

Flux Station Measurement Validation with Redundant Sensors and Remote Sensing

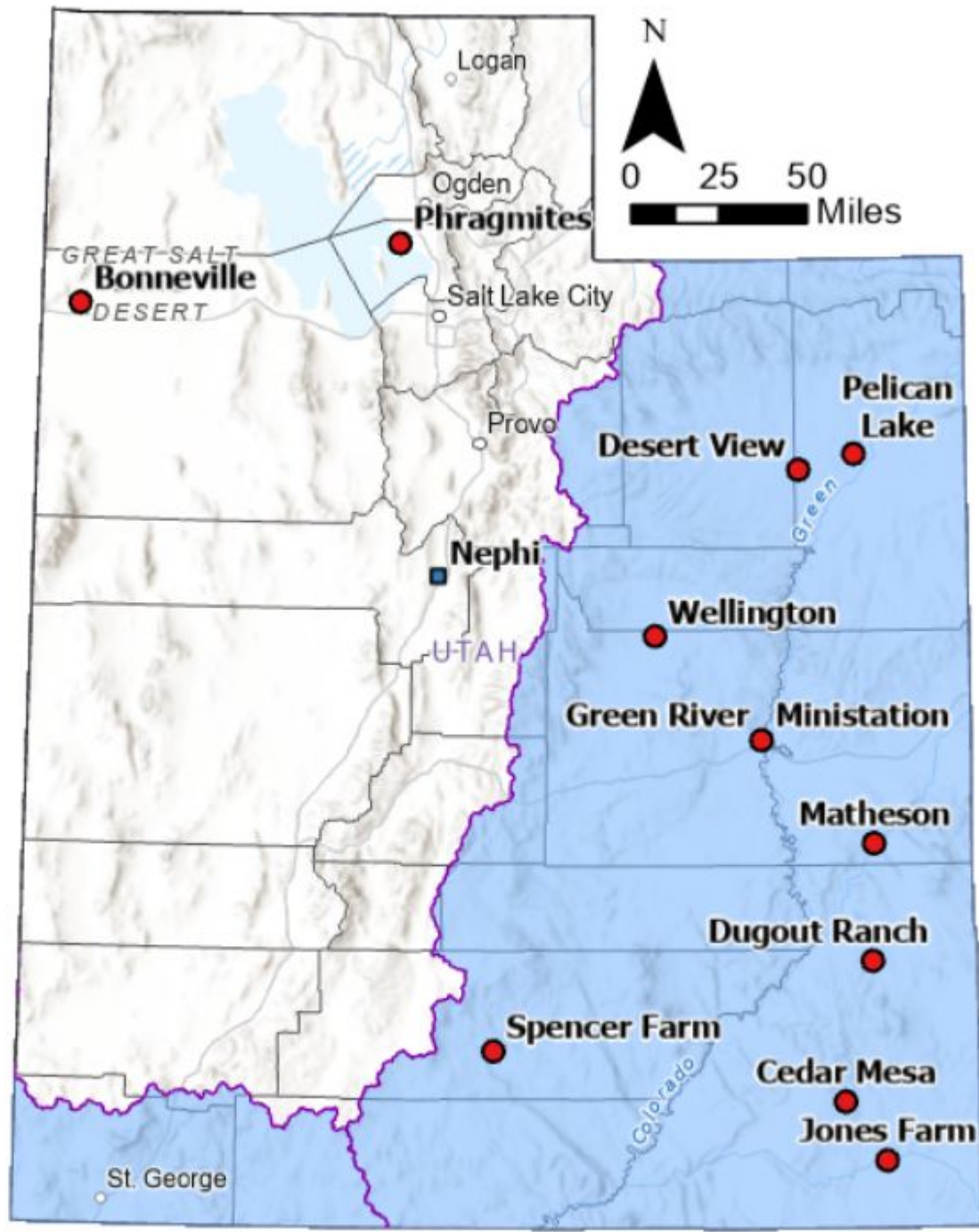
Board 13
Thursday, 18 September 2025

Paul Inkenbrandt, Kathryn Ladig, Diane Menuz
Utah Geological Survey
paulinkenbrandt@utah.gov, kladig@utah.gov, dmenuz@utah.gov



I. The Utah Flux Network

- Utah uses estimates of evapotranspiration to manage water
- OpenET, a remote sensing dataset, is readily available for Utah, and Utah has invested in it as a management tool
- Utah is working with OpenET to ground-truth their dataset, and to better understand how the data are representing Utah's different ecosystems
- With support from the Colorado River Authority of Utah and others, the Utah Geological Survey has established the Utah Flux Network (UFN), consisting of 10 stations across Utah
- Each site is equipped and programmed consistently, with redundant sensors for sensor validation.
- Some of our sites show poor (<60%) energy balance closure, and we want to understand why



II. Questions

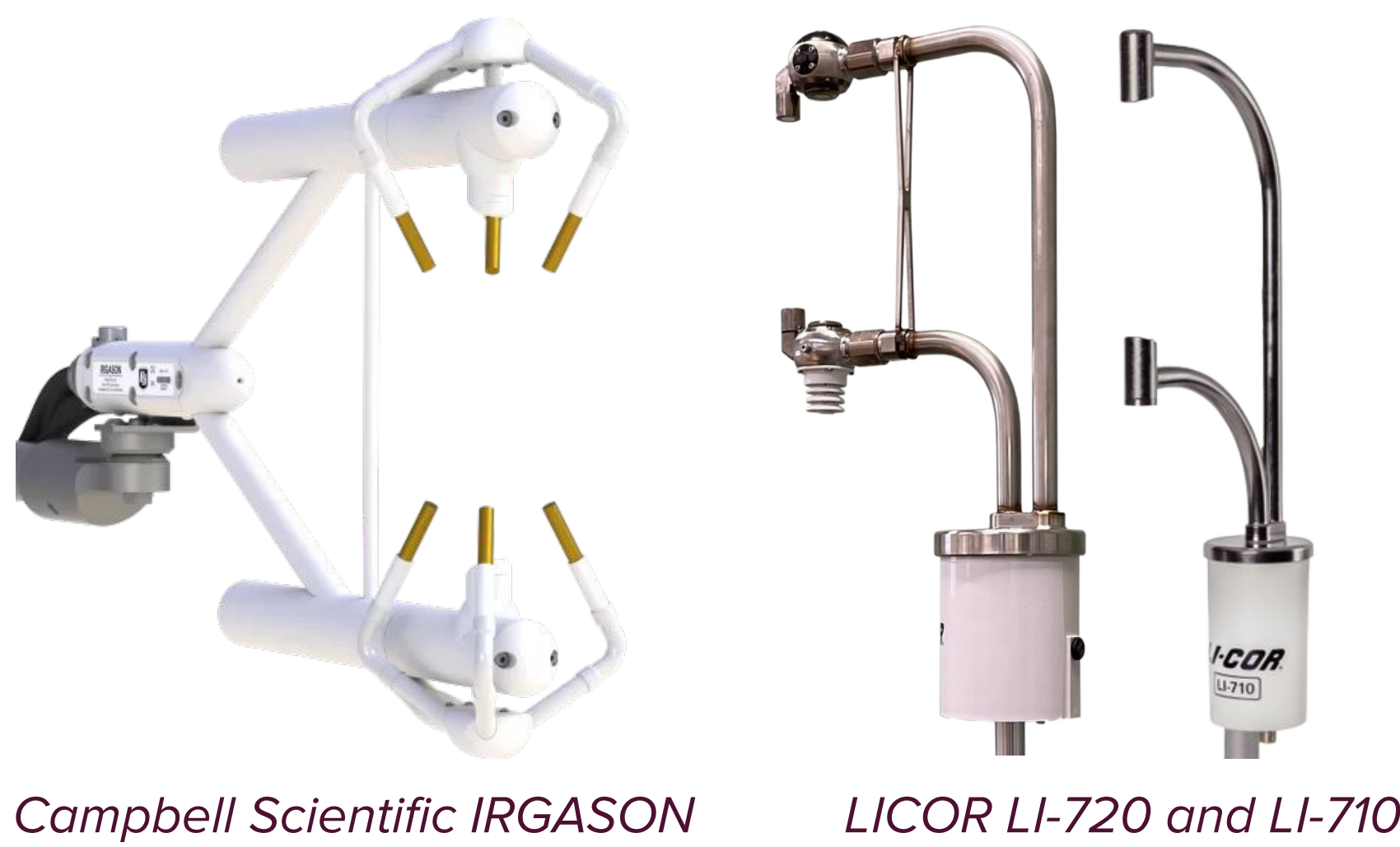
- How does sensor selection influence energy balance closure?
- How does sensor placement influence energy balance closure?

