Montana Water Supply Initiative
Method for Estimating ET and Consumptive Use

Montana State Library: Troy Blandford and Gerry Daumiller
DNRC: Chuck Dalby and Russ Levens
Retiree: Bill Greiman

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- Intro: why the DNRC/MSL partnership
- Background/impetus for the project
- Workflow
- Concept
- Challenges encountered
- Results
- What’s next

MONTANA State Library

Information Services

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State Publications

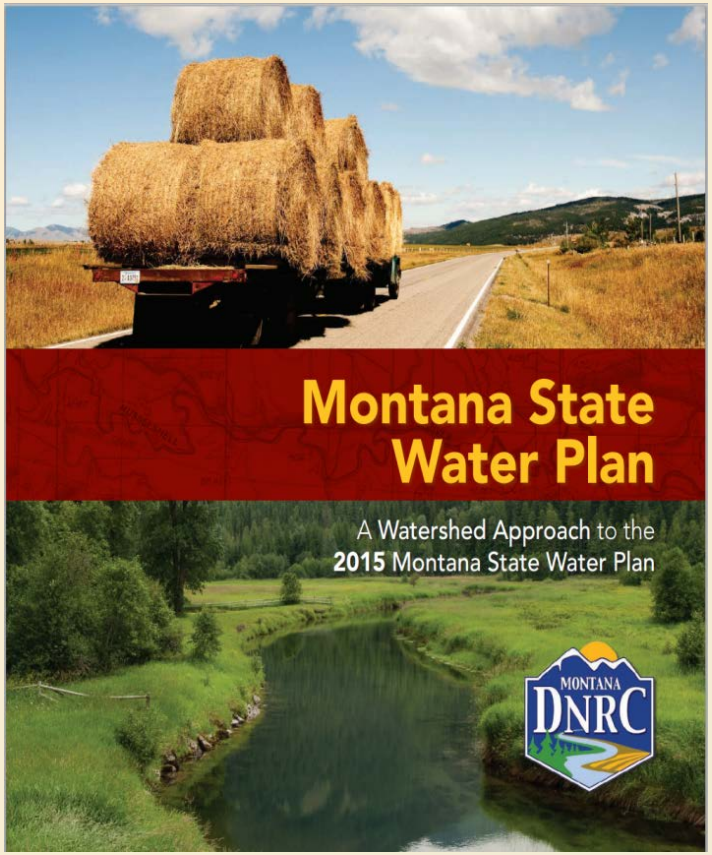
Geographic Information

Natural Heritage Program

NRIS

Water Information System

Background: Impetus for the ET Project



<u>Challenges</u>

- Big scope
- Relatively short timeframe
- Few additional $ and resources

<u>Therefore;</u>

- Rapid approach required
- Purpose - Overview/planning
- Build on previous work and available resources

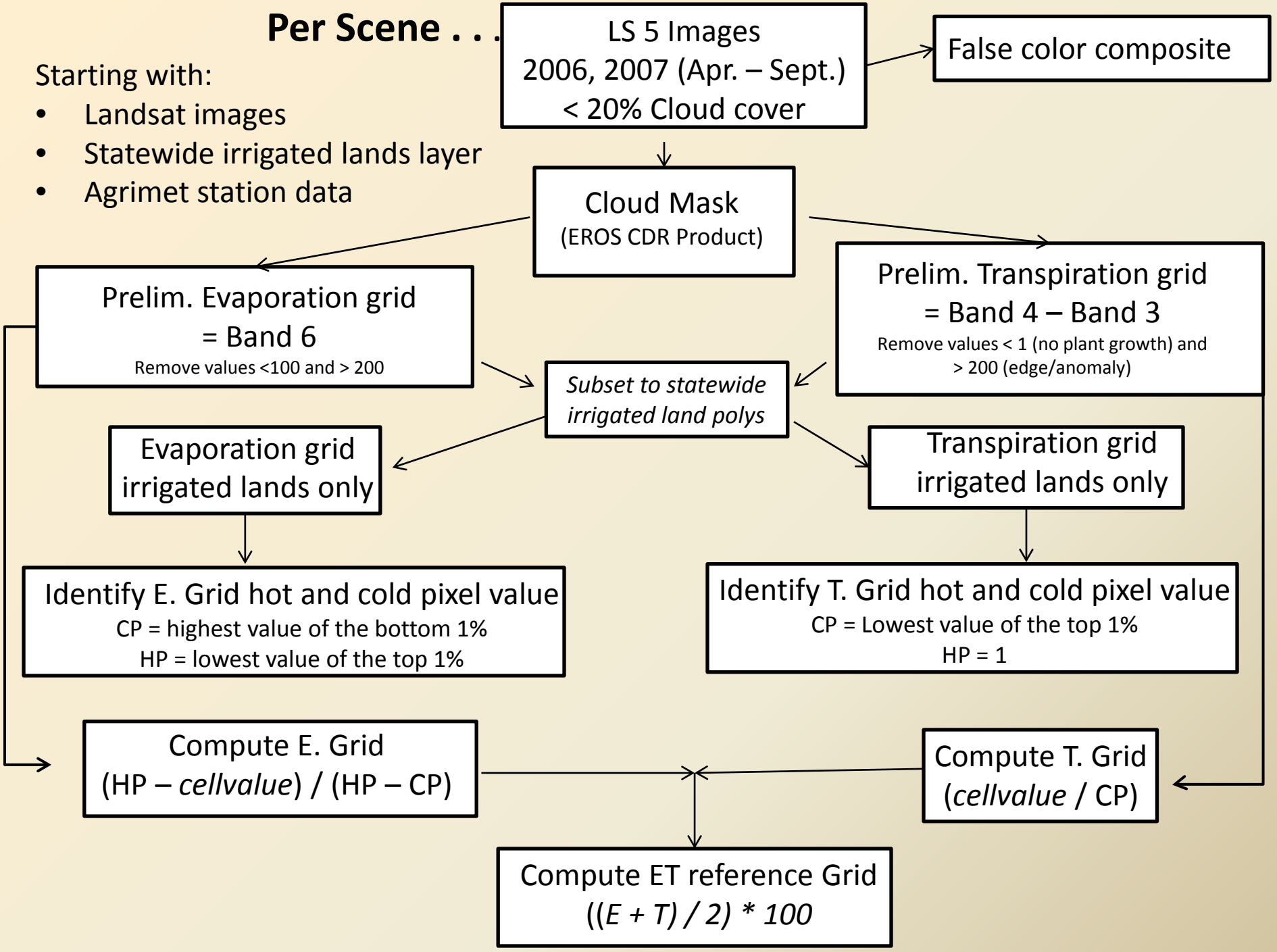
Goal: A *reasonable* statewide estimate of water use for irrigated lands (with potential for subbasin and land-use/field-level review)

- A documented, repeatable process (resident expert Bill was nearing retirement)
- Better spatial representation (gridded) than previous DNRC consumptive use approach
- Better resolution than MODIS
- Easily rerun for any month(s) or year(s)
- A preliminary-look, proof-of-concept

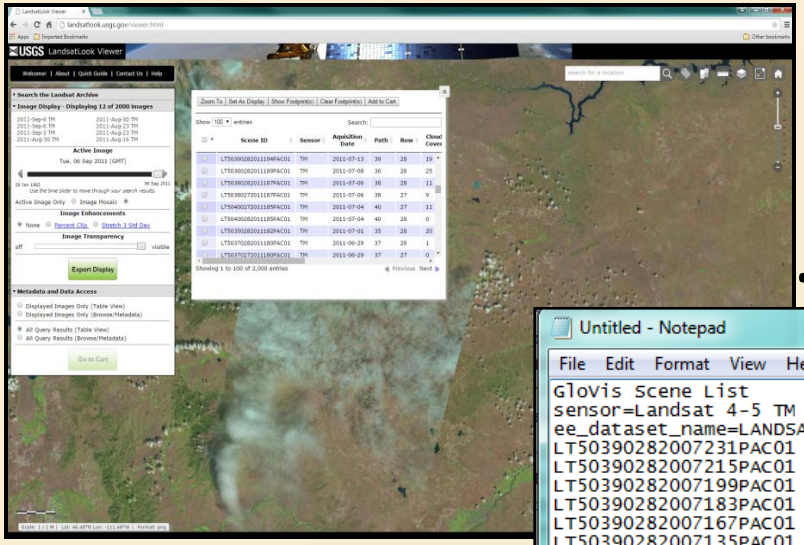
Per Scene . . .

