Climate Change 101
Presentation for USBR Managers

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Outline

• Changing Climate
• Impact on Western US Watersheds
• **Weather** is local and short-term. It can change day to day, hour to hour, and even minute to minute.

• **Climate** is what the weather is normally like year to year and decade to decade. Climate is usually measured over periods of about 30 years.

*Climate tells you what clothes to buy and have in your wardrobe.*  
*Weather tells you what to wear each day.*
Without a natural greenhouse effect, Earth’s average temperature would be close to 0°F rather than it’s current 58°F average.
2014 Warmest Year on Record
## Global Temperatures

<table>
<thead>
<tr>
<th>RANK</th>
<th>YEAR</th>
<th>ANOMALY °C</th>
<th>ANOMALY °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2014</td>
<td>0.69</td>
<td>1.24</td>
</tr>
<tr>
<td>2 (tie)</td>
<td>2010</td>
<td>0.65</td>
<td>1.17</td>
</tr>
<tr>
<td>2 (tie)</td>
<td>2005</td>
<td>0.65</td>
<td>1.17</td>
</tr>
<tr>
<td>4</td>
<td>1998</td>
<td>0.63</td>
<td>1.13</td>
</tr>
<tr>
<td>5 (tie)</td>
<td>2013</td>
<td>0.62</td>
<td>1.12</td>
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<tr>
<td>5 (tie)</td>
<td>2003</td>
<td>0.62</td>
<td>1.12</td>
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<tr>
<td>7</td>
<td>2002</td>
<td>0.61</td>
<td>1.10</td>
</tr>
<tr>
<td>8</td>
<td>2006</td>
<td>0.60</td>
<td>1.08</td>
</tr>
<tr>
<td>9 (tie)</td>
<td>2009</td>
<td>0.59</td>
<td>1.06</td>
</tr>
<tr>
<td>9 (tie)</td>
<td>2007</td>
<td>0.59</td>
<td>1.06</td>
</tr>
</tbody>
</table>

**1 = WARMEST PERIOD OF RECORD: 1880–2014**
Temperature Change by Decade

- 2001-2012 even warmer. Every year warmer than 1990s average.
- 1990s even warmer. Every year warmer than 1980s average.
- 1980s warmest decade on record at the time.
Why is it warming?

• Possible reasons
  ➢ The sun
  ➢ Heat release from earth itself into atmosphere (e.g. volcanos)
  ➢ Part of longer term variability
  ➢ Stuff in the atmosphere
Three Influences on Global Temperature

El Niño / La Niña
~ -0.4°F to +0.7°F

Volcanoes
up to ~-1.0°F

Solar Activity
~ -0.1°F to +0.2°F

Source: Foster and Rahmstorf (2011)

Red line = NASA surface temperatures
Blue line = RSS lower troposphere temperatures
Temperature vs Sun’s Energy Output

Global Surface Temperature

Degrees F

Sun’s Energy Output

Watts per square meter

Year

Increasing Carbon Dioxide (CO$_2$) Emissions

Trends in the Northern Hemisphere

![Graph showing trends in Carbon Emissions](image-url)

- **Fossil-fuels (Gt C)**
- **Land-use Change (Gt C)**

Source: Climate Change Impacts on the US, NAST, 2001
Moving Outside the Range of Historical Variation

Average for 2011 (almost 392 ppm)

Updated from Karl et al 2009
Most major greenhouse gases are:

- Carbon dioxide (CO$_2$)
- Methane (CH$_4$)
- Nitrous Oxide (N$_2$O)
Increasing Temperatures Correlate with Human Influences

Global Temperature and CO$_2$

Separating Human and Natural Influences on Climate

- Observations
- Models using only natural forces
- Models using both natural and human forces
All indicators expected to increase in a warming world are increasing and those expected to decrease are decreasing.
From 1941 to 2004, the glacier retreated more than seven miles and thinned by more than 875 yards and ocean water filled the valley.

Image Credit: National Snow and Ice Data Center
Main Messages

- Largest & most comprehensive for the U.S.

- Climate change is happening now

- America is feeling the effects

- Important opportunities to manage & prepare
Global climate is changing and this is apparent across the US in a wide range of observations.

