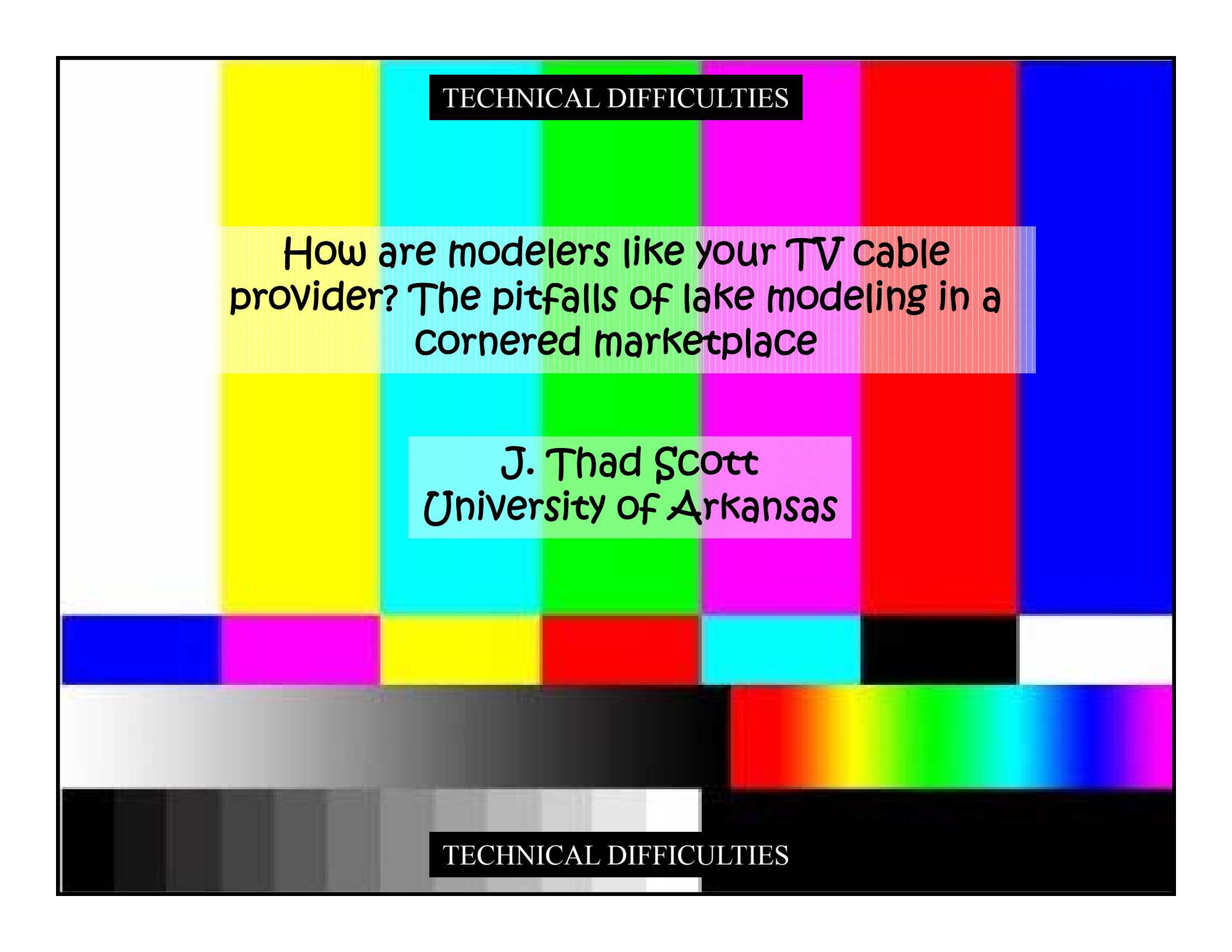




TECHNICAL DIFFICULTIES

How are modelers like your TV cable provider? The pitfalls of lake modeling in a cornered marketplace

J. Thad Scott
University of Arkansas

TECHNICAL DIFFICULTIES

All Channels Wednesday November 21 | 11:36

■ Documentary
 ■ Kids
 ■ Movie
 ■ Music
 ■ News
 ■ Special
 ■ Sports

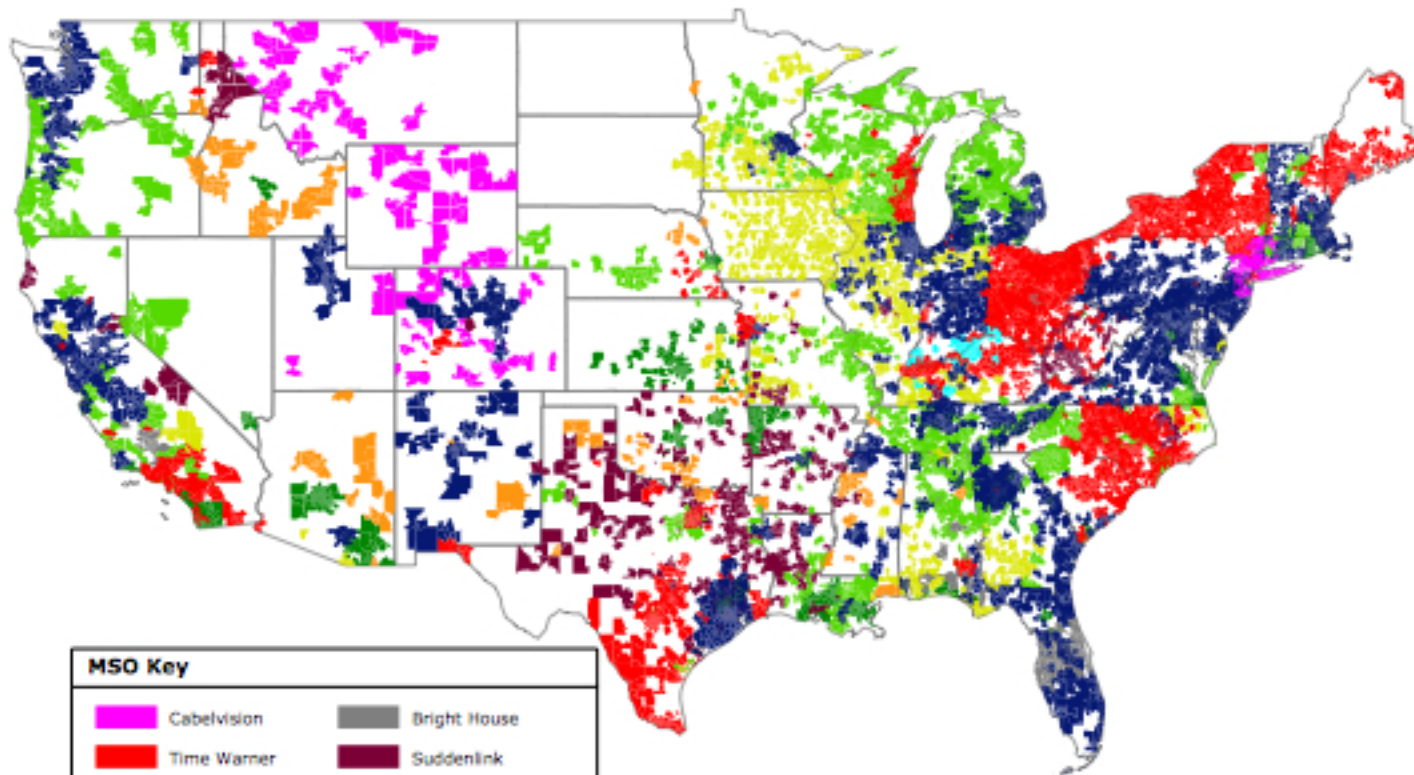
◀ Wed 21-11 ▶ ◀ ▶ 11:30 12:00 12:30 13:00

