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Mapping Arctic Water Tracks

One of the projects we are working on in Professor Marisa Palucis's lab is understanding the effects of warming global temperatures on Arctic landscapes and geological systems. This includes diving deeper into the science of more fine-scale landscape processes, and tying them into our larger picture. Water tracks are small curvilinear streams of water, running parallely in groups off of hillslopes, as opposed to typical rivers that are meandering or braided. Water tracks typically stem from the snow melt of snowdrifts. These features are defined by subtle topographic lows, differences in soil chemistry and color, and slight contrasts in the phenology of the surrounding vegetation. In satellite imagery, water tracks appear to have relatively darker soil and greener vegetation from earlier budding due to the added moisture. The water tracks' small size makes them difficult to distinguish and map, often leaving them left out of climate research considerations. Both a database of mapped water tracks, and an understanding of the common characteristics and geological consequences of water tracks, would allow us to incorporate this important, overlooked Arctic feature into research on water runoff dynamics. "Computer vision" has been successfully applied to automated detection of thermokarst and polygonal ground, and water tracks have been remotely sensed and categorized in the past, but no similar effort exists to automate the mapping of water tracks as flow networks.

The goal of our work is to automate the identification and extraction of flowpaths in the Arctic to better understand their role in thawing permafrost landscapes. This first consisted of making "training data" this summer by manually tracing water tracks over satellite imagery of permafrost landscapes, namely in Alaska, Russia, Northern Canada. I used Planet's high resolution satellite imagery archive to pick the best scenes, filtering by metrics such as date, cloud coverage, and image resolution. I then cut these scenes into tiles and reformatted them with python scripts in the Research Computing Servers. Using Doodler, an open-source Python software for labeling and segmenting imagery, I created classes by which to label my images and "doodled" out the water tracks. Doodler then took my doodles and segmented the rest of the image with pattern recognition. This whole process involved a lot of trial and error- I learned how to properly set Planet's filters to get clear images with good vegetation contrast in order to make my doodling process more straightforward. Additionally, I learned how to properly distinguish water tracks in the imagery, and I learned the nuances of Doodler and how to get the best segmented results from its pattern recognition and computer independence. The next step in the work, which I propose to do as a Neukom Scholar, is to use my training data from the summer to train a machine learning tool to map water tracks automatically. I will implement Doodler's companion, Segmentation Gym, an open-source software tool for training convolutional neural networks for image segmentation. I also plan to optimize my process of imagery sourcing by adding bands to my current RGB imagery, in the ultimate goal of teaching the AI to look for more characteristics of water tracks besides visual appearance, like moisture content and vegetation index. With an AI that can identify water tracks, researchers can do observational experiments on how water track location, size, and density are affected by increased permafrost thaw and changes water runoff levels and chemistry.