

Advancing the Implementation of Hydrologic Models Through Automated Data Preparation Approaches



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.



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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

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.

Section 1: Introduction / Background

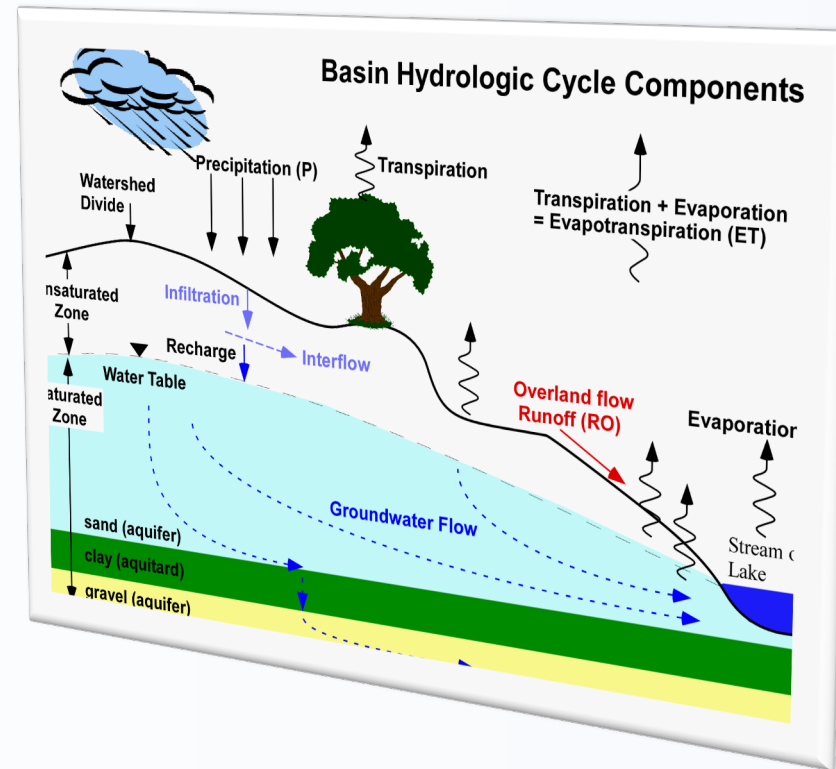
What do Models do?

- 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



Section1: Introduction / Background



Data Related Challenges

Time consuming



Many data sources



Repetitive, so boring



Hinders reproducible science



Data archiving hassle

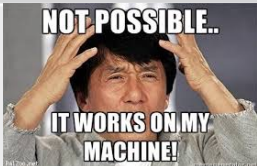


Additional Challenges

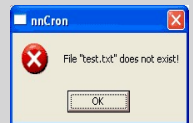
Demands wide skill set



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,

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

+ 𠄎
MY LIST SHARE

Author | Eduardo Bravo

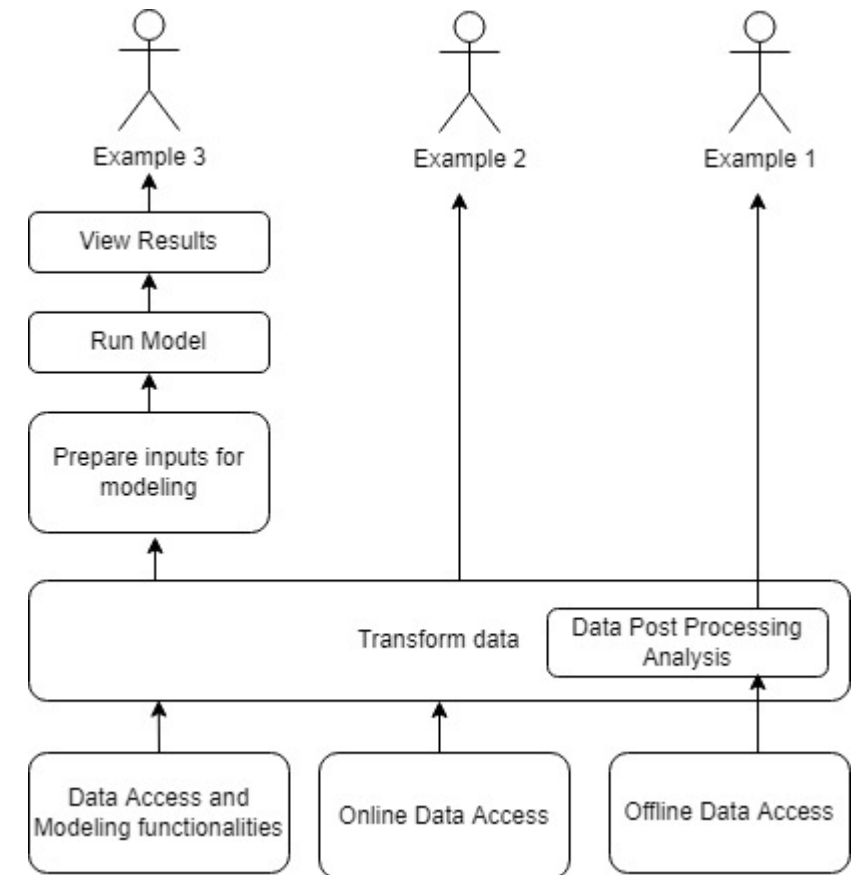
Tech giants such as Google, Amazon, Microsoft, Toshiba or Cisco are building smart cities in various parts of the world. This decision may come as a surprise to some however, it is related to their core business from the very moment smart cities incorporate many of the technology advancements developed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



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?



