# Assessing the accuracy of SpotWX during the winter season in backcountry locations within the South Columbia Mountain Range, British Columbia

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# Disclaimer

## Abstract

Backcountry weather forecasting is becoming increasingly popular as winter backcountry recreation has experienced significant growth. SpotWX is a useful tool that provides a variety of weather model forecasts for any specific location the user chooses through a map system. This study analyzes SpotWX forecast accuracy based on 14 backcountry field days during the 2019/2020 winter season in the South Columbia Mountain Range. Forecasted temperature, precipitation, wind intensity, and cloud cover are analyzed for both two- and ten-day forecast models. Temperature accuracy was demonstrated by an average temperature discrepancy of 1.6°C. SpotWX was found to provide forecasts with different elevations than the desired elevation. Wind intensity forecasts were found to not represent the variability of wind in mountainous terrain. Varying spatial resolution of forecasts was found to affect the accuracy of forecasted cloud cover and precipitation. By understanding the limitations and what accuracy to expect of SpotWX users can be better suited to use this resource.

## 1. Introduction

At present, due to technology advancements, nearly everyone can access a variety of weather forecasting applications. Most of these resources forecast only for the location of cities and only provide basic forecasts without much detail. Environment Canada, a commonly used resource for weather forecasts of city locations, offers seven-day forecasts and 24-hour hourly forecasts (Canadian … c2019). Detailed weather information may not be needed or desired in cities, yet people in more remote locations, where weather can be a serious factor, will be looking for more data. Weather can be a major safety concern, especially during the winter season for backcountry users, both recreational and professional alike. Weather plays a large role in trip planning, as people often base their plans on the forecast and often seek specific weather conditions.

Weather forecasts for backcountry locations are of increasing importance as winter backcountry recreation is experiencing significant growth and becoming more mainstream. There are more people in the mountains, covering more ground, and recreating more, often due to technological advancements of backcountry equipment such as skis, snowboards, snowmobiles, and snowshoes (Tremper 2008). For example, skier visits at Glacier National Park, British Columbia (BC), have increased by approximately fifty percent between the winter season of 2010/2011 and that of 2015/2016 (Stuart 2016). With modern snowmobiles, riders are able to access avalanche terrain in any snow condition and they are able to cover 100 times more terrain than skiers in a day, leading to an increase in avalanche fatalities (Tremper 2008). There have been 123 avalanche fatalities in Canada between the years 2009 and 2018, and 83 percent of these fatalities occurred in British Columbia (Avalanche … 2018). Because weather plays a vital role in the creation of avalanche conditions, avalanche forecasters closely monitor weather throughout the winter (Tremper 2008). The Canadian Avalanche forecast resource *avalanche.ca/weather/forecast* experienced an 81 percent increase in page views between the years 2017 and 2018 (Avalanche … 2018). This increase in Canadians monitoring avalanche forecasts likely indicates that backcountry users are increasingly seeking information about backcountry conditions, including weather forecasts.

SpotWX, an online weather forecasting tool, was developed by Garth Hoeppner, a Fire Weather Forecaster for Manitoba's Wildfire Program (SpotWX 2019). Garth created SpotWX from his home to use as a tool for his own forecasting job. This interface enables the user to choose the location of their desired forecast by locating a "spot" on the map system provided or by entering coordinates. Once a location is selected, SpotWX provides the user with a variety of weather models, ranging in temporal and spatial resolution. The weather models range temporally from 48 hours to 16-day forecasts, and the spatial resolutions range from 2.5 square kilometers to half a degree of latitude and longitude. SpotWX forecasts list the elevation that the forecast model represents. This availability of location specific weather forecasts fills the void for backcountry users who were previously unable to gather weather forecasts for remote areas. Spot WX is very appealing for many backcountry users as it is an efficient tool to obtain weather forecasts presented in a user-friendly graph format (SpotWX 2019).

