Will Climate Change Impact Water Supply and Demand In the Puget Sound?

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UNIVERSITY OF WASHINGTON

Talk Overview

- Comments on Climate Change
- Potential Impacts to the Puget Sound
- The Art of Translating GCM Outputs into Hydrology Models
- Anticipated Temperature Impacts
- Anticipated Precipitation Impacts
- Typical Impacts on Hydrology
- Will Climate Impact Demands?
- Conclusion- Is the Sky Falling?

SCIENCE DESK | January 13, 2004, Tuesday
Alaska Thaws, Complicating the Hunt for Oil

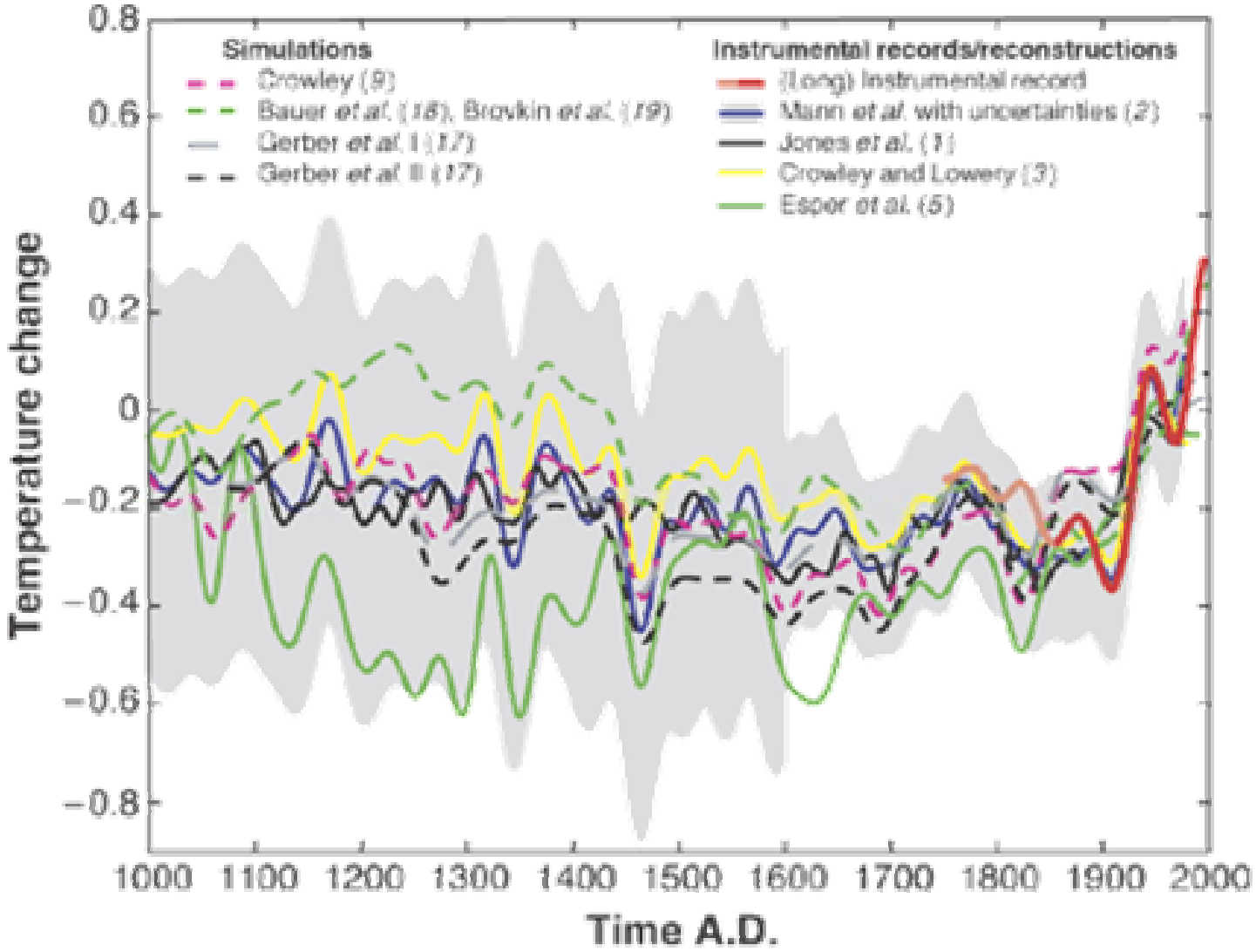
Science of climate change

- Thousands of scientific papers
- Intergovernmental Panel on Climate Change (IPCC)
- Major reports in 1990, 1996, 2001
- Conclusions:
  - "An increasing body of observations gives a collective picture of a warming world and other changes in the climate system."
  - "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

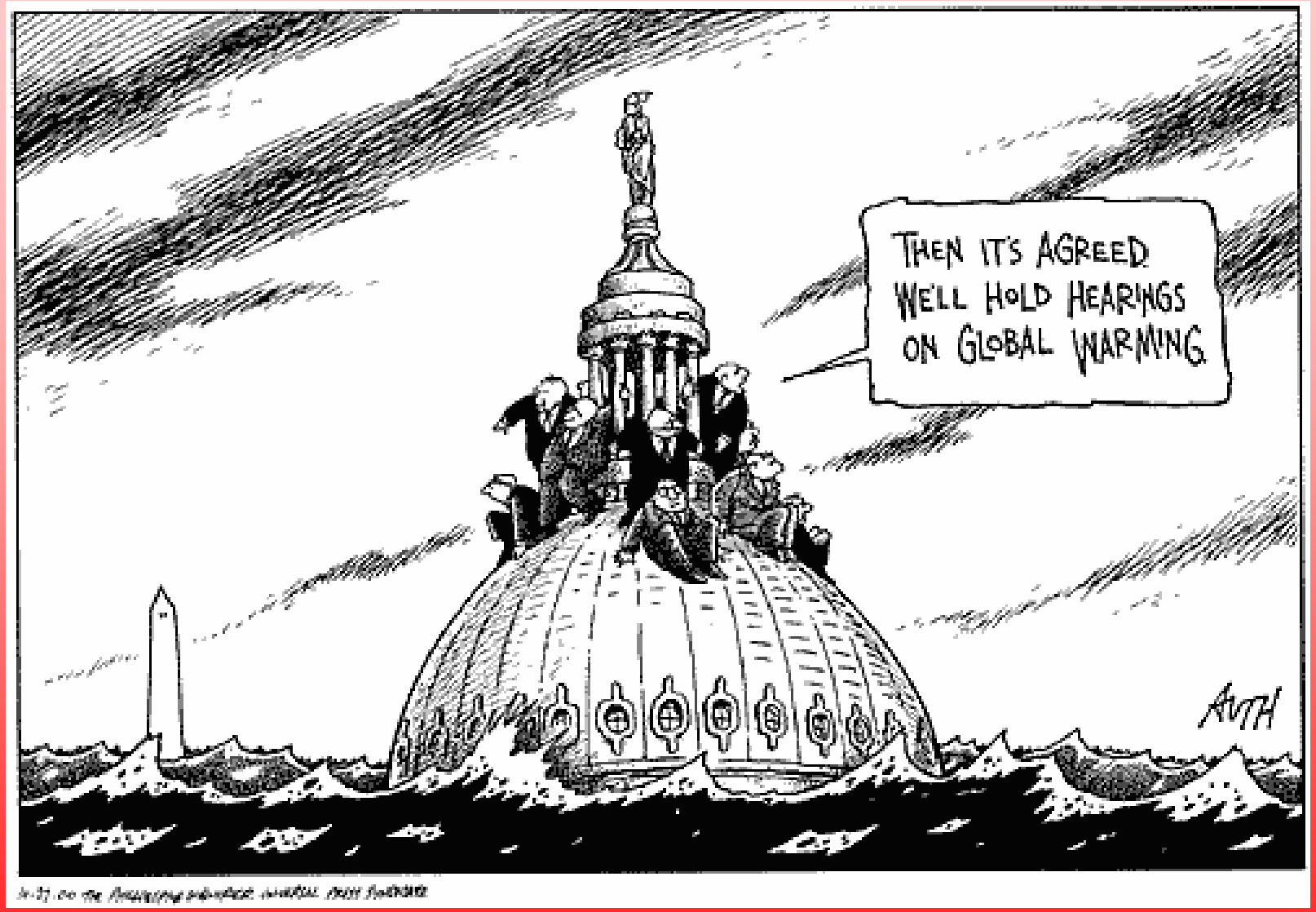
Some evidence that the Earth is warming

- Global average surface temperature computed using thermometers includes correction for small urban heat island effect
- Permafrost, glaciers melting
- Arctic ice thinning
- Frost-free season longer in many places

