ARL Surface Energy Budget Network (SEBN)

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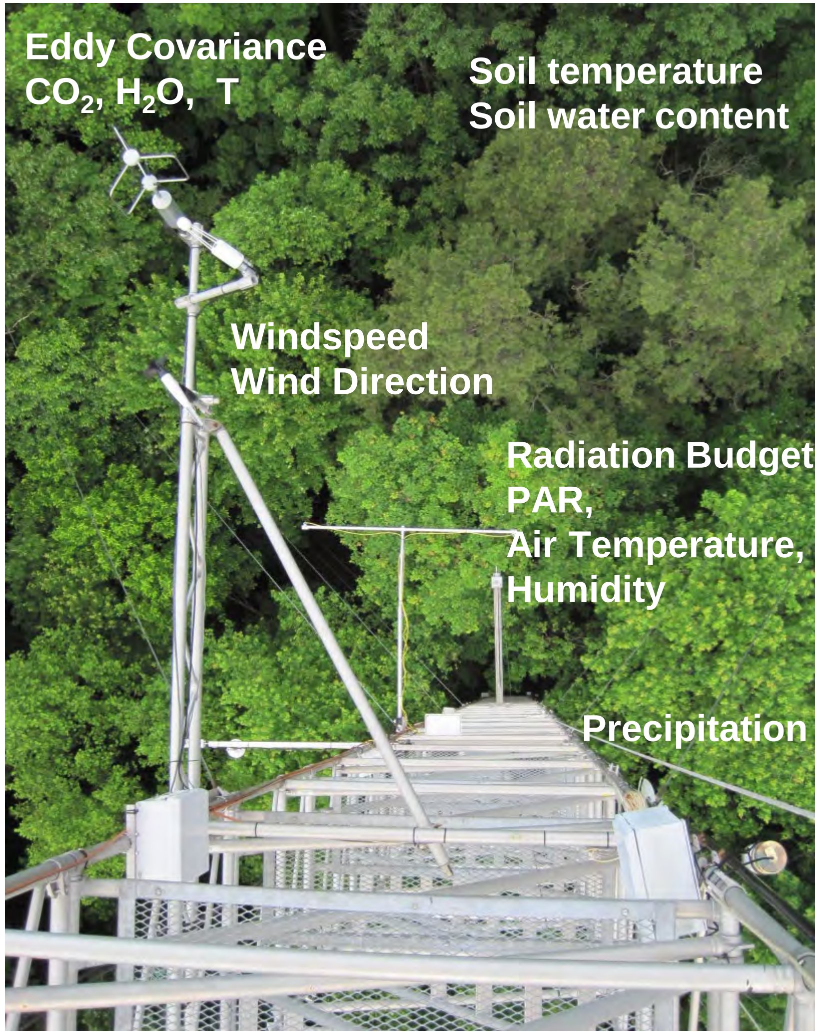
ARL Surface Energy Budget Network

- Assess land-surface feedbacks and related exchange processes
- Better understand drivers of regional climate and improve weather predictions
- Heat, water, and CO_2 exchange are monitored continuously
- Radiation, meteorology, and soil measurements are also recorded



Relevance: ARL Surface Energy Budget Network

OAR Goals:

Goal 2.2: Identify and address gaps in observation requirements needed to understand causes of variability and change

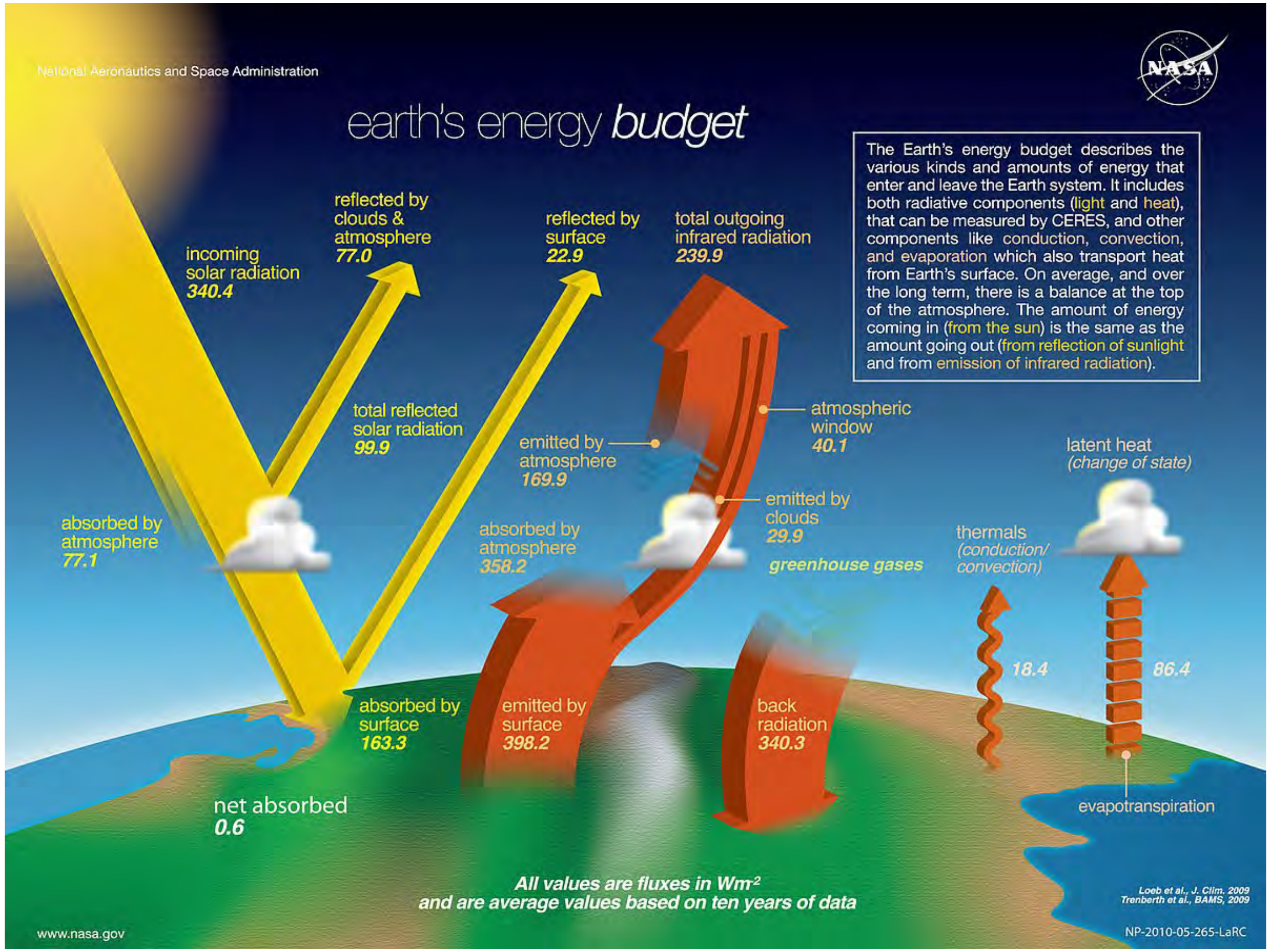
Goal 3.1: Develop interdisciplinary Earth system models

