Estimating terrestrial carbon dioxide and water fluxes in near-real time using GOES-R: progress to date and looking forward to GeoXO

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http://alive-abi.github.io/alive/index.html

Funding

Thanks!

ALIVE

Advanced Baseline Imager Live Imaging of Vegetated Ecosystems

Danielle Losos

Sadegh Ranjbar

Sophie Hoffman

Avanti Kekane

Data

Einara Zahn

Elie Bou-Zeid

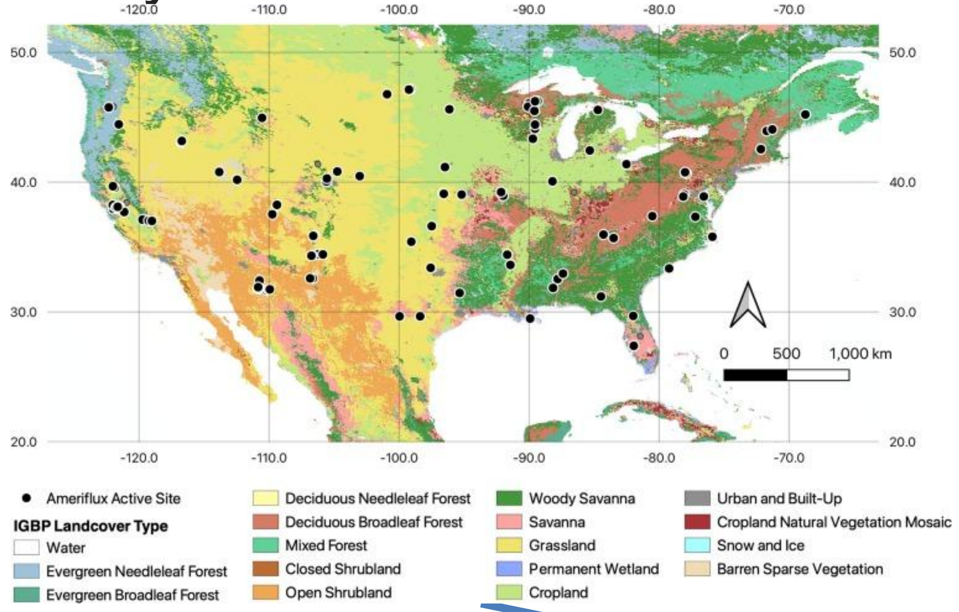
Bethany Blakeley

Ojaswee Shrestha

Ankur Desai

What is ALIVE?

Eddy covariance



GOES-R data products

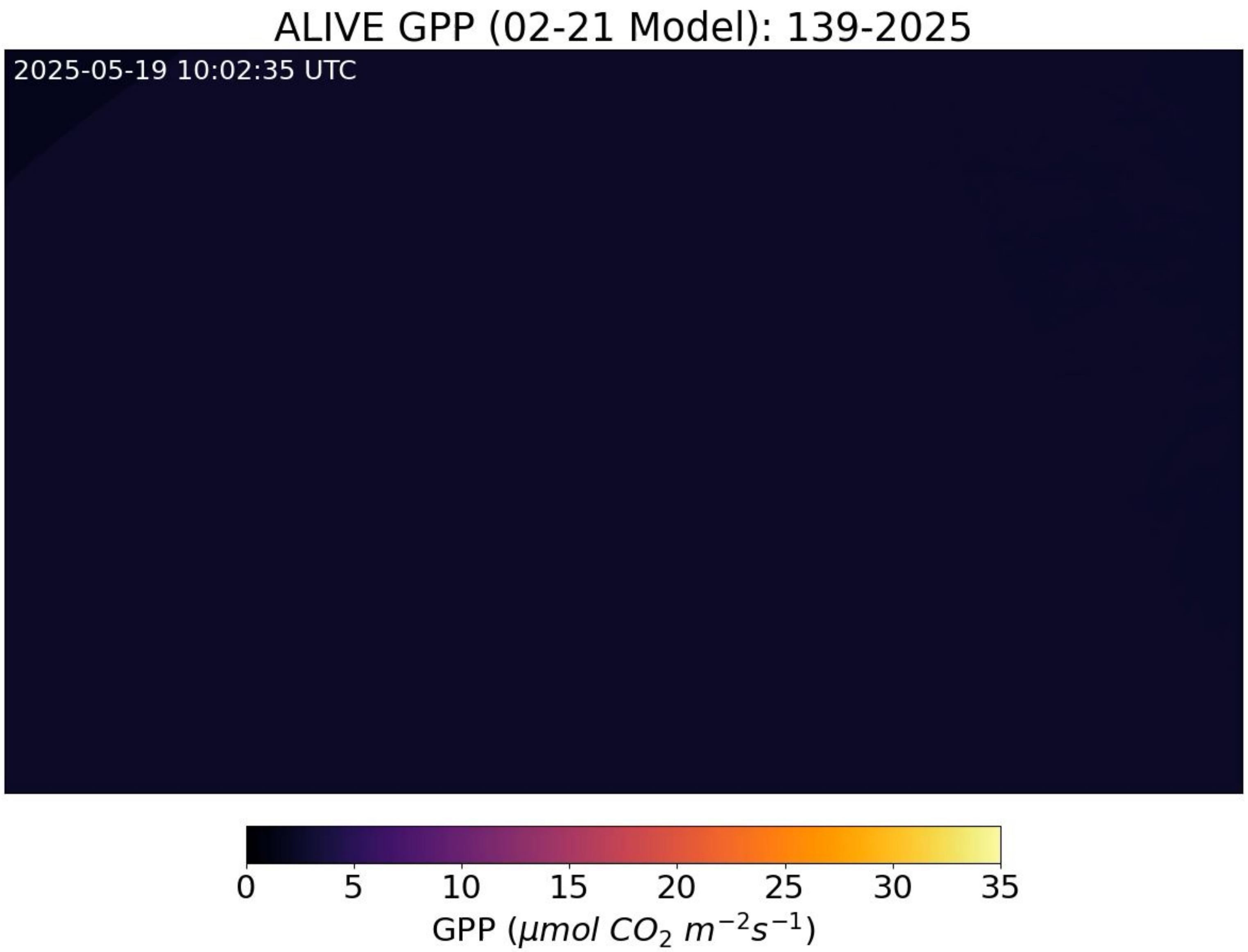
Machine Learning

predictions

An empirical benchmark for real-time carbon & water flux models

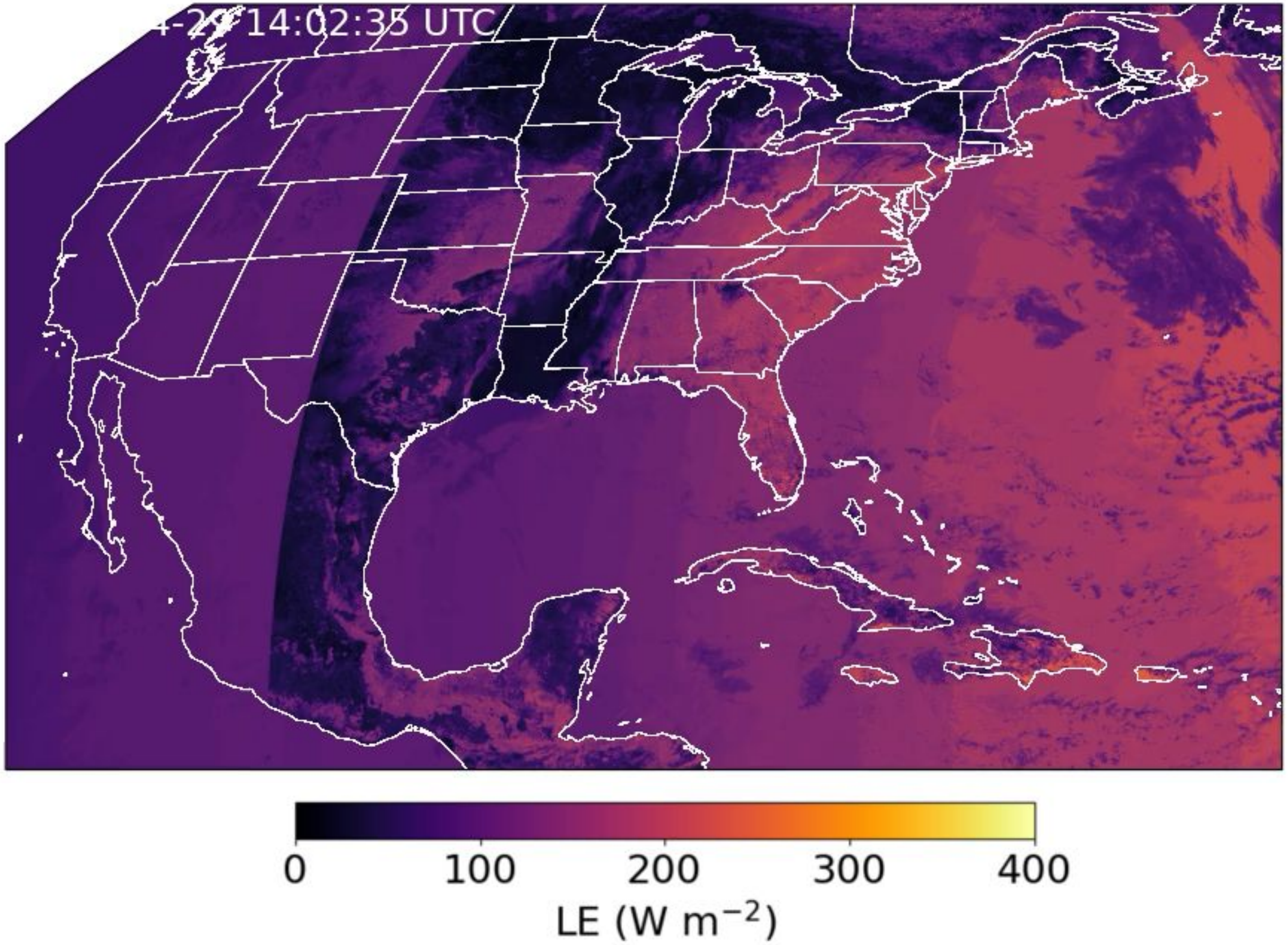
Ranjbar et al. (2024) https://doi.org/10.1029/2024MS004341
Losos et al. (2024) *Scientific Data* https://doi.org/10.1038/s41597-024-03071-z
Losos et al. (2025) *RSE* https://doi.org/10.1016/j.rse.2025.114759

