Biogeosciences Discuss.,
doi:10.5194/bg-2015-667-RC2, 2016

Biogeosciences Discussions

Interactive comment on "Evidence for a maximum of sinking velocities of suspended particulate matter in a coastal transition zone" *by* Joeran Maerz et al.

Anonymous Referee #3

Received and published: 23 May 2016

General Comments

The authors analyse an extensive data-set of vertical SPM concentration profiles in the German Bight. They analyse this data-set to reveal the overall cross-shore spatial structure in settling velocities of (aggregates of) particulate matter. They find a maximum in estimated settling velocities in a 15-20m depth zone. The authors put forward two alternative possible explanations for this maximum. First, this could be the zone with optimal balance between turbulence controlled floc-formation and break-up, resulting in the largest flocs and hence the largest settling velocities. Second, they hypothesize that the composition of SPM could vary along a cross-shore gradient. They demonstrate that a functional relation linking settling velocity to primary particle size,

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Discussion paper

floc size, fractal dimension of flocs and relative amount of organic matter in SPM can also show a maximum when all explanatory variables are allowed to vary linearly along a cross-shore gradient. They discuss these observations in terms of the biogeochemical cycling of the German Wadden Sea and hypothesize that along shore differences in the spatial variability of settling velocities could explain regional differences in nutrient cycling and eutrophication status. Although speculative, the discussion of potential implications is interesting. To interpret the observations the authors make use of existing hydrodynamic model simulations, i.c. to estimate the vertical eddy diffusivity and energy dissipation rate. As such they are able to present a 2D data set of SPM concentrations and settling velocities as a 1D relation with energy dissipation rate. This is a nice example of the combined use of in-situ observations and model simulations to retrieve new and insightful information from a system. My major comment is regards the discussion section, which I find short and incomplete. On a first reading it is not clear that the authors are discussing two alternative explanations for the observed maximal settling velocity. This could be made more clear. Neither of both possible explanations of a maximal settling velocity is properly discussed on how realistic it is. No attempt is made to compare the epsilon values at which the a maximum occurs to other research on floc formation and break-up. Is the reported epsilon range of maximal settling velocities indeed those that lead to maximal floc size, and under which circumstances? Similar for the results of the conceptual model. Is there any additional support that the different explanatory variables increase linearly over the same distance across the shore? Only the end-members are shortly introduced in relation to other work. It is unclear whether the location of the maximum in the conceptual model can indeed be in the same zone as the observed maximum settling velocity, and under which assumptions. Consequently, it should be discussed which of both potential explanations the authors find the most important, or whether both are deemed equally important. Finally, the authors make no attemt to discuss other explanation for the spatial variabiliy in eutrophication status of the Wadden Sea and why the proposed mechanism here is the most plausible, as seems to be implied by their manuscript. Partially because of the incomplete discussion, I find the conclusions often speculative, e.g.

P11 L21-22 “Algae with their seasonality seem to be strongly involved”. There is no evidence in the underlying paper supporting this statement. On the contrary, the authors demonstrate that also turbulence controlled flocculation and break-up can explain the existence of a maximal settling velocity. In that case, algae are not involved in the establishment of the coastal transistion zone. Overall, I think the authors will be able to address most of the comments with a few additional paragraphs and rewriting the existing text. Therefore I recommend Minor Revisions for this paper.

Technical points

The draft needs many textual and technical improvements, and different parts of the methods need further clarification among which:

p4 L25 eq 1 Clarify: z-axis pointing downward

p4 L28-30. The text motivates why k is taken constant over time (i.e. because settling time scales are much longer than the tidal time scale.). This does not motivate why k can be taken constant over depth, which is the essential assumption to arrive at solution (2). This should be motivated separately. In fact, equation (1) only makes sense as a tidally averaged balance in which k_v is already taken constant in time. Otherwise dC/dt would not vanish, and horizontal advection would not be zero.

P4 L30 I think the authors are wrong here: the exponential solution of equation (1) assumes zero net fluxes across the vertical boundaries. Otherwise source terms would show up in the solution.

P4 L30 rephrase: “Assuming zero fluxes across the vertical boundaries and a vertical diffusivity that is constant over depth, equation (1) can be integrated over a water column with arbitrary height H_p. This results in an exponential concentration profile. The unknown integration constant can be expressed as a function of the (unknown) average concentration of the profile as: ”

P4 L30: motivate why you express the exponential profile as a function of the unknown average concentration over the profile. You could as well express it as a function of the concentration at a specified depth (e.g. at the top or bottom of the concentration)

P4 L31 C_m is not defined

P4 L31 Be precise in your notation: in this formula <.> denotes a depth average over concentration profile, while later in the text, you state that <.> means an ensemble average.

P5 L2-4 It would be helpful to specify the turbulence model that was used in the hydrodynamic simulations and how vertical turbulent diffusivity was estimated from it.

P5 L2 required → requires

P5 L 8 remove comma between “both” and and “observed”

P5 L13-15 How do you motivate the choice for the limits of density gradient standard deviation. You state that they are “somewhat arbitrary”, which implicates that they are also “somewhat motivated”. Please do so.

P5 L14 See above: here <.> denotes averaging over ensembles. Be precise.

P5 L14 Clarify: What do you mean by ensemble average, is it the average over an epsilon-bin?

P5 L17-27. I have difficulty to believe this is a correct way to split the vertical SPM profile in subsections. To my best knowledge, density stratification in the German bight is related to water temperature. SPM concentrations and their vertical gradients in the German bight seem too low to me to induce a significant impact on densities and induced turbulence dampening. Large density gradients are in itself the cause of reduced turbulence, whatever the cause of the density gradient. This indeed causes a strongly reduced turbulent diffusivity in the deeper waters compared to the surface waters. As I understand it, this is the principal reason why profiles need to be split in 2 sections on which 2 exponential profiles with constant k_v are fitted, one representative for “deep” waters and the other for “surface” waters . Therefore, the authors should motivate why they not just split the profiles at the level where maximal density gradient exists, and what the difference would be with their method.

P5 L23. Here again: what kind of averages are denoted with <.>. It seems each single profile was considered, thus <.> would mean averaging over depth.

P5 L34 It took me a while to find what F means. Perhaps this can be clarified here again

P7 L8. Rephrase: “The sensitivity of w_s to changes in each parameter was assessed by varying each parameter separately while keeping the other parameters at their typical values for coastal waters, I.e....”

P7 L11 “Vertically and temporally averaged model-derived ...” Over which period was the temporal averaging

P7 L26 & Fig5 I find the tilted figure a bit difficult to read, why not put it straight up?

P11 L4 Change “rises” to “raises”

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