

Interactive comment on “Steady-state solutions for subsurface chlorophyll maximum in stratified water columns with a bell-shape vertical profile of chlorophyll” by X. Gong et al.

Anonymous Referee #1

Received and published: 12 July 2014

1 General comments

The study presented in this manuscript considers the parameter dependencies of subsurface chlorophyll maximum layers (SCML) in aquatic systems based on an analytical approach. Assuming a Gaussian shape of the Chl *a* profile leads to a set of analytical expressions that link the three parameters thickness, amplitude and depth of the SCML to phytoplankton growth and losses, surface irradiance and light attenuation, phytoplankton sinking speed and subsurface vertical mixing.

This new approach allows us to integrate previous results from a variety of studies.

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Some of the results confirm existing knowledge, others go beyond. Having analytical expressions for the functional relationship between SCMLs and various parameters is certainly very helpful. There are, however, a few points that need clarification and/or improvement, before I can recommend publication:

2 Specific comments

- p. 9513: The discussion of the difference between SCM and SBM (subsurface *biomass* maximum layer) is weak. The text uses phytoplankton concentration and chlorophyll concentration as synonyms, an assumption which is not necessarily valid. This also leads to another point:
- p. 9515: The model currency seems to be mg m^{-3} (according to Figure 1) but then the limiting nutrient N needs to be given in the same units as well (or a conversion factor needs to be introduced). In my view, the prognostic model variables P and N should be given in mmol N m^{-3} , in which case it is more appropriate to talk about an SBML instead of an SCML.
- I suggest the authors point out (e.g., in the discussion section), that several effects have been neglected: self-shading (p. 9516(09): self-shading is only included in this formulation, if the vertical concentration of P is constant, clearly not the case for the assumed Gaussian profile.), sinking of detritus as a separate compartment, etc. I find it quite remarkable that the 2-equation model reproduces some of the results of a more complex model with three equations (e.g., Beckmann and Hense, 2007). This fact should be mentioned explicitly.
- p. 9519(04): I am unable to confirm the statement that $z_{c1} > z_m - \sigma$. Instead, it seems to me that $z_{c1} \leq z_m - \sigma$. As a consequence, z_o is not generally within the SCML interval $[z_m - \sigma, z_m + \sigma]$ (this is true only for $\frac{K_{v2}}{w\sigma} \geq \frac{1}{2}$). This also affects equation (A2) and the arguments connected to it.

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- p. 9538: in Figure 1, please indicate typical locations of z_o , z_m , z_{c1} and z_{c2} (rather than a depth in m – which is misleading anyway), as well as σ .
- In general, the text could be more explanatory. For example, 9519(12-19) is not easily understandable and should be rewritten.

3 Technical corrections

- 9512(12): “but independence of” should be “but independent of”.
- 9512(16): “parameters difficultly obtained from on-site observations” should probably better be “parameters which are difficult to observe on site”.
- 9512(24): “SCM is commonly believed” should be “An SCM is commonly believed” or “SCMs are commonly believed”.
- 9513(02): “reason forming” should be “reason for forming”.
- 9513(12): “SCM has been attracted” should be “The SCM has attracted”.
- 9513(25): “thickness of SCML” should be “thickness of the SCML” or “thickness of SCMLs”.
- 9514(03): “variations of environment parameters” should be “variations of environmental parameters”.
- 9515(17): “etc.” refers to which processes and factors?
- 9515(19): it should be explicitly mentioned that w is positive in the chosen coordinate system.
- 9518(20): “stead” should be “steady”.
- 9518(23): the factor of the first term on the right hand side should be $-\frac{K_v w^2}{\sigma^4}$, instead of $-\frac{K_v w^2}{\sigma^2}$.

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- 9519(21): “the depth of the SCML must occur below or equal to the depth for phytoplankton having the maximum growth rate” should be something like “the depth of the SCML maximum lies at or below the depth of maximum phytoplankton maximum growth”.
- 9520(03): “the numerical modelling can support” should be “numerical modelling results support”.
- 9520(19): “et al.” should only be used in the context of unnamed co-authors of a paper, not instead of “etc.”. Besides, it would be better to give a complete list here (as it is not too long).
- 9522(18): “provided” should be “provide”.
- 9523(03): what does “etc.” include – the list not so long that it could not be given completely.
- 9523(04): “appendixes” should be “appendices”.
- 9523(19): “it is not surprised” should be “it is not surprising”.
- 9523(19): “environmental factors (... , ϵ , ...)” the loss rate of phytoplankton ϵ is not really an *environmental* factor as it includes natural mortality.
- 9524(01): it should be added that the Taylor series is truncated after the linear term.
- 9524(14): with “should be identified by $\frac{\mu_m}{2}$ ” the authors probably mean “depends on $\frac{\mu_m}{2}$ ”.
- 9524(16): “half-saturate constant” should be “half-saturation constant”.
- 9524(19): “In summarize” should be “In summary” or “To summarize”.
- 9525(19): “can be infered” should be “can be inferred”.
- 9525(01): “is constant with varying surface light intensity” simpler “does not depend on surface light intensity”.

- 9528(15): “the thickness of SCML thickens” should be “the thickness of the SCML increases” or “The SCML thickens”.
- 9530(21): it should be mentioned that this approximate equation is derived from equation (2). Furthermore, it seems to be dimensionally incorrect (even if we assume that P and N have the same unit): the left hand side has is in $\text{mg m}^{-3}\text{s}^{-1}$ while the right hand side is in $\text{mg m}^{-2}\text{s}^{-1}$.

BGD

11, C3437–C3441, 2014

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