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Gas-phase carbon exchange between mangrove forests and the atmosphere

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Mangrove ecosystems are believed to be highly productive, storing carbon at rates as high as or higher than terrestrial tropical rainforests. Their high productivity is reflected in the high levels of organic carbon stored within, and exported from, these ecosystems. This includes so-called blue carbon – carbon of terrestrial origin sequestered in coastal margins. Despite their potential importance, significant knowledge gaps exist both in the magnitudes of the components of mangrove carbon balance, and the factors controlling them. These gaps result from the lack of primary datasets, which is itself a consequence of the complex nature of mangrove ecosystems, and of the difficult working conditions found there. Here, we report on a study designed to elucidate some of the environmental controls on the exchange of CO_2 and CH_4 to and from intact mangrove ecosystems in East Africa. Gazi Bay (4°25'S, 39°30'E), south of Mombasa, Kenya, encompasses around 600 ha of mangrove forest, including partially and severely degraded stands as well as restored areas. The area contains all 10 species of mangrove found in East Africa, including mono-specific areas of the two most common species, *Avicennia marina* and *Rhizophora mucronata*, sufficiently extensive for robust eddy covariance (EC) measurements. During 2012, open path EC measurements were made at both *Avicennia marina* and *Rhizophora mucronata* sites throughout a spring/neap tidal cycle. Flux data were fitted to a simple model describing the ecosystem level response to environmental variables. Stands of both species exhibited higher maximum net ecosystem uptake, but lower apparent quantum efficiency and lower dark respiration when inundated by high tides. Maximum net ecosystem uptake was higher in *Rhizophora* (12.8 (dry) - 16.5 (wet) μmol m^{-2} s^{-1}) than in *Avicennia* (5.1 (dry) - 5.9 (wet) μmol m^{-2} s^{-1}). Apparent quantum efficiency was twice as high in *Rhizophora* (0.09 (wet) - 0.12 (dry) mol mol^{-1}) than in *Avicennia* (0.03 (wet) - 0.06 (dry) mol mol^{-1}). Dark respiration rates were broadly similar when the tide was out (8.3 μmol m^{-2} s^{-1} (*Rhizophora*), 7.3 μmol m^{-2} s^{-1} (*Avicennia*)), but high tide reduced respiration much more in *Avicennia* (0.5 μmol m^{-2} s^{-1}) than in *Rhizophora* (7.5 μmol m^{-2} s^{-1}). Methane exchange between the *Rhizophora* ecosystem and the atmosphere was small and dependant on tidal state, varying between a methane consumption of around 0.2 mg (C) m^{-2} hr^{-1} at low and incoming tide to a methane production of around 2.5 mg (C) m^{-2} hr^{-1} during outgoing tides. The *Avicennia* ecosystem was consistently a small consumer of methane (ca. 0.2 mg (C) m^{-2} hr^{-1}).