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Decision-oriented Uncertainty Characterization to Inform Adaptation and Mitigation: Implications for Adaptation Science

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Characterizing Uncertainty for Regional Mitigation and Adaptation Decisions

- Regional climate-related decisions will be made under uncertainty
- Models can help decision makers explore the implications of uncertainties for their decisions
- The complexity and size of models relevant to adaptation and mitigation decisions at regional scales make this challenging
- Research is needed to improve
  - Methods to apply insights from high resolution science models in reduced forms
  - Methods to propagate and analyze adaptation and mitigation relevant uncertainties
  - Methods to engage stakeholders in model development and application

Developing an Integrated Regional Model with Stakeholder Input

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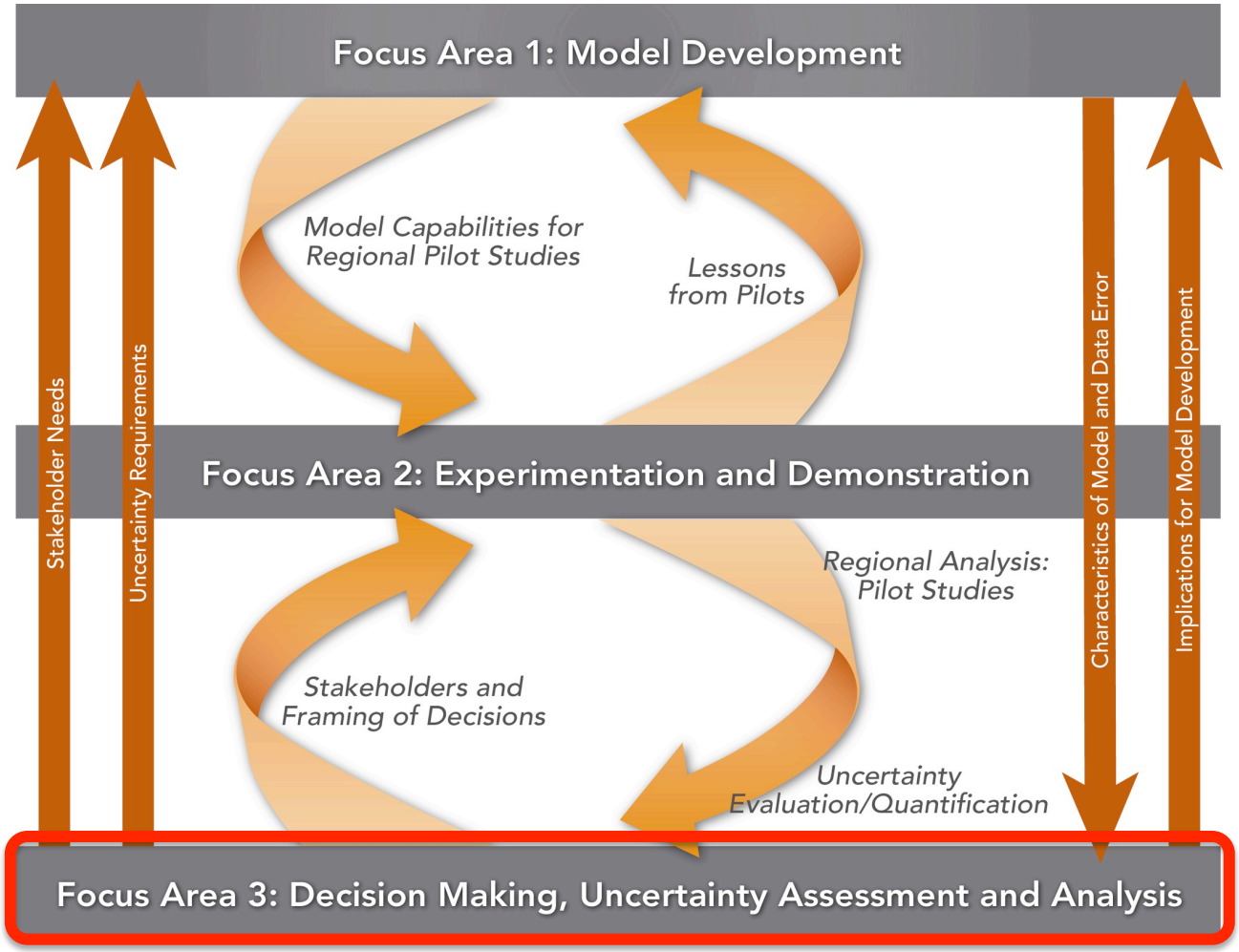
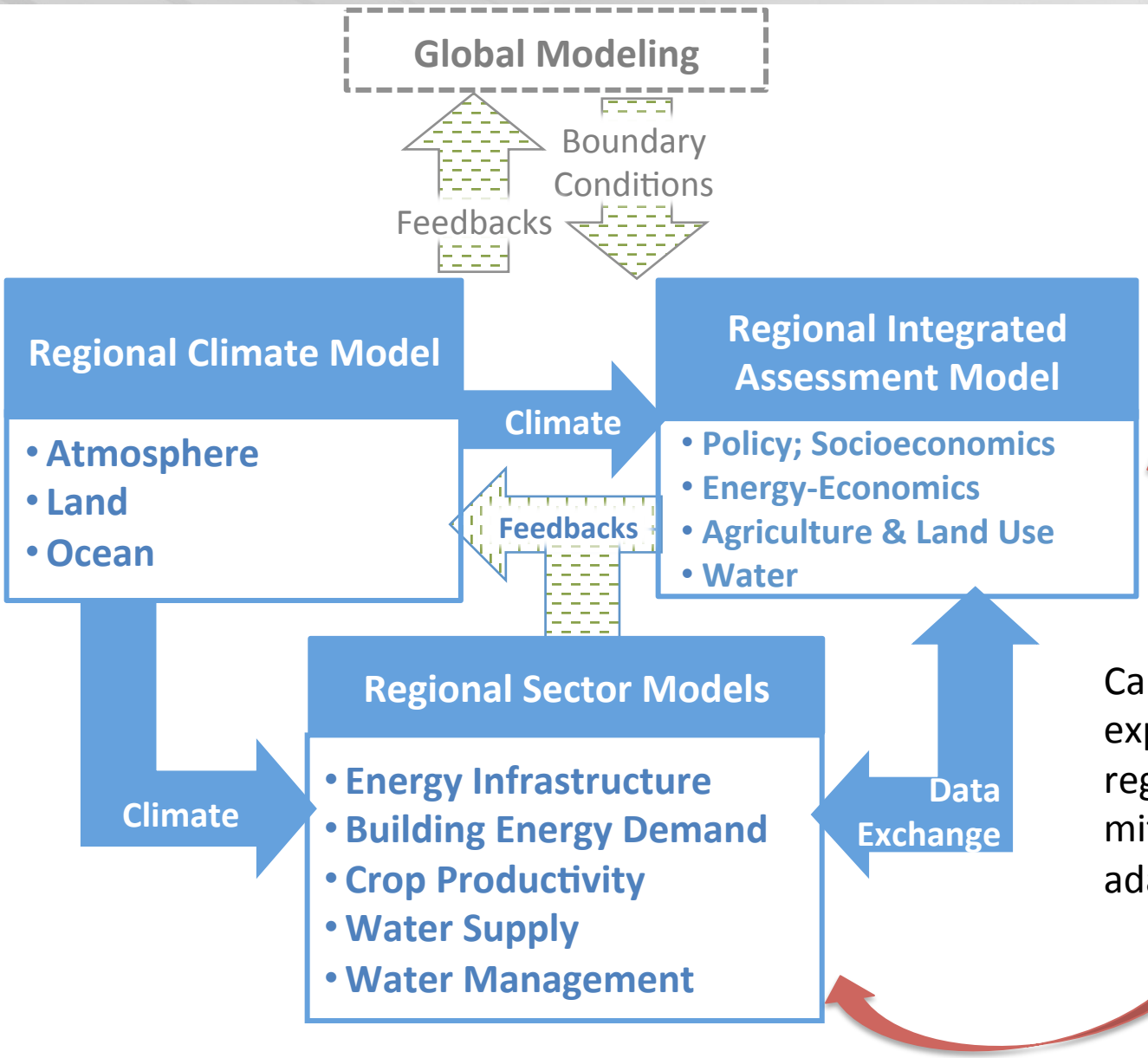
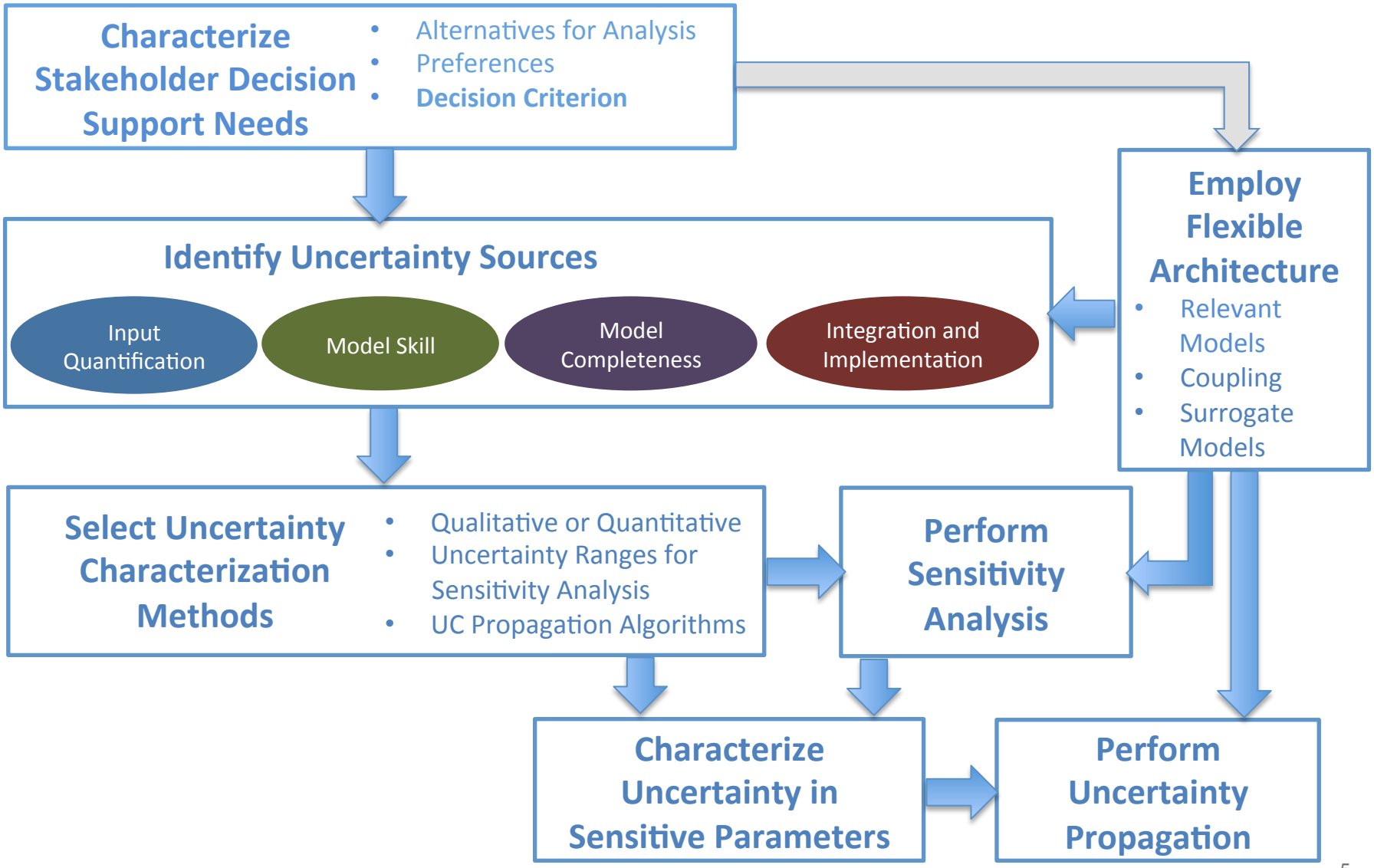


