

System dynamics modelling of interactions within the society-biosphere-climate system

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2 | PRESENTATION

Outline



- Project information
- ANEMI model
 - Modeling approach
 - Model structure
- Scenario analyses
 - Choice
 - Results
- Conclusions



3 | INTRODUCTION

Project information



- NSERC Strategic Grant (2007 – 2011)
- Project objectives

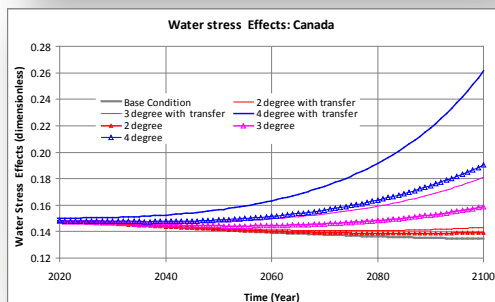
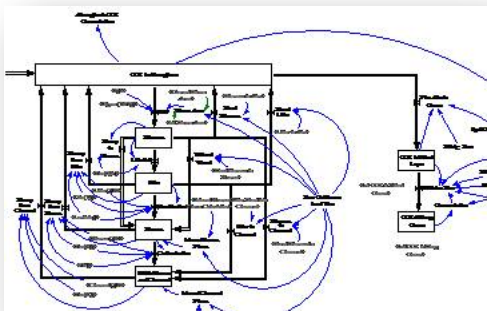


- To develop system dynamics-based model sectors of all biophysical elements of the environment that are relevant to climate change.*
- To develop system dynamics-based model sectors of all socio-economic elements of the environment that are relevant to climate change.*
- To couple the biophysical sectors of the model with important socio-economic sectors.*
- To provide support for communication between the science and policy communities.*
- To examine the effects of climate change on socio-economic and environmental sustainability through the model outputs.*



4 | INTRODUCTION

Project information



- Selection of the methodological approach
- First workshop – August 2008
- ANEMI model development
 - Structure
 - Sectors
 - Preliminary results
- Identification of key issues
 - Communication with the project collaborators
 - Selection of simulation scenarios
- Second workshop – November 2009
- ANEMI model expansion
 - Economy-energy integration
 - Model regionalization
- Model use
 - Scenario analyses
 - Model limitations
- Third workshop – April 2011
- Model transfer
- Future work





Main sectors

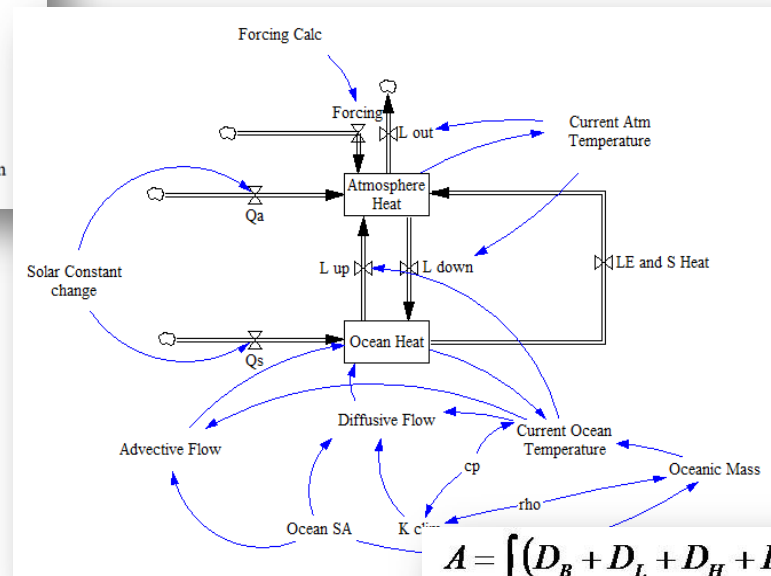
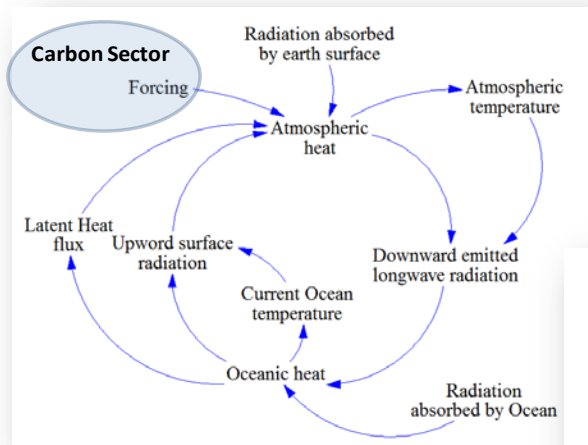
- Carbon
- Climate
- Land use
- Food production
- Population
- Energy-economy
- Surface flow
- Water demand
- Water quality

