

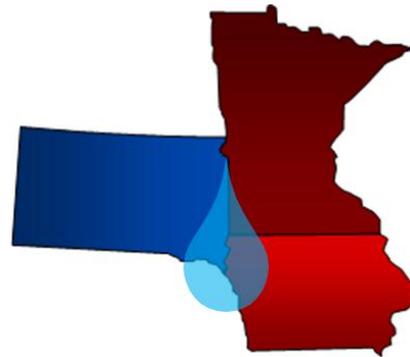


UNIVERSITY OF MINNESOTA | EXTENSION  
Driven to Discover<sup>SM</sup>

# A Presentation of the 2012 Drainage Research Forum

November 20, 2012  
Farmamerica, Waseca MN

IOWA STATE UNIVERSITY  
University Extension



SDSU  
Extension

The logo for SDSU Extension, featuring a stylized leaf with three segments in blue, green, and yellow.

# Remote Sensing-based Estimations of Evapotranspiration from Cover Crops



Jeppe Kjaersgaard

Brett Hankerson

Christopher Hay

South Dakota State University

# Cover crops



- Capture nitrogen and other nutrients
- Improve soil structure
- Build organic matter
- Improve soil biology
- Improve soil water holding capacity
  
- ...but what about the water use?

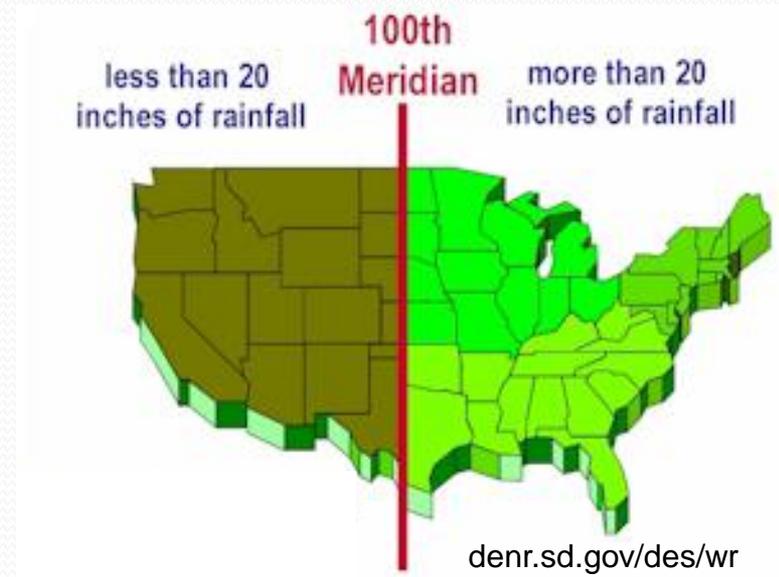
# Water use

**Same ... or different**

Photo courtesy of USDA NRCS



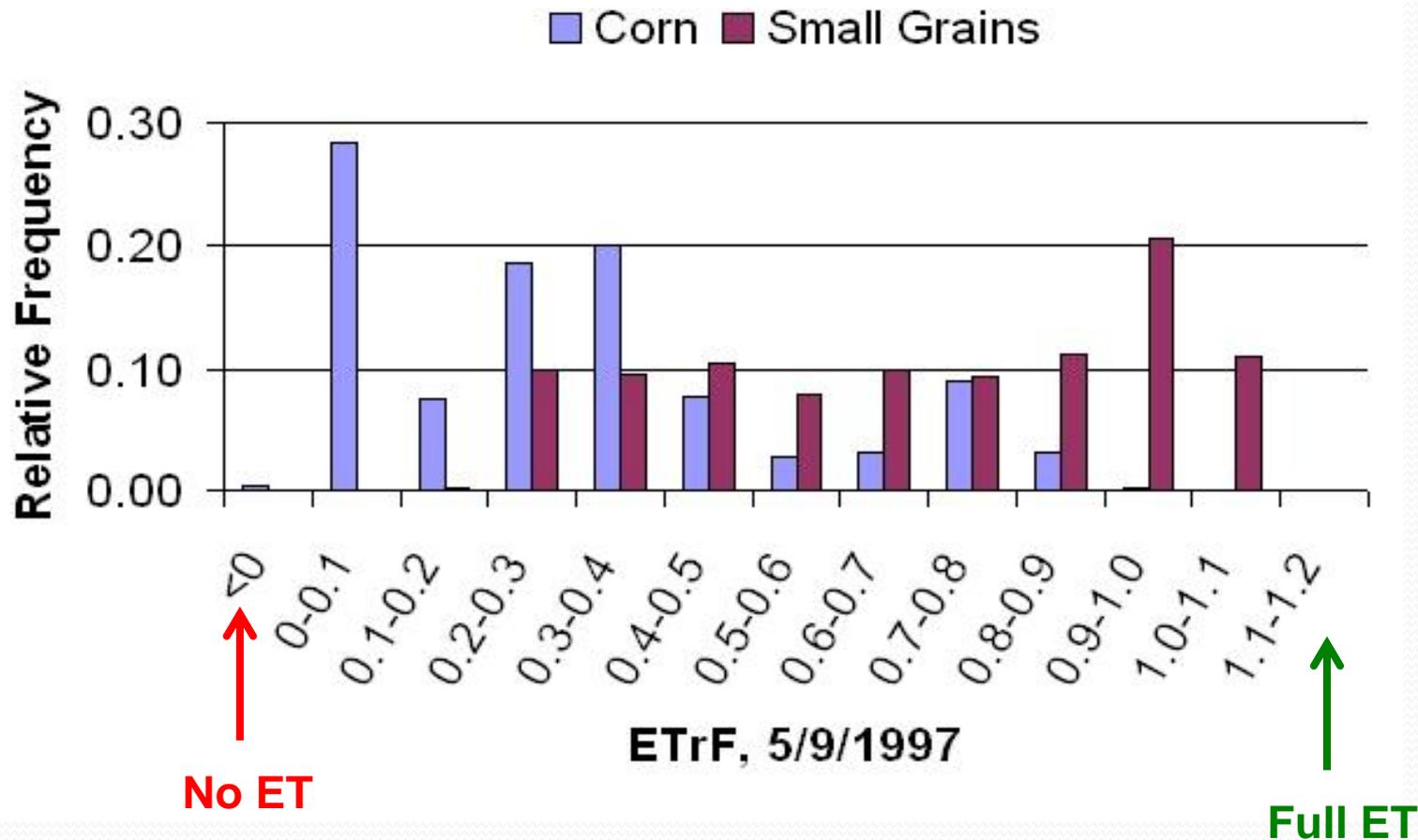
# Geography of South Dakota



# Evapotranspiration Populations

Corn n=900

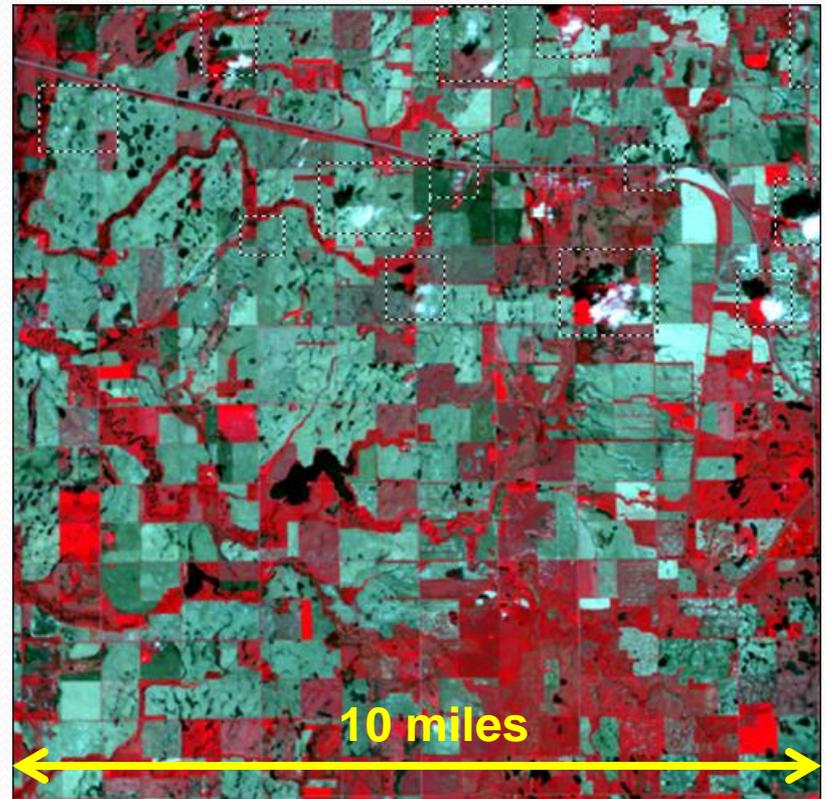
Small Grains n=797



Fields sampled in the Nebraska Panhandle. Kjaersgaard et al.

# Objective

- Can we use remote sensing to estimate the water use from cover crops?
- How does the data compare to *in situ* monitored crop water use?



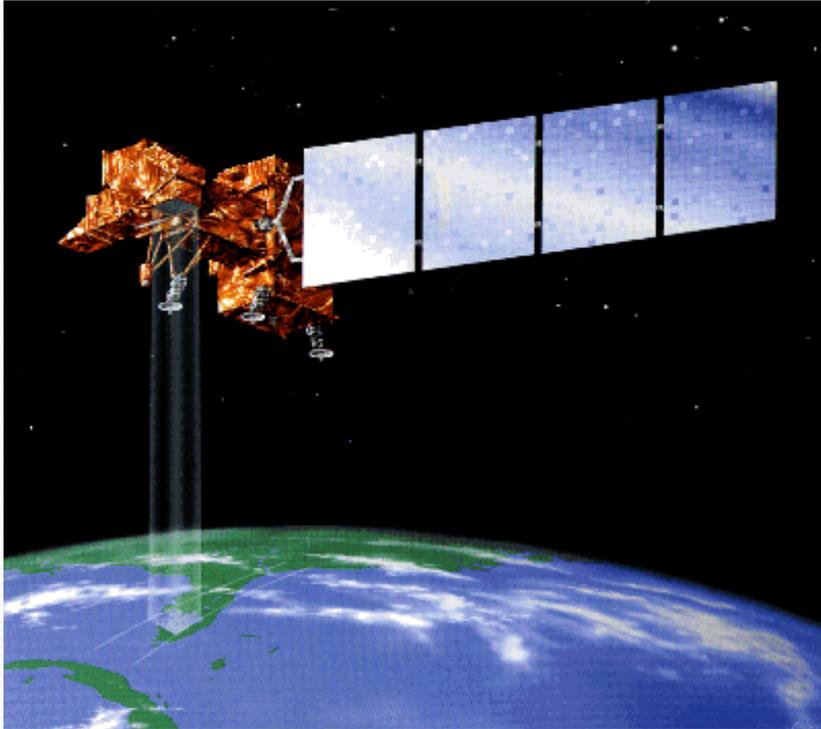
False color Landsat 5 image  
of the study area 6/4 2011

# Why use remote sensing?

We can “see” differences in crop water use caused by e.g.

