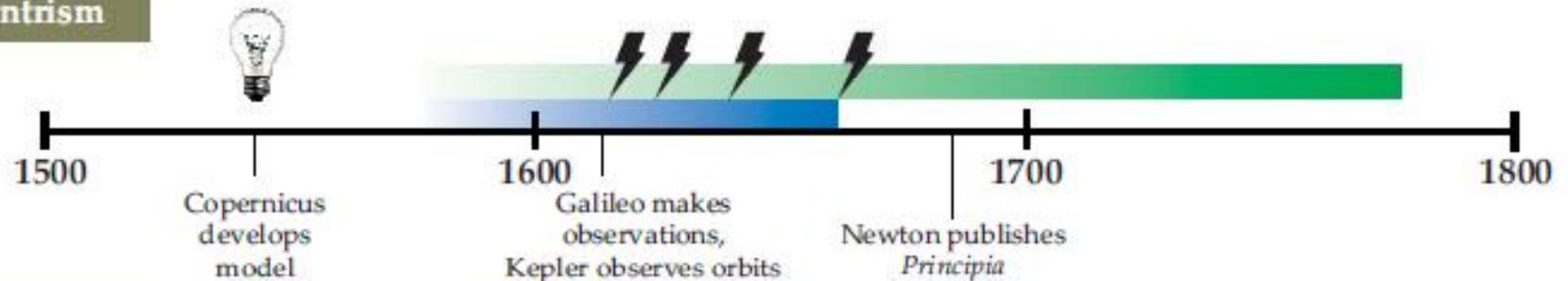


# The Rigors of Gaining Public Consensus on Scientific Theory

Bruce McGurk, PhD, P.H.  
McGurk Hydrologic

# Timelines for New Theories

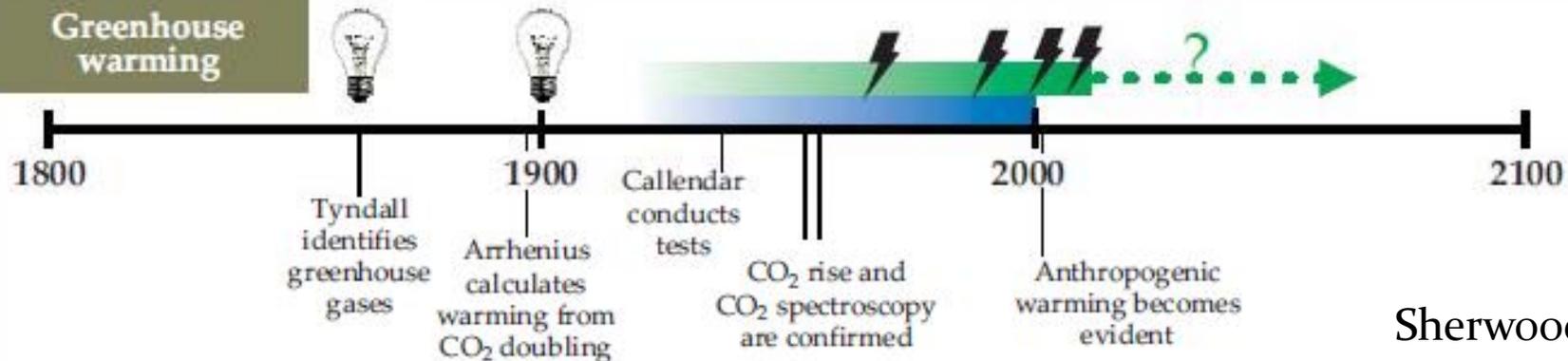
