REACCH Model Integration, Scenario Design and Preliminary Results

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In this presentation:

- Project goals and the role of modeling
- Technology and socio-economic scenario design from Objectives 1 and 4 Teams
- Objective 1 Team approach to data and model integration
- Some (very!) preliminary example of results from a proof-of-concept exercise: impact of climate on the winter wheat-fallow system
- Next steps

The Impact Assessment Challenge

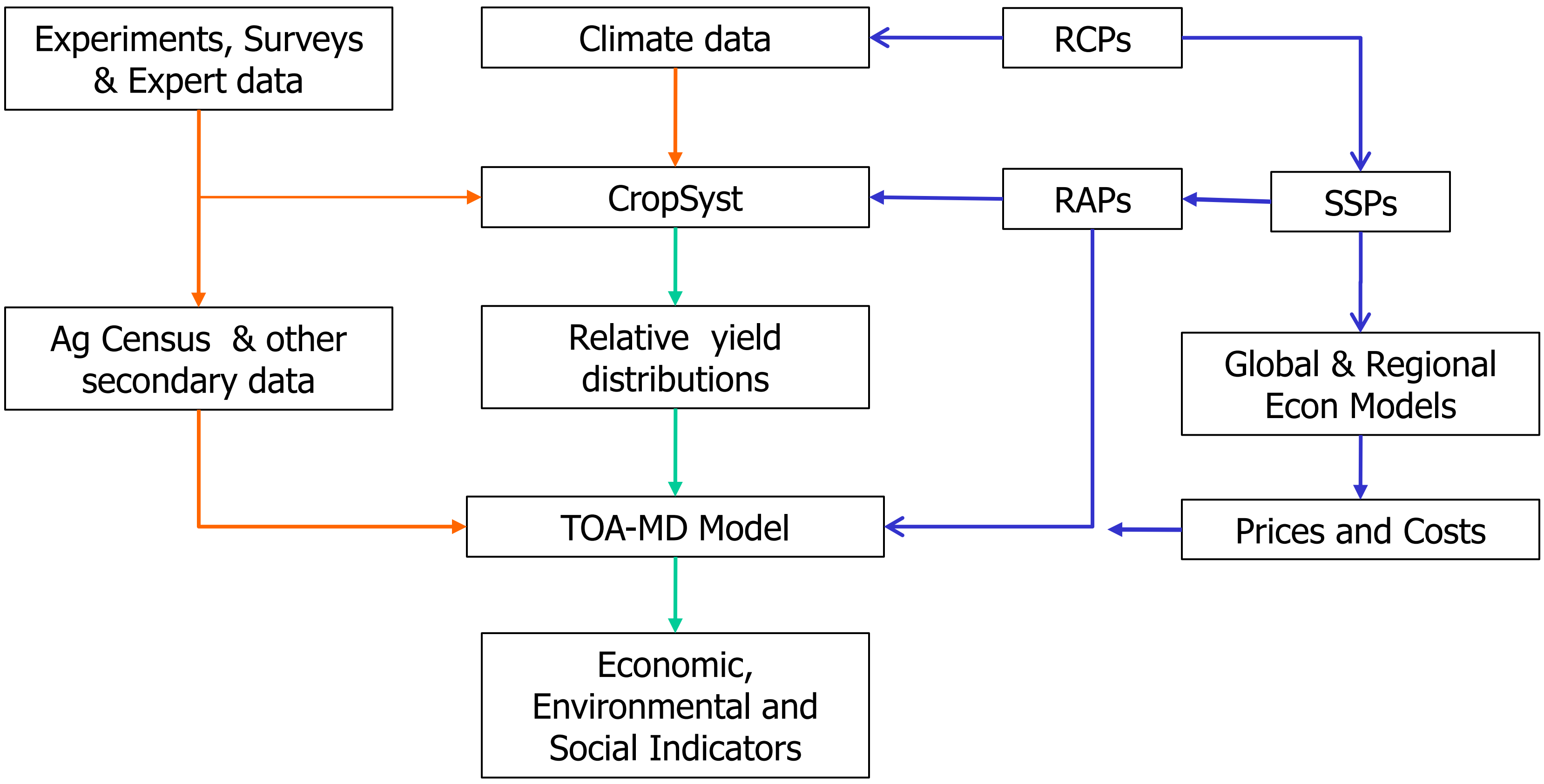
- How do current and possible future PNW ag systems perform under present and possible future climate, technology, economic, social and policy conditions?
- Approach: assess impacts of climate change on economic, environmental and social *outcomes* using quantifiable *indicators, taking into account spatial heterogeneity in systems and impacts*
- Outcomes
  - economic: production, income & distribution, employment
  - environmental: soil and water quantity & quality; GHG emissions etc.
  - social: health, gender, age, community
- Indicators
  - mean or aggregate (farm, regional)
  - variability and risk of exceeding critical thresholds (vulnerability)

The Impact Assessment Challenge (cont.)

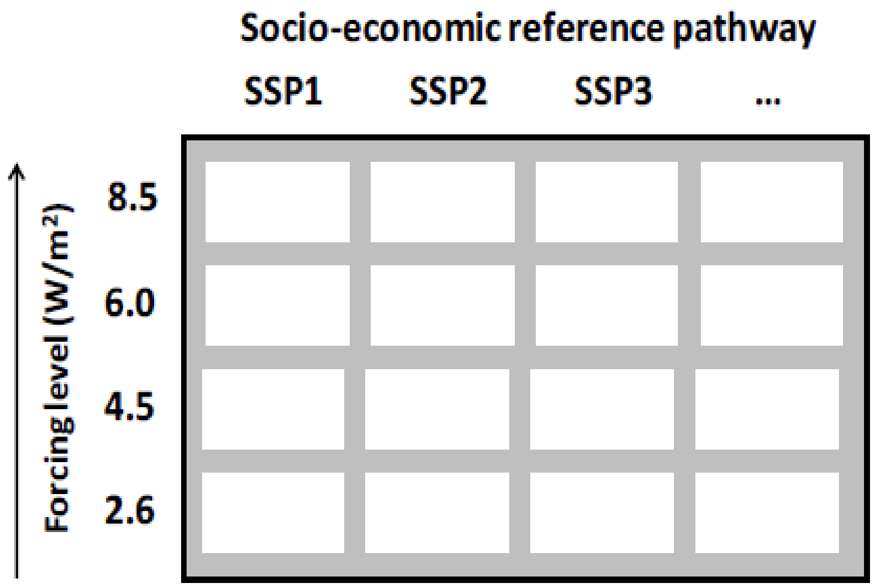
- This is a hugely complex challenge!
- To make IA manageable, we carry out different types of *simulation experiments*
  - *reference scenarios* for model evaluation, validation, intercomparison
  - *sensitivity analysis*, varying some parameters while holding others constant
  - *pathway analysis* to explore possible future states of the world
- IA simulations involve multiple dimensions:
  - climate (base, future)
  - production system (current systems, adapted systems)
  - policy (mitigation, other)
  - socio-economic conditions (prices, costs of production, farm size etc.)

