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# National Operational Hydrologic Remote Sensing Center SNOw Data Assimilation System (SNODAS) Products at NSIDC

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### **Citation**

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For additional information, or if you have questions about this document, please contact NSIDC User Services at [nsidc@nsidc.org](mailto:nsidc@nsidc.org).

## ***Background***

The National Snow and Ice Data Center (NSIDC) has an agreement with the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) to archive output from their SNOW Data Assimilation System (SNODAS) beginning 1 October 2003. This report gives a brief description of SNODAS and the output archived at NSIDC, identifies a set of potential users of this data and discusses these users' needs. The format of archived output is also discussed. This report is current as of its publication date. Details of the SNODAS products and the archive at NSIDC may change with time.

## ***SNODAS in Brief***

SNODAS is a modeling and data assimilation system developed by the NOHRSC to provide the best possible estimates of snow cover and associated variables to support hydrologic modeling and analysis. The aim of SNODAS is to provide a physically consistent framework to integrate snow data from satellite and airborne platforms, and ground stations with model estimates of snow cover (Carroll et al. 2001). SNODAS includes procedures to ingest and downscale output from Numerical Weather Prediction (NWP) models; a physically based, spatially-distributed energy- and mass-balance snow model; and procedures to assimilate satellite-derived, airborne and ground-based observations of snow covered area and snow water equivalent. The snow model has high spatial (1km) and temporal (1 hour) resolutions and is run for the conterminous United States. SNODAS is run each day, forced by downscaled output from the RUC2 NWP model. Each day, analysts decide whether or not to use remote sensing and ground based observations to update the snow water equivalent state in the model. Difference fields between model and observed snow water equivalent are generated. The model is then re-run for the last 6 hours of the hindcast step using scaled difference fields to 'nudge' model estimates of the snow water equivalent estimates. A 12 hour forecast of snow cover is then made using NWP model output. A more detailed description of SNODAS is given in Appendix A. Figure 1 is an example of the SNODAS snow water equivalent (SWE) field displayed as an image.

