# Visual Analytics Tools for the Global Change Assessment Model

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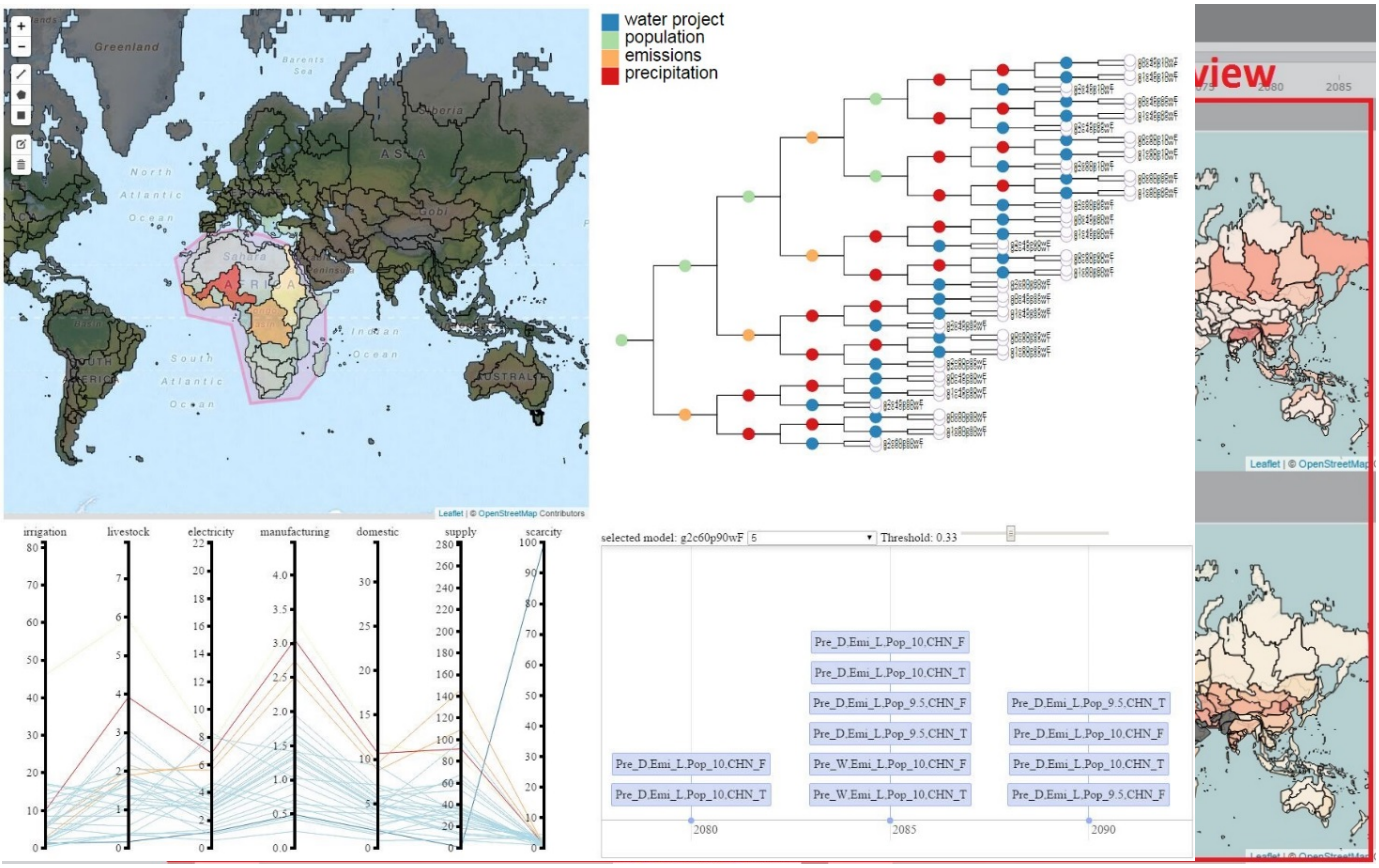
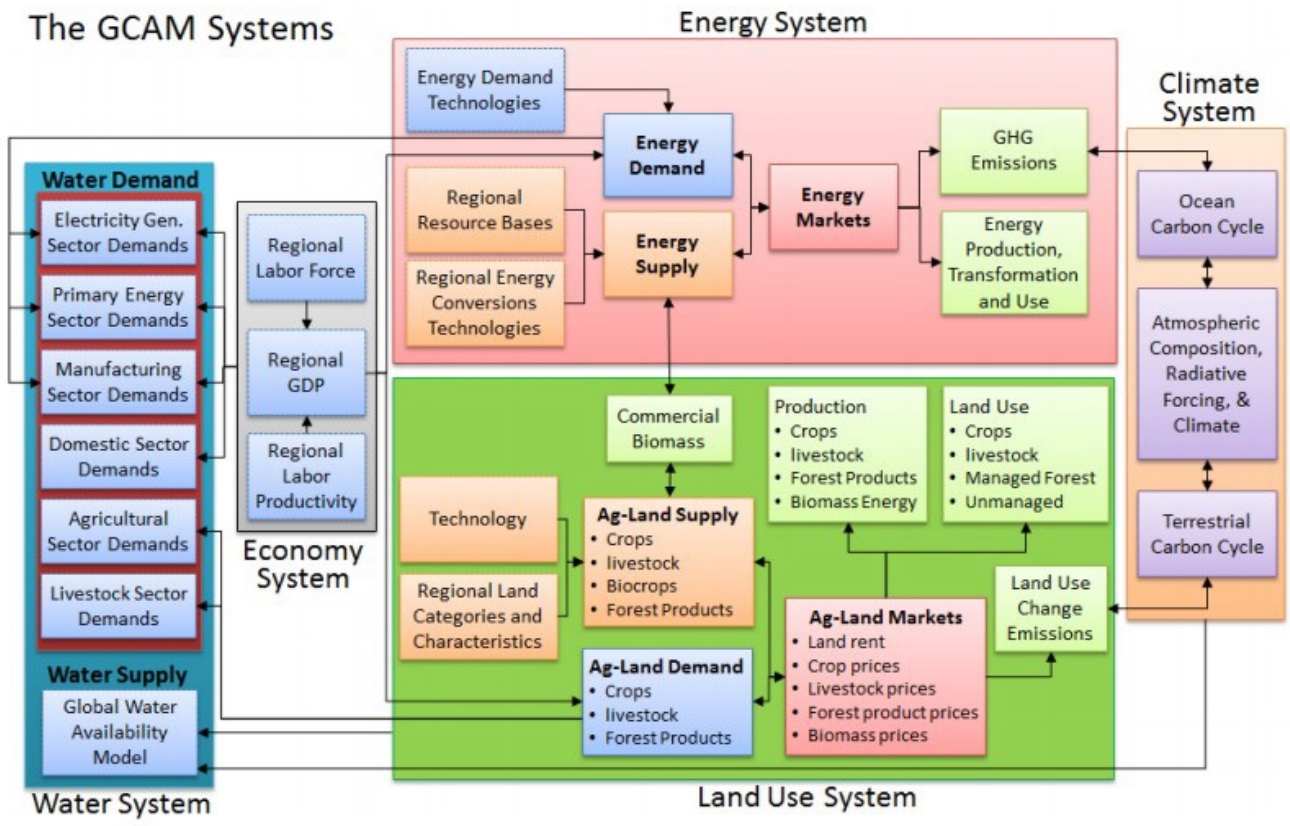
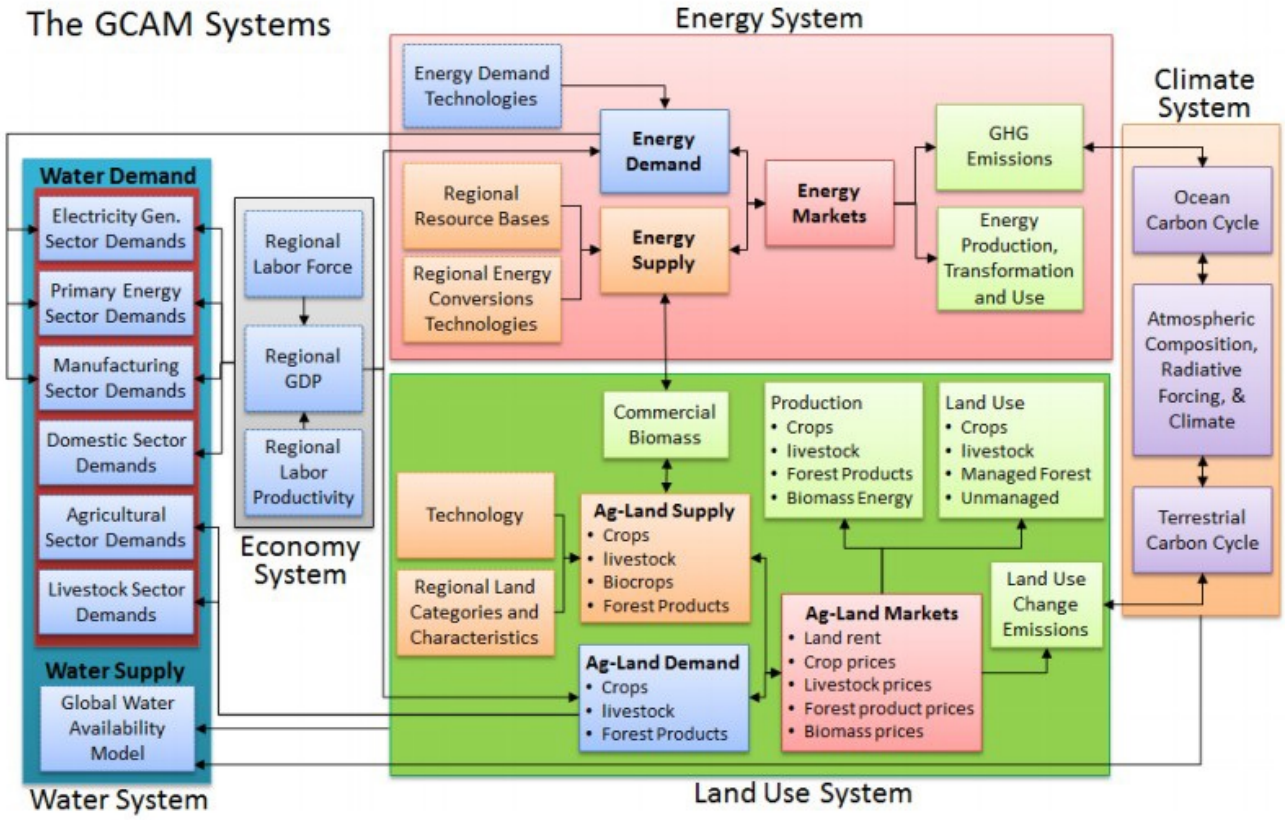
# Result


