The Ideal Atmospheric "Recipe" Behind The Deadly Maui Wildfires

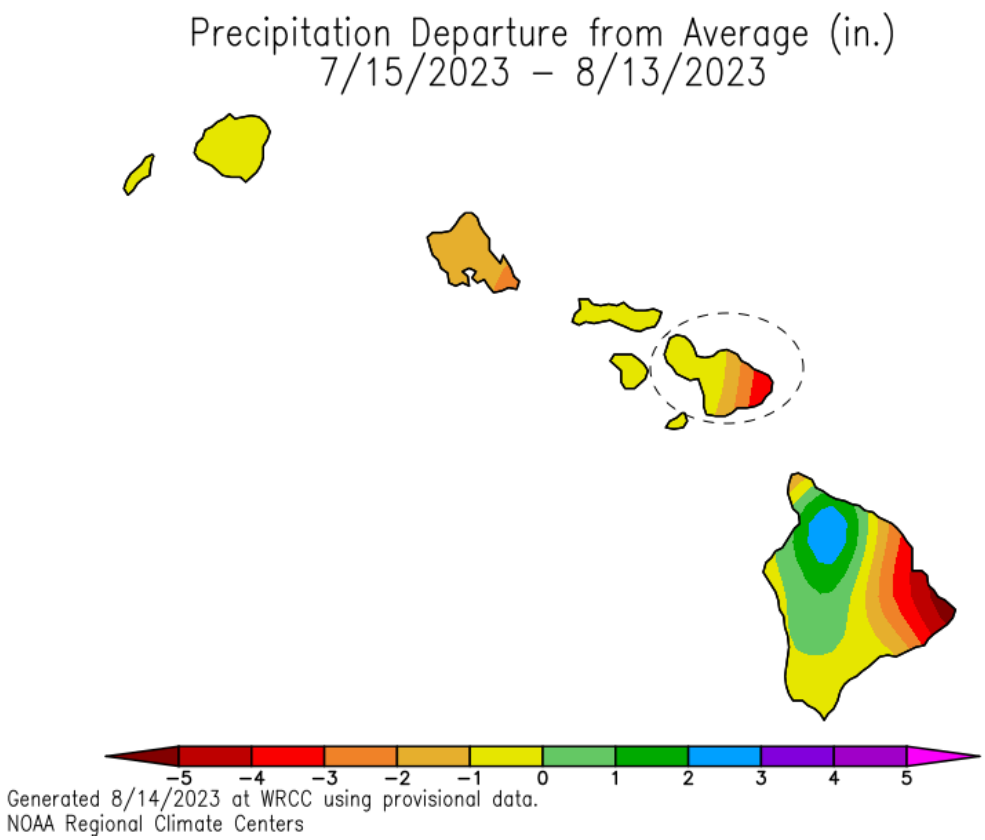
There are specific atmospheric ingredients that meteorologists and forecasters look at to determine if conditions will be favorable for **fire weather.**

1.) Winds – Gusty, persistently breezy winds promote drying, can initiate the fire itself, and of course allow for spreading.
2.) Temperatures – Warmer than normal temperatures make the ambient environment (vegetation) susceptible to heating; therefore, easier to catch fire.
3.) Moisture – Low, to near minimal relative humidity levels. It takes 4x the amount of energy to heat up an equivalent volume of air with water as opposed to a volume of dry air, so **dry air heats up very quickly!**
4.) Dryness – Has there been little to trivial rainfall recently? Drought? Lack of any moisture in the vegetation allows for it to heat up swiftly.

Now that this was specified, we can dig into the factors that resulted in the fire devastation we've seen and remains unfortunately present in Maui, Hawaii. We'll dive into the "big picture" overview by analyzing large scale atmospheric processes that led to the spreading and exacerbation of the wildfires.

First, let's look at Hawaii's last two weeks in terms of precipitation. With data from the National Centers For Environmental Information (NCEI), we can see the accumulated total precipitation over the last thirty days relative to the climatological average within this timespan (late July to mid-August). While the entire state is below average, we're zoning in on Maui (outlined).

