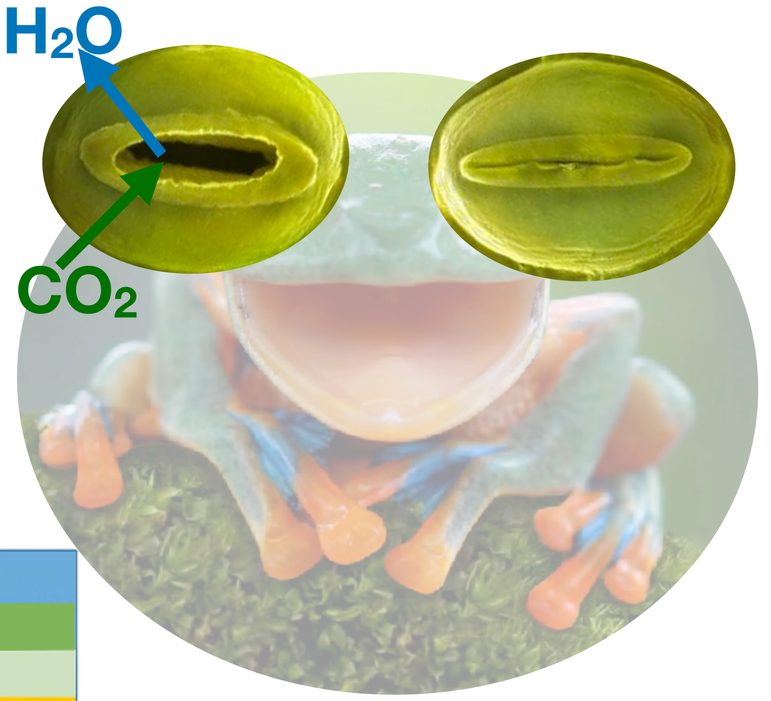
GRC 2024 Multiscale Plant Vascular Biology

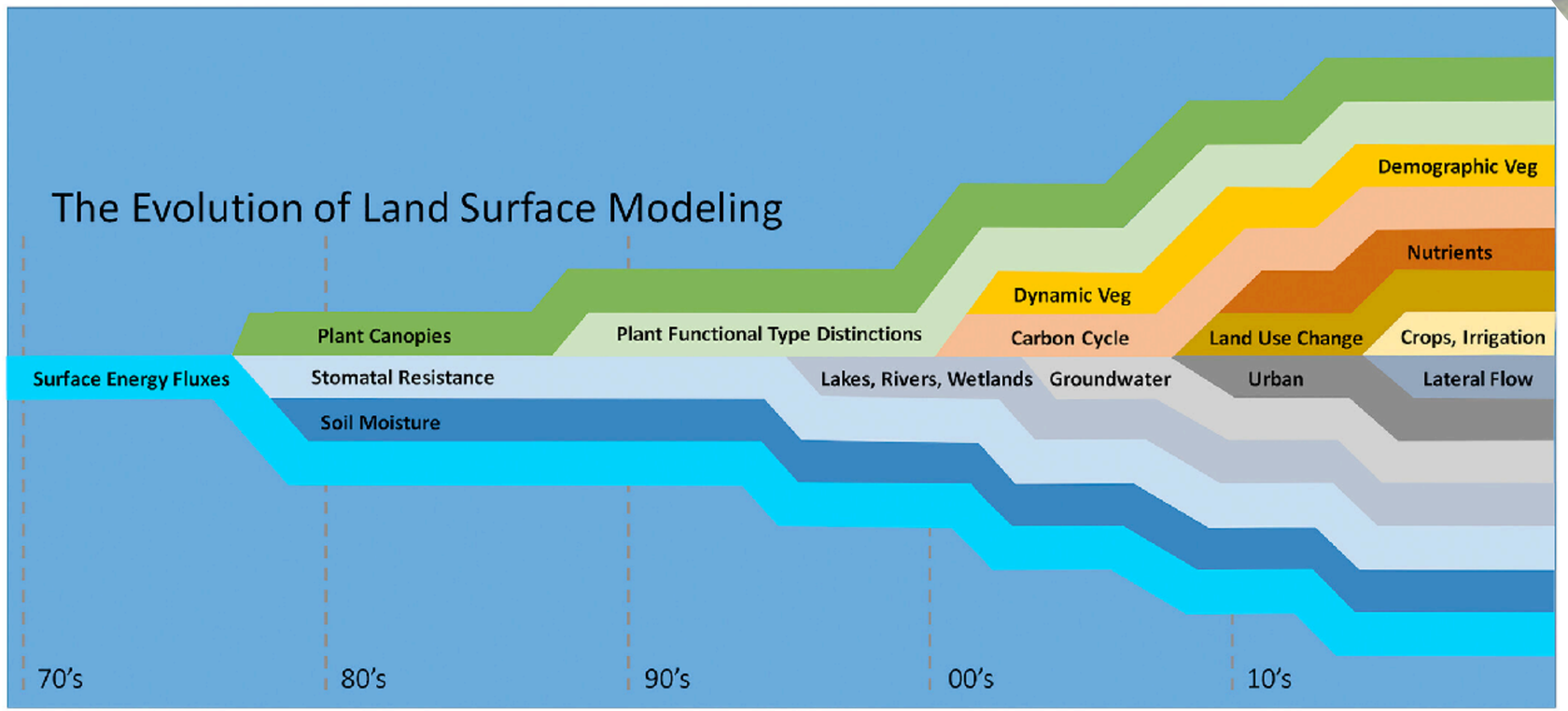
(Modeling) Hydraulics from Rhizosphere to Landscape

