Western United States UCLA Daily Snow Reanalysis, Version 1

USER GUIDE

How to Cite These Data

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

Fang, Y., Y. Liu. and S. A. Margulis. 2022. *Western United States UCLA Daily Snow Reanalysis, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/PP7T2GBI52I2. [Date Accessed].

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

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

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION 2
1.1 Parameters 2
1.2 File Information 2
1.2.1 Format 2
1.2.2 File Contents 2
1.2.3 Naming Convention 3
1.2.4 Browse File 4
1.3 Spatial Information 4
1.3.1 Coverage 4
1.3.2 Resolution 5
1.3.3 Geolocation 5
1.4 Temporal Information 5
1.4.1 Coverage 5
1.4.2 Resolution 5
2 DATA ACQUISITION AND PROCESSING 5
2.1 Background 5
2.2 Acquisition 5
2.3 Processing 6
2.4 Quality, Errors, and Limitations 7
3 SOFTWARE AND TOOLS 7
4 VERSION HISTORY 8
5 RELATED DATA SETS 8
6 RELATED WEBSITES 8
7 CONTACTS AND ACKNOWLEDGMENTS 8
8 REFERENCES 8
9 DOCUMENT INFORMATION 9
9.1 Publication Date 9
9.2 Date Last Updated 9

1 DATA DESCRIPTION

1.1 Parameters

This data set is a snow reanalysis over the Western United States derived by assimilating satellite retrieved fractional snow-covered area (fSCA) observations from the Landsat satellite platforms between Water Year (WY) 1985 and 2021 (Margulis et al., 2019). The data set contains daily estimates of posterior snow water equivalent (SWE), fSCA, and snow depth (SD). Ensemble statistics (e.g., mean, standard deviation, median, 25th and 75th percentiles) from the fifty replicates are given for the key posterior snow estimates (SWE, fSCA, and SD).

1.2 File Information

1.2.1 Format

Data are provided in NetCDF files.

1.2.2 File Contents

Each data set granule consists of two files, one contains posterior SWE (SWE_POST) and posterior fSCA (SCA_POST), and one contains posterior SD (SD_POST). Table 1 lists the main parameters, the corresponding file name extensions, and a reference to where to find more file parameter details. The detailed parameter description for each file type can be found in Table 2 and Table 3. The dimensions (225 x 225 x 5 x 366) for SWE, fSCA, and SD correspond to latitude by longitude by number of ensemble statistics by day of water year. The ensemble statistics are given in the order of: ensemble mean, ensemble standard deviation, ensemble median, 25th percentile, and 75th percentile.

The water year refers to October 1st - September 30th, where the year number corresponds to the ending year., i.e., WY 2000 = 01 October 1999 – 30 September 2000.

Table 1. Parameter Details

File name extensions	Parameters	Reference to Parameter Details
SWE_SCA_POST	Posterior snow water equivalent (SWE) and posterior fractional snow-covered area (fSCA)	Table 2
SD_POST	Posterior snow depth (SD)	Table 3

Table 2. Parameter Details for *SWE_SCA_POST* files

Parameter	Description	Unit	Dimension
SCA_Post	posterior fSCA	-	225 x 225 x 5 x 366
SWE_Post	posterior snow water equivalent	m	225 x 225 x 5 x 366
Latitude	latitude	degrees N	225 x 1
Longitude	longitude	degrees E	225 x 1

Table 3. Parameter Details for *SD_POST* files

Parameter	Description	Unit	Dimension
SD_Post	posterior snow depth	m	225 x 225 x 5 x 366
Latitude	latitude	degrees N	225 x 1
Longitude	longitude	degrees E	225 x 1

1.2.3 Naming Convention

The data files are named according to the following convention, which is described in Table 4 below:

`WUS_UCLA_SR_v[nn]_N[latitude]_0W[longitude]_0_agg_16_WY[YYYY_YY]_[parameter].nc`

