

UNITED STATES GEOLOGICAL SURVEY/ GLACIER NATIONAL PARK AVALANCHE PROGRAM



2021 GOING-TO-THE-SUN ROAD SPRING OPENING PROGRESS REPORT

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Table of Contents

Developments and Accomplishments.....	2
Weather, Snowpack, and Avalanche Summary.....	7
Recommendations.....	12
Resources.....	14

Figures and Tables

Figure 1: Example of an avalanche hazard forecast for the Going-to-the-Sun Road, April 19, 2021.....	3
Figure 2: Daily Avalanche Ratings during the 2021 GTSR spring opening season.....	5
Figure 3: Snow Water Equivalent and daily accumulated precipitation at Flattop SNOTEL site.....	9
Figure 4: Daily temperature measurements at WGM8 weather station in West Glacier, MT	9
Figure 5: Timeline of observed avalanches along the GTSR during the 2021 spring opening season	11
Table 1: Going-to-the-Sun Road Avalanche Hazard Rating Scale.....	4
Table 2: Observed avalanches in paths affecting the GTSR, April 5 - June 3, 2021.....	11



Developments and Accomplishments

U.S. Geological Survey (USGS)/Glacier National Park (GNP) Roads Department Avalanche Program.

The avalanche program's 19th season of full-time field operations started April 5 and continued to June 3, 2021. This season continued many of the major procedures and practices instituted over the past 18 seasons.

The goal of the GTSR Avalanche Program is to increase the safety and efficiency of plowing operations by providing daily weather and avalanche hazard information and avalanche safety training. This year the two National Park Service (NPS) Avalanche Specialists, Noah Keller and Jon Hageness, worked full time for the avalanche program from April 13 to June 3. USGS Northern Rocky Mountain Science Center Research Physical Scientist Erich Peitzsch, worked full time for the first four weeks of the season and Physical Scientist, Zachary Miller, worked full time for the final five weeks of the season.

Training

Keller and Hageness instructed three half-day rescue training sessions throughout the season for the employees of the west-side and east-side road crews. These training sessions involved a brief indoor avalanche awareness presentation, discussion of avalanche dynamics, and explanation of rescue basics. The discussion session was followed by an outside equipment refresher which covered the fundamentals of companion avalanche rescue. All crew members, both year-round and seasonal, practiced with avalanche beacons, probes, and shovels and reviewed the core skills needed to rescue a coworker involved in an avalanche burial incident.

Miller, Keller, and Peitzsch also led an avalanche rescue scenario for the west-side permanent road crew members on May 27 at Oberlin Bend. The scenario involved multiple full avalanche burials, medical/CPR response, incident command organization, and full radio communications with Glacier Dispatch. The west side road crew performed the rescue efficiently and the debrief following training was valuable for all involved.

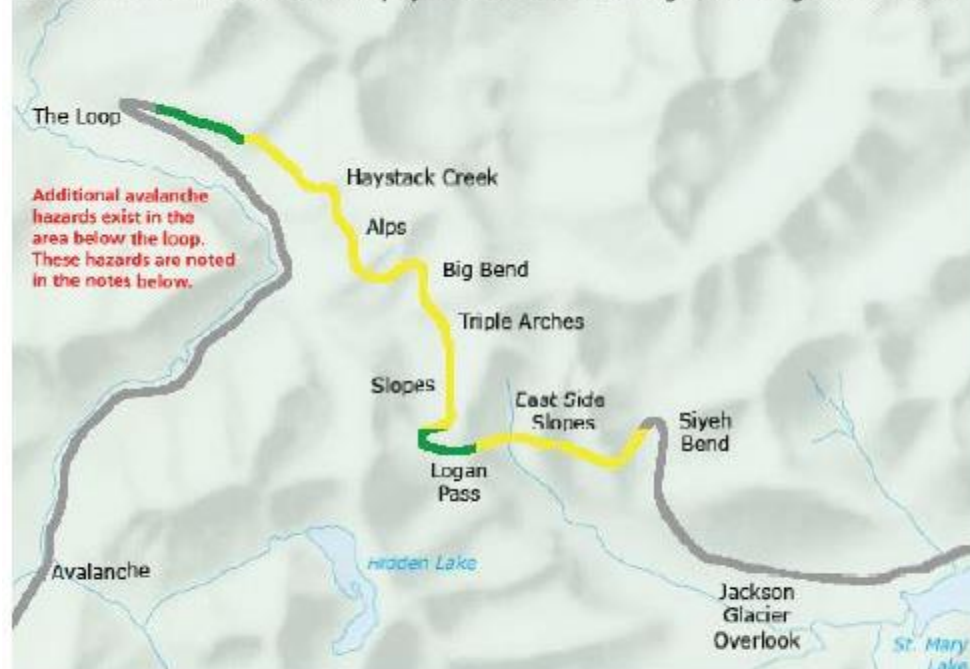
Avalanche Forecasting

Avalanche specialists issued avalanche hazard forecasts (e.g. Figure 1) by 6:00 a.m. each morning road crew personnel were scheduled to work along the GTSR. The forecasters issued weather and avalanche briefings as necessary from April 6 – April 14 and daily (Monday – Thursday) forecasts from April 15 – June 3. They issued 34 full avalanche forecasts between April 6 and June 3, using the GTSR avalanche hazard rating scale (Table 1). Depending on conditions, there are some areas along the GTSR that were more hazardous than others. As such, the highest and lowest hazards were reflected in the daily forecast. The lowest daily avalanche rating was LOW on 32 of 34 days and MODERATE the remaining two days during the 2021 GTSR spring opening season. The highest daily avalanche rating was HIGH on three days, MODERATE on 20 days, and LOW on only 4 days of the 2021 GTSR spring opening season (Figure 2). Forecasts were printed and discussed each day during the morning meeting at the West Side Road Crew office.

