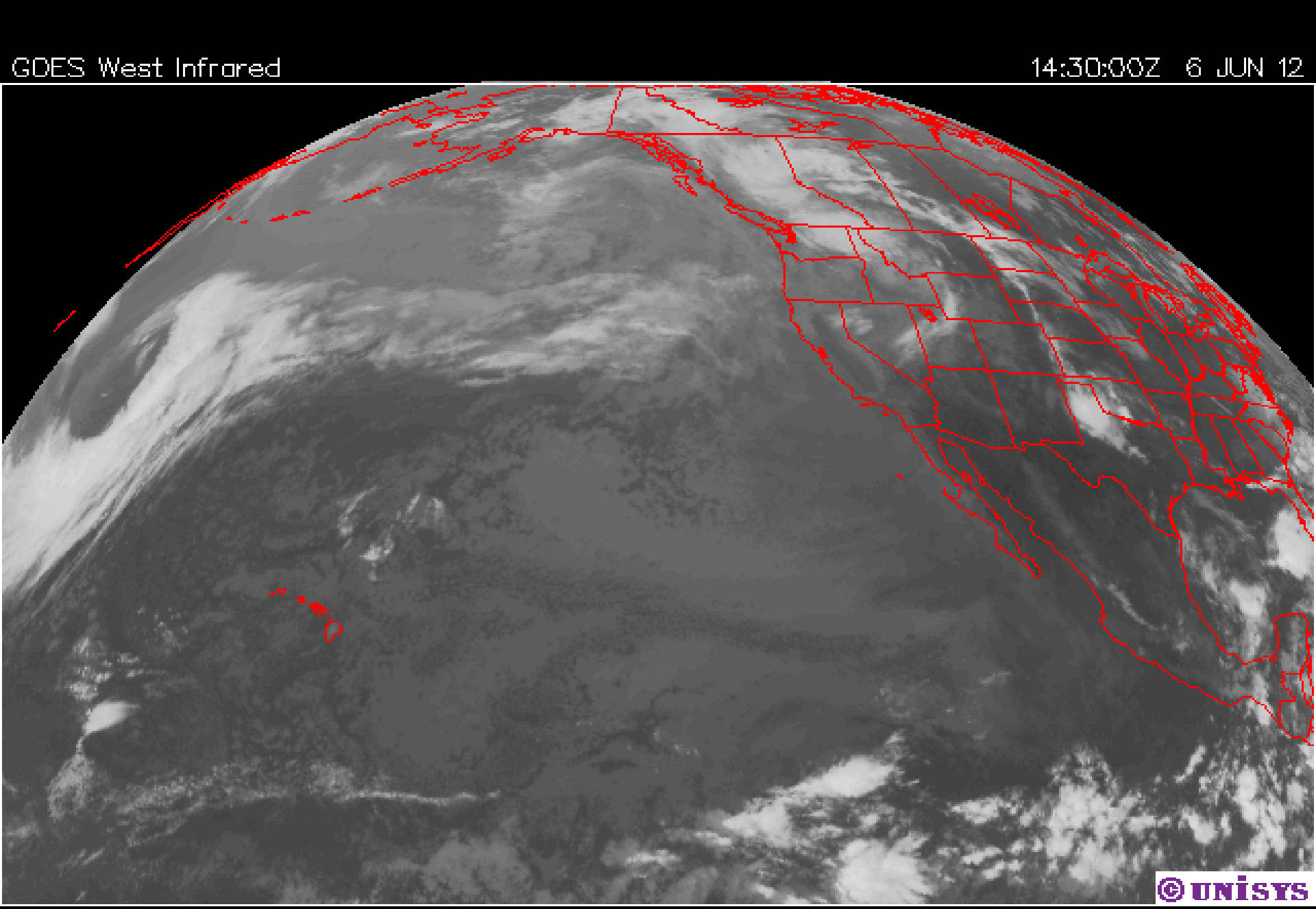
Seasonal Carbon and Energy Fluxes for Restored Wetlands in the Sacramento – San Joaquin Delta

Frank Anderson, USGS

9th INTECOL International Wetlands Conference, Orlando, Florida, June 8, 2012

Goals

- What are the atmospheric conditions that can lead to maximum wetland productivity
- Annual Carbon Budget from a Temperate Wetland
- Wetland Annual Variability


GOES West Infrared
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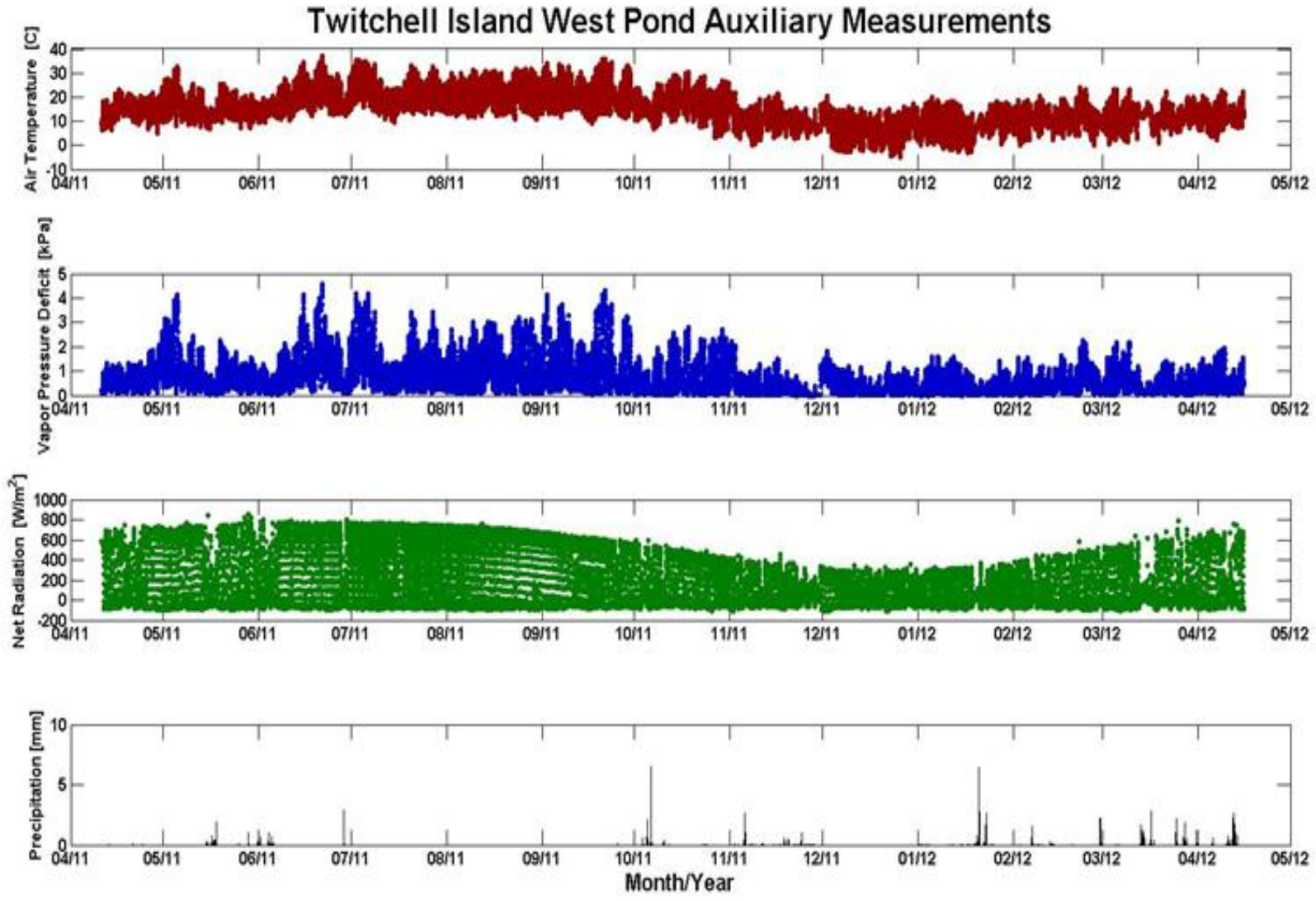
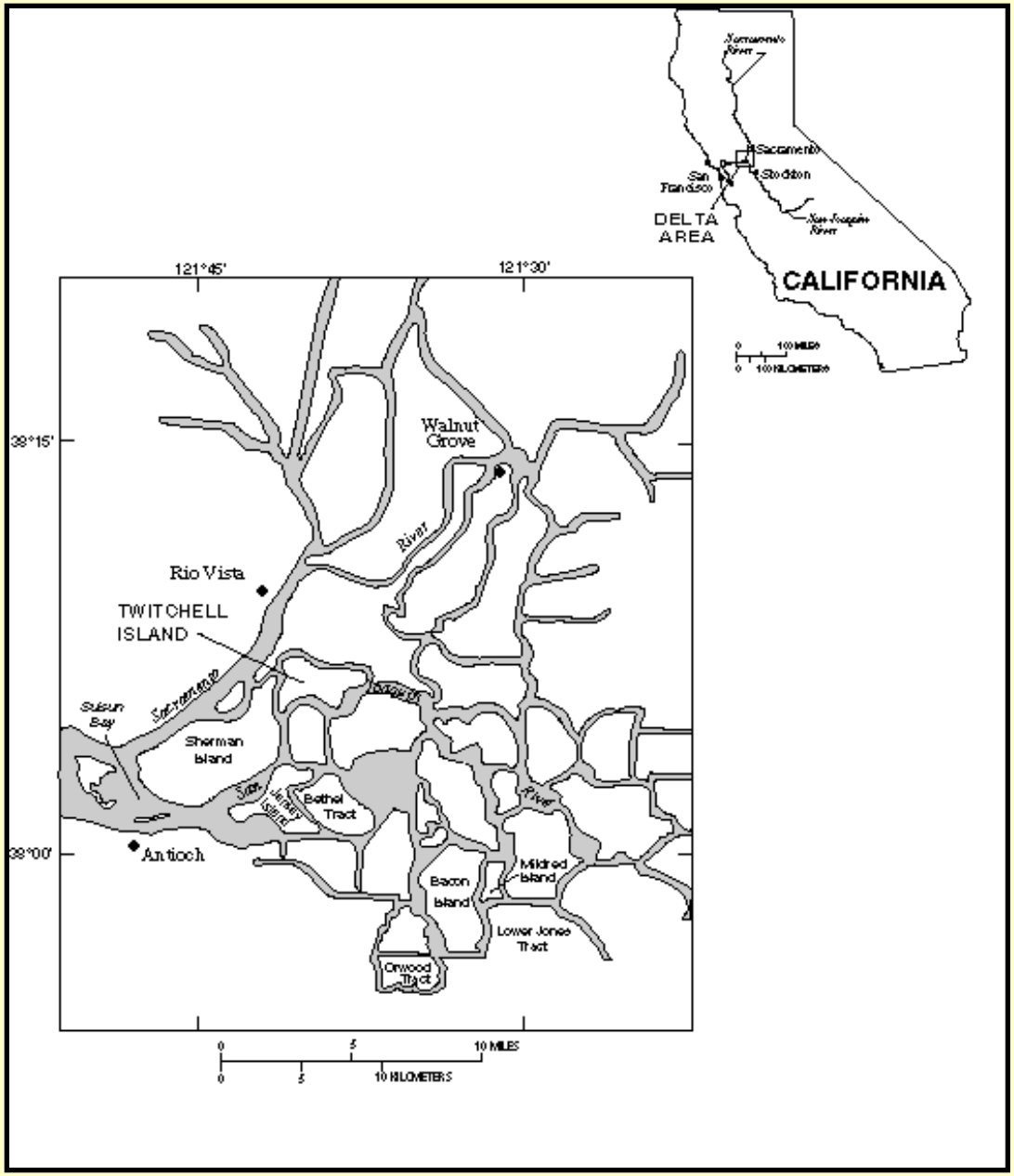
©UNISYS

