BioEarth

Biosphere-relevant earth system model

PDs: J.C. Adam[1], S.H. Chung[1], M.P. Brady[1], R.D. Evans[1], C.E. Kruger[1], B.K. Lamb[1], C.O. Stöckle[1], J.K. Vaughan[1], J.A. Harrison[1], C.L. Tague[2], A. Kalyanaraman[1], Y. Chen[3], A. Guenther[4], F.Y. Leung[1], L.R. Leung[4], A.B. Perleberg[1], J.C. Stephens[5], J. Yoder[1]
(1) WSU, (2) UCSB, (3) OSU, (4) PNNL, (5) Clark U.

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

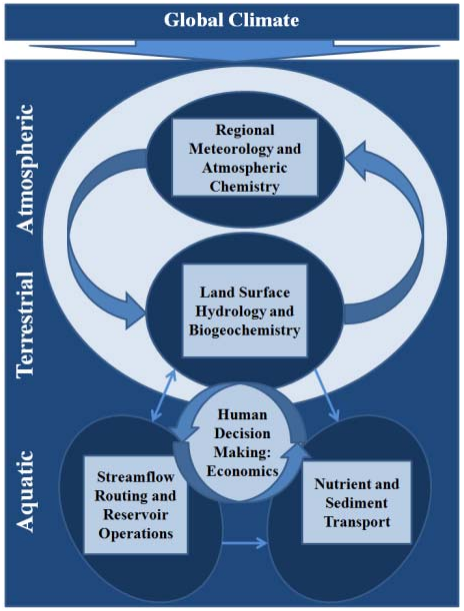
Goal

BioEarth is an integrated modeling initiative with a focus on the U.S. Pacific Northwest region that explores the coupling of multiple stand-alone models to generate usable information for resource decision making.

Our ***overarching goal*** is 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.

Approach



BioEarth is a modular Earth system Modeling (EaSM) framework that integrates atmospheric, terrestrial, aquatic, and economic models. Our land surface models utilize a bottom-up approach that preserves fine spatial-scale sensitivities. Our economics approach is two-pronged; allowing for both rich economic analysis and spatially-explicit biophysical-socioeconomic integration. Direct engagement with non-academic stakeholders throughout model development informs priorities for model development and scenarios.

Each application is designed to match the level of model integration to the interconnectivity of the decision process under investigation.

Example Management Scenarios

Cropland: crop selection/rotations, irrigation, fertilization, tillage
Rangeland: grazing, restoration
Forests: fuel and carbon management, restoration
Water supply: reservoirs, water rights curtailment, water transfers
Air quality: regulations for emission of pollutants
Exogenous agents: policy, international trade, domestic demand

Impacts

As managers of agricultural and natural resources are confronted with uncertainties related to global change, the complexities associated with the interconnected cycling of nitrogen, carbon, and water present daunting management challenges. BioEarth can provide regionally-consistent information as to the impacts of changes in climate, management, and policy on cropping, rangeland, and forested agroecosystems; while explicitly considering environmental impacts, water resource sustainability, and energy production.

Example Model Outputs

Air quality: GHG emissions and other pollutants
Water quantity and deficit: soil moisture, rivers, reservoirs, unmet demand
Water quality: dissolved inorganic/organic nitrogen and carbon
Terrestrial ecosystem health: species composition, net primary productivity, water stress, nutrient limitations
Economic: crop yield, forest/range productivity, hydropower generation, carbon mitigation

For more information, contact: Jennifer Adam, Washington State University, 509-335-7751
Email: jcadam@wsu.edu and visit http://www.cereo.wsu.edu/bioearth/

Funding Acknowledgement
United States Department of Agriculture
National Institute of Food and Agriculture

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

BioEarth

Biosphere-relevant earth system model

PDs: J.C. Adam[1], S.H. Chung[1], M.P. Brady[1], R.D. Evans[1], C.E. Kruger[1], B.K. Lamb[1], C.O. Stöckle[1], J.K. Vaughan[1], J.A. Harrison[1], C.L. Tague[2], A. Kalyanaraman[1], Y. Chen[3], A. Guenther[4], F.Y. Leung[1], L.R. Leung[4], A.B. Perleberg[1], J.C. Stephens[5], J. Yoder[1]
(1) WSU, (2) UCSB, (3) OSU, (4) PNNL, (5) Clark U.

Example Specific Research Questions: Sustainable Adaptation to Drought

Cropping Systems	Rangelands	Forests
Q1. How can agriculture in the western U.S. adapt to increasing frequency and severity of droughts, while minimizing environmental impacts?	**Q2.** How can rangelands be managed to reduce competition by invasive species and sensitivity to drought in the context of climate change?	**Q3.** How can forests be managed to adapt to increasing frequency and severity of extreme events, drought mortality and wildfire?
Atmospheric Interactions: Q4. How do proposed changes in resource management practices affect atmospheric dynamics/chemistry? How do these feed back to the land surface?		
Water Resource Interactions: Q5. What are the consequences of changes in land management practices and climate on water quality; instream flows for habitat and hydropower; and flood risk?		

For more information, contact: Jennifer Adam, Washington State University, 509-335-7751
Email: jcadam@wsu.edu and visit http://www.cereo.wsu.edu/bioearth/

Funding Acknowledgement
United States Department of Agriculture
National Institute of Food and Agriculture

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

BioEarth

Biosphere-relevant earth system model

Communication Research and Stakeholder Engagement

Working Group Members: Elizabeth Allen[a], Chad Kruger[b], Jennie C. Stephens[c], Fok-Yan Leung[d], Georgine Yorgey[b]
a School of the Environment, WSU
b Center for Sustaining Agriculture and Natural Resources, WSU
c International Development, Community and Environment, Clark U.
d Department of Civil and Environmental Engineering, WSU

Objective: To develop model outputs that natural and agricultural resource managers can use to explore potential consequences of their decisions, with a focus on quantifying environmental feedbacks and tradeoffs.

Approach: Promoting bi-directional communication among researchers and stakeholders

Design

Stakeholders engaged include representatives from industry, government agencies (federal, state, local and tribal), and conservation and policy advocacy organizations. The workshop format involves round table and digital-response based conversations.

Timeline

2013: N and C management, water availability
2014: Rangeland and forest management, air quality
2015: Water quality, larger meetings to promote understanding of the potential utility of the model to a wider audience

Communication Research

Via surveys and interviews we are studying communication among stakeholders and scientists. Among scientists there are a range of attitudes about the value of the stakeholder engagement and varying expectations for the production of decision-relevant information. We are comparing the stakeholder engagement process within BioEarth and other environmental modeling efforts in the Pacific Northwest.

Impacts:

1. Soliciting stakeholders' insights about scenarios to be explored in the integrated model.
2. Communicating potential utility of the model to stakeholders and enhancing their understanding of environmental models.
3. Increasing researchers' awareness of the factors driving resource management decisions.

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture
Washington State University
Clark

BioEarth

Biosphere-relevant earth system model

Sub-project participants:
K. Rajagopalan, B. Chandrashekharan, K. Malek, M. Brady, Y. Chen, R. Nelson, C. Stockle, C. Kruger, J. Adam

Assessing the impacts of climate (change & variability), crop management practices, and socio-economics on agriculture in the Columbia River basin

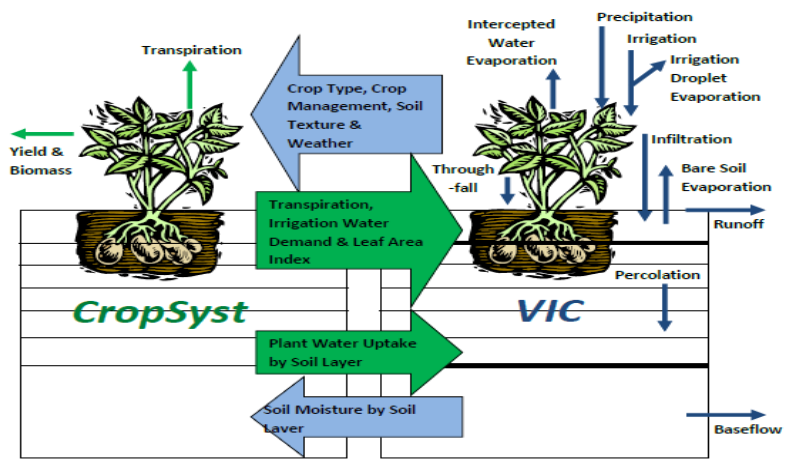
Objective

- **Understand the relationships between of climate change and variability on cropping systems (including direct and indirect effects, e.g. through irrigation water deficit) in the Columbia River basin.**
- **Capture the context of human decision making in agriculture, including technology and management practices, as well as socio-economics.**

Approach

- **Create an integrated hydrology and crop growth modeling framework, VIC-CropSyst, that is applicable to any domain.**
- **Incorporate the capability to model technological and management practices in agriculture, including irrigation and fertilization.**
- **Interface the model with socio-economics to capture agricultural producer decision making both in the long and short terms.**
- **Integrate the framework with a regional climate model, to understand the feedbacks of crop management activities on the atmosphere.**

Biophysical Model (VIC-CropSyst)



Economic Models:

