PALS Soil Moisture Data
The new Frontier in Soil Related Sciences

Kedric Szana
MWH Soft
July 2009

Project Overview

- Investigate PALS Soil Moisture Data
- Create Soil Moisture Surfaces from Point Data
- Compare Similarities between Soil Classification and Soil Moisture
- Determine Applicability for use of JPL data and Further Research

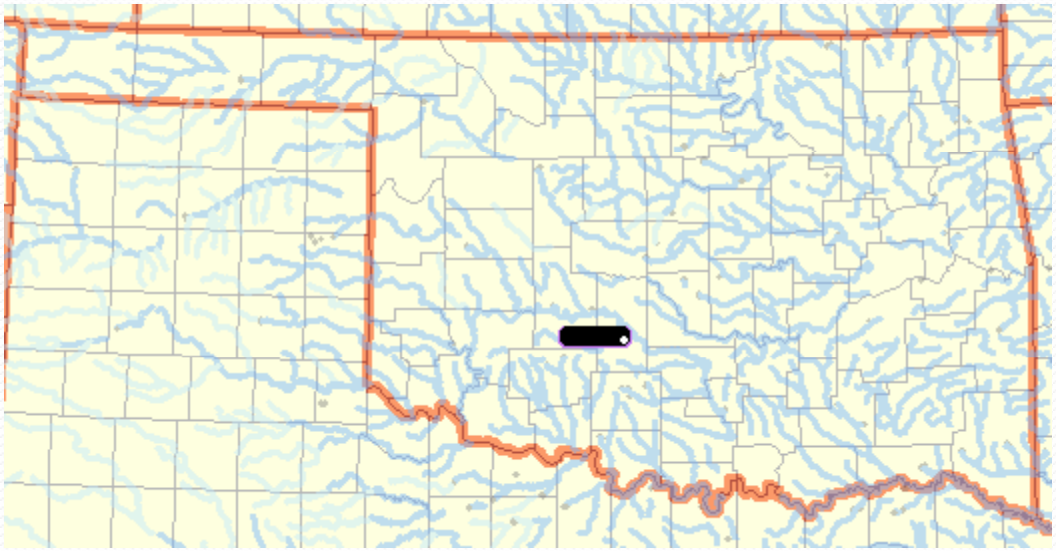
Project Overview

- Data Utilized
  - **PALS Soil Moisture Data (JPL)**
  - Elevation Data (USGS)
  - SSURGO Soil Data (SCS/NRCS)
  - StreetMap Data (ESRI)

- Tools Used
  - ArcEditor
  - **GeoStatistical Analyst**
  - Spatial Analyst
  - InfoSWMM

PALS Data

- Obtained by NASA's Jet Propulsion Laboratory
- Collected via Airborne Sensor
- Used Data for 8 Days in Summer 2007
- Project Area – Southern Oklahoma ~35 sq. mi.
- Data collected at approximately 450' intervals



Who Cares About Soil Moisture?

- Hydrologists
- Sewer System Managers
- Farmers
- Environmental Sciences
- Average People

PALS Data Analysis

- Statistics
  - Normal Distribution?
- QQ Plots
- Trend Analysis
- Semivariograms
- Surface Creation – Kriging
- Surface Analysis
- Application – Hydrology
- Conclusions

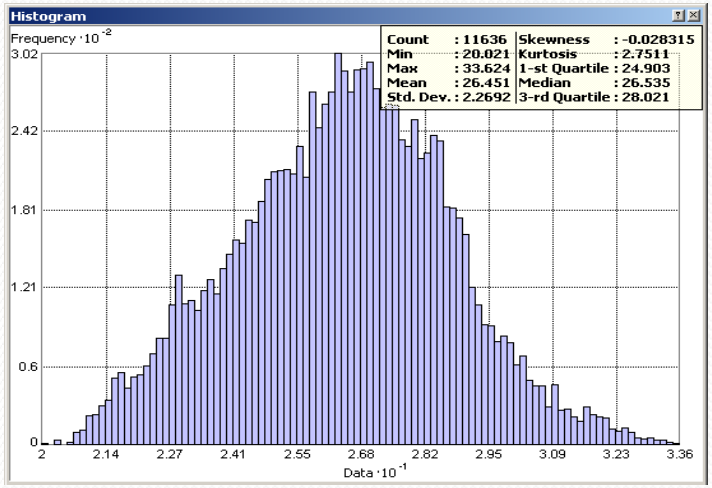
GeoStatistical Analyst

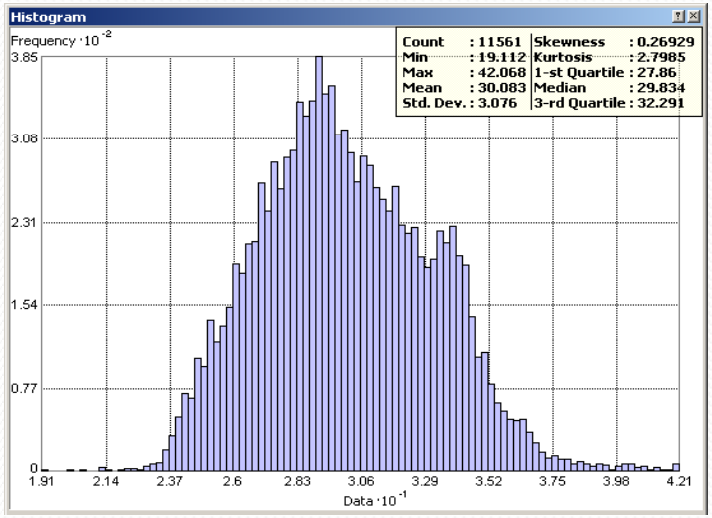
GeoStatistical / Spatial Analyst

InfoSWMM / Spatial Analyst

Statistical Analysis

- GeoStatistical Analyst
- Review Histograms
- Normal Distribution Overall
- Somewhat Skewed after Rainfall
- Statistics to Excel for Temporal View of Data

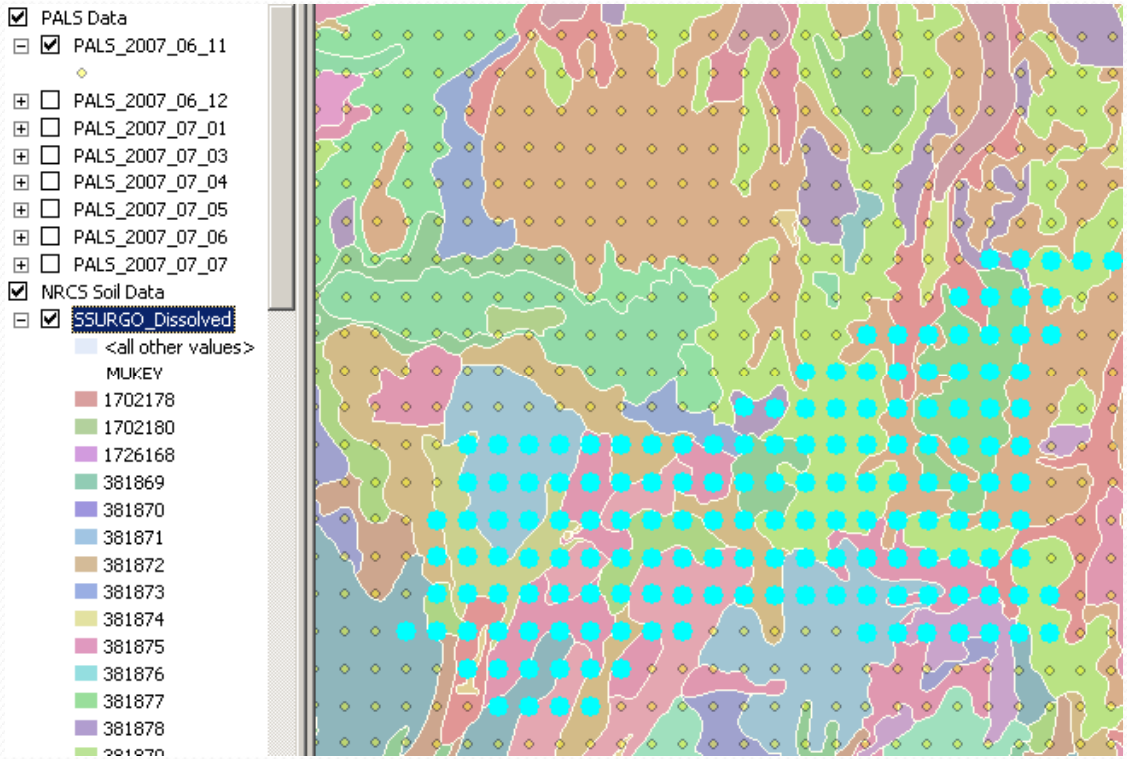




GeoStatistical Interaction

- Select statistical output
- Features are highlighted on the map
- Visual Exploration

