

Cracking the AQ Code



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Temperature Profiles, Inversions, and NO BURN DAYS

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Weather comes in many forms. It can be hot, cold, sunny, cloudy, rainy, calm, stormy, soothing and sometimes even frightening. But, when taking it all apart, weather happens simply due to one core reason: differences in temperature. Because the sun's rays are more direct over the tropics than the poles, a temperature imbalance occurs. This uneven heating of our planet results in pressure differences that drive wind and weather. Think of weather as the atmosphere trying to balance itself out by transporting the excess heat at the tropics to the poles.

Temperature is always changing due to various factors such as winds blowing hotter/cooler air from one place to another. In addition to temperature changes near the surface, temperature also changes vertically throughout the atmosphere. From the ground up, our atmosphere is divided into several layers: the troposphere, stratosphere, mesosphere, and thermosphere. Each of these layers has its own temperature profile (how temperature changes with height). For the purpose of this topic, we will focus mainly on the troposphere because it is the layer closest to the surface and has the greatest effect on air quality. Click [here](#) to learn more about the different layers.

Inversions

What is an inversion?

As mentioned in the link above, the temperature of the air normally cools as you move higher and higher into the troposphere. Within the troposphere, the ground acts as a heat source. Therefore, the air should be warmest nearest the ground. However, there are instances when the temperature actually increases with height. Meteorologists call this phenomenon a *temperature inversion*. From here on out, we'll just call them "inversions." Read on to see how inversions play a key role in Arizona's air quality.

About "Cracking the AQ Code"



In an effort to further ADEQ's mission of protecting and enhancing the public health and environment, the Forecast Team has decided to produce periodic, in-depth articles about various topics related to weather and air quality.

Our hope is that these articles provide you with a better understanding of Arizona's air quality and environment. Together we can strive for a healthier future.

We hope you find them useful!

Upcoming Topics...

- ENSO (A.K.A El Niño)
- All About Fog
- The Jet Stream, Cold Fronts, etc.

The Nocturnal Inversion

Inversions are more common than you might think. Have you ever wondered why the wind is often very calm at night? We can thank the nocturnal inversion for that. The Phoenix Brown Cloud is an example of a nocturnal inversion. The ground begins to cool as the sun sets. The air closest to the ground cools faster than the air right above it. For the most part, this can result in a layer of cooler air at the surface with warmer air above it, forming an inversion (see Figure 1). This inversion then acts as a barrier, separating air at the ground from faster-moving air higher in the atmosphere. Ultimately, this causes lighter winds near the ground at night. As long as there is no large, organized weather system providing stronger winds or cloud cover, we can count on an inversion developing near the ground during the night.

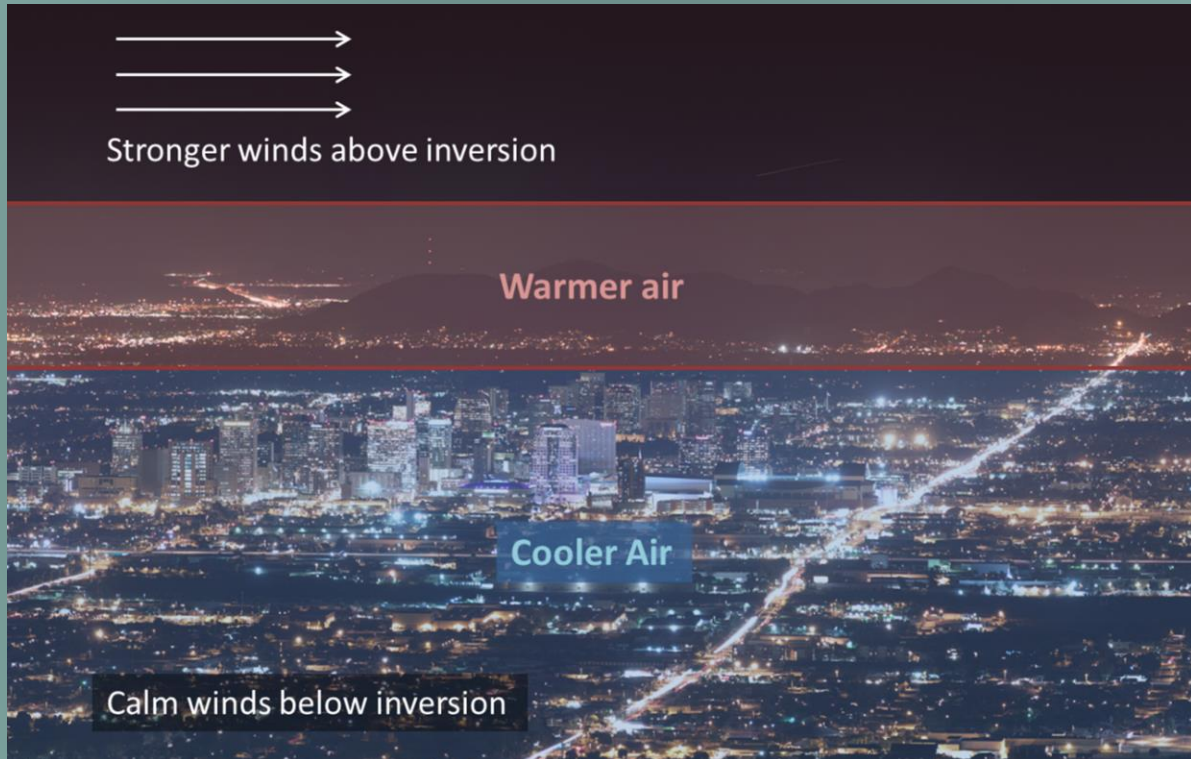


Figure 1: A basic visualization of a nocturnal inversion under a clear night sky, which is important for inversions. *Photo source:* Wikipedia Commons

