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Ecosystem fluxes in complex topography: insights, challenges, and opportunities from the Coweeta eddy covariance tower

A. Christopher Oishi, Research Ecologist

USDA Forest Service, Southern Research Station

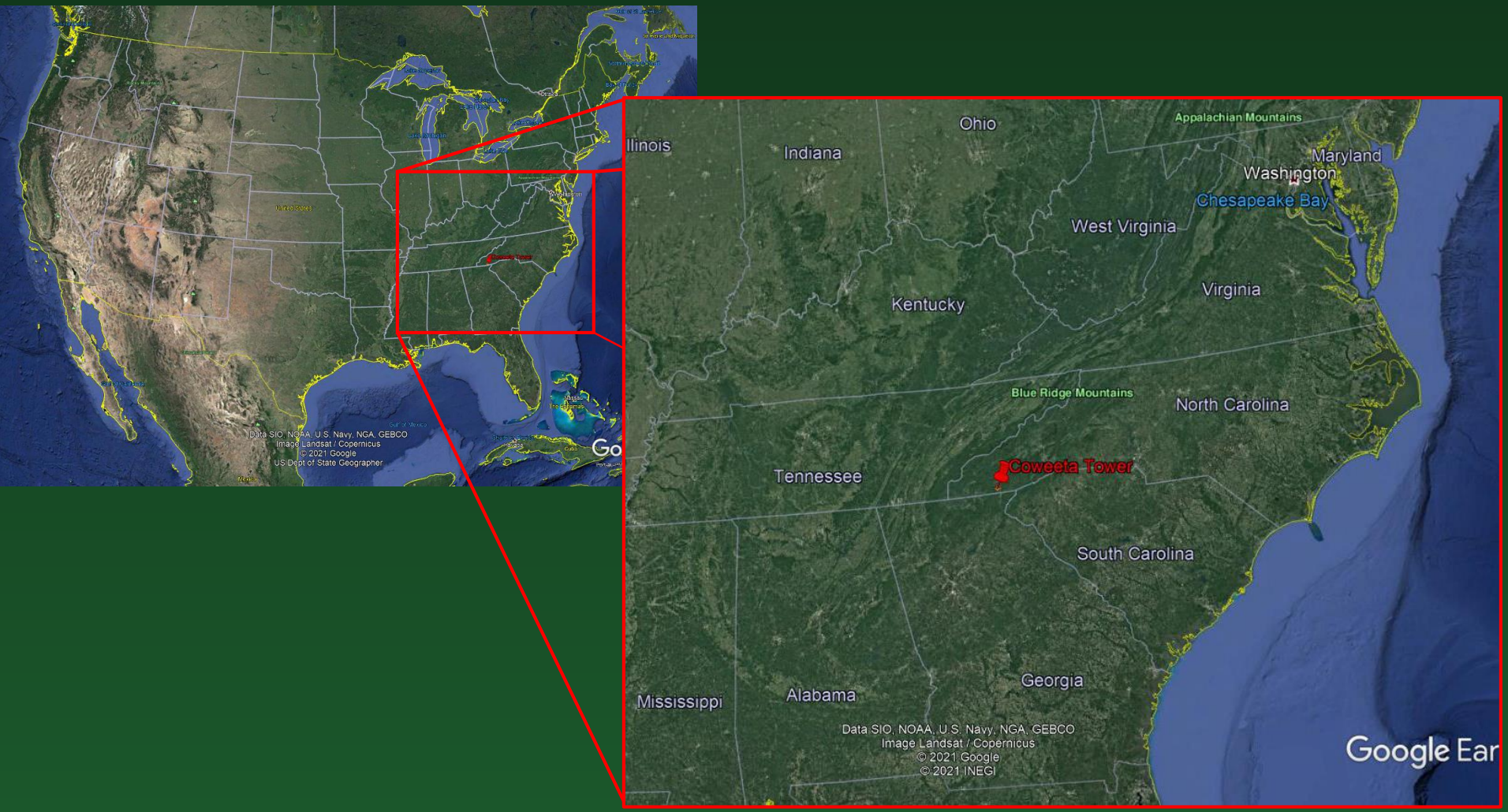
17th US-China Carbon Consortium (USCCC)

July 31 – August 1, 2021

Presentation outline

- Research site overview
- Motivating research objectives
- Methods and challenges
- Results
  - Phenology and growing season
  - Evapotranspiration
  - Carbon fluxes
- Synergistic opportunities and future directions