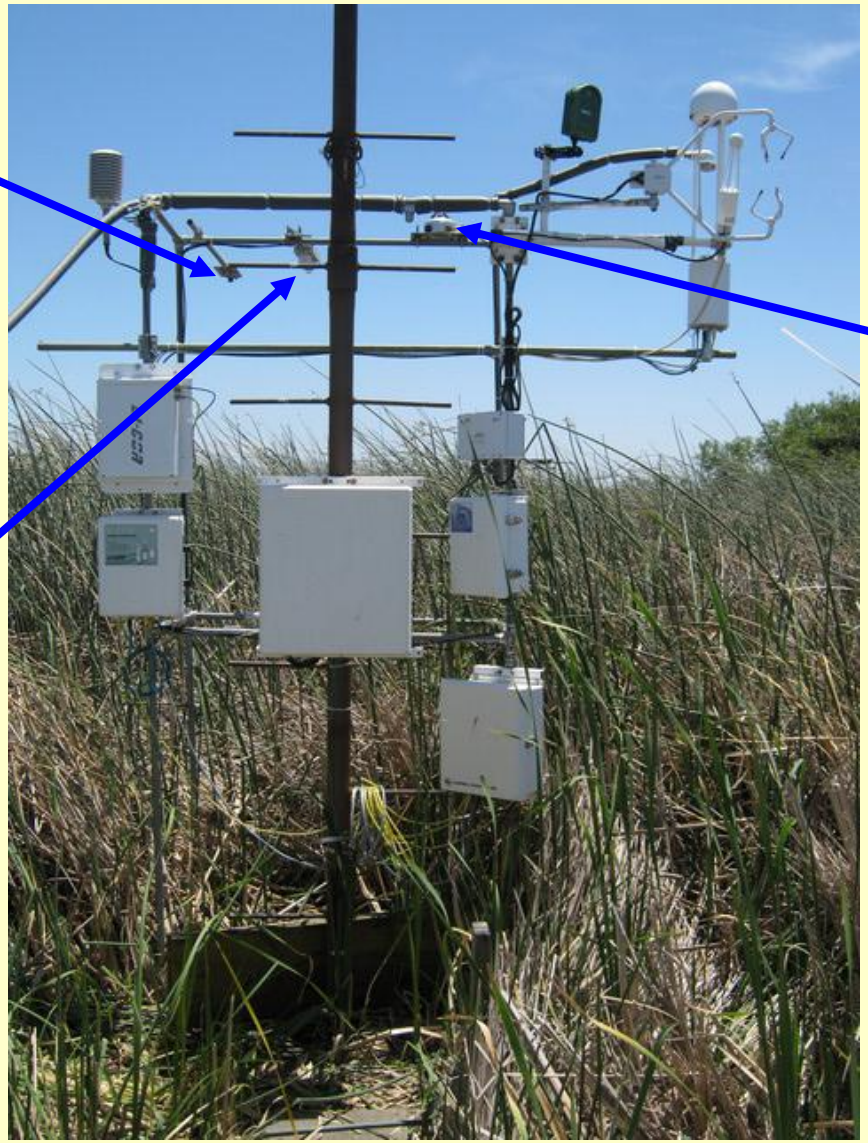

Twitchell Island West Pond Auxiliary Measurements
Air Temperature [C]
Vapor Pressure Deficit [kPa]
Net Radiation [W/m2]
Precipitation [mm]
04/11
05/11
06/11
07/11
08/11
09/11
10/11
11/11
12/11
01/12
02/12
03/12
04/12
05/12
Month/Year


Sacramento
Stockton
San Francisco
DELTA AREA
CALIFORNIA
121°45'
121°30'
38°15'
38°00'
Walnut Grove
Rio Vista
TWITCHELL ISLAND
Sherman Island
Bethel Tract
Antioch
Mildred Island
Bacon Island
Lower Jones Tract
Orwood Tract
10 MILES
10 KILOMETERS

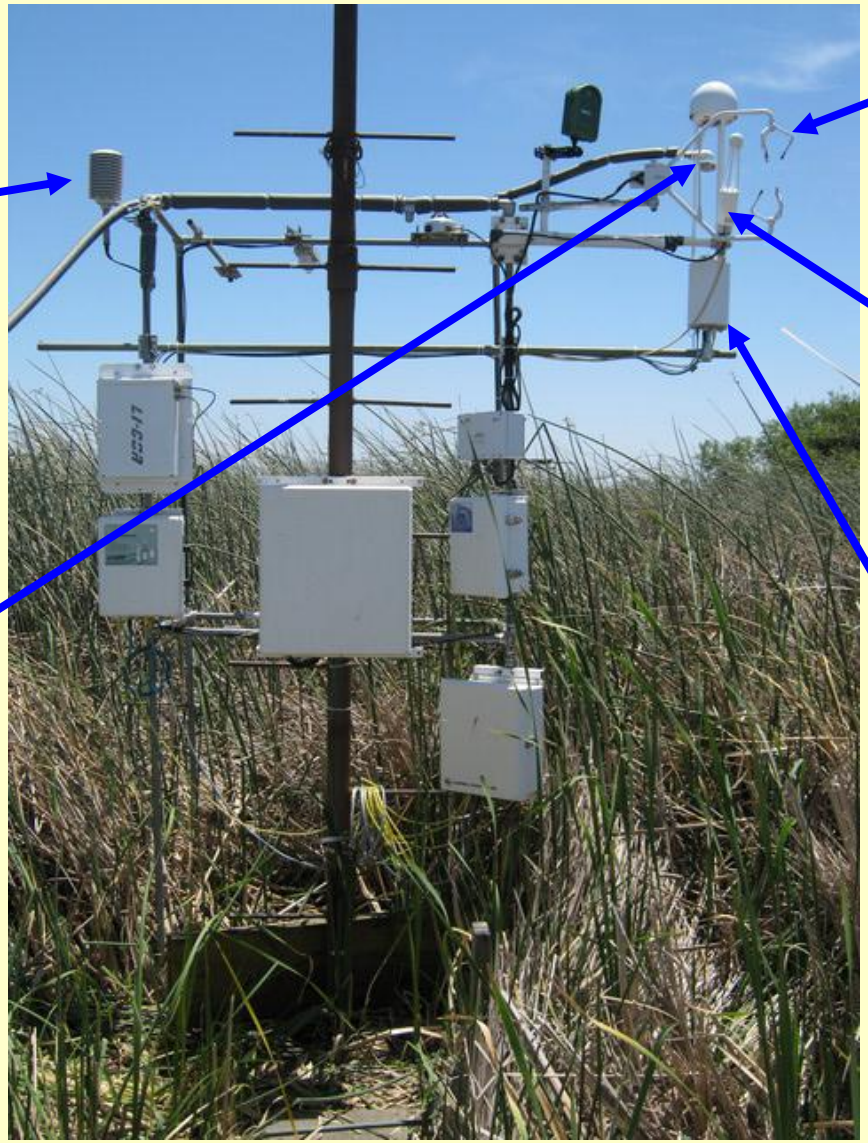
Twitchell Island

Wetland Met Tower (ET, CO2, CH4)

Radiometers



Eddy Covariance Instrumentation



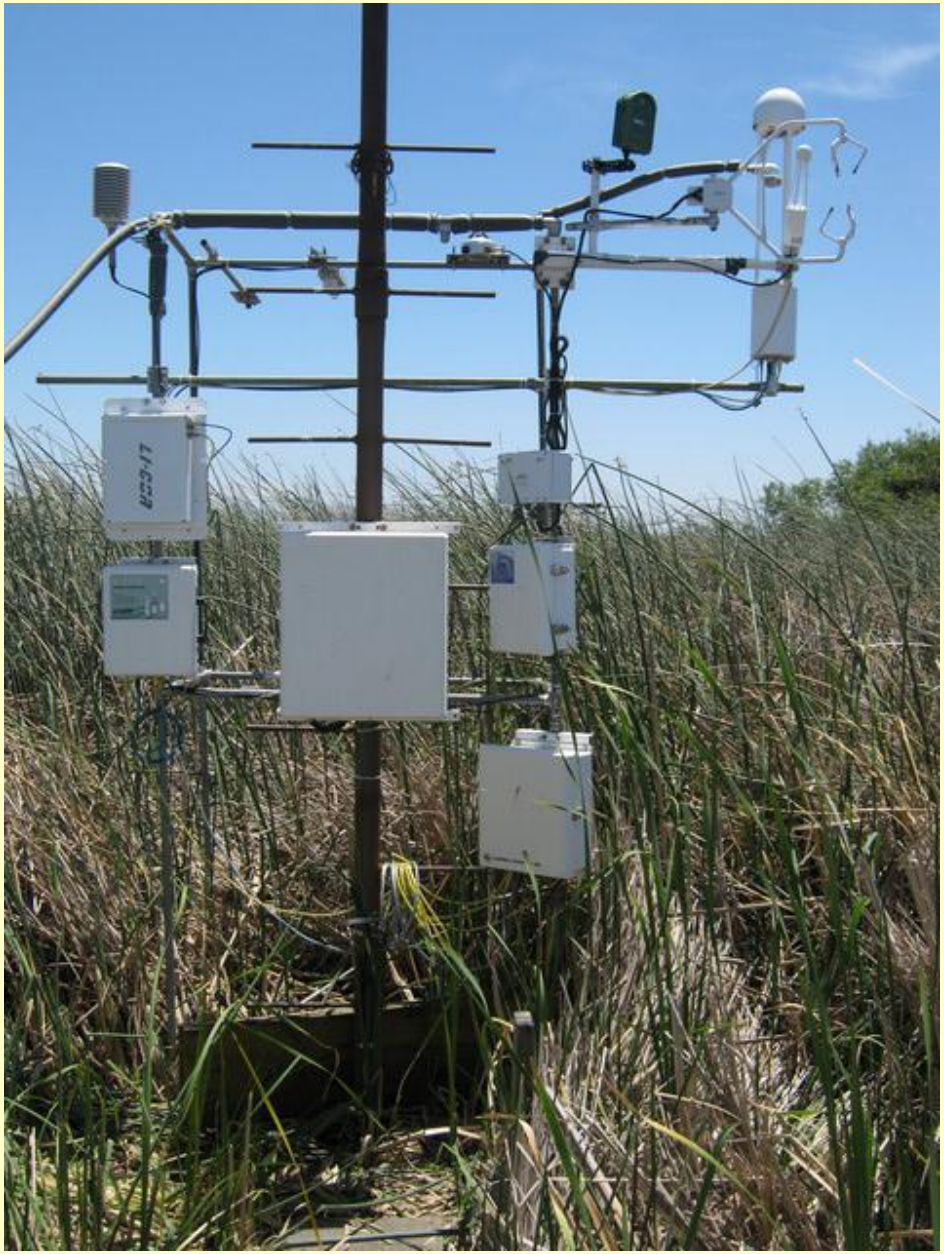
CSAT3 Sonic Anemometer

HMP45C: Relative Humidity Air Temperature

LI7500: CO2/H2O

Intake for Closed Path LGR CH4 Sensor

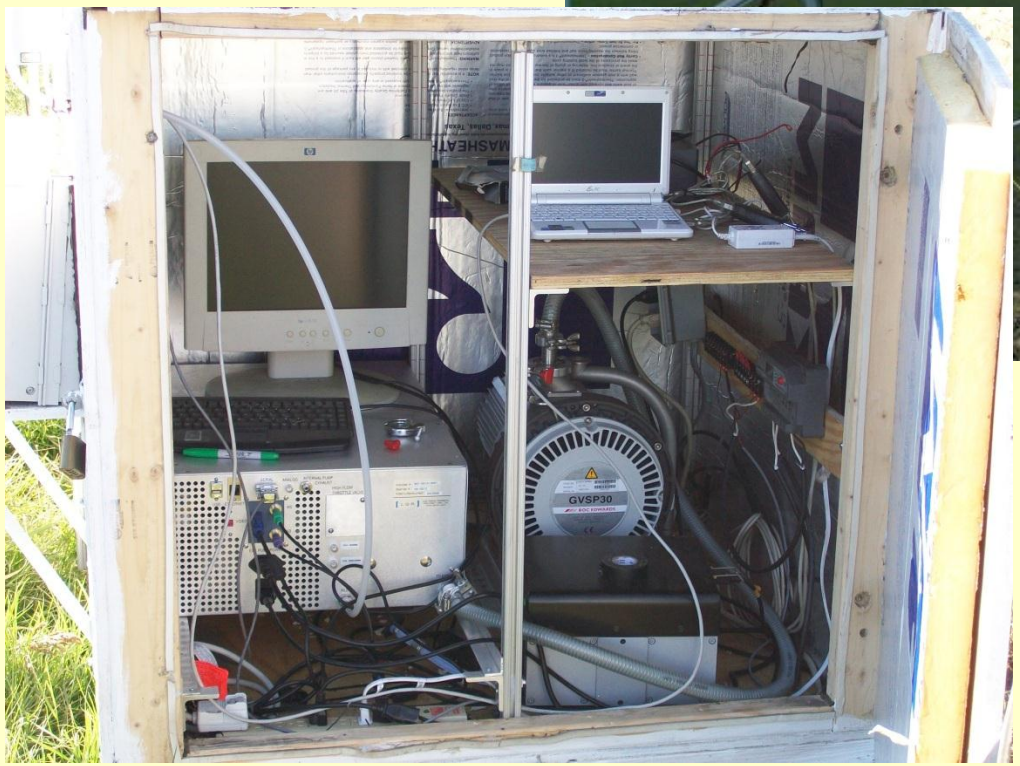
LI 7700 Open Path CH4 Sensor


LI-COR

Twitchell Island

Wetland Met Tower (ET, CO2, CH4)

UCB Rice Met Tower (ET, CO2, CH4)