Starting with:

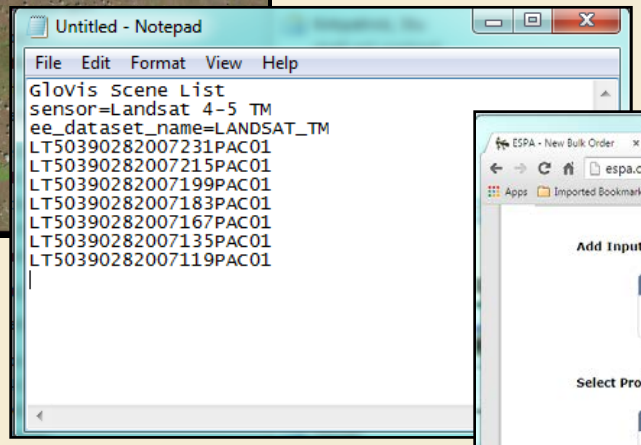
- Landsat images
- Statewide irrigated lands layer
- Agrimet station data



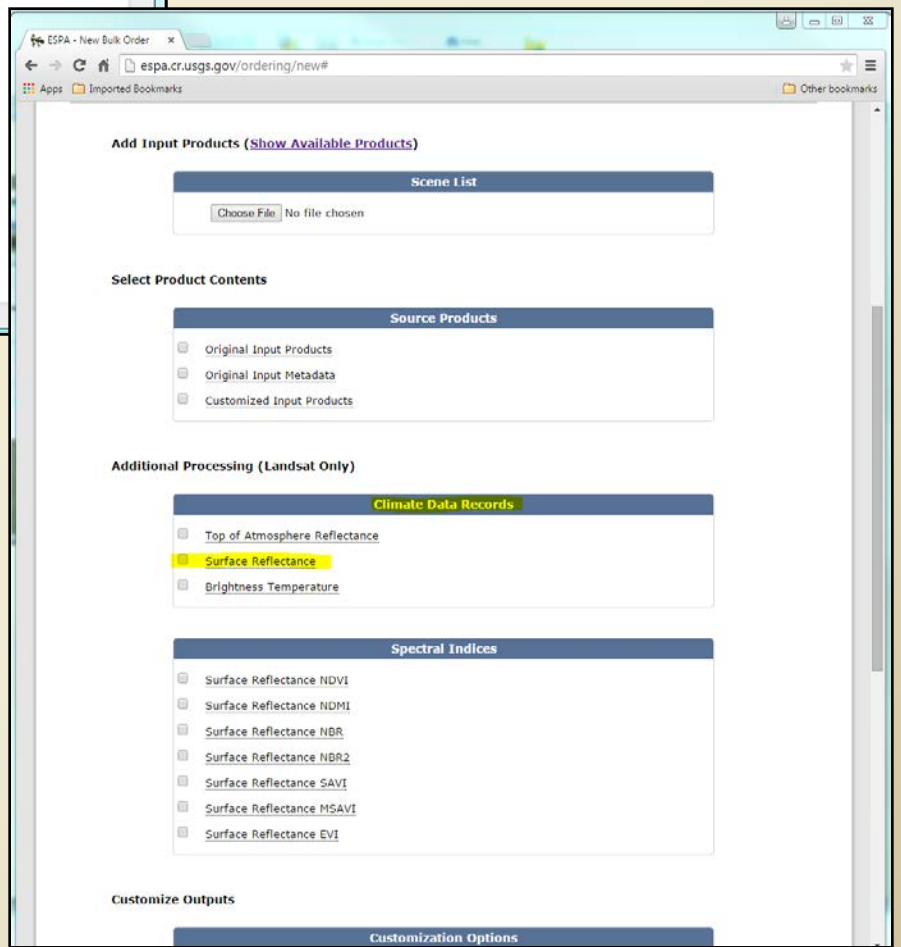
LANDSAT LOOK



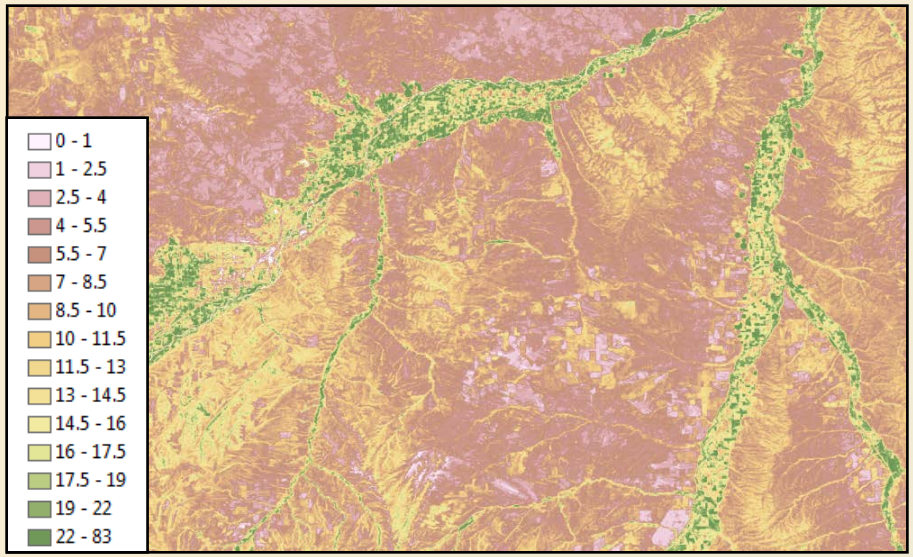
.txt list of images



ESPA bulk order

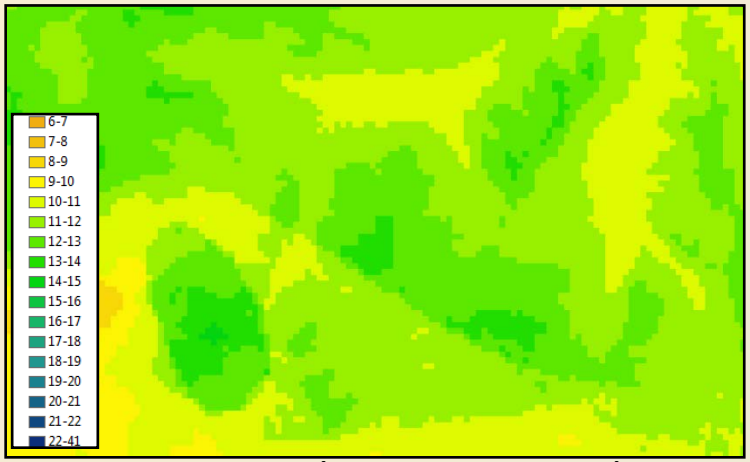


ET estimate = (Etref) x (Agrimet ET for day and time of image acquisition)

