BioEarth: A Regional-Scale Earth System Model to Inform Agricultural and Natural Resource Management Decisions

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ABSTRACT

As managers of agricultural and natural resources are confronted with uncertainties in global change impacts, the complexities associated with the interconnected cycling of nitrogen, carbon, and water present daunting management challenges. Existing models provide detailed information on specific sub-systems (e.g., land, air, water, and economics). An increasing awareness of the unintended consequences of management decisions resulting from interconnectedness of these sub-systems, however, necessitates coupled regional earth system models (EaSMs). Decision makers' needs and priorities can be integrated into the model design and development processes to enhance decision-making relevance and "usability" of EaSMs.

The Biosphere-relevant Earth System Model (BioEarth)

http://www.cereo.wsu.edu/bioearth/

BioEarth is a current research initiative with a focus on the U.S. Pacific Northwest region that explores the coupling of multiple stand-alone EaSMs to generate usable information for resource decision making. Direct engagement between model developers and non-academic stakeholders involved in resource and environmental management decisions throughout the model development process is a critical component of this effort.

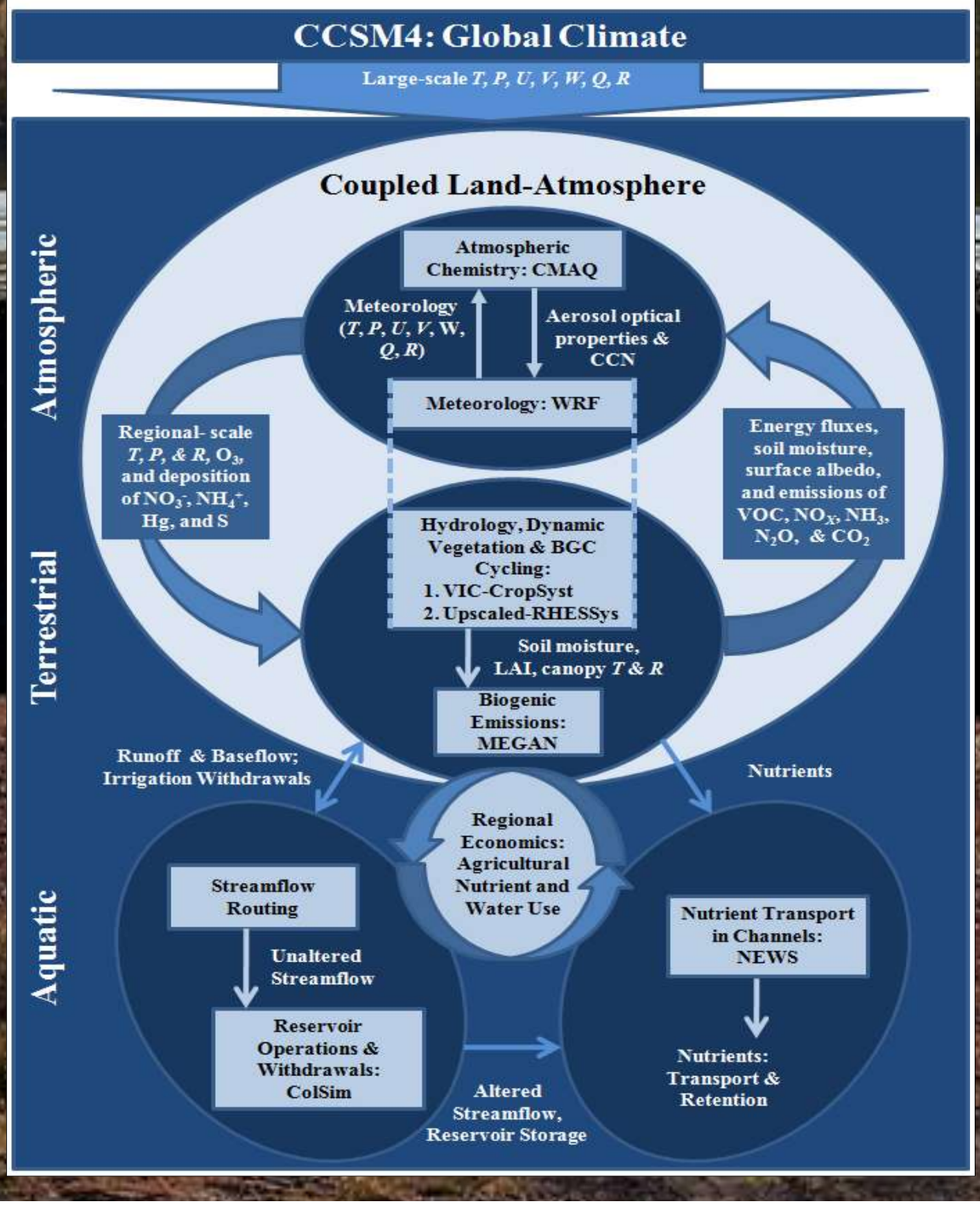
Goal: To improve understanding of the interactions between coupled C:N:H_2O dynamics and human actions at regional and decadal scales under global change to

1) better understand the role that resource management actions have in impacting earth system dynamics, and

2) inform resource managers about the consequences of their decisions on the earth system, with a particular focus on quantifying environmental feedbacks and ecological and environmental tradeoffs.

