Challenges in climate assessments for climate change impacts, vulnerability and adaptation: the potential use of gridded datasets

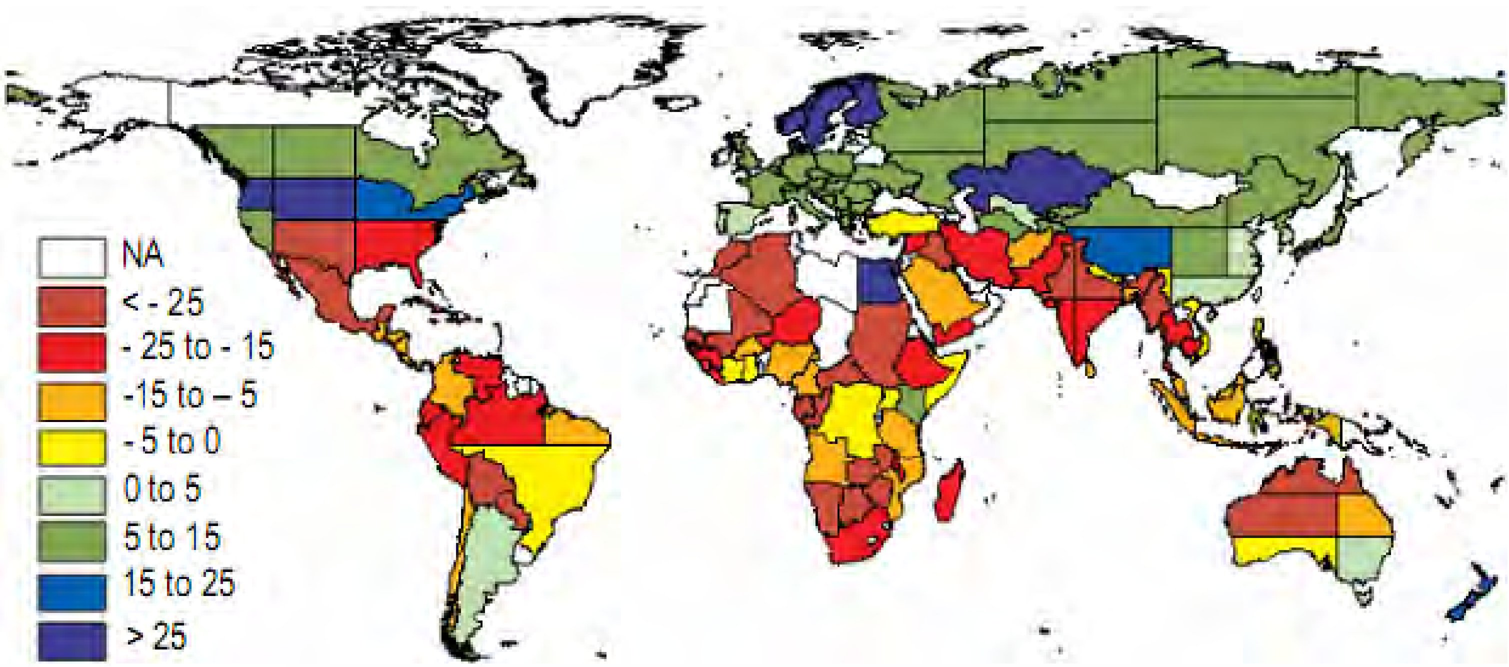
Perdinan

Department of Geophysics and Meteorology,
Bogor Agricultural University

International Conference on Integrated Space Technology Applications to Climate Change
September 2-4 2013

Background

- The need for climate assessments
  - "*climate assessments frequently are undertaken to evaluate climate change impacts, vulnerability, and adaptive capacity*" (Perdinan and Winkler 2013)
  - This presentation focuses on challenges of climate change assessments for climate change impacts, vulnerability and adaptation



Percentage change in agricultural productivity under scenarios of climate change with carbon fertilization by 2080 relative to agricultural productivity in 2003 (Cline, 2007)

Challenges Climate Assessments

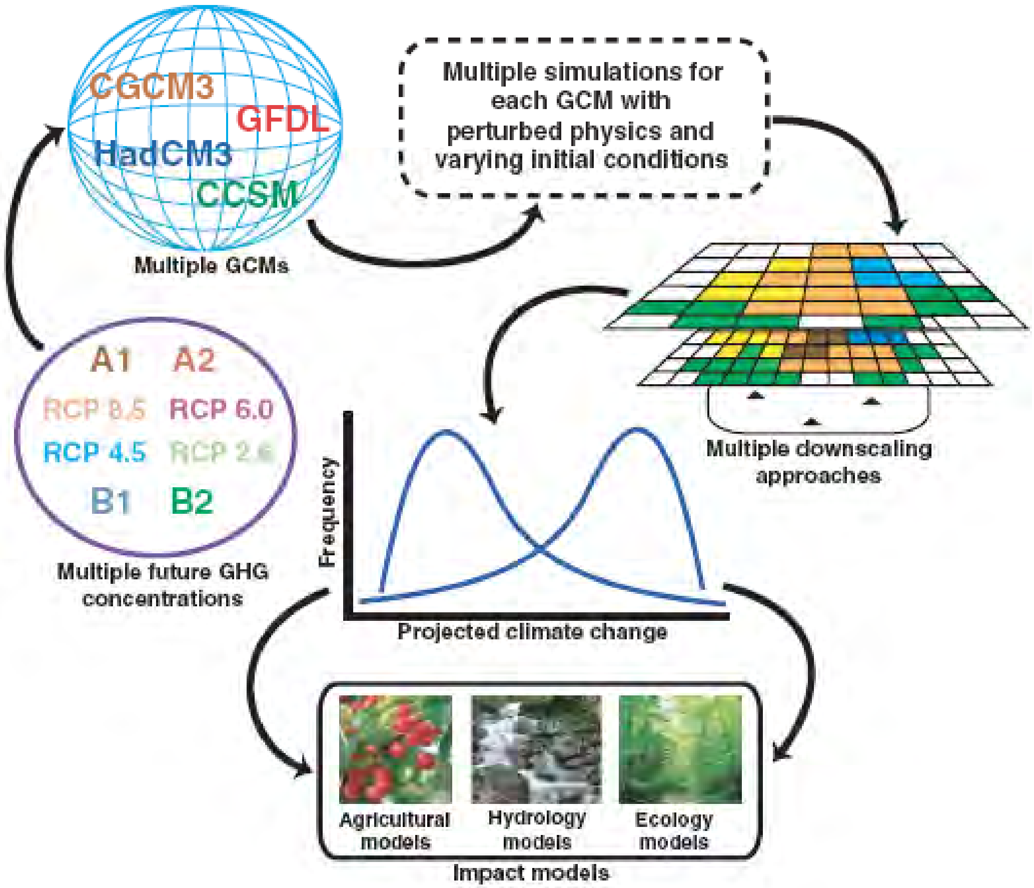
- Issues in climate assessments for climate change impacts, vulnerability and adaptation (Perdinan and Winkler 2013)
  - **the choice of assessment strategy**
  - incorporation of spatial linkages and interactions
  - **constraints of climate observations**
  - interpretation of a climate projection ensemble
  - uncertainty associated with weather/climate dependency models
  - **consideration of landscape–climate influences**