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6 | ANEMI model

Model structure



$$A = \int (D_B + D_L + D_H + D_K - NPP + B_B + B_L + E - F_O) \cdot dt$$

$$B_{jk} = \int (NPP_{jk} - FL_{B_{jk}} - FH_{B_{jk}} - FK_{B_{jk}} - B_{B_{jk}} - UB_{jk}) \cdot dt$$

$$NPP_{jk} = p_{jk} \cdot \sigma(NPP_j) \cdot SA_j / 1 \times 10^{15}$$

$$\sigma(NPP_j) = \sigma(NPP_j)_0 \times (1 + \beta \ln(A/A_0))$$

$$FH_{B_{j4}} = B_{j4} / \tau(B_{j4})$$

7 | ANEMI model

Model structure

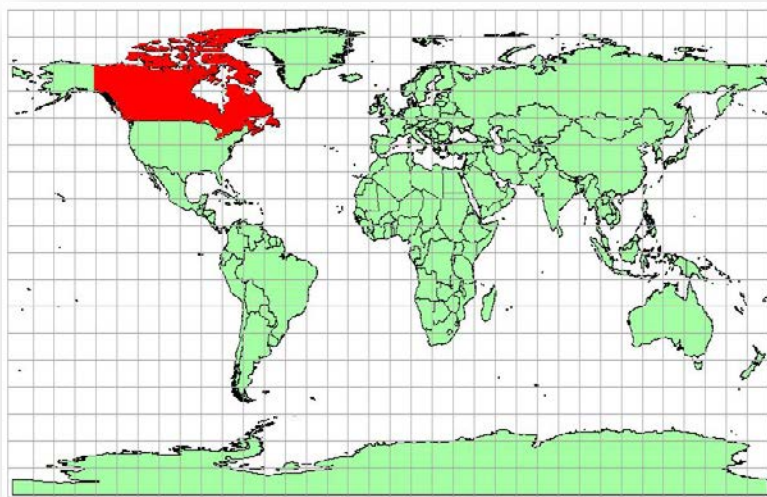


- Key variables
 - Atmospheric CO₂
 - Available surface water
 - Biome areas
 - CO₂ emissions
 - Economic output (GDP)
 - Land use change
 - Population
 - Surface temperature
 - Water withdrawals and consumption
 - Water stress
 - Wastewater treatment and reuse
 - Energy remaining resources
 - Energy price
 - Energy investment strategy
 - Energy maximum production capacity and actual production
 - Energy demand
 - Sea level rise
- Two model versions
 - Global model
 - Regional model



