CLIMATE CHANGE IN THE SKAGIT RIVER BASIN

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June 21st, 2012
County Commissioner’s Hearing Room, Mt. Vernon
Reduce vulnerability of human communities and ecosystems in the Skagit River basin to the impacts of a changing climate.
To support Skagit communities as they adapt to climate change, SC²:

• *Fosters collaborative scientific research* to understand the diverse and interrelated impacts of climate change from the Skagit’s headwaters to Puget Sound.

• * Produces relevant climate-related products* closely integrated with the Skagit community’s needs and concerns.

• *Connects Skagit communities and SC² scientists* to assist in the development of adaptation strategies.
Envision Skagit 2060
Preserving Our Heritage, Shaping Our Future

Reports, Data Sources and Archives

Major Reports:

- **Economic Indicators of Agriculture's Future in Skagit County, Tasks 1 & 2 Final Report**
  Prepared by ECONorthwest for Envision Skagit 2060, November 2010. (Pdf)

- **Evaluation of Fiscal Implications of Growth Management Options in Skagit County, Washington**
  Prepared for Skagit County and Envision Skagit by Terry Moore, Lorelei Juntunen, Tom Soulhas, and Whit Perkins, ECONorthwest, Portland, OR, February 2012

- **Skagit River Basin Climate Science Report**
  Prepared for Envision Skagit and Skagit County by Se-yeun Lee and Alan F. Hamlet, Department of Civil and Environmental Engineering and The Climate Impacts Group, University of Washington, September, 2011. (Pdf)

  - Title page
  - Master Page (Table of Contents)
  - Executive Summary
  - Chapter 1 Basin Overview
  - Chapter 2 Climate Variability
  - Chapter 3 Climate Change Scenarios
  - Chapter 4 Glaciers
  - Chapter 5 Hydology
  - Chapter 6 Geomorphology
  - Chapter 7 Ecosystems
  - Chapter 8 Human Systems

  - Complete Report (10MB Pdf)
WEATHER VS. CLIMATE

WEATHER:
Current state of the atmosphere (timescale: hours, days, weeks)

CLIMATE:
Statistics of weather over time (timescale: usually 30 or more years)

• Climate is what you expect today (norms)
• Weather is what you get today (rainy, sunny, cold, hot, windy)
The Greenhouse Effect

There is a natural greenhouse effect that warms the earth’s average surface temperature by ~33 C (about 60 deg. F)

http://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/models
Sources of Global Climate Change:

- Carbon Dioxide (ppm)
- Methane (ppb)
- Nitrous Oxide (ppb)

Graphs showing concentrations and radiative forcing over time, from 10000 years before the present to the present day.
Paleoclimatic Reconstructions:
Climate models are systems of differential equations based on the basic laws of physics, fluid motion, and chemistry. To “run” a model, scientists divide the planet into a 3-dimensional grid, apply the basic equations, and evaluate the results. Atmospheric models calculate winds, heat transfer, radiation, relative humidity, and surface hydrology within each grid and evaluate interactions with neighboring points.
Global climate modeling experiments reproduce the history of global temperatures remarkably well when both human and natural factors are included.

Volcanic eruptions, variations in solar radiation, etc. cannot alone explain rapid rise in temperature at the end of the 20th century.
REGIONAL TRENDS

Global and continental temperature change

- Models using only natural forcings
- Models using both natural and anthropogenic forcings
- Observations
FUTURE EMISSIONS SCENARIOS
PNW TEMPERATURE AND PRECIPITATION SCENARIOS

Model Consensus:

- Strong Warming in All Seasons, and Especially Summer
- Relatively Small Changes in Annual Precipitation
- Wetter Falls, Winters, and Springs
- Drier Summers
How will the Skagit basin respond to a changing climate?
Changing Glaciers

There are approximately 394 glaciers in the Skagit Watershed (Post et. Al 1971)

Between 1900-1998 the North Cascades lost ~ 50% of its glacial area (Granshaw, 2002)
Other Pacific Northwest glaciers are also rapidly receding. Some, like Lillian Glacier in the Olympic National Park, are already gone.
Skagit glaciers provide 120-180 billion gallons of water in the summer months when:

- Agriculture
- Power generation
- Salmon
- Water supply
- Lake Recreation

need it most.