III. Approach & Instruments

Instruments for Latent & Sensible Heat Flux (LE & H)

Approach

- Examine 3 sites
- Compare sensors at each site
- Consider sensor placement and site conditions



Processing

- UFN sites use Campbell Scientific CR6 data loggers with EasyFluxDL on the primary data logger
- Data post-processed using Python following the FLUXNET data QA/QC standards

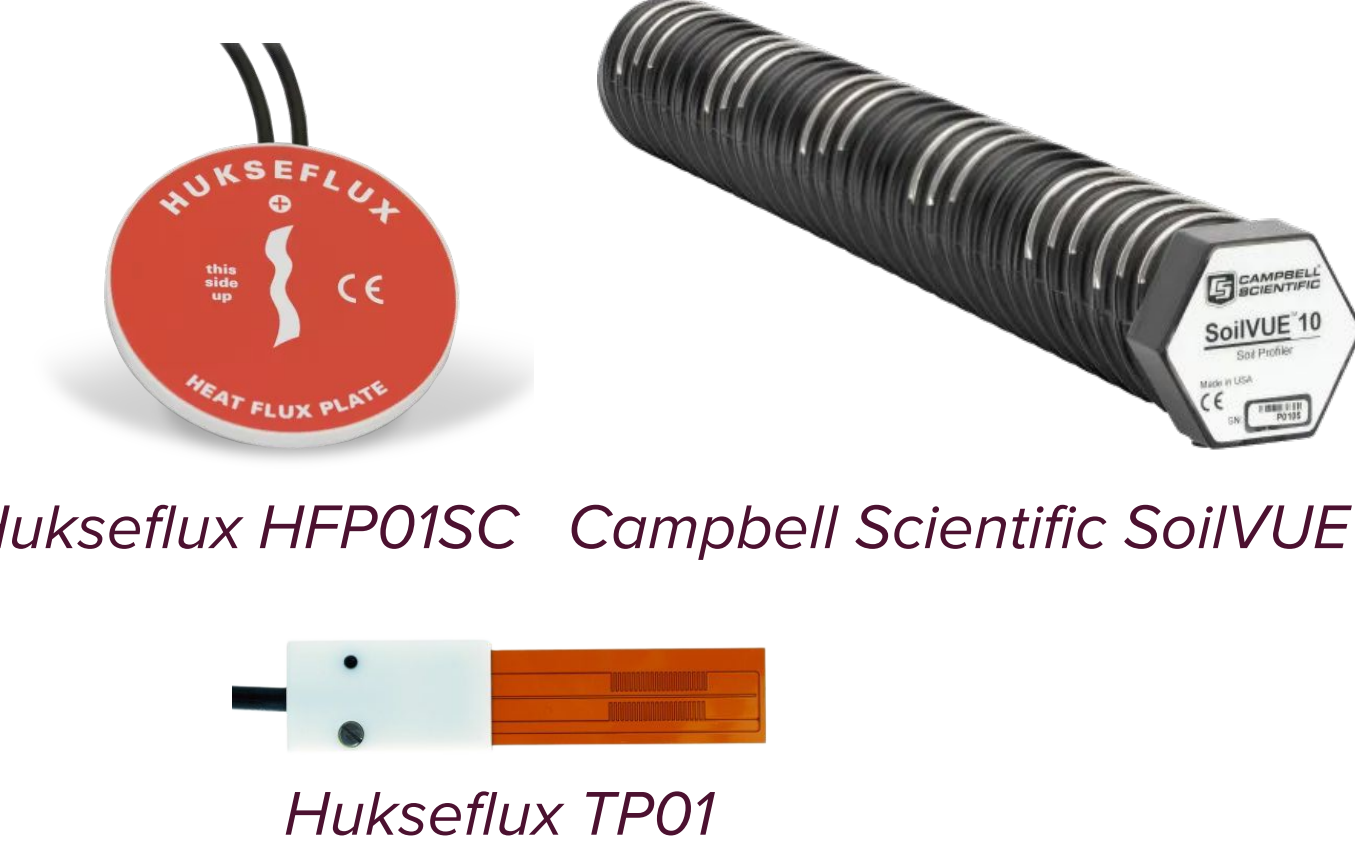
Python Libraries Used

- <https://github.com/inkenbrandt/MicroMet>
- https://github.com/inkenbrandt/soil_heat
- <https://github.com/inkenbrandt/footprints>
- <https://github.com/Open-ET/flux-data-qac>
- <https://github.com/inkenbrandt/advection>

