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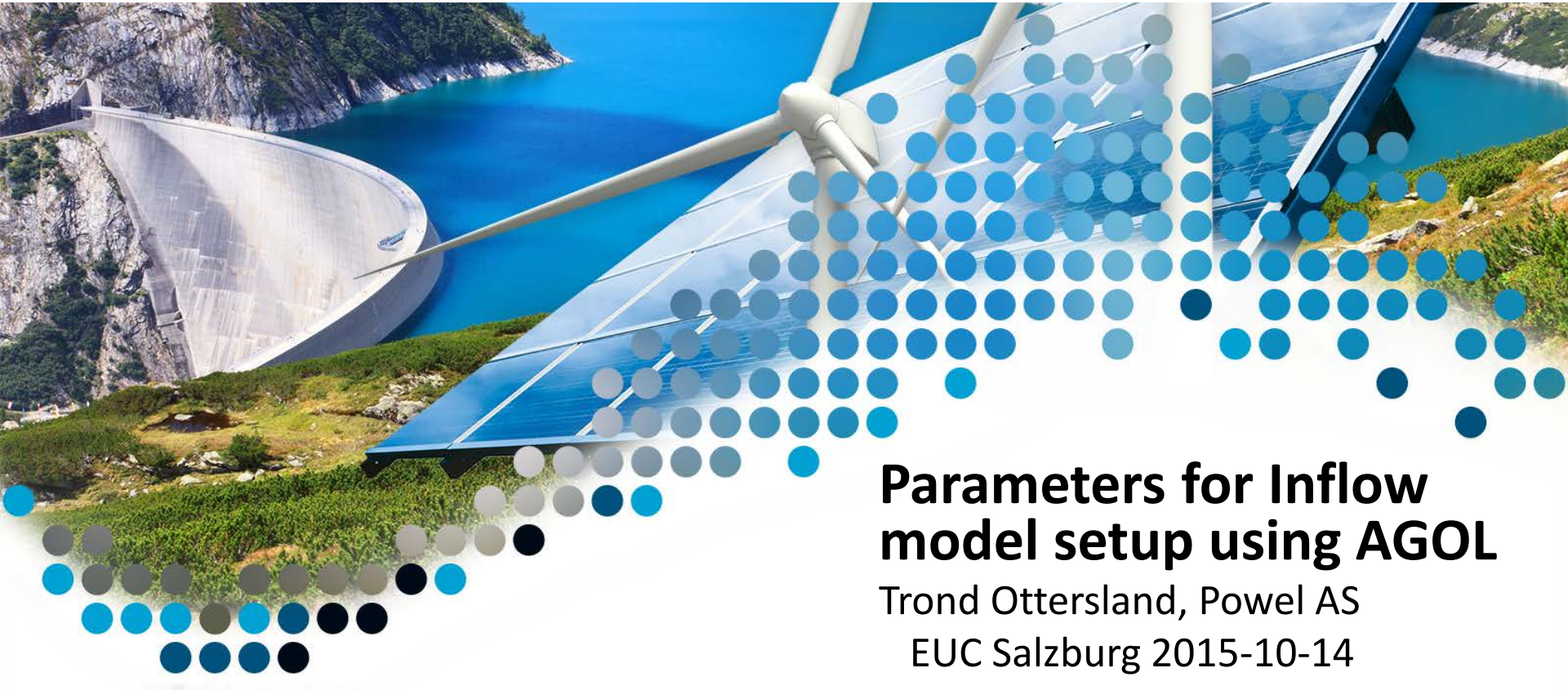

Parameters for Inflow model setup using AGOL

Trond Ottersland, Powel AS

EUC Salzburg 2015-10-14

Helping utilities work smarter

About me

- Solution Manager at Powel AS, Esri Business Partner and reseller
- Esri user since 1996
- Main focus now: Utilising GIS in power generation
- Live in the middle of Norway, 600 km north of Oslo

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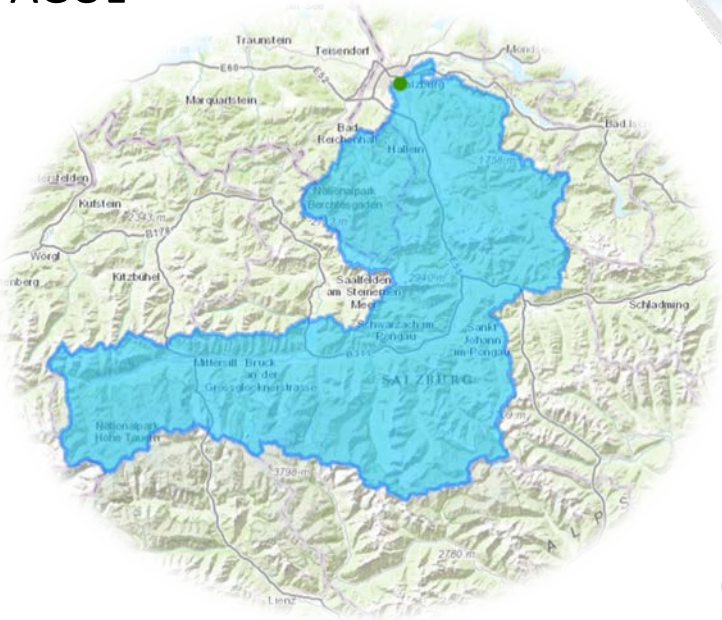
Contents

- Powel Inflow model description
- Getting parameters with ArcGIS and AGOL
- Some examples and results
- Further improvements and work



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Sustainable Water Management
Hydropower producer’s perspective

- Maximize profit
- Minimize spill
- Operate inside discharge limits
- Operate inside reservoir level limits
- Minimize flood damages

Hydrological variables are crucial for short and long term planning

- Inflow and price the most important stochastic input for production planning
  - **Profit:** Avoid spill - Use assets to optimally exploit peak prices
  - **Safety:** Reduce risk - Improve flood warning
- Improve your understanding of the power market outlook

Hydrology is an obvious and important part of the power market – but applied individually due to topology and climate variations

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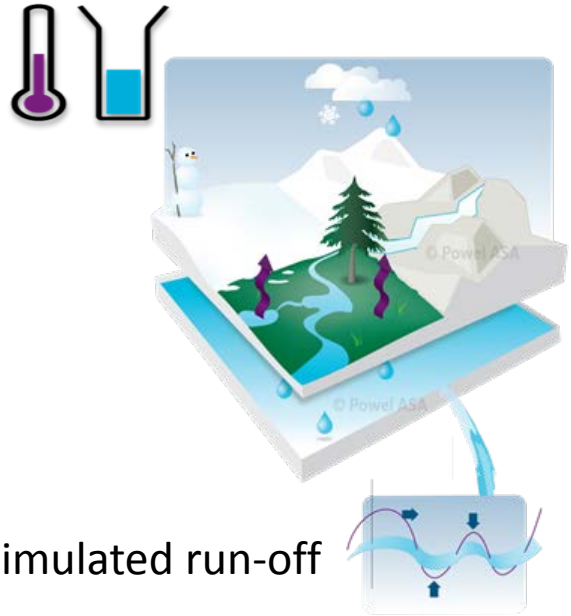
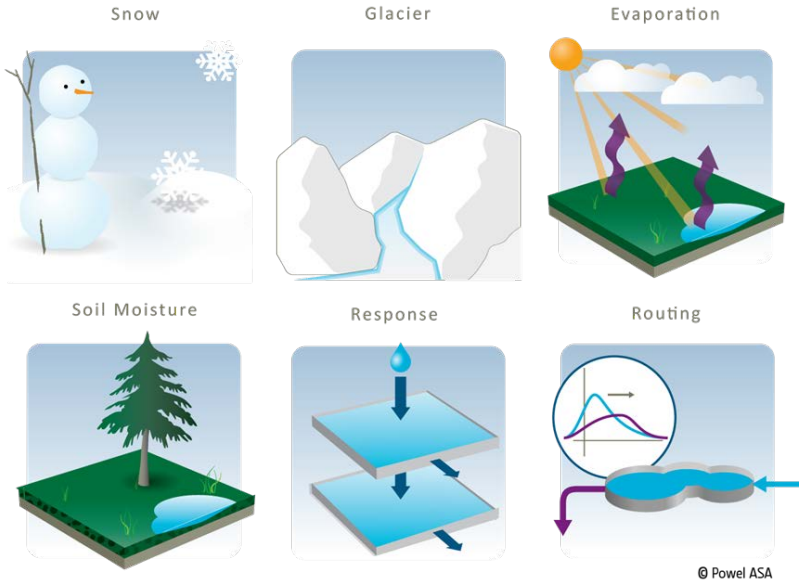
How to calculate inflow forecast?
The Powel Inflow model