Yesterday's ALIVE Gross Primary Productivity (GPP) prediction



What do we need to make it better? 1. water fluxes, 2. KGML, 3. GeoXO

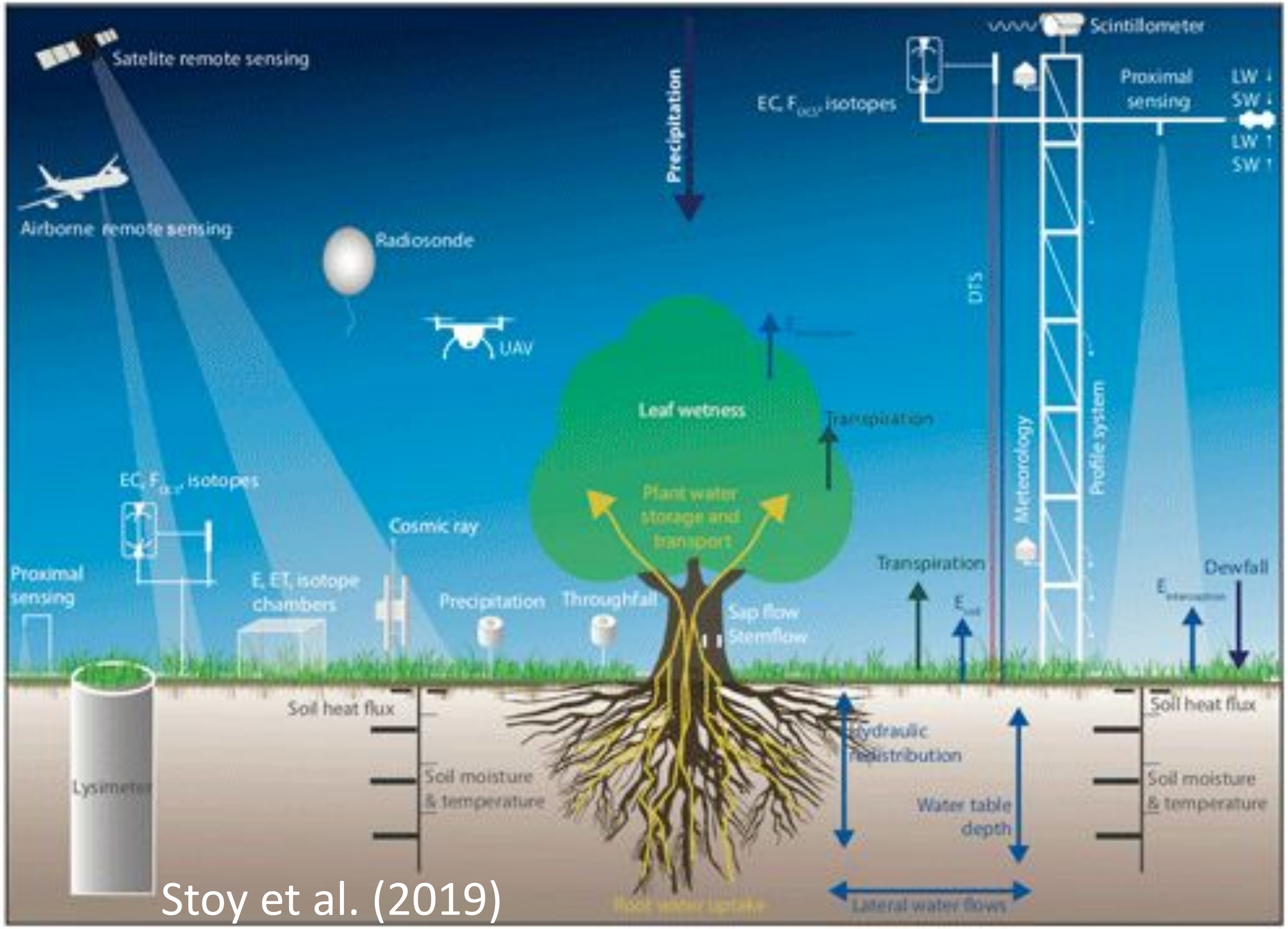
Primitive ALIVE evapotranspiration loop: We can do better!



See Ranjbar et al. (in review)

We also want process-based models

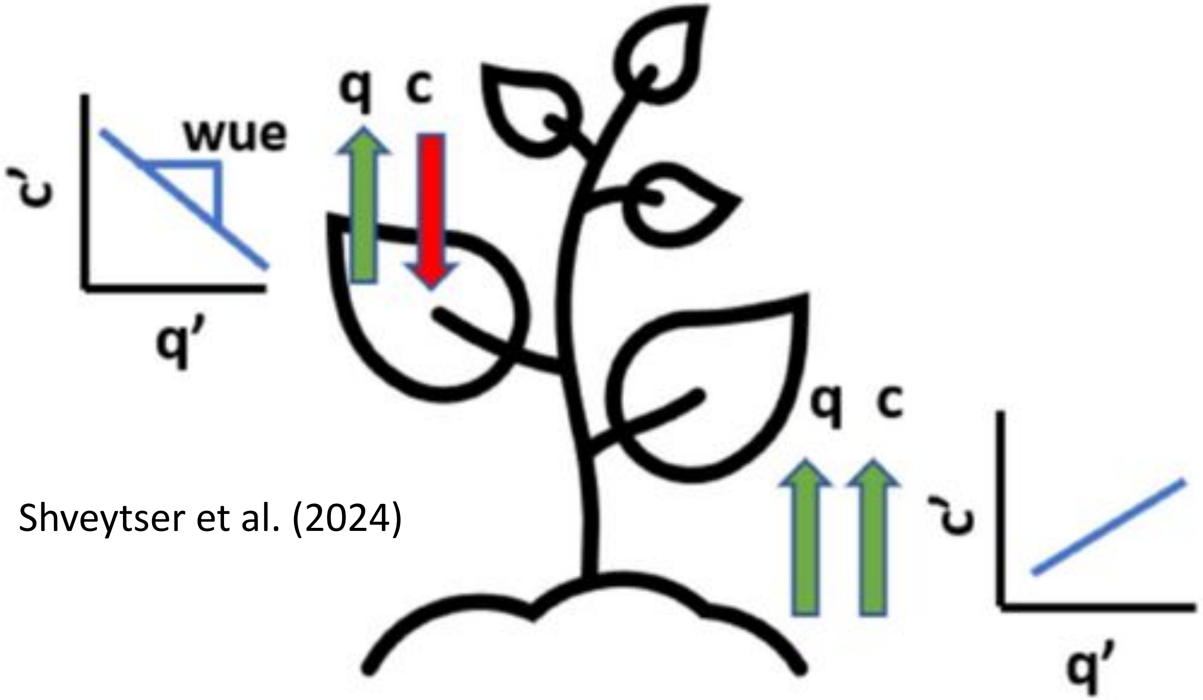
Challenge: The components of ET are relatively hard to measure