What we see is an entire territory that spans anywhere from 1 to 3 inches below average dating back to mid-July. It's the lack of rainfall that allows the vegetation across Maui to lean on the drier side thanks to evaporation processes continuously extracting moisture. Vegetation in the context of "fire weather" becomes synonymous with "fuel", since now fire can continue to grow and spread. This means the "groundwork" had already been set just in time for this anomalous atmospheric setup we're about to dig into

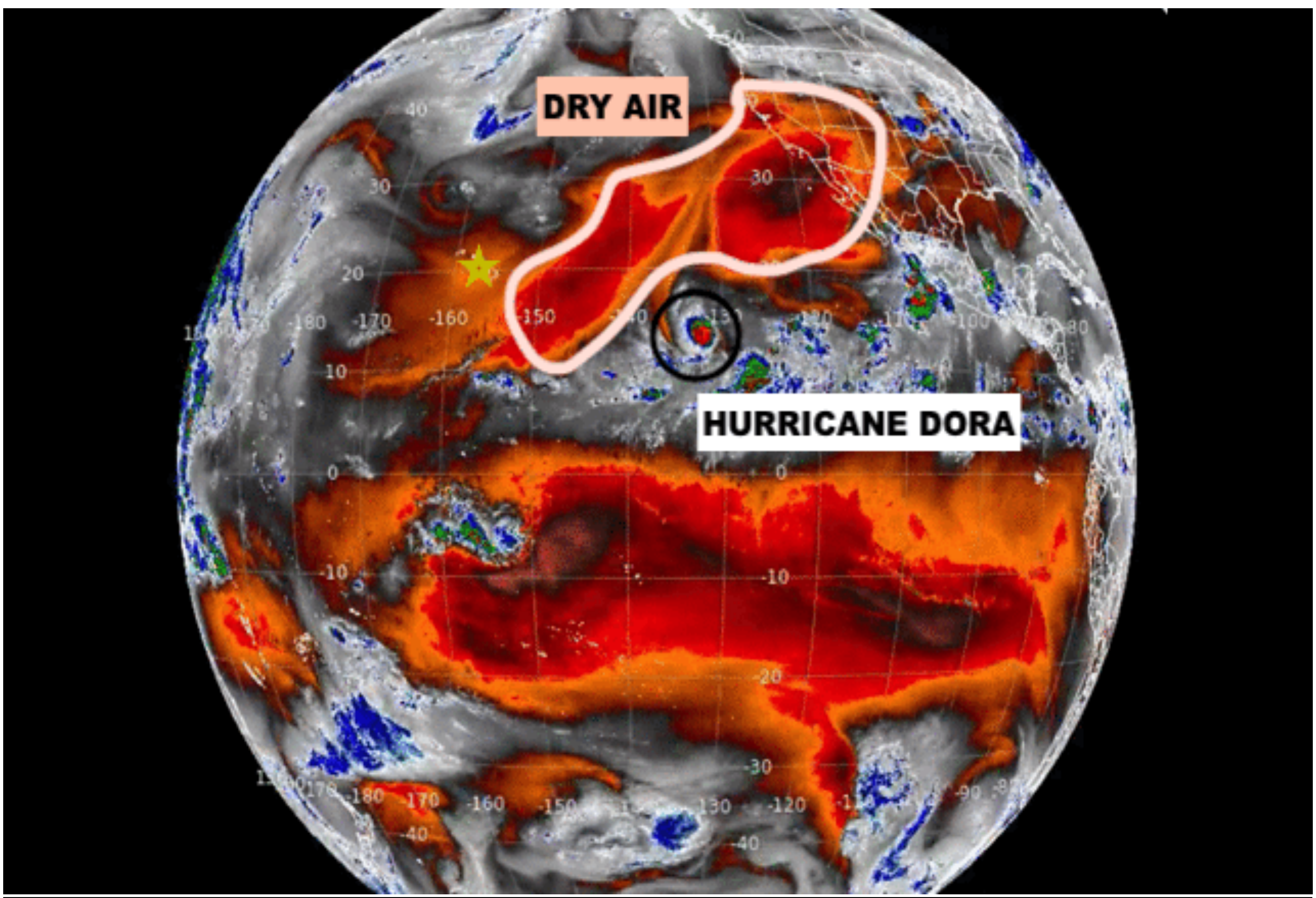


Now, let's really dig into the setup that fundamentally allowed for this calamity to unfold and worsen. Using archived water vapor imagery, lets analyze a frame-by-frame GIF approach that allows us to see the entire broad view of the Pacific basin down below.

