



Climate Change, Water Quality and the Future: Lessons from the Western Water Assessment

Western Coalition of Arid States
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Denver, CO

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Western Water Assessment

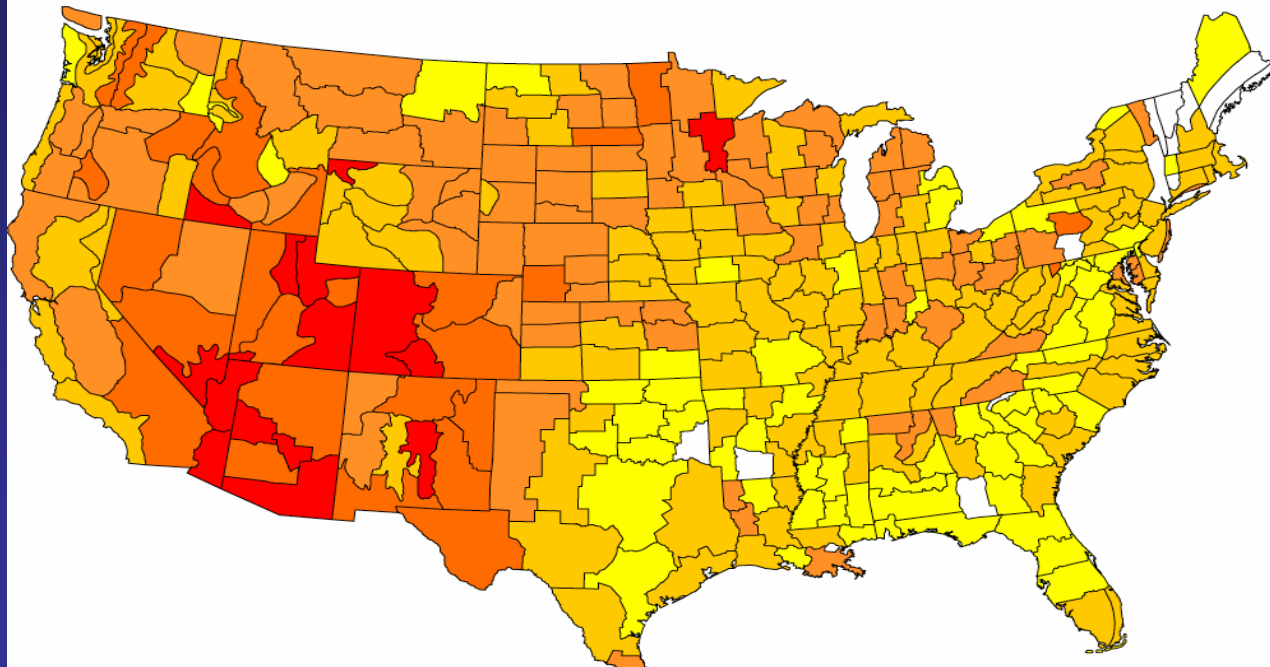
Colorado
University of Colorado at Boulder



A little extra heat, anyone?

U.S. Annual Temperature Departure
(2000-04) minus (1961-90)

