National Aeronautics and Space Administration

Tropical-Forest Profiles and Biomass from TanDEM-X, Single-Baseline Interferometric SAR: InSAR Performance at Higher Frequencies and Bandwidths

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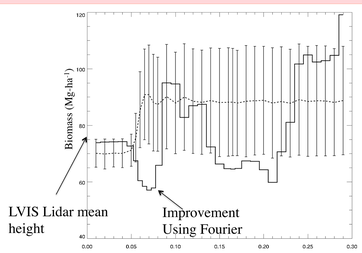
Lidar Says: Profile Fourier Transforms at Multiple Frequencies Yield Better Biomass Estimates than Height

Instead of expressing biomass as a linear function of InSAR coherence and phase

$Biomass = a + b * coherence + c * phase$

Express biomass as a function of Fourier transforms (FT) of the vertical waveform, and their derivatives

$$Biomass = a + b\ FT + c\ \frac{dFT}{d\ freq} + d\ \frac{d^2FT}{d\ freq^2}$$

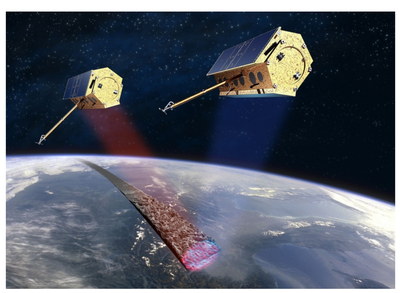


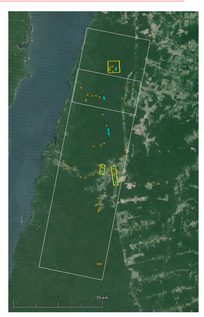
Blair et al. Processing of NASA LVIS elevation and canopy data products (2006)

Treuhaft et al. Revista Brasileira de Cartografia (2013)

InSAR Says: Only one Fourier Frequency per baseline-length

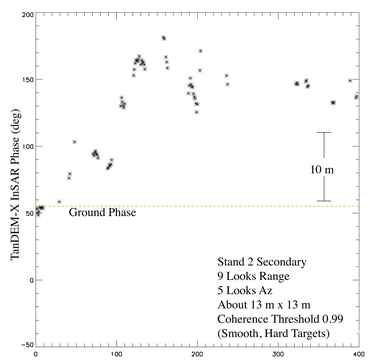
TanDEM-X is the first dedicated radar interferometer in space (Krieger et al. 2007). ~50 baselines, at about 2-3 different lengths, have been/will be acquired over Tapajós between June 2011 and December 2015. This poster proposes to obtain many Fourier frequencies from one baseline taken 22 September 2011. The vertical wavelength (2π/Fourier Frequency) is 73 m. Small-footprint lidar data were taken within the yellow rectangles over 1000 ha areas. The blue dots are 30 field sites acquired in 2010, orange dots 58 field sites in 2013. Total height, commercial height, canopy dimensions, canopy asymmetries, diameter and species (for wood density) were measured.

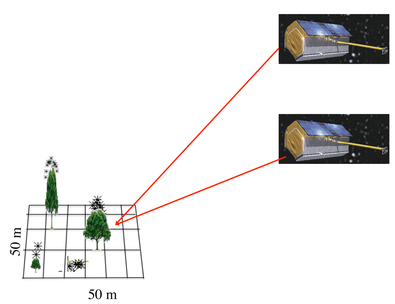




Increase # of Fourier Frequencies by Sampling Vertical Profile With Lateral Look-Phase-Height

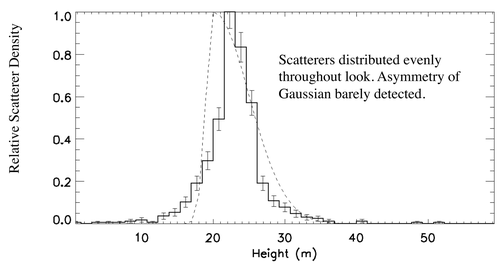
High-coherence phases suggest hard targets not only at ground level, but in the trees as well. Phases and phase heights are near the attenuation-weighted average height. Maybe looks are sampling, hard, local targets through holes? Sampling the profile? 1 range look=1.5 m, 1 az=2.5 m

