



Climate Science 2015: Report to the Board on the IPCC and NCA

Susanne Moser, Ph.D.

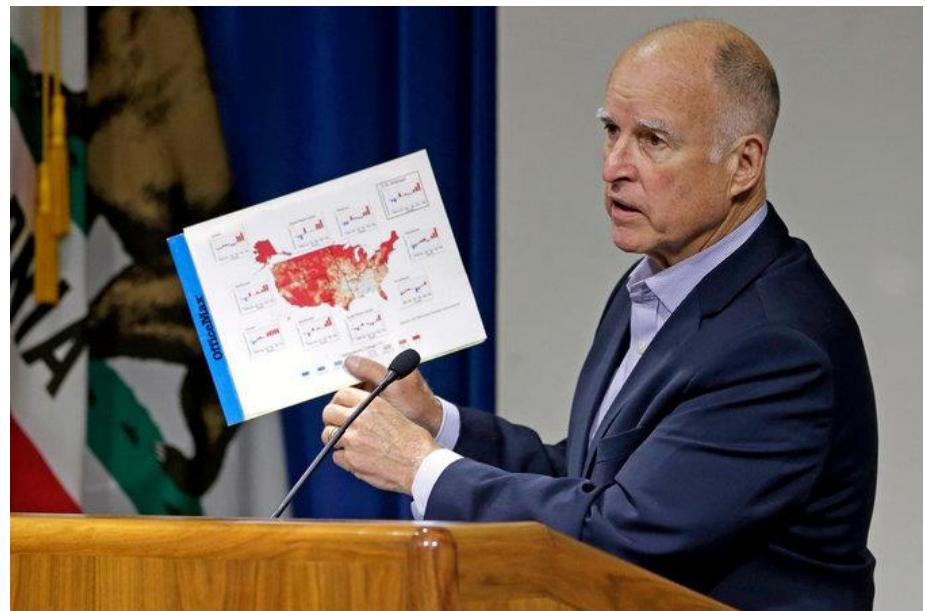
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California Air Resources Board Meeting • Sacramento, CA • February 19, 2015