July 4



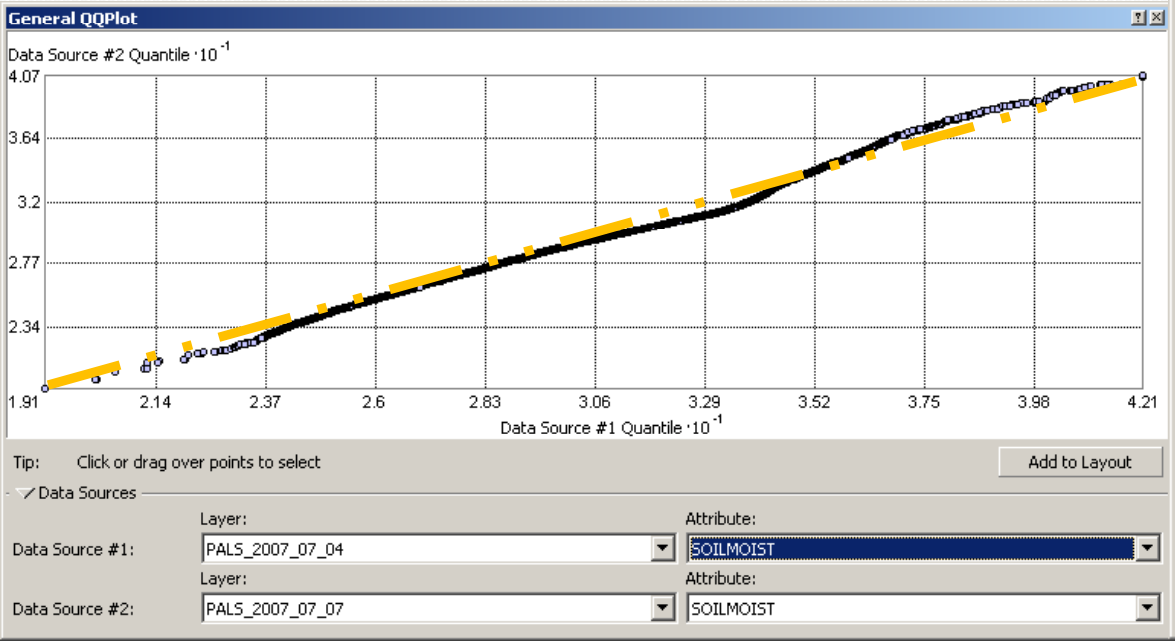
Statistical Summary Over Time

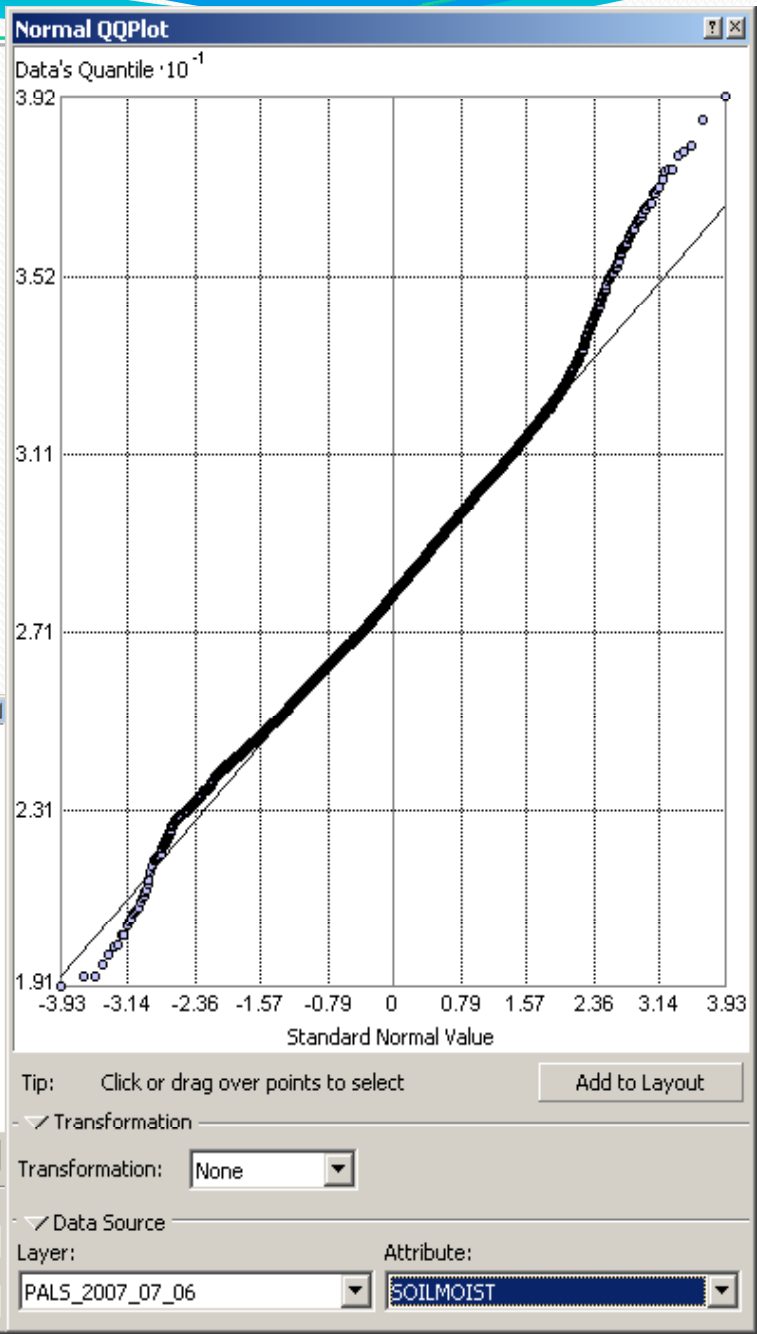
- Apparent Rain Events July 3, 4, and 7
- Skewness and Deviation increase with Wetness
- Kurtosis changes with multiple rain events
- July 4 Wettest Day
- Why?

	11-Jun	12-Jun	1-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul
Count	11636	11736	11736	11166	11561	11676	11736	11676
Minimum Value	20.02	19.11	19.11	19.11	19.11	19.11	19.11	19.11
Maximum Value	33.62	32.37	36.1	37.55	42.07	39.12	39.17	40.67
Mean	26.45	24.61	26.96	29.04	30.08	28.41	28.03	28.92
Standard Deviation	2.269	2.084	2.277	2.424	3.076	2.583	2.215	2.859
Skewness	-0.0283	0.113	-0.0003	0.0716	0.2693	0.2196	0.3222	0.4913
Kurtosis	2.751	2.951	2.885	2.958	2.799	2.541	3.691	3.593
1st Quartile	24.9	23.16	25.31	27.37	27.86	26.38	26.53	26.97
Median	26.54	24.61	27.05	28.98	29.83	28.27	27.93	28.74
3rd Quartile	28.02	25.97	28.53	30.7	32.29	30.42	29.46	30.62

Q/Q Plots

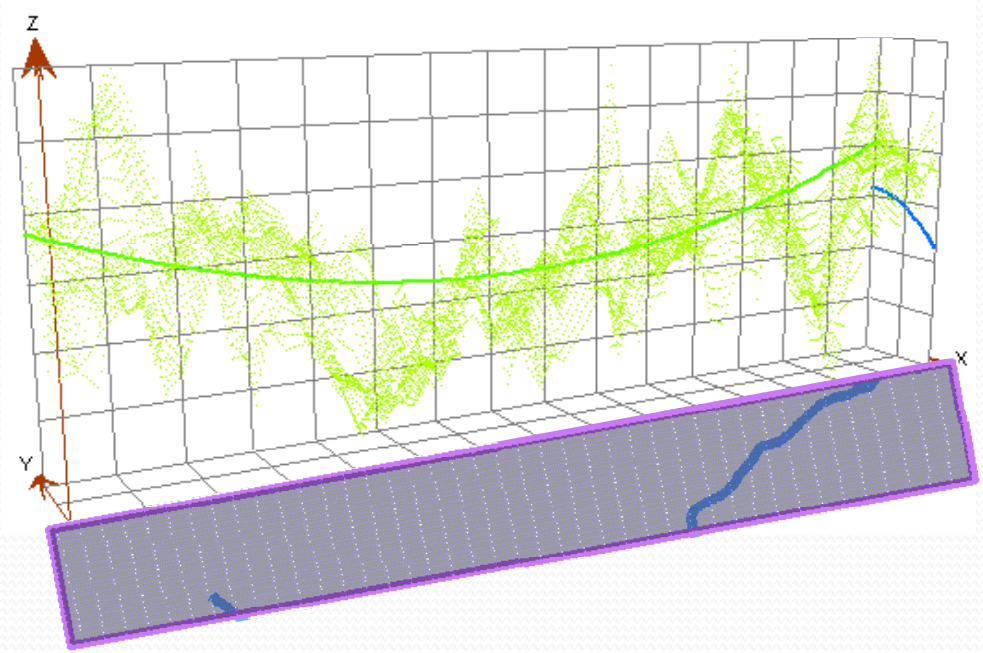
- Compare Data vs. Theoretical Normal Distribution
- Plot Rankings From 2 Datasets





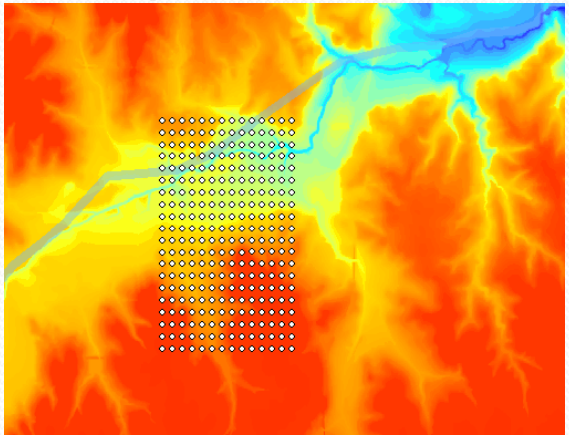
Trend Analysis

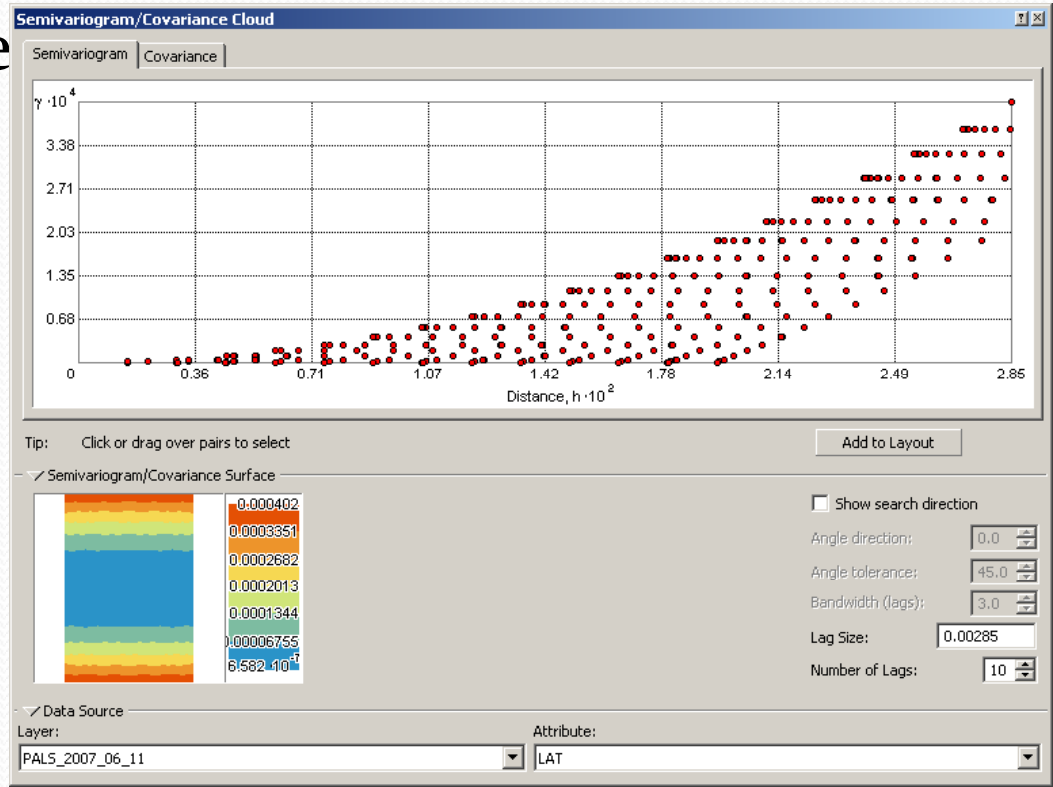
- View Data in Space
- Find Directional Trends
- Latitude and Longitude make simple example
- Polynomial trends possible
- Trends can be removed during surface creation if necessary



