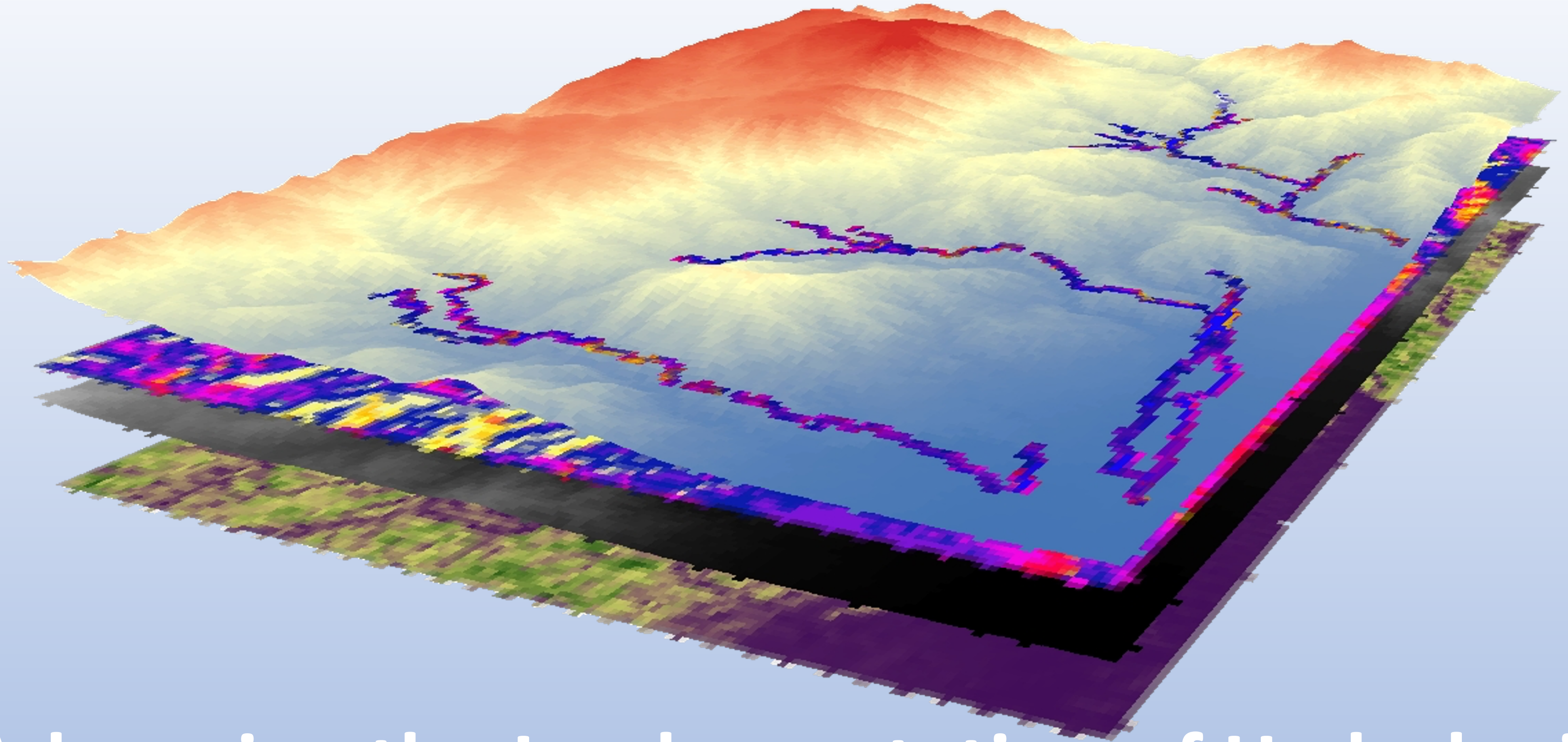

Advancing the Implementation of Hydrologic Models Through Automated Data Preparation Approaches

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Bioretention Done Right

0.25 CEUs/2.5 PDHs

Doug Beyerlein
Co-Founder, Clear Creek Solutions

This course will discuss how bioretention systems are designed, how different engineered soil media impact the movement of stormwater runoff through the engineered soil layers, and how this is typically modeled. Modeling assumptions, good and bad, will be identified along with their potential impact on bioretention facility sizing and effectiveness in providing water quality treatment.

Prasanna Dahal

M.S., P.E.

Project Engineer

Sunrise Engineering Inc.

pdahal@sunrise-eng.com

Learning Objectives

- Learn a mindset of automating data preparation processes for common modeling tasks
- Learn programmatic access to public data source
- Learn power of open source platforms such as Python and R to pre-process dataset

Sections

- Introduction / Background
- Digital Mindset
- Data Acquisition
- Data Cleaning
- Conclusion

Section1: Introduction / Background

- Importance of H/H modeling
- Challenges in H/H modeling (data aspect)
- Automation: A better approach to tackle existing challenges

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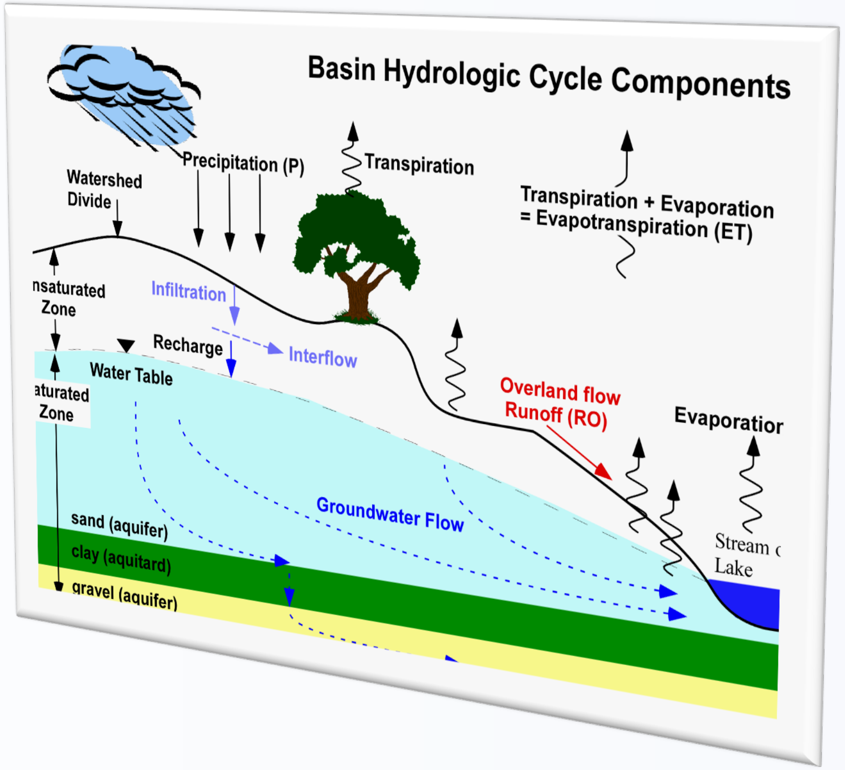
Section1: Introduction / Background

Deeper understanding of hydrologic process is imperative to solve water related problems and to better plan and manage city water infrastructure. Advanced computer models are essential in helping us understand such relationships. However, preparing such models requires huge investment of time and resources, much of which are concentrated on acquisition and curation of data.

Section1: Introduction / Background



What do Models do?

- Try to capture physical process for further analysis

Why do we model?

Analyze or predict scenarios like floods and droughts

How changes today impact in the future

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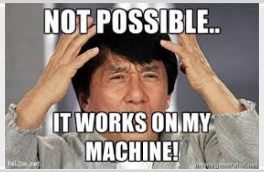
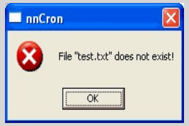
*Image sources: http://www.bratttree.com/

Section1: Introduction / Background

Data Related Challenges	
Time consuming	
Many data sources	
Repetitive, so boring	
Hinders reproducible science	
Data archiving hassle	

Additional Challenges	
Demands wide skill set	
Machine dependencies	
Prone to errors	
Distraction to main analysis	

Section1: Introduction / Background

- Use of computer simulations for modeling environmental system has been around for a long time.
- Rise of Cyber-Infrastructure (CI) has made use of computer to solve problems even more relevant.
- ‘Model as a Service’ vision.
- We are headed towards web based modeling solutions

Section2: Digital mindset

There is an ongoing Digital trend.

- Improved Digital Infrastructure
  - Increased digitization
    - GIS Vs PDF contour maps etc.
    - Increased GIS leads to advanced APIs
    - FOSS scientific computing with huge community of developers (Python/R,)
    - Google earth engine
- Advantage over legacy approach: Faster, Reliable
- We need to leverage increased digitization for data acquisition,

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Section2: Digital mindset

- There is an ongoing digital trend.
  - Bigger consulting companies adopting it
  - Smart cities
  - Google earth engine
- Improved digital infrastructure has resulted in ever improving increased digitization

Land Use/Land Cover Data

National Land Cover Dataset. https://viewer.nationalmap.gov/basic/ and Multi-Resolution Land Characteristics Consortium (MRLC). http://www.mrlc.gov/

National Land Cover Institute http://landcover.usgs.gov/

Land Cover Change 2001 to 2006 to 2011 http://www.mrlc.gov/nlcdrlc.php

National Wetlands Inventory Center http://www.fws.gov/wetlands/

Water Resources Maps and GIS Information http://water.usgs.gov/maps.html. This site is a listing data sources with map data from the USGS or organizations connected with the USGS.

