Geophysical Research Abstracts
Vol. 20, EGU2018-7606-4, 2018
EGU General Assembly 2018

Constraints on 15-year carbon sequestration in Aleppo pine forest

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A large terrestrial carbon sink is significantly influencing the rate of change in atmospheric CO_2 concentration, but its location and size remains uncertain. This uncertainty stems from that in the primary measurement methodology at the ecosystem scale (primarily eddy-covariance) and its extension to global scale, and its implementation in models.

Here we focus on the primary uncertainty in the ecosystem measurements. We use detail carbon inventory to constrain 15 years of flux measurements in a dry Aleppo pine forest in Yatir, Israel. Changes in ecosystem carbon stocks (CS) over time (NEP_{CS}) were estimated in five representative plots based on the original analysis in 2001, with repeated analyses in 2016, and accounting for major 'thinning and mortality events' (TME) in 2011-13. Measurements included site-specific allometric equations for both above and below ground tree biomass, soil cores (5 depths) for organic and inorganic carbon and litter layer.

The results indicated, that mean plot biomass increased from 3.6 kg m^{-2} in 2001 through 5.1 kg m^{-2} before the TME, and to 4.1 kg m^{-2} in 2016. The total accumulated carbon in the forest since plantation in 1965-7 was 6341$\pm$511 gC m^{-2} in 2001, and increased to 9144$\pm$980 gC m^{-2} in 2016. Consequently, the total carbon accumulation over the past 15 years was 9144-6341=2803 gC m^{-2} ($\pm$469 gC m^{-2}based on the SE among plots). This was compared to our cumulative long-term eddy-covariance flux measurements since 2001 indicating a total NEP of 2881 ($\pm$576 gC m^{-2}, based on 20% error estimate). Translating these values to annual NEP values, mean NEP_{CS}over the 15-year study period was 193$\pm$32 gC $m^{-2}y^{-1}$ (including carbon in standing tree biomass, soil organic, annuals, thinning, and removal in sanitation); and based on the flux measurements, to mean NEP_{EC} of 199 gC $m^{-2}yr^{-1}$ ($\pm$40 gC $m^{-2}yr^{-1}$ using a conventional $\pm$20% error estimate).

Our results provide a relatively rare long term constraint over the primary EC approach to estimate ecosystems carbon uptake and its spatial and temporal variations. We observed a good agreement (to within the error of measurements) between CS approach and the cumulative EC flux measurements across 15 years, at a site with good measurement conditions (dry environment, very deep ground water) and consequently high 'energy budget closure' and 'closed hydrological budget'. The results confirm our earlier estimates of relatively large carbon sink potential in semi-arid pine forest plantations. We will discuss to what extent such results provide confidence in the widely-used EC approach.