GVSP30

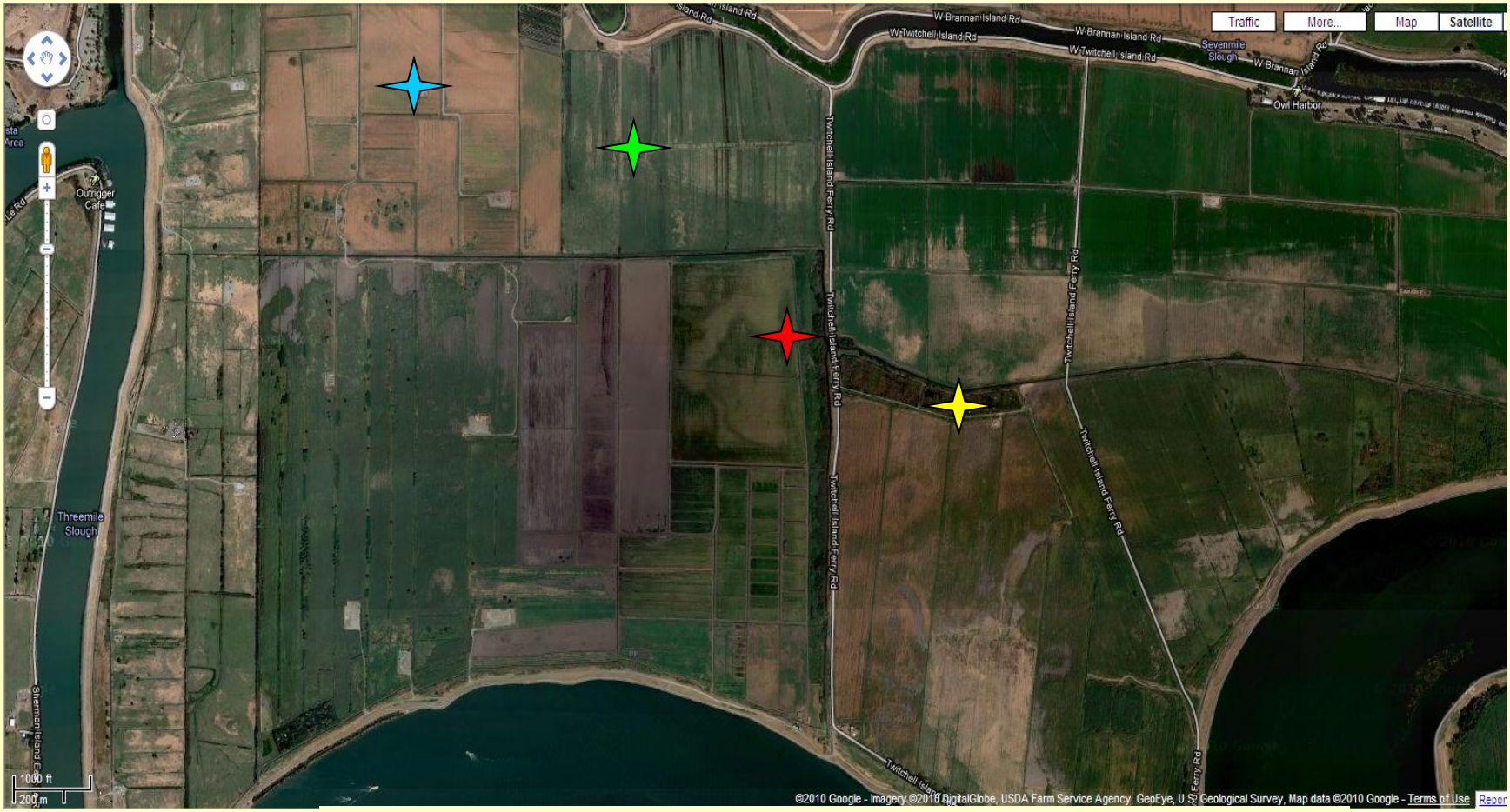
Twitchell Island

Wetland Met Tower (ET, CO2, CH4)

UCB Rice Met Tower (ET, CO2, CH4)

Feed Corn Met Tower (ET)

Twitchell Island



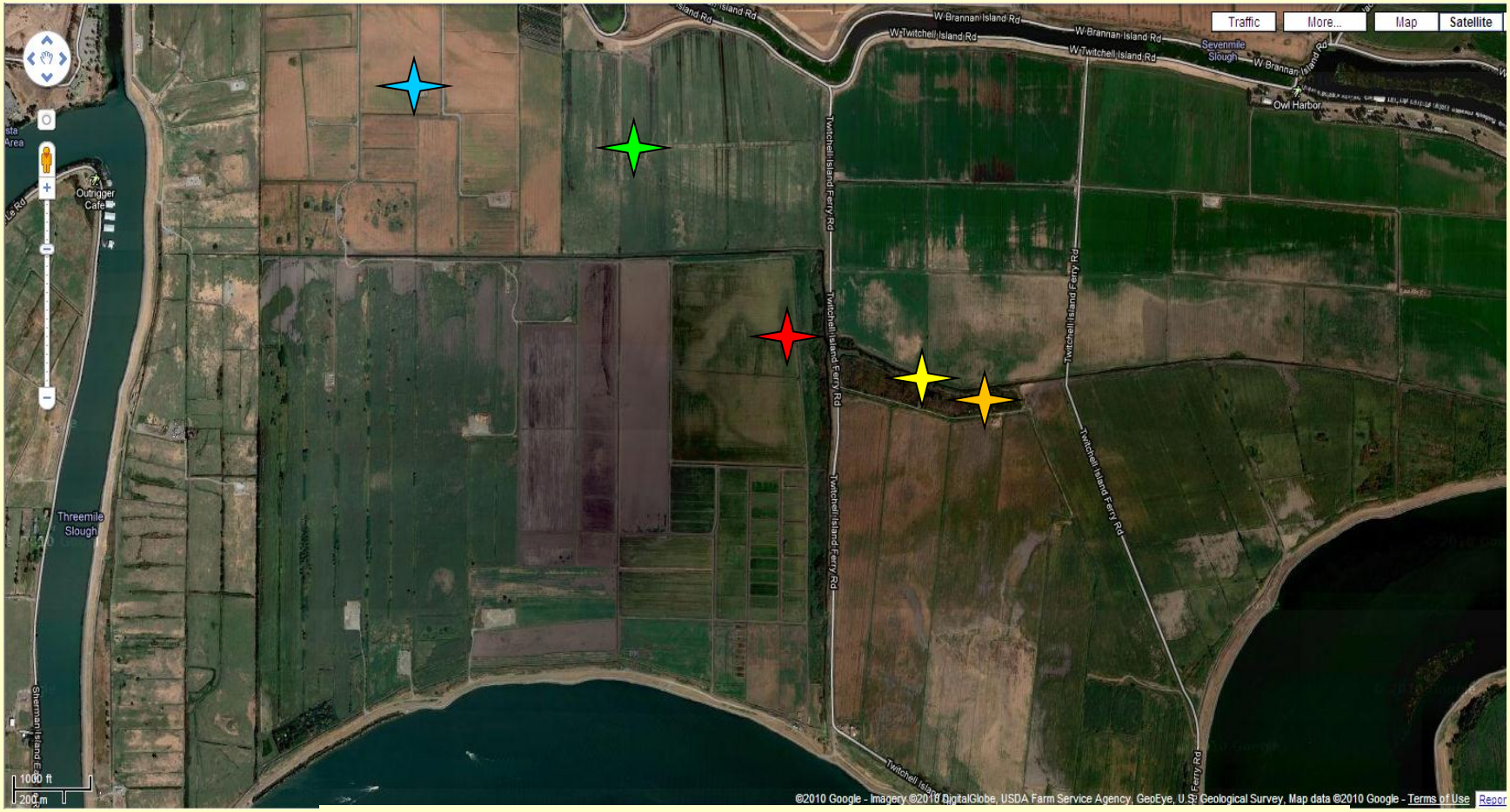
Wetland Met Tower (ET, CO2, CH4)

UCB Rice Met Tower (ET, CO2, CH4)

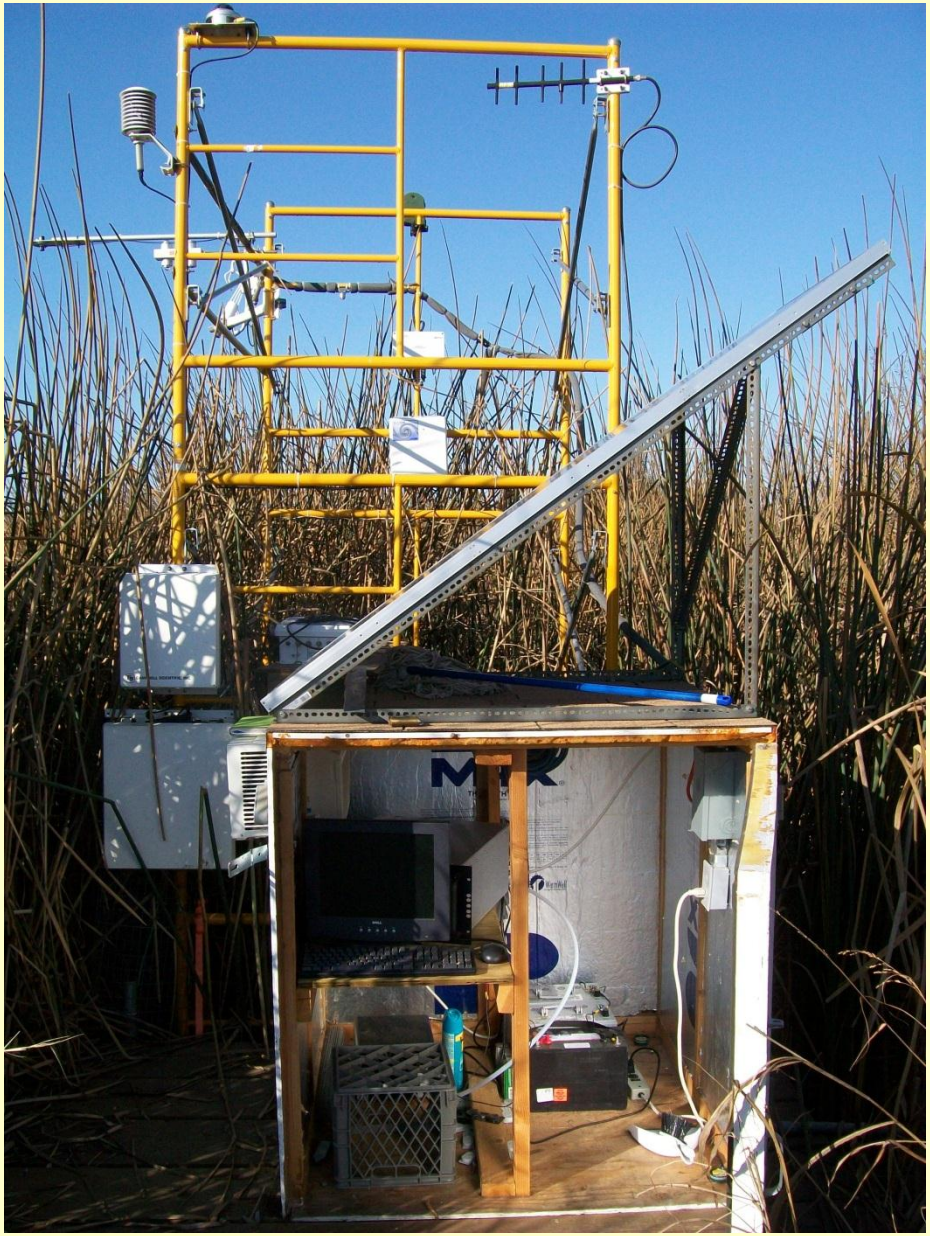
Maize (grain) Met Tower (ET, CO2)

CIMIS Met Tower (Reference ET)

