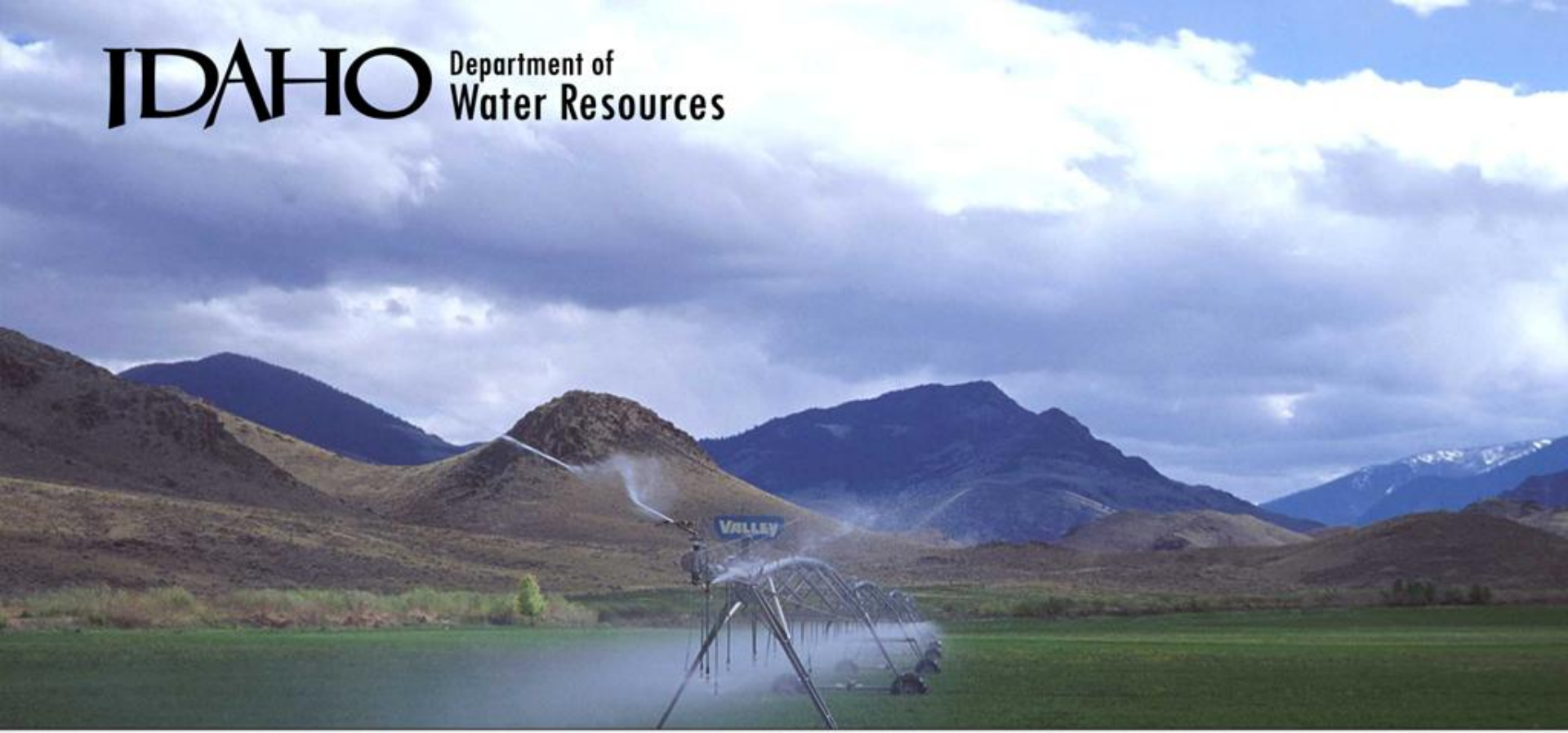

Evapotranspiration: How to use METRIC and NDVI estimates (Part 1) Wood River Valley Groundwater Flow Model

Presented to the Modeling Technical Advisory Committee 12/05/2013

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Quick Recap on Remote ET Estimation

- Reference ET (ETr) is theoretical ET from an ideal crop of alfalfa.
  - Based on weather data.
- Crop Coefficient (Kc) is an adjustment to the ETr for non-alfalfa crops.
- Traditional Method of estimating ET involves multiplying crop data by weather data.
  - $ET_{trad} = Kc \times ETr$.
- ET Fraction (ETrf) is the ratio of satellite image ET to ETr.
- METRIC uses the ET fraction, which serves the same mathematical purpose as Kc.
  - $\mathbf{ET_{METRIC} = ETrf_{METRIC} \times ETr}$
- NDVI uses a relationship with METRIC to generate ETrf.
- NDVI uses the ETrf and ETr like METRIC.
  - $\mathbf{ET_{NDVI} = ETrf_{NDVI} \times ETr}$

