gLidar: Multimodal observation of atmospheric convection

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https://glidar-project.github.io

A data-driven approach to characterise convection combining Eulerian and Lagrangian observations from paraglider, sailplanes, and LIDAR.

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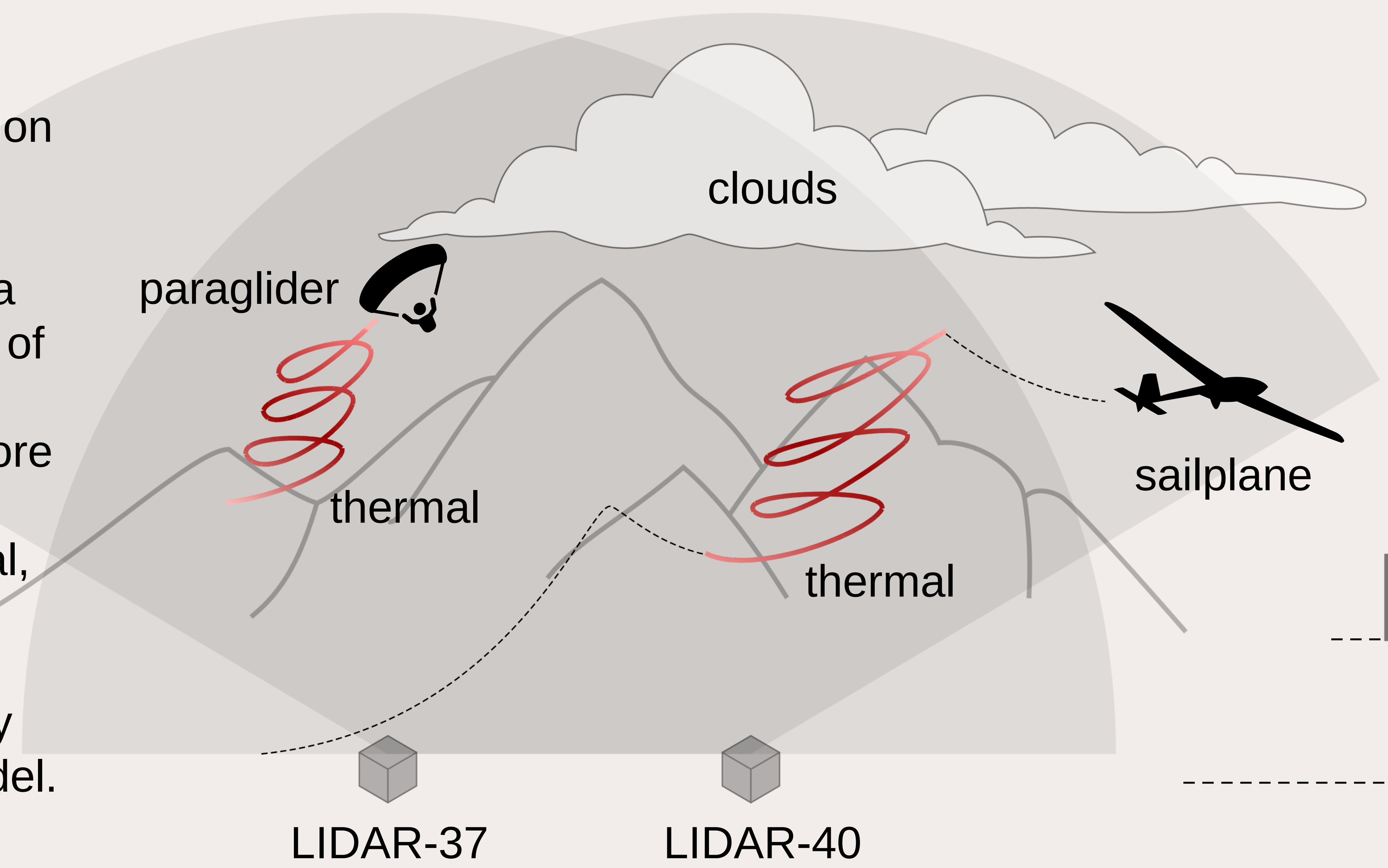
Background

