Draft Modeling Episode Meteorological Description

1.1 Episode dates

Summer (June 15 00Z - August 1 00Z) 2017 was selected as the modeling period, with days in June included to allow for sufficient photochemical model spin-up time. The photochemical modeling results exclude spin-up days, and focus on June 26th – August 1st.

1.2 Description of ozone exceedances

Table 1. Number of ozone exceedances at the monitoring sites within the northern Wasatch Front O3 Nonattainment Area during June and July, 2017

2017 Time Period	Monitoring Station						
	Bountiful	**Hawthorne**	**Herriman**	**Erda**	**Harrisville**	**Ogden**	**Brigham City**
June	1	2	2	2	3	1	0
July	14	11	8	10	6	9	2

The modeling episode was characterized by multiple ozone exceedances throughout the nonattainment area, most often in July (Table 1 and Figure 1). Ozone exceedances in August and September of 2017 were determined to be heavily impacted by wildfire smoke, and therefore were not included in the modeling episode. Although wildfire events also occurred during July 2017, an examination of hourly PM2.5 concentrations (Figure 2) suggests that their influence on local O3 concentrations was not significant. With the exception of July 4-5 which are traditionally impacted by fireworks, daily average PM2.5 concentrations on exceedance days were less than monthly average + 1 standard deviation July concentrations.

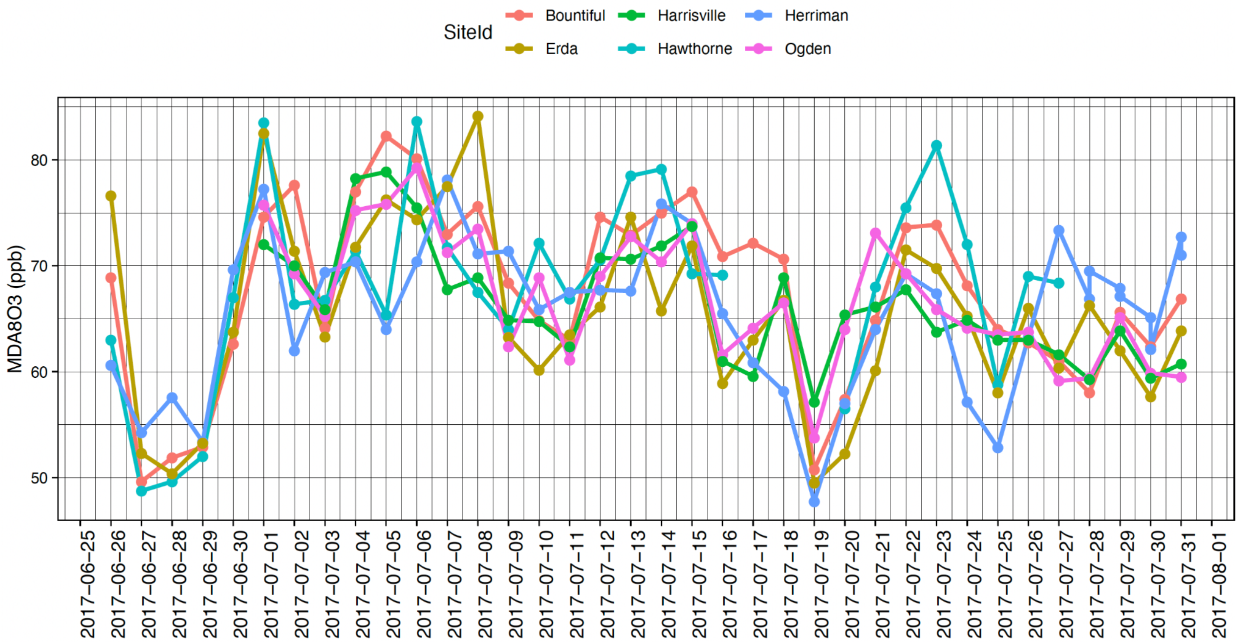

Figure 1. Time series of Maximum Daily 8-hr Average Observed O3 (MDA8O3) values at monitoring sites within the Northern Wasatch Front O3 Nonattainment Area during the photochemical modeling episode of June 26 - August 1 2017 which excludes spinup days.