Channel	11:30	12:00	12:30	13:00
BBC ONE	Watchd	Cash in the Attic	Bargain Hunt	BBC News at One
BBC TWO	Daily Politics			See Hear
ITV1	This Morning		Loose Women	
Channel 4	A Place in the Sun	Ch SuperScrimpers	Come Dine with Me	
Channel 5	The Hotel Inspector	5 Superior Interiors With Kelly...	Home	
ITV2	Judge Judy	Emmerdale	Nanny 911	
BBC THREE	This Is BBC Three			
BBC FOUR	This Is BBC Four			
ITV3	Casebook of Sherlock Hol	Wycliffe	He	


 11:45-12:15 | Cash in the Attic | leisure hobbies (general)
 Pat and Bernard Field want to raise money for a Colombian children's charity. Lorne Spicer and Jonty Hearnden help to look for potentially valuable items in their home. [S] Then BBC News; Weather.

How is it that I pay \$150 per month for 350 channels and....
There is never anything to watch!

**Cable Provider Footprints
Top 10 MSOs
January 2011**



MSO Key

	Cablevision		Bright House
	Time Warner		Suddenlink
	Comcast		Cox
	Charter		Insight
	Cable One		Mediacom

Source: MediaCensus © 2011 MediaBiz
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There are very few companies that own the necessary infrastructure to provide service

TRUE FOR TV CABLE PROVIDERS

TRUE FOR LAKE MODELERS



*“All models are wrong, but
some are useful”*

George E.P. Box – Statistician, Princeton University

Types of Models:

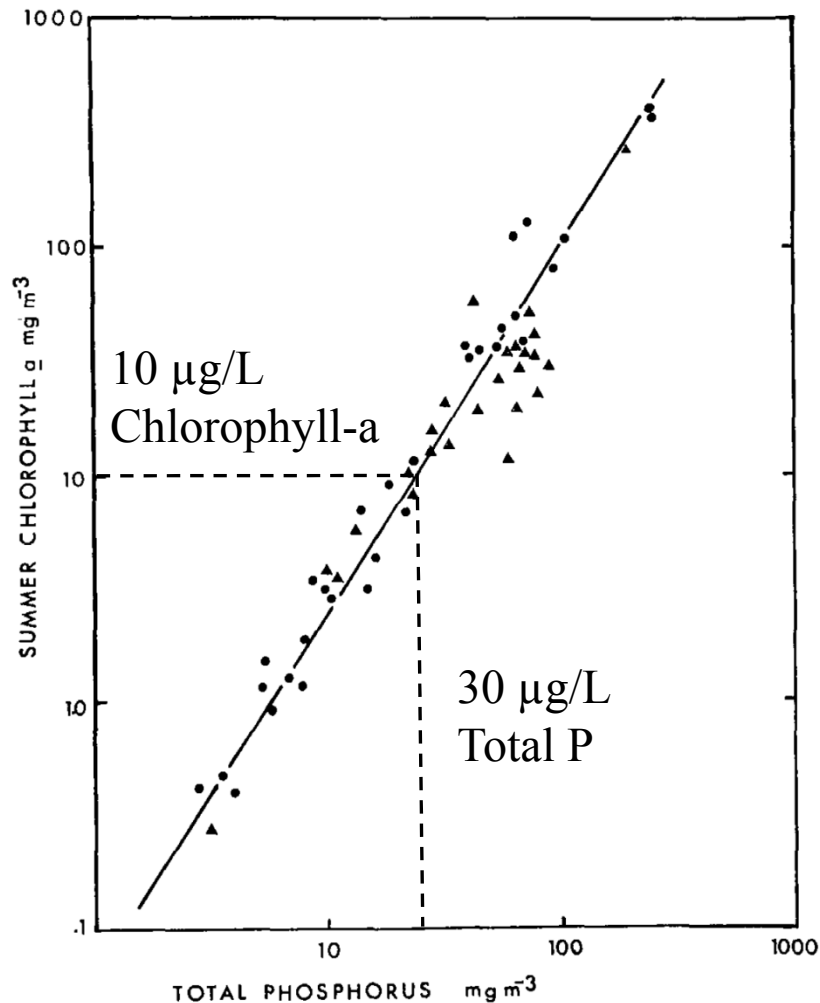
Statistical – linear and non-linear regression, logistic regression, hierarchy, categorical (anything with a p value)