Climate and weather

Climate.gov maps: http://www.climate.gov/maps-data

National Centers for Environmental Information https://www.ncei.noaa.gov/

USDA Agricultural Applied Climate Information System http://www.wcc.nrcs.usda.gov/climate/index.html

PRISM Climate Group Oregon State University http://prism.oregonstate.edu/

DayMET http://daymet.ornl.gov/ Gridded daily precipitation and temperature on a 1 km grid.

Nexrad radar data (including precipitation) https://gis.ncdc.noaa.gov/maps/ncei/radar

NRCS National Water and Climate Center http://www.wcc.nrcs.usda.gov/ that includes water supply forecasts, snow, precipitation and temperature.

SNOTEL http://www.wcc.nrcs.usda.gov/snotel/ real time snow data

US Drought Portal http://www.drought.gov/

Water Resources

USGS National Water Information System http://water.usgs.gov/usa/nwis/

Real Time USGS Data on Water Watch http://water.usgs.gov/nwis/rt

CUAHSI Data Services https://www.cuahsi.org/data-models and HydroClient at http://data.cuahsi.org/

National Weather Service Advanced Hydrologic Prediction Service http://water.weather.gov/ahps

National Water Model http://water.noaa.gov/about/nwm. http://water.noaa.gov/map

WHY ARE TECH GIANTS BUILDING CITIES?

FRIDAY, AUGUST 14, 2020

MY LIST SHARE

Author | Eduardo Bravo

Tech giants such as **Google**, **Amazon**, **Microsoft**, **Toshiba** or **Cisco** are building **smart cities** in various parts of the world. This decision may come as a surprise to some however, it is related to their core business from the very moment smart cities incorporate many of the **technology advancements** developed by these companies.

GitHub

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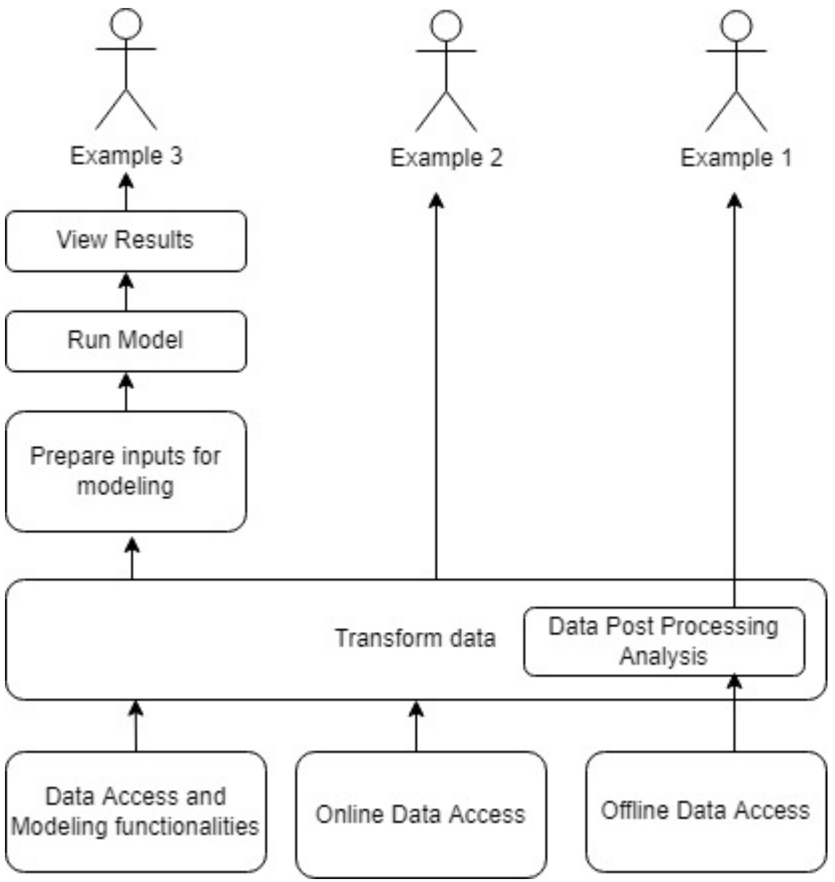
Section2: Digital mindset

- Different levels of Automation possible,
  - Depends on
    - Software availability
    - Platform supports
    - Time availability
  - End-to-end modeling services have been implemented: RHESSys, My Thesis?



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Section3: Data Acquisition

- Some important sources of data
- Examples/Demo: call from Python/R
- Code walk-throughs

Section3: Data Acquisition

https://thredds.daac.ornl.gov/thredds/ncss/ornldaac/1328/2020/daymet_v3_srad_2020_na.nc4?var=lat&var=lon&var=srad&north=44.9&west=89.454&east=89.5&south=44.47&disableProjSubset=on&horizStride=1&time_start=2020-01-01T12:00:00Z&time_end=2020-12-30T12:00:00Z&timeStride=1&accept=netcdf

Imports

```
import requests
```

Inputs (area and date)

```
list_of_years = [2015, 2016, 2020]
west, east, south, north = 89.454, 89.50, 44.47, 44.9
```

In a loop so multiple files can be requested at once

Make proper requests

```
for year in list_of_years:
    for var in ['tmin', 'tmax', 'prcp', 'vp', 'srad']:
        str = 'https://thredds.daac.ornl.gov/thredds/ncss/ornldaac/1328/%s/daymet_v3_%s_%s_na.nc4?' \
              'var=lat&var=lon&var=%s&north=%s&west=%s&east=%s&south=%s&disableProjSubset=on&horizStride' \
              '=1&time_start=%s-01-01T12:00:00Z&time_end=%s-12-30T12:00:00Z&timeStride=1&accept=netcdf'\
              %(year,var,year ,var,north, west, east, south, year, year)
```

Write request to file

```
        response = requests.get(str)
        if response.status_code == 200:
            res =  response.content
            f = open ('./%s_%s.nc'%(var, year), 'wb')
            f.write(res)
            f.close()
```

Section3: Data Acquisition

```
from climata.usgs import DailyValueIO
import pandas as pd

# set parameters
nyears = 10
ndays = 365 * nyears
station_id = "06730200"
param_id = "00060"

datelist = pd.date_range(end=pd.datetime.today(), periods=ndays).tolist()
data = DailyValueIO(
    start_date=datelist[0],
    end_date=datelist[-1],
    station=station_id,
    parameter=param_id,
)
```

INPUTS

```
for series in data:
    flow = [r[1] for r in series.data]
    dates = [r[0] for r in series.data]
data_df = pd.DataFrame({'Date':dates, 'Flow':flow})
print (data_df)
```

```
           Date  Flow
0    2011-12-05  6.66
1    2011-12-06  7.23
2    2011-12-07  8.78
3    2011-12-08  9.62
4    2011-12-09  8.37
...         ...   ...
3643 2021-11-25  6.90
3644 2021-11-26  6.21
3645 2021-11-27  6.04
3646 2021-11-28  4.57
3647 2021-11-29  7.24

[3648 rows x 2 columns]
```

Moral of the story:

It gets easier with help from active community and established package

Section3: Data Acquisition

Data Sources

National/State/Global Data repositories

- Hydrography
- USGS National Water Information System
- Land Cover
- Census
- Elevation
- Soil (STATSGO/SSURGO)
- Weather

