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In-situ measurement of the airflow over an escarpment with a UAV

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The expansion of renewable energies continues to be a priority in Germany. However, the design and placement of wind energy turbines in the diverse landscape of southern Germany requires a good understanding of the wind flow over complex terrain.

As part of a joint research project operating a wind turbine test field, the Environmental Physics working group of the University of Tuebingen uses the MASC (Multipurpose airborne carrier), an unmanned aerial vehicle (UAV) to carry out in-situ measurements over an escarpment.

The MASC is an electrically powered unmanned airplane with 3 m wingspan and a weight of 5 kg. It is capable of autonomous flight along a predefined flight pattern with flight times of up to one hour and a range of about 80 km. The sensor payload consists of temperature sensors, a humidity sensor, a flow probe, an inertial measurement unit and a GNSS. Fluctuations of wind and temperature can be measured with a resolution of up to 20 Hz and are stored internally, while a lower resolution telemetry feed is available in real time for the UAV operator.
In past projects, only flights with a fixed altitude above sea level were possible. With the implementation of the new Pixhawk autopilot system, the MASC can now keep a certain altitude above ground level and possesses sufficient precision to fly at a very low altitude.

To generate a profile of the wind flow over the escarpment, a series of straight, very low altitude “race-track” flights perpendicular to the escarpment are carried out. A grid pattern is flown along the escarpment edge to measure the lateral distribution of the wind flow. The data from this flight strategy is also used for comparison with numerical models.

The resulting data, which will be presented here, completes our understanding of the wind flow over complex terrain and the influence of topography and terrain roughness. Results from these measurements will be used to verify numerical simulations of the escarpment carried out by another research group. The advanced features of the new autopilot will also lead to a wider range of possible applications for the MASC in future projects, enhancing its already superior flexibility for in-situ wind measurement.