8 | ANEMI model

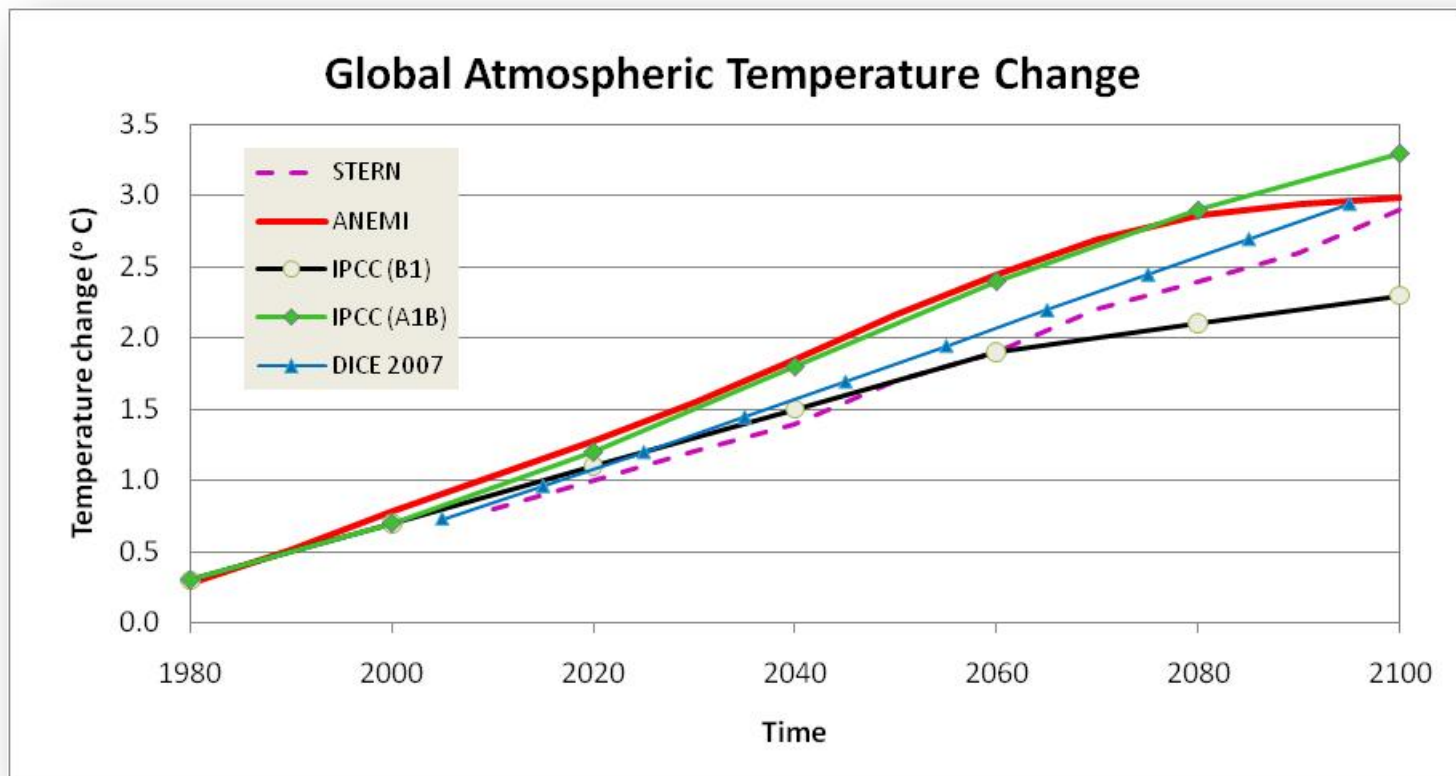
Model structure



- Global model
 - Nine sectors
 - Global issues
 - Global interactions
- Regional model
 - Canada
 - The rest-of-the-world (ROW)
- Scale issues
 - Global: carbon, climate, part of surface flow
 - Regional: land use, food production, population, energy-economy, part of surface flow, water demand, and water quality

