Questions & Answers Part 3

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Amita Mehta (amita.v.mehta@nasa.gov) or Sean McCartney (sean.mccartney@nasa.gov).

Question 1: Do we have a global snow product (snow mask or snow cover fraction) based on this SMA model?
Answer 1: Currently there is no global SMA snow fraction map. As part of Snow Today at NSIDC we are expanding coverage to the following regions in the next year: 1) continental United States, 2) Alaska 3) western Canada, 4) New Zealand 5) High Mountain Asia 6) Chile. We'll publish and announce the new data through NSIDC.

Question 2: Can the journal names and links be provided?
Answer 2:

MODSCAG Algorithm (Input to STC):
Painter, T. H., Rittger, K., McKenzie, C., Slaughter, P., Davis, R. E., & Dozier, J. (2009). Retrieval of subpixel snow-covered area, grain size, and albedo from MODIS. Remote Sensing of Environment, 113, 868–879. https://doi.org/10.1016/j.rse.2009.01.001

MODDRFS Algorithm (Input to STC):
Painter, T. H., Bryant, A. C., & Skiles, S. M. (2012). Radiative forcing by light absorbing impurities in snow from MODIS surface reflectance data. Geophysical Research Letters, 39(17), L17502. https://doi.org/10.1029/2012gl052457

STC Snow Cover Algorithm and Validation:
Rittger, K., Raleigh, M. S., Dozier, J., Hill, A. F., Lutz, J. A., & Painter, T. H. (2020). Canopy adjustment and improved cloud detection for remotely sensed snow cover mapping. Water Resources Research, 55. doi.org/10.1029/2019wr024914

STC Snow Cover Use in NRCS M4 Model:

Fleming, S. W., Rittger, K., Oaida Taglialatela, C. M., & Graczyk, I. (2024). Leveraging Next-Generation Satellite Remote Sensing-Based Snow Data to Improve Seasonal Water Supply Predictions in a Practical Machine Learning-Driven River Forecast System. Water Resources Research, 60(4), e2023WR035785. doi.org/10.1029/2023WR035785

SPIReS Algorithm

Bair, E. H., Stillinger, T., & Dozier, J. (2020). Snow Property Inversion from Remote Sensing (SPIReS): A generalized multispectral unmixing approach with examples from MODIS and Landsat 8 OLI. IEEE Transactions on Geoscience and Remote Sensing, early access. https://doi.org/10.1109/TGRS.2020.3040328

MODSCAG/MODDRFS Data (Contains Gaps, Not Corrected for Vegetation or Clouds)
https://nsidc.org/data/stc_modscgdrf_hist/versions/1

STC Data (Gap Filled – Spatially and Temporally Continuous)
Historical data: https://nsidc.org/data/stc_modscgdrf_hist/versions/1

SPIReS Data (Gap Filled – Spatially and Temporally Continuous)
Historical data: https://nsidc.org/data/spires_hist/versions/1
NRT data: https://nsidc.org/data/spires_nrt/versions/1

Question 3: How can we modify the images after cropping the area of interest? Is there a specific easily-accessed code or method?
Answer 3: Snow Today provides data as netCDF which can be manipulated with many softwares. Images can be modified by open source (QGIS, GDAL, Python, etc.) and commercial software (ArcGIS, ENVI, MATLAB, etc.).

Question 4: Is ground water relevant in these examples, compared to snow melt, and can it be estimated from satellite data?
Answer 4: Ground water contributes to streamflow and is accounted for in water supply forecast models. It can not be directly measured from satellites but ground water is often estimated using GRACE, a satellite which estimates total water storage by using gravity measurements. In order to accurately estimate ground water with

GRACE, you need to know other components of the water cycle such as snow water equivalent and surface water. GRACE observations are very coarse.

Question 5: In the future, are there any plans for a snow study using Synthetic Aperture Radar (SAR) remote sensing? There are multiple papers using cross ration and INSAR, but it would be good to hear from the authors.
Answer 5: Yes. The NASA SnowEx field campaign collected radar data to test the INSAR method for remote sensing of snow water equivalent (SWE). Sentinel-1, a European satellite, is currently used to estimate total SWE using C-band radar. NASA recently launched a L-band radar on NISAR which can be used to estimate SWE change (not total SWE). In heavily forested areas or wet snow, the method is not as effective.

