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Development of a process-based model for analyzing the land-atmosphere exchange of CO2, CH4, and N2O: plot-scale study in a temperate deciduous forest in central Japan

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Land-atmosphere exchange of greenhouse gases can exert considerable feedback effects on the human-induced climatic change. However, there remain large uncertainties in our understanding and quantification of the greenhouse gas exchange, owing to complexity and heterogeneity of terrestrial ecosystems. To evaluate the global warming potential (GWP) reasonably, we should account for net budgets of major greenhouse gases, carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), each of which are regulated by different biogeochemical mechanisms. We developed a process-based model of land-atmosphere exchange of the major greenhouse gases, on the basis of a carbon cycle model (Sim-CYCLE). First, methane oxidation schemes were considered for one by Potter et al. (1996) and Ridgewell et al. (1999), in which CH4 oxidation rate by soil was parameterized as functions of temperature and soil moisture. Second, schemes of nitrous oxide emission by nitrification and denitrification were considered for one by Parton et al. (1996) and Potter and Klooster (1998), in which N2O emission rate from soil was parameterized as functions of soil inorganic nitrogen, temperature, and moisture conditions. Preliminarily, we applied the model to a cool temperate deciduous broad-leaved forest in Takayama, an AsiaFlux site in central Japan, using a time-series climate data of the NCEP/NCAR from 1948 to 2004. The land-atmosphere exchange of the greenhouse gases showed clear seasonal variations: strong net uptakes of CO2 and CH4 and strong N2O emission in summer. The model estimations were compared with observations with a flux tower and soil chambers, showing fair agreements. On average during the last 10 years, the model

estimated that the temperate forest net absorbed CO2 and CH4 at rates of 804.53 g CO2 m-2 yr-1 and 0.34 g CH4 m-2 yr-1, and net released N2O at a rate of 0.02 g N2O m-2 yr-1, respectively. Based on the 100-year GWP of greenhouse gases in IPCC (2001), the forest was estimated to have a negative effect of GWP by 807.74 g CO2 (equivalent) m-2 yr-1. In our forthcoming study, after modifying the model for water and nitrogen cycles, we will apply the model to other AsiaFlux sites and estimate the Asian greenhouse gas budget.