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Dynamics of forest biomass pools estimated from spaceborne SAR data

Maurizio Santoro (1), Oliver Cartus (1), Nuno Carvalhais (2), Martin Thurner (3), and Johan Fransson (4)

(1) Gamma Remote Sensing, Gümligen, Switzerland (santoro@gamma-rs.ch), (2) Max Planck Institute for Biogeochemistry, Jena, Germany (ncarval@bgc-jena.mpg.de), (3) Department of Environmental Science and Analytical Chemistry (ACES) and the Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden (Martin.Thurner@aces.su.se), (4) Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå, Sweden (johan.fransson@slu.se)

The comprehensive view of land surfaces offered by spaceborne remote sensing make such observations the primary candidate for quantifying dynamics of biomass at large scale. Yet, there is controversy in the results obtained with Earth Observation data from space when compared with results obtained using forest inventory (Pan et al., 2011; Liu et al. 2015). To overcome limitations due to the fact that biomass is not directly sensed and imaging conditions (cloud cover, moisture etc.) can distort the estimates of biomass estimated from remote sensing data, approaches that maximize the information content on biomass embedded in the remote sensing observations should be used. In addition, multiple observations from the same sensor are needed to overcome effects of imaging conditions. Here, we present two examples of ongoing work having the objective of capturing the trajectories of aboveground biomass, i.e. a major predictor of carbon in forests, with long records of spaceborne synthetic aperture radar data (SAR) backscattered intensity.

Since the SAR backscatter intensity is affected by the volume structure of vegetation, we have developed an approach referred to as BIOMASAR (Santoro et al., 2011; Santoro et al., 2015) that estimates forest wood volume density (also referred to as growing stock volume, GSV) from repeated observations of the SAR backscatter. GSV is then converted to AGB by means of a biomass conversion and expansion factor (BCEF); for this, we use a global raster derived from wood density and stem-to-total biomass in situ observations (Thurner et al., 2014; Santoro et al., in preparation).

Until recently, spaceborne SAR instruments have not operated according to a predefined plan of observations. At coarse resolution, large amounts of opportunistic observations have been collected. From the 2002-2012 C-band Envisat ASAR dataset of SAR backscatter, we have created a 10 years time record of AGB estimates at 1 km spatial resolution. For a latitudinal transect covering Europe and Africa currently under evaluation, we observe systematic trends with clear spatial patterns. While the biomass pool in Scandinavia appears to increase, this being in line with values reported by National Forest Inventories, losses are observed in the tropics and in regions affected by large fires.

With increasing operations of high-resolution SAR instruments in space, time series are also being built up so to allow for a more precise detection of small-scale changes of biomass. In Sweden, extensive dataset of in situ measurements of biomass and plentiful observations by remote sensing platforms enabled setting up a biomass monitoring system. Using image observations acquired by L-band ALOS PALSAR in 2010 and ALOS-2 PALSAR-2 around 2015 over Sweden, we derived spatially explicit estimates of GSV and total carbon stocks with a spatial resolution of 25 m. Total volume (aboveground) for 2010 is 3,033$\pm$11 Million m3, with a 2.4% increase between 2010 and 2015. Accordingly, the total carbon stock in forest is 1.069$\pm$0.004 PgC, with an increase of 2.7%. These numbers are between 5% and 10% less than those reported by the National Forest Inventory (Skogsdata, 2013; Skogsdata, 2018; FAO, 2010).