Goal 3.3: Transition science that meets users' current and future needs

Surface energy budget observations:

- Energy balance measurements are not included in typical weather or climate observations
- The energy and CO_2 absorbed and emitted by earth's ecosystems causes variability and long-term changes in weather and climate
- A better understanding of the relationship between earth's atmosphere and its surface is necessary to improve weather, climate, and Earth system models

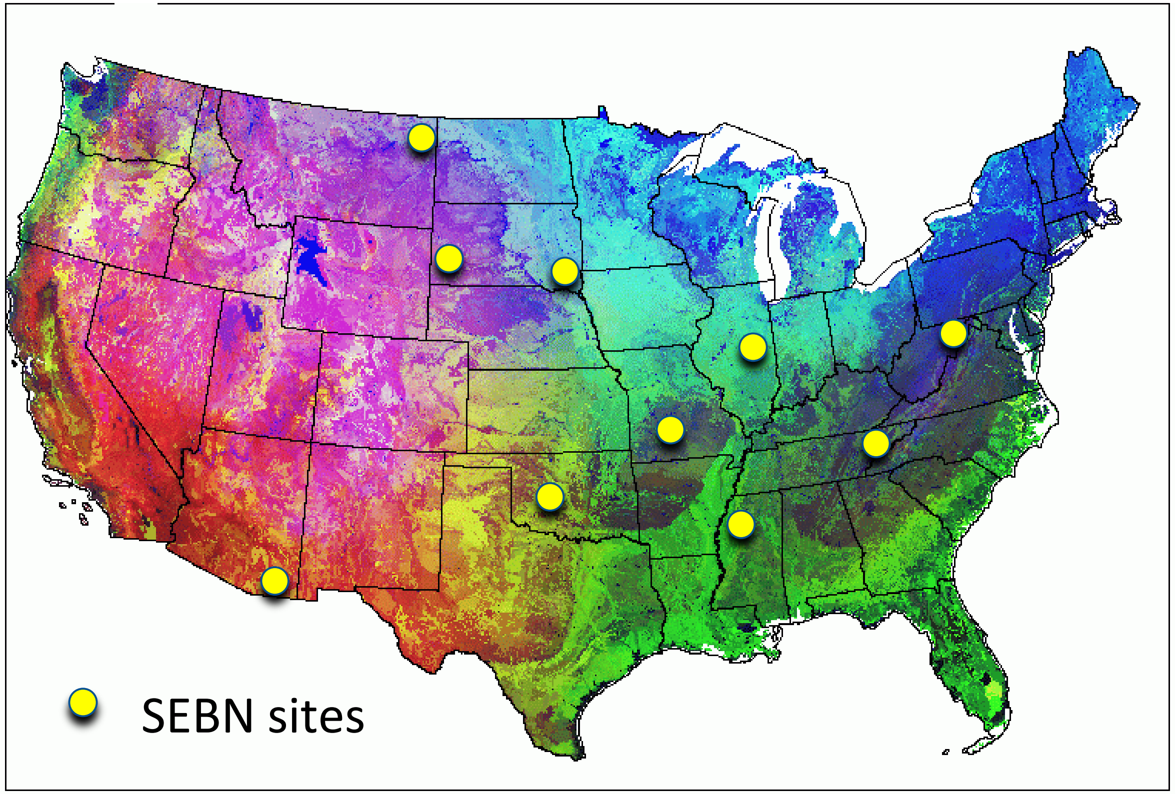
ARL Surface Energy Budget Network



- Land surface processes moderate the seasonal and annual water and carbon budgets
- The land surface response to extreme climatic events is poorly understood
- Surface-atmospheric exchange measurements are needed to improve NOAA's models

ARL Surface Energy Budget Network

Sites chosen for representative land surface types



<u>Long-term SEBN Sites</u>

Site name	Vegetation	Dates
Audubon, AZ	Grassland	2002-present
Bondville, IL	Corn, Soybean	2002-present
Bondville2, IL	Corn, Soybean	2003-2007
Brookings, SD	Grassland	2004-2015
Fort Peck, MT	Grassland	2000-2015
Walker Branch, TN	Hickory/Oak/Maple	1999-2007
Chestnut Ridge, TN	Hickory/Oak/Maple	2004-present

