REVISITING CZECH SYSTEM FOR INSAR MONITORING USING SENTINEL-1 DATA

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Abstract

This contribution will revisit a complex system established to prepare analysis ready data from Copernicus Sentinel-1 satellite system, primarily to allow independent interferometric (InSAR) measurements of terrain deformation over Czechia, in both local and nation-wide scale. With the high revisit rate of 6 days, medium ground resolution of several meters and sensitivity to millimetric motion in the satellite line of sight (LOS), the quality of InSAR results from Sentinel-1 are applicable practically. This contribution will present results over selected areas of interest in Czechia, where a subsidence or other deformation was detected.

Keywords: Sentinel-1, SAR Interferometry, Subsidence

INTRODUCTION

Copernicus Sentinel-1 Synthetic Aperture Radar (SAR) satellite constellation offers a medium resolution radar imagery of the European continent every 12 days since October 2014 and every 6 days since autumn 2016. It covers whole Czechia from 9 different orbital tracks with an annual increment of approx. 6 TB.

As a reaction to increased demands on data storage and computing resources in the Big Data era, a system IT4S1 has been developed and has operated until 2019, establishing a specific workflow for processing data from Sentinel-1 satellite system over whole Czechia [1] that uses some of the technical solutions of an open-source LiCSAR system [2]. Sentinel-1 single look complex (SLC) data were specifically preprocessed using open-source tools, primarily ISCE2 [3] and stored in a Czech public infrastructure of CESNET Metacentrum.

In this work, we show basic differences between results of radar interferometry (InSAR) methods applied to the preprocessed dataset, demonstrate possibilities of precise measurements of terrain deformations, and provide recommendations for further development. Although the data also contains radar backscatter amplitude, also ready for multitemporal analyses, this work is focusing only on assessment of the interferometric phase.

METHODS

The Czech analysis ready data are stored per a burst unit that is an area typically 20x80 km in approximately latitude x longitude directions, in resolution of approximately 14x3 m (ground range). External grids per bursts containing coordinates can be used to transform the data in radar coordinates to WGS-84 geographic system if needed. The data allow direct processing using interferometry methods (InSAR), as they are already precisely coregistered, including spectral diversity correction and removal of topography-correlated phase [1].

In 2020, a full processing of the complete dataset was performed, using open-source persistent scatterer (PS) interferometry [4] tool STAMPS [5]. Several locations were analysed using other methods, such as small baselines (SB) interferometry [6] by STAMPS or NSBAS method [7] implemented in LiCSBAS [8], but further optimised and will be described within this contribution - e.g. selection of interferometric connections or optimised approach for phase unwrapping.

Finally, we have used the nation-wide PS processing results calculated within each burst, in reference to median values per burst. We have removed 2-D trends overall each burst and used standard deviation estimated for the final velocity estimate to weight spline interpolator to reach a burstwise deformation trend. We then merge bursts related to each orbital track of the satellite and swath, correcting for the median difference between bursts. After such stitching, we refer velocity and time series values to a median of the whole scene within each track and swath. As each of such track mosaic is a result of data acquisition from different look angle and E-W direction, we were able to perform a decomposition to project the estimated velocities into vertical and horizontal (in E-W) directions of the estimated motion [9].

RESULTS

The difference of processing outputs between PS, SB and NSBAS implementation is demonstrated in Fig. 1 that captures an area affected by mining-related subsidence. While both PS and SB use a selection of pixels having a stable scattering properties throughout the whole monitored time period, the NSBAS approach allows for extracting information also for pixels that decorrelate, e.g. seasonally. However, many such pixels should be masked from the final products for dissemination as these may be biased by non-deformation signal. As will be shown by a comparison with insitu measurements, the high deformation gradient has been extracted using NSBAS approach in appropriate accuracy.

