . "
Russia:
"detailed quantitative analysis of **biogenic and soil components**"

THE UNIVERSITY of York

SEI STOCKHOLM ENVIRONMENT INSTITUTE

The global carbon budget



Global Carbon Project 2011; Updated from Le Quéré et al. 2009, Nature G; Canadell et al. 2007, PNAS

Global soil (organic) carbon stocks

Biome		IGBP* 100 cm IPCC 2001	IGBP 100 cm GLCM 2000#	WBGU[‡] 100 cm IPCC 1990	ISLSCP II[δ] 150 cm GLCM 2000#	ISLSCP II 30 cm GLCM 2000#
Forest	Tropical & subtropical	213	209	216	275	109
	Temperate	153	97	100	131	43
	Boreal	338	174	471	255	62
Savanna & grassland	Tropical & subtropical	247	206	264	276	98
	Temperate	176	171	295	236	80
Desert & semi desert		159	199	191	276	86
Tundra		115	106	121	158	42
Boreal		165	76	-	110	29
Croplands		-	76	128	101	36
Wetlands		-	147	225	211	53
Bare		-	36	-	50	16
Total C stock		**1566**	**1497**	**2011**	**2079**	**654**

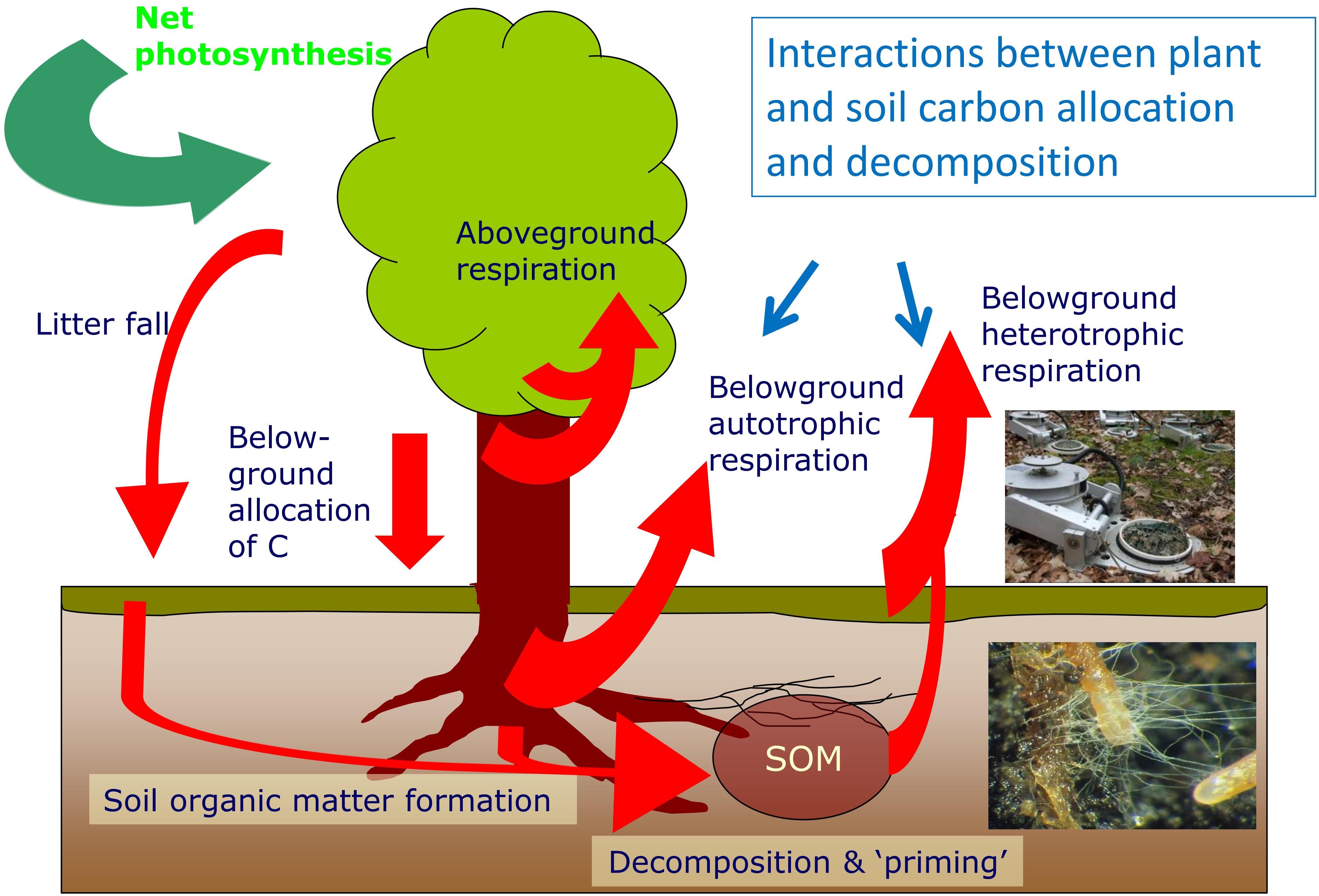
(in Gt C)

100 cm

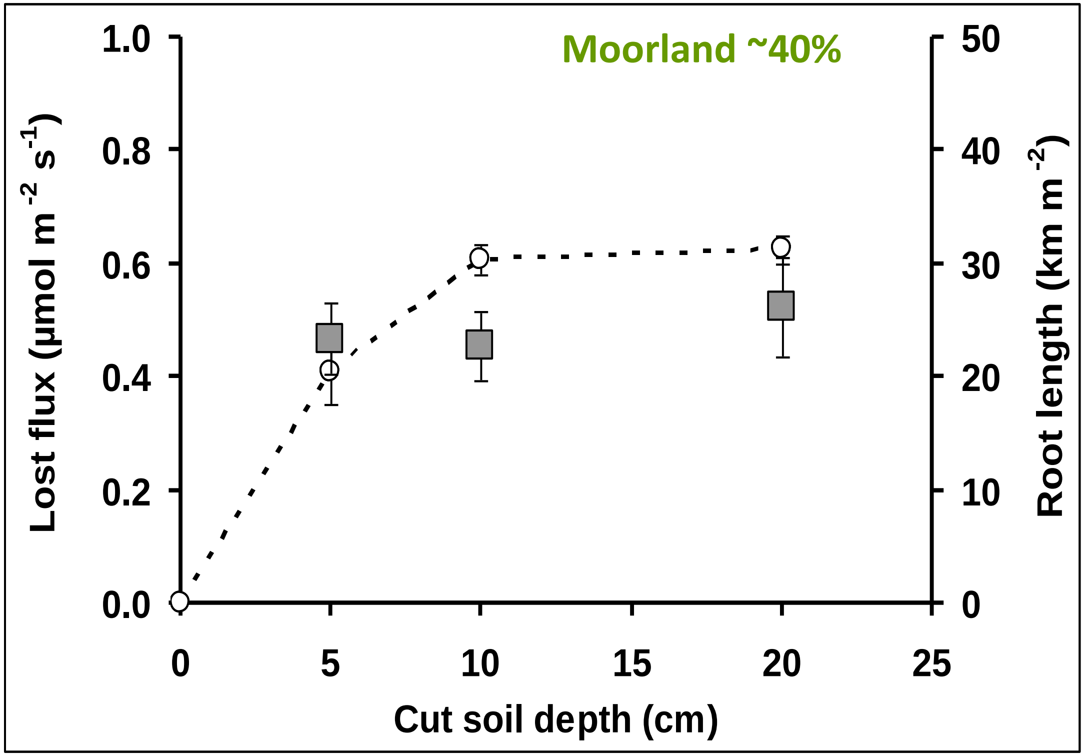
Latest estimate is 3000 Gt C (Tarnocai et al, 2009)

