ECOSTRESS L3 / L4 Calibration and Validation

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Overview

- L3 / L4 Products
- Validation Approach
  - FluxNet "Network of regional networks"
  - Eddy covariance
- Additional Sites
  - Agricultural and natural systems
  - JPL self-calibrating thermal radiometers
- Challenges and Opportunities

L3, L4 Products

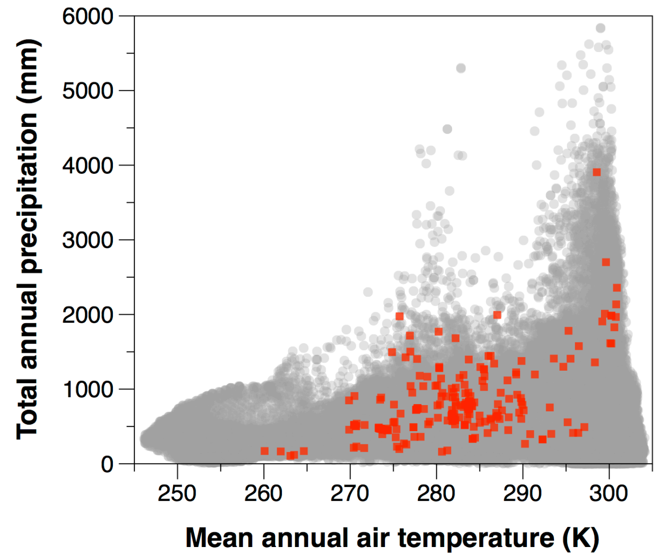
- Evapotranspiration (L3) [mm H_2O / day]
  - ET → ALEXI, METRIC, PT-JPL

- Water Use Efficiency (L4) [mass C / mass H_2O]
  - WUE = ET / GPP
  - GPP derived from satellite-based products (i.e. OCO-3, MODIS, VIIRS, Landsat) or modeled

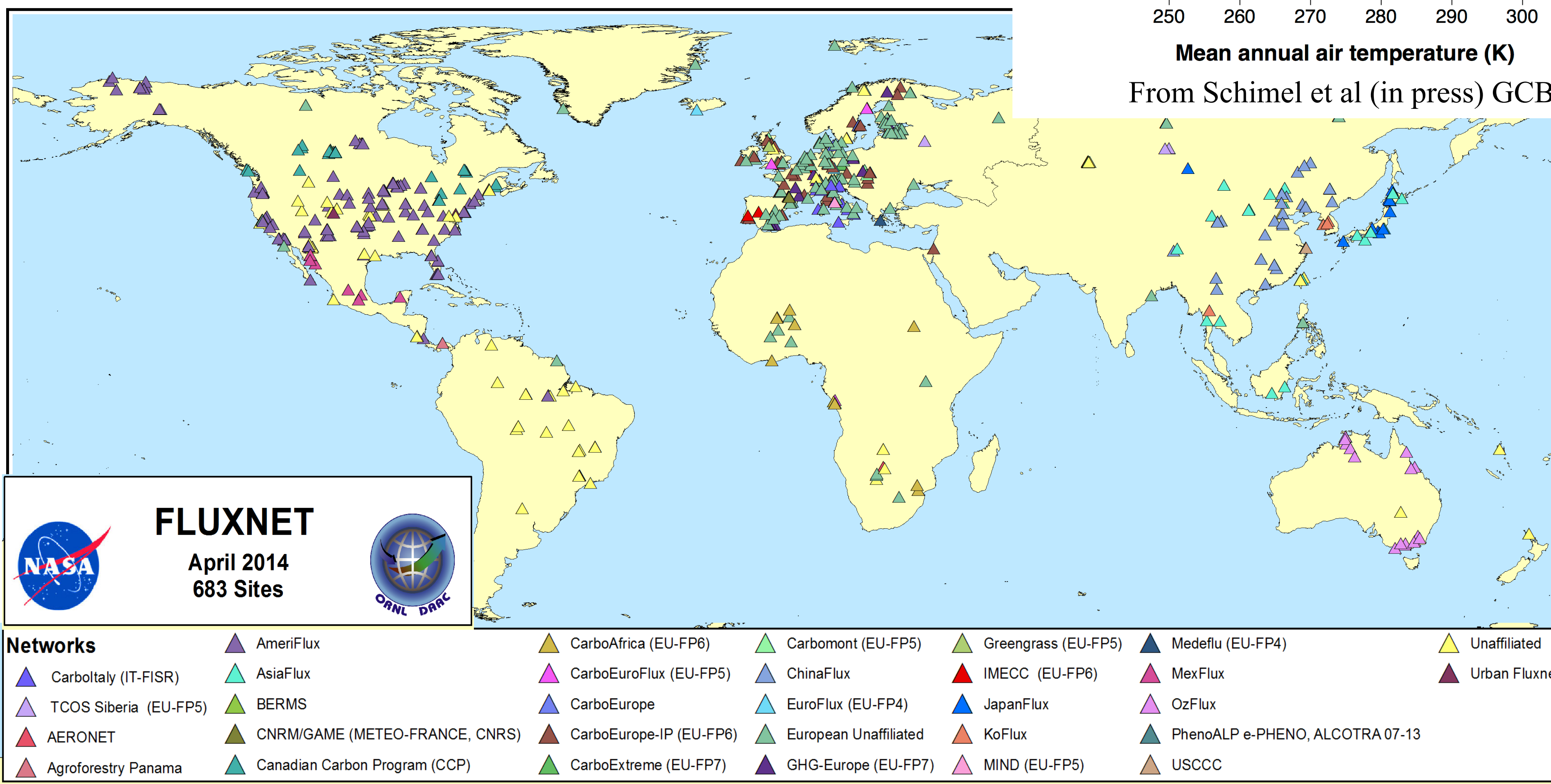
- Evaporative Stress Index (L4) [-]
  - ESI = ET / PET
  - PET computed as standard output from ET algorithms

FluxNet

- Continuous monitoring of energy exchange (LE, H), net ecosystem exchange (NEE), meteorological drivers, soil conditions
- Span most major biomes, climate space

