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Anywhere the Wind Blows does Really Matter

Nicola Montaldo (1) and Ram Oren (2)

(1) Università di Cagliari, Ingegneria del Territorio, Cagliari, Italy (nicola.montaldo@unica.it, 39 070 6755310), (2) Nicholas School of the Environment, Duke University Durham, NC 27708-0328

The variation of net ecosystem carbon exchange (NEE) has been explained at coarse scales with variation of forcing variables among climate regions and associated biomes, at the intermediate, mesoscale, with differences among dominating vegetation types and conditions, and at the misoscale with heterogeneity of the eddy covariance footprint properties. Wind is rarely considered in analysis of surface fluxes for its effects on periodic budgets of water and carbon. In many regions conditions change frequently between maritime and continental depending on wind velocity (VW) and direction. In these regions, water and carbon fluxes may respond to mesoscale weather patterns extending maritime influences far inland. Using eddy-covariance data from Sardinia, we show that daytime net carbon exchange (NEE) of a mixed pasture-woodland (grass-wild olive) ecosystem (Detto et al., 2006; Montaldo et al., 2008) increased with VW, especially during summer-dry conditions. As VW increased, the air, humidified over sea, remains relatively moist and cool to a greater distance inland, reaching only $\sim$50 km during slow Saharan Sirocco wind but >160 km during mostly Mistral wind (4 m/s) from Continental Europe. A 30% lower vapor pressure deficit (D) associated with high VW (average 2 kPa at 4 m/s), allowed a 50% higher canopy stomatal conductance (gc) and, thus, photosynthesis. However, because gc and D have opposite effects on evapotranspiration (Ee), Ee was unaffected by VW. Thus, higher NEE during summertime Mistral reflects increased ecosystem water-use efficiency (We) and a departure from a costly carbon-water tradeoff.

Yet many regions often experience high velocity winds, attention is typically focused on the capacity of strong winds to fan regional fires, threatening human habitation and natural habitats, and reducing Carbon storage (C), NEE and latent heat flux. However, depending on their origin, high velocity winds can bring continental air to the coast (e.g., Santa Ana winds along the mid-eastern Pacific coast) or maritime air far inland. Such wind-generated changes in atmospheric D cause a departure from a tradeoff between carbon and water, whereby increasing C sequestration must be at the cost of increasing Ee and decreasing water yield and availability to downstream users. Mesoscale processes that affect the prevailing atmospheric D may increase or decrease We without affecting the water cycle, and should be considered in predictions of the effects of climate change and associated wind properties on net ecosystem carbon exchange. Indeed, increasing or decreasing scope of maritime influences with future climate will amplify or negate the effect of increased atmospheric [CO_2] on We.