Prediction of Alpine Foehn from time series of GNSS troposphere products using machine learning

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Abstract

Remote sensing of water vapor using the Global Navigation Satellite System (GNSS) is a well-established technique and reliable data source for Numerical Weather Prediction (NWP) nowadays. One of the phenomena rarely studied using GNSS are foehn winds. However, since foehn winds are typically associated with significant humidity gradients between lee/luv sides of a mountain range, GNSS signals are also affected by their occurrence. Time series of tropospheric estimates reveal characteristic features like distinctive minima/maxima and a significant decrease in correlation between specific stations north and south of the main alpine ridge for dedicated foehn events. However, detecting such signals becomes increasingly difficult for large data sets.

Therefore, the present study develops an innovative approach for both detection and prediction of foehn events at the SwissMetNet (SMN) station Altdorf by utilizing machine-learning classification algorithms. We present results based on the different algorithms, using long-term time series of high-quality GNSS troposphere products from the Automated GNSS Network Switzerland (AGNES) as well as records of operational foehn index at Altdorf.

First case studies show very promising results, especially when reprocessed GNSS products are utilized. Detection- and alarm-based measures reach 65-85% and thus are comparable to those reported by studies using meteorological measurements. For operational prediction, some limitations due to the availability and quality of GNSS products in near-real time (NRT) exist. However, the performance might be enhanced significantly by including additional NRT products and improved data processing in the future.