GTSR Avalanche Hazard Forecast

As of 4-19-2021 at 5:49AM (this forecast expires on 4-20-2021 at 5:49AM)

This information is intended for Park employees and contractors working on the Going-to-the-Sun Road



Avalanche Hazard Forecast			
Avalanche Rating	Avalanche Probability	Travel Danger	Work Danger
Low	Mostly stable snow. Natural avalanches are unlikely to affect the Going-to-the-Sun Road.	Generally safe	Work generally safe. Normal operations
Moderate	Areas of unstable snow. Natural avalanches possible and small avalanches may affect the Going-to-the-Sun Road.	Generally safe with spotter	Normal operations with caution. Use of spotter may be necessary.
High	Mostly unstable snow. Natural avalanches likely to affect the Going-to-the-Sun Road. A moderate to large amount of snow on the road is possible.	Travel not recommended. Emergency traffic only if warranted.	Work not safe.
Extreme	Widespread unstable snow. Natural avalanches certain. A large amount of snow on the Going-to-the-Sun Road is likely.	Avoid Travel on Road	Work not safe.
Not Rated	Information not available or no rating was obtained.		

Avalanche Forecast

Mountain Weather

A quick moving storm Sunday into Monday brought strong to extreme winds (30-40 mph gusting to 80+ mph) and modest snow accumulation (4-8 inches above 8000 feet) throughout the region. Northeast winds moving at 10-15 mph will continue this morning and decrease throughout the day. Skies will also clear allowing for ample sunshine along the GTSR by the afternoon. Temperatures are currently 10-15°F and will rise to the mid to upper-20s F by the afternoon.

Snowpack

(Figure 1 continued to next page)

The combination of new snow and clearing skies will cause a wet, loose avalanche cycle today with some avalanches capable of reaching the road. Avalanche hazard will rise as skies clear at upper elevations. Cold temperatures and moderate to strong NE winds will delay the onset of wet, loose avalanches, but afternoon sunshine and warmth will likely produce wet loose avalanches, especially in steep terrain. As the clouds break, keep an eye out for rollerballs and pinwheels as indicators of rising wet loose avalanche hazard. We expect wet loose avalanches to remain small to medium-sized given the amount of new snow measured at remote weather stations.

Glide cracks exist on slopes in Haystack and Big Bend. Glide avalanches are unlikely today, but continue to minimize time spent beneath glide cracks and use a spotter when exposed to these looming hazards.

Today, a **LOW** hazard will rise to **MODERATE** along the GTSR today.

Avalanche Concern

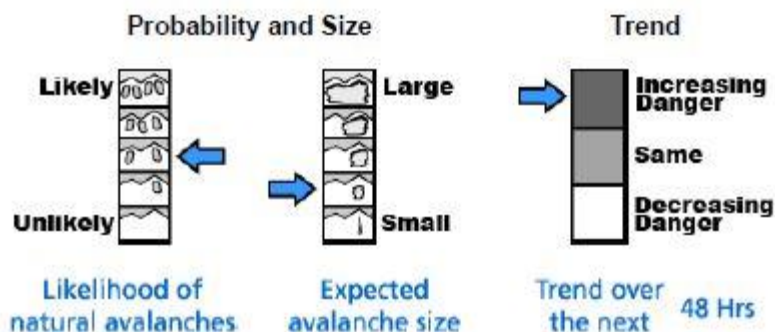


Figure 1: Example of an avalanche hazard forecast for the Going-to-the-Sun Road April 19, 2021.

Table 1: Going-to-the-Sun Road Avalanche Hazard Rating Scale.

Avalanche Rating	Avalanche Probability	Travel Danger	Work Danger
Low	Mostly stable snow. Natural avalanches are unlikely to affect the Going-to-the-Sun Road.	Generally safe.	Work generally safe. Normal operations.
Moderate	Areas of unstable snow. Natural avalanches possible and small avalanches may affect Going-to-the-Sun Road.	Generally safe with spotter.	Normal operations with caution. Use of spotter may be necessary.
High	Mostly unstable snow. Natural avalanches likely to affect the Going-to-the-Sun Road. A moderate to large amount of snow on the road is possible.	Travel not recommended. Emergency traffic only if warranted.	Work Not Safe.
Extreme	Widespread unstable snow. Natural avalanches certain. A large amount of snow on the Going-to-the-Sun Road is likely.	Avoid Travel on Road.	Work Not Safe.
Not Rated	Information not available or no rating was obtained.		

