The Risks of Climate Change and Extreme Hydrologic Events: From Food to National Security

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SO, HOW 'BOUT THIS WEATHER?

I KNOW RIGHT? THE WHOLE JET STREAM LAYER IS NUTS!

UM, SURE...

THE 18Z GFS FORECASTS 960MB BY TUESDAY. THINK IT'LL VERIFY?

WHAT?

...RIGHT. SORRY. UH, YEAH! WEATHER SURE HAS BEEN CRAZY.

WEATHER GEEKS HAVE IT TOUGH.
Climate and Extreme Hydrologic Events

What do we observe and expect?

Why Do We Care?

The California drought 2012 to ?
Food and agriculture
Water and conflicts. Syria: Drought, water, agriculture, and civil war

What Do We Do?
Climate and Extreme Hydrologic Events

- What do we expect? (Projections)
- What do we see? (Observations)
- What are the risks? (Vulnerabilities)
- What do we do? (Responses)
Projections
[From basic physics to models]
Climate Change Effects on Water Resources

Total precipitation may increase or decrease

Increased air temperature

Less snowpack

More precipitation as rain than snow due to higher temperatures

Earlier runoff from snow melt

Changes in timing and amount of river flows

Changes in water resource system operations

Sea level rise
Projected Seasonal Precipitation Changes 2080-2099

Source: U.S. Global Change Research Program
Change in Projected Runoff
2041-2060 vs. 1901-1970

Source: U.S. Global Change Research Program 2013; Hatched areas have higher confidence levels.

Milly et al.151
Snowmelt Will Occur Earlier

Source: Hoekstra et al. 2010
Projected Changes in Streamflow Timing
2080 - 2099 vs. 1951 - 1980

Source: USGCRP, Stewart et al. 2011
Water “Stress” (Runoff:Water Use)

Source: Alcamo et al. 2003; Hoekstra et al. 2010
Sea Level Rise will Contaminate Coastal Aquifers

From Vulnerability of coastal aquifers to groundwater use and climate change, Ferguson and Gleeson
Wastewater Treatment Plants at Risk from Sea-Level Rise

- 22 wastewater treatment plants
- Capacity of 1.2 million cubic meters per day

Source: Heberger et al. 2011
Observations
Humans Are Changing the Climate

Carbon Dioxide in the Atmosphere for the Past 800,000 Years

Latest CO₂ reading
January 01, 2015
400.37 ppm
Carbon dioxide concentration at Mauna Loa Observatory

Emergence of Homo sapiens

Where we are today

Peter Gleick 2015
Current data from Mauna Loa, January 1, 2015.
Humans Are Changing the Climate

Temperature Anomalies (deg C)

Instrumental Record

Paleoclimatic Reconstruction

Jones and Mann, Review of Geophysics 2004

Deviation from 1856-1995 Average, smoothed fit
Contiguous US Average Temperatures
1895-2014 and trend

http://www.ncdc.noaa.gov/cag/
Contiguous US Average Precipitation
1895-2014 and trend

http://www.ncdc.noaa.gov/cag/
Climate Changes Are Already Affecting Water Resources
Observed Change in Heavy Precipitation

Percent increases in precipitation falling in the heaviest 1% of all daily events) from 1958 to 2012.
Glaciers are Disappearing

What About Extreme Weather Events?

NOAA 2014
Extreme Events are Increasingly *Influenced* by Climate Change
Human Factors Are Also Key to Risk
Projected Population Changes by County, 2000 to 2050

Source: U.S. Global Change Research Program
Munich Re:
(one of the world’s leading reinsurers)

• “The only plausible explanation for the rise in weather-related catastrophes is climate change.”

Digression:
Causality versus Influence

There is rapidly growing evidence from a combination of basic climate science, models, and real-world observations that human-caused climate change is influencing extreme weather events.
Vulnerabilities

[What do we really care about?]
We’ve Built Vast Water Systems, Now Vulnerable to Changing Climate

Source: Photos by Peter Gleick
Case Study:
The California Drought
California 24-month P, 1895-2014

California, Precipitation, 24-Month Period Ending in December

- 1901-2000 Avg: 44.77"
- Precip

Graph showing precipitation data from 1900 to 2010 with a notable peak in 2010.
California 24-month T, 1895-2014

California, Average Temperature, 24-Month Period Ending in December

- 1901-2000 Avg: 57.4°F
- Avg Temperature

Temp: °F
California Temperature and Precipitation Anomalies (1895-2014) (36-month periods)

Source: NOAA/NCDC ClimDiv data, 12-12-14
California Drought Worst in 1200 years?

