Lasers over New Zealand – atmospheric researchers examine gravity waves

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Atmospheric gravity waves influence the weather and long-term, climate-related atmospheric processes. For a number of nights between 29 June and 23 July 2014, the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) Falcon research aircraft will be flying over the New Zealand Alps (Southern Alps) to investigate how these waves propagate from Earth's surface up to an altitude of around 100 kilometres using modern laser metrology and other instruments. The results will help to improve climate and weather prediction models.

The international aircraft measurement campaign is being carried out in cooperation with United States partners such as the National Center for Atmospheric Research (NCAR), the Naval Research Laboratory, Yale University and the University of Utah. It is being supported by the National Science Foundation (NSF). The research aircraft being used by the US scientists is a Gulfstream V. In addition, the New Zealand National Institute of Water and Atmospheric Research (NIWA) is involved in the research mission, along with other partners from the region.

An important element in climate research

In the past, scientists studied gravity waves either in the lower atmosphere, known as the troposphere, or in the higher altitudes of the overlying middle atmosphere. Until now, it had not been possible to measure the complete life cycle of the waves from their excitation at ground level to their dissipation at the edge of space at an altitude of around 100 kilometres. "In New Zealand, we have launched the first international research campaign, which is analysing atmospheric gravity waves continuously from the ground up to the middle atmosphere," says the Director of the DLR Institute of Atmospheric Physics, Markus Rapp. "For climate research, understanding gravity waves is an important element in gaining a better understanding of global circulation patterns and being able to provide more accurate predictions," Rapp continues. Developments in laser metrology, the use of these instruments on research aircraft and international cooperation are the cornerstones of the research mission DEEPWAVE (Deep Propagating Gravity Wave Experiment), which will now deliver a more comprehensive picture of gravity wave propagation in the atmosphere.

Between mountains and oceans

Gravity waves are formed when atmospheric circulation systems are disturbed. They manifest themselves as periodic temperature, pressure and wind fluctuations, which propagate up into the middle atmosphere, comprised of the stratosphere and mesosphere. They are found, for example, where strong winds meet high mountains. In New Zealand, this phenomenon occurs where the wind passes over the Southern Alps. Gravity waves have already been observed over the southern peninsula of New Zealand and the surrounding Southern Ocean. With its extensive north-south mountain range situated directly on the Pacific Ocean, New Zealand is an ideal location to study the lifecycle of these waves.

The DEEPWAVE mission team is using two aircraft and a ground station to record gravity waves continuously into the middle atmosphere. The laser-based measuring technique LIDAR (Light Detection and Ranging) is particularly useful for this. "Our aircraft, the DLR Falcon, will be flying at an altitude of between 10 and 12 kilometres and will look down from there into the troposphere with its LIDAR – in the area where gravity waves are excited by the airflow over the mountains," explains Markus Rapp. "With its upward-looking LIDAR, the NCAR Gulfstream flies at a similar height, to follow the course of the waves into the middle atmosphere." Using lasers, the researchers measure the wind and temperature fluctuations caused by the gravity waves as

they propagate through the atmosphere. A mobile DLR LIDAR, which is housed in a container at NIWA's Lauder Atmospheric Research Station, also serves as an information source in addition to the aircraft measurements. With this system, the researchers are able to measure temperature fluctuations induced by gravity waves at altitudes of between 30 and 80 kilometres. At Lauder, they also use radiosondes to capture the waves at lower altitudes – from ground level up to 30 kilometres.

Lasers criss-cross the night sky

For the laser measurements to be performed without disruption, research flights only take place at night. "For our crew, the numerous night flights are a challenge," explains DLR test pilot Philipp Weber. "In the dark, it is difficult to identify clouds and the related occurrence of turbulence or icing, especially in the vicinity of the mountains." The flights take off from Christchurch, where the DLR Falcon is stored in a hangar at an international airport. Prior to this, at the end of June, the research aircraft and crew flew for six days and in 11 stages from DLR Oberpfaffenhofen, near Munich, over the Arabian Peninsula, India, Southeast Asia and Australia to the South Island of New Zealand. The equally long journey home is scheduled for the end of July.

DLR intends to expand its capability for atmospheric gravity wave research. To this end, other national and international research campaigns are being prepared. The aim over the next few years is to make significant advances in the characterisation of these waves in weather and climate forecast models.

