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Understanding the origins of uncertainty in landscape-scale variations of emissions of nitrous oxide

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Nitrous oxide is a potent greenhouse gas which is over 300 times more radiatively effective than carbon dioxide. In the UK, the agricultural sector is estimated to be responsible for over 80% of nitrous oxide emissions, with these emissions resulting from livestock and farmers adding nitrogen fertilizer to soils. For the purposes of reporting emissions to the IPCC, the estimates are calculated using simple models whereby readily-available national or international statistics are combined with IPCC default emission factors. The IPCC emission factor for direct emissions of nitrous oxide from soils has a very large uncertainty. This is primarily because the variability of nitrous oxide emissions in space is large and this results in uncertainty that may be regarded as sample noise. To both reduce uncertainty through improved modelling, and to communicate an understanding of this uncertainty, we must understand the origins of the variation.

We analysed data on nitrous oxide emission rate and some other soil properties collected from a 7.5-km transect across contrasting land uses and parent materials in eastern England. We investigated the scale-dependence and spatial uniformity of the correlations between soil properties and emission rates from farm to landscape scale using wavelet analysis. The analysis revealed a complex pattern of scale-dependence. Emission rates were strongly correlated with a process-specific function of the water-filled pore space at the coarsest scale and nitrate at intermediate and coarsest scales. We also found significant correlations between pH and emission rates at the intermediate scales. The wavelet analysis showed that these correlations were not spatially uniform and that at certain scales changes in parent material coincided with significant changes in correlation. Our results indicate that, at the landscape scale, nitrate content and water-filled pore space are key soil properties for predicting nitrous oxide emissions and should therefore be incorporated into process models and emission factors for inventory calculations.