

Landsat-based ET data for a Water Delivery Call in Idaho

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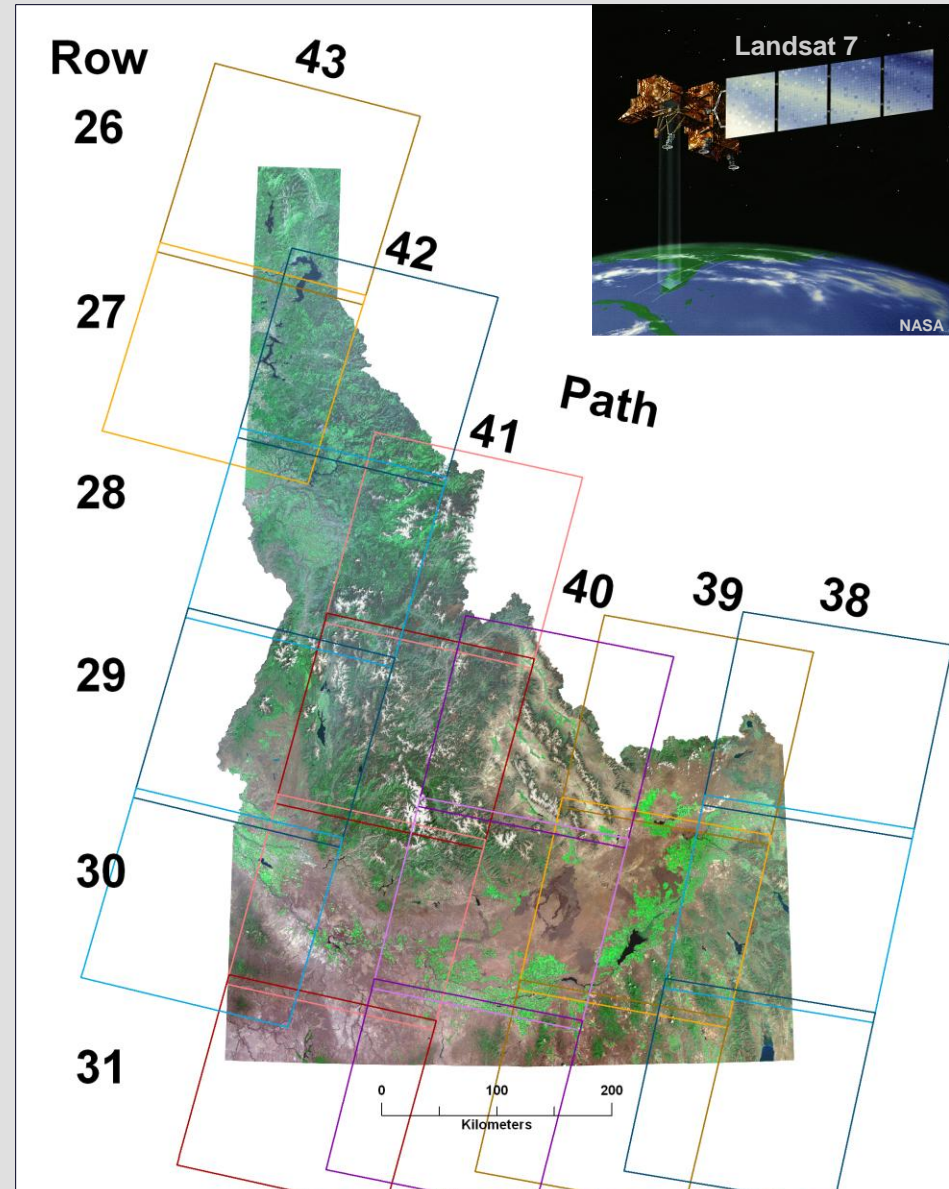
Why is measuring Evapotranspiration (ET) important

- ET is the water consumed by irrigated agriculture
- Important for administration, management, and planning of water resources
- Irrigated agriculture in Idaho
 - 3.4 million acres
 - Accounts for over 90% of the water consumed
- Irrigation in the U.S.
 - 50 million acres agriculture, 32 million acres recreational
 - Accounts for over 80% of the water consumed



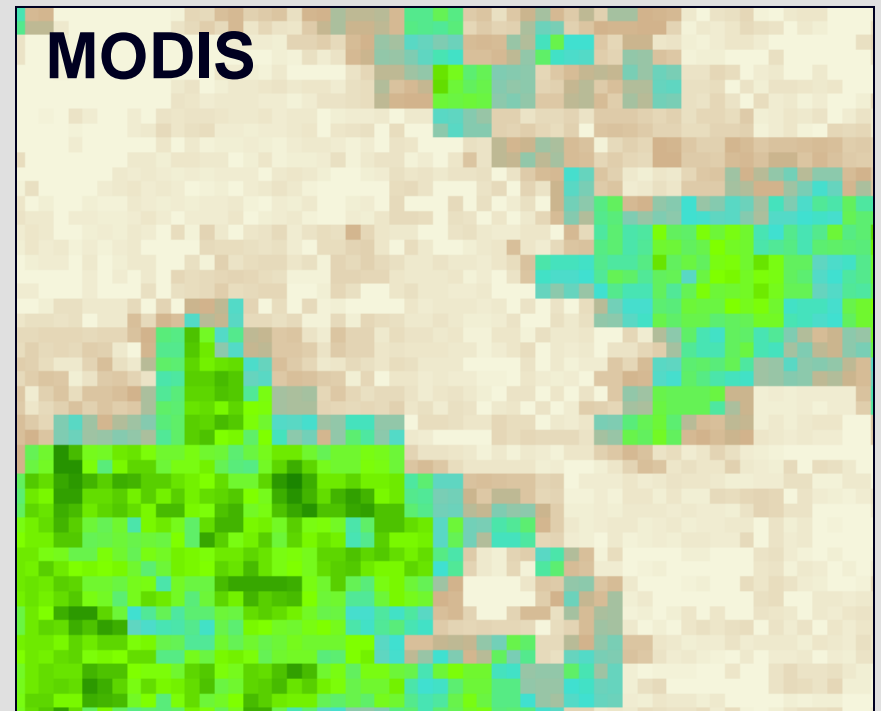
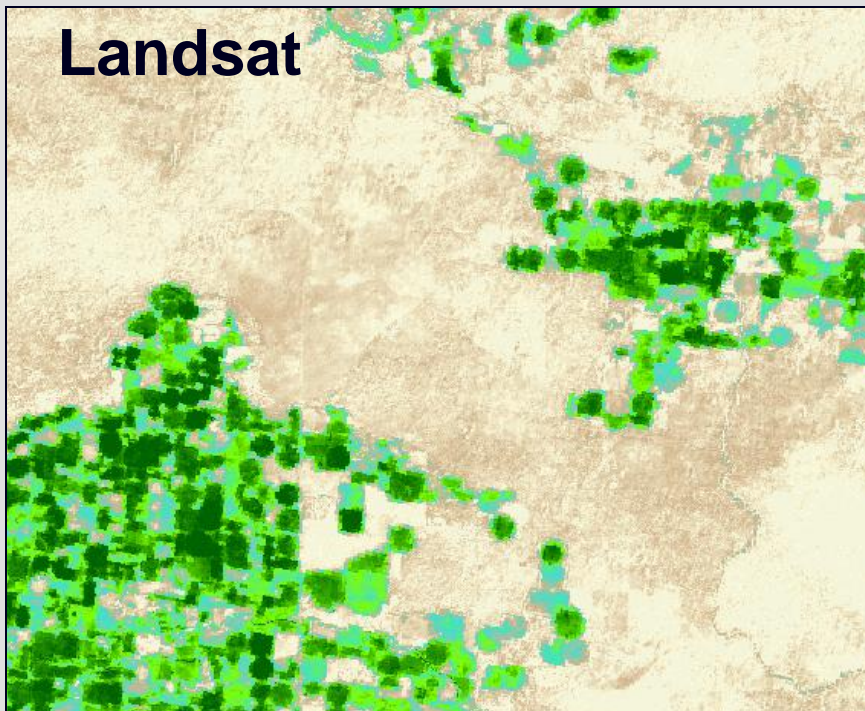
Landsat

- USGS/NASA mission
- Landsat 5 launched 1984
(TM halted November 2011)
- Landsat 7 launched 1999
(anomaly May 2003)
- 30 meter pixels
- 16 day cycle
- 185 by 180 kilometers
- *Free*
- Landsat 8 launches Feb. 2013
- Landsat 9 ?