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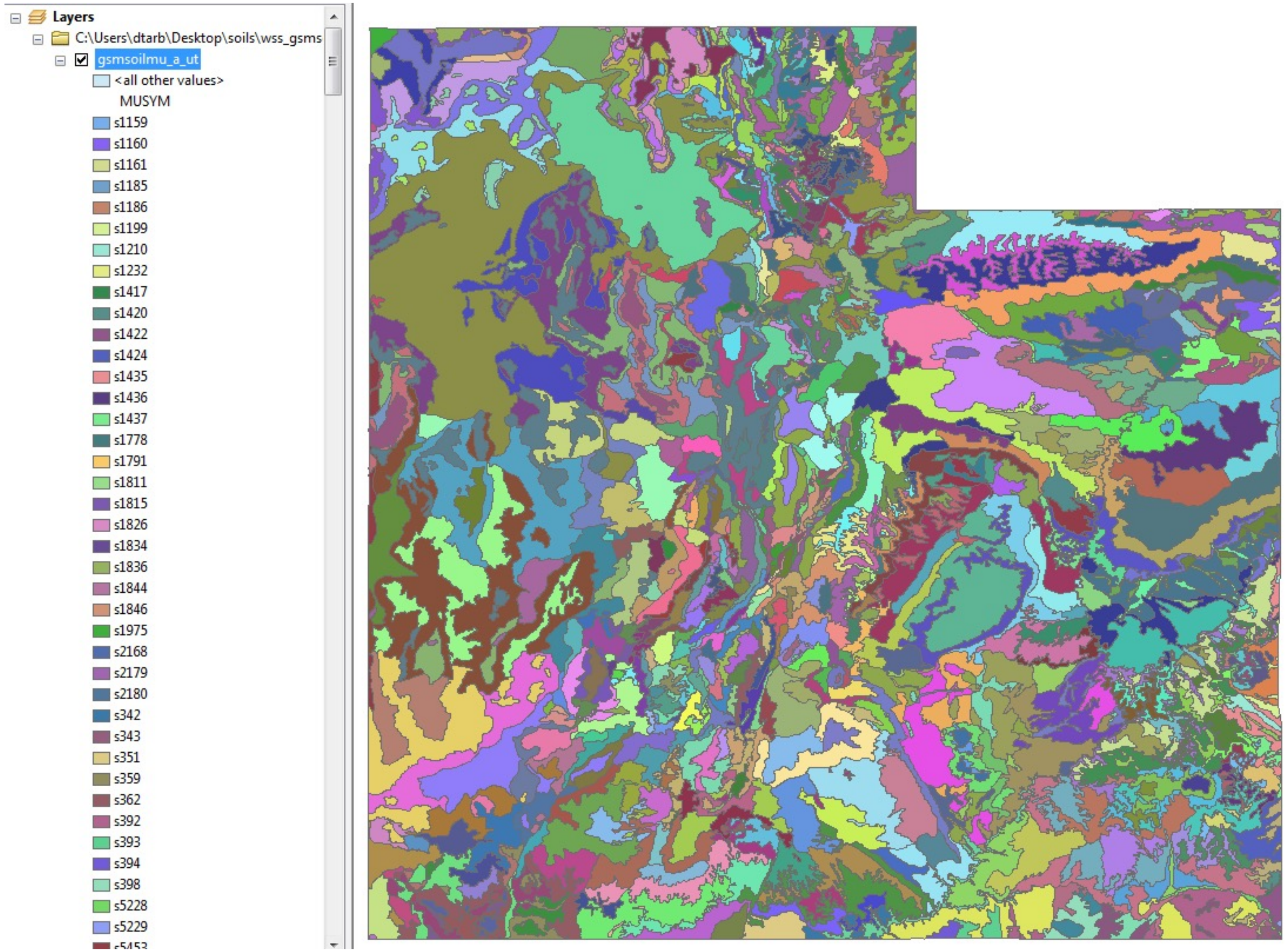
National STATSGO Database

