Water, Energy and Carbon Cycling in Greater Everglades Forested Wetlands

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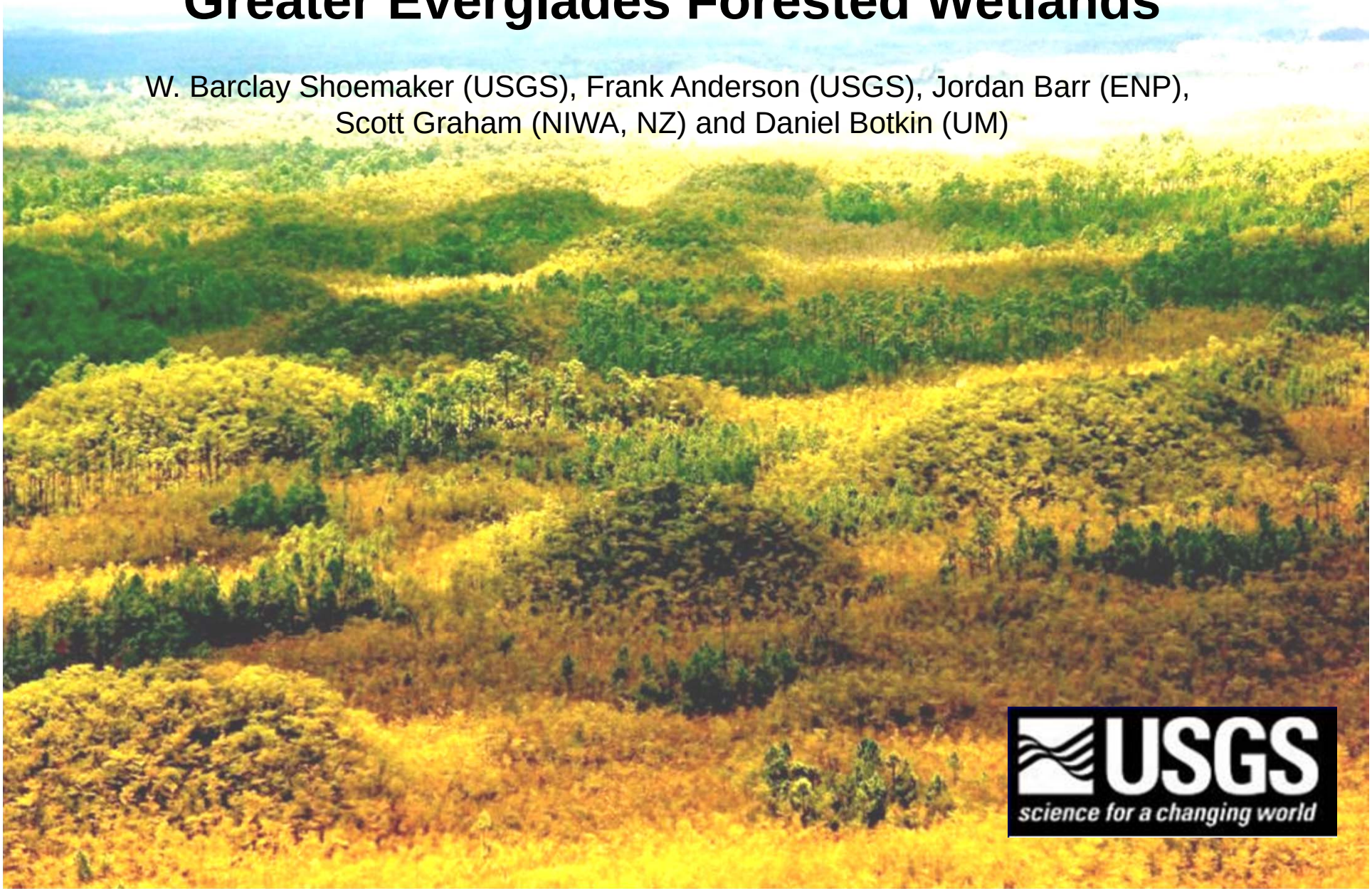

