Methods for computing ET
using Remote Sensing

- **METRIC**
  - Mapping EvapoTranspiration at high Resolution with Internalized Calibration
  - Surface energy balance
- **NDVI**
  - Normalized Difference Vegetation Index
  - Based on regression with METRIC
- **AgriMet**
  - Evapotranspiration (ET) by crop type
  - Used with the USDA's Cropland Data Layer (CDL)

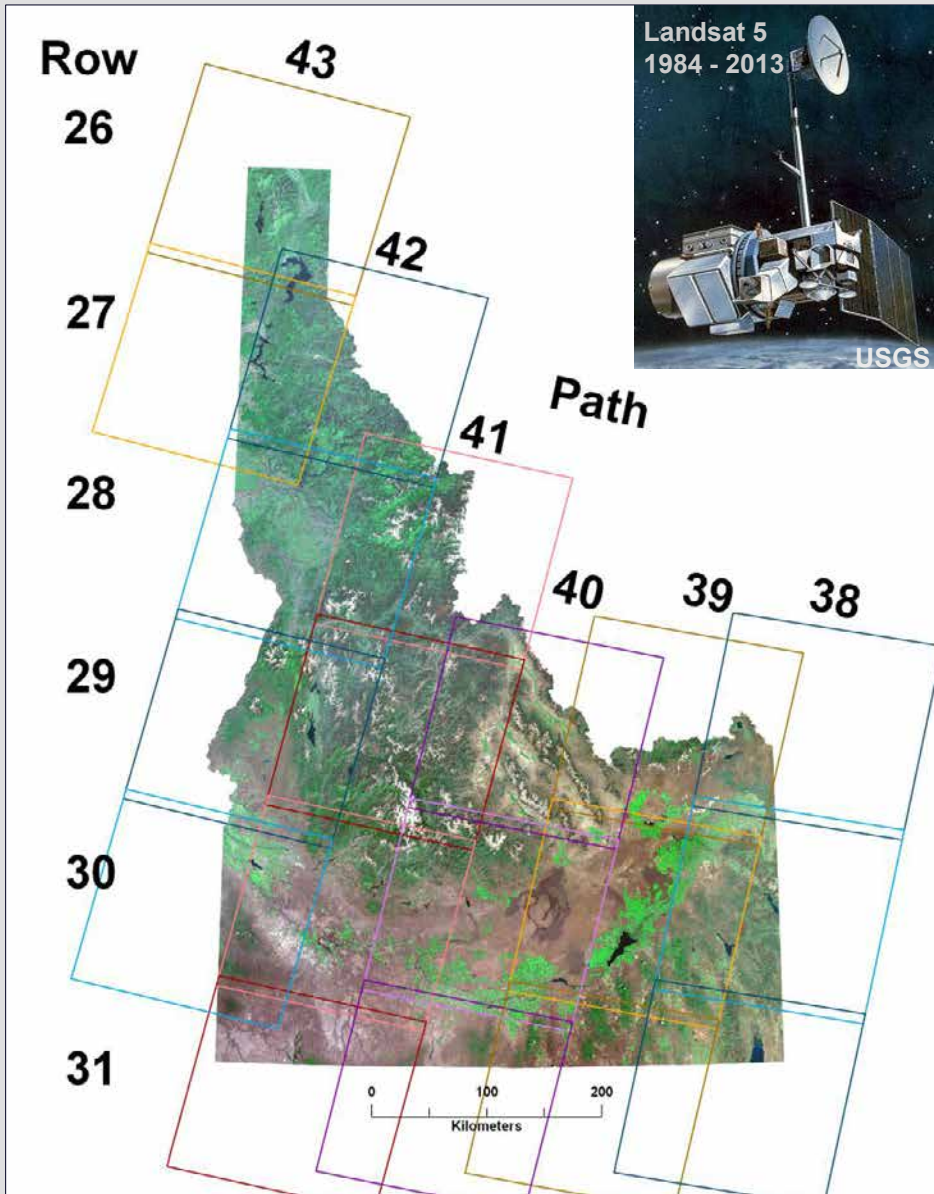
Data used by all methods

- Landsat satellite images
- AgriMet
- Ground Water Fraction
- Irrigated lands

Landsat

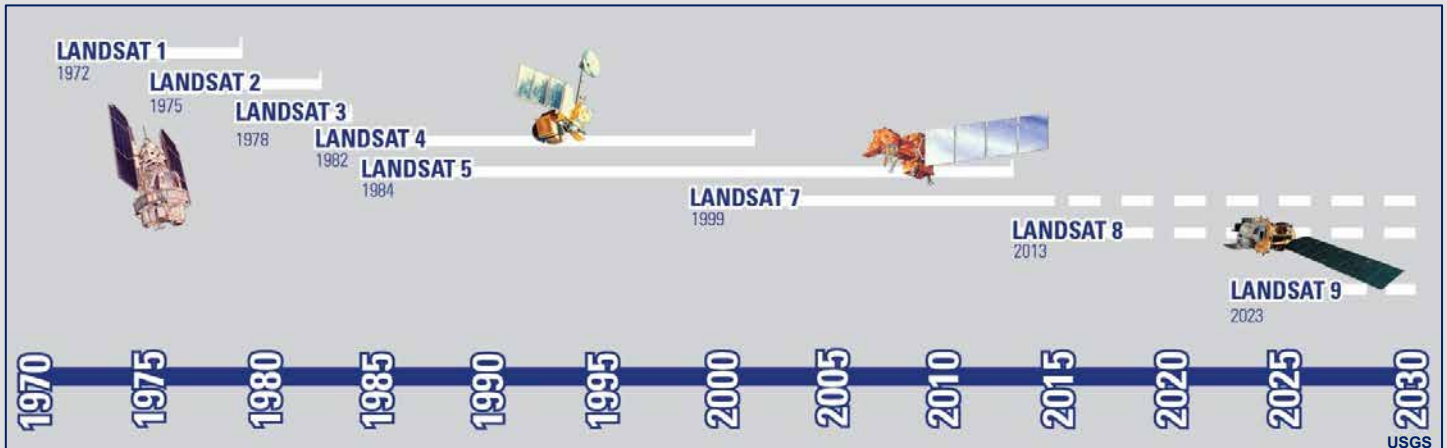
- USGS/NASA mission
- L1 launched 1972

- Current satellites
  - L7 1999 - 2019
  - L8 2013 - 2023
- 30/120-60-100 meter (L5 / L7 / L8)
  (Multispectral/Thermal)
- 16 day cycle
- 106 by 115 miles
- <u>Landsat 9 launch 2023</u>



Landsat Archive

- USGS EROS Center, Sioux Falls, SD
- Over 4 million scenes
- July 1972 to present (thermal since 1982)
- <u>Free</u>
- Search and download sites:
  - Earth Explorer (earthexplorer.usgs.gov)
  - GloVis (glovis.usgs.gov)

