

## **Vision:**

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Carbon and energy exchanges between the terrestrial biosphere and the atmosphere are important drivers of the Earth's climate system. The net carbon exchange results from a balance between ecosystem uptake (photosynthesis) and losses (respiration), which could be measured and quantified by eddy covariance flux method. Monitoring, mapping and modeling of carbon fluxes in different terrestrial ecosystems are essential for understanding the contribution of these ecosystems to the regional carbon budget. This information will be particularly useful for decision making regarding various carbon-related climate change mitigation strategies.

Although CO<sub>2</sub> inventory databases offer the potential for estimating the regional ecosystem carbon budgets in some locations, ecological models have proven to be essential tools for expanding the coverage of these data as compared to the dispersed point site measurements. Therefore, modeling of CO<sub>2</sub> flux from other micrometeorological variables is vital for large scale assimilation. But the non-linearity of the relationship between CO<sub>2</sub> flux and other micrometeorological flux parameters (such as energy fluxes) limits the applicability of process-based carbon flux models to accurately estimate the flux dynamics. The application of data-driven models by machine learning (ML) methods (e.g., artificial neural networks, support vector machines, regression and model trees) provides an empirical model based on the patterns contained in data, and is able to identify the complex non-linear relationship and estimate land surface–atmosphere fluxes from site level to regional or even global scales. This enables us to diagnose the state of the biosphere from observational data streams, which provide valuable insights for local climate variations.

## **Objectives**

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Over the course of this study, our overall objectives include:

- (1) Investigate the carbon flux dynamics and investigate the temporal and spatial pattern in net ecosystem exchange (NEE) measured using eddy covariance flux towers.
- (2) Link NEE with micrometeorological indicators across diverse ecosystems using appropriate machine learning techniques.
- (3) Utilize the extracted relationship for spatio-temporal mapping to the whole domain, where possible.
- (4) Evaluate the performance of the ML-based carbon flux simulation compared to observed values.

## **Success Criteria**

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In this study, the main questions that we aim to answer are as follows:

- What governs the carbon dynamics of terrestrial ecosystems? And why does the atmospheric CO<sub>2</sub> budget vary from year-to-year regionally?
- Can we project net ecosystem-atmosphere exchange of CO<sub>2</sub> into the future?
- How does the interaction among different land surface properties influence NEE and climate?

## Deliverable Timeline

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**Week 1-2:** Identify regions of interest, collect quality-checked data from FluxNet and get ready for processing.

**Week 3-4:** Quantify CO<sub>2</sub> turbulent flux and diagnose environmental drivers (temperatures, land surface properties, etc) of each flux observation.

**Week 5-6:** Extract explanatory variables between flux responses and drivers using machine learning techniques.

**Week 7-8:** Project turbulent exchange grids over the target area based on extracted key drivers in each grid cell.

**Week 9-10:** Evaluate the overall predictive capacity and consistency of ML approaches. Prepare for final presentation.