Other empirical – simple mathematical formulations that directly link predictor and outcome (usually involve statistics)

Physically-based models – complex mathematical formulations to simulate physical, chemical, and biological variation on a short time step (often daily)

Let's cover some lake models used for eutrophication management and TMDL work

Examples of Models: Statistical



The phosphorus–chlorophyll relationship in lakes^{1,2}

P. J. Dillon³ and F. H. Rigler

Department of Zoology, University of Toronto, Toronto, Ontario

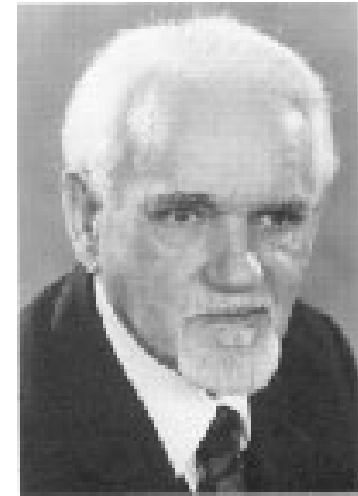
$$y = mx + b$$

$$\text{Summer chla} = m[\text{P}] + b$$

Examples of Models: Other Empirical

Vollenweider (1968)

$$L_c = \frac{[P]_c \times q_s}{(1 + \sqrt{\tau_w})}$$



L_c = critical P load (mg P m⁻² y⁻¹)

$[P]_c$ = critical P concentration of lake (mg/L)

q_s = annual hydraulic load (m y⁻¹)

τ_w = average water residence time (y)

Timestep = annual

Combination of Vollenweider with Dillon and Rigler gets you:

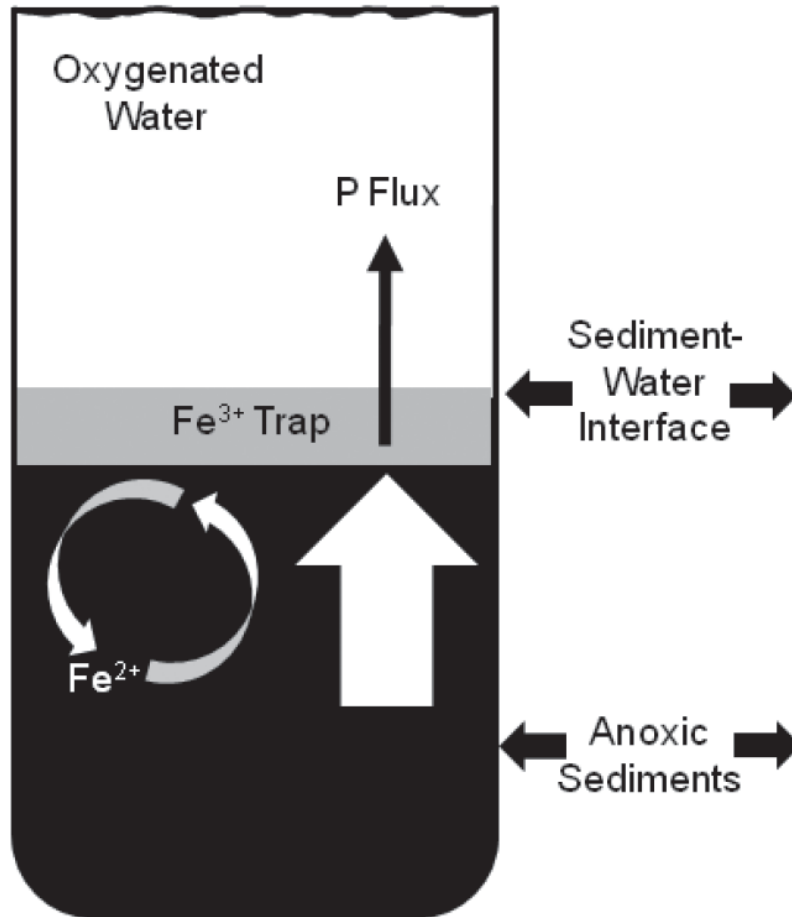
The annual phosphorus load reduction needed to reduce algal biomass to a certain level

This assumes:

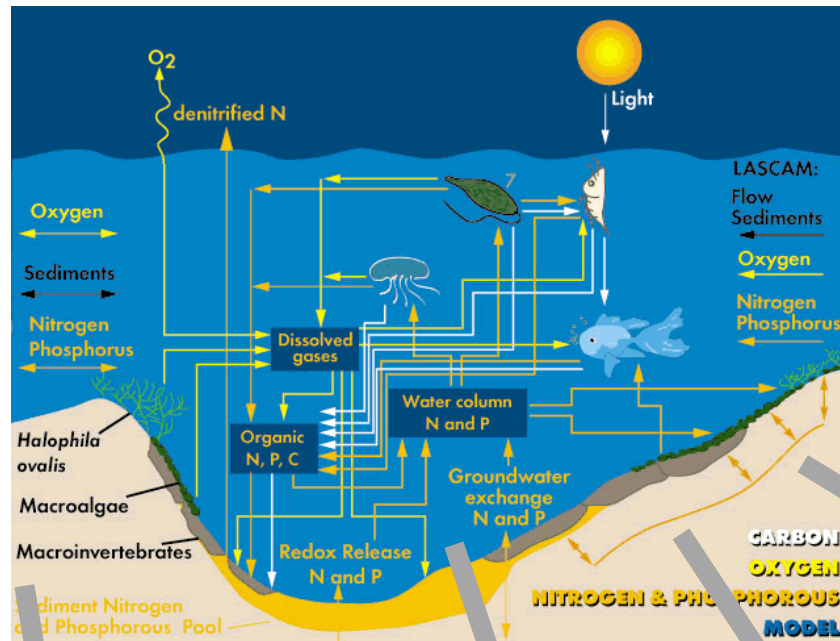
1. Lake has come into equilibrium with watershed
2. Other factors like internal loading do not dominate

We deal with these assumptions by increasing model complexity:
of processes simulated and a finer resolution time step

