Iterative Near-Term Ecological Forecasting: Applications to Land-Atmosphere CO_2 Fluxes

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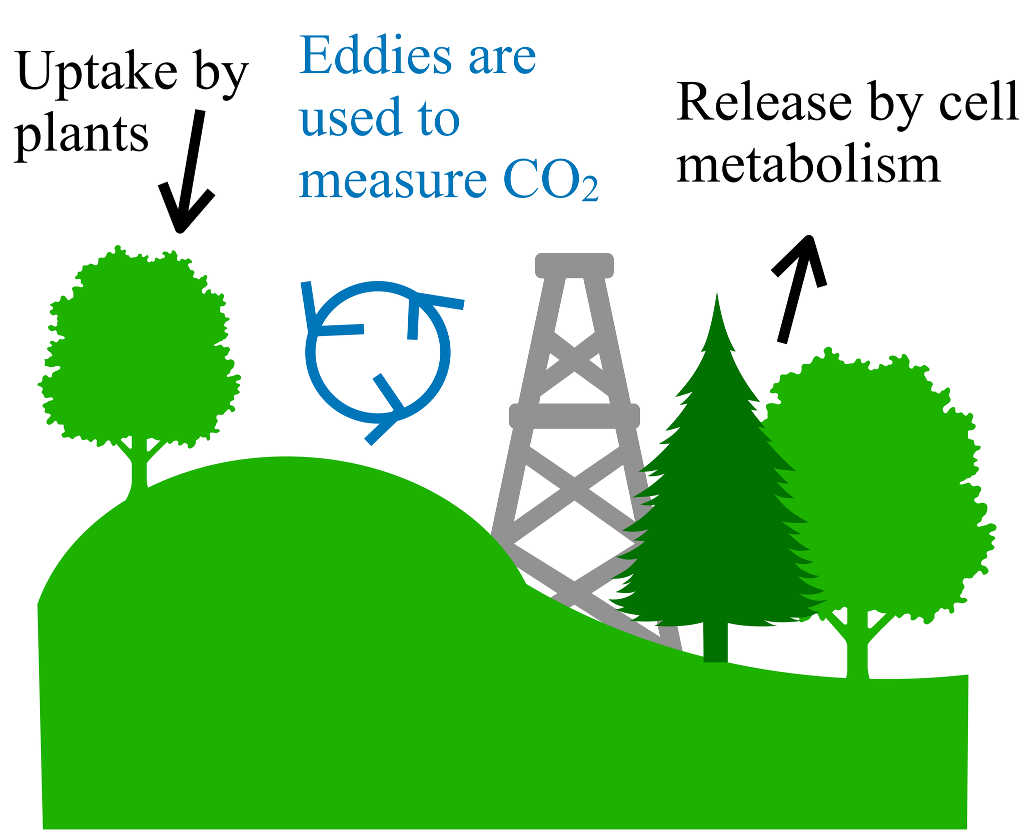
Abstract

Modeling is fundamental to the nature of informed prediction in ecology, yet it is difficult to verify the accuracy of long-term hypotheses due to the impossibility of obtaining future data. Models can be incrementally improved, however, with an iterative, short-term forecast/test/adjustment cycle in which a forecast is compared with real data results. This project focused on building the software infrastructure for model improvement by parameter and model adjustment through iterative forecasting.

Carbon Fluxes

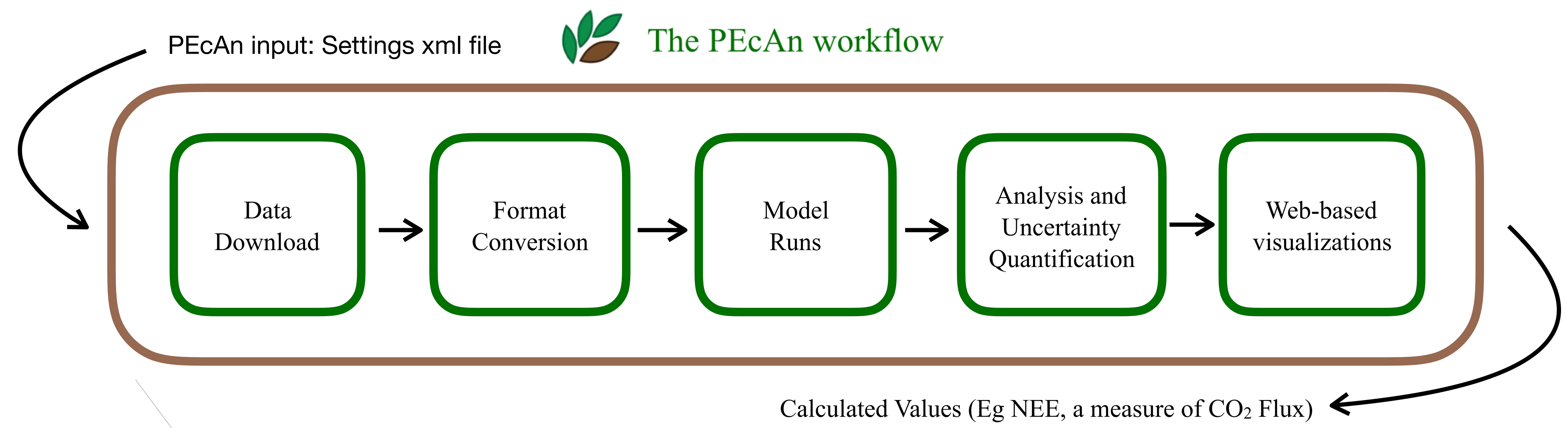


The term "carbon flux" refers to the exchange of carbon (often as CO_2) between different reservoirs in the environment and the atmosphere.

