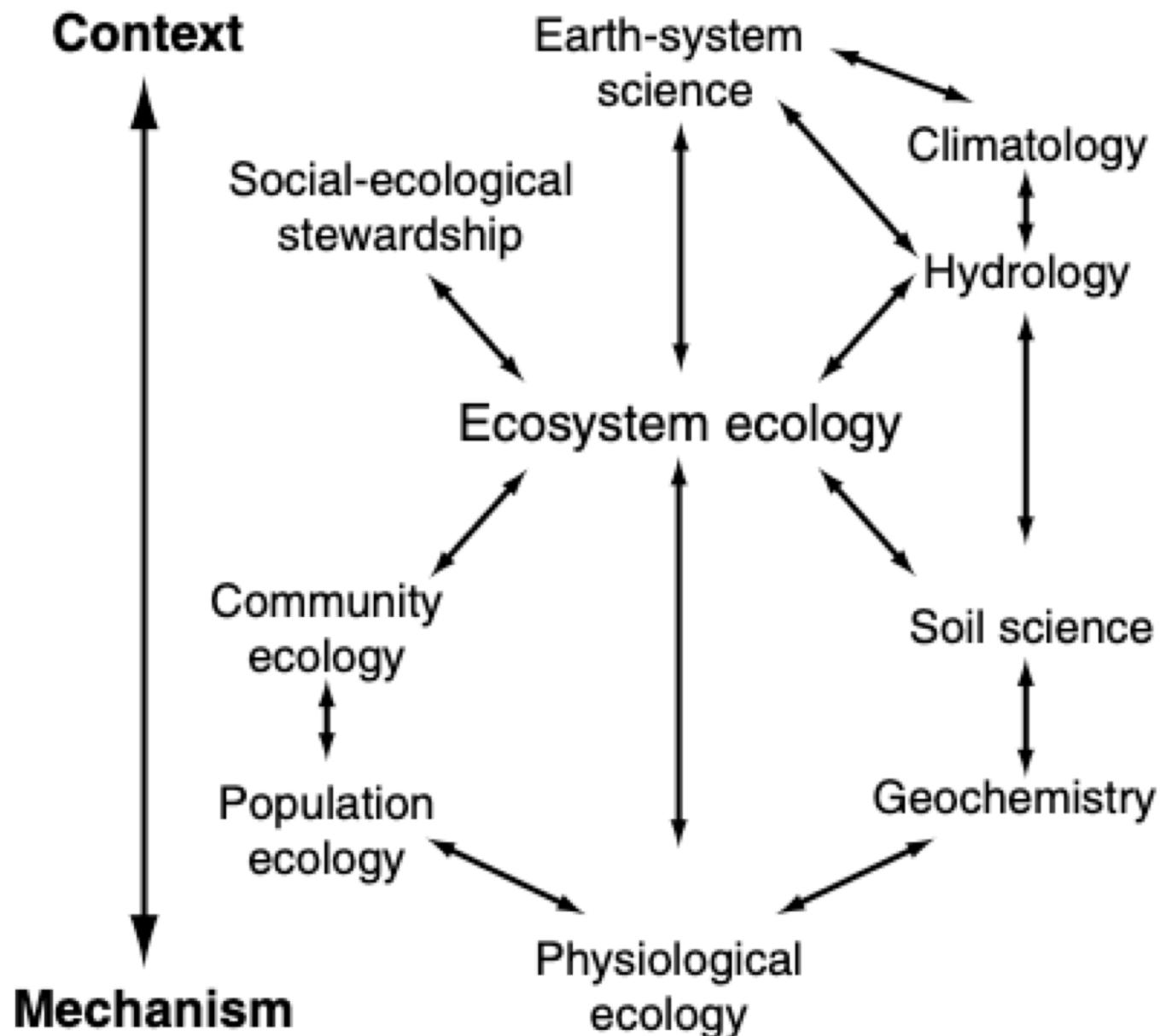


Systems thinking for terrestrial ecosystem modeling

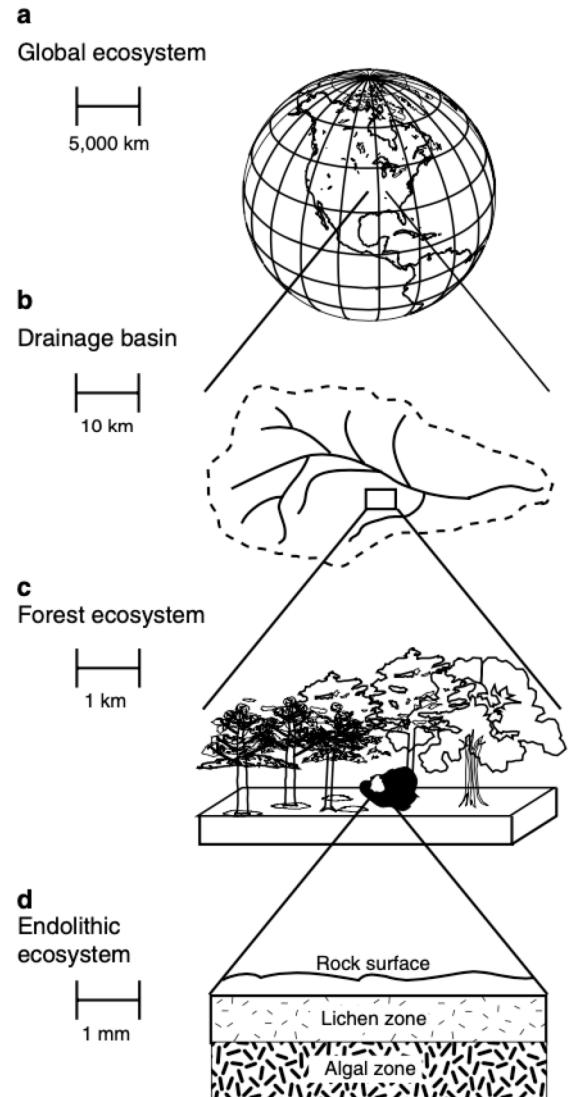
What are terrestrial ecosystems?