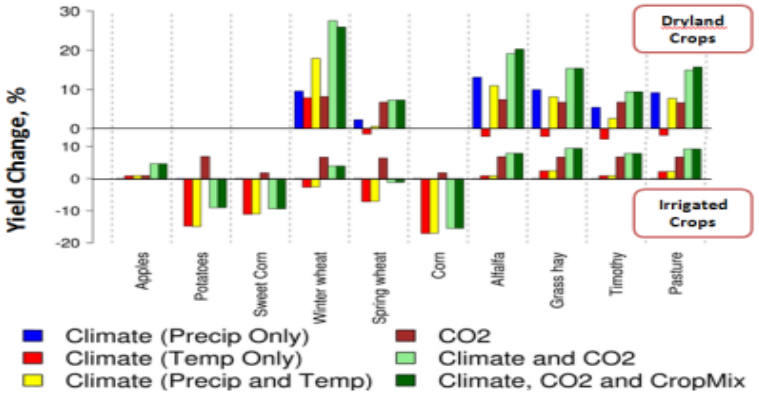
1. **Computable General Equilibrium (CGE) model = richer economic analysis**
2. **Agent-Based Model (ABM) = spatially-distributed decision-making for tighter integration**

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

Impact and Example Results

- **Ability to identify non linear and non monotonic responses of the integrated system to changes over time.**
- **Better inform agricultural resource decision making by evaluating the overall consequences of multiple adaptation strategies in an integrated manner.**

Year 2030 Projected Impacts on WA Crop Yield: Climate, CO_2, Crop Patterns



Washington State University

BioEarth

Biosphere-relevant earth system model

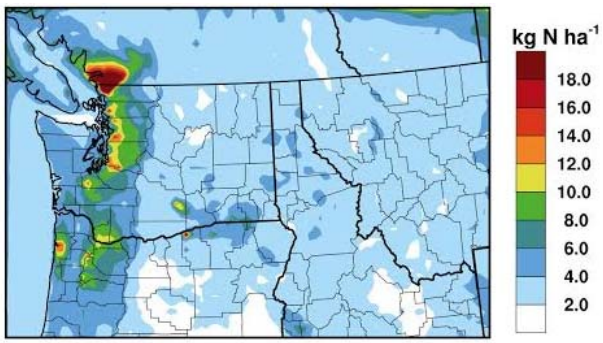
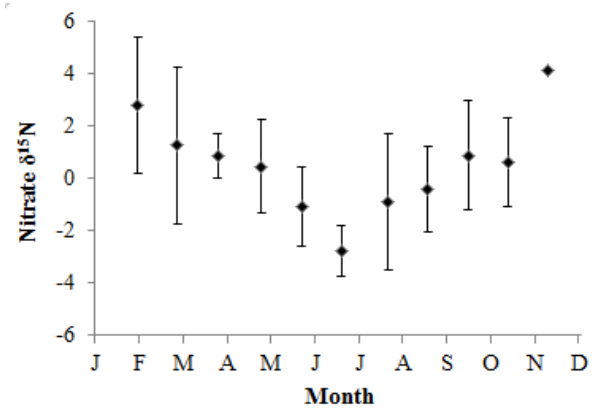
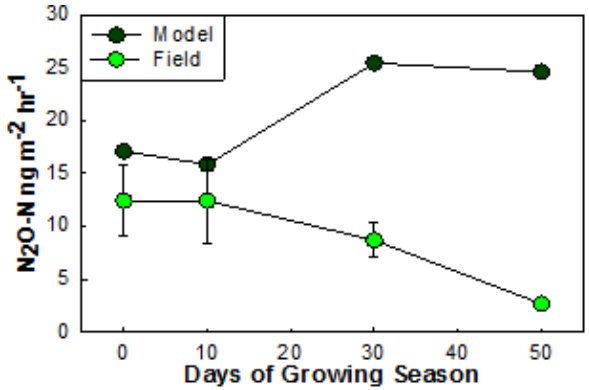
USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Sub-project participants: T. Nergui, J. Poinsatte, S.M. Anderson, S.H. Chung, R.D. Evans, B.K. Lamb, J.C. Adam

Using BioEarth's framework to model, measure, and study effects of nitrogen deposition

Objective: Understand emission sources of N deposition and their impacts on sensitive ecosystems

	N Deposition Modeling	N Deposition Measurements	Measuring and Modeling Ecological Impacts
Approach	WRF-CMAQ simulations to assess model performance on precipitation and N deposition	Measuring N concentrations in precipitation for N deposition rates and isotopic composition for N emission sources	Field experiments to parameterize RHESSys simulations to evaluate N deposition effects on ecosystem services
Example work	 WRF-CMAQ output for annual total (wet and dry) N deposition rates in 2008. Highest modeled N deposition rates (+20 kg N ha^{-1}) are more than ten times greater than background levels of deposition.	 Shifts in N isotopic values of nitrate indicate seasonal changes in N sources with greater influence from fossil fuel combustion in colder months and from biogenic emissions in warmer months.	 Modeled and field measured N_2O emissions differ greatly in the subalpine vegetation community due to dissimilarities in parameterized soil moisture and field conditions.

Impacts: Inform policy decisions regarding regulations of N emissions in the Pacific Northwest
Improve model linkages between atmospheric and terrestrial systems

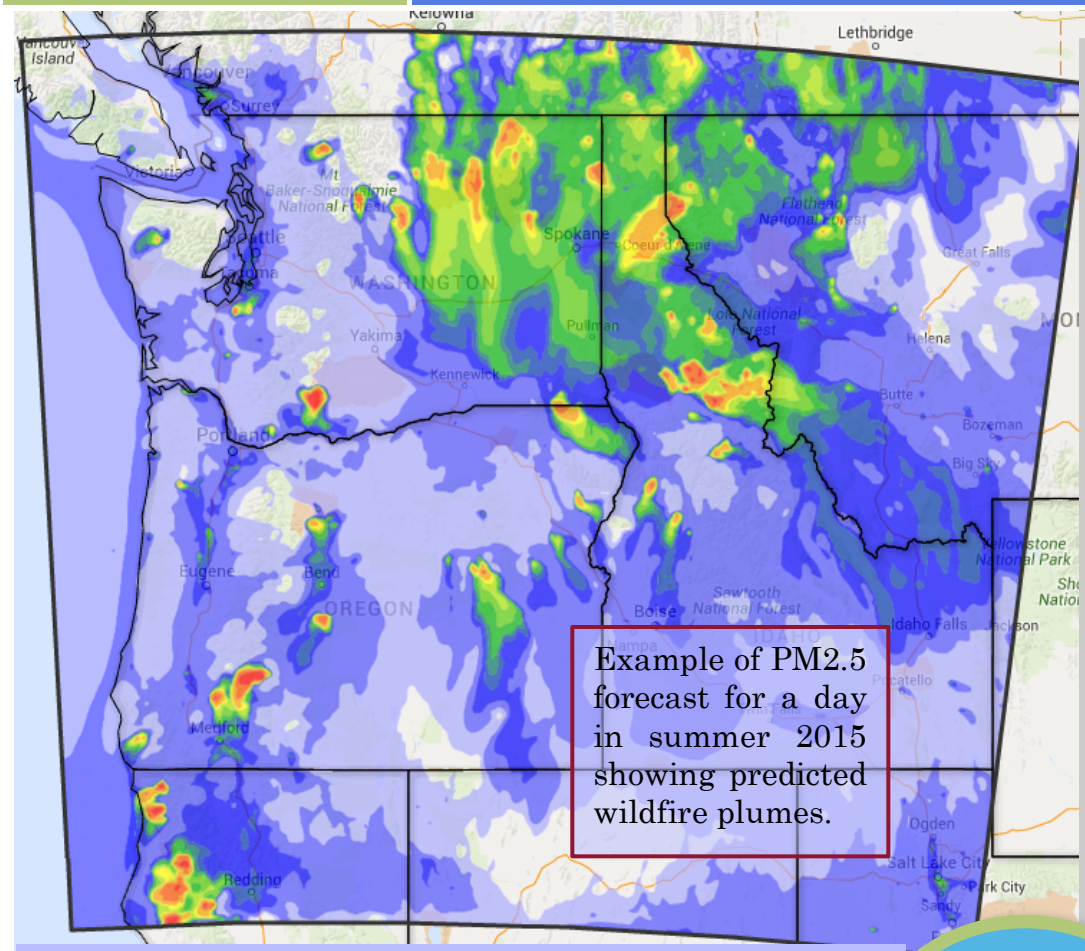
WASHINGTON STATE UNIVERSITY

Laboratory for Atmospheric Research
Washington State University

Daily Air Quality Forecasting System

AIRPACT

http://www.lar.wsu.edu/airpact



Example of PM2.5 forecast for a day in summer 2015 showing predicted wildfire plumes.