Internal P loading is controlled by and influences multiple in-lake variables



Examples of Models: Physically-based



Algal Dynamics

$$S_a = \underbrace{K_{ag} \Phi_a}_{\text{growth}} - \underbrace{K_{ar} \Phi_a}_{\text{respiration}} - \underbrace{K_{ae} \Phi_a}_{\text{excretion}} - \underbrace{K_{am} \Phi_a}_{\text{mortality}} - \underbrace{\omega_a \frac{\partial \Phi_a}{\partial z}}_{\text{settling}}$$

Heat exchange

$$H_{aw} = -K_{aw}(T_w - T_e)$$

Flow

$$Q = C_D C_v \frac{2}{3} \sqrt{\frac{2}{3}} g W H^{3/2}$$

Dissolved OM Decomp & Settling

$$S_{LDOM} = \underbrace{\sum K_{ae} \Phi_a}_{\text{algal excretion}} + \underbrace{\sum (1 - P_{am}) K_{am} \Phi_a}_{\text{algal mortality}} + \underbrace{\sum K_{ee} \Phi_e}_{\text{epiphyton excretion}} + \underbrace{\sum (1 - P_{em}) K_{em} \Phi_e}_{\text{epiphyton mortality}} - \underbrace{\gamma_{OM} K_{LDOM} \Phi_{LDOM}}_{\text{labile DOM decay}} - \underbrace{K_{L \rightarrow R} \Phi_{LDOM}}_{\text{labile to refractory DOM decay}}$$

Particulate Matter Decomp & Settling

$$S_g = \underbrace{-K_0 \theta_g^{(T-20)}}_{\text{0-order decay}} - \underbrace{K_1 \theta_g^{(T-20)} \Phi_g}_{\text{1st-order decay}} - \underbrace{\omega_g \frac{\partial \Phi_g}{\partial z}}_{\text{settling}}$$

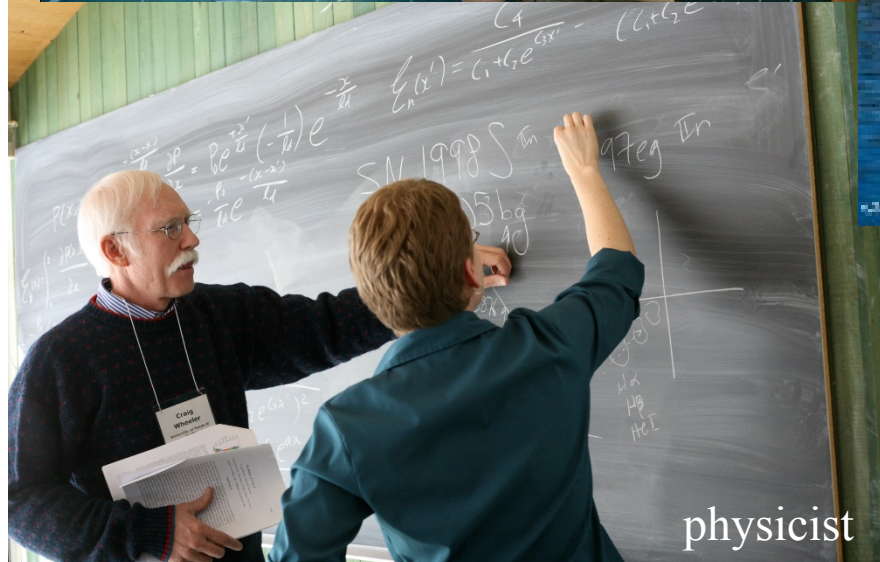
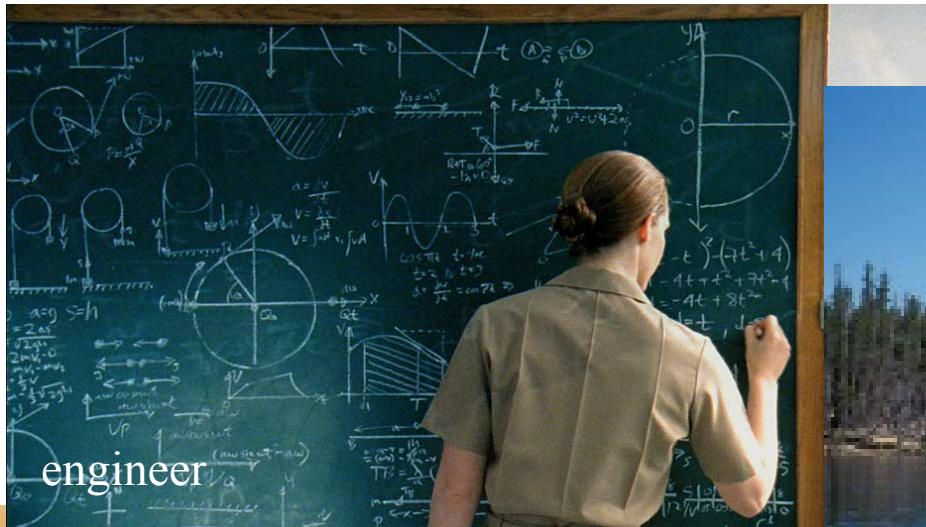
What modelers promise and what they
provide are often very different

WHY?

