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Detailed dynamic land cover mapping of Chile: Accuracy improvement by integrating multi-temporal data

Yuanyuan Zhao [a], Duole Feng [a], Le Yu [a], Xiaoyi Wang [b,c], Yanlei Chen [c], Yuqi Bai [a], H. Jaime Hernández [d], Mauricio Galleguillos [e,h], Cristian Estades [f], Gregory S. Biging [c], John D. Radke [g], Peng Gong [a,b,c,*]

[a] Ministry of Education Key Laboratory for Earth System Modelling, Centre for Earth System Science, Tsinghua University, Beijing 100084, China
[b] State Key Laboratory of Remote Sensing Science, Jointly Sponsored by Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, and Beijing Normal University, Beijing 100101, China
[c] Department of Environmental Science, Policy, and Management, UC Berkeley, Berkeley, CA 94720, USA
[d] Geomatics and Landscape Ecology Lab, Forestry and Nature Conservation Faculty, University of Chile, Santiago, Chile
[e] Department of Environmental Sciences, Faculty of Agronomic Sciences, University of Chile, Santiago, Chile
[f] Wildlife Ecology Lab, Forestry and Nature Conservation Faculty, University of Chile, Santiago, Chile
[g] Department of Landscape Architecture and Environmental Planning, UC Berkeley, Berkeley, CA 94720, USA
[h] Center for Climate and Resilience Research (CR)2, University of Chile, Santiago, Chile

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ABSTRACT

Stretching over 4300 km north to south, Chile is a special country with complicated landscapes and rich biodiversity. Accurate and timely updated land cover map of Chile in detailed classification categories is highly demanded for many applications. A conclusive land cover map integrated from multi-seasonal mapping results and a seasonal dynamic map series were produced using Landsat 8 imagery mainly acquired in 2013 and 2014, supplemented by MODIS Enhanced Vegetation Index data, high resolution imagery on Google Earth, and Shuttle Radar Topography Mission DEM data. The overall accuracy is 80% for the integrated map at level 1 and 73% for level 2 based on independent validation data. Accuracies for seasonal map series were also assessed, which is around 70% for each season, greatly improved by integrated use of seasonal information. The importance of growing season imagery was proved in our analysis. The analysis of the spatial variation of accuracies among various ecoregions indicates that the accuracy for land cover mapping decreases gradually from central Chile to both north and south. More mapping efforts for those ecoregions are needed. In addition, the training dataset includes sample points spatially distributed in the whole country, temporally distributed throughout the year, and categorically encompassing all land cover types. This training dataset constitutes a universal sample set allowing us to map land cover from any Landsat 8 image acquired in Chile without additional ad hoc training sample collection.

1. Introduction

Land cover information plays a key role in many Earth system studies (Yang et al., 2013). It is an important input to Earth system models (Dai et al., 2003; Jung, Henkel, Herold, & Churkina, 2006; Liu, Chen, Cihlar, & Park, 1997) or habitat models (Liang et al., 2010; Özesmi & Mitsch, 1997; Pearson, Dawson, & Liu, 2004; Yu, Shi, & Gong, 2015). It is also essential for natural resources planning and management (Gong, 2012; LaFontaine, Hay, Viger, Regan, & Markstrom, 2015; Pauleit & Duhme, 2000; Zhong, Gong, & Biging, 2012). Although a large number of efforts have been made to map land cover at various spatial scales, the quality of land cover maps are hardly satisfactory to meet the needs of diverse user communities (Yu et al., 2014a). A large gap in land cover mapping is the shortage of land cover maps at the national scale for many countries in the world. Global land cover maps cannot fully fill this gap because their land cover categories are usually designed for specific global applications. Given the considerably improved availability of medium resolution satellite data and data processing capabilities, a critical task in producing useful land cover maps for a particular country is adopting a land cover classification scheme developed with the participation of users in that country. Chile is such a country that does not have a comprehensive land cover map at medium spatial resolution. This study describes our national land cover mapping effort for Chile.

Bounded by the Pacific on the west, the Andes on the east and the Atacama Desert in the north, Chile is a virtual continent island stretching over 4300 km north to south with rich biodiversity. Notably

* Corresponding author at: Ministry of Education Key Laboratory for Earth System Modelling, Centre for Earth System Science, Tsinghua University, Beijing 100084, China.
E-mail address: penggong@tsinghua.edu.cn (P. Gong).

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Table 1
Regional land cover products covering the entire Chile.

Product name	Data time	Resolution	Sensor	Scheme	Reference
UMD SA	1987–1983	1 km	AVHRR	16 classes	Townshend et al. (1987)
LBA-ECO	1987–1991	1 km	AVHRR	39 classes	Stone et al. (1994)
JRC SA	1995–2000	1 km	ATSR, VGT, OLS	10 classes (L1)	Eva et al. (2004)
SERENA	2008	500 m	MODIS	22 classes	Blanco et al. (2013)
MERISAM2009	2009–2010	300 m	MERIS	9 classes	Hojas Gascon et al. (2012)
USGS SA	2010	30 m	TM, ETM +	5 classes	Giri & Long (2014)