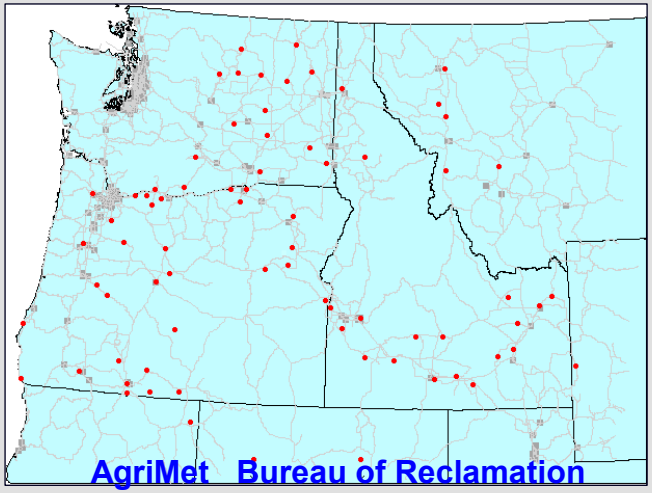


AgriMet

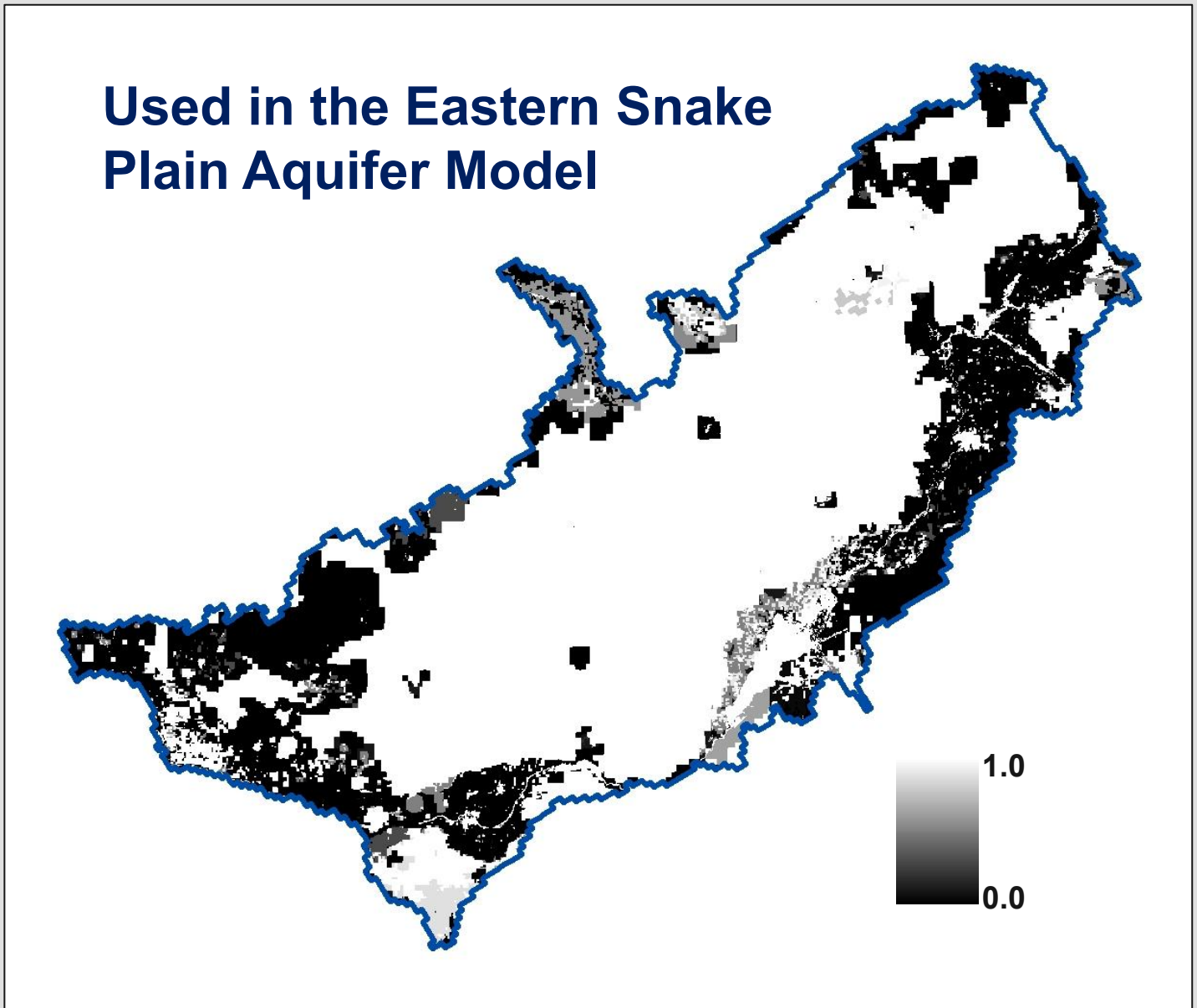
Bureau of Reclamation's Agricultural Weather Stations

- Hourly Reference ET for calibrating METRIC
- Daily Reference ET to extrapolate ET
  - 24-hour period
  - Days between images

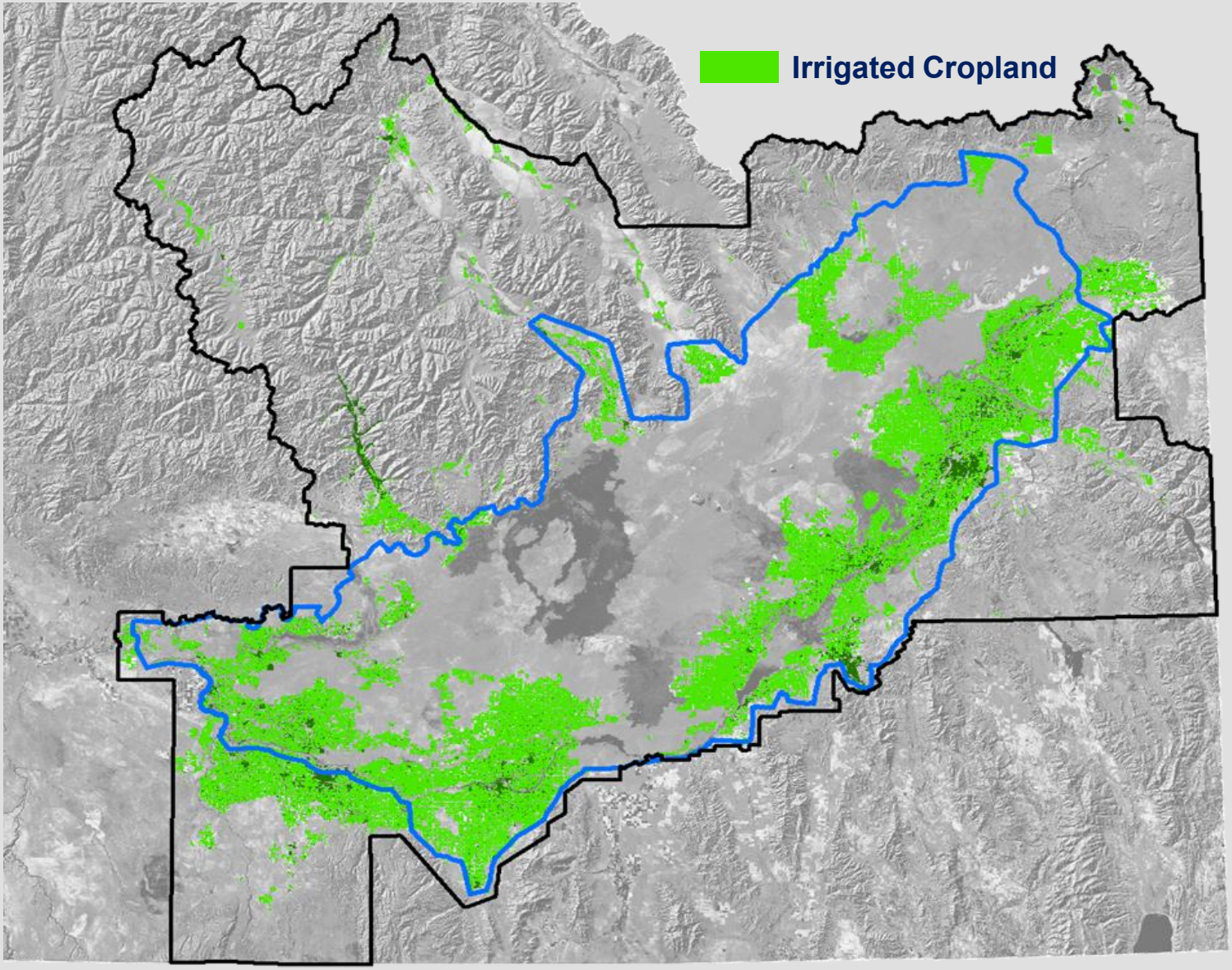
- Eight AgriMet sites within ESPAM
- Several AgriMet sites were added since 2014