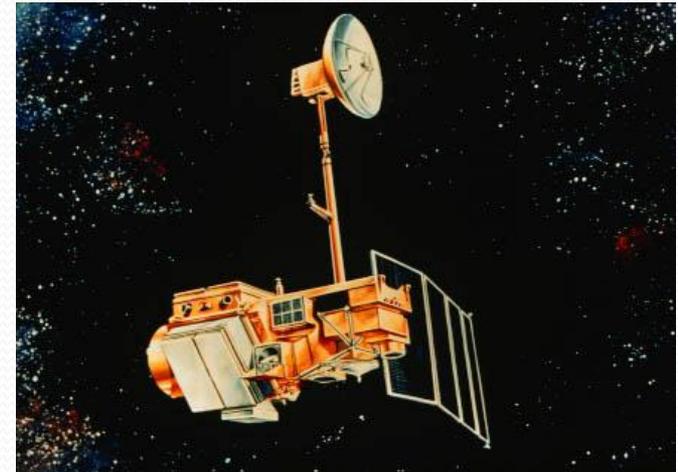
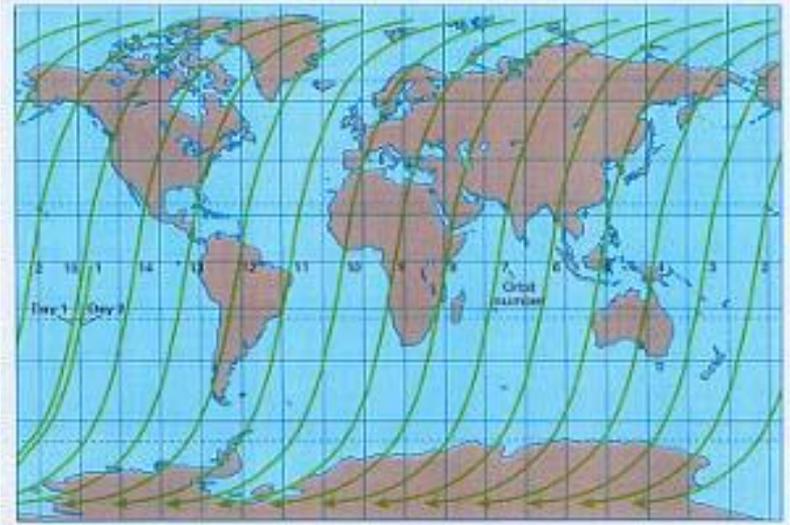
- soil water shortage (stress)
- plant density
  - low plant population or size
  - planting skips
  - wide row spacings
- soil salinity
- fertility deficiencies
- disease
- insect pressures
- weeds
- senescence
- tillage/traffic
- hail/frost

# Landsat – Polar Orbiting



Landsat 7

*Each Landsat satellite acquires a new image each 16 days for a specific location*



Landsat 5

# Fraction of Reference ET

- Atmospheric demand

- Air temperature
- Air humidity
- Net radiation
- Wind speed

(via reference crop)

- Plant and soil, such as

- Type and cultivar
- Plant density
- Water availability
- Fertility status, salinity
- Soil characteristics

$$ET_{act} = ET_{ref} \times K_c$$

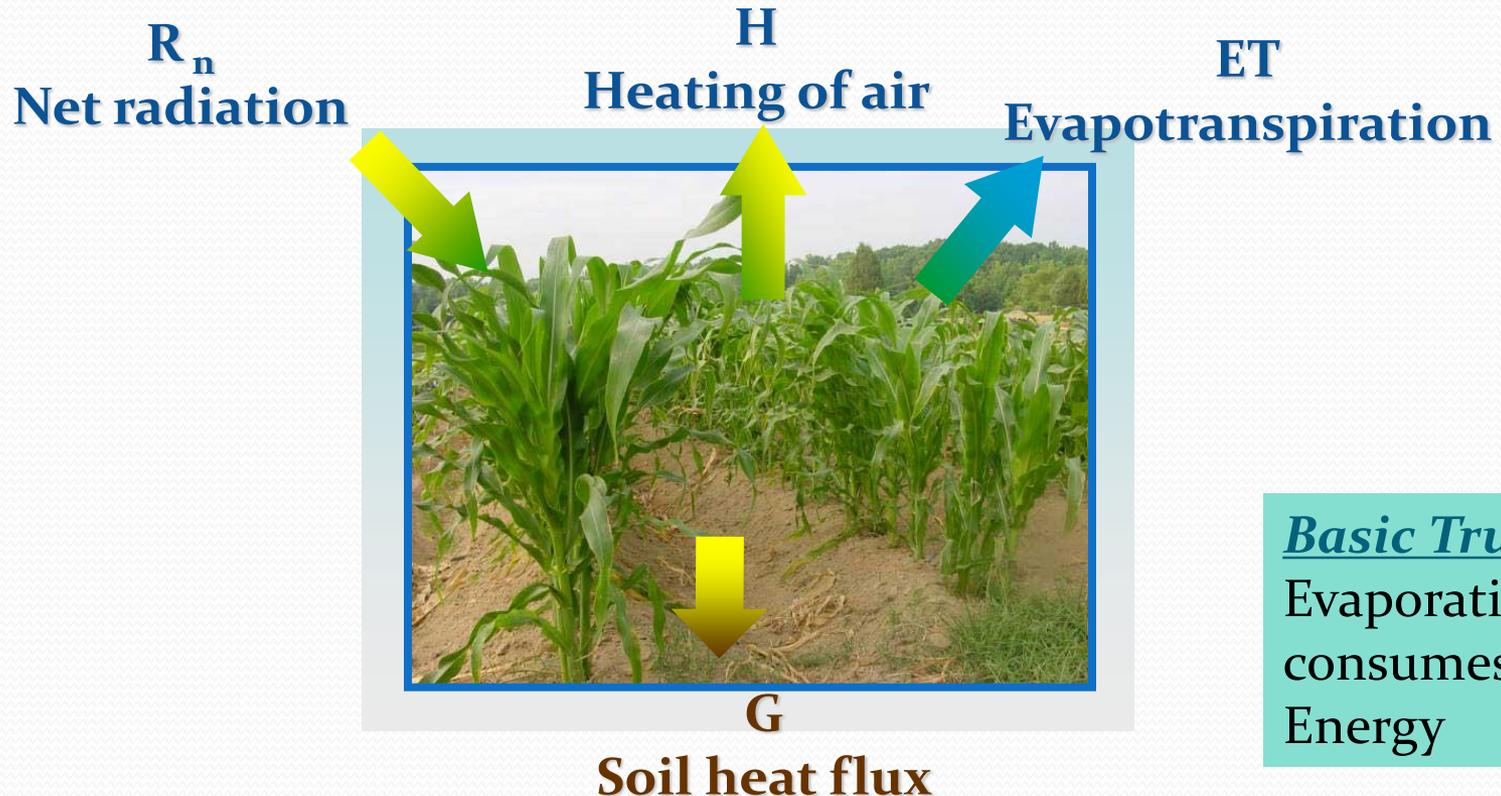
ET Index (fraction of reference ET)