In: Kutsch, Bahn, Heinemeyer, **2009**

Terrestrial carbon cycling



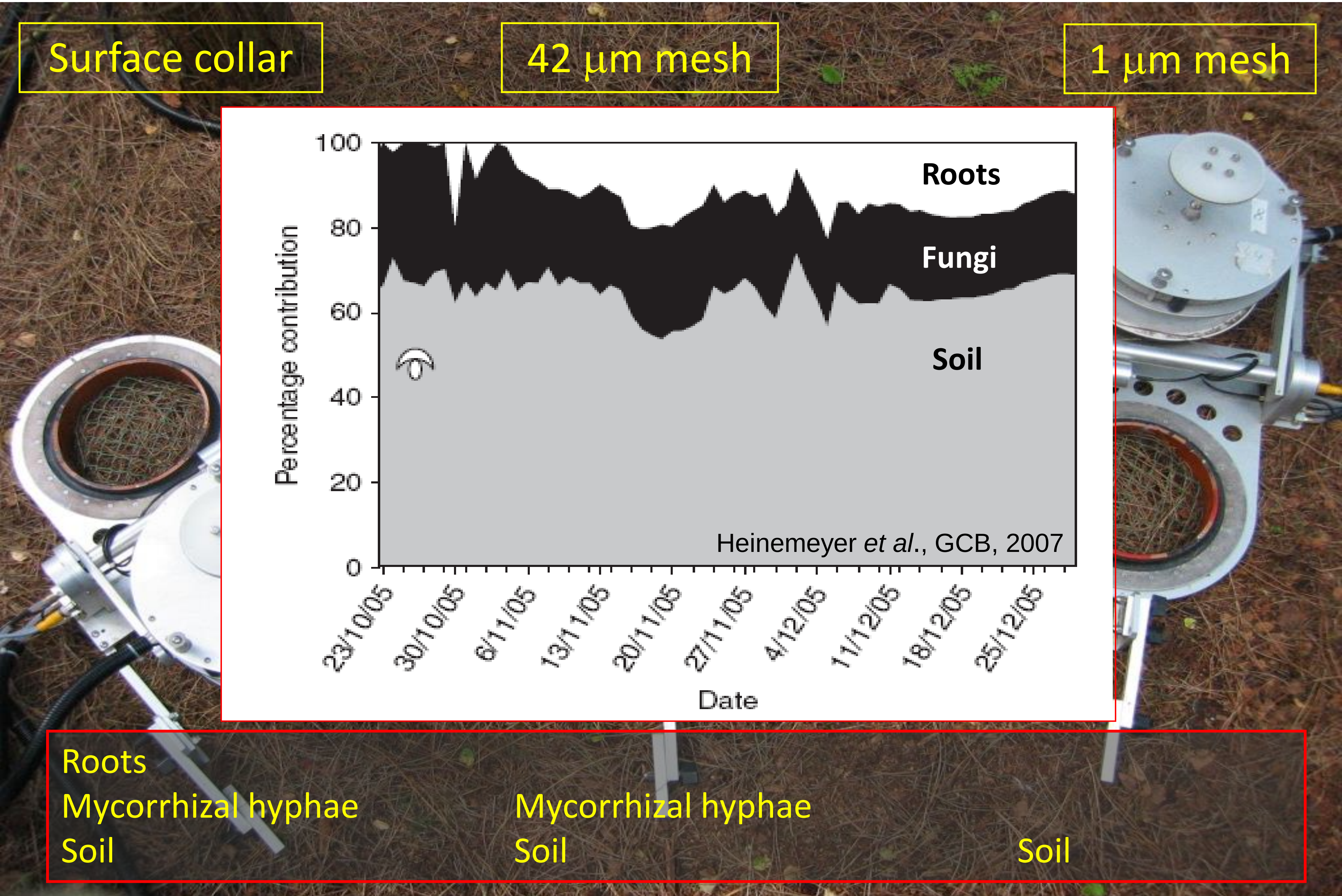
Collar insertion and 'cut' root flux



Heinemeyer *et al*., EJSS, 2011

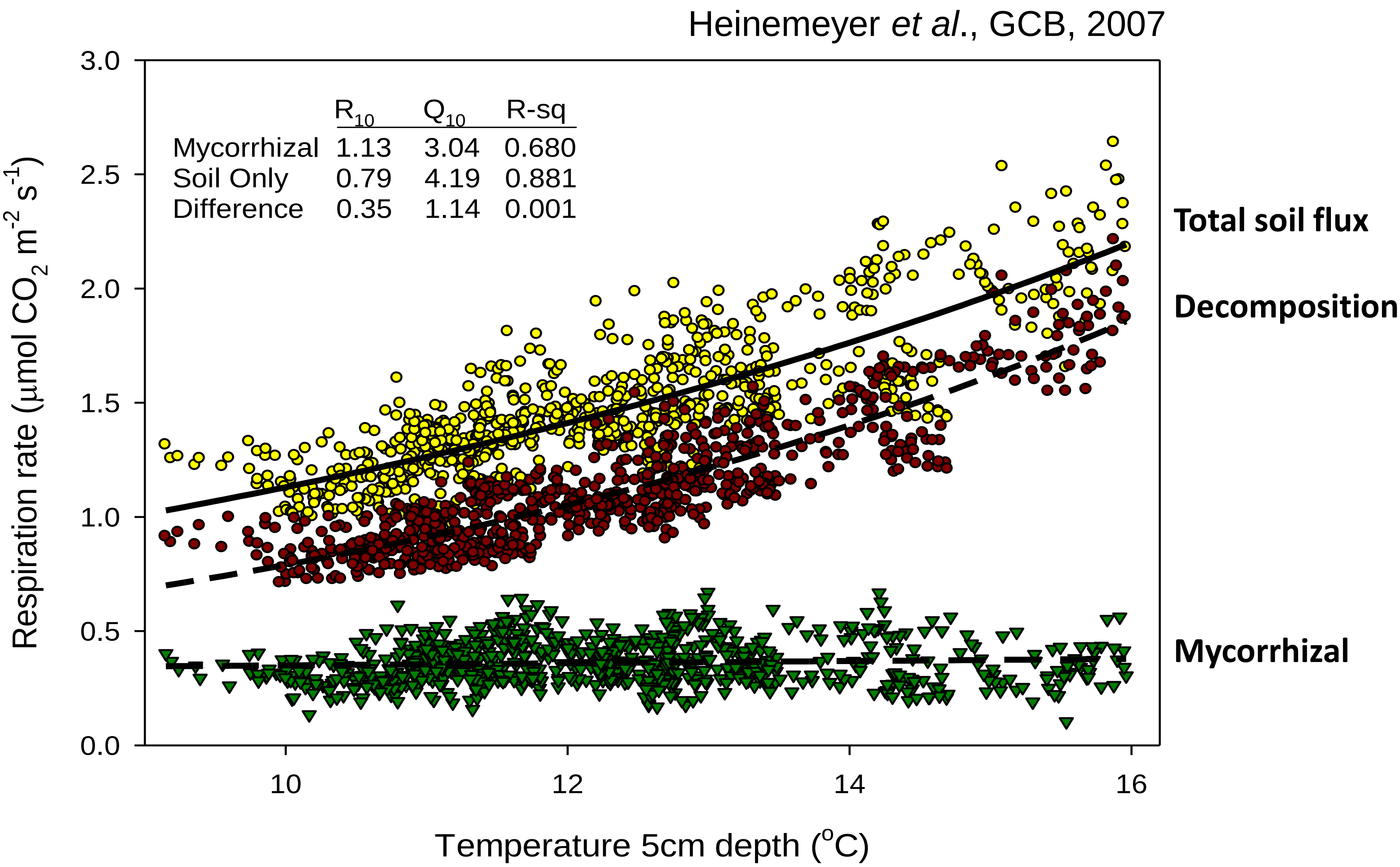
Tundra	trop. Forest	con. Forest	dec. Forest	Moorland
6 cm	7 cm	7 cm	4 cm	17 cm

