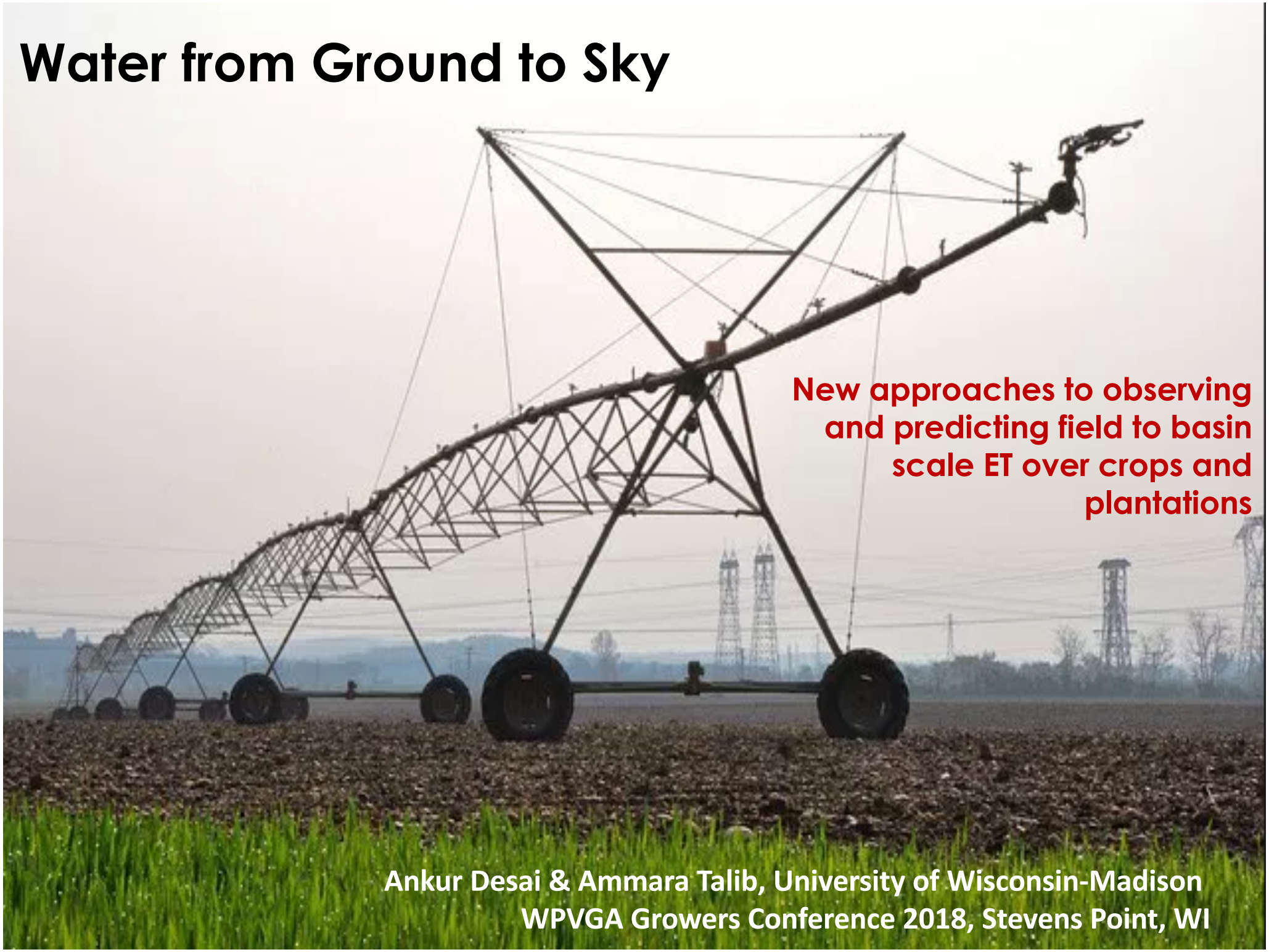
Water from Ground to Sky



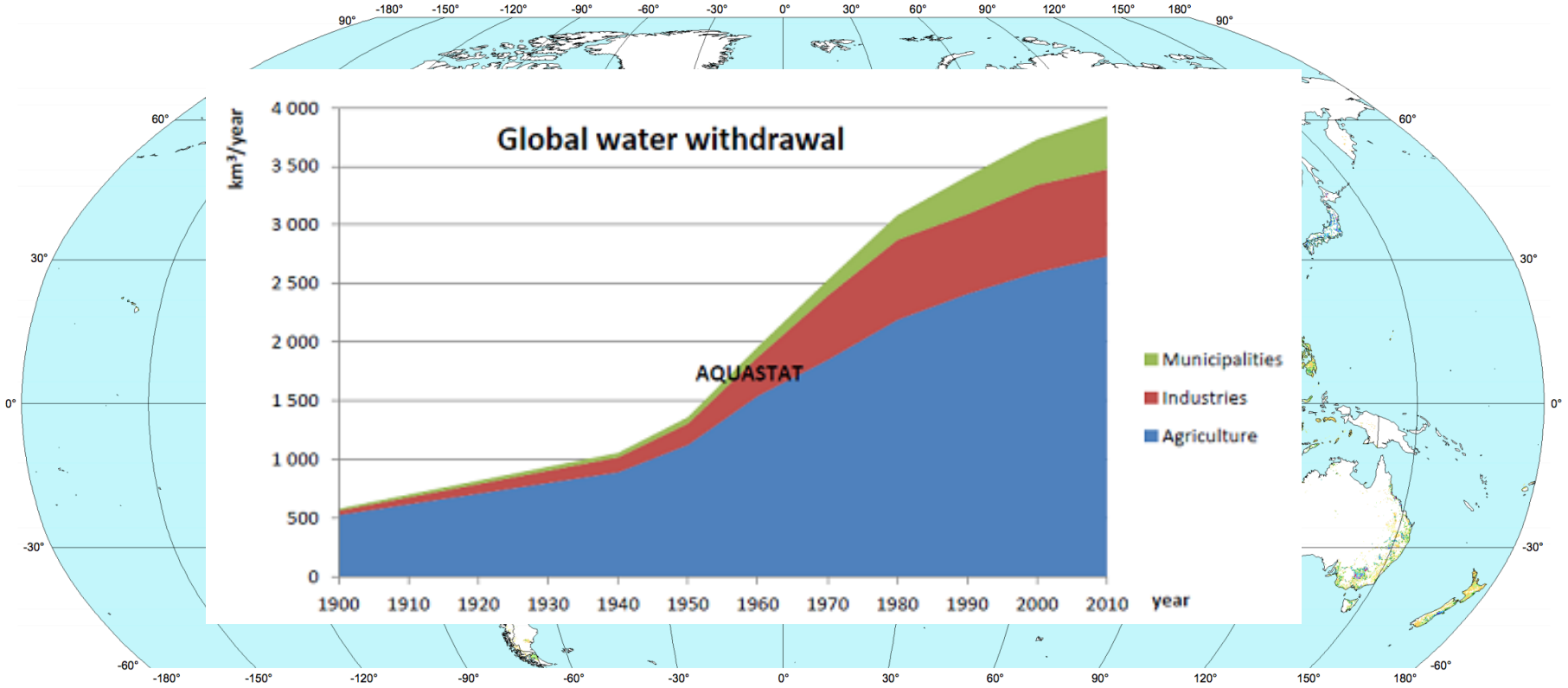
New approaches to observing and predicting field to basin scale ET over crops and plantations

Ankur Desai & Ammara Talib, University of Wisconsin-Madison

WPVGA Growers Conference 2018, Stevens Point, WI

The digital global map of irrigation areas

October 2013



Area equipped for irrigation in percentage of land area

0	10 - 20
< 0.1	20 - 35
0.1 - 1	35 - 50
1 - 5	50 - 75
5 - 10	75 - 100

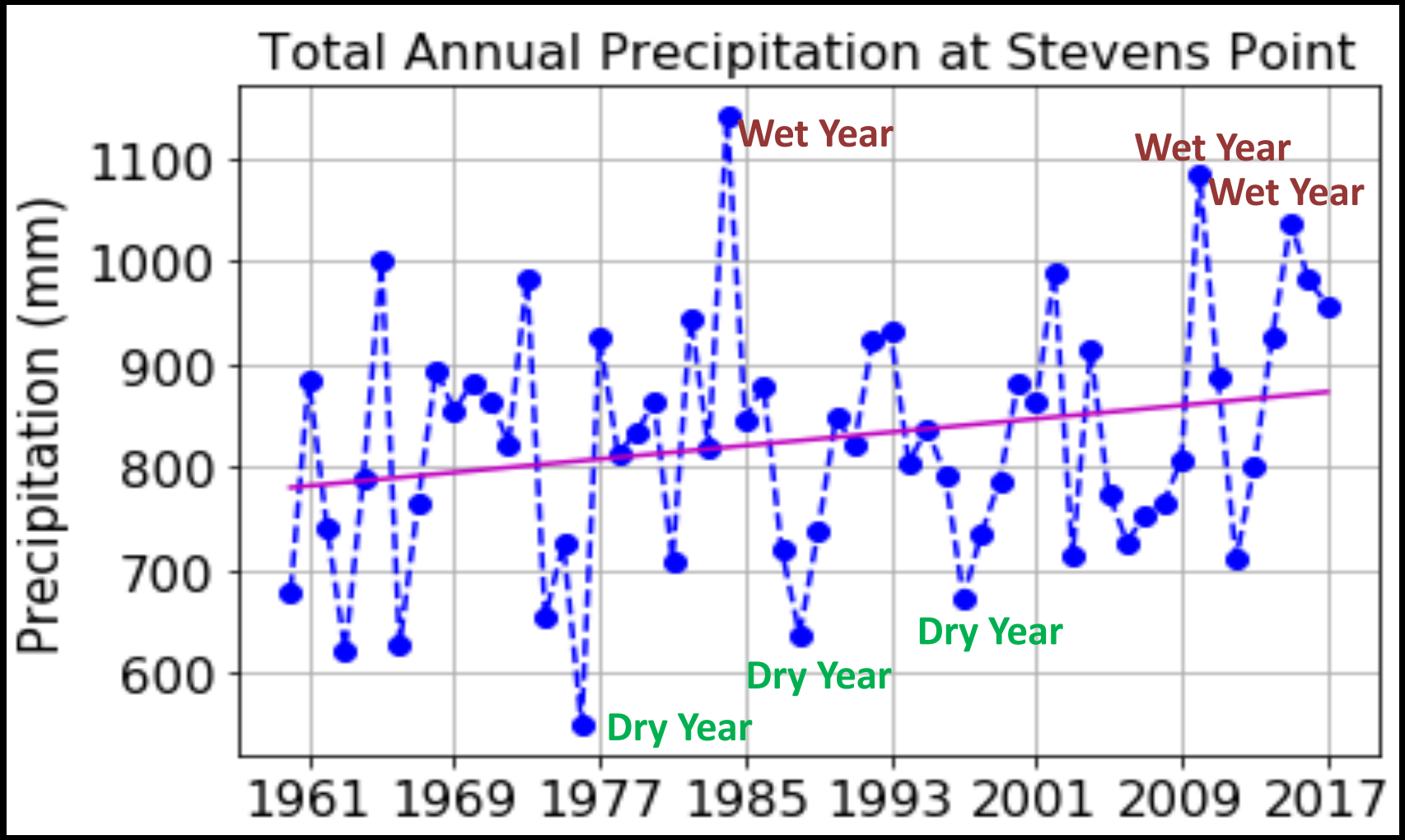
The map shows area equipped for irrigation in percentage of cell area. For the majority of countries the base year of statistics is in the period 2000 - 2008.