The earth is warming -- abruptly



source: Mann et al., EOS


THEN IT'S AGREED WE'LL HOLD HEARINGS ON GLOBAL WARMING
AUTH

Potential Puget Sound Impacts of Climate Change

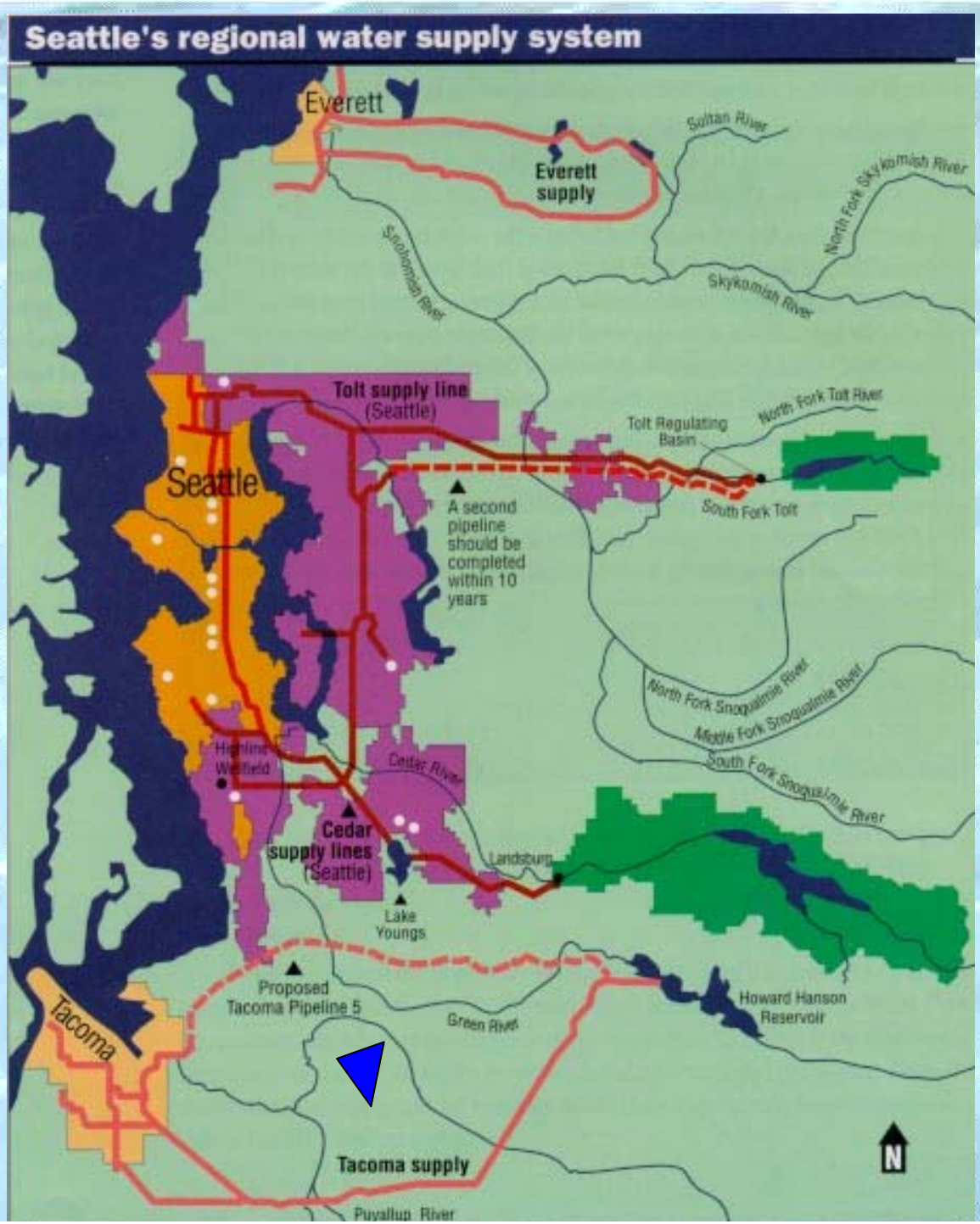
Potential Changes

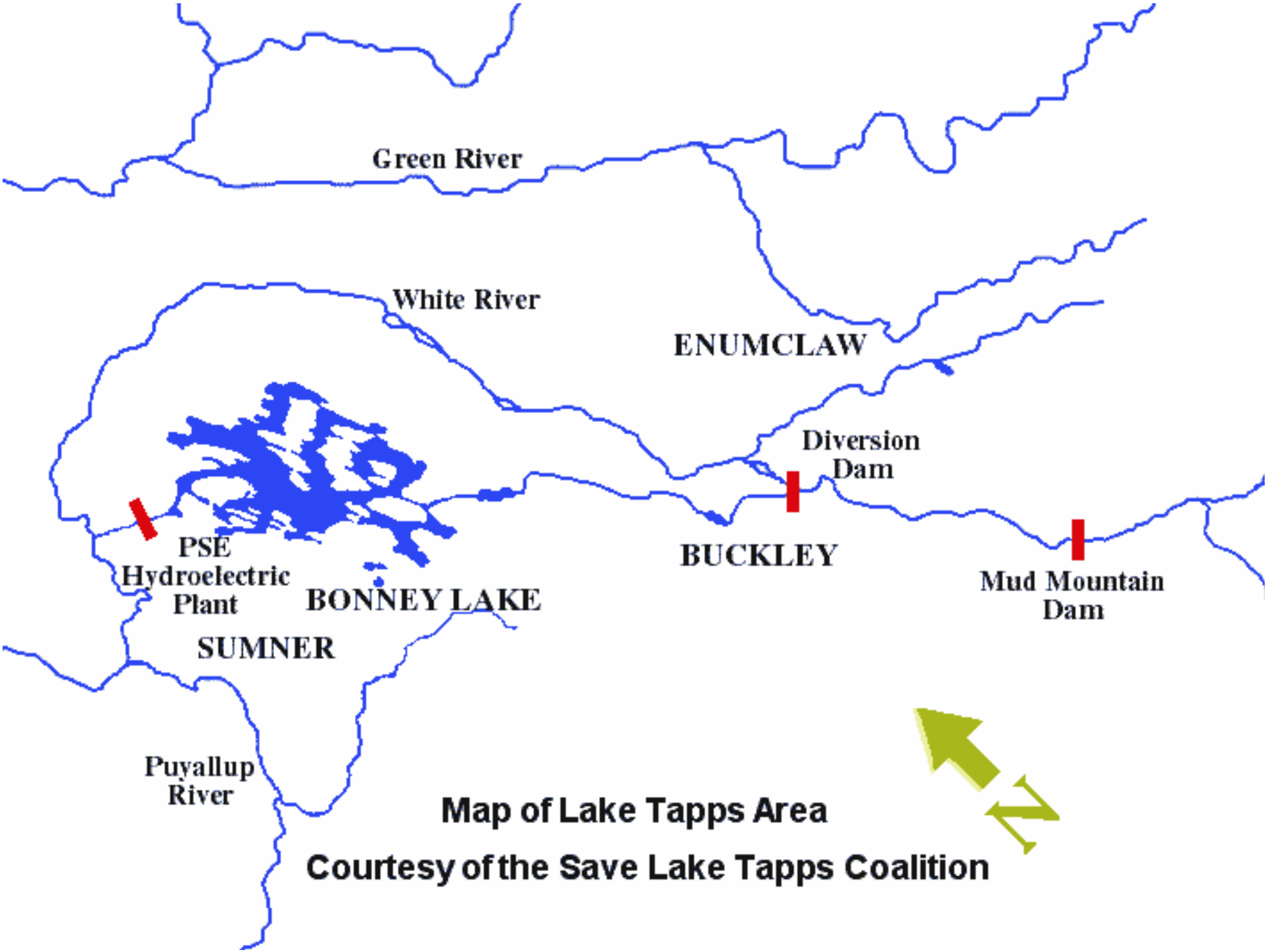
- Temperature
- Precipitation
- Water Demands
- Streamflows
- Water temperature
- Floods
- Sediment Loads
- Vegetation

Water Supply Sources

- Seattle
- Tacoma
- Everett
- Westside - East Side

All supplied by forested watersheds with transitional snowpack hydrology that are susceptible to warm winters and/or dry springs and summers


Seattle's regional water supply system
Everett
Everett supply
Sultan River
North Fork Skykomish River
Skykomish River
Snohomish River
Tolt supply line (Seattle)
Tolt Regulating Basin
North Fork Tolt River
South Fork Tolt
Seattle
A second pipeline should be completed within 10 years
North Fork Snoqualmie River
Middle Fork Snoqualmie River
South Fork Snoqualmie River
Highline Wellfield
Cedar River
Cedar supply lines (Seattle)
Landsburg
Lake Youngs
Proposed Tacoma Pipeline 5
Howard Hanson Reservoir
Green River
Tacoma
Tacoma supply
Puyallup River
N



Map of Lake Tapps Area

Courtesy of the Save Lake Tapps Coalition

Washington Department of Ecology - Lake Tapps - Microsoft Internet Explorer

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Address http://www.ecy.wa.gov/programs/wr/swro/lktappshome.html Go Links

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Water Resources

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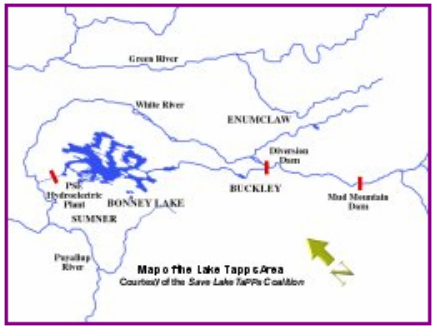
Lake Tapps
Public Water Supply Project

Ecology Approves Lake Tapps Water Rights | Related Documents | Related Links | Contacts

Lake Tapps Reports of Examination (3.0MB pdf)
Frequently Asked Questions

Ecology Approves Lake Tapps Water Rights



On June 30, 2003 the Department of Ecology (Ecology) approved a proposal to help supply the long-range municipal water needs of the Central Puget Sound region, protect salmon and assist ongoing efforts to preserve Lake Tapps.

Ecology has granted three new interrelated water rights (3.0MB pdf) to Puget Sound Energy (PSE) that allows the utility to continue diverting water from the White River and store it in the Lake Tapps reservoir. The 50-year project gives PSE new authority to take an average of 64.6 million gallons of lake water a day for public use by 2053.

The Cascade Water Alliance, a coalition comprising the cities of Bellevue, Issaquah, Kirkland, Redmond and Tukwila and the Covington, Sammamish Plateau and Skyway water districts, is negotiating an agreement to purchase the water right from PSE. The alliance will construct the necessary water treatment and delivery systems to get water from the lake to its members.

The arrangement will help PSE offset the cost of operating its 1912 White River hydroelectric project, which created Lake Tapps.

In 1980, Ecology adopted a rule that closed the White River to new water-right allocations. Therefore, PSE had to demonstrate that the Lake Tapps water-supply proposal would significantly benefit the environment and the public. To satisfy this requirement, the water-rights package Ecology approved stipulates that PSE must:

- Increase flows in the White River from February through April to help protect fish and improve water quality

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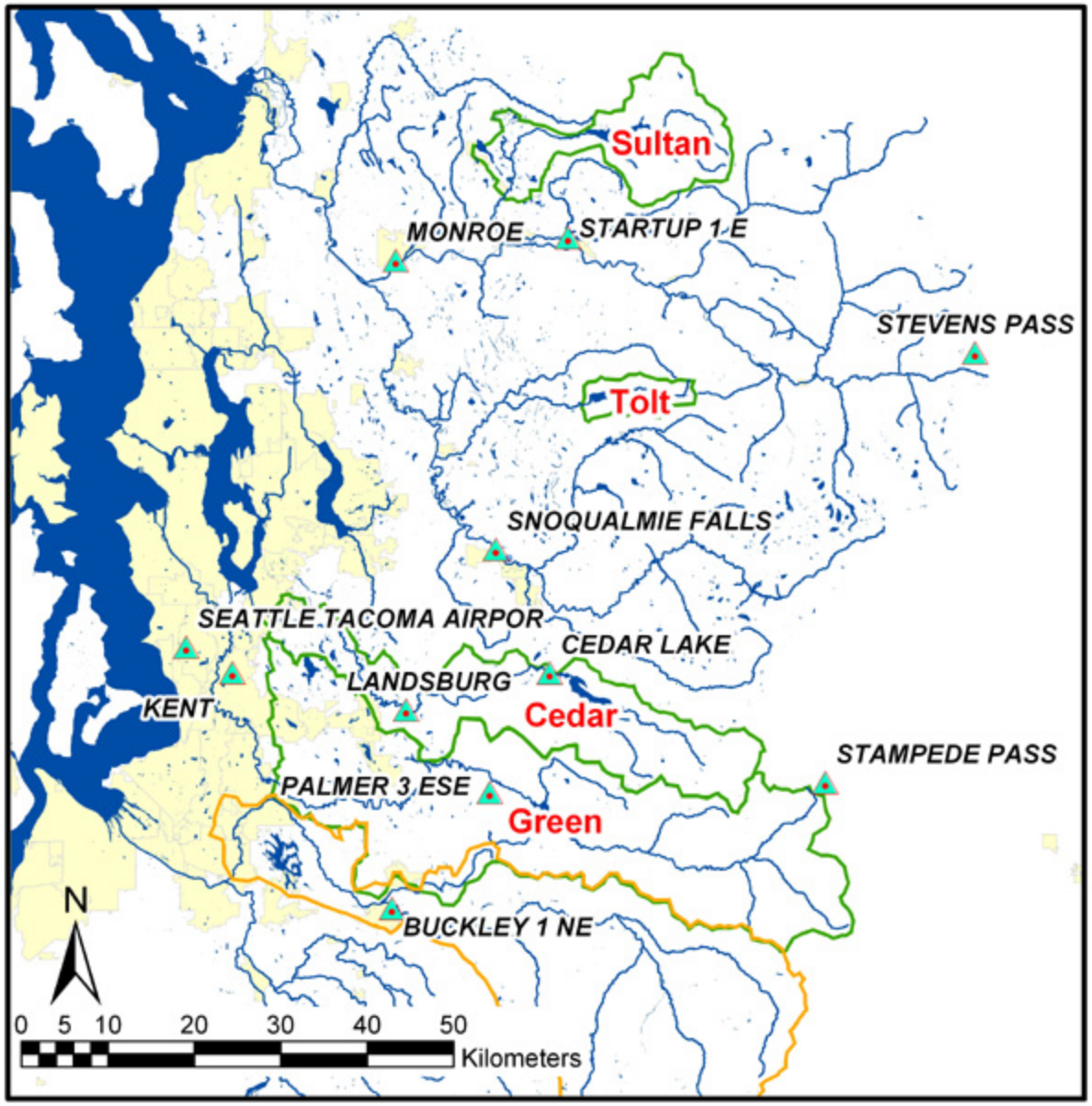
MT RAINIER
POWER
PUGET SOUND
LIGHT
DAM
FISH
SCREENS
FISH BY PASS
CANAL
White
River
Lake Tapps
FOUR
STANDPIPES
INTAKE
CONTROL HOUSE
TUNNEL
PIPE LINE
CONTROL HOUSE
TAIL RACE
LENGTH:
DAM TO LAKE TAPPS 7 3/4 MILES
DAM TO END OF TAIL RACE 14 MILES
WHITE RIVER POWER PLANT
"HORSE SENSE + HORSE POWER = PUGET POWER"

The Art of Translating GCM Outputs into Water Resources Impacts

Frederick and Gleick's 1999 report on Global Climate Change proposed using a 3 step modeling process

