Effects of historical changes in land-use, N fertiliser application and atmospheric N deposition on terrestrial carbon and nitrogen fluxes

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We present a first estimate of the consequences of historical anthropogenic perturbations of the terrestrial carbon and nitrogen balances, in particular the emission of climatically relevant biogenic nitrogen trace gases (NO, N₂O) due to land-use changes, increases in N fertiliser application and atmospheric deposition of reactive nitrogen. These changes are evaluated relative to a baseline simulation taking historical climatic changes and increases in atmospheric CO₂ concentrations into account. The estimates are obtained using the global, process-based terrestrial ecosystem model O-CN, which encodes a mechanistic understanding of the coupling between terrestrial C and N dynamics for twelve global vegetation types. In particular, O-CN estimates N trace gas emissions using a process-based approach. Evaluation exercises show that the simulated effect of N additions on vegetation productivity and net C storage agrees well with observations from a range of field studies and manipulation experiments. N trace gas emissions fall well within the observed ranges for individual vegetation types and global biomes, however, site-scale analyses reveal model deficiencies in capturing the temporal dynamics of NO and N₂O emissions. Based on our global modelling results we identify key important processes and regions for which further observations, as well as model development and validation work are required to provide a comprehensive assessment of the effect of anthropogenic activities on nitrogen controlled greenhouse gas balances.