NEAR REAL TIME METRIC

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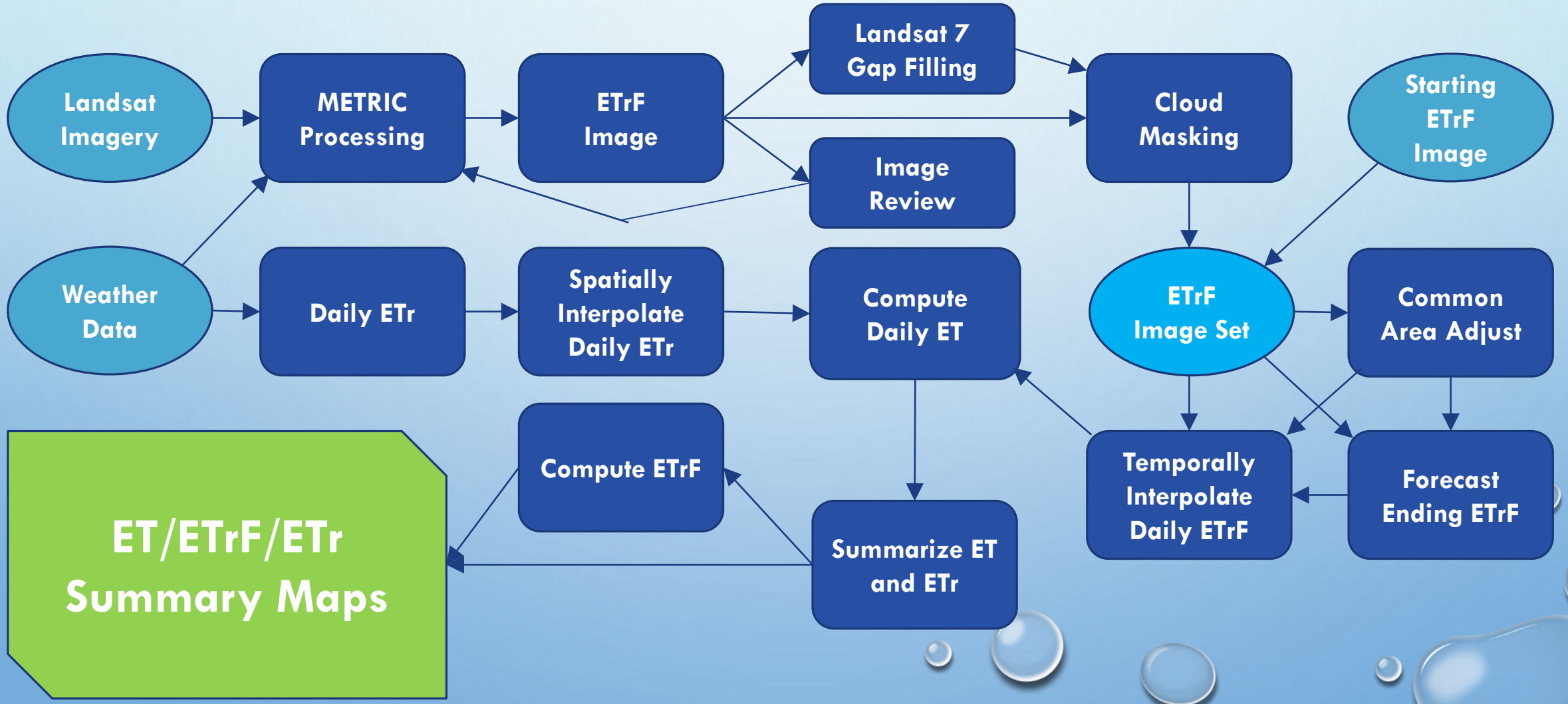
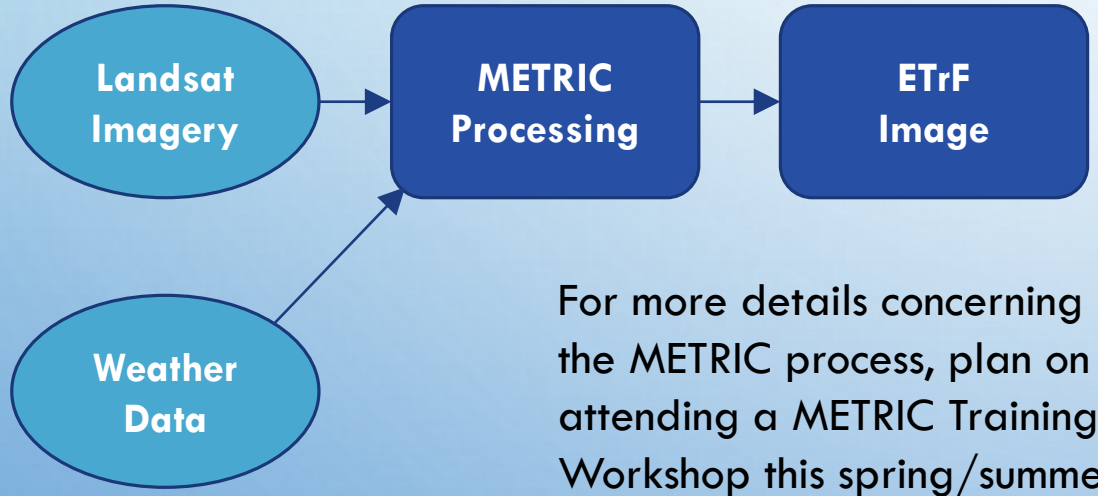
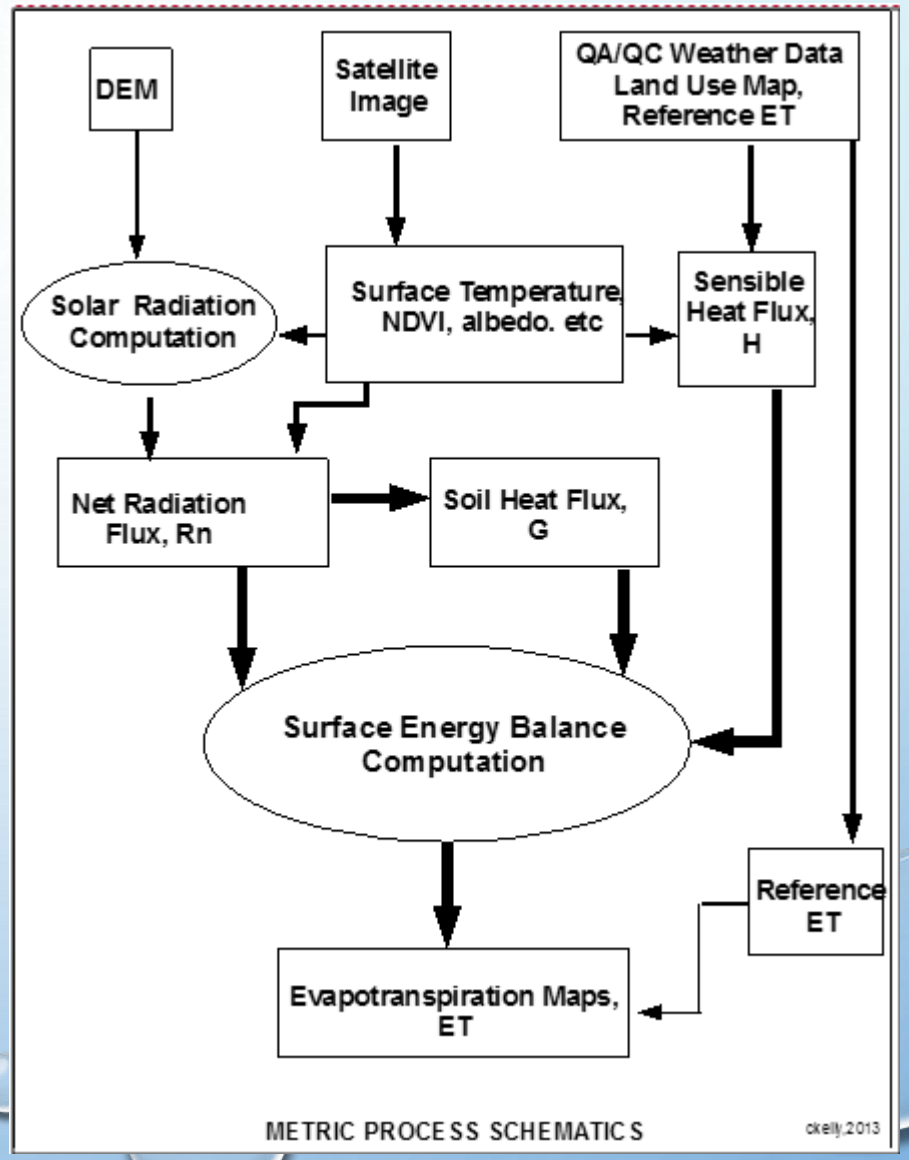
Near Real Time METRIC Products
Monthly and Period ET/ET$_r$F Maps Processing Steps



STANDARD METRIC PROCEDURE



For more details concerning the METRIC process, plan on attending a METRIC Training Workshop this spring/summer hosted by IDWR.



Landsat Image Selection

- Landsat overpass frequency is sixteen days
- Landsat 7 and Landsat 8 are eight days apart – potentially 4 images during a month for a path
- Due to clouds, one may not have any usable images for a month.
- A cloudy image that would not have been selected for historical processing may be selected for near-real time because we do not know what the future holds.
- An image after the 27th of a month might not be included on the first provisional release for the month.

2016 Landsat Image Selection

- **Path 39: No images available for October-November**
- **Path 40: No images for November**
- **June 7th image (Path 40) was in provisional but not the final.**

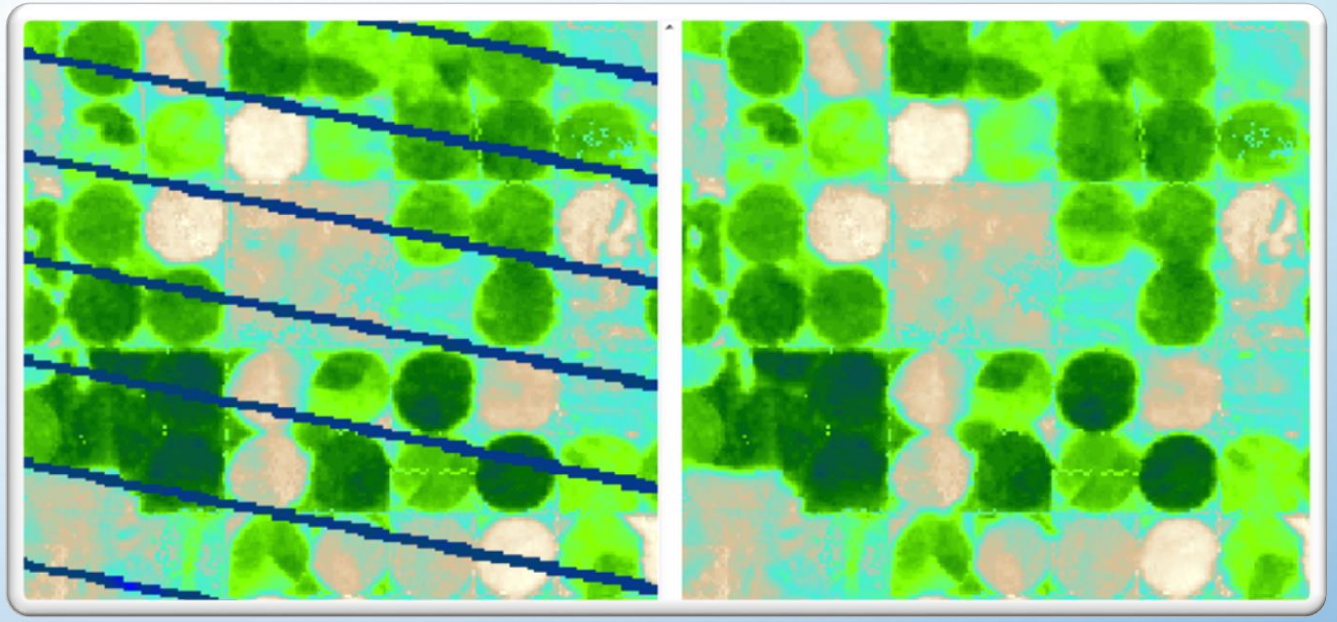
#	Path 40	Image Type	Path 39	Image Type
1	03/19/2016	L7 ETM+	03/20/2016	L8 OLI-TIRS
2	04/12/2016	L8 OLI-TIRS	04/05/2016	L8 OLI-TIRS
3	04/20/2016	L7 ETM+	04/21/2016	L8 OLI-TIRS
4	05/30/2016	L8 OLI-TIRS	05/31/2016	L7 ETM+
5	06/07/2016	L7 ETM+ **	06/08/2016	L8 OLI-TIRS
6	06/23/2016	L7 ETM+	06/24/2016	L8 OLI-TIRS
7	07/01/2016	L8 OLI-TIRS	07/02/2016	L7 ETM+
8	07/09/2016	L7 ETM+	07/18/2016	L7 ETM+
9	07/17/2016	L8 OLI-TIRS	07/26/2016	L8 OLI-TIRS
10	07/25/2016	L7 ETM+	08/03/2016	L7 ETM+
11	08/02/2016	L8 OLI-TIRS	08/19/2006	L7 ETM+
12	08/10/2016	L7 ETM+	09/20/2016	L7 ETM+
13	08/18/2016	L8 OLI-TIRS	09/28/2016	L8 OLI-TIRS
14	09/11/2016	L7 ETM+		
15	09/19/2016	L8 OLI-TIRS		
16	09/27/2016	L7 ETM+		
17	10/21/2016	L8 OLI-TIRS		

No useful October-November Landsat Images for Path 39

** Image considered to be to cloudy to fill for final product.

Landsat 7 Gap Filling

- Gap filling of Landsat 7 due to the malfunction of the scan line corrector (SLC) occurs after METRIC processing for ETrF and NDVI.
- If an ETrF image review occurs after the gapping has been performed, the ETrF has to be refilled.
- For a single path with 3 rows, this takes awhile.

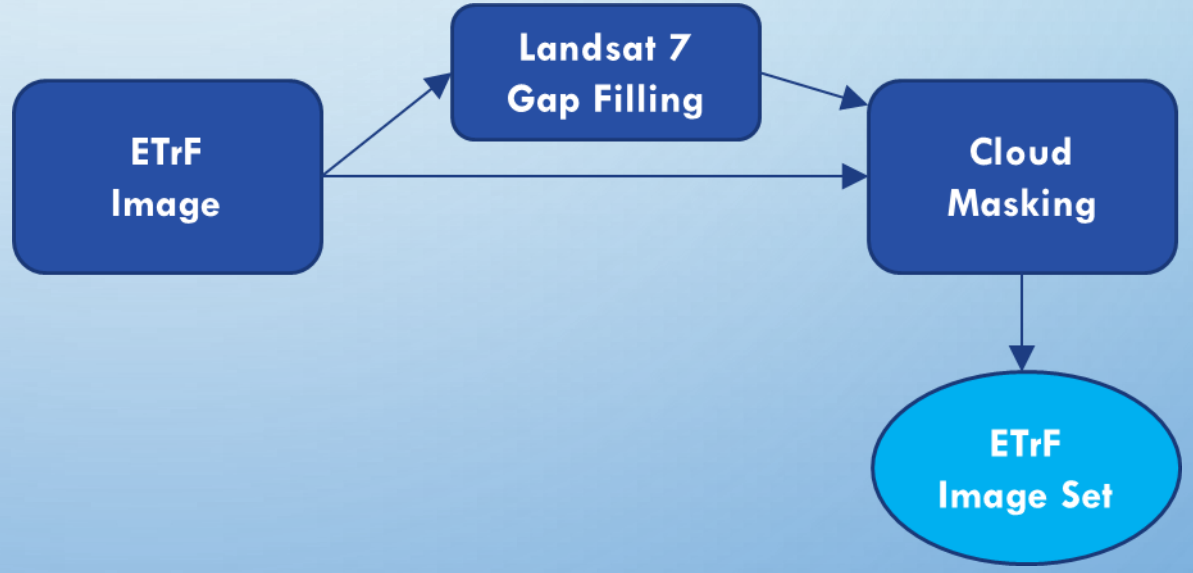


ETrF Image

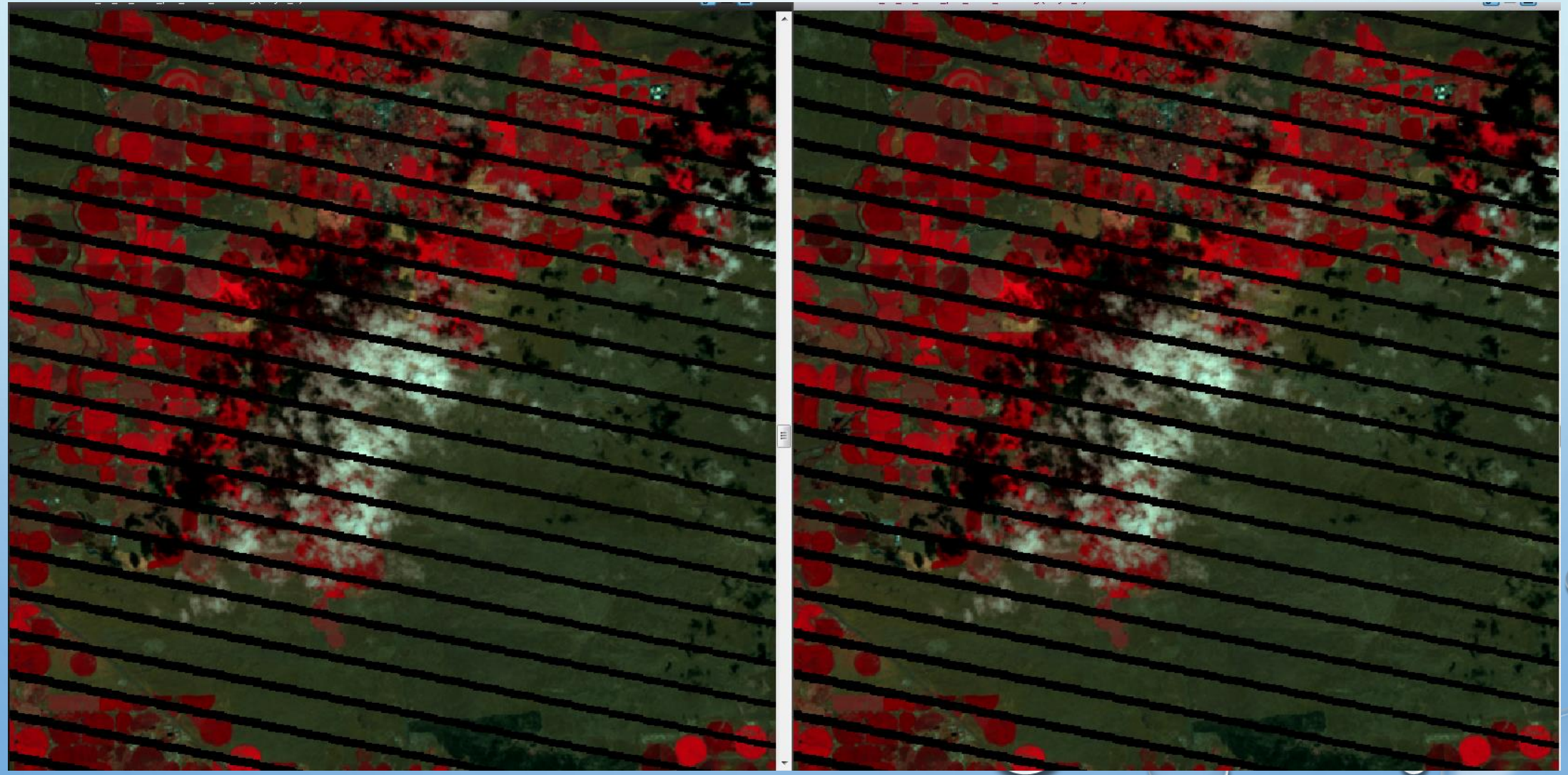
Landsat 7 Gap Filling

ETrF Image Cloud Masking

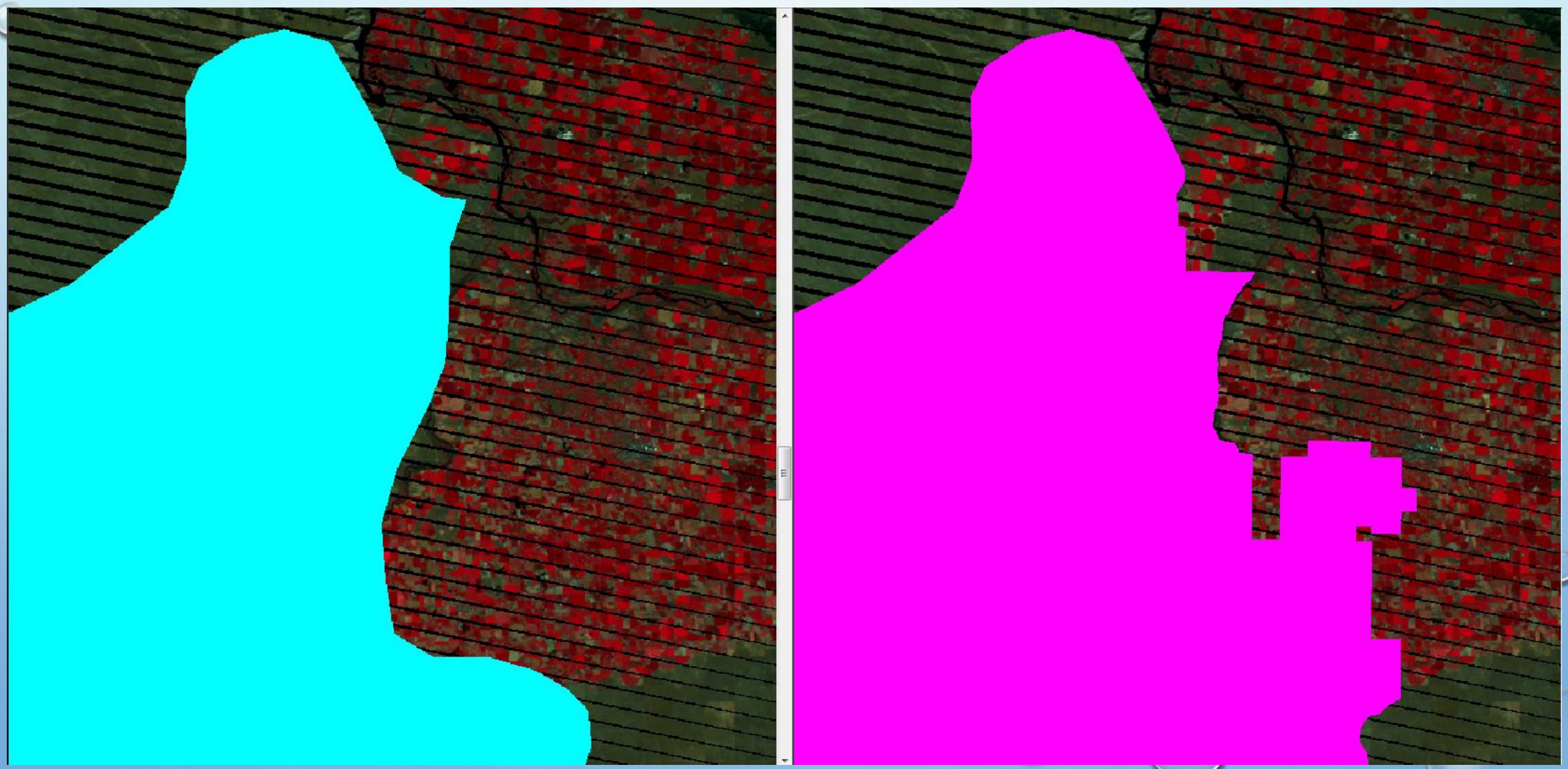
- Cloud masking is required.
- Landsat 7 are difficult at times due to SLC gaps.
- Gross cloud masks for near-real may split a field, field boundaries are ignored.
- Gross cloud mask areas for near-real maybe over or under estimated.
- Final products are based on time intensive cloud masking with a human where field boundaries are observed.



