Global distribution of calcifiers and silicifiers in an ecological indicator model

Artur P. Palacz[1] (arpa@aqua.dtu.dk) , Michael A. St. John[1], Robert W. Brewin[2], Takafumi Hirata[3] and Watson G. Gregg[4]

[1]*National Institute of Aquatic Resources, Technical University of Denmark* [2]*Plymouth Marine Laboratory, Plymouth, UK* [3]*Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Japan* [4]*NASA Global Modeling and Assimilation Office, Greenbelt, MD, USA*

Silicifiers vs calcifiers: do we get it right?

- **The ratio of diatoms (silicifiers) to coccolithophores (calcifiers)** is strongly **overestimated in most phytoplankton models**, especially in **high latitude high-nitrate, low-chlorophyll (HNLC)** regions [1].
- **Misrepresentation of these plankton traits** can have tremendous **implications for the accuracy of** our current and future **estimates of ocean carbon cycling**.

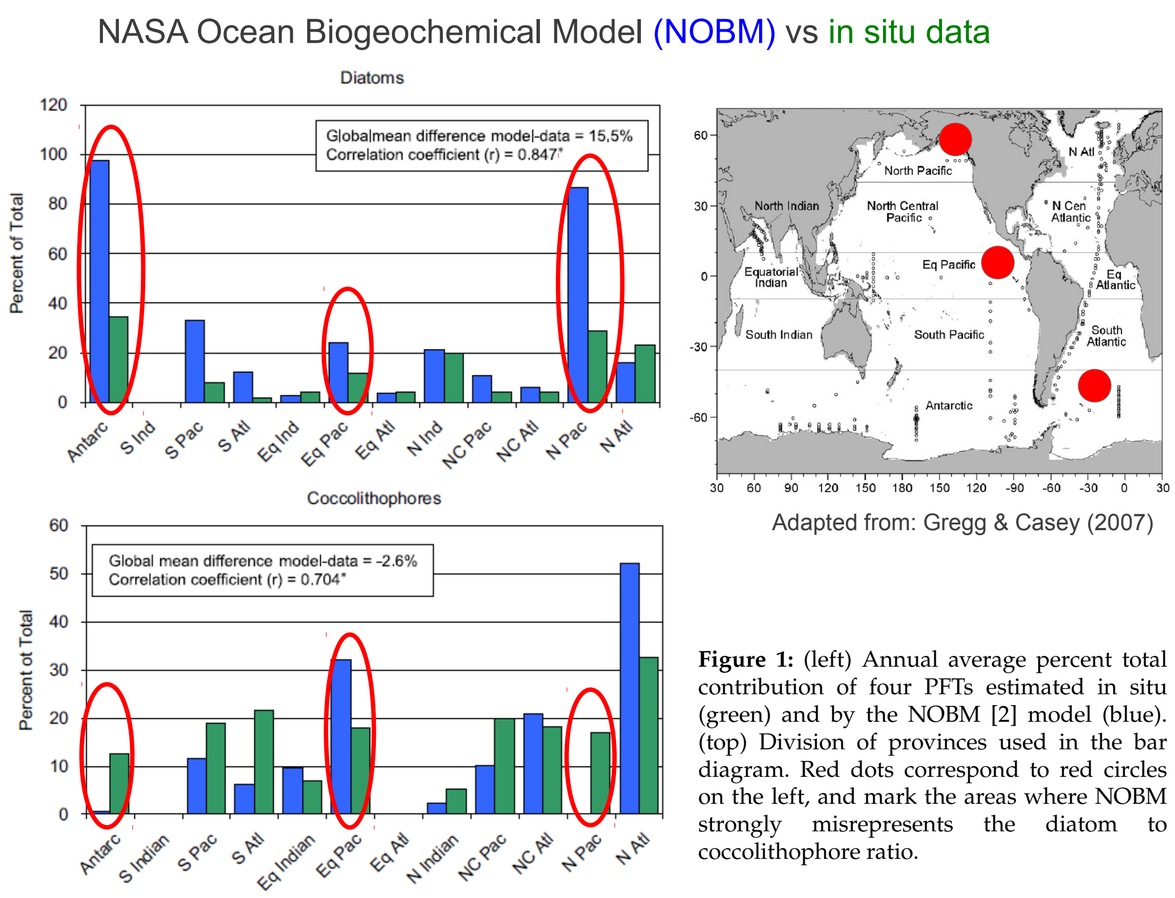


Figure 1: (left) Annual average percent total contribution of four PFTs estimated in situ (green) and by the NOBM [2] model (blue). (top) Division of provinces used in the bar diagram. Red dots correspond to red circles on the left, and mark the areas where NOBM strongly misrepresents the diatom to coccolithophore ratio.