water project
population
emissions
precipitation
irrigation
livestock
electricity
manufacturing
domestic
supply
scarcity
selected model: g2c60p90wF
Threshold: 0.33
Pre_D.Emi_L.Pop_10.CHN_F
Pre_D.Emi_L.Pop_10.CHN_T
Pre_D.Emi_L.Pop_9.5.CHN_F
Pre_D.Emi_L.Pop_9.5.CHN_T
Pre_W.Emi_L.Pop_10.CHN_F
Pre_W.Emi_L.Pop_10.CHN_T
2080
2085
2090

# What is the Global Change Assessment Model ?

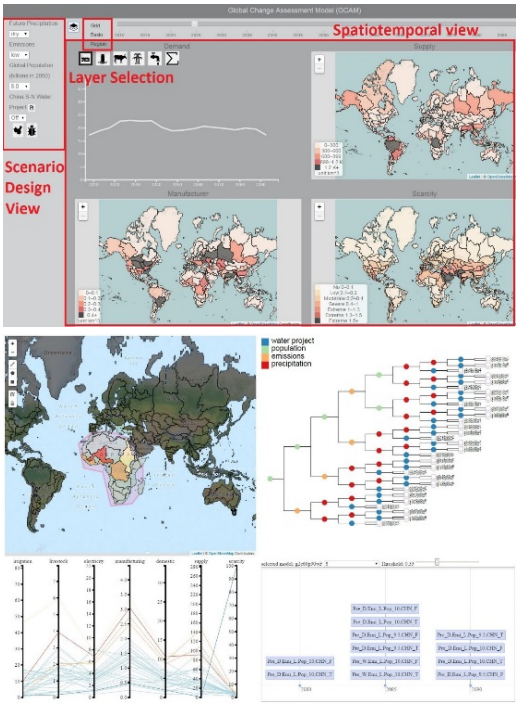


# Challenges


The GCAM Systems
Energy System
Energy Demand Technologies
Energy Demand
Regional Resource Bases
Energy Supply
Regional Energy Conversions Technologies
Energy Markets
GHG Emissions
Energy Production, Transformation and Use
Climate System
Ocean Carbon Cycle
Atmospheric Composition, Radiative Forcing, & Climate
Terrestrial Carbon Cycle
Water Demand
Electricity Gen. Sector Demands
Primary Energy Sector Demands
Manufacturing Sector Demands
Domestic Sector Demands
Agricultural Sector Demands
Livestock Sector Demands
Water Supply
Global Water Availability Model
Water System
Regional Labor Force
Regional GDP
Regional Labor Productivity
Economy System
Commercial Biomass
Technology
Regional Land Categories and Characteristics
Ag-Land Supply
• Crops
• livestock
• Biocrops
• Forest Products
Ag-Land Demand
• Crops
• livestock
• Forest Products
Production
• Crops
• livestock
• Forest Products
• Biomass Energy
Land Use
• Crops
• livestock
• Managed Forest
• Unmanaged
Ag-Land Markets
• Land rent
• Crop prices
• Livestock prices
• Forest product prices
• Biomass prices
Land Use Change Emissions
Land Use System

# Research Goal

- Design and develop the first web-based visual analytics tool for the GCAM.
  - Scenario exploration
    - Geospatial perspective
    - Temporal perspective
  - Similarity analysis
    - Between scenarios
    - Between basins



# GCAM Data

- Inputs:
  - Future precipitations
  - Greenhouse Gas control policies
  - Global population
  - China South-North Water Transportation Project
- Outputs:
  - Water demand
  - Water supply
  - Water scarcity

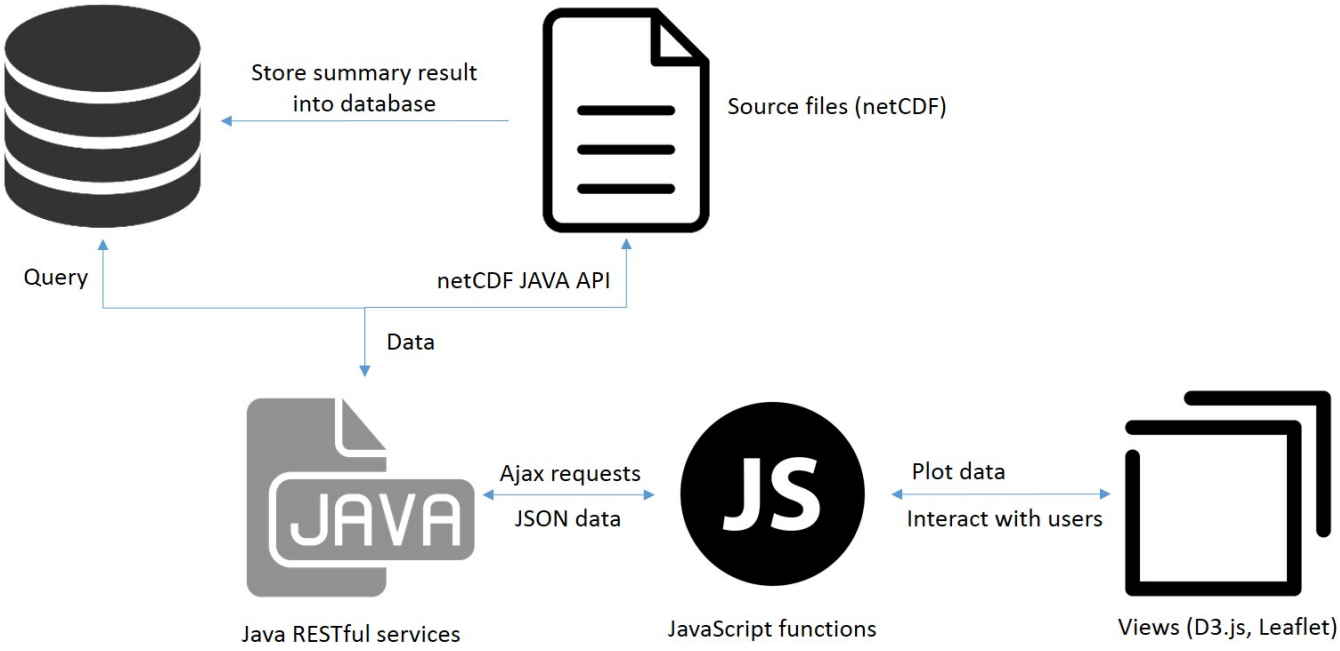
| Name | Description |
|---|---|
| Irrigation | Demand for irrigation use |
| Livestock | Demand for livestock use |
| Electricity | Demand for electricity use |
| Manufacturing | Demand for manufacturing use |
| Domestic | Demand for domestic use |
| Total | Demand in total |
| Scarcity | Scarcity value |
| Supply | Supply value |