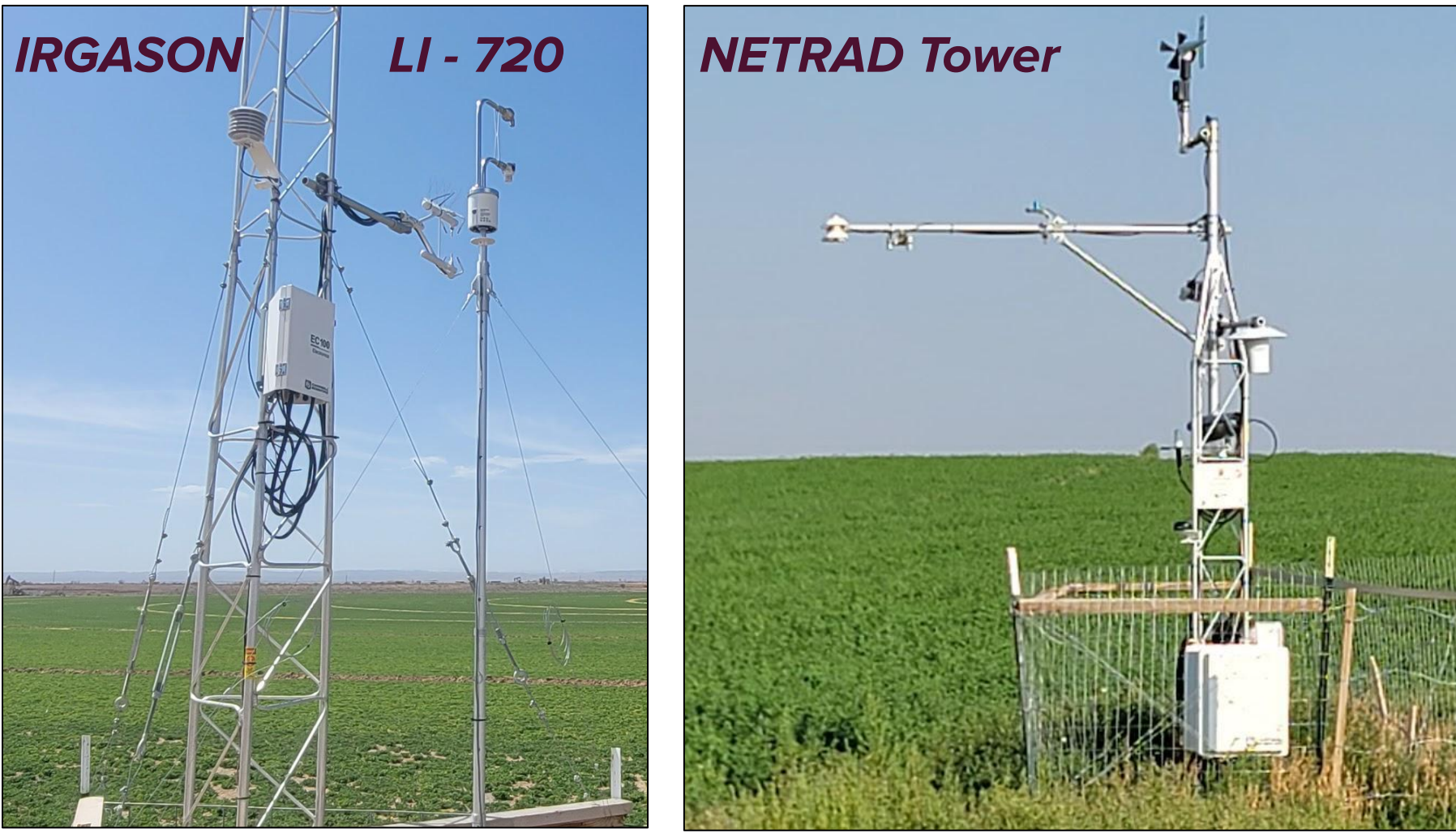
Instruments for Net Radiation (NETRAD)



Instruments for Ground Heat Flux

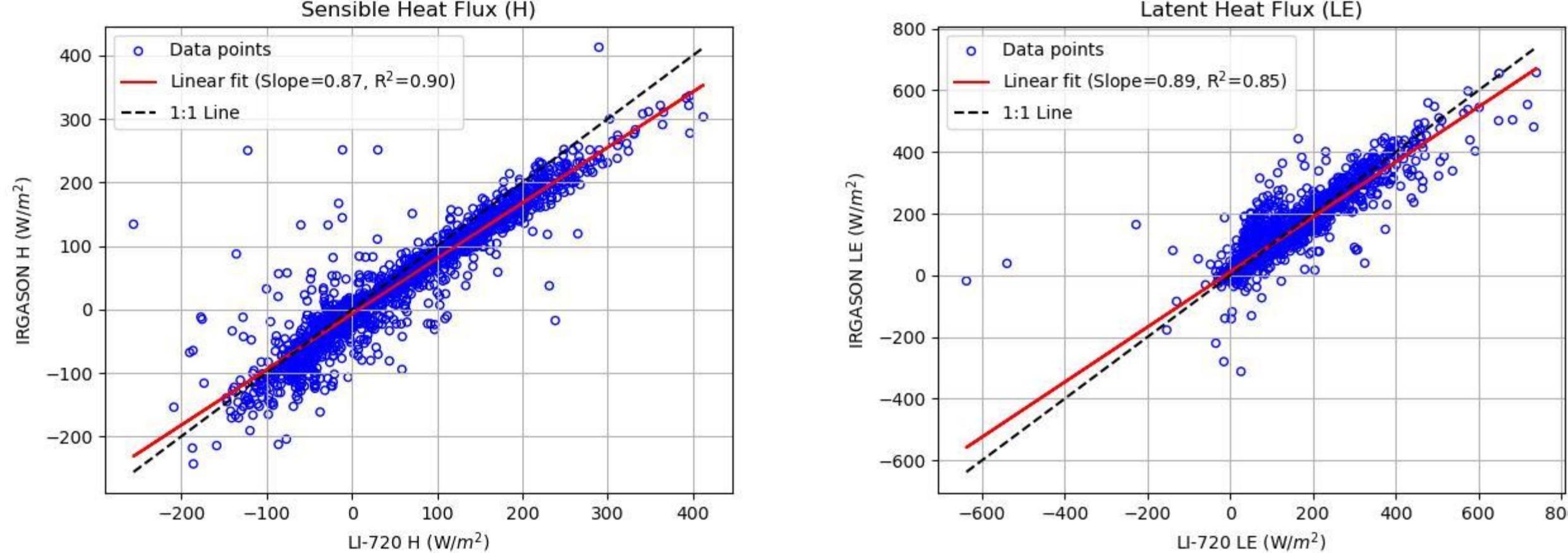


Desert View (US-UTV)