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/ornl/daac/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/ornl/daac/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,
)

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)
```

INPUTS

	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

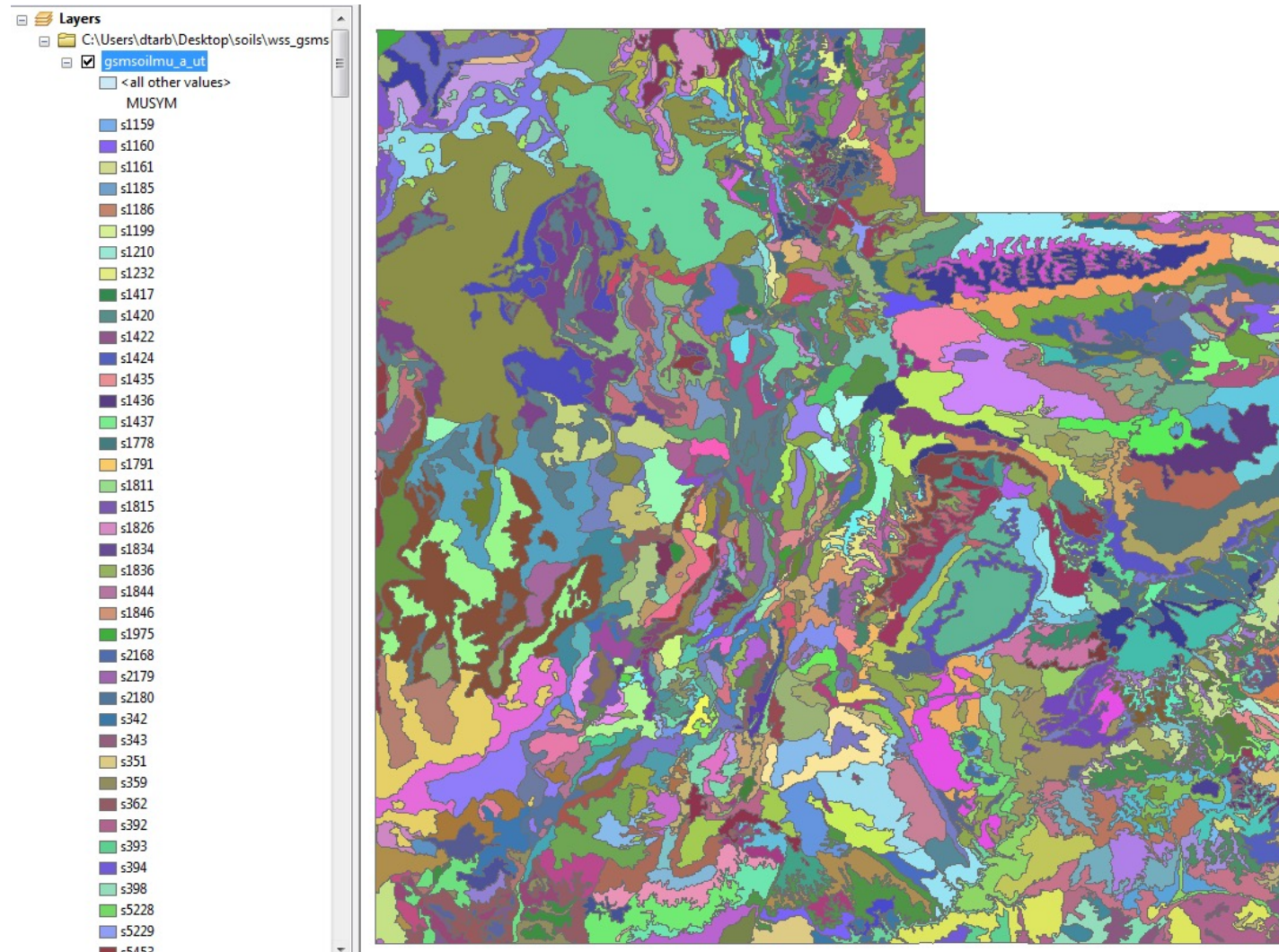
National/State/Global Data repositories

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

National STATSGO Database

USDA-NRCS Soil Survey Division *Data Access*

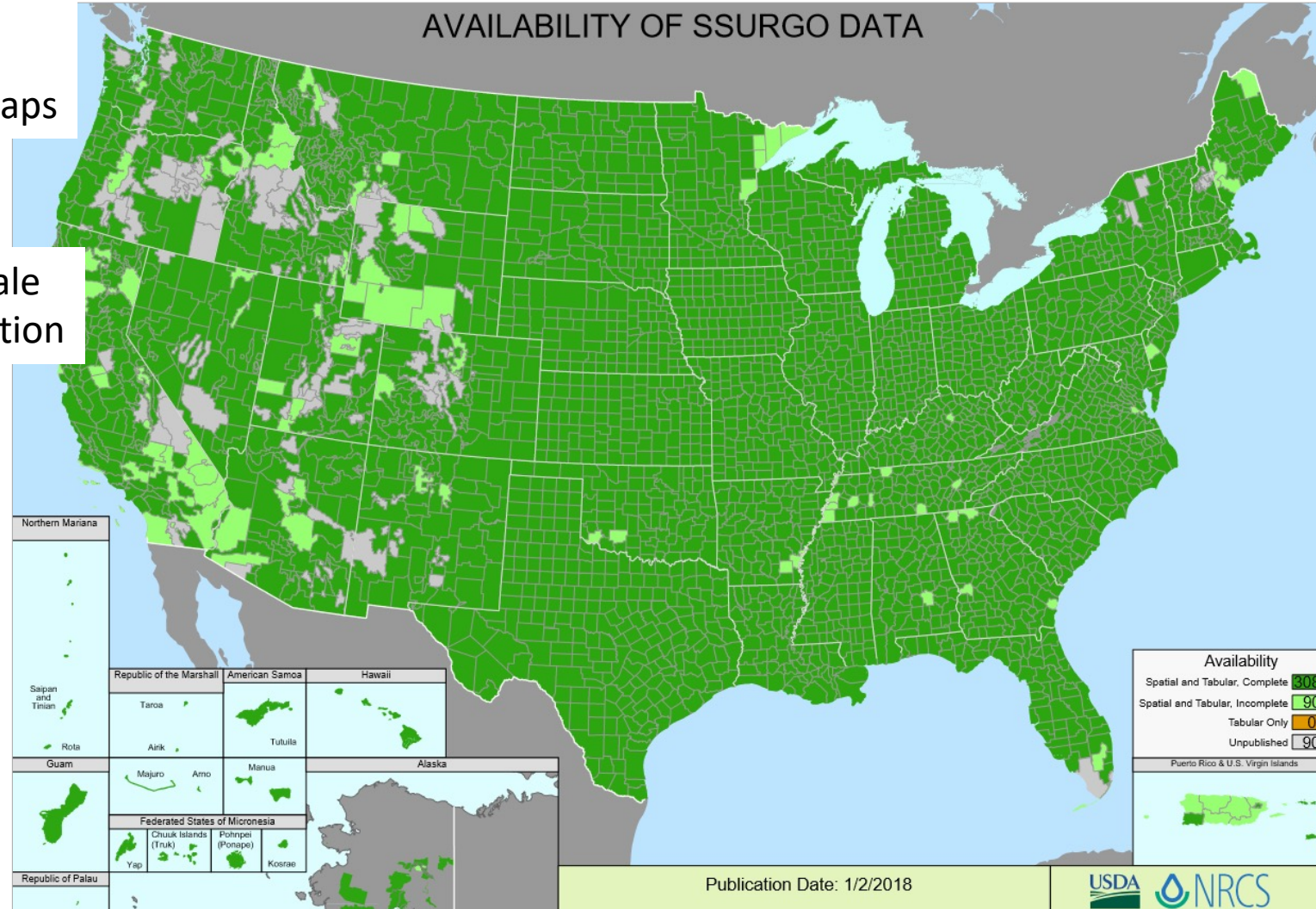
1:250,000 Scale Soil Information



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

SSURGO:
County Level
Digital Soil Maps

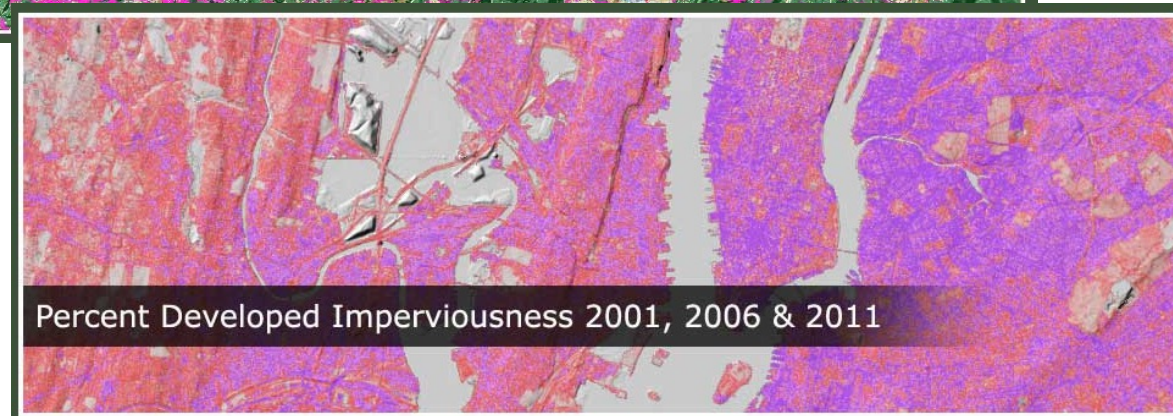
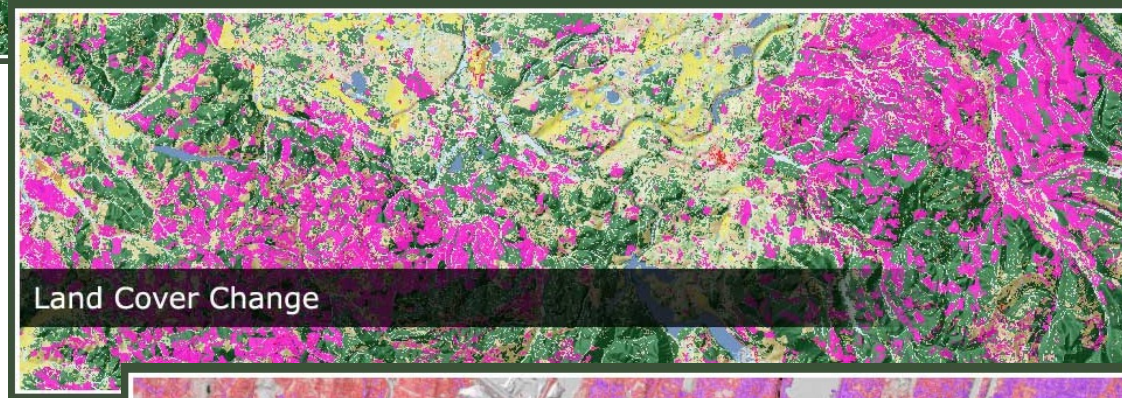
1:24,000 scale
soil information



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

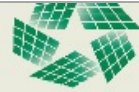
National Land Cover Data

<http://www.mrlc.gov/>



The National Map

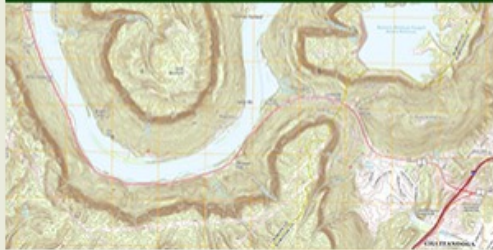
<http://nationalmap.gov/>



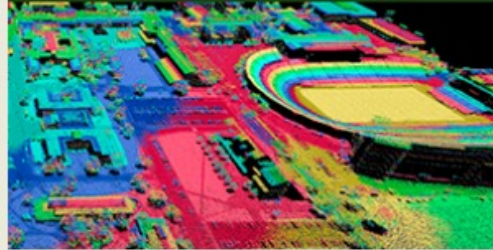
The National Map

Your Source for Topographic Information

US Topo



3D Elevation Program



National Hydrography Data Set



Historical Topographic



[Maps](#)

[Elevation](#)