Representative Land Surface Measurements

Chestnut Ridge, TN

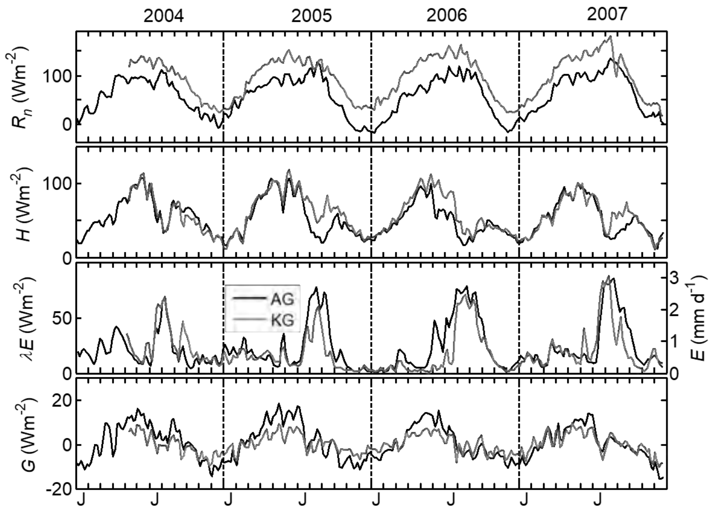
Bondville, IL

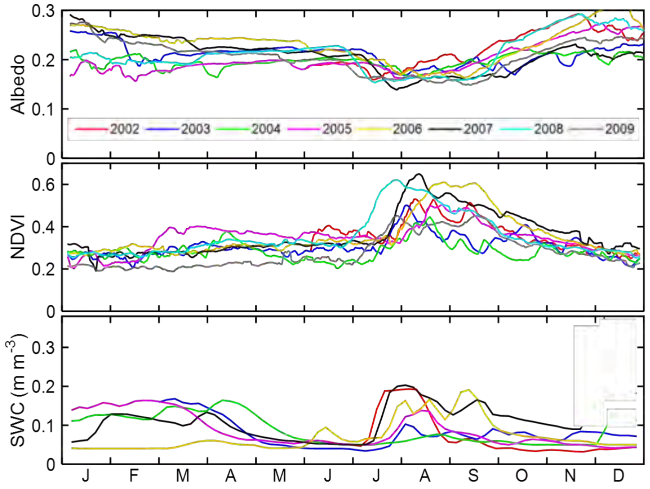
Post-fire energy, water and CO_2 fluxes over a semi-arid grassland

Drylands occupy ~40% of the land surface and dominate global carbon (C) cycle and its inter-annual variability (IAV)

Audubon grasslands

- ✓ Seasonal and interannual variation in energy and water vapor fluxes
- ✓ Effects of seasonal change in vegetation and soil water conditions on evapotranspiration (*E*) and canopy level biophysical parameters
- ✓ Factors controlling the interannual variation in evapotranspiration (*E*)

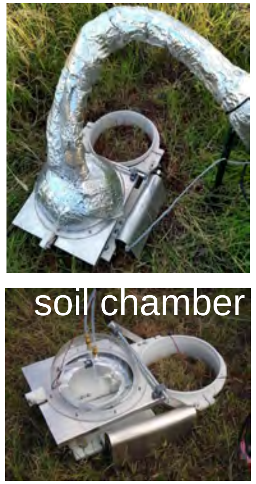


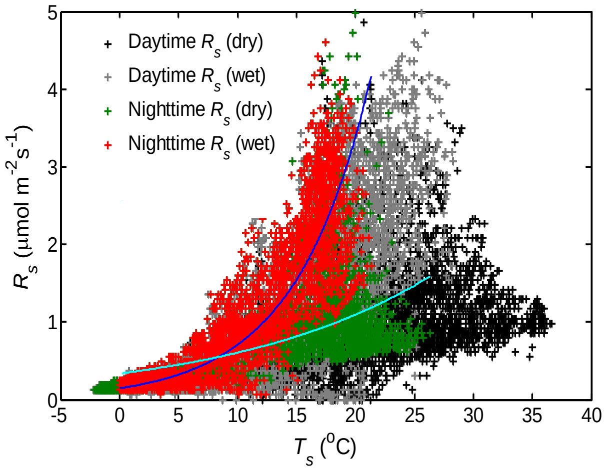


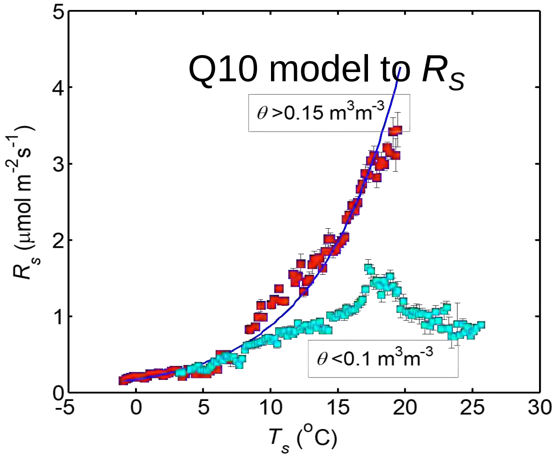
Long-term observations (2002-till date) over **Audubon semi-arid grassland** in Arizona supports synthesis & Terrestrial Biosphere Models