Jun/11/2024

Yujie WANG

Water Supply to Stomata

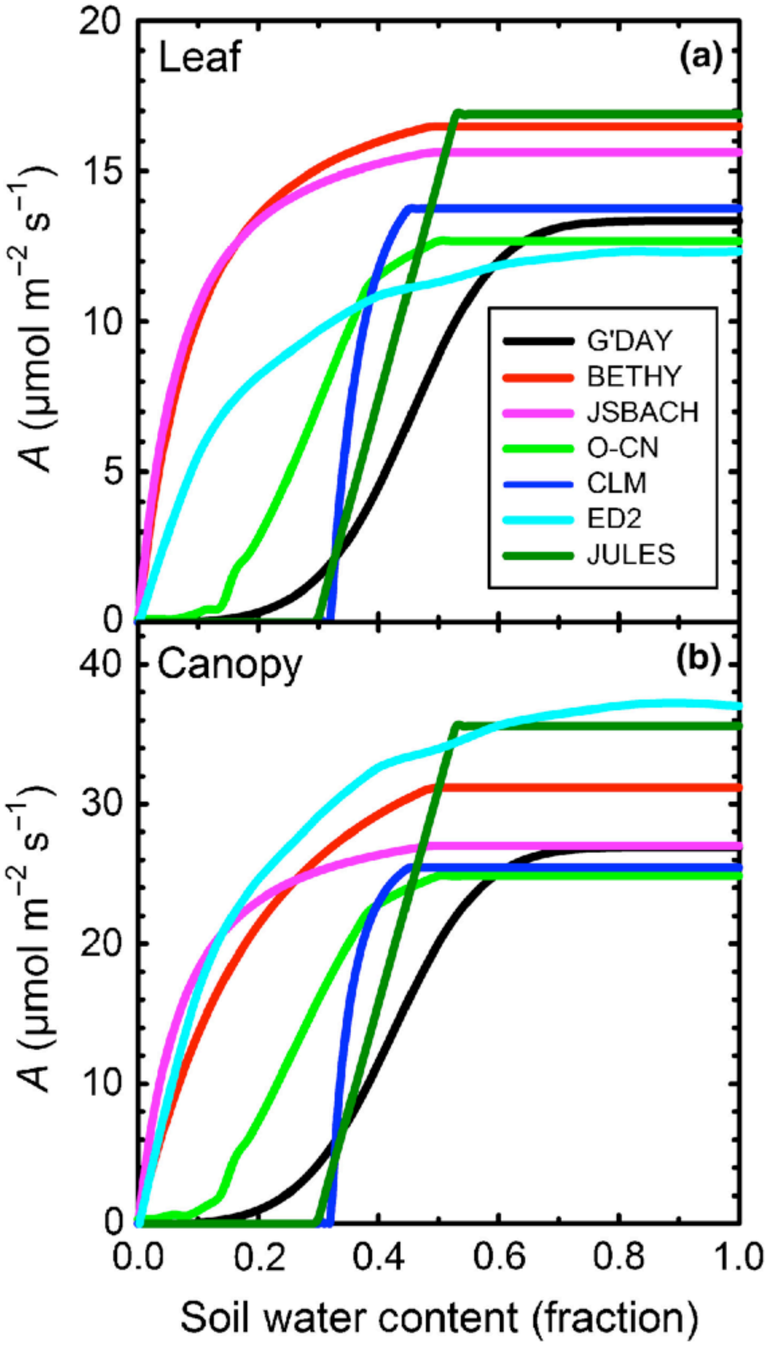




Fisher & Koven (2020) JAMES

Response to Drought

- Trait independent
- Some are soil texture independent

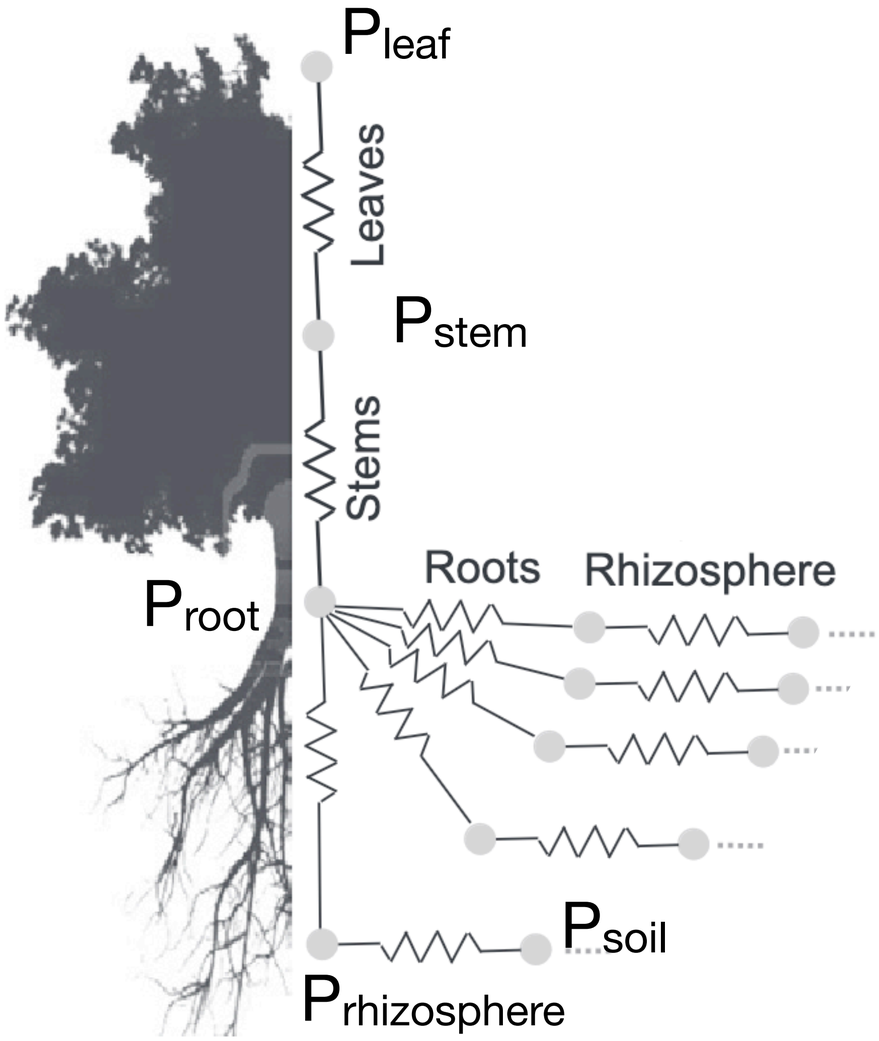