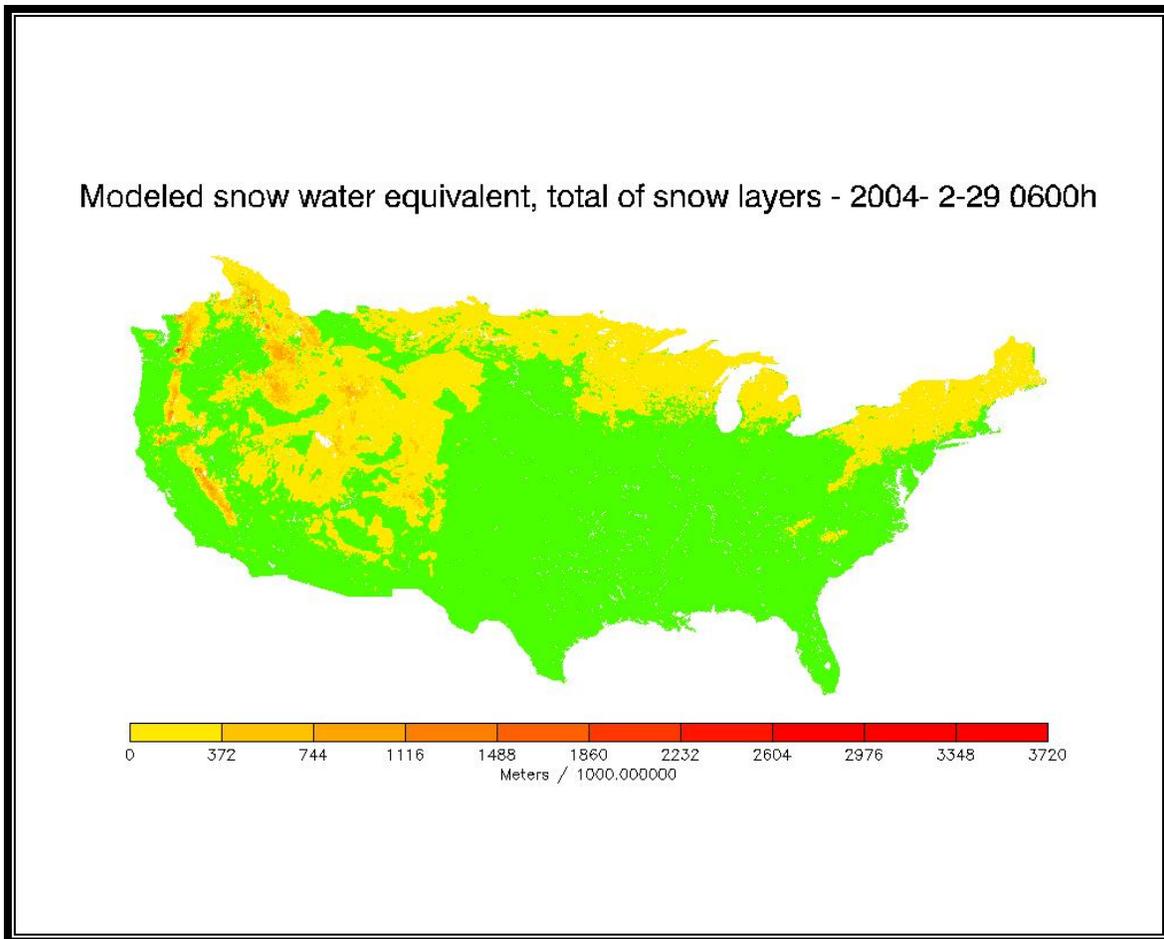


Figure 1: Sample snow water equivalent output from SNODAS

### ***The Products***

Seven driving, state and diagnostic variables are archived by NSIDC. Driving variables are ingested from the RUC2 NWP and used to force the snow model. State variables are defined here as variables that the snow model keeps track of and which describe the 'state' of the model snow pack. State variables are modeled snow pack characteristics that are also required to initialize the model. Diagnostic variables are model output but do not describe the internal state of the model. The variables archived by NSIDC are listed below.

1. Snow Water Equivalent (SWE); liquid and solid water in the pack (*State var.*)
2. Snow Depth (*State var.*)
3. Snow melt runoff at the base of snow pack (*Diag. var.*)
4. Sublimation from the snow pack (*Diag. Var.*)
5. Sublimation of blowing snow (*Diag. var.*)
6. Solid precipitation (*Driving var.*)
7. Liquid precipitation (*Driving var.*)
8. Snow pack average temperature (*State var.*)

The suite of variables archived at NSIDC can be used to compute a snow pack water balance. A complete list of model variables can be found in Table A1.

Fields representing the model state for 06:00 UTC are archived by NSIDC. The time 06:00 UTC was chosen because this is closest to midnight for the whole United States. The U.S. spans 70 W to 130 W. Snow data are for 01:00 local time for the East Coast and 22:00 for the West Coast.

SWE, snow depth, and snow pack average temperature represent the state of the snow pack at 06:00 UTC. Snow melt runoff, sublimation and evaporation, and precipitation variables that describe sources and sinks of snow pack water are integrated for the previous 24 hours, giving daily totals.

Note that output for 06:00 UTC is a best estimate of snow pack characteristics. Because SNODAS only updates snow fields once a day, 18 out of 24 time-steps in each day's model run do not use observations to update model estimates. Therefore, hourly data from SNODAS is model output only and does not represent the best possible estimate of the snow pack.

SNODAS output fields are supplied to NSIDC as flat binary grids with a header/metadata file. Data and header files for each field are tarred and zipped into a .grz file. Appendix B contains instructions for extracting grid and header files and ingesting data into workstation ArcInfo, ArcGIS and ENVI software packages.

Compressed file sizes of sample files are between 60kb and 317kb. Table 1 shows the size of uncompressed header and data files, and compressed tarred and zipped packages for sample data. Total size of all files is also given. The naming convention for files is explained in Appendix C. Compressed file sizes will vary depending on how many cells are snow covered.

Table 1. Sizes of uncompressed and compressed SNODAS output files.

<i>File name</i>	<i>Header file (kb)</i>	<i>Data file (Mb)</i>	<i>Compressed archive (kb)</i>
us_ssmv01025SIL00T0024TTNATS2003102305DP001.grz	3.6	46.5	274.8
us_ssmv01025SIL01T0024TTNATS2003102305DP001.grz	3.6	46.5	126.1
us_ssmv11034tS__T0001TTNATS2003102305HP001.grz	3.8	46.5	266.5
us_ssmv11036tS__T0001TTNATS2003102305HP001.grz	3.8	46.5	318.3
us_ssmv11038wS_A0024TTNATS2003102305DP001.grz	3.6	46.5	95.0
us_ssmv11039IL00T0024TTNATS2003102305DP000.grz	3.6	46.5	60.1
us_ssmv11044bS__T0024TTNATS2003102305DP000.grz	3.6	46.5	101.6
us_ssmv11050IL00T0024TTNATS2003102305DP000.grz	3.6	46.5	175.8
<b>Total</b>	<b>29.2</b>	<b>372.0</b>	<b>1418.2</b>

Header files contain information about creation and modification of each file, data type of each file, geo-referencing data, maximum and minimum values and any calibration/scaling information, and a time stamp for each field. Appendix D contains a sample header file.