Simulated run-off



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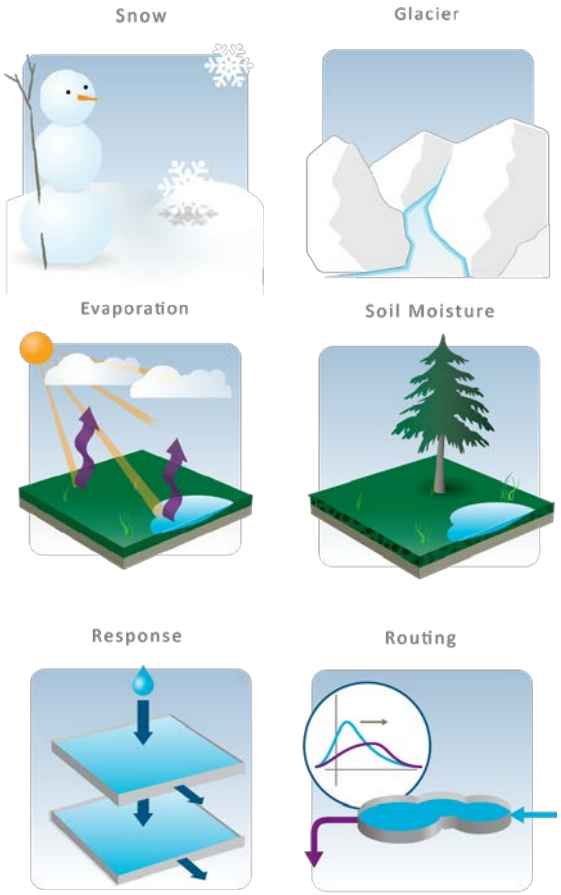
Calculation routines

- Snow: accumulation, distribution and melting in 10 elevation zones
- Glacier: accumulation and distribution in 10 elevation zones
- Evaporation: transpiration and evaporation from soil, vegetation, lake and reservoir
- Soil moisture: water delay in upper soil layer
- Response: quick run-off (upper zone) and slow run-off (lower zone)
- Routing: delayed run-off due to water held up in lakes and streams



Inflow differs due to catchment topology and climate variations

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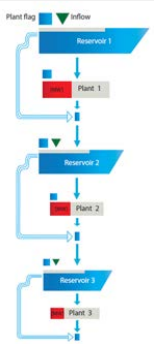
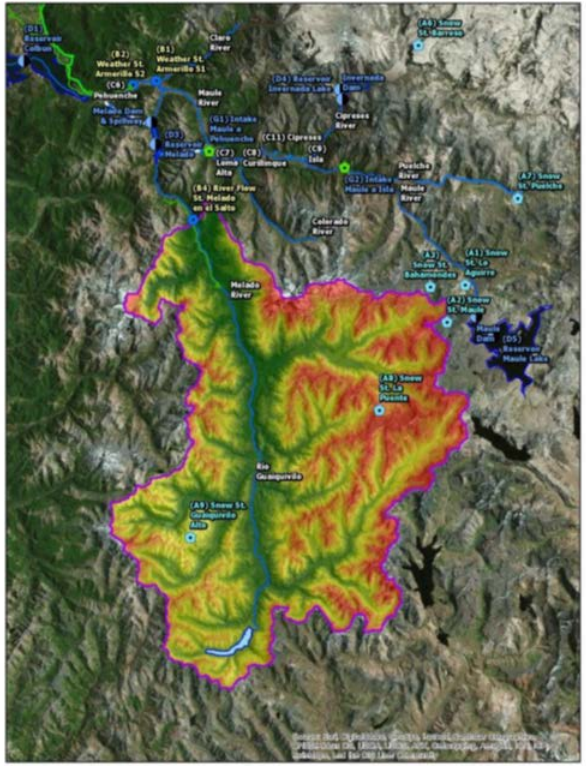
Task: Inflow model setup

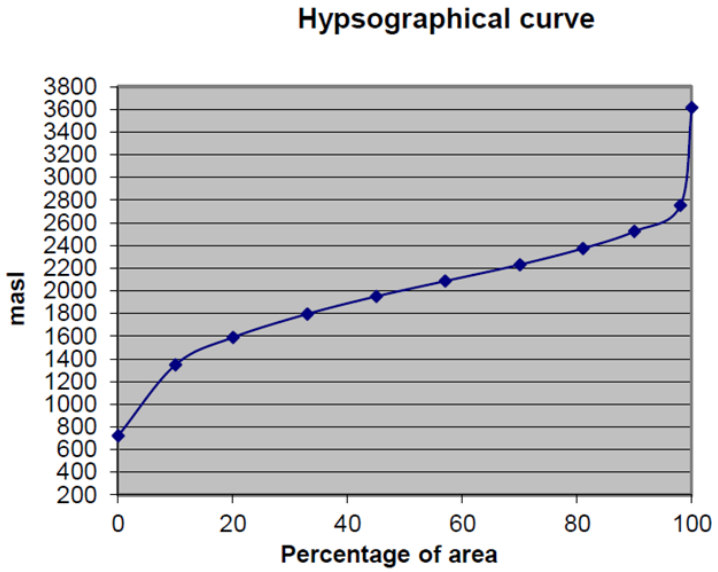
- Requirements: Parameters and historical data
- Auto-calibration routine fine tunes model
- Target R^2 >= 0.8



Need from GIS: Catchment area and hypsographical curve

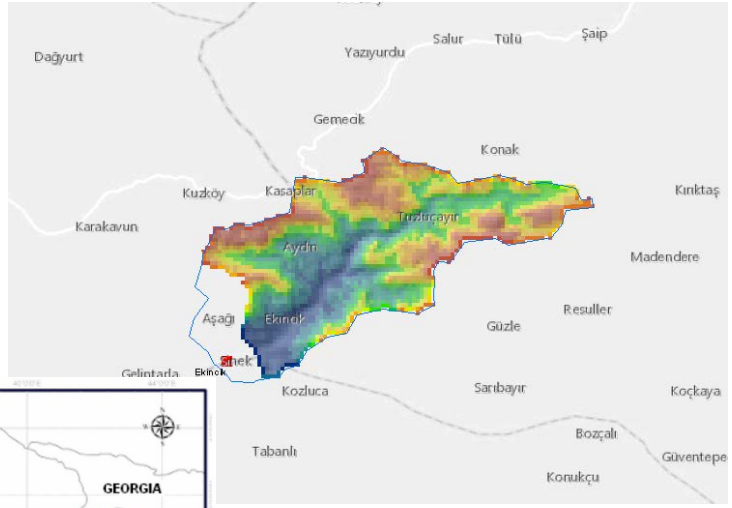
Melado case study, Chile

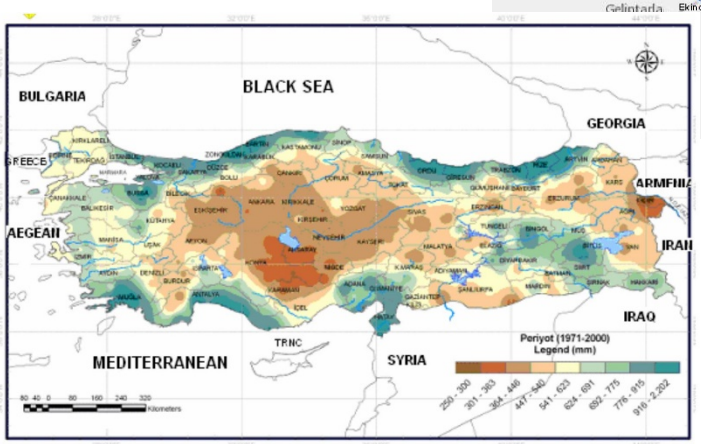




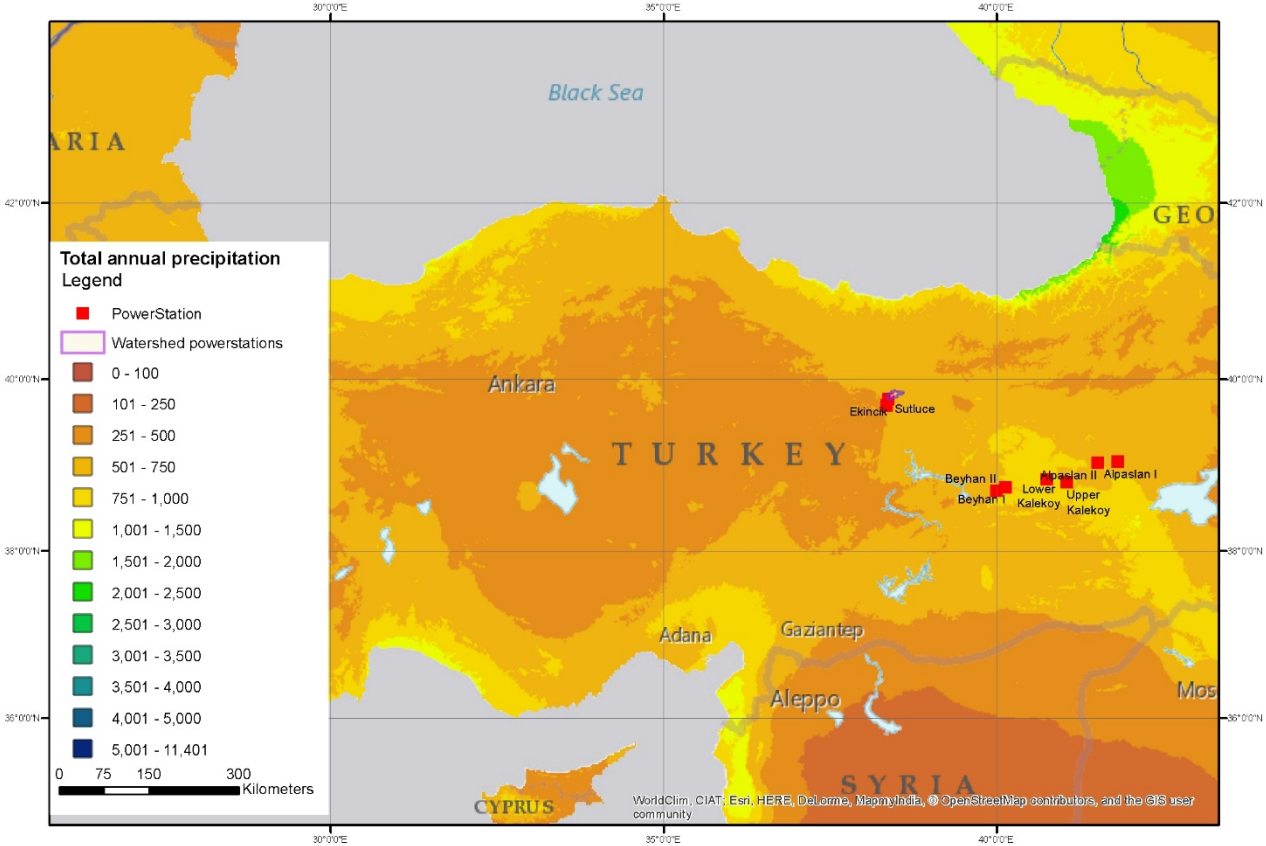
Easy in Norway, how about Turkey or Chile?