SpotWX weather forecasts have the potential to be valuable, however, the user must understand the limitations of the weather models to appropriately use this tool. The complex mountainous terrain of the BC Interior makes forecasting winter weather a challenging task (Mo et al. 2012). How much confidence can a user have on a winter weather forecast provided by SpotWX? My research goal is to assess the accuracy and reliability of Spot WX winter weather forecasts by comparing forecasts to field based weather observations. To achieve this goal, I will address the following objectives:

- Research background literature on SpotWX and field weather observations.
- Conduct field studies that compare SpotWX weather forecast data to observed environmental conditions collected in a number of backcountry locations in the West Kootenay region of the BC Interior.
- Compare SpotWX weather forecasts and field weather observations with regards to temperature, wind, cloud cover, and precipitation in order to assess accuracy and identify trends.
- Use results to develop recommendations that explain the accuracy and reliability of SpotWX winter weather forecasts in mountainous backcountry terrain.

## 2. Methods

### 2.1 Study Area

The area of study is the South Columbia Mountain Range in British Columbia (BC) (Figure 1). Study sites have been chosen in a variety of backcountry locations that are within an achievable distance for a field day based out of Nelson, BC. All study locations have been accessed by snowmobiling or skiing up logging or mining roads and into treeline or alpine ecosystems. The topography of the study area is composed of rugged terrain with steep valleys and tall mountain peaks. Study sites were located at a variety of aspects and elevations. From November 4, 2019 to January 31, 2020, I made a total 14 trips to record weather observations resulting in 18 two-day and 16 ten-day forecast comparisons. Two-day forecast models are high resolution forecasting for a 2.5 $km^2$ area, and ten-day forecast models are lower resolution covering a 25 $km^2$. During each of these trips I recorded between one and three observations at different times and locations. Weather observations were conducted while travelling through the backcountry with at least one partner experienced in avalanche rescue.

### 2.2 Background Literature Research

Background literature research was conducted throughout the duration of the project from a variety of sources. Internet research was conducted through weather and avalanche forecasting websites, journals, reports, blogs, books, magazines, and field manuals (e.g., The Avalanche Journal, The Avalanche Handbook).

### 2.3 Project Design and Data Collection

The project consists of gathering and compiling weather forecast data from SpotWX a day or more before the field day. Weather forecast data were downloaded from the SpotWX website in a chart format as a JPEG file, as well as in a tabular format as a CSV file. It is useful to have data in a chart format as well as in a tabular format to be able to observe data in multiple ways for analysis. Data compiled from SpotWX consists of the following:

- Date and time (yyyy/mm/dd, 24-hr clock)
- Location (latitude, longitude)
- Elevation (m)
- Air temperature (°C)
- Wind speed (km/hr)
- Wind direction (degrees true)
- Accumulated snow (cm for snow)
- Cloud coverage (%)
- Precipitation type (rain, snow, ice pellets, or freezing rain)

Field weather observations were conducted based on standards outlined in the Observation Guidelines and Recording Standards for Weather Snowpack and Avalanches (CAA 2016), with some modification due to limited availability of complex instruments. Field weather observations consist of the following:

- Date and time (yyyy/mm/dd, 24-hr clock)
- Location determined using Avenza Maps on an iPhone (UTM)
- Elevation (m)
- Air temperature recorded with a digital thermometer 1.3 m above the ground in the shade (°C)
- Wind speed measured with a Kestrel hand-held wind meter (km/hr)
- Wind direction estimated based on visual indicators and recorded using a compass (cardinal direction)
- Snow precipitation rate recorded by measuring a cleared surface after 15 minutes then converting to cm/hr or by visual estimation
- Cloud coverage estimated based on visual indicators (%)
- Precipitation type (rain, snow, ice pellets, or freezing rain)

### 2.4 Data Analysis

Of the weather data collected, I decided to analyze temperature, precipitation, wind intensity, and cloud cover for the purpose of weather data comparison. This decision was due to the high confidence in the field weather observations of these categories, as well as them being most important to a backcountry user.