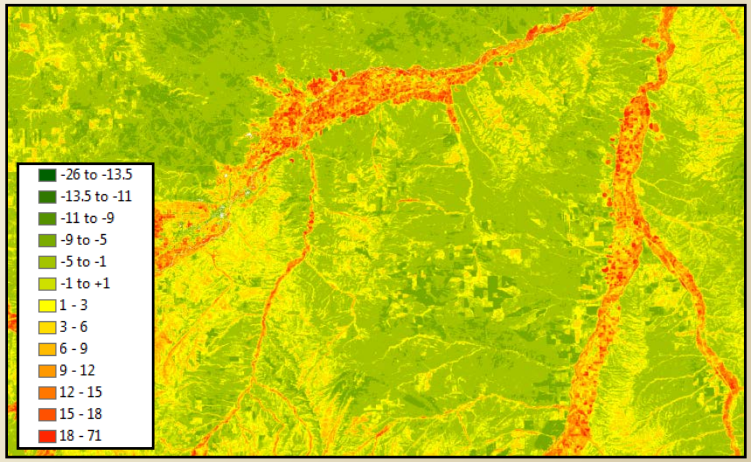


middle Yellowstone

Subtract gridded precip (DAYMET, PRISM from MT Climate Office) to estimate water use



2007 pcp (MCO, DAYMET)



Consumptive water use

Call it what it is . . .

What it is not?

A surface energy balance model

So what is it?

A vegetation index with "some-sort-of-a thermal band adjustment"

Challenges

For a pixel, we have daily values for potential evapotranspiration from AgriMet stations, but we only figured the ET fractions and water use for dates which have Landsat images.

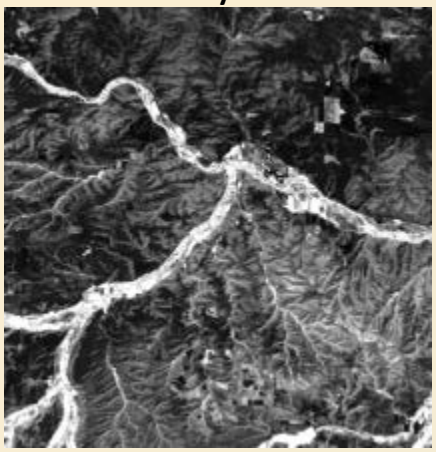
Date	7/1/2007	7/2/2007	7/3/2007	7/4/2007	7/5/2007	7/6/2007	7/7/2007	7/8/2007	7/9/2007	7/10/2007
Potential ET, inches	0.37	0.34	0.39	0.38	0.35	0.26	0.28	0.35	0.32	0.32
ET Fraction			0.78			0.88			0.84	
Estimated ET, inches			0.3042			0.2288			0.2688	

To estimate the actual evapotranspiration, we must assign ET fractions to the missing dates. We have decided to use the ET fraction from the image with the closest date.

Date	7/1/2007	7/2/2007	7/3/2007	7/4/2007	7/5/2007	7/6/2007	7/7/2007	7/8/2007	7/9/2007	7/10/2007	TOTAL
Potential ET, inches	0.37	0.34	0.39	0.38	0.35	0.26	0.28	0.35	0.32	0.32	
ET Fraction	0.78	0.78	0.78	0.78	0.88	0.88	0.88	0.84	0.84	0.84	
Estimated ET, inches	0.2886	0.2652	0.3042	0.2964	0.308	0.2288	0.2464	0.294	0.2688	0.2688	2.769

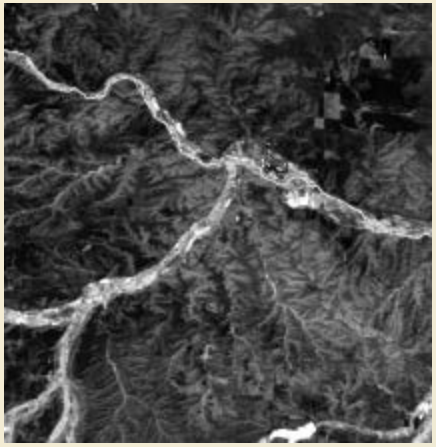
Because of clouds, we have to do spatial overlays to find out how far backwards and forwards in time to assign the ET fractions for each pixel from an image.

July 4

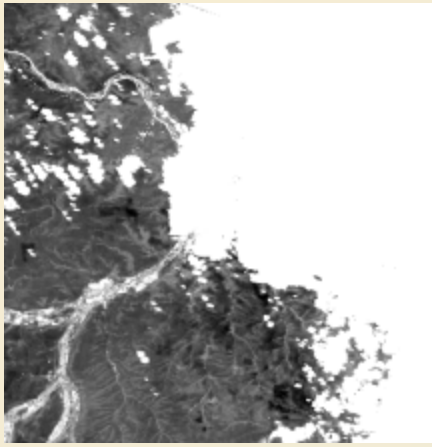


July 11

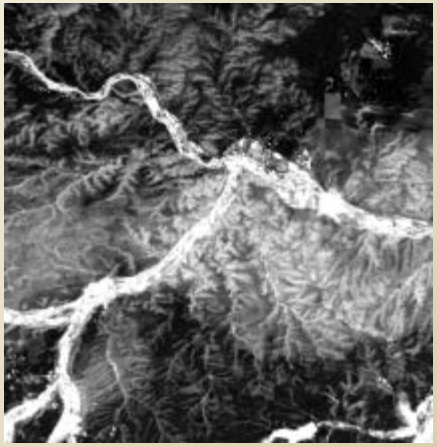
July 20



July 27

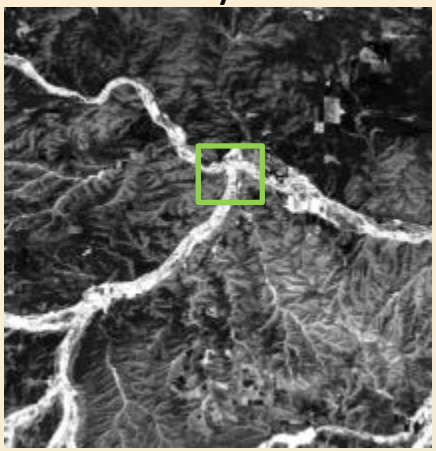


August 5

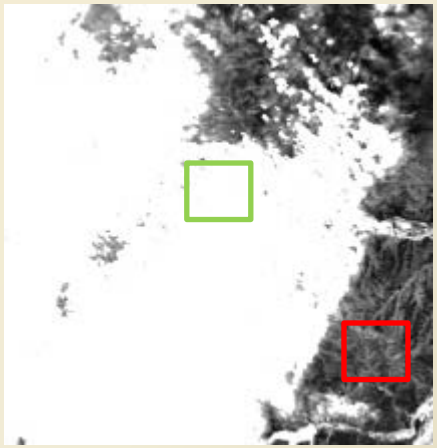


For the red square, the ET fractions for July 20th will be multiplied by the sum of potential ET values extending back to July 16th (midpoint between the 20th and 11th). For the green square, we have to sum ET values back to July 12th (midpoint between the 20th and the 4th).

