Microclimate of the Clearwater Valley around Seeley Lake, MT

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I. Overview

Seeley Lake, located near the Continental Divide in Western Montana, has been observed as one of the colder forecast points in the Missoula CWA during the winter months of December, January and February. There are two general patterns that dramatically affect the observed minimum temperatures at Seeley Lake are 1) arctic intrusions and, 2) calm/clear night(s) after fresh snowfall. Under these two patterns, spotter and automated surface observations from the area often are colder than forecasted values. This quick study is an effort to evaluate the topographic and synoptic influences that support such reported minimum temperatures below 0°F and to investigate model biases in gridded temperature guidance.

II. Synoptic Scale Description

The community of Seeley Lake lies in the southern end of a north-south oriented valley nestled between the Mission Mountains and the Swan Range of the Bob Marshall Wilderness in Western Montana (Figure 1). Traveling north along the Highway 83 corridor, the valley begins to narrow between Mission Mountains and the Swan Range while decreasing in elevation down into the swamp/marsh lands east of Flathead Lake. Seeley Lake sits at 4000ft ASL and in the winter runs as one of the coldest forecast points in the CWA. East of Seeley lies the uninhabited Bob Marshall Wilderness with the average terrain height between 6000ft to 8000ft ASL. Directly northeast lies the Morrell Creek drainage that can collect cold air from the surrounding four or five peaks and channel it into Seeley.