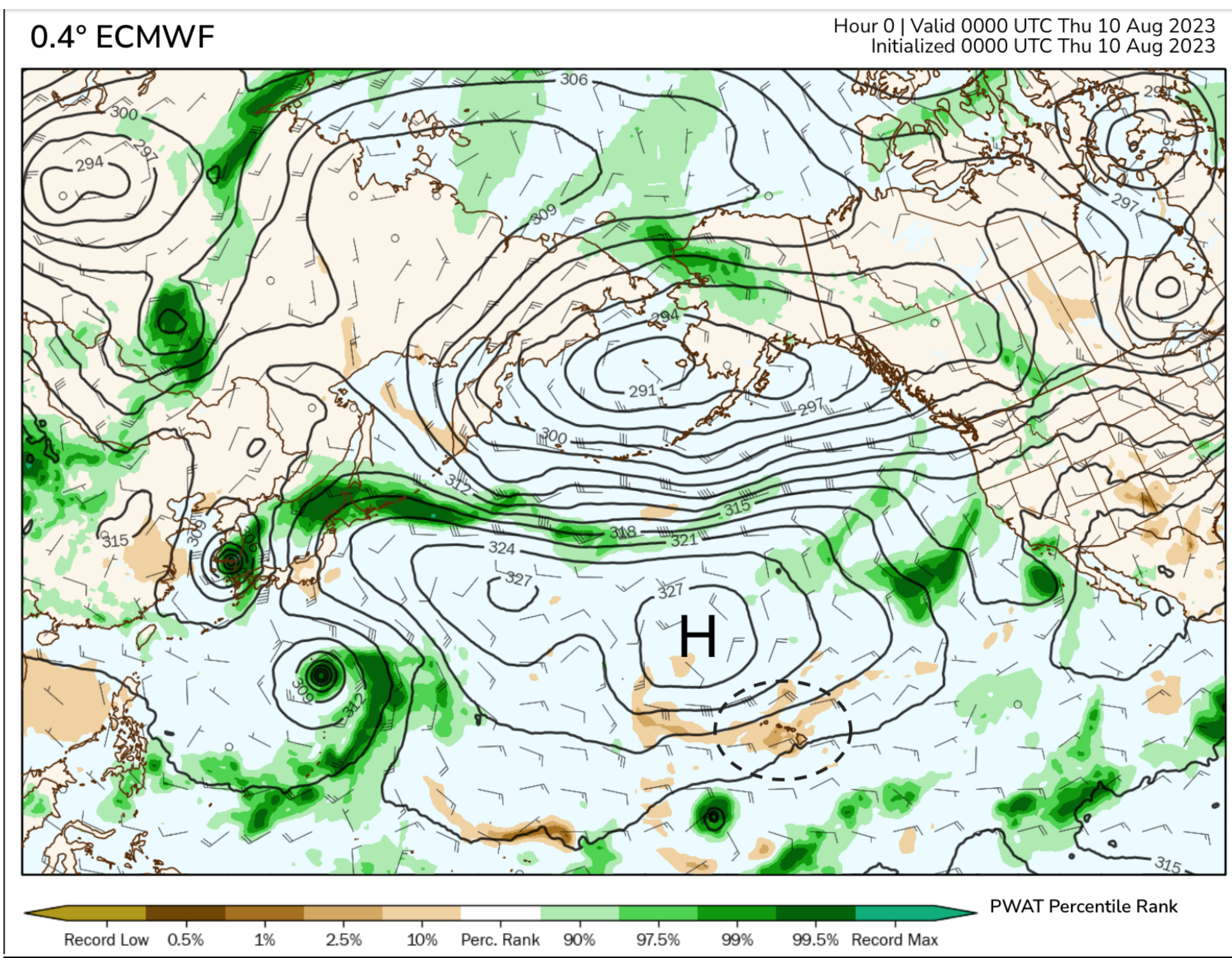
Beginning August 4th, we see a maturing Hurricane "Dora" trek toward the Central Pacific, taking a west-southwest track. Initially, your eyes should immediately gravitate to the expansive deep red, orange, and brown colors off the Southern California coast. That entire region reveals a whole lot of dry air due to the absence of moisture verbatim. As we progress into the first full week of August, a large sprawling ridge (high pressure center) builds and emerges out across the Northern Pacific.