[Hydrography](#)

[Geographic Names](#)

[Transportation](#)

[Structures](#)

[Boundaries](#)

[Orthoimagery](#)

[Land Cover](#)

Find Data + View & Download

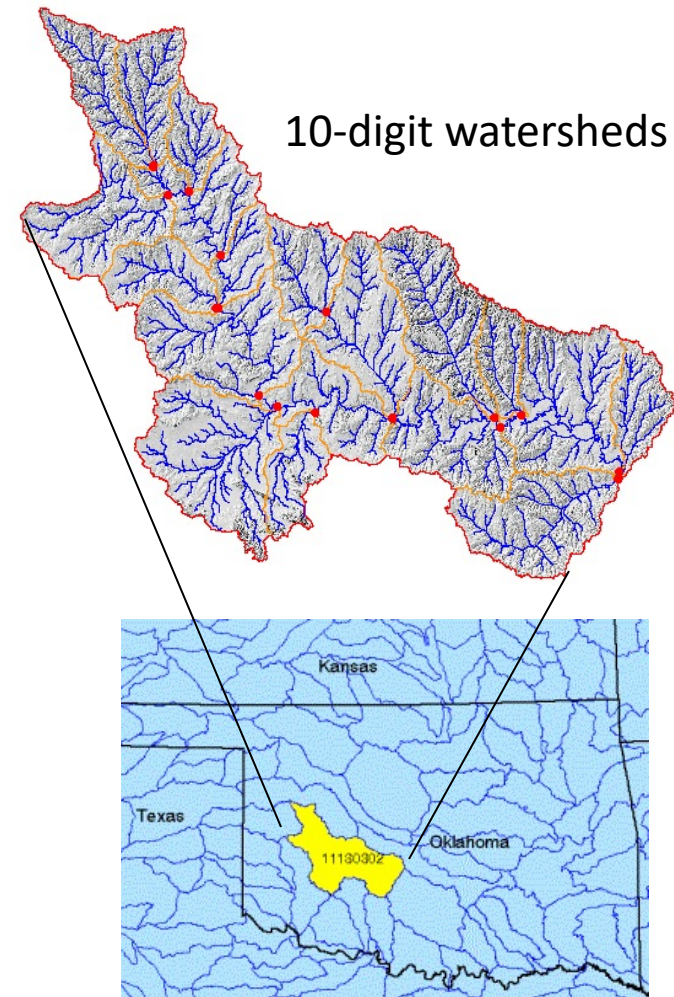


A central source for US Government data

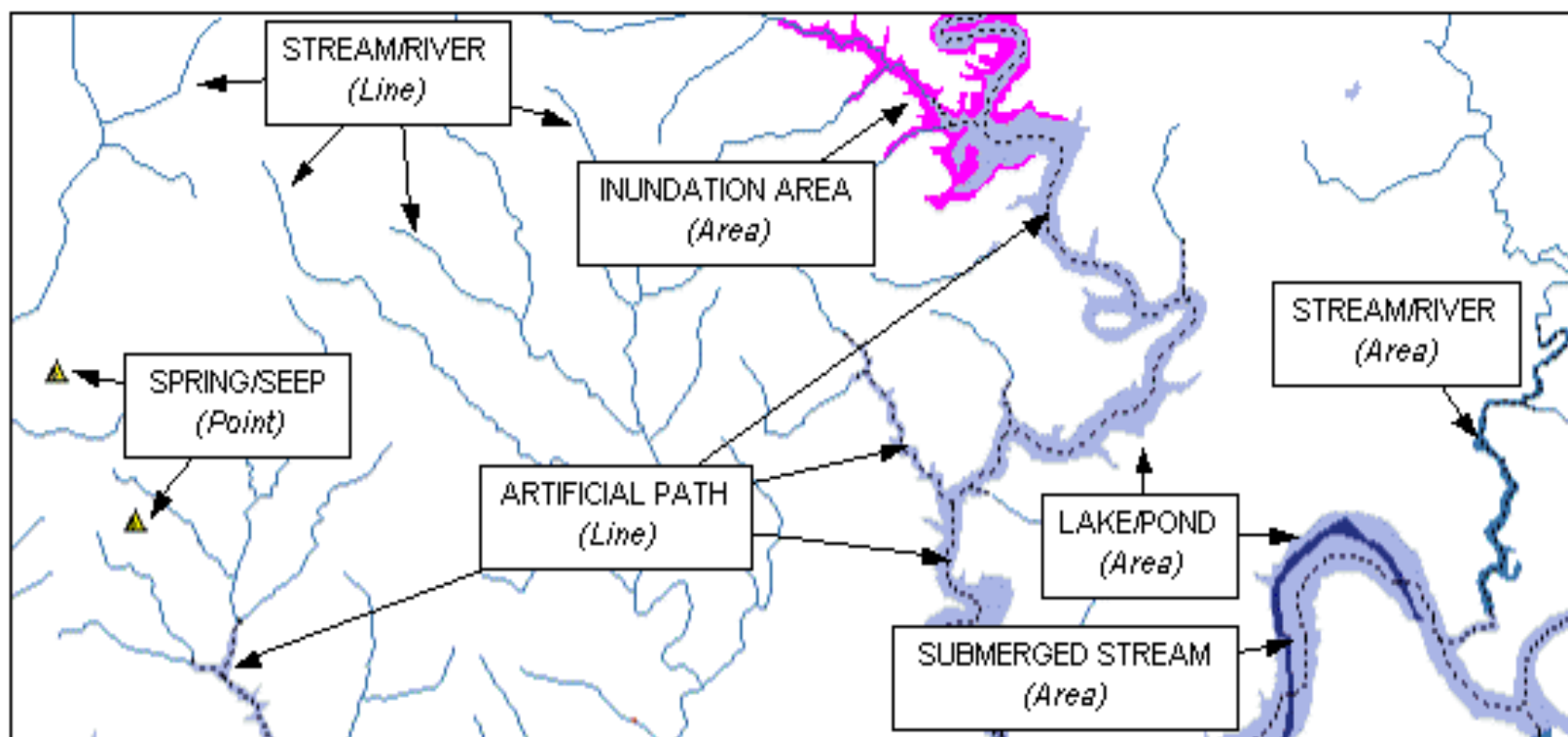
Watershed Boundary Dataset

<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





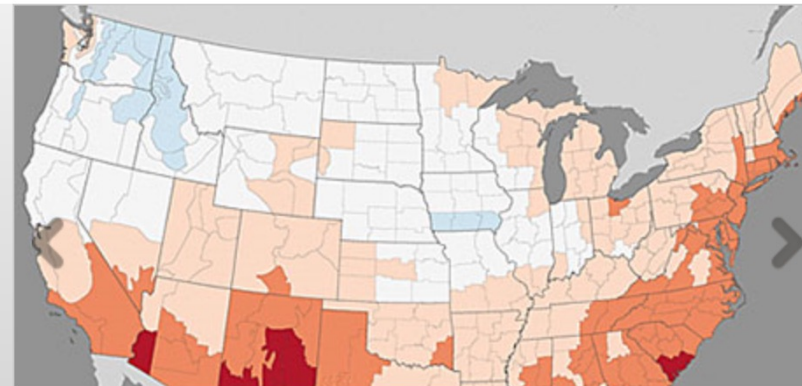
Formerly the National Climatic Data Center (NCDC)... [more about NCEI](#) »



NOAA's National Centers for Environmental Information (NCEI) is responsible for preserving, monitoring, assessing, and providing public access to the Nation's treasure of climate and historical weather data and information. [Learn more about NCEI](#) »

How may we assist you?


- [I want to search for data at a particular location.](#)
- [I want quick access to your products.](#)
- [I want to see your monthly climate reports.](#)
- [I want to find a specific dataset.](#)
- [I want to know about climate change and variability.](#)



Assessing the U.S. Climate in July 2016


The July temperature averaged across the contiguous United States was 75.3°F, or 1.6°F higher than the 20th century average.

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



