Treasure Valley METRIC Results Year 2015 and Overview

University of Idaho

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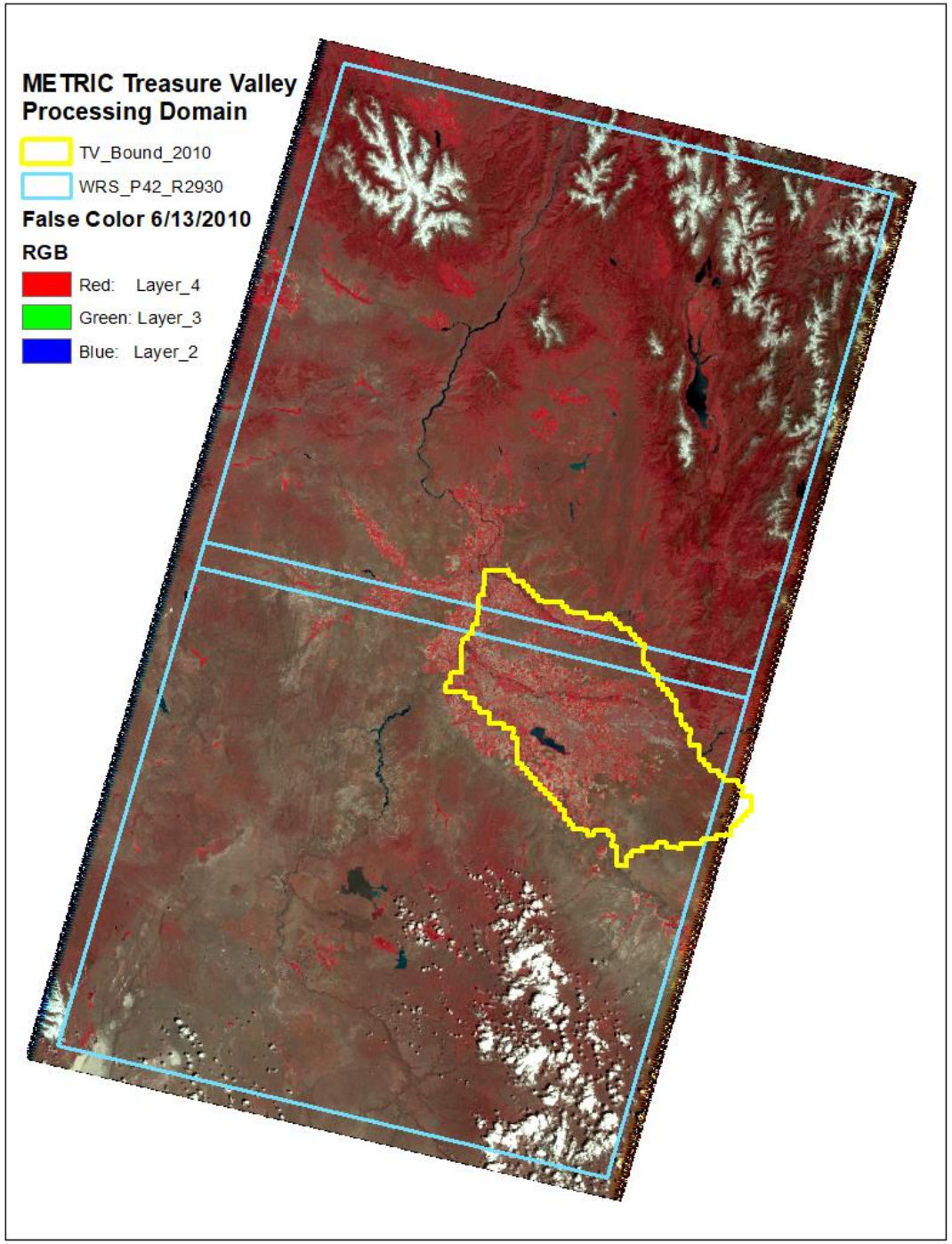
University of Idaho

Quantifying Evapotranspiration

- METRIC Processing for years: 1987, 1994, 1997, 2000, 2004, 2007, 2010, 2015

- ET_{Idaho} based estimation for intervening years: 1986, 1988-93, 1995, 1996, 1998, 1999, 2001-2003, 2005, 2006, 2008, 2009, 2011-2014 using METRIC-based crop specific ET estimates and spatial (county) crop distributions.



METRIC processing of Landsat Path 42, Rows 29 and 30

Status on Years

- METRIC Processing for years:
- 1987 – begun, but put on hold until IWRRI classification is complete
- 1994
- 1997
- 2000 – all images processed, reviewed, being updated (refined calibration) (40%)
- 2004
- 2007 – all images processed, to be reviewed; not yet cloud filled (30%)
- 2010 – most images processed, to be reviewed; not yet cloud filled (30%)
- 2015 – **complete** (but will rerun monthly ET using updated ETIdaho ETr)

Year 2015 – Dates and Images Processed

Date	Satellite	DOY	% clouds	Notes
02/19/2015	L8	50	20%	A lot of clouds over the NW of the image, but the TV area are almost clear. It has been cloud filled.
03/07/2015	L8	66	30%	A lot of clouds in this image, but the TV area has relatively fewer clouds, It has been cloud filled.
04/16/2015	L7	106	0%	This is a good clear image, although there are some clouding over some mountains.
05/02/2015	L7	122	45%	A lot of clouds in this image, but the TV area has relatively fewer clouds, IIt has been cloud filled.
05/26/2015	L8	146	40%	A lot of clouds in this image, but the TV area has relatively fewerclouds, It has been cloud filled.
06/11/2015	L8	162	0%	A nice clear L8 image.
06/19/2015	L7	170	5%	There are clouds over the north mountain areas, but the TV area is clear. It has been cloud filled.
07/29/2015	L8	210	0%	A nice clear L8 image.
08/06/2015	L7	218	1%	Good image, almost clear. Small clouds have been cloud filled.
08/14/2015	L8	226	20%	Most of the clouds are cirrus. Quite a lot of clouds over the TV area. It has been cloud filled.
08/22/2015	L7	234	40%	A lot of Ci clouds distributed over the middle and the north part of the image. It has been cloud filled.
09/23/2015	L7	266	0%	A nice clear L7 image.
10/09/2015	L7	282	20%	There are clouds in the southern part of the image. There are only a little clouds over the TV area. It has been cloud filled.
11/18/2015	L8	322	25%	There are clouds in the southern part of the TV area, the Northern part of TV is clear. However, there are clouds over mountains. It has been cloud filled.

Year 2015 Monthly and Growing Season ET

- Monthly and Growing Season (March-October) ET are produced by:
  - Processing individual image dates using METRIC
  - Masking clouded areas (and shadows)
  - Filling in clouded areas with ETrF material from adjacent scenes in time
    - Employing process to adjust ‘donor’ material for trends in NDVI and in background evaporation from precipitation
    - Result are complete ETrF images for each date (ETrF is fraction of reference ET ~ Kc)
  - Interpolating ETrF between image dates using a cubic spline with a dampening function to avoid negative ETrF and ETrF > ~1.1 to 1.2
  - Summing daily ET over each month to produce monthly ET
  - Dividing monthly ET by monthly reference ET (ETr) to produce monthly ETrF
- Daily reference ET maps are produced using point weather station data and ArcGIS interpolation (2/3 Splining 1/3 Natural Neighbor mix with IDW on edges)

Reference Evapotranspiration (ET_r)

- Reference ET is a near maximum upper limit on the hourly or daily rate of evapotranspiration by an agricultural crop.
- Approximates ET from full-cover alfalfa (large leaf area, 0.5 m tall)
- ET requires energy to transform liquid to vapor
  - Energy comes from solar radiation and convection of heat from the air
- ETr is calculated using the American Society of Civil Engineers (ASCE) Standardized Penman-Monteith equation. Inputs are:
  - solar radiation (hourly or daily)
  - air temperature (hourly or daily)
  - humidity (i.e., RH, dewpoint, wet bulb; hourly or daily)
  - wind speed (hourly or daily)

Use of Reference ET in METRIC

- ET_r is used in two major ways in METRIC

1. To interpolate ET in between Landsat images (these are ≥ 8 days apart)
   - Interpolation uses a cubic spline function
   - The fraction of reference ET (called ET_rF) is interpolated rather than ET
   - ET_rF is relatively constant over short periods of time regardless of weather
   - Daily ET is calculated following splining by multiplying ET_rF x ET_r
2. To 'calibrate' the METRIC surface energy balance model
   - provide guidance on establishing maximum values of ET
   - to drive a daily soil water balance model to estimate how wet or dry a bare soil surface will be following recent rainfall

Full Penman-Monteith

Penman Equation:

$$ET = \left(\frac{\Delta(R_n - G) + \gamma\,(a_w + b_w\,u_2)(e_s - e_a)}{\Delta + \gamma} \right) / \lambda$$

Penman Monteith Equation:

$$ET = \left(\frac{\Delta(R_n - G) + K_{time}\,\rho_a\,c_p\,\dfrac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \dfrac{r_s}{r_a}\right)} \right) / \lambda$$

Rn=net radiation, G = soil heat flux = f (solar radiation)

actual vapor pressure = f (humidity)

f (crop)

surface resistance = f (veg)

f (temperature)

aerodynamic resistance = f (wind)

John L. Monteith

ρ_a is density, c_p is specific heat, λ is latent heat of vaporization, Δ is slope of sat. vapor pressure curve, γ is psychrometric constant

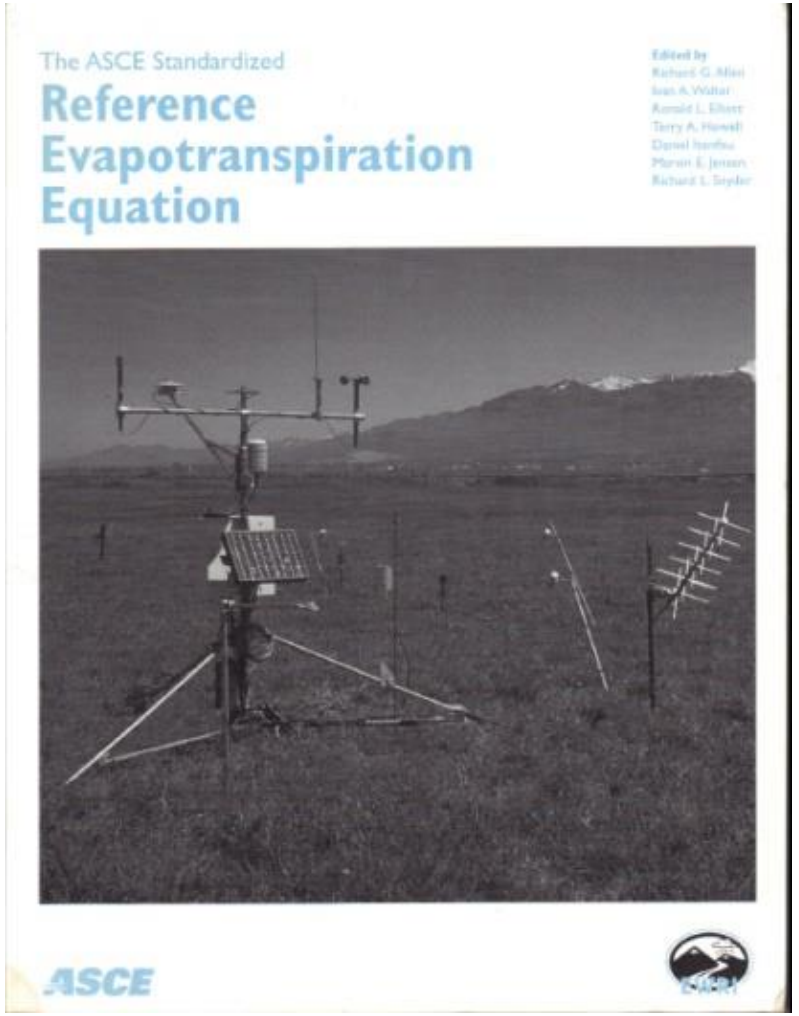
Standardized Reference ET

Penman-Monteith *equation applied to* ***alfalfa*** *for* ***hourly*** *application*

$$ET_{ref} = \frac{\Delta(R_n - G) + \rho c_p (e_s - e_a)/r_a}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)\lambda}$$

30 s m^{-1}
(daylight)

= f(0.5 m ht)



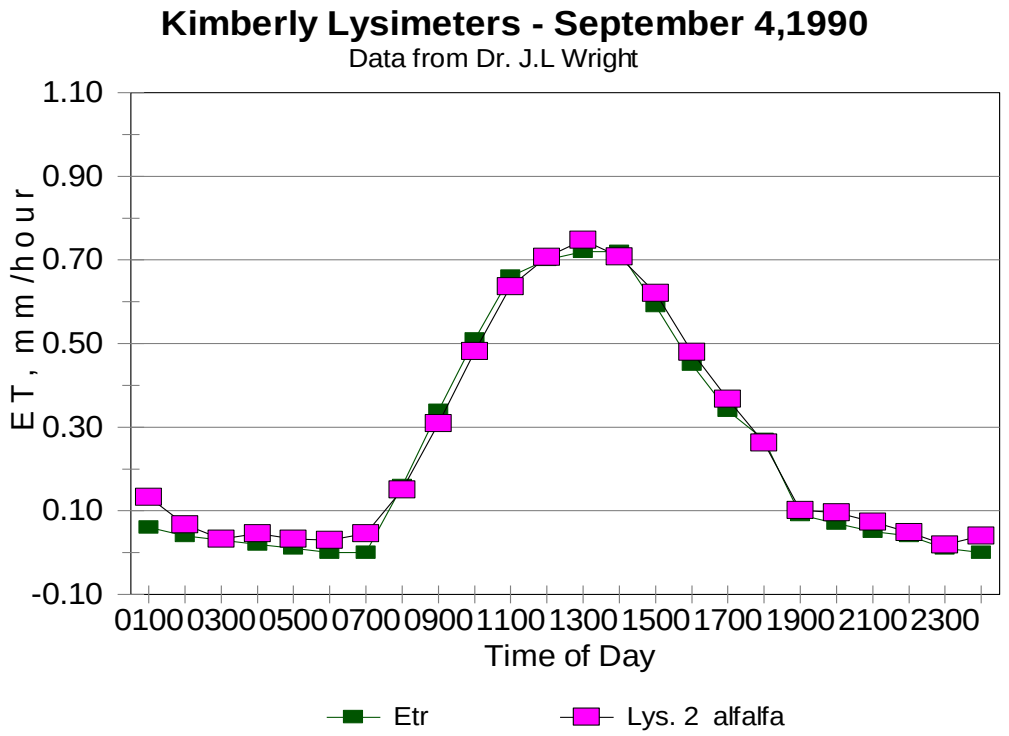
(ASCE-EWRI, 2005)

Kimberly Lysimeters

Comparisons with Measurements

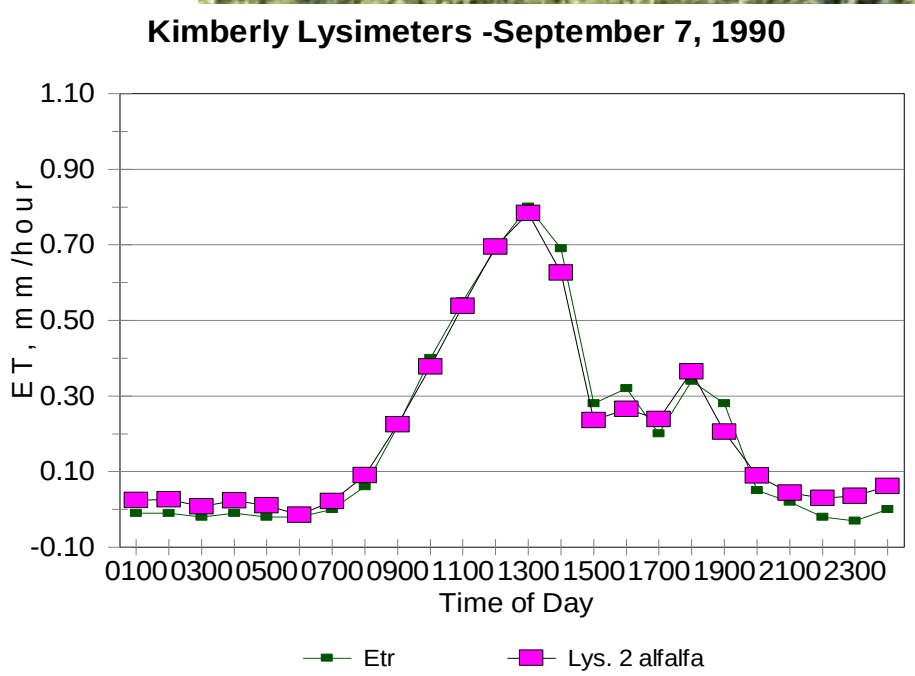
Weighing Lysimeter System at Kimberly, Idaho