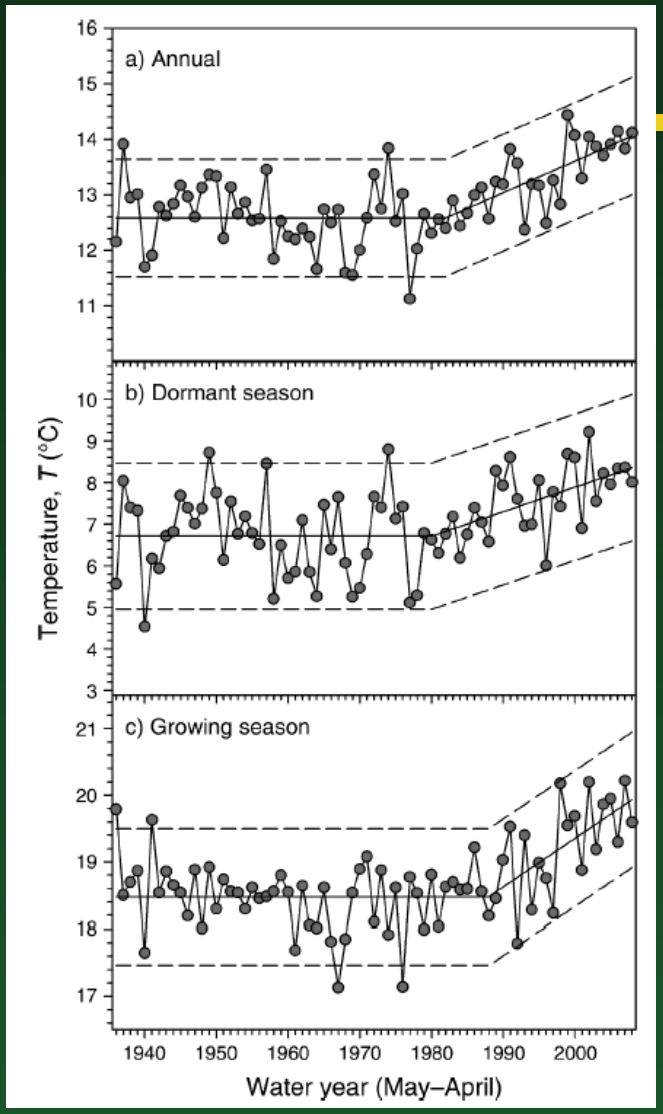
U.S. Forest Service
Coweeta Hydrologic Laboratory & Experimental Forest



Climate

- Long-term climate record (1934)
- Koeppen climate: Dfb (Warm Summer Continental: significant precipitation in all seasons)
- Mean annual precipitation = 1,813 mm (SD = 317)
- Mean daily temperature
  - Annual: 13.0 °C (SD = 0.7)
  - July: 22.0 °C (SD = 1.0)
  - January: 3.5 °C (SD = 2.7)

Climate



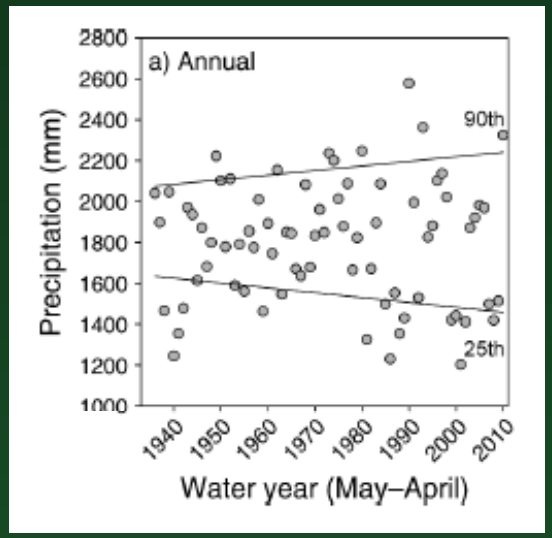
Hydrological Processes

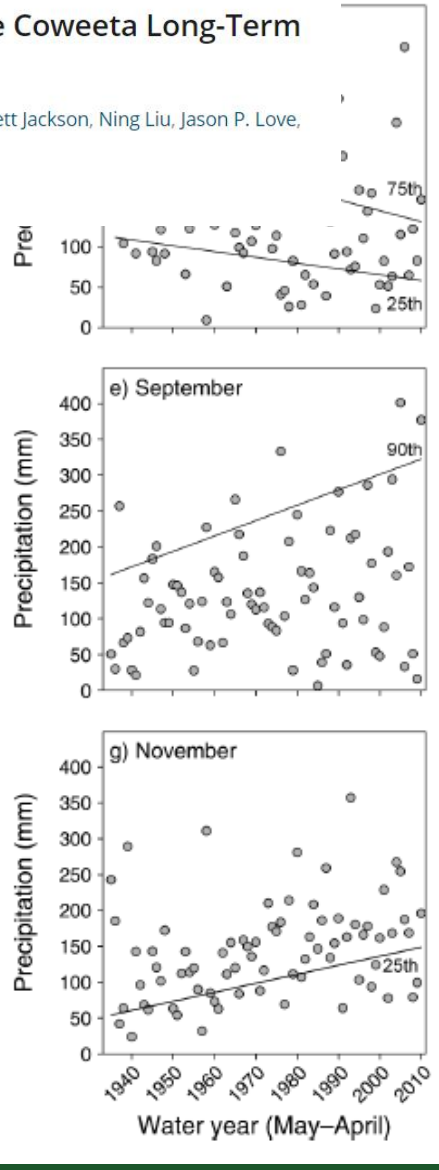
RESEARCH AND OBSERVATORY CATCHMENTS: THE LEGACY AND THE FUTURE | Full Access

The Coweeta Hydrologic Laboratory and the Coweeta Long-Term Ecological Research Project

Chelcy Ford Miniat, Andrew Christopher Oishi, Paul V. Bolstad, C. Rhett Jackson, Ning Liu, Jason P. Love, Catherine M. Pringle, Kelsey J. Solomon, Nina Wurzburger

First published: 01 July 2021 | https://doi.org/10.1002/hyp.14302





Ford *et al*., 2011, *Ecological Applications*

Effects of climate on coupled carbon-water-energy cycles

- Increasing temperature is expected to lead to:
  - Extended growing season

    (↑ET & ↑GPP)
  - Increased respiration

    (↑RE & ↓NPP)
  - Increased vapor pressure deficit

    (↑ET)
  - Progressive water limitation

    (through higher ET)

- Increasing variability in precipitation may lead to:
  - Dryer conditions and period drought