Five reasons modeling efforts sometimes derail

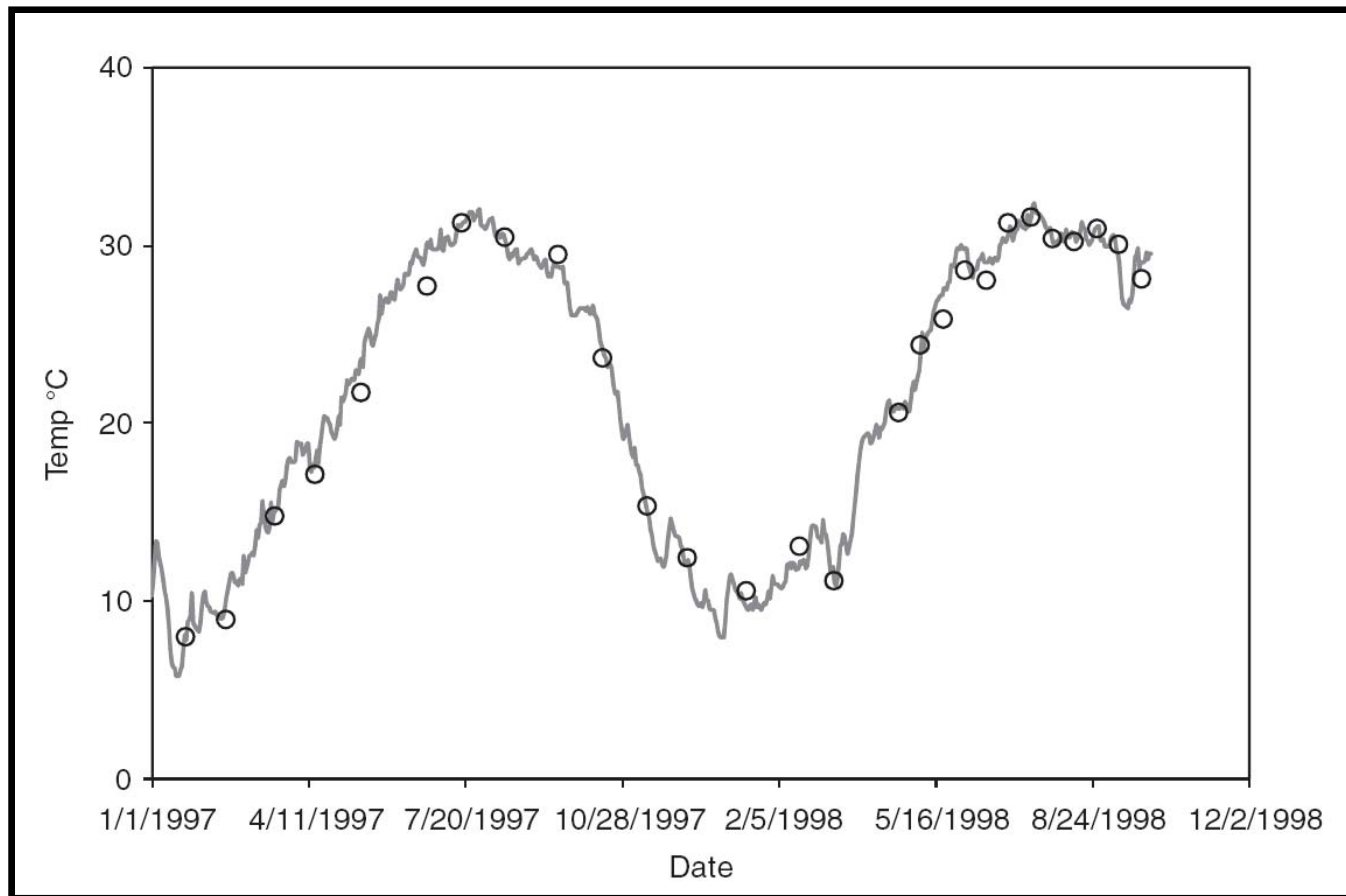
- Science is used as a tool to perform lake models rather than lake models being used as a tool to perform science
- Biological variables cannot be simulated as well as physical and chemical variables
- Lake models need sufficient data for calibration and validation
- Different ecosystem process control biological structure and function in different lakes
- Inference should be based on straightforward hypothesis testing of well-calibrated and validated models

- Science is used as a tool to perform lake models rather than lake models being used as a tool to perform science



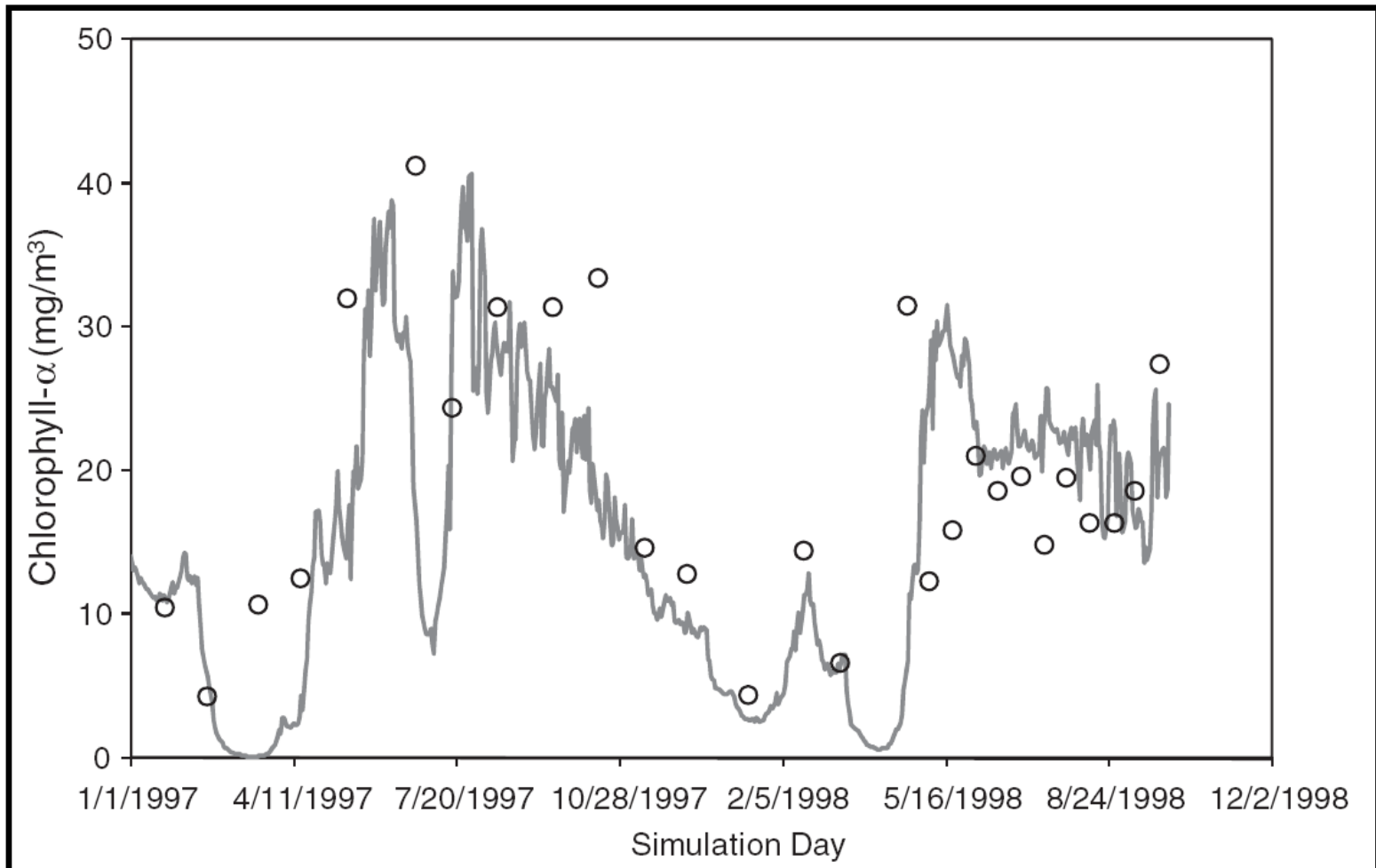
**HAVE YOU HUGGED A
LIMNOLOGIST TODAY ?**
"LIMNOLOGY" – THE STUDY OF INLAND WATERS