Forecasting:

Inputs:

Meteorology from:
University of Washington, *Weather Research & Forecasting Model* (WRF) Weather Forecasts

Emissions from:
- **Vehicles**
- **Industry**
- **Agriculture**
- **Biological Sources**

Boundary Conditions from MOZART4

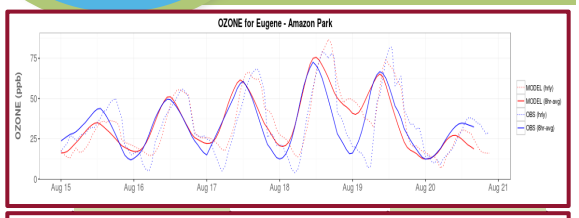
Initial Conditions from previous run

Outputs:

Predicted Air Pollutants:
- **Particulates**
- **Ozone**
- **NOx**
- **CO**
- **and more.**

WSU's Laboratory for Atmospheric Research created AIRPACT v.1 in 2001; it was the first operational high-resolution air-quality forecasting system deployed in the USA. AIRPACT-4, LAR's current operational system, operates on a 285 E-W by 258 N-S grid (shown above) of 4 km by 4 km cells, with 21 vertical layers that extend from the surface into the stratosphere. AIRPACT-4 uses the *Community Multi-Scale Model for Air Quality* (CMAQ) to solve the many equations describing horizontal transport by wind, vertical mixing and dispersion, gas phase and gas-to-aerosol atmospheric chemistry, wet deposition by precipitation and dry deposition by diffusion to surfaces. AIRPACT also gets observations from AIRNow for plotting comparisons (shown on the right). The AIRPACT modeling framework has been used in numerous studies and is regularly applied to address needs of local, tribal and state air-quality agencies.

Public Health Protection



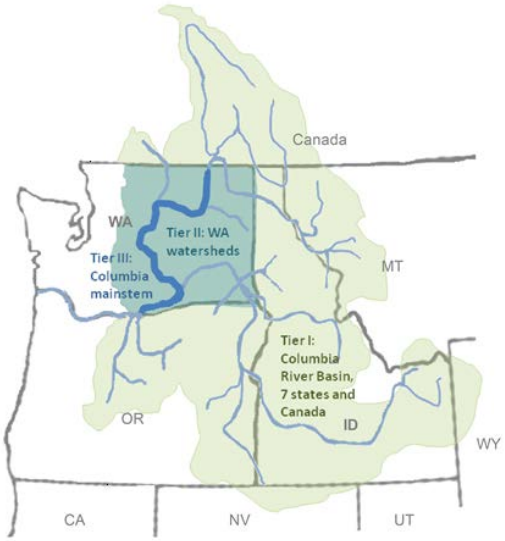
Contact: Joe Vaughan <jvaughan@wsu.edu>

WASHINGTON STATE UNIVERSITY

Long-Term Water Supply and Demand Forecast

Background: Since its establishment in 2006, the Department of Ecology's Office of Columbia River (OCR) has rapidly improved water supply for eastern Washington, with approximately 150,000 acre-feet already developed and another 200,000 acre-feet in near-term development. Consistent with its legislative directives, OCR is developing a portfolio of diverse projects including modification of existing storage, new storage facilities, conservation piping and canal lining projects, transmission piping projects, and water right acquisitions. Every five years, OCR is required to submit a long-term water supply and demand forecast to the Legislature. The 2016 Forecast will help OCR strategically fund water supply projects by improving under-standing of where additional water supply is most critically needed, now and in the future. The Forecast provides a generalized, system-wide assessment of how future environmental and economic conditions are likely to change water supply and demand By the 2030s, and is evaluated at three geographic tiers: the entire Columbia River basin, Eastern Washington's watersheds, and Washington's Columbia River mainstem.

Three Geographic Tiers

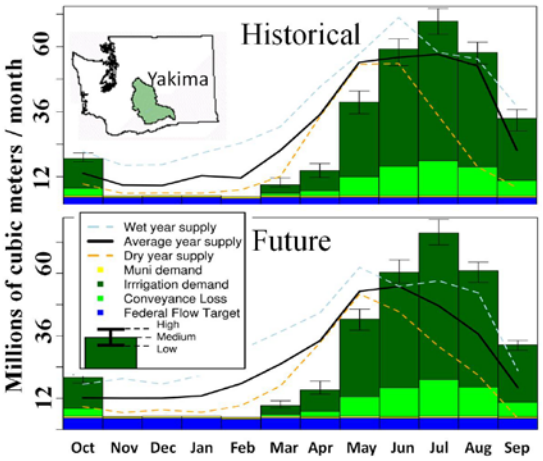


Example Results from the 2011 Forecast

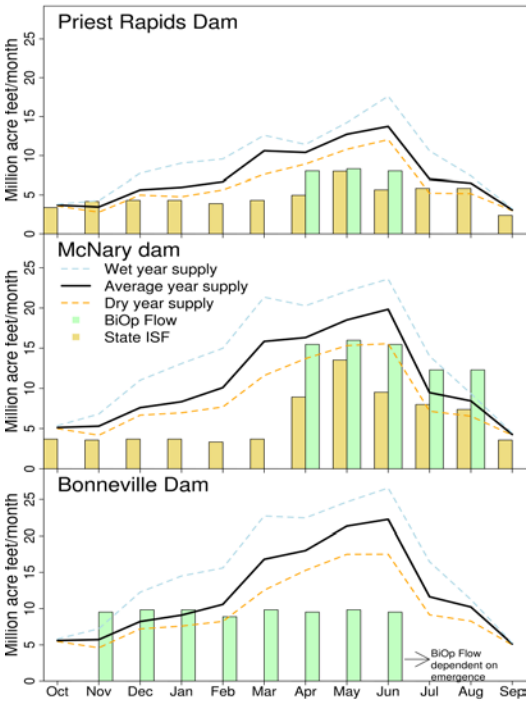
Tier I: Columbia River Basin

- Small increase of around 3% in average annual supplies
- Timing changes will shift water away from times when demands are highest: 14% decrease Jun.-Oct.; 18% increase Nov.-May.
- Increase in WA irrigation demand of 5%

Tier II: Yakima Basin Supply and Demand



Tier III: Future Surface Water Supply



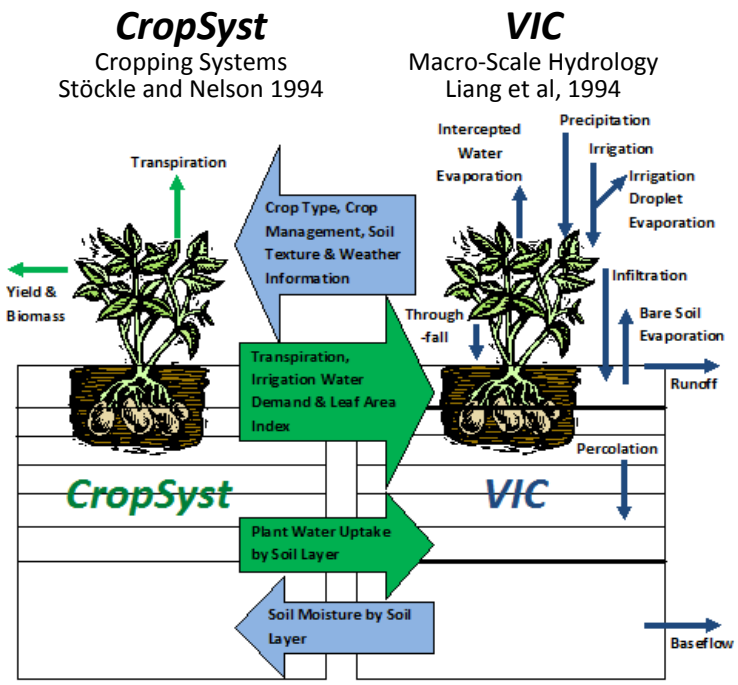
Planned Improvements for the 2016 Forecast

Substantially improved modeling platform: framework integration and feedbacks; irrigation technology, management, consumptive losses; reservoirs and curtailment modeling; multiple time-period economics (within-season, multi-year, long-term); improved climate forecast data; Yakima in-depth analysis; and incorporation of additional modules (see attached).

For More Information: www.ecy.wa.gov/programs/wr/cwp/forecast/forecast.html

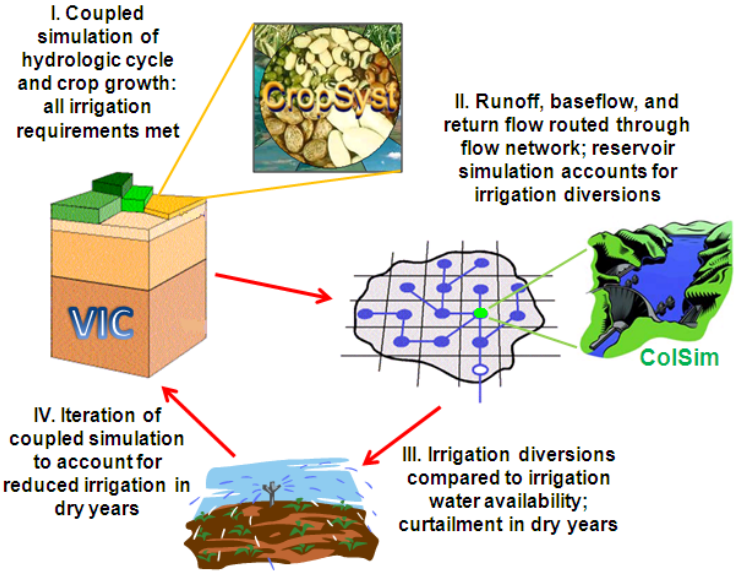
Long-Term Water Supply and Demand Forecast

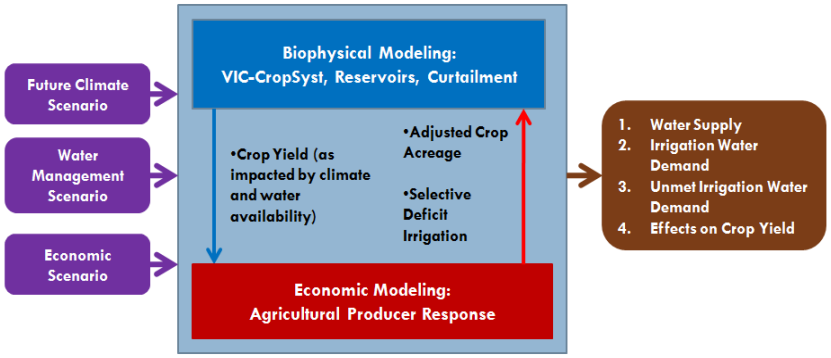
Approach: Development of three novel integrated modeling tools.



