Methane consumption in two temperate forest soils

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Abstract. Forest soils are thought to be an important sink for atmospheric methane. To evaluate methane consumption, 14C-labeled methane was added to the headspace of intact soil cores collected from a mixed mesophytic forest and from a red spruce forest located in the central Appalachian Mountains. Both soils consumed the added methane at initially high rates that decreased as the methane mixing ratio of the air decreased. The mixed mesophytic forest soil consumed an average of 2 mg CH4 m⁻² d⁻¹ versus 1 mg CH4 m⁻² d⁻¹ for the spruce forest soil. The addition of acetylene to the headspace completely suppressed methane consumption by the soils, suggesting that an aerobic methane-consuming microorganism mediated the process. At both forest sites, methane mixing ratios in soil air spaces were greater than that in the air overlying the soil surface, indicating that these soils had the ability to produce methane. Models of methane emission from forest soils to the atmosphere must represent methane flux as the balance between production and consumption of methane, which are controlled by very different factors.

Introduction

Efforts to understand the observed 1% annual increase of tropospheric methane have focused primarily on increased emissions of methane from biogenic sources to the atmosphere (Cicerone & Oremland 1988 and references cited therein). A portion of the increase may also result from reduced strength of a methane sink, such as depletion of tropospheric hydroxyl radicals that remove atmospheric methane (Khalil & Rasmussen 1985; Isaksen & Hov 1987). Forest soils are also thought to be a sink of atmospheric methane (cf., Seiler & Conrad 1987). That is, field studies have shown that methane is lost from the headspace of chambers placed over soil surfaces for short time periods (Keller et al. 1983, 1986; Seiler et al. 1984). If all forest soils consumed atmospheric methane at the mean rate measured in these studies, the sink would be large enough to influence the global
atmospheric methane budget. However, few data have been collected and the mechanism involved is undefined.

Forest soils are mostly aerated, suggesting that aerobic methane-consuming microorganisms are likely to be present (Hanson 1980). Yet aerated forest soils can still have anaerobic microsites where oxygen consumption exceeds the rate of oxygen supply by diffusion (Smith 1980). These might be able to support active populations of anaerobic methane-producing bacteria, suggesting that methane fluxes are the balance between production and consumption.

In the studies reported here, soils from both a mixed deciduous forest and a red spruce forest located in the central Appalachian Mountains showed consumption of atmospheric methane as well as methane production. Thus, the balance between production and consumption of methane appears to determine whether a forest soil will be a source or sink of atmospheric methane.

**Methods**

**Field site**

Two forest stands in the Monongahela National Forest located in the Appalachian Mountain region of West Virginia were selected for study. One stand (39°07'N, 79°35'W; 990-m elevation) was a mixed mesophytic forest with American beech (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), yellow birch (*Betula alleghaniensis* Brit.), black cherry (*Prunus serotina* Ehrh.), and an occasional codominant eastern hemlock (*Tsuga canadensis* (L.) Carr.) established on an extremely stony, fine-loam, mixed, mesic Aquic Fragiudult soil derived from Homewood sandstone. The other stand (38°43'N, 79°32'W; 1100-m elevation) was a monospecific red spruce (*Picea rubens* Sarg.) forest established on a loamy-skeletal, mixed, mesic Typic Dystrochrept soil also derived from Homewood sandstone.

The spruce forest had higher soil organic matter content and higher annual precipitation, which combined with lower evapotranspiration, contributed to greater soil moisture content compared to that in the mixed mesophytic forest.

**Soil core collection**

Five intact soil cores (10-cm dia × 25-cm depth) were obtained from each forest in May 1988 by driving separate PVC cylinders, each with a sharpened