*2.4.1 Temperature*

Temperature was analyzed by observing differences in degrees Celsius. The differences in temperature were broken into three categories: forecasts warmer than observed, forecasts colder than observed, and an average of both warmer and colder.

*2.4.2 Precipitation*

Precipitation was categorized by presence or absence of precipitation rather than precipitation rate.

*2.4.3 Wind Intensity*

In order to analyze wind intensity, this variable was divided into the following three categories: 0-10 km/hr, 10-25 km/hr, and greater than 25 km/hr. These categories are based on wind chill and snow transport qualities of wind intensity (Environment ... c2014). Wind intensities less than 10 km/hr do not produce significant wind chill. Wind chill is noticeable when wind intensities are equal or greater than 10 km/hr. For example, a temperature of -10ºC with winds of 10 km/hr feel like -15ºC (Environment ... c2014). Snow transport and wind packing occurs with wind intensities greater than 25 km/hr, an important consideration when travelling in avalanche terrain (McClung et al. 2006).

*2.4.4 Cloud Cover*

Cloud cover was divided into the following three categories: 0-20%, representing a sunny day; 20-80%, representing a mix of sun and clouds; and, 80-100%, representing an overcast day.

## 3. Results

The following observations are the result of 18 two-day and 16 ten-day forecast comparisons from 14 weather observation field days.

### 3.1 Temperature

Forecasted temperatures were warmer than actual observed conditions for both two-day (72%) and for ten-day (69%). Figure 2 identifies the difference in average temperature difference between forecasts and actual observed conditions broken down by forecasts that were warmer or colder than observed. The largest temperature difference observed for both two and ten-day forecasts was 5.4 °C, and the lowest temperature difference was 0 °C. Of 34 forecasts, 14 (41%)

resulted in a temperature difference of 1°C or less (Figure 3). The average temperature difference was 1.6°C.

### 3.2 Precipitation

Precipitation was forecasted when it was observed 78% of the time for two-day forecasts and 94% of the time for ten-day forecasts (Figure 4).

### 3.3 Wind Intensity

Both forecasted wind intensity fit and actual observed wind intensity fit in the same category 61% of the time for two-day forecasts and 100% of the time for ten-day forecasts (Figure 4). There was also a wind intensity discrepancy noted as 78% of two-day forecasts and 56% of ten-day forecasts were higher than those observed.

### 3.4 Cloud Cover

Forecasted cloud cover fell within the same category as actual observed cloud cover 61% of the time for two-day forecasts and 69% of the time for ten-day forecasts (Figure 4).

### 3.5 Elevation

Every forecast resulted in a lower elevation than the actual elevation of paired observation. On average, the elevation of the two-day forecast model was 316 meters lower than the elevation of the actual observed conditions, and elevations of ten-day forecasts were 636 meters lower than actual. The largest elevation discrepancy was 964 meters.

## 4. Discussion

### 4.1 Temperature

My data analysis showed that forecasted temperatures were warmer than those observed. This discrepancy was likely a result of the forecasted elevations being lower than the elevations of the actual observed conditions. On average, temperature drops 6.5°C per 1000 meters of elevation gained (Deziel 2020). Regardless of the elevation discrepancy, however, the average temperature difference of 1.6°C demonstrates a good level of accuracy.

### 4.2 Precipitation

Ten-day forecasted precipitation was more accurate than two-day forecasts. This may be due to the resolution difference between the two models. Two-day forecast models are high resolution forecasting for a 2.5 km² area, and ten-day forecast models are lower resolution covering a 25 km². Although a higher resolution model is intended to produce more accurate forecasts for a more specific area, a lower resolution model may identify precipitation that is found outside of the higher resolution model's range. This suggests that a lower resolution model may be useful in identifying precipitation that a higher resolution model would not identify.

