Environmental Protection

Overview of New York City Water Supply Climate Change Research

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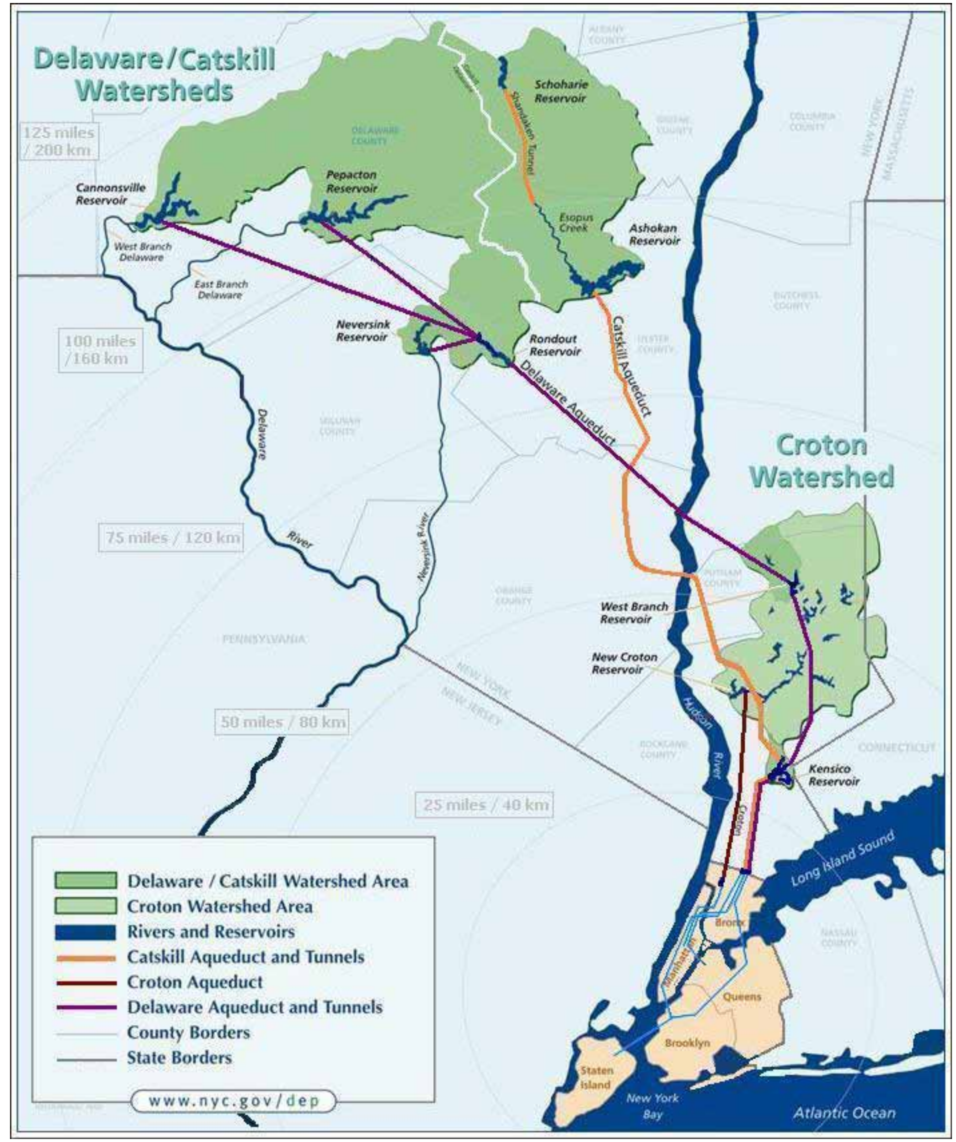
New York City's Water Supply System

NYC Environmental Protection

- New York City draws its drinking water from 1,972 square miles of watershed, extending to the Catskill Mountains, up to 125 miles north of the city.
- 19 reservoirs and 3 aqueducts supply 1 billion gallons to more than 9.3 million people daily.
- Catskill and Delaware watersheds currently supply 100 % of demand.
- Croton watershed has potential to meet up to 30 % of demand.