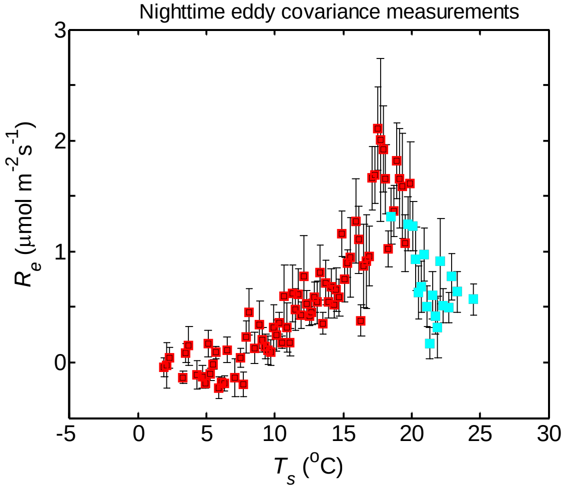
- ❑ CO_2 exchange and evapotranspiration across dryland ecosystems of southwestern North America (*Biederman et al., 2017*)
- ❑ Dynamic global vegetation models underestimate the magnitude and variability of CO_2 fluxes in dryland ecosystems (*Mcbean et al., 2021*)
- ❑ Optimizing Carbon Cycle Parameters Drastically Improves Terrestrial Biosphere Model Underestimates of Dryland Mean Net CO_2 Flux and its IAV (*Mahmud et al., 2021*)

Effect of soil water stress on soil respiration in a semiarid grassland







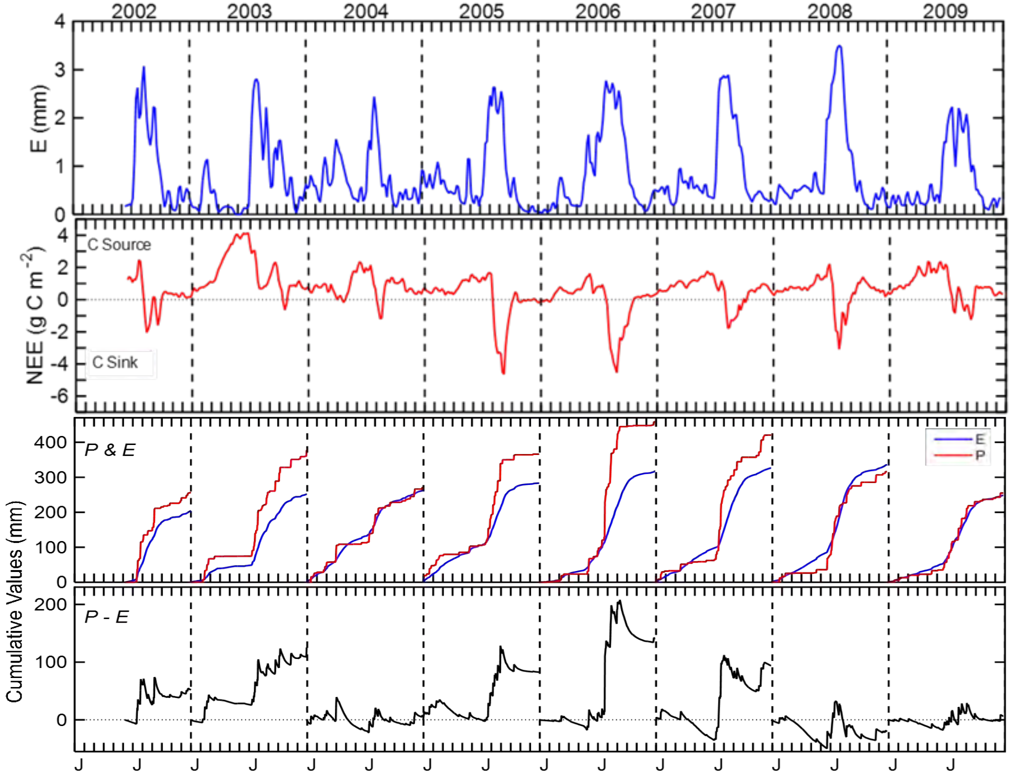


- Soil surface CO_2 efflux or soil respiration (R_S) is one of the most important components of the ecosystem carbon cycle
- Understanding and quantifying the response of soil respiration to environmental variables is critical for assessing the impacts of climate on ecosystem carbon fluxes.

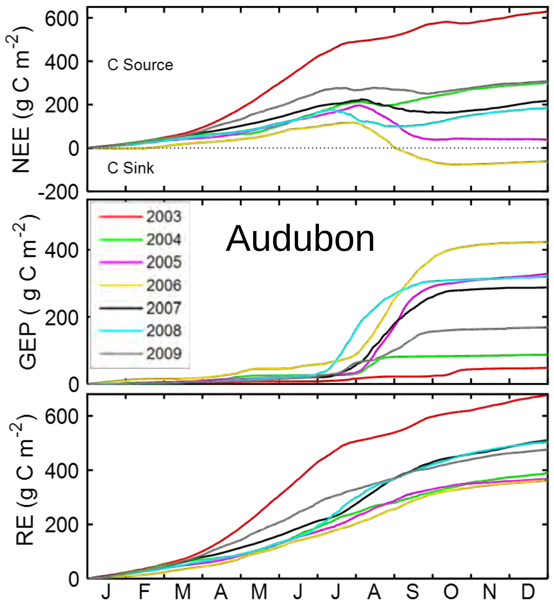
- ✓ Soil temperature and soil water content largely controlled soil CO_2 efflux
- ✓ Soil water stress significantly reduced soil CO_2 efflux (Rs) and ecosystem respiration(Re)
- ✓ Soil water stress substantially reduced the sensitivity of Rs to temperature
- ✓ Below the threshold soil water content, nighttime soil CO_2 efflux decreased with increase in soil temperature, mostly above ~18 °C.