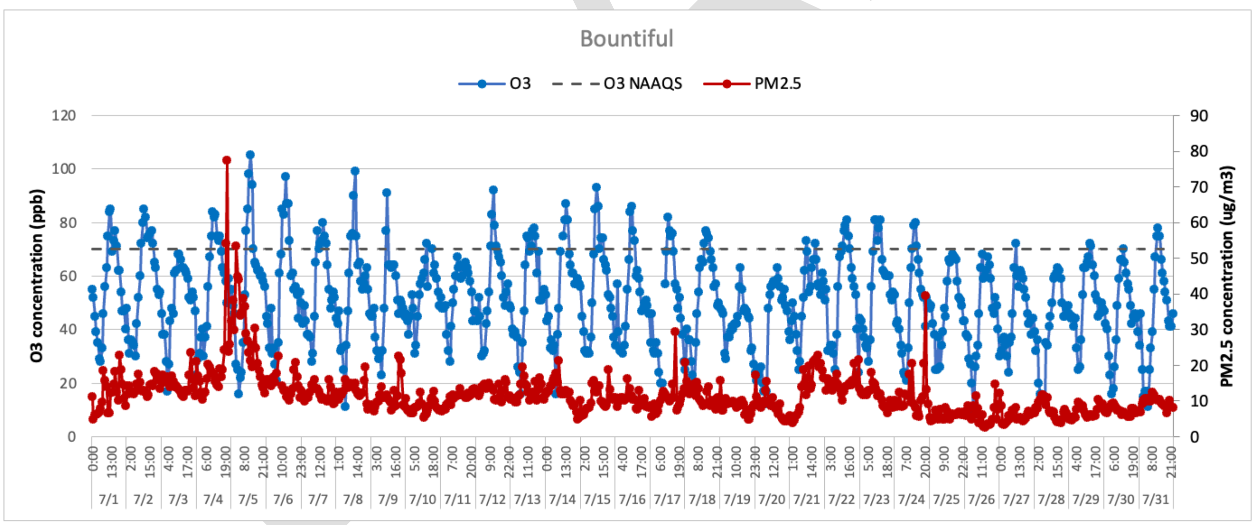

Figure 2. Hourly O3 and PM2.5 concentrations at Bountiful monitoring station during July, 2017. July 4th-5th and 24th PM levels were impacted by local firework emissions.

2 Meteorology

2.1 Observational datasets and forecasts

To understand meteorological conditions during the modeling episode, an analysis was conducted using available meteorological observations and datasets, described below.

- Ground-based observations were used to understand surface temperature, wind speed, wind direction, and precipitation conditions.
- Upper-air and 500mb charts were used to understand larger, synoptic-scale air transport.
- Vertical temperature profiles were used understand atmospheric stability and vertical air mixing.
- Radar measurements, PRISM outputs (Parameter-elevation Relationships on Independent Slopes Model[1]), and satellite imagery were used to track cloud coverage, precipitation, and storm motion.
- To help add context to the local observations, archived National Weather Service forecast discussions were referenced.

A detailed examination of synoptic patterns during the selected period showed that the majority of ozone exceedance days are characterized by upper-level high pressure systems that bring warm temperatures, no frontal passages, low surface winds (stagnation of local transport), and increased solar radiation; all of which are conducive to the build-up of O3 and its precursors. Upper level, high-pressure ridges also allow cyclic, terrain–driven circulations that reduce long-range transport of pollution away from its source. Under these conditions, O3 and O3 precursors can be brought back to source regions by daytime, thermally driven upslope flows. The land-lake breeze influenced by the Great Salt Lake function in a similar cyclic way. Upper level ridges can also increase background O3 concentrations within the ridge, where the complex topography of the region can enhance vertical transport and recapture of ozone from aloft[2].

2.2 Detailed episode description

2.2.1 June 24^{th} – June 27^{th}

The first portion of the photochemical modeling episode (spin-up days excluded) was

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[1] PRISM Climate Group, Oregon State University, https://prism.oregonstate.edu, data created 21 Oct 2019, accessed 21 September 2021.

[2] Reddy, P. J., & Pfister, G. (2016). Meteorological factors contributing to the interannual variability of midsummer surface ozone in Colorado, Utah, and other western U.S. states. Journal Of Geophysical Research-Atmospheres, 121, 2434-2456. doi:10.1002/2015JD023840

characterized by strong high pressure aloft which was centered over Utah from June 24 – June 26th. This period of high pressure and surface stagnation ended on June 27th when a weak cold front moved through the monitoring area. Surface weather (Figure 3) and 500-mb height contour maps (Figure 4) of this period show the frontal passage, which coincided with a decrease in measured ground-level O3 across the monitoring network (Figure 1).

