

## Supplementary Materials

### Methods

#### *Sample filtration*

In this study, we operationally defined “dissolved iron”, as the fraction passing through 0.45 or 0.22  $\mu\text{m}$  filter size. In some cases, we also used larger pore size filtration at 5, 3 and 2.5  $\mu\text{m}$  to recover together small particles and dissolved Fe fraction. The colloidal and truly dissolved fractions (i.e. < 1 kDa) are obtained using ultra filtration and dialysis methods. For Lena and Ob' river waters, the samples were collected from a small boat and immediately filtered through 0.45  $\mu\text{m}$  filters. Filtered waters were stored in Nalgene high-density polyethylene (HDPE) and frozen until further analysis as described in (Holmes et al., 2012). Samples from Alaska were collected following the ultra clean method of Shiller (2003) and further described in Schroth et al. (2011) where Fe partitioning in river water is determined as soluble (< 0.02  $\mu\text{m}$ ) and colloidal (< 0.45 or 0.2  $\mu\text{m}$ ) size fractions using trace metal clean syringe filtration of small volume samples (~15 mL to 30 mL) (Shiller, 2003).

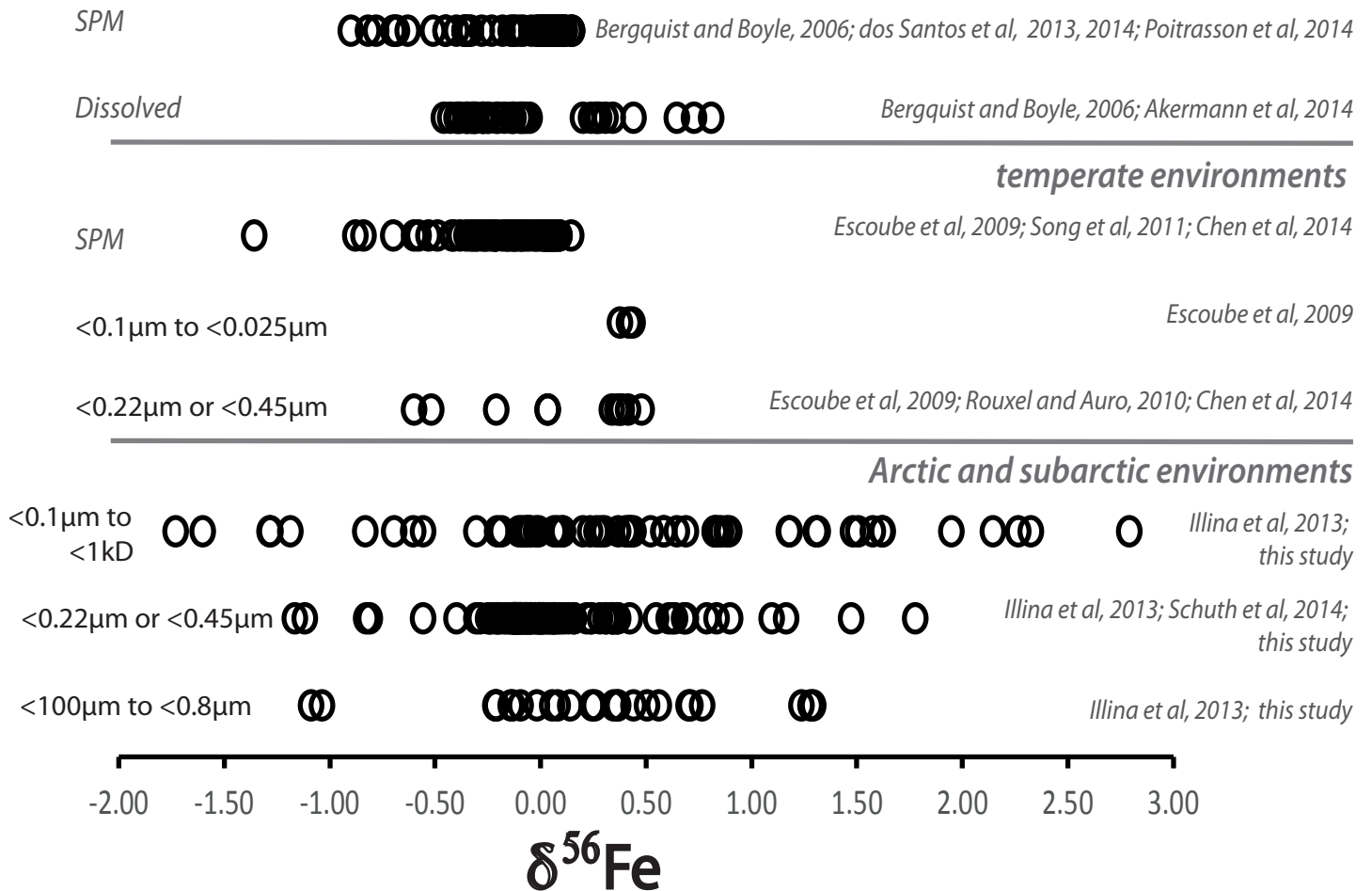
The White Sea samples were collected from the middle of the flow channel, using 1 liter HDPE containers held out from the beach on a non-metallic stick. The samples were collected and manipulated as described elsewhere (Ilina et al., 2013, Pokrovsky et al., 2012, Pokrovsky et al., 2010, Vasyukova et al., 2010). Water samples were immediately filtered on-site through sterile, single-use filter units (Sartorius, acetate cellulose filter) with pore sizes of 5, 2.5, 0.45 and 0.22  $\mu\text{m}$ . The first 50 ml of the filtrate was systematically discarded before sampling. Two techniques of ultra-filtration (100 kDa, 10 kDa and 1 kDa) have been used: (1) frontal ultrafiltration (UF) was carried out using a 50-ml polycarbonate cell (Amicon) equipped with a suspended magnet stirring bar located beneath the filter to prevent clogging during pressure filtration at 3 bars; (2) in-situ dialysis filtration involved the use of trace-metal clean SpectraPor 7<sup>®</sup> dialysis membranes containing ultrapure MQ deionized water placed in flotation in natural water during more than 24h (Vasyukova et al., 2010).