Dr. James L. Wright, USDA-ARS

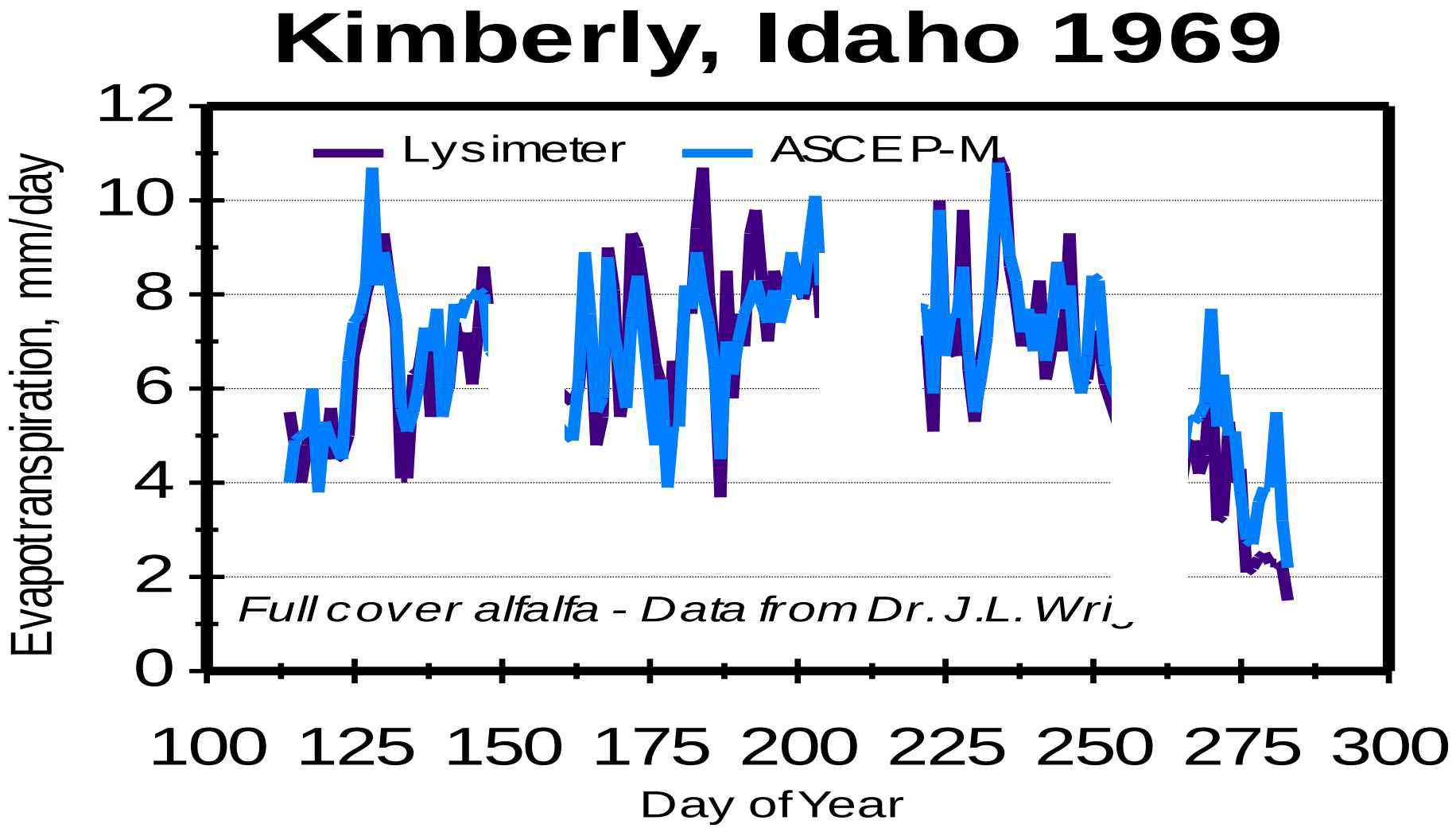


ASCE Standardized
Penman-Monteith
(alfalfa reference)
at Kimberly, Idaho

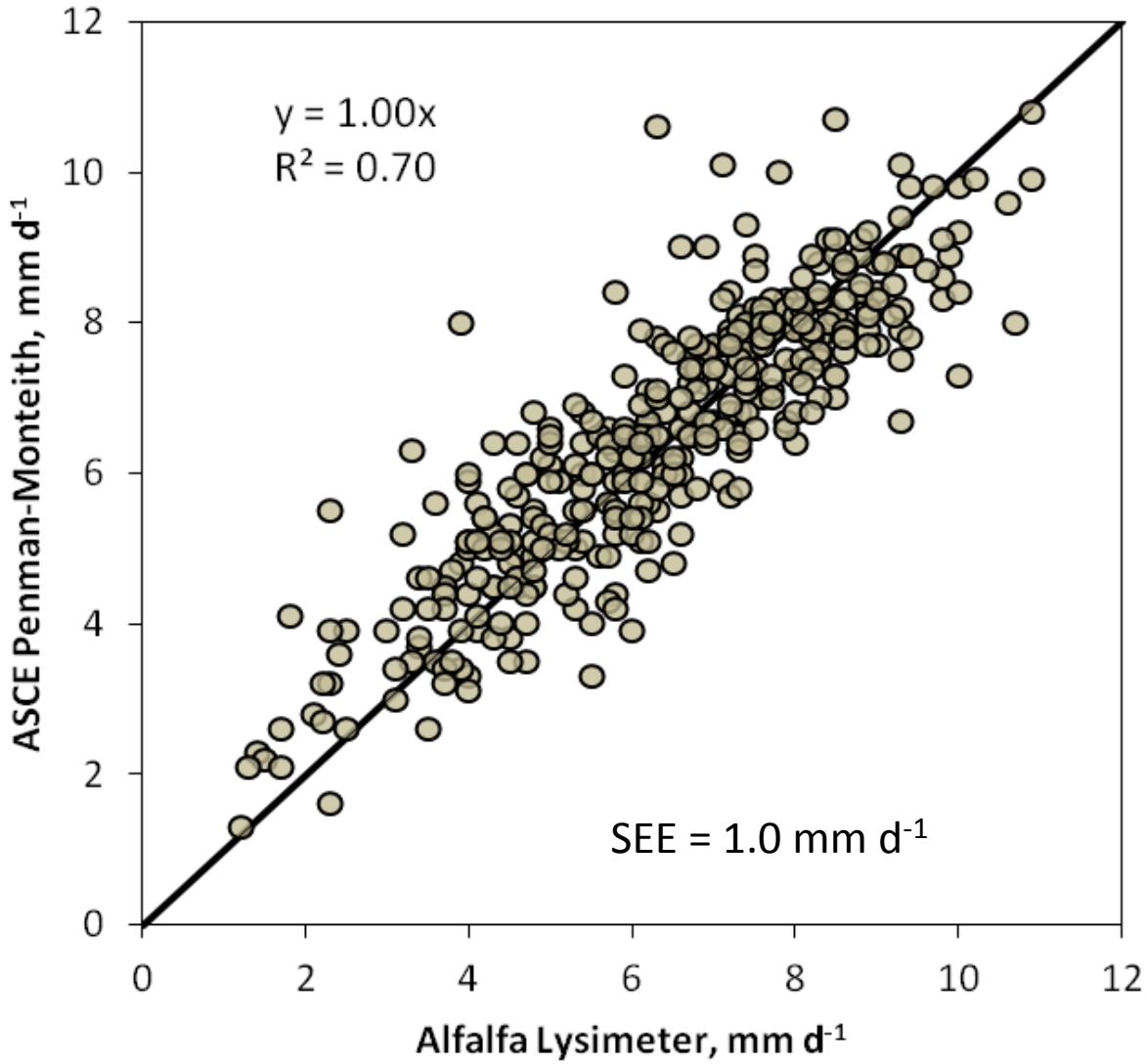
- hourly time step



Good day to day correspondance with lysimeter



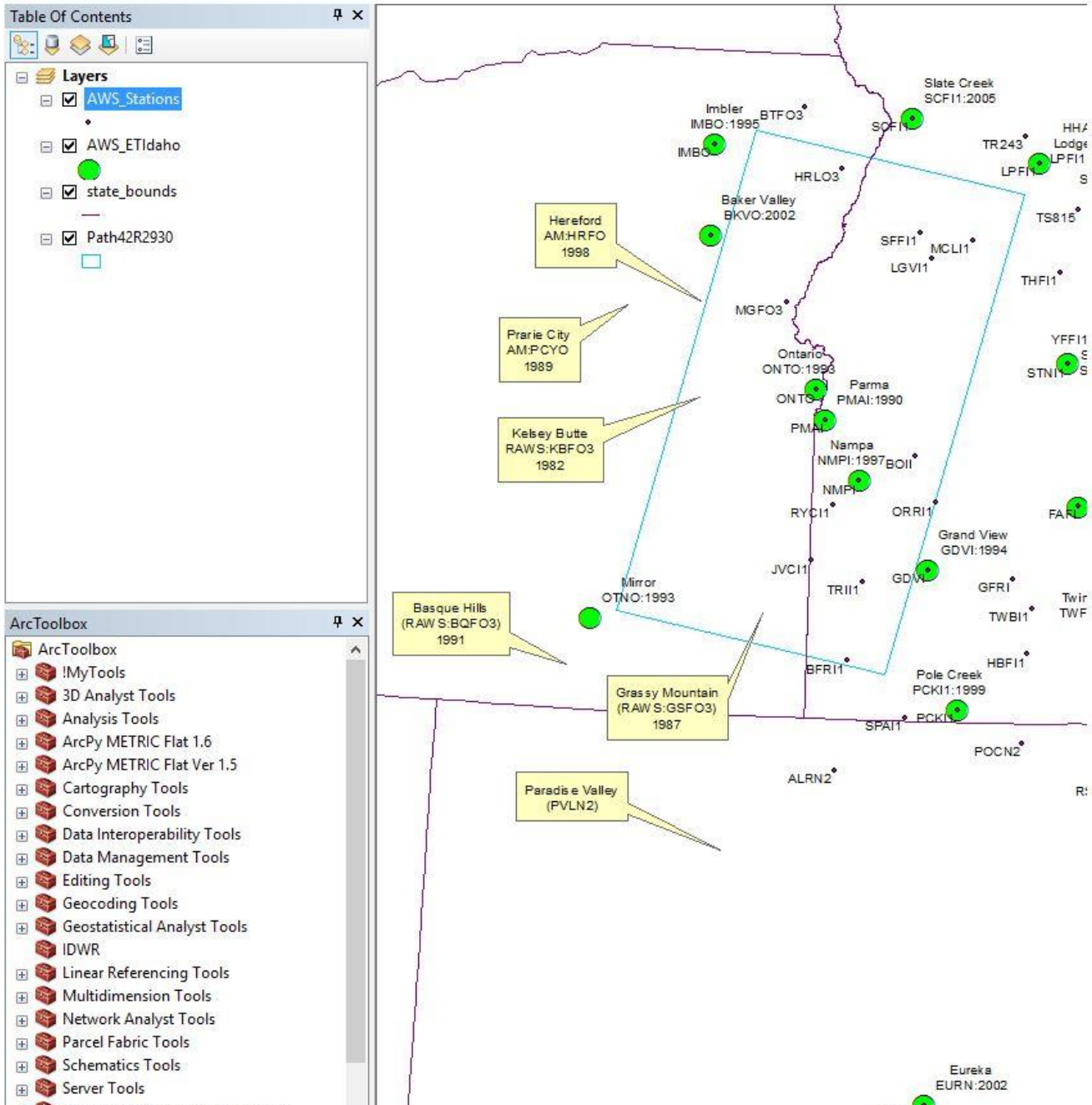
Kimberly, Idaho, Daily Alfalfa ET 1969-1971



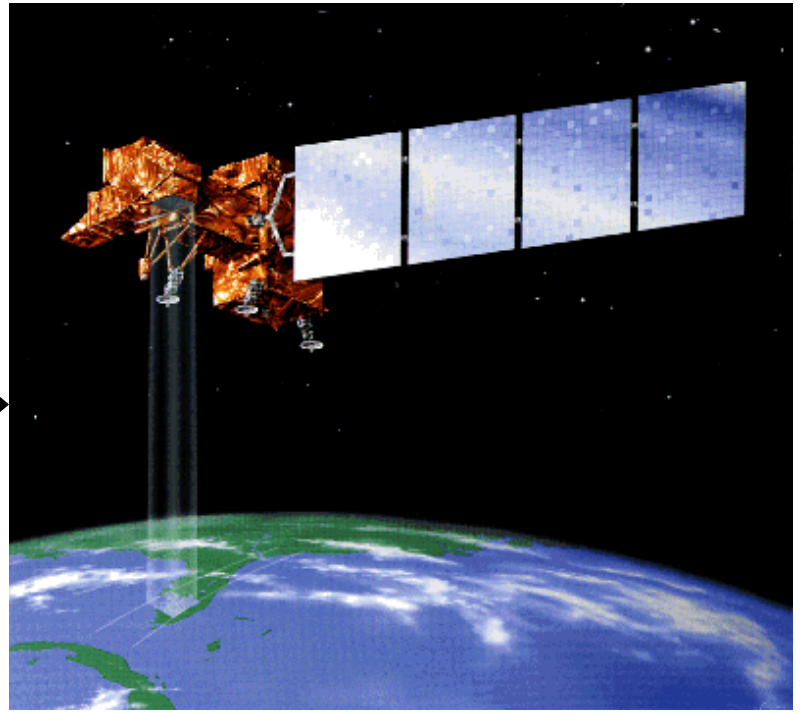
Periods of
Full Cover

Weather Stations used for 2015

- Mostly Automated Weather Stations (Agrimet and RAWS)
  - Screened for location in relatively ‘wet’ (ag., etc.) environments (green points) (black dots not used)
  - QAQC performed on solar radiation, humidity, wind speed



8-days apart



Landsat contains a thermal sensor that measures surface temperature.
Pixel size of shortwave is 30 m. Pixel size of thermal is 60 to 120 m.

Landsat 5 1984 – 2011

Landsat 7 1999 – 2021

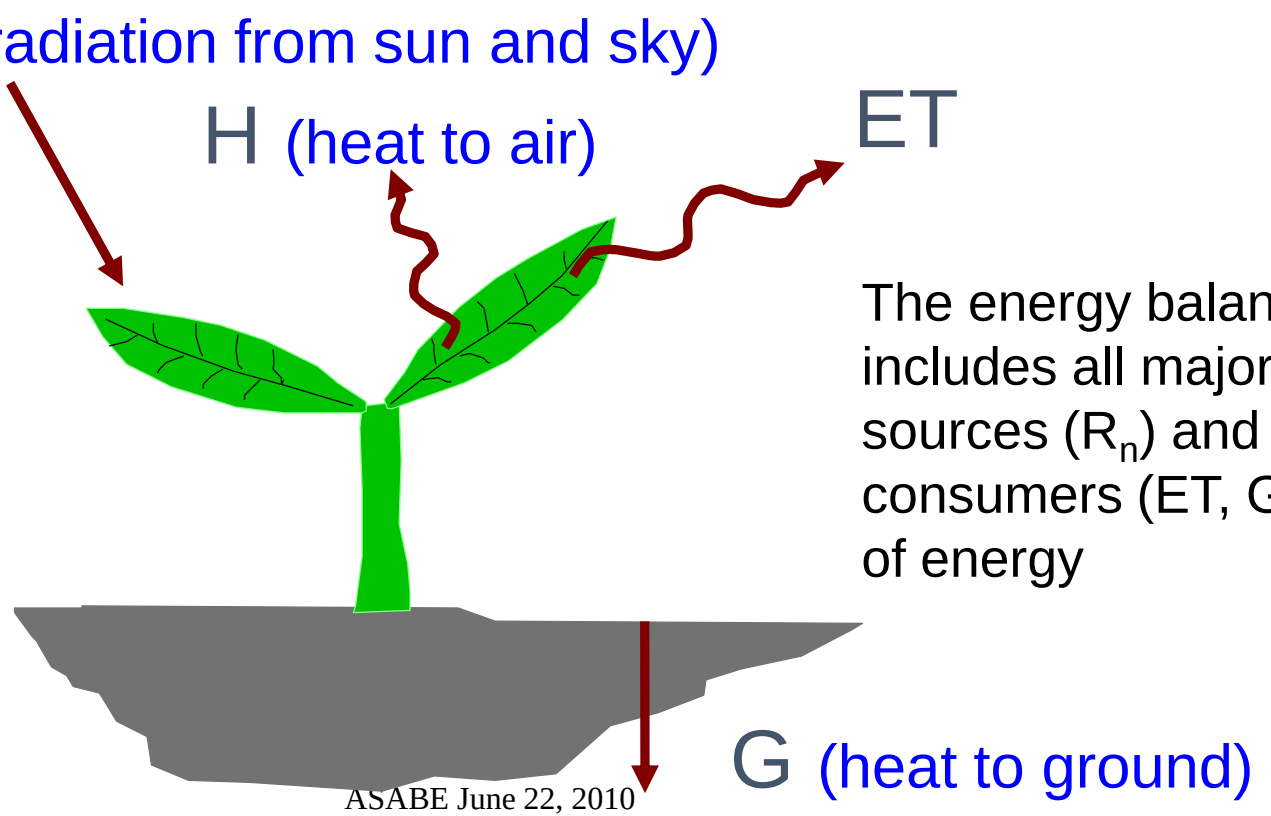
Landsat 8
Feb. 2013 – 20xx
(replaced LS5)

Each Landsat revisits each 16 days

Landsat 9 in 2021
Landsats..10..11??....
For ET, we would like a 4-day 'return time' *funding needed.....*

ET is constrained by Energy Availability

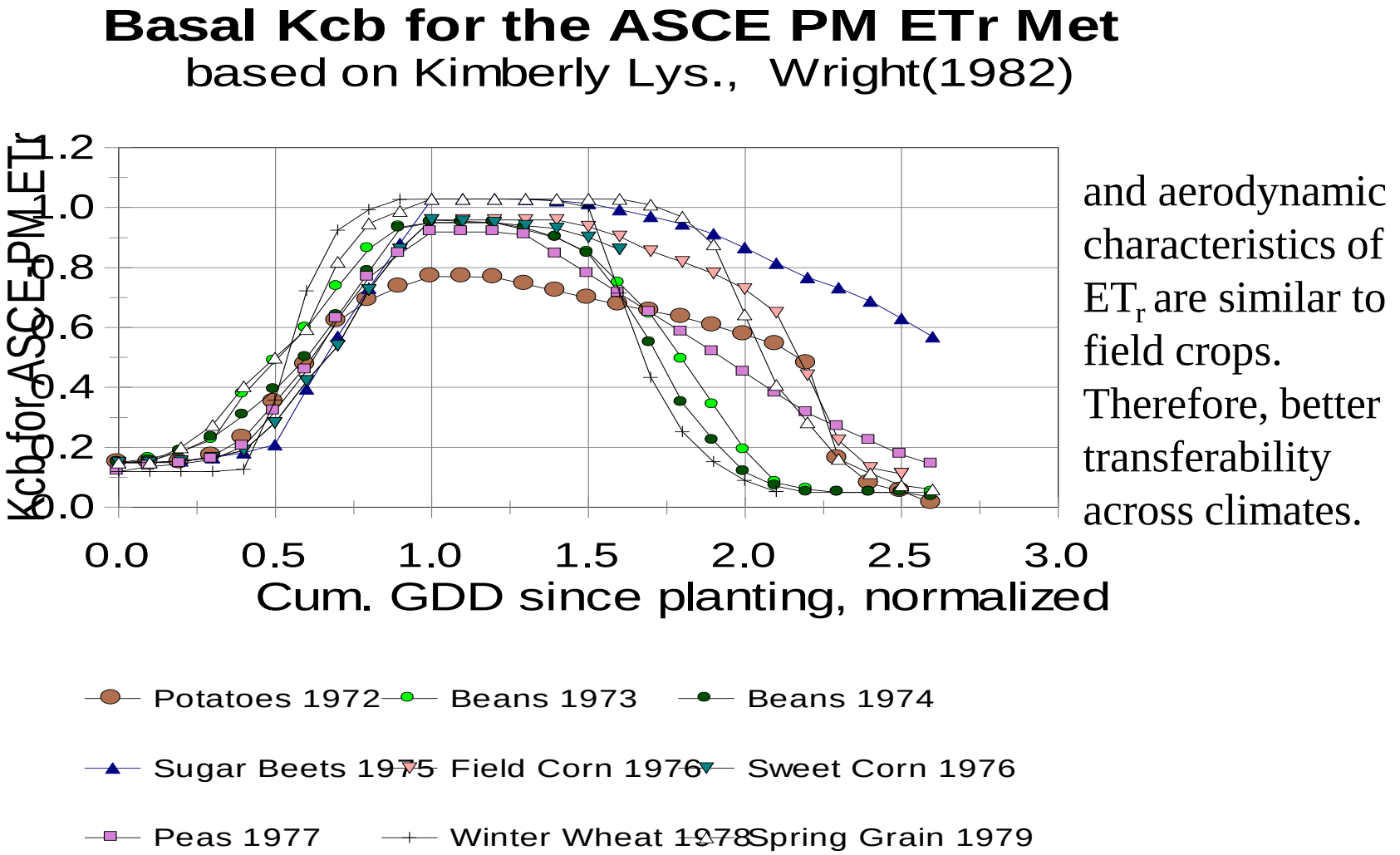
$$ET = R_n - G - H$$



Basic Truth: Evaporation consumes Energy

The energy balance includes all major sources (R_n) and consumers (ET, G, H) of energy

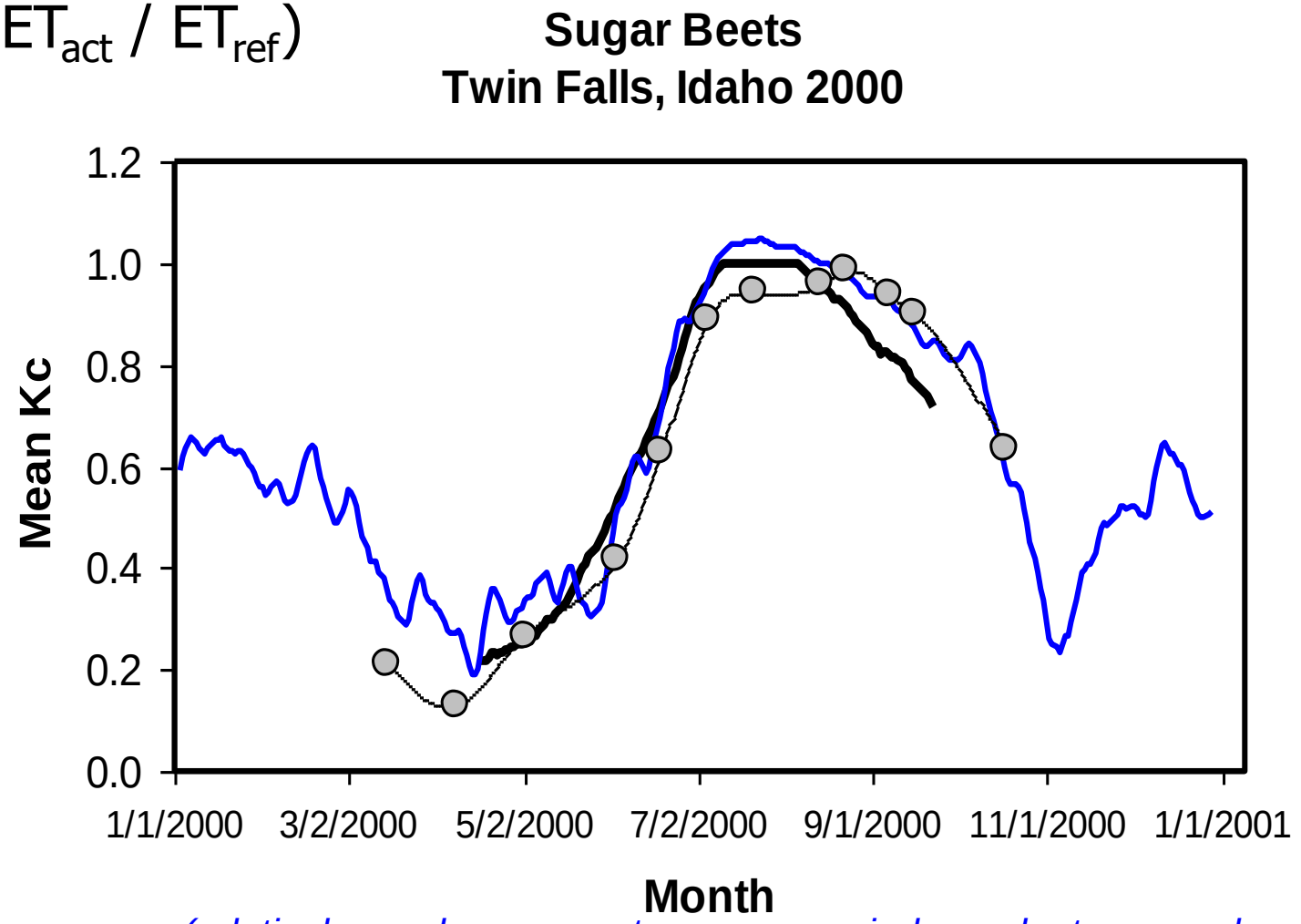
An argument for 'alfalfa' ET_r is that Maximum K_{cb} tends toward 1.0



and aerodynamic characteristics of ET_r are similar to field crops. Therefore, better transferability across climates.

Comparing METRIC vs. traditional K_c ET_{ref} methods

($K_c = ET_{act} / ET_{ref}$)



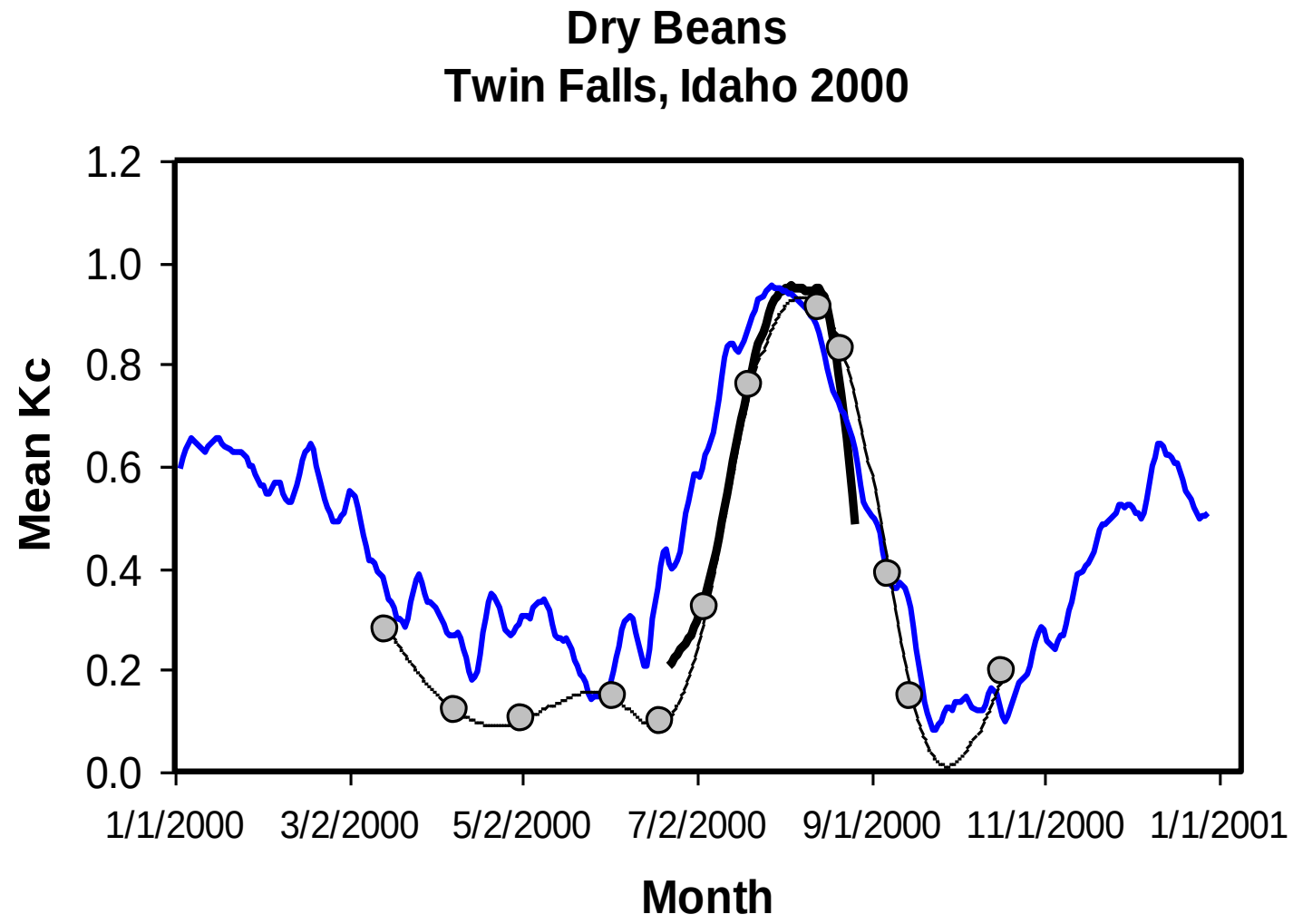
(relatively good agreement among very independent approaches, including during the 'shoulder' periods when ground has partial cover)