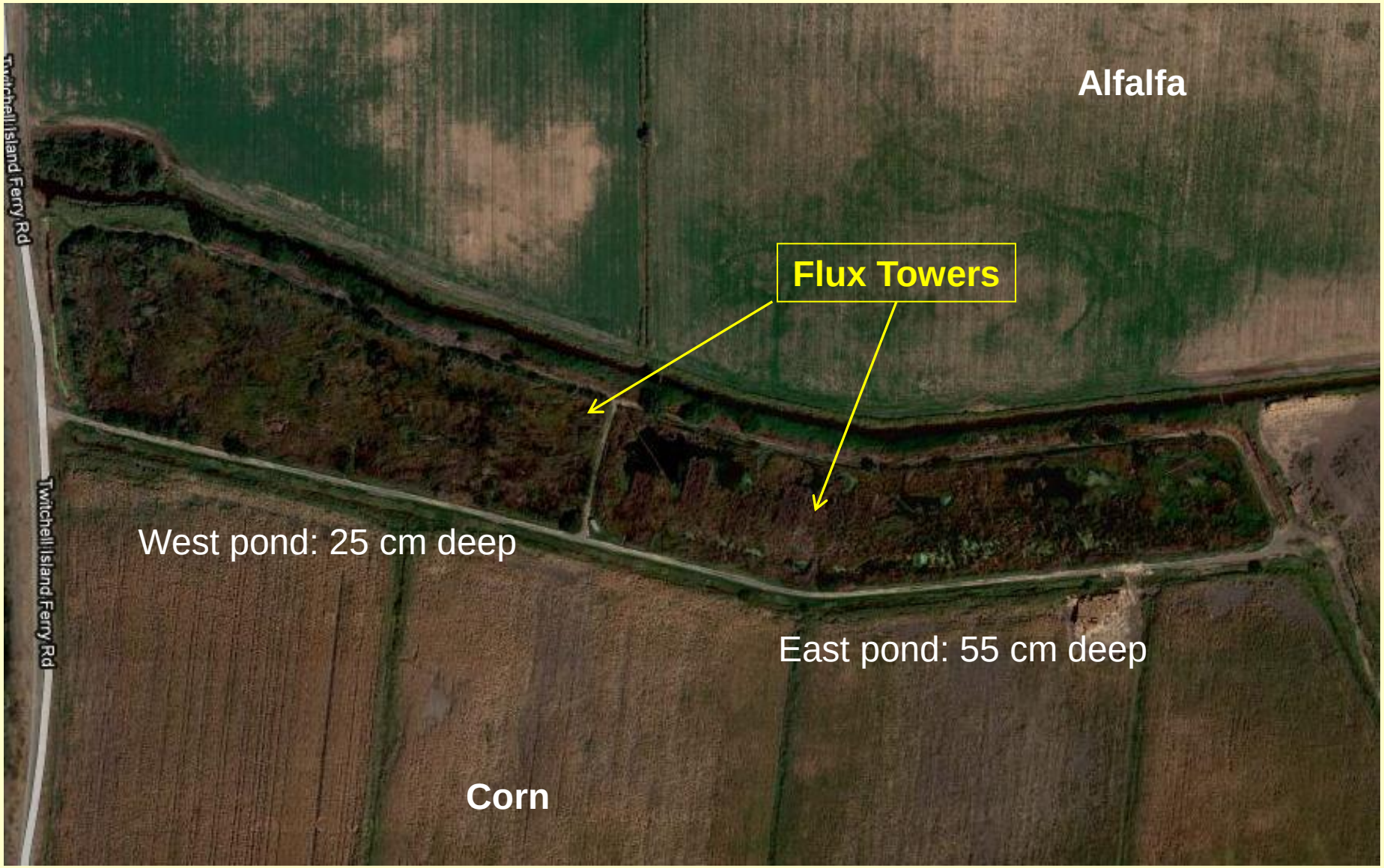
Twitchell Island



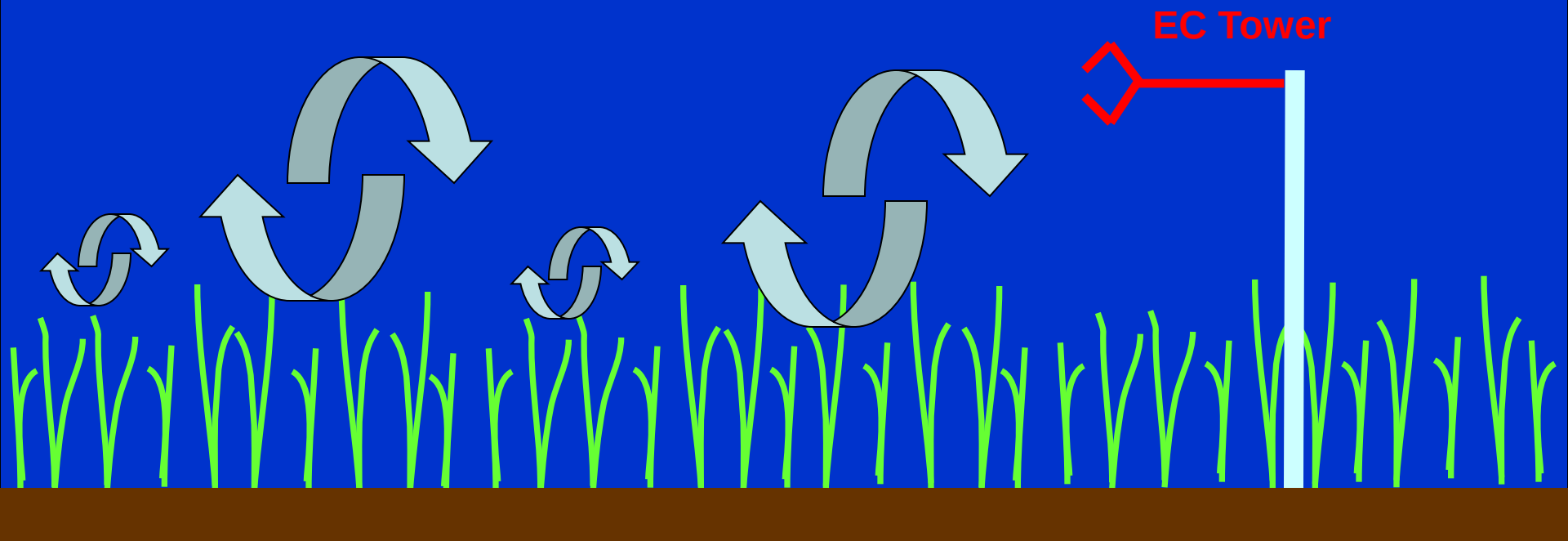
- **West pond Met Tower (ET, CO2, CH4)**
- **East pond Met Tower (ET, CO2)**
- **UCB Rice Met Tower (ET, CO2, CH4)**
- **Maize (grain) Met Tower (ET, CO2)**
- **CIMIS Met Tower (Reference ET)**



Study Site on Twitchell Island



Calculating Eddy Covariance Flux

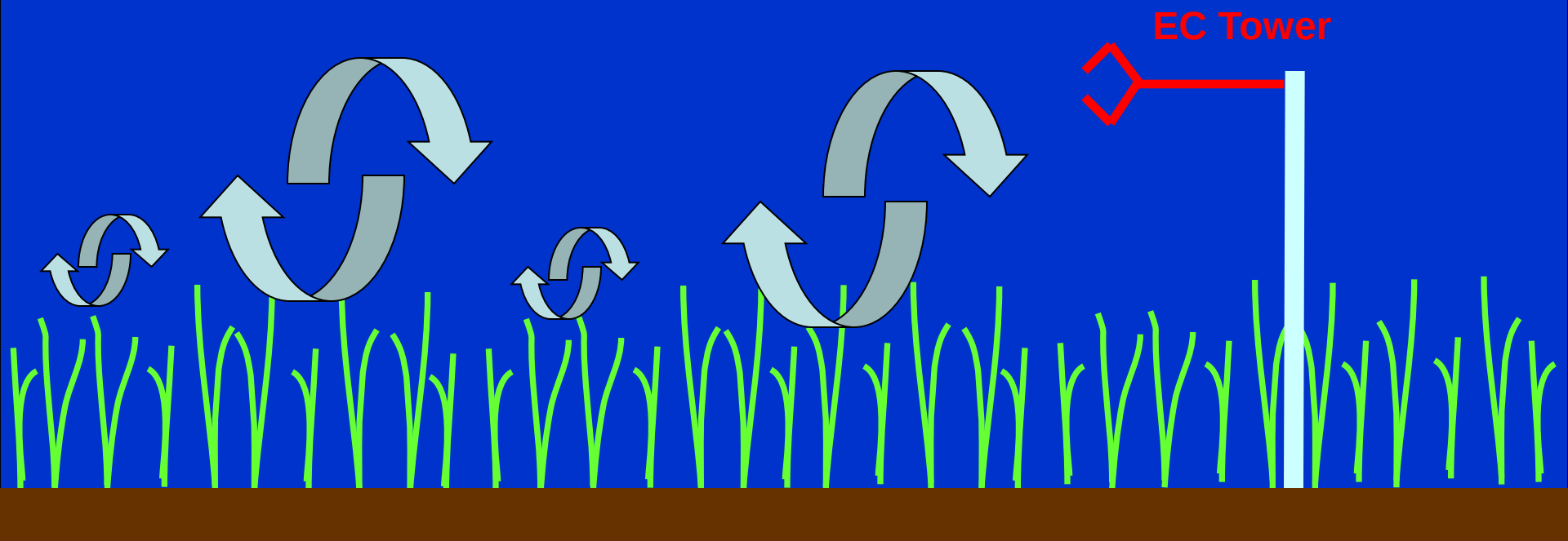


Calculating Eddy Covariance Flux

Vertical Wind Component

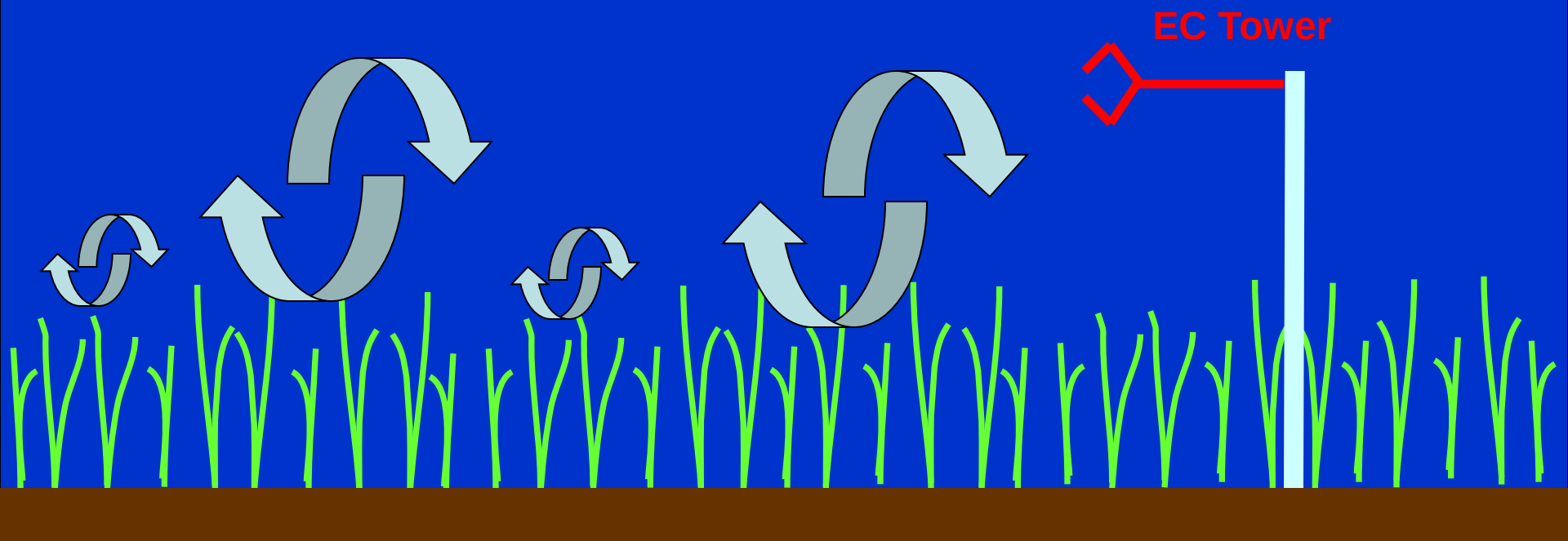
$$W = \overline{W} + w'$$

$$w' = W - \overline{W}$$



Calculating Eddy Covariance Flux

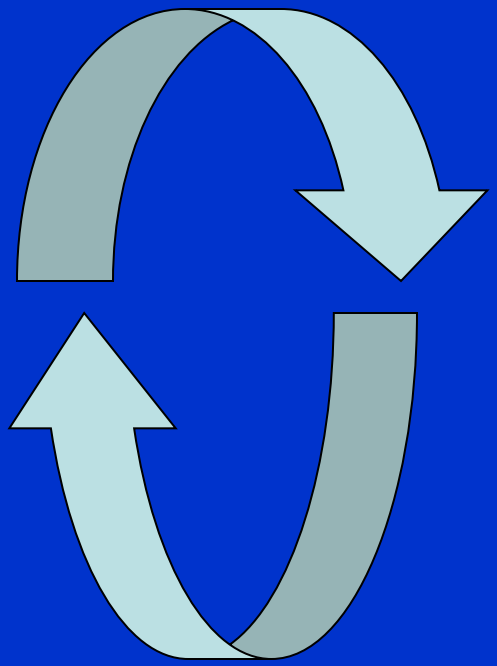
$$\text{Flux} = \overline{\rho_a} \bullet \overline{w's'}$$



