



Models in Environmental Chemistry Education, Decision-making & Science

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Models in Environmental Chemistry Education, Decision-making & Science

- Introduction – Why model?
- What is the role of models in:
 - Education?
 - Decision-making?
 - Science?
- What characteristics should models have?
- Summary & a challenge...

Why model?

- Because we cannot help it!
 - Everyone is an *implicit* modeler
- It is valuable to make models *explicit*
 - Assumptions are defined
 - Sensitivity and scenario analysis is possible
 - Others can replicate your results

Models can never be verified

- Models are limited conceptualizations of the real system
- Models are limited in the empirical accuracy of their governing equations
- Models are limited with respect to input parameterization

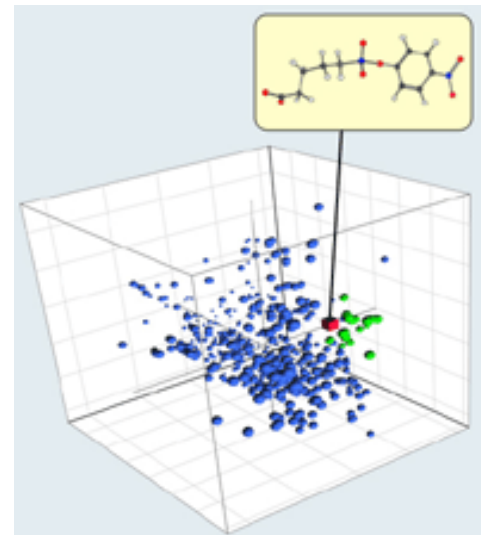
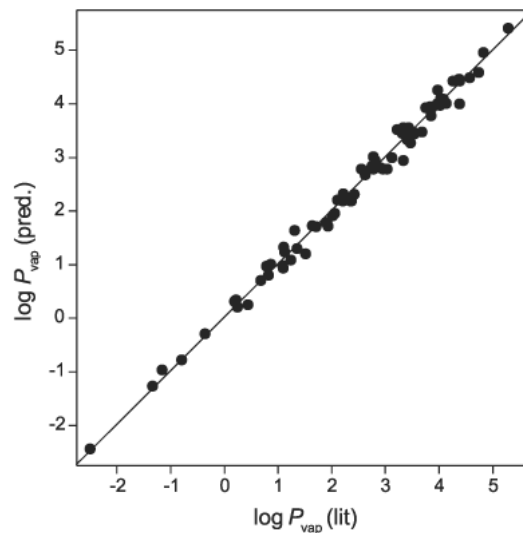
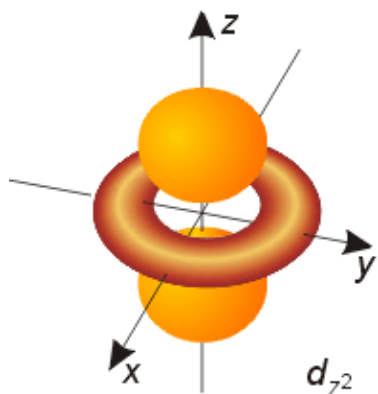
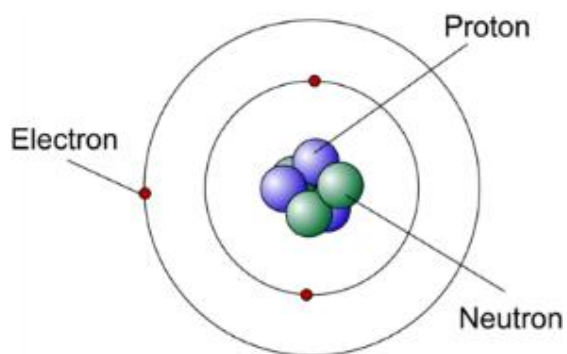
Oreskes, N. **2003**. "The role of quantitative models in science," in *Models in Ecosystem Science*, Princeton University Press, pp. 13-31.

