Surface Energy Balance Across the 18-site New York Mesonet Flux Network

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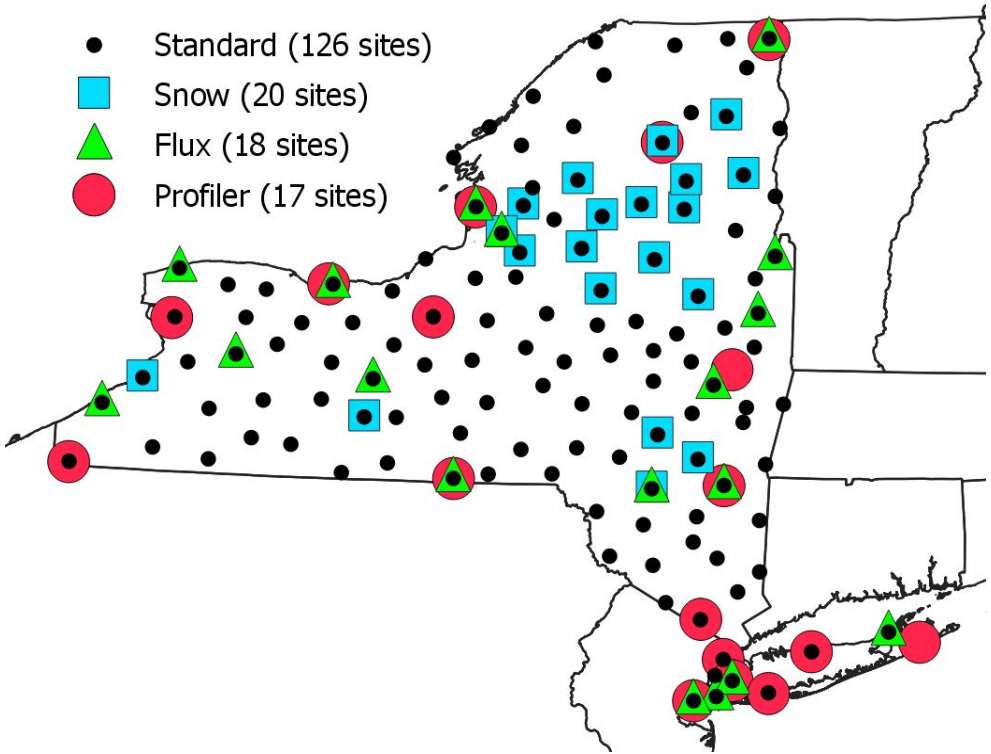
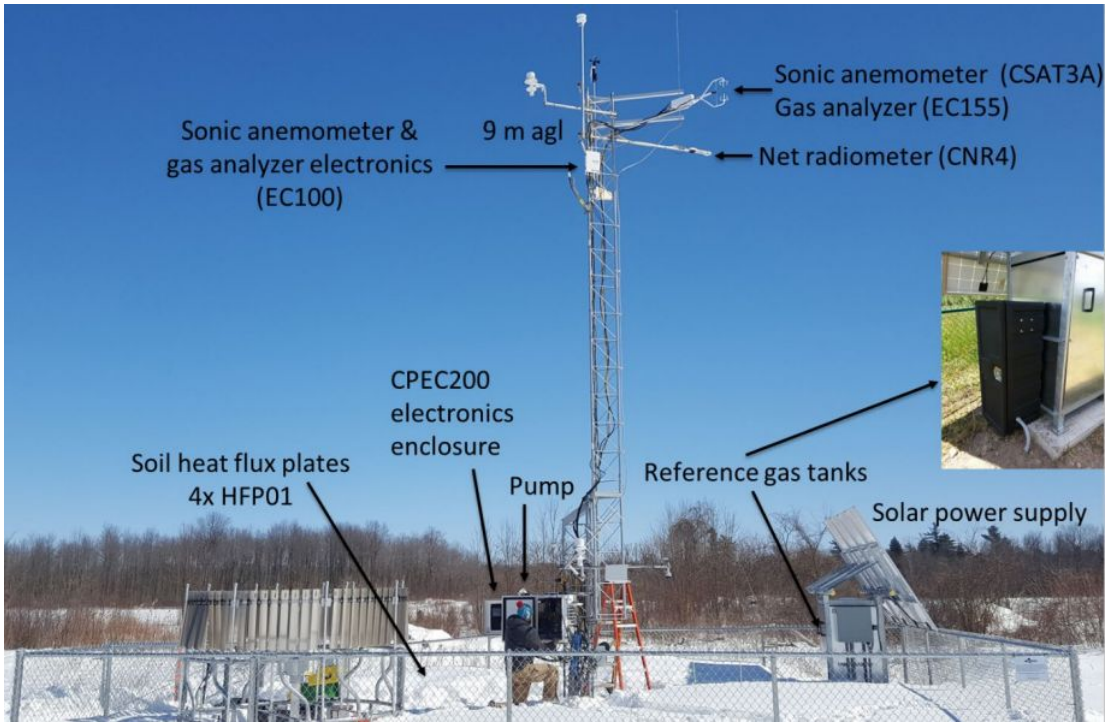
New York State Mesonet Flux Network