Calculating Eddy Covariance Flux

Net Upward Flux

w’ = positive
s’ = positive

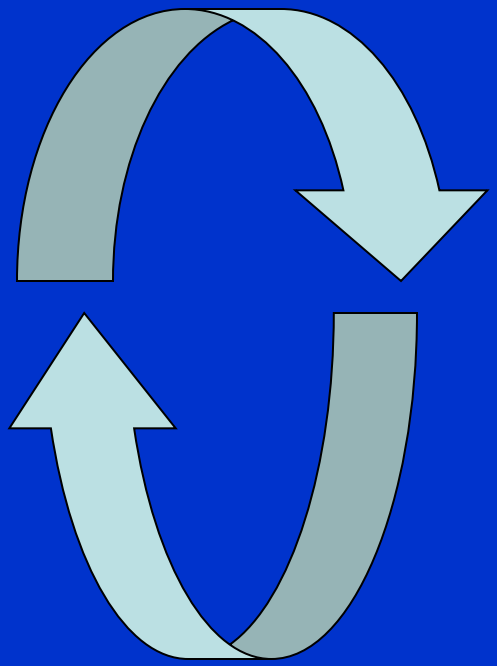


w’ = negative
s’ = negative

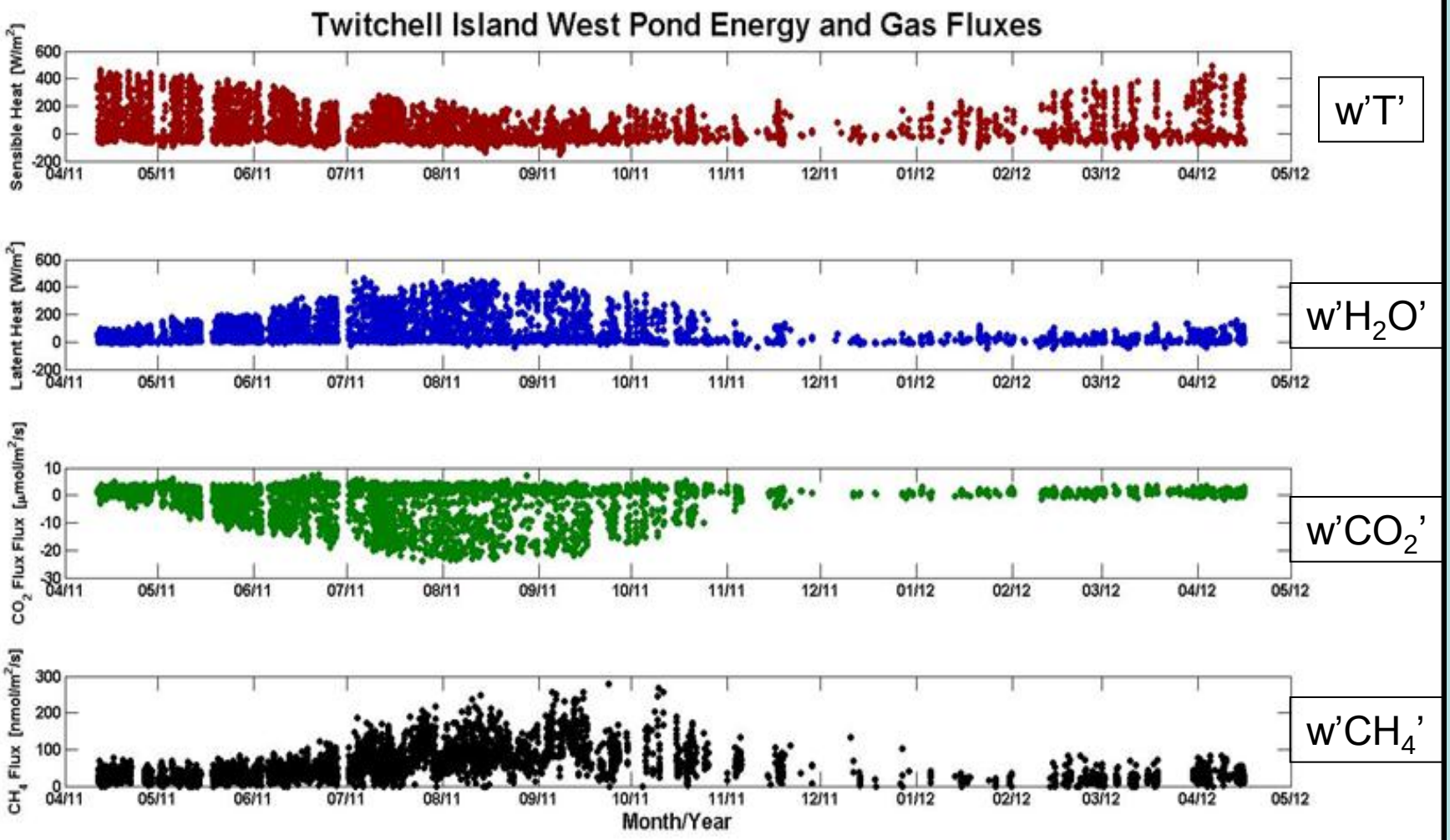
Calculating Eddy Covariance Flux

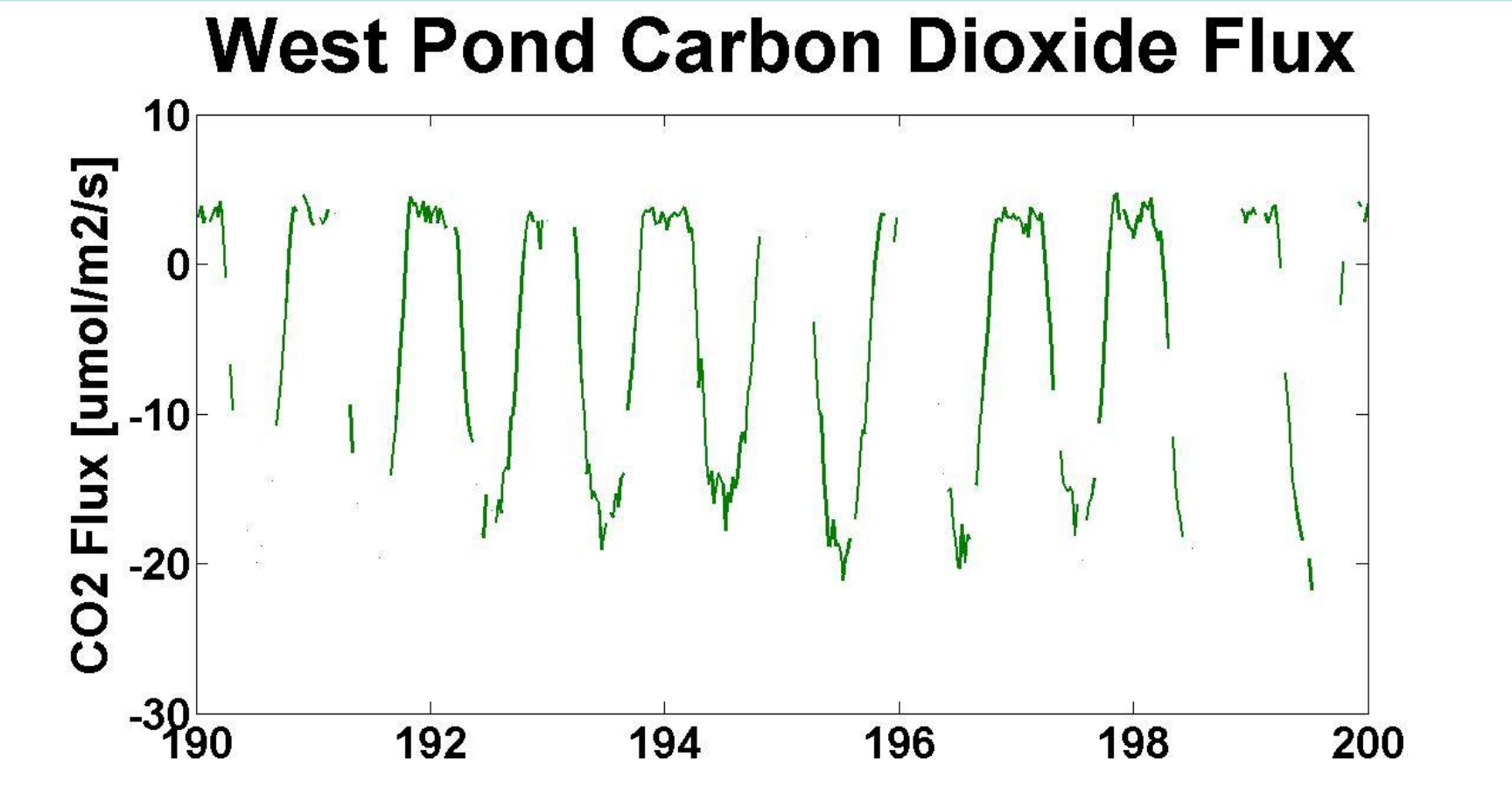
Net Downward Flux

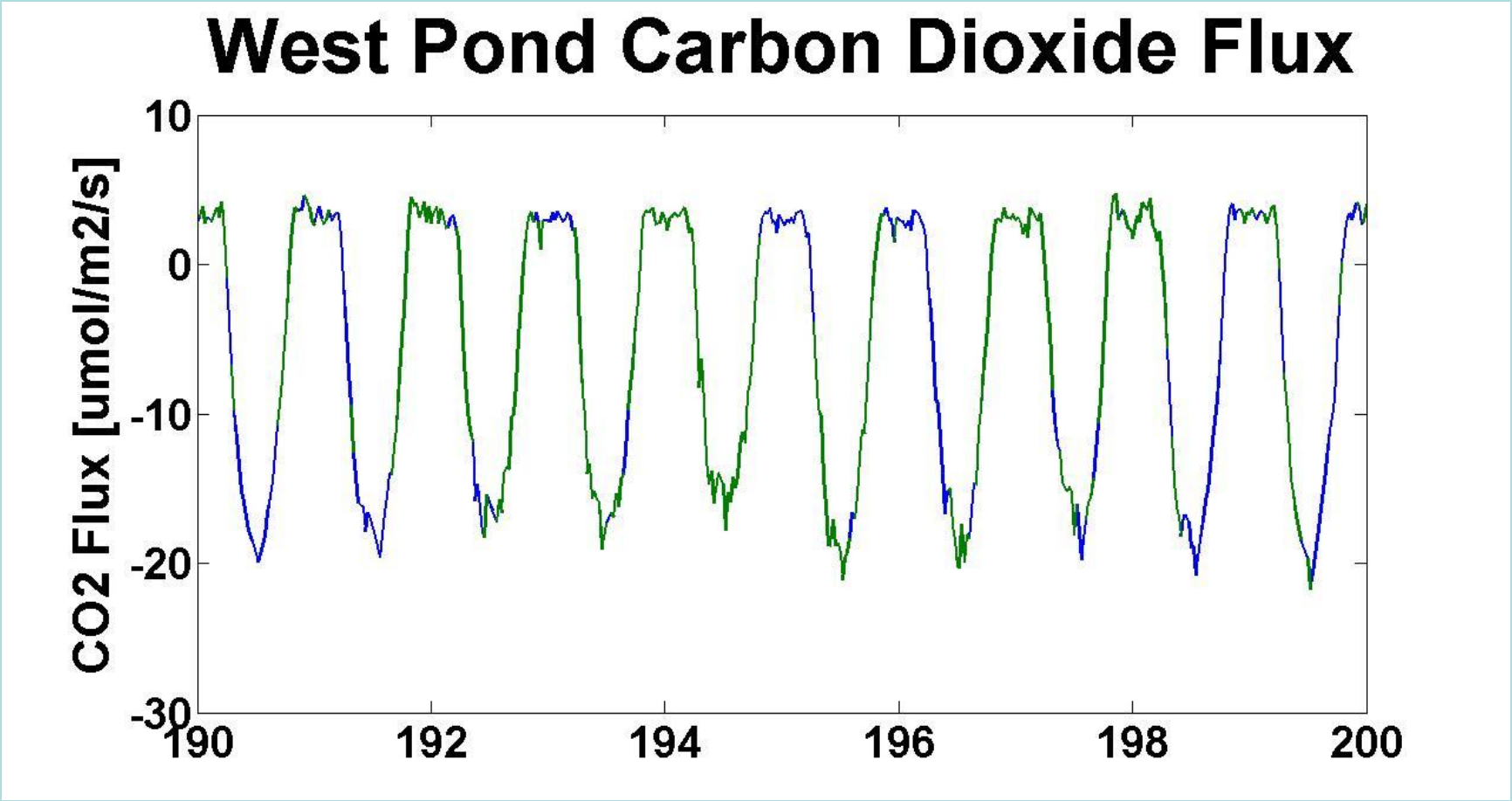
w’ = positive
s’ = negative



w’ = negative
s’ = positive


Twitchell Island West Pond Energy and Gas Fluxes
Sensible Heat [W/m²]
Latent Heat [W/m²]
CO₂ Flux Flux [µmol/m²/s]
CH₄ Flux [nmol/m²/s]
04/11
05/11
06/11
07/11
08/11
09/11
10/11
11/11
12/11
01/12
02/12
03/12
04/12
05/12
Month/Year
w'T'
w'H₂O'
w'CO₂'
w'CH₄'