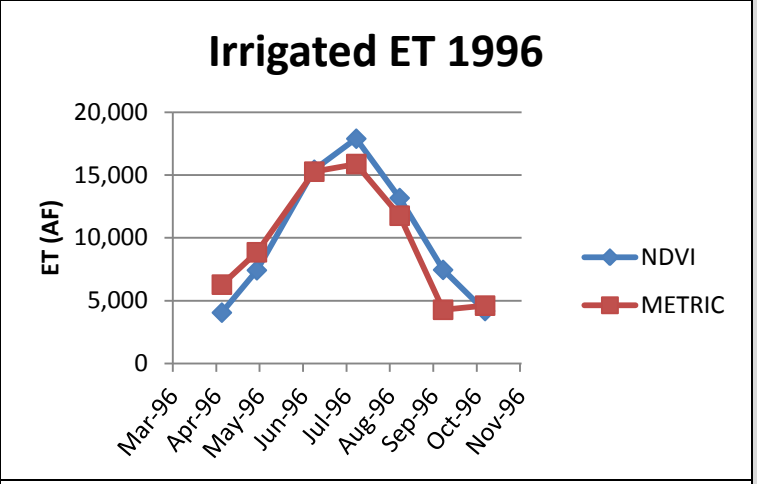
ET Data Availability

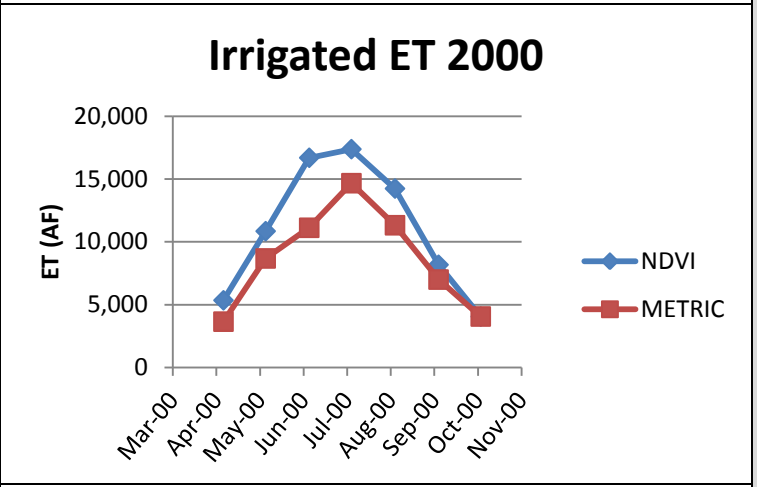
ET Estimate	Year	Available Data
NDVI	**1995**	July
METRIC	**1996**	All irrigation season
NDVI	**1997**	Sep and Oct
NDVI	**1998**	Aug-Oct
NDVI	**1999**	Jul-Oct
METRIC	**2000**	All irrigation season
NDVI	**2001**	Jun-Oct
METRIC and NDVI	**2002**	METRIC All season, Triangle only; NDVI May-Oct, all domain
NDVI	**2003**	May-Sep
NDVI	**2004**	Apr, Jul, Oct
NDVI	**2005**	All irrigation season
METRIC	**2006**	All irrigation season
NDVI	**2007**	All irrigation season
METRIC	**2008**	All irrigation season
METRIC	**2009**	All irrigation season
METRIC	**2010**	Not done yet, due in 2013

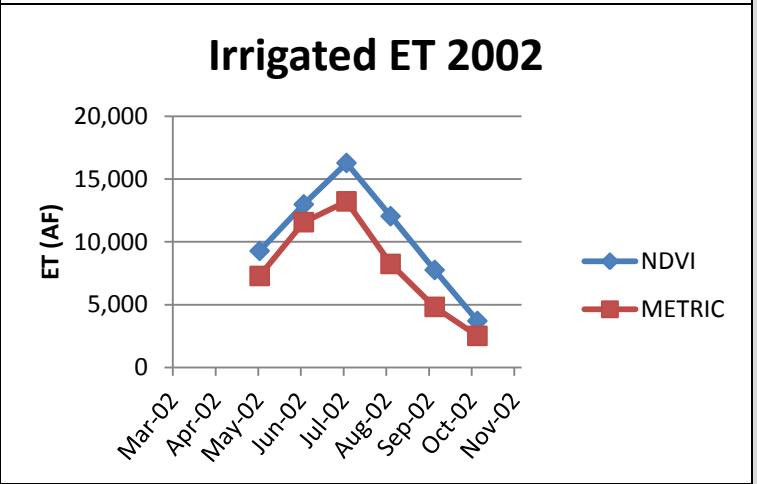
Processing ET for Best Estimate

METRIC is our best estimate of ET, but it is not available for all months (or not available in time for calibration). We can use a relationship between NDVI and METRIC to estimate ET from NDVI images (NDVI is substantially quicker). In order to use satellite-derived data for all months in the calibration period two processes must be completed:

1. Compare NDVI to METRIC. Compare years with both METRIC and NDVI estimates to investigate the relationship between the methods.
   a) Are the methods producing comparable estimates?
   b) Is there a bias to the NDVI estimates?
   c) Correct any bias.
2. Interpolate or Estimate years with no Satellite data. Some months are too cloudy to produce either METRIC or NDVI estimates.
   a) Use Reference ET (ETr) from weather data for date of interest.
   b) Interpolate ET fraction (ETrf) from neighboring months with ET estimates.
   c) Calculated ET using actual weather data and interpolated ETrf.