## Heliocentrism



## Relativity

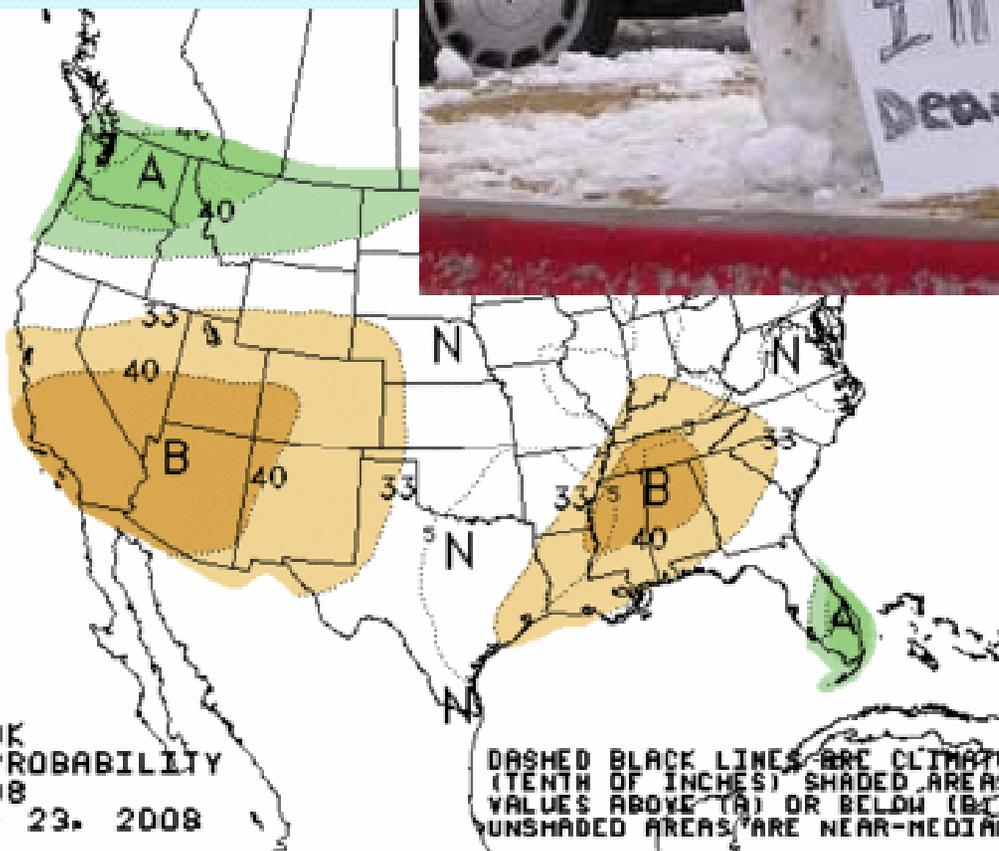


## Greenhouse warming



Sherwood, 2011

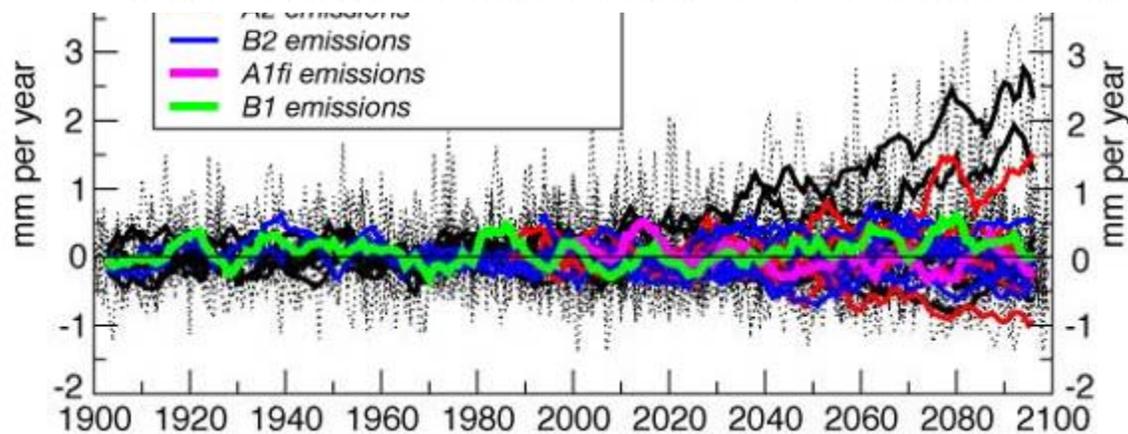
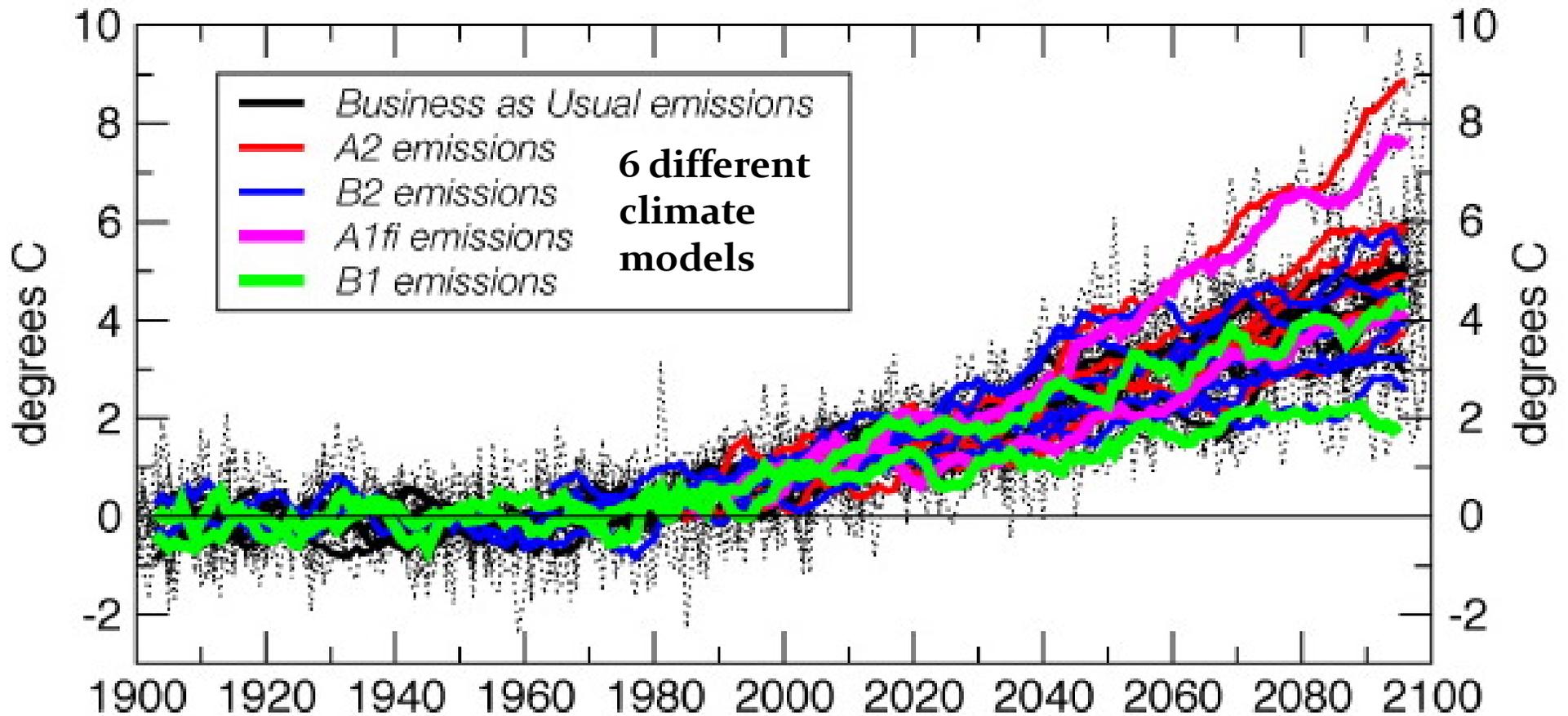
# Climate Change?



