Land Cover Classification, Snow Cover, and Fractional Snow-Covered Area Maps from Maxar WorldView Satellite Images, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Hu, J.M. and D. E. Shean. 2023. *Land Cover Classification, Snow Cover, and Fractional Snow-Covered Area Maps from Maxar WorldView Satellite Images, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/USXB6X9CD4Q2. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/WV_LCC_SC_FSCA

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This dataset contains high-resolution land cover classification and snow cover maps and lower resolution fractional snow-covered area (fSCA) maps derived from imagery acquired by WorldView-2 and WorldView-3 (WV-2 and WV-3) satellites operated by Maxar Technologies. The source imagery are 8-band multispectral images, orthorectified and converted to top-of-atmosphere reflectance, available under the NGA NextView/EnhancedView license. Also included are Landsat and MODSCAG fSCA maps.

1.1 Parameters

This data set presents three different image-based data files: high-resolution land cover classification maps, snow cover maps, and fractional snow-covered area maps. Unique parameters are available for each data product as follows:

- Land cover classification: unclassified, illuminated snow, shaded snow, vegetation, exposed surface, surface water, cloud cover
- Snow cover: snow-free, snow-covered
- Fractional snow-covered area: percent snow cover

1.2 File Information

1.2.1 Format

Data are provided as GeoTIFF files.

1.2.2 File Contents

Each type of data product utilizes a different value key for interpretation of parameters, as described in Table 1.

Table 1. Value Keys for Data Interpretation

Data Product Category	Value	Description
Land Cover Classification Maps	0	Unclassified
	1	Illuminated snow
	2	Shaded snow
	3	Vegetation
	4	Exposed surface
	5	Surface water

Data Product Category	Value	Description
	6	Cloud cover
	99	No data
Binary snow cover maps	0	Snow-free
	1	Snow-covered
	99	No data
Fractional Snow-covered area maps	0-100	Snow fraction
	-9999	No data

1.2.3 Naming Convention

File naming conventions vary by file content, as described below and in Table 2. Note, all file names begin with the NSIDC data set ID: `WV_LCC_SC_FSCA`.

Land cover classification original land cover map:

- `WV[sensor]_[YYYYMMDD]_[CatID]_[trainingROI]_class_[res]m.tif`

Binary snow cover original land cover map and corresponding 32m resolution browse image:

- `WV[sensor]_[YYYYMMDD]_[CatID]_snow_[res]m.tif`
- `WV[sensor]_[YYYYMMDD]_[CatID]_snow_32m.tif;`

WorldView fSCAs map downsampled to coarser Landsat or MODIS resolution grid:

- `WV[sensor]_[YYYYMMDD]_[CatID]_fSCA_LSgrid_[res]m.tif`
- `WV[sensor]_[YYYYMMDD]_[CatID]_fSCA_[res]m.tif`

Coarse resolution Landsat and MODSCAG fSCA maps in Landsat and MODIS resolution grids:

- `WV[sensor]_[YYYYMMDD]_[CatID]_ LS_[YYYYMMDD]_fsca_LSgrid_[res].tif`
- `WV[sensor]_[YYYYMMDD]_[CatID]_ LS_[YYYYMMDD]_fsca_[res].tif`
- `WV[sensor]_[YYYYMMDD]_[CatID]_ MOD_[YYYYMMDD]_fsca_[res].tif`

Table 2. File Naming Variable Descriptions

Variable	Description
`WV`	WorldView
`sensor`	Satellite (WorldView-2 or WorldView-3)

Variable	Description
YYYYMMDD	Date, expressed as 4-digit year, 2-digit month, and 2-digit day: If following WV[sensor]_, refers to collection date of WV image product If following LS_ or MOD_, refers collection date of Landsat or MODIS image product
CatID	Unique catalog identifier for an image collection
trainingROI	Training region location identified by a two/three-letter code, followed by the YYYYMMDD date: GM: Grand Mesa, Colorado SCG: Southern Cascade Glacier, Washington NC: North Cascades, Washington
Class	Classified land cover categories
res	Spatial resolution of file
m	Meters, refers to spatial resolution units
fSCA	Fractional snow-covered area
LSgrid	Landsat grid
LS	Landsat
MOD	MODIS

