Jet Stream Jargon

National Weather Service

Billings, Montana

From the Desk of the Meteorologist in Charge

It has been nearly six (6) months since I provided an update on how our Operations changed in response to the COVID-19 pandemic that had just emerged onto the scene in March. At that time, we had no real idea of how long we would operate with our limited in-office presence. Yet here we are still operating within a limited routine in-office presence capped at 25% of our staffing (roughly 5 to 6 people). The remainder of our staff have been working from home to meet the various mission demands and to support our operations. Up until early August, we had been limited to just two (2) people in our office routinely, unless severe weather demands dictated otherwise. In mid August, we were allowed to add 3-4 more people to the in-office presence. At this time, it remains to be seen when or if we'll be able to return to our more typical Monday-Friday in-office staffing profile, but we are being told that this may not occur until late Spring or early Summer.

One of the impacts of COVID-19 has been a reduction in our in-person outreach efforts. However, the last 6 months have provided us with an opportunity to find new ways to work virtually using the myriad of technology we have available to us.

Most impressive to me has been our team's ability to address all the mission needs that have emerged across our area of responsibility, whether it be supporting the efforts to battle wild fires or tracking and warning severe weather. The commitment of your NWS Billings Team really speaks volumes about their professionalism and dedication to serving you.

In closing, the last six (6) months have noticeably increased the stress and anxiety levels of everyone trying to deal with the unusual changes to their lives and the many unknowns lurking around what seems to be every corner marking the end and beginning of each day. To borrow a greeting I recently heard - "Stay Healthy and Be Nice". We all can help each other out in both these ways.

Keith W. Meier

THIS EDDITION

COOP Corner — *Submitted by: Kurt Hooley, Meteorologist*

The past six months have brought a variety of challenges to many aspects of our lives, and the COOP Program was not immune. Although I have made a few emergency repair visits in person, COVID-19 prevented me from making the annual Spring and Fall routine visits. As a result, I continue to be in the process of contacting by phone each of our 78 observers across the Billings Forecast Area. This has provided me a way to introduce myself and to see how you all are doing and if you need anything, as well as to thank you for the important job that you do. The response from everyone has been very positive.

I have enjoyed talking with many of you about your calving season, as well as your summer harvests. Most areas did not receive their beneficial Spring and early Summer rains, and as a result, the grasshopper invasion played a heavy toll on some crops and many hay fields, as well as gardens. Even the fish seemed to have tired of this food source!

I look forward to seeing you all as visits allow. Please do not hesitate to call me at 406-652-0851 ext 5 if you need anything or just want to talk! I can also be reached at kurt.hooley@noaa.gov

For more information about the National Weather Service Cooperative Observer Program please visit http://www.weather.gov/coop

CoCoRaHS Corner — *Submitted by: Linda Brennan*

Thank you for all the work you do, we appreciate it. It is time again to remove your tubes and funnels from your rain gauges to prepare for winter snow. Please leave your cylinders outside for the winter to catch your snow, so that you can melt the snow for your precipitation reports. The CoCoRaHS website http://cocorahs.org has a wealth of information regarding snow in the Resources section. There are short animated videos on how to measure snowfall and snow depth and how to report the snow water equivalent.

If you are interested in joining us, please feel free to open the web page, http://cocorahs.org, review the short training videos and click on **"Join CoCoRaHS"** under the Main Menu.

If you are currently a CoCoRaHS Observer please spread the word to the people you know!
Feel free to contact us at the phone/email listed below, if you have any questions at all.

Tom Frieders – tom.frieders@noaa.gov
Office - (406) 652-0851

Kurt Hooley – kurt.hooley@noaa.gov
Office - (406) 652-0851 Ext. 5

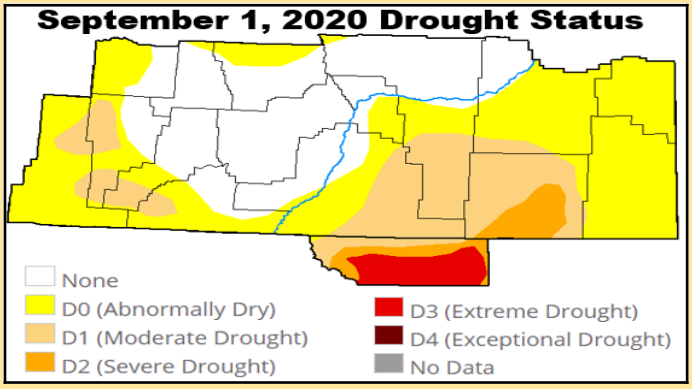
A Recap of Meteorological Summer (June – August)

The summer of 2020 leaned on the warm and dry side for most of the region, and the severe weather season was somewhat quiet. Warmest and driest conditions occurred from near Sheridan to Broadus, and in this region drought conditions worsened to severe to extreme by late summer.

Our office issued a total of 71 Severe Thunderstorm Warnings in 2020, which is about half of the 25-year average. The first severe storm of the season occurred quite early, on May 3rd, when golf ball sized hail was reported near Ridgeway. On May 20th, a storm produced hail up to the size of a tennis ball (2.5") in Lavina at 1:19 am! Later that afternoon, another severe storm produced large hail and damaging winds near Miles City. A semi on I-94 was tipped over and large trees were downed. Another memorable thunderstorm produced 1.5-2" hail which damaged crops from near Musselshell and Melstone to Sanders and Forsyth. The hail left a scar of damage which could be seen on satellite imagery over the following weeks.