Question 6: Is there an ongoing project in High Mountain Asia (HMA) to have ground validation also. For this SMA model-based outputs?
Answer 6: SMA HMA data from MODIS at 500 m has been created through the NASA High Mountain Asia projects. Validation has been done typically with higher resolution satellite imagery such as Landsat (30 m) and comparison of STC and SPIReS. Ground validation has been done for snow darkening in collaboration with ISRO scientist Chandan Sarangi.

Question 7: What is the accuracy of optical remote sensing in wet snow?
Answer 7: Optical remote sensing is not highly impacted by wet snow like radar is. This is because the impact of wet snow on snow changes the signal in the visible, NIR, and SWIR by only small amounts (of reflectance) compared to radar where there are large changes. Validation work for optical remote sensing shows similar accuracy to dry snow periods in the winter.

Question 8: How does grain size estimated from the SCAG model compare to grain size derived from Landsat OLI data, and is there a known method or empirical relationship to convert Landsat-derived grain size estimates to actual in-situ grain size measurements?
Answer 8: To clarify, grain size estimates can be calculated from the Snow Covered Area and Grain (SCAG) size model using any multispectral satellite data including MODIS (daily 500 m), VIIRS (daily 500 m), Landsat [8 or 9 currently] (16-day 30 m), or

Sentinel 2 [a,b,c] (5-day 20 m). I'm unaware of any published direct comparison between grain size from SCAG across satellites, but this is important to do as we try to assess the best estimates of snow albedo that depend on grain size. The SPIReS model also estimates grain size, and the Normalized Difference Grain Size Index (NDGSI) can also be used to estimate grain size. Models currently available assume spherical grain radius but grains can be many shapes, so differences between the space observations/model and in-situ data exist.

Question 9: Is Snow Today only for the lower 48 states? What about Alaska? Canada?
Answer 9: We are in the process of expanding Snow Today to include Alaska and the Canadian provinces of British Columbia and Alberta as well as other regions. We have created a historical dataset and are currently in the process of validation. We hope to provide that data this coming winter as both historical data (2000-2025) and near real time data (through present).

Question 10: Which snow parameters are measured in field campaigns and what are typical tools for those measurements? What temporal and spatial frequency do we typically get from such measurements?
Answer 10: Field measurements and campaigns can vary widely depending on the goals. The largest recent field campaign is NASA's SnowEx.
https://snow.nasa.gov/campaigns/snowex
https://nsidc.org/data/snowex
https://nsidc.org/data/clpx

Snotel: https://www.nrcs.usda.gov/resources/data-and-reports/snow-and-water-interactive-map

Typical information collected includes:

1) Snow water equivalent.
    a) This can be measured with snow pits where depth and density are measured. Federal samplers are also used.
    b) Ground and airborne based lidar and radar.
2) Snow water content using lysimeters

3) Energy balance (i.e. incoming and reflected solar and longwave radiation; air temperature and vapor pressure used to estimate sensible and latent heat exchange)
    a) This can include in situ observations
    b) This can include airborne observations for snow albedo (ratio of reflected to incoming solar radiation).

Question 11: To follow up, how much of a limiting factor are these field measurements on greater watershed models?
Answer 11: Point measurements have been used for a while. In reference to in situ monitoring, it is based on tools such as federal samplers. Telemetered snow pillows are also a limiting factor as well conducted by different operations in different regions. There is over 100 years of experience in measuring snow on watershed models. Using the data in watershed models works well, but knowledge and information between in situ stations can be limited. Remote sensing fills in gaps where in situ measurements miss the mark.

Question 12: What is the feasibility of using MODIS TERRA and MODIS Aqua to study the Antarctica area? How to treat data?
Answer 12: As you move towards the poles the sun gets lower in the sky, so it can be more challenging than at mid-latitudes to estimate snow cover, snow albedo, and other surface properties. Spectral mixture models account for the lower sun by using different spectral libraries (snow reflectance). Similarly, NDSI methods for snow cover divide the difference in a visible and SWIR band by the sum of them to account for less light. Still, periods of the winter receive no sunlight making it infeasible to map snow with optical satellites.

Aalstad, K., Westermann, S., & Bertino, L. (2020). Evaluating satellite retrieved fractional snow-covered area at a high-Arctic site using terrestrial photography. Remote Sensing of Environment, 239, 111618. https://doi.org/https://doi.org/10.1016/j.rse.2019.111618