With the clockwise flow around the high, and counterclockwise flow around Dora, this allows for two manifestations to transpire:

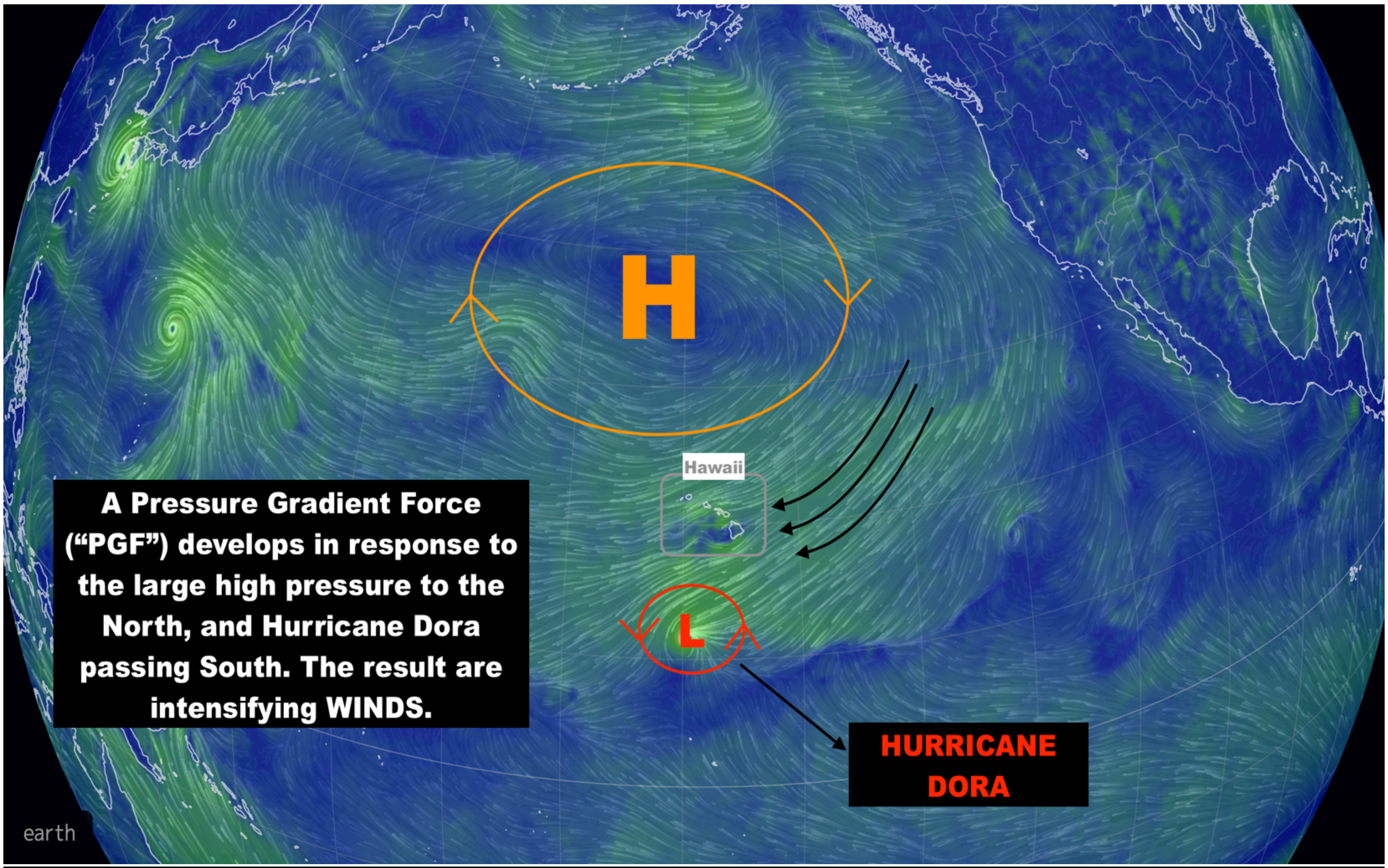
1. Advects (transportation of parcels horizontally) the dry air toward and across Hawaii.
2. Establishes a PGF (pressure gradient force) with the high to the north and the low to the south hence forming a pressure gradient where winds blow from high to low and are curved (to the right) due to the Coriolis effect.



