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ABoVE: Fractional Open Water Cover for Pan-Arctic and ABoVE-Domain Regions, 2002-2015

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Data Set Version: V1

Summary

This data set provides land surface fractional open water cover maps for two overlapping regions: the entire pan-Arctic region (latitude ≥ 45 degrees) and the Arctic-Boreal Vulnerability Experiment (ABoVE) domain across Alaska and Canada. The data represent a fractional water average over a 10-day time step at 5-km spatial resolution for the period 2002-2015. Data represent the aerial portion of a grid cell covered by open water. The data were produced using high frequency (89 GHz) brightness temperatures from the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and the Advanced Microwave Scanning Radiometer 2 (AMSR2), with other ancillary inputs from AMSR-E/AMSR2 25-km products and the Moderate Resolution Imaging Spectroradiometer (MODIS). The resulting data record for fractional water is suitable for documenting open water patterns and inundation dynamics in boreal-Arctic ecosystems experiencing rapid climate change.

Unlike open water maps derived from satellite optical-infrared remote sensing, the fractional water record benefits from strong microwave brightness temperature sensitivity to surface water and relative insensitivity to potential data loss from cloud cover and atmosphere aerosol contamination, and conditions of low solar illumination which are prevalent in Arctic environments.

There are 469 data files in GeoTIFF (.tif) format for the pan-Arctic region and 469 files for the ABoVE study domain. Each file represents the average over a ten-day period. There are also two data quality files in GeoTIFF (.tif) format, one for each region, for a total of 940 files.



Figure 1. Land surface fractional open water for the extended ABoVE domain for Julian days 171-180 of 2002 depicted with a black to white gradient.

Citation

Du, J., J.S. Kimball, and J.D. Watts. 2016. ABoVE: Fractional Open Water Cover for Pan-Arctic and ABoVE-Domain Regions, 2002-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1362>

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1. Data Set Overview

This data set provides land surface fractional open water cover maps for two overlapping regions: the entire pan-Arctic region (latitude > 45 degrees) and the defined Arctic-Boreal Vulnerability Experiment (ABoVE) domain across Alaska and Canada. The data represent a fractional water average over a 10-day time step at 5-km spatial resolution for the period 2002-2015. Data represent the aerial portion of a grid cell covered by open water. The data were produced using high frequency (89 GHz) brightness temperatures from the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and the

Advanced Microwave Scanning Radiometer 2 (AMSR2), with other ancillary inputs from AMSR-E/AMSR2 25-km products and the Moderate Resolution Imaging Spectroradiometer (MODIS). The resulting data record for fractional water is suitable for documenting open water patterns and inundation dynamics in boreal-Arctic ecosystems experiencing rapid climate change.

Unlike open water maps derived from satellite optical-infrared remote sensing, the fractional water record benefits from strong microwave brightness temperature sensitivity to surface water and relative insensitivity to potential data loss from cloud cover and atmosphere aerosol contamination, and low solar illumination.

Project: Arctic-Boreal Vulnerability Experiment (ABoVE)

The [Arctic-Boreal Vulnerability Experiment](#) (ABoVE) is a NASA Terrestrial Ecology Program field campaign based in Alaska and western Canada between 2016 and 2021. Climate change in the Arctic and Boreal region is unfolding faster than anywhere else on Earth. ABoVE seeks a better understanding of the vulnerability and resilience of ecosystems and society to this changing environment.

Related Publications:

Du, J., J.S. Kimball, L.A. Jones, and J.D. Watts. 2016. Implementation of satellite based fractional water cover indices in the pan-Arctic region using AMSR-E and MODIS. *Remote Sensing of Environment*, 184: 469-481. doi: [10.1016/j.rse.2016.07.029](https://doi.org/10.1016/j.rse.2016.07.029)

2. Data Characteristics

Spatial Coverage:

(a) pan-Arctic region: Northern hemisphere above 45 degrees latitude

(b) ABoVE Domain: Core and extended ABoVE study regions

ABoVE Grid Cells: Ah0v0, Ah1v0, Ah2v0, Ah3v0, Ah0v1, Ah1v1, Ah2v1, Ah3v1, Ah1v2, Ah2v2, Ah3v2, Ah2v3, Ah3v3

Spatial Resolution: 5 km

Temporal Coverage (YYYYMMDD): 20020620 - 20111004 and 20120719 - 20151231

Temporal Resolution: 10 day

Study Area: (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
pan-Arctic	-180.000	180.000	90.000	45.000
ABoVE domain	-176.125	-66.752	81.609	39.383

