Vermont EPSCoR

Experimental Program to Stimulate Competitive Research

Research on **A**daptation to **C**limate **C**hange
An Update

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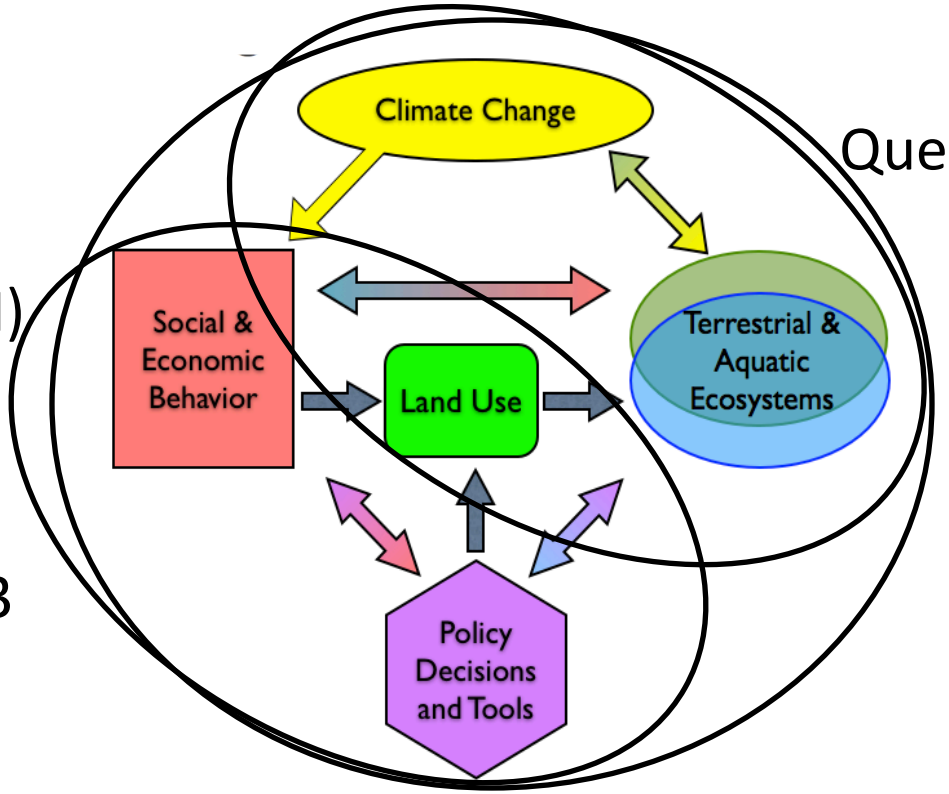
The Overarching RACC Question

How will the interactions of climate change and land use alter hydrological processes and nutrient transport from the landscape, internal processing and eutrophic state within Lake Champlain, and what are the implications for adaptive management strategies?

Integrated Assessment Model (IAM)



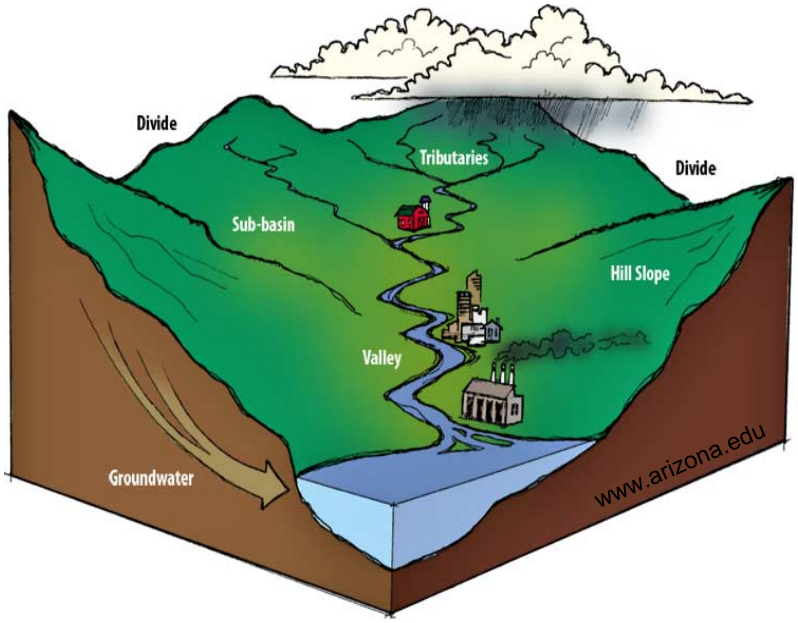
Questions 1 and 2

Question 3

The Core RACC Research Questions

- Q1: What is the relative importance of endogenous (in-lake) processes versus exogenous (to-lake) processes to eutrophication and harmful algal blooms?
- Q2: Which alternative stable states can emerge in the watershed and lake resulting from no-linear dynamics of climate drivers, lake basin processes, social behavior, and policy decisions?
- Q3: In the face of uncertainties about climate change, land use and lake response scenarios, how can adaptive management interventions be designed, valued, and implemented in the multi-jurisdictional region?