- The New York State Mesonet (NYSM) Flux Network consists of 18 sites across New York that have been measuring surface energy balance components since 2018
- Radiation components, turbulent fluxes (containing onboard calculated quality control scores), and ground heat flux
- Currently 100+ site years of 30-minute flux data

Flux Sites



- 18 eddy covariance stations
- *Net radiometer:* incoming and outgoing shortwave and longwave radiation
- Ground heat flux
- *Turbulent fluxes*: momentum, sensible and latent heat, and carbon dioxide
- Turbulence sensors measure at 10 Hz

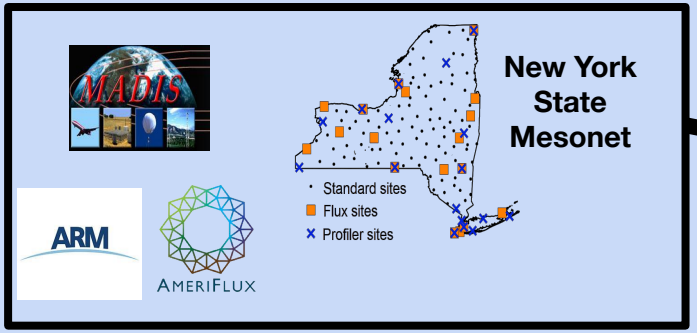
Chazy Flux Site

Advanced Coupling Evaluation Metrics in METplus for UFS Land Surface Models

Project Objectives:

1. Combine NYSM standard site data with flux data and include quality control parameters
2. Advance land-atmosphere coupling evaluation metrics within METplus[1] framework using NYSM observations
3. Demonstrate new capabilities by evaluating high-resolution forecast model output, experimental version of the Unified Forecast System (UFS)

[1] Verification system for UFS



from NOAA/EMC

Coupled UFS model output

Evaluation Metrics for LSM Processes

Standard: *T*, *q*,...

Flux: *Latent heat*, *Sensible heat*, *Momentum*

➔ Metrics: Bowen ratio, etc...

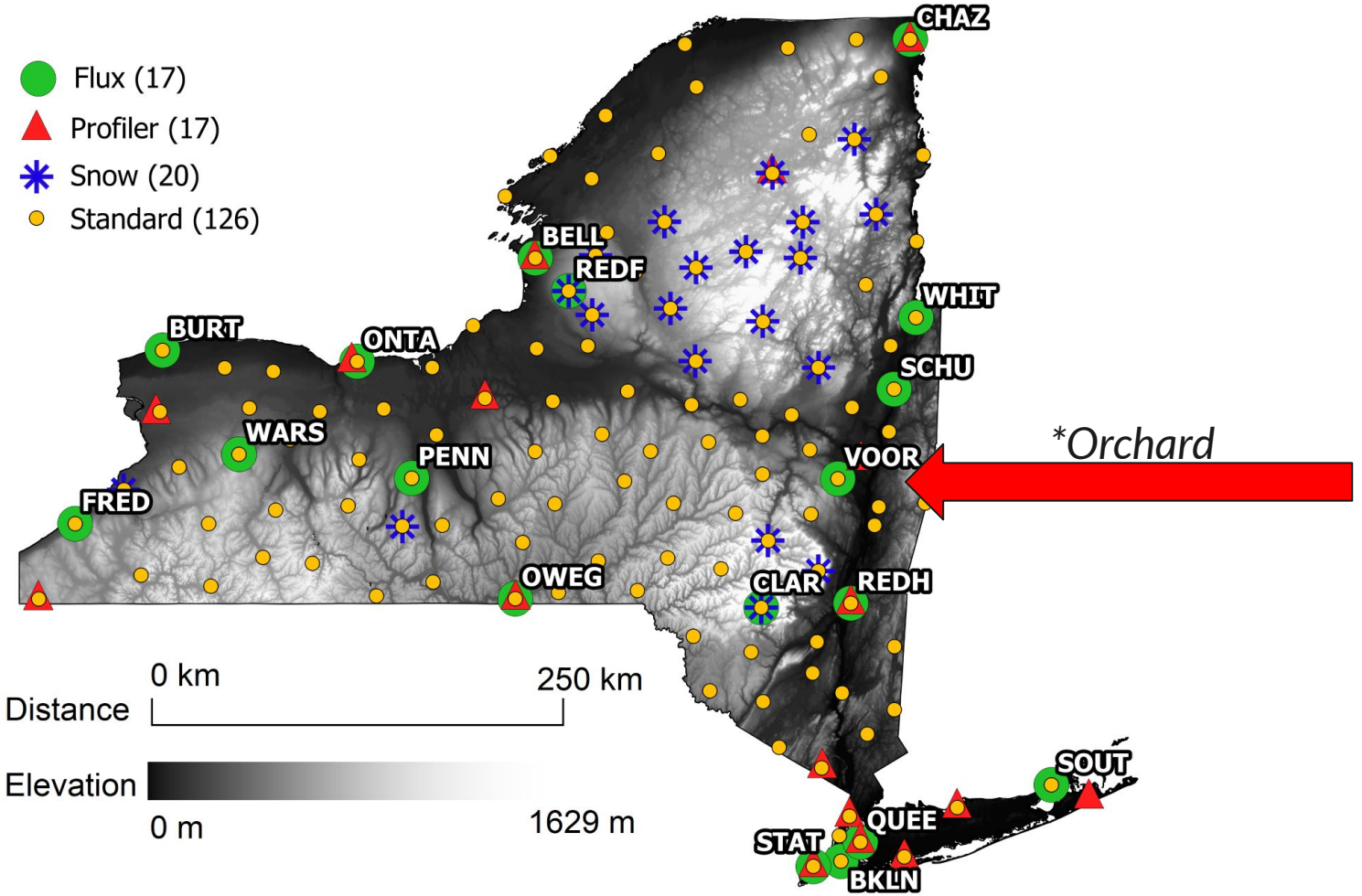
1. Retrospective METplus use-cases
2. Near real-time METplus