What are terrestrial ecosystems?

- Physical, chemical, and biological components of a given area of land that interact with each other and the surrounding environment
- Form the basis of the largest scale in ecology, encompassing all other scales



The scale of an ecosystem must be defined



Why study terrestrial
ecosystems?



Can any of these be understood without an ecosystem-scale understanding?

Why models?

Why models? Answers from Bonan (2019)

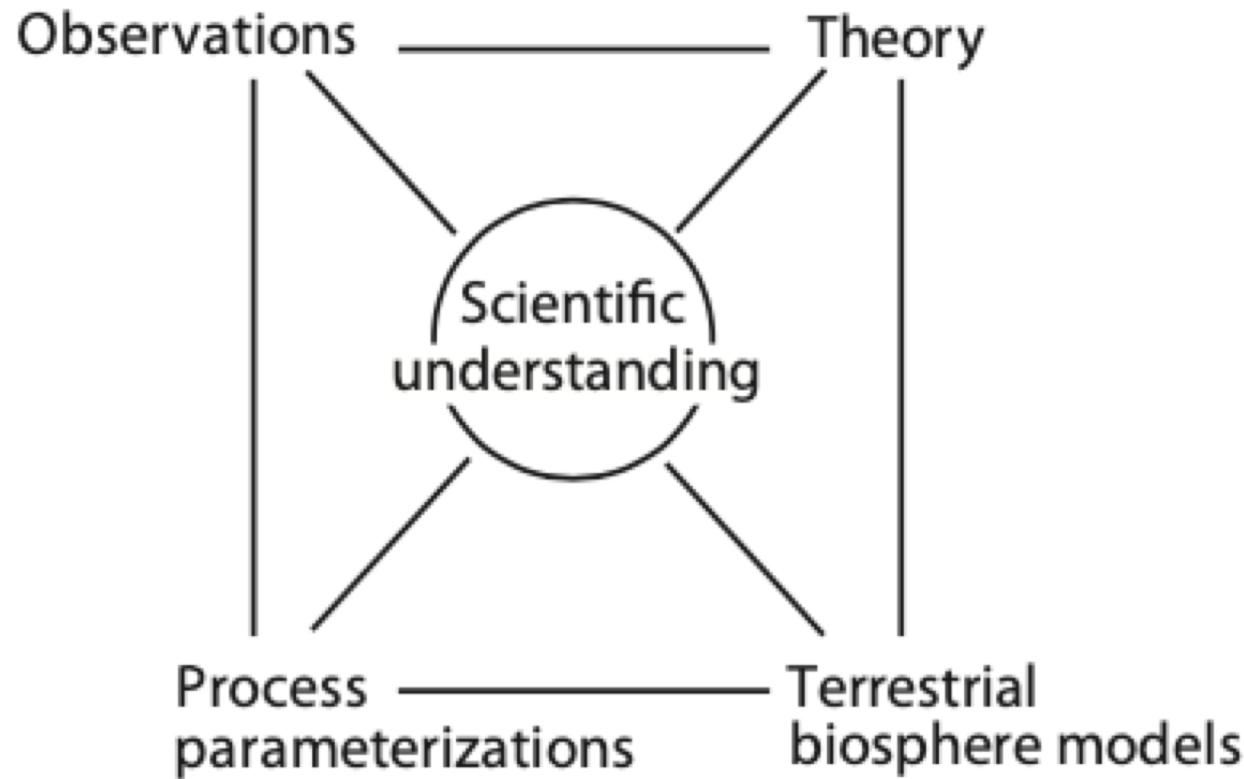
- Study system behavior beyond range of measurements
- Inform management and policy decisions

Why models? Answers from Bonan (2019)

- Study system behavior beyond range of measurements
- Inform management and policy decisions
- To inform understanding of a system
 - Using model experiments to generate and test hypotheses
 - Develop process-level understanding at multiple scales

Why models? Answers from Bonan (2019)

- Study system behavior beyond range of measurements
- Inform management and policy decisions
- To inform understanding of a system
 - Using model experiments to generate and test hypotheses
 - Develop process-level understanding at multiple scales
- **To guide data collection**



How do we start to model a system?