Potential use of gridded datasets?

The Choice of Assessment Strategy

A Typical Method for Climate Assessments

- Top-down Approach
  - goal: measure the potential risks of climate change and identify the need for adaptation (Carter et al. 2007)
  - modeling approach
  - key issue: uncertain climate projections
  - frequently employed
- Bottom-up Approach
  - goal: understand the processes and actions that can affect vulnerability and adaptive capacity (Carter et al. 2007)
  - local thresholds/responses
  - key issue: heavily rely on stakeholder's experience

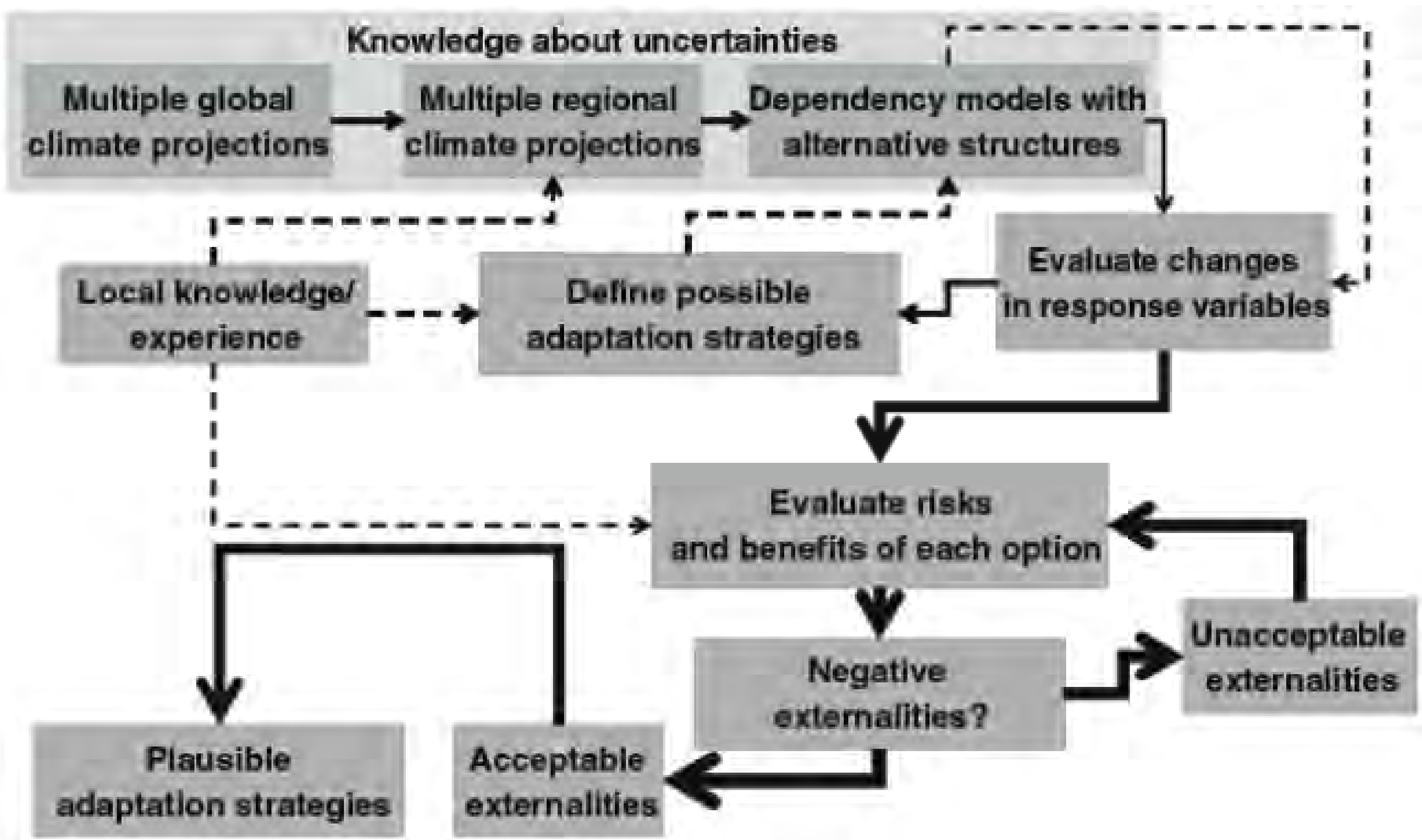


Sources of uncertainty and possible distributions of ensemble projected local/regional climate change (Winkler et al. 2011)