CA Climate Policy Informed by the Latest Science

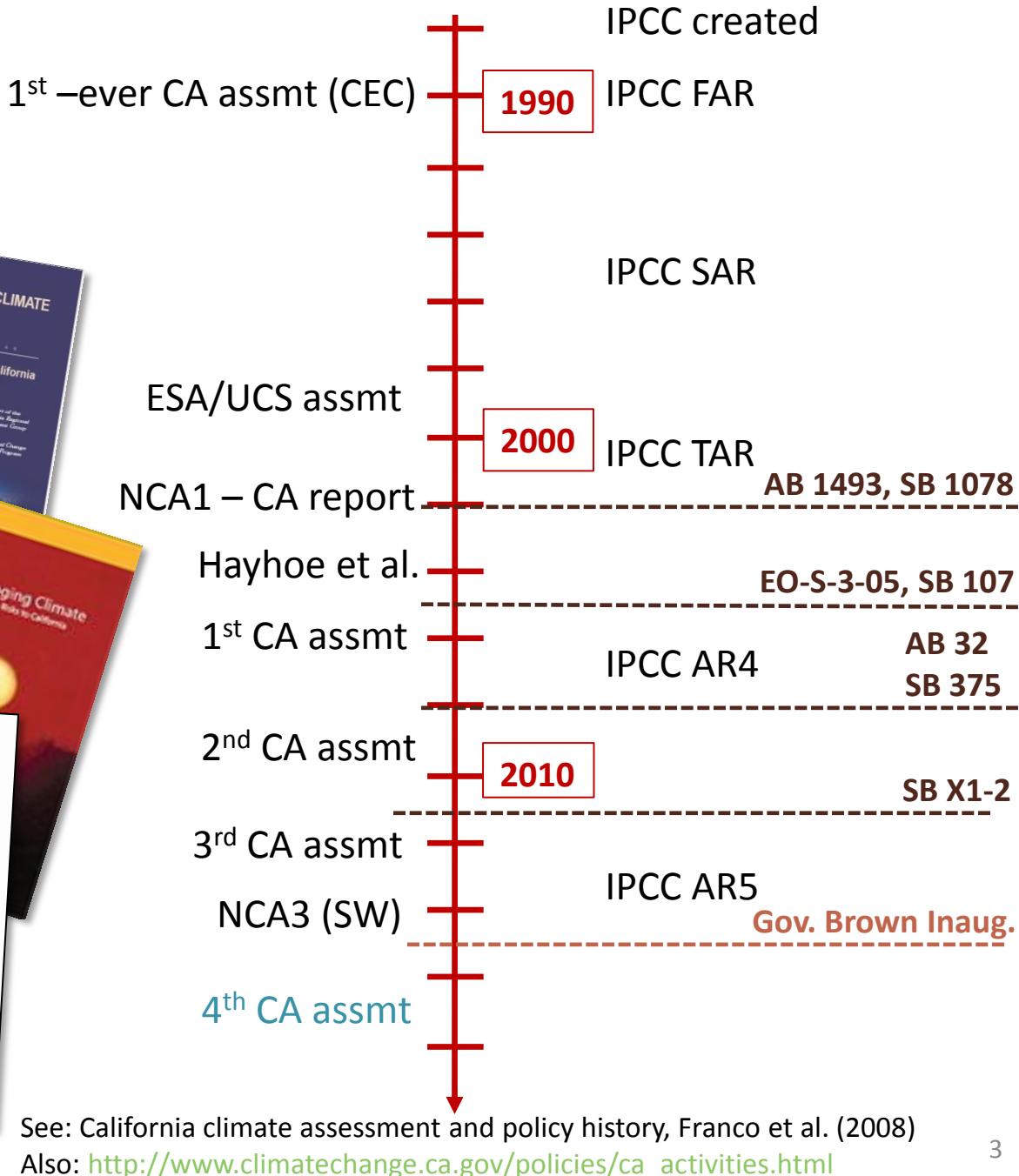
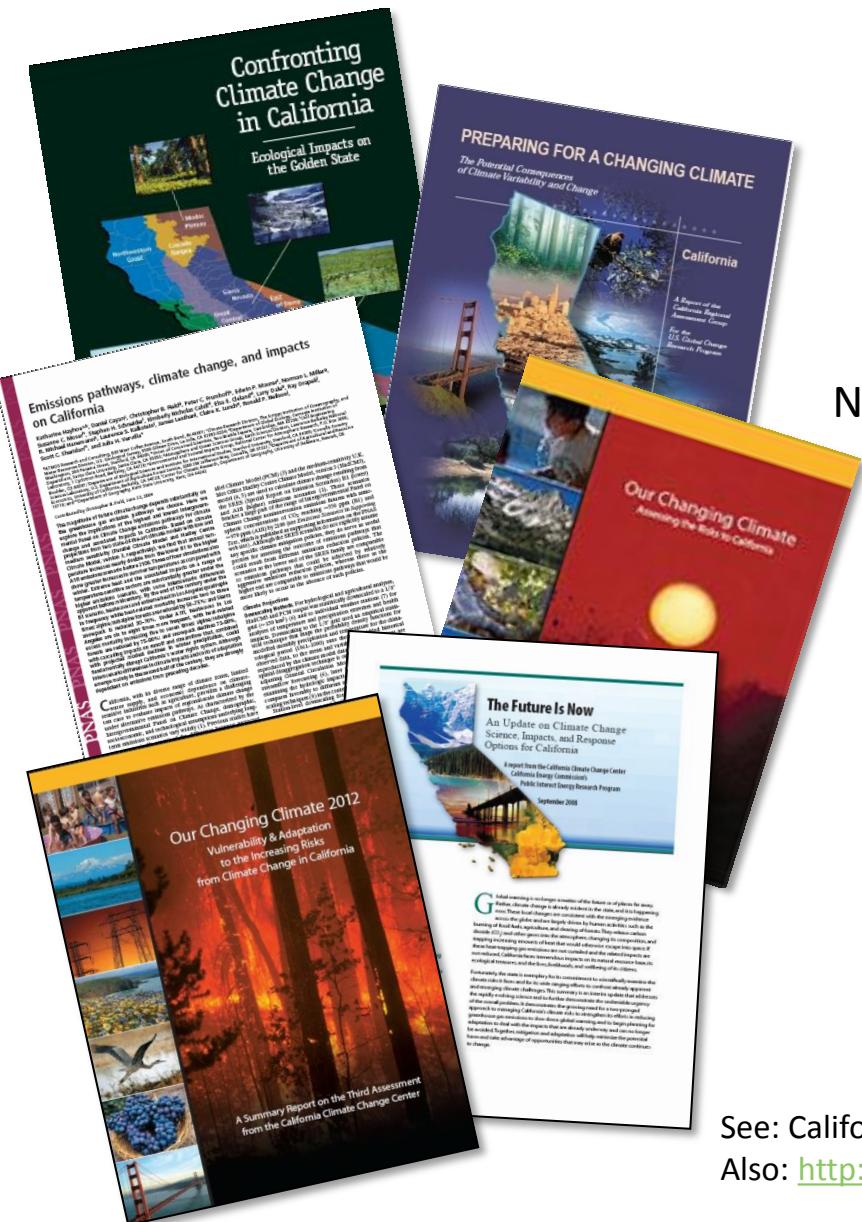


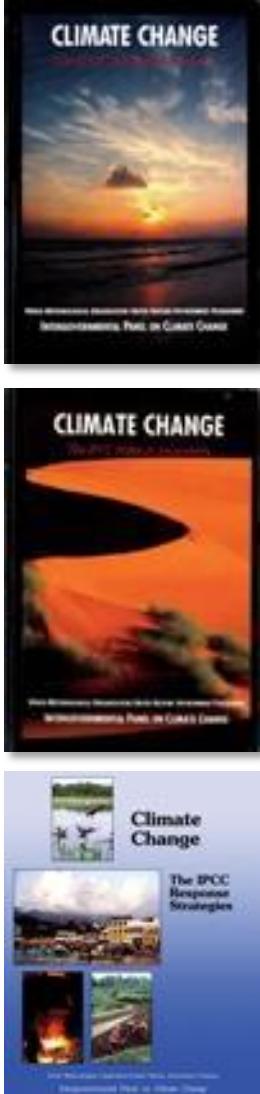
**Gov. Schwarzenegger signing EO-S-3-05
(2005)**



**Gov. Brown speaking to the press after having
been briefed by scientists on the NCA (2014)**

History





IPCC in 1990 (FAR)

- Global mean surface air temperature has increased by 0.3°C to 0.6°C over the last 100 years ...
- The size of this warming is **broadly consistent** with predictions of climate models, but it is also of the **same magnitude as natural climate variability**
- There is **no firm evidence** that climate has become more variable over the last few decades...
- There are **many uncertainties in our predictions** particularly with regard to the timing, magnitude and regional patterns of climate change



IPCC in 1995 (SAR)

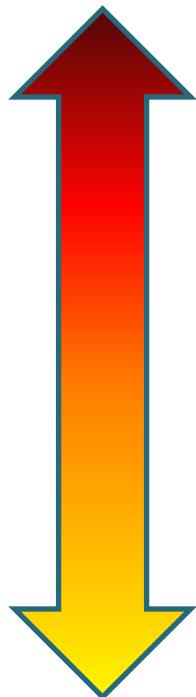
- Global mean surface temperature has increased by between about 0.3 and 0.6°C since the late 19th century, a change that is **unlikely to be entirely natural** in origin
- The balance of evidence ... suggests **a discernible human influence** on global climate

How Certain Are Scientists?