Approach to Question 1



- What are the important sources of nutrients & sediment to the lake?
- How do land use and climate affect the nature and strength of these sources?
- How are nutrients and sediments transformed in transport to the lake and within the lake?
- How do the loadings of these materials affect lake processes?

Focus Watersheds

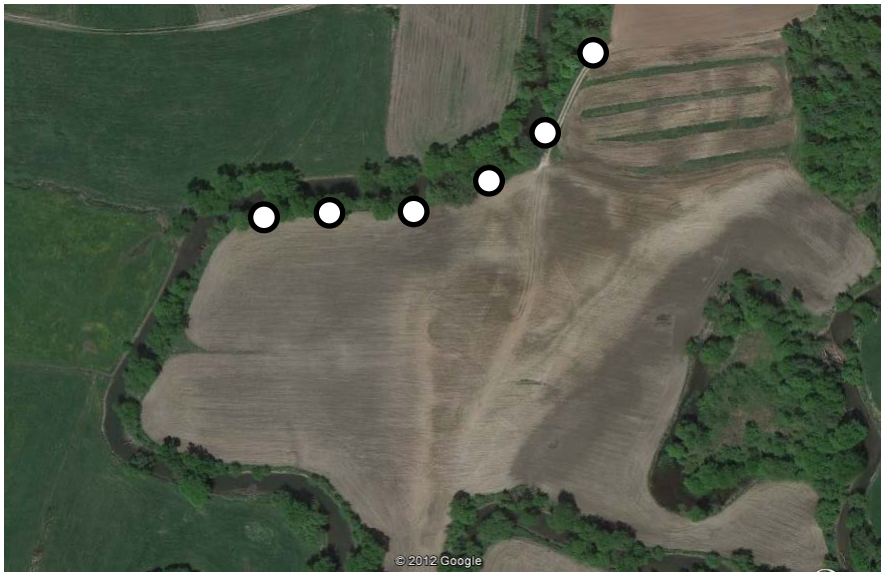
Agriculture: runoff, groundwater, soils, stream bank erosion

Forested: soils, groundwater, roads, channel migration, erosion

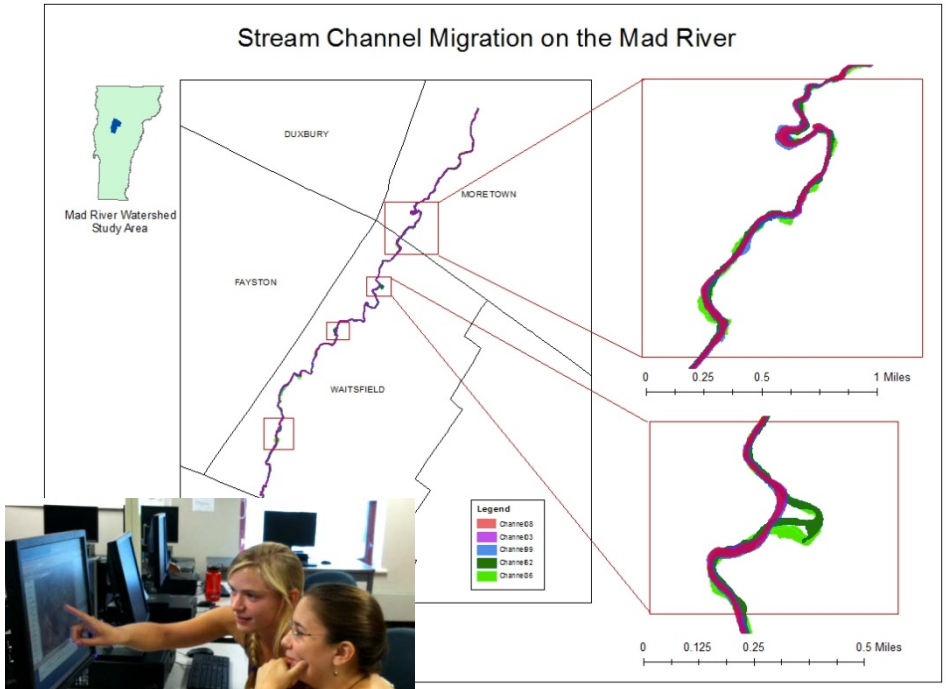
Urban: stormwater runoff, wastewater, stream erosion

What we have accomplished?

