RIVERINE TRANSPORT OF ATMOSPHERIC CARBON : SOURCES, GLOBAL TYPOLOGY AND BUDGET

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Abstract. Atmospheric C (TAC) is continuously transported by rivers at the continents' surface as soil dissolved and particulate organic C (DOC, POC) and dissolved inorganic C (DIC) used in rock weathering reactions. Global typology of the C export rates ($g.m^{-2}.yr^{-1}$) for 14 river classes from tundra rivers to monsoon rivers is used to calculate global TAC flux to oceans estimated to 542 $Tg.yr^{-1}$, of which 37 % is as DOC, 18 % as soil POC and 45 % as DIC. TAC originates mostly from humid tropics (46 %) and temperate forest and grassland (31 %), compared to boreal forest (14 %), savannah and sub-arid regions (5 %), and tundra (4 %). Rivers also carry to oceans 80 Tg. yr^{-1} of POC and 137 $TG.yr^{-1}$ of DIC originating from rock erosion. Permanent TAC storage on land is estimated to 52 $Tg.yr^{-1}$ in lakes and 17 $Tg.yr^{-1}$ in internal regions of the continents.

1. Introduction

Delivery of inorganic C budget to the oceans by rivers was first estimated by Clarke (1924) but reliable budgets of total organic carbon (TOC) have become available only recently. There is little mention of TOC in Livingstone's master review on world's rivers (1963). The first budgets were published in 1981 by Schlesinger and Melack, and by Meybeck. Since then, our understanding of the C content in world's rivers has improved substantially largely by means of the SCOPE-CARBON

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program (1982) headed by E. Degens and his Hamburg team which lead to numerous published workshops and the book by Degens *et al.* (1991), as well as numerous reviews of the global budget of riverine TOC (Milliman *et al.*, 1984 ; Kempe, 1985 ; Meybeck, 1988 ; Ittekkot, 1988). Related topics, such as lake retention of TOC and anthropic influences on the river C budget, have also been considered by Mulholland and Elwood (1982), Kempe (1984) and Kempe *et al.* (1991).

Numerous methods have been employed to evaluate global riverine budget (Meybeck, 1988). Perhaps the most interesting is that which relies on a global typology of specific export rates of C (in t $C.km^{-2}.yr^{-1}$ or g $C.m^{-2}.yr^{-1}$) attributing one mean value for each environmentally classified category (e.g., the taiga, the tropical rain forest). This method is particularly well suited for the estimation of global elemental budgets for each major biome, such as the boreal regions or the humid tropics, and has already been used for major ions - including dissolved inorganic carbon (DIC) by Meybeck (1979), and TOC by Schlesinger and Melack (1981), as well as Meybeck (1981, 1982, 1988). The budget of particulate organic carbon (POC) derives from another approach based on the global distribution of total suspended matter in rivers (TSS) and on the TSS *vs* POC relationship (Meybeck, 1982 ; Ittekkot, 1988).

Considering the more extensive data base on river C now available, a new C budget is possible through the combination of several budget development methodologies (Meybeck, in preparation), of which only the global results have been published (Meybeck, 1993). In this paper, I focus on the global classification of river C export of all C species, i.e., on major river C sinks on land. Anthropic influences in terms of the global river C budget are treated by Downing *et al.* (this volume).

2. Natural Sources of Atmospheric Carbon and Rock Carbon in Rivers

Table 1 lists riverine C in its multiple forms, its characteristics, residence time, and its different sources and origins (Figure 1). Riverine C may be classed as dissolved (DIC, DOC) or particulate (PIC, POC), organic (DOC, POC, TOC) or inorganic (DIC, PIC).

Dissolved inorganic carbon exists mostly in the form of bicarbonate (HCO_3^-) in rivers where the pH range is commonly between 6 and 8.4. In non-carbonate environments, such as plutonic, metamorphic and volcanic regions, and most of shale and sandstone regions, river DIC results entirely from soil and atmospheric CO_2 according to the general weathering equation :