How do we start to model a system? Let's start with an example exercise



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Data description paper |

Global Carbon Budget 2023

Pierre Friedlingstein , Michael O'Sullivan, Matthew W. Jones, Robbie M. Andrew, Dorothee C. E. Bakker, Judith Hauck, Peter Landschützer, Corinne Le Quéré, Ingrid T. Luijckx, Glen P. Peters, Wouter Peters, Julia Pongratz, Clemens Schwingshackl, Stephen Sitch, Josep G. Canadell, Philippe Ciais, Robert B. Jackson, Simone R. Alin, Peter Anthoni, Leticia Barbero, Nicholas R. Bates, Meike Becker, Nicolas Bellouin, Bertrand Decharme, Laurent Bopp, Ida Bagus Mandhara Brasika, Patricia Cadule,

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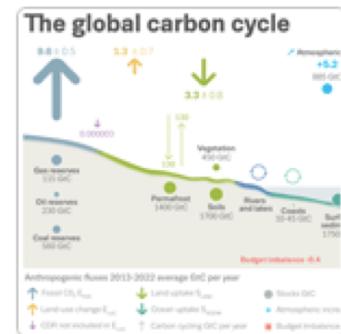
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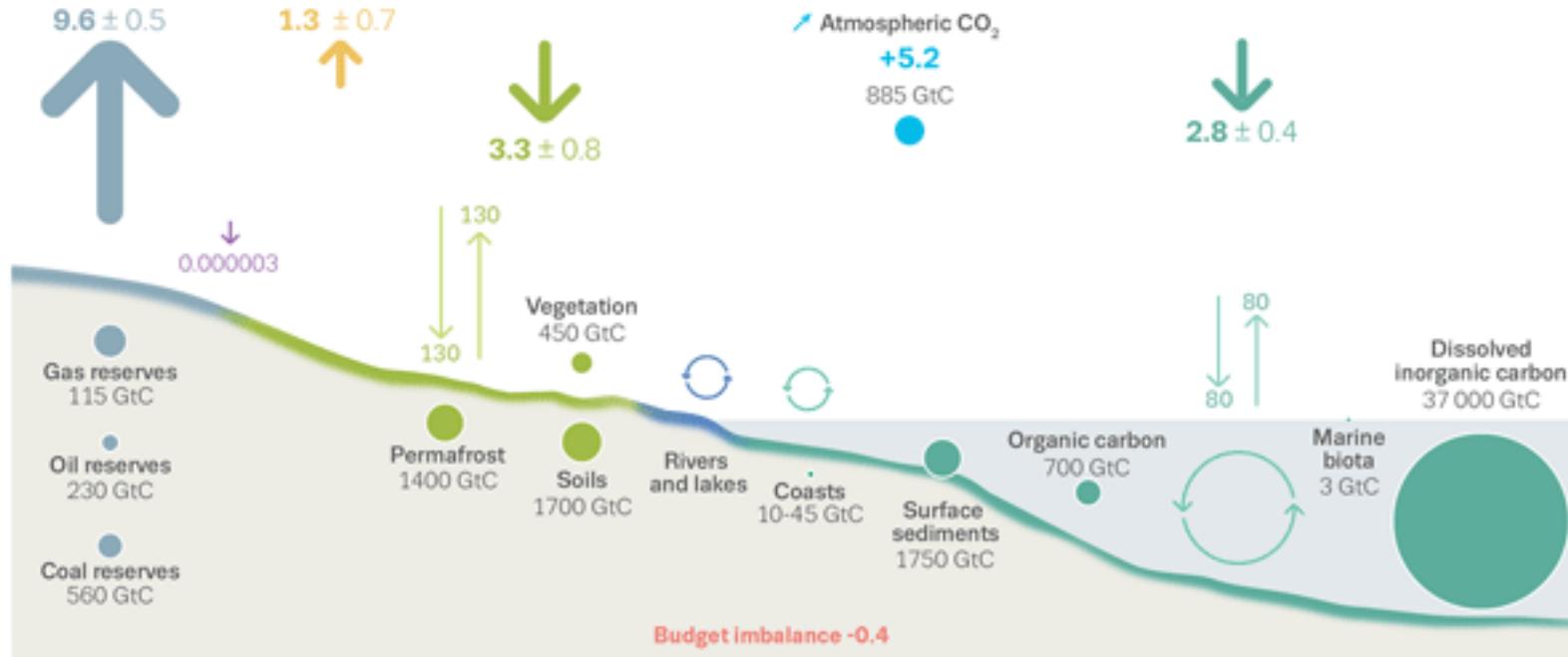
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The global carbon cycle

