Assessment of Water Quality and Quantity Using Satellite Remote Sensing

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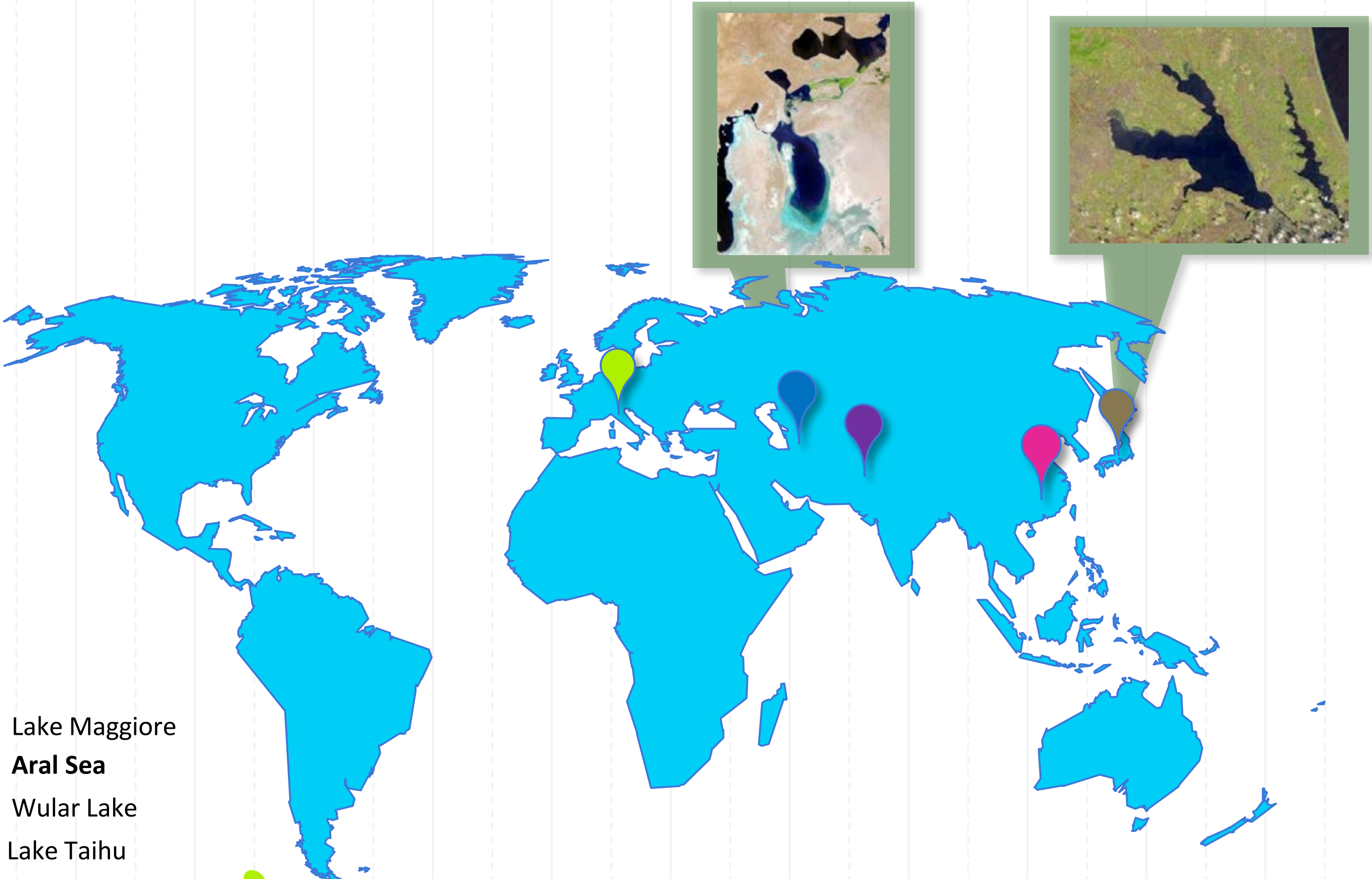
Why are lakes important?

Lakes provide...

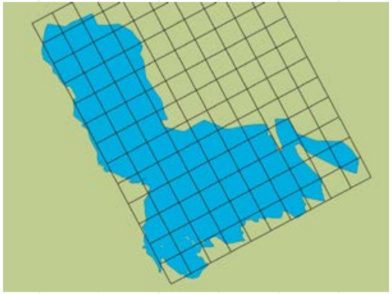
- Fisheries
- Tourism and recreation
- Hydroelectric power
- Flood and drought security
- Drinking, household and industrial water supply
- Irrigation
- Biodiversity



- Lake Maggiore
- **Aral Sea**
- Wular Lake
- Lake Taihu
- **Lake Kasumigaura**

What are we looking for?