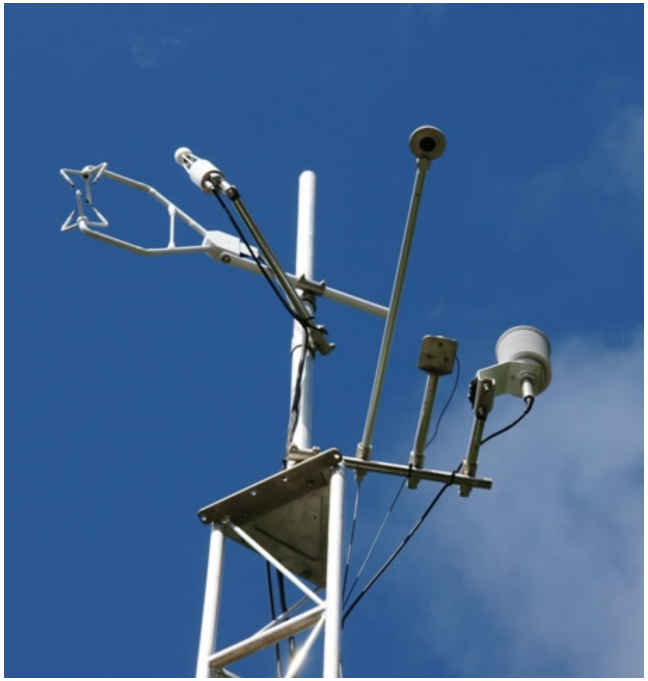


From Schimel et al (in press) GCB



Eddy Covariance Flux Estimation

- A vertical flux in turbulent flow can be estimated by the following:



$$F = \overline{\rho w s} = \ldots \approx \bar{\rho}\,\overline{w's'}$$

$$\rho = \text{ air density}$$
$$w = \text{ vertical wind speed}$$
$$s = \text{ mixing ratio}$$

  - Reynolds Decomposition
  - Assume incompressible flow
  - Mean vertical flow assumed negligible (horizontal, homogeneous terrain)
- Measurements made at O(10Hz), averaged over ~30 minutes

Eddy Covariance Flux Estimation

- Meteorological / environmental variables commonly measured
  - Net radiation flux (R_n)
  - Air temperature
  - Humidity
  - Wind speed / direction
  - Soil moisture, temperature

- Fluxes measured:
  - Latent heat (LE; evapotranspiration)
  - Sensible heat
  - Net ecosystem exchange

- Energy Balance Closure: $R_n = LE + H + G$

Target Sites

FLUXNET and Calibration/Validation Sites			
Campbell River, Canada	ENF	49.9	-125.3
Hartheim, Germany	ENF	47.9	7.6
Howland Forest, ME, USA	ENF	45.2	-68.7
Metolius, OR, USA	ENF	44.5	-121.6
Quebec Boreal, Canada	ENF	49.7	-74.3
Tatra, Slovak Republic	ENF	49.1	20.2
Wind River Crane, WA, USA	ENF	45.8	-122.0
Guyaflux, French Guyana	EBF	5.3	-52.9
La Selva, Costa Rica	EBF	10.4	-84.0
Manaus K34, Brazil	EBF	-2.6	-60.2
Santarem KM67, Brazil	EBF	-2.9	-55.0
Santarem KM83, Brazil	DBF	-3.0	-55.0
Chamela, Mexico	DBF	19.5	-105.0
Duke Forest, NC, USA	DBF	36.0	-79.1
Hainich, Germany	DBF, Cal/Val	51.1	10.5
Harvard Forest, MA, USA	DBF	42.5	-72.2
Hesse Forest, France	DBF	48.7	7.1
Tonzi Ranch, CA, USA	DBF/WSA	38.4	-121.1
ARM S. Great Plains, OK, USA	CRO, Cal/Val	36.6	-97.5
Aurade, France	CRO	43.5	1.1
Bondville, IL, USA	CRO, Cal/Val	40.0	-88.3
El Saler-Sueca, Spain	CRO	39.3	-0.3
Mead 1, 2, 3 NE, USA	CRO	41.2	-96.5
Salton Sea, CA	Cal/Val	33.3	-115.7
Lake Tahoe, CA	Cal/Val	39.2	-120.0
Gobabeb, Namibia	Cal/Val	23.5	15.1
Algodones Dunes, CA	Cal/Val	33.0	-115.1

