NOAA SATELLITE AND INFORMATION SERVICE | GOES-R SERIES PROGRAM OFFICE

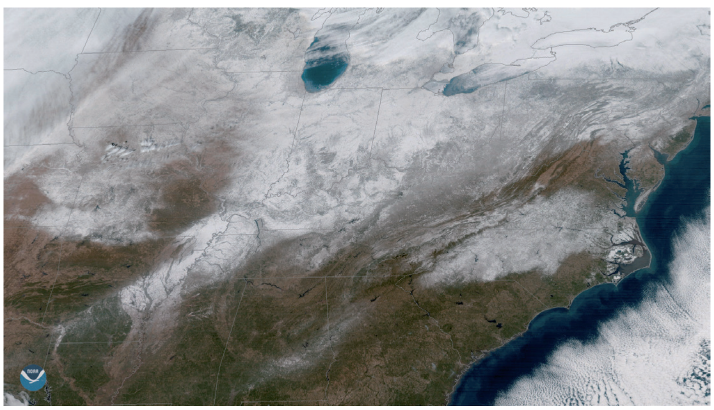
GOES-R
Snow and Ice Applications

FACT SHEET

What is the cryosphere?

Snow cover in the high-latitude forest (left), ice in Green Bay, Wisconsin, in 2017 (center), and the U.S. Coast Guard icebreaker Mobile Bay (right). Pictured is George Leshkevich (Great Lakes Environmental Research Lab) drilling a hole to measure ice thickness. Credit: Jeff Key

The cryosphere includes snow, sea ice, lake and river ice, icebergs, glaciers, ice caps, ice sheets, ice shelves, permafrost, seasonally frozen ground, and solid precipitation. The cryosphere is global, existing in approximately one hundred countries and at all latitudes. The cryosphere provides among the most useful indicators of climate change yet is one of the most under-sampled domains of the climate system. Changes in the cryosphere have major impacts on water supply, agriculture, transportation, freshwater ecosystems, hydropower production, health, and recreation. Notable cryosphere-related hazards include floods, droughts, avalanches, and sea-level rise. Satellite instruments are essential for delivering large-scale observations of the cryosphere and are a key to extending ground-based measurements.

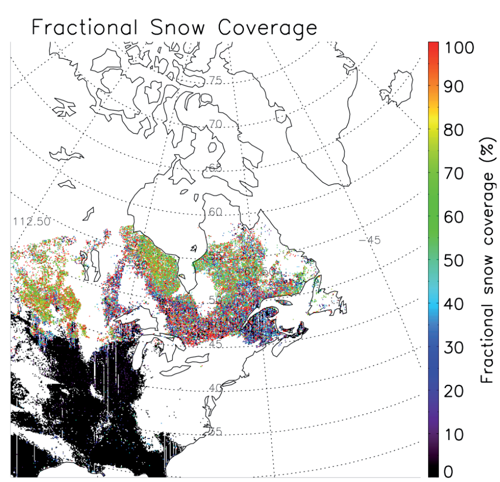


GOES-16 captured the extent of snow cover over the eastern U.S. on January 18, 2018. In this image, a faint swath of snow is even visible across southern Alabama and western Georgia. Brighter white areas indicate greater snow depths, as seen in parts of Arkansas, southern Missouri, Indiana and Ohio. Credit: NOAA

How do GOES-R Series satellites monitor snow and ice?

The GOES-R Series **Advanced Baseline Imager (ABI)** monitors snow cover as well as sea and lake ice surface temperature, concentration, thickness, and motion with unprecedented frequency, precision and accuracy. New channels on the ABI allow for new and improved data products compared to previous GOES.

The new capabilities from ABI allow for a more detailed characterization of **snow cover**. Instead of simply characterizing a scene as either having the presence of snow or not, the GOES-R Series snow cover data product provides a quantitative area representation of the amount of snow and the grain size of that snow cover. Earth's surface is complex, comprised of vegetation, rock, soil, snow, water, ice, and other materials, and ABI can distinguish how much of a surface is or is not covered in snow.