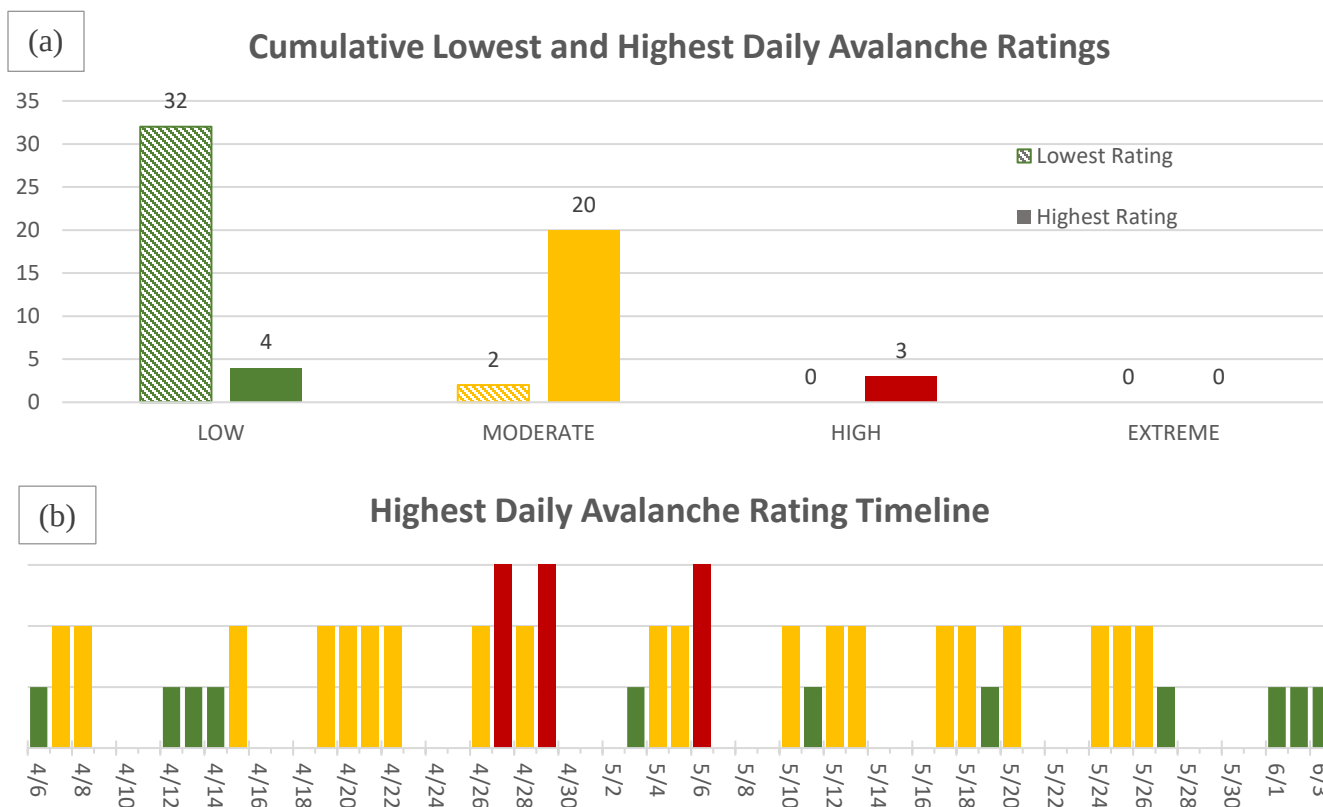


Figure 2: Daily avalanche hazard ratings during the 2021 GTSR spring opening season. (a) represents the lowest daily rating (striped bars) and highest daily rating (solid bars) with cumulative counts of forecast occurrences above the bars. (b) shows a timeline of the highest daily avalanche ratings (LOW (green), MODERATE (yellow), and HIGH (red)) ratings during the 2021 GTSR spring opening season.

The forecast was distributed through a dedicated web page on an NPS server in Denver and linked internally to the GNP intranet (<http://home.nps.gov/applications/glac/gtsravalhazard/gtsravalhazard.cfm>). These forecasts are available to all GNP employees each day they are issued during the forecasting season. The administrative pages for this forecast are not kept behind the GNP firewall which allows the USGS avalanche specialists to access them through the internet.

Weather Stations and National Weather Service Forecasts

The Garden Wall Weather Station (GWWX) is a remote, automated weather station located beneath the Garden Wall at an elevation of 7400 feet a.s.l. It was placed on a ridge between and adjacent to the Haystack Creek and Little Granite avalanche path starting zones and provides real-time measurements of weather and snowpack conditions in the starting zones of two of the largest avalanche paths threatening the GTSR. The station transmits the following data hourly:

- temperature
- relative humidity
- barometric pressure
- wind speed and direction
- net radiation

These data are available remotely via radio-uplink on the internet:
<http://wxstns.net/wxstns/glaciernet/SOULOW.html>



In September of 2013, 2018, and 2020 USGS personnel upgraded and repaired the GWWX with assistance from a helicopter flight to transport heavy and bulky equipment. These upgrades were invaluable and have allowed the weather station to remain operational under very harsh winter conditions. It is a tremendous tool, and the availability of continuous representative weather data increases avalanche forecasting accuracy and personnel safety. Weather data from GWWX are automatically linked to our database where they can be viewed in tabular or graphical format.

