New results of interferometric processing of the northern Bohemia scenes

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1 Comparison of the two-pass and three-pass methods

We are processing a deformation pair, i.e. scenes acquired on March 8, 1999 (master) and December 28, 1998 (slave), and a tandem pair, i.e. scenes acquired on March 8, 1999 (master) and March 7, 1999 (slave).

When applying the three-pass method, the topography from the deformation interferogram is subtracted using the tandem interferogram; when applying the two-pass method, the topography is subtracted using an external DEM. We use the SRTM DEM with resolution of 3 arc sec.

The advantages of the three-pass method are the "automatic coregistration" of both interferograms and high resolution of the topographic interferogram. Due to the fact that both interferograms have common master scene, they are coregistered to a fraction of a pixel. Also, both interferograms have the same resolution. The disadvatage of the method is that there can be some errors in the topographic interferogram, e.g. atmospheric influence, or satellite orbit errors etc. They transfer to the deformation interferogram as artifacts. Another disadvantage of the three-pass method is that its application requires phase unwrapping of the topographic interferogram, which is not always reliable and sometimes is even impossible.

The advantage of the two-pass method is the errorfreeness (at least relative) of the external DEM. The accuracy of the SRTM DEM is cca 5 m, which is a negligible value considering our altitude of ambiguity (about 70 meters). An important disadvantage is the coregistration of the interferogram with the external DEM (the shifts are between 100 and 1000 pixels in the azimuth direction and between 10 and 100 pixels in the range direction): topography subtraction can be performed only approximately in DORIS. In addition, the resolution of the SRTM DEM is 3 arc sec, i.e. almost 100 m. After radarcoding the DEM, wrong-sloped areas must be interpolated in order to avoid areas without a height information (this is caused by an inoptimal implementation of the radarcoding step in DORIS).

Another advantage of the SRTM DEM is, in our case, the fact it was acquired a year after the other scenes (February 2000). The result is that we can find areas where no deformation can be seen in the interferogram with temporal baseline of two months, but we can see some changes in the interferogram with the topography subtracted using SRTM DEM. But, this is not probably the deformation we are looking for, this features can be classified as the "DEM error", measured with much smaller accuracy than a deformation. In a deformation interferogram, we usually cannot recognize deformation and the DEM error.

2 Results

As seen in figures 1 a 2, most of the area of interest is decorrelated in the deformation interferogram, although quite good correlated in the tandem interferogram. Although the scenes are acquired in winter season, there is a high grass in the area of interest, and the interferograms may be decorrelated due to new snow cover between the two acquisitions.

Also, the decorrelation may be caused by large deformations in the azimuth direction. The slope is oriented in the south-north direction and deformation measured by geotechnic methods are about 10–20 cms/year, but occuring mainly in spring and summer, when the rains are most frequent and strong.

The interferograms (both two-pass and three-pass) of the area of interest are shown in figures 3 and 4. A great part of the area of interest (marked red) is decorrelated in both interferograms. We would like to process a sequence of the scenes in order to see what is the cause of this performance.