- Two years ago: Find AOI, download from NASA or ASTER if data, otherwise use worldwide 1km DEM
- Prepare DEM
- Delineate watershed
- …





Rainfall distribution



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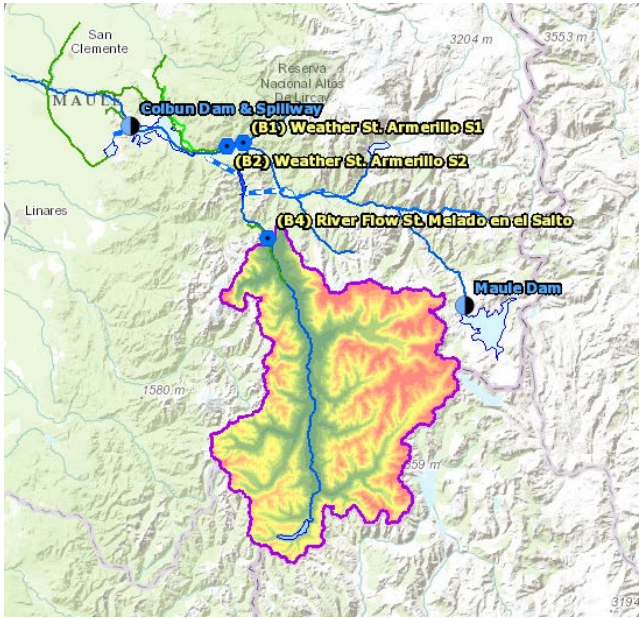
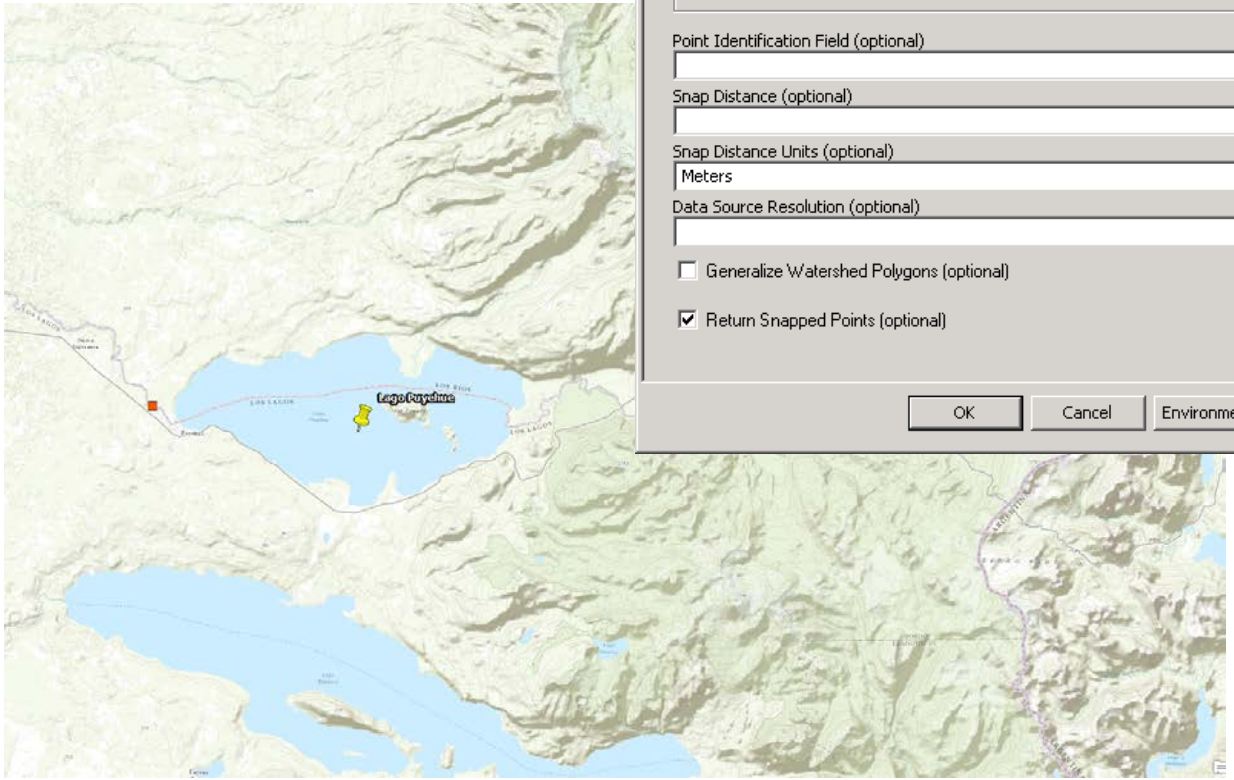
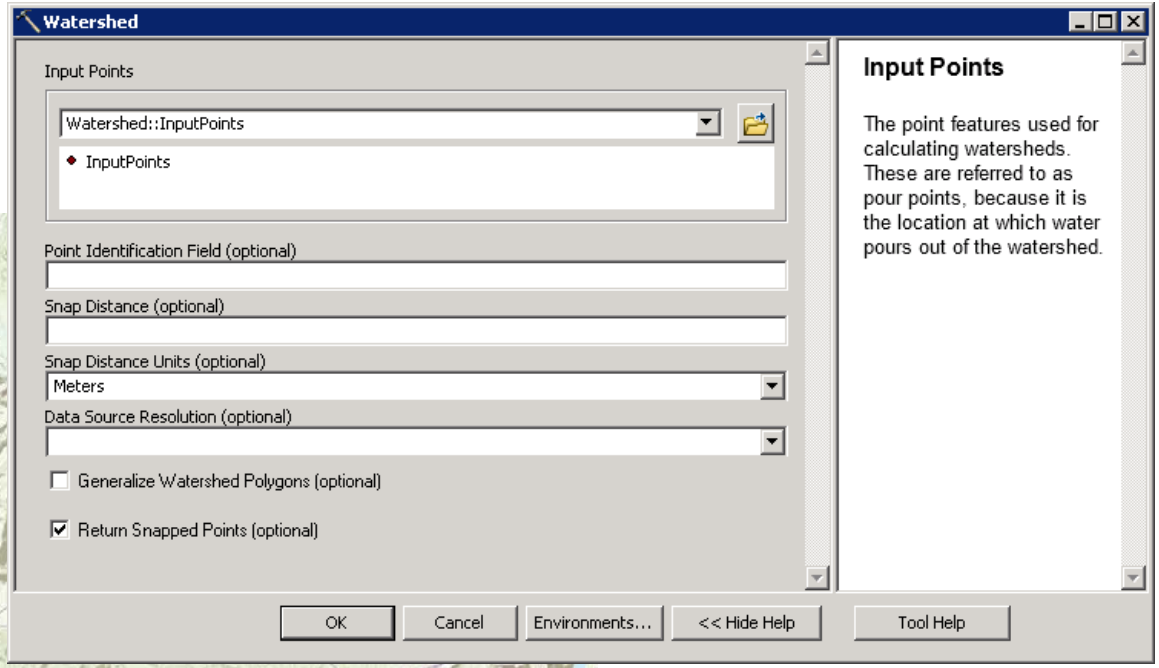
Now: AGOL!

