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Modelling carbon dynamics in forest soils, with emphasis on DOC

Ed Tipping, CEH Lancaster

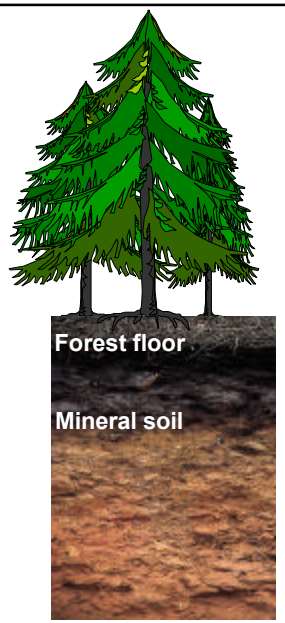
B. Michalzik, J. Mulder, J.F. Gallardo Lancho, E. Matzner, C. Bryant, N. Clarke, S. Lofts, M.A. Vicente Esteban, M. Fröberg, D. Berggren, B. Bergkvist

Dissolved organic carbon (DOC)

- Carbon flux in soils
- Nitrogen flux (DON)
- Binding and transport of contaminants

[Simple means of monitoring changes in soil C]

Soil organic carbon pools g m^{-2}



Birkenes Norway

5700

3100

5100

Objectives of DyDOC

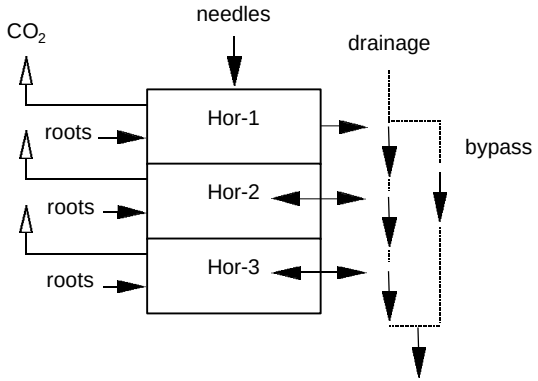
Michalzik et al., 2003

- Unifying framework
  - interpretation of diverse field and laboratory data

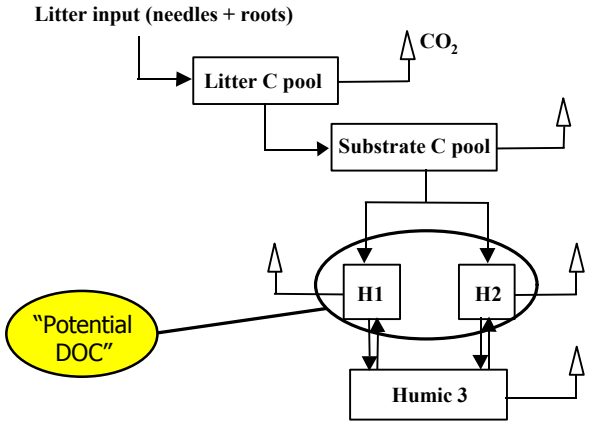
2) Simulation of fluxes and concentrations of DOC
   - short term (days to years)
   - long-term (centuries)

3) Relate DOC flux to other fluxes of C

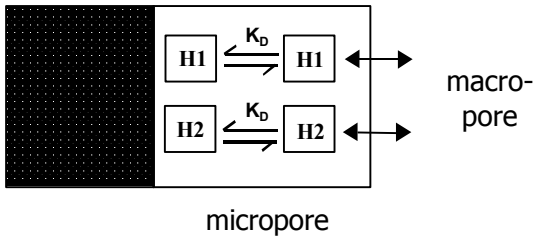
Carbon transfers in DyDOC



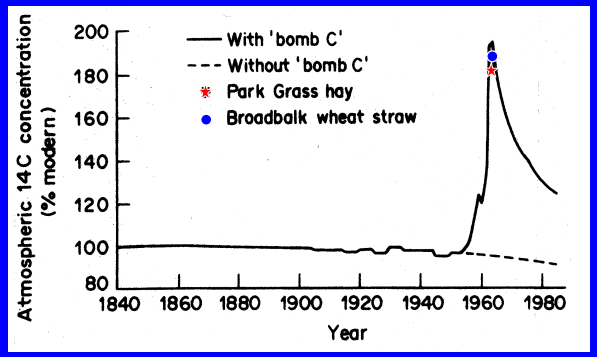
Model Version 01
Metabolic transformations in horizons O, A and B