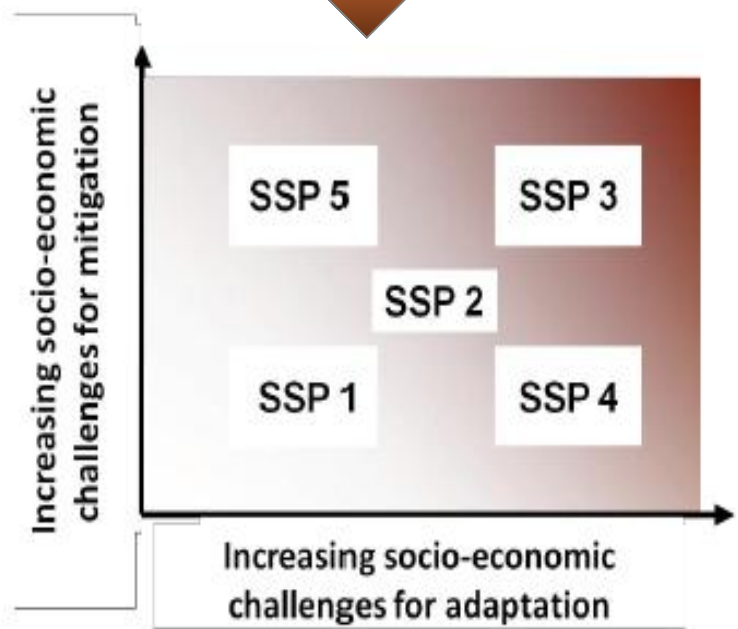
Data, Model and Scenario Integration

RCP = Representative Concentration Pathway
SSP = Shared Socio-Economic Pathway
RAP = Representative Agricultural Pathway



RCPs, SSPs and RAPs





Representative Ag Pathways

- economic & social development storylines
- agricultural technology trends
- prices and costs of production
- ag, conservation, other policy

Technology and Socio-Economic Scenario Design: Objective Teams 1 & 4 Meeting, Hood River, Feb 10 2012

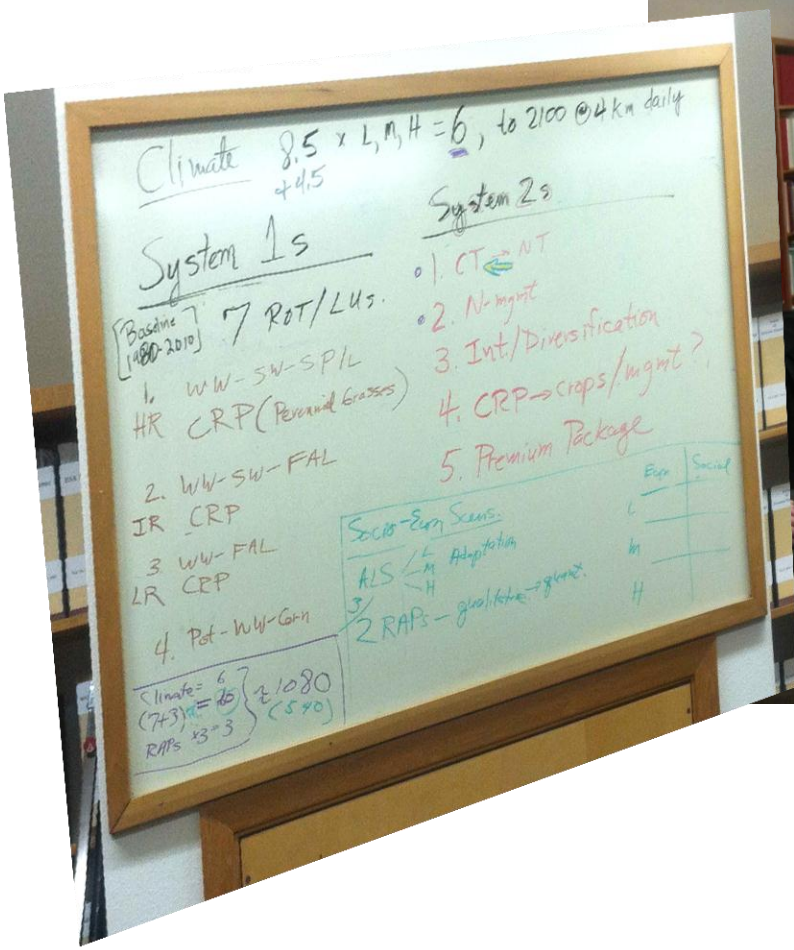
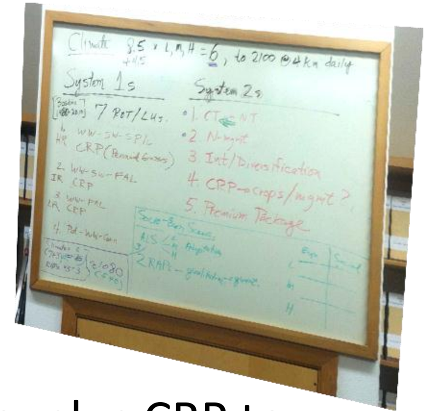


Table 1. Description of conventional and alternative management strategies by location and AEZ.

AEZ	Conventional System	Location of expt stations and farmer field sites	Alternative Management Strategies and Research Variables			
			Tillage	N Management	Crop Intensity	Recycled C and N
2	w. wheat-s. wheat-s. legume; chisel plow; field scale NH_3	Moscow/Pullman	direct seed^{O}	site-specific N^{O}	perennials^{O}, winter crops^{O}, oilseeds/legumes^{O}	biosolids^{N}
3	w. wheat-s. cereal-tilled fallow; field scale NH_3; deep soil	Pendleton	direct seed^{O}	NUE assessment^{O}	perennials^{O}, fallow replacement, oilseeds^{O}	animal manure^{O}
4	w. wheat-s. cereal-till fallow; field scale NH_3; shallow soil	Davenport, St. John, Okanogan	chemical fallow-direct seed^{O}	site-specific N^{N}	perennials; flex annual cropping^{O} / oilseed/legume^{O}	biosolids^{N}
5	w. wheat-fallow; field scale NH_3	Lind/Moro/ Douglas/Ralston	undercutter-fallow^{O}	NUE assessment^{O}	perennials; ww-s. oilseed-fallow	biosolids^{O}
6	irrigated tilled corn-w. wheat-bean; field scale UAN	Othello	direct seed^{N}	N catch crops^{O}	perennials; winter cover crops^{O}	biosolids^{N}

Superscript 'O' designates existing old study while 'N' represents study to be initiated in the ACCPNA project.

