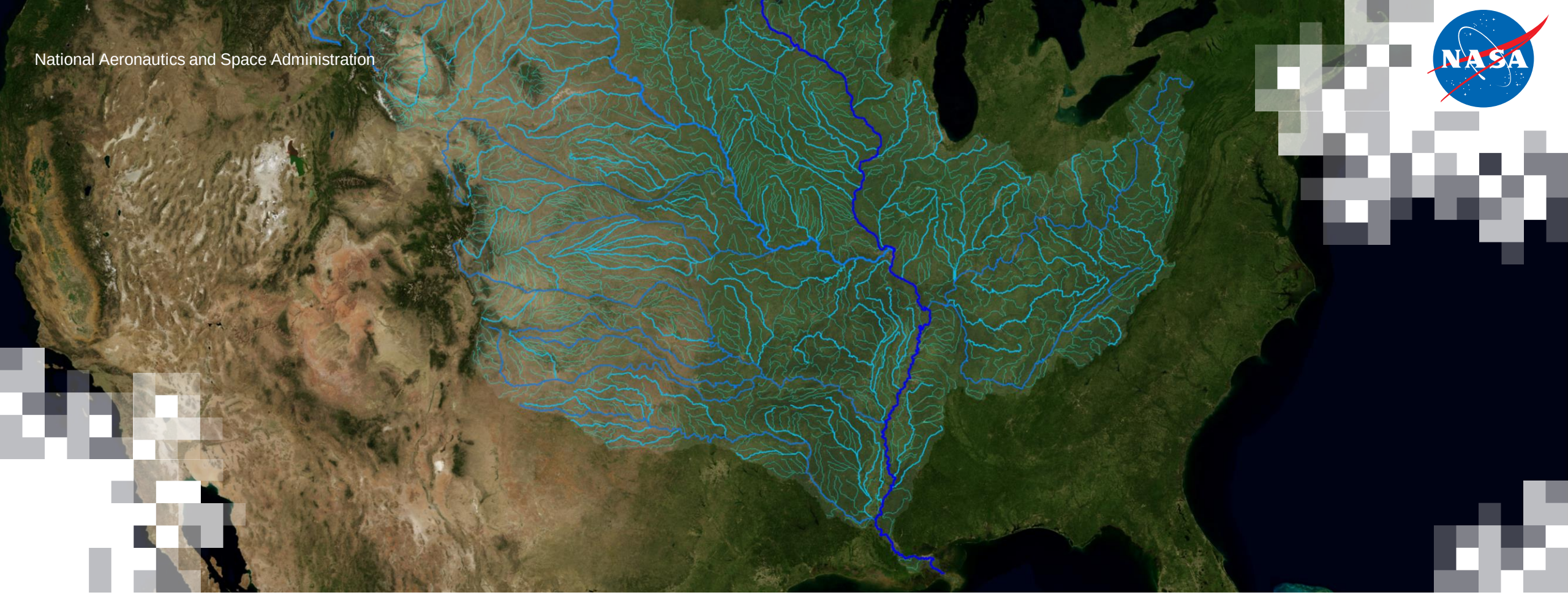


Applications of Remote Sensing for Monitoring Water Budget Within River Basins

Amita Mehta and Sean McCartney

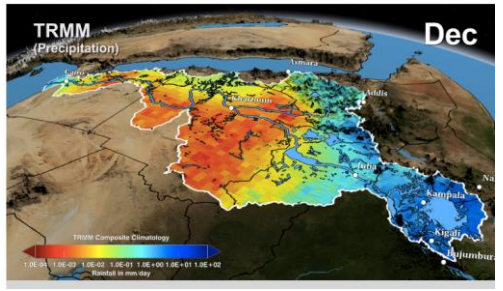
3 April 2019

Training Outline

13 March 2019
Overview of Remote Sensing Data For River Basin Monitoring

http://wwf.hu/en/the-river-basin-management-plan

20 March 2019
Applications of Remote Sensing for River Basin Monitoring: Nile Basin

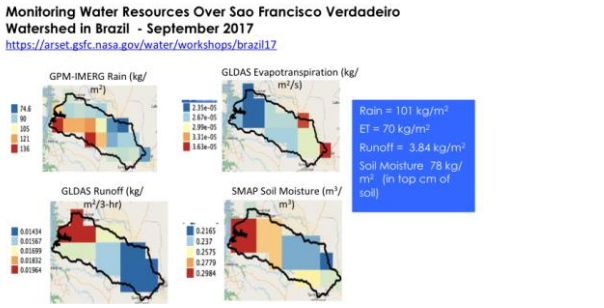


https://svs.gsfc.nasa.gov/4044

27 March 2019
Applications of Remote Sensing for River Basin Monitoring: Mekong Basin

https://earthobservatory.nasa.gov/images/91761/a-new-reservoir-in-cambodia

3 April 2019
Surface Fresh Water Budget Estimation



https://arset.gsfc.nasa.gov/water/workshops/brazil17