The output from METRIC is commonly stated as  $ET_oF$

$$K_c = ET_oF = \frac{ET_{act}}{ET_{ref}}$$

# METRIC Energy Balance

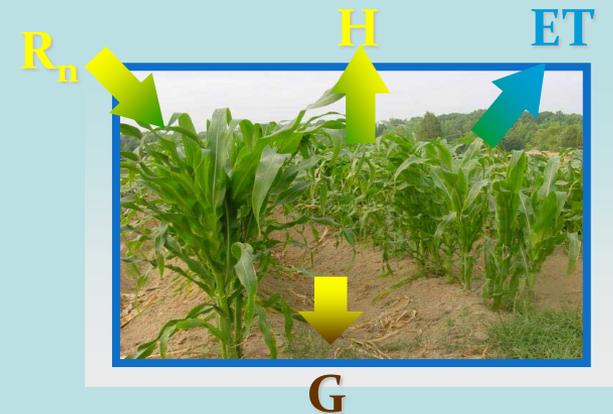
The satellite can not "see" ET therefore ET is calculated as a "residual" of the energy balance:  $ET = R_n - G - H$



***Basic Truth:***  
Evaporation  
consumes  
Energy

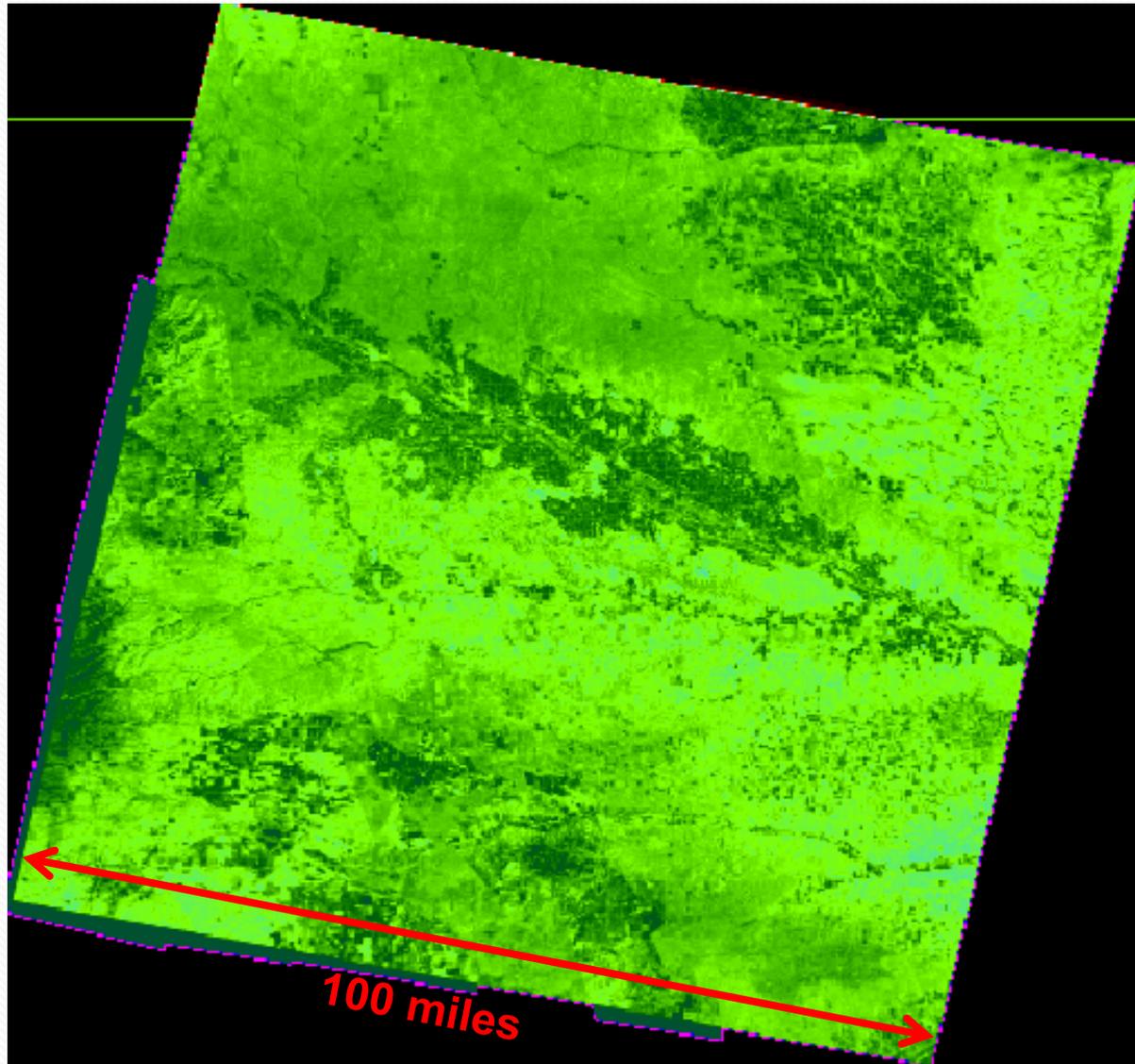
# METRIC Energy Balance

- **Net Radiation ( $R_n$ )**, calculated using
  - Sun-earth geometry
  - Spectral reflectance from the surface
  - Thermal radiance from the surface
  - Transmissivity of Atmosphere
- **Ground Heat Flux ( $G$ )**, Calculated using
  - Vegetation Amount
  - Net radiation
  - Thermal radiance
- **Sensible Heat Flux ( $H$ )**, Calculated using
  - Thermal radiance
  - Wind speed
  - Surface cover type and roughness
  - Surface to air temperature difference,  $dT$