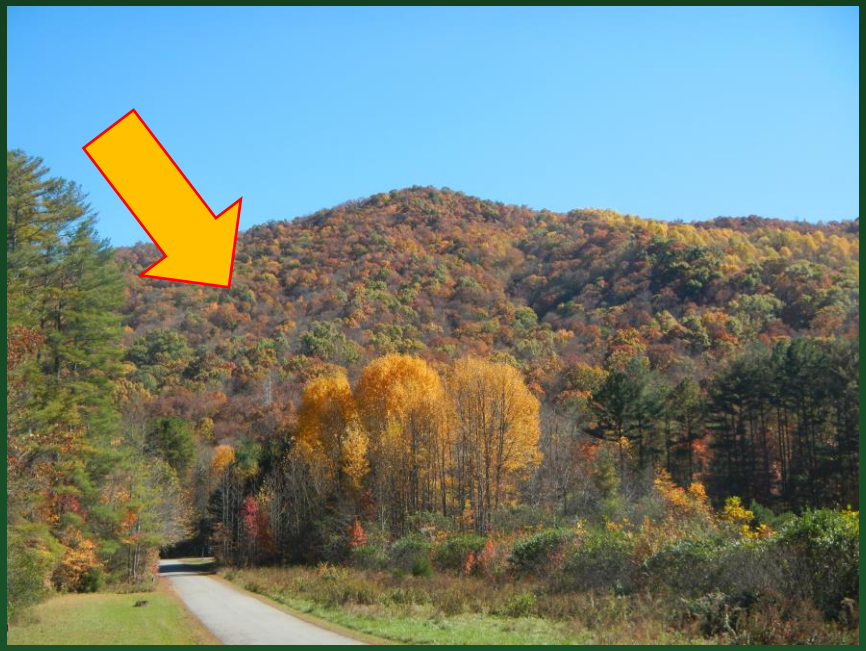
    (↓ET & ↓GPP & ↓RE)
  - A greater number of cloudy, energy-limited days

    (↓ET & ↓GPP)

Combined effects of a changing climate are unknown

Site characteristics

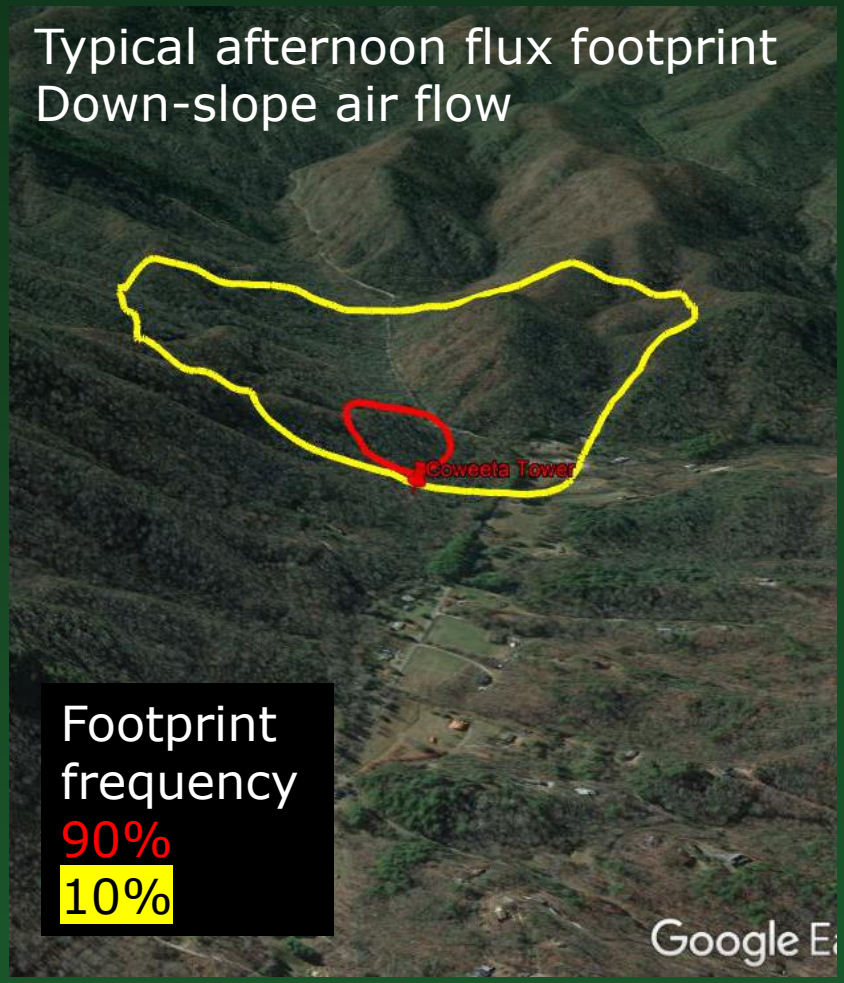
- Vegetation IGBP: Deciduous Broadleaf Forests (DBF)
- Unmanaged following extensive logging through early 1930s
- Dominated by *Quercus, Acer, Liriodendron, Carya* (formerly *Tsuga*)
- Substantial understory of evergreen woody shrubs (*Rhododendron* & *Kalmia*)
- Elevation range 700 – 1,600 m
- Basal area = 29 m^2 ha^{-1}
- Leaf area index = 4.6 m^2 m^{-2}