Why not use other satellites

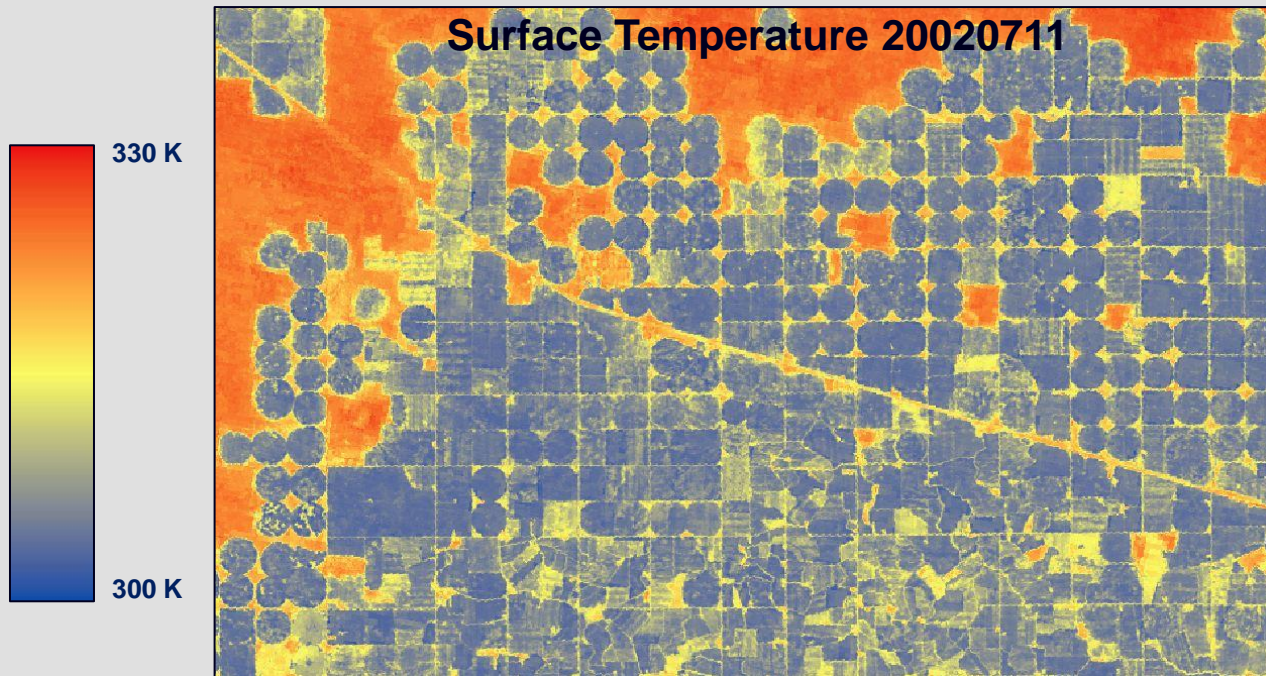
- **MODIS:** 500 meter pixels
- **AVHRR:** 1000 meter pixels
- **SPOT:** no thermal band
- **IRS AWiFS:** no thermal band
- **Aster:** for research



Landsat Thermal Band

Required for **surface temperature**

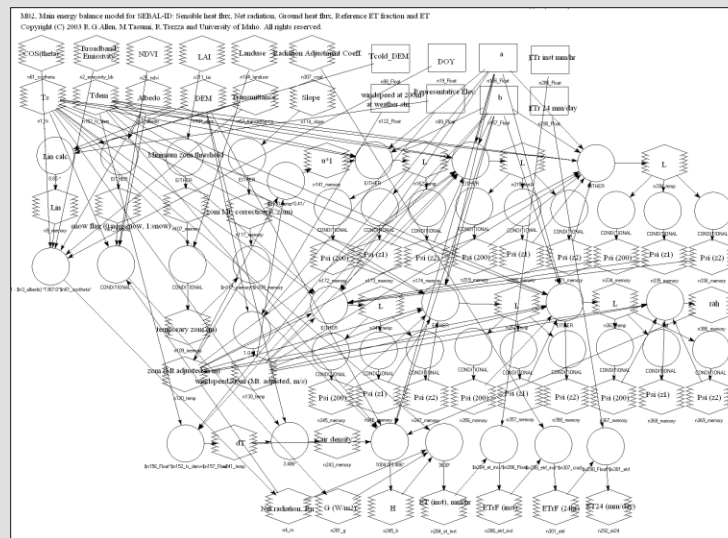
Landsat is the only **operational** satellite with a “**thermal band**” and a pixel size small enough to map ET for **individual fields!**



METRIC

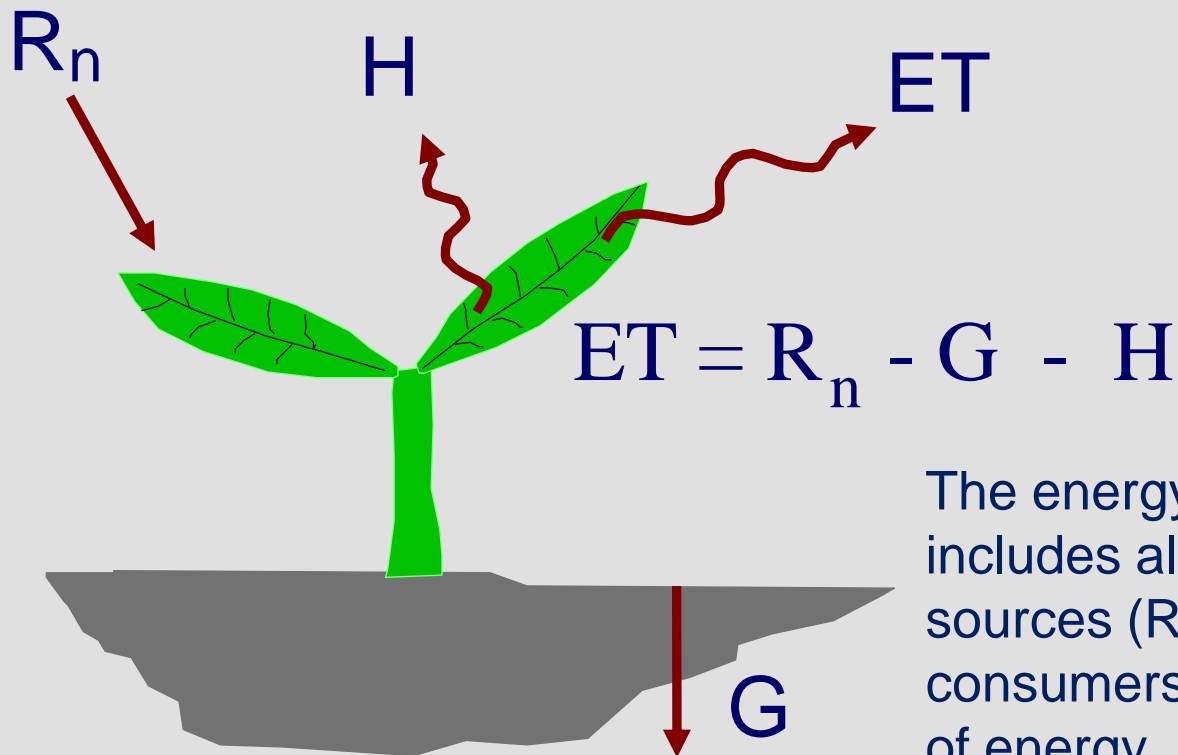
Mapping EvapoTranspiration at high Resolution with Internalized Calibration

- Satellite-based energy balance model that computes and maps actual ET
- Internalized Calibration ties down ET to weather data
- Over 90% accurate compared to precision weighing lysimeter



Energy Balance for ET

ET is calculated as a “residual”
of the energy balance



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

Energy balance computes “actual” ET

Can ‘see’ impacts on ET caused by:

- water shortage
- disease
- crop variety
- planting density
- cropping dates
- salinity
- management
- wet soil



Weather Data

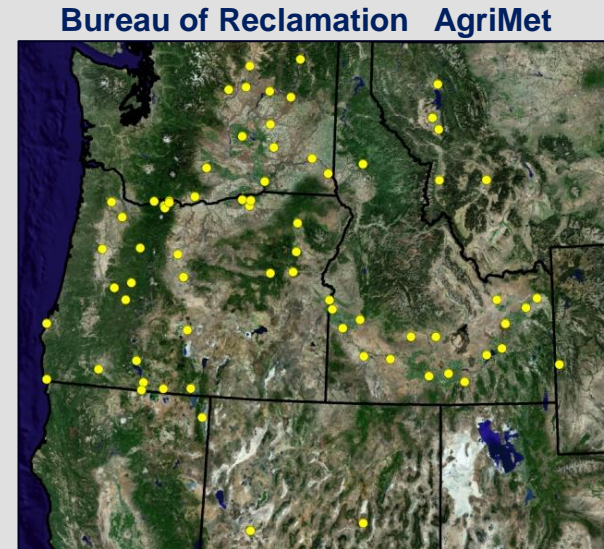
In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