The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.
Observed US Precipitation Change

Alaska

Great Plains North

Midwest

U.S. Average

Northwest

Southwest

Hawaii

Great Plains South

Southeast

Precipitation Change (%)

- >15
- 10 to 15
- 5 to 10
- 0 to 5
- -5 to 0
- -10 to -5
- -15 to -10
- <-15
Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.
Observed Change in Very Heavy Precipitation

Climate 101
Human-induced climate change is projected to continue, and it will accelerate significantly if emissions of heat-trapping gases continue to increase.
Projected Temperature Change

Lower Emissions (B1)  Higher Emissions (A2)

Temperature Change (°F)

- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 15
Projected Precipitation Change
Higher Emissions (A2)
Projected Changes Global Sea Level

- Proxy Records
- Tide Gauge Data
- Satellite Data

Sea Level Change (feet) vs. Year (1800-2100)

- 0.66 ft
- 1 ft
- 4 ft
- 6.6 ft
Water quality and water supply are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.

Projected Changes in Water Withdrawal

(a) Without Climate Change

(b) With Climate Change

% change
- < 0
- 0 to 10
- 10 to 25
- 25 to 50
- > 50

Map showing projected changes in water withdrawal across the United States.
Shift in Plant Hardiness Zones

Zone Changes in Past 10 Years
In color of New Planting Zone

Zone Changes in Next 30 Years
In color of New Planting Zone

Average Annual Extreme Minimum Temperature by Climate-Related Planting Zone

- No Change in Zone
- Zone 4 (-29 to -20 °F)
- Zone 5 (-19 to -10 °F)
- Zone 6 (-9 to 0 °F)
- Zone 7 (1 to 10 °F)
- Zone 8 (11 to 20 °F)
- Zone 9 (21 to 30 °F)
- Zone 10 (31 to 40 °F)
Third National Climate Assessment
Key Messages for the West

Northwest:
1. Water Related Challenges
2. Coastal Vulnerabilities
3. Impacts on Forests
4. Adapting Agriculture

Great Plains:
1. Energy, Water, and Land Use
2. Sustaining Agriculture
3. Conservation and Adaptation
4. Vulnerable Communities
5. Opportunities to Build Resilience

Southwest:
1. Reduced Snowpack and Streamflows
2. Threats to Agriculture
3. Increased Wildfire
4. Sea Level Rise and Coastal Damage
5. Heat Threats to Health
Projected Precipitation Change
Higher Emissions (A2)
Future Shift in Timing of Stream Flows

Reduced Summer Flows
Water-related Challenges

Projected Snow Water Equivalent

1971-2000: 100%
2006-2035: 84% 66% 43%
2041-2070: 98% 91% 66%
2070-2099: 96% 87% 74%

Legend:
- Red: 100%
- Orange: 98%
- Pink: 96%
- Light Pink: 99%
Figure 6. Big Cottonwood Creek runoff sensitivity to temperature as indicated by 30-yr mean (water years 1981–2010) monthly runoff volumes forced by various temperature changes. Temperature changes (°F) are indicated in the legend, where “base” signifies base climate historical simulation with no temperature adjustment. Also shown is the observed mean monthly streamflow.

Credit: Bardsley et al, 2013
Concluding Thoughts

• As the impacts of climate change continue to be realized, resource managers will need to be proactive, innovative, and open to meeting the challenges of a changing future.

• Communication and collaboration are essential to being successful and developing future productive and lasting partnerships.

• We have exactly enough time to address the impacts of climate change, starting NOW.
CLIMATE SUMMIT

WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?

- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.
Regional Reports

Southwest:
nc2014.globalchange.gov/report/regions/southwest

Northwest:
nca2014.globalchange.gov/report/regions/northwest
Regional Resources

• NOAA
  – Regional Climate Service Director (me!)
  – NOAA River Forecast Centers: Colorado Basin River Forecast Center
  – NOAA Regional Integrated Climate Assessments: Western Water Assessment
  – Regional Climate Centers: Western Regional Climate Center
  – State Climatologists: Utah State Climate Office, USU

• DOI
  – Landscape Conservation Cooperatives
  – DOI Climate Science Centers

• USDA Agriculture Hubs

• And more
Meet the Challenges of a Changing Climate

The Climate Resilience Toolkit provides resources and a framework for understanding and addressing the climate issues that impact people and their communities.

1. Identify the Problem
2. Determine Vulnerabilities
3. Investigate Options
4. Evaluate Risks & Costs
5. Take Action

Find Out How People Are Building Resilience

- Forests to Faucets
  [Watch video](http://toolkit.climate.gov/)
- Building a Bridge to Reduce Risk
  [Watch video](http://toolkit.climate.gov/)
- Dune Migration and Shoreline Protection
  [Watch video](http://toolkit.climate.gov/)
- Louisiana's Front Line Defense from Storm and Surge
  [Watch video](http://toolkit.climate.gov/)
Questions?

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