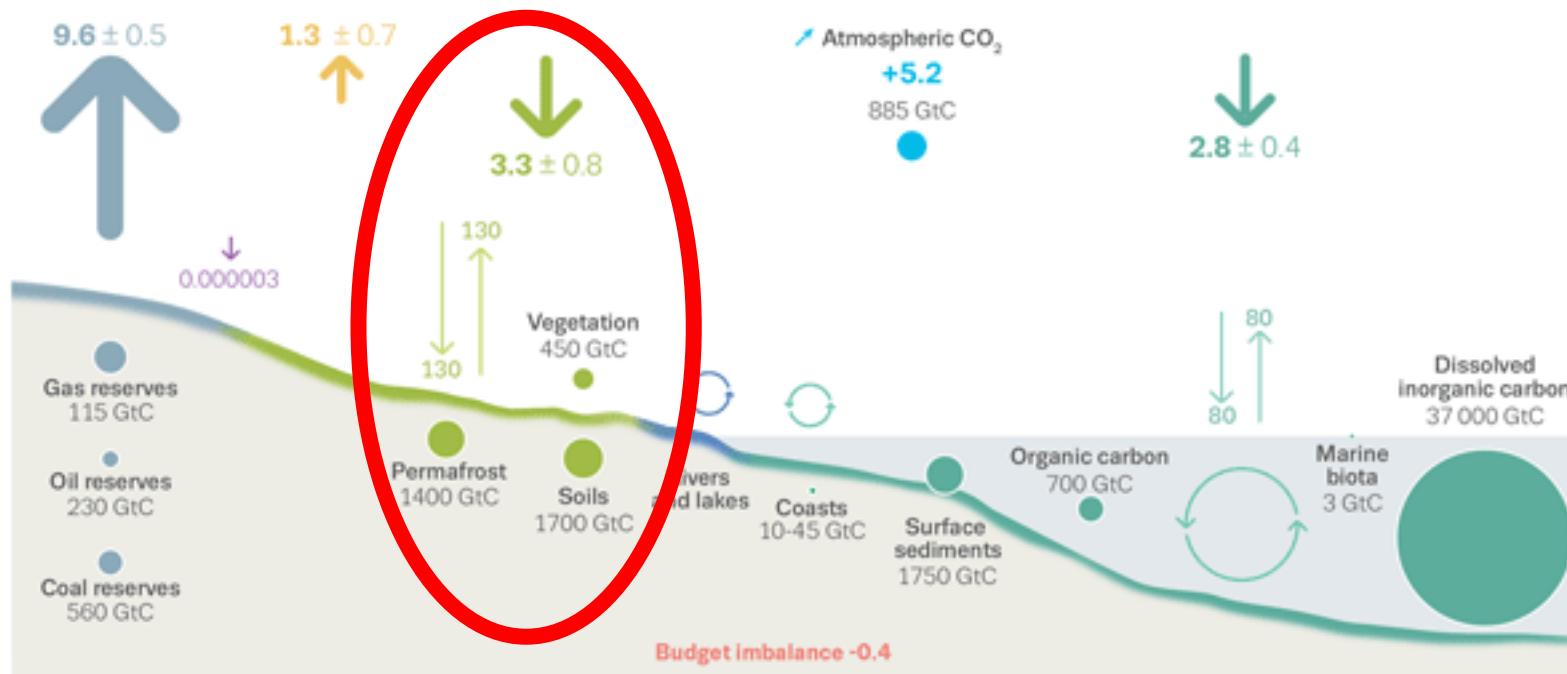


Anthropogenic fluxes 2013-2022 average GtC per year

- ↑ Fossil CO₂ E_{FOS}
- ↑ Land-use change E_{LUC}
- ↓ CDR not included in E_{LUC}
- ↓ Land uptake S_{LAND}
- ↓ Ocean uptake S_{OCEAN}
- ↑ Carbon cycling GtC per year
- Stocks GtC
- + Atmospheric increase G_{ATM}
- Budget Imbalance B_{IM}

Why is understanding the global carbon cycle important?