8-14 DAY OUTLOOK  
PRECIPITATION PROBABILITY  
MADE 9 OCT 2008  
VALID OCT 17 - 23, 2008

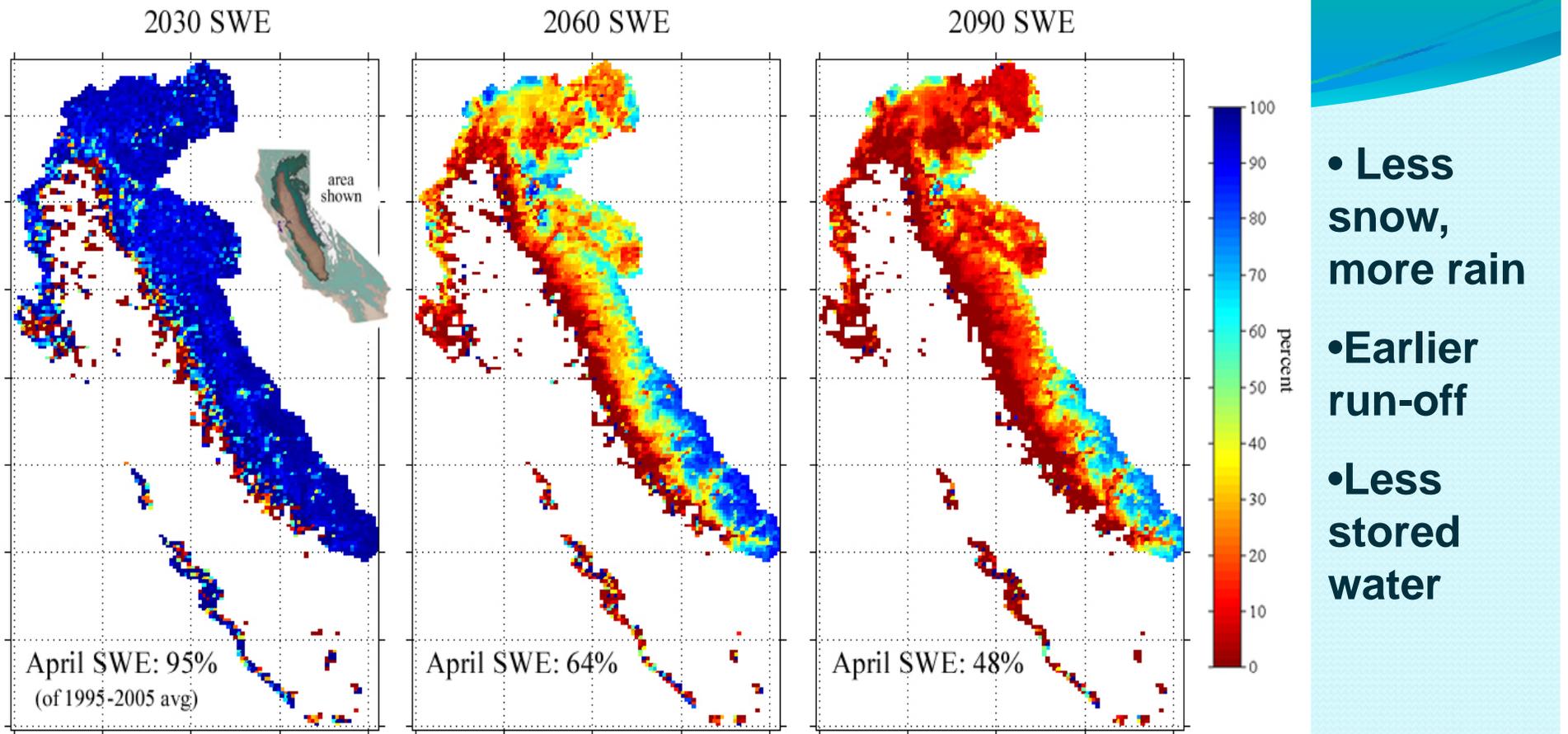
DASHED BLACK LINES ARE CLIMATE  
(TENTH OF INCHES) SHADED AREAS  
VALUES ABOVE (A) OR BELOW (B).  
UNSHADED AREAS ARE NEAR-MEDIAN