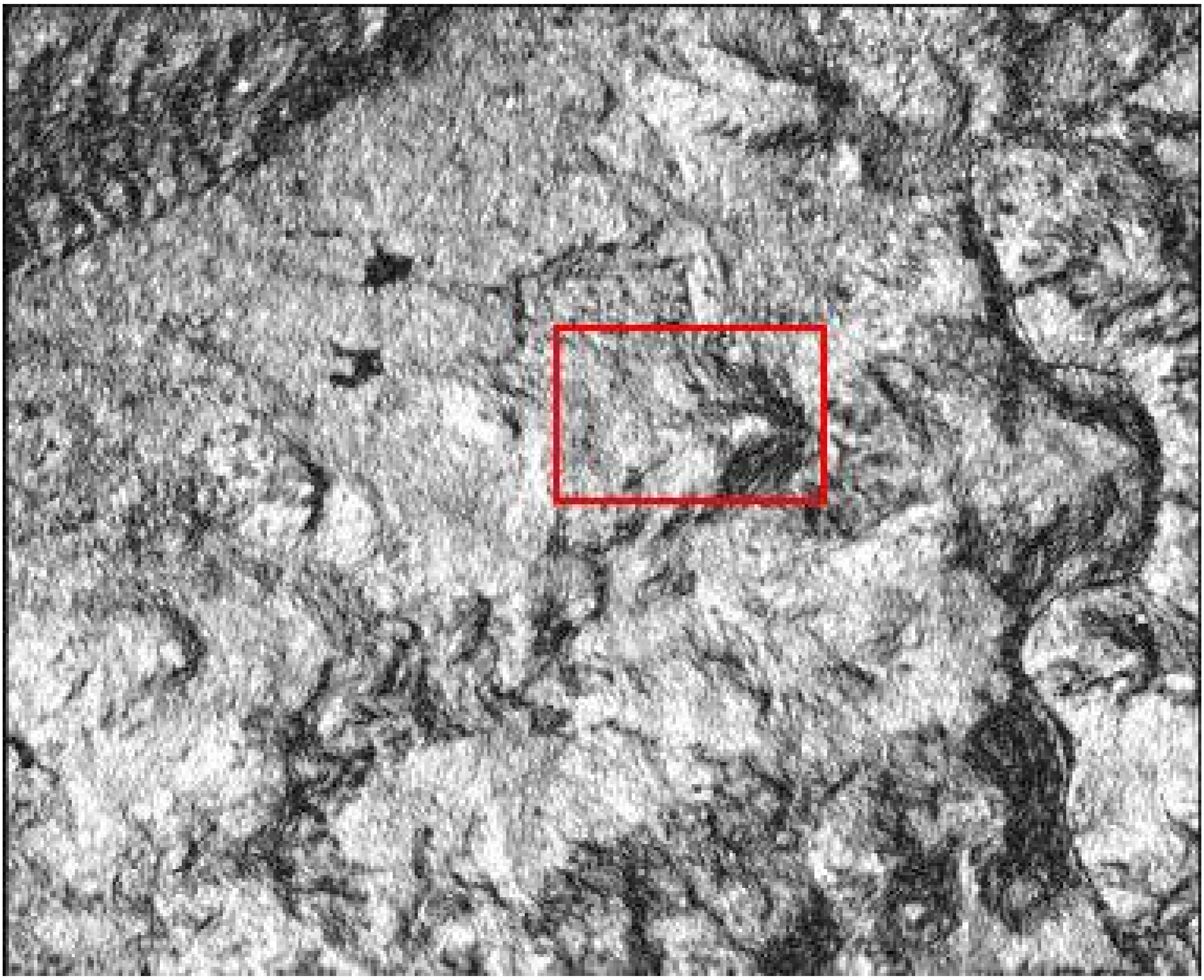

Figure 1: Coherence of the interferogram processed from March 8, 1999 and March 7, 1999 scenes. Area of interest is marked red.

In order to see the performation of the interferometric method, we processed also different part of the scene, not only the area of interest. In the sourthern part of the north-Bohemian coal basin (figures 5 and 6), some deformation areas can be seen. These are marked red and have quite sharp borders. We think that these areas are agricultural fields which are cared for in a different way than those surrounding them. Their coherence is a little worse than the coherence of the surrounding fields.

The orbit error influences can be seen in figures 7 and 8. Comparing them with each other, we can say that the orbit error influence is partially compensated in the case of three-pass method. In addition, in the two-pass interferogram there may be some errors caused by nonperfect coregistration between the interferogram and the DEM.

In figure 9, the "DEM error" feature can be seen. This is probably an active mining area and the error is caused by a DEM change between March 1999 and February 2000 (when the SRTM DEM was acquired). But, we are able to detect the "DEM changes" with accuracy which is much worse than the accuracy of detected deformations. In the deformation interferogram (center of figures 8 and 7), this area is decorrelated.

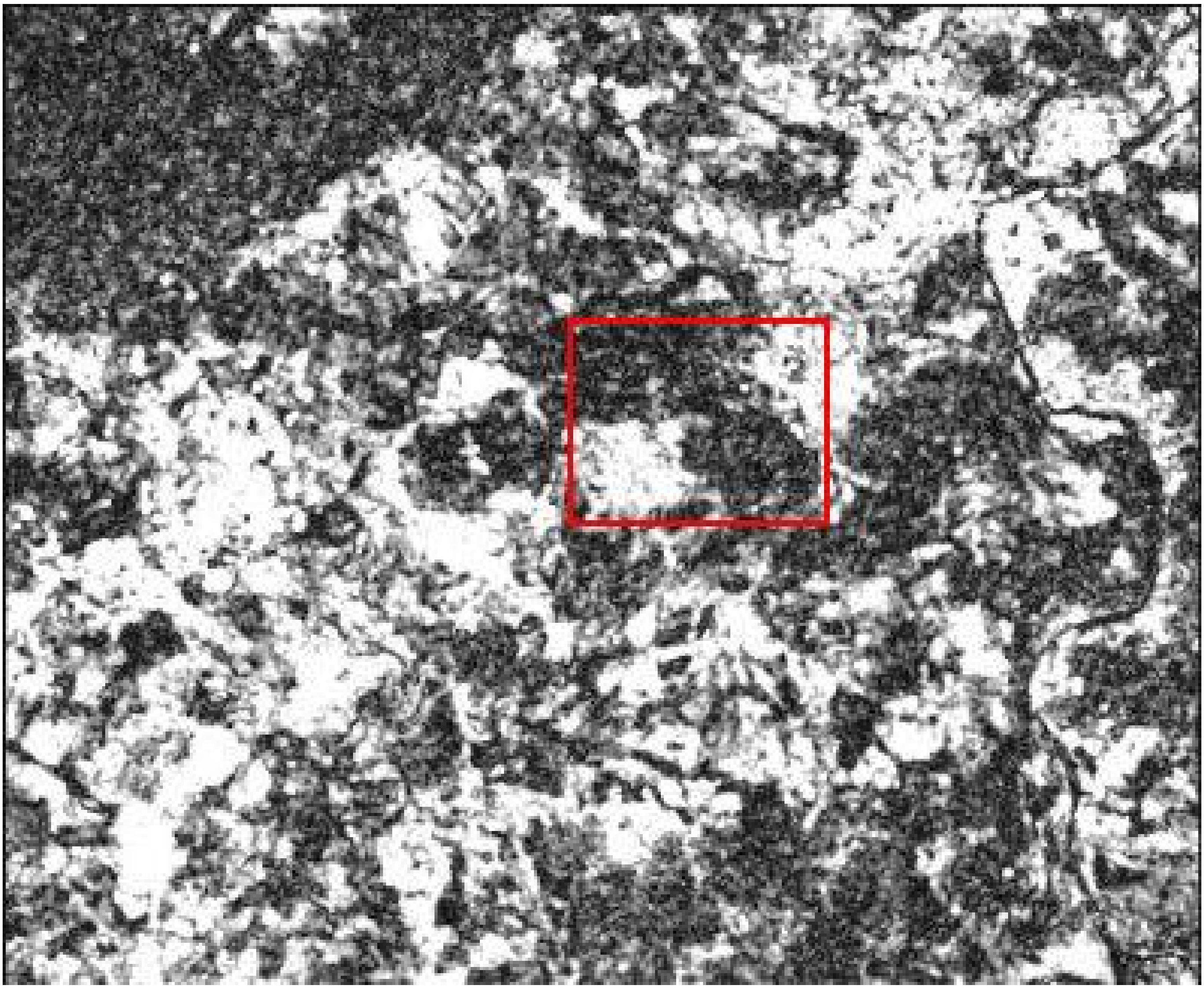

Figure 2: Coherence of the interferogram processed from March 8, 1999 and December 28, 1998 scenes. Area of interest is marked red.

