# CLIMARK: Climate Change and International Market Systems


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Michigan State University


*Presentation at the:*

Northwest Michigan Orchard and Vineyard Show

*Acme, Michigan*

*January 22, 2013*

# CLIMARK: Climate Change and International Market Systems

- Approximately 30 faculty, students, and extension personnel from the United States (Michigan), Germany, Poland, Hungary, and Ukraine
- Disciplinary expertise includes: Geography, Agricultural Economics, Computer Science, Economics, and Horticulture

# CLIMARK Project Investigators

- ***Michigan State University***
  - Julie Winkler (Geography)
  - Suzanne Thornsbury (Agricultural Economics)
  - Pang-Ning Tan (Computer Science)
  - Jeffrey Andresen (MAES, MSUE)
  - J. Roy Black (Agricultural Economics)
  - Scott Loveridge (Agricultural Economics)
  - Shiyuan Zhong (Geography)
  - Nikki Rothwell (MSUE)
  - Jinhua Zhao (Economics)
  - Amy Iezzoni (Horticulture)

- ***International Collaborators:***
  - Géza Bujdosó (Research Institute for Fruit Growing and Ornamentals, Hungary)
  - Frank-M. Chmielewski (Humboldt University, Germany)
  - Yuriy Farion, National Academy of Sciences of Ukraine
  - Peter Hilsendegen (DLR Rheinpfalz, Germany)
  - Dieter Kirschke (Humboldt University, Germany)
  - Robert Kurlus (University of Poznan, Poland)
  - Malgorzata Liszewska (University of Warsaw, Poland)
  - Tadeusz Niedzwiedz (University of Silesia, Poland)
  - Denys Nizalov (Kyiv School of Economics, Ukraine)
  - Zbigniew Ustrnul (Jagiellonian University)
  - Harald von Witzke (Humboldt University, Germany)
  - Alexandr Yareschenko, Ukrainian Academy of Agriculture
  - Costanza Zavalloni (University of Udine, Italy)

# Traditional Assessments

## (following Carter et al. 2007)

Single Location or Region

Specific System, Process or Industry

Isolated time slice

Static Modeling

Output is an assessment of potential impacts for a SYSTEM or ACTIVITY for a LOCATION/REGION

- Local/regional in scale
- Focus on a specific system, process, or industry
- Isolated time slice(s)
  - assessments for different time slices are not informed by earlier time periods
- Local/regional climate projections downscaled from simulations from global climate models
  - Also referred to as a "top-down" approach
- Static modeling
  - often used a series of linked models
  - "feed forward" approach to downstream models without interactions and feedbacks
- Limitations
  - spatial interactions and interdependencies are not considered

# Comprehensive Integrated Assessments

- Global viewpoint
- Sectoral or cross-sectoral interactions
- Often use dynamic modeling
  - Complex integrated models
  - Include system components and feedbacks
  - Continuously running models
  - Examples include IMAGE, DICE, PAGE, etc.
- Limitations
  - often not fully integrative across all aspects of a system
  - relatively simple characterizations for some if not all of the system components

Global

Sector (Multiple Industries)

Dynamic Modeling

Continuously running models

Output is an assessment of potential impacts for a SECTOR or multiple sectors at the GLOBAL scale

# What is missing?

- Assessment methods for sub-sectors (i.e., a specific industry) with international production regions and markets

# *An Example of a Traditional Assessment*

## *The Pileus Project: Climate Science for Decision Makers in the Great Lakes Region*

The *Pileus Project* is named after the *Pileus* cloud which appears as a cap or a hood above or  attached to the top of a cumulonimbus cloud.

# *Pileus Project*
# Specific Goals

- Better understand the influence of climate on Michigan's agriculture and tourism industries.
- Quantify the impacts of past and projected climate variability and change on agriculture and tourism in Michigan.
- Develop web-based decision-support tools for weather and climate-related risk management.

# *Pileus Project*: Conceptual Framework
# *A "Traditional Assessment"*

Single Location or Region

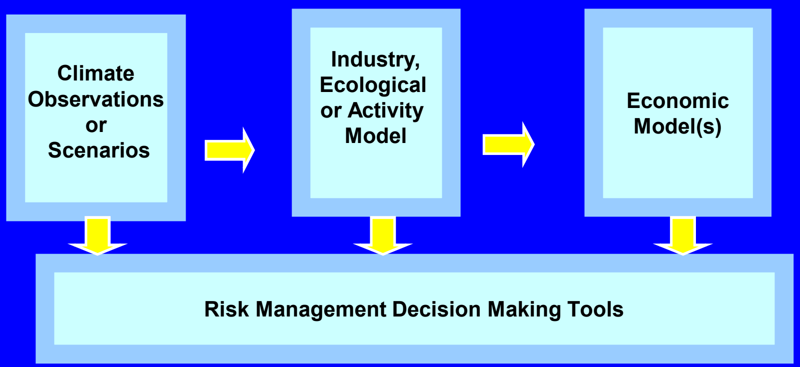
Specific System, Process or Industry

Static Modeling

Isolated time slice(s)

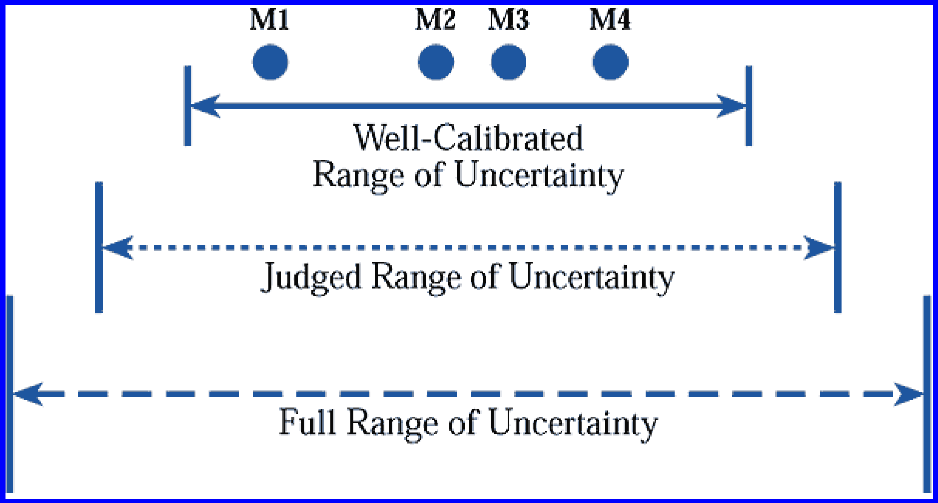
Output was an assessment of potential impacts for a SYSTEM or ACTIVITY for a LOCATION/REGION