Source area characteristics



N/P Distribution across riparian zones

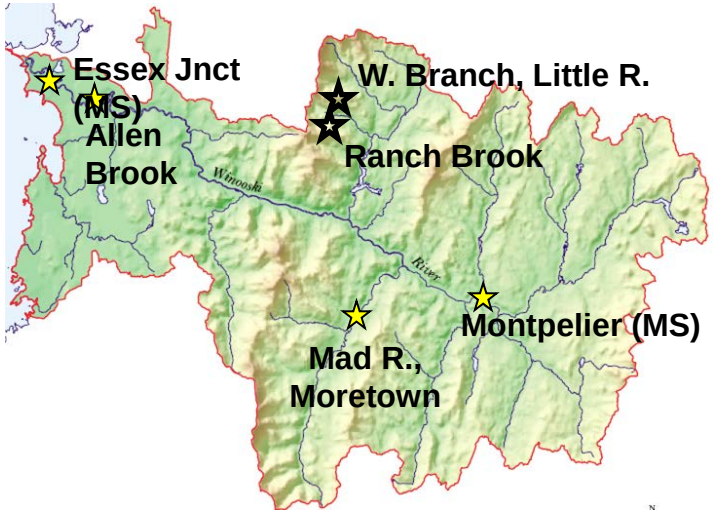


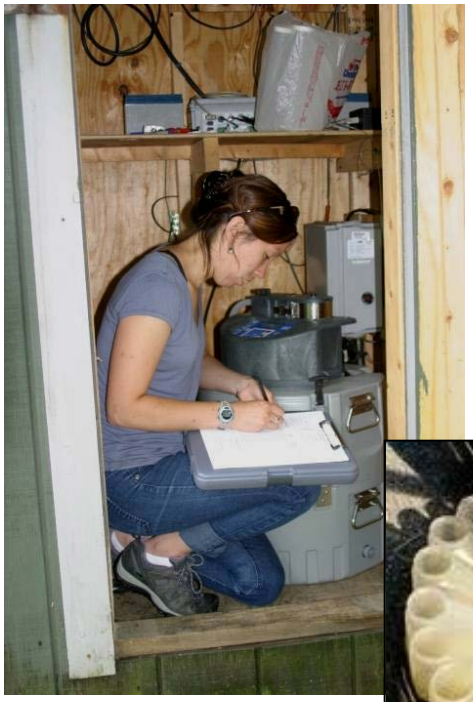
What we have accomplished?

Instrumented key sub-watersheds

Missisquoi

Winooski

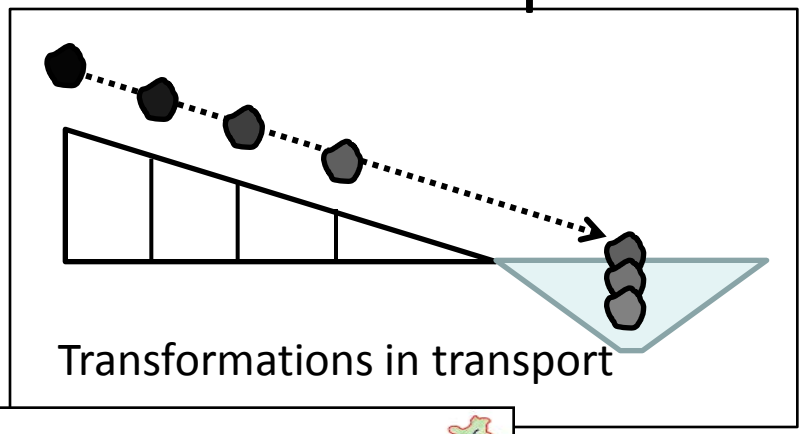


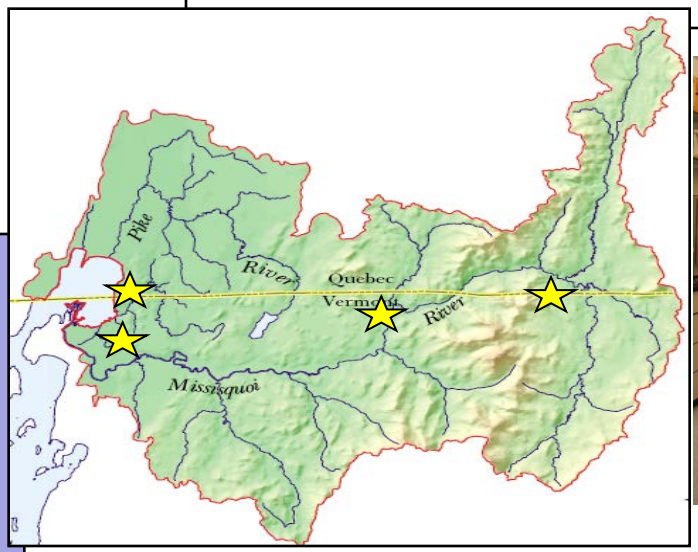


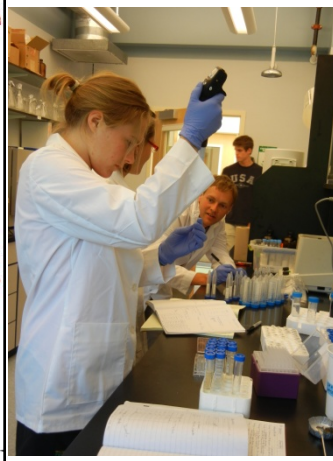
What we have accomplished?