Expressed in

- confidence levels

... or when possible
- probabilistically

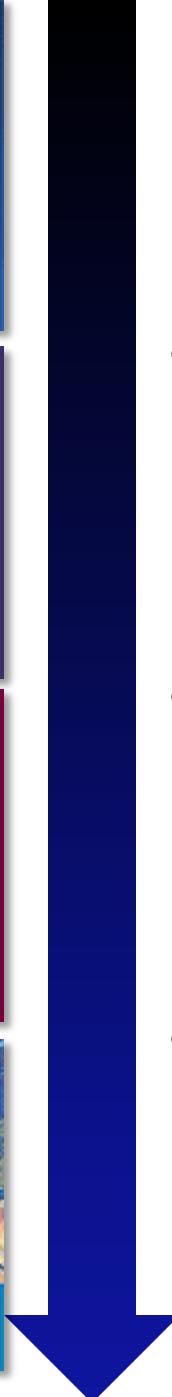


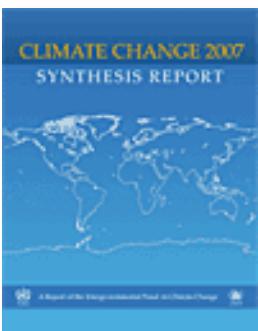
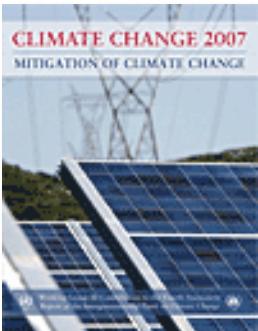
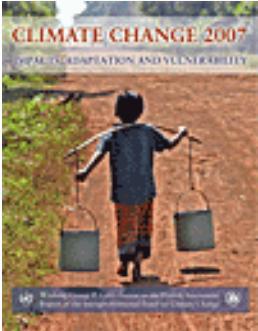
Unequivocal

99-100%	Virtually certain
90-100%	Very likely
66-100%	Likely
33-66%	As likely as not
0-33%	Unlikely
0-10%	Very unlikely
0-1%	Exceptionally unlikely



- # IPCC in 2001 (TAR)
- The Earth's climate system has **demonstrably changed** on both global and regional scales since the pre-industrial era...
 - An increasing body of observations gives **a collective picture of a warming world** and other changes in the climate system
 - There is new and stronger evidence that **most of the warming observed over the last 50 years is attributable to human activities**



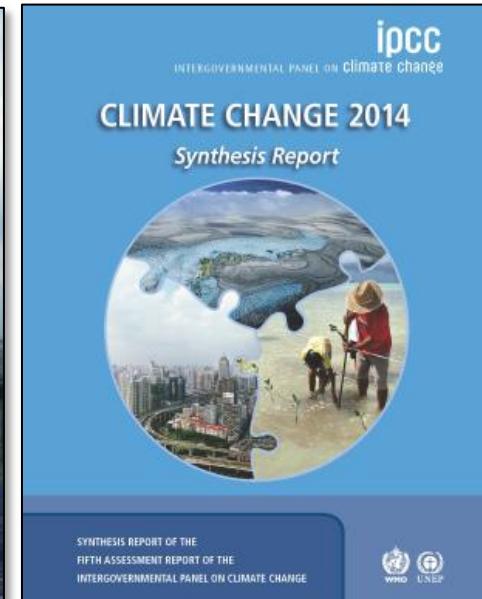
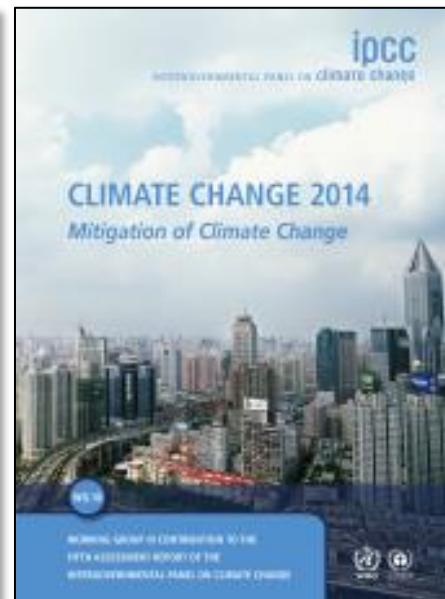
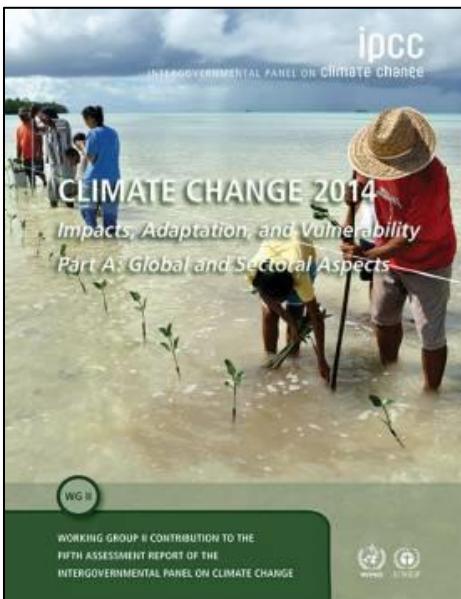
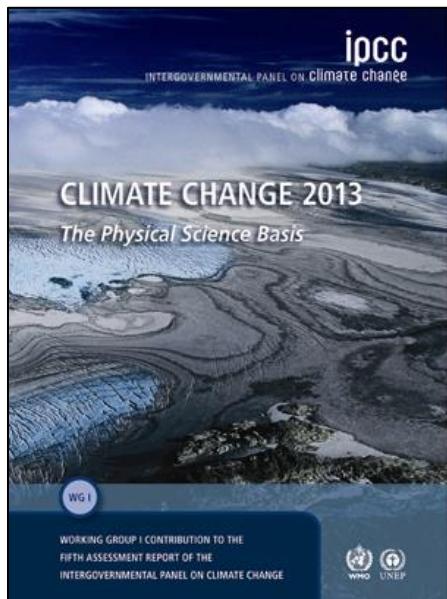


