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Detection of Volcanic Deformations in InSAR Velocity Maps - a contribution to TecVolSA project

Teo Beker, Homa Ansari, Sina Montazeri, and Qian Song
Remote Sensing Technology Institute (IMF), Weßling, German Aerospace Center (DLR), Germany

TecVolSA (Tectonics and Volcanoes in South America) is a project with a goal of developing intelligent Earth Observation (EO) data processing and exploitation for monitoring various geophysical processes in central south American Andes. Large amount of Sentinel-1 data over the period of about 5 years has been processed using mixed Permanent Scatterer and Distributed Scatterer (PS/DS) approaches. The received products are velocity maps with InSAR relative error in the order of 1 mm/yr on a large scale (>100km). The second milestone of the project was automatic extraction of information from the data. In this work, the focus is on detecting volcanic deformations. Since the real data prepared in such manner is limited, to train a deep learning model for detection of volcanic deformations, a synthetic training set is used. Models are trained from scratch and InceptionResNet v2 was selected for further experiments as it was found to give best performance among the tested models. The explainable AI (XAI) techniques were used to understand and analyze the confidence of the model and to understand how to improve it. The models trained on synthetic training set underperformed on real test set. Using GradCAM technique, it was identified that slope induced signal and salt lake deformations were mistakenly identified as volcanic deformations. These patterns are difficult to simulate and were not contained in synthetic training set. Bridging this distribution gap was performed using hybrid synthetic-real fine-tuning set, consisting of the real slope induced signal data and synthetic volcanic data. Additionally, false positive rate of the model is reduced using low-pass spatial filtering of the real test set, and finally by adjustments of the temporal baseline received from a sensitivity analysis. The model successfully detected all 10 deforming volcanoes in the region, ranging from 0.4 - 1.8 cm/yr in deformation.