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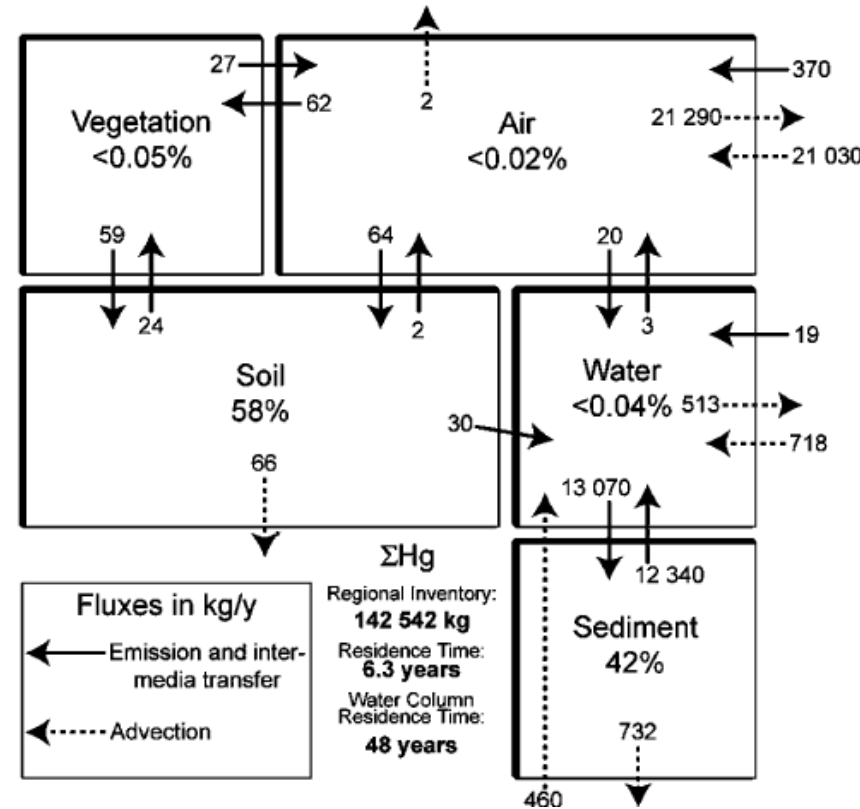
The ground rules for model development...

- Epstein:
 - “You must make models”
- Oreskes:
 - “Your models will always be wrong”
- These two rules are unbreakable, and are not in conflict