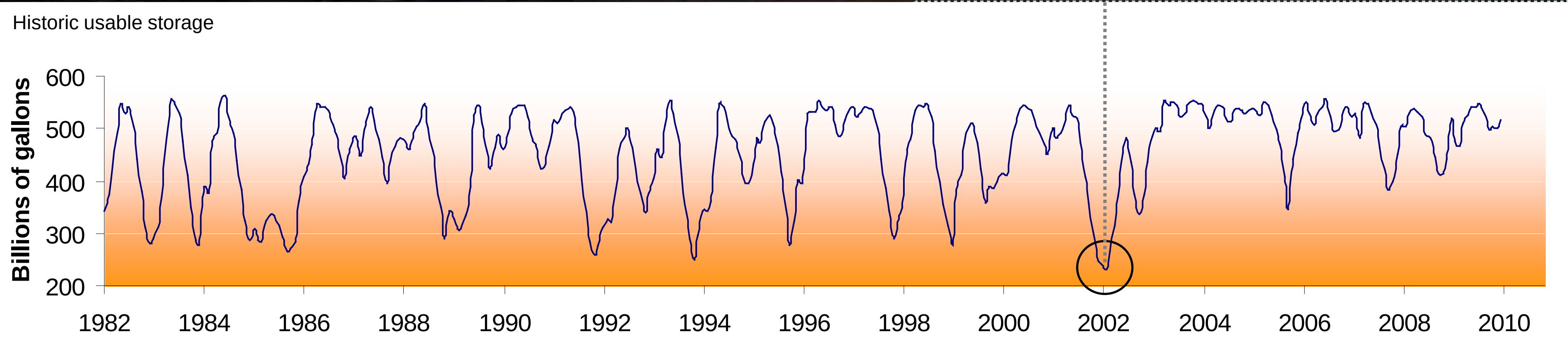
Main Goals

- Identify the potential impacts of climate change using a quantitative modeling frame work.
  - Interested in both Water Quantity and Quality
  - Consequences are difficult to predict as a result of complex interactions between processes
- Begin to evaluate paths to adaptation.
  - WRF project 4262. Vulnerability assessment and risk management tools for climate change: Assessing potential impacts and identifying adaptation options
  - WRF Project 4306. Analysis of reservoir operations under climate change

Issues of Concern

Water Availability

- Our region currently experiences intermittent drought and flooding



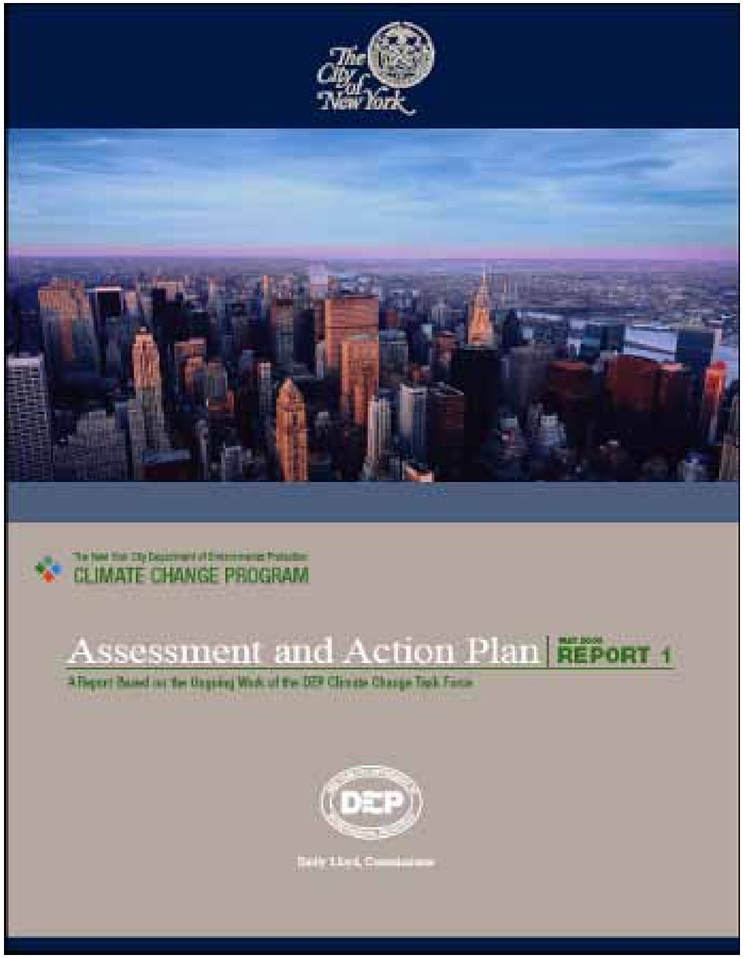
Drinking Water Quality - Turbidity

- Increased precipitation may cause increased turbidity in the Catskill system.

