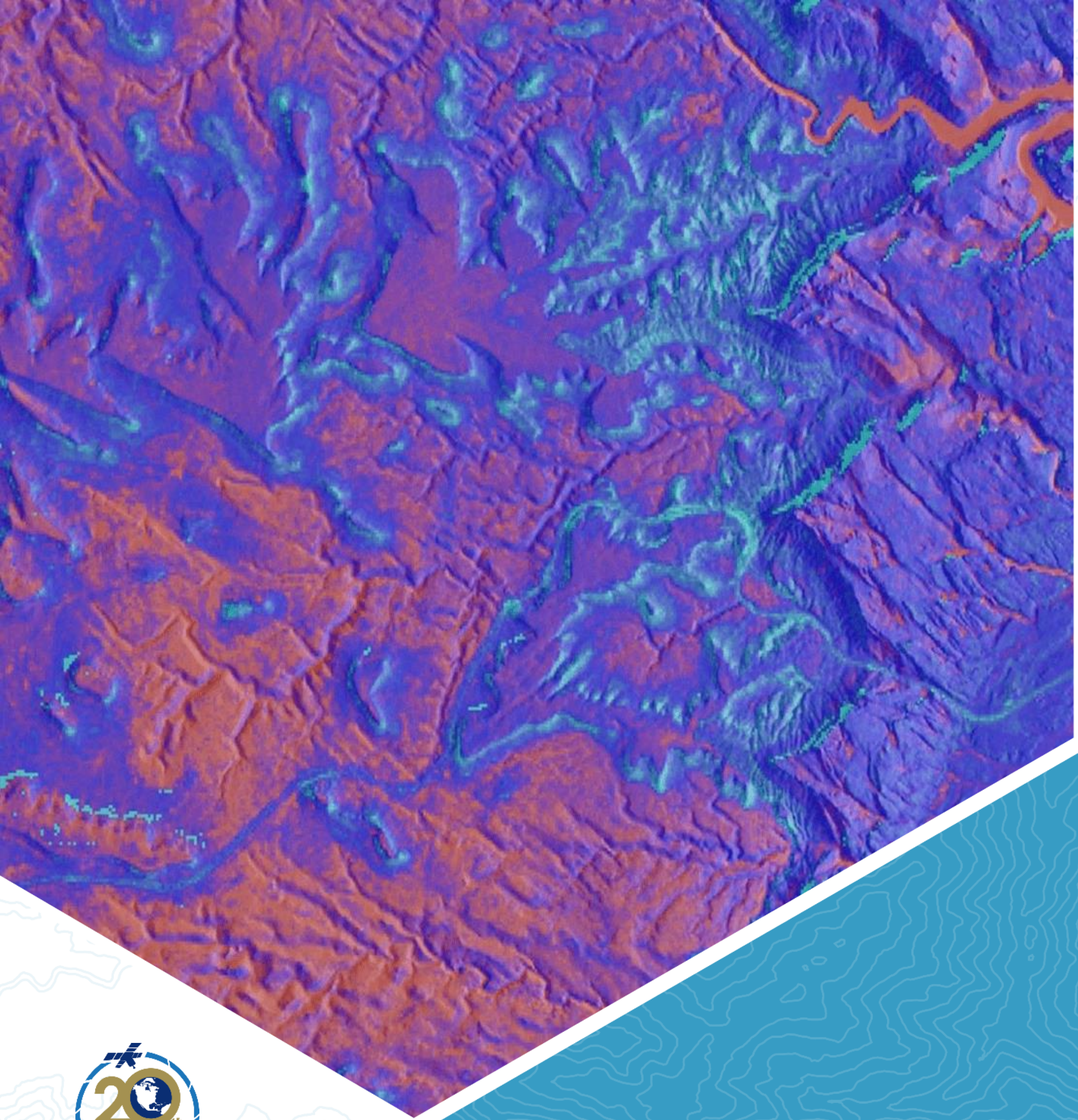

National Aeronautics and Space Administration

Utah Water Resources

Utilizing Landsat to Detect Ephemeral Water Sources in Support of a USGS Feasibility Assessment and Management Strategy of Equids

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Anson Call

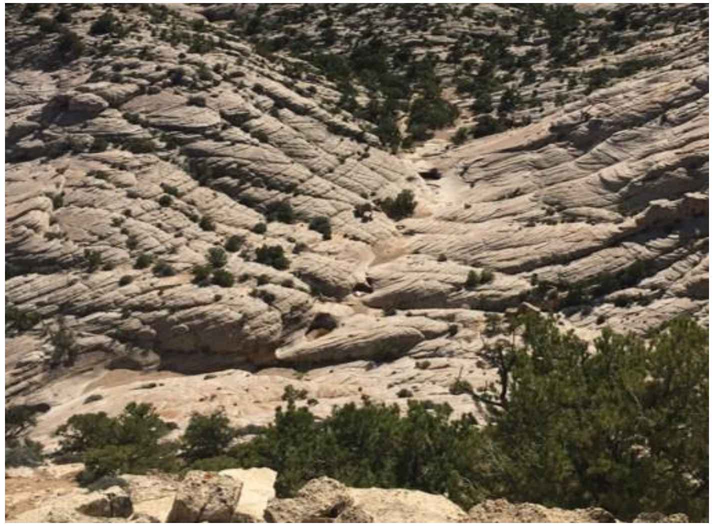
Timothy Mayer

Gary Olds

DEVELOP 20th Anniversary

Overview

- Wild horses and burros are cultural icons of the American West
- Effective management requires understanding of environmental factors such as cover, forage, and water
- Management areas are located in semi-arid environment
- Surface water in this location is ephemeral
- Goal: employ NASA Earth observations to identify smaller scale surface water sources

The Sinbad HMA, Utah.
(Credit: Sarah King, Savannah Summers, Tessa Roos)

Community Concern

Wild burros on the Sinbad HMA, Utah.
(Credit: Savannah Summers)

Federal agencies support healthy populations of free-roaming burros on the rangelands.

