Hydro Temporal Variability version 1

"HTV_v1.tif"

Alberta Biodiversity Monitoring Institute

Geospatial Centre

May 2017

Contents

1. Overview

1.1 Summary

This Hydro Temporal Variability (HTV) dataset represents a summary of variability in surface water extent in Alberta during the 2014-2016 time period. The layer values demonstrate the percent of time a given pixel was identified as water. It is intended to support monitoring of lake level fluctuations and identify recurring and permanent lakes in Alberta. This dataset represents a proof of concept for the methodology. Version 2 and beyond should have more accurate data as more data becomes available. Full details for this dataset can be seen in the publication DeLancey *et al.* (2017) in progress.

1.2 Description

This layer is calculated with Sentinel-1 C-band Synthetic Aperture Radar (SAR) from the Copernicus Program (Copernicus Sentinel data [2014, 2015, 2016]). The algorithm was developed and implemented in Google Earth Engine (Google Earth Engine Team, 2015). Sentinel-1 data became available in 2014 and therefore this dataset shows surface water fluctuations during 2014-2016 in ice free months (April-October). Sentinel-1 orbital path covers the entirety of Alberta and therefore each 10m pixel in Alberta has a value.

1.3 Credits

This dataset was developed and generated by the ABMI's Geospatial Centre Research Team with help from Brian Brisco at the Canadian Centre for Mapping and Earth Observation.

1.4 Citation

This product should be cited as:

Alberta Biodiversity Monitoring Institute Geospatial Centre. 2017. "Hydro Temporal Variability version 1." Edmonton, Alberta.

1.5 Contact Information

If you have questions or concerns about the data, please contact:

Geospatial Centre
Alberta Biodiversity Monitoring Institute
CW 405 Biological Sciences Centre
University of Alberta Edmonton, Alberta, Canada, T6G 2E9
Email: abmigc@ualberta.ca

1.6 Keywords

Alberta, geospatial, remote sensing, temporal, synthetic aperture radar, surface water, lakes, rivers, hydro-period, variability, wetlands, Sentinel-1.

2. Use Limitations

The HTV dataset is based on freely available open source Sentinel-1 data. This data may freely be used if cited properly. Version 1 of the HTV layer may be limited in data coverage for the 2014-2016 time period and thus some areas of Alberta may not have accurate data, such as Lake Athabasca and surrounding areas (see Figure 2 for areas with limited data).

2.1 Open Sourced Data

This dataset contains data originating from open sources, which has subsequently been enhanced through computer processing (the "Open Sourced Data"). The Open Sourced Data may be reproduced in

whole or in part and in any form for educational, data collection or non-profit purposes without special permission from The Alberta Biodiversity Monitoring Institute ("ABMI") provided acknowledgement of the source is made. No use of the Open Sourced Data may be made for resale without prior permission in writing from the ABMI.
By accessing the Open Sourced Data, you agree to indemnify and hold harmless the ABMI and the ABMI's subsidiaries, affiliates, related parties, officers, directors, employees, agents, independent contractors, advertisers, partners, co-branders, and Open Sourced Data sources from any and all actions, proceedings, claims, demands, liabilities, losses, damages, and expenses which may be brought against or suffered by the ABMI or which it may sustain, pay or incur, arising or resulting from your violation of this clause.
The Open Sourced Data is provided on an "As Is" and "As Available" basis and the ABMI does not guarantee that the Open Sourced Data will be suitable for your purposes or requirements. The ABMI further states that the Open Sourced Data is subject to change, and the ABMI gives no guarantee that the content is complete, accurate, error or virus free, or up to date. The ABMI disclaims all warranties, conditions, and other terms of any kind, whether express or implied, whether in contract, tort (including liability for negligence) or otherwise, including, but not limited to any implied term of satisfactory quality, fitness for a particular purpose, and any standard of reasonable care and skill.