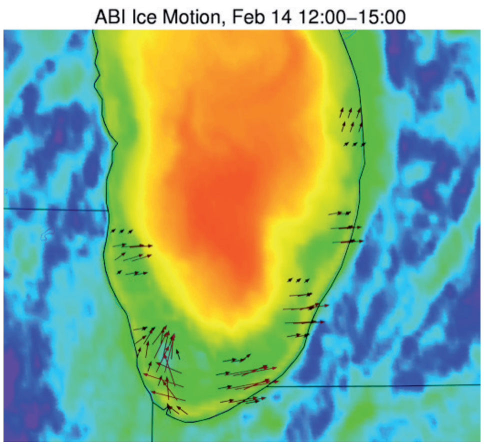


GOES-16 snow cover retrieval on March 21, 2018, which shows high fractional snow cover north and west of the Great Lakes, and snow-free land south of the Great Lakes. There are no fractional snow cover retrievals over areas east of the Great Lakes and elsewhere due to cloud cover. Credit: NOAA

Ice surface temperature (IST) integrates the ice surface energy budget and thus controls ice growth and melt. Remote sensing of IST from satellites is critical due to challenging weather and physical conditions on the ground. ABI provides IST retrievals with high spatial resolution over inland waters and ocean at mid to high latitudes. The ABI IST product provides the radiating, or "skin," temperature at the ice surface. It is not strictly an ice temperature; it is the aggregate temperature of objects comprising the ice surface, including snow on the ice for most of the year and melt water on the ice during part of the summer.

Ice cover and concentration are the most important ice characteristics for numerical weather prediction and operational ice services. Ice cover products indicate the presence or absence of ice for every water pixel. With ABI, ice is mapped over ocean and inland lakes. Ice concentration is the fraction (in percentage) of the sea or lake surface covered by ice in every ABI pixel.

There are no satellite instruments that provide a direct measurement of sea or lake ice thickness. The most direct method utilizes space-based altimeters that measure the elevation of the surface, from which ice thickness can be estimated. GOES-R **ice thickness** measurements use derived data products, rather than direct ABI channel data. Ice thickness inputs include surface skin temperature, air temperature, radiation fluxes at the surface, snow depth, atmospheric moisture, and wind.



Ice along the southern Lake Michigan shoreline (denoted by arrows) on February 14, 2018, contrasts with the warmer, unfrozen lake water in this GOES-16 infrared imagery. Using a pair of images three hours apart, the ice motion code detected strong eastern/northeastern motion along the lakeshore. Some features were tracked moving more than 10 km in three hours. Credit: NOAA

Ice motion refers to the displacement of sea and lake ice over time. Sea ice moves relatively quickly, typically 10-30 km per day or more. Monitoring changes in ice position from space allows satellites to track ice motion over the entire Arctic with only a few images. Under clear conditions, ABI is able to provide accurate and precise measurements of sea ice motion at high spatial resolution. Since ABI scans the full disk every ten minutes, it provides a unique advantage for tracking sea ice compared to polar-orbiting satellites, which have orbital periods around 100 minutes and may not see the same ice feature twice. The greater frequency of sampling, combined with the high spatial resolution of ABI, allow for the tracking of individual ice floes.

What benefits do GOES-R snow and ice monitoring applications provide?

Cryospheric observations and information from the GOES-R Series ABI provide a new opportunity to continuously observe snow and ice from geostationary orbit, improving weather forecasting and hazard warnings and helping to reduce the risk of loss of life and property from natural and human-induced disasters. These observations provide a better understanding of environmental factors that affect human health and well-being, are critical to marine navigation at high latitudes, and improve management of water resources, and terrestrial, coastal and marine ecosystems.

The GOES-R snow and ice applications are also important to the climate community. Our climate is highly dependent upon the location, extent, and timing of the annual cycle of snow and ice cover. In time, GOES-R cryosphere observations will also play an important role in climate analyses. Improved cryospheric monitoring and integration of that monitoring are essential to fully assess, predict, and adapt to climate variability and change. The performance of numerical weather forecasts strongly depends on the accuracy of initial conditions for predictive models, including snow and ice cover.

Snow and ice play a major role in the hydrologic cycle. Depending on the region, the snowpack 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 snowpack 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.

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Related links:

Snow cover product info: https://go.usa.gov/xmV9t
Day snow/fog RGB quick guide: http://bit.ly/SnowFog
National Operational Hydrologic Remote Sensing Center: https://www.nohrsc.noaa.gov
National Ice Center: https://www.natice.noaa.gov
NWS Alaska Sea Ice Program: https://www.weather.gov/afc/ice