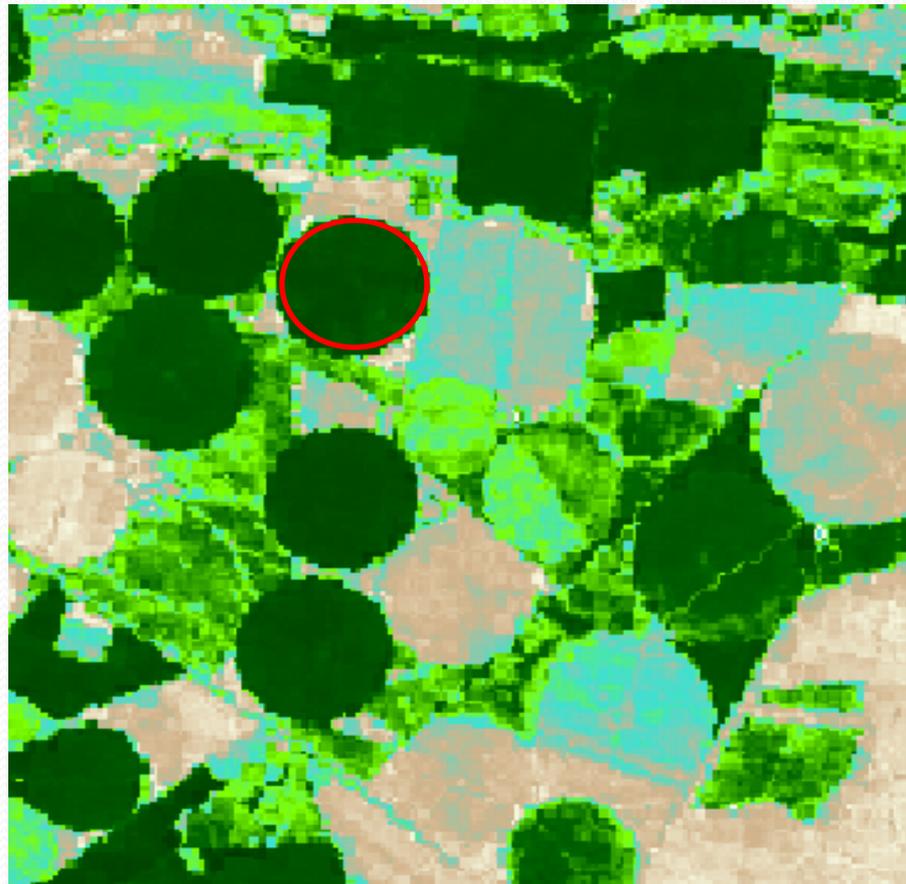


underlined terms are obtained from the satellite data

# “Map” of Evapotranspiration



# "Maps" of Evapotranspiration



# Field sites

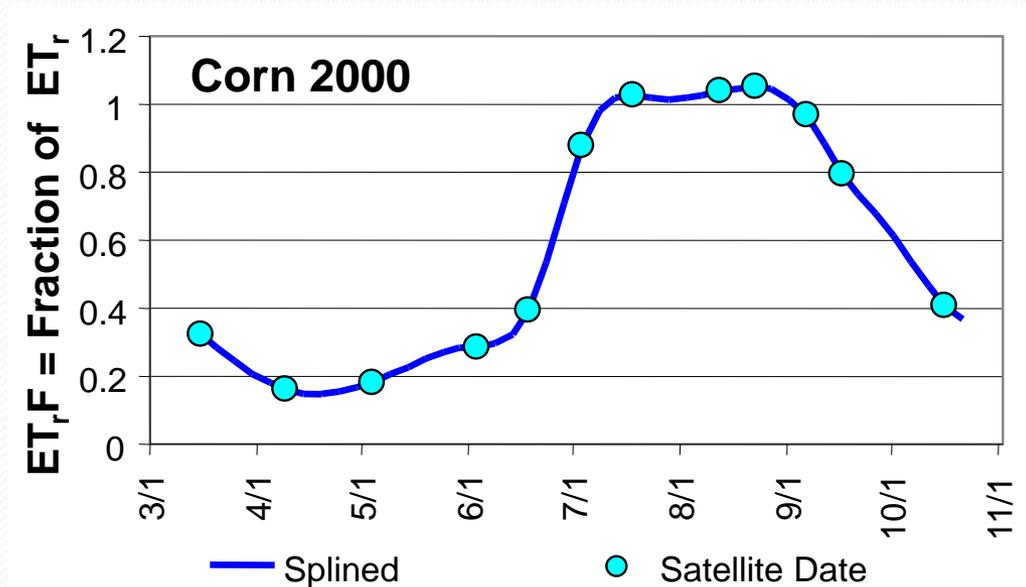
- Located in NE South Dakota
- Typical rotation: Corn, Beans, Wheat
- Typical cover crops: Ryegrass, field radish and field peas
- 2011 planting and harvest dates:

Activity	Approximate date
Wheat planted	April 29 2011
Wheat harvested	August 5 2011
Cover crop planted	August 12 2011
Killing frost	October 18 2011

