Irrigation Water Use in the Harney

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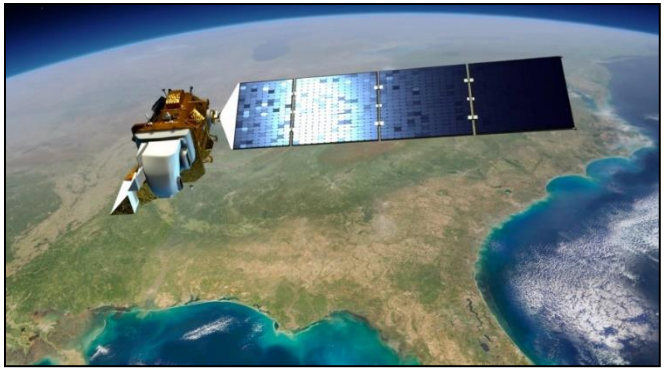

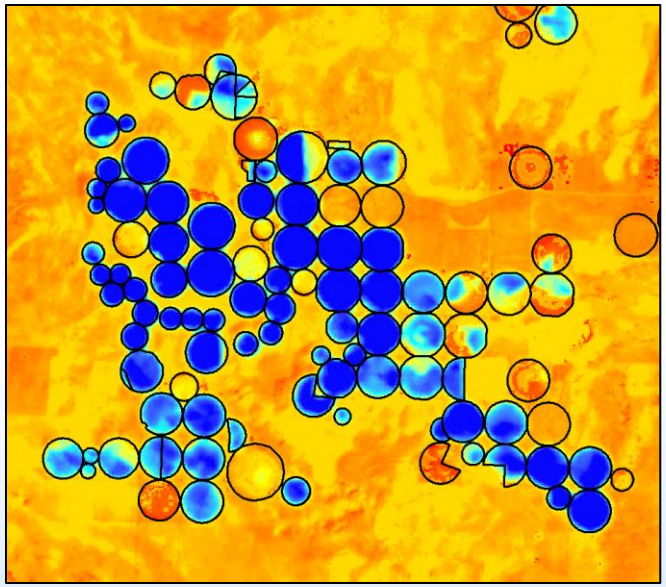

Jordan Beamer, Hydrologist

Harney Groundwater Study Advisory Committee Meeting

Burns, OR March 21, 2019

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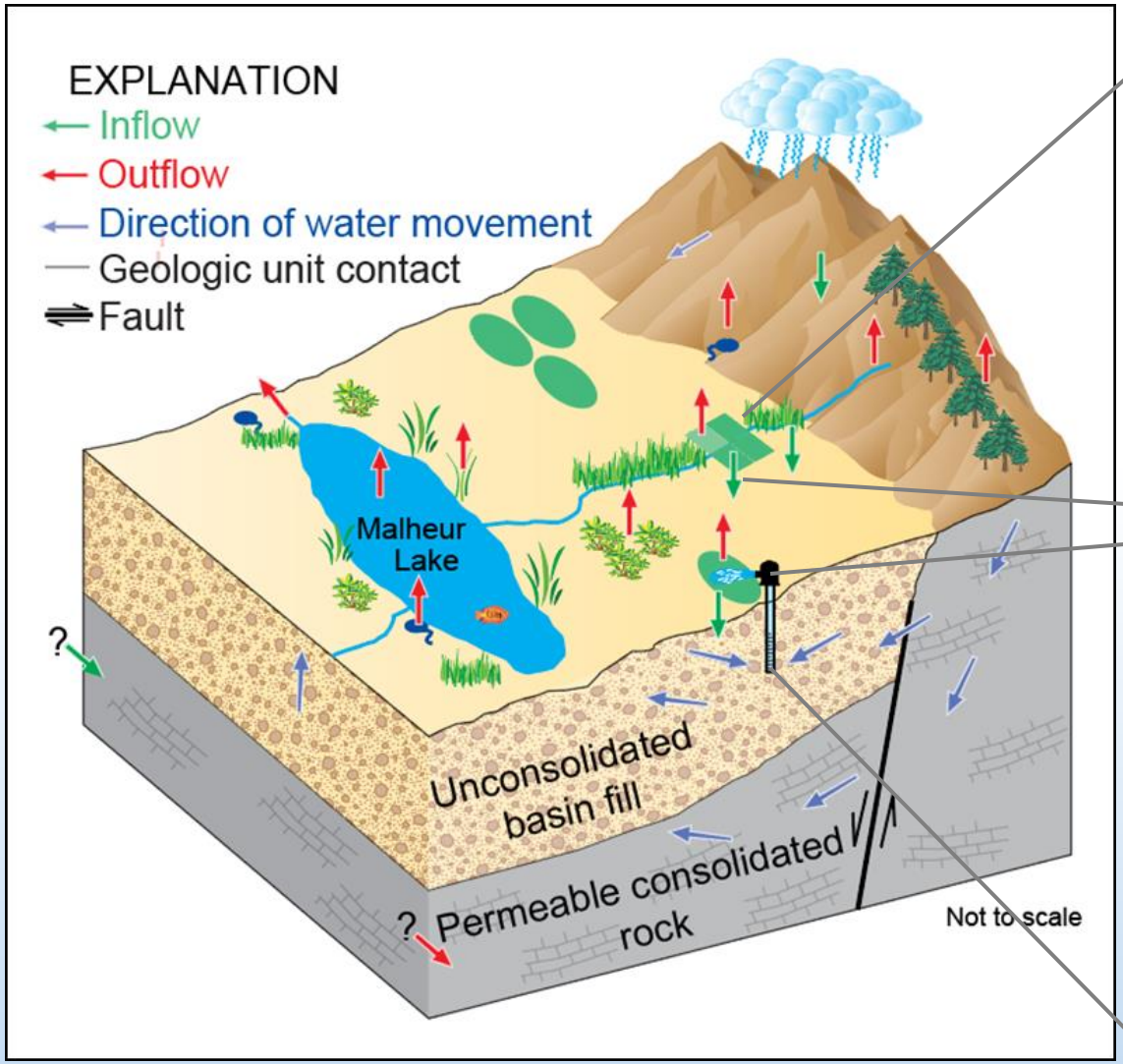
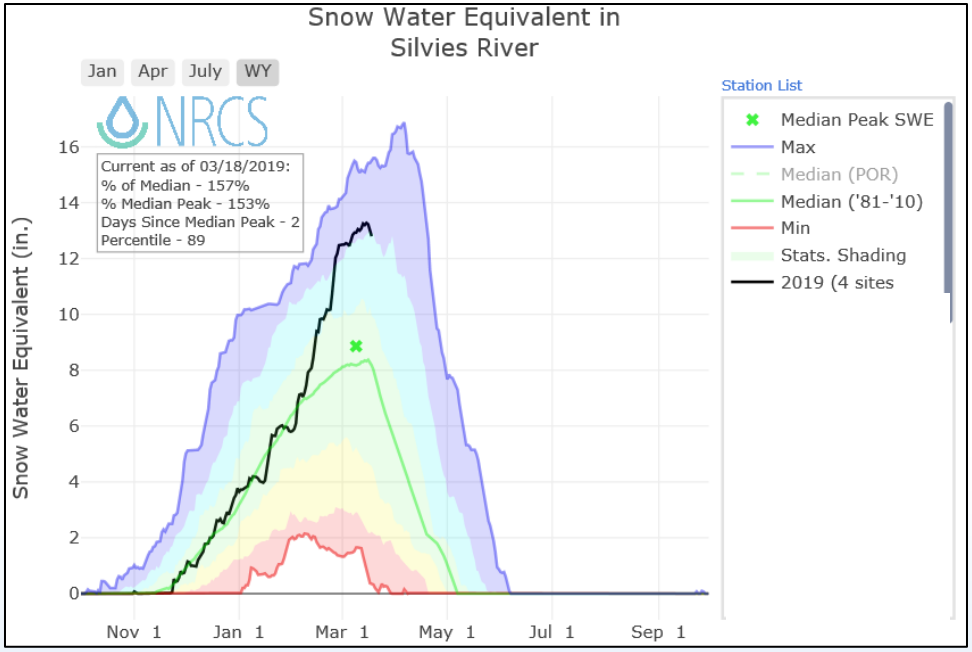
Basin Water Budget



Harney Hydrology

- Irrigation uses majority of available water for growing crops
- Surface water availability reliant on snowpack – high variability