Ground Water Fraction



Irrigated Lands Datasets



Years completed

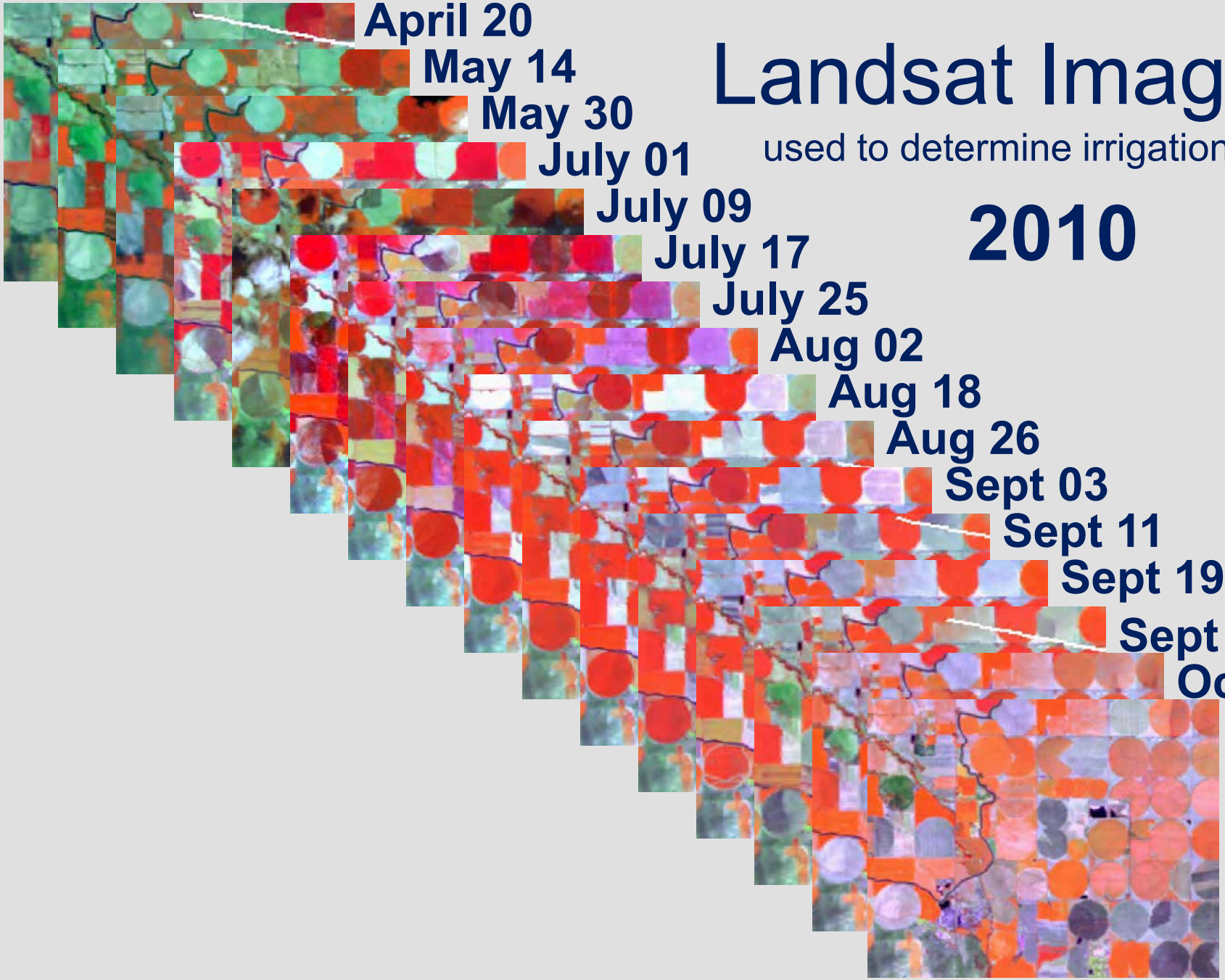
1986
1996
2000
2002
2006
2008
2009
2010

2011
in progress

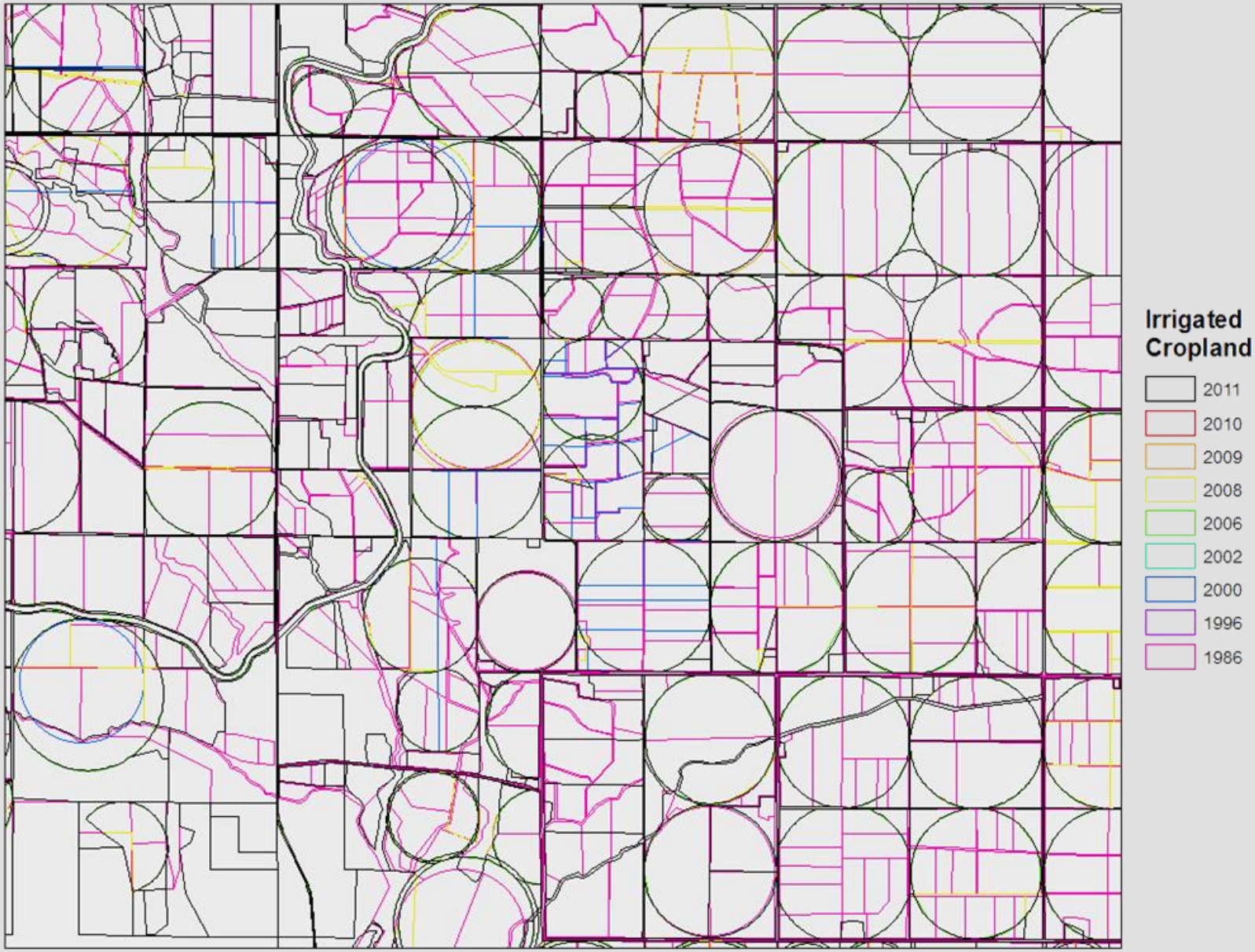
Landsat Imagery

used to determine irrigation status

2010



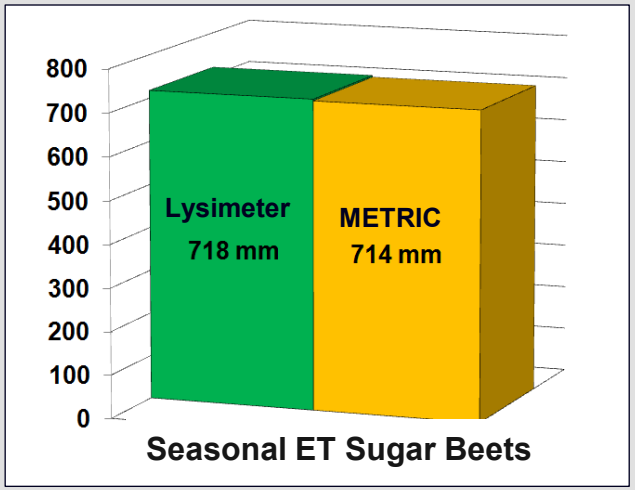
Complexity of Geometry



METRIC

Mapping **E**vapo**T**ranspiration at high **R**esolution with **I**nternalized **C**alibration

- Satellite-based surface energy balance model
  - Computes and maps actual ET
