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InSAR coherence-based land cover classification of Okara, Pakistan

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ABSTRACT

Reliable and current availability of land cover knowledge are essential for many studies regarding planning, management, monitoring and updating activities. The optical satellite sensor data has been utilized for the classification of land use/land cover. In this study, the capability of synthetic aperture radar (SAR) interferometric coherence is practiced for land cover classification in Okara, Pakistan using Sentinel-1A imagery. Two Single Look Complex (SLC) product of months April and May 2016 were used and processed to create backscatter and interferometric coherence layers. From backscatter layers of each month, the mean backscatter and backscatter difference layer were obtained. False color composite (FCC) were developed comprising mean backscatter, backscatter difference and coherence, and performed supervised classification using maximum likelihood method to generate land cover classes i.e. water, barren, vegetation and built-up. Kappa statistics were employed for accuracy assessment of the output map. Results showed the good potential of Sentinel-1C-band for land cover classification having 0.69 Kappa coefficient and 80% overall accuracy. This study investigated the potential of C-band backscatter coefficients and coherence map for land cover discrimination. Coherence proved to be efficient in the examination of vegetative and non-vegetative areas.

1. Introduction

Land use/land cover (LULC) of a particular region provides information that acts as a vital element for policy making related to environmental changes at the national level as well as globally. Remote sensing technology enables us to monitor surface dynamics of the earth by various earth observation satellites. Advances in Remote Sensing techniques along with the real-time ground data have proven to produce precise information of land-cover in a cost-effective way.

In past, multiple types of research have been conducted to study land cover diversity using earth observation techniques (Bhatta et al., 2010a,b; Blaschke, 2010; Sole et al., 2011; Taubenböck et al., 2008a,b). Techniques of identification are diverse from supervised classification (Chen and Stow, 2002; Wang, 1990) to object-oriented techniques (Blaschke, 2010; Taubenböck et al., 2010) and sub-pixel methods (Mitraka et al., 2012; Powell et al., 2007; Yang et al., 2003).

Despite the limitations of the optical sensor, Landsat multispectral data is the most common space-borne sensor that has been widely used for LULC classifications. But, due to cloud cover and in the presence of fog, it is nearly impossible to work out for any seasonal variations of earth surface.

Therefore, in recent time, a new technology of remote sensing such as LIDAR (Antonarakis et al., 2008; Chen et al., 2009) and RADAR (Dobson et al., 1995; Lee et al., 2001) have become popular which can capture data even in all weather conditions. This Active Remote Sensing may also be utilized even in the absence of sunlight.

Earlier, space shuttle SIR-C/X-SAR (Pierce et al., 1998; Saatchi et al., 1997) was used to detect a change in the earth surface, and further airborne radar imagery systems were deployed to investigate LULC (Yeh and Qi, 2015). These techniques were only occasionally executed for a very short period experimental data. The satellite-based operation of radar systems with SAR was achieved after a successful operation and regular data collection of ERS-1 and ERS-2, JERS-1, RADARSAT-1, TerraSAR-X, RISAT-1 and Sentinel-1 that was used for timely information of LULC changes (Yeh and Qi, 2015).

The limitation of SAR as being single frequency data caused an error in the mapping of LULC classes as it was difficult to separate those feature having same backscatter (Li and Yeh, 2004; Ulaby

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et al., 1986). Therefore, there was a need to incorporate polarimetric SAR (PolSAR) data that overcome the limitation of single frequency systems (da Freitas et al., 2008; Lee et al., 2001; Pierce et al., 1994; Ulaby et al., 1986). Initially tested for river catchments and flood affected areas, LULC measurements by PolSAR revealed much far better results than single polarization SAR (Biro et al., 2013; Qi et al., 2015, 2012) and then successfully implemented for urban areas (Gamba and Aldrighi, 2012; Niu and Ban, 2013; Werner et al., 2014).

Statistical measurements over a moving window of a particular size of SAR image can be quantified regarding image texture. (For instance, ALOS PALSAR 50 m FBD images were employed to derive land cover map in Riau province, Sumatra, Indonesia (Longépé et al., 2011)). The textural parameters are required to achieve discrimination in land cover classes along with its radiometric information. The results showed that around 80% accuracy could be achieved from ASAR time-series, incorporating multi-temporal statistics and texture information (Riedel et al., 2008).