3 Problems

We have several problems in our project testing radar interferometry in the mining area in northern Bohemia:

- The most important problem is the lack of data. We can just process three scenes: those acquired on March 7, 1999 (ERS-1), March 8, 1999 (ERS-2) and December 28, 1998 (ERS-2). Data selection was performed using too strict criteria as thought about now. The other two scenes cannot be processed yet, the reason is described below.
- Also, we miss interferometric pairs with small perpendicular baseline in order to recognize deformations from DEM errors.
- The scenes acquired on November 13, 2002 and February 26, 2003, are somehow distorted (either they are from non-parallel orbits or have a little bit different azimuth resolution) and DORIS software (which is the only accessible software for us) cannot process them (coregistration step fails). We would like to implement new methods to process this scene in future.
- The processed interferograms contain trend originating from orbit errors, which we were not able to eliminate yet . This is the first problem to solve in the future.

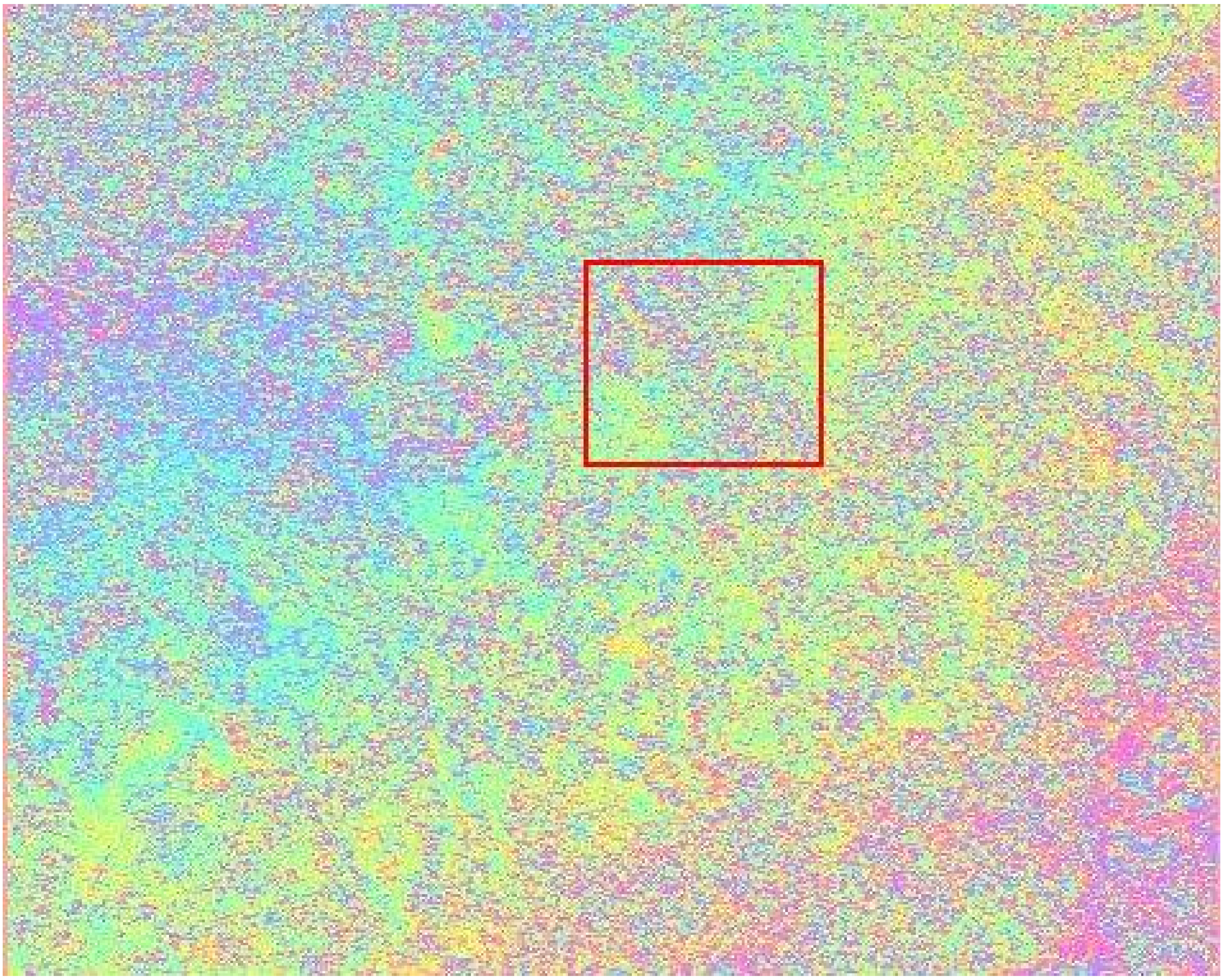

Figure 3: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (three-pass method, the area of interest)

4 Sensitivity of topography on InSAR data coregistration

A study of influence of topography on coregistration was performed during processing this project. It was realised by cooperation with the DEOS group at TU Delft.

In interferometric data coregistration, both the windows and polynomial approaches influence the offsets calculation and coregistration results because of topography in the area of SAR image. By using precise orbit data of ERS satellite and topographic information, we analyzed qualitatively the relation between offsets difference and several influence factors as elevation, distance from near range to far range and perpendicular baseline and the selection of the order of the polynomial for different kinds of topography. The results show that the DEM influence in range direction has a direct ratio relation with the elevation and perpendicular baseline but an inverse ratio relation with the distance from near to far range, the DEM influence in azimuth direction has a direct ratio relation with the elevation but small correlation with the perpendicular baseline and the distance from near to far range. Moreover, in the polynomial approach different orders of the polynomial are needed in different topographies to achieve more accurate offset result. The study shows that this influence is small enough to be neglected in our conditions. But in the case of Las Vegas area, the error reaches stumbling border of 0.5 px error in many parts . In figure 10, this influence can be seen.

