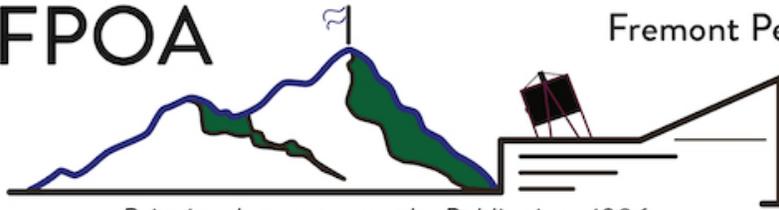


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2025 Edition

Weather Forecasting at Fremont Peak

Accurate weather forecasts are crucial for making decisions about observing the night sky. In addition, running a public observatory not only affects us but also our guests. Therefore, it's essential to get the predictions right.

This paper outlines the techniques we've learned over the past few years. With the advent of full access to weather models, even though through paywalls, we've gained a new perspective on determining whether we'll have a good night or if a guest should not come up the mountain.

Full Disclosure: While I've been fascinated by weather forecasting for nearly 50 years, having almost become a meteorologist, I'm not one myself. If a trained meteorologist identifies any errors in the information presented here, please let us know.

The Observatory is located in coastal California. That's the most crucial aspect to grasp about our weather. This paper focuses on the weather from mid-May to mid-September. During these months, the interaction between the local ocean and land significantly influences our weather, not always as I mentioned in the final section, but usually.

In spring, which typically lasts until mid-May but can extend into June, global patterns play a more prominent role. The lingering effects of winter can still manifest as widespread storms, whose prediction is beyond the scope of this discussion. While these tools can still be useful, the considerations will differ.

By fall, the weather pattern I'll describe in the next chapter begins to break down. Coastal clouds become less frequent, leading to more clear-to-the-ground weather. However, this respite is short-lived as winter systems start moving southward.

Central California's weather is predominantly governed by a high-pressure system positioned off the coast. The presence or absence of this system is referred to in TV forecasts as "the storm door." When it's present, Seattle experiences storms, while its absence allows storms to hit further south, eventually reaching us.

Therefore, the remainder of this paper will delve into the late spring to end-of-summer weather. The Observatory site stands at the precipice of benefiting from or being affected by the weather pattern described in the next chapter.

Challenges of Summer Peak Weather

The typical weather pattern during mid-May to mid-September is known as a “temperature inversion.” Normally, the air cools as you ascend. However, an inversion occurs when cold air at the surface is topped by a layer of warm air. The water in Monterey Bay is exceptionally cold. Our typical coastal wind originates from the west. When this wind blows inland, it cools the ground, but as you ascend, the air is less cooled and is warmer.



The boundary between these two layers is crucial. Clouds tend to form at night due to the humid coastal air blowing in. This boundary limits the height to which clouds can rise. Locating the height of this boundary is the forecast’s “secret sauce.” We should be fine if the boundary is safely below us (subject to the caveat in the last section).

This should raise two questions:

1. How high is the inversion?
2. What if there is no inversion?

Why “Astronomical” Forecast do not work here

“Astronomical” forecasts like Clear Sky Chart don’t adjust their forecasts for topology. Simply put, they are for Salinas and don’t apply to the peak. So, while someone in Salinas might be experiencing a depressingly gray day, we might consider it the “best day of the year.”

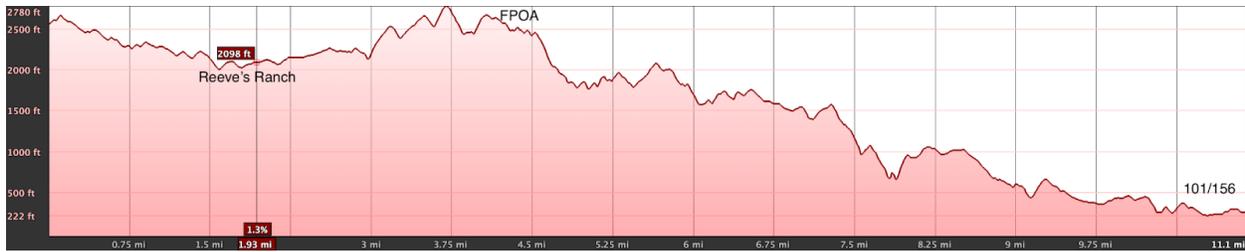
If you take a cross-section, you can see the problem.