MISSION | 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



Climate.gov
science & information for a climate-smart nation



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Maps & Data

Teaching Climate

About

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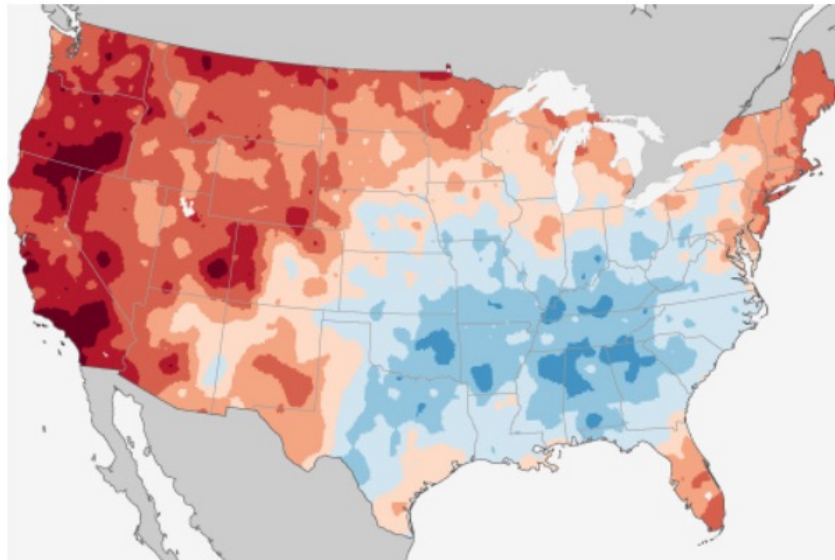
FAQs

Site Map

What's New?

• El Niño & La Niña

Featured on Climate.gov 1 2 3 4 5



How is September climate changing in the U.S.?

September 11, 2018

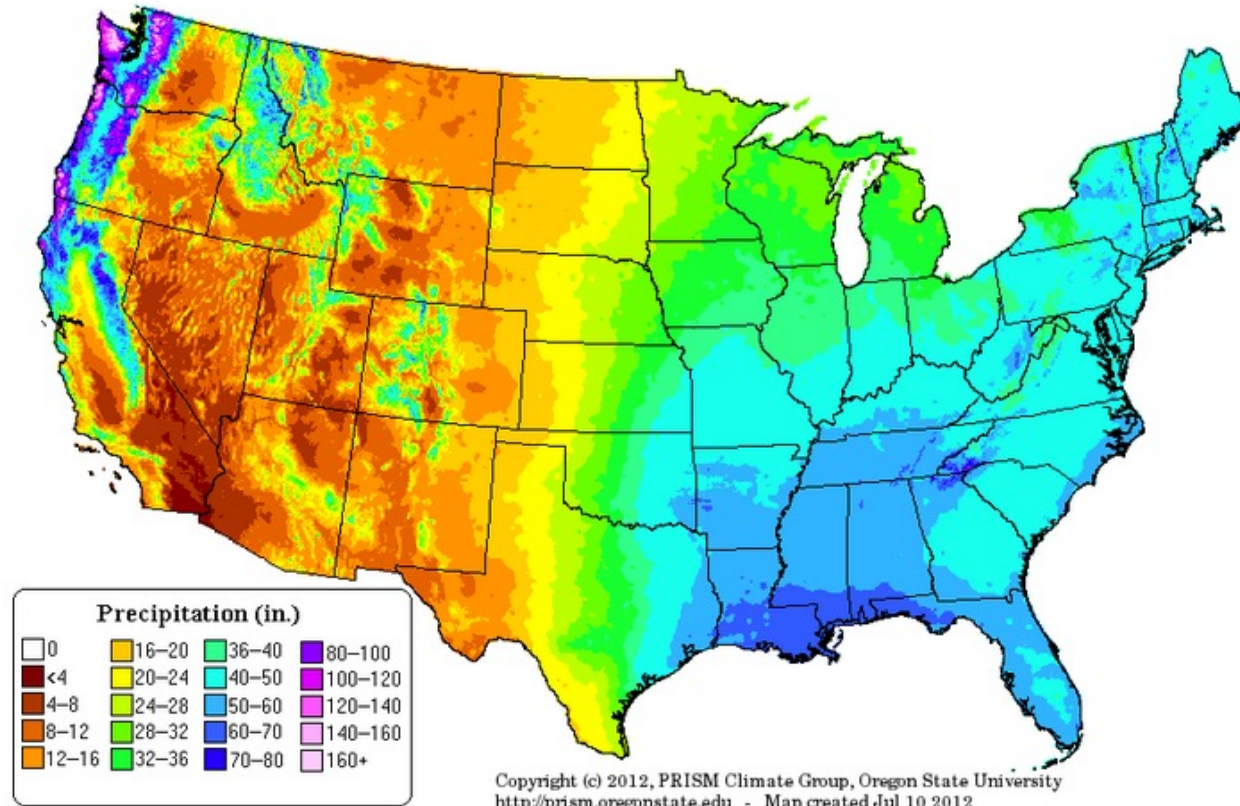
Filed in: News & Features

Warming in the West outstrips cooling in the East for a slight overall U.S. warming trend in the first month of fall.

[read more](#)

PRISM Mean Annual Precipitation (Oregon State U.)

Precipitation: Annual Climatology (1981-2010)



<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

USGS Water Data for the Nation

Search for Sites With Data

Current
Conditions

Sites with real-time or recent surface-water, groundwater, or water-quality data.

Site Information

Descriptive site information for all sites with links to all available water data for individual sites.

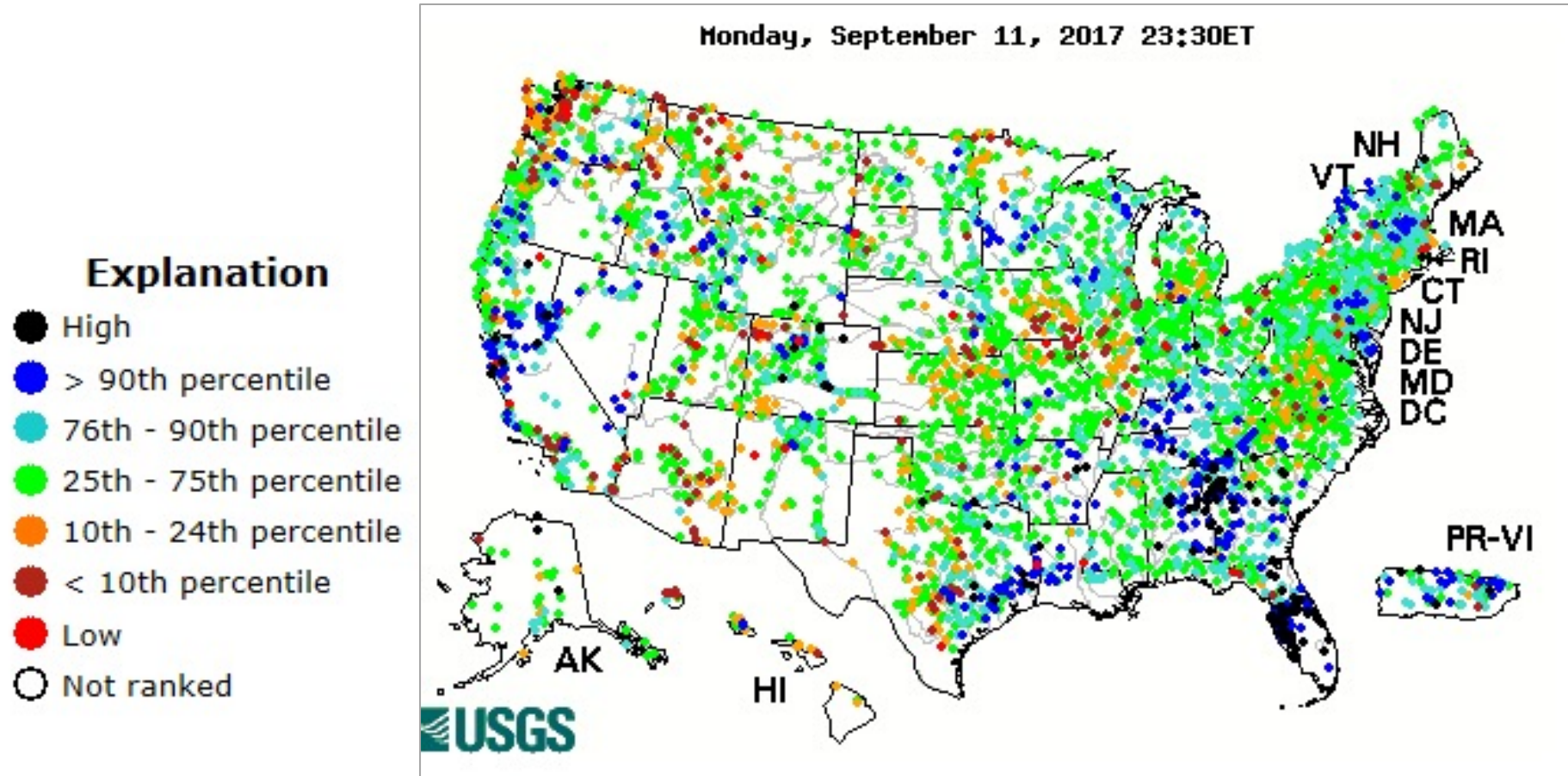


Map of all sites with links to all available water data for individual sites.

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

