Lightning in the Peaks: Upslope Winds

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

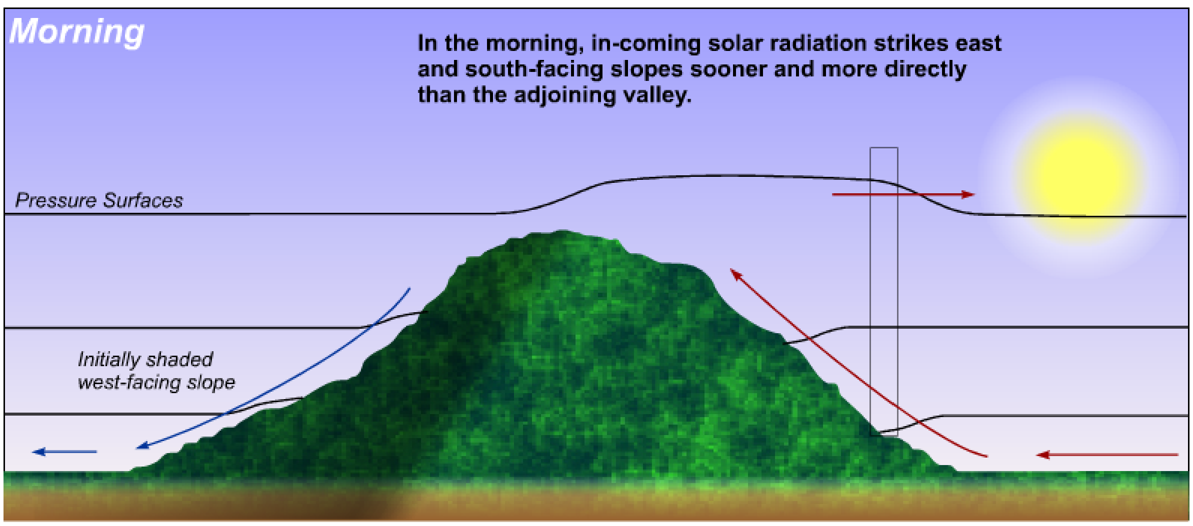
Started: May 18 at 4:35pm

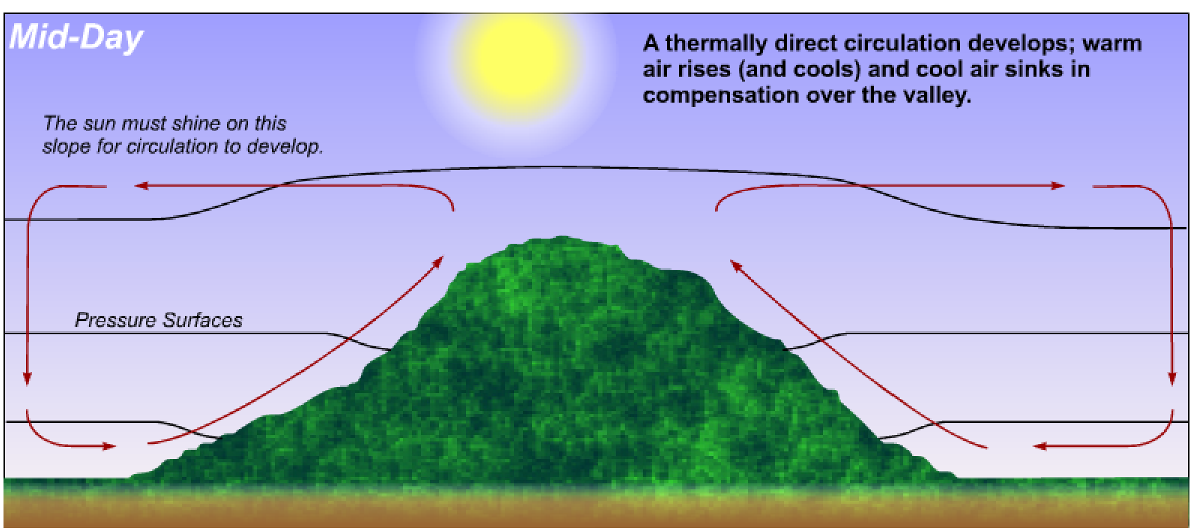
Quiz Instructions

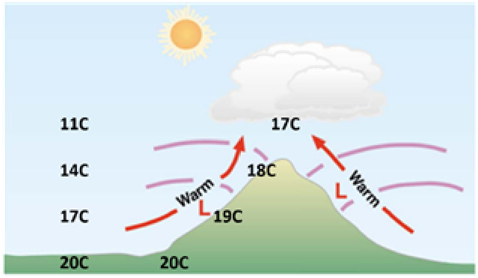
Typically, during the summer in the US Southwest, surface winds are much weaker. However, in mountainous topography, mountains can create their own winds. Surface heating along the mountain slopes creates a pressure gradient between air lower down and air near the top, because air near the mountainside is much warmer than the air aloft at the same height. As air flows from higher to lower pressure, this pressure imbalance leads to air flowing up the sides of the mountain, which is why they are called upslope winds. These upslope winds can be thought of as columns of air moving up the mountain slopes and rising away in towering, warm columns of air. You will use temperature instead of pressure.