Site Name	ID	Site Description	Notes
*Belleville	BELL	Grass/ Crop field	Profiler
Brooklyn	BKLN	Urban	NYC
Burt	BURT	Vineyard/ Crop field	
Chazy	CHAZ	Crop field	Profiler
Claryville	CLAR	Pasture	Snow
Fredonia	FRED	Vineyard	
Ontario	ONTA	Orchard	
Owego	OWEG	Grassy field	Profiler
Penn Yan	PENN	Crop field	
Queens	QUEE	Urban	NYC, Profiler
Redfield	REDF	Grassy field	Snow
Red Hook	REDH	Grass/ Orchard	Profiler
Schuylerville	SCHU	Grassy field	Canal
Southold	SOUT	Vineyard	
Staten Island	STAT	Suburban	NYC, Profiler
*Voorheesville	VOOR	Orchard	Profiler
Warsaw	WARS	Crops	Wind Farm
Whitehall	WHIT	Grassy field	Canal

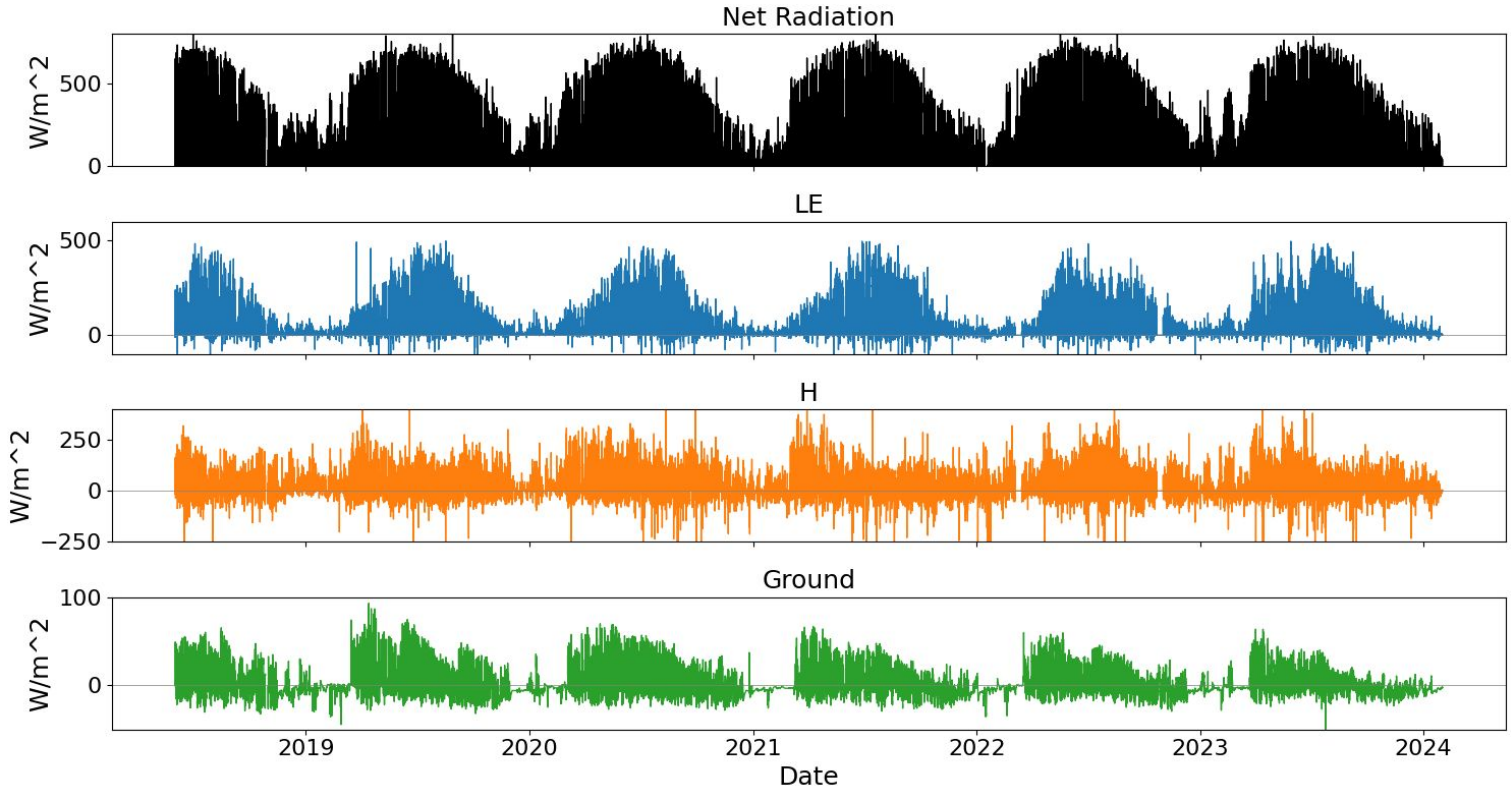
Data & Quality Control