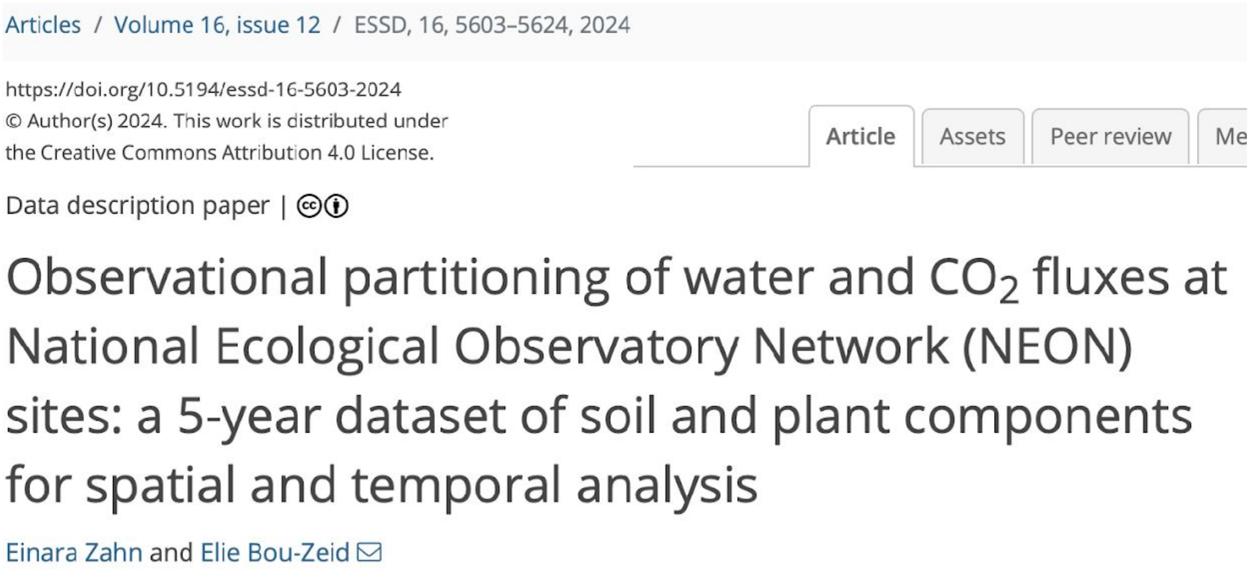
Stoy et al. (2019)

And the machine is hungry for data!

A solution: Flux partitioning to estimate evaporation and transpiration



Shveytser et al. (2024)



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Article | Assets | Peer review | Me

Data description paper |

Observational partitioning of water and CO_2 fluxes at National Ecological Observatory Network (NEON) sites: a 5-year dataset of soil and plant components for spatial and temporal analysis

Einara Zahn and Elie Bou-Zeid

5-year time series of:

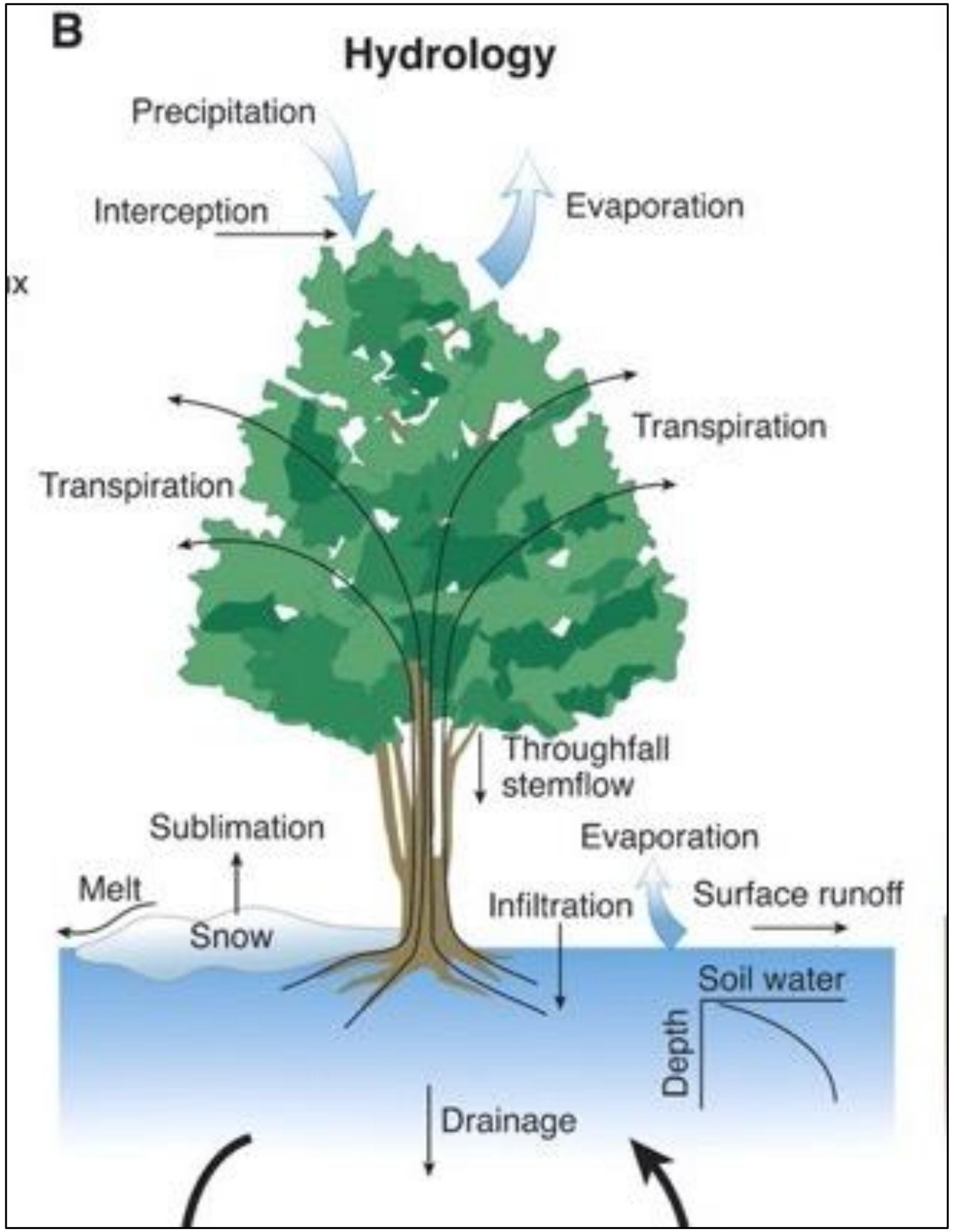
- Flux variance similarity (FVS)
- Conditional eddy covariance (CEC)
- ***Conditional eddy accumulation (CEA)***
- Modified relaxed eddy accumulation (MREA)

At NEON eddy covariance sites

CO_2 is a 'tracer' to estimate water sources
-E. Zahn

Challenge: Canopy-intercepted evaporation (Ei), is extremely hard to measure and happens quickly

Needs to be partitioned from Transpiration (T) & soil evaporation (Es)



Bonan, 2008, Nature

A solution: Knowledge-guided machine learning to estimate Ei

Physical constraints:

Ei = 0 when time since precipitation > 24 hours

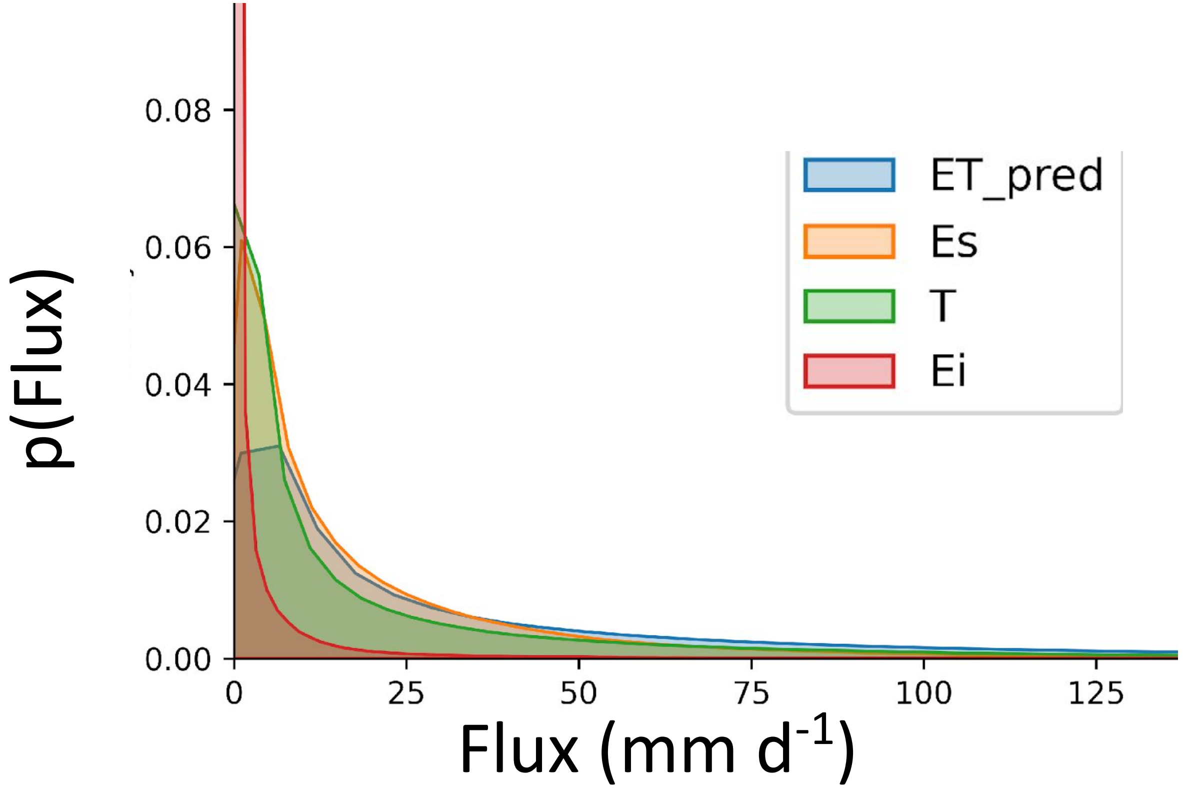
Ei = 0 eight hours after Tdew >= Ta

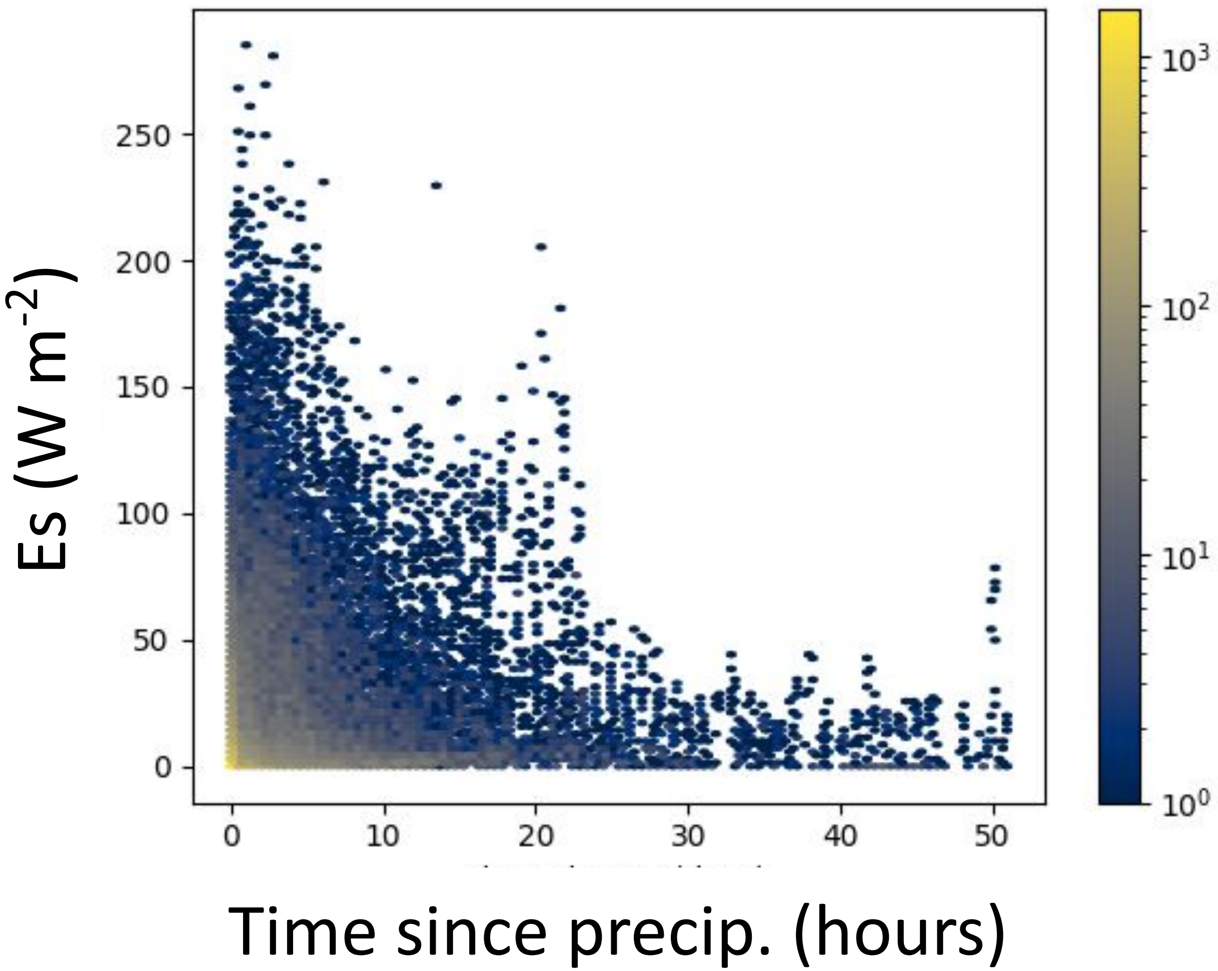
ET = T + Es + Ei + Deposition

T_{CEA} = T + Ei (?)

ET, T, Es & Ei are positive

Deposition is negative

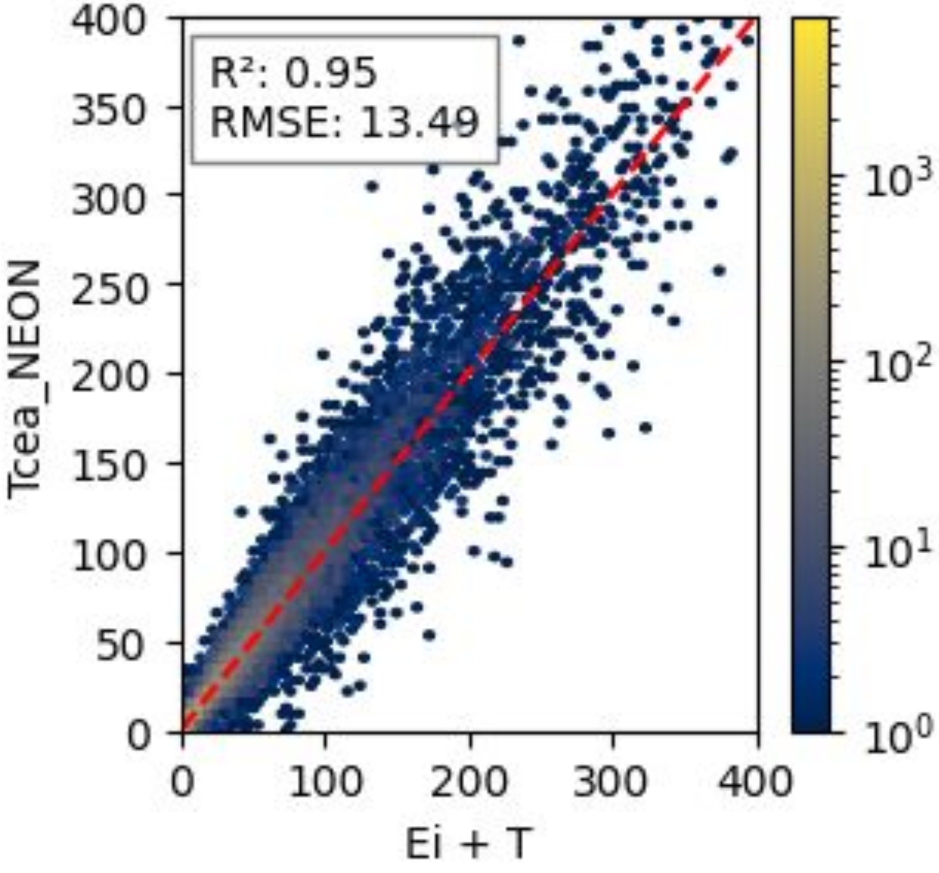


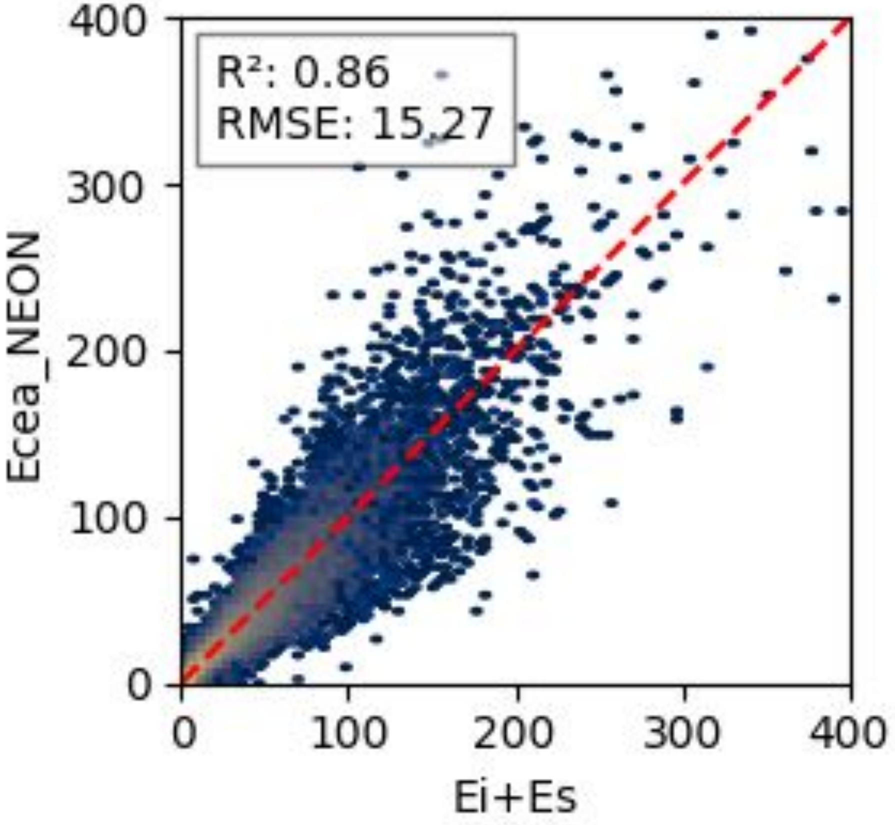


Figures: S. Ranjbar

Should we take Ei from T?