# PROJECTED CHANGES IN ANNUAL TEMPERATURE, NORTHERN CALIFORNIA



**Strong consensus for warming**  
**But large uncertainty with precipitation**

Cayan & Dettinger

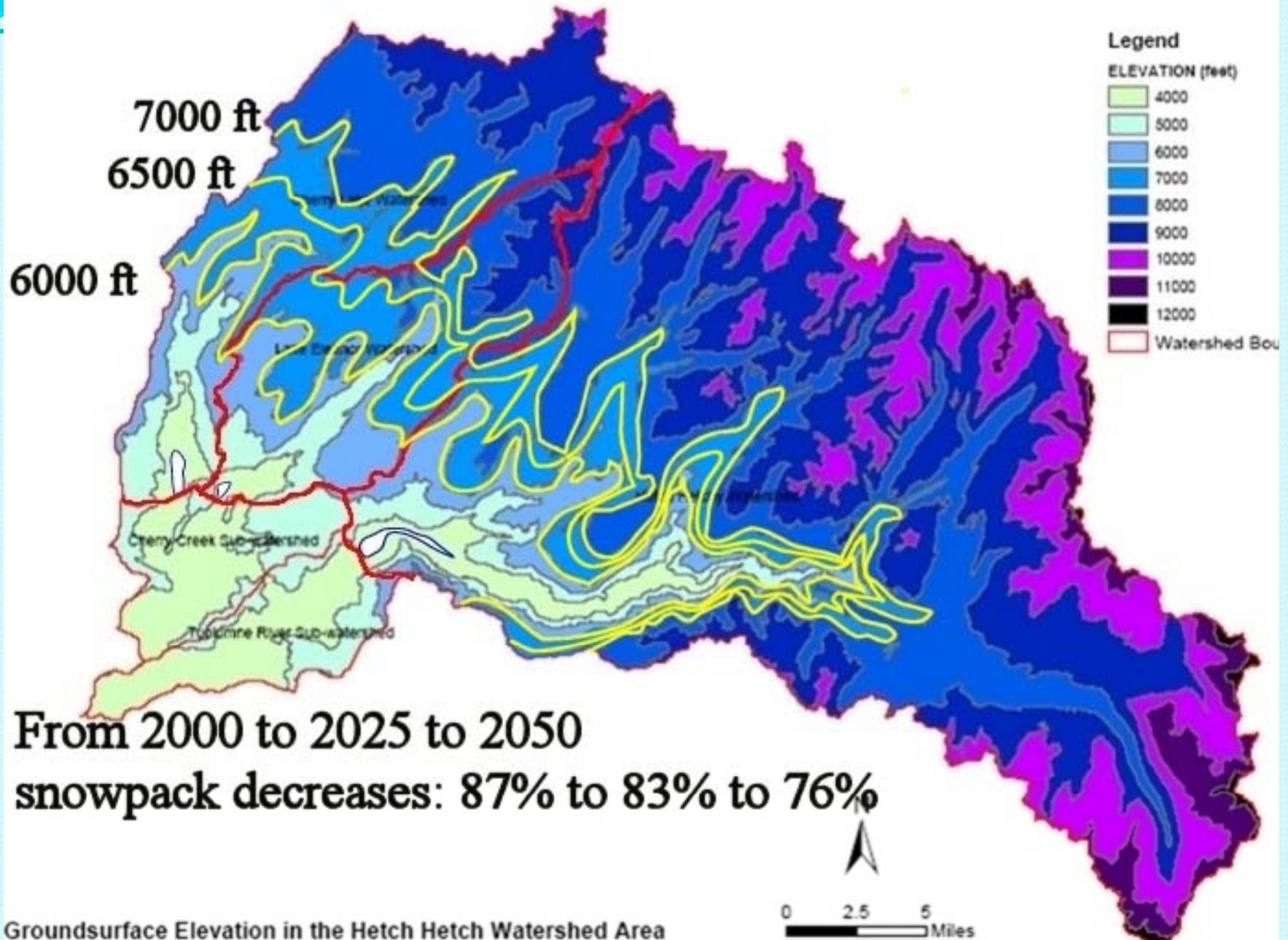


## We face significant losses of spring snowpack

Better understanding of present day and future snow accumulation and melt processes is needed