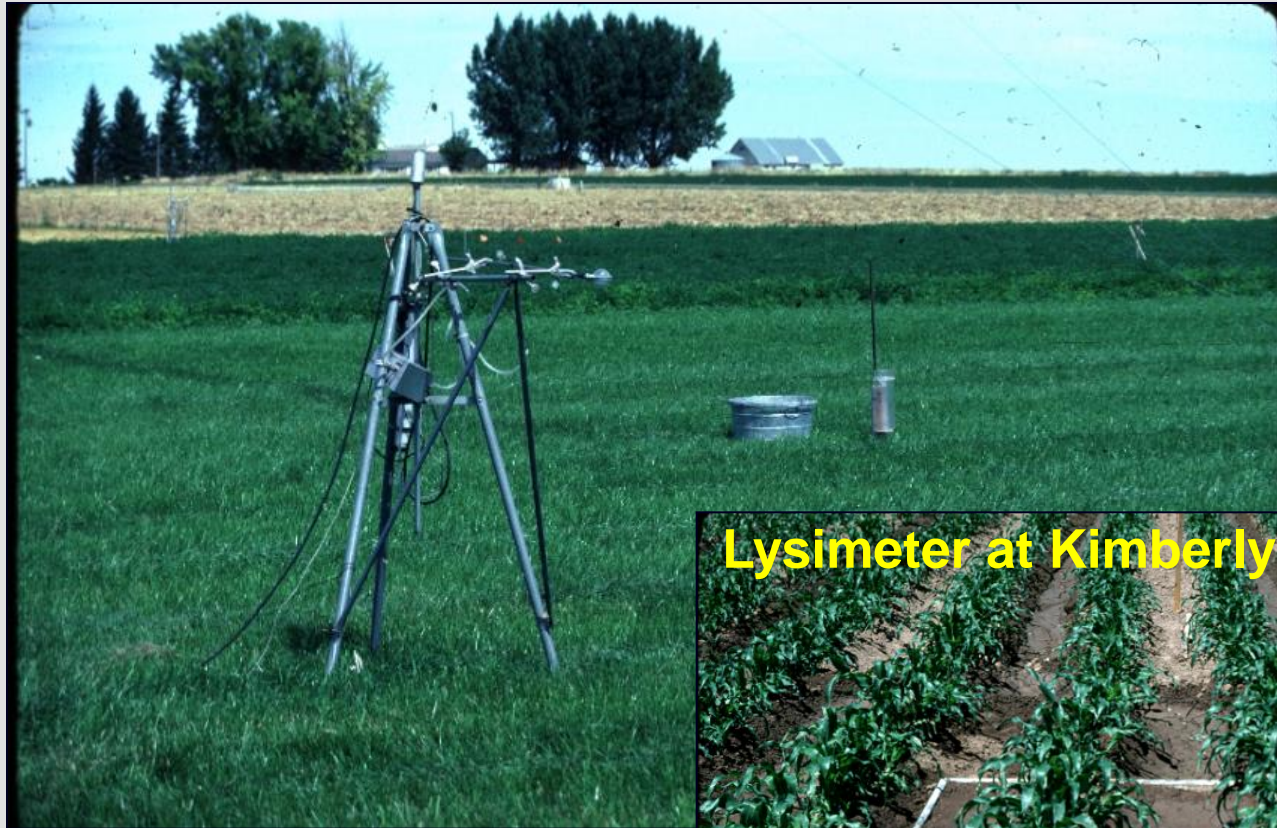
Reference ET for calibrating the Energy Balance

