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Why Are Weather Models Sometimes Wrong?

Numerical weather models are one of the primary tools meteorologists use to forecast the weather. These models consist of mathematical equations which ingest physical data from several sources, eventually forming a “solution” for how the atmosphere will behave. The atmosphere is governed by the same laws of physics as everything else on earth, and we can use mathematics to explain how objects will behave. Yet sometimes, the solutions offered by weather models are wrong, but why? Is the math incorrect?

We can trace much of the error in weather models back to the data they ingest. More specifically, the quality of the data and the abundance of the data. A good analogy for this is baking a cake in your kitchen. You want to bake a delicious cake, but some of the ingredients you used were spoiled. No matter how good of a cook you are, your cake will *never* be delicious because you used bad ingredients. Similarly, access to quality data can be a problem.

This data consists of surface observations from local weather stations, real-time observations, and various upper-air data from weather balloons/airplanes/satellites etc. Unfortunately, the instrumentation used to gather this data can be inconsistent and prone to error. Even very small errors can magnify significantly over time and space as the weather model attempts to solve the future behavior of the atmosphere.

The availability of this data is not uniform over the earth or even the United States either. As we would expect, there is a significant lack of data over the oceans, which cover roughly 70% of the earth’s surface. Despite the lack of data, weather models must still offer solution for better or worse. Unfortunately, many of our storm systems are of Pacific origin.

Closer to home, there is a general lack of data over the Intermountain West. With fewer urban centers, weather stations, balloon launches etc., available

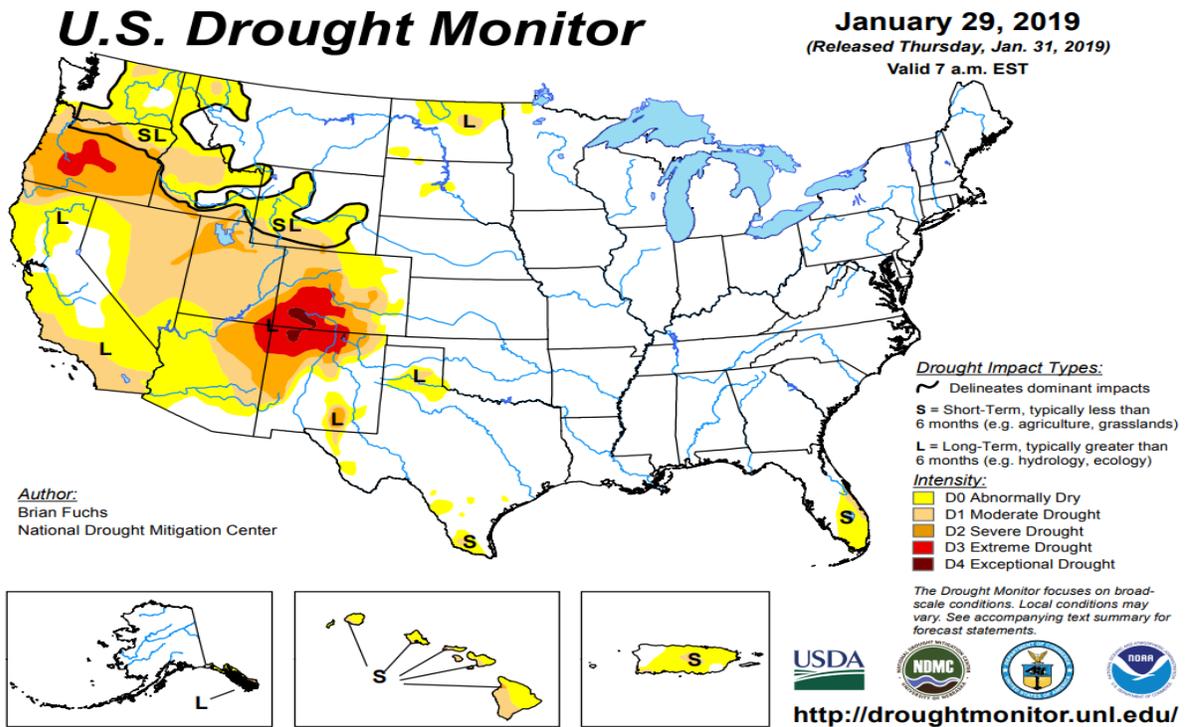
data can be few and far between. Unfortunately for us here in Colorado, this data gap is directly upstream. This is where our weather comes from, where storms strengthen/weaken, change course etc. It's no mystery that weather models are often more accurate east of the Rocky Mountains, simply because there is more data available.