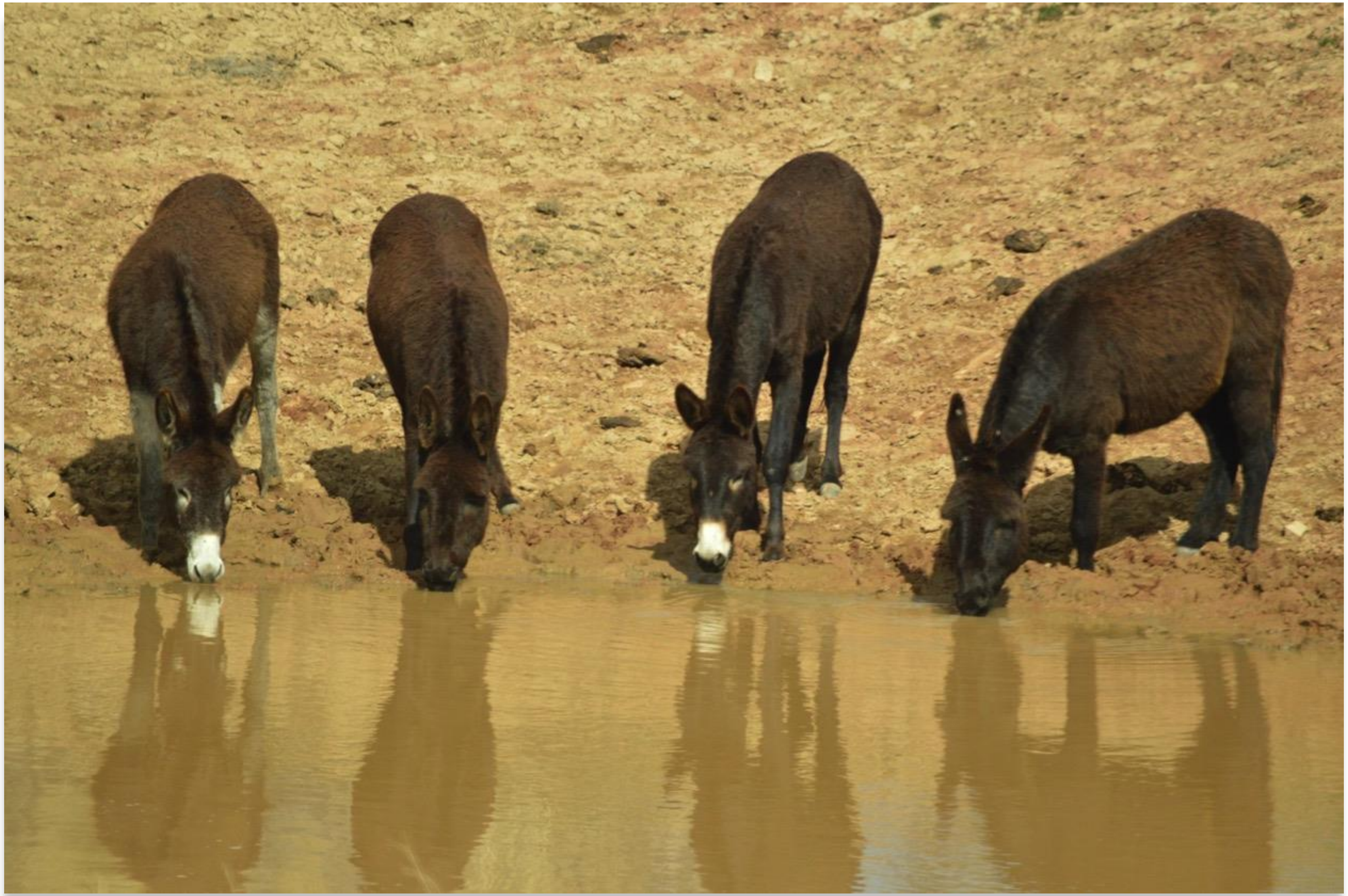
Information is needed for the BLM and USGS to enact informed and effective management decisions.

USGS researcher in Utah.
(Credit: Jessica Mikenas, USGS)

Shallow ponds in Emery County, Utah.
(Credit: Michael Freeman, USGS)

Information regarding water resources for equids in semiarid ecosystems is limited.

Partners



- USGS
  - Dr. Kate Schoenecker, ecologist
- BLM
  - Gus Warr, BLM Program Manager
- BLM and USGS partnered to study habitat selection of burros on the Sinbad Herd Management Area

Burros at a watering hole in Sinbad HMA, Utah. (Credit: Savannah Summersr)

Objectives

Our study objectives include:

1)Testing the feasibility of using NASA earth observations to **detect surface water** at small scales

2) Determine the **seasonality** of the available surface water

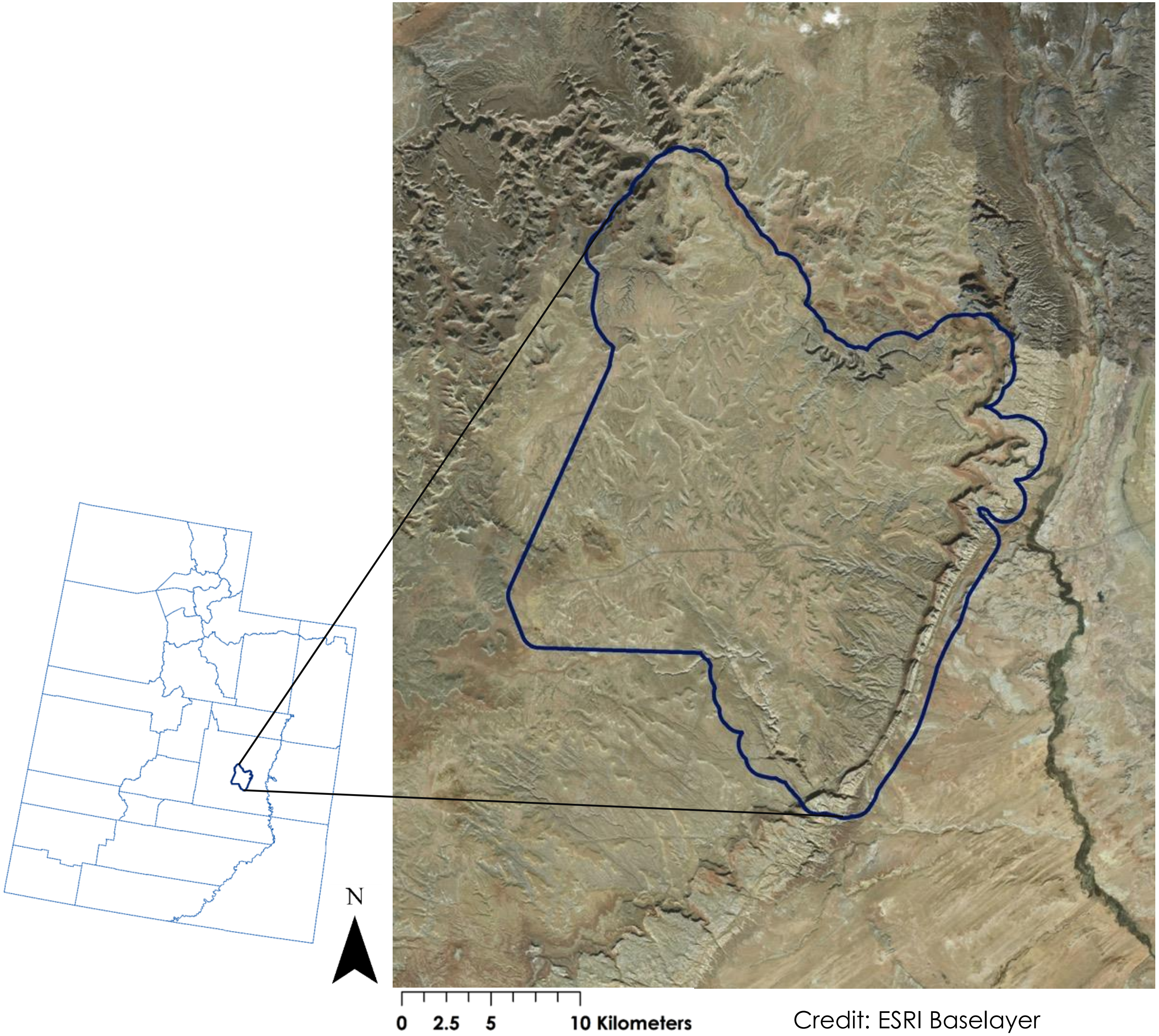
3) Up-scaling the methods by creating a **toolset** and **tutorial** for use in other regions and organizations