As severe thunderstorm activity decreased in mid summer, wildfire potential increased. For details, please see the separate story on the 2020 fire season. The first week of September was quite hot and dry. On September 5th, Billings (102°), Livingston (102°) and Sheridan (103°) all experienced their latest 100-degree weather on record. This was followed by snow in the mountains and along the foothills two days later.

The following is a summary of June - August statistics at our four main climate stations:



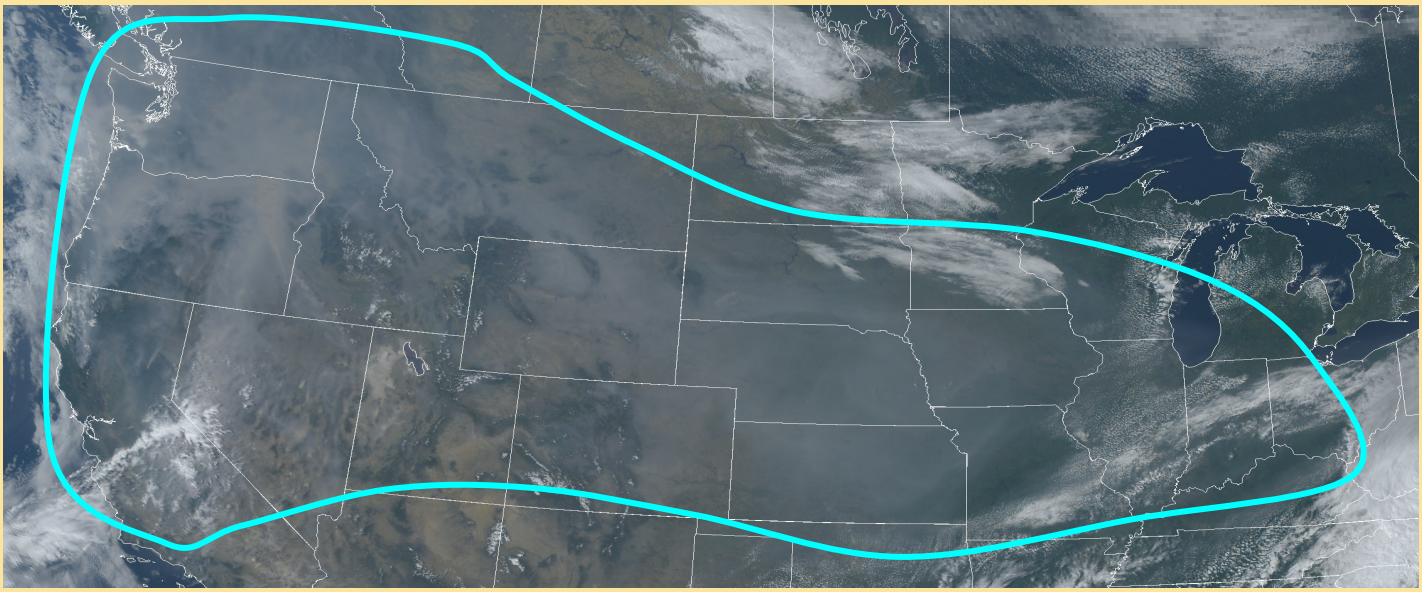
	Average Temp (°F)	Depart from Normal	Ranking	Total Precip (inches)	Depart from Normal	Ranking	Period of Record Began
Billings	**70.8**	**+ 1.1**	**21st warmest**	**6.29**	**+ 2.10**	**15th wettest**	**1934**
Livingston	**65.4**	**+ 0.5**	**24th warmest**	**3.73**	**- 1.24**	**26th driest**	**1948**
Miles City	**71.3**	**- 0.2**	**36th warmest**	**3.63**	**- 1.43**	**17th driest**	**1937**
Sheridan	**69.6**	**+ 2.2**	**11th warmest**	**2.32**	**- 1.70**	**18th driest**	**1907**

Hot, Dry, and Smoky: Fire Season 2020

As you could see in the recap of summer, it was generally hotter than normal and drier than normal for much of the area. However, even with the dry and hot conditions, much of the fire season this year was quiet, with few large fires across the area. Most fires were caught early and firefighters were able to get them contained before they grew. One of the larger fires was on July 22-23 when the Buffalo Fire in southern Powder River county burned over 11,000 acres. However those hot, dry, and windy days to start September very quickly kicked the season into high gear. Some of the more notable wildfires included “BobCat” south of Roundup which burned over 30,000 acres, “Sarpy” northeast of Crow Agency which burned over 50,000 acres, “Rice/Snider” near Ashland burning 47,000 acres, and “Bridger Foothills” near Bozeman, burning just over 8,000 acres.