Model resolution can also be a significant source of error in weather models. Despite recent advances in numerical modeling, weather models still cannot resolve very small, localized weather features like narrow bands of heavy snow or individual thunderstorm cells. Prior to the event, meteorologists can uncover clues that banded snowfall or thunderstorms may occur, but there is no way of knowing *exactly* where these features will set up. Weather models will offer a solution to consider, but their spatial accuracy is rarely 100% correct.

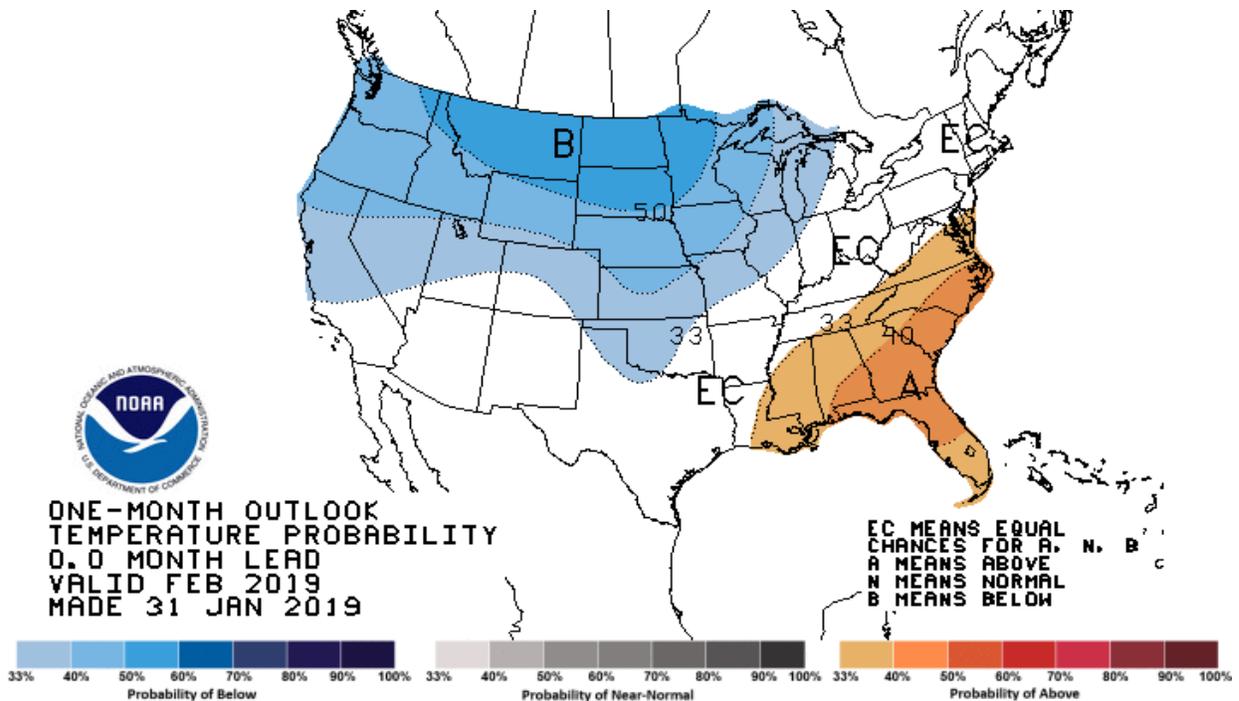
Complex terrain can also pose a problem for weather models, especially in places like Colorado. Terrain can have a significant influence on the resulting weather, especially concerning precipitation. It's no mystery that our mountains and higher terrain receive more snowfall than lower elevations. Do weather models know that we have complex terrain in Colorado? The answer is "yes," but only to a certain degree. This is where model resolution comes into play once again. Models recognize there is a terrain barrier in place, such as the Front Range or Palmer Divide, but their resolution does not recognize the smaller nuances of the terrain, which can be very important. Meteorologists must rely on local knowledge of the terrain and past experience to read between the lines and attempt to offer a more accurate forecast.