GeoTIFF Spatial Data Properties

pan-Arctic

Spatial Representation Type: Raster

Data Type: 2-byte integer

Number of Bands: 1

Number Columns: 1957

Column Resolution: 5000 meter

Number Rows: 1957

Row Resolution: 5000 meter

Fill value: -999

Projection: EASE-GRID Version 2 (Brodzik et al., 2014)

Datum: WGS_1984

ABoVE domain

Spatial Representation Type: Raster

Data Type: 2-byte integer

Number of Bands: 1

Number Columns: 805

Column Resolution: 5000 meter

Number Rows: 713

Row Resolution: 5000 meter

Fill value: -999
 Projection: Canada Albers projection
 Datum: NAD83

Data File Information

There are 469 data files in GeoTIFF (.tif) format for the pan-Arctic region and 469 files for the ABoVE study domain. Each file represents the average over a ten-day period.

The fractional water cover data files are named by study domain and temporal coverage, such as:

domain_FW_YYYY_SSS_EEE.tif

where *domain* = either PanArctic or ABoVE

YYYY = year

SSS = day of the year at the start of the ten day period

EEE = day of the year at the end of the ten day period

Example file names:

- *PanArctic_FW_2002_271_280.tif* - contains fw data for the pan-Arctic domain for 2002, day of the year 271 to 280.
- *ABoVE_FW_2002_271_280.tif* - contains fw data for the ABoVE domain for 2002, day of the year 271 to 280.

The two additional data quality files (QA), one each for the ABoVE domain and pan-Arctic region, provide information regarding: (a) retrievable pixels within the study domain; (b) ocean areas excluded from the fractional water (*fw*) retrievals; (c) land-ocean boundary pixels subjected to larger *fw* retrieval errors; (d) non-retrievable pixels including those within large water bodies (i.e. water area > 312.5 km²), frozen conditions or with permanent ice/snow cover; and (e) areas outside of the product domain. Class definitions for the QA files are listed in Table 1.

ABoVE_FW_QA.tif and *PanArctic_FW_QA.tif* are quality flag files for the ABoVE domain and pan-Arctic, respectively. The QA data are in the same format as the corresponding Spatial Data except that data type is byte.

Table 1. Class definitions for QA files

Cell Value	Definition
0	Retrievable land
1	Ocean
2	Ocean-land boundary
3	Non-retrievable land pixels
255	Land areas outside of retrieval domain

Feedback

3. Application and Derivation

This data set provides an improved resolution satellite environmental data record documenting open water patterns and inundation dynamics in boreal-Arctic ecosystems experiencing rapid climate change. Accurate estimation of open water dynamics has become a prerequisite for strengthening the current understanding of northern high latitude ecosystems and carbon cycle related feedbacks to climate change.

4. Quality Assessment

Three fine-scale static open water maps were used to evaluate this *fw* data set:

- 1) the 30-m Global Land 30-water 2010 (GLC30; Liao et al., 2014), derived from Landsat TM/ETM+ imagery and HJ-1 sensors collected over the 2010 base year;
- 2) the 300-m ENVISAT Advanced Synthetic Aperture Radar (ASAR) Global Water Bodies map (ASAR300; Kirches et al., 2014), derived from multi-temporal ASAR acquisitions in wide swath mode for years 2005 to 2010;
- 3) the 250-m MOD44W product (Carroll et al., 2009), derived from a compilation of the SRTM Water Body data set and the MODIS (MOD44C) Collection 5 (2000-2008) open water classification product.

The AMSR-E *fw* summer seasonal composites from 2003 to 2010 correspond favorably ($R \geq 0.86$, $p < 0.001$) with the fine resolution static open water maps, as shown in Figure 2. The *fw* retrievals capture significant seasonal drought and flooding events inferred from river discharge records within the major Arctic basins (Du et al., 2016). They are found to be reliable for discriminating open water in moderately dense vegetation areas, but with greater

uncertainty over barren land. The ability of the fw retrievals to detect surface water under vegetation decreases exponentially with increasing canopy optical thickness (Du et al., 2016). In addition, AMSR2 brightness temperature has been calibrated against AMSR-E, but the impacts of different sensor spatial resolutions and instrument calibration systems on fw retrievals cannot be completely removed. Possible retrieval biases may exist between the AMSR-E and AMSR2 retrievals.