iRESM Modeling Framework



Capability to explore impacts of regional scale mitigation and adaptation

iRESM Decision-Relevant Uncertainty Characterization



iRESM Pilot Study Region

Stakeholder organizations met with (to date):

- Wisconsin Bioenergy Initiative
- Wisconsin Climate Change Initiative (represents a wide range of stakeholders)
- Nelson Institute for Environmental Studies, University of Wisconsin
- Center for Sustainability and the Global Environment, University of Wisconsin
- Center for Science, Technology and Public Policy, Humphrey School of Public Affairs, University of Minnesota
- Minnesota Forest Resources Council
- Minnesota Pollution Control Agency
- Iowa State University, Climate Science Program, Agricultural Meteorology
- University of Iowa, Center for Global and Regional Environmental Research
- Great Lakes Commission
- Midwest Independent System Operators (MISO)
- International Plant Nutrition Institute
- U.S. Department of Agriculture, ARS
- Illinois Department of Agriculture
- Chesapeake Energy
- Illinois Energy Office, Illinois Department of Commerce & Economic Opportunity
- Illinois EPA
- City of Chicago Department of Environment
- Great Lakes and St. Lawrence Cities Initiative
- Metropolitan Water Reclamation District of Greater Chicago
- Pennsylvania State University, several departments

Literature Review Reveals Pilot Region Decisions/Priorities Underway or in Prospect

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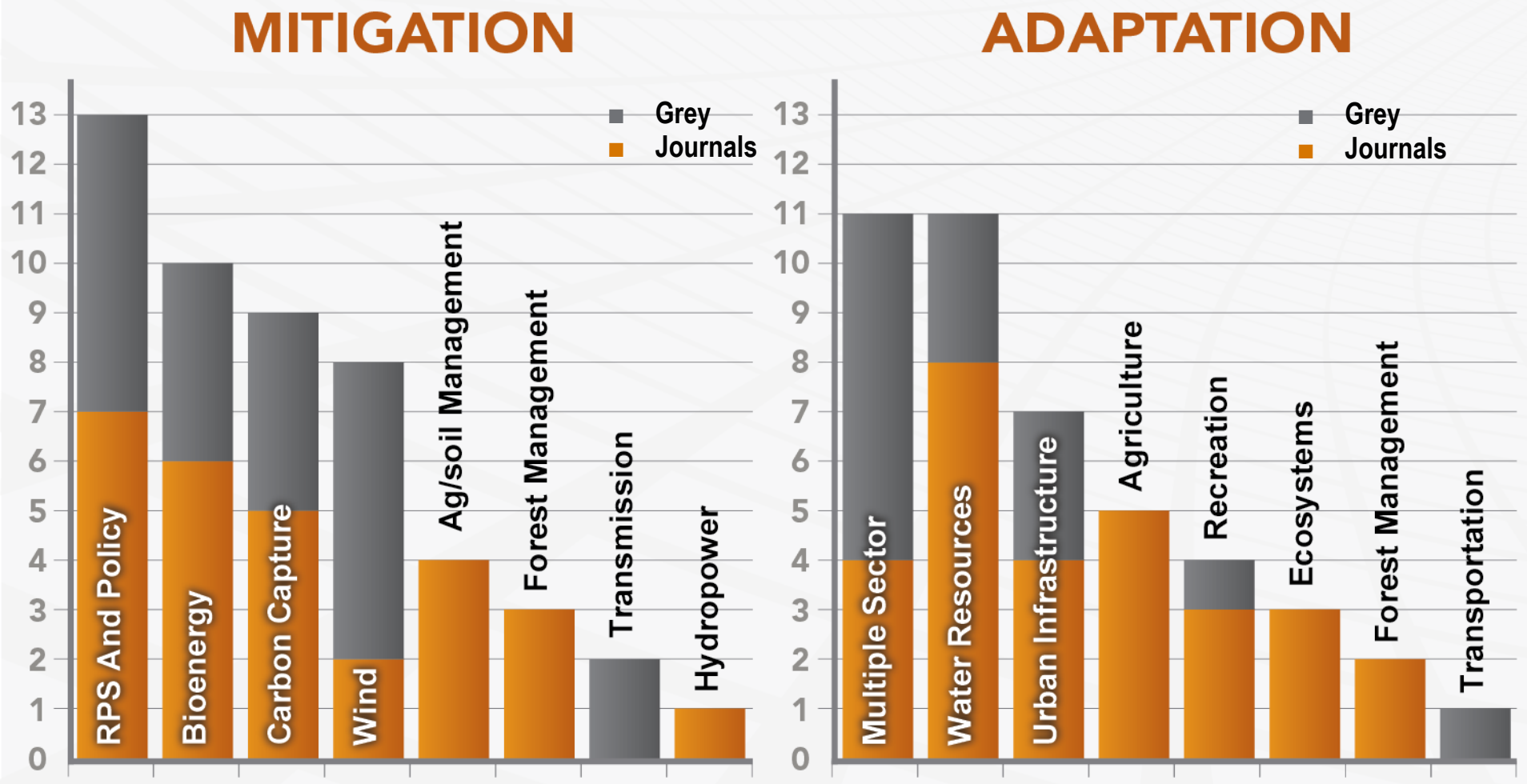

Rice JS, RH Moss, PJ Runci, KL Anderson, and EL Malone. 2012. "Incorporating stakeholder decision support needs into an integrated regional Earth system model." *Mitigation and Adaptation Strategies for Global Change*. DOI: 10.1007/s11027-011-9345-3.