Area



Surface area increase and decrease

Eutrophication

Chlorophyll increase and decrease (algal blooms)

Total Suspended Solids (TSS)

TSS increase and decrease

Objective: Determine how the water quality and quantity of important lakes have changed throughout time.

IOPs (Inherent Optical Properties)

Red and blue bands in RGB images were analyzed to see the presence chlorophyll and suspended solids

Red band decrease

Blue band decrease

Suspended solids increase

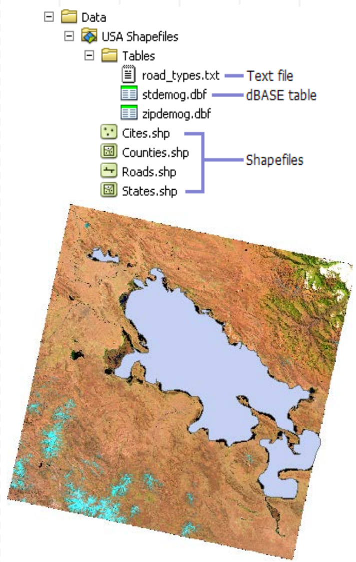
Chlorophyll increase

Methodology

Satellite data extraction from Landsat using Earth Explorer

Create shapefiles to measure the surface area of the lakes

Analyze chlorophyll and TSS in RGB lake images



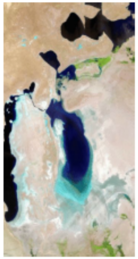
Band 1

Band 2

Band 3

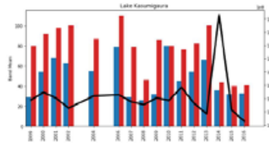
(Figure 1)

The figure above shows the Landsat-7 image of the Aral Sea in the first year of the study: 1999.

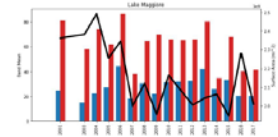


(Figure 2)

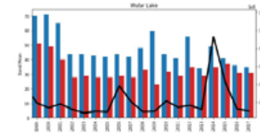
The figure above shows the Landsat-7 image of the Aral Sea in the final year of the study: 2017.



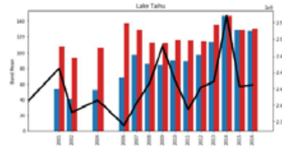
(Figure 4)
(Graph of Lake Kasumigaura with all three parameters. Blue representing blue band values, red representing red band values, and black line shows the trend for surface area)



(Figure 6)
(Graph of Lake Maggiore with all three parameters. Blue representing blue band values, red representing red band values, and black line shows the trend for surface area)



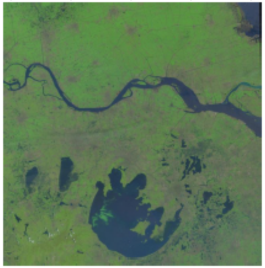
(Figure 5)
(Graph of Wular Lake with all three parameters. Blue representing blue band values, red representing red band values, and black line shows the trend for surface area.)



(Figure 7)
(Graph of Lake Taihu with all three parameters. Blue representing blue band values, red representing red band values, and black line shows the trend for surface area)

(Figure 9)

(The figure above shows an image of Lake Taihu in 2001, maintaining non uniformity about it in its color, with the northern region of the lake suffering from greater nutrient concentration, creating a faint green tint.)



(Figure 10)

(The figure above shows an image of Lake Taihu in 2016, having maintained a more consistent and clearer body of water, attesting to the decrease in pollution.)

Abstract

Assessment of both water quality and quantity pose a great challenge to those studying the effects of anthropogenic activities on bodies of water. Eutrophication created by the increased concentration of nutrients including nitrates and phosphates has been known to contribute to the development of both toxic algal blooms, which serve as limiting factors in the ecosystems of the water, rendering it useless for consumption.[1,2] Another common development is the buildup of suspended sediments (SS/TSS), contributing to the anoxic conditions characterizing environmental hypoxia.[3] Because current methods for the assessment of the presence of such issues rely upon tedious and costly methods such as geographic surveys and usage of technology such as Compact Airborne Spectrographic Imagers, a timely and cost-efficient method is desirable for application to the practice.[4] This research relies upon analysis of the inherent optical properties of chlorophyll and sedimentation present within the bodies of water in question, achieved through analysis of the reflectance values of the red and blue bands from Landsat satellite images of five bodies of water. [5] The analysis, performed using Geographic Informations System ArcMap, allows for determination of the values that attest to changes in surface area, turbidity, and eutrophication. The data show the high concentration of TSS is more prevalent than high concentrations of algal blooms attributed to eutrophication. The trends in the data hold consistency with the natural occurrences surrounding the bodies of water associated with the three parameters outlined above, supporting usage of remote sensing for qualitative and quantitative analysis of water.