- Michigan
- Tart cherry industry
- End-to-end assessment
- Early, mid, and late century time slices
- *No consideration of*
  - *Climate impacts on tart cherry production outside of Michigan*
  - *Adaptation*



# *Pileus Project:* Conceptual Framework *Addressing Uncertainty*

- Uncertainty analysis limited to uncertainty in future climate projections
- Ensemble approach where multiple scenarios are used to estimate the "quantifiable range of uncertainty




Source: IPCC, 2001

# Web-based Tool Delivery

# Historical Yield Tool

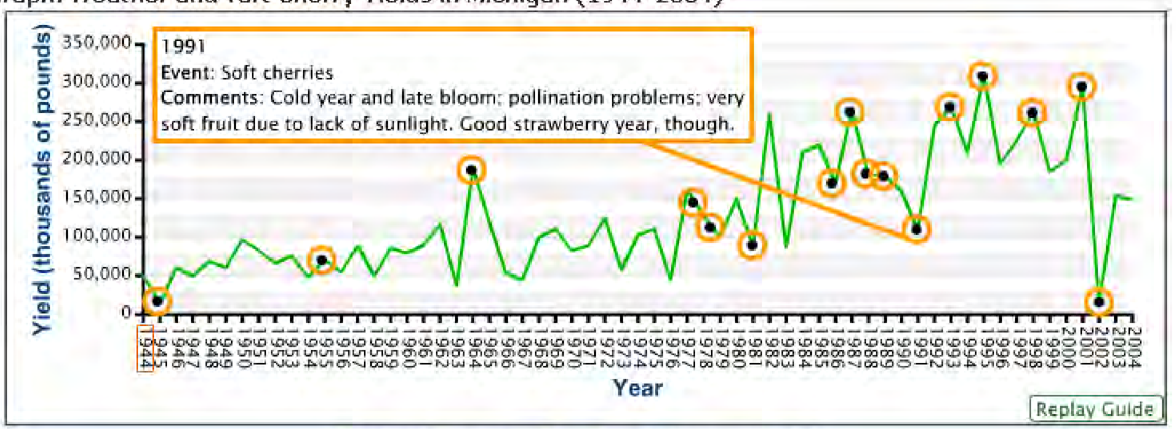
**Agriculture** > Historical Tart Cherry Yield Tool

## Historical Tart Cherry Yield Tool

Learn about this tool

Top graph displays variability in historical tart cherry yields (1944-2004) and the associated weather events as recalled by farmers who have been part of the industry since early 1940s. Blue box at the bottom shows the results from our simulation model for the same period. **We strongly recommend that you visit the** Learn About page to understand the benefits of this tool.

**Graph: Weather and Tart Cherry Yields in Michigan (1944-2004)**




### Critical Drivers for Tart Cherry Yield

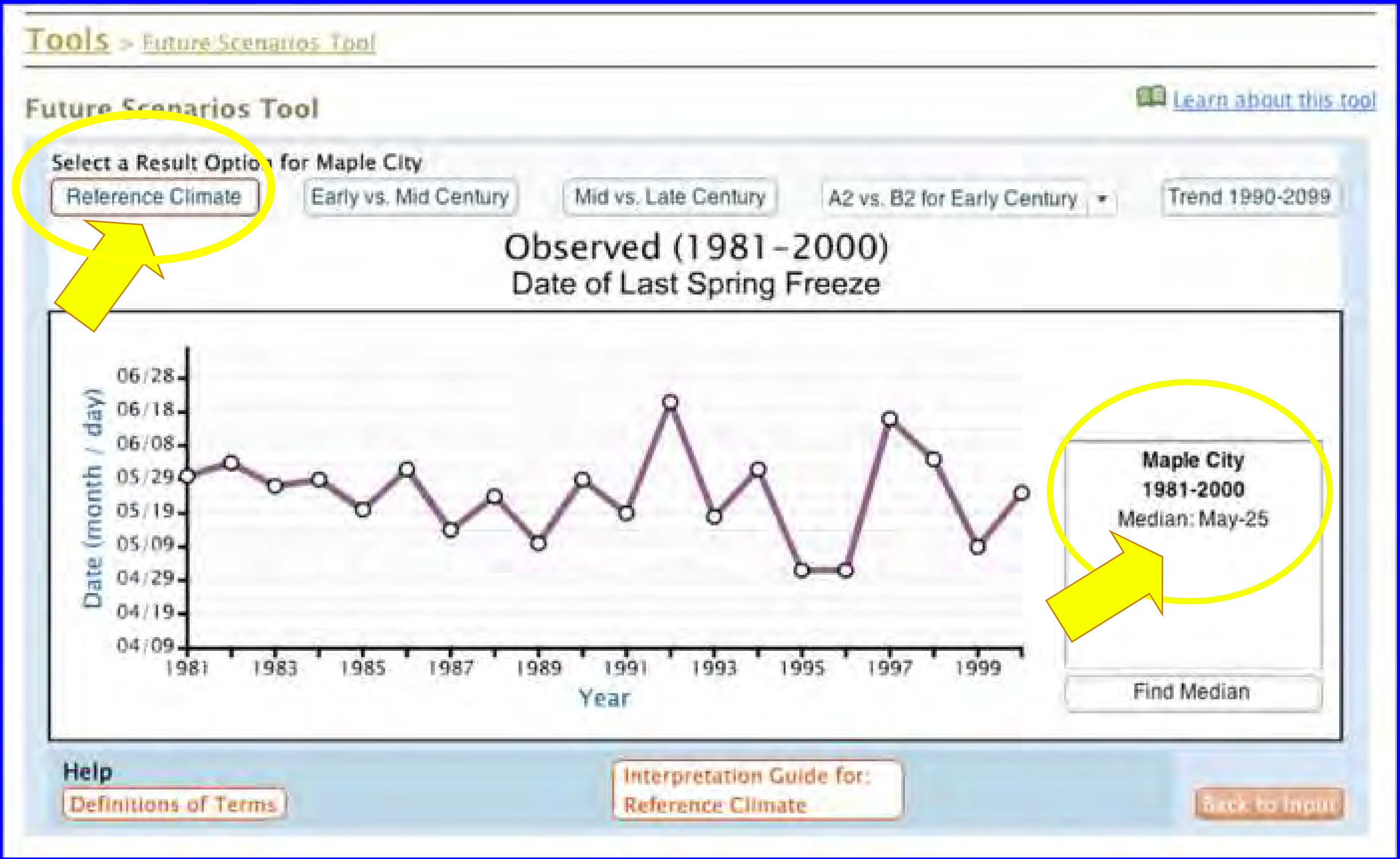
**1944 – Modeled simulation conditions**

| | | | |
|---|---|---|---|
| Bud cold damage: | Light | Moderate | Severe |
| Pollination conditions: | Poor | Average | Favorable |
| Late season precip. last year: | Light | Average | Heavy |