Reference text: Perdinan and Winkler (2013)

A Proposed Method for Climate Assessments

- An integration of top-down and bottom-up approach



Proposed integrated top-down and bottom-up assessment strategy for translating climate information for adaptation assessments (Perdinan and Winkler 2013)

The Potential Use of Gridded Datasets: Consideration of Landscape–Climate Influences

Land-Climate Interactions

- The impacts of human activities to land use change

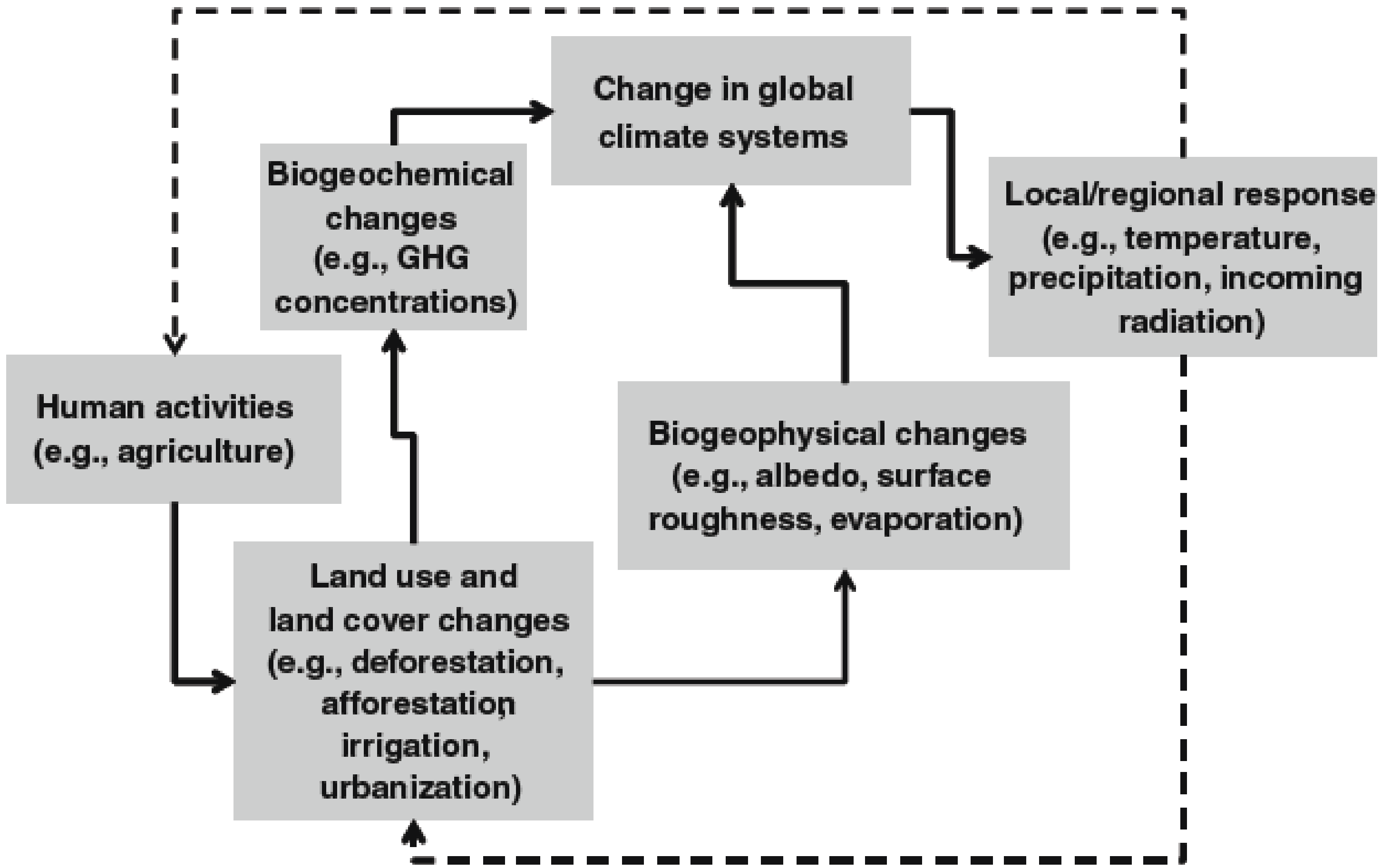
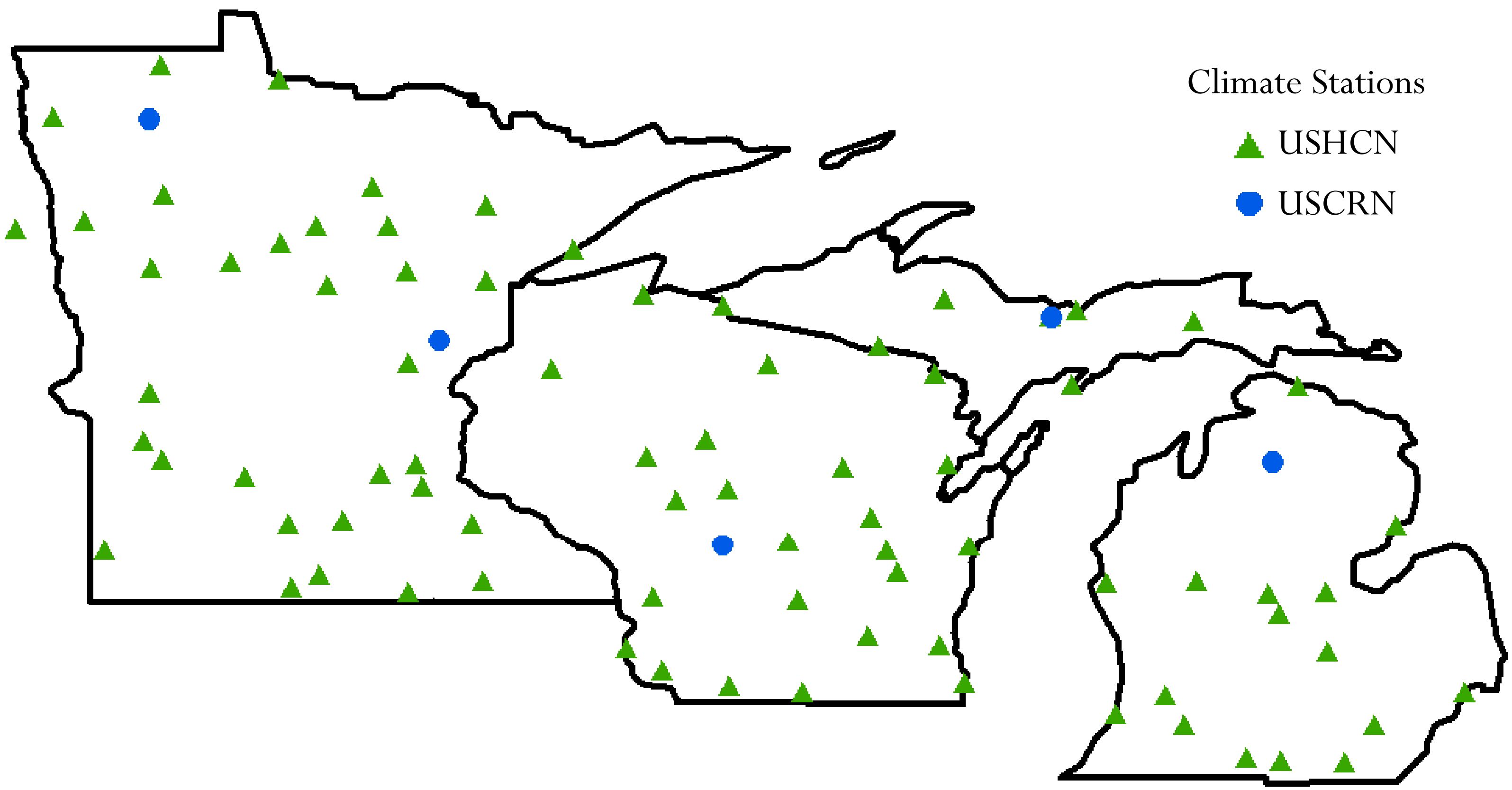


