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Geoscientific Model Development Discussions

Interactive comment on "S2P3-R (v1.0): a framework for efficient regional modelling of physical and biological structures and processes in shelf seas" *by* R. Marsh et al.

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In this manuscript the authors apply a 1D physical-biological framework in a regional implementation in select years and select shelf regions.

General comments: Although the manuscript is well written, I feel that the content is more suitable for a technical report appearing on a modeling website, than a peer-reviewed publication in GMD. Manuscripts within GMD are expected to "represent a substantial contribution to modeling science", which I do not feel is the case for this manuscript. Furthermore, although the modeling framework discussed here could potentially be useful in an undergraduate ocean modeling curriculum, it is not clear to me

that the S2P3-R model has "the potential to perform calculations leading to significant scientific results" as would be required for publication in GMD.

Response: The utility of S2P3-R in undergraduate (and postgraduate) level projects does not preclude its ongoing and future use in research contexts. In regions where shelf sea physics (and biology) is dominated by vertical processes, the framework facilitates large-ensemble experiments to investigate the sensitivity of measurable quantities (e.g., chlorophyll concentration) to a wide range of physical and biological processes that can be adjusted with corresponding model parameters. Where high quality observations are available (e.g., E1 in the western English Channel), S2P3-R thus provides a means for improving our fundamental understanding of the system. As mentioned in response to Referee 1, we are now embarking on this approach.

The authors spend several pages describing the existing S2P3 model, which has already been published and is available online. The new methodology employed here appears to consist of modifying the source code so that it can run in a Unix environment and run at 5000-20000 grid points. Matlab plotting scripts are also provided. However, this in itself does not consist of a substantial advance in modeling science, or represent a particularly novel concept or idea.

Response: We disagree that the development of S2P3-R "does not consist a substantial advance", as only now can we routinely carry out multi-year simulations of physical and biological processes and structures at unprecedented temporal, vertical and horizontal resolution. We return to this issue in some of the responses below.

The primary issue I have with the manuscript, however is that the authors are essentially attempting to study 3D physical/biological shelf processes by ignoring advection. In many/ most shelf systems, advective processes play a critical role in controlling the distributions of nutrients and phytoplankton, and thus neglecting this key process is a major deficiency in the paper. Perhaps this may be why the observed chlorophyll concentrations (Fig. 4f) look nothing like the modeled chlorophyll concentrations (Fig.

4g)?

Response: While we agree that advective processes are of leading importance at some locations, 1D processes exert a first order control at many other locations (e.g., the northwestern North Sea, as emphasized by Sharples et al. 2006), and we might reasonably use S2P3-R accordingly and judiciously. We re-emphasize the key point that very high resolution is both appropriate and necessary for representing key 1D (vertical) processes and 2D (horizontal) structures observed in shelf seas (e.g., tidal mixing fronts). More complete 3D dynamical models cannot easily be deployed experimentally to investigate such processes and features. Regarding the discrepancy between observed chlorophyll concentrations in Fig. 4f and modeled chlorophyll concentrations in Fig. 4g, it is clear to us that the northward-shifted surface maximum in the model is coincident with a more northward location of the tidal mixing front, which could quite easily be attributed to inadequacies in meteorological and/or tidal forcing, rather than neglected horizontal advection. The higher maximum chlorophyll value in the model may have several "biological" causes, such as the relatively simple description of phytoplankton physiology and grazing, none of which are related to horizontal advection, although we furthermore note that the observed chlorophyll values are somewhat uncertain. We reiterate that the model successfully reproduces key patterns in chl-a distributions with respect to physical structure (i.e., a SCM in the thermocline, increased surface chl-a at the front). Without a priori knowledge, the 1D approach is anyhow valid for testing whether or not advection is important! We will revise the text towards the end of Section 3.1 accordingly.