- 30-minute fluxes computed in real time on Campbell CR6 datalogger using EZFlux software and transferred back to NYSM servers
- For each 30 minute flux, a QC flag is included in the final dataset

- Despiking
  - Applied to radiation components and fluxes
  - Flag values that are outside of a variable specific threshold and deviate more than 3.5 standard deviations from the mean


Flux (17)
Profiler (17)
Snow (20)
Standard (126)
CHAZ
BELL
REDF
WHIT
BURT
ONTA
SCHU
WARS
PENN
VOOR
*Orchard
FRED
OWEG
CLAR
REDH
SOUT
QUEE
STAT
BKLN
0 km
250 km
Distance
Elevation
0 m
1629 m

30-minute Fluxes (6 years,Voorheesville)



QC 1-6 and despiking

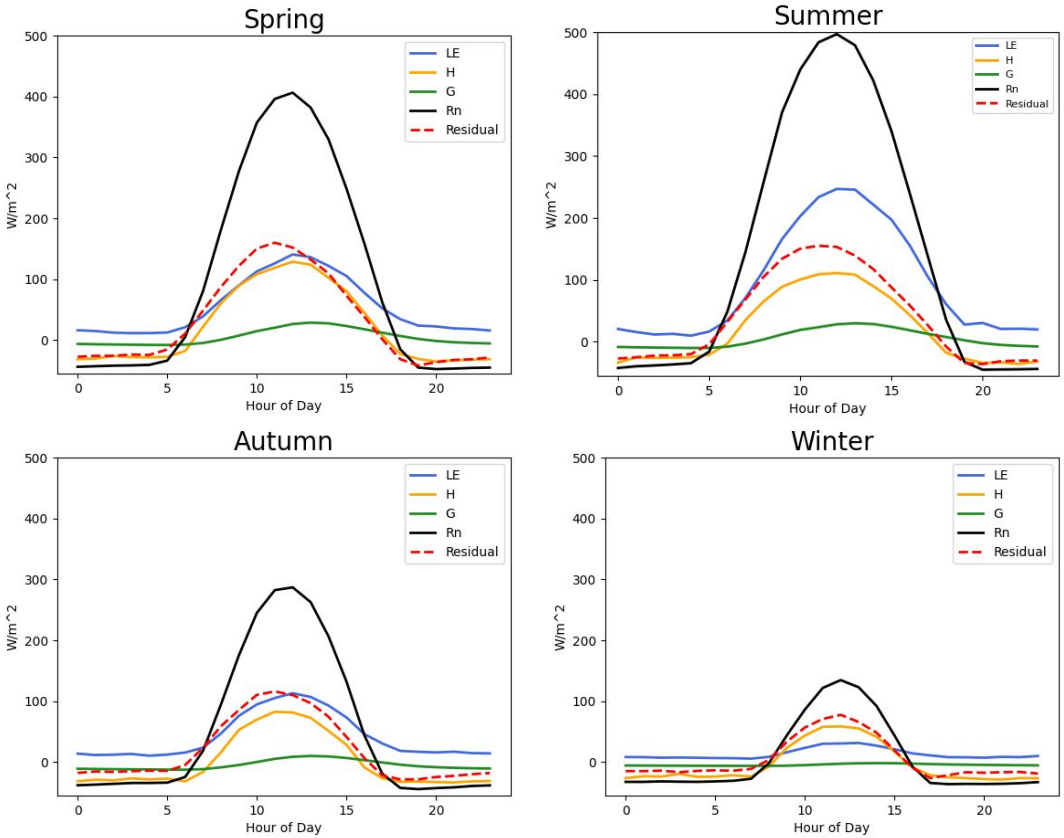
Diurnal Energy Budget (Voorheesville)

