BioEarth: A Regional-Scale Earth System Model to Inform Land and Water Management Decisions

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ABSTRACT

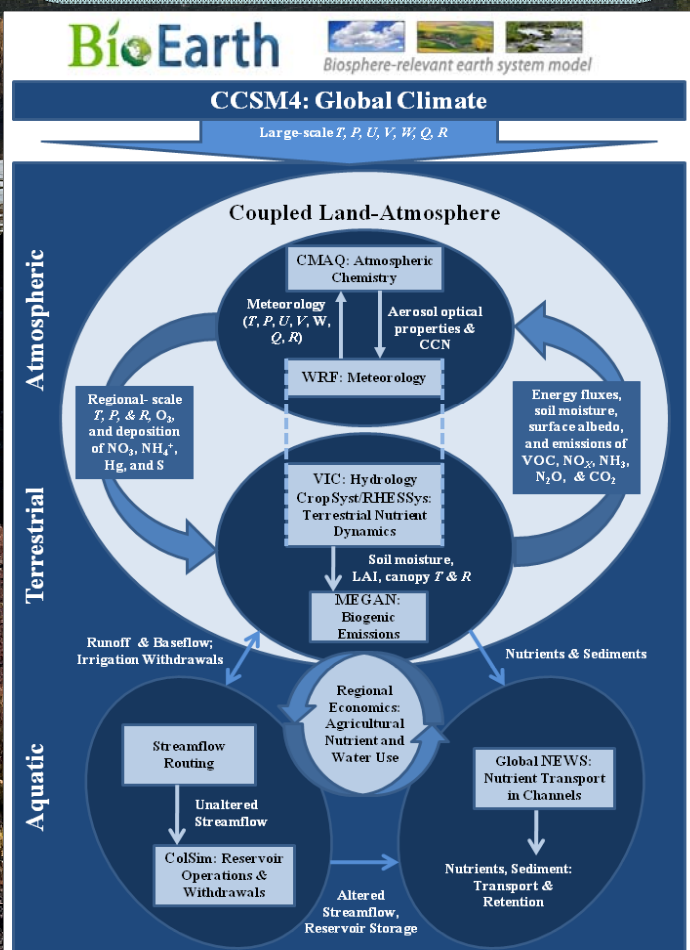
For better management in the face of climate change, Earth system models must explicitly account for natural resource and agricultural management activities. Including cropping systems, water management, and economic models into an Earth system modeling framework can help in answering questions related to the impacts of climate change on water resource availability, water demand, crop productivity, and environmental impacts. Herein we describe example results from integrated modeling efforts over the Pacific Northwest (PNW) region. Results were designed with the intent to inform decision making by water managers and agricultural producers, the utility for whom is enhanced through stakeholder input throughout model development.

The Biosphere-relevant Earth System Model (BioEarth)

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

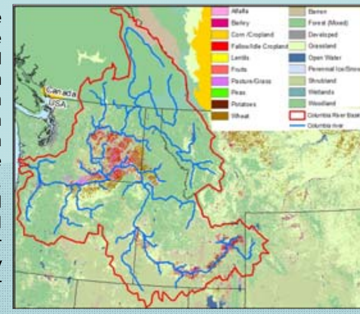
Motivation: The 21st Century's Grand Challenges include understanding how changes in the balance of nutrients -- carbon, oxygen, hydrogen, nitrogen, sulfur, and phosphorus -- in soil, water, and air affect the functioning of ecosystems, atmospheric chemistry, and human health.

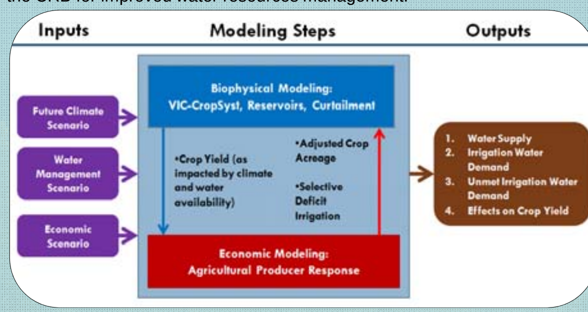
Objective: To improve the understanding of regional and decadal-scale C:N:H_2O interactions in context of global change to better inform decision makers involved in natural and agricultural resource management, we are developing a new earth system modeling framework that will explicitly address N and C flows in the context of decadal climate variability. The framework includes atmospheric models (for meteorology and atmospheric chemistry), land surface models (for hydrology, cropping systems, and biogeochemical cycling), aquatic models (for reservoir operations and nutrient export in rivers), and economic models.