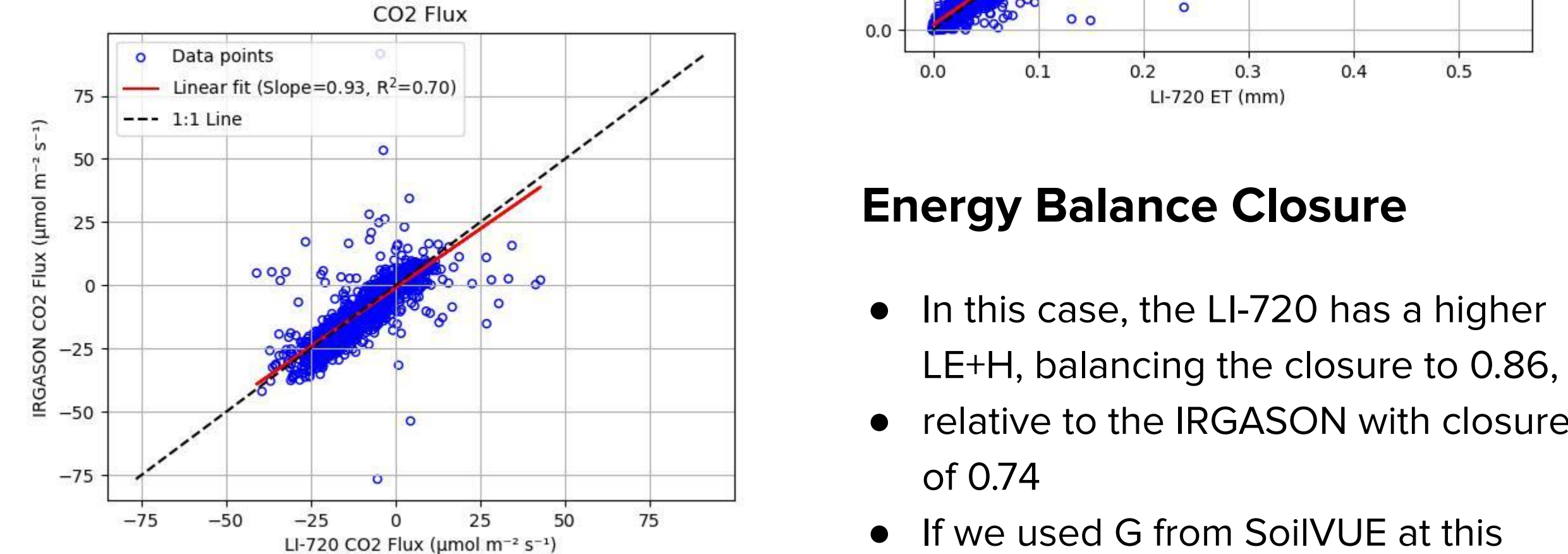
Setting

- Edge of a pivot-irrigated alfalfa field
- Near Myton, Utah
- Built 2023-09-26
- IRGASON & LI-720
- Area next to field is arid
- Pivot has a meter to measure diversion



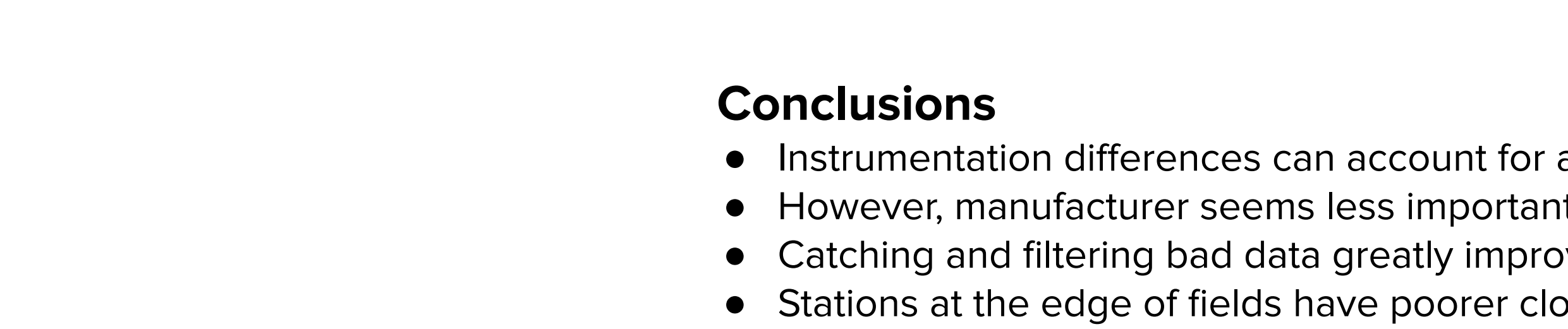
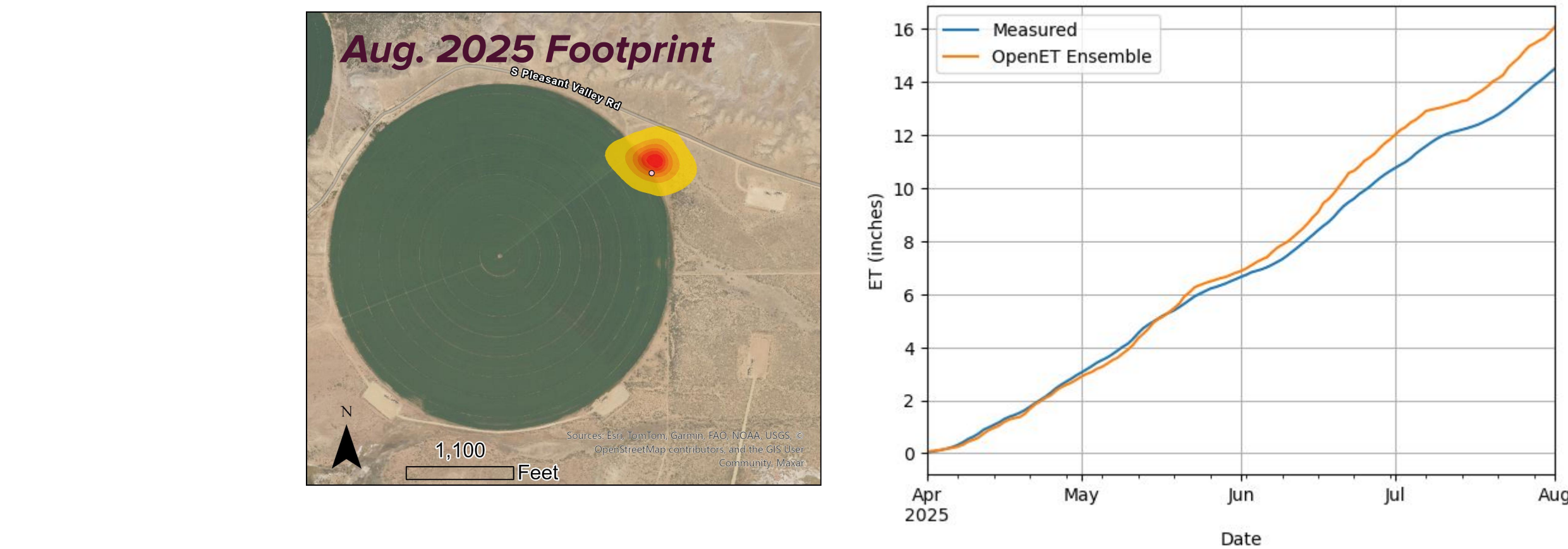
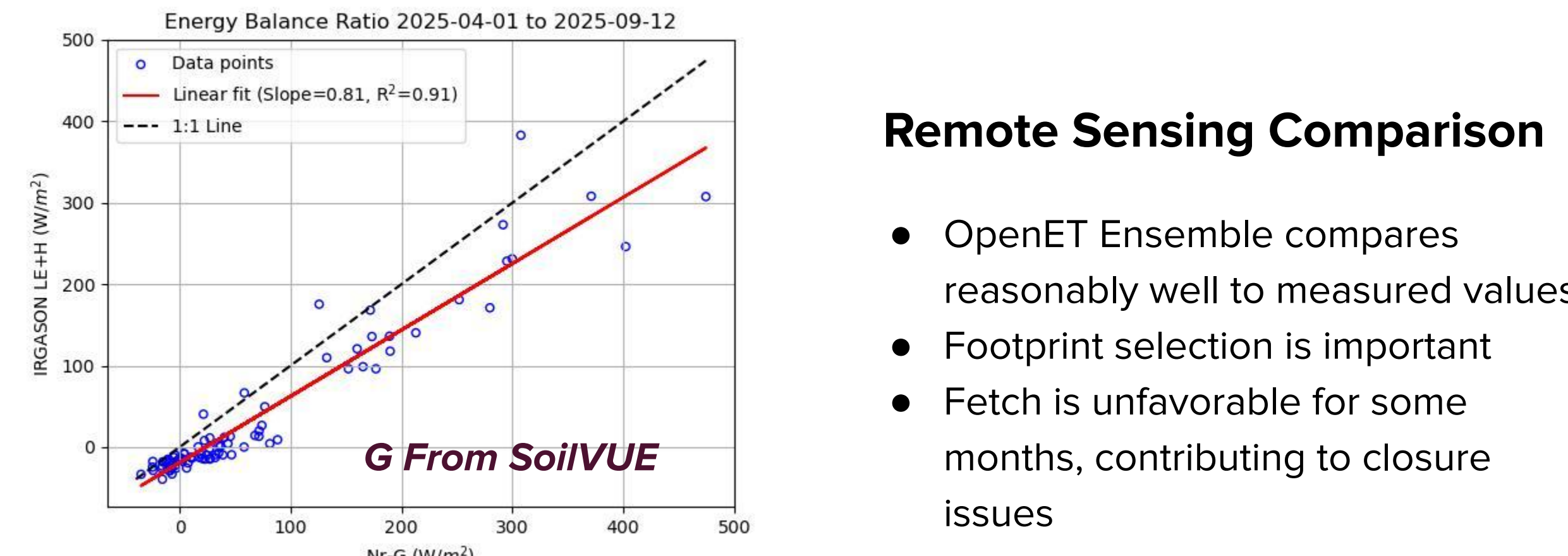
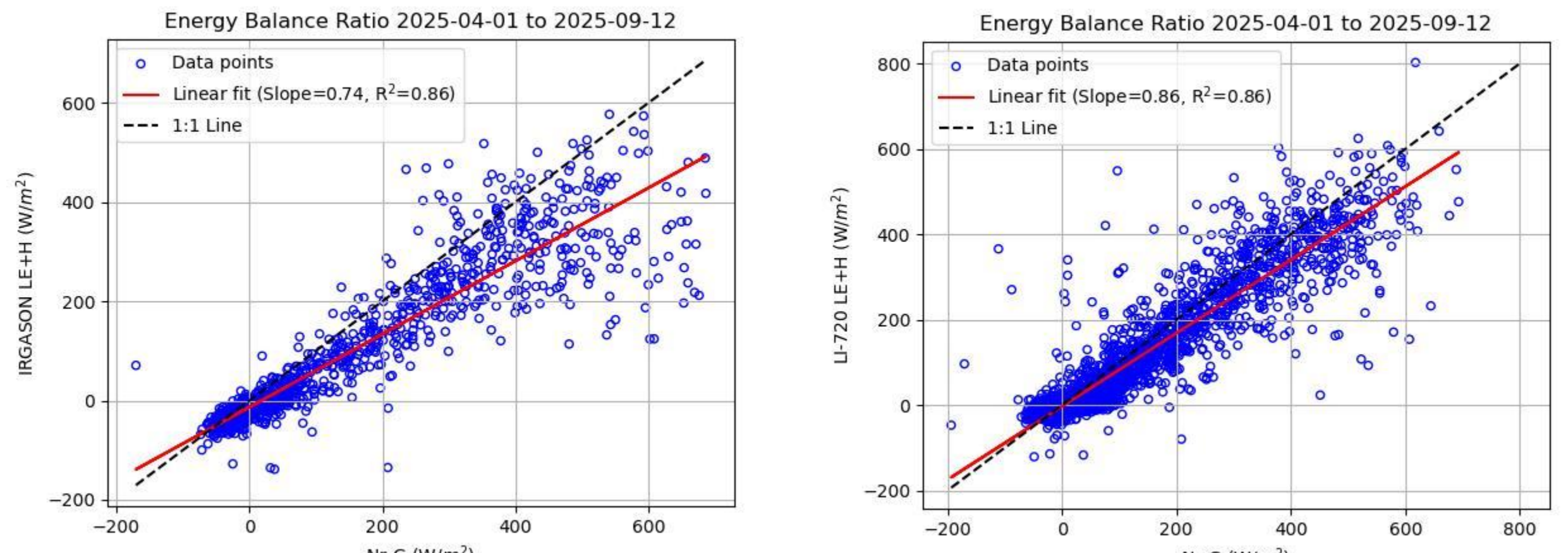
IRGASON & LI-720