Instrumentation

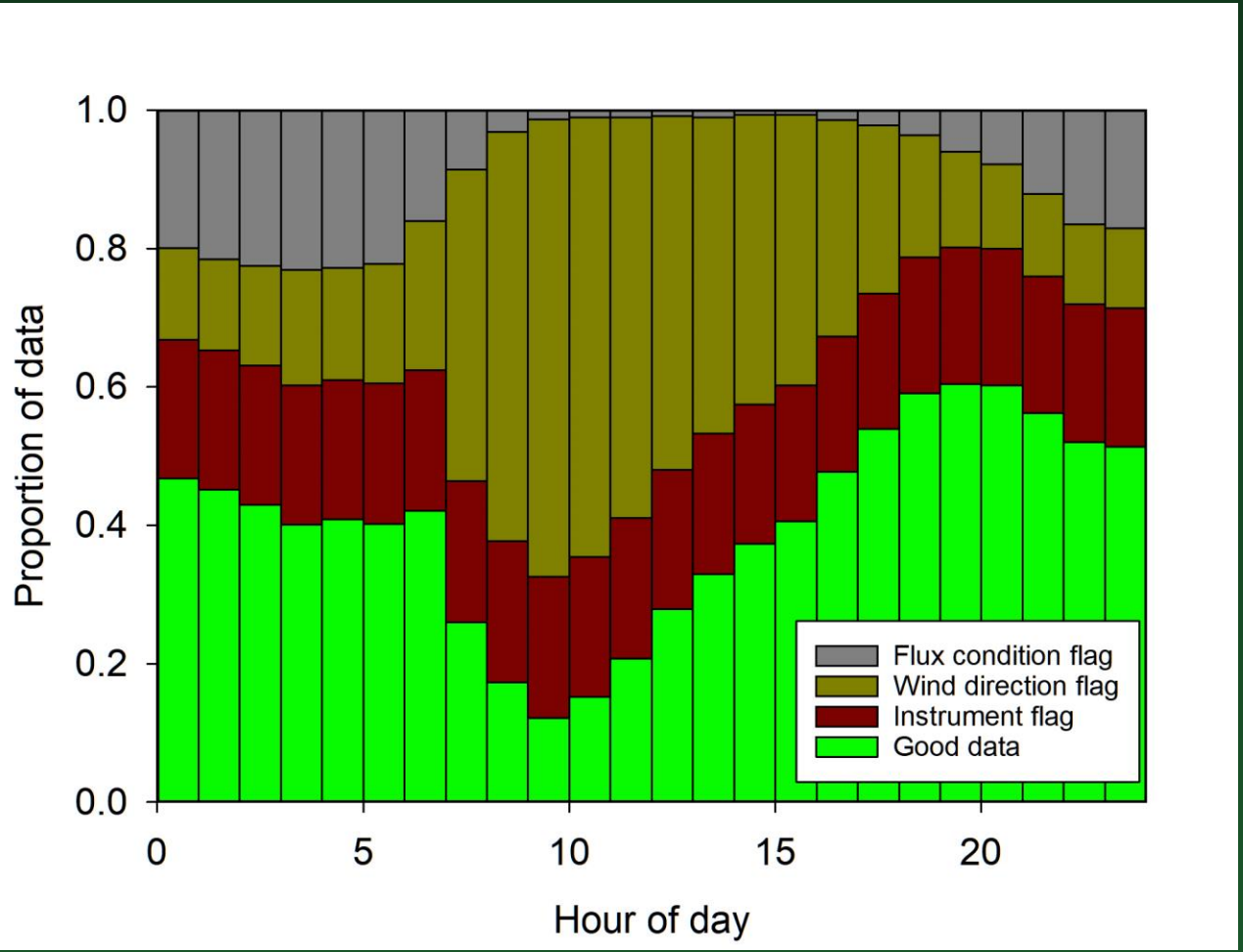
- 37 m tall tower
- Eddy covariance system
  - Closed-path IRGA
  - CO_2, H_2O, and wind profile system
  - Secondary subcanopy (2 m) EC system
- Environmental sensors
  - Air temperature and RH
  - Radiation (LW, SW, PAR)
  - Soil temperature, moisture, heat flux
  - Sap flux

Eddy covariance footprint



After Novick et al. AgForMet, 2016

Flux data quality and filtering



Leaf phenology

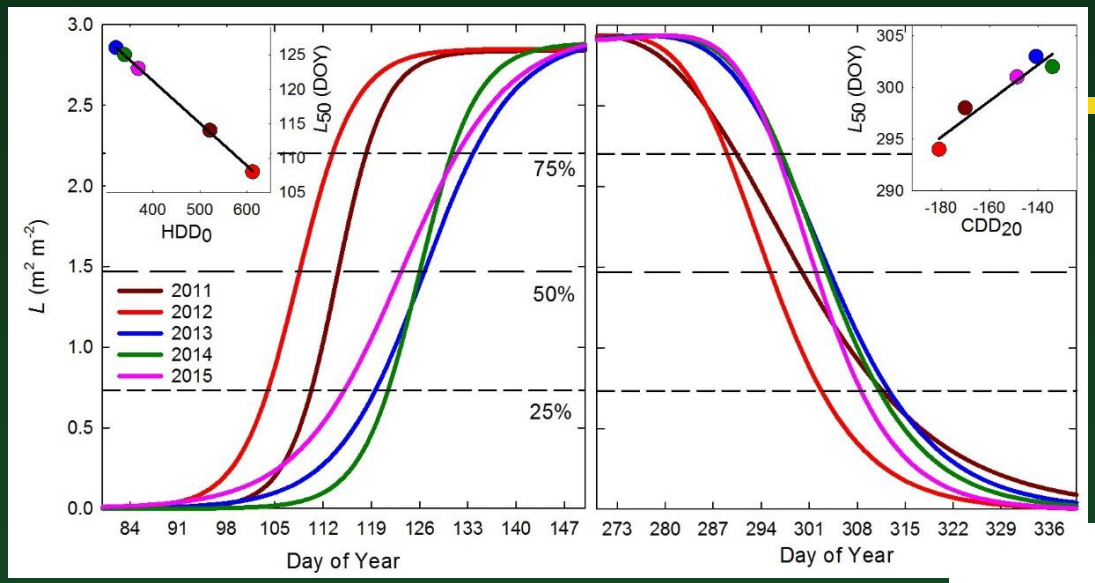
2012 (warmer)