Drought Update

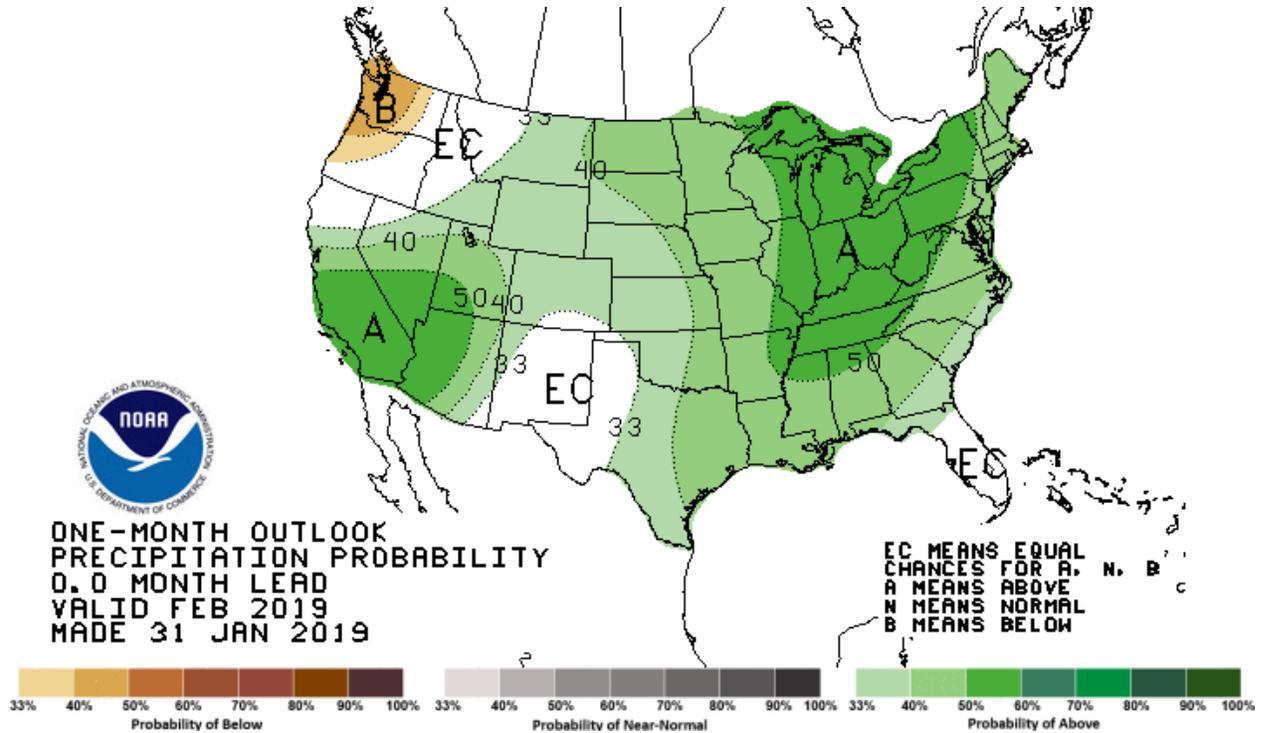
Drought conditions continue over most of Colorado with the most severe drought conditions over SW Colorado and the San Juan mountains.



The map below shows forecasted temperature deviances for February 2019. There is a slight bias towards below normal temperatures over much of Colorado with a lesser bias towards above normal temperatures over S and SW Colorado.