# GCAM Data

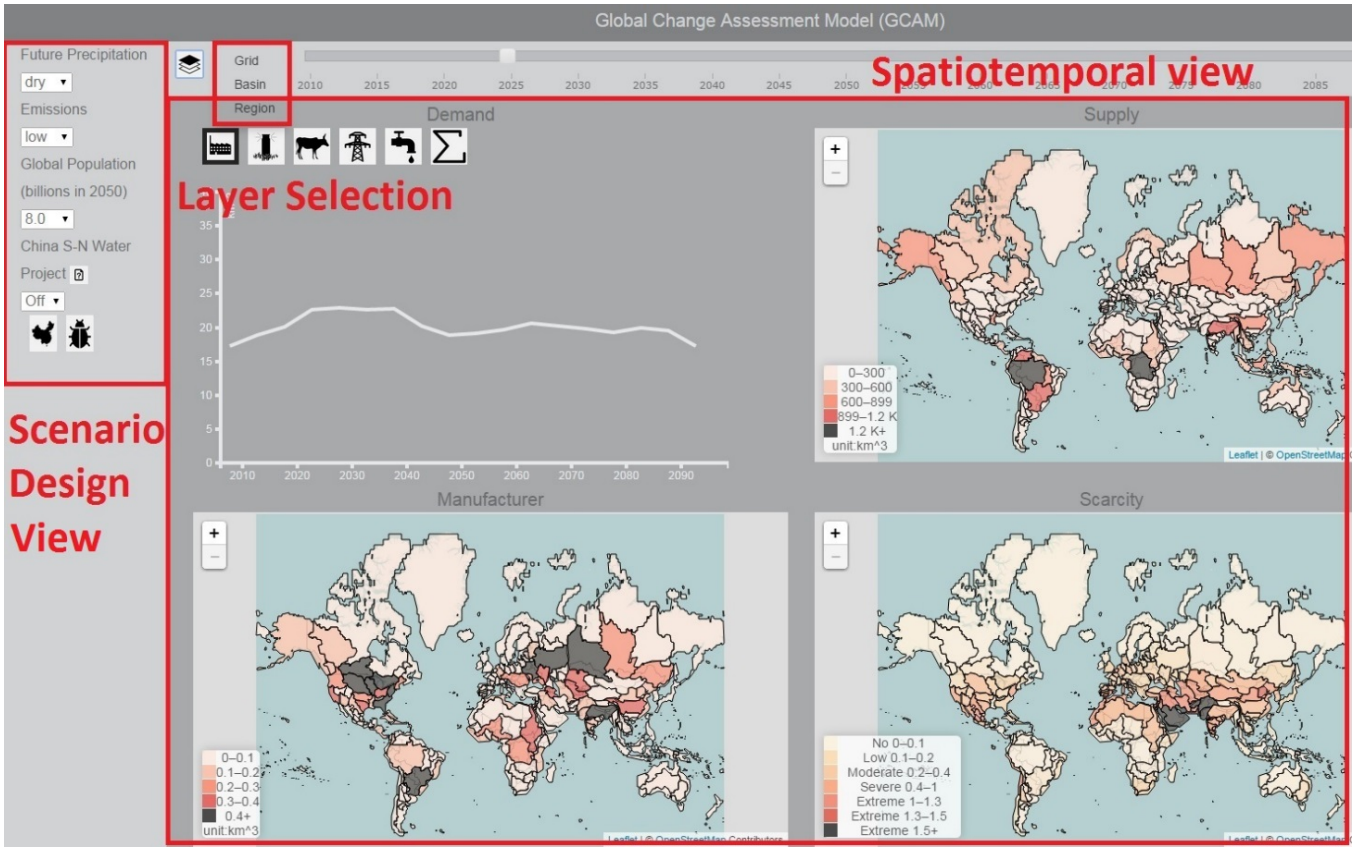
- Temporal info: From 2010 to 2095 at five year intervals , 18 year steps in total
- Spatial info:
  - Grid level: 0.5°×0.5°, which is 720×360 in total
  - Basin level: 235 basins
  - Region level: 62 regions including 31 divisions in China

# System Design

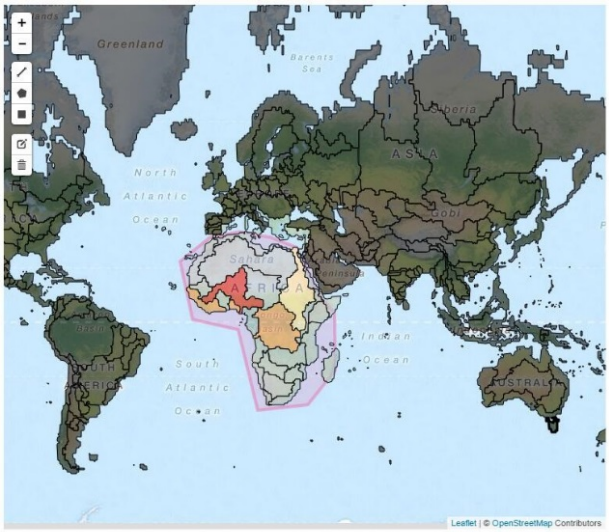
- Model-View-Controller (MVC)