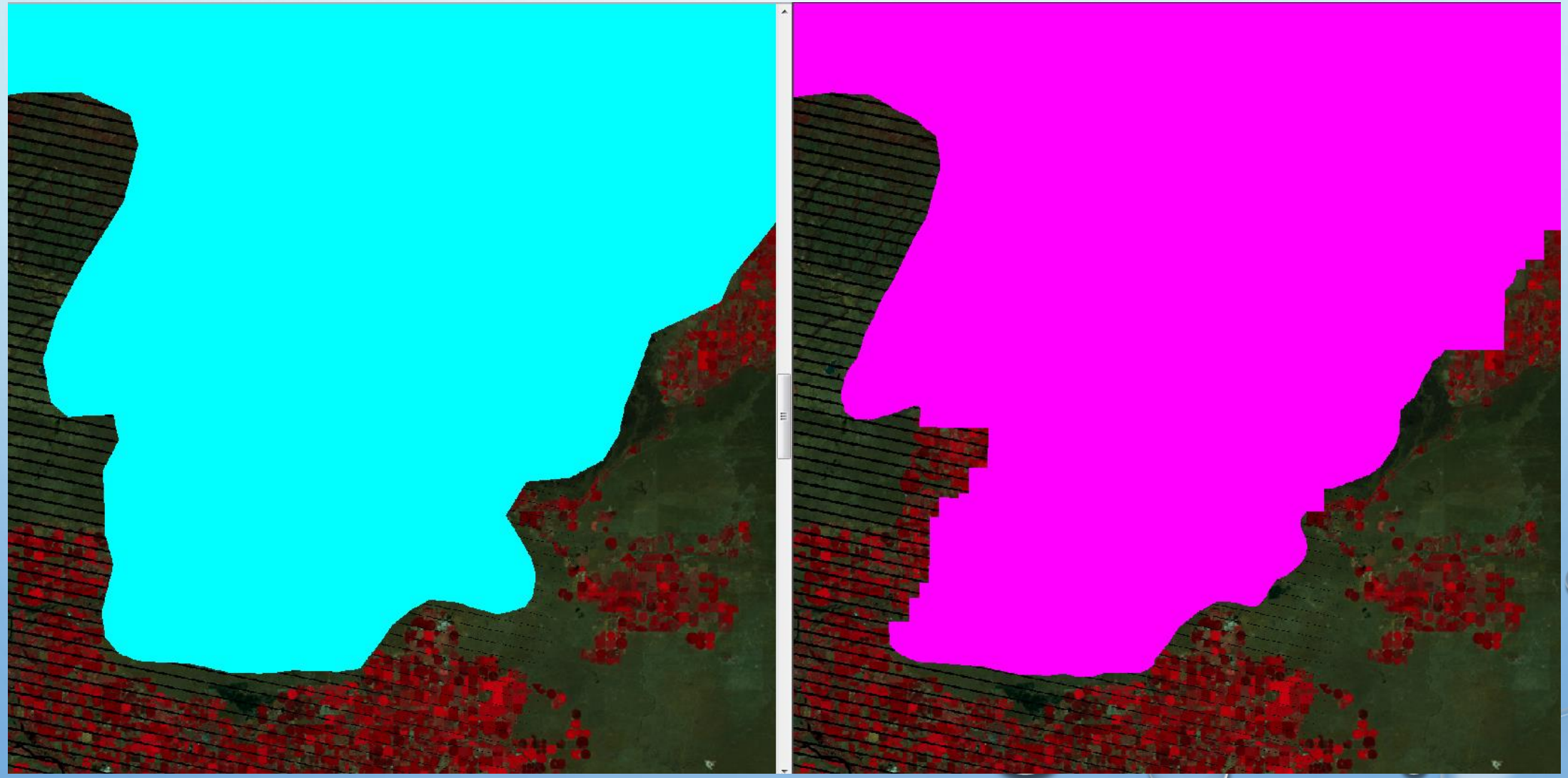
Tough to identify field boundaries for Landsat 7



NRT Cloud masking (left), and Final Cloud masking (right)

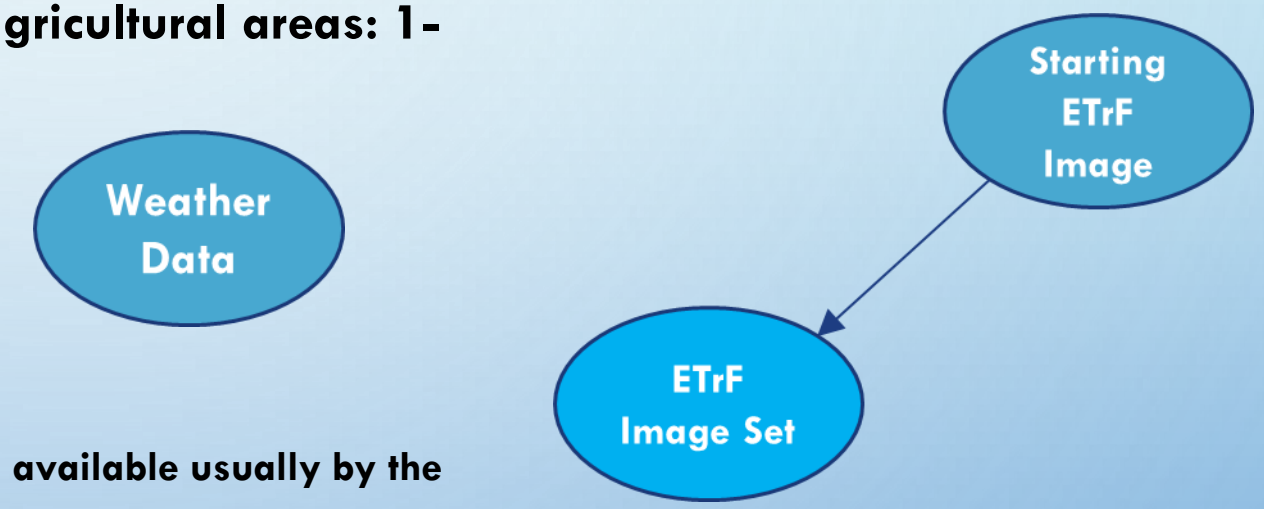


NRT Cloud masking (left), and Final Cloud masking (right)



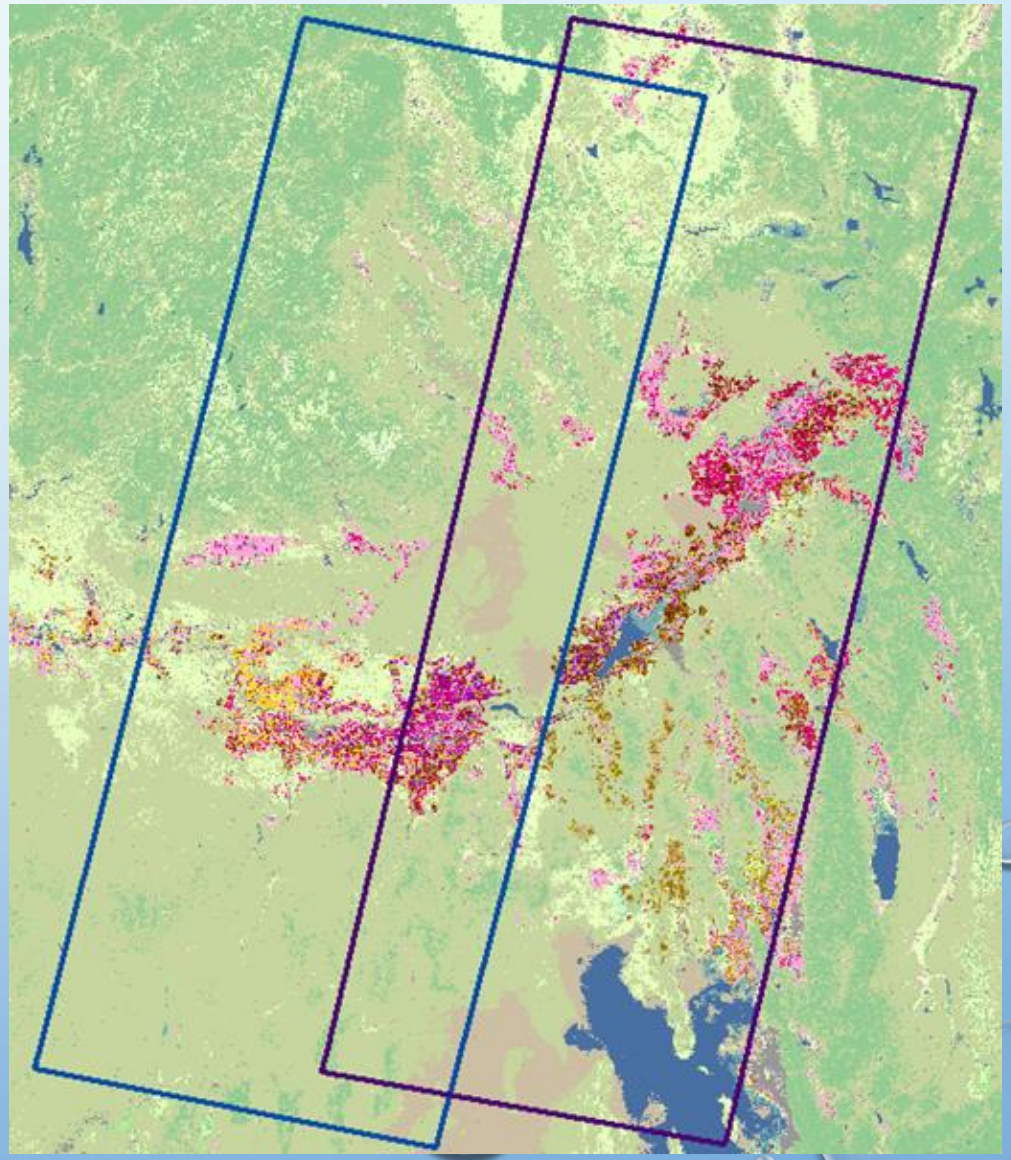
Starting ETrF Surface

- A "cloud free" ETrF image is required to initialize the interpolation process.
- It could be an early March Landsat processed image provided it is cloud free for the entire scene including non agricultural areas: 1-path/3-rows. (Not going to happen).
- Landuse (NLCD) based ETrF.
  - What ETrF value is assigned?
  - Current version is 2011.
- CropScape based ETrF.
  - The current year is not known, the preceding year is available usually by the end of February.
- When to base a synthetic image for the starting?



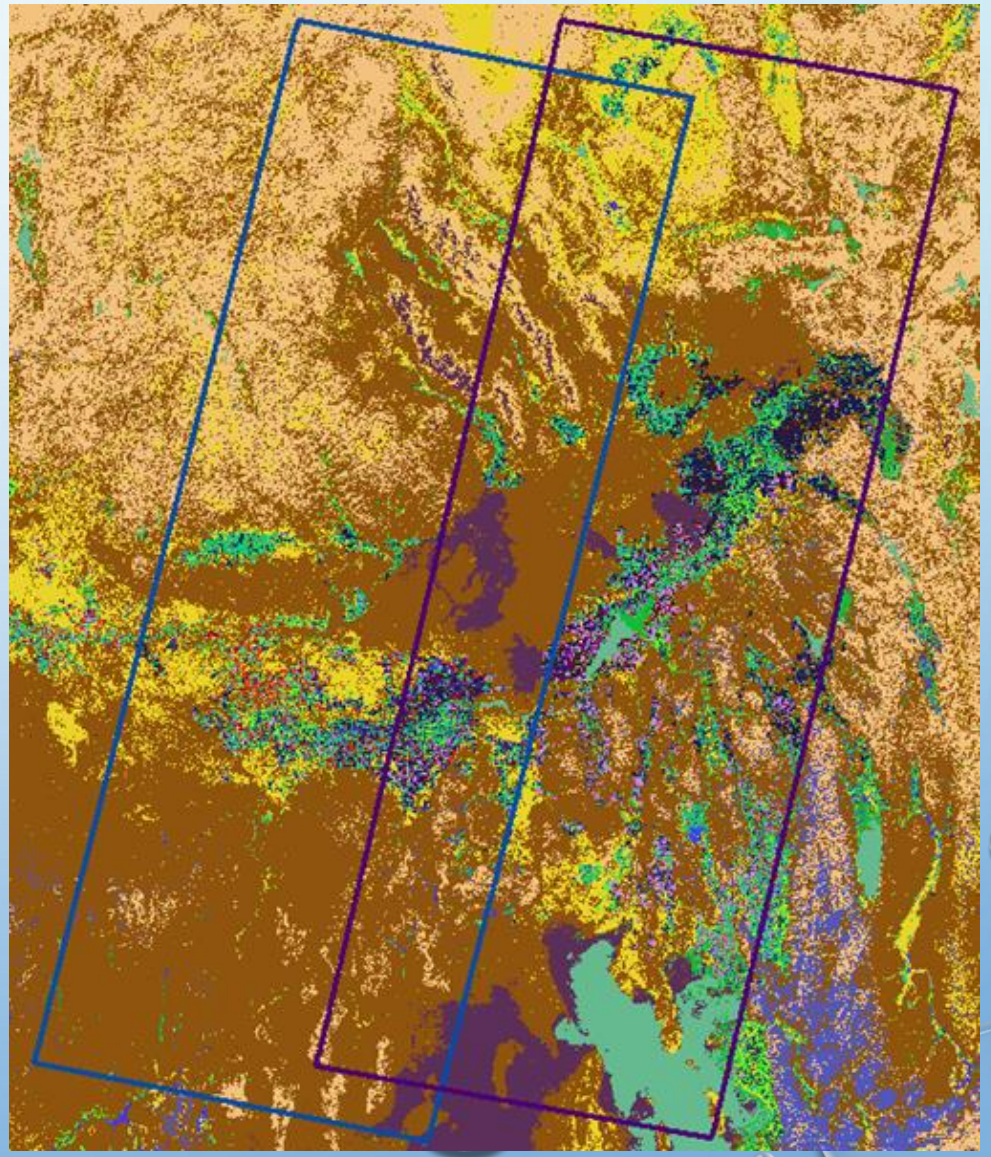
CropScape/ETIdaho Dormant Synthetic Image

- **CropScape Data for prior year (for 2016 the 2015 was used).**

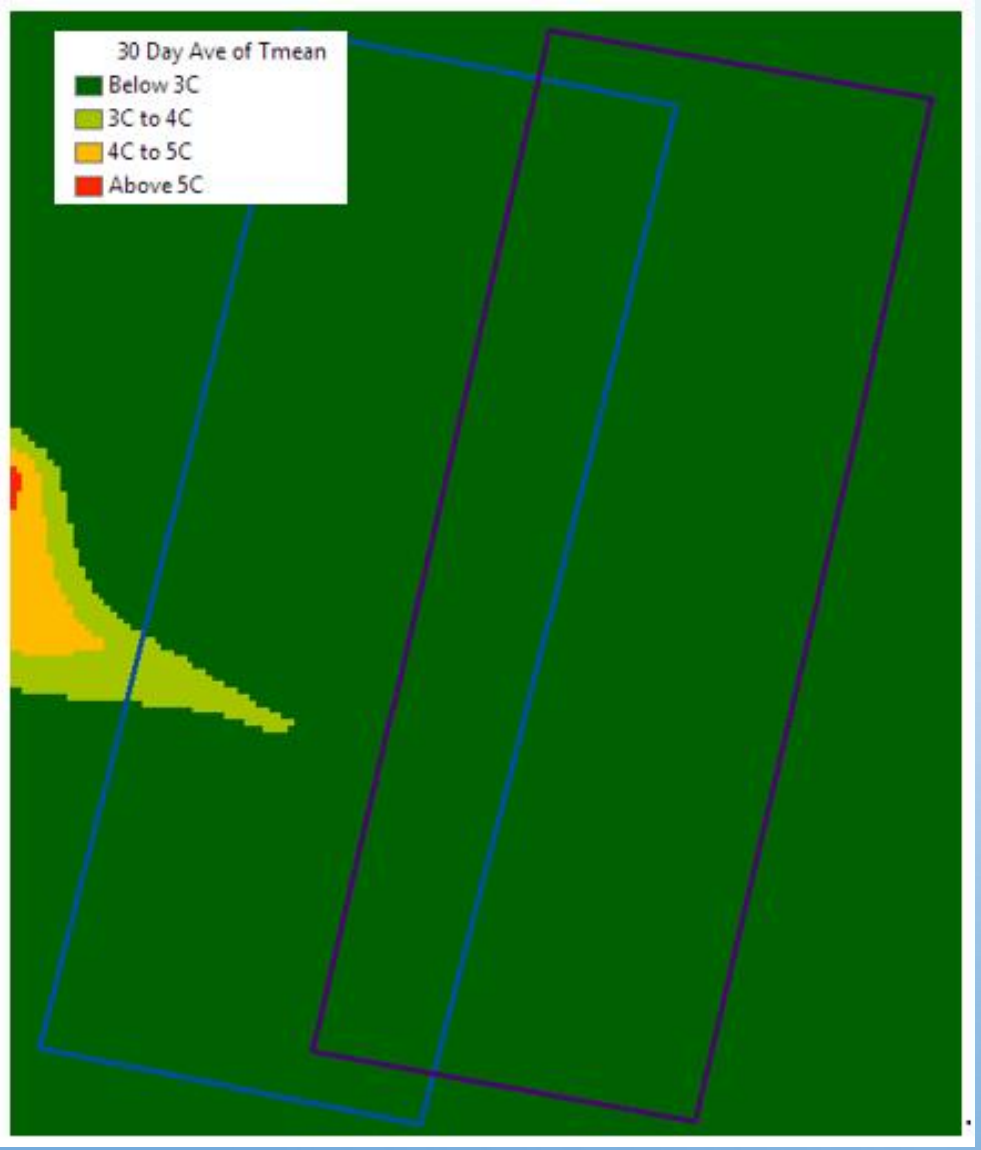


CropScape/ETIdaho Dormant Synthetic Image

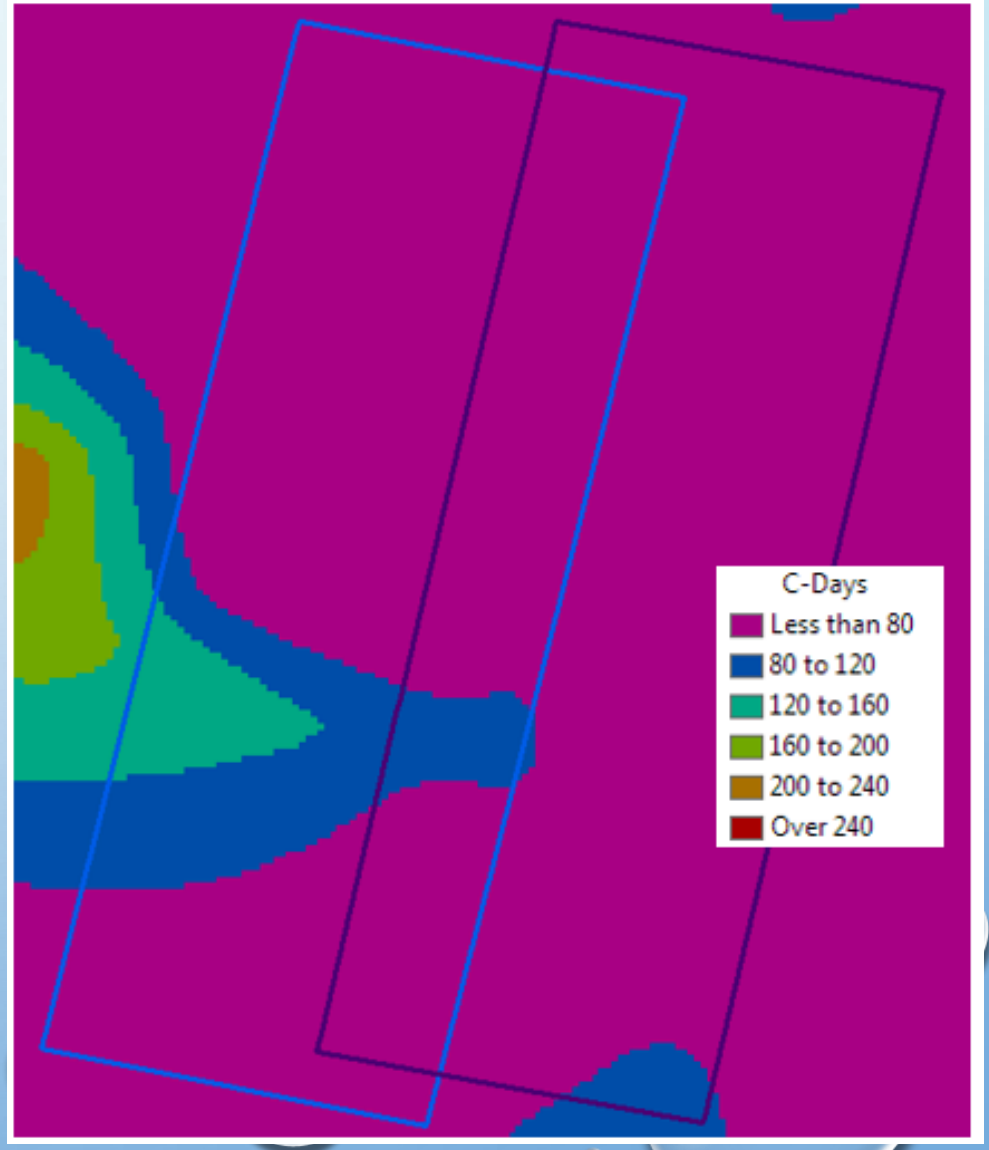
- CropScape data for prior year.
- **Reclassified into ETIdaho land covers**



CropScape/ETIdaho Dormant Synthetic Image

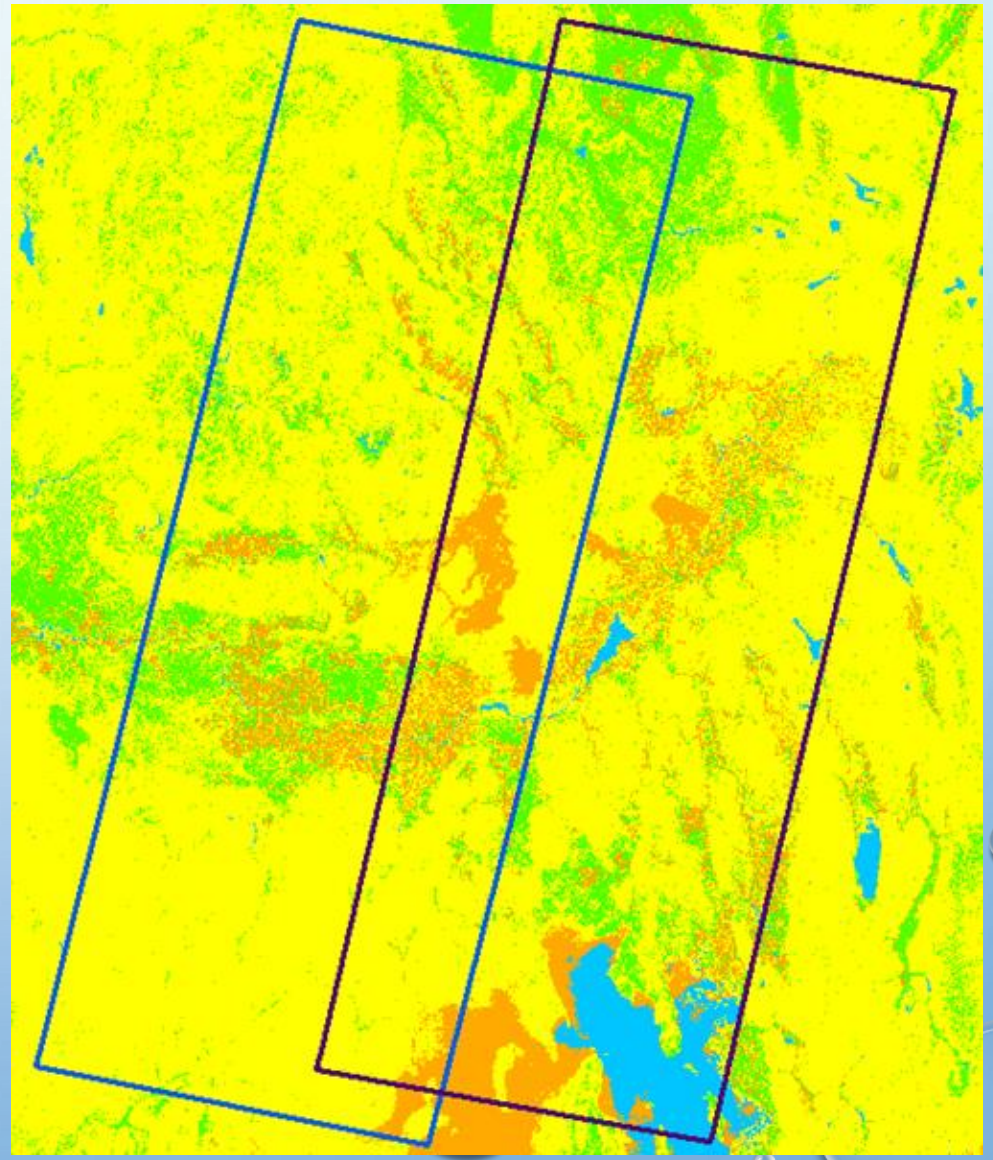


- CropScape data for prior year.
- Reclassified into ETIdaho land covers
- **Assessment of dormancy criteria (30 day average of mean air temperature and cumulative degree days) for ETIdaho covers. Determines the date associated with a synthetic dormant image.**