Soil component CO_2 fluxes

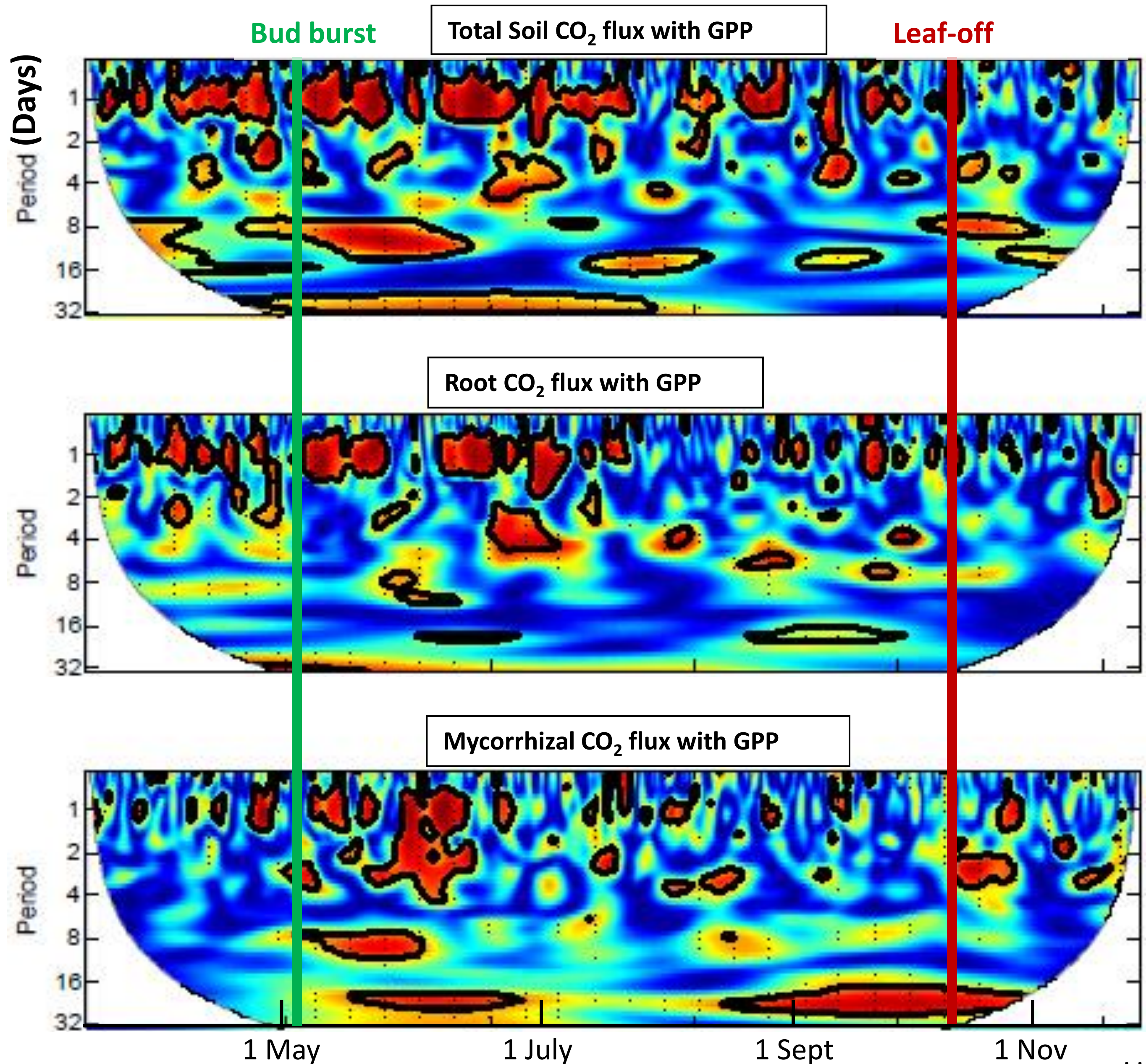


Surface collar	42 μm mesh	1 μm mesh
Roots		
Mycorrhizal hyphae	Mycorrhizal hyphae	
Soil	Soil	Soil