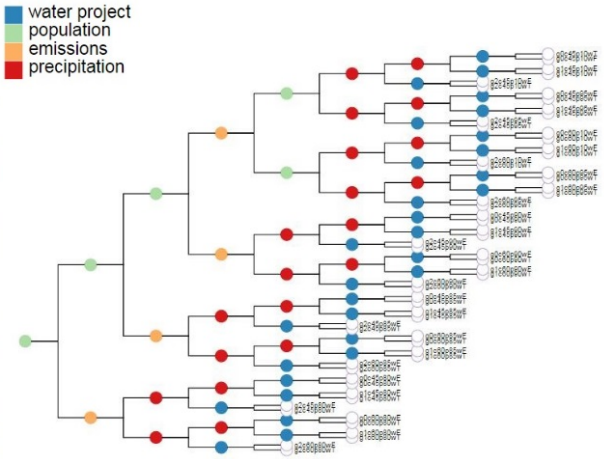


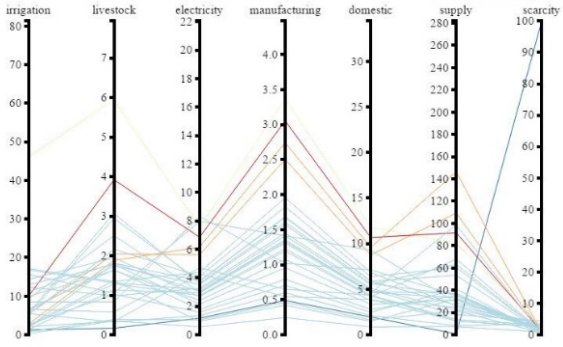
# GCAM Visual Analytics View

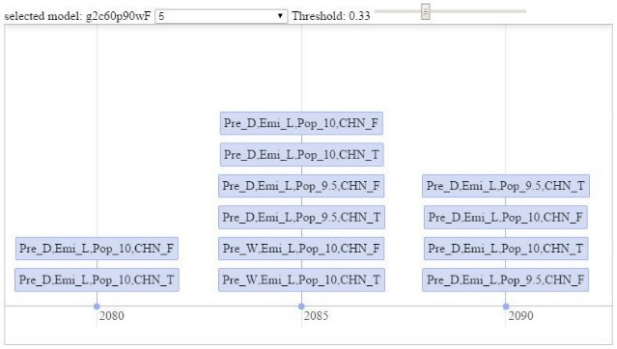


# Similarity Analysis View



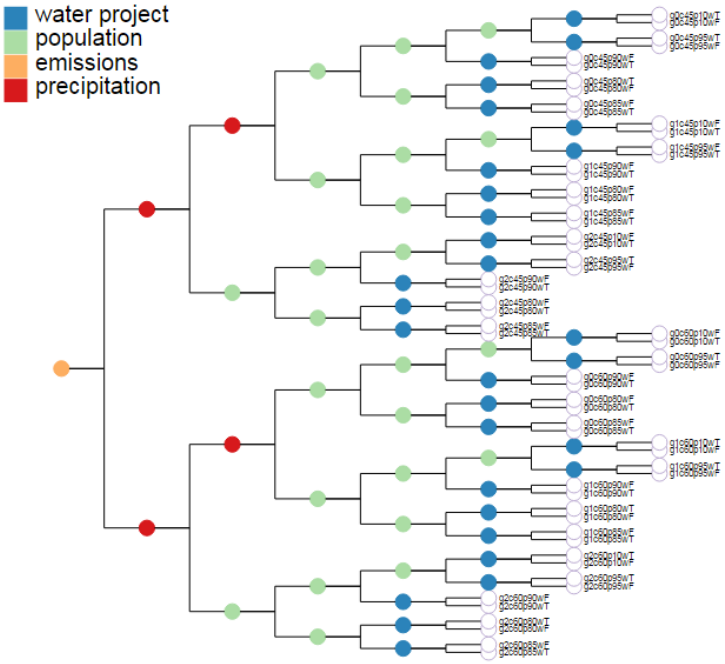



# Dendrogram

## -Model Level Similarity

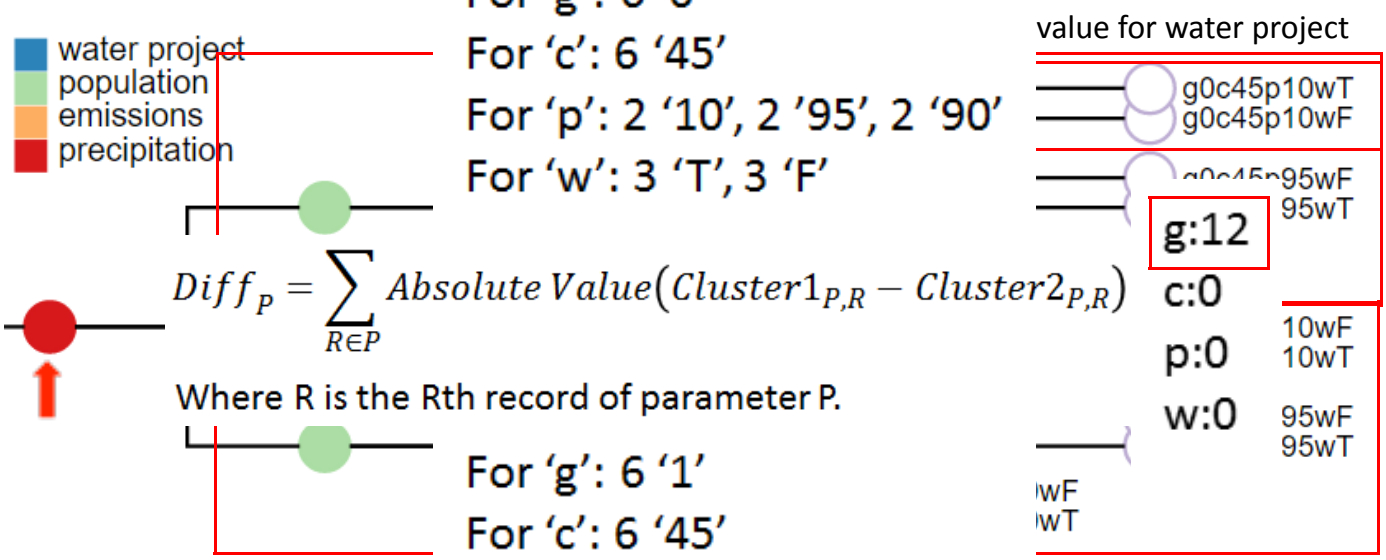
- Parent Nodes are labeled with the parameters that have the smallest impact on the grouping procedure.




Dendrogram is one of the most frequent visualization approaches to illustrate the arrangement of the clusters in a hierarchical structure [2].

[2] Everitt, B. S. and A. Skrondal, “The cambridge dictionary of statistics", Cambridge: Cambridge (2002).

# Node Labeling




Scenario Name and th
Precipitation: term 'g'
Emissions: term 'c'
Population: term 'p'
Water Project: term 'w'

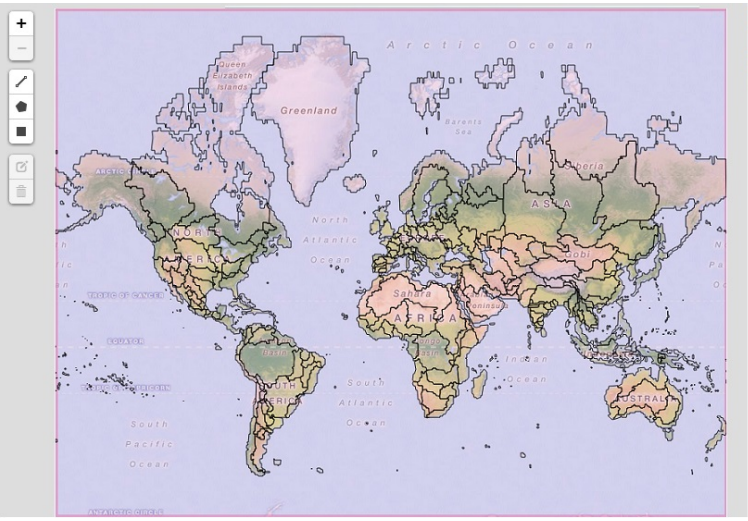
# Case Study - The impact of spatial variations and scales on scenario similarity

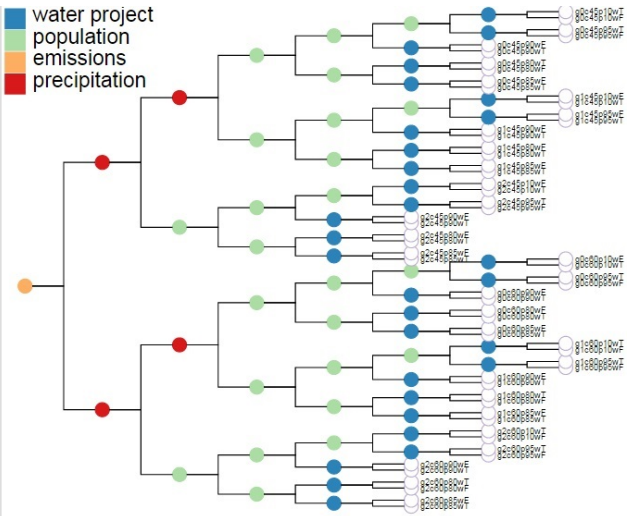
-World: 235 basins
-Continental: continents at the basin level
-Country, 31 divisions in China

# World Scale

- World level: all 235 basins

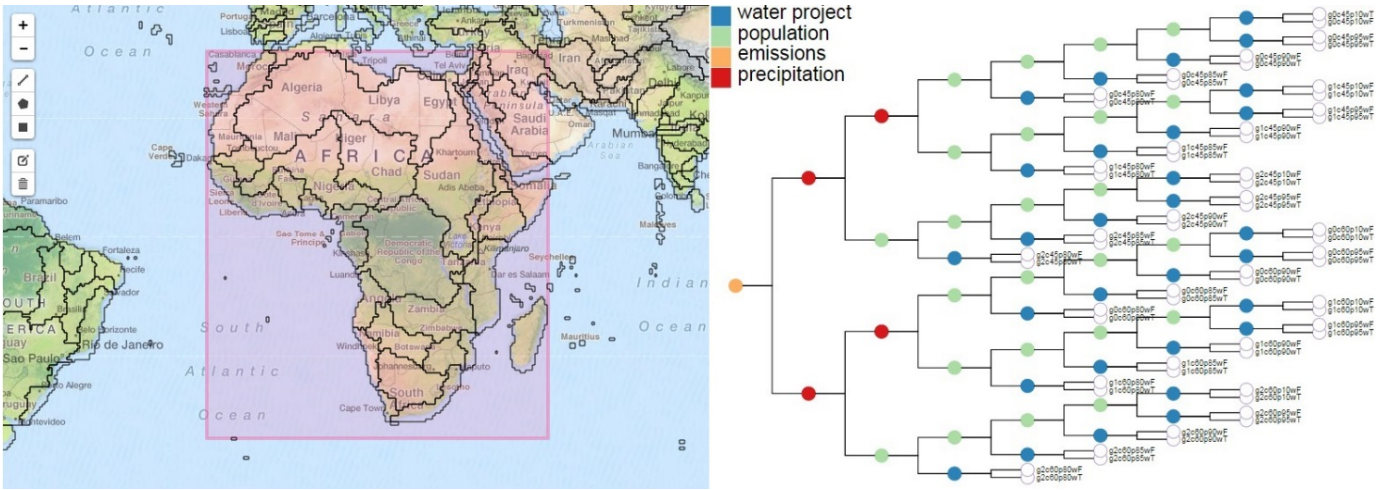
  Future emissions will make the largest impact on the scenario dissimilarity, followed by precipitation, population, and the China S-N Water Transportation Project.