- LI-710 H and LE each about 10% higher
- CO2 also comparable
- Fair agreement
- Still testing



Energy Balance Closure

- In this case, the LI-720 has a higher LE+H, balancing the closure to 0.86,
- relative to the IRGASON with closure of 0.74
- If we used G from SoilVUE at this site, it would favor the IRGASON



Green River (US-UTG)



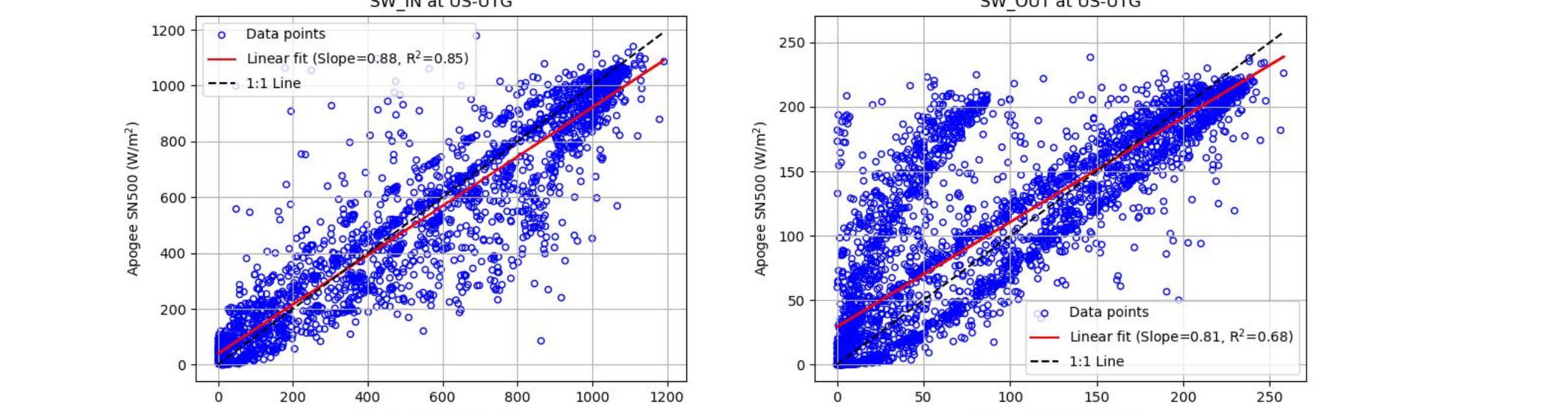
Setting

- Main site at edge of a pivot-irrigated corn field
- Green River, Utah
- Built 2023-09-26
- IRGASON & LI-710
- Ministation in field with LI-710, SN-500, SI-111, MetSense, and SoilVUE
- Near an Agrimet Station (USCAN 124033)