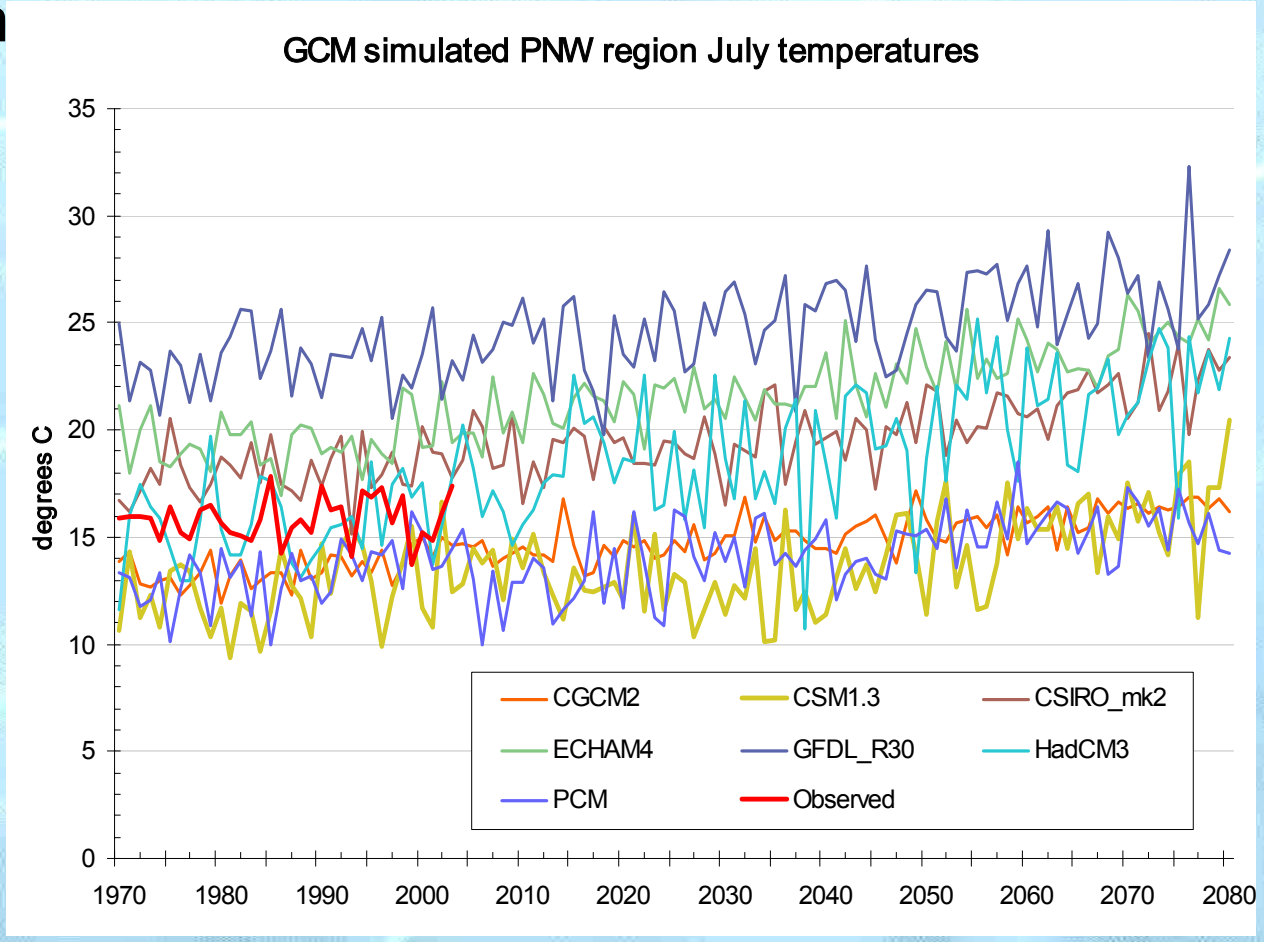
- General Circulation Models (GCMs)
- Hydrologic Model
- Systems Operations Model



- Global climate models operate at a scale of 2° to 5° latitude
- Global data must be downscaled to the local station scale in order to assess the impacts of climate change on water resources.

Climate Change Impacts on Water Resources

- We are currently examining seven GCMs for uses in local impacts assessments
- Results for the PNW vary widely among models
- Downscaling process is needed to correct for various model biases.

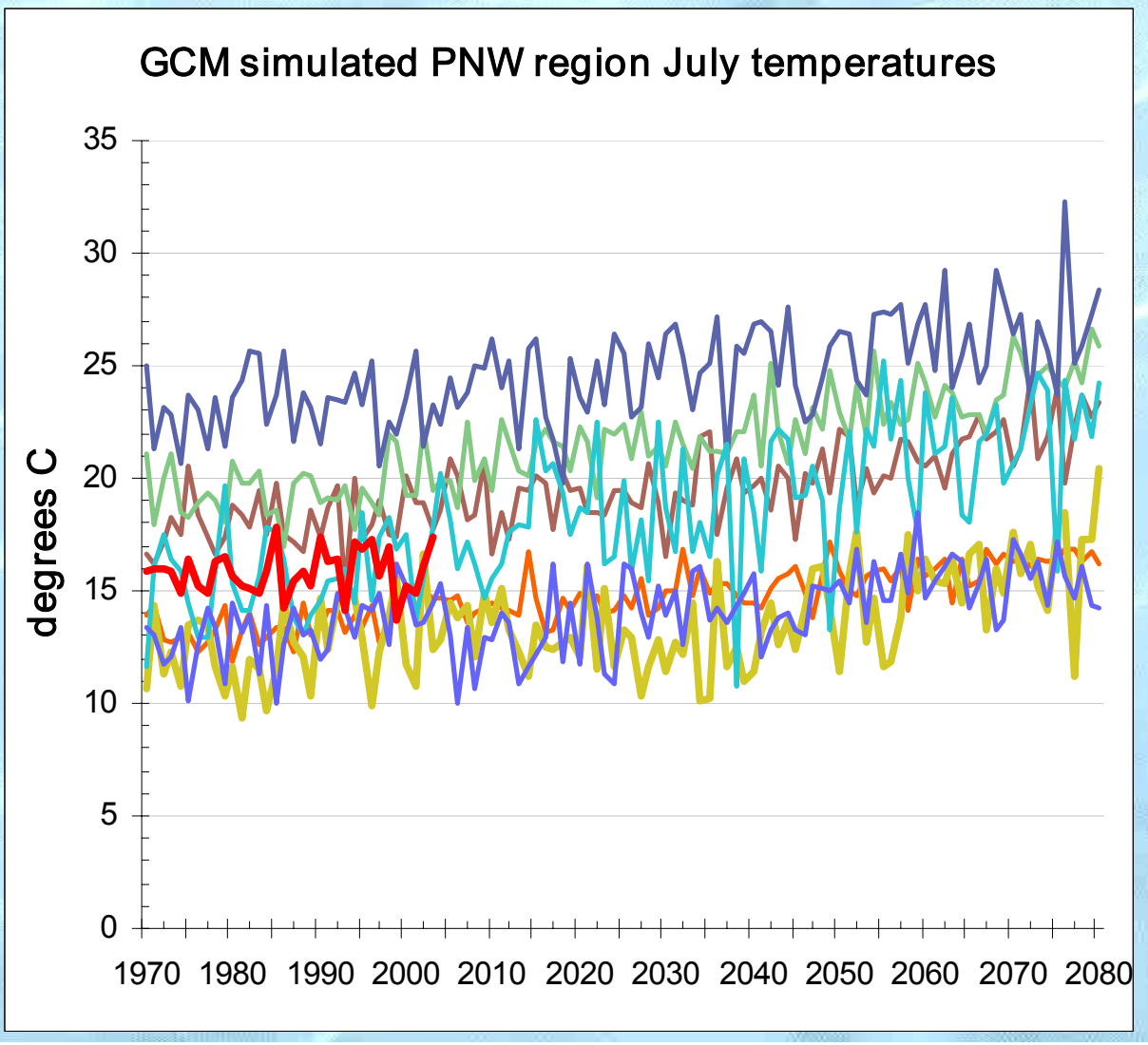


Quantile Mapping

- Climate change can be measured by shifts in GCM simulations of historic and future climate (deltas)
- The quantile mapping process is a method for determining a set of delta values that vary in magnitude across the cumulative distribution function of the climate variables.

Quantile Mapping

- Select a GCM
- Extract selected decades
- Calculate cdf for overlapping "historic" period
- Use cdf based quantile maps as a transfer function to bias correct "future" climate period.



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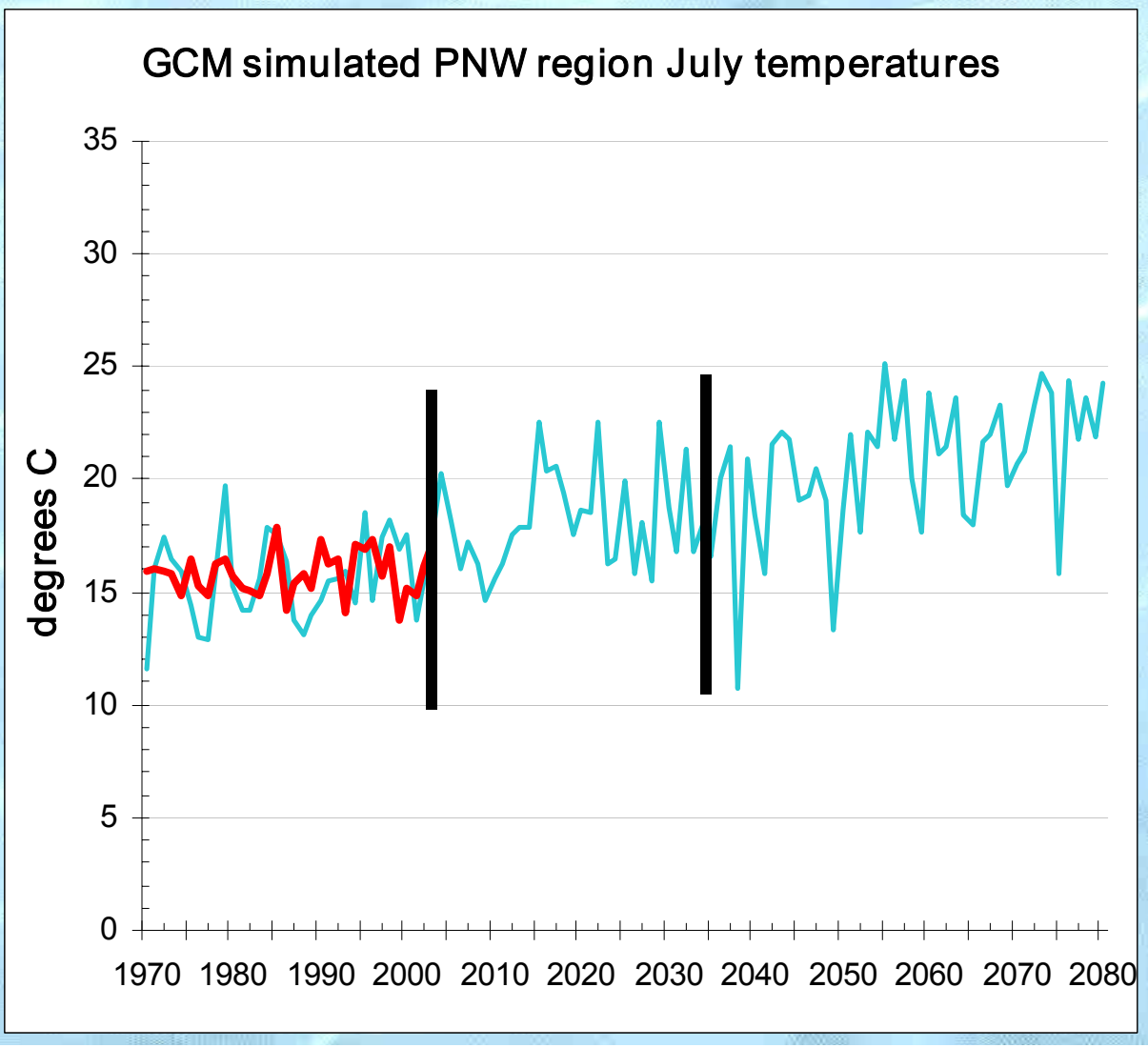