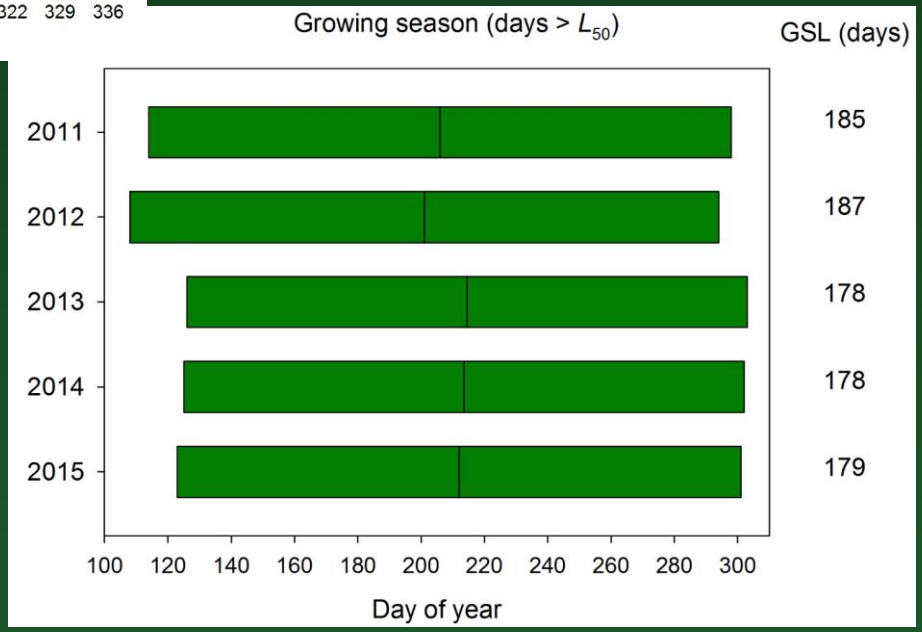
2013 (cooler)

April 1 (DOY 91) April 15 (DOY 104) April 29 (DOY 119) May 13 (DOY 133)

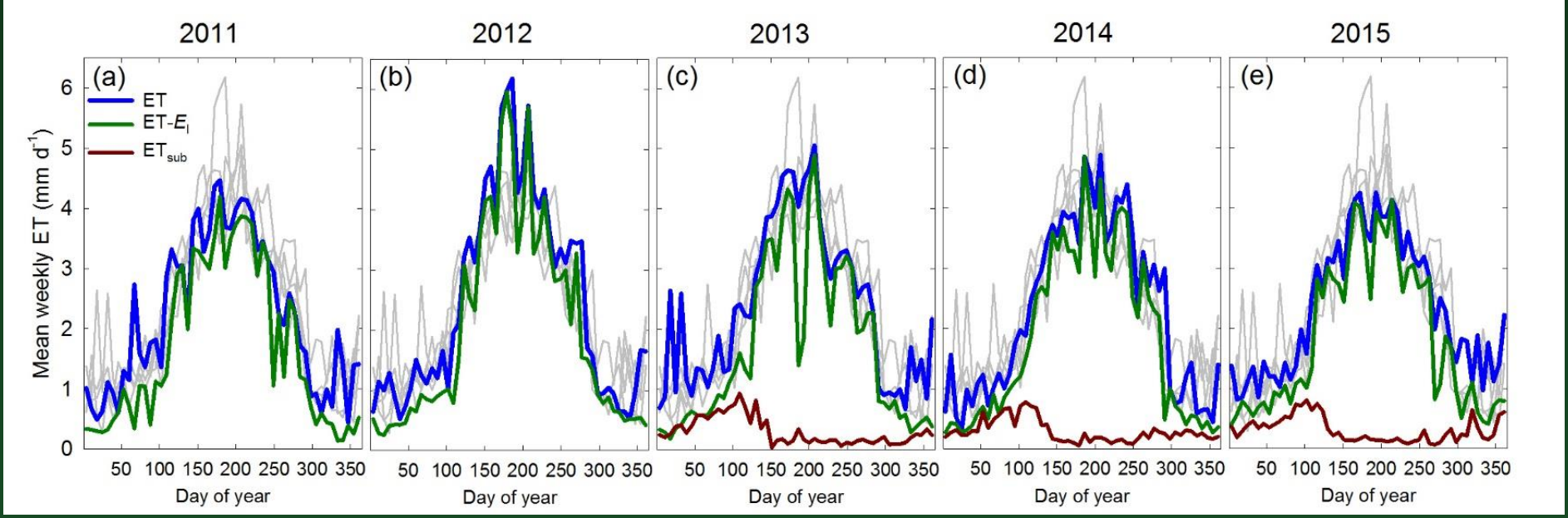
http://phenocam.sr.unh.edu/webcam/sites/coweeta/