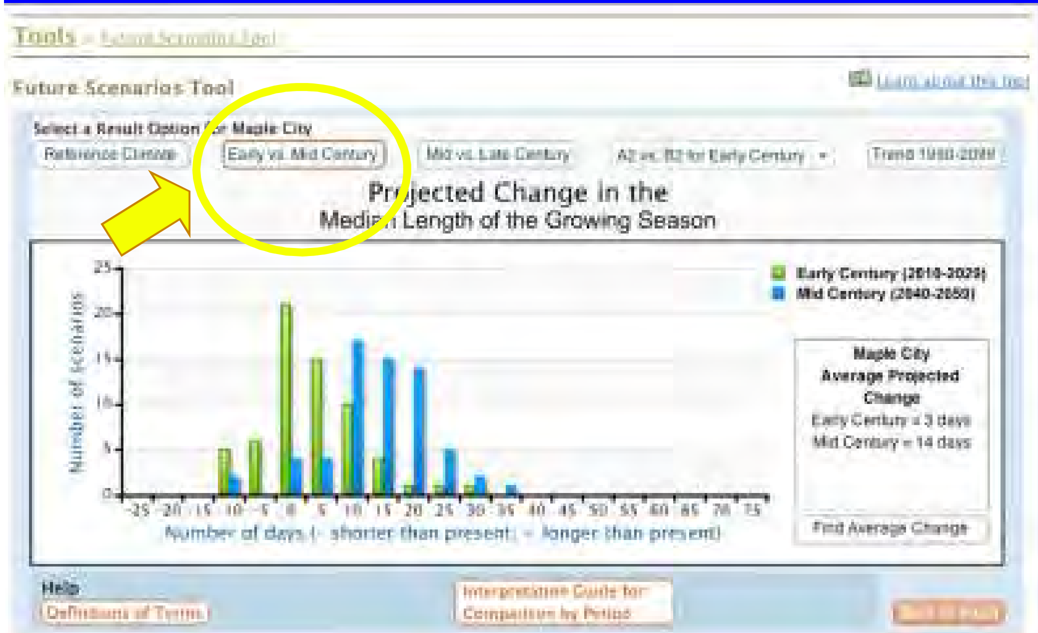
In general terms of impact on yield, the greater the bud damage, the less the yield, the warmer and drier the pollination period, the greater the yield, and the greater the precipitation total at the end of the previous growing season, the greater the yield. Note that these associations may not always hold true due to other factors not considered in yield estimation (e.g. wind whip, poor fruit quality).