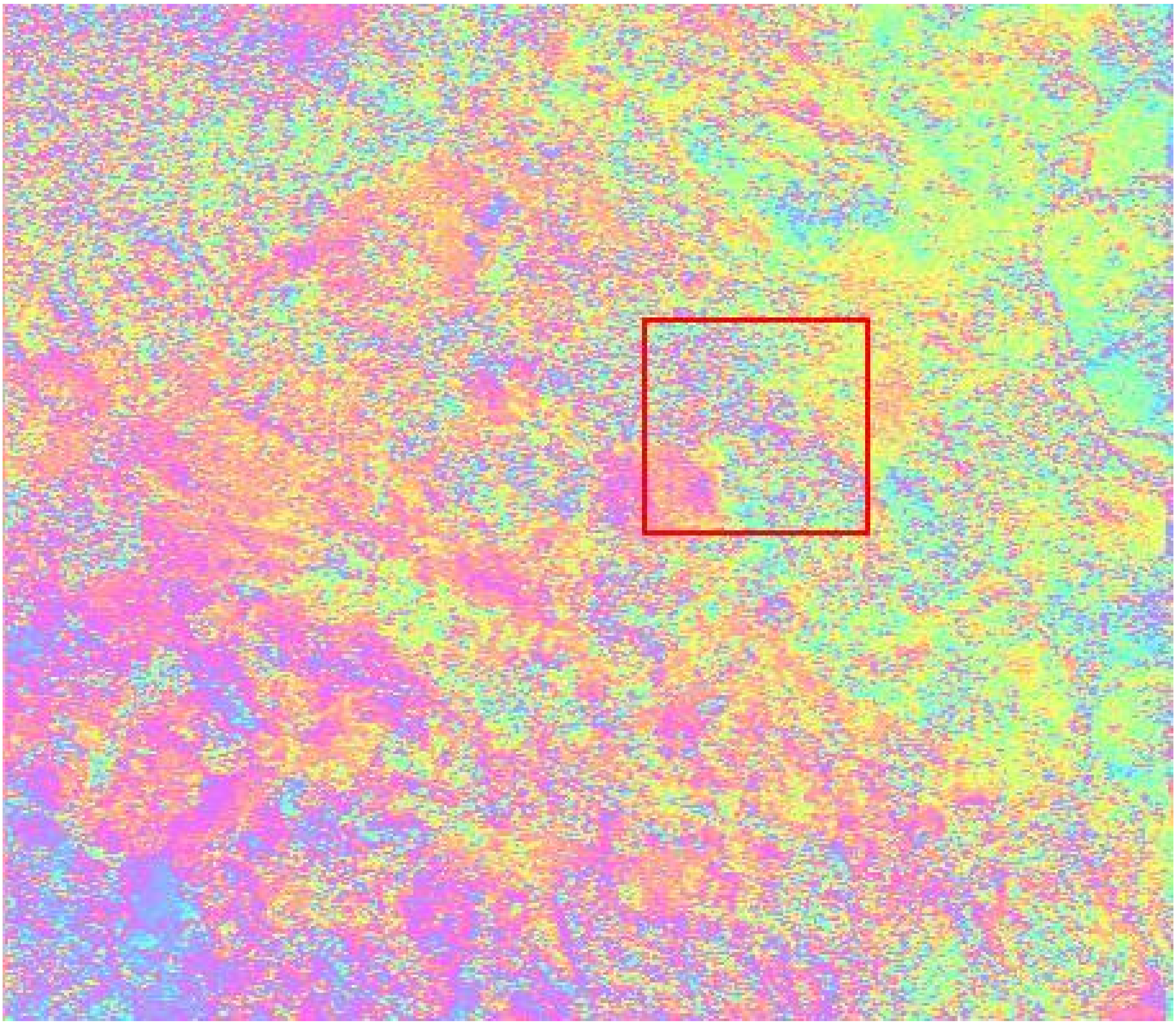

Figure 4: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (two-pass method, the area of interest)

5 Future work

First, we plan to eliminate the trend due to orbit errors from the interferograms. We would like to use the `cpxdetrend` utility developed by DORIS group at the Delft University of Technology.

At the same time, we will perform a new data selection, using less strict criteria with respect to the weather conditions, with a greater emphasis on the baseline values.

Next, we would like to implement and test a new method based on phase corregistration of the interferogram (with the topography included) with an external DEM.

We would also like to implement a method for corregistrating scenes of non-parallel orbits and process the pair acquired in 2002/2003.