Illustration of the interactions between land use and land cover change (LULCC) and global and local/regional climate (Perdinan and Winkler 2013)

The Potential Use of Gridded Datasets: Constraints of Climate Observations

Availability of Climate Observations

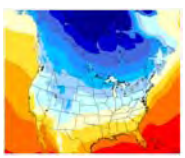
- Availability of climate data for climate assessments
  - agriculture application
  - concern with the availability of daily solar radiation observations



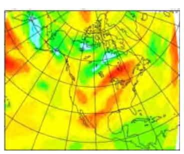
Locations of USHCN and USCRN climate stations

Approaches to Estimate Daily Solar Radiation

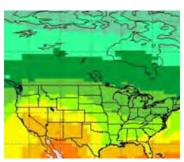
- Traditional approaches
  - stochastic: weather generator (e.g. Weatherman, ClimGen)
  - mechanistic: rad = f(extraterrestrial radiation, transmissivity)
  - empirical: rad = f(temperature, precipitation)
- "Modern approaches"



North American Regional Climate Change Adaptation Project (NARCCAP)



North American Regional Reanalysis (NARR)

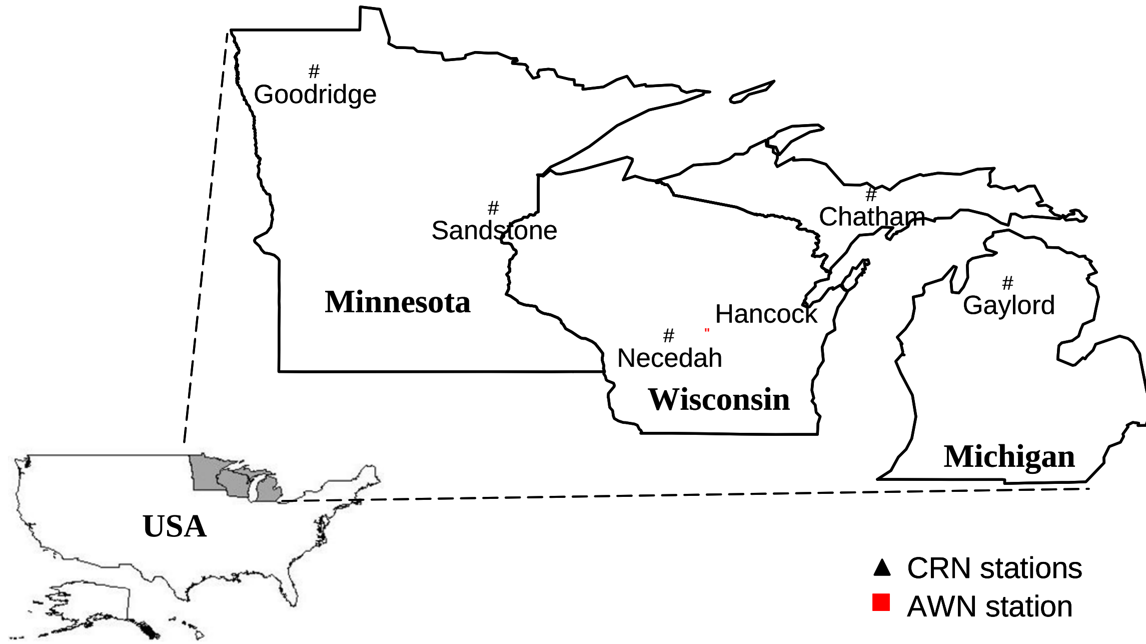


NASA POWER Database

- Which daily solar radiation estimates are appropriate for climate change impact assessments of crop yield?
- NARR and NASA Power, although not appropriate for future periods, were included to provide a complete evaluation of possible daily solar radiation sources

