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Radar interferometry for ground subsidence identification and monitoring using ALOS-2 PALSAR-2 data: a case study of KOSH region of South Africa

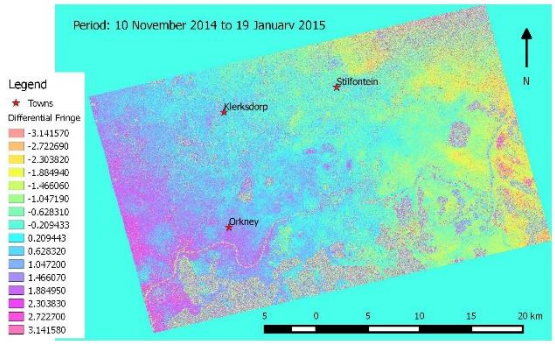
Thomas, A.

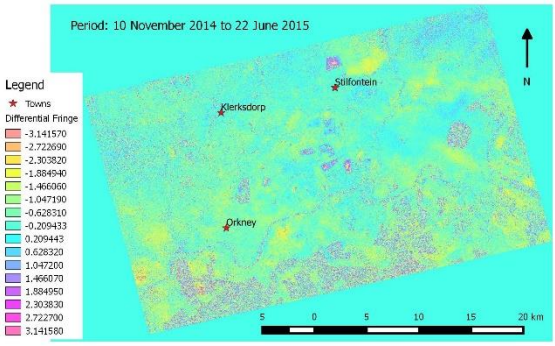
Council for Geoscience, P. Bag X112, Pretoria 0001, South Africa; Email: athomas@geoscience.org.za

This paper describes the results obtained from radar interferometry using ALOS-2 PALSAR-2 data acquired on 10 November 2014, 19 January 2015 and 22 June 2015 for the purpose of identifying small scale subsidence in the KOSH (Klerksdorp-Orkney-Stilfontein-Hartebeestfontein) region of South Africa, using the differential interferometric synthetic aperture radar (DInSAR) technique. The PALSAR-2 aboard ALOS-2 is a L band SAR sensor that emits L band radio (micro) waves and receives their reflection from the ground. Due to the higher range resolution (3-10m) and longer wavelength (L band) of PALSAR-2 images, fairly accurate displacement/subsidence maps can be generated using DInSAR) technique. The two pass DInSAR technique with SRTM DEM was used / applied on PALSAR-2 data in Strip Map mode having 70km x 70km swath, about 10 m range resolution and single polarisation (HH and HV) in order to identify the location and amplitude of ground subsidence/deformation. The PALSARReMap2 software ver3.0.0 developed by Ryoichi Furuta of Remote Sensing Technology of Japan (RESTEC) was used for the data processing and DInSAR analysis.

The adopted methodology for this analysis involves importing Level 1.1 SLC data in EOS format (range and azimuth compressed), creating amplitude images as 'master' (pre) and 'slave' (post) representing two selected periods, determining a subset area using QGIS, making parameter files of subset area and reference ground control point, extracting orbital information, sub-setting SLC data and orbital information, calculating slant range length, local incidence angle and making latitude/longitude maps, calculating coherence values and sub-setting images of amplitude, simulating orbital fringe, calculating initial fringe and topographical fringe, preparing SRTM-3 version 2.1 data and GEOID data for the study area, calculating parameters for DInSAR and orthorectification process using DEM, calculating differential fringe and fringe correction(if necessary), phase filtering of the differential fringe and finally orthorectification.

Three subsidence maps (interferograms) were generated with three PALSAR-2 images from ascending (night time) orbits for the periods: 10 Nov 2014 to 19 Jan 2015, 19 Jan 2015 to 22 June 2015 and 10 Nov 2014 to 22 June 2015 (Figures 1a & 1b). From the generated differential fringe images (interferograms) one can see that the predicted small subsidence areas are seen in the mine residue areas of KOSH region associated with the tailings dam and mine waste rock dumps.


Period: 10 November 2014 to 19 Januarv 2015
Legend
Towns
Differential Fringe
-3.141570
-2.722690
-2.303820
-1.884940
-1.466060
-1.047190
-0.628310
-0.209433
0.209443
0.628320
1.047200
1.466070
1.884950
2.303830
2.722700
3.141580
Stilfontein
Klerksdorp
Orkney
N
5 0 5 10 15 20 km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Stilfontein
Klerksdorp
Orkney
N
5 0 5 10 15 20 km

Figures 1a & 1b: DInSAR results of small scale subsidence in KOSH mining region and mine dumps.

A comparison of Figures 1a & 1b reveals that at some sites, the more subsidence occurred after January 2015. These sites of tailings dam and mine residue/dumps have no access to verify any subsidence in the field and the results obtained could not be compared with any ground survey data also as no such data exists. This study could illustrate usefulness of PALSAR-2 data in mapping small scale subsidence. The interferometric analysis helps to locate subsidence/deformation areas formed due to the presence sinkholes also, but no such big areas could be located during this study period.

Example.....