Long-term measurements of evapotranspiration and net ecosystem exchange

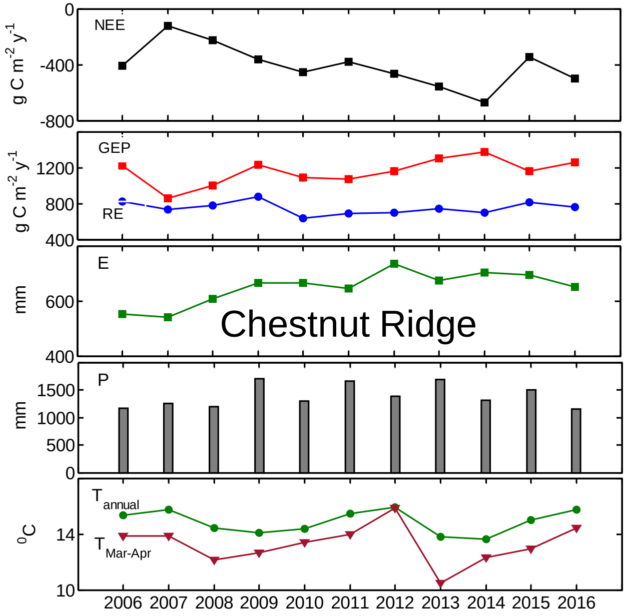
Fire-induced changes in land cover evapotranspiration (E) and net ecosystem exchange (NEE) over a semi-arid grassland



Audubon grassland was a source of C (NEE=231± 221 $gCm^{-2}y^{-1}$) during 2003-2009

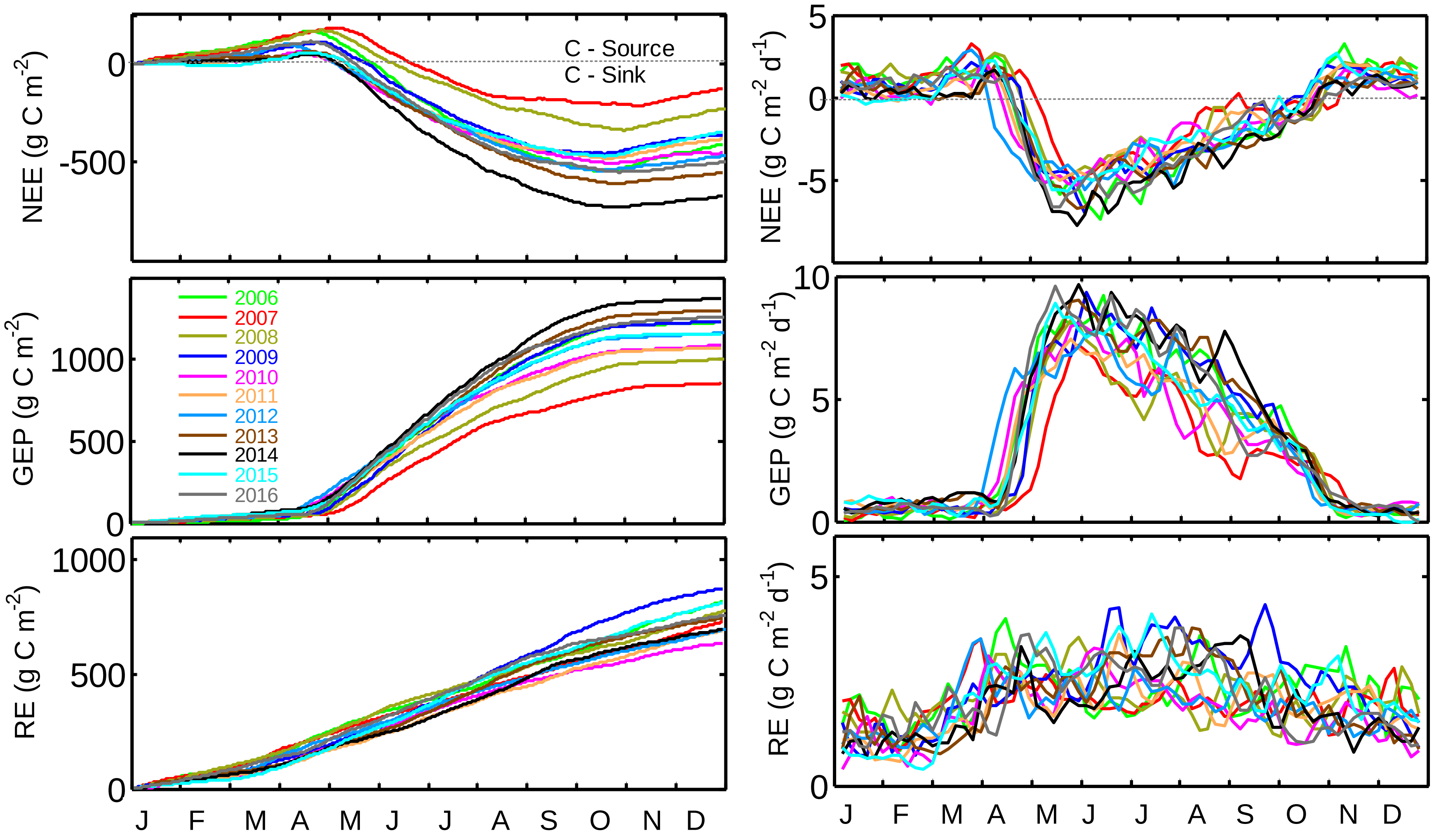


Chestnut Ridge deciduous forest was a strong sink of carbon (C) over the 11-year period (NEE = -408 ± 150 $gCm^{-2}y^{-1}$).



Controls on seasonal and interannual variability in ecosystem exchange of CO_2 (NEE),ecosystem respiration (RE) and gross ecosystem photosynthesis (GEP) over different ecosystems were evaluated.