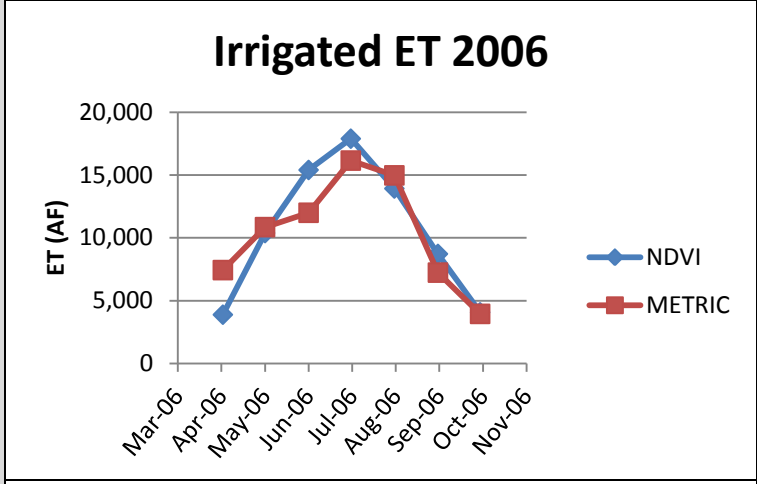


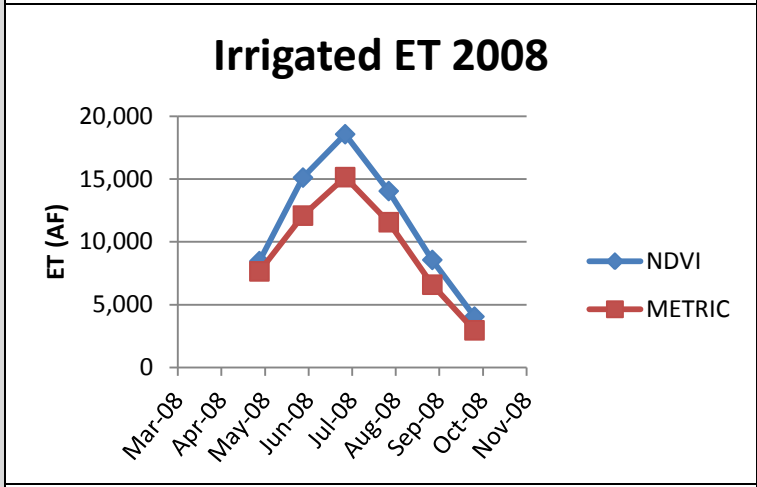


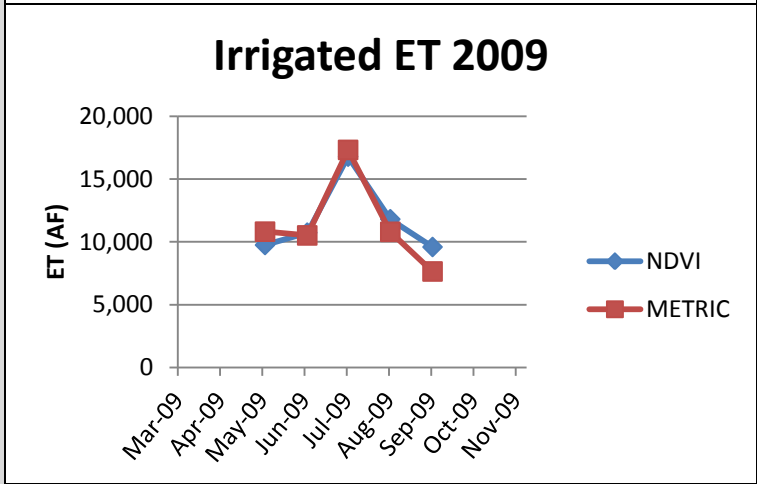
METRIC Vs NDVI

NDVI generally estimates more ET than METRIC.

NDVI is approximately 9% higher than METRIC over the entire concurrent period of record.





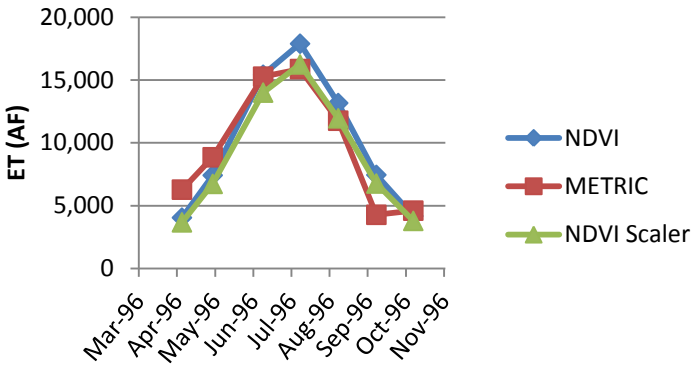


Adjusting NDVI Estimates

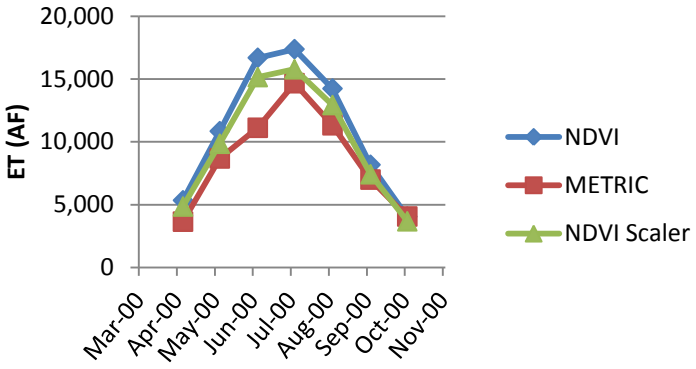
METRIC is our best estimate.
It appears that NDVI tends to estimate more ET than METRIC.
Given this information, we need to decide how to use the NDVI:

1. Use NDVI directly. It is another method of estimating ET that we are using.
2. Scalar Adjustment of all NDVI data. NDVI values tend to estimate more ET than does METRIC. Since METRIC is our best estimate, we should try to fit NDVI to METRIC.
3. Month Specific Adjustment. Try to bring NDVI more in line with METRIC by adjusting with monthly averages. Months that have bigger differences on average, are adjusted more.
4. Month Specific Adjustment by Drought Index. Some months show variable differences from METRIC depending on precipitation. For example, NDVI estimates in spring months tend to be higher in dry years and lower in wet years.