Grids are 6935 columns by 3351 rows. Grid values are 2 byte integers. Fields are not projected but have geographic coordinates (Latitude and Longitude). Grid cells have a 30 arc second spacing (nominally 1km on the ground). Model output and precipitation variables are point estimates for the center of each grid cell and not an areal estimate. However, for the purposes of hydrologic and snow cover forecasts, these point estimates are assumed to represent average conditions in each grid cell.

### ***Potential Users***

SNODAS output archived at NSIDC will be primarily a research data set rather than an operational data set. NOHRSC provides SNODAS output in near-real time directly to operational users such as the Bureau of Reclamation and River Flow Forecast Centers.

Anticipated 'research' users of archived SNODAS output include hydrologists, hydrologic modelers, climatologists, ecologists, and land-surface modelers. Different users will require data in many different formats, map projections, spatial extents and time-scales. Hydrologic modelers will want high resolution, daily maps of snow cover to develop new basin-scale and distributed hydrologic models. Daily SNODAS output best suits their needs. Most of the model development work will be at the basin scale. Subsets of grids will be needed. Hydrologists and ecologists may want data summarized at the monthly or annual time step, also at the basin scale, to compute basin water balances. Climatologists require data for larger spatial regions at monthly and annual time-scales.

One potential user is the NASA GRavity And Climate (GRACE) mission. One of the goals of GRACE is to close the water balance over large scales. GRACE will provide an estimate of total change in water storage (from total change in mass determined from gravity fields). SNODAS output could be used by the GRACE mission in two ways. Estimates of SWE from SNODAS and estimates of other hydrological stores and fluxes could be used to 'forward-model' changes in water balance. These estimates of the water balance could be used to optimize techniques used to invert GRACE data. Another use of SNODAS and other data is to use them to 'strip-away' the better-known components of the water balance to examine the less well known components.

The U.S. Fish and Wildlife Service may also have a need for SNODAS data. Snow plays an important role in habitat dynamics, providing water and nutrients to soil and plants, a habitat to smaller mammals, and may prevent larger mammals from grazing. Currently available remote sensing data can provide snow cover information, but this information is often sparsely distributed in time because of cloud cover. Continuous fields of snow depth are not available at scales less than 25km. SNODAS products provide a spatially and temporally continuous estimate of snow cover, including snow depth and water equivalent.

SNODAS output has great potential to improve hydrologic forecasts and aid the development of distributed basin scale hydrologic models. Estimates of SWE can be used to initialize snow cover in stand-alone models. Alternatively, daily estimates of

snow melt from SNODAS can be used as input for models, circumventing the need for snow routines in these models. The 1km spatial scale and daily time step are sufficient for this need.

### ***Data Format***

Potential users may want data as flat binary files, quick-look style images or in a format that can be ingested directly into a GIS. Currently, SNODAS output is stored in flat binary files with a corresponding header file. Binary files can be read by user-written routines (e.g. Fortran and C programs), off the shelf image processing packages such as ENVI, IDL, MATLAB and ERDAS IMAGINE, and by GIS and other mapping packages such as GMT, GRASS and ARC/INFO. The header files contain information to georegister grids contained by the binary files.

Almost all GIS packages have tools to read binary grids. An example of one such tool is ARC/INFO's *imagegrid* tool. This tool ingests binary grids into ARC/INFO's GRID data format (see Appendix B). *Imagegrid* requires a separate header file that contains grid dimensions and georegistration information. All of this information is included in the header files that correspond to SNODAS output grids. Other GIS packages have similar tools. NSIDC may consider adding a help page for GIS users to read binary data into their chosen GIS package. Scripts or GIS specific macros to extract header information required by GIS packages would enhance the usability of flat binary SNODAS output for GIS users. Alternatively NSIDC may consider providing SNODAS fields directly in GIS package formats.

### ***Alternative Projections***

SNODAS fields are effectively grids of point estimates of snow cover. Estimates of SWE and snow depth, as well as other variables have no real areal extent. Therefore, projecting SNODAS output to a particular projection is unnecessary. Moreover, different users prefer different projections. For example, Federal agencies are likely to use the Albers Equal Area projection, while researchers may use an alternative projection such as the EASE-Grid. Given that SNODAS outputs are essentially point estimates, the decision to re-project and choice of projection can be left to individual users.