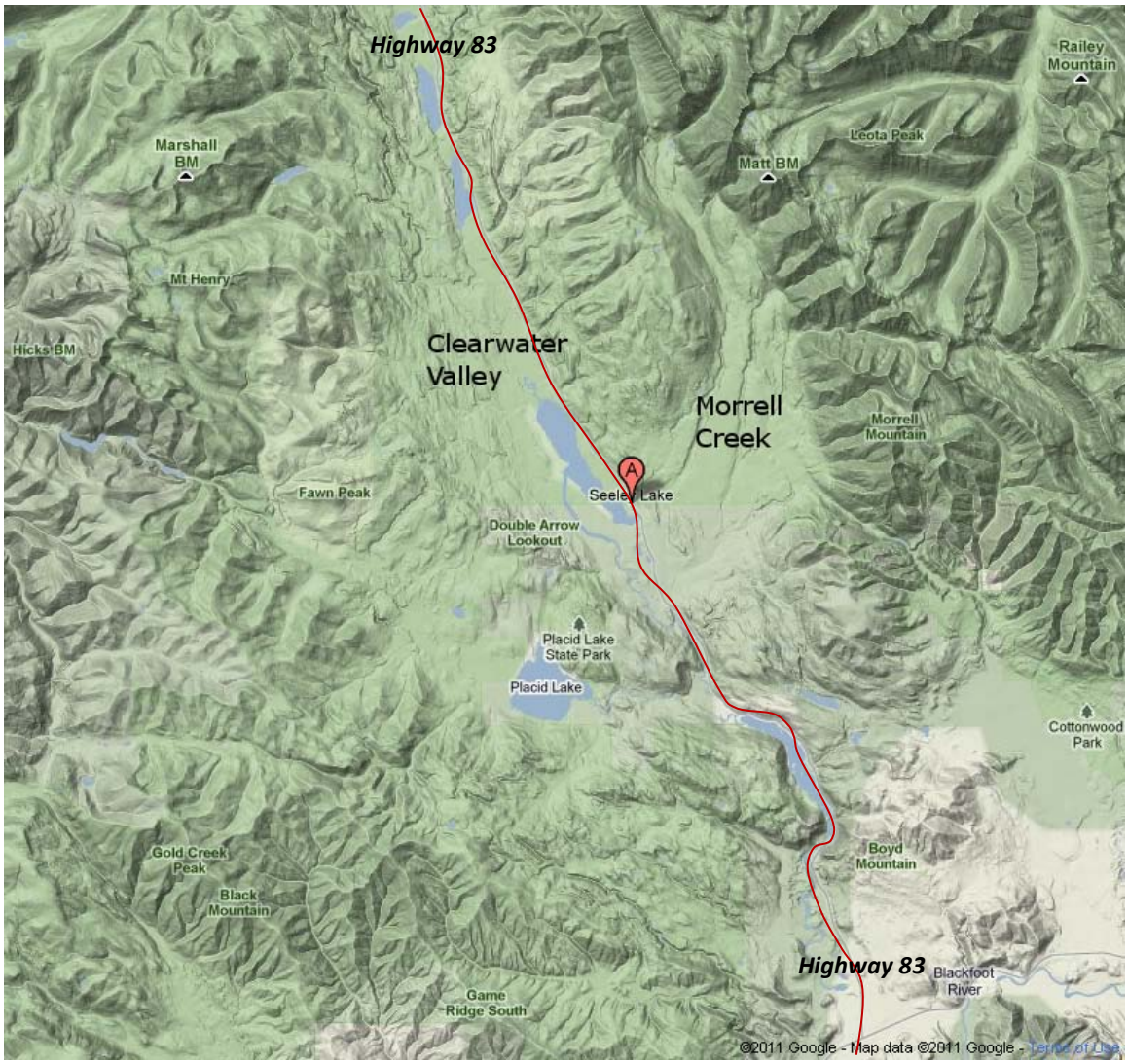

Figure 1. Location of Seeley lake in Western Montana

The first synoptic pattern, an arctic intrusion, occurs when a severely cold air mass moves along the Continental Divide from the continental Canadian provinces. The cold air presses along the Divide and dependent on its depth can funnel through the lower gaps of the Divide, or fully spill over the Divide, sending Arctic air into the valley locations of Western Montana. Seeley Lake is not known for severe gap winds that can occur with arctic intrusions across the Divide. Nor is it known for classic valley-scale cold pool formation, as the Clearwater River Valley is open to the south, allowing cold air drainage down the Blackfoot River.

The second pattern is clear/calm conditions after a fresh snowfall allowing for temperatures to plummet. Stipulations on the snow mostly require it to stick on most surfaces and that the snow is fresh/new, creating conditions favorable for optimal radiational cooling. Average monthly snow depth for Seeley Lake is 10” for December, 18” for January and 22” for February.

The presence of a surface high southeast to east-southeast of Seeley Lake has been observed for both patterns throughout the minimum temperature data set. This was quickly evaluated by interrogating the NCEP/NCAR hourly data at 12z for surface mean sea level pressure (Figure 2). The reanalyzed values of MSLP at 12z for Seeley Lake were examined. There are differences between the strength of the surface high between the two winters as well as the occurrence of minimum temperatures less than 0°F. Those differences are noted in Table 1 below, as well as the ENSO index for those three months.

Table 1. Surface High Readings, Frequency of 0° degree mornings, and ENSO Index

	Avg Surface High (mb)	**Highest Surface Reading (mb)**	**Lowest Surface Reading (mb)**	**Frequency of 0° mornings**	**ENSO Index Value for DJF**
Winter 2010	1028.8	1040	1012	17	1.7
Winter 2011	1028.0	1047	1007	25	-1.3

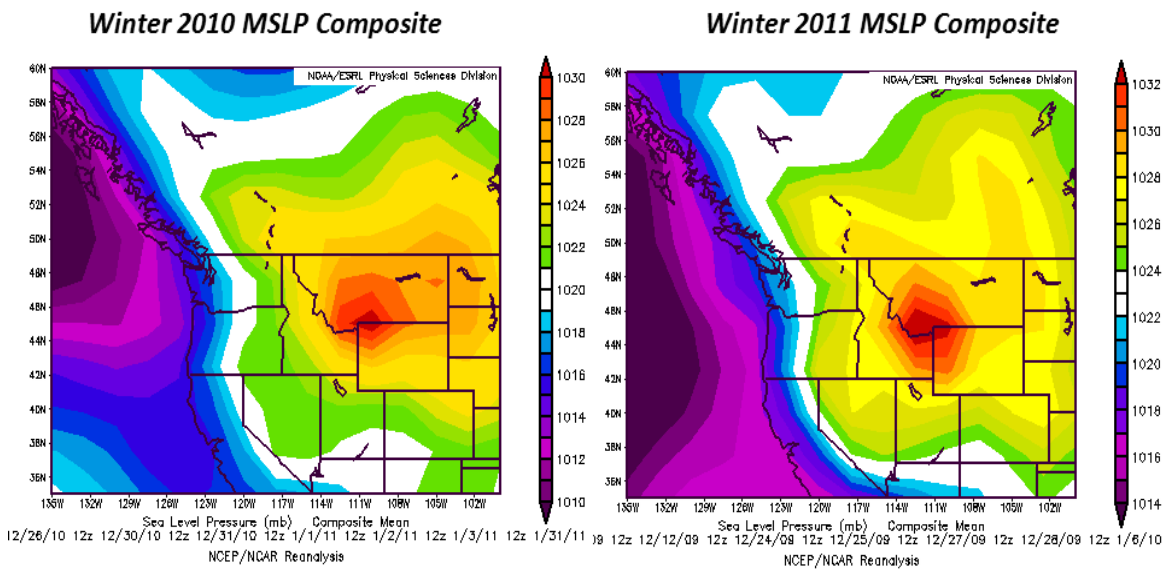

Figure 2. Winter 2010 and Winter 2011 12Z MSLP Composites

III. Impact on Forecasts

For this study, the data were from two different observing sites near Seeley Lake. The first was the Cooperative Observer (CoOp) station located at the Seeley Lake Ranger Station, located north of the town (Figure 3), a little over three miles up Highway 83 and just a few hundred feet from the east shore of Seeley Lake. The second site was the Seeley Lake RAWS, located at the Seeley Lake Airstrip. The data were pulled for Winter 2010 (Dec 2009, Jan 2010 and Feb 2010) and Winter 2011 (Dec 2010, Jan 2011, Feb

