Geophysical Research Abstracts
Vol. 18, EGU2016-814, 2016
EGU General Assembly 2016

Drivers of methane uptake by montane forest soils in the Peruvian Andes

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The exchange of methane between the soils of humid tropical forests and the atmosphere is relatively poorly documented. This is particularly true of montane settings where variations between uptake and emission of atmospheric methane have been observed. Whilst most of these ecosystems appear to function as net sinks for atmospheric methane, some act as considerable sources. In regions like the Andes, humid montane forests are extensive and a better understanding of the magnitude and controls on soil-atmosphere methane exchange is required.

We report methane fluxes from upper montane cloud forest (2811 - 2962 m asl), lower montane cloud forest (1532 - 1786 m asl), and premontane forest (1070 - 1088 m asl) soils in south-eastern Peru. Between 1000 and 3000 m asl, mean annual air temperature and total annual precipitation decrease from 24 ˚C and 5000 mm to 12 ˚C and 1700 mm. The study region experiences a pronounced wet season between October and April. Monthly measurements of soil-atmosphere gas exchange, soil moisture, soil temperature, soil oxygen concentration, available ammonium and available nitrate were made from February 2011 in the upper and lower montane cloud forests and July 2011 in the premontane forest to June 2013.

These soils acted as sinks for atmospheric methane with mean net fluxes for wet and dry season, respectively, of -2.1 (0.2) and -1.5 (0.1) mg CH_4 m^{-2} d^{-1} in the upper montane forest; -1.5 (0.2) and -1.4 (0.1) mg CH_4 m^{-2} d^{-1}in the lower montane forest; and -0.3 (0.2) and -0.2 (0.2) mg CH_4 m^{-2} d^{-1} in the premontane forest. Spatial variations among forest types were related to available nitrate and water-filled pore space suggesting that nitrate inhibition of oxidation or constraints on the diffusional supply of methane to methanotrophic communities may be important controls on methane cycling in these soils. Seasonality in methane exchange, with weaker uptake related to increased water-filled pore space and soil temperature during the wet season, was only apparent in the upper montane forest. Differences in patterns of soil-atmosphere methane exchange and environmental conditions here and in previous studies of similar ecosystems allow us to speculate that the interaction between soil structure and rainfall regimes may help explain observed variability.