Interannual Variability of CO2 Exchange at Chestnut Ridge

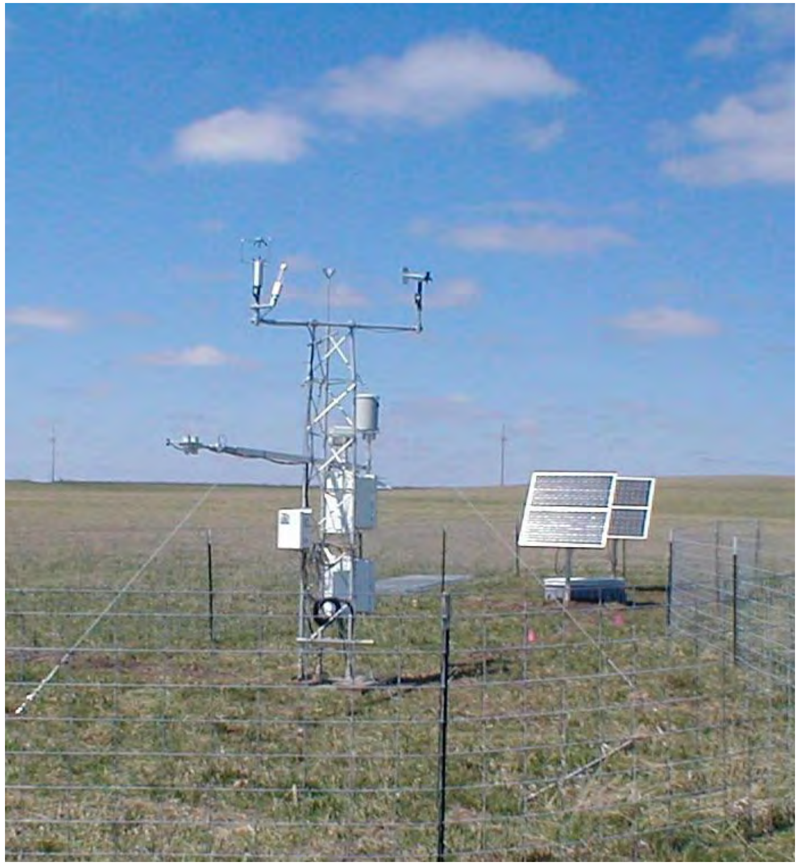


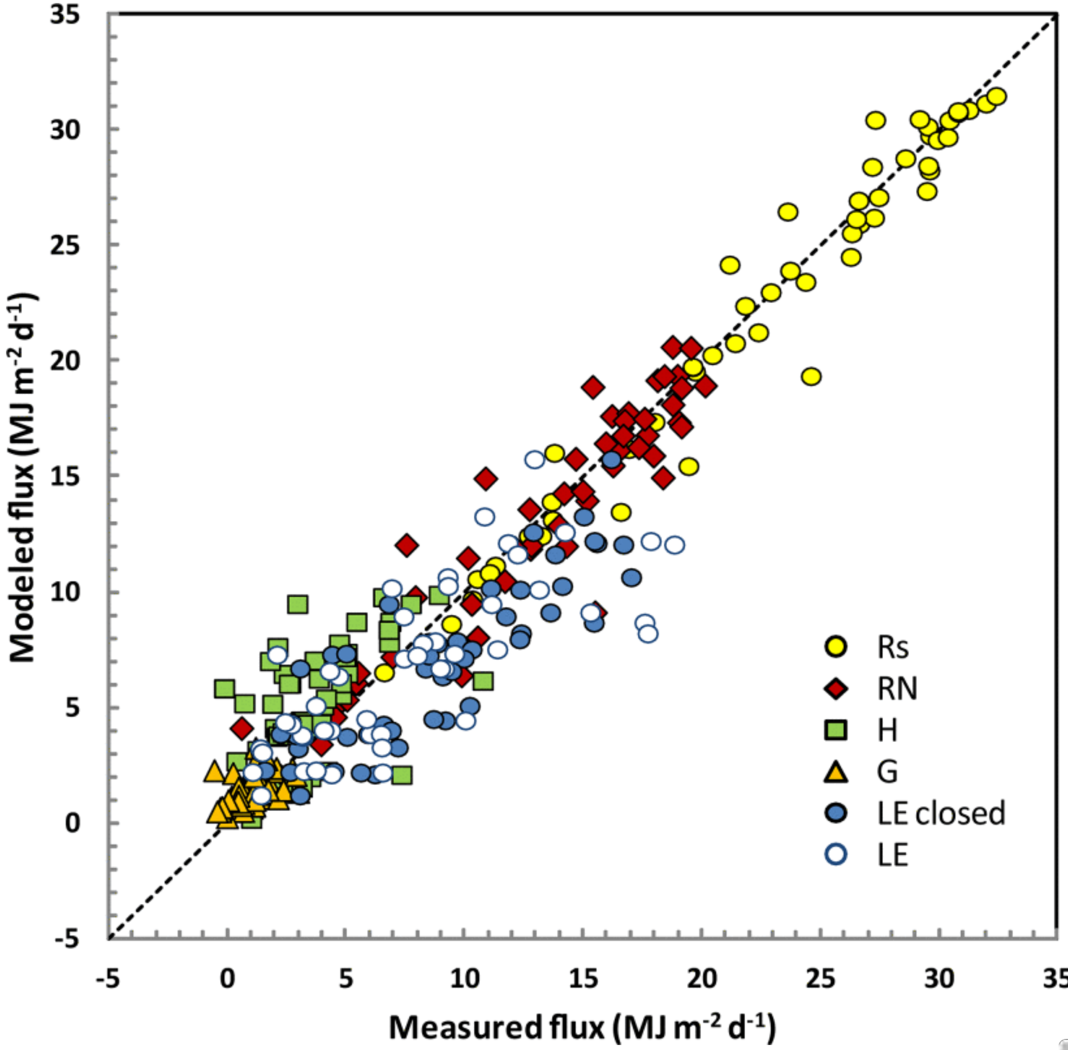
- Variations in annual NEE were mainly due to variation in annual GEP
- Seasonal and interannual variations primarily controlled by *P* through changes in soil water content and vegetation growth
- A late spring freeze in 2007 affected leaf development, and energy fluxes and resulted in lowest annual *E*, GEP and NEE of the record