Projection: Robinson
Resolution: 5 arc-minutes

http://www.fao.org/nr/water/aquastat/irrigationmap/index.stm

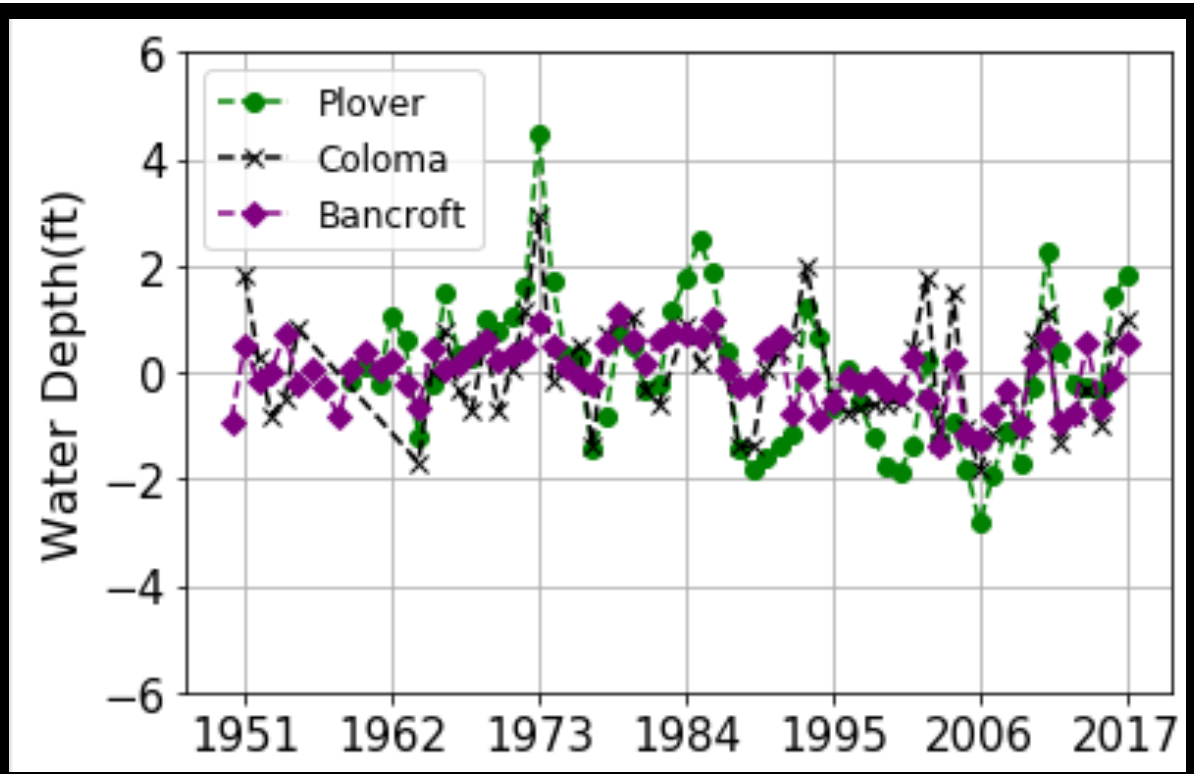
Stefan Siebert, Verena Henrich (Institute of Crop Science and Resource Conservation, University of Bonn, Germany) and
Karen Frenken, Jacob Burke (Land and Water Division, Food and Agriculture Organization of the United Nations, Rome, Italy)

universitätbonn

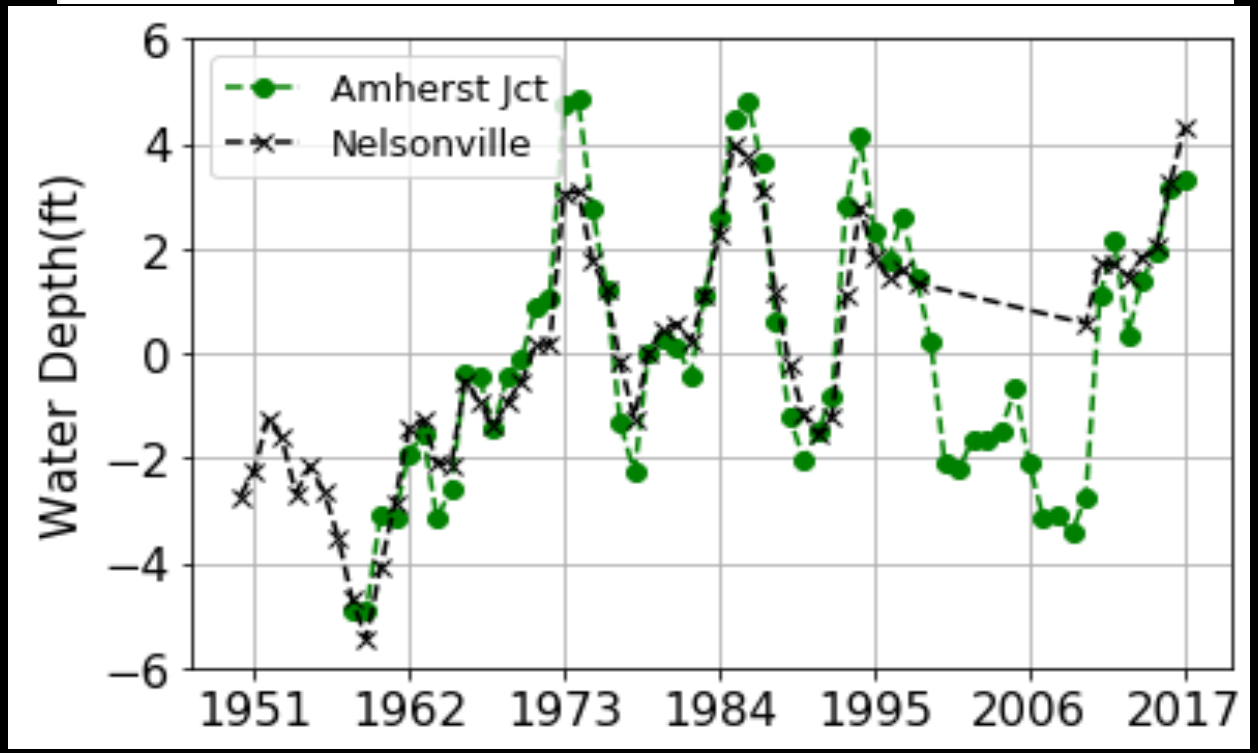

Total Annual Precipitation at Stevens Point
Precipitation (mm)
1100
1000
900
800
700
600
1961
1969
1977
1985
1993
2001
2009
2017
Wet Year
Wet Year
Wet Year
Dry Year
Dry Year
Dry Year


War Over Water in a Land of Plenty


- NOTICE -
TREATED LAKE
ADVISE
CATCH & RELEASE
NO LITTERING
PREVENT THE SPREAD OF
INVASIVE SPECIES
IT'S THE LAW
STOP AQUATIC HITCHHIKERS!
Long Lake
No Wake