A NORTHEAST TRACK FROM SALINAS AIRPORT (SNS) THROUGH FPOA TO HOLLISTER

Weather models operate by dividing the world into squares. The two models we’ll discuss the most break it into 9 km and 3 km squares. While the models do consider altitude, the peak juts up from relatively flat land on either side. If you simply take the “surface” forecast as the “astronomical,” as even the NWS forecasts do, you won’t notice the difference.

Fortunately, if you’re aware of this and have access to the models behind these forecasts, you can take advantage of the fact that the models also predict the weather above the “surface.” That’s where the real value lies.



A TRACK ROUGHLY NW FROM REEVE'S RANCH THROUGH FPOA TO 101/156

Reeve's ranch to our south is frequently the source of our clouds. If you start your path from Reeve's Ranch which is just south of the Observatory it would appear that we would not have a problem. This is deceiving though as I will show the clouds get there later in this paper.

How high is the inversion?

The rest of this paper will teach the reader how to predict this level and how to observe if the prediction is correct

What if there is no inversion?

Then we could be in trouble depending on the prediction for low cloud formation. That will be one of the examples presented below

Observational Tools

There are a couple of tools that will allow us to actually measure what the weather is doing

Aviation Forecast

The first is the aviation report for the Salinas airport (SNS or KSNS in the aviation weather forecast list). While this site has limitations (e.g. it frequently does not report clouds over 12,000 ft) it does provide both a short term [forecast](#) and [measurements](#) of the actual cloud configuration up to the first layer of overcast. Here is a typical observation/forecast

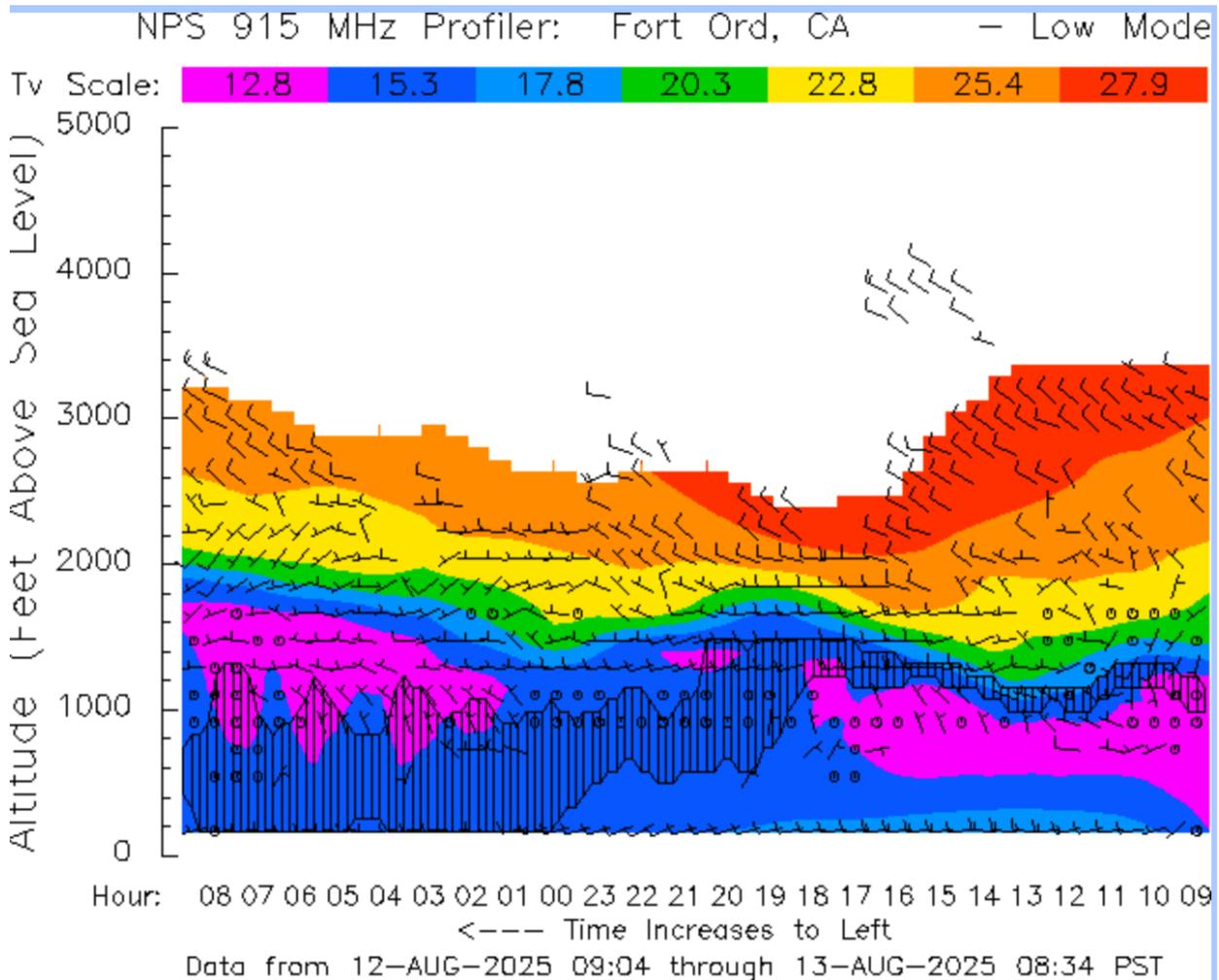
Clouds: scattered clouds at 3,100 ft, broken clouds at 5,000 ft, broken clouds at 20,000 ft

