



ARSET Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

🍠 @NASAARSET

ta Helen

Parque Naciona

Overview of NASA Snow Products

www.nasa.gov



To be able to access NASA snow cover and snow water equivalence (SWE) data useful for climate monitoring and for water resources management, e.g. snow-fed river management.

Outline

- Remote Sensing of Snow
- NASA Snow Products from Satellites and Earth Systems Models
- MODIS Snow Data Products and Access

Remote Sensing of Snow

Definitions

What is ice?

• When a mass, layer, or surface of water freezes into a solid at cool temperatures

What is snow?

- Deposition: when water vapor freezes directly into ice crystals
- Snowflakes are the aggregation of many ice crystals
- Snowfall is when snowflakes precipitate out of clouds

Sea Ice



Snow on Mountains



Need for Snow Measurements

Important measurements to know about snow covered areas:

- Starting and remaining snow coverage
- Reduction in snow cover
- Rate of snowmelt

Snow Dominated Regions of the World



Figure courtesy Tim Barnett (Scripps Inst. Ocean)

Remote Sensing Approach



Energy is emitted by the Sun as well as planet sources The energy is transmitted and scattered by the atmosphere and reflected from the surface The imaging sensor responds to the energy (L) within a field-of-view and spectral range Sensor signal is digitized and relayed to the ground and recorded The signal is calibrated, processed, and analyzed to answer the questions of interest

Snow Properties

- Snow covered surfaces affect albedo – fraction of solar radiation reflected back into space
- Size of snow particles influences albedo
- Snow cover can highly vary in space-time



Single Scattering by Snow Particles



Multiple Scattering by Snow Particles



Snow Reflectance

Satellite sensors measure solar radiation scattered by snow



Benefits of Remote Sensing Measurements of Snow Cover

- Surface-based snow sensors collect point measurements and fail to provide accurate spatial distribution of snow
- Snow sensors do not cover the highest mountain elevations
- Remote sensing provides continuous spatial coverage and provides observations in hard to reach areas



Fractional snow cover from Landsat TM on July 2 and 18, 2011

NASA Snow Products from Satellites and Earth System Models

NASA Snow Products Available from Satellites

Satellite	Sensors	Quantities			
Terra	 MODerate Resolution Imaging Spectroradiometer (MODIS) 				
Aqua	500m spatial resolution~daily temporal resolution				
NPOESS Preparatory Project (NPP) - Sumoi	 Visible Infrared Imaging Radiometer Suite (VIIRS) 750m spatial resolution ~daily temporal resolution 	 Snow covered area Snow albedo Snow grain size Dust/BC radiative forcing 			
Landsat Data Continuity Mission (LDCM) (launch Feb 2013)	 Operational Land Imager (OLI) 30m spatial resolution 16 day temporal resolution 				

NASA Snow Products: Models

Snow Product	Source	Spatial Temporal						
Snow Fall (kg/m ² /second) Snow Depth Snow Mass	MERRA* GLDAS-NOAH	 0.5°x0.625°, monthly (1980-02/2016) 0.125°x0.125° and 1°x1°, 3-hourly (1948-05/2016) 						
Snow Water Equivalent* (kg/ m ² or m)	GLDAS-NOAH	 0.125°x0.125° and 1°x1°, 3-hourly (1948-05/2016) 						

*MERRA: Modern-era Retrospective Analysis for Research and Applications *Snow Water Equivalent is the depth of water to which a snowpack melts down

MODIS Snow Data Products and Access

Parque Estadual

MODIS Snow Cover Data Products

- High resolution, daily coverage
- 1999 present
- Available at 500m and 0.05°
- There are two snow cover products based on MODIS Spectral Reflectance:
 - Standard MODIS Product Fractional Snow Cover
 - MODSCAG (MODIS Snow Covered Area and Grain-size) Product
 - Fractional snow cover, grain size, snow water equivalent (SWE)



MODIS Standard Products

http://nsidc.org/data/modis/data_summaries#snow

Snow Cover

Version 6 Version 5

The following Version 6 snow cover data sets are currently available at NSIDC. This table will be updated as new data sets are released. NSIDC will continue to distribute Version 5 until Version 6 reprocessing is complete.