$$R_n - G \stackrel{?}{=} H_S + H_L$$

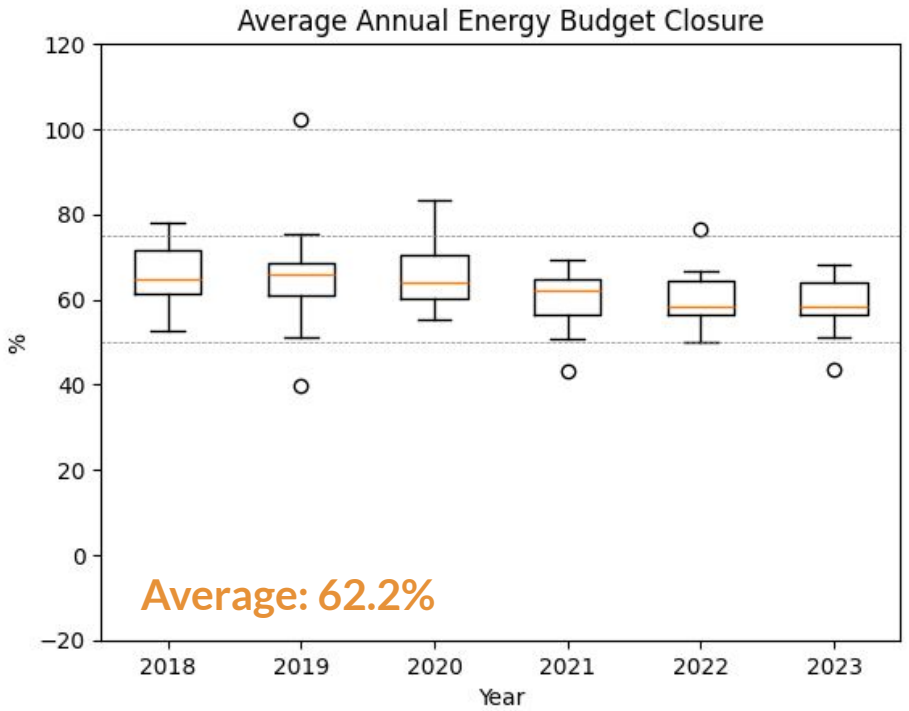
$$Residual = (R_n - G) - (H_S + H_L)$$

- Residual is the amount of energy not accounted for in the energy budget equation when closure is not 100%

- Higher residual values in warmer months… but a larger radio of residual to total radiation in the winter



Annual Midday Energy Balance Closure



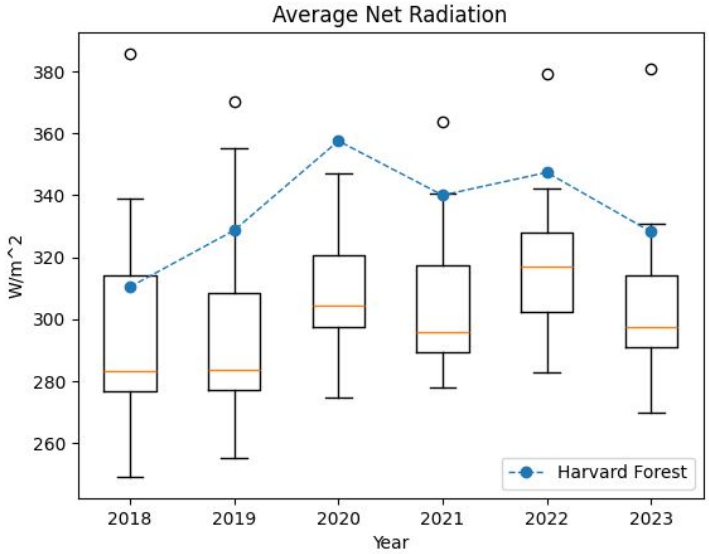
Energy budget closure = $(H_s+H_L)/(R_n-G)*100$

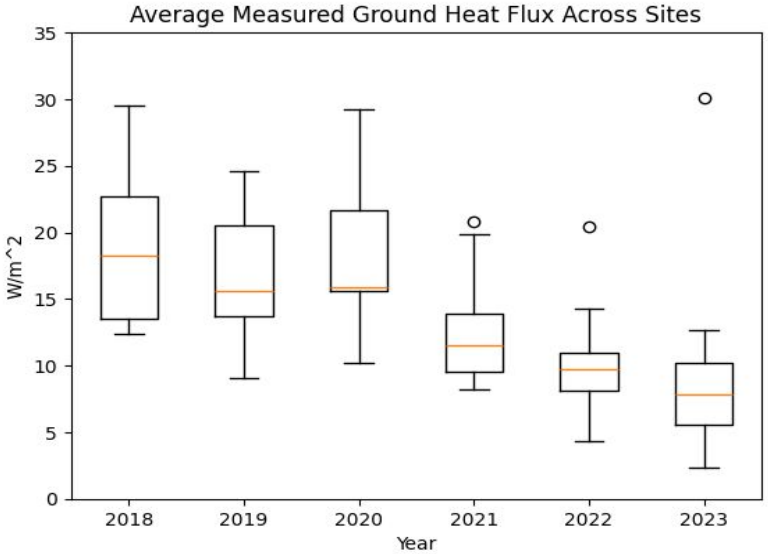
- Each boxplot represents the 15 non-urban sites
- Calculated the average energy budget closure during peak radiation hours at each site each year (approx 10am-2pm)
- Slight decreasing trend
- *Note*: does not include ground storage between surface and 6 cm

