UTAH HAZARD PLANNING TOOL

April 2022

WESTERN WATER ASSESSMENT
A NOAA RISA TEAM

CIRES

University of Colorado
Boulder

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Regional Integrated
Sciences and Assessments

UTAH HAZARD PLANNING TOOL

April 2022

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Front Cover Photos

Dry ephemeral lake bed in Utah, flames from an actively burning Utah wildfire, avalanche in Stairs Gulch, Big Cottonwood Canyon, UT and flood damage along the Virgin River in St. George, UT.

Design and Layout

Ami Nacu-Schmidt, Cooperative Institute for Research in Environmental Sciences

Introduction

Hazards

Supporting Materials

INTRODUCTION

ABOUT THE UTAH HAZARD PLANNING TOOL

The following resource is a compilation of relatively easy-to-use online interactive information tools, maps, and graphs about natural hazards in Utah. This tool was developed with input from local and state hazard planners and providers of hazard information. The purpose of the tool is to provide hazard planners, emergency managers and other users with the best available information about the historical incidence natural hazards, current hazard risks and information about the future occurrence of hazards. For some hazards, information tools exist to provide meaningful future projections. In many cases, no such tool exists and a brief summary of the current scientific understanding of each hazard and climate change is provided. Appendix 1 provides a more detailed summary of existing scientific literature about each hazard and climate change. The tool may not answer all questions about hazards in the past, present and future, but it aims to cut through the internet clutter and point to relatively simple data tools that can be used during planning processes and in plans. The Utah Hazard Planning Tool was developed by Western Water Assessment in collaboration with the Southern Climate Impacts Planning Program (SCIPP, www.southernclimate.org). This tool was modeled after The Simple Planning Tool for Oklahoma Climate Hazards which was produced by SCIPP in 2019.

ABOUT WESTERN WATER ASSESSMENT

Western Water Assessment (WWA) is a university-based applied research program that addresses societal vulnerabilities to climate variability and climate change through working with resource managers, planners and local governments in Utah, Colorado and Wyoming. WWA's mission is to conduct innovative research in partnership with decision-makers to help make the best use of science to manage for climate impacts. WWA is funded through a National Oceanic and Atmospheric Administration program called the Regional Integrated Sciences and Assessment (RISA) Program. The RISA program funds ten regional organizations in the United States with the general goals to help the nation better understand and prepare for changes in climate and climate variability. The WWA Team is comprised of researchers in multiple disciplines – climatology, hydrology, ecology, social science and law – at the University of Utah, the University of Colorado-Boulder, the University of Wyoming and several other institutions around the region. WWA works directly with stakeholders to articulate research questions and to ensure that research products will be directly usable for planning and decision-making processes.

ABOUT THE AUTHOR

Seth Arens: Seth is the Utah Research Scientist for WWA. He is based at the University of Utah in Salt Lake City and works with Utah resource managers, planners and different levels of Utah government to foster a better understanding of climate risks, changes in climate and adaptation through developing collaborative research projects, information tools and workshops. Seth's background is in ecosystem ecology, snow hydrology, chemistry, climate science and atmospheric science. He worked previously as an Environmental Scientist for the Utah Division of Air Quality.

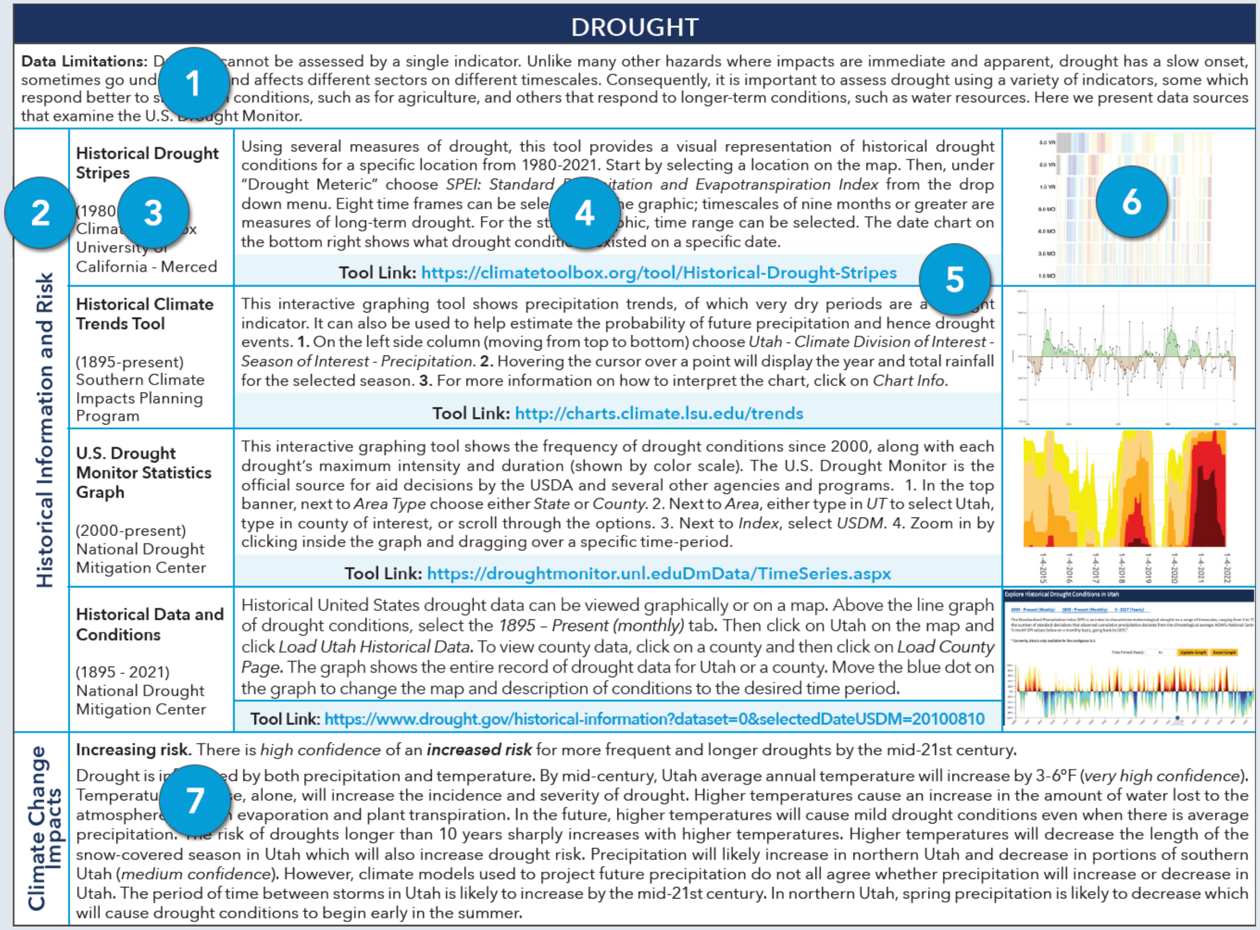
Photo: Aerial view of the Wasatch Front Rocky Mountain Range. Credit: Jeremy/Adobe Stock.

USER INSTRUCTIONS

This document is alphabetically organized by hazard. A table is included for each hazard and describes the data limitations, historical climate and risk tools, and climate change impacts. See the example table below and corresponding descriptions to the left for more details on how each table is organized.

Table Components

1. This section describes known data limitations for the hazard. Knowing limitations can help one interpret data results more accurately.
2. The historical information and risk rows show several tools that provide historical data or current risk relevant to each hazard.
3. For each individual tool, this column provides its name, period of record of the data used, and the source.
4. This column provides a description of the information available and instructions on using the tool.
5. This row provides the website link to access the tool.
6. This column shows an image of the tool's final product (i.e. map, graph, table).
7. The Climate Change Impacts row provides a concise summary on how climate change will alter risk and what impacts may occur. See the Climate Change Impacts Appendix for more detailed information.



DROUGHT			
Data Limitations: D cannot be assessed by a single indicator. Unlike many other hazards where impacts are immediate and apparent, drought has a slow onset, sometimes go und nd affects different sectors on different timescales. Consequently, it is important to assess drought using a variety of indicators, some which respond better to s conditions, such as for agriculture, and others that respond to longer-term conditions, such as water resources. Here we present data sources that examine the U.S. ught Monitor.			
Historical Information and Risk	**Historical Drought Stripes** (1980 Clima x University California - Merced	Using several measures of drought, this tool provides a visual representation of historical drought conditions for a specific location from 1980-2021. Start by selecting a location on the map. Then, under "Drought Meteric" choose *SPEI: Standard itation and Evapotranspiration Index* from the drop down menu. Eight time frames can be sele e graphic; timescales of nine months or greater are measures of long-term drought. For the st phic, time range can be selected. The date chart on the bottom right shows what drought conditi xisted on a specific date. **Tool Link:** https://climatetoolbox.org/tool/Historical-Drought-Stripes	
	Historical Climate Trends Tool (1895-present) Southern Climate Impacts Planning Program	This interactive graphing tool shows precipitation trends, of which very dry periods are a ht indicator. It can also be used to help estimate the probability of future precipitation and hence drought events. **1.** On the left side column (moving from top to bottom) choose *Utah - Climate Division of Interest - Season of Interest - Precipitation*. **2.** Hovering the cursor over a point will display the year and total rainfall for the selected season. **3.** For more information on how to interpret the chart, click on *Chart Info*. **Tool Link:** http://charts.climate.lsu.edu/trends	
	U.S. Drought Monitor Statistics Graph (2000-present) National Drought Mitigation Center	This interactive graphing tool shows the frequency of drought conditions since 2000, along with each drought's maximum intensity and duration (shown by color scale). The U.S. Drought Monitor is the official source for aid decisions by the USDA and several other agencies and programs. 1. In the top banner, next to *Area Type* choose either *State* or *County*. 2. Next to *Area*, either type in *UT* to select Utah, type in county of interest, or scroll through the options. 3. Next to *Index*, select *USDM*. 4. Zoom in by clicking inside the graph and dragging over a specific time-period. **Tool Link:** https://droughtmonitor.unl.eduDmData/TimeSeries.aspx	
	Historical Data and Conditions (1895 - 2021) National Drought Mitigation Center	Historical United States drought data can be viewed graphically or on a map. Above the line graph of drought conditions, select the *1895 – Present (monthly)* tab. Then click on Utah on the map and click *Load Utah Historical Data*. To view county data, click on a county and then click on *Load County Page*. The graph shows the entire record of drought data for Utah or a county. Move the blue dot on the graph to change the map and description of conditions to the desired time period. **Tool Link:** https://www.drought.gov/historical-information?dataset=0&selectedDateUSDM=20100810	
Climate Change Impacts	**Increasing risk.** There is *high confidence* of an ***increased risk*** for more frequent and longer droughts by the mid-21st century. Drought is i ed by both precipitation and temperature. By mid-century, Utah average annual temperature will increase by 3-6°F (*very high confidence*). Temperatu e, alone, will increase the incidence and severity of drought. Higher temperatures cause an increase in the amount of water lost to the atmosphere evaporation and plant transpiration. In the future, higher temperatures will cause mild drought conditions even when there is average precipitation. risk of droughts longer than 10 years sharply increases with higher temperatures. Higher temperatures will decrease the length of the snow-covered season in Utah which will also increase drought risk. Precipitation will likely increase in northern Utah and decrease in portions of southern Utah (*medium confidence*). However, climate models used to project future precipitation do not all agree whether precipitation will increase or decrease in Utah. The period of time between storms in Utah is likely to increase by the mid-21st century. In northern Utah, spring precipitation is likely to decrease which will cause drought conditions to begin early in the summer.		

CLIMATE DATA AVAILABILITY

Data availability differs among weather variables. Some variables are easier and less costly to observe than others. For example, temperature and liquid precipitation have longer and more complete periods of record than snowpack and wildfire. In addition, it is not scientifically appropriate to analyze long-term trends for some hazards due to reporting differences over time. For example, the long-term trends of certain climate parameters may be biased due to population increases and advances in the ability to detect and communicate information. **Refer to the data limitations portion of each hazard section for specific details.**

Ideally, every city and county in Utah would have detailed, long-term climate records and records of other hazard occurrences. Although great advances in data collection have occurred, there are still limitations. Data products such as tables, graphs, and maps are commonly produced from single point observations, then analyses are used that interpolate between data points (for those locations that do not have individual records), or average data points. **Users should be aware that this document references tools that use various data analysis techniques.**

Although individual stations are often favored because they provide specific, local data, a single station's data may not be the best choice for long-term risk analysis if the data is poor quality (i.e. has data gaps or has not been calibrated) or has a short period of record. Some stations have long-term temperature or precipitation records that begin in 1895 while others may have much shorter records. It is important to consider both location and length of record when using a specific site to assess the historical incidence of a hazard. **Depending on user needs, it may be more appropriate to look at data from a station that is relatively close to the desired location (i.e. not in the exact city or county) if it has a longer period of record.** In other words, if a user is looking to assess a location's long-term risk, a nearby station with 60 or 100 years' worth of data may be more valuable than a local station that only contains 15 years of data or has long periods of missing data. Furthermore, if a nearby station does not have a long-term record, it may be more valuable to focus on the tools with interpolated analyses or averages. These tools are acknowledged by scientists to represent the best and most relevant data when locations are under-represented.