Agrimet for 2000 — K_{cmean} ET_{ref}

Allen-Robison - 14 yr ave. — $(K_{cb} + K_e)$ ET_{ref}

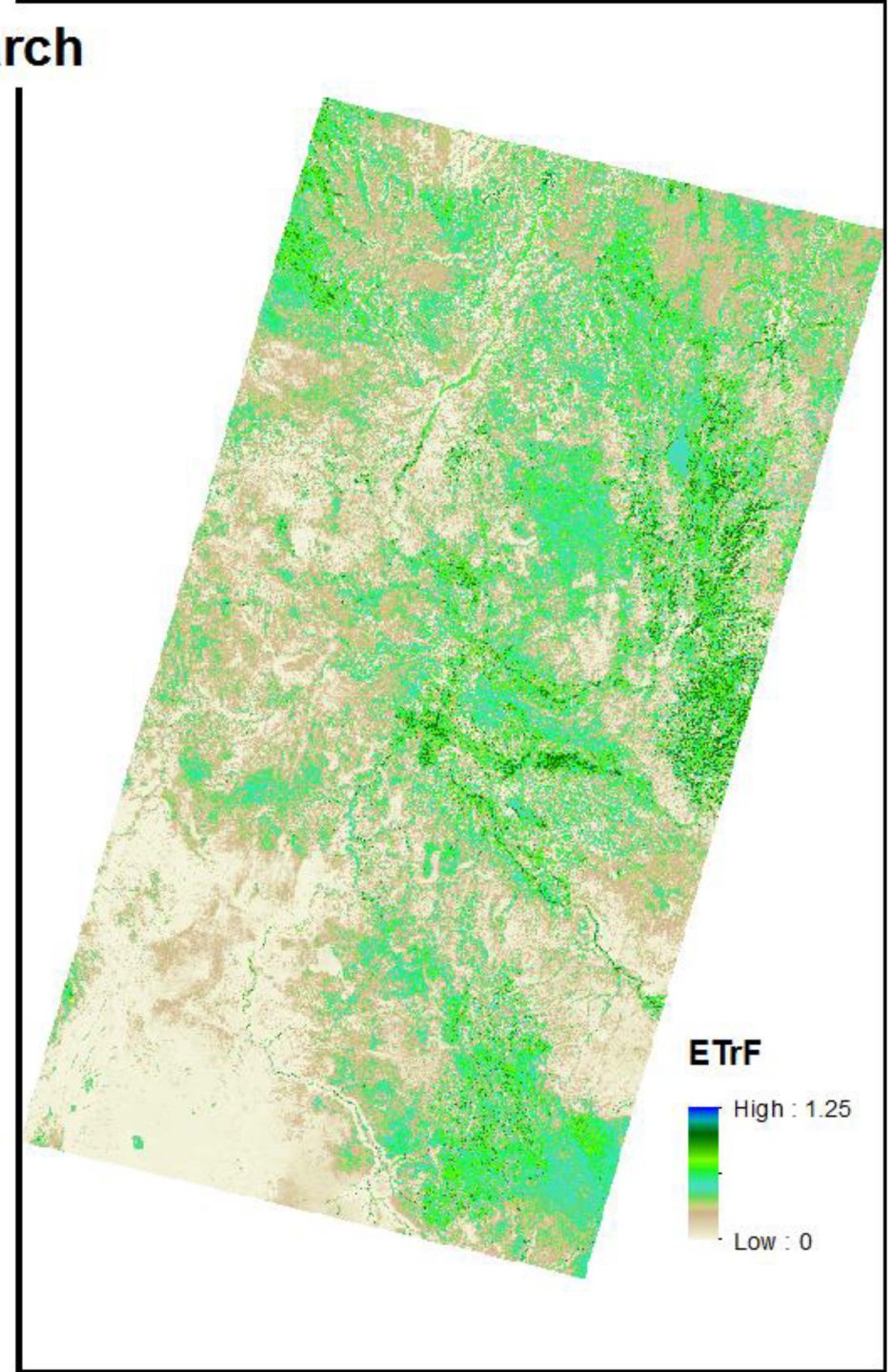
METRIC for 2000 — Energy Balance

Comparing METRIC vs. traditional K_c ET_{ref} methods

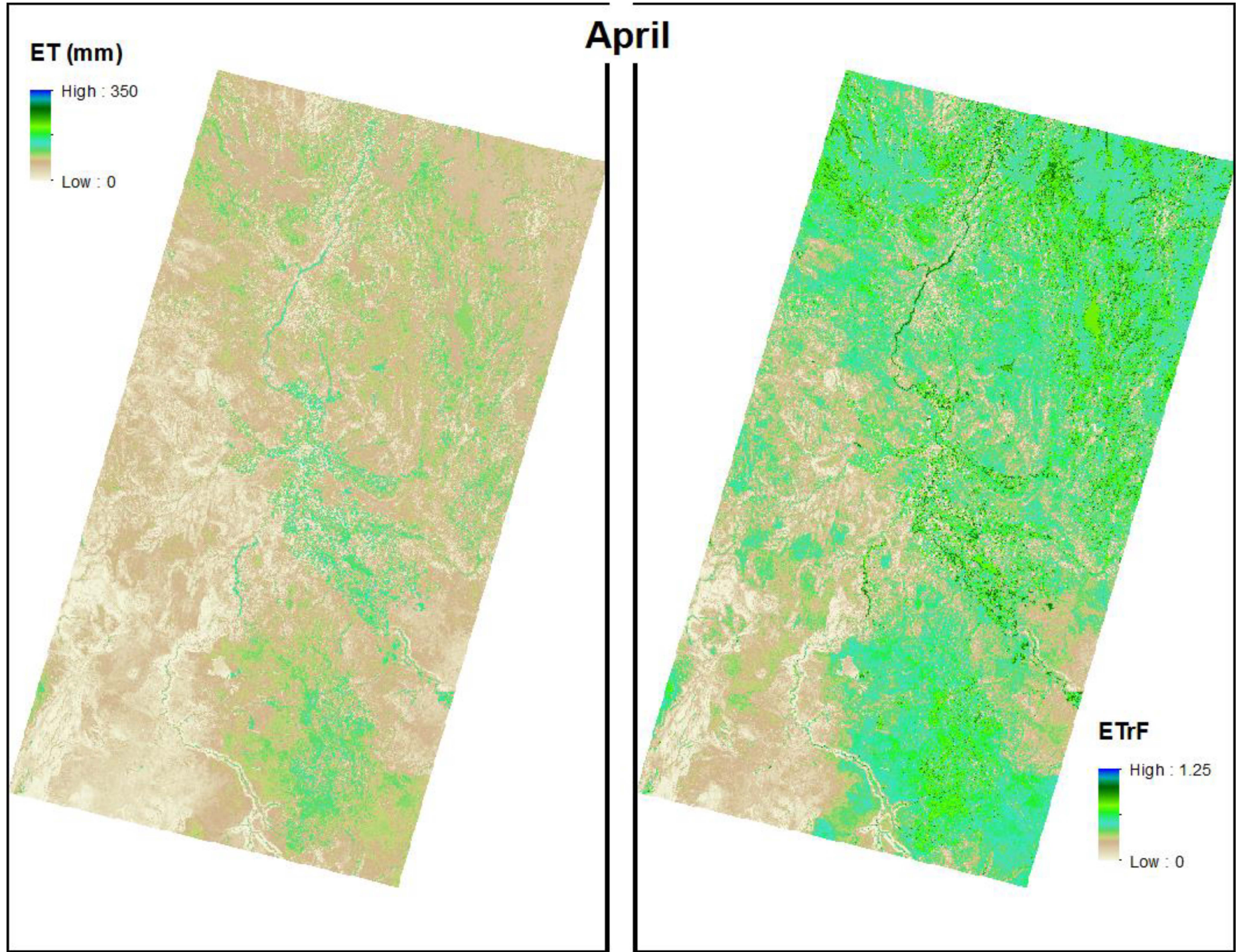


(relatively good agreement among very independent approaches, including during the 'shoulder' periods when ground has partial cover)