West Pond Carbon Dioxide Flux
CO2 Flux [umol/m2/s]
10
0
-10
-20
-30
190
192
194
196
198
200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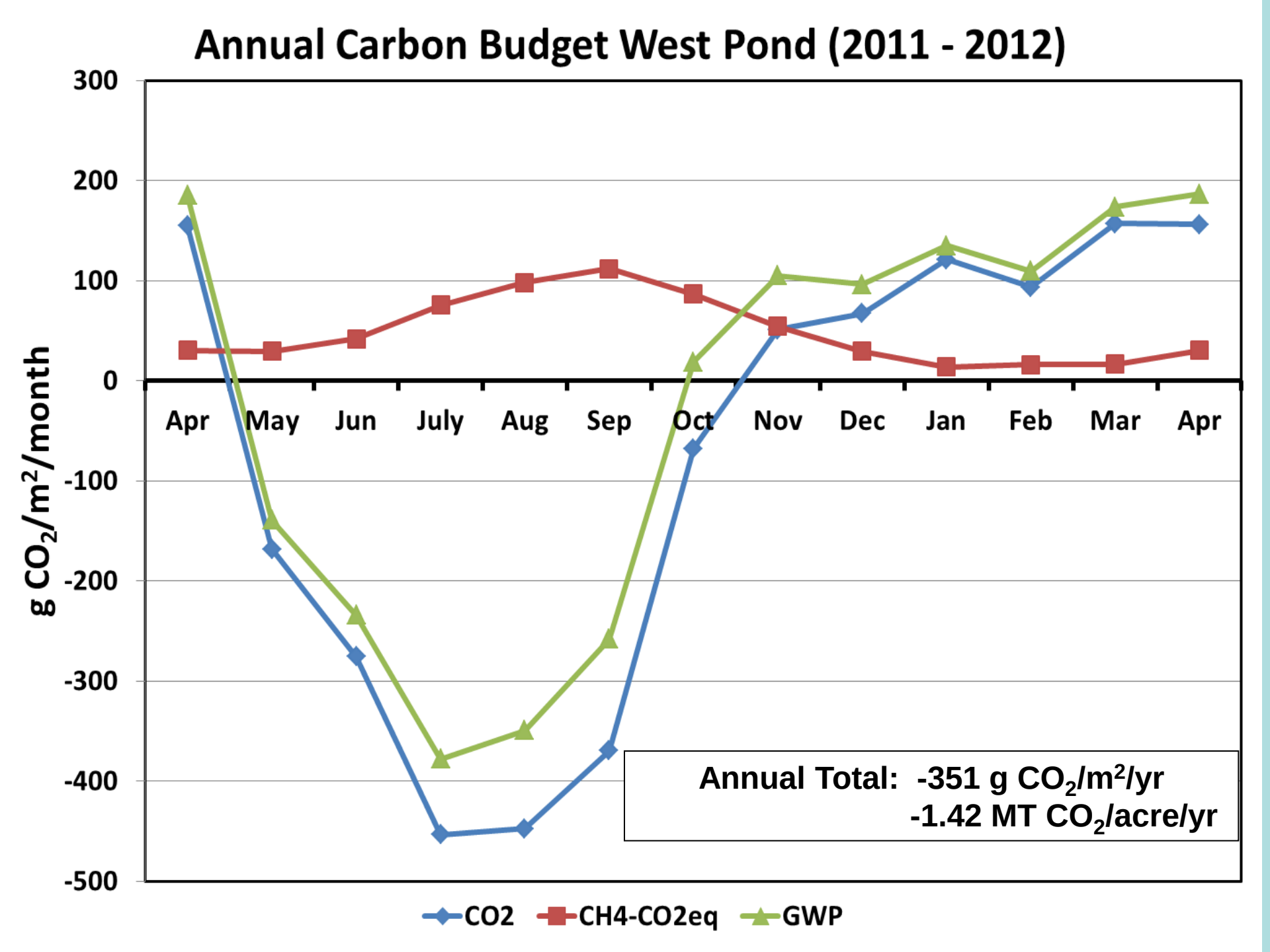
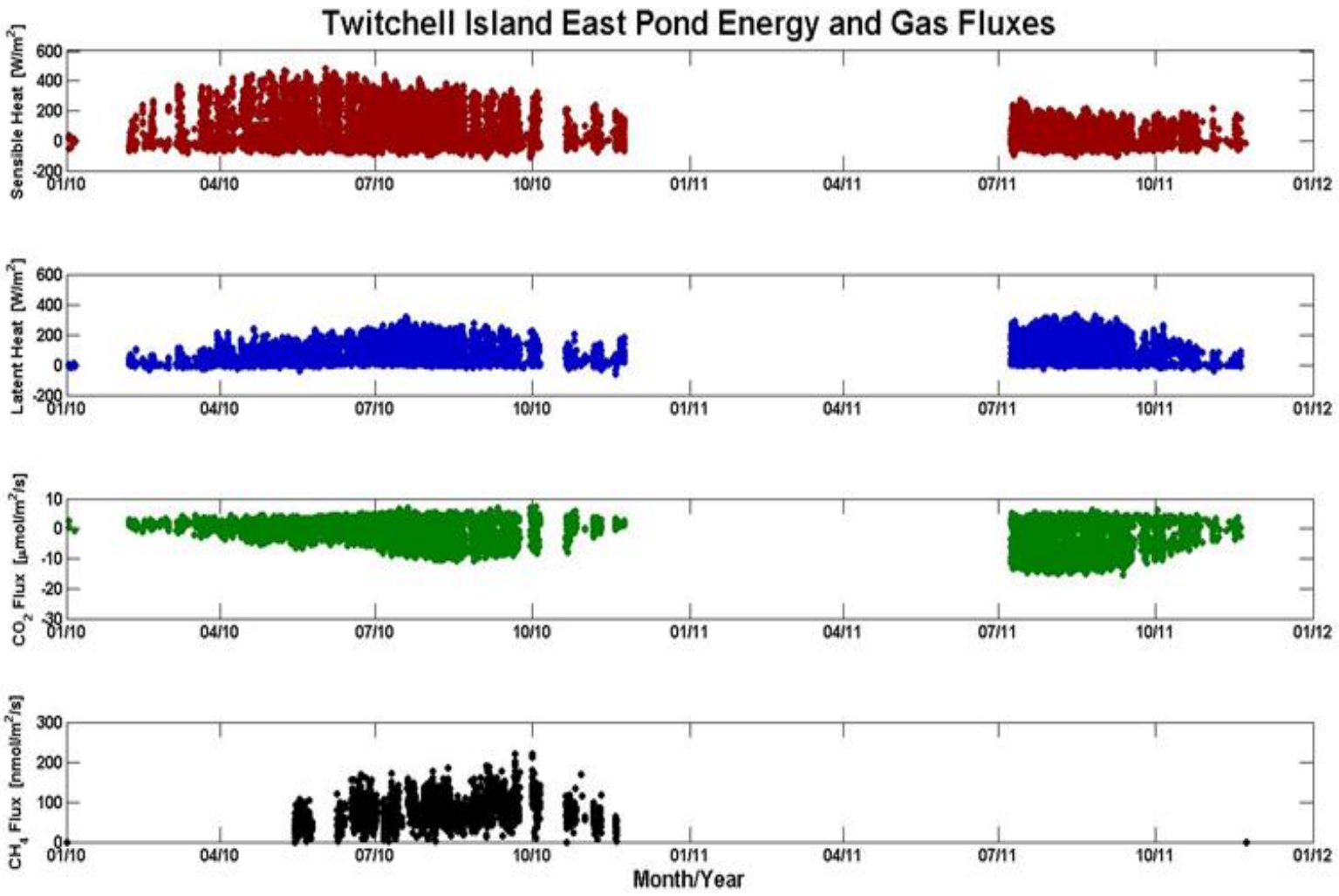

Annual Carbon Budget West Pond (2011 - 2012)
300
200
100
0
-100
-200
-300
-400
-500
g CO2/m2/month
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Annual Total: -351 g CO2/m2/yr
-1.42 MT CO2/acre/yr
CO2
CH4-CO2eq
GWP


Twitchell Island East Pond Energy and Gas Fluxes
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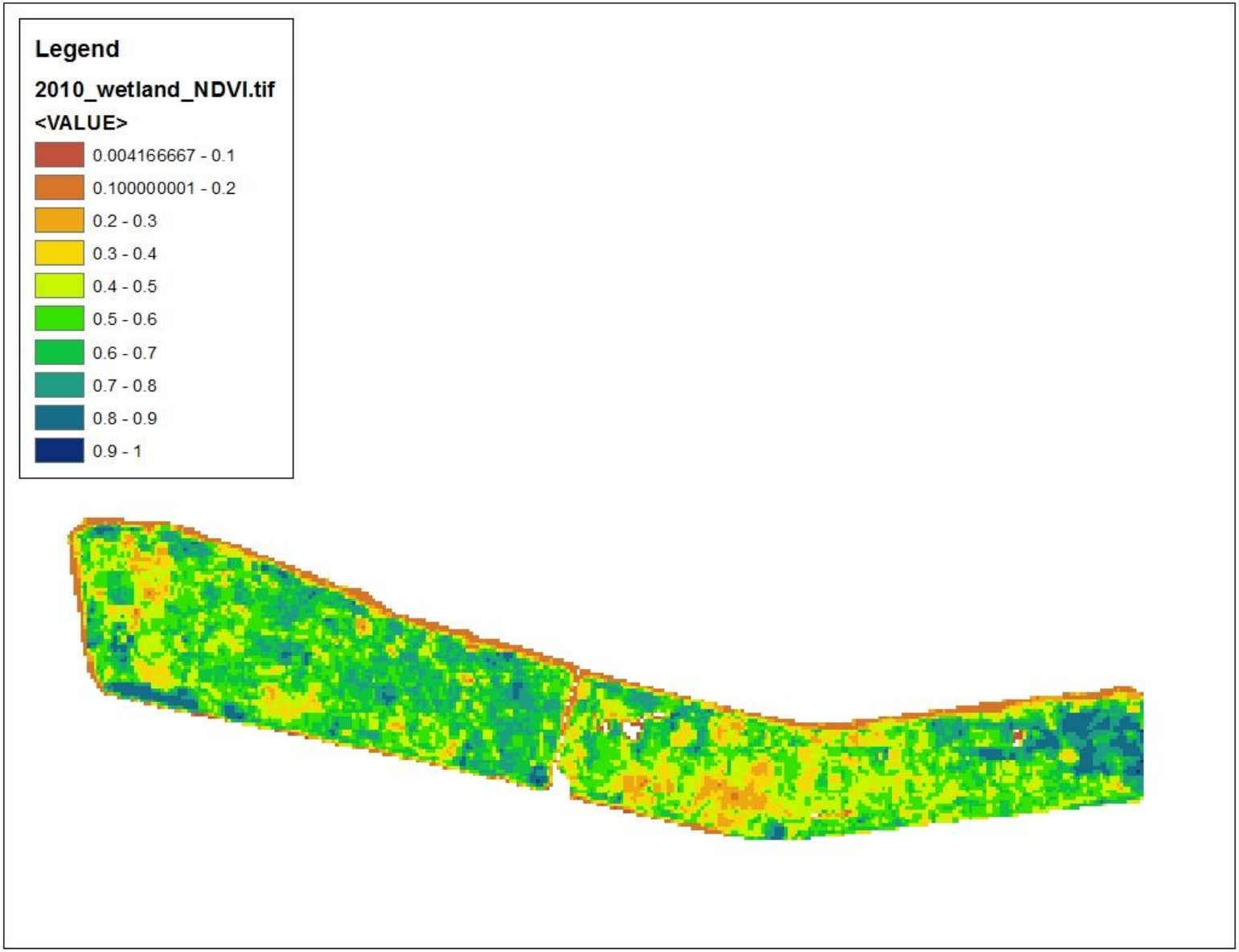
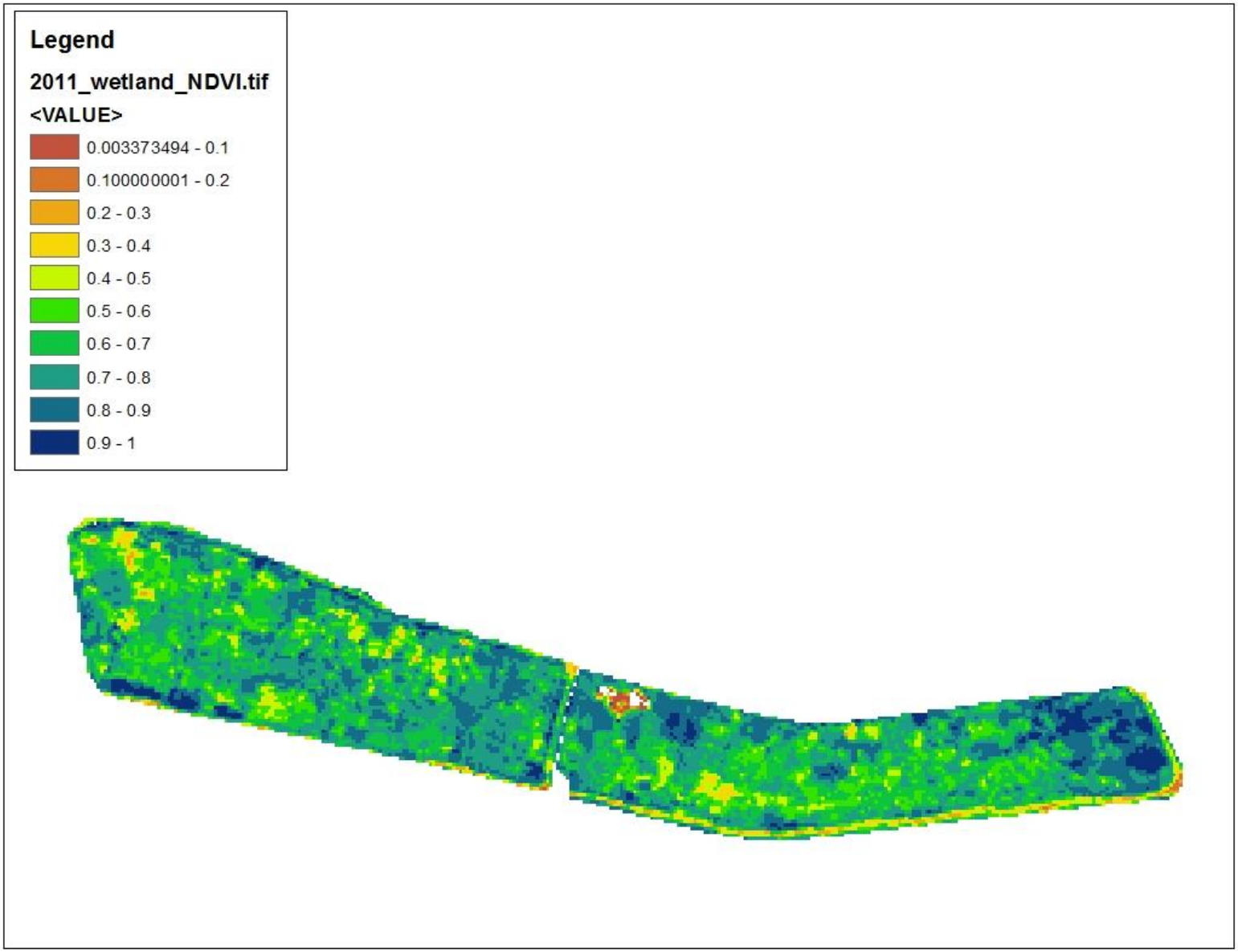
Latent Heat [W/m2]
CO2 Flux [μmol/m2/s]
CH4 Flux [nmol/m2/s]
600
400
200
0
-200
10
-10
-20
-30
300
100
01/10
04/10
07/10
10/10
01/11
04/11
07/11
10/11
01/12
Month/Year