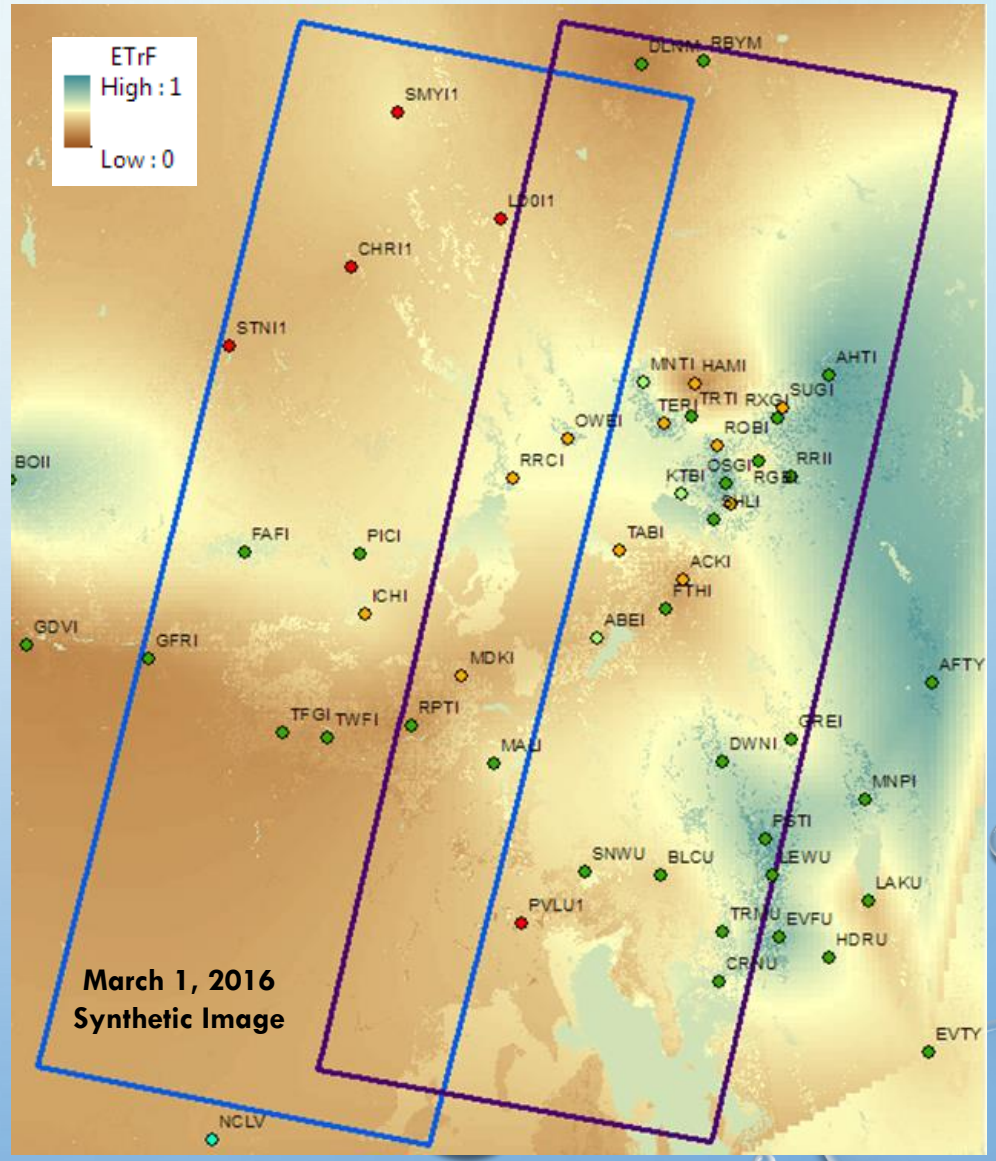
CropScape/ETIdaho Dormant Synthetic Image

- CropScape data for prior year.
- Reclassified into ETIdaho land covers
- Assessment of dormancy criteria for ETIdaho covers.
- **Reclassified into dormant covers of:**
  - **Water**
  - **Bare Soil**
  - **Mulch**
  - **Turf (grass)**



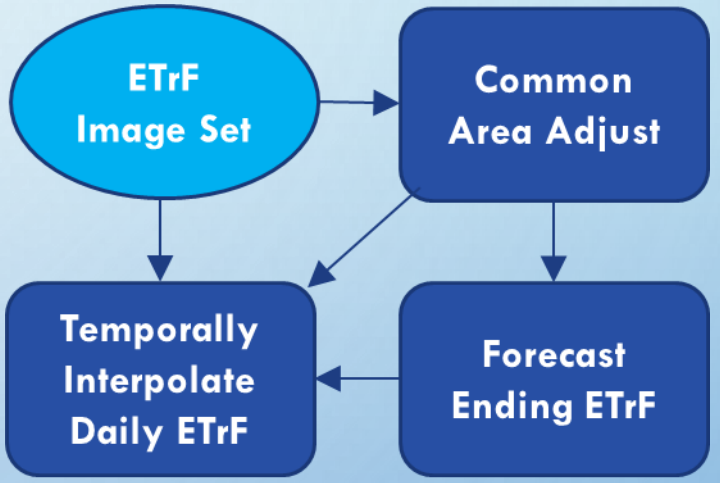
CropScape/ETIdaho Dormant Synthetic Image

- Assessment of dormancy criteria for ETIdaho covers.
- Reclassified into dormant covers of:
  - Water
  - Bare Soil
  - Mulch
  - Turf (grass)
- **Apply meteorological data to determine ETr, Es, and Ke and compute ETrF based on:**
  - **Water:** **0.6**
  - **Bare Soil:** **$0.1 < (1.0 - 0.0)*K_e + 0.1 <= 0.9$**
  - **Mulch:** **$0.1 < (1.0 - 0.25)*K_e + 0.1 <= 0.85$**
  - **Turf:** **$0.1 < (1.0 - 0.30)*K_e + 0.1 <= 0.80$**



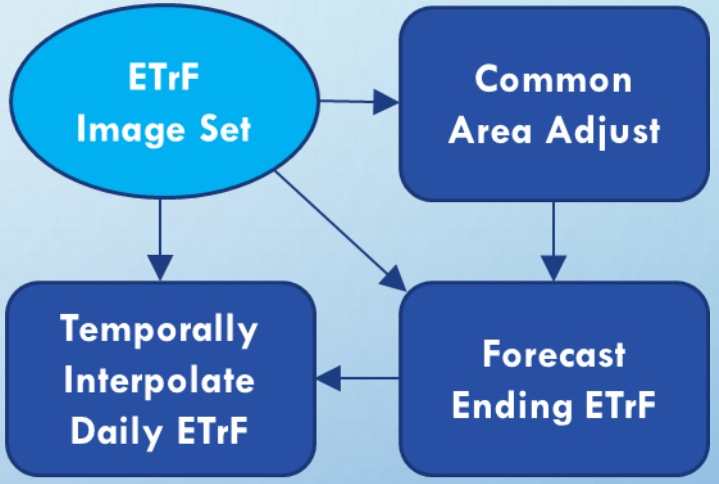
Changing Landsat (7-8) Footprint Common Area between Images

- For the interpolation process and forecasting the ending ETrF image, a congruent common area between images is required.
- Each provisional release required the common area map (binary 1/0) to be adjusted – shrunk.
- Landsat 8 TIR (thermal band) edge wanders even within an image.
- Landsat 7's orbit adjustments by USGS/EROS/NASA are being minimized to preserve onboard fuel.



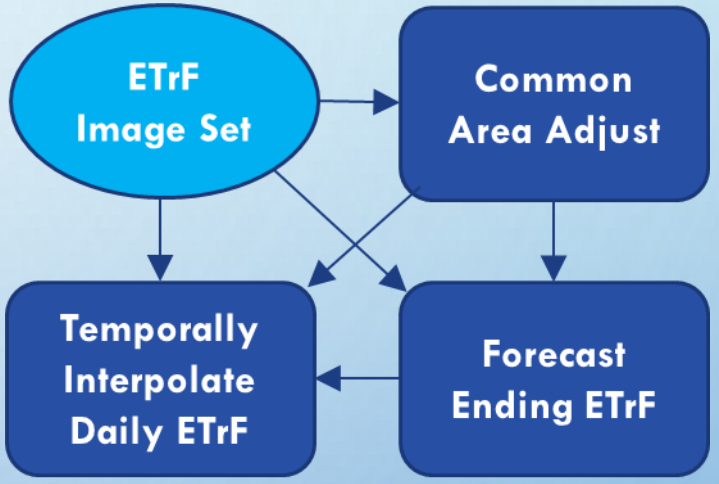
Forecasting the ending ETrF surface

- For the temporal interpolation ETrF process a ending ETrF image is required with every pixel populated.
- The forecast ending ETrF image for a path is based on linear interpolation with limits.
  - Each pixel is interpolated from the last two images where the pixel was not considered to be cloudy, was not a NaN or +/-INF, less than 2.0 and greater than -1.0.
  - Forecast ETrF maximum limit was 1.0, if a pixel value exceeded 1.0 it was set to 1.0.
  - Forecast ETrF minimum limit was 0.05, if a pixel value was less than 0.05 it was set to 0.05.
- Initially Path 39 and Path 40 overlap area forecasts were separate. Now for near-real time the overlap area is based on a "blended" (average) mosaic of the two paths.



Interpolation for Daily ETrF surfaces

- Daily ETrF interpolation from a set ETrF Images.
- Interpolation process requires a starting and ending ETrF image without "clouds".
- Provisional products are based on linear interpolation.
  - Interior images can have cloudy areas (masks) which have not been filled.
  - Each pixel is interpolated from a before (time) image and after (time) image where those pixels are not cloudy and the ETrF value is reasonable.
- Final products are based on cubic spline with dampening.
  - Images with cloudy areas have been filled.
  - Cubic spline is based on the entire ETrF image set.

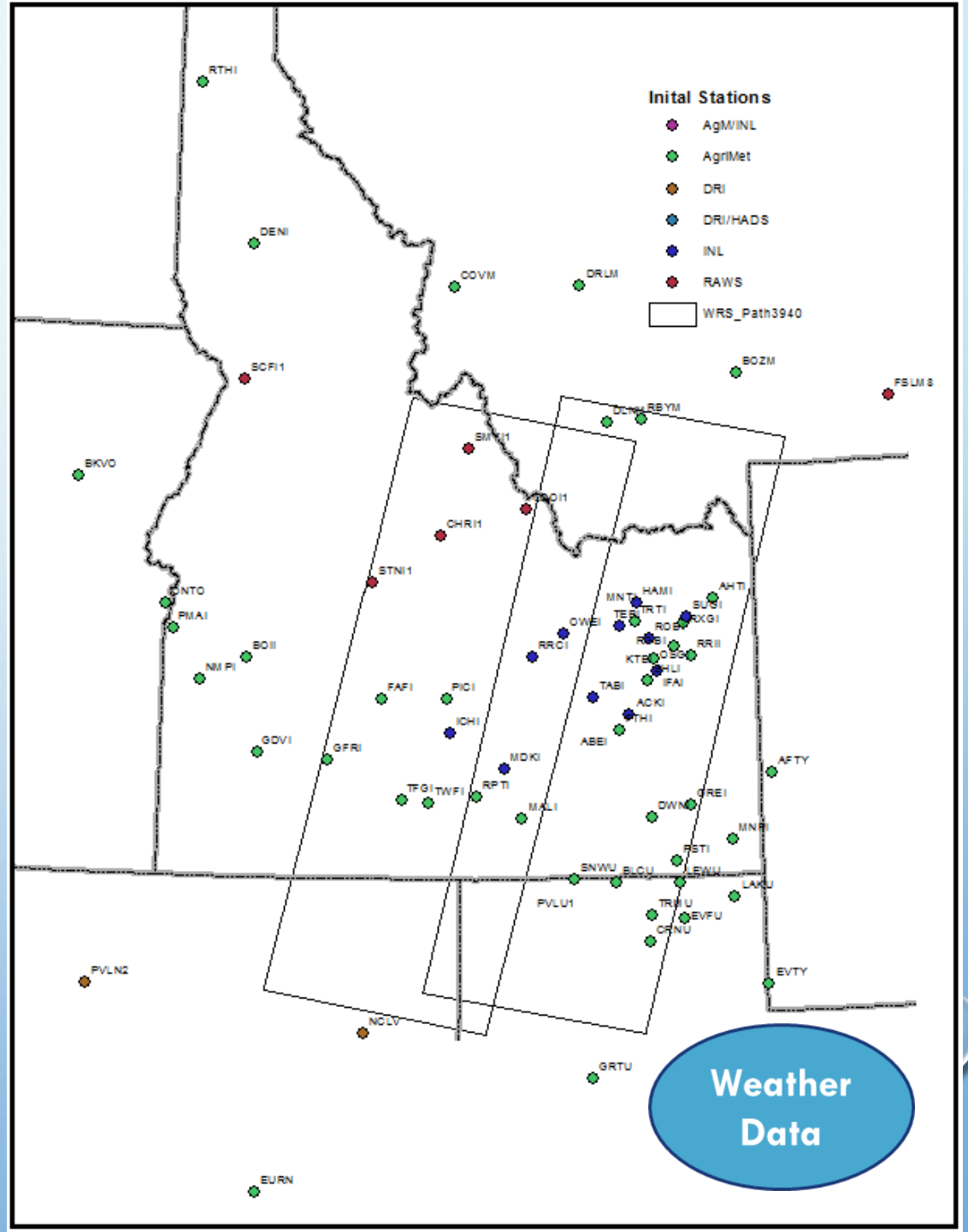


Daily ETr Surfaces

- Daily ETr spatial interpolation based on automatic weather station (AWS) ETr.
  - ETr calculations based on ETIdaho methods for AgriMet locations.
- Interpolation method is a weighted average of a "clipped" spline interpolation and a natural neighbor interpolation.
  - AWS set includes stations outside the Path 39/40 Row 29-31 area to extend the interpolated surfaces to the edges of the area. (67 stations with 44 interior stations)
- Provisional products are based non quality controlled meteorological data and the entire AWS station set.
- Final products are based meteorological data that has been reviewed and adjusted. Some AWS stations were not included due to periods of missing data and applicability to the interpolation process.

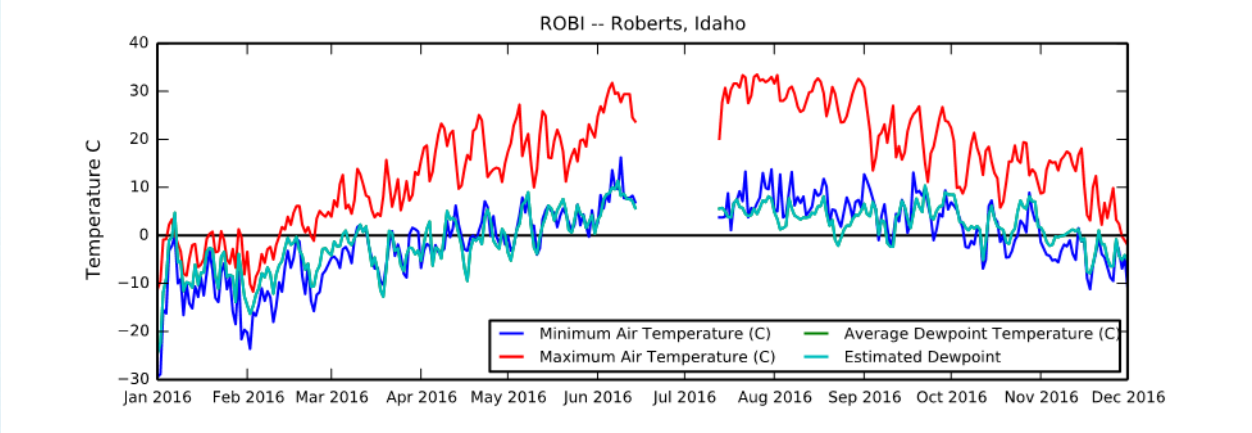
AWS Meteorological Sites

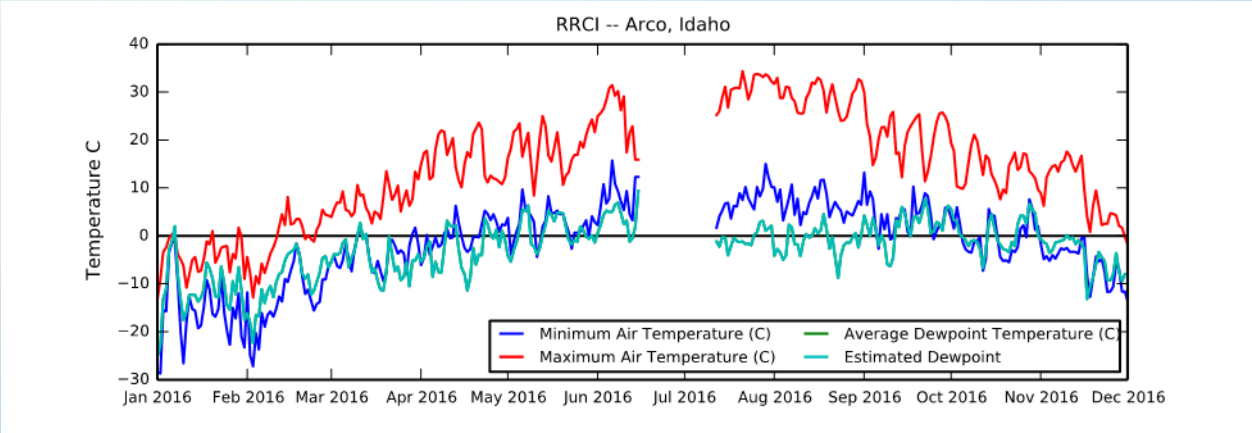
- Initially 67 locations from Agrimet (PN and GP), INL/NOAA, UCC, DRI, SCAN and RAWS networks.
- Data downloaded from:
  - PN-Agrimet, GP-Agrimet, Mesowest, WRRC/DRI
  - Each source requires a separate script.
  - For synthetic starting image need to start January 1.
- Each station required determining:
  - Latitude and elevation
  - Wind Speed Sensor Height: 2m, 3m, 6.1m and 15m (3, 6.1 and 15 wind speed conversion to 2m)
  - Area soil characteristics for upper 15 cm (Field capacity, Wilting point and Readily evaporable water)
  - Assumption concerning aridity of station.

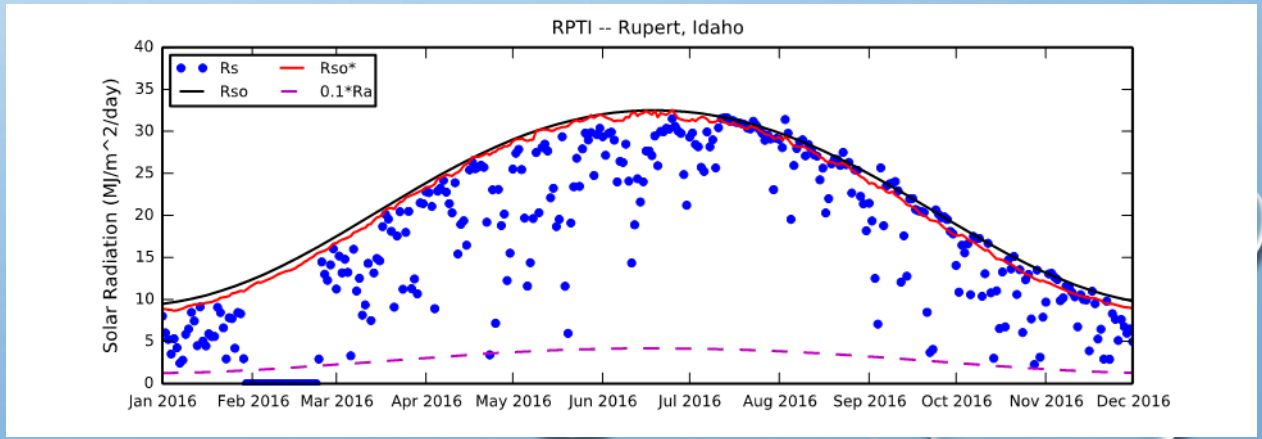


AWS Meteorological Data

- Some of stations went off line -- missing.
  - Initially data was downloaded daily for the prior 5 days. That was extended to 45 days.
- Initially missing periods were estimated from the last day with data. That was changed to only estimate data for periods with missing data less than 3 days.
- Some parameters reported with values when they should have been identified as missing.

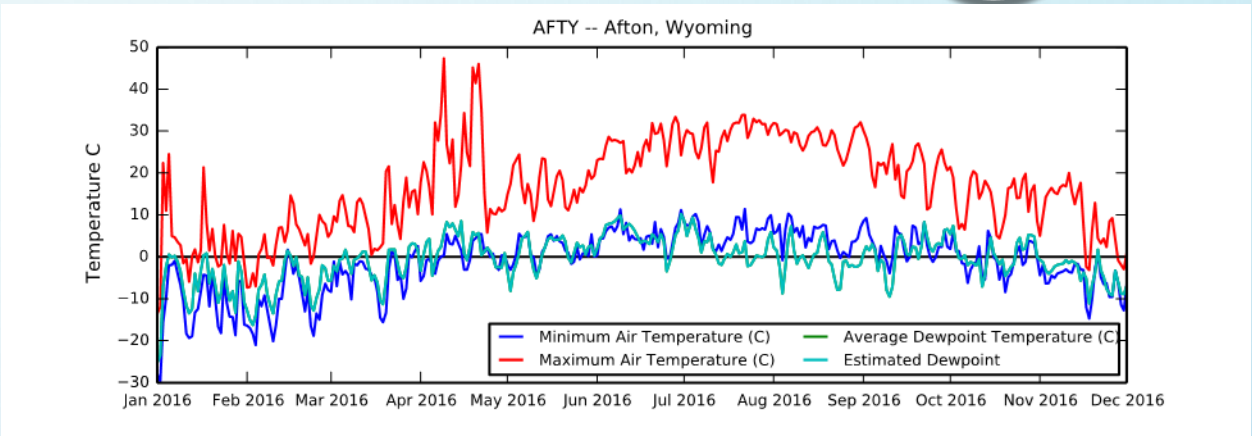


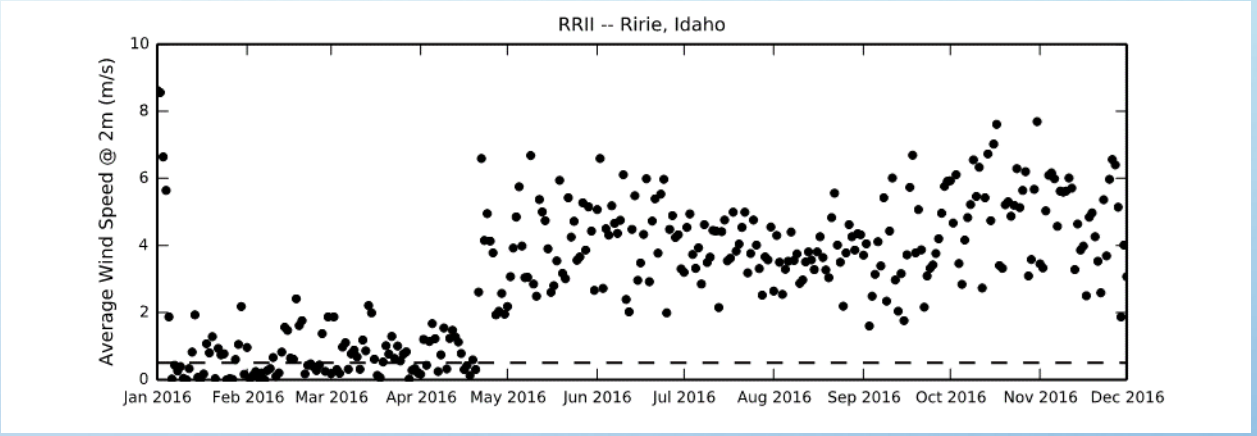


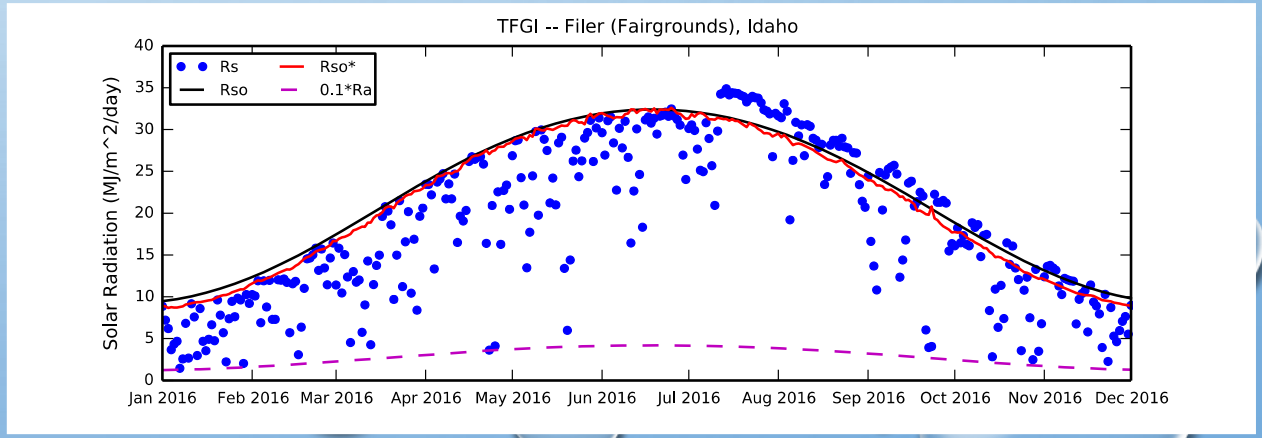


AWS Meteorological Data

- No Quality review of meteorological data for near-real time. One needs to see long term series to assess.
- Faulty sensor data in the station time series
- Vandalized sensor with data in the time series.
- Changes in sensor coefficients by station operator.

