Updated July 2015

GOES-R Cryosphere Products
Snow Cover

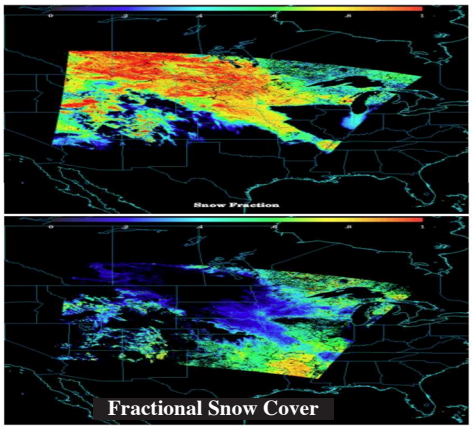
What is GOES-R?
The Geostationary Operational Environmental Satellite - R Series (GOES-R) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary Earth-observing systems. Superior spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), a sixteen channel imager with two visible channels, four near-infrared channels and ten infrared channels, will provide three times more spectral information, four times the spatial resolution and more than five times faster coverage than the current system. Other advancements over current GOES capabilities include total lightning detection (in-cloud and cloud-to-ground flashes) and mapping from the Geostationary Lightning Mapper (GLM) and increased dynamic range, resolution and sensitivity in monitoring solar X-ray flux with the Solar Ultraviolet Imager (SUVI). The first satellite in the GOES-R series is scheduled for launch in 2016.

Why are snow cover estimates important?
Airborne, satellite and modeled snow data and products are used by the National Weather Service, other government agencies, the private sector and the public to support operational and research hydrology programs across the nation. Mapping the areal extent of snow cover is critical to operational water resource management and for flood forecasting and risk assessment because of the critical role snow maps play in quantifying snowmelt area and volume. The value of water from spring snowmelt can exceed $348 billion annually (Adams et. al. 2004). Additionally, the persistent nature of snow cover strongly affects continental climate conditions because of its high albedo (reflectivity) and low thermal conductivity (insulating ability), which together can make for more stable atmospheric conditions. Weather forecasting is therefore much improved by knowledge of the extent of snow cover. The ability to map patchy snow cover along the perimeter is critical to understanding changing hydrology in a changing climate.

How will GOES-R map snow cover?
The spaceborne imaging technology developed for the GOES-R series will provide unprecedented accuracy and precision in estimates of snow cover. Earlier snow mapping algorithms relied on a single visible band of imagery using simple brightness threshold methods to identify pixels that are mostly covered in snow, overlooking some of the snow cover. By contrast, the GOES-R ABI spans the solar spectrum with several imaging bands (0.47, 0.64, 0.865, 1.378, 1.61, and 2.25 μm) to quantitatively retrieve the fractional portion of any pixel that contains even a tiny portion of snow cover. Other snow algorithms must first determine whether the surface to be assessed is either mostly snow covered or, instead, mostly covered with clouds. The GOES-R **Snow Cover** product, on the other hand, will interact directly with the GOES-R **Cloud Cover** products to determine which cells are cloud covered and which are snow covered. Since the fractional **Snow Cover** algorithm can estimate snow grain size, it can assess both the magnitude and the image-to-image persistence of grain size to reinforce the assurance of cloud discrimination.

Snow Cover includes two snow products: **Viewable Snow Cover** and **Tree Canopy-adjusted Snow Cover**. The **Viewable Snow Cover** will be that which is discernable, from the satellite, as snow – so in the case of tree-covered snow it will be the fraction of each cell that has viewable snow, and in the case of tree-free snow, such as on the prairies where snow cover can be patchy, it will be the actual fraction of the cell that is covered by snow. The **Tree Canopy-adjusted Snow Cover** product will use ancillary

*Simulated GOES-R ABI **Fractional Snow Cover** from GOESRSCAG processing of proxy ABI data from Moderate Resolution Imaging Spectroradiometer (MODIS), March 1, 2009.*



information about the location of tree cover to adjust the **Viewable Snow Cover** to actual snow cover below the canopies. In open areas, the fractional snow cover will remain the same. Both of these products are critical to NOAA interests. The **Viewable Snow Cover** provides the exposure of snow cover to the atmosphere and as such provides critical information for weather forecasting and climate analysis. The **Tree Canopy-adjusted Snow Cover** gives operational water managers more accurate working knowledge of complete snow cover and the regions of contributing snowmelt.

Above: *San Juan Mountains, Colorado – a prominent contributor of snowmelt runoff to the Colorado River.* ***Right: Snow Cover*** *maps will be coordinated with mountain weather stations for integrated operational hydrologic forecasting. Photos: Senator Beck Basin Study Area, Center for Snow and Avalanche Studies.*

How does this algorithm work?

The GOES-R **Snow Cover** algorithm has its legacy in imaging spectroscopy and multi-spectral imaging. With the advent of ABI, the enhancement in spectral sampling coupled with frequent acquisitions will allow more detailed characterization of fractional snow cover and grain size of that fractional snow cover. The algorithm is an optimized spectral mixture analysis that uses the broad ABI spectrum to determine the fractional cover of snow, trees and other vegetation, and soils.

What are the benefits?

GOES-R snow products will be indispensable to the climate community. Our climate is highly dependent upon the location, extent and timing of the annual cycle of snow accumulation, persistence and depletion. The ebb and flow of continental climate conditions is influenced by snow's high albedo and low thermal conductivity.

Snow also plays a major role in the hydrologic cycle. GOES-R snow products, along with in-situ observations, are assimilated into land surface, weather and hydrologic models to produce climatic, weather and river forecasts. Depending on the region, the snow pack can store several months of precipitation which, when it melts, may release a season's worth of precipitation in a short amount of time. This is beneficial when snow may be the single most important source of fresh water for industrial, agricultural, energy, recreational and consumptive use. However, for others, the melting of the snow pack is a harbinger for the onslaught of flooding. Given today's climate concerns, the availability of fresh water, and the threat of loss of life and property due to flooding, the ability to monitor and measure snow cover conditions is important to our daily and long term wellbeing.

GOES-R will provide a new opportunity to continuously observe snow cover from a geostationary platform. The ABI sensor, with its high spatial resolution and multi-sensor capability in both the solar and thermal spectrums, is well suited to modern **Snow Cover** retrieval algorithms that are capable of detecting snow at sub-pixel levels. Today's **Snow Cover** products can accurately determine not only what fraction of a pixel is covered in snow but also snow grain size and reflectivity. GOES-R can inform us about extent and morphology with a frequency and accuracy never before enjoyed - characteristics that are critically important to climatologists and hydrologists as they observe, monitor and measure our environment.

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Research and Development Partners for Snow Cover Products

- National Operational Hydrologic Remote Sensing Center (NOHRSC)
- Snow Optics Laboratory (SOL), University of Utah
- University Corporation for Atmospheric Research (UCAR)

On the Web

http://www.nohrsc.noaa.gov/
http://www.snow.utah.edu/
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