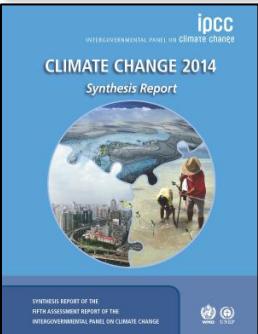
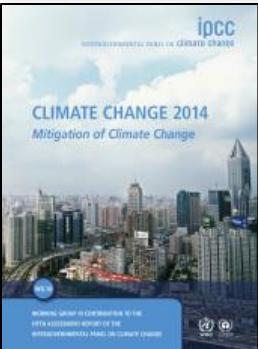
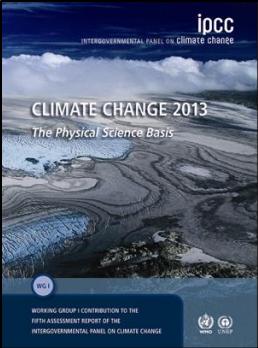
IPCC in 2007 (AR4)

- **Warming of the climate system is unequivocal**, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level
- **Most of the observed increase** in global average temperatures since the mid-20th century is **very likely due to the observed increase in anthropogenic GHG concentrations**. ...
- ... **likely** had a **discernible influence at the global scale on observed changes in many physical and biological systems**
- Anthropogenic warming **could lead to some impacts that are abrupt or irreversible**, depending upon the rate and magnitude of the climate change



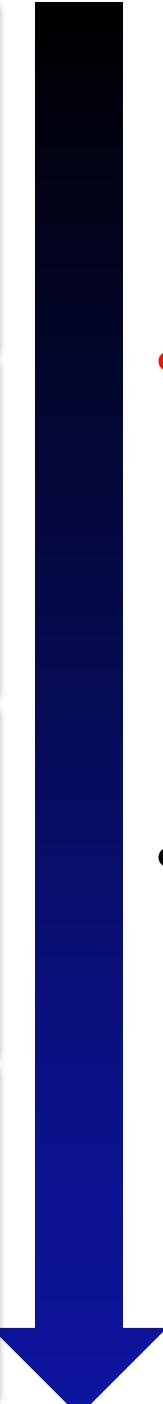
The Fifth IPCC Assessment





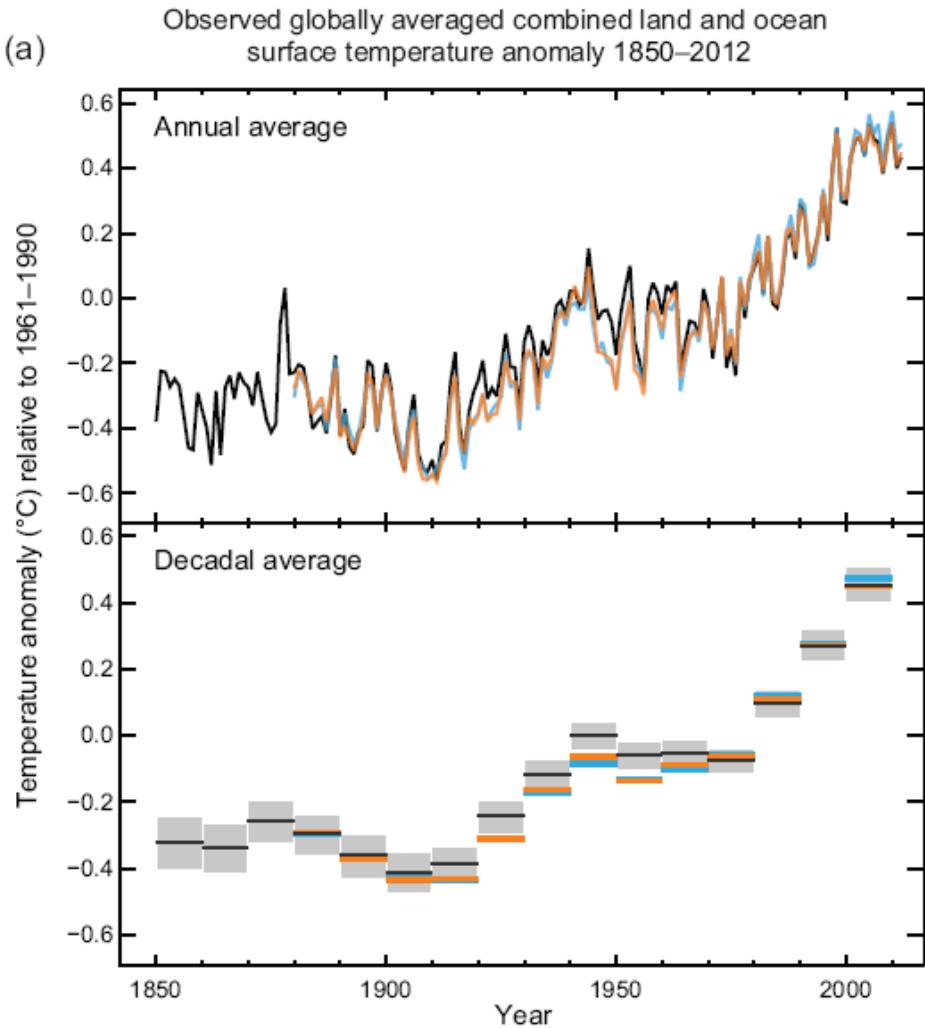
IPCC in 2013-14 (AR5)