Observed



Degrees Celsius

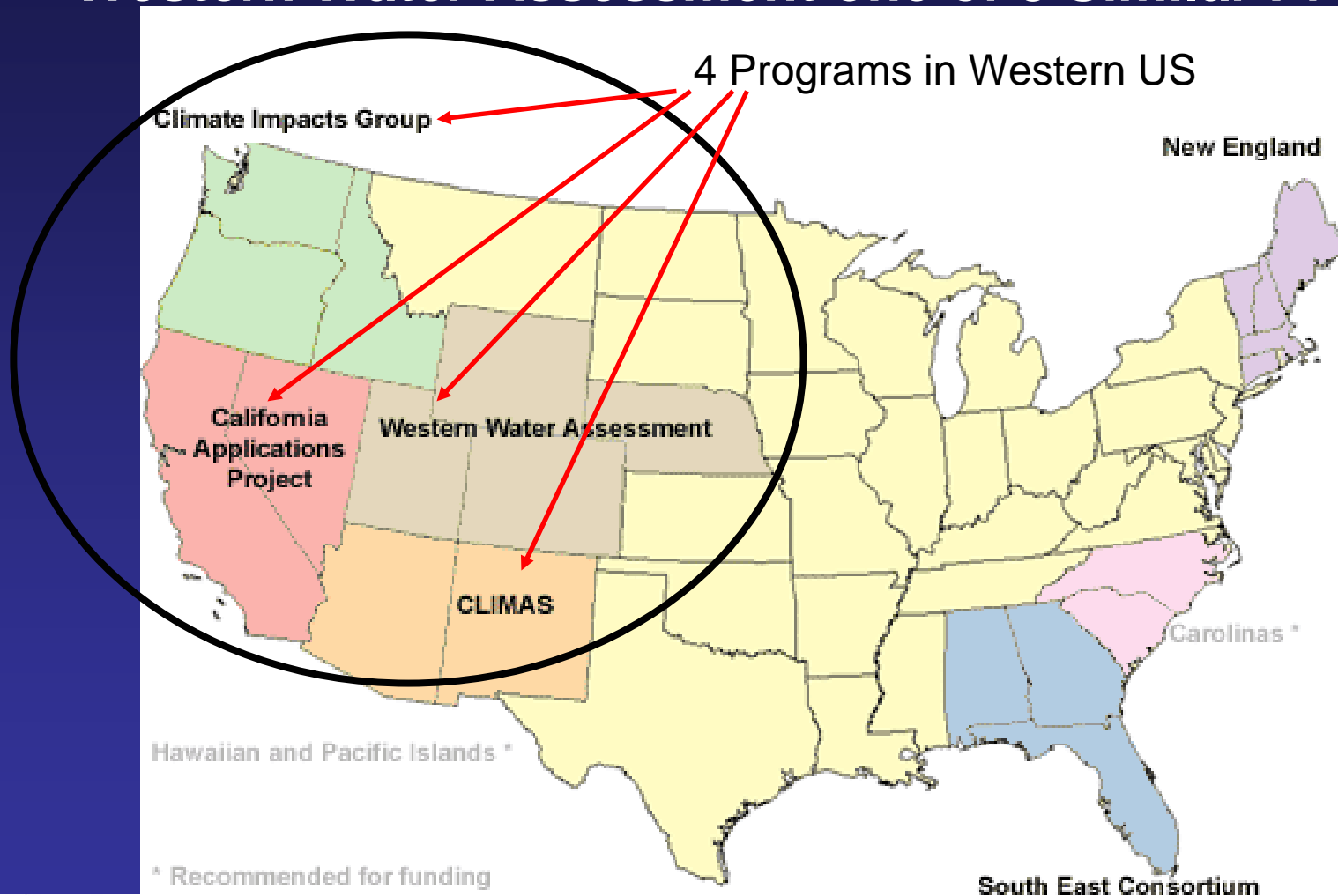


Outline

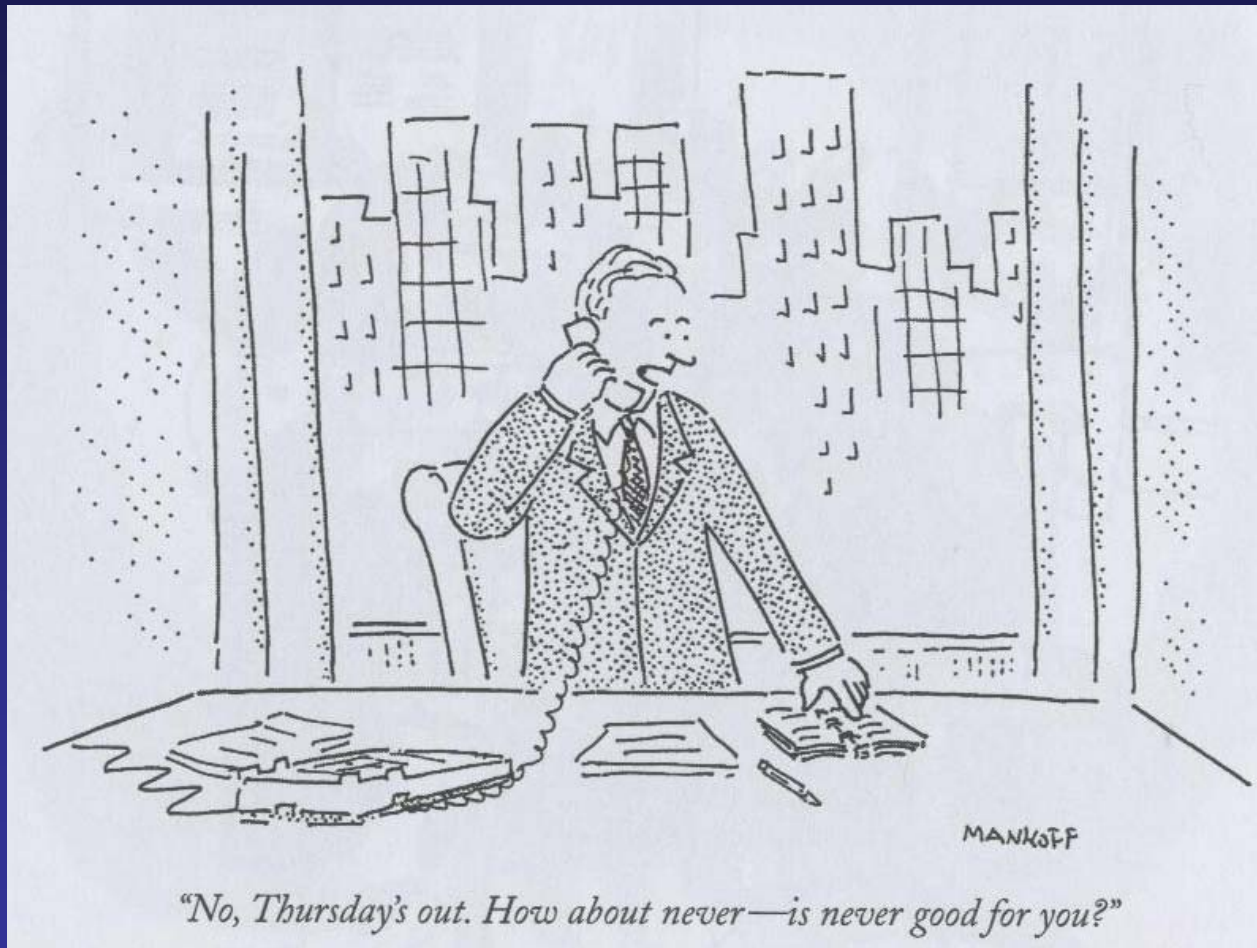
- Western Water Assessment Overview
- Changing Politics of Climate Change
- Underappreciated Facts
- Energy-Water Nexus
- Water Quality Issues for Speculation
- What's a Water Manager to Do?
- Information Sources



Western Water Assessment one of 8 Similar Programs.



When are we going to get to work?



Changing Politics....

Ex-Chiefs of E.P.A. Urge Action on Greenhouse Gases, NYT – January 19, 2006

- WASHINGTON, Jan. 18 - Six former heads of the Environmental Protection Agency, including five who served Republican presidents, said Wednesday that the Bush administration needed to act more aggressively to limit the emission of greenhouse gases linked to climate change.
- Speaking on a panel that also included the current agency chief, Stephen L. Johnson, they generally agreed that the need to address global warming was growing urgent and that the continuing debate over what percentage of the problem was caused by human activities was a waste of time.



Changing Politics - 2

- "To sit back and push this away and deal with it sometime down the road is dishonest and self-destructive."
 - Russell E. Train (Nixon)
- "We've got to start on this action. We can't wait."
 - Lee Thomas (Reagan)
- "This is a debate we should not be having."
 - William Reilly (HW Bush)
- "Why argue about things you can't prove? We need to fashion policies with proper incentives to reduce the amount of carbon we are putting in the atmosphere. There are all kinds of things we can do right now, and we ought to be taking those steps."
 - William Ruckelshaus (Nixon and Reagan)



Changing Politics - 3

Evangelical Leaders Join Global Warming Initiative – NYT February 8, 2006

- ‘Despite opposition from some of their colleagues, 86 evangelical Christian leaders have decided to back a major initiative to fight global warming, saying "millions of people could die in this century because of climate change, most of them our poorest global neighbors.'”
- ‘Among signers of the statement, which will be released in Washington on Wednesday, are the presidents of 39 evangelical colleges, leaders of aid groups and churches, like the Salvation Army, and pastors of megachurches, including Rick Warren, author of the best seller "The Purpose-Driven Life.'”