9 | MODEL USE

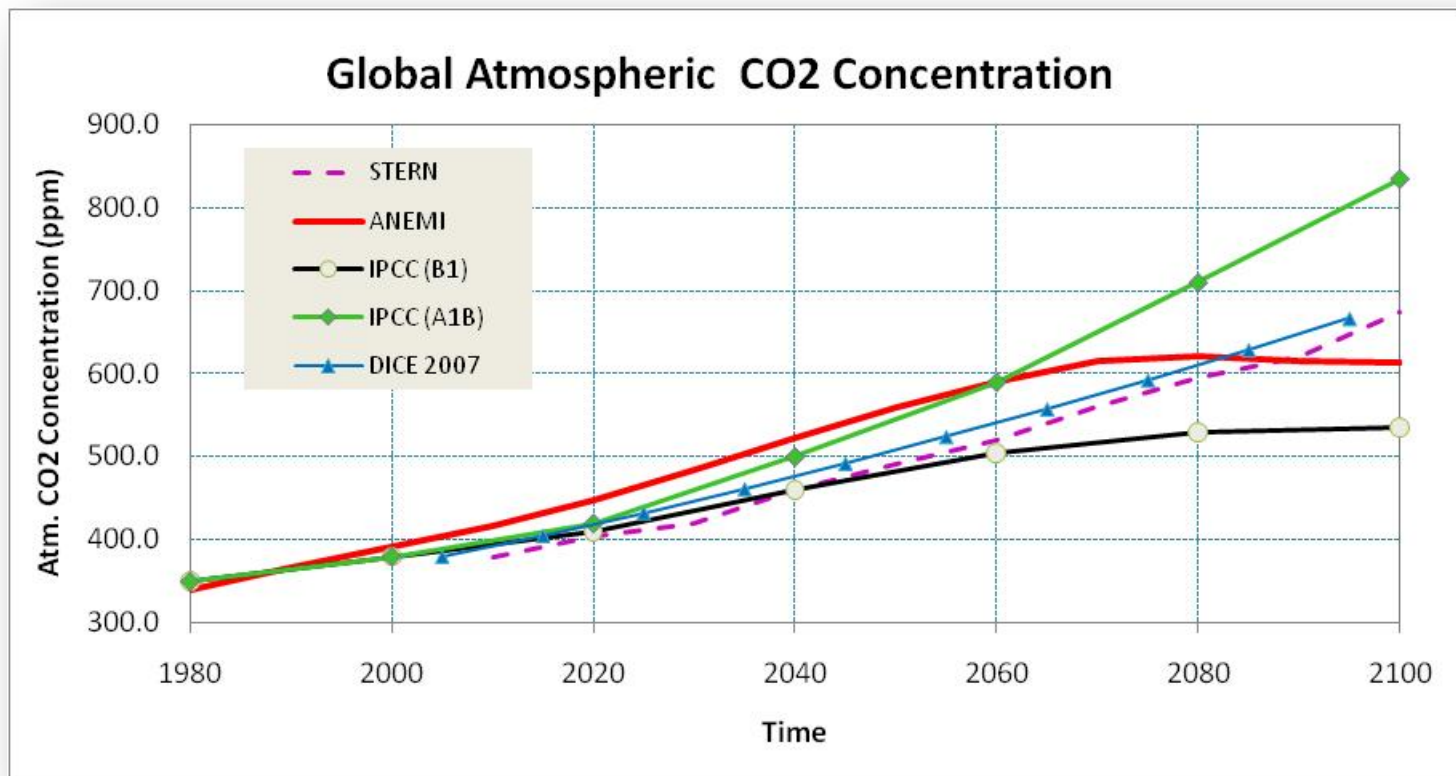
Results



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10 | MODEL USE

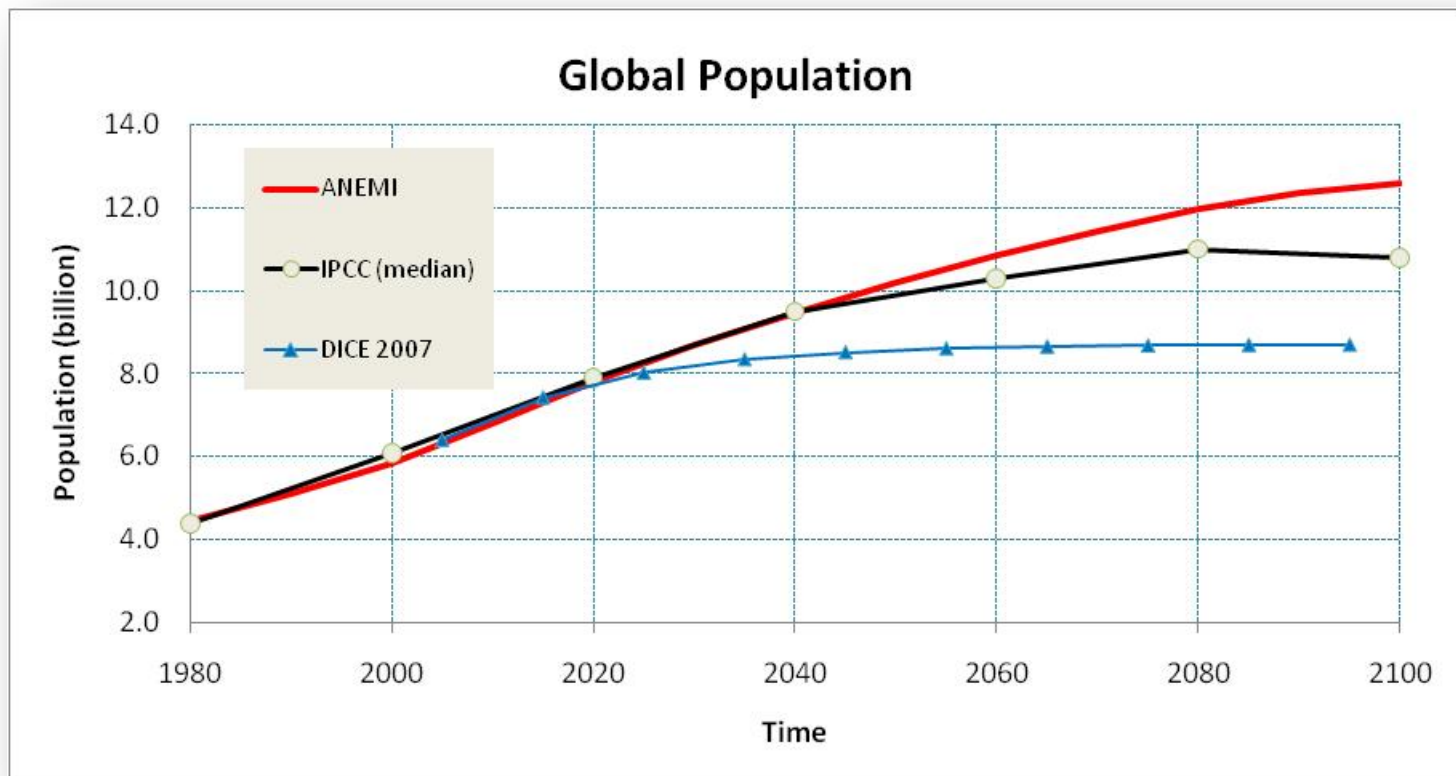
Results



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11 | MODEL USE

Results



12 | MODEL USE

Scenarios

- **Policy communication process**
 - Set of interviews
 - Identification of policy questions by the research team
 - Identification of scenarios (the second project workshop)
- **Initial set of scenarios**
 - Carbon pricing
 - Economic growth rate
 - Water pricing
 - North American water stress
 - Irrigation
 - Energy subsidies and pricing
 - Land use change
- **Final choice**
 - Carbon tax
 - Increased water use
 - Food production increase

