Remote Sensing Applications: Society and Environment 1 (2015) 36–49

Contents lists available at ScienceDirect

Remote Sensing Applications: Society and Environment

journal homepage: www.elsevier.com/locate/rsase

Mapping woody vegetation clearing in Queensland, Australia from Landsat imagery using the Google Earth Engine

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ARTICLE INFO

Article history:
Received 16 April 2015
Received in revised form
25 June 2015
Accepted 25 June 2015
Available online 26 July 2015

Keywords:
Google Earth Engine
Vegetation clearing
Landsat
Queensland Australia
Time-series

ABSTRACT

Monitoring of vegetation clearing in Australia is the province of state governments. Only recently have data and services become available for generalised access to change detection tools suited to this task. The objective of this research was to examine if a globally available cloud computing service, Google Earth Engine Beta, could be used to predict decreases of woody vegetation with accuracies approaching those obtained by the government of the state of Queensland, Australia. This research compared the remote sensing results derived with the Google Earth Engine with those reported by the Queensland Government, using their standard remote sensing methods. Four change detection approaches were investigated using the Landsat-5 TM and 7 ETM+ time-series and algorithms available through the Google Earth Engine Application Programming Interface: (1) Classification and Regression Tree (CART) and (2) Random Forest classifiers; and a normalised time-series of (3) Normalised Difference Vegetation Index (NDVI) and (4) Foliage Projective Cover (FPC) combined with a spectral index, used to predict woody vegetation change between two image composites. The CART and Random Forest classifiers produced the highest user's (78–92%) and producer's (55–77%) mapping accuracies of clearing compared against the woody vegetation loss maps produced by the Queensland Government when detecting change within epochs for which training data were available. Extrapolation to epochs without training data reduced the mapping accuracies. The normalised FPC and NDVI time-series approaches were more robust for calculating clearing probability, as no training data were required, and can hence be tuned to provide automated alerts for large woody vegetation clearing events by selecting suitable thresholds. This research provides a foundation to build further capacity to use globally accessible, free, online image datasets and processing tools to detect woody vegetation clearing in an automated manner.

1. Introduction

Earth observation is the most important tool for monitoring vegetation and land surface dynamics at regional to global scales over time (Sonnenchein et al., 2011). It is the only feasible means for detecting and monitoring vegetation change in Queensland, Australia, as the state covers an area of 1.73 million km^2. Changes to woody vegetation in Queensland are mapped annually using the Landsat time-series (Scarth et al., 2008).

The Statewide Landcover and Trees Study (SLATS) is a major vegetation monitoring initiative of the Queensland Department of Science, Information Technology & Innovation

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http://dx.doi.org/10.1016/j.rsase.2015.06.002
2352-9385/

(DSITI) in Australia. SLATS has been running since 1991 and gathers field validated information on woody vegetation cover and its change for vegetation management planning and compliance, and for State Government greenhouse gas inventory purposes. Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) satellite image data are used to compare the vegetation cover from 1988 to a target date (Armston et al., 2009; QLD Government, 2014). Prior to the detection of woody vegetation loss, the Landsat images are pre-processed by the Remote Sensing Centre at DSITI to normalise the images to topographically corrected, top-of-atmosphere reflectance with Bidirectional Reflectance Distribution Function (BRDF) correction (Danaher et al., 2010; Danaher and Collett, 2006; Robertson, 1989; Shepherd and Dymond, 2003; Zhu and Woodcock, 2012). Many different change detection and time-series analysis approaches have been applied to monitor change over time (e.g. Bhandari et al., 2012; Chen et al., 2012; Coppin et al., 2004; Lu et al., 2004; Radke et al., 2005; Tushaus et al., 2014). The SLATS woody vegetation loss detection approach uses analyses of operator-interpreted and field-checked woody vegetation loss data sets from previous years to develop spectral and temporal Foliage Projective Cover (FPC) change indices (Scarth et al., 2008). FPC from vegetation above 2 m in height is a standard vegetation structure metric mapped from Landsat imagery on an annual basis by SLATS. FPC is defined as the vertically projected cover of photosynthetic foliage of all strata (Specht, 1983), or equivalently, the fraction of the vertical view that is occluded by foliage stemming from woody vegetation (Armston et al., 2009). A desktop assessment of the difference classification is conducted for each scene to identify actual woody vegetation loss. Field validation and associated corrections as well as final quality control checks by senior staff refine the analysis to a uniform standard (Danaher et al., 2010).