Proposed Scenario Design



Climate: 2 RCPs x 3 models

Base Systems:

- High rainfall: Winter Wheat-Spring Wheat-Spring Legume, plus CRP to annual crop transition
- Intermediate rainfall: Winter Wheat-Spring Wheat-fallow plus CRP to annual crop transition
- Low rainfall: Winter Wheat-fallow plus CRP to annual crop transition
- Irrigated: Potato-Winter Wheat-Corn

Alternative Systems:

- Adoption of conservation, direct seed or no-tillage practices
- Improved N management
- Intensification (reduction of fallow) and diversification (replacement of fallow and existing crops by new crops)
- Conversion of Conservation Reserve Program acreage to crop production.

Socio-Economic Scenarios: 2 RAPs + policy scenarios TBD

Proposed Scenario Design (cont.)

Some Issues & Challenges:

- "curse of dimensionality":

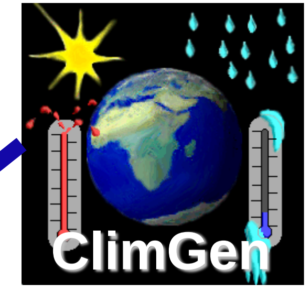
  4 AEZs x 6 climates x S Systems x R Socio-econon scenarios = 24 x S x R = ???
- how to estimate productivity and costs of future technologies
  - need to include more "current alternative" systems as future scenarios?
- linkage of scenarios to "dynamic AEZs"
- representation of uncertainty in climate, crop and econ models
- quantifying "adaptation likelihoods" or adaptive capacity

Modeling Team Proof-of-Concept Exercise

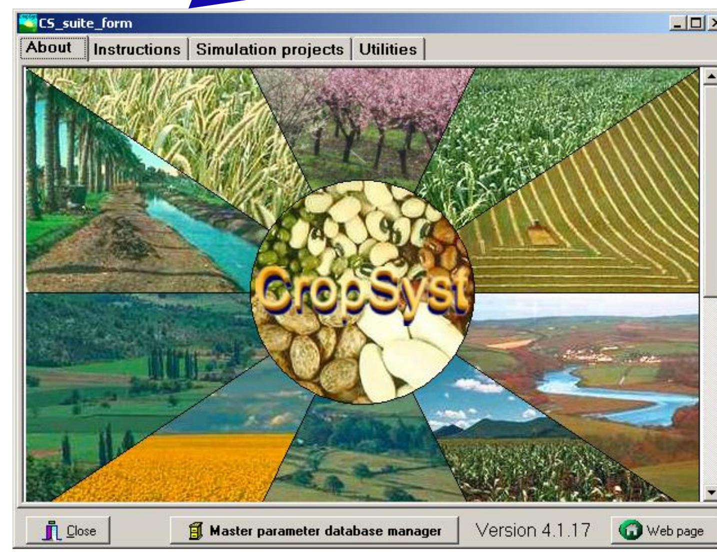
- Goal: test methods & process for linking climate data to CropSyst and TOA-MD
- Use simplest case: WW-F system in REACCH region
- 2007 ag census data:
  - 978 “winter wheat” farms with 2.26 million cropped acres, average farm size 2308 ac
  - 860,000 acres in WW wheat-fallow
  - average yield 51 bu/ac, average 38% in fallow
- IMPORTANT DISCLAIMER: THE FOLLOWING MATERIAL IS ONLY TO ILLUSTRATE THE METHODS BEING DEVELOPED AND NOT FOR QUOTATION OR CITATION.

CropSyst Model

bsyse.wsu.edu/CS_Suite/CropSyst



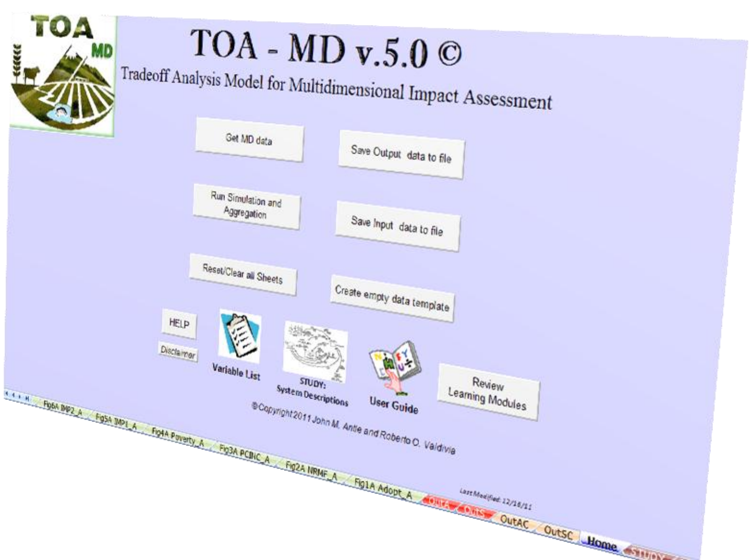
- Multi-year, multi-crop, process-based, daily and hourly time step cropping systems model.
- A handful of key crop parameters are “observable” by simple field measurements.
- Used extensively in the PNW and around the world.
- Provides reliable estimates of crop growth and yield in response to weather, soil, water and N availability, and management.