### ***Summaries for Monthly and Annual Timescales***

Some users may want model output summarized for monthly and annual timescales. NSIDC would enhance the data product by adding summaries generated on request or routinely. Some thought should be given to how these summaries are derived. Averages of cumulative processes such as accumulation and depletion of snow are inappropriate because snow depths and SWE include information about the state of the snow pack at previous time-steps. Additionally, in most snow climates, snow accumulation is the result of a few large storms, often during spring. Averages of snow accumulation will give more weight to low accumulation that dominates most of the year. One alternative approach is to use estimates of snow water equivalent and snow depth for the first day of each month for monthly summaries and April 1 for annual summaries, providing snapshots of the state of the snow pack. April 1 is chosen because it is assumed by most water resource managers to be the date closest to maximum accumulation in temperate latitudes of the northern hemisphere. Another alternative is to use annual maximum

accumulation of SWE or snow depth as the annual summary variable. Precipitation, snow pack and blowing snow sublimation (and condensation), and snow melt should be expressed as monthly and annual totals. This approach will allow monthly and annual snow water budgets to be computed relatively easily. Snapshots of snow accumulation and totals of precipitation and other fluxes to and from the snow pack will also provide meaningful information for users who are not interested in the water balance.

### ***Data Quality and Value***

Some preliminary validation of SNODAS output has been conducted in-house by NOHRSC. This validation is based on one or a few years (G. Fall, personal communication). Although data for one or two years can be used in case studies to compare model output with observations, it is unlikely that the accuracy of SNODAS output can be assessed properly until several tens of years of data have been collected. Model output archived at NSIDC will be required for validation efforts. It is important, therefore, that changes to the SNODAS model and updating routines, and inputs, are fully documented and available to any users.

Even with sufficient data, validation of SNODAS may be difficult because the data sets normally used to validate this output are assimilated into the product already. No independent validation data set is available at the scale of the output (i.e. 1km). One possible validation method is to use SNODAS output to compute runoff with a hydrologic model. Comparison of observed and simulated runoff could provide one estimate of the quality of SNODAS output at the drainage basin scale. This approach may be successful at annual timescales but less successful at shorter timescales because the timing of runoff is largely dependent on the hydrologic model used.

It should be emphasized that SNODAS output is model output updated with observations. Although this output provides a 'best-estimate' of the state of the snow pack, this estimate is dependent on the quality of driving variables from the NWP model, the functioning of the snow model, the procedures used to update model output with satellite and ground-based observations, and the quality of these observations. Where no observations are available to update the model, the 'best-estimate' is no better than a model estimate. It is therefore important to know when and where model data are updated with observations.

One of the snow covered area products assimilated into SNODAS that may result in poor estimates of snow cover is the NOHRSC snow maps. This product does not detect snow underneath forest canopy very well (Barrett et al. 2001, Bitner et al. 2002). Companion Advanced Very High Resolution Radiometer (AVHRR) products produced by the U.S. Army's Cold Regions Research and Engineering Laboratory that use the Rosenthal AVHRR algorithm have similar problems, as do products from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. In general, there is considerable uncertainty associated with satellite derived snow covered area maps where trees are present. Satellites only 'see' snow through gaps in the forest canopy. In spring, in areas of dense canopy, only a small amount of snow is visible to satellite sensors. Much of the reflected radiance is from the canopy itself which will not be snow covered at this time. Therefore areas of dense forest canopy are classified as being free of snow while large amounts of snow remain on the ground beneath the canopy. Ground beneath forest canopies often remains snow covered for longer than ground with no forest canopy. In the Inter-Mountain West and other mountain regions, large areas of drainage basins are

covered by trees. This results in a considerable underestimate of snow covered area and snow volume. This issue, along with others, will need to be addressed through validation.

### ***Alternative Products***

Currently, no alternative products of this type at the same spatial scale and extent, and temporal frequency are available. Satellite derived maps of snow covered area are available but lack the frequency because of cloud cover. Satellite derived estimates of SWE have much larger spatial scales.

### ***References***

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## **Appendix A: Detailed Description of SNODAS**

The Snow Data Assimilation System (SNODAS) has been developed by the National Operational Hydrologic Remote Sensing Center to provide the best possible estimate of snow cover in the United States. SNODAS has three components: a data ingest, quality control and downscaling component for meteorological information from numerical weather prediction models; a snow mass and energy balance model; and data assimilation routines to update snow model estimates of snow pack variables with satellite, airborne, and ground-based observations of snow covered area, snow depth and snow water equivalent. The snow mass and energy balance model forms the core of the system. The snow model is run daily at hourly increments at 30 arc second resolution (nominally 1km) for the conterminous U.S. The snow model is run with temperature, wind, relative humidity, pressure and precipitation analyses from the RUC2 numerical weather prediction model (Benjamin and others 2002).