KMGL likes it more when we do.

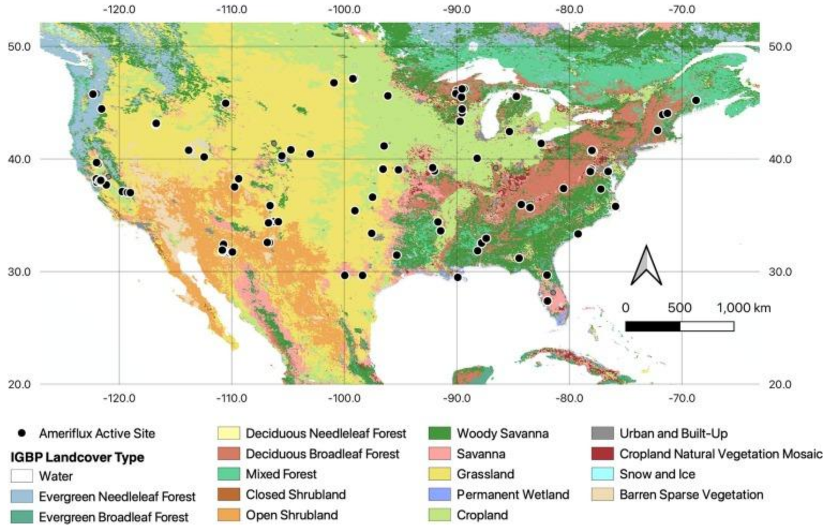




Figures: S. Ranjbar

Adding surface meteorology to ALIVE: integrating the HRRR

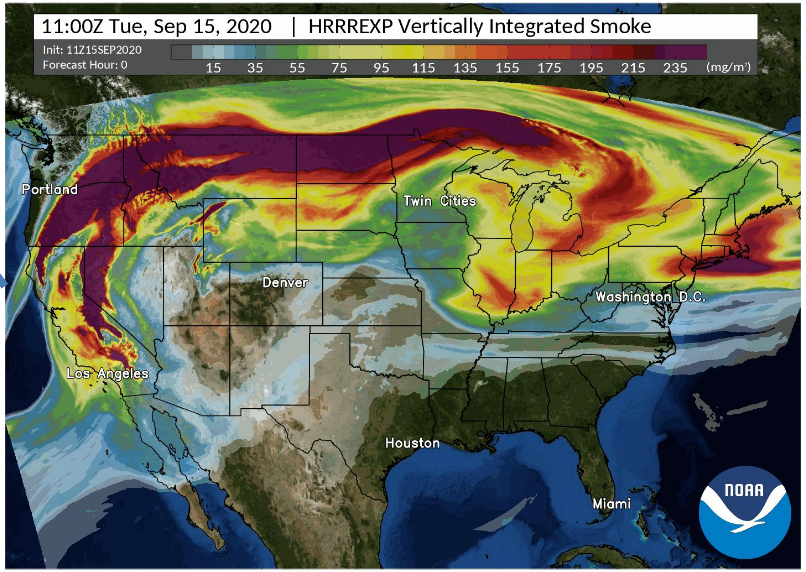
Eddy covariance



GOES-R data products

Machine Learning

HRRR



ABI Live Imaging of Vegetated Ecosystems
ALIVE

Moving from 5 minutes to 1 hour

GOES-R CONUS pixels to 3 km

ALIVE Evapotranspiration predictions coupling GOES-R & HRRR

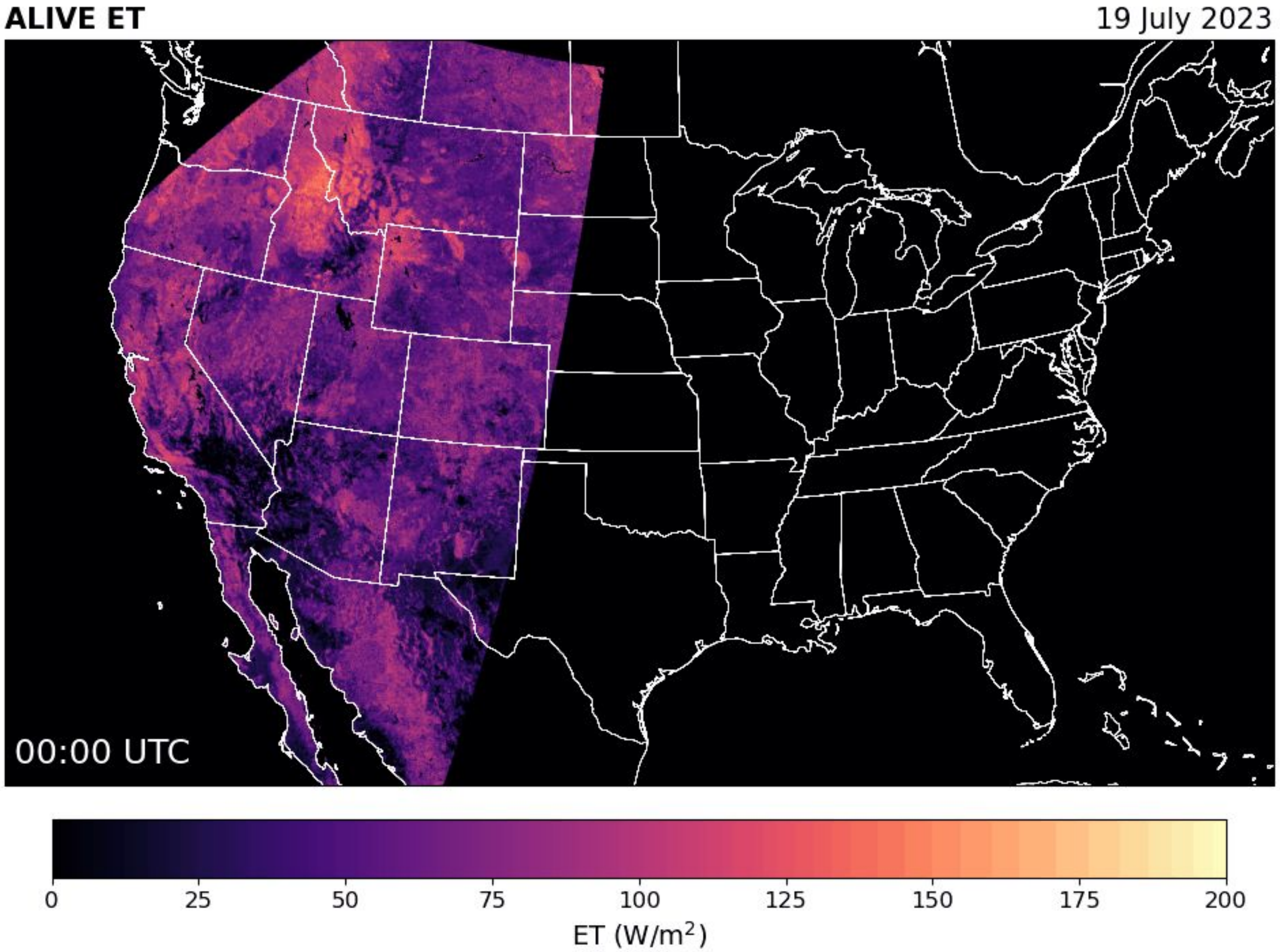


Figure: D. Losos

ALIVE workflow

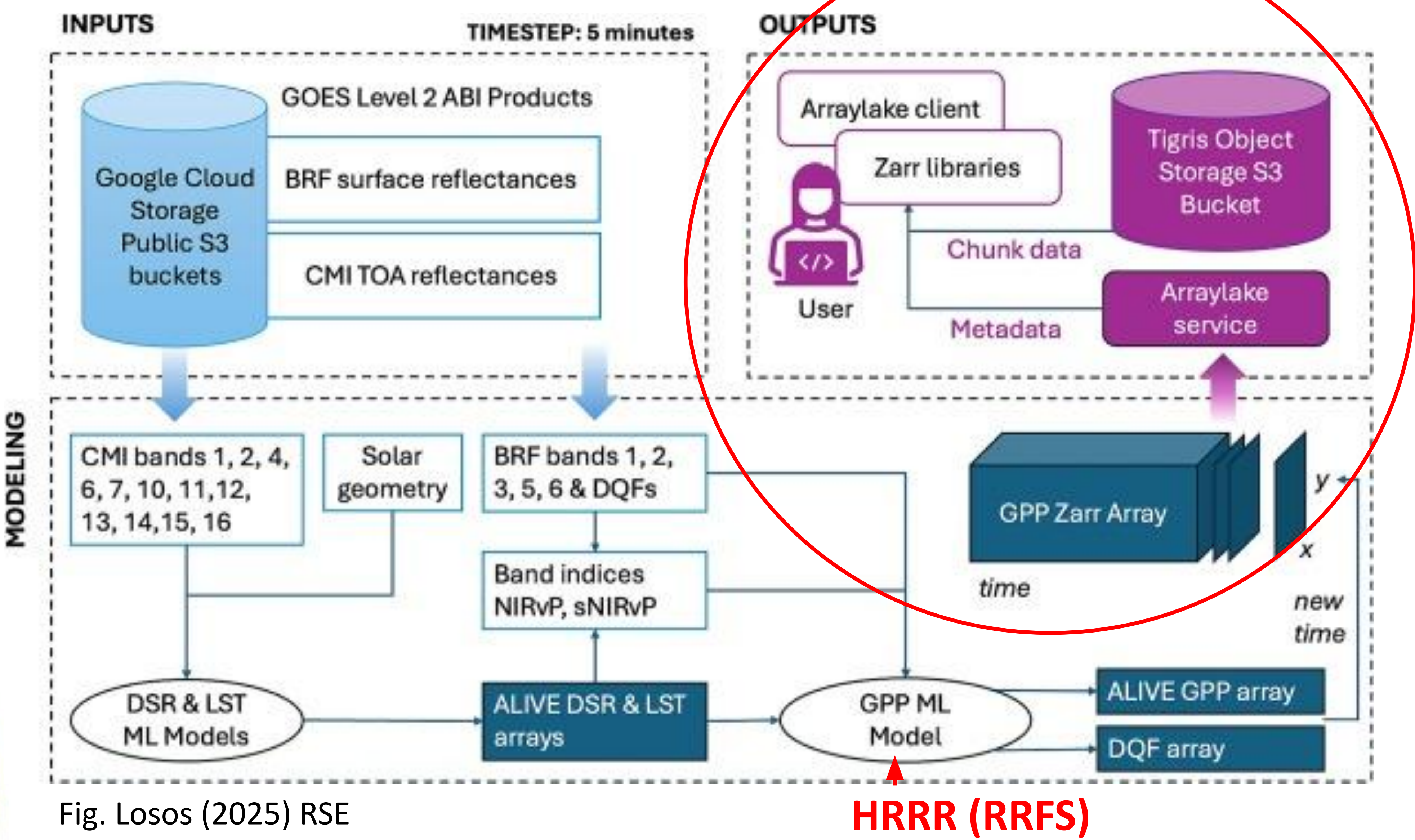


Fig. Losos (2025) RSE

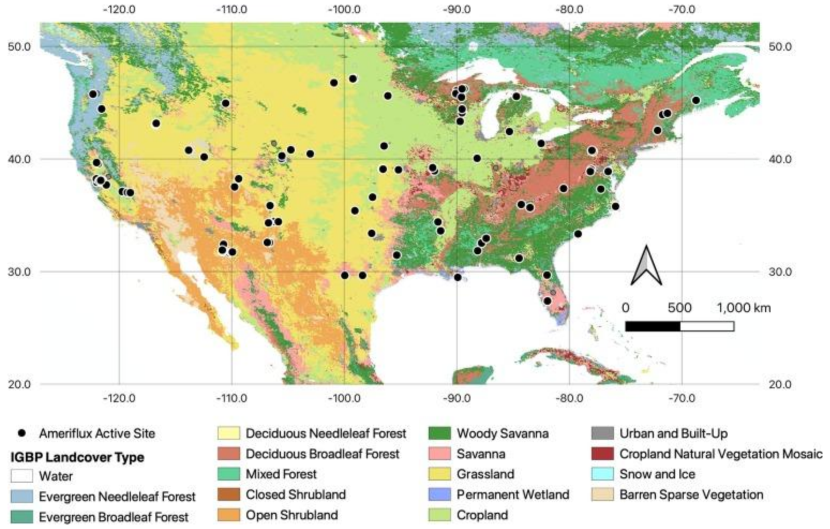