Characterization of transformations in transport

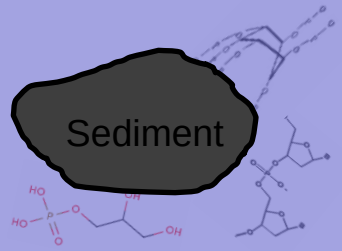
- What are the primary forms of P transported to Lake Champlain via *external sediment loading*?
- How algal-available are these sediment-bound-P forms?
- How do redox processes influence P cycling and *internal loading* from lake sediments?







Sediment-Bound-P
Species Analysis



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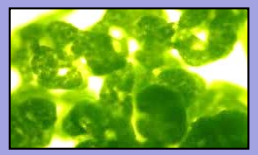
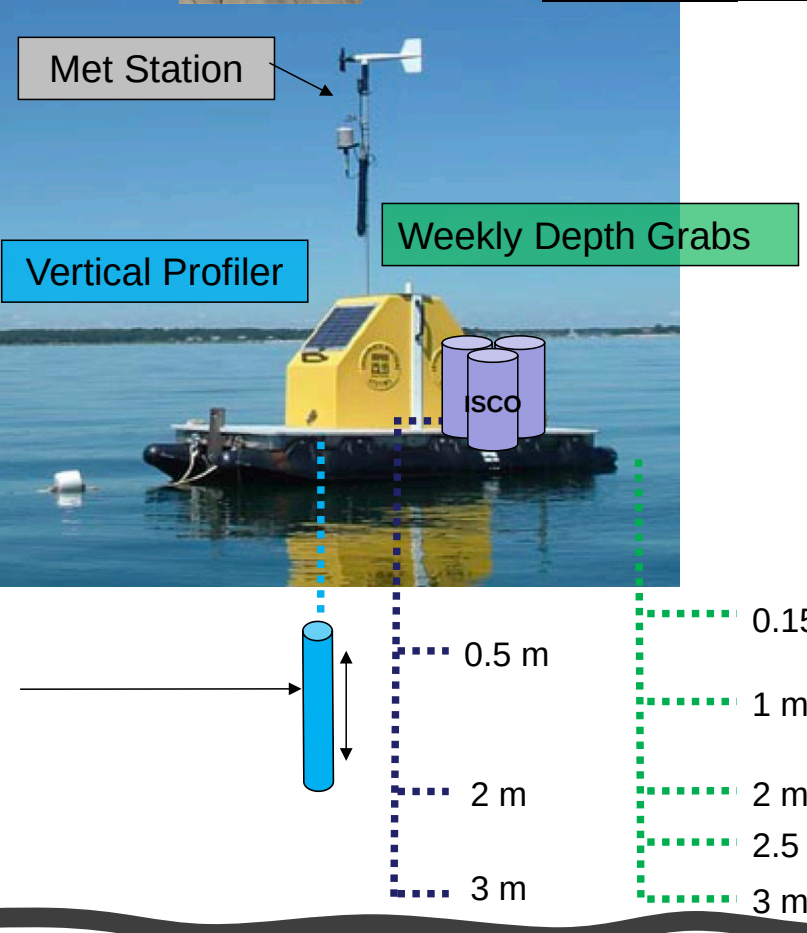


cyanobacteria

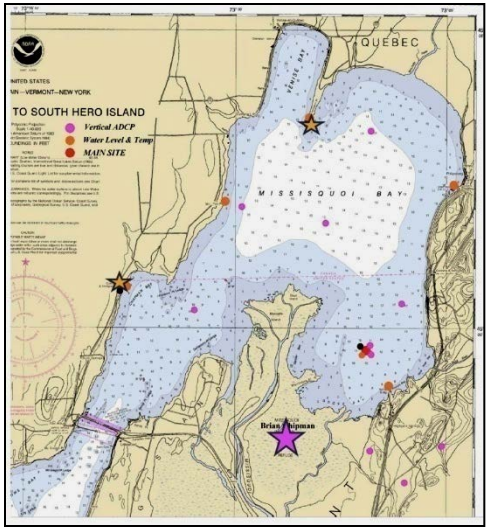
ENZYME HYDROLYSIS
Solution ^{31} P NMR Spectroscopy

What we have accomplished?

Missisquoi Bay Advanced Environmental Monitoring Systems



Spatial Hydrodynamic Array and Grab Sampling Efforts

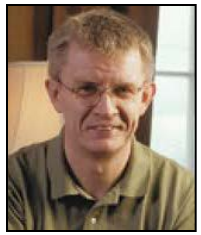


What we have accomplished?

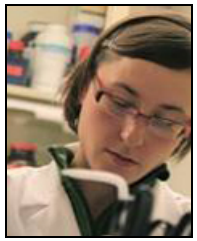
Integrated water sampling & analysis network

Johnson State College

St. Michael's College



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We are taking a SYSTEMS APPROACH to impacts and adaptation studies.