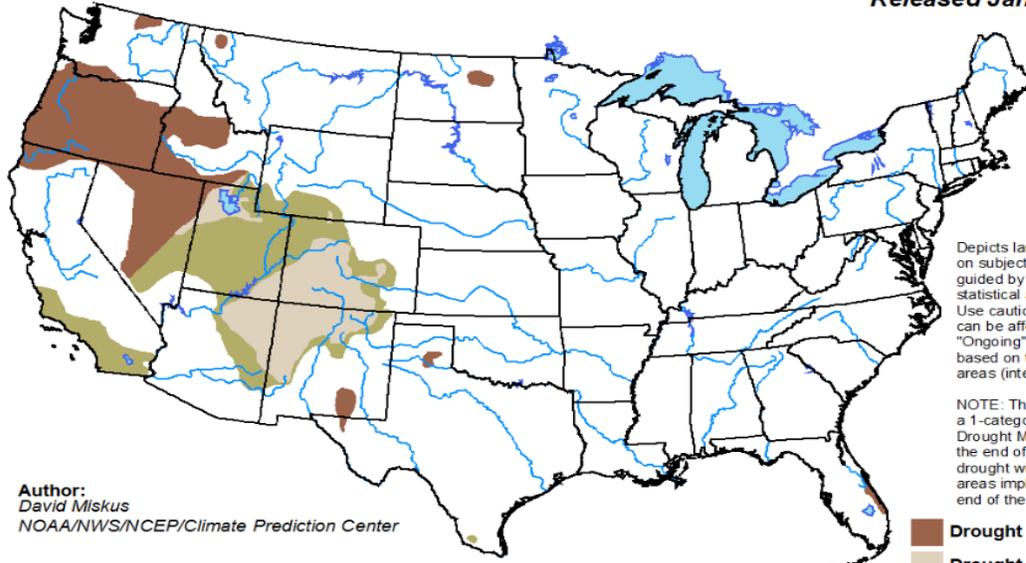
The map below shows forecasted precipitation deviances for February 2019. There is a slight bias towards above normal precipitation over much of Colorado.



Drought conditions are expected remain over much of Colorado but improve over the next month. Some drought removal is likely outside of SW Colorado.

U.S. Monthly Drought Outlook
Drought Tendency During the Valid Period

Valid for February 2019
Released January 31, 2019



Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely

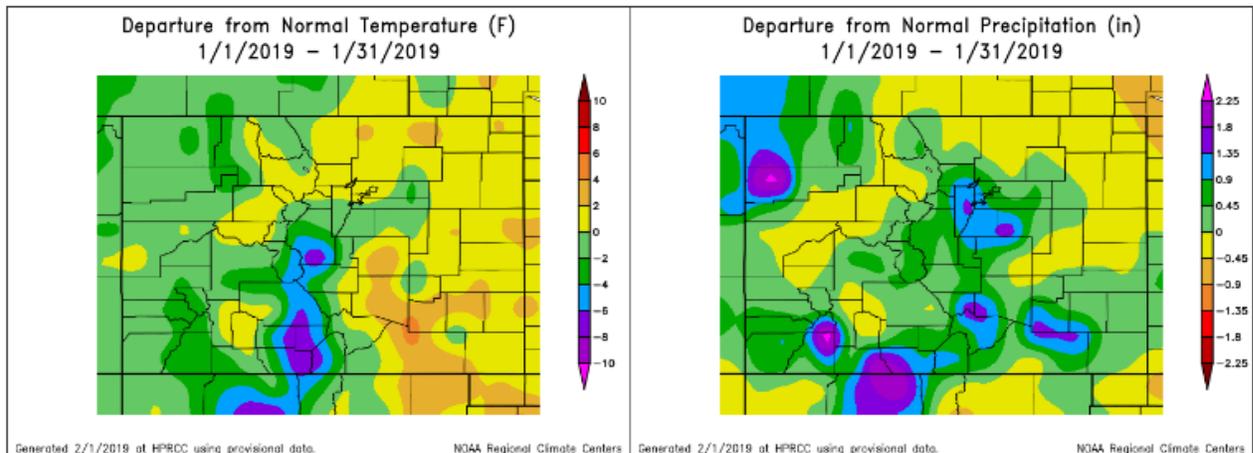
Author:
David Miskus
NOAA/NWS/NCEP/Climate Prediction Center