# Future Scenarios Tool: Input Page

# Display Option: Reference Climate

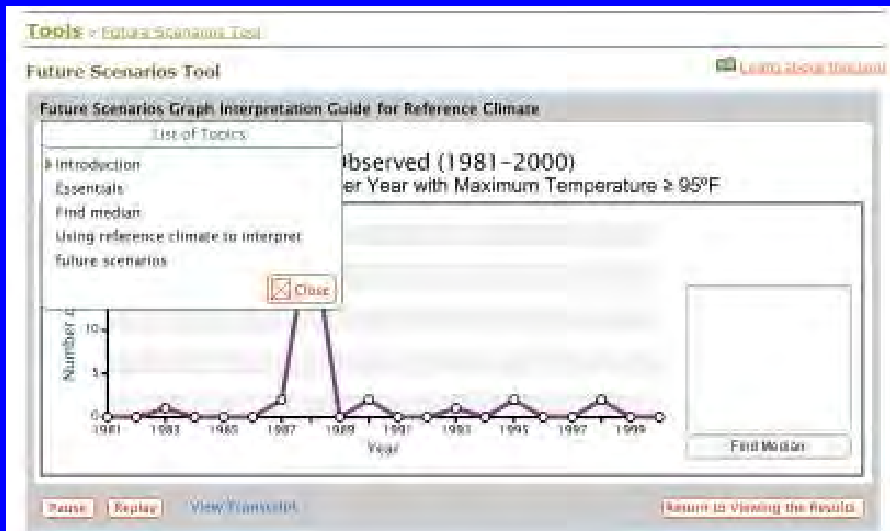


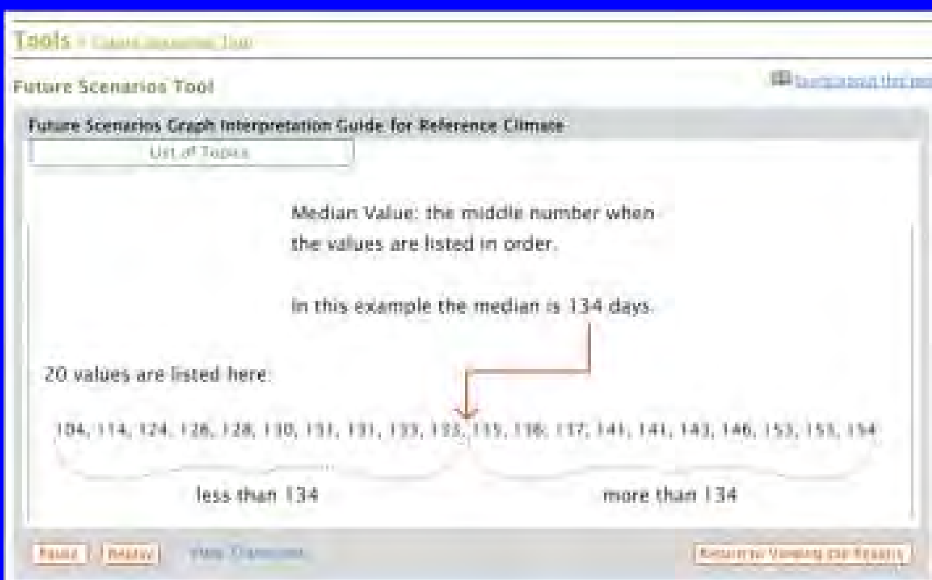
# Display Option: Time Slices

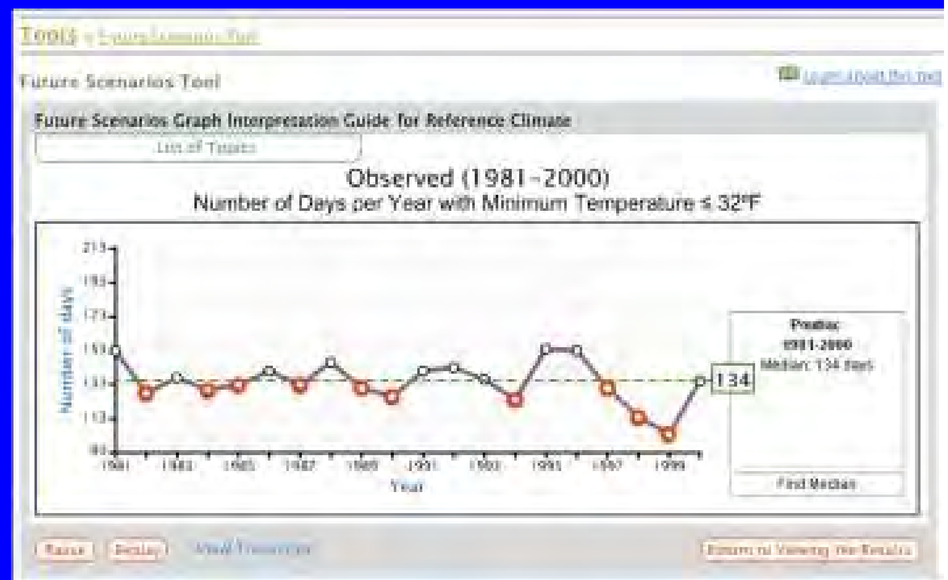



# Interpretation Guide

*What is a median?*



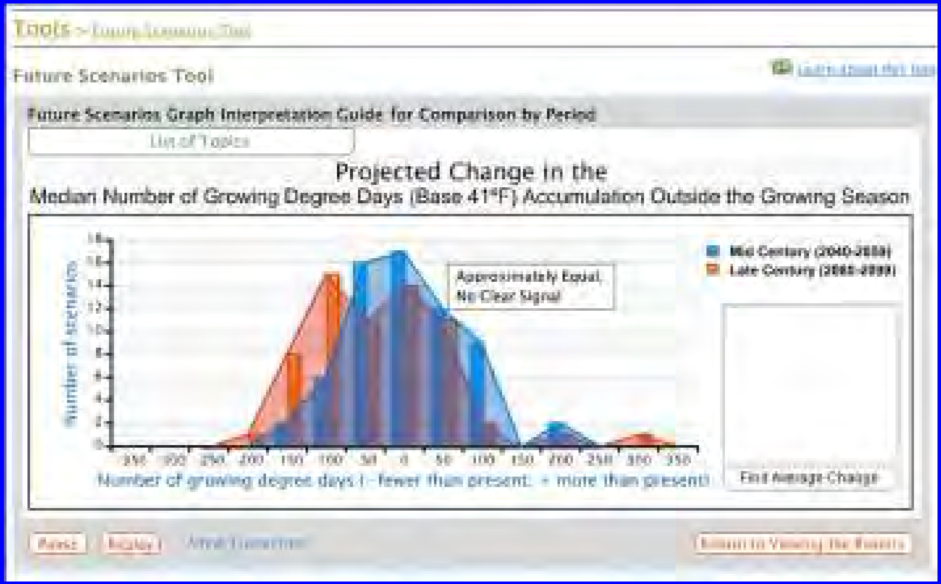



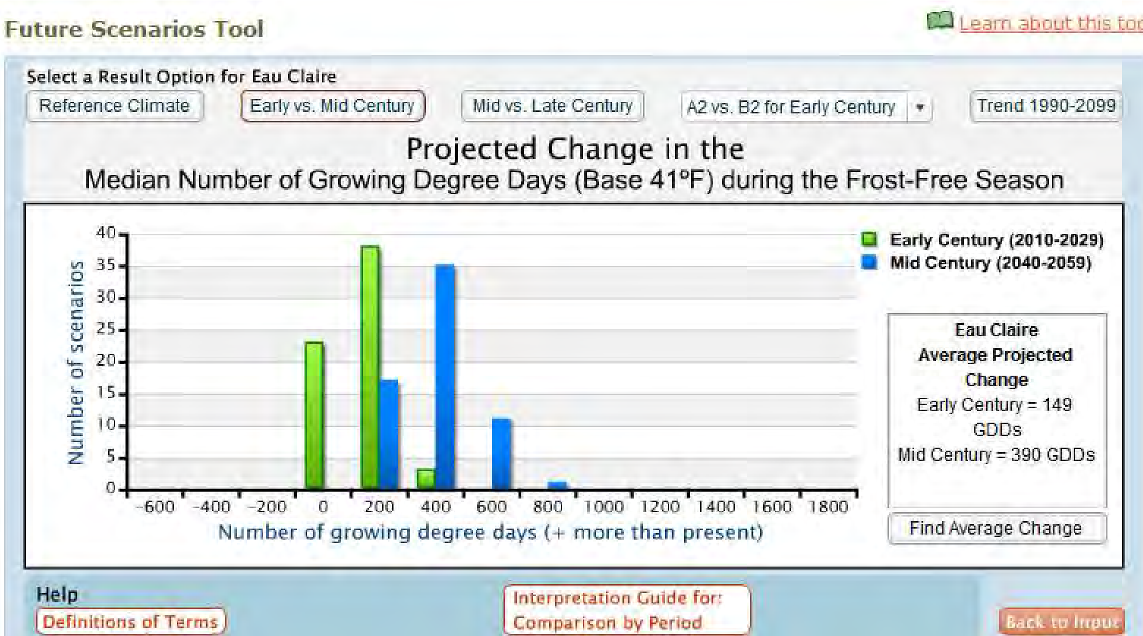



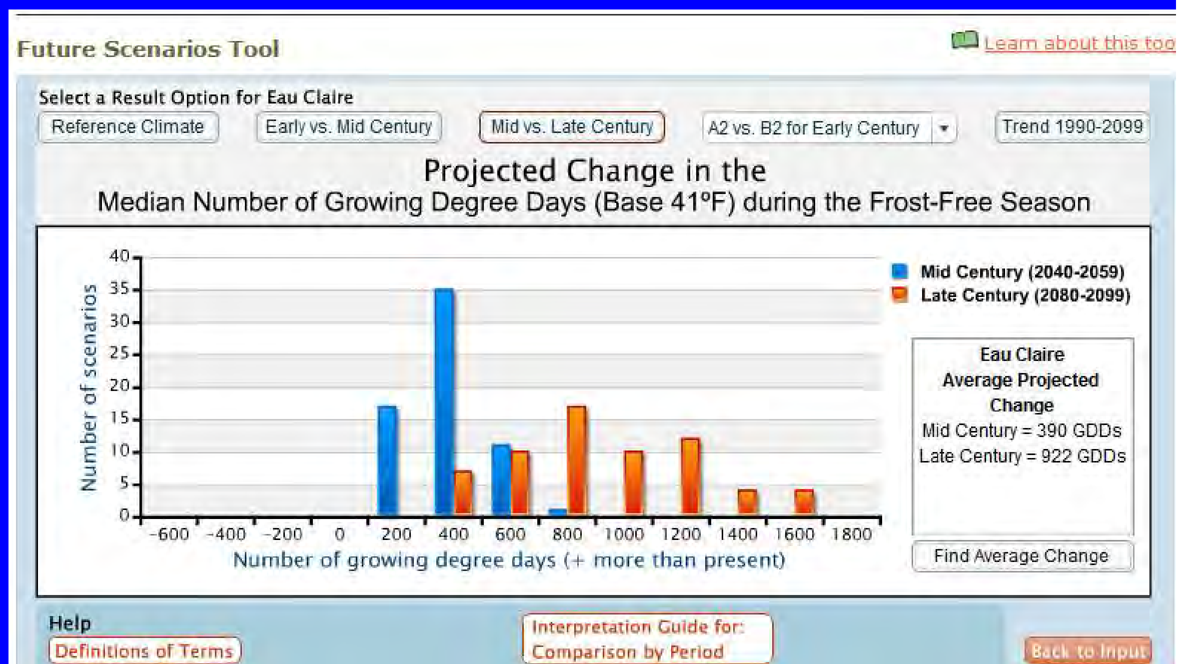
# Interpreting Uncertainty

**Example 1: Consistent signal but considerable uncertainty**


**Example 2: No clear signal**




Future Scenarios Tool
Learn about this too
Select a Result Option for Eau Claire
Reference Climate
Early vs. Mid Century
Mid vs. Late Century
A2 vs. B2 for Early Century
Trend 1990-2099
Projected Change in the