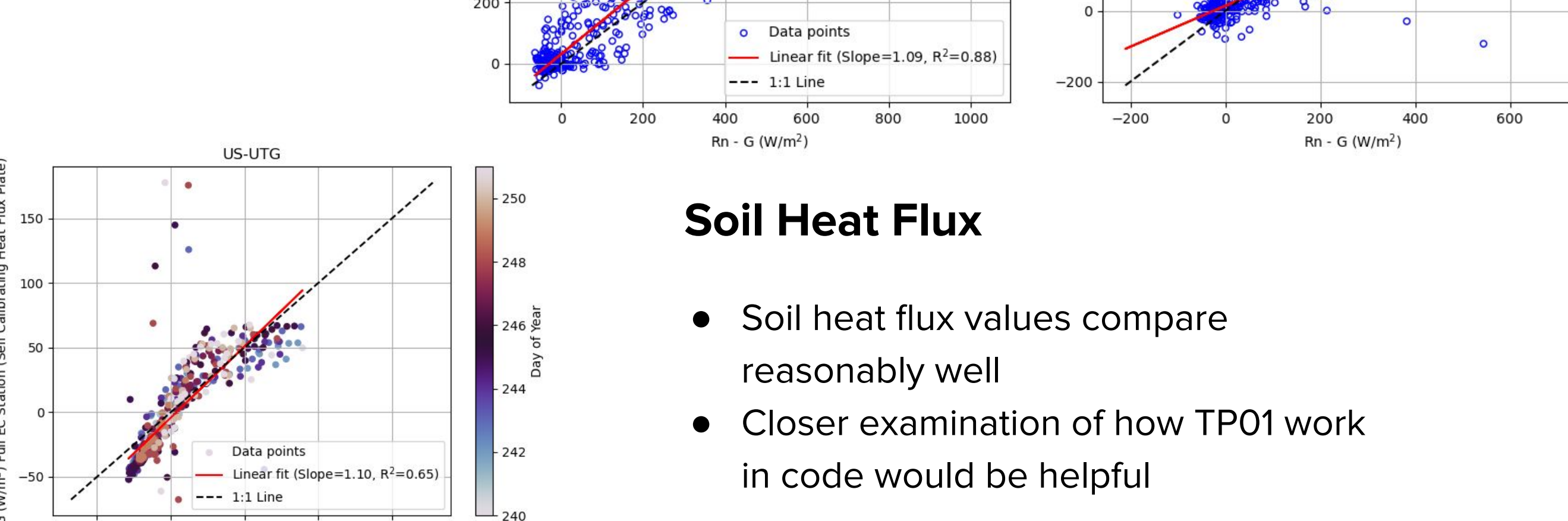
NETRAD Comparison

- Comparing data from 2025-03-25 to 2025-07-17
- SN500 Generally slightly lower than NR01 (at this site)
- SW_OUT noise with the SN500
- Most noise from March 26 to May 15
- This site was tangled with the pivot, tilting one of the radiometers



Ministation Comparison

- NETRAD - G compares very well
- LE+H is lower at full station than ministation
- Poor relationship for sensible heat flux
- Decent relationship for latent heat flux, but
- LE is 40% lower at main station than ministation
- Closure at the ministation seems good, whereas closure at the main station is about 40% off.



Soil Heat Flux

- Soil heat flux values compare reasonably well
- Closer examination of how TP01 work in code would be helpful

Cedar Mesa (US-CdM)

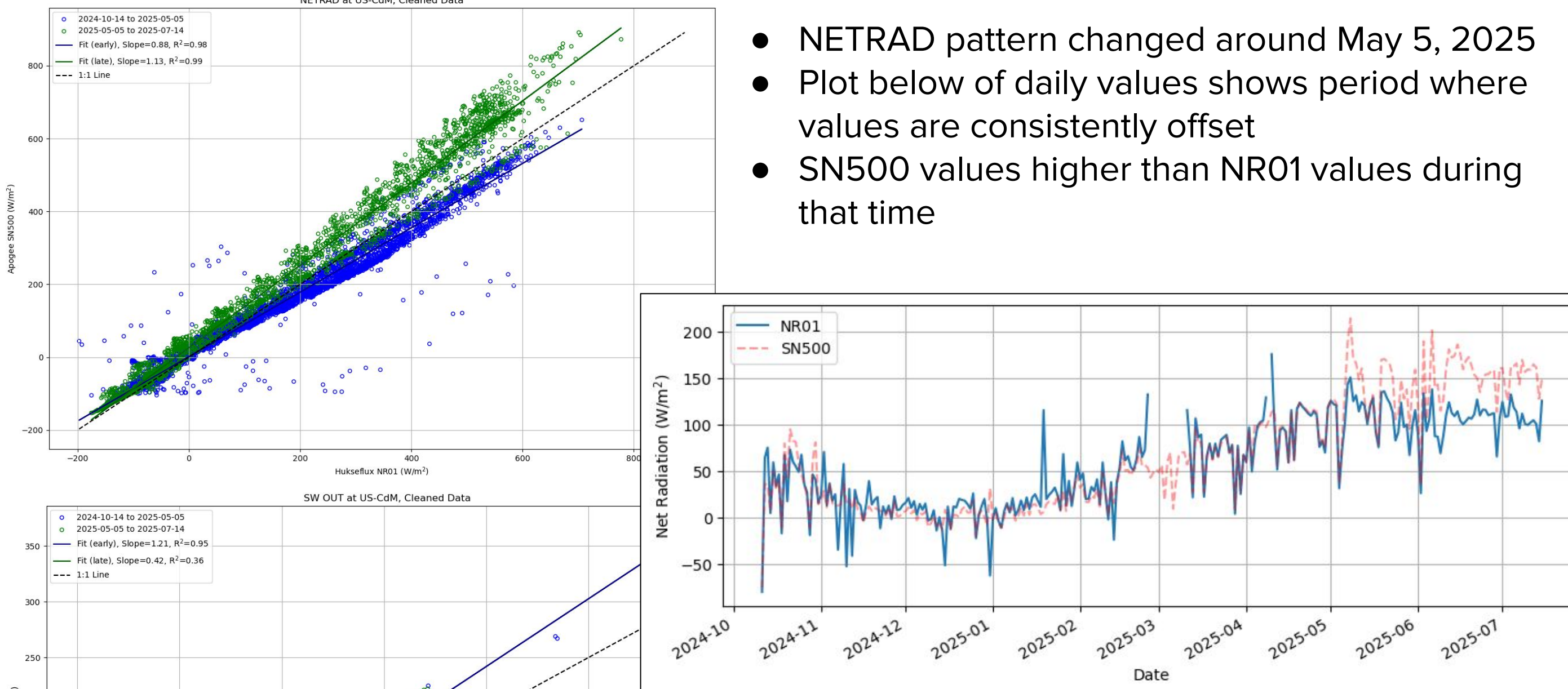
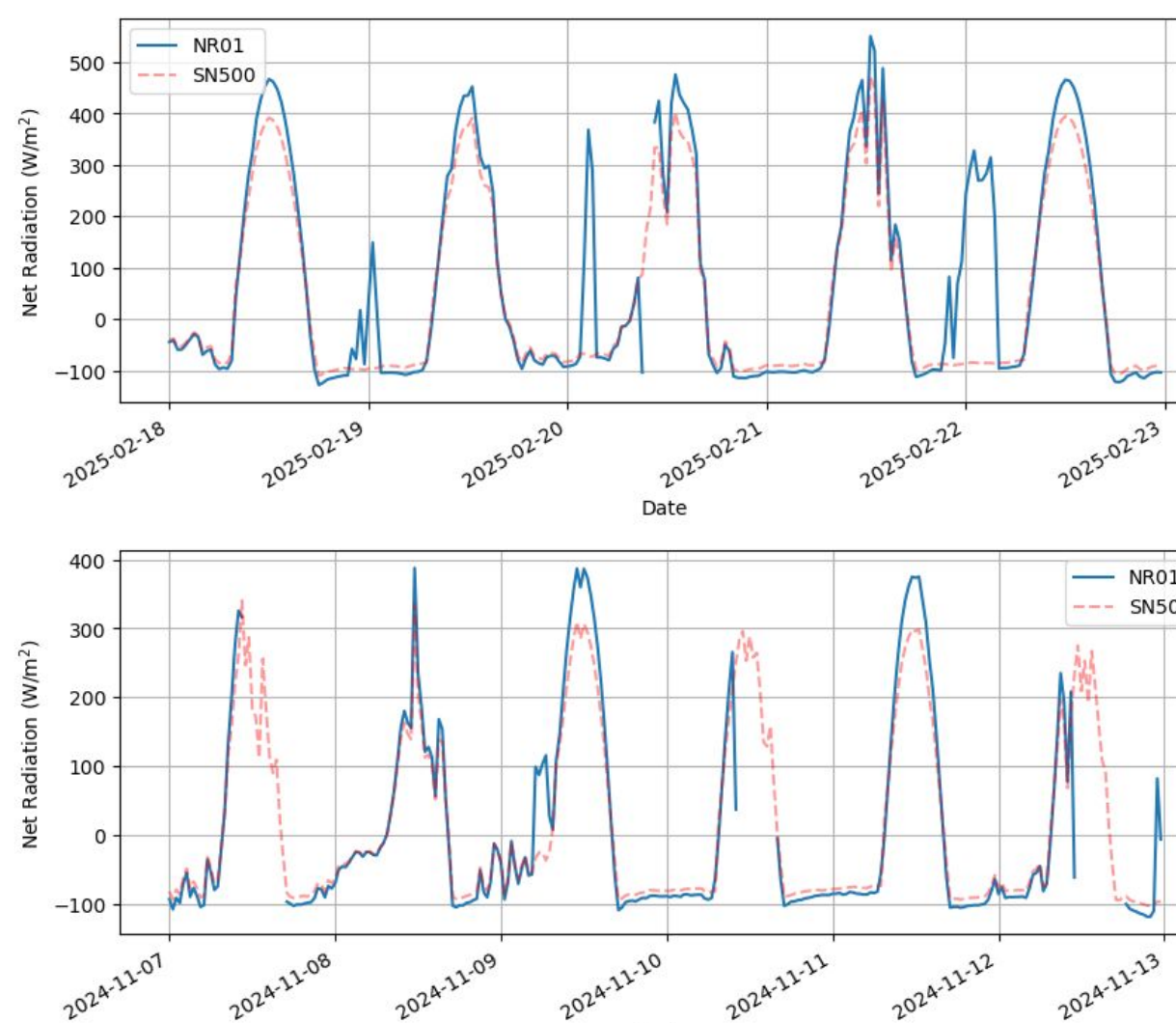