You may think well okay, so we have dry air by looking at water vapor, but it doesn't reveal just how dry it is. This, or "big deal" there's dry air elsewhere across other regions globally. A useful graphic we can look at is precipitable water (PWAT), which verbatim is the amount of water vapor readily available in the atmosphere that can be condensed instantly and fall to Earth's surface. Here, however, is the rank of PWAT's relative to climatology from a great source created by Tomer Burg (polarwx.com). We see here that the large plume of dry air that was advected across Hawaii happened to be ranked within the lowest 10th (and less) percentile, meaning it was anomalously dry. With the amount of widespread dry air, it's directly related to the absence of moisture so relative humidity values were very low. The fact that Hawaii is in the tropics makes this entire situation even more abnormal.

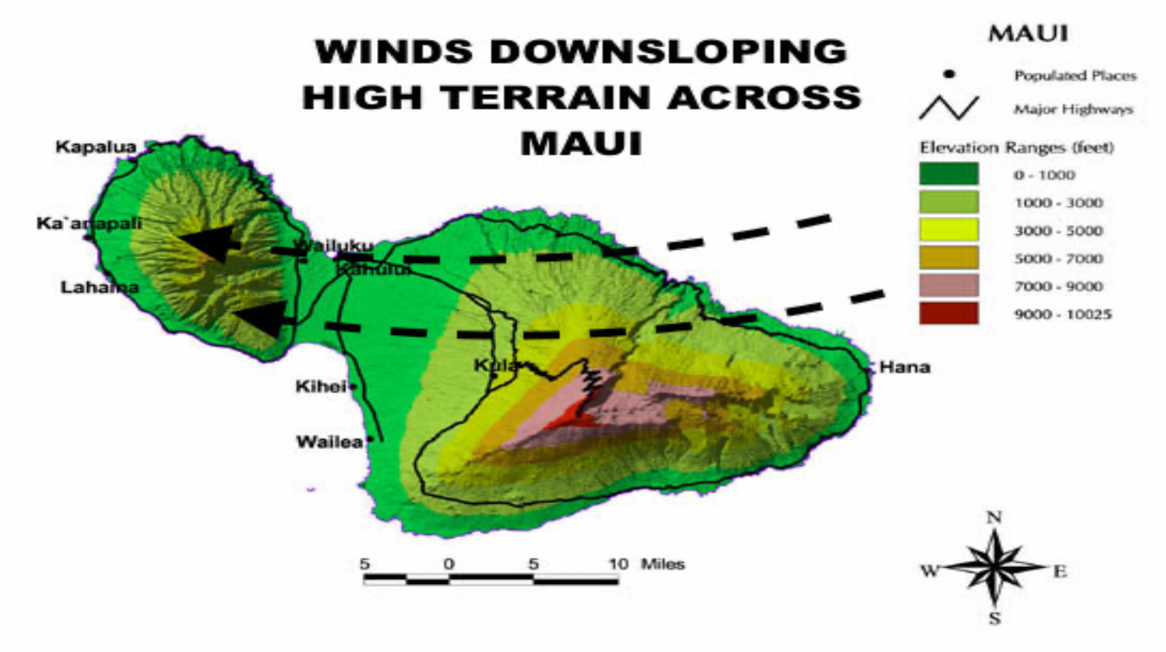


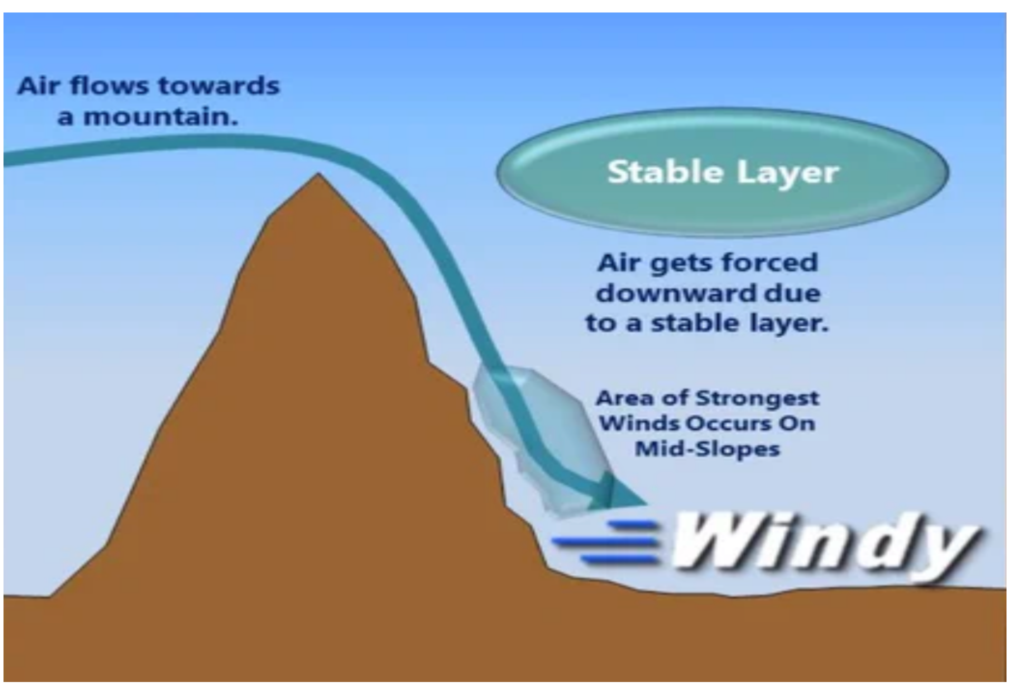
The lack of rainfall mixed with the dry air enhancement from advection has begun to "piece" in toward the ideal atmospheric setup, but we're not done yet. Data taken from an excellent site (https://earth.nullschool.net), here we analyze surface streamlines on August 8th (date where the fires initiated). The large high pressure is clear as day outlined north of Hawaii, with Dora passing harmlessly south (greater than 400 miles from Hawaii in fact). While many have made both conclusions and assumptions that it was Dora that caused this; technically, it's the pressure gradient force between the high pressure and low (Dora) that manifested this entire impactful devastation.