Image source :
NARCCAP , http://www.narccap.ucar.edu/
NARR, http://www.ncl.ucar.edu/
NASA POWER, http://earth-www.larc.nasa.gov/
Question mark: http://2.bp.blogspot.com/

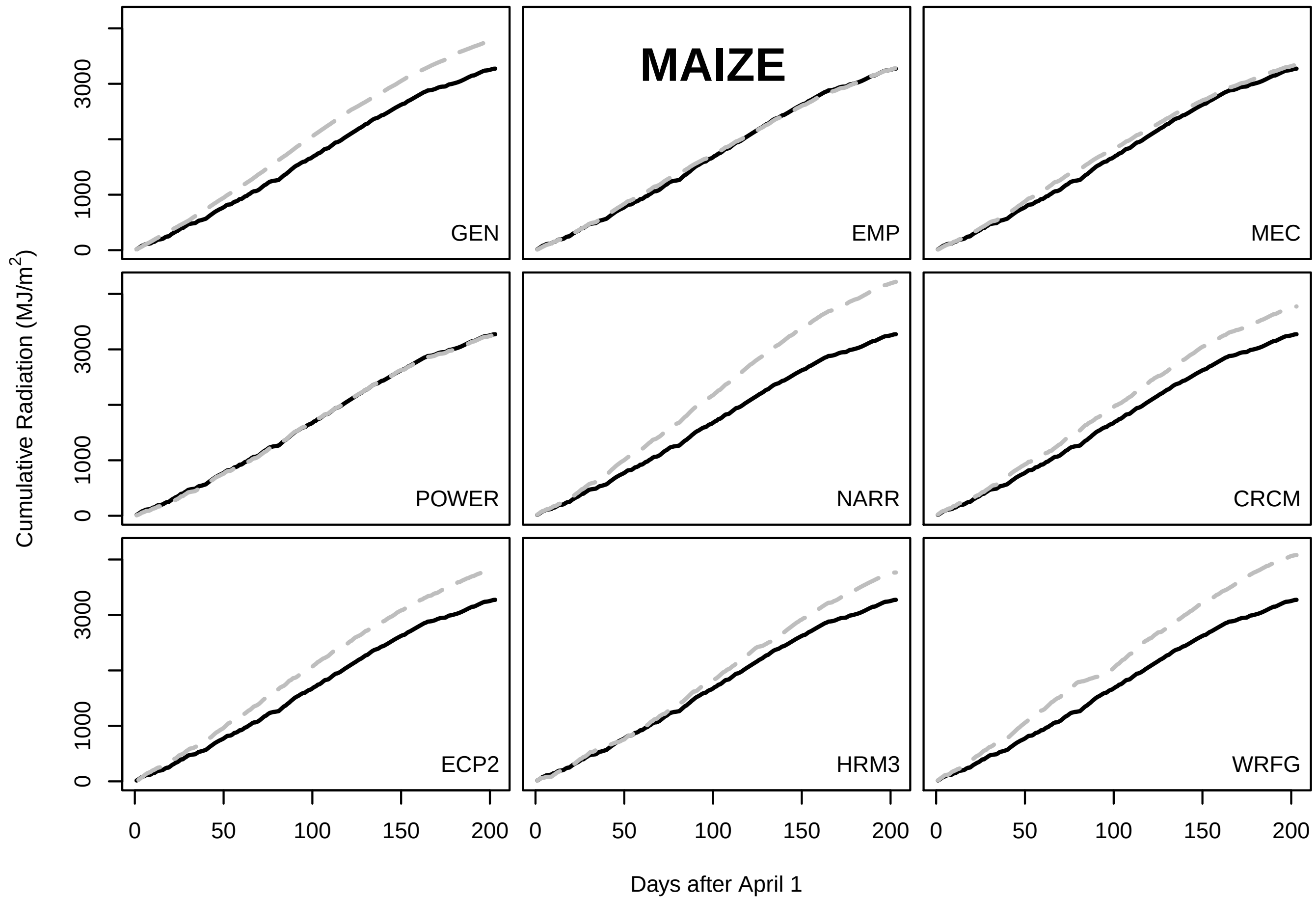
Research Methods



- Study location and period
  - Hancock, part of Wisconsin automated weather network
    - radiation data are statistically similar to a nearby Climate Research Network (CRN) station (Necedah) as the reference station
    - Analysis period: 1990,1992-1998
- Simulation of crop yields
  - used the CERES-Maize and CROPGRO-Soybean to simulate grain yield
  - only changed solar radiation, other variables were held constant
- Analysis methods
  - solar radiation: R^2 and RMSE
  - comparison of cumulative distribution: seasonal evapotranspiration and total biomass

Solar Radiation

- **Cumulative daily solar radiation**
  - satellite data (POWER) can capture daily fluctuations



A sample plot of cumulative daily solar radiation over a growing season for maize production in 1993 simulated using different daily solar radiation sources (gray lines) indicated by the text in each plot: weather generator (GEN), empirical equation (EMP), mechanistic model (MEC), satellite observation (POWER), reanalysis data (NARR), regional climate models (i.e., CRCM, ECP2, HRM3, WRFG). Black solid lines are observed daily solar radiation.