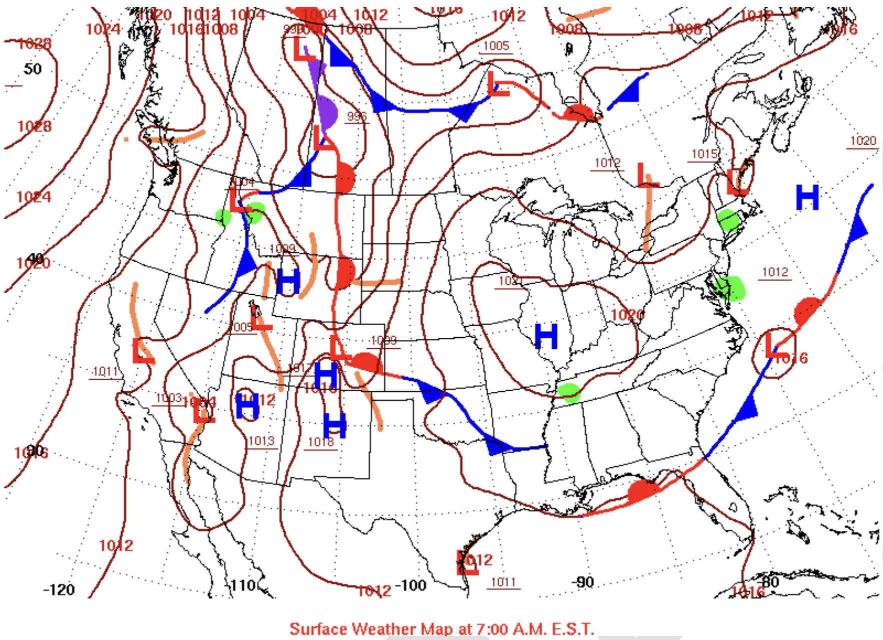

Figure 3. Surface weather map on June 27, 2017.

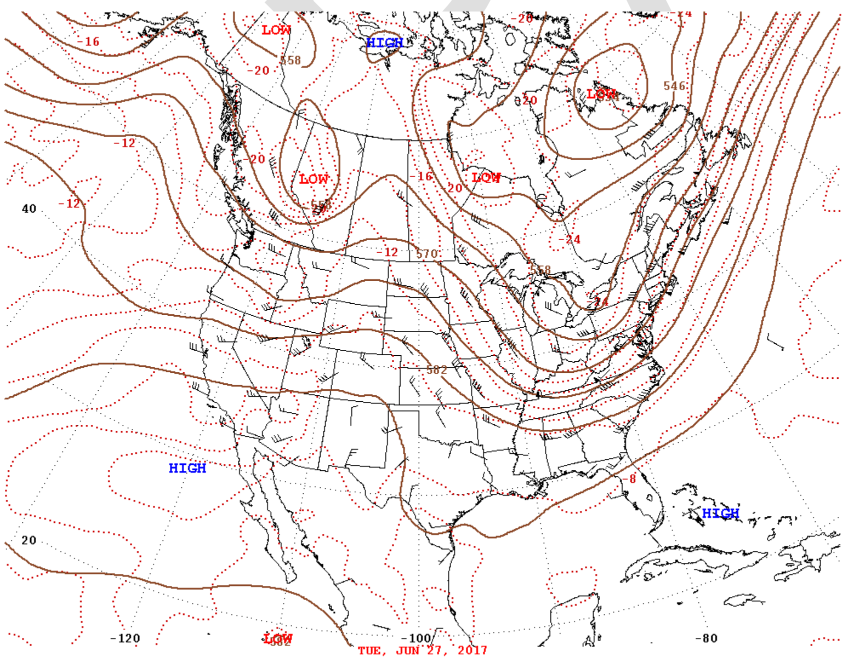

Figure 4. 500-Millibar Height Contours chart on June 27, 2017.

2.2.2 June 28^{th} – July 5^{th}

The frontal passage returned monitored O3 levels to near-background levels (~50 ppb) through June 29^{th}, when a final dry cold front (no precipitation) moved through the Northern Wasatch Front. This cold front suppressed surface temperatures through the end of June (Figure 5). A high-pressure system moved in on July 1^{st}, but was disturbed briefly by a weak trough on July 3^{rd}, which increased windspeed and helped to transport pollution away from the modeling area (Figure 6).

