Exploring gravity waves in the Pyrenees by ground based observations, in-flight measurements, and model analysis

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We report preliminary results obtained both during a long term campaign to study mountain gravity waves and orographic precipitation (GWOP 17) and for glider based in-flight data monitoring .

The scope of the field campaign is to improve the knowledge of mountain waves and associated processes: rotors and subrotors, turbulence and boundary layer separation, to study the dynamics and microphysics of the precipitation processes influenced by orographic effects, with emphasis on heavy precipitation events, and to analyze the interaction of gravity waves with cloud structures and its influence on precipitation.

The field campaign took place from October 2016 to April 2017 in the higher Segre valley in the southern part of the Pyrénées. The valley is located in the Cerdanya county and consists of a relatively flat area located at 1100m above mean sea level (AMSL) surrounded by mountains mostly aligned west to east and exceeding 2900m AMSL. In the West it narrows into a more incised valley and in the East it is limited by the Col de la Perche 1500m AMSL.

Ground based instrumentation such as lidar, UHF radar, microwave radiometer, wind profiler, ceilometer, and disdrometer was located at or in the direct vicinity of La Cerdanya aerodrome, and a large number of temperature and humidity sensors were distributed all over the valley. In addition, radiosonde and tethered balloon measurements were carried out. Among the monitored data are horizontal wind, vertical wind profiles, temperature and humidity profiles, and turbulence parameters.

Observational data have been screened for the occurrence of gravity waves in order to identify relevant atmospheric parameters indicating trapped lee-wave mountain events. Selected events have been analyzed using the Weather Research and Forecasting (WRF) Model. The model is able to capture a trapped lee-wave event using the 1 km horizontal grid model outputs. Finally, the model results are compared to the observational data.

A serious limitation of ground based instrumentation is its limited observation range. Thus, we have explored the possibility to complement ground based observation by in-flight measurements using sailplanes equipped with state of the art miniaturized measurement equipment in accordance with the space and energy available. With the advent of small yet very powerful all-in-one computers such as the Raspberry Pi or the Arduino and a tremendous amount of low cost, yet powerful and reasonably accurate sensors it has become feasible to build a data logger for gathering meteorological and flight data for mountain wave research. The hardware consists of pressure sensors for static and dynamic air pressures, a high resolution GPS, a real time clock, an outside air temperature probe, a 3-axis gyroscope, a 3-axis accelerometer, a 3-axis digital magnetic compass as well as air temperature and humidity sensors.

The potential of glider-based in-flight meteorological monitoring is highlighted for a wave event in the Cerdanya valley in the spring of 2015. Turbulence, potential temperature, and vertical wind have been determined for altitudes up to 6000m AMSL. Based on this demonstration, the prospect of combining ground-base observation with glider-based in-flight data monitoring and model analysis is discussed.