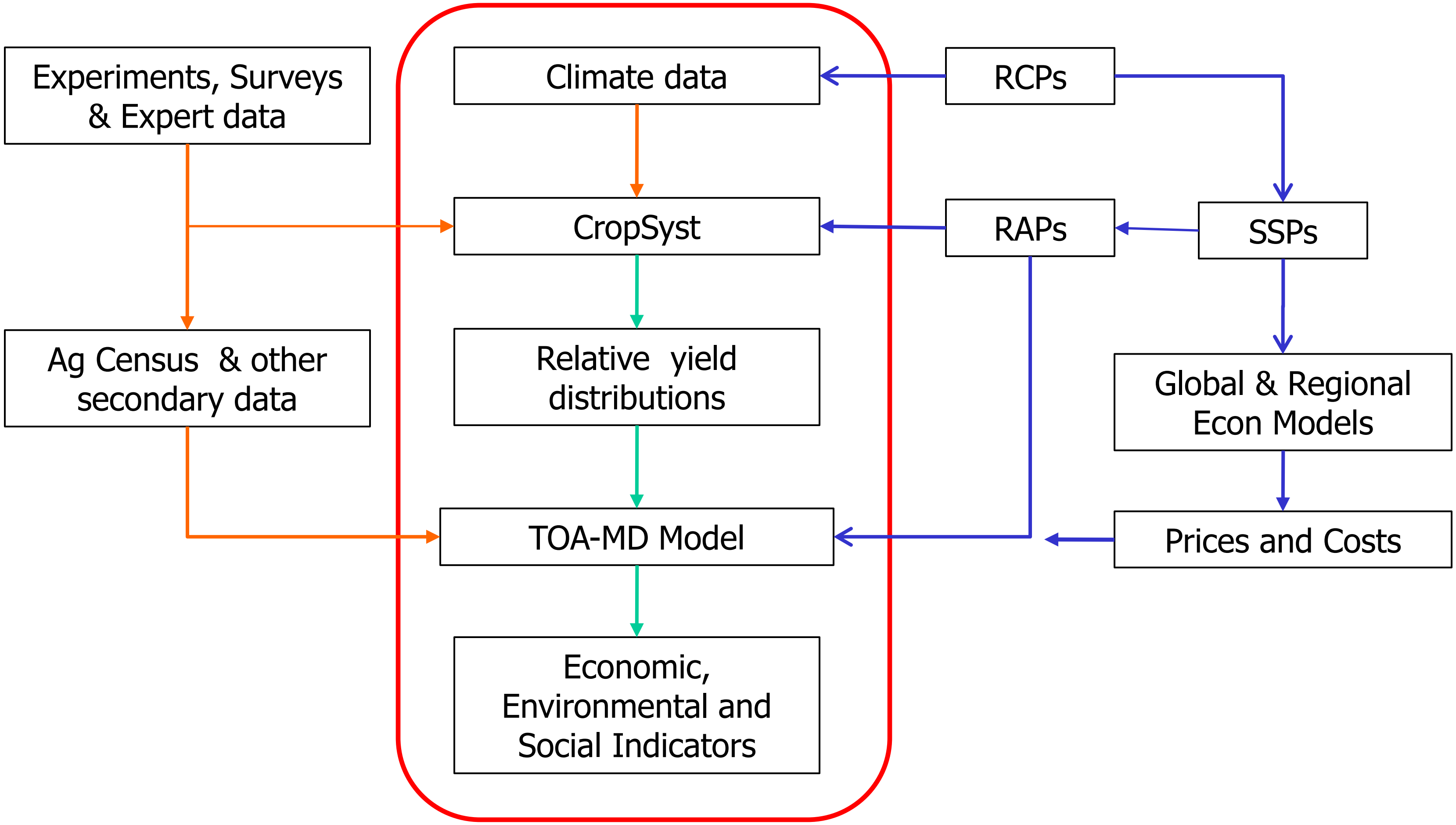
Arc GIS – CropSyst Cooperator

TOA-MD Model: Multi-Dimensional Impact Assessment *tradeoffs.oregonstate.edu*

- A novel simulation approach to assessment of economic, environmental and social impacts of technology adoption, environmental change, and ecosystem services
- Integrates various types of data (crop model simulation outputs, experimental data, expert knowledge, economic, environmental and social data) to represent a population of heterogeneous farms
- Simulates "impact experiments" to measure the effects of environmental change or policy change
- Simulates "adoption experiments" under specified environmental and economic conditions
- Used globally by researchers and institutions including CGIAR centers and AgMIP