Silicifiers vs calcifiers: we can get it right!

- The PhytoANN model projects a **much more realistic global distribution of calcifier biomass** using Particulate Inorganic Carbon (PIC) as a reference [4].
- The PhytoANN captures **patterns of both seasonal and interannual variability in PFT biomass**, including those of calcifiers.

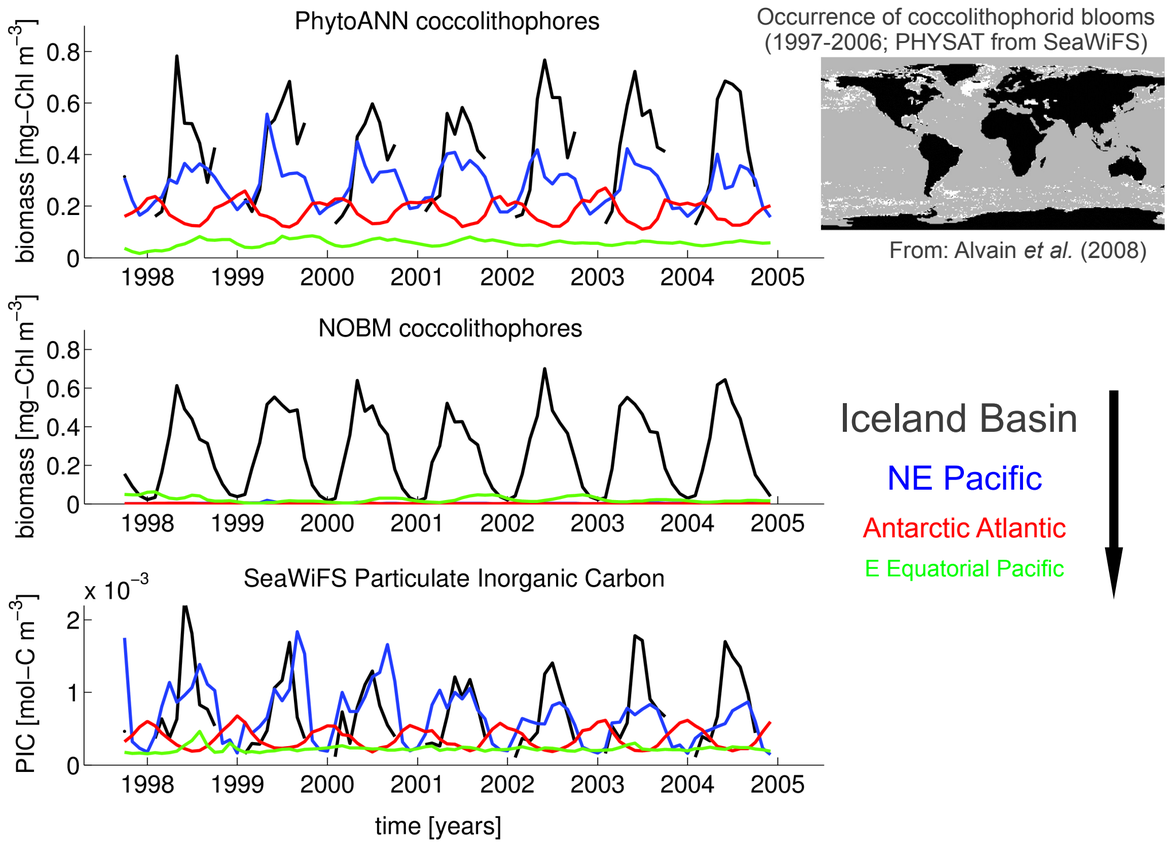
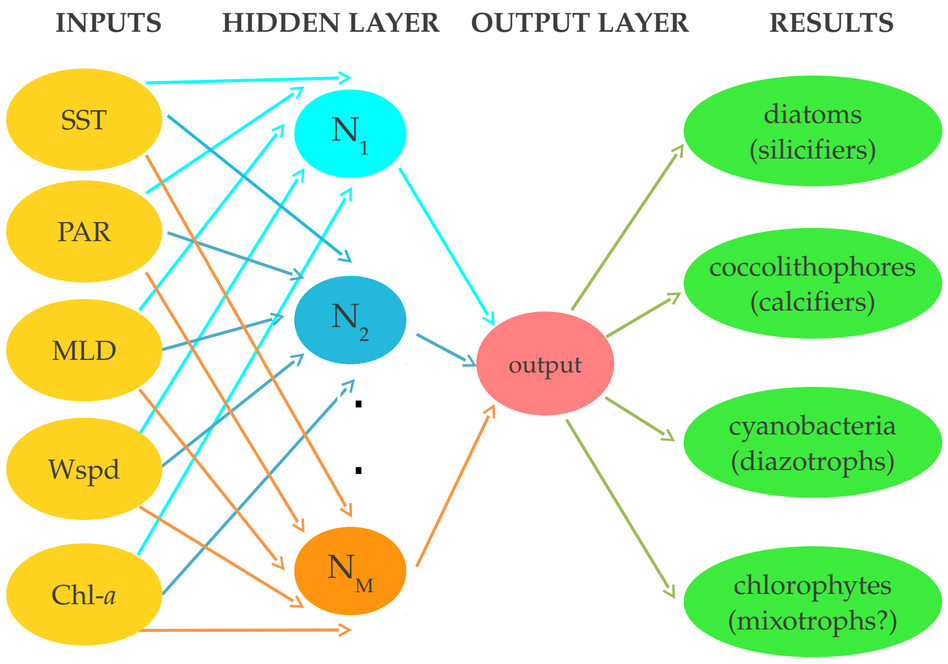