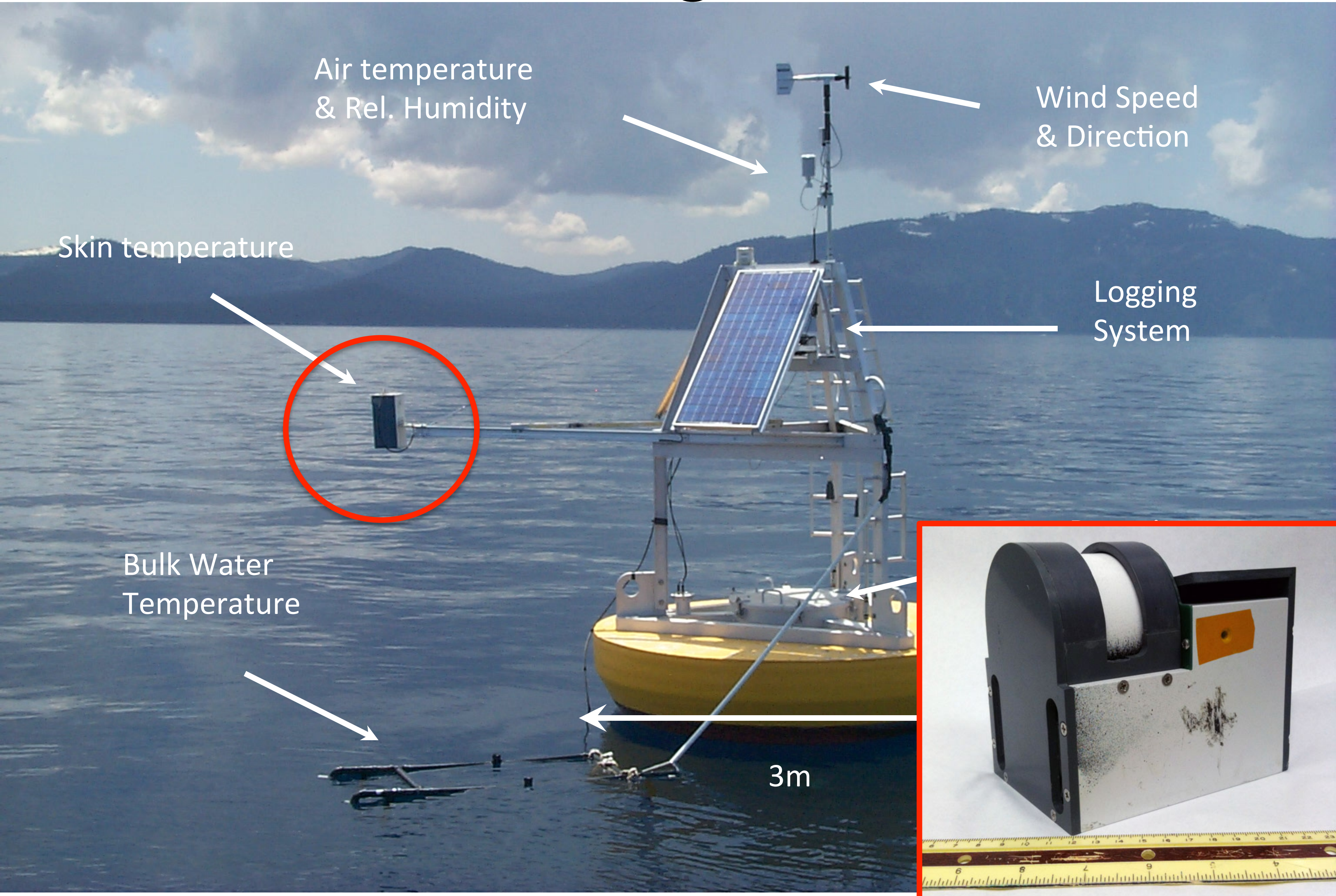
Evergreen Needleleaf Forest

Evergreen Broadleaf Forest

Deciduous Broadleaf Forest

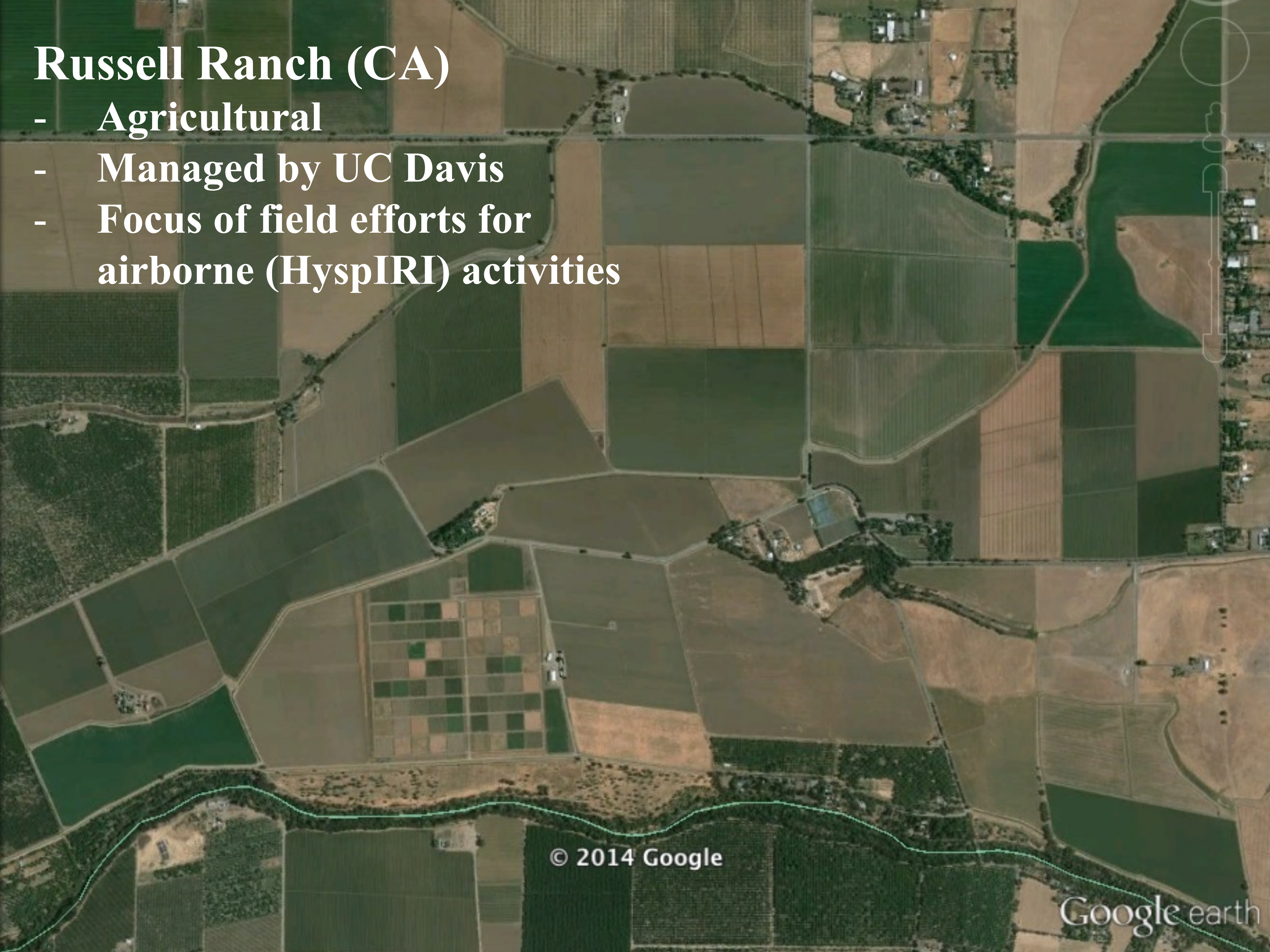
Cropland

Self-Calibrating Radiometers