Changing Politics -4

California Climate Change Initiative

- “I say the debate is over. We know the science, we see the threat and we know the time for action is now.”
 - California Governor Arnold Schwarzenegger ,
June 1, 2005
- Draft Plan already out

Changing Politics - 6

California Climate Change Initiative

- Greenhouse Gases Emissions reduced to
 - 2000 levels by 2010
 - 1990 levels by 2020
 - 80% below 1990 by 205
- <http://www.climatechange.ca.gov>

Welcome to *California*



California Climate Change Portal

Home

Background

Policy &
Program

West
Coast
Initiative

Documents

Glossary

Links

Research

Events

Funding

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Protection Agency

Calif. Air Resources Board

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Commission

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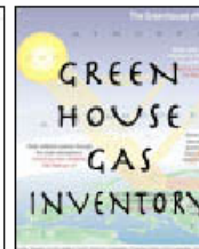
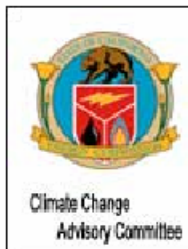
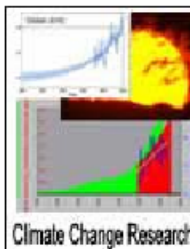
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ANNOUNCEMENTS

[February 9, 2006](#)

PIER Informal Presentation
New Developments in
Macroeconomic Modeling
using CGE Models for
Climate Change Studies

**["No Reason to Wait -
the Benefits of
Greenhouse Gas
Reduction in São Paulo
and California"](#)**

Paper by José
Goldemberg, Secretary of
the Environment, State of
São Paulo, Brazil, and
Alan Lloyd, Secretary of
the Environment, state of
California.

(Acrobat PDF file, 37
pages, **3.3 megabytes**)



**DRAFT
Climate Action Team
Report to the
Governor and Legislature**

Is now available! Click image.

Governor Schwarzenegger announces
Greenhouse Gas Targets at United Nations
World Environment Day 2005 in San Francisco.

Click below for various items...



Western Water Assessment

Colorado
University of Colorado at Boulder



Underappreciated Climate Change Theories and Facts -1

- Don't confuse climate with weather!
- How much warming, where it will warm, and how fast it will warm are hotly debated, not will it warm!
- Warming is not just summer maximums!
- Warming will heat atmosphere, land, oceans, and melt ice.
- CO2 residence time on the order of 100+ years.
- Don't know where approximately HALF current Carbon is going – it is being emitted, but not ending up in the atmosphere.
- Abrupt Change a reality. How hard do we want to push?
- Feedbacks are key to the answer – clouds, water vapor is biggest ghg – and we don't and won't understand them for some time.
- Ocean acidification from CO2 likely as big a problem as warming.
- Approximately half of uncertainty is due to different future emissions
- 380ppm = 0.038%
- Carbon per unit of energy: natural gas=1, oil=1.4, coal=1.8



Underappreciated Climate Change Theories and Facts - 2

- A last minute technological solution is quite unlikely.
- Global mean temperature increase means nothing....no one lives in a 'mean' location.
- Different models show different precipitation changes in some parts of the world. Mid-continental US is one such location.
- Mid-continental areas are expected to warm more than average, and face more precipitation variability.
- Northern Hemisphere will warm more than Southern Hemisphere.
- Models perform poorly in complex terrain such as the Rocky Mountain West.
- Embedded warming a real worry – stop emissions today and it still warms for at least 100 years
- 9 IPCC Lead Authors in Colorado.
- CO₂ Rising 1.5 to 2 ppm / year
- Once carbon in atmosphere, very difficult to remove..



Water Quality and Climate Change - 1

- Literature is thin!
- Typical Summary

“There is a consensus that the broad-scale hydrological cycle will intensify as the climate warms, with water quality adversely affected by the impacts of warmer temperatures, increased frequency of low-flow conditions, and possible increases in the intensity of episodic high precipitation events. These two extremes of the hydrologic cycle, flooding and drought, pose potential threats to water quality.” ~ NCAR/AWWARF Document

- Major Problem is uncertainty over total precipitation
- Planning is important: “it’s not about the bike”

Water Quality and Climate Change - 2

- WQ Potentially Affected by..
 - Increased Temperatures
 - Changes in Flows
 - Runoff Rates and timing
 - Ability of watersheds to assimilate wastes and pollutants
 - Droughts leading to Forest Fires
- Examples
 - High Flows could increase erosion and sediment loads but could also decrease pollutant concentrations
 - Low Flows could reduced dissolved oxygen, decrease dilution, increase temps
- Air temperature increases leading to increased water temperatures are likely to lead to adverse changes in water quality, even in the absence of precipitation changes
- One study projected increased rates of oxygen depletion in already eutrophied water under warming