2.2 Exclusive ABMI Sourced Data

This dataset contains data created by The Alberta Biodiversity Monitoring Institute ("ABMI") through computer processing (the "ABMI Sourced Data"). The ABMI Sourced Data may be reproduced in whole or in part and in any form for educational, data collection or non-profit purposes without special permission from the ABMI provided acknowledgement of the source is made. No use of the ABMI Sourced Data may be made for resale without prior permission in writing from the ABMI.
By accessing the ABMI Sourced Data, you agree to indemnify and hold harmless the ABMI and the ABMI's subsidiaries, affiliates, related parties, officers, directors, employees, agents, independent contractors, advertisers, partners, and co-branders, from any and all actions, proceedings, claims, demands, liabilities, losses, damages, and expenses which may be brought against or suffered by the ABMI or which it may sustain, pay or incur, arising or resulting from your violation of this clause.
The ABMI Sourced Data is provided on an "As Is" and "As Available" basis and the ABMI does not guarantee that the ABMI Sourced Data will be suitable for your purposes or requirements. The ABMI further states that the ABMI Sourced Data is subject to change, and the ABMI gives no guarantee that the content is complete, accurate, error or virus free, or up to date. The ABMI disclaims all warranties, conditions, and other terms of any kind, whether express or implied, whether in contract, tort (including liability for negligence) or otherwise, including, but not limited to any implied term of satisfactory quality, fitness for a particular purpose, and any standard of reasonable care and skill.

3. Data Product Specifications

3.1 Spatial resolution

The algorithm was run on original Sentinel-1 spatial resolution of slightly under 10m (smaller in the north and larger in the south). The final product was resampled to a consistent 10m spatial resolution.

3.2 Processing Environment

Google Earth Engine code editor and Microsoft Windows 7 Version 6.1 (Build 7601) Service Pack 1; Esri ArcGIS 10.3.0.4322.

3.3 Extents

West: -120.90˚
East: -108.45˚
North: 60.09˚
South: 48.89˚

3.4 Resource Maintenance

Maintenance will be done annually to include the Sentinel-1 images of the previous year, e.g., the 2017 release represents data from 2014-2016 and the 2018 release will represent data from 2014-2017.

3.5 Spatial Reference

NAD_1983_10TM_AEP_Forest
WKID: 3400 Authority: EPSG
Projection: Transverse Mercator
False Easting: 500000.0
False Northing: 0.0
Central Meridian: -115.0
Scale Factor: 0.9992
Latitude of Origin: 0.0
Linear Unit: Meter (1.0)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
Spheroid: GRS_1980
Semimajor Axis: 6378137.0
Semiminor Axis: 6356752.314140356
Inverse Flattening: 298.257222101

4. Lineage

The HTV dataset was built with and processed with open source data and freely available processing environment. This dataset represents the first attempt at monitoring surface water fluctuation over time. The accuracy of the HTV layers will increase as more Sentinel-1 data becomes available.

5. Methodology

The HTV dataset was calculated with Sentinel-1 C-band SAR (S1) data (Copernicus Sentinel data, 2014, 2015, 2016). All S1 images were gathered and processed in Google Earth Engine (GEE) (Google Earth Engine Team, 2015). The GEE stores S1 ground range detected scenes which have been pre-processed with the Sentinel-1 Toolbox (Sentinel Application Platform – Sentinel 1 Toolbox). These pre-processing steps include thermal noise removal, radiometric calibration, and terrain correction (Google Earth Engine Team, 2015).

To develop V1 of the HTV dataset all S1 images intersecting with Alberta, Canada from April 1st – October 31st for the years 2014 - 2016 were used. Winter months were not included as most lakes in Alberta are frozen from November to March. Additionally, only images with a 10m resolution were used, which resulted in omission of HH or HV polarizations as these images are only available in 40m resolution. All images were collected in VV or VV-VH modes but only the VV polarization was used in this analysis due to the lack of dual polarization images (VV-VH). The VV polarization mode was used for the analysis as it had far more revisits over Alberta when compared to the other polarization modes (VV-VH, HH, HH-HV), however Brisco, 2015 and Bolanos *et al*., 2016 states that the VV polarization is typically the least suitable polarization, although still very useful (Kasischke and Bourgeau-Chavez, 1997) for water detection. This resulted in a temporal pixel stack of anywhere from 1 to 56 values across Alberta. Each image was smoothed using a 3x3 mean filter to remove noise (versions of this seen in Foucher and Lopez-Martinez, 2009 and Liu, 2016).