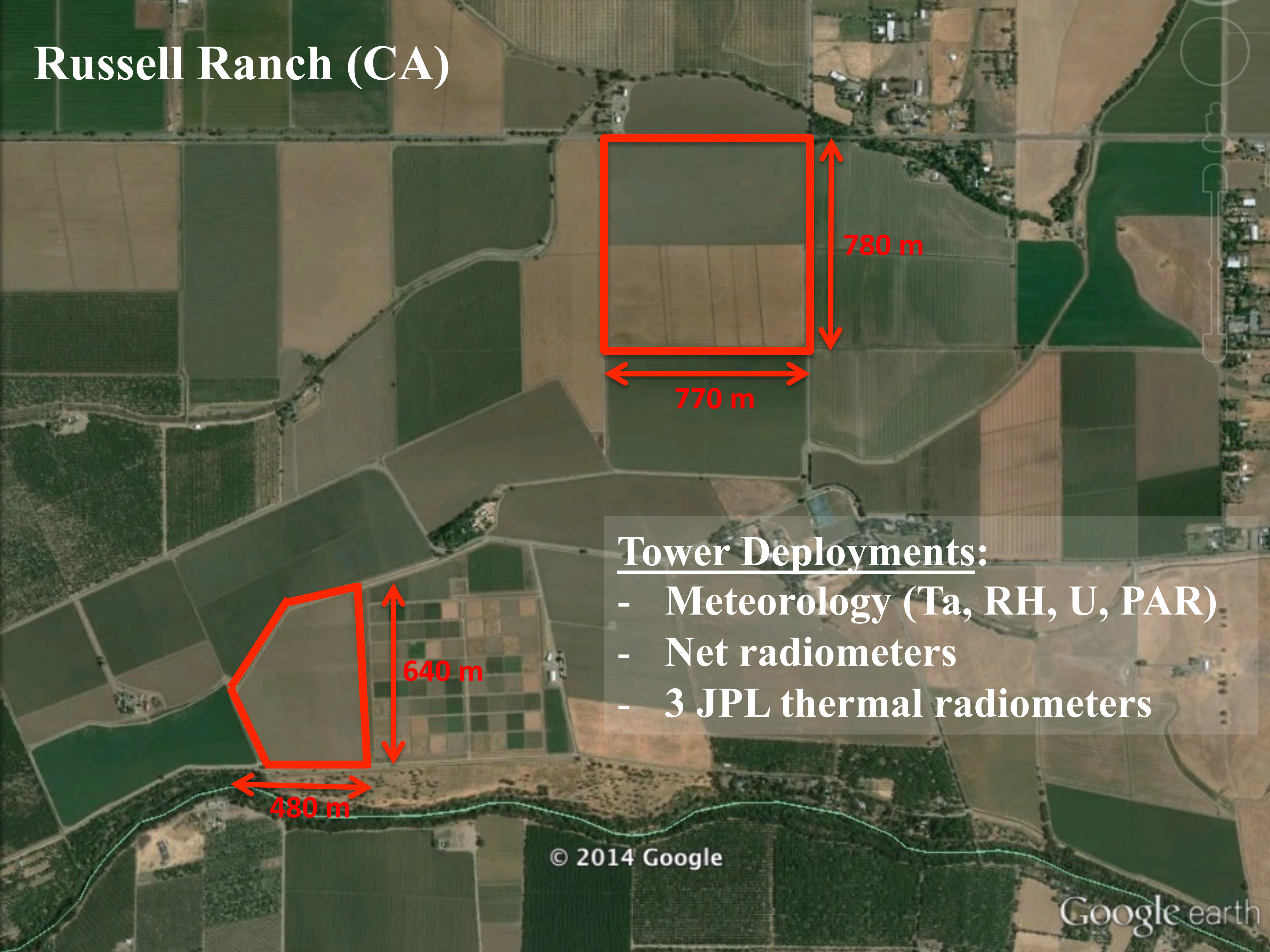


Russell Ranch (CA)

- Agricultural
- Managed by UC Davis
- Focus of field efforts for airborne (HyspIRI) activities



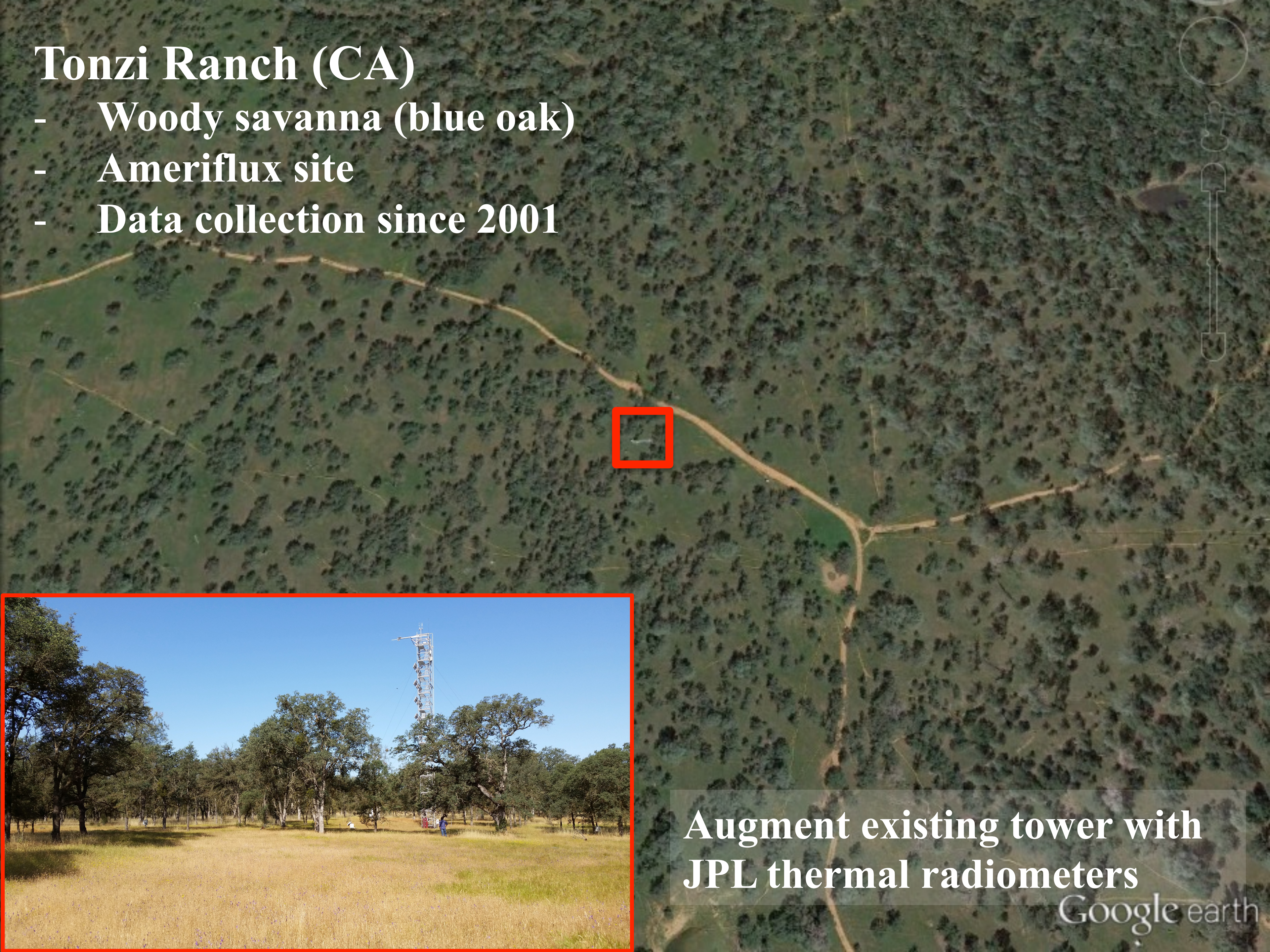
Russell Ranch (CA)