  - Internalized Calibration ties down ET to AgriMet data
- High agreement with precision weighing lysimeter
  - No lysimeters in Idaho anymore—too expensive



Energy balance computes "Actual ET"

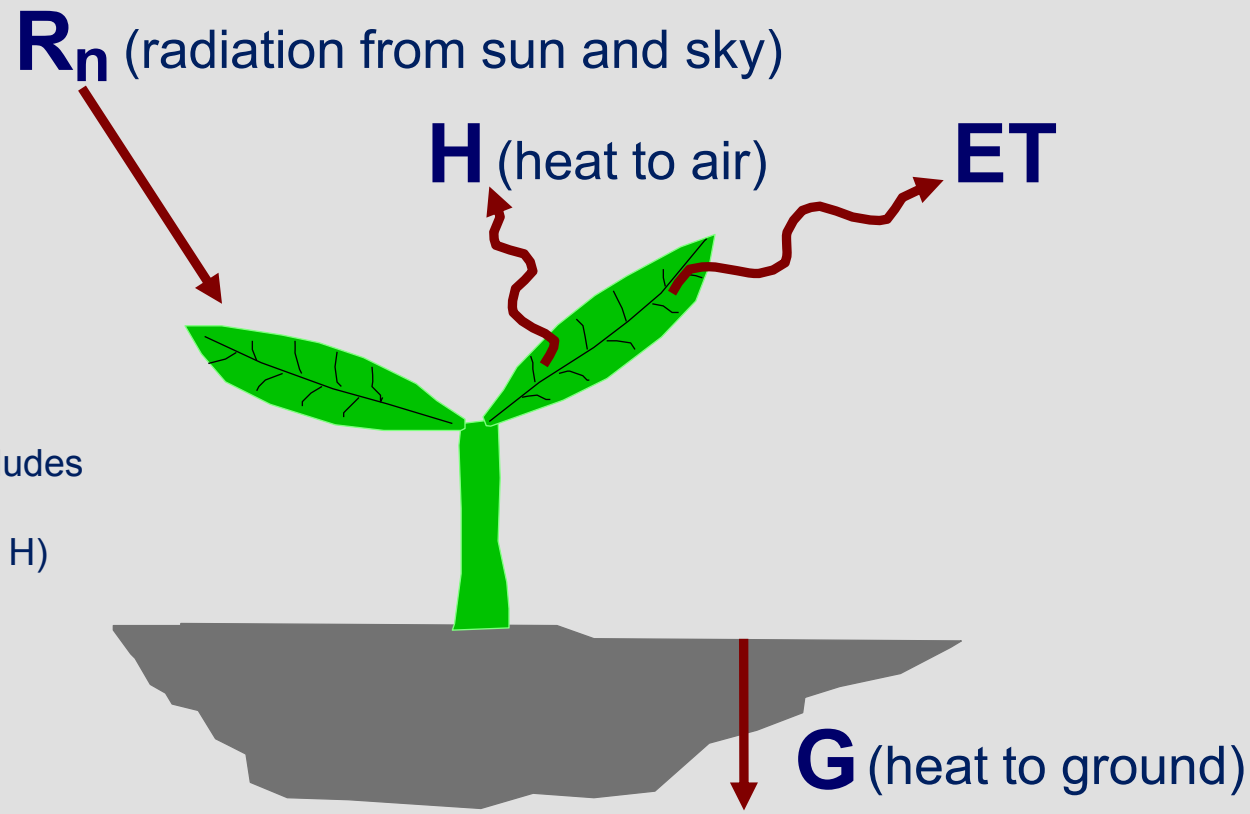
Can 'see' impacts on ET caused by:

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

Energy Balance for ET

ET computed as “residual” of the energy balance

$$ET = R_n - G - H$$

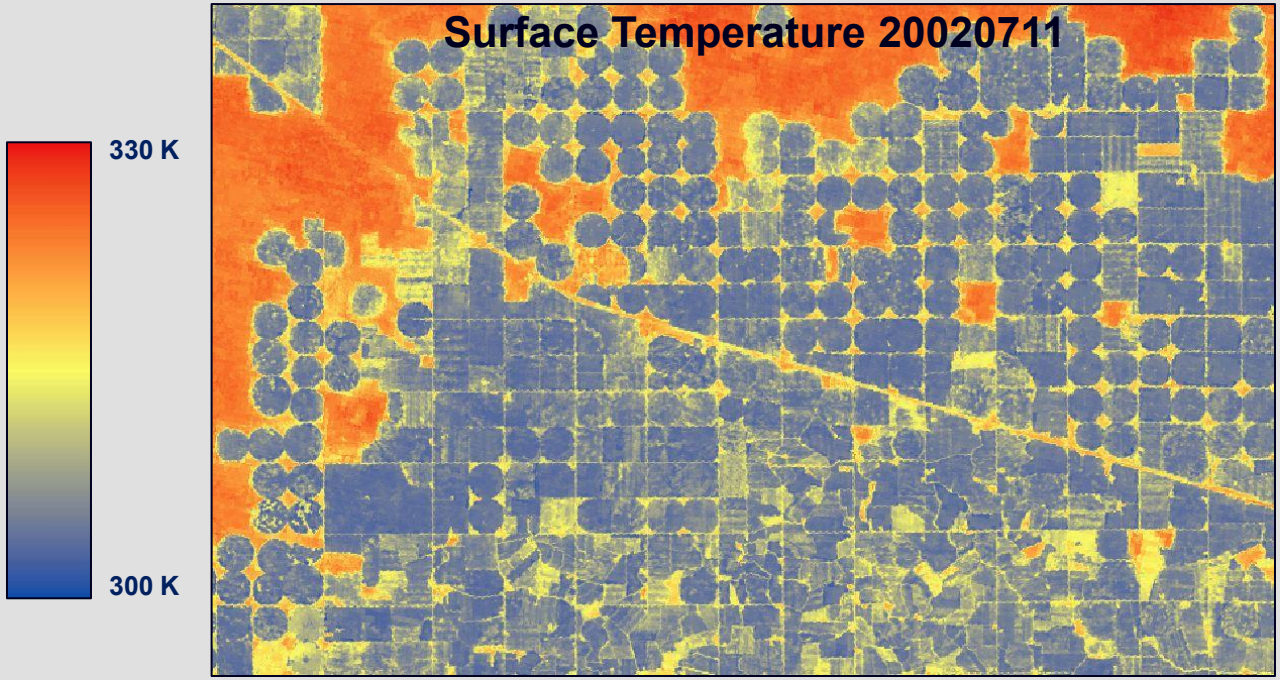


The energy balance includes all major sources (R_n) and consumers (ET, G, H) of energy