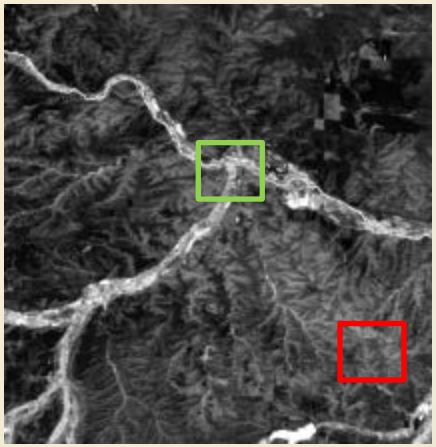
July 4



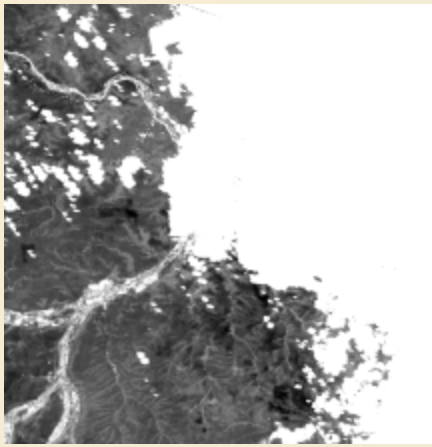
July 11



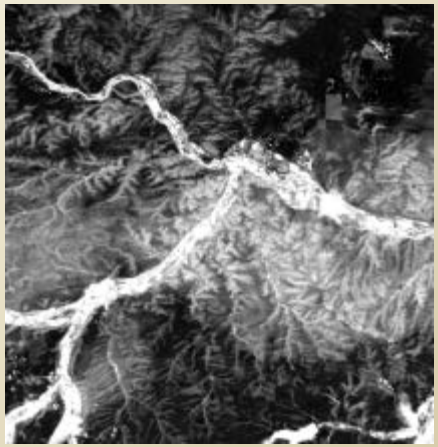
July 20



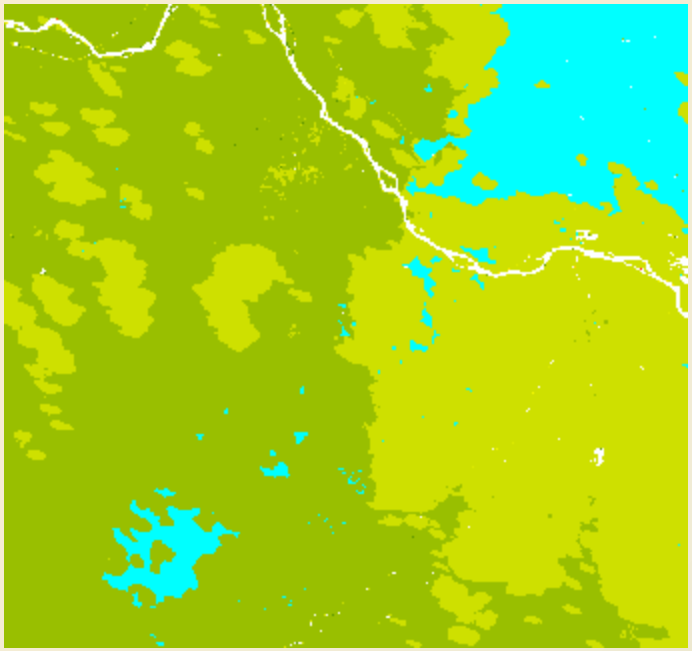
July 27



August 5



The results of the spatial analysis for a sample area show that the ET fractions in the highlighted region of the July 11 image will be multiplied by the sum of the Agrimet ET values for July 7 – July 15. The script has looked up the values for those dates and summed them, and the result is 2.54 inches.

