

## The heterogeneous nature of rivers

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Rivers carrying the products of erosion and weathering, they are powerful integrating tools to study these processes at the continental scale. Nevertheless:

- (1) various geological, climatic and biological conditions in a river catchment may generate waters of different compositions, that may be not well-mixed downstream from confluences.
- (2) the suspended river material carried by rivers present a large variety of solid grains in terms of grain size, mineralogy, chemistry and isotopic signatures. These grains are likely to be hydrodynamically sorted in river channels.

We investigate the chemical and isotopic composition of the Amazon River and its main tributaries along cross-sections and by sampling at different depths. Both sediments and water show that rivers are not chemically homogenous

Based on high-precision measurements of Sr isotopes, we show that poor-mixing of tributaries can persist over hundreds of kilometers, and that given the size of the Amazon River tributaries, the Amazon is not well-mixed for the dissolved load.

In the particulate phase, an enrichment of insoluble elements is observed from channel bottom to surface. This is interpreted as the result of the granulometric sorting that operates within the river. Large chemical and mineralogical fractionations are observed within depth-profiles. For instance, in the Solimões River, the amount of plagioclase is found to vary by a factor of more than two from bedload to channel surface suspended load. When two tributaries of different granulometric patterns mix, the resulting depth-profile of sediments show varying relative contributions of the two tributaries. This is observed, based on Sr isotopes, in the Amazon River. The finest fraction is more influenced by the sediments of the Madeira, whereas the bottom sediments reflect the contribution of the Solimões River.

## The spontaneous development of Fe-limited, Si-rich waters in polar oceans with rapid nutrient supply

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Roughly one third of the global ocean surface maintains inorganic macronutrients (nitrate and phosphate) at the surface throughout the year, despite the complete consumption of these nutrients throughout the rest of the sunlit surface ocean. These 'High Nitrate Low Chlorophyll' (HNLC) regions - dominated by the subarctic Pacific and Southern oceans - have long intrigued oceanographers, and have been shown to exert a strong influence on atmospheric carbon dioxide concentrations. Understanding the mechanisms that regulate the existence and character of HNLC regions is key to gauging their role in past and future climate change. Clear demonstrations that phytoplankton growth in HNLC regions is currently handicapped, due to vanishingly low ambient iron concentrations, has led to widespread belief that an inadequate supply of iron to these regions is primarily responsible for their existence. In addition, the abundance of heavily-silicified diatoms within these regions has been attributed to high Si:N uptake ratios as an additional result of weak iron supply. We suggest that, instead, HNLC regions can be more simply understood as arising spontaneously from rapid nutrient supply, a function of the physical ocean circulation regime. Differential cycling of iron and silica causes these elements to be distilled within the biogeochemical refineries of HNLC regions, altering their abundances relative to N and P. Because iron has a short residence time, being rapidly removed from the water column by scavenging, it is preferentially lost from HNLC regions while N and P pile up in the subsurface. Meanwhile, the relatively efficient export of opaline silica from the mixed layer bypasses lateral transport of residual N and P out of the HNLC region, causing it to become relatively enriched in the waters below. The result is that open-ocean domains in which the upward supply of nitrate and phosphate exceed the rate of export production tend to become Fe-limited and Si-rich, regardless of the distribution of iron supply.