Median Number of Growing Degree Days (Base 41ºF) during the Frost-Free Season
Number of scenarios
Number of growing degree days (+ more than present)
Early Century (2010-2029)
Mid Century (2040-2059)
Eau Claire
Average Projected
Change
Early Century = 149 GDDs
Mid Century = 390 GDDs
Find Average Change
Help
Definitions of Terms
Interpretation Guide for:
Comparison by Period
Back to Input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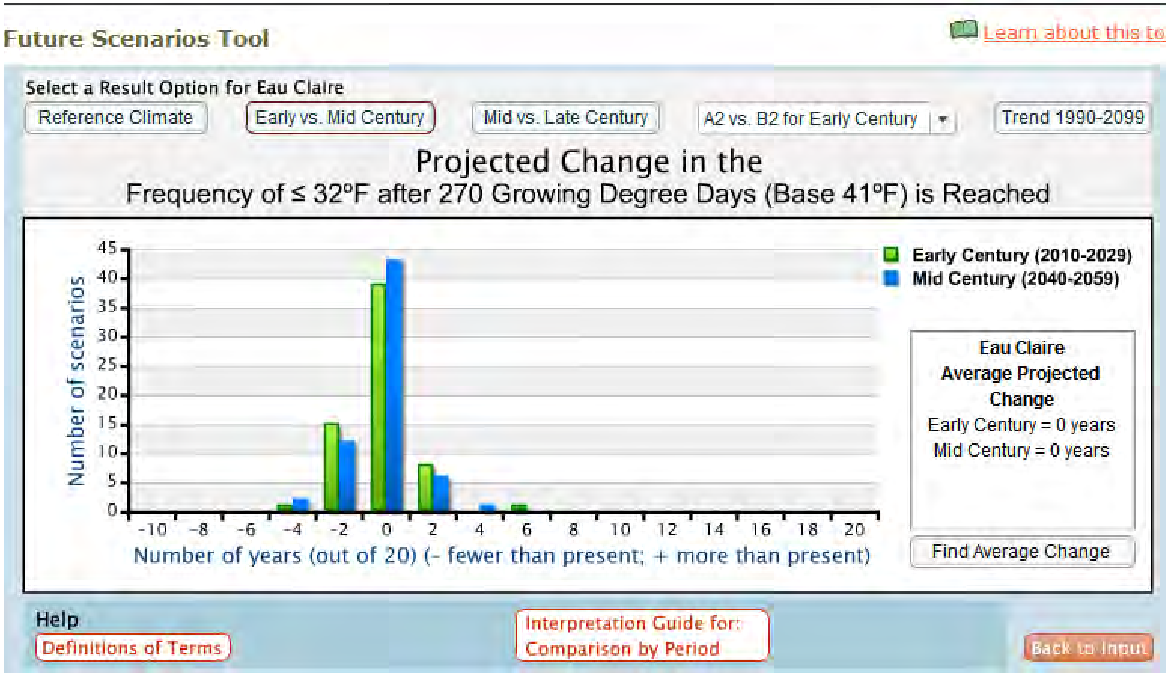
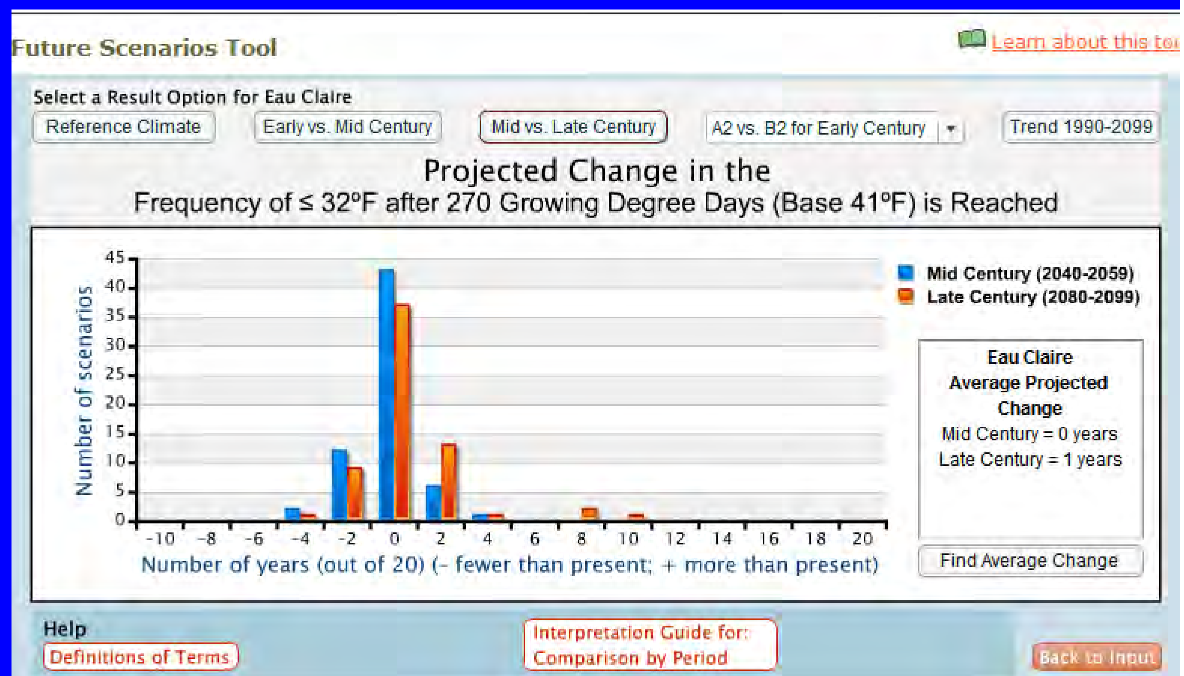
Mid Century (2040-2059)
Late Century (2080-2099)
Eau Claire
Average Projected
Change
Mid Century = 390 GDDs
Late Century = 922 GDDs
Find Average Change
Help
Definitions of Terms
Interpretation Guide for:
Comparison by Period
Back to Input


