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# Using the ecosys mathematical model to simulate topographic effects on spatial variability of nitrous oxide emissions from a fertilized agricultural field

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Calculation of emission factors (EFs) for nitrous oxide (N2O) is complicated by their large spatial variability. The objective of this study was to test the hypotheses that spatial variation in N2O emissions can be explained by (1) spatial and temporal variation in soil water-filled pore space (WFPS) among topographic positions that shed or collect water according to topographically-driven water movement, and (2) spatial variation in soil properties which may themselves be caused by topographically driven water movement. These hypotheses have been incorporated into a detailed processed-based, three-dimensional mathematical model of terrestrial ecosystems, ecosys. We simulated emissions using ecosys at different spatial scales – meter, fetch and field, using a 20 x 20 matrix of 36m x 36m grid cells from a digital elevation model (DEM) to represent topography of a fertilized agricultural field in Ottawa, Canada. Modeled results were compared to fluxes measured with chambers placed at different topographic positions to measure spatial variability of N2O emissions at the meter scale, and with stationary and mobile flux towers with tunable diode lasers (TDL) and a flux-gradient technique to assess spatial N2O variability at the fetch scale. Most modeled and measured emissions occurred during a 10-day interval in late spring/early summer, due to a combination of fertilizer N application, rainfall and rising soil temperatures. Coefficients of spatial variation (CSVs) measured amongst 4 chamber replicates (2 x 3 m grid) during emission events were 28 to 195 %, indicating that spatial variation of N2O occurs at a very small spatial scale. Annual CSVs modeled at the field scale rose from 25% when soil properties in the model were assumed uniform to 101% when soil properties in the model were allowed to vary according to results from a field soil survey. The modeled EF (assumed uniform soil properties) for a fertilizer application of 112 kg N ha-1 was larger in an area of the field with lower topography (0.3%) than in one with higher (0.1%). EFs were low compared to those of other studies because delayed spring warming in the year of study caused nitrification of fertilizer N to occur under lower temperatures than average for this site. These results show that hourly time-step 3-dimensional models such as ecosys used with input from DEMs can fully reproduce large spatial and temporal variability of N2O from topographically-driven water movement at different spatial scales even in seemingly flat (0.2% slope) landscapes.