GeoSpatial Semivariogram / Covariance

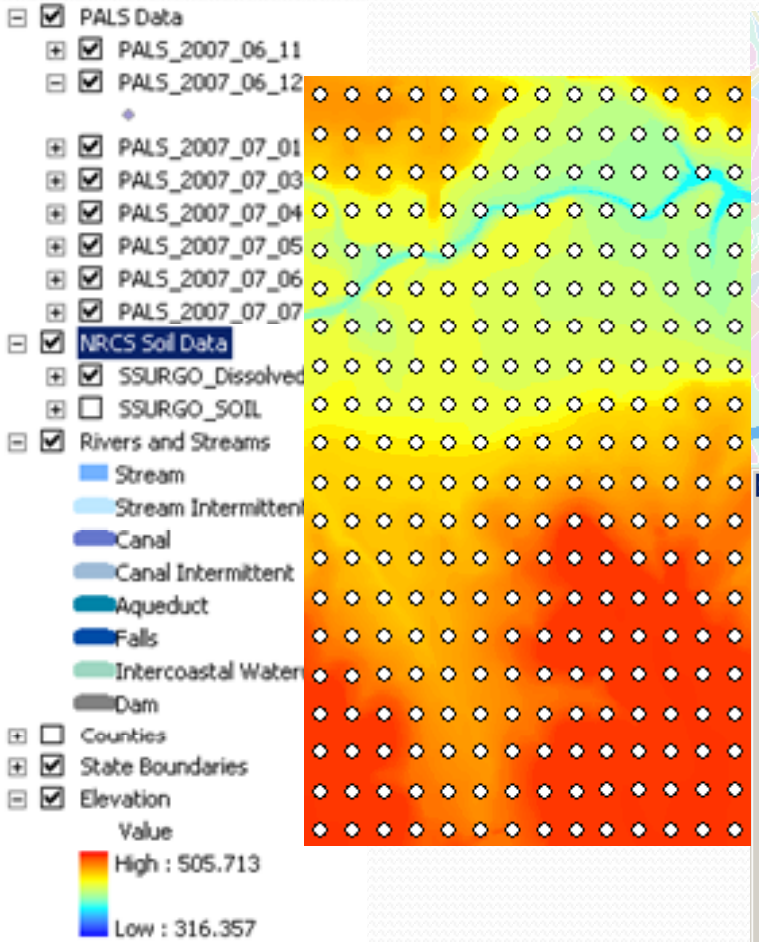
- Variogram – Degree of Spatial Dependence
- Can Display Covariance as a function of Distance
- Latitude and Longitude used as initial example
- 280 Points Selected for Analysis

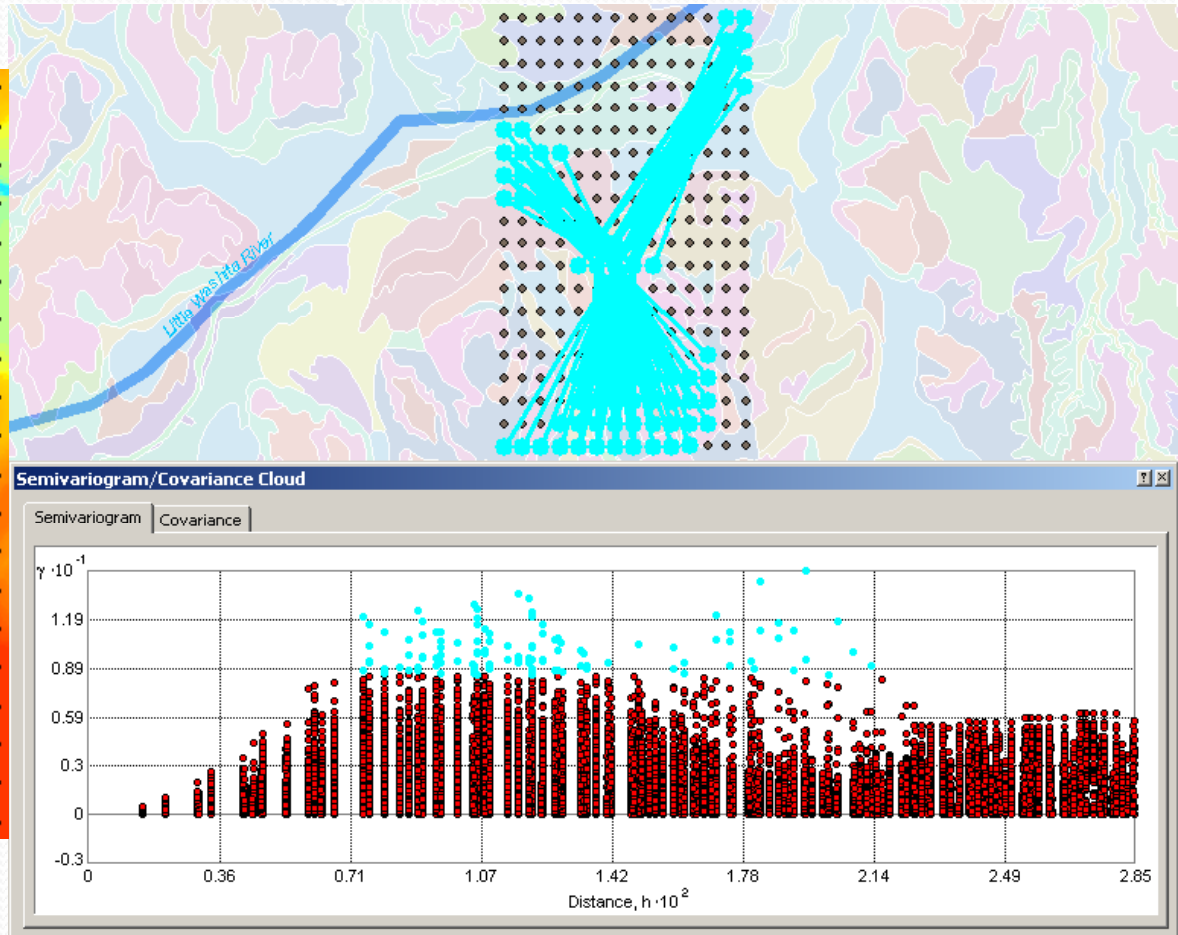




Interacting with Semivariogram Models

- Where is there Spatial Independence?
- Highest Variance Changes over Time (amount and locations)

