C-FARM: A Simple Model to Evaluate the Carbon Balance of Soil Profiles

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Introduction and Relevance

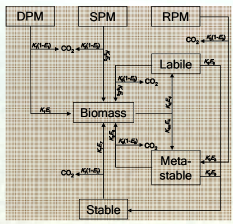
- The carbon cycle is biogeochemically of interest due to its reactions with other elements that undergo oxidation and reduction transformations.
- There is a strong demand for methods to compute and certify the soil carbon balance under different agricultural managements due to both environmental concerns and to support the carbon and environmental credits markets.
- Complex cropping systems simulation model are input intensive and often require local calibration if they were to be used to analyze the impact of different management scenarios in the soil carbon balance.

Objective

Develop a simple soil carbon model to compute the carbon balance of the soil profile with the following properties:

- no calibration requirements
- provide the carbon balance on a layer by layer basis
- accommodate the impact of different management practices on the carbon balance

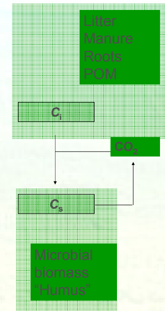


Reducing the complexity of soil carbon modeling

Multiple pools with *fixed* properties

Single pool with *variable* properties



Basic C-FARM equation for the soil carbon balance

$$dC_s/dt = hC_i - kC_s$$

$$h = h_c[1 - (C_s/C_x)^n] \qquad k = f_e f_t k_x (C_s/C_x)^m C_s$$

C_s Soil Carbon

h humification rate

k apparent soil carbon decomposition rate

h_c depends on soil texture resembling Roth-C

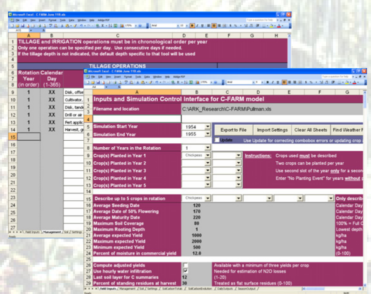
C_x depends on soil texture (Hassink and Withmore, 1997)

f_e soil temperature and water content factor controlling microbial activity

f_t is a function of tillage tool and number of operations (NRCS) and soil texture

Model Inputs

- daily weather
- soil texture and organic carbon by layer
- cropping systems sequence (crop seeding and maturity dates)
- grain yield (max, min, average) for each crop
- tillage sequence (tools, date, depth of operation)
- irrigation scheme



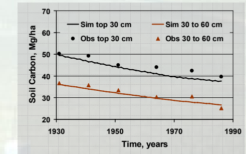
Testing With Long-Term Experimental Data

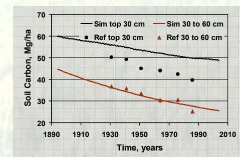
Pendleton long-term winter wheat summer fallow rotation

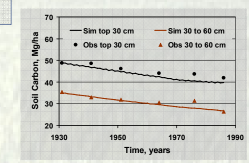
Right top panel: <u>0kg N ha^{-1}, no residue burn</u>
Yield: obs 2.62 Mg ha^{-1} sim 3.09 Mg ha^{-1}
Abvgrd Carbon Input, obs 1.24 Mg ha^{-1} sim 1.27 Mg ha^{-1}

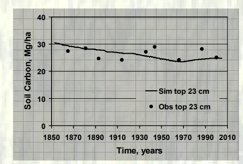
Right lower panel: <u>90 kg N ha^{-1}, no residue burn</u>
Yield: obs 3.73 Mg ha^{-1} sim 3.97 Mg ha^{-1}
Abvgrd Carbon Input, obs 0.95 Mg ha^{-1} sim 0.96 Mg ha^{-1}

Lower Panel: projected evolution of soil carbon with abvgrd carbon inputs of = 1.8 Mg ha^{-1} under *no-till*









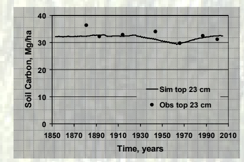
Rothamsted UK continuous wheat rotation

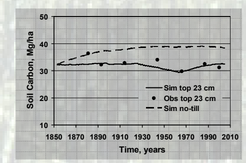
1853 – 1926 continuous wheat
1927 – 1962 wheat – fallow
1963 – 2005 continuous wheat

Left top panel: 0 N applied, no residue burn
Aboveground carbon input ~ 1.2 Mg ha^{-1} year^{-1}

Left lower panel: 144 kg N ha^{-1} year^{-1} applied, no residue burn
Aboveground carbon input ~ 2.2 Mg ha^{-1} year^{-1}

Projected soil carbon evolution for the 144 kg N ha^{-1} year^{-1} under *no-till* (difference at the end of simulation: 6 Mg C ha^{-1})





Conclusions

- C-FARM carbon dynamic is scientifically sound
- Model successfully tested in two environments with different precipitation regimes and management systems
- The simple interface and limited input requirements make C-FARM useful for students, producers and consultants

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