USGS
science for a changing world

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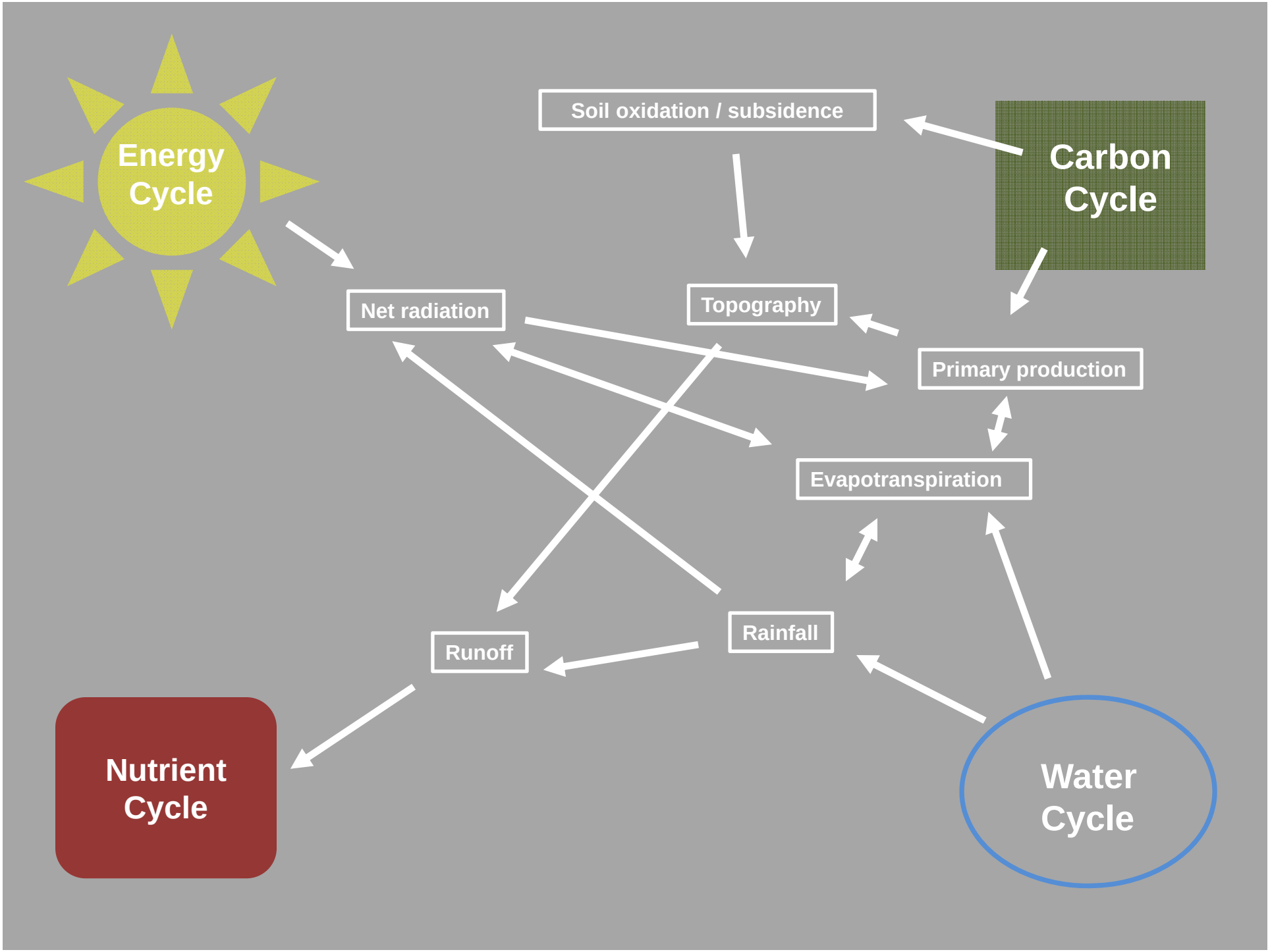
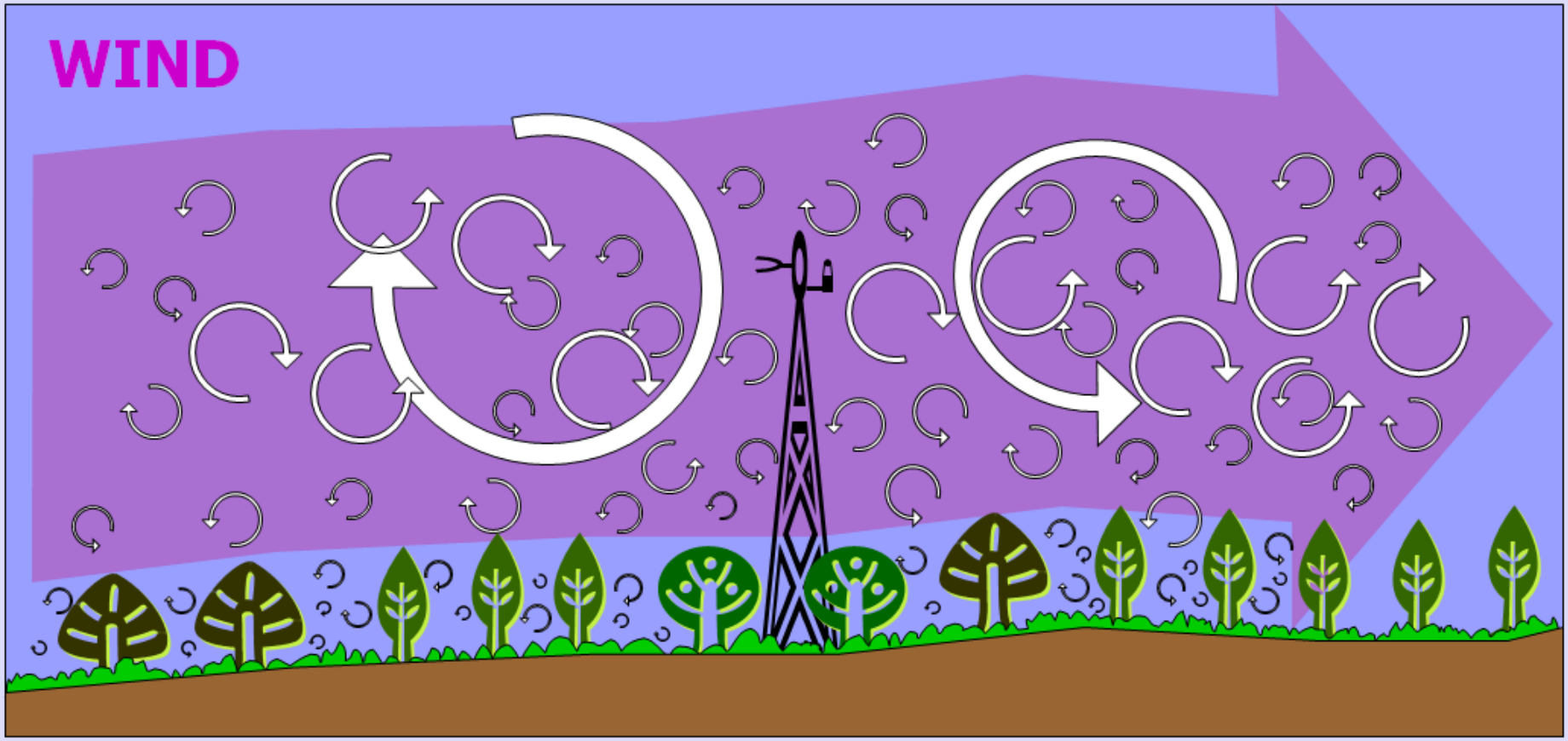
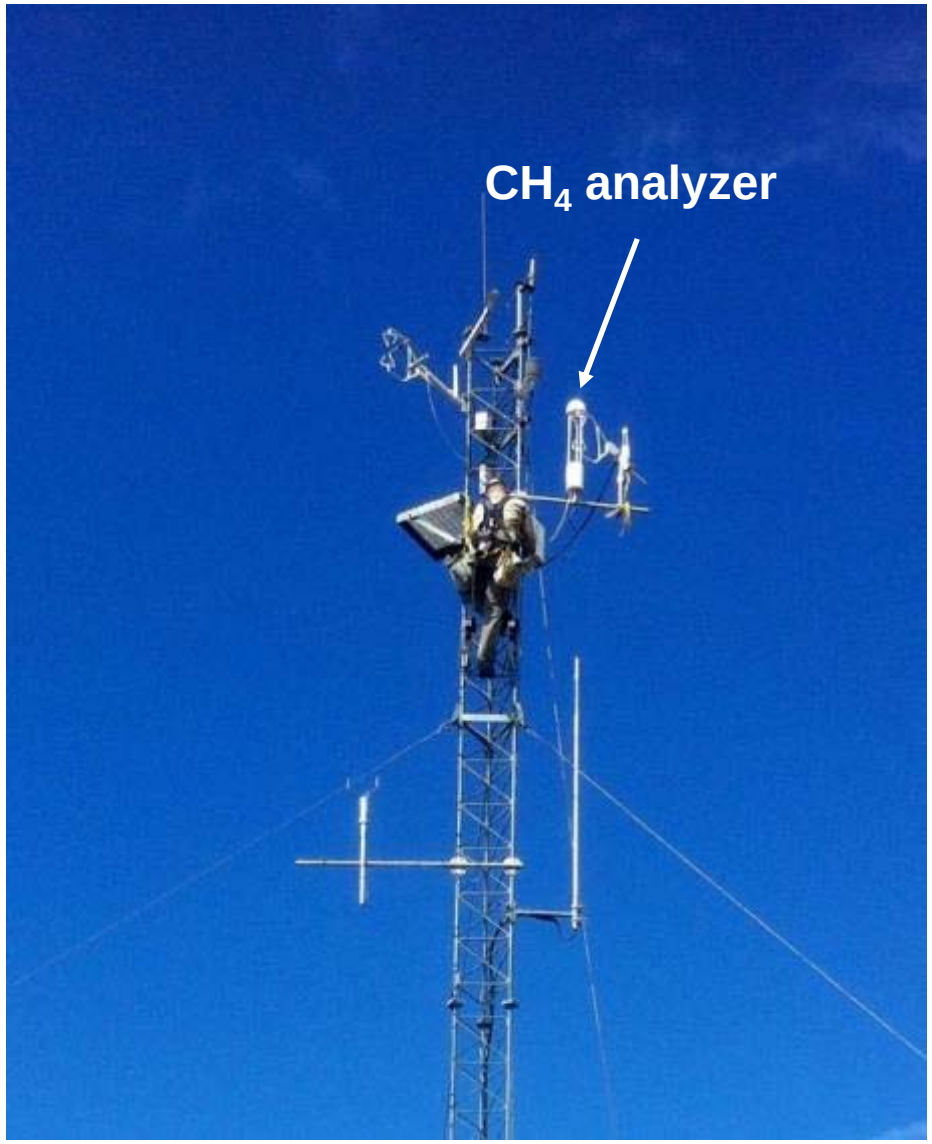