To calculate HTV, each image was first turned into a binary "water" (1) and "non-water" (0) image. Any pixel below -20, -18.75, -17.5 decibels (dB) for zones 1, 2, 3 respectively was considered water (see Figure 1 for zones). To account for lake waves causing higher backscatter values, any pixel where max wind speed, for the day of acquisition, was above 10, 13, 13 km/h for zone 1, 2, 3 respectively was removed. Daily wind speed data was taken from the NCEP Climate Forecast System Version 2 (Saha, 2014). To account for low backscatter values on the lee side of mountain slopes, all pixels above 2,000m were removed from the analysis using SRTM DEM (USGS, 2006). All pixels overlapping with cultivation (the ABMI Human Footprint Inventory for 2014 conditions, ABMI, 2016) were assigned a value of zero. Finally, all pixels in zone 1 and the Rocky Mountains with a temporal standard deviation of less than three (vegetation) or greater than eight (mountain slopes) were assigned a value of zero. After all the thresholds and decisions, the binary water images were summed to get the number of times each pixel was classified as water. This was then divided by the number of pixels in the total pixel stack, multiplied by 100, and turned into integer format to get the percent of time a pixel was identified as water.

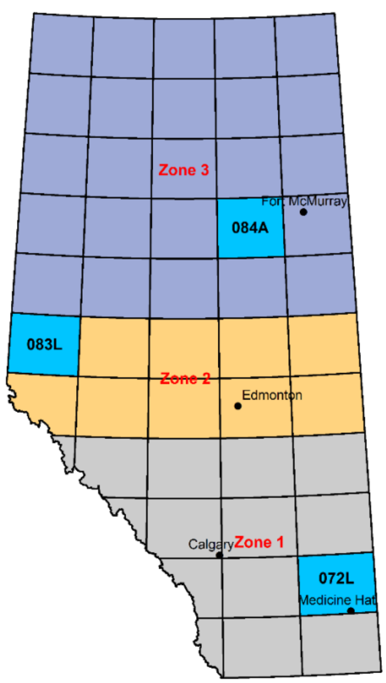

Figure 1: Zones for given thresholding decisions. Blue NTS tiles colours represent original test locations for the algorithm.

Table 1: Summary of chosen water and wind speed thresholds for HTV dataset calculation.

	Water threshold (db)	Wind speed threshold (km/h)	Temporal standard deviation threshold
Zone 1: South of 53˚ N	< -20	< 10	> 3 and < 8
Zone 2: 53˚- 55˚	< -18.75	< 13	NA
Zone 3: North of 55˚	< -17.5	< 13	NA