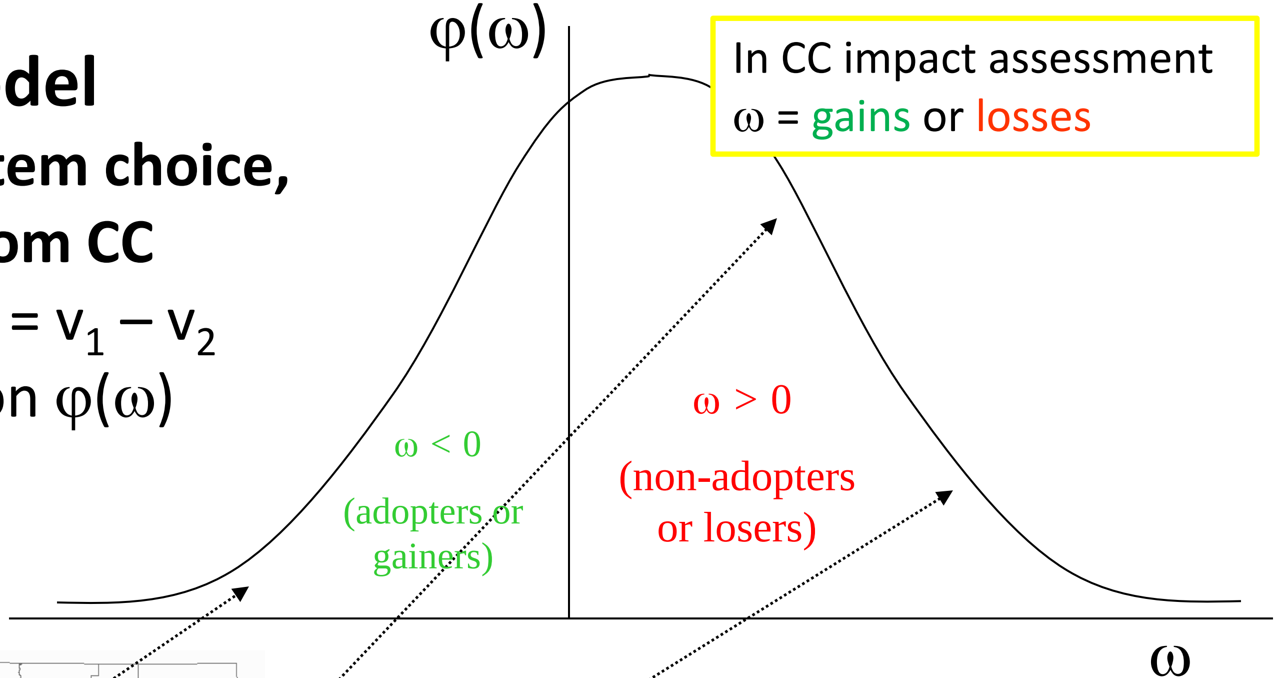
Proof-of-Concept Exercise

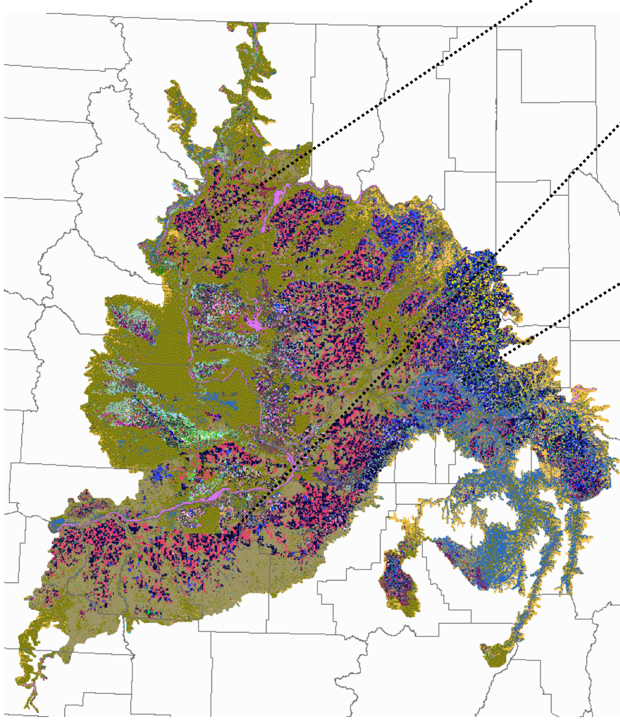


TOA-MD Model

Opportunity cost, system choice, gains & losses from CC

Opportunity cost $\omega = v_1 - v_2$ follows distribution $\varphi(\omega)$





"every farm has its ω"

A "Proportional Relative Yield" Model to Link CropSyst Simulations to TOA-MD

B = simulated crop yield with current climate

C = simulated crop yield with future climate

$R = C/B$

μ_R = mean of R, σ_R = std dev of R

y(1) = expected yield for system 1

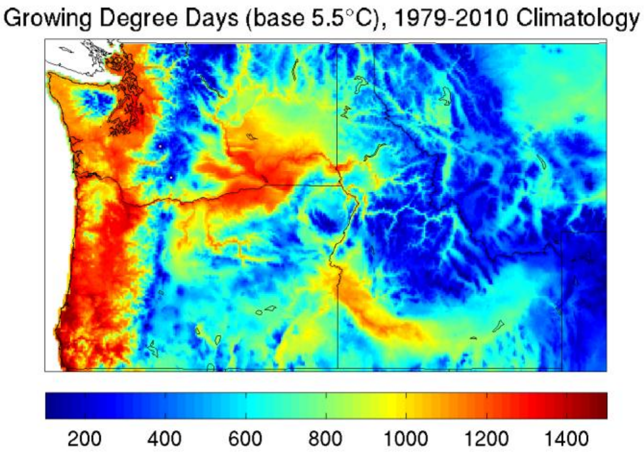
y(2) = R y(1) = future expected yield

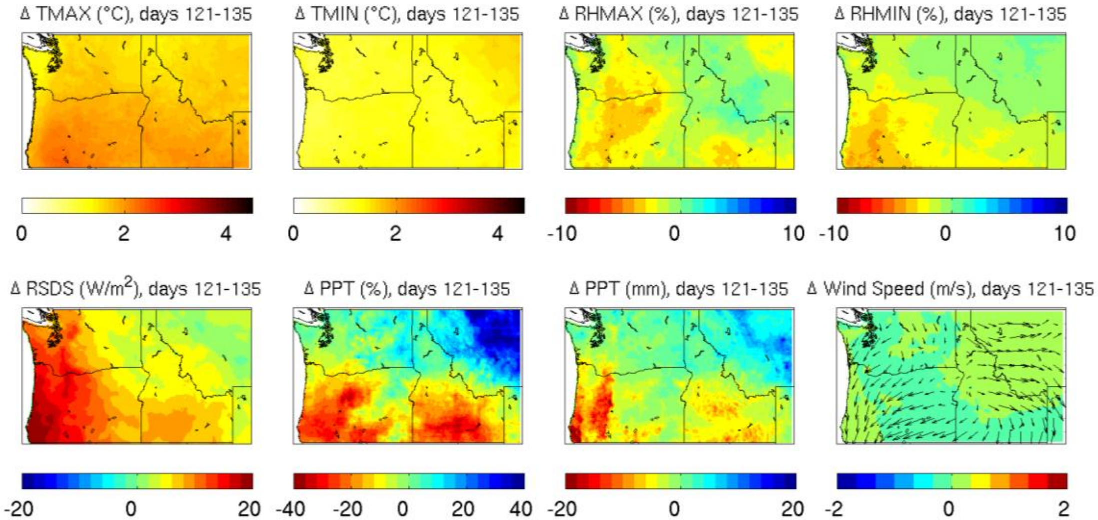
Key point: most previous studies use only averages over large areas, and would treat this region as one "representative farm" (e.g., previous US assessment)

- CropSyst simulations used to estimate μ_R and σ_R.
- Ag Census data used to estimate the y(1) distribution
- These two sets of parameters can be used to calculate the spatial distribution of y(2) and **opportunity cost (distribution of gains and losses)** needed to implement the TOA-MD model

Climate Data

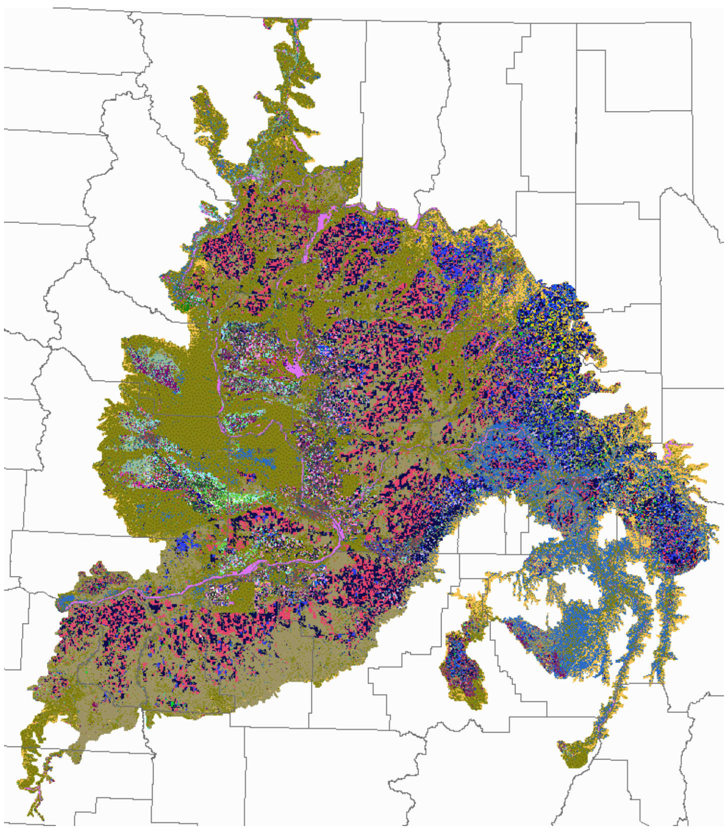
- A new gridded dataset of historical meteorological data was prepared
- CMIP3 downscaled data provided to the team
- Work on CMIP5 and NARCCSP is in progress