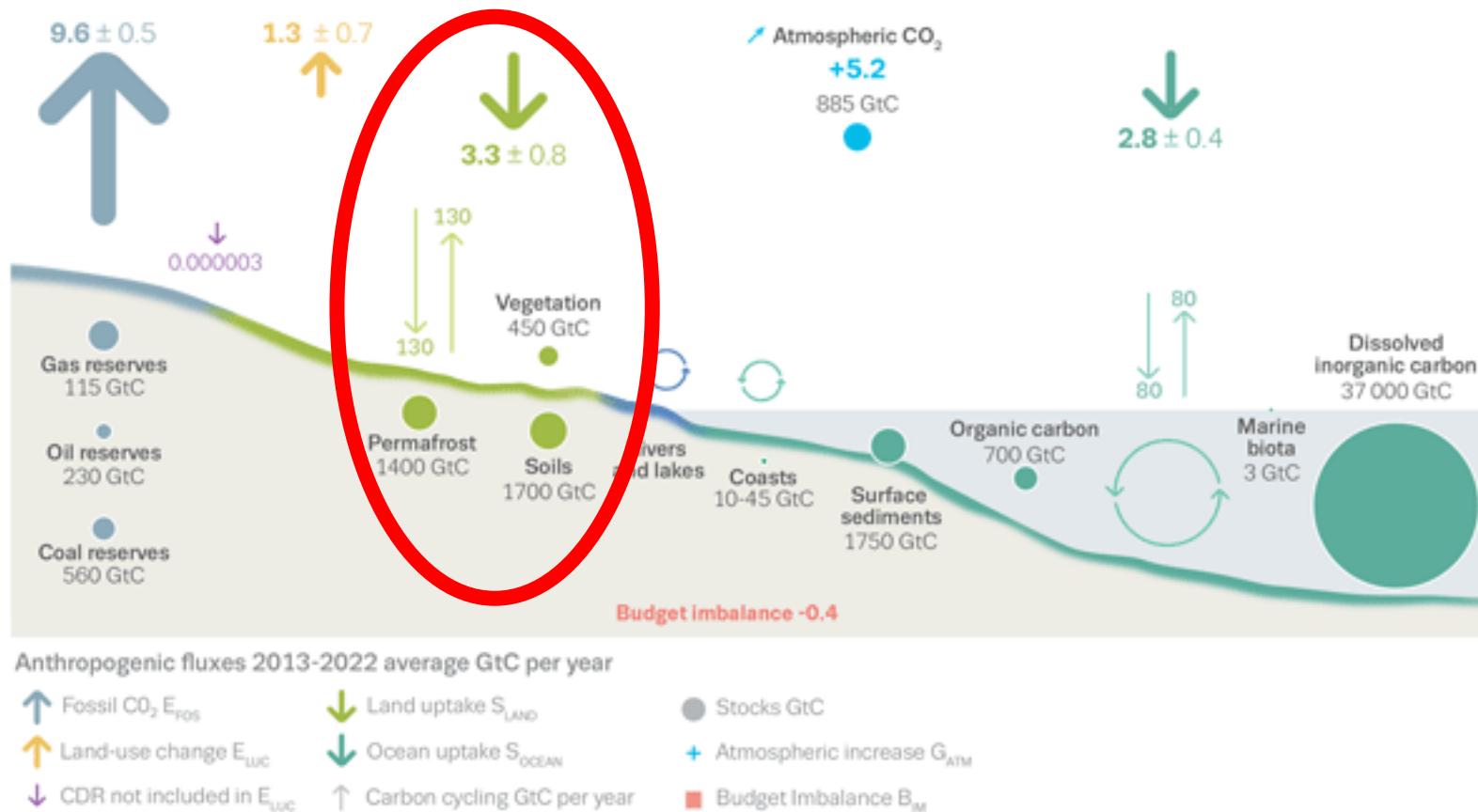
The global carbon cycle



Anthropogenic fluxes 2013-2022 average GtC per year

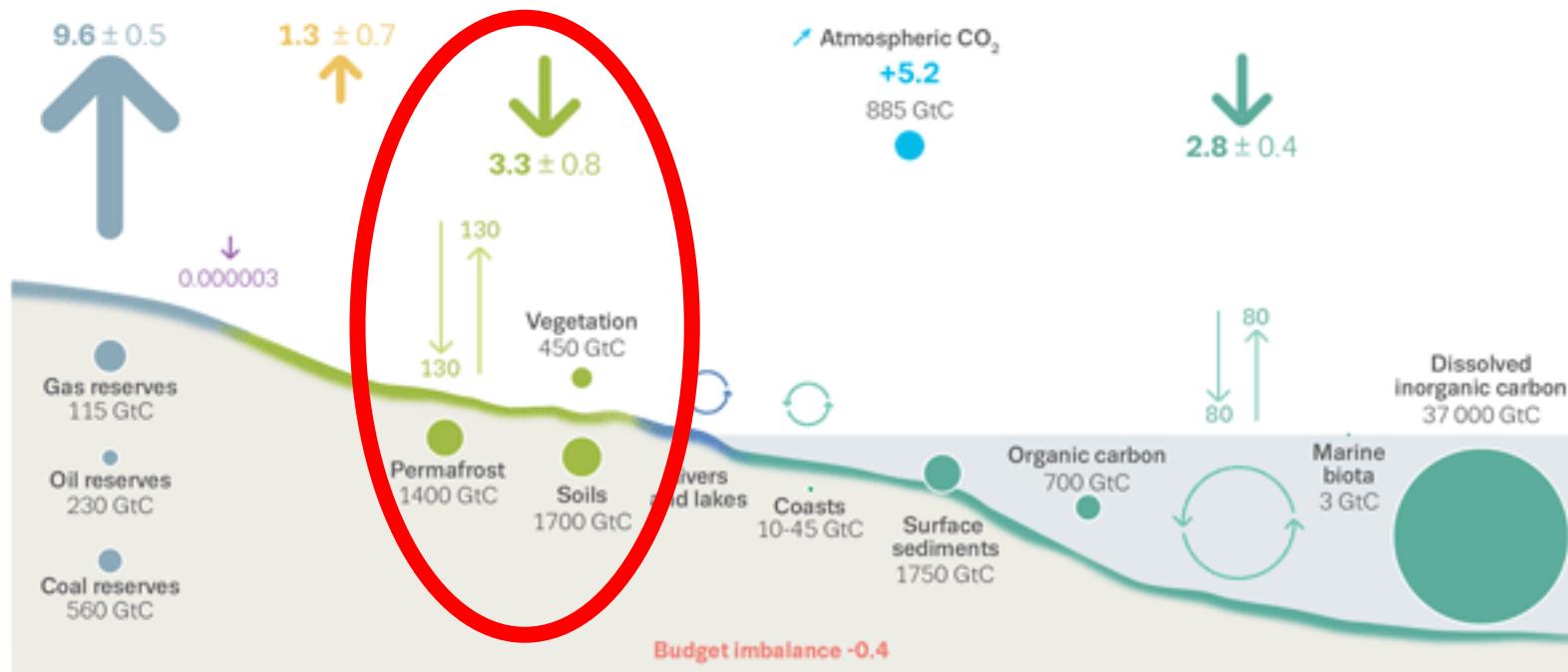
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The global carbon cycle



Why is understanding terrestrial ecosystems important for understanding the global carbon cycle?