Cayan & Dettinger

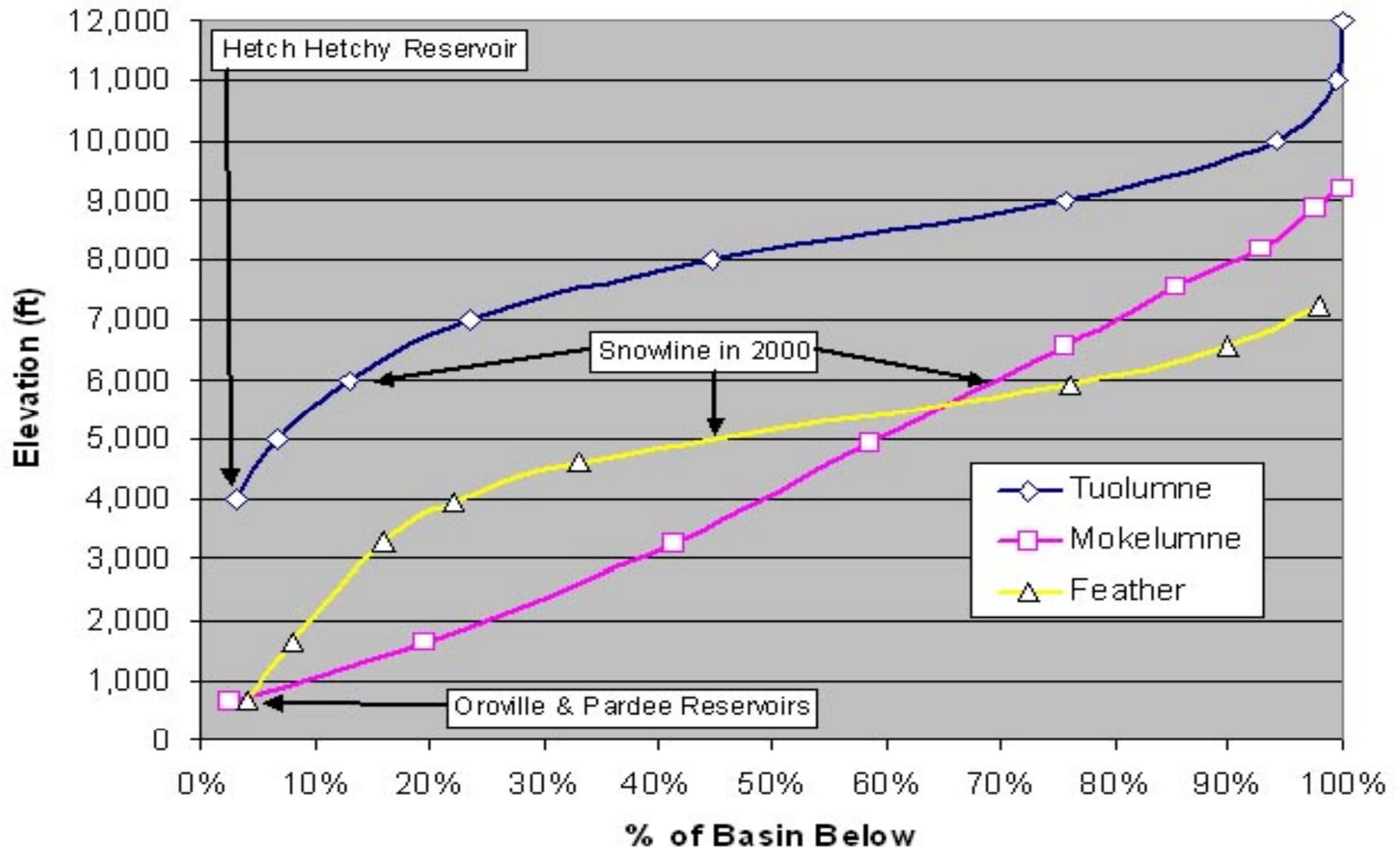
# Effect of Rising Snowline



Groundsurface Elevation in the Hetch Hetchy Watershed Area

# Basin Sensitivity

## Basin Area-Elevation Profiles



# Hundreds attend global warming protest



# Public Perception



Figure 1. Global warming's six Americas in May 2011, as categorized by a 2011 public-opinion study by a team from Yale and George Mason universities.<sup>3</sup>

Steven Sherwood, Physics Today, 2011  
Climate Change Research Center, U. of New South Wales, Sydney, AU

# Public Perception vs Scientist's

- 97% of climate change researchers agree climate change is occurring and that it is human-induced
- In Nov. 2008, 71% of Americans thought climate change was occurring
- Now, only 64% of Americans think CC is occurring
- Only 39% of Americans think that scientists believe climate change is occurring
- 40% of Americans think there is a lot of disagreement among scientists about CC occurring

# Reasons for Confusion?

- Strength of economy positively related to acceptance
- A well-organized and well-funded disinformation campaign has been waged against climate science
  - Oil and gas industries fear profits will be reduced
  - Controls might limit personal freedoms and free market
- Widespread scientific illiteracy, and non-science opinion leaders portraying CC as a “hoax”
- For centuries, weather has been an “Act of God”
- Media portrayal of CC as a “controversy”

# Reasons for Confusion, #2

## Terms that have different meanings for scientists and the public

Scientific term	Public meaning	Better choice
enhance	improve	intensify, increase
aerosol	spray can	tiny atmospheric particle
positive trend	good trend	upward trend
positive feedback	good response, praise	vicious cycle, self-reinforcing cycle
theory	hunch, speculation	scientific understanding
uncertainty	ignorance	range
error	mistake, wrong, incorrect	difference from exact true number

# Climate change is not the first inconvenient truth...Thanks, AI!

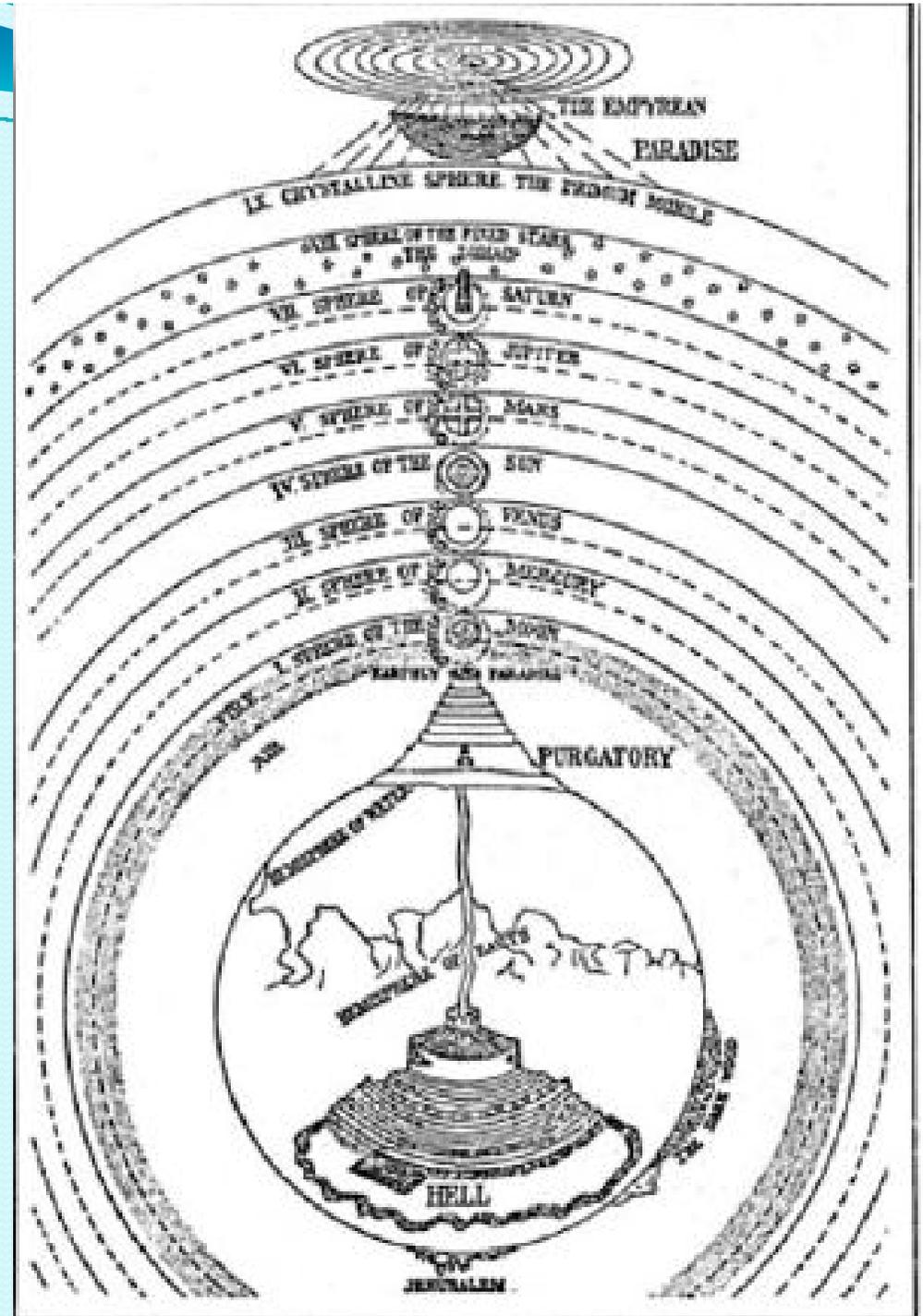
- 1543 – Copernicus – Heliocentrism, a description of our solar system
  - Contradicted Ptolemy and Scriptures – the heavens circled the earth
- 1916 – Einstein – General relativity, mass variable with speed, time similarly variable
  - Contradicted classical mechanics and Newtonian constants of space and time