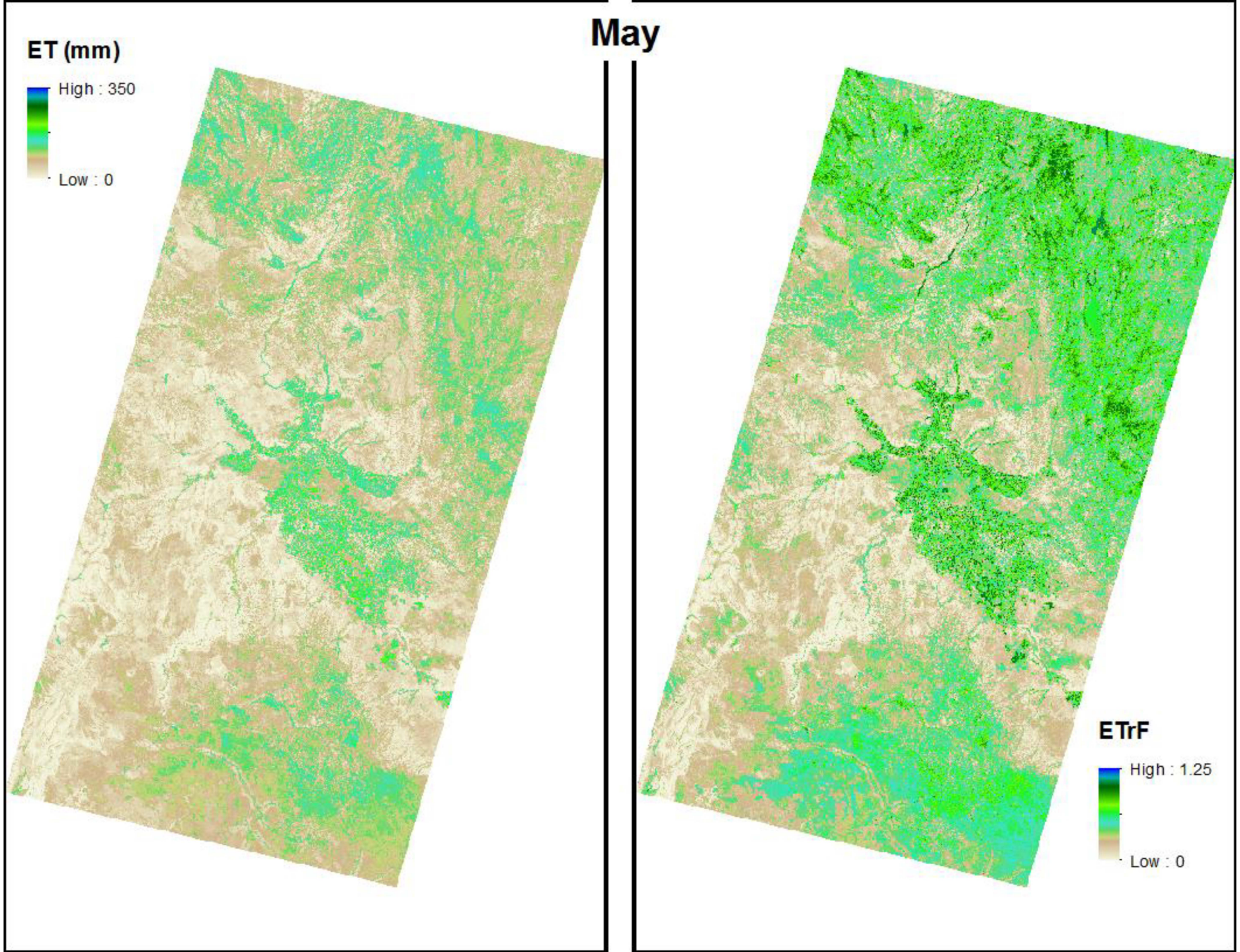
March



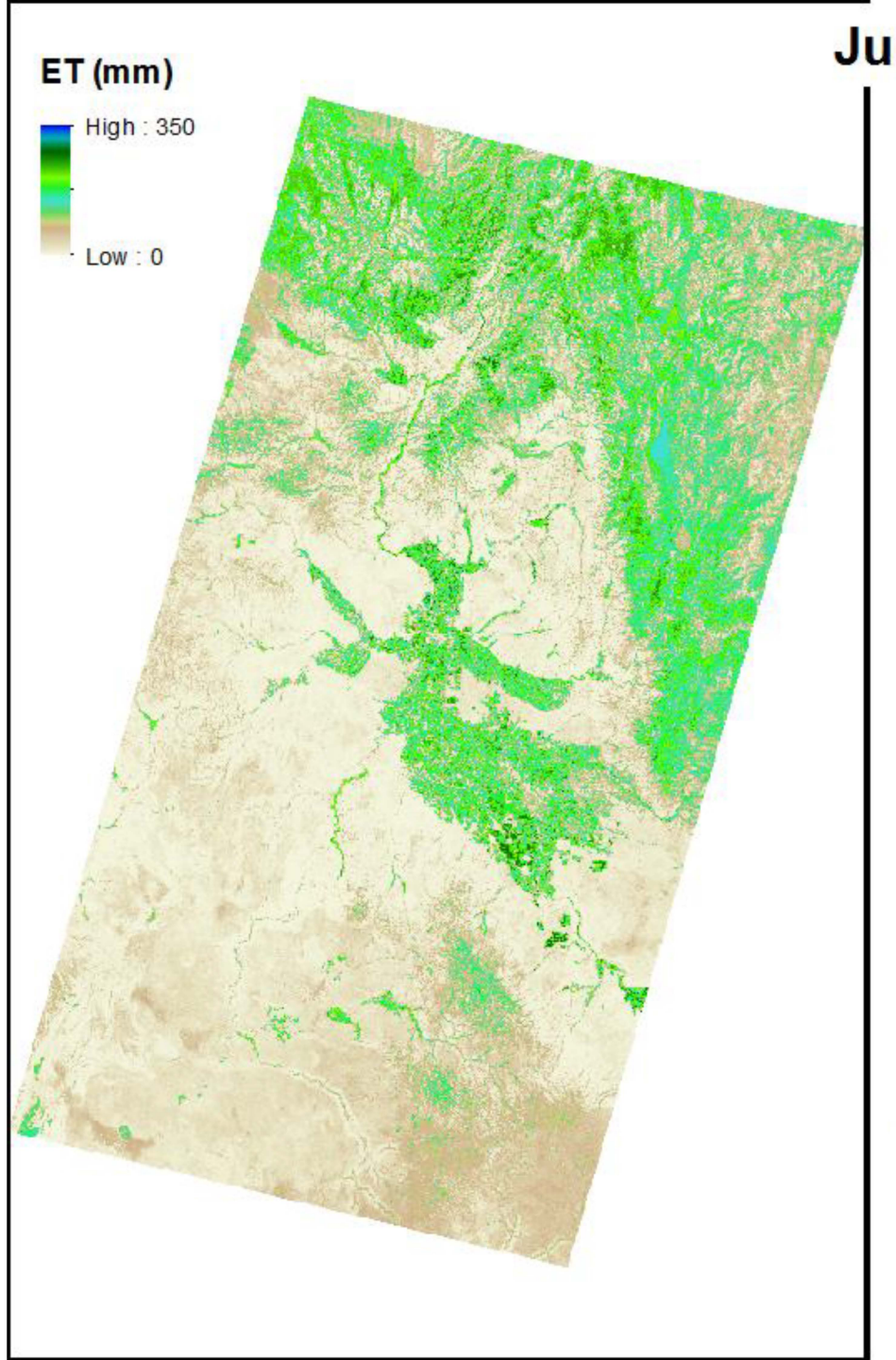
April

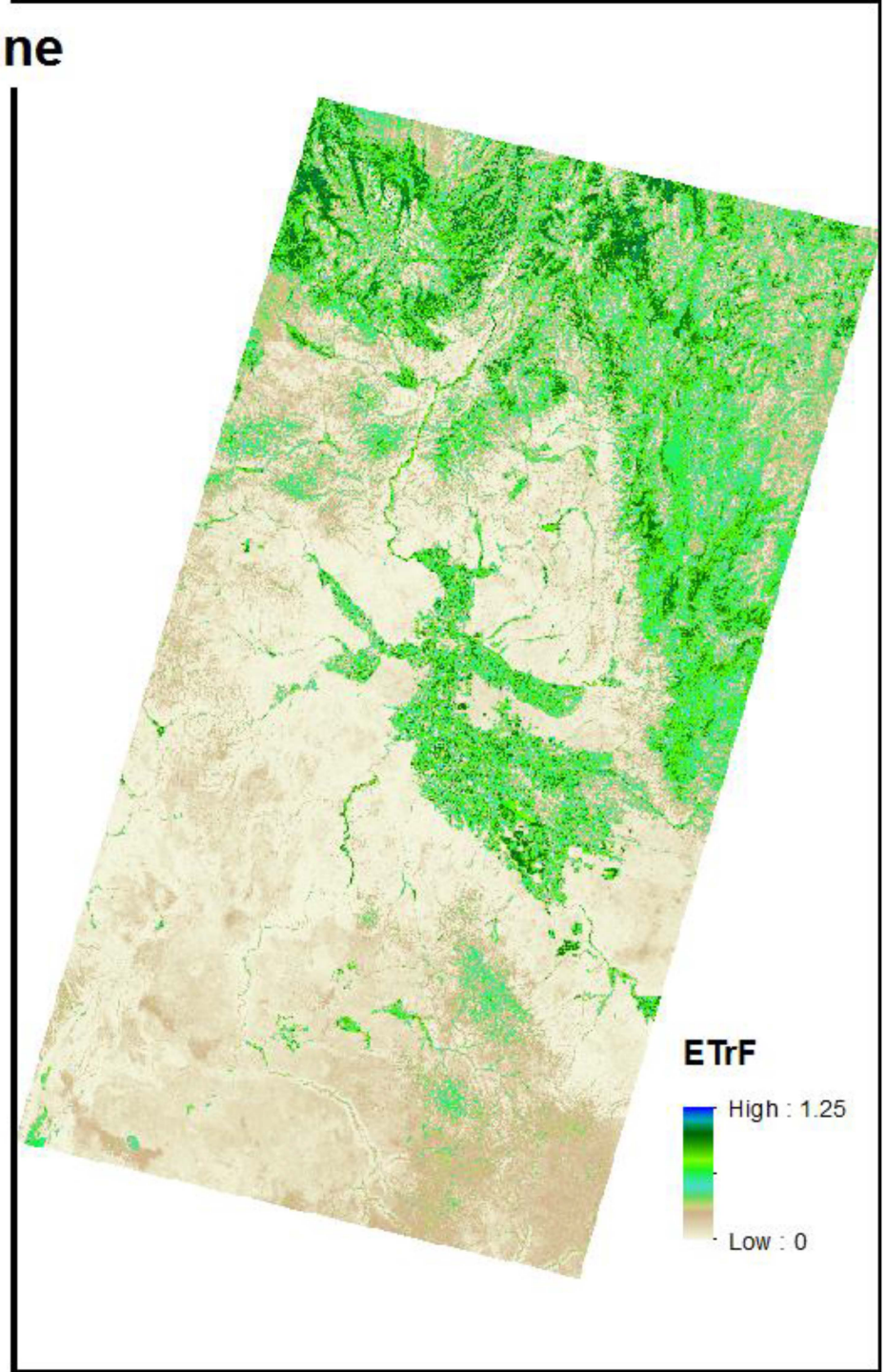


May

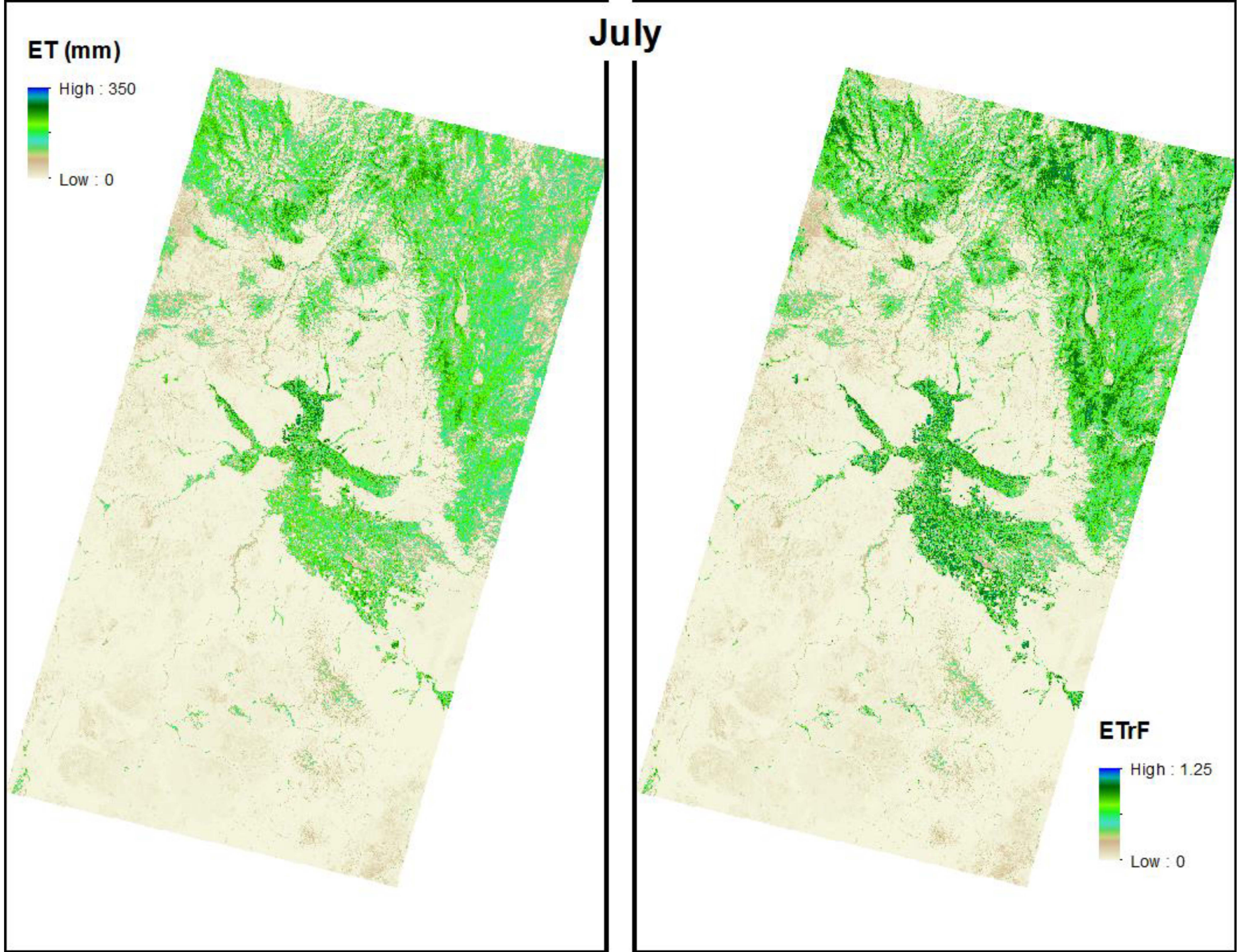


June

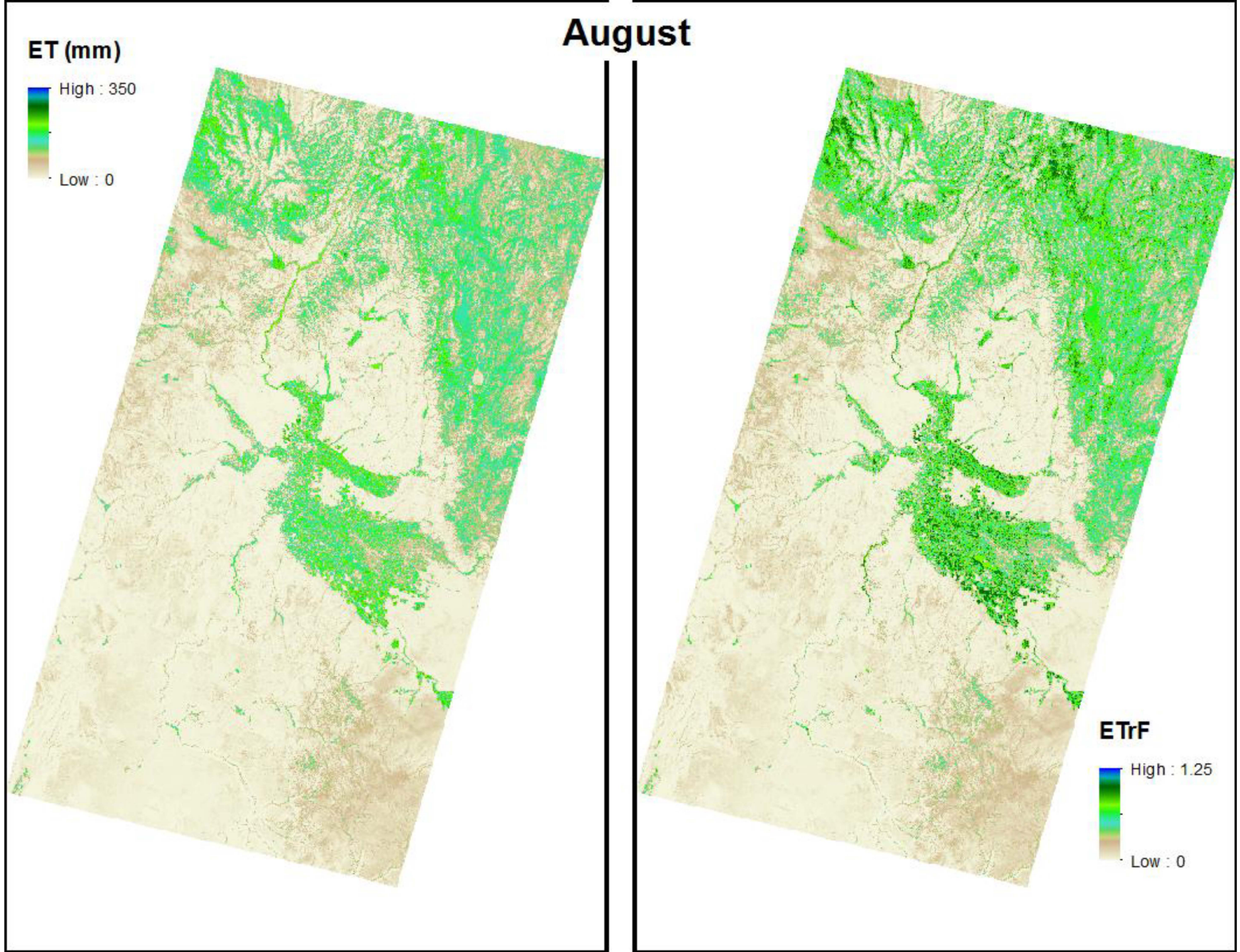




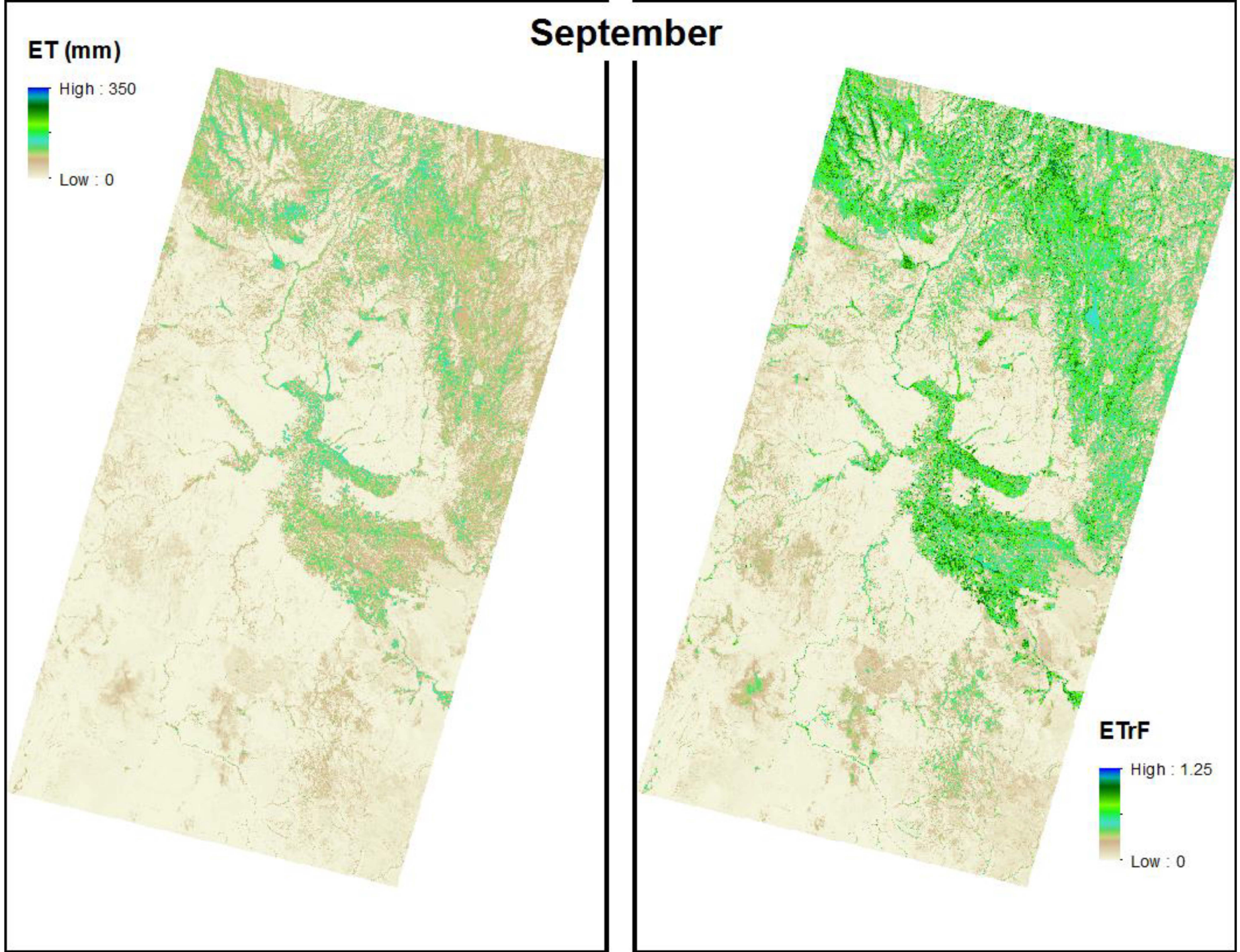
July



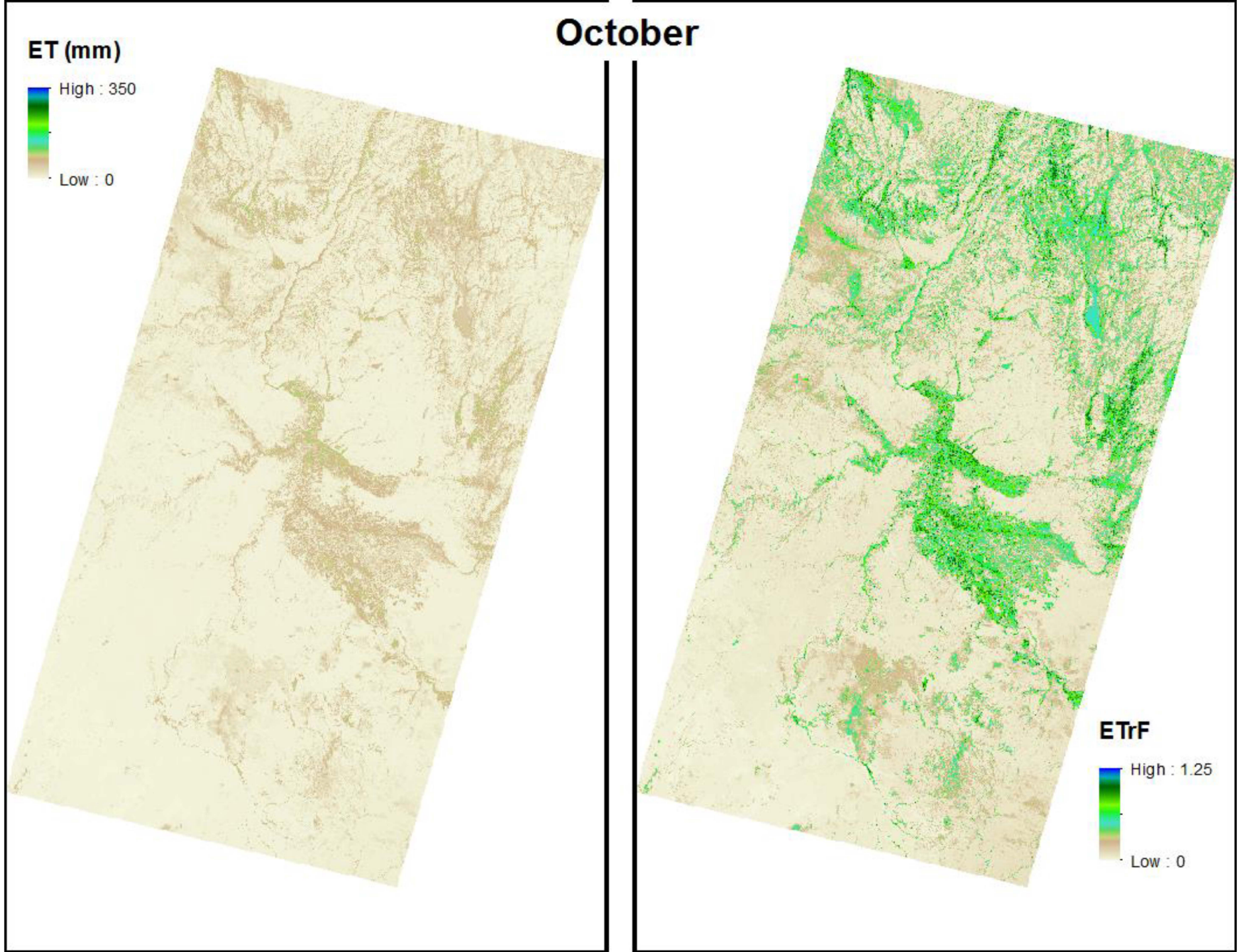
August



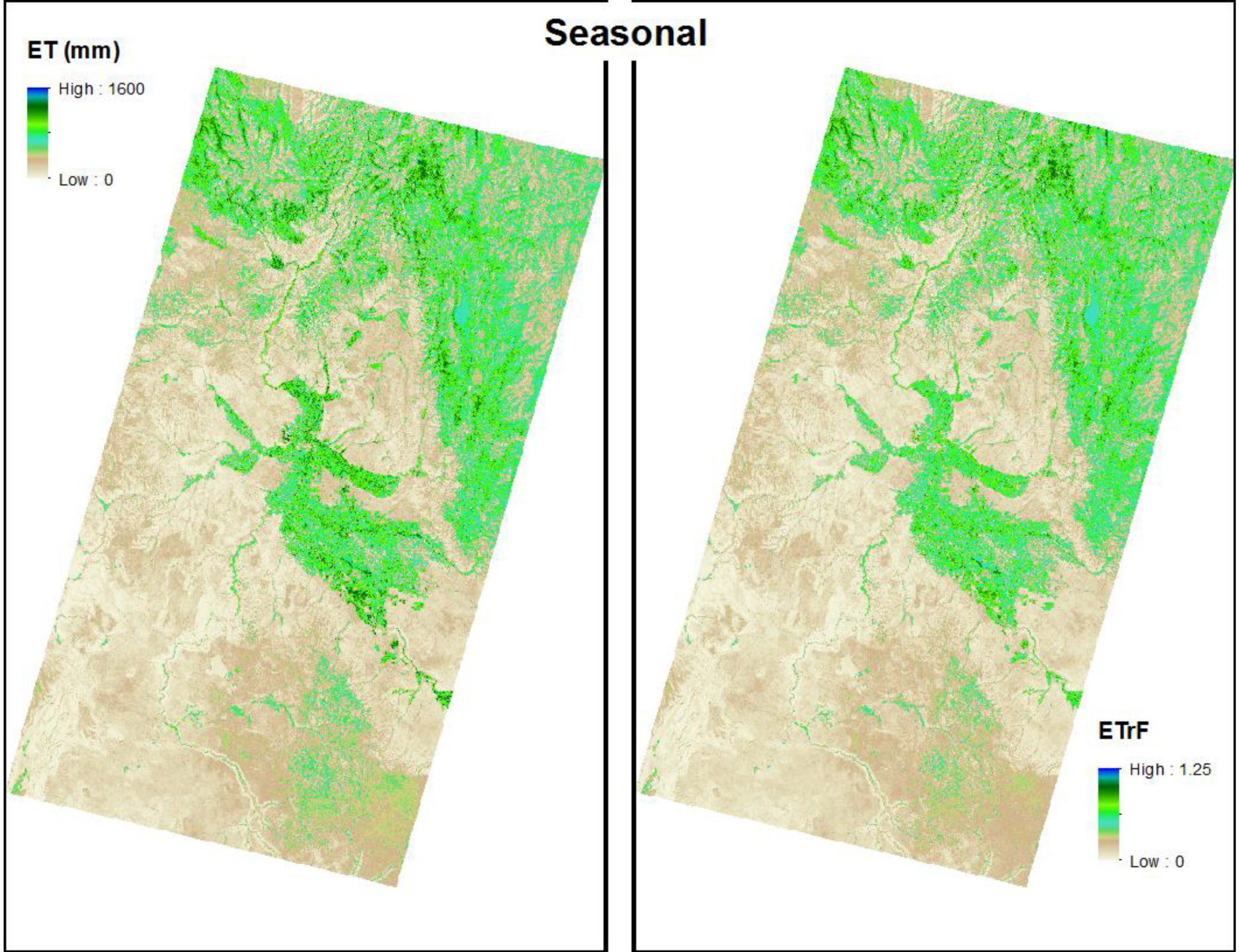
September

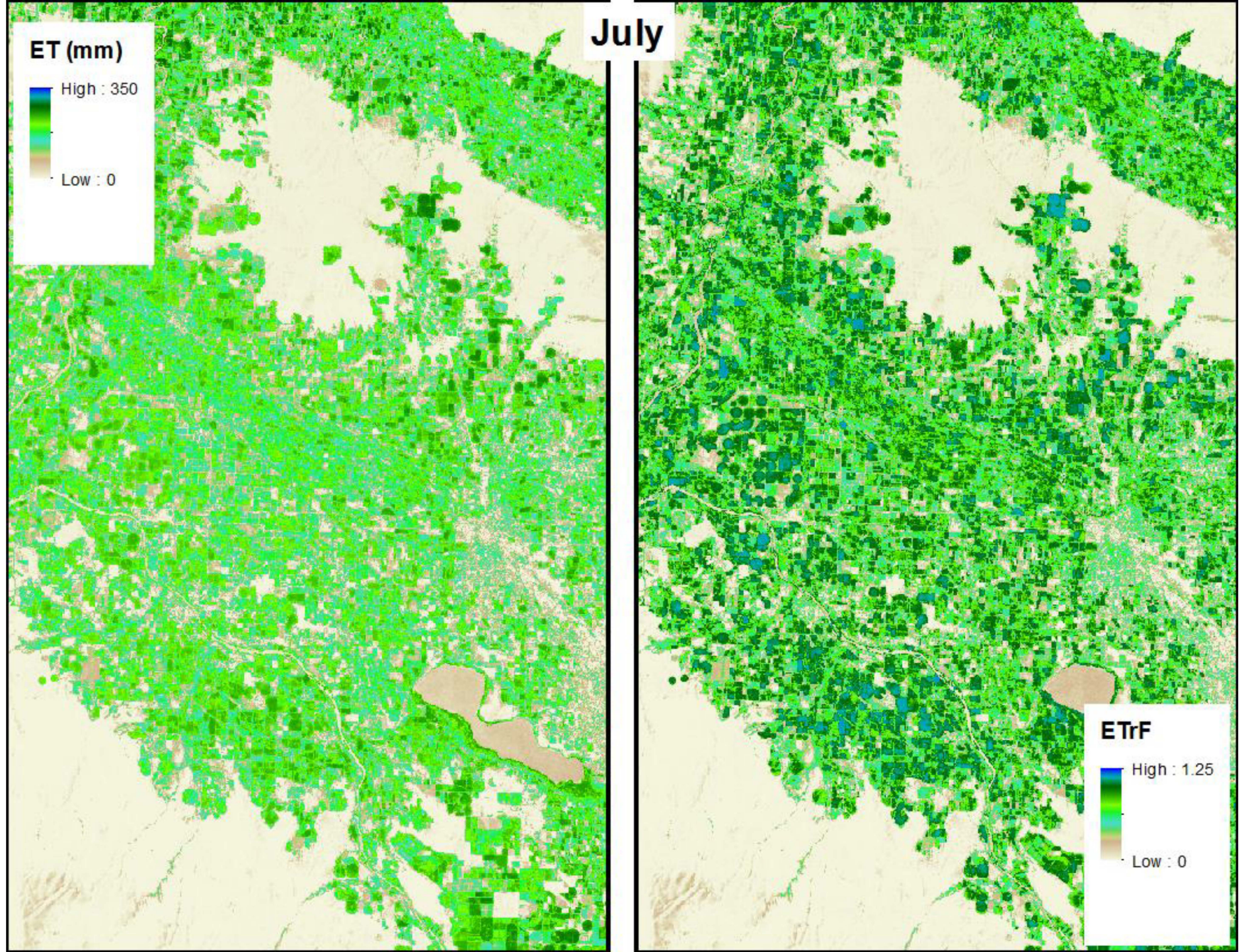


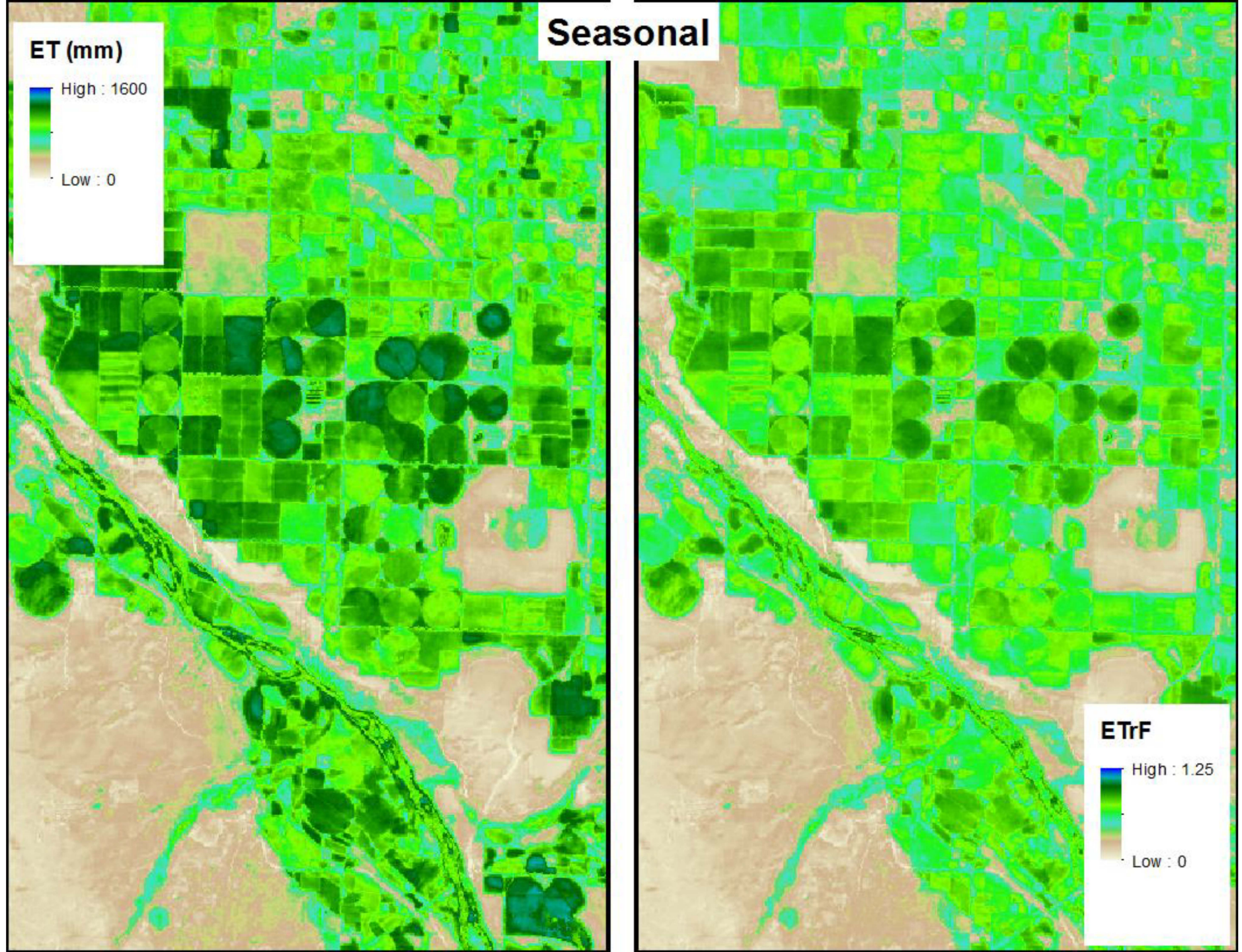
October

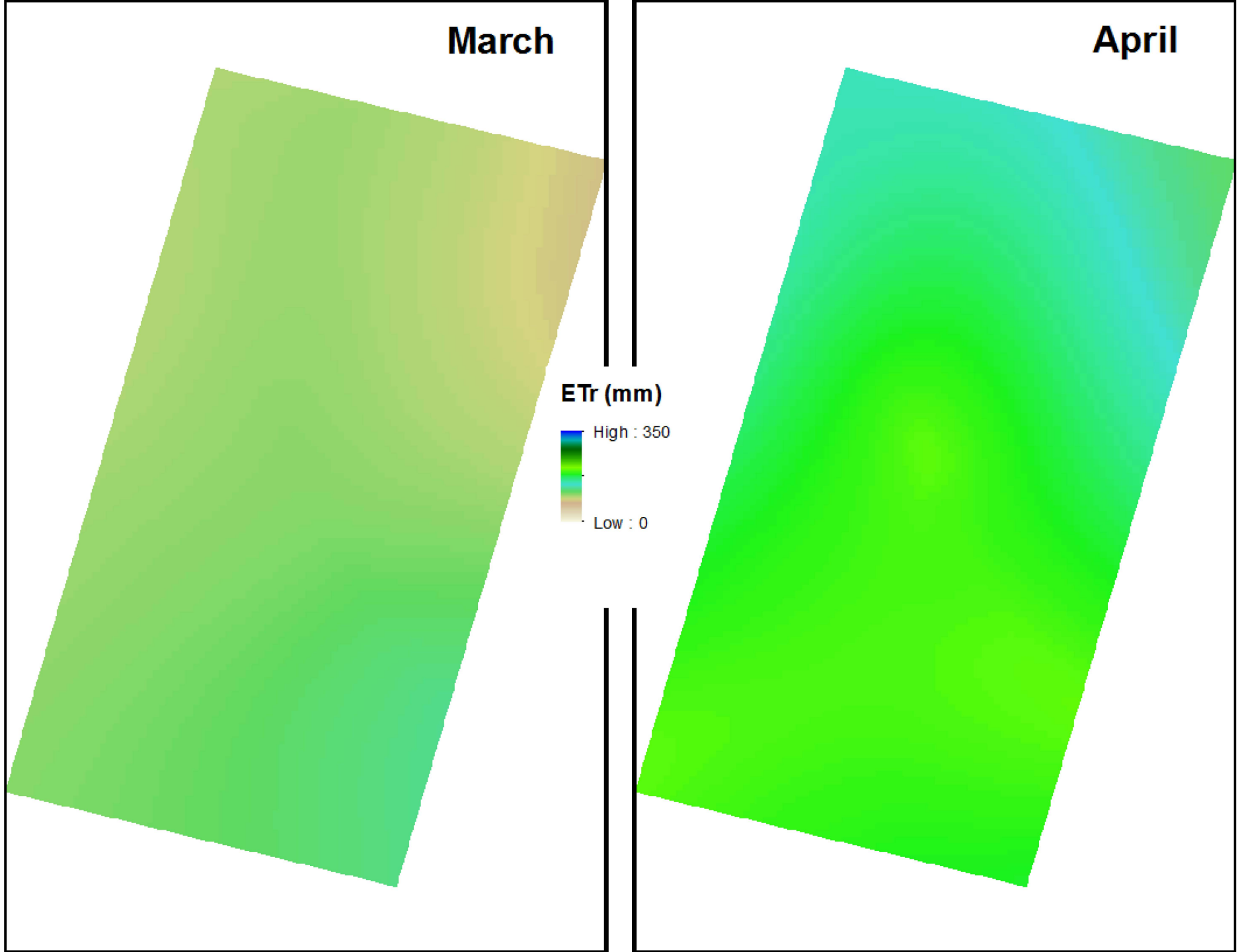


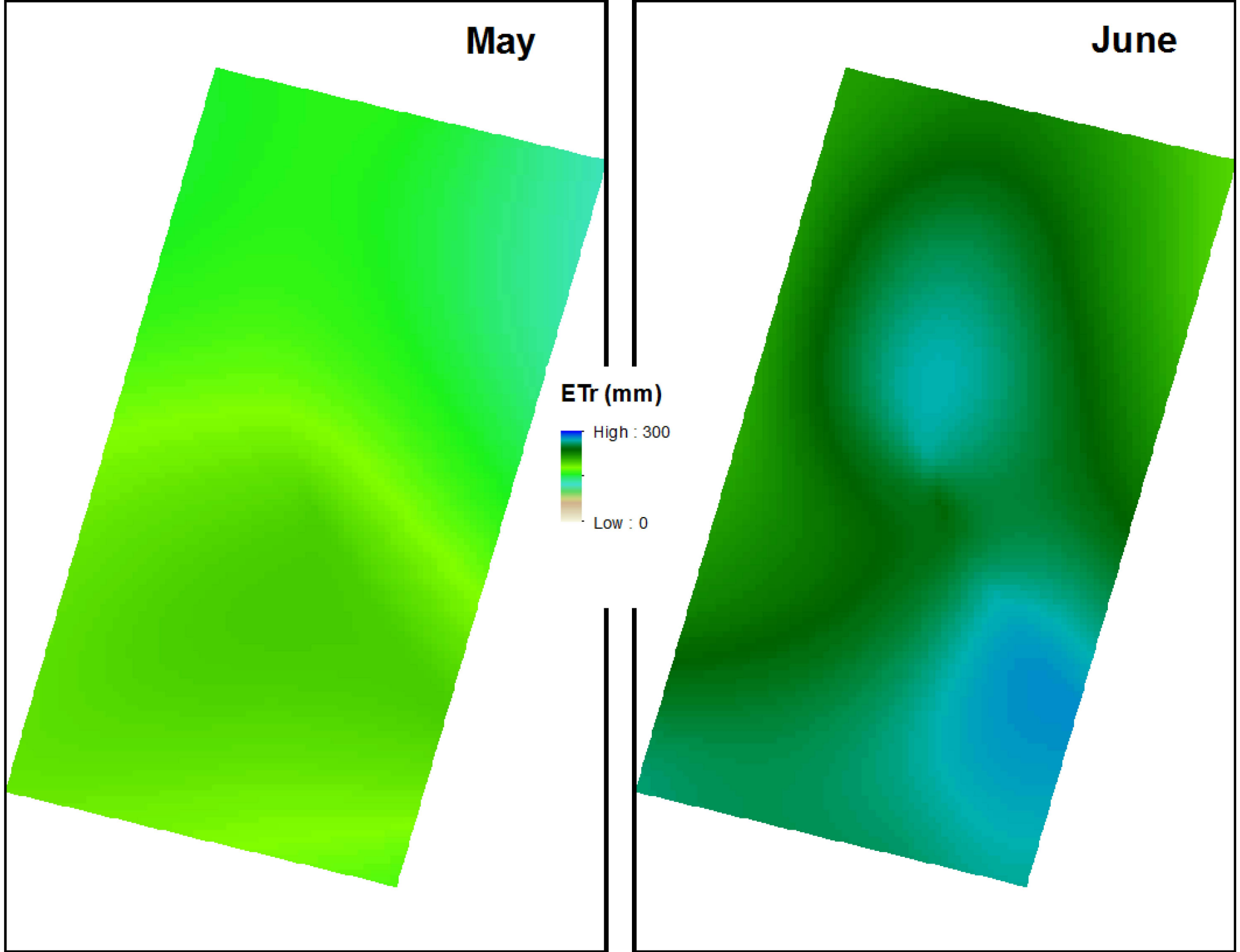
Seasonal

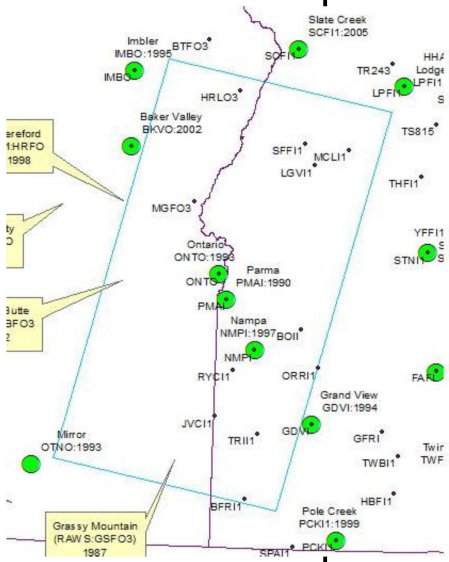



July
ET (mm)
High : 350
Low : 0
ETrF
High : 1.25
Low : 0


Seasonal
ET (mm)
High : 1600
Low : 0
ETrF
High : 1.25
Low : 0


March
April
ETr (mm)
High : 350
Low : 0


May
June
ETr (mm)
High : 300
Low : 0



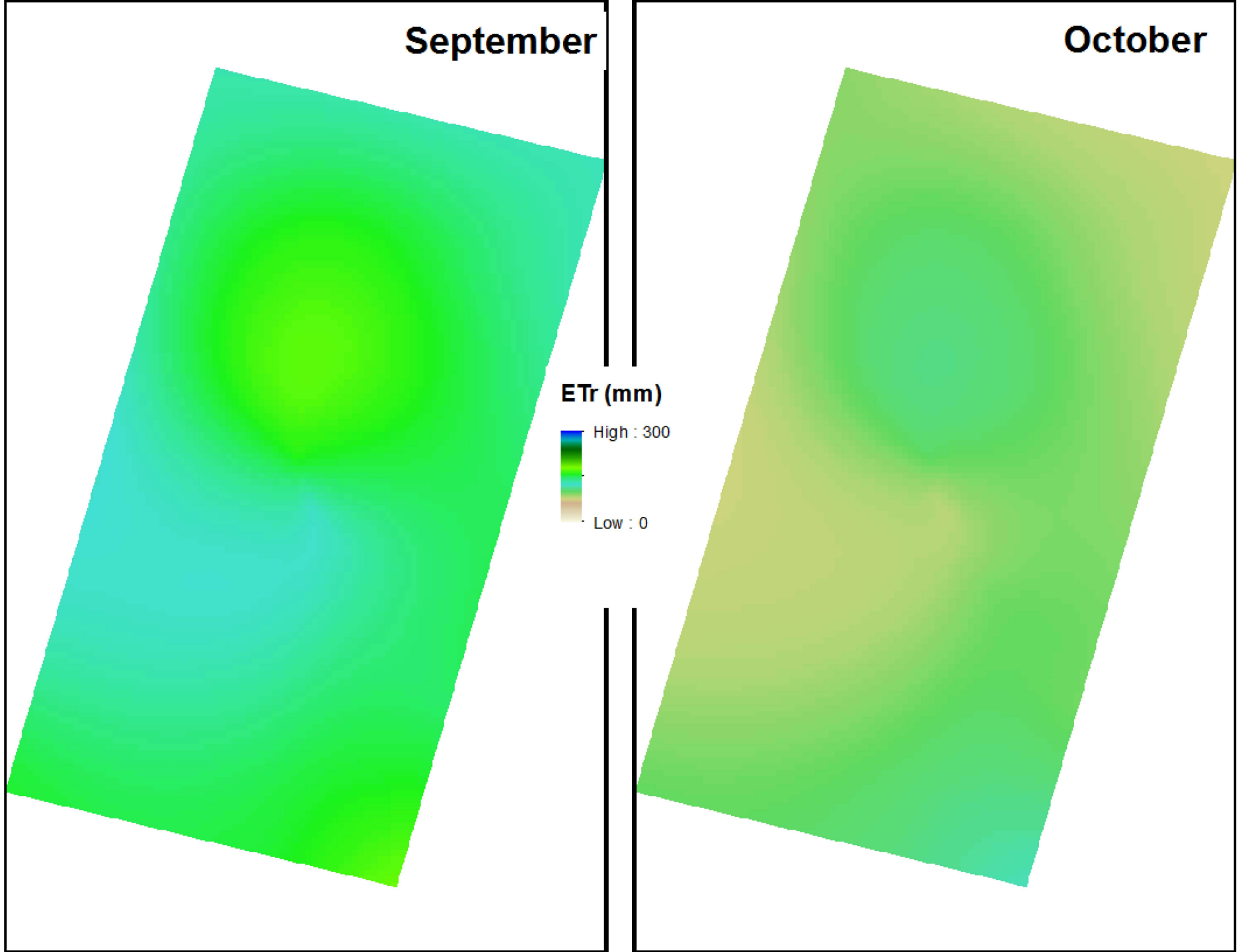
July

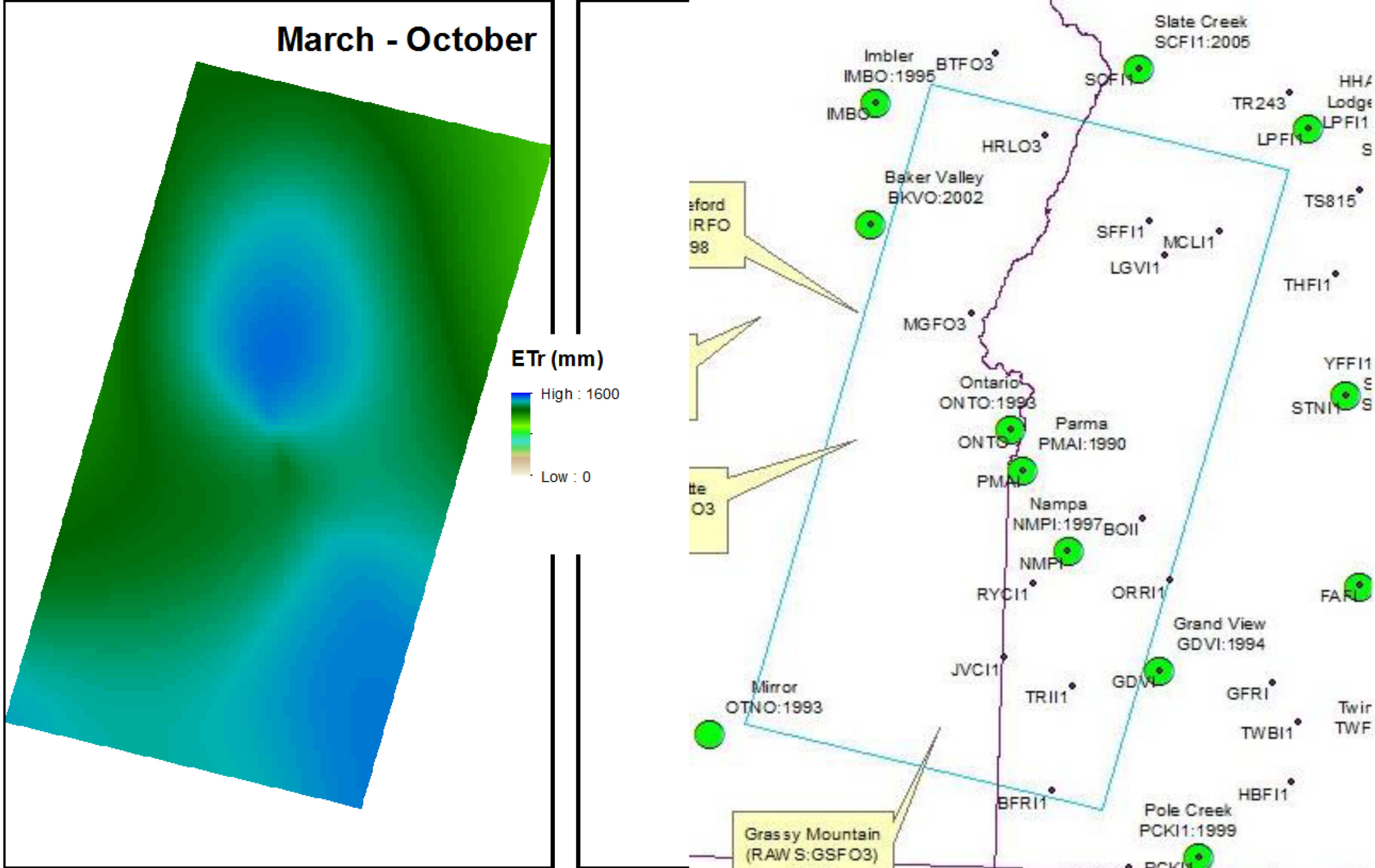
August

ETr (mm)

High : 300

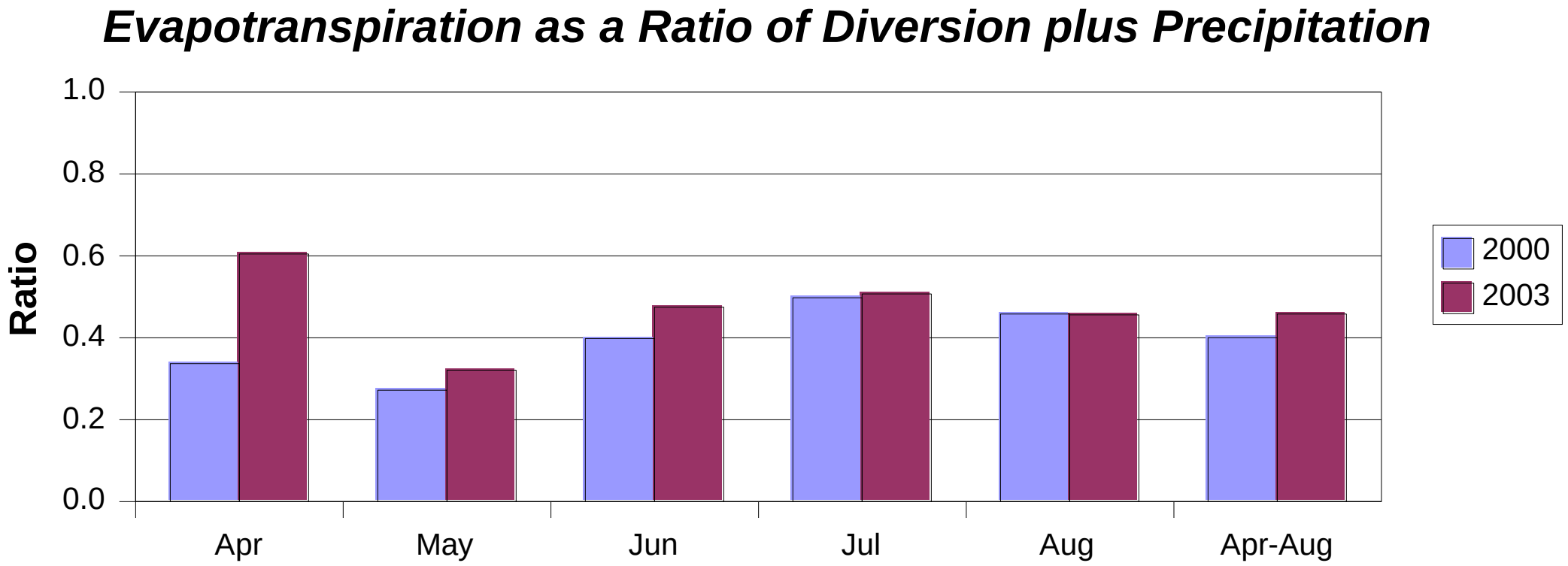
Low : 0


September
October
ETr (mm)
High : 300
Low : 0

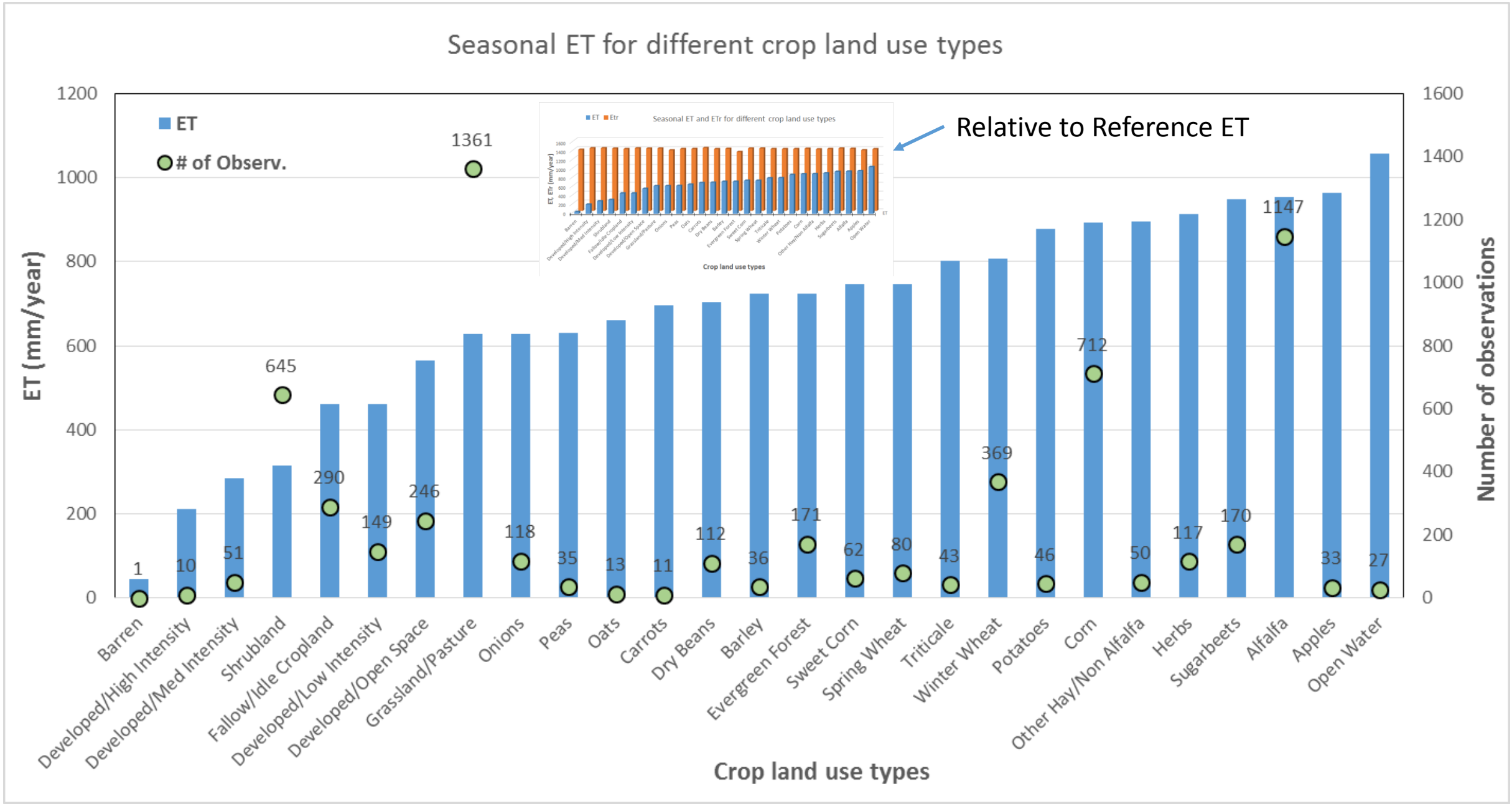

March - October
ETr (mm)
High : 1600
Low : 0
Slate Creek
SCFI1:2005
Imbler
IMBO:1995
BTFO3
IMBO
SCFI1