<http://go.usa.gov/3eZGd>

January Summary

January of 2019 was slightly above normal in temperature and above normal in precipitation but snowfall at DIA came in slightly below normal despite much higher totals over much of the Denver Metro area. The average high temperature for the month was 44.6 degrees, 0.6 degrees above the normal of 44.0 degrees. The average low temperature for the month was 19.5 degrees, 2.1 degrees above the normal of 17.4 degrees. The combination of the average high and low temperature produced a monthly mean temperature of 32.0 degrees which was 1.3 degrees above the normal of 30.7 degrees. The highest temperature of the month was 62 degrees which occurred on the 4th of the month. The coldest temperature of the month was -5 which was set on the 1st. There were 6 days during January which the high temperature did not exceed 32 degrees. There were not any temperature records during the month. Precipitation for January 2019 came in at 0.75" which was 0.34" above the normal of 0.41". Much of the moisture came from a single storm on the 11th of the month when 0.45" was reported. The 11th storm actually produced some rainfall before changing over to snow. Precipitation falling as rain for any meaningful amount of time in January is quite rare. Snowfall at DIA came in at 6.2" which was 0.8" below the normal of 7.0". The 6.2" did not represent the Denver Metro area very well as a whole with many areas from Boulder to Castle Rock reporting between 10-25" for the month. There were 5 snow events during the month with the majority of the snow falling for many areas on the 11-12th and the 28th. The maps below show departure from normal temperature and precipitation over the state of Colorado.



January Stats

TEMPERATURE (IN DEGREES F)

AVERAGE MAX	44.6	NORMAL	44.0	DEPARTURE	0.6
AVERAGE MIN	19.5	NORMAL	17.4	DEPARTURE	2.1
MONTHLY MEAN	32.0	NORMAL	30.7	DEPARTURE	1.3
HIGHEST	62 on the 4 th				
LOWEST	-5 on the 1 st				

DAYS WITH MAX 90 OR ABOVE	0	NORMAL	0.0
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DAYS WITH MAX 32 OR BELOW	6	NORMAL	5.5
DAYS WITH MIN 32 OR BELOW	29	NORMAL	29.4
DAYS WITH MIN ZERO OR BELOW	1	NORMAL	1.7

TEMPERATURE RECORDS

NA

HEATING DEGREE DAYS

MONTHLY TOTAL	1016	NORMAL 1063	DEPARTURE -47
SEASONAL TOTAL	3388	NORMAL 3531	DEPARTURE -143

COOLING DEGREE DAYS

MONTHLY TOTAL	0	NORMAL 0	DEPARTURE 0
YEARLY TOTAL	0	NORMAL 0	DEPARTURE 0

PRECIPITATION (IN INCHES)

MONTHLY TOTAL	0.75	NORMAL 0.41	DEPARTURE 0.34
YEARLY TOTAL	0.75	NORMAL 0.41	DEPARTURE 0.34
GREATEST IN 24 HOURS 0.45" on the 11 th			
DAYS WITH MEASURABLE PRECIP. 5			

SNOWFALL (IN INCHES)

MONTHLY TOTAL	6.2	NORMAL 7.0	DEPARTURE -0.8
SEASONAL TOTAL	14.4	NORMAL 29.5	DEPARTURE -15.1
GREATEST IN 24 HOURS 2.3"			
GREATEST DEPTH 1.0"			

WIND (IN MILES PER HOUR)

AVERAGE SPEED	9.9 mph
PEAK WIND GUST	54 mph from the N on the 22 nd

MISCELLANEOUS WEATHER

NUMBER OF DAYS WITH THUNDERSTORM	0	NORMAL	0
NUMBER OF DAYS WITH HEAVY FOG	3	NORMAL	1

NUMBER OF DAYS WITH HAIL	0
NUMBER OF SUNNY DAYS	10
NUMBER OF PARTLY CLOUDY DAYS	17
NUMBER OF CLOUDY DAYS	4
AVERAGE RELATIVE HUMIDITY	58%