# Ptolemy's View

AD 150

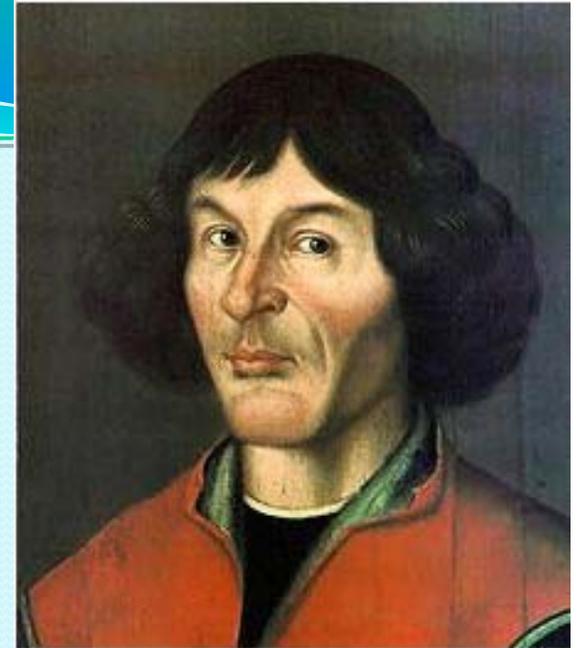
## Crystalline Spheres

Earth, Moon, Mercury,  
Venus, Sun, Mars, Jupiter,  
& Saturn



# Nicolaus Copernicus

1473-1543



- His book in 1543 is often regarded as the starting point of modern astronomy and the key that started the scientific revolution
- His work stimulated further scientific investigations
- Among the great polymaths of the Renaissance, he was a mathematician, astronomer, jurist with a doctorate in law, a physician, quadrilingual, a classics scholar, an artist, a Catholic cleric, and an economist.

# Deathbed Publication -1543

- Copernicus feared persecution from Catholic Church
- To those not involved in the study of celestial bodies, heliocentricity seemed impious and absurd. The resulting clamor was widespread, vicious, and bitter (Kuhn, 1957)
- Many astronomers quietly adopted the new theory
- Galileo's telescope aided the acceptance, but some scientists refused to even look through it
- Scientists adopted it by 1660, and the public by 1780

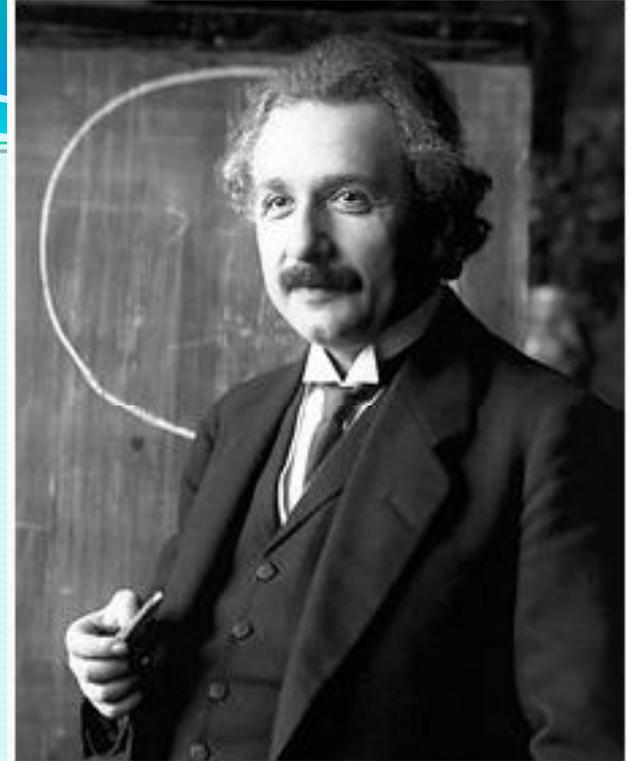
# Relativity vs Newton's Laws

- Sir Isaac Newton (1642 – 1742) stated the three laws of motion: the law of inertia; force is equal to mass times acceleration; and the law of action and reaction
- He showed that these laws govern both earthly and celestial objects.
- Newton developed the calculus which is necessary to perform the mathematical calculations involved in classical mechanics
- Newton avoided consideration of wave theory and electromagnetic forces

# Albert Einstein

## 1879 - 1955

- German-born theoretical physicist
- Father of modern physics and a prolific intellect, 1916 - relativity
- Nobel Prize for physics in 1921
- Visiting USA in 1933 when Hitler came to power, never went home
- Recommended that FDR start the Manhattan Project, but wrote against use of nuclear bombs
- The word Einstein now synonymous with genius