1. We performed a tight coupling between models for land surface hydrology and cropping systems; this tool can be applied over both dryland and irrigated crop-lands from watershed to global scales. CropSyst has the flexibility to simulate any crop type and was parameterized for ~40 crop groups. Capabilities were included to predict the impacts of changes in irrigation technology and practices.

2. We linked our coupled crops/hydrology model (VIC-CropSyst) with water resources management modules (including reservoir operations and water rights curtailment) that allowed us to predict the impacts of water scarcity (in space and time) on agricultural productivity. This tool can be used to inform management decisions in drought periods.





3. This biophysical modeling framework was then linked to economic decision making for both long- and short-term agricultural producer responses, and run under a range of scenarios.

WRC STATE OF WASHINGTON WATER RESEARCH CENTER

WASHINGTON STATE UNIVERSITY

THE UNIVERSITY OF UTAH

Aspect CONSULTING

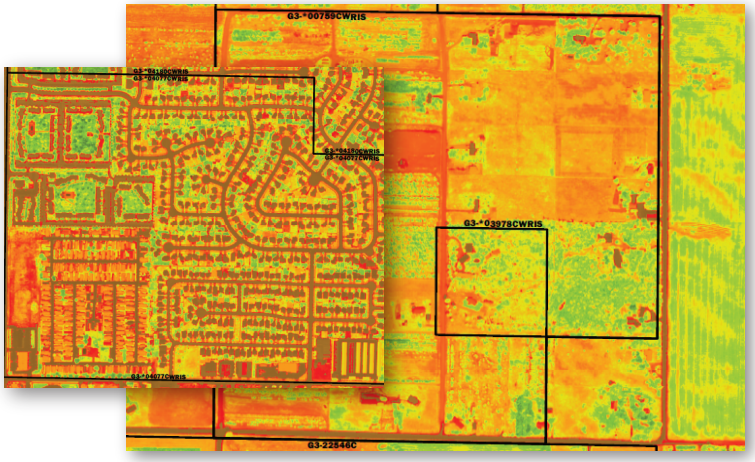
DEPARTMENT OF ECOLOGY State of Washington

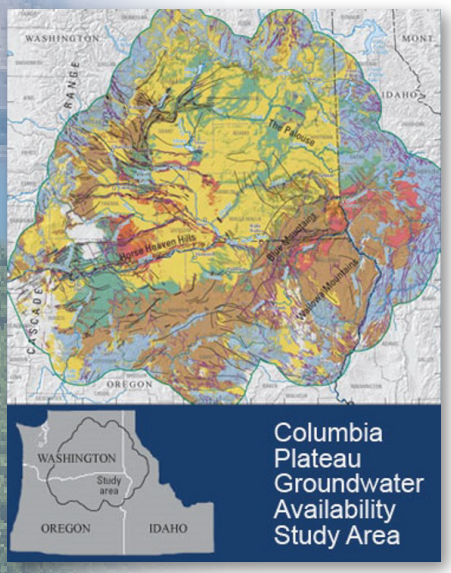
Long-Term Water Supply and Demand Forecast

Washington State University, University of Utah, and Aspect Consulting are collaborating with Ecology's Office of Columbia River to address technical and policy issues associated with the Long-Term Water Supply and Demand Forecast.

METRIC

METRIC is a satellite-based image processing methodology that calculates evapotranspiration at the field scale (~30 meters). The WSU Team will collaborate with farmers in Eastern Washington to measure water use and soil moisture to field-calibrate satellite aerial imagery and weather data. METRIC can be used to determine basin-level ET for forecasting purposes, identify crop stress areas, and estimate water use without meters.



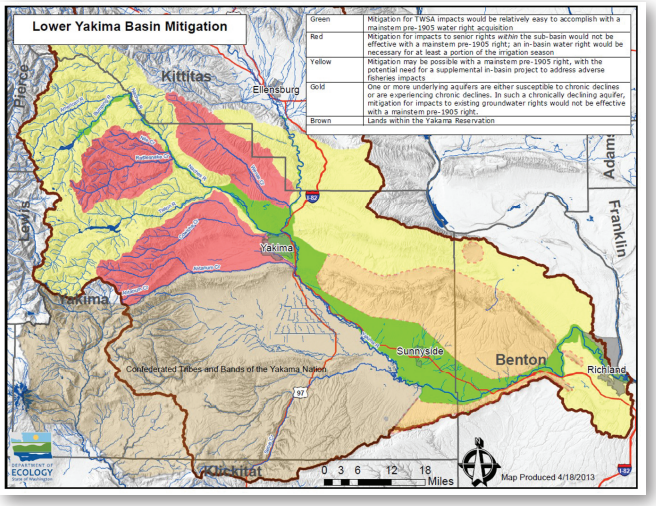


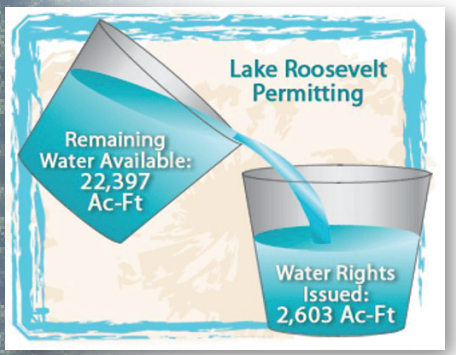
GROUNDWATER INTEGRATION

The 2011 Forecast Model did not include groundwater limitations as a control on future water use. The 2016 Forecast Model will begin to integrate groundwater information by identifying published areas of groundwater decline, summarizing existing groundwater models and tools used by basin planners, and forecasting delayed impacts (physical and economic) of declining groundwater on the water budget.

WATER BANKING

Water banking has emerged as a strong potential tool for meeting demands in critical areas of the State. In the last 10 years, the number of water banks has expanded tremendously. At the same time, Ecology's portfolio of trust water rights has expanded and diversified to meet instream flow needs and mitigation of out-of-stream needs. The WSU Team will evaluate the different roles Ecology plays in water banking, how water banking can be enhanced in Washington, and how OCR's mission can be met through water banking functions.





COST OF WATER EFFECTS ON APPLICANTS

Since 2000, the Legislature has begun to change the dynamics of water right processing for applicants, move from a State-pay to a more of an applicant-pay system. Existing programs are in place for cost recover of both the cost to process the application and the water supply used to hydrate the project. The WSU Team will evaluate the effect this change is having on applicant's willingness to pursue projects, and on Ecology's backlog of applications.

Washington State University · Department of Ecology, State of Washington · The University of Utah · Aspect Consulting

WISDM

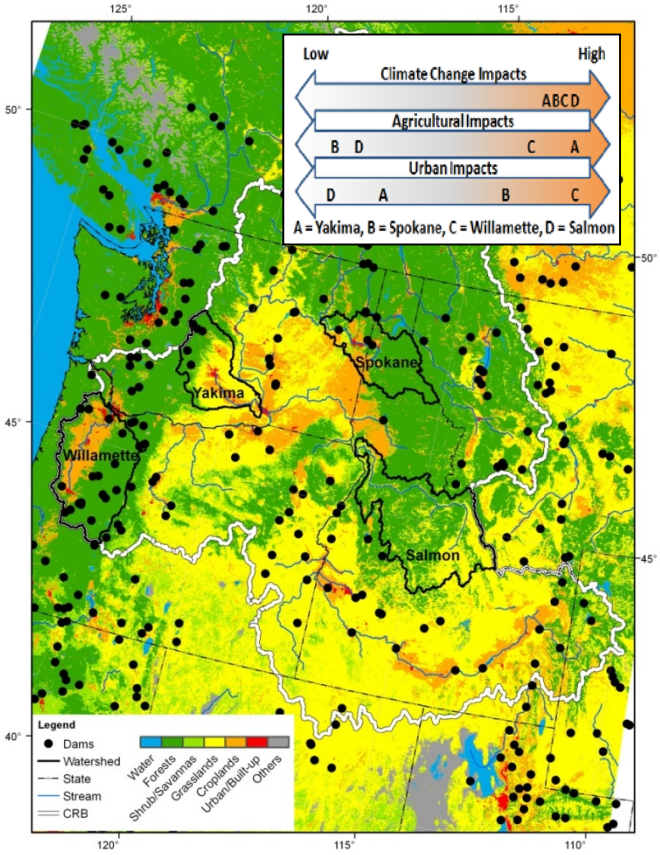
Watershed Integrated Systems Dynamics Modeling (WISDM)

Motivation: As one of the great river basins in the U.S., the Columbia River Basin offers a key constellation of water-management challenges, with highly engineered streamflow due to reservoirs and irrigation, excess nitrogen and phosphorous loadings from municipalities and agricultural sources, and salmonid habitat issues, all of which will be affected by climate change.