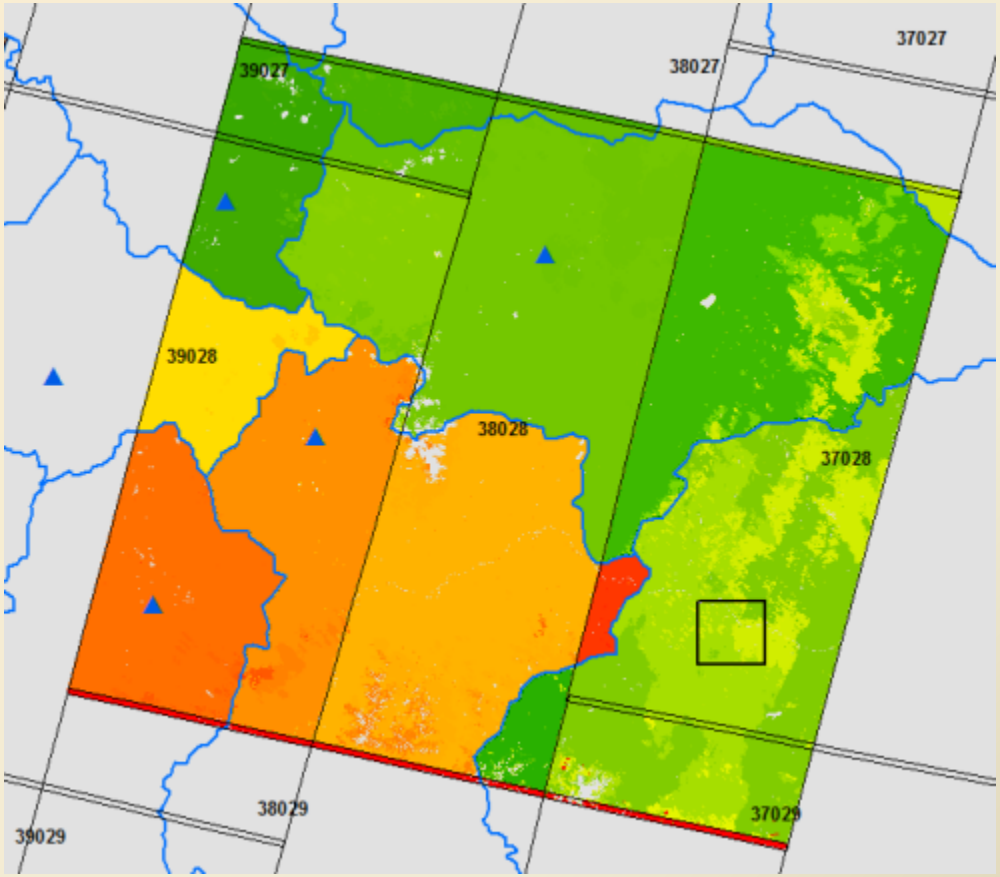


Zones3828_0711.tif

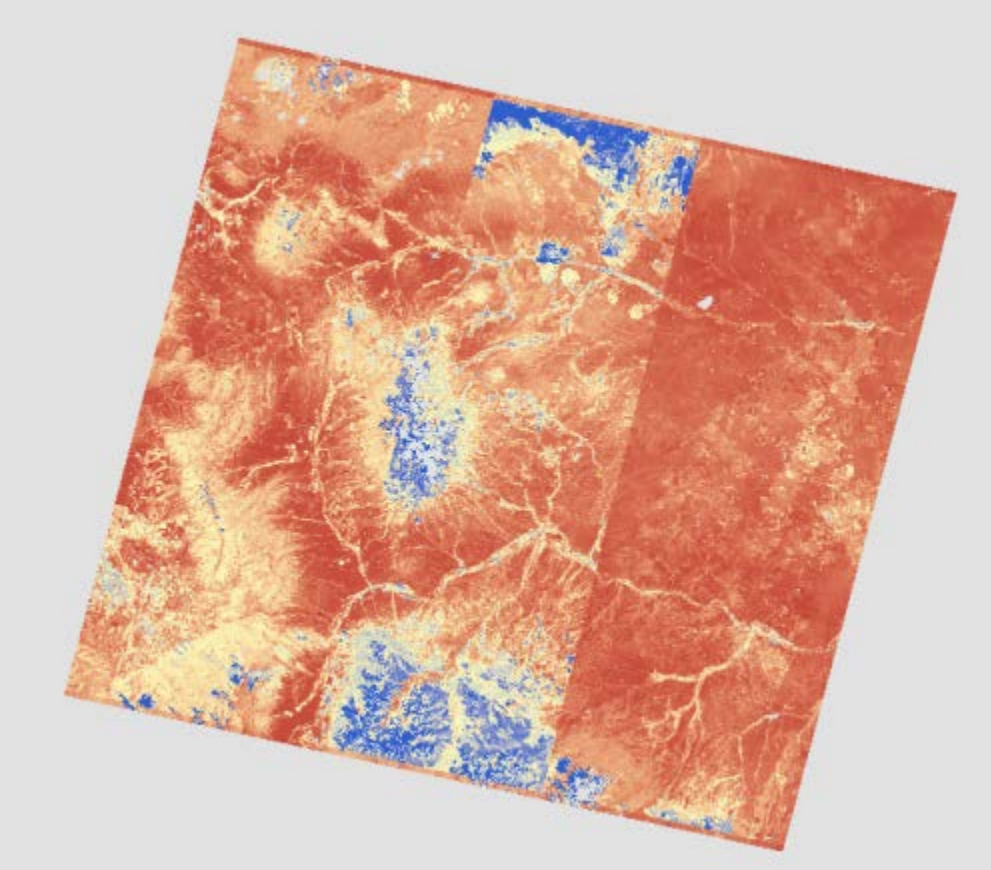
OID	VALUE	COUNT	START_DAY	END_DAY	STATION	ALFP
51	52	1076	20070706	20070727	UMHM	6.84
52	53	666661	20070707	20070715	UMHM	2.54
53	54	56	20070706	20070930	UMHM	23.12

1 (1 out of 278 Selected)

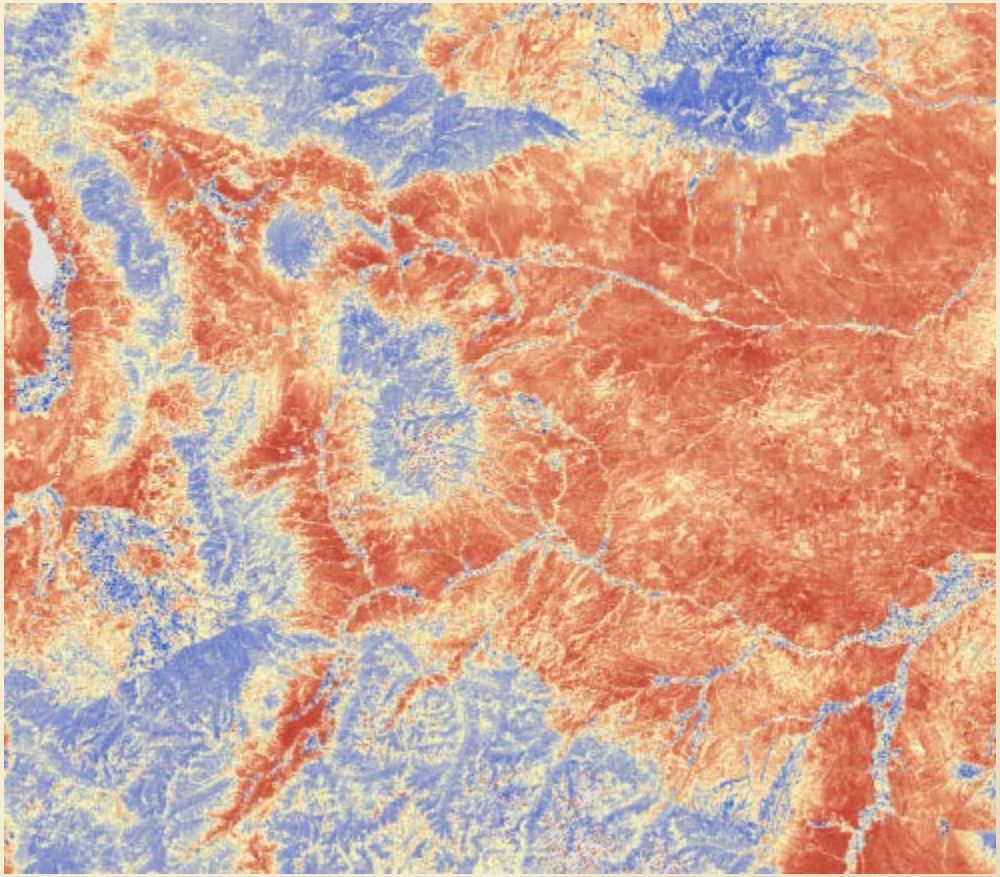
The spatial analysis of the entire image shows that it has been segmented by the presence of adjacent scenes, by the regions each Agrimet station data is being applied to, and by the presence of clouds in earlier and later images. Each region (color) represents a different range of dates and agrimet station



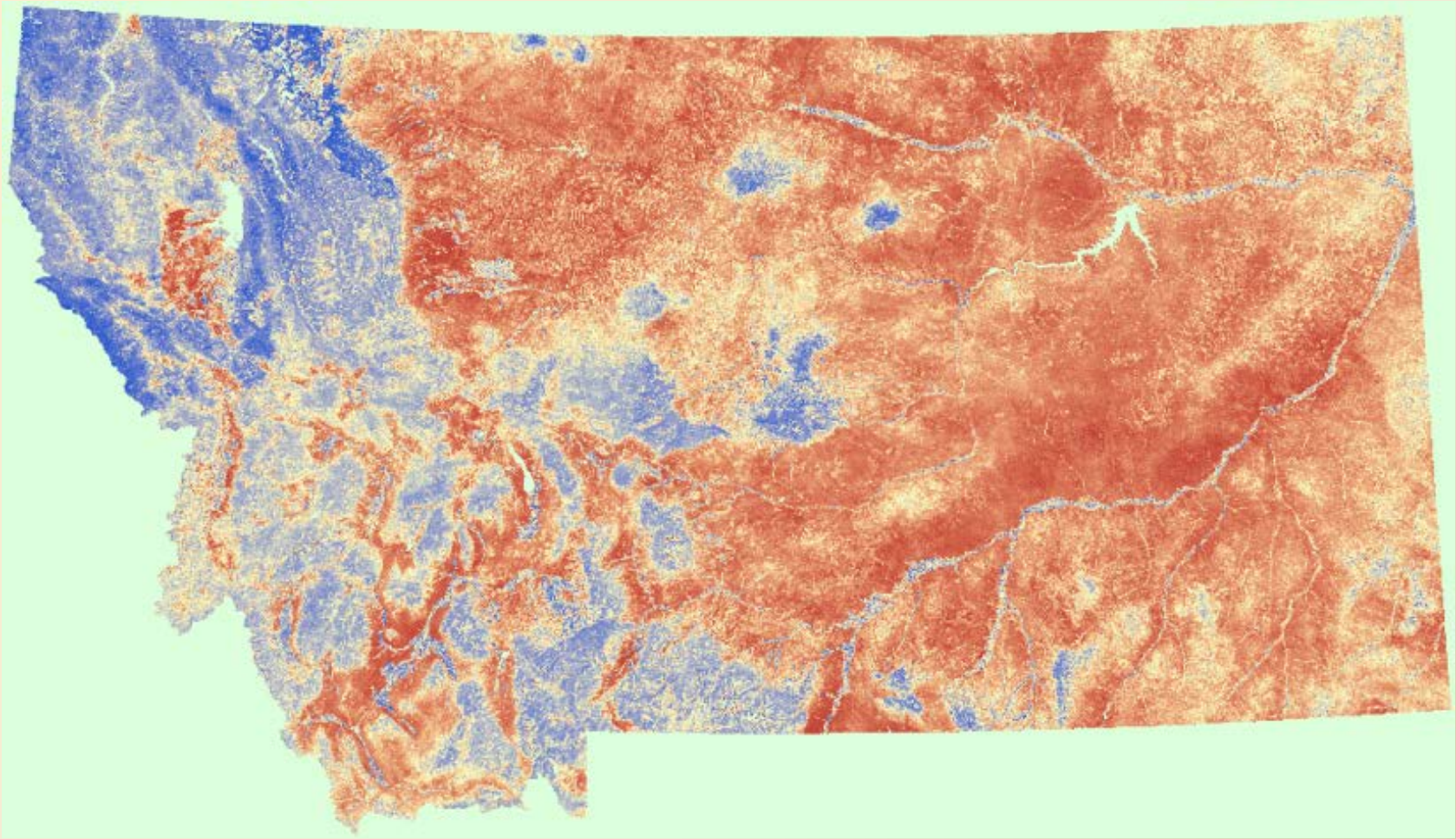
When the ET fractions for the image are multiplied by the Agrimet ET data totals, it shows more estimated ET in the center of the image. This is because there are fewer images covering the center and the ET fraction values from the center of the image are being applied to a greater number of dates.