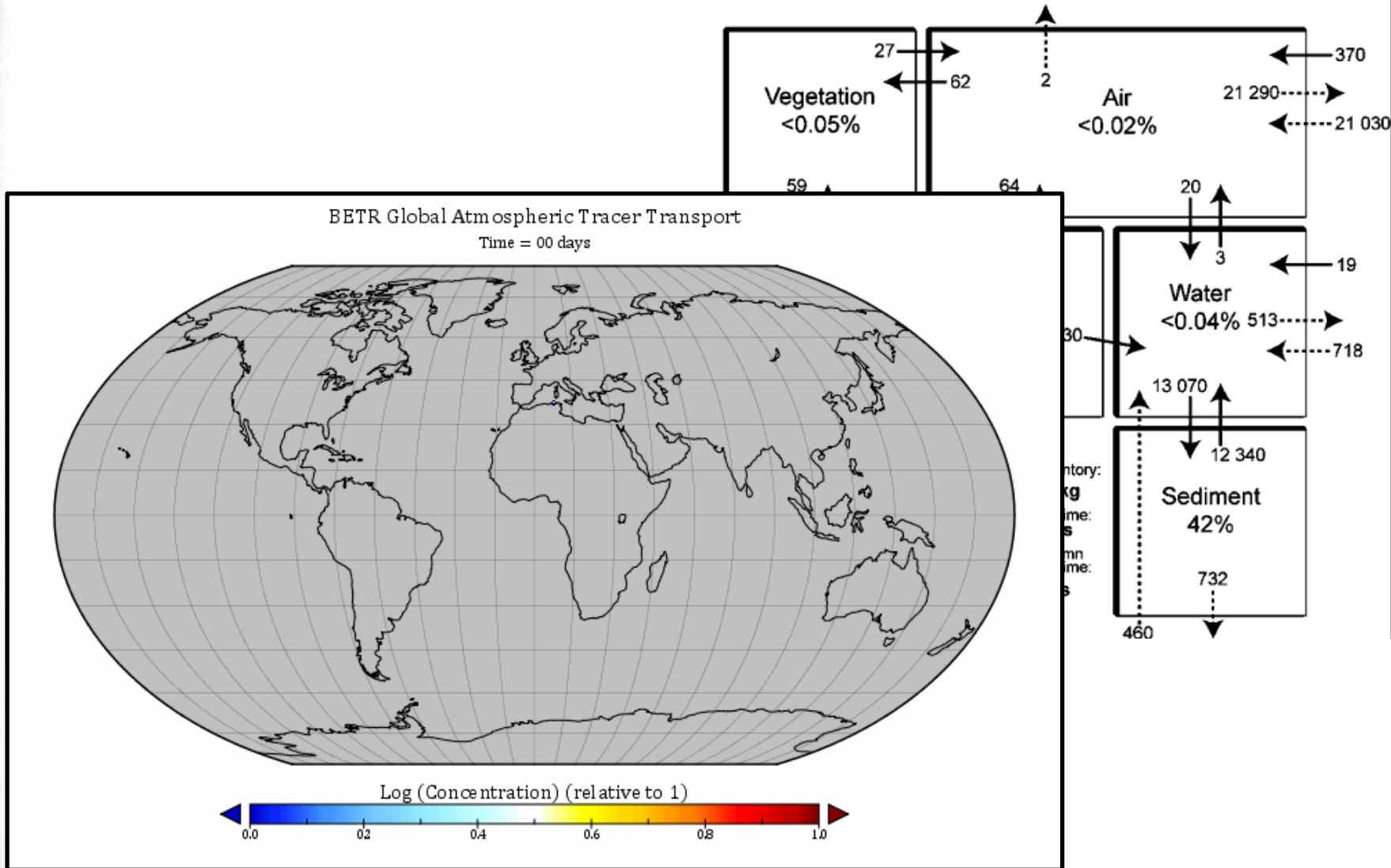
There are many types of models in environmental chemistry