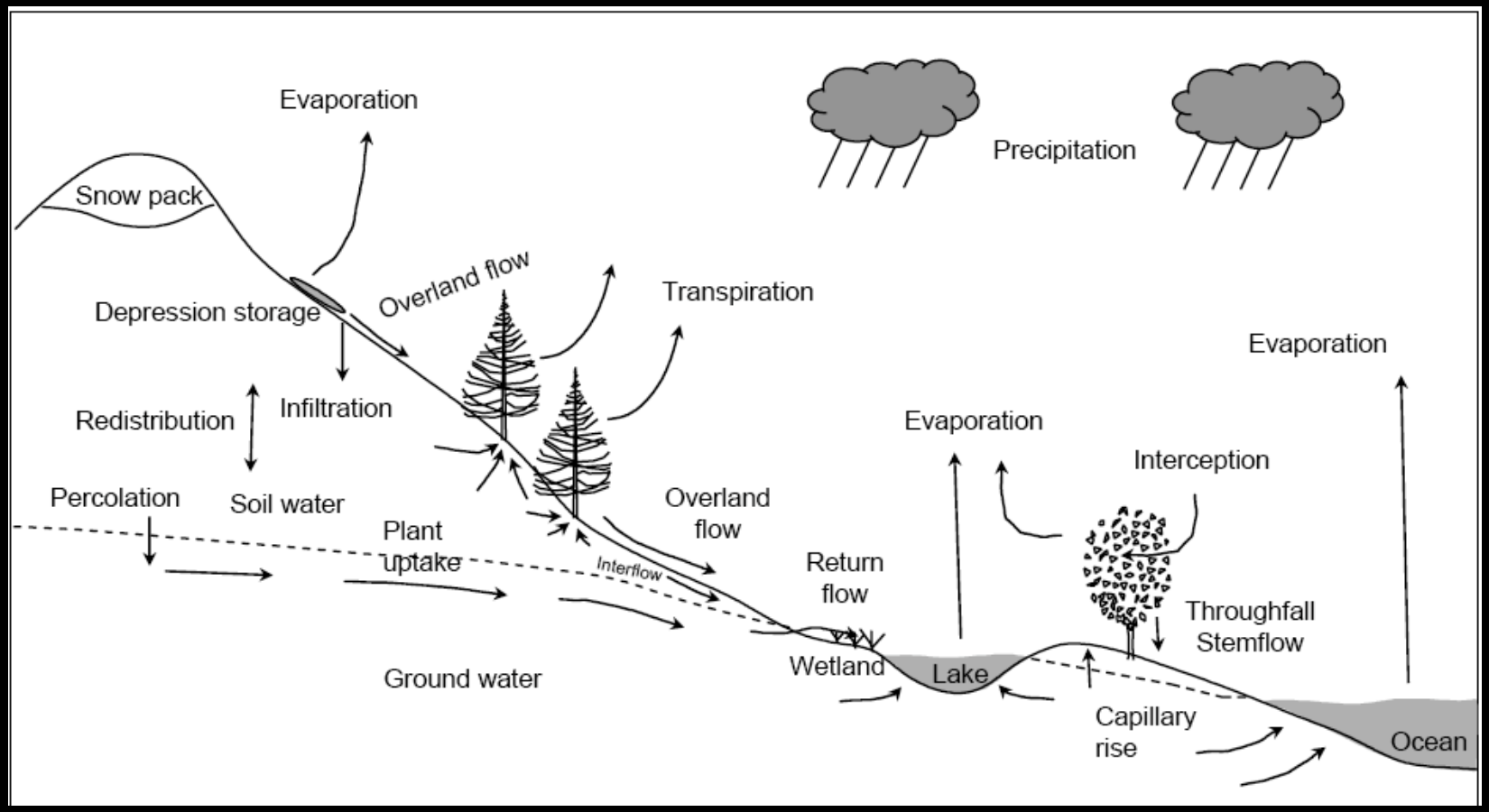
High Capacity Wells



Low Capacity Wells

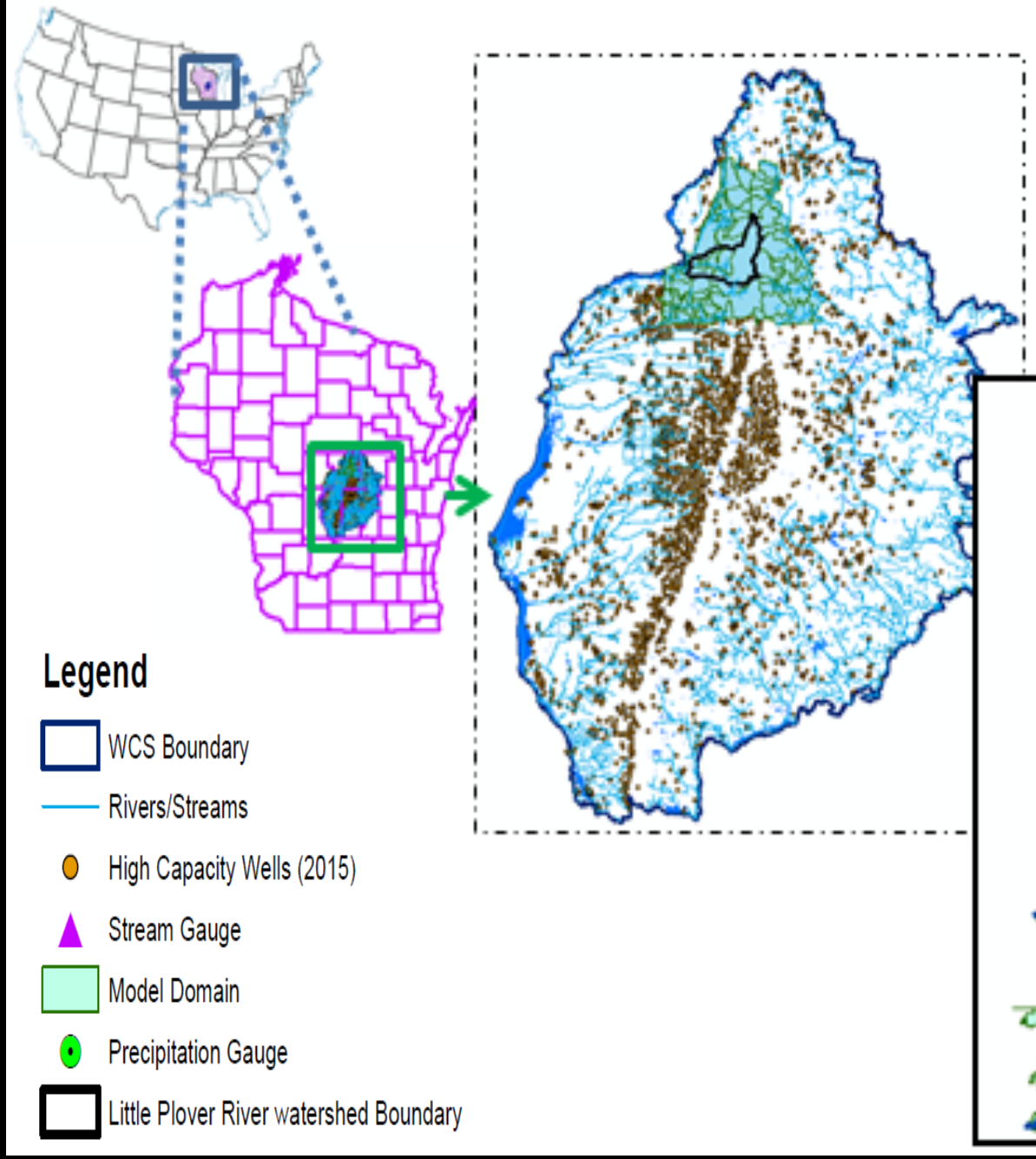
Regionally, terrestrial evapotranspiration (ET) is a dominant component of the water cycle

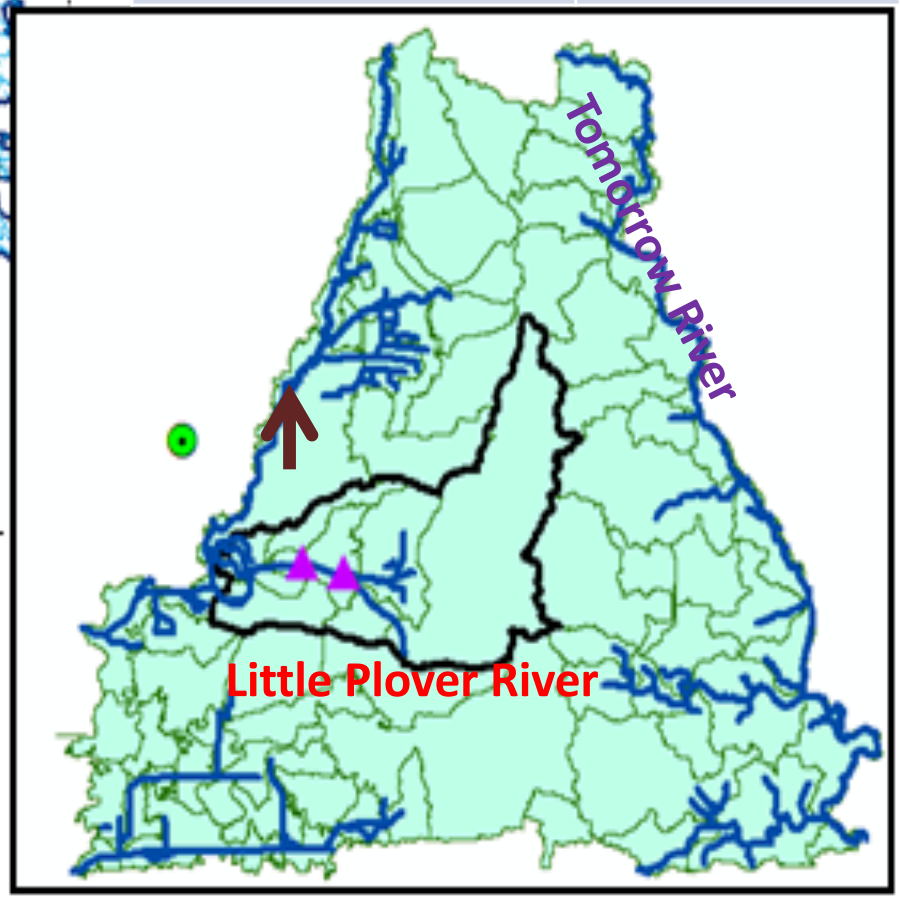
AND HARD TO MEASURE WELL!



Chapin, 2011, Principles of Terrestrial Ecosystem Ecology

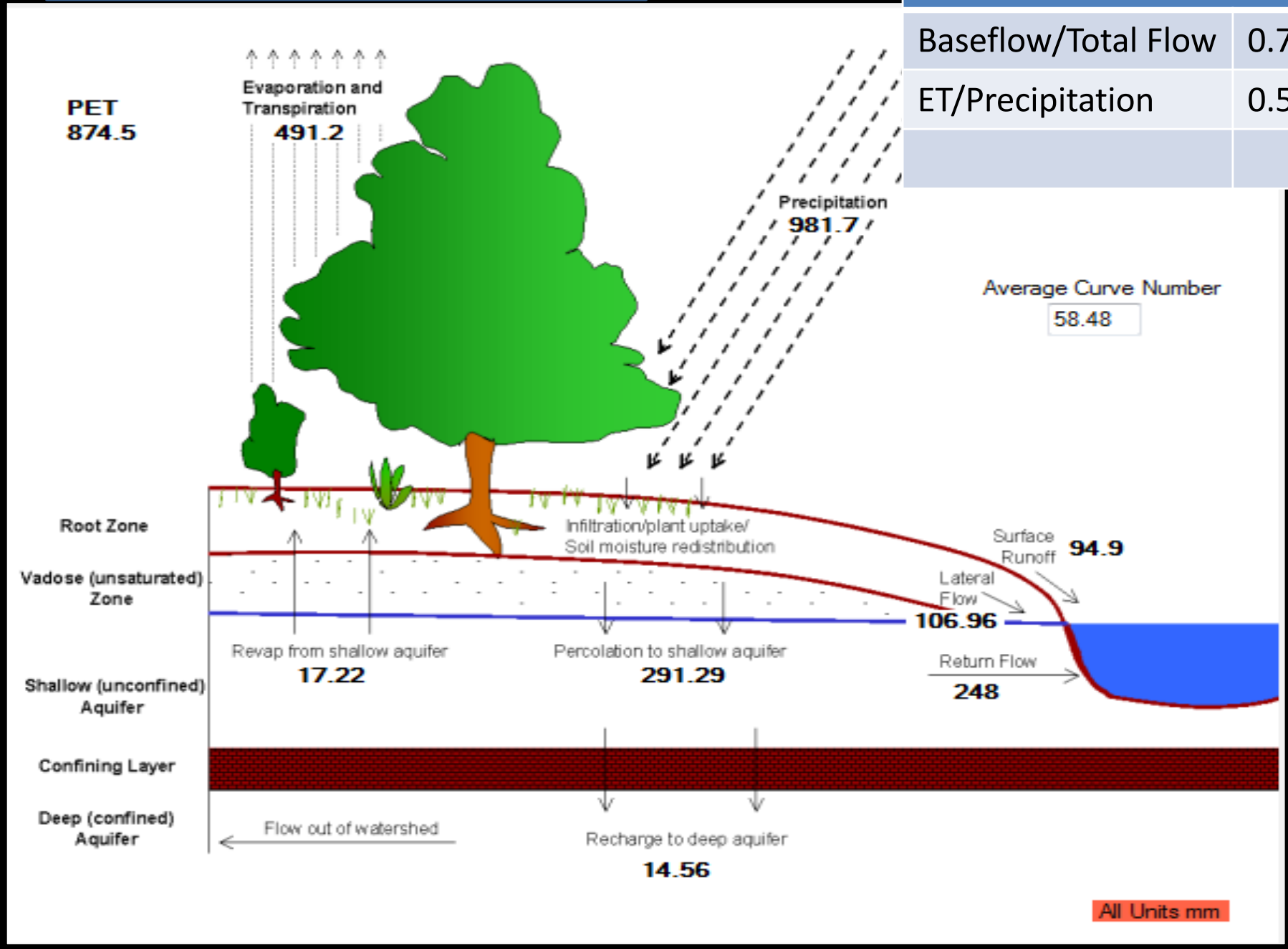
Landuse	Percentage
Deciduous Forest	32
Corn	20
Alfalfa	12
Sweet Corn	7
Potato	5