Table 4. File Naming Convention

File Designator	Description
`WUS_UCLA_SR`	Data set ID.
`v[nn]`	Data set version number.
`N[latitude]_0`	N for north, followed by a 2-digit latitude, e.g. N37_0 for 37° N indicating the latitude of the lower-left corner of the 1° latitude by 1° longitude file.
`W[longitude]_0`	W for west, followed by a 3-digit longitude, e.g. W120_0 for 120° W indicating the longitude of the lower-left corner of the 1° latitude by 1° longitude file.
`agg_16`	This refers to a spatial aggregation factor of 16 from the original resolution of the DEM (1 arc-second) to the model resolution (16 arc-seconds).
`WY[YYYY_YY]`	WY is short for water year, followed by the starting year and the last two digits of the ending year. E.g. WY1999_00 refers to data for the period of 01 October 1999 to 30 September 2000.
`[parameter]`	Main data parameter. Options are SWE_SCA_POST or SD_POST. More details on each individual file type can be found in Table 2 and Table 3.
`.nc`	File extension indicating this is a NetCDF file.

Example file names:

- WUS_UCLA_SR_v01_N37_0W120_0_agg_16_WY1984_85_SWE_SCA_POST.nc
- WUS_UCLA_SR_v01_N37_0W120_0_agg_16_WY1984_85_SD_POST.nc

1.2.4 Browse File

A .png browse file is provided for each data granule showing the SWE of the day of water year 90 (DOWY 90). Figure 1 shows an example browse file.