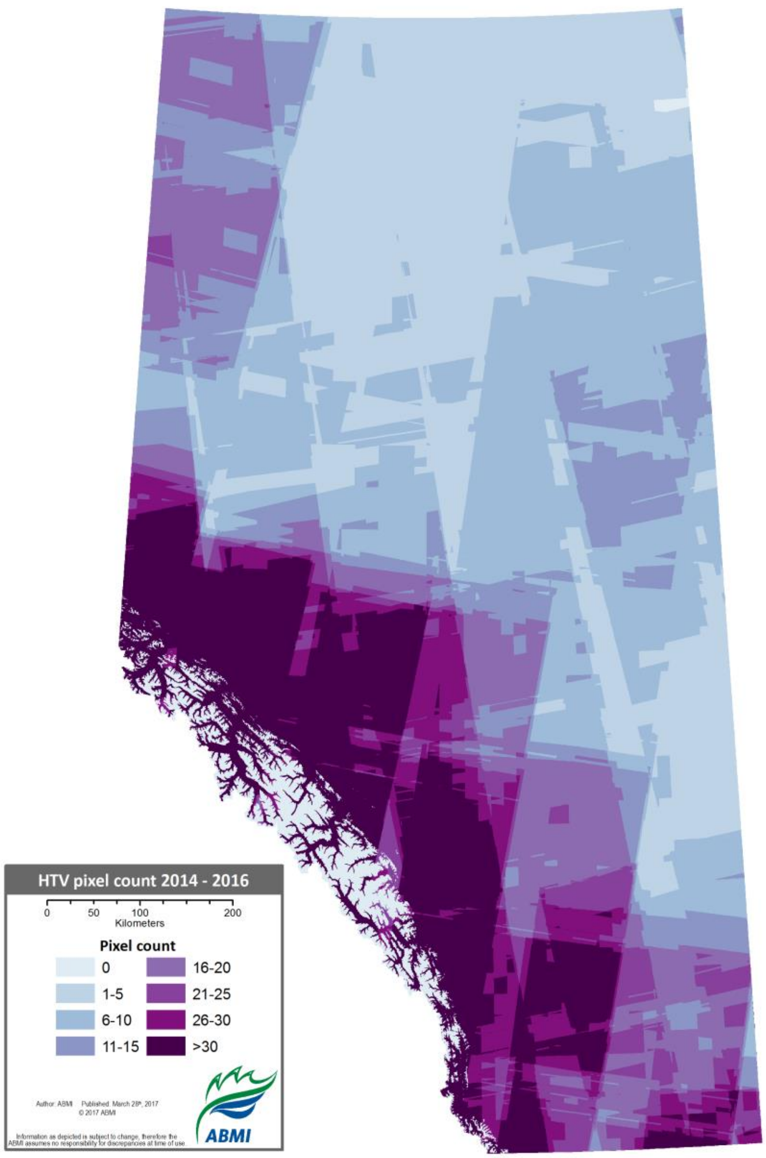

Figure 2: Pixel count of 10m pixels used in the HTV calculation (elevation greater than 2,000 and wind speeds over 10 or 13 km/h removed from calculation).

6. Results

Figure 3 shows the results of the HTV algorithm over all of Alberta. It is able to differentiate recurring versus perennial lakes and also shows lake fluctuations during the 2014-2016 time period. This represents a solid proof of concept for this algorithm and the data will get more accurate as more Sentinel-1 data comes in. The limitations with this data are mainly due to wind causing many large permanent water bodies to appear as land 20-50% of the time. For example, Lake Athabasca and Lesser Slave Lake have HTV values of 30-70 when they should be 100. This can be fixed by lowering the wind threshold but it was not done in this version as lowering the wind threshold would have caused many areas to have a pixel stack of zero. Future versions of this dataset should have a lower wind threshold and thus large permanent lakes should be seen as water 90-100 percent of the time.