# Uproar over Relativity

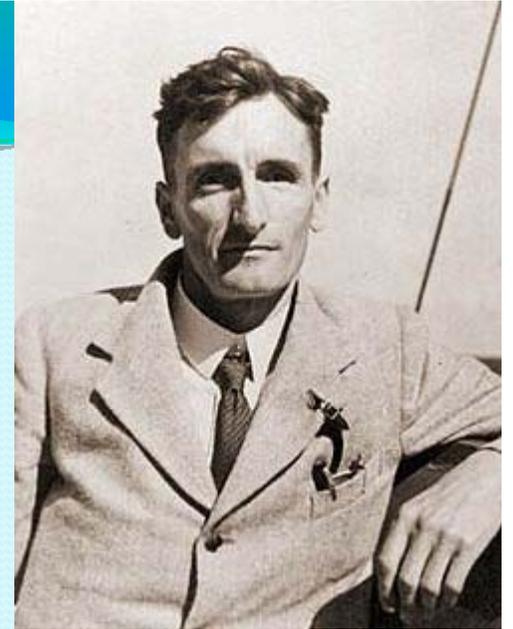
- In 1919, a solar eclipse allowed observations to confirm the bending of light, supporting relativity
- In 1920, Einstein wrote to a fellow mathematician:
  - “The world is a strange madhouse. Currently, every coachman and every waiter is debating whether relativity theory is correct. Belief in this matter depends on political party affiliation.” (Van Dongen, 2010)
- Einstein was derided by political opponents as a Communist and a fraud through the 20's and 30's
- Backlash was strong due to a minority of jealous scientists, but also due to anti-Semitism
- Scientists adopted it by 1970, and the public by 1980

# Deduction, Empiricism, & Prediction

- “Inconvenient ideas” are hard to accept, especially outside expert circles, when there is no benchtop experiment that clearly demonstrates an outcome
- Heliocentricity and relativity succeeded by requiring fewer assumptions and better explaining a wide variety of circumstances
- How unlikely is it for all those circumstances to follow the theory by accident?
- The daunting math of relativity made understanding possible to only those with detailed knowledge

# Climate Change History

- CC is a messy physics problem, plus meteorology, oceanography, & geology
- In 1896, Nobelist Svante Arrhenius predicted warming would be caused by coal burning
- Between 1938 and 1964, English steam engineer Guy Callender published 25 papers on global warming, infrared radiation, and anthropogenic carbon dioxide
- The “Callender Effect”, as it was called, was initially thought beneficial because warming would delay “the return of the deadly glaciers.”



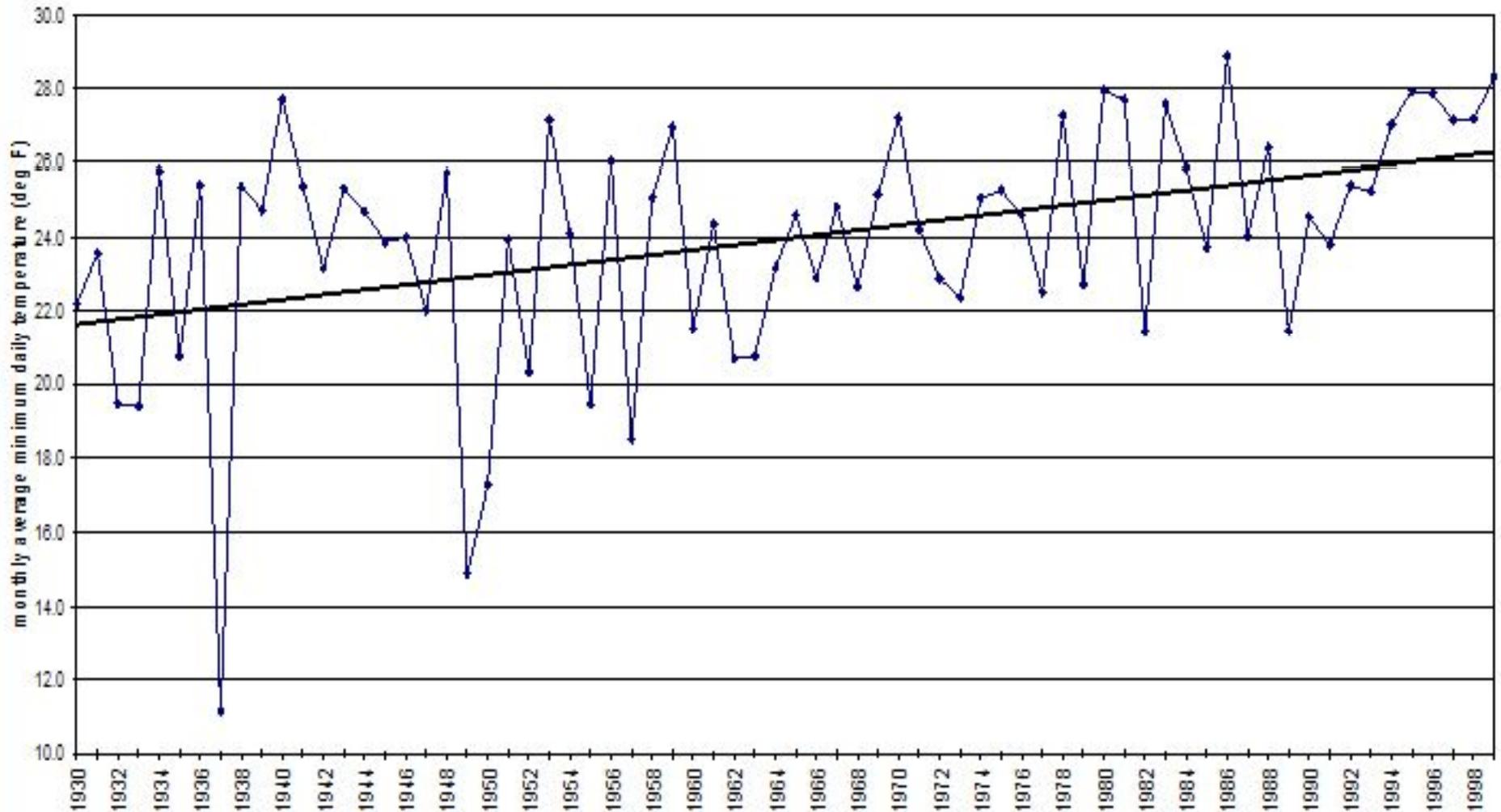
# Resistance to “New” Theory

- At first, few scientists accepted the idea that humans could change an entire planet’s climate
- As with Copernicus, observers found factors that would negate the problem:
  - The CO<sub>2</sub> spectrum was already saturated
  - The ocean would absorb any extra CO<sub>2</sub>
  - Humans were only causing small additional changes
- By the 1970’s, the objections were largely dispelled, and an ever-increasing number of scientific papers were projecting climate change
- Republicans and Democrats were equally concerned

