New York State Mesonet: Implementation of an Eddy Covariance Flux Sub-network

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The New York State Mesonet (NYS Mesonet)

The NYS Mesonet is an integral component of the New York State Early Warning Weather Detection System that was established by the Department of Homeland Security in January 2014 to improve weather monitoring and forecasting in New York State. It is currently the largest Mesonet in the United States, consisting of 126 standard weather stations, spaced approximately 19 miles apart, and three advanced **sub-networks (sub-nets)** including:

Profiler: **17 –** Co-located lidars and upward looking radiometers for vertical profiling of the atmosphere
Snow: **20 –** Specialized instrumentation to measure snow water equivalent
Flux: **17 –** Closed-path eddy covariance flux systems for measuring net radiation and fluxes of CO_2, latent heat, sensible heat, and momentum (i.e. surface energy balance)

About the Flux Sub-network

The NYS Mesonet Flux Sub-net consists of seventeen closed-path eddy covariance flux systems mounted on seventeen existing NYS Mesonet towers throughout New York State (NYS). Most instrumentation are as-included with the commercially available Campbell Scientific CPEC200 flux system, though the Mesonet's system is customized (in house) to meet our specific needs and limitations. The objective of the flux sub-net is to provide a platform for research to improve numerical weather prediction in NYS thereby serving the economic, societal, and safety needs of NYS stakeholders. The design, siting, and implementation of the Flux sub-net reflects the desire for it to be utilized for a variety of other research purposes as well including but not limited to; agricultural research, carbon budget studies, boundary layer-land surface research, model and satellite validation, and instrument R&D. Those interested in using data from or collaborating with the NYS Mesonet Flux Sub-net are encouraged to contact the authors above or the NYS Mesonet directly via http://nysmesonet.org.

Flux Sub-network By the Numbers

2/13/2017	first flux installation at Voorheesville, NY
9 flux sites	co-located with atmospheric profilers
11 months	to fully deploy network (less automated calibrations)
9 m	AGL measurement height (wind, radiation, gas)
15 Watts	steady state power draw (3 W winter running mode)
330 days	of data at Voorheesville, NY site
$750 K	initial investment
$30 K	annual operating budget

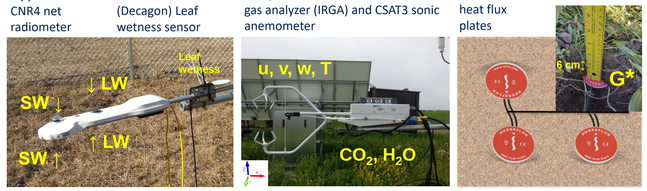
Instrumentation

Kipp & Zonen CNR4 net radiometer

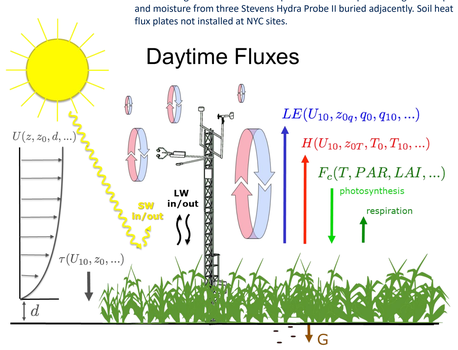
Meter Environment (Decagon) Leaf wetness sensor

