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Pre-industrial and contemporary fluxes of nitrogen through rivers: a global assessment based on typology

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Abstract. This paper provides a global synthesis of reactive nitrogen (Nr) loading to the continental landmass and subsequent riverine nitrogen fluxes under a gradient of anthropogenic disturbance, from pre-industrial to contemporary. A mass balance model of nitrogen loading to the landmass is employed to account for transfers of Nr between atmospheric input sources (as food and feed products) and subsequent consumer output loads. This calculation produces a gridded surface of nitrogen loading ultimately mobilizable to aquatic systems (Nmob). Compared to the pre-industrial condition, nitrogen loading to the landmass has doubled from 111 to 223 Tg/year due to anthropogenic activities. This is particularly evident in the industrialized areas of the globe where contemporary levels of nitrogen loading have increased up to 6-fold in many areas. The quantity of nitrogen loaded to the landscape has shifted from a chiefly fixation-based system (89% of total loads) in the pre-industrial state to a heterogeneous mix in contemporary times where fertilizer (15%), livestock (24%) and atmospheric deposition (15%) dominate in many parts of the industrialized and developing world. A nitrogen transport model is developed from a global database of drainage basin characteristics and a comprehensive compendium of river chemistry observations. The model utilizes constituent delivery coefficients based on basin temperature and hydraulic residence times in soils, rivers, lakes and reservoirs to transport nitrogen loads to river mouths. Fluxes are estimated for total nitrogen, dissolved inorganic nitrogen, and total organic nitrogen. Model results show that total nitrogen fluxes from river basins have doubled from 21 Tg/year in the pre-industrial to 40 Tg/year in the contemporary period, with many industrialized areas of the globe showing an increase up to 5-fold. DIN fluxes from river basins have increased 6-fold from 2.4 Tg/year in the pre-industrial to 14.5 Tg/year in the contemporary period. The amount of nitrogen loading delivered to river mouth as flux is greatly influenced by both basin temperatures and hydraulic residence times suggesting a regional sensitivity to loading. The global, aggregate nitrogen retention on the continental land mass is 82%, with a range of 0–100% for individual basins. We also present the first seasonal estimates of riverine nitrogen fluxes at the global scale based on monthly discharge as the primary driver.