In addition, the S2P3-R implementation described here can take nearly a day to generate a year of 3D model results. Sophisticated community models including key physical processes lacking here (e.g. horizontal and vertical advection) as well as complete biogeochemical modules (rather than simply just phytoplankton and nutrient components) often take less than a day of run-time per year simulation for similar regional shelf applications. Because such commonly used models (e.g. the Regional Ocean Modeling

System (ROMS)) include more key physical processes and take less time to run, it is not clear why the modeling framework described here (S2P3-R) is superior to (or even a logical alternative to) these existing and well-documented regional shelf community models.

Response: The quoted 1-day CPU demand is rather arbitrary, as S2P3-R can easily be run as a multi-processor job in separate domains. We have recently implemented S2P3-R in a larger western English Channel domain (3-9°W, 49-51°N) configured as twelve $1^\circ \times 1^\circ$ sub-domains (see initial results in Fig. 1 below), for an order of magnitude increase in speed of computation, and more sophisticated methods could be used to achieve much faster computation. We know of no other 1-km regional model of shelf sea physics and biology that is so easily configured and used. The UK Met Office continues to develop shelf sea models of increasing resolution (presently working on a 1-km model), but the high demands on human and computational resources preclude the wider community from undertaking such efforts (see also our response to Referee 1).

In summary, although I fully appreciate the utility of purely 1D models such as S2P3 for the purposes of scientific inquiry and as an instructional tool, the utility of implementing a 1D model regionally at 5000-20000 separate sites in an attempt to estimate 3D physical/ biological maps, while ignoring key 3D physical processes such as advection, is simply not clear.

Response: Ultimately, the S2P3-R framework is developed for use in suitable regions, where we know the shelf sea system to be dominated by 1D (vertical) processes, with horizontal processes dominated by tides and limited net horizontal transport. We will clearly emphasize that model applications need to be carefully chosen and designed, bearing in mind the model framework.

However, the very fact that we are able to accurately reproduce monthly observations of thermal structure at E1 in the western English Channel over 2002-13 (see Fig. 7 of our

manuscript), suggests that S2P3-R can be successfully used to investigate the wider region – from the seasonally stratified western approaches to year-round mixed waters further to the east in the English Channel (see Fig. 6 of our manuscript). We therefore consider there is much potential for S2P3-R to inform our fundamental understanding of physical and physiological controls on primary productivity across this wider region. The purpose of our manuscript is to document and establish the framework for these future investigations.

Summarizing these responses to Referee 2, we will revise the introduction and discussion of the mansucript to emphasize the points we make above, stressing in particular: (1) S2P3-R utility - computational speed and framework flexibility; (2) S2P3-R novelty - very high resolution of processes and structures, in three dimensions and time; (3) recommended experimental use, interpreting simulations with key model caveats in mind.

Interactive comment on Geosci. Model Dev. Discuss., 8, 673, 2015.

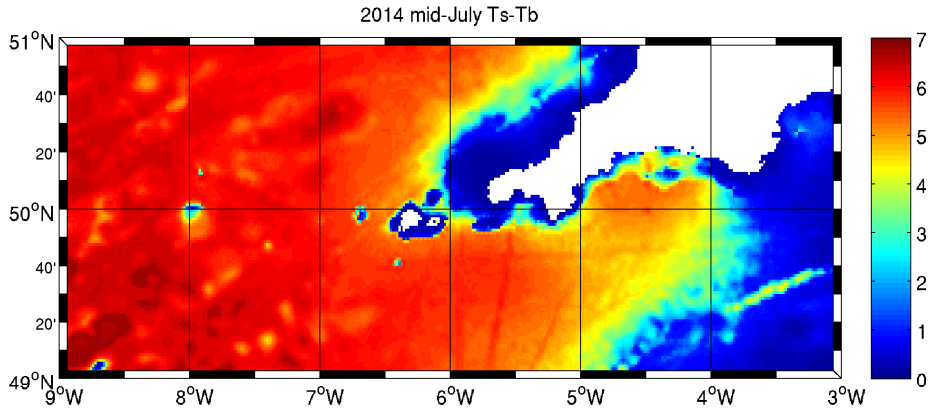

Fig. 1. Surface-bottom temperature differences across the western approaches and western English Channel, in mid July of 2014, simulated with S2P3-R configured to running in 12 sub-domains, as indicated.