Simulation of Soil Respiration at Hourly Time Step

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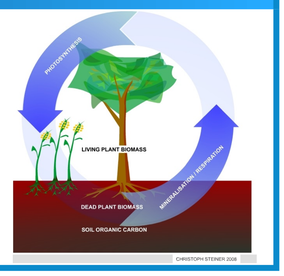
Introduction

- CO_2 is being taken up by plants, then it enters the soil as plant residue and finally it returns back to the atmosphere directly and indirectly by root respiration and decomposition [1].
- Microbial and root respiration are the two major constituent of soil respiration.
- Many efforts have been made on modeling of soil CO_2, but there has been a lack on incorporating the photosynthesis/solar radiation driven portion of soil respiration (root respiration).



Objectives

- To asses the indirect contribution of photosynthesis to soil respiration driven by root respiration.
- To develope and test an hourly time step model for simulation of soil respiration.

Materials & Methods

Theory :

- Root respiration has been defined as sum of the enegry costs for producing new material and maintaining the current status of plant [2].

$$R = (\frac{1 - Y_g}{Y_g})\frac{\Delta W}{\Delta t} + mW \quad (1)$$

Where, R($\frac{gCO_2}{m^{-2}hr}$) is respiration, Y_g is the conversion efficiency (-), m is maintenance coefficient ($time^{-1}$), ΔW is the change in dry matter and W is the dry mass of living tissue (gCO_2 equivalents)

- Y_g and m can be found by fitting a linear model on $\frac{1}{Y}$ and $\frac{1}{\mu}$.

$$\frac{\Delta W}{\Delta t} = Y_g(P - mW) \quad (2)$$

where P is the photosynthesis ($\frac{gCO_2}{m^{-2}hr}$), $\mu(\mu = \frac{\Delta W}{W(\Delta t)})$ is the specific growth rate and Y ($Y = \frac{\Delta W}{P}$) is the total conversion efficiency (-).

Model Development :

Data measurements: root and shoot biomass @ 4 crop growth stages and for 2 years.

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BioCro was calibrated and evaluated. (BioCro simulates C4 photosynthesis, biomass production and plant physiological parameters at hourly time step.)

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Using BioCro, photosynthesis was estimated and it was used for finding the Y_g and m (Eq.2)

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Estimated coefficients were implemented in the BioCro for predicting the root respiration.

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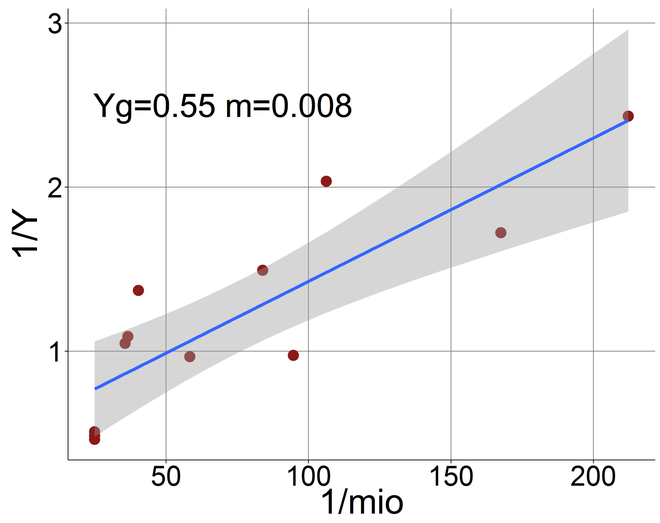
An hourly time step version of CENTURY model also was developed and coupled to the root respiration to account for microbial respiration.