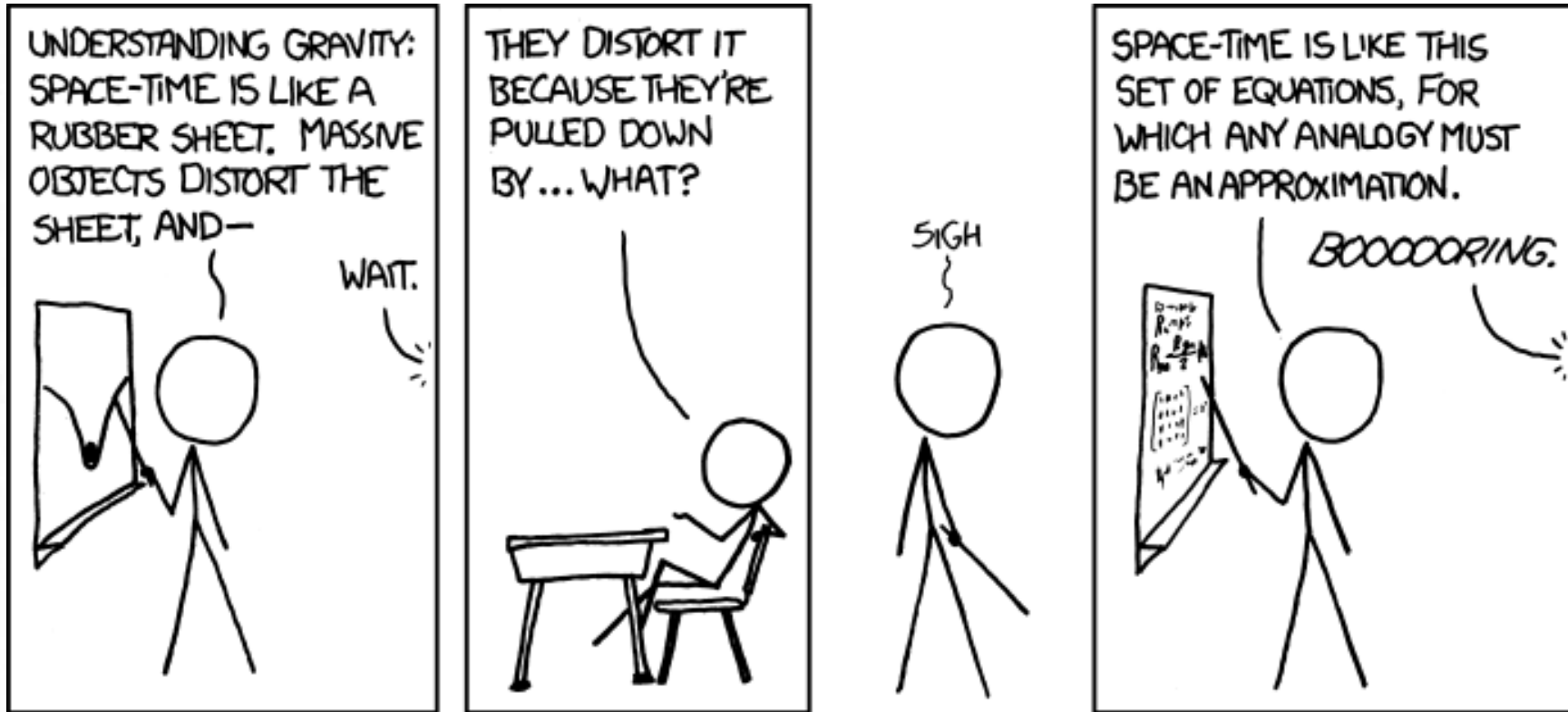
Mass balance chemical fate models



Mass balance chemical fate models