The Logan Pass Visitor Center Weather Station (LPVC) operated throughout the 2021 forecasting season but suffered transmitting issues until early-May when forecasters could safely access it. It provides valuable real-time weather data from the Continental Divide. LPVC is a remote weather station mounted to the roof of the Logan Pass Visitor Center at an elevation of 6700 feet a.s.l. and transmits the following data hourly:

- temperature
- relative humidity
- barometric pressure
- wind speed and direction

These data are available remotely via radio-uplink on the internet:

http://wxstns.net/wxstns/glaciernet/LOGAN_PASS.html

The Sperry Glacier Weather Station (SPERRY) operated continuously throughout the 2021 forecasting season and was frequently used to supplement the intermittent GWWX and LPVC meteorological data. It is a USGS station installed next to Sperry Glacier at 8038 feet a.s.l. and transmits the following data hourly:

- temperature
- relative humidity
- incoming shortwave radiation
- wind speed, gust and direction

These data are available remotely via radio-uplink on the internet:

<http://wxstns.net/wxstns/glaciernet/SPERRY.html>

The Natural Resources Conservation Service's (NRCS) Flattop SNOTEL weather station located about 5 miles northwest of GTSR at 6300 feet a.s.l. continued to be invaluable as a source of snow depth and snow water equivalence (SWE) measurements.

We also utilized a National Weather Service (NWS) Spot Forecast. The NWS Forecast Office in Missoula provides a daily weather forecast for the high elevation areas around GTSR. This aids in our mountain weather forecasts and is a tool we use in conjunction with other weather models.

Media and Public Contact

The avalanche program captured photographs of weather and avalanche conditions as well as plowing operations. These photographs provided a unique perspective on the challenges the road crew faced during the plowing season. The GNP Public Affairs Department posts many of these images on GNP's various social media outlets. These continue to be popular and provided the public a unique perspective on avalanche conditions and plowing operations along the GTSR.



Data Management and Publications

The USGS designed an avalanche database in 2003 and we continue to use this as a daily data management tool. However, we are in the process of updating this database to a more equitable platform for ease of access to forecasters and partners. The data from the GWWX and Flattop SNOTEL weather stations are automatically linked to the database where they can be viewed in a graphical or tabular format. Each day, avalanche specialists enter snowpack observations and avalanche occurrences into the database where they are stored for operational and research purposes. This database keeps all important information in one central, organized location and allows for the maintenance of accurate historical records. The USGS Climate Change in Mountain Ecosystems (CCME) research group recently published a data release of the 2003-2020 avalanche occurrence records along the GTSR, which will be updated annually, and is publicly available here:

<https://www.sciencebase.gov/catalog/item/5f3d89b082ce8df5b6c73f59>

The avalanche program continued daily printouts of updated forecasts, observations, weather, and pictures. These daily printouts were categorized in folders that were kept in both the USGS office and in the Roads Department office. They were useful tools that helped both the forecasters and road crew stay up to date with current conditions.

The data collected along the GTSR since the inception of the avalanche program has yielded numerous professional papers as well as presentations at a variety of professional conferences. These papers and presentations can be found here: https://www.usgs.gov/centers/norock/science/climate-change-mountain-ecosystems-ccme?qt-science_center_objects=3#qt-science_center_objects.

Weather, Snowpack, and Avalanche Summary

Weather and Snowpack

The 2020-2021 winter exhibited a distinct split between low snow at lower elevations and average snow depths at higher elevation throughout the Flathead area. The season began with a few small storms in October and November before sustained high-pressure weakened lingering snow throughout the upper elevations into early December. Repeated warm and wet storms throughout December established a variety of crusts, persistent weak layers, and smaller slabs that remained active to skier and natural triggering into mid-January. A major atmospheric river event occurred on January 12-13, 2021 with over 2 inches of precipitation accompanied by over 100 mph winds and freezing levels above 7000 feet a.s.l. This storm resulted in a widespread large avalanche cycle and a robust surface crust at all elevations and aspects that remained problematic throughout the rest of the season. With each additional storm cycle, avalanches occurred on weak layers developed above the now buried crust. Additionally, unseasonal glide avalanche problems plagued the region throughout the season due to intermittent sporadic warming events.

In Glacier National Park, snowfall at upper elevations accumulated throughout February and March, leading to an average snowpack at upper elevations to start the 2021 GTSR spring opening season. Flattop SNOTEL reached its seasonal maximum snow depth at of 117 inches on March 30 and measured an April 1 snow-water-equivalent (SWE) value of 44 inches (102% of the point-of-record median). Lower elevations held substantially less snow at the beginning of the 2021 GTSR clearing season, with Peitzsch reporting the “least snow observed on the GTSR since 2007” in field notes from the Lower McDonald Valley on April 5, 2021.



April was unusually dry with limited precipitation mostly falling as rain below 6000 feet a.s.l. and snow above. Snow depths decreased slightly throughout the month from 113 inches to 100 inches at Flattop SNOTEL before a final storm deposited 10 inches of new snow in late April. There were eighteen days without measurable precipitation at the Flattop SNOTEL site in April (Figure 3). Total accumulated precipitation for April was 3.2 inches, half of the 40-year average (6.5 inches). The SWE at Flattop increased steadily for most of April with a gain of 4 inches over the month. SWE peaked on April 30 at 48.2 inches, 0.3 inches less than the average peak SWE of 48.5 inches for the 50-year record. Meteorological data from West Glacier (Figure 4) show the monthly average high temperature in April was 57° F and the daily average was 42° F, while the 50-year averages for the site are 54° F and 43° F respectively.

