Tower-Based Optical Sensing Architecture for Facilitating the Investigation of Fine Scale Biosphere-Atmosphere Interactions via Optical-Flux Data Integration

Y. Hamada, R. Sankaran, D. Cook, D. Bales, R. Matamala, C. Weber, R. Herrera, N. Ferrier, R. Graham; Argonne National Laboratory

Introduction

Our ability to forecast ecosystem functions and climate at regional and global scales has significantly advanced. However, little is known about how local phenomena such as variations in water and carbon fluxes at a fine temporal scale relate to large scale phenomena and vice versa.

Aim

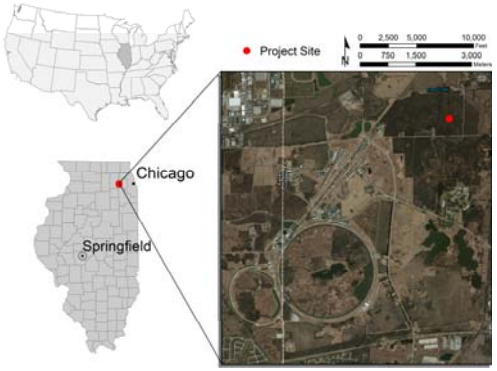
Identify patterns and associations between high frequency optical data and fluxes of energy, water, carbon dioxide, and biological measurements for investigating interactions between biosphere and near-surface atmosphere.

Approach

Construct an integrated multiple sensor optical tower measurement system (EcoSpec System)

Study Area

AmeriFlux Fermilab Agricultural Site (US-IB1; corn-soybean rotation)

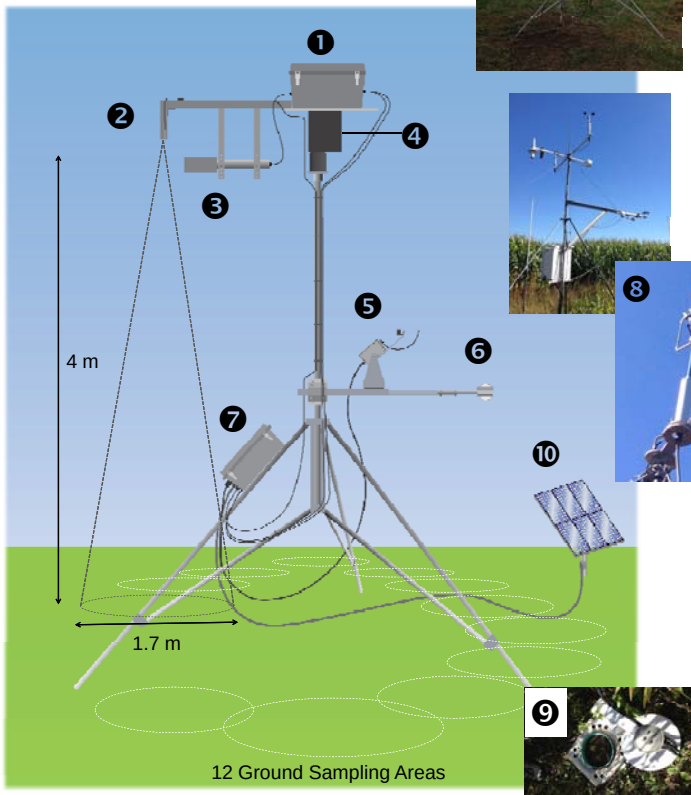


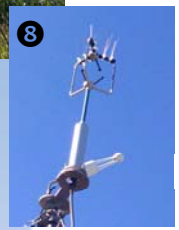
Aerial imagery provided by Esri.

EcoSpec System

Features:

- ❖ Self-sufficient*
- ❖ Solar-powered
- ❖ Easily deployable
- ❖ Near real-time data transfer
- ❖ Remotely controlled/managed*





❶ Optical sensors (spectrometer [ASD FieldSpec4] and RGB camera [Asix Q1604])

- Provide VIS-SWIR hyperspectral data indicative of plant chemical and physical properties and visual/contextual information of each field of view.

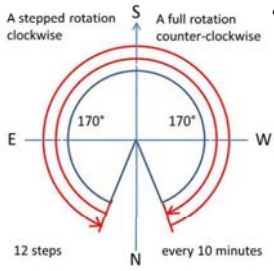
❷ Thermal infrared temperature sensor (Apogee IRTS-P)

- Provides temperature of canopy and surface soil, which influence ecosystem functions.

❸ White reference plane (Labsphere Spectralon 99%) with Actuator (PA-15-8-11)

- Collect dark current and white reference data before every optical measurement to mitigate variability of atmospheric and solar conditions.

❹ Pan-tilt unit (PTU-D300)

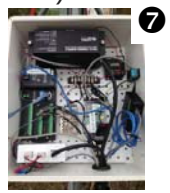


- Rotates 340° every 10 minutes from dawn to dusk each day during a growing season. A single rotation collects optical data from 12 pre-defined ground sampling areas.

❺ Shadowband radiometer (Irradiance RSR-2)

❻ Albedometer (NOVA LYNX 204-8104)

❼ Control box



- Single-board computer (Raspberry Pi) controls movement of the apparatus with a pre-define timeline; datalogger tracks measurements from ❷❺❻; cellular modem transfers all measurements to the remote server near real-time

❽ Eddy flux tower and ❾ Soil respiration chamber

- Collect flux measurements

❿ Solar power system

Currently under Development:

- ❖ Automated data collection and preprocessing by developing the appropriate database architecture
- ❖ Data QA/QC protocols for data accuracy and reproducibility
- ❖ Summer field campaign to simultaneously measure fluxes and optical data
- ❖ Statistical methods for data analytics and visualization

* Some maintenance and adjustment requires physical access to the system on site.

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