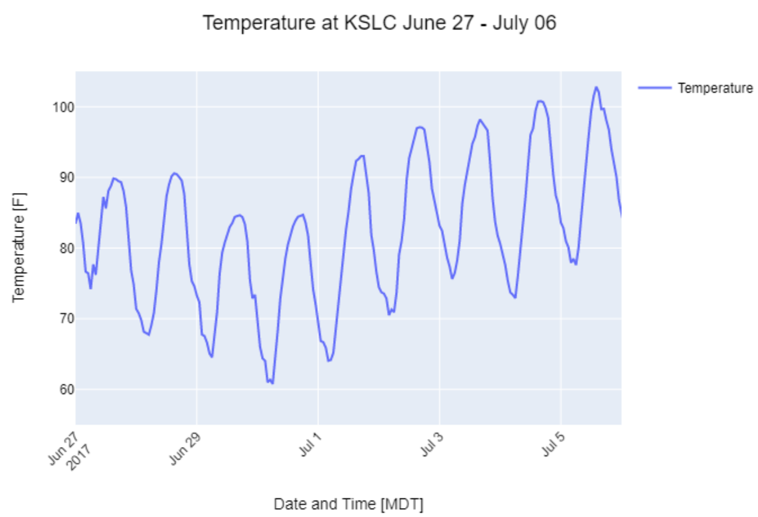

Figure 5. Surface temperature at KSLC.

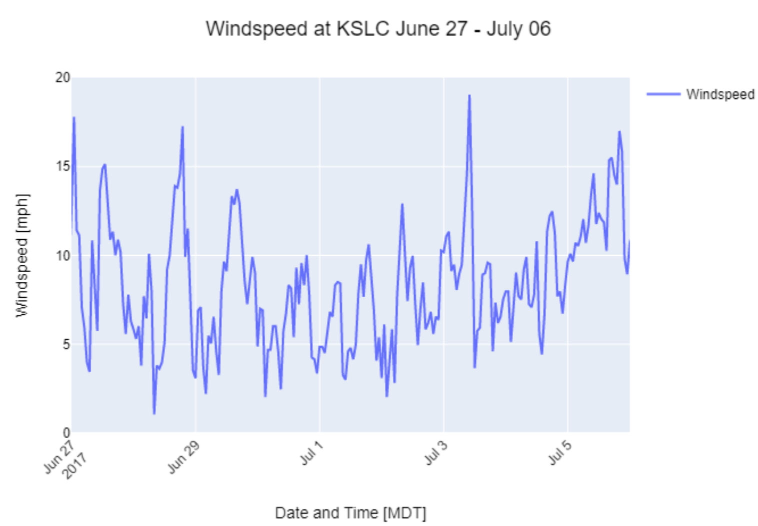

Figure 6. 10-meter windspeed observations at KSLC.

2.2.3 July 6th – 17th

Relatively stable and sunny meteorological conditions during the first portion of July were followed by a period of increased stagnation, with surface high pressure (Figure 7) and upper-level ridging (Figure 8) settling in on July 6th. Surface observations also showed a slight increase in pressure on July 6th (Figure 9). The high-pressure weakened on July 10-12, then quickly re-strengthened, with high pressure building across the region and remaining in place until July 16th (Figure 10). The high-pressure system brought moisture from the south/southwest into Utah, which eventually impacted the nonattainment area with spotty convective cloud cover that occasionally suppressed ozone production July 9-16th. A weak and shallow cold front moved through Northern Utah on July 16th, bringing storms and increased surface winds.