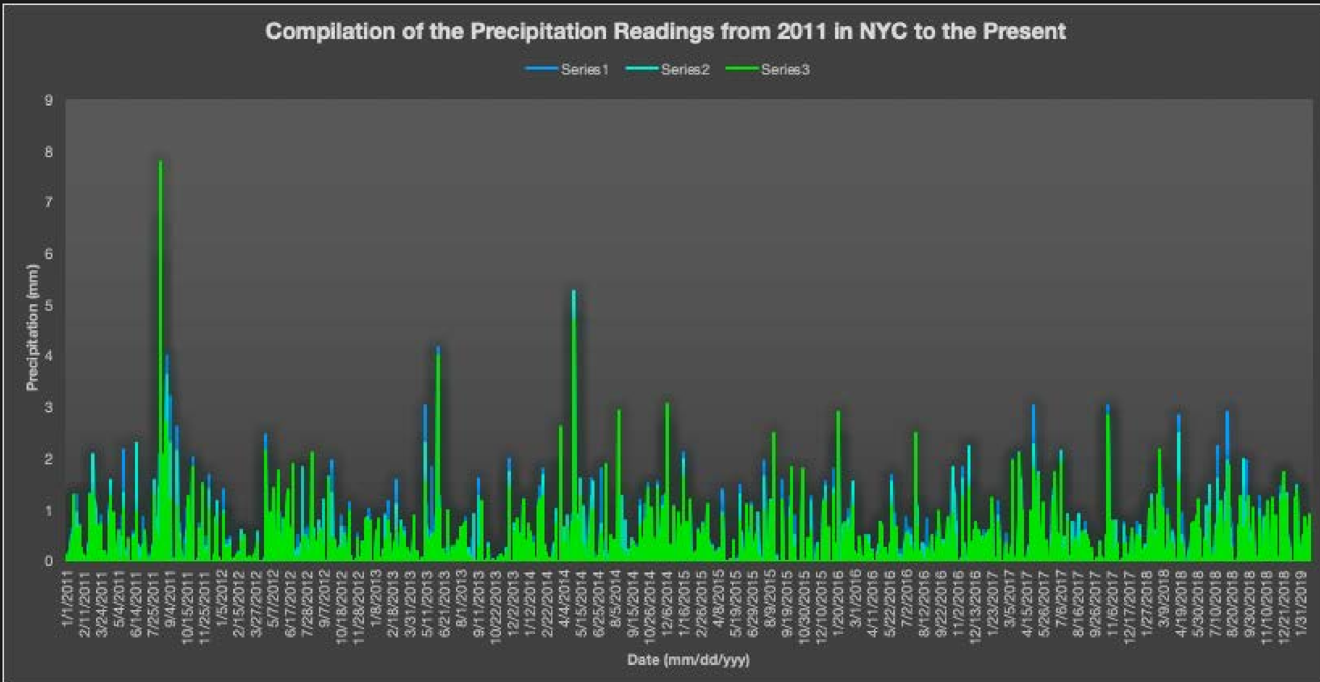
1. Smith, V., Tilman, G., & Nekola, J. (1999). Eutrophication: Impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. *Environmental Pollution,100*(1-3), 179-196. doi:10.1016/s0269-7491(99)00091-3
2. Chislock, M.F.; Doster, E.; Zitomer, R.A.; Wilson, A.E. (2013). "Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems". Nature Education Knowledge. 4 (4): 10. Retrieved 10 March 2018.
3. Michaud, Joy P. (1994). "Measuring Total Suspended Solids and Turbidity in lakes and streams." Archived 2010-07-30 at the Wayback Machine. A Citizen's Guide to Understanding and Monitoring Lakes and Streams. State of Washington, Department of Ecology.
4. Mumby, P., Green, E., Edwards, A., & Clark, C. (1999). "The cost-effectiveness of remote sensing for tropical coastal resources assessment and management". *Journal of Environmental Management,55*(3), 157-166. doi:10.1006/jema.1998.0255
5. Alesheikh, A. A., et al. "Coastline Change Detection Using Remote Sensing." International Journal of Environmental Science & Technology, vol. 4, no. 1, Jan. 2007, pp. 61–66., doi:10.1007/bf03325962.

The Socioeconomic Analysis of Hurricane Events in New York City

NOAA CREST Scholar: Erin Wengerter
Mentor: Tarendra Lakhankar

So, What’s the Problem?