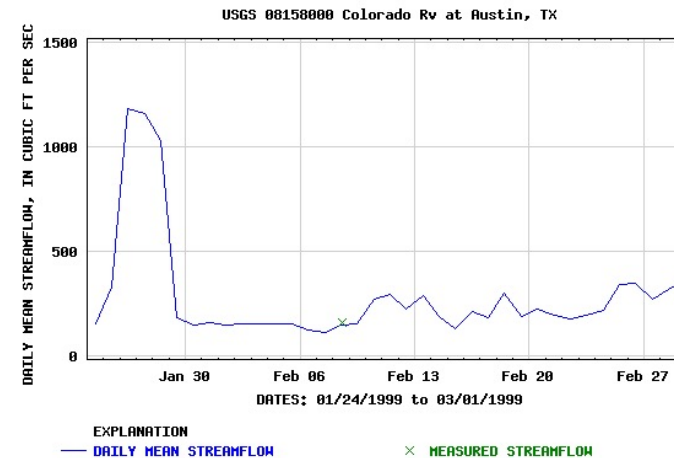
<http://waterdata.usgs.gov/nwis/rt>

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/>

The screenshot displays the ArcGIS Living Atlas of the World interface. At the top, the Esri logo is on the left, and navigation links for ArcGIS, Industries, About, and Support are in the center. On the right, there are links for Sign In and English. Below this is a dark navigation bar with the title 'ArcGIS Living Atlas of the World' and menu items: Home, Browse (highlighted), Benefits, Apps, Blog, My Contributions, and My Favorites.

Below the navigation bar, there is a search and filter section. It includes a 'Filters:' label followed by three dropdown menus: 'All Content Types', 'All Time', and 'All Regions'. There is also an unchecked checkbox for 'Esri-only Content' and a 'Sort by: Relevance' dropdown. On the right side of this section, a grey button indicates '72 Results'.

The main content area shows four map results in a grid:

- Top Left:** 'National Weather Service Precipitation For...' with a thumbnail showing a precipitation map of the US. It is a 'Map Image Layer' by 'esri'. Description: 'Precipitation forecast for the next 72 hours across the Continental United States. ArcGIS Online subscription required.' It has a 'Subscriber' icon and share, star, and menu icons.