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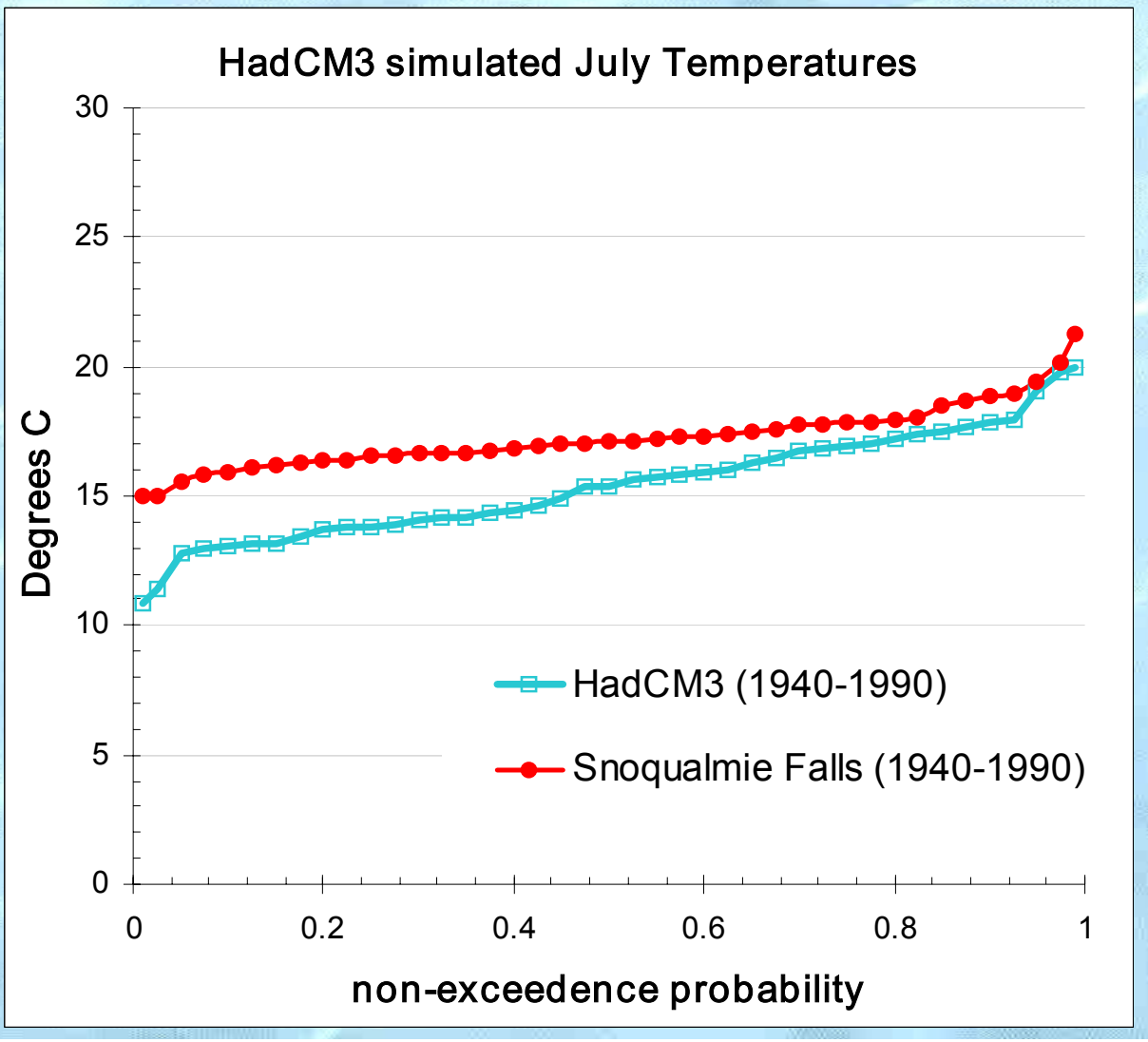

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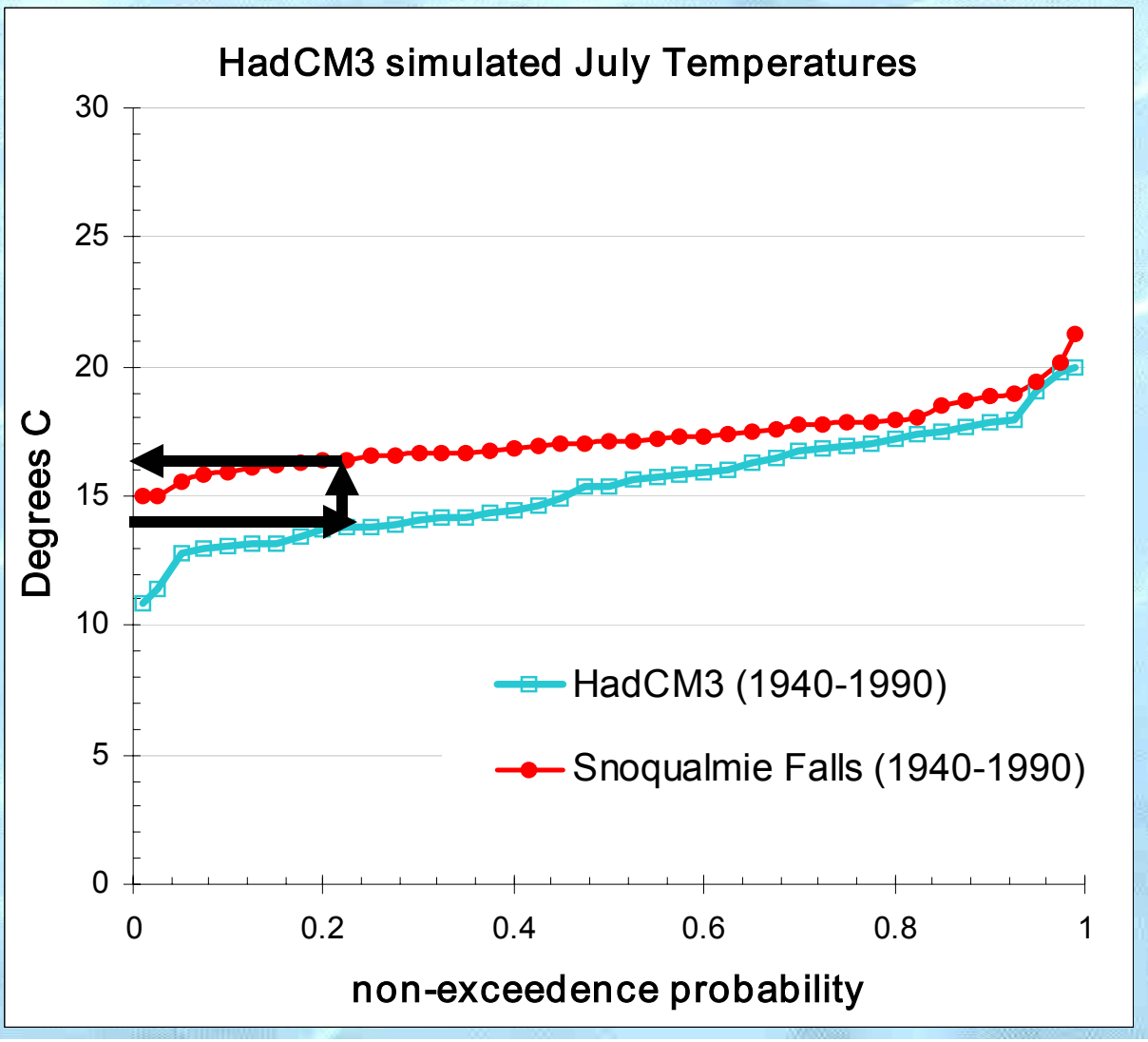

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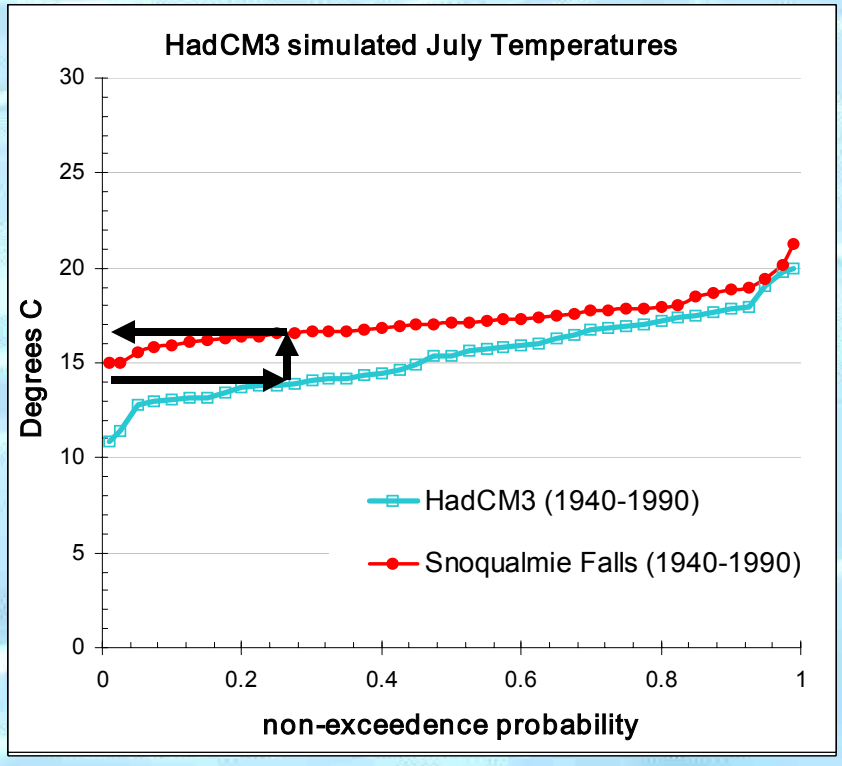