Using point data may also miss important events that pose a risk to the city. For example, if a flash flood or wildfire occurred both close to a city and a larger geographic area, using only historical tracks from within city limits would not include the event and therefore under-estimate risk. **It is wise to consider nearby areas along with the particular location of interest when assessing hazard risk.**

CLIMATE CHANGE IMPACTS

The climate change impacts portion accompanying each hazard section in this document provides concise summaries of the most up-to-date scientific knowledge regarding how climate change currently is or is expected to impact each hazard. The science is clear that the global climate is changing and changing at a much greater rate than any time in at least the last 650,000 years. Multiple lines of evidence that humans are the primary influence behind this rate of change. For some Utah hazards, tools for projecting future incidence of the hazard are provided. However, in many cases, only descriptive information about likely changes can be given, as climate models are currently not capable of providing detailed information about specific hazards. For example, models may be able to examine changes in environmental conditions favorable to winter storms but lack the resolution to determine likely storm severity or frequency on a seasonal timescale. The tool provides very brief summaries regarding climate change impacts on each hazard. A detailed review of the current state of the science of climate change and each hazard is provided in the Climate change Impacts Appendix.

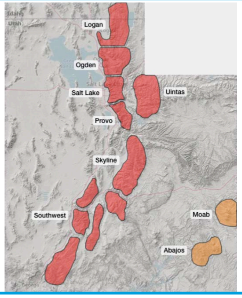
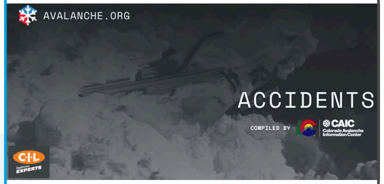
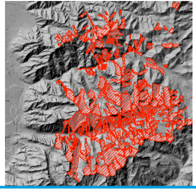
The Climate Change Impacts section of each table begins with a statement about how climate change will affect future risk for each hazard. Risk is summarize as increasing, decreasing, or uncertain depending on the scientific information available. Confidence in the expected direction of change in the risk (increasing or decreasing) is expressed as low confidence, medium confidence or high confidence. A high confidence reflects a change that is almost certain to occur while a low confidence reflects a change that is less certain either due to a lack of scientific research in the western United States, or complexities of future changes that climate models cannot yet resolve.

AVALANCHE

Photo Credit: Katherine/Adobe Stock.

AVALANCHE

Data Limitations: Avalanche forecasts and current observations in Utah are robust, but long-term records of avalanche occurrence are unavailable. No information resources and very little scientific research exists regarding the impacts of climate change on avalanches.

<table>
<tr>
<td rowspan="3">Historical Information and Risk</td>
<td>Avalanche forecasts
(November - April)
Utah Avalanche Center</td>
<td>The Utah Avalanche Center provides daily avalanche forecasts for 4 locations in the Wasatch Mountains (Logan, Ogden, Salt Lake and Provo), the Uinta Mountains, Skyline (central Utah), Moab (La Sal Mountains), the Abajo Mountains and southwestern Utah. Observations of snow conditions and recent avalanches are posted by recreational users for each mountain region. Avalanche watches and warnings issued by the National Weather Service are posted prominently on daily forecasts.
Tool Link: https://utahavalanchecenter.org</td>
<td> </td>
</tr>
<tr>
<td>US Avalanche Fatalities
(2009 – 2020)
Colorado Avalanche Information Center</td>
<td>Database provides avalanche fatalities for the entire United States by each winter season from 2009 - 2021. To quickly find Utah fatalities from each year, click on the "State" heading at the top of the table to organize by state. Click on the location of each avalanche to get a detailed report on each avalanche incident. Reports on Utah avalanche fatalities were compiled by the Utah Avalanche Center.
Tool Link: https://avalanche.org/avalanche-accidents</td>
<td> </td>
</tr>
<tr>
<td>Avalanche Path Maps
Utah Automated Geographic Reference Center (AGRC)</td>
<td>GIS data describing avalanche paths in the central Wasatch Mountains. The dataset contains the name, size of slidepath, return interval, starting zone elevation, vertical relief and starting zone aspect.
Tool Link: https://gis.utah.gov/data/geoscience/avalanche</td>
<td></td>
</tr>
<tr>
<td>Climate Change Impacts</td>
<td colspan="3">Uncertain impact to risk. There is <i>high confidence</i> in a <i>decreasing risk</i> of avalanches at low elevations in Utah. There is <i>high confidence</i> of an <i>increasing risk</i> of avalanches due to wet avalanches caused by warmer temperatures and rain-on-snow events. There is <i>low confidence</i> of an <i>increasing risk</i> of avalanches due to ice crusts caused by rain-on-snow events.
Avalanches are very localized hazards that occur due to a complex interaction of terrain, climate and specific weather conditions that vary dramatically between years and within a winter season. Very little scientific research on the impact of climate change on avalanches exists. However, expected increases in temperature will have three important impacts on avalanches. One, warmer temperatures will cause more rain and less snow at lower elevations, less snowpack at low elevations and therefore a decrease in avalanche frequency at low elevations. Two, warmer temperatures will lead to an increase in the frequency of wet snow avalanches which are typically more destructive types of avalanche. Three, warmer temperatures will lead to more rain-on-snow events at mid- to high elevations. Mid-winter rain-on-snow typically causes a layer within the snowpack that increases the risk of avalanches. Changes in the timing, intensity and duration between winter storms will also change the risks associated with avalanches, but future projections of these specific parameters associated with winter storms are less certain than projections of future temperature.</td>
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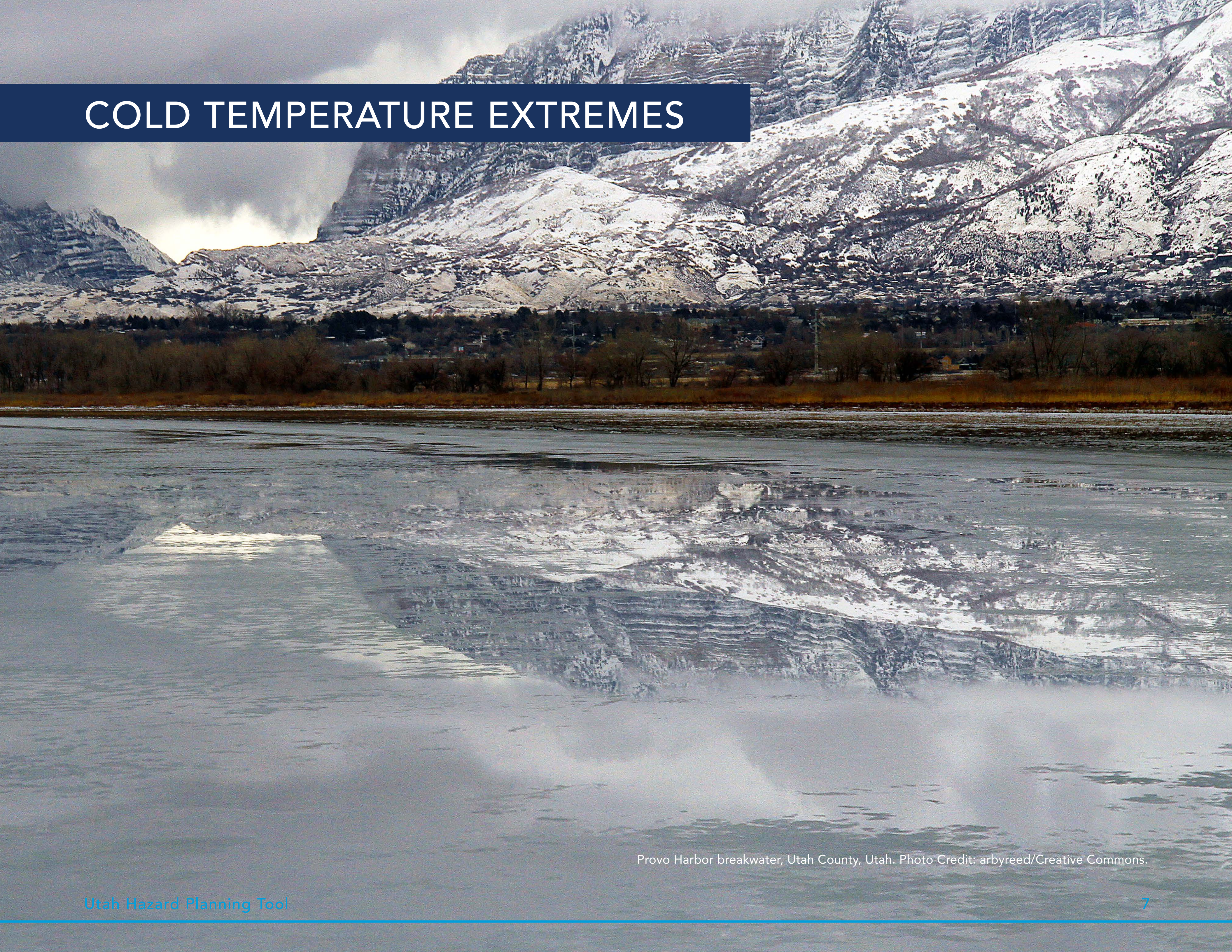
COLD TEMPERATURE EXTREMES



Provo Harbor breakwater, Utah County, Utah. Photo Credit: arbyreed/Creative Commons.

COLD TEMPERATURE EXTREMES

Data Limitations: Temperature data from hundreds of sites across Utah are available dating back to 1895 in some cases. However, there are no tools available that utilize the entire air temperature dataset from Utah in a way that easily determines cold temperature extremes at specific sites.

Historical Information and Risk

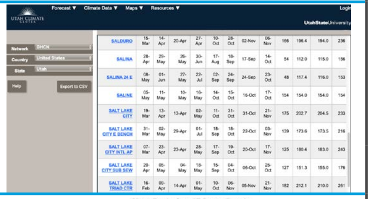
First/Last freeze dates

(1900 - 2020)

Utah Climate Center

First and last freeze dates from sites in Utah and other states are found in the database. Data can be viewed by specific weather stations and provides early, late, average and median last spring freeze and first fall freeze. The freeze-free season is described by the shortest, longest, average and median seasons. Data can be exported as a CSV file.

Tool Link: https://climate.usu.edu/reports/newFreezeDates.php

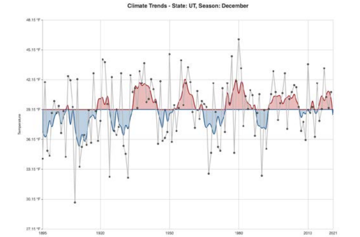


Historical Climate Trends Tool

(1895 - 2020)
Southern Climate Impacts Planning Program

This tool provides a historical perspective on temperature, or precipitation by state and regions within a state. For Utah, temperature can be examined for the entire state or by climate divisions (Dixie, North Central Uinta Basin, South Central, Western, Southeast and Northern Mountains). Annual, seasonal or monthly time periods can be selected to examine temperature.

Tool Link: https://charts.climate.lsu.edu/trends/

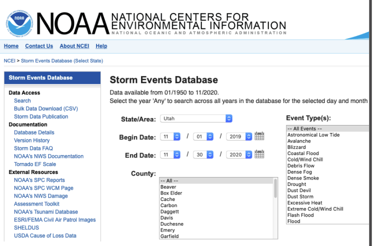


Storm Events Database

(1996-present)
NOAA National Centers for Environmental Information

This searchable database provides the historical record for individual cold temperature extreme events, within individual counties or statewide. Reports include data on crop damage, property damage, injuries, and deaths.
1. On the lower left side of the screen, select *Utah* in the "Select State or Area" menu. **2.** Use the menu options to select the date range of interest. 3. Select *Cold/Wind Chill* in the *Event Types* menu. **4.** Select your county of interest in the *County* menu, or select *-All-* to see events statewide. **5.** Select the desired *Begin Date* and *End Date*. Select 1996 – present to view the entire dataset. Then click *Search*. **6.** The results page shows a table with all events that meet your search criteria. Click on an hyperlinked event name in the *Location* column to see a full report on that event. You can download data in spreadsheet form using the *CSV Download* link.

Tool Link: https://www.ncdc.noaa.gov/stormevents



Storm Events Database

Data available from 01/1950 to 11/2020.
Select the year 'Any' to search across all years in the database for the selected day and month

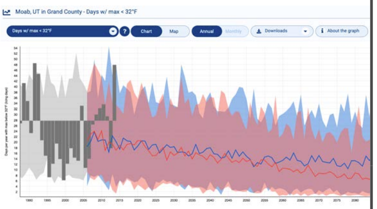
State/Area: Utah
Begin Date: 11 / 01 / 2019
End Date: 11 / 30 / 2020
County: -- All -- Beaver Box Elder Cache Carbon Daggett Davis Duchesne Emery Garfield
Event Type(s): -- All Events -- Astronomical Low Tide Avalanche Blizzard Coastal Flood Cold/Wind Chill Debris Flow Dense Fog Dense Smoke Drought Dust Devil Dust Storm Excessive Heat Extreme Cold/Wind Chill Flash Flood Flood

Climate Change Impacts

The Climate Explorer - Climate Charts Tool
(1930 - 2020)
U.S. Climate Resiliency Toolkit

Start using the tool by entering a county, town or zip code into the search bar. Then select the *Climate Charts* tool. In the top left of the page click the down arrow next to *Avg Daily Max Temp (°F)*. Select *Days with max <32°F* or *Days with min <32°F*. Click on *Historical Observed* at the bottom left to view the actual historical observations. The graph shows the climate variable from 1950 – 2100. Data from 2006 – 2100 are projections of future climate.