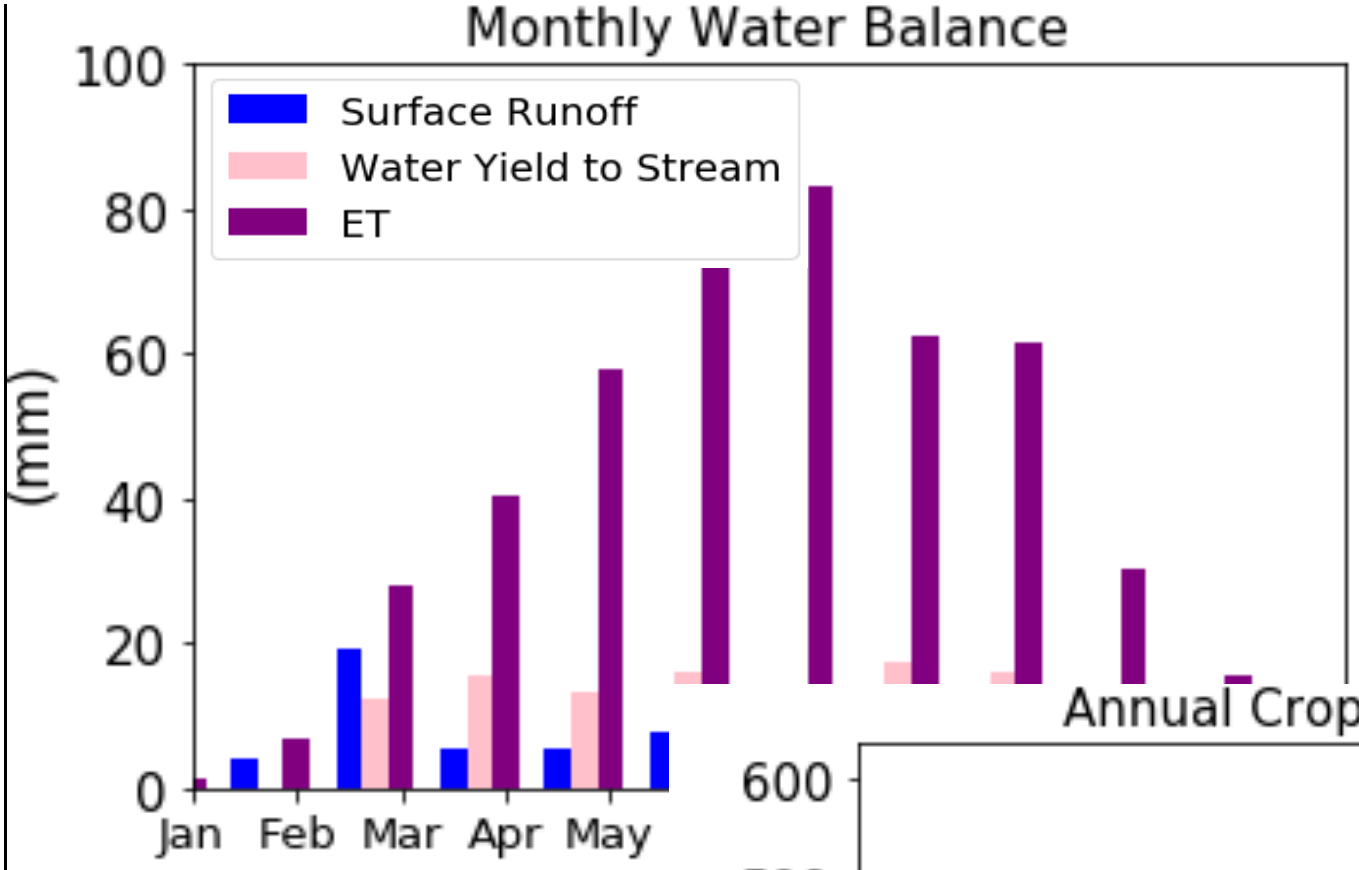


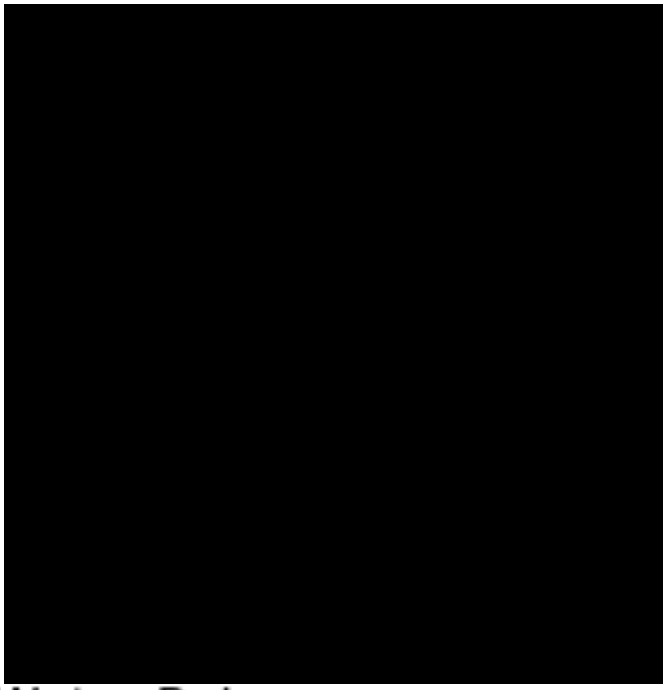


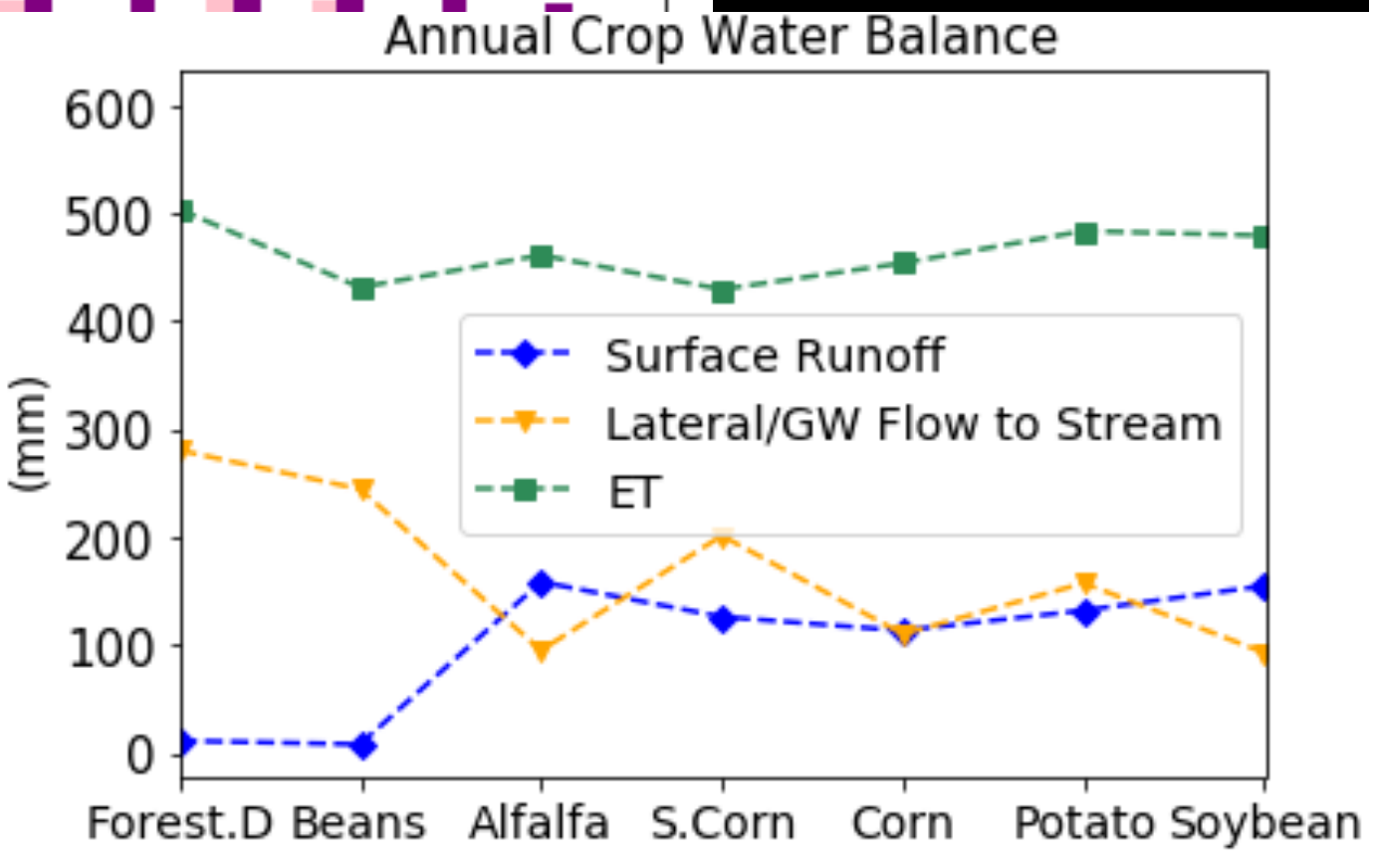
Annual Average water Budget

Water balance Ratio	
Baseflow/Total Flow	0.79
ET/Precipitation	0.5

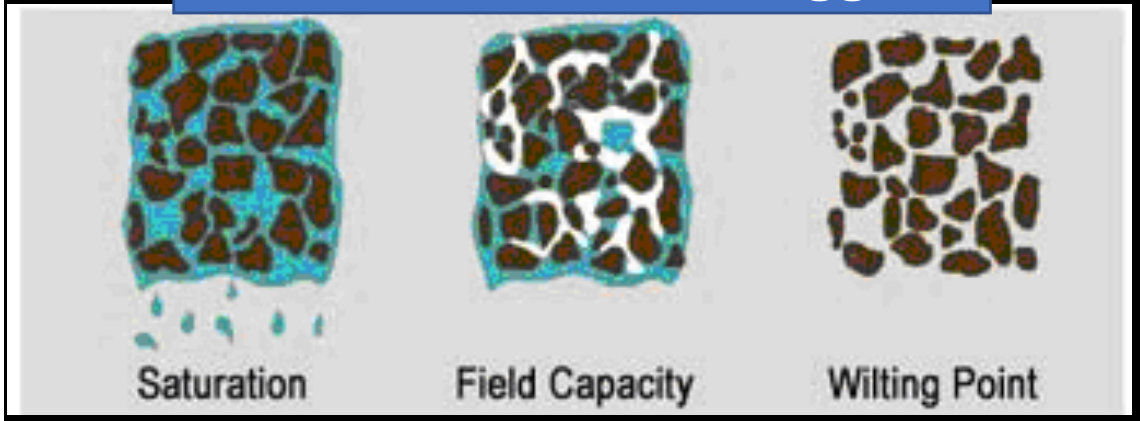



Monthly Water Balance
Surface Runoff
Water Yield to Stream
ET
(mm)
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May

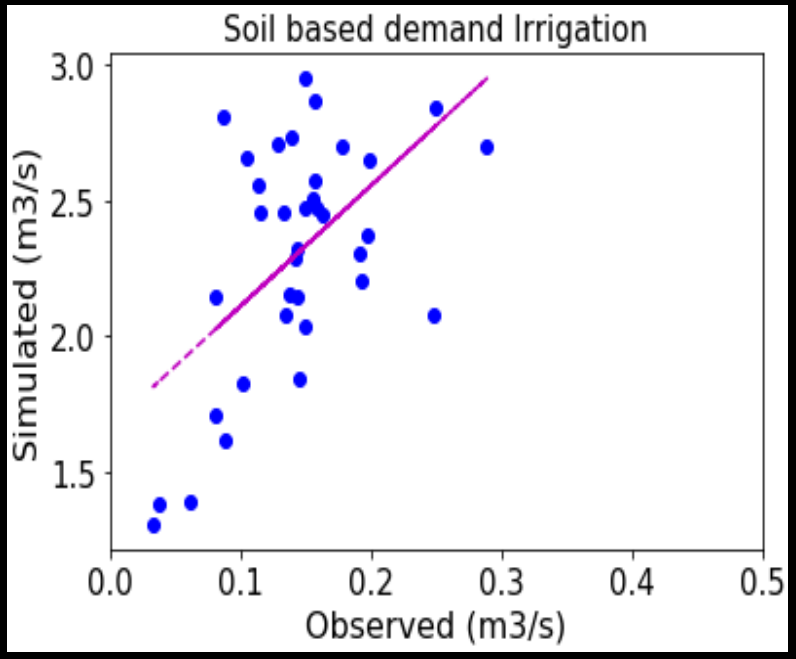


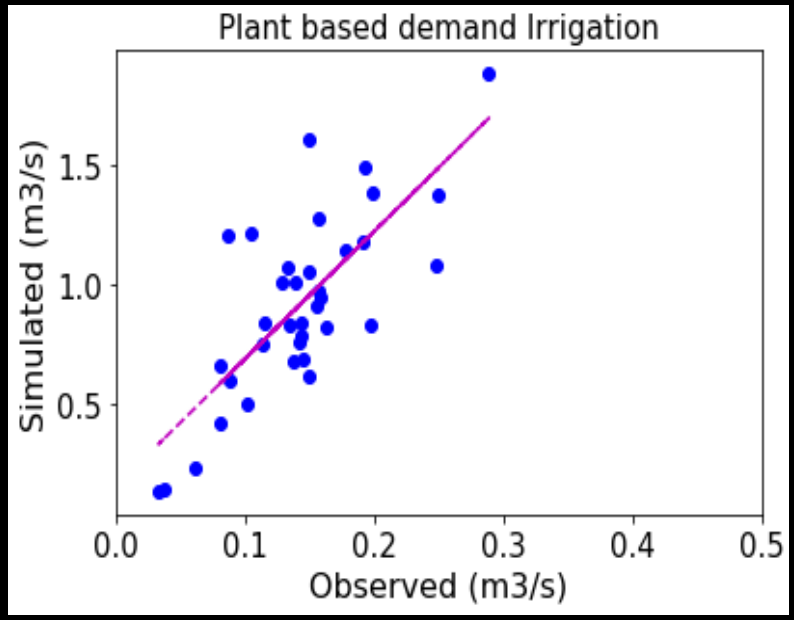

Annual Crop Water Balance
(mm)
600
500
400
300
200
100
0
Surface Runoff
Lateral/GW Flow to Stream
ET
Forest.D
Beans
Alfalfa
S.Corn
Corn
Potato
Soybean