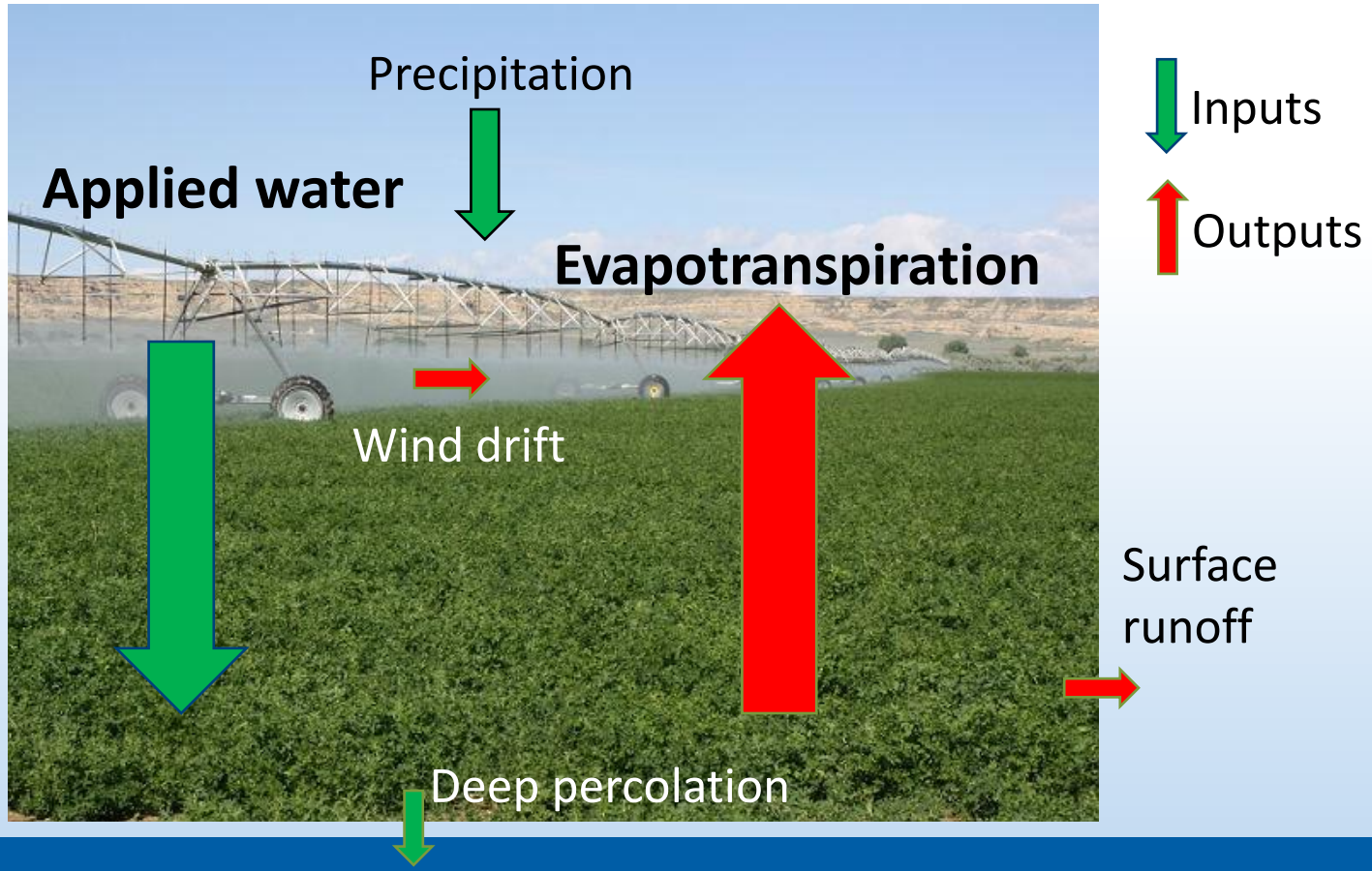


- Recent development of groundwater for primary and supplemental irrigation

https://www.nrcs.usda.gov/Internet/WCIS/basinCharts/POR/WTEQ/OR/Silvies%20River.html

Irrigation Water Use

We use evapotranspiration (ET) from crops to estimate irrigation water use. ET = evaporation + transpiration.



Crop Evapotranspiration

Factors that influence crop ET:

- Water availability
- Crop type and phenology
- Growing season length
- Irrigation / land management
- Environmental demand (solar radiation, air temp, humidity, and wind speed)

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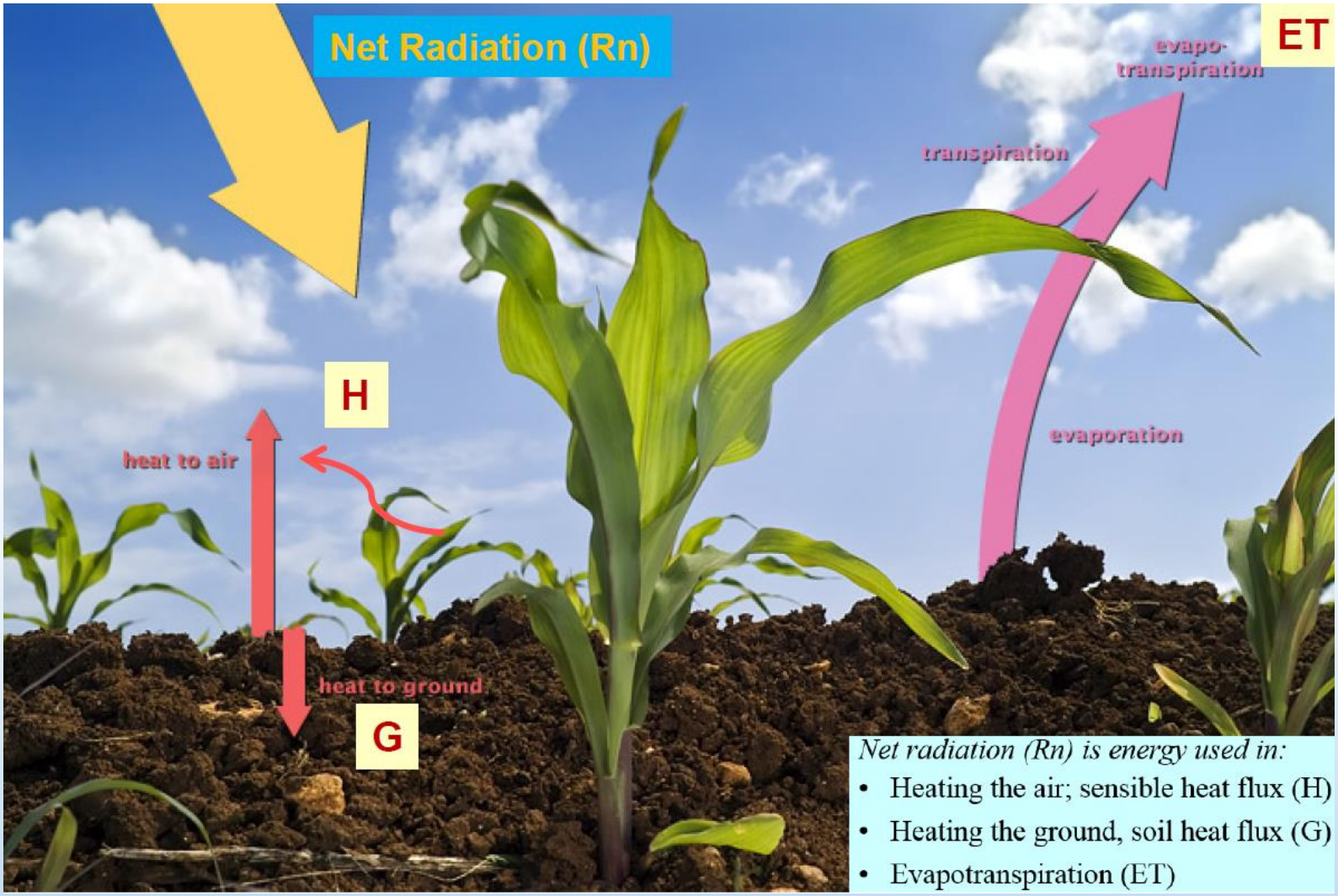
Energy Balance



Credit: R. Trezza

University of Idaho

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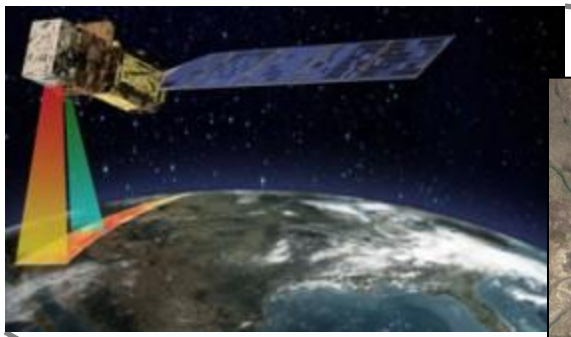
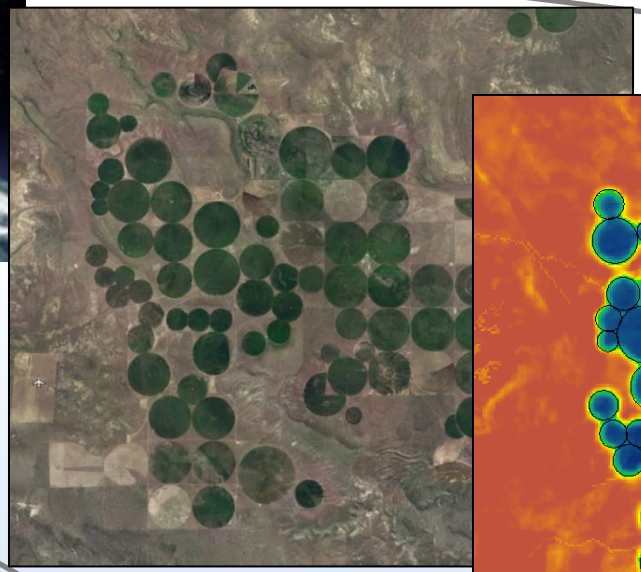
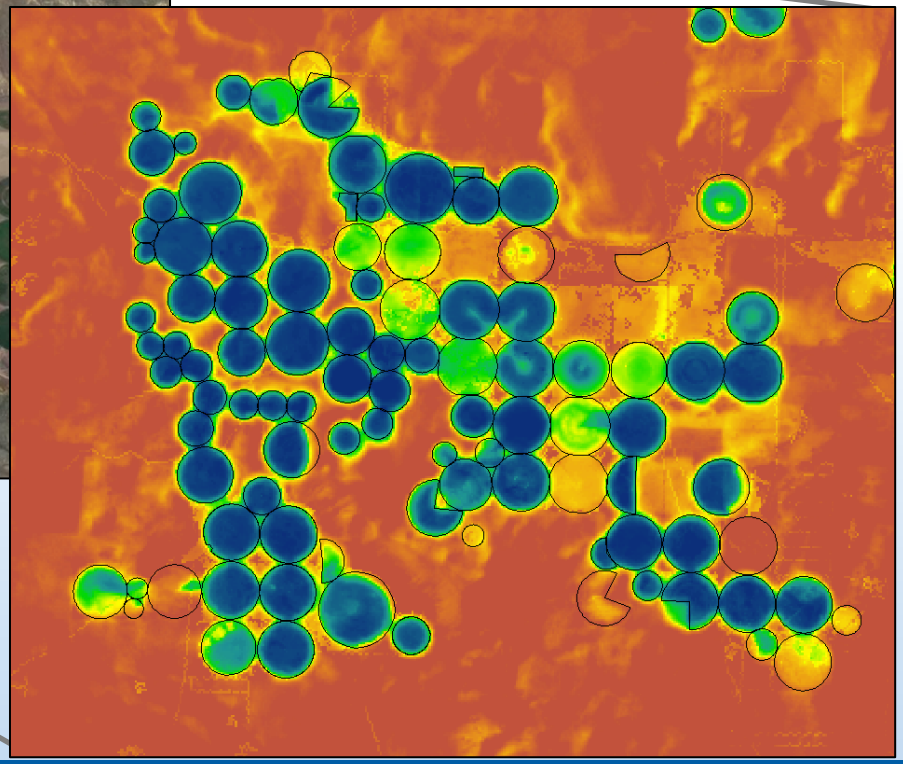
Images of Water Use

Satellite imagery captures the field conditions impacting crop ET over large areas and time periods







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Study Objectives

- Develop and report field scale estimates of crop ET from irrigated agriculture in the Greater Harney Valley Groundwater Area of Concern (GHVGAC).