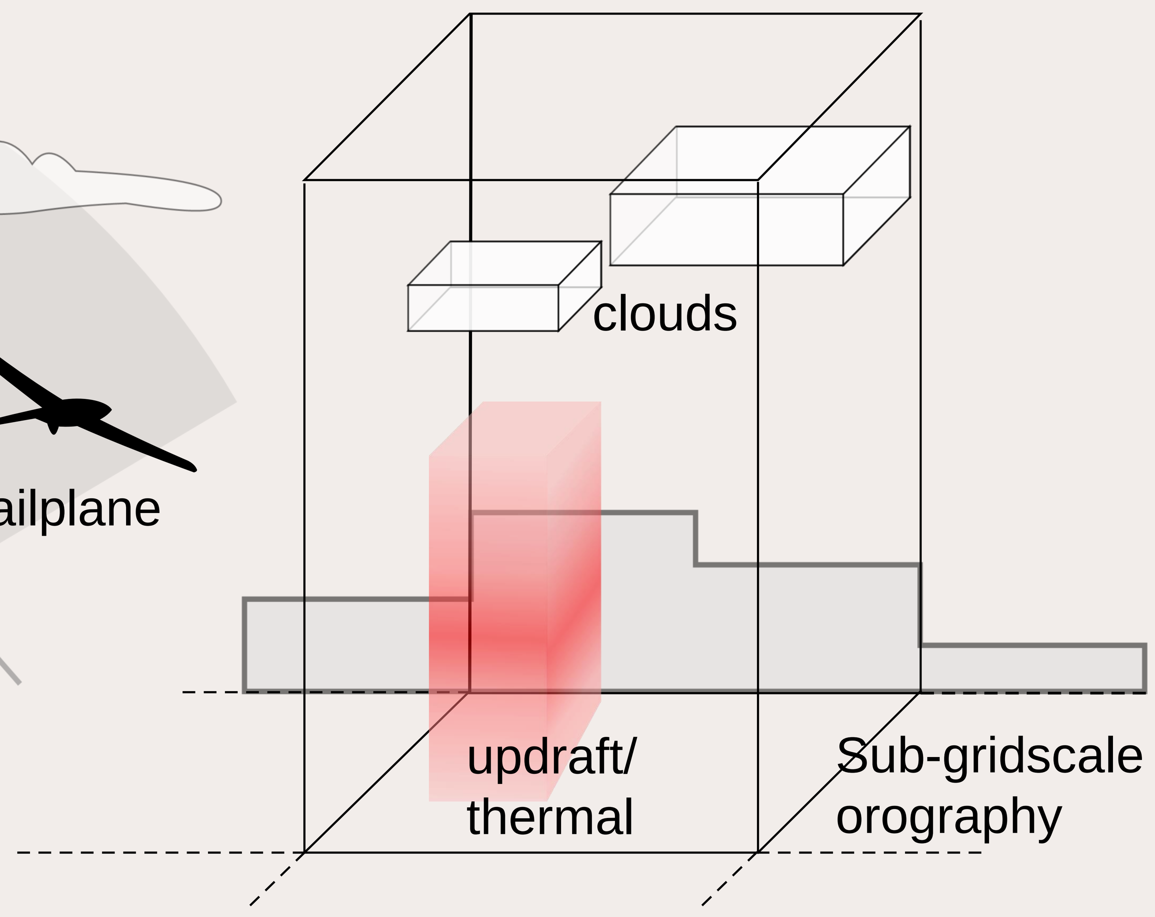
Atmospheric convection describes the process of warm air rising due to density differences. It is responsible for moisture and energy transport in the lower atmosphere and cloud formation. Due to the small-scale characteristics of the process, the treatment of atmospheric convection in state-of-the-art simulations has to rely on simplified equations called parameterizations. The parameterization schemes are a key source of uncertainty in weather prediction and climate modelling.