2011). The CoOp data had no missing values and only one MinT reading is missing for each winter for the RAWS site. MinT observations at or below 0°F degrees were logged between to the two sites. In general, the RAWS site runs a slightly higher frequency of observed 0°F degrees or colder days than compared to the CoOp site (Table 2).

Table 2. Frequency of at or below 0 degrees for MinT Readings

	Winter 2010	**Winter 2011**
Seeley Lake CoOp, Elev. 4100ft	17 days	33 days
Seeley Lake RAWS, Elev 3908ft	21 days	36 days

The coldest temperature observed at the CoOp site was -28° on February 1st, 2011 and also on January 7th, 2010. The coldest temperature observed at the RAWS site was -26° also on February 1st, 2011. While the RAWS site runs with a higher frequency of subzero MinT readings, the CoOp site has the coldest temperature readings.

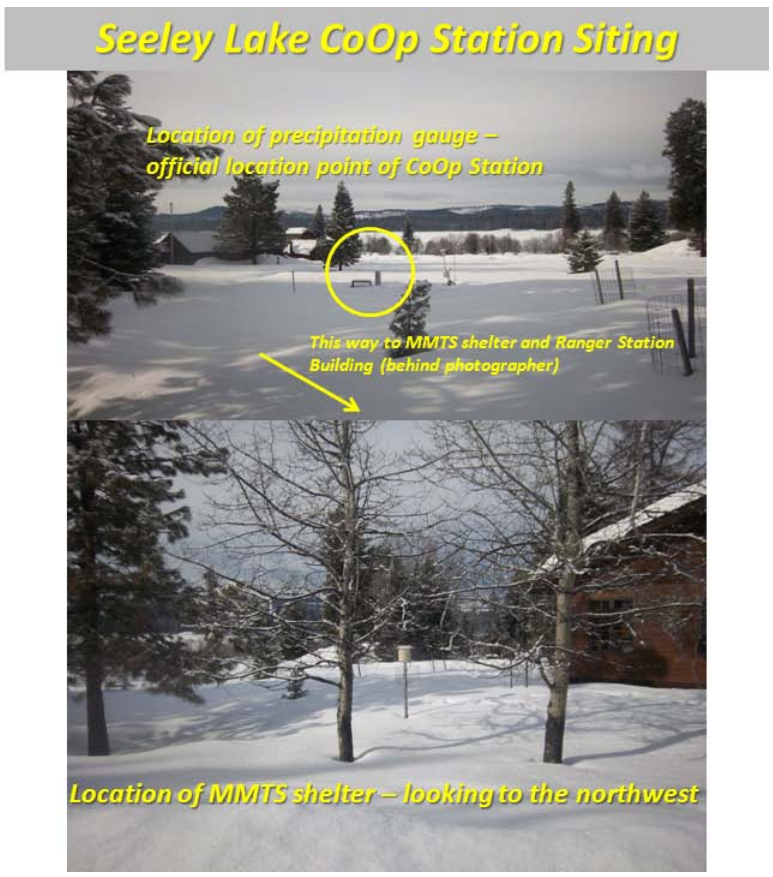

Figure 3. Seeley Lake CoOp Siting

IV. BOIVerify/Gridded Temps: Strengths/Weaknesses

Gridded data errors and bias were reviewed for a number of GFE grid points around Seeley Lake using the BOIVerify system. In general, the gridded model guidance has a warm bias even up to 24 hours away from the event at these grid points. The bias corrected (BC) grids performed better than their raw counterparts, but still remained too warm to capture the best MinT forecast. Also, while the forecast office as a whole was running a general cold bias across all temperature grids for this most recent winter (Winter 2011), the calculated bias over the points for Seeley Lake shows that we are still not going cold enough for that forecast point (Table 3, Table 4 and Figure 4).

