RAY-TRACED TROPOSPHERE SLANT DELAYS FROM NUMERICAL WEATHER MODELS AS CORRECTIONS FOR INSAR

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1. INTRODUCTION

Highly variable weather conditions, especially the rapidly changing water vapor distribution, bias the interpretation of interferometric synthetic aperture radar (InSAR) images. Any change of atmospheric condition is reflected as differential propagation delay in the InSAR images, which is difficult to distinguish from the real ground motion. Moreover, for areas which cover a wide range of altitudes the proper treatment of the hydrostatic delay component becomes important, too. In the past there have been several studies using numerical weather models for compensation of such effects [1]. Founded on these investigations, we have developed an advanced troposphere delay mitigation algorithm, based on the computation of ray-traced delays for each InSAR pixel using 4D fine-mesh numerical weather models.

2. RAY-TRACED TROPOSPHERE DELAYS FOR INSAR

[2] have presented fast and accurate ray-tracing algorithms which are applicable to space geodetic techniques. But for InSAR, the requirements on the ray-tracer as slightly different as the concerned satellites are much closer than navigation satellites. Whereas for many space geodetic techniques, the vacuum elevation angle can be computed apriori and is used within the ray-tracing, in the case of InSAR one can not rely on this information as the corresponding satellite is only a few hundred kilometer away from the Earth's surface. Thus the initial value (azimuth, elevation) problem, in the case of space geodesy, transforms to a boundary value problem, i.e. position of satellite and georeferenced InSAR pixel. Nevertheless, the solutions described in [2] can be modified to solve the boundary value problem by an iterative strategy. Using a sophisticated algorithm for InSAR adapted ray-tracing allows to solve for the complex ray-geometry between each ground pixel and the satellite based on the 4D refractivity field. The total troposphere delays, including both electromagnetic delays and geometric excesses, along these ray-paths are computed for each scan. In the final stage two epochs are differenced to obtain differential troposphere corrections for the InSAR image. Beside the modification of the ray-tracing algorithms, the large number of rays, caused by the pixel dimensions of the InSAR images, turned out to be a challenge which has to be solved in order to obtain the atmosphere corrections with minimum computational effort. Since InSAR images consist of millions of pixels which correspond to independent ray-paths, a parallel algorithm has been developed which reduces the computation time to an acceptable amount of time.

3. SIMULATION RESULTS

In order to study a region which has strong temporal changes of refractivity and which covers a wide range of altitudes an InSAR image from the phased array type L-band synthetic aperture radar (PALSAR) over Hokkaido, Japan has been selected. Figure 1 depicts the ellipsoidal heights of the concerned area, revealing fine structures caused by steep mountains and small valleys. Before the corrections for the concerned InSAR image have been computed, a simulation study was carried out in order

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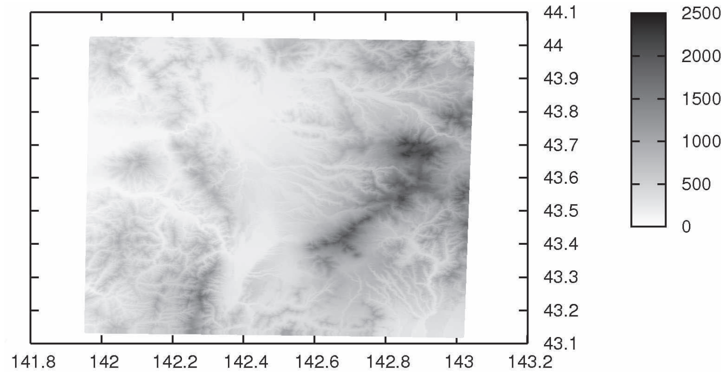

Fig. 1. Ellipsoidal heights (in meter) of the georeferenced InSAR image points.

to reveal the magnitude of the atmosphere biases. The meso-scale analysis (MANAL) data-set from the Japanese meteorologic agency (JMA) which offers the user a spatial resolution of 10 km, paired with a three-hourly time resolution, has been selected for the generation of the 4D refractivity fields. Figure 2 shows the results from a simulation run, assuming the satellite to be located at a height of 800 km at (lon = 140 degree, lat = 43.5 degree). The two InSAR epochs were simulated for 1.5 UT, DOY 100, 2007 and 0 UT, DOY 257, 2007, respectively.

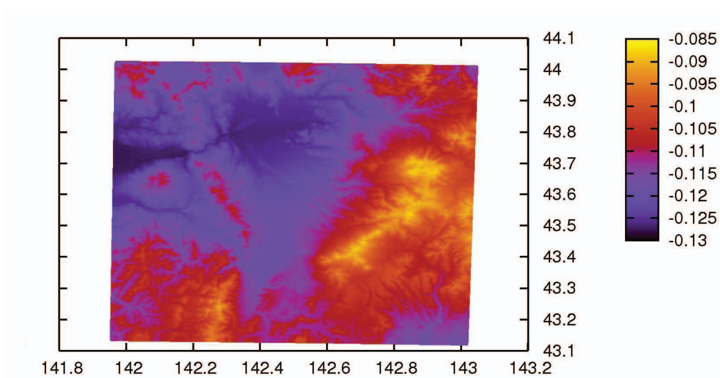

Fig. 2. Differenced ray-traced troposphere delays (in meter) between simulated PALSAR scans on 1.5 UT, DOY 100 and 0 UT, DOY 257, 2007, assuming identical satellite positions.

4. CORRECTION OF INSAR DATA

As confirmed by the simulation study (figure 2) water vapor causes the main part of the atmosphere noise in the InSAR images, but also hydrostatic delay contributions caused by extreme weather phenomena like Typhoons can lead to noticeable signatures, which might be interpreted wrongly as ground motions with long wavelengths. Thus, after ray-traced troposphere delays are introduced in the InSAR post-processing stage one can expect that the magnitude of atmosphere artifacts is reduced to a level which does not markedly bias the images. Results from this approach will be shown on the conference, together with an in depth discussion about the requirements on the utilized numerical weather models.

5. REFERENCES

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