Soil respiration: component responses

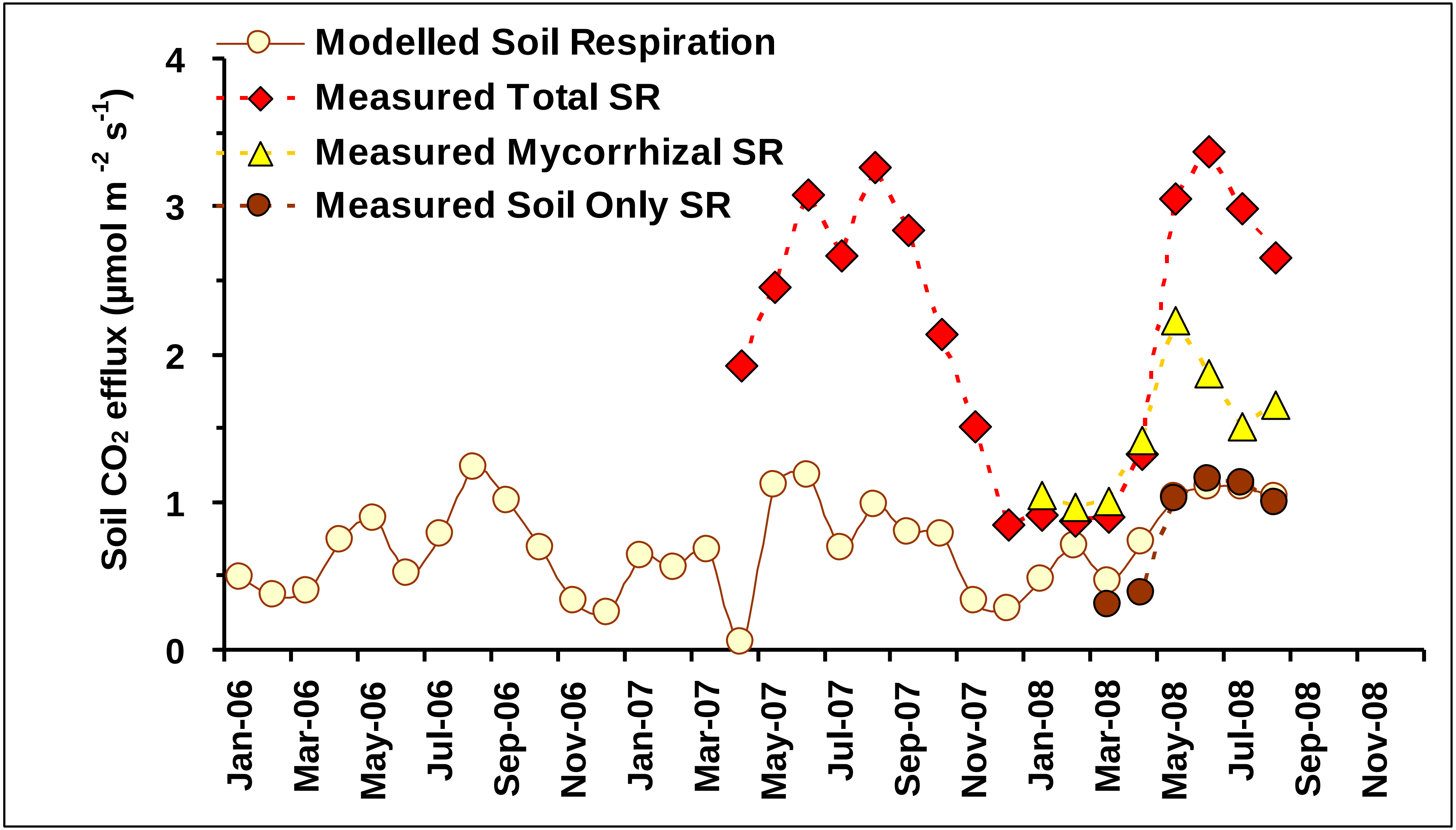


Carbon 'overflow tap' theory



Heinemeyer et al., BGS, 2012

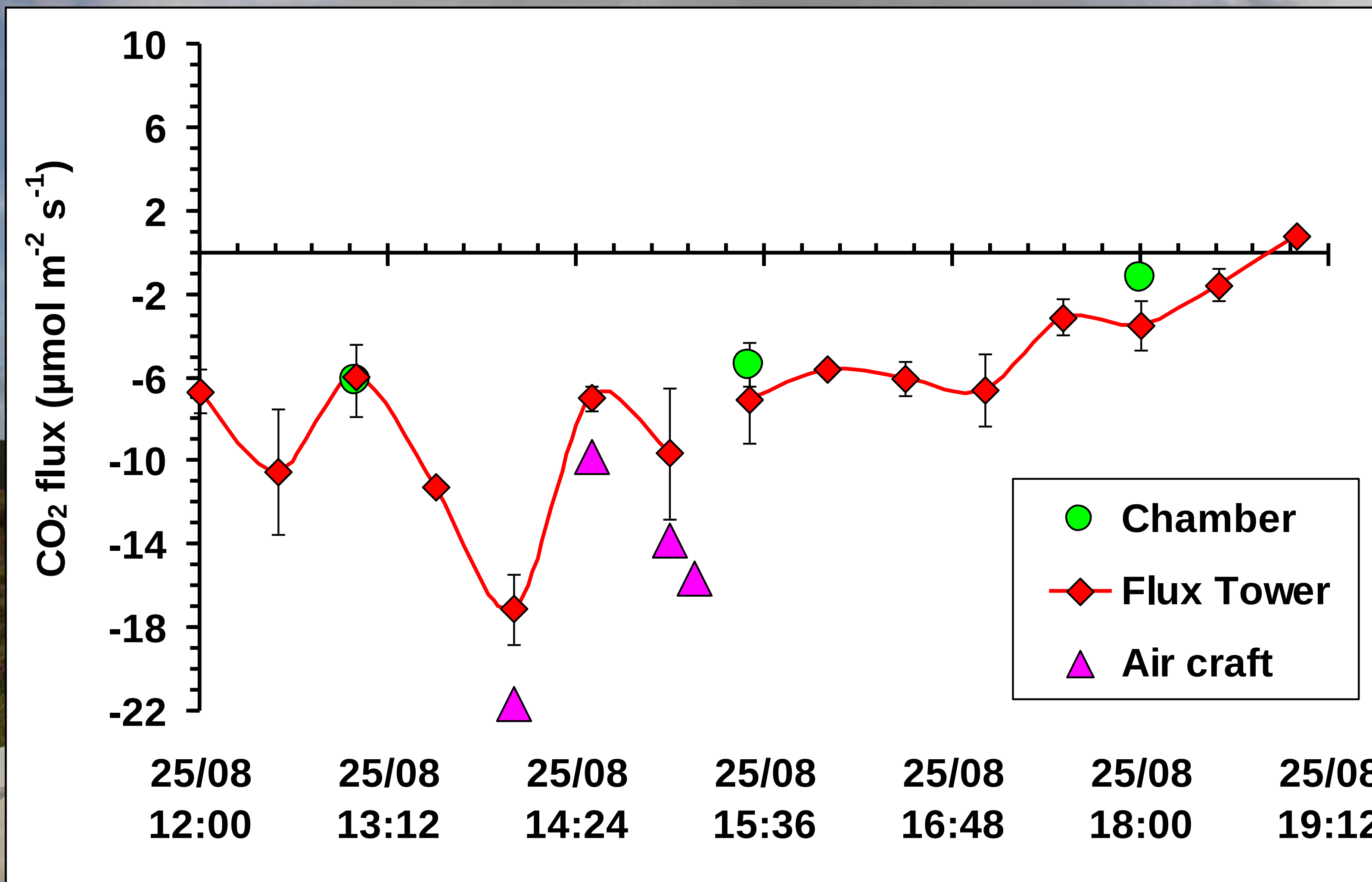
Soil respiration: modelled vs. measured



Heinemeyer et al., *unpublished*

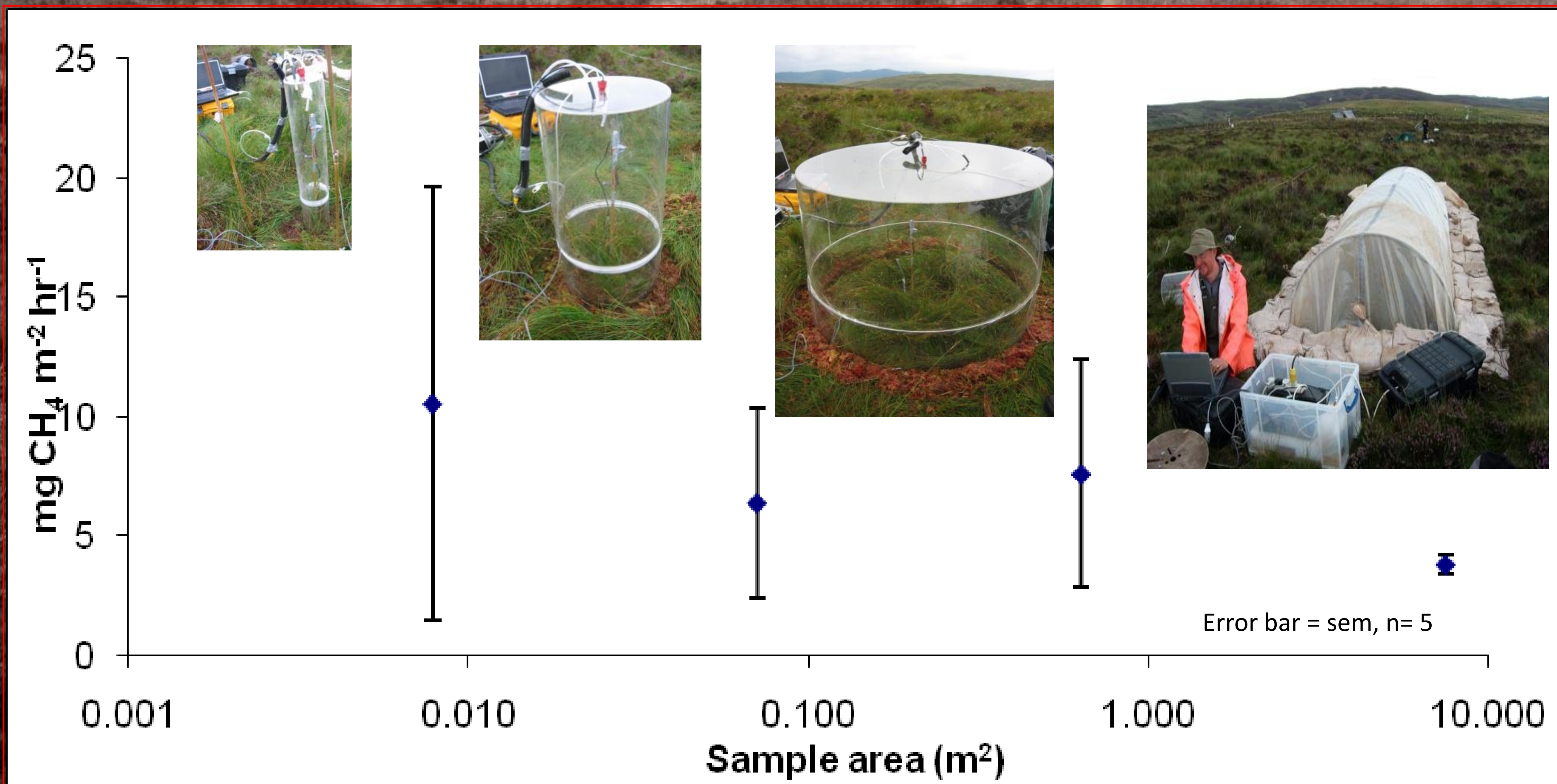
Scaling up from plot to landscape

Heinemeyer et al., *unpublished*



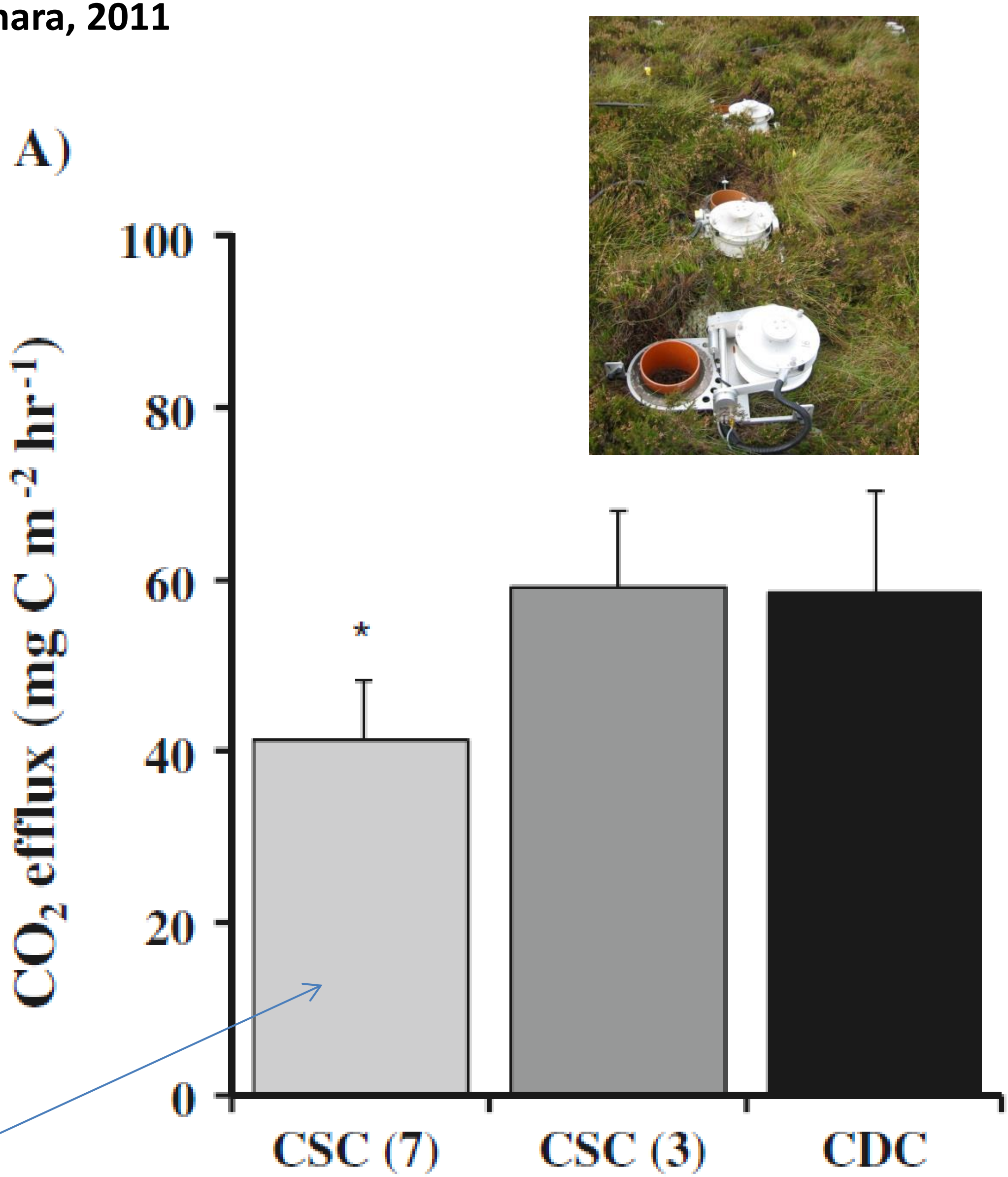
GHG measurement scale and uncertainties

Heinemeyer et al., *unpublished*



Chamber method comparison

Heinemeyer & McNamara, 2011



~40% less!

