

Snow Today

Delivering impactful information on snow cover and albedo to diverse global users through web based big data visualizations.

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Objective

Snow Today is a leading source of cutting-edge environmental data products on seasonal snow. This NASA funded website is used by scientists, water resource managers, and recreationalists for up to date information on the state of seasonal snow at the basin to regional level. A new round of NASA funding is enabling us to expand the scope of the Snow Today website. The website is expanding in spatial domain from Western US coverage to all of North America, Greenland, and High Mountain Asia. In addition, spatial products currently limited to snow covered area and snow cover days are expanding to include snow albedo and spatial/temporal uncertainty quantification for all products. The existing web design and data processing pipeline will not support the new expanded scope required by NASA. We are revising the Snow Today website and need Mater of Environmental Data Science students to determine how to best display these global data and information on the new Snow Today website. The objective of this proposal is:

Interactive prototype web application of updates to Snow Today data visualization webpages.

Significance

Earth's cryosphere is changing. Duration of snow cover has become shorter (1, 2), and earlier onset of snowmelt and more frequent rain-on-snow lead to earlier streamflow in snow-dominated basins (3). Climate models show more countries will experience water stress in the future, particularly those that rely on melt of snow and ice (4). Observations of glaciers show mass loss in most regions (5), and land ice loss directly contributes to rising sea level (6). The high albedo of snow – and the anthropogenic forcing's that reduce it – play a significant role in Earth's climate. Because of the vast area of earth covered by snow, small decreases in snow albedo over the Northern Hemisphere are twice as effective as a doubling of CO₂ at raising global air temperature (7). For example, during the COVID-19 lockdowns, a cleaner snowpack, presumably from a reduction in anthropogenic emissions, resulted in 6.6 km³ of snow/ice remaining frozen instead of melting in the Upper Indus basin in High Mountain Asia (8). Understanding the current state and trajectory of global snow cover and snow albedo is critical for understanding global climate change and the impacts that changes will have on the lives of billions.



Figure 1. Northern hemisphere snow, a globally significant climate forcing and water supply for billions.

Background

Space borne instruments monitor snow surface properties such as snow cover fraction, snow albedo, snow grain size, and snow surface temperature (9-15). The high reflectivity of snow in visible and near infrared wavelengths, and low reflectivity in the shortwave infrared where typical multispectral sensors measure make snow easy to distinguish from other land surfaces. These observations can be used to: A) better understand the temporal and spatial distribution of snow, B) drive energy balance models to

estimate snow water volume (SWE), C) calibrate/validate models of snow cover, albedo, or snow volume, or D) directly improve SWE and melt estimates in existing models.