The terms few, scattered, and broken refer to different amounts of cloud coverage. Clear and overcast should be obvious.

Bear in mind that what it reports is the bottom of the cloud layer. We are frequently interested in the top.

Ft Ord Profiler

A second observational tool is the profiler located at the old Fort Ord.



As stated earlier in a normal sky the air should cool as altitude increases. In the summer here that is frequently not the case. Notice that at 8 AM in the above figure it is 15.3 at the surface. By 1400 feet it drops to 12.8. All good. That is the way it is supposed to work. But then at about 1800 feet the temperature starts rising. By 2600 feet (Observatory height) it has increased to nearly 25.4. That is what an inversion looks like in the sky.

An important caveat here. **The profiler is not always operating.** Always check the dates.

Introduction to the Weather Models

While observations are excellent to understand the current weather conditions (or within a short timeframe), what about planning a visit in three days or more? Fortunately, tools now exist that provide access to the same weather models used by professionals. This section will guide you on how to utilize these models to make informed decisions.

A weather model is a computer program that processes station reports and weather balloon data to predict how the current weather conditions will evolve over time. Some models make predictions for a maximum of 72 hours, while others can extend their forecasts beyond a week.

All weather models divide the world into squares and then make predictions about the weather in each square. Since the Earth is not flat, these models also account for this factor (with varying degrees of accuracy). For us, this is a crucial aspect, which is why we need to go beyond a mere glance. A coarse model like GFS (22 km) or the Canadian model used by CSC and others will struggle with the varying terrain in our area.

In my experience there are two models that are my go-to sources of information. In a perfect world they will agree. If they do not I tend to trust ECMWF more, but take the alternative prediction as uncertainty.

ECMWF 9 km

This is an exceptionally accurate model provided by the European Centre for Medium-Range Weather Forecasts. It stands out as the most reliable forecast model among others. However, since the model is commercial, only a select few companies worldwide offer it with the tool described below being one of them. It comes in a lower public domain resolution that I would not bother with.

While this model makes good long-term predictions, its short-term predictions are also the most accurate for our area. One important factor to consider is that the model is only updated every 6-7 hours, which means it may not track rapidly changing conditions as effectively.

HRRR 3 km

The HRRR, a NOAA real-time atmospheric model, operates at a 3-km resolution and is updated hourly. It is cloud-resolving and allows for convection simulation. The model is initialized using 3-km grids with 3-km radar assimilation. Radar data is assimilated into the HRRR every 15 minutes over a 1-hour period, enhancing the detail provided by the hourly data assimilation from the 13-km radar-enhanced Rapid Refresh.

While the HRRR offers the best resolution, it consistently makes worse predictions compared to ECMWF. However, it appears to perform better than the other short-duration high-update model, NAM. I recommend to treat it as a good “second opinion” to ECMWF. It may offer a better prediction of rain events.

Introduction to [Windy.com](https://www.windy.com)

Many websites now provide access to the weather models described below. The author has experimented with various websites, but one stands out: [windy.com](https://www.windy.com) (not the similarly named windy.app, which, in the author’s

opinion, is not worth your time). windy.com offers both web access and access via apps on iOS and Android. It provides a premium subscription for \$24 per year. Among the benefits of the paid subscription is access to the ECMWF 9 km model, which we will be using the most.