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 39.176 N
Southernmost Latitude: 38.868 N
Westernmost Latitude: 108.298 W
Easternmost Latitude: 108.032 W

Northernmost Latitude: 48.673 N
Southernmost Latitude: 48.481 N
Westernmost Latitude: 121.204 W
Easternmost Latitude: 120.993 W

Northernmost Latitude: 48.442 N
Southernmost Latitude: 48.270 N
Westernmost Latitude: 121.180 W
Easternmost Latitude: 120.933 W

1.3.2 Resolution

Data product resolution varies by image source. Products derived from WV-3 source images have a 1.2 m resolution while products derived from WV-2 images have a 2.0 m resolution. Fractional snow cover maps were downsampled to 30m and 465 m resolutions.

1.3.3 Geolocation

The following table provide information for geolocating this data set. Each file was orthorectified to a common grid, with grid cells sizes and resolutions which vary based on the image source (2.0 m for WV-2, 1.2 m for WV-3, 30 m for Landsat, and 465 m for MODIS imagery).

Table 3. Geolocation Details

Geographic coordinate system	WGS 84	WGS 84
Projected coordinate system	WGS 84 / UTM Zone 10N	WGS 84 / UTM zone 12 N
Longitude of true origin	-123	-111
Latitude of true origin	0	0
Scale factor at longitude of true origin	0.9996	0.9996
Datum	WGS 1984	WGS 1984
Ellipsoid/spheroid	WGS 84	WGS 84
Units	Meters	Meters
False easting	500000	500000
False northing	0	0
EPSG code	32610	32610
PROJ4 string	+proj=utm +zone=10 +datum=WGS84 +units=m +no_defs +type=crs	+proj=utm +zone=12 +datum=WGS84 +units=m +no_defs +type=crs
Reference	https://epsg.io/32610	https://epsg.io/32612

1.4 Temporal Information

1.4.1 Coverage

20 May 2015 to 05 May 2019

1.4.2 Resolution

Tempoeral resolution varies. Maps were derived from imagery collected nearly contemporaneously (30-60 second offset) and repeat observations of each study site were spaced apart at variable intervals ranging from months to years .

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set includes three distinct data products: (1) fine-scale snow and land cover maps from two mountainous study sites in the Western U.S., produced using machine-learning models trained to extract land cover data from WorldView-2 and WorldView-3 (WV-2 and WV-3) stereo panchromatic and multispectral images; (2) binary snow maps derived from the land cover maps; and (3) two resolutions of fractional snow-covered area (fSCA) maps, produced via downsampling of the binary snow maps. The land cover classification maps feature between three and six classes common to mountainous regions and integral for accurate stereo snow depth mapping: illuminated snow, shaded snow, vegetation, exposed surfaces, surface water, and clouds.

Two snow monitoring sites in the Western US were selected for this work: the North Cascade Range in Washington and Grand Mesa in Colorado. These sites were chosen due to their contrasting snow conditions caused by variations in climates, topography, and land cover. The North Cascades site features a dynamic elevation range of 430–2703 m. Landcover includes thick forests, subalpine meadows, and alpine lakes, in addition to perennial snowfields and active glaciers. Annual snowfall can exceed 15 m, with snowpack consisting of dense maritime snow. Conversely, Grand Mesa is a high-elevation, flat-topped mountain in Western Colorado, exhibiting an elevation range of 3000-3400 m. This site, which is also one of the primary field sites for the NASA SnowEx 2017, 2020, and 2021 campaigns, has sparse stands of trees, multiple lakes and reservoirs, and abundant exposed bedrock. Annual snowfall in Grand Mesa averages ~5-6 m, with snowpack consisting of continental snow.