ARL Surface Energy Budget Sites

Yun Yang et al 2017 *IEEE J. of App Earth Obs. and Rem. Sens.* vol. 10, no. 6, pp. 2550-2564

Grasslands
Brookings, SD





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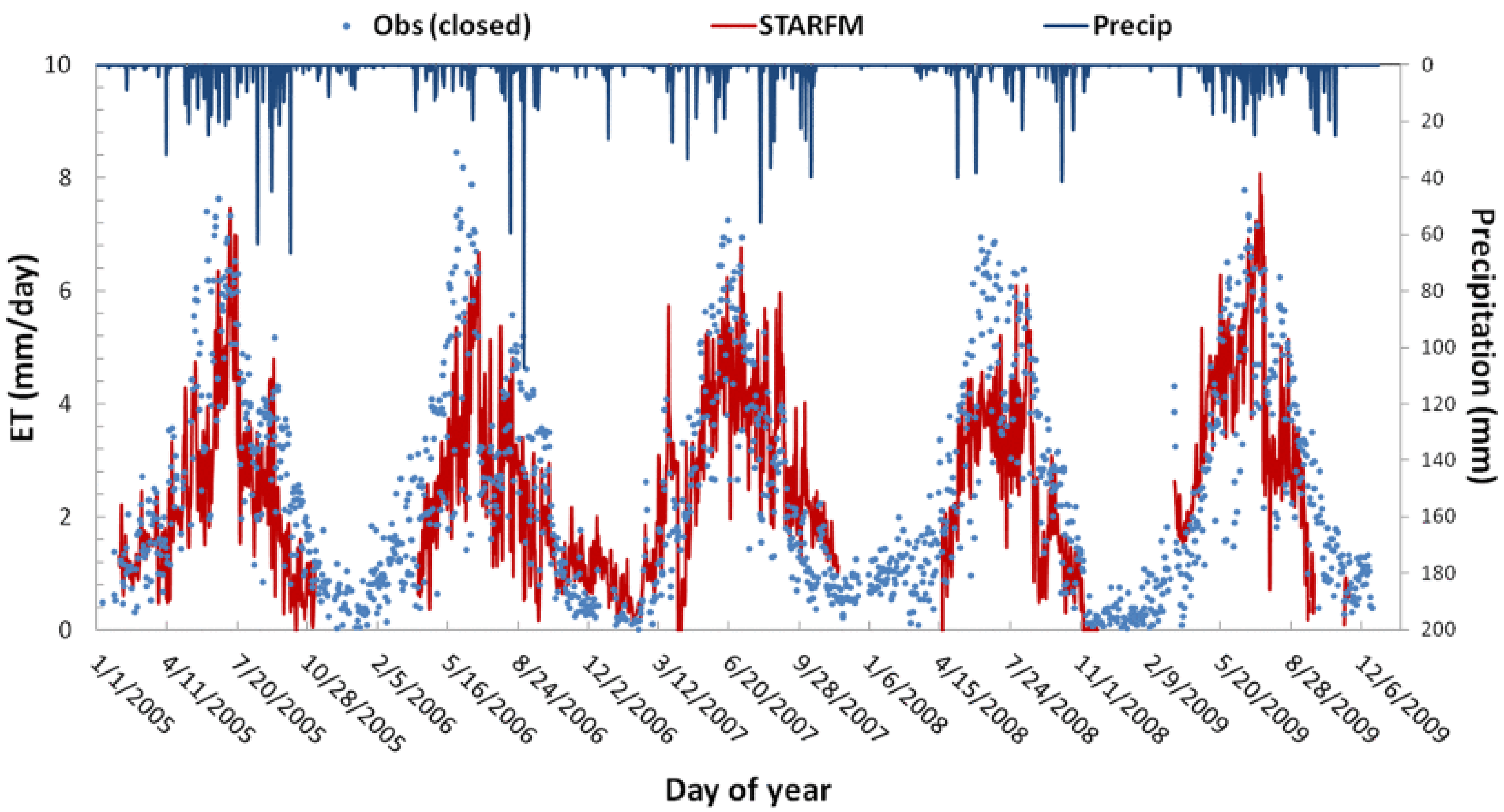
Grasslands
Brookings, SD

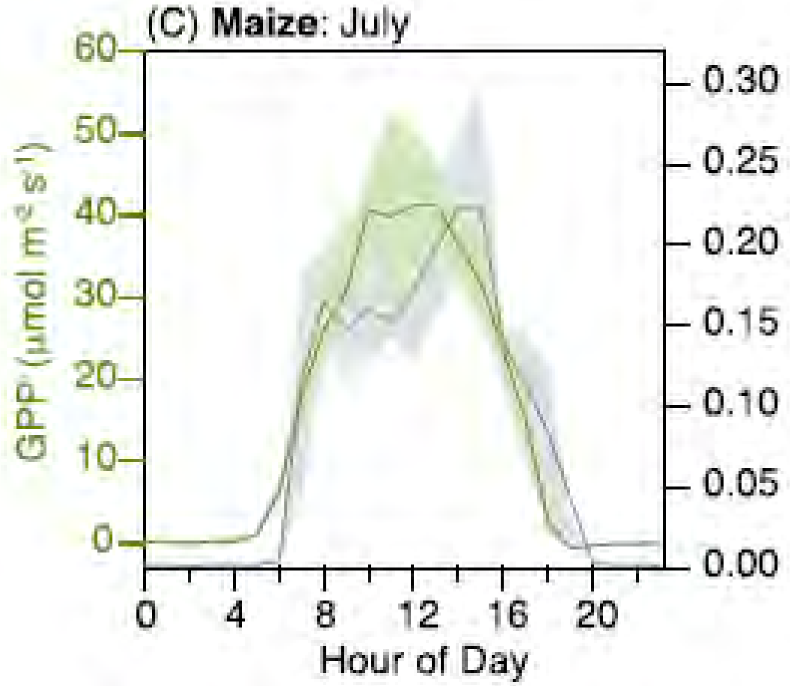
- The remote sensing-based energy balance model compared well to SEBN site measurements, and was used to estimate regional evapotranspiration (ET)
- The effects of agricultural practices on ET were evaluated throughout South Dakota
- Drained fields were more productive, and had lower total annual water use