Drinking Water Quality - Eutrophication

- Changes in climate may affect trophic status and phytoplankton.
  - Changes in water temperature , thermal structure and mixing, and the timing of nutrient delivery

DEP Climate Change Program Objectives



Assessment and Action Plan, Report 1

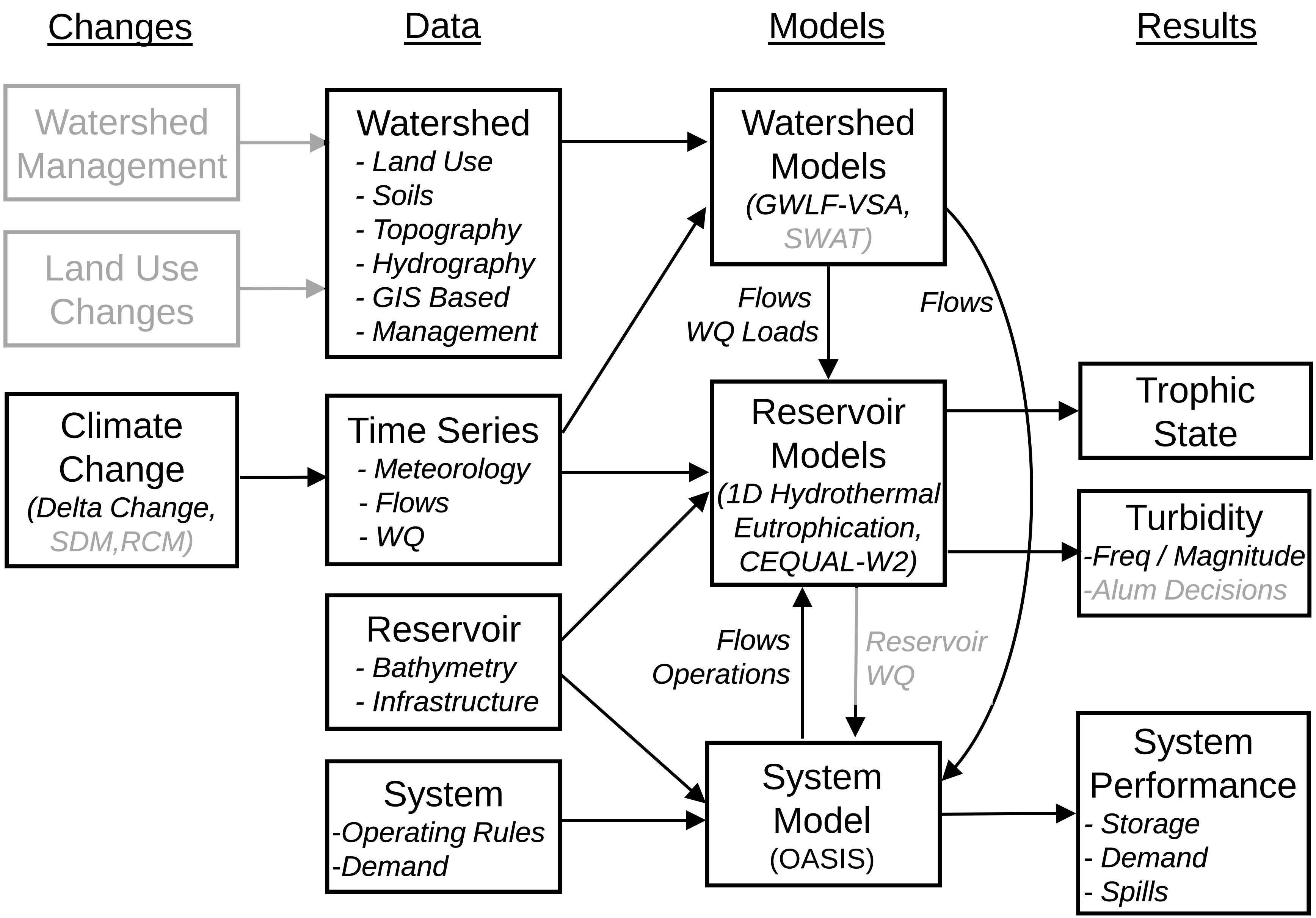
1. **Work with Climate Scientists to Improve Regional Climate Change Projections**
2. **Quantify Potential Climate Change Impacts on NYC Water Systems**
3. **Determine and Implement Appropriate Adjustments to NYC's Water Systems**
4. **Inventory and Reduce Greenhouse Gas Emissions**
5. **Improve Communication and Tracking Mechanisms**

