Hydro temporal variability – summary

ABMI Geospatial Centre

December, 2017

Introduction

Surface water can vary on time scales from hourly to seasonally to decadally. Monitoring changes in surface water resources is important in Alberta, as it appears the Prairie Provinces may be heading towards a future water crisis (Schindler and Donahue, 2006). Some monitoring of surface water fluctuation is done by the National Hydrological Service (Environment and Climate Change Canada, 2015), however the program cannot possibly cover all waterbodies in Alberta. The main source of surface water information comes from the GoA hydropolys. This dataset provides great spatial coverage of Alberta's waterbodies but are limited to a certain point in time. Consistent, repeated satellite data collection may be the best way to achieve large spatial coverage and frequent (weekly) monitoring for surface water. The best data for this is Synthetic Aperture Radar (SAR) data as it is capable of detecting standing water (Malenovsky *et al.,* 2012; Brisco, 2015) at all times and all weather conditions (day, night, cloud, sun, rain). Sentinel-1 data (Copernicus [2014, 2015, 2016, 2017]) is a great source for this application as it has 10m resolution, minimum 6-day revisit time, and is freely available.

This project set out to achieve the following goals:

1. Develop a methodology to monitor waterbody fluctuation across the province of Alberta using open source data
2. Produce a yearly Alberta wide data set which summarizes waterbody variability

Methods

The methods for the production of the Hydro temporal variability (HTV) layer follow the methods seen in DeLancey *et al.,* (2018). This methodology was implemented in Google Earth Engine (Google Earth Engine Team, 2015) as it allows for easy access to Sentinel-1 data and uses cloud computing which allows for quick processing of hundreds of billions of pixels.

To generate the HTV layer, all Sentinel-1 images intersecting the province of Alberta during April-October were gathered. In each image a simple threshold was applied which divided the image into water (1) and non-water (0) pixels. If a pixel had a wind speed of over 9 km/h on the day of acquisition, that pixel was removed from the HTV algorithm (modeled wind speed was taken from the NCEP Climate Forecast System Version 2 (Saha *et al.*, 2014)). This was done since wind induced waves often cause confusion between water and land signatures in SAR data. Once this was done the HTV value was calculated for each pixel. The HTV value represents the percent of time a 10m pixel is seen as water. This is calculated by dividing the total number of times water was identified in the pixel stack by the total pixel stack (see Figure 1).

Once the layer is generated, masks were applied to the layer to remove some "false water" pixels. Areas with known agriculture or roads (ABMI, 2017) were assigned a HTV value of 0. Areas with slope greater than 15˚ (USGS, 2006) were assigned a value of 0 and areas in the south with grassland habitat were assigned a value of 0 (Alberta Environment and Parks, 2011).

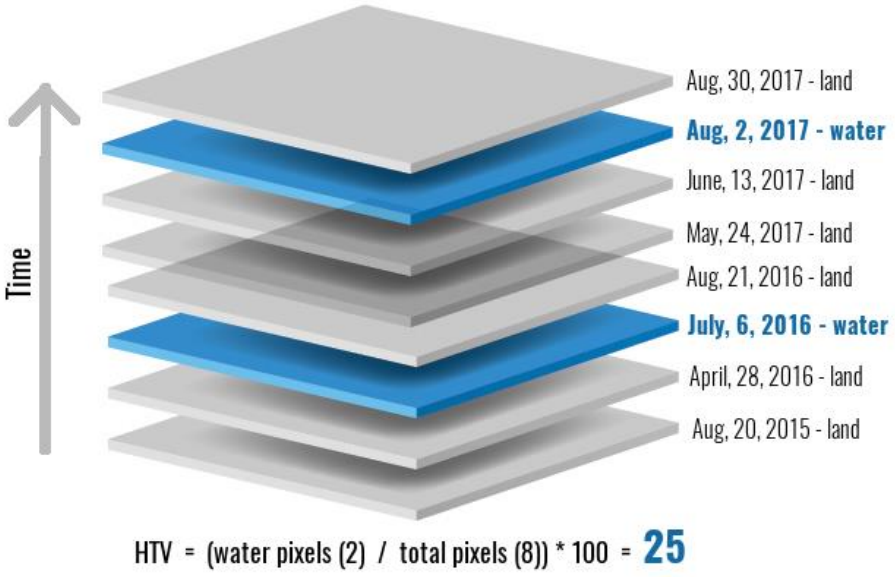

Figure 1: Visual representation of a Sentinel-1 pixel stack showing changing water/land pixels through time. The HTV calculation for this given example is shown at the bottom.

Results

Figure 2 shows the HTV algorithm applied across the landscape. This product uses a total of 125 billion pixels in the calculation (temporal pixel stack x number of 10m pixels in Alberta). For each Sentinel-1 image the expected water classification accuracy is 90-95%. The accuracy is seen to be lower in the grassland regions on Alberta and higher in the forested regions. Overall, this data set can be used to identify permanent and recurring lakes as well as the dynamic/fluctuating regions in lakes.