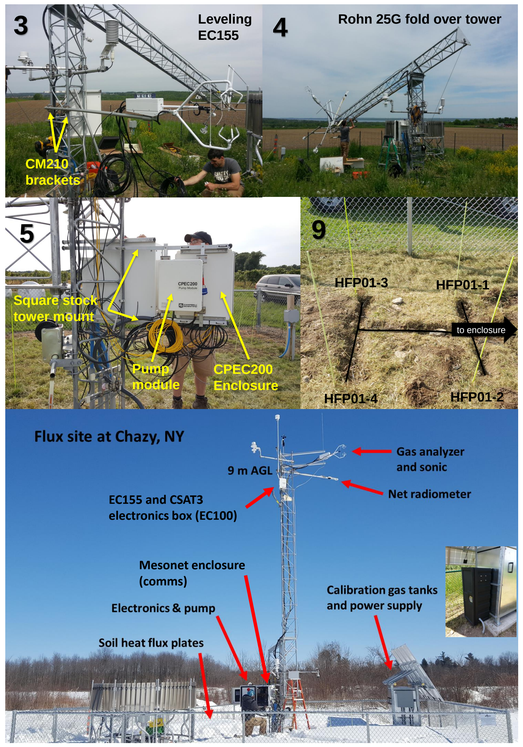
Campbell Scientific EC155 infrared gas analyzer (IRGA) and CSAT3 sonic anemometer

4x Hukseflux HFP01 soil heat flux plates



*Heat storage above soil heat flux plates can be computed using soil temp and moisture from three Stevens Hydra Probe II buried adjacently. Soil heat flux plates not installed at NYC sites.

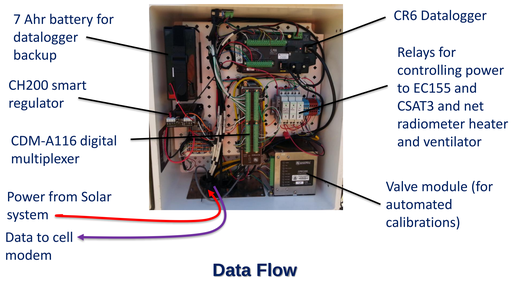




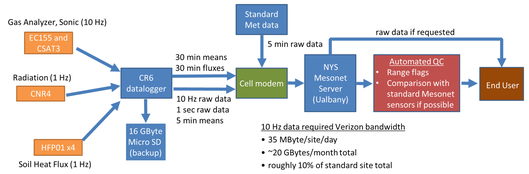
Power and Data Management

- Flux system relies on Mesonet solar power system entirely
- **Power consumption:**
  - 3 W (net radiation, soil heat flux only)
  - 6 W (net radiation, soil heat flux, and wind only)
  - 15 W (Full power mode, all data collected)
  - 30 W (Full power mode + net radiometer heaters on)
- 15 W, full time operation only possible between late April and early October given solar power system limitations
- Net radiometer and soil heat flux plates are operated year-round
- CR6 Datalogger runs a modified version of Campbell Scientific's **EasyFlux DL** program for computing fluxes and running the system

CPEC200 Enclosure



Data Flow



Installation Process

Phase 1 (December 2016 – June 2017)

1. Flux system is wired, tested, and prepped at the Atmospheric Sciences Research Center (ASRC) for transport-into-field and installation.
2. Flux system shipped by NYS Mesonet truck to the field site.
3. Net radiometer, IRGA, and sonic are leveled using bottom of the tower as reference.
4. Instruments and enclosure are mounted on the tower at their respective heights using Campbell Scientific tower mounting kit pn. CM210, U-bolts, and 6 ft long aluminum round tube.
5. Enclosure is affixed to a custom square stock tower mount
6. Cables and tubes run down the tower to the enclosure
7. System is field tested, connected remotely to Mesonet servers, and data transmission is initiated.
8. Data is monitored, datalogger program tweaked (ongoing process)

Phase 2 (June 2017 – November 2017)

9. Trenches dug and conduit laid for calibration tubes and soil heat flux cables
10. Soil heat flux plates inserted gently into the soil profile 6 cm subsurface
11. Cables and gas tubing routed through conduit
12. Calibration tank enclosure mounted to Mesonet battery box
13. Locations of buried plates are recorded using coordinate system

Phase 3 (Underway)

13. Calibration tank concentrations verified in the lab before shipment to flux site
14. Calibration tanks shipped to site and installed
15. Automatic calibration procedure initiated on a schedule