Reference ET to extrapolate ET

- 24-hour period
- Days between images



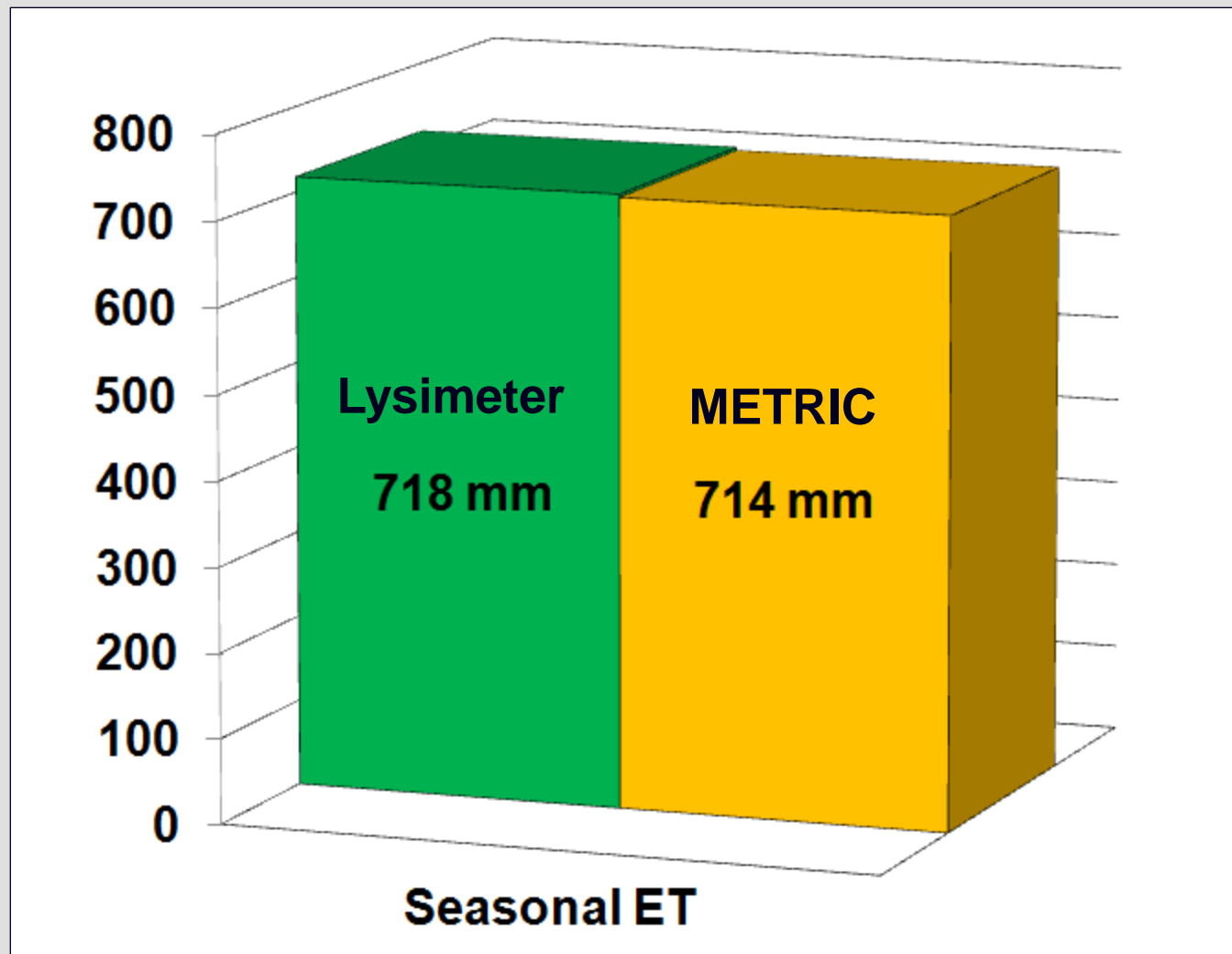
Comparison with Lysimeter Measurements



1968-1991



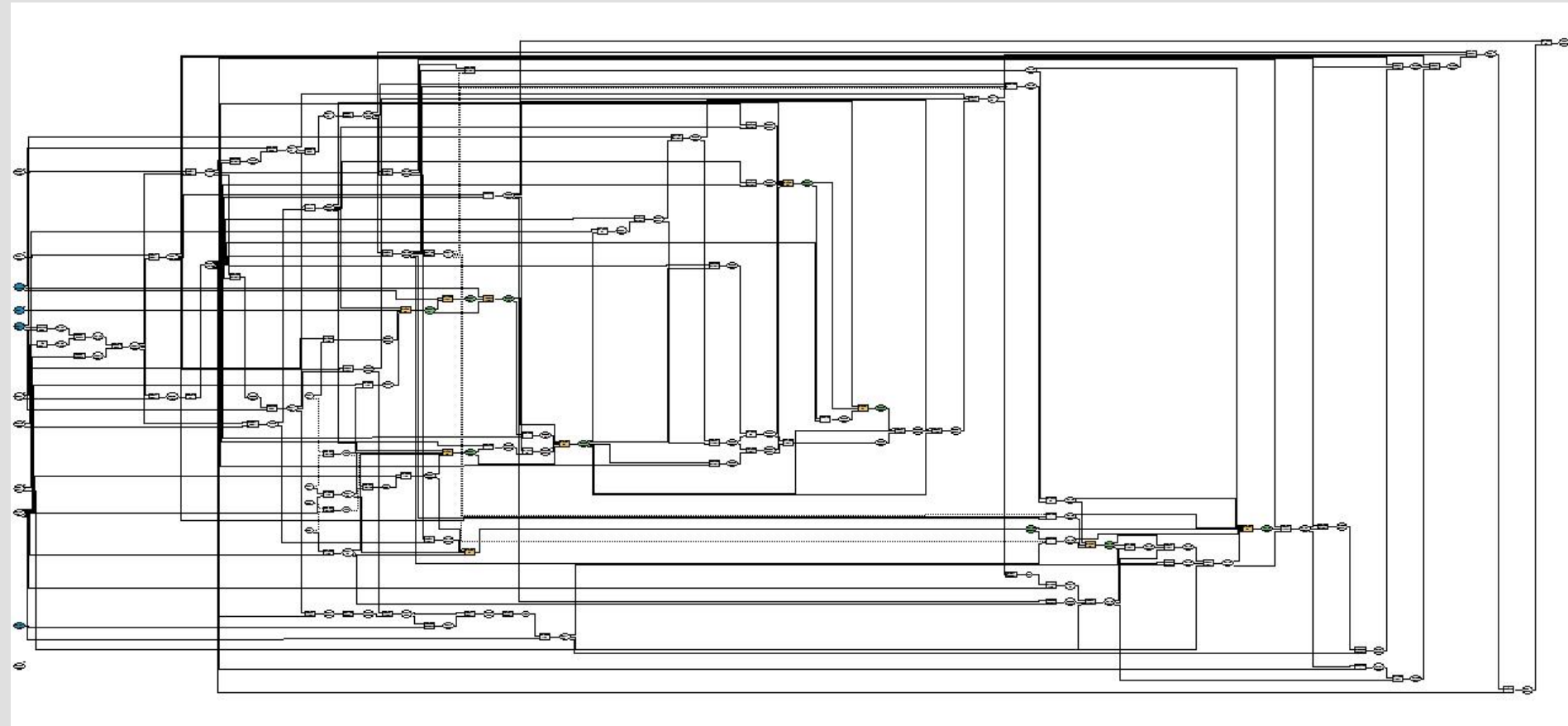
Lysimeter at Kimberly (Wright)



Seasonal ET for sugar beets at the Kimberly Research Station, April to September, 1989.