Water Quality and Climate Change - 3

- Increased productivity leads to increased nutrient cycling and accelerated eutrophication in lakes with sufficient nutrients and oxygen; otherwise oxygen depletion may limit overall productivity
- Possible lake stratification weakening in cold regions of country, anoxic zones could disappear
- Increased temperatures enhances toxicity of metals and increases accumulation of toxics in organisms
- Increased bioaccumulation could decrease toxics in water column
- Higher temps may lead to faster transfer of toxics from water column to sediments
- Not just climate, but other human actions affect WQ

Water-Energy Nexus -1

- No water without energy, no energy without water
- Lots of DOE Attention
- In a carbon constrained world, energy is almost certain to get more expensive
- Ripple effects into supply, demand, treatment
- How to plan for this?



Water-Energy Nexus – 2

California Water Energy Intensity

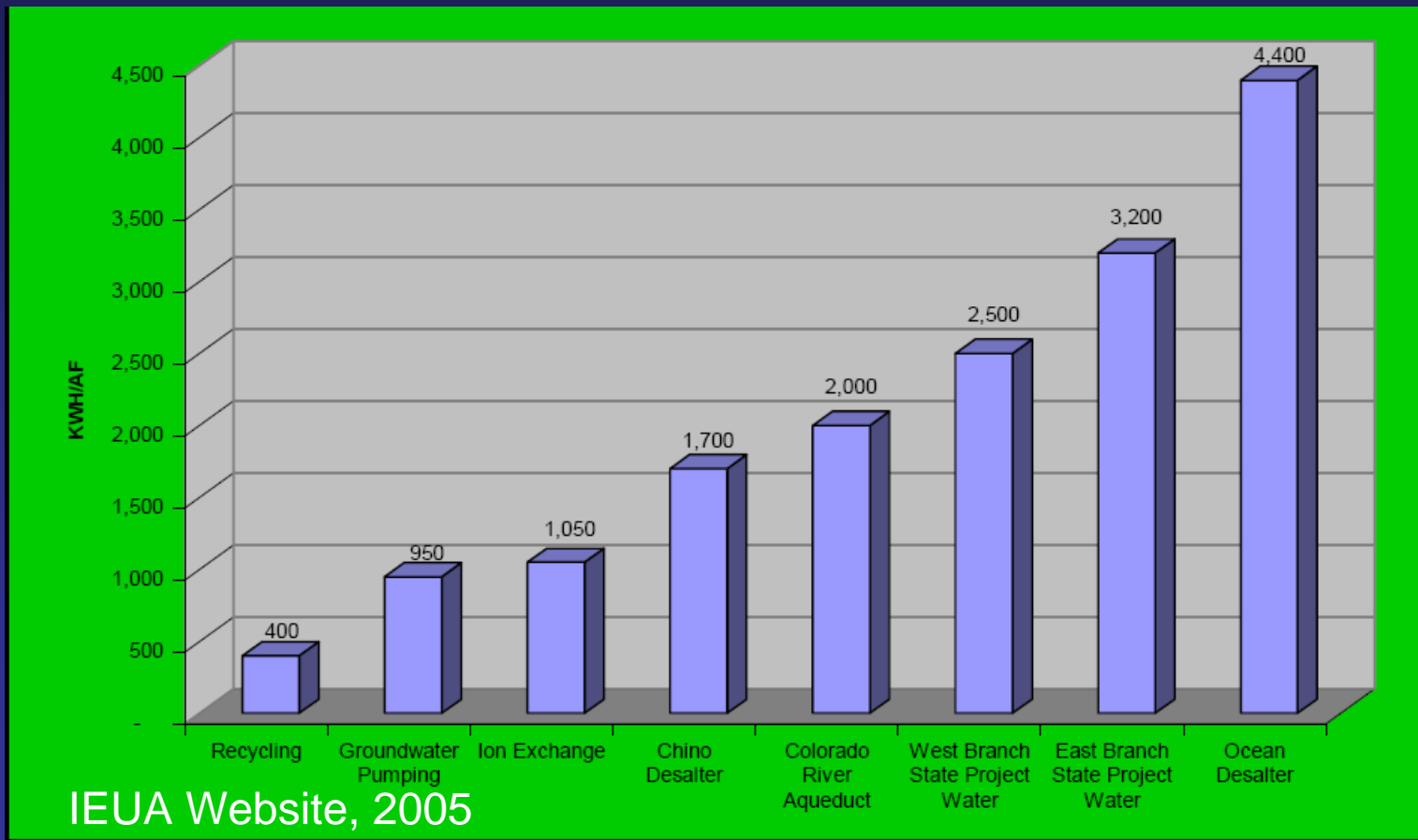
- Approximately 19 percent of all electricity, 30 percent of all natural gas, and 88 million gallons of diesel are used to convey, treat, distribute and use water and wastewater. The California Energy Commission (CEC) estimates 44 million tons of CO₂ emissions are expelled annually on average to provide the 44 million acre feet (MAF) of water used statewide.
- The key to the reduction of climate change emissions through water use efficiency is strategic investment in measures tied to water energy intensity. When a unit of water is saved, so too is the energy required to convey, treat, affect local delivery, perform wastewater treatment and safely dispose of that unit of water. In short, saving water saves energy. Saving water that gets treated as wastewater saves more energy. Saving water that gets heated or additionally pressurized saves still more.

