Water and Climate: Observations from Seattle

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September 21-25, 2009
Sequim – 43 cm (17”)
Seattle – 94 cm (37”)
Cedar River Watershed – 254 cm (100”)
Hoh River Valley - 381-457 cm (150-180”)

Annual Rainfall
Seattle’s Water System

- **Responsibilities:**
  - Drinking water to 1.3 million people for municipal and industrial use – no agriculture
  - Instream flows for salmon
  - Flood management
  - Hydropower generation
- Surface water reservoirs in the central Cascade Mountains, small amount of groundwater
- Rely on snowpack and rain, may be more dependent on rain than snow
- Ratio of storage to inflows is low, but critical to supplying water
  - 19% on Cedar
  - 48% on Tolt
Seattle’s Water Supply Outlook

Average Daily Demand:
- 2007: 477,000 m$^3$ (126 MGD, 390 AF)
- 2060: 602,000 m$^3$ (159 MGD, 490 AF) with conservation

Available Supply:
- 647,000 m$^3$ per day (171 MGD, 525 AF/d) can be diverted, after meeting instream flows
- 98% reliability - not available in 1 year in past 76 years

Without considering climate change, new supply needed after 2060
SPU’s Involvement with Downscaling Studies

Statistical Downscaling – Water Supply

- **2002-2006**: SPU-funded project with University of Washington – Climate Impacts Group (UW CIG)
  - Methods and Uncertainties
  - Supply Impacts

- **2006-2008**: Regional study with UW CIG - *Will focus on this study*
  - Regional Datasets
  - Supply and Demand Impacts
  - Adaptation Strategies

- **2008**: UW CIG study for State of Washington
  - Supply Impacts

Dynamical Downscaling – Urban Drainage

- **2008**: UW CIG study for State of Washington
  - For infrastructure chapter, SPU funded study to run downscaled precipitation data through urban hydrology watershed model
SPU’s Involvement with Downscaling Studies

**2002-2006:** SPU-funded project with UW CIG
- SPU interest: establish internal capacity (knowledge and models) to use climate data for planning purposes.
- Objectives: exploration and development of analytical methods, evaluation and documentation of the uncertainty and limitations, and exploratory-level assessment of possible impacts on supply.
- “Chain of models” Method used by UW CIG:
  - ECHAM4, HadCM3, GFDL_R30, and PCM with SRES A2 for 2000, 2020, and 2040 (air temperature and precipitation)
  - Statistical downscaling to the local watershed, extending time series
  - Watershed hydrology models used to produce inflows
  - Systems simulation model to evaluate supply
- Reported results in 2007 Water System Plan
  - A climate change scenario shows that a 50 percent loss in average snowpack could result in a 10 percent loss in firm yield by 2040. If so, a new source of supply would be needed in 2055.
- No specific analysis on adaptation
**SPU’s Involvement with Downscaling Studies**

**2006-2008:** Regional study with UW CIG

- Funded by four agencies (local and state) as part of regional water supply planning process
- Used Echam5-A2, IPSL_CM4-A2, and GISS_ER-B1 for decades surrounding the years 2000, 2025, 2050, and 2075
- Work products included an on-line database of downscaled meteorology and hydrology for 3-county region
- CIG generated datasets; utilities used it to gain understanding of their own systems
- SPU’s use of the data:
  - assess impacts on supply and demand
  - assess effectiveness of operational adaptation options
- To be reported in Water Supply Forum’s *2009 Water Supply Outlook*
  - Utility-reported impacts on supply for Everett, Seattle and Tacoma
  - Consultant-generated impacts on demand for Everett, Seattle and Tacoma
Selected 3 GCM model/scenario couples that provide a broad range of future scenarios for Pacific Northwest:

- Warm
- Warmer/Mid-range
- Warmest

Based on simple average of the temperature and precipitation values at all the Pacific Northwest grid points to define a regionally averaged time series. Here, the Pacific Northwest is defined as the region between 124° and 111° west longitude, 42° to 49° north latitude: Washington, Oregon, Idaho, and western Montana. GCMs have different resolutions; the number of model grid points enclosed in this latitude-longitude box is typically 12-20.