- Top Right:** 'Surface Meteorological and Hydrologic An...' with a thumbnail showing a precipitation radar map. It is a 'Map Image Layer' by 'NOAA.GeoPlatform'. Description: 'Maps displaying the latest quantitative precipitation estimates from NOAA/OAR/NSSL MRMS System for 1, 3, 6, 12, 24, 48, and 72-hour accumulation periods.' It has share, star, and menu icons.
- Bottom Left:** 'GLDAS Precipitation 2000 - Present' with a thumbnail showing a global precipitation map. It is an 'Imagery Layer' by 'esri'. Description: 'Total monthly precipitation modeled globally by NASA'. It has share, star, and menu icons.
- Bottom Right:** 'National Weather Service 72 Hour Precipit...' with a thumbnail showing a precipitation map of the US with labels for 'Richmond', 'Raleigh', and 'Charlotte'. It is a 'Web Map' by 'esri_livefeeds'. Description: 'Predicted precipitation for the next 72 hours across the Continental United States'. It has share, star, and menu icons.

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

The screenshot displays the CUAHSI HydroClient web application interface. The main map shows the Houston area with numerous blue circular markers representing streamflow data points. The interface includes a search bar at the top left, a navigation menu with options like 'Workspace', 'About', 'QuickStart', and 'Help Topics', and a 'Sign in with Google' button. On the right side, there is a 'SEARCH' panel with the following sections:

- Select Dates:** Radio buttons for 'All Dates' and 'Date Range' (selected). Input fields for 'From: 08/01/2017' and 'To: 10/01/2017'.
- Data Service(s):** A button labeled 'Data Service(s)' with a dropdown showing 'Selected 1 of 99'.
- Keyword(s):** A button labeled 'Keyword(s)' with a dropdown showing 'Discharge, stream'.
- Advanced Search:** A button labeled 'Advanced Search' with a dropdown showing 'All'.
- Search Now:** A green button labeled 'Search Now'.
- Time Series Found:** A grey button showing the number '36'.
- Filter Results:** A blue button labeled 'Filter Results'.

The map at the bottom left shows 'Map' and 'Hybrid' options. The map itself is a detailed view of Houston, Texas, with various neighborhoods and highways labeled. Blue circular markers are scattered across the map, indicating the locations of streamflow data points.

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)

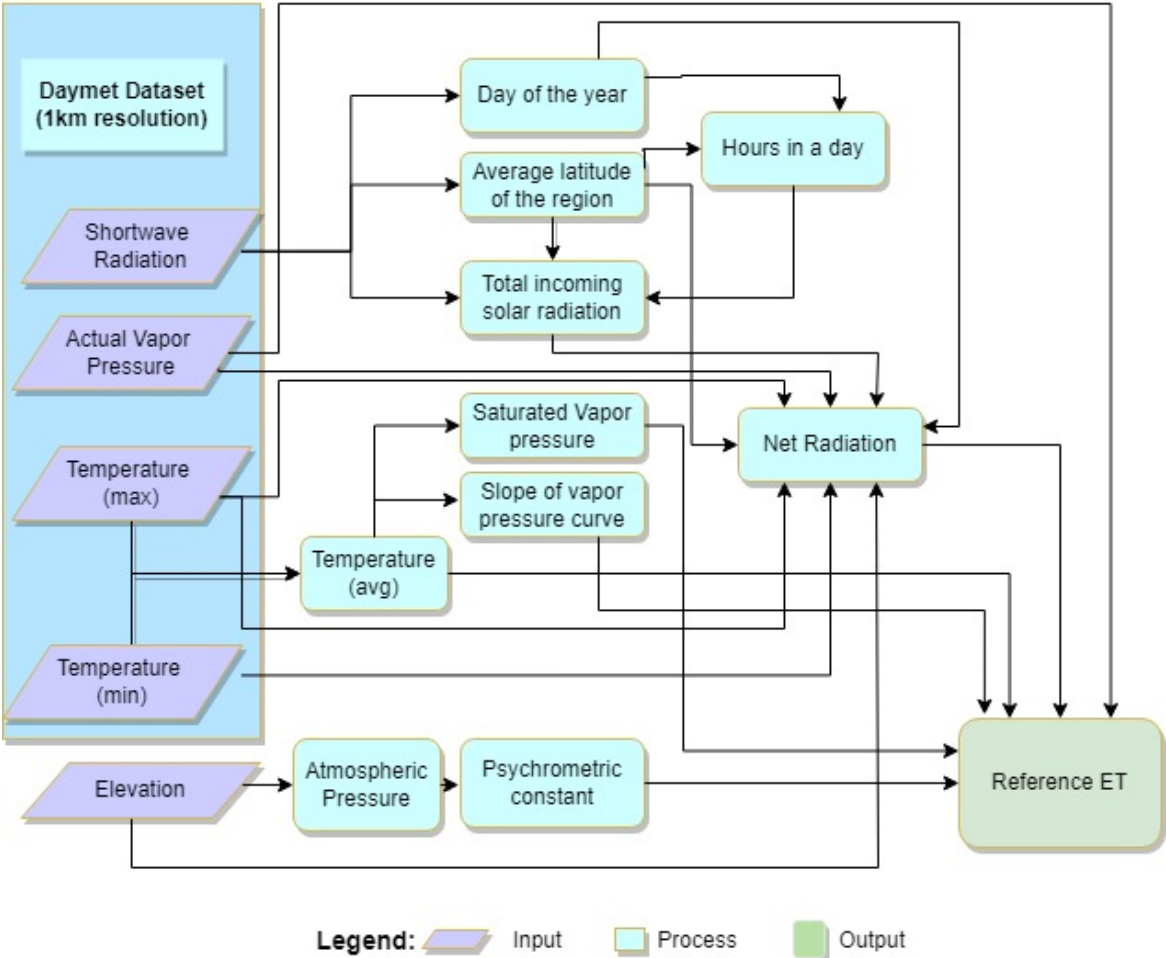
5.712515614432705
```