- **Human influence on the climate system is clear**, and recent anthropogenic emissions of GHGs are the **highest in history**. Recent climate changes have had **widespread impacts** on human and natural systems
- Warming of the climate system is **unequivocal**, and since the 1950s, many of the observed **changes are unprecedented** over decades to millennia



The Temperature Record

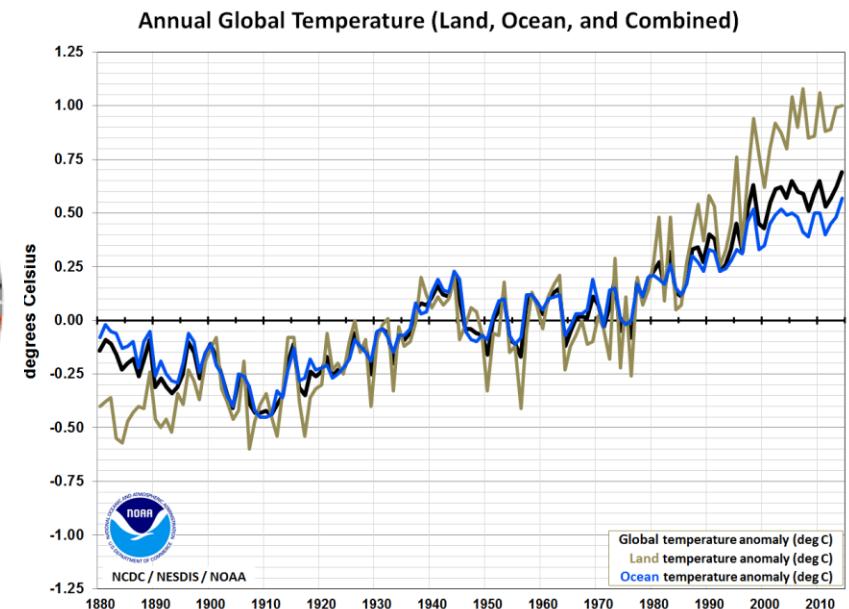
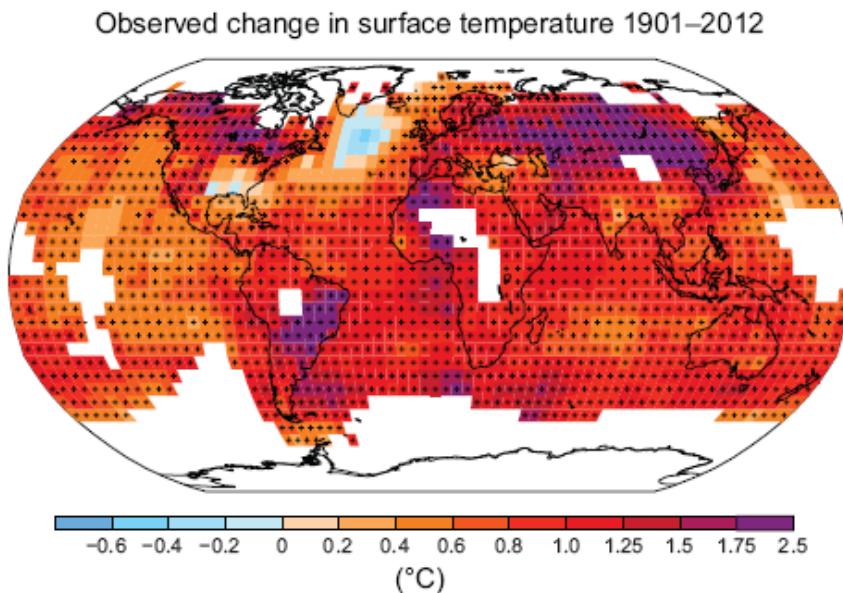
(a)



- 2014 was the warmest year since records began in 1880
- The 38th consecutive year (since 1977) that the yearly global temperature was above average
- 9 of the 10 warmest years in the 135-year period of record have occurred since 2000