February Preview

Average highs begin to climb into the mid 40s in February as we begin to gain sunlight each day. On the 1st of the month the sun rises at 7:08am and at the end of the month the sunrise is 6:34am a gain of 34 minutes on the sunrise side alone. The sun sets at 5:20pm on the 1st and 5:51 on the 28th adding 31 minutes on the sunset times. For the month there is a gain of 1 hour and 5 minutes of daylight! Average lows climb 1.5 degrees from December and highs gain 2.2 degrees from December. There are on average 4 days during the month where high temperatures remain below freezing with one overnight period where temperatures fall below zero. Average precipitation for February is only 0.32" with 5.7" of snowfall. There are usually 5 days during the month with measureable precipitation greater than a trace. For February 2019 near normal temperatures to slightly below normal temperatures are expected despite starting off on the warm side through the first 4 days of the month. Near normal to above normal snowfall is expected with northern Colorado being favored for the above normal snowfall. Although the month has started out mild and dry the weather pattern is expected to become more active in the coming days and continue through the middle and latter part of the month.

DENVER'S FEBRUARY CLIMATOLOGICALLY NORMAL (NORMAL PERIOD 1981-2010 DIA Data)

TEMPERATURE

AVERAGE HIGH	46.2
AVERAGE LOW	18.9
MONTHLY MEAN	32.5
DAYS WITH HIGH 90 OR ABOVE	0
DAYS WITH HIGH 32 OR BELOW	4
DAYS WITH LOW 32 OR BELOW	27
DAYS WITH LOWS ZERO OR BELOW	1

PRECIPITATION

MONTHLY MEAN	0.32"
DAYS WITH MEASURABLE PRECIPITATION	5
AVERAGE SNOWFALL IN INCHES	5.7"
DAYS WITH TRACE OR MORE OF SNOW	NA

MISCELLANEOUS AVERAGES

HEATING DEGREE DAYS	908
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COOLING DEGREE DAYS	0
WIND SPEED (MPH)	8.8mph
WIND DIRECTION	South
DAYS WITH THUNDERSTORMS	0
DAYS WITH DENSE FOG	2
PERCENT OF SUNSHINE POSSIBLE	70%

EXTREMES

RECORD HIGH	77 on 2/4/1980, 2/28/2006
RECORD LOW	-25 on 2/8/1936, 2/1/1951
WARMEST	43.7 in 1954
COLDEST	17.6 in 1899
WETTEST	2.01" in 1934
DRIEST	0.01" in 1970
SNOWIEST	22.5" in 2015
LEAST SNOWIEST	TR in 2009

Snowfall

October 2018 to May 2019

City	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Aurora (Central)	2.5	4.6	0.9	12.7					20.7
Boulder	10.0	15.9	5.7	13.9					45.5
Brighton	3.4	4.6	0.7	3.4					12.1
Broomfield	5.1	8.3	2.1	20.0					35.5
Castle Rock	5.5	9.2	3.2	25.0					42.9
Colo Sprgs Airpor	5.3	2.8	1.5	2.6					12.2
Denver DIA	3.2	4.5	0.5	6.2					14.4
Denver Downtowr	2.5	6.0	1.4	15.1					25.0
Golden	7.0	7.0	2.4	16.9					33.3
Fort Collins	6.0	5.6	1.1	1.6					14.3
Highlands Ranch	6.5	7.0	1.2	19.8					34.5
Lakewood	3.4	6.6	1.2	15.2					26.4
Littleton	4.5	6.2	2.2	16.5					29.4
Parker	3.8	7.4	2.1	17.6					30.9
Sedalia - Hwy 67	5.2	6.6	2.4	23.1					37.3
Thornton	5.0	5.9	0.7	13.4					25.0
Westminster	3.2	6.8	2.5	19.8					32.3
Wheat Ridge	4.1	8.5	1.5	13.8					27.9

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