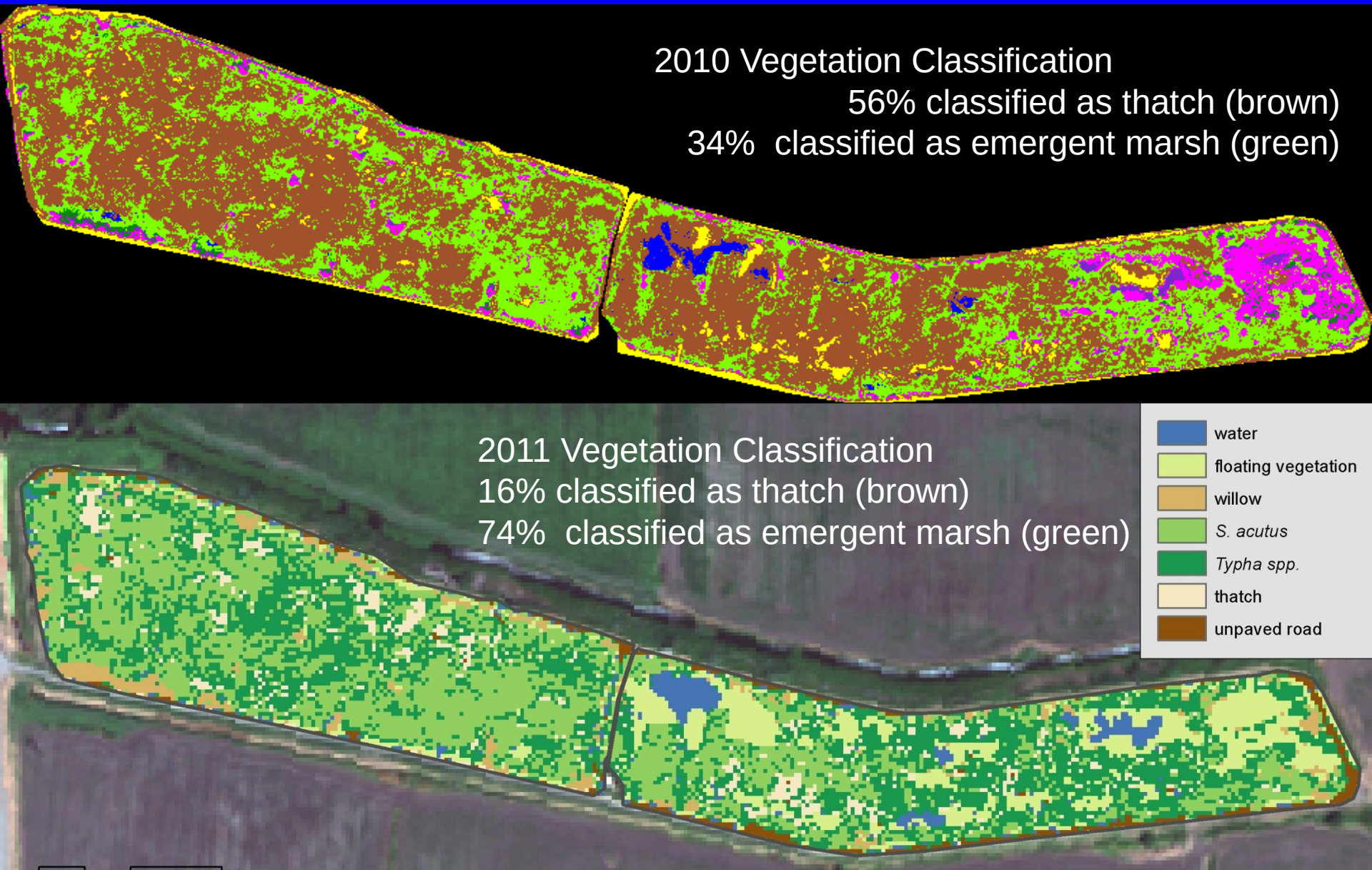
Early Summer 2010

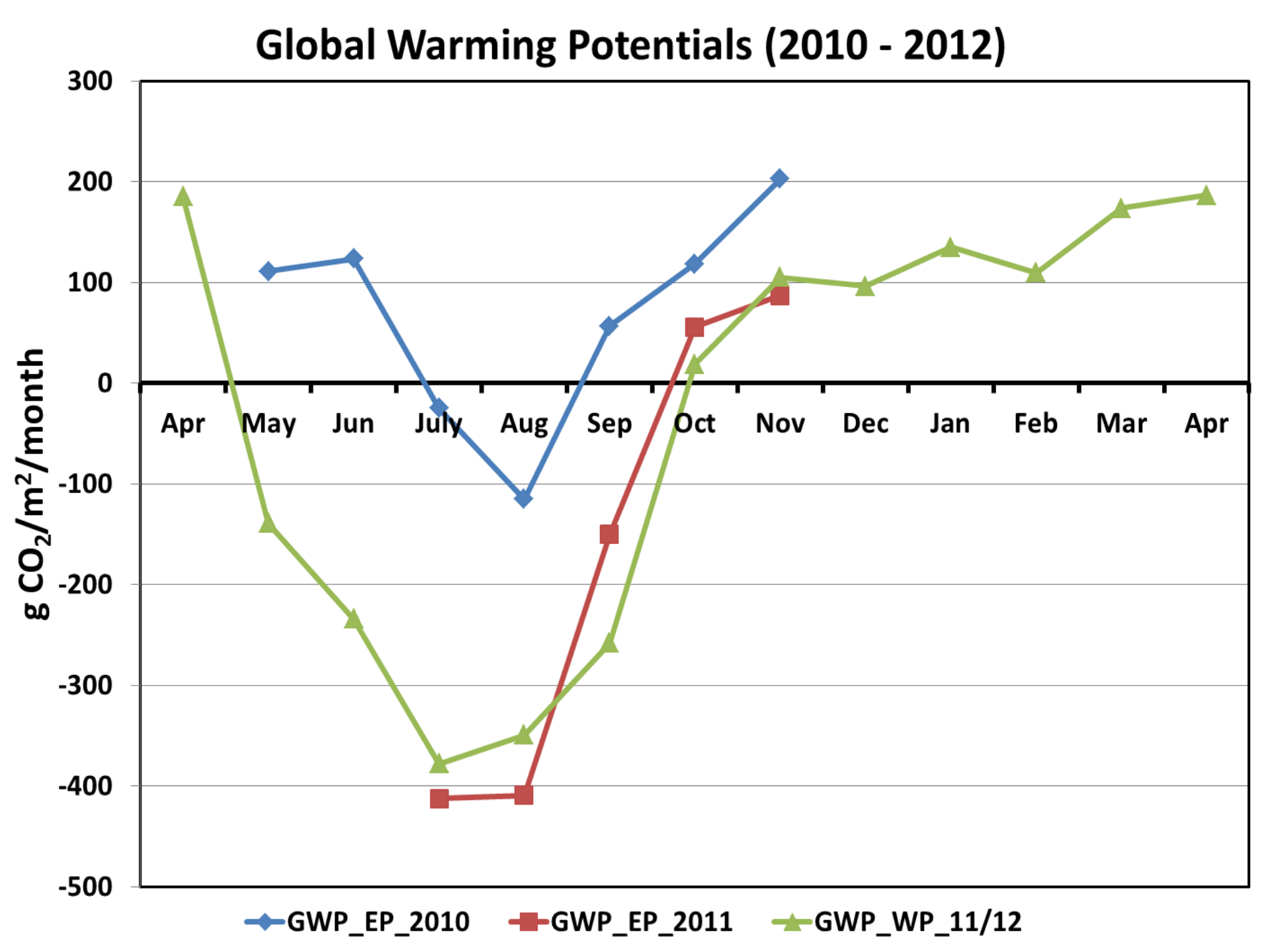

Legend
2010_wetland_NDVI.tif
<VALUE>
0.004166667 - 0.1
0.100000001 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1


Legend
2011_wetland_NDVI.tif
<VALUE>
0.003373494 - 0.1
0.100000001 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

To keep Carbon Sequestration rates high, need to

- **Maintain water levels**
- **Remove or bury thatch ("lodging")**




Global Warming Potentials (2010 - 2012)
300
200
100
0
-100
-200
-300
-400
-500
g CO2/m2/month
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
GWP_EP_2010
GWP_EP_2011
GWP_WP_11/12

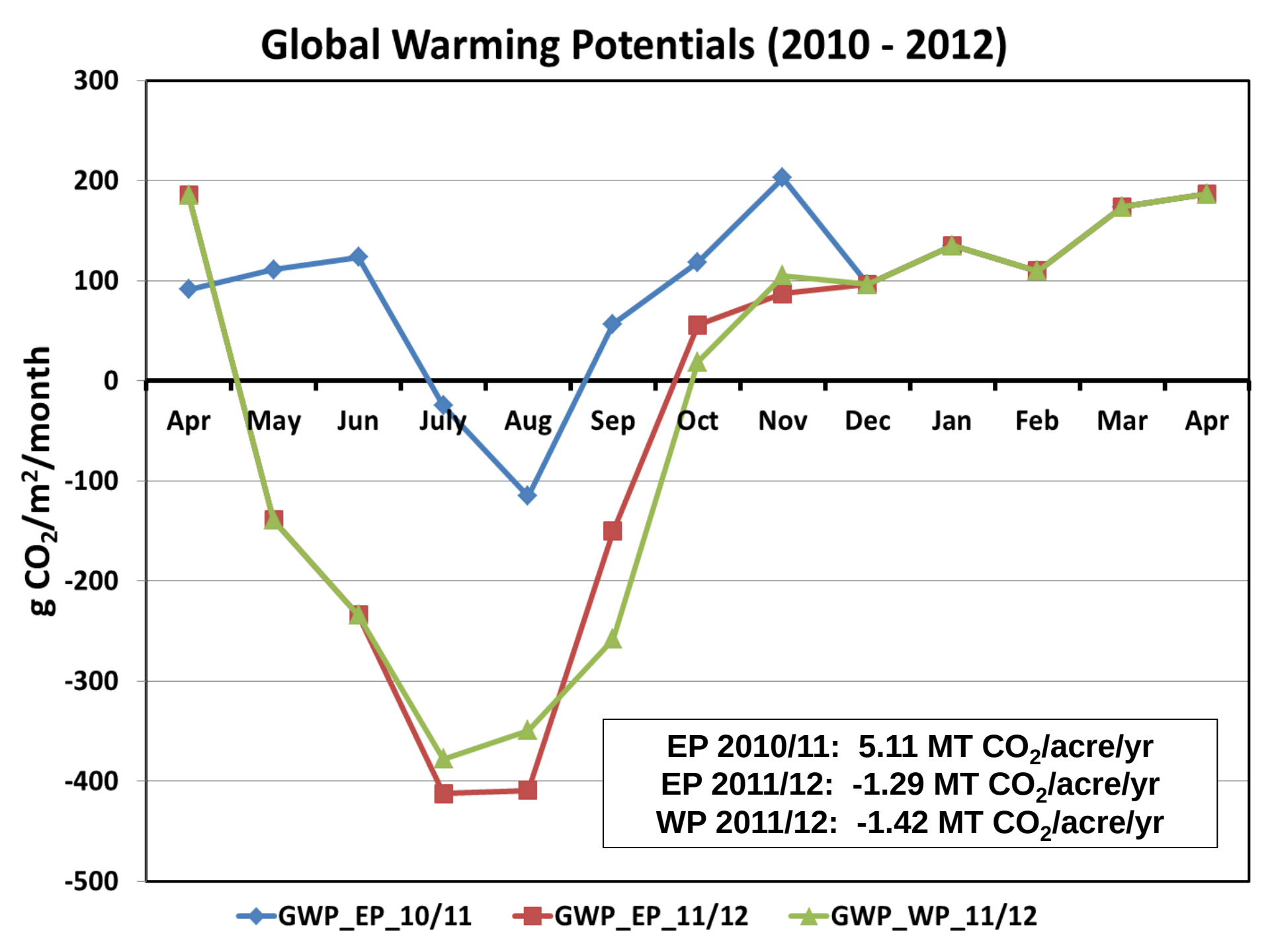

Global Warming Potentials (2010 - 2012)
300
200
100
0
-100
-200
-300
-400
-500
g CO2/m2/month
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
EP 2010/11: 5.11 MT CO2/acre/yr
EP 2011/12: -1.29 MT CO2/acre/yr
WP 2011/12: -1.42 MT CO2/acre/yr
GWP_EP_10/11
GWP_EP_11/12
GWP_WP_11/12