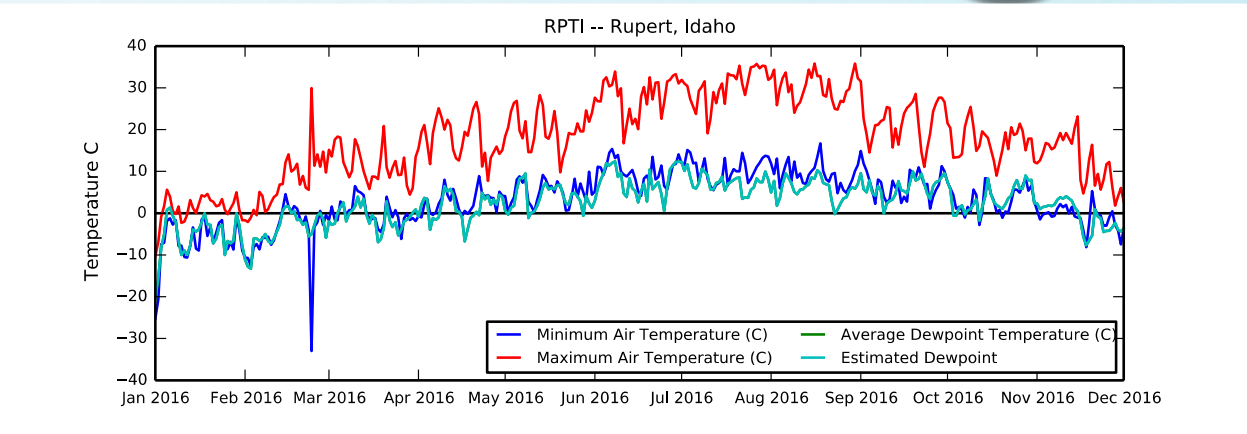


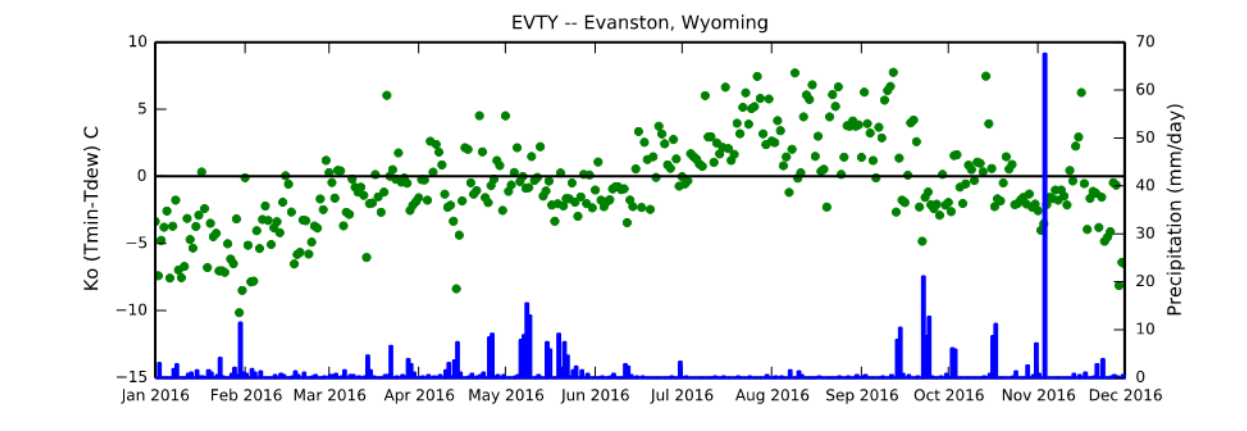


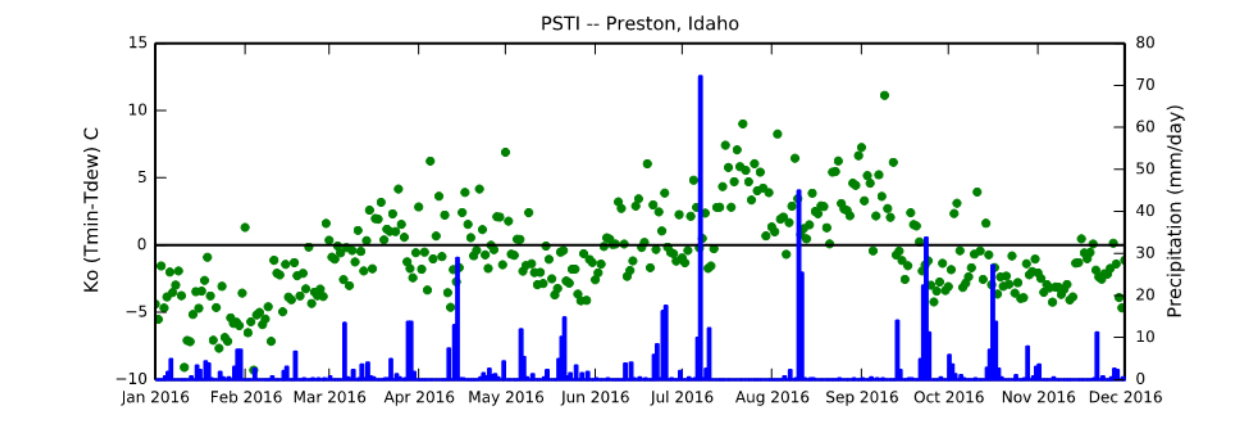


AWS Meteorological Data

- **Station maintenance resulting in spikes and unreasonable daily values.**
- **Faulty sensor data in the station time series.**

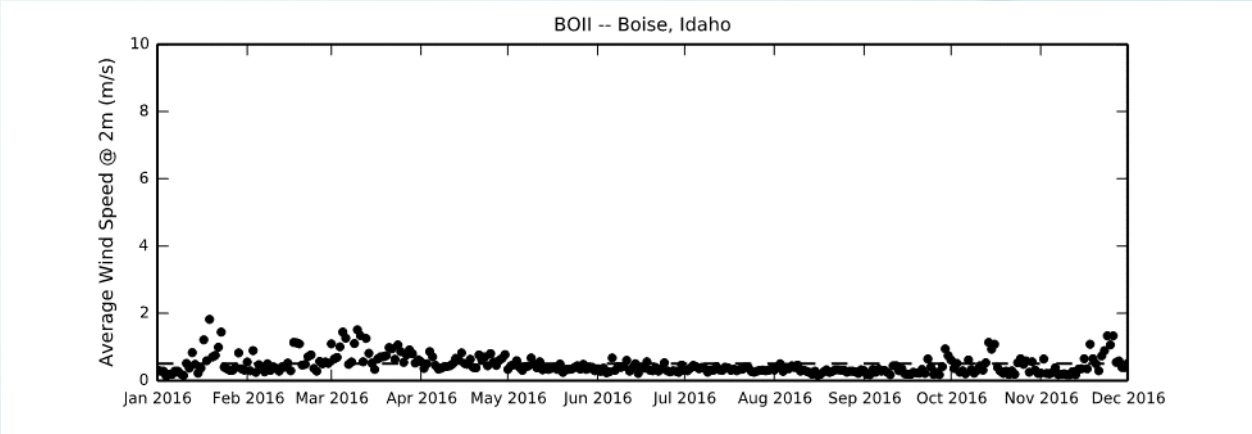


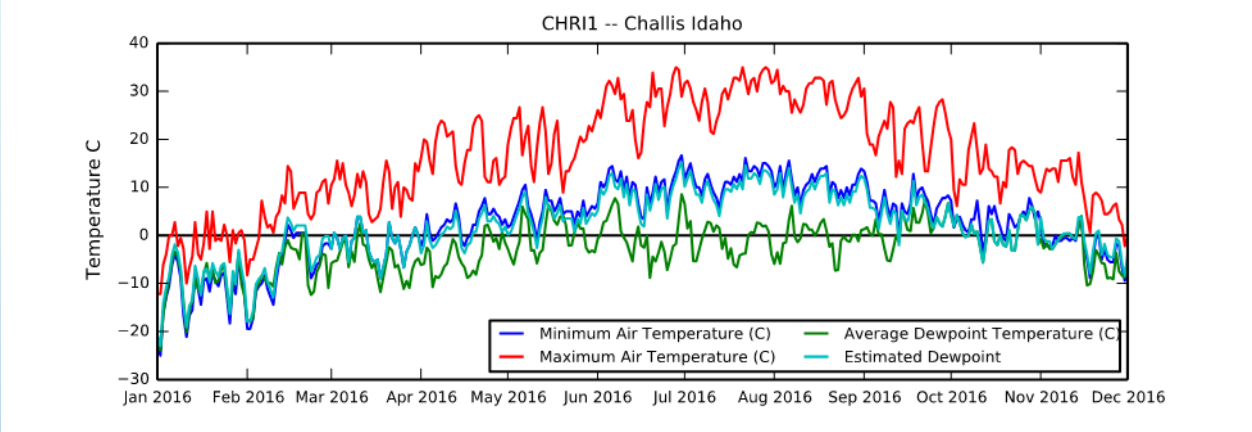


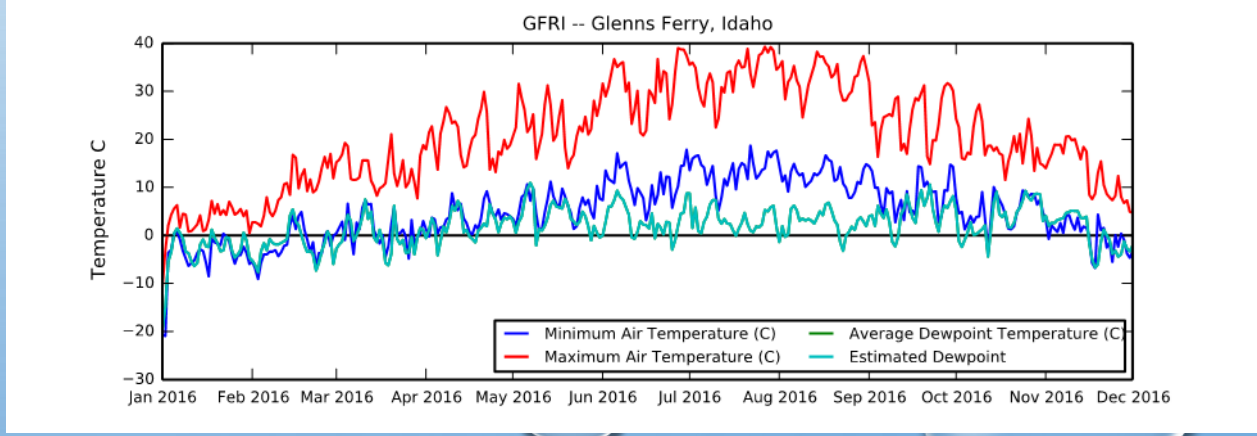


AWS Meteorological Data

- Extremely low wind speeds
  - Station siting issue, or
  - Faulty sensor.
- Wrong assumption about station aridity
  - Surrounding area now in fallow?
  - For stations that were part of an agricultural weather network the reported dew point was used for ETr calculations.
  - For stations that were not part of an agricultural network (assumed not to be in an irrigated area) the ETIdaho (2012) dew point depression from minimum air temperature was used for ETr calculations.

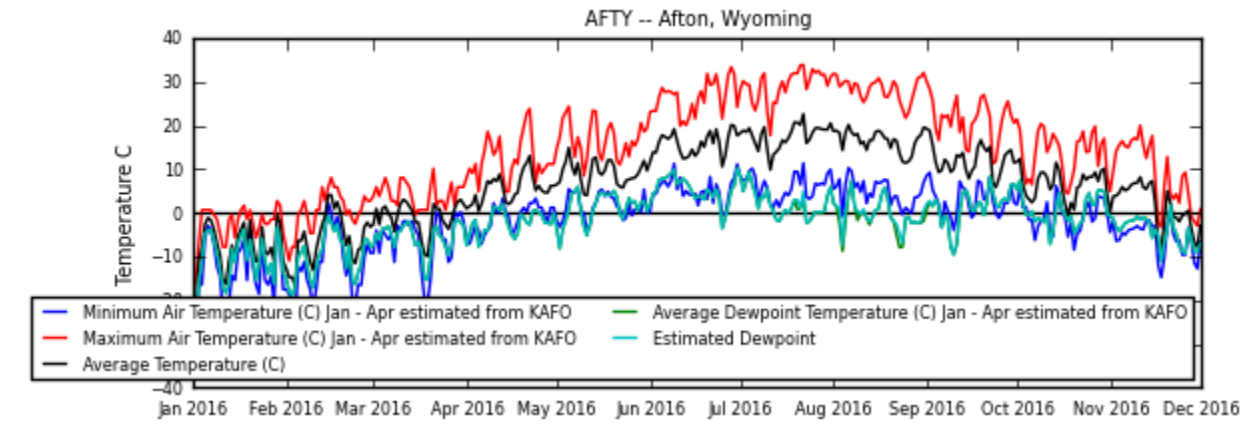


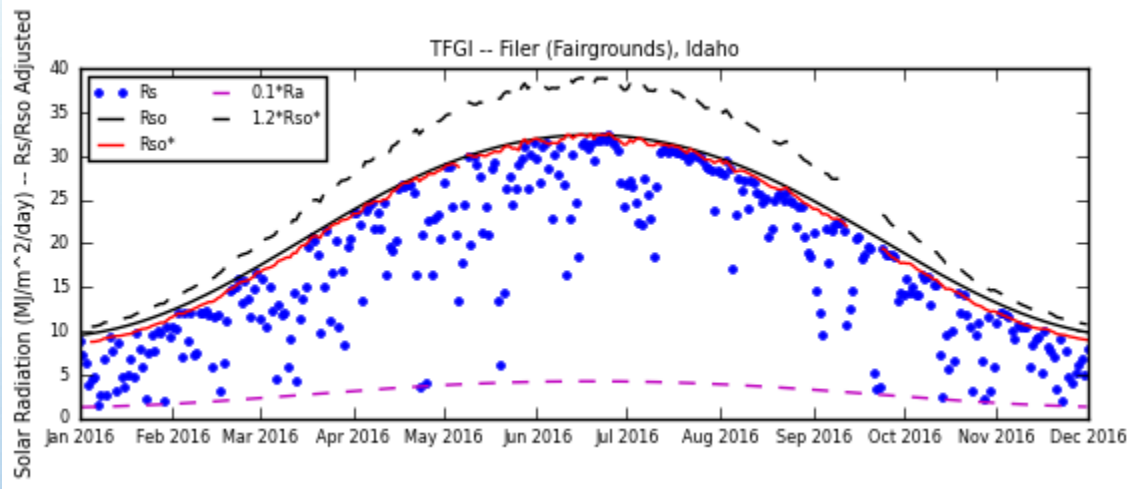


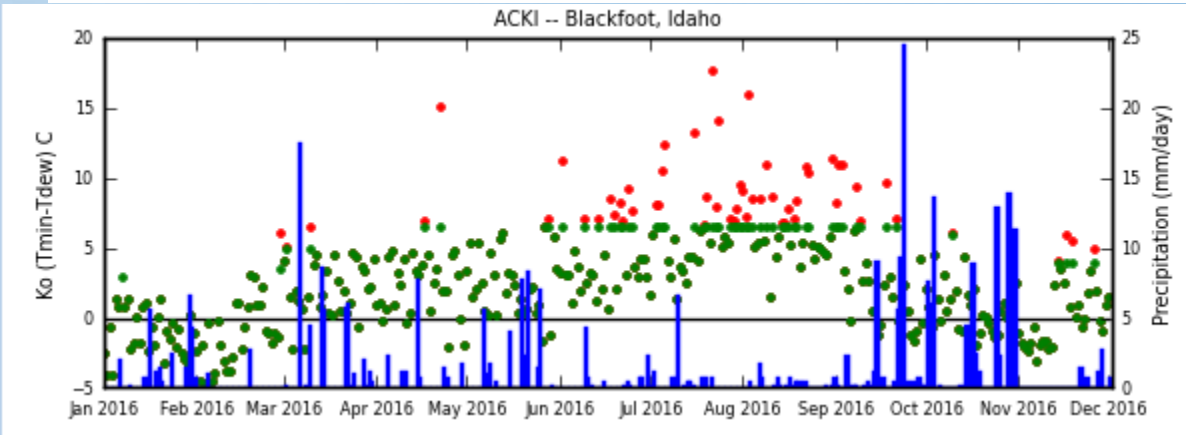


AWS Final Data

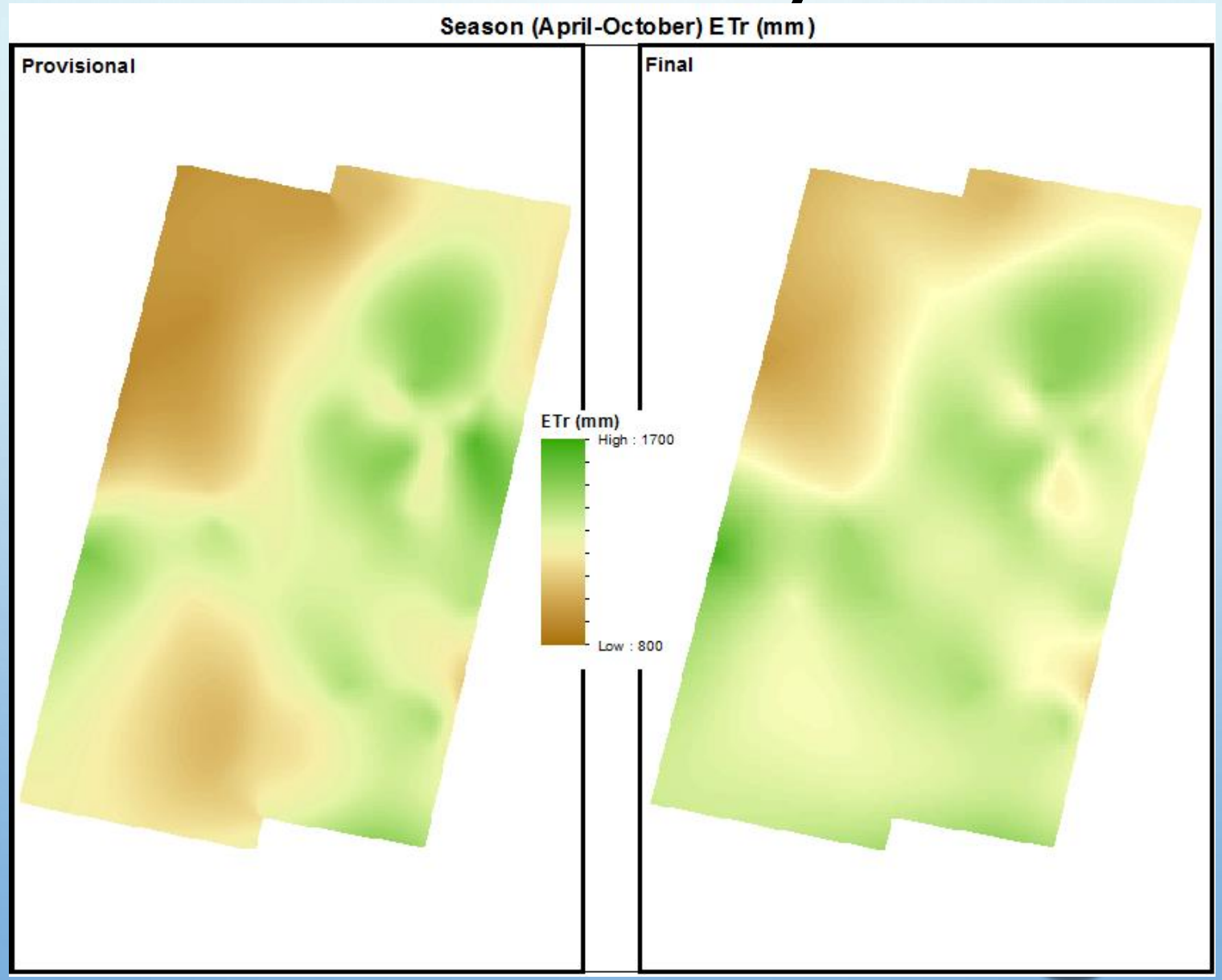
- Missing and faulty sensor periods filled from available sources.
- Spikes replaced.
- Solar Radiation adjusted based on expected "clear day" solar radiation.
- Dew point temperatures resulting in depression greater than 5C + ETIdaho depression limited to that depression.
- Stations removed from the set based on missing data and neighboring stations. Final AWS set of 60 stations.





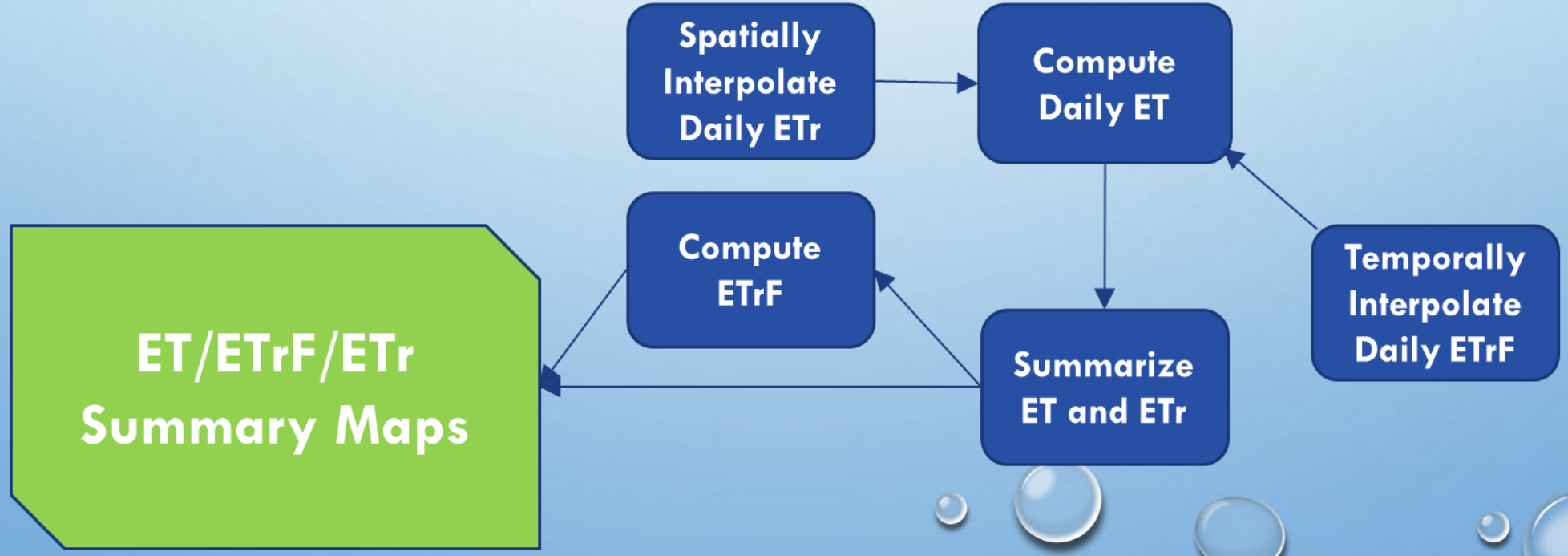


Provisional vs Final Daily ETr Surfaces



Daily ET to Summary Period ET/ETrF/ETr (Monthly or Seasonal)

- Daily ETrF surface multiplied daily ETr surface results in the daily ET surface.
- Summary ET is the sum of the daily ET surfaces corresponding to the period.
- Summary ETr is the sum of the daily ETr surfaces corresponding to the period.
- Summary ETrF is the ratio of summary ET to summary ETr.



Near Real Time METRIC Issues

What do you do when there are no acceptable Landsat images for a month?