Rogers et al. (2017) NPH

A Continuous Flow Path

from Soil to Air

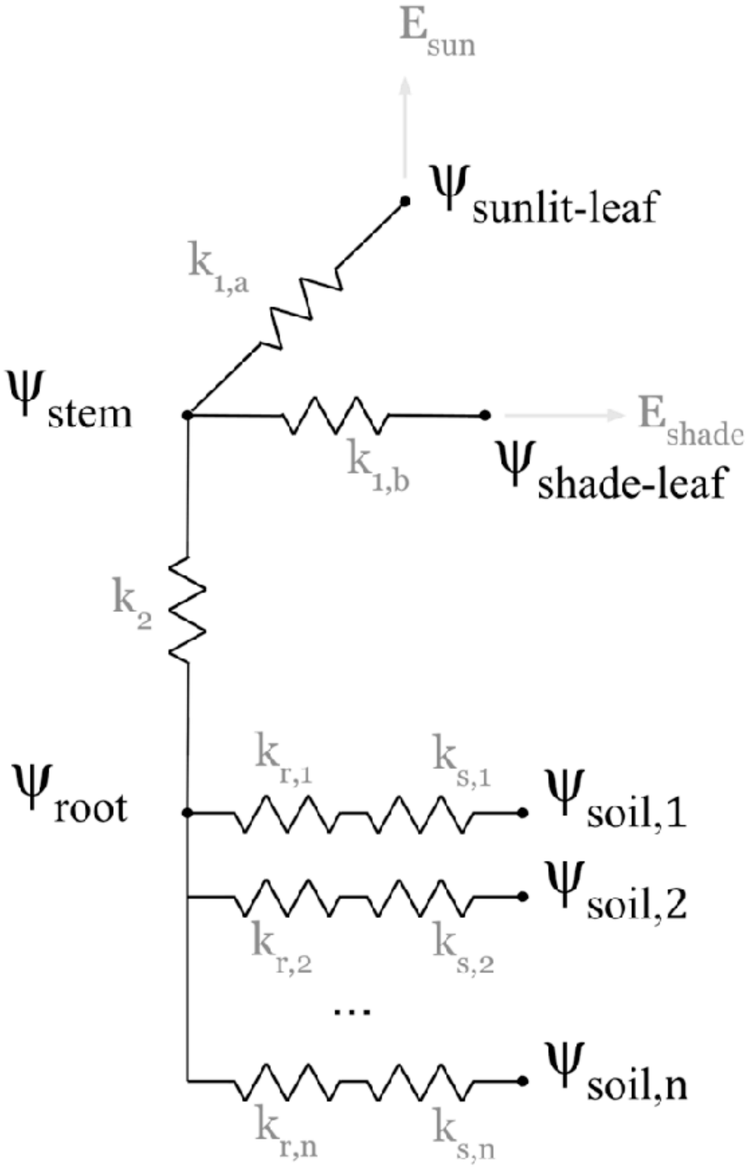
- Leaf Xylem (P_{leaf})
- Stem (P_{stem})
- Root (P_{root})
- Rhizosphere ($P_{rhizosphere}$)
- Bulk soil (P_{soil})



