

PhD Proposal: Application of EO data to the estimation of representative and adaptive parameterisations in marine ecosystem models

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Summary

A key limitation of existing ecosystem models is that they do not include phenotypic plasticity or the ability of individuals or populations to adapt to future carbon and climate scenarios, i.e. to vary their parameterisations in response to environmental change. This PhD will address this challenge by investigating approaches to implement variable parameterisations for marine phytoplankton using relationships derived from satellite Earth Observation (EO) data. Recent advances in bio-optics and the application of satellite ocean colour have shown robust relationships between bio-optical traits (BOT) and bio-energetic (BE) rates, for example pigment and optical absorption ratios with photosynthetic quantum efficiency (Aiken et al. 2008), optical absorption with primary production (Marra et al. 2007; Hirata et al, accepted). The optical properties of the marine environment can be derived from satellite ocean colour data using inherent optical property (IOP) models (e.g. Smyth et al. 2006). Furthermore, the bio-optical relationships can also be used to differentiate phytoplankton size classes and functional types from satellite ocean colour data (e.g. Aiken et al. 2007; Hirata et al. 2008). This project will investigate these BE-BOT relationships in the context of different environmental forcing regimes (temperature, meteorology, nutrients) to develop statistical distributions that can be used in the estimation of representative and adaptive parameterisations for photo-physiological rate processes in the modelling of marine phytoplankton.

Rationale and Approach

Marine ecosystem models have developed from NPZD to functional group or sized defined structures with some limited success in improving their conceptual and predictive capabilities. Further improvement has followed from including adaptive functionality such as variable stoichiometry (e.g. variable Chl:C:N:P) (Blackford et al. 2004, Friedrichs et al. 2007). However it is clearly apparent that no existent model really captures the full ecological heterogeneity of global or regional systems; nor is this particularly surprising given the wide range of physical conditions, optical properties and the diversity of the marine biota that inhabit them. This situation is compounded by the changes that anthropogenic activities are imposing on the marine system such as the physical effects of climate change and the biochemical implications of ocean acidification and altering riverine loadings.

Thus there is a clear requirement to improve the representation of diversity and community structure within ecosystems models. The scope for further increases in model complexity is limited by available computing power and interpretability of the results, so an alternative approach is required. Currently, modelled organisms or functional groups use fixed parameterisations based on laboratory experiments, often limited to a few species. The assumption that these parameterisations are representative of the diversity of species, rates and responses in natural communities is clearly a key limitation, both in simulating contemporary marine ecosystems and in allowing these to adapt to changes in external forcing. A key challenge is, therefore, to develop methods for incorporating representative parameter ranges within existing ecosystem models.

Recent advances in the application of satellite ocean colour have shown robust relationships between bio-optical properties and photo-physiological rates, for example pigment and optical absorption ratios with photosynthetic quantum efficiency (Aiken et al. 2008), optical absorption with primary production (Marra et al. 2007; Hirata et al, accepted). The optical properties of the marine environment can be derived from satellite ocean colour data using inherent optical property (IOP) models (e.g. Smyth et al. 2006). Furthermore, the bio-optical relationships can also be used to differentiate phytoplankton size classes and functional types from satellite ocean colour data (e.g. Aiken et al. 2007; Hirata et al. 2008). This PhD project will apply these relationships to develop statistical distributions that can be used in the estimation of representative and variable parameterisations for photo-physiological rate processes in modelling marine phytoplankton.

Another recent development has been the novel approach of defining model structure using stochastic adaptive approaches (sometimes termed Darwinian, e.g. Follows et al. 2007). Here a large number of planktonic types are generated by random selection from a pre-defined set of physiological traits and initialised in a model system. The environmental and ecological conditions of the model

determine which over time survive and become dominant and which become marginal or extinct. The key to the realism of this approach is that the assignment of parameterisations & physiological traits must be constrained by sensible physiological rules. Thus having defined improved parameterisations of photo-physiology an important further step will be to ensure that the other physiological parameterisations are consistent and follow appropriate rules.

This project will investigate these photophysiological relationships in the context of different environmental forcing regimes (temperature, meteorology, nutrients) and physiological processes to develop statistical distributions (possibly including stochastic approaches) that can be used in the estimation of representative and adaptive parameterisations for photo-physiological rate processes in the modelling of marine phytoplankton. The ability of this approach to improve model hind casts of recent decades, including the observed planktonic 'regime shifts', will be tested (Reid et al. 1998, Beaugrand et al. 2004).

Requirements, training and opportunities

We seek an enthusiastic team player with strong scientific interests and self-motivation. You will have at least a 2.1 honours degree in a scientific discipline, with strong numerical and computing skills. Experience in handling large data sets and/or numerical modelling would be an advantage, however, training in the use of satellite observations and ecosystem models will be provided. As well as providing you with the opportunity to contribute to globally important scientific advances as part of an internationally-leading science team, the project will allow you with the opportunity to develop a range of highly useful and transferable skills such as: project planning, handling and visualization of data, effective collaboration, scientific writing and presentation skills.

- More information about PML can be found online at www.pml.ac.uk
- More information about the Department of Biological Sciences at University of Essex can be found online at: <http://www.essex.ac.uk/bs/>

Application Procedure

All applicants must apply online to the University of Essex (<https://www.essex.ac.uk/pgapply/>).

References

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