May continued a general trend of warming temperatures and melting snowpack along the GTSR corridor, with below average precipitation. At Flattop SNOTEL, the snow depth decreased from 99 inches to 68 inches and SWE decreased by 13 inches throughout the month (Figure 3). This SWE loss is similar to 2016, 2017, 2019, and 2020 (12.2, 13.6, 11.7, and 11.8 inches respectively). Steady SWE losses at the Flattop site are a fairly reliable indicator that the snowpack at upper elevations along the GTSR will also begin losing water shortly thereafter. There were an additional 4.3 inches of accumulated precipitation during the month, although nearly half of that (2 inches) fell during the storm on May 23-25. In West Glacier, the temperatures aligned with seasonal norms, recording a mean daily temperature of 50°F and the average high temperature of 64° F. High temperatures in late-May exceeded 68° F for eight straight days with five days above 80° F (Figure 4).

The first two weeks of June continued to exhibit warming temperatures and frequent rainfall. These trends contributed to a rapidly melting snowpack throughout the final weeks of the GTSR spring opening season. The GTSR officially opened for the season on June 25, 2021.

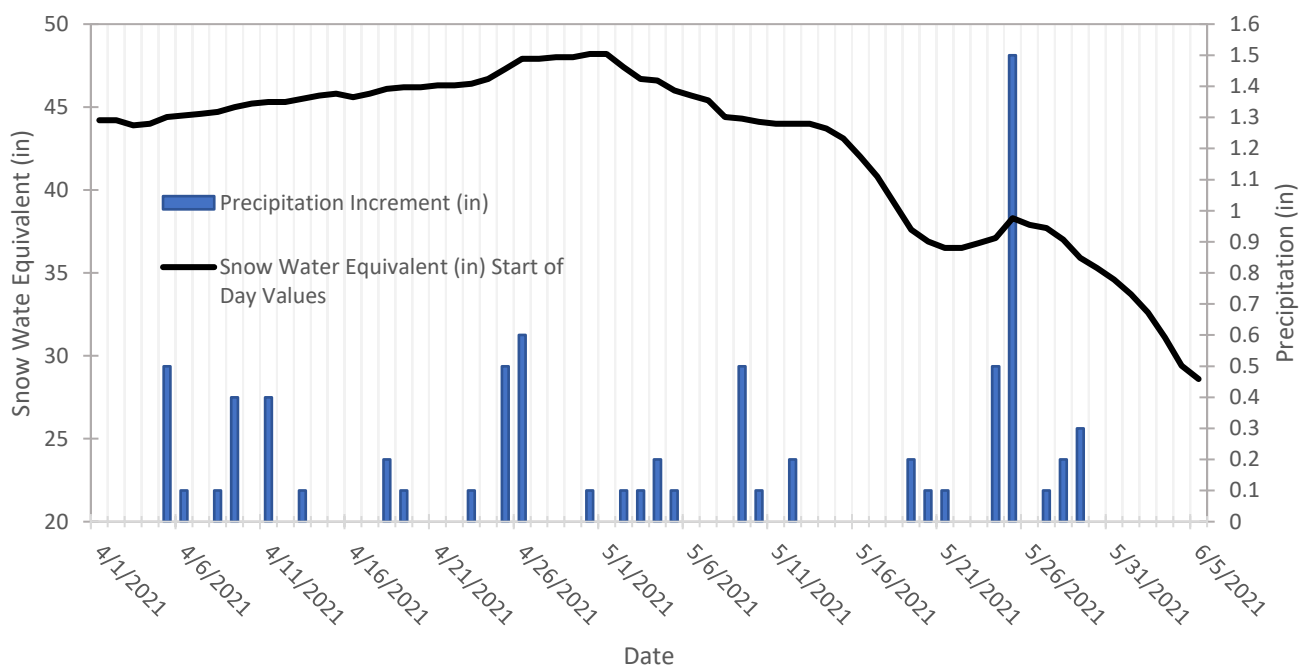


Figure 3: Snow Water Equivalent and daily accumulated precipitation at Flattop SNOTEL site (elev. 6300 ft) in Glacier National Park, MT. The measured SWE (black line and left y-axis) and daily accumulated precipitation (blue bars and right y-axis) from both snow and rainfall during the 2021 GTSR spring opening season.