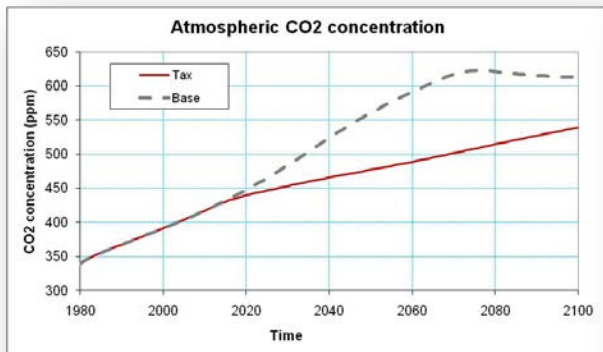


13 | MODEL USE

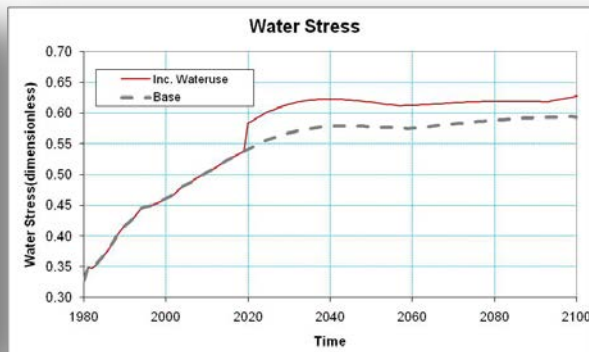
Scenarios - global



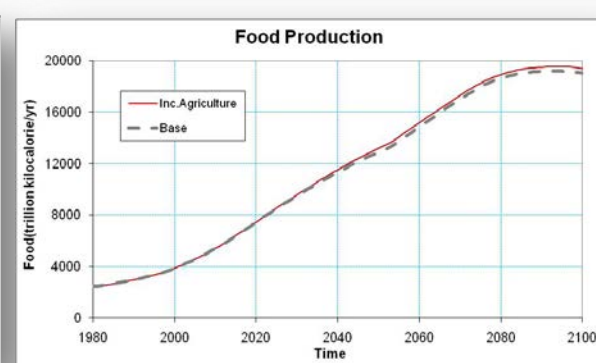
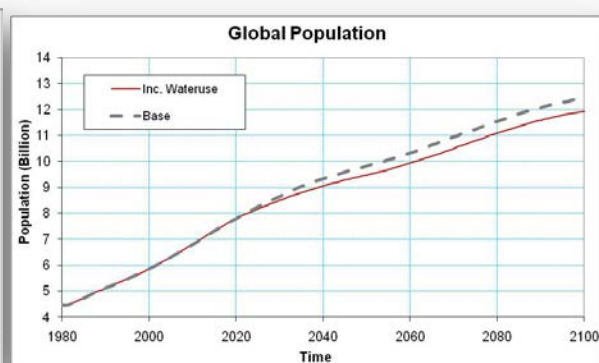
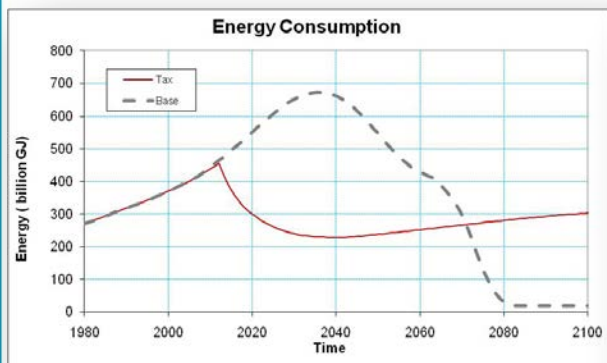
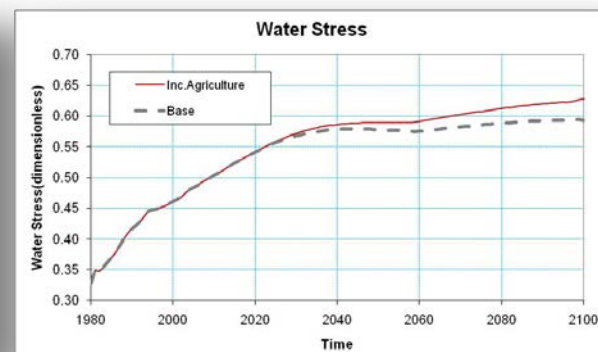
Carbon tax