Using Stakeholder Input: A Typology of Decisions and Decision Criteria

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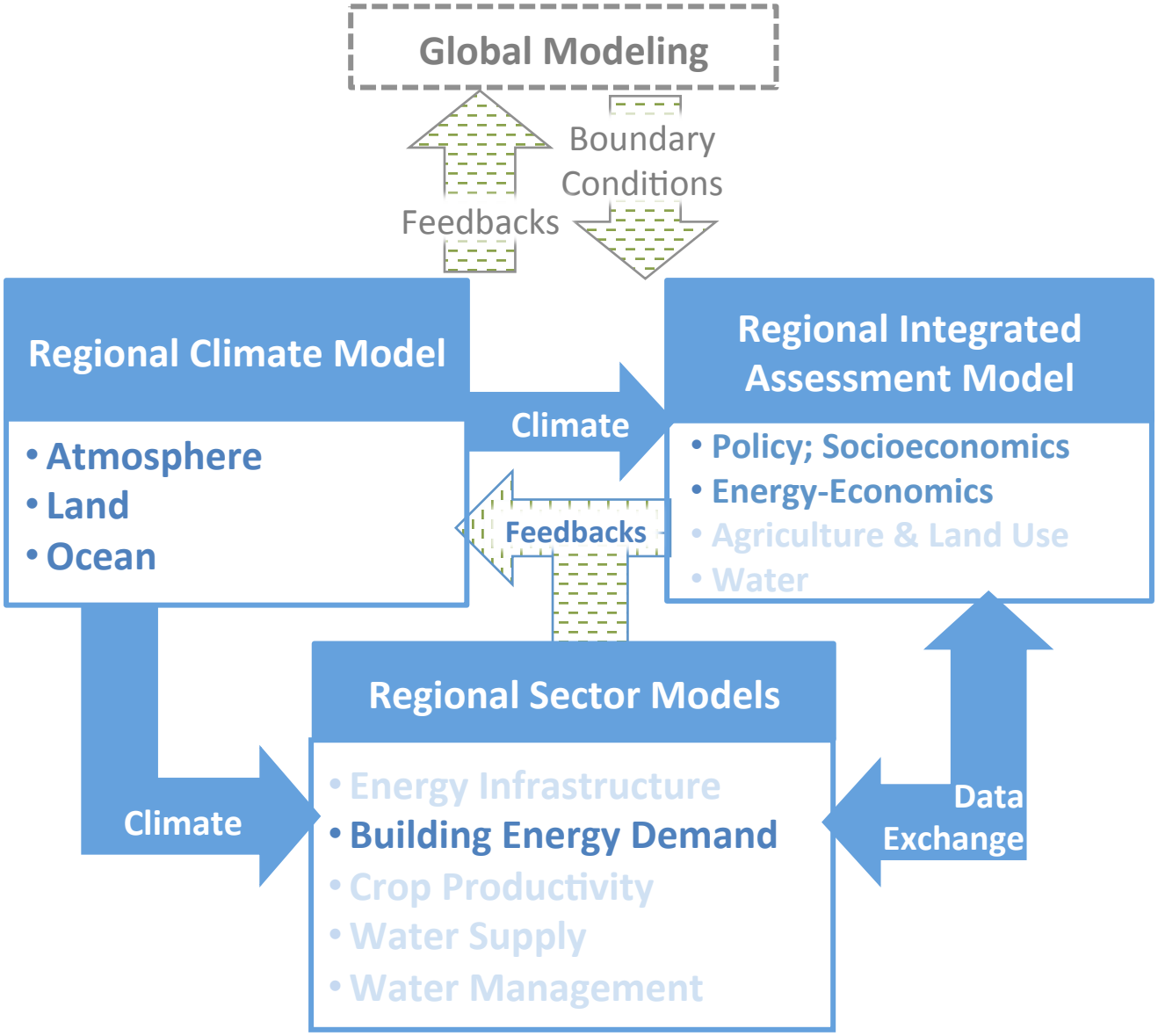
Code	Mitigation Decision Types	Code	Adaptation Decision Types	Code	Type of Decision	Code	Decision Criteria	Code	Decision Process	Code	Decision Framework
M1	Carbon tax	A1	Improve building codes; retrofit existing HVAC	D1	Regional policy mandate	C1	Net benefits	P1	State-level task force or committee	D1	Risk
M2	Renewable Portfolio Standard (RPS)	A2	Reduce thermoelectric operations	D1.1	Regional incentives	C1.1	Economic benefits	P1.1	Legislation	D2	Multi-criteria
M3	Cap and trade	A3	Invest in dry cooling; cooling towers	D2	Meeting RPS requirements	C1.2	Peak demand	P1.2	Scientific advisory group	D3	"Cost-benefit"
M4	Improve building codes; retrofit existing HVAC	A4	Increase generation in urban areas	D2.1	In-state sourcing	C1.3	Reduced emissions	P1.3	Governor's executive order	D4	

