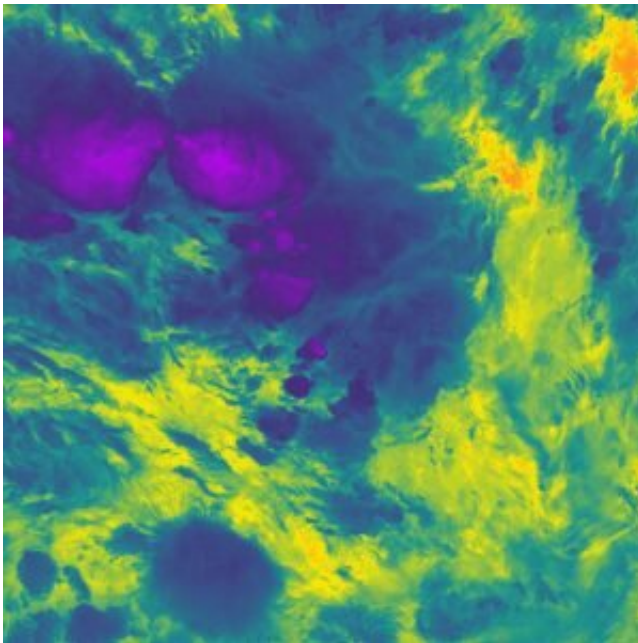


# Coldest recorded cloud temperature measured by satellite

March 31 2021

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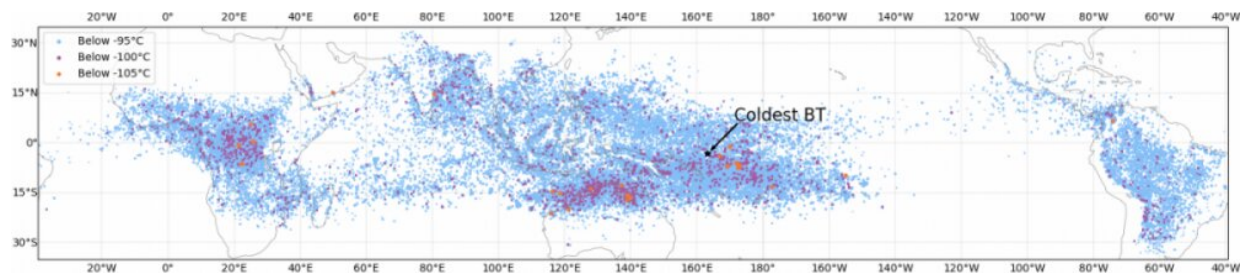


VIIRS infrared view of storms near Nauru on 29th December 2018. The coldest portions of cloud are purple while the warm Pacific Ocean is orange. Credit: Natural Environment Research Council

A new paper led by Dr. Simon Proud, research fellow at the Department of Physics and the National Centre for Earth Observation, describes an unprecedentedly cold temperature measured atop a severe thunderstorm cloud in the Pacific by an Earth-orbiting satellite. This temperature of  $-111^{\circ}\text{C}$  is more than  $30^{\circ}\text{C}$  colder than typical storm clouds and is the coldest known measurement of storm cloud temperature.

In the lowest section of the Earth's atmosphere, known as the troposphere, air temperature decreases with altitude and can reach as low as  $-90^{\circ}\text{C}$  in the tropics. Thunderstorms and tropical cyclones can grow to high altitudes, up to 18km (11mi), and therefore the tops of these [storm](#) clouds become extremely cold. Temperature measuring sensors aboard Earth-orbiting satellites can detect these cold clouds: Enabling meteorologists to monitor such storms and issue severe weather warnings.

On 29 December 2018, the VIIRS sensor aboard the American NOAA-20 [satellite](#), overflowed a severe thunderstorm in the South Western Pacific, approximately 400km South of Nauru. This storm was so powerful that it pushed through the troposphere and into the stratosphere; continuing to cool as it gained height despite the surrounding air being warmer: An event known as an overshooting top. This overshoot led to the storm cloud becoming the coldest known storm cloud temperature recorded,  $-111^{\circ}\text{C}$ , and the tops of the clouds reached an altitude of over 20.5km (12.8mi) above sea level.



Map of all extremely cold cloud temperatures detected by NASA's Aqua satellite between 2004-2020. Credit: Natural Environment Research Council

"This storm achieved an unprecedented [temperature](#) that pushes the

limits of what current satellite sensors are capable of measuring' Dr. Proud explains. "We found that these really cold temperatures seem to be becoming more common—with the same number of extremely cold temperatures in the last three years as in the 13 years before that. This is important, as thunderstorms with colder clouds tend to be more extreme, and more hazardous to people on the ground due to hail, lightning and wind. We now need to understand if this increase is due to our changing climate or whether it is due to a "perfect storm" of weather conditions producing outbreaks of extreme thunderstorms in the last few years."

The success of VIIRS in identifying these [cold temperatures](#) is due to its ability to measure on exceptionally detailed spatial scales. Co-author Scott Bachmeier, a research meteorologist at the Cooperative Institute for Meteorological Satellite Studies/Space Science and Engineering Center, University of Wisconsin-Madison, explains that "since the coldest portion of a cold overshooting top turret can sometimes be 1 km or less, the superior spatial resolution of polar-orbiting satellite instruments (such as VIIRS and MODIS) provides a more accurate detection of the overshooting top's thermal characteristics compared to instruments carried aboard geostationary satellites" that are more commonly used for weather monitoring. Upcoming satellite missions, such as EUMETSAT's MetOp-Second Generation, will allow even more detailed analysis of future extreme storm events.

The work of NCEO staff in understanding uncertainty and designing future satellite missions is vital to monitoring such cold [clouds](#): Sensors are less accurate at [cooler temperatures](#) and without accurate knowledge of this uncertainty our ability to monitor whether extreme storms are becoming more frequent is hampered.

**More information:** Simon Richard Proud et al. Record-Low Cloud Temperatures Associated With a Tropical Deep Convective Event, *Geophysical Research Letters* (2021). [DOI: 10.1029/2020GL092261](https://doi.org/10.1029/2020GL092261)

Provided by Natural Environment Research Council

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