- Biological variables cannot be simulated as well as physical and chemical variables



White et al. 2010

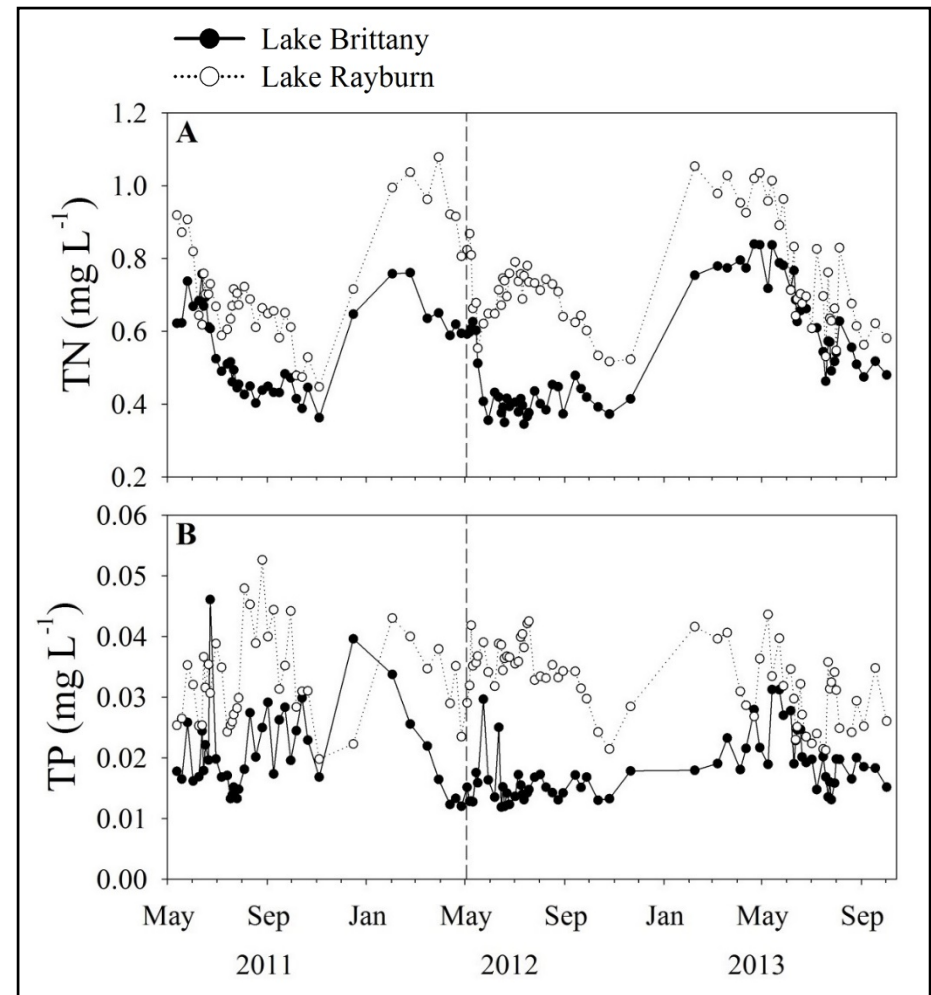
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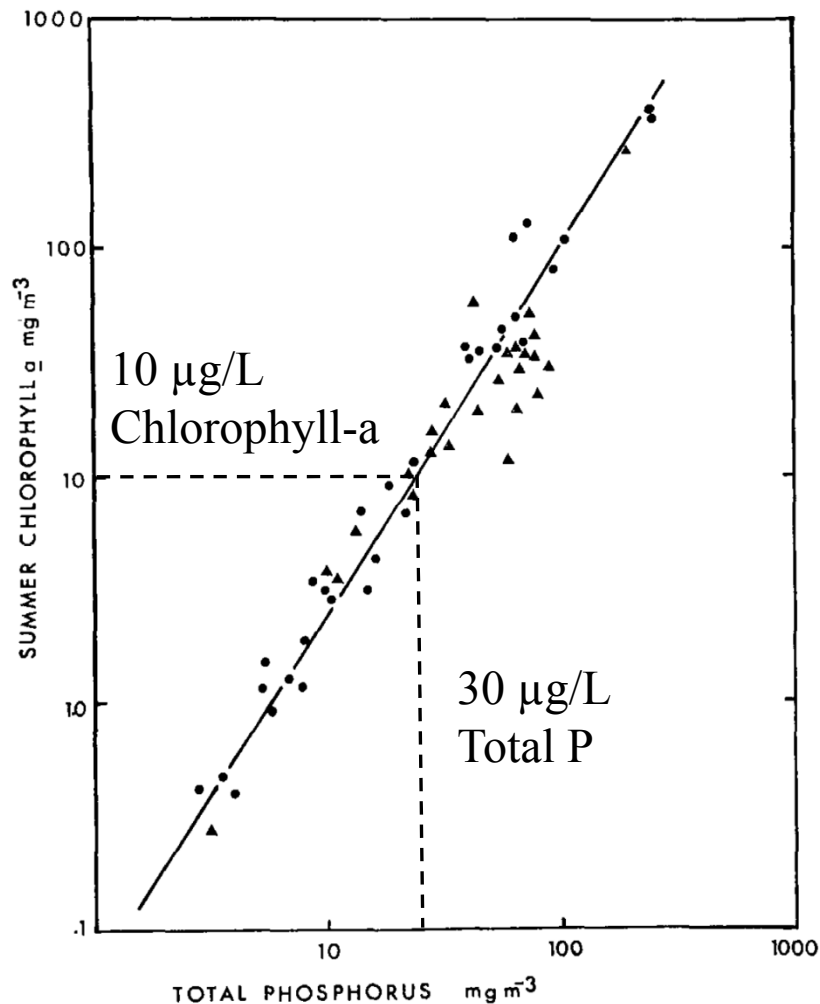
White et al. 2010

