Geophysical Research Abstracts
Vol. 14, EGU2012-10582, 2012
EGU General Assembly 2012

High N2O emission in an N-saturated subtropical forest, southwest China

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Nitrogen (N)-saturated forests in subtropical China are significant N sinks, despite low forest growth rates. In a forested headwater catchment at Tieshanping, Chongqing, SW China, with 4 g N $m^{-2}a^{-1}$ atmogenic deposition (60% of which as NH_4^+-N) and leaching of only 0.6 g N m^{-2} a^{-1} (NO_3^--N dominated), we applied state-of-the-art field and laboratory methodologies to investigate the nature of the N sinks. The study included the determination of spatiotemporal patterns of N_2O emission, a ^{15}N labeling experiment and laboratory incubations to determine nitrification and denitrification characteristics and their gaseous product stoichiometries.

Emission of N_2O occurred predominantly during the wet season (summer), driven by rain episodes. N_2O emission rates were particularly high along a hill slope (HS) with a thin organic surface layer overlaying an argic B horizon causing transient interflow during storm flow conditions. Lower N_2O emission rates were observed at the foot slope in a colluvium-derived groundwater discharge zone (GDZ). Laboratory incubation experiments suggested that the difference in N_2O emission rate is primarily due to higher N_2O/N_2 product ratios of denitrification in the HS topsoil being exposed to frequent drying-rewetting. Lower N_2O/N_2 product ratios in soils of the GDZ, in turn, could be attributed to more stable anoxia, lower NO_3^- availability and higher pH as compared with the hillslope, all of which favor the expression of N_2O reductase.

Estimated annual N_2O emission for the relatively dry hydrological year 2009-2010 was 0.4 g N m^{-2}, which is equivalent to approximately 10% of the annual input of reactive N. Measurements during summer 2009 indicated that N_2O emissions can be even higher during wet years. A $^{15}NO_3^-$ labeling experiment conducted on HS soils during summer revealed that between 75 and 86% of the N_2O emission derived from denitrification during the first 6 days after label addition, accounting for 8-15% of the applied NO_3^--N. Our study indicates that N-saturated subtropical forests in south China, receiving large inputs of agriculturally derived atmogenic NH_4^+, may be significant secondary sources of N_2O, which should be taken into account when estimating the CO_2 footprint of subtropical agriculture.