- Study period includes 11 years of estimates starting 1991 and ending 2016.

- Partition the field scale crop ET into water source types: groundwater, surface water, and a combination of both.

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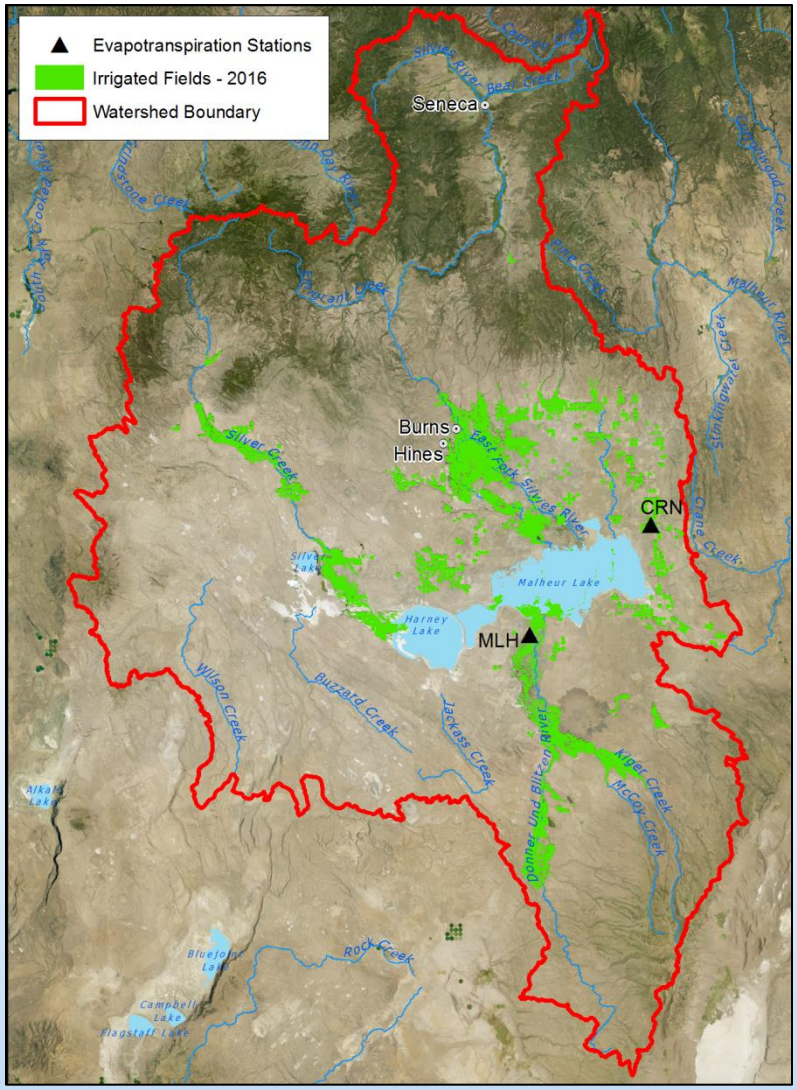
Study Area



- All irrigated agricultural fields in GHVGAC
- Annual precipitation 9 to 16 inches, 75% from October to April
- Principal crops Alfalfa and Grass Hay

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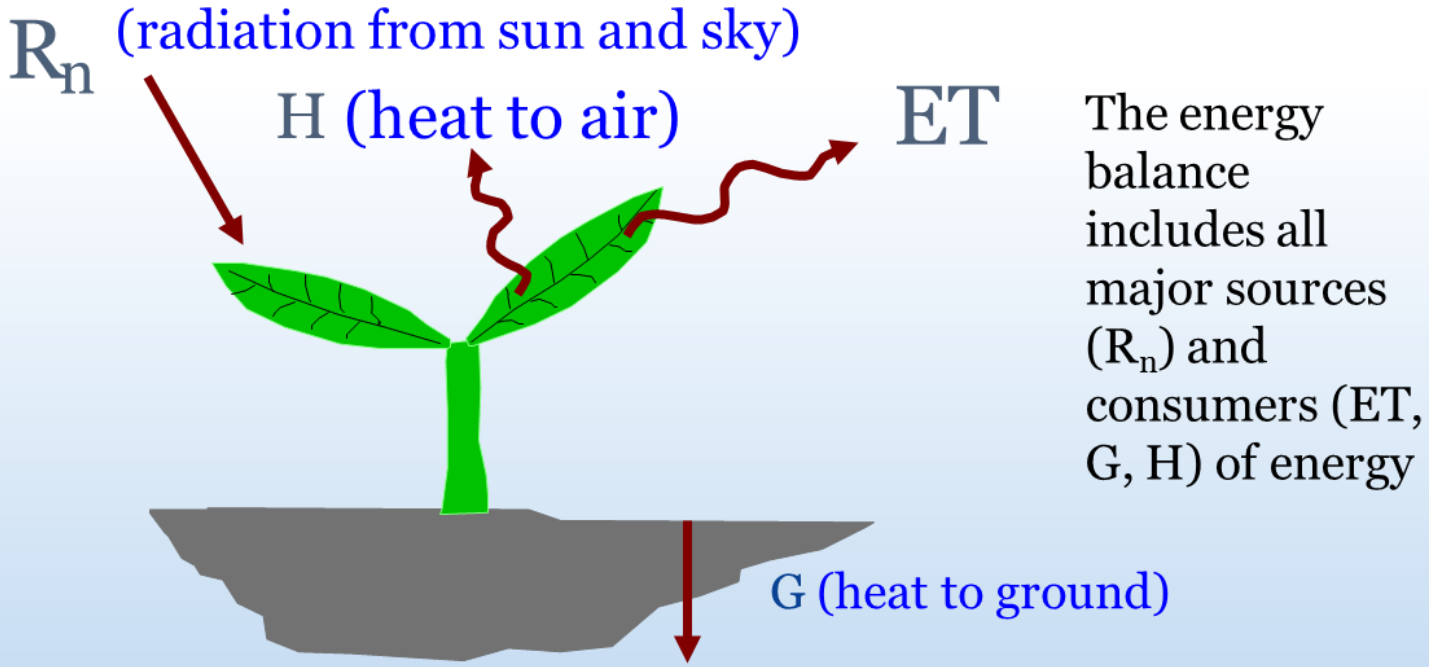
ET Mapping with METRIC

- **M**apping **E**vapotranspiration with high **R**esolution and **I**nternalized **C**alibration
  - Allen, Tasumi, Trezza, University of Idaho
  - Works well in advective conditions of western US



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

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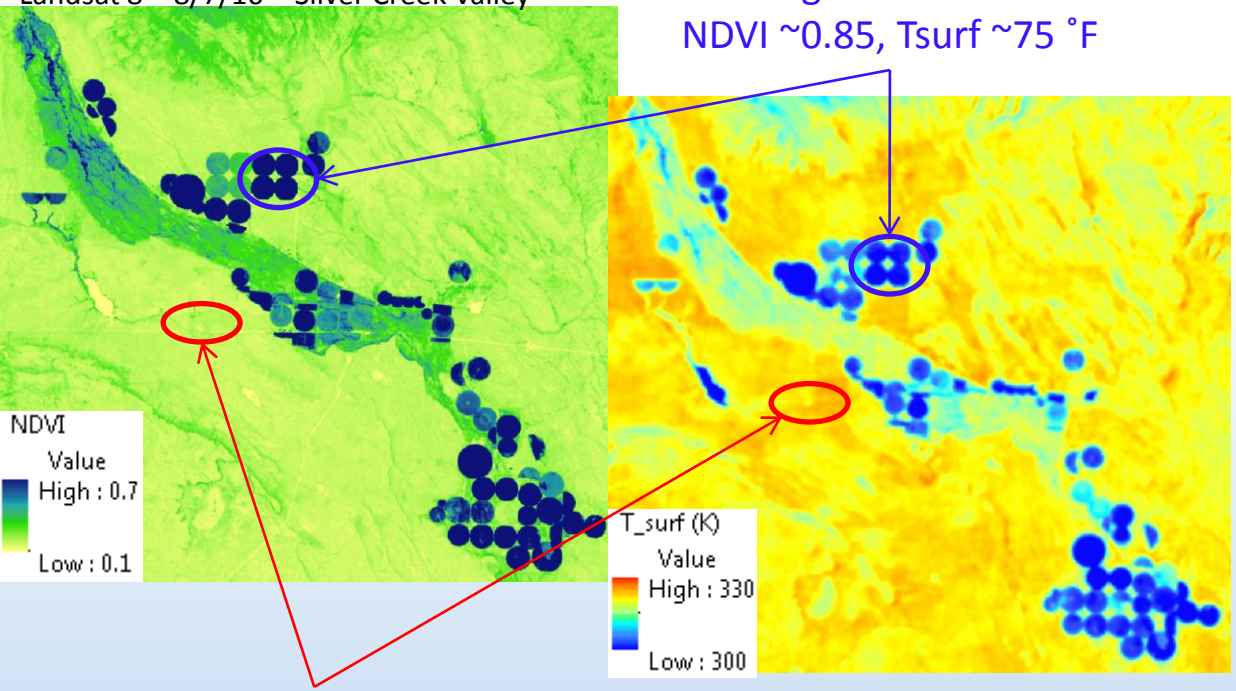
Satellite Energy Balance

Satellite optical and thermal imagery
(Veg indices, albedo, surface temp)

Agricultural weather data
(Reference ET, winds, precip)

Landsat 8 – 8/7/16 – Silver Creek Valley

Irrigated Fields:
NDVI ~0.85, Tsurf ~75 ˚F



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Desert: NDVI ~0.15, Tsurf ~125 ˚F