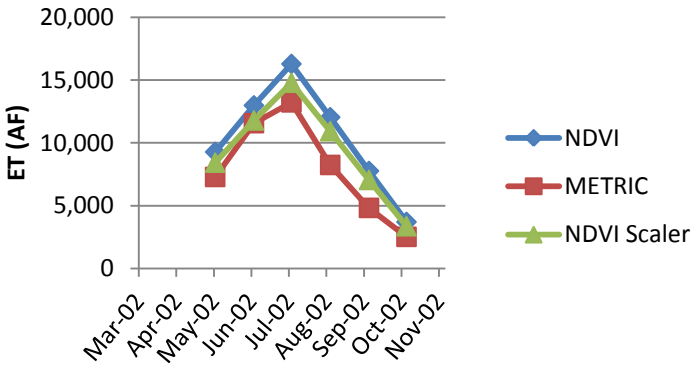
Irrigated ET 1996



Irrigated ET 2000



Irrigated ET 2002

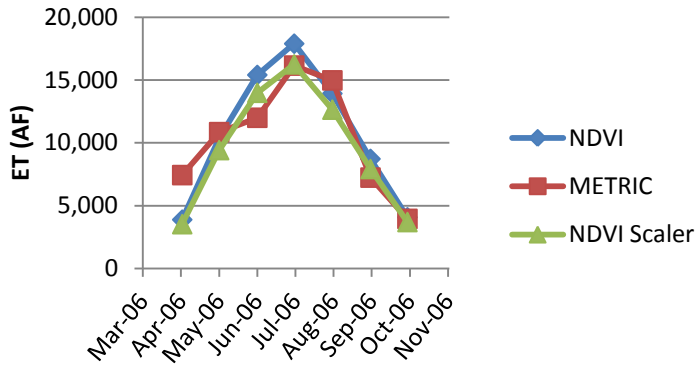


9% Scalar Adjustment

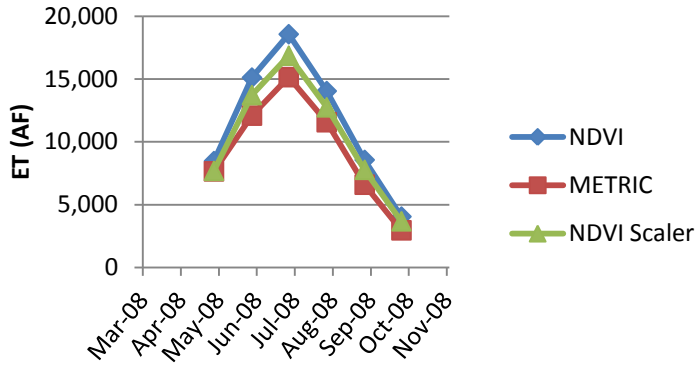
Green lines on charts are Adjusted NDVI.

NDVI values adjusted down by 9%.