- Rising sea levels bring about **more powerful** and **destructive** storms for all coastal cities
- Hurricanes v.s. Tropical Storms
- Negative Effects:
  - Infrastructure (e.g. drainage and piping systems)
  - Transportation
  - Human behavior and welfare
- Problems are not limited to the coast


Compilation of the Precipitation Readings from 2011 in NYC to the Present
Series1
Series2
Series3
Precipitation (mm)
0
1
2
3
4
5
6
7
8
9
1/1/2011
2/11/2011
3/24/2011
5/4/2011
6/14/2011
7/25/2011
9/4/2011
10/15/2011
11/25/2011
1/5/2012
2/15/2012
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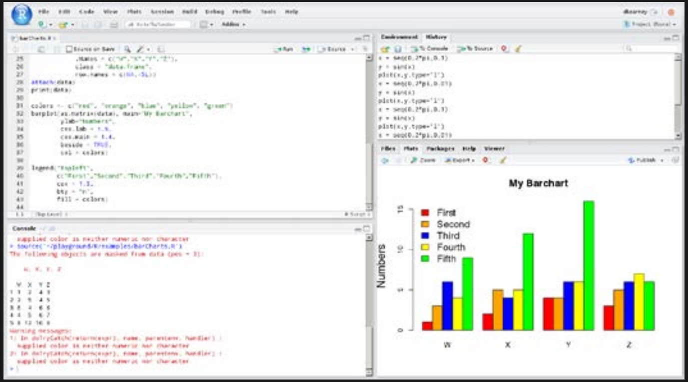
What will you be working with?



Data Collection:

- NYC Open Database
  - free public data published by New York City agencies and other partners
- NOAA's National Climatic Data Center (NCDC)

Applications to be used:

- Excel
- Rstudio
  - programming language for statistical computing and graphics
- ArcGIS
  - platform for organizations to create, manage, share, and analyze spatial data

Expected Results

- Finding the following before and after major hurricane events:
  - Frequency of street floods
  - Location of street floods
  - Socioeconomic Effect of street floods

Project Potential

- Finding such patterns allow us to see
  - Which neighborhoods/communities present infrastructure issues/neglect and its social implications
  - Actions for adaptation to prevent future damage
  - A better understanding of the causes of street flooding in NYC boroughs

An Analysis of Economic Impact on New York City’s Transit System of Extreme Weather Events

By: Murshedur Shahy
Mentor- Dr. Tarendra Lakhankar

Problem Statement

- Climate change impacts will increase the total costs to the nation’s transportation systems and their users, but these impacts can be reduced through rerouting, mode change, and a wide range of adaptive actions. [1]
- After hurricane Sandy MTA proposed a $5B budget for repairs.
- By extreme weather conditions (e.g. snow, flooding, hurricane, and tornadoes), as well as preparatory and residual costs totaled- $36.731 million dollars in 2017 CY budget.[2]
- What are the weather impacts on NYC tolls & bridges, and subway?
- MTA has revenue loss in the Subways but making profit in “Bridges and Tunnel”

Goals

● Investigate correlation between precipitation, snowfall and temperature with the transportation system:

- **Trends**: Does the ridership goes up or down with different weather predictors?
- **Economic Assessment**: Revenue model based on the weather data
- **Vulnerability Assessment:** Identifying existing vulnerable facilities and systems, together with the expected consequences

● Better prepared to present and future environmental challenges enhances the resilience of communities.

● NOAA's goal: "study causes and consequences of climate change, the physical dynamics of high-impact weather events"

Hurricane Sandy Causes Flooding in New York City Subway Stations

Figure 5.4: The nation's busiest subway system sustained the worst damage in its 108 years of operation on October 29, 2012, as a result of Hurricane Sandy. Millions of people were left without service for at least one week after the storm, as the Metropolitan Transportation Authority rapidly worked to repair extensive flood damage (Photo credit: William Vantuono, Railway Age Magazine, 2012[32]).

