USING C-Tool TO SIMULATE SOIL CARBON AND RADIOCARBON DEVELOPMENT

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The program C-Tool[1] (v. 1.0) can enhance SOM model development by aiding the construction, revision and testing of soil carbon turnover models. Models can be created directly, without the aid of programmers. Any time step between one day and one year can be used, and the program can be run either for a predefined period or continue until specified steady-level criterions for carbon pools are reached.
Simulation of carbon isotopes ^{13}C and ^{14}C is facilitated, and it is possible to simulate a specific isotope tagging in order to investigate carbon flow properties in the implemented model.
The program is based on discrete carbon pools, which exhibit first-order decay.
Standard driving variables are temperature (in air or soil), soil water content (given either as absolute content, relative content or pressure potential) and amount, type and application date for input of carbon to the soil.
The near doubling of atmospheric ^{14}C in the 1960ties (Fig. 1) can be utilised in a test of carbon turnover model performance[2], provided time series of soil samples are available.

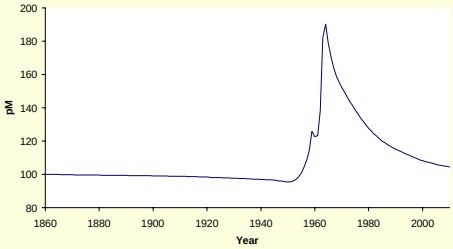

Figure 1. Atmospheric ^{14}C development (percent modern) in the Northern Hemisphere, provided as a table with the program.

A simple three-pool model is used for demonstration. This model structure will not suffice to simulate short-term C or N turnover, but may be fully adequate for long term C development, and only requires determination of four parameters. These include the initial size of the inert (IOM) pool, and the fraction of animal manure assumed to enter the HUM pool directly (f_{HUM}).

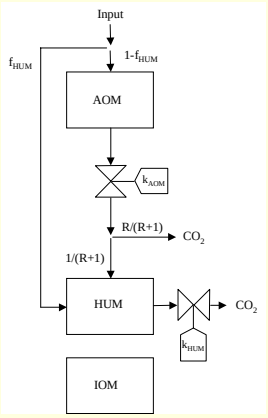

Figure 2. Model structure. Boxes represent carbon pools, and valves represent decay rates. R depends on the clay content, and is calculated as in the SOM model RothC. Preliminary turnover rates: k_{AOM} = 0.7 y^{-1}, k_{HUM} = 0.022 y^{-1} at 10 °C. For simplicity, monthly mean air temperature is the only present turnover modifier. 5% of C in animal manure is assumed to enter the HUM pool directly. Where "pre-bomb" ^{14}C samples are available, the size of the IOM pool can be calculated by assuming it to have a ^{14}C content of 75 percent modern (guesstimate).

Simulations

Full lines indicate modelled values. All samples were taken in 0-20 cm depth. The Askov Experimental Station is located in Jutland, Denmark.

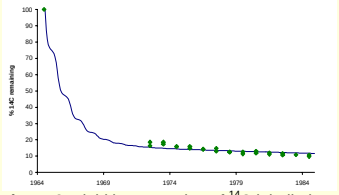

Figure 3. Field incorporation of ^{14}C labelled barley straw[3] at Risø, Denmark (two frames).

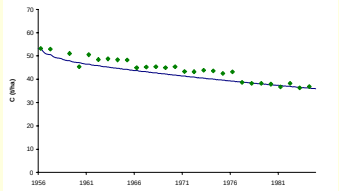

Figure 4. Organic C in soil from a fallowed field experiment in Askov (average values from two fields). 0.2 t C ha^{-1} y^{-1} from weed residues etc. is assumed to enter the soil.

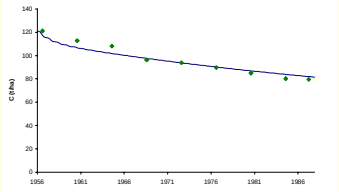

Figure 5. Organic C in soil from a fallowed field experiment in Askov (average values from two frames). 0.2 t C ha^{-1} y^{-1} from weed residues etc. is assumed to enter the soil.

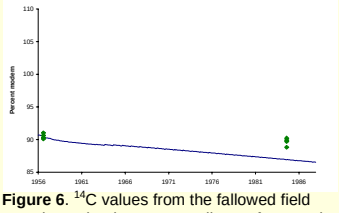

Figure 6. ^{14}C values from the fallowed field experiment in Fig. 5, two replicates from each frame.

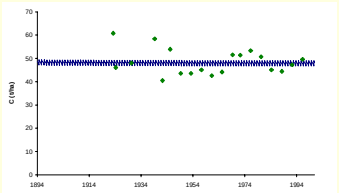

Figure 7. Organic C in soil from a four crop field rotation in Askov with mineral fertiliser. 2.9 t C ha^{-1} y^{-1} is assumed to enter the soil.

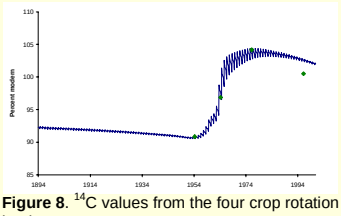

Figure 8. ^{14}C values from the four crop rotation in Fig. 7.

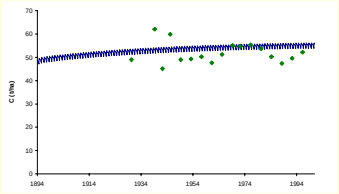

Figure 9. Organic C in soil from a four crop field rotation in Askov with animal manure. An average of 0.9 t C ha^{-1} y^{-1} from animal manure enters the soil, and 2.5 t plant derived C ha^{-1} y^{-1}

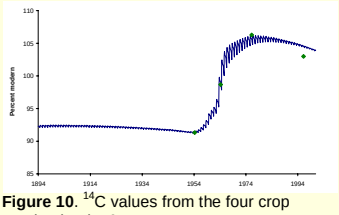

Figure 10. ^{14}C values from the four crop rotation in Fig. 9.

Conclusions and suggestions

- A very simple model could adequately describe the data series.
- Utilising carbon isotopes in SOM modelling greatly enhances the possibility to verify model assumptions.
- Model parameters should be based on a larger data set than presented here, and should be determined with the aid of statistical techniques.
- When modelling sites outside humid climate regions, water response should be added.
- Some of the major withstanding challenges in SOM modelling are determination of the inert pool size, robust ways to determine C input to the soil, and quantification of the influence of soil tillage.

References

1. B.M. Petersen, J.E. Olesen, J.E. & T. Heidmann (In press) A flexible tool for simulation of soil carbon turnover. *Ecological Modelling*.
2. D.S. Jenkinson & K. Coleman (1994) Calculating the annual input of organic matter to soil from measurements of total organic carbon and radiocarbon. *European Journal of Soil Science*, 45, 167-174.
3. L.H. Sørensen (1987) Organic matter and microbial biomass in a soil incubated in the field for 20 years with 14C labelled straw. *Soil Biology and Biochemistry*, 17, 747-756.

Further radiocarbon data series from Askov are presently being analysed by the AMS laboratory at the University of Aarhus.
C-Tool with accompanying manual can be downloaded from www.agrsci.dk/c-tool.

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