Implementing Plant Hydraulic Stress in CLM

Daniel Kennedy, Pierre Gentine
Columbia University
Outline

- Motivation
- PHS Model in CLM
- Parameterization
- Preliminary flux tower results from the model
- Next steps
Plant Water Dynamics

- How does water move within the SPAC?
- Vegetation plays a key role
- Plants operate at the intersection of the carbon, water, and energy cycles
- Drought, VPD expected to increase
Model Drought Response

Confronting model predictions of carbon fluxes with measurements of Amazon forests subjected to experimental drought

Thomas L. Powell¹, David R. Galbraith²,³, Bradley O. Christoffersen⁴, Anna Harper⁵,⁶, Hewlley M. A. Imbuzeiro⁷, Lucy Rowland⁸, Samuel Almeida⁹, Paulo M. Brando¹⁰, Antonio Carlos Lola da Costa¹¹, Marcos Heil Costa⁷, Naomi M. Levine¹, Yadivender Malhi³, Scott R. Saleska⁴, Eleneide Sotta¹², Mathew Williams⁸, Patrick Meir⁸ and Paul R. Moorcroft¹

¹Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA; ²School of Geography and the Environment, University of Arizona, Tucson, AZ 85721, USA; ³College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, EX4 4QF, UK; ⁴School of Geosciences, University of Edinburgh, Edinburgh, EH9 3JU, UK; ⁵Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil; ⁶School of Science and Technology, University of Trangos, Rio Grande do Sul, Brazil; ⁷Centro de Geociências, Universidade Federal de Santa Catarina, Florianopolis, SC, Brazil; ⁸School of Geosciences, University of Edinburgh, Edinburgh, EH9 3JU, UK; ⁹Grupo de Pesquisas em Ciências da Terra, UNESP, Ribeirão Preto, SP, Brazil; ¹⁰Laboratoire de Physiologie des Plantes, UMR CNRS 5557, Montpellier 3, FR; ¹¹Biogeochemistry Group, Climate Change Institute, School of Geography and the Environment, University of Arizona, Tucson, AZ 85721, USA; ¹²Centro de Geociências, Universidade Federal de Santa Catarina, Florianopolis, SC, Brazil

Author for correspondence:
Paul R. Moorcroft
Tel: +1 617 496 6744
Email: paul_moorcroft@harvard.edu
Received: 12 February 2013
Accepted: 20 May 2013

"Model predictions ... poorly replicated the response to drought treatment"
Plant Water Stress - Btran

- Applied as attenuating factor for stomatal conductance, photosynthesis, and respiration calculations
- Not in line with typical field measurements
- Lacks flexibility to reproduce observed plant water use strategies

\[ \beta = f(\Psi_{soil}) \]
Isohydric vs. Anisohydric species

Isohydric

Ambient Pinion

Anisohydric

Juniper (anisohydric)

Piñon (isohydric)

NCAR - Joint WG Presentation – Daniel Kennedy  Feb 9, 2016
Model Development

- Simple model to resolve water transport through the SPAC
- Water supply modeled via simple hydraulic framework
- Loss relative to unstressed transpiration modeled based on leaf-level water potential
- Water stress function used to calculate conductance, photosynthesis, and respiration
Parameterization

- Are PFTs right for plant hydraulics?
- Below, ecosystem-scale isohydricity by PFT derived from VOD dynamics
- Lower values are more isohydric

Konings and Gentine, submitted
Vegetation Optical Depth

- PHS models vegetation water status
- Allows interface with new stream of observations for model evaluation and parameterization

Global Variations in isohydricity slope. Lower values are more isohydric.

Konings and Gentine, submitted
Flux tower results: well-watered

University of Michigan Biological Station

NCAR - Joint WG Presentation – Daniel Kennedy   Feb 9, 2016
Flux tower results: Semi-arid

Metolius Intermediate Pine: Central Oregon
Next steps

- Global parameterization
- Model evaluation relative to Btran and available obs
- Drought response case studies
- Future simulations
Questions?

Thank You!