The Temperature Record

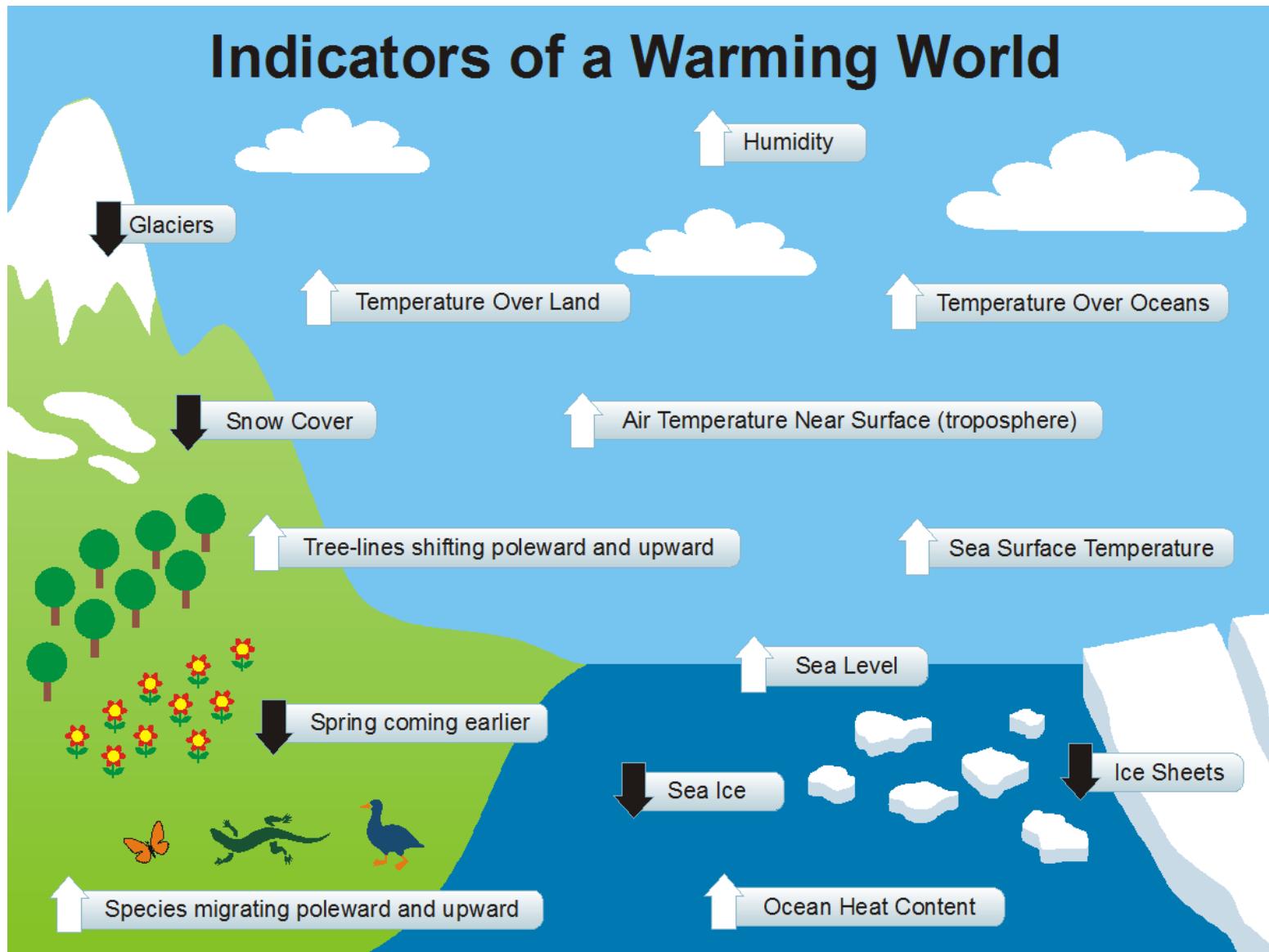
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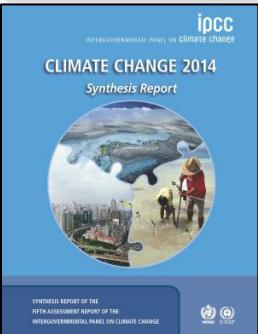
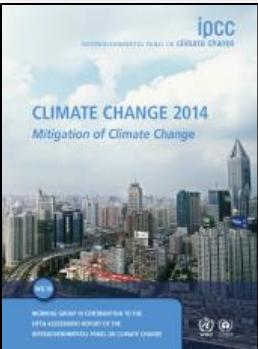


Source: IPCC, WG1 (2013)

Source: NOAA-NCDC (2015)

Climate Change is Evident Everywhere





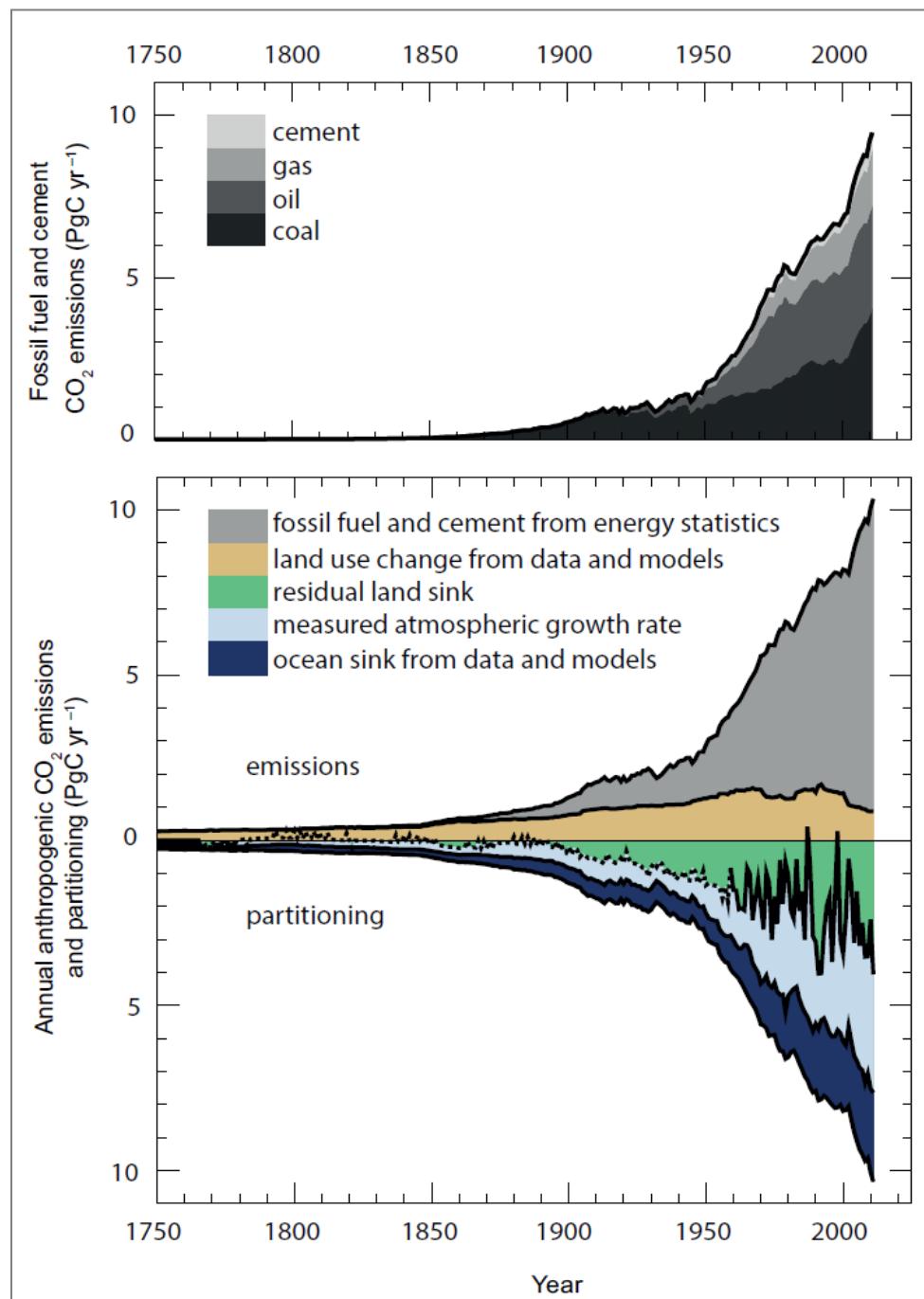
IPCC in 2013-14 (AR5)