1. Models in Education

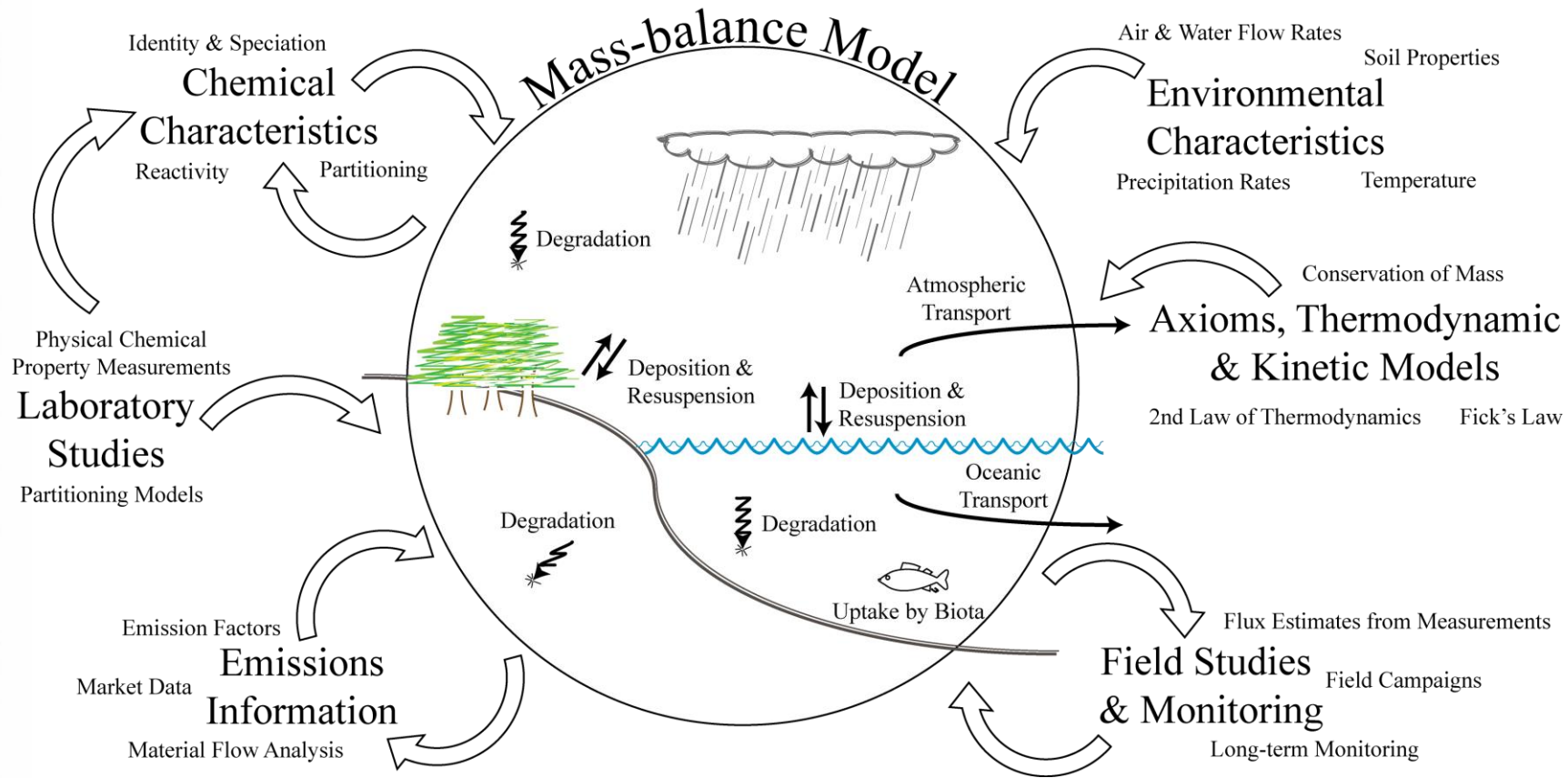