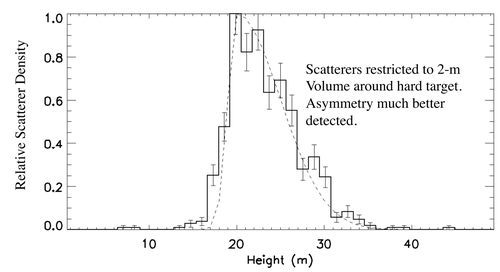




Simulation Suggests Only localized, hard scattering (High Frequencies?) Will Enable Lateral Sampling to Recover Vertical Profile

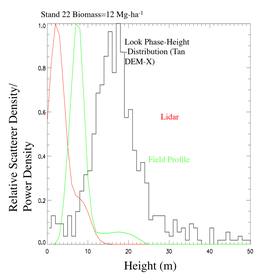
Asymmetric Gaussian Vertical Density Distribution of scatterers (dashed line) thrown. Solid histogram recovered by look sampling.

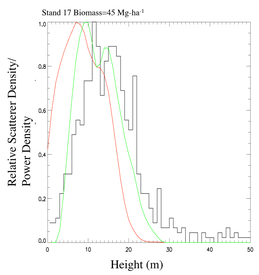


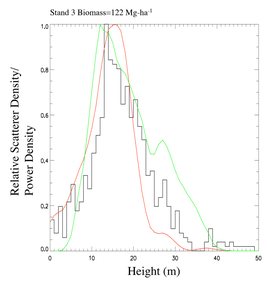


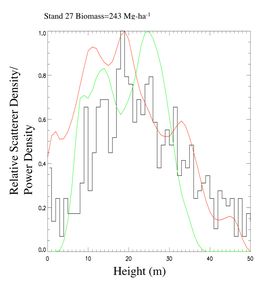
Comparison of TanDEM-X Look-Phase-Height Profiles to Lidar and Field

Except for the youngest stand, which we believe has extreme radar attenuation, the Look-Phase-Height Distribution is in as good a qualitative agreement with lidar or field, as they are with each other. There may be ground-finding issues with both TanDEM-X and lidar. Large bandwidth (150 MHz) allows for many look samples (~700 per 0.25 ha)









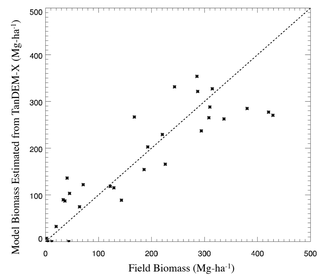
Use Fourier Transform of Look-Phase-Height Distribution to Estimate Biomass

Compare biomass estimated as a linear function of InSAR coherence and phase

$Biomass = a + b * coherence + c * phase$

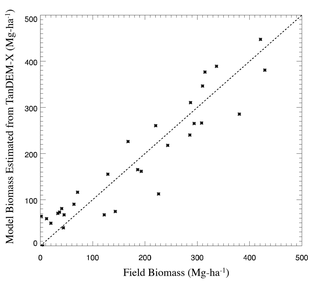
to biomass as a function of Fourier transforms (FT) of the look-phase-height profile, and their derivatives

$$Biomass = a + b\ FT + c\ \frac{dFT}{d\ freq} + d\ \frac{d^2FT}{d\ freq^2}$$



Biomass estimated From, TanDEM-X Phase and Coherence Observations RMS=57 Mg-ha^{-1}

Treuhaft et al. IEEE Geoscience and Remote Sensing Letters (2015)



Biomass estimated from, TanDEM-X Fourier transforms of Look-Phase-Height and derivatives RMS=48 Mg-ha^{-1}

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