Buffalo Fire July 23rd/Bureau of Land Management

While southern Montana may not have had many large fires, the end of August into September was filled with smoke across much of the western US due to wildfires along the Pacific Coast. This smoke at times produced hazardous air conditions, especially in western Montana. The smoke also reduced the visibility down to a mile at times. Across the US, over 6.8 million acres have burned, an area larger than some states. To support the fire-fighting efforts across the country, many of the Incident Meteorologists (IMETS) have been deployed, including our own from Billings.



Smoke as seen on GOES-16 on Sept. 17, 2020

2020 Spring-Summer Hydrology Recap

Spring snowpack was near average across area mountains on May 1st 2020. This advertised a near normal runoff season heading into June. However, despite the normal snowpack, several rivers (Yellowstone, Clarks Fork of the Yellowstone, Boulder, Stillwater) reached levels that put them in the top 10 on record.

River	Location	Crest Rank
Clarks Fork of the Yellowstone	Edgar	Highest on Record
	Belfry	2nd Highest
Yellowstone	Corwin Springs	7th Highest
	Livingston	4th Highest
	Billings	8th Highest
Boulder	Big Timber	2nd Highest
Stillwater	Absarokee	4th Highest

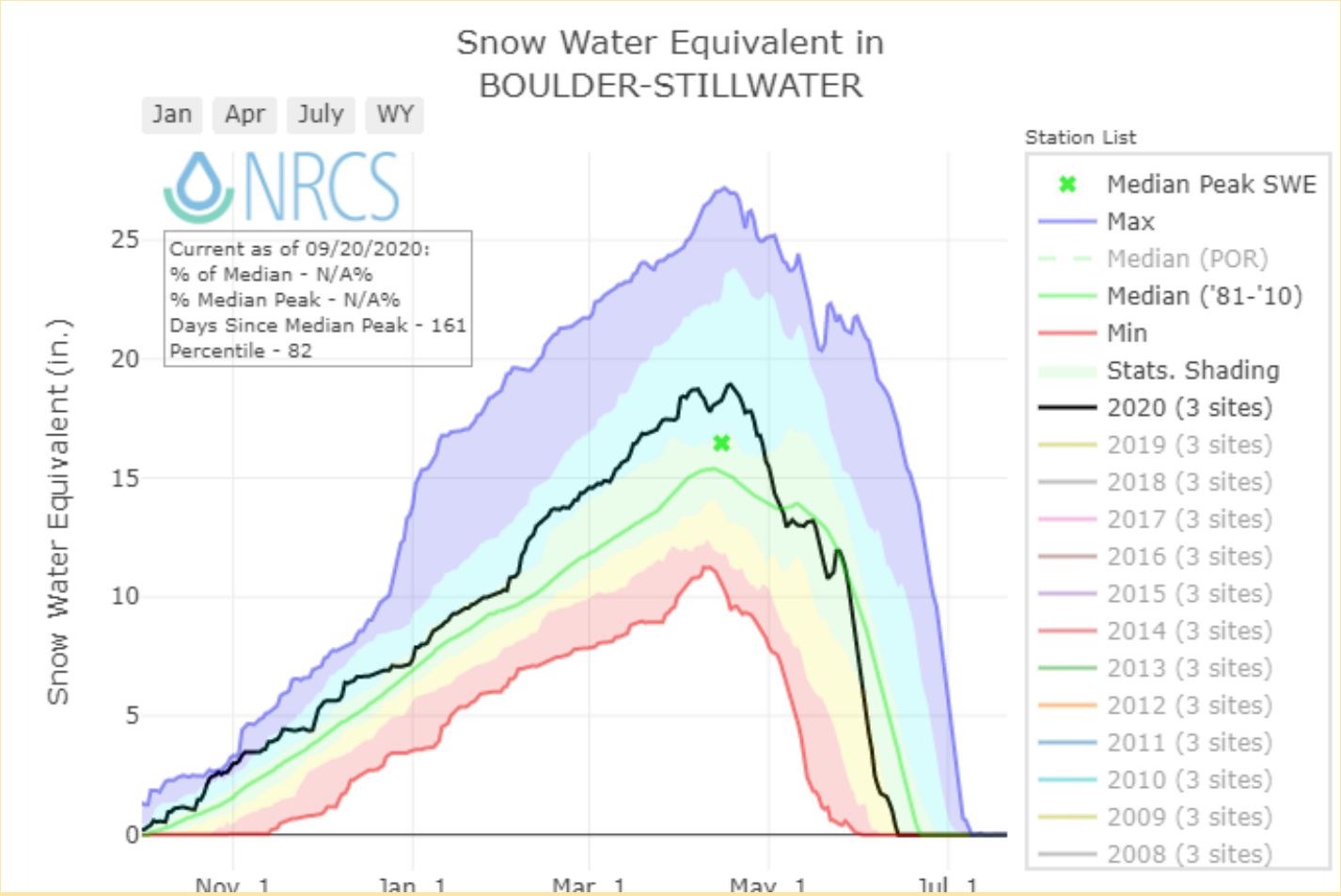
Despite the high water levels, reports of flooding were minimal. The most impactful flooding occurred on the Yellowstone River just east of Billings near Shepherd, where a few houses were flooded due to the river channel shifting and filling in an old oxbow. Only minor low land flooding was reported along the Clarks Fork of the Yellowstone River where a new record was set at Edgar.