Use latest
GHG analysers

UK peatland management (Google: PeatlandESUK)

- **Carbon**
- **Water**
- **GHGs**
- **Biodiversity**

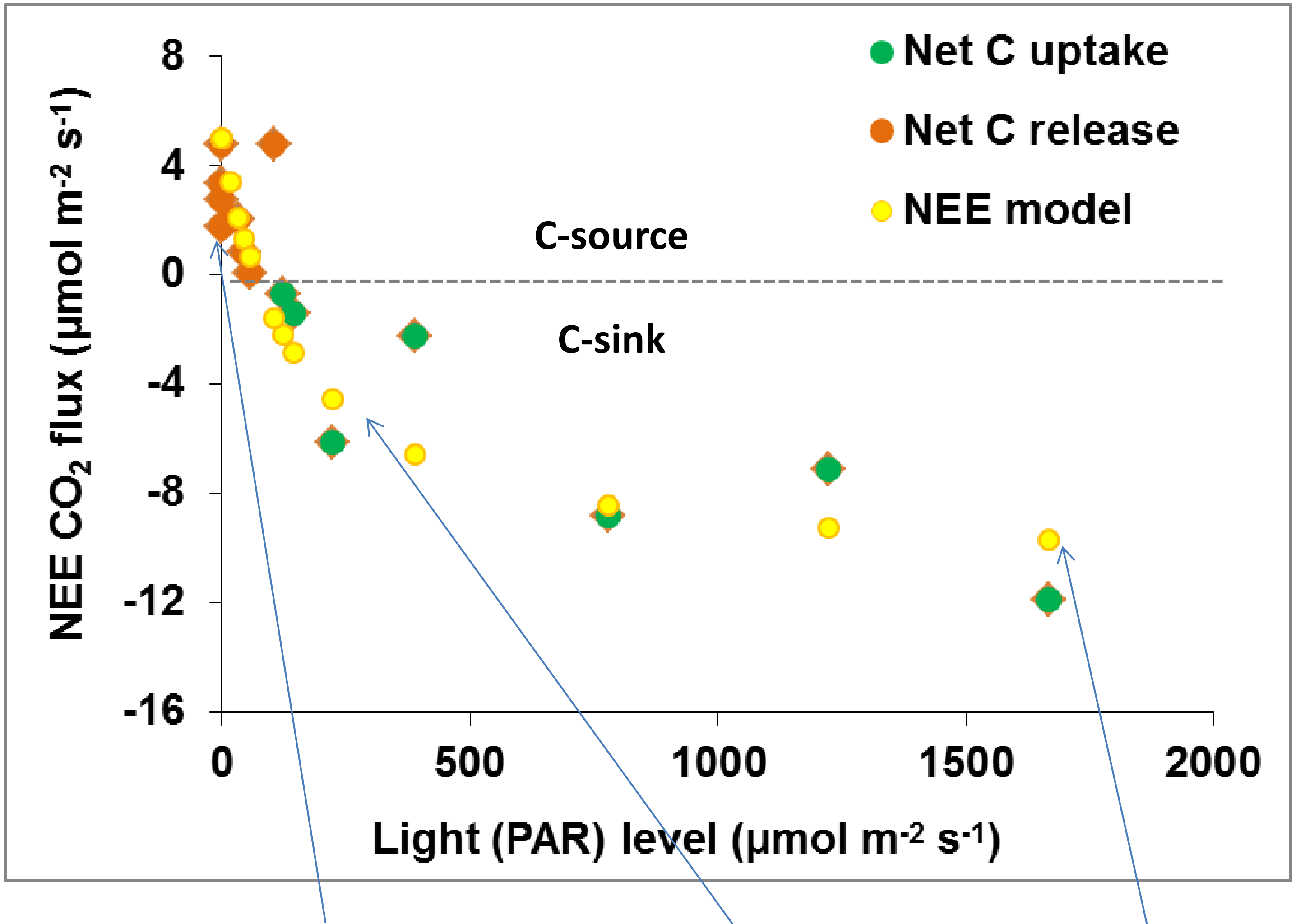
Peat = 95% water!
(*terrestrial* **blue carbon**)


Burning


Mowing


"Do Nothing"

Net Ecosystem Exchange (CO_2)

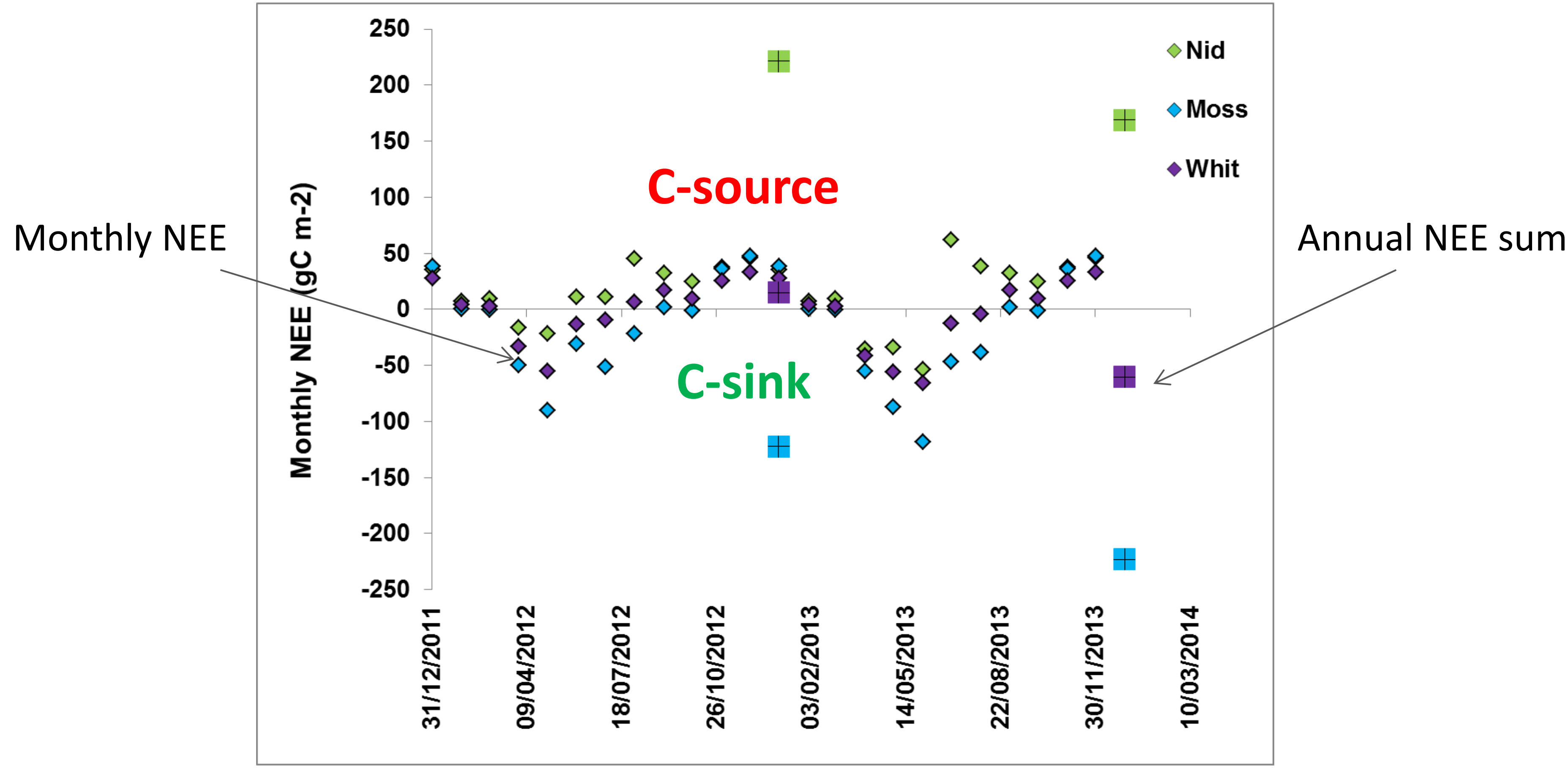


R_{eco}
(Respiration)

Slope
(activity)

P_{max}
(Photosynthesis)

Carbon budget variability (preliminary)



C budget = NEE + stream export of DOC + POC (gC m^{-2} p.a.)

GWP (kgC-CO_2 eq. ha^{-1} yr^{-1})

Nidd 2012 = **+306** (221 + 80 + 5)	2013 = **+254** (169 + 80 + 5);	GWP ~3300
Moss 2012 = **-19** (-122 + 100 +3)	2013 = **-120** (-223 + 100 +3);	GWP ~ 200
Whit 2012 = **+95** (15 + 70 +10)	2013 = **+20** (-60 + 70 +10);	GWP ~1300