Satellites “sense” the latent cooling from ET

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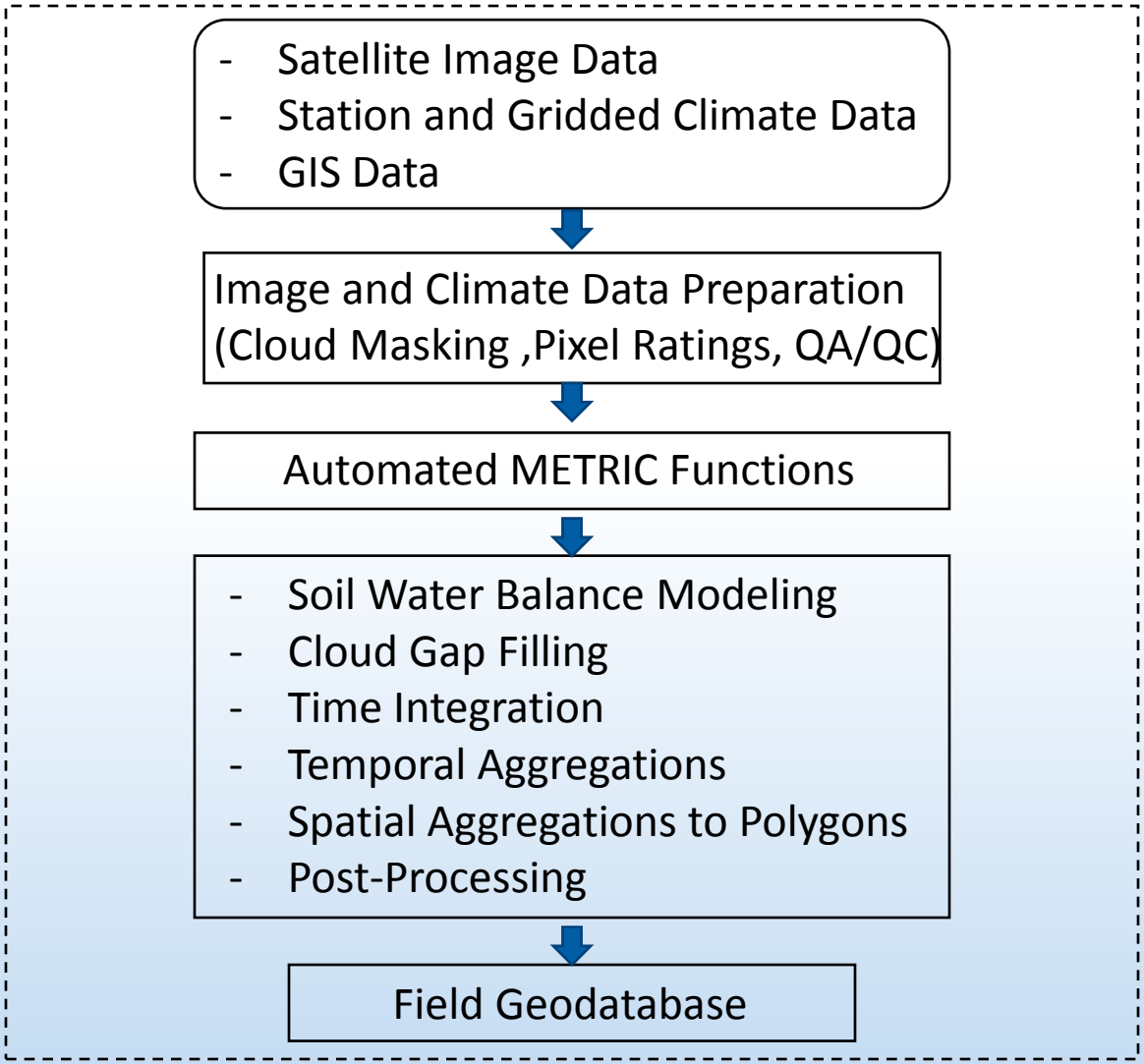
Approach



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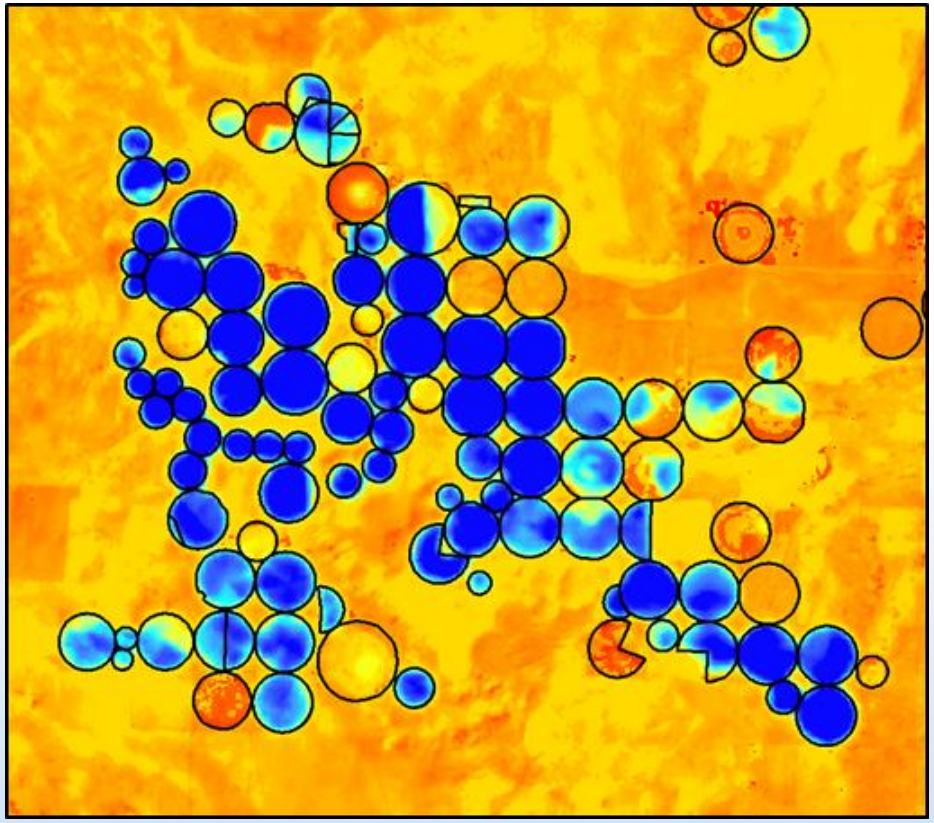
Data Requirements



- Landsat data
  - Back to 1984
  - 30-meter
  - 16-day satellite overpass
- Local reference ET and weather data
  - Weather station
  - Gridded product

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Deliverables

- METRIC crop ET summed to monthly, seasonal (May-Sept), and annual totals
- Precipitation from GridMet used to estimate precipitation and net ET (ET – precip) for ag. areas
- Primary output geodatabase - field scale monthly ET – average METRIC ET to agricultural field boundary
- WRD Open File Report

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Weather Data Prep

- No AgriMet in basin ☹ - use gridded weather data to compute ASCE Penman-Montieth alfalfa reference ET (ETr)

- GridMET ETr consistently bias high (too hot, dry) compared to nearby AgriMet, compute monthly bias correction ratio:

Ratio = Station ETr / GridMET ETr

- Interpolate monthly ratios from surrounding AgriMet stations to irrigated areas in the basin

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Ratio	0.80	0.87	0.90	0.93	0.91	0.91	0.90	0.87	0.86	0.82	0.81	0.83	0.87

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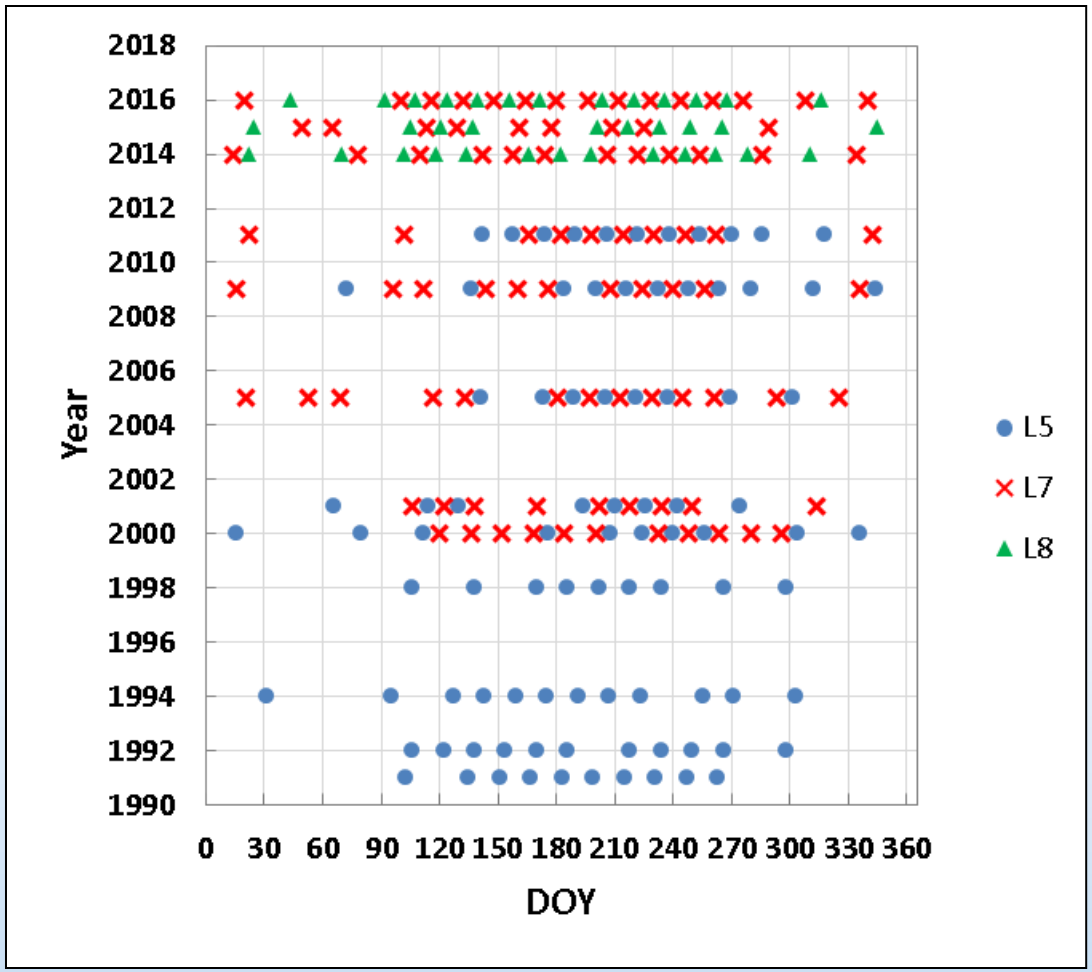
Clear Scene Selection

Selecting years to run METRIC

- Study period 1991-2016
- Aerial Imagery available
- 1 clear scene/month
- Water year type

In clear scenes, clouds and other areas masked out.