- Lake models need sufficient data for calibration and validation

- Most advanced models run on a daily time step
- Daily calibration data is not an option
- Daily and weekly variation can be substantial
- What resolution of monitoring data is needed for calibration?



- Different ecosystem process control biological structure and function in different lakes



The phosphorus–chlorophyll relationship in lakes^{1,2}

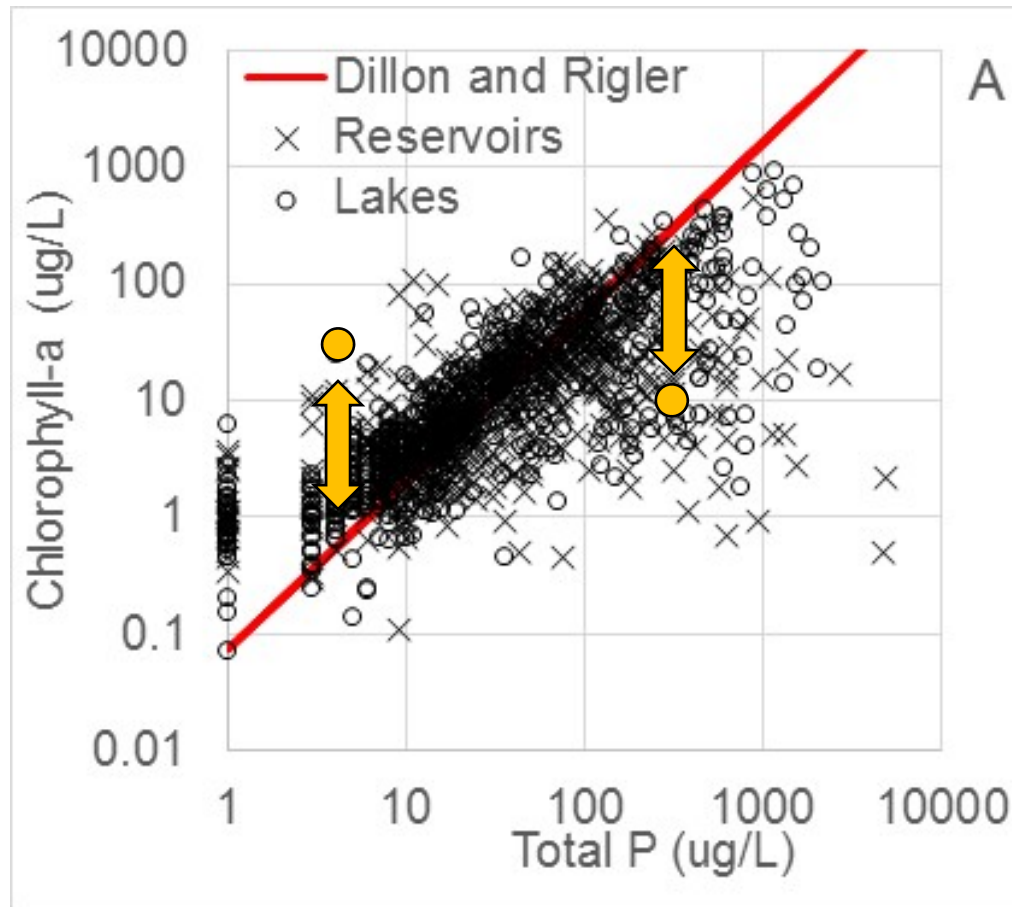
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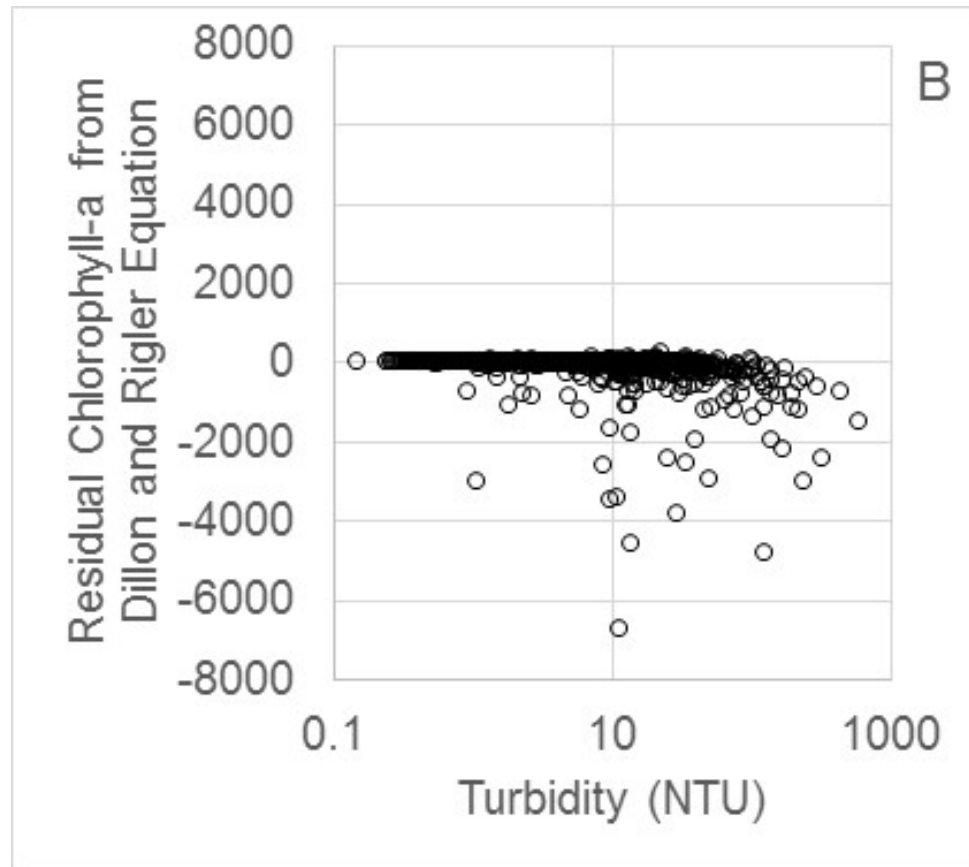
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EPA National Lake Assessment Data 2007