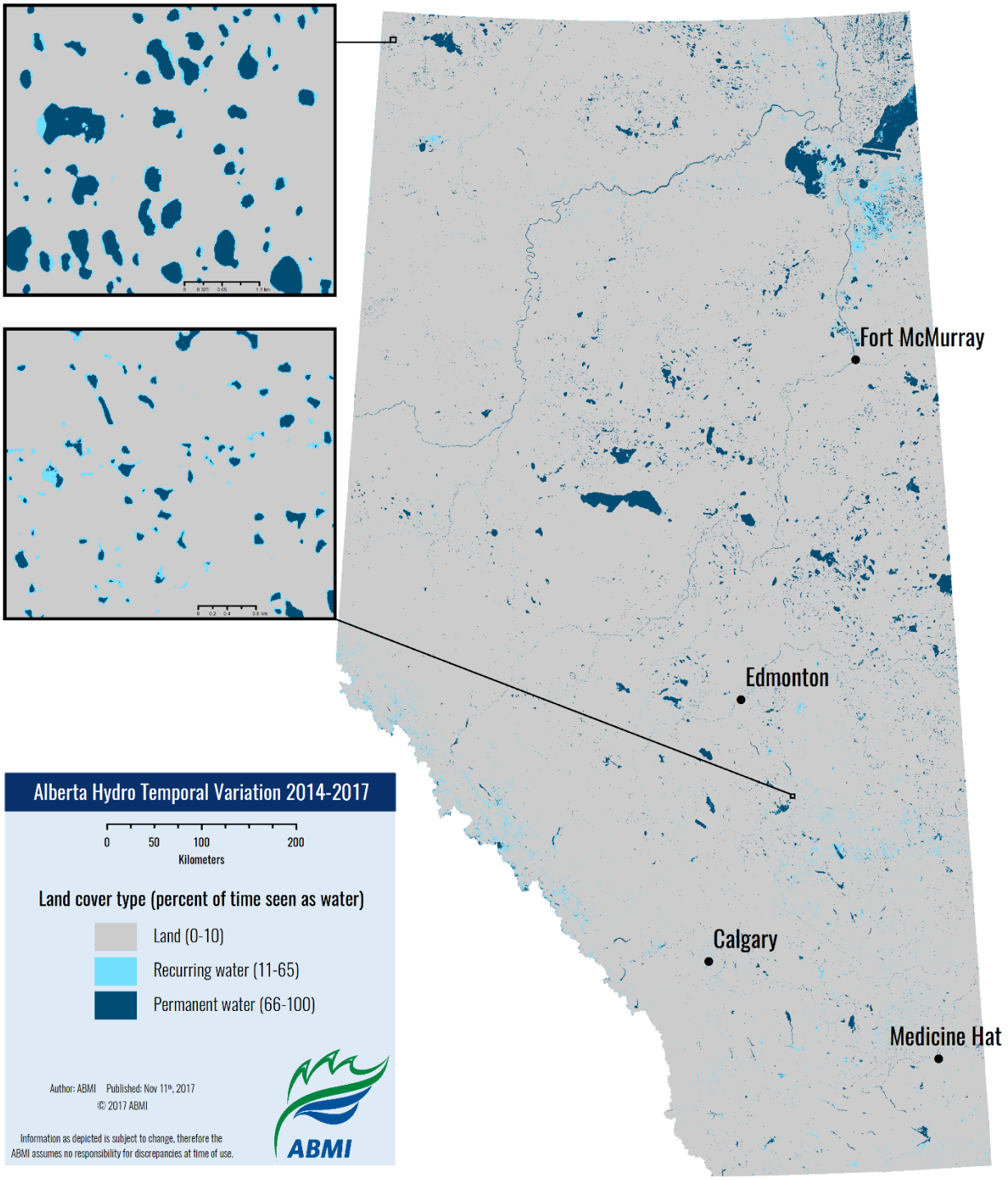

Figure 2: HTV for all of Alberta between 2014 and 2017. HTV values are represented as three classes: Land (HTV values 0-10) – where water is never or rarely seen, Recurring water (11-65) - lakes which are seasonal or the area of lake level fluctuation around a permanent water body, and Permanent water (66- 100) - areas with consistent water. Inset areas provide more detail to show the dynamic regions around permanent lakes.

Strengths

1. The HTV data set provides Alberta wide data on surface water variability.
2. Due to the use of Google Earth Engine cloud computing, this product can be generated in a matter of days.
3. The processing environment and satellite data is open source.
4. The data set is able to differentiate permanent and recurring lakes (see DeLancey *et al.,* (2018)).
5. Given proper weather conditions, this method is able to monitor weekly changes to surface water across the entirety of Alberta. This could eventually lead to the production of dynamic surface water maps which can be updated weekly.

Limitations

1. Using the simple threshold method only provides about 90-95% accuracy for classifying water/land.
2. Low biomass grassland regions are often confused with water in Sentinel-1 imagery. This causes many “false water” pixels in southeast Alberta.
3. Wet snow can often be confused with water in Sentinel-1 imagery. These “false water” pixels can be seen in the Rocky Mountains in the HTV layer.
4. Modeled wind data used to filter out windy days only removes potentially windy days. It does not necessarily reflect the wind at the exact time of acquisition.

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