The global carbon cycle

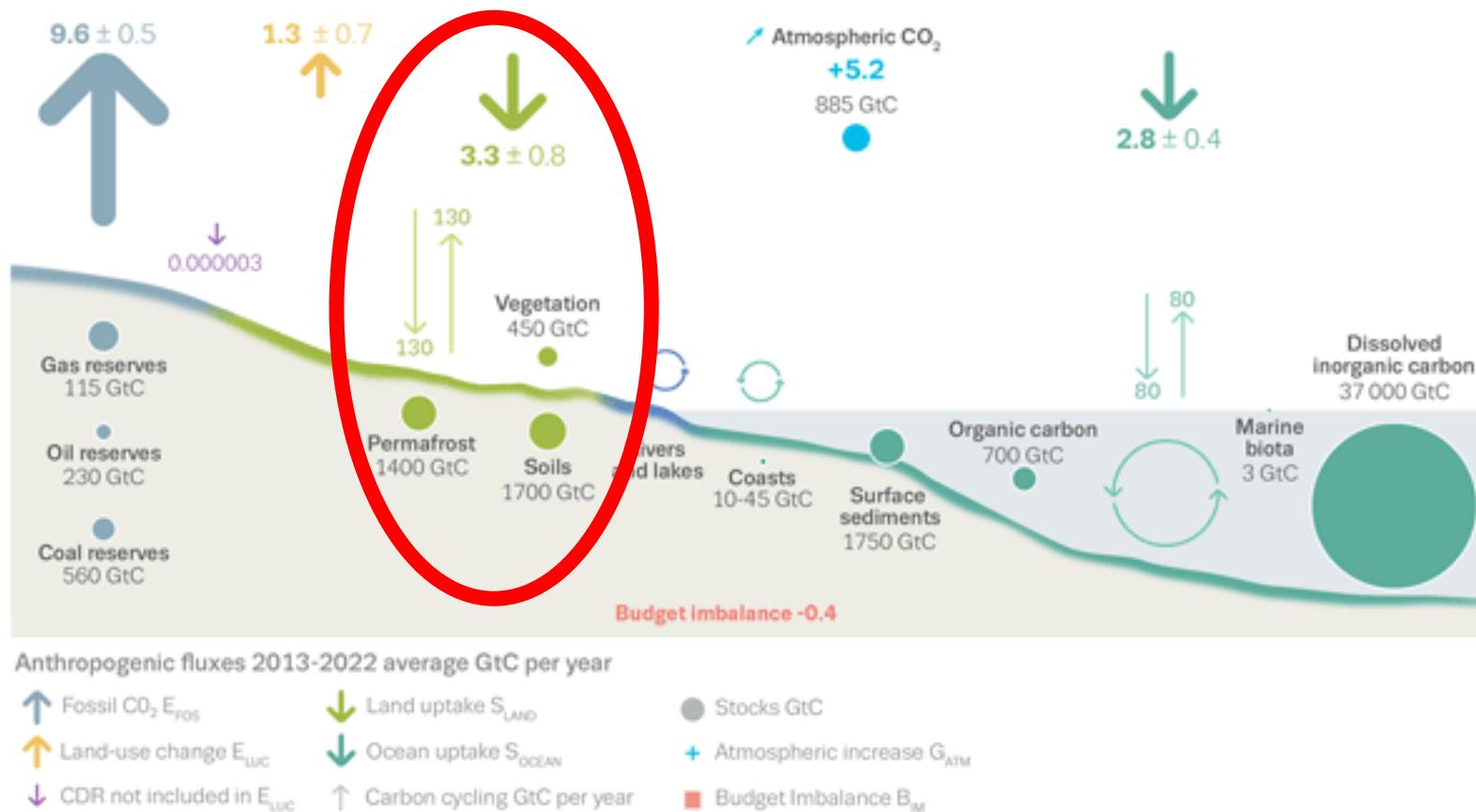


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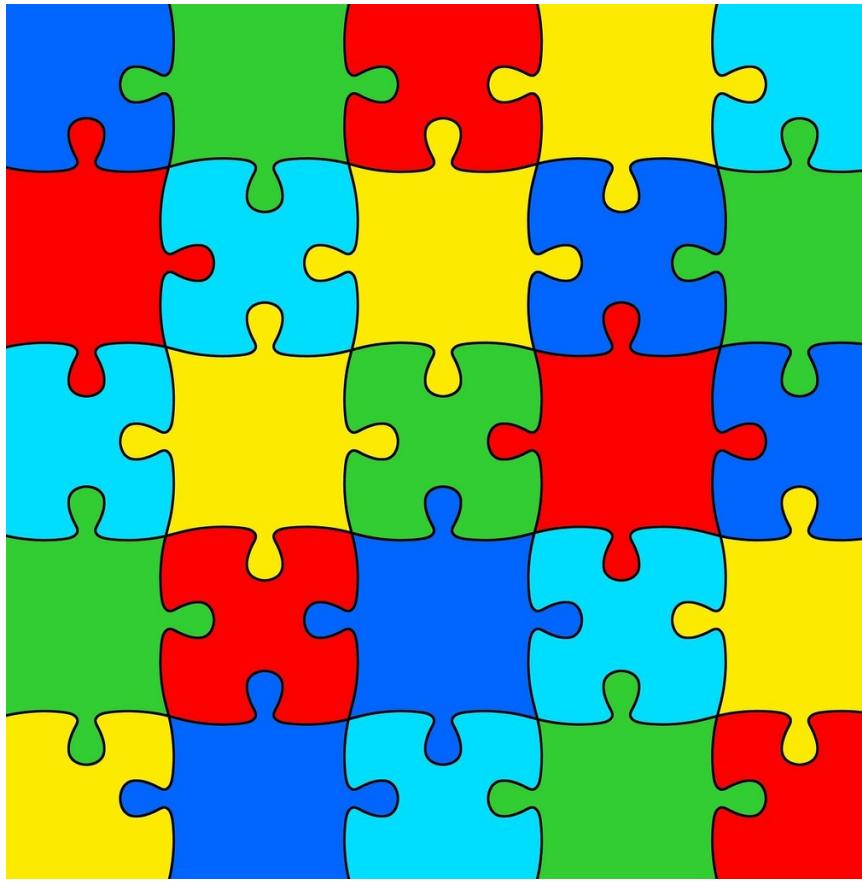
What pools and fluxes are involved?