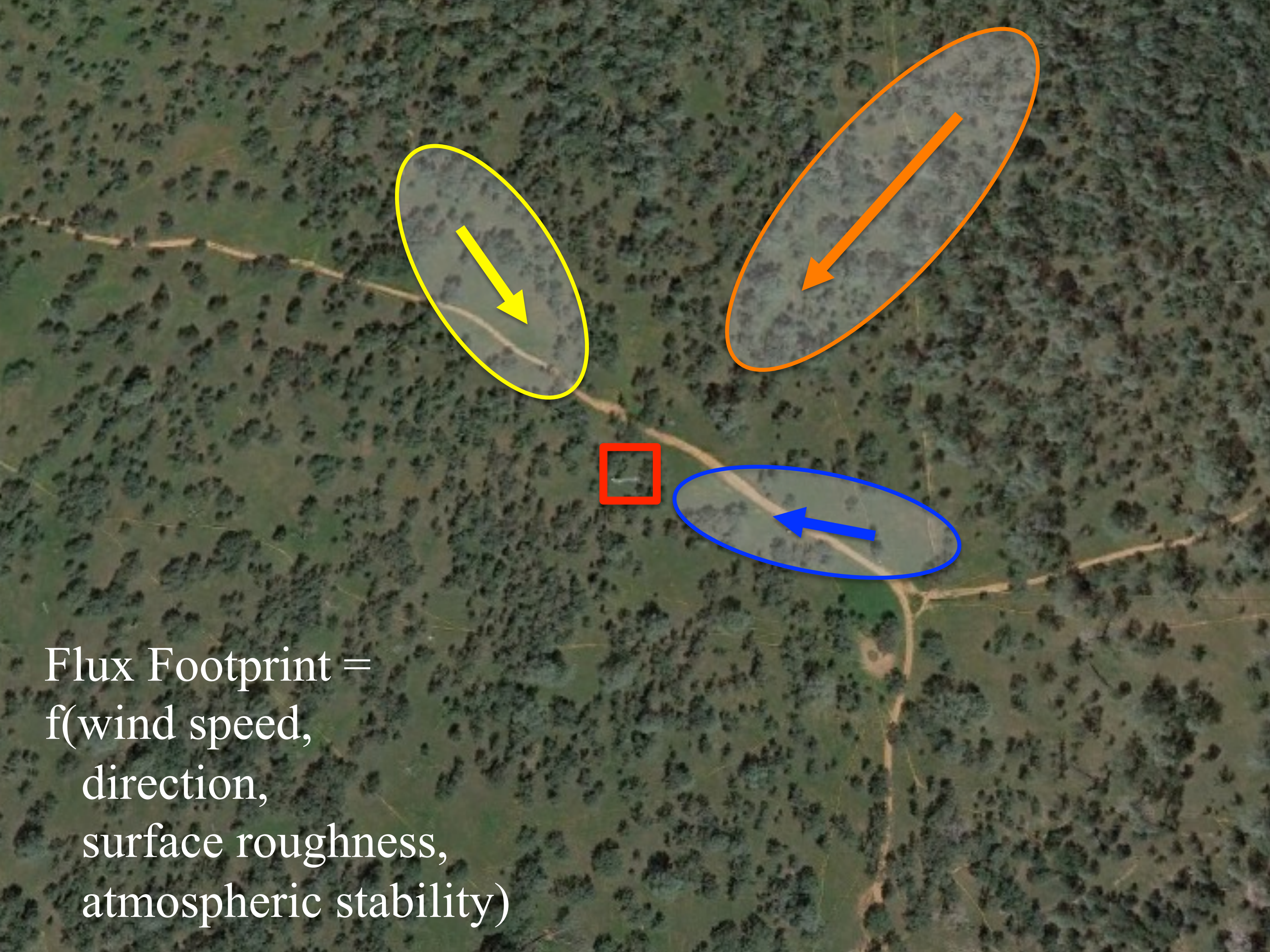
Tower Deployments:
- Meteorology (Ta, RH, U, PAR)
- Net radiometers
- 3 JPL thermal radiometers

Tonzi Ranch (CA)

- Woody savanna (blue oak)
- Ameriflux site
- Data collection since 2001



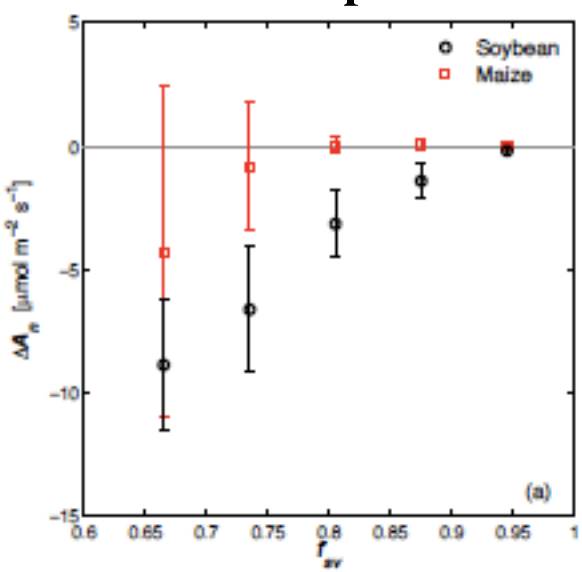
Augment existing tower with JPL thermal radiometers


Flux Footprint =
f(wind speed,
direction,
surface roughness,
atmospheric stability)

Hydraulic constraint on net canopy-atmosphere exchange

ΔA_n [μmol m^{-2} s^{-1}]

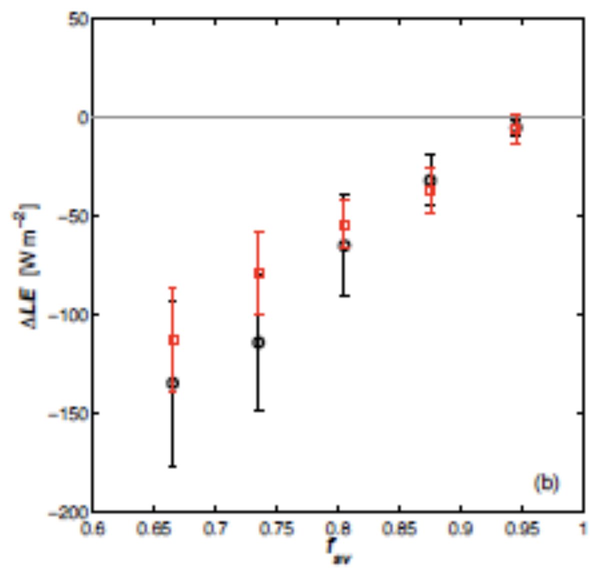
"Change in net carbon uptake"