Sperry et al. (2016) NPH

Plant Hydraulics in CLM5

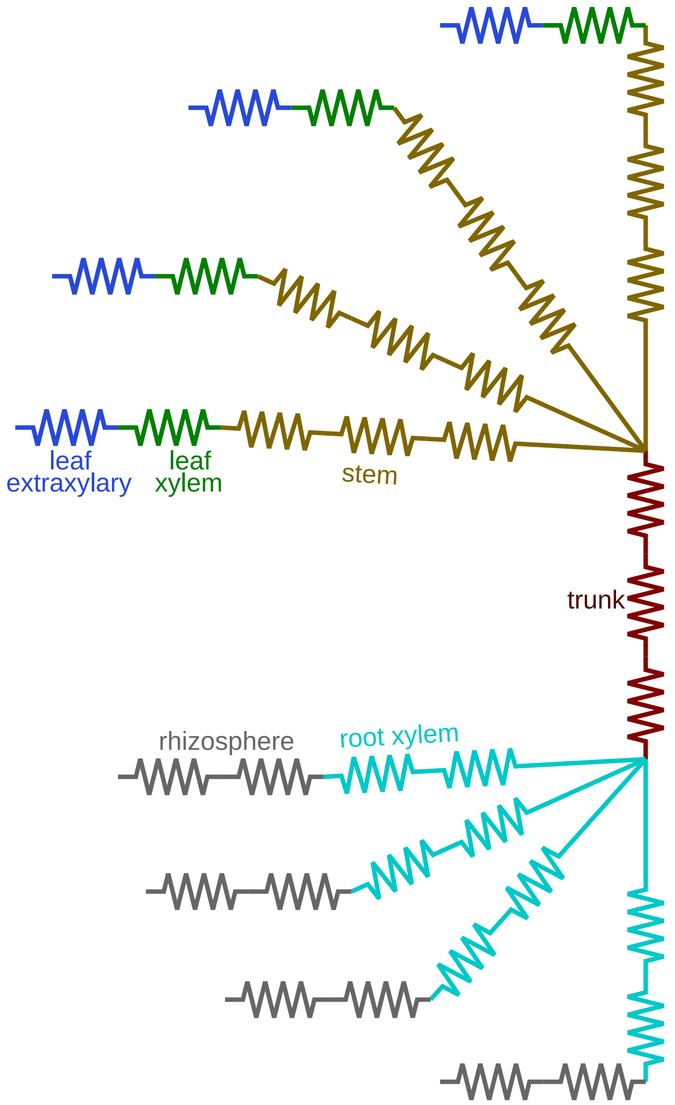
- Leaf Xylem (P_{leaf})
- Stem (P_{stem})
- Root (P_{root})
- Rhizosphere ($P_{rhizosphere}$)
- Bulk soil (P_{soil})



Kennedy et al. (2019) JAMES

PlantHydraulics.jl in CliMA Land

- Leaf Extraxylary Path (P_{ox}, storage)
- Leaf Xylem (P_{leaf})
- Stem (P_{stem}, storage, gravity)
- Root (P_{root}, storage, gravity)
- Rhizosphere ($P_{rhizosphere}$)
- Bulk soil (P_{soil})



Stomatal Optimality

New Phytologist

Review

Tansley review

A theoretical and empirical assessment of stomatal optimization modeling

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Full Paper

New Phytologist

Optimization theory explains nighttime stomatal responses

Yujie Wang[1], William R. L. Anderegg[2], Martin D. Venturas[2], Anna T. Trugman[3], Kailiang Yu[4] and Christian Frankenberg[1,5]

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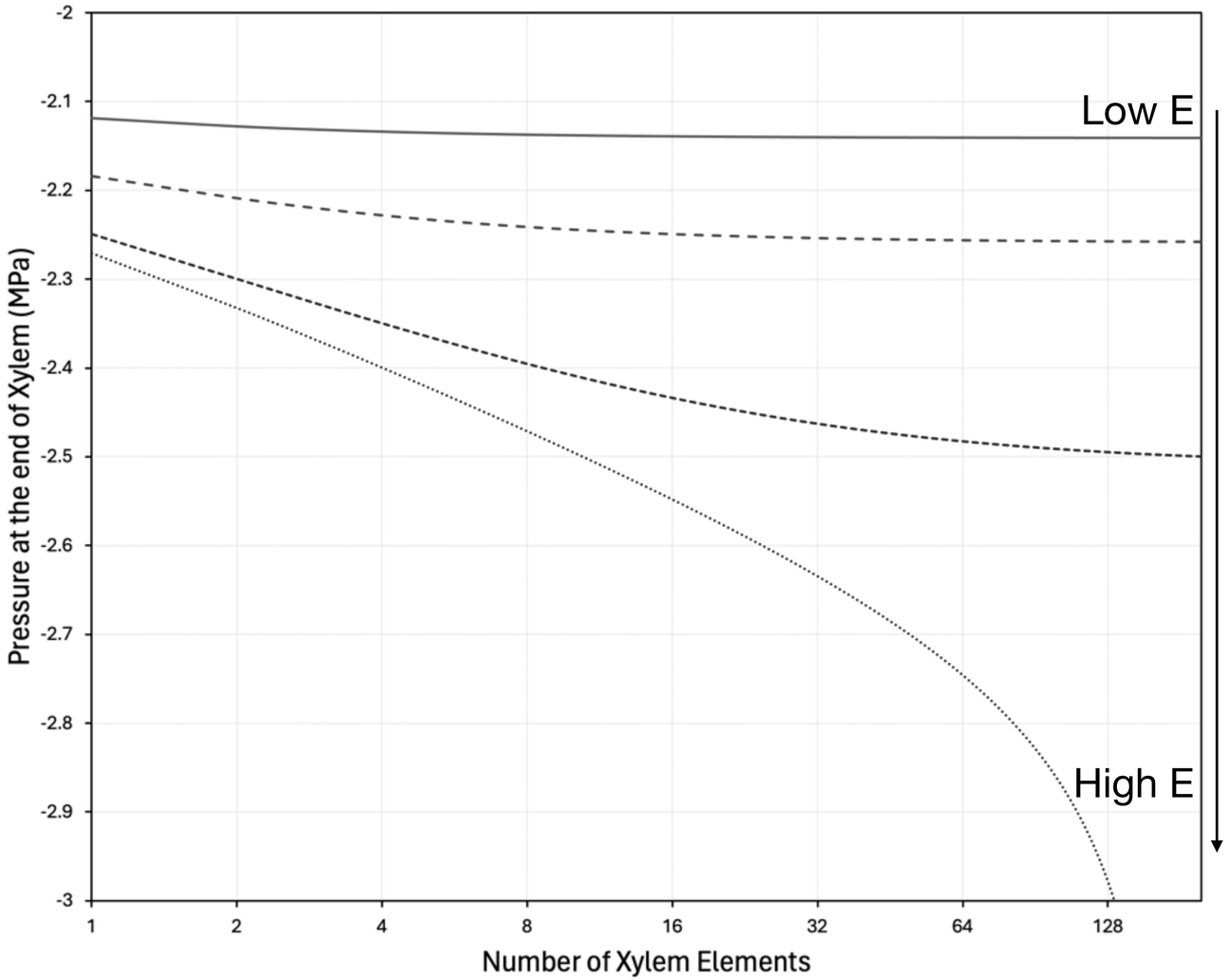
Fact