USDA-NRCS Soil Survey Division

Data Access

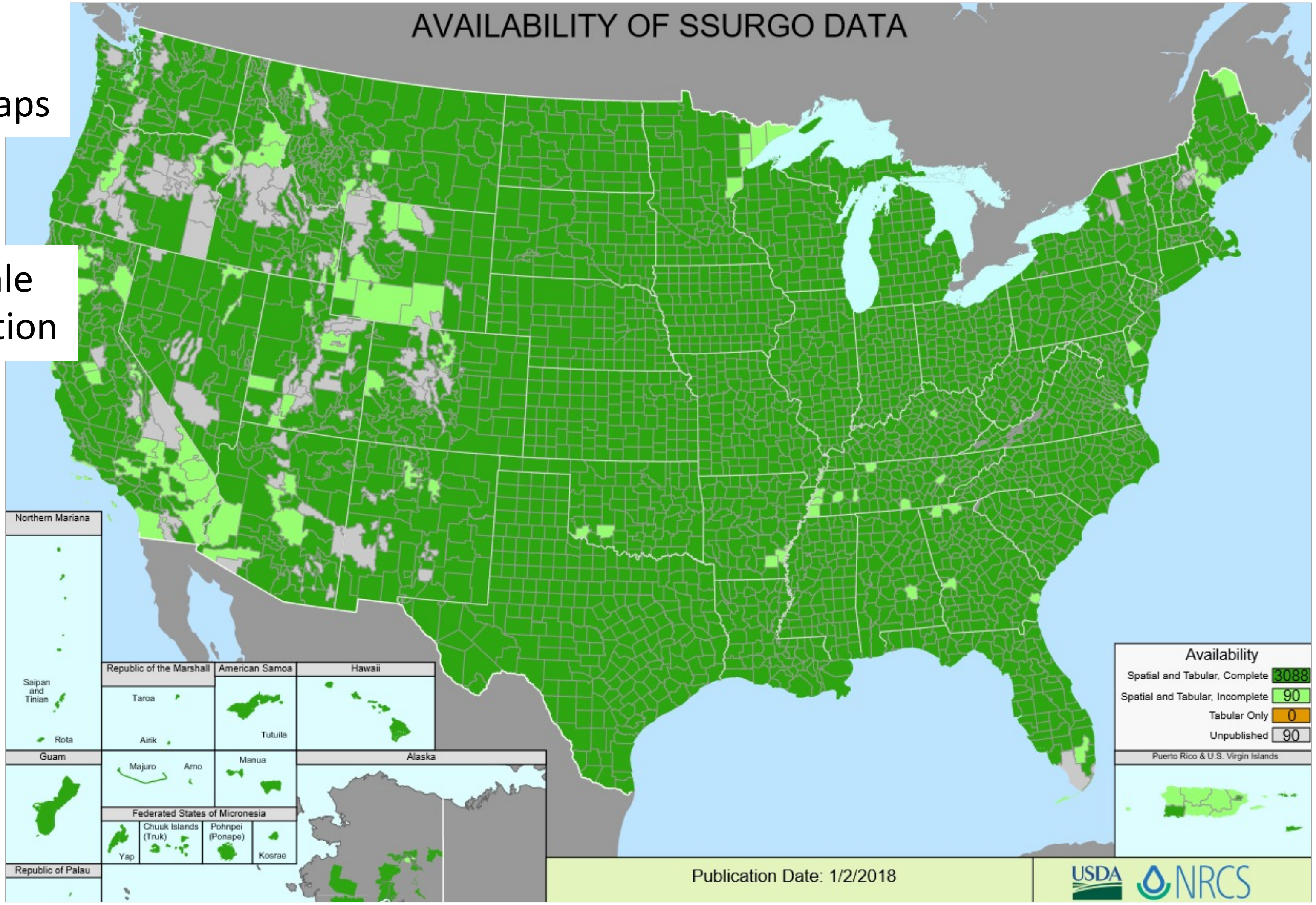
1:250,000 Scale Soil Information



https://gdg.sc.egov.usda.gov/

SSURGO:
County Level
Digital Soil Maps

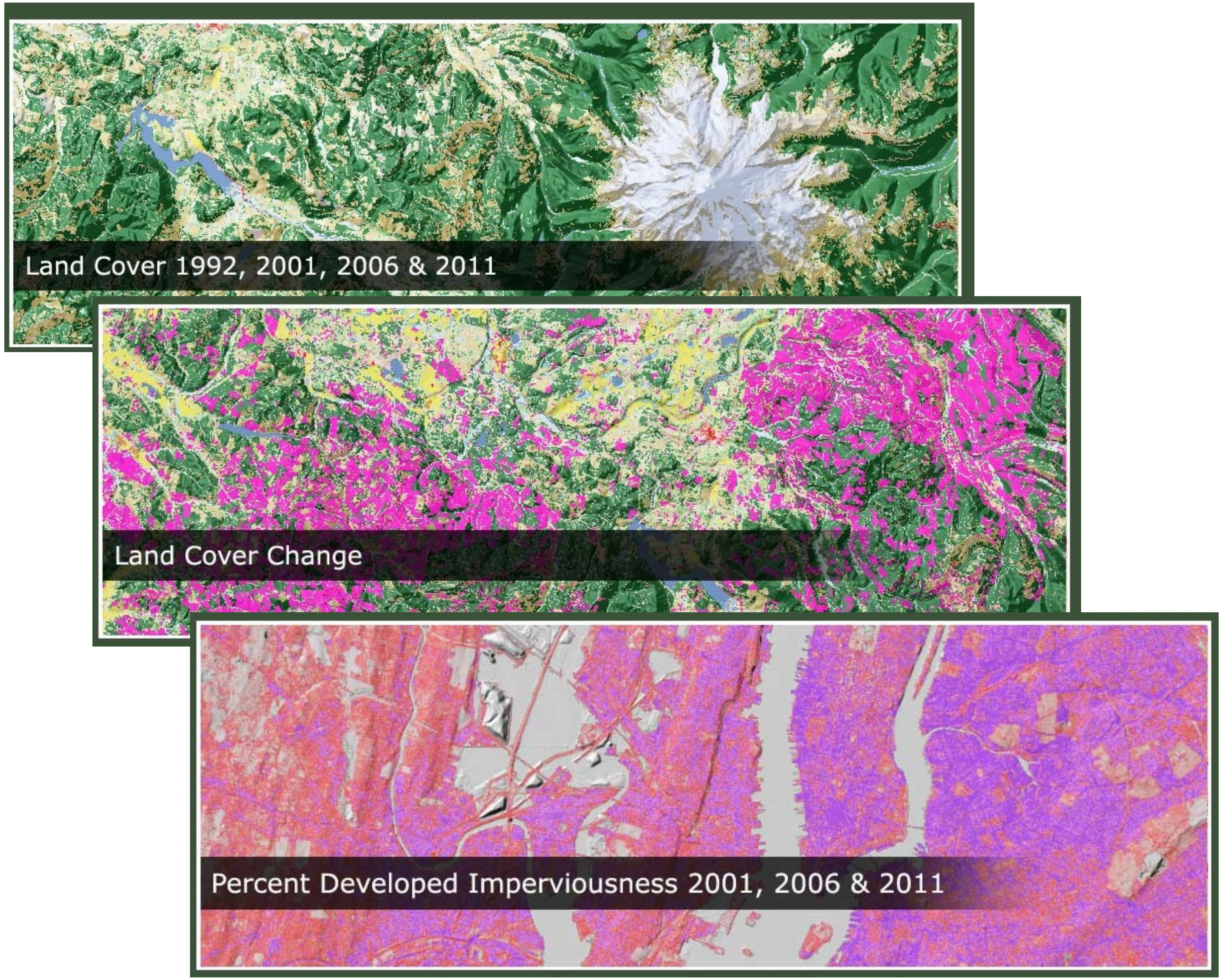
1:24,000 scale
soil information



http://websoilsurvey.nrcs.usda.gov/DataAvailability/SoilDataAvailabilityMap.pdf

National Land Cover Data

http://www.mrlc.gov/



The National Map

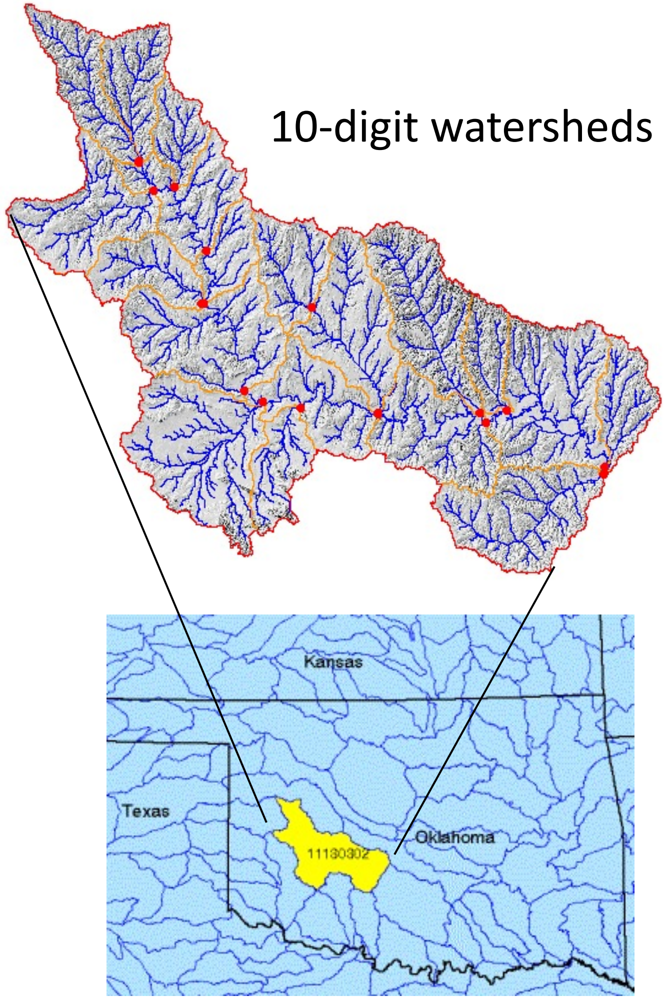
http://nationalmap.gov/

A central source for US Government data

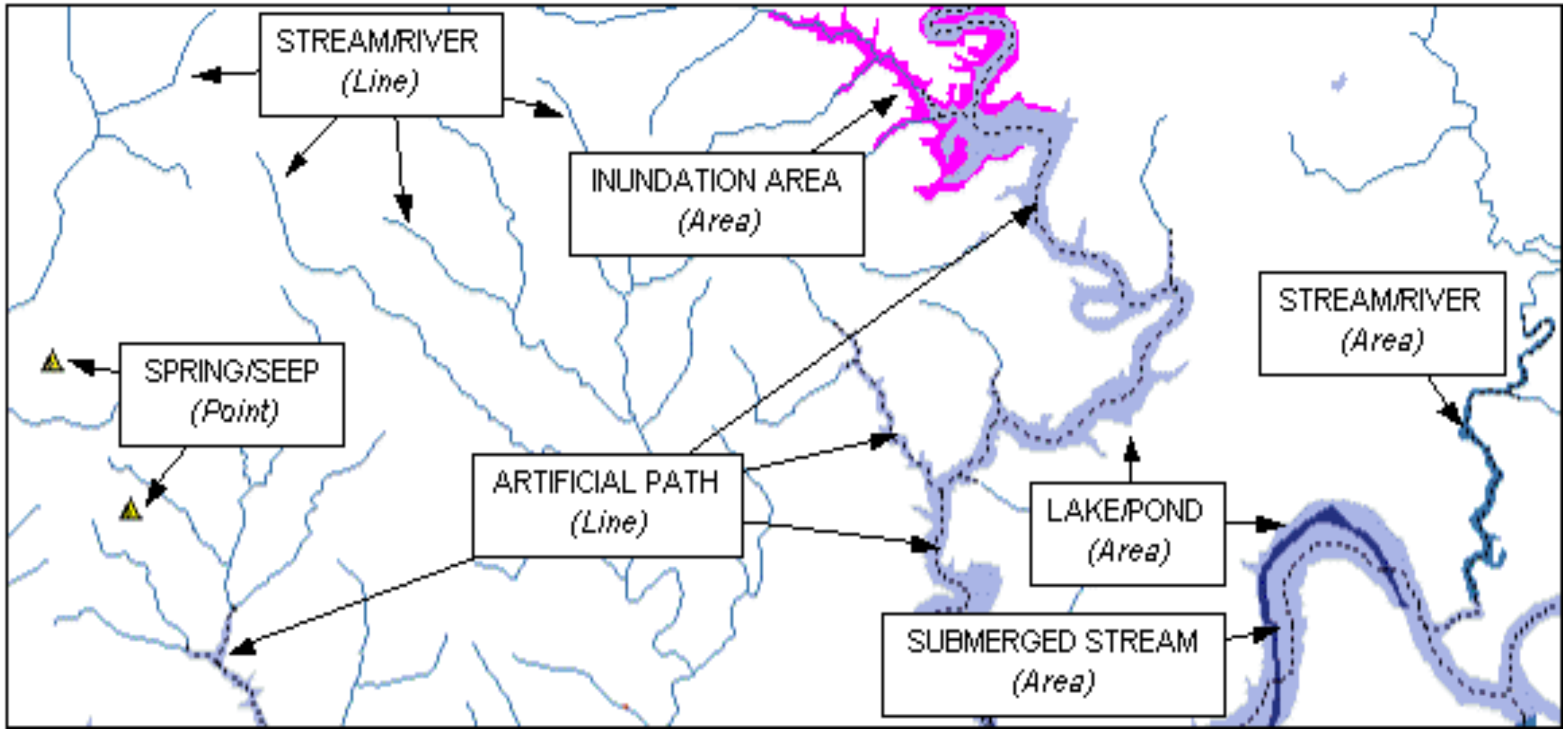
Watershed Boundary Dataset

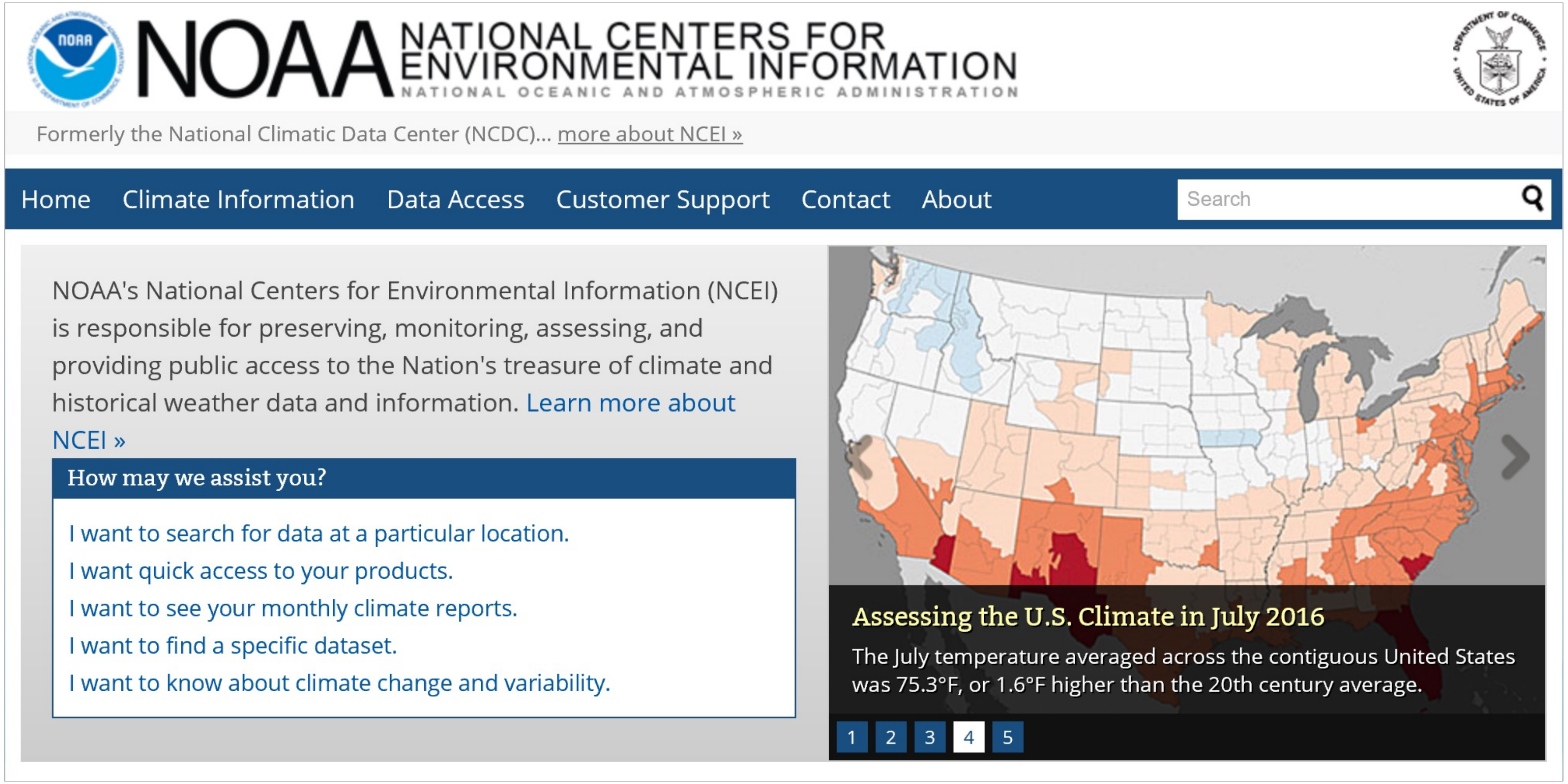
http://nhd.usgs.gov/wbd.html

- National Program by USGS and USDA (NRCS)
- Boundaries for 10- and 12- digit watersheds
- First cut is by automated delineation from NED
- Hand checked and edited



National Hydrography Dataset





https://www.ncei.noaa.gov/

SRTM Topographic Data
(all 30m data now public for world)