Future Scenarios Tool
Learn about this too
Select a Result Option for Eau Claire
Reference Climate
Early vs. Mid Century
Mid vs. Late Century
A2 vs. B2 for Early Century
Trend 1990-2099
Projected Change in the
Frequency of ≤ 32°F after 270 Growing Degree Days (Base 41°F) is Reached
Number of scenarios
Number of years (out of 20) (- fewer than present; + more than present)
Early Century (2010-2029)
Mid Century (2040-2059)
Eau Claire
Average Projected
Change
Early Century = 0 years
Mid Century = 0 years
Find Average Change
Help
Definitions of Terms
Interpretation Guide for:
Comparison by Period
Back to Input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Early vs. Mid Century
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Projected Change in the
Frequency of ≤ 32°F after 270 Growing Degree Days (Base 41°F) is Reached
Number of scenarios
Number of years (out of 20) (- fewer than present; + more than present)
Mid Century (2040-2059)
Late Century (2080-2099)
Eau Claire
Average Projected
Change
Mid Century = 0 years
Late Century = 1 years
Find Average Change
Help
Definitions of Terms
Interpretation Guide for:
Comparison by Period
Back to Input

# Perennial Crop Investment Tool

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Pileus Project

Climate Science for Decision Makers

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## Perennial Crop Investment Tool

Learn about this tool | User Cases

This tool will help you to develop a planning horizon that maximizes your average profitability per year. This tool builds upon the impact of climate on average yield as you estimate the profitability of your orchards during the 5 stages of Production, Growth, Price, Quality and Cash Flow. By including cost information, interest rates and tart cherry prices, this tool enables you to calculate long-term average profitability. You may choose to rely on the default values or customize the information to represent your individual orchard costs.

### STEP-1: Projected Yield at Peak Production

**Your primary objective in this section is to calculate the predicted yield per acre, for each year, over the projected life time of a block of trees.**

| Production: | Unit | Value |
|---|---|---|
| Trees/acre: | trees/acre | 120 |
| Expected yield at peak production: | lbs/tree | 100 |

| Set-aside: (Due to the Federal Marketing order, enter the percent of production that is not harvested) | Unit | Value |
|---|---|---|
| Expected percent of production marketed (averaged across years) | % | 95 |

Start Over | Next »

The models and software applications on the *Pileus* website are provided "as is." MSU makes no warranty, express or

# Industry Inputs

- Recollections of years of high and low yield.
- Input on the critical factors that influenced production methods, markets, cost, and price.
- Provided essential, unpublished data on phenological timing and yield for their orchards.
- Provided information on the costs incurred over the life cycle of an orchard block.
- Helped identify the climate parameters most relevant to tart cherry production.
- Reviewed the initial model output to help assess the adequacy of the models.
- Provided input on configuration of the decision-support tools

CLIMARK

# CLIMARK: Moving beyond *Pileus*

- Impetus came from tart cherry industry
  - 2002 freeze event "opened the door" to imports of tart cherries
- Need for an expanded conceptual framework for climate change assessments
  - Traditional local/regional climate impact and adaptation assessments do not consider important spatial and temporal interactions for international market systems
- The tart cherry industry was an appropriate example industry as:
  - Highly sensitive to weather and climate extremes
  - Production is concentrated in a few countries