Ok, so what could turn a normal snowpack into a runoff year with many rivers reaching top ten levels? Well, a few things can be at work to create such a turn of events.

First, there could have been heavy rainfall during the runoff period. A check of precipitation late May into the first week of June shows near normal rainfall. Therefore, rainfall didn't play a major role in these high river levels.

The second factor is how fast the snowpack melts out. Here is a trace of the snow pack melting out for the Boulder-Stillwater river drainage.

Hydrology Recap Cont…..Submitted by Todd Chambers, Lead Meteorologist



It shows the basin melting out a bit faster than average from late May into early June, but not enough to anticipate top 10 river levels on its own.

Another factor is a change in the stream channel near the river gauge. Over the past decade we have seen several heavy mountain snowpack runoff years that have moved a lot of water through our rivers and streams. This has caused extensive channel changes on many rivers, with the most noticeable being along the Musselshell River. Extensive bank erosion has also been noted on most rivers over the past decade. The lack of major flooding despite the top 10 river levels is pretty good evidence that there have been some big shifts in the channels of area rivers and streams.

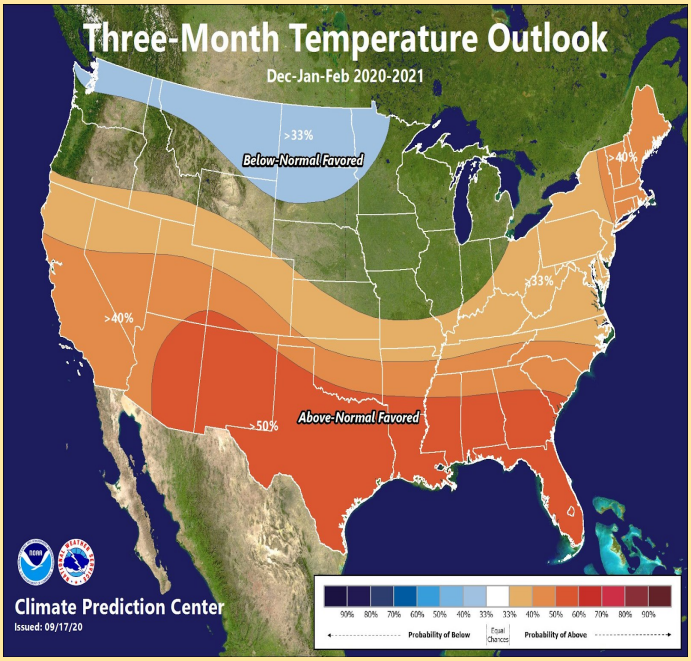
In conclusion, a combination of the three factors was responsible for the unusual events that occurred on area rivers and streams, with channel changes likely playing an outsized role in many areas.

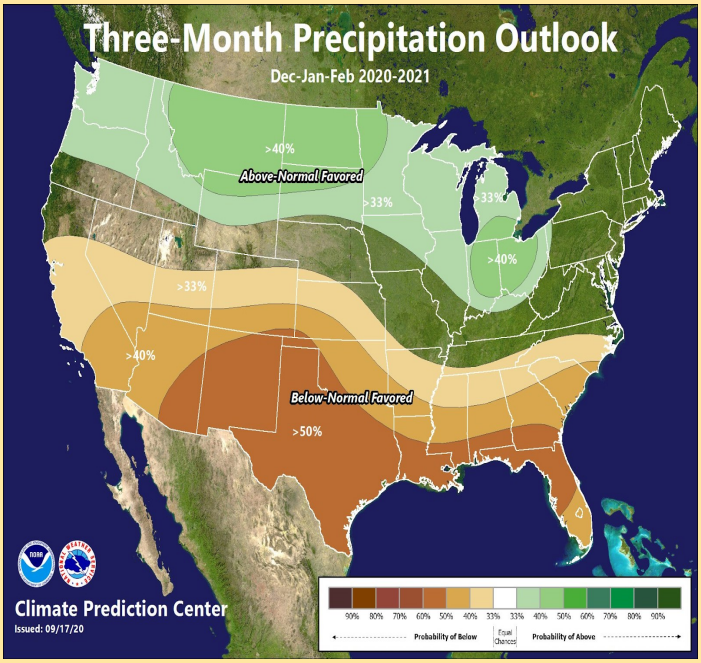
2020-2021 Winter Outlook *Submitted by Joe Lester, Lead Meteorologist*

Seasonal outlooks are created once per month by the Climate Prediction Center (CPC) in College Park, MD. These outlooks display probabilities of either above normal, below normal, or if there are equal chances of above/below/near normal temperatures and precipitation across the country over a three-month period. For the winter, December-January-February is used. CPC uses a variety of dynamical and statistical models to assist with their predictions.

La Nina conditions have developed in the Pacific Ocean and are expected to persist through the fall and winter. Historically, La Nina tends to lean on the cool and wet side for the northern Rockies, due to an active Pacific jet stream. However, with the warming climate and less polar sea ice, we have also seen some warm and dry La Ninas too. This includes the mild/dry 2011-12 and 2007-08 winters. That being said, our snowfall record season 2017-18 was a weak La Nina winter. We should also point out that more open water in the Arctic means greater atmospheric moisture with clipper systems from the north.