Credit: Mike Tweddell, BLM

Credit: Mike Tweddell, BLM

Study Area

- Sinbad HMA and surrounding area
- Emery County, Utah
- 61,126 ha / 875,071 Landsat pixels
- Semi-Arid with bimodal precipitation regime



Credit: ESRI Baselayer

Satellites & Sensors

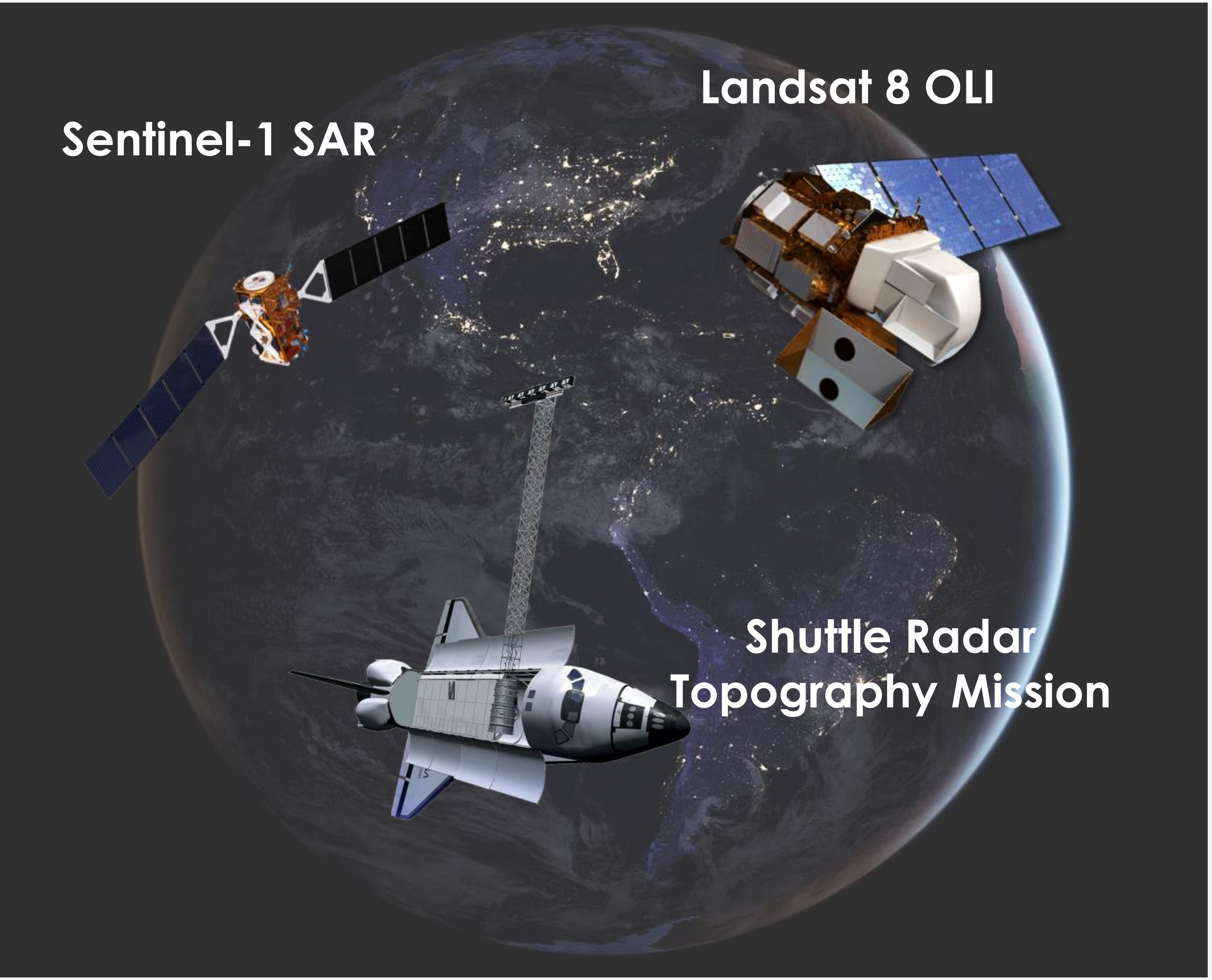
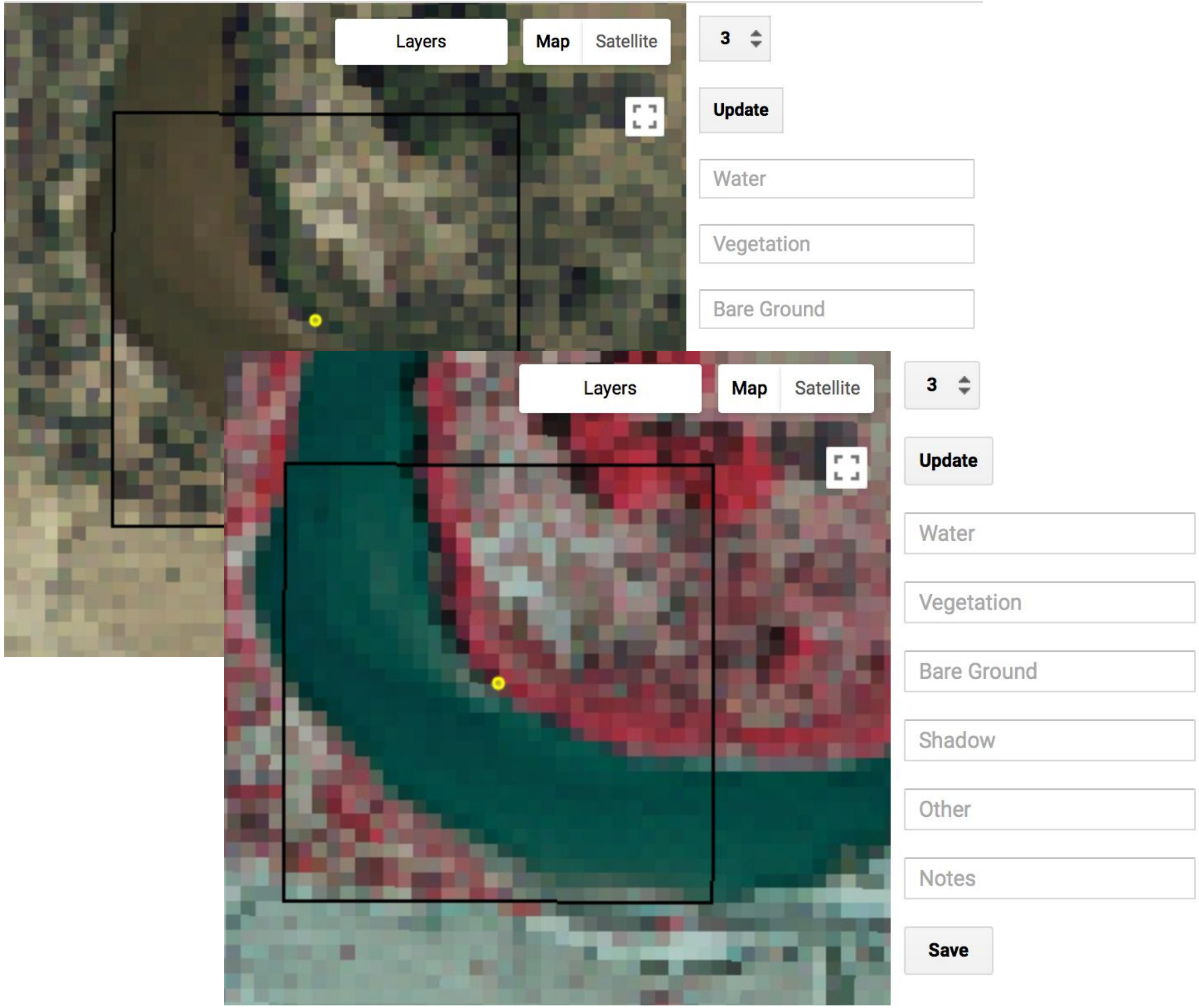


