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Going beyond the stationary flux towers to assess the interactions of land use and climate

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Networks of permanent, stationary flux towers that allows continuous canopy-scale measurements over annual time-scales have revolutionized the study of the contemporary carbon cycle over the past two decades. However, this approach is limited in addressing questions related to dynamic changes in land use, vegetation types, disturbance, and their interactions with variations in environmental conditions. Using mobile laboratory for measuring CO_2, water, energy, COS, and VOC fluxes, permitted us to extend our stationary flux tower measurements across many sites, but also limited measurements to short-time campaigns (days to weeks). To overcome this limitation, we adopted an empirical approach (often used in remote sensing) and used state of the art campaign-based ecosystem flux measurements to 'calibrate' local meteorological data available on continuous basis, to estimate annual-scale carbon, water, and energy budgets. Using this approach, we investigated the interactions of land use change (afforestation) and climate (humid Mediterranean to semi-arid, 730 to 300 mm in annual precipitation) on the ecosystem fluxes. The results showed that across this climatic range, afforestation increased ET markedly more in the wet (+200 mm yr-1 or ∼30% of P) than in the dry end (+58 mm yr-1 or ∼19% of P). Similarly, increase in carbon sequestration (NEE) associated with forestation was greater in the wet sites (+460 gC m-2 yr-1) than in the dry sites (+30 gC m-2 yr-1). In contrast, ecosystem net-radiation (Rn) and sensible heat flux (H) increased due to afforestation much more in the dry sites than in the wet sites (∼47 vs. ∼27 and 49 vs. 17 Wm-2, respectively). COS and VOC fluxes were also measured but reported separately. The results provided quantitative assessment of shifts in the tradeoffs associated with afforestation in this region, between the hydrological and energy-budget 'costs', vs. carbon sequestration and other ecosystem services, (e.g, surface cooling, erosion protection, wood production, recreation) 'benefits'. This study also demonstrates the potential and importance in extending the stationary flux tower approach currently dominating research of ecosystem exchange fluxes.