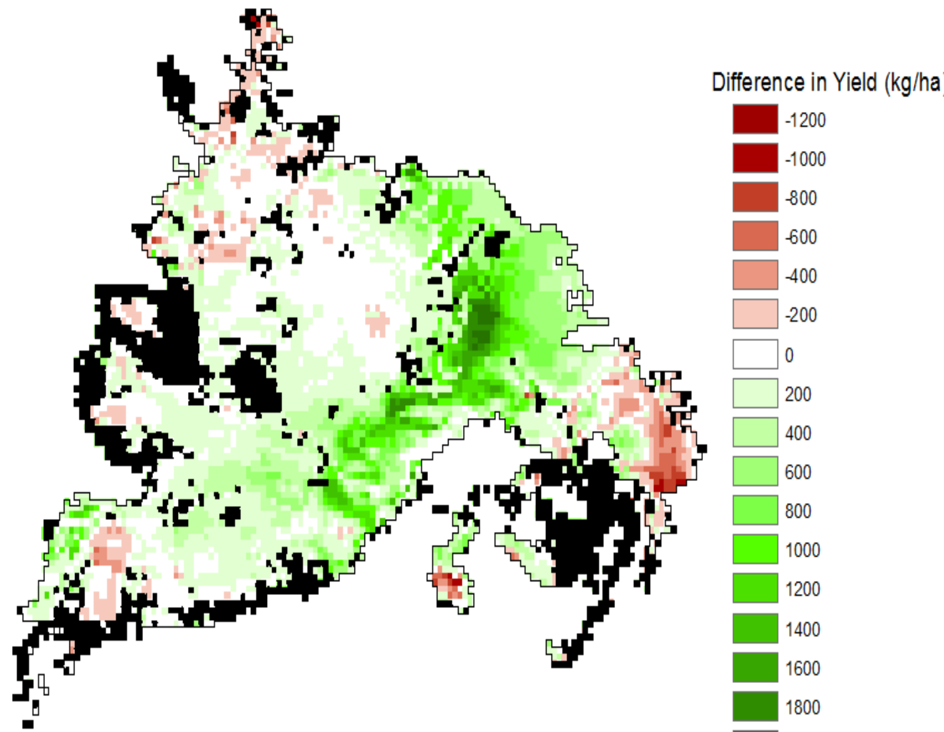


CropSyst PROOF OF CONCEPT TEST SIMULATIONS

Land suitability
(WW = dark blue)



Simulated WWF yield differences
(future minus historical)



WWF Farm Statistics and Relative Yield Distribution

PROOF-OF-CONCEPT EXERCISE

Ryield = 2020-2035 yield/1995-2010 yield

WWF Farm Statistics

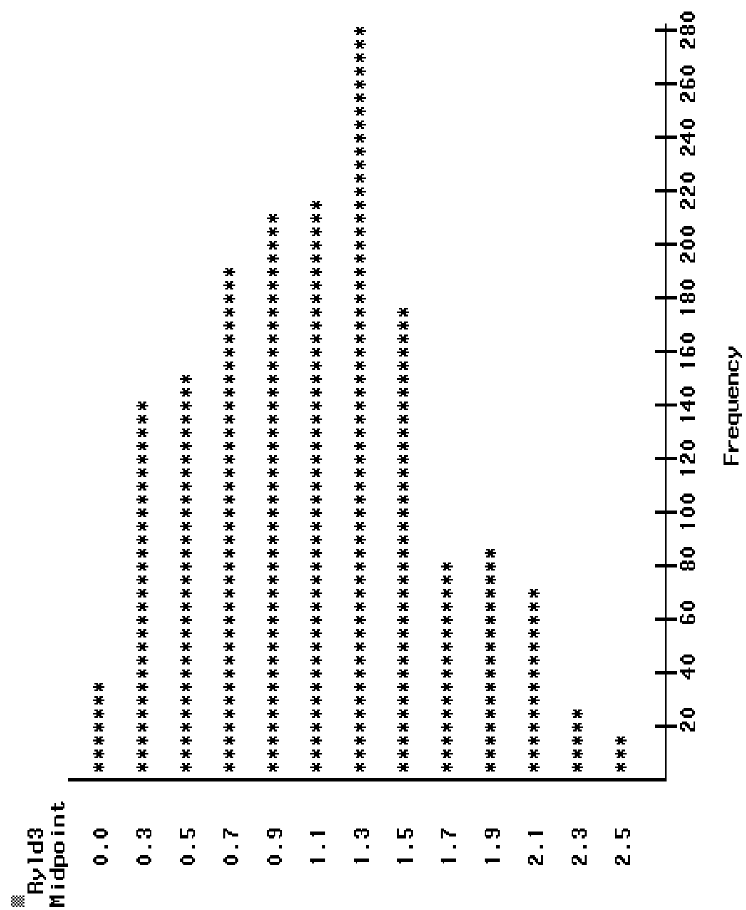
2007 Ag Census

978 farms
2.26×10^6 cropped acres + fallow
860,000 ww acres

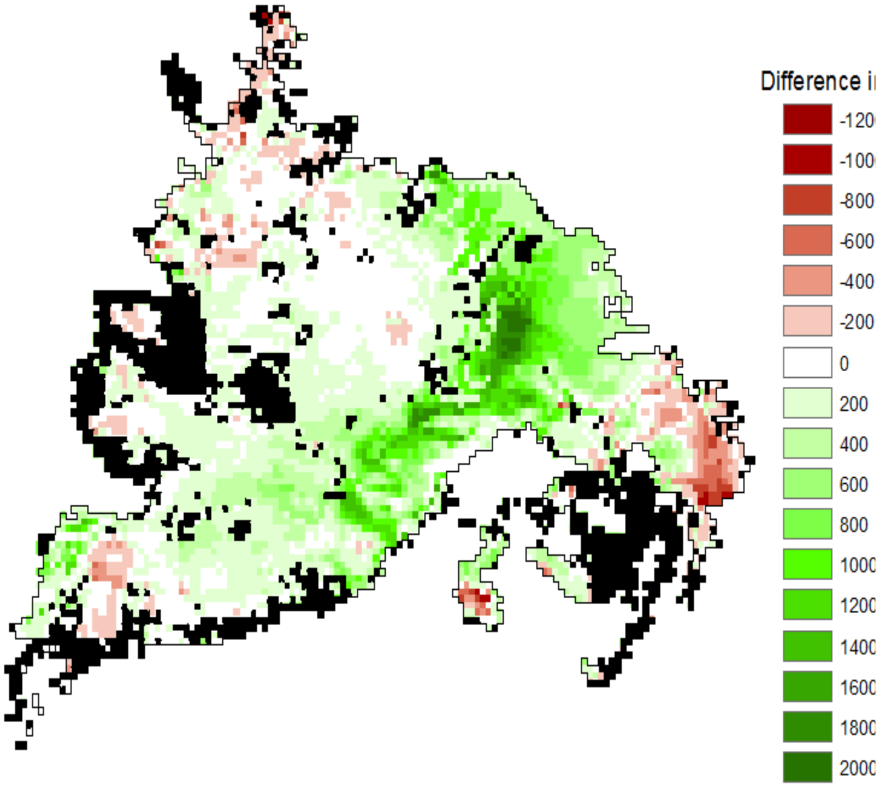
	Mean	Std
Farm size (ac)	2308	782
Yield (bu/ac)	51	13
Fallow (%)	38	8
Ryield	1.25	0.73

