

Review of Validation Report for DayCent-CR Version 1.1.0

Proponent: Indigo Ag, Inc

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Overall Summary

I have reviewed the Indigo Agriculture Draft “Validation Report for DayCent-CR Version 1.1.0” submitted on December 21, 2023. **I confirm that the report overall meets the requirements for model development, calibration, validation, and uncertainty reporting** as laid out in the Climate Action Reserve (CAR) Version 1.1.a April 2022 “Requirements and Guidance for Model Calibration, Validation, Uncertainty, and Verification For Soil Enrichment Projects (SEP)”. Further, the report is also aligned properly with implementation as described in the CAR “U.S. Soil Enrichment Protocol: Reducing Emissions and Enhancing Soil Carbon Sequestration on Agricultural Lands” Version 1.1 from Mar 31, 2022. The team is well qualified and experts in the model and in its validation. Based on prior validation, the changes reported here continue to follow best practices for validation and expand the capability for additional practices to be validated with respect to N₂O emissions.

Changes from prior version

This report focuses on DayCent Version 1.1.0 which builds on the previously validated versions 1.0 and 1.0.2 for Soil Organic Carbon (SOC) in CAR1459. Version 1.1.0’s primary changes are related to improvements to the SOC validation and an inclusion of validation of N₂O emission changes. To accomplish these tasks, this version adds the following:

- Nitrification inhibitors (NIs) from controlled release nitrogen fertilizers (CRNFs)
- Capping of daily modeled nitrous oxide (N₂O) emissions to limit unrealistic short-term fluxes that were too high in the model
- Development of calibration and validation of N₂O flux
- Additional validation sites and addition of practice categories (PC) for nitrogen-fixing C3 crop functional group (CFG) for SOC
- Joint calibration of N₂O and SOC by adding one-at-a-time sensitivity analysis for selection of additional parameters
- Shift to global pool model uncertainty (PMU) instead of PMU per PC x CFG x Emission source, to better account for available data per category
- Migration of codebase from R to Python

Section by Section Comments

Report type

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Report documents release r23aa16b Daycent-CR 1.1.0 with DayCent-CR model parameters v3.0 revision a7f2701.

Model description

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

The model is well described. The new algorithms on NI is based on a published daily reduction factor that appears appropriate for this model.

I confirm that the use of initial SOC estimates for model initialization (after spin-up) as described complies with CAR SEP section 5, including the use of a model C:N ratio to maintain consistency within DayCent.

Model calibration

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

DREAM-MCMC is a well-established popular algorithm for parameter estimation and the normalized sum of log likelihood of SOC and N₂O is appropriate practice, assuming number of observation points in each are relatively well balanced.

The k-fold cross validation with 5 folds with separate assignment for SOC and N₂O with one reserved for validation. Out of sample validation based on posterior parameters and withheld validation is appropriate.

The approach to run model to mid-experiment SOC when initial SOC is not measured is sound.

One at a time sensitivity for addition of N₂O parameters is admittedly likely to miss some non-linear interactions, but it appears to be a reasonable approach to modify the existing validation to allow for joint SOC and N₂O calibration and validation.

Project domain

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

I support the lack of validation for WATER PC given background practice nature of irrigation and the range of precipitation in the validation dataset.

Data Requirements

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Validation Data Collection

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Clearly, IndigoAg has developed a very rich dataset of experiments and sites that allows for a full validation across multiple CFG, LRR, PCs, and emission source (SOC and N₂O).

Bias Evaluation

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Model Prediction error

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Model Validation Outputs

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

No comments.

Evaluation of final parameter set

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

Restrictions on application of model

This section was reviewed in full and found to have met the appropriate requirements of the validation guidance document.

The removal of need for variance inflation factor and removal of filter for large changes in SOC are good to see and reflect improvements in protocol and validation data.