Land-use/land-cover classification of an urban area has always been a challenging task. For this purpose, SAR image fused with optical image lead to more accuracy by using different algorithms (Gamba and Aldrighi, 2012; Hongsheng Zhang et al., 2015). The combination of quad-polarized Radarsat-2, Landsat 8 and dual-polarized TerraSAR-X (HH/VV) imageries have resulted up to 87% accuracy (Ullmann et al., 2014). For agriculture purpose, multi-temporal and multi-sensor radar image combined with optical image led to accurate crop mapping of the farm with up to 85% accuracy (Werner et al., 2014).

After the launch of ERS-1 in 1991, vegetation mapping with C-band multi-temporal InSAR became evident. It was found that backscattered intensity and coherence contained corresponding information which was a vital element to identify any change (Rignot and van Zyl, 1993). ERS-1 InSAR multi-temporal observations were also effectively used for forest mapping (Hagberg et al., 1995; Wegmuller and Werner, 1997, 1995).

Sentinel-1 (C-band) based on two polar orbiting satellite constellations with revisit period of 12 days was launched by European Space Agency (ESA) to explore additional applications of Microwave data. These SAR applications were focused for earth surfaces, including land, ocean, and cryosphere (Malenovský et al., 2012; Torres et al., 2012). The data has also been successfully utilized for disaster management (Plank, 2014) and identifying rapid changing environments of wetlands (Muro et al., 2016). The analyses of dual polarimetric Sentinel-1 data have presented the most precise outcomes for suburban and urban areas (Roychowdhury, 2016). By implementing different combinations of VV and VH polarizations, overall accuracy up to 93% can be achieved (Abdikan et al., 2016). For better land use classification and identification of temporal changes, INSAR coherence may also be implemented (Wegmüller et al., 2015).

This comprehensive literature review affirms lots of studies have been done for land cover mapping using different datasets. Few attempts have been made using Sentinel 1 data with different techniques. But there are limited studies on INSAR coherence with backscattering coefficient classification method using Sentinel-1A SAR data.

In this study, we attempted to examine the potential of Sentinel-1A C-band data comprising of the average backscatter, the backscatter change and the interferometric coherence obtained from two scenes of the interferometric pair for the discrimination of different land-cover categories.

2. Study area and data used

The region of interest for this study is Okara district located in Punjab province of Pakistan (Fig. 1). It is bounded on the West by Sheikhupura, Faisalabad and Sahiwal districts, on the North Kasur district lies, Pakpattan and Bahawalnagar make its southern boundary and bordered by India on the east. The geographical extent of Okara is from 30.26°N, 73.27°E to 31.13°N, 74.21°E having an area of 4419 km^2. The annual average rainfall of the area is approximately 200 mm. The hottest months are considered as for May and June with the maximum temperature of 44 °C and January the coldest one with minimum temperature of 2 °C.

In this paper, Sentinel-1 Single Look Complex (SLC) datasets were downloaded from the European Space Agency (ESA) data hub. The data were acquired on 17th of April and 11th of May 2016 in descending orbit at VV polarization over the study area. The reference data consisted of Landsat 8 OLI image retrieved from the web page of USGS Earth Explorer (www.earthexplorer.usgs.gov) and Google imageries from the Google Earth. These reference

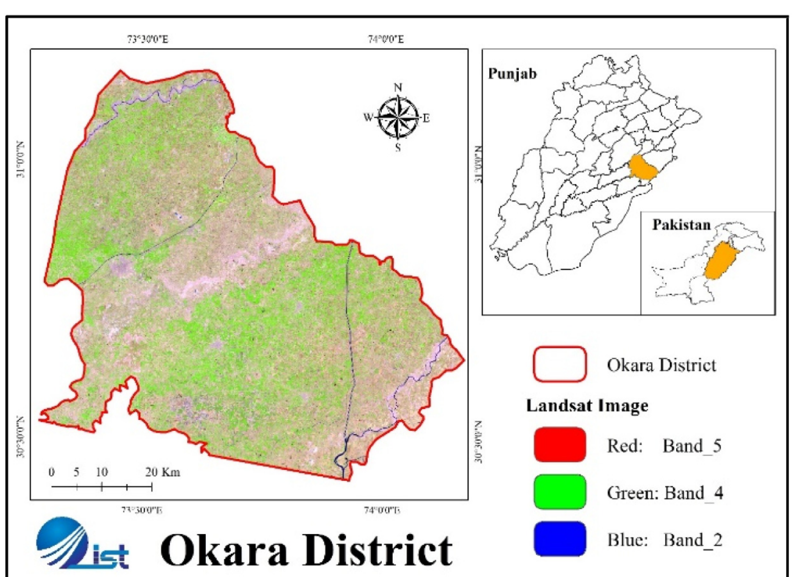

Fig. 1. Okara District, Punjab, Pakistan.