IISSION | INSTRUMENT | DATA PRODUCTS | MULTIMEDIA | OUTREACH

U.S. Releases Enhanced Shuttle Land Elevation Data

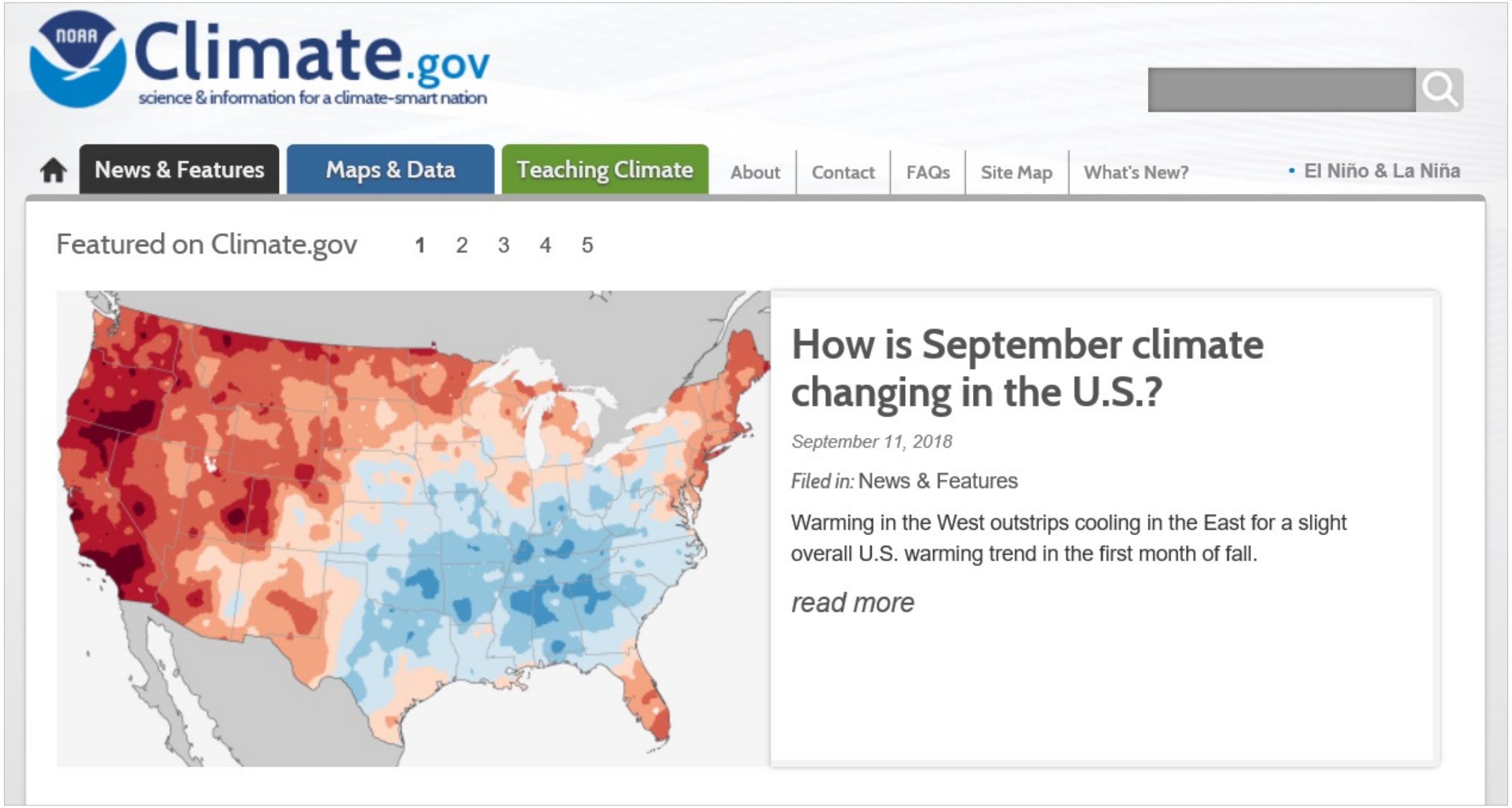
On September 23, 2014, the White House announced that the highest-resolution topographic data generated from NASA's Shuttle Radar Topography Mission (SRTM) in 2000 was to be released globally by late 2015. The announcement was made at the United Nations Heads of State Climate Summit in New York. Since then the schedule was accelerated, and all global SRTM data have been released.

See the full JPL Release 2014-321.

Previously, SRTM data for regions outside the United States were sampled for public release at 3 arc-seconds, which is 1/1200th of a degree of latitude and longitude, or about 90 meters (295 feet). The new data have been released with a 1 arc-second, or about 30 meters (98 feet), sampling that reveals the full resolution of the original measurements.