The snow model is a multi-layered, spatially distributed but uncoupled energy and mass balance model. There are 3 snow layers and 2 soil layers. The thermal dynamics of the model are based on SNTHERM.89 (Jordan 1990). The model computes snow pack state variables (snow water equivalent, internal energy, thickness, average temperature and unfrozen fraction of water) for each layer. Total snow water equivalent in the snow pack, snow thickness, melt water runoff from the base of the pack, and snow surface to atmosphere fluxes (sublimation of saltated and suspension transported snow, evaporation and condensation) are among the diagnostic/prognostic variables (see table A1 for a full listing of driving, state and diagnostic variables).

The snow model is run daily at 1 hour time steps. A mass and energy balance is computed for each grid point. Model estimates of snow water equivalent and thickness are then updated with ground-based and remotely sensed observations. The assimilation procedure is a simple nudging or Newtonian Relaxation Procedure. Differences between estimated and observed values are first computed. Difference fields are analyzed manually to identify regions to update. Satellite data is used to identify snow-no snow boundaries where cloud free images are available. All differences are computed for observation points. Differences are then interpolated to the model grid. All observations within the last 18 hours are candidates for assimilation. Difference fields are then divided by 6 to produce mean hourly nudging fields (the increment by which model estimates are 'nudged'). The model is then re-run for the last 6 hours. At the end of each model time step (1 hour) estimated state variables are 'nudged' using the 'nudging fields'. When there are large amounts of cloud cover, only station observations of snow variables are used. This avoids problems with misclassification of clouds when large amounts of clouds are present.

Table A1. Snow model parameters and variables (after Carroll et al. 2001).

---

### ***Parameters***

Forest cover fraction

Soil bulk density

Soil plasticity

### ***Driving variable***

Surface zonal wind  
Surface meridional wind  
Surface air temperature  
Surface relative humidity  
Snow precipitation  
Non-snow precipitation  
Solar radiation

***State variables***

Snow water equivalent  
Snow pack internal energy  
Snow pack thickness  
Snow pack average temperature  
Snow pack unfrozen fraction

***Diagnostic variables***

Blowing snow sublimation rate  
Compaction rate  
Conductive heat flux  
Convective water flux  
Latent heat flux  
Melt rate  
Net convective water flux  
Net convective water heat flux  
Net long wave radiation flux  
Net solar radiation flux  
Sensible heat flux  
Snow pack sublimation rate  
Snow pack surface temperature  
Vapour diffusion flux

---

## ***Appendix B: Instructions to Extract and Ingest SNODAS Data into GIS or Image Processing Software***

### **Extract the data and header files**

SNODAS files archived at NSIDC contain two files; a data file (.dat) and a metadata (header) file (.Hdr). These two files are archived using the UNIX command tar and zipped using gzip. These tarred and zipped files have the extensions .grz. This extension will have to be renamed before the files can be extracted. The following instructions apply to a Unix machine.

1 - change file name to filename.tar.gz

```
mv filename.grz filename.tar.gz
```

2 - unzip and extract the two files

```
gzip -dc filename.tar.gz | tar xf -
```

The .dat file is a binary file that contains the gridded data. The .Hdr file is a metadata file that includes information about data type, units, grid size, projection and location.

### **Ingesting the data into Workstation ArcInfo or ArcGIS**

Gridded data can be ingested into the ArcInfo or ArcGIS packages using the IMAGEGRID command (ArcGIS does not include documentation for this command but the command does exist). The following commands are for Workstation ArcInfo but should work on ArcGIS. The name of the data file must be changed from .dat to .bil and a .hdr file containing grid dimensions and georeferencing information must be generated before the IMAGEGRID command is given. The .hdr file should have the same root name as the data file (e.g. filename.bil and filename.hdr). The hdr file is an ASCII text file and can be created in a text editor such as vi or emacs on UNIX or Windows Notepad. Do not use a word processor.