References

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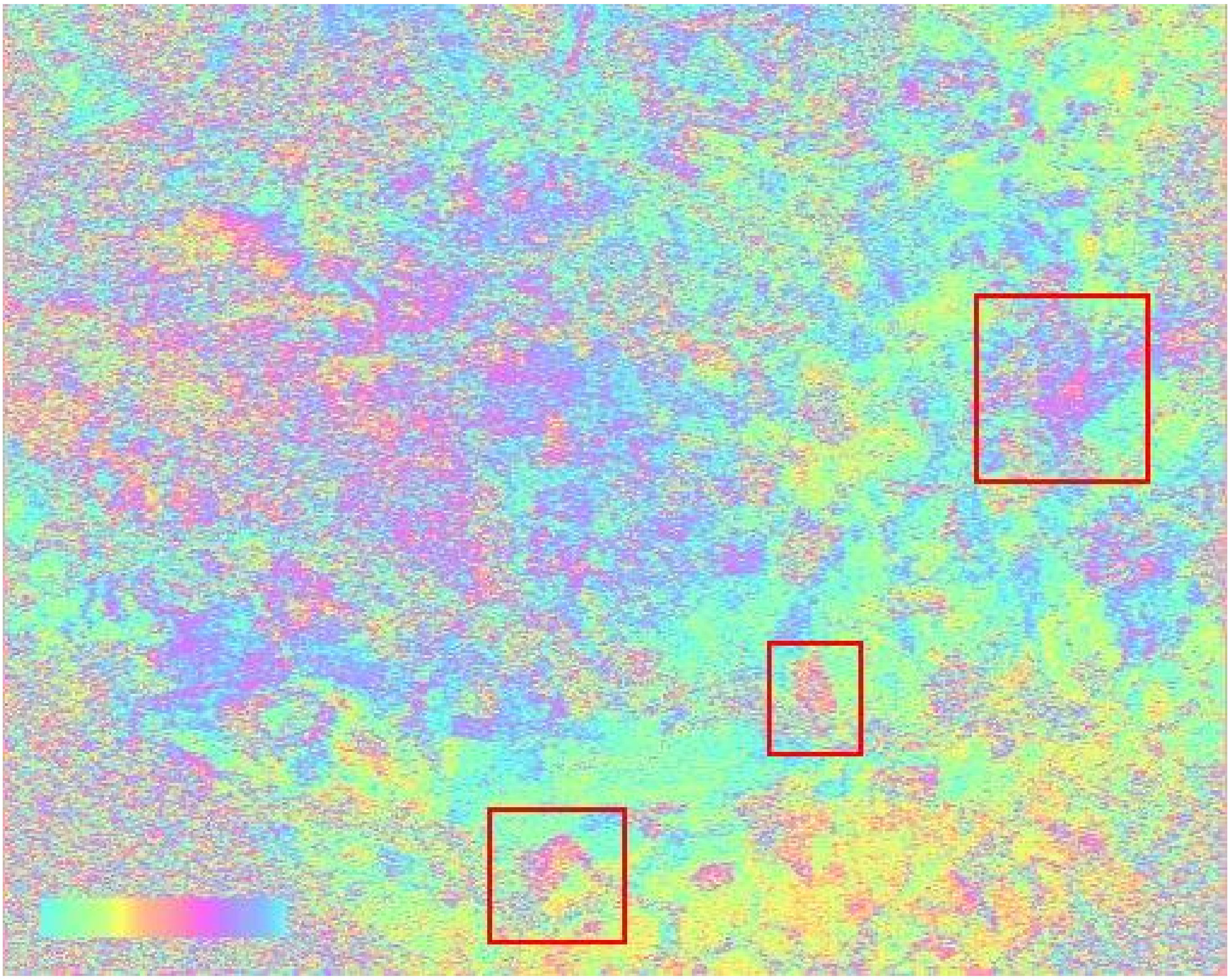

Figure 5: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (three-pass method, southern part of the north-Bohemian coal basin)

[2] Čapková, I.: Radar Interferometry: mapping deformations in northern Bohemia, Current problems in photogrammetry and Remote Sensing, seminar at CTU, faculty of Civil Engineering, 2004

[3] Kianička, J.: The potential of SAR Interferometry, Current problems in photogrammetry and Remote Sensing, seminar at CTU, faculty of Civil Engineering, 2004