Image Credit: NASA

Platform and Sensor	Data Product	Dates/ Availability	Acquisition Method
Landsat 8 OLI	Collection 1, Tier 1 Raw and TOA Reflectance (Orthorectified) scenes	April 2013 - present	Google Earth Engine
Sentinel-1 SAR	C-band Synthetic Aperture Radar Ground Range Detected, Level-1C	October 2014 - present	Google Earth Engine
STRM	Digital Elevation and Topography Models	June 2015 - present	Google Earth Engine

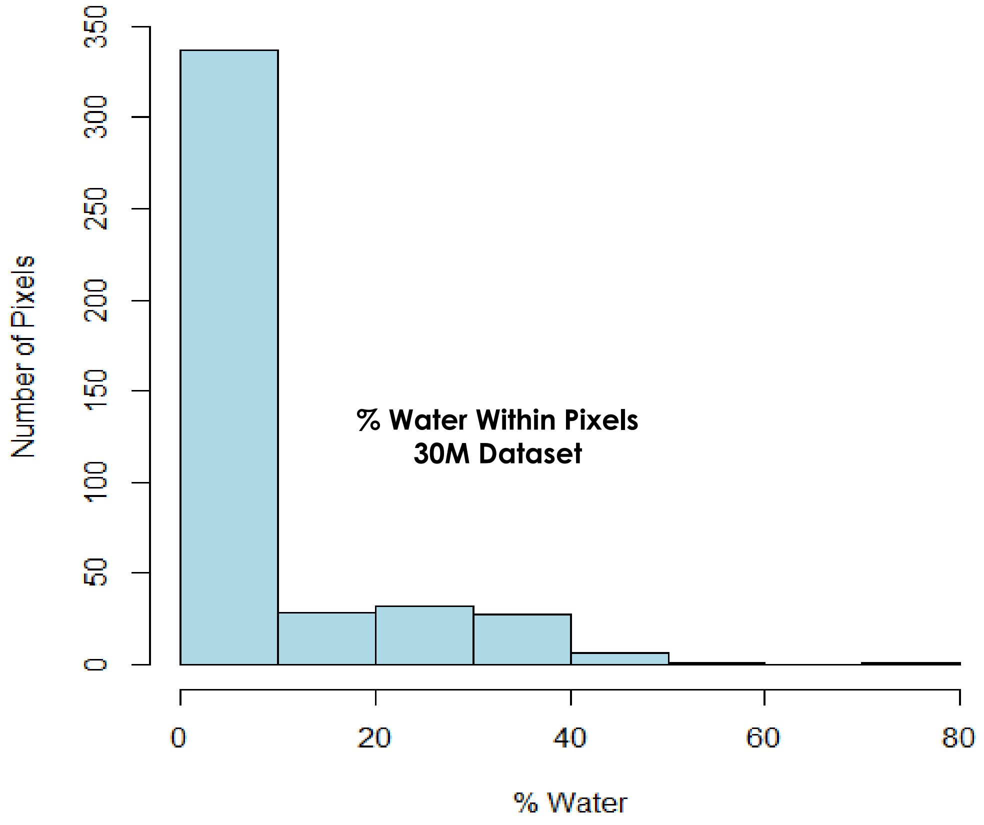
Digital Sampling in Earth Engine

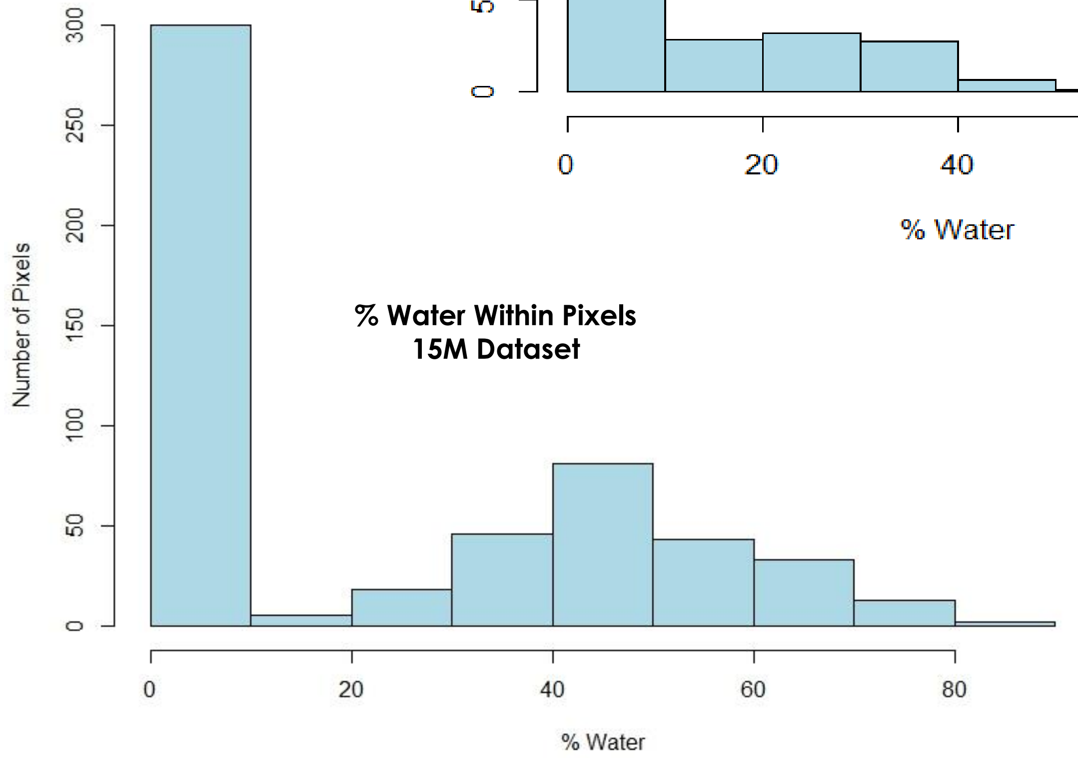


- Two Sampling Efforts
  - 15M Sampling (Panchromatic)