Energy Cycle
Soil oxidation / subsidence
Carbon Cycle
Net radiation
Topography
Primary production
Evapotranspiration
Rainfall
Runoff
Nutrient Cycle
Water Cycle

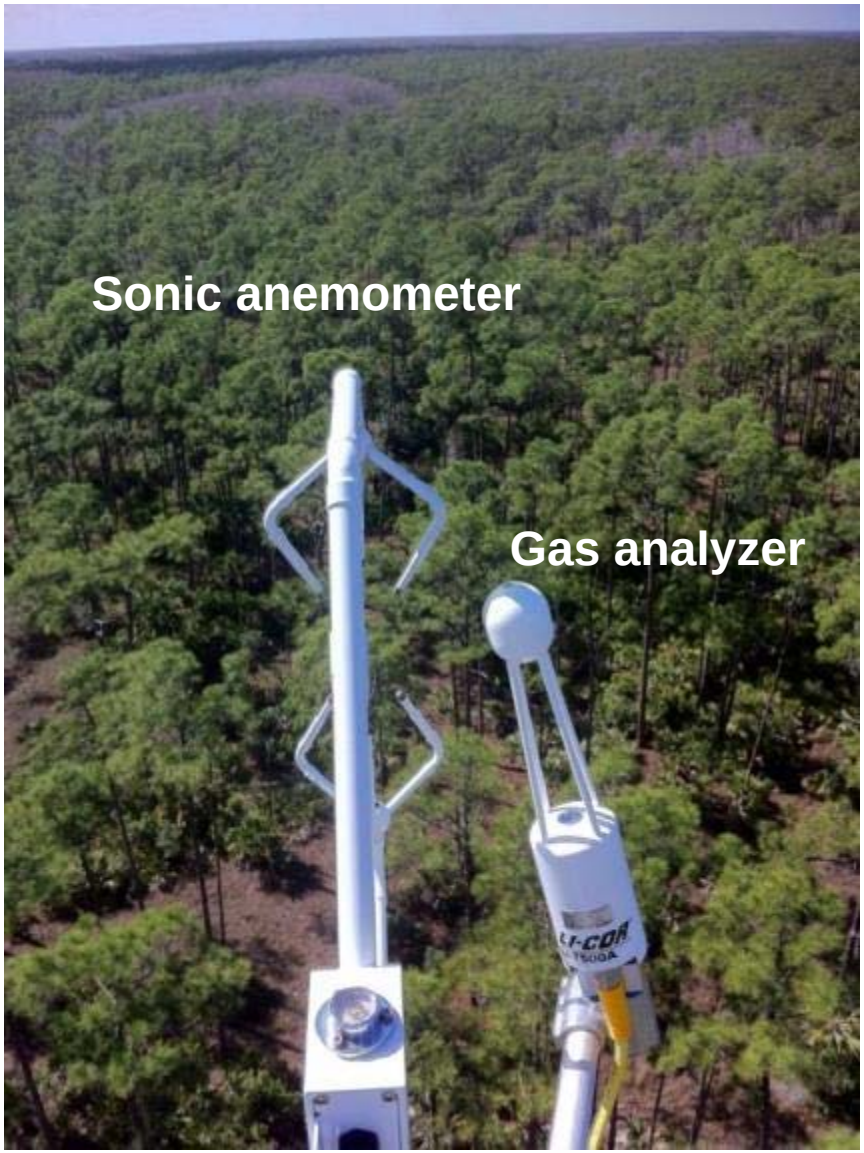
AIR FLOW IN ECOSYSTEM

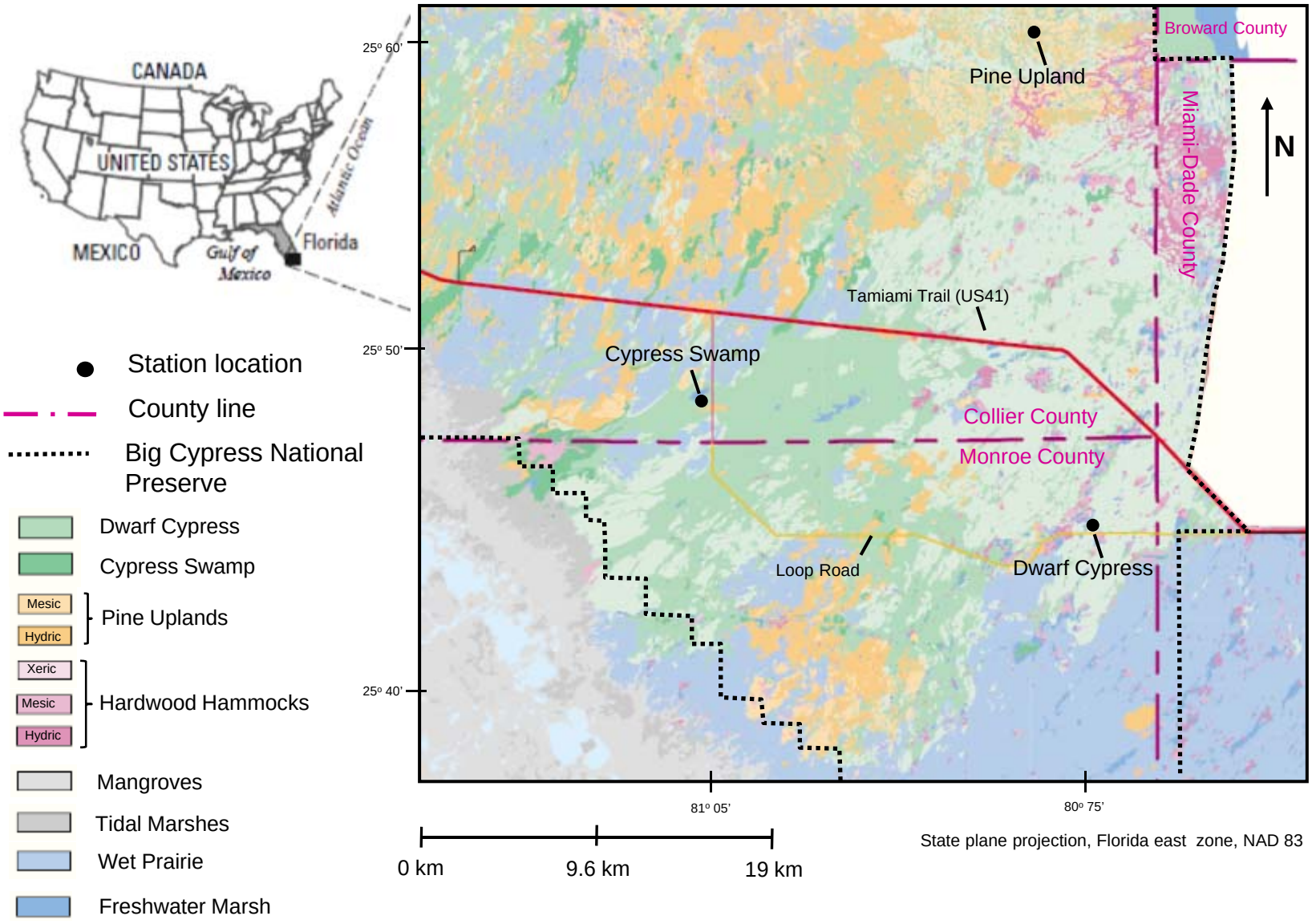


- Air flow can be imagined as a horizontal flow of numerous rotating eddies
- Each eddy has 3D components, including a vertical wind component
- The diagram looks chaotic but components can be measured from the tower