California Energy Commission, 2005



Water Energy Nexus – 3

Inland Empire Utility Agency Energy Intensity (kwh/af)



How not to solve these problems

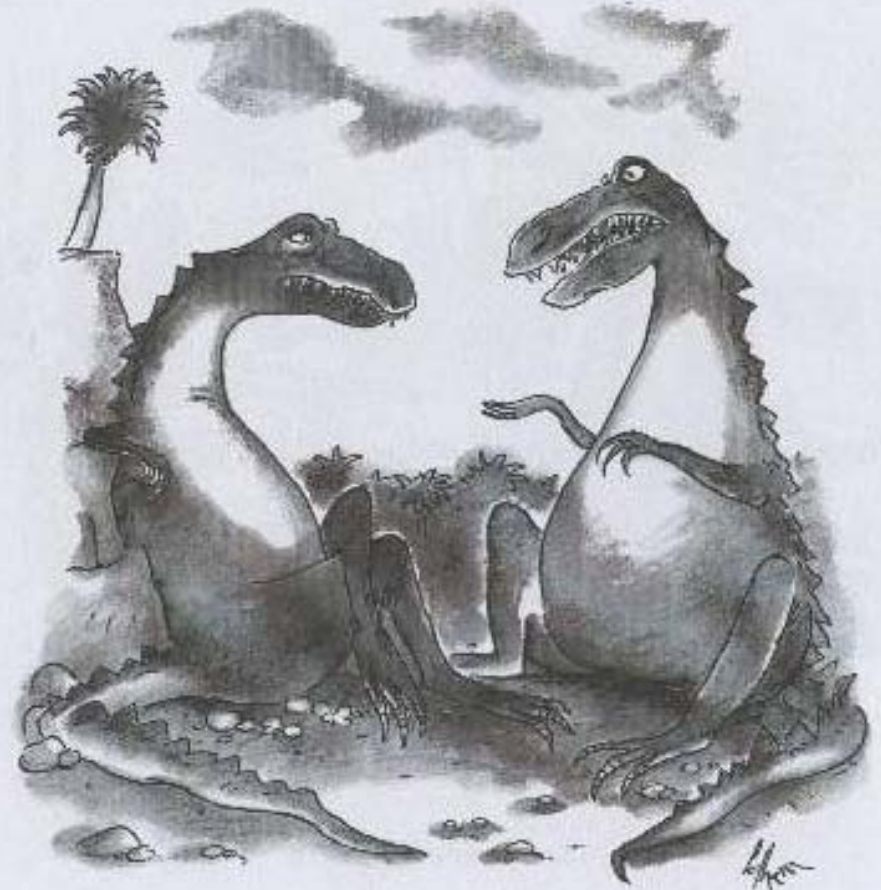
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What's a water manager to do??

- How is Climate Science like Aer Lingus Customer Service?
- Hard to plan for something that will take time to appear and has significant unknowns
- Don't Expect Miracles from Science –progress will be slow.
- Educate yourself on Climate Change!
- But Consider:
 - Dam about to burst on partisan politics related to change
 - Environmental uses may be first to get shorted, creating legal problems
 - Long term planning should consider potential wq impacts including how to minimize energy use. Energy likely more expensive
 - Water-Energy Nexus – recycling, conservation likely to be very important
 - Drought, Population Pressures as analog for climate change?

One Ending,
Others are
Possible and
even
Likely...



"All I'm saying is now is the time to develop the technology to deflect an asteroid."