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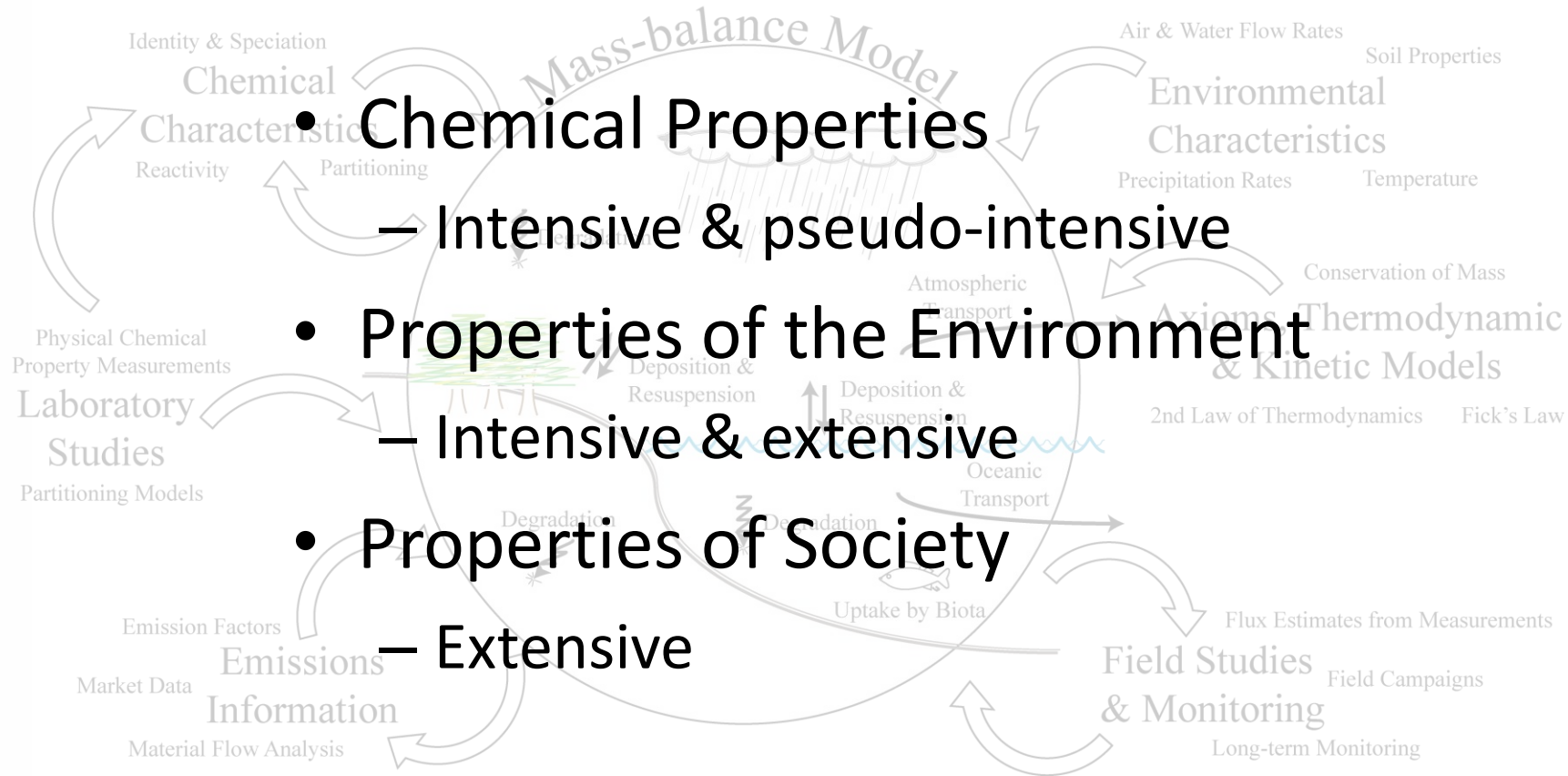
1. Models in Education