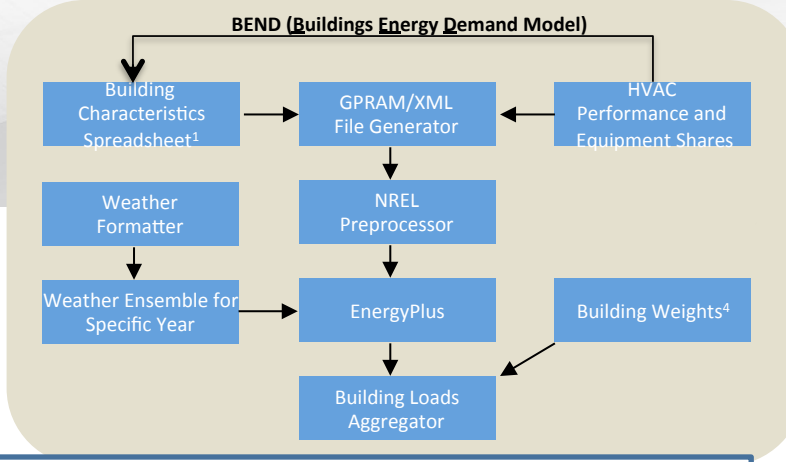
Example Application: Regional Building Standards

- Decision maker: Midwest Governors Association
- Decision: Improved regional building standards—at what level?
- Decision criteria: economics, emissions, peak demand (reduce demand during heat waves)
- Decision process: multi-state policy decision
- Decision framework: multi-criteria

iRESM Model Couplings to Explore Building Code Revisions



Uncertainty Sources in BEND – Sample Results



UNCERTAINTY SOURCE IDENTIFICATION

Input Quantification

- Count of building types in a region
- Building stock characteristics
- Necessary spatial resolution
- Inputs from RESM and R-GCAM

Model Skill

- Representative-ness of locations chosen to represent the region
- Count of buildings by building type is calibrated to reproduce base year total annual energy demand and hourly electricity profiles