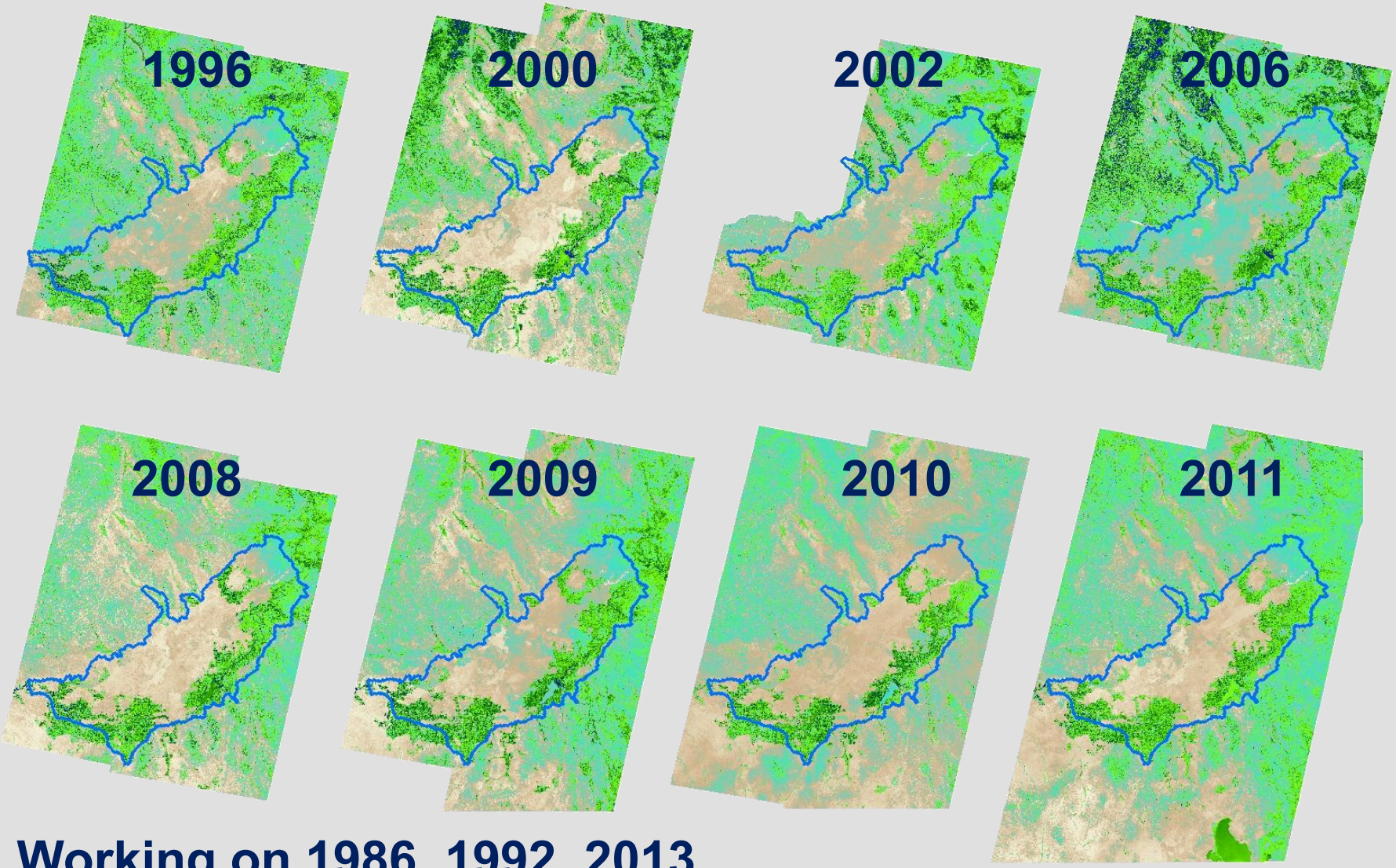
Landsat Thermal Band

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!