#### *Analysis*

Major and trace element analyses were all performed on samples acidified at pH 2 with ultrapure double-distilled  $\text{HNO}_3$ . Trace element analyses were measured by HR-ICP-MS

either at LMTG (France) or WHOI (USA). The riverine water reference material SLRS-4 (National Research Council of Canada) was used to check the accuracy and reproducibility of each analysis. Samples for dissolved organic carbon (DOC) analysis were collected in pyrolyzed sterile Pyrex glass tubes after filtration through 0.45 or 0.22  $\mu\text{m}$  and analyzed using a Total Carbon Analyzer (Shimadzu TOC 5000).

The procedure for Fe-isotope analysis follows previously described methods in (Escoube et al., 2009) for riverine and brackish waters. In short, acidified samples are evaporated to dryness at 80°C with distilled  $\text{HNO}_3$  and  $\text{H}_2\text{O}_2$  (ultrapure grade) on a hot plate to release the iron from organic complexes. The samples are then purified through anion exchange resin (AG1-X8, Bio-rad). Iron isotope compositions were determined with a *Neptune* (Thermo-Scientific) multicollector inductively coupled plasma mass spectrometry (MC-ICPMS) operating at WHOI and IFREMER using medium or high-resolution mode. Instrumental mass bias is corrected using  $^{62}\text{Ni}/^{60}\text{Ni}$  isotope ratio as internal standard simultaneously measured. All analyses are reported in delta notation relative to the IRMM-014 standard, expressed as  $\delta^{56}\text{Fe}$ , which represents the deviation in per mil relative to the reference material. As  $\delta^{56}\text{Fe}$  and  $\delta^{57}\text{Fe}$  are on a single mass fractionation line ( $r^2 = 0.9956$ ), only  $\delta^{56}\text{Fe}$  values are reported in this paper.



**Figure S1:** Compilation of Fe isotope composition of rivers reported in the literature: (i) Arctic and subarctic environments including russian rivers, ponds and swamps of the White Sea basin, and Ob' and Lena rivers (Illina et al, 2013; this study), and alaskan rivers (Schroth et al, 2011, this study). ; (ii) Temperate environments include the North River (USA; Escoube et al, 2009); Seine river (France; Chen et al, 2014); Aha lake and its inflowing rivers (China; Song et al, 2011); (iii) Tropical environments including the Amazon River and tributaries (Bergquist and Boyle, 2006; Poitrasson et al, 2014 ; dos Santos Pinheiro et al, 2013, 2014) and Mendong (Cameroon; Akermann et al, 2014). Note that results from Ingri et al (2006) have not been included since they correspond to saturated filters collecting both particles and some class of colloids. SPM corresponds to suspended particulate matter retained on filters of 0.22  $\mu\text{m}$  or 0.45  $\mu\text{m}$  pore size.

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