# Satellite image date review

Date	Clearness index	Date	Clearness index	Date	Clearness index
5-3-2011	1	7-6-2011	0.9	9-8-2011	0.95
5-11-2011	0.95	7-14-2011	0	9-16-2011	0
5-19-2011	0.4	7-22-2011	0.7	9-24-2011	0.8
5-27-2011	0	7-30-2011	0.5	10-2-2011	1
6-4-2011	0.85	8-7-2011	0.55	10-10-2011	0
6-12-2011	0	8-15-2011	1	10-18-2011	1
6-20-2011	0	8-23-2011	1	10-26-2011	0.2
6-28-2011	0.75	8-31-2011	1		

# Interpolation for Monthly or Seasonal ET



fraction of reference ET

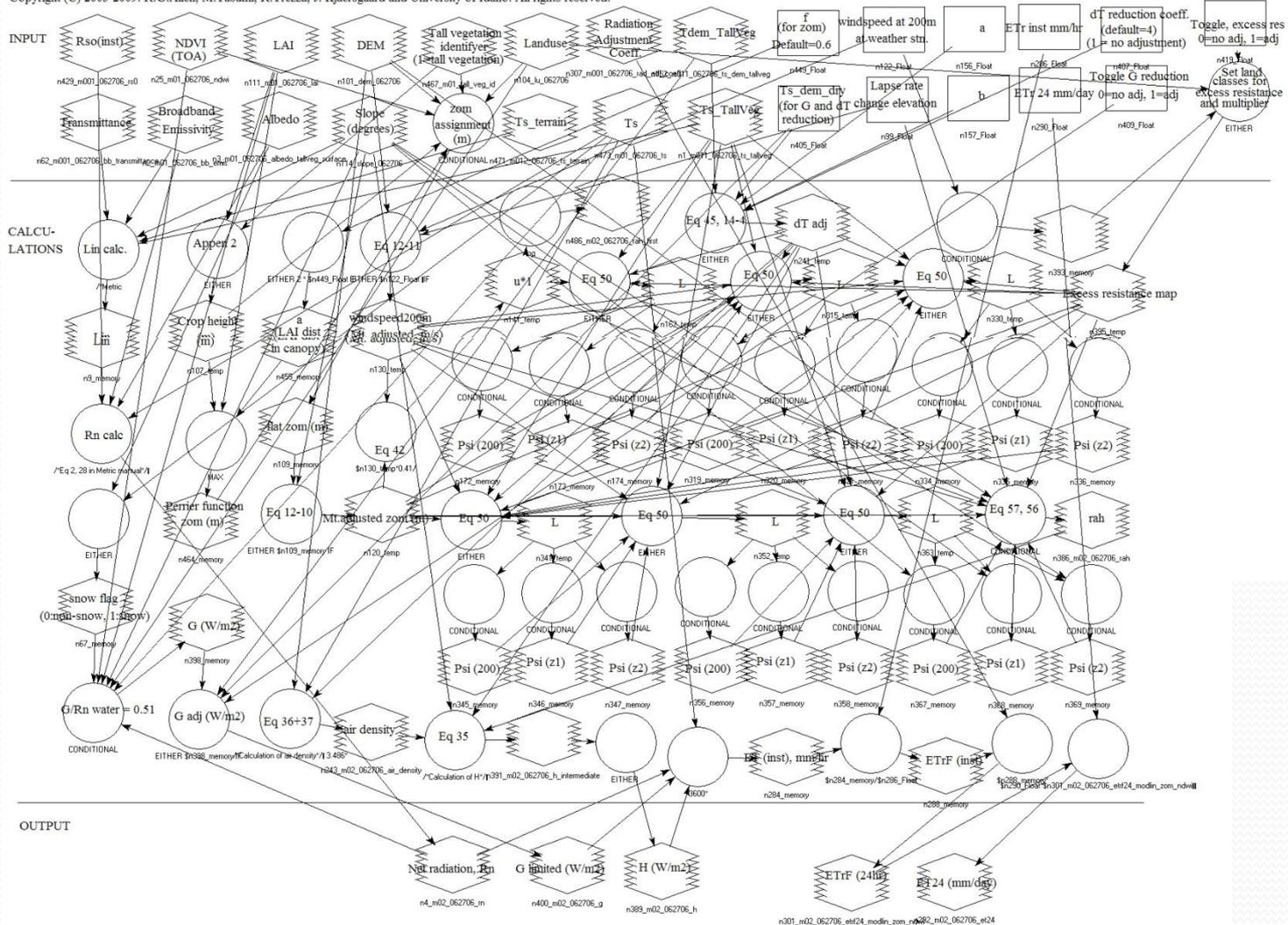
$$ET_{period} = \sum_{i=m}^n ET_r F_i \times ET_{r24i}$$