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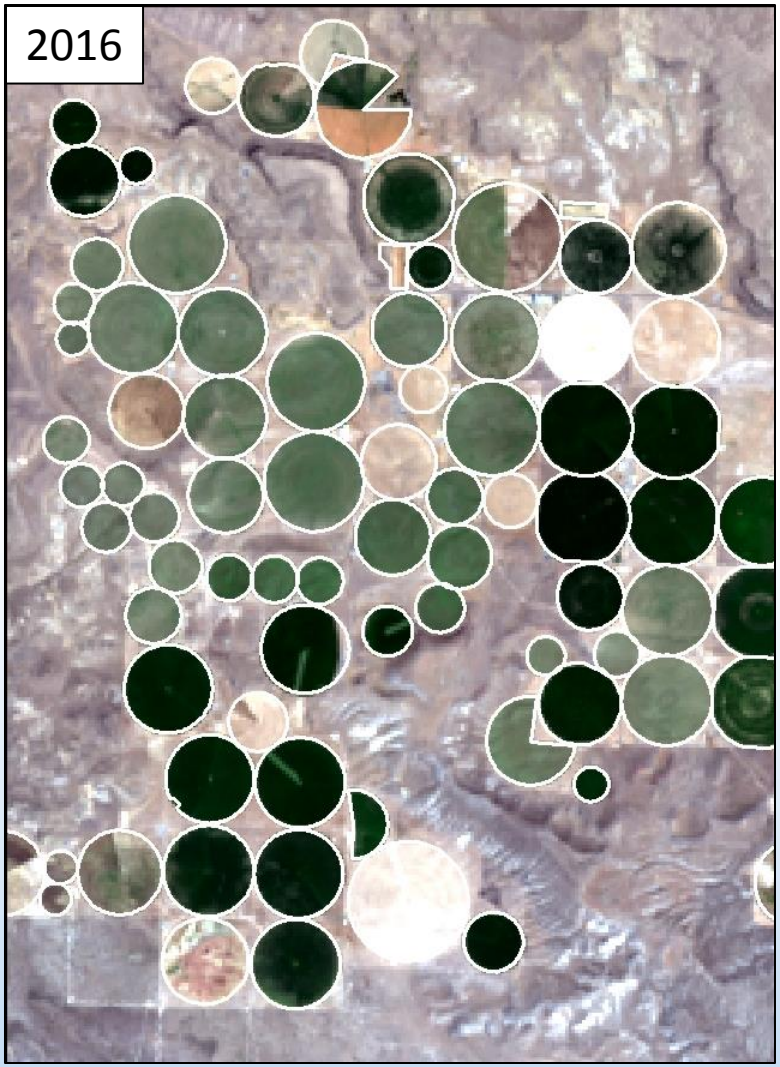
Field Mapping



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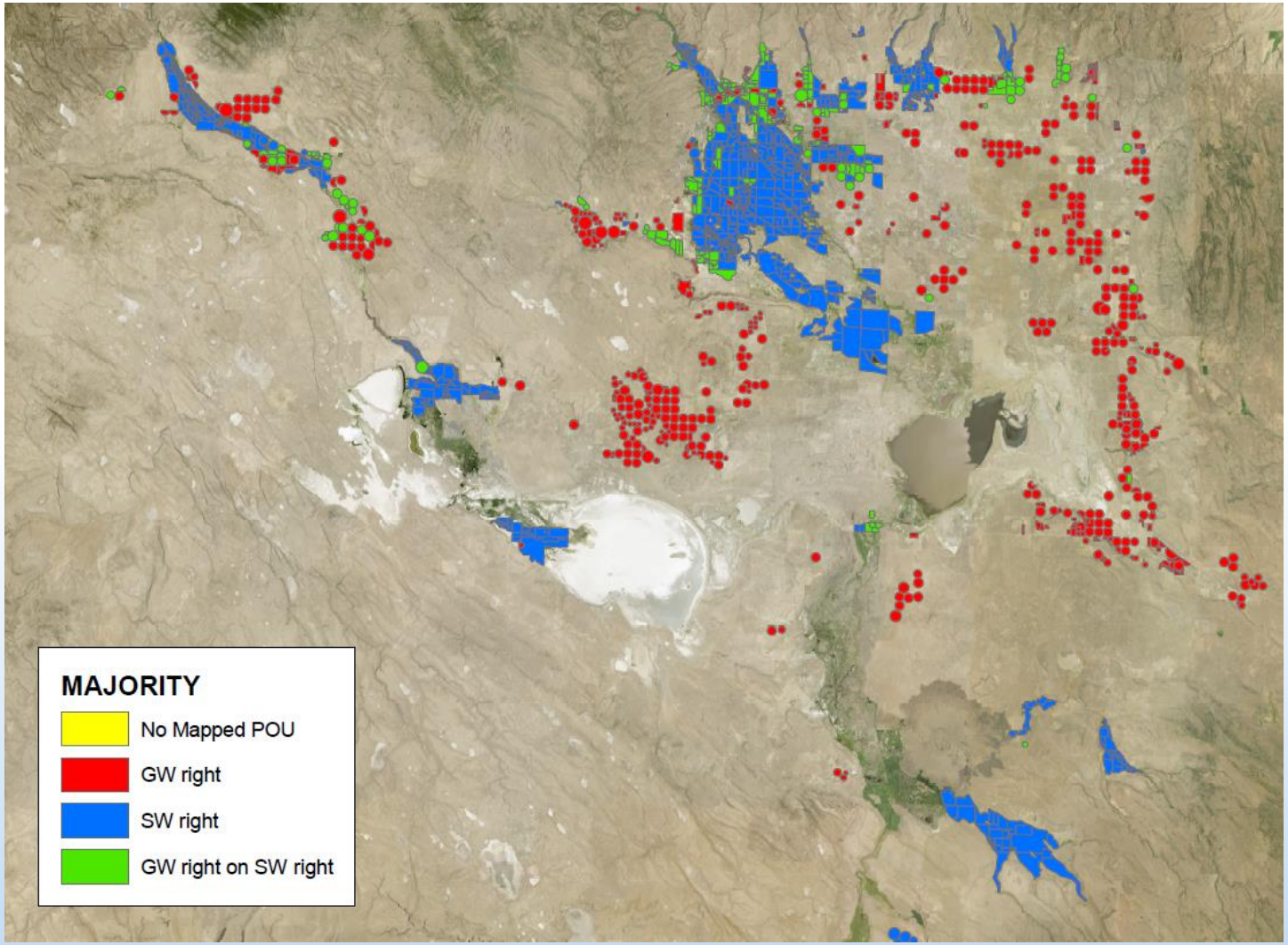
Water Source Type



METRIC Model

- Crop ET is calculated from the Energy Balance:

$$Rn = ET + H + G$$

$$ET = Rn - G - H$$

Rn – Net Radiation
G – Soil Heat Flux
H - Sensible Heat Flux
ET – Latent Heat Flux

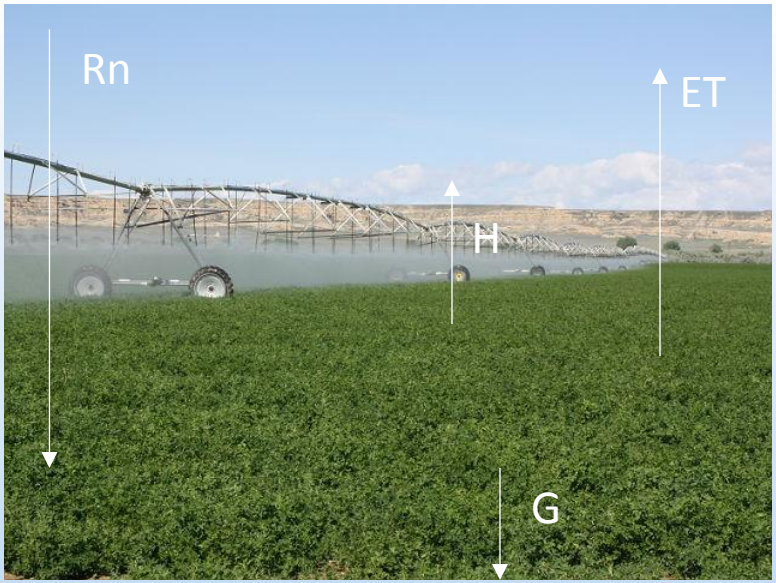


Figure: Allen et al., 2014

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METRIC Model

- METRIC utilizes:
  - Reflectance of light energy (albedo)
  - Vegetation indices
  - Surface temperature
  - Relative variation in surface temperature
  - Weather information (from ground station)

- Rn and G estimated directly from satellite data

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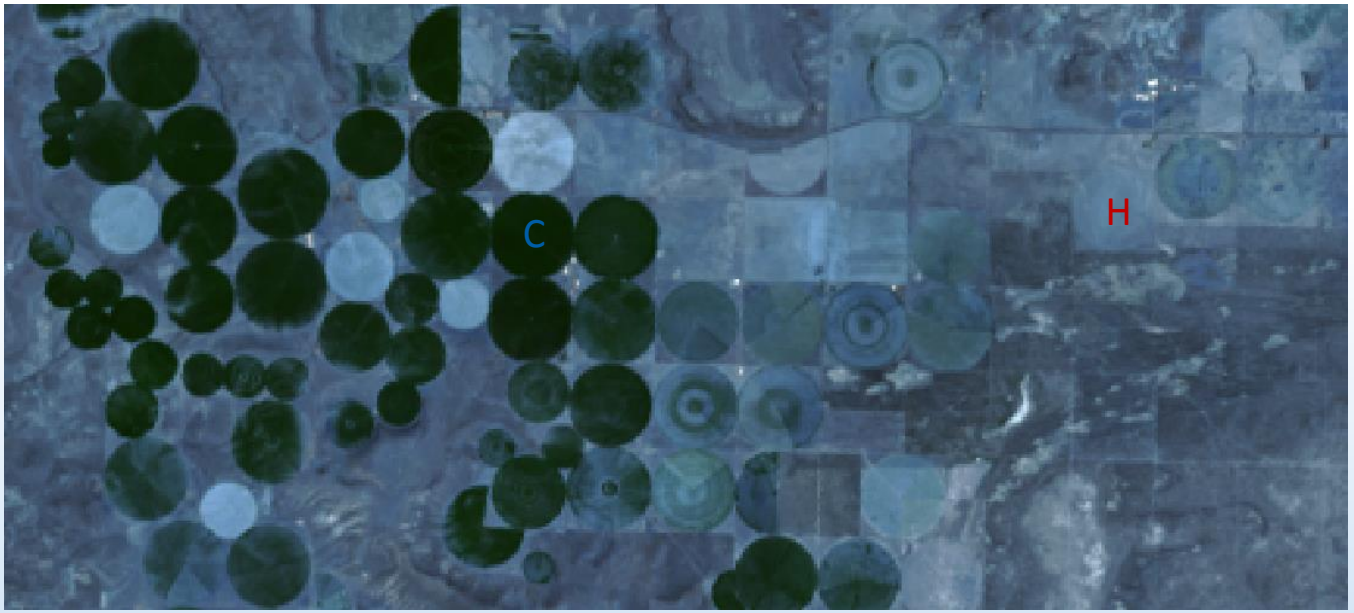
Model Calibration

