The manuscript by Maya et al. presents a very interesting data set on carbon and nitrogen isotope variability in shallow Indian Ocean waters off the coast of the state of Goa (India) through the seasons. Isotopes are a powerful tool to trace the sources and fate of organic matter in aqueous ecosystems. The potential impact of anthropogenic nutrient supply on near-shore primary productivity is one of the motives of the study the authors mention in their introduction. Having said that and regarding the fact that the sampling site is just 10km off the mouths of some tropical rivers (e.g., the Mandovi River) I am surprised that the authors do not consider the potential supply of nitrogen-rich and ^{12}C-depleted soil organic matter (SOM) when it comes to interpreting their data. Thinking of my own experience when tracing terrestrial organic matter export through a tropical river (Congo River) I couldn't help commenting on this issue.

I was intrigued by the fact that both organic carbon to total nitrogen ratios (C/N) and organic carbon isotope values ($\delta^{13}C_{org}$) of suspended particulate organic matter (SPOM) investigated off the coast of Goa are in a fairly similar range compared to those observed by my co-authors and myself in sediments of the Congo deep-sea fan. Even more important: the isotopic composition shows very little variation over times with very different hydrological regimes – which again matches exactly our observations at the Congo fan. Using a multi-proxy approach to further characterise the sedimentary organic matter (OM) it finally occurred to us that common proxies to asses terrestrial and marine proportions of sedimentary organic matter, namely the C/N ratios and bulk $\delta^{13}C_{org}$ values, were largely controlled by the supply of SOM through the Congo River, with a variable admixture of plant litter (Holtvoeth et al., 2005). The SOM of the major soil type (Oxisol) in the catchment of the Congo River is heavily degraded and, as a result, enriched in ^{13}C and inorganic nitrogen (ammonium). It also appears to be firmly bound to clay minerals, probably by forming metal-organic complexes with iron and aluminium sesquioxides that are abundant in these central African tropical soils. Organic petrological observations favour a substantial supply of fine-grained soil OM as almost 90% of the terrigenous particles are smaller than 10 μm, 67% even smaller than 5 μm. Organic coatings on clay minerals that might account for the bulk of SOM would have been invisible, though.
The conclusion that SOM is a dominating fraction of the sedimentary OM on the Congo fan was later confirmed by studies using different organic-geochemical approaches such as biomarkers for soil bacteria (Weijers et al., 2009; Cooke et al., 2008). These findings have the fundamental implication that the contribution of terrestrial OM in marine sedimentary systems might have been severely underestimated when assessed through the application of simple two end-member models (phytoplankton vs. terrestrial plants) for the two most commonly used proxies, C/N and $\delta^{13}C_{org}$.

In 1997, John Hedges and his co-authors asked: "What happens to terrestrial organic matter in the ocean?" They were puzzled by the fact that, although terrestrial organic matter reaching the ocean is assumed to be more resistant to microbial degradation than marine organic matter, its proportion in marine sediments appeared to be too low in relation to the global terrestrial export.
From my own experience described above I would now say: under certain circumstances it can simply slip our attention and go undetected into the ocean. The reason for this lies in the fact that its chemical properties, in particular the bulk organic carbon isotopic composition and the C/N ratios of some clay-rich, deeply weathered tropical soils, can be very close to those of marine organic matter (see Holtvoeth et al., 2005, 2003). There is some indication that similar circumstances might as well exist off the coast of Goa:

- According to a governmental report (Government of India, Ministry of Water Resources, 2010) the flood plains of the Zuari and Mandovi rivers in the districts of Tiswadi, Bardez, Ponda and Pernem - all along the coast adjacent to the investigated site are covered by saline soils which are "deep, poorly drained and less permeable" and contain "humus and organic matter". This description suggests to me that these soils are rich in clay minerals and therefore might contain a type of SOM similar to that in central African soils.

- Sahrawat (1995) observed C/N ratios below 8 in the deeper sections of soil profiles from tropical India although, I think, in a different soil type. It is probably worth searching for some more soil data from the area.

John Hedges' question is still hanging in the air, although there is increasing evidence suggesting that soil-derived terrestrial OM may have been vastly underestimated in earlier studies. However, the amount of terrestrial carbon exported to the oceans is still a hot topic and of high relevance for global carbon budgets. A reliable method to identify and quantify SOM in marine settings with likely contribution from clay- and OM-rich soils is still missing.

Maya et al. might have a good tool at hand to contribute to this important issue. During the post- and pre-monsoon phases C/N and $\delta^{13}C_{org}$ values appear to correlate (exception: mid March 2008) which may generally reflect varying proportions of OM from phytoplankton and terrestrial plant sources, perhaps with some contribution of SOM that keeps the C/N ratios on a relatively lower level. During the last phase of the 2007 SW monsoon, however, low $\delta^{13}C_{org}$ values are observed along with "surprising low $\delta^{15}N$ values" and low C/N ratios. Could it be that these low values result from higher than usual proportions of ammonium-rich, clay-bound SOM delivered during times of increased terrestrial run-off? Ammonium released during microbial SOM breakdown and subsequently bound to clays in the soil is presumably depleted in the heavi nitrogen isotope. Or would one expect rather heavier $\delta^{15}N$ values when SOM supply is increased as is possibly the case at the late phase of the 2008 SW monsoon? It would be great to know the isotopic signature of soils in the catchment areas of the Goa District's rivers. Otherwise, would it be possible to determine the inorganic nitrogen (ammonium) content of some of the investigated samples?

In any case, I would strongly recommend the authors consider the possibility of nitrogen- and ^{13}C-enriched SOM contributing to the SPOM in coastal waters off Goa in their discussion. If fertiliser from agriculture can reach the investigated area SOM might just as well. If no data from soils in the river catchments is available - well, there's your next project idea! We need new definitions for terrestrial end-members in various settings, particularly tropical near-shore and river-influenced environments, and I would be happy to contribute to any such approach if material is available. I hope these comments were helpful.

With kind regards,

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References:

Cooke, M. P., H. M. Talbot, and T. Wagner (2008): Tracking soil organic carbon transport to continental margin sediments using soil-specific hopanoid biomarkers: A case study from the Congo fan (ODP site 1075). *Organic Geochemistry*, **39**, 965-971.

Government of India, Ministry of Water Resources, Central Ground Water Board: Ground Water Information Booklet North Goa District, Goa State, 2010.

Hedges, J. I., R. G. Keil, and R. Benner (1997): What happens to terrestrial organic matter in the ocean? *Organic Geochemistry*, **27**, 195-212.

Holtvoeth, J., S. Kolonic, and T. Wagner (2005): Soil organic matter as an important contributor to Late Quaternary sediments of the tropical West-African continental margin. *Geochimica et Cosmochimica Acta*, **69**, 2031-2041.

Holtvoeth, J., T. Wagner, and C. J. Schubert (2003): Organic matter in river-influenced continental margin sediments: The land-ocean and climate linkage at the Late Quaternary Congo fan (ODP Site 1075). *Geochemistry, Geophysics, Geosystems,* **4**, doi:10.1029/2003GC000590.

Sahrawat, K. L. (1995): Fixed ammonium and carbon-nitrogen ratios of some semi-arid tropical Indian soils. *Geoderma*, **68**, 219-224.

Weijers, J. W.H., S. Schouten, E. Schefuß, R. R. Schneider, and J. S. Sinninghe Damsté (2009): Disentangling marine, soil and plant organic carbon contributions to continental margin sediments: A multi-proxy approach in a 20,000 year sediment record from the Congo deep-sea fan. *Geochimica et Cosmochimica Acta*, **73**, 119-132.