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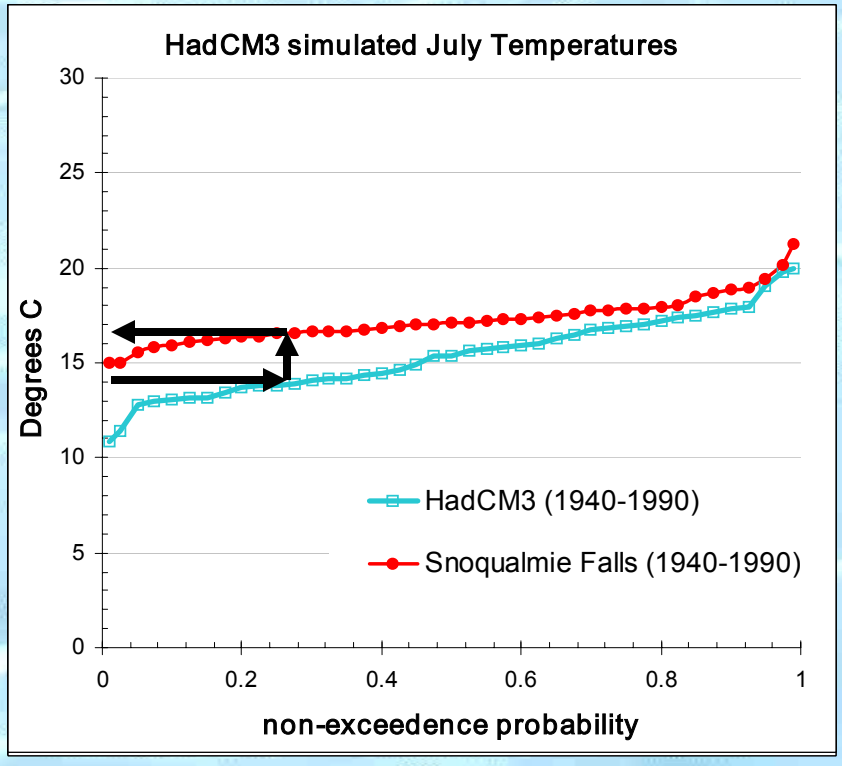
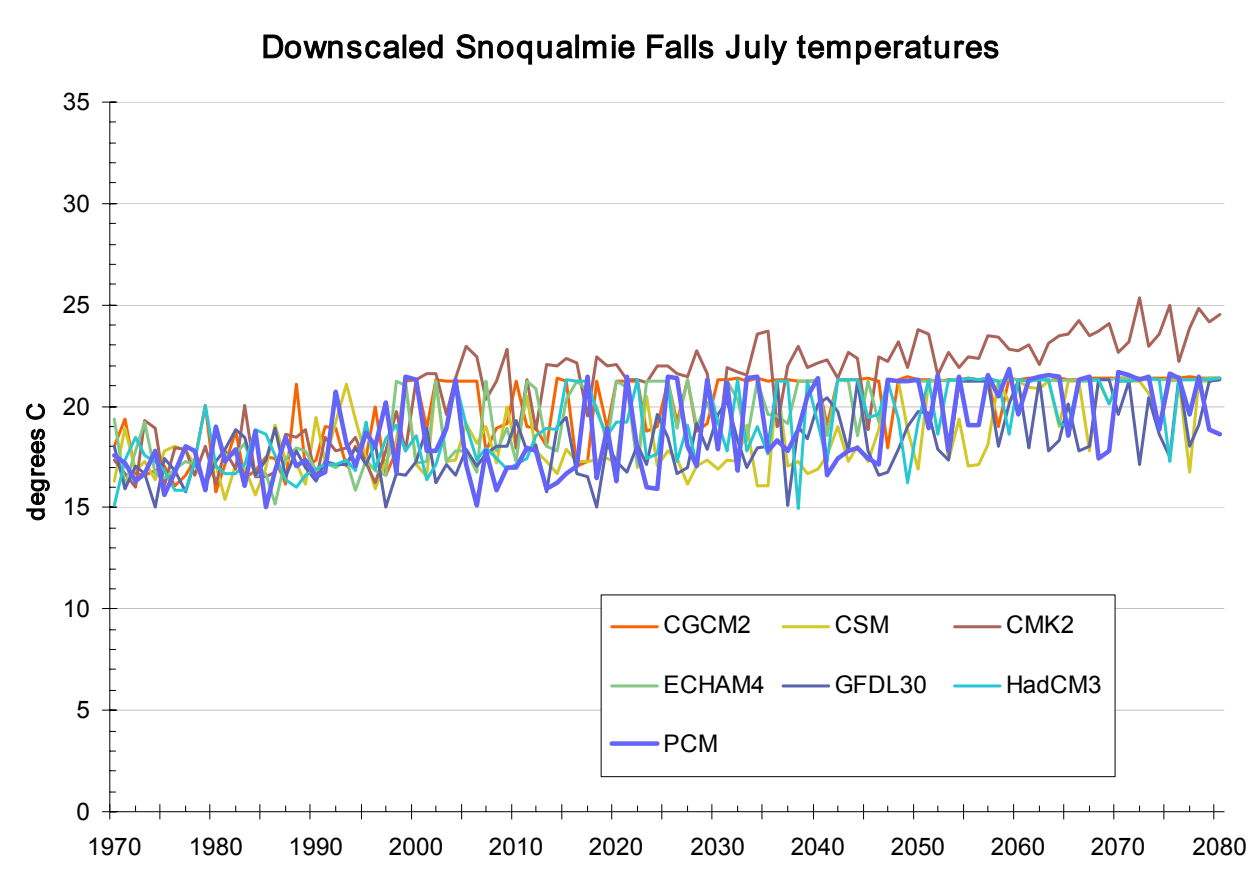
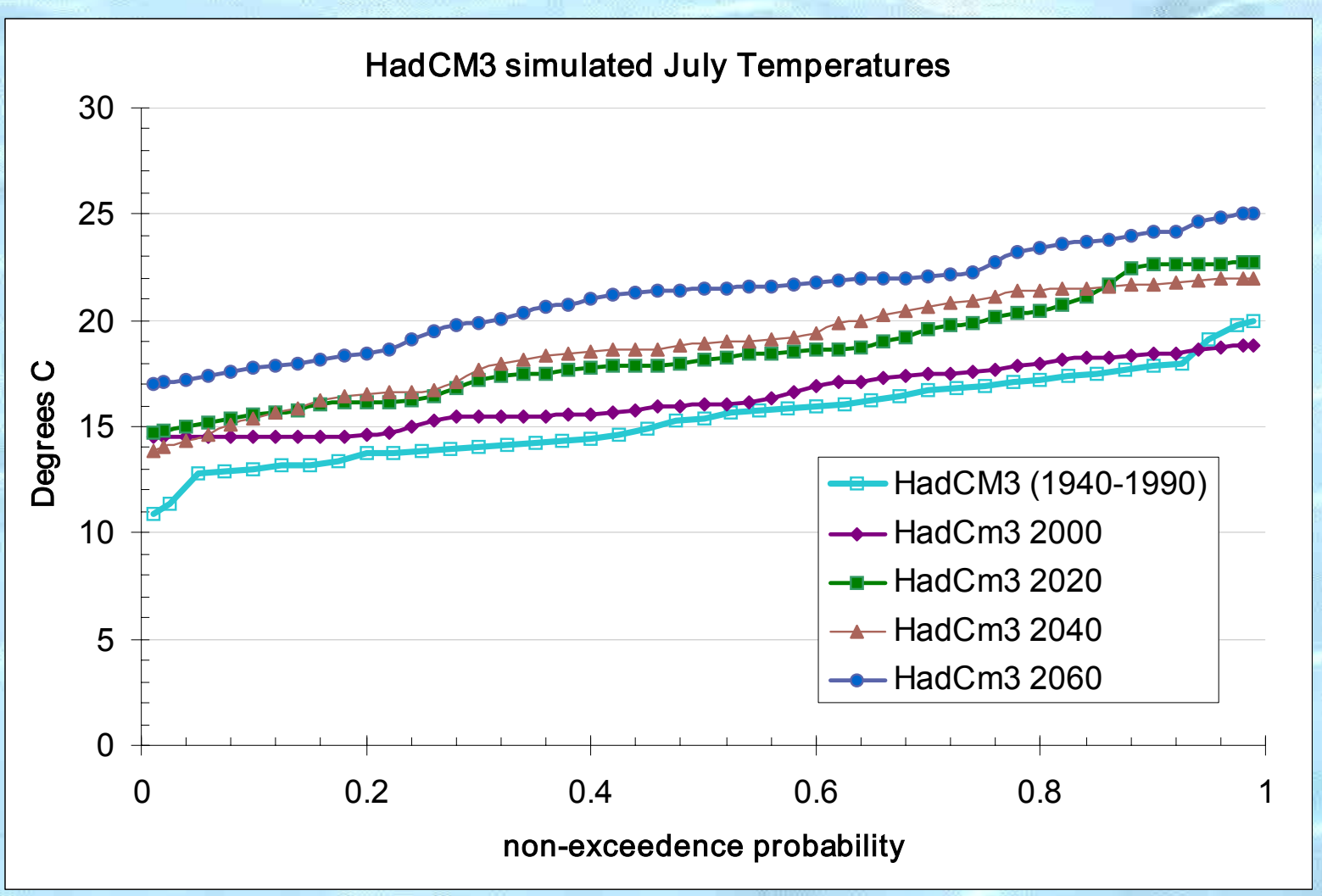


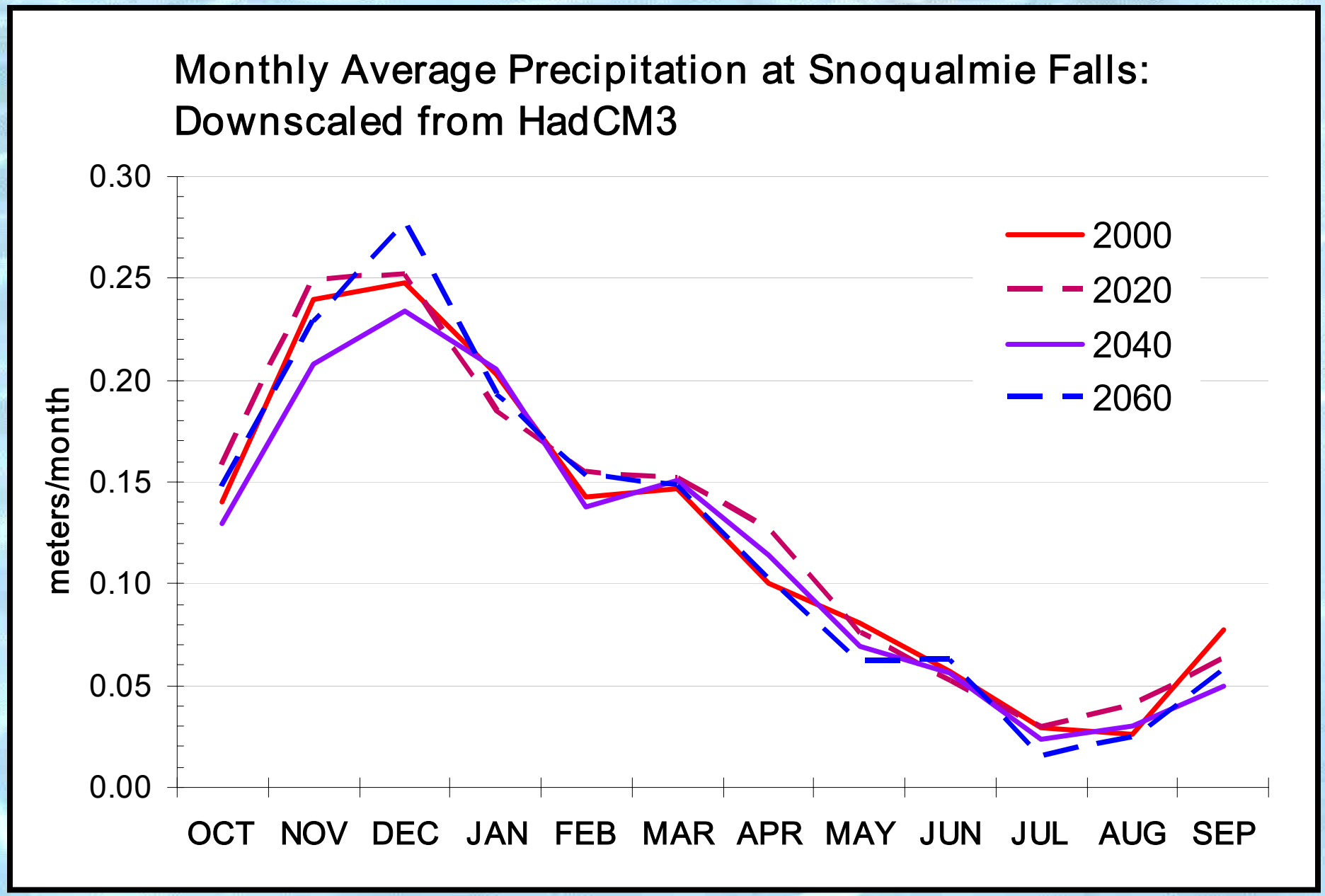
Quantile Mapping

- GCMs are now scaled to the station location.
- Repeat process for multiple stations.
- Scale from monthly to daily values by applying monthly differences to observed records

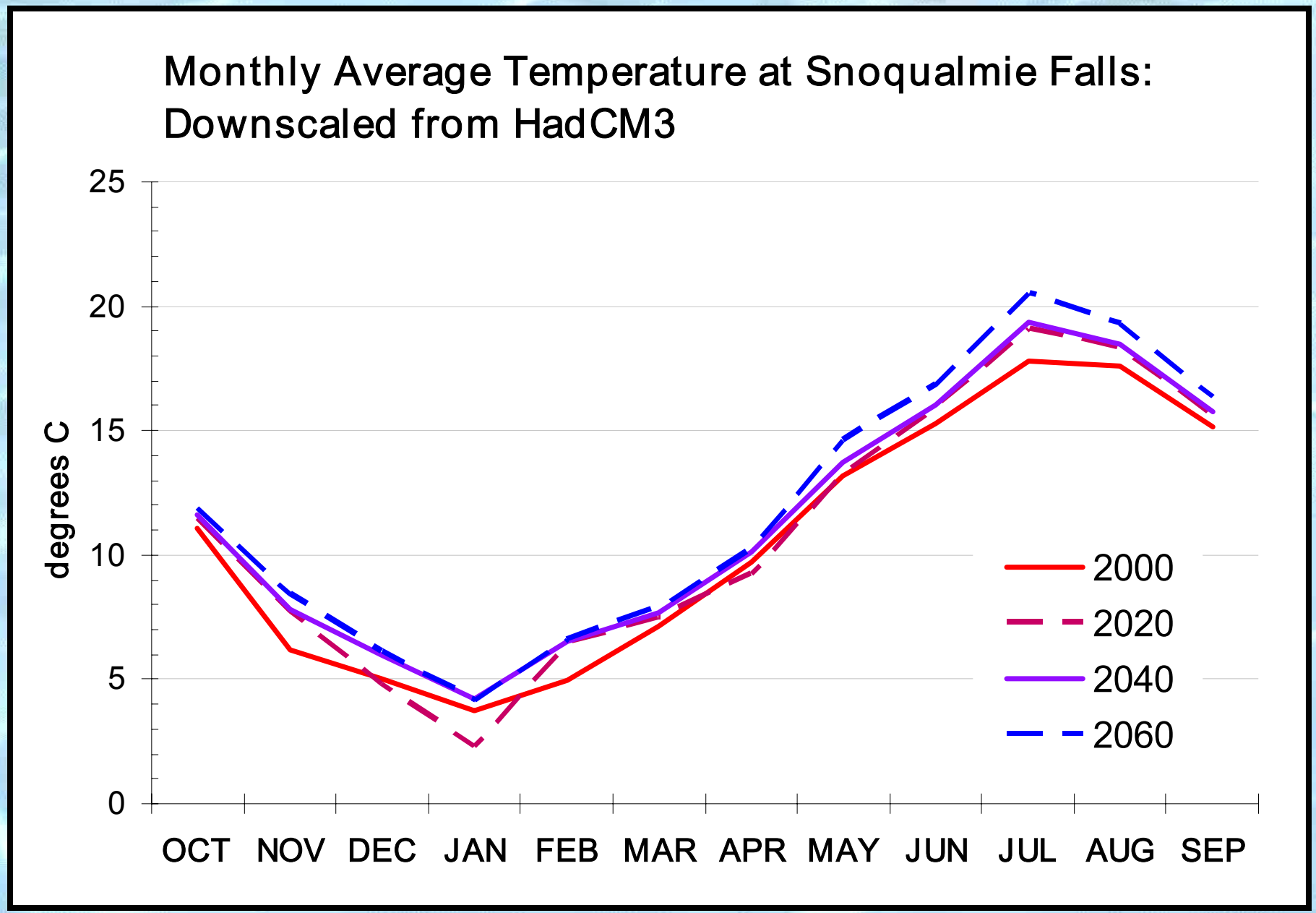



HadCM3 simulated July Temperatures
Degrees C
30
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
non-exceedence probability
HadCM3 (1940-1990)
HadCm3 2000
HadCm3 2020
HadCm3 2040
HadCm3 2060

