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Interactive comment on "Past and present of sediment and carbon biogeochemical cycling models" *by* F. T. Mackenzie et al.

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General Comments:

I found it a pleasure to read the paper by Mackenzie et al.; not only does it provide an informative and thoughtful report on the status and latest developments in global-scale modelling of sediment and carbon biogeochemical cycling, but it also explains the conceptual and technical history of the field. This review and context-setting is particularly important to understanding complex interdisciplinary topics such as this, and it is a feature that has become all too rare in the scientific literature with the growing emphasis on abbreviated presentation of the least publishable unit.

It is also a paper ideal for initiating a broader discussion, since I find little to criticize in the publication itself, but much that could and should be extended and connected with by other authors. In general, I contend that it is past time for more sustained and thoughtful efforts to integrate and compare the results of these kinds of studies - global-scale modeling with long-term budgetary 'calibration' - with the growing body

of observational data and shorter-term, higher resolution modeling results. The two classes of approach to the subject develop from different disciplinary backgrounds, tend to use different data sets, and thus can offer each other substantially independent definitions of constraints and hypothesis testing as well as potentially useful insights. An excellent example is the CO2-calcification interactions discussed in the paper. Although the paper by Kleypas et al.(1999) was considered an important contribution to marine biology and oceanography and was the point of departure for a rapidly expanding body of literature, the linkages among atmospheric CO2, ocean chemistry, and biogenic calcification had long been amply and clearly discussed in the literature on geochemistry and earth evolution. There are undoubtedly other "ahas" awaiting those who peer over the disciplinary fences, and we would be well advised to devote as much attention to concept-mining as we do to data-mining.

Specific Comments:

One point on which I wish the authors had provided more information can serve to illustrate some of the points I consider important. Their figure 5b shows past and predicted riverine inputs of organic C, N and P to the coastal zone based on the TOTEM model. Although the answers can presumably be found in the TOTEM publications cited, the curves presented make me immediately curious about the river water discharge scenario used. Was it constant flow or were there any changes incorporated to reflect past or future modifications of terrestrial hydrology (Graf, 1999; Vörösmarty and Sahagian, 2000), or the possible effects of future climate change (Nearing et al., 2004)? GCM predictions are for an accelerated hydrologic cycle in a warmer future, but expanding demand for fresh water for human use is also expected. The former would imply increasing runoff, while the latter suggests even more flow regulation and consumptive use, potentially decreasing runoff in some areas. Smith et al. (2003) recently showed that contemporary nutrient loads to the ocean could be described in terms of river basin runoff and population. Studies of that sort suffer from difficulties in establishing the fluxes under unaltered (natural, or "pristine"), while model studies of the SOCM-

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TOTEM type tend to generalize or ignore the details of anthropogenic effects. The complementary strengths and weaknesses of these two types of approaches suggests that they may be real potential in linking them, especially in ways that facilitate testing of future hydrologic and population scenarios.

Another suggestion for future publications building on this contribution is the blending or interaction of approaches to characterizing oceanic budgets and fluxes at various scales. Mackenzie et al. discuss (the last three paragraphs of section 6) a number of regional or integrative studies that relate to their model results. The number and variety of such studies is growing rapidly, as exemplified by a partial list of other recent papers (e.g., Calderia and Duffy (2000); Sandberg et al. (2004); Hansell et al. (2004); Palmer and Pearson (2003); Thomas et al. (2004)); it seems to me that the global "umbrella" predictions of Mackenzie et al. provide both an integrative theme and a comparison target for exploring the combined results of the diverse local and regional studies. The diversity and geographic patchiness of the local studies make them not worth the effort of attempted integration in the absence of some overall framework. However, the aggregated smaller-scale studies provide detail on spatio-temporal distributions of uptake and inventory that are necessarily missing from the model calculations of (for example) the depth of an equivalent uptake layer of uniform depth, while the global model provides a means of identifying quantities and candidate locations of the CO2 not described by the direct, real-time observations. Taken together, and perhaps with the addition of output from coupled GCMs, the combined results would permit both budgetary cross-checks and refinement of the remaining research questions and their relative priorities, with new insights for both the real-time and the global/paleo communities.

The top-down approach developed and presented here by Mackenzie et al. seems to have gone nearly as far as it can reasonably be expected to go; the bottom-up approach is a long way from having enough component pieces to add together for a complete picture, and the global GCM models, at least to date, have not been cali-

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brated against the long-term, multi-variable budgetary concepts and data discussed by Mackenzie et al. Some combination of the approaches - comparison if not actual hybridization - offers potential for understanding not available from any one alone.

I hope that the community of those working on short-term or predictive biogeochemical flux and budget issues will regard this paper not as a remotely related contribution in a different field, but as a novel and challenging finding to be integrated and reconciled with the ongoing research that is conducted at higher resolution, but probably with less-well-defined overall constraints.

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