Path 39 for October

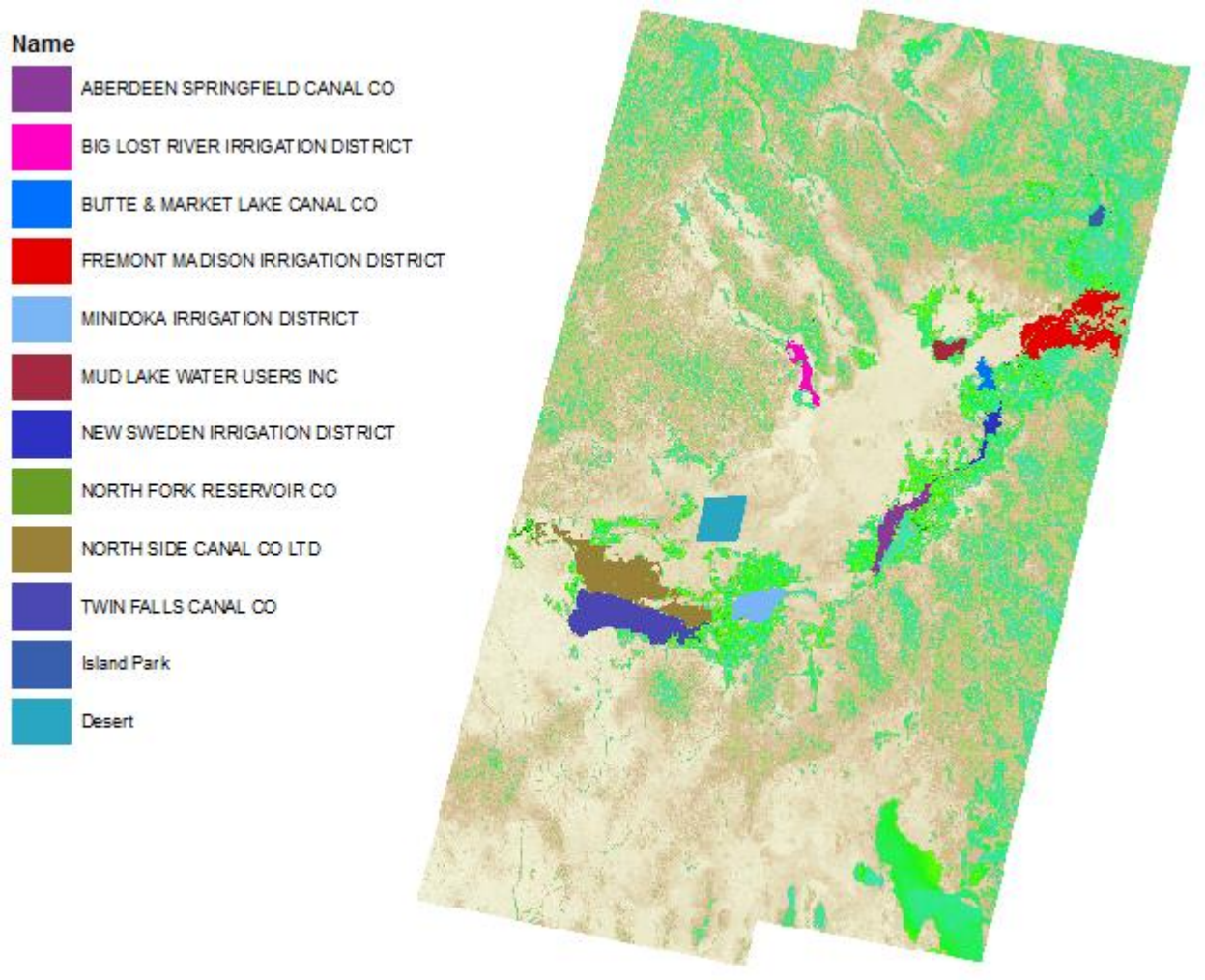
We were worried during May and June

Final Products Additional Operations

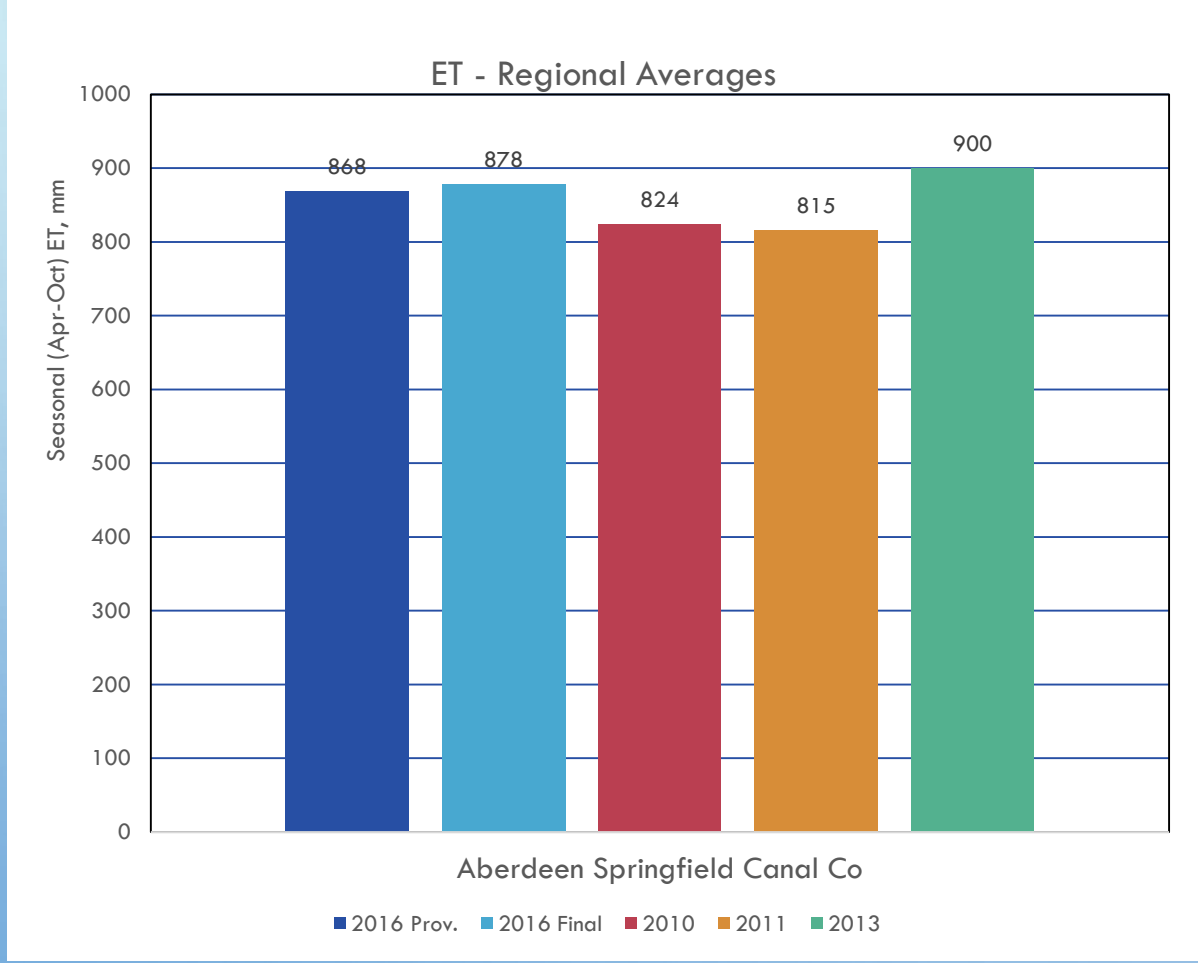
- Landsat 8 images: TIR is sharpened based on NDVI.
- Precision cloud masks and filling of cloud masks
  - Cloud shadow trails identified -- thin cirrus clouds identified -- Con trails.
  - Field boundaries are respected -- the fill edge is not visible or noticeable in ETrF filled images.
- Daily weather data reviewed, checked and adjusted/filled/discarded.
- Final ending image created.
- Synthetic ETrF images produced for months without acceptable images.
- Final background evaporation adjustment – typically 6 months after final month.
- Complete reviews of each image and its calibration.
- Spline interpolation instead of linear.

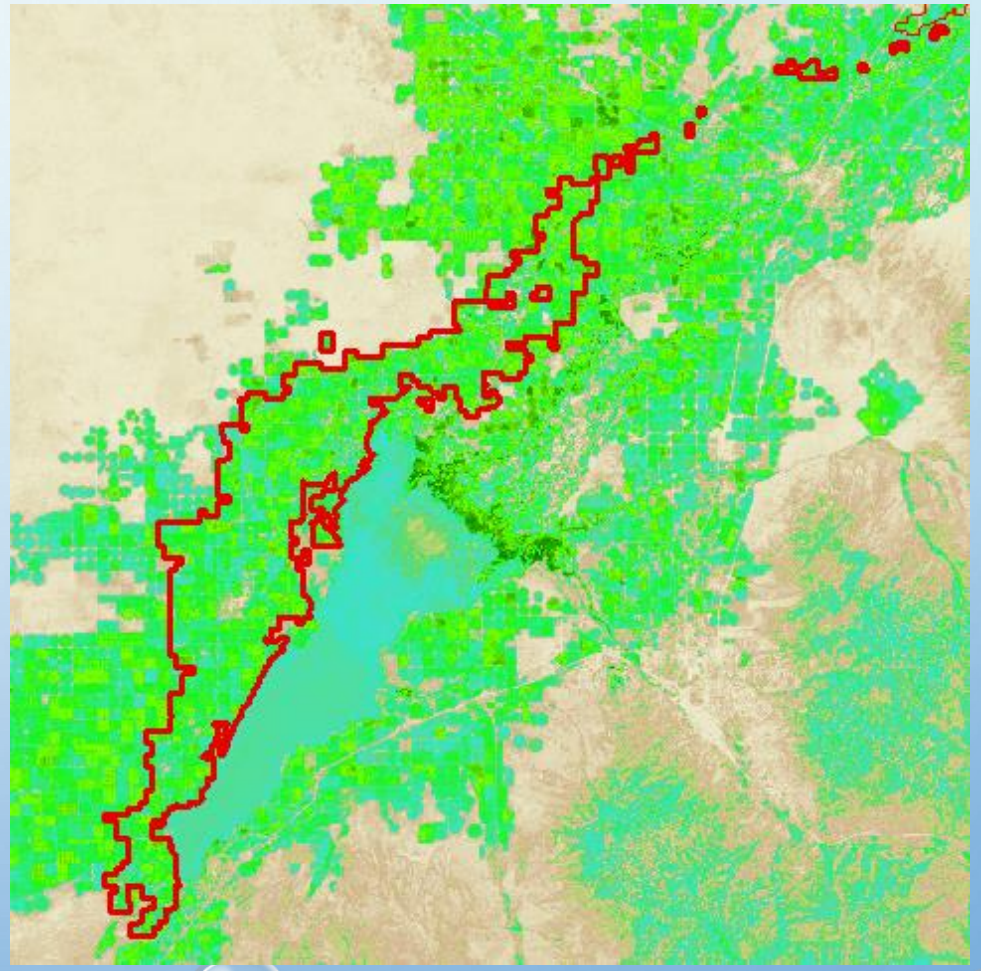
Provisional versus Final Seasonal Products and historical ET maps by region

- Irrigation areas based on IDWR "Permissible Place of Use" (downloaded 1/20)
- Two of the areas are in the overlap of the Path 39 and 40. These will be reported twice.
- Big Lost area limited to the overlap area.
- Fremont Madison area limited to Path 39.

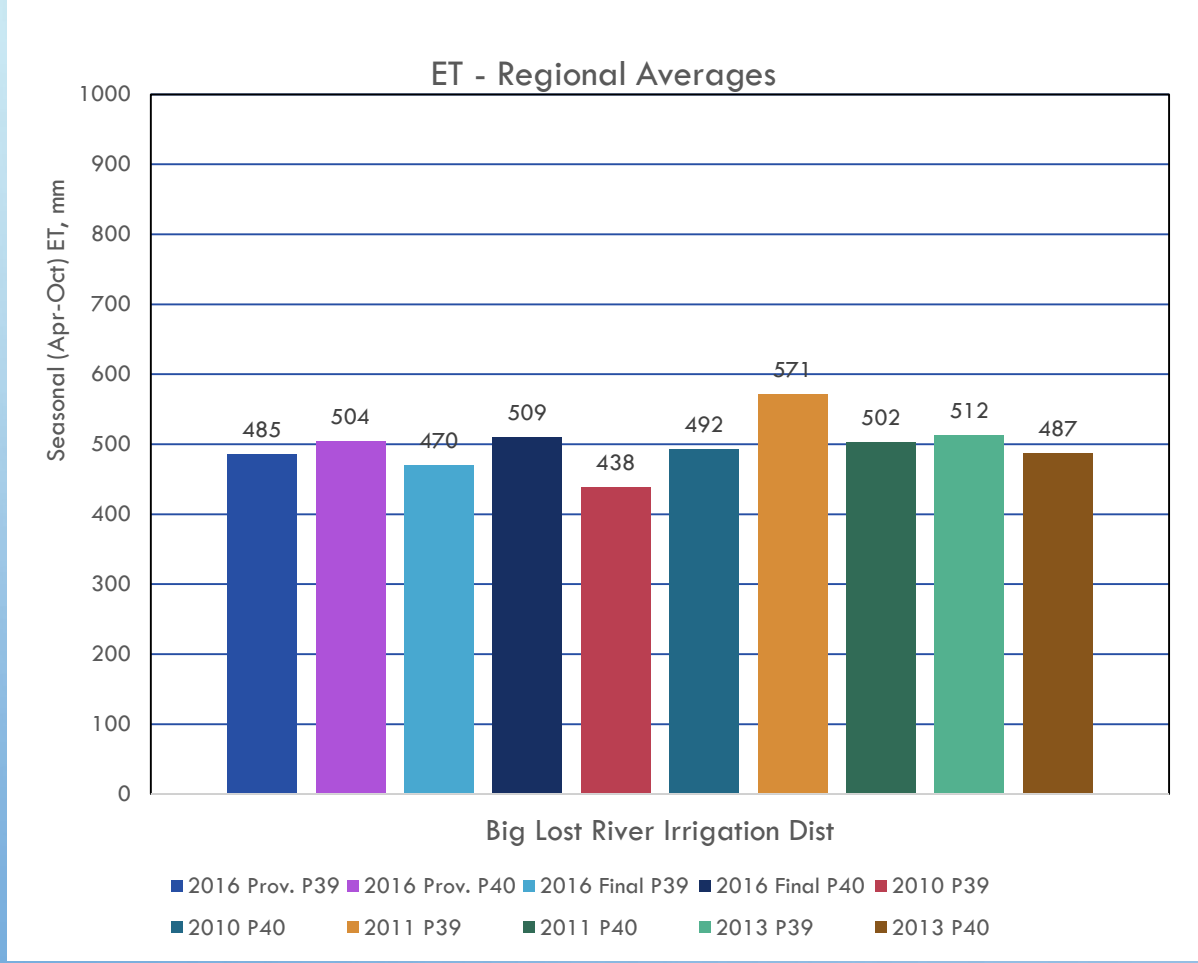


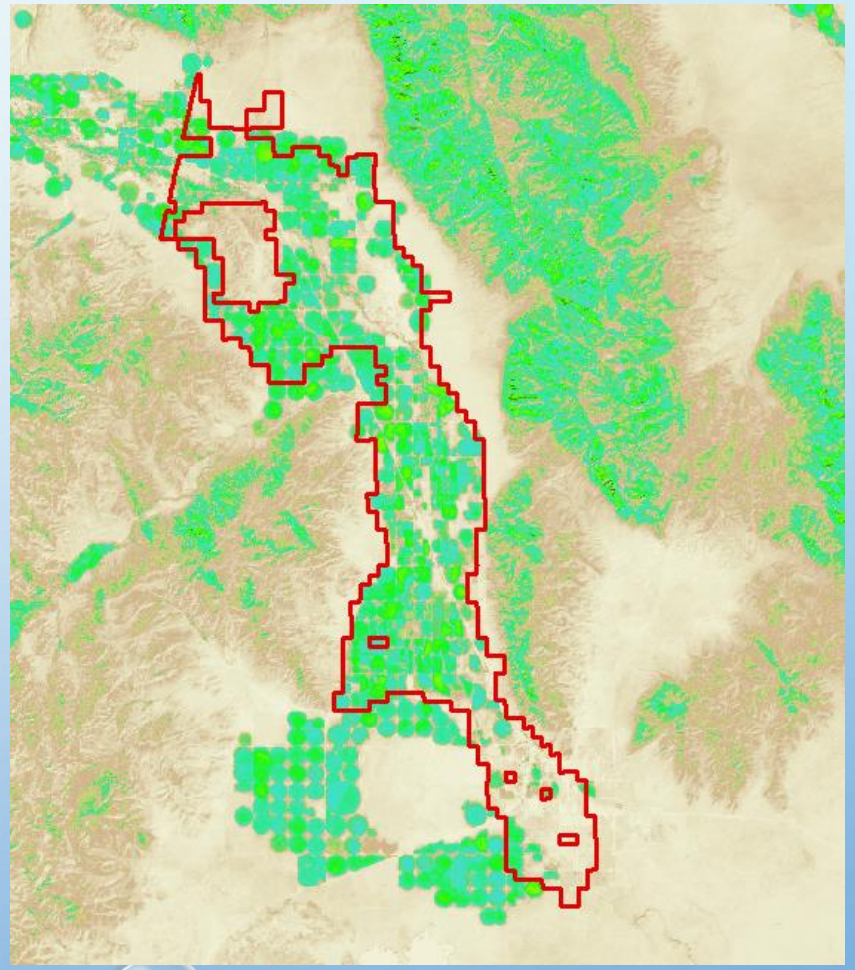
Aberdeen Springfield Canal Co. Area



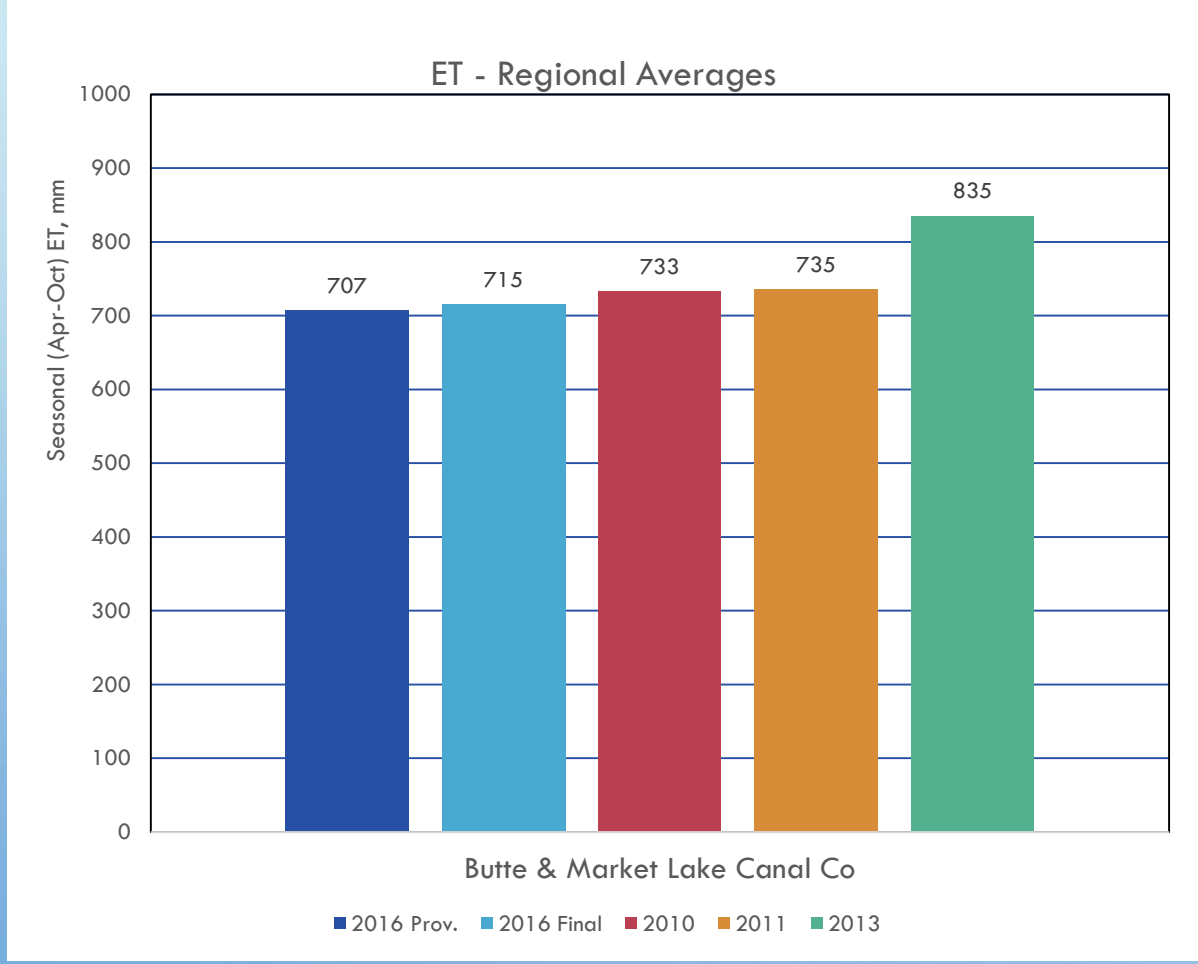


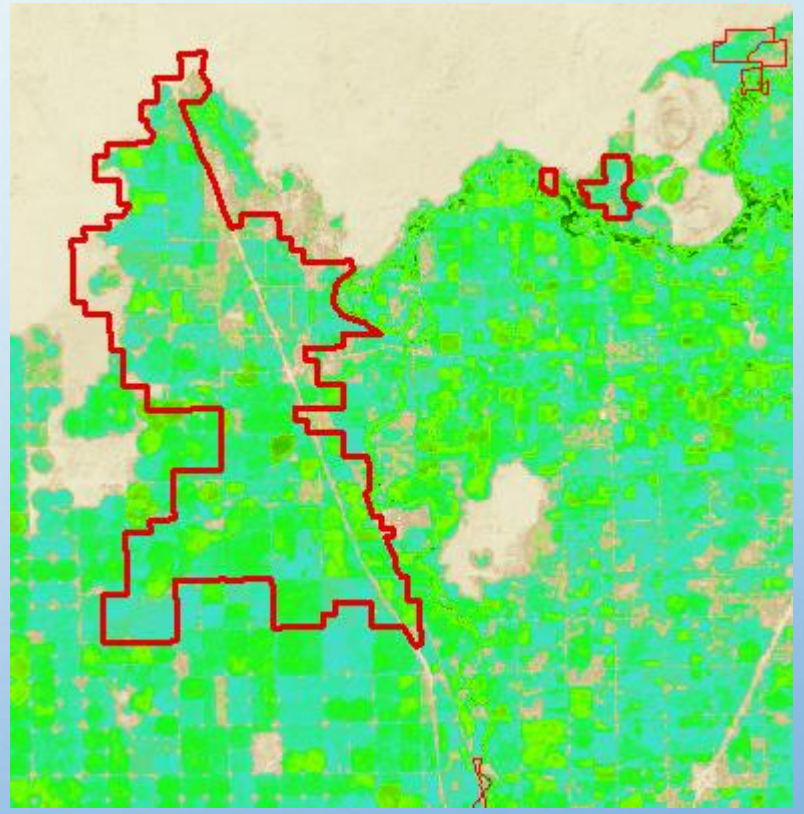
Big Lost River Irrigation Dist. (Overlap only)