1 - Change .dat filename to .bil

```
mv filename.dat filename.bil
```

2 - Create .hdr file

Here is an example header file:

```
byteorder M
layout bil
nbands 1
nbits 16
ncols 6935
nrows 3351
ulxmap -124.729583333331703
ulymap 52.871249516804028
xdim 0.008333333333
ydim 0.008333333333
```

This example header file should work for any SNODAS grid. It can be cut and pasted into a text editor and saved as filename.hdr where filename is the same root filename as the .bil file. Values for the .hdr can be found in the original SNODAS .Hdr file (see Appendix D)

- byteorder - is the byte order in which image pixel values are stored (M - Motorola or big-endian, I - Intel or little-endian.)
- layout - The organization of the bands in the image. These grids only have one band but layout is set to bil (Band Interleaved by Line) in the example.
- nbands - number of bands in grid (only 1).
- nbits - number of bits per value. This can be found from the .Hdr file line 'Data bytes per pixel'. Nbits is two in this example. Therefore there are 2\*8 bits per pixel/value.
- ncols - number of columns in the grid. This is found on the 'Number of columns' line of the .Hdr file and is 6935
- nrows - number of rows in the grid. This is found on the 'Number of Columns' line of the .Hdr file and is 3351
- ulxmap - the x-axis coordinate of the center of the upper left hand cell. This is given in the 'Benchmark x-axis coordinate' of the .Hdr file line and **\*\*not\*\*** the 'Minimum x-axis coordinate' which is the left edge of the upper left hand cell.
- ulymap - the y-axis coordinate of the center of the upper left hand cell. This is given in the 'Benchmark y-axis coordinate' line of the .Hdr file and **\*\*not\*\*** the 'Maximum y-axis coordinate' line which is the top of the upper left hand cell.
- xdim - the size on the x-axis of each pixel/cell in map units. In the case of the SNODAS data this is degrees and is given in the 'X-axis resolution' line of the .Hdr file
- ydim - the size on the y-axis of each pixel/cell in map units. In the case of SNODAS data this is degrees and is given in the 'Y-axis resolution' line of the .Hdr file.

### 3 - import data to Arc/Info

At the command line in arc type imagegrid to get a usage

```
Arc: imagegrid
```

```
Usage: IMAGEGRID <in_image> <out_grid | out_stack>
{out_colormap_file} {in_band} {NEAREST | BILINEAR | CUBIC} {DEFAULT
| SQUARE}
```

Only the first two arguments are needed

```
Arc: imagegrid filename.bil outgrid
```

This will produce an ArcInfo Grid.

```
Arc: listgrids
```

```
Workspace: /HOME/PEOPLE/APBARRET/PROJECT/NOHRSC_EVAL/NEW_DATA/TEMP
```

```
Available GRIDS-----
```

```
GRID
```

```
Arc: describe grid
```

```

                                Description of Grid grid
Cell Size =                    0.008      Data Type:                Integer
Number of Rows =               3351      Number of Values =        248
Number of Columns =            6935      Attribute Data (bytes) =    8
```

```

                                BOUNDARY STATISTICS
Xmin =      -124.734           Minimum Value =      0.000
Xmax =      -66.942           Maximum Value =     55537.000
Ymin =       24.950           Mean =                26775.734
Ymax =       52.875           Standard Deviation =  27746.006
NO COORDINATE SYSTEM DEFINED

```

Note. There is no projection defined. In workstation Arc/Info this can be done using the command projectdefine

```

Arc: projectdefine
Usage: PROJECTDEFINE <COVER | GRID | FILE | TIN> <target>
Arc: projectdefine grid grid
Define Projection
Project: projection geographic
Project: units dd
Project: datum wgs84
Project: parameters
Arc: describe grid

```

```

                                Description of Grid grid
Cell Size =          0.008      Data Type:          Integer
Number of Rows =     3351      Number of Values =  248
Number of Columns =  6935      Attribute Data (bytes) = 8

```

```

                                BOUNDARY STATISTICS
Xmin =      -124.734   Minimum Value =      0.000
Xmax =      -66.942   Maximum Value =     55537.000
Ymin =       24.950   Mean =                26775.734
Ymax =       52.875   Standard Deviation =  27746.006

```

```

                                COORDINATE SYSTEM DESCRIPTION
Projection      GEOGRAPHIC
Datum           WGS84
Units          DD              Spheroid WGS84
Parameters:

```

## Ingesting the data into ENVI

- 1 - From the **File Menu** select **Open Image File** and then select the data grid. The Available Bands window will pop-up.
- 2 - Highlight/select the image band and then click **Load Band**
- 3 - Three windows will pop up; a scroll window, an image window and a zoom window.

The black shape of the US surrounded by white should be visible. Select the **Enhance Menu** in the image window tool bar and one of the stretches to see some snow. The **Linear 1-255** enhancement stretch works well.

OR

Select **Color Mapping** from the Tools menu in the image window tool bar and select **Density Slice**.