Tool Link: https://crt-climate-explorer.nemac.org



Decreasing risk. There is very *high confidence* in a ***decreasing risk*** of cold temperature extremes by the mid-21st century.

Average temperatures are projected to increase by 3 - 6°F by the mid-21st century. In many parts of Utah minimum temperatures will warm faster than maximum temperatures. For example, the number of days when minimum temperatures are less than 32°F is expected to decrease from 155 to 115 days in Salt Lake City and from 205 to 160 days in Logan. The number of days with maximum temperatures less than 32°F is expected to decrease from 35 to 15 days in Salt Lake City and from 65 to 35 days in Logan. Future temperature projections show that the number of very cold days is decreasing faster than the number of very hot days is increasing.

DAM OR LEVEE FAILURE

Virgin River, Utah. Photo credit: Ken Lund/Creative Commons.

DAM OR LEVEE FAILURE

Data Limitations: The tools below do not provide dam or levee failure information but rather information on the locations of and pertinent details about dams and levees in Utah. The dam inventory is limited to dams with a height of at least 25 feet and exceed 15 acre-feet in storage or at least 50 acre-feet of storage and exceed six feet in height unless the dam is classified as high hazard potential. The high hazard potential dam is a dam where failure will probably cause loss of human life regardless of the physical condition of the structure.

Historical Information and Risk

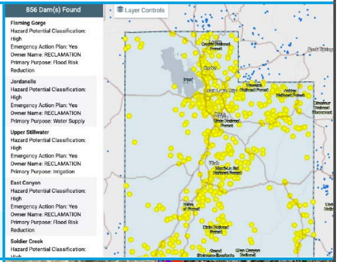
National Inventory of Dams by State

(1900 - 2016)
U.S. Army Corps of Engineers

This tool provides you with an overview of the dams in Utah, including the number by hazard potential, height, owner type, primary type, primary purpose, and completion date.

1. In the map viewer, click on Utah to see dams in Utah. **2.** Click on the *Browse These Dams tab* to see more detailed information about Utah dams. **3.** When you click on a Utah county, the viewer zooms into that county. **4.** Click on a red dot to get information on a specific dam. **5.** Click on a dam name to the left of the map for detailed dam information.

Tool Link: https://nid.usace.army.mil/#/



856 Dam(s) Found

Flaming Gorge
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: RECLAMATION
Primary Purpose: Flood Risk Reduction

Jordanelle
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: RECLAMATION
Primary Purpose: Water Supply

Upper Stillwater
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: RECLAMATION
Primary Purpose: Irrigation

East Canyon
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: RECLAMATION
Primary Purpose: Flood Risk Reduction

Soldier Creek
Hazard Potential Classification:

Utah Dam Failure Flooding maps

Utah Division of Water Rights

The map-based tool provides maps of inundation areas of potential dam failure in Utah.

1. To the right of the map, select high, moderate or low hazard dams. **2.** Click on the red icon next a dam name on the map. **3.** Select *Click Here for More Info*. **4.** Select *Dam Break Map* at the top of the page to view the area inundated by a potential dam failure.

Tool Link: https://maps.waterrights.utah.gov/EsriMap/map.asp?layersToAdd=Dams

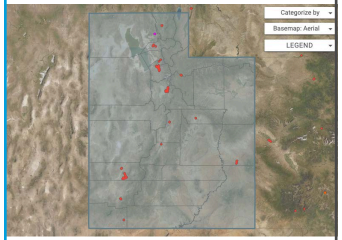
National Levee Database
(1882-Present)

U.S. Army Corps of Engineers

This tool allows you to explore levees in your area, including location, year constructed, length, number of people and structures at risk should failure occur, property values in the risk area, and more.

1. On the left side of the screen, click *Utah*. **2.** Explore the map or click on the county of interest on the left side of the page. **3.** Click on the *Basemap* drop-down menu on the upper-right corner of the map to select a different map layer. **4.** To view more details about each levee, scroll down and click *Map* in the Resources section. **5.** You will see several layer options on the left side of the screen. **6.** Click *National Levee Database* (or other layer of interest). **7.** To view the details of each levee, zoom-in on the map and click on the levee of interest (red line). **8.** Click on the levee link of interest to obtain details about the levee.

Tool Link: https://levees.sec.usace.army.mil/#/



Climate Change Impacts

Increasing risk. There is *medium confidence* of an ***increasing risk*** of dam or levee failure due to increases in flooding risk and aging dam and levee infrastructure.

Dam or levee failure is impacted by climate conditions that cause flooding and the age or integrity of the dam. In general, dams in the United States are relatively old and receive low scores for safety due to age and lack of maintenance. Changes in climate that lead to an increase in the number and severity of flooding events will increase the risk of dam failure. Extreme precipitation events that lead to flooding are likely to increase in Utah during the 21st century. The amount of precipitation that falls during short-duration rainfall events from thunderstorms will increase as temperature increases. More precipitation falling during thunderstorms will increase the probability of flash flooding and increase the probability of dam failure in small reservoirs. This type of dam failure occurred in Santa Clara, Utah in 2012. Rain falling on snow during winter causes flooding because of new precipitation and snow melted by the rain. As temperatures warm in the 21st century, more rain-on-snow events are likely to occur, especially at low and mid-elevations of Utah. Rain-on-snow events increase the probability of flooding and consequently dam failure. A dam failure caused by rain-on-snow flooding occurred on the Humboldt River in central Nevada in 2017.

DEBRIS FLOWS

Burn scars from the 2019 Coal Hollow fire. Photo credit: Utah National Guard.

DEBRIS FLOWS

Data Limitations: Not all historic burn scars in Utah are mapped and monitored. The Utah Geological Survey and the U.S. Geological Survey began providing detailed maps of wildfires and probability of debris flows in 2018.

Historical Information and Risk

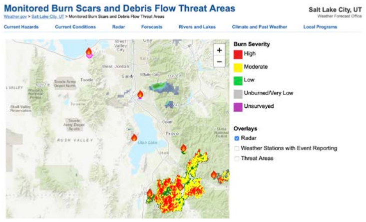
Monitored Burn Scars and Debris Flow Areas

(2018 - present)

National Oceanic and Atmospheric Administration

Tool shows recent wildfire burn scars and the severity of each burn scar. At a large scale, each fire is marked by a fire icon. Click on the fire icon to view the fire name and then on the ⓘ icon to view information about the burn scar including how much rainfall over what duration is likely to trigger a debris flow. Zoom in to see the mapped area of each fire. Current precipitation is overlaid on the map of burn scars.

Tool Link: https://www.weather.gov/slc/burnscar



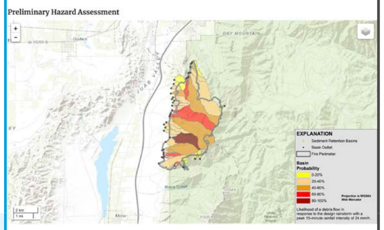
Emergency Assessment of Post-Fire Debris-Flow Hazards

(2020 - present)

U.S. Geological Survey

This map-based tool uses geospatial data such as, basin topography, burn severity, soil properties and rainfall characteristics to estimate the probability and volume of post-fire debris flows from select wildfires. Zoom in on Utah and click on individual fires to see more detailed information about specific fires. The tool provides information about when the fire started, its size and map the fire extent. Each small watershed within the burn area is assigned a probability of debris flow occurrence in response to a one-inch in 15-minute rainfall event. Information about debris flow probability from fires since 2013 is accessed below the map.

Tool Link: https://landslides.usgs.gov/hazards/postfire_debrisflow



Climate Change Impacts

Increasing risk. There is *medium confidence* that debris flows will ***increase in frequency*** due an ***increase in wildfire risk and flooding risk*** by the mid- 21st century. There is *high confidence* that wildfire risk will increase (number, size and intensity of fire) and *low to medium confidence* that flooding risk will increase due to uncertainties in the frequency of extreme rainfall events. Please see the *Flooding* and *Wildfire* sections for additional climate change information.

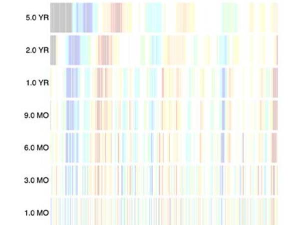
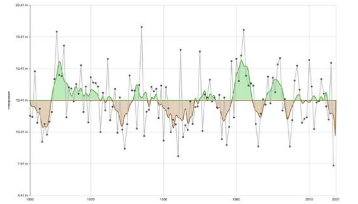
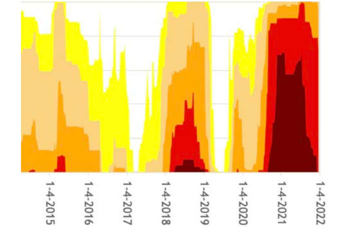
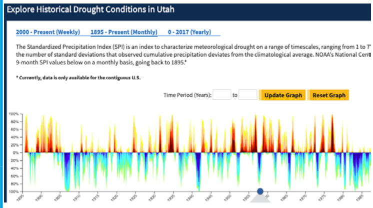
Post-wildfire debris flows is a compound hazard that requires both recent wildfire, possibly exacerbated by drought, and high intensity rainfall to occur. Wildfire risk will increase by the mid-21st century due to increased temperature, increased fire season length and increased dryness of fuels for wildfire. Wildfires will occur more frequently in Utah and many of these fires will be larger. Consequently, there will be a larger area of burn scars (land that was recently burned by a wildfire) that have a the risk of debris flow. The amount of precipitation that falls during intense rainfall events during thunderstorms will increase by the mid-21st century. This type of rainfall event is likely to increase in frequency in the future, but there is less confidence in this projection.

DROUGHT

Jordanelle Reservoir in Wasatch County, Utah. Photo credit: Central Utah Water Conservancy District.

DROUGHT

Data Limitations: Drought cannot be assessed by a single indicator. Unlike many other hazards where impacts are immediate and apparent, drought has a slow onset, sometimes go undetected, and affects different sectors on different timescales. Consequently, it is important to assess drought using a variety of indicators, some which respond better to short-term conditions, such as for agriculture, and others that respond to longer-term conditions, such as water resources. Here we present data sources that examine the U.S. Drought Monitor.

Historical Information and Risk	**Historical Drought Stripes** (1980 - 2021) Climate Toolbox University of California - Merced	Using several measures of drought, this tool provides a visual representation of historical drought conditions for a specific location from 1980-2021. Start by selecting a location on the map. Then, under "Drought Meteric" choose *SPEI: Standard Precipitation and Evapotranspiration Index* from the drop down menu. Eight time frames can be selected for the graphic; timescales of nine months or greater are measures of long-term drought. For the stripes graphic, time range can be selected. The date chart on the bottom right shows what drought conditions existed on a specific date. **Tool Link:** https://climatetoolbox.org/tool/Historical-Drought-Stripes	
	Historical Climate Trends Tool (1895-present) Southern Climate Impacts Planning Program	This interactive graphing tool shows precipitation trends, of which very dry periods are a drought indicator. It can also be used to help estimate the probability of future precipitation and hence drought events. **1.** On the left side column (moving from top to bottom) choose *Utah - Climate Division of Interest - Season of Interest - Precipitation*. **2.** Hovering the cursor over a point will display the year and total rainfall for the selected season. **3.** For more information on how to interpret the chart, click on *Chart Info*. **Tool Link:** http://charts.climate.lsu.edu/trends	
	U.S. Drought Monitor Statistics Graph (2000-present) National Drought Mitigation Center	This interactive graphing tool shows the frequency of drought conditions since 2000, along with each drought's maximum intensity and duration (shown by color scale). The U.S. Drought Monitor is the official source for aid decisions by the USDA and several other agencies and programs. 1. In the top banner, next to *Area Type* choose either *State* or *County*. 2. Next to *Area*, either type in *UT* to select Utah, type in county of interest, or scroll through the options. 3. Next to *Index*, select *USDM*. 4. Zoom in by clicking inside the graph and dragging over a specific time-period. **Tool Link:** https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx	
	Historical Data and Conditions (1895 - 2021) National Drought Mitigation Center	Historical United States drought data can be viewed graphically or on a map. Above the line graph of drought conditions, select the *1895 – Present (monthly)* tab. Then click on Utah on the map and click *Load Utah Historical Data*. To view county data, click on a county and then click on *Load County Page*. The graph shows the entire record of drought data for Utah or a county. Move the blue dot on the graph to change the map and description of conditions to the desired time period. **Tool Link:** https://www.drought.gov/historical-information?dataset=0&selectedDateUSDM=20100810	Explore Historical Drought Conditions in Utah The Standardized Precipitation Index (SPI) is an index to characterize meteorological drought on a range of timescales, ranging from 1 to 7 the number of standard deviations that observed cumulative precipitation deviates from the climatological average. NOAA's National Cent 9-month SPI values below on a monthly basis, going back to 1895.* * Currently, data is only available for the contiguous U.S. Time Period (Years): to

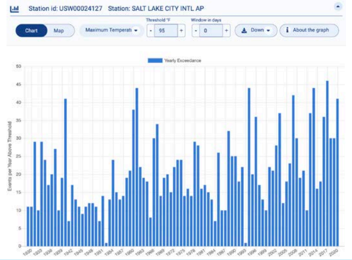
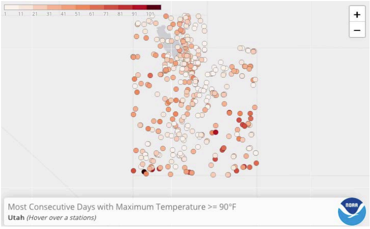
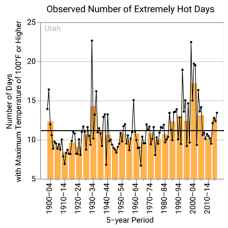
Climate Change Impacts

Increasing risk. There is *high confidence* of an ***increased risk*** for more frequent and longer droughts by the mid-21st century.