LST: Ranjbar et al. (2025) https://doi.org/10.1029/2024JH000464

DSR: Ranjbar et al. (2024) https://doi.org/10.1109/JSTARS.2024.3420148

Vegetation indices: Ranjbar et al. (2024) https://doi.org/10.1029/2024JG008240

Going forward:

Eddy covariance



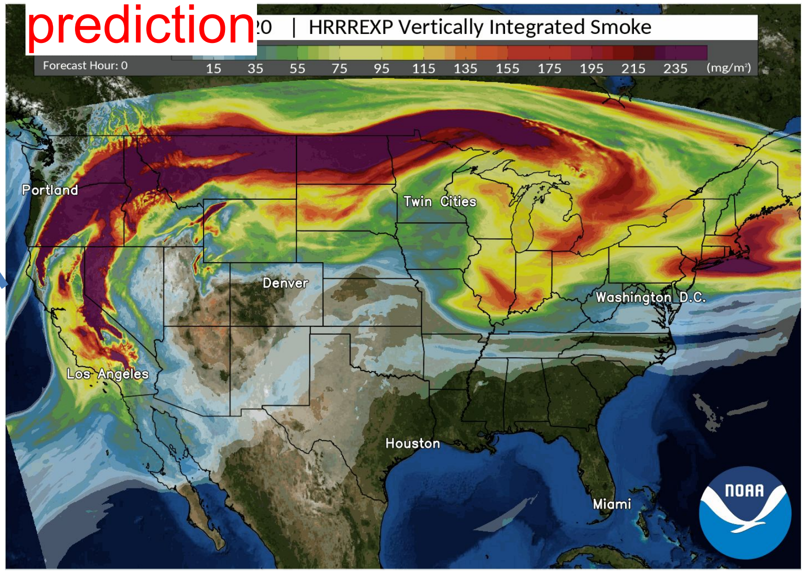
GeoXO data products

Knowledge Guided Machine Learning

ABI Live Imaging of Vegetated Ecosystems

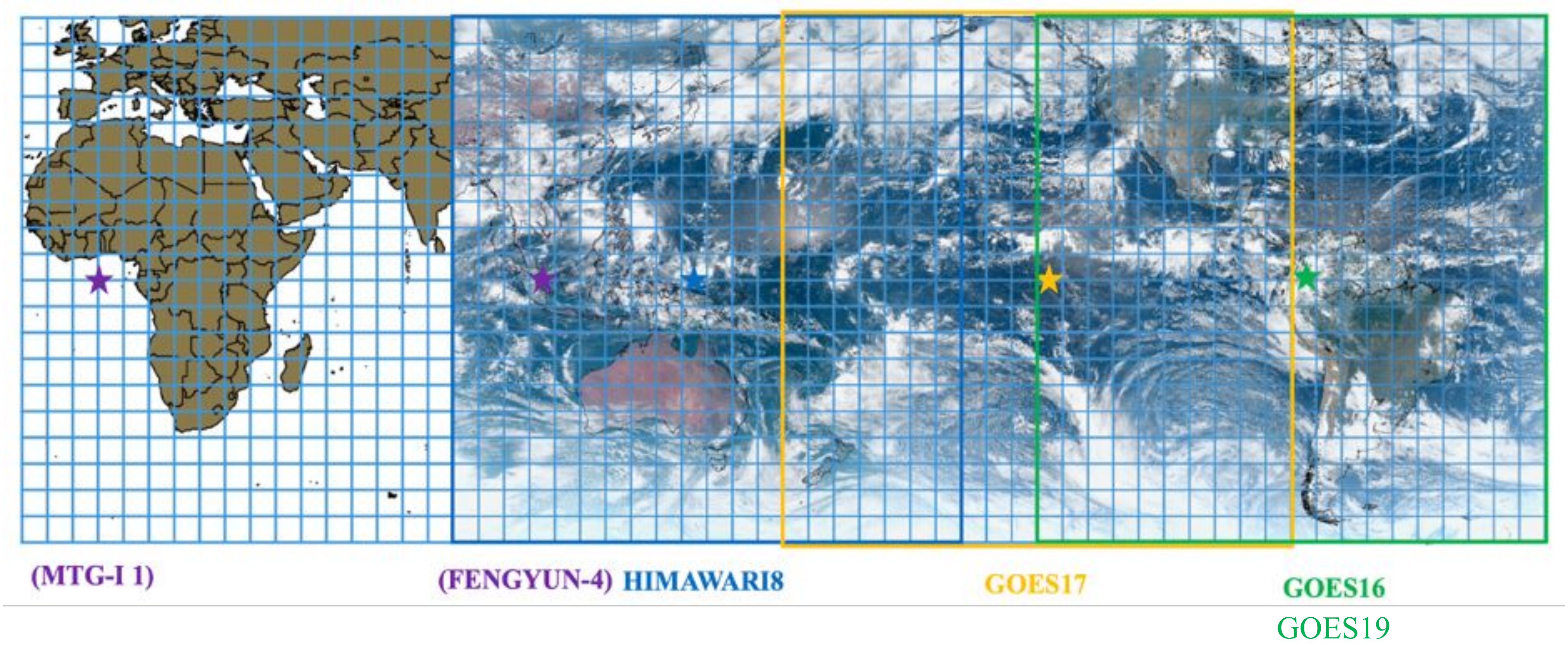
ALIVE

AI-enhanced weather prediction



Applications:
Yield forecasting
Drought forecasting
Phenology prediction
Integration with high-res RS & models
More

Going forward: GEONEX



Thanks again!

