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Biogeochemical processes and fluxes of trace metals from the Amazon River system and mangrove belt into the Atlantic under high and low discharge conditions

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The Amazon River system is responsible for about half of the total freshwater input into the tropical Atlantic Ocean and has the largest catchment area in the world. The global importance of this system for the bioproductivity of the coastal ocean and beyond, as well as the drastic current changes of the Amazon River system due to climate change and other anthropogenic impacts, urgently require a comprehensive study of estuarine processes, including dispersal patterns and variability of trace metals and other compounds over space and time. Water discharge rates fluctuate significantly between a maximum after the wet season and a minimum after the dry season. Therefore, the far-reaching effects of Amazon runoff on the input of trace elements into the Atlantic Ocean and the associated bioproductivity and other biogeochemical processes are seasonally variable. Geochemical reactions occurring in Amazon estuarine waters significantly affect the flux of these components, including biological modification, adsorption/desorption to/from particles, coagulation, precipitation and dissolution of particles.

We investigated these processes during two GEOTRACES process study cruises (M147, GApr11; M206, GApr21) during the high (April-May 2018) and low (December 2024) discharge seasons by sampling surface waters and the water column in the Pará and Amazon River mouths and estuaries, as well as the northwest-propagating river plume, to cover the entire range of river-freshwater mixing between the riverine end-members and the Atlantic Ocean seawater end-member. A second focus was on the previously underestimated contribution of trace metals from the mangrove belt south of the Pará outflow to the total material flux into the coastal ocean. The different sources, i.e. the Pará River, the Amazon River and the mangrove belt, revealed distinct trace metal signatures that merged to form a flux across the shelf transported north-eastward by the North Brazil Current. While the data for cruise M206 have yet to be determined, the pronounced difference in water fluxes between the two seasons, which was likely exacerbated during the M206 cruise due to extreme drought conditions throughout the Amazon River basin in the preceding months, suggest that trace metal fluxes also varied considerably between seasons.