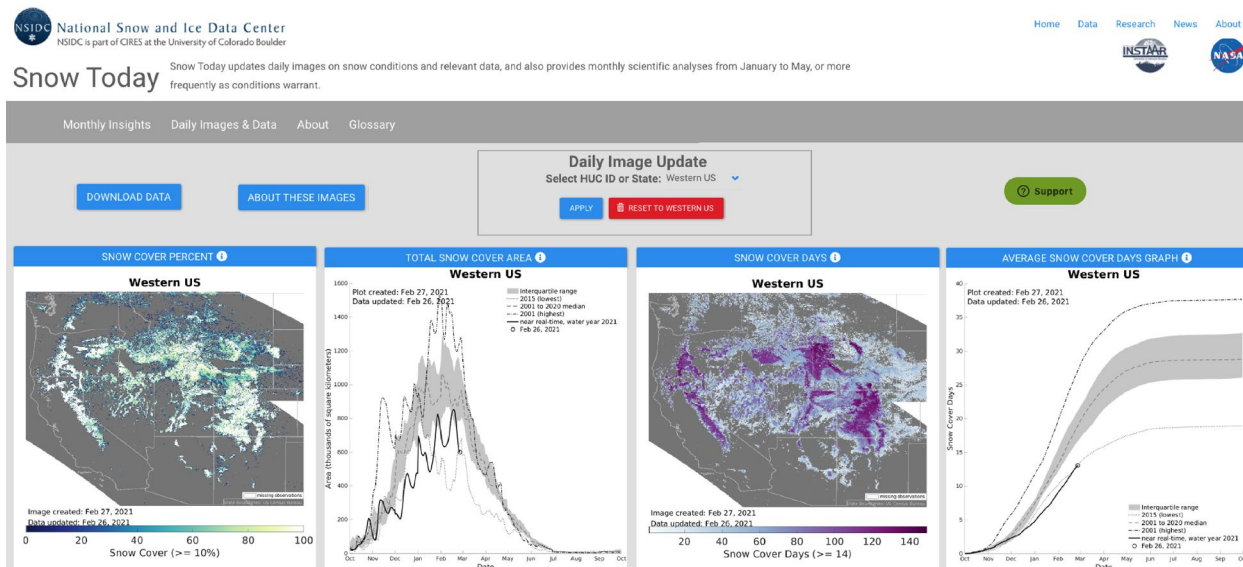


Figure 2. Snow Today website visualizations of western US snow cover and historical context for today's observations.

Currently, the Snow Today website (<https://nsidc.org/reports/snow-today/daily-image-updates>) displays maps of snow cover percent and snow cover days from MODIS along with snow water equivalent from in-situ observations covering the Western United States. For snow cover percent and snow cover days (Figure 2), this year's observations are shown in context with the historical MODIS record including the minimum year, maximum year, and the interquartile range. While snow cover can vary immensely (large storms and melt events), snow cover days (SCD) are more stable over time, better representing the true context of accumulated snow this season. Observations of snow-covered area (SCA) and SCD are especially important late in the melt season when in-situ observations, located at predominantly mid-elevations, no longer monitor snow (16). Additionally, during the melt season snow albedo and the impact of dust on the albedo of snow are important as they drive snow melt rate (17).

Equity

Environmental big data offers the opportunity to democratize access to environmental information. In a low trust environment, common to Environmental Justice issues, the ability to access environmental information directly can shine light on issues that may be selectively ignored or downplayed if received through historically powerful channels. Communities around the world rely on mountain snowmelt for drinking water. Snow Today's expansion to the High Mountain Asia (HMA) domain is an important step towards improving the information available to populations of hundreds of millions in HMA that rely solely on the annual melt of snow and ice to sustain their livelihoods. This project is a stepping stone in our efforts to collaborate with The International Centre for Integrated Mountain Development (ICIMOD) (<https://www.icimod.org/>) and SERVIR (<https://www.servirglobal.net/>) in the region.

Data

All data necessary to execute a successful project are hosted locally at UCSB and available here:

<https://snow.ucsb.edu/index.php/remotely-sensed-products/>

All data on the Snow Today website is also available through GLOBUS endpoints.

In short, the datasets are:

- MODIS 21-year daily timeseries from two models (MODSCAG) and (SPIReS).
- Co-incident Landsat 8 products for uncertainty quantification of MODIS estimates.
- Airborne LiDAR measurements of basin wide snow cover for independent verification of approaches. <https://nsidc.org/data/aso/data-summaries> (we have a copy at UCSB as well)
- Albedo measurements from CUES at Mammoth Mountain, CA for independent verification. <https://snow.ucsb.edu/index.php/level-2-model-ready/>

Possible approaches

Our approach will use data processing and statistical analyses to gain meaningful insights into the new Snow Today albedo datasets in the context of how these values influence climate. The results of the albedo analysis will be incorporated into the larger Snow Today framework. To address the expanded spatial domain of Snow Today, our visualization approach will consider:

- How to best serve the data and visualization products to end users
- What pages the website should have and how they should be organized
- What the data dashboard(s) should look like to specific end user groups (segmented by geographic region and user type [scientist, water manager, recreationalist]).
- How to enable data access and user navigation so users can extract the data that is important to them (slippy maps, query options, special high priority regions, on the fly graphs)
- How to present real-time data in the context of statistical analyses of historical records
- Approaches to display albedo information for various user groups to guide knowledge of upcoming melt patterns and dust impacts

Based on discussions with the clients, and interviews with the operational programmers, end users, and other stakeholders, the project will develop an interactive prototype web application of updates to Snow Today data visualization webpages. This prototype will lead to implementation of changes to the Snow Today website. We expect some combination of wireframes/mockups, R+Shiny, Javascript, ect.