# Continental Scale and Variations

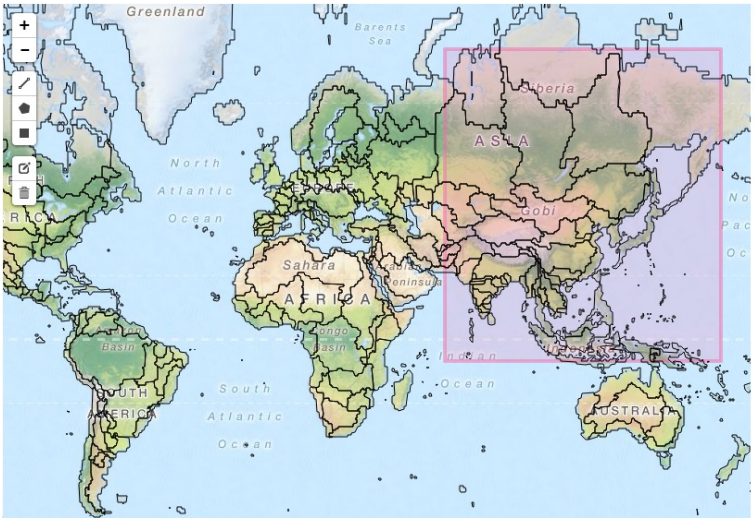
- Africa
  Same as the world scale result

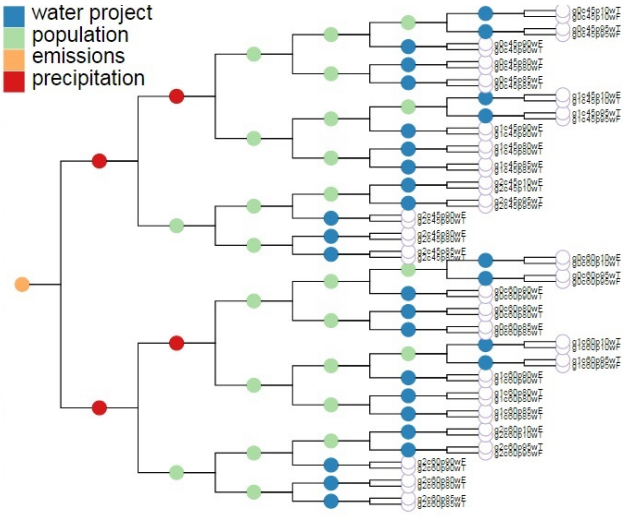


# Continental Scale and Variations

- Asia

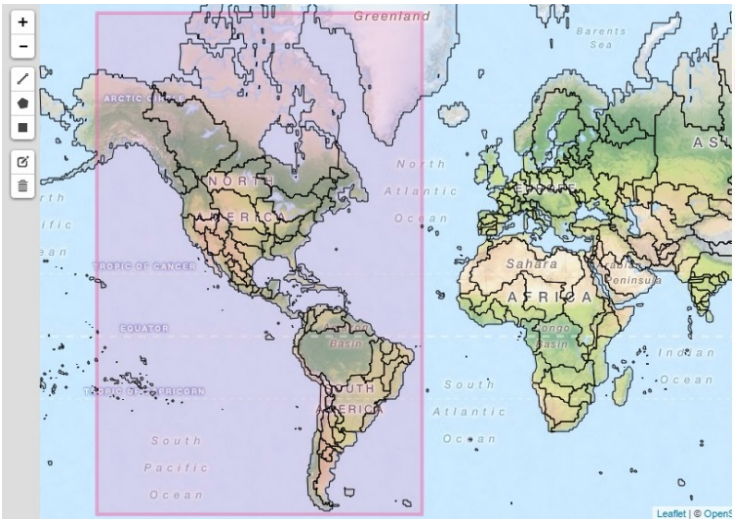
  Same as the world scale result

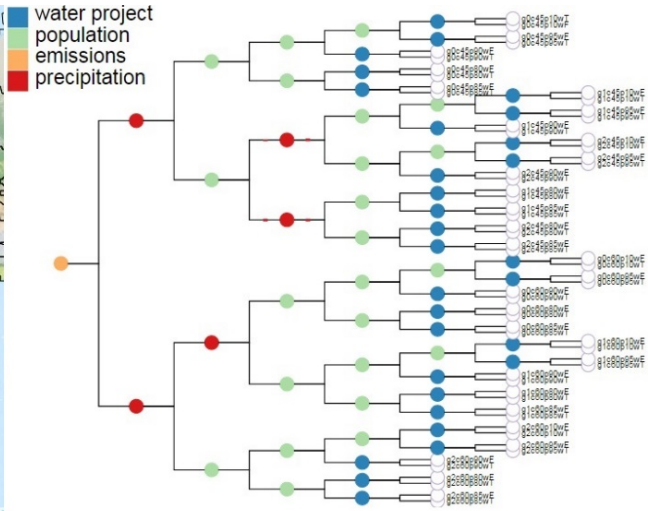


# Continental Scale and Variations

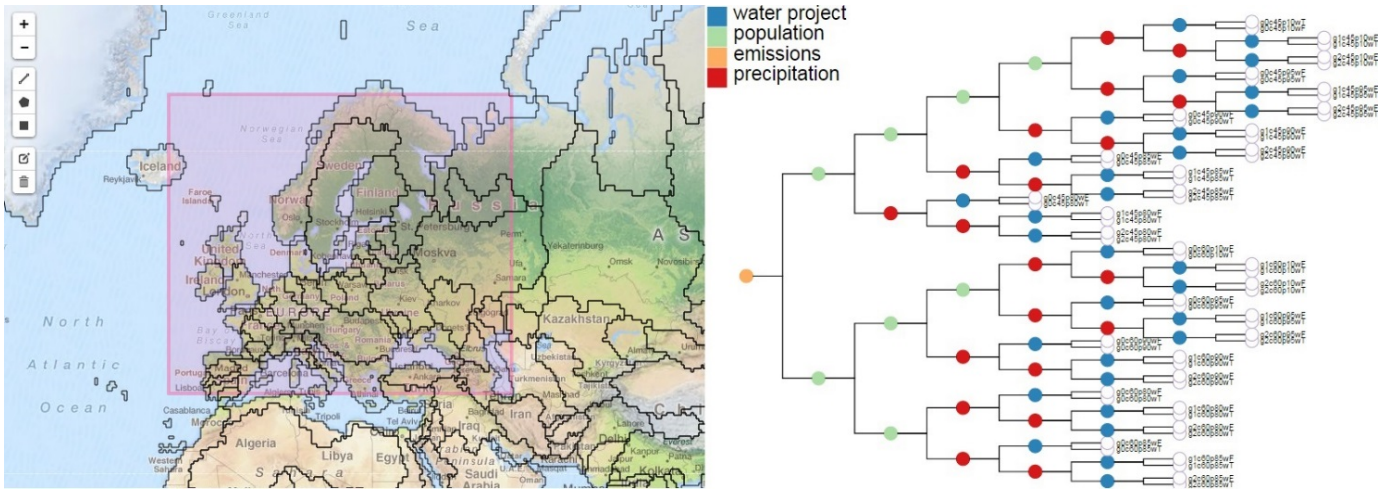
- America
  Same as the world scale result



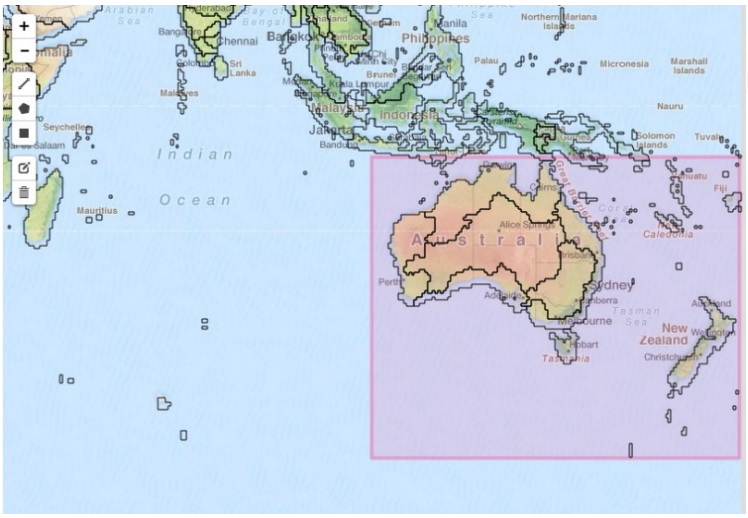
# Continental Scale and Variations

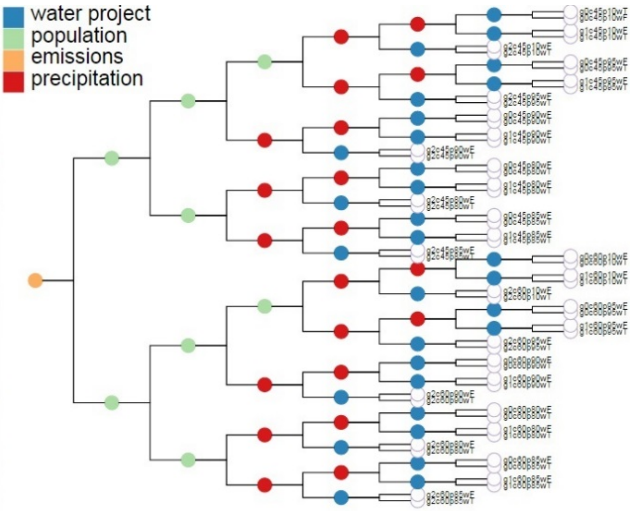
- Europe
  The population makes bigger impacts