The current December-January-February outlook shows slightly increased probabilities for cooler and wetter than normal conditions in our region. This is based primarily on the expectation of a persistent La Nina. Please keep in mind, whether it is a cold/snowy or warm/dry winter overall, our climatology on the eastern slopes of the mountains is for rapid shifts in weather – so always be prepared for extremes! If you are interested in learning more about climate outlooks, please see the Climate Prediction Center website at https://www.cpc.ncep.noaa.gov.





Fall Tables

Fall Normals

Meteorological fall is considered the months of September, October and November. Here are the normal temperatures and precipitation for Billings, Miles City and Sheridan for the fall season. Normals are 30-year averages calculated from 1981 to 2010. All temperatures are in degrees Fahrenheit and all precipitation amounts are in inches.

Billings					
Date	High	Low	Average	Precipitation	Snowfall
9/1 – 9/30	73.1	47.5	60.3	1.30	1.1
10/1 – 10/31	59.4	37.1	48.2	1.18	4.1
11/1 – 11/30	45.3	26.3	35.8	0.63	6.5
9/1 – 11/30	59.3	37.0	48.2	3.11	11.7

Miles City				
Date	High	Low	Average	Precipitation
9/1 – 9/30	74.2	46.1	60.1	1.08
10/1 – 10/31	59.2	33.8	46.5	0.92
11/1 – 11/30	43.2	20.9	32.0	0.39
9/1 – 11/30	59.3	34.7	47.0	2.39

Sheridan				
Date	High	Low	Average	Precipitation
9/1 – 9/30	74.2	41.6	57.9	1.43
10/1 – 10/31	60.1	30.9	45.5	1.41
11/1 – 11/30	45.9	19.4	32.7	0.71
9/1 – 11/30	59.9	31.5	45.7	3.55

Winter Tables

Winter Normals

Meteorological winter is considered the months of December, January and February. Here are the normal temperatures and precipitation for Billings, Miles City and Sheridan for the winter season. Normals are 30 year averages calculated from 1981 to 2010. All temperatures are in degrees Fahrenheit and all precipitation amounts are in inches.

Billings					
Date	High	Low	Average	Precipitation	Snowfall
12/1-12/31	35.2	17.8	26.5	0.50	8.2
1/1-1/31	36.4	17.8	27.1	0.48	8.4
2/1-2/28	40.2	20.6	30.4	0.48	6.2
12/1-2/28	37.2	18.7	28.0	1.46	22.8

Miles City				
Date	High	Low	Average	Precipitation
12/1-12/31	30.9	9.7	20.3	0.29
1/1-1/31	30.0	8.9	19.5	0.32
2/1-2/28	35.5	13.2	24.4	0.23
12/1-2/28	32.4	11.5	22.0	0.84

Sheridan				
Date	High	Low	Aver-age	Precipitation
12/1-12/31	35.2	10.6	22.9	0.56
1/1-1/31	36.2	11.4	23.8	0.56
2/1-2/28	39.0	14.2	26.6	0.54
12/1-2/28	36.7	12.9	24.8	1.66

Average Frost and Freeze Dates

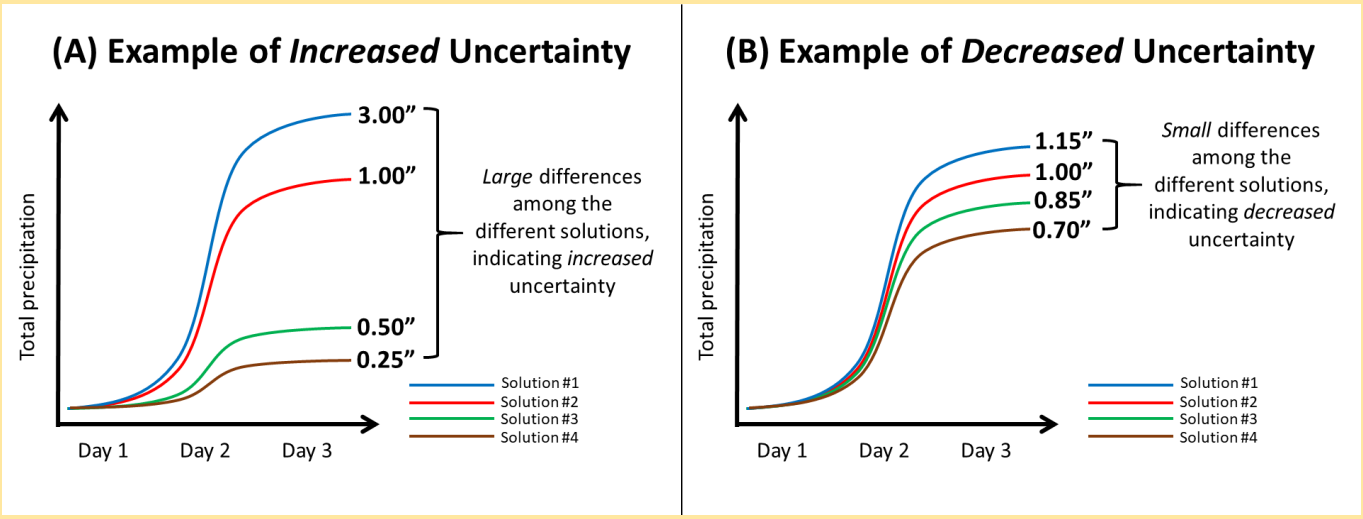
The following are the normal first frost, freeze and hard freeze dates for Billings, Miles City and Sheridan. The frost temperature is based on 36 degrees Fahrenheit, the freezing temperature is based on 32 degrees Fahrenheit and the hard freeze temperature is based on 28 degrees Fahrenheit. The normal dates are based on a 30 year average from 1981 to 2010. The earliest frost, freeze and hard freeze dates are based on a period of record. Recordkeeping began for the Billings Airport in 1934, the Miles City Airport in 1937 and at the Sheridan Airport in 1907.