- H – Internal Calibration - METRIC

$ET_{cold} \approx ET_r$

ET_r = reference ET calculated with weather information

$ET_{hot} \approx 0$



$H_{cold} = Rn_{cold} - G_{cold} - ET_r$

$H_{hot} = Rn_{hot} - G_{hot} - 0$

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Pixel Selection Criteria

- Hot Pixel – Min. ET – Bare, dry agricultural soil
  - Evidence of surface heating
  - NDVI ~ 0.11-0.2
  - Albedo ~ 0.17-0.23

- Cold Pixel – Max. ET – Full cover, well irrigated crop
  - Cool surface
  - NDVI ~ 0.76-0.84
  - Albedo ~0.18-0.24
  - Select near center of field

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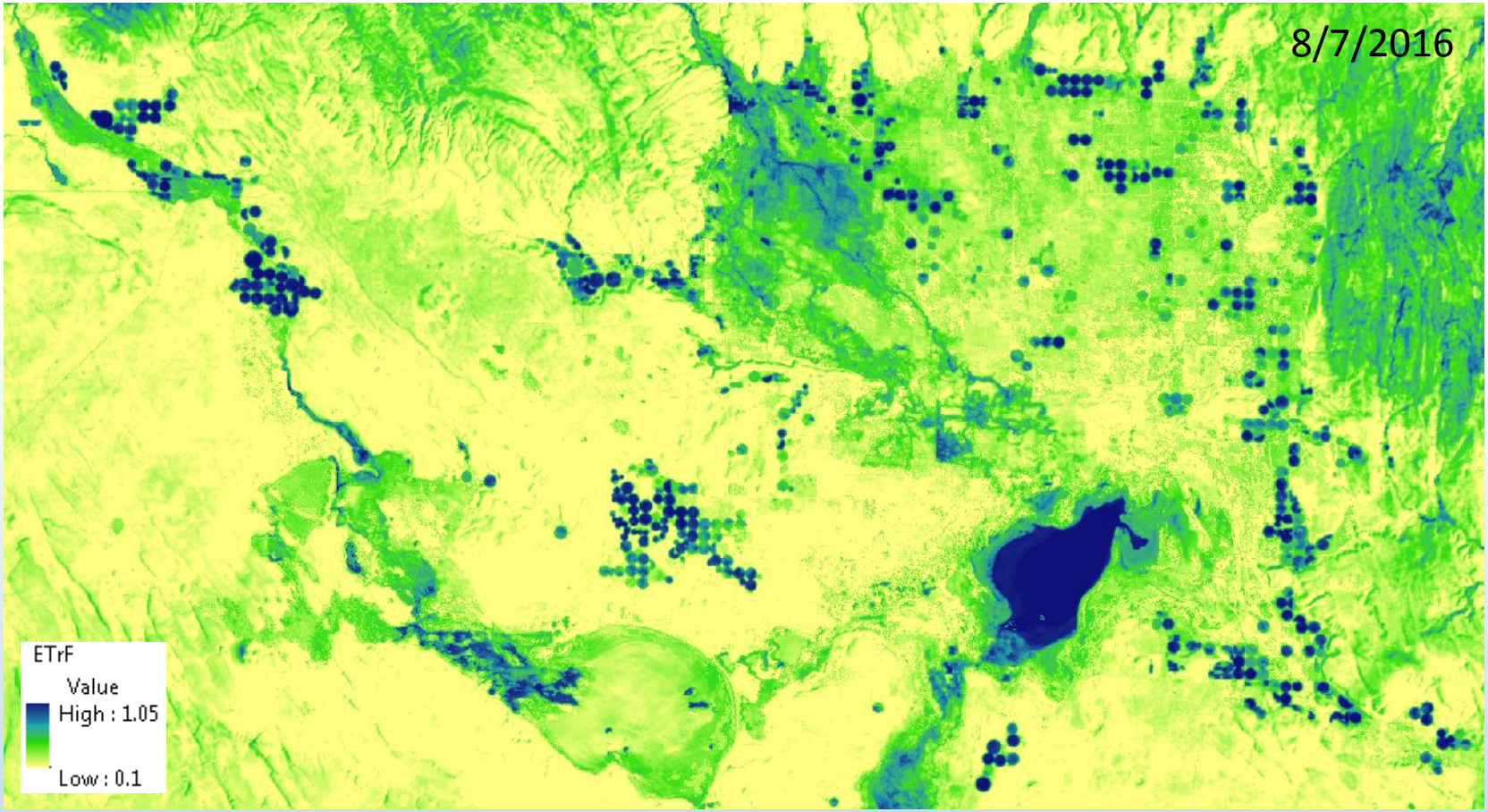
Satellite overpass ET

Map of daily ET fraction (ETrF= ET_{inst} / ETr_{inst})



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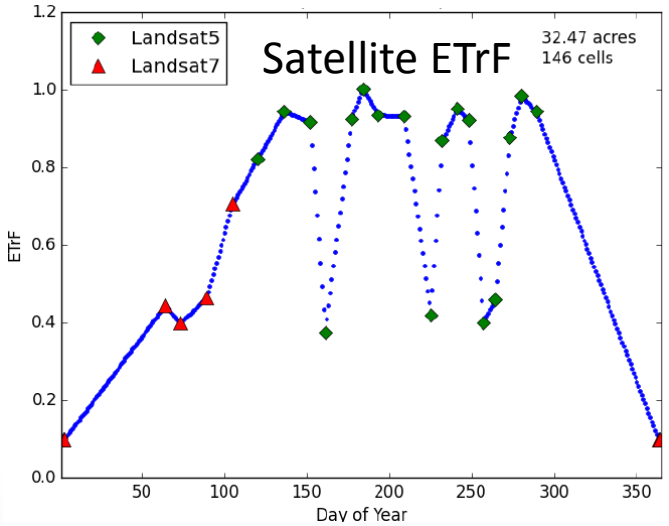
Time Integration



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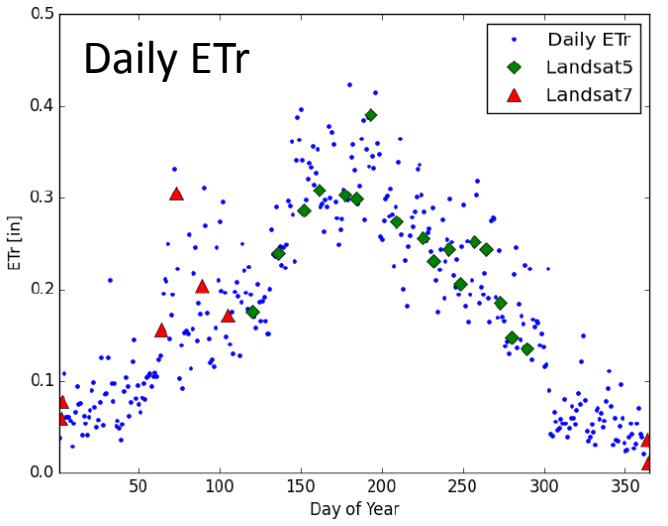

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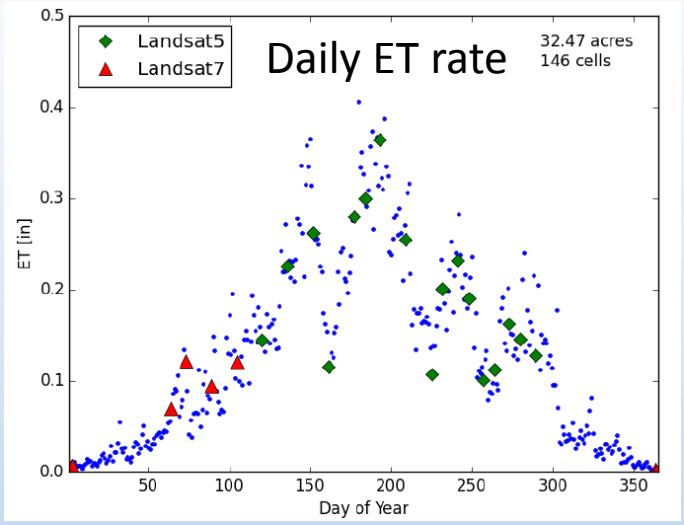

Use to get monthly, seasonal, annual summaries

Huntington et al. 2019

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Application

- Python program (pyMETRIC v. 1.0) used to perform METRIC process on personal workstations
- Results QA/QC'd by inspecting Landsat ETrF maps to identify pixels above/below thresholds
- For each year, create monthly, seasonal, and annual:
  - ET and net ET 30-m rasters (.img)
  - Spatially averaged ET and net ET totals for all fields (.csv)

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Results

May-Sept Net Evapotranspiration Rates, in feet, by irrigation source type				
YEAR	GW Crops	GW and SW	SW Crops	SW Refuge
1991	1.81	1.77	1.71	2.11
1992	1.96	1.72	1.14	1.76
1994	2.15	1.81	1.75	2.31
2000	2.05	2.04	1.88	2.21
2001	2.05	1.92	1.52	2.36
2005	1.68	1.82	1.77	1.90
2009	1.90	2.02	1.97	1.70
2011	1.79	1.89	2.01	2.28
2014	2.23	2.14	1.84	1.97
2015	1.95	1.83	1.40	1.44
2016	2.09	2.09	1.86	1.84
Mean	1.97	1.91	1.71	1.99
SD	0.16	0.14	0.26	0.29