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USDA

ABI Live Imaging of Vegetated Ecosystems
ALIVE

Danielle Losos

Sadegh Ranjbar

Sophie Hoffman

Avanti Kekane

Data

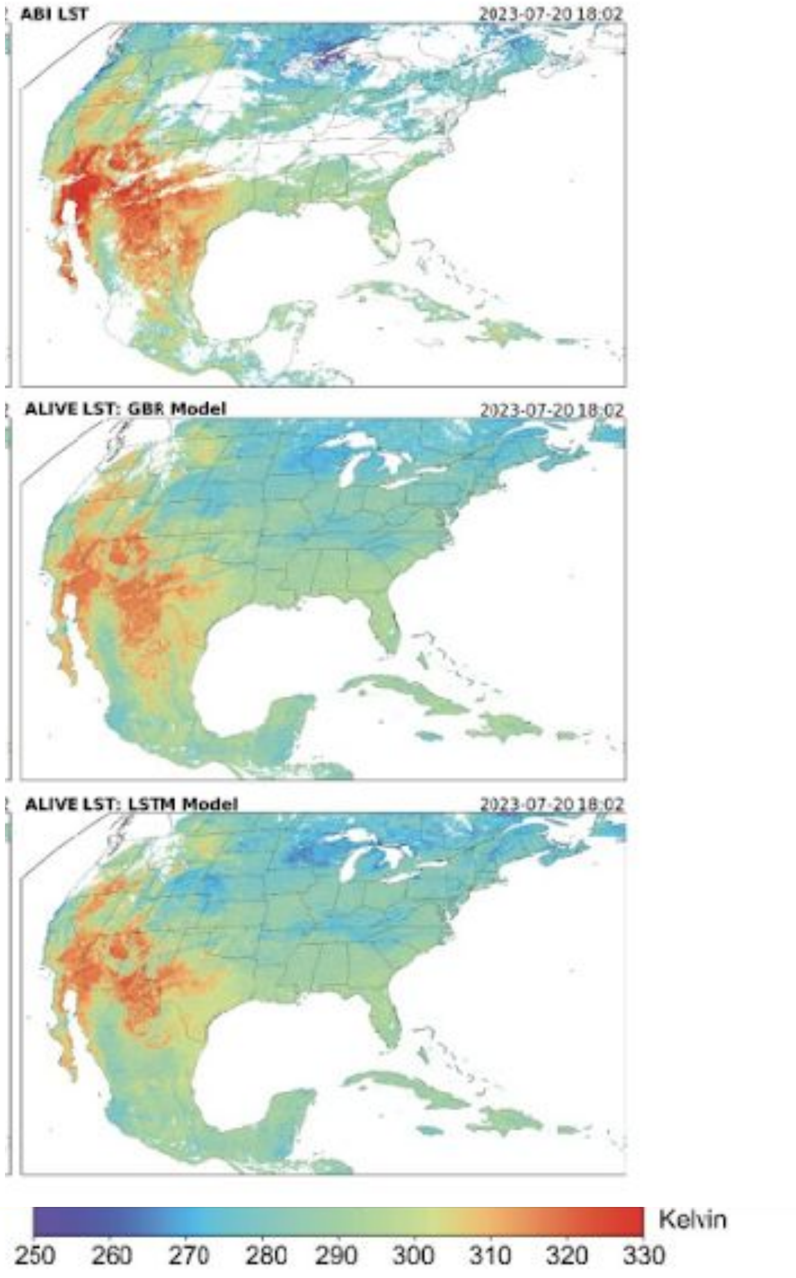
AmeriFlux

neon
Operated by Battelle

Einara Zahn

Elie Bou-Zeid

Sub-models for DSR and LST



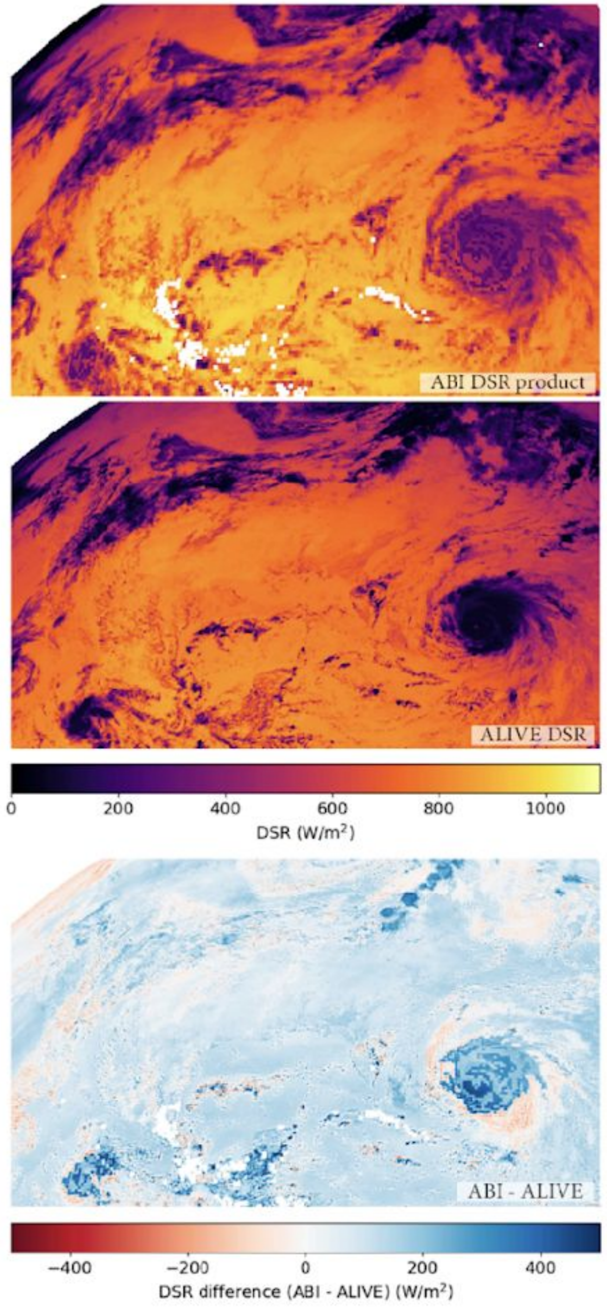
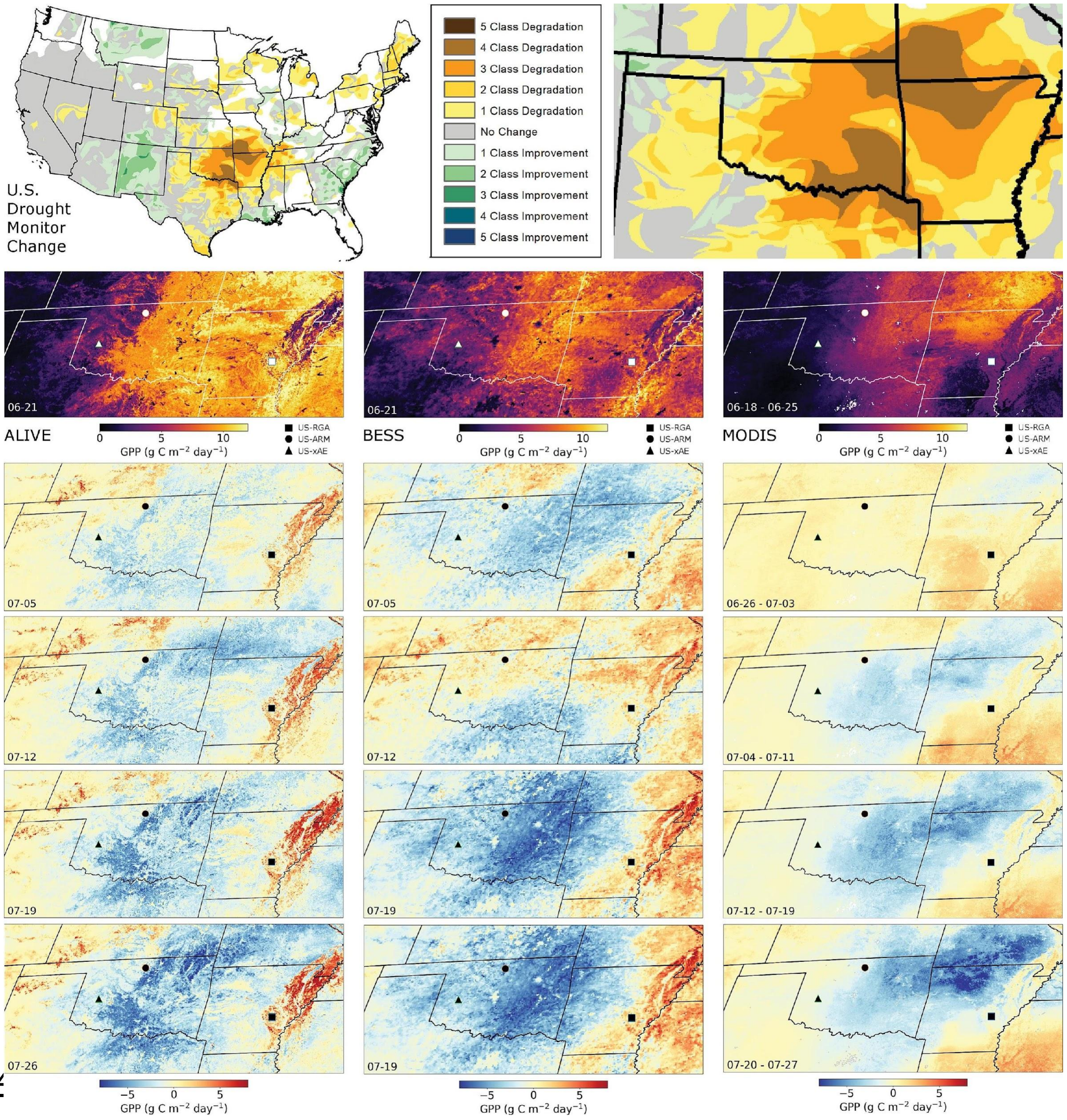


Fig. 9. DSR_{ABI}, estimated DSR_{ALIVE}, and their differences (ABI-ALIVE) maps at hour 6 P.M. UTC on September 21, 2022, with a CONUS view from the GOES satellite.

