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A machine learning-based regression technique for prediction of tropospheric phase delay on large-scale Sentinel-1 InSAR time-series

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Spatiotemporal variations in temperature, pressure, and relative humidity in the atmosphere produce the biggest source of error in InSAR data. The tropospheric phase delay effects can be partly mitigated by applying the advanced Multi-Temporal InSAR (MTI) methods aiming at retrieval of the velocity field and displacement time-series using a stack of SAR data. However, applying MTI methods on the tropospherically-corrected interferograms further improves the accuracy of velocity and displacement time-series. One way for the tropospheric delay correction in interferograms is using external sources such as ERA-Interim model or the Global Navigation Satellite System (GNSS). However, interpolation of the data is a big challenge, as we need to find a suitable function to predict the delay for the whole interferogram, which is challenging for large-scale Sentine-1 interferograms.
In this study, we propose a new technique based on machine learning (ML) Gaussian processes (GP) regression approach using the combination of small-baseline interferograms and GNSS derived zenith total delay (ZTD) values to mitigate tropospheric phase delay. The method facilitates the corrections, as we do not need to deal with finding a suitable function for interpolation of low-resolution and/or sparsely distributed external observations. We implemented our method on 12 concatenated frames of Sentinel-1 images acquired between May-October 2016 along a track over Norway.
The results on the stack of large-scale Sentinel-1 interferograms showed that the ML-based method improves tropospheric corrections by 81% compared to 47% and 50% RMSE reduction gained by using ERA-Interim and GNSS only, respectively. In addition, sensitivity analysis to the number of training data showed that the ML-based method is robust in the case of few GNSS stations. Comparing the displacement time-series derived by small-baseline interferograms corrected by our method with GNSS measurements showed overall RMSE of 5.2 mm.