Increase in water use



Increase in food production

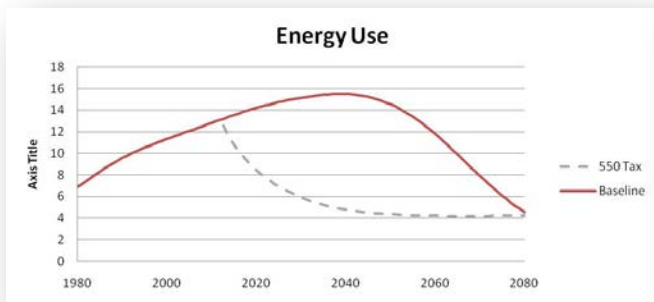


14 | MODEL USE

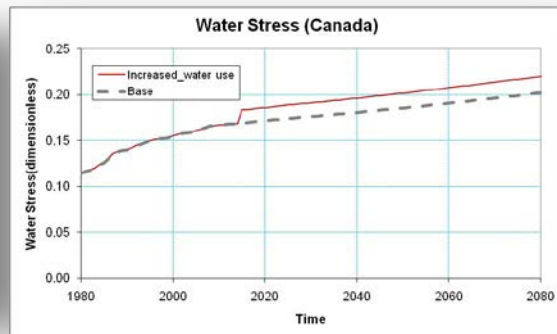
Scenarios - regional



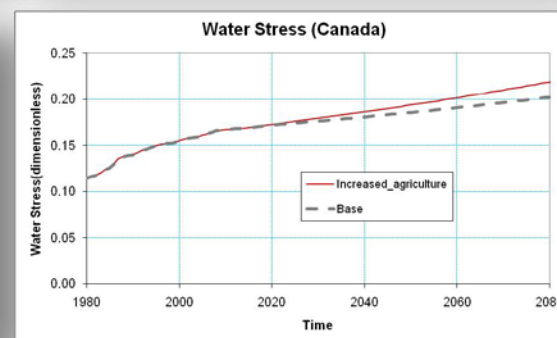
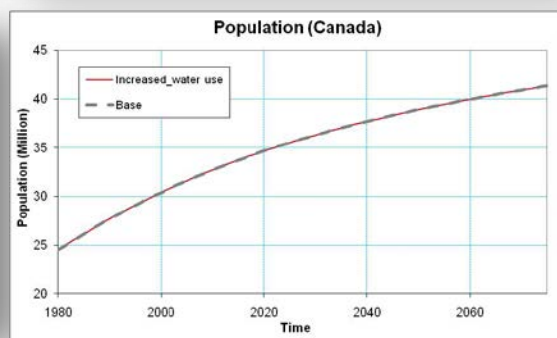
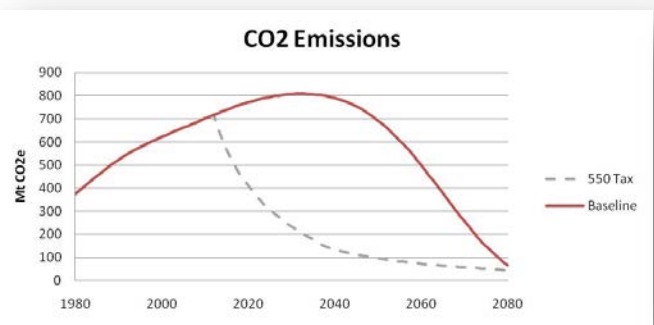
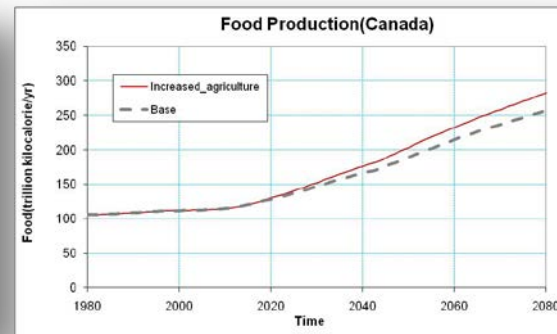
Carbon tax



Increase in water use



Increase in food production



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15 | CONCLUSIONS



- Future work
 - Model sensitivities
 - New scenarios
 - Great Lakes regional model
 - Arctic regional model
- Resources
 - www.slobodansimonovic.com
 - research →publications
 - research →FIDS →research →project name