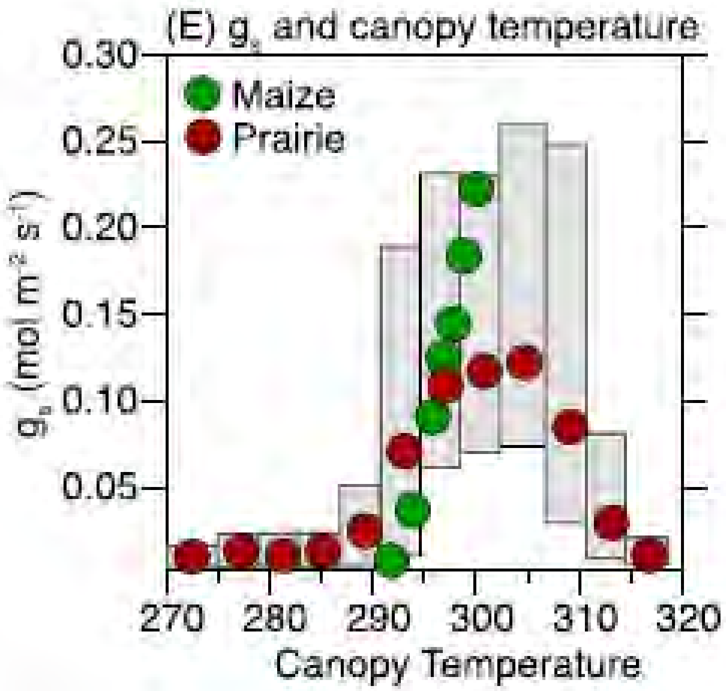


ARL Surface Energy Budget Sites

Berkelhammer, M., et al. 2020 *Geophy Res Lett,* 47, e2019GL085652

Agriculture
Bondville, IL





Quality and Performance

- **Publications (14)**
  - **21 Citations:** Anderson, M. C., Yang, Y., Xue, J., Knipper, K. R., Yang, Y., Gao, F., Hain, C. R., Kustas, W. P., Cawse-Nicholson, K., Hulley, G., Fisher, J. B., Alfieri, J. G., Meyers, T. P., Prueger, J., Baldocchi, D. D., and Rey-Sanchez, C. (2021). Interoperability of ECOSTRESS and Landsat for mapping evapotranspiration time series at sub-field scales, **Remote Sensing of Environment**, 252, 112189.
  - **176 Citations:** Pastorello, G., Trotta, C., Canfora, E. et al. The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data. **Sci Data** 7, 225 (2020).
  - **105 Citations:** Biederman, J. A., Scott, R. L., Bell, T. W., Bowling, D. R., Dore, S., Garatuza-Payan, J., Kolb, T. E., Krishnan, P., Krofcheck, D. J., et al. (2017). CO2 exchange and evapotranspiration across dryland ecosystems of southwestern North America, **Global Change Biology**, 23, 4204-4221.
  - **31 Citations:** Yang, Y., Anderson, M., Gao, F., Hain, C., Kustas, W., Meyers, T., Crow, W., Finocchiaro, R., Otkin, J., Sun, L., and Yang, Y (2017). Impact of Tile Drainage on Evapotranspiration in South Dakota, USA, Based on High Spatiotemporal Resolution Evapotranspiration Time Series From a Multisatellite Data Fusion System, **IEEE J. Selected Topics in Applied Earth Obs. and Remote Sensing**, 10, 2550-2564.
- **Presentations (14)**

Surface Energy Balance Network Users

Modeling groups

NOAA GFDL
NCEP
ECMWF
EPA
DOD
ESRL GSD
NWS CPC
U. Of Washington
METEO FRANCE

Satellite validation

NESDIS GCIP
NESDIS GOES-R
NASA Langley
NASA GSFC
NASA Marshall
U. of Maryland
U. Of Boston
Texas A&M

Other uses

USGS
Northrup Grumman
U. of Central Fla.
U. of Texas
U. of Mississippi
U. of Michigan
U. of Illinois
U. of Helsinki
Vanderbilt U.
Canada Centre for Remote Sensing
AmeriFlux
FLUXNET

Renewable Energy

DOE NREL
NCAR
IBM
U. of Central Fla.

Future plans

Model Validation Using SEBN Measurements

- Collaborate with the GFDL Land Surface Modeling group using SEBN measurements to validate and improve the LM4.2 Land Surface Model
- Evaluate long-term trends in atmospheric composition, vapor pressure, air temperature, soil moisture, and CO_2 and H_2O fluxes
- Dryland methane fluxes from a deciduous forest at the Chestnut Ridge site
- NOAA fire research – characterize energy fluxes near fires

Boundary Layer Testbeds and Upscaling

- Leverage existing NOAA collaborations to expand boundary layer profile, remote sensing, and radiation measurements to improve Bedrock to Boundary Layer observations and model validations
- Use Unmanned Aerial Systems to map areas surrounding our sites and extend SEBN site measurements to satellite and regional scales

Questions?