EDDY-COVARIANCE SENSORS

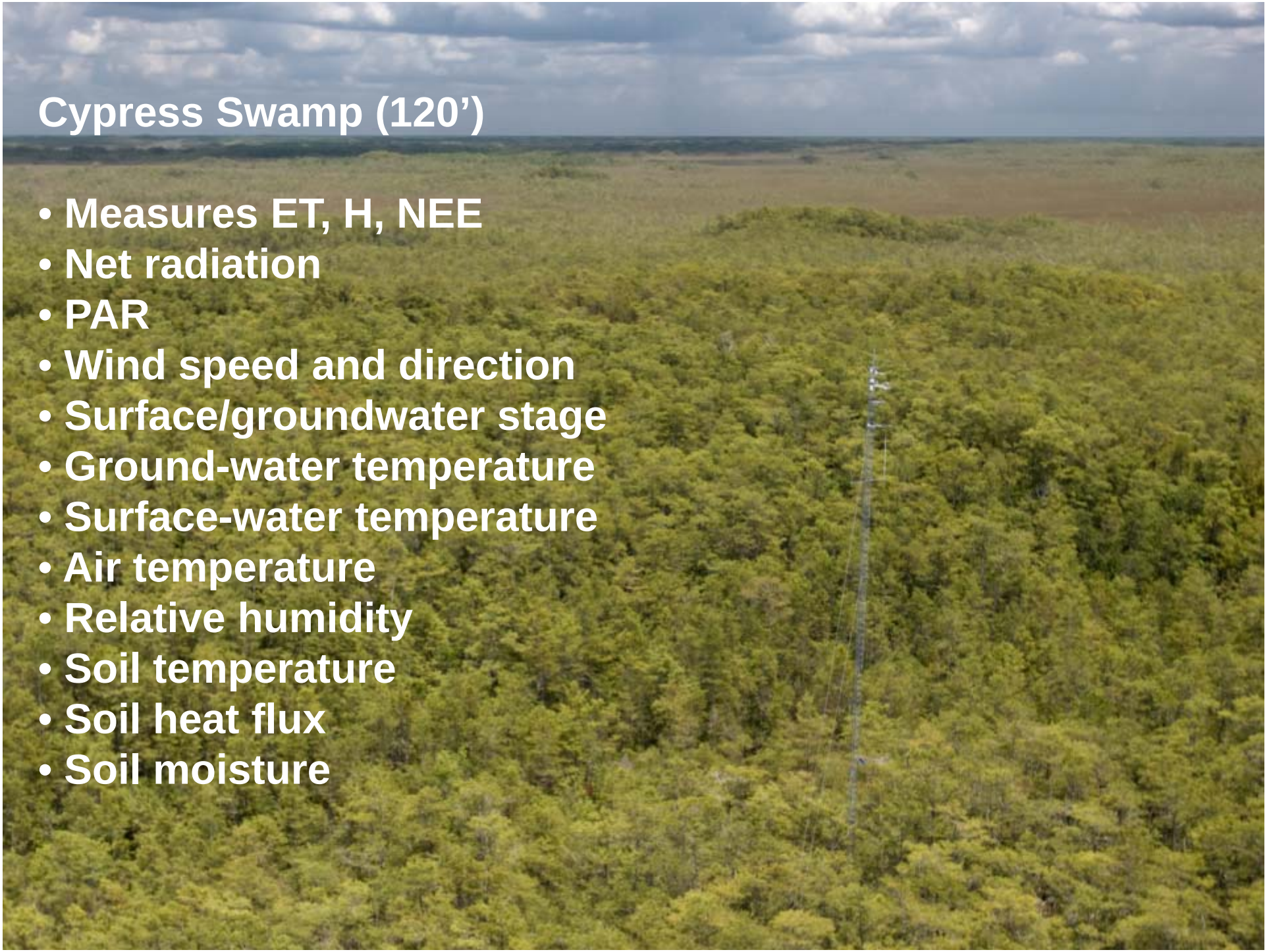





CANADA
UNITED STATES
MEXICO
Gulf of Mexico
Atlantic Ocean
Florida
Station location
County line
Big Cypress National Preserve
Dwarf Cypress
Cypress Swamp
Mesic
Hydric
Pine Uplands
Xeric
Mesic
Hydric
Hardwood Hammocks
Mangroves
Tidal Marshes
Wet Prairie
Freshwater Marsh
25º 60'
25º 50'
25º 40'
81º 05'
80º 75'
Pine Upland
Broward County
Miami-Dade County
N
Tamiami Trail (US41)
Cypress Swamp
Collier County
Monroe County
Loop Road
Dwarf Cypress
0 km
9.6 km
19 km
State plane projection, Florida east zone, NAD 83

Dwarf Cypress (55’ tower)