Project Goal: Our overall goal for this program is to improve understanding of interactions between water resources, water quality, climate change, and human behavior in agricultural and urban environments, including exploring how primary water users can be involved in the research process to develop scientifically sound and economically feasible public policy.

Mission: This project's mission is to:

- Understand how climate / land use changes have affected water quantity and quality in recent decades, and how will climate variability / change impact water quantity and quality in the future.
- Determine what agricultural practices will promote agricultural productivity under a new hydrologic regime while preserving water quality and minimizing greenhouse gas emissions.
- Explore possibilities for how dam operation could evolve to meet irrigation needs associated with sustained agricultural productivity, along with competing in-stream flow and hydropower requirements, under anticipated climate variability and change.
- Consider how changes in demand and supply-side economic conditions and climate change affect water use across space and time, and how will (or can) regulatory institutions adapt as water becomes increasingly scarce.



For more information, contact:

Cailin Huyck Orr, Washington State University
509-335-8868
Email: chorr@wsu.edu
and visit http://www.cereo.wsu.edu/wisdm/

USDA WSC

CEREO

Washington State University

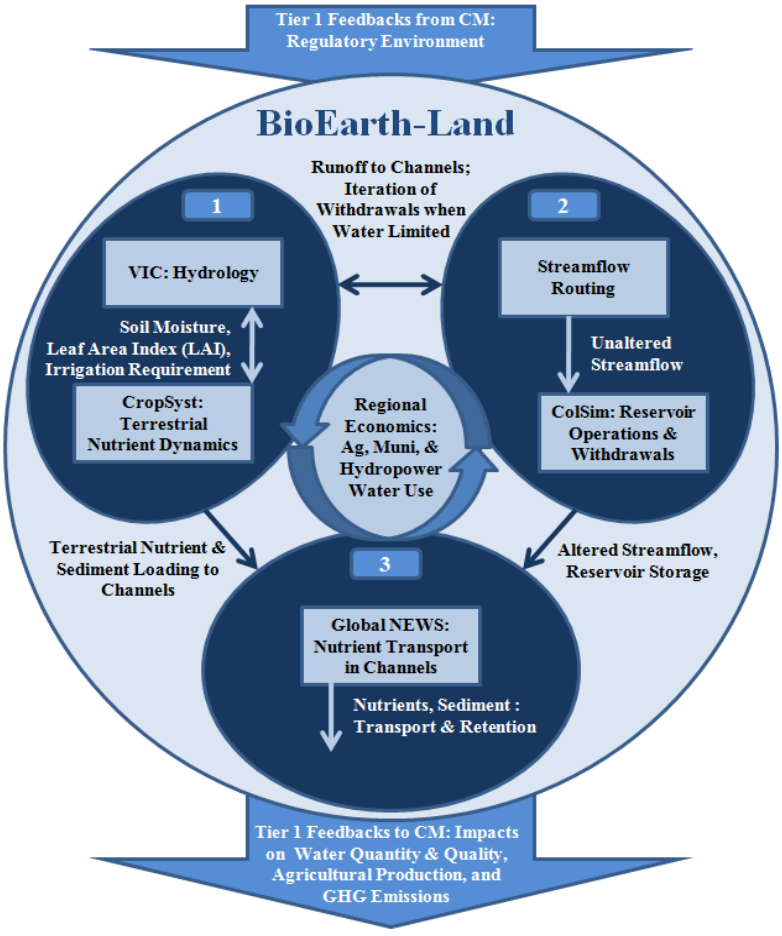
CWU Learn. Do. Live. Central Washington University

University of Idaho

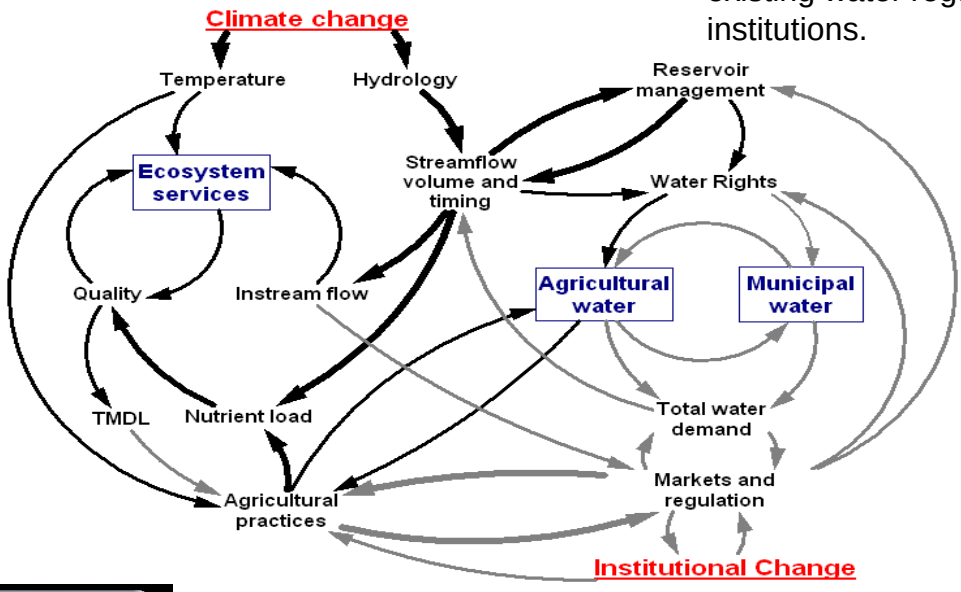
Center for Sustaining Agriculture & Natural Resources

State of Washington Water Research Center

WISDM



Approach: The WISDM approach integrates a system of existing and widely-applied models into an interdisciplinary framework that allows us to address the key issues surrounding the sustainability of water resources. This approach houses information provided by a complex integrated biogeochemical / economic model (BioEarth-Land; shown at right) within a system dynamics modeling environment, a user-friendly, graphics-based approach (shown below) that allows concerned stakeholders and scientists to jointly generate ideas for and explore adaptations to existing water regulatory institutions.



USDA WSC

CEREO

Washington State University

CWU Learn. Do. Live. Central Washington University

University of Idaho

Center for Sustaining Agriculture & Natural Resources

State of Washington Water Research Center

Pacific Northwest
NATIONAL LABORATORY

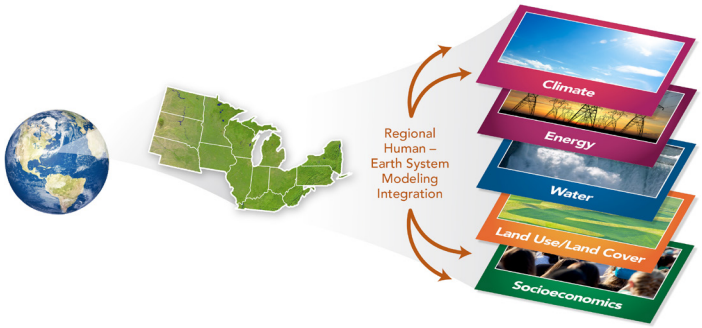
Proudly Operated by Battelle *Since 1965*

PRIMA

PLATFORM FOR REGIONAL INTEGRATED MODELING AND ANALYSIS

A unique capability for simulating complex interactions among human and natural systems at decision-relevant spatial scales:

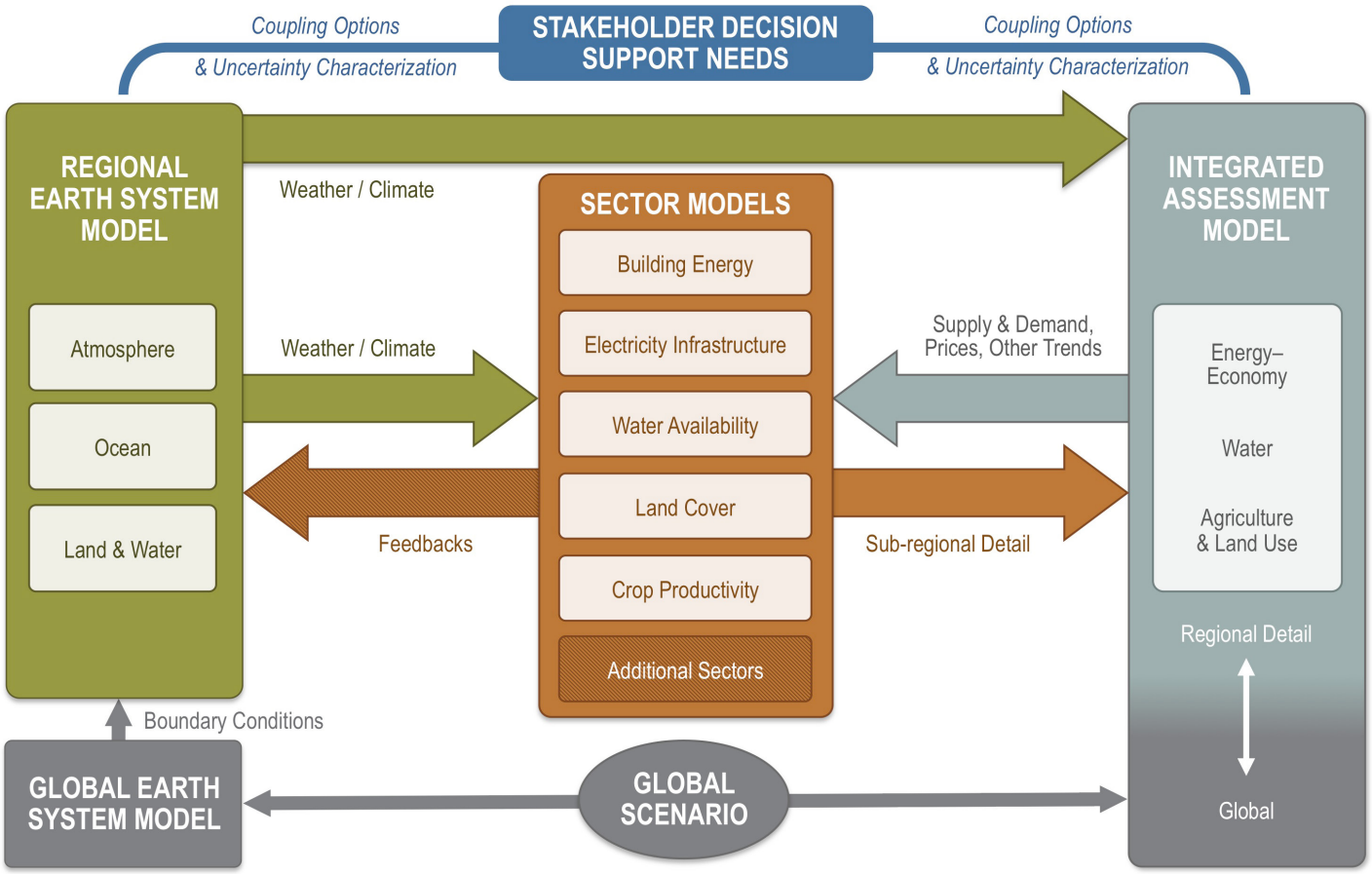
- Integrates detailed models of regional climate, hydrology, energy, agriculture, socioeconomics, and other systems
- Flexible, modular, and portable to any region
- Individual component models driven by consistent global boundary conditions
- Stakeholder input used to design numerical experiments and guide uncertainty characterization.