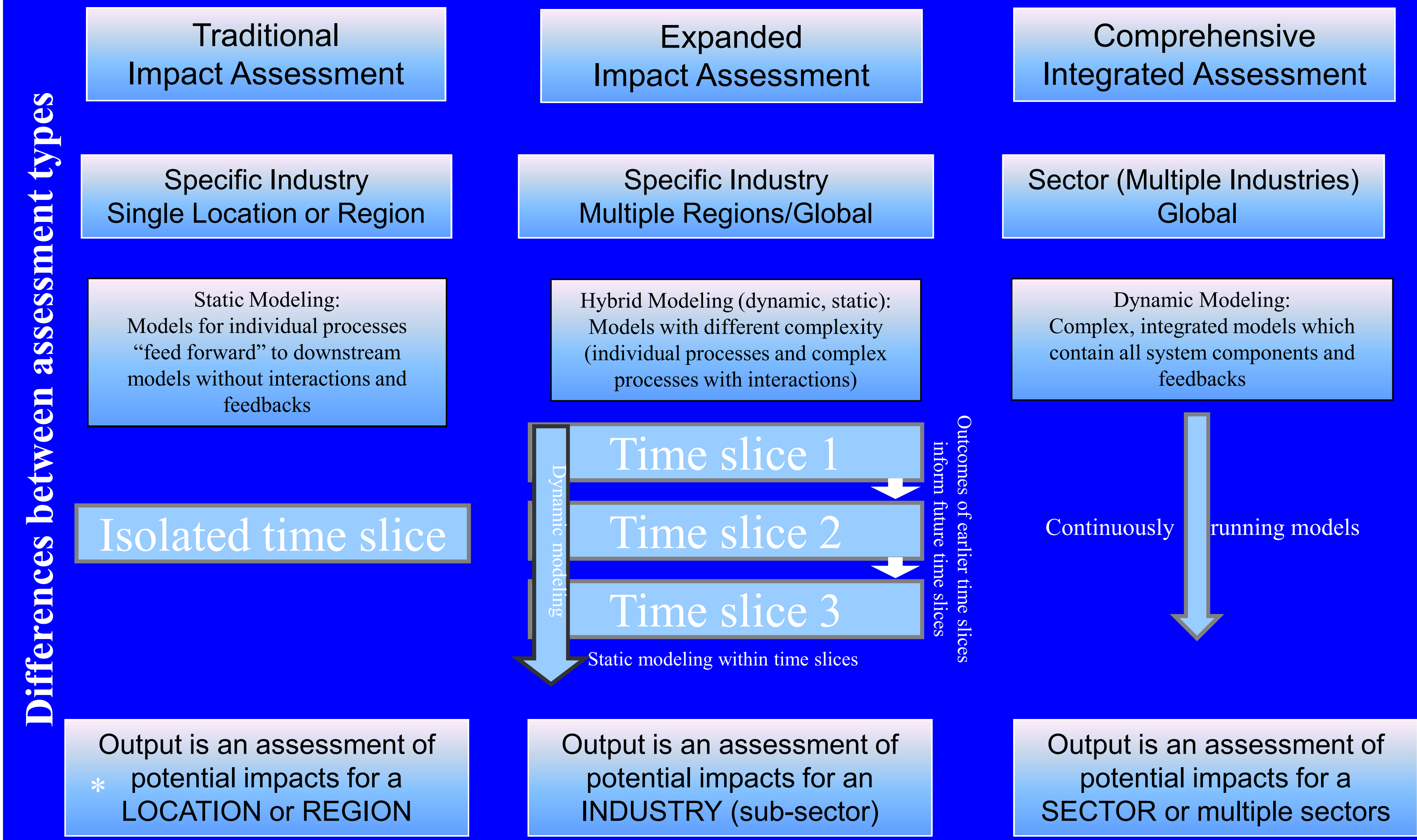
# CLIMARK Project: Overall Objective

- Can we demonstrate that it is possible, in spite of numerous constraints, to conduct a meaningful, industry-wide assessment of the potential impacts of climate change?

# CLIMARK Project

- First step was to build a research team
  - Agricultural economists, climatologists, computer scientists, economists, horticulturalists
  - U.S. (Michigan), Germany, Poland, Hungary, Ukraine

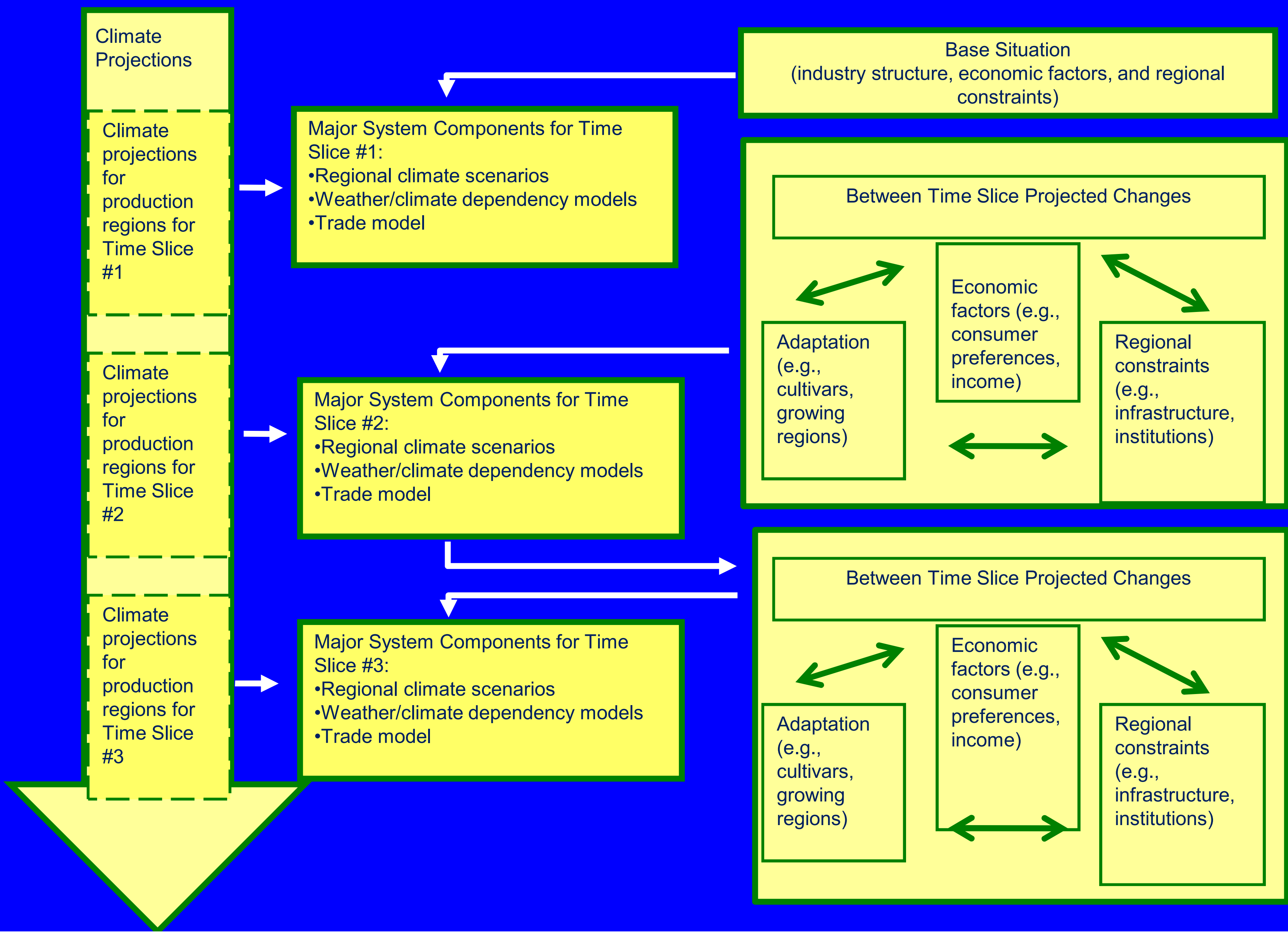
# An "Expanded" Impact Assessment Approach