Cloud, Wind, and Rain Forecasts

In the summer, medium and high clouds are rarely an issue. However, during spring and fall, these are forecasts you should pay attention to. These displays simply show the cloud density.

However, I must introduce a significant caveat. While the models' names suggest some precision, if clouds are near the observatory but not over it, I would still consider the observatory impacted. If rain is forecast for Big Sur, I probably wouldn't allow the roof to be rolled unless I was thoroughly convinced this was a local event.

Interpreting the wind forecast can be even more tricky. The prevailing wind in our area is from the west; however, we are in a wind shadow from the peak and the ridge where the campgrounds are. Thus I have found the wind forecasts to be less useful except with respect to Reeve's Ranch as discussed below.

Reading a Sounding Profile

For our location the most important feature of windy.com is something called a "Sounding". This tool¹ will give you a vertical profile of the dewpoint and temperature plotted as aqua and red lines vs altitude. In addition it will show a wind barb for each level. It will also make a stab at where clouds are likely (but I would treat this with grain of salt). Ignore the other lines.

The manner of viewing this chart differs from the website to app.

- On the web you select a location and right click for tool selection. Sounding is the bottom tool
- On at least iOS you put the site in a cross hairs and select sounding at the time

¹ There is an alternative display called a skew-T. This plots the same information, but differently. I will not cover that here.

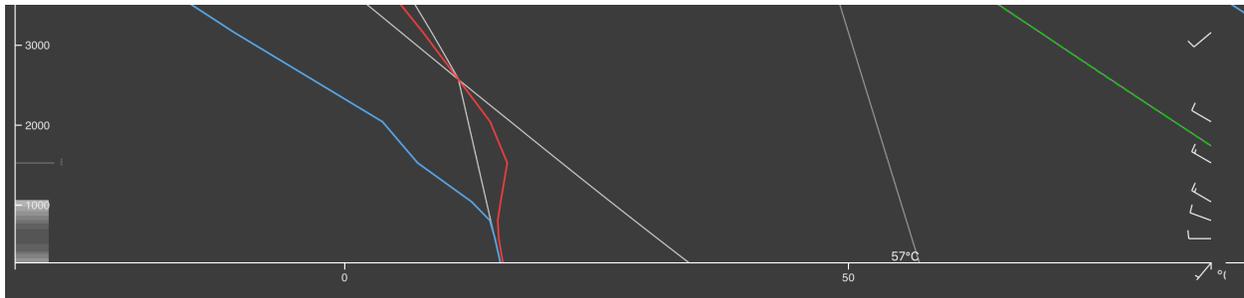
On either platform if you have made the peak a favorite then you can refine the location using a dropdown.

Another caveat. Weather models operate by pressure altitude not physical altitude. The sounding display displays physical altitude but it gets there by extrapolating the from the pressure altitude vs physical altitude predictions². These are not always correct.

Fair warning. As a scientist I prefer working in Celsius so that is how the displays are set. For reference the Observatory is at 860 meters.

Here is an example of a day where clouds are probable

The dewpoint and temp track closely up beyond 1000 meters. I would agree their cloud prediction was likely.



On the next page I expand three sections of the chart.

The left figure shows altitude. On iOS you can zoom this access to see it better. You can also put a cursor over the temp graphs and read altitude.