PRIMA can address complex, multifaceted questions, such as:

- How resilient is current and proposed future energy infrastructure to extreme events, such as drought, heat waves, and hurricanes?
- How do policies in one sector influence outcomes in other sector? For example, how would different bioenergy crop incentives influence energy costs, water availability, and land use in different regions?
- How do the intrinsic characteristics of a region enhance or constrain its ability to reduce greenhouse gas emissions or adapt to the impacts of climate change?

How PRIMA Works



Why PRIMA?

- Many environmentally relevant decisions—from natural resource management to renewable portfolio standards—are made at spatial scales that are not well resolved in global models or without accounting for the full set of interactions among relevant human and natural systems.
- Each region differs in its distribution of energy, land, water, and other resources, as well as in its capacity to respond to climate change and other environmental and socioeconomic challenges.
- Regional stakeholders need tools to evaluate different strategies for responding to climate change that can account for complex, multi-scale interactions among different systems and sectors.

CONTACT INFORMATION

Ian Kraucunas
PRIMA Initiative Lead
Ian.Kraucunas@pnnl.gov

Jennie Rice
PRIMA Demonstration
Jennie.Rice@pnnl.gov

Kathy Hibbard
PRIMA Chief Scientist
Kathy.Hibbard@pnnl.gov

Charity Plata
PRIMA Communications
Charity.Plata@pnnl.gov

Visit **PRIMA** online at ***http://prima.pnnl.gov/***

PRIMA fills these knowledge gaps by explicitly resolving key regional-scale processes and interactions in a consistent multiscale modeling framework that also accounts for larger-scale drivers and boundary conditions.

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

PRIMA:
Platform for Regional Integrated Modeling and Analysis

U.S. DEPARTMENT OF ENERGY

DEVELOPING A FRAMEWORK FOR REGIONAL INTEGRATED ASSESSMENT MODELING

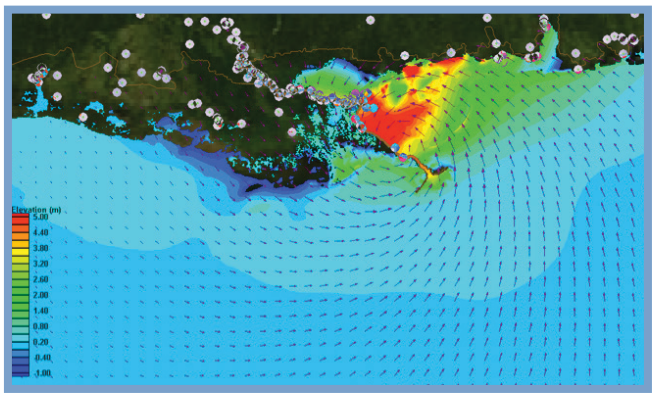
Pacific Northwest National Laboratory (PNNL), in partnership with Oak Ridge National Laboratory (ORNL) and supported by the Department of Energy's (DOE) Integrated Assessment Research Program, is developing a framework for regional integrated assessment and Earth system modeling, known as RIAM, and applying this framework to the Gulf Coast region of the United States—a region where climate impacts, land use changes, sea level rise, and energy supply issues are interacting to increase the vulnerability of the energy and agriculture sectors.

The RIAM project links regional climate, hydrology, socioeconomics, energy infrastructure, coastal processes, and agriculture and land use models to investigate the multifaceted impacts of climate change, as well as potential adaptation and mitigation strategies being considered by regional stakeholders. The project is highlighting the vulnerability of regional energy systems to heat waves, droughts, coastal storm surges, and other extreme events, with an initial focus on climate change impacts on electricity supply and demand across the southeast. Another key goal is improving understanding of the benefits and challenges associated with integrated, multiscale modeling and the interdependencies among human and natural systems in the context of climate change.

CHALLENGES

The project will generate new insights into the following questions:

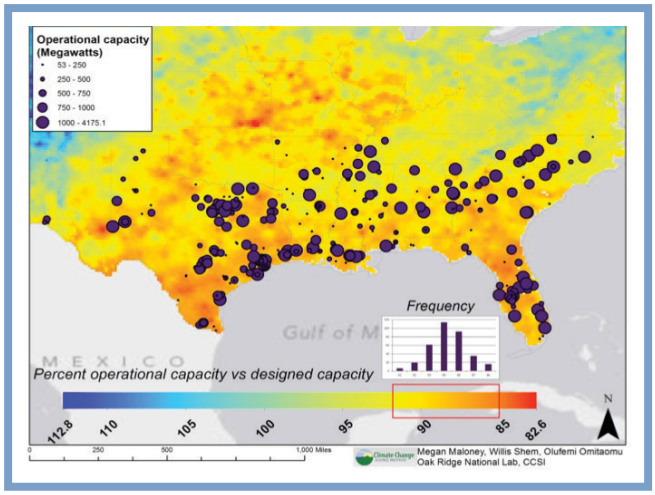
- How is climate change affecting the vulnerability of Gulf Coast energy infrastructure to the combined effects of storm surge, subsidence, and sea level rise? How does vulnerability change under different scenarios of future climate change and regional energy and land use planning?
- How will regional climate change, especially changes in the duration, frequency, and intensity of heat waves and droughts, affect building energy demand and the performance of thermal power plants? How will these changes influence regional grid reliability and electricity prices and what potential adaptation measures exist?
- What are the intrinsically regional characteristics and opportunities for mitigation and adaptation? Are there physical or economic constraints that make the implementation of, for example, different energy technologies or land use policies more difficult?
- What are the benefits, challenges, and implications of integrated modeling at regional scales? In particular, are there insights that cannot be gleaned from models that are less integrated or have coarser spatial or temporal resolution?



Simulation of wind and storm surge during Katrina landfall (grey dots = energy facilities)

MAJOR COMPONENTS AND/OR THEMES

This project leverages PNNL's Platform for Regional Integrated Modeling and Analysis (PRIMA) and also includes the development of new models and improvements to existing community models needed to resolve additional regional-scale processes and interactions. The primary integrating element of the framework is a regionalized version of the Global Change Assessment Model (GCAM), which has been extended and downscaled to represent energy supply and demand



SE electricity producing gas fired turbines, +50MW capacity: sensitivities under July 12, 2050 temperatures

at the state level, as well as offer more highly resolved representations of agricultural productivity and land management technologies. A regional Earth system model, driven by global boundary conditions provided by the Community Earth System Model (CESM), provides detailed, dynamically downscaled simulations of regional climate change under different scenarios of global climate forcing. These regional climate change scenarios are used to drive the other modeling components.

For example, the high-resolution coastal storm surge model, which has been validated with historical hurricane data, simulates inland flooding for future hurricanes and can be coupled to a GIS-based model that relates storm surge height to impacts on specific energy infrastructure elements along the affected coastline. Likewise, regional climate is used to drive the detailed models of regional building energy demand and electricity operations at the utility zone scale to provide realistic assessments of increases in electricity demand during heat waves and decreases in electricity supply due to either high air temperatures or low water quantity or quality. Collectively, these unique modeling capabilities are yielding an unprecedented level of detail and insight into the interactions among changes in climate, energy, and water systems at regional scales and allowing the exploration of key issues facing regional stakeholders.