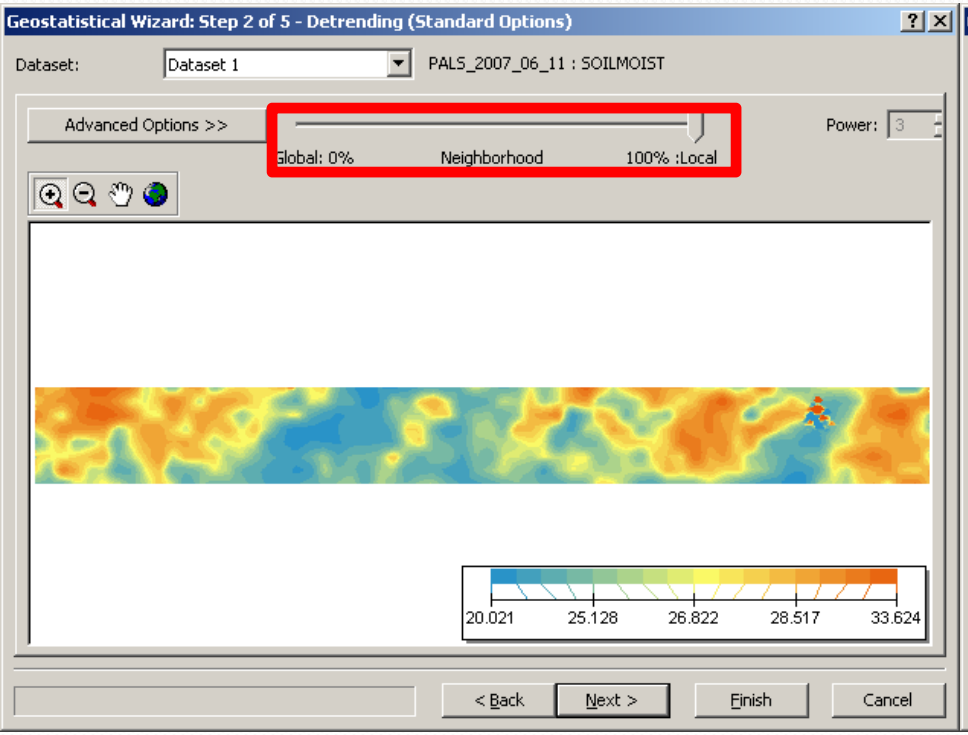


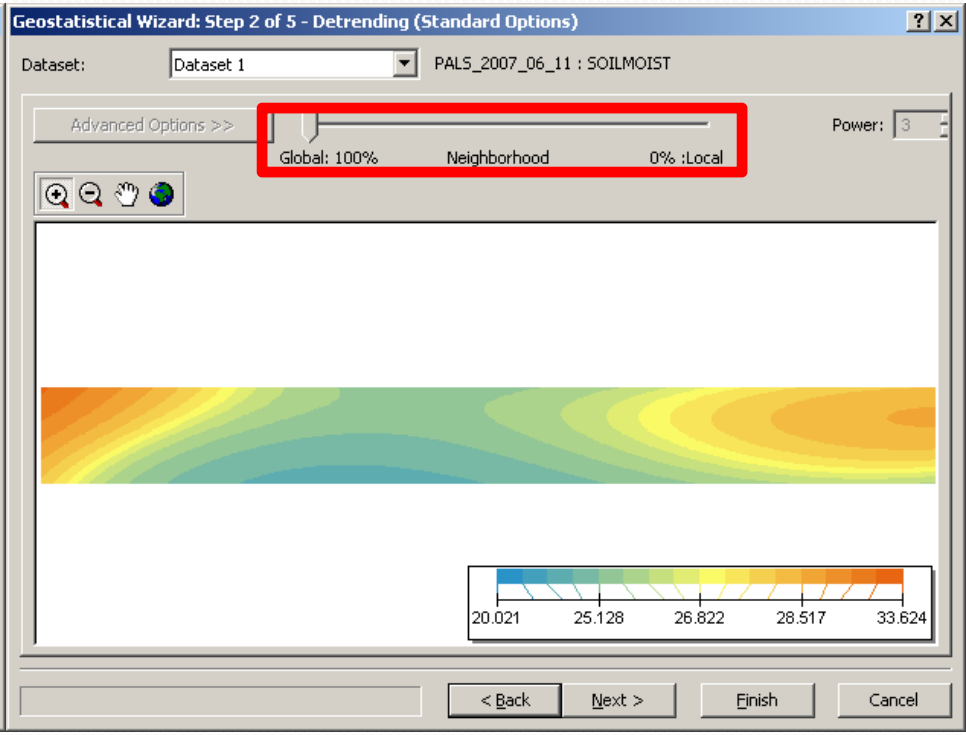


Surface Creation

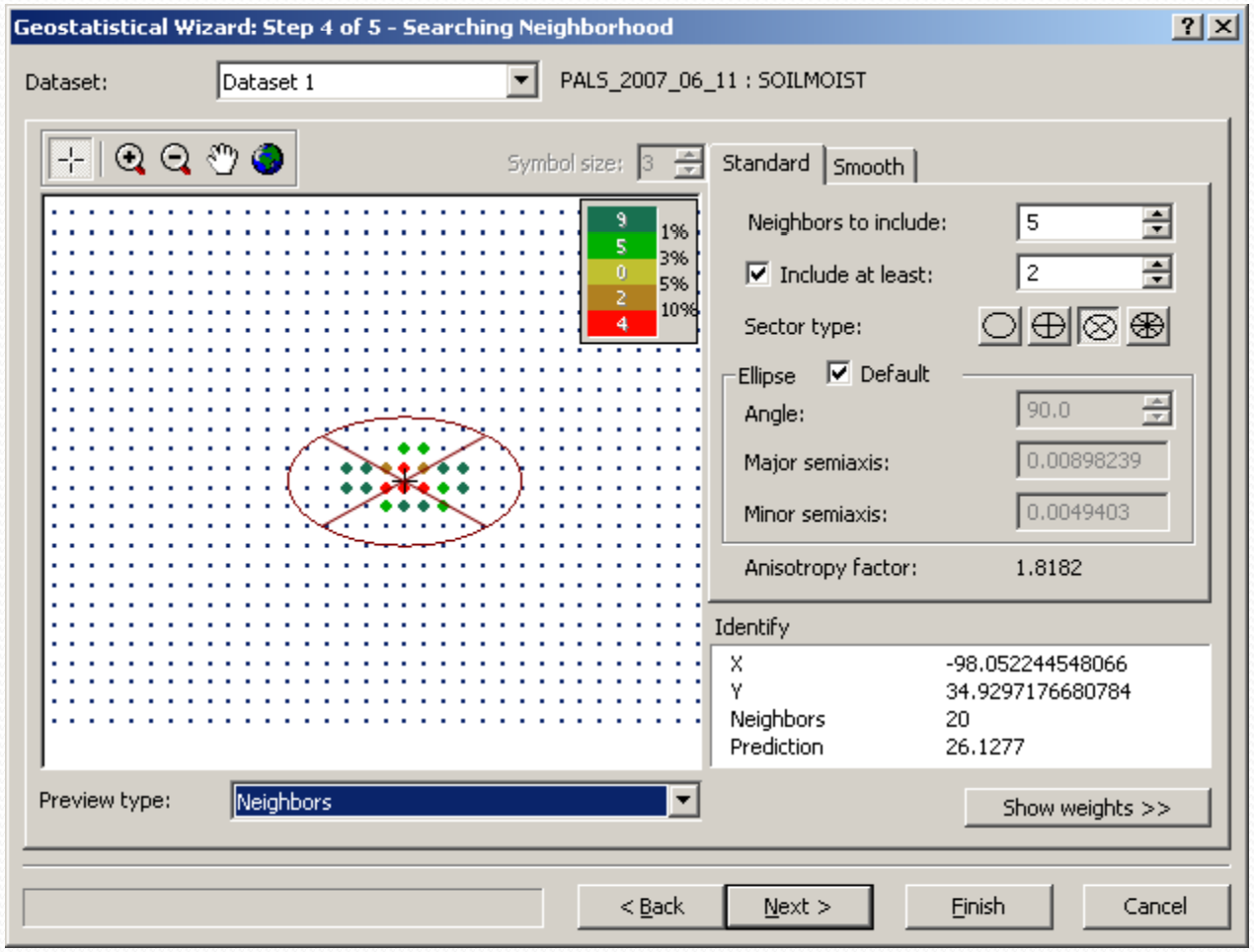
- Kriging Used
- Estimates areas with no return
- Trends Removed – 3rd Order
- Directional Searching utilized
- Tetraspherical Semivariogram model used
  - Lag Size (Auto Calc)
  - # of Lags (Auto Calc)
  - Partial Sill (Auto Calc)
  - Anisotropy (Auto Calc)