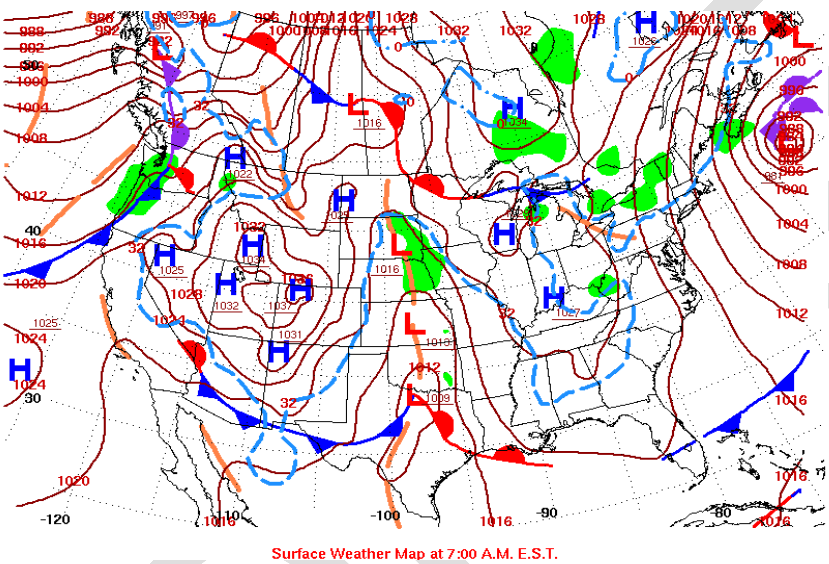

Figure 7. Surface weather map on July 6, 2017.

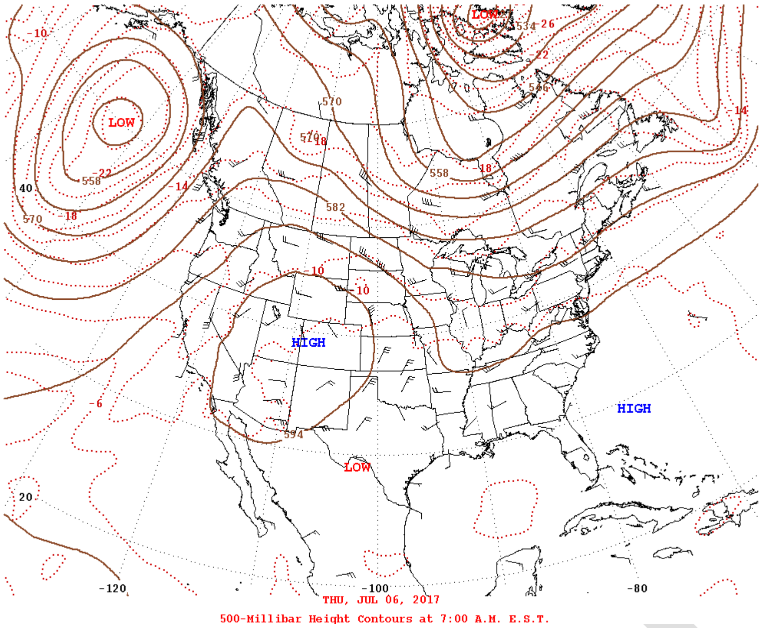

Figure 8. 500-Millibar Height Contours chart on July 6, 2017.

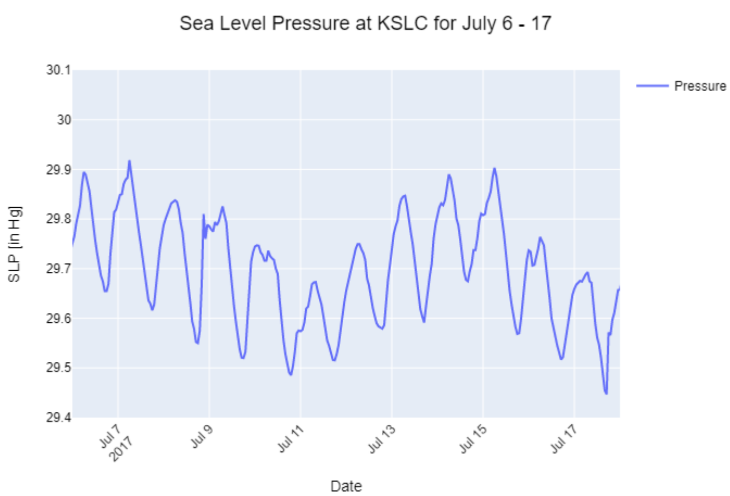

Figure 9. Sea level pressure observations from KSLC.