Setting

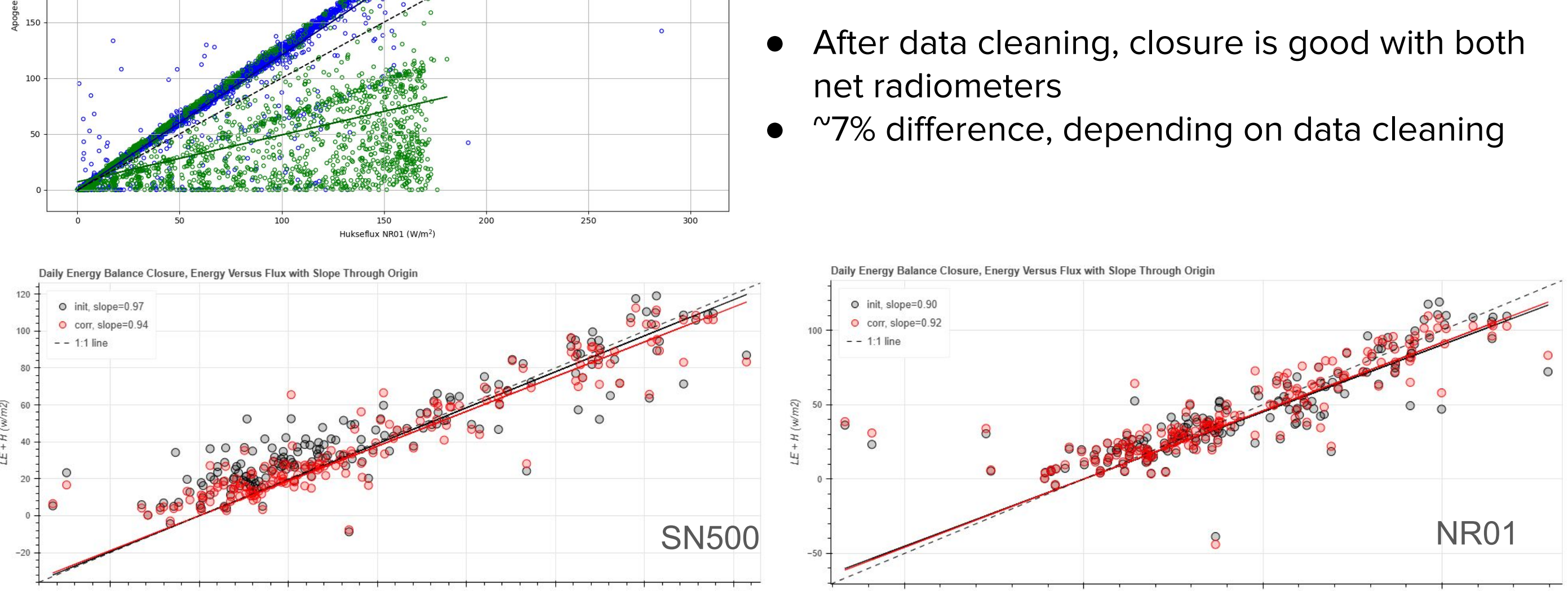
- Pinyon-Juniper forest
- West of Blanding, Utah
- Previously Managed by U of U (Steven Kannenberg)
- UFN occupied 2023-09-26
- IRGASON & LI-710
- Ministation in field with LI-710, SN-500, SI-111, MetSense, and SoilVUE
- Near an Agrimet Station (USCAN 124033)
- Research site for NAU (Oscar Zimmerman)