TR243
LPFI1
HRLO3
Baker Valley
BKVO:2002
TS815
SFFI1
MCLI1
LGVI1
THFI1
MGFO3
Ontario
ONTO:1993
ONTO
Parma
PMAI:1990
PMAI
Nampa
NMPI:1997
BOII
NMPI
RYCI1
ORRI1
Grand View
GDVI:1994
JVCI1
GDVI
TRII1
GFRI
Mirror
OTNO:1993
TWBI1
HBFI1
BFRI1
Pole Creek
PCKI1:1999
Grassy Mountain
(RAWS:GSFO3)

Irrigation Project Performance -- Idaho

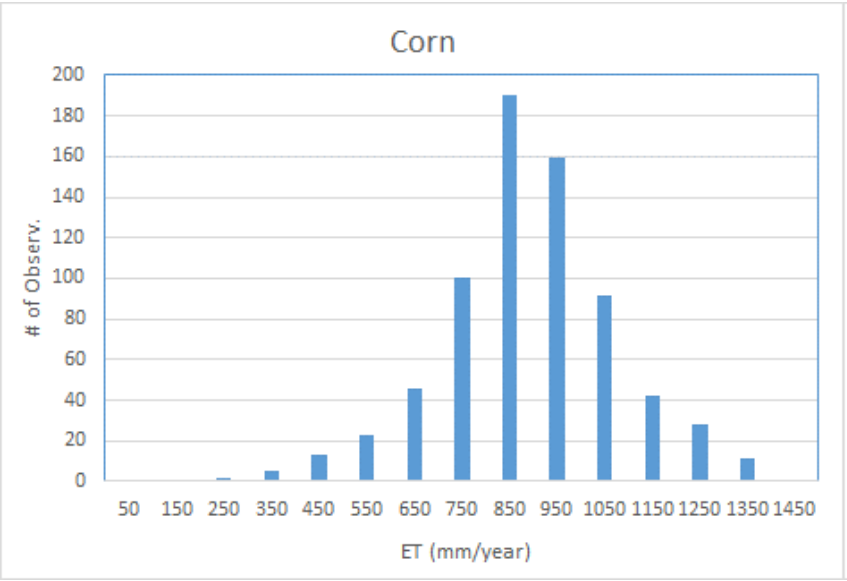
Twin Falls Canal Company, Idaho

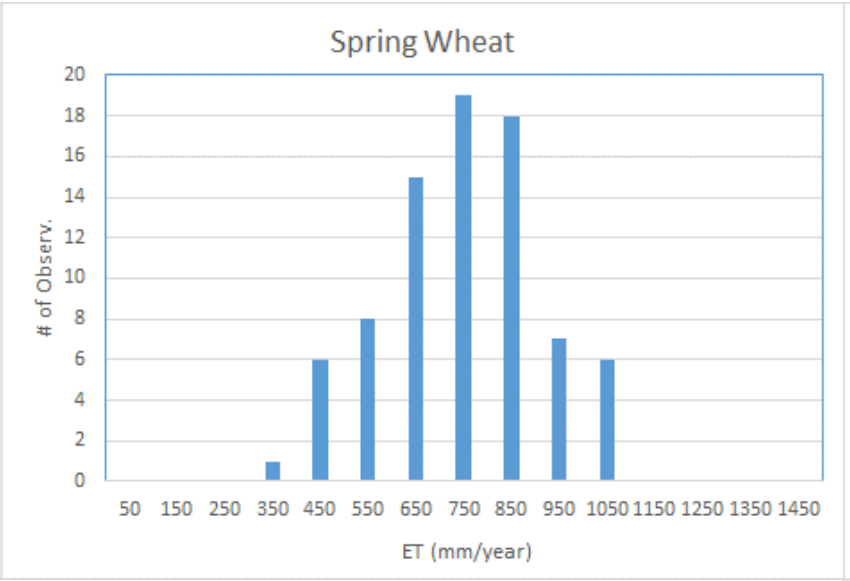


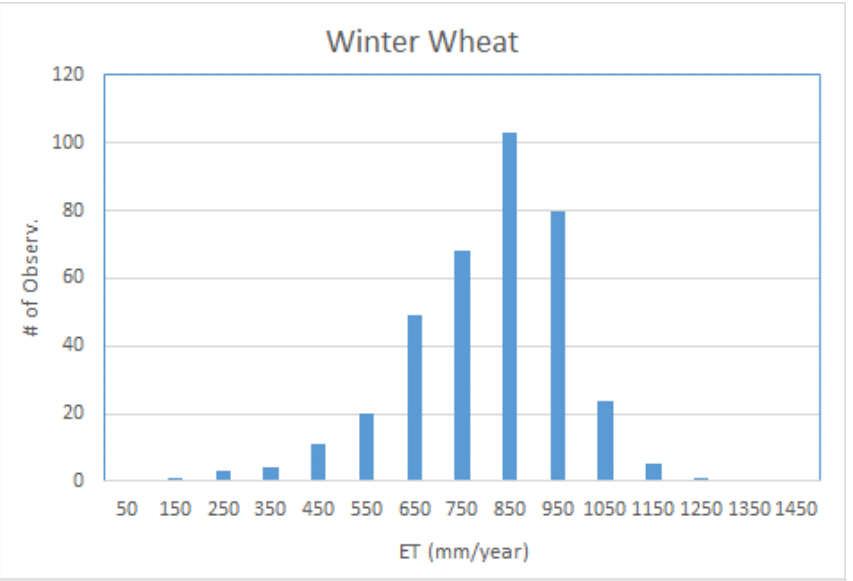
Summary Statistics on Year 2015 by Crop

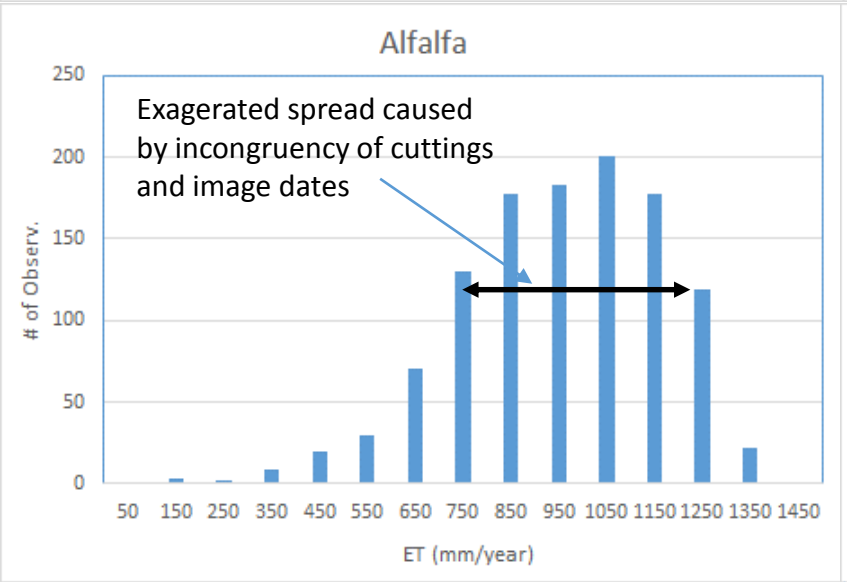

Seasonal ET for different crop land use types
ET
# of Observ.
Relative to Reference ET
ET (mm/year)
Number of observations
Crop land use types
0
200
400
600
800
1000
1200
1400
1600
1
10
51
645
290
149
246
1361
118
35
13
11
112
36
171
62
80
43
369
46
712
50
117
170
1147
33
27
Barren
Developed/High Intensity
Developed/Med Intensity
Shrubland
Fallow/Idle Cropland
Developed/Low Intensity
Developed/Open Space
Grassland/Pasture
Onions
Peas
Oats
Carrots
Dry Beans
Barley
Evergreen Forest
Sweet Corn
Spring Wheat
Triticale
Winter Wheat
Potatoes
Corn
Other Hay/Non Alfalfa
Herbs
Sugarbeets
Alfalfa
Apples
Open Water