Session-4 Outline

- Review of remote sensing data sources for surface water budget components in a river basin
- Estimation of water budget

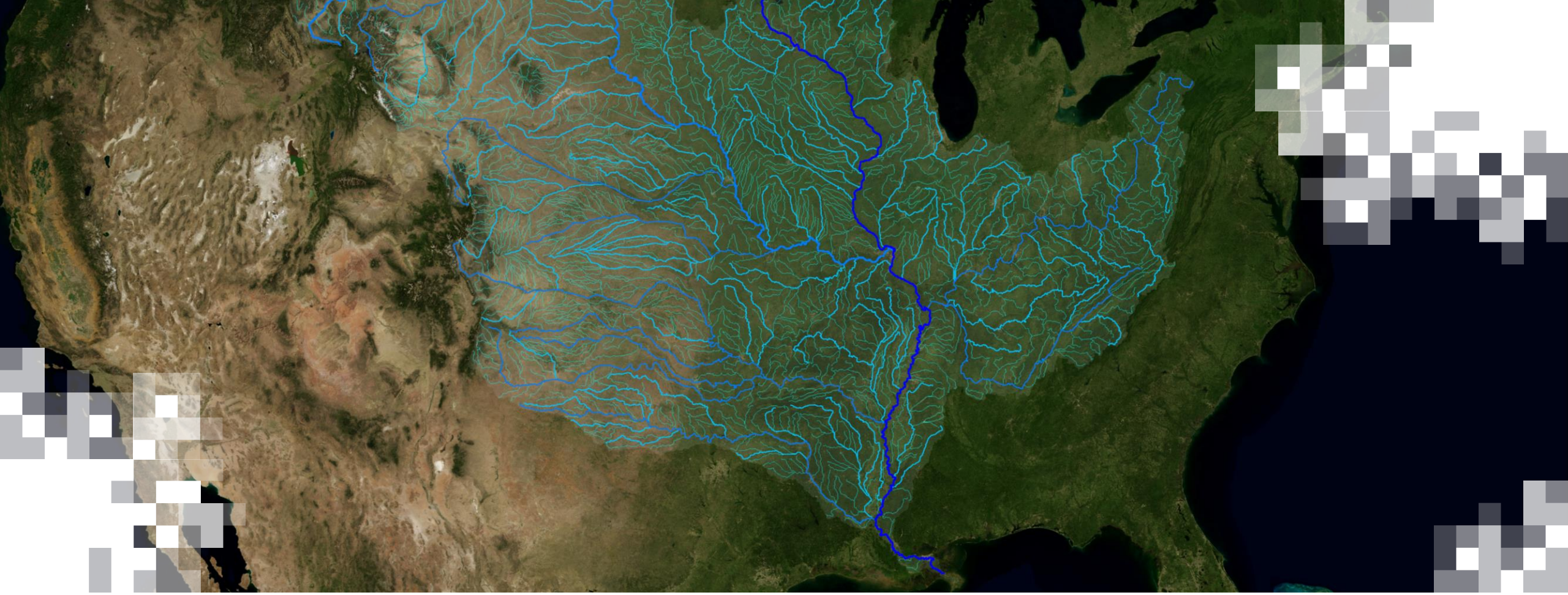
  Demonstration of data access and analysis in:

  – Potomac River Basin (USA)

  – Parana River Basin (Argentina, Bolivia, Brazil, Paraguay)
- Summary

Homework and Certificate

- Homework will be available after Sessions 2 and 4 from:
  https://arset.gsfc.nasa.gov
  - Answers must be submitted via Google Form
  - Due dates: 4 April (Homework 1) & 17 April (Homework 2)
- Certificate of Completion will be awarded to those who:
  - Attend all webinars
  - Complete homework assignments
- You will receive certificates approximately two months after the completion of the course from: marines.martins@ssaihq.com