- Environmental chemistry is a vast & multidisciplinary field
- Learning to understand the system of chemicals & the environment is a daunting task!

Models can provide a framework to categorize concepts and information



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1. Models in Education

- In science we routinely & instinctively use models to introduce & explain difficult concepts
- This is useful at the micro-detailed level, and also at the macro-integrative level
- Models must be explicit, with limitations and assumptions stated

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2. Models in Decision-making

- Decision-making should be supported by “sound science”
- But, science is always uncertain and very few decisions are made based solely on considerations that can be measured by scientifically

People don't recognize their own incompetence

(Dunning et al. *Current Directions in Psychological Science*, 12 (3), 2003)

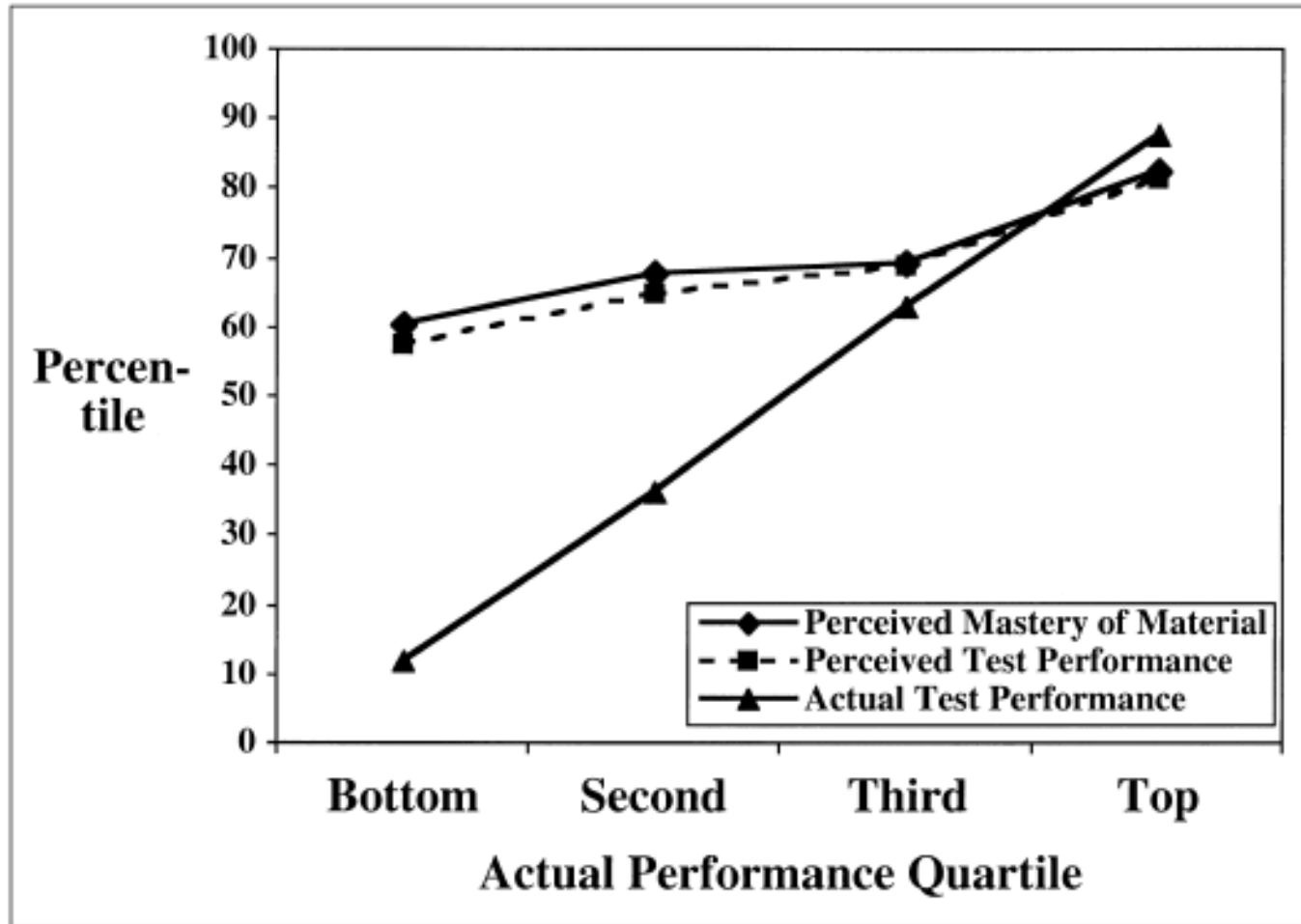


Fig. 1. Perceived percentile rankings for mastery of course material and test performance as a function of actual performance rank.

Bad decision-makers don't know they are incompetent!