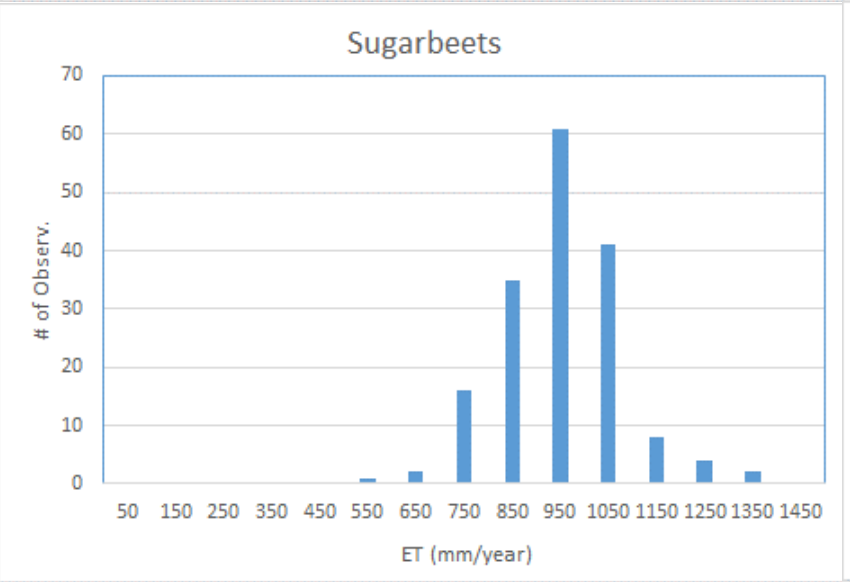
Distribution of Growing Season ET by Field

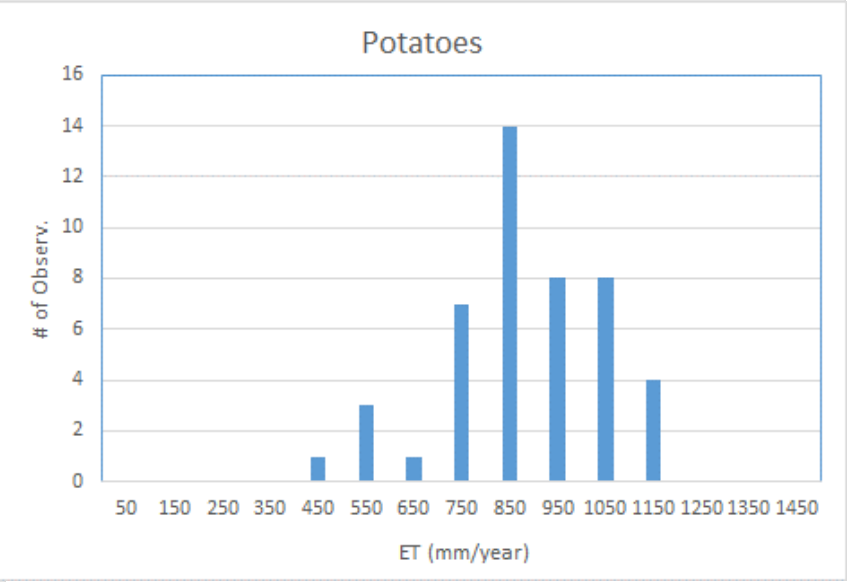




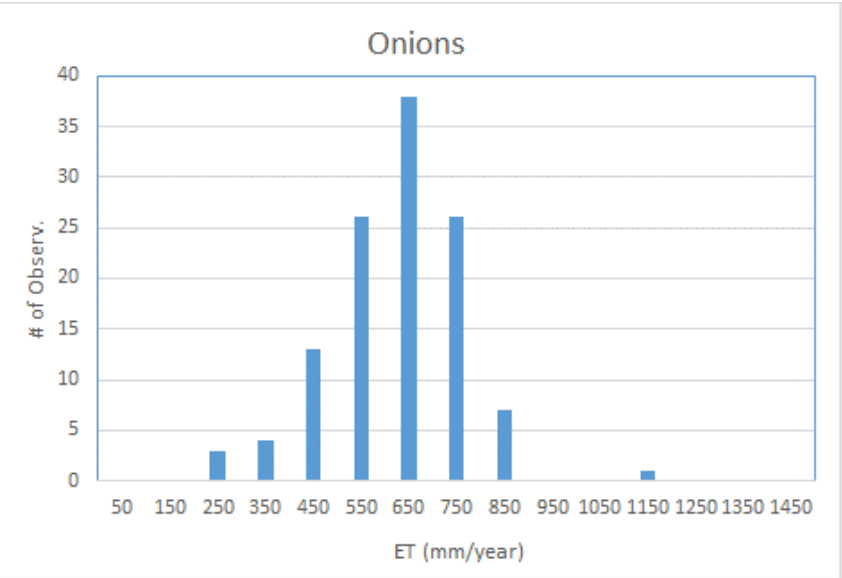


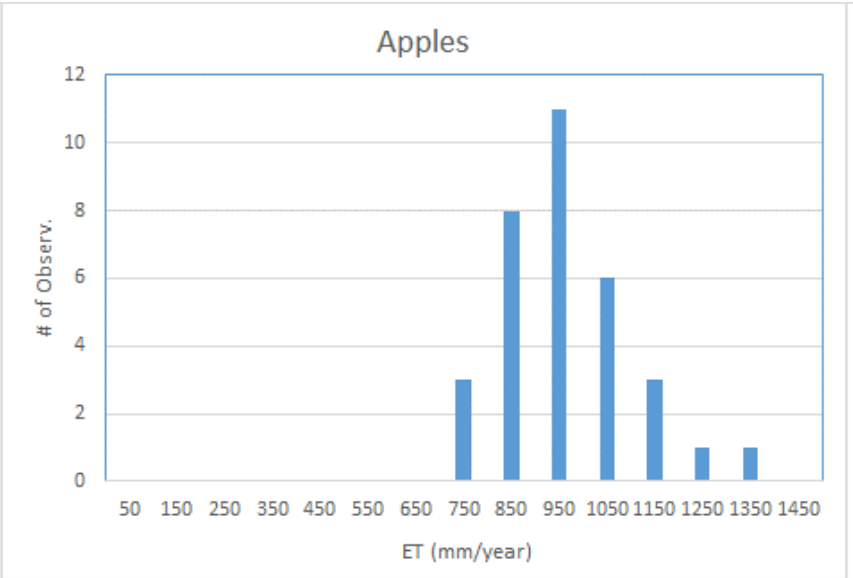


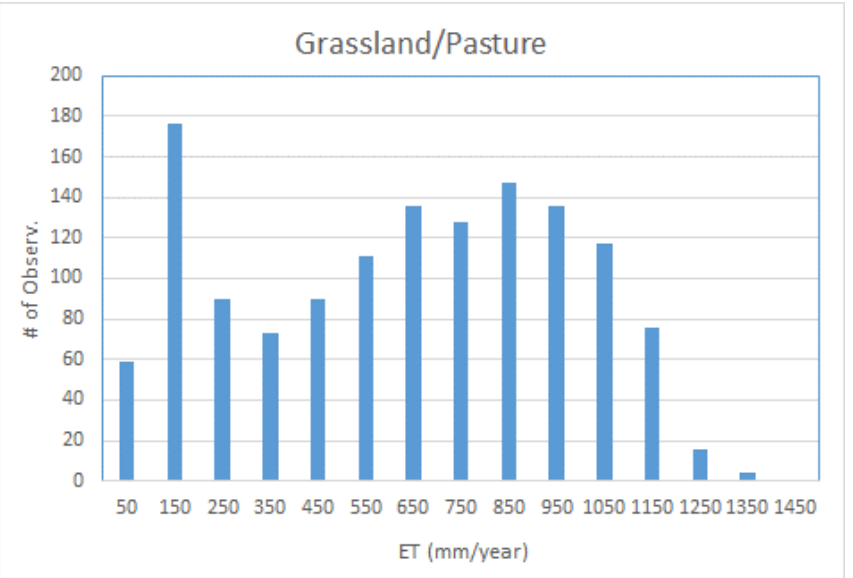


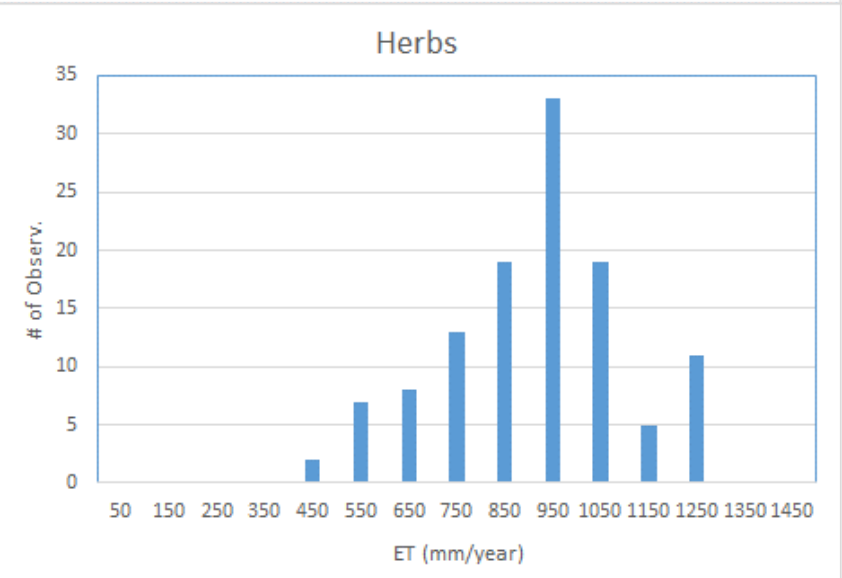


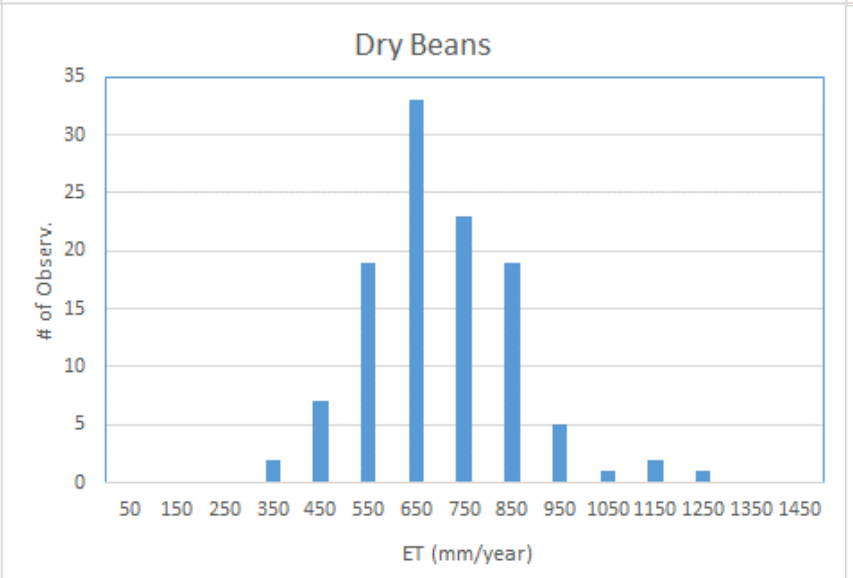
Distribution of Growing Season ET by Field

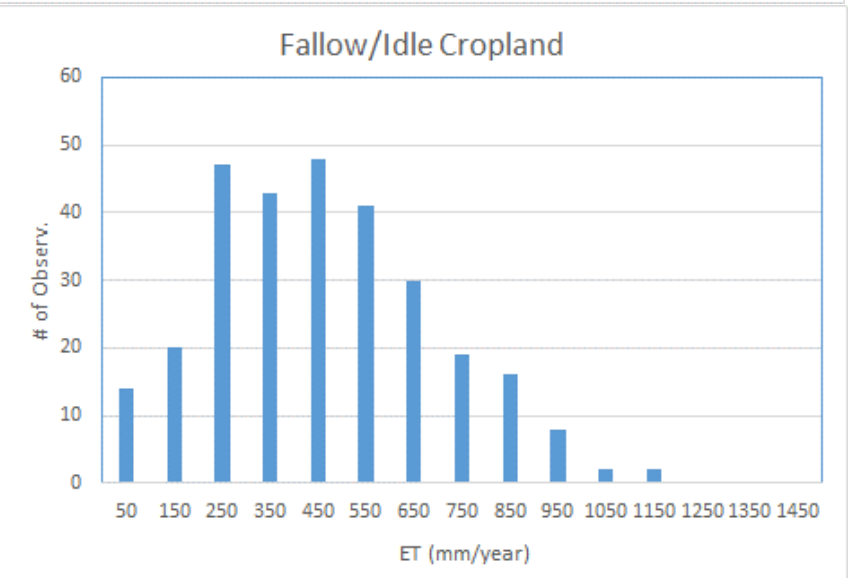




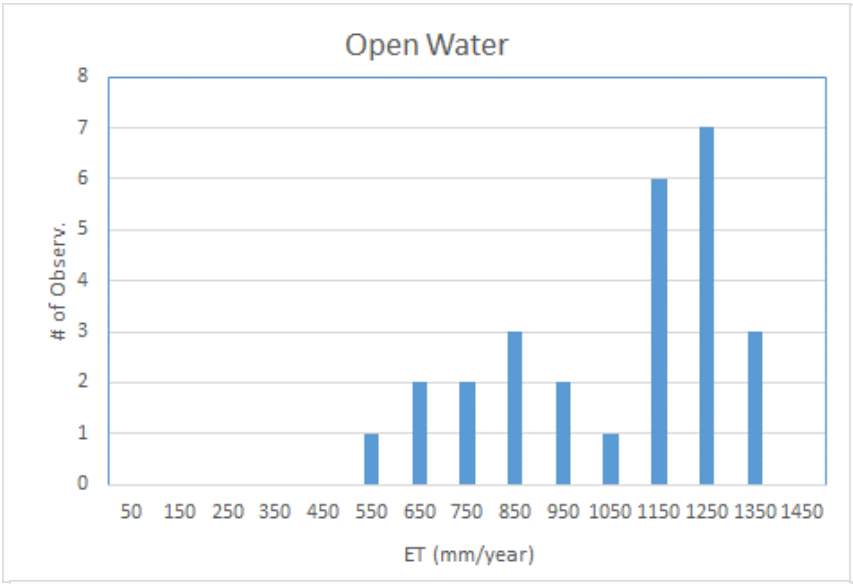


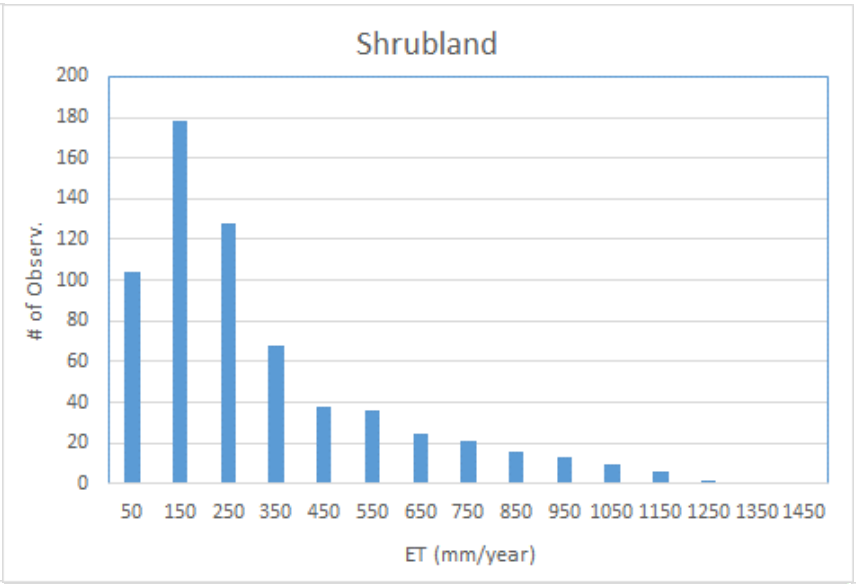


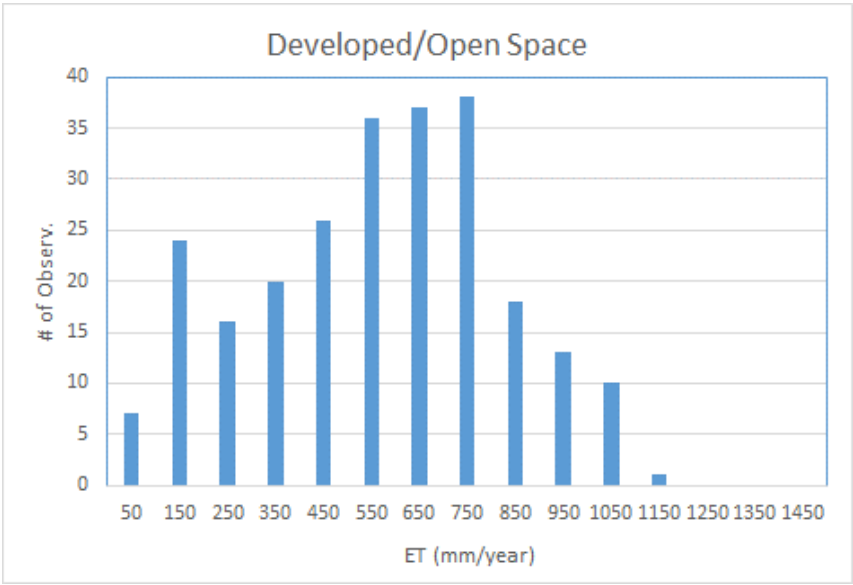


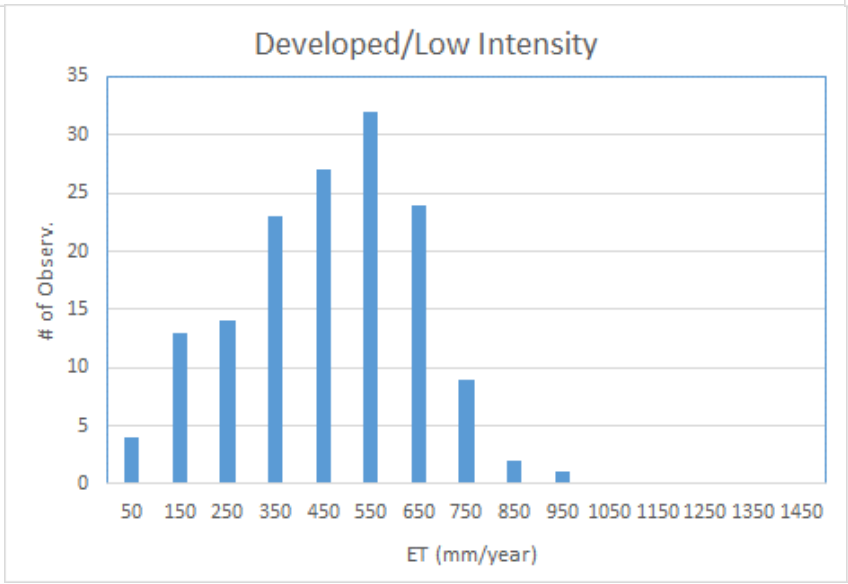


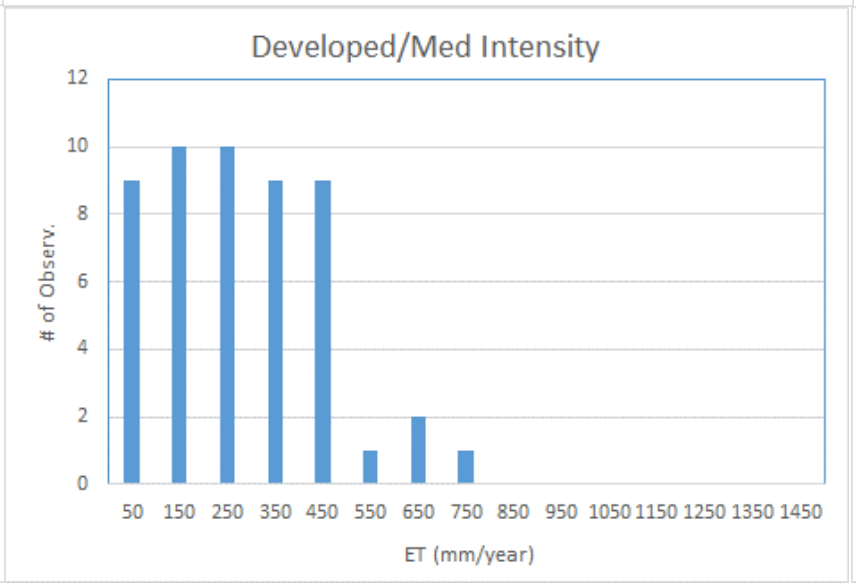
Distribution of Growing Season ET by Field