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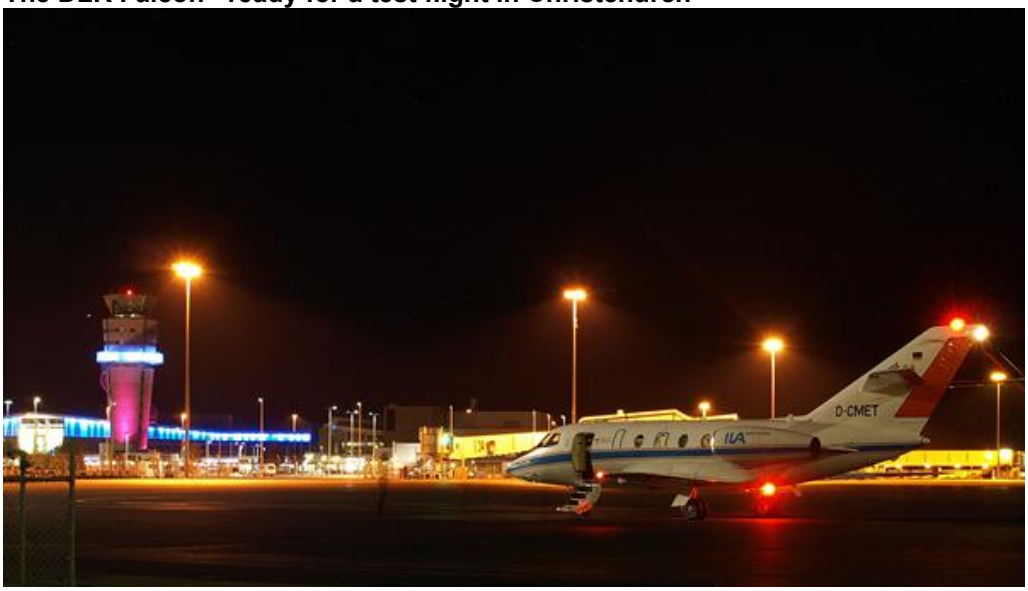
Gravity wave activity: Clouds over Lauder at sunrise

Gravity waves are formed when atmospheric circulation systems are disturbed. They manifest themselves as periodic temperature, pressure and wind fluctuations, which propagate up into the middle atmosphere, comprised of the stratosphere and mesosphere.

Credit: LMU.

The DLR Falcon - ready for a test flight in Christchurch



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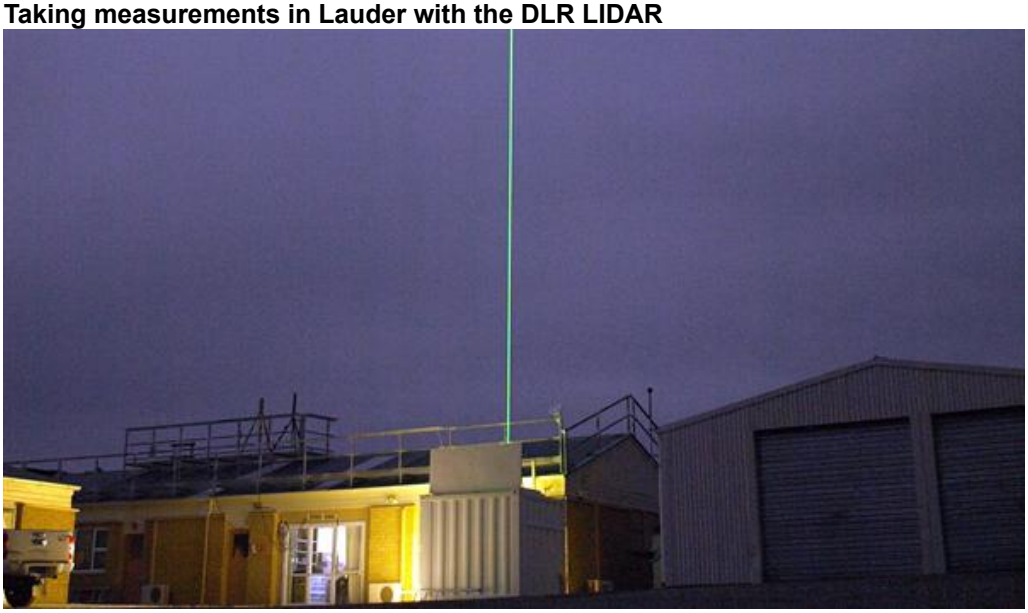
Credit: DLR (CC-BY 3.0).

Taking measurements in Lauder with the DLR LIDAR



A mobile DLR LIDAR, which is housed in a container at NIWA's Lauder Atmospheric Research Station, also serves as an information source for studying gravity waves in the mesosphere.

Credit: DLR (CC-BY 3.0).

DLR Falcon over the South Island of New Zealand

Gravity waves are found, for example, where strong winds meet high mountains. In New Zealand, this phenomenon occurs where the wind passes over the Southern Alps. Gravity waves have already been observed over the southern peninsula of New Zealand and the surrounding Southern Ocean.

Credit: NCAR.

The NCAR Gulfstream V above New Zealand

With its upward-looking LIDAR, the NCAR Gulfstream follows the course of the waves into the middle atmosphere.

Credit: DLR (CC-BY 3.0).

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