Drought is influenced by both precipitation and temperature. By mid-century, Utah average annual temperature will increase by 3-6°F (*very high confidence*). Temperature increase, alone, will increase the incidence and severity of drought. Higher temperatures cause an increase in the amount of water lost to the atmosphere through evaporation and plant transpiration. In the future, higher temperatures will cause mild drought conditions even when there is average precipitation. The risk of droughts longer than 10 years sharply increases with higher temperatures. Higher temperatures will decrease the length of the snow-covered season in Utah which will also increase drought risk. Precipitation will likely increase in northern Utah and decrease in portions of southern Utah (*medium confidence*). However, climate models used to project future precipitation do not all agree whether precipitation will increase or decrease in Utah. The period of time between storms in Utah is likely to increase by the mid-21st century. In northern Utah, spring precipitation is likely to decrease which will cause drought conditions to begin early in the summer.

EXTREME HEAT

Bonneville Salt Flats, Wendover, Utah. Photo credit: Fabio Achilli/Creative Commons.

<table>
<tr><th colspan="4">EXTREME HEAT</th></tr>
<tr><td colspan="4">Data Limitations: Temperature data from hundreds of sites across Utah are available dating back to 1895 in some cases. However, there are few tools that analyze the full dataset in a manner that easily expresses the frequency that certain temperature thresholds are crossed.</td></tr>
<tr><td rowspan="3">Historical Information and Risk</td><td>The Climate Explorer - Historical Thresholds Tool
(1930 - 2020)
U.S. Climate Resiliency Toolkit</td><td>Start using the tool by entering a county, town or zip code into the search bar. Click on the <i>Historical Thresholds</i> tool. The <i>Historical Threshold</i> tool can tell you how often a temperature value was exceeded historically at a specific location. Select <i>Maximum Temperature</i> from the drop-down tab at the top left of the screen. Then, select the threshold temperature of interest from <i>Threshold °F</i> at the top center of the screen. Set <i>Window in days</i> to zero. Finally select a specific site of interest in Utah by clicking on a red dot. The data is presented as a bar graph with the number of days each year that the temperature threshold was exceeded.
Tool Link: https://crt-climate-explorer.nemac.org</td><td>Station id: USW00024127 Station: SALT LAKE CITY INTL AP
Maximum Temperat
Threshold °F 95
Window in days 0 </td></tr>
<tr><td>Extremes – U.S. Streaks
(period of record varies)
NOAA National Centers for Environmental Information</td><td>Interactive tool that displays the streak, in number of days, of temperature above 90°F or 100°F. Under the <i>State</i> drop down tab, select Utah. Under the <i>Streak</i> drop down tab, select <i>Maximum Temperature >= 90°F</i> or <i>Maximum Temperature >=100°F.</i> The link brings up a page with dropdown boxes for selecting a state and "streak" or parameter of interest. Select <i>All Time</i> to see the longest streaks on record at each site. Streak data is listed on the map as different colored circles or on a table with all sites and the date of the streak. Click on a site on the map to see more detailed information.
Tool Link: https://www.ncdc.noaa.gov/extremes/streaks</td><td>Most Consecutive Days with Maximum Temperature >= 90°F
Utah <i>(Hover over a stations)</i> </td></tr>
<tr><td>Observed Number of Extremely Hot Days
(1900-2015)
NOAA National Centers for Environmental Information</td><td>Figure from the a report on climate in Utah displaying the number of observed extremely hot days in Utah from 1900-2015. Extremely hot days are defined as days hotter than 100°F. Scroll down until you reach Figure 2. Shows the observed number of extremely hot days (>100°F) per 5-year periods.
Tool Link: https://statesummaries.ncics.org/chapter/ut</td><td> </td></tr>
</table>

EXTREME HEAT

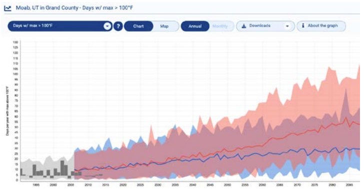
Climate Change Impacts

The Climate Explorer - Climate Charts Tool

(1950 - 2099)
U.S. Climate Resiliency Toolkit

Start using the tool by entering a county, town or zip code into the search bar. **1.** Select the *Climate Charts* tool. **2.** In the top left of the page click the down arrow next to *Avg Daily Max Temp (°F)*. Select *Days with max >90°F, 95°F , 100°F* or *105°F*. **3.** Click on *Historical Observed* at the bottom left to view the actual historical observations. The graph shows the climate variable from 1950 – 2099. Data from 2006 – 2100 are projections of future climate.

Tool Link: https://crt-climate-explorer.nemac.org



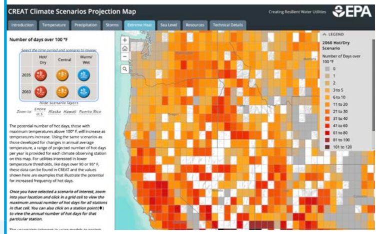
CREAT Climate Scenarios Projections Map

(2030 - 2060)
Environmental Protection Agency

This tool uses climate models to project the number of days over 100°F. Three scenarios are used to project extreme heat, hot/dry, warm/wet and the central tendency which is the average of all climate models used. Two time periods can be selected, 2035 and 2060.

Select the *Extreme Heat* tab at the top of the page. Future projections of extreme heat are shown on a map. At the top left of the page, three scenarios (*hot/dry*, *warm/wet* and *central*) can be selected for two time periods (2035 and 2060). The map shows the number of days each year with temperatures greater than 100°F.

Tool Link: https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=3805293158d54846a29f750d63c6890e

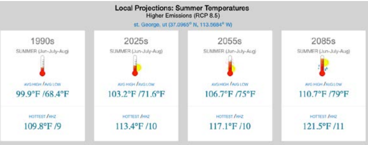


Future Climate Dashboard

(1990 - 2099)
The Climate Toolbox

The tool creates a dashboard that shows measures of extreme heat for the 1990s and projected temperatures for the 2025s (2010–2039), 2055s (2040–2069) and 2085s (2070–2099). **1.** Click on the *Choose location* box in the top left of the page. **2.** Enter a place under *GeoLocation*, move the red market, or enter coordinates to choose the location. Then click *Set location*. **3.** Under *Choose Data*, select either *Heat Indices* or *Summer Temperatures* under the *Dashboard* tab. Under the *Future Scenario* tab choose a *Lower Emission* or *Higher Emission* scenario. Under *summer temperature*, the average high, average low and extreme high temperatures are shown.

Tool Link: https://climatetoolbox.org/tool/future-climate-dashboard



Local Projections: Summer Temperatures
Higher Emissions (RCP 8.5)
st. George, ut (37.0965° N, 113.5684° W)

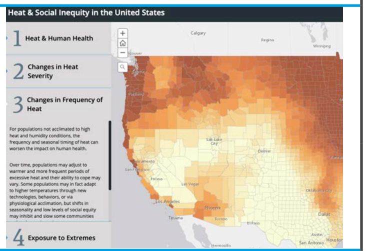
1990s	2025s	2055s	2085s
SUMMER (Jun-July-Aug)	SUMMER (Jun-July-Aug)	SUMMER (Jun-July-Aug)	SUMMER (Jun-July-Aug)
AVG HIGH / AVG LOW	AVG HIGH / AVG LOW	AVG HIGH / AVG LOW	AVG HIGH / AVG LOW
99.9°F /68.4°F	103.2°F /71.6°F	106.7°F /75°F	110.7°F /79°F
HOTTEST / HHZ	HOTTEST / HHZ	HOTTEST / HHZ	HOTTEST / HHZ
109.8°F /9	113.4°F /10	117.1°F /10	121.5°F /11

Future Heat Events and Social Vulnerability

(2020-2090)
National Integrated Heat Health Information System

This tool maps various aspects of heat and social inequality parameters to the county level. Click on *1 Heat & Human Health* for a description of the tool. Selecting 2-6 in the left panel displays different map layers which include, *Changes in heat severity*, *Changes in heat frequency*, *Exposures to extremes*, *Social vulnerability score* and *Heat vulnerability score*.

Tool Link: https://nihhis.cpo.noaa.gov/vulnerability-mapping



Increasing risk. There is *very high confidence* of an ***increasing risk*** of extreme heat in Utah by the mid-21st century.

Global climate models are most certain that temperatures will increase throughout the 21st century. By the mid-21st century, the number of days with maximum temperatures greater than 95°F will increase from 7 to 35 days in Salt Lake City and from 27 to 65 days in St. George. Similarly, the number of days with temperatures greater than 100°F will increase from 1 to 12 days in Salt Lake City and from 10 to 35 days in St. George. If extreme heat is defined by the number of days with maximum temperatures greater than 95°F, then by mid-century, Salt Lake City will see a 500% increase in extreme heat and St. George will see a 250% increase. To put the extreme heat increase in a different context, by the end of the 21st century, Salt Lake City is projected to have the same number of extreme heat days that Las Vegas, NV currently experiences.

FLOODING AND HEAVY RAINFALL

The dry wash is flooded with muddy water after rain storm in Southern Utah desert. Photo credit: sumikophoto/Adobe Stock.

FLOODING AND HEAVY RAINFALL

Data Limitations: Utah is a large and rural state that has many gaps in the coverage of sites that record precipitation and other meteorological information. Most flash flooding events are caused by isolated thunderstorms which may not be recorded by meteorological sites. Only 10% of Utah has flood risk maps.

Historical Information and Risk

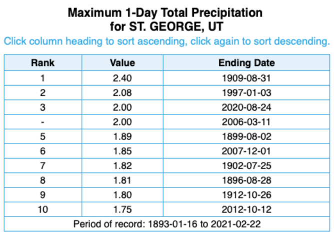
Daily Extreme Precipitation on xmACIS2

(period of record varies by station)
NOAA Regional Climate Centers

Interactive tool shows the highest daily (user chooses duration) rainfall totals for a station of interest in a table. It can be used to determine the upper level thresholds of multiple day rainfall amounts that have occurred, and what one could expect to occur again.

1. On the left side of the screen, select *Single-Station*, then *Extremes*. **2.** Next to *Variable*, select Total Precipitation. **3.** Enter length of period of interest (e.g. 1 Day for 1-day rainfall totals). **4.** Click on *Select station* tab. **5.** Search for a location. The stations near that location appear on a map. To expand the search area, click *Expand Search Area* at the bottom of the page. **6.** Click *Go*. **7.** Table will be displayed on screen. Note the period of record (POR) on the bottom of the table. Choose a station with longer POR if possible. Double click on a station shown on the map to see the POR.

Tool Link: http://xmacis.rcc-acis.org



Maximum 1-Day Total Precipitation
for ST. GEORGE, UT
Click column heading to sort ascending, click again to sort descending.

Rank	Value	Ending Date
1	2.40	1909-08-31
2	2.08	1997-01-03
3	2.00	2020-08-24
-	2.00	2006-03-11
5	1.89	1899-08-02
6	1.85	2007-12-01
7	1.82	1902-07-25
8	1.81	1896-08-28
9	1.80	1912-10-26
10	1.75	2012-10-12

Period of record: 1893-01-16 to 2021-02-22

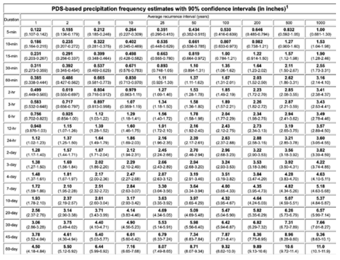
NOAA Atlas 14 Precipitation Frequency Data Server

(Last updated in 2013)
NOAA Hydrometeorological Design Studies Center

Interactive tool shows rainfall frequency estimates for select durations (e.g. 1-, 3- and 24 hours) and recurrence intervals (e.g. 100-, 500-, and 1000-years) with 90% confidence intervals. Probable maximum precipitation (PMP) values are not represented in this tool. Such values will be available through an additional tool in the near future.