City	Normal First Frost	Earliest Frost on Record	Normal First Freeze	Earliest Freeze on Record	Normal First Hard Freeze	Earliest Hard Freeze on Record
Billings	Sep 24	Aug 24	Oct 4	Sep 4	Oct 11	Sep 11
Miles City	Sep 21	Aug 22	Sep 29	Sep 2	Oct 7	Sep 11
Sheridan	Sep 11	Jul 2	Sep 20	Aug 17	Oct 3	Aug 25

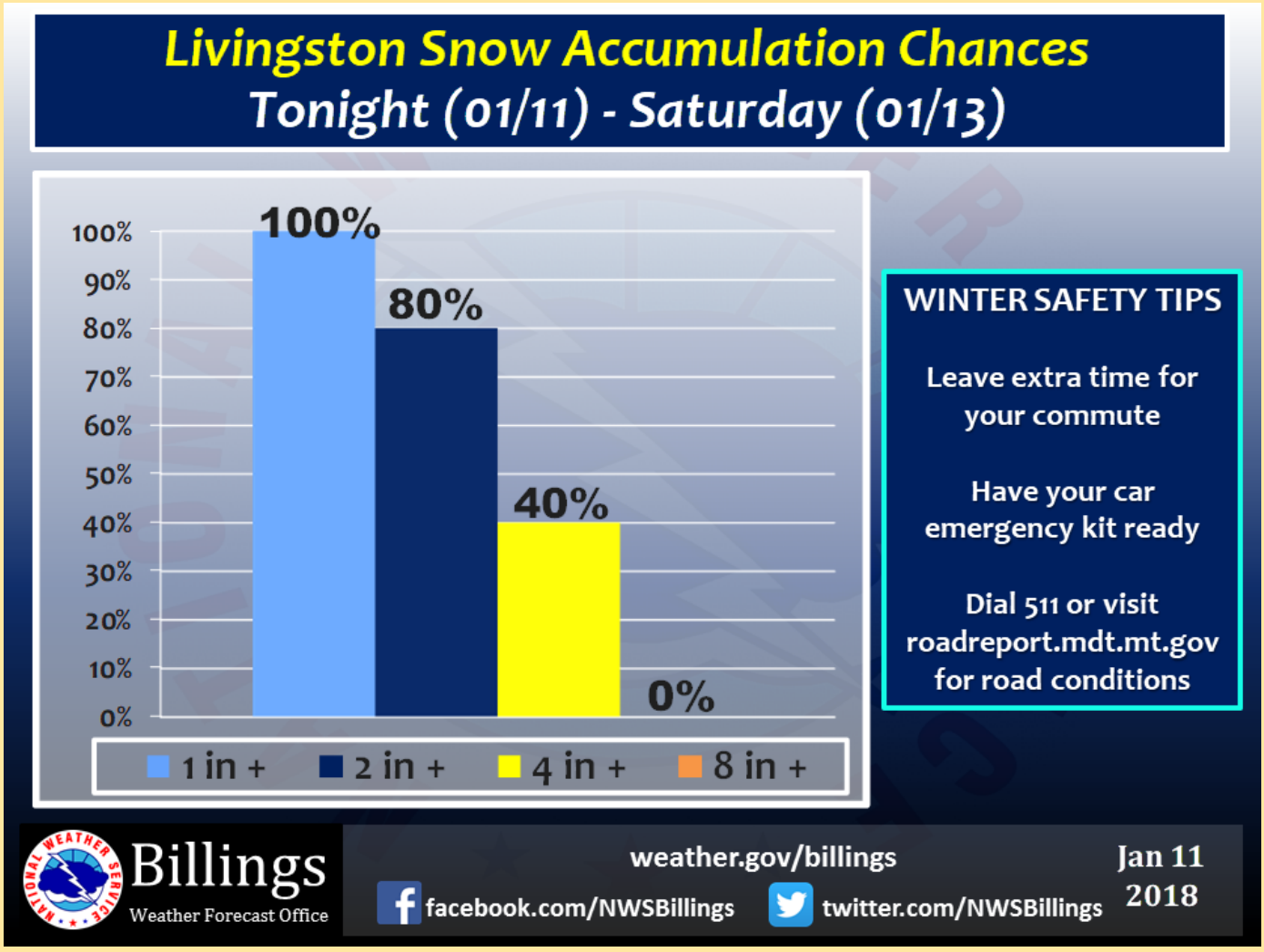
How Meteorologists Use Computer Model Ensembles to Improve Forecasts