- Worldwide DEM 30m/90m in AGOL
- Watershed delineation service
- Temperature and precipitation datasets as before

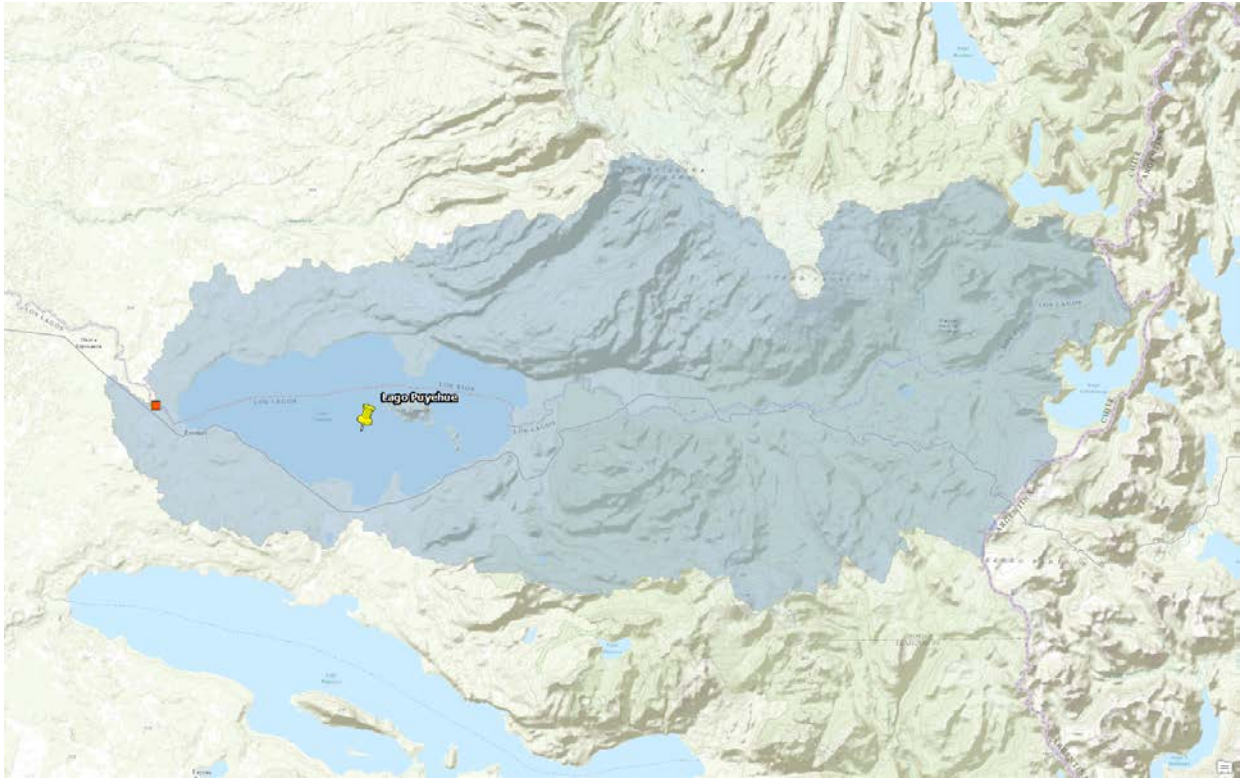


Find area


Lago Puyehue

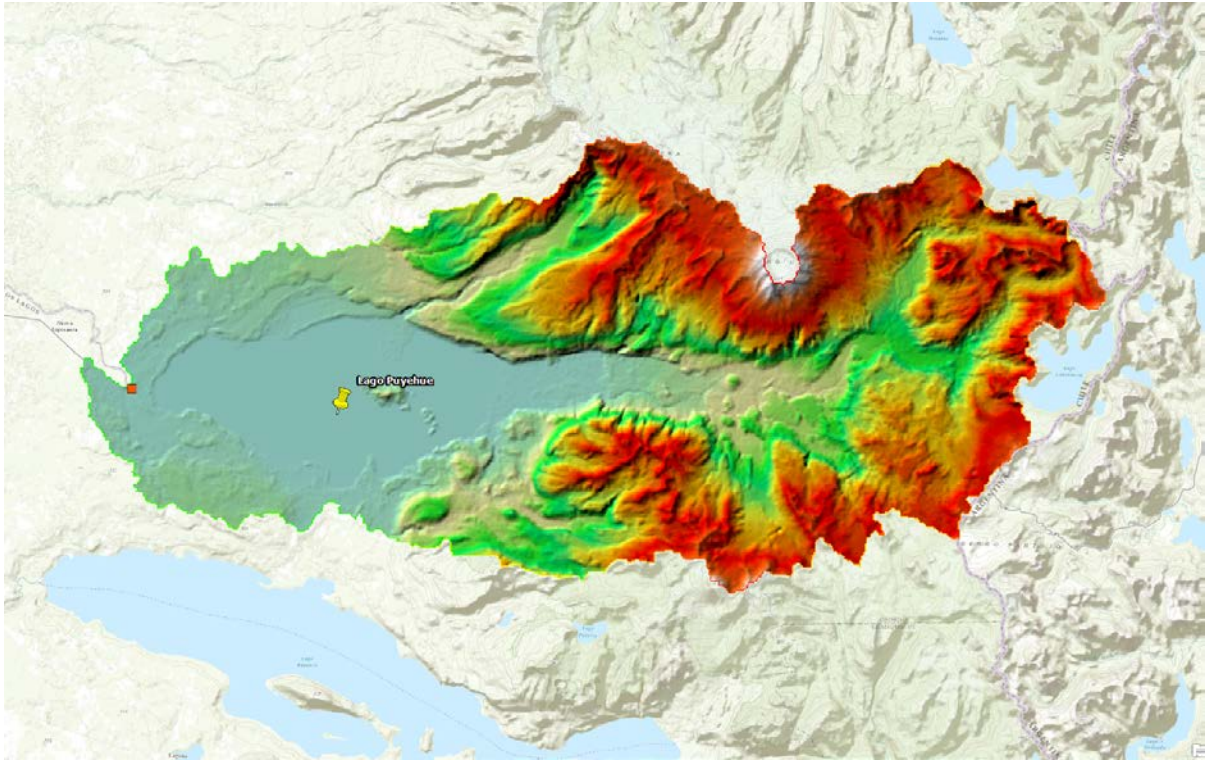

Watershed
Input Points
Watershed::InputPoints
InputPoints
Point Identification Field (optional)
Snap Distance (optional)
Snap Distance Units (optional)
Meters
Data Source Resolution (optional)
Generalize Watershed Polygons (optional)
Return Snapped Points (optional)
OK
Cancel
Environments...
<< Hide Help
Tool Help
Input Points
The point features used for calculating watersheds. These are referred to as pour points, because it is the location at which water pours out of the watershed.

