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Inescapable variation – effects of a non-homogeneous flux tower footprint on diurnal and seasonal carbon fluxes in a temperate forest

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A homogenous flux tower footprint is an underpinning assumption of the eddy covariance method, typically requiring even terrain and uniform vegetation structure and species composition. However, large tracts of uniform native forests are rare in south-eastern Australia, where variable topography is confounded by local-scale variations in disturbance history (harvesting, prescribed fire, and wildfire).

From 2010 to 2014, the Wombat Forest Flux site in central Victoria (south-eastern Australia) was a strong carbon sink compared with other flux sites in Australia, but net ecosystem exchange (NEE) varied widely (e.g. 2013: NEE$\sim$4 t C ha-1yr-1, 2012: NEE$\sim$12 t C ha-1yr-1), and was not clearly associated with inter-annual climatic variation only. Concomitantly, intra-annual variation was greater in 2014 than 2013, and was highly correlated with air temperature, which also varied with wind direction. We examined the implications of a non-homogenous flux tower footprint on diurnal and seasonal variation in NEE. The approach included characterisation of the variation in topography and forest structure in each of four directional sectors, and analysis of diurnal and seasonal variability in carbon fluxes and associated weather with wind direction.

Our results indicate that the S/SE footprint sector (lower relative stem densities, more recent harvesting disturbance) was a seasonally-persistent strong sink (particularly in summer and autumn), while the N/NE sector (higher relative stem densities with numerous resprouts, no recent harvesting or thinning) was a weaker sink. Lower annual NEE in 2013 coincided with predominantly northerly winds, and greater annual NEE in 2014 with a predominance of southerly/south-easterly winds. Our data demonstrate that seasonal and annual variations in main wind directions and therefore also flux tower footprint can have significant implications on the magnitude of seasonal and annual estimates of NEE from flux towers.