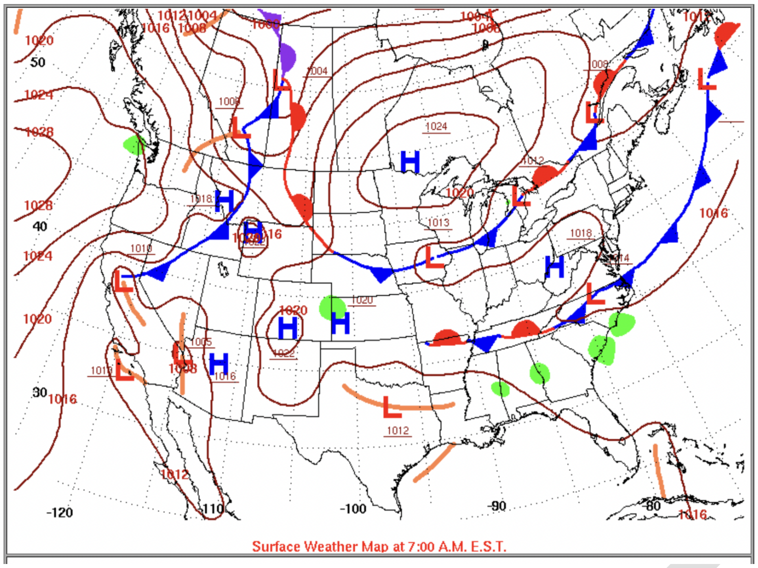

Figure 10. Surface weather map on July 16 2017.

2.2.4 July 17^{th} – 31^{st}

A mid-level ridge slowly set up over northern Utah, bringing dry conditions and mostly clear skies by July 20^{th}. These hot, dry conditions persisted until July 24^{th}, when moisture-rich air from the south pushed into northern Utah, causing spotty clouds but no precipitation in the modeling area. As moisture continued to increase, heavy convection over portions of the Nonattainment area were experienced from July 25^{th} – 27^{th}. Figure 12 includes the daily estimated precipitation over Northern Utah using the PRISM model, with the modeling area centered in the plots. Cloud cover and precipitation were widespread during this time period, reducing O3 concentrations and ambient temperatures (Figure 13). After this monsoonal period, Northern Utah continued to experience afternoon convection and cloud cover, but conditions became progressively drier and hotter toward the end of July (Figure 14).

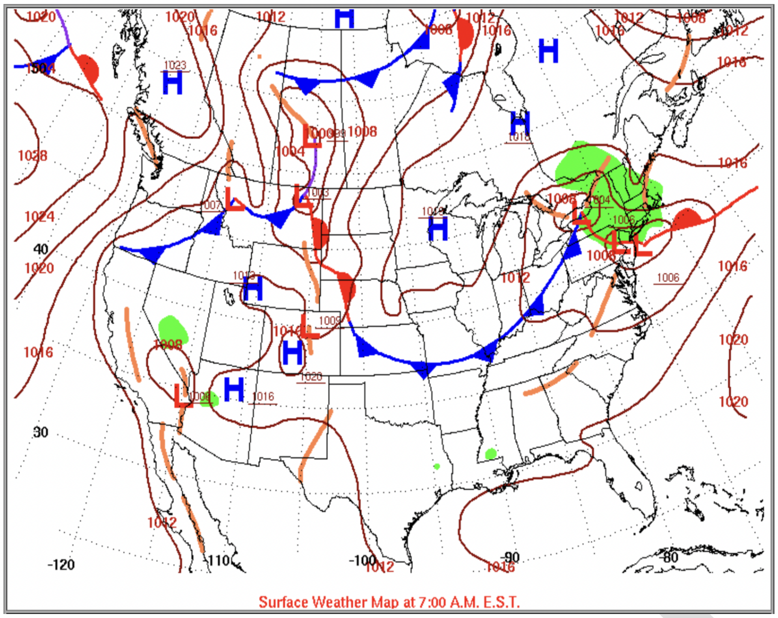

Figure 11. Surface weather map on July 24th, 2017.