- Anthropogenic GHG emissions have increased since the pre-industrial era ... this has led to atmospheric concentrations of CO₂, CH₄ and N₂O that are **unprecedented in at least the last 800,000 years**

- Homo sapiens first appeared 200,000 years ago
- 10,000 years ago, at the beginning of the Holocene, global human population was ca. 5 million (=LA + San Diego)

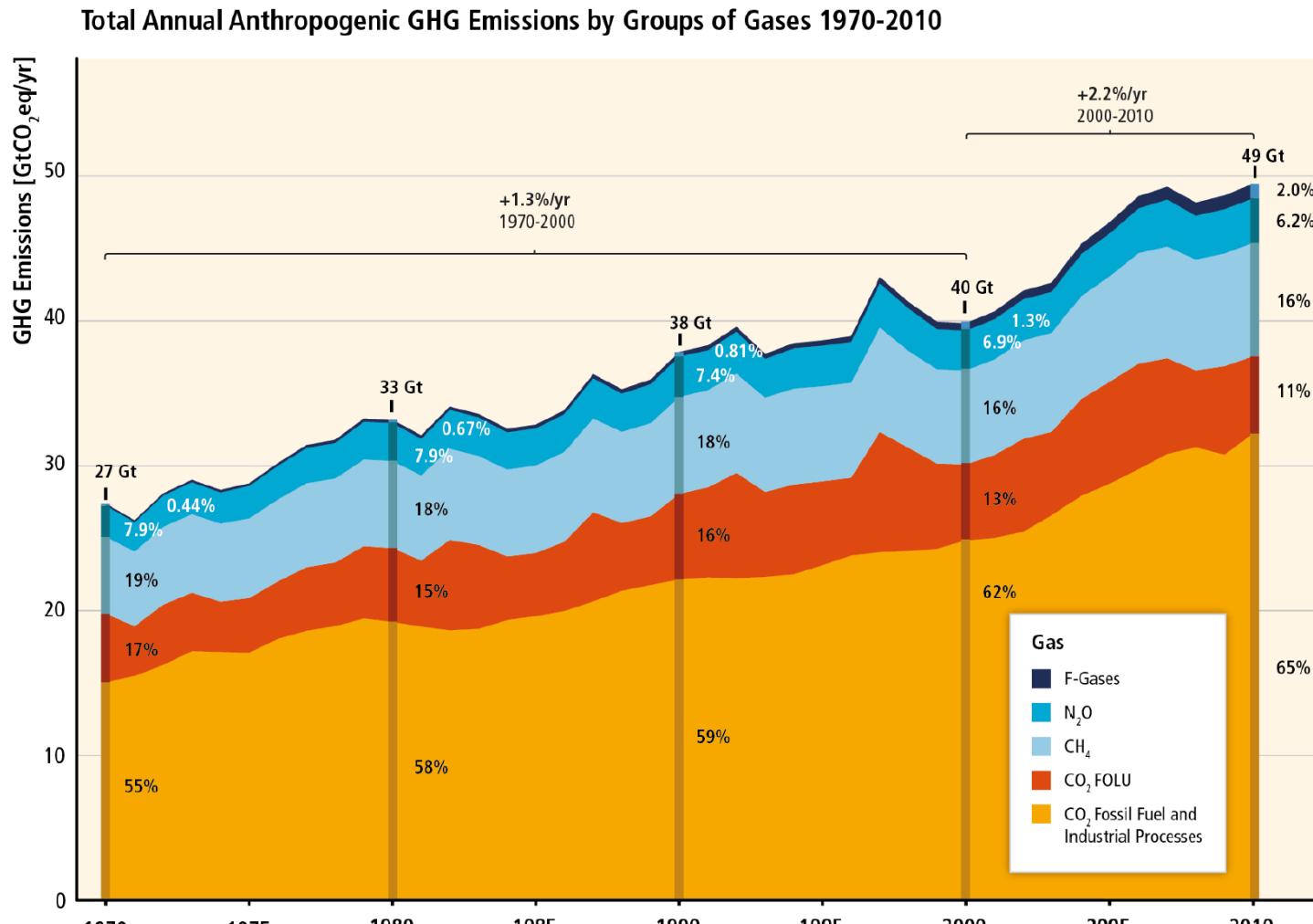
Growing Human Sources, Declining Natural Sinks