References

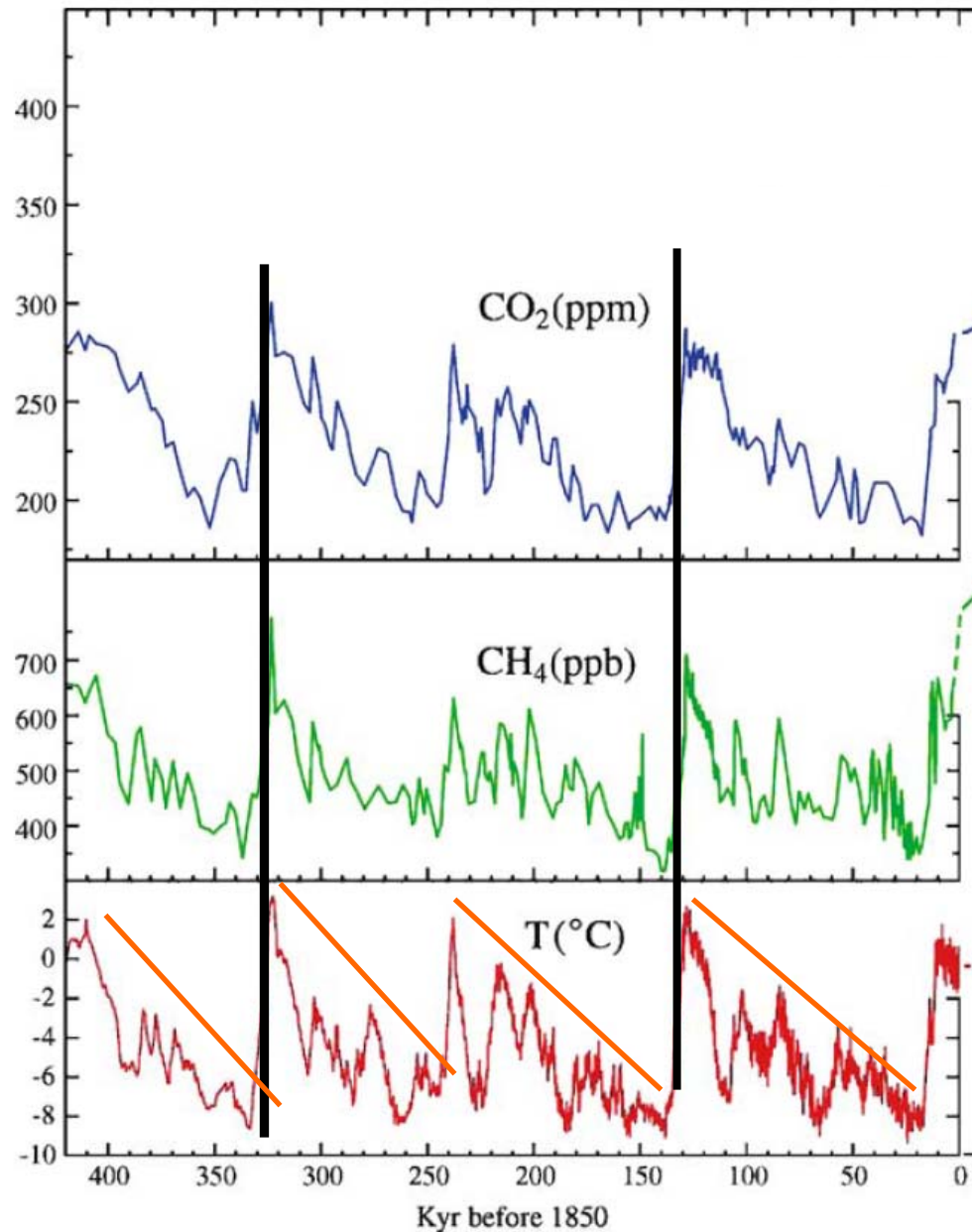
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Pushing a climate system well beyond its norms.....

400,000 years of Temps, CO₂ and CH₄.

