Diverse Diazotrophs in a Model Ocean

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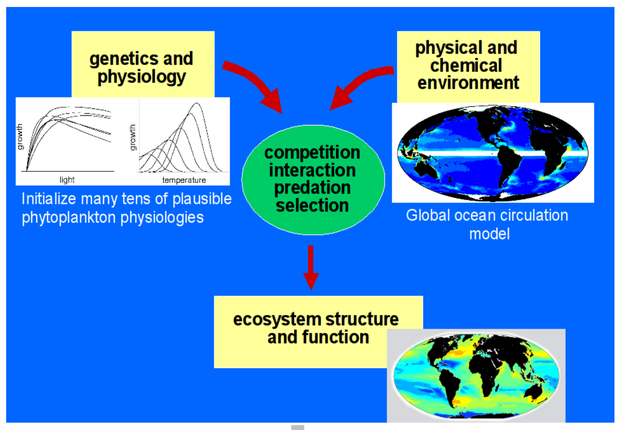
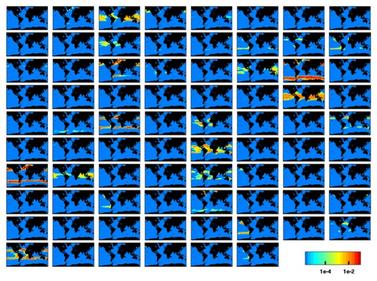
Overview

- **Global ocean model with self-assembling phytoplankton communities**
- **Allow nitrogen fixation with trade-off of slow growth and high Fe:P**
- **Emergent diverse population of diazotroph analogs**
- **Plausible habitat and abundances**
- **Strong regulation by iron availability**
- **Described concisely using resource competition theory**

The Model

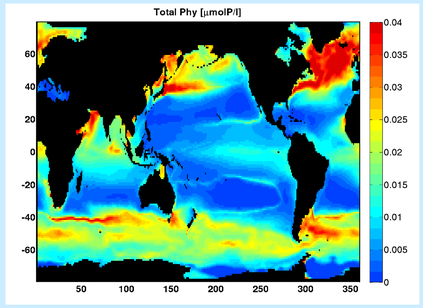
• Global ocean circulation and biogeochemistry model
• Initialize many tens of phytoplankton "types"
• Random assignation of physiological functionality and sensitivities to light, temperature and nutrients
• Constrained by simple, size-based trade offs.
• Nitrogen fixation possible trait, randomly assigned
• Trade-offs: Low max growth rate, high Fe:P stoichiometry



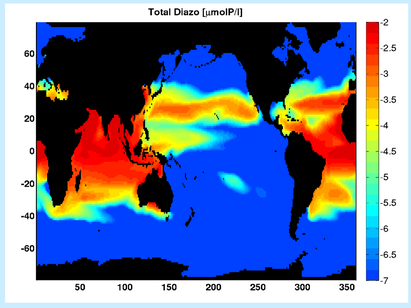


After some years of interaction, the fittest "types" persist and occupy distinct habitats

Model Solutions: Emergent Diazotroph Analogs



Total phytoplankton biomass (µmol P l^{-1})

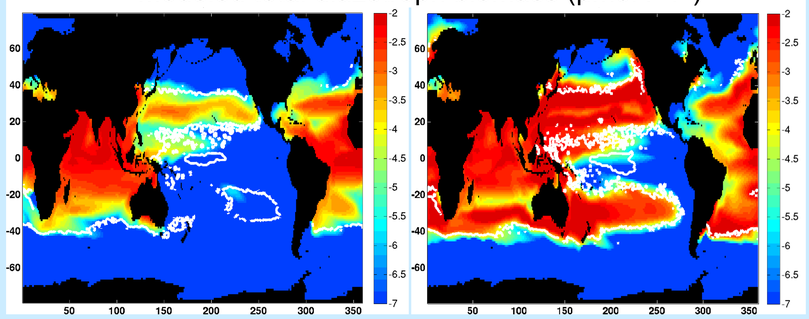


Total diazotroph biomass (µmol P l^{-1})

What Regulates the Habitat of the Diazotrophs?

• Inhabit only warmer waters but temperature is not the key control. Model diazotrophs with cold optimal growth temperatures are never persistent.
• Confined to oligotrophic (warm) waters where nitrogen stress makes the trade-off between nitrogen fixation and slow growth viable.
• Sensitive to iron availability. In the South Pacific changes to the atmospheric iron source can switch the diazotroph population on and off.
• R* of iron, from resource competition theory (Tilman, 1977), accurately characterizes diazotroph habitat.

Modeled total diazotroph biomass (µmol P l^{-1})



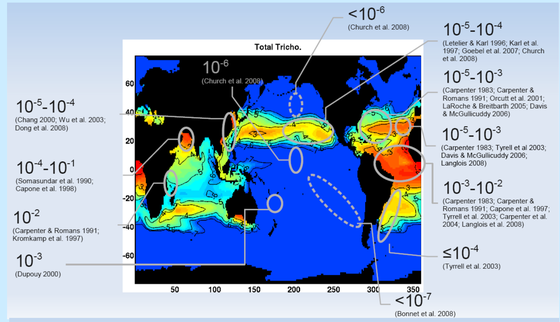
Low solubility of aeolian iron **High solubility of aeolian iron**

• White contours indicate where R*(Fe) = $[Fe_T]$.
• Resource competition theory (Tilman, 1977; ...) predicts this should bound habitat of diazotrophs if iron is the limiting resource.

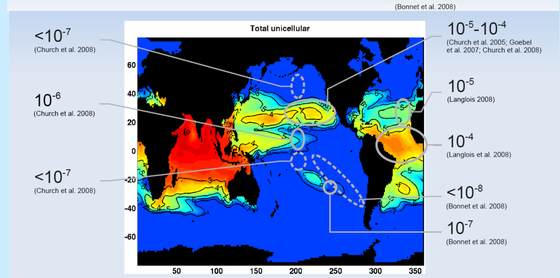
Diverse Model Diazotrophs

• Reflecting the observed diversity of nitrogen fixers in the ocean, diazotrophy can be a successful strategy associated with a variety of other physiological characteristics.
• Emergent analogs of *Trichodesmium,* unicellular diazotrophs and diatom-diazotroph assocations.
• Plausible distributions and abundances of the three groups.

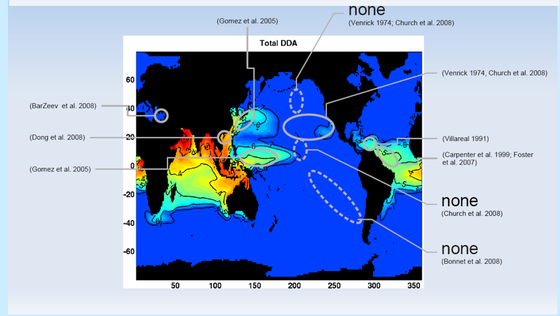
Distributions and Comparison to Observations



***Trichodesmium* - analogs**



Unicellular-analogs



Diatom - Diazotroph Association analogs

Published observations converted to estimated phosphorus biomass

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