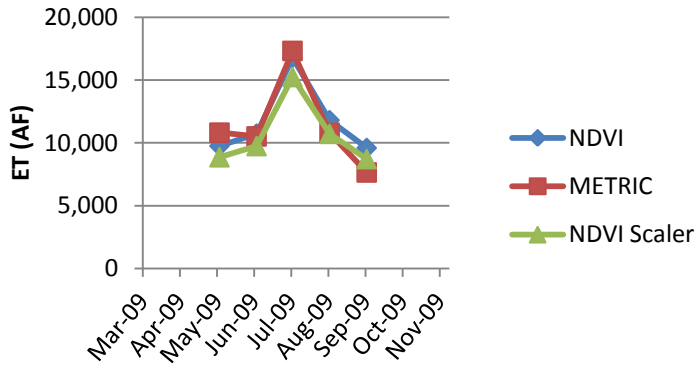
Irrigated ET 2006



Irrigated ET 2008



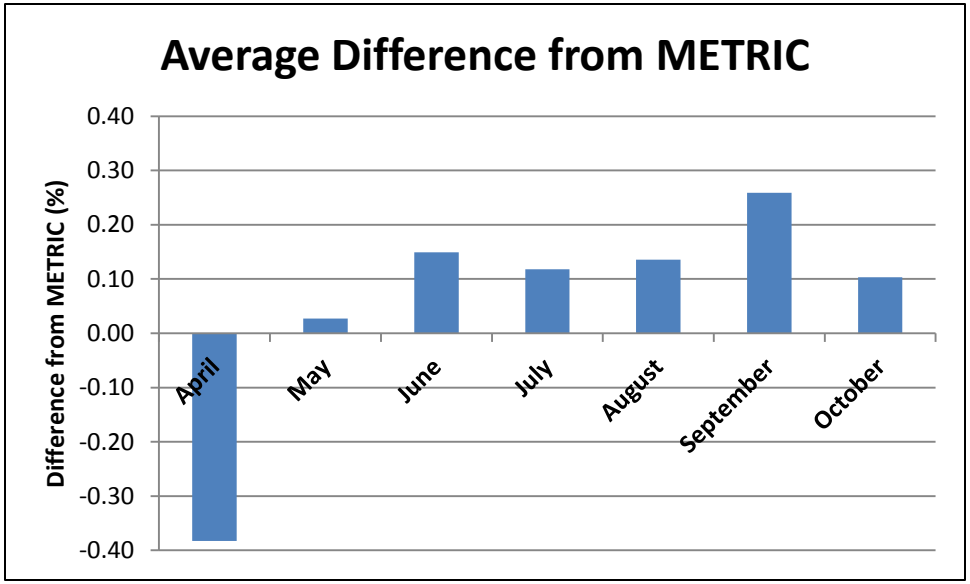
Irrigated ET 2009



Month Specific Adjustments to NDVI

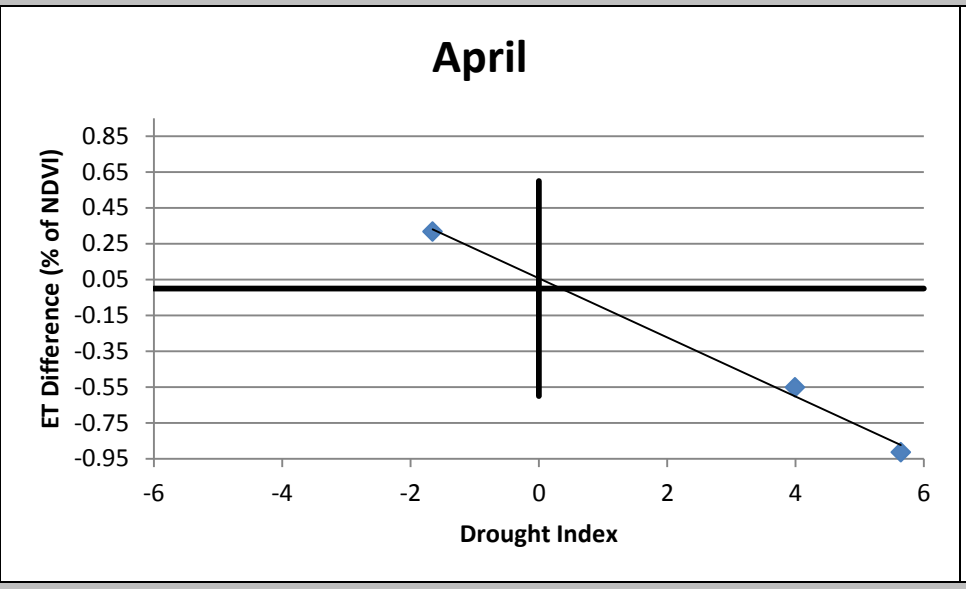
Using a scalar adjustment may create bigger differences between estimations for April.

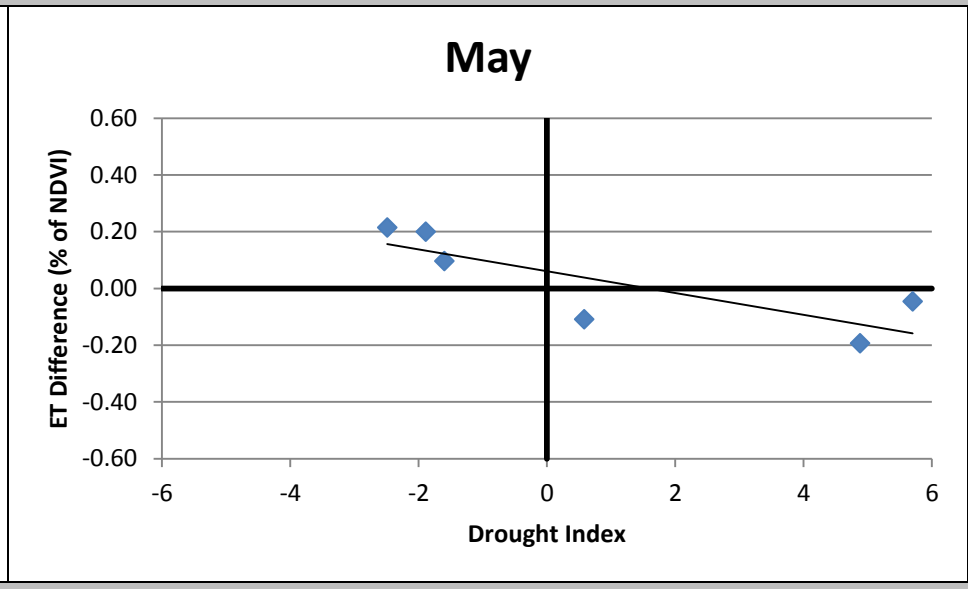
Remember these averages are based on only a few data points.

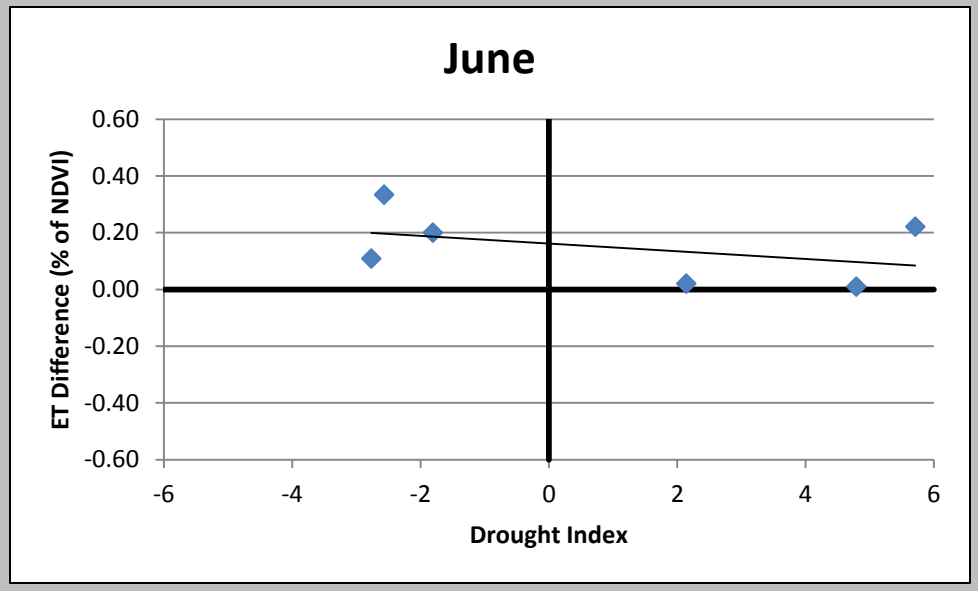


Month Specific Adjustments to NDVI- Drought Index

Monthly differences seem to be correlated with precipitation – especially in the spring.