Source: Hansen, Climatic Change 2005, based on Petit, Nature 1999



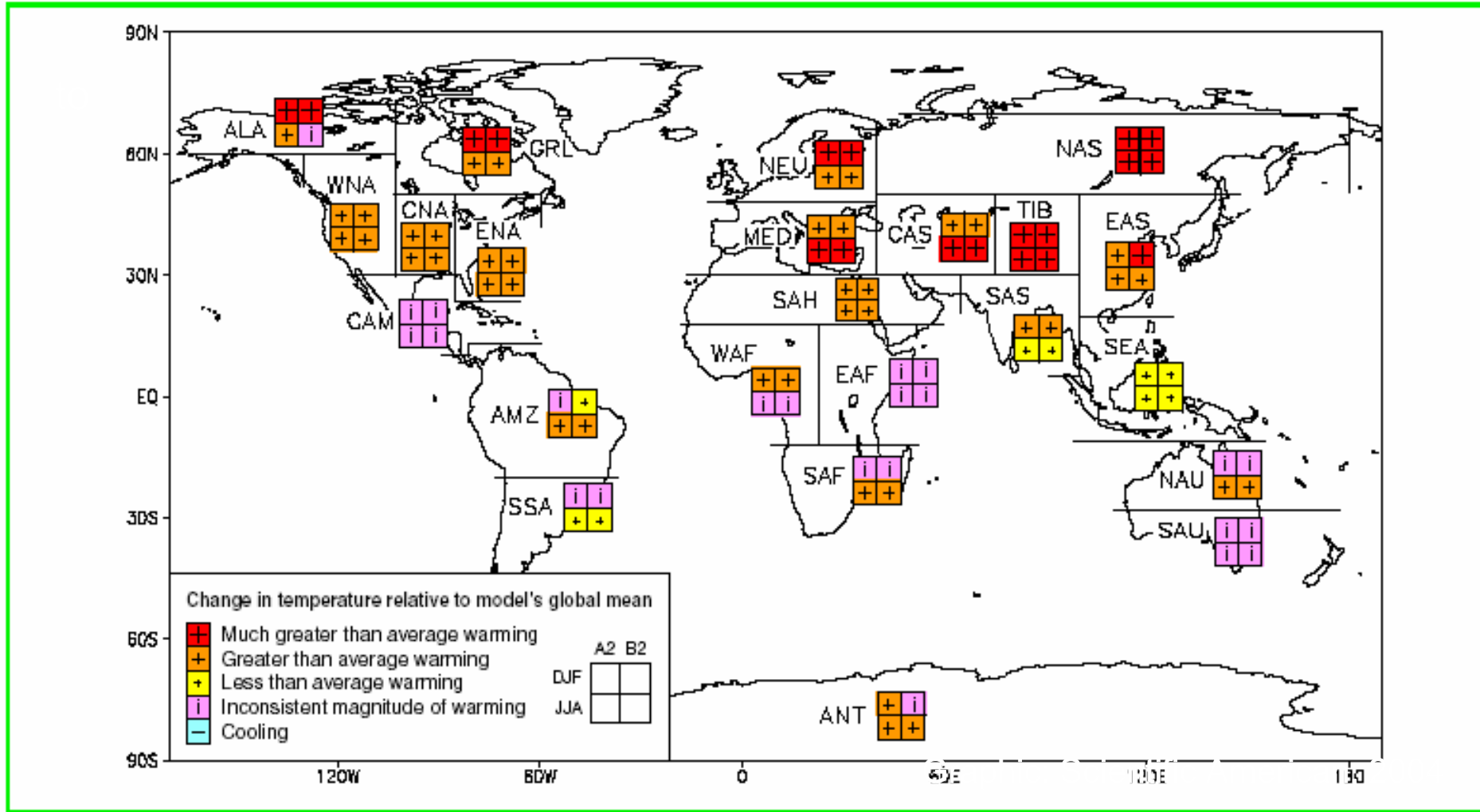
IPCC Projected Changes

Table 1: Estimates of confidence in observed and projected changes in extreme weather and climate events.

Confidence in observed changes (latter half of the 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely ⁷	Higher maximum temperatures and more hot days over nearly all land areas	Very likely ⁷
Very likely ⁷	Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely ⁷
Very likely ⁷	Reduced diurnal temperature range over most land areas	Very likely ⁷
Likely ⁷ , over many areas	Increase of heat index¹² over land areas	Very likely ⁷ , over most areas
Likely ⁷ , over many Northern Hemisphere mid- to high latitude land areas	More intense precipitation events^b	Very likely ⁷ , over many areas
Likely ⁷ , in a few areas	Increased summer continental drying and associated risk of drought	Likely ⁷ , over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	Increase in tropical cyclone peak wind intensities^c	Likely ⁷ , over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities^c	Likely ⁷ , over some areas



IPCC Temperature Projections



IPCC Precipitation Projections