1. Click on *Utah* from the map. A new screen will open. **2.** To select a location, either enter the desired location, station or address manually OR select a station from the interactive map. **3.** Precipitation frequency estimates will be displayed in both table and graph forms below. **4.** For additional help, select *FAQ* from the left-hand menu, then refer to the *Section 5* link under section 1.1.

Tool Link: https://hdsc.nws.noaa.gov/hdsc/pfds/index.html



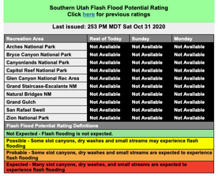
PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.122** (0.107-0.142)	**0.155** (0.136-0.179)	**0.212** (0.185-0.246)	**0.264** (0.227-0.309)	**0.351** (0.295-0.413)	**0.434** (0.352-0.515)	**0.530** (0.416-0.639)	**0.646** (0.485-0.794)	**0.832** (0.592-1.05)	**1.00** (0.681-1.30)
10-min	**0.186** (0.164-0.215)	**0.235** (0.207-0.272)	**0.322** (0.281-0.375)	**0.402** (0.345-0.469)	**0.535** (0.448-0.629)	**0.661** (0.536-0.785)	**0.807** (0.633-0.973)	**0.982** (0.738-1.21)	**1.27** (0.900-1.60)	**1.53** (1.04-1.98)
15-min	**0.231** (0.203-0.267)	**0.291** (0.256-0.337)	**0.399** (0.348-0.464)	**0.498** (0.428-0.582)	**0.663** (0.555-0.780)	**0.819** (0.664-0.972)	**1.00** (0.784-1.21)	**1.22** (0.914-1.50)	**1.57** (1.12-1.98)	**1.90** (1.28-2.46)
30-min	**0.311** (0.273-0.359)	**0.392** (0.345-0.454)	**0.537** (0.469-0.625)	**0.671** (0.576-0.783)	**0.893** (0.748-1.05)	**1.10** (0.894-1.31)	**1.35** (1.06-1.62)	**1.64** (1.23-2.02)	**2.11** (1.50-2.67)	**2.55** (1.73-3.31)
60-min	**0.385** (0.338-0.444)	**0.486** (0.427-0.562)	**0.665** (0.581-0.773)	**0.830** (0.713-0.970)	**1.11** (0.925-1.30)	**1.37** (1.11-1.62)	**1.67** (1.31-2.01)	**2.03** (1.52-2.50)	**2.62** (1.86-3.31)	**3.16** (2.14-4.10)
2-hr	**0.499** (0.449-0.565)	**0.619** (0.555-0.697)	**0.804** (0.716-0.912)	**0.979** (0.863-1.11)	**1.27** (1.09-1.46)	**1.53** (1.28-1.78)	**1.85** (1.49-2.19)	**2.23** (1.72-2.70)	**2.85** (2.08-3.55)	**3.41** (2.38-4.37)
3-hr	**0.583** (0.532-0.648)	**0.717** (0.656-0.797)	**0.897** (0.813-0.998)	**1.07** (0.959-1.19)	**1.34** (1.18-1.50)	**1.58** (1.36-1.80)	**1.89** (1.57-2.21)	**2.26** (1.82-2.72)	**2.87** (2.21-3.59)	**3.43** (2.53-4.41)
6-hr	**0.756** (0.702-0.823)	**0.925** (0.854-1.00)	**1.12** (1.03-1.22)	**1.29** (1.18-1.41)	**1.56** (1.40-1.72)	**1.78** (1.58-1.98)	**2.04** (1.77-2.29)	**2.34** (1.98-2.75)	**2.94** (2.41-3.62)	**3.49** (2.78-4.46)
12-hr	**0.948** (0.876-1.03)	**1.15** (1.07-1.26)	**1.39** (1.28-1.52)	**1.60** (1.46-1.75)	**1.91** (1.72-2.10)	**2.16** (1.92-2.40)	**2.43** (2.12-2.75)	**2.73** (2.34-3.13)	**3.19** (2.65-3.75)	**3.57** (2.89-4.50)
24-hr	**1.12** (1.02-1.23)	**1.37** (1.25-1.50)	**1.64** (1.49-1.79)	**1.86** (1.69-2.03)	**2.16** (1.96-2.35)	**2.39** (2.17-2.61)	**2.63** (2.37-2.88)	**2.88** (2.58-3.15)	**3.21** (2.85-3.78)	**3.60** (3.05-4.55)
2-day	**1.28** (1.17-1.40)	**1.57** (1.44-1.71)	**1.87** (1.71-2.04)	**2.12** (1.94-2.31)	**2.45** (2.24-2.66)	**2.70** (2.46-2.94)	**2.96** (2.68-3.23)	**3.22** (2.90-3.53)	**3.56** (3.18-3.92)	**3.82** (3.39-4.59)
3-day	**1.38** (1.27-1.50)	**1.69** (1.56-1.84)	**2.02** (1.86-2.20)	**2.29** (2.10-2.49)	**2.66** (2.43-2.89)	**2.94** (2.68-3.20)	**3.24** (2.93-3.53)	**3.53** (3.18-3.86)	**3.92** (3.50-4.31)	**4.22** (3.74-4.85)
4-day	**1.48** (1.37-1.61)	**1.81** (1.67-1.97)	**2.17** (2.00-2.36)	**2.47** (2.27-2.68)	**2.87** (2.63-3.12)	**3.19** (2.91-3.46)	**3.51** (3.19-3.82)	**3.84** (3.47-4.20)	**4.28** (3.83-4.70)	**4.63** (4.10-5.11)
7-day	**1.72** (1.59-1.86)	**2.10** (1.95-2.28)	**2.51** (2.32-2.72)	**2.84** (2.63-3.07)	**3.30** (3.04-3.56)	**3.64** (3.34-3.94)	**4.00** (3.65-4.33)	**4.35** (3.95-4.73)	**4.82** (4.34-5.26)	**5.18** (4.63-5.68)
10-day	**1.93** (1.78-2.10)	**2.37** (2.19-2.57)	**2.81** (2.60-3.04)	**3.17** (2.93-3.42)	**3.63** (3.35-3.92)	**3.97** (3.65-4.29)	**4.32** (3.95-4.67)	**4.64** (4.24-5.03)	**5.07** (4.59-5.51)	**5.37** (4.84-5.87)
20-day	**2.56** (2.37-2.76)	**3.14** (2.90-3.38)	**3.71** (3.43-3.99)	**4.14** (3.83-4.46)	**4.69** (4.34-5.05)	**5.09** (4.69-5.48)	**5.47** (5.04-5.90)	**5.82** (5.35-6.29)	**6.26** (5.73-6.79)	**6.57** (5.99-7.14)
30-day	**3.06** (2.86-3.28)	**3.75** (3.49-4.02)	**4.40** (4.10-4.71)	**4.90** (4.56-5.23)	**5.53** (5.14-5.91)	**5.98** (5.56-6.40)	**6.42** (5.94-6.87)	**6.82** (6.29-7.32)	**7.31** (6.72-7.89)	**7.66** (7.01-8.27)
45-day	**3.78** (3.52-4.04)	**4.61** (4.30-4.94)	**5.40** (5.03-5.77)	**6.01** (5.60-6.42)	**6.79** (6.33-7.24)	**7.34** (6.83-7.84)	**7.87** (7.31-8.41)	**8.36** (7.75-8.95)	**8.96** (8.28-9.60)	**9.36** (8.63-10.1)
60-day	**4.50** (4.18-4.84)	**5.50** (5.12-5.92)	**6.44** (5.99-6.92)	**7.16** (6.65-7.68)	**8.07** (7.49-8.65)	**8.71** (8.07-9.34)	**9.32** (8.62-10.0)	**9.89** (9.13-10.6)	**10.6** (9.72-11.4)	**11.0** (10.1-11.9)

Flash Flood Information
(2019)
National Weather Service - Salt Lake City Regional Office

Flash flood watches and warnings are issued for days 1-3 for southern Utah. Flash flood forecast sites are for national parks and areas where people recreate in slot canyons, where flash flood risk is highest. Flash flood danger ratings (not expected, possible, probable and expected) are issued May 1st through October 31st.

Tool Link: https://www.weather.gov/slc/flashflood



Southern Utah Flash Flood Potential Rating
Click here for previous ratings

Last issued: 253 PM MDT Sat Oct 31 2020

Recreation Area	Rest of Today	Sunday	Monday
Arches National Park	Not Available	Not Available	Not Available
Bryce Canyon National Park	Not Available	Not Available	Not Available
Canyonlands National Park	Not Available	Not Available	Not Available
Capitol Reef National Park	Not Available	Not Available	Not Available
Glen Canyon National Rec Area	Not Available	Not Available	Not Available
Grand Staircase-Escalante NM	Not Available	Not Available	Not Available
Natural Bridges NM	Not Available	Not Available	Not Available
Grand Gulch	Not Available	Not Available	Not Available
San Rafael Swell	Not Available	Not Available	Not Available
Zion National Park	Not Available	Not Available	Not Available

Flash Flood Potential Rating Definitions

Not Expected - Flash flooding is not expected.

Possible - Some slot canyons, dry washes and small streams may experience flash flooding

Probable - Some slot canyons, dry washes and small streams are expected to experience flash flooding

Expected - Many slot canyons, dry washes, and small streams are expected to experience flash flooding

FLOODING AND HEAVY RAINFALL

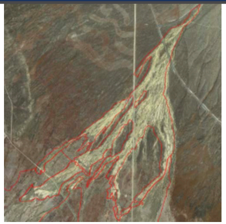
Historical Information and Risk

Alluvial Fan Mapping

(2019)
Utah Division of Emergency Management

Utah Division of Emergency Management (DEM) is currently working on mapping all alluvial fans in Utah. Alluvial fans are geologic landforms that are subject to infrequent, but destructive flooding events. This resource provides GIS shapefiles of mapped areas of Utah. Alluvial fan mapping has been completed in the Wasatch and Oquirrh Mountains and parts of Cache, Sevier, Salt Lake, Sanpete, Utah and Washington Counties. **Active Alluvial Fan Inventory: Wasatch and Oquirrh Mountains**, Utah report provides more detailed information on alluvial fan mapping effort by DEM.

Tool Link: https://gis.utah.gov/data/geoscience/alluvial-fans



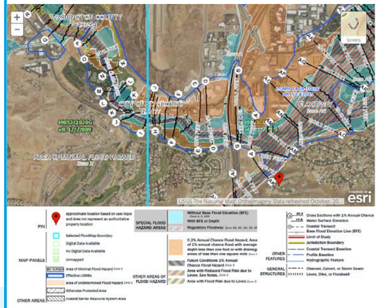
FEMA Flood Map Service Center

Federal Emergency Management Agency

Website can be used to locate and identify flood hazard zones in a jurisdiction and produce maps for inclusion in a hazard mitigation plan. When combined with other map layers it can provide a spatial relationship between flood hazard zones and critical facilities and infrastructure. Note that the 100-yr floodplain is an estimate used for insurance and regulatory purposes. Floods can and do occur outside of the areas depicted.

1. Enter an address, place, or coordinates in the search bar near the top of the page. **2.** Click *Streets* view in the upper right corner of the map. **3.** The panel of land outlined in light blue is the one that will be mapped. If you need a different panel, click on the one of interest (Zoom out if needed. It may take a few seconds for it to be selected). **4.** Zoom in to view details in the map such as those shown at right. Note, the legend below the map and effective date in bold above the map. **5.** To download a black & white static image of the full original FIRM panel, click on the *Map Image* icon. **6.** To access a colored map, click on the *Dynamic Map* icon. You may need to disable your browser's pop-up blocker.

Tool Link: https://msc.fema.gov/portal



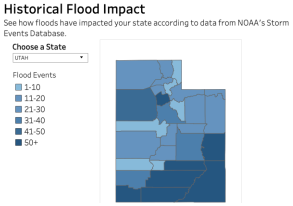
Historical Flood Risk and Costs

(1996-present)
Federal Emergency Management Agency

Map visualization and graphs show state and county flood events that are documented in NOAA's Storm Events Database. It shows the number of flood events by county and costs of flooding based on average National Flood Insurance Program and FEMA's Individual and Household Program payments.

1. Under *Choose a State*, select Utah. **2.** Utah statistics will be displayed on the page. **3.** If you wish to view statistics by county, click on a county on the map displayed on the page.

Tool Link: https://www.fema.gov/data-visualization-floods-data-visualization



Historical Flood Impact

See how floods have impacted your state according to data from NOAA's Storm Events Database.

Climate Change Impacts

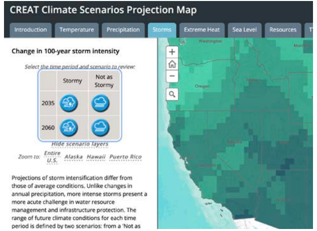
CREAT Climate Scenarios Projections Map

2030 - 2060)
Environmental Protection Agency

This tool uses climate models to project the change in intensity of 100-year storm events. For example, if a 2" in 1-hour rainfall event occurs once every 100 years in Salt Lake City and the future climate projection is a 50% increase in storm intensity, then , on average, a 100-year rainfall event would increase to 3 inches in 1-hour.