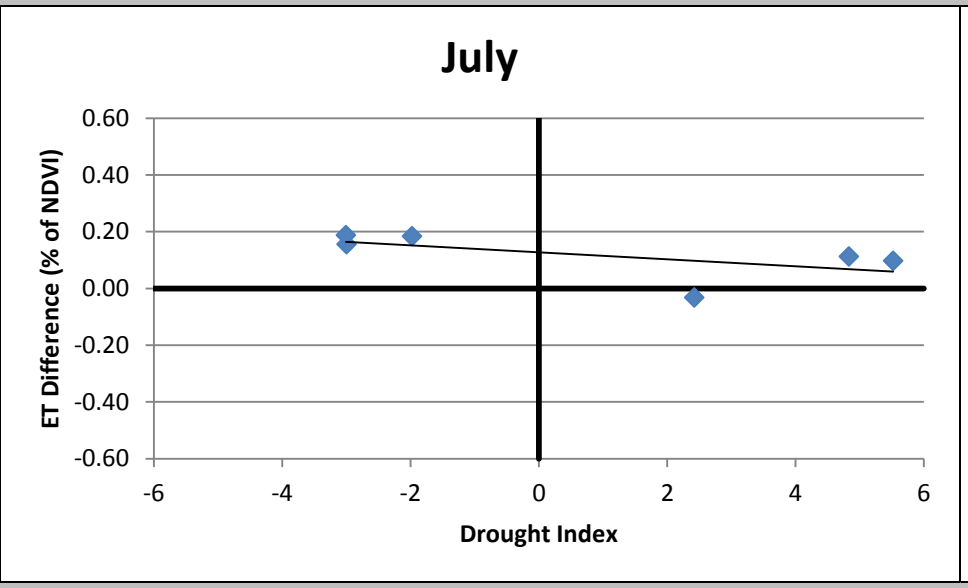


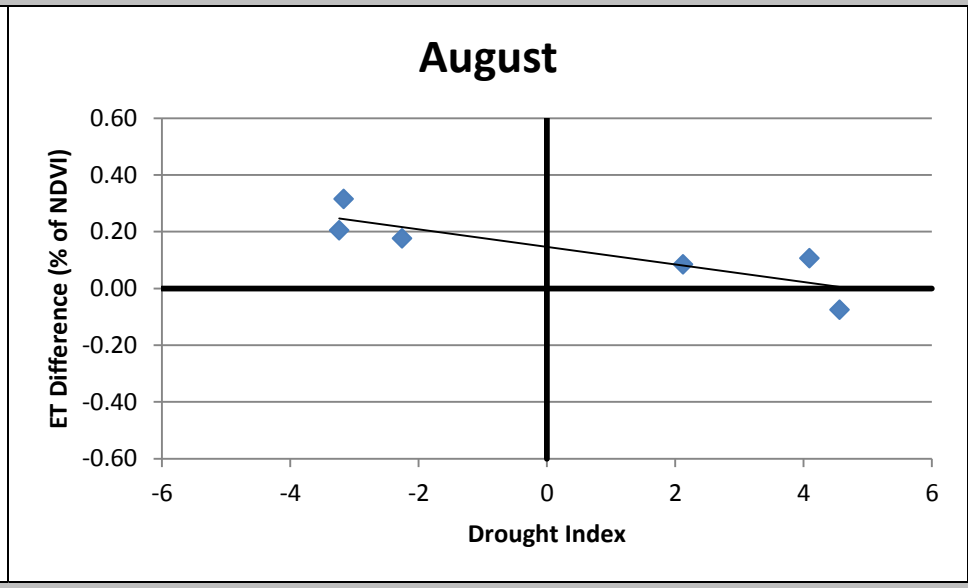
The character of the differences between estimates match expectations based on the development of the methods.

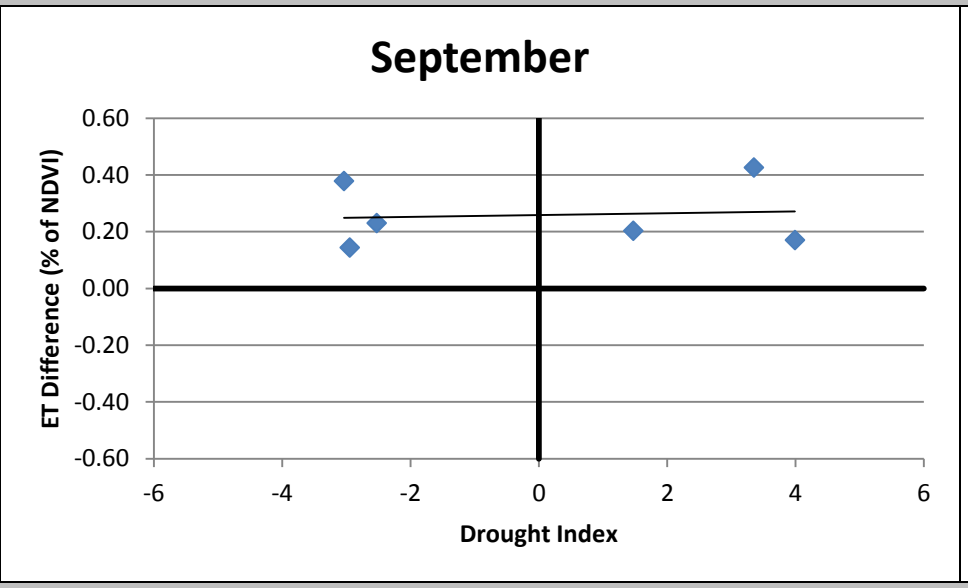
(very few data)