NETRAD Comparison

- Comparing data from 2024-10-12 to 2025-07-15
- SN500 Generally slightly lower than NR01 (at this site)
- More missing data in NR01
- More clearly problematic data in NR01
- Most problems in the earlier part of the dataset for NR01, then issues much rarer
- After data cleaning, 1.89% of half-hourly records missing from NR01, vs 0.1% missing from SN500
- Spikes in the middle of the night

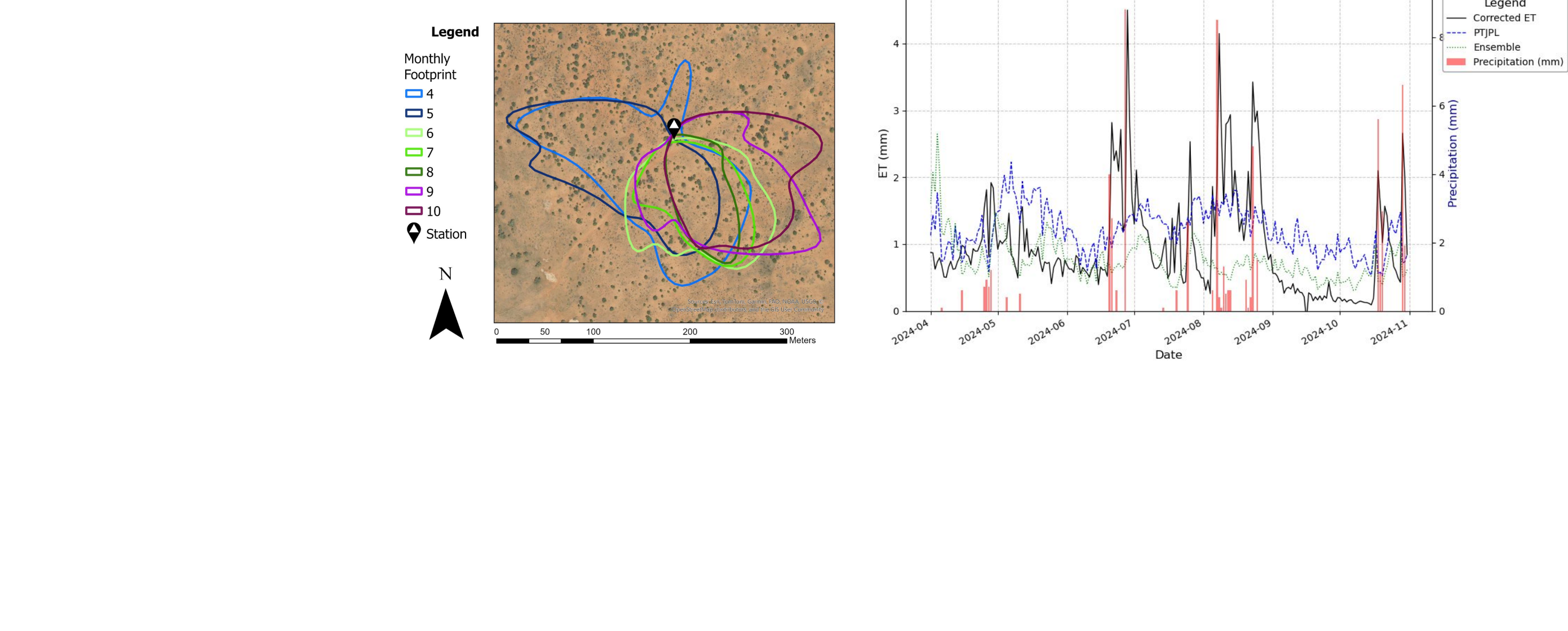
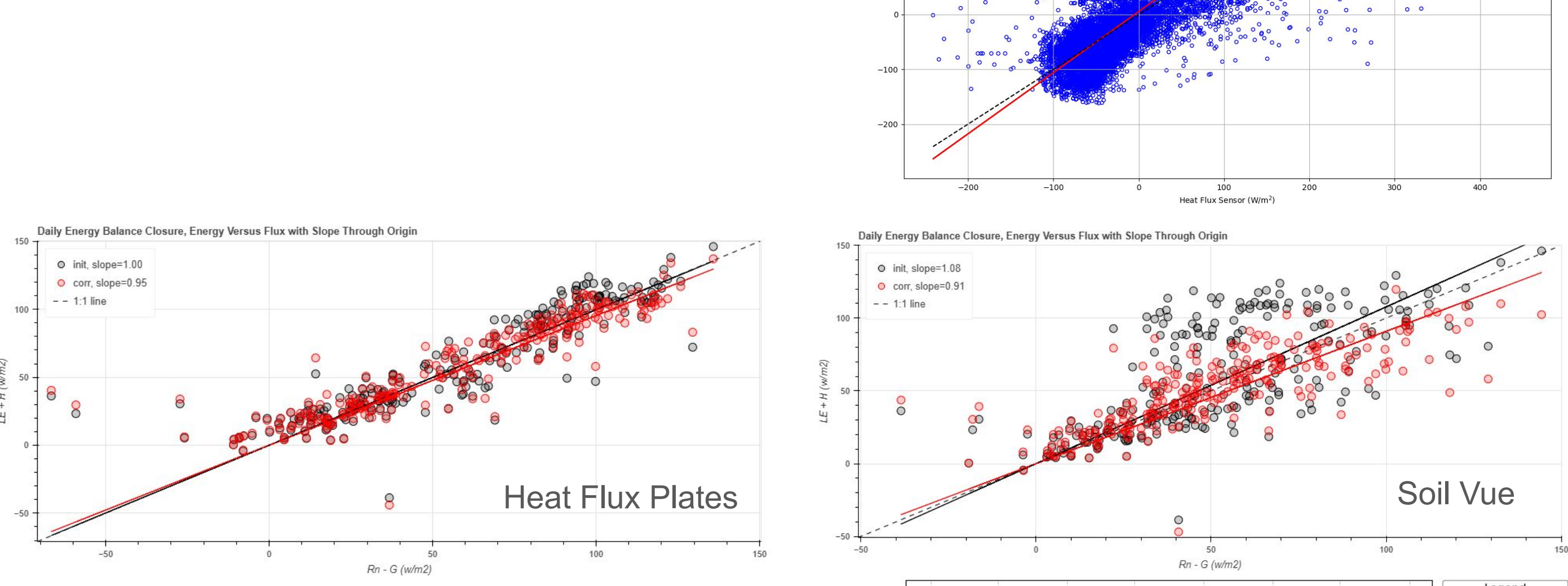


- NETRAD pattern changed around May 5, 2025
- Plot below of daily values shows period where values are consistently offset
- SN500 values higher than NR01 values during that time



Soil Heat Flux Comparison

- Comparing data from 2024-10-12 to 2025-07-15
- SoilVUE generally had higher daytime and lower nighttime values
- Better estimate of soil properties may be needed if SoilVUE approach is used
- Closure is better with heat flux plates ("8%")
- Much more scatter with the SoilVUE data



Conclusions

- Instrumentation differences can account for as much as 12% of the variance in closure
- However, manufacturer seems less important than careful deployment and properly maintaining the equipment
- Catching and filtering bad data greatly improves closure
- Stations at the edge of fields have poorer closure than those in fields, and this can likely be attributed to advection