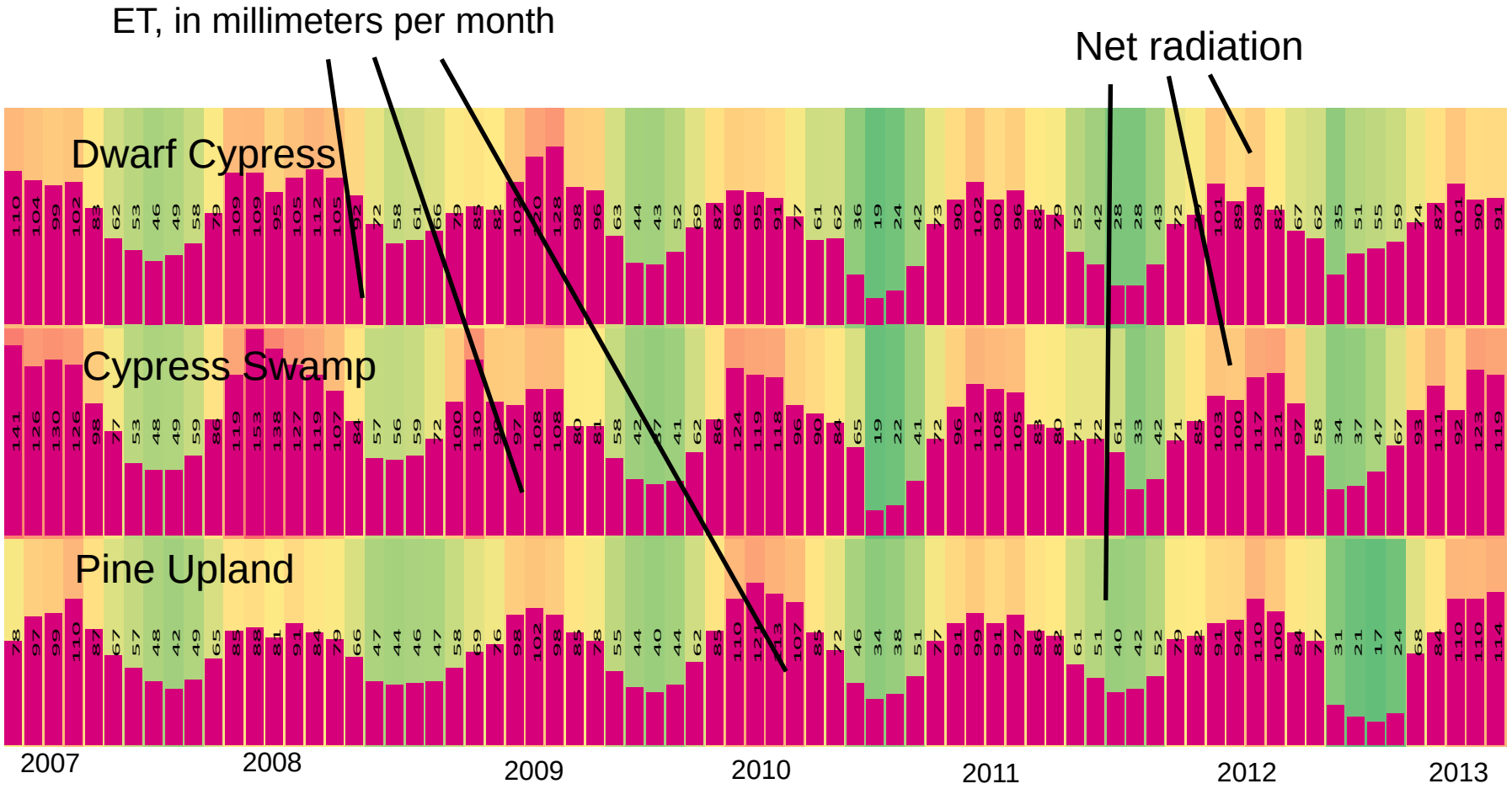
- Measures ET, NEE, CH_4
- Net radiation
- PAR
- Wind speed and direction
- SW/GW stage
- GW temperature
- SW temperature
- Air temperature
- Relative humidity
- Barometric pressure
- ORP


Cypress Swamp (120')
• Measures ET, H, NEE
• Net radiation
• PAR
• Wind speed and direction
• Surface/groundwater stage
• Ground-water temperature
• Surface-water temperature
• Air temperature
• Relative humidity
• Soil temperature
• Soil heat flux
• Soil moisture

Pine upland (120’ tower)

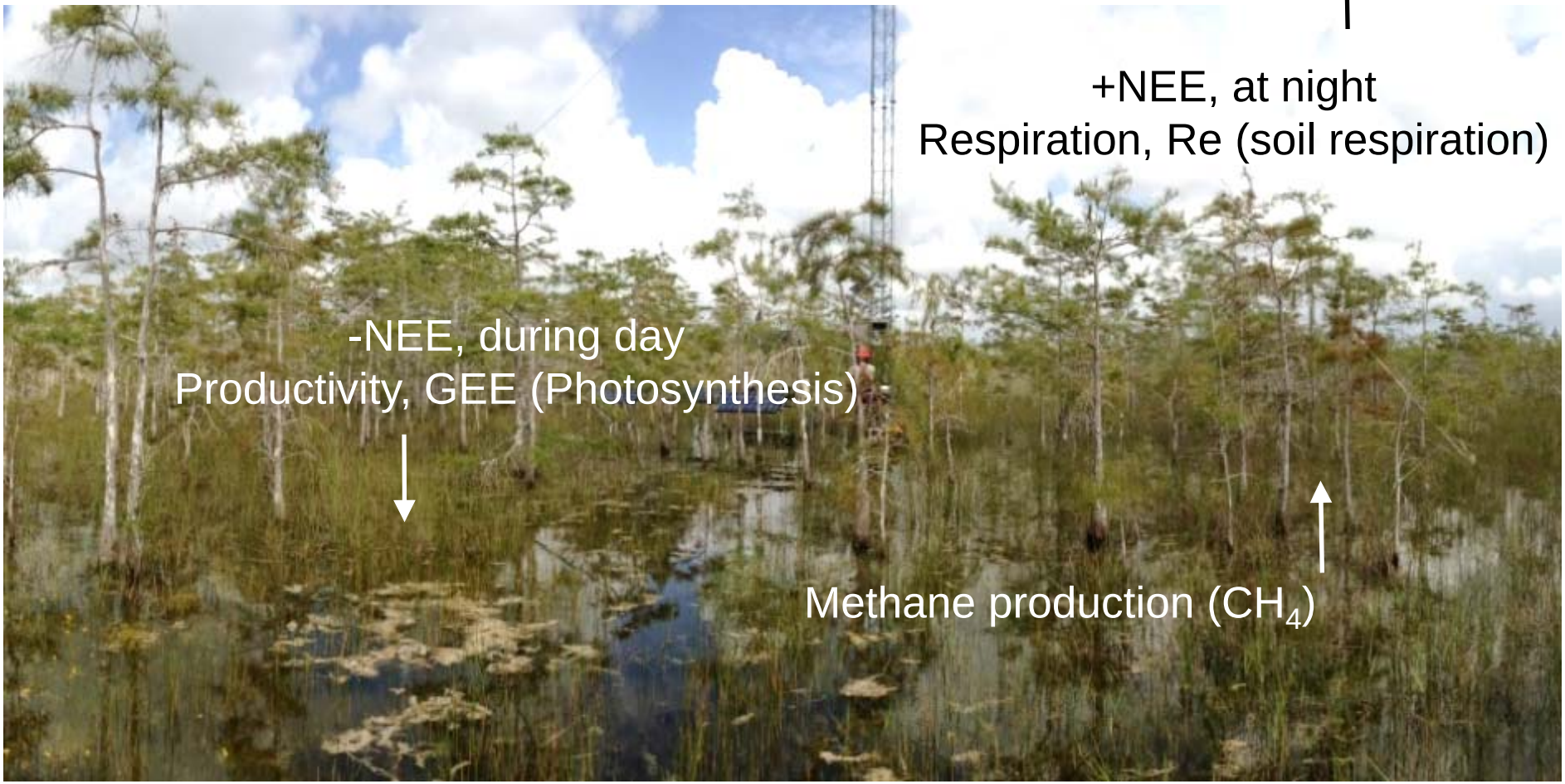
- Measures ET, NEE
- Net radiation
- SW/GW stage
- GW temperature
- SW temperature
- Air temperature
- Relative humidity
- Soil moisture
- Soil temperature
- Soil heat flux