Inversion Strength

The lifetime of an inversion is determined by its strength. The stronger the inversion, the longer it will remain in place. Inversion strength depends on the temperature difference between the cooler air near the ground and the warmer air above it. The larger this difference, the stronger the inversion. Typical conditions for an inversion include clear skies and calm winds. Clear skies allow for the most efficient heat loss from the ground. Calm conditions prevent the warmer air above from mixing down with the cooler air near the ground, which would reduce the temperature difference between the cool and warm air layers.

Inversion strength can also be enhanced by terrain. Inversions over valleys are stronger because colder air drains to their bottom. This colder air increases the temperature difference between the air near the ground and the warm air above. Phoenix is an example of a city where inversions can be influenced by surrounding terrain. The season also matters. Inversions are stronger during the colder months because

the night hours are longer. Long nights allow for more cooling at the ground, which leads to a larger temperature difference between the cold and warm air layers.

Inversions and Air Quality

Ultimately, inversions are of interest to the ADEQ Forecast Team because of their negative impact on air quality. Inversions act as lids, preventing air near the ground from rising higher into the atmosphere. This traps pollutants closer to the ground and results in poor air quality.

Of particular interest as the weather gets colder is the accumulation of fine particulates (PM_{2.5}) during the night. PM_{2.5} sources typically involve fuel combustion (e.g. cars, trucks, power plants, etc.). As we enter into the colder months, fireplace activity increases, which releases additional PM_{2.5} into the air. If an inversion is set in place over the Valley and these sources are active, PM_{2.5} levels will increase overnight. Inversions are also stronger during the colder months, giving PM_{2.5} more time to accumulate near the ground overnight. This can make it more difficult for sensitive populations to breathe comfortably (e.g. children, the elderly, people with respiratory problems, etc.)



Classic example of fireplace smoke shrouding downtown Phoenix under a strong inversion on Christmas morning (2006) *Source: phoenixvis.net*

No Burn Day

What is a No Burn Day?

The Maricopa County Air Quality Department is responsible for issuing No Burn Days. The county will issue a No Burn Day based on the ADEQ Forecast Team's PM₁₀ and PM_{2.5} forecasts. When weather conditions are conducive for particulate levels to *approach* the federal health standard, a **Health Watch** will be issued. A **High Pollution Advisory** is issued when levels are expected to *exceed* the standard. In the event that either a Health Watch or High Pollution Advisory is issued for particulates, the county will declare a No Burn Day. This restricts most wood burning activities within the county. (The *county's woodburning restriction ordinance* can be found by clicking [here](#).)



Forecasting a No Burn Day

Now that we know what a No Burn Day is, let's look at the factors that go into determining whether one needs to be issued or not. Ultimately, it comes down to the stability of the atmosphere. Particulates typically increase under a more stable atmosphere when there is less atmospheric mixing. In other words, the same "pool" of air is able to sit over the region for an extended period of time allowing pollutant concentrations to accumulate with nowhere to go.

Earlier we discussed how an inversion can act as a barrier from winds aloft reaching the surface; well, the inversion can also trap the air near the surface from ascending. When a significant amount of wood burning takes place under an inversion, the particulates settle in the area and begin to build up. Under severe enough events, particulates can accumulate to the point of causing health concerns for people. There are two primary factors leading to especially severe events. The first is a large amount of time between "clearing events." A clearing event is a weather feature capable of clearing out the air and allowing it to be replaced by fresh, new air. This is usually accomplished by a traversing weather system bringing wind and/or rain to the area. The longer we go without a clearing event, the more likely particulate concentrations will accumulate to unhealthy levels. The second and perhaps the most important factor leading to unhealthy particulate levels is the amount of burning taking place. Wood burning is most common around the holidays, which is why the majority of our federal health standard exceedances occur during this time of the year.

What can you do on a No Burn Day?

The most important thing you can do is simply not burn wood. Though there are other sources of PM_{2.5} such as vehicle emissions and industry, scientific data has shown that wood burning has the largest impact.

If you are sensitive to particulates you may want to consider staying inside when possible to limit your exposure to the fine particles.

If you see friends or someone you know burning on a No Burn Day, you can help by kindly informing them of the No Burn Day.

Proactive things you can do

- Not burn wood
- Sign up to receive No Burn Day alerts at CleanAirMakeMore.com or call (602) 506-6400
- Pay attention to your body and stay inside if you're having trouble breathing
- Check the [forecast](#) daily to plan your upcoming activities
- Remind friends, family members, and others to follow this guidance
- For more information on Frequently Asked Questions, click [here](#)

For our next topic, the ADEQ Forecast Team will look at ENSO (A.K.A El Nino)
Thanks for reading!

Sincerely,

The ADEQ Forecast Team
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In case you missed the previous Issues...

June 2015: [Tools of the Air Quality Forecasting Trade: Capturing Dust Storms on Doppler Radar](#)

July 2015: [Ozone: An Invisible Irritant](#)

Sept 2015: [North American Monsoon](#)

Oct 2015: [The Genesis of a Thunderstorm: An Arizona Perspective](#)



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