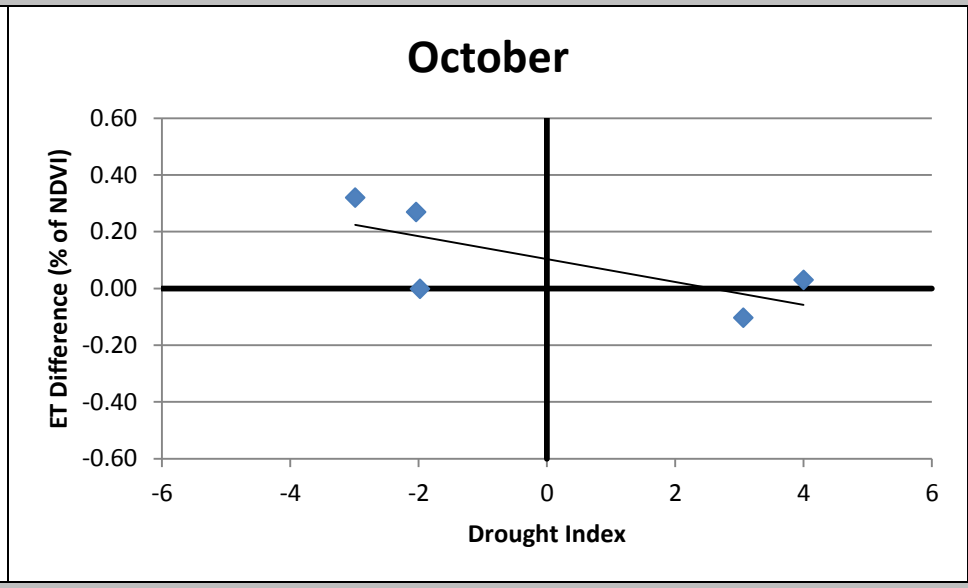
Month Specific Adjustments to NDVI- Drought Index

Monthly differences seem to be correlated with precipitation – especially in the spring.





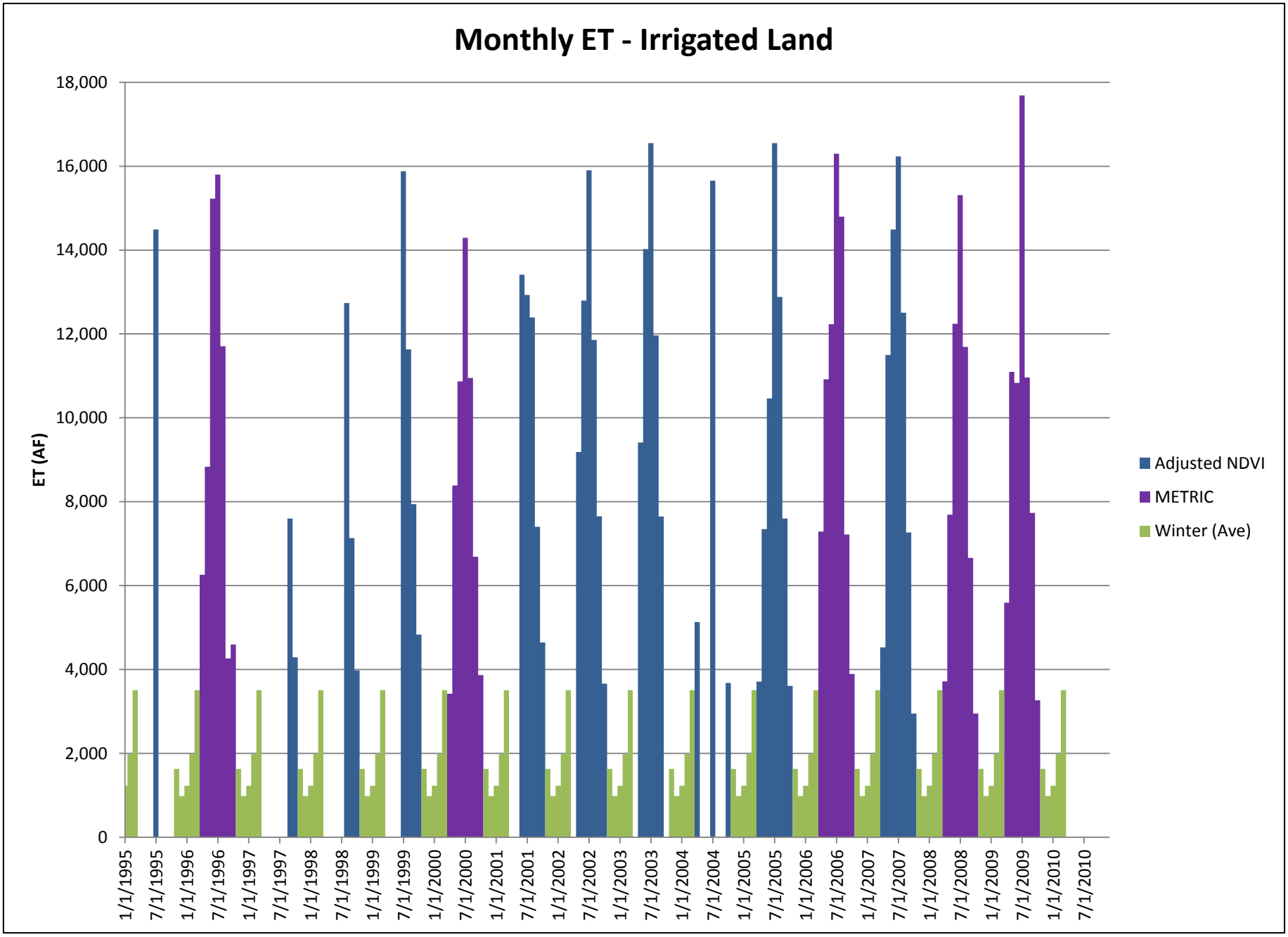




Month Specific Adjustments to NDVI

Although monthly differences are not consistent, and the correlation with precipitation matches expectations, there are few data .

Therefore, a scalar adjustment of 9% has been applied to all NDVI data.


Monthly ET - Irrigated Land
ET (AF)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1/1/1995
7/1/1995
1/1/1996
7/1/1996
1/1/1997
7/1/1997
1/1/1998
7/1/1998
1/1/1999
7/1/1999
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7/1/2004
1/1/2005
7/1/2005
1/1/2006
7/1/2006
1/1/2007
7/1/2007
1/1/2008
7/1/2008
1/1/2009
7/1/2009
1/1/2010
7/1/2010
Adjusted NDVI
METRIC
Winter (Ave)

Months to be Interpolated/Estimated

Year	Missing Months
1995	Apr, May, Jun, Aug, Sep
1997	Apr, May, Jun, Jul, Aug
1998	Apr, May, Jun, Jul
1999	Apr, May, Jun
2001	Apr, May
2002	Correlate All-Season-METRIC (Triangle) to All-Domain-NDVI
2003	Apr, Oct
2004	May, Jun, Aug, Sep

How to Interpolate ET

Remember METRIC uses an ET fraction multiplied by the weather conditions.

$$ET = ETrf \times ETr$$

Interpolate to months without estimates, use weather data from the year/month we want and a ratio of the ETrf's that we know.