2.2 Acquisition

The source satellite imagery used to create this data set were “System-ready” Level-1B (L1B) Maxar WorldView-2 and WorldView-3 (WV-2 and WV-3) satellite images, available for use under the NGA NextView/EnhancedView license (now accessible through the Commercial Smallsat Data Acquisition (CSDA) program). The source images of the study sites include both panchromatic (PAN, 450–800 nm) and 8-band multispectral (MS, 397–1040 nm) imagery, collected as in-track stereo pairs between 2015 and 2019. Image specifications for the individual WorldView source

imagery, including acquisition date, mean sun elevation, mean sun azimuth, mean satellite elevation, mean satellite azimuth spectral coverage and ground-sample distance (GSD), are available in Table 1 and Supplementary Table S1 of Hu and Shean, 2022.

2.3 Processing

To produce this data set, the authors trained a machine learning model which employed a random forest algorithm to classify landcover categories from input WorldView satellite imagery. The source imagery underwent multiple stages of pre-processing prior to use for training purposes and subsequent model input for data product creation. Preprocessing steps included: 1) orthorectifying the sources images to a common 1.2 m (for WorldView-3) or 2.0 m (for WorldView-2) grid, 2) applying absolute radiometric corrections and solar spectral irradiance corrections to the data, and 3) calculating spectral indices for use in the model input data stack.

The random forest algorithm model was trained using input data stacks featuring manually delineated polygons outlining pixel clusters of each desired landcover feature class (illuminated snow, shaded snow, vegetation, exposed ground, surface water, and cloud cover). Detailed information about the machine learning model training and accuracy assessment are available in Section 3 of Hu and Shean, 2022. Successful implementation of the trained random forest model produced the very-high resolution (VHR) landcover classification maps data products.

Two additional data products were created from the VHR land cover maps. First, VHR binary snow cover maps were created by categorizing each pixel in the land cover maps as either 0 (non-snow feature classes) or 1 (snow features classes). The VHR binary snow maps were then reprojected and downsampled to create lower resolution fractional snow-covered area (fSCA) maps. Two resolutions of fSCA maps were produced: one at 465 m resolution for comparison to existing MODIS fSCA products (MODSCAG fSCA) and one at ~30 m resolution for comparison to existing canopy-adjusted Landsat fSCA products. The temporally equivalent MODSCAG fSCA and Landsat fSCA maps for each study site are also included with this data set.

2.4 Quality, Errors, and Limitations

Testing of the random forest algorithm used in the creation of this dataset suggests snow, shaded snow, and vegetation classes were typically classified correctly, while exposed surfaces, clouds, and water were more likely to be classified incorrectly. In most cases, misclassified pixels fell along the boundaries of feature classes or in shaded areas.

Comparison of the WorldView derived fSCA products to existing fSCA products (Landsat/MODSCAG fSCA maps) suggests the WorldView derived maps generally agree with the

existing maps when imaging open areas, and can thus be used in these areas to provide finer spatial resolution to existing lower resolution products. However, issues related to satellite viewing angles when evaluating regions with thick vegetation or steep terrain cause both the Worldview and the MODSCAG fSCA products to underestimate snow cover in such areas.

Detailed discussion of the limitations of the random forest model, and its use in classifying land cover from high resolution Worldview-2 and Worldview-3 imagery is available in Section 5.5 of Hu and Shean, 2022, in addition to suggestions for model improvements.

3 VERSION HISTORY

Table 5. Version History Summary

Version	Release Date	Description of Changes
1	June 2023	Initial release

4 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

5 RELATED WEBSITES

Snow Ex at NSIDC | Overview

Snow Ex at NASA

6 CONTACTS AND ACKNOWLEDGMENTS

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7 REFERENCES

Hu, J. M., & Shean, D. (2022). Improving Mountain Snow and Land Cover Mapping Using Very-High-Resolution (VHR) Optical Satellite Images and Random Forest Machine Learning Models. Remote Sensing, 14(17), 4227. MDPI AG. http://dx.doi.org/10.3390/rs14174227

8 DOCUMENT INFORMATION

8.1 Publication Date

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8.2 Date Last Updated

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