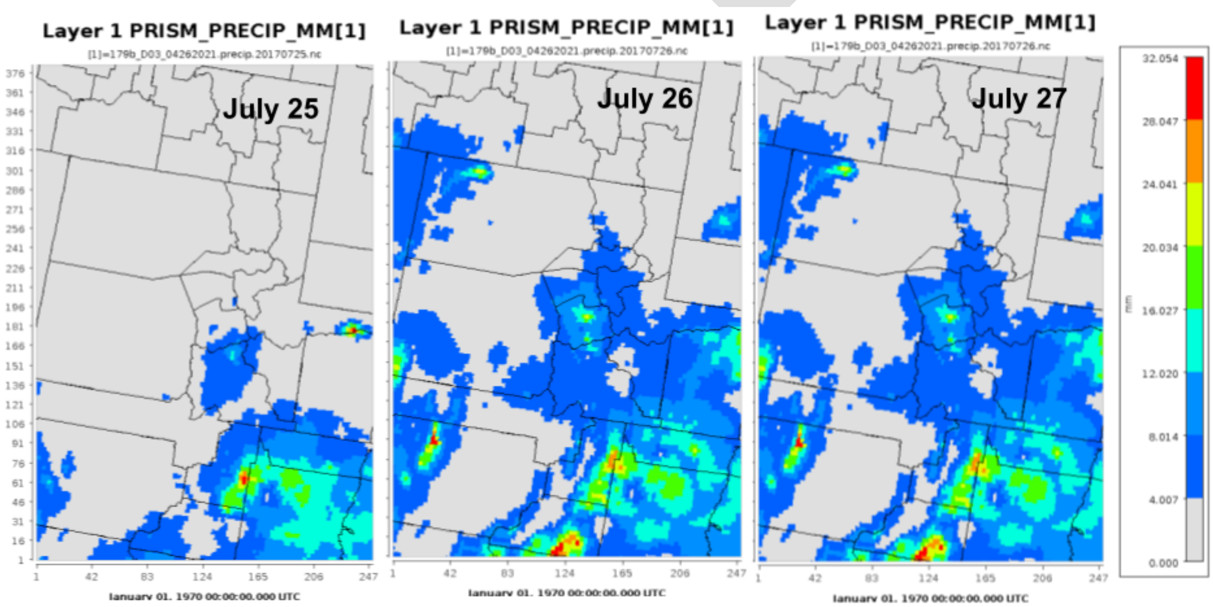

Figure 12. PRISM daily precipitation for July 25 - 27, 2017.

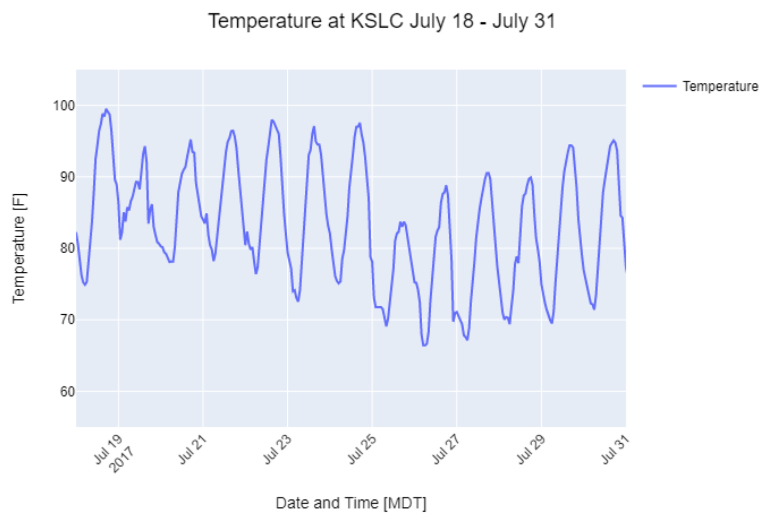

Figure 13. 2-m temperature observations at KSLC.

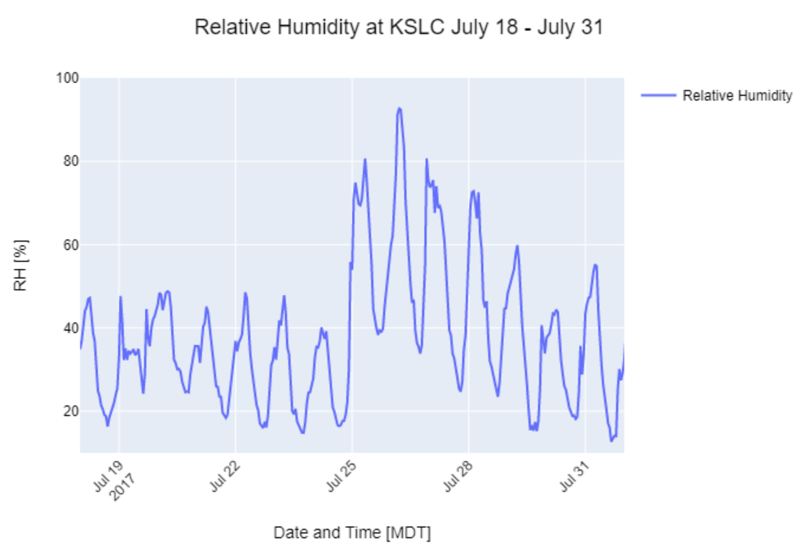

Figure 14. Relative humidity (%) at KSLC.