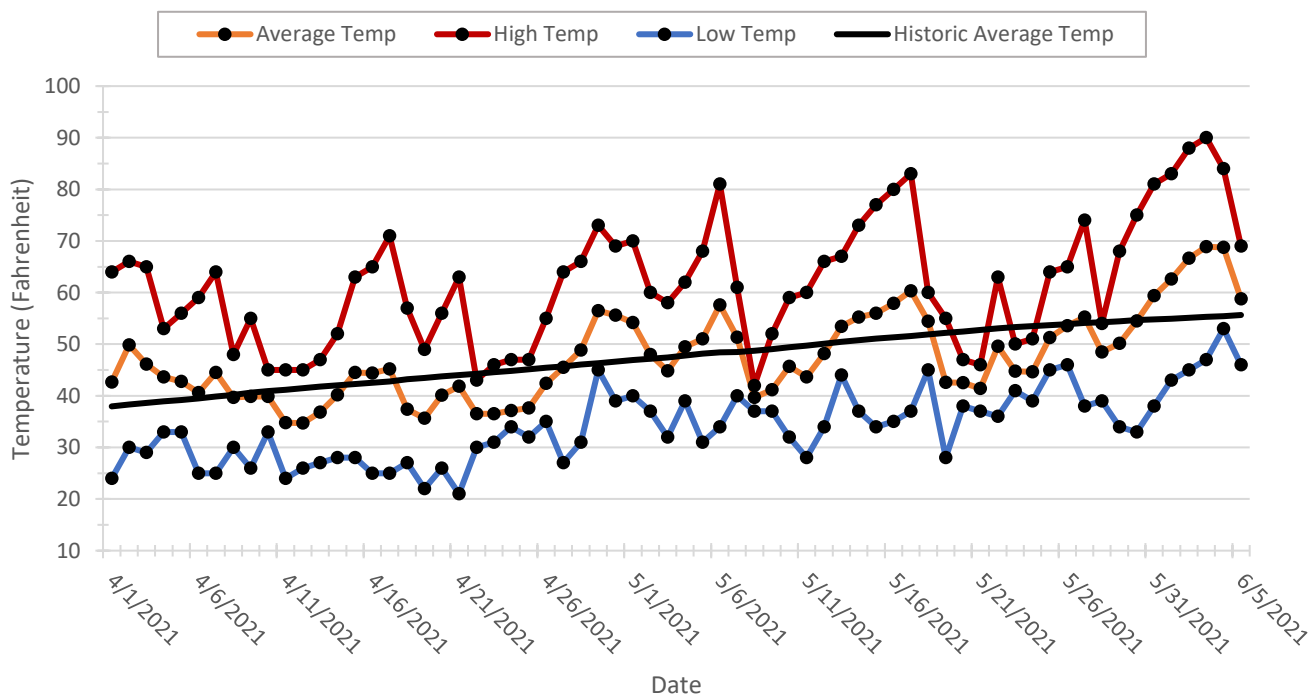


Figure 4: Daily temperature measurements at WGM8 weather station in West Glacier, MT (elev. 3165 ft). Maximum (red), minimum (blue), and average (orange) daily temperatures during the 2021 GTSR spring opening season, along with the historical average daily temperature (black).



Observed Avalanche Activity

NOTE: Observation of avalanche activity is closely associated with the road plowing progress. In the early stages of plowing, we are often unable to observe avalanche activity on the upper reaches of the road; later in the season, more terrain becomes visible as we work closer to Logan Pass. Consequently, it is likely that some avalanche activity goes undetected in the early phase of plowing.

The 2021 spring season was a typical avalanche year along the GTSR corridor in terms avalanche activity. Prior to the start of the 2021 GTSR avalanche forecasting season, several destructive persistent slab avalanche cycles resulted from the development of a series of crusts during the early season and unseasonal glide avalanches occurred due to intermittent sporadic warming events throughout the winter. Despite these deeply buried instabilities within the snowpack, very little avalanche activity occurred during the beginning of the GTSR spring opening season due to an unusually dry April (Figure 5).

Small storm events and a stable snowpack in early April resulted in very few avalanches observed for the first three weeks. These avalanches were small wet loose avalanches in the Haystack and Big Bend avalanche paths. During the last week of April, a storm deposited approximately 10 inches of new snow which resulted in a small avalanche cycle resulting in 13 wet loose avalanches observed during the week along the upper reaches of the GTSR. These avalanches occurred in the Alps, Haystack, Big Bend, Weeping Wall, Beargrass, 2nd Chute Below Triple Arches, Triple Arches and the Slopes.

A sustained six-day warm-up and associated rainfall in early May resulted in a brief glide avalanche cycle with avalanches observed on Heaven's Peak and in the Haystack, Weeping Wall, Big Bend, and Clown Couloir avalanche paths along the GTSR. During the first week of May, wet loose activity continued in the upper elevations of the GTSR, with avalanches releasing in Beargrass, the Alps, and Big Bend. We observed 21 small wet loose avalanches between May 10-13. Snow deposited at elevations above 5500' a.s.l. shed off of the old snow surface as a result of increasing temperatures and solar radiation throughout the week. We observed the majority of the avalanches in Triple Arches, the Chute above Triple Arches and the Slopes avalanche paths, with debris reaching the already cleared road in each path.

On Thursday May 13, 2021, a natural avalanche in Triple Arches stranded cyclists above the avalanche path on the GTSR and required a formal rescue response from the GNP Rangers and GTSR avalanche forecasters. A further summary of the incident can be found below in the "May 13, 2021 Avalanche Incident Summary" section.

The warm-up peaked over the weekend, and we observed 13 new avalanches that occurred between when the road crew left the road Thursday May 13 and returned Monday May 17. These avalanches were all relatively small avalanches despite refilling and crossing the GTSR in multiple paths between Triple Arches, Chute Above Triple Arches and the Slopes. This sustained warm-up also triggered a small glide avalanche cycle with five avalanches observed between May 17 and 18. A powerful storm originating from southeast of the region the third week of May deposited 6-12 inches of snow above 5000 feet. This storm was followed by two days of continued mixed precipitation resulting in a widespread wet loose avalanche cycle with 18 avalanches observed between May 23 and May 26 in the Slopes. This was the final avalanche cycle of the 2021 GTSR spring opening season.



