Investigating Physical Changes in Tundra Lakes and Ponds in Alaska's Yukon-Kuskokwim Delta Using Remote Sensing and Stable Isotopes

Jordan A. Jimmie[1], Kelly Turner[2], Paul J. Mann[2], John D. Schade[3], Susan M. Natali[3], and Greg Fiske[3]

[1]University of Montana, Missoula, MT USA; [2]Northumbria University, Newcastle-Upon-Tyne, United Kingdom; [3]Woods Hole Research Center, Falmouth, MA USA

Introduction

Surface air temperatures in the Arctic have been increasing at approximately twice the global average, contributing to myriad changes including groundwater hydrology[1]. Wildfire frequency and intensity have also been increasing. During summer 2015, more area burned in the Yukon-Kuskokwim (Y-K) Delta than in the previous 74 years combined (Fig. 1).

Our project investigates if water bodies within burned and unburned sites across the Y-K delta receive different source waters and if they have difference levels of susceptibilities to drying.

Study Site

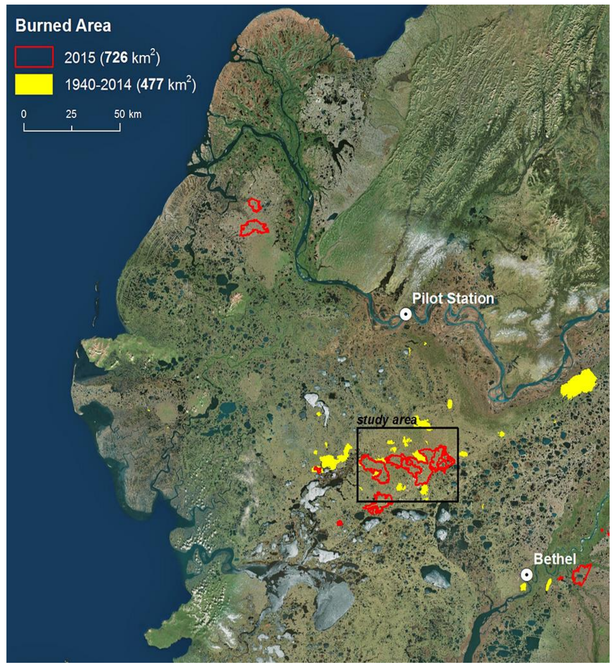

Figure 1. Satellite image of the Y-K Delta showing the study region and locations of 2015 and historical fires.

Approach

- 278 water bodies sampled during June and September 2016, July 2017, and July 2018 (Table 1).
- Water isotope ratios of waters from these water bodies were measured (LGR IWA-45EP), and evaporation/inflow ratios were calculated using HydroCalculator Software[2,3].
- Google Earth Engine (i.e. Water Occurrence Change Intensity[4] data layer), and GIS techniques were used to extract water surface area, changes in water occurrence/presence (extent) and elevation[5].

Results: Source Water Determination

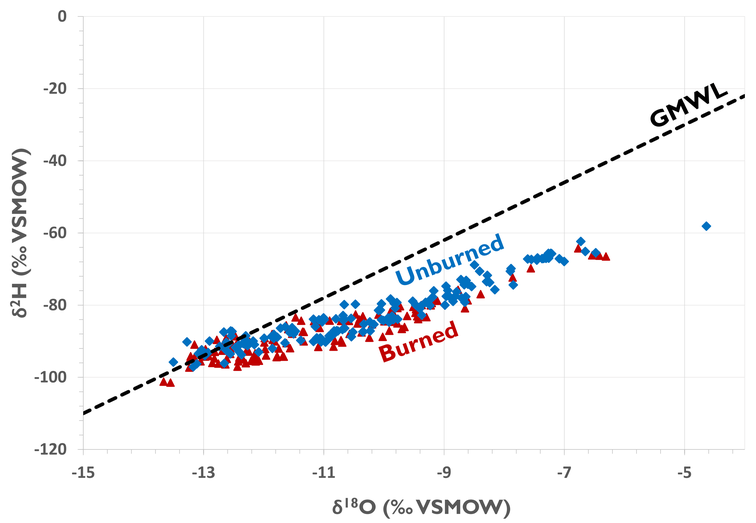

Figure 2. Burned (blue diamonds) and unburned (red triangles) water body isotope ratios shown with the Global Meteoric Water Line (GMWL)

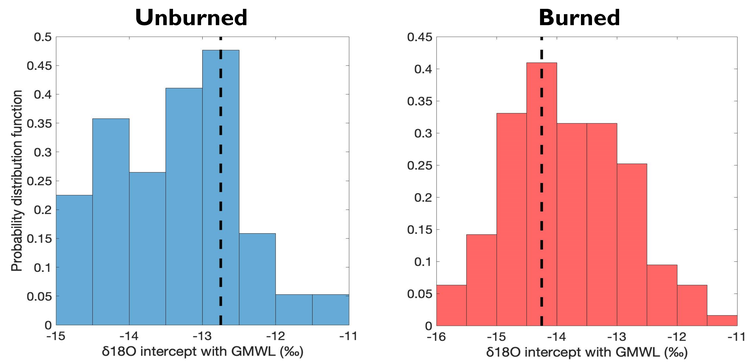

Figure 3. Probability distribution function for unburned and burned samples showing where water samples intercepted with GMWL using an assumed LEL ratio of 5 for each sample[6].