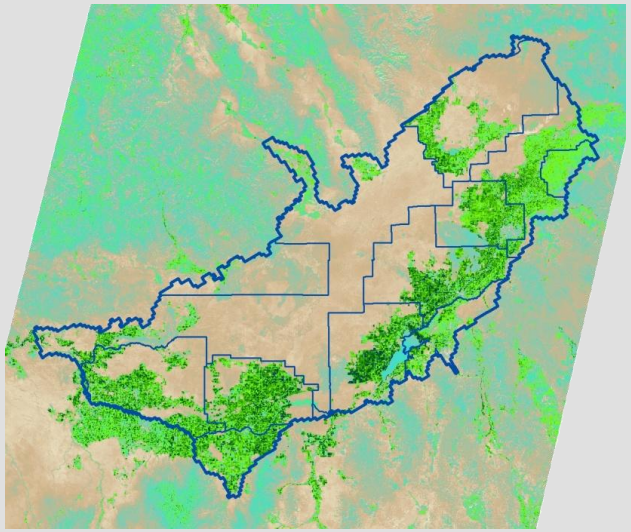
METRIC for ESPAM



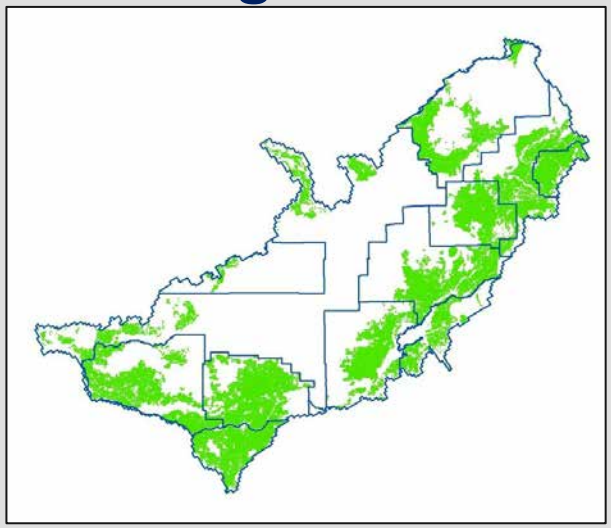
Working on 1986, 1992, 2013

METRIC ET for Ground Water Districts

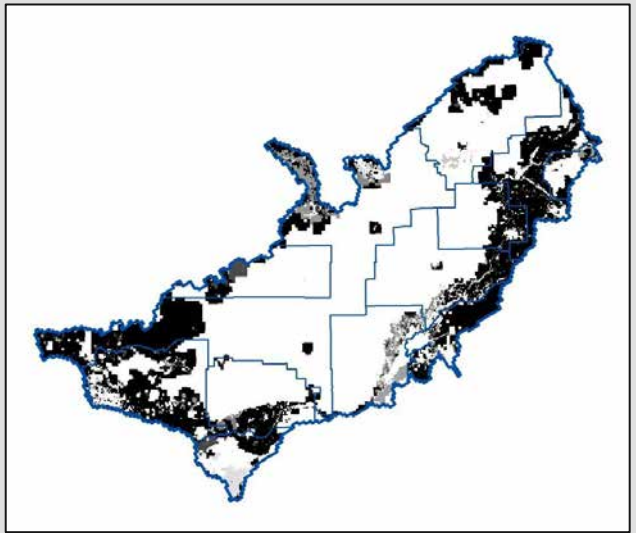
2010 METRIC



2010 Irrigated Lands

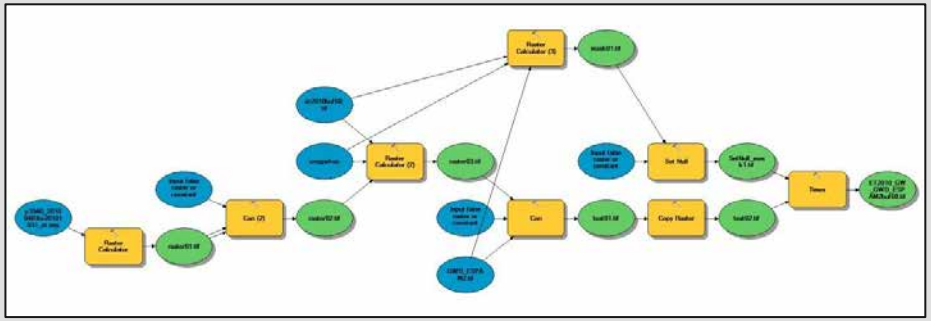


Ground Water Fraction

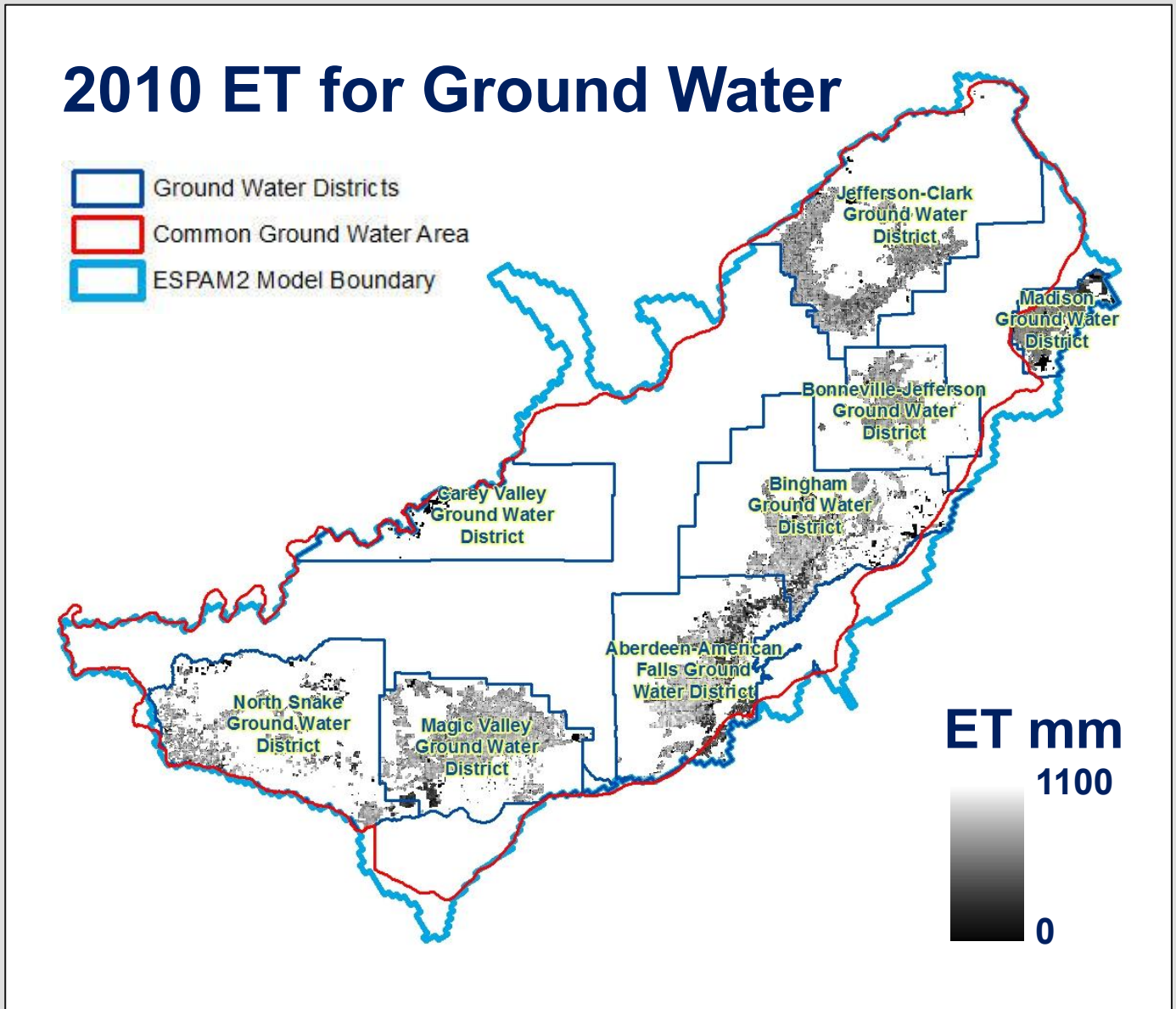


ArcGIS Model

Input: METRIC, Irrigated Lands, GWF

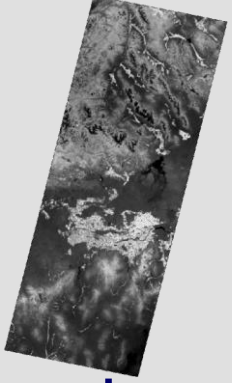


ArcGIS Model Output



NDVI ET

Normalized Difference Vegetation Index

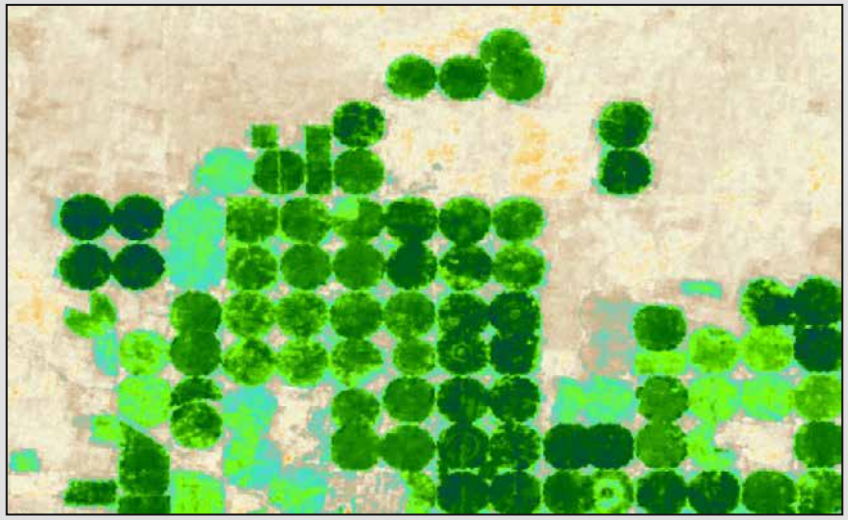


- Landsat Near-Infrared (NIR) and Red (R) bands
  - NDVI = (NIR – R) / (NIR + R)
  - NDVI is sensitive to green biomass
- ET from regression between METRIC and NDVI
  - ETrF = 0.15 + 1.06 NDVI
- Faster than METRIC
  - Within ~9% of METRIC for full season over large areas
  - Less agreement for small areas and shorter time periods
- Data requirements
  - Landsat: at least one image per month
  - Daily AgriMet and NWS data for ETr surfaces