The global carbon cycle

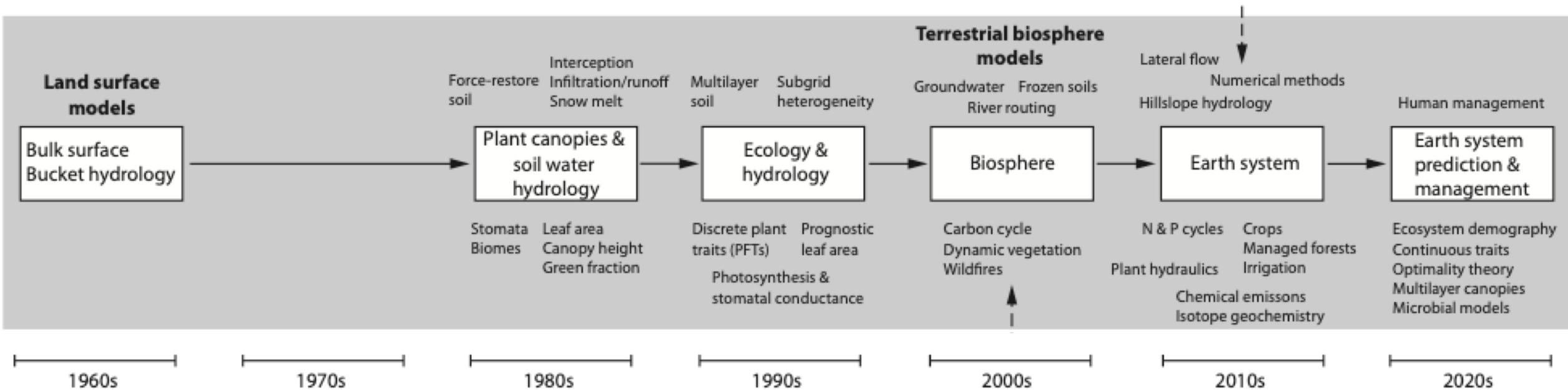


What factors may influence these pools and fluxes?

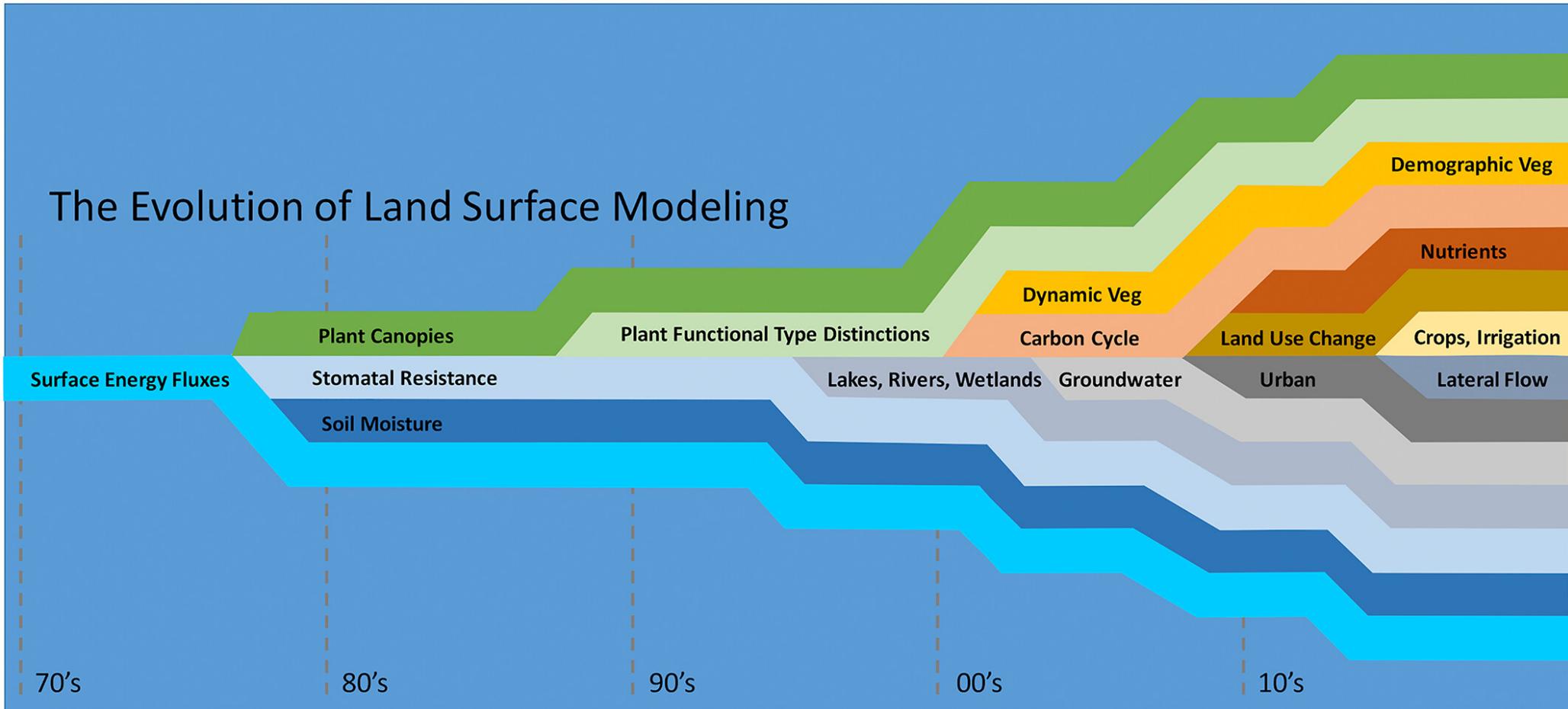
Systems thinking is a way to begin piecing each of these together (1) conceptually and (2) quantitatively