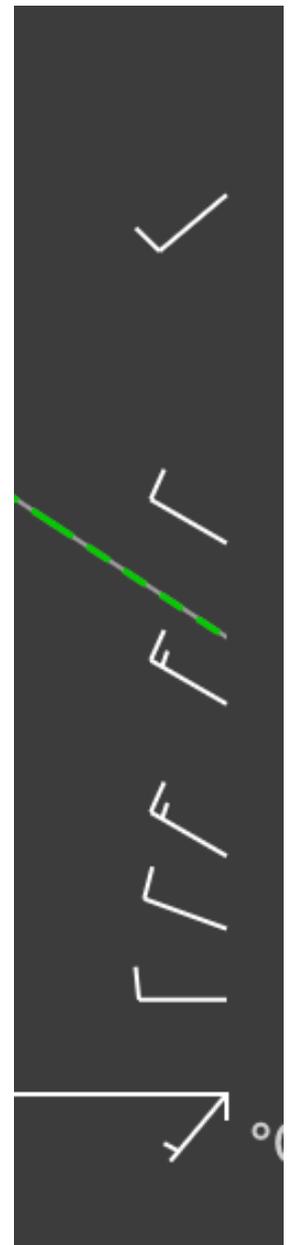
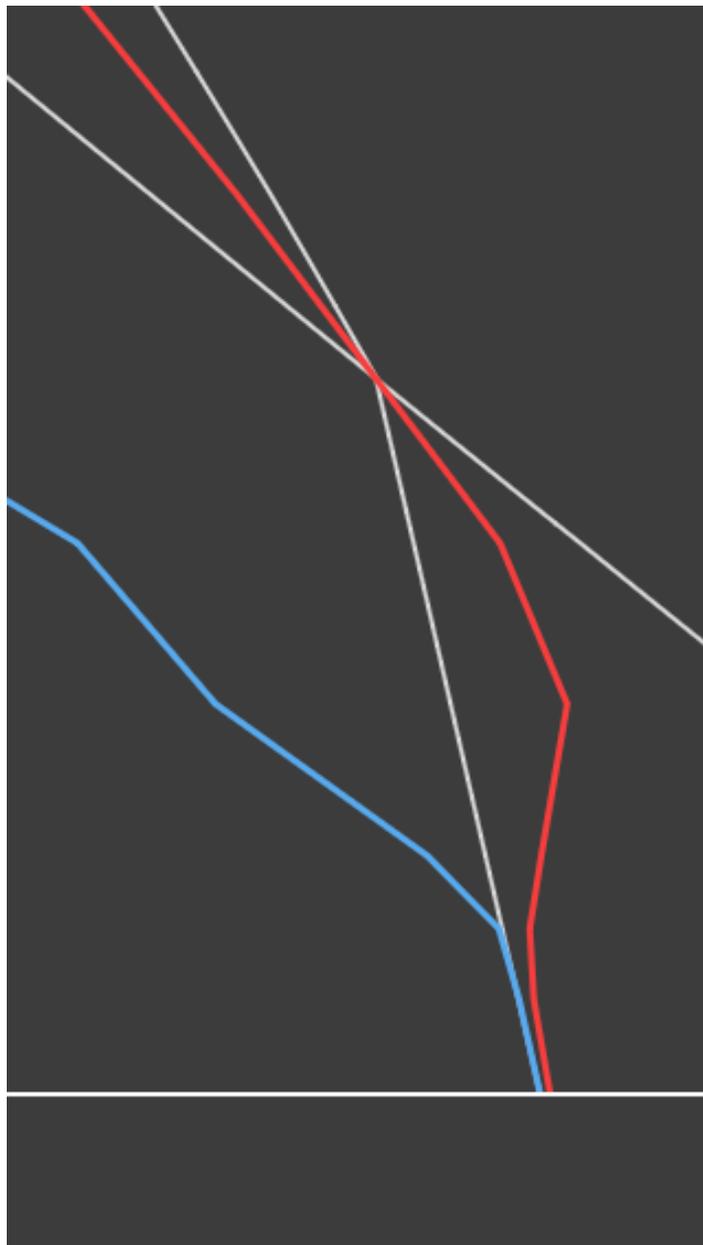
In the middle I have zoomed into the temperatures

On the right the wind barbs are displayed.