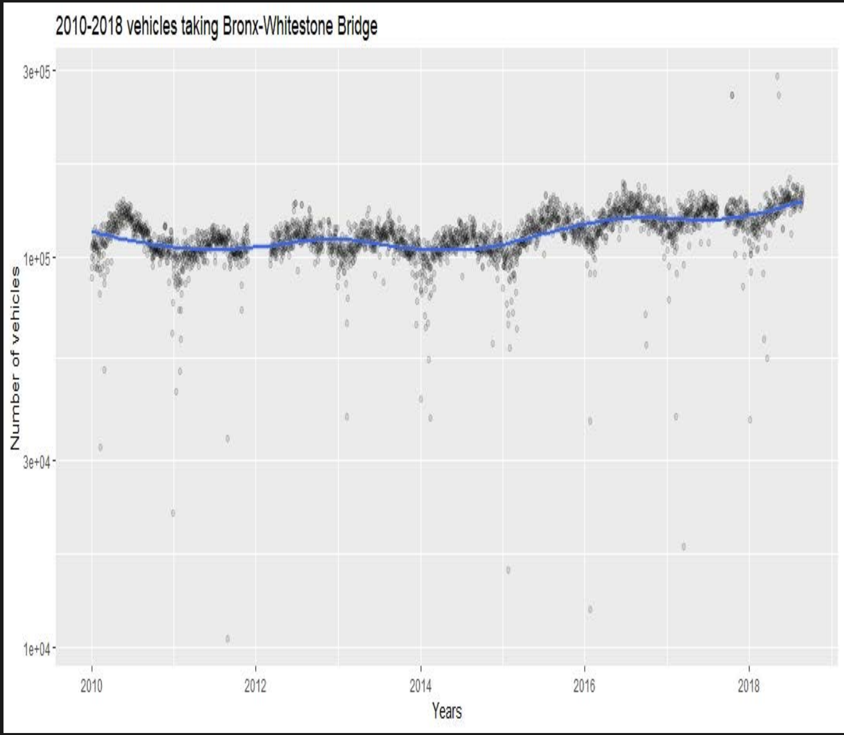
What you will be working with

MTA subway data

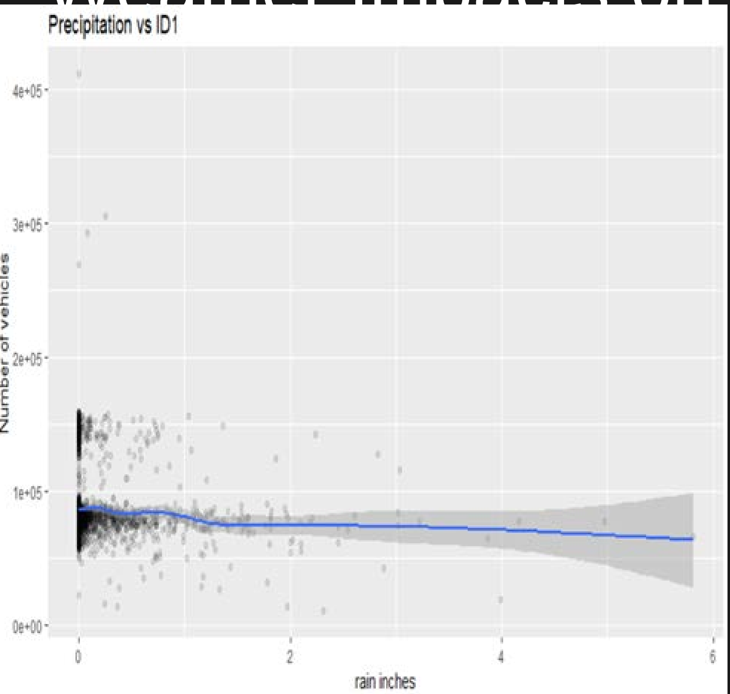
- 424 subway stations
- weekly data for turnstile swipes
- from 2011-Present

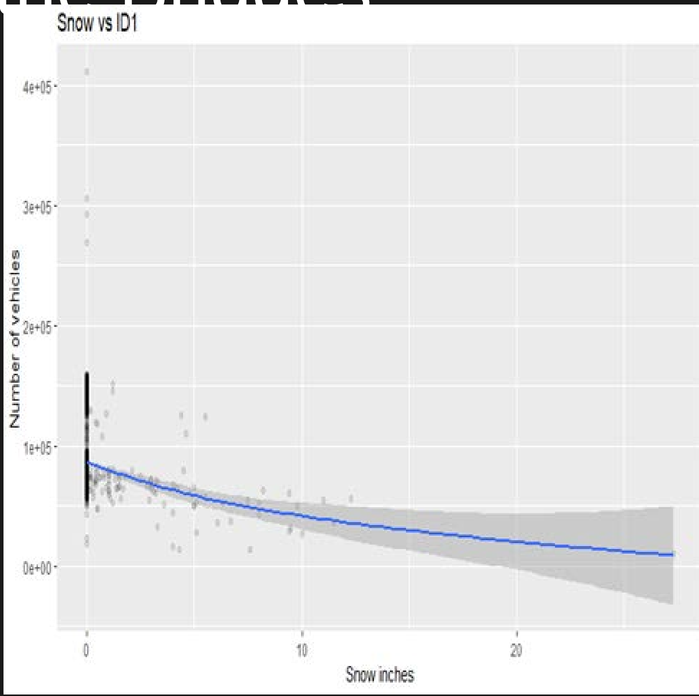
MTA Bridges and Tunnels data

- 10 different bridges
- daily data of vehicles passing through the bridge
- from 2010-2018