Kriging – Trend Removal



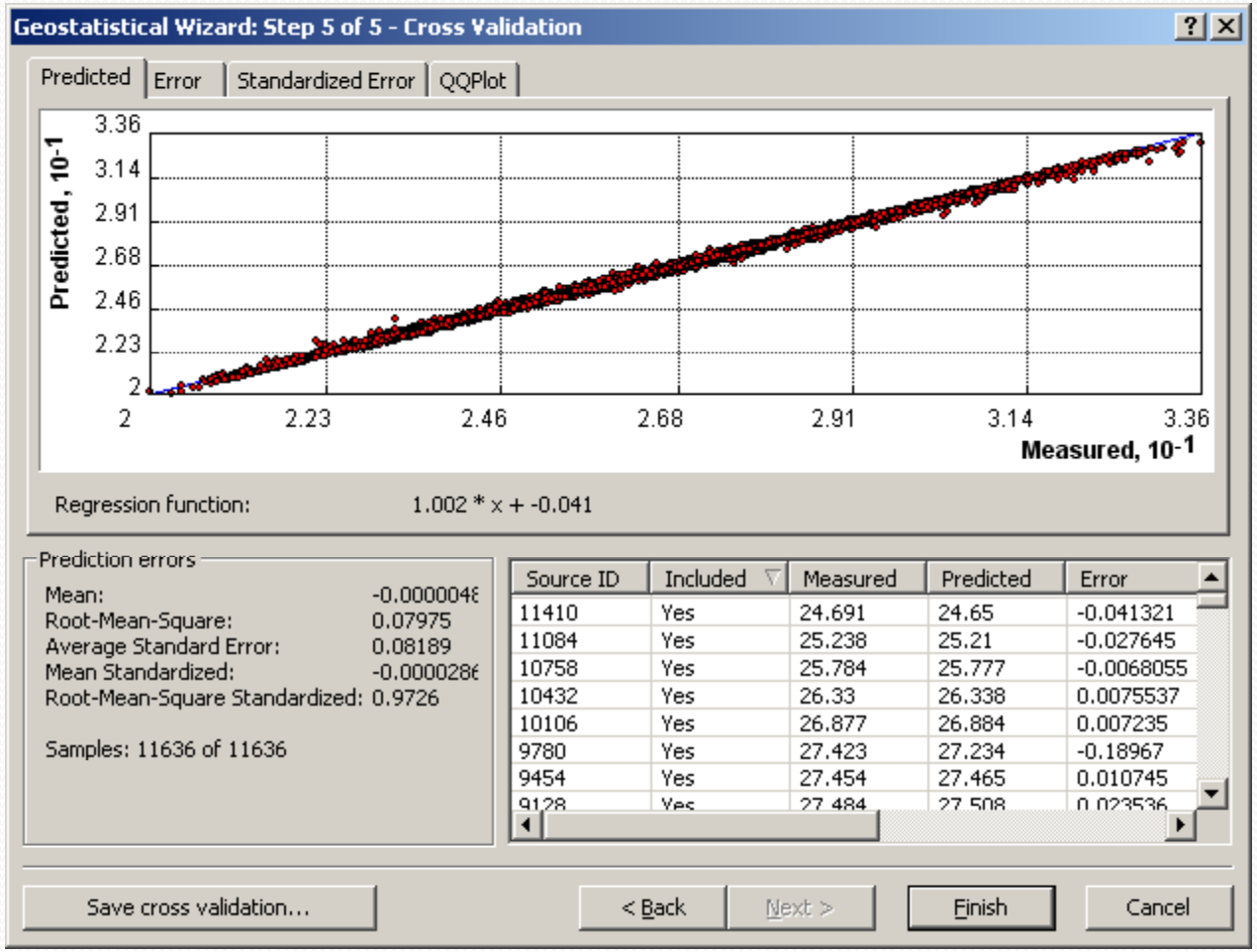


Kriging – Searching Neighborhood

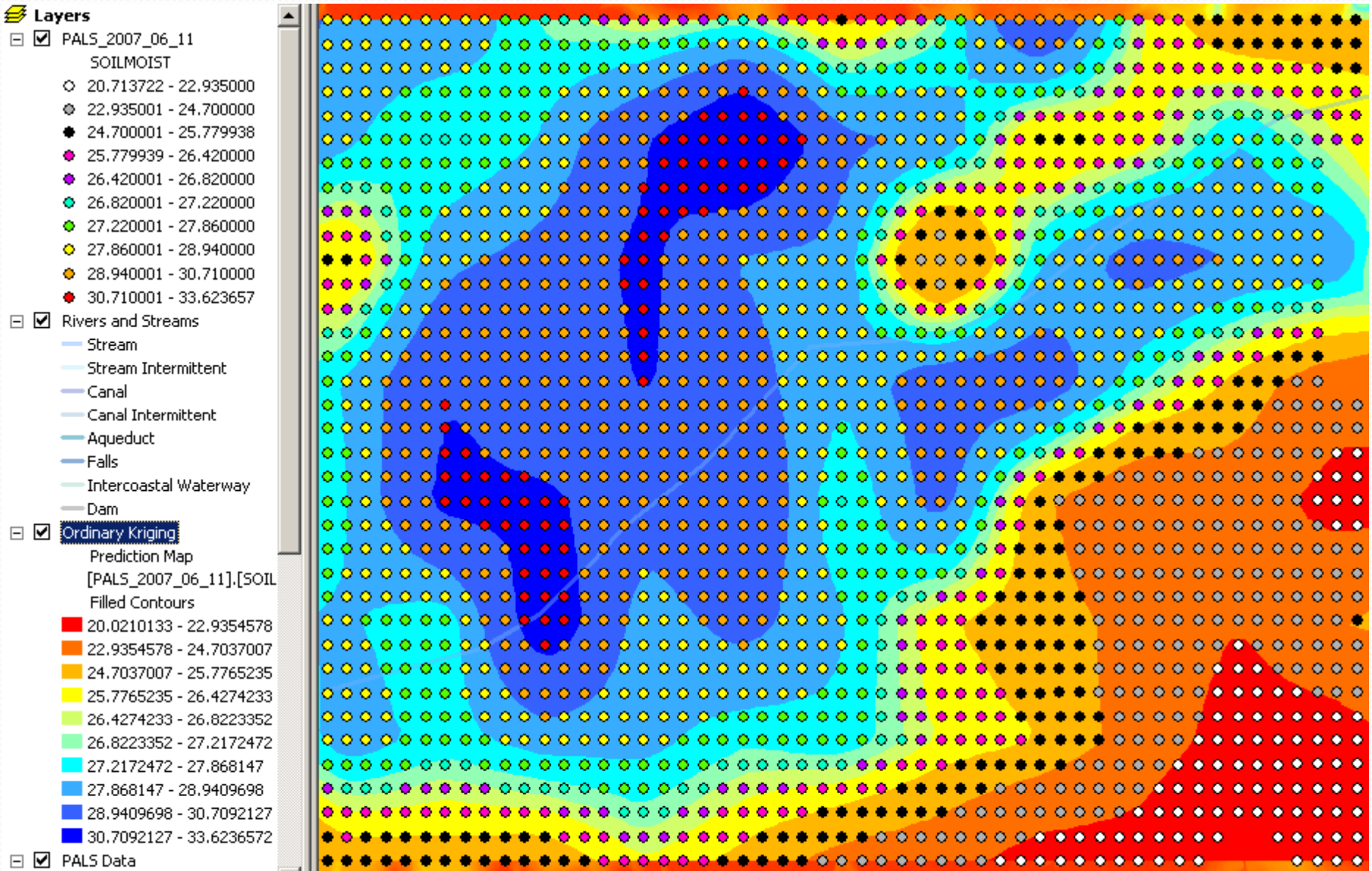


Kriging – Cross Validation

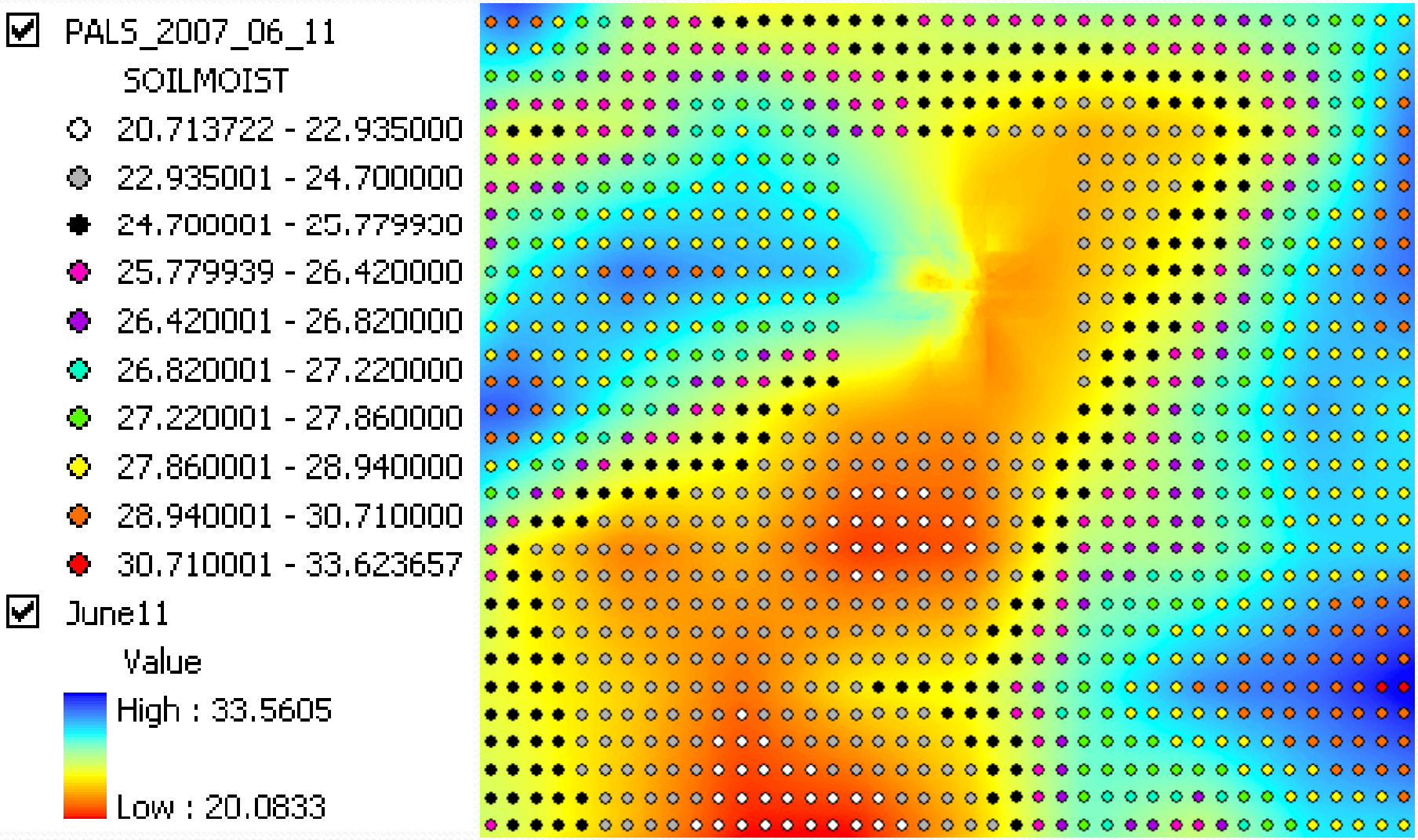
- Take One Point Away
- Create a Test Surface
- Compare Created Point to Actual Value



Created Dataset

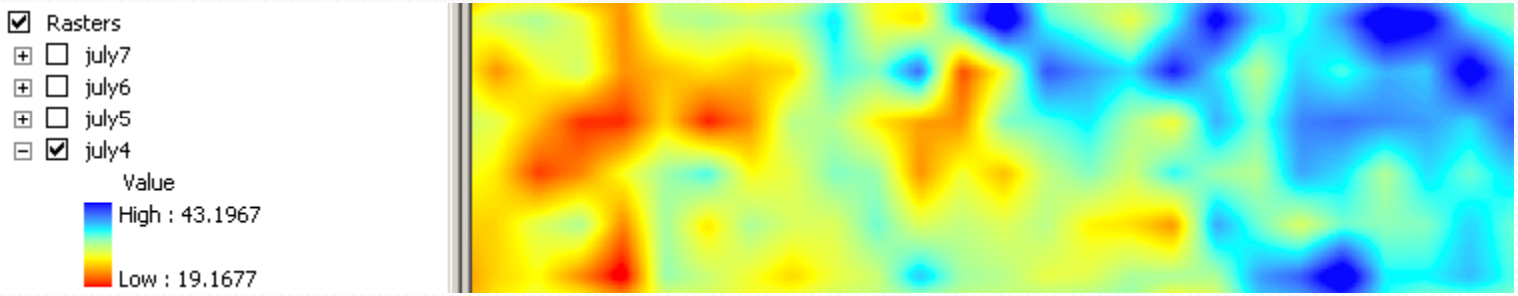


Filling in Gaps

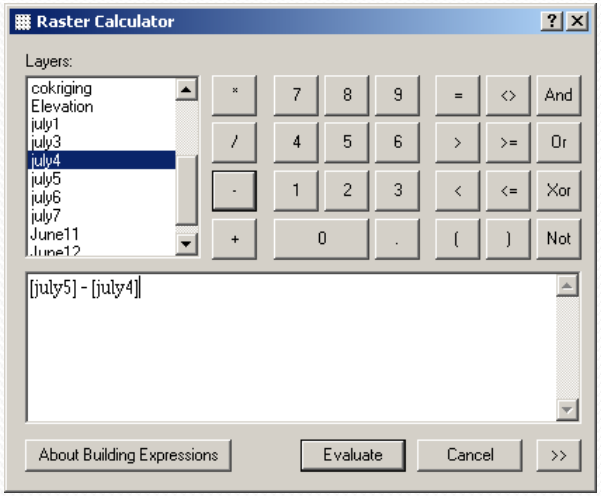


Surface Summary

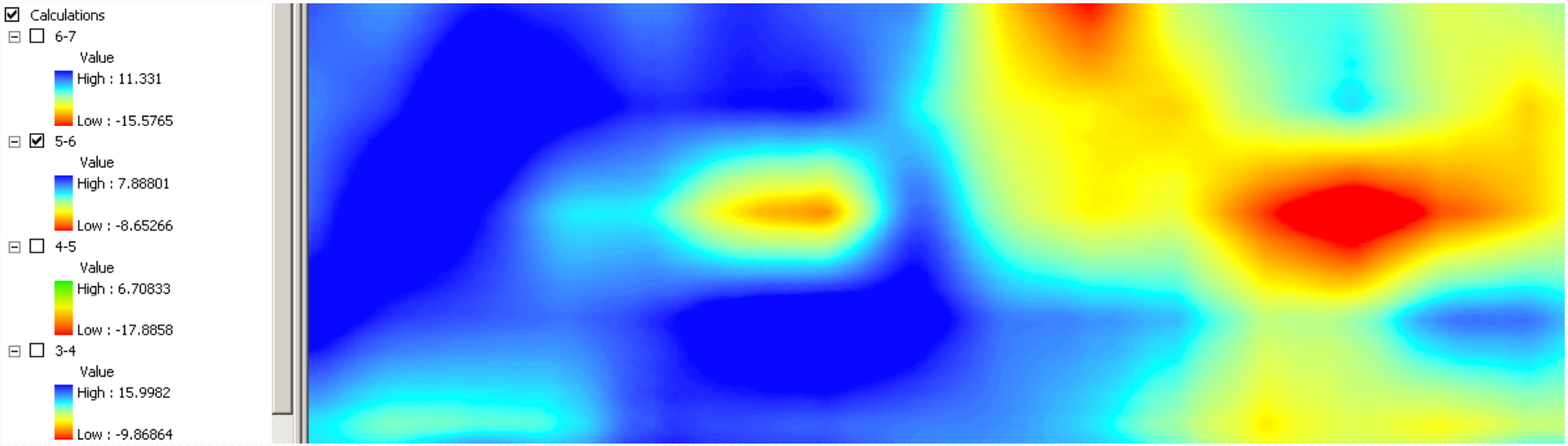
- Probability Map exported to Raster
- 10 Meter Cell Size
- Surfaces for each day with recordings
- Missing Data estimates for final surface creation not applied