Figure source: Perdinan et al. in revision)

Solar Radiation

- **R^2 and RMSE (with observations as the reference)**

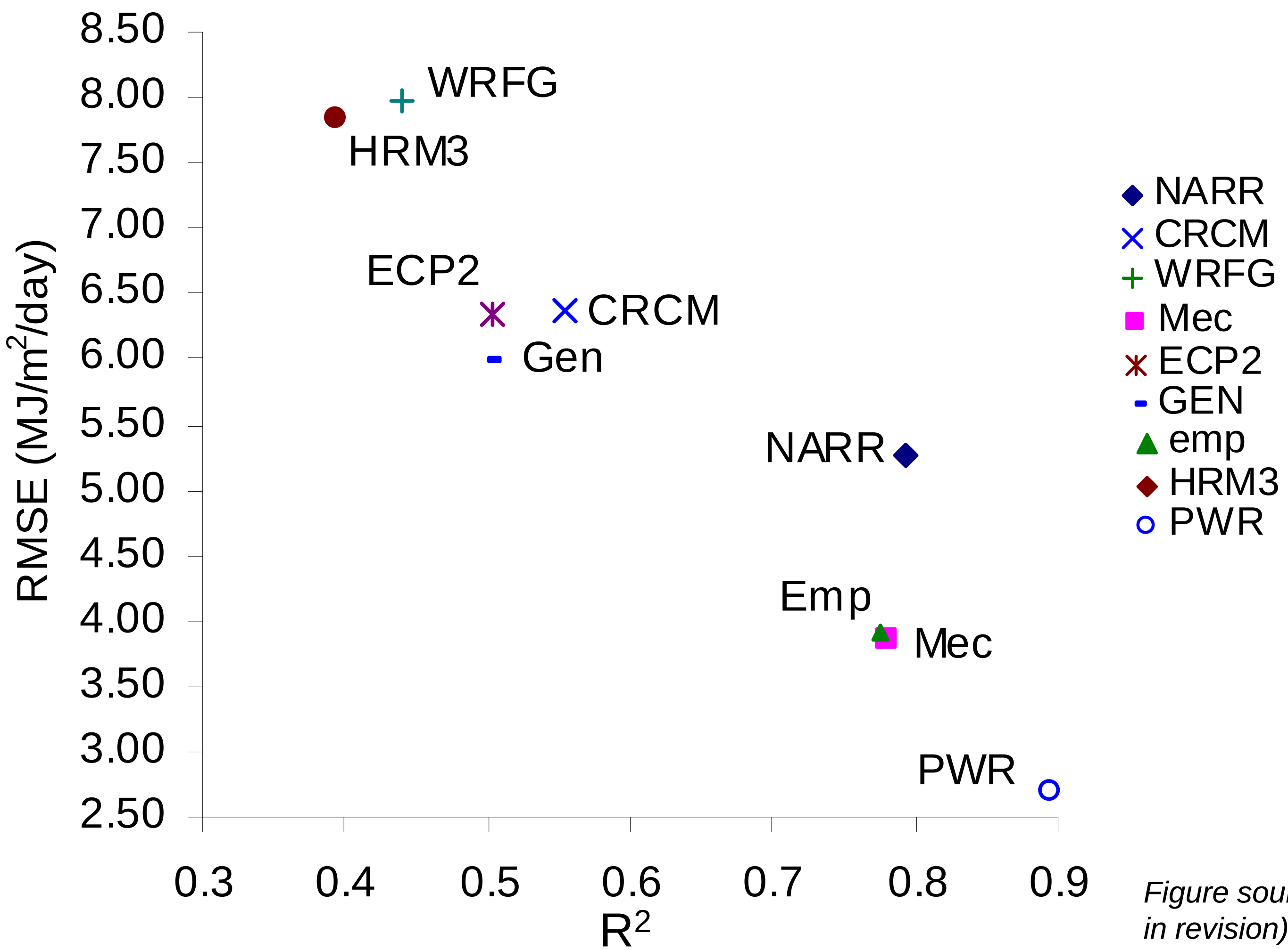
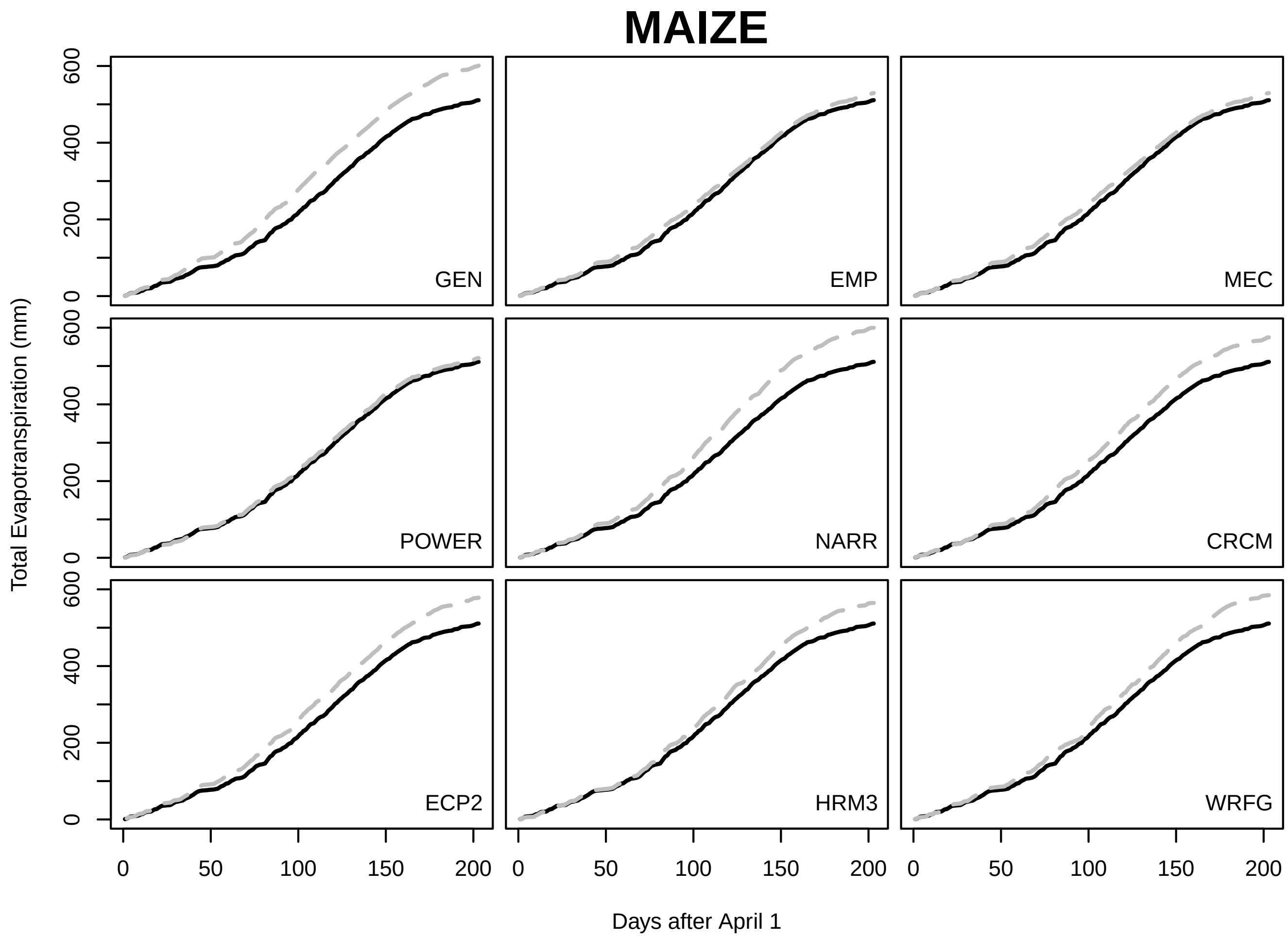