Weather Impacts on the Bridges





Expected Results Potential

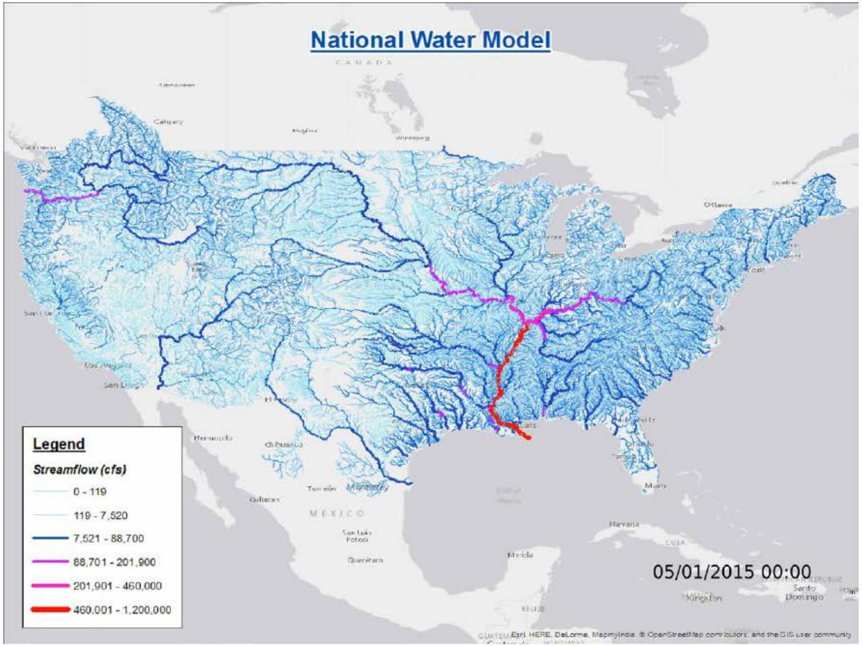
- How does the weather impact the NYC Subway/Bridges
- Research on other implication such as- human perception of weather, weather warnings and social implications
- Estimate a concrete amount in loss of revenue in dollar amount

Project

- Which bridge gets affected the most and what can be done about it?
- Actions for adaptation to prevent future revenue loss

National Water Model (NWM) & WRF-Hydro

The NOAA National Water Model



Source: www.ral.ucar.edu

NWM Run Configurations:

1. Analysis and Assimilation – current conditions
2. Short Range -18 hr forecast
3. Medium Range – 10 day forecast
4. Long Range – 30 day forecast

Forcing Sources:

1. Multi-Radar/Multi-Sensor System (MRMS) - radar-gauge observed precipitation data, and
2. High Resolution Rapid Refresh (HRRR), Rapid Refresh(RAP), Global Forecasting System (GFS) and Climate Forecast System (CFS) – Numerical Weather Prediction data

Routing:

1. Muskingum-Cunge channel routing down National Hydrography Dataset (NHDPlusV2) stream reaches

Land surface process simulation:

1. Noah-MP Land Surface Model (LSM)

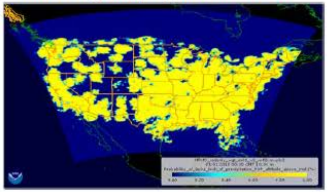
	Analysis & Assimilation	Short-Range	Medium-Range	Long-Range
Cycling Frequency	Hourly	Hourly	4 x Day at 00Z, 06Z, 12Z, 18Z	Daily Ens (16 mem)
Forecast Duration	- 3 hrs	0-18 hours	0-10 days	0-30 days
Forecast Latency (latency of external forcing data accounts for most of delay)	1 hour	1 hour 45 mins	6 hours	19 hours
Meteorological Forcing	MRMS blend/ HRRR/RAP bkgnd.	Downscaled HRRR/RAP blend	Downscaled GFS	Downscaled & bias-corrected CFS
Spatial Discretization & Routing	1km/250m/NHDPlus Reach	1km/250m/NHDPlus Reach	1km/250m/NHDPlus Reach	1 km/NHDPlus Reach

Assimilation of ~7,000 USGS Obs

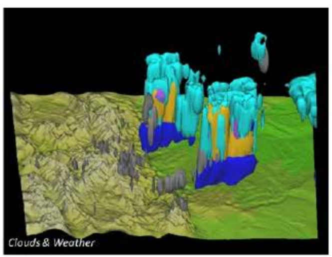
Reservoirs (1260 water bodies parameterized with level pool scheme)