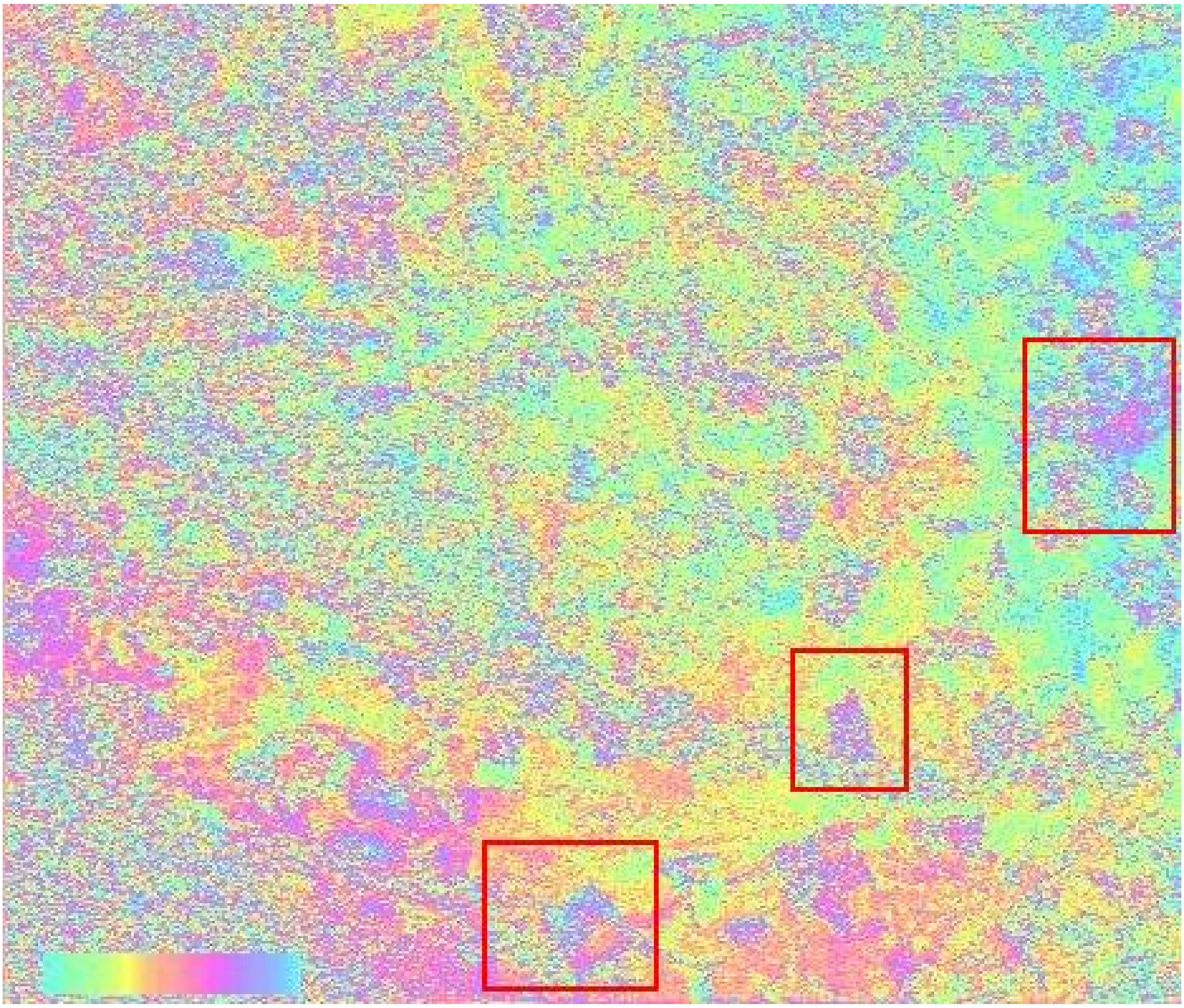

Figure 6: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (two-pass method, sourthern part of the north-Bohemian coal basin)

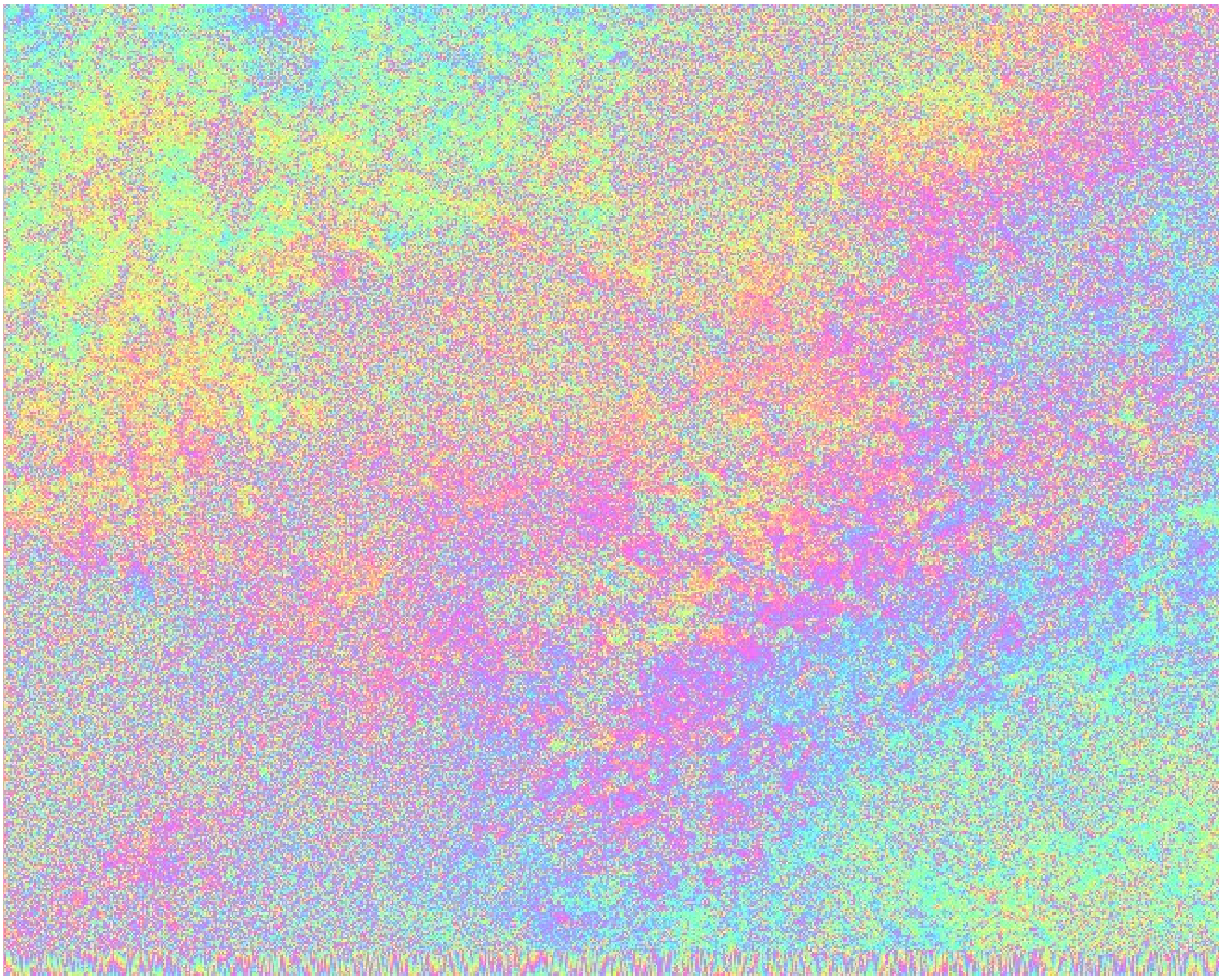

Figure 7: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (three-pass method, whole north-Bohemian coal basin)