Figure source: Perdinan et al. in revision)

Seasonal Evapotranspiration

- **Cumulative evapotranspiration over the growing season**
  - **satellite data (POWER) can mimic well the cumulative distribution**

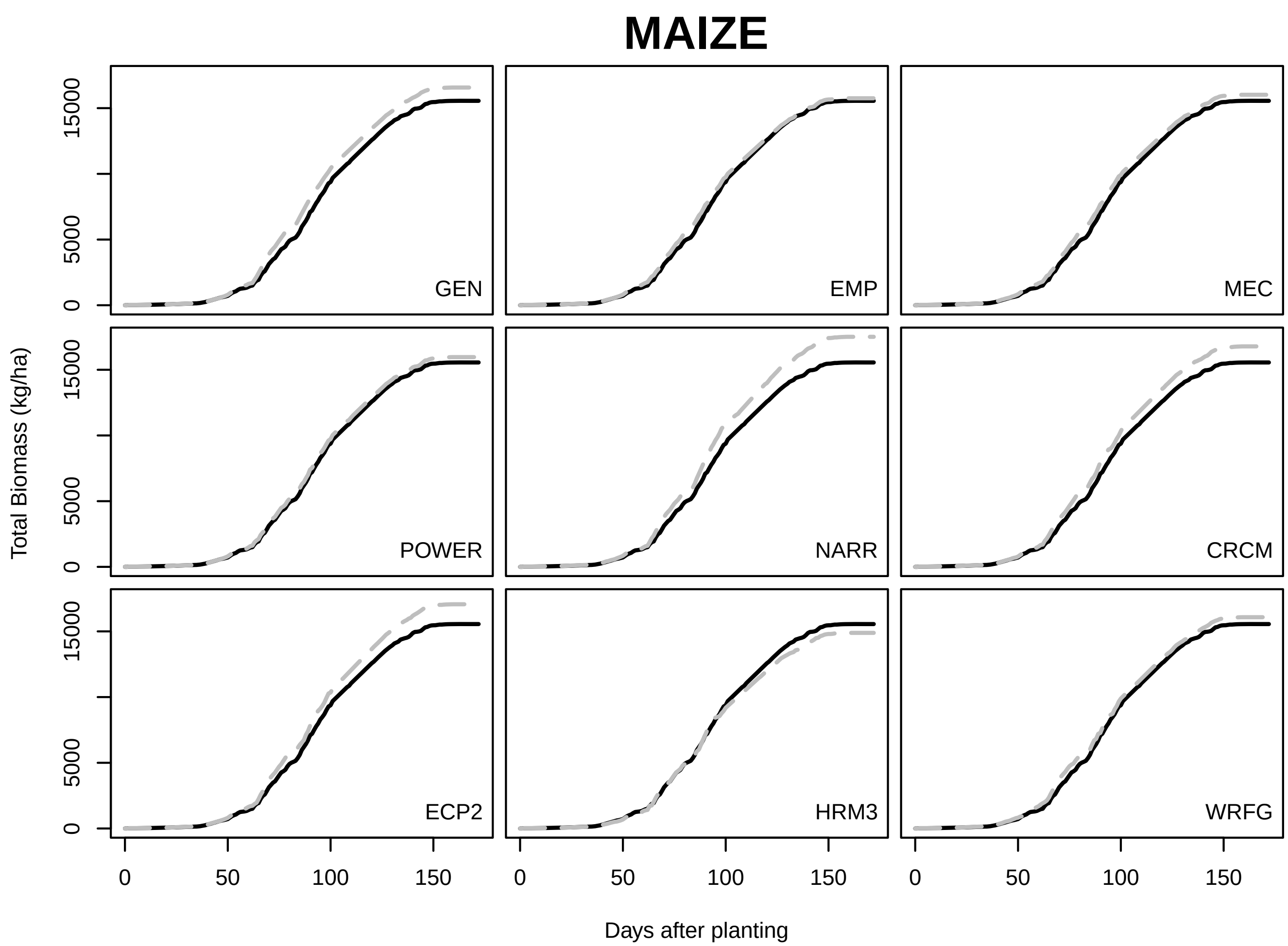


A sample plot of cumulative evapotranspiration over a growing season for maize production in 1993 simulated using different daily solar radiation sources (gray lines) indicated by the text in each plot. Black solid lines are observed daily solar radiation.