Soil water demand trigger



Plant water demand trigger





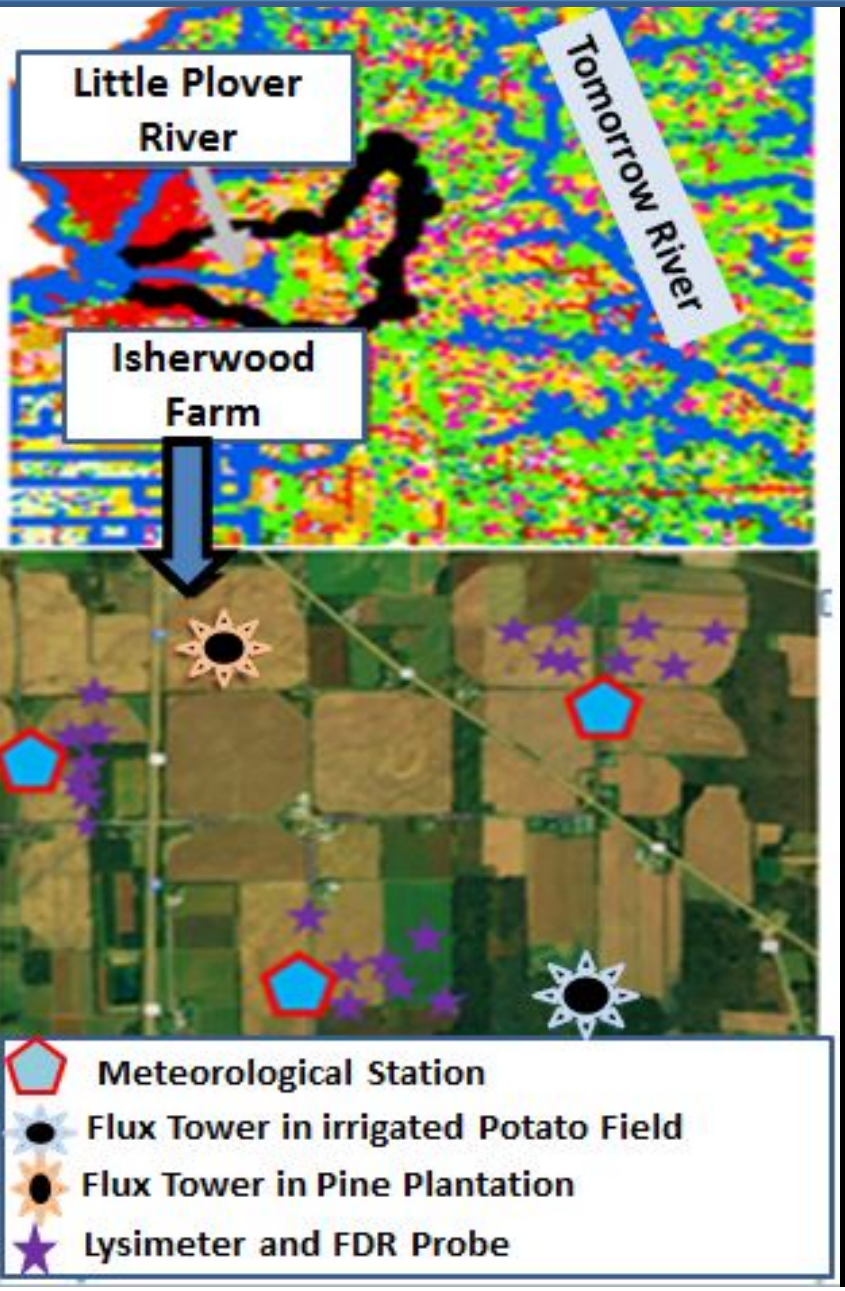
Average Monthly Streamflow (m^3/s)

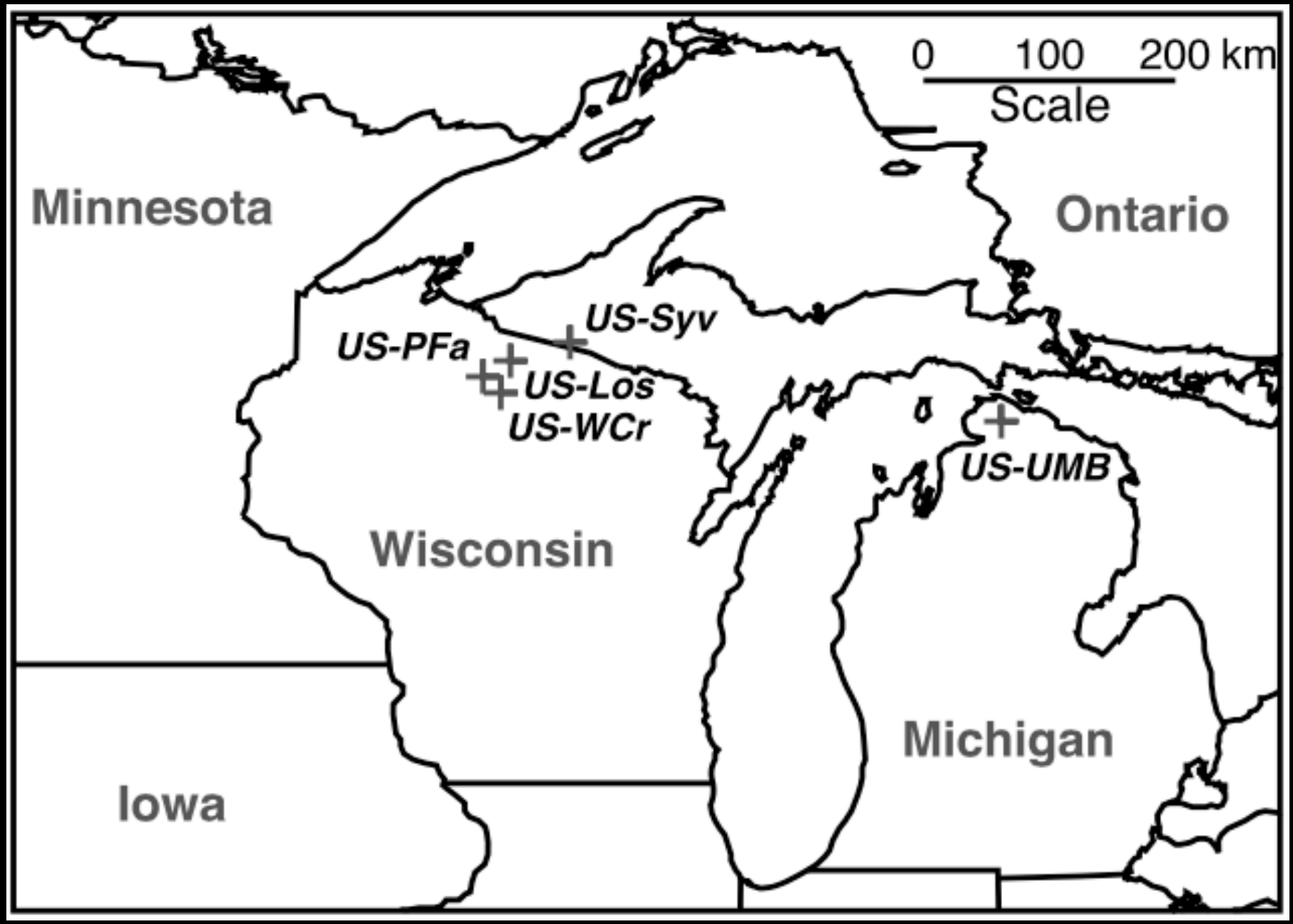
Evapotranspiration and recharge measurements

Coupling with Ground water Model for Recharge

Irrigation Demand uncertainty in Model

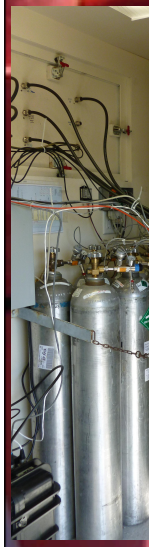
Optimization of Hydrologic model

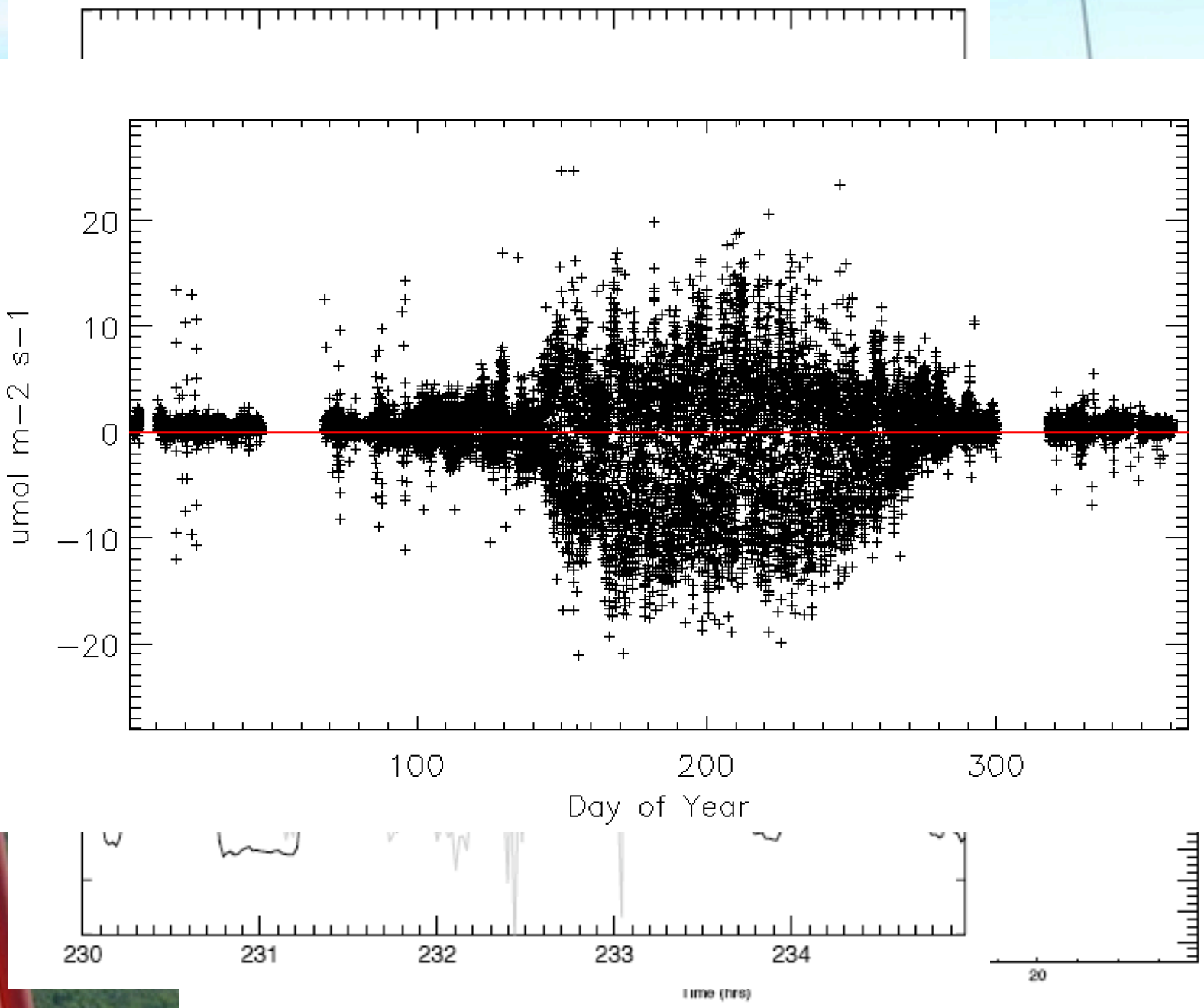



0 100 200 km
Scale
Minnesota
Ontario
US-Syv
US-PFa
US-Los
US-WCr
US-UMB
Wisconsin
Michigan
Iowa