Climate Change Integrated Model Project

- **Purpose : Evaluate the affects of climate change on NYC water supply**
  - Water storage and system operation
  - Turbidity
  - Nutrient loading and Eutrophication
- **Project grew out of discussions in NYCDEP Climate Change Task Force – Component of Climate Change Action Plan**
- **Major Project Tasks**
  - Develop credible future climate scenarios that can be used to drive watershed and reservoir models
  - Develop watershed hydrology, biogeochemical, erosion and sediment transport models that adequately account for climate mediated processes
  - Develop models of reservoir sediment transport and phytoplankton production that adequately account for climate mediated processes
  - Develop competence in forest modeling
  - Apply models and data sets to make future predictions of the state on NYC water supply
- **Collaboration**
  - CUNY Hunter College
    - Allan Frei PI –
    - 7 Post Docs hired – based at NYCDEP Kingston Offices
  - Post Doc Advisors
    - Tammo Steenhuis Cornell University
    - Larry Band University of North Carolina

Integrated Modeling System

Climate Change Analysis – Phase I



Scales of Concern

NYC Environmental Protection

- West of Hudson Water Supply 3500 km^2
- Individual WOH reservoir watersheds 1180 km^2-245 km^2
- Watershed hydrologic simulations for reservoir system supply and operation ~ 1000 km^2-4000 km^2
- Watershed nutrient loading simulations ~100 km^2 - 2000 km^2
- Watershed turbidity loading simulations ~10 km^2-100 km^2
- Reservoir model simulations ~ 1km^2 -50 km^2

Results of CCIMP

Climate Data analysis

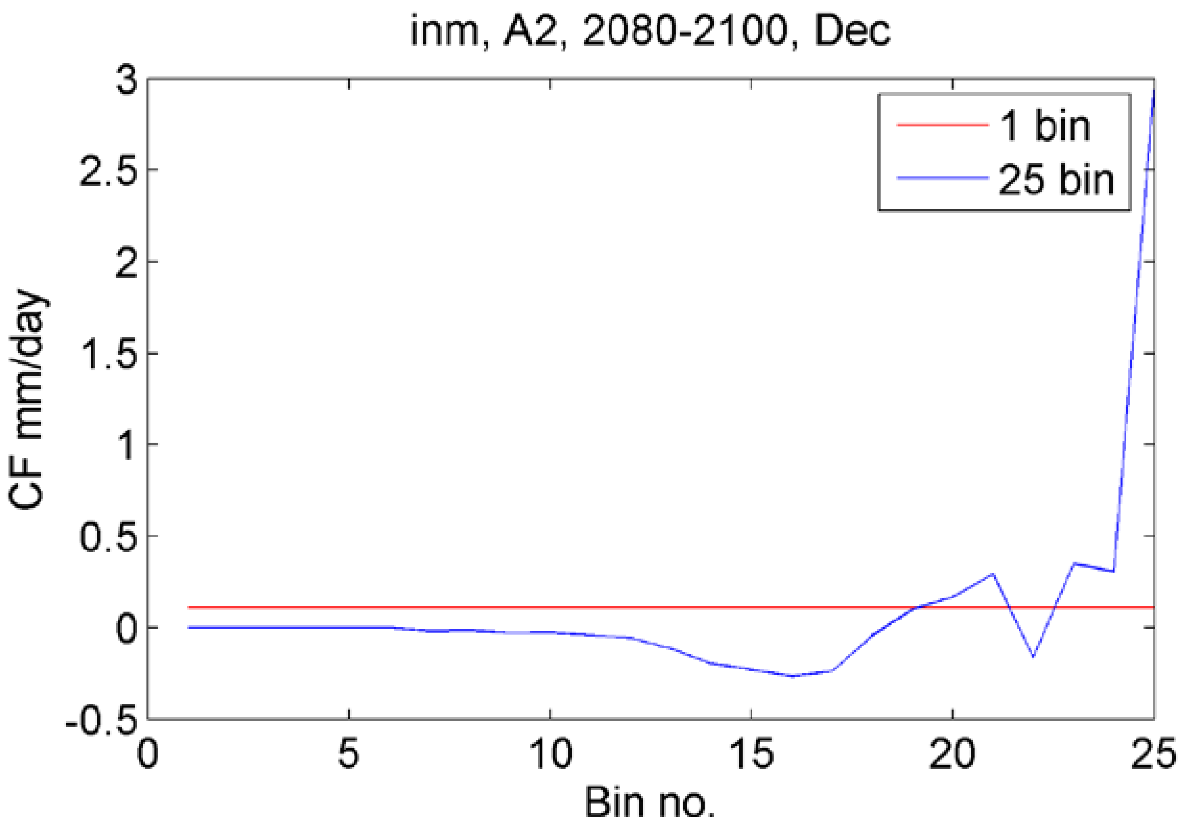
- Daily data sets obtained for 20 models 20c3m SRES A1B, A2, B1 scenarios 1960-2000, 2046-2065, 2081-2100
- Data have been interpolated to a common grid
- Common file format developed.
- Initial delta change (monthly factors) downscaling completed
- New frequency distribution downscaling method developed, that we think better simulates change in events of different size
  - Anandhi et al. *Examination of change factor methodologies for climate change impact assessment   Accepted Water Resources Research*
- GCM data evaluation/ranking of 20C3M scenarios – submitted to BAMS
- Alternative methods for estimating future climate scenarios will be evaluated
  - Weather generators
  - Dynamic downscaling methods
  - Other statistical methods?