  - 30M sampling
- Used NAIP imagery to create training data
  - 15M: 299 "dry" points, 242 "wet" points
  - 30M: 226 "dry" points, 206 "wet" points
- Sampling criteria: ocularly survey a single Landsat pixel, estimating cover of 5 different land classes:
  - Water
  - Vegetation
  - Bare ground
  - Shadow
  - Other

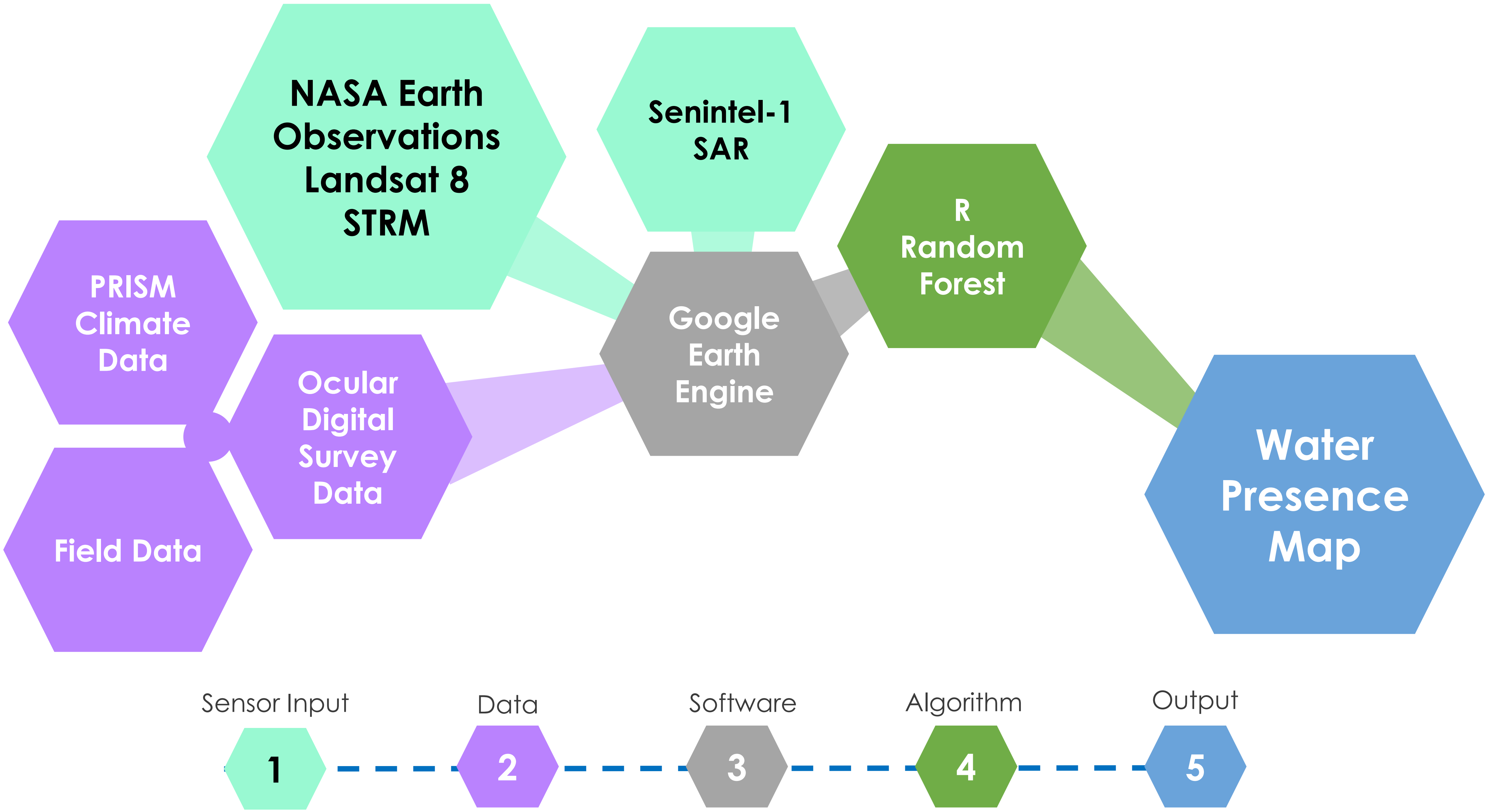
Digital Sampling Effort

- Two Sampling Efforts
- Observed 30M Dataset
  - Highly skewed: few pixels have >40% water
- Observed 15M Dataset
  - Still skewed, but includes more pixels with high percentage of surface water