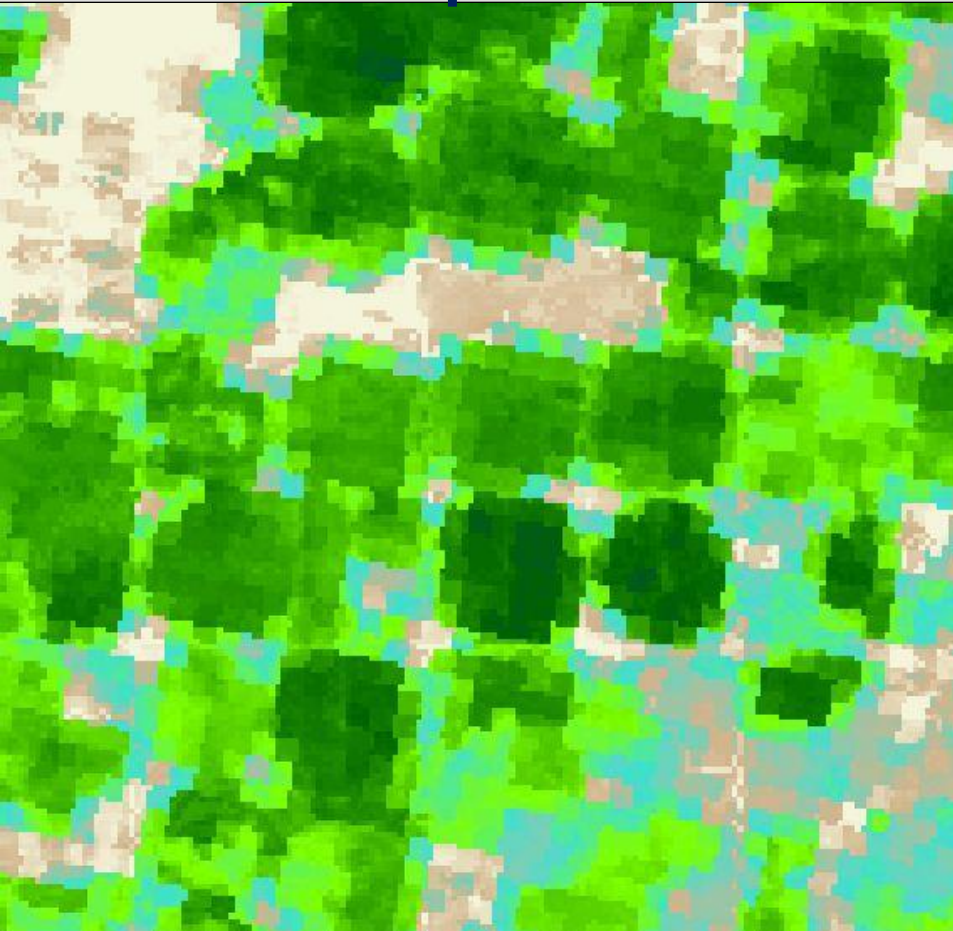
Sharpen Thermal Infrared Landsat 5

ArcGIS ModelBuilder

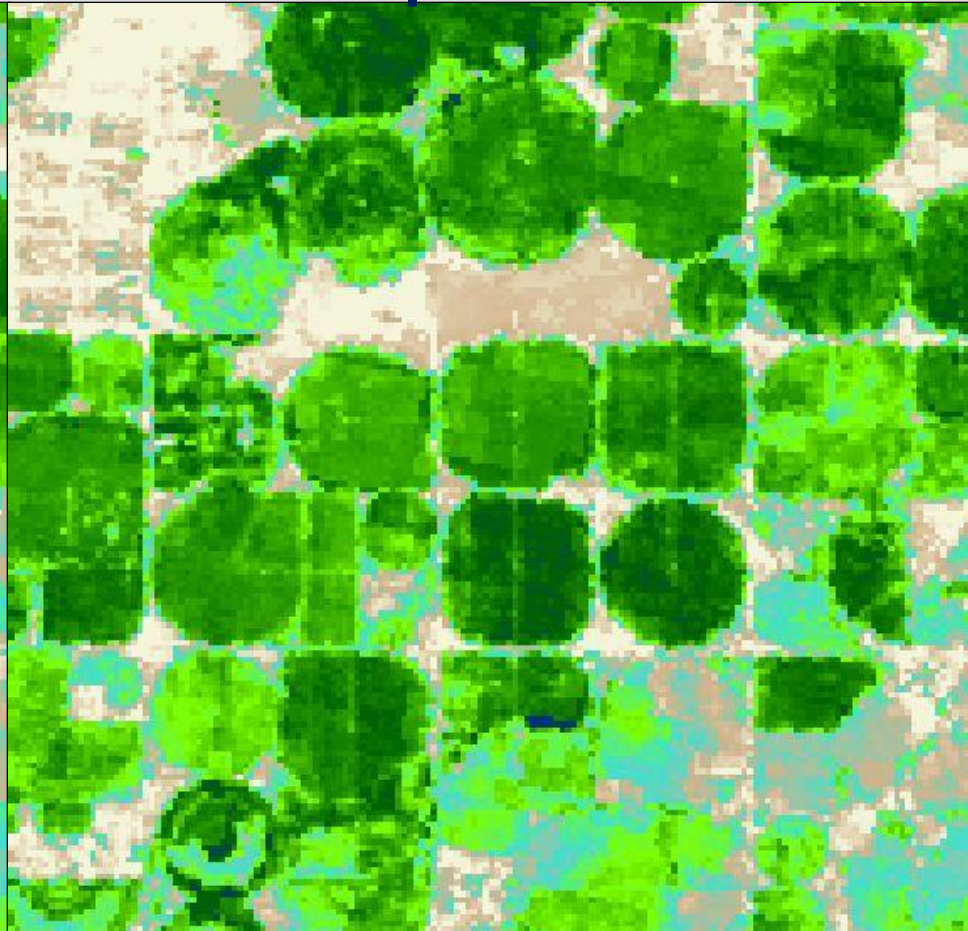


Sharpen Thermal Infrared Landsat 5

ET using 120 meter
thermal pixels

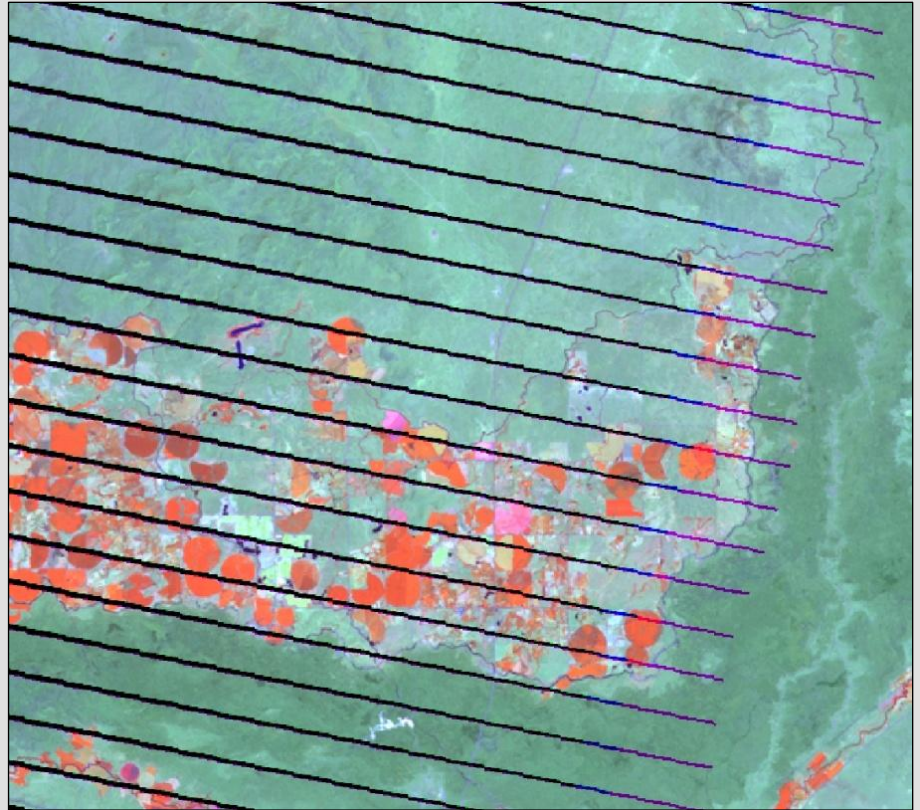
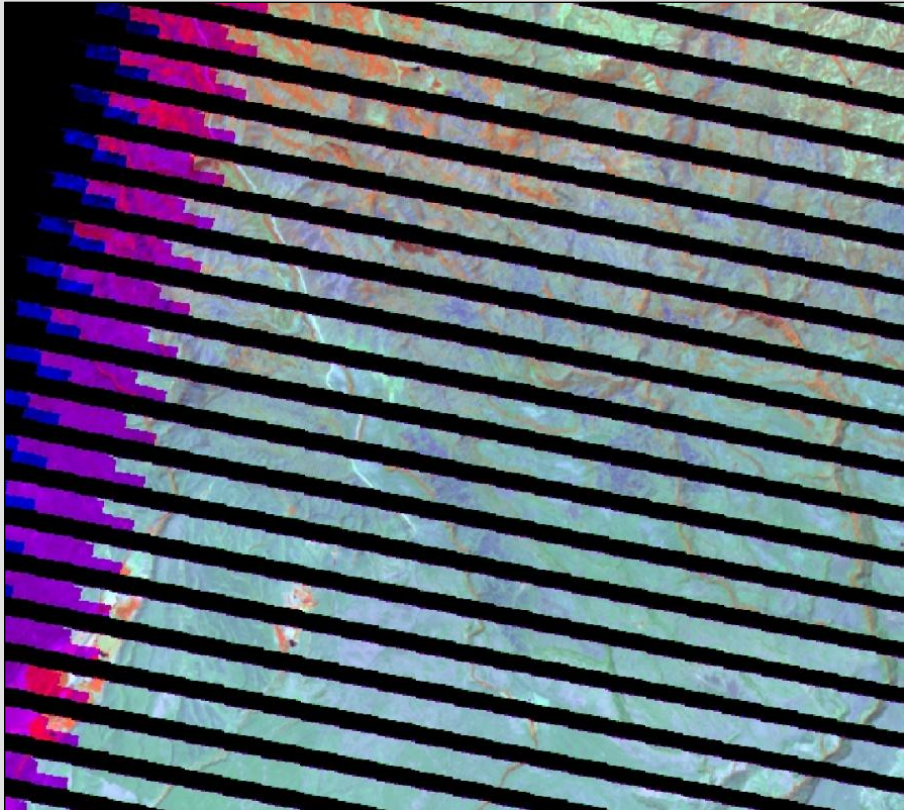


ET using 'Sharpened'
thermal pixels



Gaps in Landsat 7

Scan line corrector failed May 31, 2003

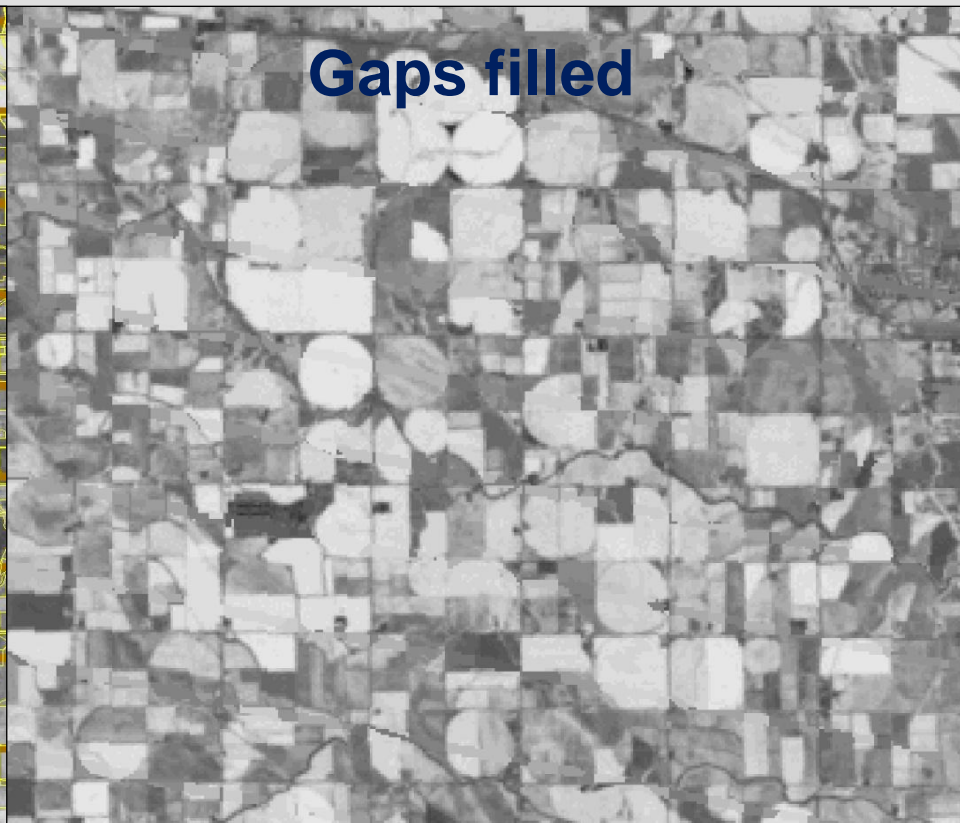
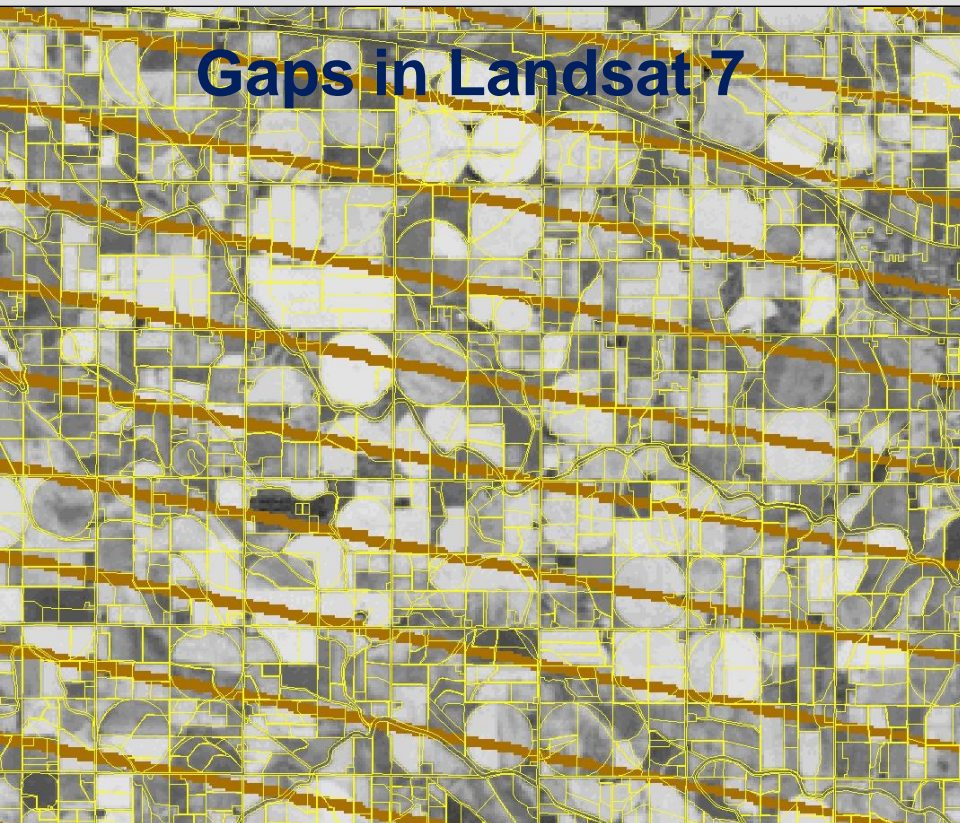