Thermistor, hygrometer,

Infi
ana



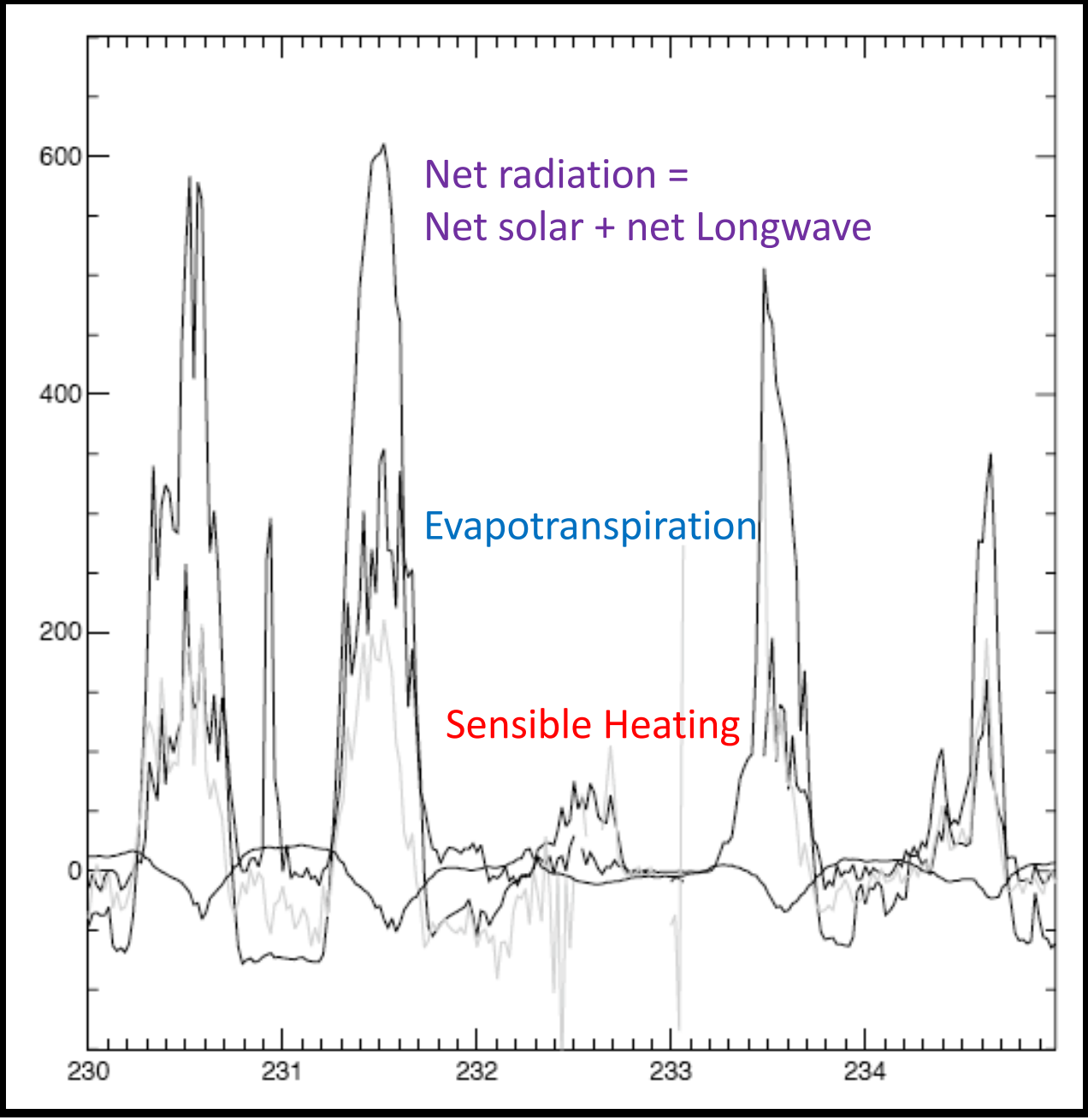


Some questions

- How tall? The taller the tower, the large area ET you measure (around 10-100x upwind of tower). Needs to be at least ~6 feet above canopy.
- How much power? Can be run on solar, continuously log data at ten times a second, output ET and carbon fluxes every 30 minutes
- Cost? $30-40K per system
- How reliable? As long as sample area is homogenous and uptime is good, eddy covariance is the gold standard for field-regional ET

