GLEON-PRAGMA Science Expedition
Agenda

• 8:30 – 9:00: Meet and greet
• 9:00 – 9:45: Motivation for the GLEON-PRAGMA Science Expedition
• 9:45 – 10:30: Technology overview
• 10:30 – 10:45: Break
• 10:45 – 11:15: Demonstration of the overlay at work
• 11:15 – 11:45: Discussion and next steps
Background

• Ecology has had a long tradition of empiricism and modeling – *but* the nature of those models is changing
  – We can’t measure everything we want to know about, including the future
  – Models are a way of testing hypotheses *in silico*

• Certain questions benefit greatly from a modeling approach that couple physical, chemical, and biological processes, e.g., *What are the factors influencing the wax and wane of phytoplankton communities underlying blooms?*

• Making those models serve the needs of science can require lots of computing resources and specialized skill.

• Results can push the boundaries of science.
Eutrophication leads to...

- Poor water clarity
- Loss of macrophytes
- Bad smell
- Toxic water conditions
- Dead fish
- Reduced ecological and economic value
Can we predict the occurrence of cyanobacterial blooms in lakes?

- Blooms are patchy both in space and time, problematic, and difficult to predict
- It is very difficult to collect continuous field data to track bloom development
- Can we use a modeling approach to better understand the factors driving their occurrence, magnitude, and duration?
Recreating the phytoplankton dynamics underlying blooms is a major challenge because of the complex physical, chemical, and biological interactions.
Lake Kinneret: Physical-biological interaction

- Transport processes work in concert with biological dynamics to shape biomass concentrations and distribution

3D: hydrodynamic-ecological model
Modelling Lakes & Reservoirs with GLM

1D – laterally averaged models: assume most variability is vertical
A more complex model structure...
Workflow within the context of numerical simulation of phyto communities:

1. Setup a numerical simulation
   1. Data that setup and drive the model
   2. Data to evaluate the model predictions
   3. Simulation software

2. Calibrate the simulation: Adjust parameters until predictions of lake physics/WQ show some agreement with observations of physics/WQ

3. Run scenarios with the calibrated simulation to better understand the controls over phytoplankton
Drivers
1. e.g., Meteorology, Inflow/outflow, nutrient loads
2. Drive the changes in ecosystem dynamics

Drivers are changed to simulate scenarios of, e.g., land use and climate change

Setup
1. e.g., hypsometry, initial conditions,
2. Defines how a simulation represents a particular lake

The equations represent the processes (or “rules”)

Parameters in the equations
1. e.g., P uptake rate, OC degradation rate, P
2. Determine how driver data are expressed in the predictions, given the equations (“rules”)

To calibrate the model, parameters are adjusted to make predictions ~ observations

Predictions
Lake physics, chem, bio

Observations
Lake physics, chem, bio = phytoplankton!
**FABM**: A flexible approach to disentangle physics and biology

**Hydrodynamics**
- Store physical variables
- Advection, diffusion, time integration
- Input/output

**FABM:**
Framework for Aquatic Biogeochemical Models

**Biogeochemical modules**
- Provide variable names, units
- Given a local environment, provide local sink and source terms

Application Programming Interface
Example Simulation Result

Kara et al. 2012
L. Mendota 2009 daily values
one day moving window, no overlap, bits=5, alphabet=3

Water temperature

Observed

Modeled

PaulsSAX3.m, plot(ksdensity(AllStd))
Although we predict the mean well, and we can predict seasonal succession, we have a problem...

Two approaches to solving this problem: (1) Search parameters for combinations that reproduce the features we want; (2) If #1 doesn’t work, play with rules.
Break to Run Simulation
Scaling up. What if...

- What is the fate of allochthonous OC loads to lakes, and how certain are we about those predictions? (Hanson et al. 2011)
- How do the thermal regimes of all lakes in a region respond to changing climate? (Read et al. 2014)
- Do the current models governing phytoplankton community dynamics allow us to recreate blooms? (PRAGMA-GLEON expedition)
1. Generate community
(throw the dice for some of the parameters, e.g., T-opt, MaxGrowth, Respiration)

(47 total parameters)

Repeat Cycle 1,000x

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<th>Feature</th>
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<td>33</td>
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<tr>
<td>Max</td>
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<td>Peak timing</td>
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<td>177</td>
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<tr>
<td>Shape</td>
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</table>

Community
2 species of cyanophytes
2 species of N-fixing cyano
2 species of chlorophytes
2 species of diatoms
8 spp total

2. Simulate one year

3. Store features
Mean biomass (mmol C m^{-3})

Peak biomass (mmol C m^{-3})

Observed biovolume
Observed phycocyanin fluorescence
Observed chlorophyll fluorescence

Simulation results

1:1
PRAGMA-GLEON Expedition:

Mission: (1) Discover the rules controlling phytoplankton community dynamics; (2) Expand opportunities for GLEONites to use HTC resources to enable the science; (3) Build an interdisciplinary community