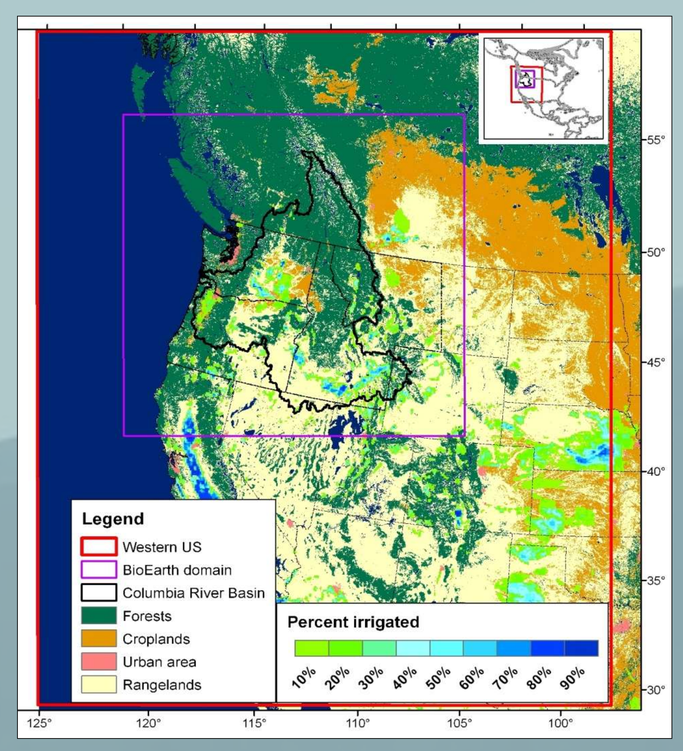
BioEarth

Biosphere-relevant earth system model



The BioEarth Domain: An Ideal Test-Bed

The BioEarth project focuses on the PNW region of the U.S. The region has extensive and diverse agricultural lands interspersed with heavily populated urban areas and surrounded by largely untransformed ecosystems; these lands provide a vast array of agricultural and natural resources. Global change is expected to impact ecosystems through warming, perturbations to precipitation patterns, changes in extreme meteorological events, and increased transport from Asian sources. Concurrent steady increases in human population are applying pressures on environmental quality with continued demand for environmental services. The sum of these effects presents a complex array of uncertainties to public decision-makers struggling to address all of these issues. The diversity of resources and complexity of issues in this region make it an ideal test-bed for the BioEarth framework for eventual application over other regions of the world.

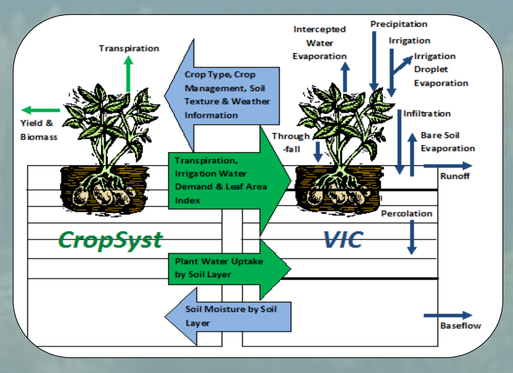


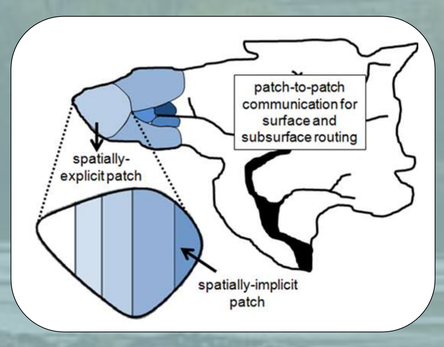
Model Development to Incorporate Agricultural Processes

1. VIC-CropSyst

Integration of a dynamic multi-crop growth/phenology model with a large-scale land surface hydrologic model enables

- spatially-explicit crop response to climate and management
- integration with economic models via crop response curves
- linking to atmospheric/aquatic models to investigate environmental/economic trade-offs





2. Upscaled-RHESSys

Refinement of this catchment-scale ecohydrologic model for forest, range, and crop processes and management allows for a bottom-up approach to regional-scale modeling. While model resolution can be increased in areas/biomes that exhibit linear responses to changes in climate/management, more complex biomes and regions are selected to run at finer scales, thus providing more realistic responses to climate/management.

A Framework *Designed* for Informing Management Decisions

Developing knowledge and tools solely for a scientific audience → ***Stakeholder Engagement*** → *Also* producing model outputs that are relevant to the needs and interests of resource managers and policy decision makers

Example Management Scenarios

1. *Cultivated agriculture:* crop selection and rotations, irrigation, fertilization, tillage
2. *Rangeland:* grazing, restoration
3. *Forests:* fuel and carbon management, restoration
4. *Water Supply:* reservoirs, water rights curtailment, water transfers
5. *Air quality:* regulations for emission of pollutants & their precursors
6. *Exogenous agents:* policy, international trade, domestic demand

Example Model Outputs

1. *Air quality:* greenhouse gas emissions and other atmospheric pollutants
2. *Water quantity and deficit:* soil moisture, rivers, reservoirs, unmet demand
3. *Water quality:* dissolved inorganic/organic nitrogen and carbon
4. *Terrestrial ecosystem health:* species composition, net primary productivity, water stress, nutrient limitations
5. *Economic:* crop-specific yield, forest and range productivity, hydropower generation, carbon mitigation

BioEarth Collaborators

Washington State University; Donald Bren School of Environmental Science & Management, University of California, Santa Barbara; NCAR National Center for Atmospheric Research; Pacific Northwest National Laboratory; Oregon State University; Clark University; University of Notre Dame; University of Washington

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