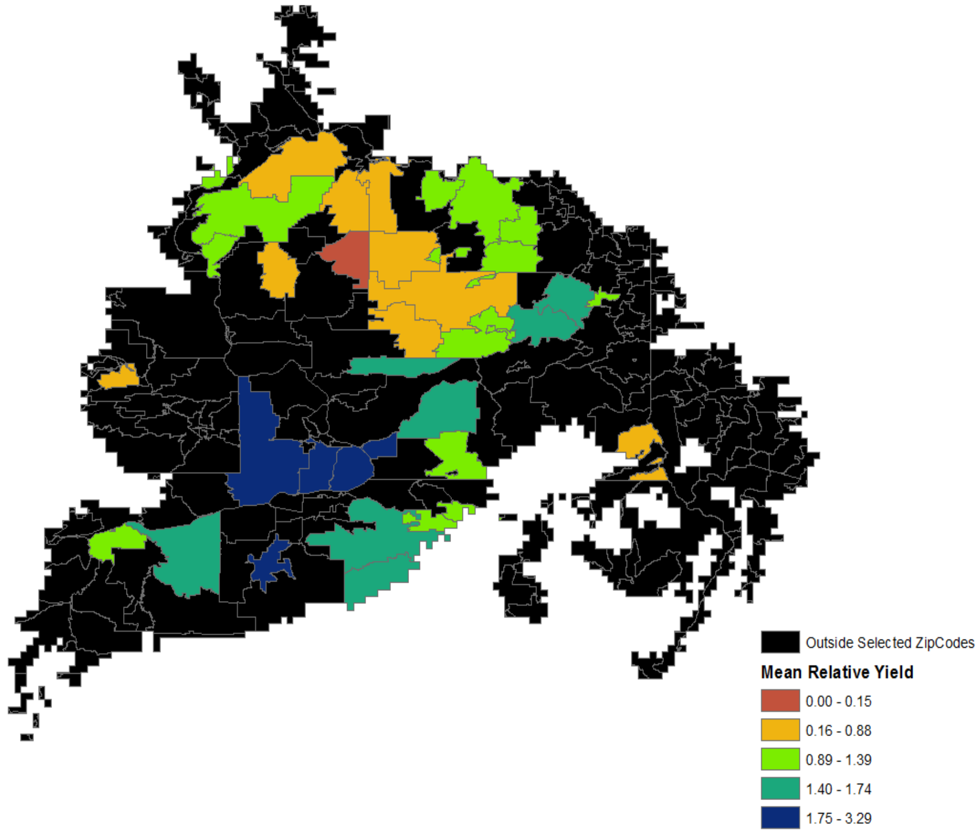
Why is mean Ryield > 1?

Ryield distribution



WWF Yield Differences and Mean Relative Yields by Zip Code Area PROOF OF CONCEPT TEST SIMULATIONS