Increasing water stress

ΔLE [W m^{-2}]

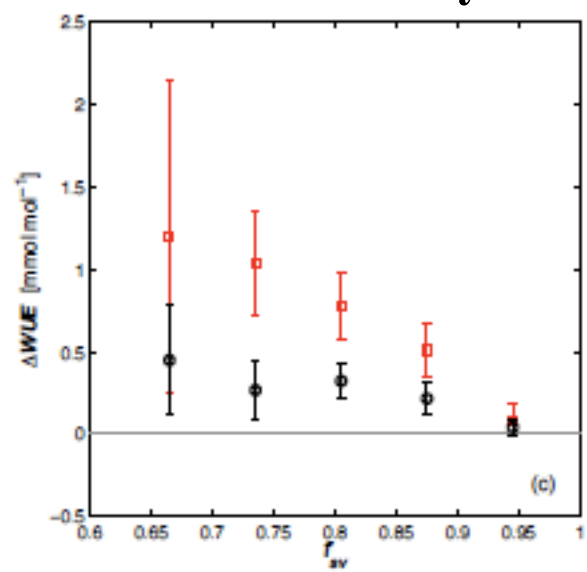
"Change in Latent Energy Flux (ET)"



Increasing water stress

ΔWUE [mmol mol^{-1}]

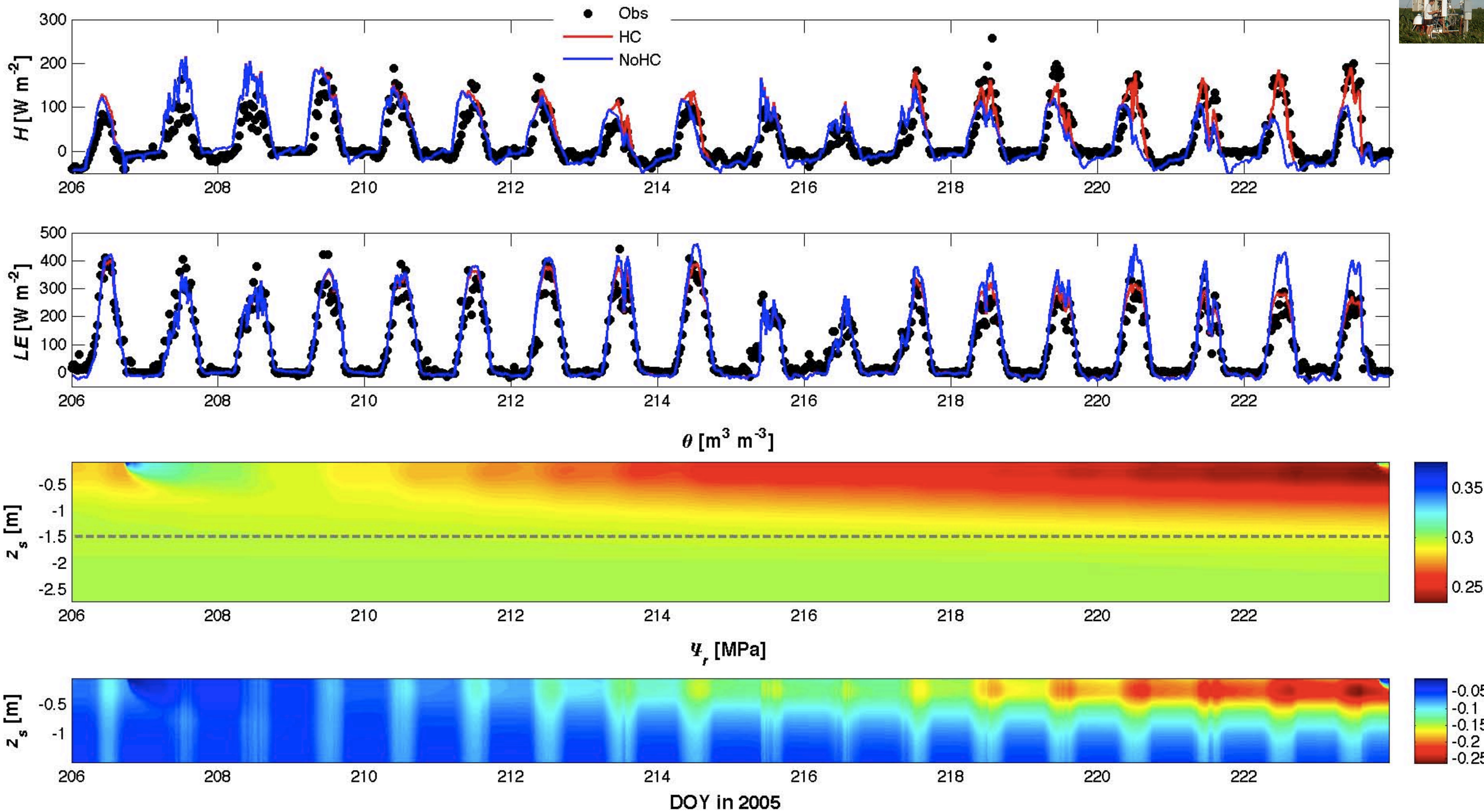
"Change in Water Use Efficiency"