Result



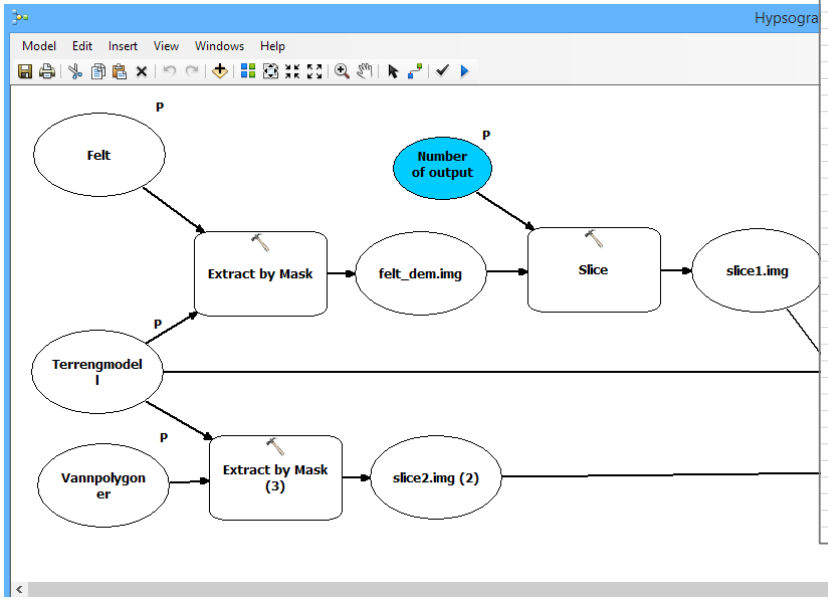
Model builder routines

- First, extract



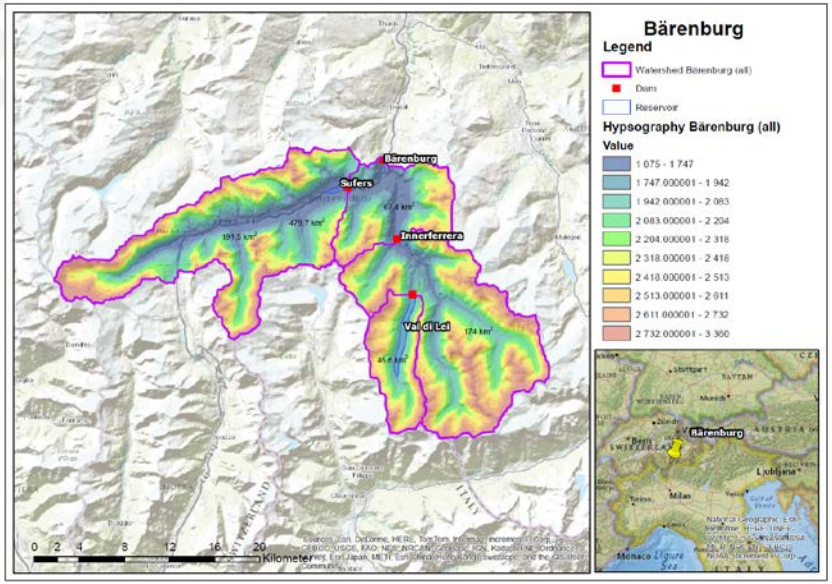
Model builder routines

- Then calculate hypsographic curve



A	B	C	D	E	F	G	H
ZONE	AREA	AREA_KM2	MIN	MAX	LAKE_AREA	LAKE_AREA_KM2	LAKE_AREA_Percent
1	5426100	5.4261	1075	1398	665100	0.6651	12.26 %
2	4248000	4.248	1399	1463	180900	0.1809	4.26 %
3	4776300	4.7763	1464	1510	5400	0.0054	0.11 %
4	4836600	4.8366	1511	1550			
5	4690800	4.6908	1551	1587			
6	4920300	4.9203	1588	1621			
7	4685400	4.6854	1622	1653			
8	4760100	4.7601	1654	1685			
9	4823100	4.8231	1686	1717			
10	4867200	4.8672	1718	1747			
11	4745700	4.7457	1748	1773			
12	4761000	4.761	1774	1797			
13	4911300	4.9113	1798	1820			
14	4806900	4.8069	1821	1841			
15	4724100	4.7241	1842	1862			
16	4859100	4.8591	1863	1883	900	0.0009	0.02 %
17	4753800	4.7538	1884	1893	2329200	2.3292	49.00 %
18	4948200	4.9482	1894	1909	865800	0.8658	17.50 %
19	4653000	4.653	1910	1925	308700	0.3087	6.63 %
20	4745700	4.7457	1926	1941	26100	0.0261	0.55 %
21	4925700	4.9257	1942	1957	4500	0.0045	0.09 %
22	4648500	4.6485	1958	1972			
23	4850100	4.8501	1973	1987			
24	4794300	4.7943	1988	2001			
25	4760100	4.7601	2002	2015			
26	4762800	4.7628	2016	2029			
27	4971600	4.9716	2030	2043			
28	4585500	4.5855	2044	2056			
29	4793400	4.7934	2057	2069			
30	4879800	4.8798	2070	2082			
31	4645800	4.6458	2083	2094			
32	4963500	4.9635	2095	2106			
33	4650300	4.6503	2107	2117			
34	4825800	4.8258	2118	2129			
35	4797900	4.7979	2130	2141			
36	4869000	4.869	2142	2153			
37	4729500	4.7295	2154	2165			
38	4749300	4.7493	2166	2177			
39	5053500	5.0535	2178	2190			
40	4635000	4.635	2191	2202			
41	4689900	4.6899	2203	2214			
42	4818600	4.8186	2215	2226			
43	4833900	4.8339	2227	2238			
44	4959000	4.959	2239	2250			

Output: Map and table



A	B	C	D	E	F	G	H
ZONE	AREA	AREA_KM2	MIN	MAX	LAKE_AREA	LAKE_AREA_KM2	LAKE_AREA_Percent
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2	4248000	4.248	1399	1463	180900	0.1809	4.26 %
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31	4645800	4.6458	2083	2094			
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35	4797900	4.7979	2130	2141			
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37	4729500	4.7295	2154	2165			
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42	4818600	4.8186	2215	2226			
43	4833900	4.8339	2227	2238			
44	4959000	4.959	2239	2250			

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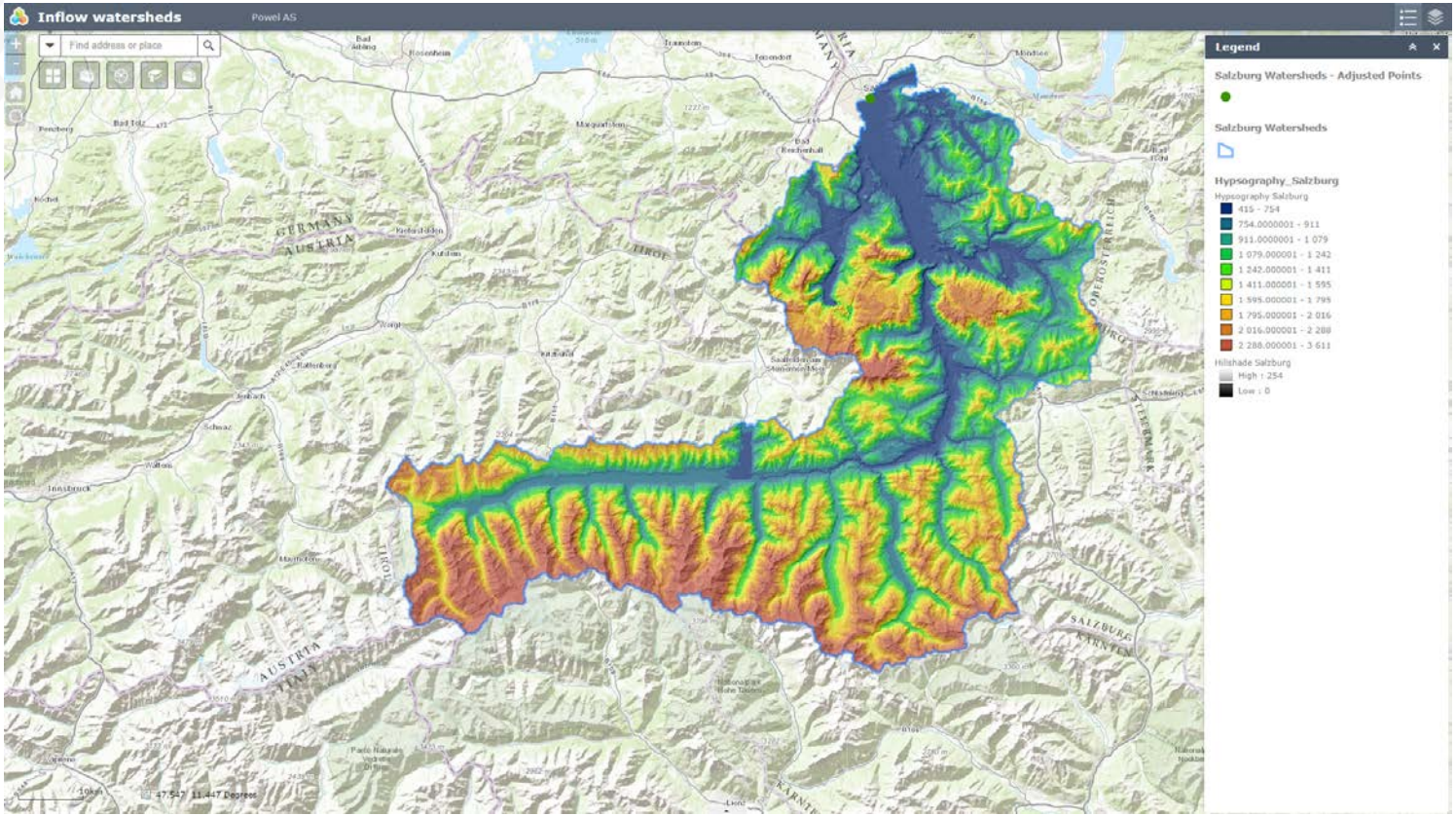
And webapp!



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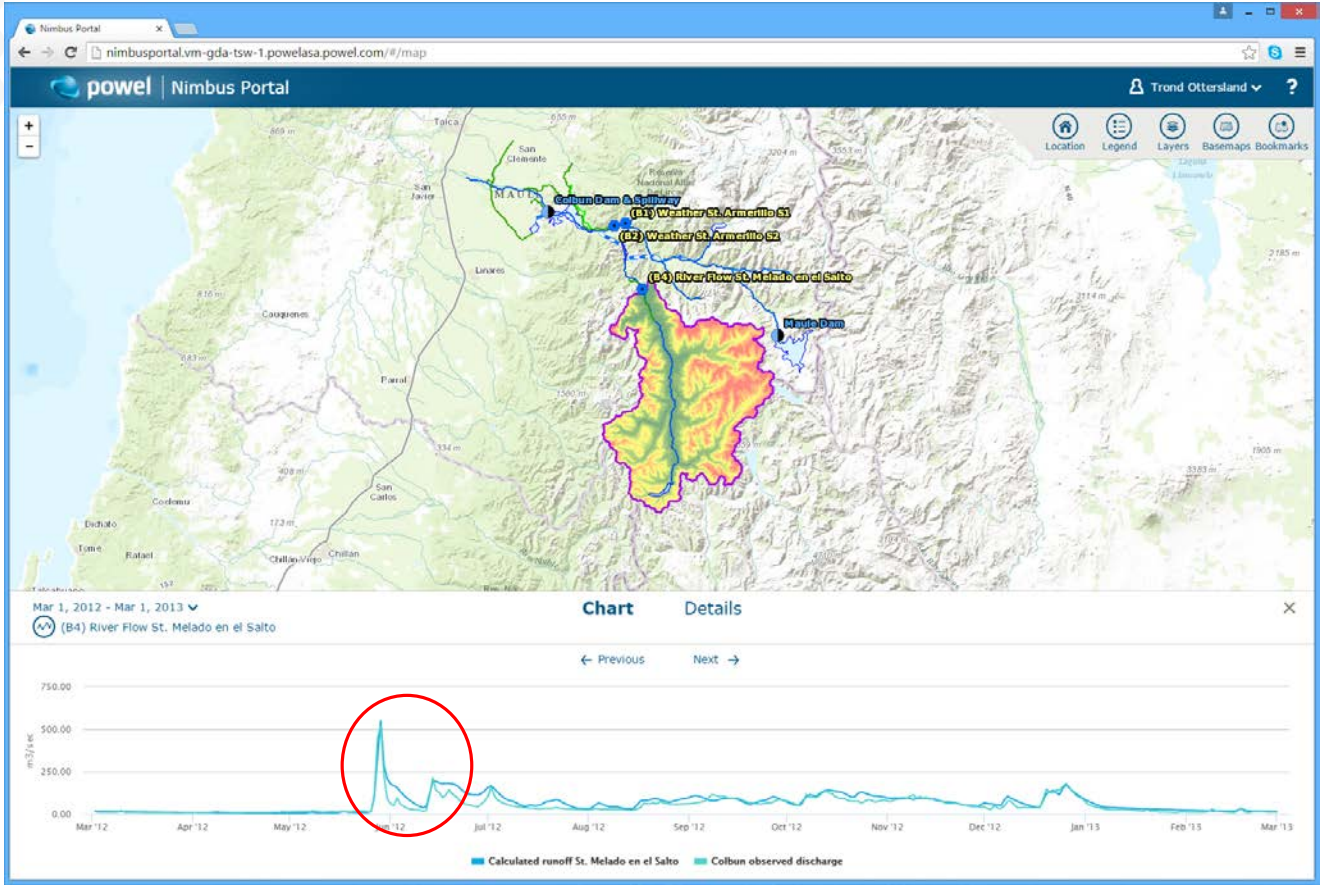
Result analysis