Reference ET for each day

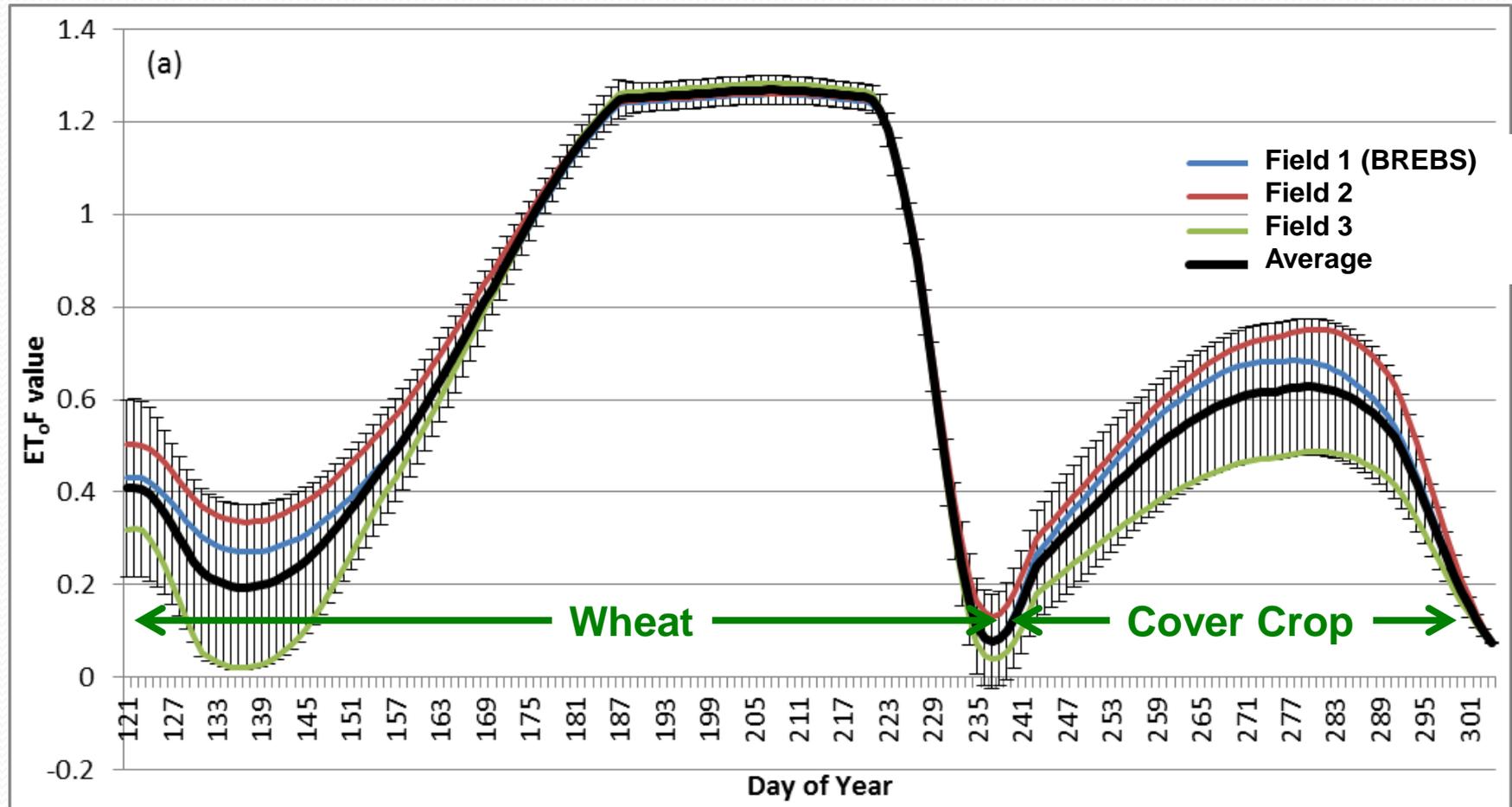
$$ET_r F_{period} = \frac{\sum_{i=m}^n ET_r F_i \times ET_{r24i}}{\sum_{i=m}^n ET_{r24i}}$$

# METRIC model

M02, Main energy balance model for METRIC: Sensible heat flux, Net radiation, Ground heat flux, Reference ET fraction and ET. Last change: 041709  
 Copyright (C) 2003-2009, R.G.Allen, M.Tasumi, R.Trezza, J. Kjaersgaard and University of Idaho. All rights reserved.