Climate Impact and Adaptation

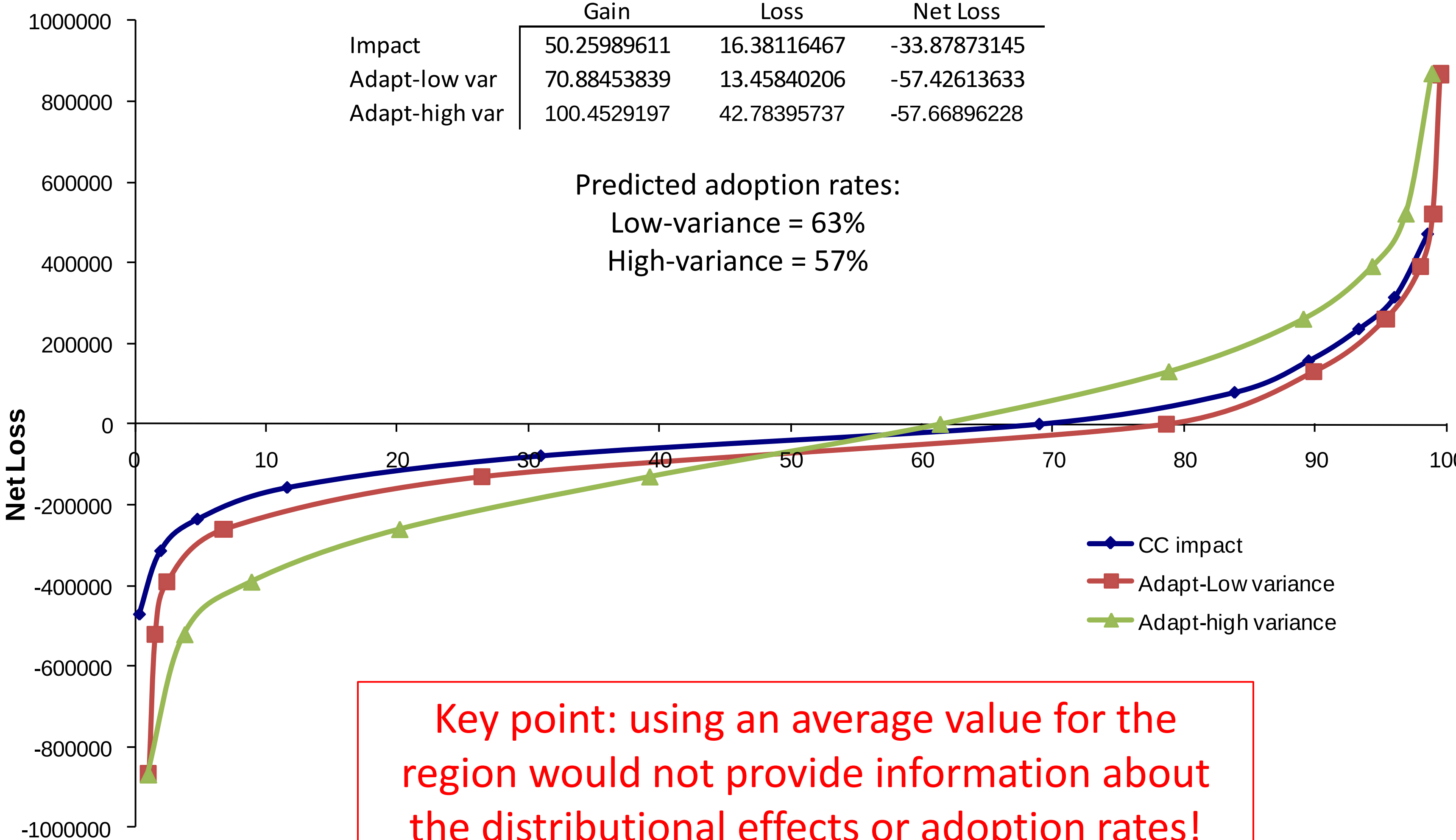
PROOF OF CONCEPT EXERCISE

- Simluate impact of CC on WWF without adaptation
- Simulate WW variety adapted to future climate
- Assumptions:
  - mean yield + 10%
  - more resilient variety increases yields in marginal areas, but lowers yields in favorable areas (spatial variance decreased 25%)
  - no change in cost of production
- Only WWF impacted by climate in this exercise

TOA-MD Climate Impact and Adaptation Analysis

PROOF OF CONCEPT EXERCISE

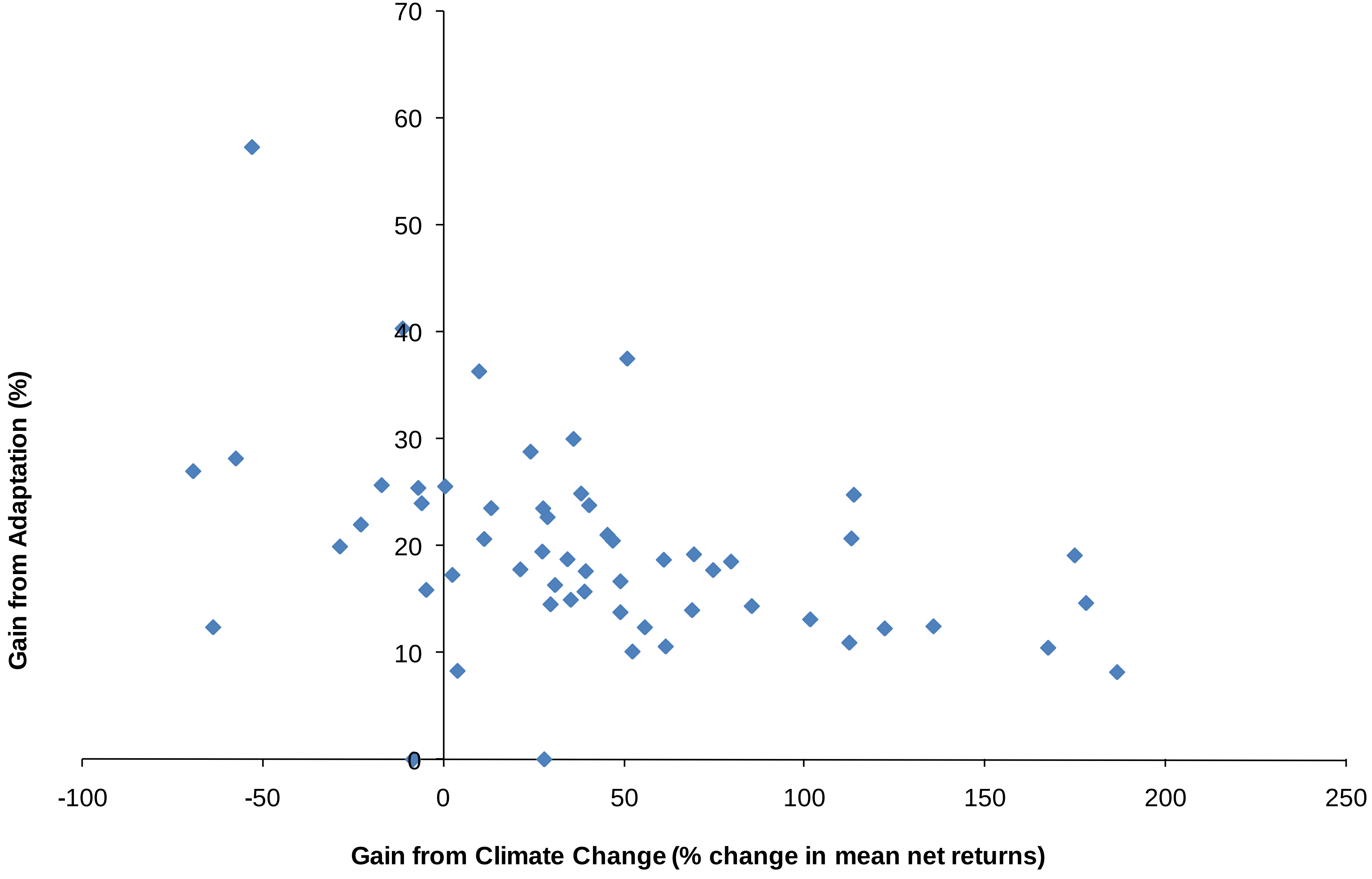
	Gain	Loss	Net Loss
Impact	50.25989611	16.38116467	-33.87873145
Adapt-low var	70.88453839	13.45840206	-57.42613633
Adapt-high var	100.4529197	42.78395737	-57.66896228



Key point: using an average value for the region would not provide information about the distributional effects or adoption rates!

Gains and Losses from CC and Adaptation

PROOF OF CONCEPT EXERCISE



Next Steps

- Evaluate feasible climate, crop system and socio-economic scenarios
- Test and implement procedures to automate simulations, document and store input data and outputs
- Develop procedures for integrating experimental, modeled and expert data to parameterize models
- Develop procedures for interpretation and communication of simulations and use with qualitative data

Discussion

- How can we bring together growers, REACCH scientists, other stakeholders to
  - Identify and “design” future systems & scenarios?

    (Global Futures Project)
  - Better understand factors driving economic, environmental and social sustainability of these systems?
  - Effectively communicate what we are doing and what we are learning?