Partitioning reactions in horizons O, A and B



Use of ^{14}C data



Atmospheric ^{14}C concentrations, 1840- 1985, Harkness et al. (1986)

Parameterisation (assuming steady state)

Hydrology
4 parameters from throughfall / temp /runoff

Partitioning
6 parameters from experimental data

Metabolism
16 parameters from C pools & fluxes, 14C, hydrophobicity

Diffusion
1 parameter from assumed [DOC] in micropores

Litter delay
Set to 5 years

Measured values and calculated values: Birkenes O horizon

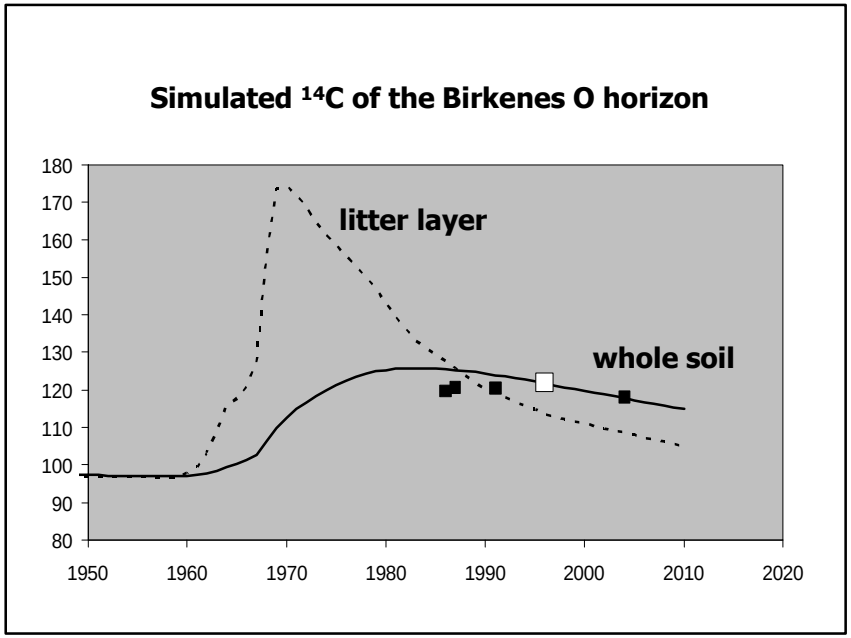
Values	*O horizon*	
	observed	*calculated*
Litter [g m^{-2}]	400	410
Substrate [g m^{-2}]	4200	4200
Humic substances (1, 2 + 3) [g m^{-2}]	1100	1000
Total Carbon [g m^{-2}]	5700	5600
^{14}C for the whole horizon	123	122
^{14}C for DOC	118	118
Annual DOC output flux [g m^{-2}]	36	42
% humic fraction 1 (hydrophilic)	~40	40