Continued loss of glacial melt water in late summer is expected to exacerbate losses of summer streamflow due to reductions in snowpack.
CHANGING LOCAL HYDROLOGY

SKAGIT RIVER NEAR MOUNT VERNON

British Columbia

Washington
Snowpack

snow water equivalent (in):

A1B

B1

2020s

2040s

2080s
SEASONAL RUNOFF TIMING

combined flow (in):

A1B

B1

2020s

2040s

2080s

combined flow (in):

A1B

B1

2020s

2040s

2080s

combined flow (in):

A1B

B1

2020s

2040s

2080s
Since 1958 the average winter snow elevation is estimated to have risen about 650 feet. A higher snow elevation increases the effective basin area that produces runoff during winter storms.
Skagit dams reduce flooding, but most of the runoff production during floods is downstream of headwater dams, which limits the role that reservoir operations can play in protecting the lower basin from projected larger future floods.

Figure 9. The magnitude of 100-year floods at the Skagit River near Mount Vernon for unregulated flows and for regulated flows under current flood control operations (CurFC) and alternative operations (AltFC). Historical run and echem5 A1B scenarios for the 2040s and the 2080s are considered.
Low flows under natural conditions are less than under regulated conditions, but climate change reduces low flows in each case.

Figure 11. The magnitude of low flow statistic (7Q10) at the Skagit River near Mount Vernon for unregulated flows and for regulated flows under current flood control operations (CurFC) and alternative operations (AltFC). Historical run and echam5 A1B scenarios for the 2040s and the 2080s are considered.
The Skagit River already moves a tremendous amount of sediment (compounded by current human land uses).

Retreating glaciers and declining snowpack are both hypothesized to increase sediment production in the future.
Current Sediment Transport Regime

Suspended-Sediment Transport Curve
Skagit River at Mount Vernon (USGS #12200500)

The transport equations and range of flow based on group-averaged data are:
1a) \( Q_s = 0.003Q_w^{0.227} \), \( Q_w < 849 \text{ m}^3/\text{s} \)
1b) \( Q_s = 1.49 \times 10^{-7}Q_w^{1.74} \), \( 849 \text{ m}^3/\text{s} \leq Q_w \leq 1,875 \text{ m}^3/\text{s} \)
1c) \( Q_s = 6.3Q_w^{1.44} \), \( Q_w > 1,875 \text{ m}^3/\text{s} \)

The ordinary least-squares regression is:
2) \( Q_s = 1.29 \times 10^{-3}Q_w^{2.39} \) (w/ bias corr.),
\( r^2 = 0.75, n=177 \)

(Source: Curran et al. 2011)
DAILY FLOW REGIME ALONE CHANGES SEDIMENT TRANSPORT

Black lines show historical sediment transport
Grey shading and lines show the range and average of 5 climate change scenarios
CHANGING SEA LEVELS
Sea Level Rise Projections are Rapidly Evolving

(Nicholls and Cazenave 2010)
Puget Sound sea levels are projected to rise 6” to 50” by 2100 (Mote et al. 2008)

12” of SLR turns 100-year flood into a 10-year event

24” of SLR turns a 100-year flood into an annual event
Coastal Flooding Scenarios (without dikes)

http://myweb.students.wwu.edu/hornep/SkagitCoastalResilience.html
ECOSYSTEMS IMPACTS
Impacts to Cold Water Fish

Projected Impacts to the Skagit Estuary

(Source: Beamer et al. 2005)
Insect Attack

Mountain Pine Beetle Damage in British Columbia
IMPACTS TO HUMAN COMMUNITIES
Floodplain Management
Coastal Inundation

Effects of a “King Tide” at the Nisqually Wildlife Refuge in Sound Puget Sound on Feb 2, 2010 (photo by Russ McMillan).
Municipal Water Supply

Judy Reservoir, Skagit PUD
http://skagitpud.org/index.php/resources/water_system/watershed/
Agriculture
Hydropower Production

Ross Dam, Seattle City Light
Recreation
Please Visit SC2 at:

http://www.skagitclimatescience.org

Please Visit Climate Impacts Group at:

http://cses.washington.edu/cig/