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Meta-analysis of the differences of soil nitrous oxide emission factors between whole years and growing seasons

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Nitrous oxide (N_2O) from croplands is a major source of anthropogenic N_2O emissions. An N_2O emission factor (EF) is proposed by the Intergovernmental Panel on Climate Change (IPCC) for greenhouse gas (GHG) inventories as the response of direct emissions from fertilizer nitrogen applied. The N_2O EF varies with management-related factors and other environmental factors, and the IPCC emission factor database requires the experimental duration of these EFs to cover at least a year, including growing seasons and fallow periods, reflecting the impacts of weather conditions during the whole year. However, a large number of N_2O field measurements have been conducted during the growing season only, instead of the whole year, and thus cannot be used for deriving N_2O EFs. The aim of this study it to identify the differences between EF for whole years (EF_{wy}) and EF for growing seasons (EF_{gs}) and their controlling factors at regional and plot scales. At the regional scale, 364 and 761 EFs were calculated for whole years and growing seasons as the percentage of fertilizer N input converted to N_2O emissions from 199 published studies. Although there was no generally significant differences between them (0.81% vs 0.87%, $P>0.05$), the differences in all climatic zones are significant (Warm-moist: 1.19% vs 0.38%; Warm-dry: 0.70% vs 0.51%; Cool-moist: 0.71% vs 1.15%; Cool-dry: 1.01% vs 0.30%; $P<0.05$). For crop types, the differences between EF_{wy} and EF_{gs} were found non-significant ($P>0.05$) except for wheat. Therefore, different crop compositions for EF_{wy} and EF_{gs} in each climatic zone led to the distinctions between EFs during whole years and growing seasons at regional scale. At plot scale, from 15 field studies, 98 pairs of EF_{wy} and EF_{gs} were collected. In general EF_{wy} was slightly lower than EF_{gs} and 93% of the variance can be explained by the regression ($EF_{wy}=0.88EF_{gs}$, $R^2=0.93$). Additionally, we found that freeze-thaw cycles, climatic zones, crop types, soil bulk density and clay content have important impacts on the ratio of EF_{wy} to EF_{gs}. Our results suggest that the difference between EF_{wy} and EF_{gs} at regional scale can be attributed to crop compositions and at plot scale EF_{wy} is generally lower than EF_{gs} and can be adjusted by surrounding environmental factors. Use of this knowledge in GHG inventories could improve data availability and efficiency of EF in the global N_2O budget, refine the accuracy of fertilizer-induced N_2O emissions, and help to bridge the knowledge gap of the differences in EFs between whole years and growing seasons.