We seek to understand:

1. The expected impact of precipitation change on:
    1. Sediment and non-point phosphorus mobilization
    2. Flooding/scouring of channels and floodplains
    3. Natural vegetation and farming practices
    4. Built environment

    } Watershed Model

2. The expected impact of temperature change on:
    1. Natural vegetation
    2. Frozen ground
    3. Snow/rain ratio

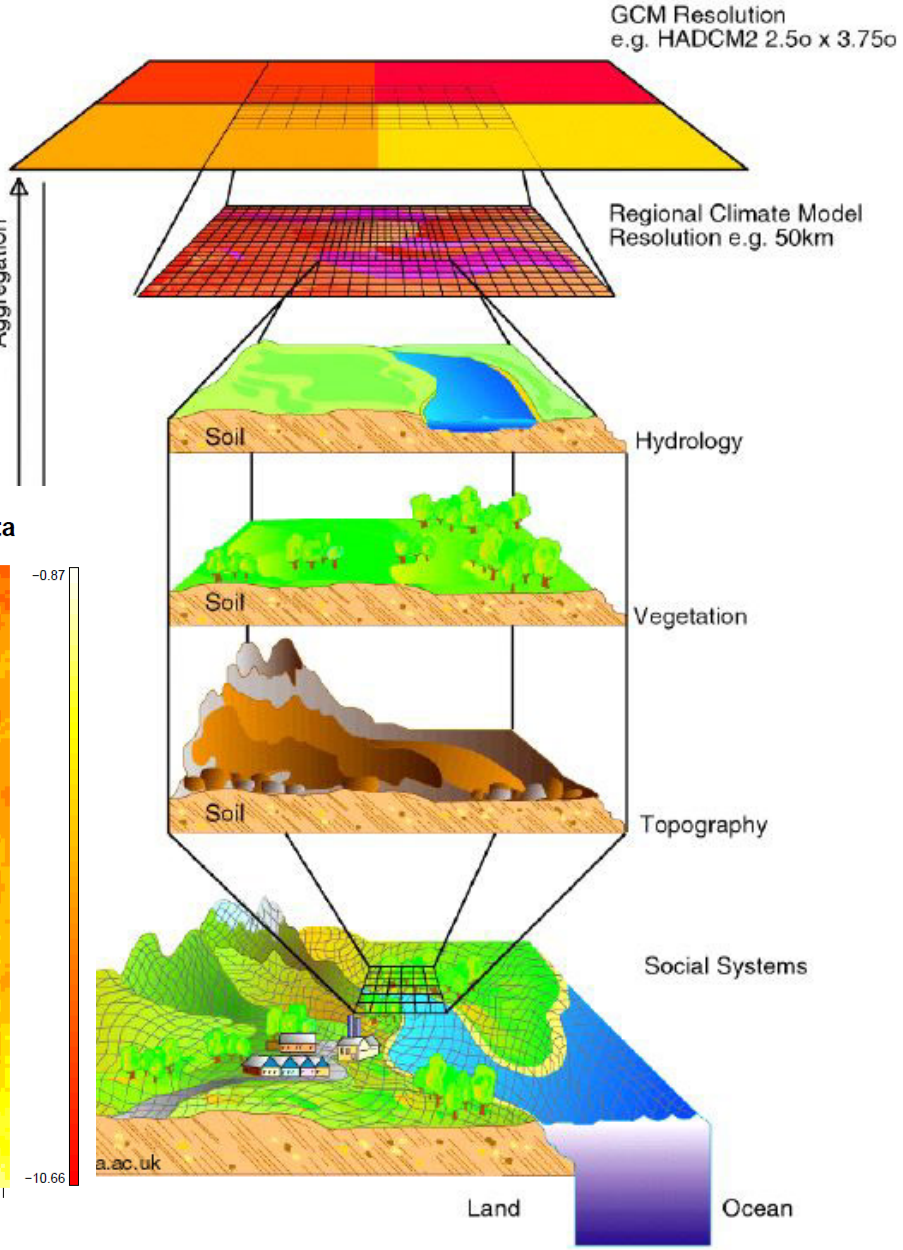
    } Regional Climate Model

3. System resilience to future changes under a variety of scenarios
    1. What variables dominate? (e.g. land use, governance, etc)
    2. What alternative stable states may the watershed take on? (agricultural/ urban, forest succession, healthy channels/impacted, etc)