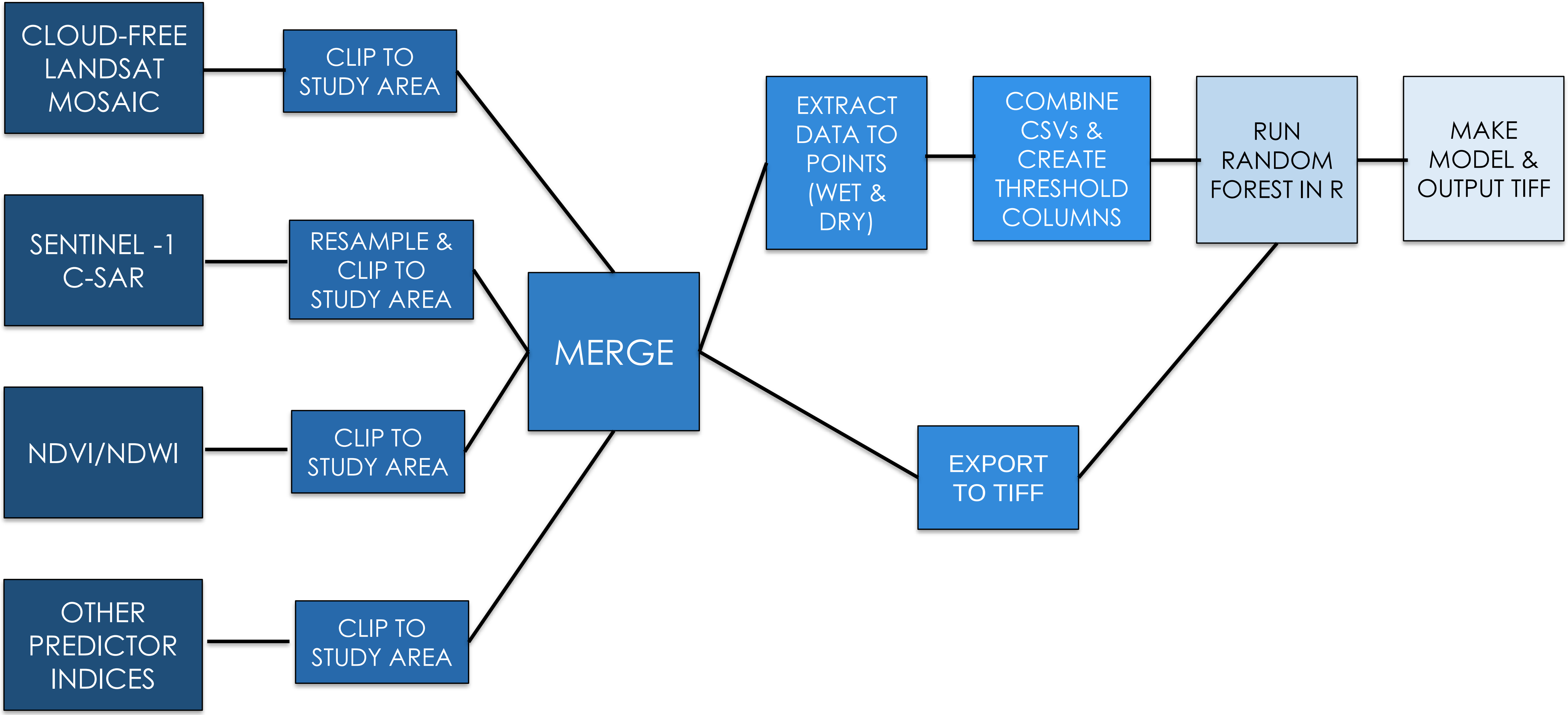




Methodology

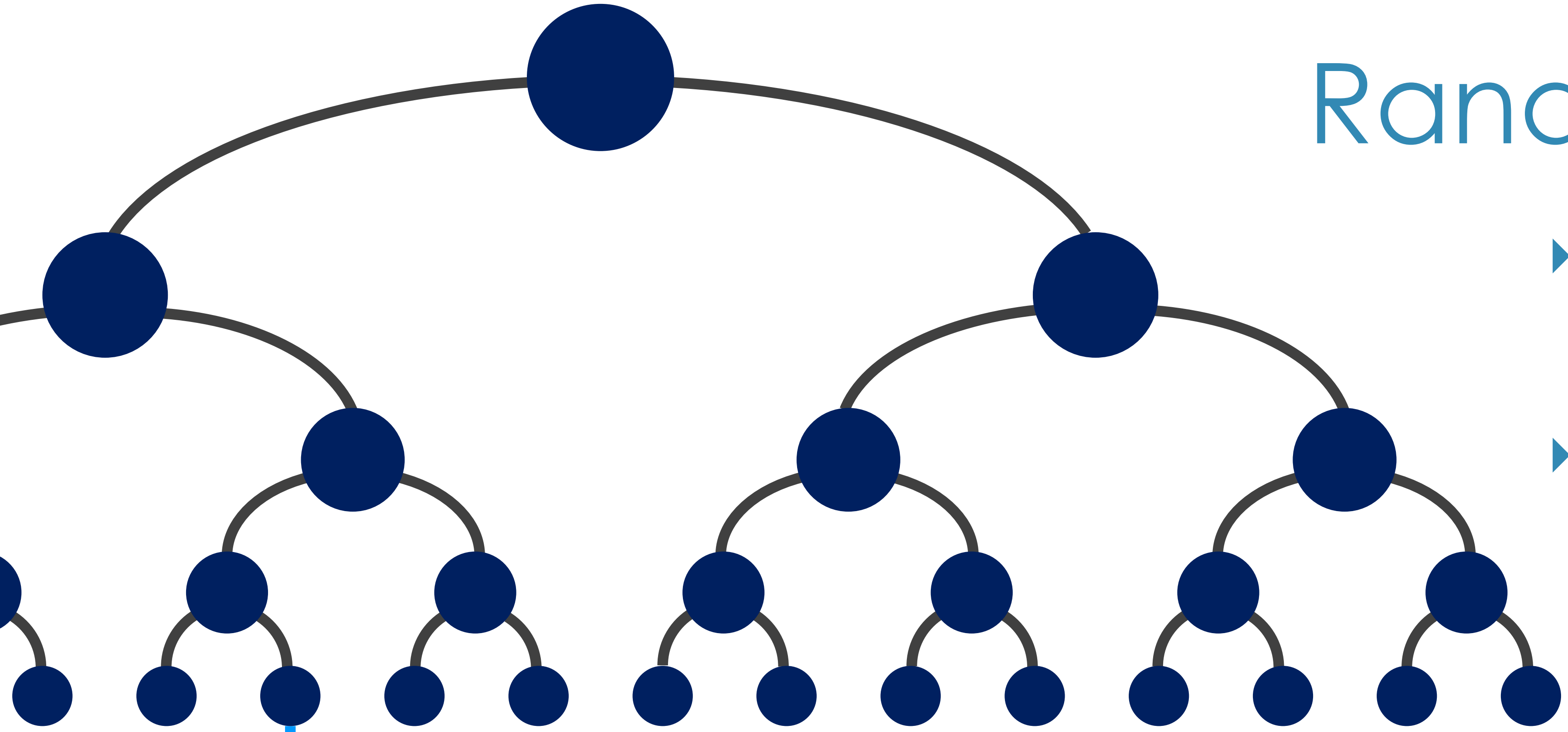


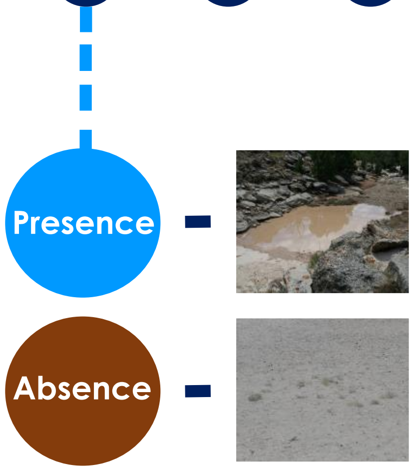
MODELING WORKFLOW



Random Forest

- Process
  - Rank variables using VSURF
  - Covariate correlation plot
- Criteria for Removing Variables
  - Correlated above 0.8
  - Remove least-predictive first