Figure 3: Monthly time series comparison of PhytoANN and NOBM coccolithophore biomass, and SeaWiFS-derived PIC concentration from four selected biogeographic domains.

PhytoANN: an ecological indicator model of PFTs

- The PhytoANN is based on an ensemble of **artificial neural networks (ANNs)** – artificial intelligence tools capable of **interpreting or 'learning' complex nonlinear interactions between** some target features (here: **PFT biomass**) and multiple explanatory variables used as inputs (here: **ecological indicators**) [3].
- In effect, our model turns a **conceptual *N*-dimensional phytoplankton mandala** into an **applied ecological indicator** model of PFTs.



For a single neuron:

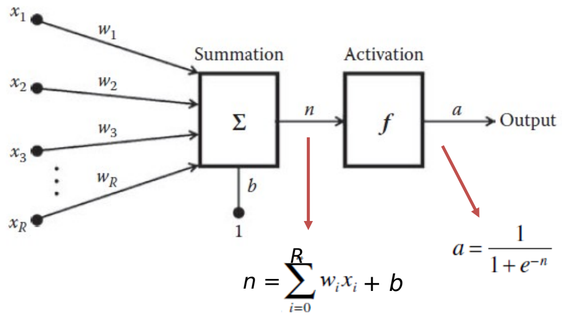
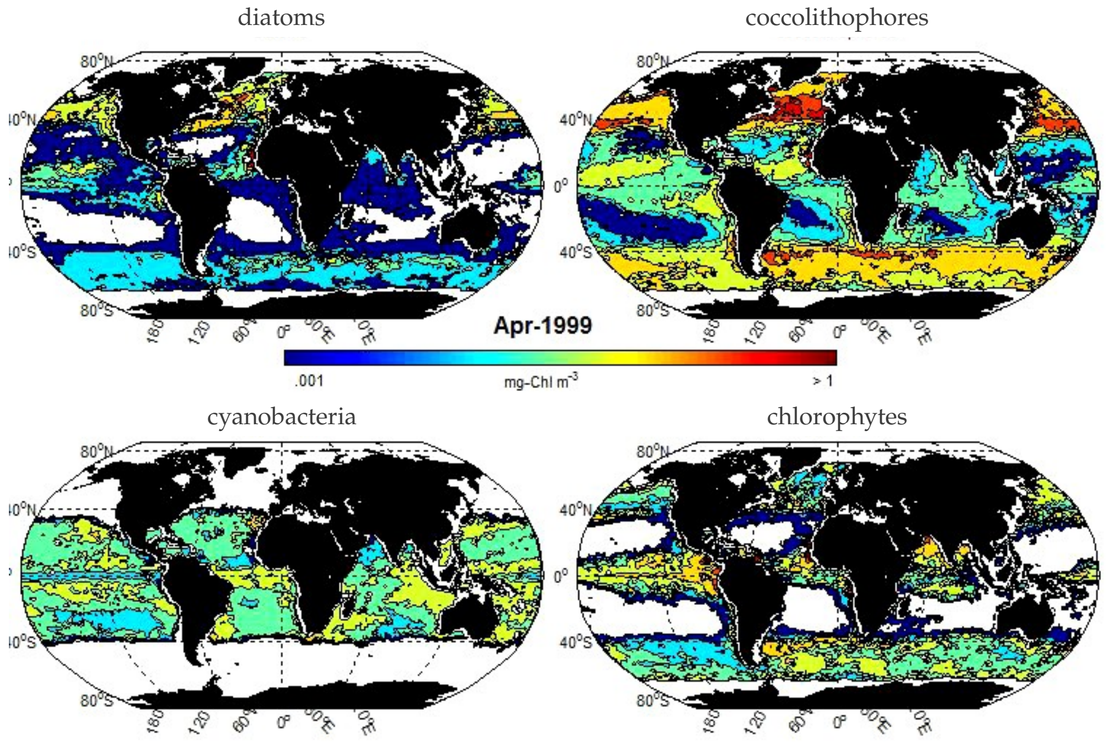


Figure 2: (top) A schematic representation of the PhytoANN model. The first layer consists of satellite-derived input parameters (yellow circles) which are all connected to a hidden layer of *M*-number of so-called neurons. The combination of signals from all neurons determines the model output which is PFT biomass (green circles). (right) Summary of the mathematical operations performed by neurons.

PhytoANN's view of the world's oceans

- Using a few **measurable, specific and sensitive ecological indicators**, the PhytoANN generates a very **dynamic and patchy PFT distribution.**
- The distribution is determined by **complex and nonlinear interactions** between **highly variable** individual **ecological niche components**.