Source: www.water.noaa.gov

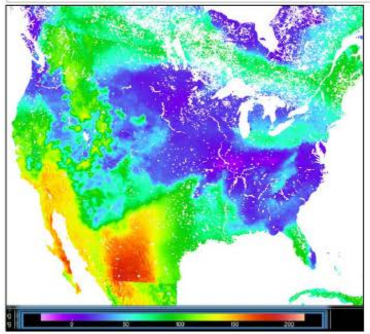
Seasonally-varying MRMS RQI



Blended MRMS-HRRR Precipitation

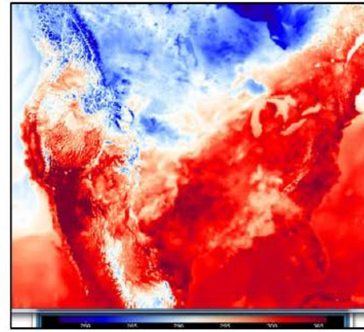


HRRR-RAP incoming longwave radiation

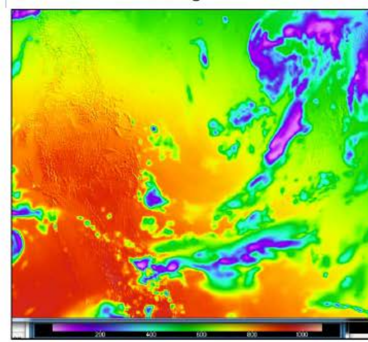


Source: www.water.noaa.gov

HRRR-RAP 2m Air Temperature

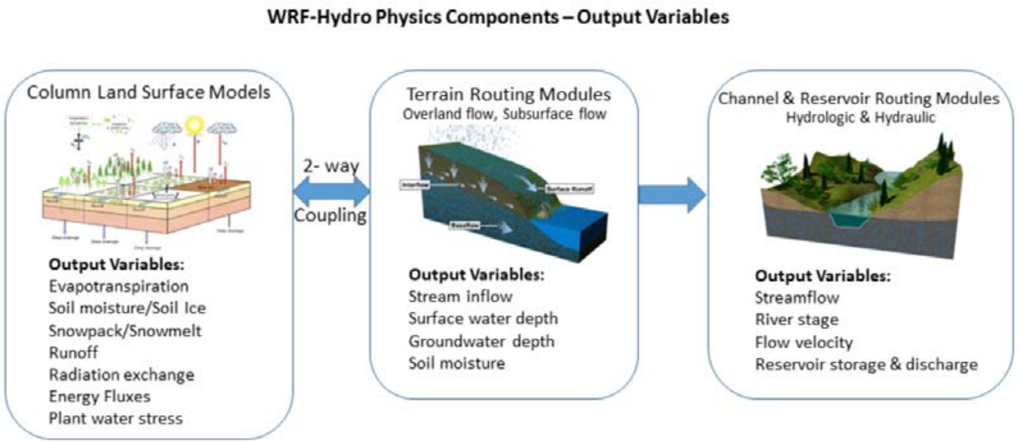


GFS – derived incoming shortwave radiation



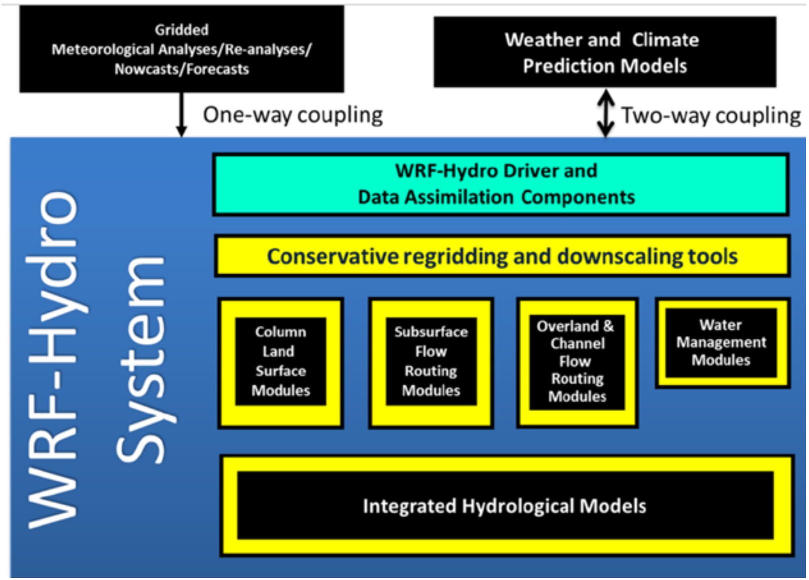
WRF-HYDRO

- Model designed to link multi-scale process of atmospheric and terrestrial hydrology
- Application – to improve hydrometeorological forecasts
  - flash flood prediction,
  - regional hydroclimate impacts assessments,
  - seasonal forecasting of water resources,
  - land-atmosphere coupling studies