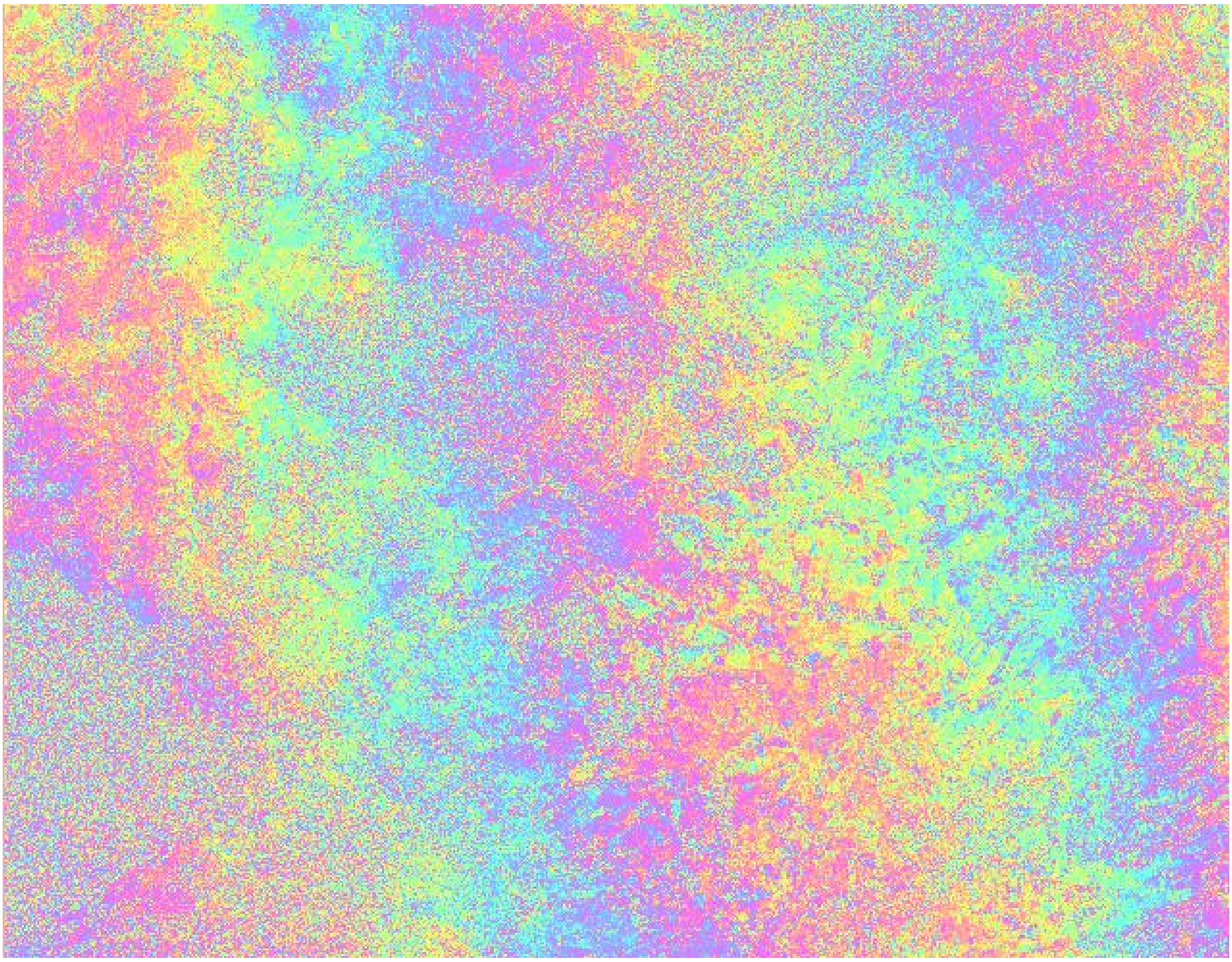

Figure 8: Interferogram processed from December 28, 1998 and March 8, 1999 scenes with subtracted topography (two-pass method, whole north-Bohemian coal basin)