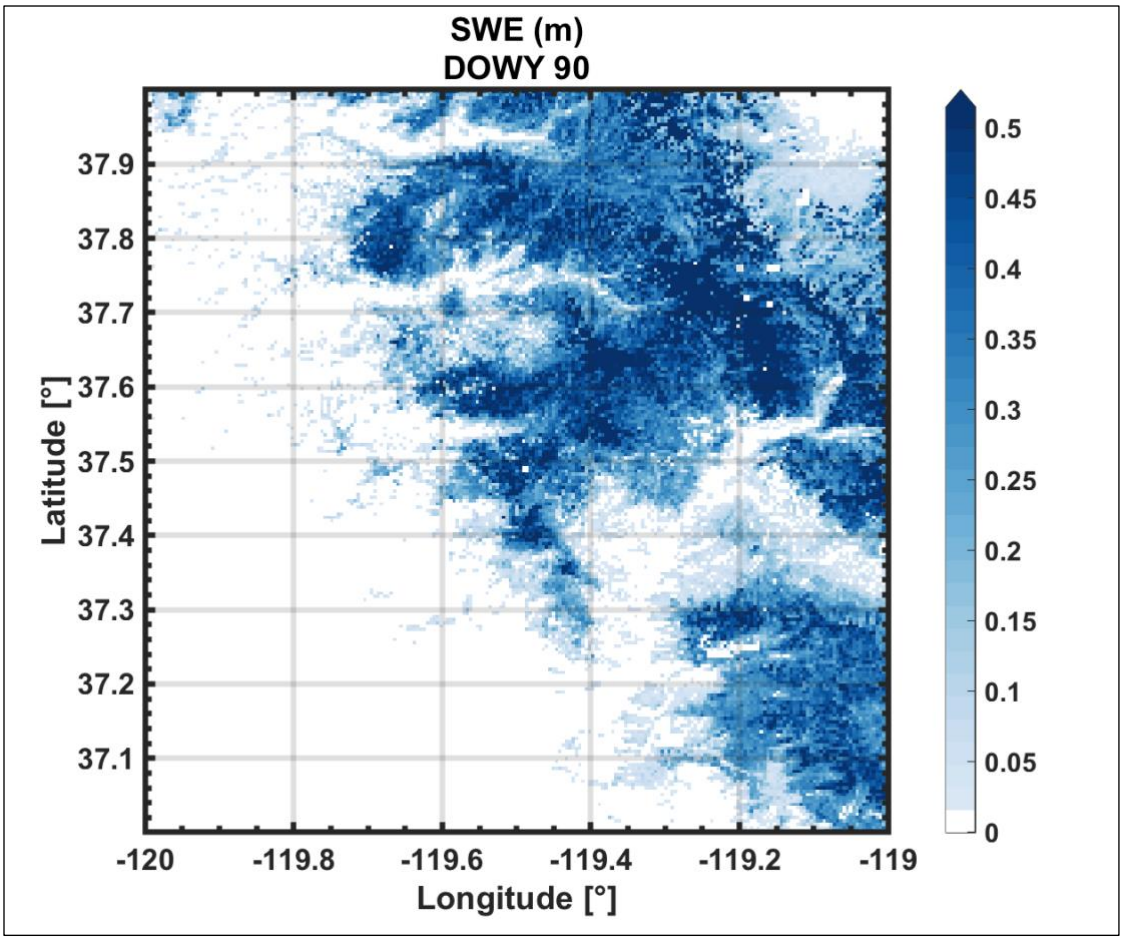

Figure 1. Sample browse file:
WUS_UCLA_SR_v01_N37_0W120_0_agg_16_WY1984_85_SWE_SCA_POST_browse.png

1.3 Spatial Information

1.3.1 Coverage

Northernmost latitude: 49° N
Southernmost latitude 31° N
Easternmost longitude: 102° W
Westernmost longitude: 125° W

1.3.2 Resolution

16 arc-seconds, or 0.004444 degrees. Nominal resolution varies between 350 and 500 m.

1.3.3 Geolocation

The following table provides information for geolocating this data set:

Table 5. Geolocation Details

Geographic coordinate system	WGS 84
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

01 October 1984 to 30 September 2021

1.4.2 Resolution

Daily

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This Western United States snow reanalysis data set contains daily estimates of posterior snow water equivalent (SWE), fractional snow-covered area (fSCA) and snow depth (SD) at 16 arc-seconds (~500 m) resolution from water years 1985 to 2021. This data set was developed to be compared to SnowEx data sets but its utility reaches way beyond as spatial and temporal bounds reach over the entire Western U.S. and over several decades.

2.2 Acquisition

Input data for the snow reanalysis are fSCA images retrieved from three Landsat sensors (Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), and Landsat 8 Operational Land Imager (OLI)) using a spectral unmixing algorithm (Painter et al., 2003; Cortés et al., 2014).

Other input data to derive this snow reanalysis data set were topographic data, land cover data, and meteorological data:

- The digital elevation model (DEM) obtained from the Shuttle Radar Topography Mission (SRTM, Farr et al., 2017) with 1 arc-second resolution served as topographic data. Gaps were filled with the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM, version 2) product with 1 arc-second resolution.
- Land cover data was obtained from the Advanced Very High Resolution Radiometer (AVHRR) global land cover classification (Hansen et al., 2000).
- Forest cover was obtained from the Tree Canopy Cover (TCC) product containing the Landsat Vegetation Continuous Fields (Sexton et al., 2013).
- Meteorological forcing data was obtained from the Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2; Gelaro et al., 2017).

2.3 Processing

This data set was derived using a previously developed snow reanalysis scheme (Margulis et al., 2019) that has been successfully applied in the High Mountain Asia, Andes, and Sierra Nevada. A coupled land surface model from SSiB3 (Sun and Xue, 2001; Xue et al., 2003) and a snow depletion curve (Liston et al., 2004) was used to generate the ensemble prior estimates of the snow states and fluxes. A Bayesian update was performed to further constrain the ensemble prior estimates on satellite retrieved fSCA observations using a Particle Batch Smoother (Margulis et al., 2015) approach, where SWE, modeled fSCA, and snow depth are updated simultaneously.

The domain used in this data set is bounded by 31° N to 49° N and 125° W to 102° W. The basic processing units for the data set were tiles of size 1° latitude by 1° longitude. The data is made available in files corresponding to these 1° latitude by 1° longitude processing units. The reanalysis data set is provided at a spatial resolution of 16 arc-seconds (~350 m - 500 m), and at a daily temporal resolution.