For example: Find **ET May 2001** given METRIC for June 2001 and all of 2000.

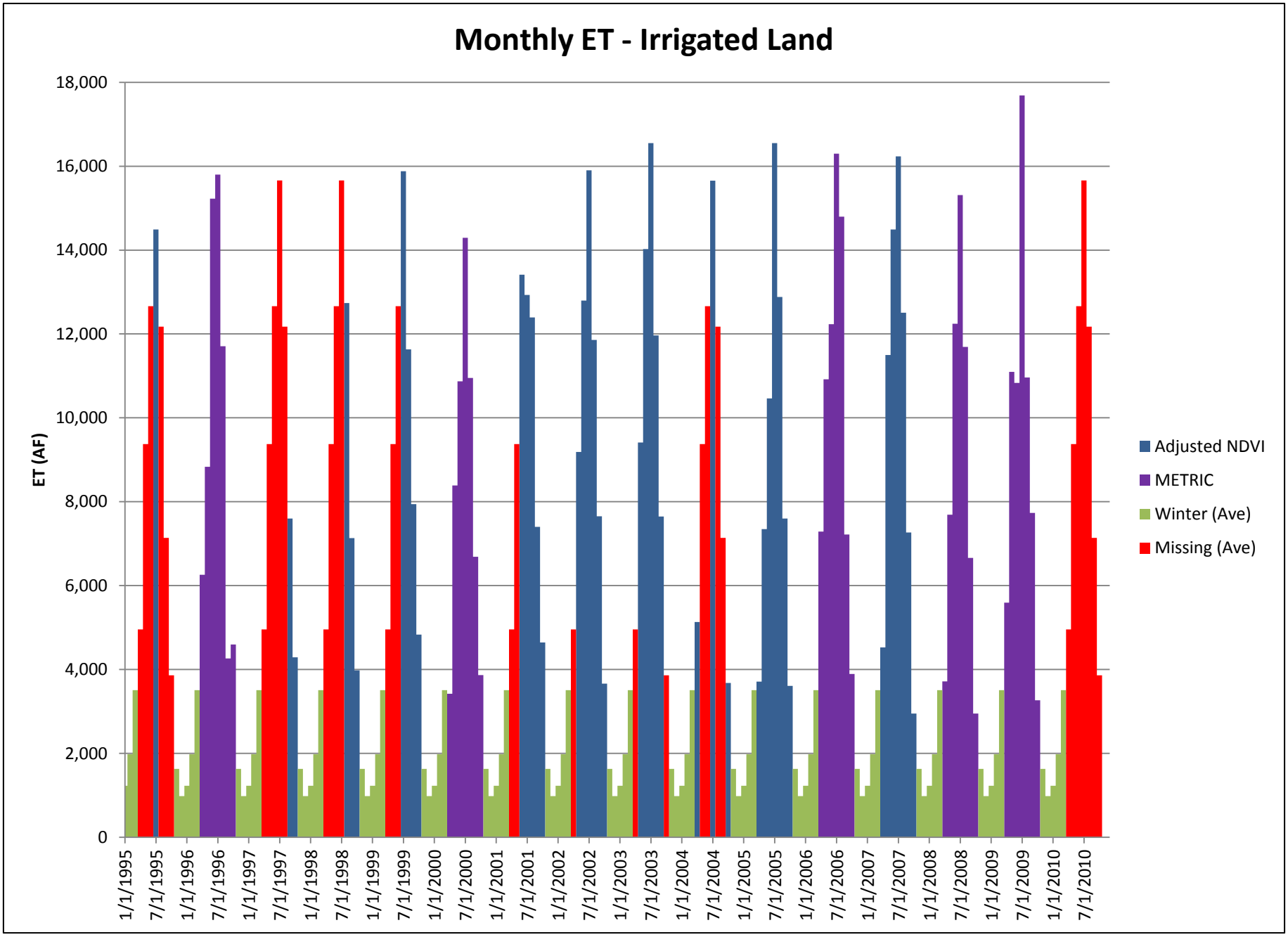
KNOW ETrf for June 2001, June 2000, May 2000 ($ETrf_{jun01}$, $ETrf_{jun00}$, $ETrf_{may00}$)
KNOW ETr for all months (ETr_{may00}, ETr_{jun00}, ETr_{may01}, ETr_{jun01})

1. Calculate ETrf from ET for May 2000, June 2000 and June 2001. ETrf = ET/ETr
2. Calculate ratio of $ETrf_{jun01}$ to $ETrf_{jun00}$. Ratio = 90% (not true ratio, only example).
3. Assume ETrf for all of 2001 is 90% of 2000 ETrf.
4. Therefore, assume May 2001 ETrf = 0.90 x May 2000 ETrf.
5. Calculate May 2001 ET as: $\mathbf{ET_{may01} = (0.9 \times ETrf_{may00}) \times ETr_{may01}}$

Next Steps

1. Evaluation of Non-Irrigated and Semi-Irrigated lands.
2. Make adjustments to NDVI for the other land uses.
3. Interpolation/estimation of missing months for all land uses.
4. Finish computation of Winter ET using previously presented methodology.

Chart on next slide is presented to illustrate current state of ET processing. Winter ET and missing months of irrigation season ET are averages.


Monthly ET - Irrigated Land
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7/1/2010
Adjusted NDVI
METRIC
Winter (Ave)
Missing (Ave)

Discussion