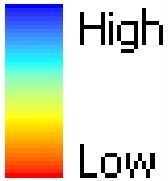
Change Datasets



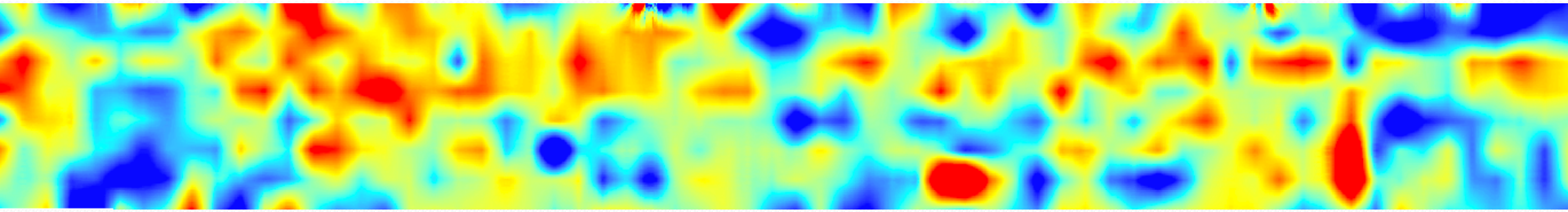
- Raster Calculator
  - Spatial Analyst
- Subtracted later date from earlier date
- Output is change in Soil Moisture Over time



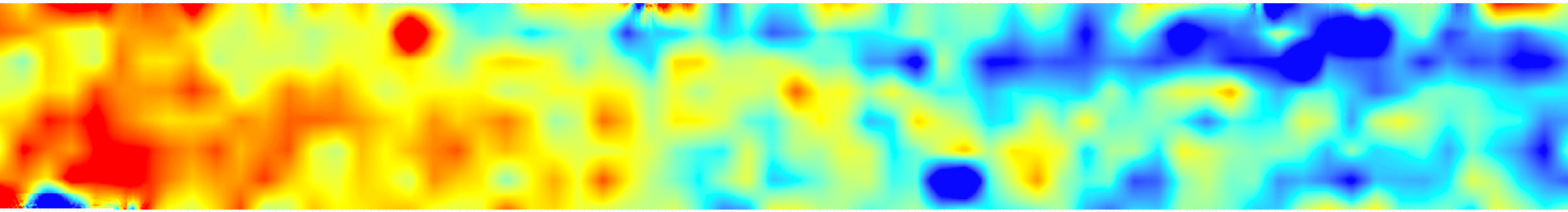
Watching Change in Soil Moisture



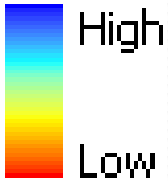
July 1 - 3



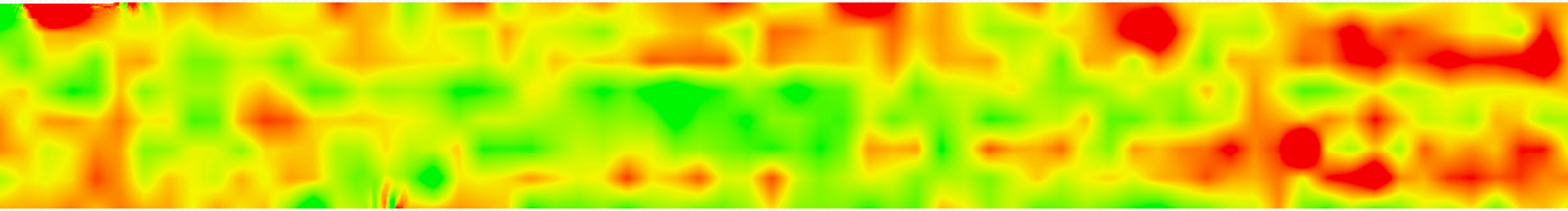
July 3 - 4



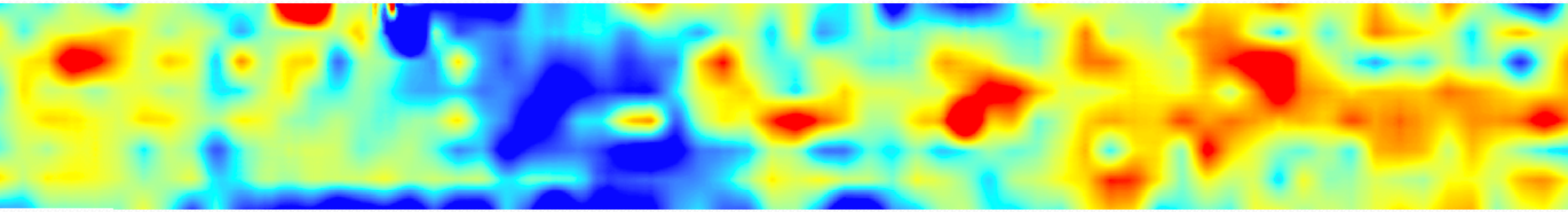
Watching Change in Soil Moisture



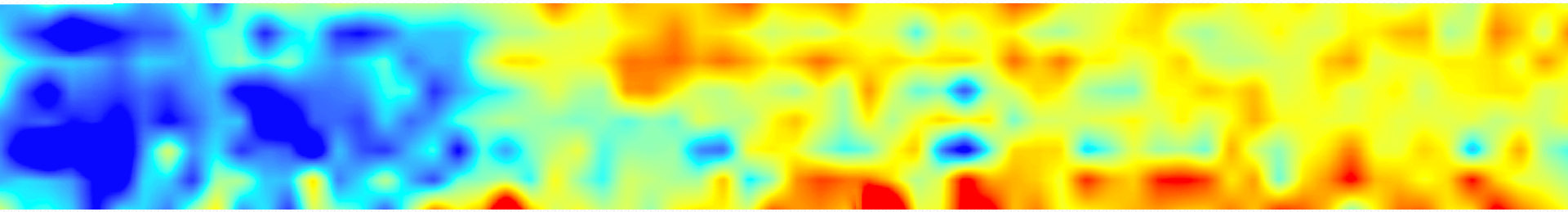
July 4 - 5



July 5 - 6

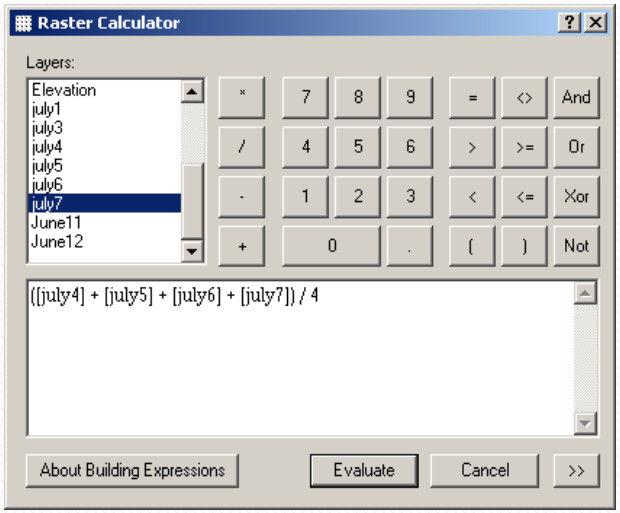


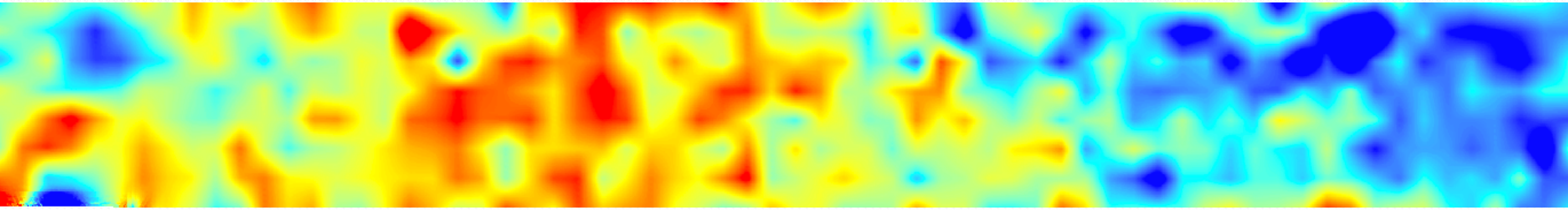
July 6 - 7

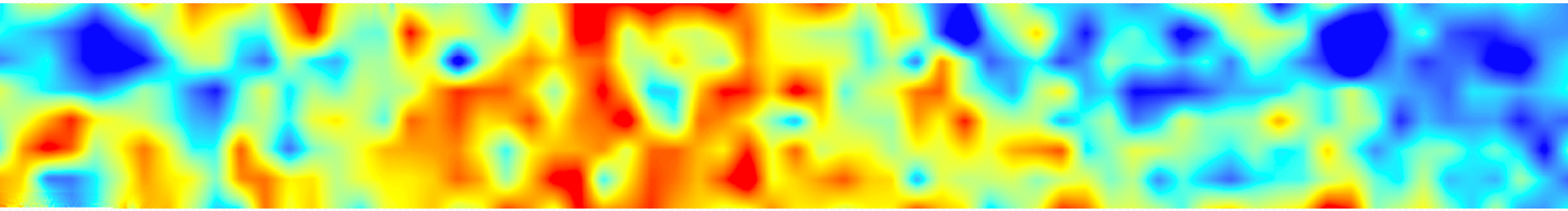


Cokriging vs. Averaging

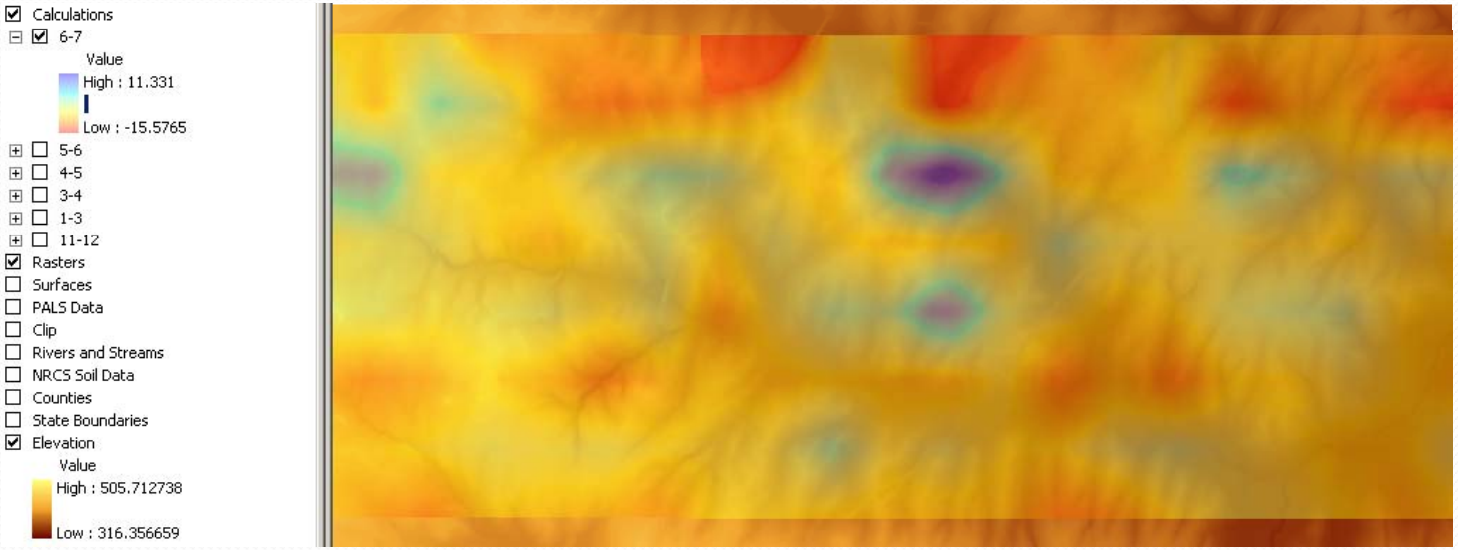
- Both provide similar data
- Cokriging maintains data extremes
- Cokriging is an in-depth estimator
- Cokriging maintains global trends across multiple datasets