FUTURE WORK

The initial focus of the project on climate change impacts on electricity supply and demand across the Gulf Coast region currently is being extended to include additional climate forcing factors, such as stream temperature and river flooding, and additional infrastructure components, including oil and gas infrastructure. Additional emphasis on changes in agricultural productivity and the potential for increased regional biomass production also are planned. On a longer-term basis, these capabilities could be leveraged to evaluate different regional adaptation and mitigation strategies in an integrated, holistic context that includes both regional climate change and consistent changes in other natural and human systems, both in the Gulf Coast and other important regions.

CONTACTS

Robert Vallario
DOE Program Manager
Integrated Assessment Research Program
bob.vallario@science.doe.gov

Ian Kraucunas
Principal Investigator
Pacific Northwest National Laboratory
ian.kraucunas@pnnl.gov

Ben Preston
Principal Investigator
Oak Ridge National Laboratory
prestonbl@ornl.gov

Project Website:
http://climatemodeling.science.energy.gov/projects/developing-regional-integrated-assessment-model-framework

FireEarth: a modeling framework to reduce the risk of fire becoming a disaster in the Pacific Northwest

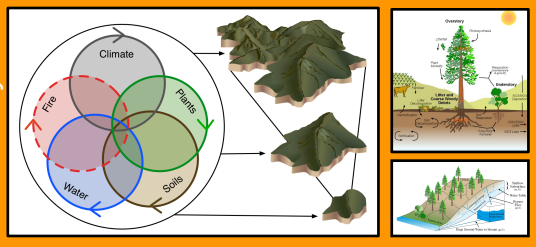
OVERVIEW

We are developing a modeling framework, FireEarth, which expands the Biosphere-relevant Earth system model (BioEarth) to include fire, insect outbreaks, drought, and erosion. FireEarth will be used to simulate the effects of disturbances on hydrologic and biogeochemical cycles, and their interactions with economic, societal, and political processes. We will evaluate policy and decision-making at local and regional scales, with an aim to reduce the risk of wildfire becoming a disaster.

MODELING FRAMEWORK

BioEarth incorporates the ecohydrologic model RHESSys to simulate biophysical processes in watersheds. FireEarth will link the fire spread model (WMFire) that is embedded in RHESSys with models for fire severity and and the effects of fire on ecohydrologic processes.

RHESSys



Grows fuels

WMFire

Dynamic integration with RHESSys
Fire–spread modeled as a function of:

- Fuel load
- Fuel moisture
- Wind
- Topography

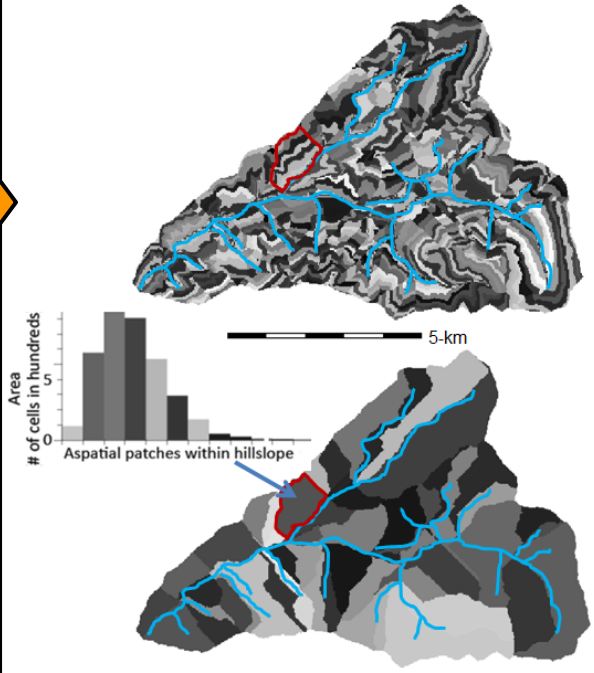
Simulates fire-spread

Feeds back to RHESSys process models

Links to models for fire severity & effects, insect outbreak, drought & erosion

SCALING UP APPROACH

Upscaled-RHESSys: We will run regional-scale simulations using multiple climate scenarios to identify locations where conditions would be most likely to cause disastrous fire.



RHESSys will then be used over a wider range of scenarios to identify actions that can be taken to reduce the likelihood of a fire becoming a disaster.

For more information visit:
http://www.cereo.wsu.edu/fireearth/

University of Idaho

Washington State University

Donald Bren School of Environmental Science & Management
University of California, Santa Barbara

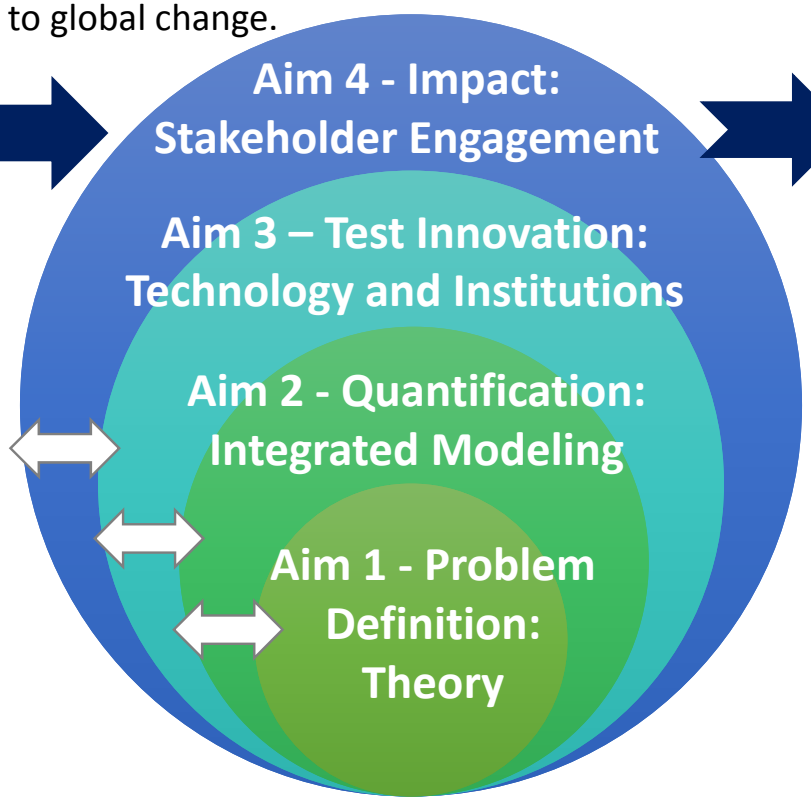
Overarching Objective: *To co-balance benefits and increase resilience across coupled F-E-W systems through coordinated management of F-E-W storage systems in concert with technological and institutional innovation.*

Inputs

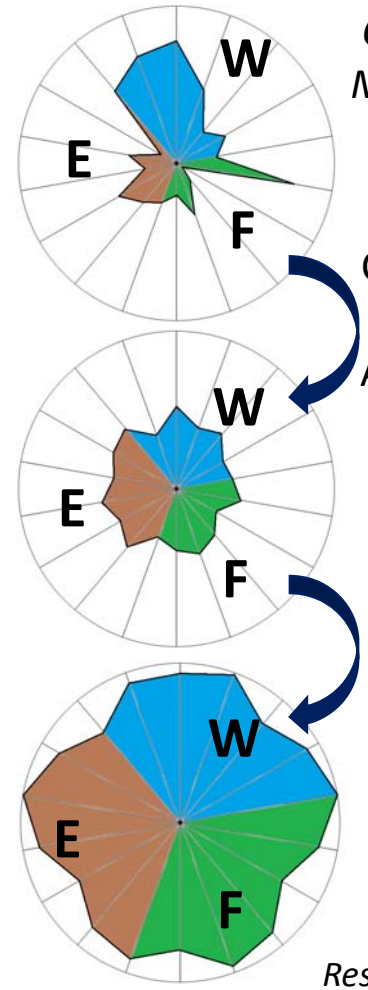
- Insight gained from our NSF FEW workshop focused on the interplay between technological and institutional FEW solutions (Padowski et al. 2014)
- Existing state-of-the science Earth system models focused on the nexus of water with food (BioEarth, Adam et al. 2014) and Energy (PRIMA, Kraucunas et al. 2014)
- Extensive regional collaboration networks related to the FEW nexus (e.g., Allen et al. 20xx)
- Cool thing
- Another cool thing

Approach

Develop a framework that spans the continuum from theory (aim 1) to informing practice (aim 4) to understand F-E-W linkages, quantify innovative solutions across the F-E-W sectors, and engage stakeholders to remove barriers to the adoption of solutions and increase system-wide resilience to global change.