MOD products are								
from Terra and								
MYD are from								
Aqua								

ID	Version	Title	Spatial Resolution	Temporal Resolution	Parameters		
MYD10_L2	6	MODIS/Aqua Snow Cover 5-Min L2 Swath 500m, Version 6	500 m	5 minute	Snow Cover		
MOD10_L2	6	MODIS/Terra Snow Cover 5-Min L2 Swath 500m, Version 6	500 m	5 minute	Snow Cover		
MYD10A1	6	MODIS/Aqua Snow Cover Daily L3 Global 500m Grid, Version 6	500 m	1 day	Albedo, Snow Cover		
MOD10A1	6	MODIS/Terra Snow Cover Daily L3 Global 500m Grid, Version 6	500 m	1 day	Albedo, Snow Cover		
MYD10C1	6	MODIS/Aqua Snow Cover Daily L3 Global 0.05Deg CMG, Version 6	0.05 Deg	1 day	Snow Cover		
MOD10C1	6	MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG, Version 6	Cover Daily L3 0.05 Deg 1 day G, Version 6		Snow Cover		
MYD10A2	6	MODIS/Aqua Snow Cover 8-Day L3 Global 500m Grid, Version 6	500 m	8 day	ay Snow Extent		
MOD10A2	6	MODIS/Terra Snow Cover 8-Day L3 Global 500m Grid, Version 6	500 m	8 day	Snow Extent		

MODIS Standard Products: Access

Available to Download from National Snow and Ice Data Center

http://nsidc.org/

Get Data



Data are in HDF format

- FTP jpg images of Level-2 and Level-3 snow cover
- Download by using Reverb or Earth Data Search (user registration required)

MODIS Standard Products Access from Reverb

http://reverb.echo.nasa.gov/reverb/



Near Real-Time MODIS Snow Cover

http://lance-modis.eosdis.nasa.gov/

	LANCE-MODIS
÷ At	+ DATA PRODUCTS + USER SERVICES
+Home	LANCE-I ODIS will execute as a 7x24 base basis LANCE-MODIS has two standalone systems that us different network routes. It is expected that this redundancy will reduce the system downtime to less than 1%.
About	Whereas the standard MODIS forward processing acquires 2-hour L0 files for Aqua and Terra from EDOS within 7-8 hours of real time, LANCE-MODIS acquires session-based L0 files from EDOS and the end of th session is available within 10-30 minutes after real time. LANCE-MODIS uses the Terra attitude an ephemeris data entrained in the L0 data. However, for Aqua the attitude and ephemeris data are acquire from the EDOS rate buffer. All of the MODIS Level 1 (L1), L2, and L3 products generated by LANCE-MODIS have been modified to add "NRT" metadata to the filenames to enable the products to be distinguished from the data suppliers. The production rules for some of the science codes have been relaxed with respect to these ancillary data to allow the data products to be generated within 3 hours of real time.
	Data products are archived in a rolling archive for 7+ days and are available for distribution by direct access t the FTP sites.
	LANCE-MODIS Details: • Hardware Configuration • Data Flows for MODIS • Distribution and Latency Metrics

Near-real Time MODIS Snow Cover

http://lance-modis.eosdis.nasa.gov/

Level-2 Swath Data 500m and 5km Resolution Snow Cover

Terra

Aqua

L2 Snow Cover, 5-Min Swath 500m	MOD10_L2	0.26	L2 Snow		07	0:46 1:32 (8) 3:14		L2 Snow Cover, 5-Min Swath 500m	MYD10_L2	0.26	L2 Snow			1:00	1:47 (25)	3:30
L2 Coarse Snow Cover, 5-Min Swath 5km	MOD10L2C	0.17	Cover Browse	N/A		0:46 1:32 (8)	3:14	L2 Coarse Snow Cover, 5-Min Swath 5km	MYD10L2C	0.17	Cover Browse	N/A	07	1:00	1:47 (25)	3:30

MODSCAG Snow Products

- Uses the MODIS surface reflectance bands
- Matrix inversion to retrieve fraction of snow cover in each pixel
- Also determines the grain size and albedo of that fractional snow cover (giving what modelers want, not the composite)
- More accurate than the standard MODIS snow cover