By June 1, 2021, the snowpack had completely transitioned to its stable summer state and the avalanche hazard along the GTSR had dissipated. The remaining snowpack above the GTSR rapidly melted out over the following three weeks of June due to sustained warm and sunny conditions.

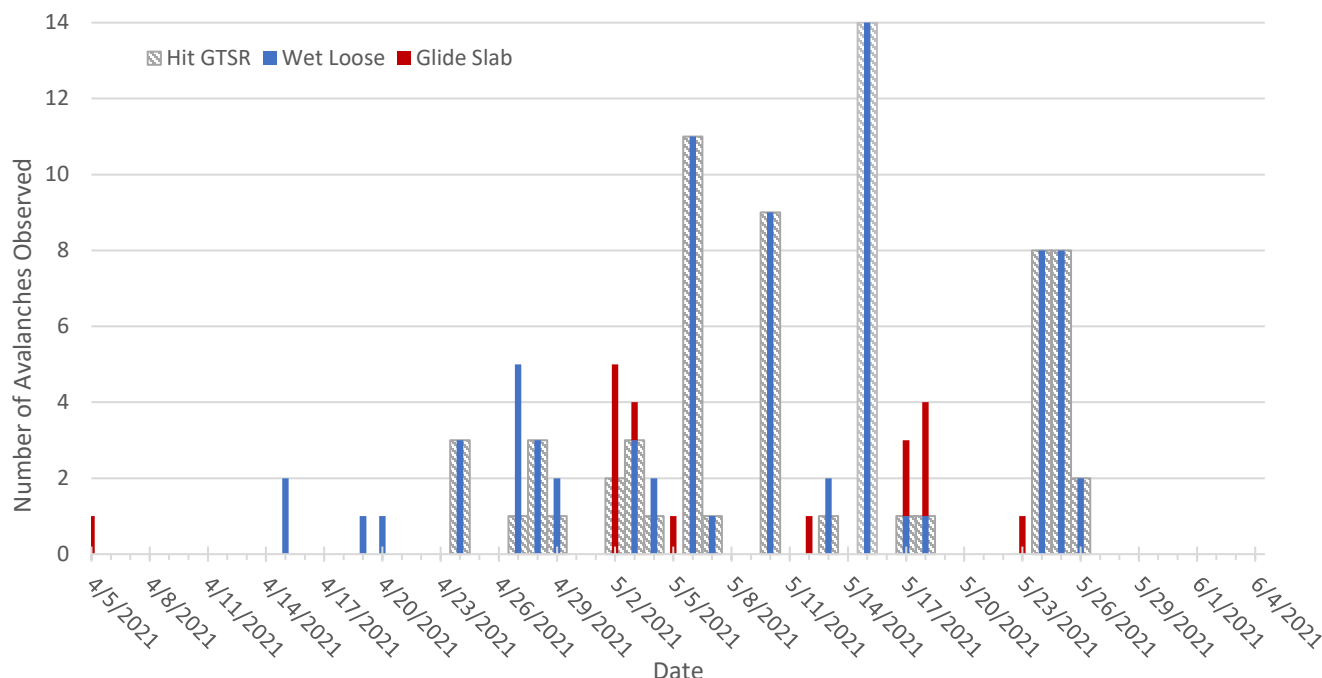


Figure 5: Timeline of observed avalanches along the GTSR during the 2021 spring opening season. Daily Wet Loose avalanches (blue bars), glide slab avalanches (green bars) and the daily total number of observed avalanches that hit the GTSR (grey striped bars) are shown.

In summary, we observed typical cycles of generally wet-loose avalanche activity that followed intermittent storms during the spring of 2021 along the GTSR. We issued hazard ratings for the GTSR corridor on 34 days targeting a variety of avalanches problems. 92 avalanches were observed during the course of the season, 70 of those affect the GTSR, and 68 of those reached the GTSR (Figure 5) which resulted in only 6 hours of additional clearing (Table 2). Fortunately, the road did not sustain any recorded damage from avalanche activity that occurred during the spring of 2021.

Table 2: Observed avalanches in paths affecting the Going-to-the-Sun Road, April 6 – June 3, 2021.

Avalanche Summary	
Observed Destructive Size 1+ avalanches affecting the GTSR	70
Observed avalanches hitting the road	68
Approx. length of road re-plowed due to avalanche burial (ft.)	1985
Total time to clear new debris from road (hrs.)	6
Average road burial depth (ft.)	5
Length of road damaged (ft.)	0

May 13, 2021 Avalanche Incident Summary

On Thursday May 13, 2021, a natural avalanche in Triple Arches stranded two e-cyclists above the avalanche path on the GTSR. The avalanche occurred after the road crew had finished work for the day,



opened the hiker/biker closure at the Loop, and descended to West Glacier. The stranded e-cyclists required rescue from Glacier National Park Rangers and GTSR Avalanche Specialists. The stranded e-cyclists were reported by the wife of one of the e-cyclists around 7:00pm. Deputy Chief Ranger Ed Visnovske responded immediately from West Glacier with two additional rangers and notified the westside roads supervisor Brian Paul, who contacted GNP Avalanche Specialist Noah Keller to respond as well. Upon arriving on scene, Keller assessed the immediate avalanche hazard as low and the condition of the cyclists as safe and warm. The rangers set up a rock anchor, 3 pickets and a rope for steep snow protection, then harnessed in and safely rescued the stranded e-cyclists one at a time. Their e-bikes were left above the slide and retrieved by the westside road crew on their next workday. The rescue was completed, and e-cyclists returned to their families at Avalanche by midnight. The hiker-biker closure would remain permanently at the Loop for the following 3 weeks.