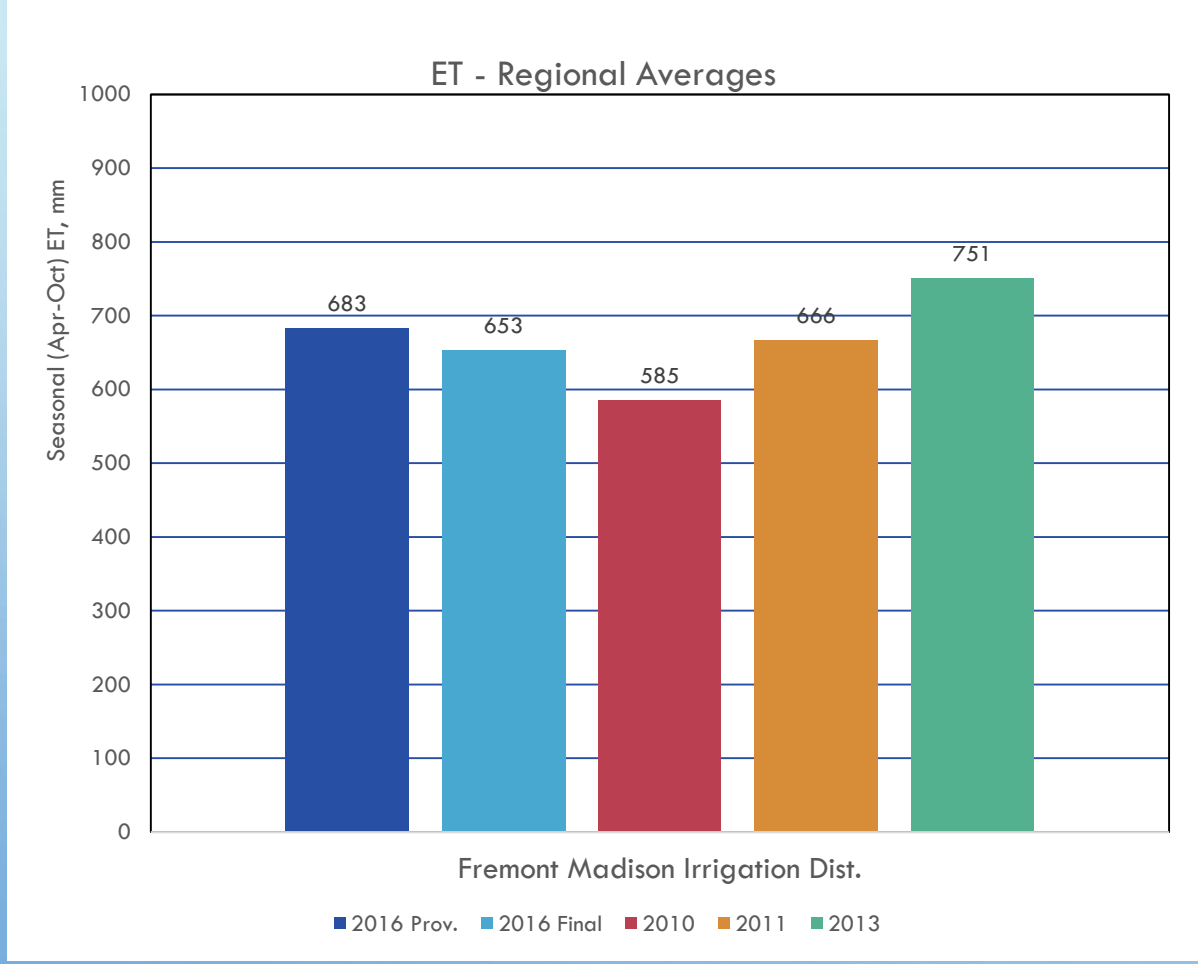


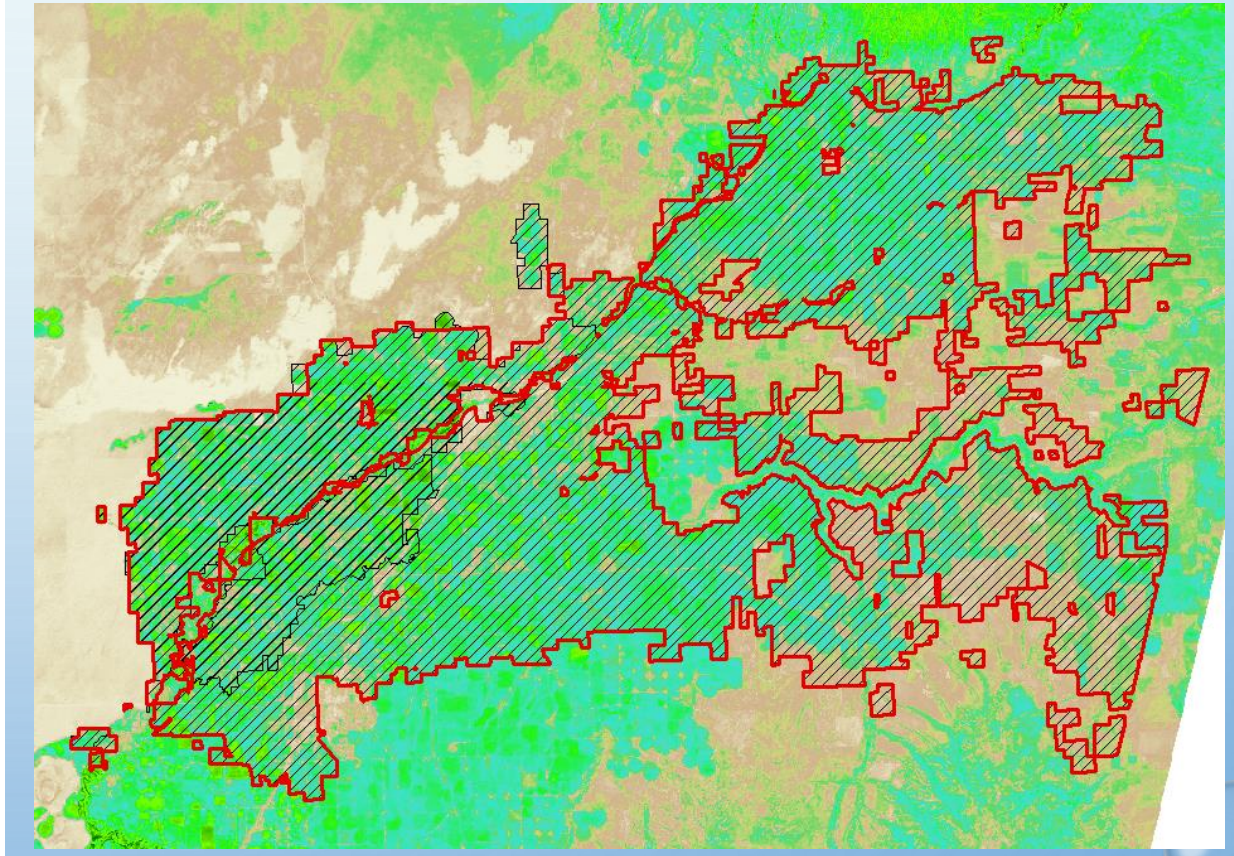
Butte Market Lake Canal Co. Area



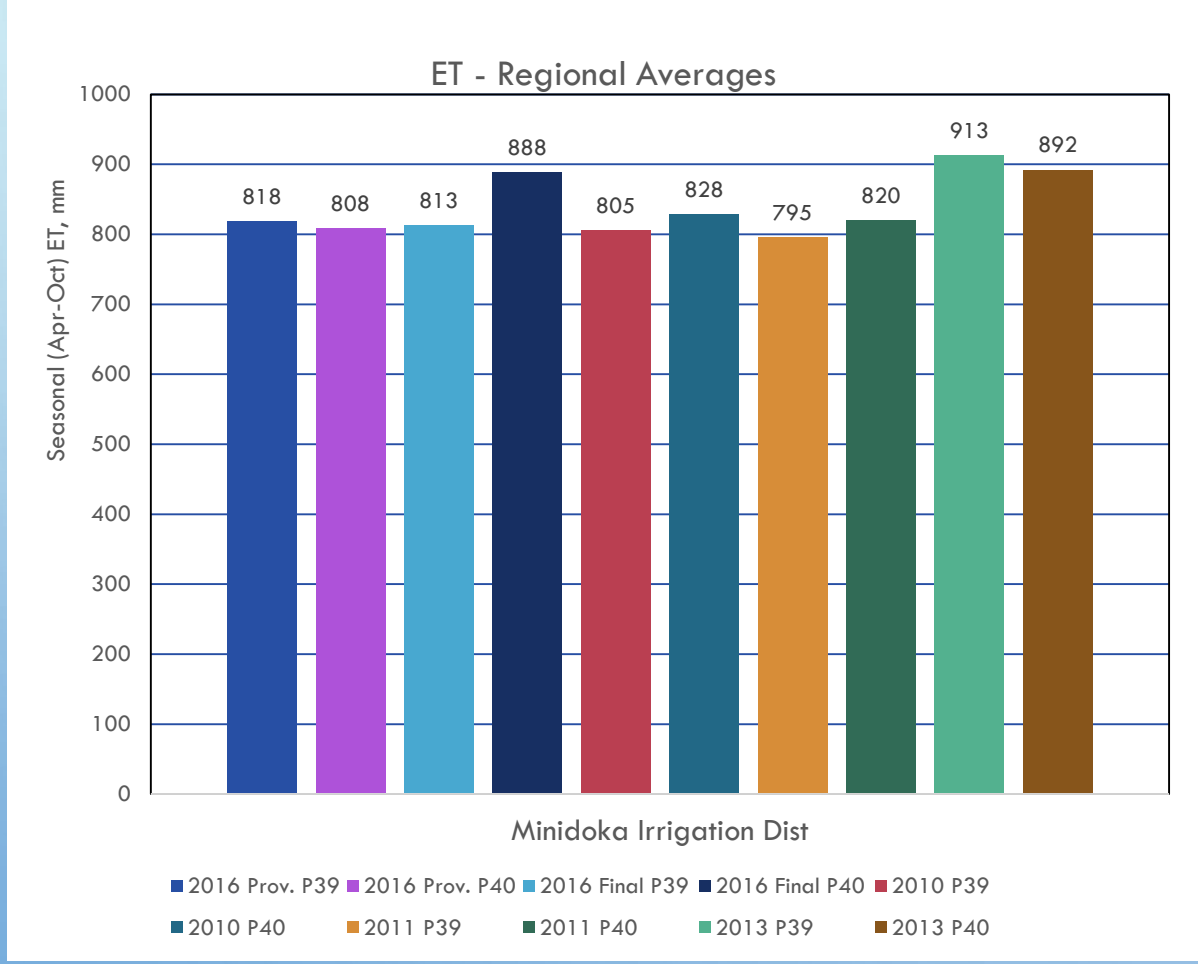


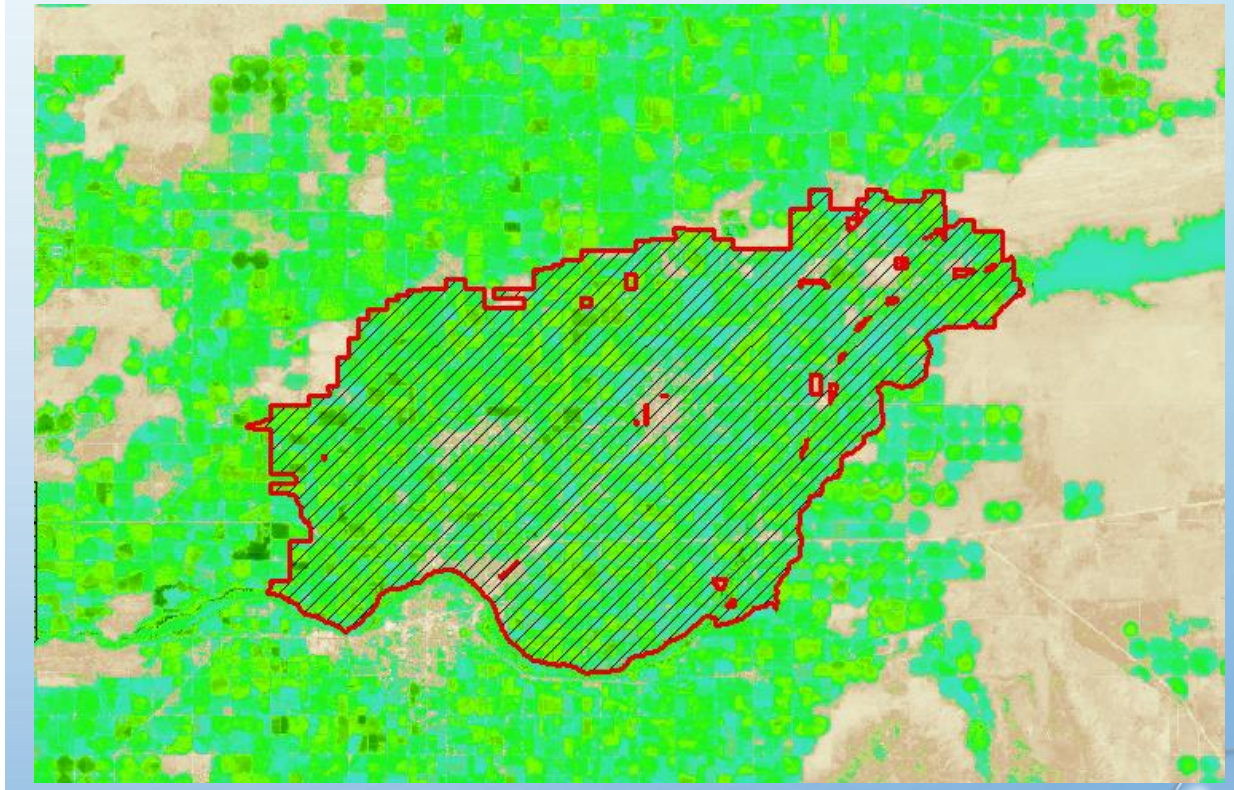
Fremont Madison Irrigation Dist. Area



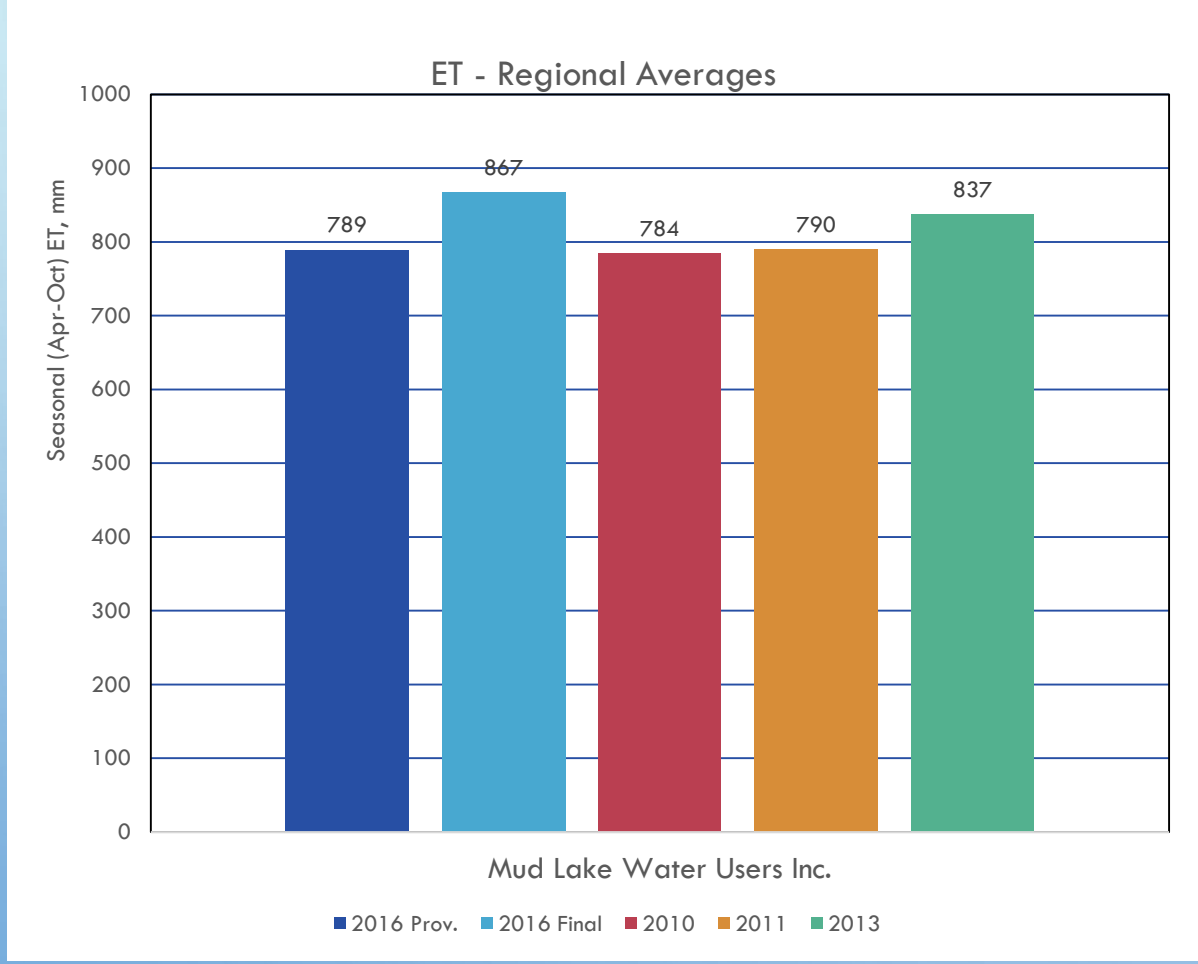


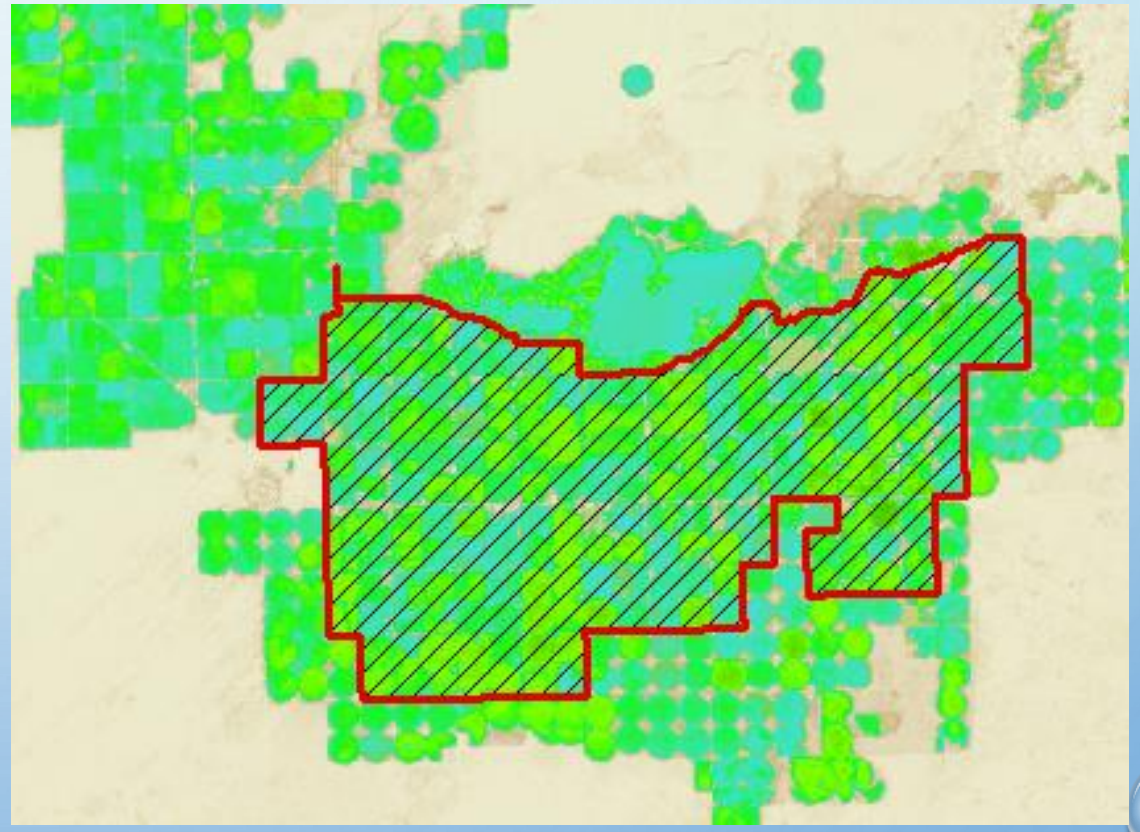
Minidoka Irrigation Dist. Area



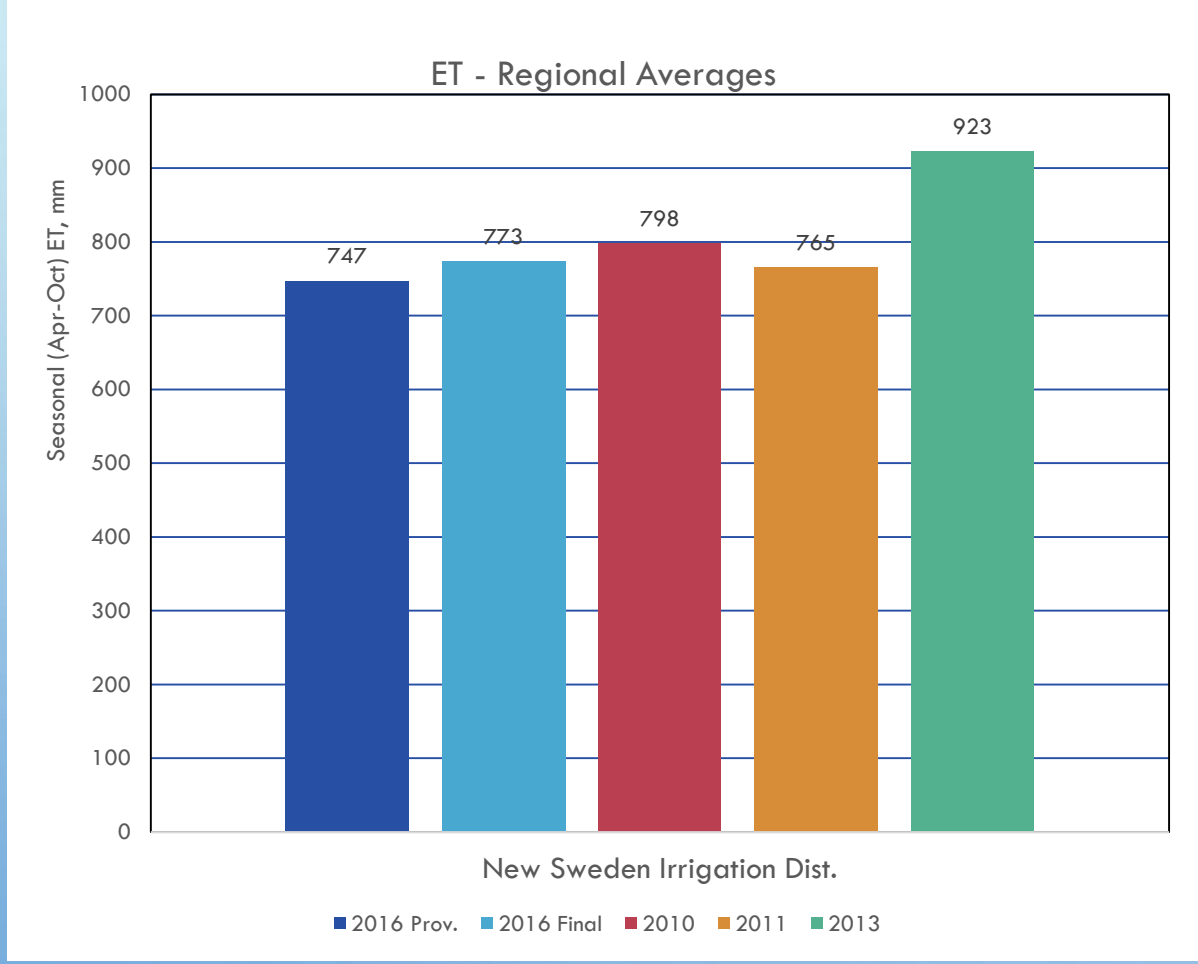


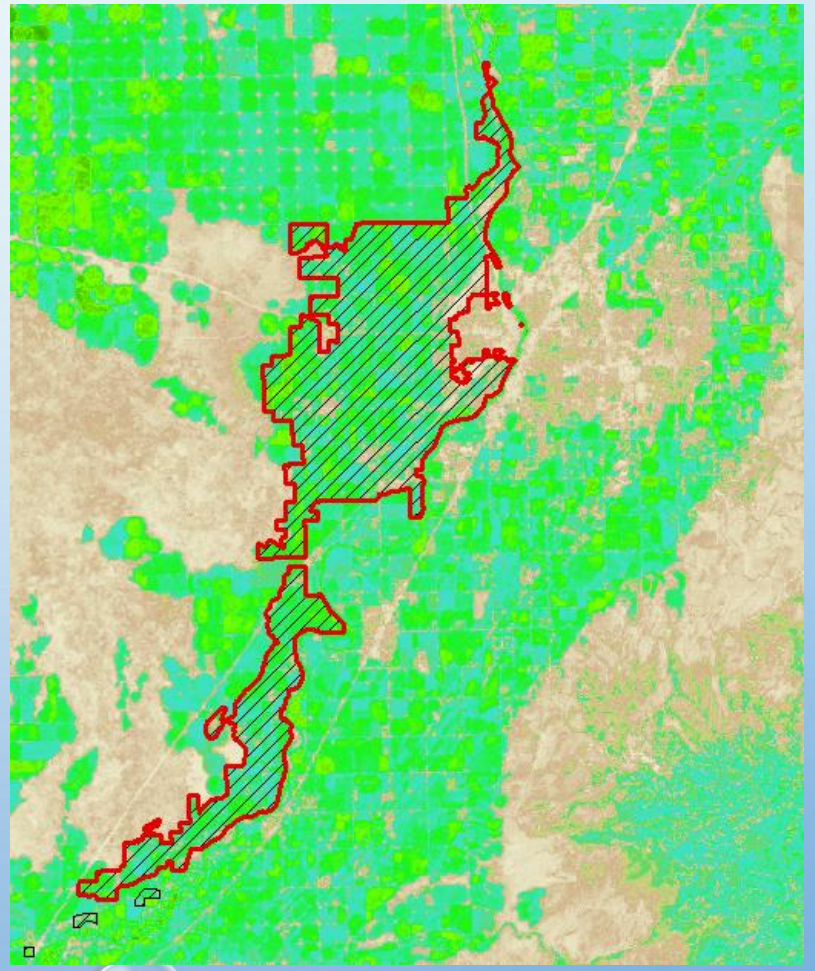
Mud Lake Water Users Inc. Area



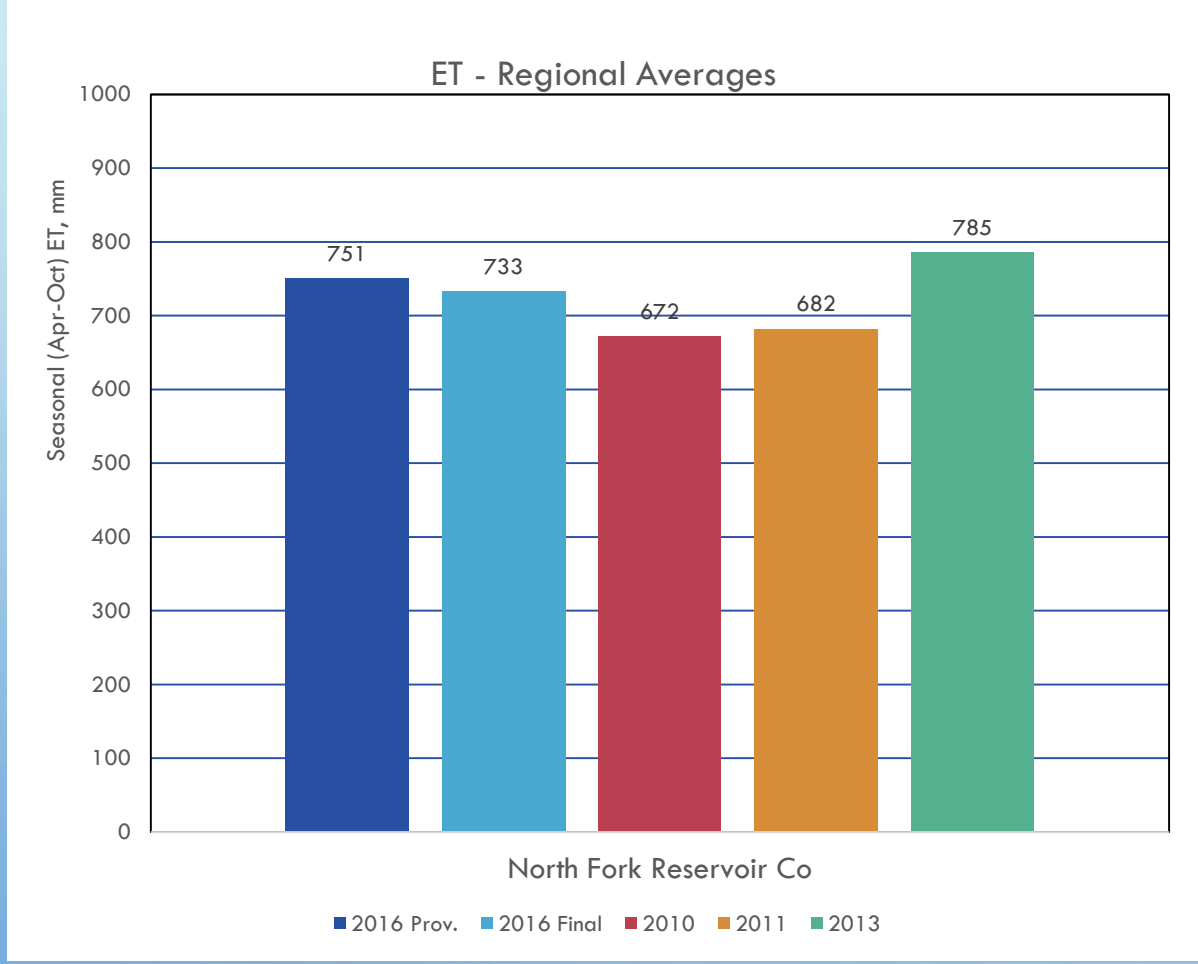


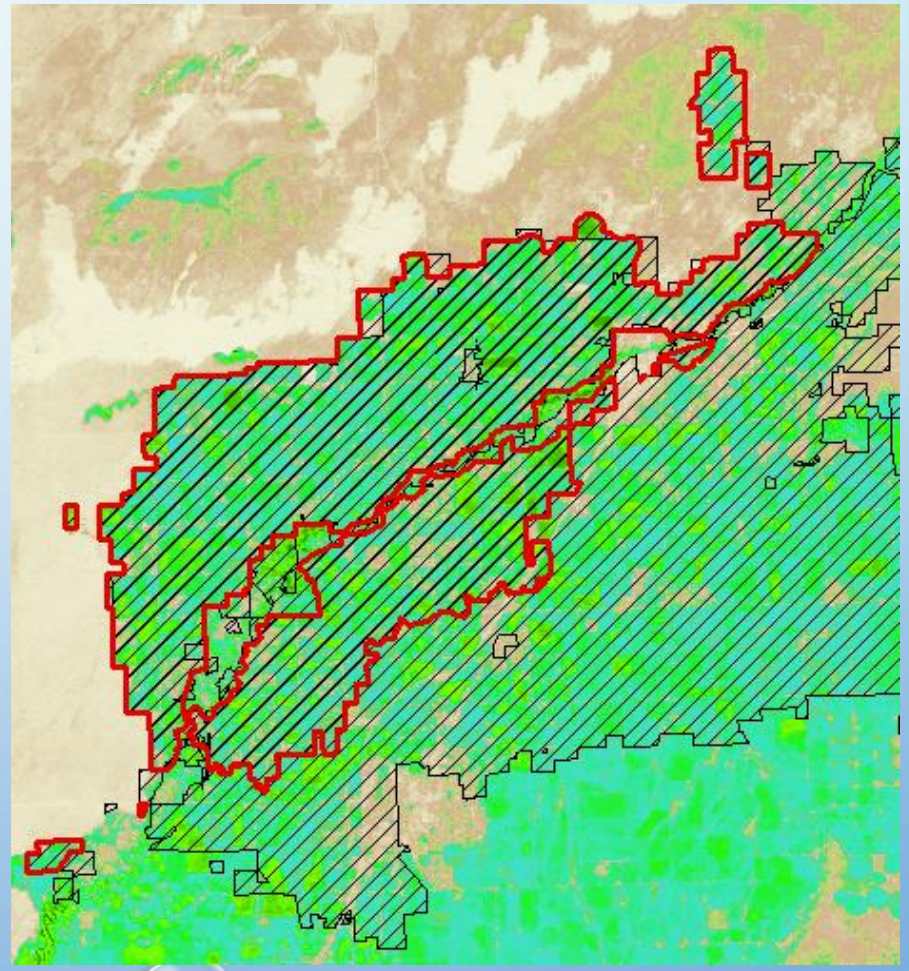
New Sweden Irrigation Dist. Area



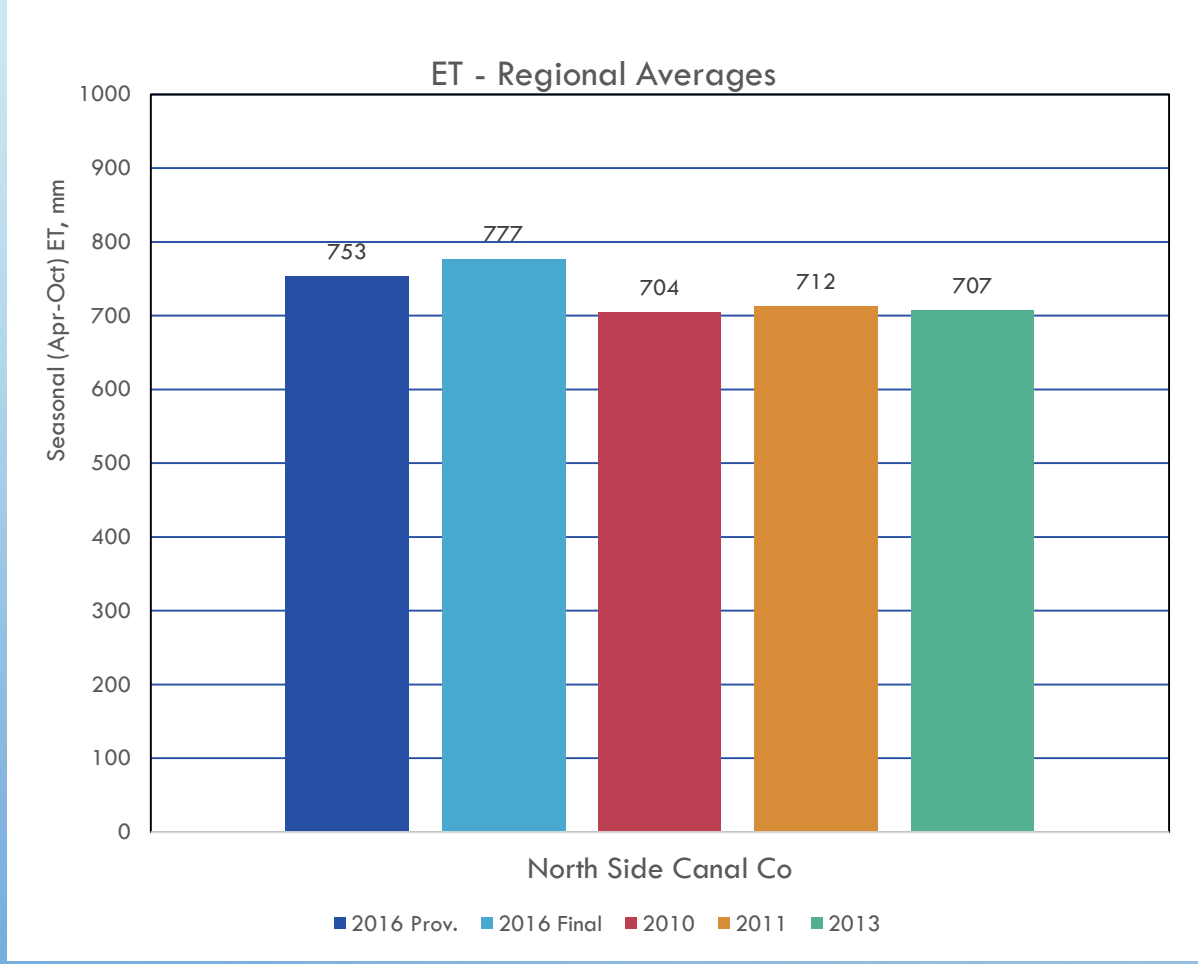


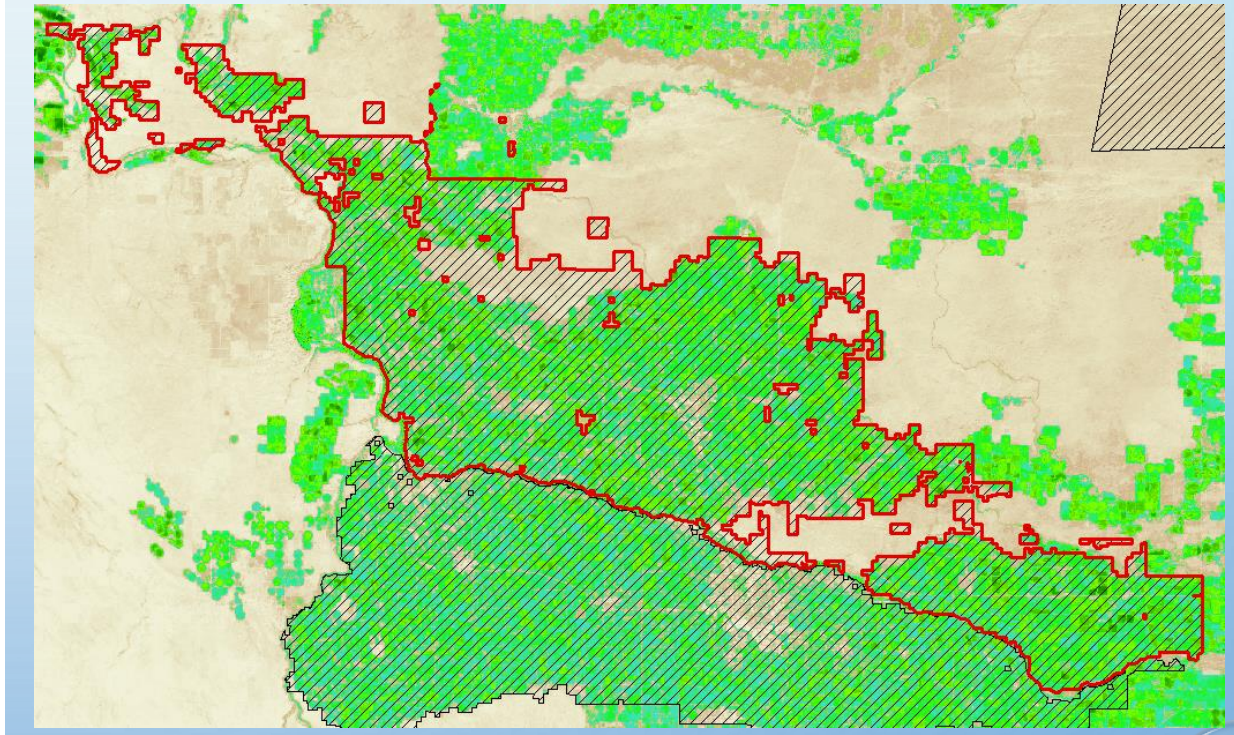
North Fork Reservoir Co. Area



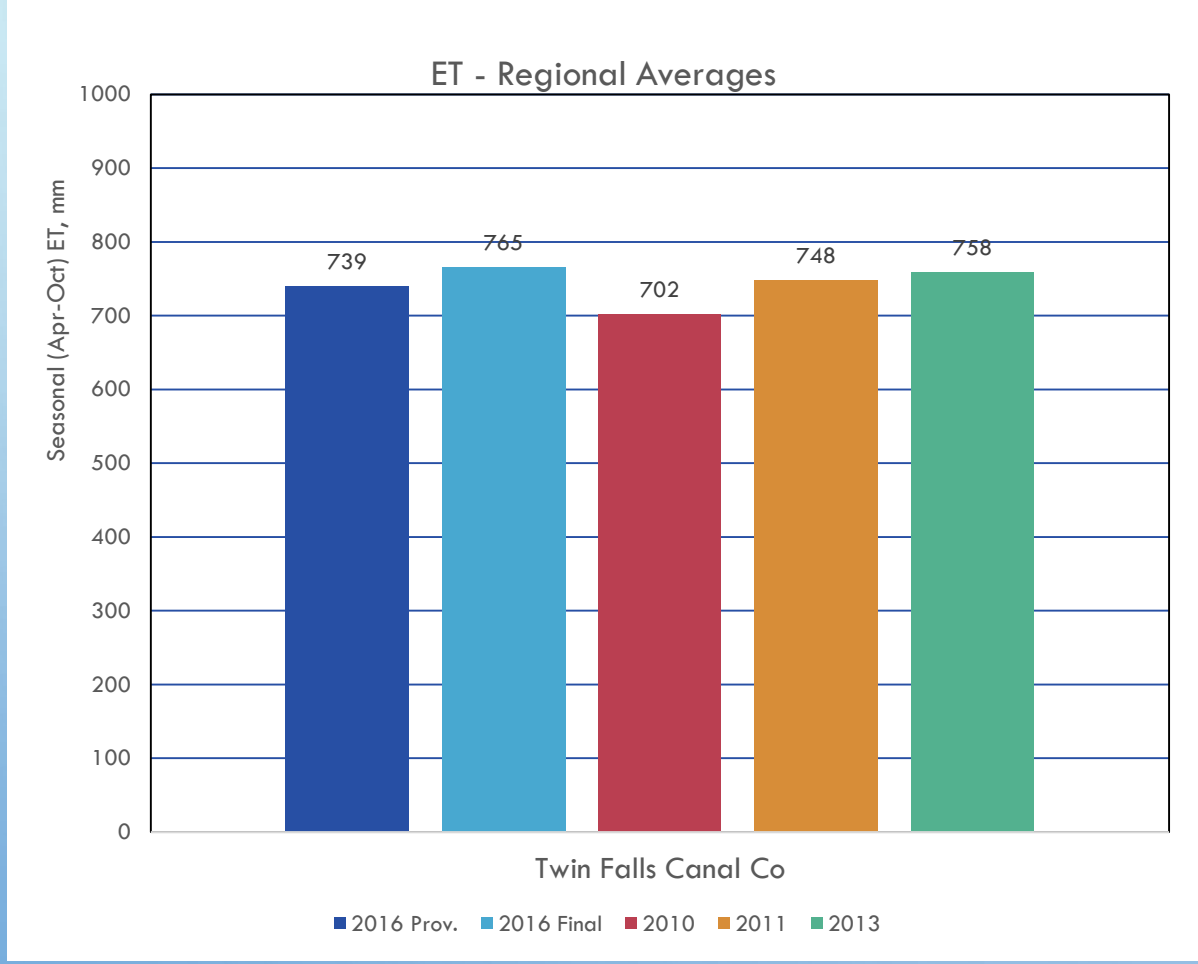


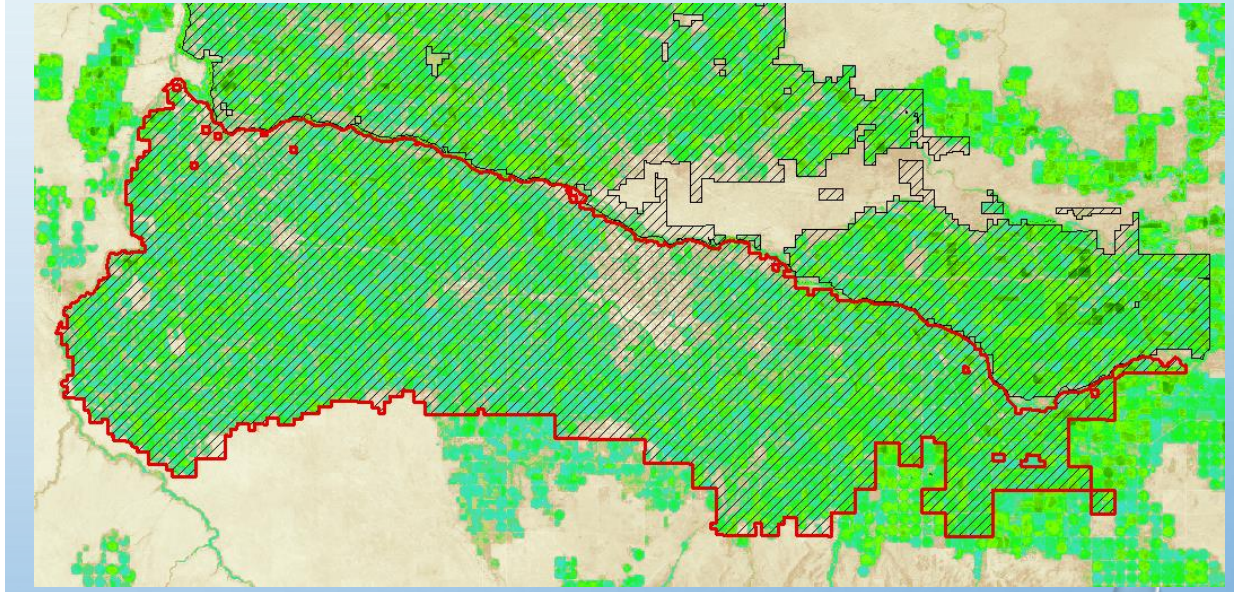
North Side Canal Co. Area



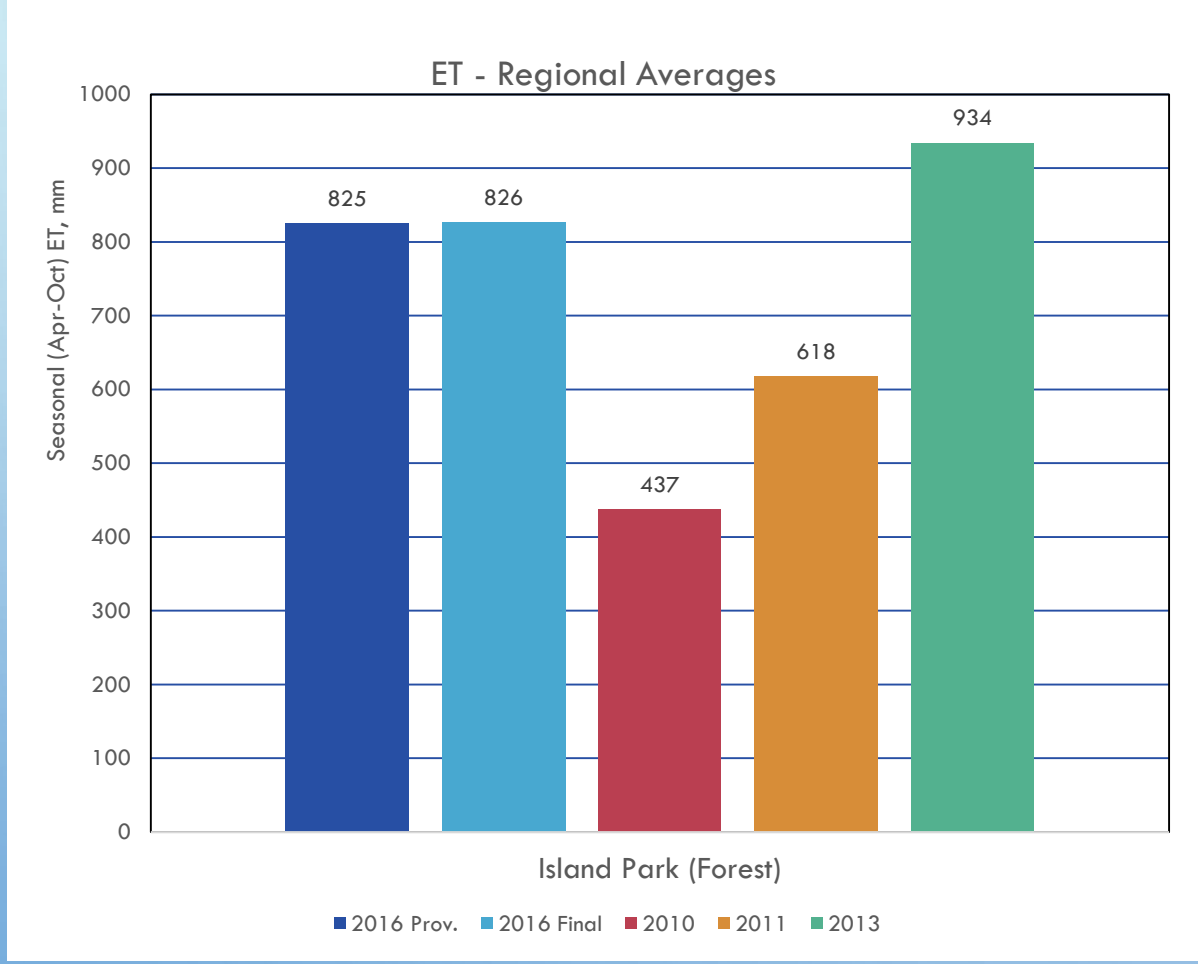


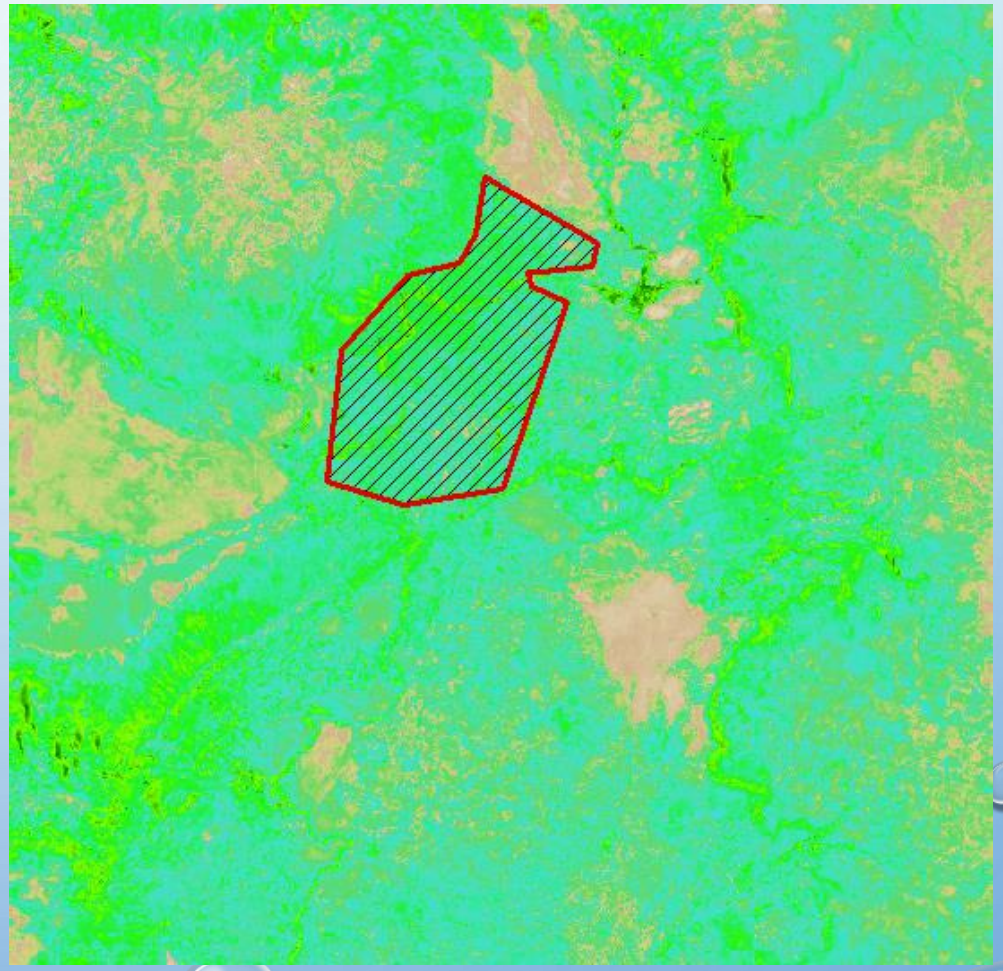
Twin Falls Canal Co. Area



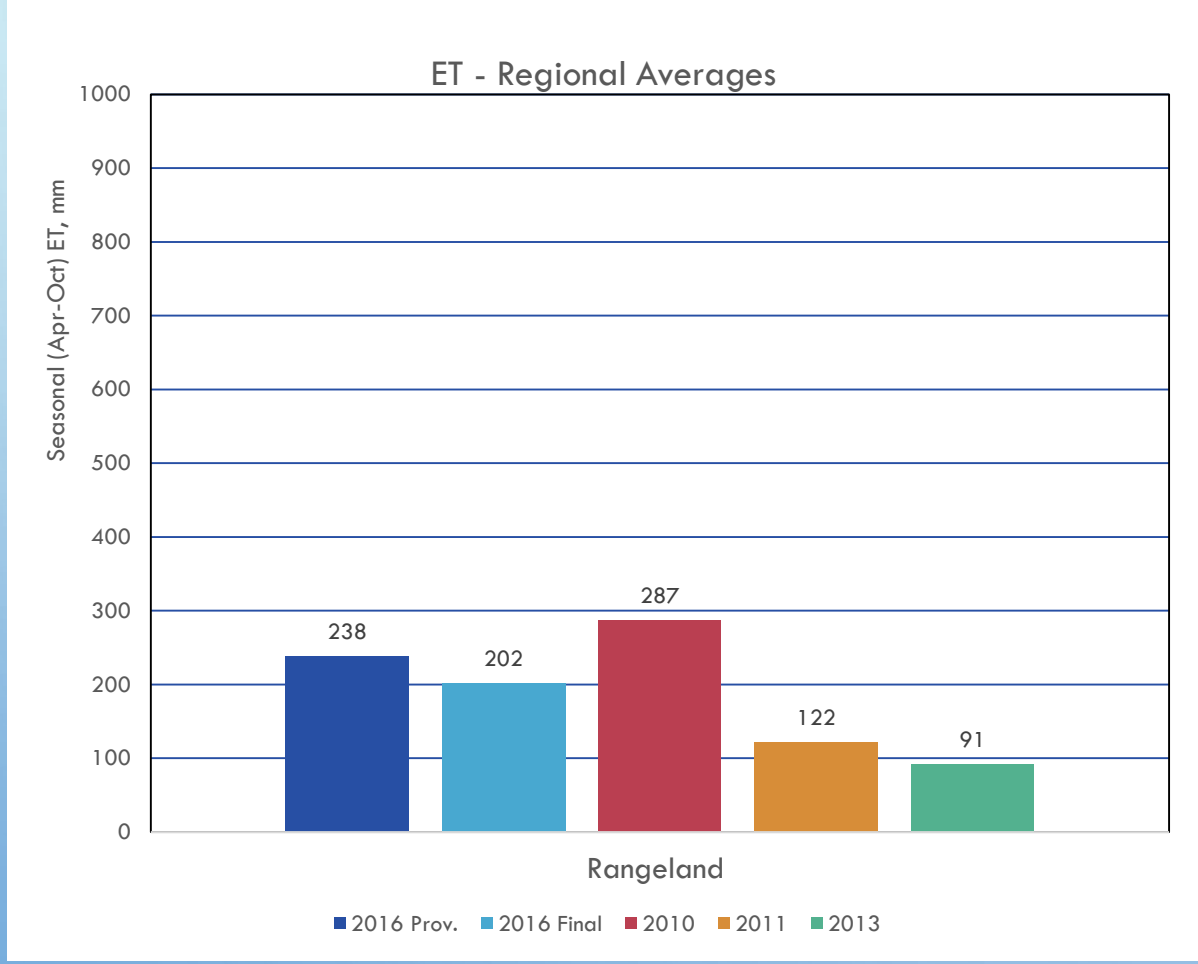


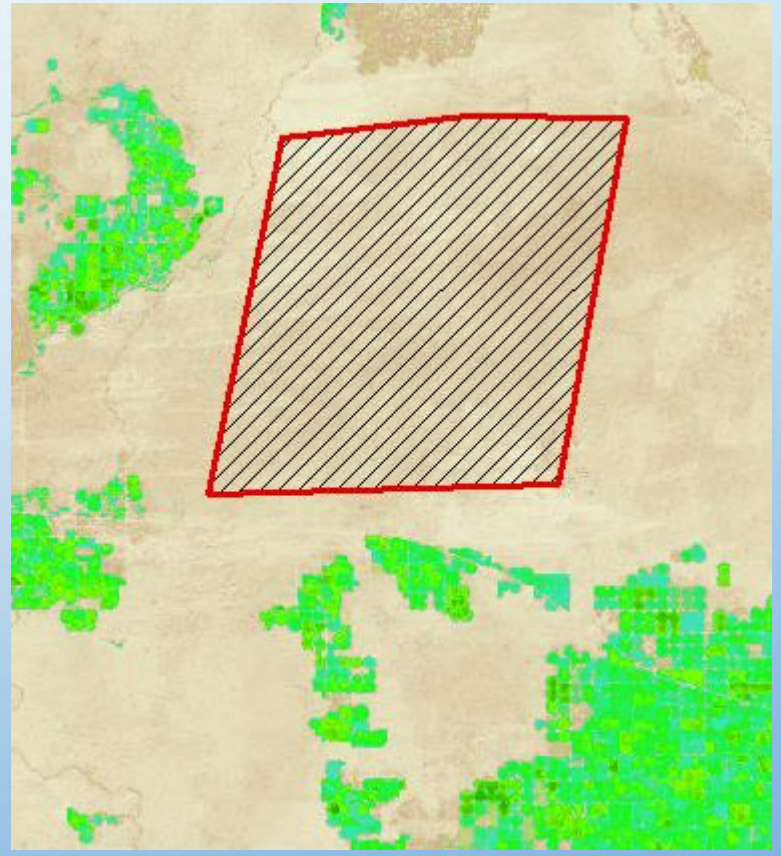
Island Park (Forest) Area



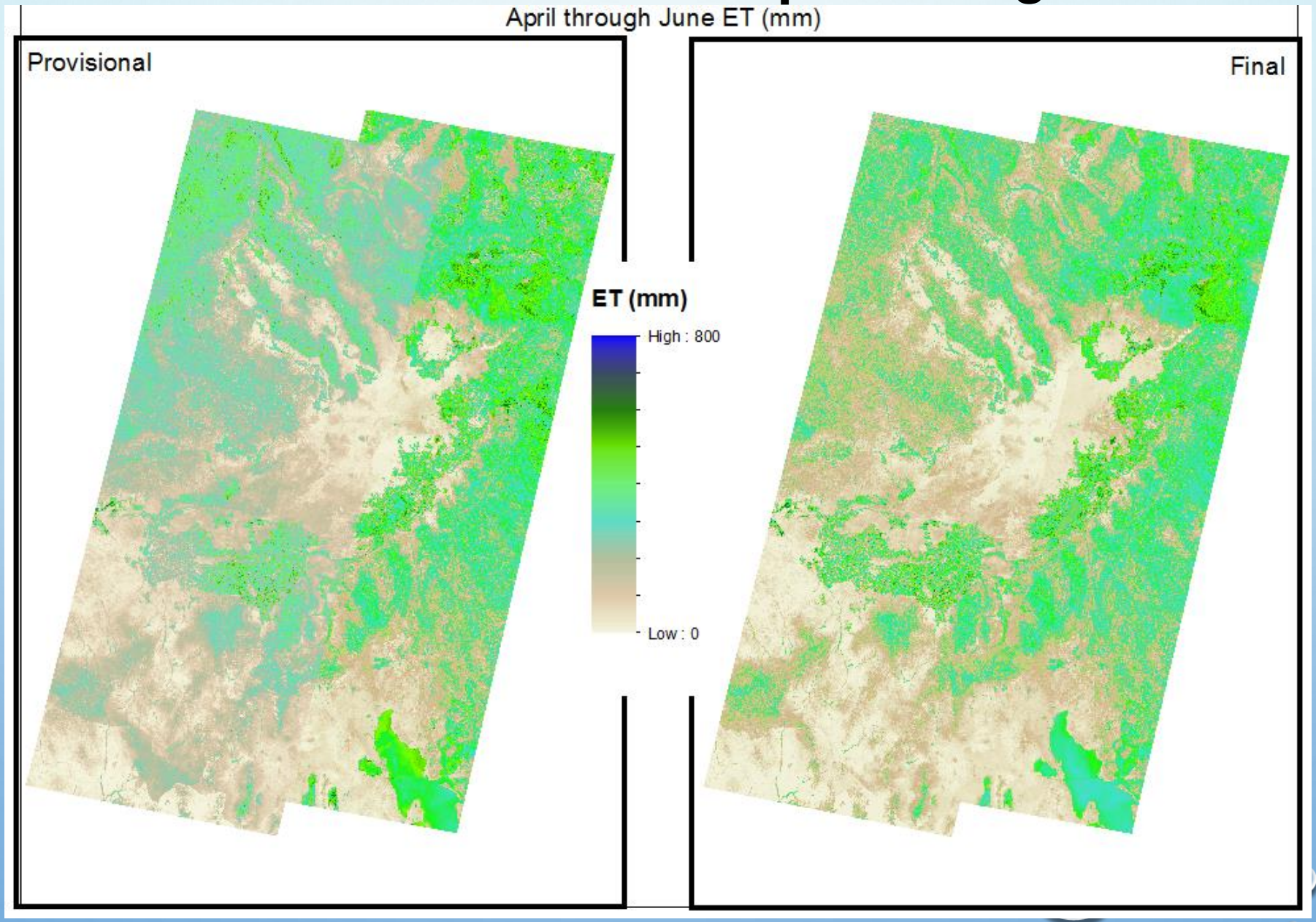


Rangeland/Desert Area



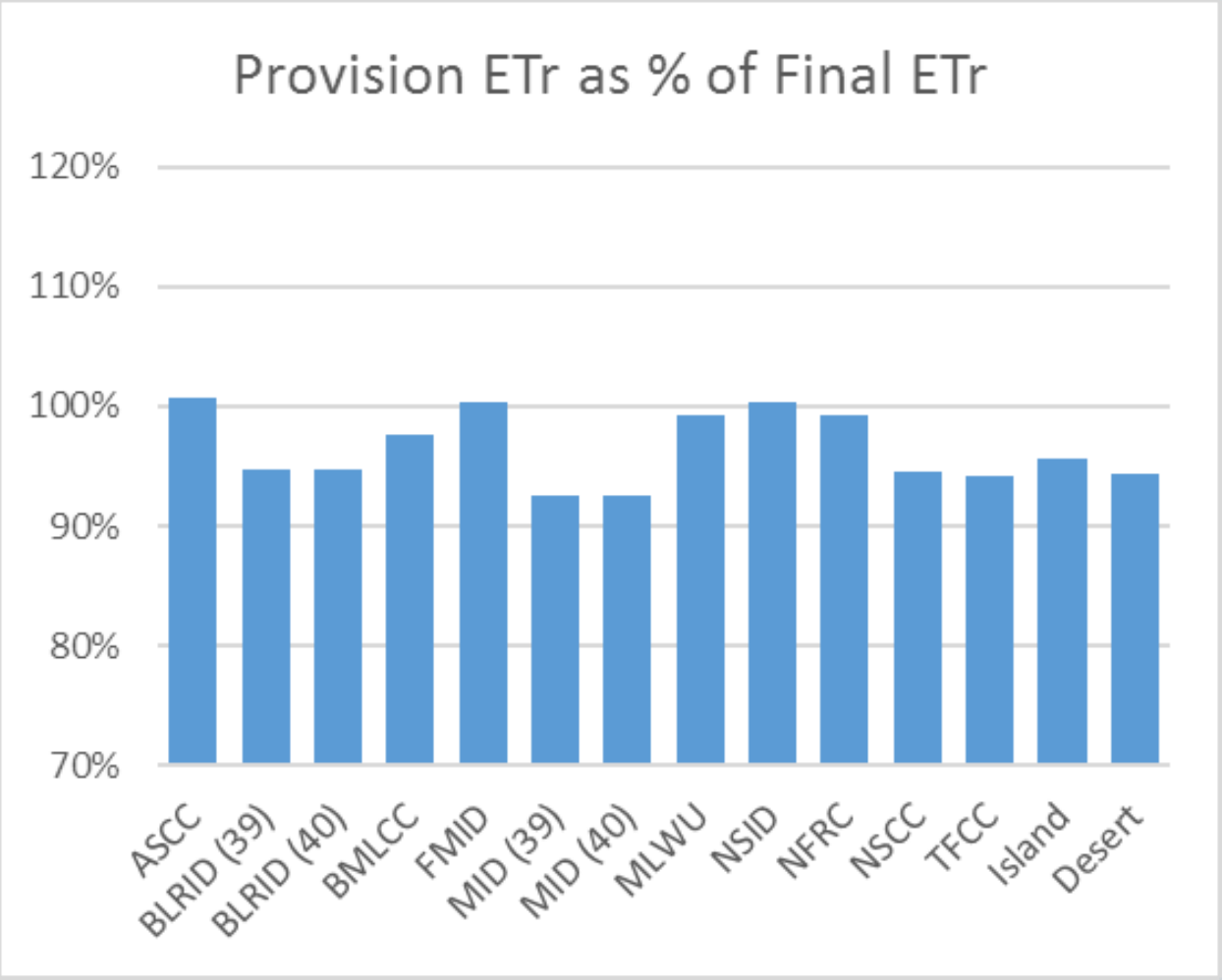


Provisional versus Final April through June



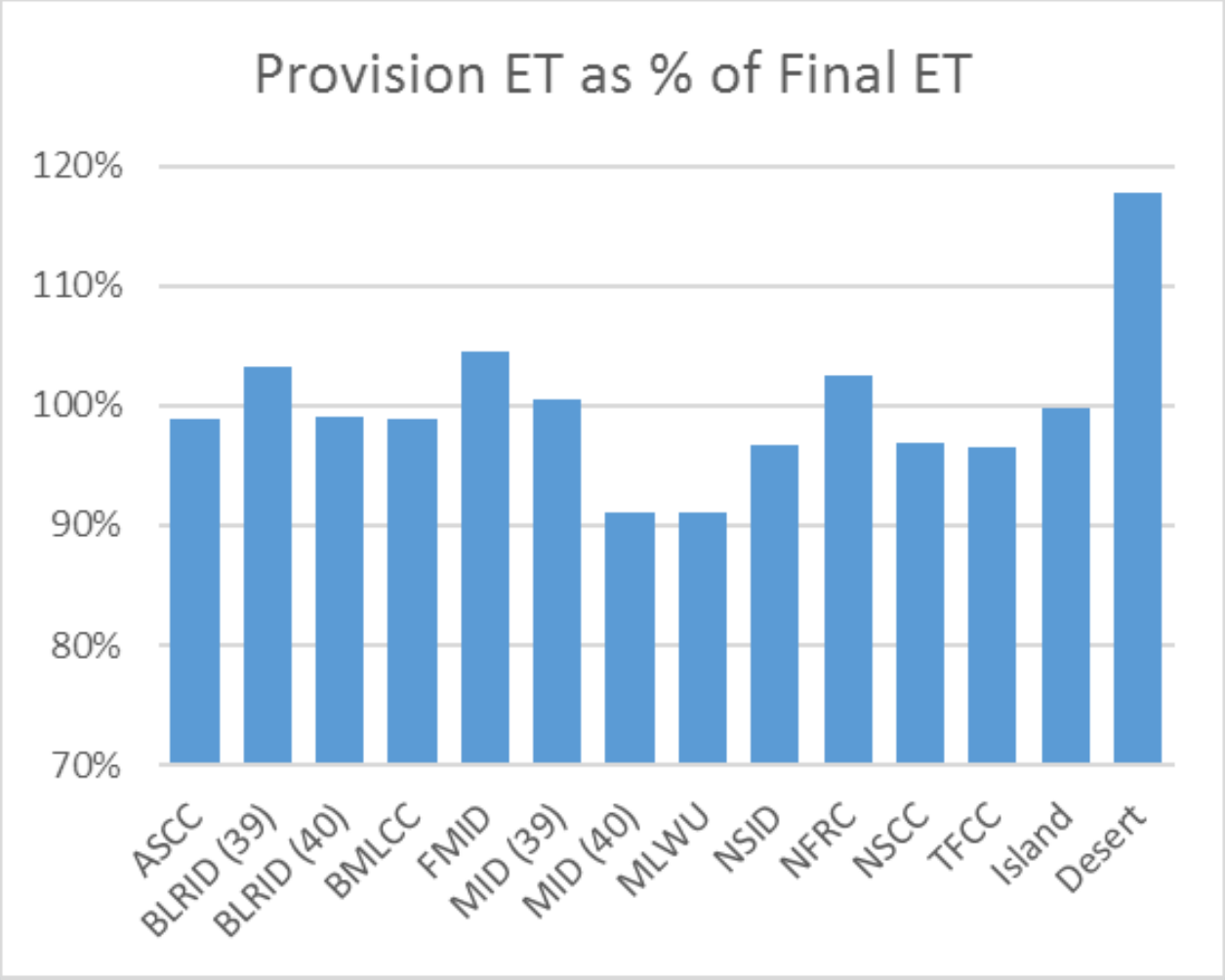