4 - To georeference the grid, left click on the image name in the Available Bands window and select **Edit Header**. The Header Info box will appear. All the georeferencing information that you need is contained in the .Hdr that corresponds to the grid you have displayed.

5 - Select **Edit Attributes** and then select **Map Info** from the menu that appears.

6 - Select **Change Proj** to change the projection. The grid is not projected and is a regular lat-lon grid so select *Geographic Lat-Lon*. Make sure the **Datum** is *WGS84* and the **Units** are *Degrees*. The datum for a grid is specified in the 'Horizontal datum' line in the .Hdr file. Click **OK**

7 - The **Image Coord X** and **Image Coord Y** are the column and row indices of the cell with the geographic coordinates entered in the projection box. Set the **Image Coord X** and **Image Coord Y**. **Image Coord X** and **Image Coord Y** correspond to the 'Benchmark column' and 'Benchmark row' lines in the .Hdr file. However, you need to set **Image Coord X** and **Image Coord Y** to 0.5 because the geographic coordinates in 'Benchmark x-axis coordinates' and 'Benchmark y-axis coordinates' are for the center of the upper left cell.

8 - Set **Pixel Size X** and **Pixel Size Y**. The cell size for the SNODAS grid is given in the 'X-axis resolution' and 'Y-axis resolution lines' of the .Hdr file. Both X and Y pixel sizes of SNODAS grids are 0.0083333 (30 arc seconds).

9 - Set the **Geographic Coordinates** of the **Image Coord X** and **Image Coord Y**. Geographic coordinates are set in the two left hand boxes below the projection information. Geographic coordinates are given in the 'Benchmark x-axis coordinate' and 'Benchmark y-axis coordinate' lines of the .Hdr file.

10 - The grid has now been georegistered. Click **OK** in the Map info dialog box and OK in the Header Info box.

Note. If you already have an Arc/Info header file for the image you are displaying in Envi, Envi will overwrite this file with its own header file. So save the Arc/Info header file to something like filename.hdr.arc.

## **Appendix C: NOHRSC SNODAS Output Naming Convention**

This description of the NOHRSC SNODAS output file naming convention is based on correspondence with NOHRSC. Data files and header files share the same file name but data files have the suffix **.dat** and header files have the suffix **.Hdr**. Data and header files are tarred and zipped and named **.grz**.

File names have the following format:

**rrmmmfppppSvvvvttttooooooIIIOOOO.grz**

**r** - is the region of the file. This code should always be **us** for the U.S.A.

**m** - is the model used to generate the estimates. Currently, this is **ssm** for "simple snow model".

**f** - signifies if the file contains snow model driving data or model output;

**v0** is driving data (precipitation etc.)

**v1** is operational snow model output.

**p** - product code:

**1025** - precipitation

**1034** - snow water equivalent

**1036** - snow depth

**1038** - snow pack average temperature

**1039** - blowing snow sublimation

**1044** - snow melt

**1050** - snow pack sublimation

**S** - denotes driving variables have been downscaled from NWP model resolution to the resolution of SNODAS. This code only appears in filenames for driving variables.

**v** - a vertical integration code that denotes where in the snow pack data is from.

For precipitation data:

**IL00** - non-snow (liquid) precipitation

**IL01** - snow precipitation.

For snow model outputs:

**IL00** - fluxes to and from the snow surface (e.g. Sublimation)

**tS\_\_** - the integral through all the layers of the snow pack.

**bS\_\_** - the bottom of the snow pack (e.g. snow melt)

**t** - a time integration code.

**T0024** - a quantity integrated over 24 hours (generally used for mass and energy fluxes).

**T0001** - a one-time snapshot (generally used for states, e.g. SWE)

**o** - a detail of snow modeling operations and will always be **TTNA**.

**d** - a time-stamp of the form **TSyyyymmddhh**. The time refers to the start of the last time step of the integration period for which this data applies. For example the time integration **T0024** and time step code **TS2003102305** is data for the time integral 2003-

10-22 06 to 2003-10-23 05.

**I** – denotes hourly **H** and daily **D**. In general, **H** is associated with rasters with a time integration code **T001** and **D** is associated with rasters with a time integration code **T0024**.

**O** – is an offset code of the form **P{offset}** and refers to where the data applies during a snow model time step in the snow model's differencing scheme.

**P001** denotes that a field represents a total flux for the entire time step (e.g. Precipitation) or that a field represents data at the end of a time step.