. Winkler, J.A., S. Thornsbury, M. Artavio, F.-M. Chmielewski, D. Kirschke, S. Lee, M. Liszewska, S. Loveridge, P.-N. Tan, S. Zhong, J.A. Andresen, J.R. Black, R. Kurlus, D. Nizalov, N. Olynk, Z. Ustrnul, C. Zavalloni, J.M. Bisanz, G. Bujdosó, L. Fusina, Y. Henniges, P. Hilsendegen, K. Lar, L. Malarzewski, T. Moeller, R. Murmylo, T. Niedzwiedz, O. Nizalova, H. Prawiranata, N. Rothwell, J. van Ravensway, H. von Witzke, and M. Woods, 2010: Multi-regional climate change assessments for international market systems with long-term investments: A conceptual framework. *Climatic Change*, DOI 10.1007/s10584-009-9781-1

# Modeling Approach



# Project Components

- Climate projections
  - Develop new downscaling procedures that combine dynamic and empirical downscaling
  - Evaluation of added value of downscaling
- Phenology and yield modeling
  - Comparison and improvement of currently available phenology models
  - Development of a physically-based yield model for tart cherries
  - Evaluation of the representativeness of phenology and yield models between diverse growing regions
- International trade
  - Modify a multi-regional trade model for climate impact analysis
  - Estimate climate change induced shifts in supply/demand curves and elasticities
- Regional economic development
  - Develop future scenarios of macro-economic variables consistent with emissions scenarios and pathways used in the climate model projections
  - Develop between time-slice projections of regional economic variables (e.g., income)
  - Evaluate impact of potential new production regions (Ukraine)
- Adaptation
  - Evaluate different adaptation options
  - Model decision making regarding land conversion (real options approach) under assumption of strategic decision making (i.e., decisions rely on information from early "adopters" )
  - Assess public's "willingness to pay" for agricultural adaptation

# “Meta-Uncertainty”

- Aggregated uncertainty due to differences in the functional form, or structure, of the suite of linked models.

# Two Examples of Project Outcomes

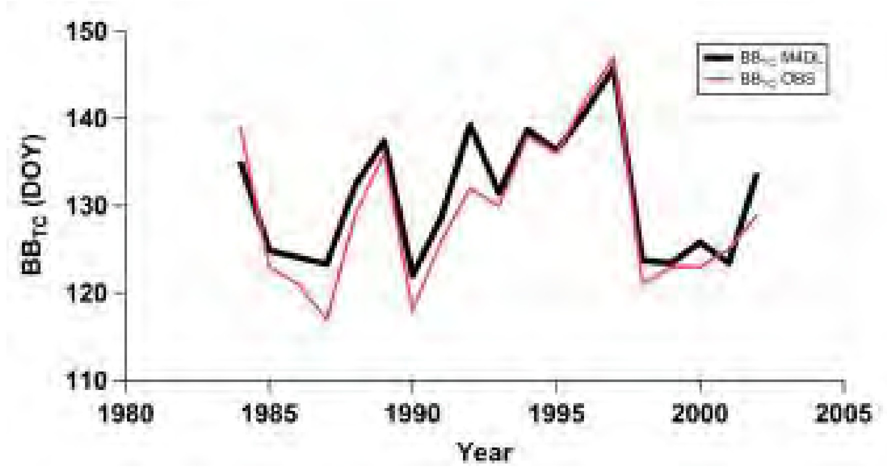
- Improved phenology model that performs well in all production regions
- Survey of "willingness to pay"

# Improved Phenology Models

- Climatic change can differently influence the date of dormancy release for deciduous fruit crops. For this reason, phenological models need to consider both chilling and forcing to calculate possible shifts in the beginning of cherry blossom.

- Developed a combined chilling/forcing model (M4DL) which calculates the chilling requirement in chill portions and the forcing requirement in photo-thermal units (modified GDD-model).

- The introduction of a day length term in the forcing model reduced the RMSE by about 1 to 3 days compared to models without a day length term




*External Model Validation at CLIMARK Experimental Sites in Michigan Model M4DL, Maple City*

# Public Opinion Survey

- Purpose: Explore public attitudes toward support of climate change adaptation of the agriculture sector
- Added questions to Michigan State University's 61st quarterly State of the State Survey (SOSS)
- Feb. 14-April 15 phone survey
- 963 adult Michigan residents responded
- Every SOSS also includes standard questions about income, age, gender, etc.

# Preliminary Results – Basic Frequencies

Unit:%

| | State Government | | US Government | |
|---|---|---|---|---|
| | Corn&soy | Veg&Fruit | Corn&soy | Veg&Fruit |
| **Strongly agree** | 22.4 | 19.9 | 19.1 | 20.2 |
| **Somewhat agree** | 43.1 | 48.5 | 48.4 | 45.4 |
| **SUBTOTAL** | **65.5** | **68.4** | **67.6** | **65.6** |
| **Somewhat disagree** | 16.8 | 15.4 | 14.4 | 16.8 |
| **Strongly disagree** | 13.8 | 11.9 | 13.9 | 14.1 |
| **Don’t know** | 3.9 | 4.4 | 4.2 | 3.4 |

# Federal Gov’t Role - Farmer Adaptation

| National Government’s Role - Corn/Soybean | | | | | |
|---|---|---|---|---|---|
| | Before Event | 1st Week of Event | 2nd Week of Event | After Event | All dates |
| **Strongly Agree** | 15.9% | 34.8% | 26.7% | 8.7% | 19.1% |
| **Somewhat Agree** | 50.2% | 44.5% | 36.6% | 54.6% | 48.4% |
| **Subtotal** | **66.2%** | **79.3%** | **63.3%** | **63.4%** | **67.6%** |
| **Somewhat Disagree** | 16.7% | 9.5% | 10.7% | 15.8% | 14.4% |
| **Strongly Disagree** | 12.8% | 7.2% | 21.9% | 16.7% | 13.9% |
| **Don't know** | 4.4% | 4.0% | 4.0% | 4.1% | 4.2% |
| **National Government’s Role - Fruit/Vegetables** | | | | | |
| **Strongly Agree** | 18.7% | 29.2% | 26.9% | 12.4% | 20.2% |
| **Somewhat Agree** | 42.8% | 46.4% | 38.9% | 52.8% | 45.4% |
| **Subtotal** | **61.4%** | **75.6%** | **65.7%** | **65.2%** | **65.6%** |
| **Somewhat Disagree** | 22.4% | 14.3% | 5.2% | 15.3% | 16.8% |
| **Strongly Disagree** | 12.1% | 7.3% | 24.8% | 17.3% | 14.1% |
| **Don't know** | 4.2% | 2.8% | 4.3% | 2.2% | 3.4% |

# CLIMARK "Challenges"

- Data (availability, differences in recording and reporting conventions, etc.)


www.pileus.msu.edu

www.cherry.cse.msu.edu

# Acknowledgements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- Current funding is from the NSF Dynamics of Coupled Natural and Human Systems Program (grant NSF BCS 0909378).