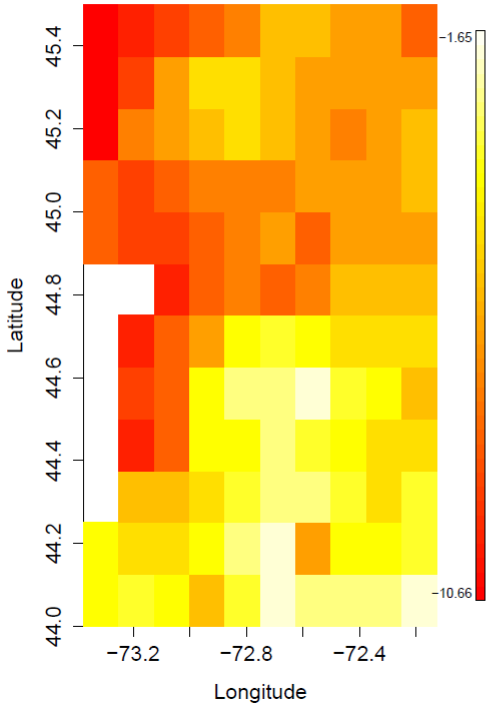
Climate Downscaling

Dynamic (regional climate models)

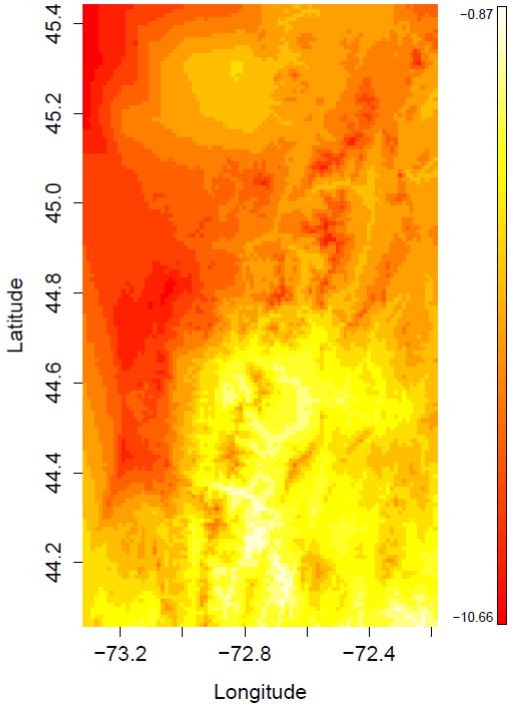
- Captures local processes and feedbacks



