Lightning in the Peaks: Why is Lightning Here?

ⓘ This is a preview of the published version of the quiz

Started: May 18 at 4:35pm

Quiz Instructions

While on many days, these storms tower up from the raised topography of the San Francisco Peaks because of low surface winds leading to upslope winds forming, this isn't always the case. You should have noticed in the first section of this lab that some areas of lightning aren't associated with any raised topography. They're sitting in a middle of a plain, or around a low hill. How does that happen?

Some days in northern Arizona, there are strong surface winds that cause orographic lift, while on other days, winds are mild near the surface but stronger aloft. These winds aloft are the primary source of direction for storms once they appear. If they don't occur, these storms go through their lifecycle directly over where they form, which you may have seen already in the geovisualization. Other times, they move the storm clouds away from the raised topography and out into the open flats around the peaks.

In this stage of the lab, you'll identify lifted condensation levels and storm speed to figure out how long it will take for a thunderstorm forming over the raised topography around the San Francisco Peaks to reach your location away from the mountain.

EXAMPLE QUESTION: What were the atmospheric conditions that led to lightning strikes around Doney Park during a day with a southern steering wind and upslope wind formed clouds clouds condensing 800 meters above above Anderson Mesa (35.1174 N, -111.5840W)?

PART 1:

For this question, we want the lifted condensation level (LCL) to be 800m above Anderson Mesa (2185m). That would be 2985 meters.

For condensation (clouds) to occur at 800m above Anderson Mesa, the dew point needs to be equal to the air temperature at this height. So….

Dew Point = Starting temperature – (Elevation Change * Lapse Rate)

Dew Point = 21.6C – (.8km * 10C/km)

Dew Point = 21.6 – (8 C) = 13.6C

Dew Point = 13.6 C for clouds to form 800m above Anderson Mesa (56F dew point is about as humid as it gets for this region)

PART 2

For lightning to form in a cloud, it needs to reach a certain height in the atmosphere, where interactions within the cloud begin to create static charge buildup, resulting in lightning. For this example, we will use a height of 10kilometers, or 10,000 meters, for this interaction to occur, and the storm to reach mature stage. We also need the updraft speed, essentially how fast the storm is growing upwards. For this example, we will use 300m/min.

How long will it take for a 10km-tall thunderstorm to form above Anderson Mesa if the updraft winds are 300m/minute, and the LCL is 800m above the mesa?

From the top of Anderson Mesa, we will have to rise our tiny cumulus cloud up to 10 kilometers. Since

Anderson Mesa is 2,185 meters high, and the base of the cloud is 800 meters above, the cloud base is 2985m, and would need to climb 7015 meters to reach a height corresponding to thunderstorm maturity and lightning. We know how fast the air rises in the updraft above the mountain, which is 360m/min. So we need to figure out long it

will take air rising at 300m/min to reach 7015 meters above our lifted condensation level (rising 10,000 meters elevation).

This is the calculation: 7015m / 300m per min = roughly 23.4 minutes. It would take roughly 23.4 minutes for the thunderstorm forming above Anderson Mesa to reach mature thunderstorm stage and create lightning

PART 3

How fast is the wind steering the storm from Anderson Mesa to Doney Park, our location of clustered lightning strikes?

It takes roughly 23.4 minutes for our cumulus cloud to form and create a towering thunderstorm capable of lightning with the current atmospheric conditions. So we now have our time for lightning formation, we just need to figure out how fast the steering wind is that is propelling the thunderstorm towards our location. We have our distance from Anderson Mesa to our lightning hotspot, and that's 14km. To find how our speed in kilometers per hour, we will have to convert our original time into hours.

ANSWER:
Hours = 23.4 minutes / 60 minutes = .39 hours
Steering Wind Speed = Distance / Time
Steering Wind Speed = 14km / .39 hours = 35km/hour or 21 miles per hour

---

Question 1

6 pts

You are exploring the Hochderffer Hills northwest of Flagstaff (35.3685N , -111.7512 W) on a humid summer morning. You look east, and see the San Francisco Peaks towering above you. The winds blow gently from the east and you observe small cumulus clouds bubbling up above Humphrey's Peak, their base roughly 500 meters over the peak. Conditions are perfect for a thunderstorm.

View of the San Francisco Peaks from Hochderffer Hills

First, let's see why we chose this location for lightning strikes. Go to the Hochderffer Hills (35.3685N , -111.7512 W) in the geovisualization. Roughly how many lightning strikes do you see here?

HINT: The small circles you see on the ground are where lightning strikes are - the game just randomly fires strikes at those circles, but you can count them or wait in the game to see their clustering if you watched the lightning actually strike these areas.

Number of Lightning Strikes at the Hills: [Select]

The next several portions of this question will ask you to identify the atmospheric conditions which lead to the lightning strikes at your location.

PART 1:
What would the dew point have to be for clouds to form 500m above Humphrey's Peak (35.3459 N, -111.6782 W) if upslope winds are flowing up from Inner Basin to the east? To help you with this question, find the temperature atop Humphrey's Peak, and determine how the temperature 500 meters above the peak using the dry adiabatic lapse rate (as it isn't saturated yet!)

Mt Humphreys' Peak Air Temperature: [Select]

Dew Point: [Select]

PART 2:
For lightning to form in a thunderstorm, it needs to climb high enough in the atmosphere where interactions of ice and water begin to create static charge within the cloud. For this example we will use a thunderstorm height of 10,000m (10km) and an updraft speed of 350m/min

How long will it take for a 10km-tall thunderstorm (a thunderstorm whose top is at 10 km in elevation) to form above Mt. Humphreys if the updraft winds are 350m/min and the cloud base is 500m above the peak?

Time for Mature Thunderstorm = Elevation difference between 10km and Cloud Base / Updraft Wind Speed

Time for Mature Thunderstorm: [Select]

PART 3:
Now we want to find out how fast the winds are blowing the thunderstorm towards our location. As mentioned before, winds during monsoon season are often light near the surface, but aloft they are often more noticeable, not to mention storms can move off mountains downhill due to gravity. For the sake of this example though, we want to know how long it will take for a lightning producing storm to arrive over our location at the Hochderffer Hills.

If the distance between the Hills and Mt. Humphreys is roughly 7km, how fast were the steering winds to push the growing thunderstorm to the Hills in the time found above?

Steering Wind Speed = Distance / Time
(*Hint: you'll need to convert your time answer from before from minutes to hours for this question, so divide your minutes by 60 to get hours)*

Steering Wind Speed: [Select]

Not saved Submit Quiz