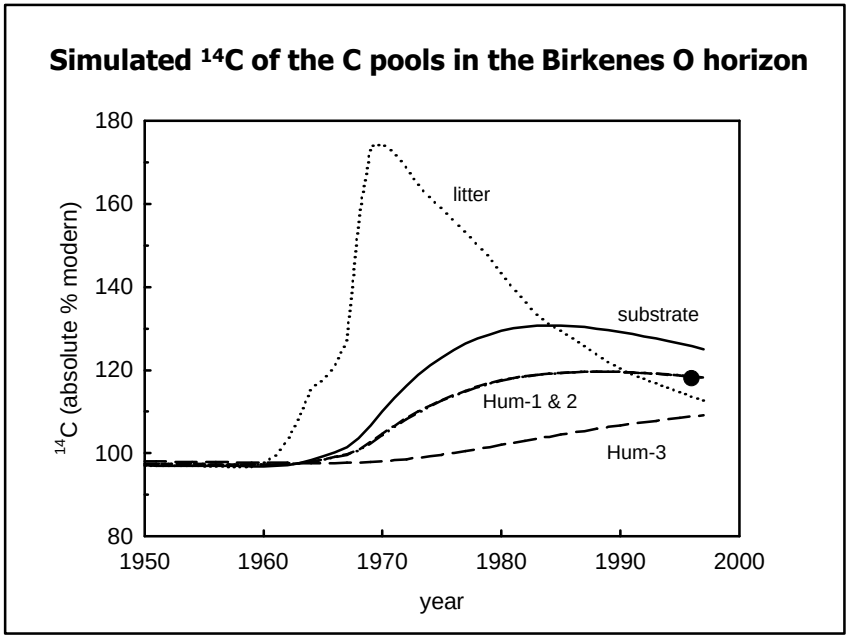
Measured values and calculated values: Birkenes A horizon

Values	*A horizon*	
	observed	*calculated*
Litter [g m^{-2}]	-	17
Substrate [g m^{-2}]	-	220
Humic substances (1, 2 + 3) [g m^{-2}]	-	2700
Total Carbon [g m^{-2}]	3100	3000
^{14}C for the whole horizon	-	102
^{14}C for DOC	113	110
Annual DOC output flux [g m^{-2}]	17	17
% humic fraction 1 (hydrophilic)	~ 50	50

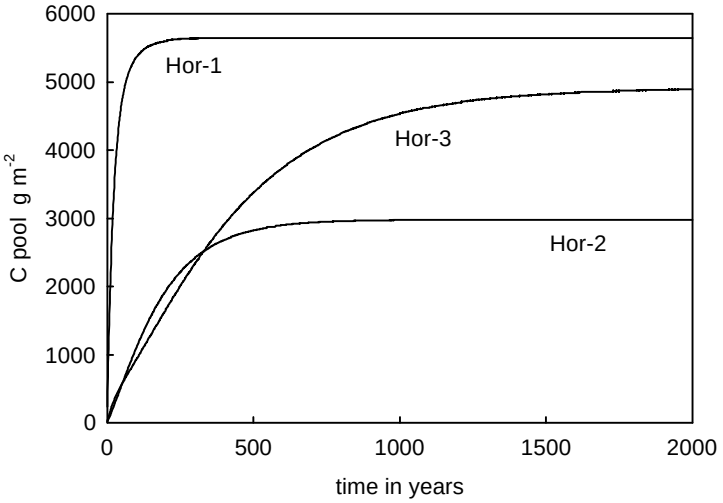
Measured values and calculated values: Birkenes B horizon

Values	*B horizon*	
	observed	*calculated*
Litter [g m^{-2}]	-	32
Substrate [g m^{-2}]	-	420
Humic substances (1, 2 + 3) [g m^{-2}]		4500
Total Carbon [g m^{-2}]	5100	5000
^{14}C for the whole horizon	99	98
^{14}C for DOC	102	102
Annual DOC output flux [g m^{-2}]	6	6
% humic fraction 1 (hydrophilic)	~ 60	60


Simulated 14C of the Birkenes O horizon
litter layer
whole soil
180
170
160
150
140
130
120
110
100
90
80
1950
1960
1970
1980
1990
2000
2010
2020