The individual processing steps are fully described in Margulis et al. (2019) and depicted in the snow reanalysis diagram below.

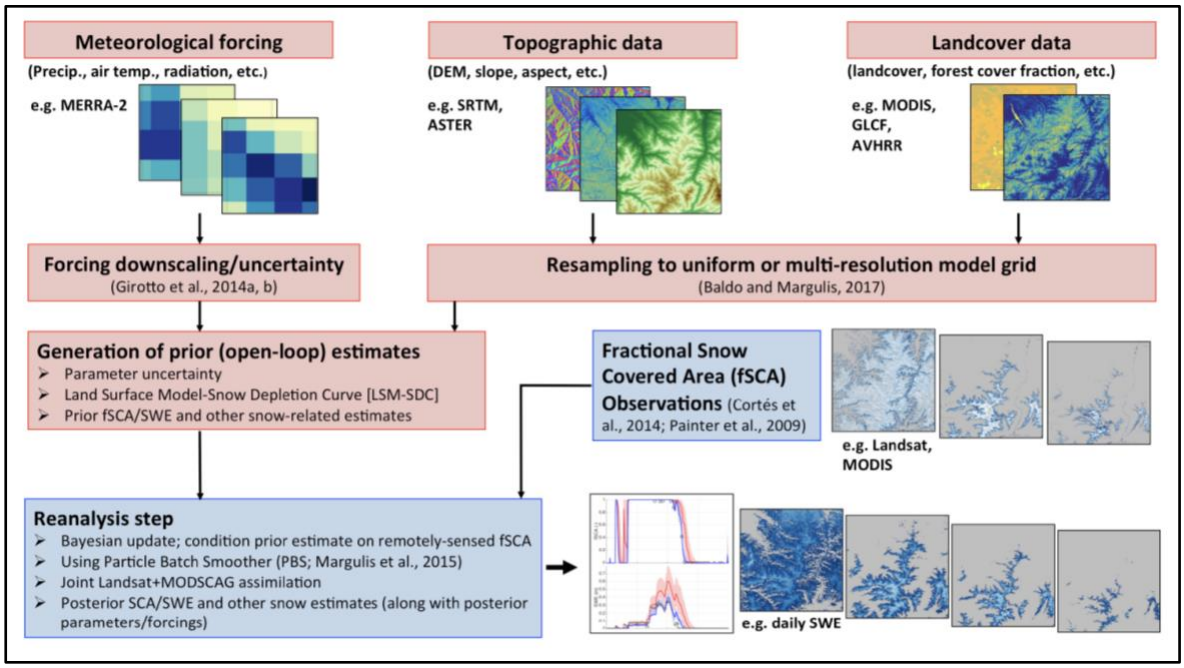

Figure 2. Schematic representation of the Bayesian snow reanalysis framework taken from Margulis et al. (2019).

2.4 Quality, Errors, and Limitations

This data set was specifically designed for seasonal snowpack estimation. Non-seasonal snow and glaciers need to be excluded before data analysis.

Landsat fSCA images are used as assimilation data set to derive this reanalysis data set. The quality of the reanalysis data set is affected by the accuracy and numbers of fSCA images. A 16-day repeat cycle of one Landsat satellite provides roughly 23 images for each location per WY. At locations where swaths overlap, about 46 fSCA images are available during those years with only one satellite in orbit (WYs 1985-86 to 1999-00 and 2012-13). Twice as many fSCA images are available in the other WYs during which two satellites were active. The internal Landsat cloud mask is used to remove areas and images significantly contaminated by clouds. In regions such as the Pacific Northwest, where cloudy days are common in the melting season, and in WYs when only one Landsat satellite is available, SWE artifacts caused by limited fSCA images may exist.

3 SOFTWARE AND TOOLS

The .nc data files can be opened using NetCDF visualization software such as Panoply or QGIS.