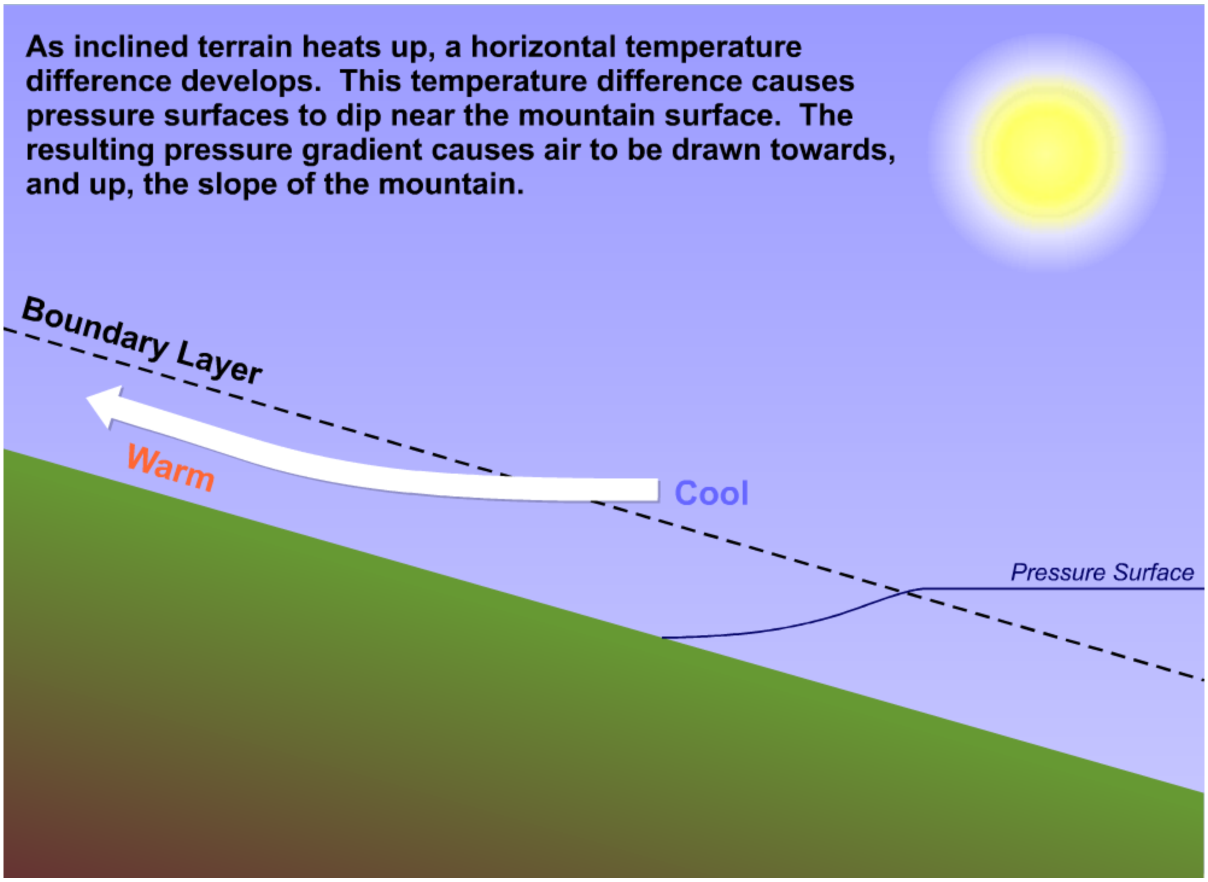
Below you can see the process of upslope winds, that can then lead to thunderstorm formation and lightning strikes on the flanks of mountains.

During the morning, the sun heats east- and south-facing slopes of mountains. Focus your attention on the sample air column. Note, near the bottom of the air column, how the constant pressure surface dips toward the mountain slope, indicating low pressure. Meanwhile, higher up in the air column, higher pressure helps to move air away from the mountain. In time, a thermally driven circulation develops.