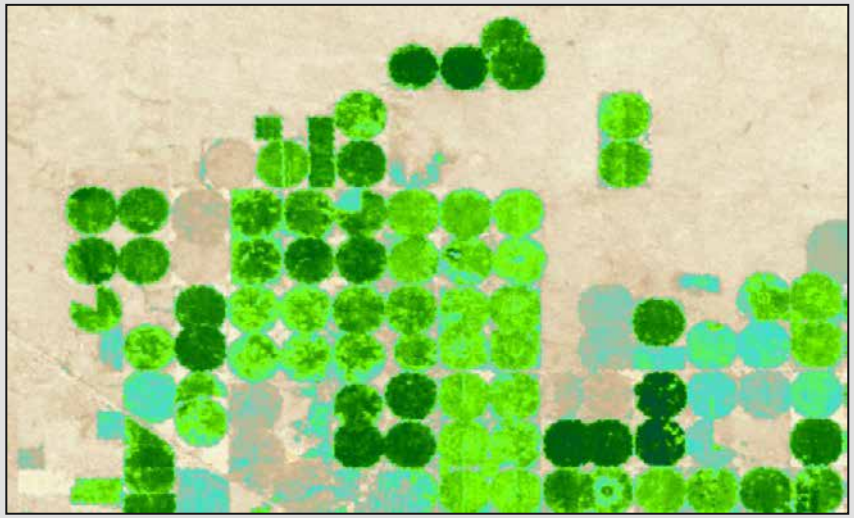
Contrast between ETrF from METRIC and ETrF from NDVI *(there are differences)*

South-central Idaho 2006

ET_rF from METRIC



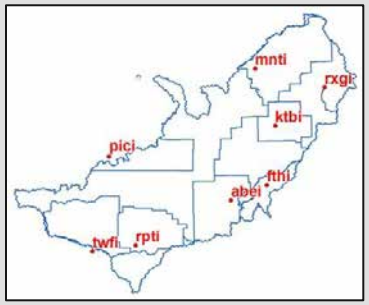
ET_rF from NDVI



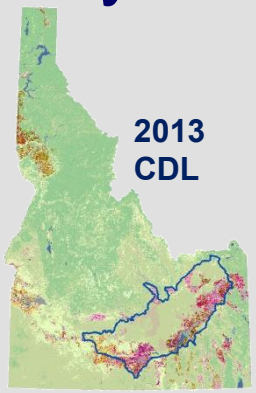
AgriMet ET for Ground Water Districts

Assign crop ET from nearest AgriMet site to crops in Cropland Data Layer (CDL)

- 8 AgriMet sites were used



- CDL is developed by USDA from Landsat images and other sources
- CDL released early February for previous year
- 2013 CDL has 87% overall accuracy