Link to Climate Change?

1. The “Ridiculously Resilient Ridge”?
2. Pacific Sea-Surface Temperatures?
3. Direct Temperature Influences.
Water Use in California

Human Water Use:
44 million acre-feet per year

Agriculture 80%
Urban 20%

Average from 2001-2010: 230 gpcd
Agricultural Drought Response

- Reduced surface water deliveries
- Massive groundwater overdraft (5-15% total ag use)
- Fallowing
- Crop switching
- Improved efficiency of water use
California Drought Has Cut Hydroelectricity Generation

$2 Billion Cost to Consumers

Source: EIA Electricity data to September 2014
Case Study: Water and Conflicts
Overview

• Theory: How *might* water issues lead to conflict?
• History: How *have* water issues led to conflict?
• Causality?
• Trends?
• Factors?
• Strategies to reduce risks of conflict.
Water Conflict

Water is one of our most critical resources, but around the world it is under threat. Worldwater.org is dedicated to providing information and resources to help protect and preserve fresh water around the globe.

Water Conflict

In an ongoing effort to understand the connections between water resources, water systems, and international security and conflict, the Pacific Institute initiated a project in the late 1980s to track and categorize events related to water and conflict, which has been continuously updated since. Our new format, updated November 2009, presents the information three ways, to better illustrate how conflicts over water impact history.

View the Water Conflict Chronology (updated 2/13)

List

An interactive map showing the geographic location where conflicts over water have occurred and information about each conflict.

Timeline

A timeline showing when conflicts over water occurred that can be filtered by region, conflict type, and date range.

Map

A table listing conflicts over water that can be filtered by region, conflict type, and date range.

Read the Water and Conflict Chronology in Spanish (2008 version) Cronología de los Conflictos del Agua en Español (versión actualizada en 2008)
Total Reported Water-Related Conflicts

Source: Gleick 2014, Water Conflict Chronology

**Water, Drought, Climate Change, and Conflict in Syria**

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Factors to Consider

• Population
• Economic trends
• Ethnic/Religious factors
• Water
  – Drought
  – Availability
  – Management
• Climate change
• Others...
Water, Food, Climate Risks to “Security”

Euphrates River Runoff

Irrigation Method, Syria

Population of Syria

Winter Precipitation Deficit/Drought
Responses
What do we do?
Continued Delay in Taking Action Means:

Rapidly Worsening Impacts and Unavoidable, More Costly Adaptation
Reducing Water-Related Risks of Climate Change

- Over 17 years ago, the American Water Works Association recommended that
  
  “while water management systems are often flexible, water agencies should re-examine water system designs and operating rules under a wider range of climatic conditions than traditionally used.”

  (AWWA 1997)
Water Strategies in a Changing World

• Traditional approaches: physical transfers of water; surface storage; supply focus.

But we are entering a world of “Peak Water”

• New risks require new strategies:
  – Rethinking water “supply” and “demand”
  – Integrate food-water-energy-climate issues
  – Virtual water transfers of goods and services
  – Smart(er) economic strategies
  – Changes in water management/institutions
Climate and Water Adaptation Strategies

• Integrate and coordinate mitigation and adaptation measures (e.g., energy/water)
• Evaluate potential for existing policies to prepare for unavoidable impacts.
• What doesn’t work under new conditions?
• Develop and implement broader adaptation strategies.
  – Economic, Technological, Institutional/Political, Regulatory, Educational
Final Thoughts

• Communication with the public is vital:
  There are many water-related risks:
  – Basic human needs
  – Reliable food production
  – Ecosystem and human health
  – Links to conflict and violence
  – Extreme events
  – Challenges of unavoidable climate change

• Time for scientists, the public, and policy makers to step up and discuss policies to reduce these risks.
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