http://www2.jpl.nasa.gov/srtm/

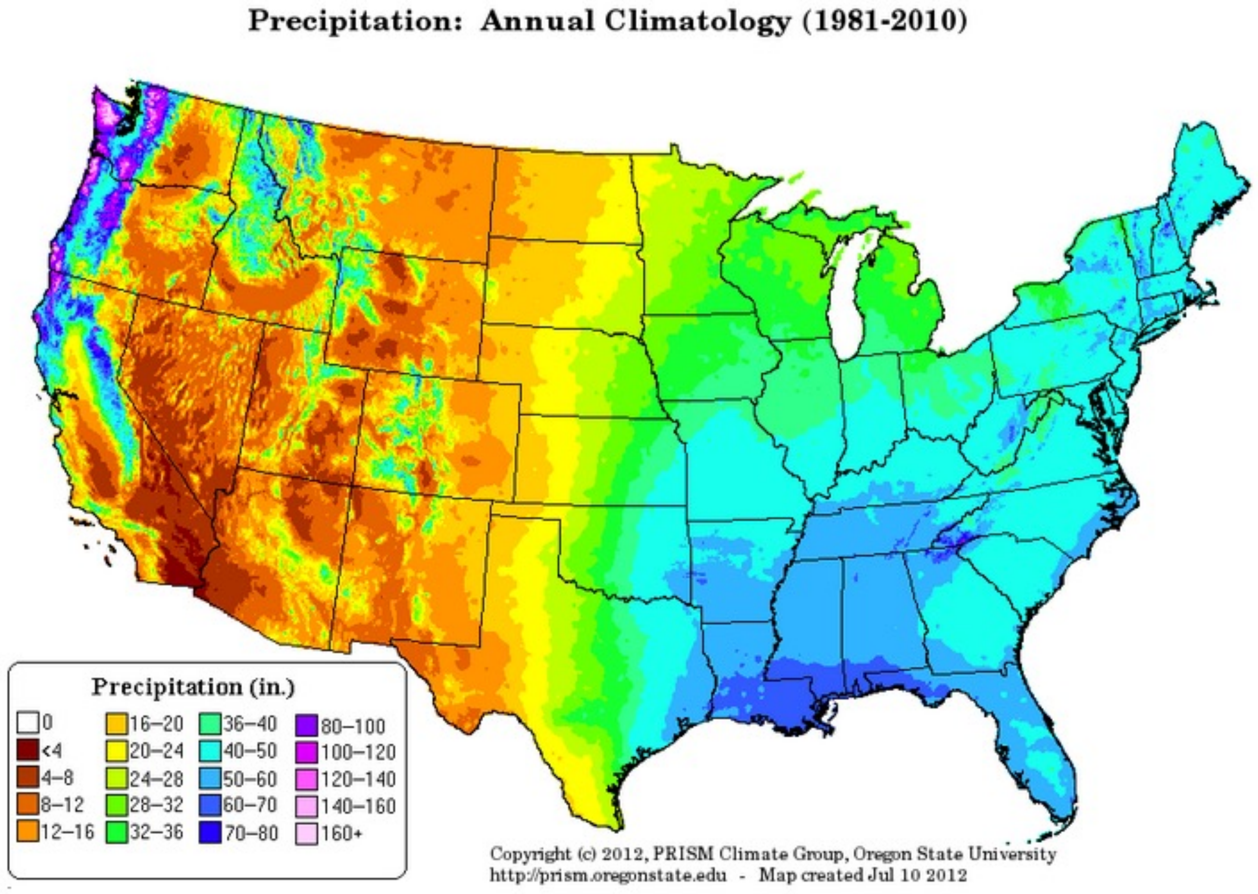
www.climate.gov



USDA CLIMATE Maps & Digital Data

USDA - NRCS NATURAL RESOURCES CONSERVATION SERVICE

PRISM Mean Annual Precipitation (Oregon State U.)



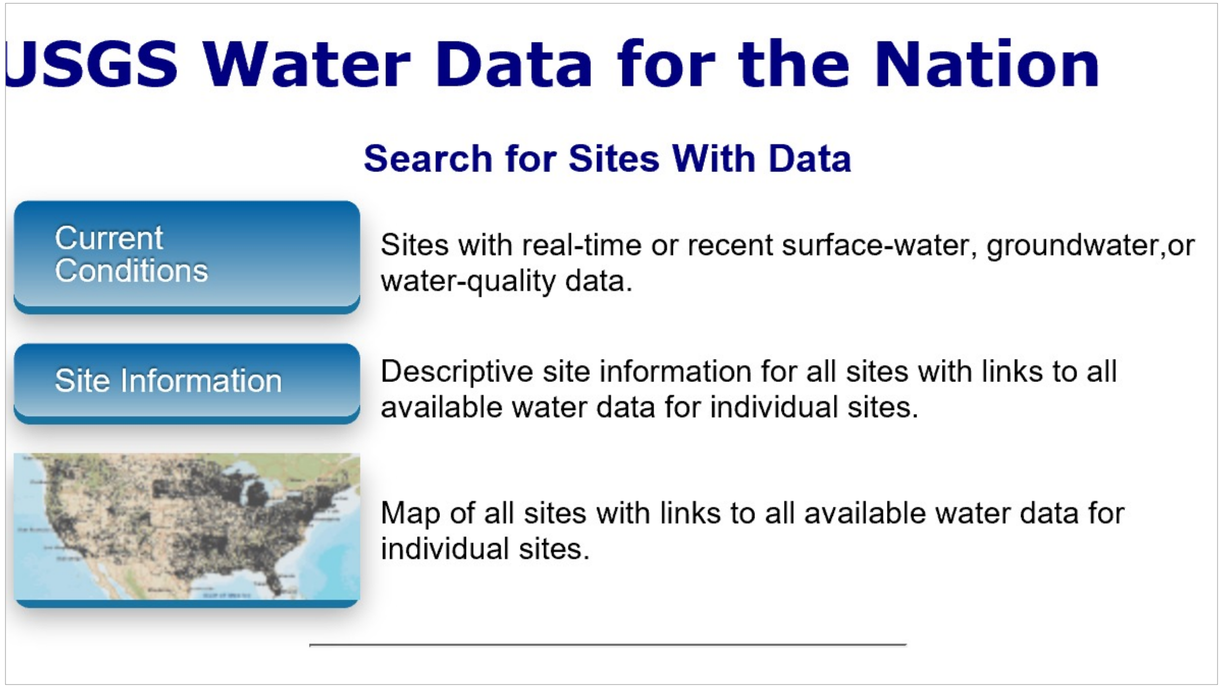
http://prism.oregonstate.edu/

American Community Survey

- Source of detailed demographic and housing characteristics, including:
  - Income
  - Language spoken at home
  - Educational attainment
  - Occupation
  - Place of work and journey to work
- Data collected annually from approximately 3 million households per year. Approximately 250,000 households per month.
- Data collected throughout the year—produces period estimates rather than point estimates.

	ACS 1-Year Data	ACS 3-Year Data	ACS 5-Year Data
Geographic Areas	65,000 or more population	20,000 or more population	All areas, block group or higher