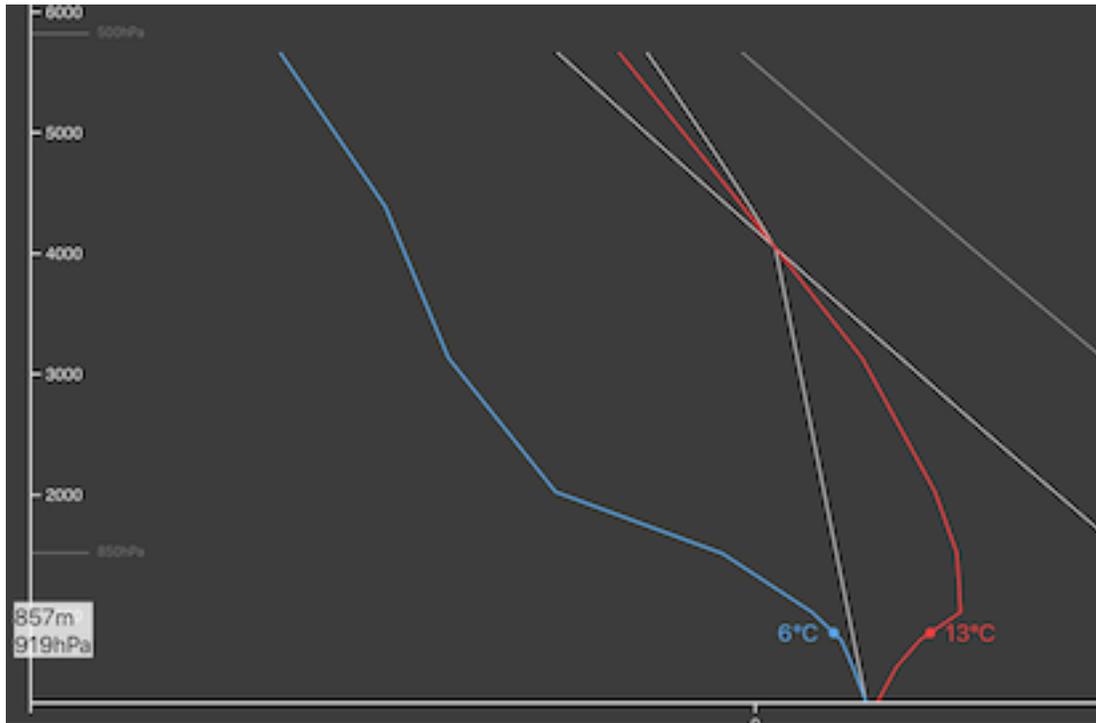
You might want to also look on what is happening above since if the two converge above you that will likely mean poor transparency. If the wind

² To be more precise the altitude of a particular pressure such as 925 hPa will vary. Nominally this should occur at 750m (2500ft). However, high and low pressure system will change this mapping. The models predict “geo potential height” which is the height that a certain air pressure actually occurs.

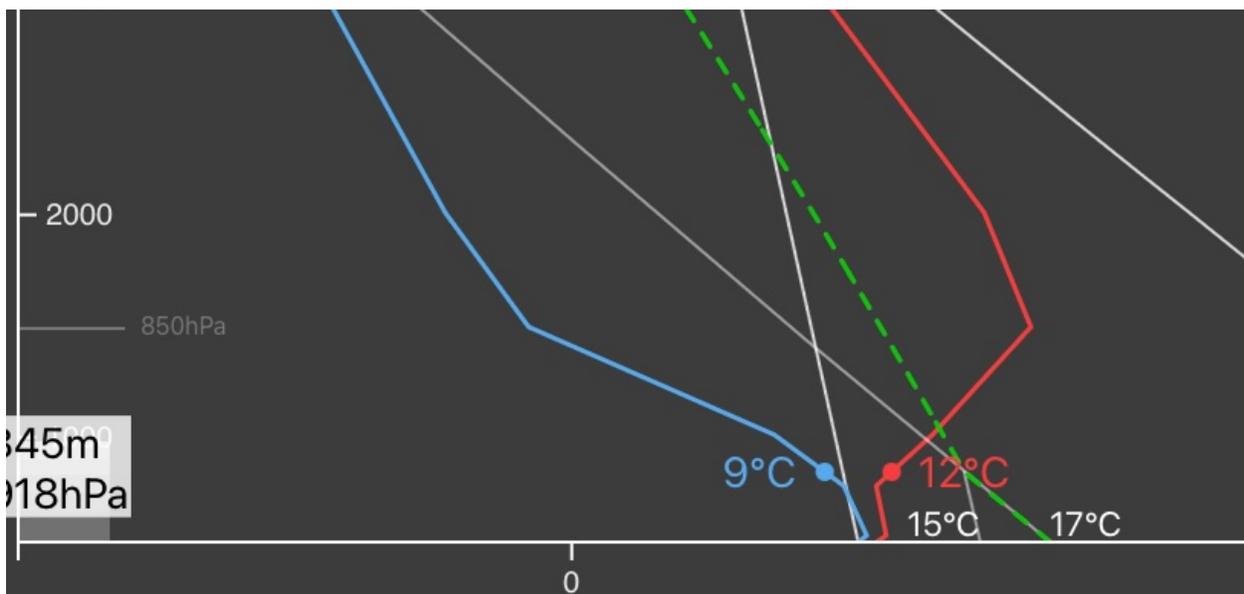
sock has a lot of barbs that will mean poor seeing particularly if the direction shifts.