Select the *Storms* tab at the top of the page. Future projections of storm intensity are shown on a map. At the top right of the page, two scenarios (*stormy* and *not as stormy*) can be selected for two time periods (2035 and 2060). The map shows a percentage increase or decrease in storm intensity.

Tool Link: https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=3805293158d54846a29f750d63c6890e



Projections of storm intensification differ from those of average conditions. Unlike changes in annual precipitation, more intense storms present a more acute challenge in water resource management and infrastructure protection. The range of future climate conditions for each time period is defined by two scenarios: from a 'Not as

Increasing risk. There is *medium confidence* of ***increased flood risk*** in Utah by the mid-21st century.

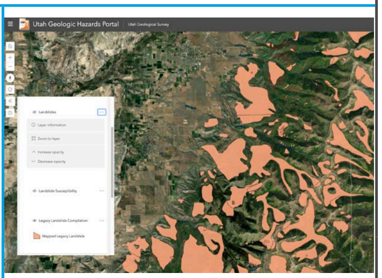
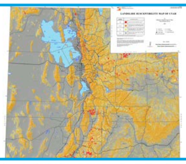
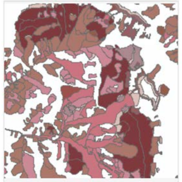
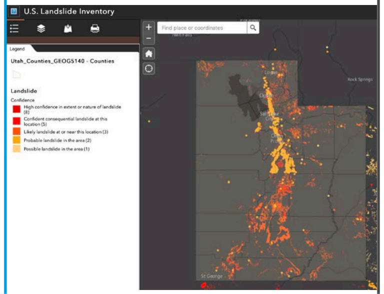
Annual average precipitation is projected to increase by 5-10% in northern Utah by the mid-21st century (*medium confidence*). Not all climate models agree that northern Utah precipitation will increase, some project a decrease. In southern Utah, there is more uncertainty around changes in precipitation; it is likely that some parts of southern Utah will see a decrease in precipitation by the mid-21st century (*low to medium confidence*). Extreme or heavy rainfall events have increased by a modest 10% in the southwestern United States since 1958. The incidence of heavy rainfall events is likely to increase in the future (*low to medium confidence*) which may lead to an increased incidence of flash flooding, especially in southern Utah. Two types of flooding events are directly impacted by temperature. As temperature increases, the amount of precipitation that falls during short-duration high intensity rainfall events, such as thunderstorms, will increase (*high confidence*). An increase in precipitation falling during thunderstorms will increase the risk of flash flooding. Increased temperatures by the mid-21st century will cause more rain and less snow during winter (*high confidence*). When rain falls on snow during winter there is an increased risk to flooding due to rapidly melting snow. A rain-on-snow event in 2017 caused extensive flooding in eastern Box Elder County.

LANDSLIDES

Landslide in Riverdale City, Utah. Photo credit: Ben Erickson/Utah Geological Survey.

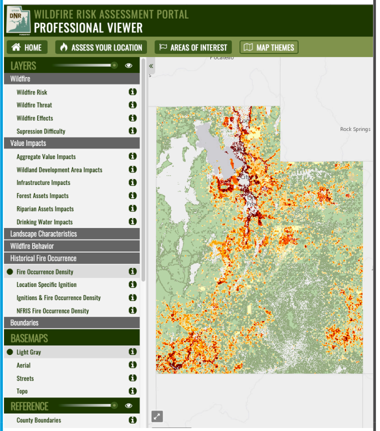
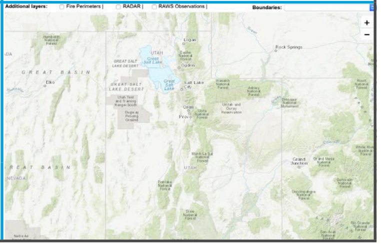
LANDSLIDES

Data Limitations: Not all historical landslides are mapped in Utah. Little research or tools exist on the impacts of climate change on landslides.

<table>
<tr>
<td rowspan="4">Historical Information and Risk</td>
<td>Utah Geologic Hazards Portal
Utah Geological Survey</td>
<td>This tool maps the location of geologic hazard risk and the historical extent of certain geologic hazards. Four types of landslide information are shown: <i>Rockfall Hazard</i>, <i>Landslides</i>, <i>Landslide Susceptibility</i> and <i>Legacy Landslide Compilation</i>.
Click on the arrow next to <i>Landslides</i> to view the four types of landslide data. Click on each dataset to view on the map. Click on the three dots next to the layer name for layer information or to change transparency. In order to view the <i>Legacy Landslide Compilation</i>, the map must be zoomed in until the pink polygons marking historical landslides appear.
Tool Link: https://geology.utah.gov/apps/hazards</td>
<td> </td>
</tr>
<tr>
<td>Landslide Susceptibility Map (2007)
Utah Geological Survey</td>
<td>Utah Geological Survey publication that maps landslide risk throughout Utah. On the map, yellow depicts low landslide hazard, orange moderate hazard and red high landslide hazard.
Tool Link: https://ugspub.nr.utah.gov/publications/maps/m-228/m-228.pdf</td>
<td></td>
</tr>
<tr>
<td>Utah Landslide and Debris Flow Maps
(2018)
Utah Automated Geographic Reference Center</td>
<td>Database provides GIS shape files of landslides and debris flow paths and deposition zones in Utah. Data before 2007 is from a compilation of landslide mapping at a 1:100,000 scale. A more detailed inventory of landslides since 2008 is available at a 1:24,000 scale. Landslides that occurred before 1989 were added from published and unpublished references. Landslides that occurred from 1989-2007 were added from geologic maps and Utah Geological Survey investigations.
Tool Link: https://gis.utah.gov/data/geoscience/landslides</td>
<td>Landslides and Debris Flows</td>
</tr>
<tr>
<td>U.S. Landslide Inventory Map
(2018)
U.S. Geological Survey</td>
<td>This mapping tool shows the location of landslides in the United States. Because a variety of data sources are used, different colors indicate confidence in the occurrence and extent of landslides. Red colors indicate high confidence in a landslide while orange and yellow depicts likely, probable and possible landslides. As a whole, the dataset gives the spatial extent of where landslides historically occurred.
First zoom in on Utah. Click on the ☰ icon to view the legend. Click on the add layer icon ⊞ to add other layers to the map. Thousands of layers are available and can be searched. For example, <i>Utah County boundaries</i> can be searched. Select Utah county boundaries, then click on the <i>layers</i> ⊞ icon to view the visible layers. Click on Utah county boundaries, then the three dots next to it to change the transparency of the county boundary layer to view other layers.
Tool Link: https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=ae120962f459434b8c904b456c82669d</td>
<td> </td>
</tr>
<tr>
<td>Climate Change Impacts</td>
<td colspan="3">Uncertain impact to risk. There is <i>medium confidence</i> of a <i>decreased landslide risk</i> due to projections of lower soil moisture by the mid-21st century. There is also <i>medium confidence</i> of an <i>increased landslide risk</i> due to an increase in frequency and severity of heavy rainfall events.
Landslides often occur when soils are completely saturated with water. Saturated soil conditions can occur due to prolonged precipitation events or extreme precipitation events. Saturated soil conditions due to prolonged precipitation events are less likely to occur in the future. Conditions like this occurred preceding the 1983 landslide in Thistle, Utah. Heavy precipitation and flash flooding also saturate soils and trigger landslides; these rainfall events are more likely in the future.</td>
</tr>
</table>

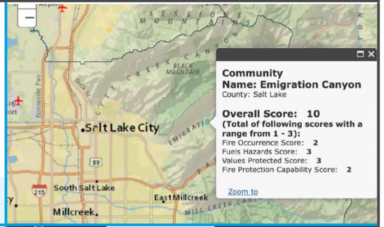
WILDFIRE

Brianhead wildfire on the Dixie National Forest in Utah on June 17, 2017. Photo credit: Eric Eastep/Intermountain Forest Service.

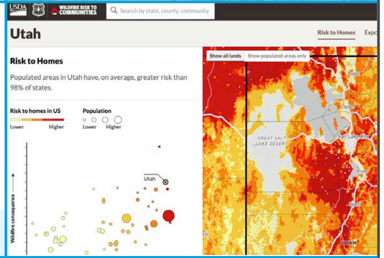
<table>
<tr><th colspan="4">WILDFIRE</th></tr>
<tr><td colspan="4">Data Limitations: Historical information on the exact location, size and extent of wildfires in Utah is incomplete. Robust datasets on wildfire risk exist for the state.</td></tr>
<tr><td rowspan="2">Historical Information and Risk</td><td>Wildfire Risk Assessment Portal
Utah Department of Natural Resources</td><td>This Utah mapping tool that depicts wildfire hazard and many parameters that help understand wildfire risk. There is a public and professional version of the tool. Both versions are useful, but sign up for an account to use the professional version; there are more available map layers and tools.
There are two main ways to view information on the map. On the top left of the page, there are three tabs; <i>Assess Your Location</i>, <i>Map Themes</i> and <i>Assess Your Location</i>. 1. <i>Assess Your Location</i>. The map shows either <i>wildfire threat</i> or <i>wildfire intensity</i> for the entire state and a specific location. The black circle with a black dot marks the location where location-specific wildfire or threat is given. Use the cursor to move the location and the + of – icons at the top right of the page to zoom in. On the left side of the page, the wildfire threat or intensity is listed with a detailed description of the threat or intensity level. 2. <i>Map Themes</i>. This function allows the selection of different map layers which are displayed on the left side of the page. There are several categories of layers. Click on a layer to view it and only one layer can be selected at a time. Click on the ℹ icon to view a description of the layer. Reference layers, at the bottom left, such as county boundaries can be selected. Some categories that may be useful to planning include wildfire, value impacts and historical fire occurrence. Click on the ◀▶ icon to view two map layers at once.
Tool Link: https://utahwildfirerisk.utah.gov</td><td> </td></tr>
<tr><td>Fire Weather Data and Forecasts
(Current)
National Weather Service, Salt Lake City Regional Office</td><td>Daily graphs of temperature, relative humidity and windspeed/direction for rural sites in forested regions of Utah. Monthly graph of precipitation for each site. Data from sites in Northern Utah, Richfield, Color Country, the Uinta Basin and Moab are presented. Current fire weather forecasts (fire weather watch and red flag warning) are shown on an interactive map of Utah. Click on each watch or warning for additional information.
Tool Link for Fire Weather: https://www.weather.gov/slc/FireData
Tool Link for Fire Weather Forecasts: https://www.weather.gov/wrh/fire?wfo=slc</td><td> </td></tr>
</table>

<table>
<tr><th colspan="4">WILDFIRE</th></tr>
<tr><td rowspan="2">Historical Information and Risk</td><td>Communities at Risk to Wildfire in Utah

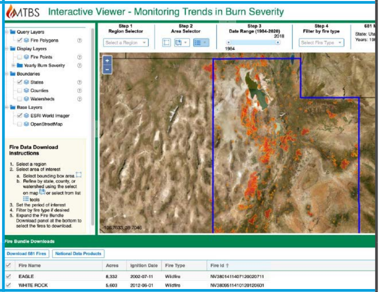
Utah Division of Forestry, Fire and State Lands</td><td>Click on the top left panel to view the map “Communities at Risk to Wildland Fire in Utah.” The map shows yellow, orange and red dots to denote different levels of fire risk in Utah communities. Click on a dot on the map to view more specific information on a community’s wildfire risk. Wildfire risk is listed as a score from 0-12 based on four factors: fire occurrence, fire fuels hazard, property values and fire protection capability.

Tool Link: https://ffsl.utah.gov/forestry/maps</td><td>Community
Name: Emigration Canyon
County: Salt Lake
Overall Score: 10
(Total of following scores with a range from 1 - 3):
Fire Occurrence Score: 2
Fuels Hazards Score: 3
Values Protected Score: 3
Fire Protection Capability Score: 2
Zoom to</td></tr>
<tr><td>Wildfire Risk to Communities – Utah

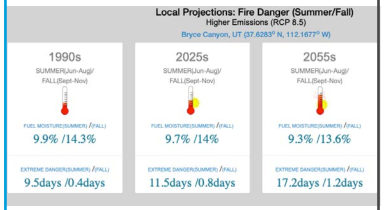
USDA U.S. Forest Service</td><td>This mapping tool presents wildfire risks for the entire country with a focus on risks to homes. At the top right of the page, there are four tabs: <i>Risk to Homes</i>, <i>Exposure Type</i>, <i>Wildfire Likelihood</i> and <i>Vulnerable Populations</i>. At the top left on the map, there is a tab to <i>show all lands</i> or <i>show populated areas only</i>. On the <i>Risk to Homes</i> tab, the scatter graph on the left shows how Utah ranks amongst states in terms of <i>Wildfire consequence</i> and <i>Wildfire likelihood</i>.

Tool Link: https://wildfirerisk.org/explore/0/49</td><td>Utah
Risk to Homes
Populated areas in Utah have, on average, greater risk than 98% of states.</td></tr>
<tr><td></td><td>Monitoring Trends in Burn Severity (MTBS) Database

(1984-2020)
USGS, USDA Forest Service</td><td>The MTBS provides geospatial data about the location and extent of burned areas in the western United States since 1984. To view data, click on <i>Get Data via Interactive Viewer</i>. 1. At the top of the page, select Utah from the drop-down tab in <i>Step 2</i>. 2. Select the date range in <i>Step 3</i> and the type of fire in <i>Step 4</i>. 3. Red areas on the map indicate wildfire burned areas and clicking on a fire shows a list of all fires at the bottom of the page. 4. GIS shapefiles of individual fires can be downloaded by selecting a fire at the bottom and using the <i>Download</i> tab.