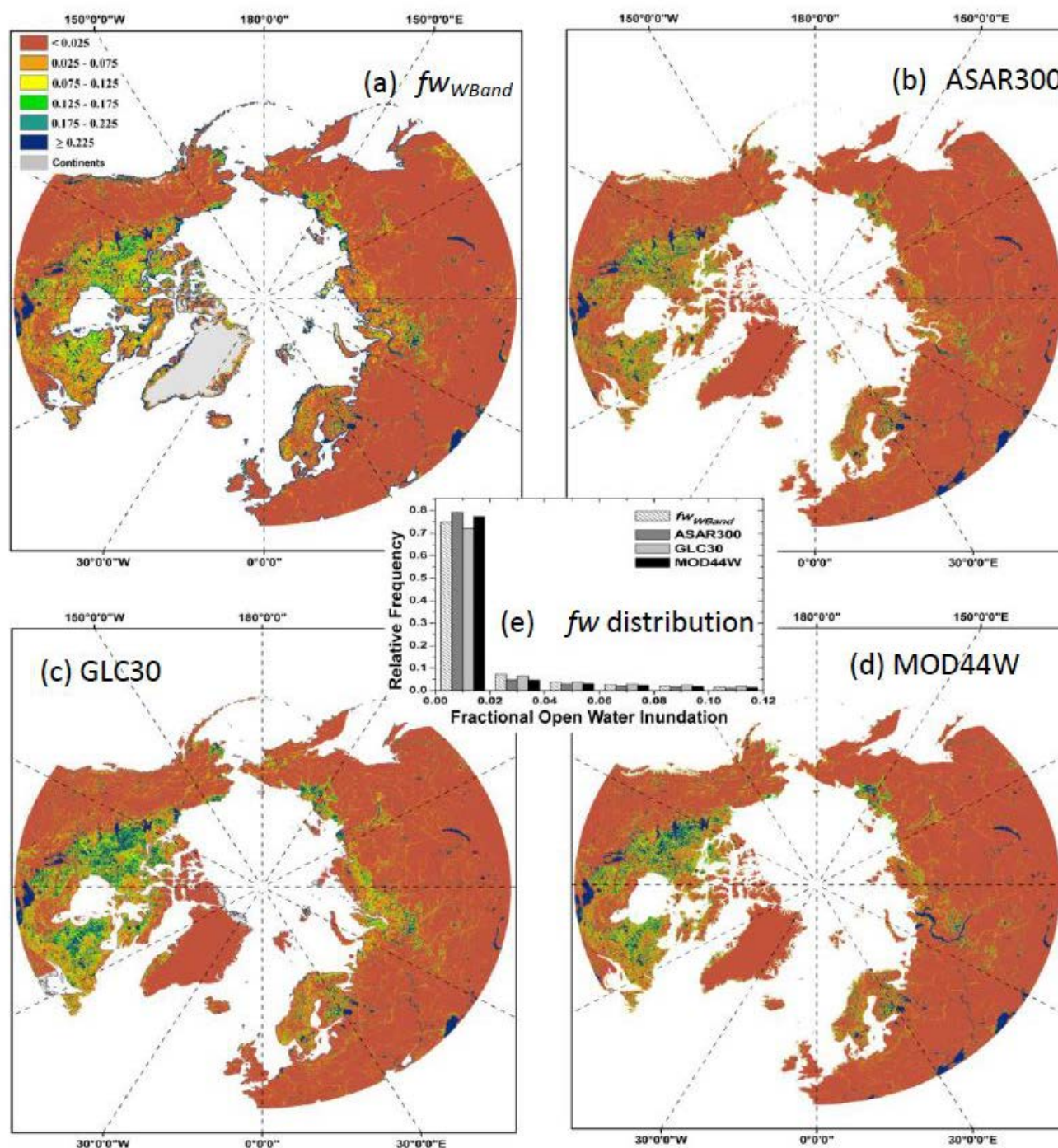


Figure 2. a) Mean fractional open water map generated at 5-km resolution from AMSR-E 89 GHz observations (fW_{WBand}); the fW_{WBand} results are presented for the 2006 reference year and mean summer conditions (June, July, August); reference fw maps generated from other finer resolution satellite data records include: (b) 300-m resolution ASAR300, (c) 30-m GLC30, and (d) 250-m MOD44W land cover maps. e) Histogram of fractional open water distributions of the fW_{WBand} , ASAR300, GLC30, and MOD44W maps. From Du et al., 2016.

5. Data Acquisition, Materials, and Methods

The data set was generated using 89 GHz brightness temperature (T_b) retrievals from calibrated AMSR-E and AMSR2 sensor records under dynamic atmospheric and land surface conditions defined by three geospatial data sets (Du et al., 2016). The general workflow is depicted in Figure 3.