Available energy explains ET variability



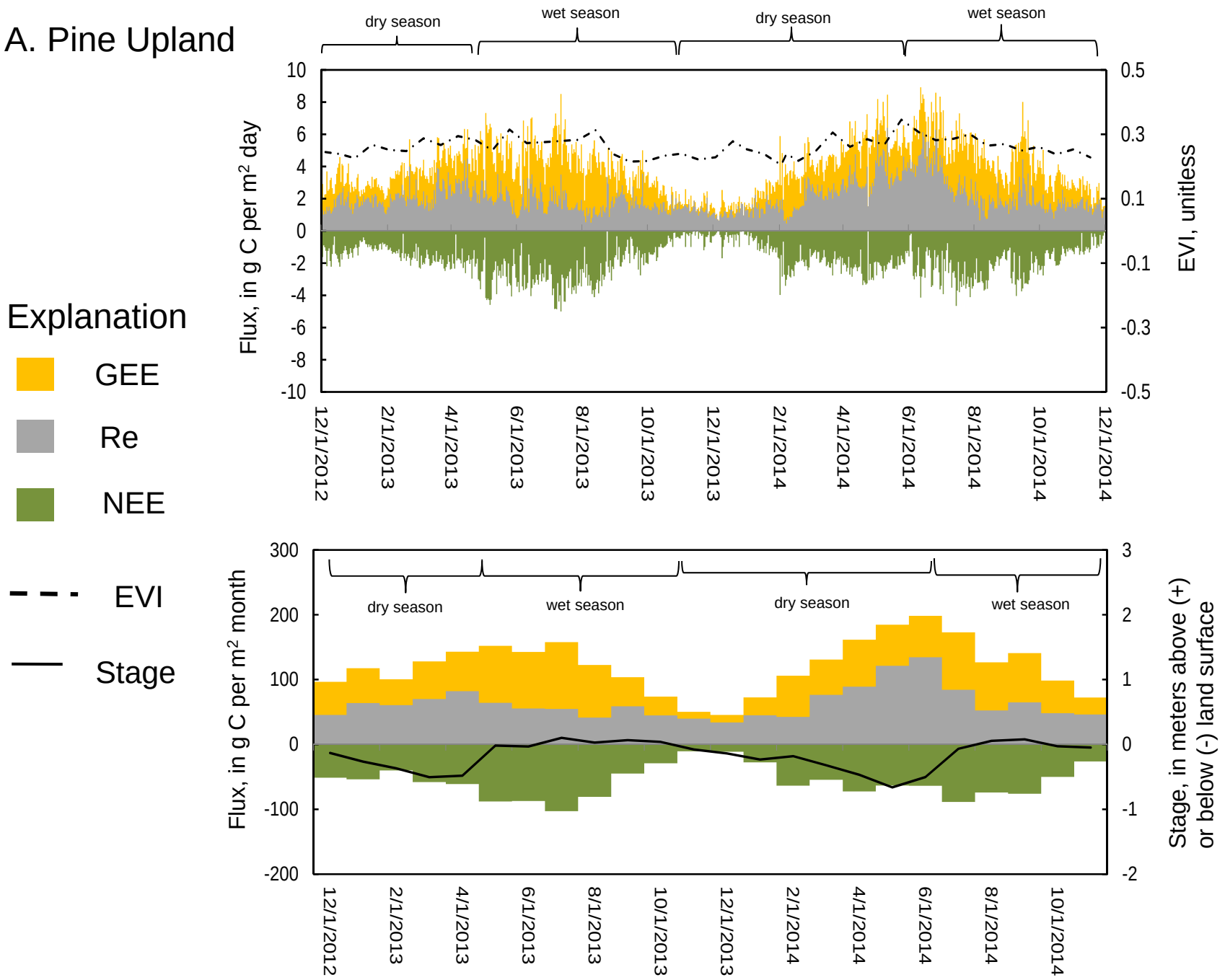
http://sofia.usgs.gov/exchange/bcnp_et/index.php