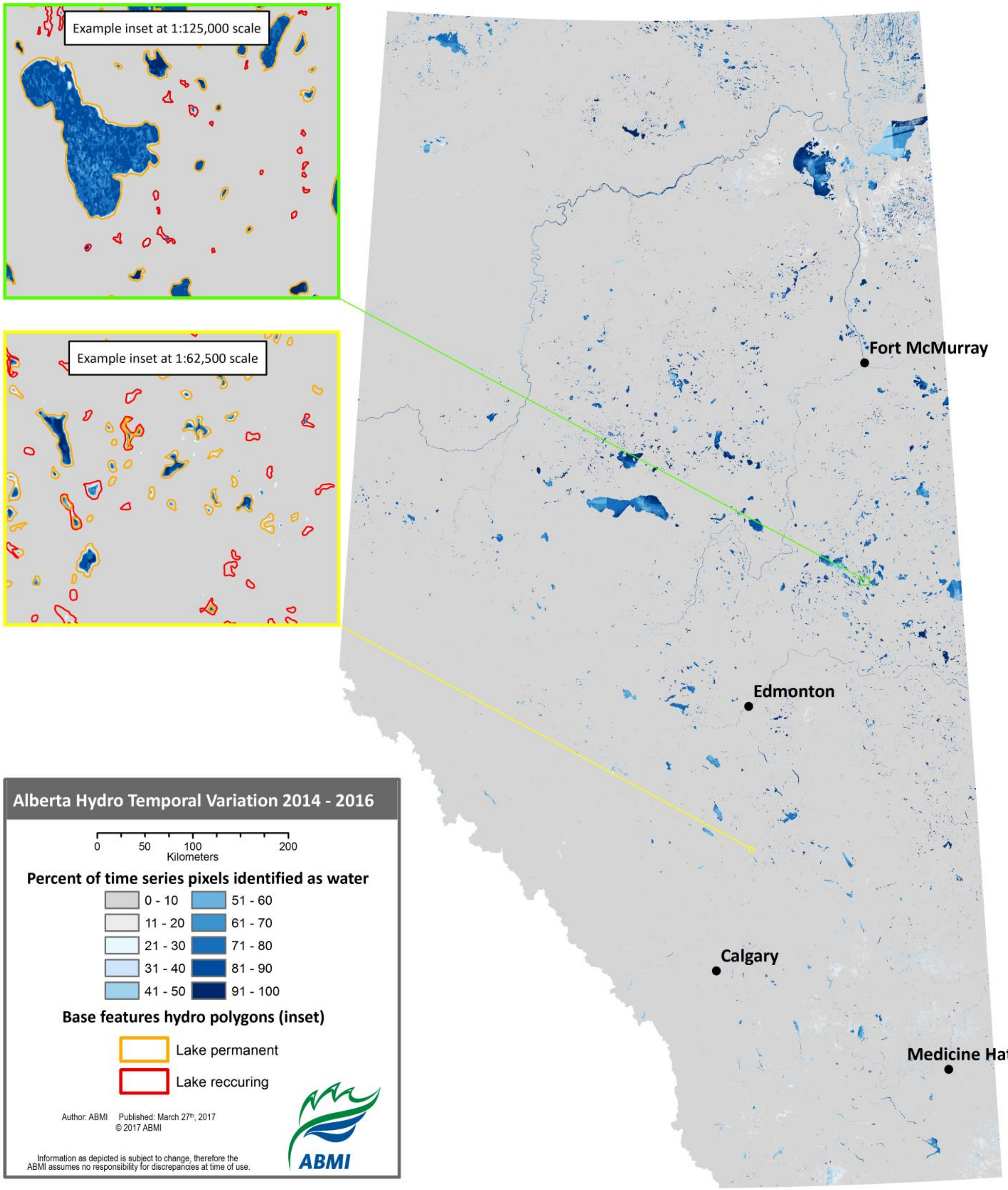

Figure 3: The HTV dataset with insets showing the comparison to the Government of Alberta Base Feature Hydrography Polygons (Alberta Environment and Parks, Government of Alberta 2004).

References

Alberta Biodiversity Monitoring Institute Geospatial Centre. 2017. “Human Footprint Inventory 2014 – Public Version, Version 3.” Edmonton, Alberta.

Alberta Environment and Parks, Government of Alberta. 2004. “Base Water Polygon.” Edmonton, Alberta, Canada

Bolanos, S., Stiff, D., Brisco, B, and Pietroniro, A. 2016. “Operational Surface Water Detection and Monitoring Using Radarsat 2.” *Remote sensing*, Vol. 8(No.4): pp. 285.

Brisco, B. 2015. “Mapping and Monitoring Surface Water and Wetlands with Synthetic Aperture Radar.” In: *Remote Sensing of Wetlands: Applications and Advances*. Bocca Raton, FL, USA. Taylor and Francis Group.

Copernicus Sentinel-1 data [2014, 2015, 2016], European Space Agency.

DeLancey, E.R. Kariyeva, J., Cranston, J., and Brisco, B. 2017. “Monitoring hydro temporal variability in Alberta, Canada with multi- temporal Sentinel-1 SAR data.” *Canadian Journal of Remote Sensing*. In progress.

Foucher, S., and Lopex-Martinez. 2009. “An evaluation of PolSAR speckle filters.” *Geoscience and remote Sensing Symposium*, 2009 IEEE International, IGARSS 2009.

Google Earth Engine Team. 2015. “Google Earth Engine: A planetary-scale geospatial analysis platform.” https://eathengine.google.com.

Kasichke, E.S., and Bourgeau-Chavex, L.L. 1997. “Monitoring South Florida Wetlands Using ERS-1 SAR Imagery.” *Photogrammetry Engineering and Remote Sensing*, Vol. 63(No.3): pp. 281-291.

Li, J., and Wang, S. 2015. “An automated method for mapping inland surface waterbodies with Radarsat-2 imagery.” *International Journal of Remote Sensing*, Vol. 36: pp. 1367–1384.

Saha, S., Moorthi, S., Wu, X., Wang, J., Nagdiga, S., Tripp, P., Behringer, D., Chuang, H-Y., Iredell, M., Ek, M., Yang, R., Mendez, M.P., Dool, H.v.d., Zhang, Q., Wang, W., Chen, M., and Becker, E. 2014. “The NCEP Climate Forecast System Version 2.” *Journal of Climate*, Vol. 27: pp. 2185-2208.

USGS. 2006. Shuttle Radar Topography Mission. Global Land Cover Facility, University of Maryland.