### 4.3 Wind Intensity

The majority of forecasted wind intensity was higher than the observed intensities, likely due to the variability of wind in mountainous terrain. For example, sheltered locations can experience calm winds when winds are more intense in exposed areas. I think it is likely that forecasts for wind do not consider the effect of the terrain.

### 4.4 Cloud Cover

The higher cloud cover accuracy of ten-day forecasts may be due to the resolution difference between two and ten-day forecasts. Ten-day forecasts may identify cloud systems that are beyond the spatial range of the two-day forecasts. This suggest that lower resolution models may be useful for identifying cloud at a broader range.

### 4.5 Elevation

The elevation discrepancy between forecasts and observations is due to the fact that weather model terrain does not match real terrain in mountainous regions (Jones 2019). Both the atmosphere and terrain are three-dimensional, yet a forecast model is a two-dimensional representation of the terrain (Jones 2019). Therefore, modelled atmosphere is not accurate of real atmosphere. In mountainous regions, this discrepancy can be larger due the complex terrain. In mountainous regions, weather models present mountain's elevation as lower and valley's elevation as higher than actual (Jones 2019).

### 4.6 SpotWX Limitations

Weather model elevation is the primary limitation of SpotWX and this discrepancy in elevation can affect the accuracy of forecasted temperatures. As a SpotWX user, this limitation can be reduced by acknowledging and making adjustments. Temperatures can be adjusted for the desired elevation by increasing the temperature by 0.65°C for every 100m decrease in elevation or by reducing the temperature by 0.65°C for every 100m increase in elevation.

Wind intensity is another limitation of SpotWX. Wind is distorted by mountainous terrain, therefore, wind intensities will be variable throughout areas covered by SpotWX forecasts. Users can reduce this limitation by analyzing the terrain. By studying topographic maps to identify if a site is on a ridge or in a sheltered valley, users can predict whether their chosen location will be sheltered or exposed to the forecasted wind.

### 4.7 Sources of Error

Locations that were sought out for recreation were likely wind sheltered, as snow that is unaffected by the wind is desirable for skiing and snowmobiling. This choice may have affected my wind intensity observations, resulting in lower intensities than forecasted.

### 4.8 Recommendations

The average difference in days between the date of forecast being published and the date of observation was 1.4 days. The lowest difference was one day, and the largest difference was four days. This small difference was due to backcountry outing locations being chosen based on current conditions a day or two before, as well as the time limitations of a two-day forecast. In future studies it would be of interest to test ten-day forecasts with a larger difference in days.

SpotWX users will be better equipped to use this tool once they understand its limitations. Users should understand the inaccuracy of weather model elevation in mountainous terrain. By understanding this limitation and adjusting temperatures accordingly this limitation can be overcome. SpotWX users should also understand the idea of forecast model spatial resolution and how it can affect precipitation and cloud cover forecasts. A higher resolution models may cover too small of an area to identify nearby storm systems. A lower resolution model may identify storm systems that are outside of a higher resolution model's range. I recommend looking at both high and low resolution models when requiring a weather forecast. Finally SpotWX users should understand the variability of wind within mountainous terrain when considering forecasted wind intensity and direction. Consider the terrain of your desired forecast location to predict how it will be affected by the forecasted wind.

## 5. Conclusion

To conclude, SpotWX is a useful tool for backcountry users filling the void of weather forecasts in remote locations. By understanding the limitations of this resource, users will be better equipped to utilize it. SpotWX users could also benefit by conducting their own comparisons. By simply comparing the weather experienced throughout a day to the weather that was expected based on a SpotWX forecast, users can develop a better understanding of the trends in their region.