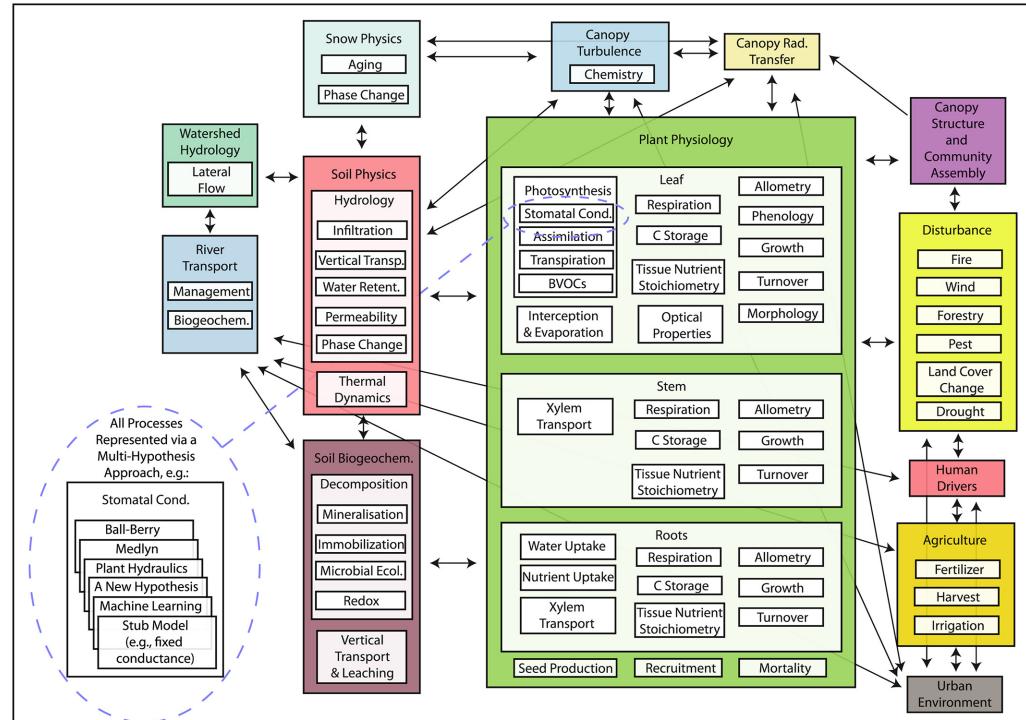


This has been done for LSMs for a long time

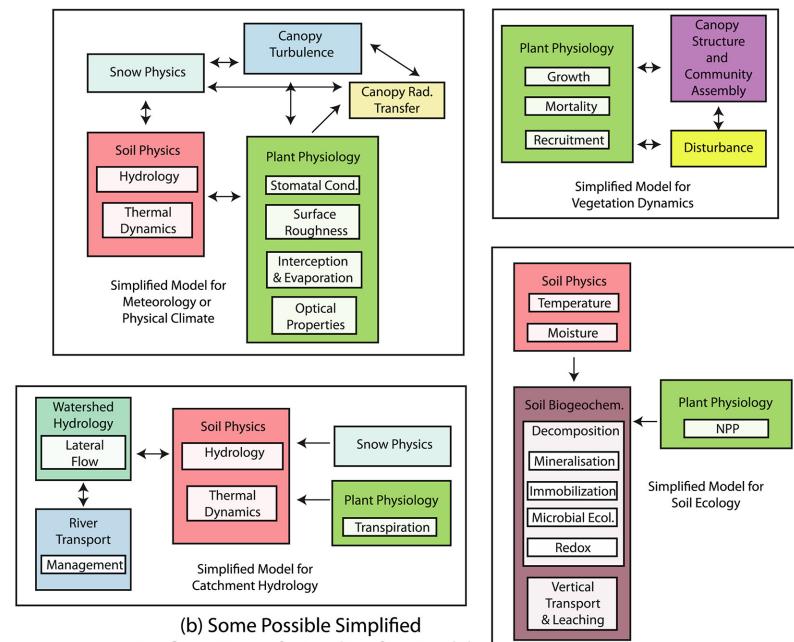


Only moving in one direction: greater complexity (**good/bad?**)





(a) Process Schematic of a Possible Full-Complexity Configuration of a Land Surface Model



(b) Some Possible Simplified Configurations of a Land Surface Model