Impacts on Temperature


Monthly Average Precipitation at Snoqualmie Falls:
Downscaled from HadCM3
meters/month
0.30
0.25
0.20
0.15
0.10
0.05
0.00
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2000
2020
2040
2060

Impacts on Temperature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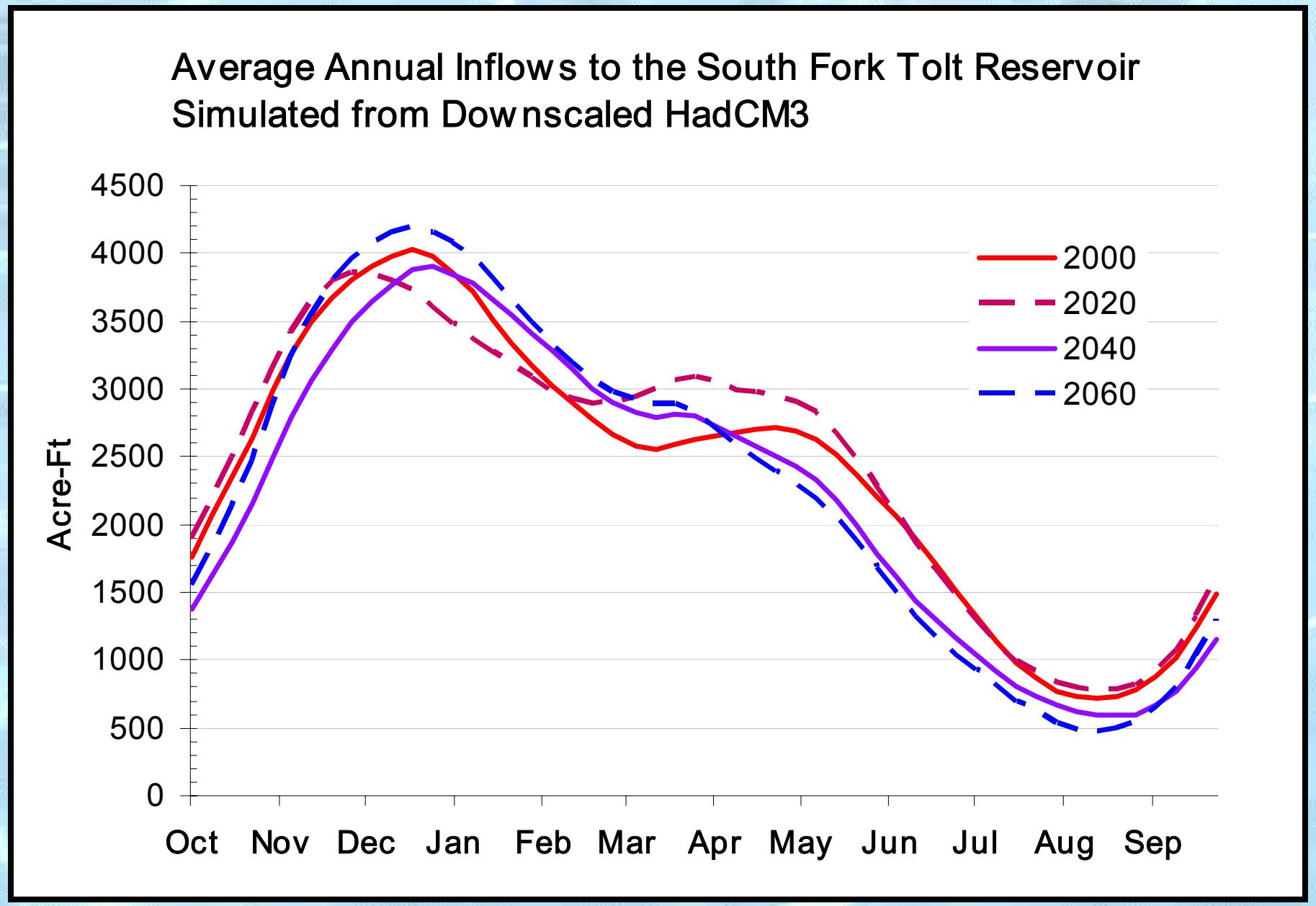
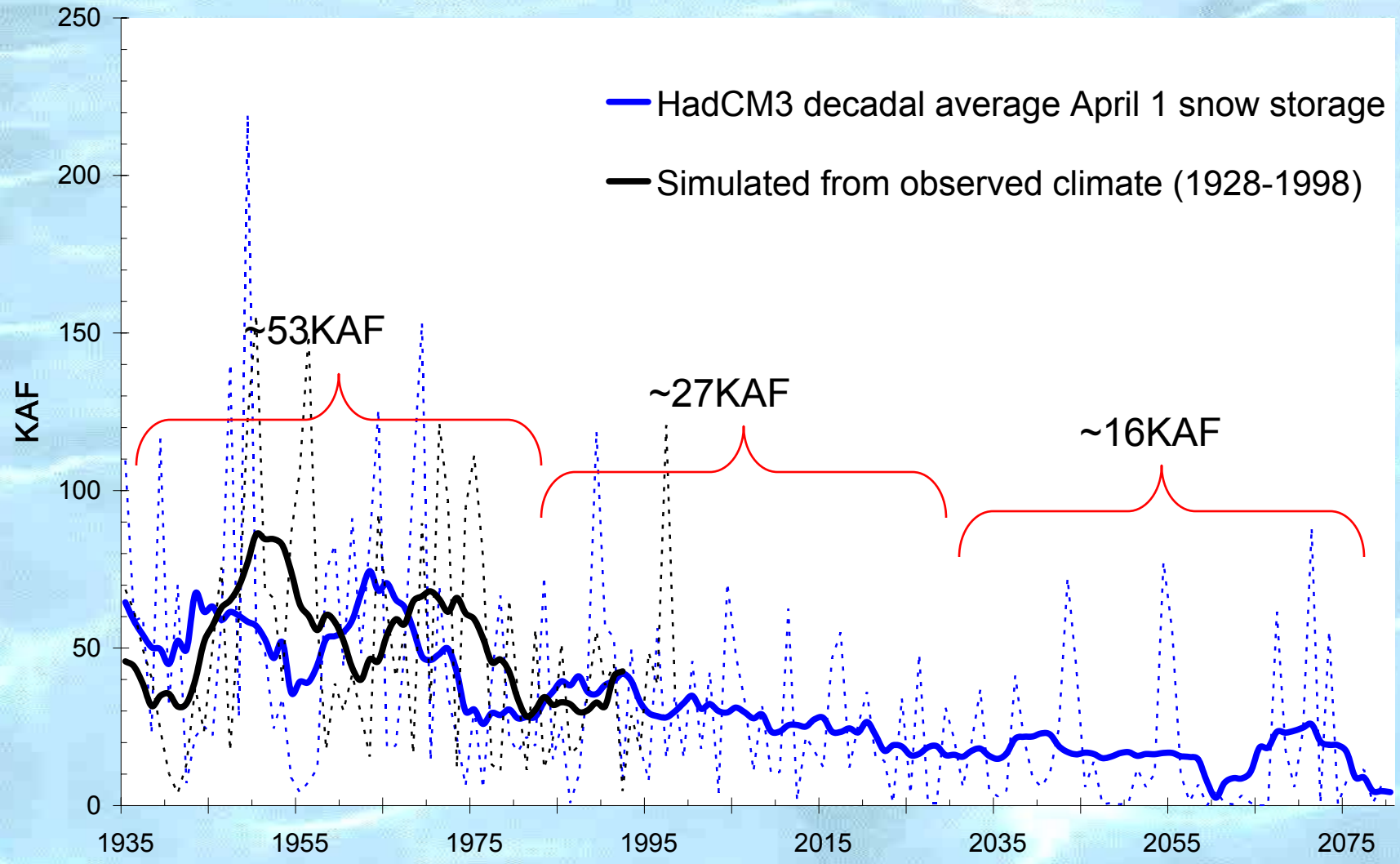
degrees C
25
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2000
2020
2040
2060

Impacts on Hydrology

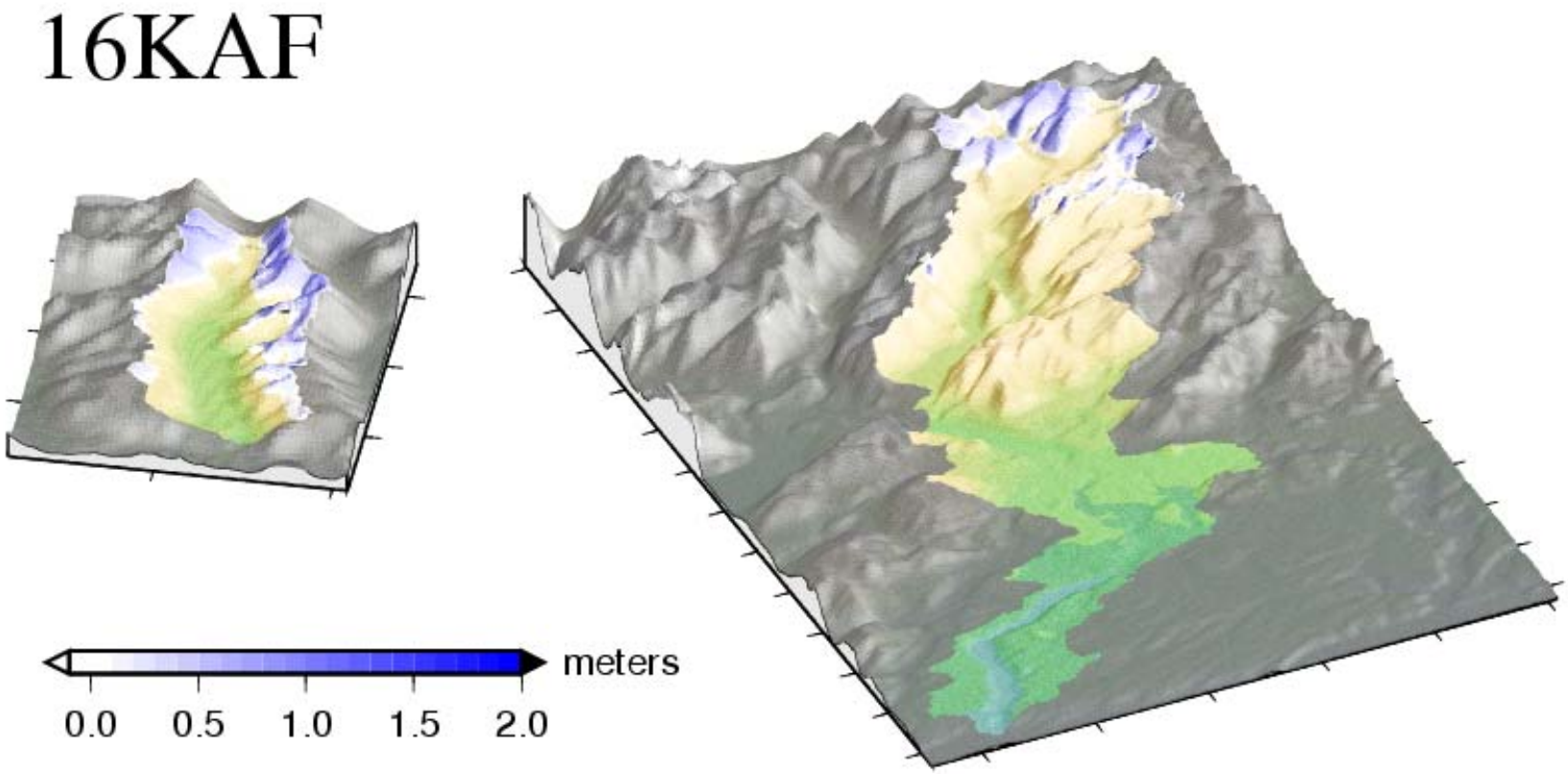

Average Annual Inflows to the South Fork Tolt Reservoir
Simulated from Downscaled HadCM3
Acre-Ft
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2000
2020
2040
2060

