Mountain Winds May Create Atmospheric Hotspots

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Rapidly fluctuating wind gusts blowing over mountains and hills can create "hotspots" high in the atmosphere and significantly affect regional air temperatures.

A research paper to be published this month in the Journal of Geophysical Research-Space Physics reports that the actions of such winds can create high-frequency acoustic waves and could stimulate a 1000-Kelvin [1,000-degree Celsius; 2,000-degree Fahrenheit]spike in a short period of time in the thermosphere, at an altitude of 200-300 kilometers [100-200 miles].

Such exceptional temperature increases would require continuous waves, and the heating rate would likely be diminished with intermittent winds.

Richard Walterscheid and Michael Hickey used a theoretical model of the interaction between rough terrain and wind eddies to suggest that high winds may represent a previously unknown source of acoustic waves in the environment.

Ocean waves and earthquakes are known to produce similar waves, which strengthen as they propagate higher in the atmosphere.

The authors speculate that the waves can heat the atmosphere at prodigious rates and could account for a large part of the unusual and unexplained high-altitude background heating seen above the mountainous landscape in parts of South America.

"We show that that the acoustic waves generated by gusty flow over rough terrain might be a significant source of heating in the upper atmosphere," Hickey says. "These mysterious so-called 'hotspots' observed above the Andes Mountains could be explained by such acoustic wave heating."

Previous observations near the Andes Mountains in Peru had found that the atmosphere directly above some peaks was approximately 100 Kelvin [100 degrees Celsius; 200 degrees Fahrenheit] hotter than in nearby regions and that the difference occasionally reached as much as 400 Kelvin [400 degrees Celsius; 700 degrees Fahrenheit]. Other research had recorded similar effects near the Rocky Mountains in Colorado.

After comparing simulations of atmospheric gravity waves and acoustic waves, the researchers found that the acoustic waves reached higher altitudes than the gravity waves, leading them to speculate that the acoustic waves constituted a far more plausible source of the observed hot spots.

They then identified wind fluctuations as the most likely source of the heating, noting that the upwind waves could only be generated by unsteady wind flow.

They cite further evidence indicating that the high- frequency acoustic waves in the thermosphere originated from the ground, including proof that nighttime atmospheric motion (convection) is not a plausible source of the persistent heating.

In addition, they note that only high-frequency acoustic waves could cause the thermospheric heating, as the slower-speed gravity waves are not fast enough to reach the higher altitudes and therefore could not produce the substantial effects at that height in the atmosphere.

The paper indicates that moderately strong winds, reaching speeds of approximately 10 meters [30 feet] per second, can generate wave amplitudes of nearly four meters [10 feet] per second above rough terrain.

In addition, the authors found that steeply sloping terrain further enhanced the waves, which are generated by rapid variations in the up-and-down turbulence in the air. Wider hills and those spaced further apart can also have a similar wave- generating effect, but the authors found that the wind effects typically do not propagate vertically near isolated hills as they do around rougher terrain.

The researchers note that there are very few detailed field studies of the wind field over hills at present. They report, however, that models and previous research indicates that even weak interactions from acoustic waves can produce significant effects in the thermosphere.