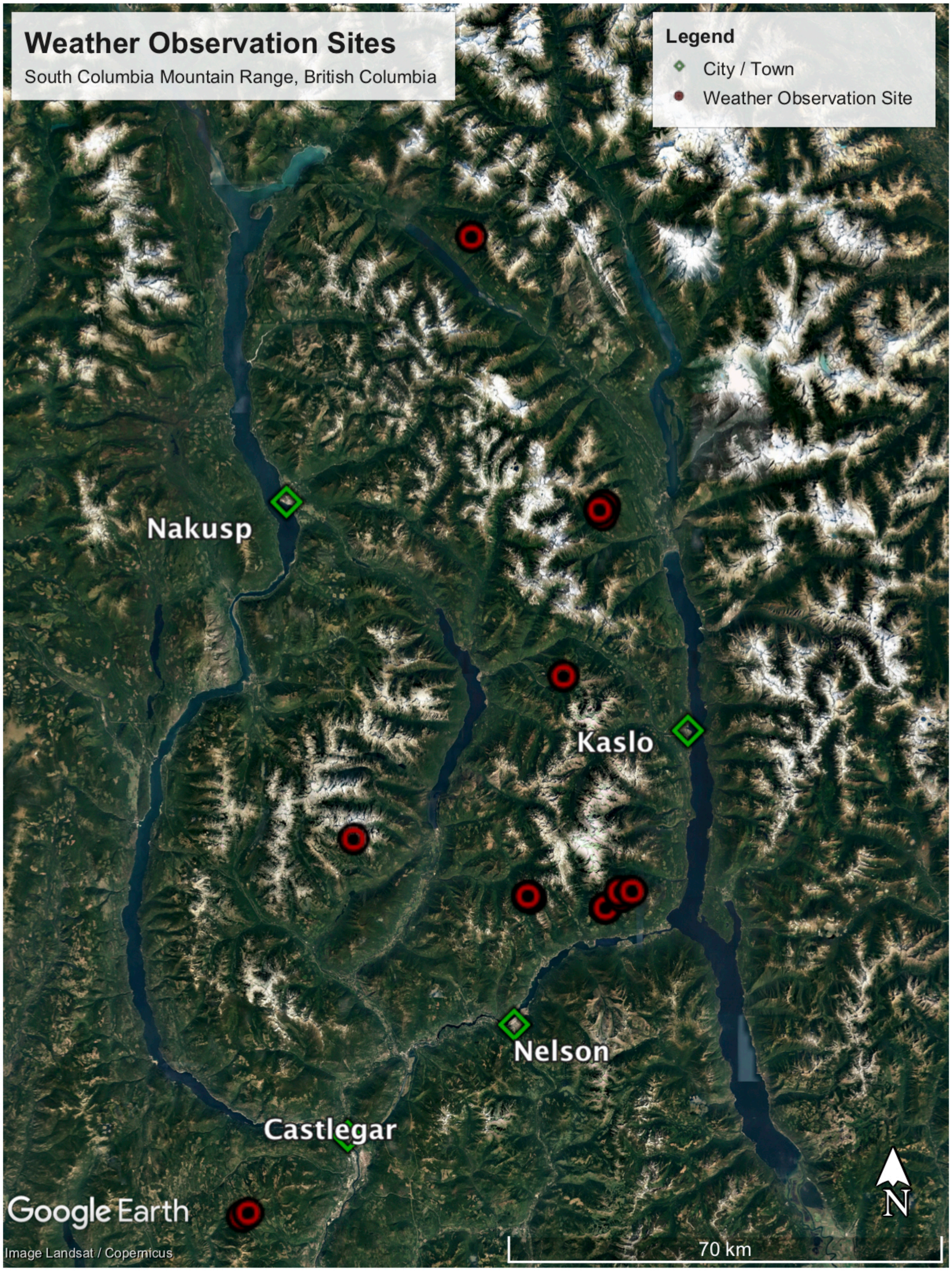


Figure 1. Study area and weather observation sites within the South Columbia Mountain Range, British Columbia (Google … c2020).