Provisional versus Final Seasonal ETr

	Seasonal ETr (mm)		
	Apr thru Oct 2016		
	Provisional	Final	% of Final
Aberdeen Springfield Canal Co	1361	1351	101%
Big Lost River Irrigation Dist (P39)	1293	1364	95%
Big Lost River Irrigation Dist (P40)	1293	1364	95%
Butte & Market Lake Canal Co	1304	1335	98%
Fremont Madison Irrigation Dist.	1302	1297	100%
Minidoka Irrigation Dist. (P39)	1292	1396	93%
Minidoka Irrigation Dist. (P40)	1292	1396	93%
Mud Lake Water Users Inc.	1274	1284	99%
New Sweden Irrigation Dist.	1251	1247	100%
North Fork Reservoir Co	1359	1369	99%
North Side Canal Co	1310	1387	94%
Twin Falls Canal Co	1252	1330	94%
Island Park (Forest)	1308	1369	96%
Rangeland	1316	1395	94%



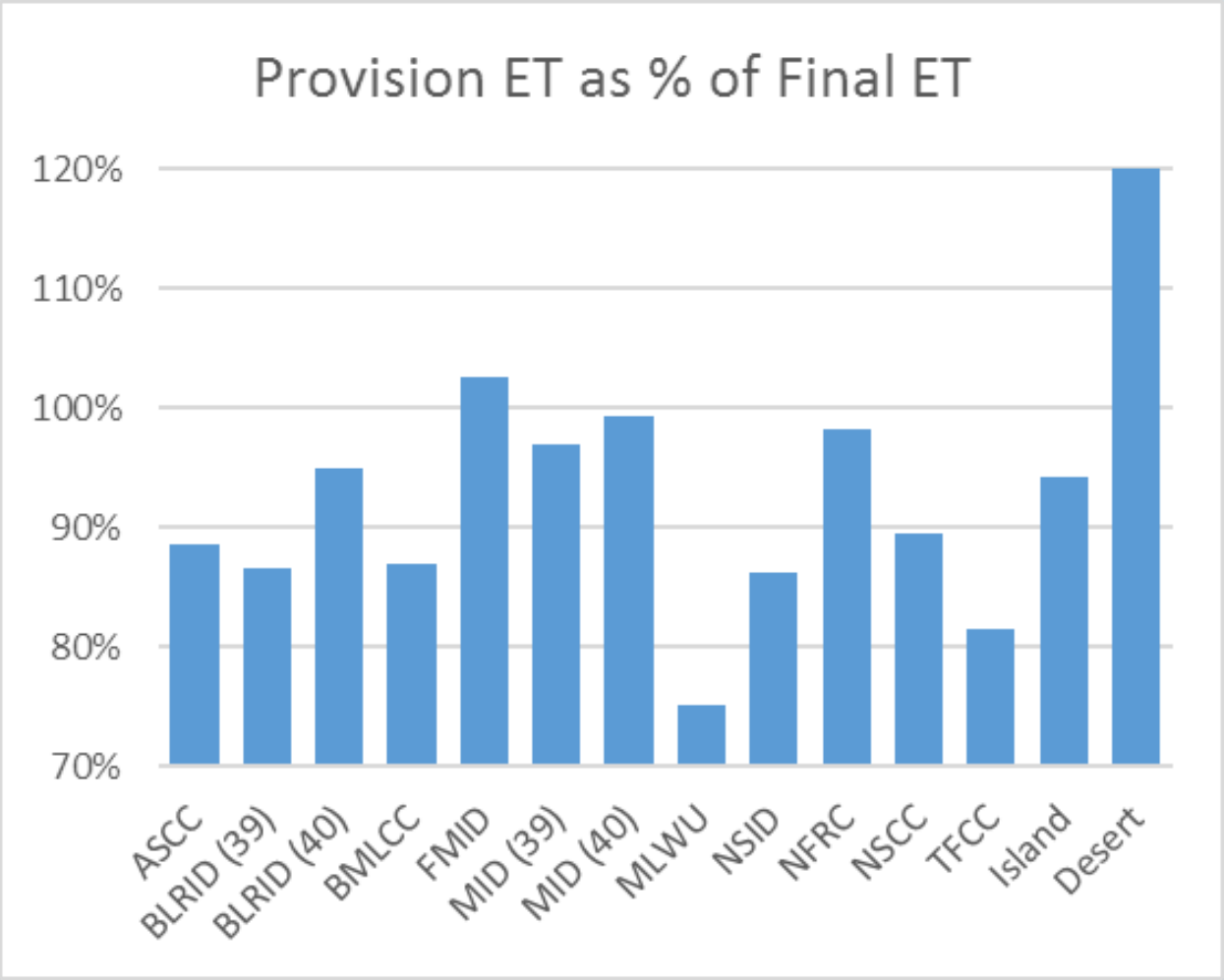
Provisional versus Final Seasonal ET

	Seasonal ET (mm)		
	Apr thru Oct 2016		
	Provisional	Final	% of Final
Aberdeen Springfield Canal Co	868	878	99%
Big Lost River Irrigation Dist (P39)	485	470	103%
Big Lost River Irrigation Dist (P40)	504	509	99%
Butte & Market Lake Canal Co	707	715	99%
Fremont Madison Irrigation Dist.	683	653	105%
Minidoka Irrigation Dist. (P39)	818	813	101%
Minidoka Irrigation Dist. (P40)	808	888	91%
Mud Lake Water Users Inc.	789	867	91%
New Sweden Irrigation Dist.	747	773	97%
