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Extending measurements in long-term permanent sites using a mobile observation system: Tradeoffs between carbon sequestration and radiation budget across a climatic gradient

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Recent observations from the semi-arid region in Israel showed that conversion of the local sparse shrubland to pine forest resulted in greatly increased surface radiation load due to reduced canopy albedo combined with reduced emission of thermal radiations, which overwhelmed the beneficial effects of the relatively high rates of the forest carbon sequestration. Here we extend this study across the local climatic gradient, and test the hypothesis that increased carbon sequestration and reduced differences in surface radiation budgets along the precipitation gradient, diminish the surface effects of forestation while enhancing the benefits of carbon sequestration.
We used a custom-built mobile laboratory (for eddy-flux and surface radiation measurements) on a campaign basis (about two weeks per site repeated along the seasonal cycle) to compare surface-atmosphere radiative (short- and long-wave radiation) and non-radiative (net carbon uptake, NEE, evapotranspiration, ET, and sensible heat, H) fluxes in three paired sites of pine forest (Pinus halepensis) and nearby non-forested ecosystems with mean annual precipitation/temperature of 291/19.5, 543/20.8, and 755/16.4 mm/°C, respectively.
Forests NEE and ET increased with increasing precipitation along the gradient from 0.8, to 1.5 gC m-2d-1, and 0.7 to 1.3 mmol H_2O m-2s-1. Forests albedo did not changed along the gradient or along the seasonal cycle (αF $\sim$0.12), while shrub land albedo (αS) varied along the gradient and the seasonal cycle due in part to variability in soil types (from 0.31 to 0.19, on average for dry and wet sites). Sensible heat flux did not markedly changed (HF$\sim$110 Wm-2 and HS$\sim$60 Wm-2), and the net thermal radiation emission along the climatic gradient increased in the forests (-90, to -105 Wm-2) and decreased in the shrub land (-112 to -104 Wm-2).
The results showed, on average, enhanced carbon sink associated with forestation of shrub land (ΔNEEF-S) increased with precipitation (from near zero to 190%) and, concurrently, diminished albedo effect ($\Delta\alpha$F-S, from $\sim$150 to 50%), which was associated both with changes in plant cover and differences in soil surfaces. Forests always showed increased sensible heat flux compared with shrub land (ΔHF-S$\sim$50 Wm-2), while the reduced thermal radiation emission associated with forestation attenuated with increasing precipitation along the gradient from -20 to $\sim$0.
The results confirmed our hypothesis and help quantify the interactions of forestation and climate. This study also demonstrates the utility of the new mobile lab, and the importance of extending long-term measurements in permanent sites with limited biome and climatic coverage.