Deliverables

Final deliverables will be agreed upon between clients and students in winter quarter and may include:

- 1.) Front end data visualization wireframes/mockups/interactive web applications of results.
- 2.) Meeting with user engagement staff and operational programmers at NSIDC (virtual) to communicate findings and discuss feasibility of implementation.
- 3.) Prioritized recommendations for operational implementation of new website features.
- 4.) Information architecture plan for Snow Today to maximize the experience of users engaging with the new content scope.
- 5.) Mobile first data visualization wireframes/mockups/web app results.

Project Skills: information architecture, data visualization, remote sensing, web design, R+Shiny, Python, Javascript, climate change, snow science, high performance computing, big data, statistical analysis.

Supplemental Materials

Citations

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Budget and Justification

This project requires no additional funding for software, data, or tools. All data are freely available, and objectives can be completed with freely available open-source software. It is expected that the students have access to a personal computer and/or basic compute resources at Bren through the shared computer lab and/or group/capstone project dedicated desktop computers.

\$1400 is budgeted for travel and accommodation for meetings in Mammoth Lakes, CA over UCSB spring break 2022. For 5 days and 4 students, we have \$500 budgeted for transportation using the daily rate of \$82/day for an unlimited mileage minivan through UCSB Transportation Services. We will provide lodging at the UCSB SNARL lodging facilities onsite at the UCSB Valentine Eastern Sierra Reserve. The current rate is \$20/person/night for UC students. (5 nights * 4 students * \$20/person/night = \$400) This \$900 travel and accommodation costs will be covered with existing travel funds held by clients at ERI at UCSB. \$500 in an existing unrestricted funds account for Timbo Stillinger held at Bren will be used to cover the cost of dinner for 7 (clients and students) for two nights during the work trip.

Client Letter of Support

Dear Capstone Committee,

This letter reiterates our support for the above MEDS capstone proposal.

We commit to providing all data necessary to complete this project. Data can be accessed off of our public FTP at snow.ucsb.edu, we can facilitate direct local download from ERI servers at UCSB to student hard drives, and all data on the backend of Snow Today (including daily NRT updates) can be accessed via GLOBUS endpoints at CU Boulder.

All data is provided with no stipulation for a non-disclosure agreement or restriction for publication. Most of the datasets have DOI's through the University of California EZID system. Published use of the data is encouraged.

In addition, we support a trip to the Valentine Eastern Sierra Reserve in the UCSB Natural Reserve System in Mammoth Lakes, CA to discuss the project. This trip would include a tour of the Cold Regions Research and Engineering Laboratory (CRREL) and University of California Santa Barbara (UCSB) Energy Site (CUES) where the in-situ data are collected that drive most of the on-the-ground validation of the satellite products the students are working with in their proposal. This trip would be a useful client/student meeting. We have allocated \$1,400 towards travel expenses for this meeting. This money is existing available travel funds at ERI at UCSB (\$900 between BE1C01, BE1N02, BE1N04) and \$500 in an existing unrestricted funds account for Timbo Stillinger held at Bren. The meeting would take place over UCSB spring break or at a mutually agreed upon time between clients and students.

Sincerely,

Timbo Stillinger, PhD
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Ned Bair, PhD
Earth Research Institute, UCSB

Karl Rittger, PhD
Institute of Arctic and Alpine Research, University of Colorado Boulder