We note that due to the limited knowledge of global plant hydraulic trait maps, we were not able to run CliMA Land using plant hydraulics-based stomatal models; thus we used the stomatal model develop by Medlyn, Duursma, Eamus, et al. (2011) combined with a tuning factor based on soil water moisture in the present study.

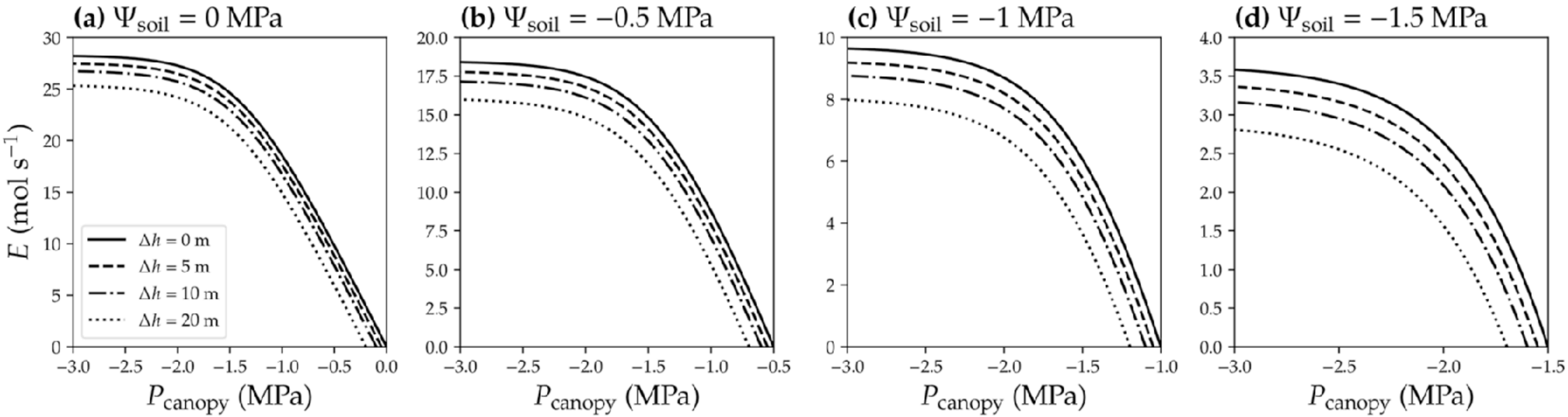
Data **Simplification**

Xylem Discretization (Numerical)



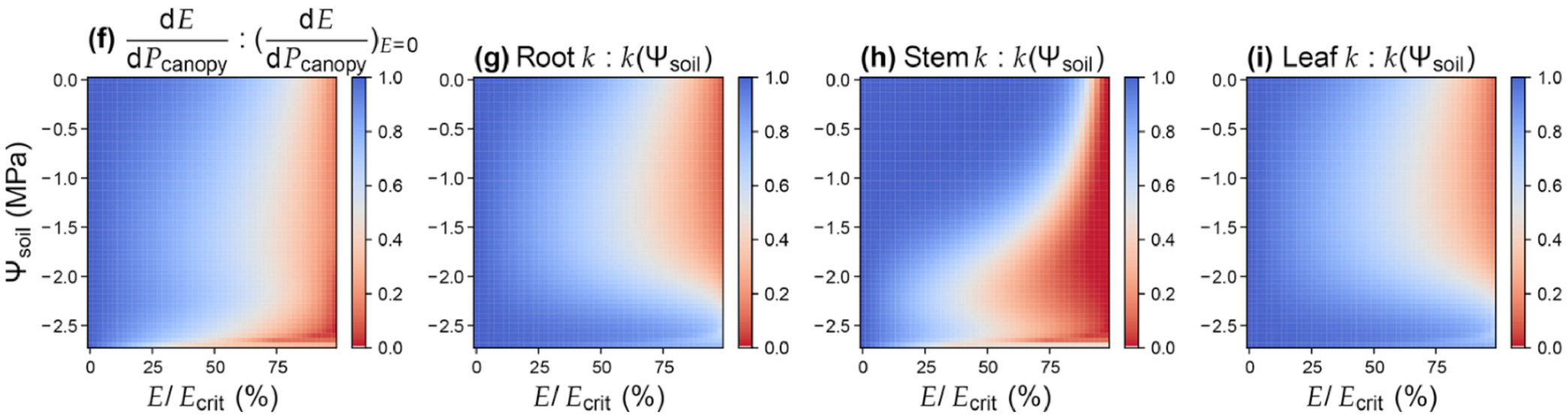
Model Results of CliMA Land

Gravity Term (Analytical)