Growing season length



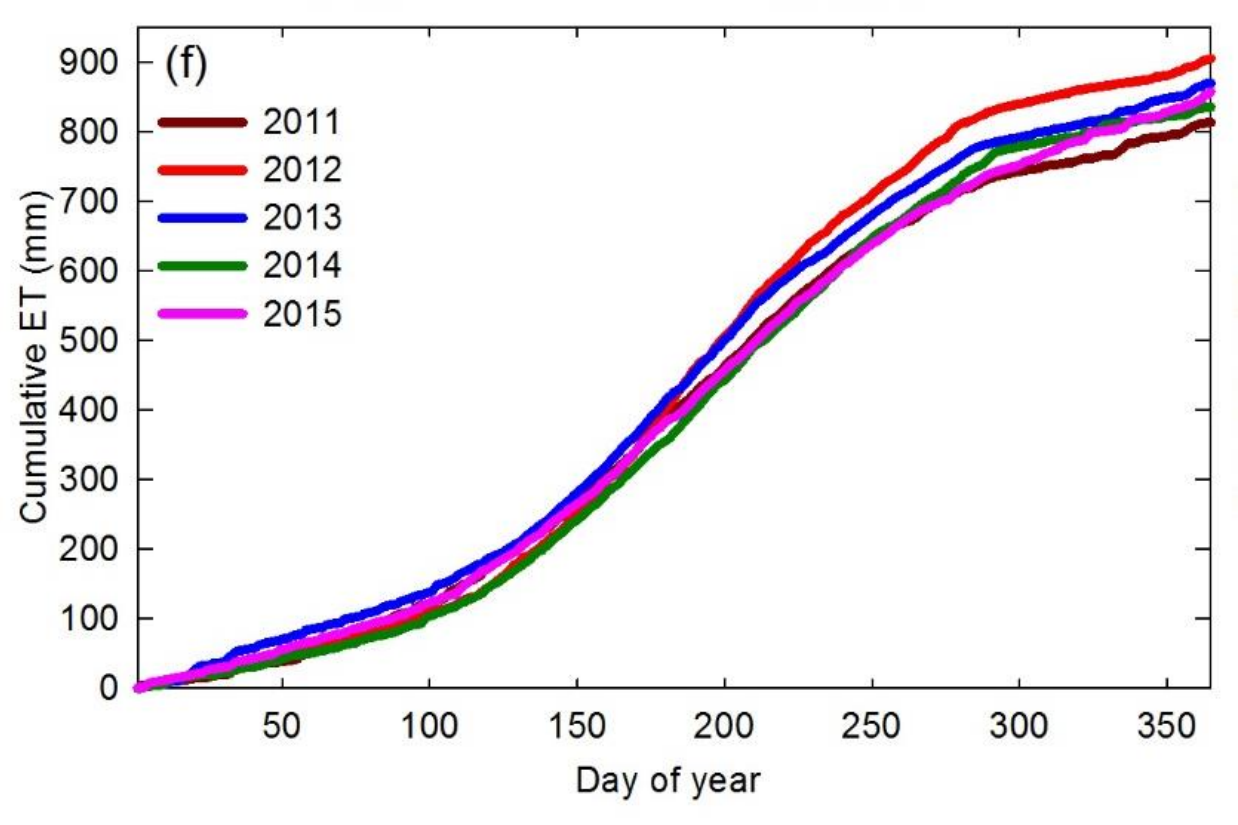


Ecosystem water fluxes



Oishi et al. AgForMet, 2018

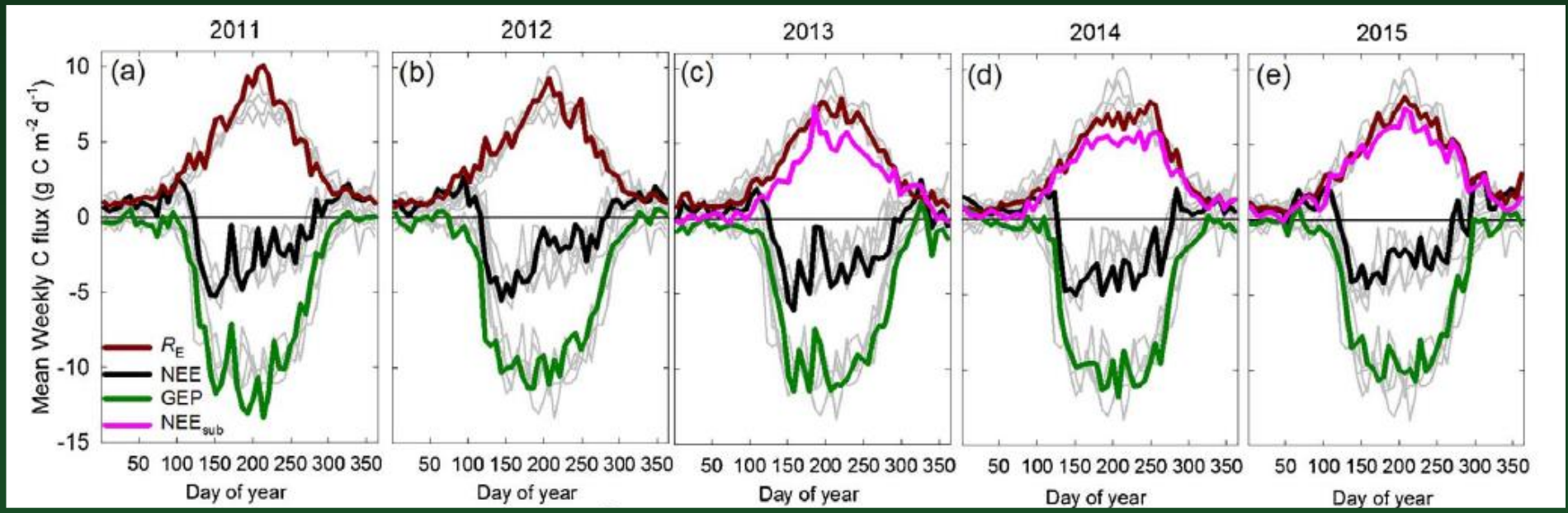
Ecosystem water fluxes



Annual precipitation ranged from 1,583 to 2,384 mm

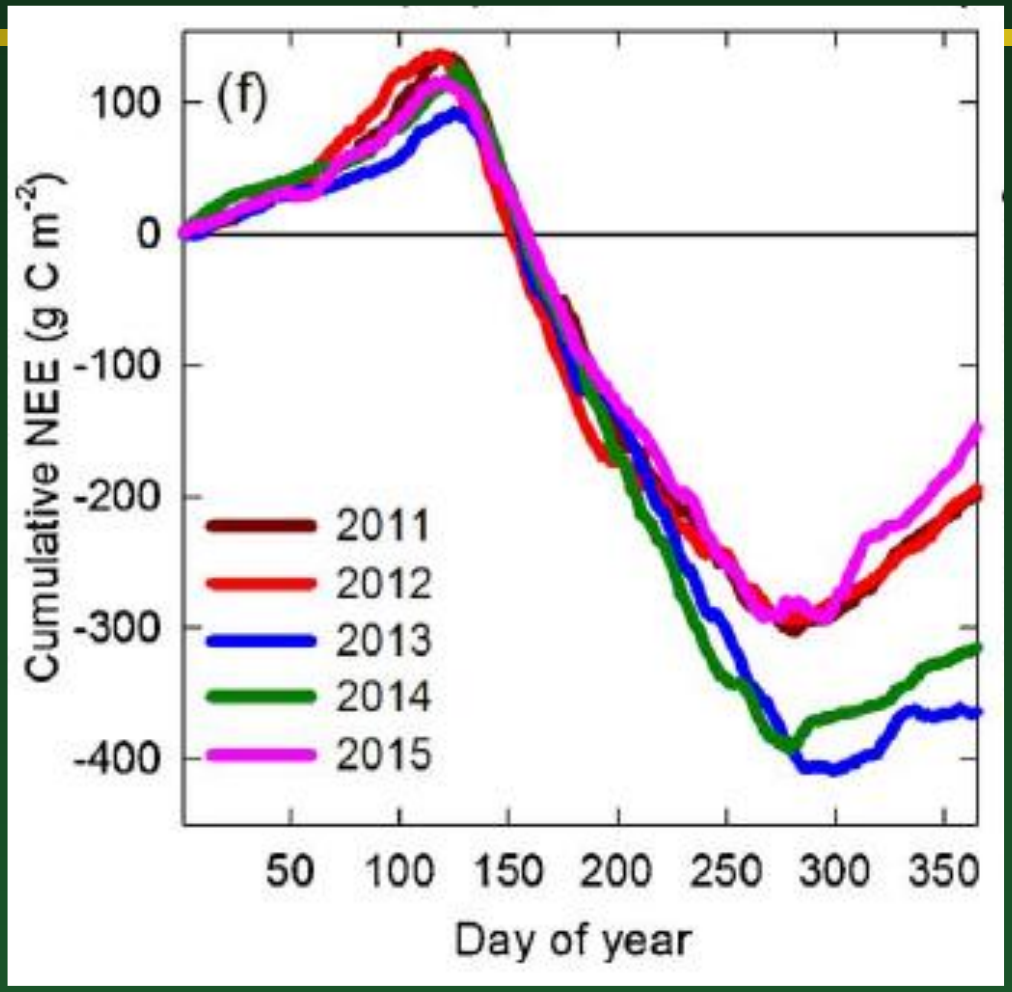
Oishi et al. AgForMet, 2018

Carbon fluxes



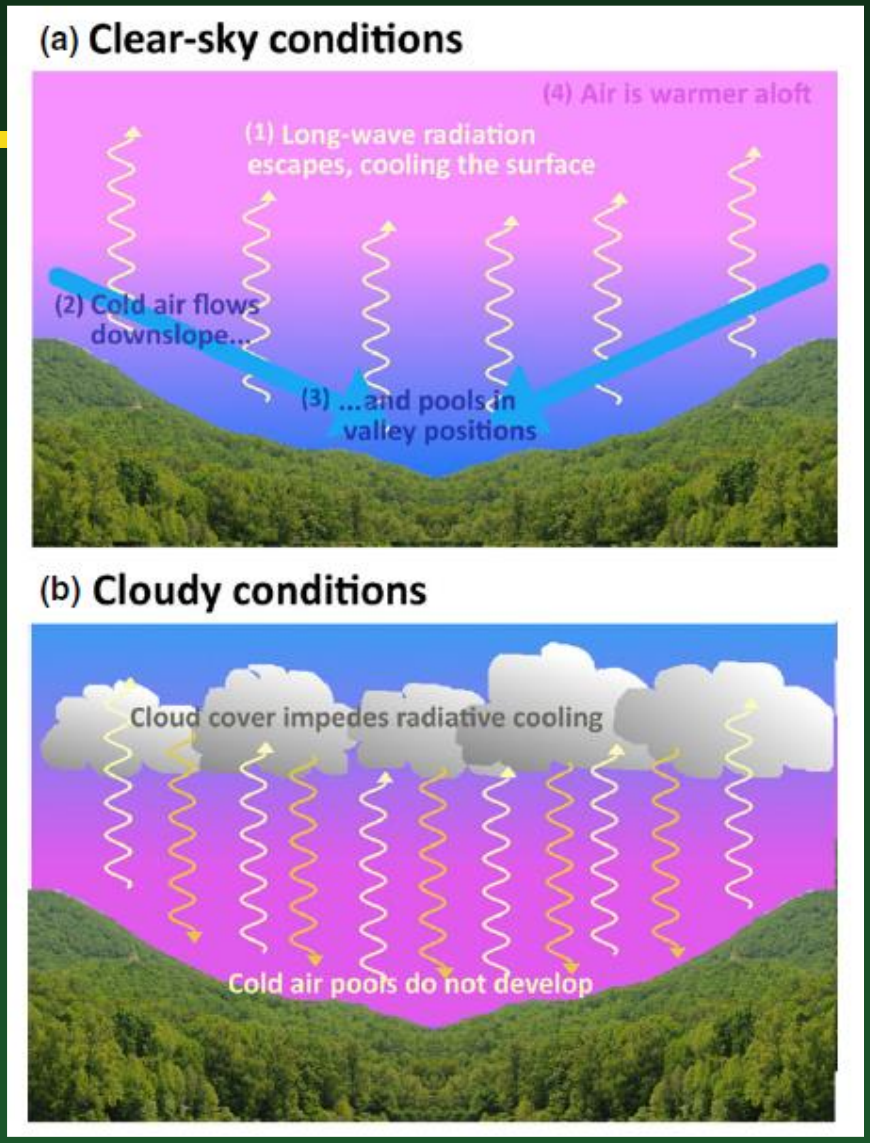
Oishi et al. AgForMet, 2018

Carbon fluxes



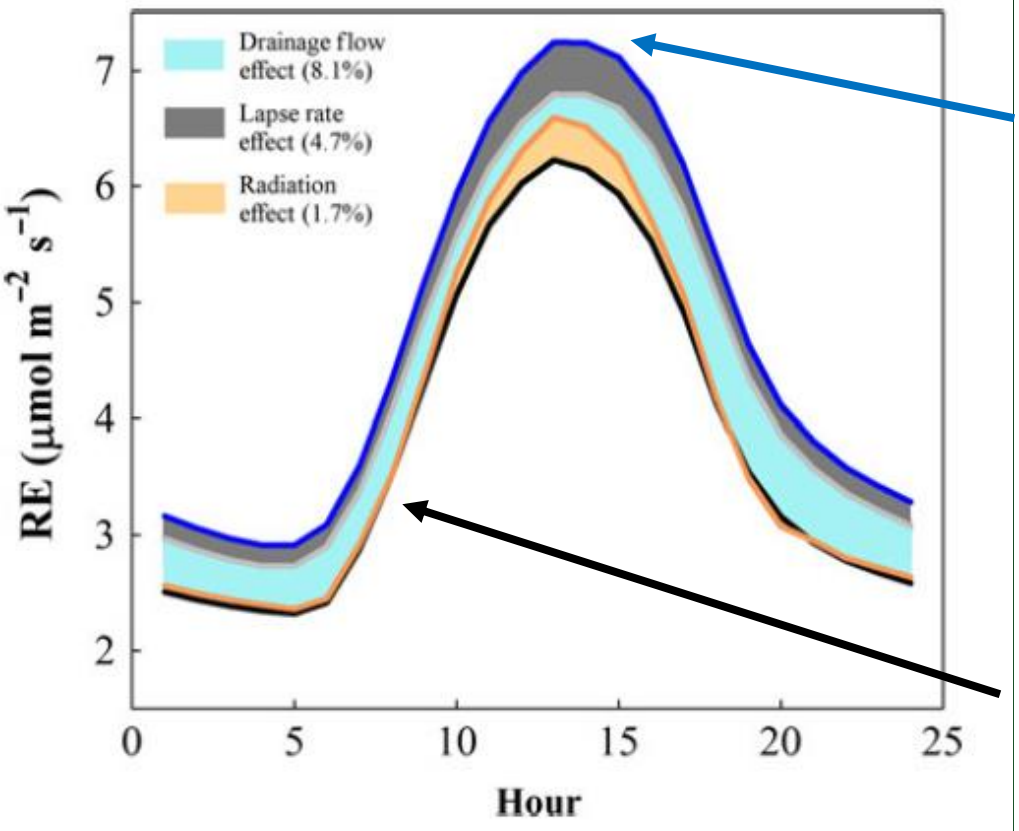
Oishi et al. AgForMet, 2018

Mountain temperature inversions



Novick et al. GlobalChangeBiol, 2016

Cold air drainage suppresses respiration in valleys



Predicted respiration

Observed respiration

Novick et al. GlobalChangeBiol, 2016

Synergistic opportunities and future directions

- High spatial resolution remote sensing validation
  - New LiDAR and remotely-sensed biomass estimates
  - NASA ECOSTRESS evapotranspiration
- Land/atmosphere exchange
  - US Environmental Protection Agency: measurement and modeling of nitrogen deposition in mountain landscapes
- Examining effects of climate change and species shifts

Acknowledgements

- Chelcy Miniat, Jim Vose, Christine Sobek (US Forest Service)
- Kimberly Novick (Indiana University)
- Steven Brantley (Jones Ecological Research Center)
- John Walker (US EPA)

- This research was supported by funding from the USDA Forest Service, Southern Research Station, EPA agreement number 13-IA-11330140-044, USDA NIFA Agriculture and Food Research Initiative Foundational Program (AFRI), award number 2012-67019-19484, National Science Foundation, Long-Term Ecological Research (LTER) program, award #DEB-0823293 and #DEB-1440485.

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