Model Completeness

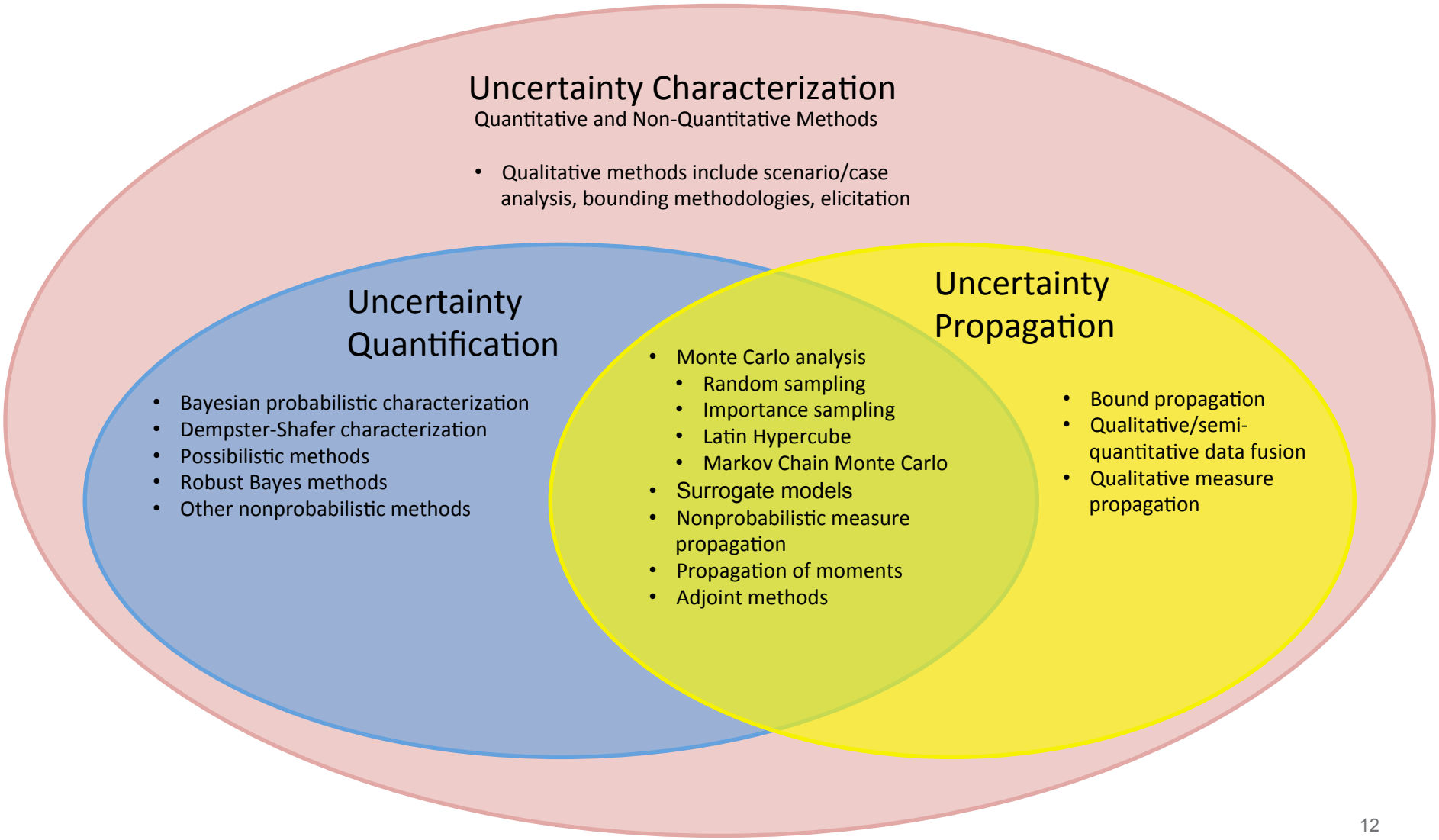
- Core of BEND is DOE's Energy Plus model--the industry's most detailed and highest pedigree model

Integration and Implementation

A priori sensitivity:

- Uncertainty in climate likely to dominate uncertainties in base year building inventory
- Demand response to price changes (interactions with R-GCAM)
- Technological change (from R-GCAM)

Apply Sensitivity Analysis and Uncertainty Propagation Approaches



Next Steps – Stakeholder and UC Process

- Build out the typology of decisions, criteria, processes, and frameworks across issues and regions
- Continue model and platform development
- Identify needed model couplings and UC needs, including reduced forms
- Apply additional UC methods (e.g., assess risk of policy framework)
- Build out standardized resources and workflows
- Experiment with visualization, scenario planning, and other methods

Insights: What We Have Learned

- The need for a decision- or problem-focused modeling approach:
  - The way to make modeling and UC relevant and feasible
- The utility of stakeholder interviews in model development
  - Identify standardized uncertainty resources and work flows
  - Clarify adaptation and mitigation options and decision situations
- The need for perseverance
  - Informing model development with a focus on decision making is challenging

Implications for Adaptation Science

- Goal: Develop flexible model architectures for decision-relevant uncertainty characterization using insights from "science" models
- Needs:
  - Reduced forms/surrogate models
    - Beyond global averages to variation in detailed patterns of climate
  - Resources for decision-focused uncertainty characterization
    - Typology of decisions and decision situations to identify priorities
    - PDFs for sensitive variables for recurring decision criteria
    - Methods/models for uncertainty propagation, e.g., standardized workflows
  - Stakeholder oriented resources
    - Participatory scenario planning – connecting global change science to place-based concerns and decision making processes
    - Implications of different decision situations for decision support and modeling needs
    - Visualization methods

Discussion