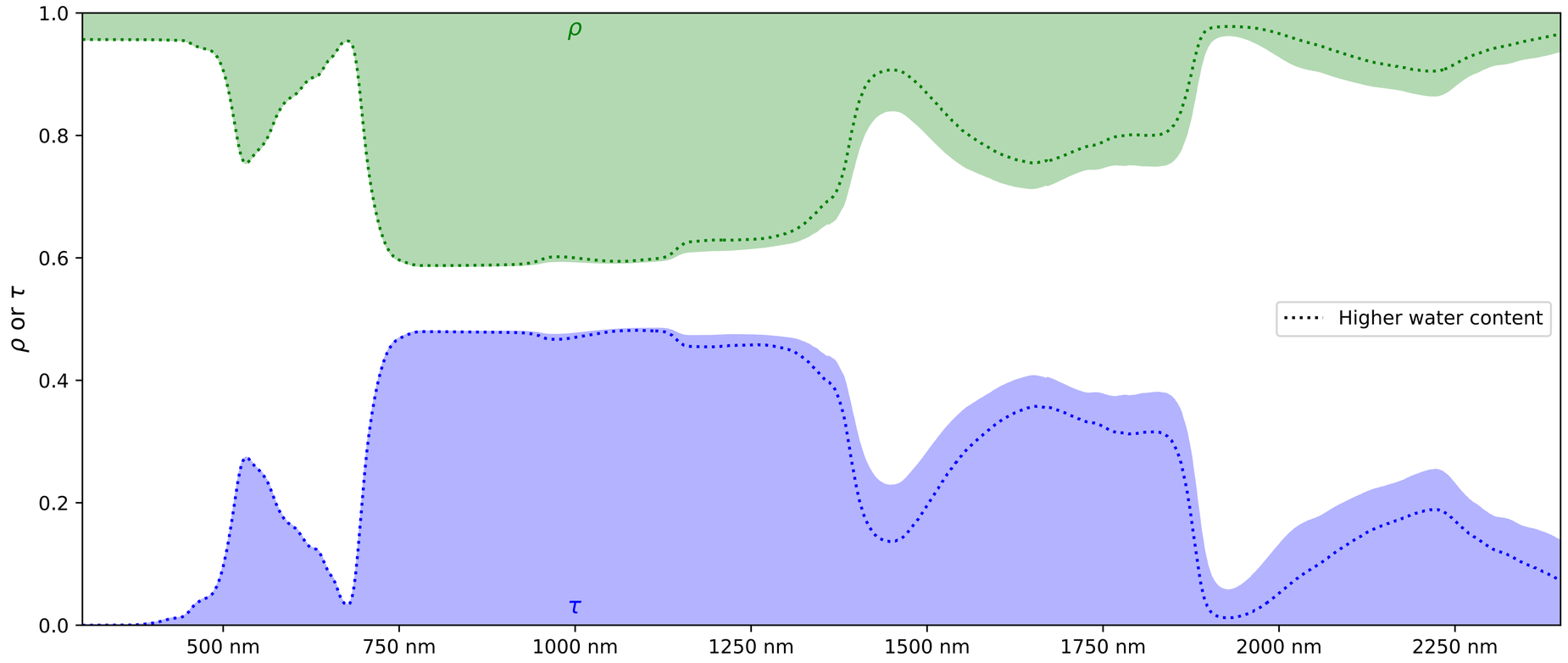
Wang & Frankenberg (2022) Biogeosciences