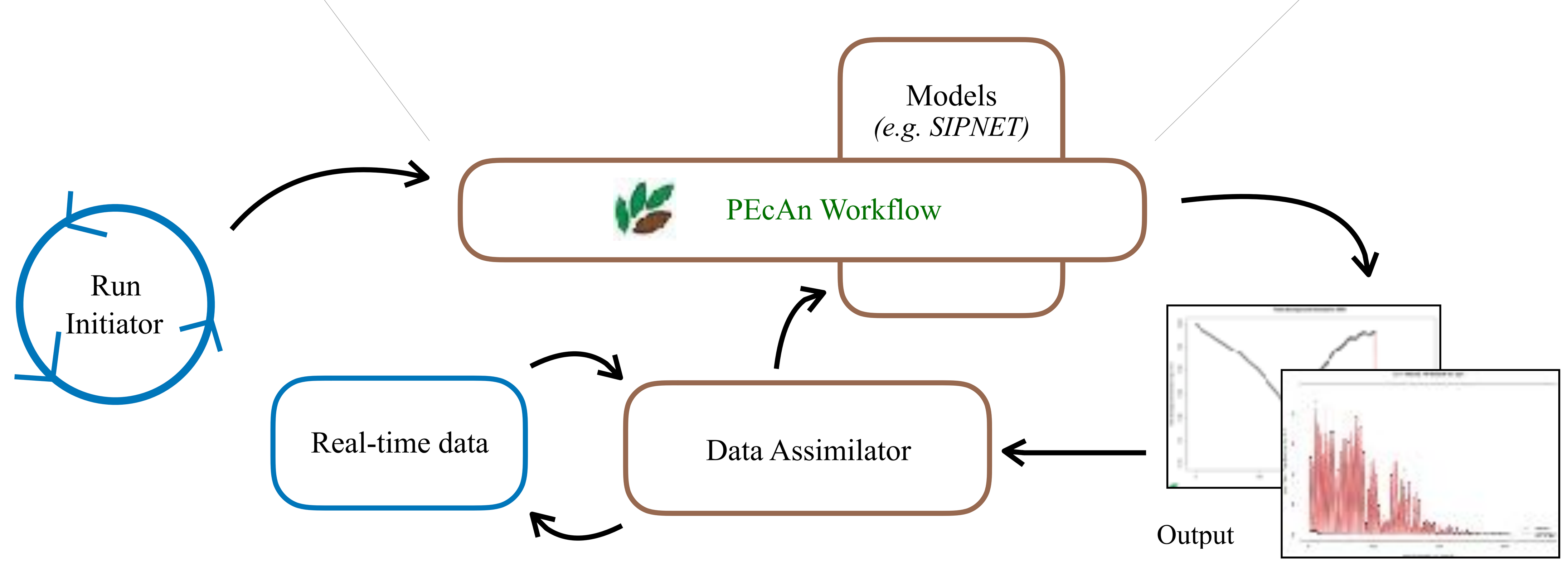
PEcAn – An Ecological Modeler's Bioinformatics Toolbox

PEcAn (the Predictive Ecosystem Analyzer) is a set of software tools and R packages that work together to

- Collect, store, and manage field data
- Convert data into model-specific formats for use as input parameters
- Run a variety of ecological models
- Analyze and provide visualizations of results
- Provide ways to measure uncertainty, such as ensemble analysis.



NEFI – Iterative Ecological Forecasting



NEFI (the Near-term Ecological Forecasting Initiative) supports iterative, automated adjustments to a model's parameters to increase accuracy.

- Runs regularly (daily) and automatically
- Compares real data to model-predicted data
- Next step: Use data assimilation to improve accuracy
- Goal: Increase model accuracy and reduce uncertainty in a given model's output, thus providing useful data that can be used to make decisions about real-world problems

Model: SIPNET

SIPNET is a simple carbon flux model.

$$Y_{t+1} = f(Y_t, X_t | \bar{\theta} + \alpha) + \varepsilon_1$$

Inputs:

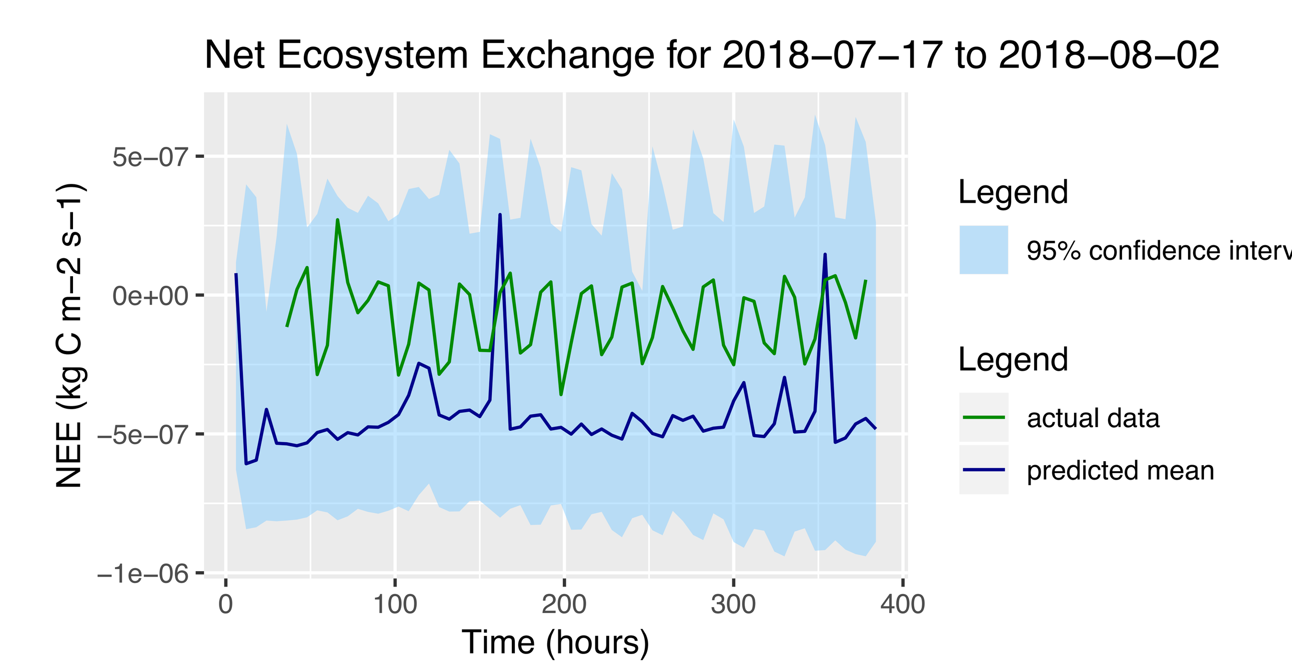
- Weather data, in this case from NOAA's Global Ensemble Forecast System, (GEFS) (X_t) at time t.
- Parameters about the state of the biomass at a given site ($\bar{\theta}$)

Outputs:

- Net Ecosystem Exchange, a measure of the rate at which carbon enters and leaves the environment as CO_2 at time t + 1.

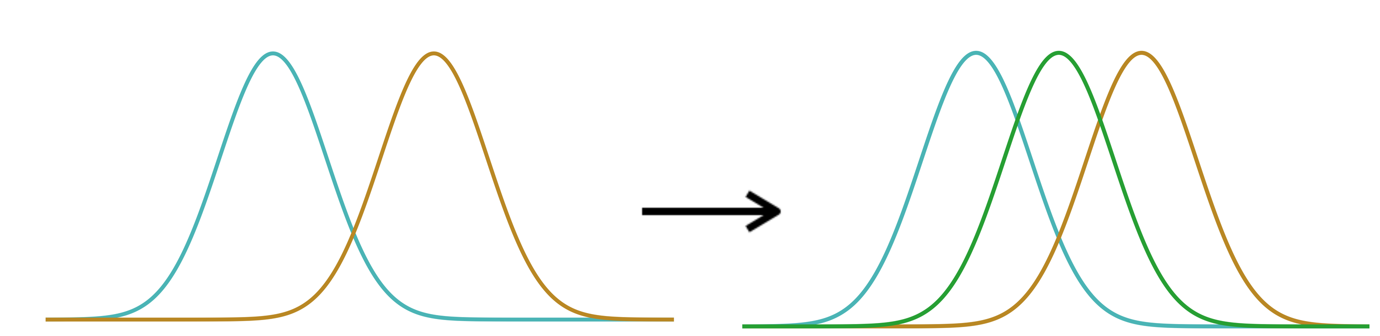
Conclusions

The workflow was able to forecast realistic, real-time predictions of Net Ecosystem Exchange (NEE) , a measure of carbon fluxes.



Next Steps

Now that the underlying software infrastructure is in place, perform real-time data assimilation to improve models.



A visual representation of data assimilation, where data is represented as a distribution.

References and Acknowledgements

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Dietze, M. C. (2017). *Ecologcial Forecasting*. Princeton, NJ: Princeton University Press.
Dietze, M.C. (2017) Prediction in Ecology a First Principles Framework.
PEcAn Project GitHub Address:
https://github.com/PecanProject/pecan
NEFI project GitHub Address
https://github.com/EcoForecast