Scatterplot of Change in Annually Averaged Temperature and Precipitation for Various GCM-scenario Combinations as of 2040's (2030 - 2059 minus 1970 - 1999)

2006-2008 Regional Study:
Climate-Altered Hydrology
Change in Water Supply
with Climate Change Scenarios

Baseline Operations

Unmitigated impacts - does not include adaptation options

Percent of Historic Supply

Historic | 2000 | 2025 | 2050 | 2075
---|---|---|---|---
Warm Scenario | 100% | 101% | 96% | 94%
GISS ER B1 | 101% | 90% | 87% | 87%
Warmer Scenario | 95% | 90% | 79% | 78%
Echam5_A2 | 96% | 94% | 87% | 75%
Warmest Scenario | 90% | 94% | 87% | 75%
IPSL_CM4_A2
Change in Water Supply with Climate Change Scenarios

Baseline Operations plus Tier 1

Percent of Historic Supply

Historic 2000 2025 2050 2075

Warm Scenario GISS ER B1

Warmer Scenario Echam5_A2

Warmest Scenario IPSL_CM4_A2

Tier 1 (light shade)
Warmest Scenario
Results from Monthly CUE and Demand Forecast Model - IPSL_CM4_A2

Supply bars show Base plus Tiers; Demand bars show forecast plus climate

Percent of Historic Supply

Historic Supply: 100%
Supply 2000: 95%
Demand 2000: 87%
Supply 2025: 90%
Demand 2025: 82%
Supply 2050: 12%
Demand 2050: 79%
Supply 2075: 20%
Demand 2075: 75%
Demand: 106%
SPU’s Involvement with Downscaling Studies

2008: UW CIG study for State
- Funded by Washington State Legislature through House Bill 1303; research partners included Washington State University and Pacific Northwest National Laboratory.
- Examined several sectors, including water and infrastructure (stormwater)
- Used 20 GCMs and two emission scenarios (A1B and B1), statistically downscaled, used in hydrology models, and run through models of Everett’s, Seattle’s, Tacoma’s water systems.
- SPU asked to be included in water sector analysis, but was turned down due to concerns over time constraints; we provided comments on draft on water sector chapter
- Study did not quantify the effectiveness of adaptation options
- Presented at Washington Climate Change Assessment Workshop in February 2009
Benefits of Using GCMs and downscaling

- Provides a glimpse at how system would be impacted/perform under plausible future climatic/hydrologic conditions
- Provide opportunity to work with best available scientific info.
- Establishes and builds institutional capacity on a critical emerging issue
- Provides a forum for two-way engagement between the research community and water utility
Challenges of Using GCMs and Downscaling

- Difficulty understanding the nature of the uncertainties associated with downscaling
- Addressing perception that probing about this uncertainty is an attempt to discredit the information
- Portraying the downscaling and impacts assessment accurately: not definitive but not useless either
- Defining role for researchers and water utilities
Challenges in Using GCMs and Downscaling

- Timestep Issues
  - Archived monthly temp/precip data statistically downscaled to hourly timestep needed for hydrology model:
    - Does this misrepresent climate impacted hydrology for these finer timescales, in both frequency and magnitude?
    - What should be used in systems model?
Challenges in Using GCMs and Downscaling

- Working with the Numbers
  - Handling mismatches between GCMs and observed data (starting point issue)
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Challenges in Using GCMs and Downscaling

- Working with the Numbers
  - Ensemble averages vs individual results
  - Again, not matching results for recent observations

- Communicating the Results
  - False sense of certainty
  - Balancing simplicity of message with appropriate portrayal of uncertainties
Challenges in Using GCMs and Downscaling

- Application of GCM data
  - Uncovering outliers as datasets are applied for different purposes?
  - Inadvertent misuse of archived data, or just luck of the draw?
  - Supports advice to use more than one GCM run

Uniquely large increase in high flow days projected by CCSM3-WRF bias-corrected data