# Validation of the PEcAn Terrestrial Ecosystem Forecast Using NASA SMAP Satellite Soil Moisture Observations

Joshua Bowers[1,2], Dongchen Zhang[3], and Micheal Dietze[3]
[1]Boston University BRITE REU Program, Summer 2022, [2]Department of Microbiology, University of Wisconsin Oshkosh,
[3]Department of Earth and Environment, Boston University

## Introduction

With ever-changing climatic conditions over the course of the last half-century, the need to predict future ecological conditions has increased dramatically. This is what has lead to the creation of the **P**redictive **Ec**osystem **An**alyzer Project or **PEcAn** for short.

**PEcAn**

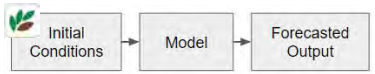
**Consists of:**

- Workflow of terrestrial ecosystem models
- Forecasting ecological processes and response variables
- Assimilation capabilities to fuse data and models

One key ecological response variable is **soil moisture**, which exerts a large influence on growth, survival, and carbon storage across a wide range of spatial and temporal scales. ***The goal of this project was to utilize real-time soil moisture data to validate the models produced by PEcAn.***

## Data Sources and Methods

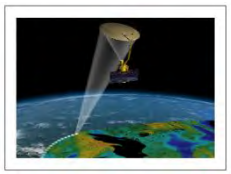
**Model Forecast Data**




PEcAn

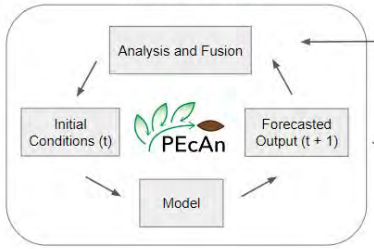
- Bayesian statistics model
- Produces forecasted soil moisture data given a set of initial conditions
- Model validation: forecasted data for past time periods

**NASA's SMAP (Soil Moisture Active Passive) Satellite**

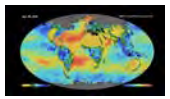


Produces real-time soil moisture observations via radio-wave backscatter

**Typical Forecast**




**SMAP Satellite**



**Validation**

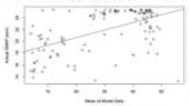


Fig 1. A typical PEcAn workflow being validated with real time soil moisture values collected by NASA's SMAP satellite and eventual model-data fusion step using validation feedback as guideline

## Results

***Correlation values for PEcAn forecasted and SMAP data depended on region for all seasons***

Asterisks denote increasing level of significance (ns: p > 0.05, *: p <= 0.05, **: p <= 0.01, ***: p <= 0.001, ****: p <= 0.0001)

**Summer 2015-2020**

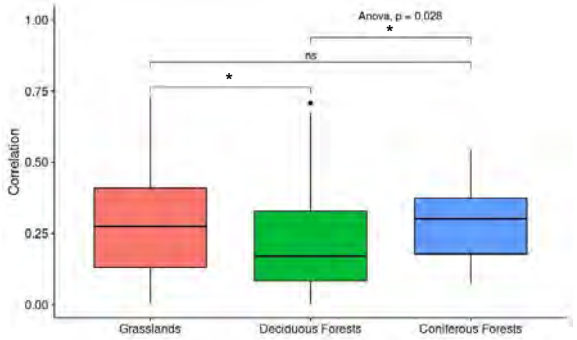



Fig 2. (n = 108 for grasslands, n = 84 for deciduous forest, n = 24 for coniferous forests

**Fall 2015-2020**

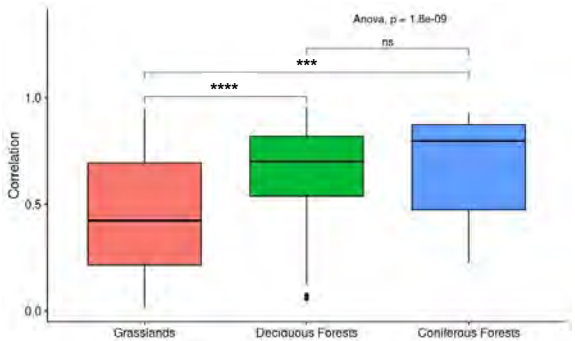



Fig 3. (n = 108 for grasslands, n = 84 for deciduous forest, n = 24 for coniferous forests

**Winter 2016-2020**

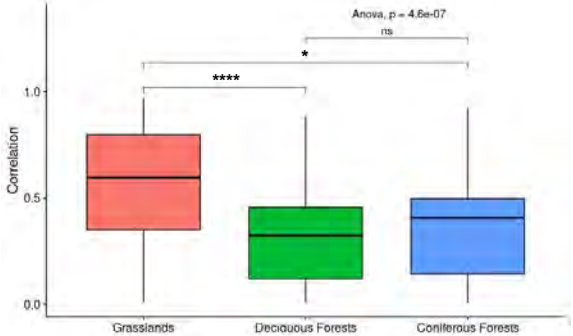



Fig 4. (n = 90 for grasslands, n = 70 for deciduous forest, n = 20 for coniferous forests

**Spring 2016-2020**

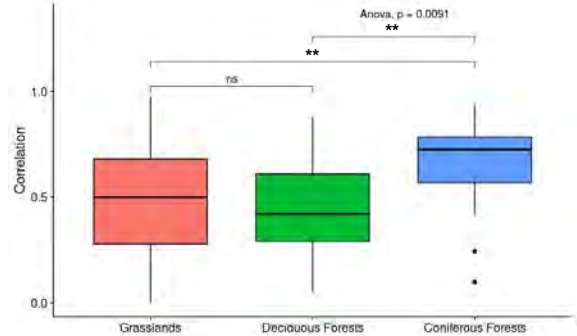



Fig 5. (n = 90 for grasslands, n = 70 for deciduous forest, n = 20 for coniferous forests

## Discussion

- PEcAn's soil moisture predictive capabilities are variable on spatial and temporal cofactors of the predictions
- Iteratively assimilate SMAP data into our model in a data-model fusion step, further increasing PEcAn's predictive capabilities
- In the presence of extreme conditions (e.g snowfall and drought), PEcAn's predictive capabilities seem to diminish significantly
- Cleanup of artifacts from previous assimilations will further increase model accuracy statistics

## References

Dietze, M. C., *et al. Proceedings of the National Academy of Sciences*, 115(7), 1424–1432 (2018).

Dokoohaki, H., *et al. Geospatial Model Development, 15(8), 5-11* (2021).

Fer, I., *et al. Global Change Biology*, 27(1), 13–26 (2021).

Raiho, A., *et al. bioRxiv* (2020). https://doi.org/10.1101/2020.05.05.079871

## Acknowledgements

This work was funded, in part, by NSF grant DBI-1949968, awarded to the Boston University Bioinformatics BRITE REU program