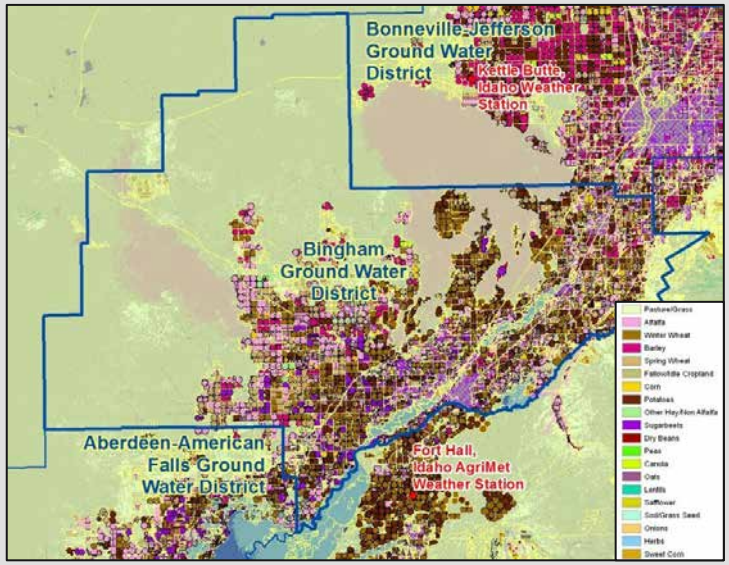


2013 AgriMet

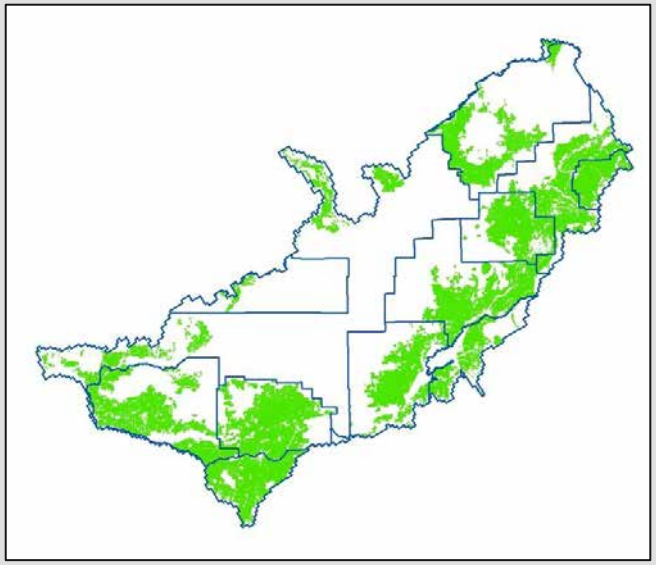
ET by crop type

Agr_Code	FTHI_ETmm
ALFM	1069
PAST	860
LAWN	1047
WGRN	695
SGRN	680
BEET	873
POTA	784
BEAN	680
FCRN	762
SCRN	762
PEAS	680

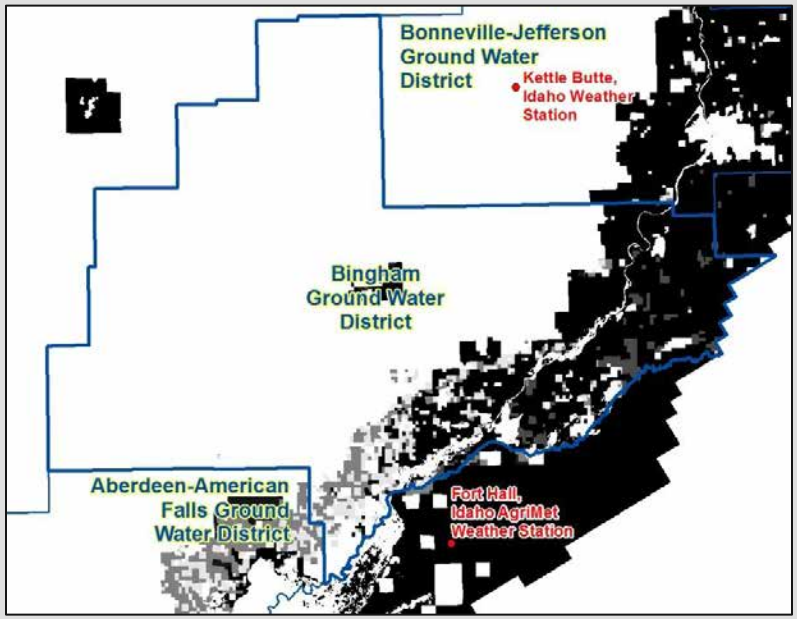
2013 USDA CDL



2010 Irrigated Lands

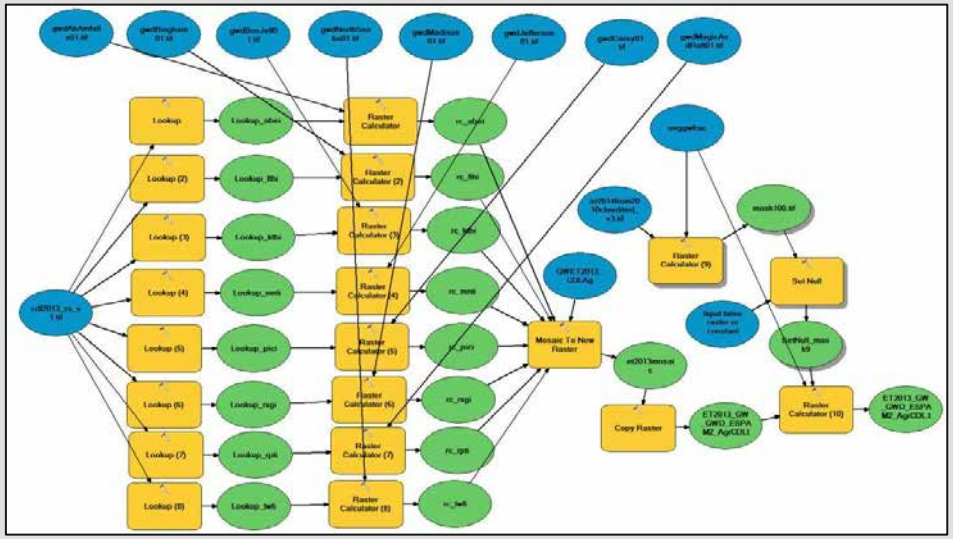


Ground Water Fraction

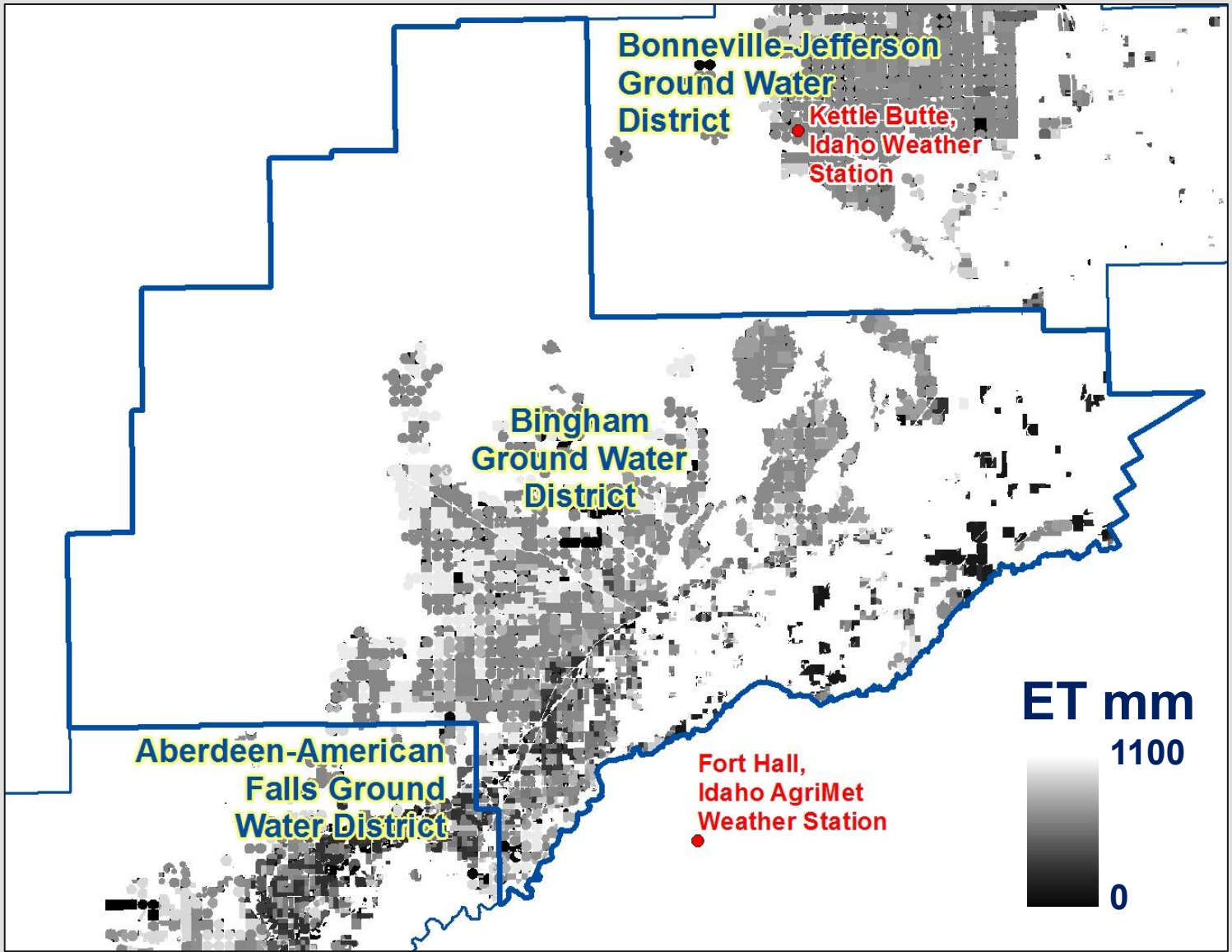


ArcGIS Model

Input: AgriMet, CDL, Irrigated Lands, GWF



ArcGIS Model Output
2013 ET for Ground Water



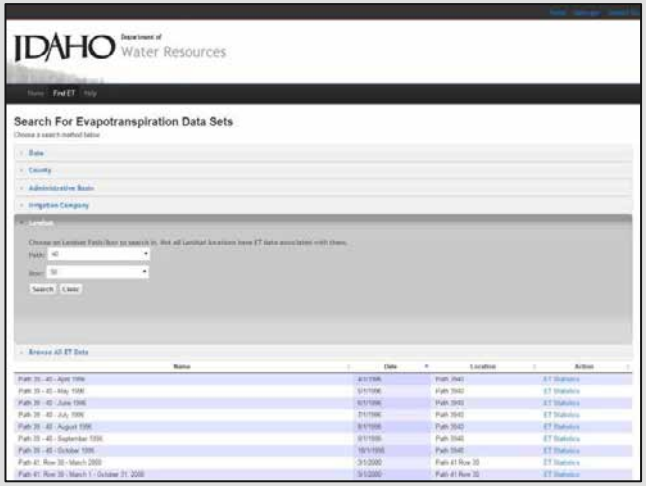
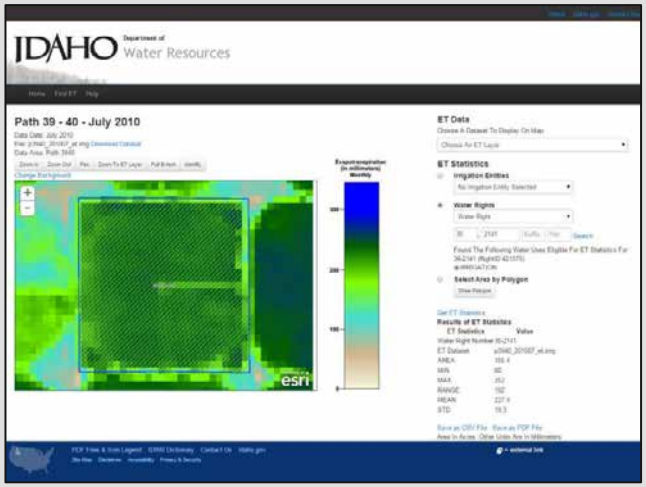
Summary of Methods

- **METRIC**
  - Actual ET
  - Most robust and widely accepted
  - Input: Landsat, AgriMet, Irrigated lands, GWF
  - About 1 year to develop
- **NDVI**
  - Based on regression with METRIC
  - Input: Landsat, AgriMet, Irrigated lands, GWF
  - About 4 months to develop
- **AgriMet**
  - Potential ET
  - Input: CDL, AgriMet, Irrigated Lands, GWF
  - About 1 week to develop

METRIC ET Viewer

maps.idwr.idaho.gov/ET

- Search for METRIC ET data
  - Date, County, Basin, Irrigation Company, Landsat scene



- METRIC ET Statistics
  - Irrigation companies
  - Water rights
  - User drawn polygon on screen