Development of Change Factor Methodology

Two Different Methods of Calculating Precipitation Change Factors

Monthly Average

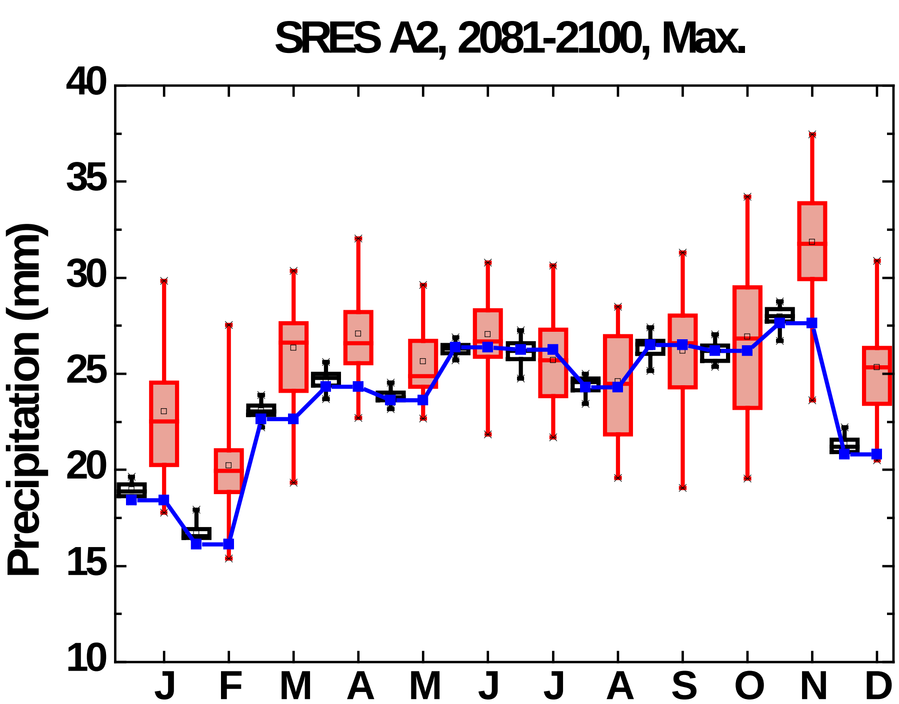
Monthly Frequency Distribution



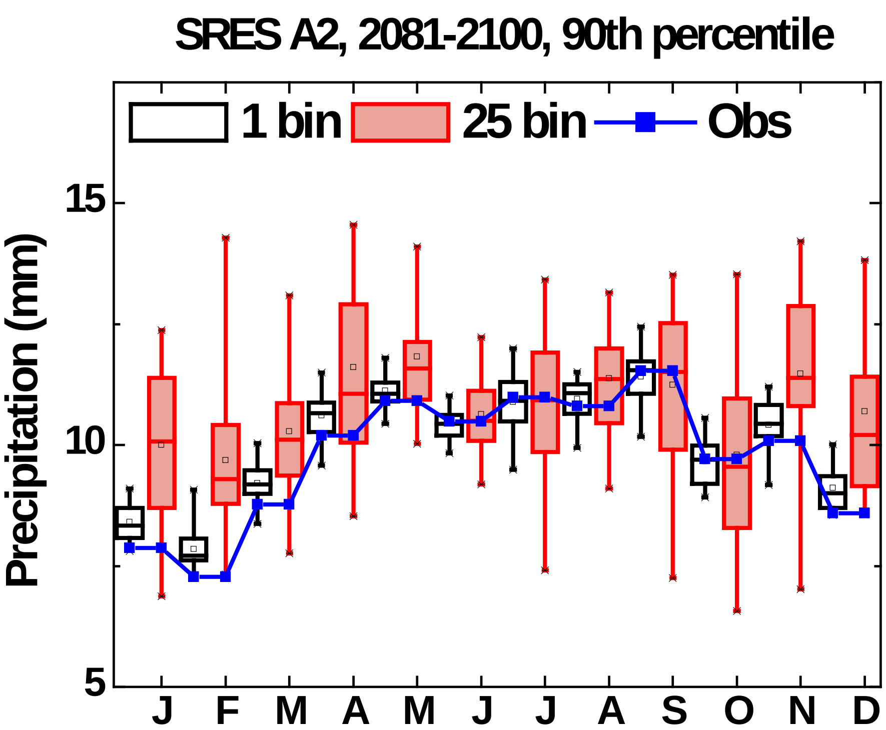
Results of Different CF Methods

Cannonsville Watershed Precipitation for 20 year Scenarios

Monthly Max



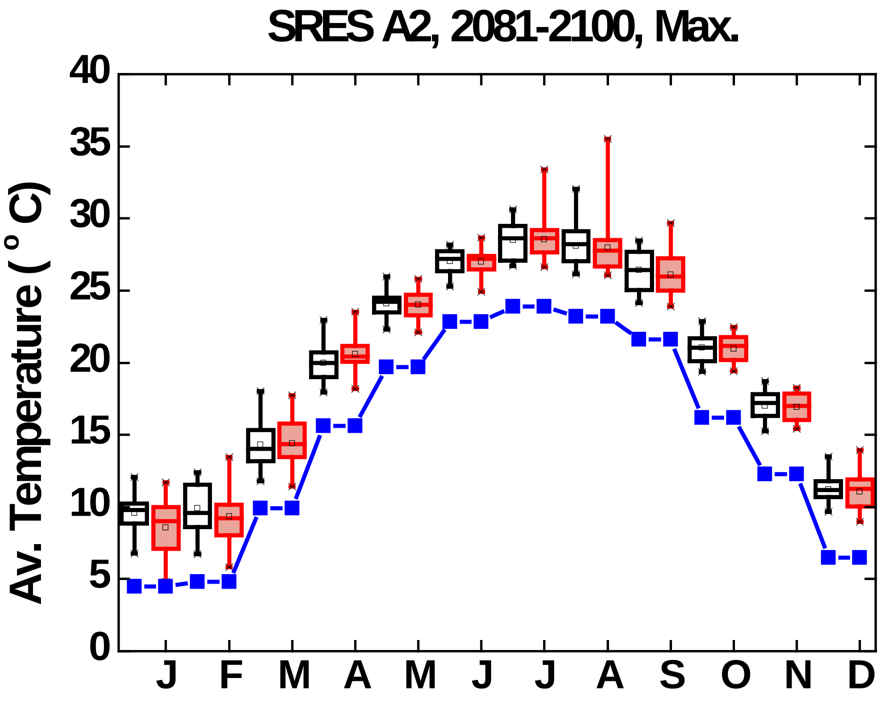
Monthly 90th Percentile



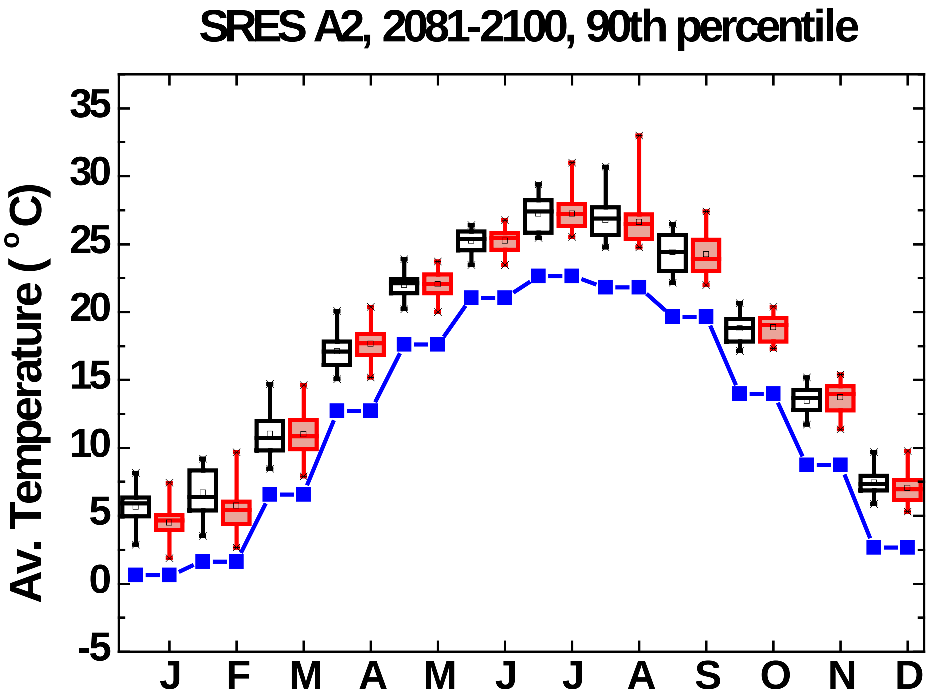
Results of Different CF Methods

Cannonsville Watershed Mean Daily Air Temperature 20 year Scenarios