Review of Remote Sensing Data Sources for Surface Water Budget Components in a River Basin

Monitoring Water Availability In River Basins

- Monitoring water availability in a basin – water flow in streams within the basin – requires information/observations/modeling of water budget components in the basin
- Water flow in a stream/river depends on the following components in the watershed contributing to the flow:
  - Precipitation
  - Evaporation and Transpiration
  - Infiltration
  - Surface water: soil moisture, reservoirs, and groundwater storage
  - Runoff

Satellites and Sensors for Water Budget Components

Satellites	Sensors	Spectral Measurements	Water Budget Component
TRMM & GPM	Microwave Radiometer and RADAR TMI, PR GMI, DPR	TMI: 10-85 GHz GMI: 10-183 GHz PR and DPR (Ku and Ka)	Precipitation
Terra & Aqua	MODIS	Visible, Near IR, Middle IR	Snow Cover, Evapotranspiration
Landsat 7, 8	TM, ETM+, OLI	Visible, Near IR, Middle IR, Thermal IR	Evapotranspiration
SMAP	Microwave Radiometer	L-Band	Soil Moisture
GRACE & GRACE-FO	Microwave Radar	K-Band	Groundwater
Jason 2, 3	Altimeter	C-Band and Ku-Band	Reservoir Height

TMI : TRMM Microwave Imager
PR Precipitation Radar
GMI: GPM Microwave Imager
DPR: Dual-frequency Precipitation Radar

MODIS: MODerate Resolution Imaging Spectroradiometer
TM: Thematic Mapper
ETM+: Enhanced Thematic Mapper
OLI: Operational Land Imager

For details see **Session 2B** on https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

Global Land Data Assimilation System (GLDAS) for Water Budget Data

http://ldas.gsfc.nasa.gov/gldas/

A water and energy balance model with assimilation of remote sensing data

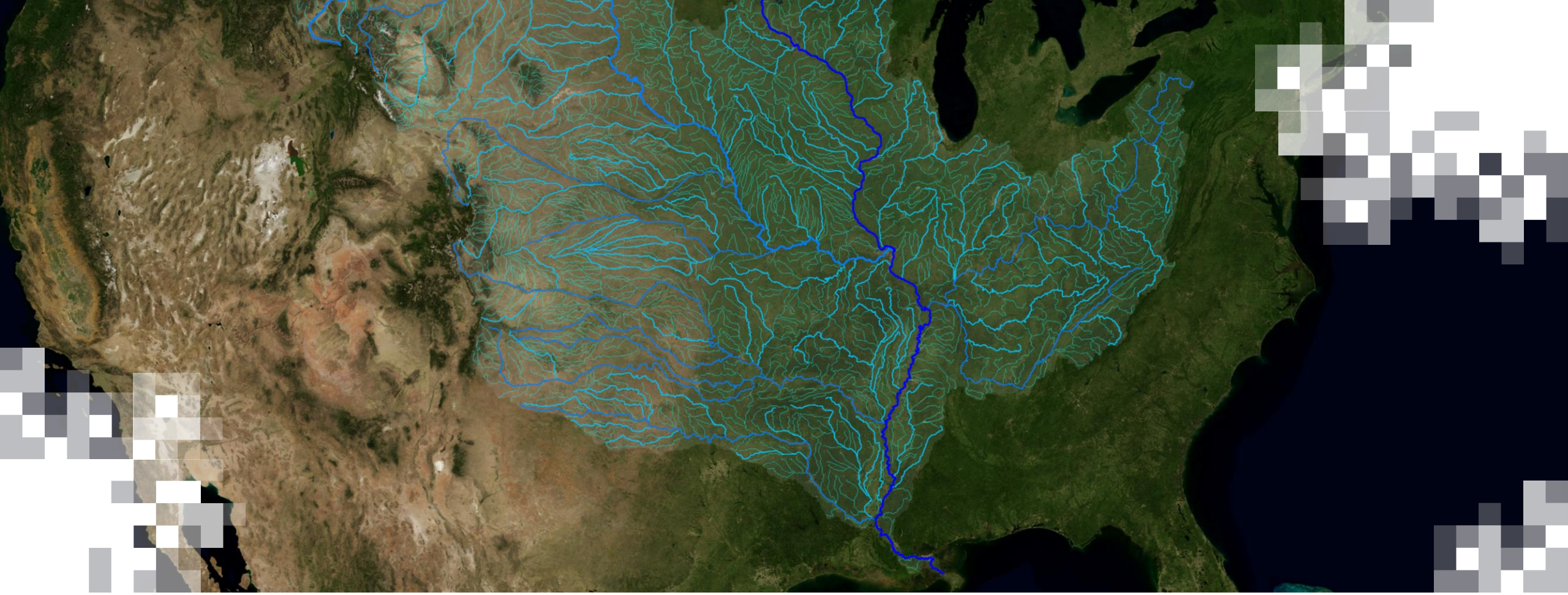
Inputs:

- Rainfall: TRMM and multi-satellite based data
- Meteorological data: global reanalysis and observations-based data from Princeton University
- Vegetation mask, Land/Water mask, Leaf Area Index (LAI): MODIS (GLDAS-2)
- Clouds and Snow (for surface radiation): NOAA and DMSP satellites

Integrated outputs include:

- Soil Moisture
- Evapotranspiration
- Surface/Sub-surface runoff
- Snow water equivalent

Reference: Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2004. The Global Land Data Assimilation System. Bulletin of the American Meteorological Society, 85(3):381–394.



Estimation of Water Budgets

Water Budget

https://water.usgs.gov/watercensus/AdHocComm/Background/WaterBudgets-FoundationsforEffectiveWater-ResourcesandEnvironmentalManagement.pdf

The water-budget equation for a small watershed can be expressed as:

*Pr = ET + DS + RO + Base Flow

Where

- Pr = Precipitation
- ET = Evapotranspiration
- DS = Change in water storage in the watershed can include surface (snow, soil moisture), and sub-surface (root zone moisture, groundwater components)
- RO = Surface Runoff
- Base Flow = Sub-Surface Runoff

* Considering that there is no surface, sub-surface, or groundwater net inflow/outflow in the watershed, surface RO and base flow contribute to discharge

Obtain Water Budget Components

The water-budget equation for a small watershed can be expressed as:

Pr = ET + DS + RO + Base Flow

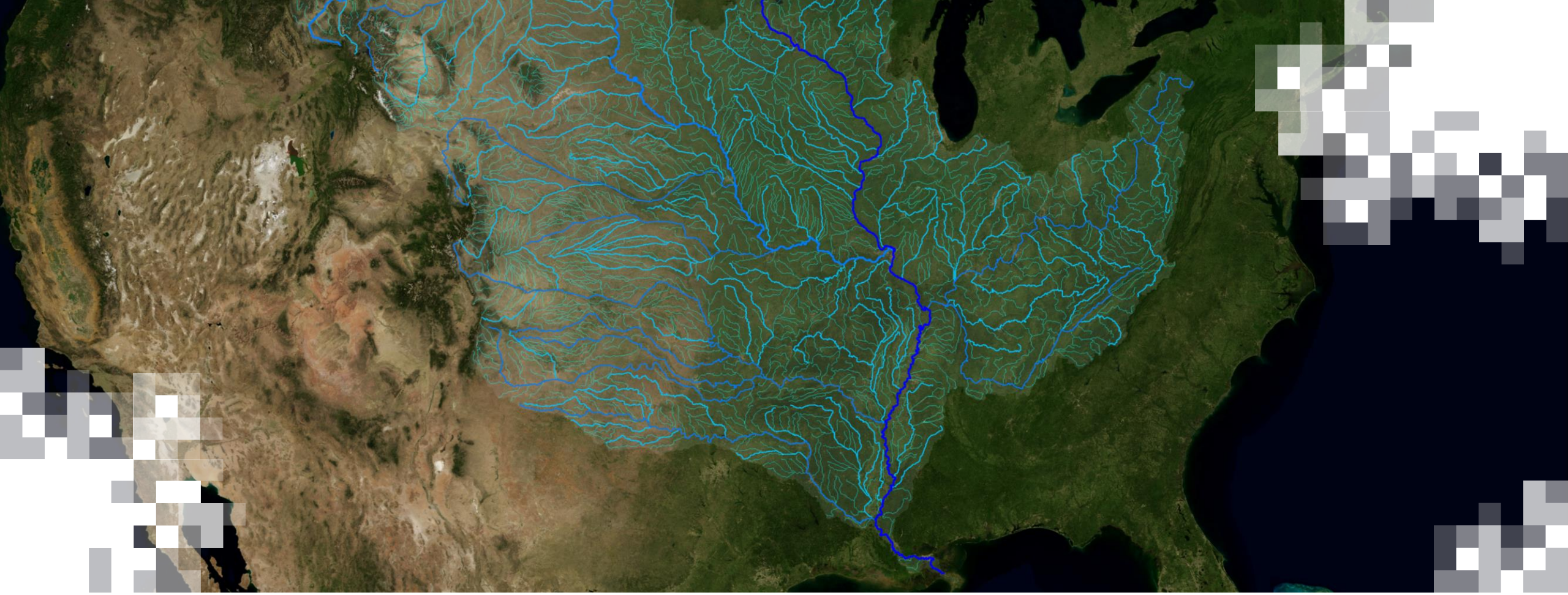
Water Budget Component	Data Sources
Pr	GPM-IMERG, GLDAS
ET	ALEXI, MOD16, GLDAS
DS	SMAP, GLDAS
RO, Base Flow	GLDAS