Conceptual Model

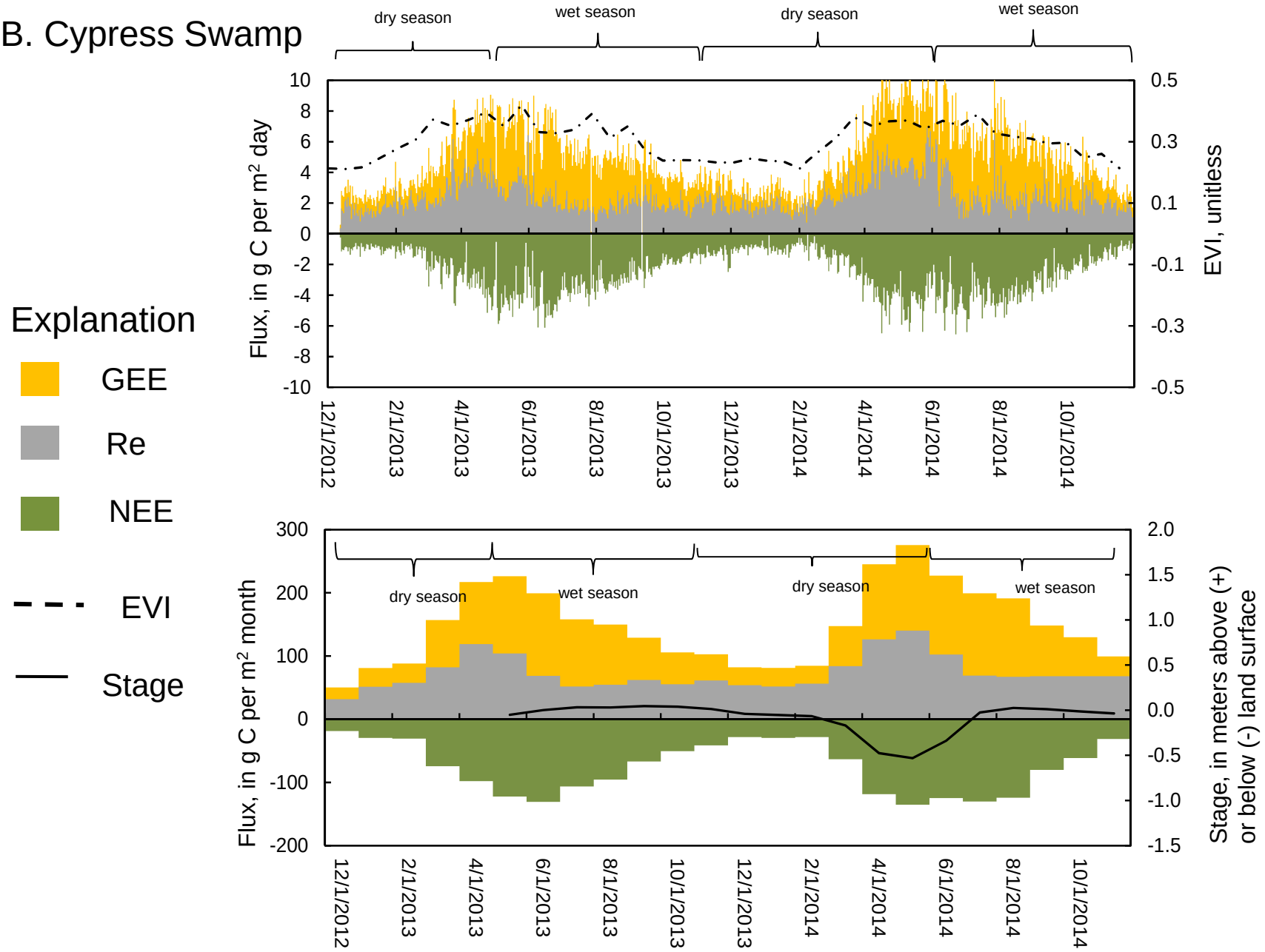


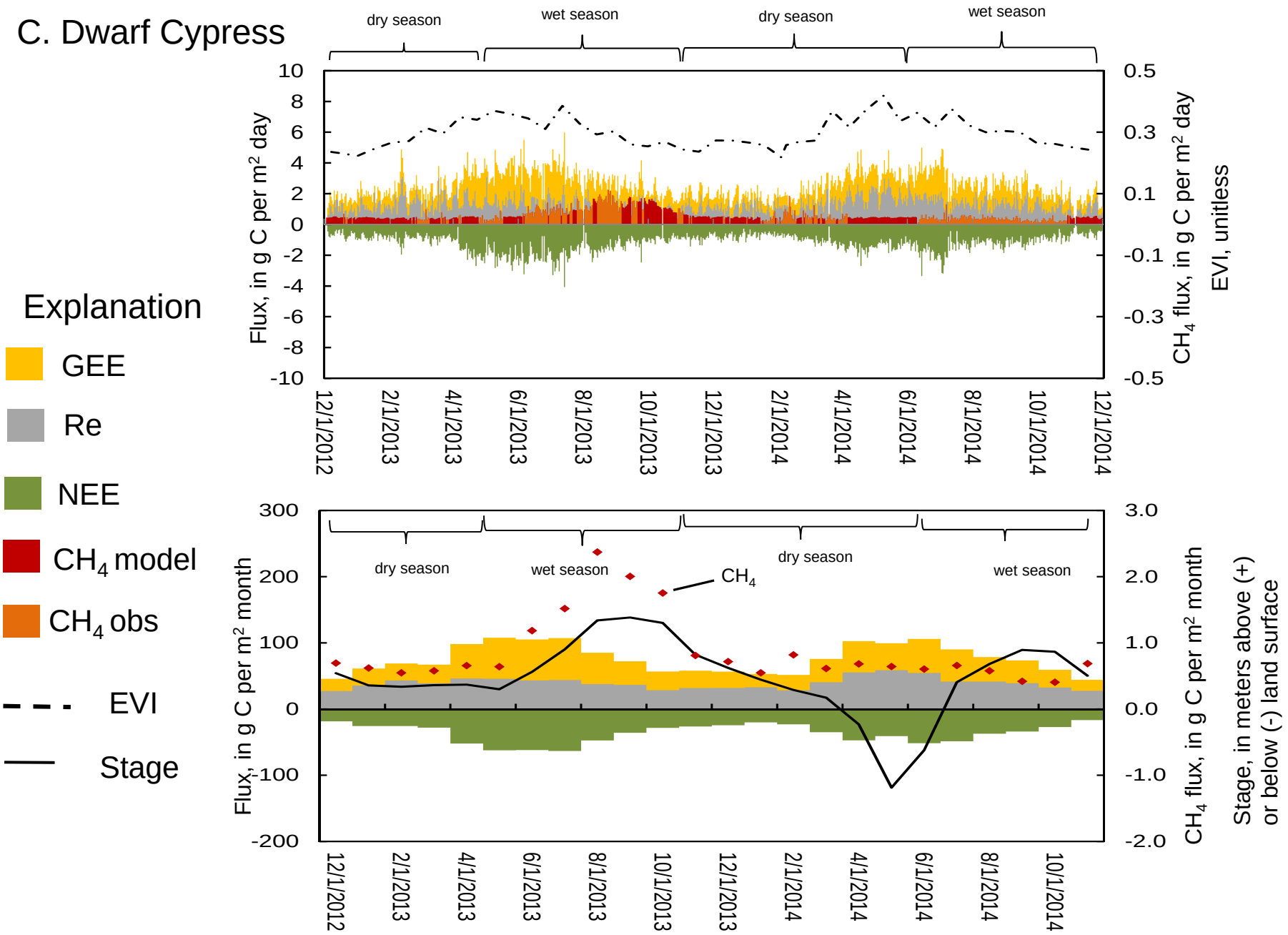
NEE is net ecosystem C exchange, measured with gas analyzer

A. Pine Upland



B. Cypress Swamp




C. Dwarf Cypress
dry season
wet season
dry season
wet season
Explanation
GEE
Re
NEE
CH4 model
CH4 obs
EVI
Stage
Flux, in g C per m2 day
CH4 flux, in g C per m2 day
EVI, unitless
10
8
6
4
2
0
-2
-4
-6
-8
-10
0.5
0.3
0.1
-0.1
-0.3
-0.5
12/1/2012
2/1/2013
4/1/2013
6/1/2013
8/1/2013
10/1/2013
12/1/2013
2/1/2014
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
Flux, in g C per m2 month
CH4 flux, in g C per m2 month
Stage, in meters above (+)
or below (-) land surface
CH4
300
200
100
0
-100
-200
3.0
2.0
1.0
0.0
-1.0
-2.0


A. Pine Upland


B. Cypress Swamp


C. Dwarf Cypress

Links between Water and C Cycles (Water-Use Efficiencies, WUE)

$$\frac{NEE}{ET}$$

C stored per mm ET (scaled to m^2)

ET, in millimeters per month

Site	ET[1]	-NEE[2]	WUE[3]
Pine Upland	1050(yr1 [4]) 1070 (yr2 [5])	-700(yr1 [4]) -700 (yr2 [5])	**0.7** / 1.0 (yr1 [4]) **0.7** / 1.0 (yr2 [5])
Dwarf Cypress	970(yr1 [4]) 900 (yr2 [5])	-450(yr1 [4]) -400 (yr2 [5])	**0.5** / 0.7 (yr1 [4]) **0.4** / 0.7 (yr2 [5])
Cypress Swamp	1000(yr1 [4]) 1100 (yr2 [5])	-900(yr1 [4]) -1000 (yr2 [5])	**0.9** / 1.4 (yr1 [4]) **0.9** / 1.4 (yr2 [5])

[1]Units are millimeters per year

[2]Units are g C per year

[3]Units are g C per millimeter ET or (/) moles CO_2 per mole ET

Forested wetlands are more "efficient" at using water to store C.

Conclusions – Key Issues

1. Pine and cypress forested wetlands are atmospheric C sinks on monthly and annual time scales.

2. C uptake (NEE) was greatest at Cypress Swamp (-900 to -1000 g C per m^2 year), moderate at Pine Upland (-650 to -700 g C per m^2 year), and least at Dwarf Cypress (-400 to -450 g C per m^2 year).