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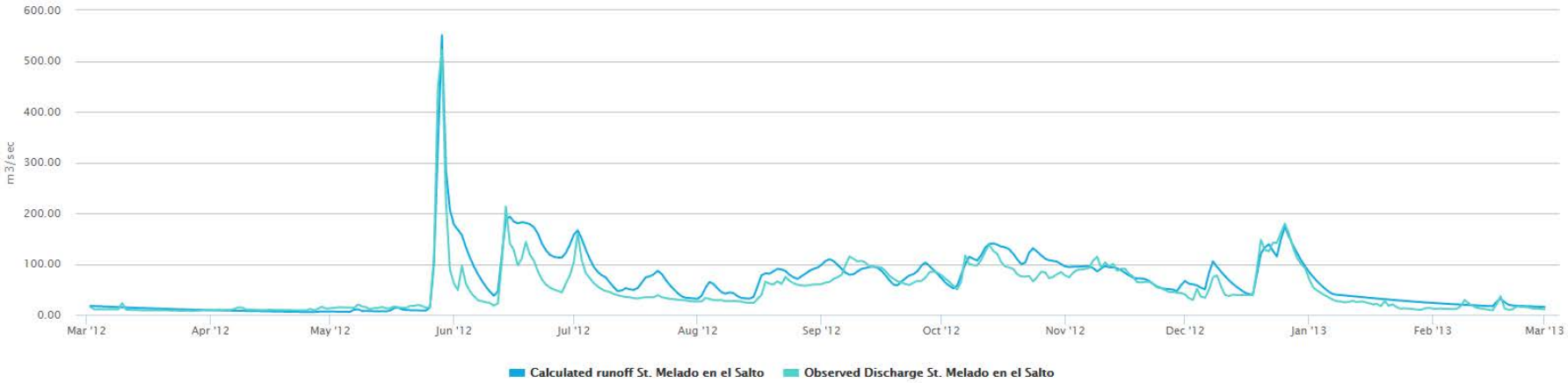
Trond Ottersland

2012-03-01 - 2013-03-01

Colbun

Table **Chart** Details

← Previous period Next period →



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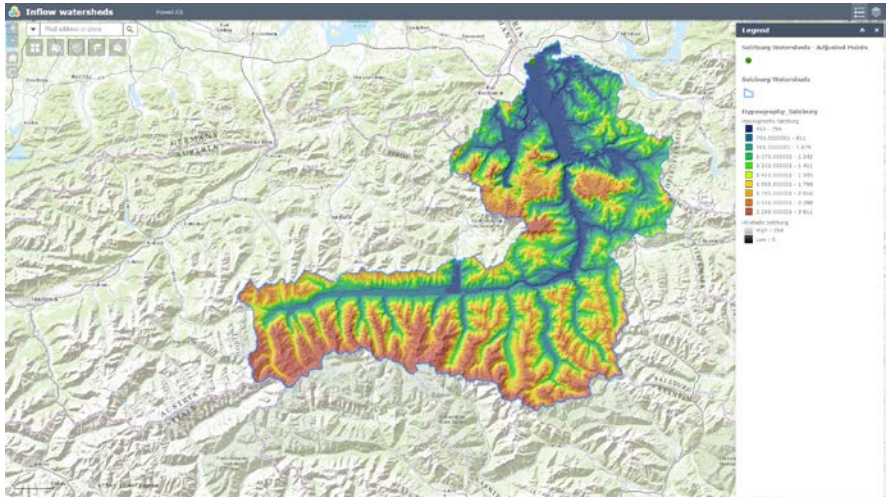
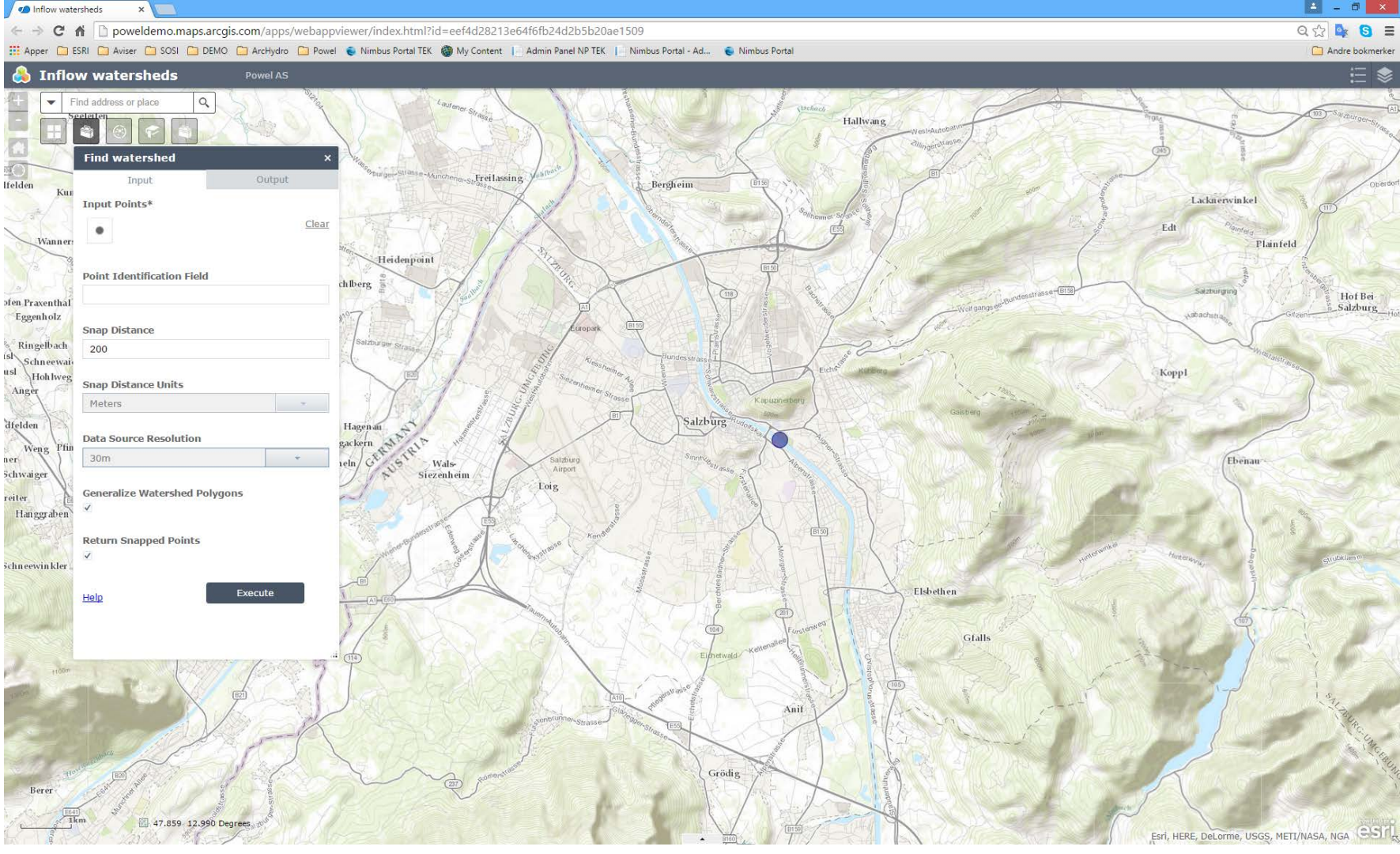
Examples

