A SPECIFIC METHODOLOGY FOR ATMOSPHERIC EFFECT REDUCTION ON SAR INTERFEROGRAMS

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1. INTRODUCTION

More than 35% of Southern Tunisia (pre-Saharan region, North Africa) is estimated to be at risk or at great risk of desertification. Monitoring the vegetation cover reduction in this region is therefore indispensable for combating and management of the desertification effects. Desertification monitoring needs to be frequent and periodic and this could not be possible with traditional ground surveys. Radar interferometry (InSAR) has proved its utility in the monitoring of desertification. However, the accuracy of the InSAR measurements is strongly conditioned with phase propagation delays through the atmosphere. The territory covered by this study is located in a coastal area in southern Tunisia, which is under maritime influence. Thus, atmospheric effects, particularly those resulting from the presence of water vapour result in a delay in the radar signal. This leads to an inaccuracy in DEMs generated by InSAR and therefore to uncertainties in the change detection in the desert extent that could be measured through a time series of InSAR DEMs. Various methods were developed for mitigating the atmospheric effects. It has been shown that methods based on ancillary data (such as GPS observations, ground meteorological data, and optic satellite data) are very effective and reduce the atmospheric effects by about 20-40 percents. In this paper, we propose a specific methodology for atmospheric effects correction on SAR interferograms generated over the Sothern Tunisia. It is based on ancillary data collected from NOAA-AVHRR sensor. The specificity of the approach consists in its applicability where no ground truth GPS measurements are available neither for calibration nor for result validation. An adaptive validation demarche is also proposed.

2. TEST SITE AND RELATED PROBLEMATIC

The study area covers some 22000 Km^2 and lies between coordinates (34°00', 11°15') and (32°00', 8°10') in the governorates of Tozeur, Medenine, Tataouine and Kebili.

In the studied area we can distinct four physiographic zones with considerable diversity of soils [1]:

- Zone 1: Coastal plains (called the Jeffara): Soils in arid areas undergo a low soil genesis. The most visible processes are the scouring and sedimentation under the action of the water and the wind.
- Zone 2: Mountainous areas (Matmatas) where agriculture is based on spate irrigation. In the mountains there are limestone and calcic-marly soils on which are developed lithosols characterized by a very shallow surface horizon (10 to 15 cm) with the rock breaking the surface here and there ; they have no agricultural potential.
- Zone 3: Large Depressions or "Chotts" where underground water resources are the origin of some oases. The soils of the zone of "Chotts" are influenced by the presence of salty materials.
- Zone 4: The Desert zone, the "Erg", formed of dunes of sand separated by small sandy depressions where develop a very sparse vegetation.

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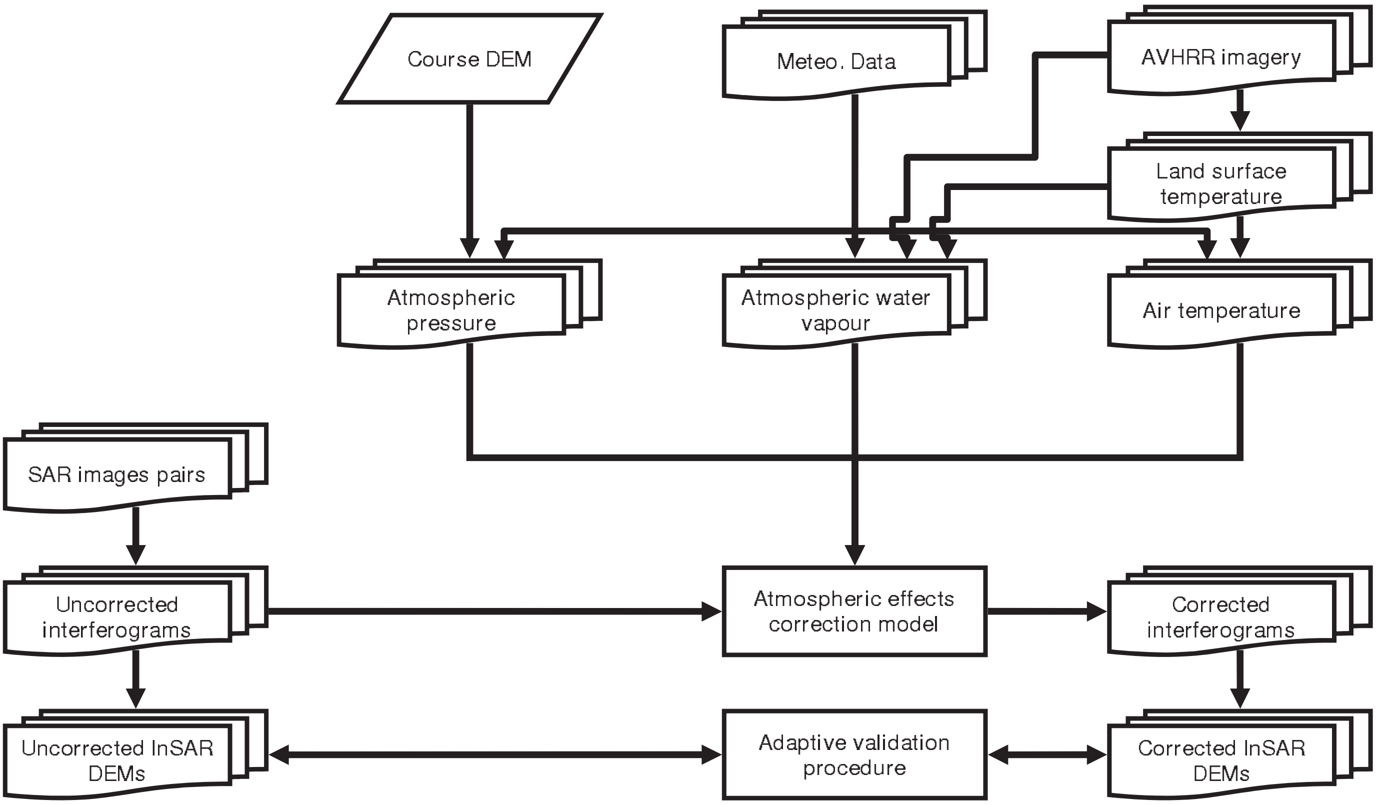