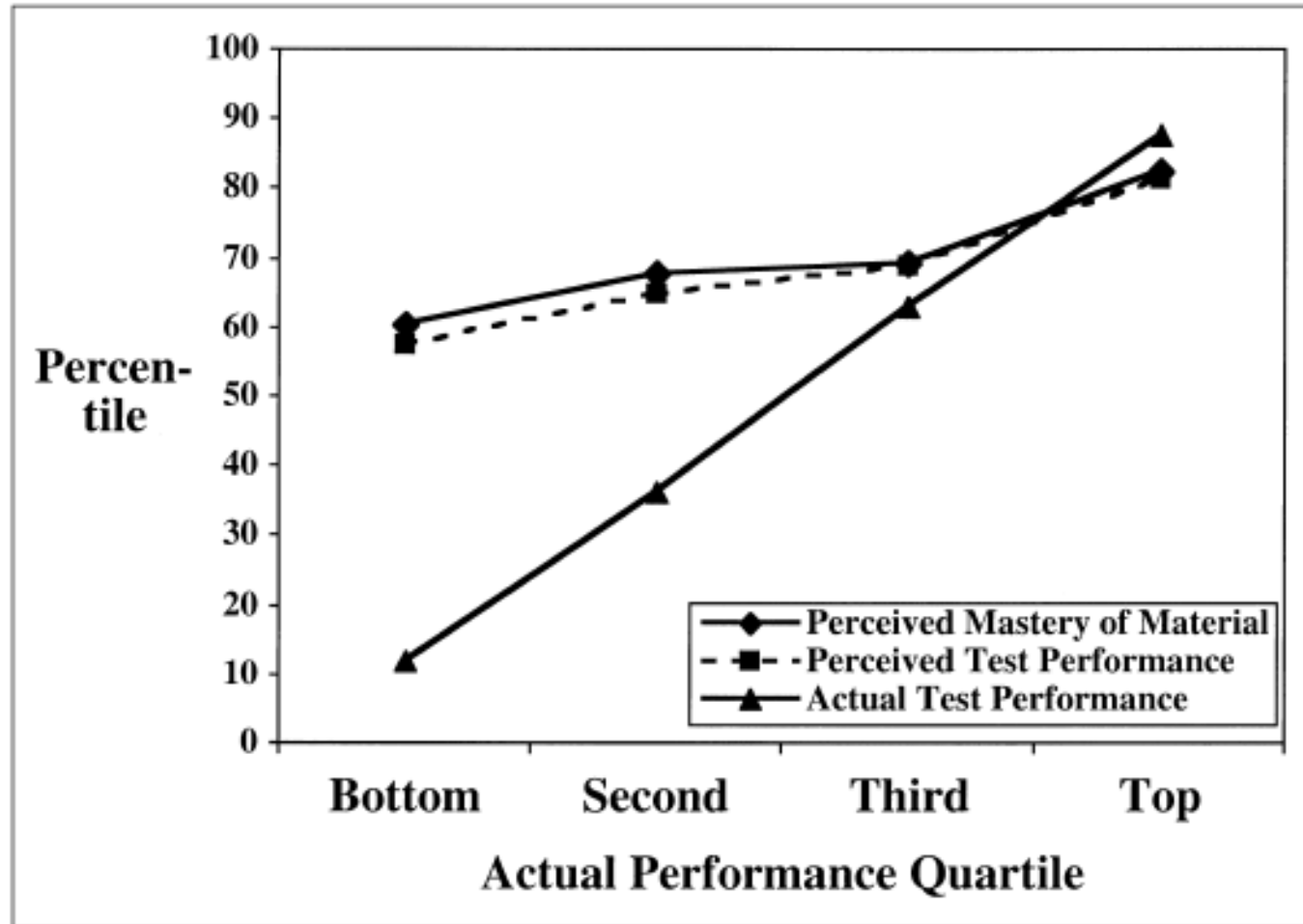


Fig. 1. Perceived percentile rankings for mastery of course material and test performance as a function of actual performance rank.

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In this environment, models used as decision-support tools ...

- must be fully understood by decision-makers
 - Conceptual basis, assumptions, input data, past applications, etc...

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Models used in decision-making should be *parsimonious* – i.e. no more complicated than necessary

3. Science

- The most interesting domain because it is the most varied
- It is a mistake to think that the only utility of models in science is to make predictions ...



16 reasons other than prediction to build models

(Epstein, *Journal of Artificial Societies and Social Simulation* 11(4), 2008)

1. Explain (very distinct from predict)
2. Guide data collection
3. Illuminate core dynamics
4. Suggest dynamical analogies
5. Discover new questions
6. Promote a scientific habit of mind
7. Bound (bracket) outcomes to plausible ranges
8. Illuminate core uncertainties.
9. Offer crisis options in near-real time
10. Demonstrate tradeoffs / suggest efficiencies
11. Challenge the robustness of prevailing theory through perturbations
12. Expose prevailing wisdom as incompatible with available data
13. Train practitioners
14. Discipline the policy dialogue
15. Educate the general public
16. Reveal the apparently simple (complex) to be complex (simple)

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3. Models in science

- Models are indispensable and highly flexible tools
- They can have varied form and levels of detail
- In science, no model should be considered intrinsically superior to any other... Models only have value in their appropriateness for addressing the question or need at hand



Models in Environmental Chemistry

- Education
 - Should be used at the detailed level and also at the macro, integrative level to categorize concepts and information
- Decision-making
 - Should be parsimonious and accompanied by an evaluation of uncertainty
- Science
 - Can be highly variable in form & purpose-built for addressing a specified question or problem

Conclusions

Models in Environmental Chemistry

- We can't avoid making models, therefore we must strive to make *explicit* models
- Given that all models are wrong:
 - there is no inherent reason to prefer complexity over simplicity
 - models with different levels of complexity should be seen as complementary
 - sensitivity and uncertainty of model scenarios should be systematically explored

Acknowledgments

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- Joop Hermans

The State of Multimedia Mass-Balance Modeling in Environmental Science and Decision-Making

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Are multimedia models dinosaurs in the modern world?