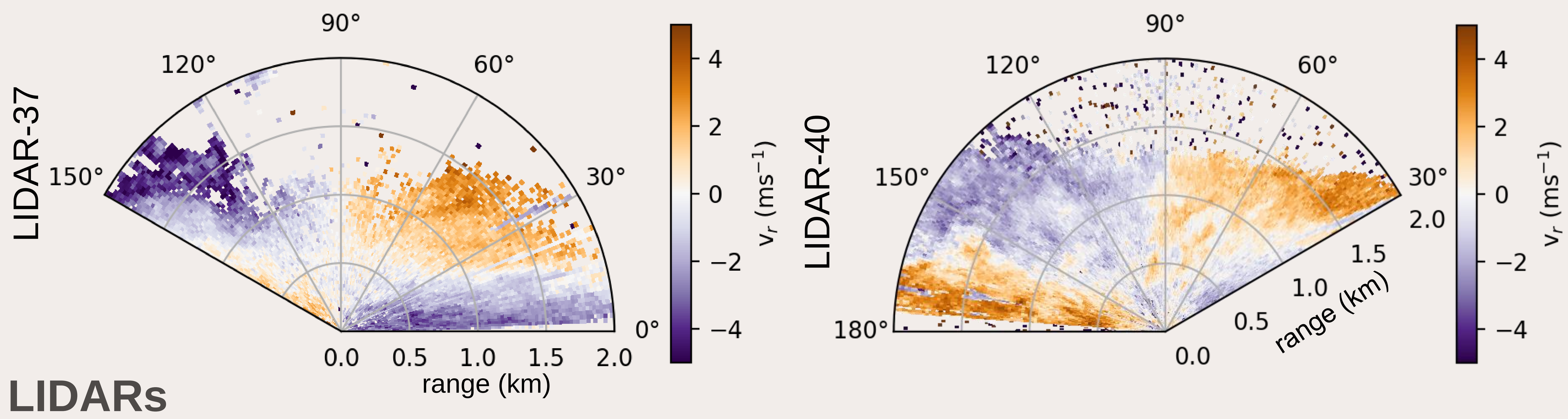
In this project we characterise and describe the atmospheric convection process using a data-driven approach, combining laser light detection and ranging (LIDAR) systems, together with tracks of paragliding flights carrying temperature sensors. We use this unique insight into convection to compare it to the parameterization scheme in the HARMONIE-AROME numerical weather prediction model, in operational use at the Norwegian Meteorological Institute.

Methodology

The most challenging part of observing convection is its localisation. We use vertically scanning doppler lidars with overlapping fields of view to obtain a 2D slice of the wind field that provides a cross-section of the thermals. We use tracklogs of paragliding flights, advected by the flow to reconstruct three dimensional structure of the core of the updraft. By combining these observations we can map out both the structure of the thermal, together with the surrounding wind field. Additionally, some of the paragliders carry iMet sensors to sample the temperature and humidity inside the updrafts to be compared with the model.