When you sum the estimated ET results from all the images for all of the scenes, it produces a relatively seamless map.



For 162 images covering Montana for the 2007 season, it takes about 9 hours to calculate the ET fractions and about 46 hours to analyze the overlaps among the images, estimate the ET for each image, and add them all up.



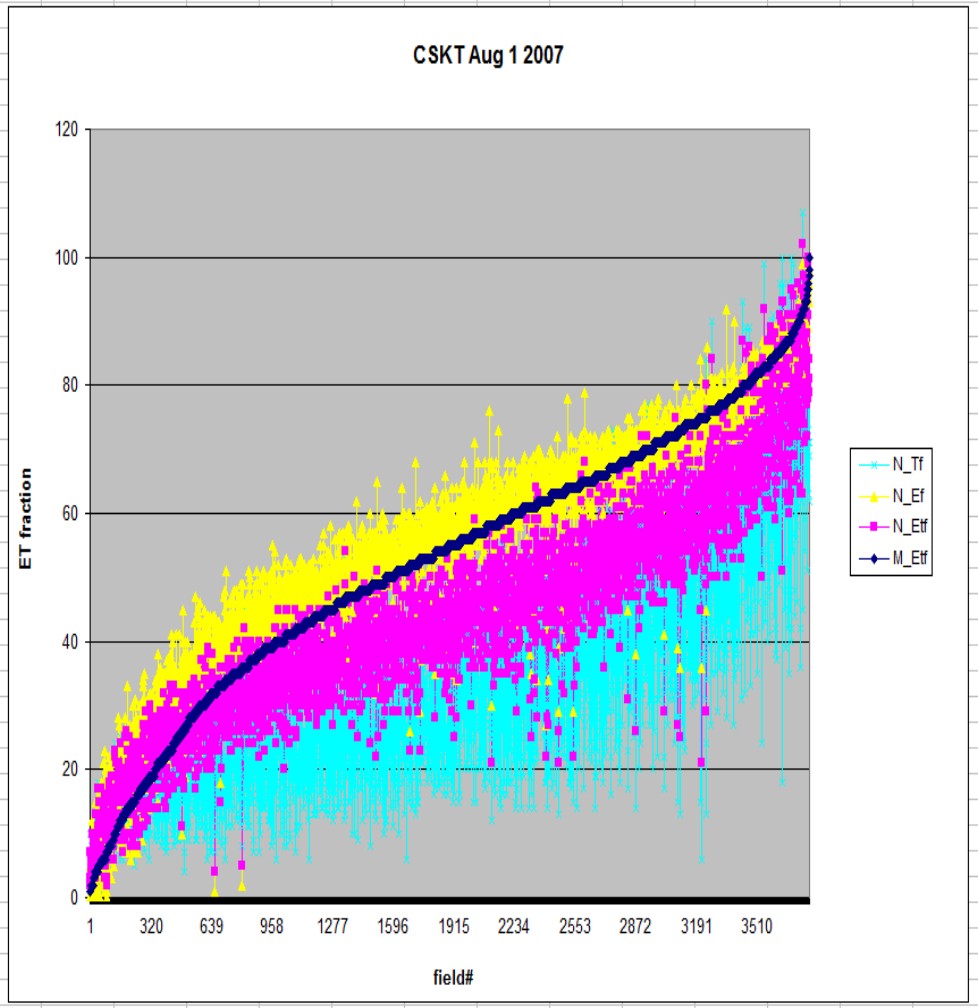
Flathead Results

Microsoft Excel - CSKT_irr_070801.xls

File Edit View Insert Format Tools Chart Window Help

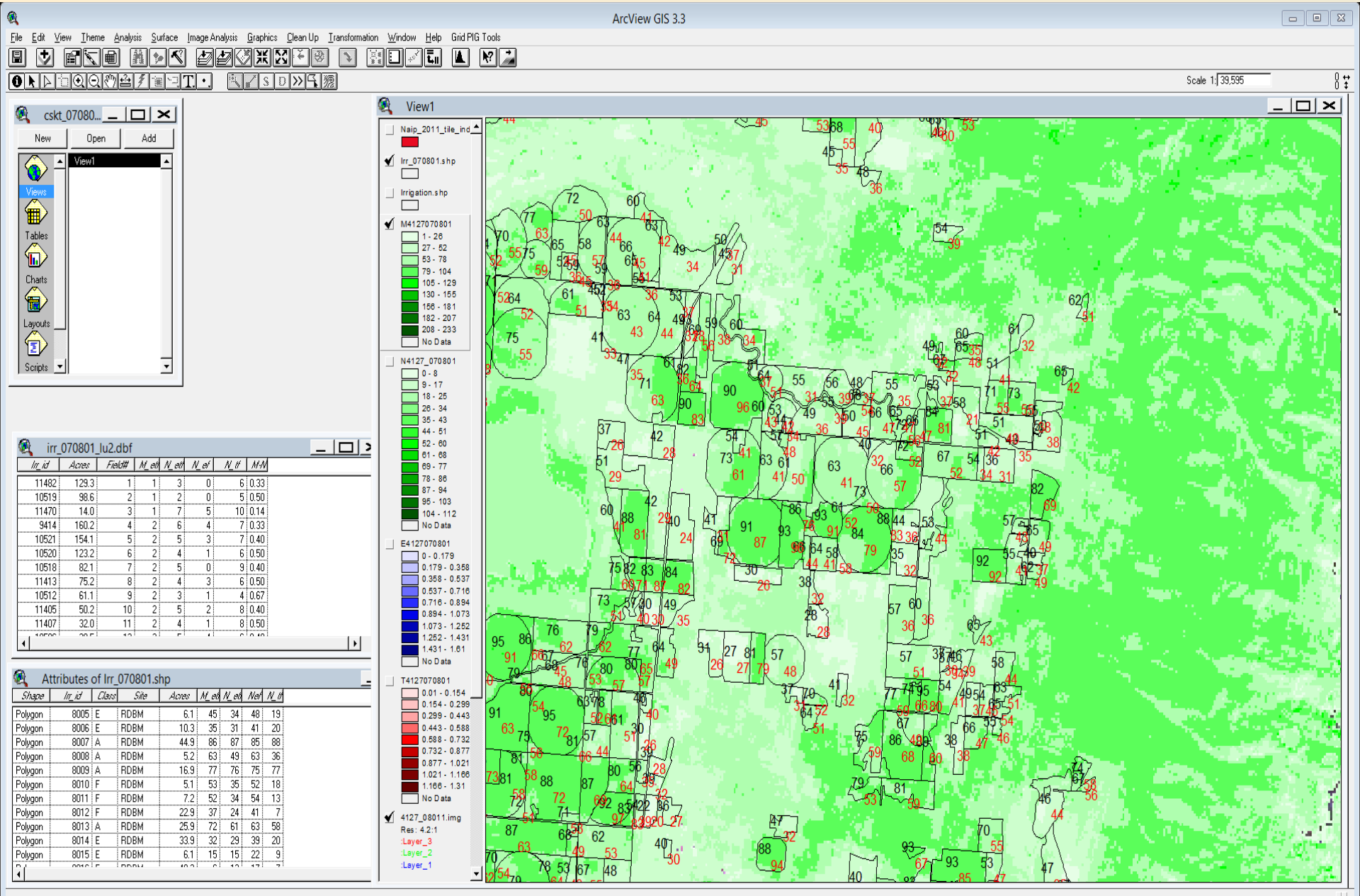
Chart Area

	A	F	G	H	I	J	K	L	M
1	IRR_ID	M_Etf	N_Etf	N_Ef	N_Tf		N_Etf	N_Ef	N_Tf
2	11482	1	3	0	6				
3	10519	1	2	0	5	RSQ	0.87	0.94	0.63
4	11470	1	7	5	10	SKEW	0.02	0.45	0.31
5	9414	2	6	4	7				
6	10521	2	5	3	7				
7	10520	2	4	1	6				
8	10518	2	5	0	9				
9	11413	2	4	3	6				
10	10512	2	3	1	4				
11	11405	2	5	2	8				
12	11407	2	4	1	8				
13	10506	2	5	4	6				
14	10504	2	6	4	7				
15	11358	2	10	12	8				
16	10978	2	5	2	9				
17	10644	2	4	2	6				
18	11395	3	8	11	4				
19	11375	3	3	3	3				
20	10510	3	9	10	9				
21	9373	3	5	2	8				
22	11364	3	7	8	7				
23	8959	3	4	3	6				
24	10507	3	5	1	10				
25	9424	3	5	1	8				
26	11415	3	3	1	5				
27	11144	3	9	7	13				
28	11469	4	5	4	6				
29	11390	4	4	3	4				
30	8353	4	4	1	8				
31	9675	4	13	15	10				
32	8307	4	7	9	5				
33	8819	4	3	0	6				
34	8308	4	7	9	5				
35	10016	4	6	6	7				
36	8354	4	8	7	8				
37	12842	4	9	9	10				
38	10508	4	4	1	8				
39	11433	4	6	5	8				
40	12841	4	10	11	9				
41	10217	4	17	15	18				
42	11409	4	8	7	9				
43	8021	4	5	6	5				
44	11475	5	11	7	15				
45	9415	5	4	1	7				



irr_070801

Ready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:Layer_2
:Layer_1
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Attributes of Irr_070801.shp

Smith Results

Microsoft Excel - sr_irr_070819.xls