Non−Downscaled Temperature Data

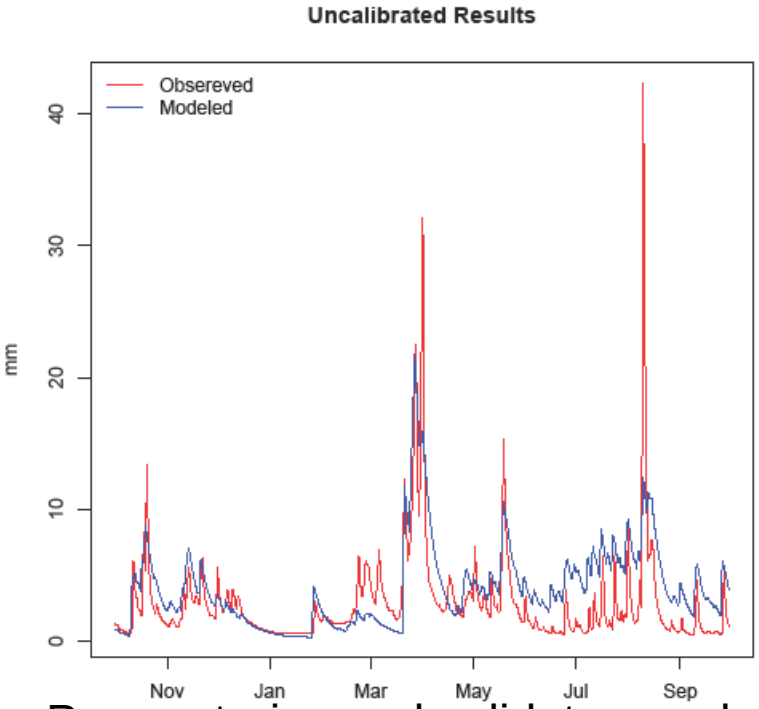


Downscaled Temperature Data

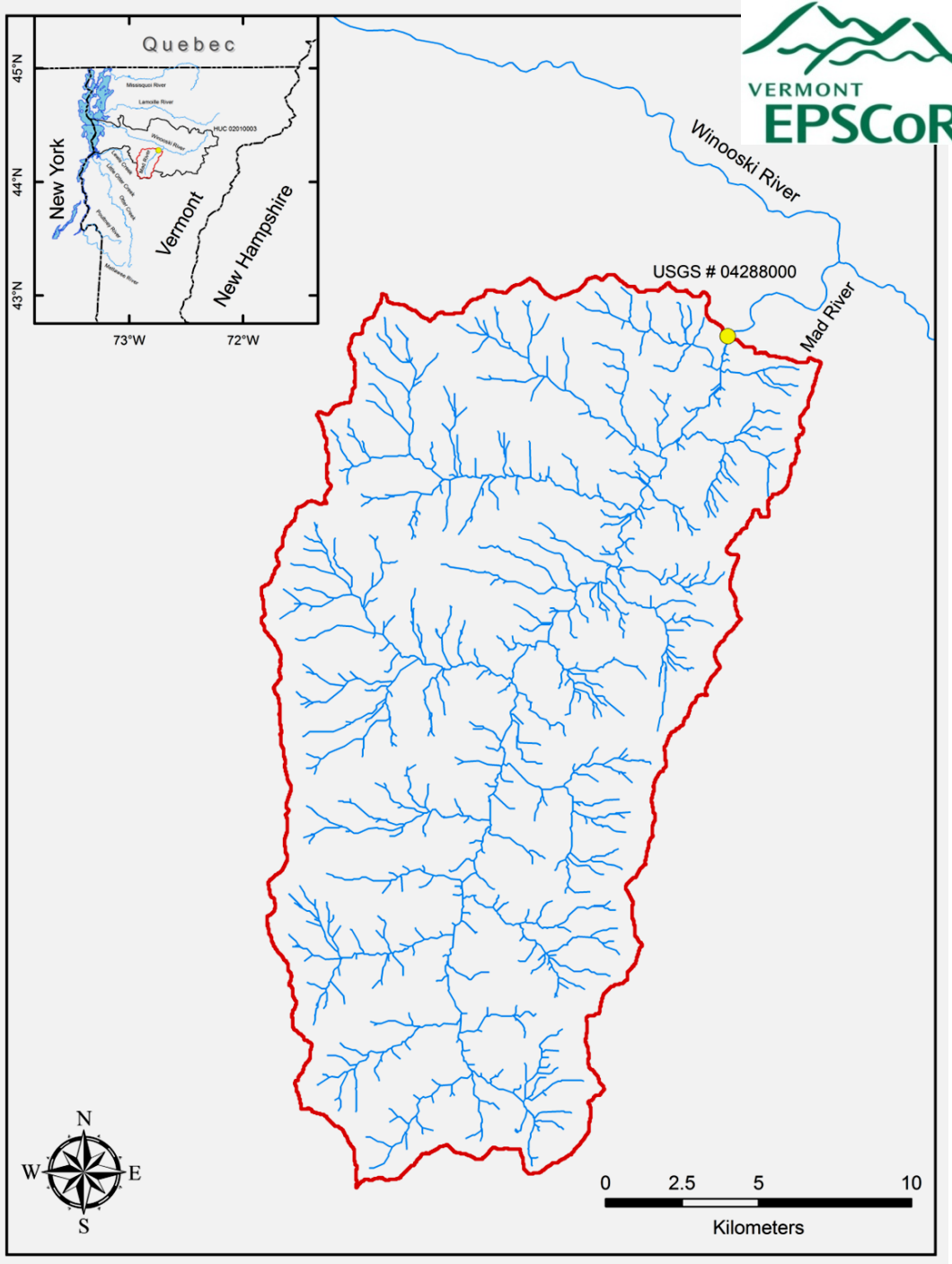


Hydrological Modeling:

Begin with Mad River watershed



Parameterize and validate coupled watershed/vegetation model



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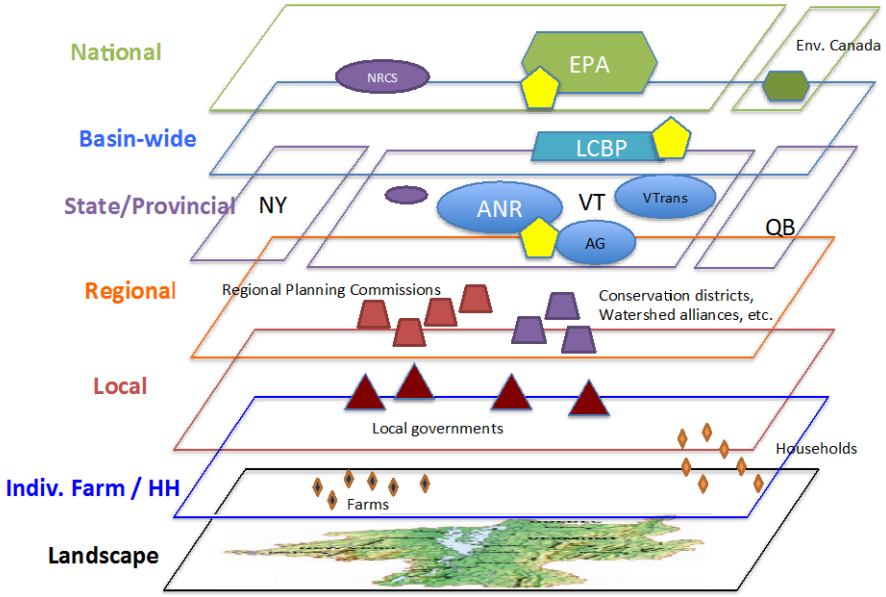
Governance Network Analysis Research & Modeling Methods

