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The Thomas Fire races toward Southern California cities of Ojai and Santa Paula, December 2017. Photo: istockphoto/JPhilipson

Climate Change May Suppress Santa Ana Winds, Particularly in Fall

Results suggest Southern California's fire season shifting towards winter

Santa Ana winds, seasonal gusts of dry desert air that can bring havoc to Southern California, might become less common, especially in fall and spring, as the conditions that drive them change, according to a pair of researchers at Scripps Institution of Oceanography at UC San Diego. Together with expected changes in precipitation patterns, this suggests a later wildfire season in the future and a possibility for longer-burning wildfires.

Climate scientists Janin Guzman-Morales and Alexander Gershunov report in the journal *Geophysical Research Letters* that Santa Ana winds are becoming less frequent as high pressure systems over the Great Basin weakenover the 21st century. The decline will be most pronounced in early and late Santa Ana wind season, which typically runs from October to April.

“These changes in Santa Ana winds add important detail to the expectation of drier and warmer conditions in the future, which is crucial to have a better understanding of changes in our regional climate,” said Guzman-Morales, lead author of the study.

Santa Ana winds – occasional dry and gusty reversals of the more typical moisture-laden winds from the west – figure prominently in the lore of Southern California. They are so long familiar to the region that they have served as a literary device employed by writers such as Raymond Chandler and Joan Didion. One explanation of the origin of the term “Santa Ana” is that it is a derivation of the word Satan (Satana) that was coined by Spanish missionaries who saw them as a malevolent force when they first encountered them some 300 years ago. There is more consensus among historians that the name comes from the Santa Ana coastal mountain range in Southern California’s Orange County, where notable wind events and fires have taken place. Santa Anas are so-called “downslope winds” which accelerate as they descend the slopes of mountains and hills.

For the most part, Santa Ana winds bring welcome warmth and intense sunshine to Southern California in winter, as well as striking sunsets and starry nights. In fiction and real life, however, the winds are sometimes cast in a role as a bringer of unease and occasional catastrophe. Santa Anas are often a force that can make driving through Southern California mountain passes hazardous. They fell trees that come crashing onto homes and roadways and create blinding and allergy-triggering gusts of dust and pollen. A succession of Santa Ana wind events fanned what became the largest fire in Southern California history, the Thomas Fire, in December 2017. The fire burned 440 square miles in Ventura and Santa Barbara counties before being contained in January 2018.

Santa Ana winds are driven by a sharp pressure difference, or gradient, between the Great Basin and the Pacific Ocean off the California coast. These pressure gradients are driven by weather activity that sets in during the fall and peaks in winter. Santa Anas are rooted in cold air masses over the Great Basin that warm as they descend to sea level. Since cold air is dense and heavy, the winds accelerate under the force of gravity towards sea level.

Fall has traditionally been the peak of the wildfire season in California as nights become longer and Great Basin air masses begin to cool down. During Santa Ana wind storms, the pressure gradient force pushes gusty winds through mountain passes covered by vegetation that grows during winter and spring, drying and sometimes dying in summer, which in turn becomes fuel for wildfires. Dry summers are getting longer in all Mediterranean climate regions, including California, according to established research.

Climate change projections made by other researchers suggest that the Great Basin will warm up more than the coastal region, but previous studies of how future climate might affect Santa Anas had produced conflicting results. Guzman-Morales and Gershunov sought to resolve the uncertainty by downscaling to fine geographical resolution winds from eight Global Climate Models (GCMs) over Southern California to construct Santa Ana regional wind projections for the 21st century.

Fine-resolution winds were derived using a combination of dynamical and statistical downscaling from coarsely resolved GCMs that had a demonstrated ability to faithfully depict California's climate. The winds were simulated under a "business-as-usual" carbon dioxide emission scenario in which society continues to produce energy primarily by burning fossil fuels. The researchers further evaluated and compared GCMs' ability to reproduce Santa Ana winds. Though some of the models were able to better reproduce Santa Ana winds than others, the two authors described the overall agreement in projected changes among models to be "rather striking."

Results show that Santa Ana wind frequency will drop on average 18 percent towards the end of the 21st century. The decrease of Santa Ana winds is not uniform throughout the season, however, with larger decreases over the shoulders of the season (-68 percent in October and -50 percent in May). These findings along with projected decreasing precipitation in Southern California during fall months would imply a shift of the traditional wildfire peak season from October to early winter months when the drop off in Santa Ana occurrence is least pronounced.

"In December, back-to-back [Santa Ana winds] are most probable, providing opportunities for wildfires to burn longer and bigger," the authors write. "In the future, the probability of back-to-back events will diminish somewhat, but will still remain much stronger in December than it ever was in October, or even November."

The authors do not address whether the change will result in more or fewer total wildfires but note that the Thomas Fire was "likely a harbinger of wildfire seasonality we would expect to experience more often in the future."

"Climate change has been projected to lengthen the dry season in California and other Mediterranean climate regimes, making vegetation more likely to remain dry into December," said Gershunov. "These changes together with the projected lessening of early season Santa Ana winds, suggest that Southern California's wildfire season could shift towards winter."

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