	A	B	C	F	G	H	I	J	K	L	M	N
1	IRR CODE	SITE	IRR_ID	M_ETF	N_ETF	N_EF	N_TF			N_ETF	N_EF	N_TF
2	400	WSSM	110444	-33	6	0	12	-5.5	SLOPE	1.19	1.16	0.91
3	400	WSSM	96913	-28	5	0		5.60	RSQ	0.87	0.99	0.56
4	0	WSSM	29807	-27	3	0	7	9.00	SKEW	0.35	0.07	0.64
5	400	WSSM	110439	-25	9	2	16	2.78				
6	400	WSSM	35651	-25	8	0	17	3.13				
7	400	WSSM	97746	-24	8	0	15	3.00				
8	400	WSSM	35642	-23	9	0	18	2.56				
9	400	WSSM	71728	-23	9	3	13	2.56				
10	400	WSSM	29815	-23	4	0	8	5.75				
11	400	WSSM	110153	-20	4	0	8	5.00				
12	0	WSSM	28819	-20	4	0	7	5.00				
13	400	WSSM	110438	-19	13	4	21	1.46				
14	0	WSSM	28820	-19	4	0	9	4.75				
15	400	WSSM	110210	-18	6	2	10	3.00				
16	0	WSSM	29802	-18	6	0	11	3.00				
17	0	WSSM	70949	-18	3	0	7	6.00				
18	400	WSSM	110456	-17	5	1	9	3.40				
19	400	WSSM	35647	-16	12	2	22	1.33				
20	0	WSSM	70947	-16	4	1	7	4.00				
21	0	WSSM	29813	-16	4	1	7	4.00				
22	400	WSSM	35659	-15	7	0	13	2.14				
23	400	WSSM	110453	-15	5	2	9	3.00				
24	400	WSSM	110449	-15	5	1	10	3.00				
25	0	WSSM	28874	-15	4	0	7	3.75				
26	400	WSSM	97747	-14	9	3	16	1.56				
27	400	WSSM	35471	-14	6	0	12	2.33				
28	400	WSSM	109751	-14	4	1	6	3.50				
29	0	WSSM	29814	-14	4	2	7	3.50				
30	400	WSSM	110437	-13	13	4	23	1.00				
31	400	WSSM	97748	-13	9	3	15	1.44				
32	400	WSSM	110152	-13	5	1	8	2.60				
33	400	WSSM	109748	-13	4	3	6	3.25				
34	400	WSSM	35726	-12	11	3	20	1.09				
35	400	WSSM	35656	-12	10	3	18	1.20				
36	400	WSSM	95896	-12	9	4	14	1.33				
37	400	WSSM	110452	-12	5	2	9	2.40				
38	400	WSSM	110158	-12	5	4	7	2.40				
39	400	WSSM	95015	-12	5	3	7	2.40				
40	400	WSSM	35665	-11	12	5	19	0.92				
41	400	WSSM	110469	-11	10	3	18	1.10				
42	400	WSSM	71729	-11	10	5	16	1.10				
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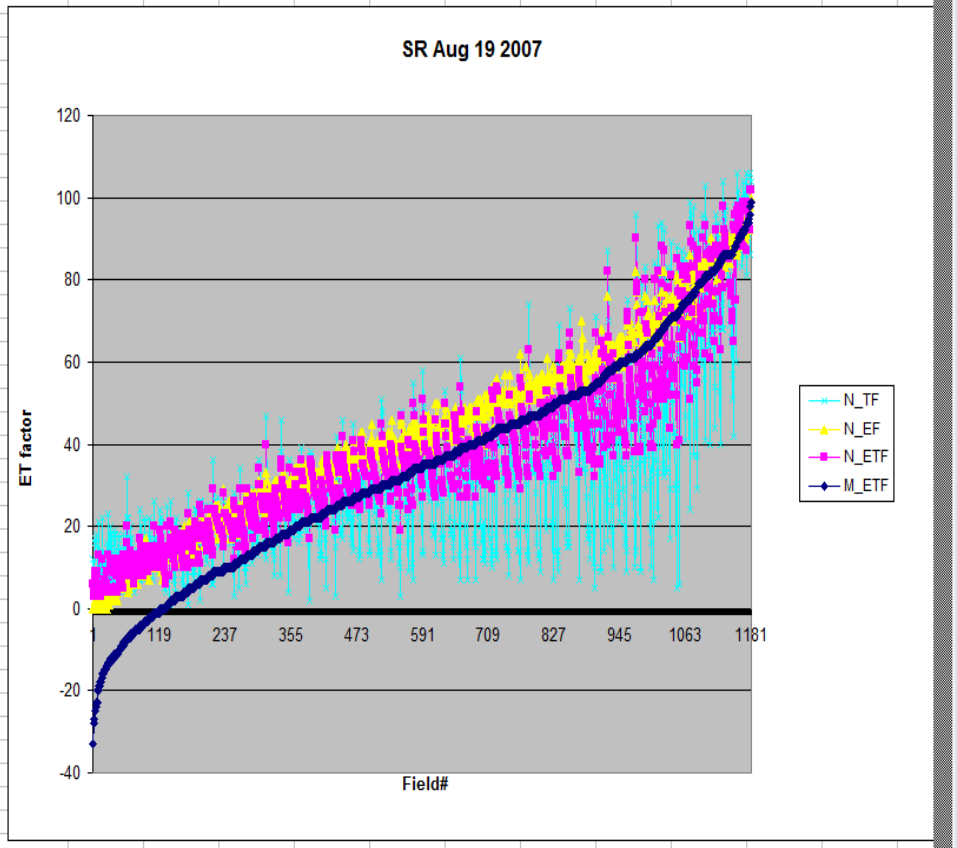