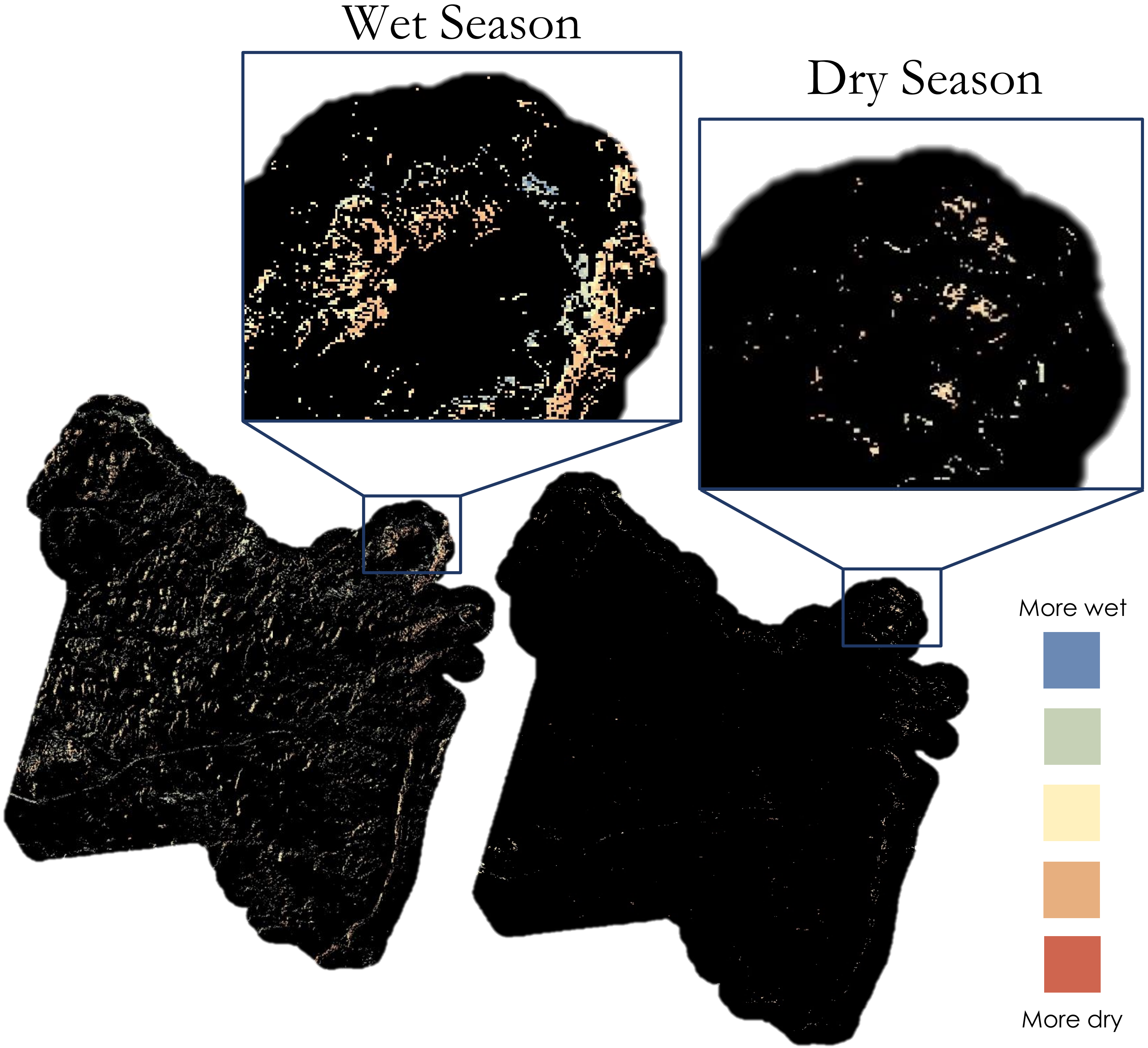


Explanatory Variables			
BLUE	SWIR 1	NBR	Sentinel-1 VV
GREEN	SWIR 2	Tassled Cap B,G,W	Slope
RED	NIR	NDMI	Eastness
PAN	NDVI	GRVI	Northness

Results:

Landsat 30m Model

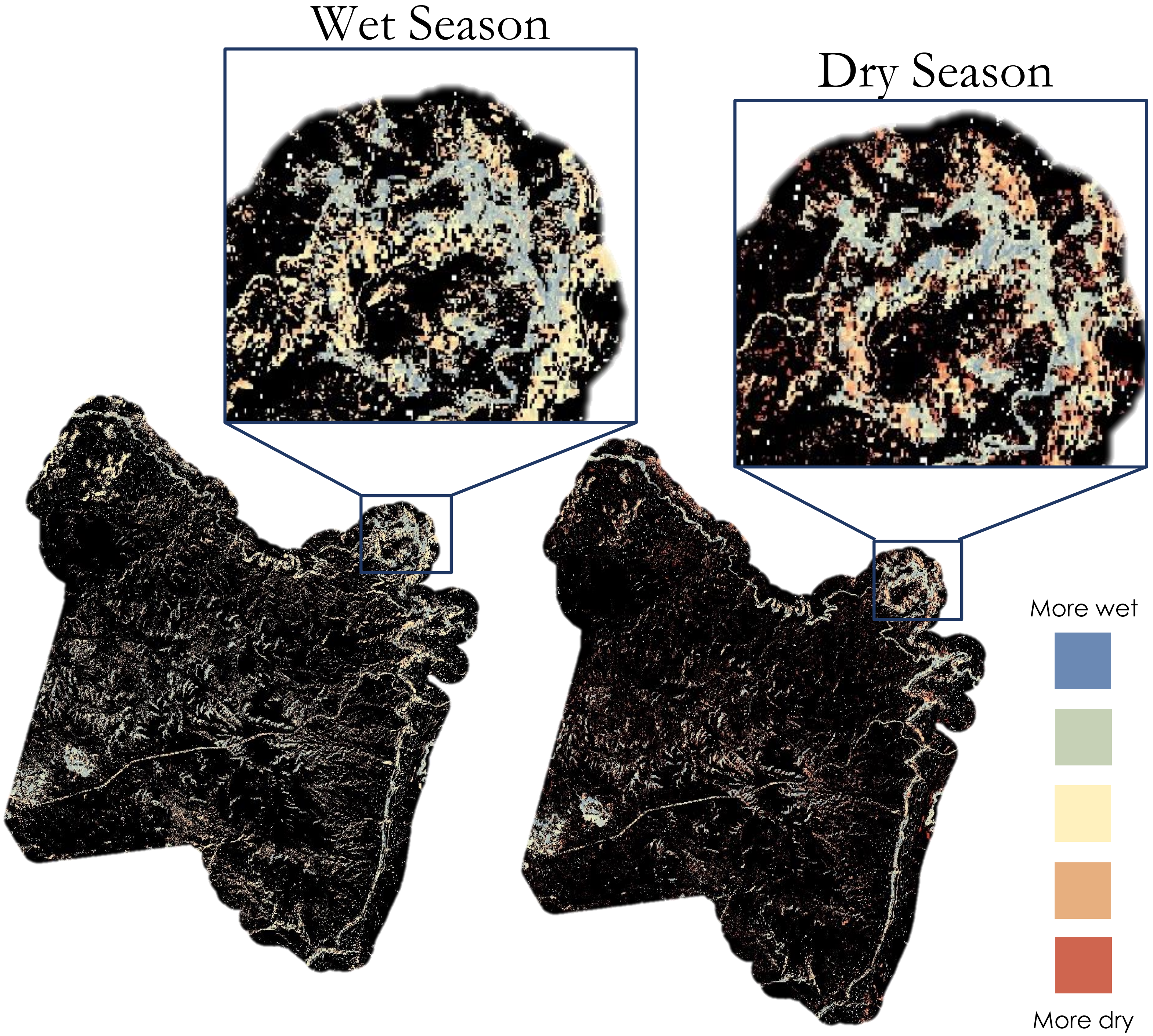
- Two Step Classification models
- Evaluation Metrics
  - Kappa: 0.3284
  - AUC: 0.6347
  - Model Accuracy: 90.7407%
  - Users Accuracy: 30.0%
  - Producer's Accuracy: 50.0%
  - Specificity: 0.3
  - Sensitivity: 0.9694



Results:

Landsat 15m Panchromatic Model

- Two Step Classification models
- Evaluation Metrics
  - Kappa: 0.8803
  - AUC: 0.7655
  - Model Accuracy: 94.0850%
  - User's Accuracy: 94.5%
  - Producer's Accuracy: 92.2%
  - Specificity: 0.9454
  - Sensitivity: 0.9373



Conclusions

- Panchromatic model:
  - Higher Resolution
  - Improved training effort
  - Provided markedly improved reflectance models
  - More accurately displays ephemeral surface water in distinct seasons
- This may be employed to inform habitat selection models

Credit: Anson Call

Errors and Uncertainties

- Potential significant influence of mixed pixel training data set.
  - Miss classified pixels could result in skewed model results.
- NAIP availability resulted in training data sets from the "Dry" season.
  - Model was projected to a typical "Wet" season scene.

Credit: Anson Call

Future Work

- Explore more predictor variables
- Potentially expand the study area to include more HMA's
- Collection of Remote Sensing oriented in-situ data by teams in the field
    - For "Wet" and "Dry" periods
- Sentinel-2 cross sensor implementation for increased resolution
- Focusing on locations with ample LiDAR data may be useful as well

(Credit: Savannah Summersr)

Acknowledgements

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This material contains modified Copernicus Sentinel data (2017), processed by ESA

References

Baig, M. H. A., Zhang, L., Shuai, T., & Tong, Q. (2014). Derivation of a tasselled cap transformation based on Landsat 8 at-satellite reflectance. *Remote Sensing Letters, 5*(5), 423-431. doi:10.1080/2150704x.2014.915434

Breiman, L. (2001). Random forests. *Machine Learning, 45*(1), 5-32. doi:10.1023/a:1010933404324

Brown, B. T., & Johnson, R. R. (1983). The distribution of bedrock depressions (tinajas) as sources of surface water in Organ Pipe Cactus National Monument, Arizona. *Journal of the Arizona-Nevada Academy of Science, 18*(2), 61-68.

Drake, J. C., Jenness, J. S., Calvert, J., & Griffis-Kyle, K. L. (2015). Testing a model for the prediction of isolated waters in the Sonoran Desert. *Journal of Arid Environments, 118*, 1-8. doi:10.1016/j.jaridenv.2015.02.018

European Space Agency. (2013-2017). Sentinel Data, processed by ESA.

Genuer, R., Poggi, J.-M., & Tuleau-Malot, C. (2015). VSURF: An R package for variable selection using random forests. *R Journal, 7(2)*, 19-33.

Jurgens, C. (1997). The modified normalized difference vegetation index (mNDVI) - a new index to determine frost damages in agriculture based on Landsat TM data. *International Journal of Remote Sensing, 18*(17), 3583-3594. doi:10.1080/014311697216810

Ko, B. C., Kim, H. H., & Nam, J. Y. (2015). Classification of potential water bodies using Landsat 8 OLI and a combination of two boosted random forest classifiers. *Sensors, 15*(6), 13763-13777. doi:10.3390/s150613763

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References

NASA Jet Propulsion Laboratory (JPL). (2013-2017). NASA Shuttle Radar Topography Mission Global 1 arc second [Data set]. NASA EOSDIS Land Processes DAAC. doi:10.5067/MEaSUREs/SRTM/SRTMGL1.003

Olthof, I. (2017). Mapping seasonal inundation frequency (1985-2016) along the St-John River, New Brunswick, Canada using the Landsat archive. *Remote Sensing, 9*(2). doi:10.3390/rs9020143

Rotz, J. D., Abaye, A. O., Wynne, R. H., Rayburn, E. B., Scaglia, G., & Phillips, R. D. (2008). Classification of digital photography for measuring productive ground cover. *Rangeland Ecology & Management, 61*(2), 245-248. doi:10.2111/07-011.1

U.S. Geological Survey Earth Resources Observation and Science Center. (2013-2017). Provisional Landsat OLI Surface Reflectance, TOA, 32-day NDVI, and 32-day NDMI. US Geological Survey. https://doi.org/10.5066/F7KD1VZ9

Wild Horse Annie Act - Public Law 86-234 (1959)

Zhou, Y., Dong, J., Xiao, X., Xiao, T., Yang, Z., Zhao, G., . . . Qin, Y. (2017). Open surface water mapping algorithms: a comparison of water-related spectral indices and sensors. *Water, 9*(4). doi:10.3390/w9040256

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