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)
```

Section4: Pre & Post Processing

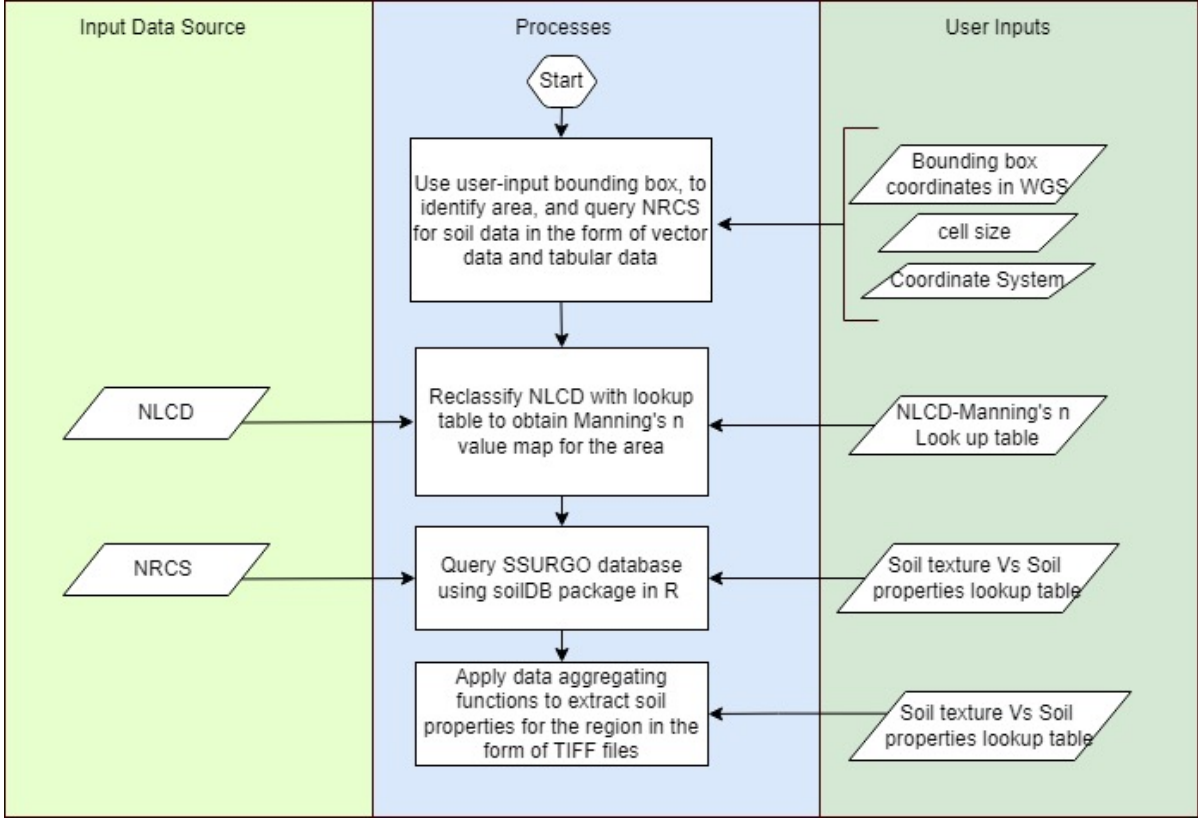


Expanding upon the idea, we could use the spatially distributed data downloaded earlier, and prepare a comprehensive spatially and temporally distributed Reference ET maps for any AOI

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



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

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)

Your Feedback Is Important

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

Presentation PDF Available

Downloadable from the Chat area of the Zoom platform and the course page at stormwateruniv.com

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.



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Job Site Management Series:

Soil Stabilization, Flocculant Applications, Winter Preparation

0.3 CEUs/3 PDHs



Pete Hanrahan
Hanrahan Environmental

20% Savings Bundle on:

- Erosion Control and Ground Stabilization in the Third Dimension
 - Flocculant Applications in Soil Stabilization
- Preparing Construction Sites for Winter Shutdown