Driving Factors

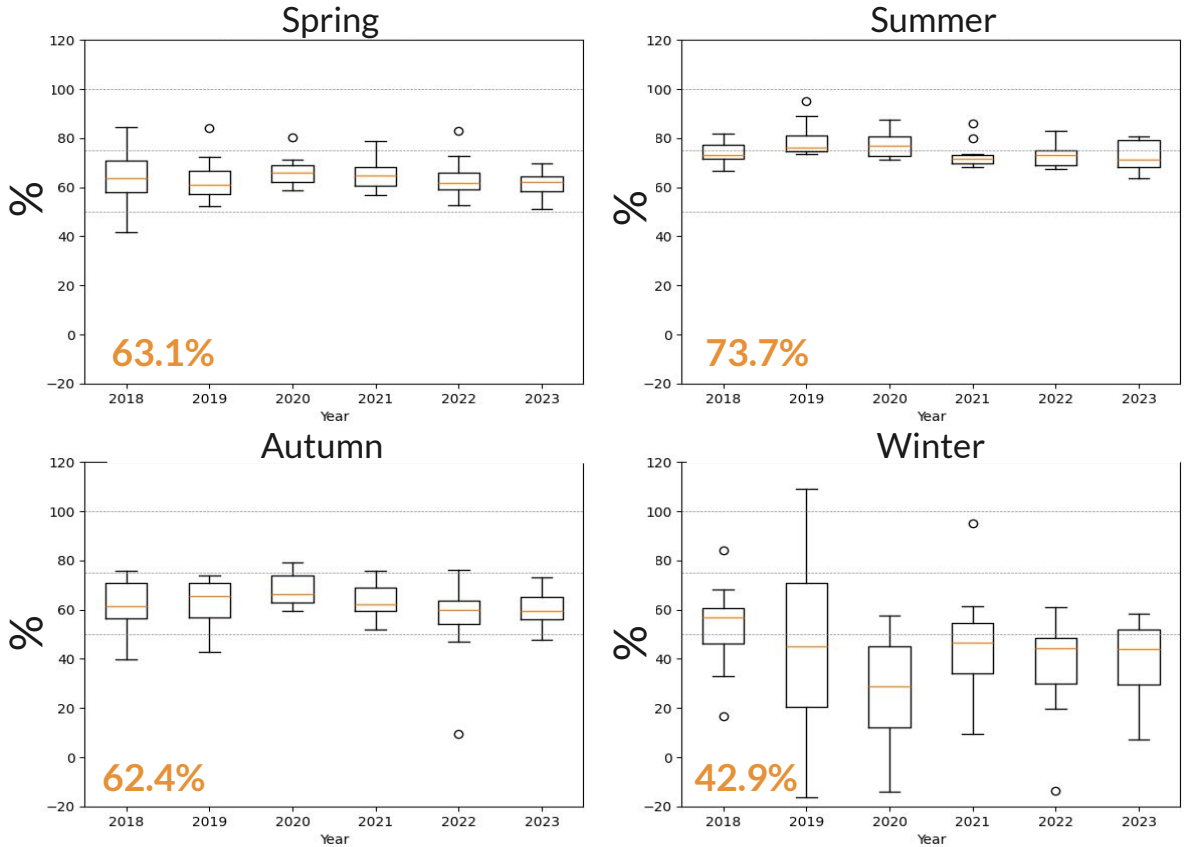
$$Residual = (R_n - G) - (H_S + H_L)$$

- Net radiation is generally increasing slightly over time
  - Same trend shown in near by NEON flux site in Harvard Forest (~85 miles from Albany)
- Ground heat flux trending downwards… *What is causing this?*
- Both of these changes increase the residual