Meteorologists use computer models of the atmosphere to aid in the preparation of forecasts. These computer models take in various observational data from satellites, aircraft, weather balloons, and weather stations at the surface, on land, and over the ocean to get a snapshot of the current state of the atmosphere. These observational data are then applied to equations that govern fluid motion and heat to produce a simulated atmosphere at some time in the future (i.e. a forecast). The caveat to using computer models is that they are sensitive to the initial conditions (the observational data). The observational data is not perfect - we do not have enough sensors to measure every molecule of air in the atmosphere! Despite the imperfect nature of the initial conditions, the observational data available does give us a reasonable picture of the atmosphere, and we have a way to assess the sensitivity of the computer model projection to the observational data. To do this, the initial conditions of the model run are perturbed a little to simulate what would happen if the observational data were a little off. This process is done dozens of times to produce an *ensemble* of model solutions.

Viewing the distribution of ensemble model solutions for various meteorological variables can indicate periods of increased or decreased uncertainty in the forecast. For example, if the ensemble solutions are showing large differences among themselves, as in Figure (A) where the forecast precipitation amounts range from 0.25” to 3.00”, the forecast would have more uncertainty. Such large differences could come from a dominant weather disturbance not being sampled well because it is located over the open ocean, or perhaps it’s a situation where a small change in the track of a low pressure system could produce a large change in the precipitation amount at a particular location. In contrast, if the ensemble solutions are showing small differences among themselves, as in Figure (B), the forecast would have less uncertainty, with the solutions ranging from 0.70 to 1.15”.



Here at the National Weather Service, we have taken the concept of ensemble model solutions a step farther by bringing the ensemble solutions of several different models together into one large set and then applying statistics to arrive at forecast guidance that meteorologists use in forecast preparation. This forecast guidance is called the National Blend of Models (NBM). The NBM provides a weighted average (blend) and insightful distributions of ensemble model solutions to give forecasters and the public (1) a "best guess" solution (i.e. the blend of ensemble solutions included in the NBM) and (2) uncertainty or probabilistic information about that best guess. As an example, say the NBM mean snowfall forecast at a location is 3". The NBM would help us to add probabilistic information to that mean forecast, such as: there's a 100% chance of receiving at least 1" of snow, an 80% chance of receiving at least 2" of snow, a 50% chance of receiving at least 3" of snow, and a 40% chance of receiving at least 4" of snow. Look for the forecast to be communicated with such probabilistic information more and more in the future.



Social Media *Submitted by Krista Carrothers, Meteorologist*

Social media has become a staple in our lives whether it be personal or professional. Nearly everyone has access to a smart phone or computer. The National Weather Service continues to evolve with everyday technology to help provide up-to-date information that is easy to understand, since meteorology can be a bit confusing at times. Interaction with our followers on social media has become a crucial part of our job as many times, you are our eyes in the sky. One limitation we face in the NWS is that southeastern Montana lacks radar coverage so we use satellite in its place but that does not give us a good representation of what is occurring on the ground. That's where you come in! Send us your report via Facebook or Twitter and it can help us make many decisions to make sure our thinking is on track.

Facebook is one platform that we use to interact with the public. We've been expanding our posts ranging from graphics to sharing links to poll questions. We try to keep Facebook light, as if you were talking to a friend by responding to your comments or trying to crack a few jokes here and there when the weather is calm. We are here 24/7 to answer questions and post updated information. Our graphics have become easier to understand over the last couple years and we are always open to changes that could help make graphics easier to understand.

This year, instead of heading to cities to do in person spotter talks, we took it online for the first time. This provided the opportunity for people who were too busy to attend in person training the option to complete it when they had time. This 7 part series is posted on YouTube and lasts less than an hour but provides the same information you would receive if it was in person. Since the online spotter training did not allow questions to be asked on topics that didn't make sense, we provided two sessions on Facebook where a meteorologist was available to answer any questions that you had. The interaction with our followers was better than expected and we hope to continue in the future with both in person and online training.

The National Weather Service is running 24/7 to make sure that when weather threatens our part of the country, we are here to provide you with up-to-date information. If you don't follow us on Facebook and Twitter, we encourage you to do so.

More Useful NWS Websites

By now, a lot of you know about our website *weather.gov/billings. While each Weather Forecast Office has its own website, there are also national centers that specialize in certain weather phenomena across the United States that have their own websites and provide even more useful information.*

Storm Prediction Center (SPC - *spc.noaa.gov)*

- One stop shop for all things severe weather, including thunderstorms, tornadoes, and even provides some fire weather support. Most may be familiar with their Convective Outlooks for the risk of Severe Storms, but for all you thunderstorm enthusiasts out there, they provide more in-depth discussions on storm potential through both these outlooks and Mesoscale Discussions.

Weather Prediction Center (WPC - *wpc.ncep.noaa.gov)*

- WPC has a bit more broad of a focus, but their main focal point is on precipitation, especially heavy rain and all winter weather from freezing rain to snow. They also provide detailed maps on where high and low pressure systems, and fronts, are across the United States, as well as forecasts showing where they will move to over the next week.