Table 3. Forecast/Guidance Bias, Bias Corrected Grids

MinT - BC	**24hrs**	**48hrs**	**72hrs**
Official	1.79	2.42	4.51
ECMWFBC	5.13	5.07	6.27
ECMWFFC	9.38	7.09	8.62
GFS40BC	6.19	5.11	4.82
MOSGuideBC	3.93	4.04	4.51

Table 4. Forecast/Guidance Bias, Raw Grids

MinT - Raw	**24hrs**	**48hrs**	**72hrs**
Official	1.79	2.42	4.51
ECMWF	11.53	11.63	12.19
GFS	9.28	6.38	4.28

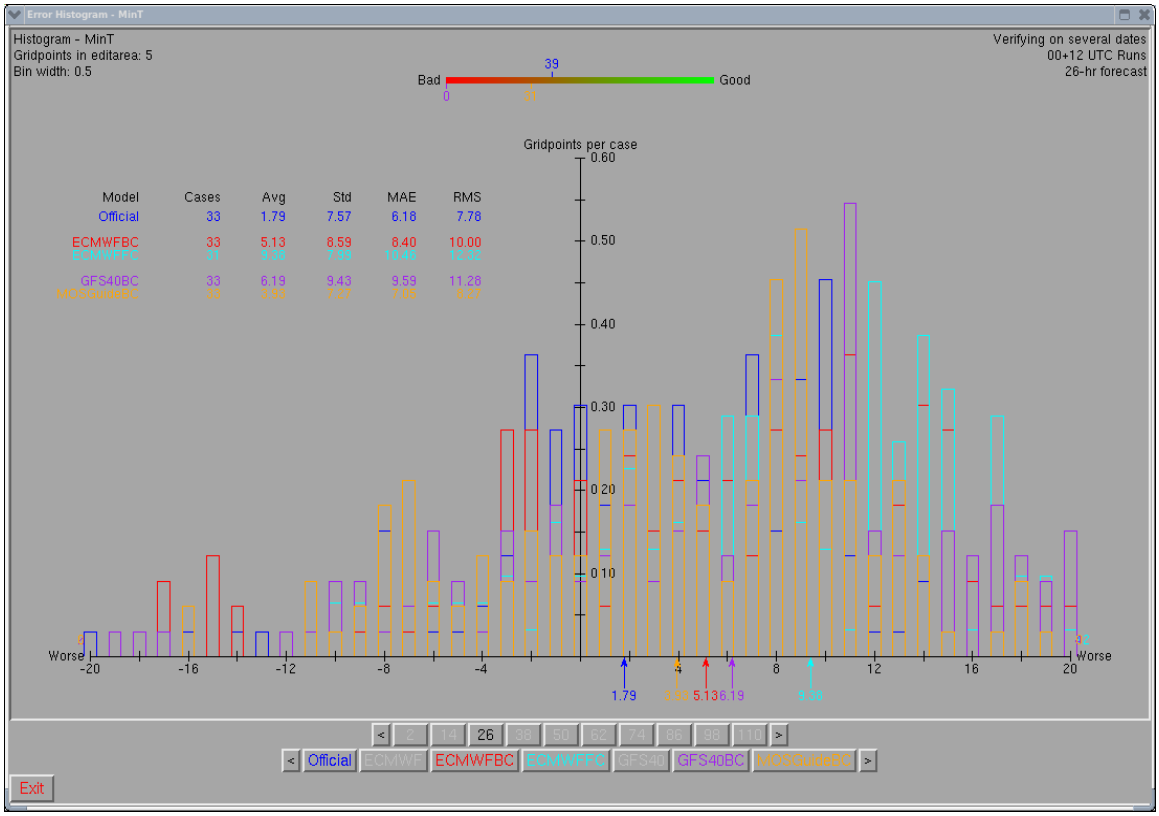

Figure 4. Example of a BOIVer Error Histogram for MinT grid points

V. Forecast "Rules of Thumb"

Below are listed some forecast "Rules of Thumb" to consider when forecasting minimum temperatures for the Seeley Lake area for the two synoptic types 1) arctic intrusions and 2) calm/clear night(s) after fresh snowfall:

- Evaluate the surface pressure and watch for decently strong surface highs (1020 to 1030 or greater range) to set up southeast or east-southeast of Seeley Lake at 12z.

- Even though Bias Corrected grids have elements of the past 30 days in their creation, closely watch them for their forecasts and don't hesitate to go colder than the coldest guidance for this forecast point.

- The CoOp station lies 3.5 miles north of town, while the RAWS is 2.65 miles east of town. The RAWS is more exposed to colder air drainage compared to the CoOp station and the town is located in between these two stations. This set-up favors for temperatures to potentially be cooler than the CoOp station north of town. If going with persistence, consider going a degree or two colder than the CoOp observation if all the variables are setting up for a sub-zero night.