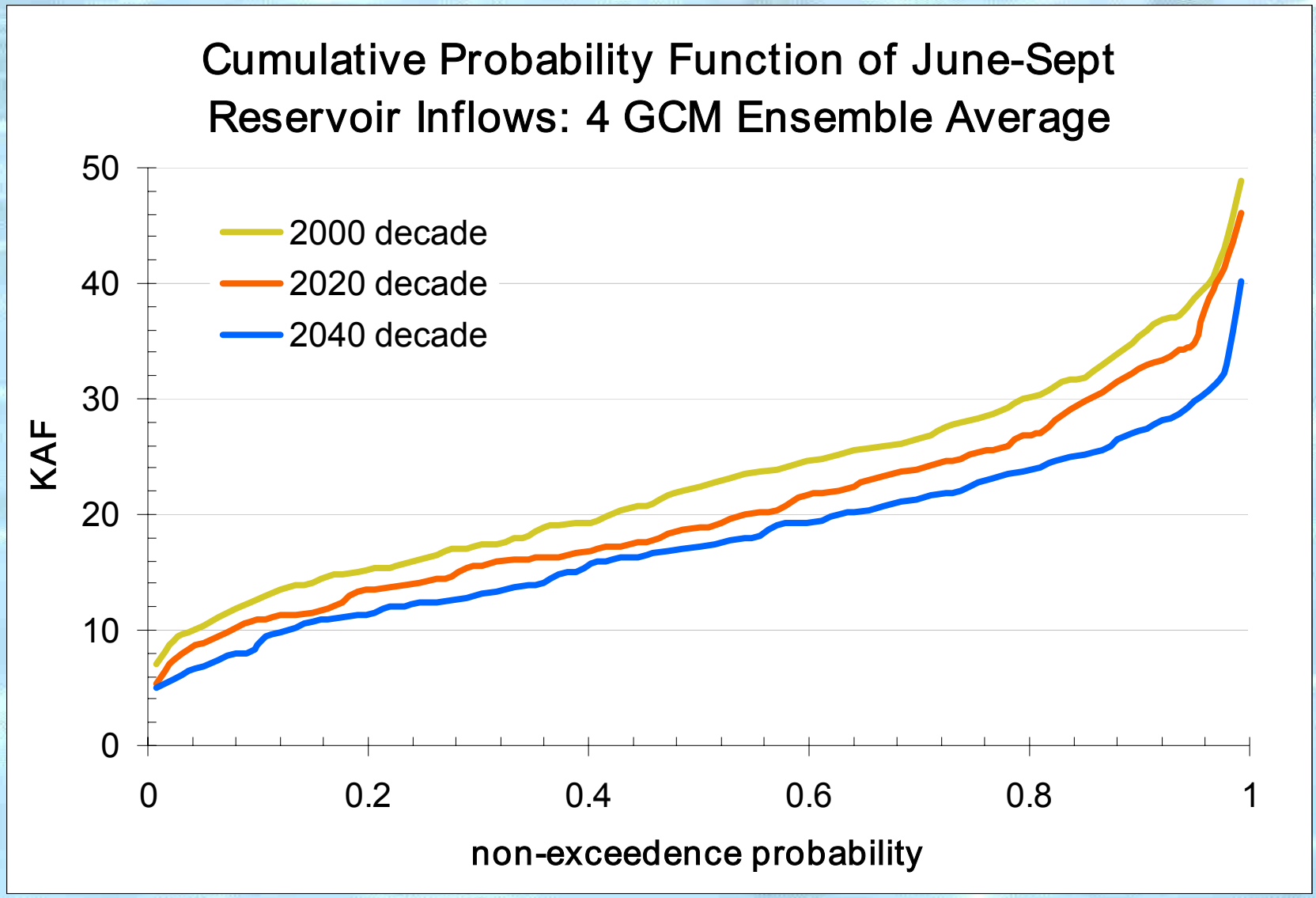
General Impacts on Water Supply

Combined Cedar-Tolt Total April Snowpack Storage (swe)



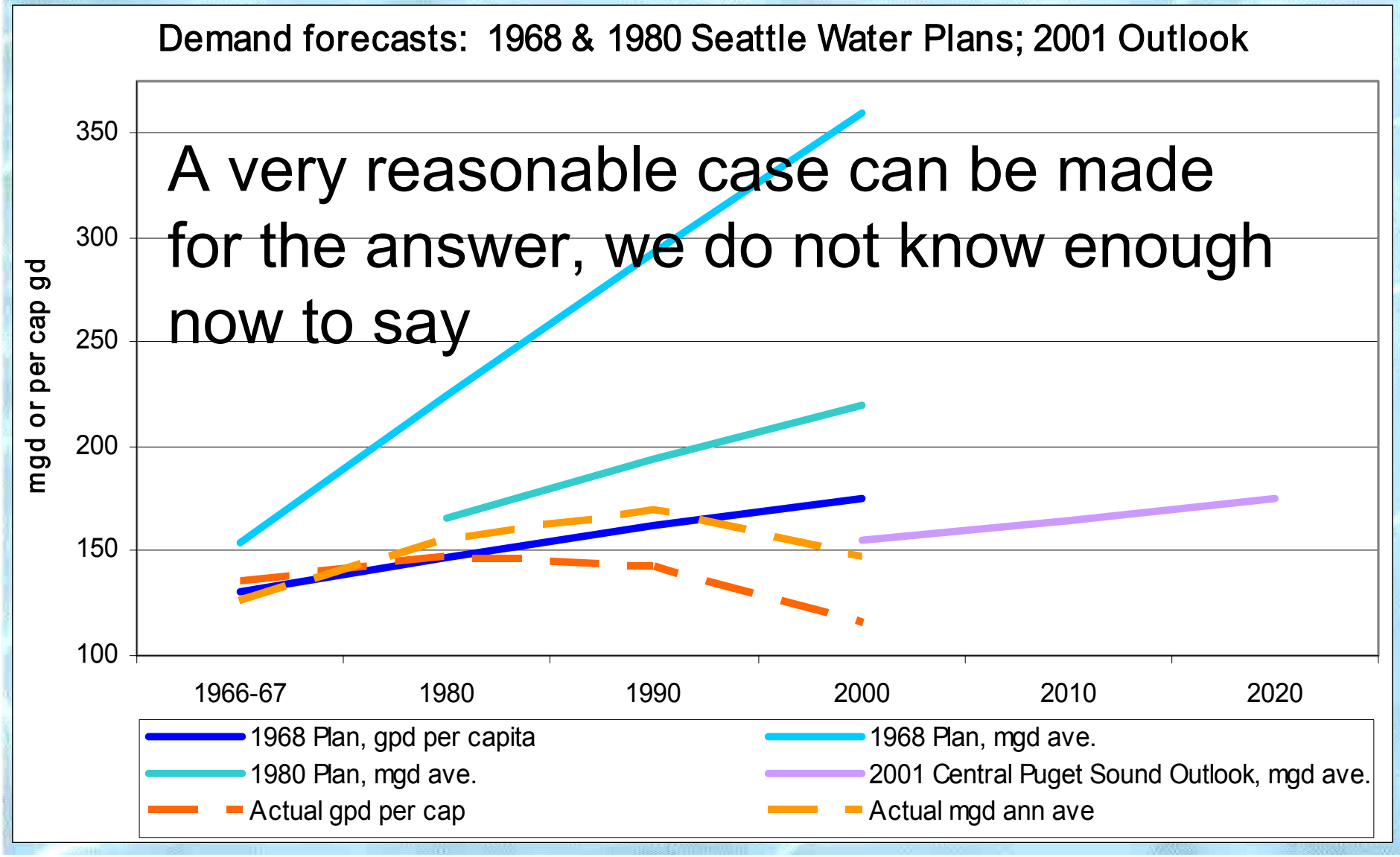
April 1st snow pack extent and depth (as snow water equivalent)