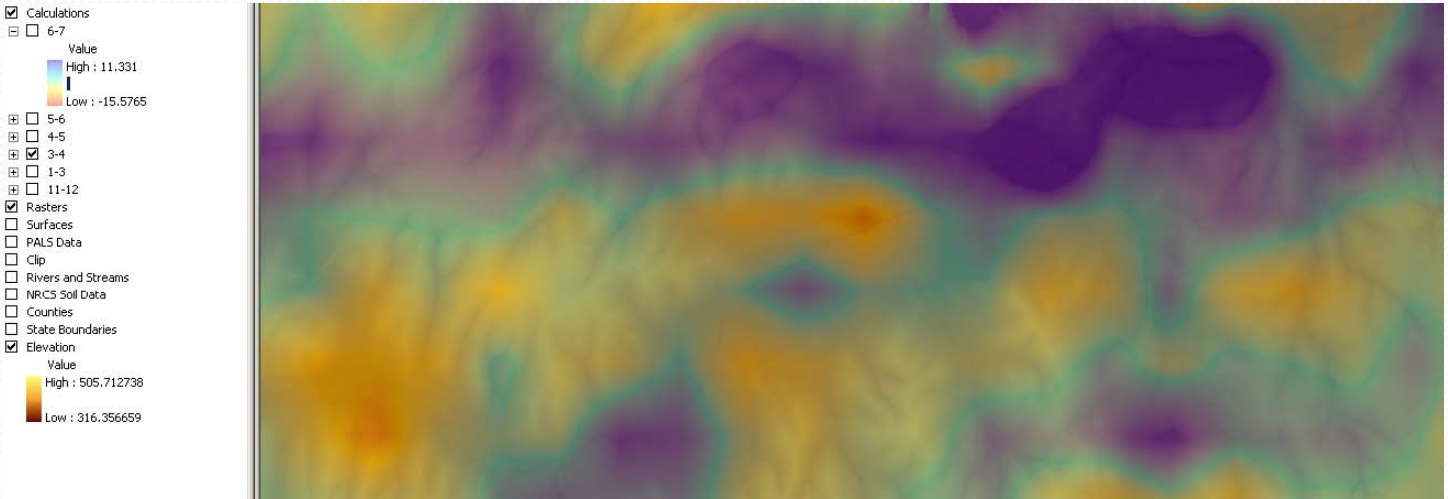




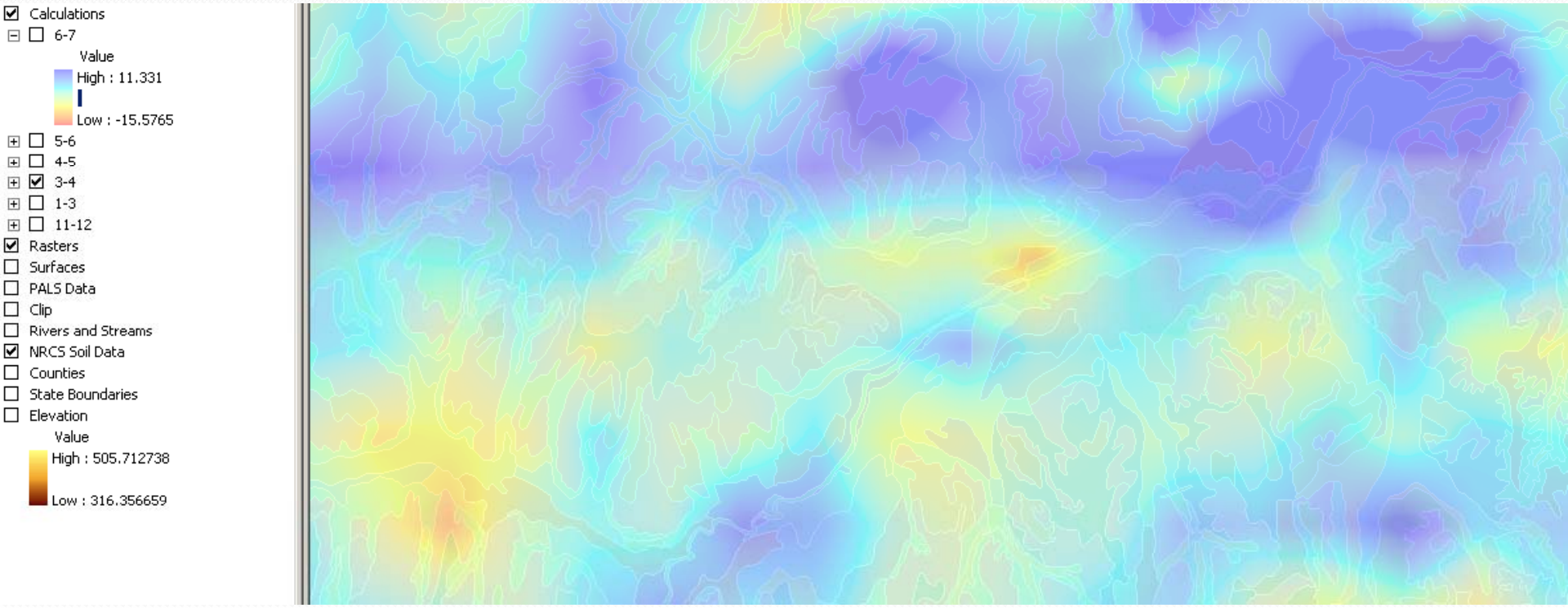


Overlay Analysis - Elevation





Overlay Analysis - SSURGO



Spatial Analysis - SSURGO

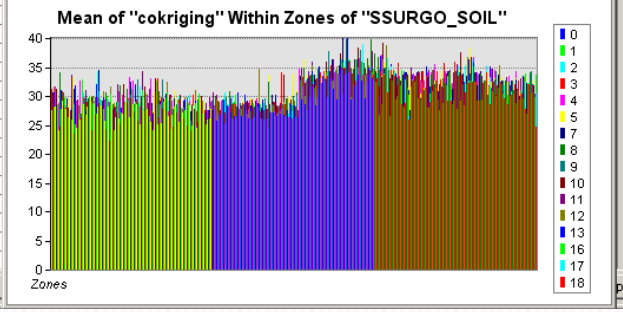
- 1 – Determine Soil Stats within each SSURGO polygon
- 2 – Join Output to SSURGO database
- 3 – Summarize information on MUKEY field

Stats of "cokriging" Within Zones of "SSURGO_SOIL"

OID	KEY	ZONE_CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
0	0	1	5389	5.389E-05	23.6705	29.6706	6.00012	27.2433	1.35702	146814
1	1	2	522	5.22E-06	26.9845	28.297	1.31245	27.629	0.327495	14422.4
2	2	3	2436	2.436E-05	25.7752	30.7075	4.93225	28.6284	1.16725	69738.7
3	3									
4	4									
5	5									
6	7									
7	8									
8	9									
9	10									
10	11									
11	12									
12	13									
13	16									
14	17									
15	18									
16	19									
17	20									
18	22									

Record:

Mean of "cokriging" Within Zones of "SSURGO_SOIL"