VC Segmentation



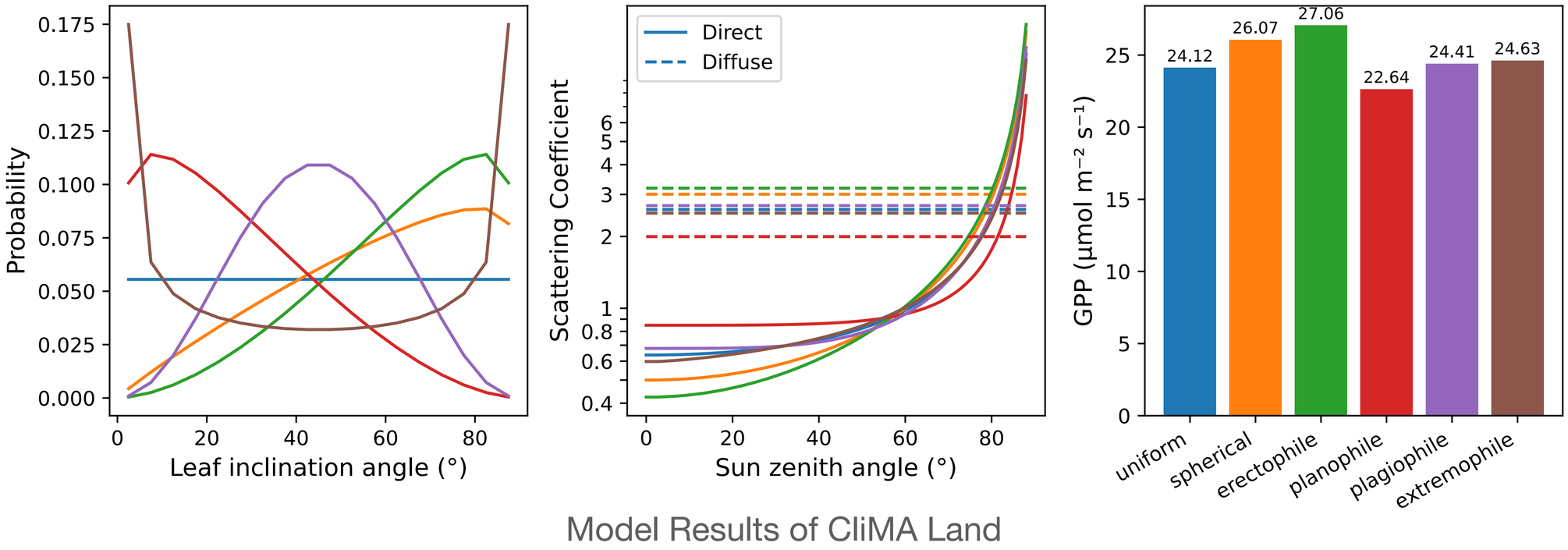
Wang & Frankenberg (2022) Biogeosciences