Next: How to access and analyze these data using web-tools and QGIS?

Obtain Water Budget Components

Water Budget Component	Source	Data Access
Precipitation	GPM IMERG, GLDAS	[1]Giovanni
Evapotranspiration	ALEXI, GLDAS	[2]SERVIR Global, [1]Giovanni
Soil Moisture	SMAP, GLDAS	[3]AppEEARS, [1]Giovanni
Snow Melt	GLDAS	[1]Giovanni
Runoff	GLDAS	[1]Giovanni

[1]https://giovanni.gsfc.nasa.gov/giovanni/
[1]https://disc.gsfc.nasa.gov/
[2]http://catalogue.servirglobal.net/Product?product_id=198
[3]https://lpdaacsvc.cr.usgs.gov/appeears



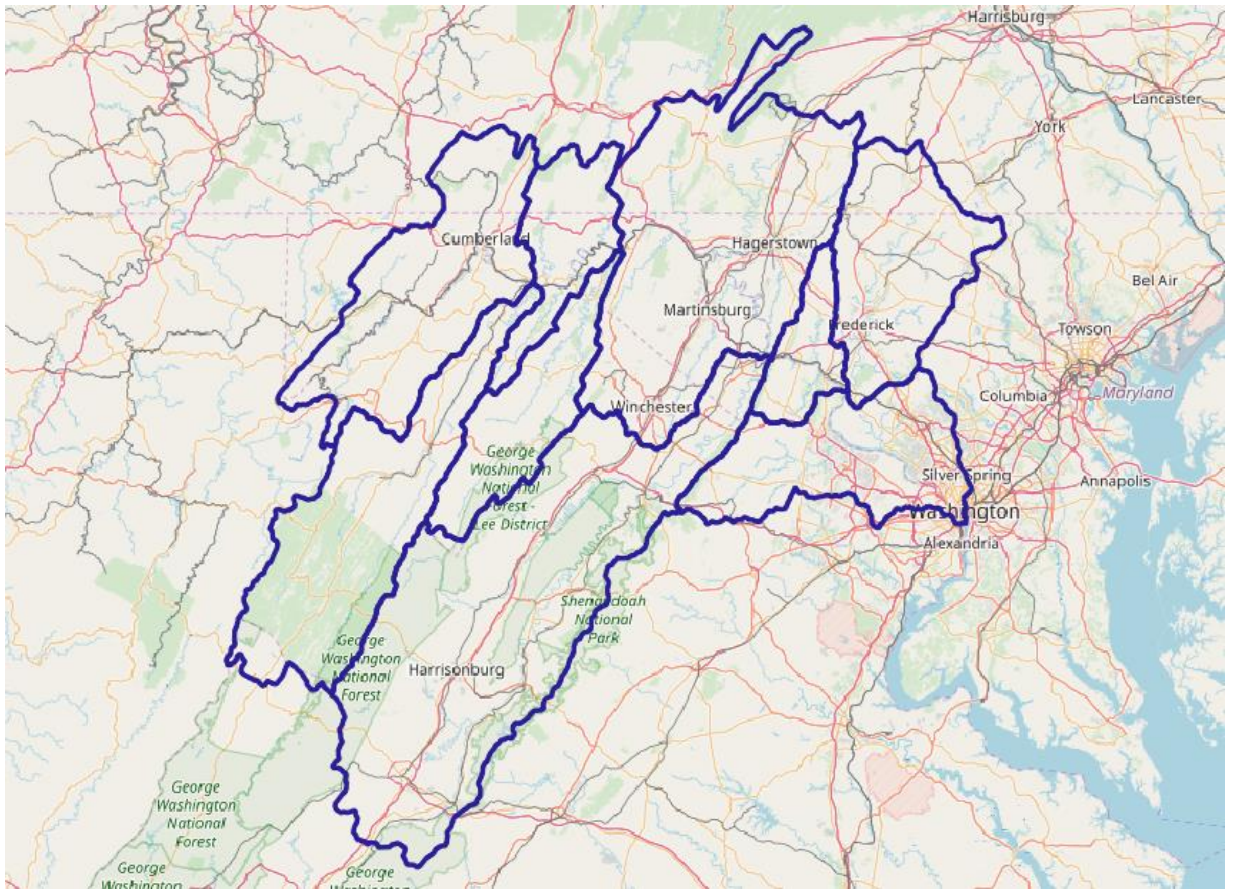
Demonstration of Data Access and Analysis

