Near-time ecological forecasting of peatland responses to warming and CO₂ treatment through EcoPAD-SPRUCE

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Introduction

- Ecological forecasting is an important service ecologists brought to the human society.
- Timely forecasting of the response of peatland to warming and CO₂ enrichment is beneficial for the Spruce and Peatland Responses Under Climatic and Environmental Change Experiment (SPRUCE) experiment.
- The Ecological Platform for Assimilation of Data (EcoPAD) facilitates model data communication and provides both near-time and long-term forecasting of ecosystem dynamics.

EcoPAD: System Design

- Enhance model-data communication through data assimilation.
- Web-based simulations bring complex ecosystem models easily accessible to experimenters and the general public.
- Scientific workflow wraps around ecosystem models and data assimilation algorithms.
- Agnostic to IT infrastructures and readily portable to other ecosystems.
- Increase transparency through referenced data storage, access, visualization and management.

Meta databases

Library of modules of process models

Toolbox of DA techniques

Data assimilation system

Evaluation of model structure

Information content of data sets

Parameter estimation

Uncertainty analysis

Prediction of future C sink and confidence intervals

Fig. 1 Framework of the Ecological Platform for Assimilation of Data (EcoPAD)

SPRUCE is unique in its whole ecosystem manipulation with both aboveground and deep peat heating in the vulnerable northern peatland ecosystem. Warming treatments include ambient, +2.25 °C, +4.5 °C, +6.75 °C and +9 °C. Atmospheric CO₂ concentration is manipulated at two levels: 380 ppm and 800 ppm.

EcoPAD at Testbed: SPRUCE

EcoPAD Components

- Metadata and Provenance Catalog.
- Ecosystem models and dynamic data assimilation.
- Scientific Workflow.
- Structured result access and visualization.

Fig. 2 Workflow of the Ecological Platform for Assimilation of Data (EcoPAD)

EcoPAD-SPRUCE: 10 Year Forecast

Fig. 4 10-year forecasting of C fluxes and pools at ambient condition after the TECO model being constraint by data (red dots) through Markov Chain Monte Carlo methods. Shading green and black areas corresponding to confidence intervals. GPP stands for gross primary productivity and ER is ecosystem respiration. Forecasting for warming and atmospheric CO₂ manipulations are accessible from the EcoPAD-SPRUCE web portal (http://ecolab.cybercommons.org/ecopad_portal/).

EcoPAD-SPRUCE: 10 Year Forecast

Fig. 5 Example tasks users can easily perform at the EcoPAD

Fig. 6 EcoPAD-SPRUCE automatically synchronize real time observations from environmental sensors managed by the SPRUCE experimental communities. Data from observations are used to update forecasting. Weekly forecasting results are displayed in the EcoPAD-SPRUCE web portal as well as sent back to the experimental groups to guide future experimental design and sampling.

Summary

EcoPAD is designed to incorporate multiple biogeochemical models, diverse data assimilation techniques and various ecosystem state variables. It aims to promote model-data integration towards a predictive ecology through bringing complex ecosystem models and data assimilation techniques easily accessible to different audiences. We envision it to greatly transform environmental education and encourage citizen science in ecology and climate change with future outreach activities to broadcast the EcoPAD platform.

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