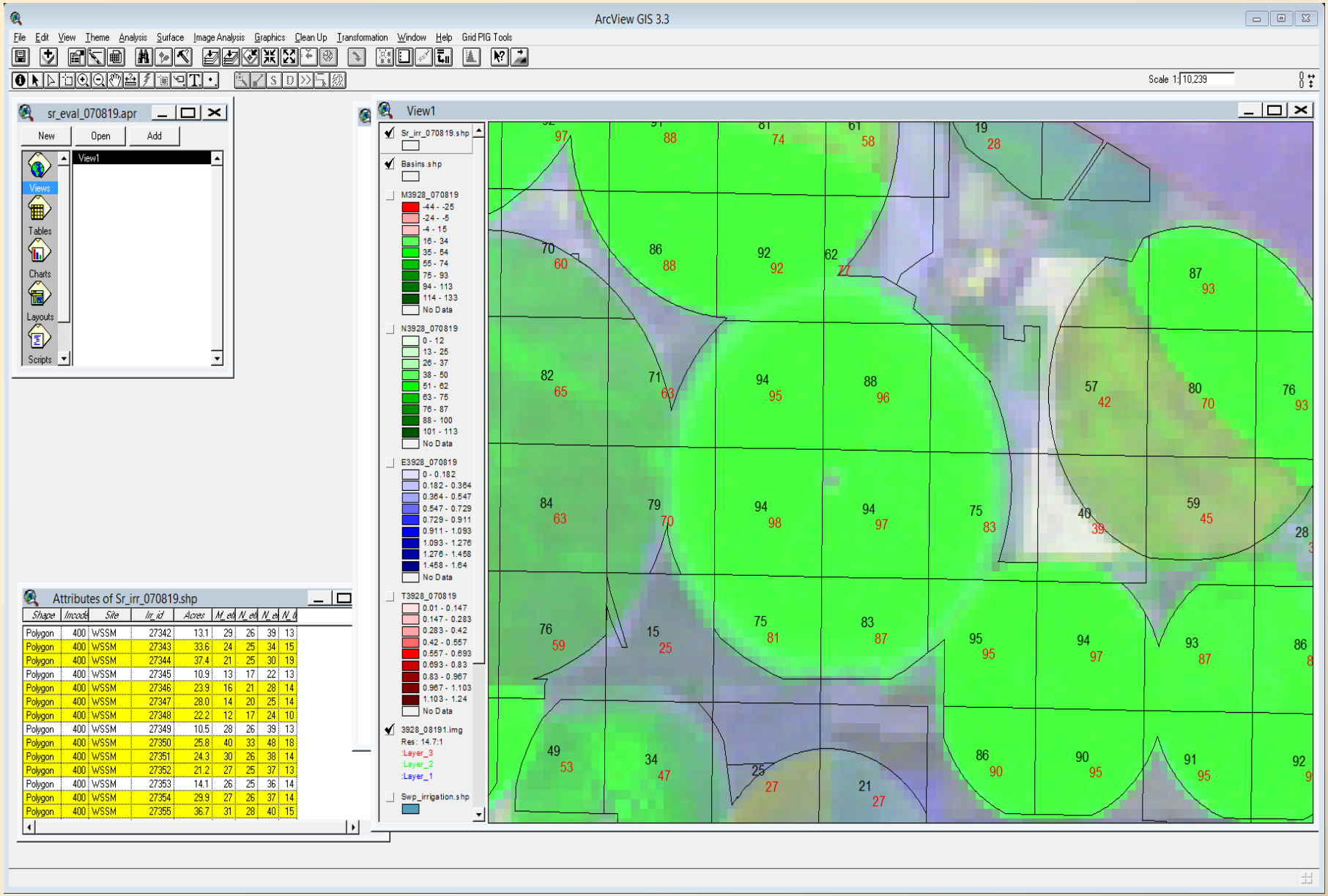
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88 - 100
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0.967 - 1.103
1.103 - 1.24
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:Layer_2
:Layer_1
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Polygon 400 WSSM 27343 33.6 24 25 34 15
Polygon 400 WSSM 27344 37.4 21 25 30 19
Polygon 400 WSSM 27345 10.9 13 17 22 13
Polygon 400 WSSM 27346 23.9 16 21 28 14
Polygon 400 WSSM 27347 28.0 14 20 25 14
Polygon 400 WSSM 27348 22.2 12 17 24 10
Polygon 400 WSSM 27349 10.5 28 26 39 13
Polygon 400 WSSM 27350 25.8 40 33 48 18
Polygon 400 WSSM 27351 24.3 30 26 38 14
Polygon 400 WSSM 27352 21.2 27 25 37 13
Polygon 400 WSSM 27353 14.1 26 25 36 14
Polygon 400 WSSM 27354 29.9 27 26 37 14
Polygon 400 WSSM 27355 36.7 31 28 40 15

What's next

- We did it…but how did we do?
  - Comparisons to SSEB and METRIC (Smith and Flathead subbasins)
  - Initially think ET estimates are within 20% - 30% of "actual" (or the best model available, METRIC)

- Project innovation is the ability to process the entire state for any year, any months in a matter of days
  - Continue to improve the concept and math
  - Modifications for Landsat 8 bands
  - Use LST and NDVI products (EROS ESPA CDR products)