- Turkey
- Switzerland
- Austria
- South America

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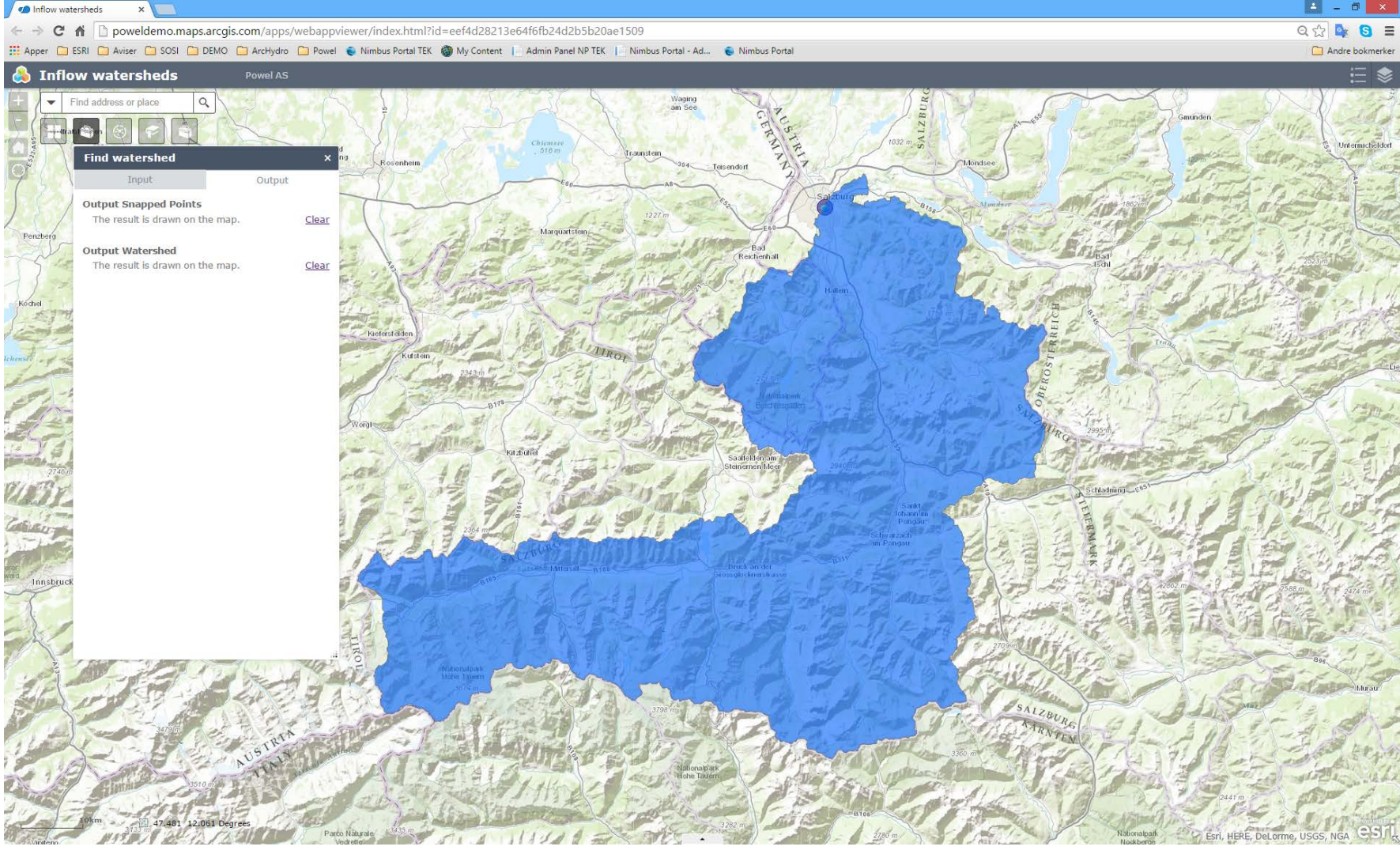
Inflow watersheds
Powel AS
Find address or place
Find watershed
Input
Output
Input Points*
Clear
Point Identification Field
Snap Distance
200
Snap Distance Units
Meters
Data Source Resolution
30m
Generalize Watershed Polygons
Return Snapped Points
Help
Execute
Salzburg
Hallwang
Bergheim
Freilassing
Heidenpoint
Lackenerwinkel
Edt
Plainfeld
Hof Bei Salzburg
Koppl
Ebenau
Elsbethen
Glaßl
Anif
Grödig
Wals-Siezenheim
Loig
Salzburg Airport
Europark
Kapuzinerberg
GERMANY
AUSTRIA
SALZBURG-UMGEBUNG
47.859 12.990 Degrees
Esri, HERE, DeLorme, USGS, METI/NASA, NGA


Inflow watersheds
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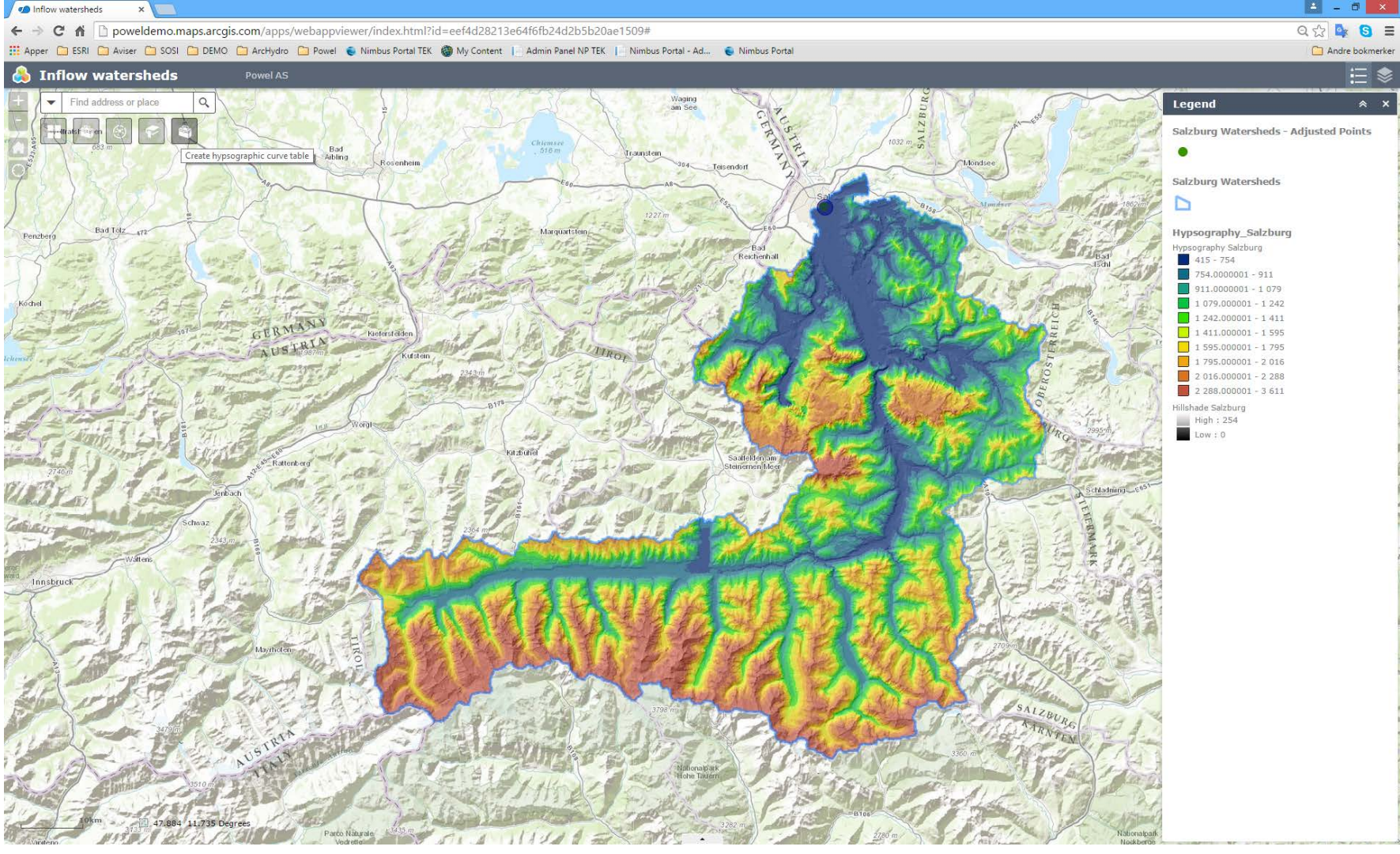
Inflow watersheds
Powel AS
Find address or place
Find watershed
Input
Output
Output Snapped Points
The result is drawn on the map.
Clear
Output Watershed
The result is drawn on the map.
Clear
Salzburg
Hallein
Bad Reichenhall
Saalfelden am Steinernen Meer
Mittersill
Bruck an der Grossglocknerstrasse
Schladming
Mondsee
Traunstein
Rosenheim
Innsbruck
Kufstein
Kitzbühel
Gmunden
Bad Ischl
Murau
Nationalpark Hohe Tauern
Nationalpark Berchtesgaden
47.481 12.061 Degrees
Esri, HERE, DeLorme, USGS, NGA
esri