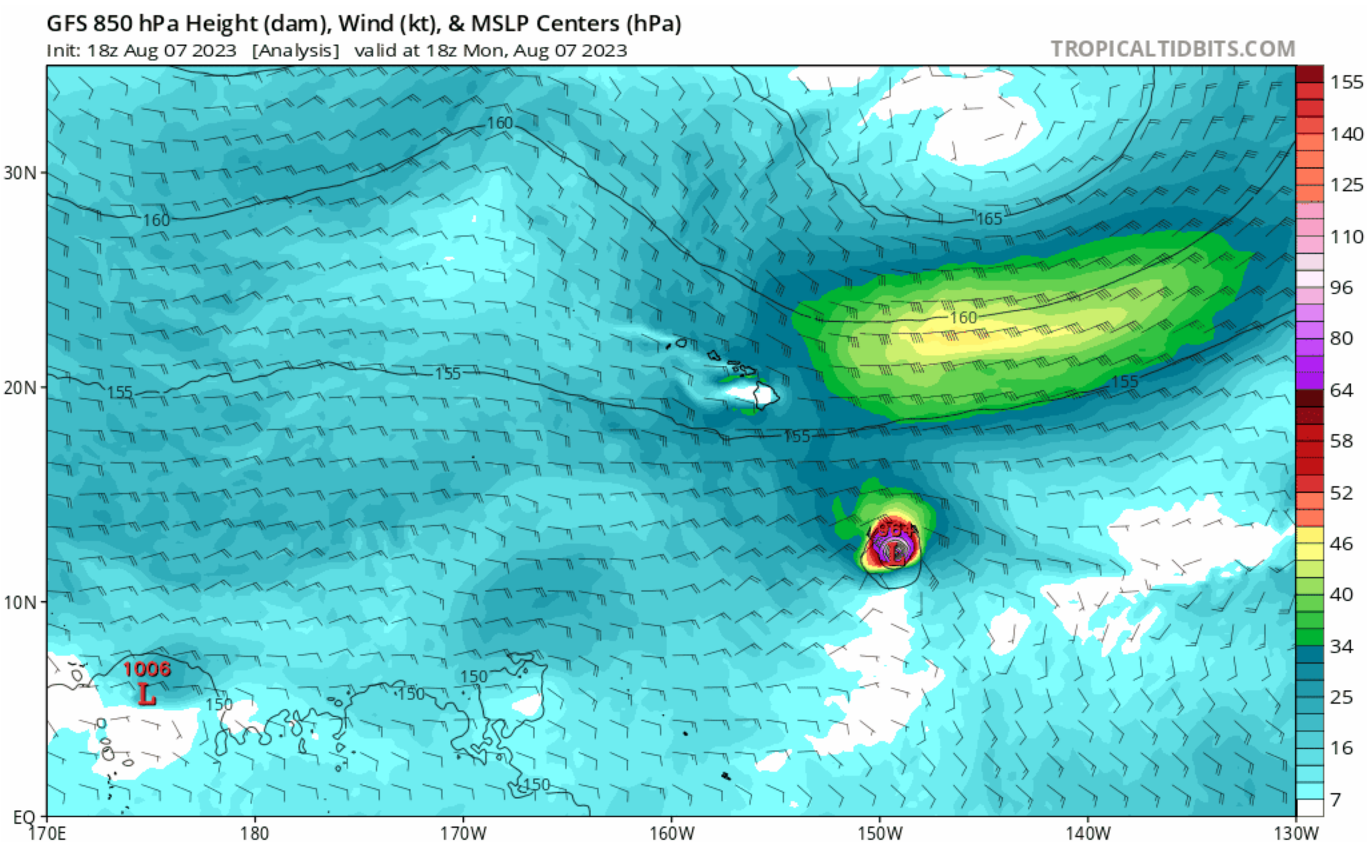
Let's quickly deviate from this topic. Everyone has either seen somewhere in the news or heard it elsewhere about "Santa Ana winds". These are infamous winds that blow across Southern California because of cold, dense air from a descending high pressure to the north. This dense air descends the mountainous terrain of California and warms adiabatically while compressing from a generic east to west direction.

This compressed warm air is now drier and denser than the ambient air, resulting in strong surface winds and gusts. Take this same concept and apply it to now Maui. Below shows two graphics: Maui’s topography and a visually appeasing illustration of downsloping created by the National Weather Service. With Pu’u Kukui mountain sitting at just over 5,000’ and Haleakalā volcano over 10,000’, there’s more than enough elevation to allow for winds to descend, compress, warm, and dry out.





Now, taking the concept above, here below shows an enhancement of this entire meteorological process. The aforementioned pressure gradient force resulted in a stout easterly low-level jet (850mb). Shown through the animation below (taken from [tropical tidbits](https://www.tropicaltidbits.com)), speeds more than 50 knots (>58 mph) occurred with this jet streak as it propagated across Hawaii between August 8th – 9th. At 850mb (~5,000' above sea level), both the momentum and energy from this jet streak were "tapped into" and were able to make its way down to the lower elevations of the hard-hit major areas of Lahaina and Kula.



Nearly 85% of U.S. wildfires are caused by humans. Fires also can start from naturally occurring processes like a lightning strike or maybe volcanic activity. Regardless, while the main catalyst remains to be seen on what exactly caused the fires according to current reports, the driving meteorological processes behind fire risk development all culminated at the perfect moment in time. During this time, red flag warnings (a certain threshold for fire weather conditions) were also in place that was forecasted by the National Weather Service. It was the *ideal* combination of atmospheric and meteorological fundamental processes that rendered low humidity, dry air (leading to enhanced drying of vegetation, trees, plants, etc.,) enhanced winds, and heat that ultimately led to such a deadly wildfire magnitude.