Results: Satellite Remote Sensing

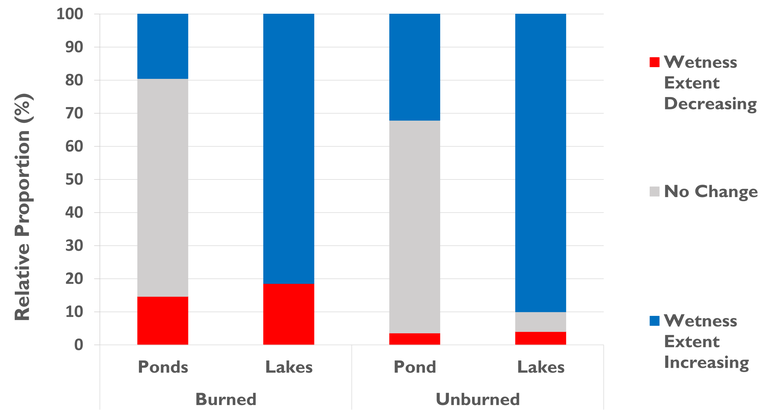

Figure 4. Relative change in water extent for burned and unburned lakes and ponds. More burned water bodies experienced drying. Results show how surface water has changed between two epochs: 1984-1999 and 2000-2015. Average changes were taken across homologous pairs of months from each epoch[4].

Results: Evaporation to Inflow (E/I) Estimates

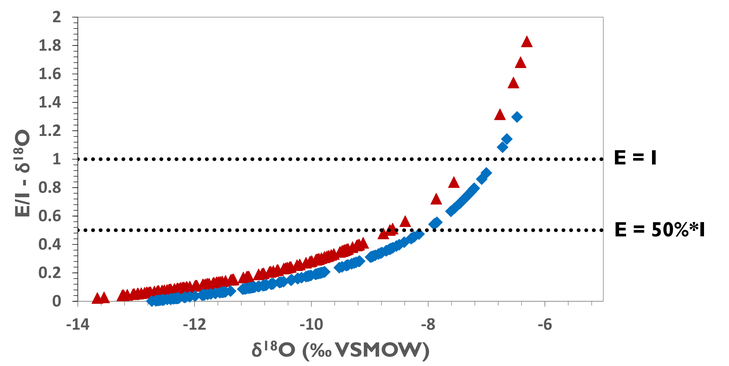

Figure 5. Populations of all burned and unburned surface water bodies with E/I>0.5 and 1, indicating when evaporative losses are greater than 50% and 100% of inflow, respectively.

	Ponds	Lakes	Fens	Streams	Rivers	Total
Unburned	50	65	18	16	2	151
2015 Burned	40	30	30	17	0	117
1972 Burned	0	10	0	0	0	10
Total	90	105	48	33	2	278

Table 1. Sample distribution for lakes, ponds, fens, streams, and rivers in burned and unburned locations.

Conclusions

- Burned water bodies receive source waters with different characteristics to unburned water bodies.
- Burned ponds and lakes experienced greater amounts of drying than unburned.
- Burned water bodies exhibited higher overall E/I ratios (red) and highest values (~1.8), indicating greater evaporation, or changes to hydrological flow-paths (i.e. infiltration) causing faster water loss.
- Future work includes:
  - Linking satellite-derived change with E/I and residence time estimates.
  - Determine differences in hydrology, surface area loss and E/I of 2015 and 1972 burned water bodies.

References

(1) Richter-Menge, J., Overland, J.E., Mathis, J.T., & Osborne, E., (2017). Arctic Report Card 2017, http://www.arctic.noaa.gov/Report-Card.
(2) Brooks, J. R., Gibson, J. J., Birks, S. J., Weber, M. H., Rodecap, K. D., & Stoddard, J. L. (2014). Stable isotope estimates of evaporation : inflow and water residence time for lakes across the United States as a tool for national lake water quality assessments. *Limnology and Oceanography*, *59*(6), 2150-2165. doi:10.4319/lo.2014.59.6.2150
(3) Skrzypek G, Mydłowski A, Dogramaci S, Hedley P, Gibson JJ, Grierson PF. (2015). Estimation of evaporative loss based on the stable isotope composition of water using Hydrocalculator. Journal of Hydrology 523, 781–789.
(4) Pekel, J., Cottam, A., Gorelick, N., & Belward, A. S. (2016). High-resolution mapping of global surface water and its long-term changes. *Nature, 540*(7633), 418-422. doi:10.1038/nature20584
(5) Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*.
(6) Anderson, L., Birks, J., Rover, J., & Guldager, N. (2013). Controls on recent Alaskan lake changes identified from water isotopes and remote sensing. *Geophysical Research Letters, 40*(13), 3413-3418. doi:10.1002/grl.50672

Acknowledgements

This work was funded by NSF as part of the Polaris Project (thepolarisproject.org; NSF-1624927). Thanks to the entire 2018 Polaris Project team for their support.