# Continental Scale and Variations

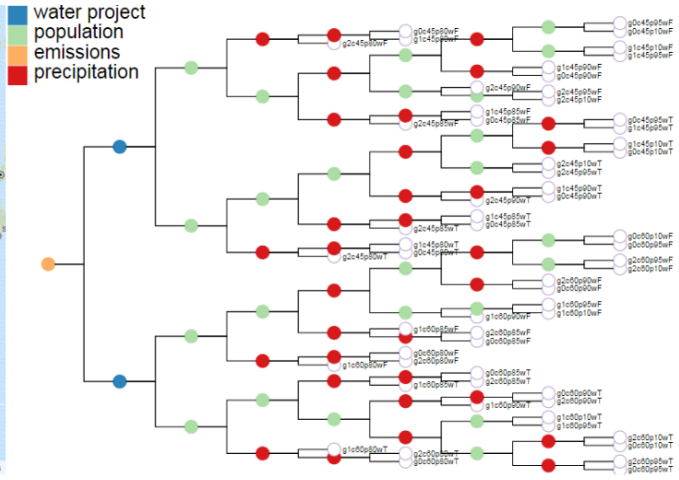
- Australia
  The population makes bigger impacts



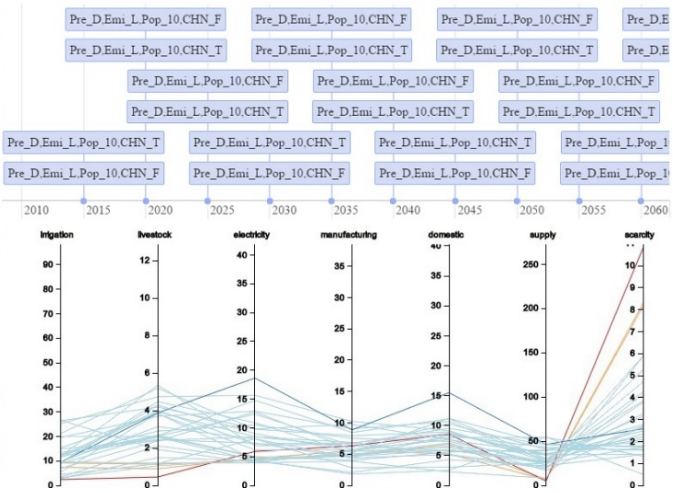
# Country Scale

- China – Scenario Similarity Analysis
  Mixed sequences of precipitation, and population

# Country Scale

- China – Basin Similarity Analysis


Average scarcity threshold: 0.4 (severe water scarcity)

# Demo

- Similarity Analysis View
- GCAM Visual Analytics View

# Thank You!

Visual Analytics &
Data Exploration Research

- Contributions
  - The first ever web-based geovisual analytics tool for the GCAM
  - Inter-comparison and similarity analysis of climate scenarios with the GCAM models across the globe
- Future Work
  - More clustering approaches
  - Methods that deal with a large number of sectors
  - More visualization features
  - UI improvement
- Contact
  - rmacieje@asu.edu, vader.lab.asu.edu

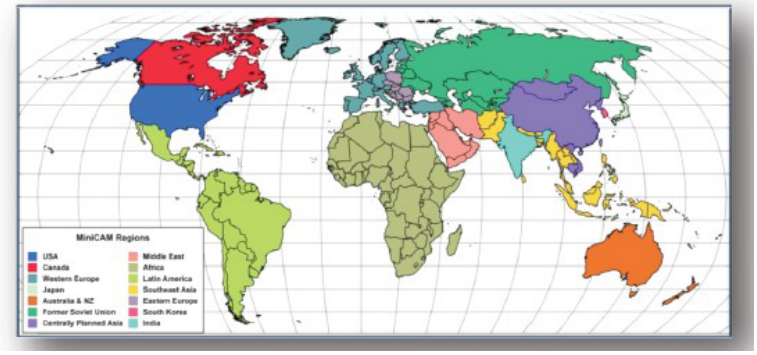
# GCAM History

- GCAM was one of four models chosen to create the representative concentration pathways for the IPCC's AR5.
- GCAM was one of three models used to create scenarios for the Climate Change Science Program's scenario analysis.
- GCAM has been a prominent tool for analysis in the Climate Change Technology Program.
- GCAM has participated in virtually every major climate/energy/economics assessment over the last 20 years:
  - Every Energy Modeling Forum study on climate
  - Every IPCC assessment
- GCAM has been used for strategic planning by energy and other private companies.
- GCAM is now used by research institutions and governments internationally.

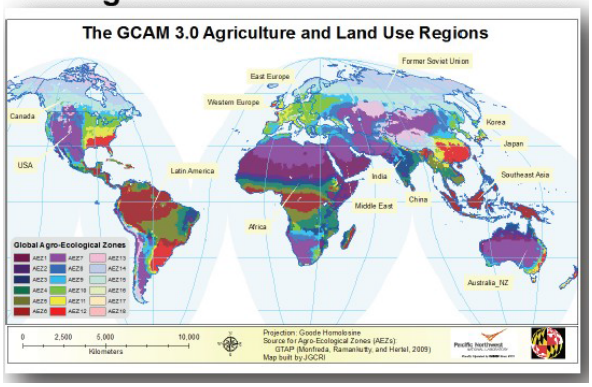
# GCAM

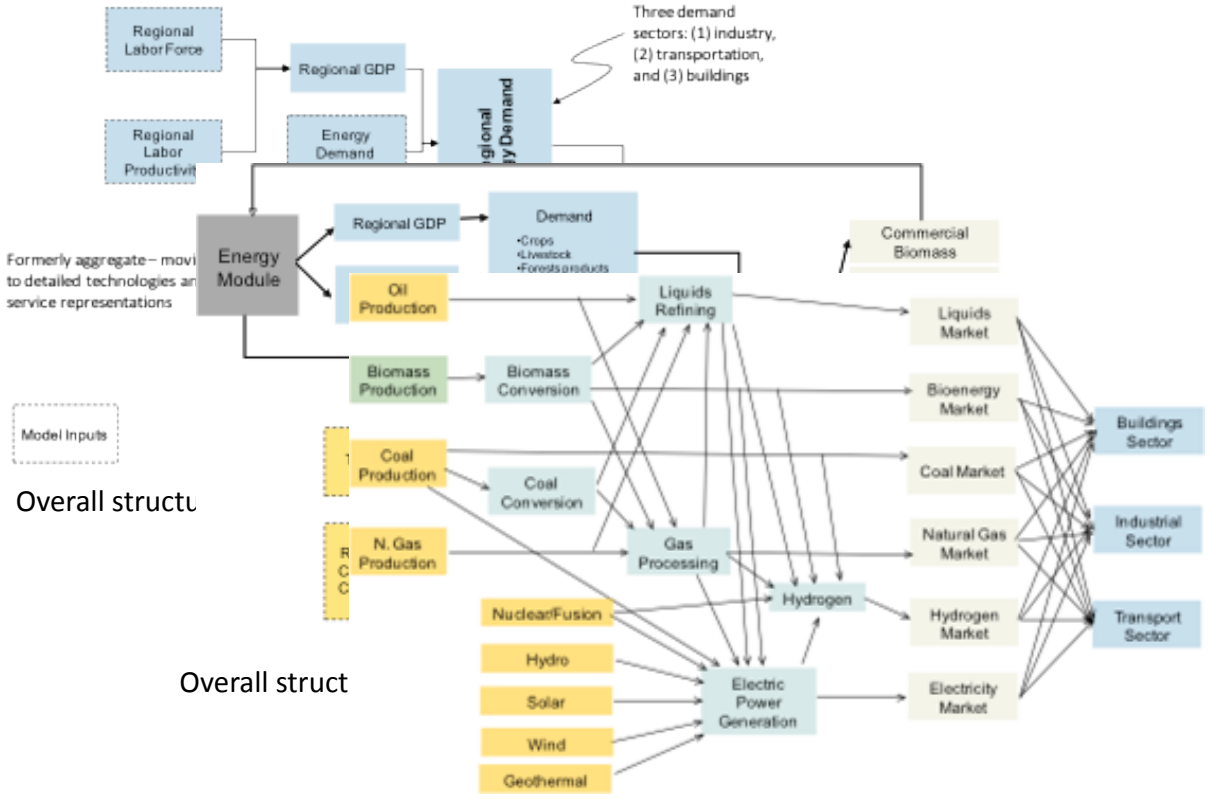
- GCAM links economic, energy, land-use, and climate systems.
- Typically used to examine the effect of technology and policy on the economy, energy system, agriculture and land-use, and climate.
- Emissions of 16 greenhouse gases.