Example Results: The Columbia River Basin (CRB) Water Supply and Demand Forecast for Year 2030

Over the PNW region, temperature is projected to rise between 1-5ºC with the greatest warming in the summer; while precipitation seasonality changes will result in even wetter winters and drier summers, with little certainty as to changes in annual precipitation (Mote and Salathe 2010). These changes will diminish surface water availability during the growing season and increase irrigation water demand, with negative consequences for irrigated agriculture (Elsner et al. 2010; Vano et al. 2010). We applied an integrated modeling framework (1. coupled hydrology and cropping systems model, 2. reservoir and water curtailment model, and 3. economics model) to study future water supply and irrigation water demand over the CRB for improved water resources management.



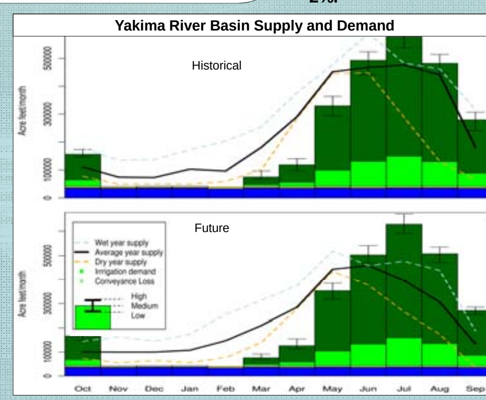


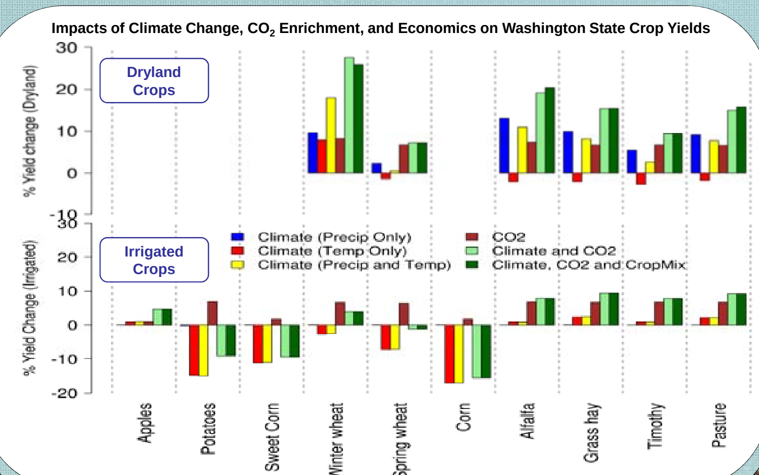
- ❑Annual supply **increased by ~3% in annual surface water supply.** However, supply seasonality shifted (**-14% during the irrigation season** and +18 in winter).
- ❑Irrigation water demand **increased by ~4%**. With the change in crop mix due to economics, this **increase is reduced to ~2%.**

Application over the area's most water-stressed system (the Yakima River basin in central Washington State) shows an increase in unmet irrigation demand by an average of 50% by 2030 (see figure at right), causing increased water stress in an already stressed system. The frequency of water rights curtailment also increases by 50%.

Climate change also impacts crop yields (Stockle et al. 2010), as follows:

- ❑Precipitation – mostly positive for non-irrigated crops
- ❑Warming – mostly negative
- ❑CO2 Enrichment – positive effect on C3 crops





Link to report: http://www.ecy.wa.gov/programs/wr/cwp/crwmp.html

BioEarth Collaborators

Washington State University; Pacific Northwest National Laboratory; Donald Bren School of Environmental Science & Management, University of California, Santa Barbara; Oregon State University; NCAR; Clark University

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