Outcomes



Coordinated Management of Storage

↓

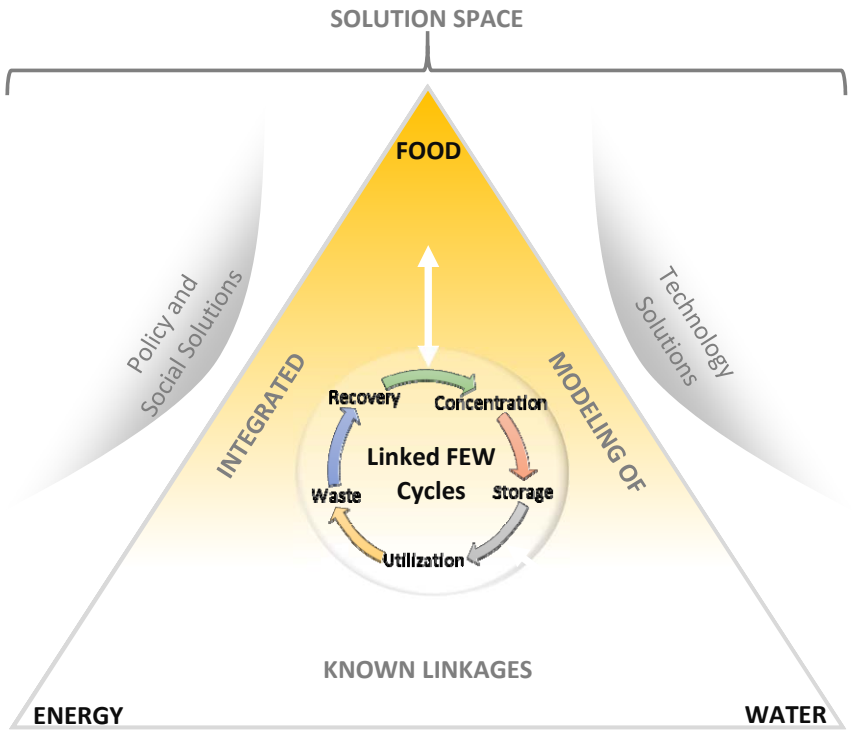
Co-Balancing Benefits Across F-E-W Systems

Innovation

↓

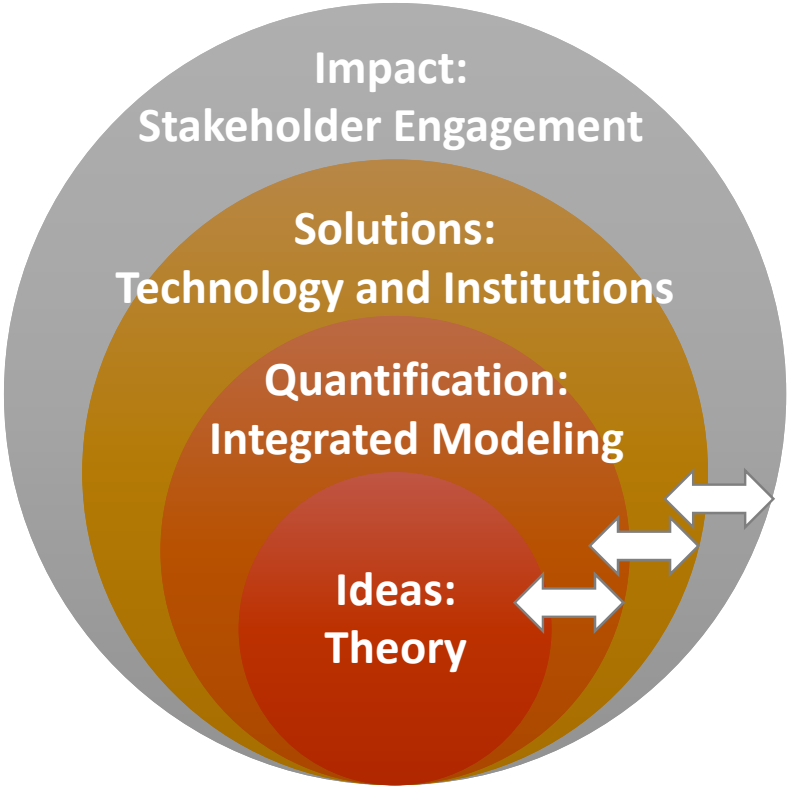
Increasing Resilience Across F-E-W Systems

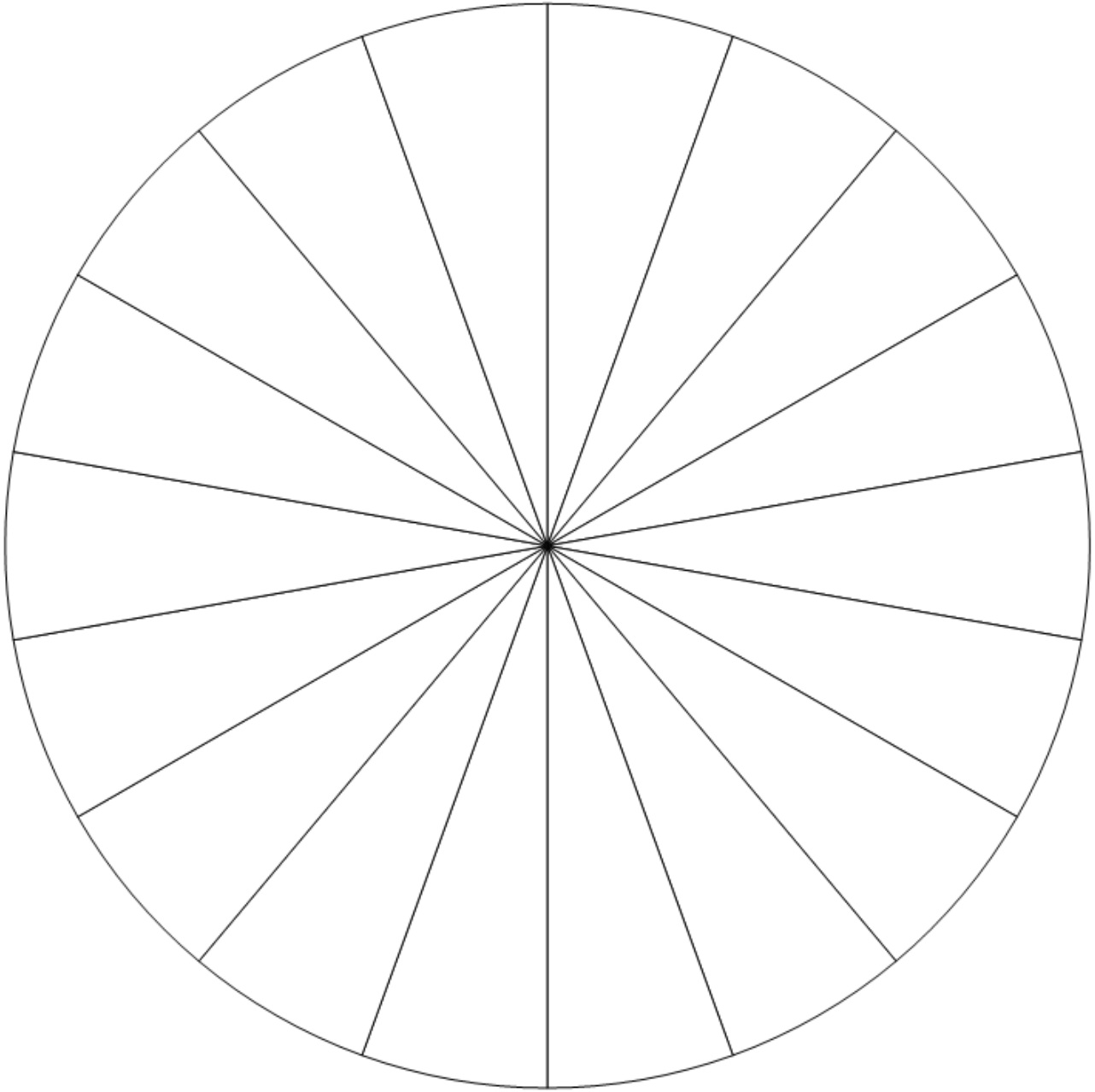
Resilience metrics: economic, environmental, and social equity impacts



- Quantify secondary benefits and unintended consequences: economic, ecologic and social
- Identify weak links and rate limitations within human impacted natural cycles and between FEW components that impair system resilience
- Test impacts of policies, practices, and technologies for FEW resilience
- Define and estimate sector specific, and cross-sector metrics for performance, efficiency, and stress
- *Scientific synthesis workshops to define "resilience" in FEW systems*
- *Stakeholder engagement to inform and enhance the feasibility of solution sets*

INCREASE FEW SYSTEM RESILIENCE


Impact:
Stakeholder Engagement
Solutions:
Technology and Institutions
Quantification:
Integrated Modeling
Ideas:
Theory



Energy Water Air Food

NEXUS

Center for Environmental Research, Education and Outreach

Seminar Series

Spring 2016

The CEREO Newsroom: a Resource for Communicating Research, Training Students, & Meeting NSF Broader Impacts Requirements

Jason Williams, *Civil & Environmental Engineering*
Todd Norton, *Murrow College of Communications*
Lucrezia Paxson, *Murrow College of Communications*
Ryan Risenmay, *Murrow College of Communications*

Wed., Feb 24, 2016 | 3-4 pm | PACCAR Clean Tech Bldg. , Room 135

This seminar will summarize opportunities available to WSU faculty and students through the CEREO Newsroom. Founded in 2014 through a CEREO seed grant, the CEREO Newsroom pairs undergraduate Murrow communications students with graduate students conducting environmental research. Under the guidance of Murrow faculty, the student teams create multimedia packages (videos and written articles) that address environmental problems and the research graduate students are doing to help solve those problems. Several example multimedia packages will be presented during the seminar. In contrast to other communications resources available (WSU communications or self-promotion of research), newsroom products are created by student teams and emphasize student training and experiential learning.

Newsroom projects consequently are a unique and compelling way to meet NSF broader impacts or other similar grant requirements. The Newsroom has the infrastructure and expertise in place to support new projects, including those associated with WSU proposals currently in preparation for the upcoming NSF Food-Energy-Water grant deadline.