Research Methods:

- Surveys
- Interviews
- Focus groups
- Source documents analysis
- Comprehensive case study
- Critical events analysis
- Institutional ethnography



Preliminary Scoping Model of Lake Champlain Watershed Governance

Computer Simulation Models:

- Agent Based Models
- Systems Dynamics Models
- Discrete Event Models
- Multi-criteria Analysis
- Social Network Analysis

Problem Concept-ualization

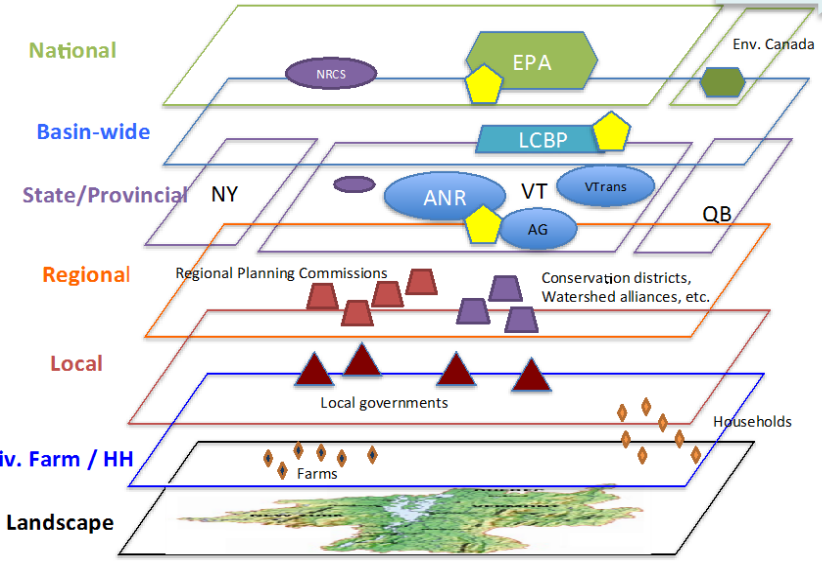
Accomplished: Stakeholder meetings; archival analysis; historical timeline completed,

Qualitative Problem Mapping

Acc*omplished:* Interviews; source documents analyzed; survey protocols designed; participant observations undertaken; additional resources secured,

Model Form-ulation

Accomplished: AnyLogic training; literature reviews; social network analysis; in progress, Regional Climate Change Scenario Development Workshop



Model Calibration

Model Testing

Policy Evaluation

Knowledge Transfer

Preliminary Scoping Model of Lake Champlain Watershed Governance

ARIES
ARtificial Intelligence for Ecosystem Services

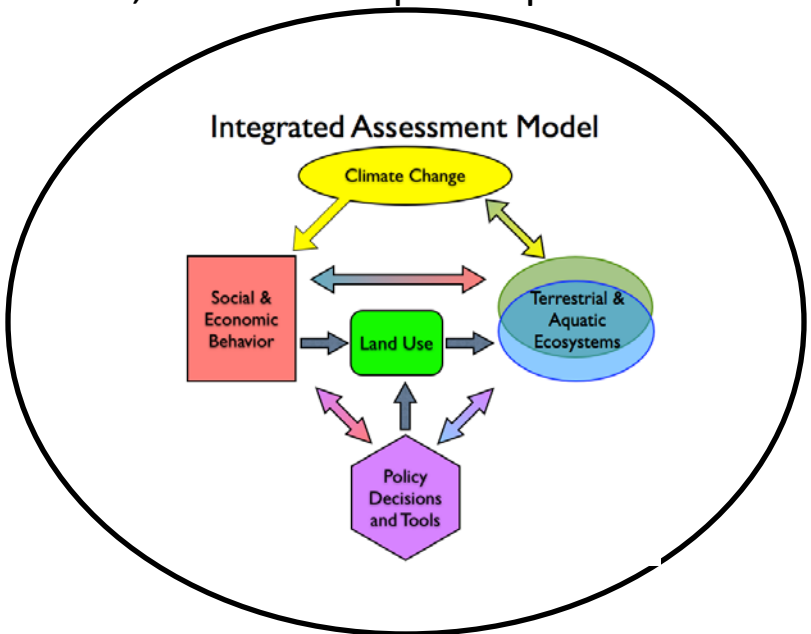
VERMONT EPSCoR

Integrated Modeling Platform Selected

ARIES: ARtificial **I**ntelligence for **E**cosystem **S**ervices

- Integrate Q1, Q2, Q3 so that models can be used to inform stakeholders and decision-makers of the likelihood of possible outcomes of climate change scenarios and adaptive management practices in the LCB.
- Target **audience** includes researchers, governmental decision and policy makers, businesses, and various public-private sustainability initiatives.

Integrated Assessment Model (IAM)



Congrats!
Have **Fun** with this!
Be **Proud** of your collective and individual work!