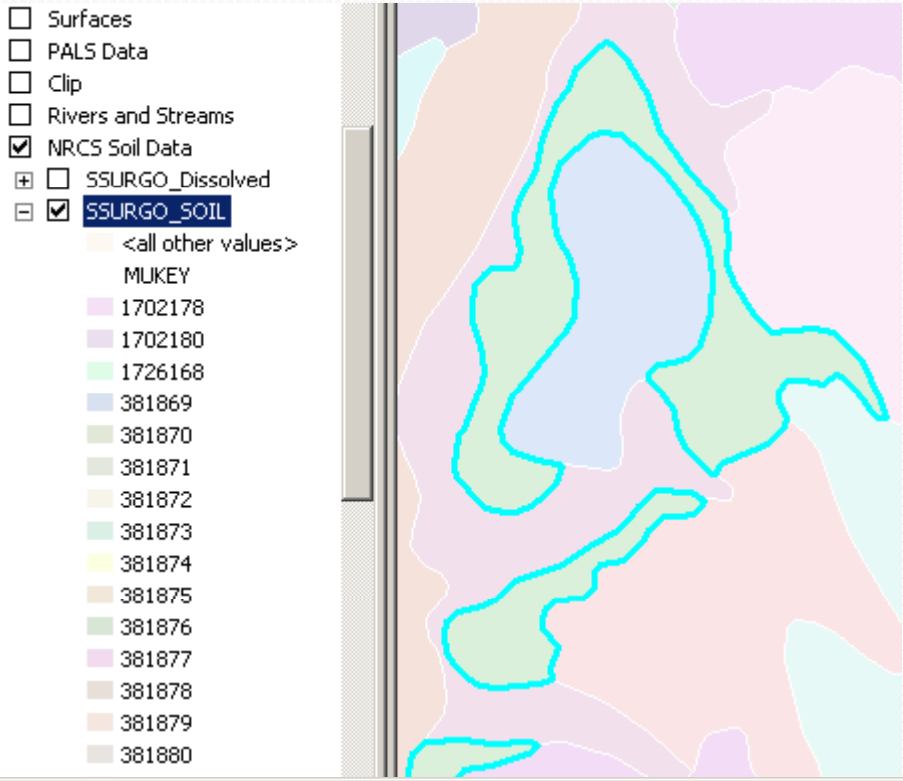
Attributes of cokriging_summary

OID	MUKEY	Count_MUKEY	Minimum_RANGE	Maximum_RANGE	Average_RANGE	StdDev_RANGE	Variance_RANGE	Minimum_MEAN	Maximum_MEAN	Average_MEAN	StdDev_MEAN	Variance_MEAN
0	1702178	2	0.772108	0.860361	0.8162	0.0624	0.0039	27.6327	27.7815	27.7071	0.1052	0.0111
1	1702180	1	2.91174	2.91174	2.9117	0	0	30.535601	30.535601	30.5356	0	0
2	1726168	7	0.267879	0.956738	0.5444	0.2064	0.0426	28.633101	36.68	32.334	2.7888	7.7776
3	381869	59	0.119856	4.93934	1.1514	1.0834	1.1736	24.623199	30.818001	27.9813	1.4188	2.013
4	381870	6	0.046156	6.29919	2.0592	2.5589	6.5479	27.571199	32.110901	29.0197	1.7263	2.98
5	381871	10	0.04776	4.83974	1.8872	1.8525	3.4319	24.486601	27.651199	26.1473	1.0897	1.1875
6	381872	45	0.029661	13.3217	2.991	2.9296	8.5828	23.5863	34.813202	28.5991	2.3457	5.5022
7	381873	6	0.053015	7.37919	2.063	2.699	7.2846	25.344801	30.3323	28.6904	1.786	3.1897
8	381874	6	0.783421	2.89378	1.5179	0.8379	0.7021	27.688999	29.966499	28.6754	0.7793	0.6072
9	381875	66	0.053568	6.82614	1.6941	1.4036	1.9701	23.5928	33.638302	27.4823	2.1257	4.5187
10	381876	8	0.050779	6.99279	2.4079	2.9019	8.421	24.7395	28.9932	26.9838	1.5516	2.4074
11	381877	3	1.01666	1.27639	1.1151	0.1408	0.0198	26.7773	28.0986	27.4886	0.6664	0.4441
12	381878	16	0.121403	4.3297	1.6196	1.1683	1.3649	25.068001	29.085501	27.4429	1.4117	1.9929
13	381879	82	0	10.1227	2.0584	1.9342	3.7413	23.8818	34.201302	27.2915	1.8967	3.5974
14	381880	6	1.17479	9.96511	3.9921	3.383	11.445	26.0758	30.594601	27.631	1.8012	3.2443

Record: 1 Show: All Selected Records (1 out of 100 Selected) Options

Human Analysis - SSURGO

- 3 Polygons
- Similar spatial proximity
- Similar elevation
- Large variability in soil moisture among the 3 polygons



Selected Attributes of SSURGO_SOIL

FID	Shape *	AREASYMBOL	SPATIALVER	MUSYM	MUKEY	KEY	OID	KEY *	ZONE_CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1213	Polygon	OK051	4	21	382640	1213	1135	1213	1136	1527	0.000015	32.2575	39.297001	7.03949	35.0597	1.83165	53536.199
1301	Polygon	OK051	4	21	382640	1301	1223	1301	1224	413	0.000004	31.0728	32.151699	1.0789	31.620501	0.248006	13059.3
1348	Polygon	OK051	4	21	382640	1348	1270	1348	1271	292	0.000003	31.017	31.9233	0.906385	31.496599	0.232379	9197

Record: 1 Show: All Selected Records (3 out of 1752 Selected) Options

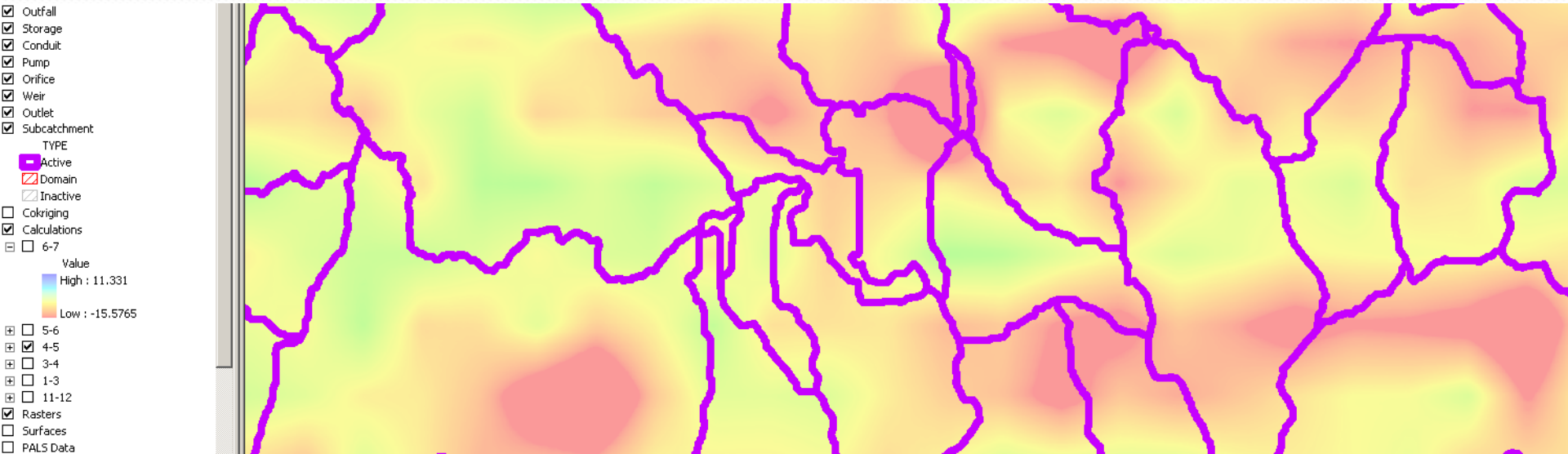
Spatial Analysis – SSURGO - Summary

- Large variability in soil moisture among polygons with the same MUKEY
- The MUKEY field is used to assign hydrologic code
- Hydrologic code very important for rainfall / runoff modeling

Overlay Analysis - Hydrology

- 1 – Create Subcatchments (Elevations / InfoSWMM)
- 2 – View Soil Moisture within Catchments

- Large Variability



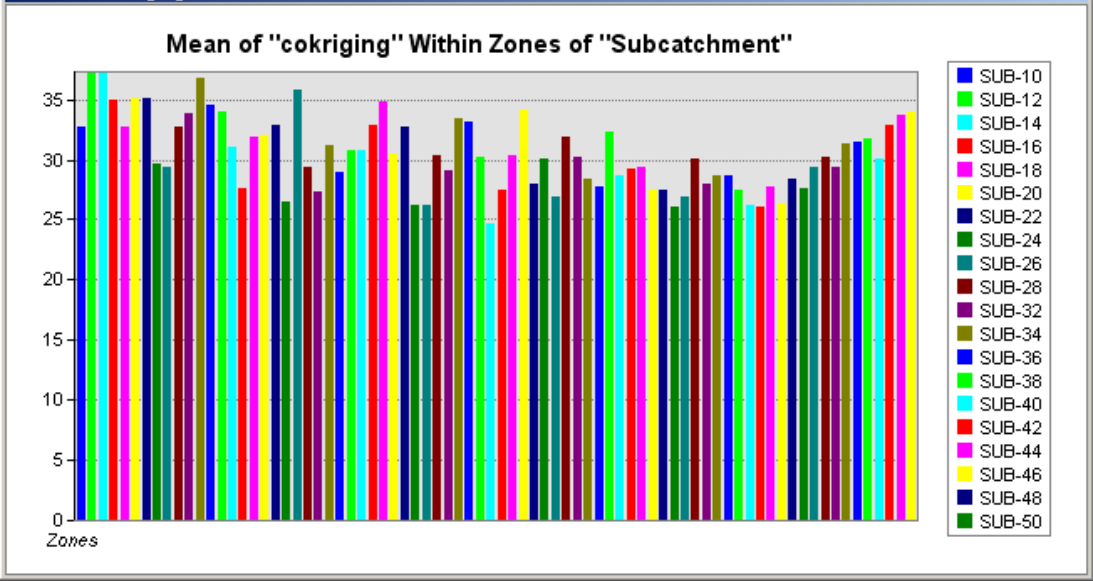
Spatial Analysis - Hydrology

- Can utilize this data to assign Horton or Green-Ampt Infiltration Parameters
- Can check current model response
- Rainfall Data needed for model verification

Attributes of catchments

OID	MOID	ZONE_CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
57	SUB-126	58	48901	4.8901E-04	23.2343	43.0378	19.8036	30.0949	3.18118	1471670
56	SUB-124	57	32788	3.2788E-04	19.7152	38.3154	18.6002	26.8318	2.04739	879760
15	SUB-42	16	42118	4.2118E-04	19.1711	35.1341	15.963	27.6322	2.68672	1163810
23	SUB-58	24	78568	7.8568E-04	24.6963	38.1765	13.4801	31.1627	2.60675	2448390
71	SUB-154	72	129220	0.0012922	25.32	38.1537	12.8337	31.3111	1.93335	4046020
20	SUB-52	21	47402	4.7402E-04	29.3442	42.0985	12.7543	35.7697	3.19025	1695550
29	SUB-70	30	47393	4.7393E-04	23.0829	35.4838	12.4009	30.4997	2.55378	1445470
76	SUB-164	77	78565	7.8565E-04	29.347	41.0284	11.6813	33.6999	1.19866	2647640
35	SUB-82	36	21791	2.1791E-04	27.991	39.3048	11.3139	33.3848	2.60646	727489
12	SUB-36	13	44637	4.4637E-04	29.6966	40.7514	11.0547	34.5018	1.36756	1540060
19	SUB-50	20	24940	0.0002494	24.0002	34.3859	10.3857	26.4964	2.01444	660819
9	SUB-28	10	28089	2.8089E-04	30.0481	40.0992	10.0511	32.7254	1.92048	919225

Mean of "cokriging" Within Zones of "Subcatchment"



Conclusions

- Soil Moisture varies significantly in time and space

- Soil Moisture is not directly correlated to any one factor; Factors include:
  - Rainfall
  - Soil Characteristics
  - Proximity to Rivers / Lakes
  - Temperature
  - Amount of Sunlight
  - Elevation
  - Etc.

Conclusions

- JPL's PALS Data significantly enhances understanding of Soil Moisture
- PALS Data can greatly benefit earth and water sciences
- Expanded research on PALS data is highly recommended in conjunction with calibrated radar-rainfall data
- Geostatistical Analyst and ArcMap provide a powerful environment for examining the PALS Data

Conclusions

- The hydrologic codes used in SSURGO data may be relatively generic
  - Source Data is from the 1920's
  - SSURGO data is impressive considering the limitations of data collection

- Watershed delineation using elevation as the only consideration may lead to force fitting models

Questions?

Contact Information:

Kedric Szana

MWH Soft

Kedric.szana@mwhsoft.com