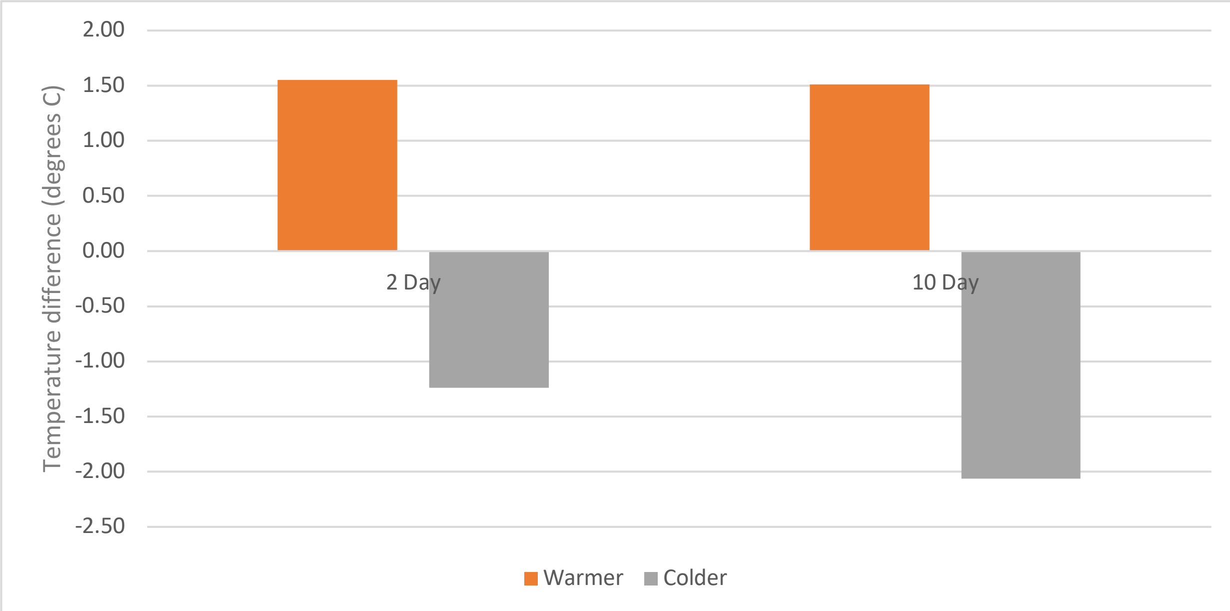


Figure 2. Average temperature difference between forecasted conditions and actual conditions of both warmer and colder than actual forecasts of 2- and 10-day forecasts in degrees Celsius.