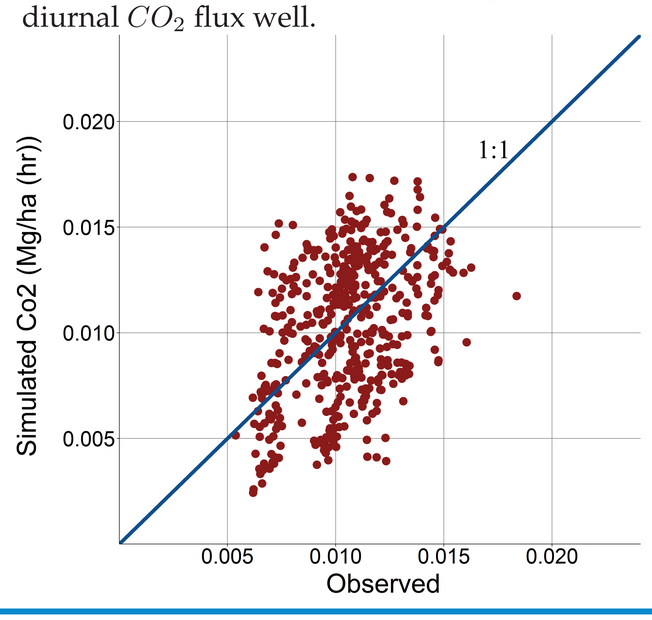
Results

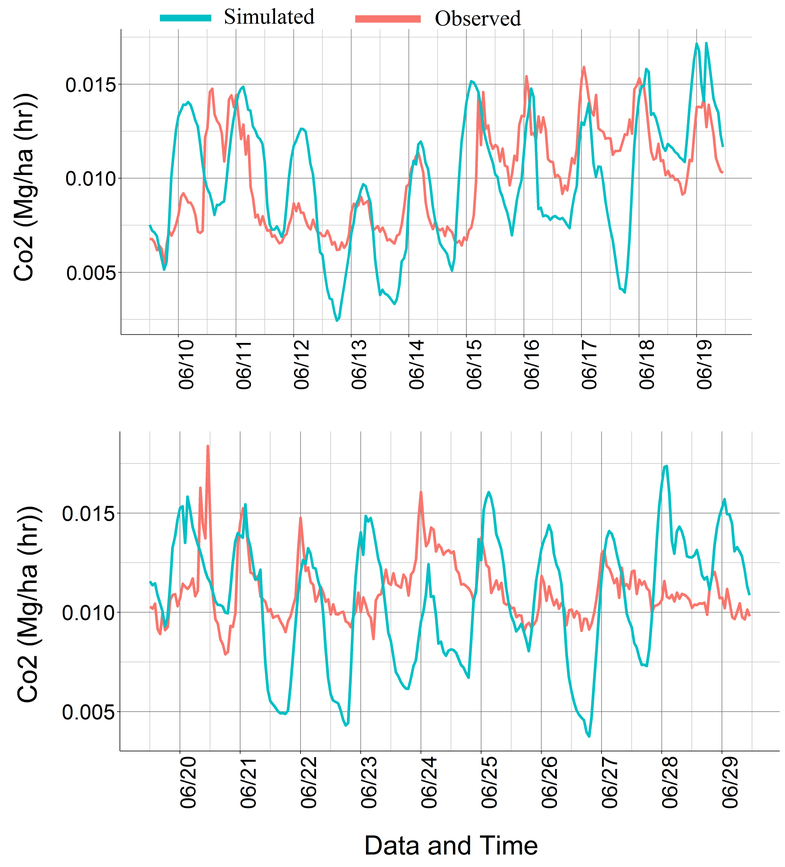


- Conversion effciency Y_g and maintenance coeffcient (m) found for root were in the range of 0.40-0.75 and 0.001-0.03 found by other researchers.

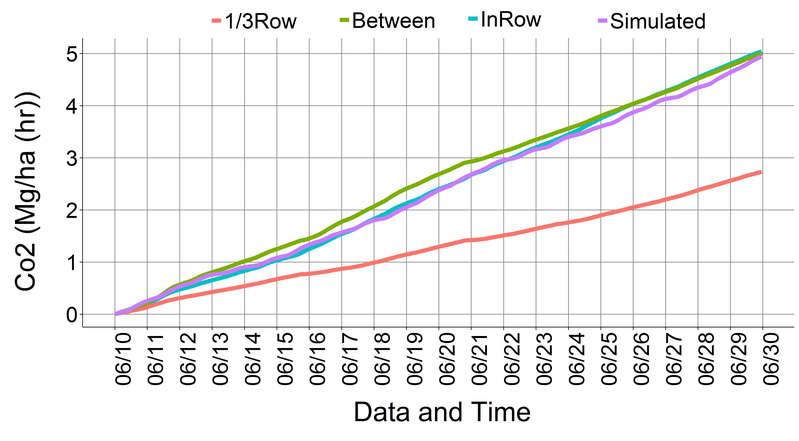
Evaluation of soil respiration :

- The new developed soil respiration module was tested against CO_2 measurements for 20 days in 2012.
- Dataset included CO_2 surface flux measurements in row, between rows and in 1/3 row in a corn field in Ames, IA.
- In row measurements matched better with simulated data rather than between rows and 1/3 rows.
- Model was able to capture the range and variation of diurnal CO_2 flux well.





- Cumulative soil respiration for 20 days of simulation had less than 5 % NRMSE.



Conclusions :

1. Simulation of root respiration improved the SOC model by lowering NRMSE by 5% and bias by 8% in simulation of cumulative soil respiration.
2. Even tough results were promising there is still a need for further evaluation and model development.

References

[1] SW Duiker and R Lal. Carbon budget study using co 2 flux measurements from a no till system in central ohio. *Soil and Tillage Research*, 54(1):21–30, 2000.

[2] JHM Thornley. Respiration, growth and maintenance in plants. 1970.

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