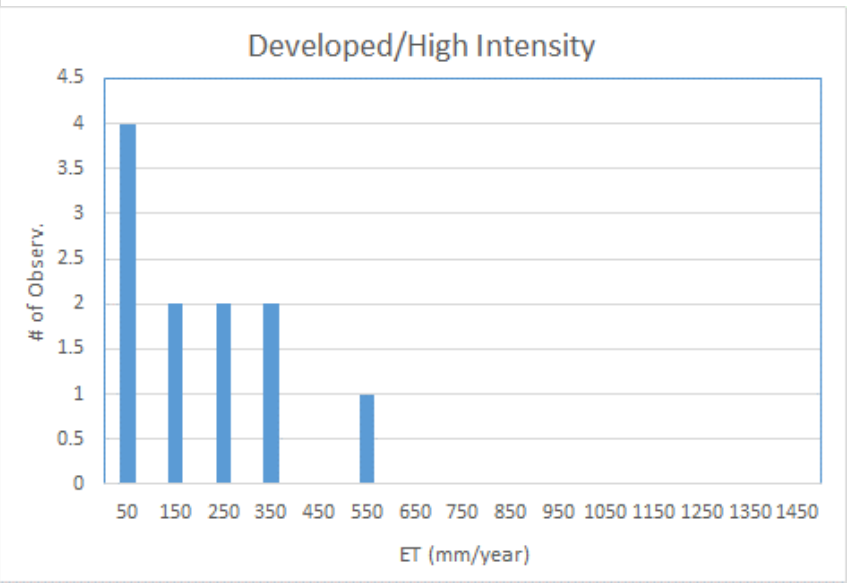




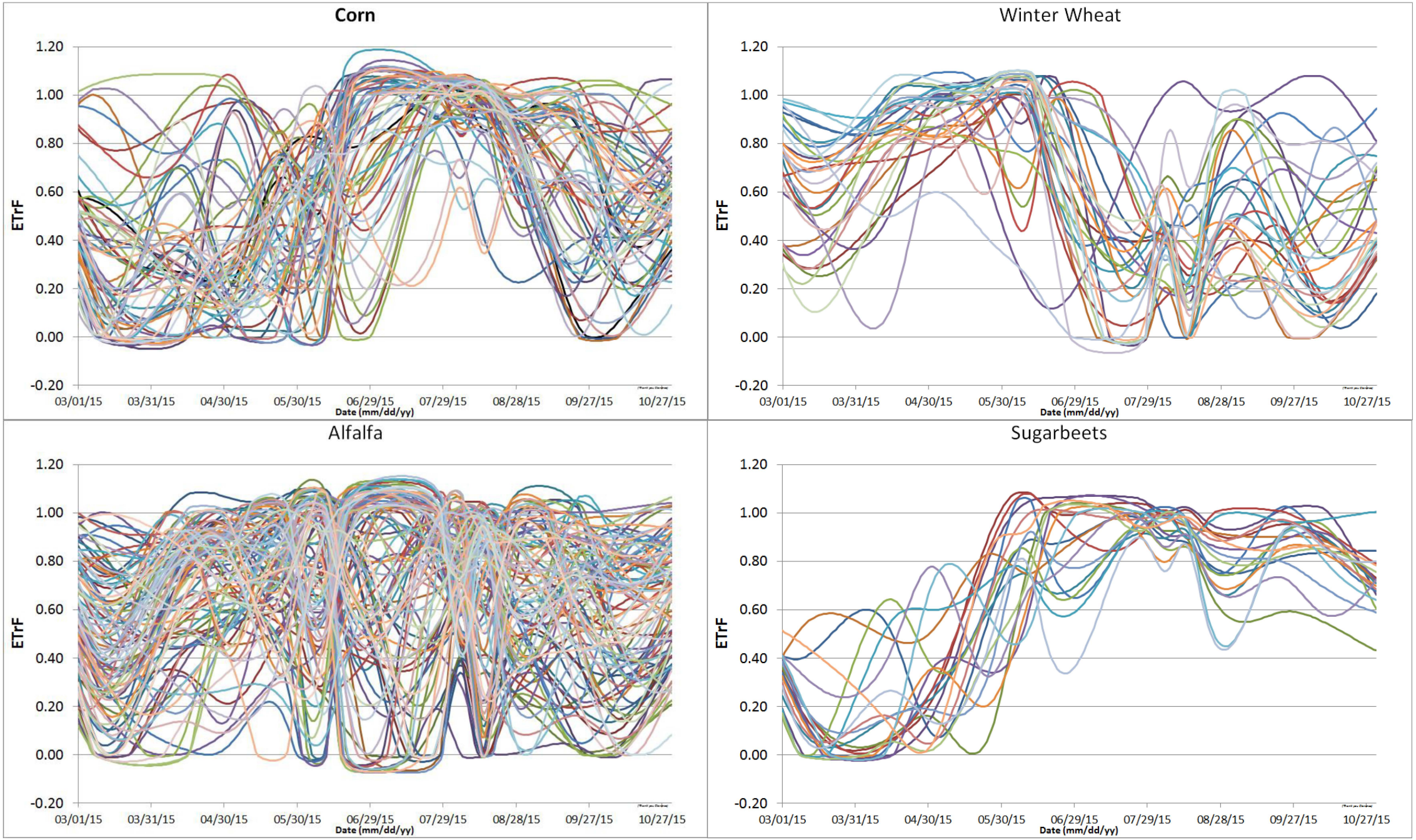


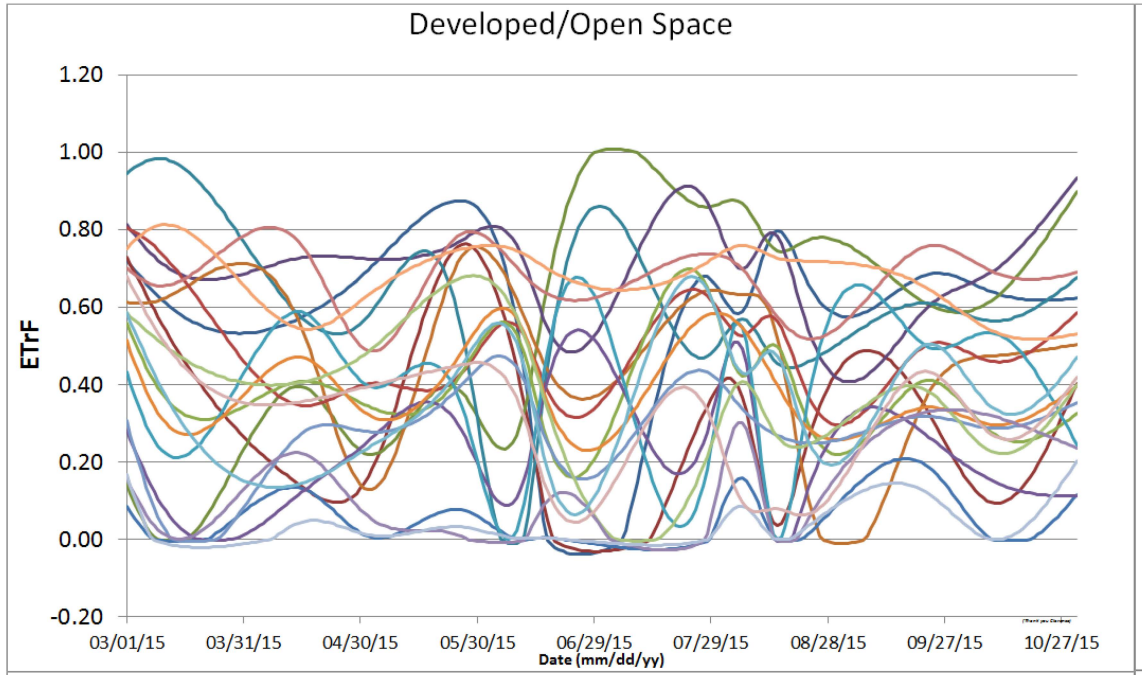


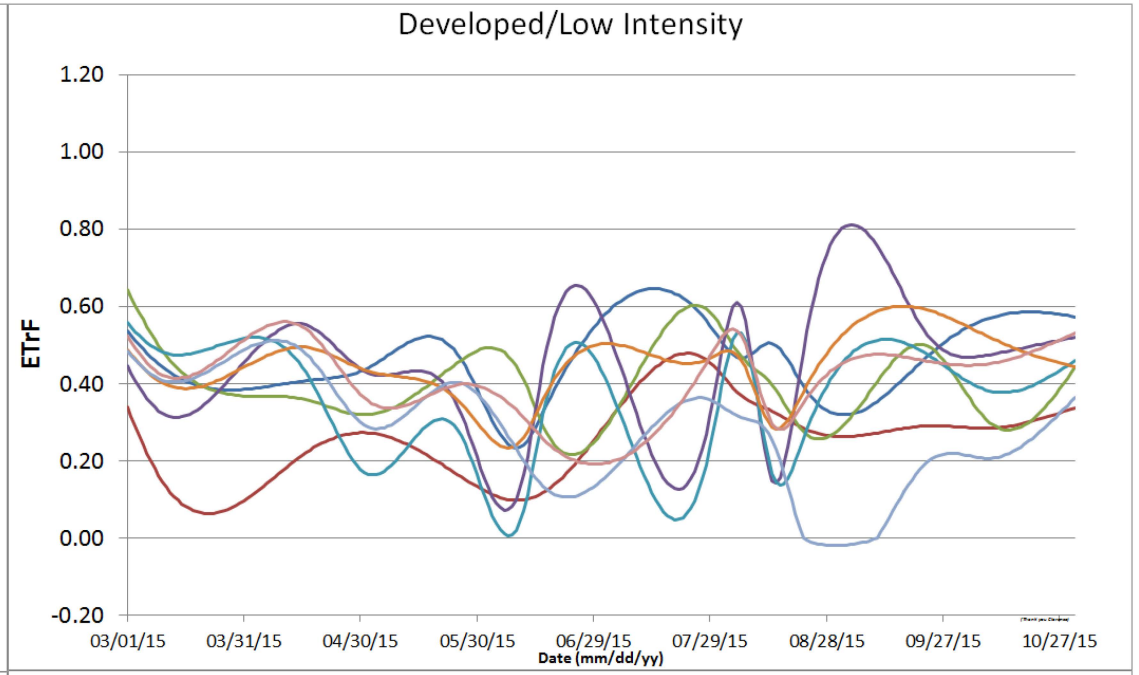


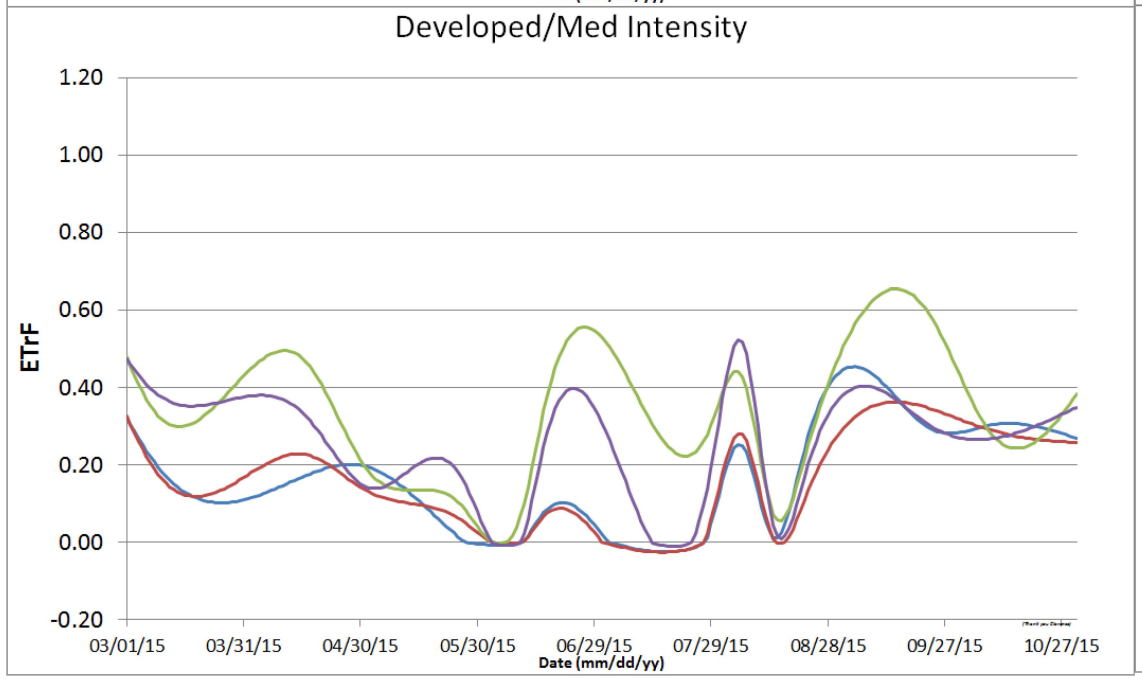


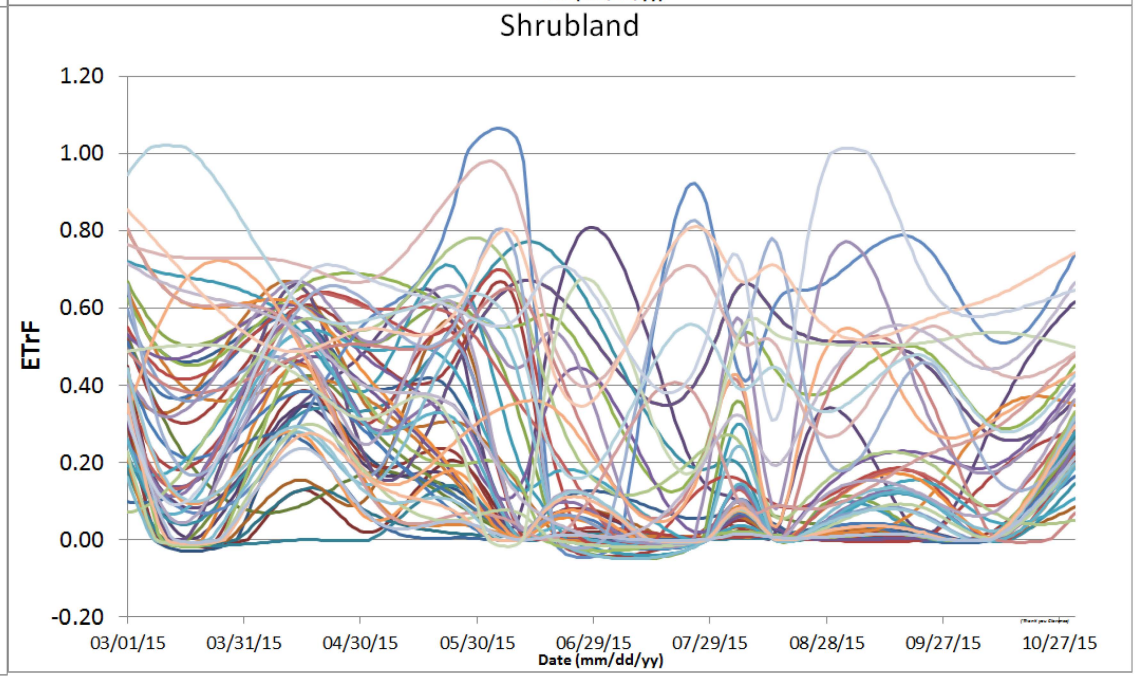
Behavior of ETrF (Kc) over time by Crop


Corn
Winter Wheat
Alfalfa
Sugarbeets
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
03/01/15
03/31/15
04/30/15
05/30/15
06/29/15
07/29/15
08/28/15
09/27/15
10/27/15
Date (mm/dd/yy)


Developed/Open Space
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
03/01/15
03/31/15
04/30/15
05/30/15
06/29/15
07/29/15
08/28/15
09/27/15
10/27/15
Date (mm/dd/yy)

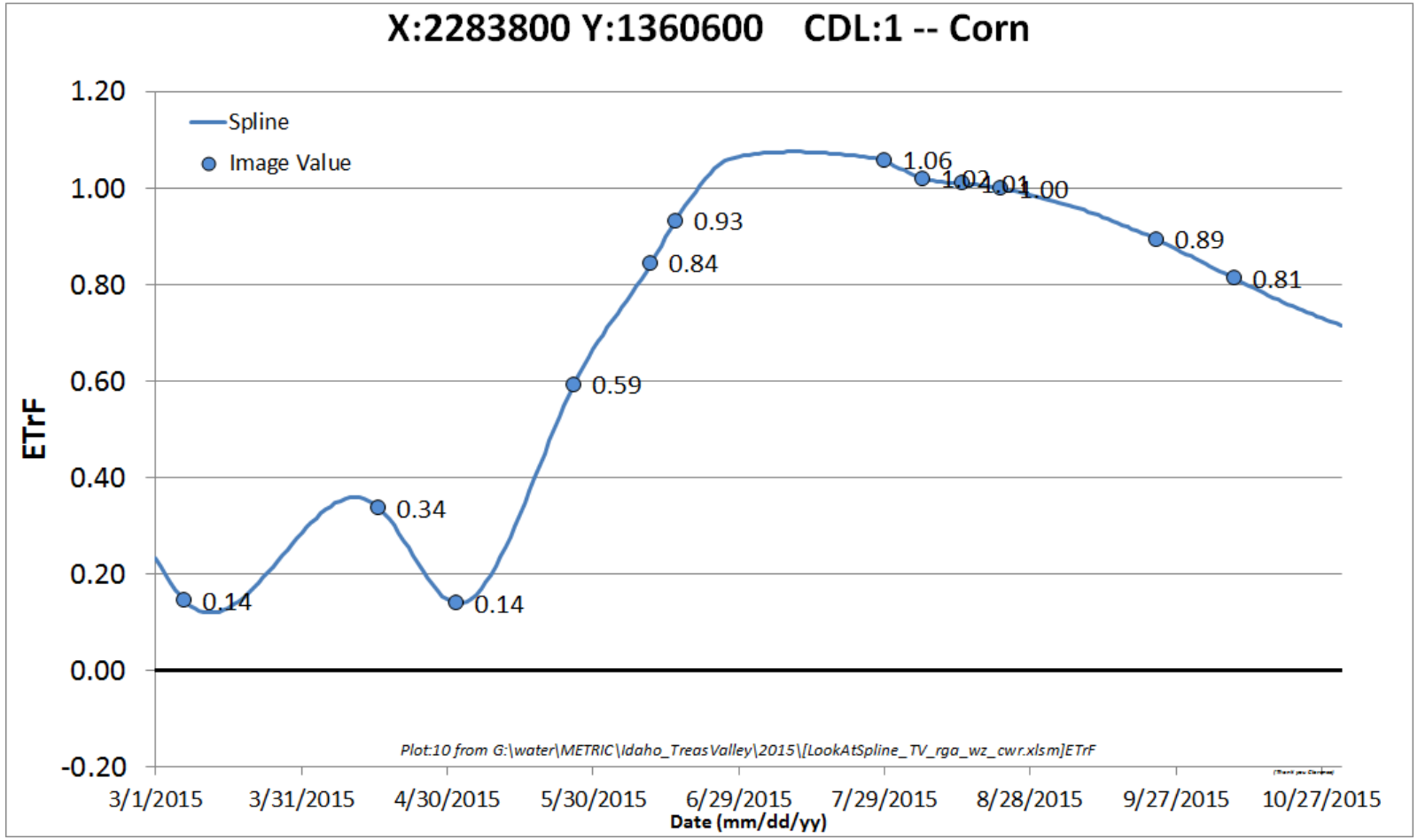

Developed/Low Intensity
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
03/01/15
03/31/15
04/30/15
05/30/15
06/29/15
07/29/15
08/28/15
09/27/15
10/27/15
Date (mm/dd/yy)


Developed/Med Intensity
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
03/01/15
03/31/15
04/30/15
05/30/15
06/29/15
07/29/15
08/28/15
09/27/15
10/27/15
Date (mm/dd/yy)

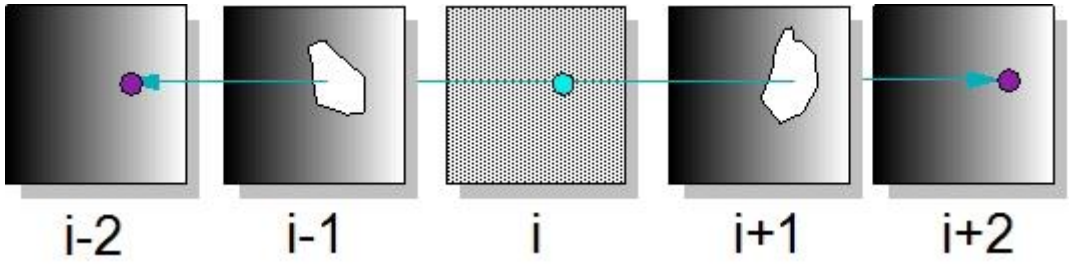

Shrubland
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
03/01/15
03/31/15
04/30/15
05/30/15
06/29/15
07/29/15
08/28/15
09/27/15
10/27/15
Date (mm/dd/yy)

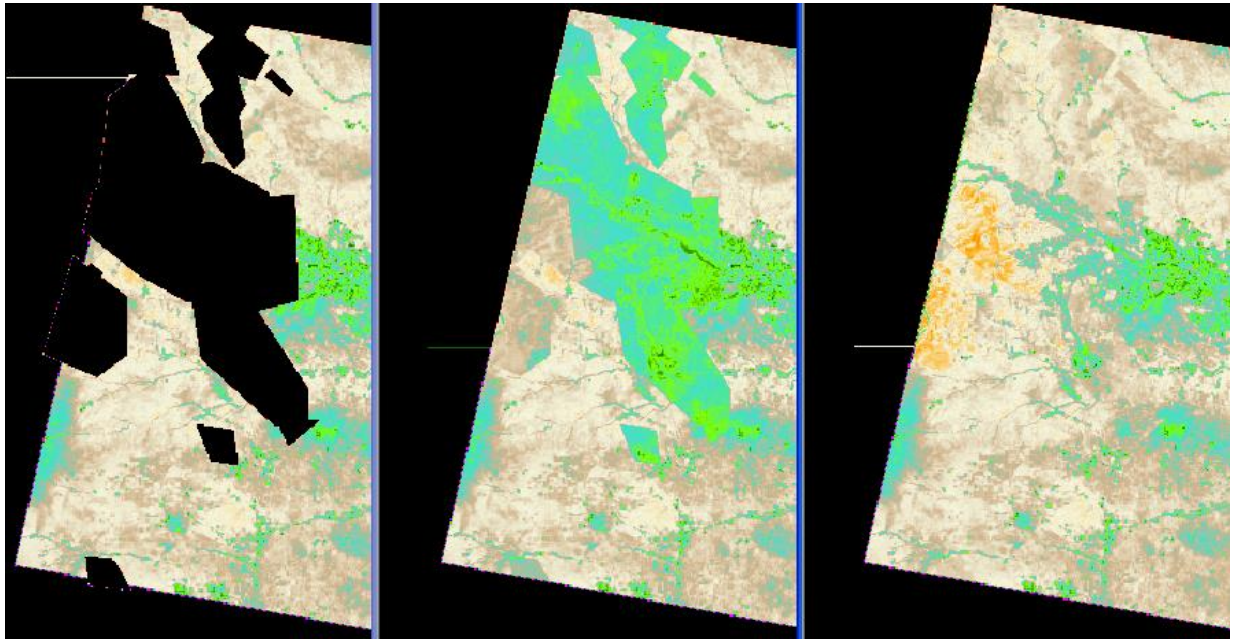
Individual Traces of ETrF vs. Time

- Splined_ETrF_2015_TV_rga_wz_cwr.xlsm



Cloud-filling ETrF Images



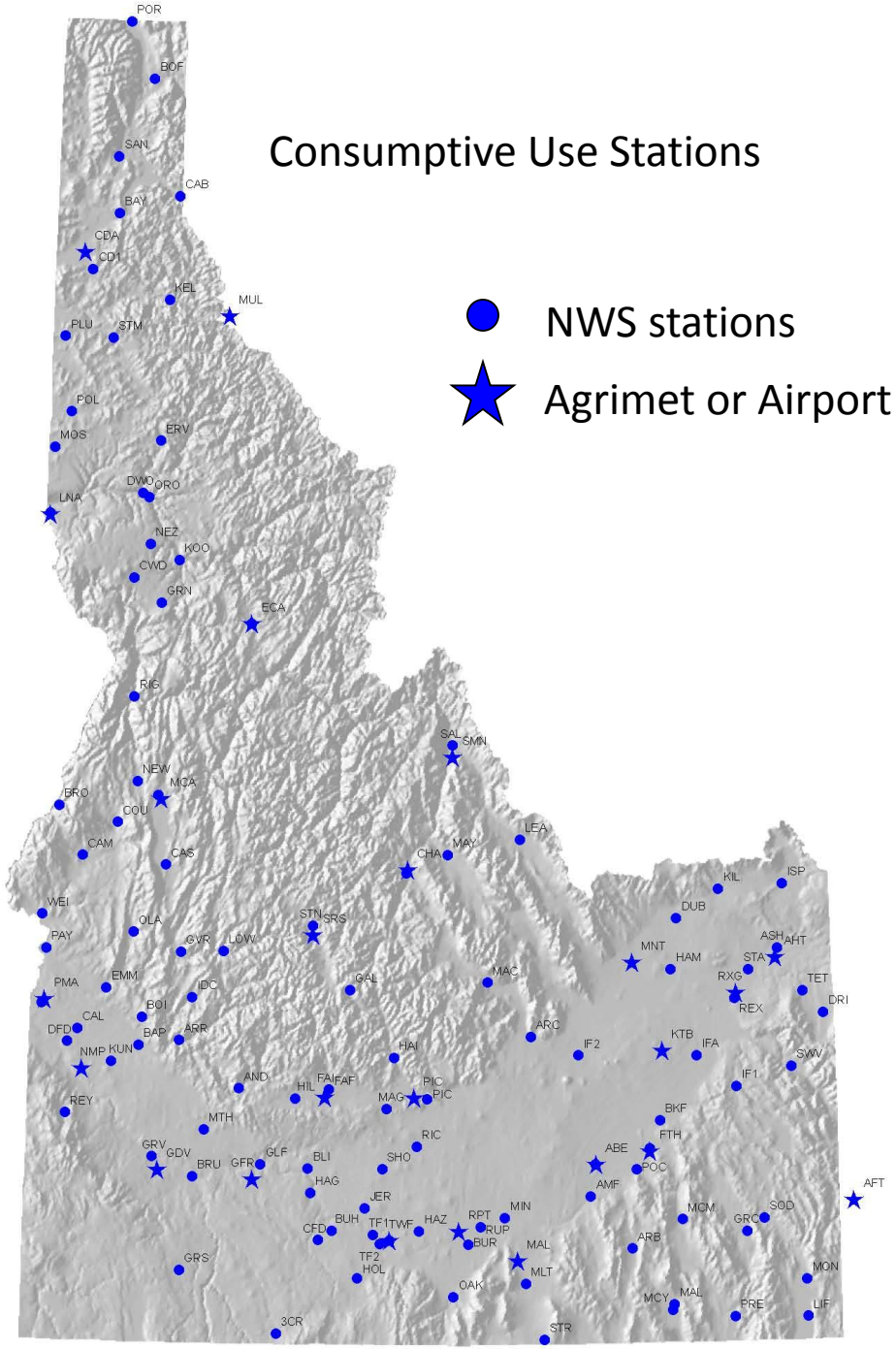


Status on Years

- METRIC Processing for years:
- 1987 – begun, but put on hold until IWRRI classification is complete
- 1994
- 1997
- 2000 – all images processed, reviewed, being updated (refined calibration) (40%)
- 2004
- 2007 – all images processed, to be reviewed; not yet cloud filled (30%)
- 2010 – most images processed, to be reviewed; not yet cloud filled (30%)
- 2015 – **complete** (but will rerun monthly ET using updated ETIdaho ETr)

Intervening Years

- Develop METRIC ET_rF based coefficients from METRIC years
- Use to perform any needed corrections on ETIdaho ET data by crop
- Use County crop statistics and Land use map (Ag., City, etc.) to distribute crop ET broadly by county.
- Compare results with ET from METRIC for the METRIC years and refine as needed
- Use Reference ET from ETIdaho



ETIdaho

first produced in 2005
Most recent revision 2017
(almost ready)

Allen and Robison, 2007

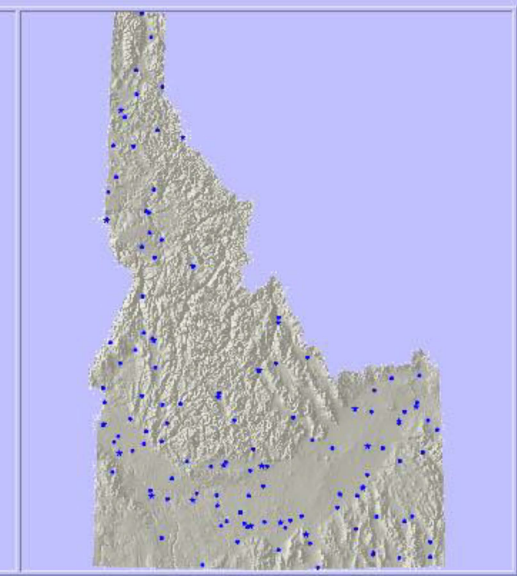
Logo Bar •••• ET *Idaho* •••• Logo Bar ..... State Map Here ...