Vegetation clearing detection and monitoring in Australia has been the province of state governments because of the considerable expense, expertise, sustained duration of activities and staffing levels required. The key question examined here is if globally and publicly accessible data and new cloud computing tools now available for detecting woody vegetation cover change, such as the GEE, can detect decreases in recent woody cover at mapping accuracies similar to those of the SLATS program. The GEE Beta provides a web portal with access to an Australia wide and global time-series of raw and processed satellite imagery, and also access to software and algorithms suitable for change detection. As Queensland is still the state in Australia with most woody vegetation clearing (State of the Environment Committee, 2011), it provides an informative study area to answer this question.

The GEE provides online access to worldwide coverage of MODIS and Landsat satellite imagery among others, dating back almost 40 years in the case of Landsat data. It also provides tools for "trusted testers" to mine this archive of image data to detect changes, map trends and quantify differences on the Earth's surface. This tool is currently available on request to a limited number of groups for testing and application development (Google Earth Engine, 2012). The GEE Application Program Interface (API) enables the access, development and application of algorithms on the full Earth Engine data archive using Google's cloud computing and processing platform (Erickson, 2014; Hancher, 2013; Moore and Hansen, 2011). Simonetti et al. (2015) developed a fully automatic classification algorithm using the GEE to map land-cover based

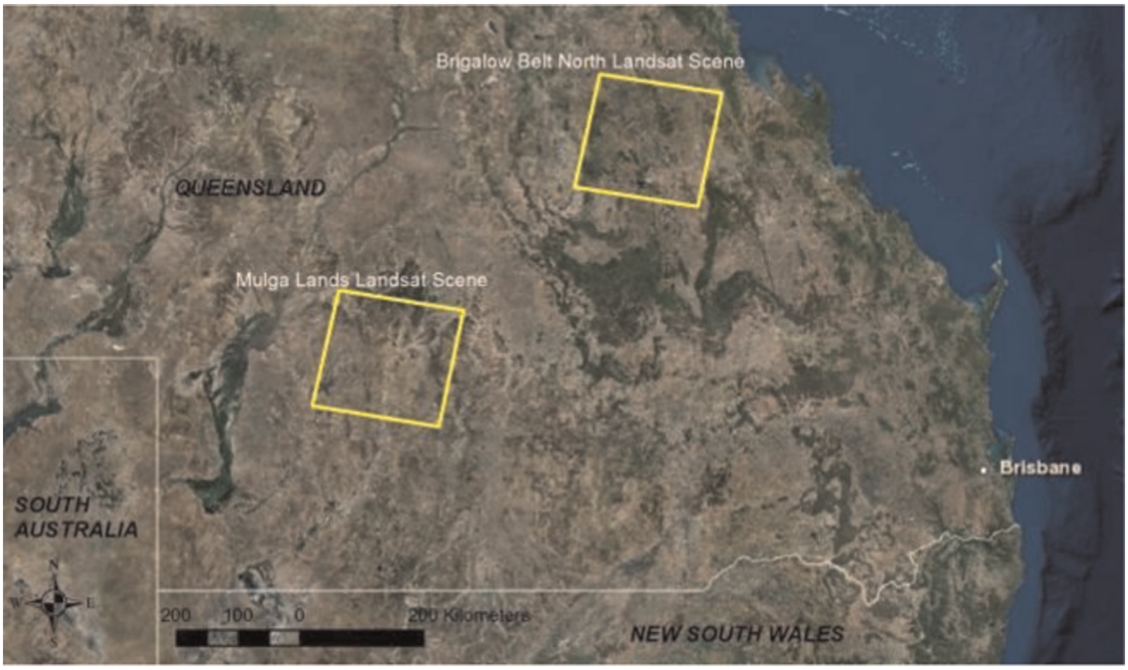

Fig. 1. Two Landsat scenes of the Mulga Lands (Path 95, Row 78) and Brigalow Belt North (Path 93, Row 76) regions, outlined in yellow, representing the two selected study areas. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)