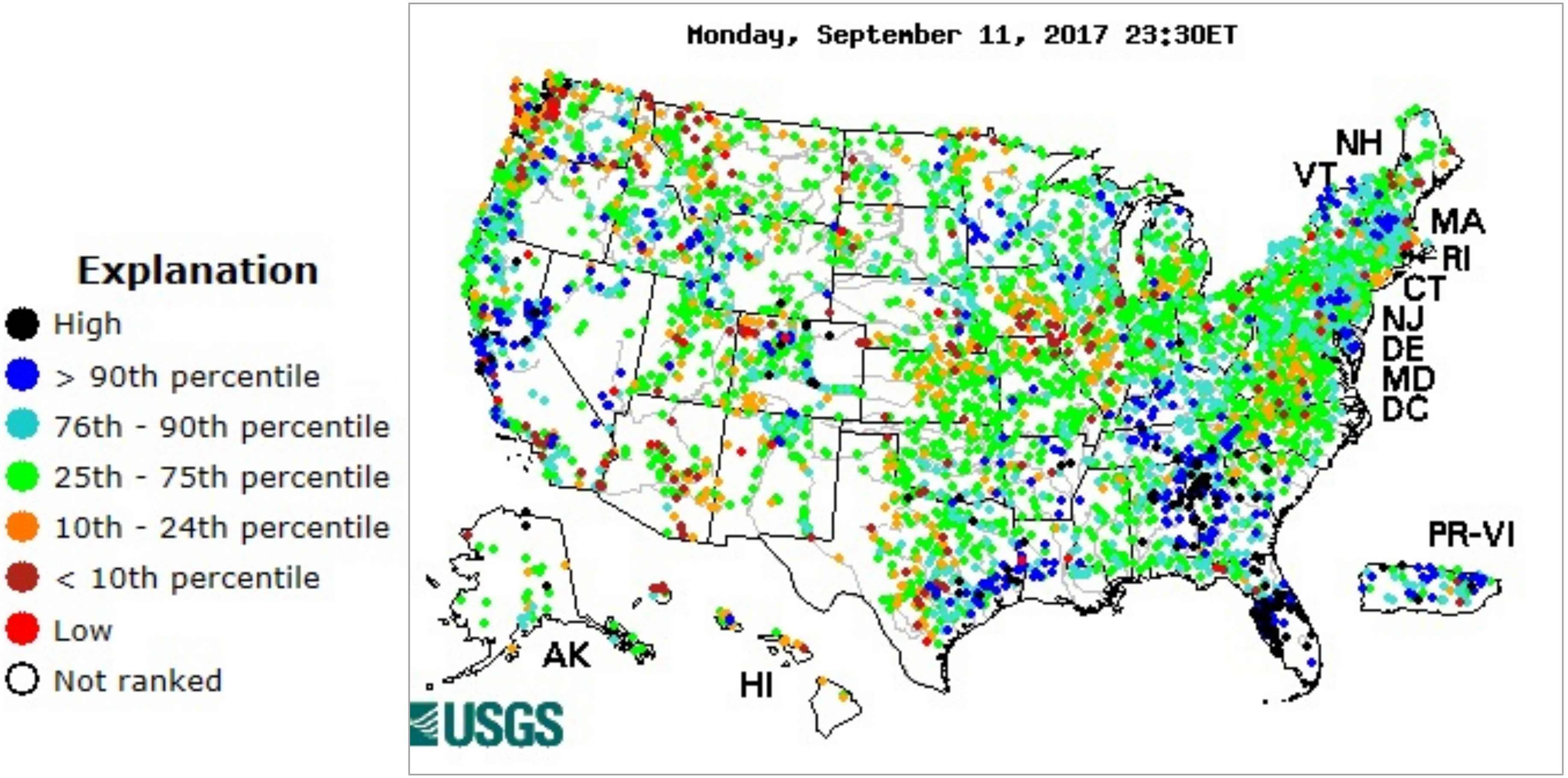
National Water Information System



Web access to USGS water
resources data in real time

http://waterdata.usgs.gov/usa/nwis/

USGS Water Watch



Web access to USGS water resources data in real time

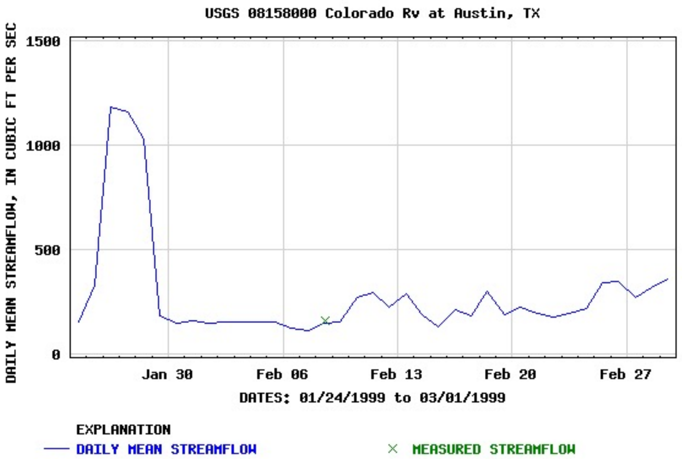
http://waterdata.usgs.gov/nwis/rt

USGS National Water Information System

http://water.usgs.gov

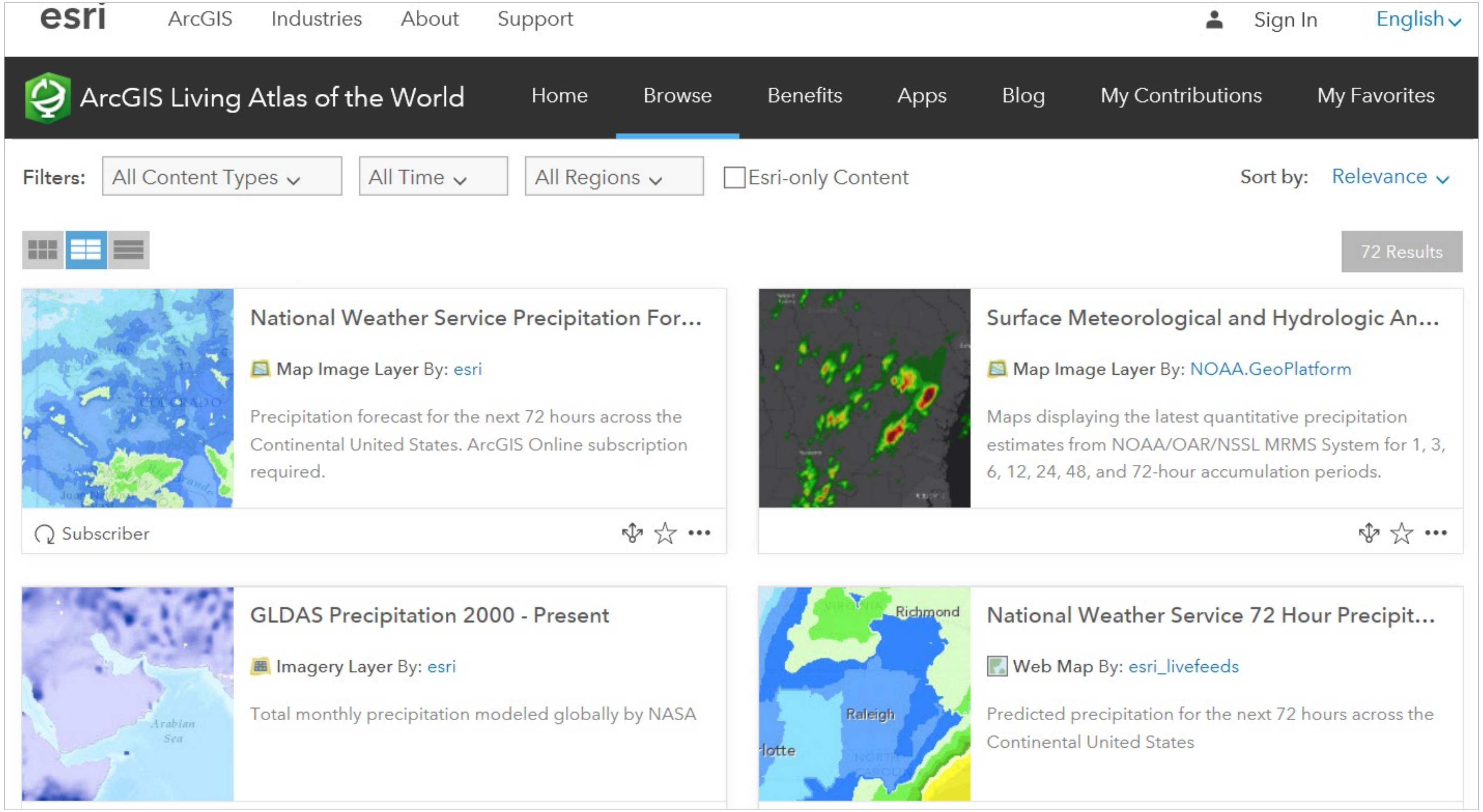
- Real-time and Historic Data
  - Streamflow and stage
  - Groundwater levels
  - Water Quality
  - Site information
- Tabular or Graphical Format

agency_cd		site_no	dv_dt	dv_va
5s	15s	10d	12n	3s
USGS	08158000	1999-01-24		152
USGS	08158000	1999-01-25		333
USGS	08158000	1999-01-26		1180
USGS	08158000	1999-01-27		1160
USGS	08158000	1999-01-28		1030
USGS	08158000	1999-01-29		184
USGS	08158000	1999-01-30		151
USGS	08158000	1999-01-31		158
USGS	08158000	1999-02-01		150
USGS	08158000	1999-02-02		152
USGS	08158000	1999-02-03		154
USGS	08158000	1999-02-04		155

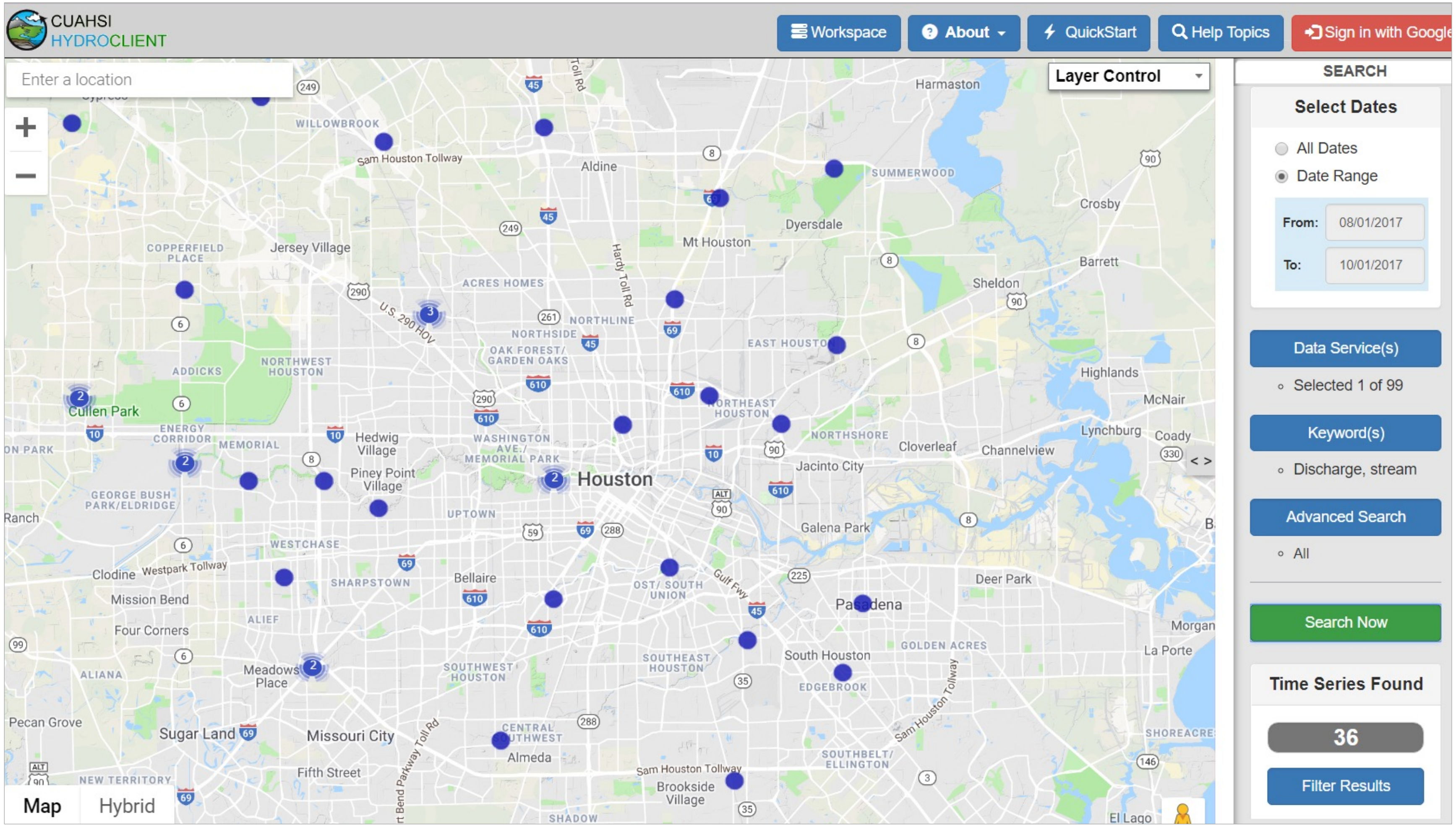


ArcGIS Online: Living Atlas

http://doc.arcgis.com/en/living-atlas/



CUAHSI HydroClient http://data.cuahsi.org
Query for Streamflow Data in Houston area