a high rate (about 45%) of the species are endemic, which can be attributed to its isolation (Squeo et al., 2012). The climate regions vary from tropical desert and semi-desert in the north, Mediterranean in the middle, temperate oceanic and sub-polar oceanic in the south. Under the effects of both climate and topography, the natural vegetation types are highly diverse. In the north lies the driest Atacama Desert, with almost no vegetation at its heart, low scrub vegetation towards the Andes and sparse shrub called the "Lomas" towards the coast, highly depending on coastal fog and humidity. After a transitional zone of matorral (shrubs) and savannas southward, the vegetation changes to Mediterranean sclerophyll woodlands and high shrubs. With the remarkable presence of the typical Araucanía forests and krummholz, the deciduous forests in central Chile transit towards temperate rain forests with high precipitation levels. For the fjords and islands in the far south, it becomes moorlands or icefields and oceanic forests reappear (Moreira-Muñoz, 2011). Chile's complicated landscape and diverse vegetation requires a monitoring approach that uses multi-temporal imagery of sufficient spatial resolution to capture important phases in the vegetation dynamics of the landscape. For example, a series of seasonal dynamic land cover map of high resolution could even capture the moment when geophytes and annuals sprout from the seemingly bare land.

Since the 1950s, the land cover type of southern-central Chile is dominated by fast-growing commercial plantations, mainly including radiate pine and eucalyptus (Toro & Gessel, 1999). Forests change mainly occurs in this region, with a loss of more than 1 million hectares and a concurrent gain of about the same area from 2001 to 2013, according to Global Forest Watch (an online platform for the public to help monitor forest change, http://www.globalforestwatch.org/), reflecting the rapid rotations of logging and replantation of trees. With the log exports being reduced, harvested wood is processed into primary and secondary products, including paper, pulp, sawnwood, engineered wood products and furniture, and 75% of the product is exported mainly to the United States, Japan and China (Cartwright & Gaston, 2002). The carbon

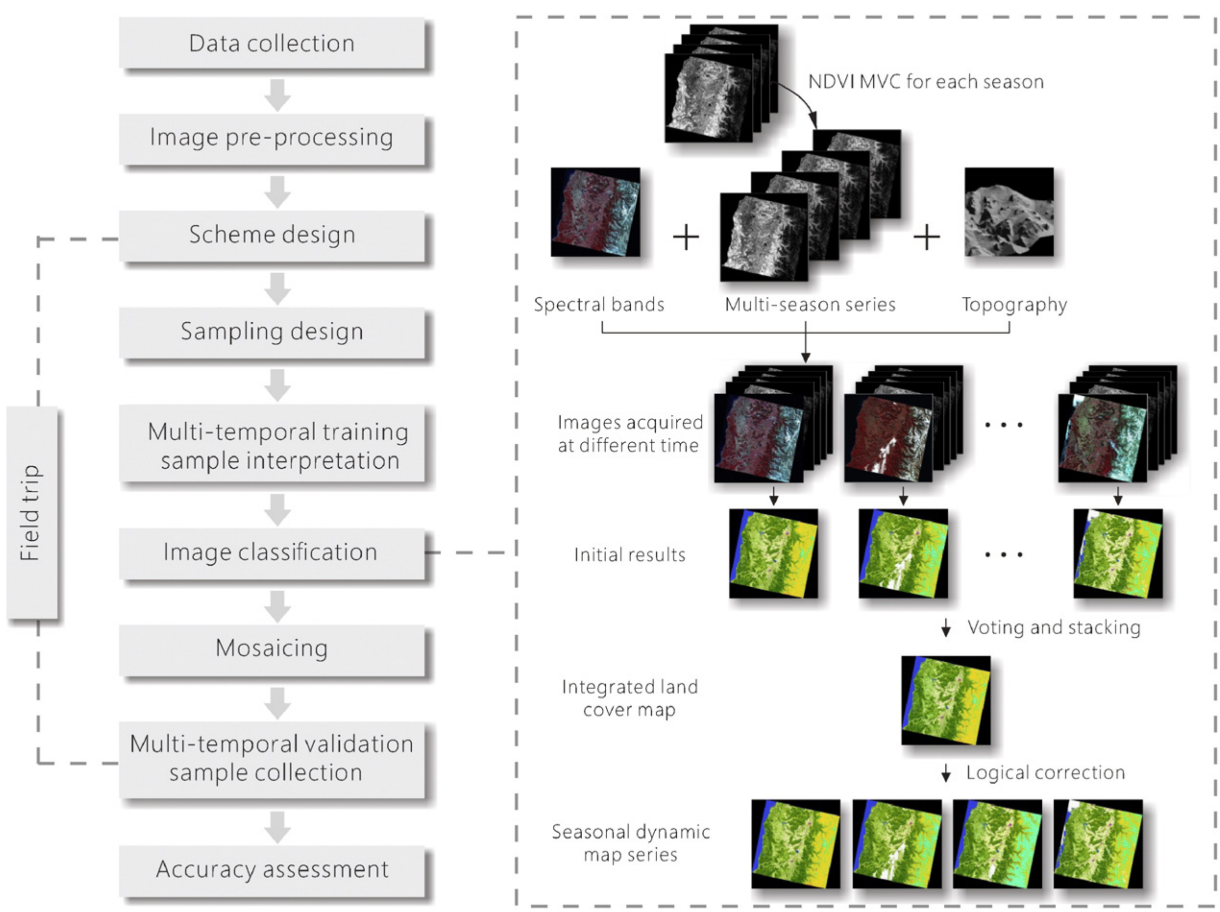

Fig. 1. Flowchart of the Chilean land cover mapping process.