Tool Link: https://mtbs.gov</td><td>Fire Name | Acres | Ignition Date | Fire Type | Fire Id
EAGLE | 8,332 | 2002-07-11 | Wildfire | NV3801411407120020711
WHITE ROCK | 5,603 | 2012-06-01 | Wildfire | NV3809511410120120601</td></tr>
<tr><td rowspan="2">Climate Change Impacts</td><td>Future Climate Dashboard

(1990 - 2099)
The Climate Toolbox</td><td>This tool creates a dashboard that shows the number of extreme fire danger days and fuel moisture for the 1990s and projected values for the 2025s (2010–2039), 2055s (2040–2069) and 2085s (2070–2099). 1. Click on the <i>Choose location</i> box in the top left of the page. 2. Enter a place under <i>GeoLocation</i>, move the red marker, or enter coordinates to choose the location. Then click <i>Set location</i>. 3. Under <i>Choose Data</i>, select either <i>Fire Danger (Summer/Fall)</i> or <i>Fire Danger (Winter/Spring)</i> under the <i>Dashboard</i> tab. Under the <i>Future Scenario</i> tab choose a <i>Lower Emission</i> or <i>Higher Emission</i> scenario. Under <i>summer temperature</i>, the average high, average low and extreme high temperatures are shown.

Tool Link: https://climatetoolbox.org/tool/future-climate-dashboard</td><td>Local Projections: Fire Danger (Summer/Fall)
Higher Emissions (RCP 8.5)
Bryce Canyon, UT (37.6283° N, 112.1677° W)
1990s SUMMER(Jun-Aug)/FALL(Sept-Nov): FUEL MOISTURE(SUMMER) /(FALL) 9.9% /14.3%; EXTREME DANGER(SUMMER) /(FALL) 9.5days /0.4days
2025s SUMMER(Jun-Aug)/FALL(Sept-Nov): FUEL MOISTURE(SUMMER) /(FALL) 9.7% /14%; EXTREME DANGER(SUMMER) /(FALL) 11.5days /0.8days
2055s SUMMER(Jun-Aug)/FALL(Sept-Nov): FUEL MOISTURE(SUMMER) /(FALL) 9.3% /13.6%; EXTREME DANGER(SUMMER) /(FALL) 17.2days /1.2days</td></tr>
<tr><td colspan="3">Increasing risk. There is <i>high confidence</i> of an <i>increasing risk of wildfire danger</i> by the mid-21st century.

The increase in wildfire danger is driven by increases in temperature. Higher projected temperatures will cause a lengthening of fire season in Utah. Longer fire seasons will occur due to a shortening of the snow-covered season. When snowpack starts to build later in the fall, then fire season and seasonal drought conditions will also continue later into the fall. For example, the 2020 East Troublesome Fire in Colorado which burned nearly 200,000 acres started in October, which is not typically considered fire season in Colorado. When snowpack melts sooner in the spring, seasonal drought conditions and consequently fire season will begin sooner. Higher temperatures will dry out dead wood, grasses and other fuels making forests more susceptible to fire and wildfires more severe. Drought conditions will be more likely by the mid-21st century which will also increase wildfire risk.</td></tr>
</table>

WIND EVENTS

2020 wind storm inLiberty Park, Salt Lake City.

WIND EVENTS

Data Limitations: Hundreds of sites collect wind data in Utah, but no tool exists to easily analyze and sort data to determine occurrence frequency of high wind events.

Historical Information and Risk

Storm Events Database

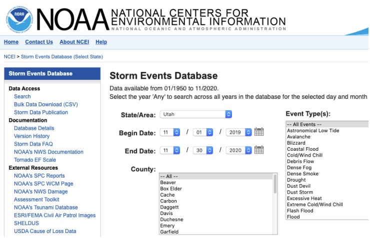
(1955-present)

NOAA National Centers for Environmental Information

This searchable database provides the historical record for wind events, within individual counties or statewide. Reports include data on crop damage, property damage, injuries, and deaths. Events classified as *Thunderstorm winds* have data from 1955-1995, while events listed under *High wind* or *Strong wind* have data from 1996-present.

1. On the lower left side of the screen, select *Utah* in the "Select State or Area" menu. **2.** Use the menu options to select the date range of interest. **3.** Select *High Wind*, *Strong Wind*, or *Thunderstorm Wind* in the *Event Types* menu. **4.** Select your county of interest in the *County* menu, or select -All- to see events statewide. **5.** Expand the *Advanced Search* and *Filter Options*, and use the *Wind Filter* menu to select wind speeds of interest. **6.** Click *Search*. **7.** The results page shows a table with all events that meet your search criteria. Click on an hyperlinked event name in the Location column to see a full report on that event. You can download data in spreadsheet form using the *CSV Download* link.

Tool Link: https://www.ncdc.noaa.gov/stormevents



Storm Events Database

Data available from 01/1950 to 11/2020.

Select the year 'Any' to search across all years in the database for the selected day and month

State/Area: Utah

Begin Date: 11 / 01 / 2019

End Date: 11 / 30 / 2020

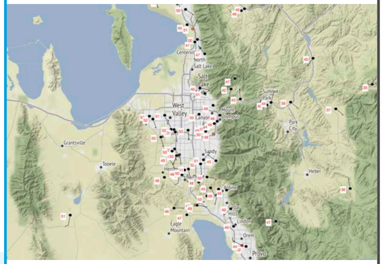
MesoWest Weather Data

(1997-present, variable)

University of Utah, Dept. of Atmospheric Sciences

MesoWest provides access the available weather data from stations across the United States. Begin search for weather data by clicking on Utah on the map. The map of Utah shows locations on weather stations with current parameters like temperature and windspeed/direction. At the top left of the interface, choose which weather station networks will be displayed on the map. Select *All Networks*, then click *Refresh Map*. This will show all weather stations in Utah; zoom in on area of interest. Click on an individual site to get recent weather information. To find past data, click on *Download Data* at the bottom right of the box. To download more than 1 day of data, sign up for a free MesoWest account. These data are raw data and can require some data manipulation to format for the intended use.

Tool Link: https://mesowest.utah.edu



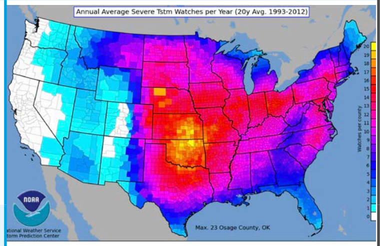
Severe T-Storm Watch Climatology Map

(1993-2012)
National Weather Service Storm Prediction Center

This map shows you a 20-year climatology of severe thunderstorm watches.

1. Under the *Storm Prediction Center WCM Page* banner near the top of the page, click on the *20y SPC Watch Climatology*. **2.** Scroll down to *20y Annual Average Watches by County*. **3.** Click on the *average number of severe thunderstorm watches per year* image to view it in larger form. Note: This page contains a lot of other statistics about the hail, severe thunderstorm and tornado products.

Tool Link: http://www.spc.noaa.gov/wcm



Climate Change Impacts

Uncertain change in risk. There is *low confidence* that ***thunderstorm frequency will increase*** in portions of southern Utah.

Damaging winds in Utah are associated with severe thunderstorms, and with synoptic wind events that include gradient, downslope and gap winds. Recent research reveals that climate change is affecting storm tracks and weather patterns, which can in turn affect the number and severity of thunderstorms and synoptic wind events in Utah. However, specific projections about changes in the frequency of thunderstorms and wind events are not available.

WINTER STORM

Bear River Refuge near Brigham City, Utah. Photo credit: John Zaker/USFWS.

WINTER STORM

Data Limitations: The most comprehensive record of snowfall information is captured by the Snotel network, but records only date back to the 1980s and sites are confined to the mountains. Long-term records of individual snowfall events, earlier than the 1980s, do not exist in the mountains. Records of heavy snowfall events in populated areas of Utah exist, but are less consistent and there is no tool to easily analyze and sort snowfall events to determine event frequency.

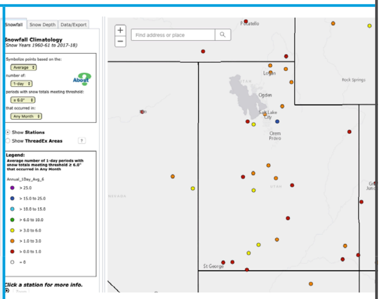
Historical Information and Risk

Snowfall Climatology Tool

(1960-present)
Midwestern Regional Climate Center

This interactive tool shows the annual average number of 1-, 2-, or 3-day periods with snow totals at certain thresholds. Stations are limited so use the one closest to your location as a proxy.

1. Position map to area of interest. **2.** On left side of screen, select Average - # of days of interest - threshold - all months (or month of your choice). **3.** Click on an individual station to receive more information. This information request is highlighted in blue. Additional information is shown below it and can be expanded by clicking *Table of All Values*.



Snowfall Climatology
(Snow Years 1960-61 to 2017-18)

Symbolize points based on the: Average
number of: 1-day
periods with snow totals meeting threshold: ≥ 6.0"
that occurred in: Any Month

● Show Stations
○ Show ThreadEx Areas

Legend:
Average number of 1-day periods with snow totals meeting threshold ≥ 6.0" that occurred in Any Month

Annual_1Day_Avg_6
- ● > 25.0
- ● > 15.0 to 25.0
- ● > 10.0 to 15.0
- ● > 6.0 to 10.0
- ● > 3.0 to 6.0
- ● > 1.0 to 3.0
- ● > 0.0 to 1.0
- ○ = 0

Click a station for more info.

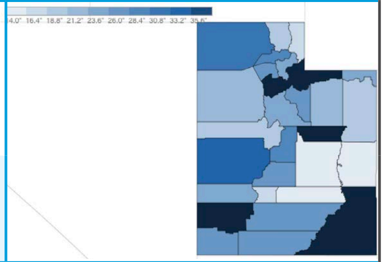
Tool Link: https://mrcc.purdue.edu/gismaps/snowclimatology.htm

Snowfall Extremes

(period of record varies by location)

NOAA National Centers for Environmental Information

This interactive static map shows the 1-Day, 2-Day, and 3-Day snowfall maximums by county. **1.** Select the day(s) of interest on the top right side of the map. **2.** Mouse over county of interest for information on the maximum snowfall event on record. **3.** A table below the map shows location (by county and station), date of event, and snowfall total details.



Tool Link: https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/OK

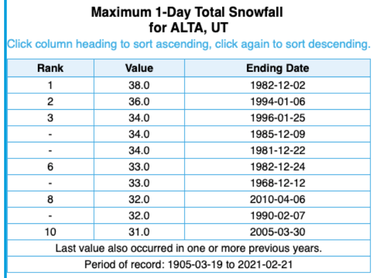
Daily Extreme Precipitation on xmACIS2

(period of record varies by station)

NOAA Regional Climate Centers

Interactive tool shows the highest daily (user chooses duration) snowfall totals for a station of interest in a table. It can be used determine the upper level thresholds of multiple day snowfall amounts that have occurred, and what one could expect to occur again.

1. On left side of screen, select *Single-Station*, then *Extremes*. **2.** Next to *Variable*, select *Total Snowfall*. **3.** Enter length of period of interest (e.g. 1 Day for 1-day rainfall totals). **4.** Click on *Select station* tab. **5.** Search for a location. The stations near that location appear on a map. To expand the search area, click *Expand Search Area* at the bottom of the page. **6.** Click *Go*. **7.** Table will be displayed on screen. Note the period of record (POR) on the bottom of the table. Choose a station with longer POR if possible. Double click on a station shown on the map to see the POR.



Maximum 1-Day Total Snowfall
for ALTA, UT

Click column heading to sort ascending, click again to sort descending.

Rank	Value	Ending Date
1	38.0	1982-12-02
2	36.0	1994-01-06
3	34.0	1996-01-25
-	34.0	1985-12-09
-	34.0	1981-12-22
6	33.0	1982-12-24
-	33.0	1968-12-12
8	32.0	2010-04-06
-	32.0	1990-02-07
10	31.0	2005-03-30
Last value also occurred in one or more previous years.		
Period of record: 1905-03-19 to 2021-02-21		

Tool Link: http://xmacis.rcc-acis.org

Climate Change Impacts

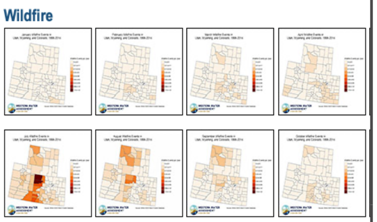
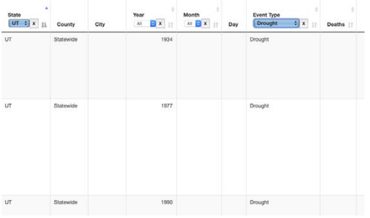
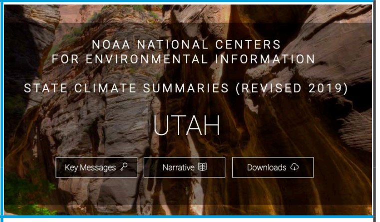
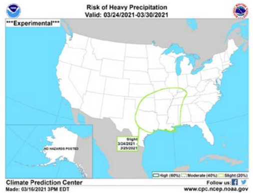
Uncertain change to risk. There is *medium confidence* of an ***decrease in winter storm risk*** at low elevations of Utah. There is *medium confidence* of an ***increase in winter storm risk*** at high elevations.