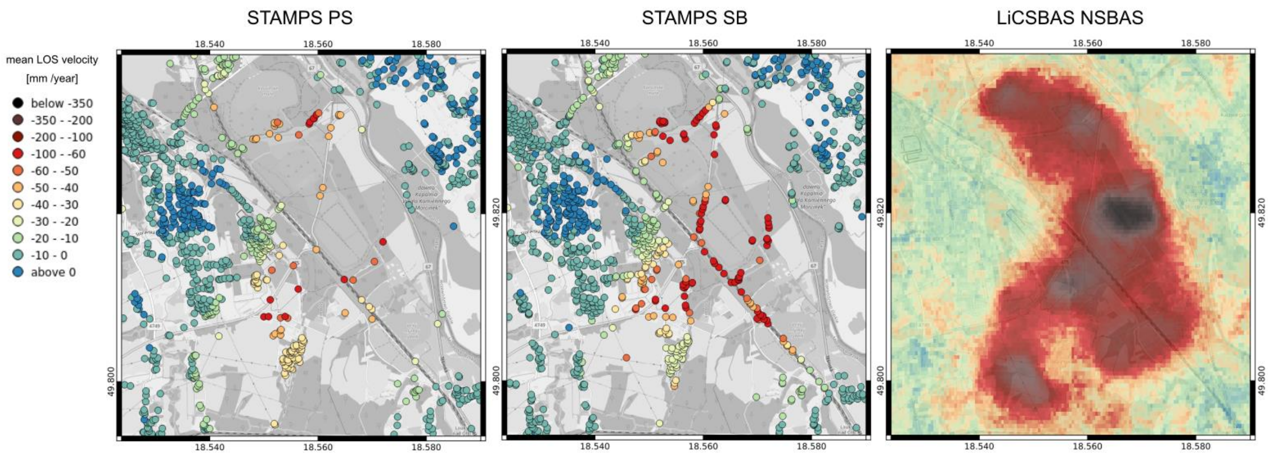

Fig. 1. Difference between processing results of PS, SB and (non-masked) NSBAS methods over an undermined area (CSM Mine).

The global stitched PS output over Czechia was prepared in two forms. First used a simple downsampling of PS point coordinates to a common grid, using their median value of deformation velocity recalculated into vertical direction (neglecting horizontal component), and is shown in Fig. 2. The second output is the interpolated result as explained in Methods and will be shown at the conference.

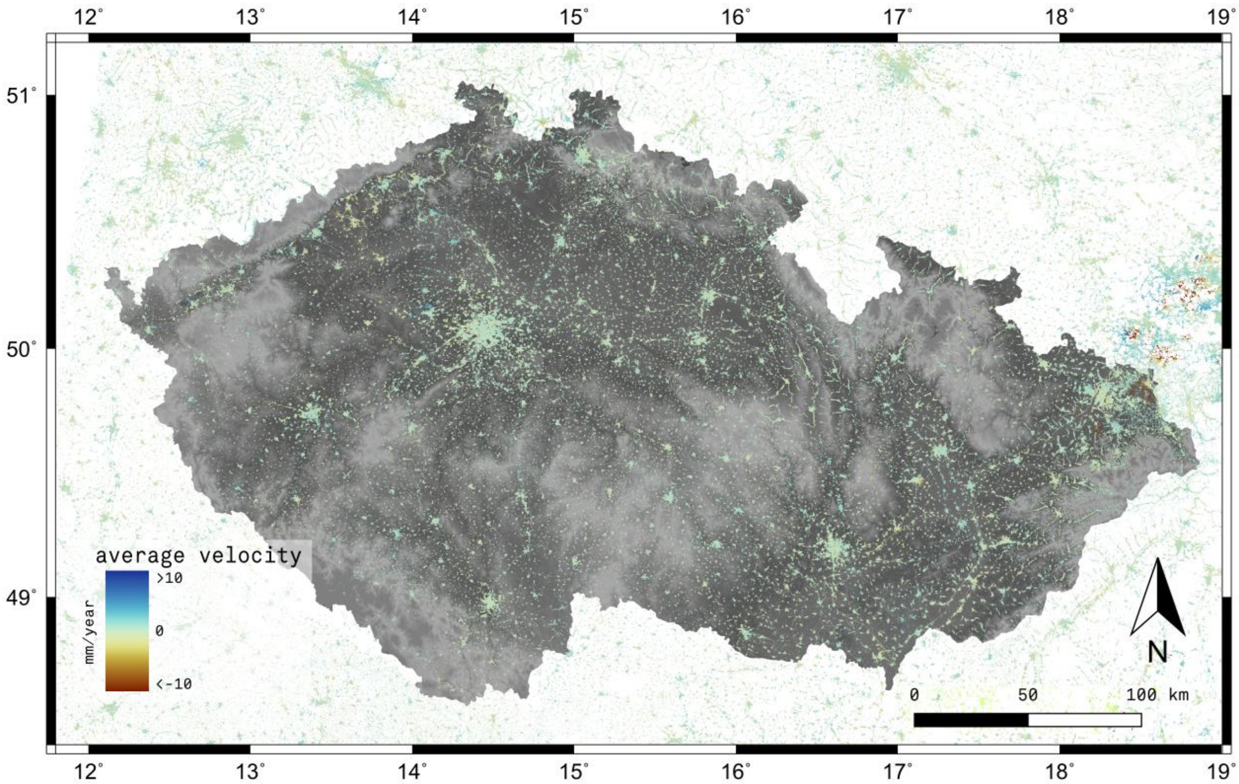

Fig. 2. A global output of PS velocity estimates over Czechia (downsampled to 100 m, no interpolation performed).

CONCLUSIONS

This contribution revisits an IT4S1 system that was used to perform nation-wide processing of Sentinel-1 data, interferometrically, using a supercomputing environment. The system is based on open-source tools and generated analysis ready data (both phase and amplitude of the radar backscatter data) are to be distributed in open access way. The system incorporates modern tools and is ready for further active development. Some of the experimental functions using Pangeo and other tools will be presented.

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