MODSCAG Products



MODSCAG Snow Data Products Examples

MODSCAG retrievals, Sierra Nevada, April 1, 20015



100% Snow Cover 100% Vegetation Cover 100% Rock Cover **Snow Grain Size**

MODSCAG Data Access

http://snow.jpl.nasa.gov/portal/

Available from JPL Snow Data Server





MODSCAG Data Access

http://snow.jpl.nasa.gov/portal/data/map/



MODSCAG-Derived Snow Water Equivalence

• Derived from snow cover, grain size, and albedo



https://instaar.colorado.edu/uploads/ research/labs-groups/mountainhydrology-group/ 20140216_real_time_swe_report.pdf

MODSCAG Application



Integration of Precision NASA Snow Products with the Operations of the Colorado Basin River Forecast Center (CBRFC) to Improve Decision Making Under Drought Conditions

Principle Investigator: Thomas Painter, Jet Propulsion Laboratory

Abstrac

The Colonado Basin River Forecast Center (CBRFC) is responsible for the entire Colorado Basin (CR8) and the eastern Great Basin (GB). From a water management prepared/we, the commitment of water to avecus usern and other occurs in the spin, and is almost enterly based on estimates of the western USA knowpack. Improving seasonal drought predictions requires use of models that provide physically realistic simulations of fundamental hydrologic processes. Among these, for the western USA, recompanion of a novi we physically malistic simulations of fundamental hydrologic processes. Among these, for the western USA, recompanion of anovi ta physically malistic simulations of fundamental hydrologic processes. Among these, for the western USA, recompanion of anovi ta physically malistic simulations of fundamental hydrologic processes. Among these, for the western USA, recompanion of anovi ta physically malistic simulations of fundamental hydrologic processes. Among these of the western USA, recompanion of anovi ta physically malistic simulations of fundamental hydrologic processes. Among these of the western USA recompanion of anovi ta physically malistic simulations of fundamental hydrologic processes. Among these of the western USA recompanion of anovi ta physically malistic simulations of fundamental hydrologic physically malistic simulations of the western tabulance of the simulations of the simulations of the section of the simulations of the section of the section of the simulation of the simulation of the simulations of the simulations of the section of the simulation of the simulation of the simulation of the section of the secti

As drought frequency increases in the CRB and GB, it is critical that the CRFEC and the dependent water managers have more comprehensive real-lines throwhold or the serve over and its properties for more proceise numfor forceasing and stakehold reclaions support. The primary objective of this proposal is in to integrate mail-time high protection MODIS Snow Covined Area and Grain size (MODSCAG) insclined innov coviered area (SCA) MIC CRFEC modeling and analysis systems and into stakehold covincies data products, disastically reducing SCA uncertainties that have hampend forceasting operations for decades A secondary objective is to ingest and study MODIS Dust Radiative Forcing in Snow (MODDRFS) radiative forcing imagery, to better understand its value as a found to modeling and forceasting approaches.

This collaboration directly addresses drought prediction, assessment, astipation, and mitigation in support of energy security efficiency, natural resource conservation; and household, minicipal, houthail, and in-terms demands for water. I will also inprove access and evaluability of actionable water monitoring, house security approximation, its down clover and that threining products with agenerated and definituati in ease real-time monitoring. In the security approximation is down clover and that threining products with agenerated and definituation in the ageneration provides and the security approximation is down clover and that threining products with agenerated and definituation in agenerations institutional horne to maintain the advances of the effort beyond the project = end.

+ to

- Decision Making for River Basin Management
 - MODSCAG
 - Snow and Dust Radiative Forcing Information
 - Colorado Basin River Forecast Center (CBRFC)

Limitations of MODIS Snow Data

- No mapping under cloud cover
- Geometric considerations
- Noise considerations

SMAP Freeze/Thaw Product

Abrque Estodual

Detecting Freeze/Thaw State with Microwave Remote Sensing



Detecting Freeze/Thaw State with Microwave Remote Sensing



SMAP Freeze/Thaw

- Indicates whether the land surface is frozen or thawed (includes snow melt)
- Characteristics
 - 36km resolution
 - Spatial repeat every 3 days
 - Binary measurement indicating frozen or thawed



Demonstration of JPL Snow Server

Parque Estodual