Gaps filled with ArcGIS Tools

Set Null: change gaps to nodata

Zonal Statistics: compute mean of polygons

Is Null & Con: replace gaps with mean value



Water Rights Litigation

Water Right

- Authorization to use water
- Includes priority date and rate of flow/volume

Delivery Call

- When a senior water right holder experiences a shortage they may place a delivery call

Curtailment Order

- Defines how the state directs junior water right holders to stop diverting water in response to a call

Mitigation Plan

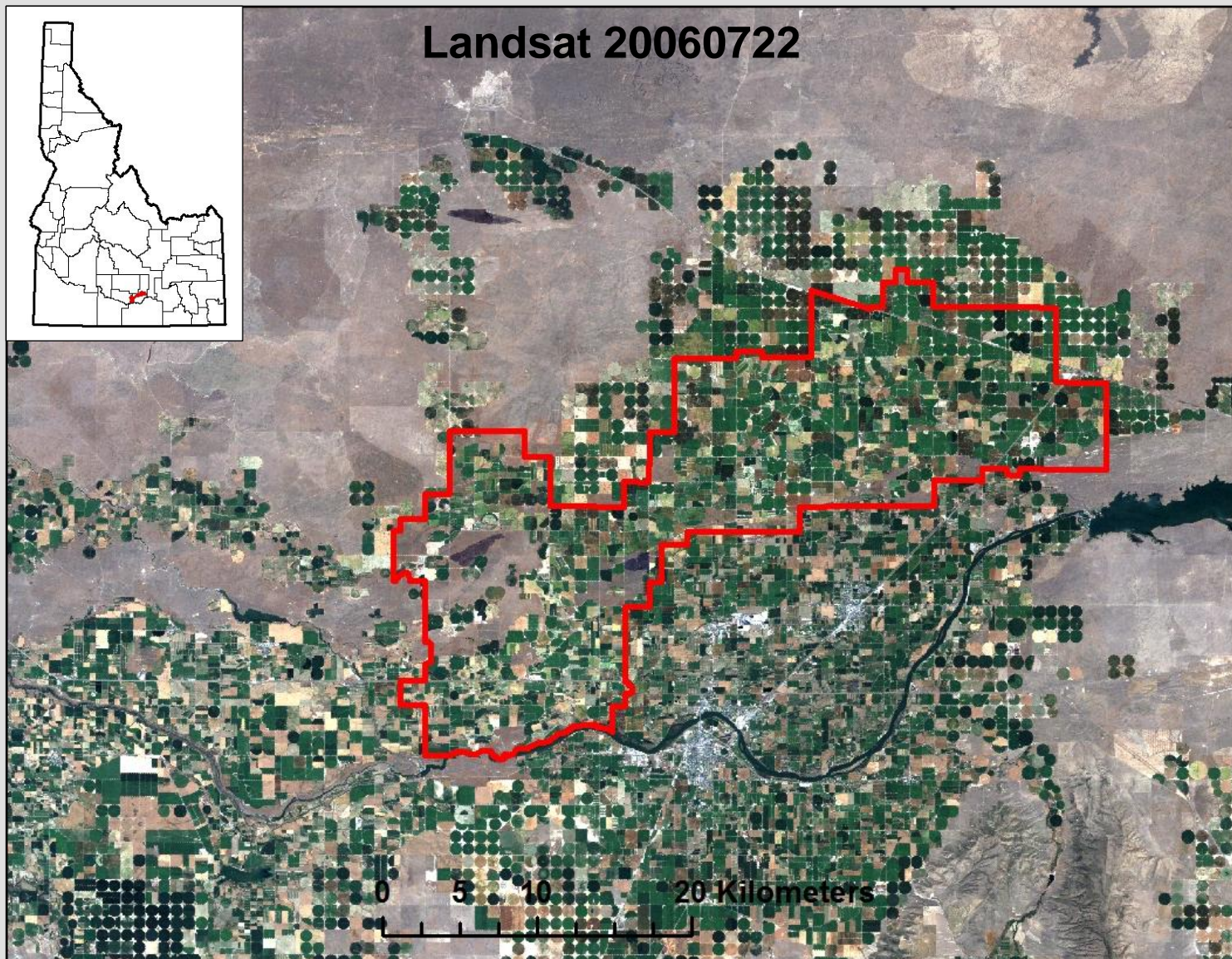
- Junior users response to a curtailment order

A&B Irrigation District Delivery Call

A&B filed a delivery call claiming that certain fields were short of water in 2006 due to diversions from junior ground water users

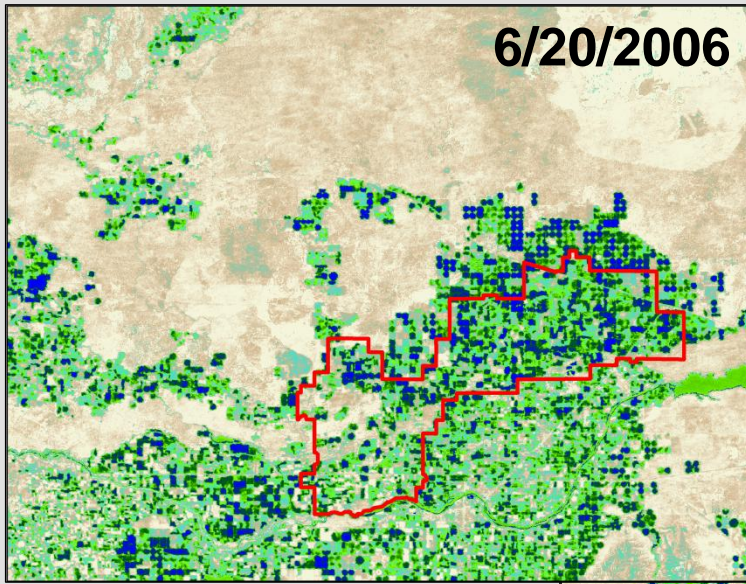
METRIC ET showed that the fields had ET rates as high or higher than surrounding fields