North Fork Reservoir Co	751	733	102%
North Side Canal Co	753	777	97%
Twin Falls Canal Co	739	765	97%
Island Park (Forest)	825	826	100%
Rangeland	238	202	118%



Provisional versus Final April-June ET

	Period ET (mm)		
	April through June 2016		
	Provisional	Final	% of Final
Aberdeen Springfield Canal Co	325	367	89%
Big Lost River Irrigation Dist (P39)	180	208	87%
Big Lost River Irrigation Dist (P40)	172	181	95%
Butte & Market Lake Canal Co	269	309	87%
Fremont Madison Irrigation Dist.	311	303	103%
Minidoka Irrigation Dist. (P39)	314	324	97%
Minidoka Irrigation Dist. (P40)	324	326	99%
Mud Lake Water Users Inc.	285	379	75%
New Sweden Irrigation Dist.	315	365	86%
North Fork Reservoir Co	325	331	98%
North Side Canal Co	241	269	90%
Twin Falls Canal Co	225	276	82%
Island Park (Forest)	447	474	94%
Rangeland	172	116	148%



Causes of differences between provisional and final products

- Recalibration of METRIC images based following a second review.
- Discarding an image used in provisional image set.
- QAQC of weather data and re-computation of ETr surfaces.
- Improved cloud masking and filling of cloud areas.
- Sharpening of thermal data for Landsat 8.

QUESTIONS -- COMMENTS

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