Recent research reveals that climate change is affecting storm tracks and weather patterns, which can in turn affect the duration, number, and severity of winter storms in Utah. A warmer, wetter atmosphere can support stronger winter storms in the future, although warming temperatures have also contributed to more precipitation falling as rain instead of snow.

GENERAL HAZARD INFORMATION

Capitol Reef National Park. Photo credit: Emily Van Ness/National Park Service.

GENERAL HAZARD INFORMATION

Historical Information and Risk	**Monthly Maps of Significant Weather Events in CO, UT, WY** (1955-2014) Western Water Assessment	This resource uses data from the NOAA Storm Events database to create storm event frequency maps for Colorado, Utah and Wyoming. The frequency of blizzard, hail, thunderstorm, winter storm, flash flood, heavy snow, tornado, flood, high wind and wildfire is mapped by county for each month. Tornado, thunderstorm and hail data is from 1955-2014; all other data is from 1996-2014. Click on a storm type to view a set of monthly hazard maps. Click on a specific map to view a large version of the map. **Tool Link:** https://wwa.colorado.edu/resources/extreme-weather-and-climate-events	
	Historical High-Impact Weather and Climate Events (1862-2017) Western Water Assessment	The resource is a searchable database of extreme or high-impact weather and climate events that occurred in Utah, Colorado and Wyoming since 1862. The types of events included in the database are cold wave, drought, flood, hail, highwind, landslide, tornado, wildfire and winter storm. The database is searchable by *state*, *year*, *month* and *event* type. Other information relevant information in the database includes, *number of deaths*, *unadjusted damage*, *CPI-adjusted damage* and *summary information*. An updated version of the database will be launched in 2022. **Tool Link:** https://wwa.colorado.edu/resources/extreme-weather-and-climate-events	
	Utah Climate Summary (updated 2019) National Centers for Environmental Information	Document provides a summary of Utah climate over the last 120 years. Graphical display of data shows trends in climate parameters like number of days >100°F, number of very cold nights, number of days with precipitation >1" and drought indices. Provides projects of changes in temperature and precipitation. **Tool Link:** https://statesummaries.ncics.org/chapter/ut	
	U.S. Week-2 Hazards Outlook (8-14 day forecast NOAA Climate Prediction Center	This tool provides a forecast of weather-related hazards 8-14 days in the future. Hazards related to high and low temperatures, precipitation, snow and wind are forecasted. A map of where specific hazards may occur and the probability of occurrence is provided. A detailed summary of the hazard outlook is located at the bottom of the page. **Tool Link:** https://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php	

State	County	City	Year	Month	Day	Event Type	Deaths
UT			All	All		Drought	
UT	Statewide		1934			Drought	
UT	Statewide		1977			Drought	
UT	Statewide		1990			Drought	

NOAA NATIONAL CENTERS
FOR ENVIRONMENTAL INFORMATION

STATE CLIMATE SUMMARIES (REVISED 2019)

UTAH

APPENDIX A - HAZARD DEFINITIONS

AVALANCHE

Definition: A mass of snow, sometimes containing rocks, ice, trees or other debris, that moves rapidly down a steep slope resulting in fatality, injury or significant damage **(National Weather Service 10-65, Storm Data Preparation, 7/26/21)**.

Description: Avalanches occur in Utah in mountainous portions of the state when snow cover is present and can occur from October through June. Avalanches can occur on any slope greater than 30° where trees and shrubs are absent or buried by snowpack and slopes greater than 30° that are sparsely covered by tress and shrubs. Avalanches occur due to specific weather and snowpack conditions and avalanche danger can vary widely based on location, aspect and previous weather and snow conditions.

COLD TEMPERATURE EXTREMES

Definition: A marked and unusual cold weather characterized by a sharp and significant drop of air temperatures near the surface (maximum, minimum, and daily average) over a large area and persisting below certain thresholds for at least two consecutive days during the cold season **(WMO 2015)**.

Note: There is no universally-recognized metric for what constitutes a cold extreme. The World Meteorological Organization recommends characterizing a cold wave by its magnitude, duration, severity, and extent. Magnitude is defined as a temperature drop below certain threshold(s), either as an absolute value or percentiles. These values must be determined by the local climatology.

Description: Cold extremes occur when polar and arctic air is displaced from polar regions toward the equator. The lack of sunlight in polar regions during winter allows the buildup of cold, dense air. Wiggles in the jet stream allow equator-ward (southward in the Northern Hemisphere) transport of cold air into the continental United States. High-amplitude jet-stream patterns (a series of large troughs and ridges in the upper atmosphere around the globe) allow air masses to move from their source regions.

DAM OR LEVEE FAILURE

Definition: Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam’s primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action **(USSD 2018)**.

DEBRIS FLOW

Definition: A slurry of loose soil, rock, organic matter and water, similar to wet concrete, which is capable of holding particles larger than gravel in suspension. They can mobilize from landslides on steep, nearly saturated slopes or be triggered by intense rain after wildfires **(NWS 2021)**.

Description: Debris flows in Utah typically occur on wildfire burn scars in steep mountainous terrain where a short-duration intense rainfall occurs. In

Utah, debris flows are typically triggered by monsoonal thunderstorms that occur from July – October. These flow can travel several miles from their source and grow in size as boulders, trees and man-made materials are entrained in it. Debris flows can cause destruction to infrastructure such as roads and bridges, homes or other structures and can alter hydrology of rivers.

DROUGHT

Definition: A deficiency of moisture that results in adverse impacts on people, animals, or vegetation over a sizeable area **(NWS 2021)**.

Description: Drought impacts vary based on the duration and intensity of the event. Drought can be short-term (less than 6 months) or long-term (greater than 6 months) and drought can occur for multiple decades in its extreme form. There are five different ways to classify drought: meteorological, hydrological, agricultural, ecological and socio-economic. Each type of drought classification has different start times and durations and focuses on different types of impacts.

Drought is rated by the weekly **U.S. Drought Monitor (2021)** on a scale from D0 (abnormally dry) to D4 (exceptional drought). D0 occurs, on average, in any given location about 21-30% of the time. D1, moderate drought, occurs on average 11-20% of the time, or roughly once every 5-10 years. D2, severe drought, occurs 6-10% of the time, or about every 10-20 years. D3, extreme drought, occurs 3-5% of the time and D4, exceptional drought, occurs 0-2% of the time, or about every 50 years. Severity is based upon a variety of drought indicators, impacts, and input from local experts.

FLOODING AND HEAVY RAINFALL

Definition: Heavy rainfall is rain with a rate of accumulation exceeding a specific value that is geographically dependent **(AMS 2012)**. Flooding is any high flow, overflow, or inundation by water which causes or threatens damage **(NWS 2021)**.

Description: Heavy rainfall is rain falling at a rate greater than infiltration through the underlying surface allows, causing runoff, inundation of low-lying areas, and flooding. This may include short-duration thunderstorms lasting a few hours or rainfall accumulating over several days. Flooding is the result of heavy rainfall but also the underlying substrate (impervious vs. porous surfaces). The rate of infiltration (how quickly water is absorbed by the soil), how quickly runoff reaches the creeks and rivers, soil moisture conditions, if the ground is frozen, and other local factors affect runoff and flooding. Consequently, a rainfall of a given rate and amount may cause flooding in one circumstance but not in another. Flooding is most likely in low-lying areas, along the edges of water bodies

(ponds, lakes, rivers), and over impermeable surfaces (such as streets and parking lots or bare rock). Flash flooding may occur with intense thunderstorms while river flooding usually requires rainfall accumulated over a longer duration. Flooding may also be caused by breaches of dams or levees, where fast-moving water may be especially destructive.

EXTREME HEAT

Definition: A marked unusual hot weather (maximum, minimum and daily average) over a region persisting at least two consecutive days during the hot period of the year based on local climatological conditions, with thermal conditions recorded above given thresholds **(WMO 2015)**. In most of Utah, two consecutive days where temperatures exceed 100°F is a reasonable definition for a heat extreme. For other locations in Utah where temperatures routinely exceed 100°F, two consecutive days of 105°F (Moab) or 110°F (St. George) could be considered a heat extreme.

Note: There is no universally-recognized metric for what constitutes a heat extreme. The World Meteorological Organization recommends characterizing *a heat wave by its magnitude, duration, severity, and extent. Magnitude is defined as a thermal measurement such as maximum temperature, or combination of several measurements, exceeding certain threshold(s). These values must be determined by the local climatology. Other studies have used thresholds based on human physiological response to heat, such as consecutive days of maximum or minimum temperatures above a threshold.*

Description: Heat extremes in Utah typically occur when a dominant large-scale high-pressure system prevents movement of other air masses into a region. The high-pressure contributes to intense heating from solar radiation, due to a lack of cloud cover, and light winds preventing the dispersion of heat, especially from urban areas. This results in both higher than average maximum and minimum temperatures.

LANDSLIDE

Definition: The downslope movement of rock, soil and debris in which the material moves a semi-cheraent or coherent slab. Landslides are classified by their movement types (falls, slides, topples and flows) and material type (rock, debris, soil) **(Utah State Hazard Mitigation Plan)**.

Description: Landslides most often occur in areas with weak rock types, steep slopes and high annual precipitation. Utah has an abundance of steep slopes and weak rocky types, but does only receives high annual precipitation in isolated mountain locations. Landslides typically occur after short-duration, high intensity rainfalls caused by monsoonal thunderstorms or after a prolonged period of above average precipitation.

WILDFIRE

Definition: Any significant forest fire, grassland fire, rangeland fire or wildland-urban interface fire that consumes natural fuels and spreads in response to its environment **(NWS 2021)**.

Description: Wildfires occur when weather conditions meet with sufficient fuel and an ignition source. Weather conditions include warm temperatures, low humidity, strong winds, and a period without precipitation allowing fuels to dry. Fuels are vegetation ranging from fine fuels such as grass and pine needles to large woody materials such as trees, dead and decaying logs, and organic material in the soil. Large woody materials are difficult to ignite; the presence of fine fuels allows fire to get started and become intense enough to ignite larger materials. Ignition sources may be natural such as lightning or human-caused such as sparks from equipment, power transformers, a chain dragging behind a vehicle, or heat sources such as discarded cigarettes.

Fire danger is measured on a Burning Index scale, ranging from 0 to 110+. Values below 20 are considered low fire potential, 40-80 is high, and 110 or higher is extreme. The burning index combines potential energy release (fire intensity), flame length, and rate of spread. The National Weather Service issues Red Flag Warnings when weather conditions are favorable for ignition and spread of wildfires. Another popular index is the Keetch-Byrum Drought Index (KBDI) that considers weather and vegetation conditions. The scale ranges from 0 to 800; values below 200 indicate high fuel moisture making ignition unlikely; values above 600 are indicative of intense wildfire conditions with any that develop capable of downwind spotting (starting new fires).

WIND EVENT

Definition: An event with elevated and sustained winds that cause damage to property of natural landscapes. **The National Weather Service (2021**) defines High Wind as sustained non-convective (not from a thunderstorm) winds 40 mph or greater lasting for 1 hour or longer, or gusts of 58 mph or greater lasting for any duration. *Note: There is no universally-recognized metric for what constitutes a wind event.*

Description: In Utah the wind event that causes the most significant damage are caused by easterly winds along the Wasatch Front. During fall on some years, a cold front where the center of the high pressure system travels to the east of the Wasatch Mountains will cause easterly winds along the Wasatch Front. The easterly winds accelerate as they move downslope on the steep westerly side of the Wasatch Mountains. During these wind events, sustained wind speeds often exceed hurricane force (62 mph) and gusts exceed 80 mph, occasionally reaching 100 mph. These wind events can last from between 3 hours to more than 24 hours. Wind events also occur during strong winter and spring storms from the Pacific Ocean. During strong spring storms, strong pre-frontal winds from the south to southwest can carry significant amounts of dust from deserts and playas of western Utah which cause poor air quality throughout Utah, including the Wasatch Front.

WINTER STORM

Definition: A winter weather event that has more than one significant hazard (heavy snow and blowing snow, heavy snow and ice, etc) and meets or exceeds 12 and/or 24 hour warning criteria for at least one precipitation type **(NWS 2021)**.

Description: Winter storms may include heavy snowfall, blowing and drifting snow, high winds, extreme cold or ice storms. Among the greatest hazards associated with winter storms are traffic accidents. The most extreme instance is a blizzard, which is defined as winds greater than 35 mph, visibility less than ¼ mile, lasting at least 3 hours. New snowfall is not necessary for a blizzard; blowing snow can similarly obscure visibility.