A&B Irrigation District

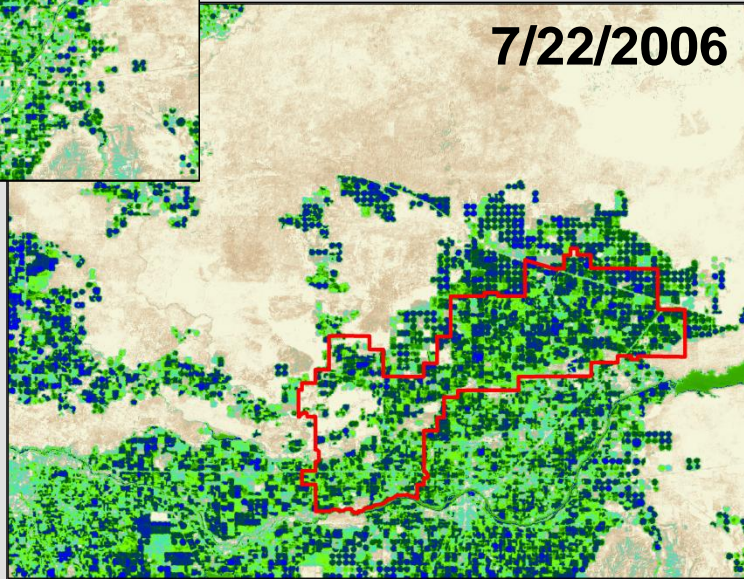


Daily ET images

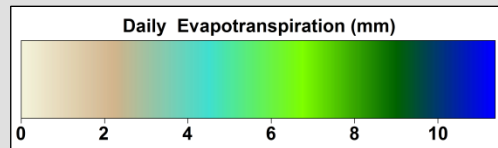
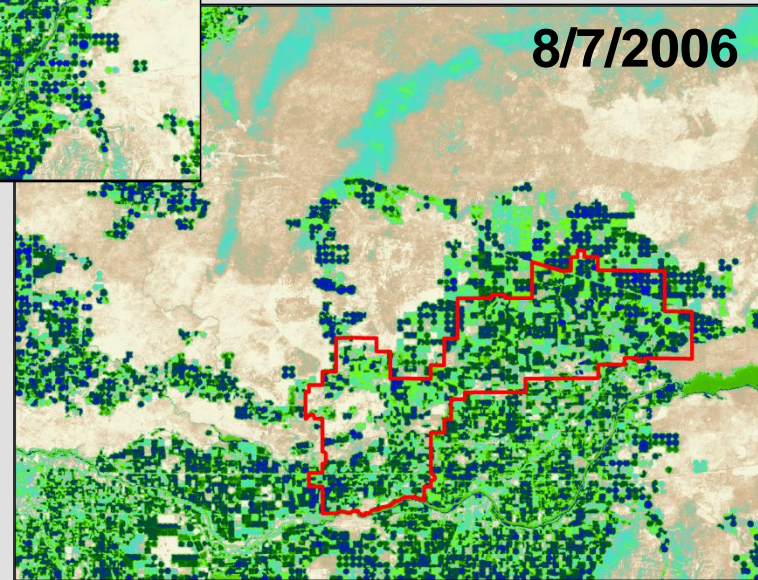
6/20/2006



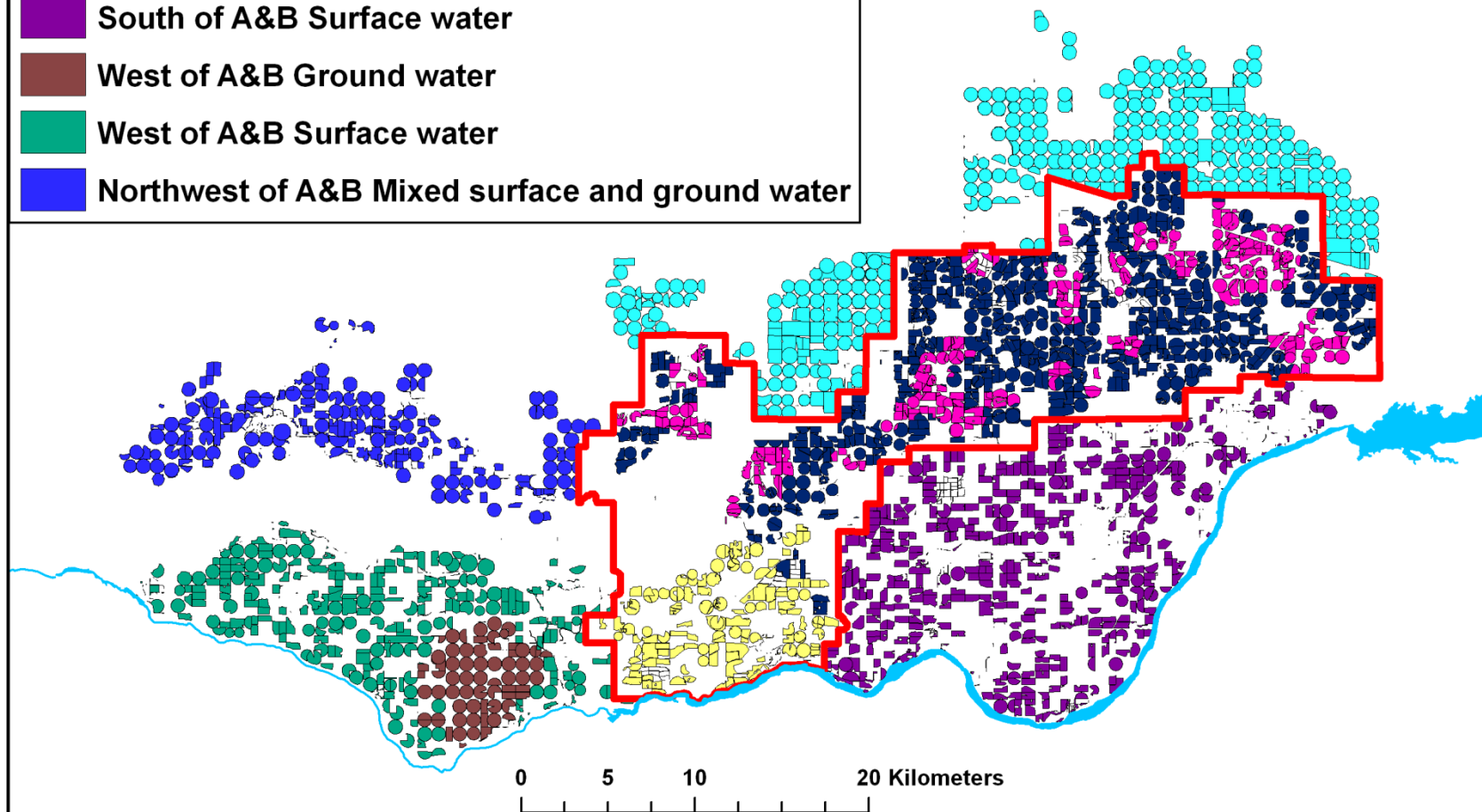
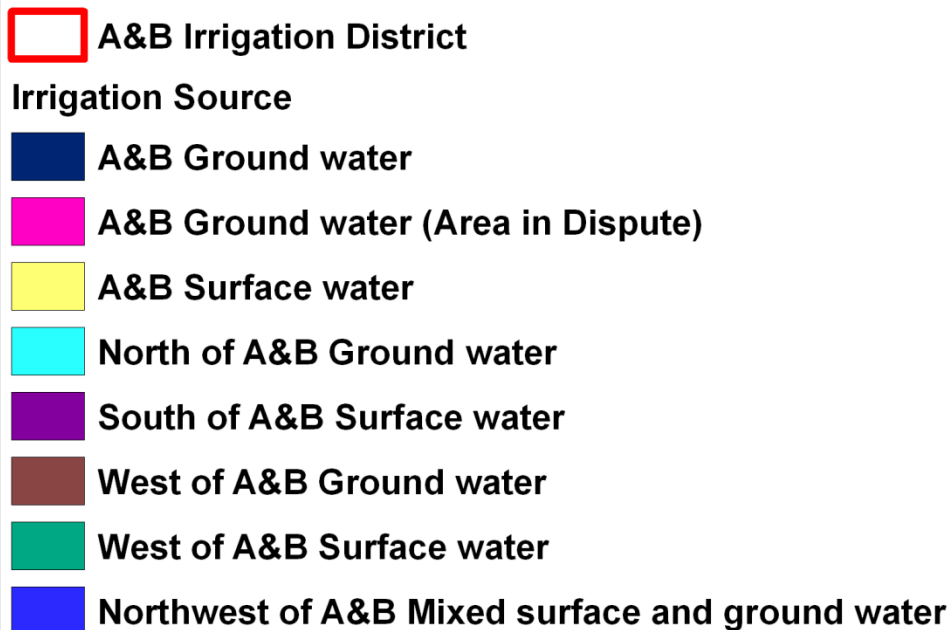
7/22/2006