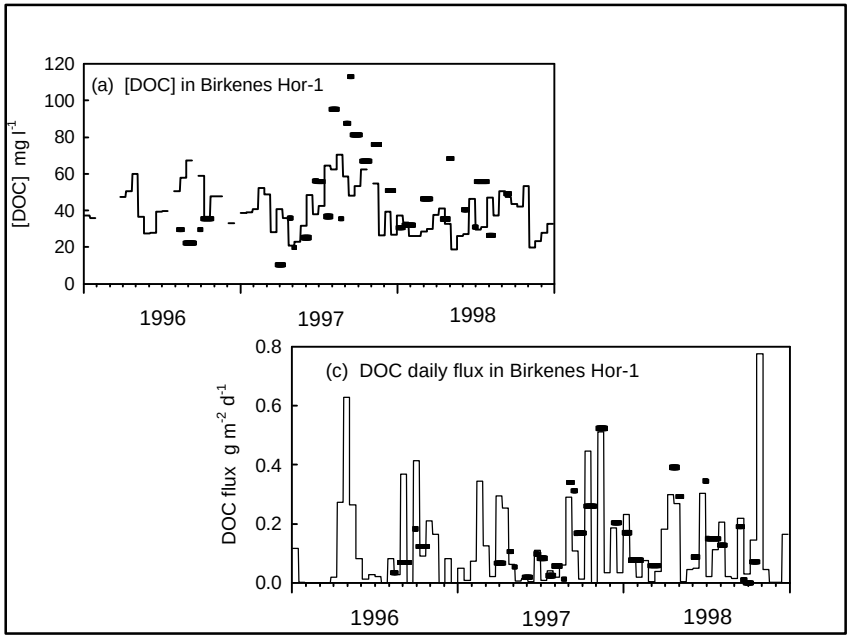

Simulated 14C of the C pools in the Birkenes O horizon
litter
substrate
Hum-1 & 2
Hum-3
14C (absolute % modern)
180
160
140
120
100
80
1950
1960
1970
1980
1990
2000
year

Simulated build-up of carbon pools at Birkenes



Organic C in the B horizon

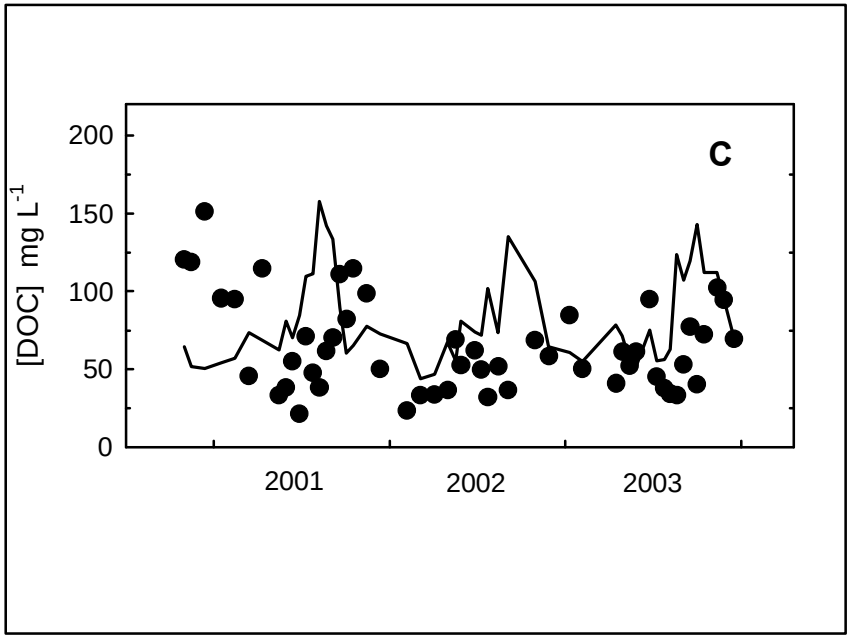
	Birkenes	**Waldstein**
% from O horizon	89	73
% from E & B root litter	11	27