Increasing water stress

Drewry et al (2010a) JGR

Example Effect of Moisture Deficit: Corn



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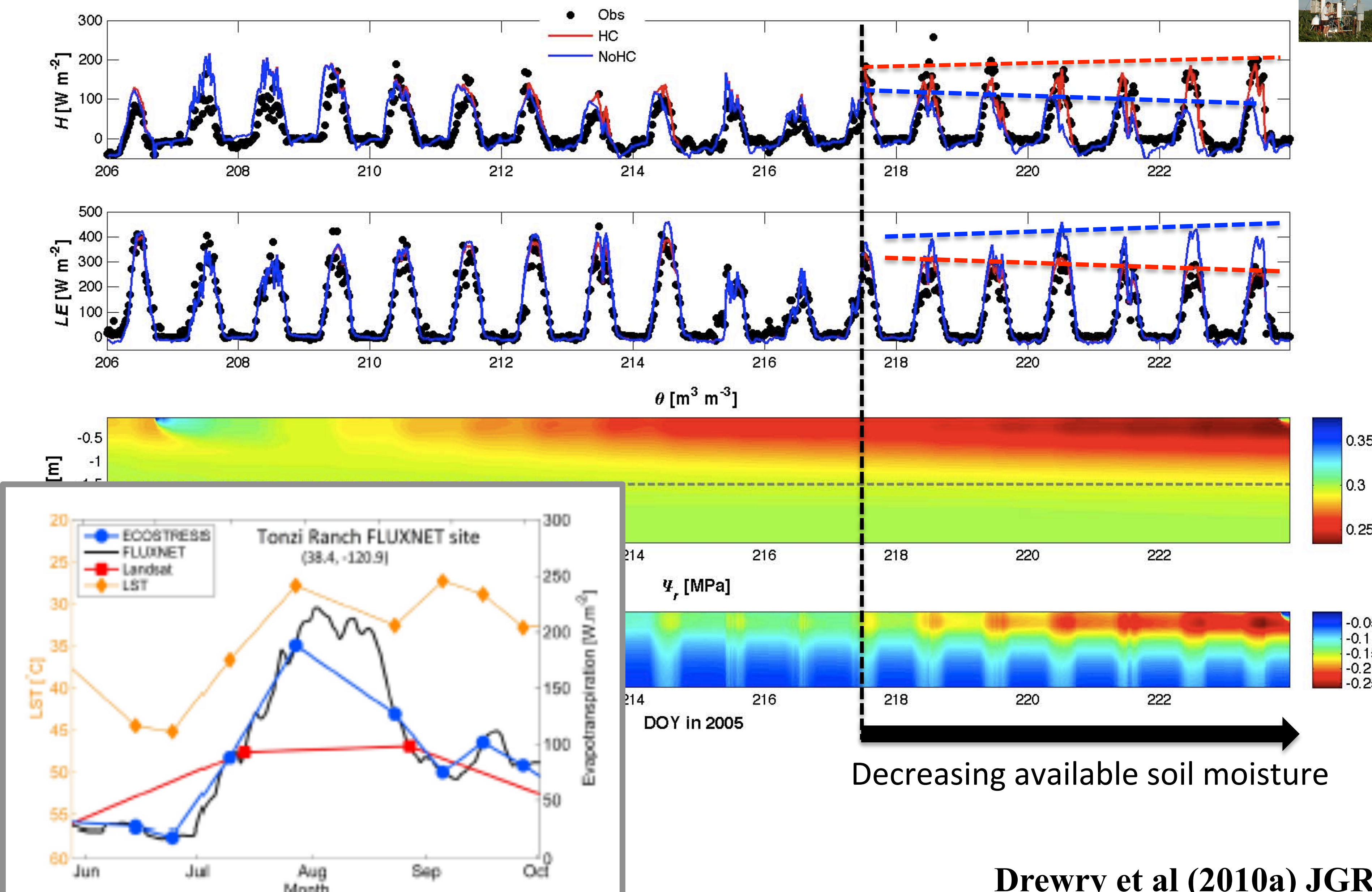

Decreasing available soil moisture

Drewry et al (2010a) JGR

- Validation efforts of Co-Is Anderson, French, Allen

FluxNet

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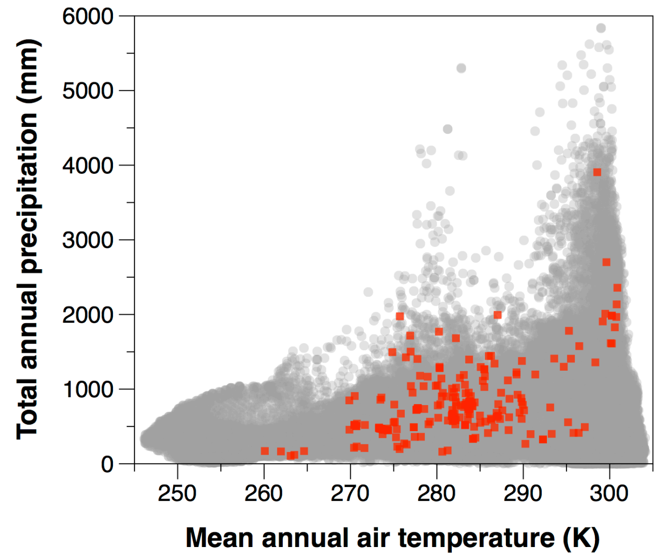
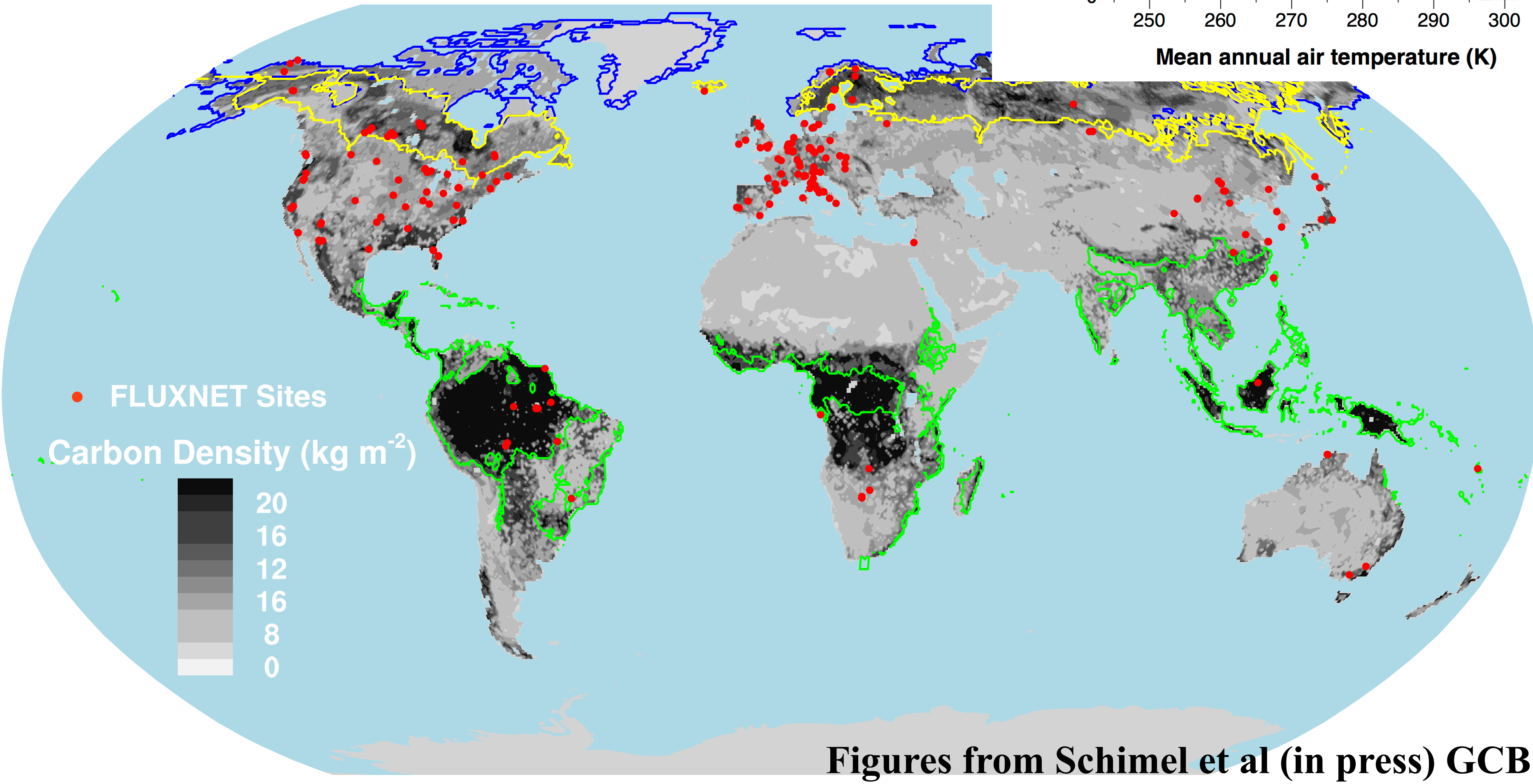