River Basin Network from HydroSHEDS

https://www.hydrosheds.org/; https://hydrosheds.cr.usgs.gov/

Parana River Basin

Potomac River Basin



Obtain Water Budget Components For Parana and Potomac Sub-Watersheds

Water Budget Component	Source	Data Access
Precipitation	GLDAS	[1]Giovanni [2] Goddard Earth Science Data and Information Service Center (GES DISC)
Evapotranspiration		
Soil Moisture		
Snow Melt		
Runoff		

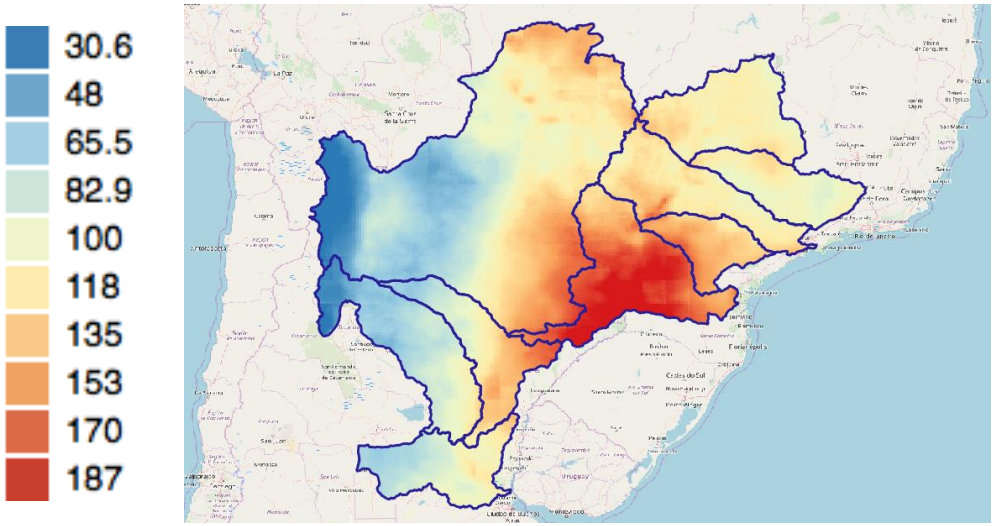
[1]https://giovanni.gsfc.nasa.gov/giovanni/