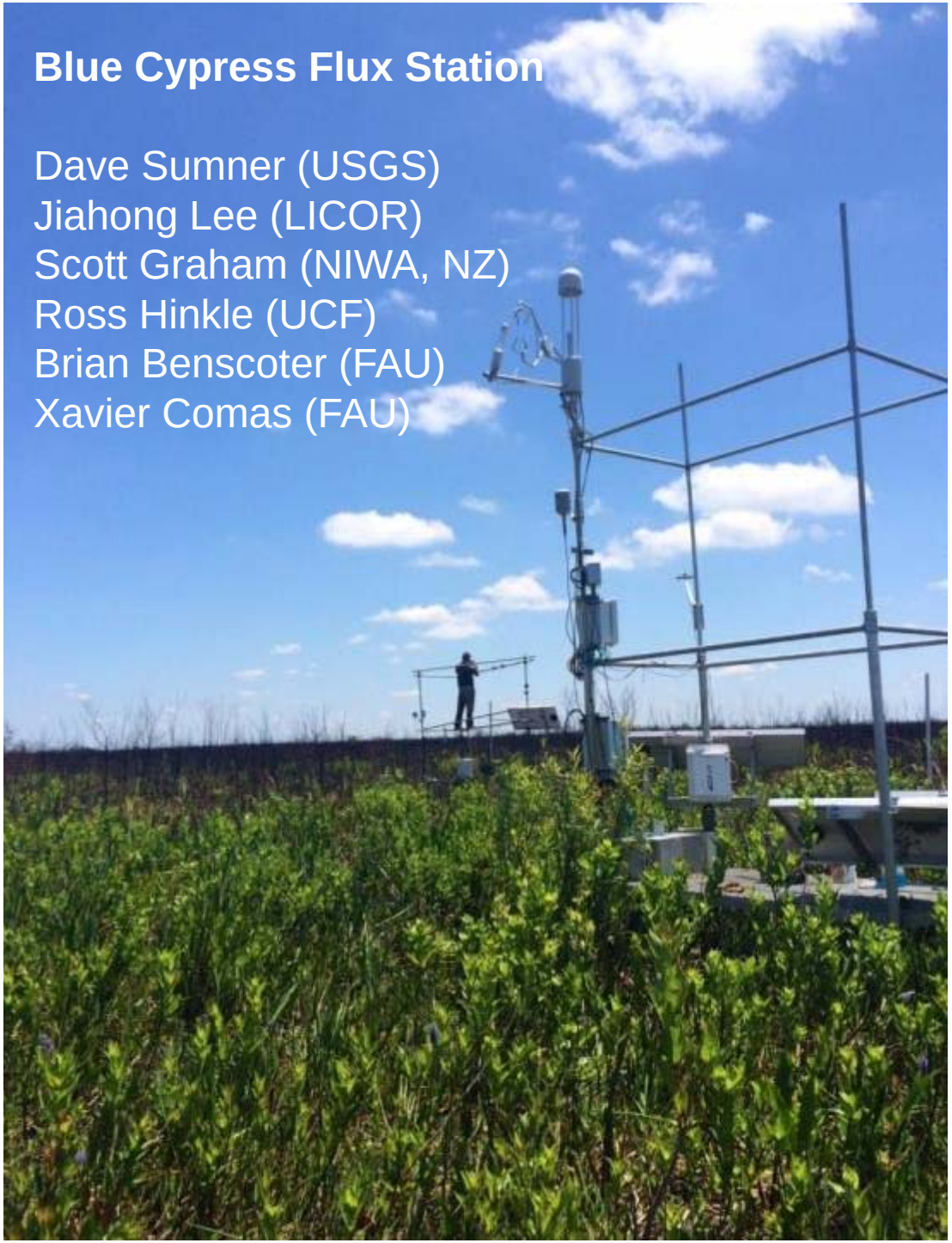
3. Seasonality in C uptake rates was enhanced by the growth of cypress leaves in early April and decay of cypress leaves in late October.

4. Changes in EVI served as a useful surrogate for monthly and seasonal changes in NEE.

5. Respiration was enhanced when water levels dropped below land surface, likely due to enhanced soil respiration.

For more information:

http://www.biogeosciences.net/12/2285/2015/bg-12-2285-2015.html



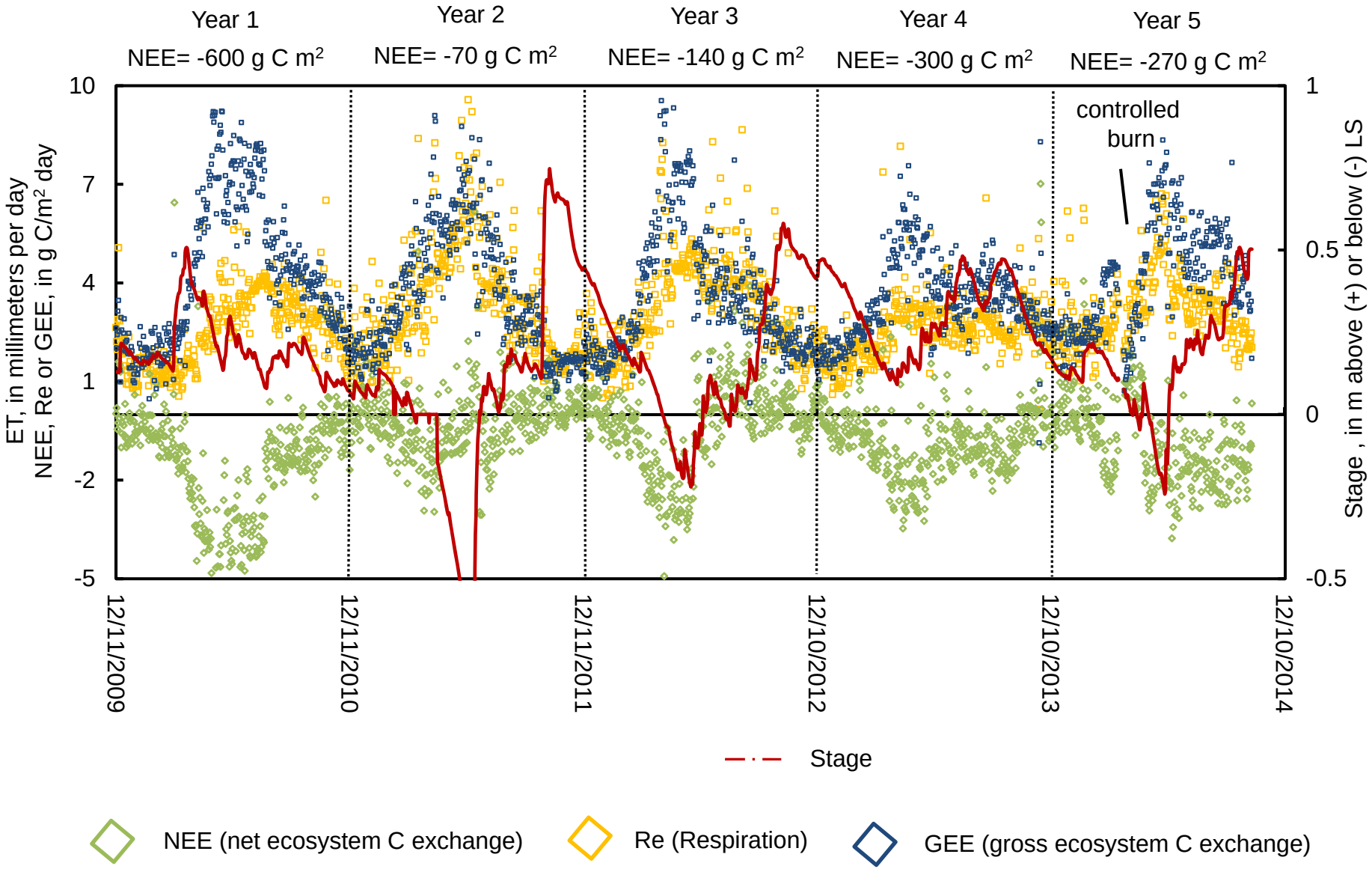
USGS/SJRWMD

4-component net radiometer
Air temp / RH
Wetland stage
SW / GW temperature
Wind speed / direction
VPD
Latent (ET) and Sensible heat

UCF/FAU - DOE Project

-NEE (photosynthesis)
+NEE (respiration)
Methane (CH4) emission

Atmospheric / Ecosystem Carbon Exchanges



Carbon Cycling Response to Fire