# Empirical Evidence

Heich Heichy January average minimum daily temperatures

$$y = 0.0873x + 19.627$$
$$R^2 = 0.1837$$



# Politics and Climate Change

- An anti-science backlash has occurred
- Backlash began when political leaders were pushed to take action on the basis of the new evidence
- Moderates have been squeezed out of the conservative parties in both the USA and Australia
- Climate scientists, and scientists as a whole, are increasingly characterized as opportunists (grant seekers), totalitarianists (want control), or downright criminals (hiding emails, conspiring)

# Noted Skeptic Agrees with NASA

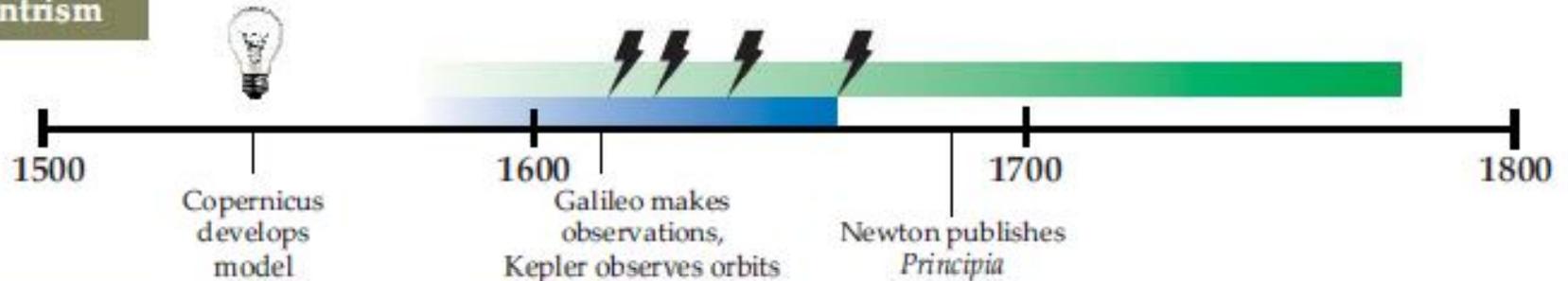
- Charles Muller, physicist at UC Berkeley and staff at LBNL, has been a strong critic.
- His 2-yr study to review evidence was funded by Charles Koch Foundation, funded by an oil & gas company that is a major CO<sub>2</sub> emitter
- He found that NASA and IPCC warming figures are right
- Shawn Otto, a critic of climate science skeptics, said Muller should expect to be harshly treated by global warming deniers. "Now he's considered a traitor. For the skeptic community, **this isn't about data or fact**. It's about team sports....He's playing for the wrong team now."

# Typical Resistance

- "After lots of work Muller found exactly what was already known and accepted in the climate community," said a Texas A&M University atmospheric sciences professor. "I am hoping their study will have a positive impact. **But some folks will never change.**"
- Some of the most noted scientific skeptics are no longer saying the world isn't warming. Instead, they question how much of it is man-made, view it as less a threat and argue **it's too expensive to do something about**, Otto said.

# Timelines for New Theories

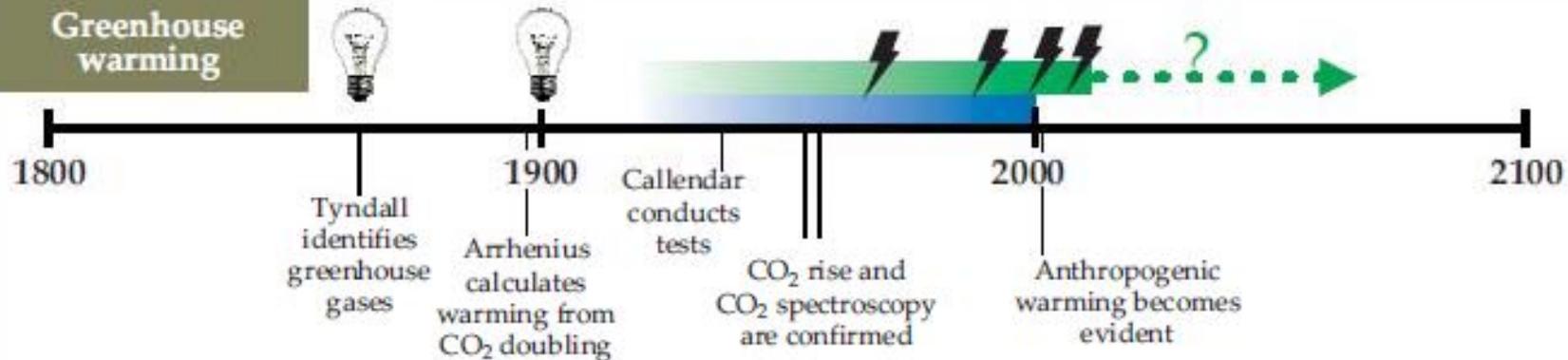
## Heliocentrism



## Relativity



## Greenhouse warming



# Lessons for Today?

- Relativity contrarians basked in conspiracy ideas, claimed to have evidence that disproved relativity, and were convinced that the scientific establishment was suppressing their alternative views
- Each of these is true for climate change today
- Weather forecasters today use the same models that climate change simulations use, eg. UK Met model
- Sadly, textbooks today have a long preface telling students to ignore talk show hosts, Internet blogs by laypeople, and their parents
- History tells us science will probably come out fine, but whether the planet and our snowpack will is another matter

Thanks for your patience!