**14 Region Energy/Economy Model**




**151 Agriculture and Land Use Model**



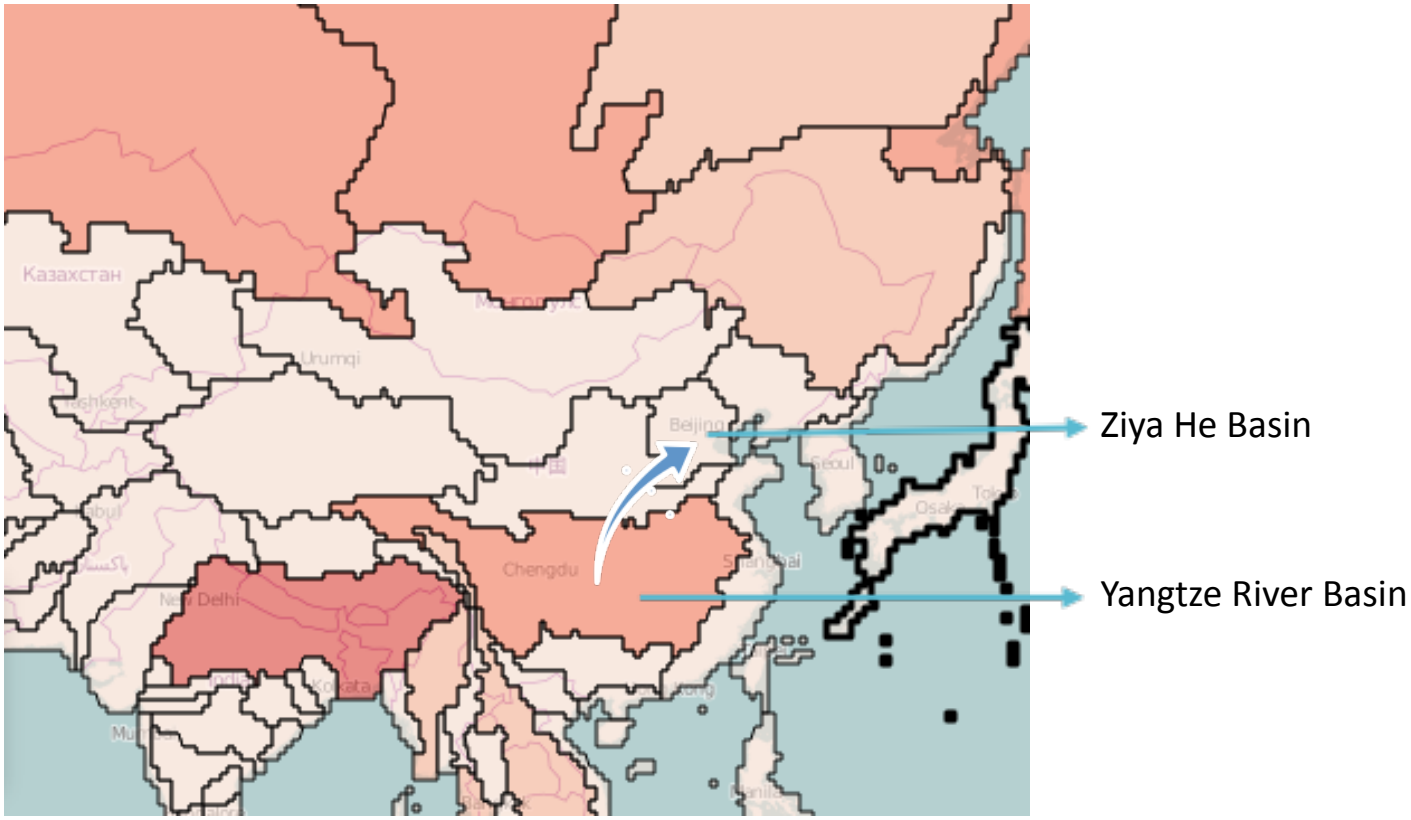



Overall structu

Overall struct

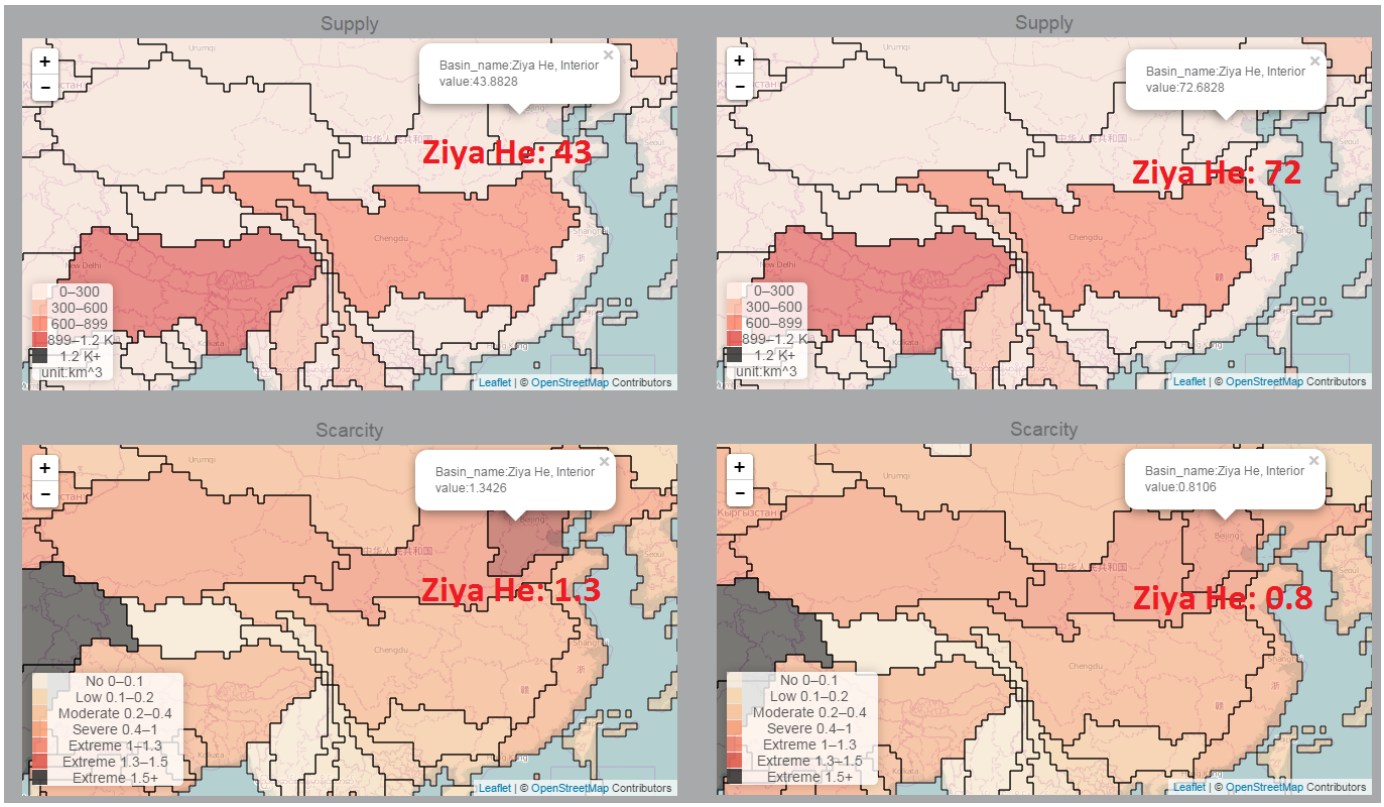
Overview of energy production and transformation in GCAM