Figure source: Perdinan et al. in revision)

Total Biomass

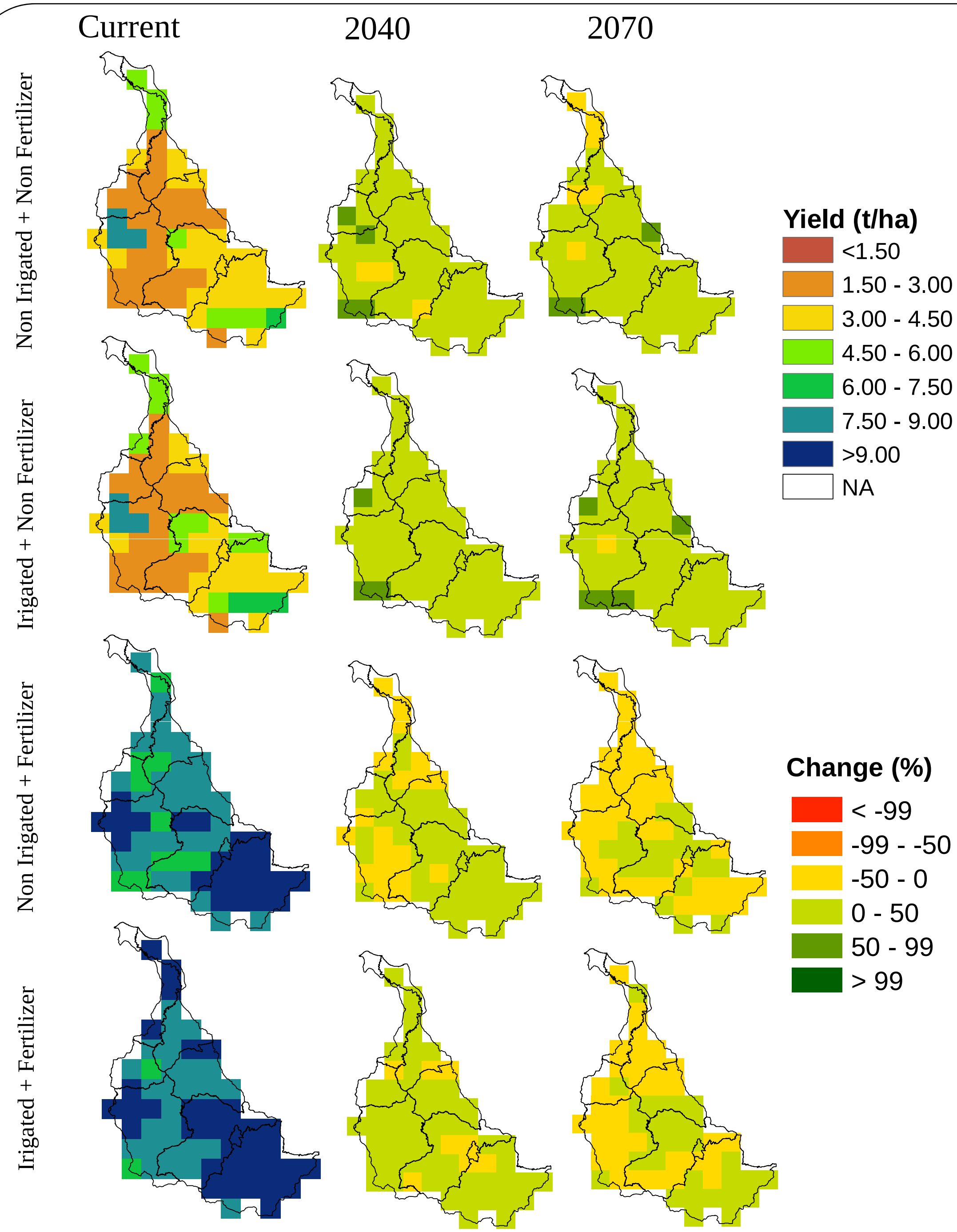
- **Cumulative daily biomass**
  - **satellite data (POWER) can mimic the cumulative distribution**



A sample plot of total aboveground biomass over a growing season for maize production in 1993 simulated using different daily solar radiation sources (gray lines) indicated by the text in each plot. Black solid lines are observed daily solar radiation.

Figure source: Perdinan et al. in revision)

An Example Application of Regional Climate Model Output: The Potential Impacts of Future Climate Change on Agriculture in Citarum Watershed



Paddy Yield

- Application of gridded datasets
  - fed into crop impact models
  - allow to analyze spatial distribution of climate change impacts
  - identify regions/areas vulnerable to climate change impacts
  - estimate regional impacts of climate change
  - evaluate adaptation options (e.g. different variety, irrigation, etc)

Image Source: Processed by Perdinan et al. 2013)

Summary

- Potential use of gridded datasets for climate assessments
  - reanalysis, regional climate model outputs and **satellite data** are promising sources for climate assessments
    - provides uniform spatial coverage
    - satellite data (NASA POWER) provides a relatively low bias when using for crop model application
  - considerations:
    - need a validation with ground observations
    - gridded data, except from regional climate model outputs, may not be available for the future

- Future research
  - validate outputs for other climate variables (e.g., temperature and precipitation)
  - consider the use of satellite datasets for monitoring and planning purposes
  - apply the outputs of regional climate models to adjust 'observations' obtained from satellite data
    - consider grid resolution of regional climate and satellite data

Questions?

Acknowledgement

- Prof. Julie Winkler (MSU)
- Prof. Jeffry Andresen (MSU)
- Prof. Rizaldi Boer (IPB)
- Dr. Akhmad Faqih (IPB)
- Ms. Sisi Febriyanti Muin
- Fulbright Presidential Scholarship
- NSF-Climark Project
- ADB Project