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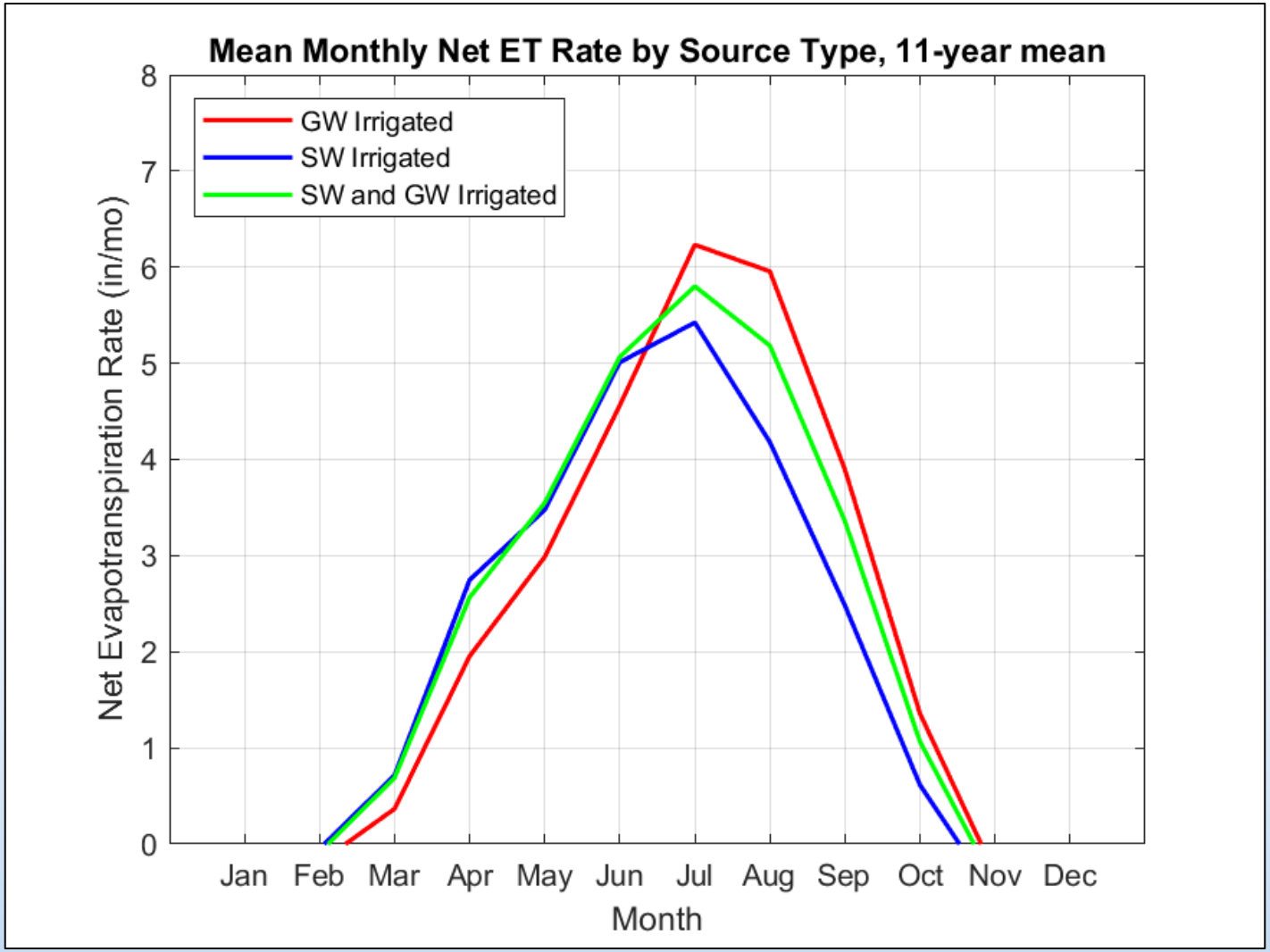
Results



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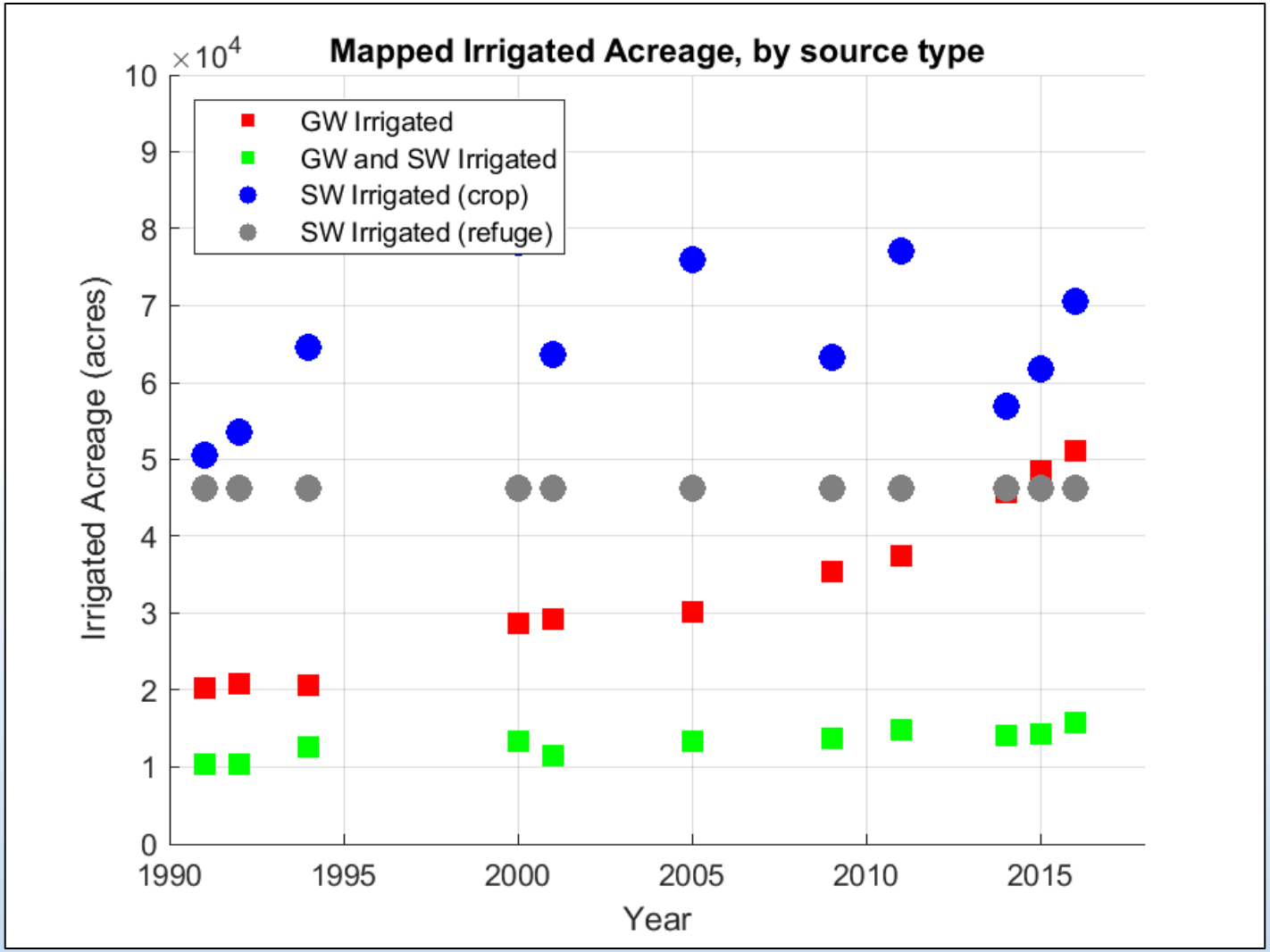
Results



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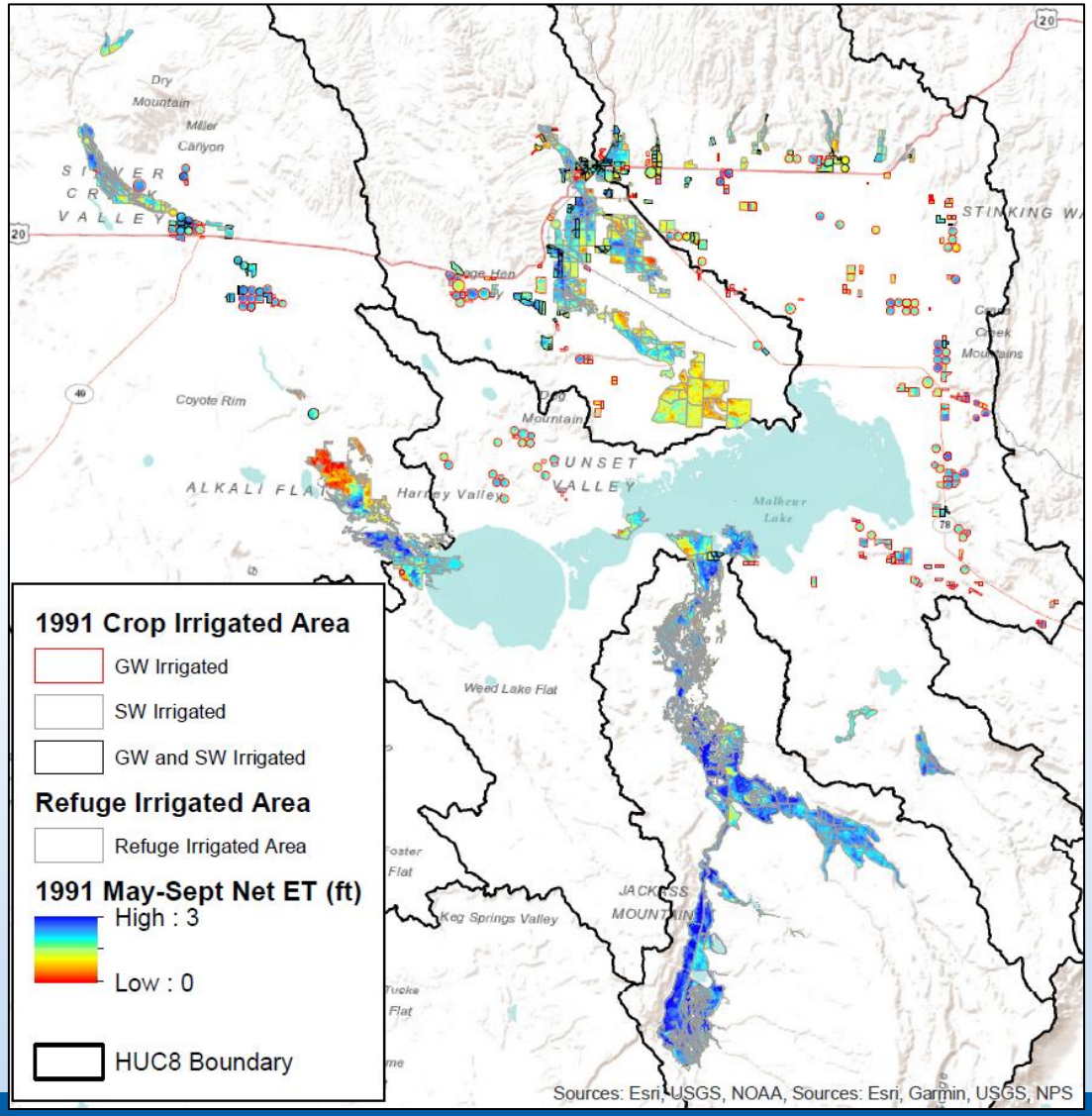
Results