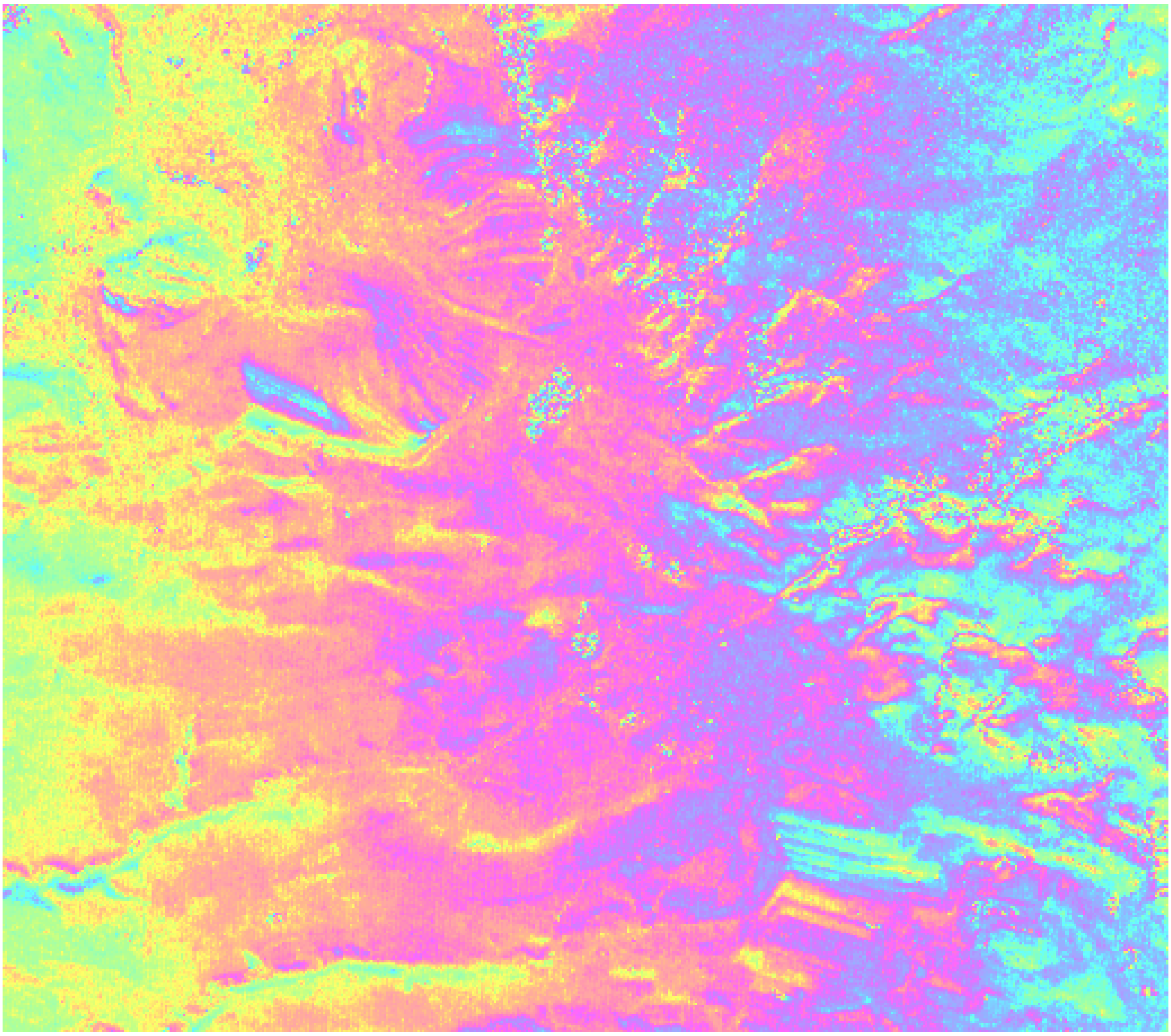

Figure 9: Tandem interferogram processed from March 7, 1999 and March 8, 1999 scenes, with SRTM DEM topography subtracted (center of the north-Bohemian coal basin

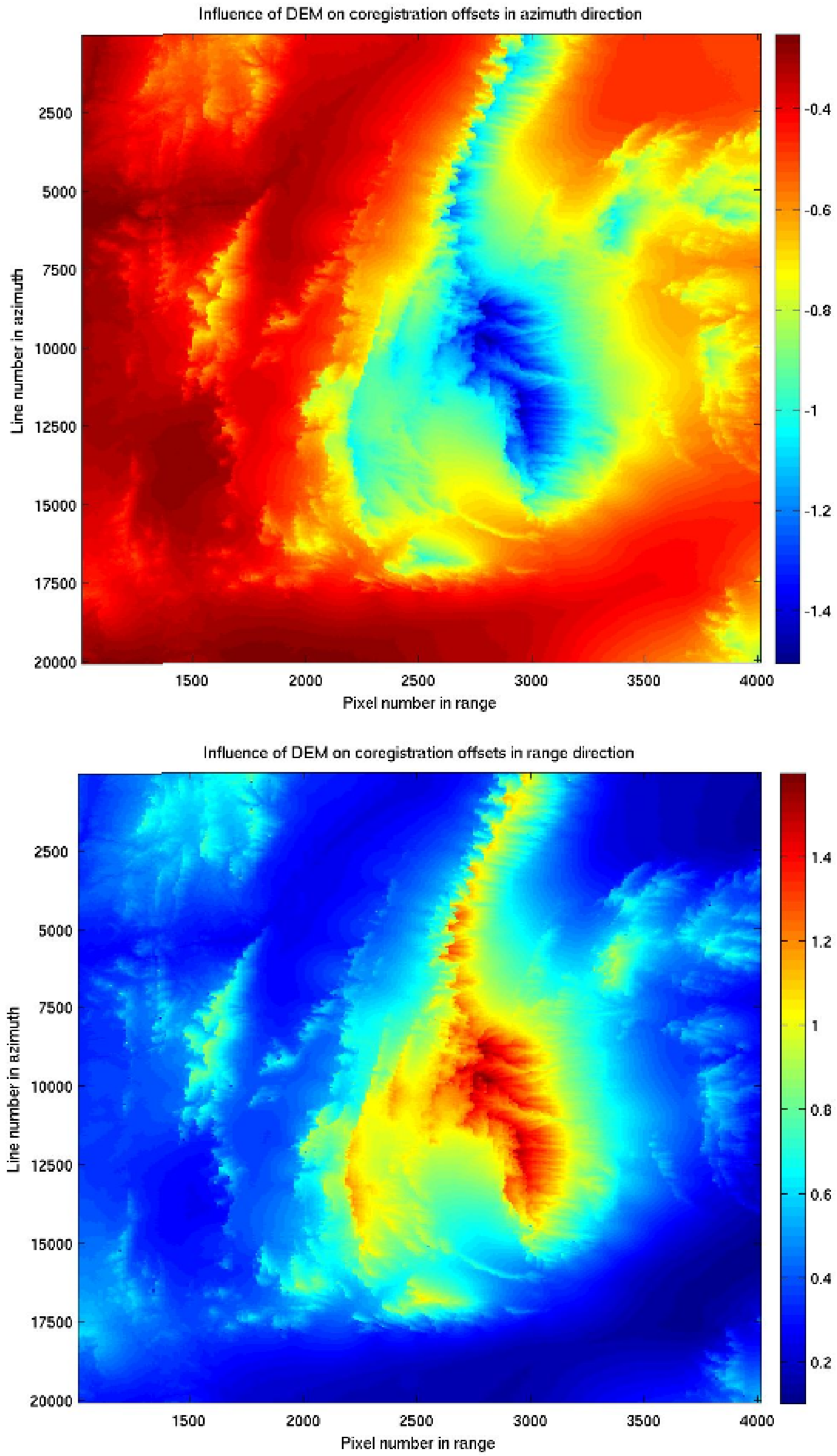

Figure 10: DEM influence on InSAR coregistration in both azimuth and range direction