What Does the Crystal Ball Indicating for Water Resources in the Pacific NW?

Regional Historical Trends

Climate Change Projections
Departure from Normal Temperature (F)
10/1/2014 - 9/30/2015
The mouth of the White Salmon River in July 2015
1920-2012 Temperature Trends

Squares aren’t significant linear trends; circles are significant at 95%

Abatzoglou et al. 2014 (J. Climate)
Precipitation Trends (1920-2012)

Squares indicate lack of significant linear trends; circles are significant at 95%

Abatzoglou et al. 2014 (J. Climate)
Trends in Fraction of Snow versus Rain in Winter (1949-2004)
Trends in the Spring Pulse Onset (1948-2002)

- > 20d earlier
- 15-20d earlier
- 10-15d earlier
- 5-10d earlier
- < 5d
- 5-10d later
- 10-15d later
- 15-20d later
- > 20d later
SnowCourse BeaverPass: April 1st SWE

Trend for 1944–2015: -1.8 in / decade

Statistically Significant

Northern Cascade Mountains of WA
USGS NF Stillaguamish at Arlington: Highest Daily Flow

Trend for 1929–2015: +950 cfs / decade

Statistically Significant
USGS Sauk R. Nr. Sauk: Highest Daily Flow

Trend for 1929–2015: +960 cfs / decade

Not Statistically Significant

Snow Dominant
WA State Summer Minimum Temperatures

Washington, Minimum Temperature, June-August

1901-2000
Mean: 48.6°F

Min Temperature

°F

°C
Low-level Humidity

WA State Humidity (Jun-Sep)
Sea Surface Temperature (SST) Anomalies Offshore the Pacific NW

HadSST (Degrees C)

40-50 N, 140-125 W
I WANT A RECOUNT.

TIME TO BURN MORE FOSSIL FUELS...

AND YOUR BOOKS.

"SCIENCE"

\[ x + y = z + \pi \]

\[ \frac{18x}{-19w} \]

???

AL GORE

FED UP CITIZENS

NEWs

COLD WAVE STRIKES

Oscar

I'M WARMING TO THAT IDEA.
Modeled Change in Temperature by the Middle of the 21st Century

Dec-Jan-Feb

Jun-Jul-Aug
Summer P Change
Temperature Changes by Season

Changes relative to 1970-1999 mean
Precipitation
Changes by Season

- Changes relative to 1970-1999 mean

**Wetter winters**

**Drier summers**

(slide courtesy of Ingrid Tohver - UW CIG)
Expected Transitions in Watershed Types

Hamlet et al. 2013
Watershed Classification

Ratio of Peak SWE to October to March Precipitation

- < 0.1 Rain dominant
- 0.1 - 0.4 Transition
- > 0.4 Snow dominant

Historical

A1B

2020s

B1

2040s

2080s

Tohver et al. 2014
Marlier et al. (2017)

Temperature (°C) | Precipitation (mm/d) | SWE (cm)

Climatology

1950-2015

2040-2069

Future Anomaly
When will the climate change signal in July streamflow exceed the interannual variability?
Positive proof of global warming.
Challenges for Water Managers

- Summer Demand versus Winter Floods
- Infrastructure (e.g., Reservoirs)
- Legal Issues
- Hydropower
- Habitats
- Recreation/Tourism
- Groundwater Withdrawals
Ecosystem Concerns

- Water and Air Temperature Impacts
- Aquatic Migration
- Invasive Species
- Sea Level Rise/Saltwater Intrusion
- Riverine Habitat
August Mean Air Temperatures (fill) and Maximum Summer Stream Temperatures (dots)
Potential Evapotranspiration (pET) in the Columbia Basin of E. WA

Summer Mean Potential ET

<table>
<thead>
<tr>
<th>Year</th>
<th>George</th>
<th>Harrah</th>
<th>Lind</th>
<th>Odessa</th>
<th>LeGrow</th>
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Bond and Bumbaco (2015)
<table>
<thead>
<tr>
<th>Factors Increasing Demand</th>
<th>Factors Reducing Demand</th>
<th>Factors With Unknown Effects</th>
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</thead>
<tbody>
<tr>
<td>Increased evaporation and evapotranspiration due to temperature increase.</td>
<td>Reduced losses of agricultural water through improvements to delivery practices and facilities.</td>
<td>Changes in the types and characteristics of crops grown.</td>
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<tr>
<td>Increased evapotranspiration due to extended growing seasons.</td>
<td>Less per-unit crop water use associated with increased atmospheric CO₂ and ozone.</td>
<td>Changes in agricultural management practices (e.g., more dry-year fallowing or deficit-irrigation cropping).</td>
</tr>
<tr>
<td>Increase in lands requiring supplemental irrigation to remain viable.</td>
<td>Increased crop failure due to increased pests, diseases, etc.</td>
<td>Transfers of water between different uses.</td>
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<tr>
<td>Increase in irrigated lands due to northward warming.</td>
<td>Conversion of irrigated cropland to other less water-intensive uses.</td>
<td>Effects on the surface energy balance from factors other than temperature.</td>
</tr>
<tr>
<td>Increased livestock water demands.</td>
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<tr>
<td>Increased total crop yield associated with increased atmospheric CO₂.</td>
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</tbody>
</table>
Modeled Change in Viticulture Suitability from 1980 to 2050

Hannah et al. (PNAS, 2013)
Summary

- Record temperature anomalies have occurred during the last 1-3 years in the NE Pacific and western US.

- Future decades are liable to bring not just warmer temperatures but also wetter winters and *maybe* slightly drier summers.

- Relative to historical norms, western US streamflows are generally expected to be greater in winter and lower in summer.

- Will overall water supply or water quality be a bigger issue?
References


I DON'T CARE WHAT THEY SAY, THIS GLOBAL WARMING SCARE IS JUST A BUNCH OF LOONY LEFT-WING ENVIRONMENTAL ANTI-GROWTH HYPE!

SO, IS THIS YOUR FIRST WINTER HERE IN ASTORIA?
To the Winter Snowfall (inches) at Snoqualmie Pass

- **El Nino**
- **La Nina**

Total Winter Snowfall (inches) at Snoqualmie Pass

El Nino

La Nina
USGS Sauk R. Nr. Sauk: Date of Peak Flow

trend for 1929–2015: –6.6 days since Aug 1 / decade

*Not Statistically Significant*
USGS Sauk R. Nr. Sauk: Lowest 7-day Flow

Trend for 1929–2015: −5.1 cfs / decade

Not Statistically Significant
ATTENTION, CHINA!
WE WILL NO LONGER FALL FOR THE
"GLOBAL WARMING"
FRAUD YOU CREATED.

MINISTRY OF DECEIT

CLOSED

TV FEED FROM
GREAT SATAN
AMERICA

CROOKED
CHINESE
OFFICIALS

LIVE
PRESIDENT THE DONALD

CLIMATE, CHANGED.
NOAA OI SST
Surface SST (°C) Composite Anomaly 1981–2010 climo

NOAA/ESRL Physical Sciences Division

Feb 2014
April–July streamflow in eight major rivers of the western Sierra Nevada,
Northwest, Precipitation, October-September

1901-2000
Mean: 32.12"