4 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
V1	26 April 2022	Initial release

5 RELATED DATA SETS

SnowEx at NSIDC | Data Sets
High Mountain Asia UCLA Daily Snow Reanalysis, Version 1

6 RELATED WEBSITES

SnowEx at NSIDC | Overview
NASA SnowEx

7 CONTACTS AND ACKNOWLEDGMENTS

Dr. Steven A. Margulis
University of California, Los Angeles (UCLA)

8 REFERENCES

Cortés, G., Girotto, M., & Margulis, S. A. (2014). Analysis of sub-pixel snow and ice extent over the extratropical Andes using spectral unmixing of historical Landsat imagery. Remote Sensing of Environment, 141, 64–78, https://doi.org/10.1016/j.rse.2013.10.023.

Farr, T. G., Rosen, P. A., Caro, E., Crippen, R., Duren, R., Hensley, S., Kobrick, M., Paller, M., Rodriguez, E., Roth, L., Seal, D., Shaffer, S., Shimada, J., Umland, J., Werner, M., Oskin, M., Burbank, D., & Alsdorf, D. (2007). The Shuttle Radar Topography Mission. Reviews of Geophysics, 45(2). https://doi.org/10.1029/2005RG000183

Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., et al. (2017). The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). Journal of Climate, 30(14), 5419–5454, http://doi.org/10.1175/JCLI-D-16-0758.1.

Hansen, M. C., Defries, R. S., Townshend J. R. G., & Sohlberg, R. (2000) Global land cover classification at 1 km spatial resolution using a classification tree approach, International Journal of Remote Sensing, 21:6-7, 1331-1364, https://doi.org/10.1080/014311600210209.

Liston, G. E. (2004). Representing Subgrid Snow Cover Heterogeneities in Regional and Global Models. Journal of Climate, 17(6), 1381–1397. http://doi.org/10.1175/1520-0442(2004)017<1381:RSSCHI>2.0.CO;2.

Margulis, S. A., Girotto, M., Cortés, G., & Durand, M. (2015). A Particle Batch Smoother Approach to Snow Water Equivalent Estimation. Journal of Hydrometeorology, 16(4), 1752–1772. http://doi.org/10.1175/JHM-D-14-0177.1.

Margulis, S. A., Liu, Y., & Baldo, E. (2019). A Joint Landsat and MODIS-Based Reanalysis Approach for Midlatitude Montane Seasonal Snow Characterization. Frontiers in Earth Science, 7, 4257. http://doi.org/10.3389/feart.2019.00272.

Painter, T. H., Dozier, J., Roberts, D. A., Davis, R. E., & Green, R. O. (2003). Retrieval of subpixel snow-covered area and grain size from imaging spectrometer data. Remote Sensing of Environment, 85(1), 64–77, https://doi.org/10.1016/S0034-4257(02)00187-6.

Sexton, J. O., Song, X.-P., Feng, M., Noojipady, P., Anand, A., Huang, C., Kim, D.-H., Collins, K. M., Channan, S., DiMiceli C., & Townshend, J. R. (2013) Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS vegetation continuous fields with lidar-based estimates of error, International Journal of Digital Earth, 6:5, 427-448, https://doi.org/10.1080/17538947.2013.786146.

Sun, S., & Xue, Y. (2001). Implementing a new snow scheme in Simplified Simple Biosphere Model. Advances in Atmospheric Sciences, 18(3), 335–354. https://doi.org/10.1007/bf02919314.

Xue, Y., Sun, S., Kahan, D. S., & Jiao, Y. (2003). Impact of parameterizations in snow physics and interface processes on the simulation of snow cover and runoff at several cold region sites. Journal of Geophysical Research: Atmospheres, 108(D22), 374. https://doi.org/10.1029/2002jd003174.

9 DOCUMENT INFORMATION

9.1 Publication Date

26 April 2022

9.2 Date Last Updated

26 April 2022