# Case Study - China South-North Water Project



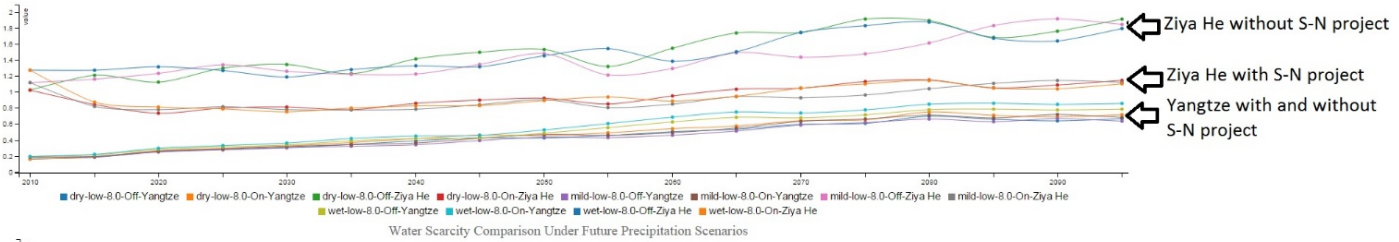
- # Spatial Exploration

  Dry future precipitation, low emissions, and 8 billion population in 2030

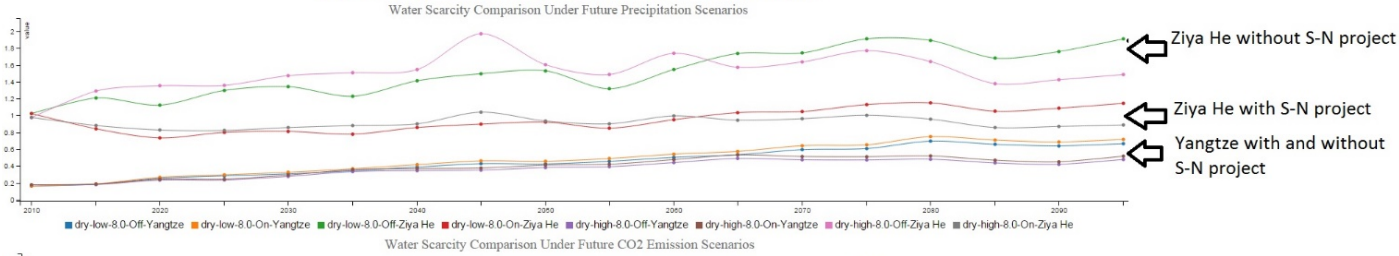


- # Temporal Exploration

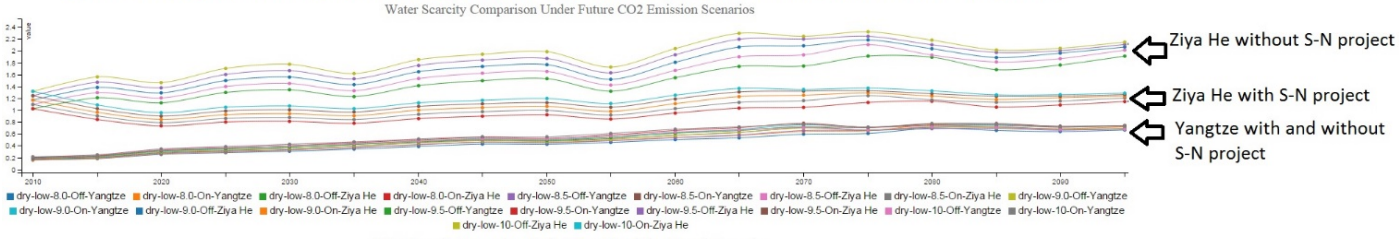
  The water scarcity situations in Ziya He Basin improves significantly when the water project carries on, whereas the water project does not dramatically worsen the water scarcity situations in Yangtze River Basin.




Water Scarcity Comparison Under Future Precipitation Scenarios



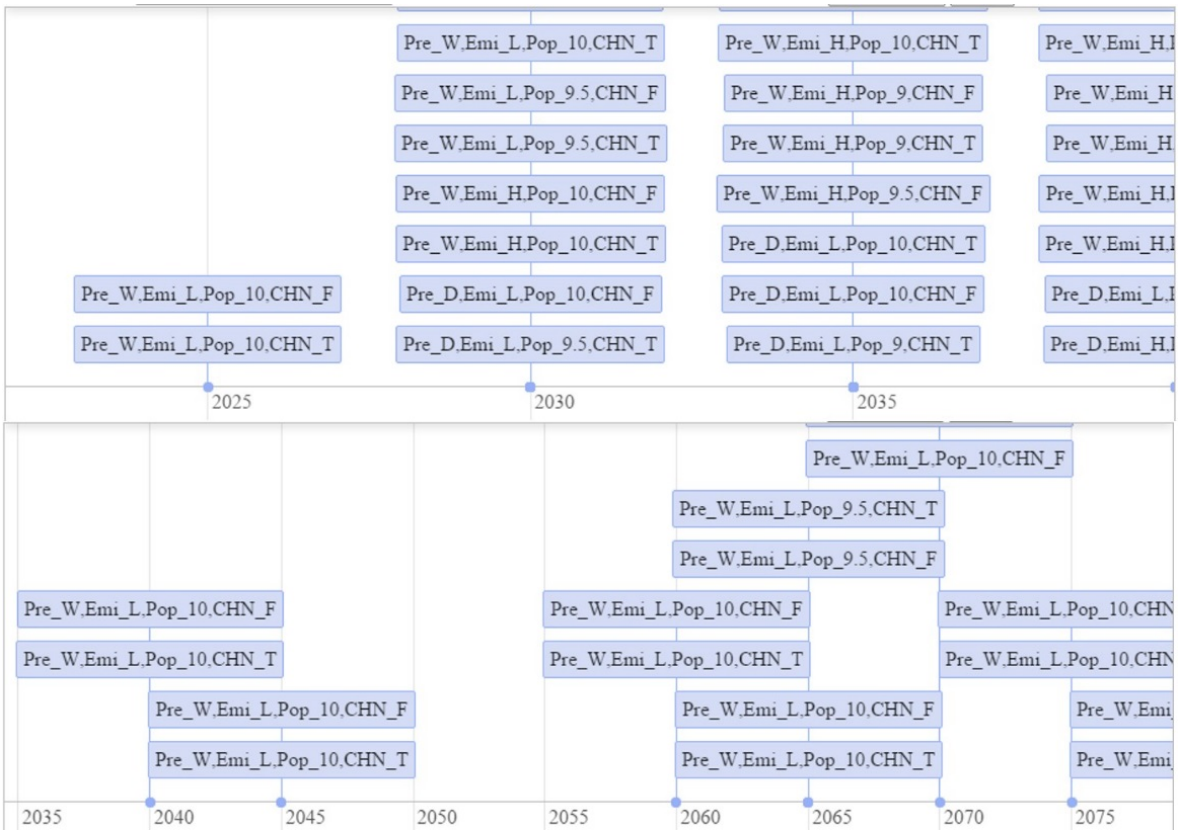

Water Scarcity Comparison Under Future CO2 Emission Scenarios




Water Scarcity Comparison Under Future Population Growth Scenarios

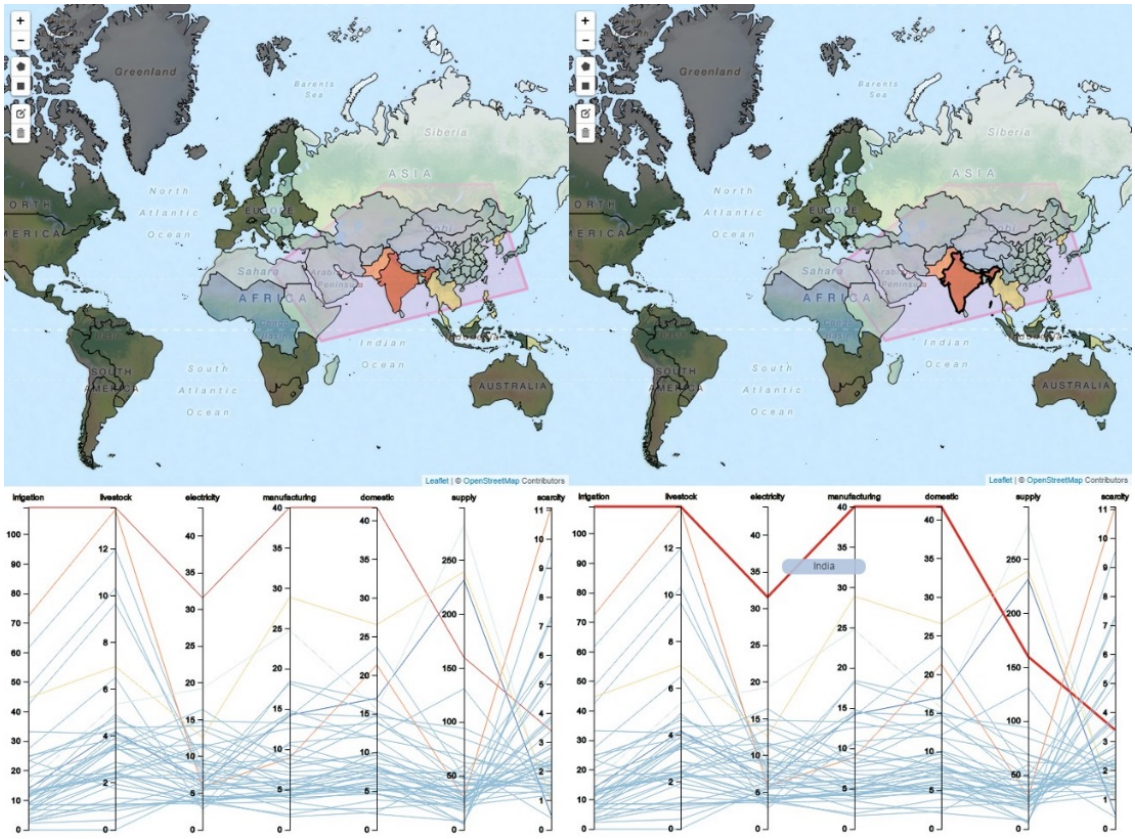
# Labeled Time Line

## -Yearly Average Water Scarcity



# Parallel Coordinate Plot

## -Basin Level Similarity



# Parallel Coordinate Plot

- Brushing on axes