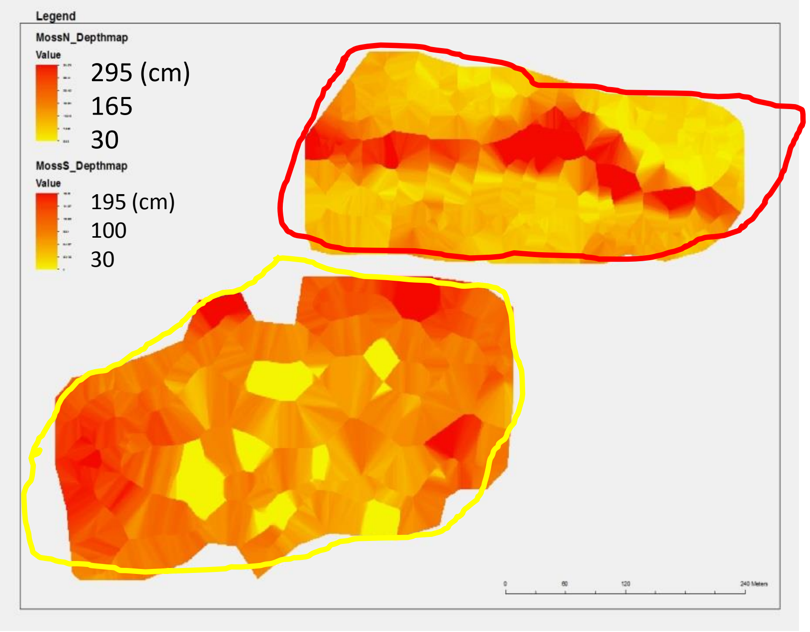
Heinemeyer et al., *unpublished*

Peat depth & carbon stocks

Ground Penetrating Radar advances

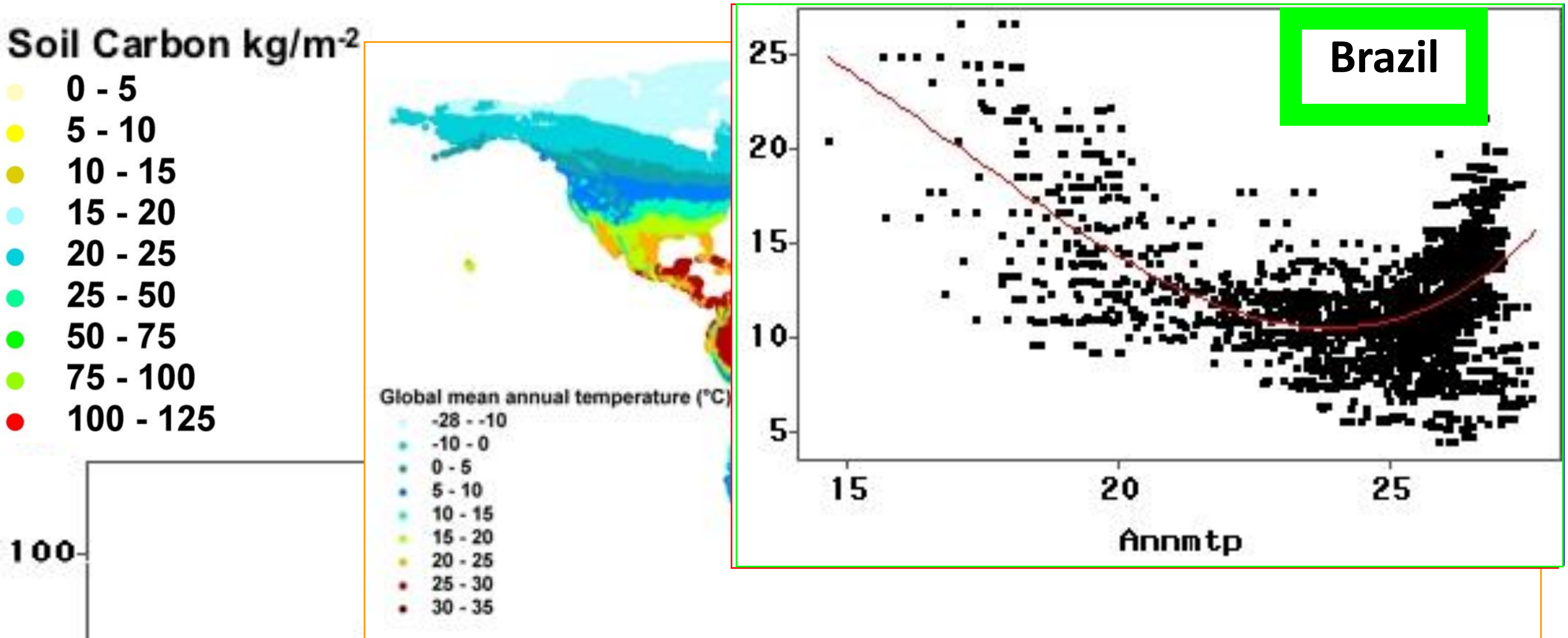
- Manual GPR – 5 x 5 m plot outline
  - ➢ about half the plots contain pipes
- Automated GPR – catchment paths
  - ➢ peat depth & bulk density profiles

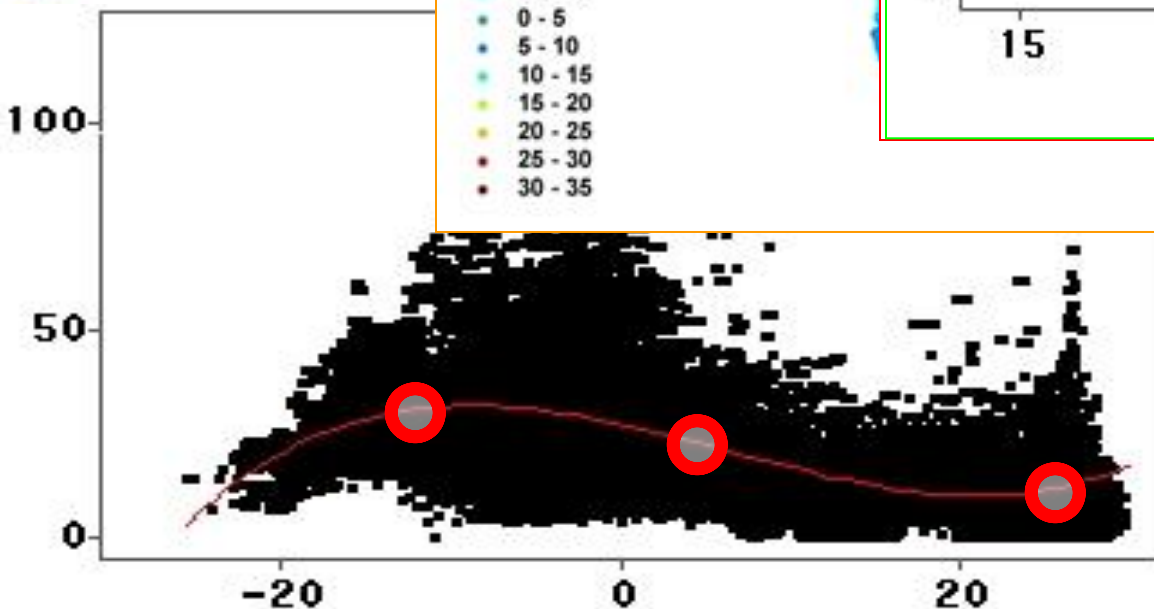
automated



manual

World soil carbon 'Roller Coaster'





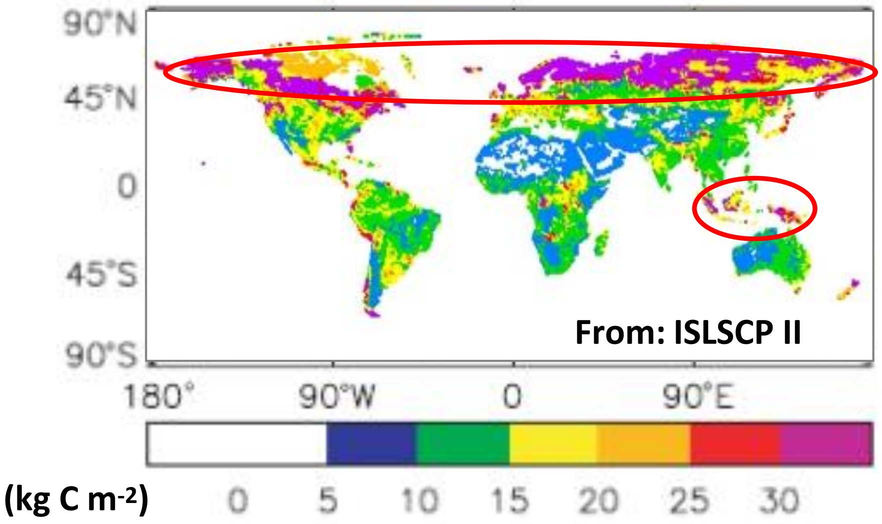
Annual mean air temperature (Annmtp)