Fig. 1. The proposed atmospheric effects correction methodology.

In terms of precipitation, the Tunisian south can be divided into three climatic zones following the annual average rainfall quantities which are the semi-arid, arid and desert zones. The selected test site corresponds to a costal region with high temperature degrees most of the time. Thus, the evapotranspiration process would play a great roles in increasing the volume of the water vapor on the tropospheric related space. It is understood ([2]) that water vapor has the most significant effect on InSAR products. Moreover, in [3] it is demonstrated that atmospheric water vapor effects greater than 4 cm can be observed even in desert regions. Then, removes the water vapor effects on SAR interferogram is imperative in order to improve the accuracy of InSAR measurements.

Several techniques are currently available for monitoring atmospheric water vapor [4]. However, there are no current or planned global sources of observational measurements of atmospheric water vapor at appropriate temporal and spatial sampling scales to satisfy all the various needs [4]. indeed, existing water vapor effects correction models need a good temporal and spatial distribution of observations. Considering that over the selected test site, the water vapor distribution can be highly variable, existing correction models will not be accurate.

3. METHODOLOGY AND RESULTS

A semi empirical model for atmospheric correction based on auxiliary data has been adopted and applied in the context of southern Tunisia. This is the Saastamoinen model which is actually a simplified physical model (Saastamoinen, 1972) which has been applied successfully by several researchers and in different contexts (Janes et al, 1991; Hanssen and Feijt, 1996; Qu et al. 2008). To estimate the delay in the radar signal, the Saastamoinen model is based on three input meteorological variables:

- water vapour pressure
- air temperature
- atmospheric pressure.

Generally, these inputs are available from observations at meteorological stations for temperature and pressure. However, the spatially and temporally discrete nature of these observations and their non-optimal spatial distribution and density prevent from getting a spatially continuous correction over the whole study area. As illustrated by Fig. 1, we propose an approach that uses satellite AVHRR imagery; ground based meteorological observations and medium resolution DEM (1 km) to generate spatially continuous input data for the Saastamoinen model throughout the area covered by the interferograms.

Air temperature maps were generated by means of a polynomial function model calibrated using air temperature ground observations and correspondent Land Surface Temperature (LST) estimated from AVHRR imagery. The Becker and Li (1990) algorithm was employed for LST estimation using Sobrino et al. (2001) method for spectral land surface emissivity retrieval. Water vapour pressure was estimated over the study area applying the Choudhury (1996) model that relates ground level humidity to precipitable water. This later was extracted from AVHRR channel 4 and 5 brightness temperature difference and LST using a newly modified version of the algorithm proposed by Mottel et al. (2002). As for ground level atmospheric pressure, a simple exponential model was built relating terrain altitude given by the medium resolution DEM and atmospheric pressure measurements at meteorological stations. All estimation procedures were validated using corss-validation and results were very satisfactory. The proposed methodology was developed and tests using 8 ERS-1 SAR images pairs acquired in 1996 and 1999. The adaptive validation procedure consisted in calculating InSAR terrain elevation variances from each type of InSAR DEMs: uncorrected and corrected for atmospheric effects; and quantifying magnitude of InSAR elevation variance decrease or increase between the two types of DEMs. Results showed that the proposed correction approach reduces the DEMs variance in over than 85% of the study territory.

4. REFERENCES

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