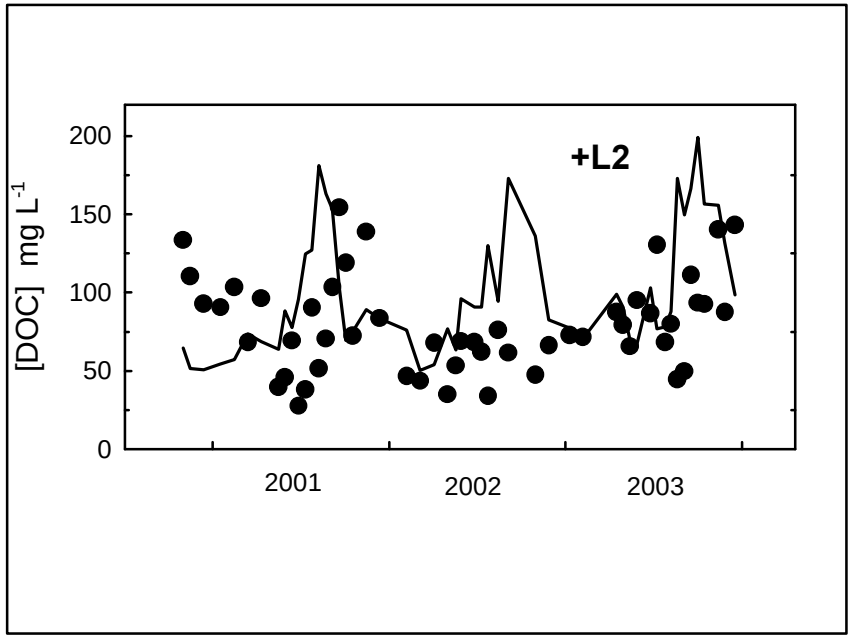


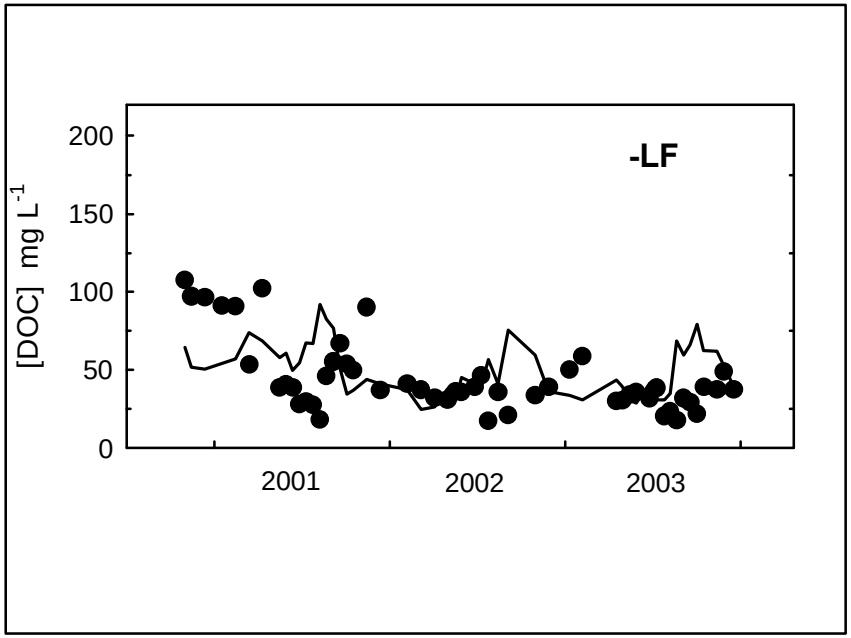
Litter manipulations at Asa, Sweden

Mats Fröberg, SAU, PhD project

Code	Treatment
C	Control
+L1	320 g m^{-2} litter (160 gC m^{-2}) added in April 2001, May 2002, May 2003
+L2	800 g m^{-2} litter (400 gC m^{-2}) added in April 2001, May 2002, May 2003
-L	Litter layer removed in April 2001, no further above-ground litter inputs
-LF	L and F layers removed in April 2001, no further above-ground litter inputs