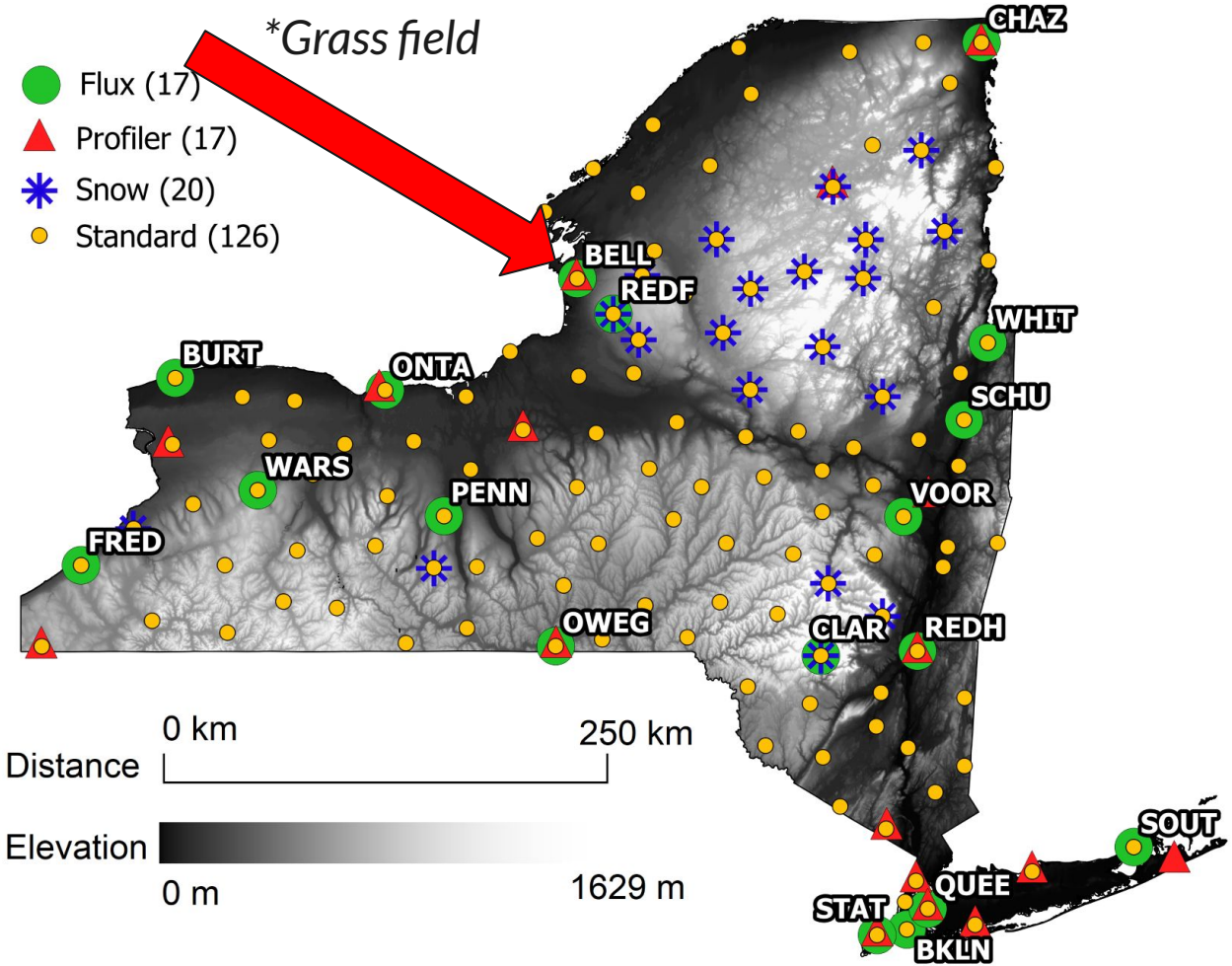




Midday Energy Balance Closure



- Highest and most consistent energy budget closure across all sites in the summer
- Low closure in the winter
  - Fluxes and net radiation components are all smaller
  - Snow and ice adds complexity to calculating heat exchange
  - Fewer readings due to sites being conditionally powered down from less solar power


*Grass field
Flux (17)
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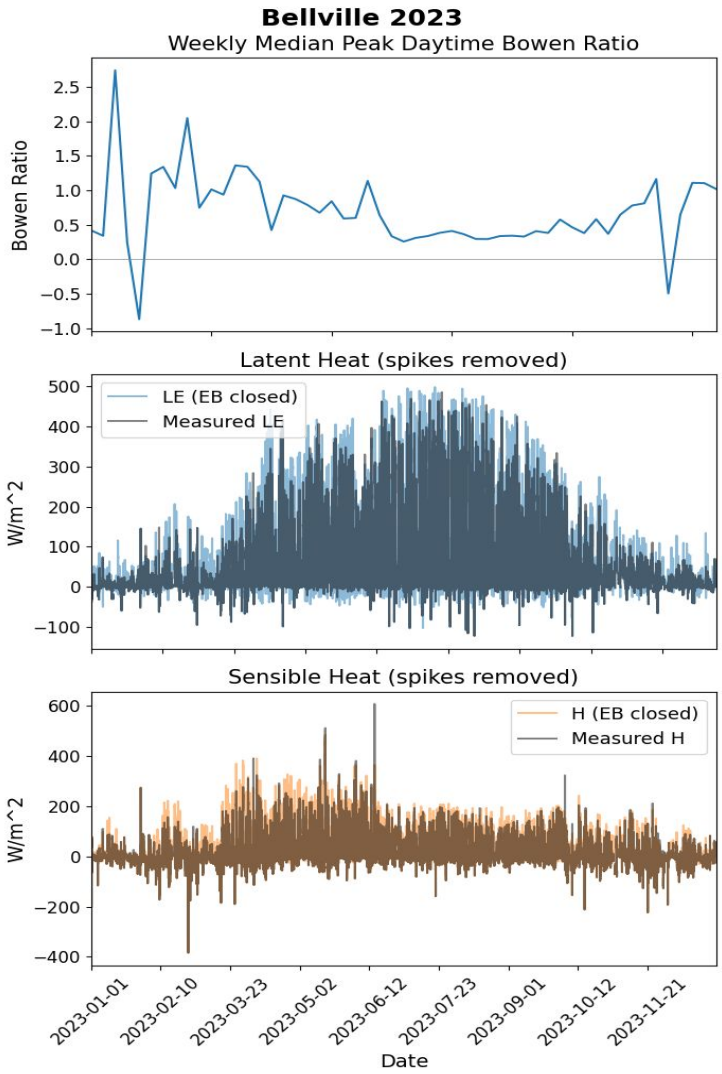