Recommendations

Training and Education:

- Training 1 (early April): **Permanent road crew employees practice avalanche rescue skills before working in avalanche terrain.** Training to focus on companion avalanche rescue while becoming re-acquainted with the associated tools: beacons, shovels, and probes. This training is very important since many permanent staff do not have the opportunity to practice avalanche rescue during the long off-season.
- Training 2 (later spring): **Seasonal road crew staff practice avalanche rescue skills before working in avalanche terrain.** Training to focus on companion avalanche rescue while becoming re-acquainted with the associated tools: beacons, shovels, and probes. This training is very important since many seasonal staff do not have the opportunity to practice avalanche rescue during the long off-season or are new to avalanche rescue.
- Training 3 (midseason): **An avalanche mock rescue scenario that includes the appropriate road crew staff (both permanent and seasonal), the avalanche specialists, as well as GNP rangers and GNP dispatch if possible.** This training should be completed in realistic terrain, such as along the GTSR, and occur earlier in the season to ensure that learning outcomes from the scenario are retained throughout the clearing season. This year, the avalanche scenario training at Oberlin Bend with the westside permanent crew, avalanche specialists, and dispatch was a success. In 2016 the GNP ranger staff joined the road crew for the spring avalanche trainings for the first time in many years and the avalanche specialists look forward to working more closely with the GNP rangers again in the future.
- Ongoing avalanche rescue training: **Allot time throughout the plow season for skills refreshers that include beacon, probing, and shoveling practice.**
- For avalanche specialists, **continue to attend and participate in industry conferences and other professional meetings** such as the International Snow Science Workshop or regional avalanche workshops. This will help specialists stay abreast of the current state of knowledge pertaining to snow and avalanches, as well as to share ideas with other snow safety professionals.
- **Transition the management of avalanche rescue trailers to GNP Rangers.** The rangers and avalanche specialists will likely be the rescuers utilizing the trailers in an incident. Re-equipping the trailers with common rescue tools will make incident response more efficient and safer.
- **Provide high angle rope rescue training for the avalanche specialists in conjunction with GNP Visitor Safety Department.** It is apparent that avalanche specialists would be the primary



response team (and team leaders) in a high angle rescue scenario. Continuing education and practice are critical for keeping technical mountain rescue skills sharp.

Avalanche Forecasts:

- **Continue to devote 5-10 minutes, or the necessary amount of time, during morning briefings with the road crew to provide the avalanche forecast summary.**
- **Continue implementation of hard-copy forecast** and data notebook that resides in the Roads Office (and another in the USGS office). This provides a means for easy non-digital viewing.
- **Adjust forecaster schedules to provide at least one “on-duty” forecaster 7-days/week.** Currently, forecasters are only permitted for field work on road crew workdays (Monday – Thursday), leaving an obvious gap in essential observational information during the 3-day weekends. Avalanche hazard does not end when the road crew leaves for the weekend. Daily snow, weather and avalanche observations help improve the accuracy and quality of the avalanche forecasts and would provide additional support to GNP Rangers managing visitor safety.
- **Continue to work with GNP Visitor Safety Department to implement an avalanche hazard information assessment during times when road is open to the public.**

Research:

- Continue to monitor glide crack movements and rates with a time lapse camera temporarily installed at the Loop.
- Continue to monitor water flow in the snowpack and its association with avalanche activity by maintaining temporary lysimeters near the Garden Wall weather station.
- Examine effectiveness of traditional propagation stability tests on wet snow as the snowpack transitions from a dry winter snowpack to a “spring” snowpack with free water present.
- Explore the diurnal temperature cycle of a “spring” snowpack with free water present.
- Continue to explore the utility of Unmanned Aerial Vehicle mapping of snow depth in avalanche start zones and for measurement of snow melt.

Any questions regarding the USGS-GNP Roads Department Avalanche Program can be directed to Erich Peitzsch (USGS), 406-599-9970 and Zachary Miller (USGS), 406-885-2599.

The USGS works under a cooperative agreement with the National Park Service in Glacier National Park. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.



Resources

- Garden Wall remote weather station data:
<http://wxstns.net/wxstns/glaciernet/SOULOW.html>
- Logan Pass remote weather station data:
http://wxstns.net/wxstns/glaciernet/LOGAN_PASS.html
- Sperry remote weather station data:
<http://wxstns.net/wxstns/glaciernet/SPERRY.html>
- Flattop SNOTEL data:
<https://www.nwrfc.noaa.gov/snow/snowplot.cgi?FTMM8>
- USGS Going-to-the-Sun Road Avalanche Forecasting Program website:
https://www.usgs.gov/centers/norock/science/going-sun-road-avalanche-forecasting-program?qt-science_center_objects=0#qt-science_center_objects
- GTSR Avalanche Occurrence Records data release:
<https://www.sciencebase.gov/catalog/item/5f3d89b082ce8df5b6c73f59>
- USGS Climate Change in Mountain Ecosystems publications:
https://www.usgs.gov/centers/norock/science/climate-change-mountain-ecosystems-ccme?qt-science_center_objects=3#qt-science_center_objects