Annual mean air temperature and NDVI (satellite) explain ~45% of the variability

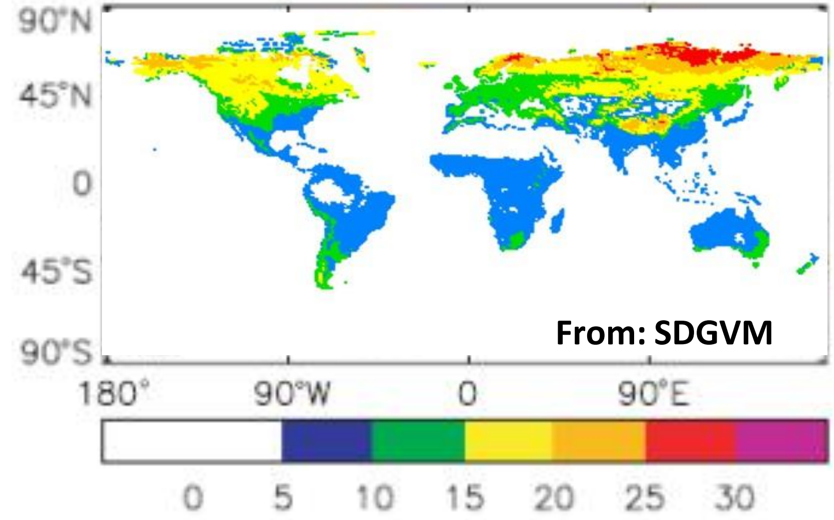
Heinemeyer et al., *unpublished*

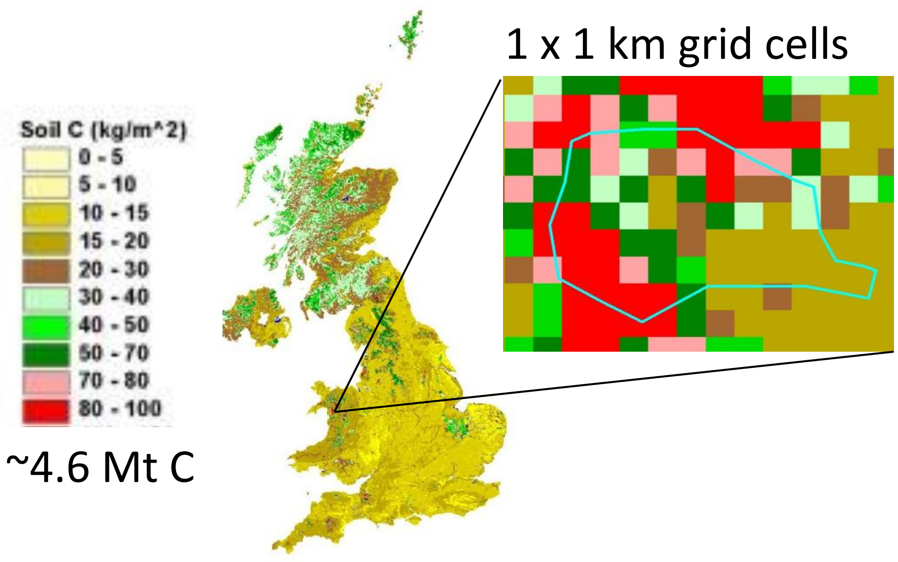
Global soil models and peat

Stock estimate



Model estimate





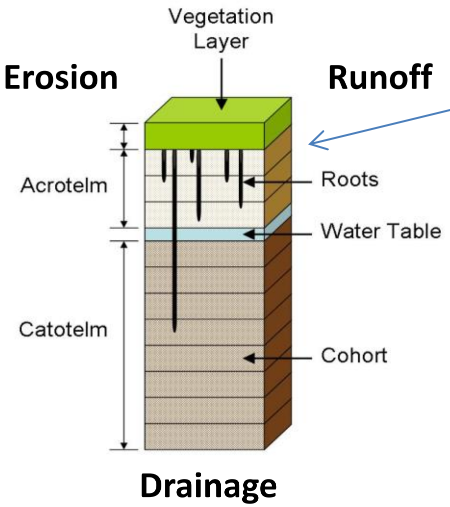
<u>Most current models lack:</u>

- **Holocene peat accumulation**
- **total peat column dynamics**
- **dynamic water table**
- **vegetation feedbacks (PFTs!)**
- **topography effects**

→ Needs **pedogenesis** concept!

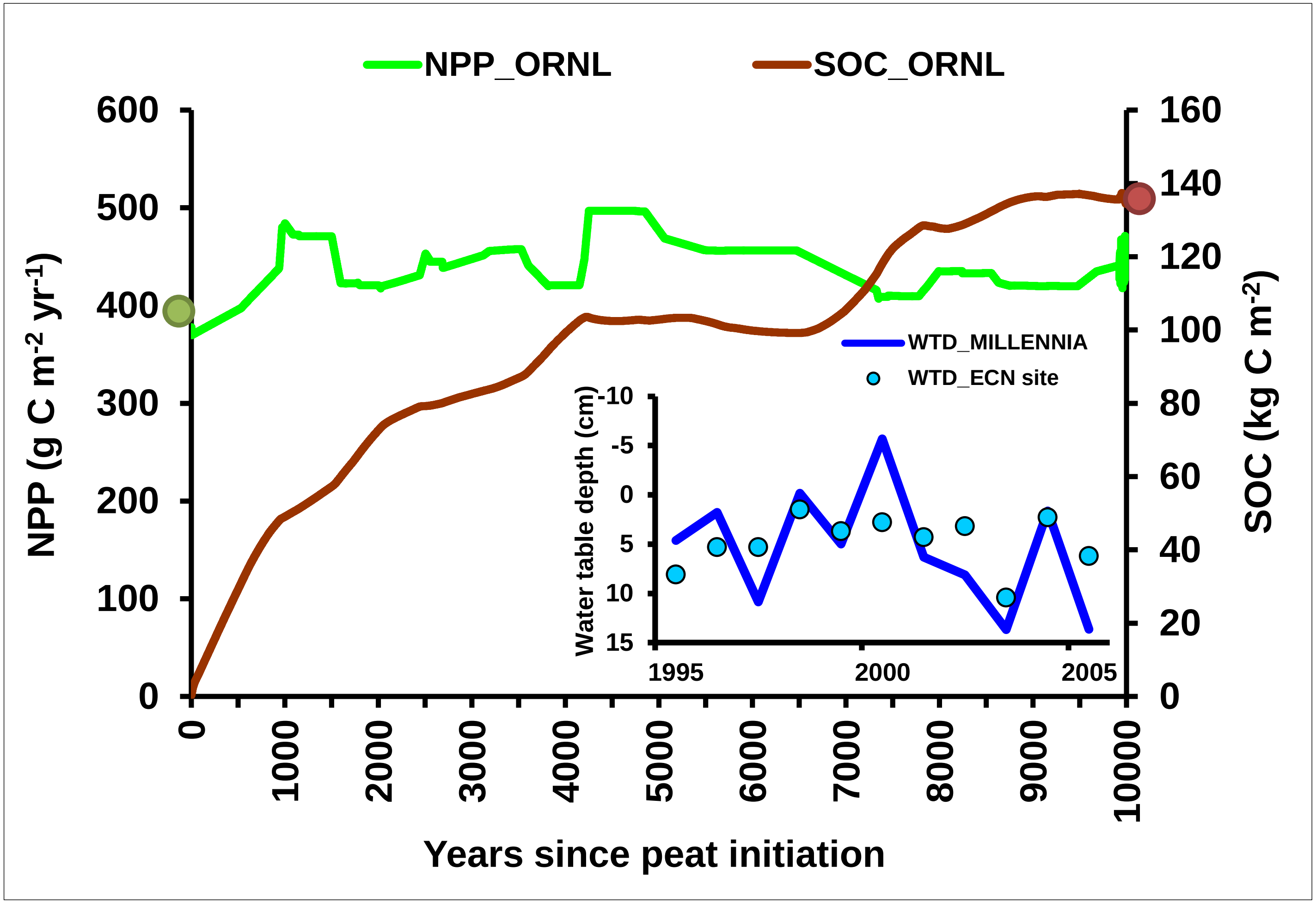
→ Needs more **sampling**!

MILLENNIA: build-up of current C stocks



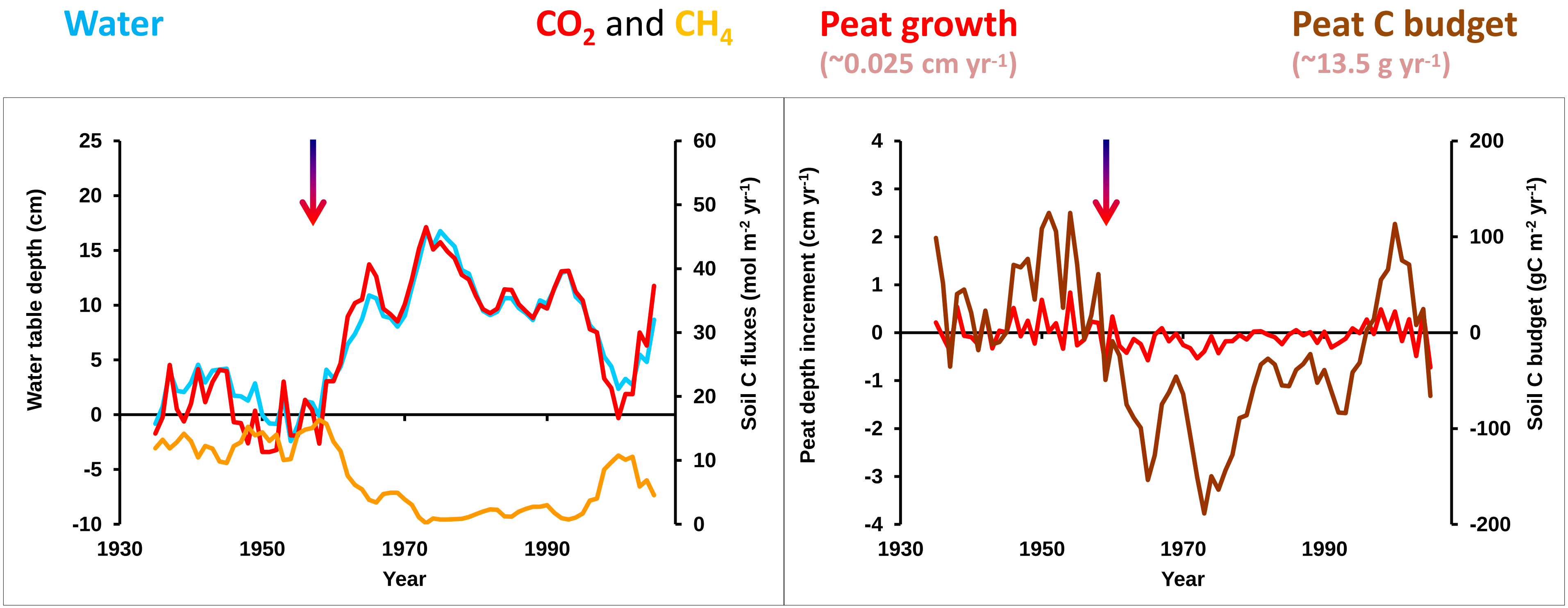
Incorporate organic matter quality (^{13}C NMR)