Fig 1

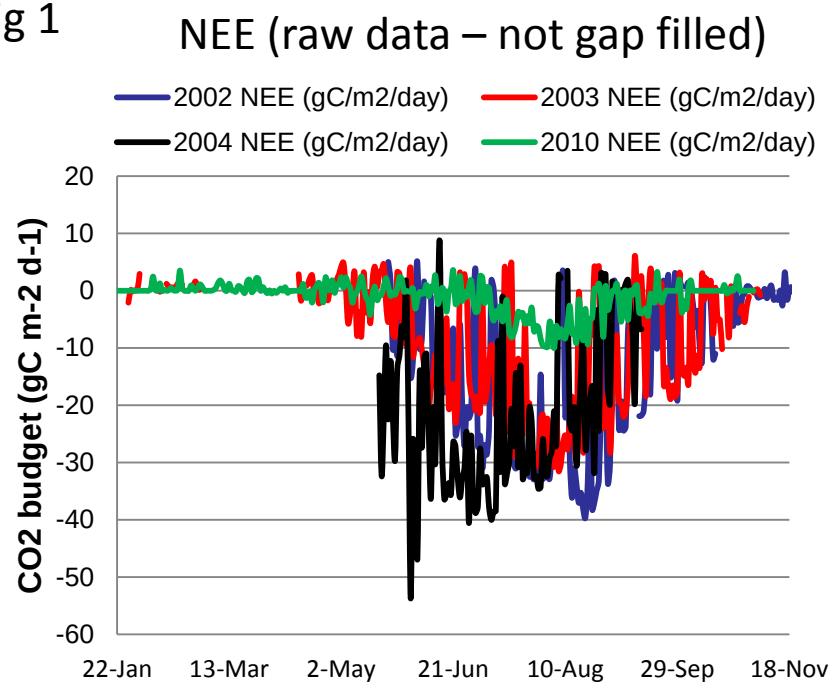


Fig 2 Continuous NEE (gapfilled 2010, 2000-2 DNDC)

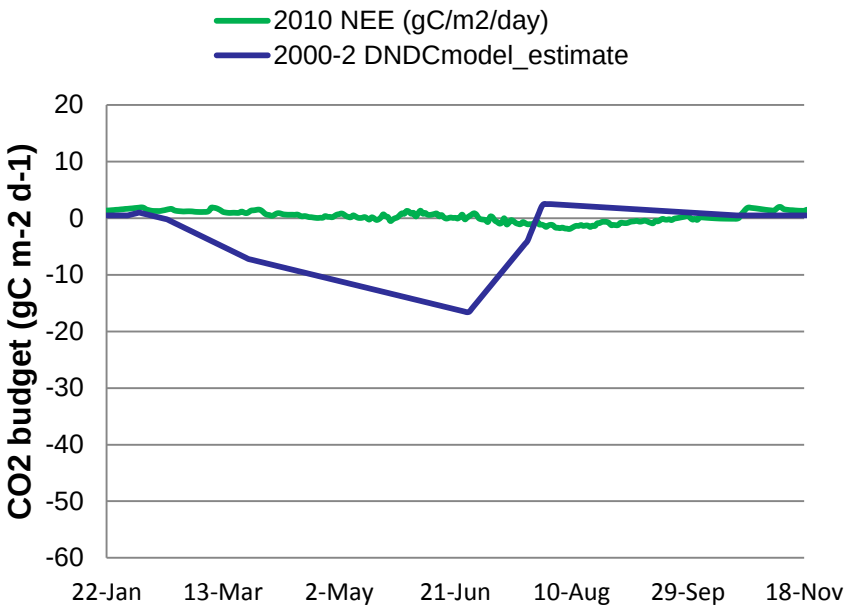


Fig 3

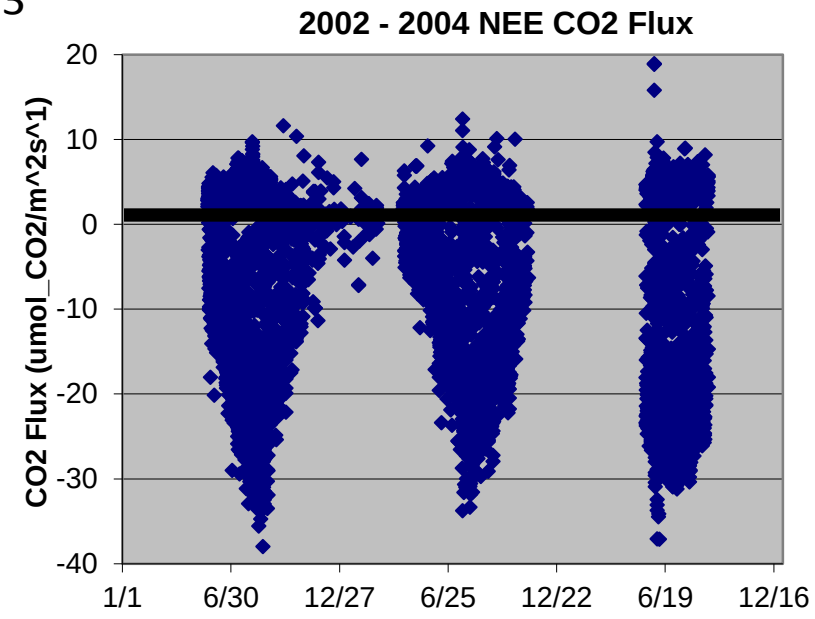
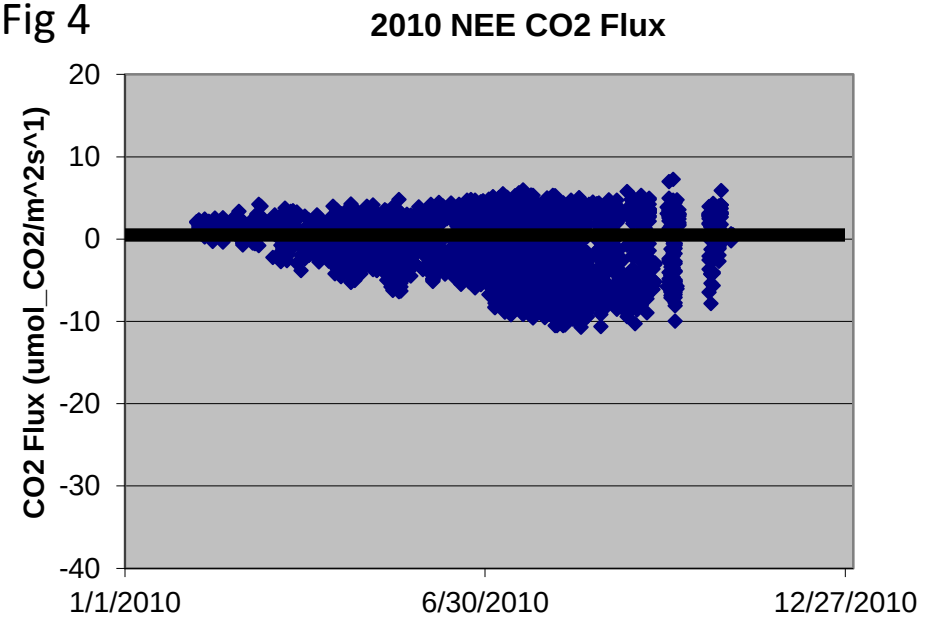


Fig 4



Summer 2003

Concluding Remarks

- The Delta's Mediterranean type climate can provide a long dry growing season with cool nights
- Annual variation in the East Pond alternating from a source to a sink
- The East Pond had 2 – 4 times higher NEE in it's earlier stages

Collaborators:

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UC Berkeley

Lisamarie Windham-Myers, Kristin Byrd, Brian Bergamaschi, Travis von Dessonneck, Kathleen Keating, Robin Miller, Roger Fujii

USGS

Funding Acknowledgements

This research is supported by:

USGS Climate Change Program, California's DWR Levee Program, and the USGS Cooperative Research Program

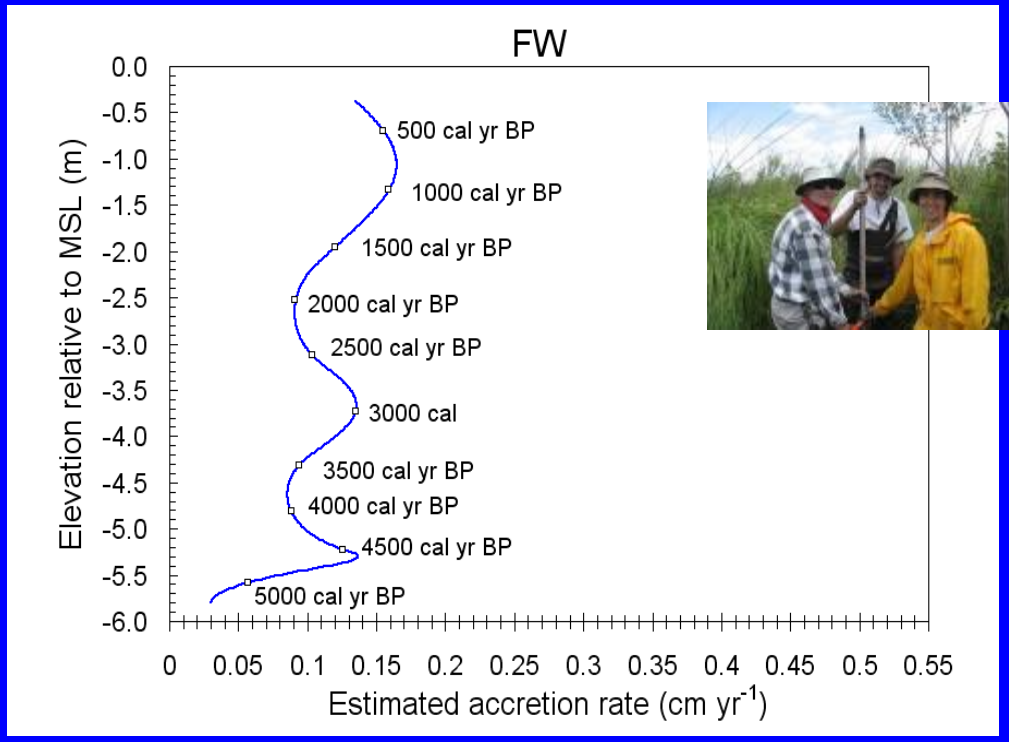
Freshwater marsh restoration on subsided Delta islands

(Peat fills the consistent 25-55cm accomodation space)

Lisamarie Windham-Myers, INTECOL, 2012

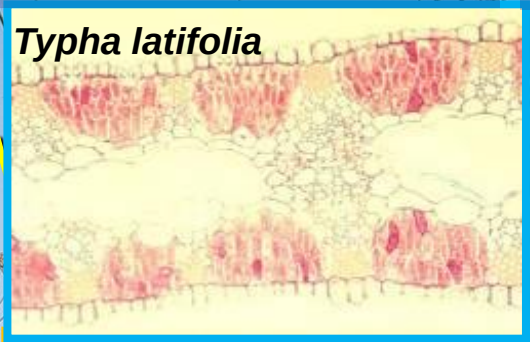
Constant, large accomodation space

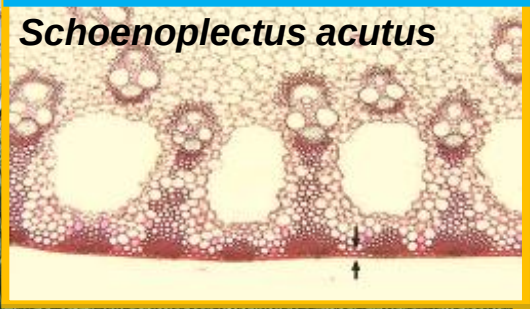
Freshwater tidal wetlands accrete peat at average rates of only ~1.5 mm yr^{-1} (RSLR)



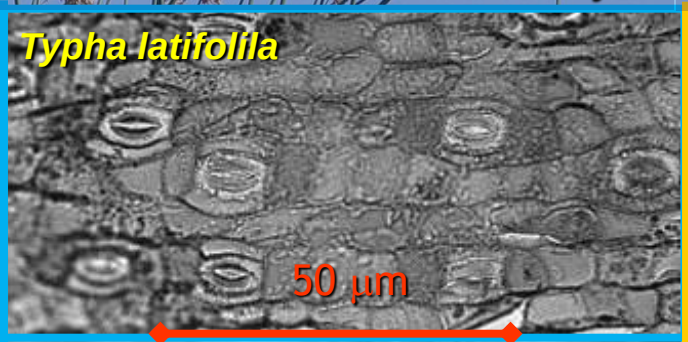
Drexler et al. (2009) Wetlands

Leaf structure





Stomate size and density



Oxidized rhizosphere

THE PLANTS

Moderate GPP w/high vertical LAI

Tule: Lignified, aerenchymous, high stomatal density