A look into the future?

- The PhytoANN can generate **future PFT projections** based on an **ensemble of ecological indicators** from other models ran in forecast mode.
- If turned into **a fully-adaptive model**, it can embrace many of the constraints of **complex adaptive systems** [5], of which marine ecosystems are prime examples.

Acknowledgements

We are grateful to all our EURO-BASIN collaborators and members of the Satellite PFT Algorithm Intercomparison Project who helped improve the design and application of this model.

EURO-BASIN
BASIN SCALE ANALYSIS, SYNTHESIS AND INTEGRATION

References

[1] Sinha, B., Buitenhuis, E. T., Qur, C. L., and Anderson, T. R. (2010): Comparison of the emergent behavior of a complex ecosystem model in two ocean general circulation models, Progress in Oceanography, 84, pp. 204 – 224.
[2] Gregg, W. W. (2008). Assimilation of SeaWiFS ocean chlorophyll data into a three-dimensional global ocean model. Journal of Marine Systems 69: pp. 205-225
[3] Recknagel, F. (2001): Applications of machine learning to ecological modeling. Ecological Modelling, 146 (1-3), pp. 303-310.
[4] Balch, W. M. (2005): Calcium carbonate measurements in the surface global ocean based on Moderate-Resolution Imaging Spectroradiometer data, Journal of Geophysical Research, 110, C002560.
[5] Levin S.A. (1998): Ecosystems and the biosphere as complex adaptive systems. Ecosystems, (1), pp. 431-436.