Section4: Pre & Post Processing

- Use of advanced Python/R packages to pre- and post-process dataset
- Example:
  - SSURGO,
  - rain/ET,
- Save data to HydroShare
- Code walk-throughs

Section4: Pre & Post Processing

- Evapotranspiration

```
import pyeto
from pyeto import convert


# Monthly ETo:
eto_monthly = pyeto.fao56_penman_monteith(
            net_rad=14.33,
            t=convert.celsius2kelvin(30.2),
            ws=2.0,              # Wind speed at 2 m height
            svp=4.42,            # Saturation vapour pressure at daily min temp
            avp=2.85,            # Actual vapor pressure
            delta_svp=0.246,     # Slope of saturation vapour pressure curve
            psy=0.0674,          # Psychrometric constant
            shf=0.14,            # Soil heat flux (G)
)
print (eto_monthly)

5.712515614432705
```

```
Module also available for estimating values
Examples:

avp = fao.avp_from_tdew(tdew)
avp = fao.avp_from_twet_tdry(twet, tdry, svp_twet, psy_const)
```

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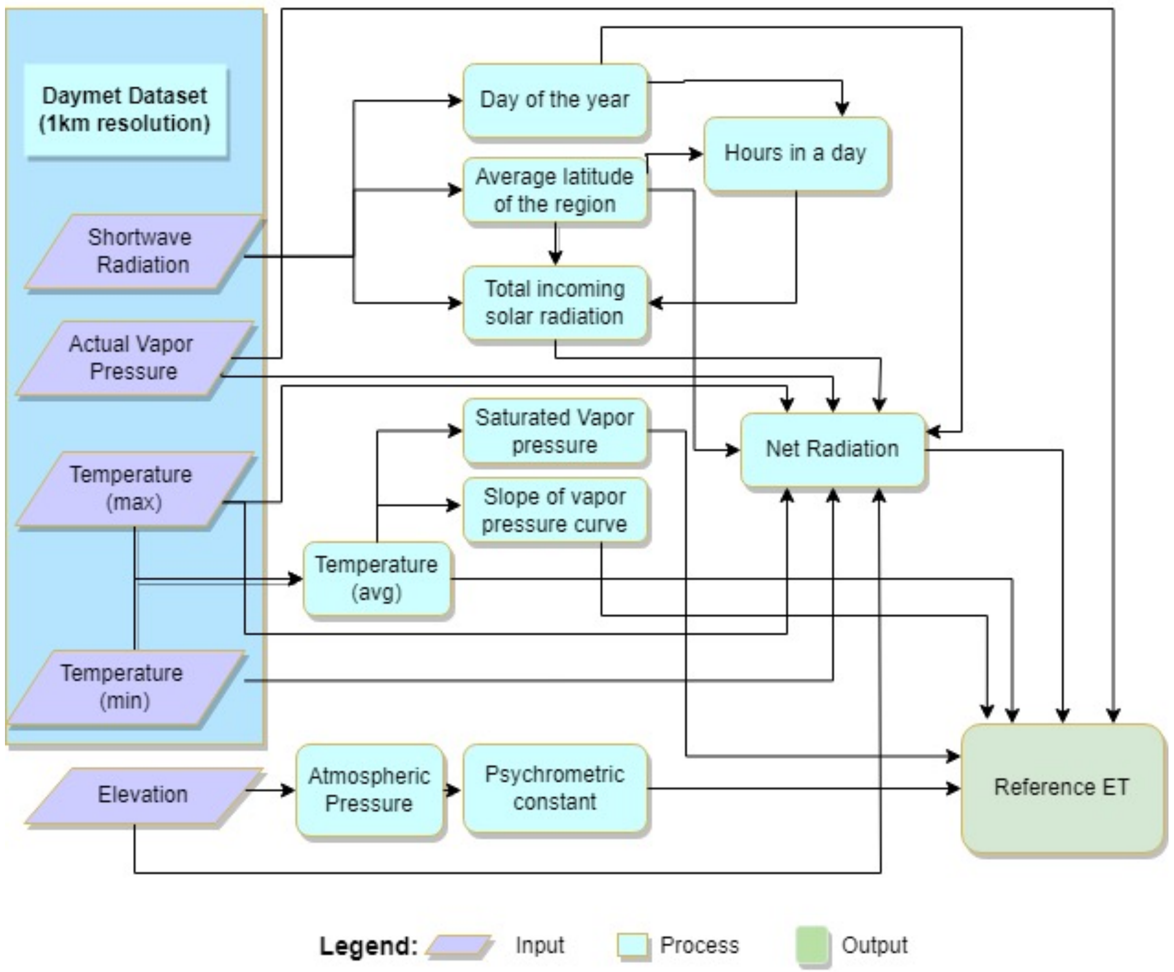
Section4: Pre & Post Processing



Expanding upon the idea, we could use the spatially distributed data downloaded earlier, and prepare a comprehensive spatially and temporally distributed Reference ET maps for any AOI

Code available at: https://github.com/prasanna310/hydrods-dev/blob/master/pytopkapi_data_service/servicefunctions_pytopkapi.py

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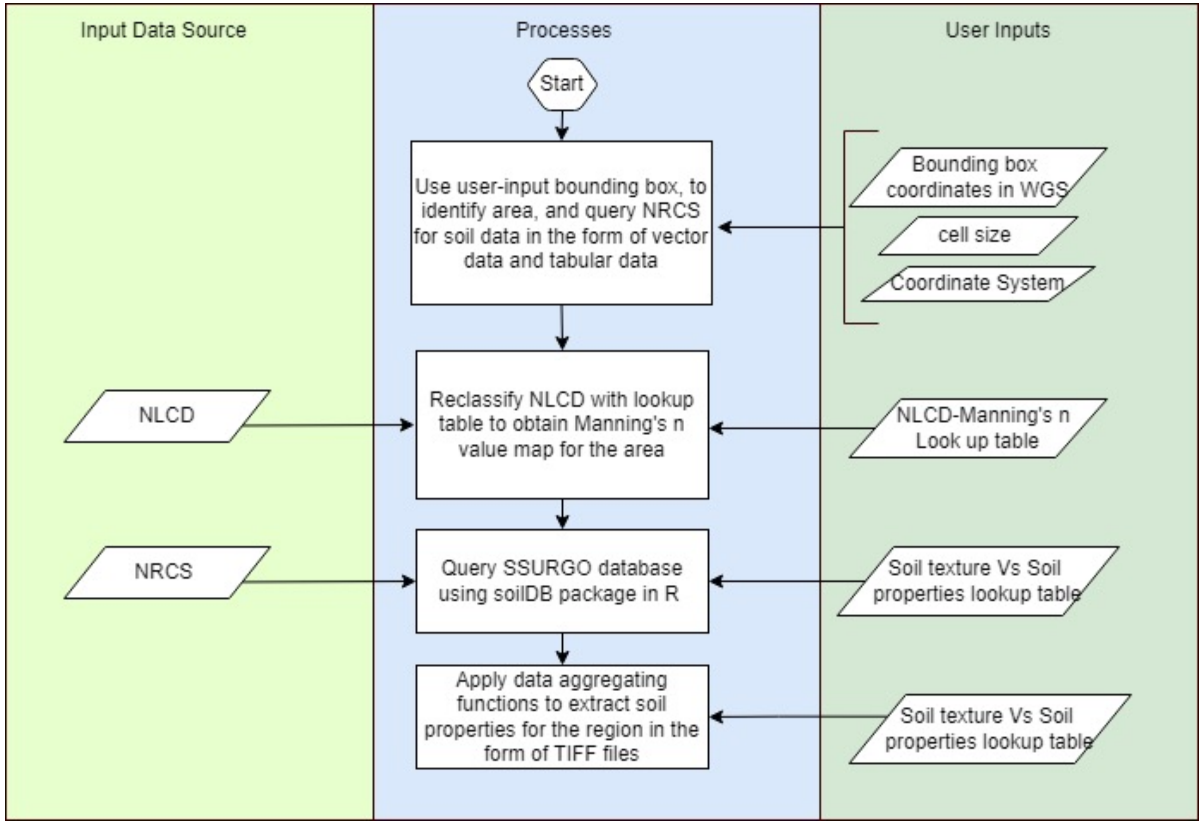
Section4: Pre & Post Processing



Similarly, another example would be preparing soil datasets on the fly after requesting data from NRCS

Code available at: https://github.com/prasanna310/hydrods-dev/blob/master/pytopkapi_data_service/Extract_Soil_Data_pytopkapi5.r

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Section5: Results & Conclusion

- A digital mindset to use advancing computer infrastructure key in engineering things faster and reliable
- Explored and identified benefits in use of computing resources for
  - data download
  - data pre & post processing
- Faster, reliable approach used to get most up-to-date data (including real time data)

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Your Feedback Is Important

Please send us your questions, comments, concerns, etc at support@stormwateruniv.com

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Recording Available

Within 48 hours on the course page at stormwateruniv.com

Certificates

Will receive email notification within 48 hours. Must have attended full session.

Prasanna Dahal

M.S., P.E.

Project Engineer

Sunrise Engineering Inc.

pdahal@sunrise-eng.com

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