http://water.epa.gov/type/lakes/lakessurvey_index.cfm

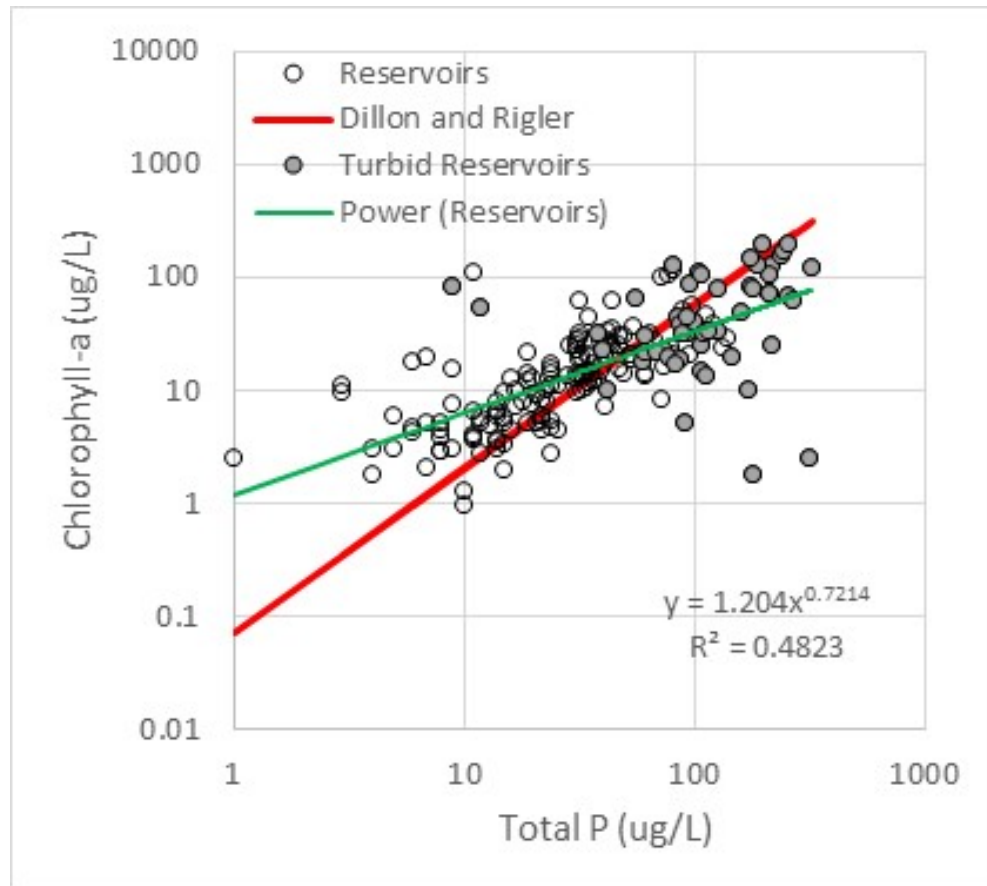
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EPA National Lake Assessment Data 2007

http://water.epa.gov/type/lakes/lakessurvey_index.cfm

- Different ecosystem process control biological structure and function in different lakes



EPA National Lake Assessment Data 2007

http://water.epa.gov/type/lakes/lakessurvey_index.cfm

- Inference should be based on straightforward hypothesis testing of well-calibrated and validated models

Testable modeling hypotheses:

Twenty five percent reduction in P loading will reduce average annual algal biomass by 5x because lake processes are in equilibrium with watershed loading

Untestable modeling hypothesis:

Blue-green algae will dominate algal biomass under increased CO₂ conditions because blue-greens outcompete other algae during summer CO₂ drawdown

Five reasons modeling efforts sometimes derail

- Science is used as a tool to perform lake models rather than lake models being used as a tool to perform science
- Biological variables cannot be simulated as well as physical and chemical variables
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Modeling as a tool to do science REQUIRES multidisciplinary collaboration



Higher education institutions need to:

- Promote modeling opportunities at B.S. and M.S. levels
- Use models for hypothesis testing
- Get involved in model applications

Federal and State agencies that need modeling efforts need to:

- Consider the cost benefit of a poorly constructed model with more empirical data
- Use resources to promote responsible and quality model development through systematic programs

THIS CAN HELP US AVOID:

The image is a technical test chart. It features a grid of colored squares at the top and bottom. The top row consists of seven large squares: white, yellow, cyan, magenta, red, and blue. The bottom row consists of seven smaller squares: blue, magenta, yellow, red, cyan, black, and white. A horizontal bar with a rainbow gradient is located in the lower right. A central text box with a light blue background and a thin black border contains the text 'Thank you!' and 'Questions?'. Two black rectangular boxes with white text 'TECHNICAL DIFFICULTIES' are positioned at the top and bottom center.

TECHNICAL DIFFICULTIES

Thank you!
Questions?

TECHNICAL DIFFICULTIES