**P000** denotes a field of data from the start of a time step.

Example: us\_ssmv11034tS\_\_T0001TTNATS2003102305HP001.grz is modeled snow water equivalent (**ssmv11034**) summed for all the layers of the snow model (**tS\_\_**). It is the output from just one hour (**T0001**), representing the time step starting at 2003-10-23 0500h (**TS2003102305**), is potentially generated for every hour of the day (**H**) and represents the snow an hour after the start of the time step (**P001**). E.g. SWE at 0600h.

## **Appendix D: Example of a NOHRSC SNODAS Header File**

Format version: NOHRSC GIS/RS raster file v1.1  
Data source: RUC2, NESDIS, etc.  
Created by module: sm\_products  
Created by module comment: number BARD codes: 0000000018 BARD codes:  
58131678 58131679 75931875 37109162 58131676 18681689 87298325 5777000  
58131674 68726564 9160380 87295989 12222 92757697 90881019 88954851  
88955144 12229  
Created year: 2003  
Created month: 10  
Created day: 23  
Created hour: 8  
Created minute: 53  
Created second: 21  
Last modified by module: sm\_products  
Last modified by module comment: Not applicable  
Last modified year: 2003  
Last modified month: 10  
Last modified day: 23  
Last modified hour: 8  
Last modified minute: 53  
Last modified second: 21  
Satellite data: no  
Satellite name: Not applicable  
Satellite channel: 0  
Satellite data calibrated: no  
Description: Modeled snow water equivalent, total of snow layers  
Thematic: no  
Theme file: Not applicable  
Data units: Meters / 1000.000000  
Product code: 96687381  
Attribute table: Not applicable  
Data file pathname: us\_ssmv11034tS\_\_T0001TTNATS2003102305HP001.dat  
Data type: integer  
Data bytes per pixel: 2  
Data intercept: 0.0000000000000000  
Data slope: 1.0000000000000000  
Minimum data value: 0.0000000000000000  
Maximum data value: 504.0000000000000000  
No data value: -9999.0000000000000000  
Number of columns: 6935  
Number of rows: 3351  
Geographically corrected: yes  
Projected: no  
Projection file: Not applicable  
Horizontal datum: WGS84  
Horizontal precision: 0.0083333333333333  
Elevation above datum: no  
Vertical datum: Not applicable  
Vertical precision: 0.0000000000000000  
Benchmark column: 0  
Benchmark row: 0  
Benchmark x-axis coordinate: -124.7295833333331703  
Benchmark y-axis coordinate: 52.871249516804028  
X-axis resolution: 0.0083333333333333  
Y-axis resolution: 0.0083333333333333  
X-axis offset: 0.0037499999996645  
Y-axis offset: -0.003750483193850  
Minimum x-axis coordinate: -124.733749999998366  
Maximum x-axis coordinate: -66.942083333334011  
Minimum y-axis coordinate: 24.950416183471813  
Maximum y-axis coordinate: 52.875416183470698  
Start year: 2003

Start month: 10  
Start day: 23  
Start hour: 6  
Start minute: 0  
Start second: 0  
Stop year: 2003  
Stop month: 10  
Stop day: 23  
Stop hour: 6  
Stop minute: 0  
Stop second: 0  
Compressed: no  
Compression file: Not applicable  
Number of color tables: 0  
Color table 01 descriptor: Not applicable  
Color table 02 descriptor: Not applicable  
Color table 03 descriptor: Not applicable  
Color table 04 descriptor: Not applicable  
Color table 05 descriptor: Not applicable  
Color table 06 descriptor: Not applicable  
Color table 07 descriptor: Not applicable  
Color table 08 descriptor: Not applicable  
Color table 09 descriptor: Not applicable  
Color table 10 descriptor: Not applicable  
Color table 11 descriptor: Not applicable  
Color table 12 descriptor: Not applicable  
Color table 13 descriptor: Not applicable  
Color table 14 descriptor: Not applicable  
Color table 15 descriptor: Not applicable  
Color table 16 descriptor: Not applicable  
Color table 01 file: Not applicable  
Color table 02 file: Not applicable  
Color table 03 file: Not applicable  
Color table 04 file: Not applicable  
Color table 05 file: Not applicable  
Color table 06 file: Not applicable  
Color table 07 file: Not applicable  
Color table 08 file: Not applicable  
Color table 09 file: Not applicable  
Color table 10 file: Not applicable  
Color table 11 file: Not applicable  
Color table 12 file: Not applicable  
Color table 13 file: Not applicable  
Color table 14 file: Not applicable  
Color table 15 file: Not applicable  
Color table 16 file: Not applicable  
Histogram: no  
Histogram file: Not applicable