Source: www.ral.ucar.edu

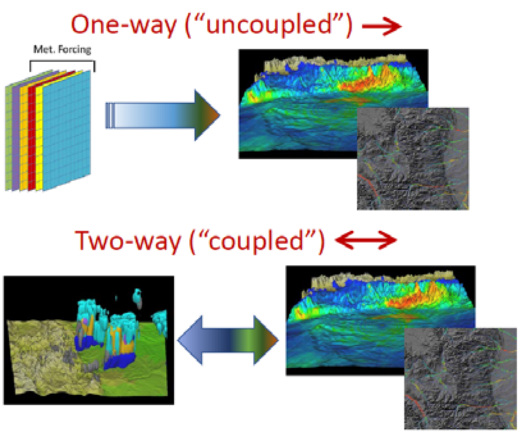
WRF-Hydro Conceptualization (multi-scale/multi-physics modelling)



Source: www.ral.ucar.edu

WRF-Hydro Operating Modes

WRF-Hydro operates in two major modes: coupled or uncoupled to an atmospheric model

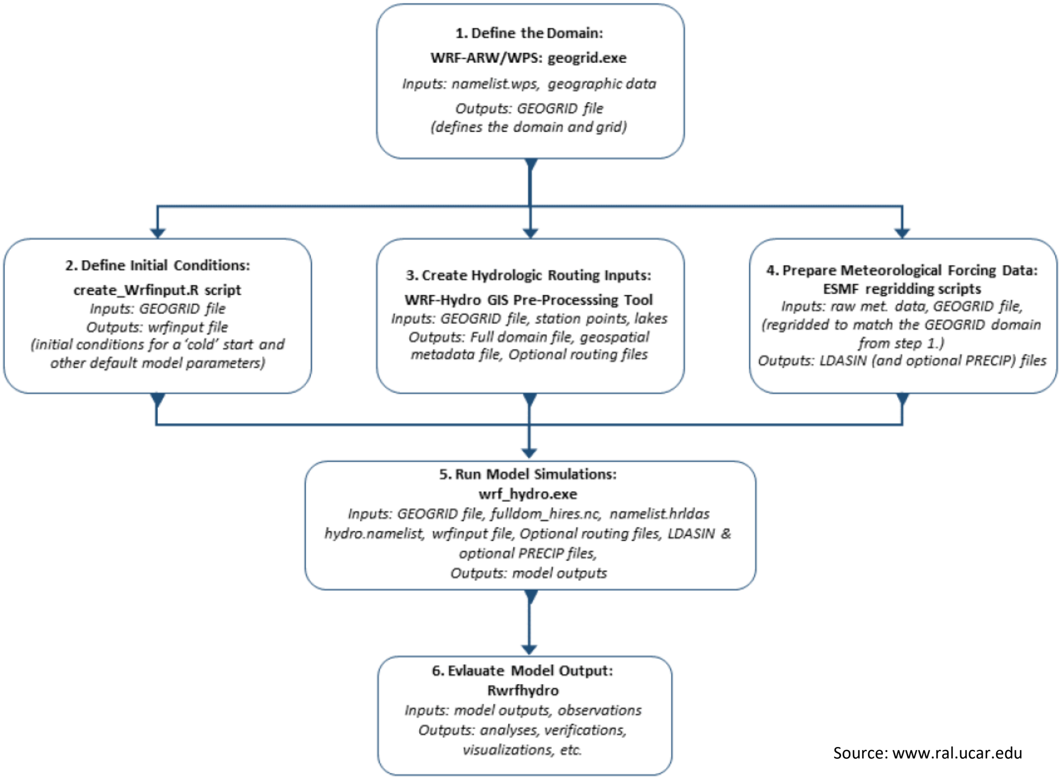


- <u>Uncoupled mode</u> critical for spinup, data assimilation and model calibration
- <u>Coupled mode</u> critical for land-atmosphere coupling research and long-term predictions
- Model forcing and feedback components mediated by WRF-Hydro:
  - Forcings: T, Press, Precip., wind, radiation, humidity, BGC-scalars
  - Feedbacks: Sensible, latent, momentum, radiation, BGC-scalars

Source: www.ral.ucar.edu

WRF-Hydro Workflow

- **GIS Pre-Processor**– Physiographic data processing
- **ESMF Regridding Scripts** –Met. data pre-processing
- **Core WRF-Hydro Model**–Model physics
- **Rwrfhydro**– Analysis, verification, visualization
- **PyWrfHydroCalib**– Model calibration toolkit



Source: www.ral.ucar.edu