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Soil N2O emissions - past, present and future

Adam Schlosser[†]; Eri Saikawa; Xiang Gao; Matt Rigby; Ron Prinn
[†] MIT, USA
Leading author: casch@mit.edu

Nitrous Oxide (N20) is currently the most important ozone depleting substance and it is one of the most significant anthropogenic greenhouse gases. Despite its damage for stratospheric ozone, it is not regulated by the Montreal Protocol, and global observations show continuous N2O mole fraction increase of 0.2 to 0.3% per year with seasonal variability. Sinks and sources of N2O still have large uncertainties but previous studies have estimated that soil emissions share more than a half of the total emissions. Because the variability in soil emissions could potentially have important implications for regional and global climate, and vice versa, it is essential to better understand the processes and feedbacks associated with soil N2O emissions. To achieve this goal and quantify global soil N2O emissions, we have included the nitrification-denitrification processes (DNDC) into the Community Land Model (CLM) version 3.5. Using the three different bias-corrected, reanalyses-based meteorological datasets (NCC, CAS and GOLD), we have constructed a suite of global gridded soil N2O emission estimates for the years 1975 through the mid-2000s. We evaluate our global soil N2O flux estimates against: 1) an existing emissions inventory - GEIA, 2) other process models (O-CN and NASA-CASA), and 3) observations from an existing forest N2O flux data in Amazon. Both the global and regional totals agree well and the model reproduces the observed seasonal cycles of N2O emissions. Next, we use these emission estimates in the 3-dimensional chemical transport model - Model for OZone And Related Tracers (MOZART) version 4 - to analyze the impact of monthly and inter-annual variability in soil emissions on predicting measurements at observational sites. These MOZART results demonstrate the importance of the interaction between soil N2O emissions and stratospheric intrusion of N2O-depleted air at capturing the seasonal and interannual variability in atmospheric mixing ratios. Then, using these emissions estimates as a priori, we also estimate regional and global N2O emissions by inverse modeling for 1995 through 2009. Data from Advanced Global Atmospheric Gases Experiment (AGAGE) and NOAA are used after having been averaged into monthly mean values with associated errors. Finally, to gauge the feedbacks between the climate and the biogeochemical cycles, we use climate projections taken from the Integrated Global Systems Model (IGSM) to estimate future soil N2O emissions under various climate scenarios as well as across the range of uncertain responses in the Earth system.