Coupling to NIR Transfer



Model Results of CliMA Land

Coupling to Leaf Angle

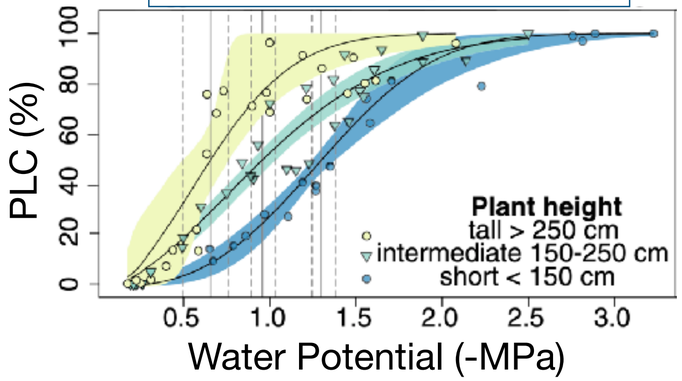


Model Results of CliMA Land

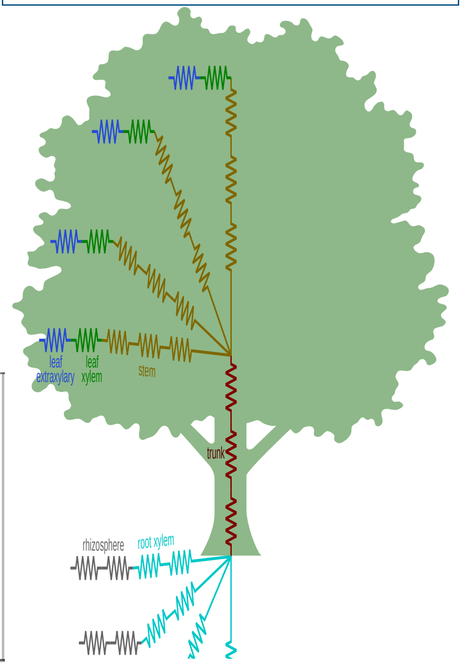
Challenges & Solutions

Caltech

Q1. Complexity

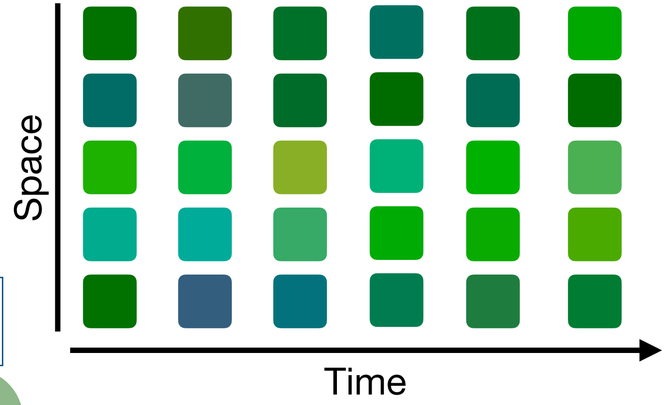


Q2. Processes



Q3. Heterogeneity

Q4. Acclimation



Q5. Data

Q6. Framework

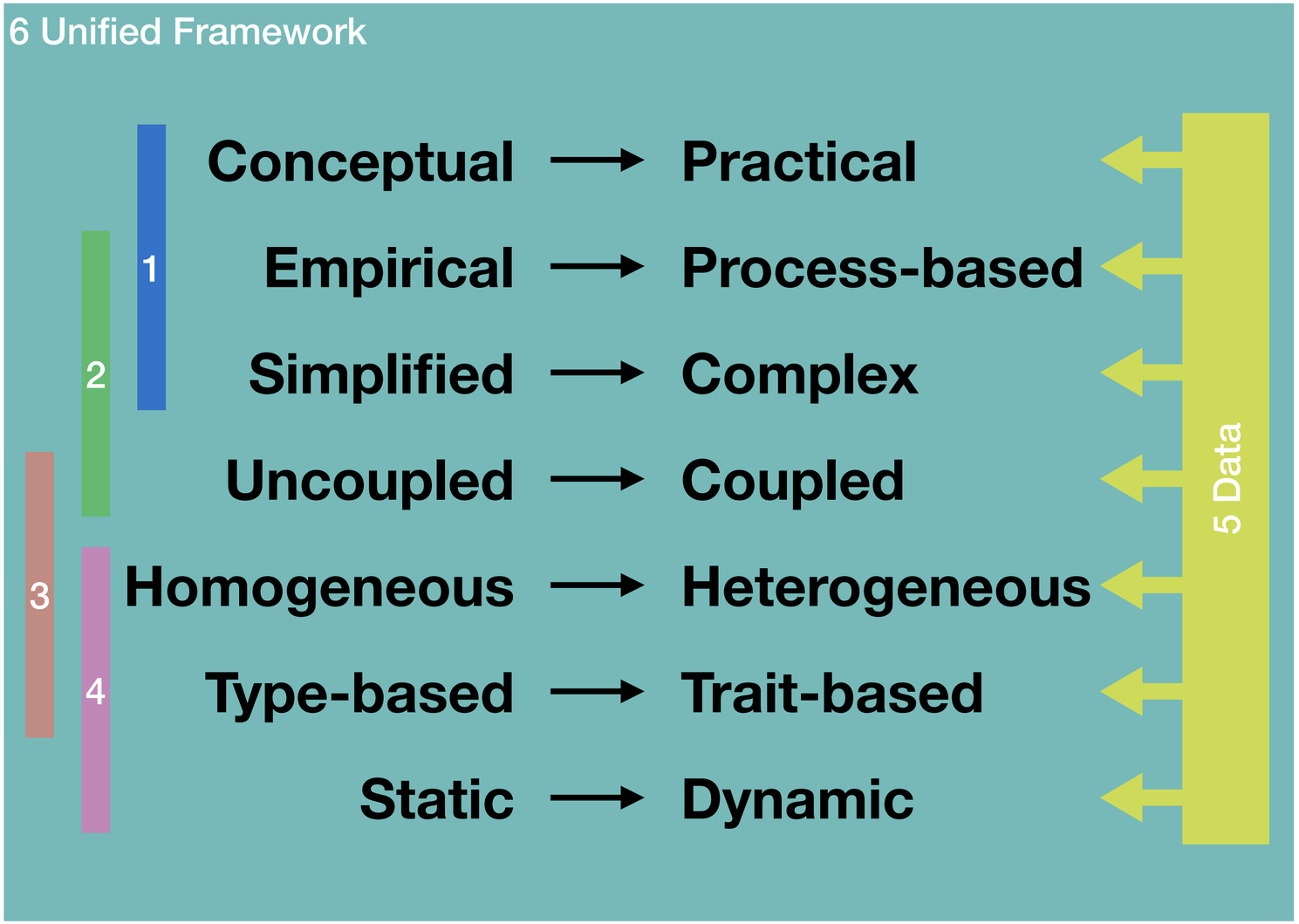
Olson et al. (2018) PNAS

PC DIY	Model Framework
CPU	Xylem
GPU	Phloem
Motherboard	Hydraulic Architecture
… …	… …
Hard Drive	Carbon Pool

SPEC Software

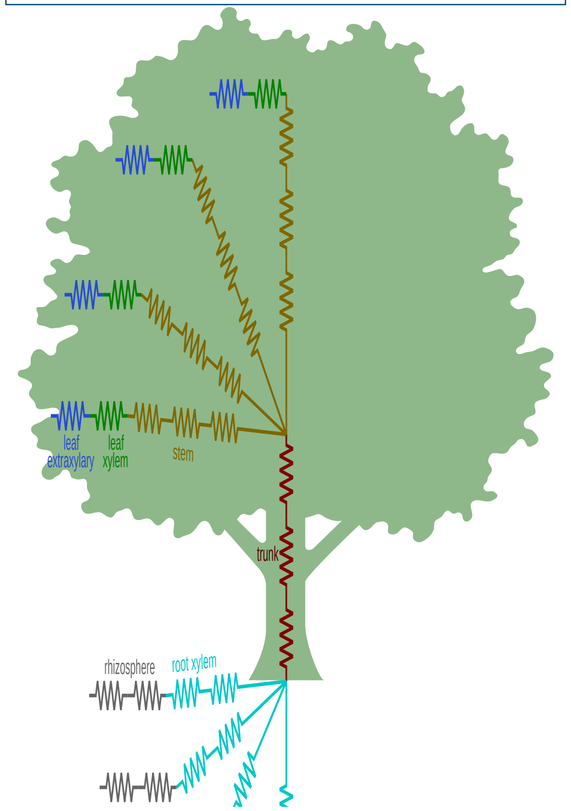
Benchmarking Datasets

Caltech


6 Unified Framework
Conceptual → Practical
Empirical → Process-based
Simplified → Complex
Uncoupled → Coupled
Homogeneous → Heterogeneous
Type-based → Trait-based
Static → Dynamic
1
2
3
4
5 Data

OUR SPEAKERS

Q2. Processes



Amanda Cardoso

Hydraulic impairments to the shoot as a result of soil waterlogging

Andrea Carminati

Soil and plant hydraulic constraints on transpiration

Xue Feng

Landscape control on urban tree hydraulics