Five days of observations

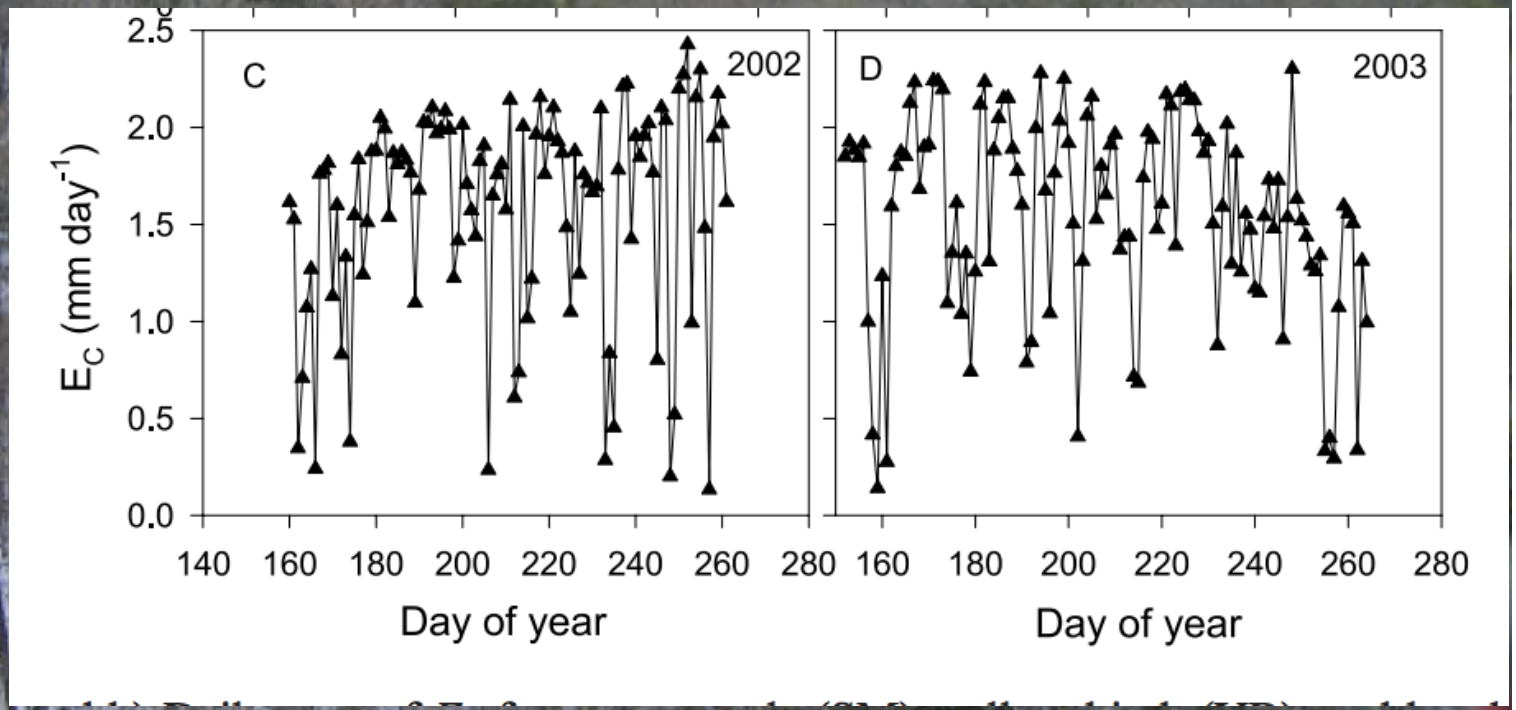
Watts
Per
Square
Meter



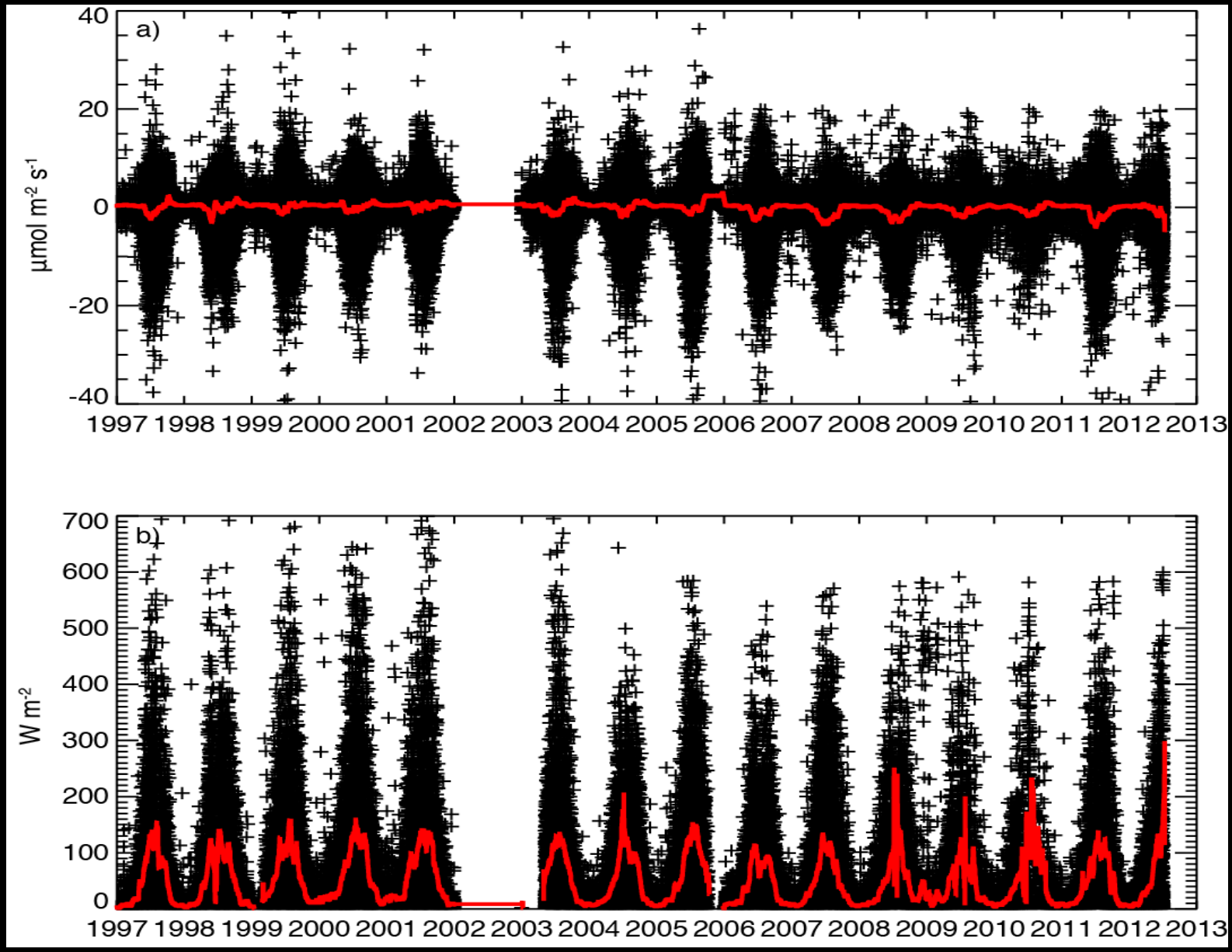
200 days of observations

Sylvania Wilderness site in UP Michigan (Watersmeet, MI), est. 2001

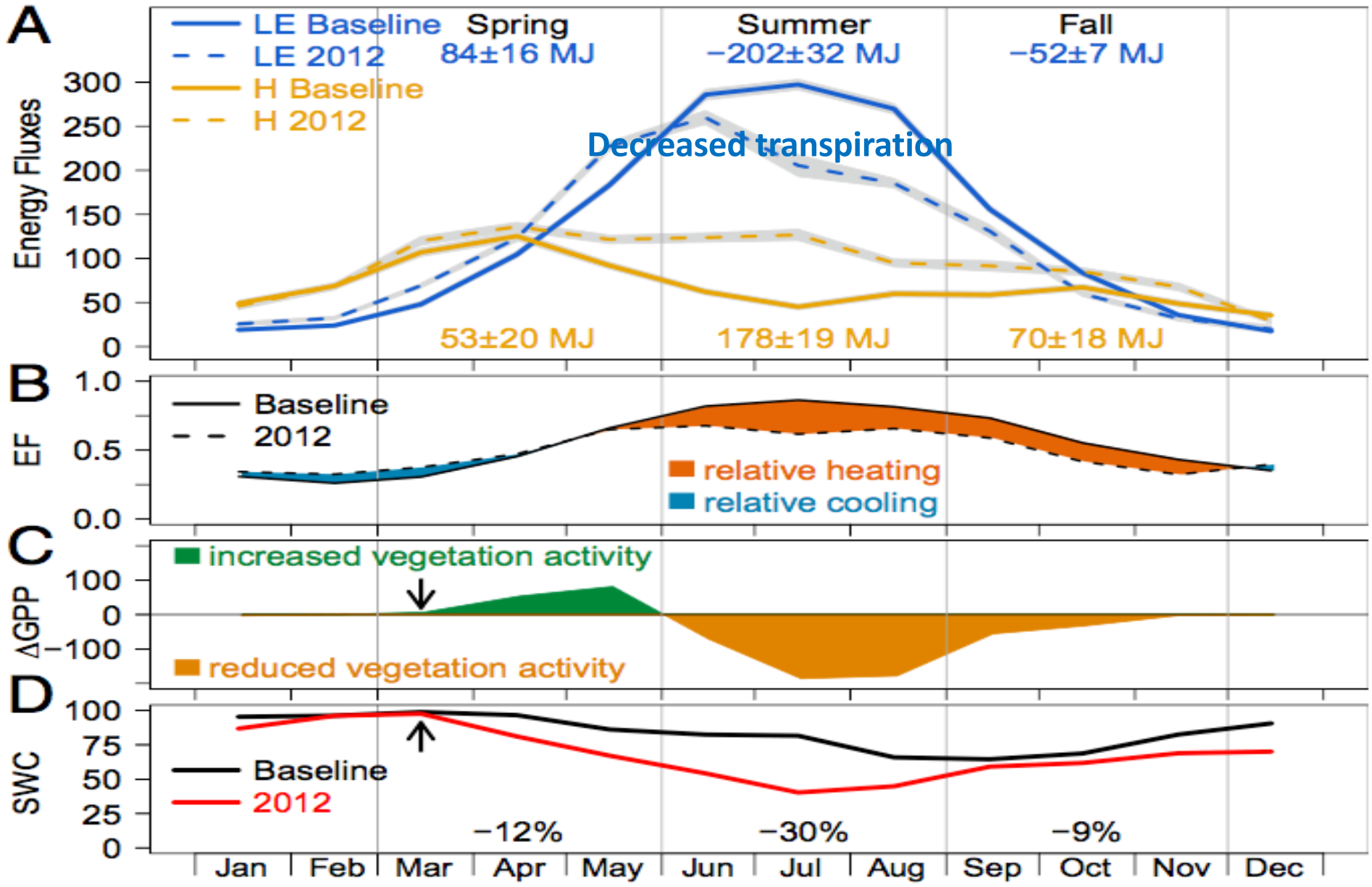
Example ET from flux tower in two seasons in mm per day (Tang et al., 2006)