Heinemeyer et al., *Climate Research*, 2010



MILLENNIA: resilience and tipping points

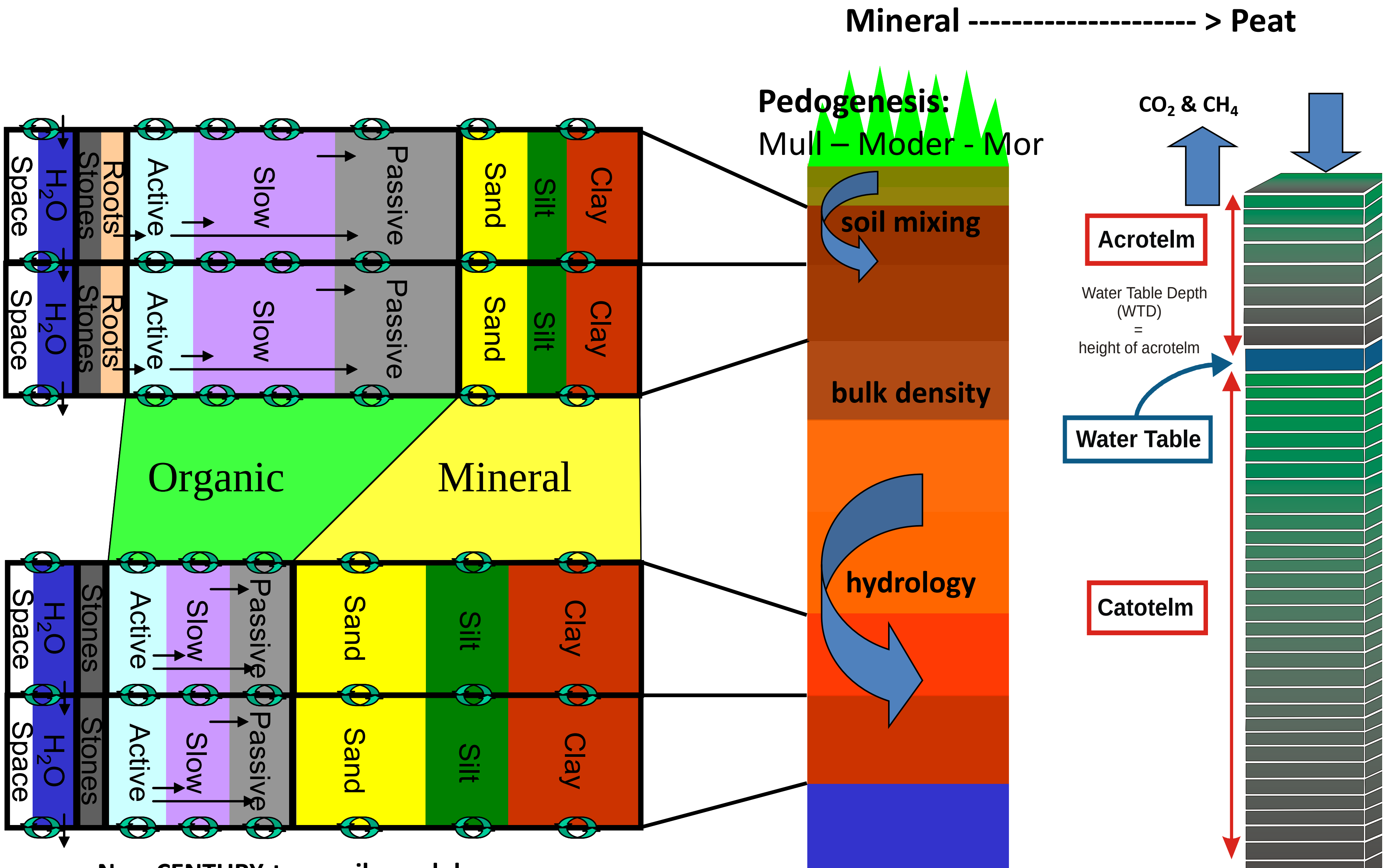
Using ECN climate data for **Moor House** (Pennines):



Predicted 5-year running means

Heinemeyer et al., *unpublished*

Future modelling: pedogenesis

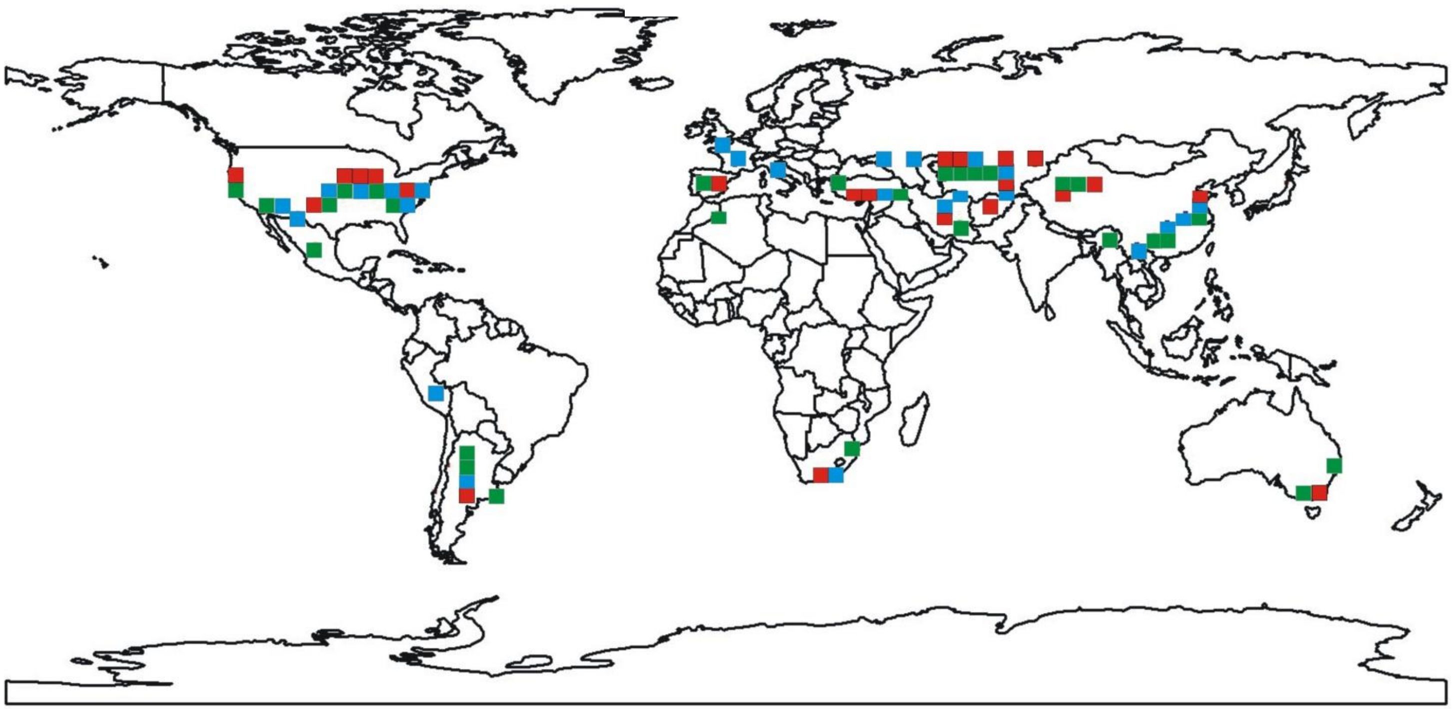


New CENTURY-type soils module

Future modelling: key organisms

Potential additive habitat loss based on future temperature predictions (HadCM3)

Enchytraeids (<**16.0**^{0}C)
- 2010 - 2039
- 2040 - 2069
- 2070 - 2100



Briones *et al.*, GCB, 2007

Outlook

Recent advances:

- **Peat C stocks**: GPR and peat depth/bulk density
- **Organic matter quality**: ^{13}C NMR
- **GHG emissions**: CH_4 and N_2O fast analysers

Urgent research needs:

- Large scale **GHG monitoring networks** (Eddy Cov.)
- Inclusion of **C export** (streams,rivers)
- Better **modelling** (pedogenesis, key organisms)

Conclusions

Conclusions:

- ➢ **Terrestrial C-uptake uncertainties:**
  → unravel plant-soil **C-dynamics**
- ➢ **Soil C-stock and flux uncertainties:**
  → improve stock & flux **methods**
- ➢ **Peat C-budgets uncertainties:**
  → set-up global **research platforms**
- ➢ **Peat modelling challenge:**
  → include process & organism **pedogenesis**