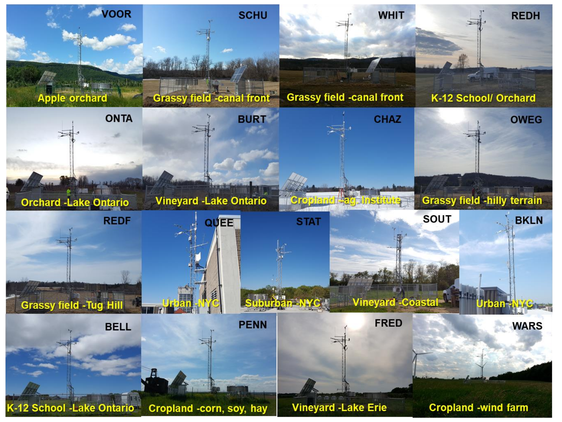
Siting Strategy

Targeted Site Types for Potential Research Areas

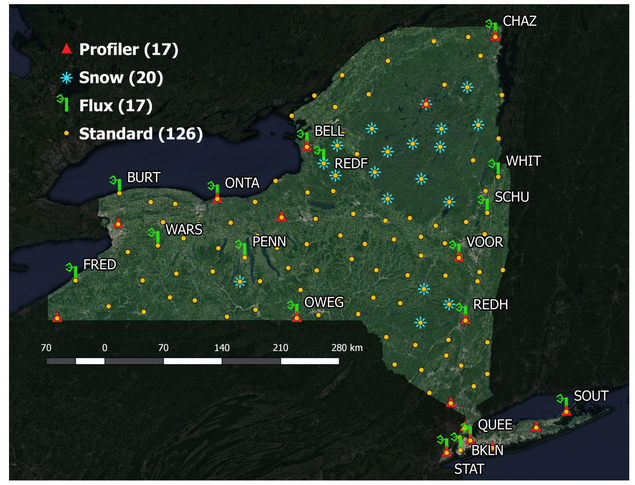
- **Infrastructure** –watersheds/water front (water/energy balance)
- **Emergency management** - urban sites (dispersion)
- **Economic** - agricultural sites
- **Numerical Weather Prediction (NWP) improvement** - all sites
- **Climate change/ecological** - all sites (carbon balance, land use/land cover change)

Other considerations for siting

- Co-location with other NYS Mesonet Sub-nets
- Representativeness of 9 m AGL flux measurement at each site
- Flow distortion potential from obstructions nearby to tower
- Uniqueness of land cover/land use surroundings
- Potentially impactful terrain features
- Predominant wind direction (land cover/use in fetch)
- Meteorologically interesting areas (e.g. Tug Hill Plateau)
- Site host interest



NYS Mesonet Site Map



Calibrations

Frequent calibrations of the EC155 infrared gas analyzer are necessary to ensure accuracy of the CO_2 and H_2O concentration measurements due to the sensitivity of the instrument to changes in ambient temperature. We plan to perform automated calibrations of the EC155's CO_2 signal once or twice daily using two reference gas concentrations stored on site in 44 inch cylinders. The two reference gasses (around 0 and 420 ppm CO_2) are procured from a local gas supplier. The cylinder concentrations are verified using a Picarro G4301 cavity ring-down spectrometer (CRDS) that is calibrated prior to every use by two high quality NOAA standard gasses. The EasyFlux DL program runs the process whereby reference gasses are sent periodically to the EC155 for calibration using the CPEC200's optional 4 valve module. The H_2O signal must be calibrated manually using a dew point generator. This is performed in the Fall and Spring with regular maintenance of the Flux system.

Ongoing & Future Projects

- Optimize power management during winter months
- Improved levelling of the net radiometer on the folding tower
- Improve current and develop new methods for automated quality control
- Evaluate representativeness of each Flux site (i.e. footprint modelling)
- Evaluation of EasyFlux DL and CPEC200 performance
- Improvement of boundary layer-surface parameterizations in NWP
- Identification of trends and data phenomena that suggest a need for further study

Contacts

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Data requests: visit http://nysmesonet.org/data/requestdata

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