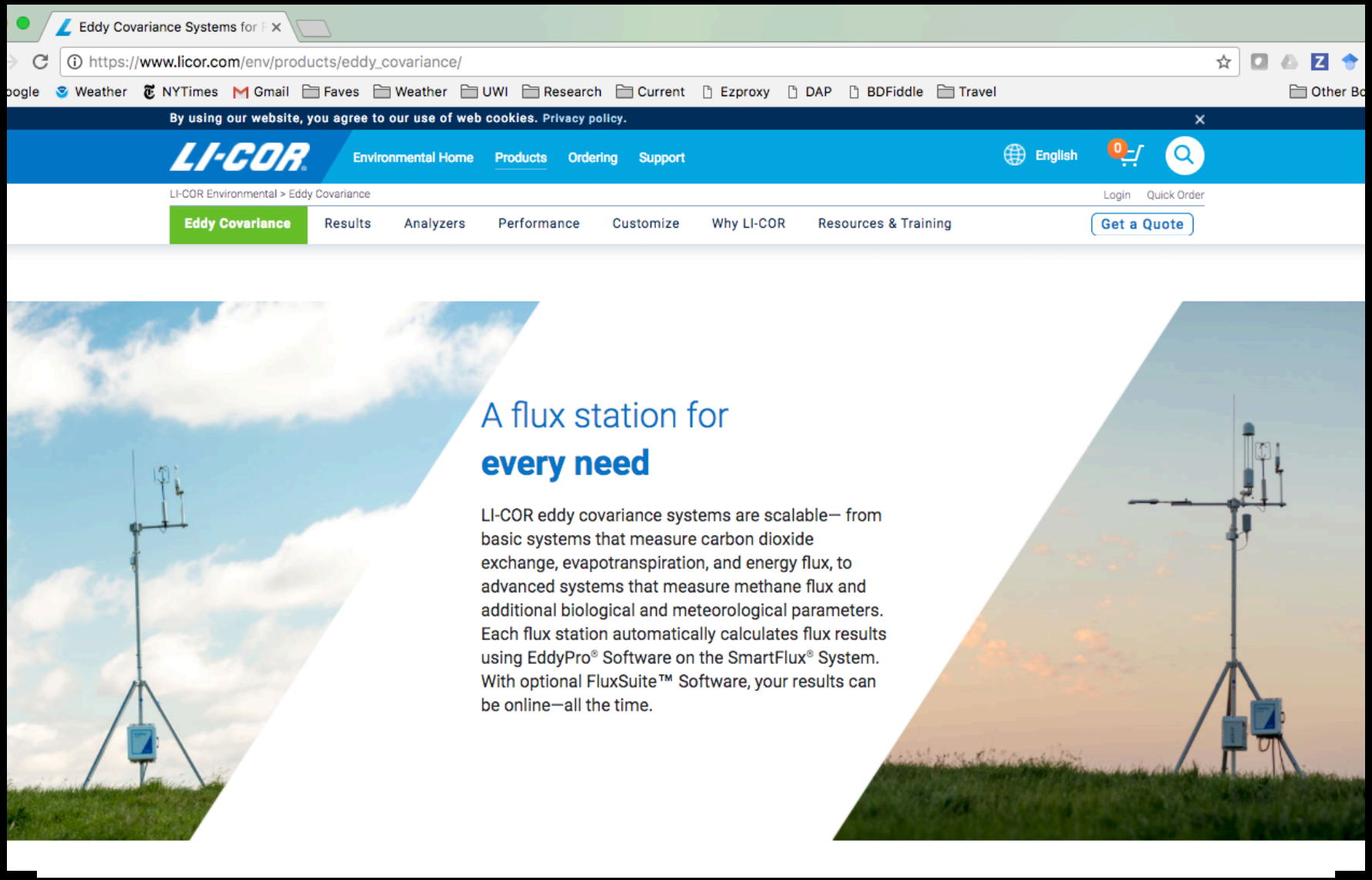
17 years of observations



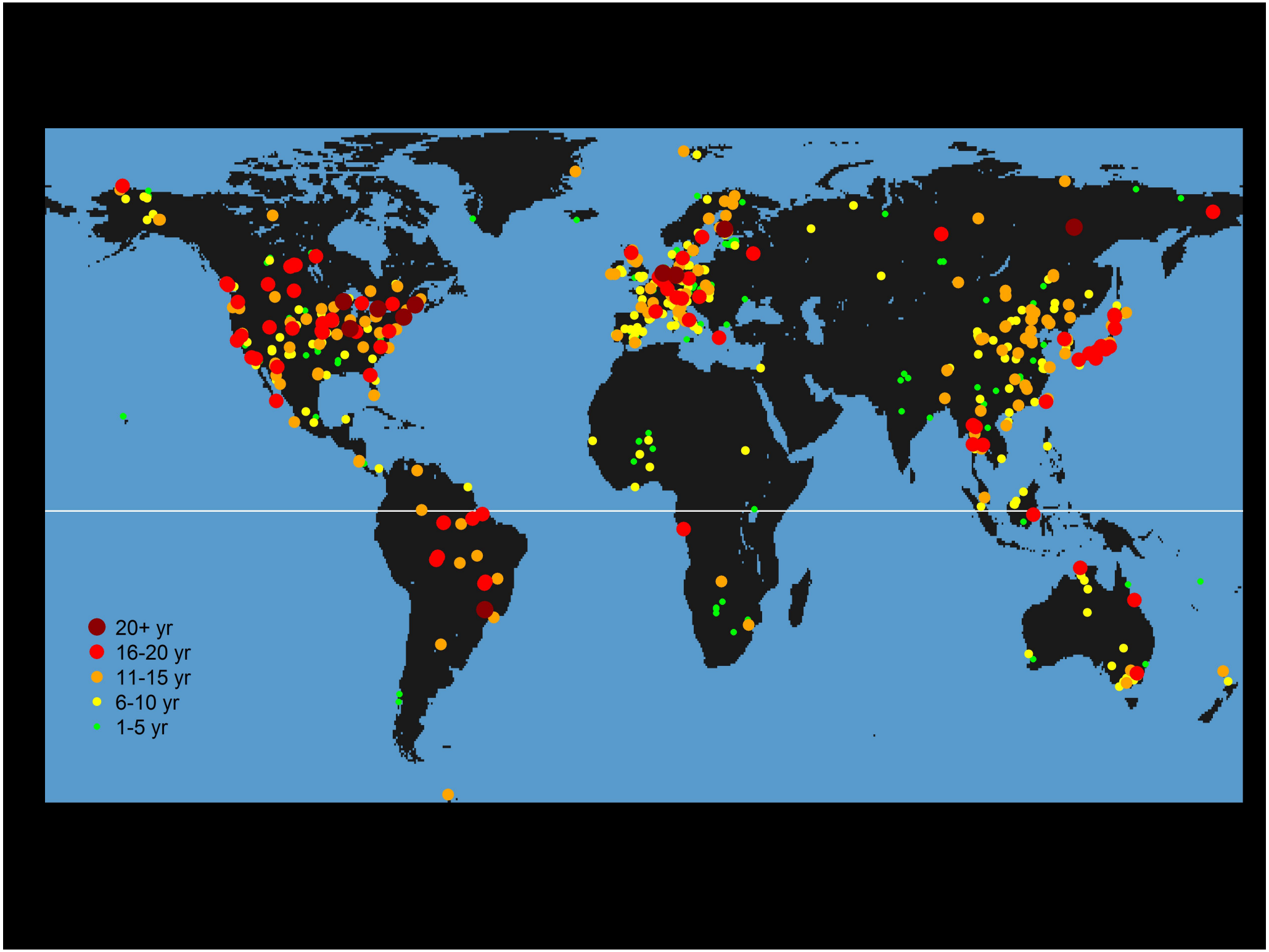
78 site-years of observations



Wolf *et al.*, 2016

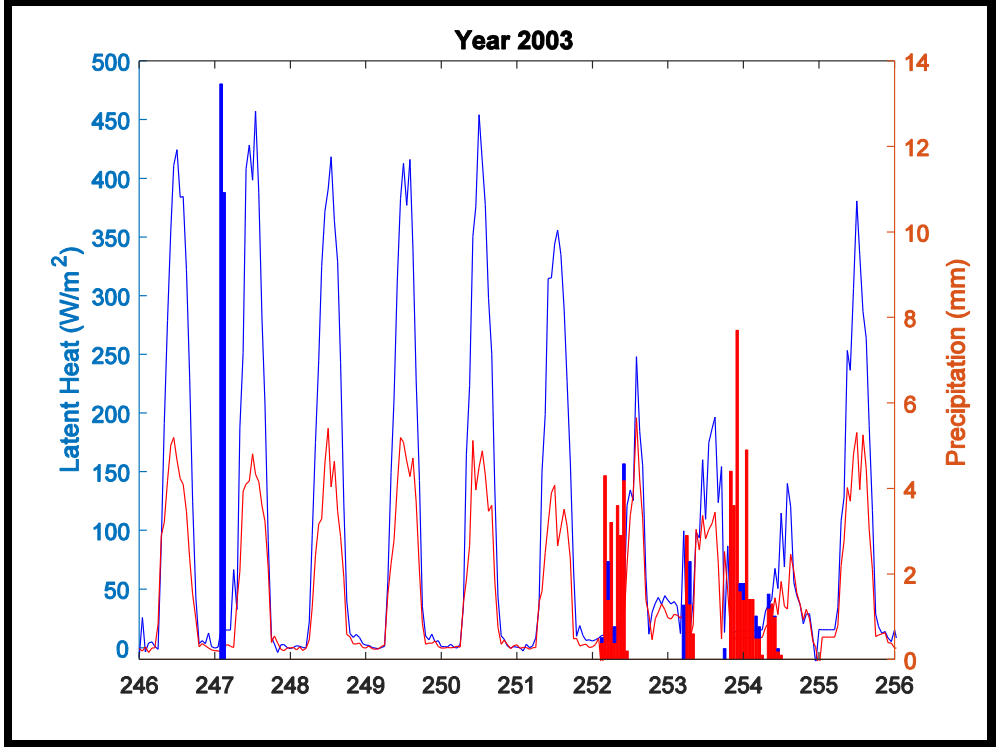


Courtesy of D. Baldocchi

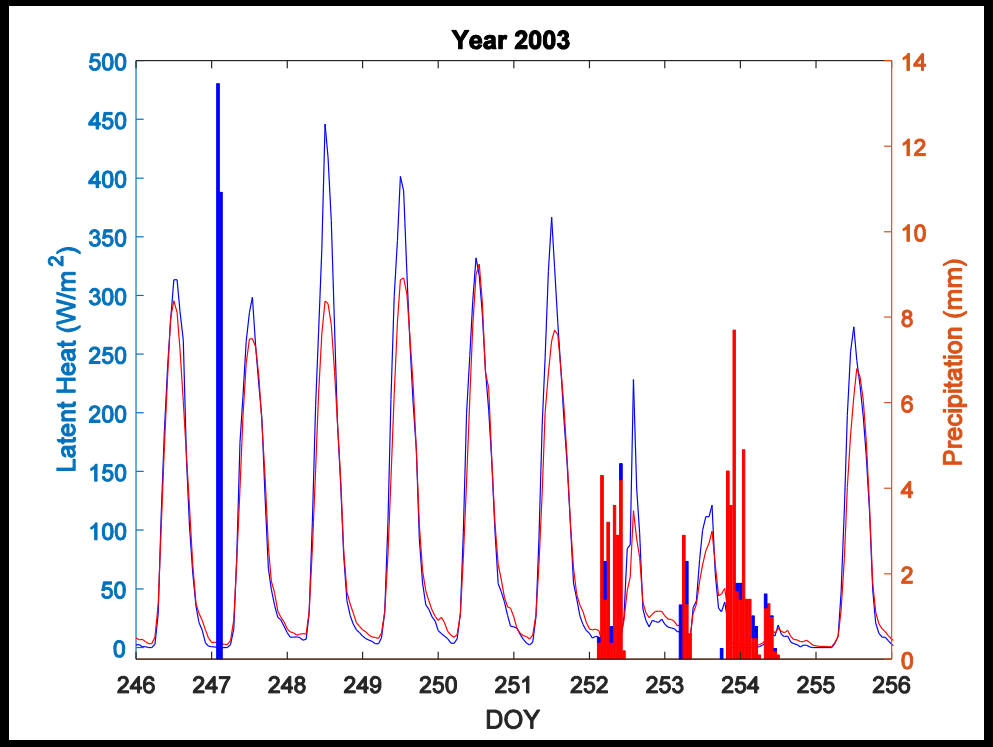

20+ yr
16-20 yr
11-15 yr
6-10 yr
1-5 yr

Paired site studies in Nebraska show us effect of irrigation on ET

- Observed



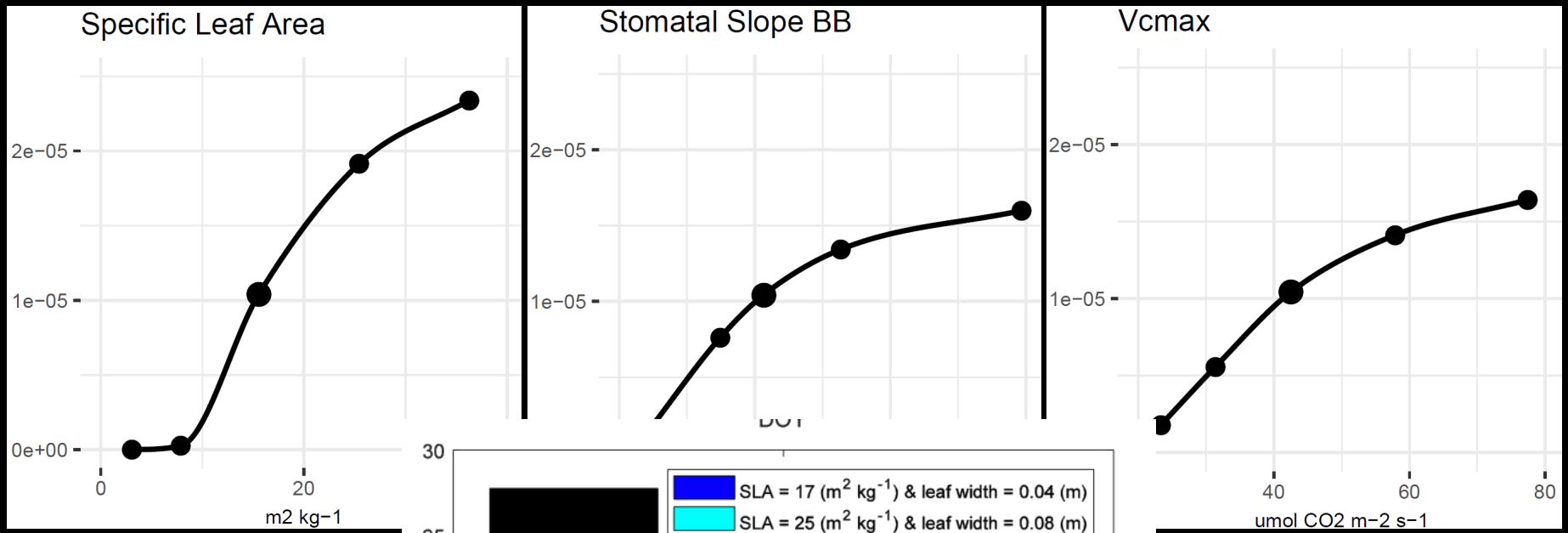
- Model

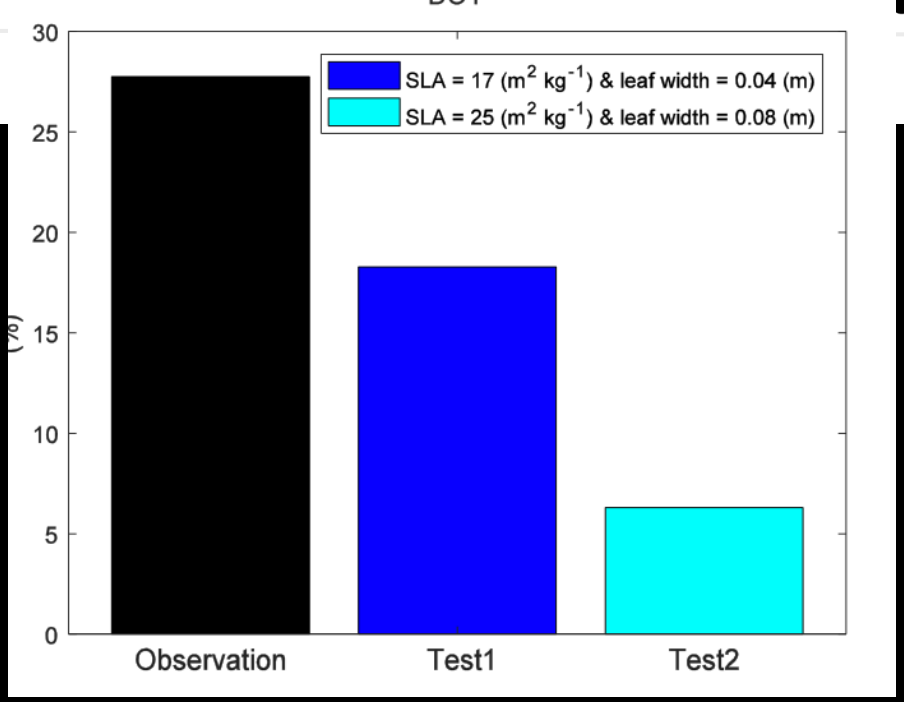


Molly Aufforth

Model: BIOCRO

Use data to constrain sensitive parameters





Flux towers have pros/cons

- PRO: Easy to deploy on a tripod in a field, on solar power, no moving parts, and mostly off-the-shelf technology, nearly 500 long running sites worldwide, “gold standard”
- PRO: It is one of the only ways to directly measure ET at hourly time scale, and at the same time, we also measure the surface heat exchange, carbon dioxide flux (productivity), and climate
- CON: It is relatively expensive (total around $40-50K to purchase), requires significant expertise (technical personnel), and regular maintenance
- CON: EC measures only upwind of the tower and when the atmosphere is “turbulent”, requiring application of methods to fill in data gaps and quality control data

Thank you

Desai Ecometeorology Lab
Dept of Atmospheric and Oceanic Sciences
UW-Madison
http://flux.aos.wisc.edu
desai@aos.wisc.edu
@profdesai
608-520-0305

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NSF DBI-1457897