[2]https://disc.gsfc.nasa.gov/

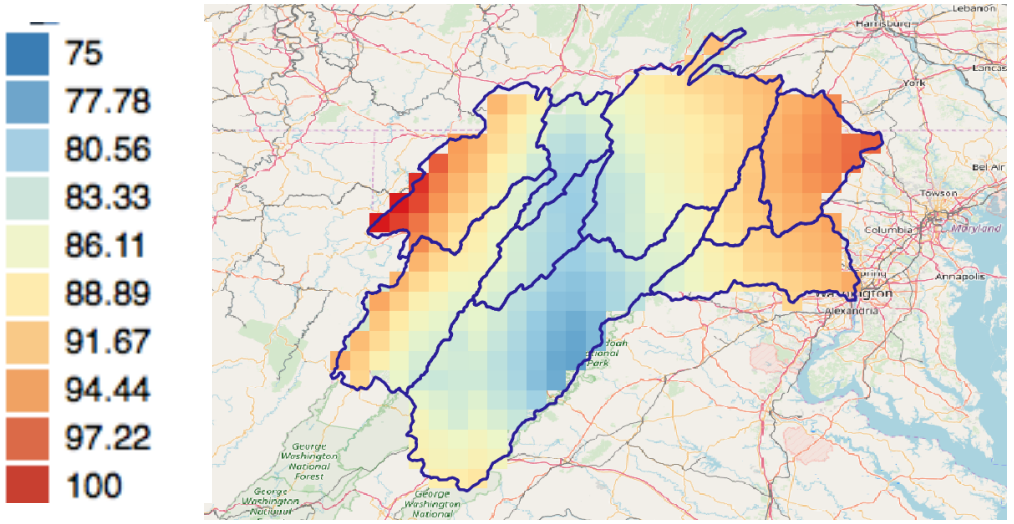
QGIS: https://arset.gsfc.nasa.gov/sites/default/files/users/QGIS-instructions.pdf

Precipitation Over Parana and Potomac River Basins

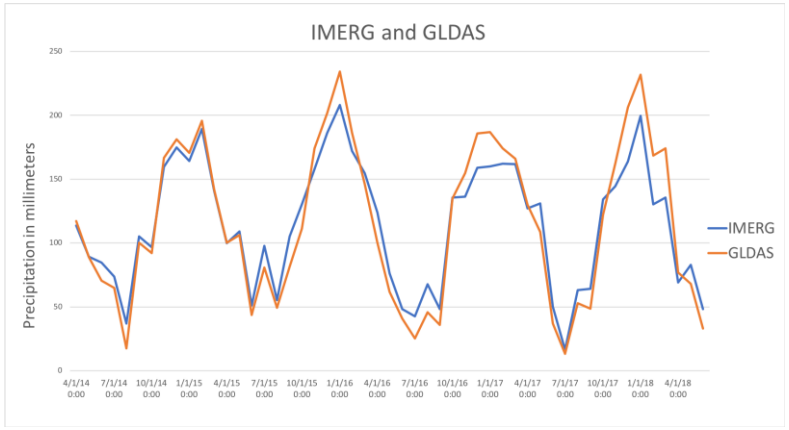
GPM-IMERG Mean Precipitation April 2014 –June 2018 (mm/month)

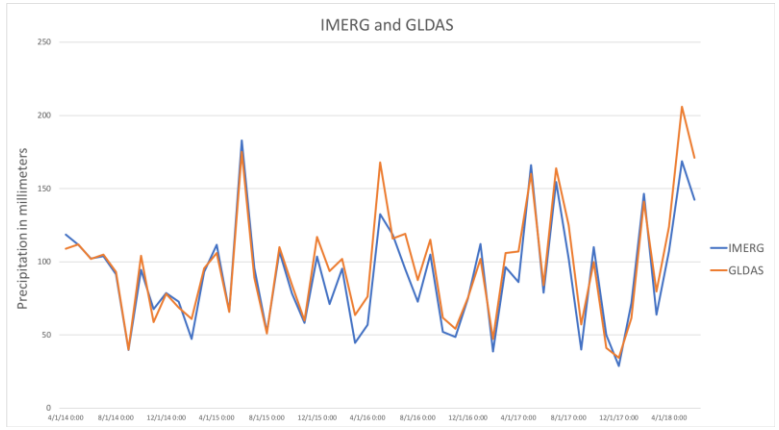


Parana



Potomac





IMERG and GLDAS Data Access Using Giovanni

https://giovanni.gsfc.nasa.gov/giovanni/

- Requires: NASA Earthdata Account
- Register using https://urs.earthdata.nasa.gov/home
- Mean and time series of precipitation from IMERG
- Water budget components in Parana and Potomac River Basins : from GLDAS for January 2017 and January 2018

For Monthly Data:

- Precipitation and ET are in kg m^{-2} s^{-1} per second → need to multiple by 3600 (s/hr) *24(hr/day)* (#days in month)
- Runoff, and Base Flow are in kg m^{-2} accumulated over 3-hour interval → need to multiply by 8 (3hr/day)*(#of days in moth)
- See https://hydro1.gesdisc.eosdisc.nasa.gov/data/GLDAS/GLDAS_NOAH025_3H.2.1/doc/README_GLDAS2.pdf