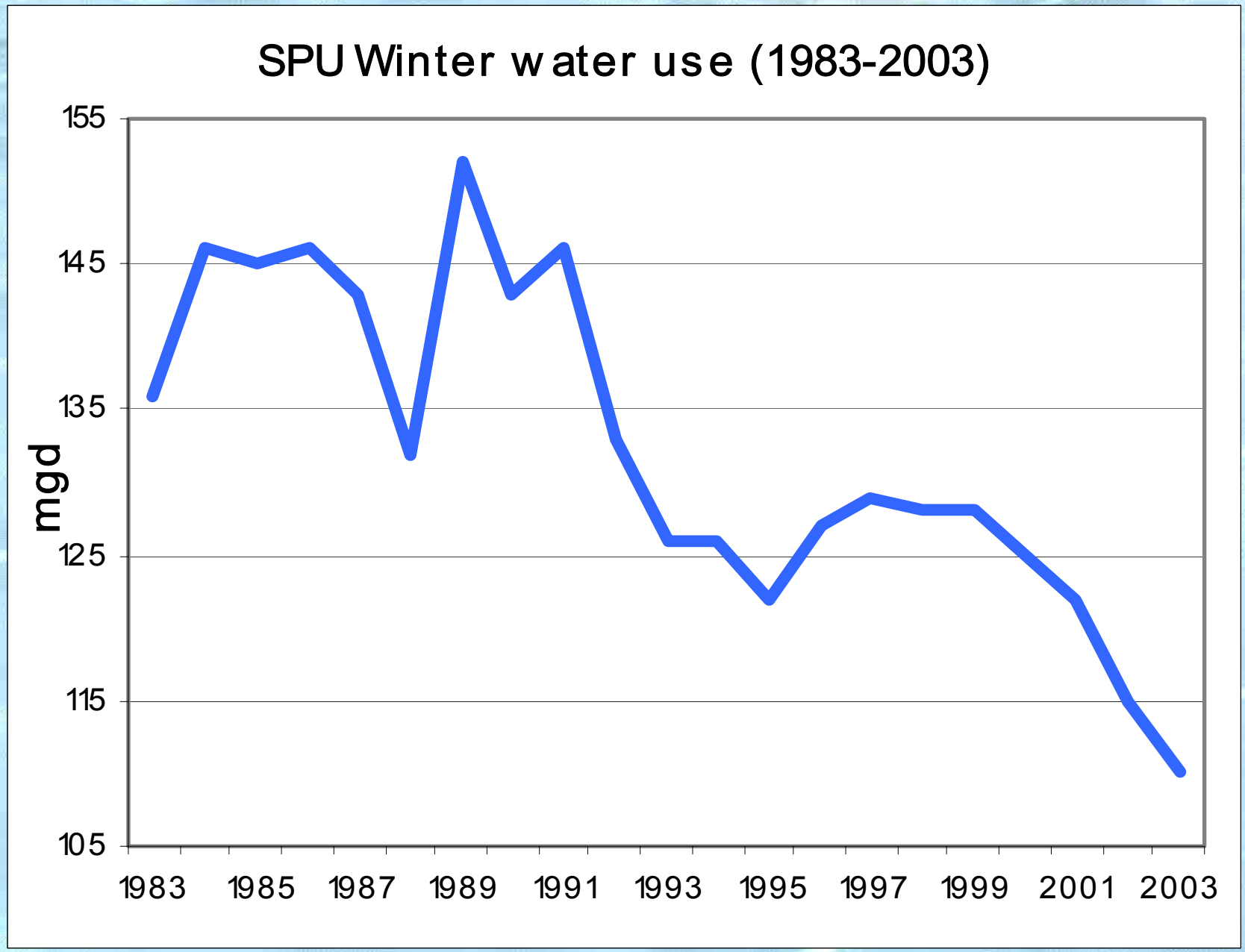




* 4GCMs: HadCM3, ECHAM4, GFDL_R30, PCM1.1, SRES A2 forcing scenario

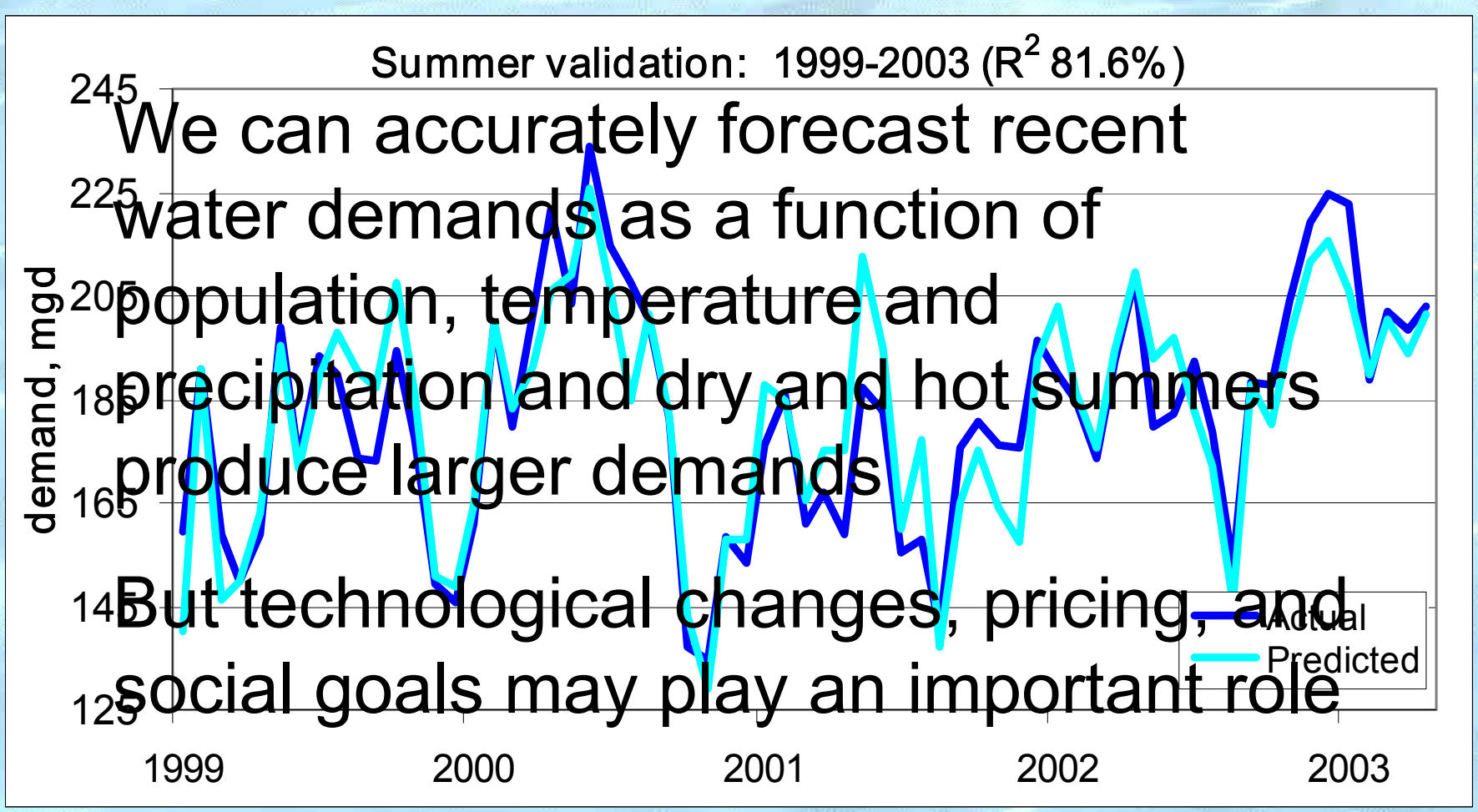
What Will Climate Change Due to Water Demands?




SPU Winter water use (1983-2003)
mgd
155
145
135
125
115
105
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003

Short-term Model Validation

Seattle Region: Summer



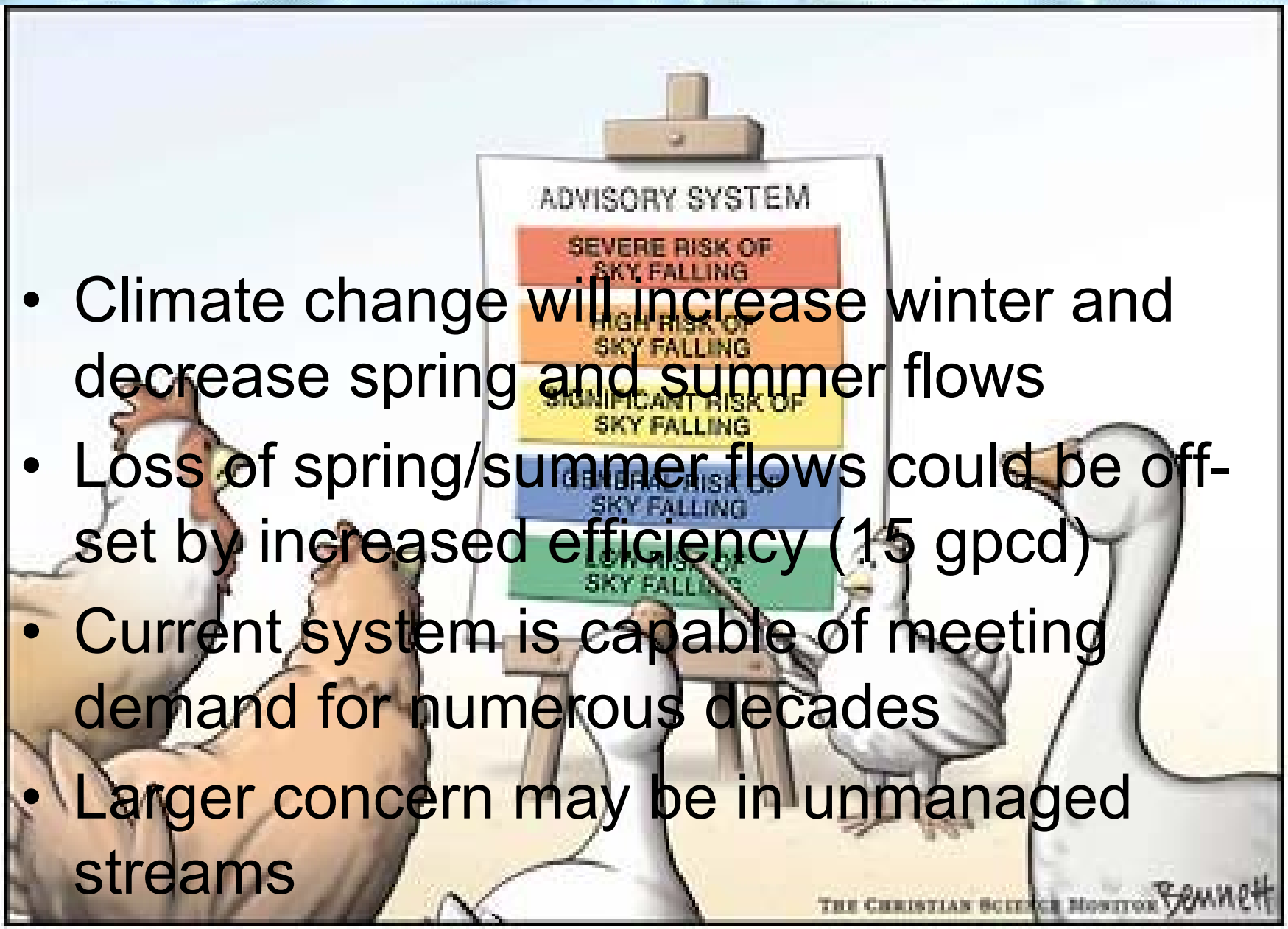
We can accurately forecast recent water demands as a function of population, temperature and precipitation and dry and hot summers produce larger demands

But technological changes, pricing, and social goals may play an important role

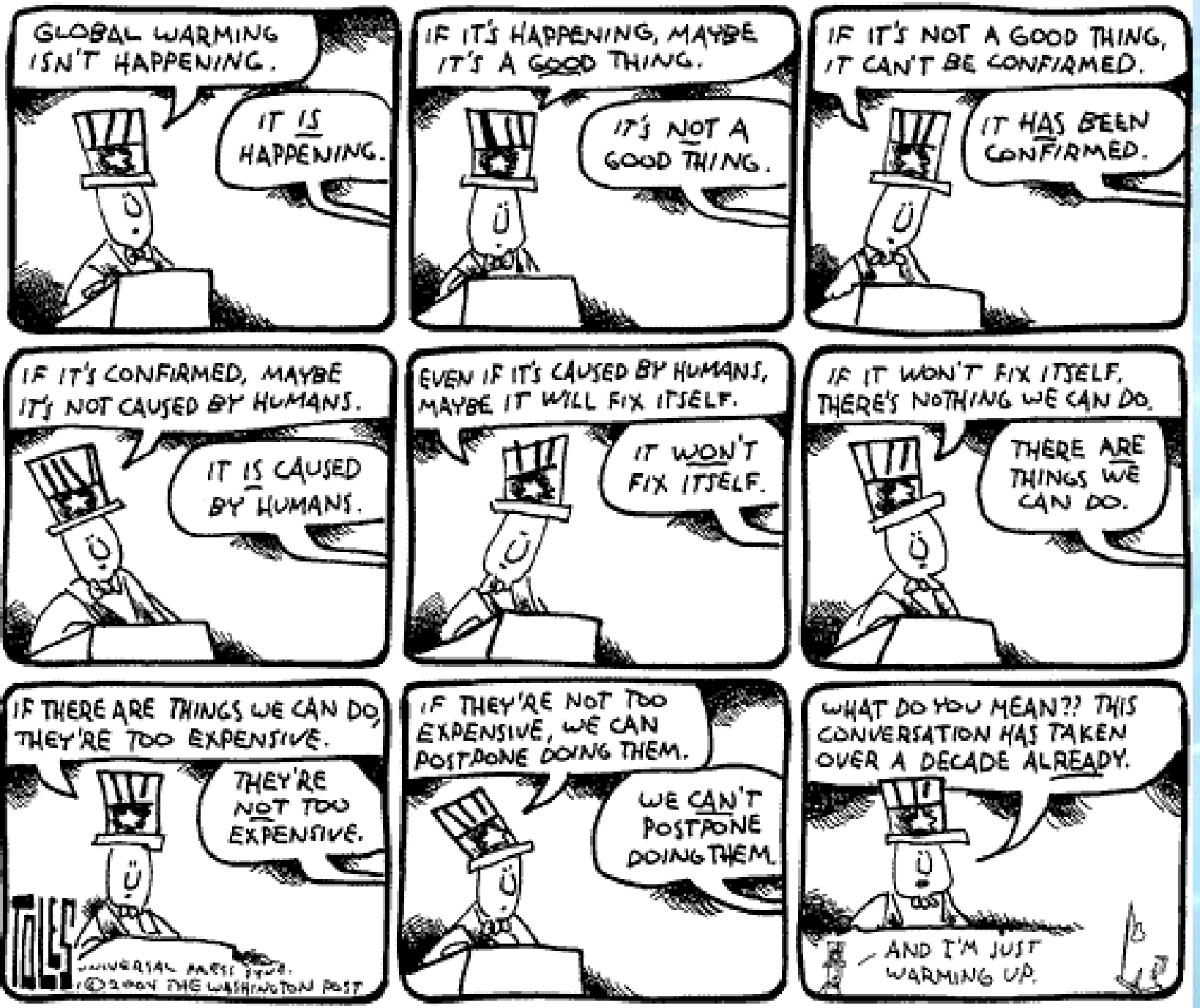
Potential Impacts on Fish

- Shift in annual runoff
- Warmer streams
- Stranded fry

- We will see more summers with lower flows



- Climate change will increase winter and decrease spring and summer flows
- Loss of spring/summer flows could be off-set by increased efficiency (15 gpcd)
- Current system is capable of meeting demand for numerous decades
- Larger concern may be in unmanaged streams


GLOBAL WARMING ISN'T HAPPENING.
IT IS HAPPENING.
IF IT'S HAPPENING, MAYBE IT'S A GOOD THING.
IT'S NOT A GOOD THING.
IF IT'S NOT A GOOD THING, IT CAN'T BE CONFIRMED.
IT HAS BEEN CONFIRMED.
IF IT'S CONFIRMED, MAYBE IT'S NOT CAUSED BY HUMANS.
IT IS CAUSED BY HUMANS.
EVEN IF IT'S CAUSED BY HUMANS, MAYBE IT WILL FIX ITSELF.
IT WON'T FIX ITSELF.
IF IT WON'T FIX ITSELF, THERE'S NOTHING WE CAN DO.
THERE ARE THINGS WE CAN DO.
IF THERE ARE THINGS WE CAN DO, THEY'RE TOO EXPENSIVE.
THEY'RE NOT TOO EXPENSIVE.
TOLES
IF THEY'RE NOT TOO EXPENSIVE, WE CAN POSTPONE DOING THEM.
WE CAN'T POSTPONE DOING THEM.
WHAT DO YOU MEAN?? THIS CONVERSATION HAS TAKEN OVER A DECADE ALREADY.
AND I'M JUST WARMING UP.

1-2-04