Natural Resources Canada | Ressources naturelles Canada

Monitoring open fresh water in northern environments, using SAR imagery and FnFCE

N. Short, B. Brisco, R. Landry, D. Raymond, and J. van der Sanden
Canada Centre for Remote Sensing

Introduction

Fresh water is tied to every aspect of the lives of Canadians and is an essential part of the natural environment. However, available fresh water resources are under increased pressure from a wide range of anthropogenic activities and subject to the effects of climate change in ways that are not yet fully understood. A large proportion of the world's fresh water resources is found in areas that are remote and logistically difficult to monitor. Satellite radar data have the advantage of being independent of cloud cover, and therefore provide a relatively reliable data stream.

Researchers at the Canada Centre for Remote Sensing are working on a tool for the automated extraction of water body outlines from radar imagery. This tool quickly generates GIS-ready water polygons that can be used by water resource managers such as those with Parks Canada and Environment Canada. Currently the tool is called FnFCE (Forest non-Forest Class Extraction). The name comes from its origins as a forestry application.

FnFCE description

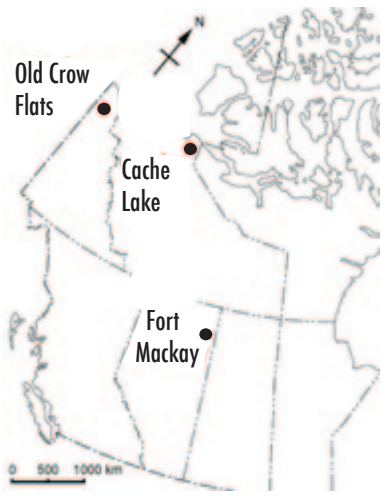
- Initially a forestry application developed by CCRS, FnFCE was later modified to include a flood mapping capability.
- This software combines image processing and geospatial operators to extract water extent polygons from RADARSAT-1 imagery.
- FnFCE operates as a menu system from the Arc/Info environment.
- Water polygons can be generated from a RADARSAT-1 image product in about one hour. Geo-referencing is separate and takes additional time.
- Quantitative, statistical approach means reproducible results.
- FnFCE is most suitable for flat areas because terrain shadows would be misclassified as water, although area masks can be applied.
- A minimum water polygon size of one hectare is necessary to maintain the performance of the software and the plausibility of results.
- Water roughened by strong winds or rapids is not distinguishable from land.

FnFCE method

1. Reads a RADARSAT-1 image product and checks the ancillary data record to determine the incidence angle range of the image.
2. Uses a water model to predict the likely backscatter value for water in a C-band HH radar image with these incidence angles – this is the "water seed."
3. Statistically analyses a histogram of image backscatter values around the water seed, looking for a trough in the frequency.
4. The lowest point of the trough becomes the water threshold value.
5. All pixels with backscatter values below the water threshold are classified as water (Lo), all others are land (Hi).
6. Uses geospatial operators and topological rules to extract vectors around groups of water pixels from the classified image.
7. Resulting water polygons exported as ArcGIS interchange. format E00.

Conclusions

1. When the water surface is not significantly roughened by wind, FnFCE efficiently delivers outlines of medium to large water bodies.
2. Polygons clearly document the progression of seasonal and inter-annual surface water availability.
3. Due to polygon size restrictions, analysis and comparisons with other data sources must be done at the appropriate scale.
4. Qualitative analysis can be done at the scene scale, but quantitative analysis should be done on each specific water body.
5. FnFCE is a quick and efficient method.

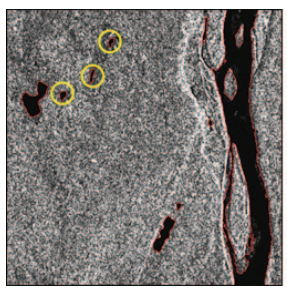


FnFCE has been used successfully in several flood situations, we decided to investigate its performance for routine monitoring of surface water in northern environments.

Site	Environment	Investigations
Fort MacKay, AB	Oil sands area	Inter and Intra – annual fluctuations in water levels
Cache Lake, NT	Tuktut Nogait National Park	Water availa-bility for ecology
Old Crow Flats, YT	Vuntut National Park	Climate change induced falling water levels

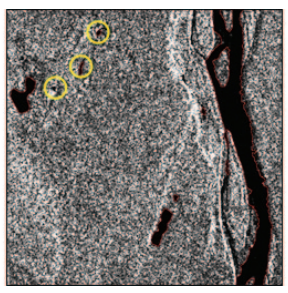
The following three figures show an example of monitoring localized lake shrinkage over seven years using FnFCE and RADARSAT-1 imagery. The study area is Fort Mackay, Alberta; an area characterized by the presence of activities that consume large amounts of water as well as patches of permafrost that can be suspected to thaw in a warming climate.

Summer 1998



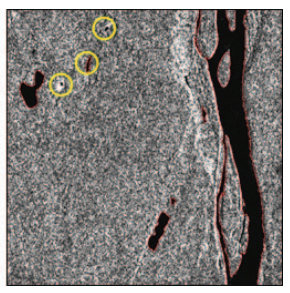
Above: Three small water bodies exceed the 1 hect-are size threshold.

Summer 2000



Above: Two water bod-ies, large enough to be extracted, remain.

Summer 2005



Above: One water body, large enough to be extracted, remains. Area has isolated patches of permafrost, therefore localized lake drainage expected.

The future

The FnFCE radar imagery tool is an efficient way to monitor surface water availability; however, the tool works currently only with RADARSAT-1 data. Our priority is to expand the tool to incorporate support for the many other space borne radar data sets: ENVISAT, RADARSAT-2, ERS1/2, ALOS and TERRASAR-X. Among other advantages, using other data sets will allow us to investigate past changes using the ERS-1 archive, and to examine changes at higher resolution (RADARSAT-2 and TERRASAR-X).

Cat. No.: M77-4/22-2010E-PDF (On-line)
ISBN: 978-1-100-15035-2

Canada