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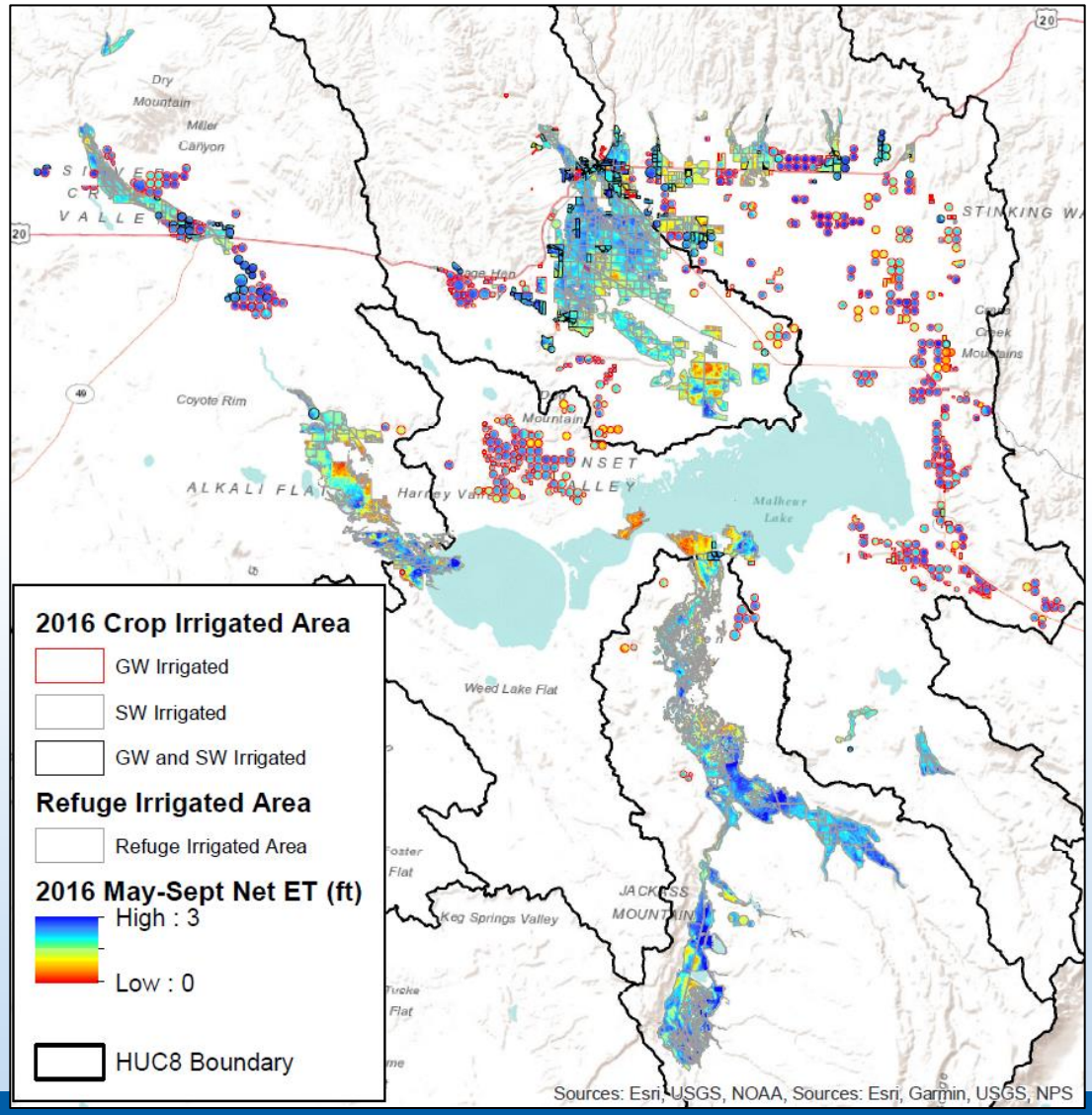
Results



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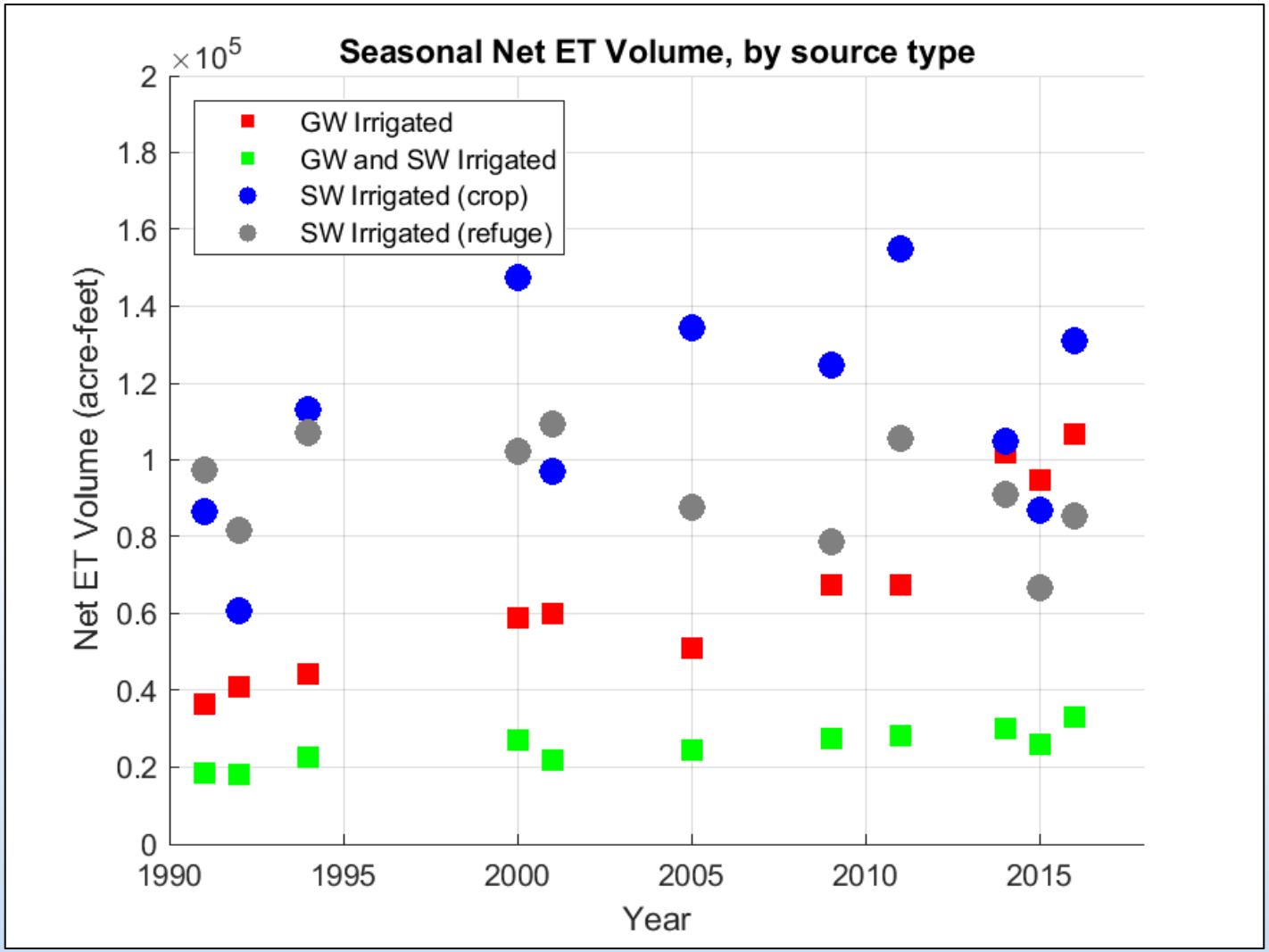
Results



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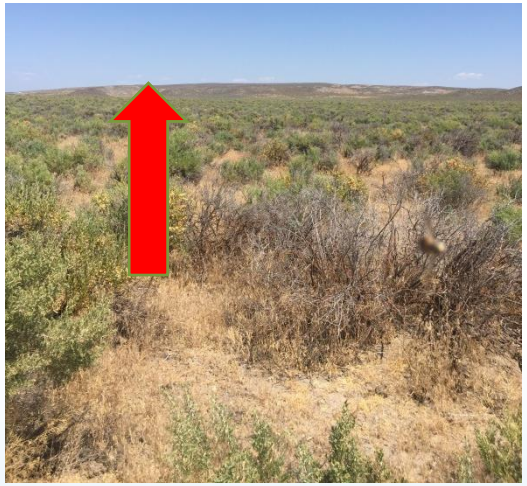
Results

May-Sept Net Evapotranspiration Volume, in acre-feet (x 1000), by irrigation source type					
YEAR	GW Crops	GW and SW	SW Crops	SW Refuge	Total
1991	36.6	18.4	86.5	97.4	238.9
1992	40.9	17.9	60.9	81.6	201.4
1994	44.5	22.7	113.0	107.0	287.1
2000	58.9	27.1	147.4	102.2	335.7
2001	60.2	21.9	97.0	109.3	288.4
2005	50.9	24.4	134.4	87.8	297.5
2009	67.4	27.6	124.6	78.9	298.4
2011	67.3	28.2	154.8	105.6	356.0
2014	102.0	30.2	104.8	91.0	328.0
2015	94.6	26.1	86.8	66.7	274.2
2016	106.7	33.1	131.2	85.3	356.2

GW Discharge Estimate

Natural ET-GW



190 – 220 KAF

+

Crop ET-GW

100 – 140 KAF

Total discharge ≈ 290 – 360 KAF

Outside est. recharge range (160 -220 AF)

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Next Steps

- Validate Satellite-based ET with ground-based measurements

- Compare Satellite-based ET with reported pumpage data

DRI Eddy Covariance ET station in Crane

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AgriMet Stations

- Two new AgriMet stations headed to the basin!
  - OWRD funding for station equipment and install
- Locations: Owens Hay and EOARC
- Thanks to Mark Owens and the Harney Watershed Council for the long-term funding support and interest in the data!

Questions?

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jordan.p.beamer@oregon.gov