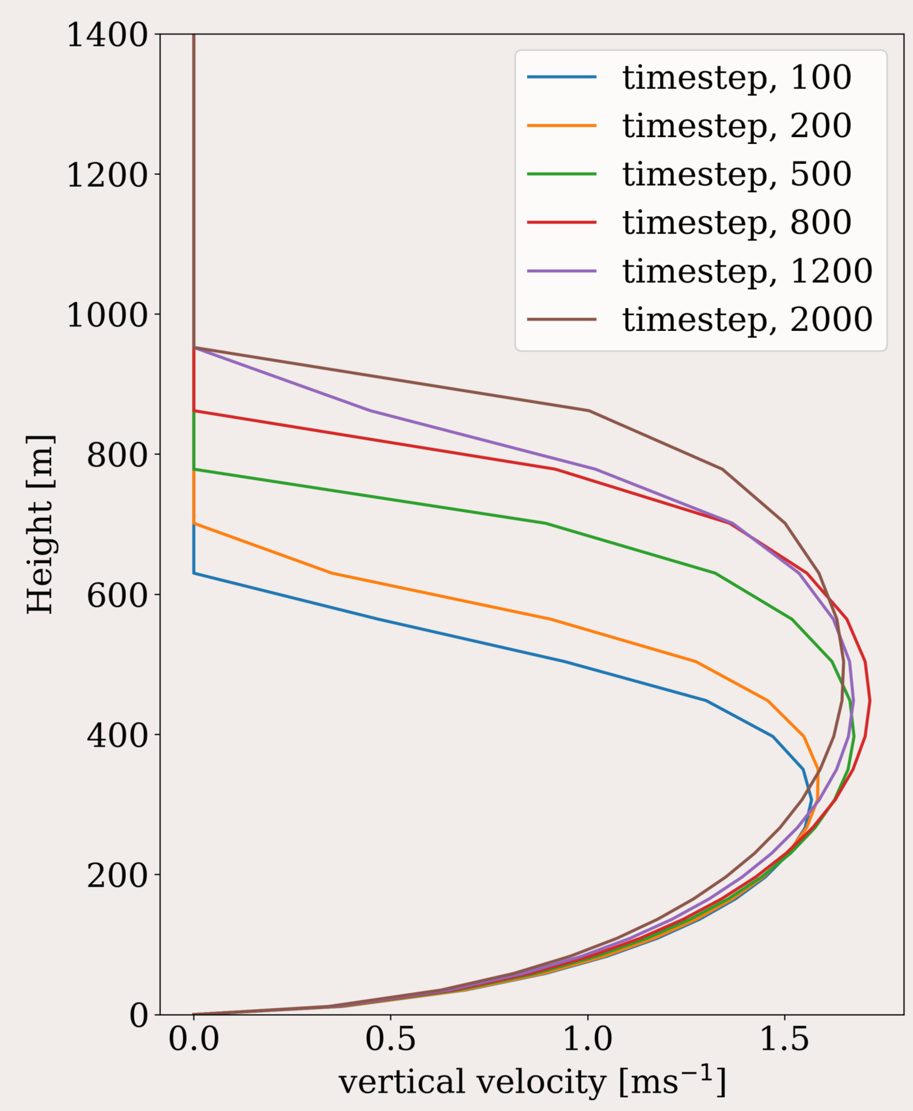






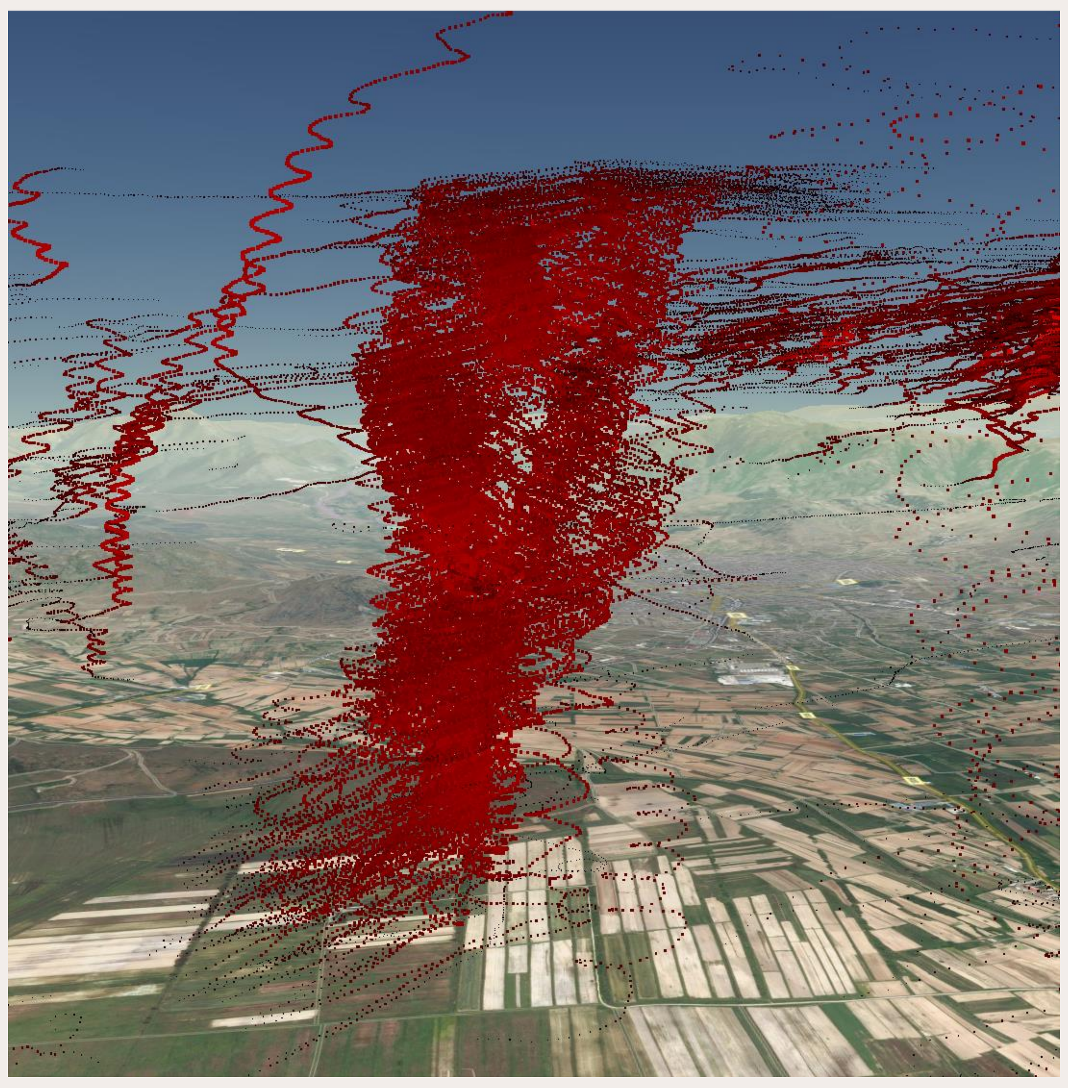
LIDARs

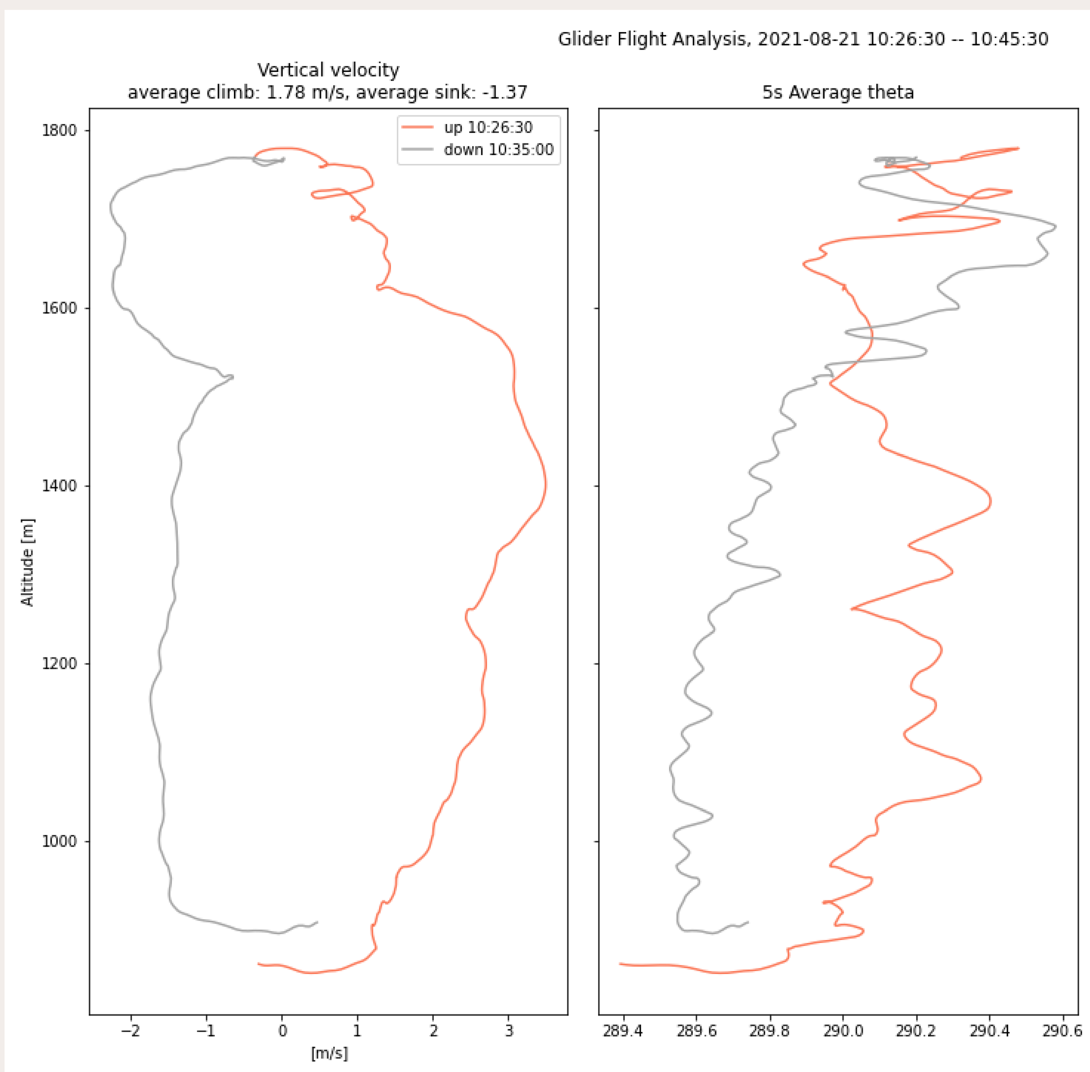
The LIDARs, each send out a laser beam, which interacts with the aerosol particles in the air, which are moved by the wind. From the doppler shift of the back-scattered beam, we obtain the line-of-sight or "radial" velocity, *vr*, of the wind at several range gates along the laser beam. From vertical slices we retrieve the horizontal and vertical wind. Example above shows data from Ulven airport on 17.05.21 10:15 UTC.



MUSC

We employ MUSC (Modèle Unifié Simple Colonne), which is the single column model of the HARMONIE-AROME model. A single column model separates a vertical column from the full, 3D model, but retains all of the science and algorithms. One of these algorithms is the shallow-convection scheme, responsible for calculating the ensemble of updrafts (thermals) occurring within a model grid-box. The figure above shows the evolution of vertical velocity, calculated by the scheme over the course of one day.





Paragliders & Sailplanes

Paragliders and sailplanes utilise the updraft velocity in convective thermals to gain altitude. Both systems use a GPS to track their location during the flight. From the evolution of the the GPS location in time, we retrieve the vertical velocity of the thermal. Figure above on the left shows an example of a thermal reconstructed from multiple paragliding flights during the world championship in 2019. Figure above on the right shows example data recorded by an iMet sensor during a paragliding flight in Voss on 21. 8. 2021.

ACKNOWLEDGEMENTS

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