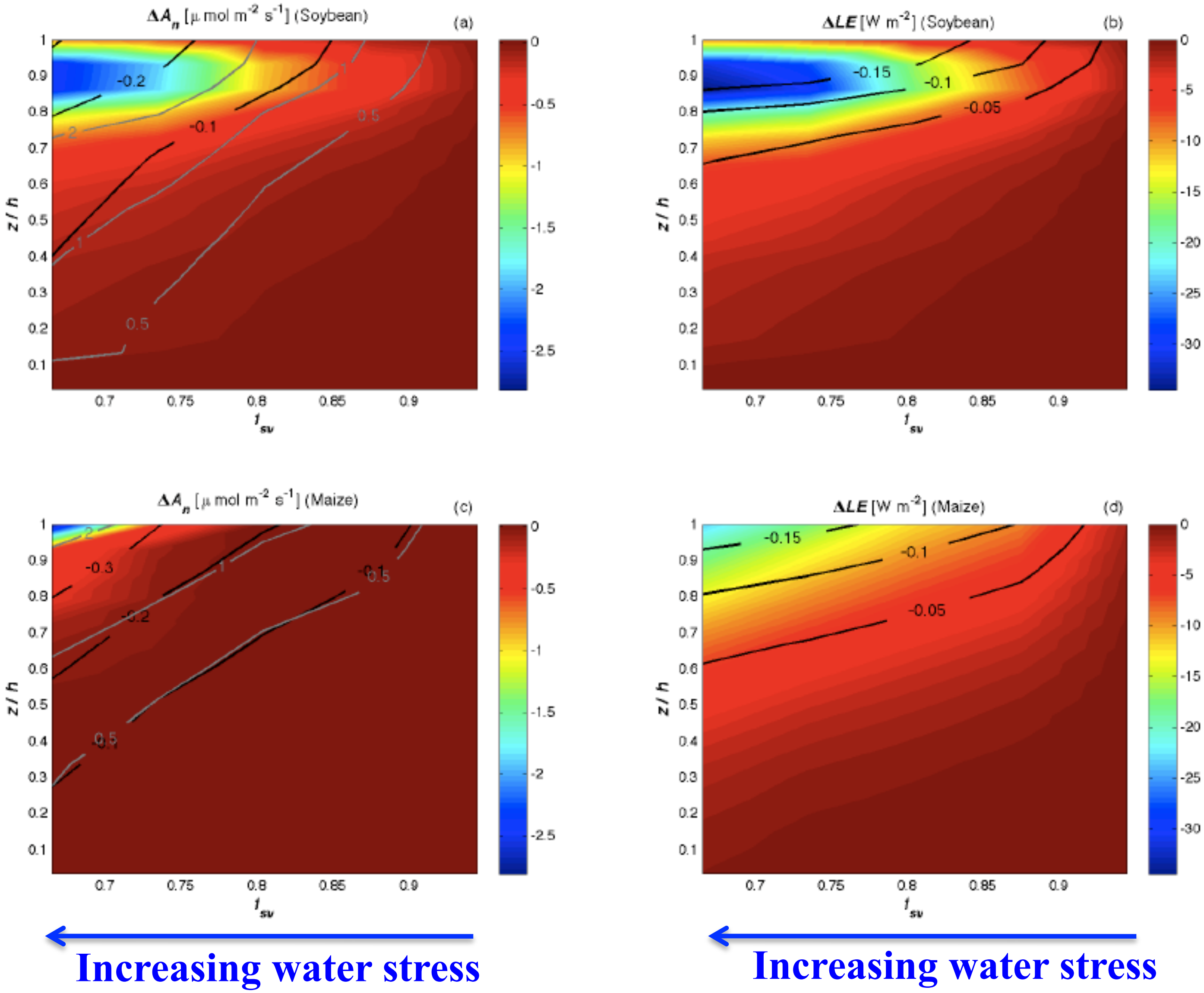


Figures from Schimel et al (in press) GCB

AmeriFlux


0 - Water
1 - Evergreen Needleleaf Forest
2 - Evergreen Broadleaf Forest
3 - Deciduous Needleleaf Forest
4 - Deciduous Broadleaf Forest
5 - Mixed Forests
6 - Closed Shrubland
7 - Open Shrubland
8 - Woody Savannas
9 - Savannas
10 - Grasslands
11 - Permanent Wetlands
12 - Croplands
13 - Urban and Built-Up
14 - Cropland-Natural Vegetation Mosaic
15 - Snow and Ice
16 - Barren or Sparsely Vegetated

Within-canopy effects of hydraulic constraint



Δ = variable$_{HC}$ – variable$_{NoHC}$; HC = Hydraulic Constraint

Drewry et al (2010a) JGR

Radiometer Calibration

Perturbation	Kinetic Temperature (degrees C)		Difference from no perturbation (degrees C)	
None	5.634	20.762	0	0
90% Water Vapor	5.640	20.767	0.006	0.005
110% Water Vapor	5.628	20.758	-0.006	-0.005
-1 deg C	5.640	20.767	0.006	0.005
+1 deg C	5.628	20.758	-0.006	-0.005
Ozone Factor 50%	5.640	20.767	0.006	0.005
Ozone factor 150%	5.629	20.759	-0.005	-0.004
-0.5 um SRF shift	5.561	20.717	-0.073	-0.045
+0.5 um SRF shift	5.673	20.815	0.039	0.053