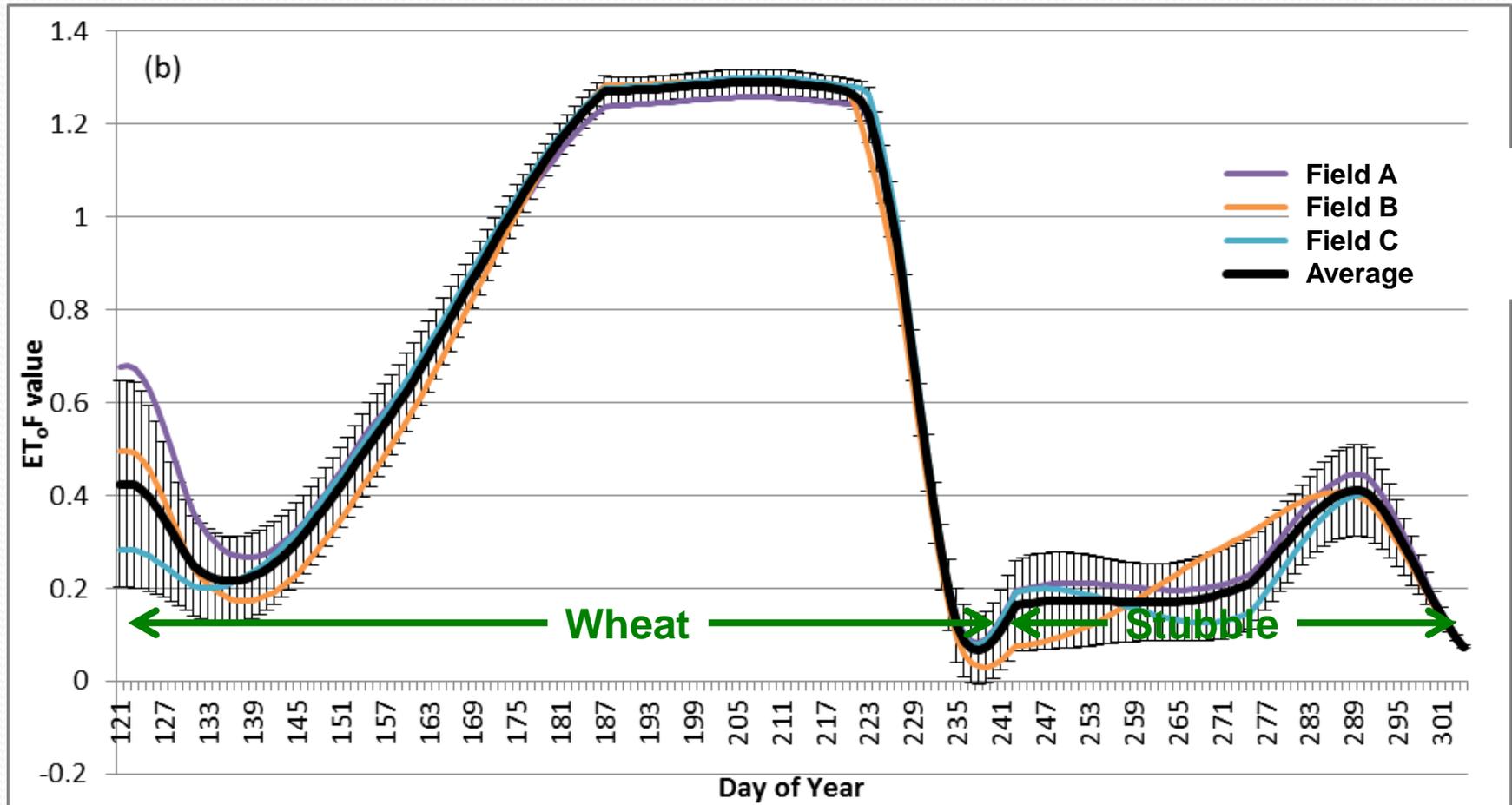
# Water use, cover crops



Error bars is one std. dev, n=1350

From Hankerson et al., 2012

# Water use, no cover crops



Error bars is one std. dev, n=1959

From Hankerson et al., 2012

# Summary

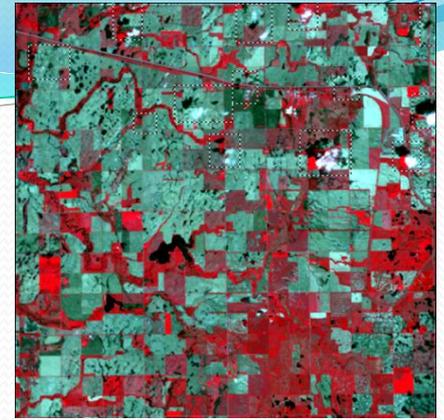
**Cumulative ET and precipitation from August 18 – October 18 2011**

<b>Measurement</b>	<b>Depth (mm)</b>
<b><math>ET_o</math></b>	266
<b><math>ET_{\lambda E}</math> (BREBS)</b>	136
<b><math>ET_{cc}</math> (METRIC)</b>	127
<b><math>ET_{no\ cc}</math> (METRIC)</b>	75
<b>Precipitation</b>	75

cc is cover crops

no cc is fields without cover crops

# Conclusion



- Remote sensing is very suited to determine differences in ET between
  - Fields with cover crops
  - Fields with and without cover crops
- Remote sensing-based ET and ground-based ET were within 7%

- Jeppe Kjaersgaard
- [jeppe.kjaersgaard@sdstate.edu](mailto:jeppe.kjaersgaard@sdstate.edu)
- [www.sdstate.edu/abe/wri/](http://www.sdstate.edu/abe/wri/)
- 605.688.5673



Visit us on  
Facebook