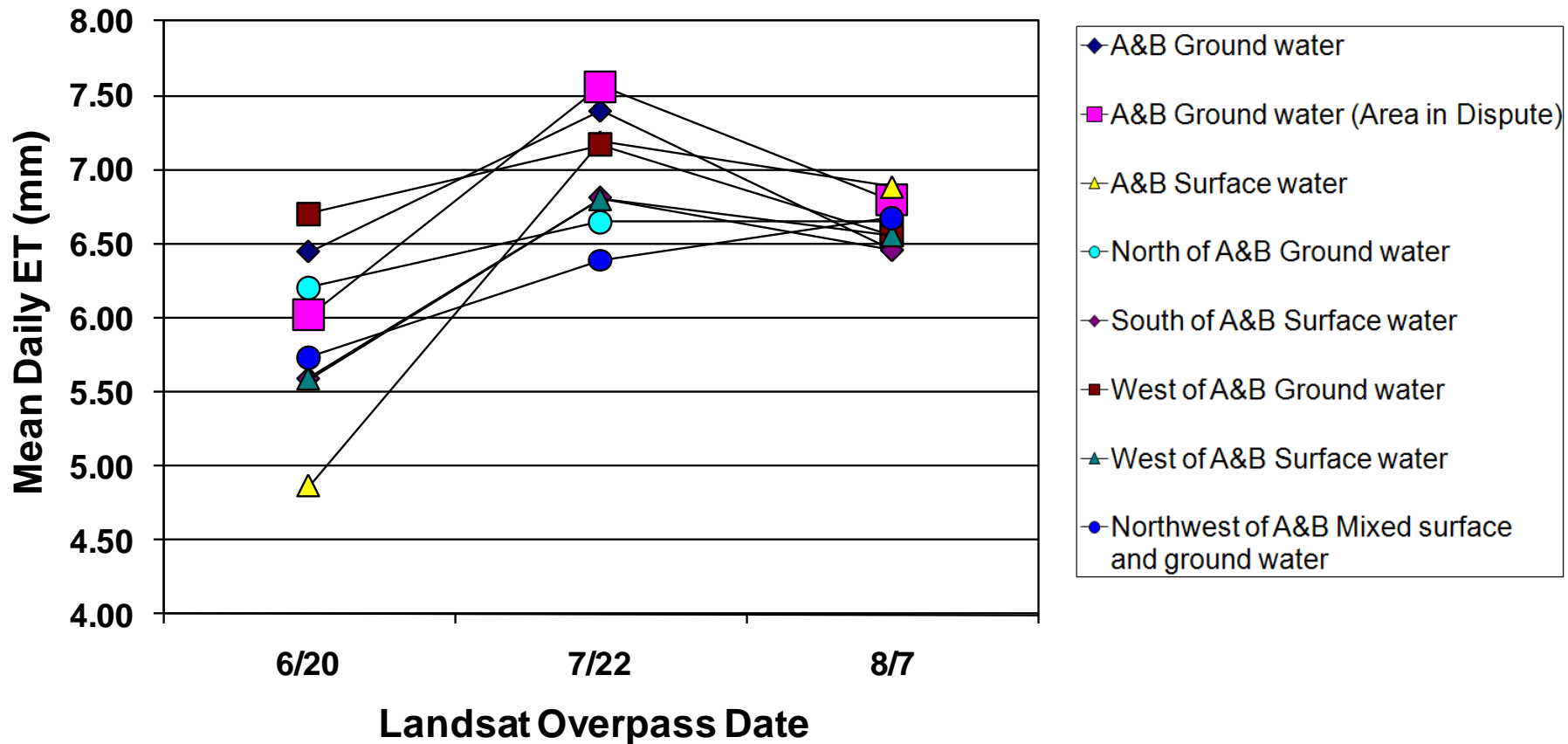
8/7/2006



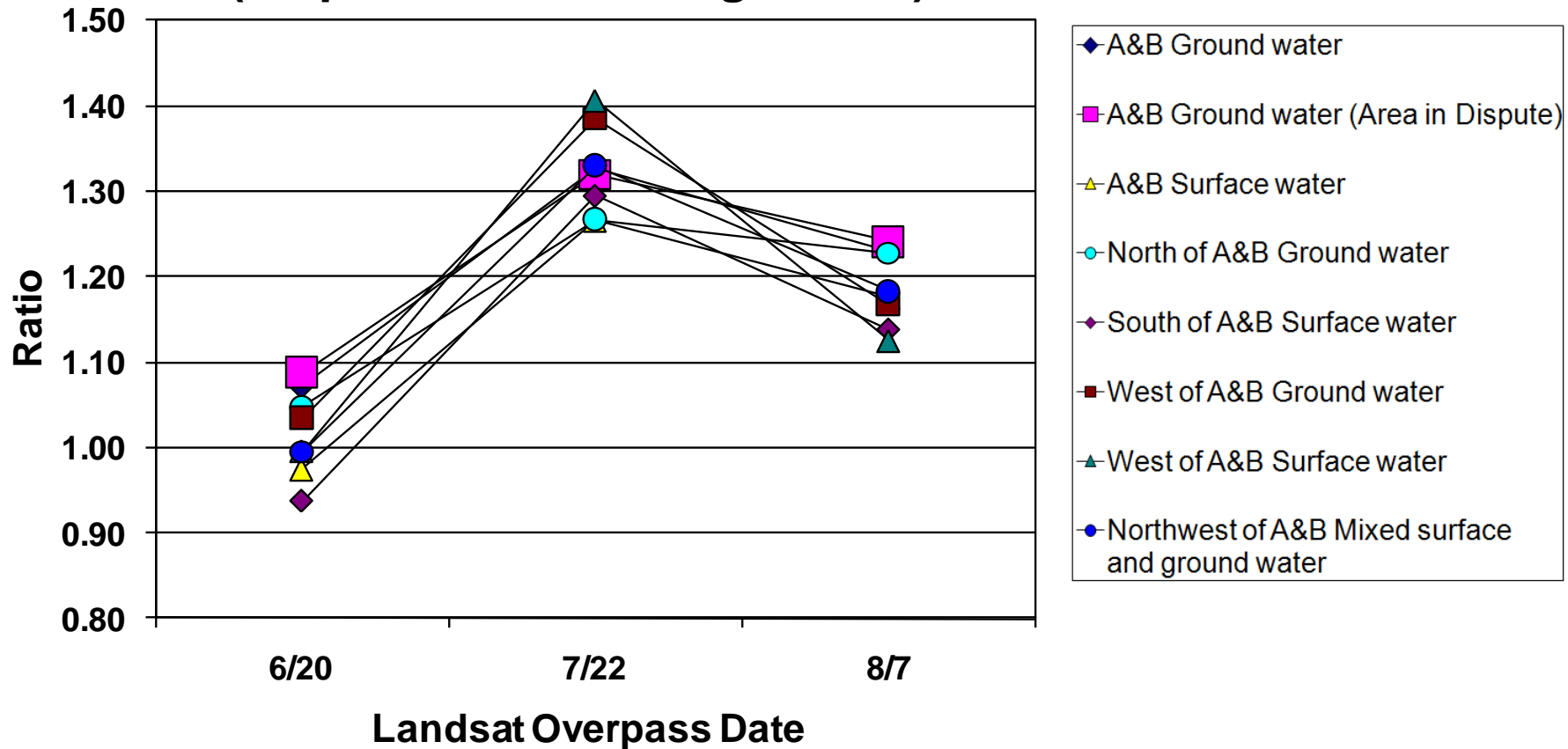
A&B Irrigation District and adjacent land



Year 2006: Mean Daily Evapotranspiration (ET)



Year 2006: Ratio of ETrF and NDVI (ET per amount of vegetation)



Sequence of events (1 of 2)

1. A&B filed delivery call (March 16, 2007)
2. Director issued order denying the call (Jan. 29, 2008)
 - ET analysis used as “legal finding of fact”
3. A&B appealed and requested a formal hearing
4. Deposition (May 15, 2008)
 - Answered questions about ET analysis
5. Formal hearing commenced (Dec. 3, 2008)
 - Evidence and testimony presented over 11 days
 - Answered questions about ET analysis

Sequence of events (2 of 2)

6. Hearing Officer issued Recommended Order agreeing with the Director (March 27, 2009)
7. Director issued final order denying the delivery call (June 30, 2009)
8. A&B appealed to District Court
9. District Court affirmed the Director's decision (May 4, 2010)
10. A&B appealed to Idaho Supreme Court
11. Idaho Supreme Court affirmed the Director's decision (August 2, 2012)

Concern about Landsat's future

Idaho Dept. of Water Resources has used Landsat data since 1975

Landsat 5 is 28 years old

- Thematic Mapper imaging halted November 2011

Landsat 7 is 13 years old

- Scan line corrector failed March 2003

Landsat 8 will launch in February 2013

Landsat 9 funding is uncertain

The Landsat Archive

- USGS EROS Center, Sioux Falls, SD
- over 3 million scenes
- July 1972 to present (thermal since 1982)
- Free
- <http://earthexplorer.usgs.gov/>

More Information

www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm

www.kimberly.uidaho.edu/water/metric

www.idwr.idaho.gov/geographicinfo/landsat/LandsatConcerns.htm

www.westernstatesetworkshop.com

0 25 50 100 Kilometers