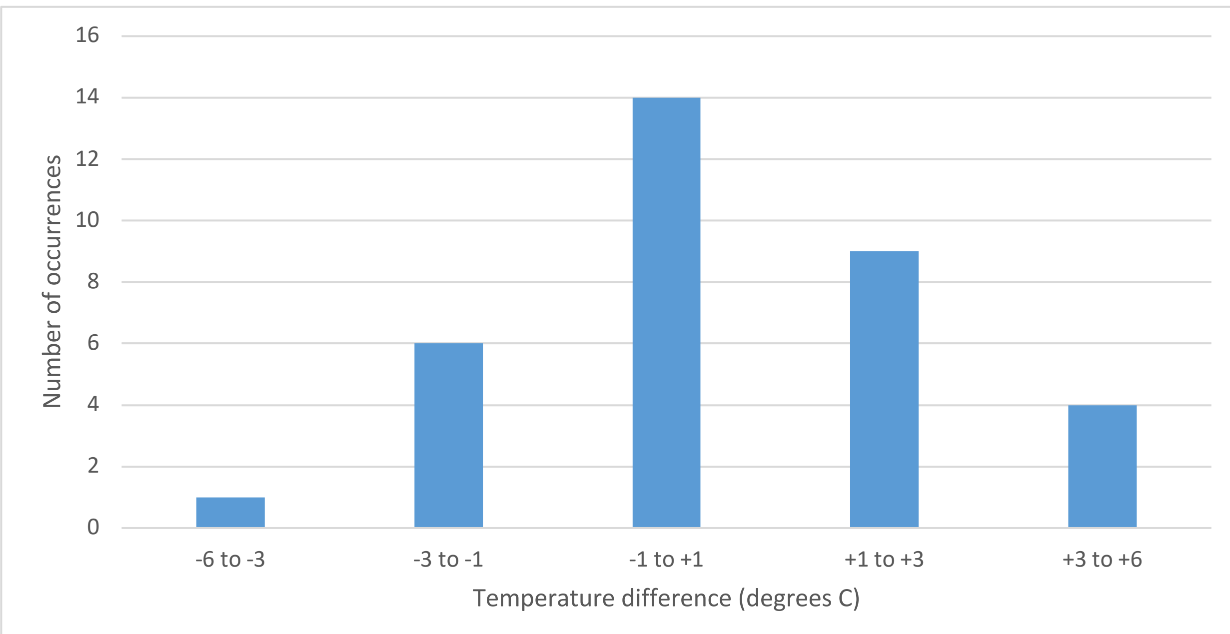


Figure 3. Occurrences of temperature difference by categories in degrees Celsius of both two and ten-day forecasts.

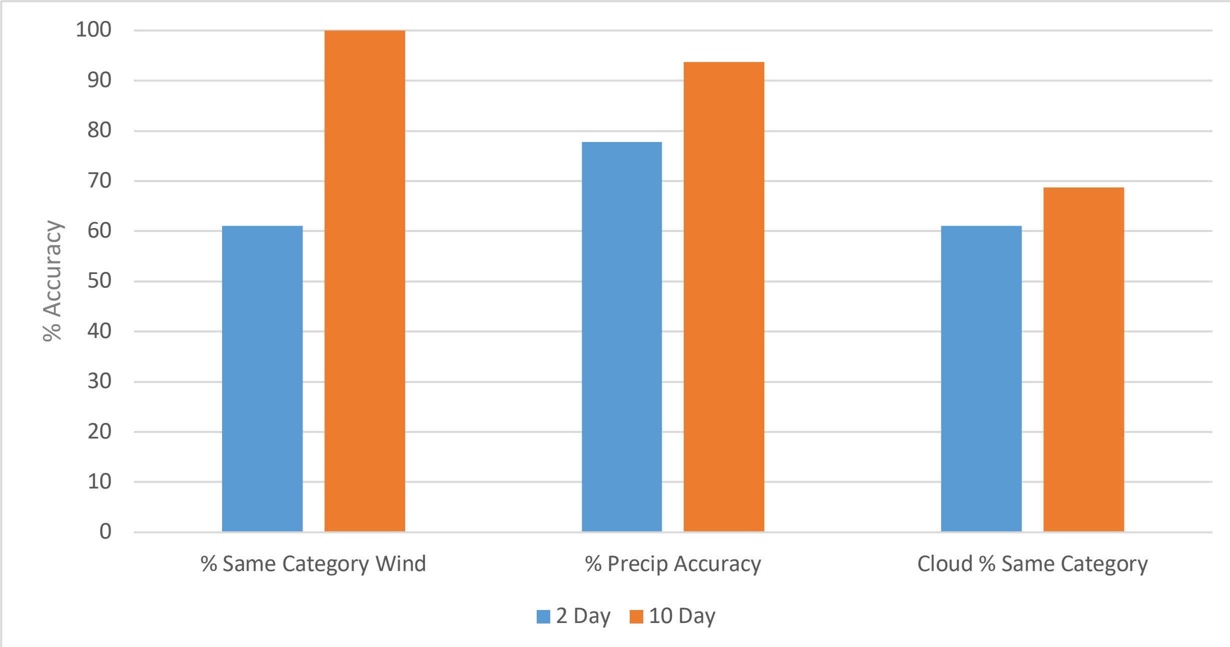


Figure 4. Percent accuracy of wind, precipitation, and cloud cover based on categories of two and ten-day forecasts.

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