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Combination of optical and LiDAR satellite imagery with forest inventory data to improve wall-to-wall assessment of growing stock in Italy

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ABSTRACT

The acquisition of information about growing stock is a fundamental step in the framework of forest management planning and scenario modeling, besides being essential for assessing the amount of carbon stored within forest ecosystems. Gallaun et al. (2010) produced a pan-European map of forest growing stock by the combination of ground and remotely sensed data. The first objective of the current paper is to assess the accuracy of this map versus the ground data collected during the latest Italian National Forest Inventory (INFC). Next, a new wall-to-wall estimation of growing stock is obtained by combining ground measurements of four regional forest inventories with the CORINE land cover map of Italy and the global canopy height map derived from Geoscience Laser Altimeter System (GLAS) and Moderate Resolution Imaging Spectroradiometer (MODIS) data. More particularly, the growing stock measurements of the four inventories are stratified by ecosystem type and extended over all Italian forest areas through the application of locally weighted regressions to the GLAS/MODIS canopy height map. When compared to the INFC measurements, the new map shows higher accuracy than that by Gallaun et al., particularly for high growing stock values. The coefficient of determination between estimated and INFC growing stocks is improved by about 0.5, whilst the mean square error is reduced from 90 to 48 m^3 ha^{-1}.

1. Introduction

Maps of forest biomass are important data sources for many scientific and practical tasks such as, for instance, carbon sink evaluation, land suitability assessment and landscape biodiversity estimation (Waring and Running, 2007). Particularly, regional scale spatially distributed estimates of forest biomass are useful as input of environmental modeling exercises (Lindner and Karjalainen, 2007). For example, Maselli et al. (2010) showed the utility of such estimates for the prediction of net forest carbon fluxes in Italy.

Traditional inventories based on ground sampling can provide an accurate statistical assessment of forest attributes (Corona, 2010; Corona et al., 2010). However, given the usual sampling intensity, their completion is generally expensive and time consuming. Moreover, the data collected by these sample-based inventories require additional and often complex processing to derive wall-to-wall maps of forest attributes (Maselli and Chiesi, 2006).

Satellite remote sensing techniques are a valuable source of information about forest attributes related to biomass (tree density, basal area, growing stock, etc.) at various spatial and temporal scales. Several studies have been conducted on the integration of ground and optical remote sensing data to map these forest attributes both over Europe (Tomppo and Halme, 2004; McRoberts and Tomppo, 2007) and North America (Franklin, 2001; Franco-Lopez et al., 2001). In particular, Chirici et al. (2008) intercompared the use of parametric and nonparametric growing stock estimation methods in the Mediterranean area.

Based on these and similar studies, an effort has been recently conducted by Gallaun et al. (2010) to map the main forest attributes over the European continent. These authors produced 500 m maps of growing stock and above-ground woody biomass for broadleaves and conifers through the combination of ground and Moderate Resolution Imaging Spectroradiometer (MODIS) data. These maps are a step forward for the characterization of European forests, but are characterized by some shortcomings, which may limit their operational exploitation. First, the accuracy of the maps has not been assessed extensively at per-pixel level, and few point tests made in Central Italy have pointed out notable uncertainty (unpublished data). Second, the growing stock values reported by the

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