LST: Ranjbar et al. (2025) https://doi.org/10.1029/2024JH000464
DSR: Ranjbar et al. (2024) https://doi.org/10.1109/JSTARS.2024.3420148

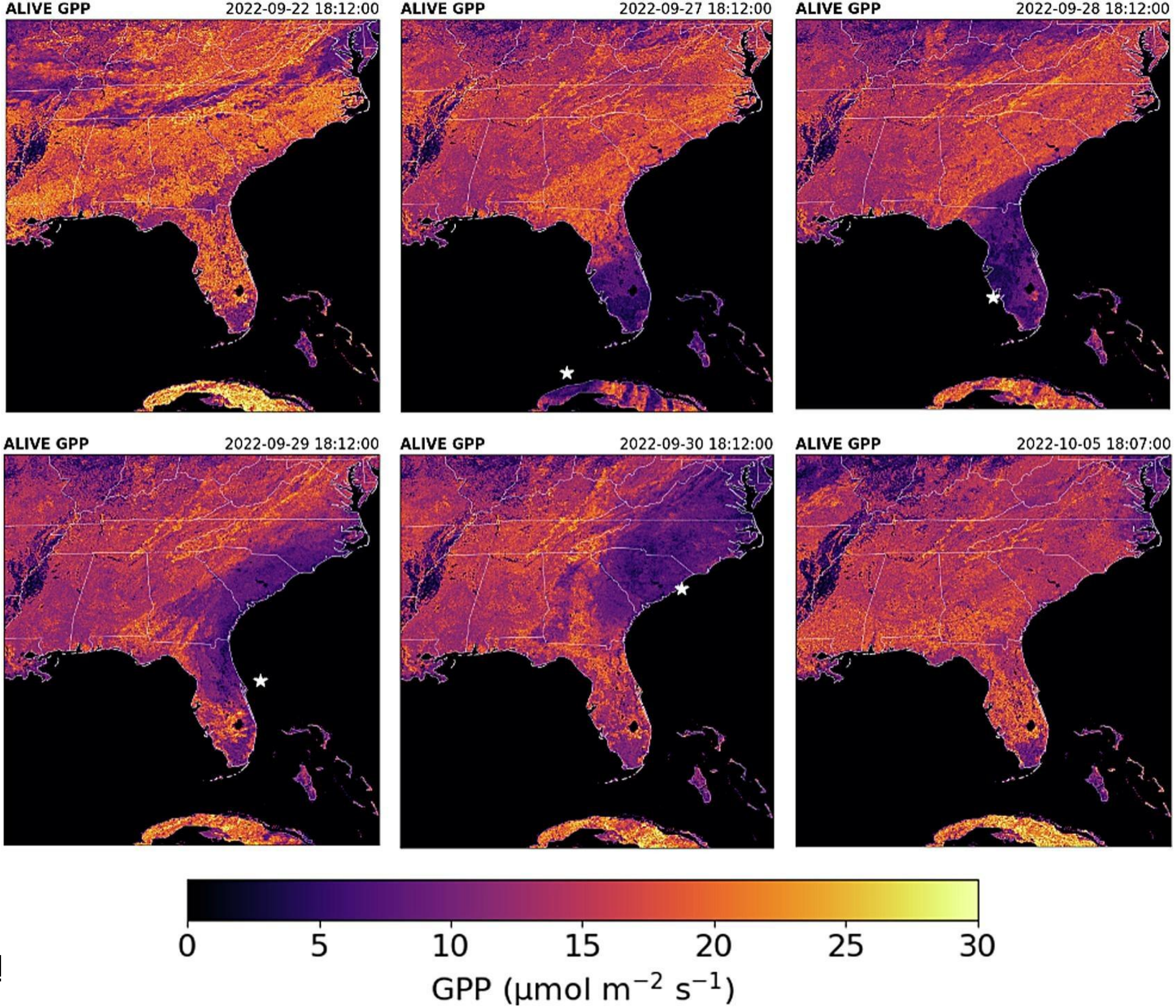
Example: Flash drought

ALIVE estimates flash drought impacts to be more muted, but can find effects quickly



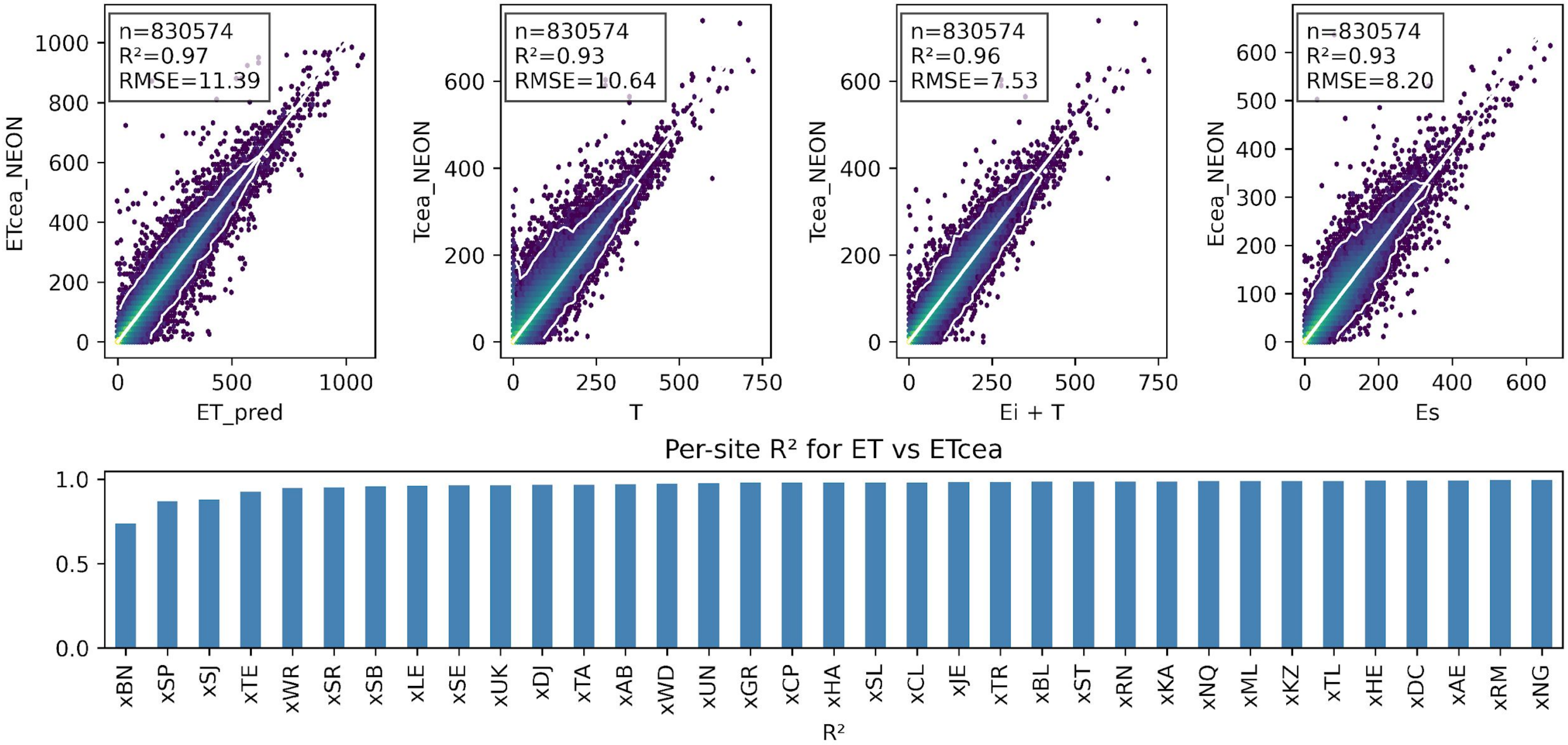
Losos et al. (2025) *RSE* https://doi.org/10.1016/j.rse.2025.114

Example: Hurricane Ian



Losos et al. (2025) *RSE* https://doi.org/10.1

The model is happy because it has data. Does it get the physics right?



Figures: S. Ranjbar