Inflow watersheds
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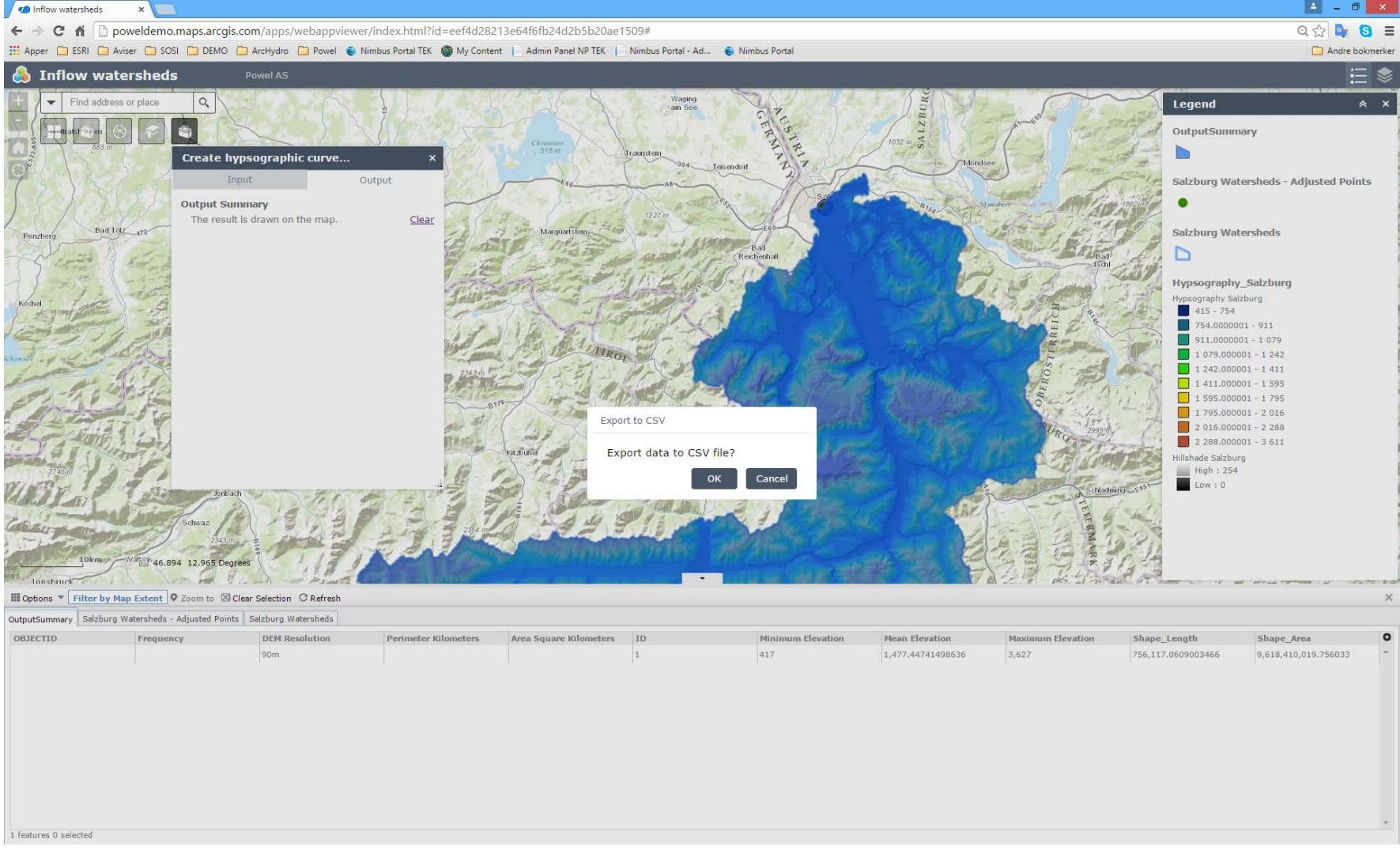
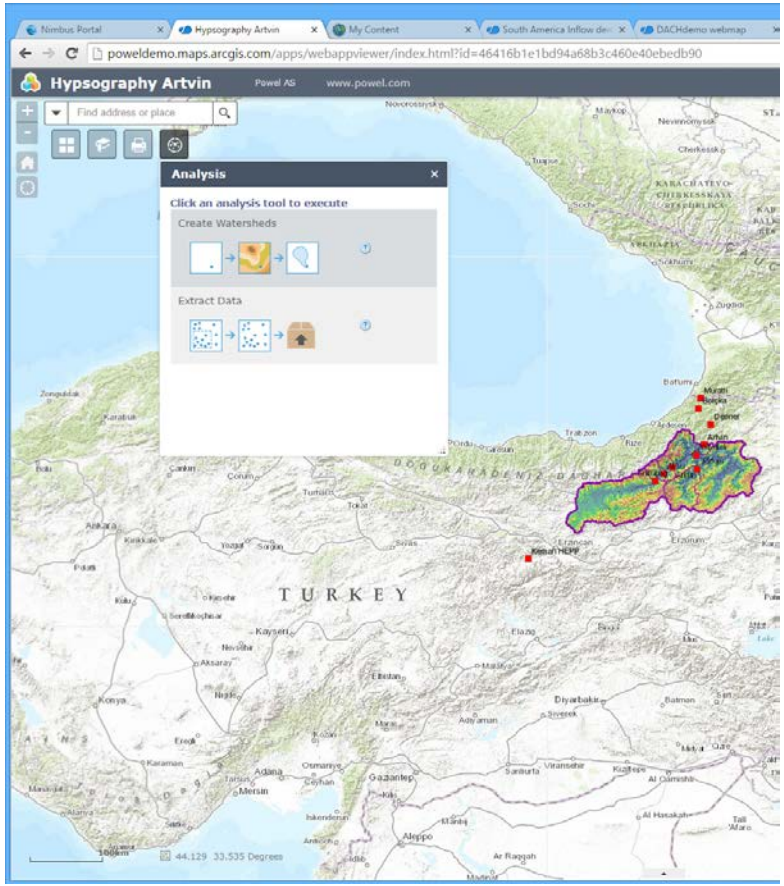
Inflow watersheds
Powel AS
Find address or place
Create hypsographic curve table
Legend
Salzburg Watersheds - Adjusted Points
Salzburg Watersheds
Hypsography_Salzburg
Hypsography Salzburg
415 - 754
754.0000001 - 911
911.0000001 - 1 079
1 079.000001 - 1 242
1 242.000001 - 1 411
1 411.000001 - 1 595
1 595.000001 - 1 795
1 795.000001 - 2 016
2 016.000001 - 2 288
2 288.000001 - 3 611
Hillshade Salzburg
High : 254
Low : 0
47.884 11.735 Degrees


Inflow watersheds
poweldemo.maps.arcgis.com/apps/webappviewer/index.html?id=eef4d28213e64f6fb24d2b5b20ae1509#
Inflow watersheds
Powel AS
Find address or place
Create hypsographic curve...
Input
Output
Output Summary
The result is drawn on the map.
Clear
Export to CSV
Export data to CSV file?
OK
Cancel
Legend
OutputSummary
Salzburg Watersheds - Adjusted Points
Salzburg Watersheds
Hypsography_Salzburg
Hypsography Salzburg
415 - 754
754.0000001 - 911
911.0000001 - 1 079
1 079.000001 - 1 242
1 242.000001 - 1 411
1 411.000001 - 1 595
1 595.000001 - 1 795
1 795.000001 - 2 016
2 016.000001 - 2 288
2 288.000001 - 3 611
Hillshade Salzburg
High : 254
Low : 0
46.894 12.965 Degrees
Options
Filter by Map Extent
Zoom to
Clear Selection
Refresh
OutputSummary
Salzburg Watersheds - Adjusted Points
Salzburg Watersheds
OBJECTID
Frequency
DEM Resolution
Perimeter Kilometers
Area Square Kilometers
ID
Minimum Elevation
Mean Elevation
Maximum Elevation
Shape_Length
Shape_Area
90m
1
417
1,477.44741498636
3,627
756,117.0609003466
9,618,410,019.756033
1 features 0 selected

Improvements

- More detailed lake data, 1:250.000 would be nice
- Utilise hillshade to help setting points for watershed in difficult areas
- Share tools with colleagues in webapp for self service (working on that)
- What about customers?



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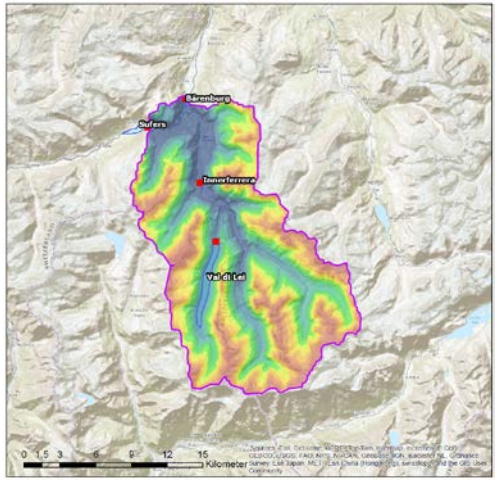
Questions?



- trond.ottersland@powel.no

- Details about HBV-model:
  - https://en.wikipedia.org/wiki/HBV_hydrology_model
  - http://www.smhi.se/forskning/forskningsomraden/hydrologi/hbv-1.1566

- Powel Inflow:
- http://www.powel.com/about/feature_stories/inflow-forecast-for-hydropower-plants/

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