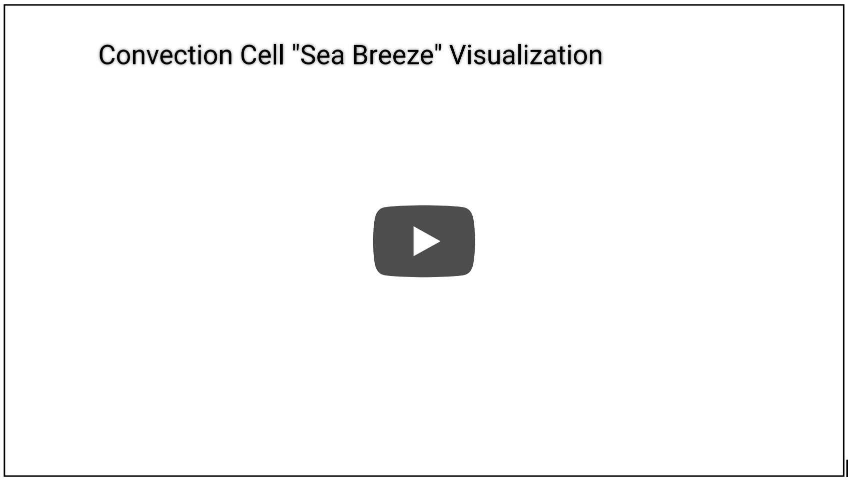




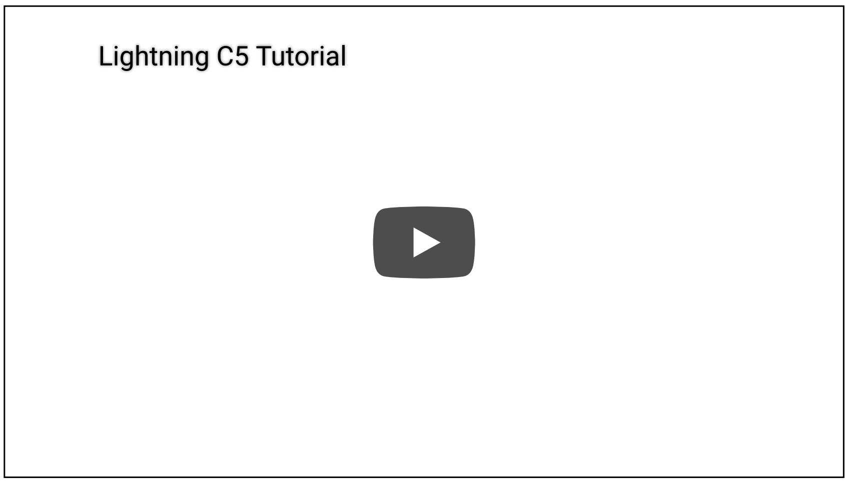
Thunderstorms around the San Francisco Peaks often form over raised topography. However, this isn't always the case. Up here on the Mogollon Rim, if conditions are right, thunderstorms can pop off from any location, even flat ground, and the sky is can be covered in a blanket of clouds, rain, and lightning.

However, keep in mind that very often the first storms to form are typically over the raised topography. Later in the day, conditions can come together to lead to storms at any location.

If these explanations do not "work" for you, perhaps this video might. Image the heat element as the same as heating the slopes of a mountain -- and watch the fluid rise up along the surface, and circulate away -- the same as the upslope winds. Clouds would form near the top of the circulation as the air cools to dew point. Eventually, you might have storms form and generate lightning, either along the mountain slopes or away from the mountain if winds push the storms away from their origin. This example looks at a sea breeze, but the mechanisms behind them are quite similar.



For this question, you will look at the temperature gradients within the game along the surface and aloft to better understand the temperature and pressure factors that create the mountain upslope winds. This is a longer style question - if you need help seeing how to work through a similar example, in this case along Mt. Elden, check out the tutorial video below.



Question 1

6 pts

Step 1
Make sure the geovisualization is displaying the air temperature layer. Observe the air temperature at Shultz Pass (35.2848 N , -111.6336 W). Input the air temperature for Shultz Pass below.

Then fast travel to Fremont Peak (35.3228 N , -111.6610 W) and input the air temperature in the table below as well.

Step 2
With the layer in the geovisualization still displaying air temperature, travel due southeast down the mountainside from Fremont Peak. Take a temperature measurement every 200m down in elevation and record it in the table below.

You may not be able to get to the exact elevation easily, so just get as close as you can to make your observation. The temperature options below also may not be exactly what you observe either, ***so choose the temperature closest to the value you find in your observation.***

Elevation	Observed Temperature
Fremont Peak 3625m	[Select]
3425m	[Select]

3225m	[Select]
3025m	[Select]
2825m	[Select]
2625m	[Select]
Shultz Pass 2455m	[Select]

Step 3
Compare your observed temperatures above with the environmental temperatures found in the column below. Choose the best answer below that represents what would be happening with the temperature pattern found between the temperature at the surface and the temperature aloft.

Question: What is happening? [Select]

Elevation	Environmental Temperature
Fremont Peak 3625m	13.8C
3425m	15.1C
3225m	16.4C
3025m	17.7C
2825m	19C
2625m	20.3C
Shultz Pass 2455m	21.6C

Step 4
The temperature gradient you observed at the surface also exists aloft, creating another layer of uplift above Fremont Peak. The air at roughly 5000m Flagstaff is the same temperature, no matter the surface below it. That means that fairly strong temperature gradients exist above the warmed, raised peaks.

Calculated the temperature gradient (in degrees C/km) between the two locations, Shultz Pass, and Fremont Peak, if the air aloft at 5000 meters is 0C.

Gradient = (Temperature difference from location to 5k) / (Elevation difference between Location to 5k)

GRADIENT CALCULATION QUESTIONS, G1 and G2:

Shultz Pass to 5000m Gradient: [Select]

Fremont Peak to 5000m Gradient: [Select]

Not saved Submit Quiz