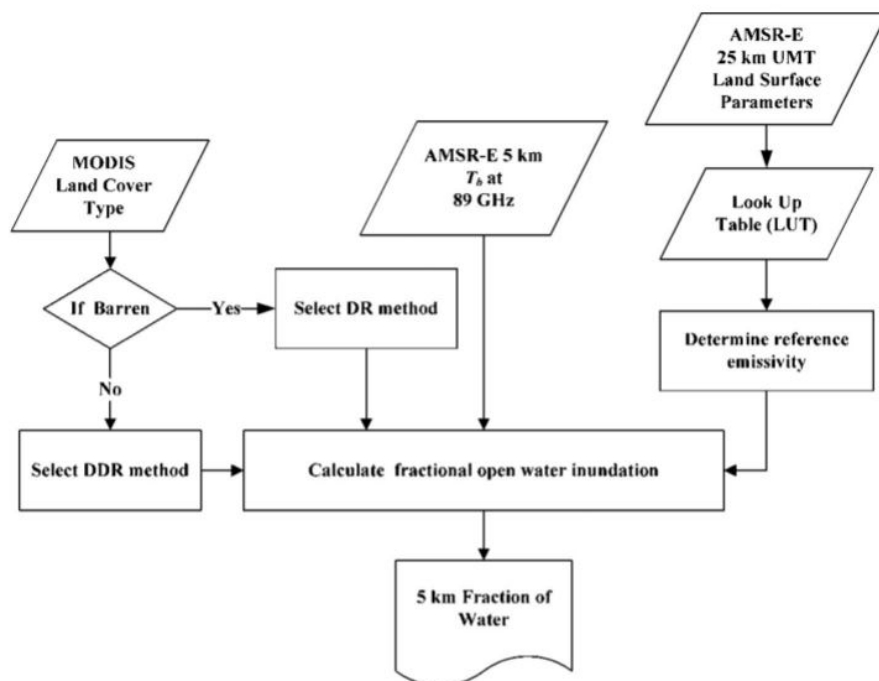


Figure 3. General data processing flowchart describing the methodology used to derive the 5-km resolution fractional open water inundation retrieval from AMSR-E/2 89 GHz T_b and the 25-km UMT Land Parameter data record. A difference ratio method was applied to classified barren land pixels and a double difference ratio method was used for vegetated pixels.

The AMSR2 multifrequency T_b retrievals were calibrated against similar T_b retrievals from AMSR-E using overlapping T_b observations from the Microwave Radiation Imager (MWRI) onboard the Chinese FY3B satellite using an empirical approach (Du et al., 2014). The ancillary data sets used for algorithm development include the University of Montana AMSR-E/2 global land parameter record (Jones and Kimball, 2012; Jones et al., 2010); a AMSR-E/2 frequency ratio data record defined as the V- and H-polarization difference ratio between 89 and 36 GHz channels; and a MODIS 1-km resolution global land cover classification (MOD12Q1) derived using the IGBP classification scheme (Friedl et al., 2006). Based on the above data sets, a look-up table was established to provide reference microwave emissivities for water and land endmembers under a range of atmosphere and land surface conditions. The fw retrievals were then obtained on a per pixel basis as described by Equations 1 and 2:

$$fw = \frac{(e_v^{obs} - e_h^{obs}) - (e_{vl}^{ref} - e_{hl}^{ref})}{(e_{vw}^{ref} - e_{hw}^{ref}) - (e_{vl}^{ref} - e_{hl}^{ref})} = \frac{(T_{bv}^{obs} - T_{bh}^{obs}) - (T_{bvl}^{ref} - T_{bhl}^{ref})}{(T_{bvw}^{ref} - T_{bhw}^{ref}) - (T_{bvl}^{ref} - T_{bhl}^{ref})}$$

where:

T_{bp}^{obs} represents the actual satellite T_b observation for p (either H or V) polarization,

T_{bpw}^{ref} denotes the T_b from the reference water endmember pixel, and

T_{bpl}^{ref} is the T_b from the reference land endmember pixel.

The corresponding variable emissivity terms are expressed as e_{bp}^{obs} , e_{pw}^{ref} , and e_{pl}^{ref} respectively. For barren land conditions, fw is determined using a Difference Ratio of only H-polarization emissivities:

$$fw = \frac{(e_{hl}^{ref} - e_h^{obs})}{(e_{hl}^{ref} - e_{hw}^{ref})} = \frac{(T_{bhl}^{ref} - T_{bh}^{obs})}{(T_{bhl}^{ref} - T_{bhw}^{ref})}$$

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[ABoVE: Fractional Open Water Cover for Pan-Arctic and ABoVE-Domain Regions, 2002-2015](https://daac.ornl.gov/ABOVE/guides/ABOVE_Frac_Open_Water.html)

Contact for Data Center Access Information:

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