Bowen Ratio Flux Adjustment

Motivation: LSMs assume a fully closed energy budget, while this is rarely seen in reality, so we manipulate the turbulent energy (H_S *and* H_L) to create 100% energy budget closure

1. Calculate the median Bowen Ratio over a specific time frame
    - Weekly or daily
2. Use that Bowen Ratio to split up the residual energy between the latent and sensible heat fluxes for readings within that time frame
3. Energy budget is closed!

Average LE adjustment: **+7.8 W/m^2**
Average H adjustment: **+4.1 W/m^2**

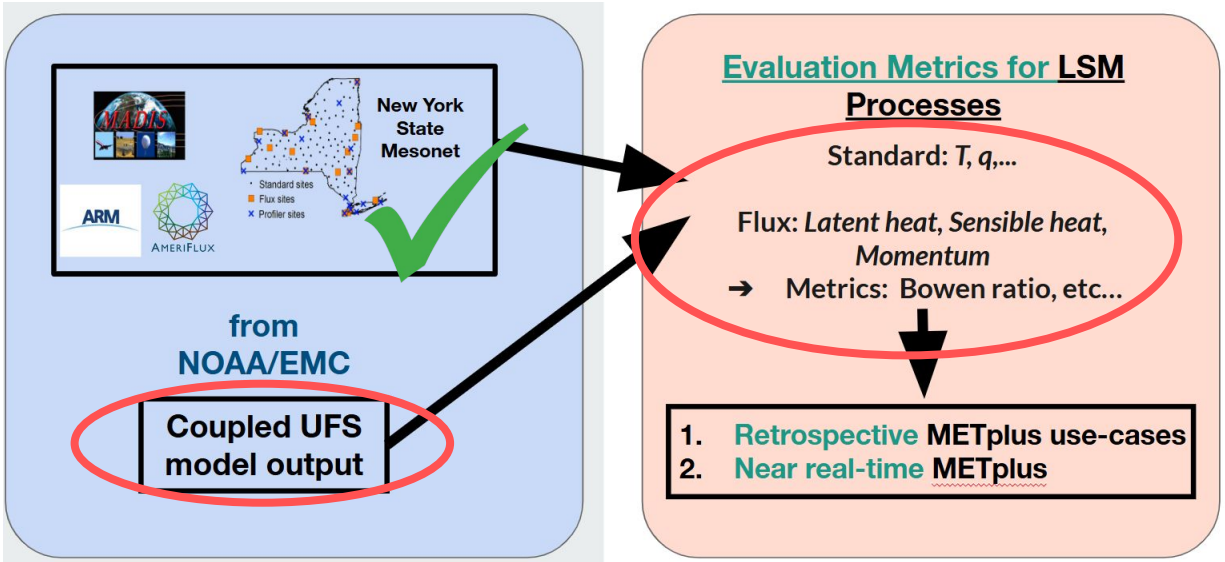
Conclusions

- NYSM Flux Network provides a unique opportunity to evaluate models with 100+ site years of data across the 18 sites in total
- The network as a whole has shown an average of **62.2%** energy budget closure since its beginning in 2018 and findings these are consistent with other flux networks
    - Spring: **63.1%**
    - Summer: **73.7%**
    - Autumn: **62.4%**
    - Winter: **42.9%**

- Additional quality control of the flux data builds upon quality control scores calculated by the datalogger using the onboarded manufacturer algorithm
- Flux adjustments to close the energy budget are beneficial for comparisons and verification of LSM models

Future Work

- Comparisons with coupled model runs (single column model, high resolution)
- Combine model output with NYSM data to create METplus suite metrics
- Develop near real time model evaluation capabilities



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