TITLE: RADAR BACKSCATTER SENSITIVITY TO FOREST BIOMASS: REVISITING THE BIOMASS SATURATION

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ABSTRACT BODY: In recent years, climate change policies and scientific research created a widespread interest in quantify the carbon stock and changes of global forests extending from forest patches to national and regional scales. However, because of the large spatial extent of forests, their heterogeneity from structural and species diversity causing meters to kilometer scales variations, their complex dynamics causing landscape scale differences in changes of biomass, and their continues degradation from human activities, the quantification of forest biomass from conventional inventory data alone has become a major challenge.
Remote sensing techniques with Lidar and Radar are considered to be the most efficient way of estimating forest biomass at large scales and with uncertainty comparable to estimation from inventory plots. Radar backscatter and interferometric based estimation of forest biomass has been studied extensively and considered as dedicated spaceborne options of monitoring and quantifying forest biomass. However, the literature on the radar-based estimation techniques of biomass has been misleading in defining the sensitivity and lack of sensitivity, so called saturation effect of radar measurements.
In this paper, I provide results from a combination of observations and model simulations to demonstrate the physical nature of the loss of sensitivity of radar backscatter to biomass, examine the biophysical that impact the sensitivity, extend the results to other radar measurements including polarimetric and interferometric modes.

In Particular, I will focus on P-band synthetic aperture radar (SAR) measurements over forest ecosystems of boreal, temperate, and tropical regions. The selection of the BIOMASS mission from the European Space Agency for global estimation of forest structure and carbon has created new interests in quantifying the sensitivity and the potential saturation of P-band polarimetric backscatter to forest biomass over global forest types. Here, we use P-band data collected by UAVSAR-P sensors used during the AIRMOSS mission over four forest study areas along temperate to boreal gradient and with differences in age, structure, species, and landscape characteristics. For each site, we use data from airborne discrete return lidar to quantify forest structure and biomass and examine the behavior of P-band backscatter measurements at spatial scales from 50 m (0.25 ha) to 250 m (6.25 m). Focusing on the P-band cross-polarized backscatter (HV), we find a strong relationship between PHV and mean canopy height and aboveground biomass with increasing sensitivity without any sign of saturation up to 300 Mg/ha at 6.25 ha scale. The analysis suggests that at small scales (< 0.25) the heterogeneity of forest structure and differences in area of the forest observed by radar as compared to lidar or ground plots can introduce significant noise in the data and a false saturation level. We found the potential variations of tree stocking on backscatter variations reduce significantly at larger scales (> 1-ha). However, soil moisture variations and topography may introduce uncertainty in the sensitivity of the PHV backscatter to forest biomass that can be readily corrected by using multiple observations as in spaceborne sensors and the radiometric correction of backscatter measurements for local topography.