Here is an example of a day where the forecast was more promising. In the absence of a strong wind the peak will likely lie above the clouds

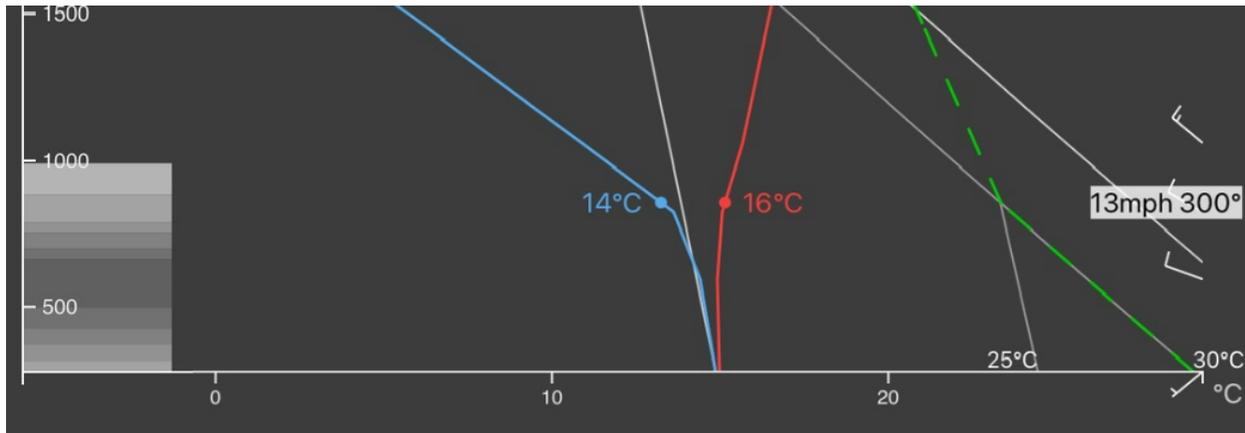


Here is an example of a day where it could go either way. There is an inversion, but the observatory will sit uncomfortably close to it. I probably would not plan an Observers trip today



Test Case August 16, 2025

The ECMWF forecast had started looking grim more than 5 days out. From Friday night it started looking downright awful. This is the ECMWF forecast for 2200 from 2025-08-16 13:00:00 PDT.



This is what greeted us as we arrived at



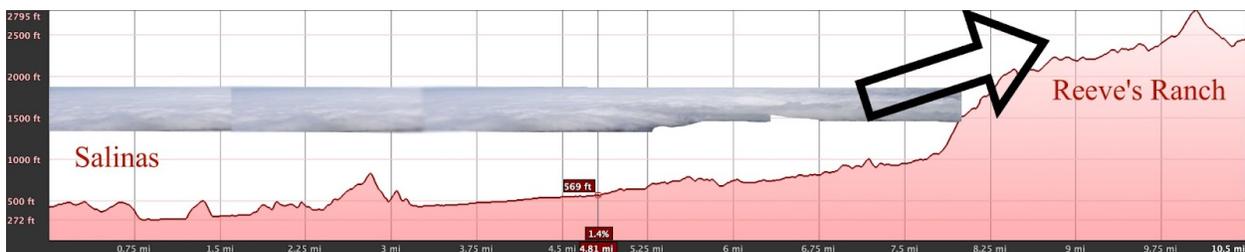
The gauges in the building indicated the outside humidity was 93%.

So the weather at the start of the program was exactly what we expected. More importantly the weather tracked the forecast as the evening progressed with clearing close to midnight.

What can mess up this neat picture?

Reeve's Ranch

So far this seems all nice and tidy. Now it is time for the fine print. If you recall the earlier drawing Reeve's ranch sits about 500 feet below the peak. However, there is a stream that provides a great path for clouds. If there is not a strong inversion below us a high cloud bank can be blown into Reeve's Ranch. There the wind is trapped. We are one of the escapes.



I have also seen strong west wind blow a high cloud deck over the ridge directly to our west and cover us.

The Monsoon

Each year a monsoon flow happens in the desert southwest that brings moist air from the Gulfs of Mexico and California into Arizona. When this is particularly strong it can spill over into California and make its way up to us. This is a regional weather system and needs to be treated like spring and fall weather.

Summary

It is important to emphasize in our outreach to the public that our weather is different than in the valleys around us. A lousy day in Salinas can be a good day for us.

I am still learning all of the things that can go wrong with weather forecasting up here. This is the first year we have used soundings, but so far they are a game changer. There have been many cases where they were not able to give a definitive answer, but on those nights we at least knew the program was at risk.