Introductory paragraph concerning the ETIdaho site to be written

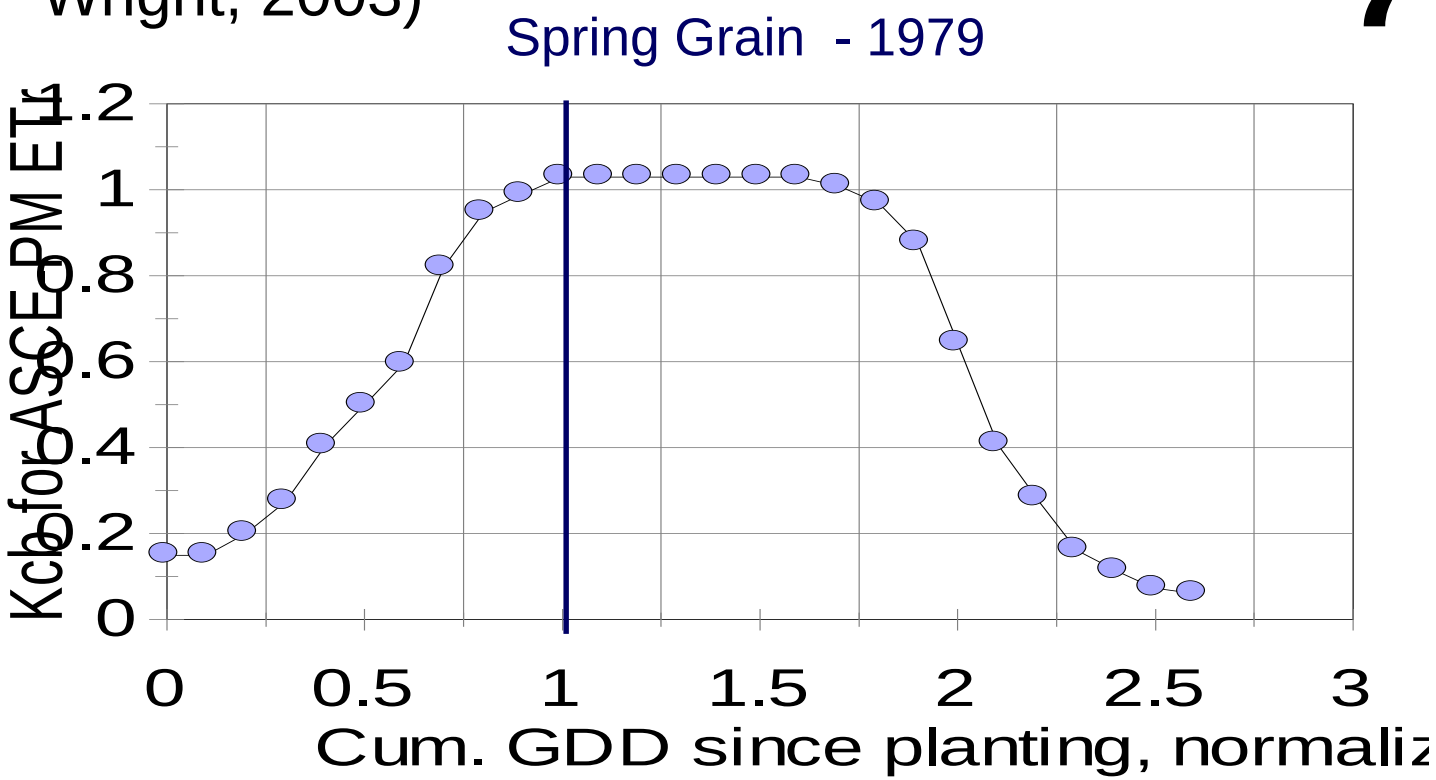
These dynamic web pages allow you to access historical evapotranspiration data for the State of Idaho at various locations. Currently, the data is based on 112 NWS cooperative weather stations and 16 AgriMet stations through out the state. Currently this site only serves the daily, monthly, and annual historical data and statistical data for the entire period of record. According the some options are not currently enabled.

Please select the type of data desired:

- Daily Time Series
- Monthly Time Series
- Annual Time Series
- Statistical Datasets
- Entire Data Package



ETIdaho uses Normalized (ratio of) Cumulative Growing Degree Days (GDD) from Planting to Effective Full Cover (Wright, 1998; Allen and Wright, 2003)



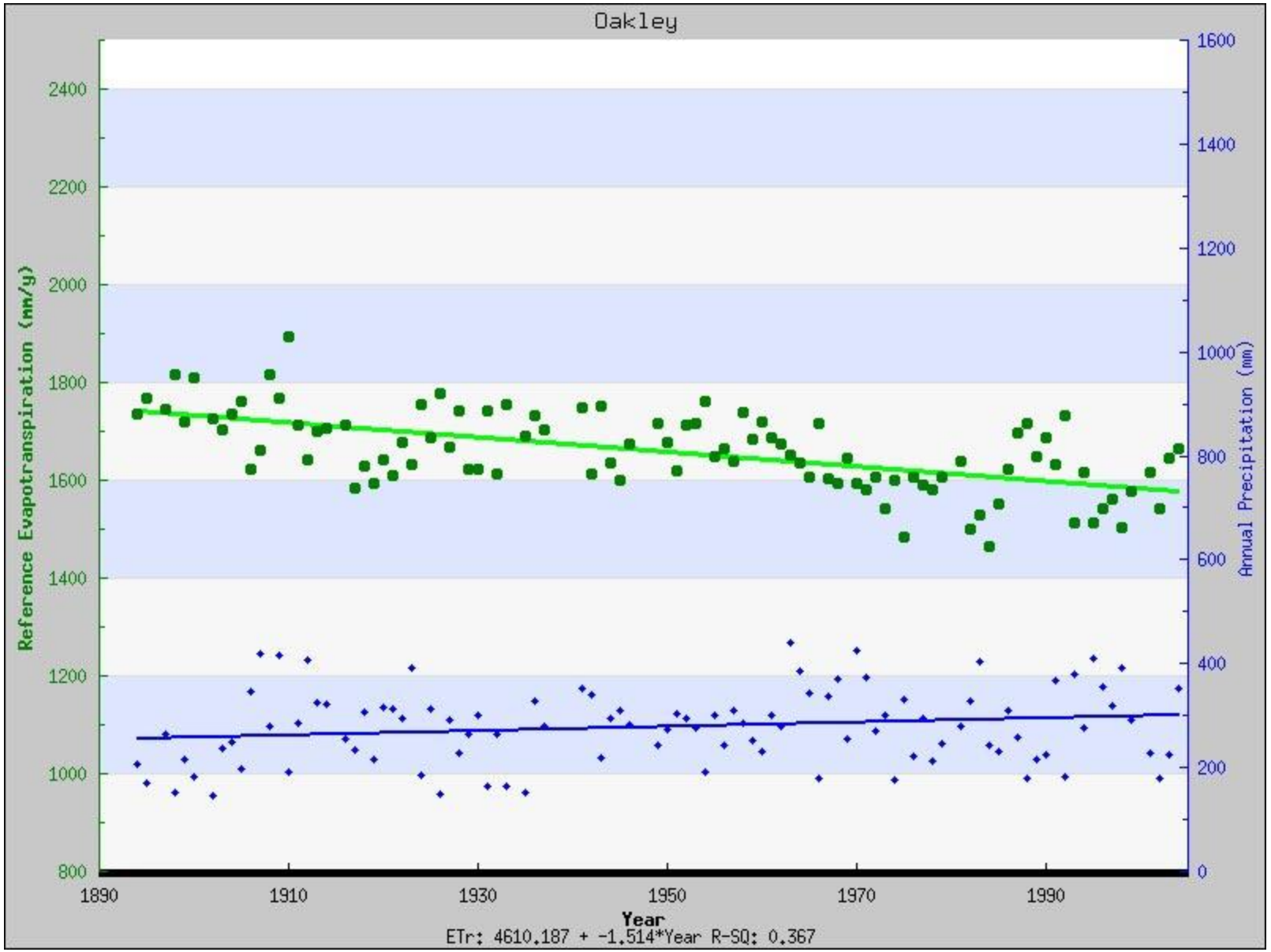
$$GDD = max\left(\frac{T_{max} + T_{min}}{2} - T_{base}, 0\right)$$

nt (198

T_{base} is 0°C for many crops, 5°C for others

Trends in annual **computed** ET_r

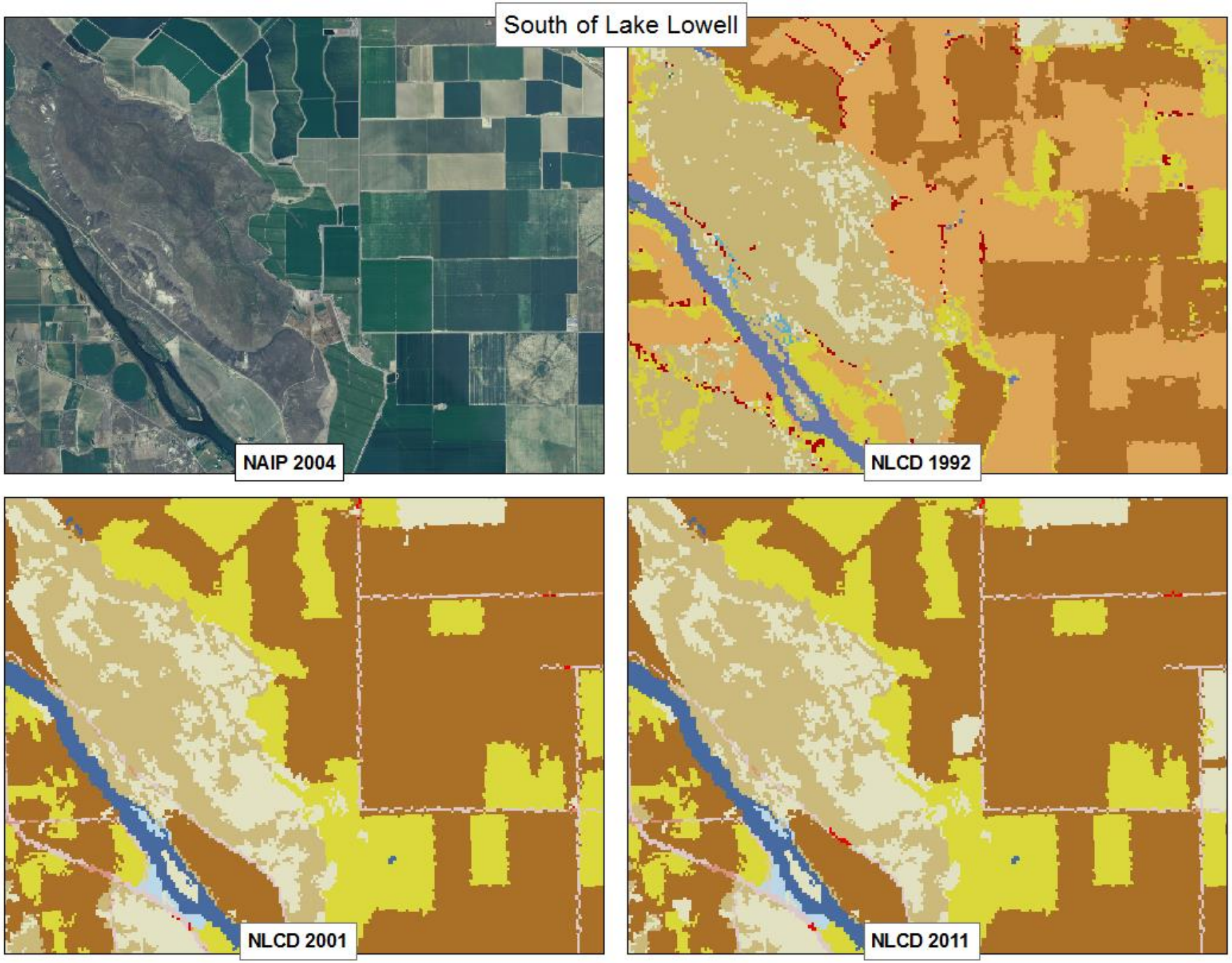
Oakley



NLCD comparison

- 2001 and 2011 NLCD are nearly identical for ag./rangeland delineation
- 1992 has less precision (used to process 1987)
- We will wait for IWRRI classification for 1982

Yellow and brown are ag.
Beige and tan are rangeland



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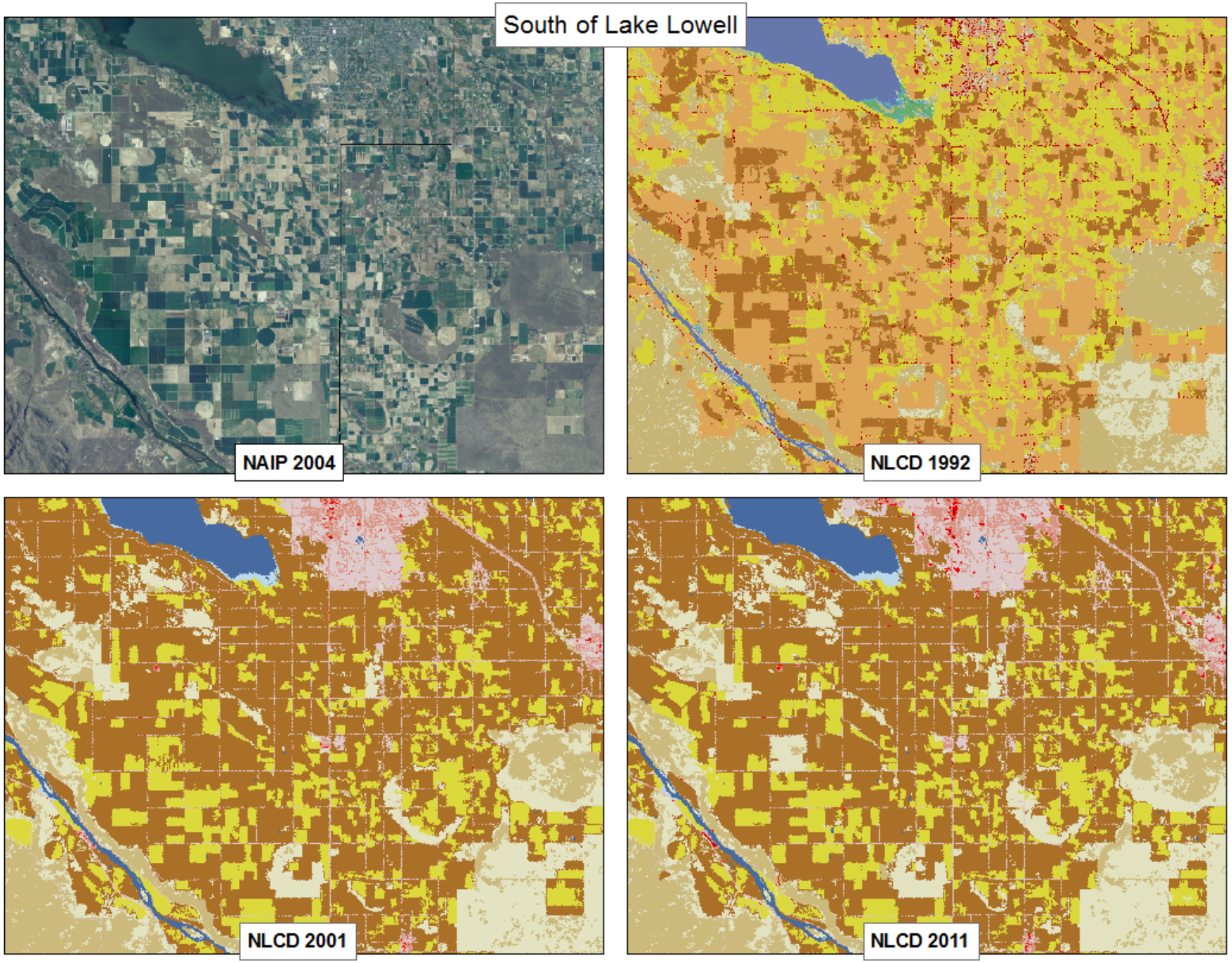

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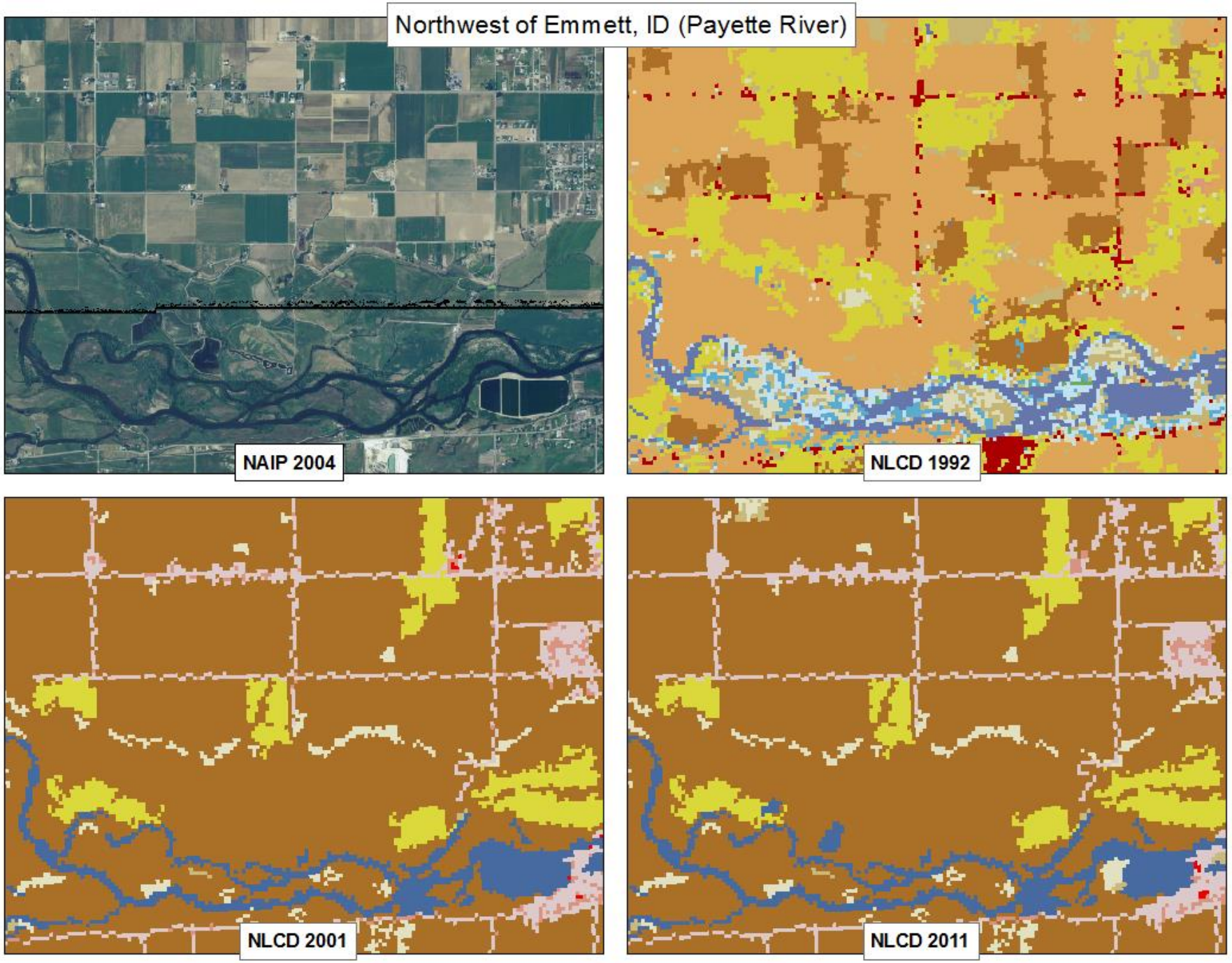

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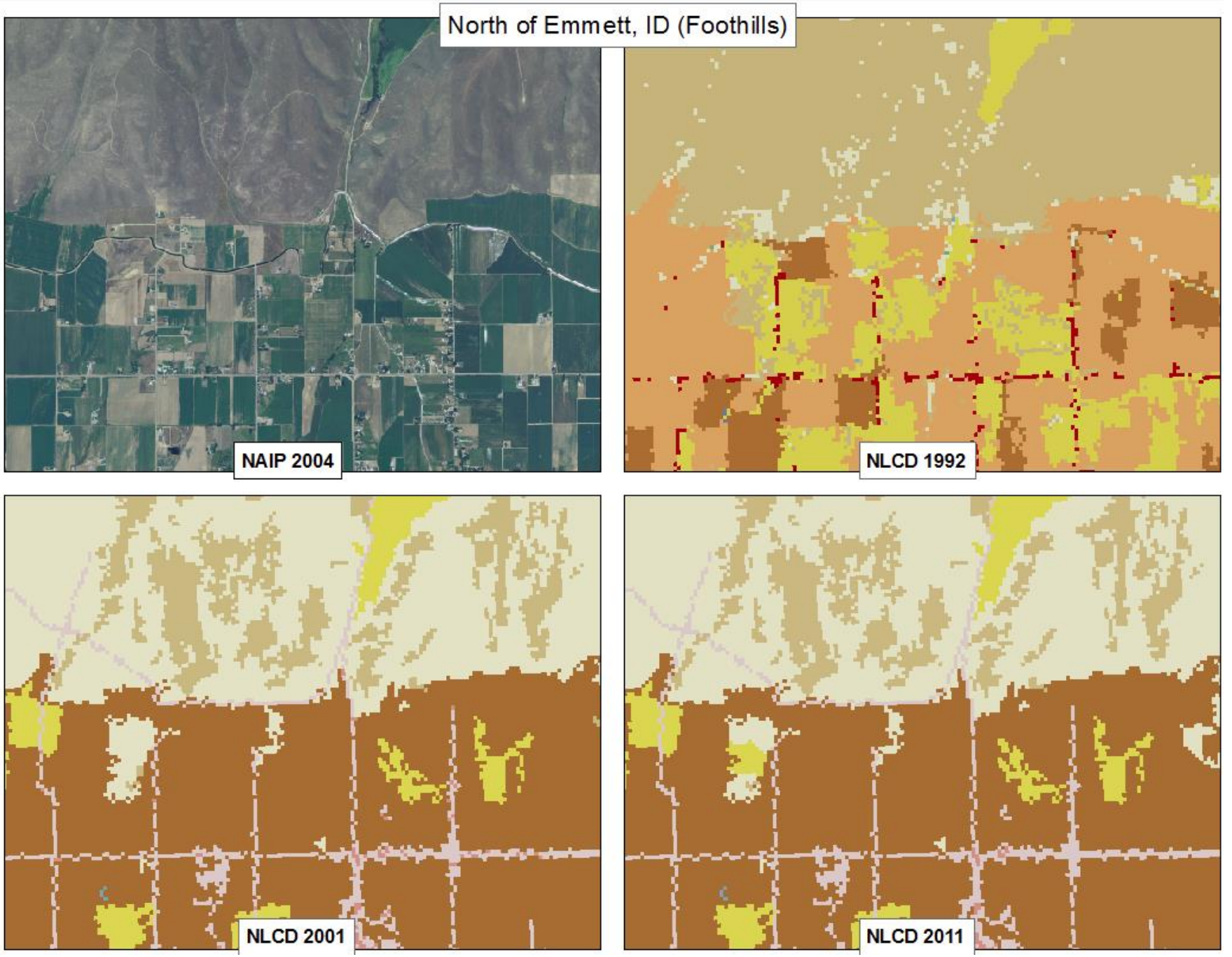

Thanks