C
[DOC] mg L-1
200
150
100
50
0
2001
2002
2003


+L2
[DOC] mg L-1
200
150
100
50
0
2001
2002
2003



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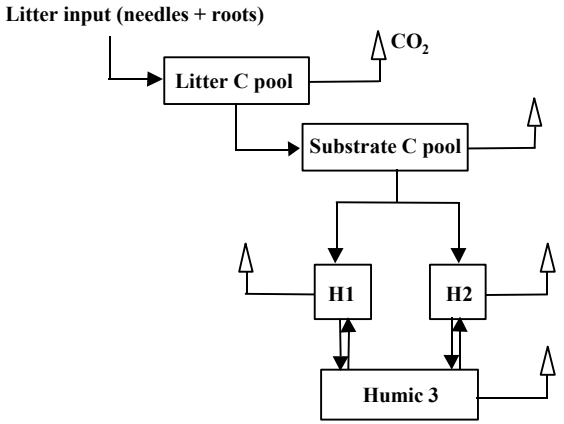
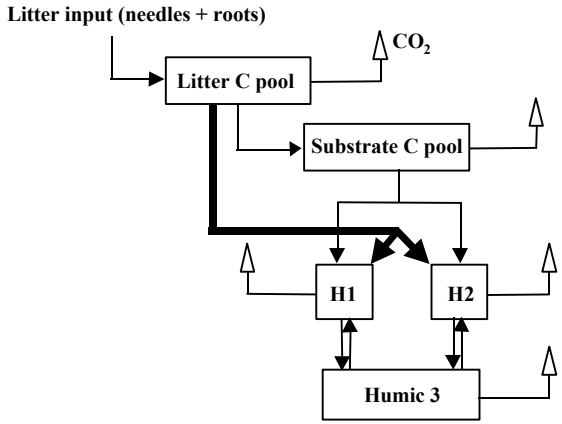
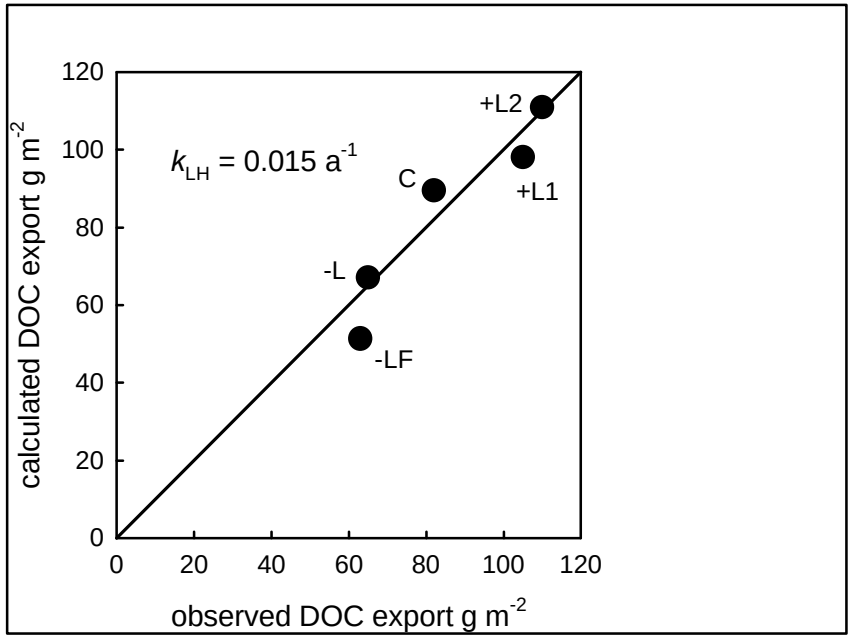


Model Version 02
Metabolic transformations in horizons O, A and B





Sources of DOC leaving the Asa forest floor

Pool	t_{res} (years)	% DOC
Litter	4.6	30
Substrate	26	32
Humic matter	36	38

Summary and outlook

- Simulation of soil C cycling and DOC
- Short and long timescales
- ^{14}C data for C turnover times / rate constants

- Current application to acid moorlands of the UK suggests rapid formation of DOC from plant litter
- Predicting future changes - need temperature-dependence of metabolic reactions