Climate Prediction Center (CPC - *cpc.ncep.noaa.gov)*

- Everyone always wants to know if it will be a cold and snowy winter, or a hot and dry winter, and the CPC is the go-to place to provide this information. They provide 2 week to 3 month outlooks for temperature and precipitation probabilities, as well as more information on the why, including discussions on El Niño/La Niña and their effects on our winters.

Prepare Before Your Next Trip—It Could Save Your Life!

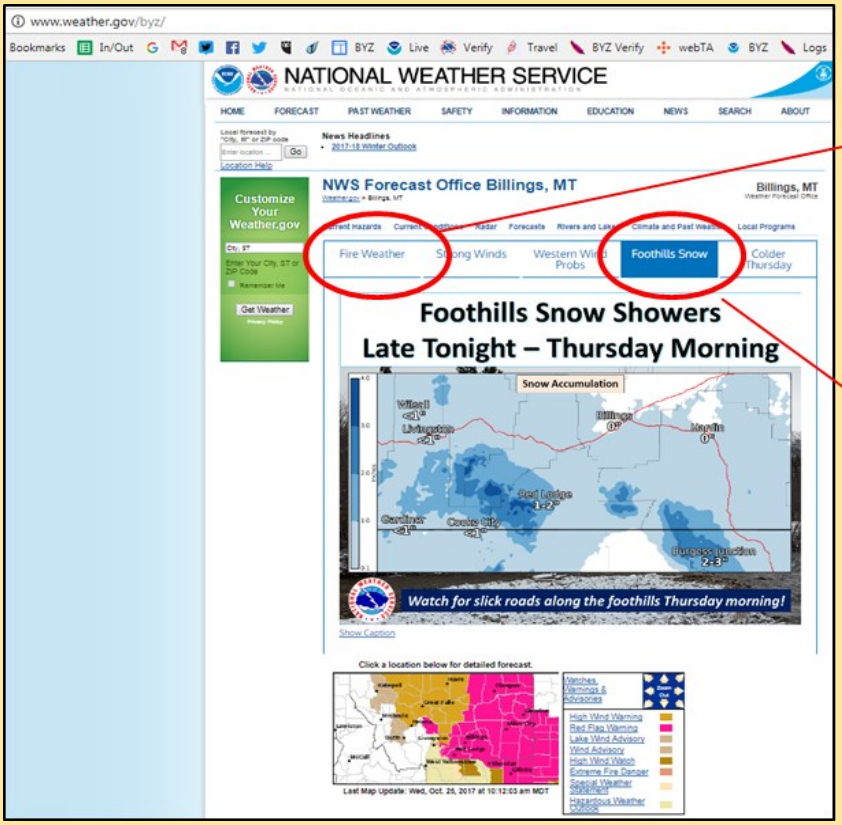
Now:

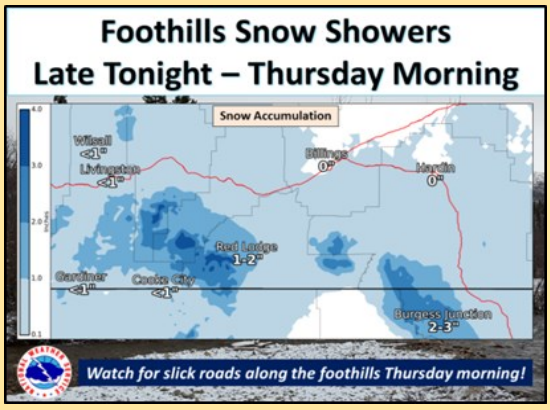
-Pack an emergency supply kit
-Winterize your vehicle

Just Before Your Trip:

-Stay mobile; fully charged cell phone
-Check current road conditions; follow the Department of Transportation
-Check the forecast!

Checking the forecast is as easy as monitoring the NWS webpage on a daily basis. Bookmark it today! On our front page, we will feature a **Weather Story** whenever hazardous weather could be an impact over the week ahead. Check it before venturing out. Multiple hazards, could mean multiple tabs and multiple stories. Clicking on each tab will give you details on each hazard.





NWS Billings Webpage with sample Weather Stories

http://weather.gov/billings

Look for Weather-Ready Tips on Social Media

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FOLLOW US ON facebook

facebook.com/

Follow us on twitter

twitter.com/

Winter Preparedness

Winter Weather Information & Safety
http://www.nws.noaa.gov/om/winter/index.shtml

Red Cross Winter Storm Safety Checklist (Downloadable PDF)
https://www.redcross.org/content/dam/redcross/atg/Chapters/Division_1_-_Media/Denver/Denver_-_PDFs/EmergencyPreparednessChecklist.pdf

Education

JetStream — An Online School for Weather
https://www.weather.gov/jetstream/

Local Climate Records
https://w2.weather.gov/climate/index.php?wfo=byz

Kids!

SciJinks. It's all about weather!
https://scijinks.gov/

Learn Science and Safety with Owlie Skywarn!
http://www.weather.gov/owlie/

Happy Fall To You All!

Have A Safe And Happy Holiday Season!