Summary

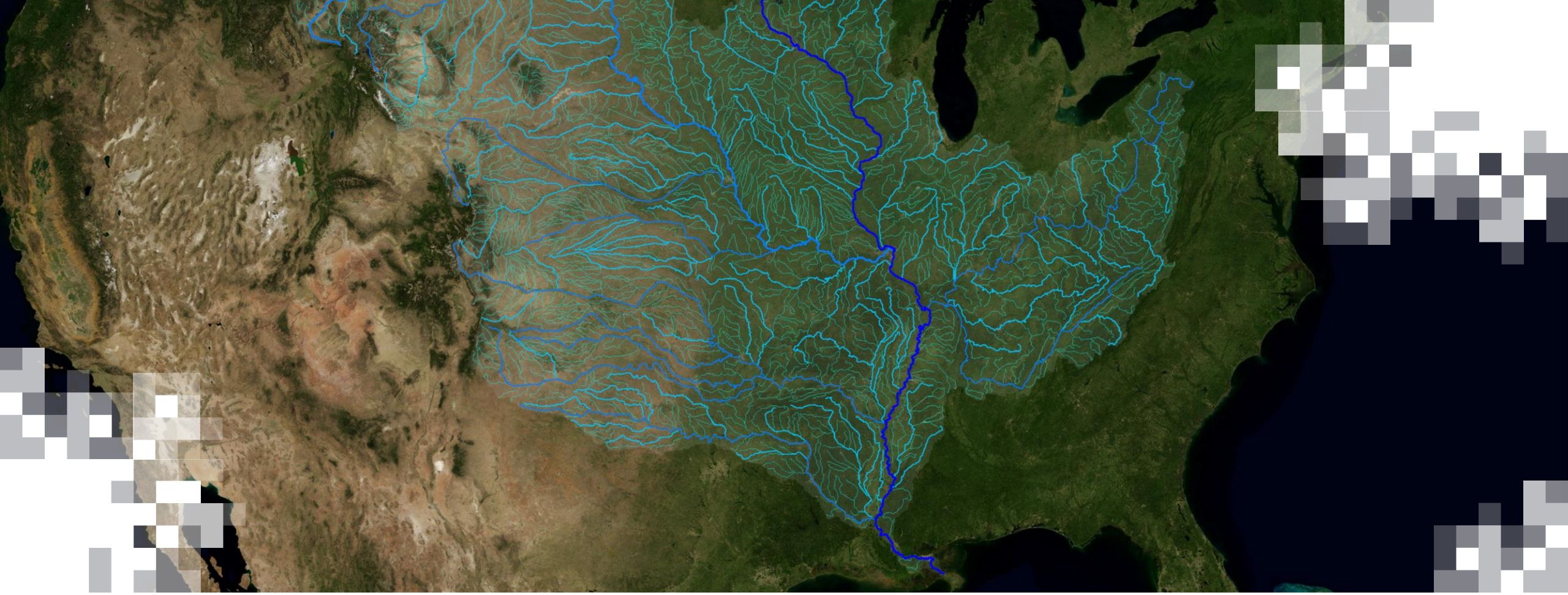
- Overview of remote sensing and land surface model data for freshwater components (Week 1)
- Water budget estimation in Nile Basin using the freshwater data (Week 2)
- Water resources and flood monitoring in Mekong Basin using customized hydrology model (SWAT) with remote sensing inputs (Week 3)
- Analysis of freshwater components using QGIS in Parana and Potomac River Basins (Week 4)

Summary

- All freshwater components are available based on remote sensing and/or Earth system models - all data are open source
- Various satellites and sensors with varying spatial and temporal resolutions, coverage, and quality
- Earth system models integrate surface-based and remote sensing observations and provide uniformly gridded, frequent information of water budget components

Summary

- Remote sensing-based data together with GIS analysis help in assessing the water budget in river basins
- Monthly/seasonal and inter-annual variations can be used in water resources and river basin management
- While all the data used in this session are validated with selected surface measurements, regional and local assessment is recommended
- In addition to the water budget component, information about socio-economic characteristics and in situ data (e.g. river discharge, ecosystems) are required for sustainable river basin management



Thank You!