Monthly Max



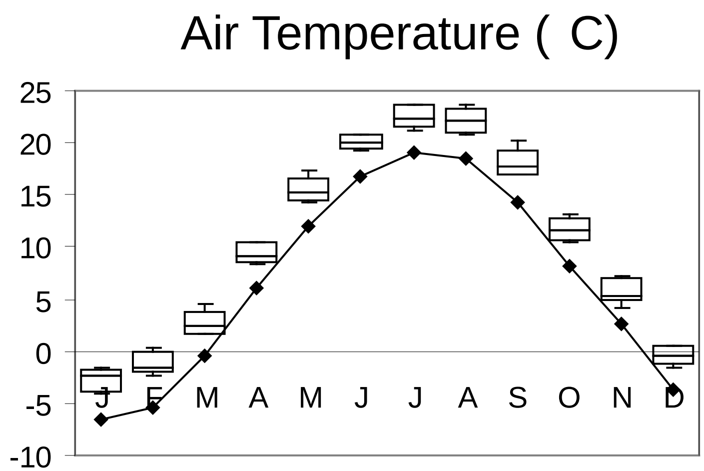
Monthly 90th Percentile

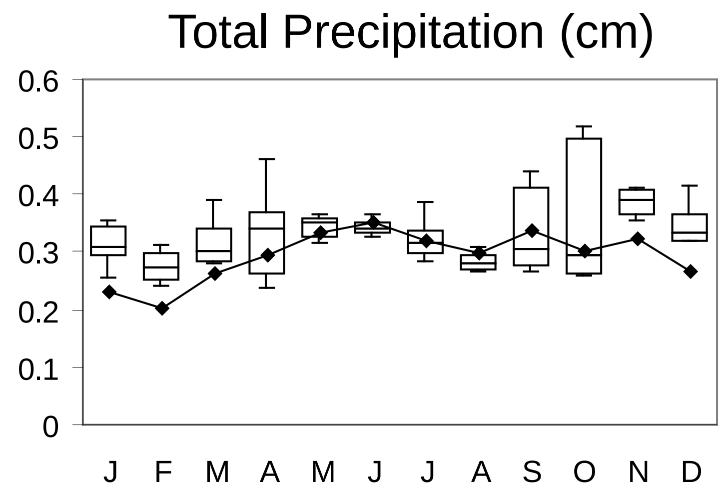


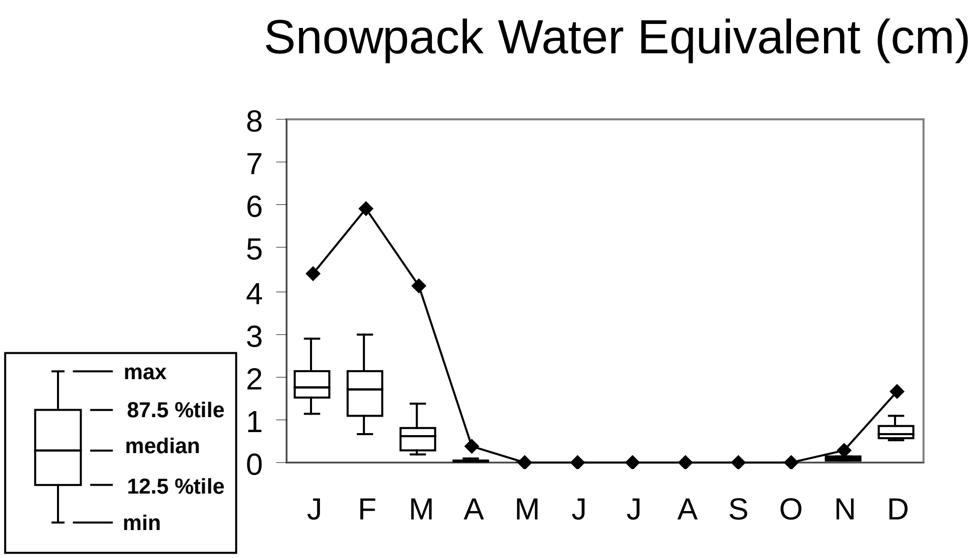
Watershed Hydrology

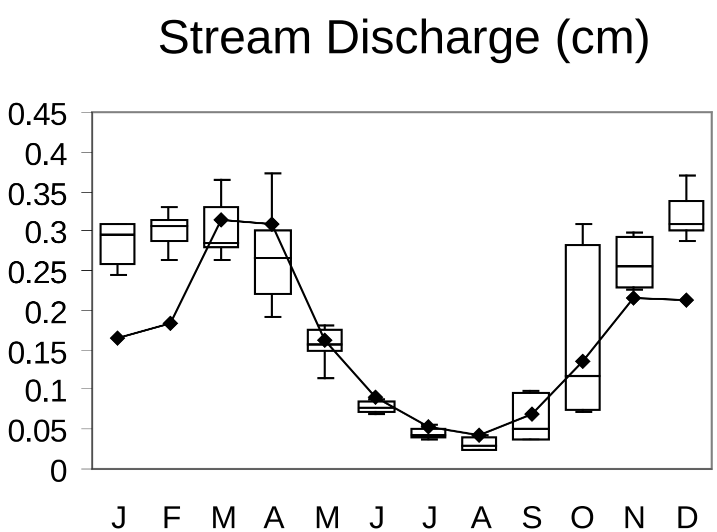
- There is an important shift in the timing of streamflow
- Future increases in air temperature and precipitation lead to:
  - Increased evaporation and streamflow
  - Decreased snow pack and snowmelt
  - Increased snowmelt rain and stream flow in winter
  - Decreased spring streamflow – due to lower snowmelt

Watershed Model Results – 2081-2100 Scenarios
Mean Daily Values









Consequences of Changing Hydrology

- Greater winter streamflows lead to:
  - Reservoirs filling earlier in Spring
  - Greater release and spill in winter and spring (including nutrients)
- Most climate scenarios suggest there will be decreases in drought conditions
- Changes in the timing of nutrient and turbidity inputs to reservoir
  - Isothermal, cold lower ambient light

Future Challenges

- How will the frequency and intensity of extreme events change in the future (e.g. mesoscale systems that cause turbidity in the reservoirs) ? How do we downscale GCM data to represent changes in the extremes?
- Model evaluation for climate sensitivity
  - What model processes are most sensitive to Climate Change?
  - Are these processes adequately represented in models?
- How do we deal with the large number of derived future climate scenarios?
- How do we deal with uncertainty? Deterministic vs. Probabalistic?
  - Extreme Events
  - Stream and reservoir turbidity levels
- How do we separate effects of future changes in landuse from climate change?

Questions?