Source: IPCC (2013, Chapter 6)



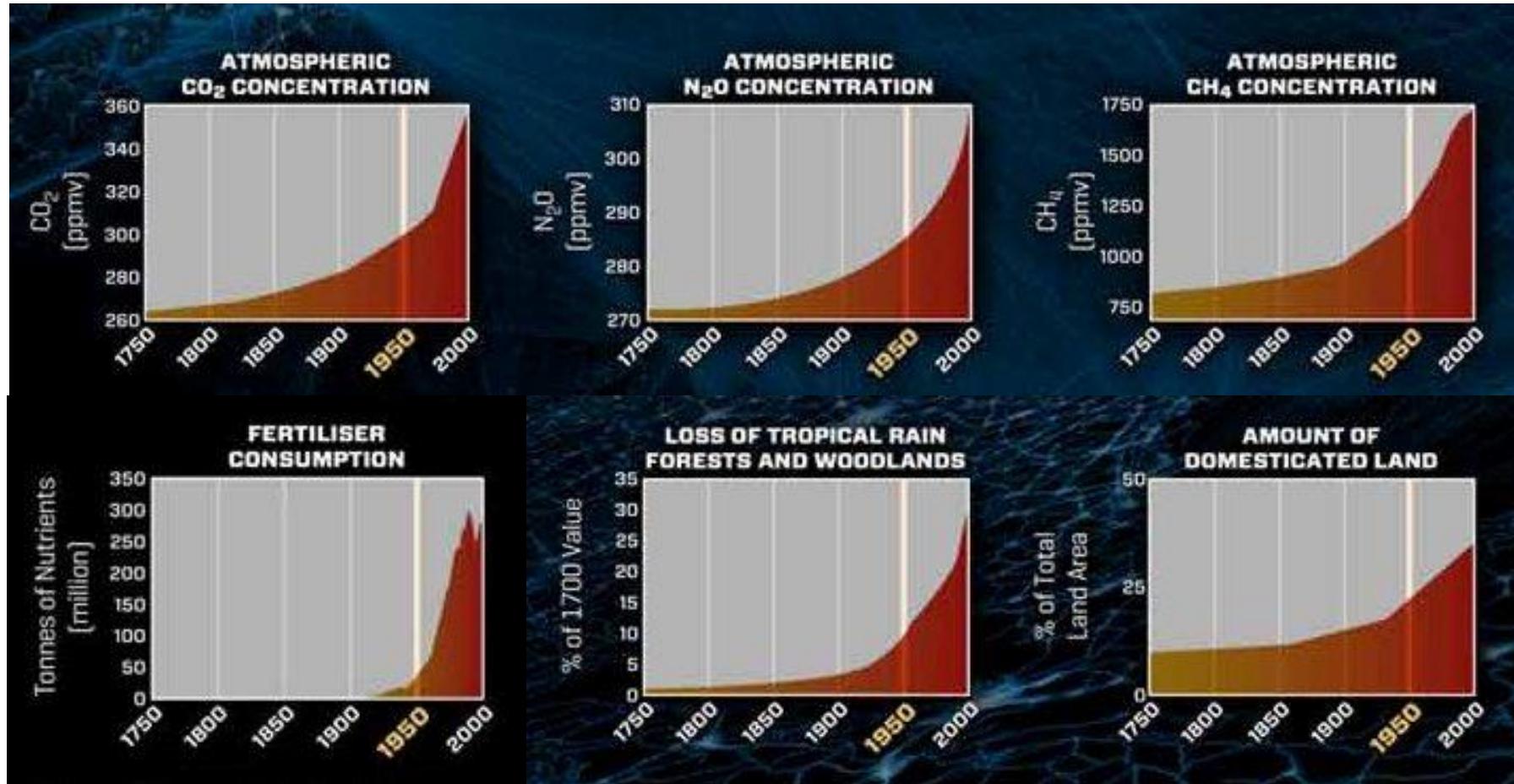
Annual Increase is Accelerating

"About half of cumulative anthropogenic CO₂ emissions between 1750 and 2010 have occurred in the last 40 years." (IPCC, WG3)

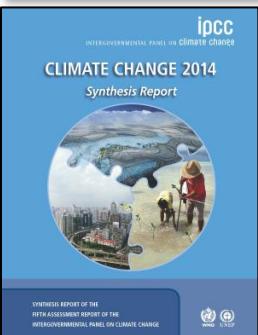
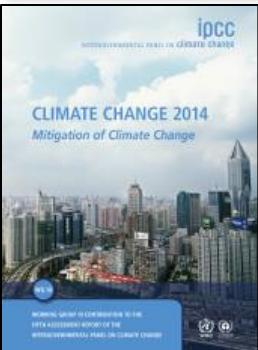
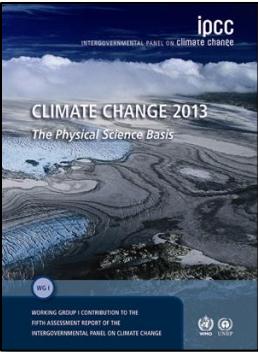


Source: IPCC, WG3 (2014)

The Great Acceleration



Source: Excerpts from: <http://www.anthropocene.info/en/anthropocene/the-great-acceleration>



IPCC in 2013-14 (AR5)

- **Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, e.g.**
 - Decline in cold temperature extremes
 - Increase in warm temperature extremes
 - Increase in extreme high sea levels
 - Increase in the number of heavy precipitation events in several regions

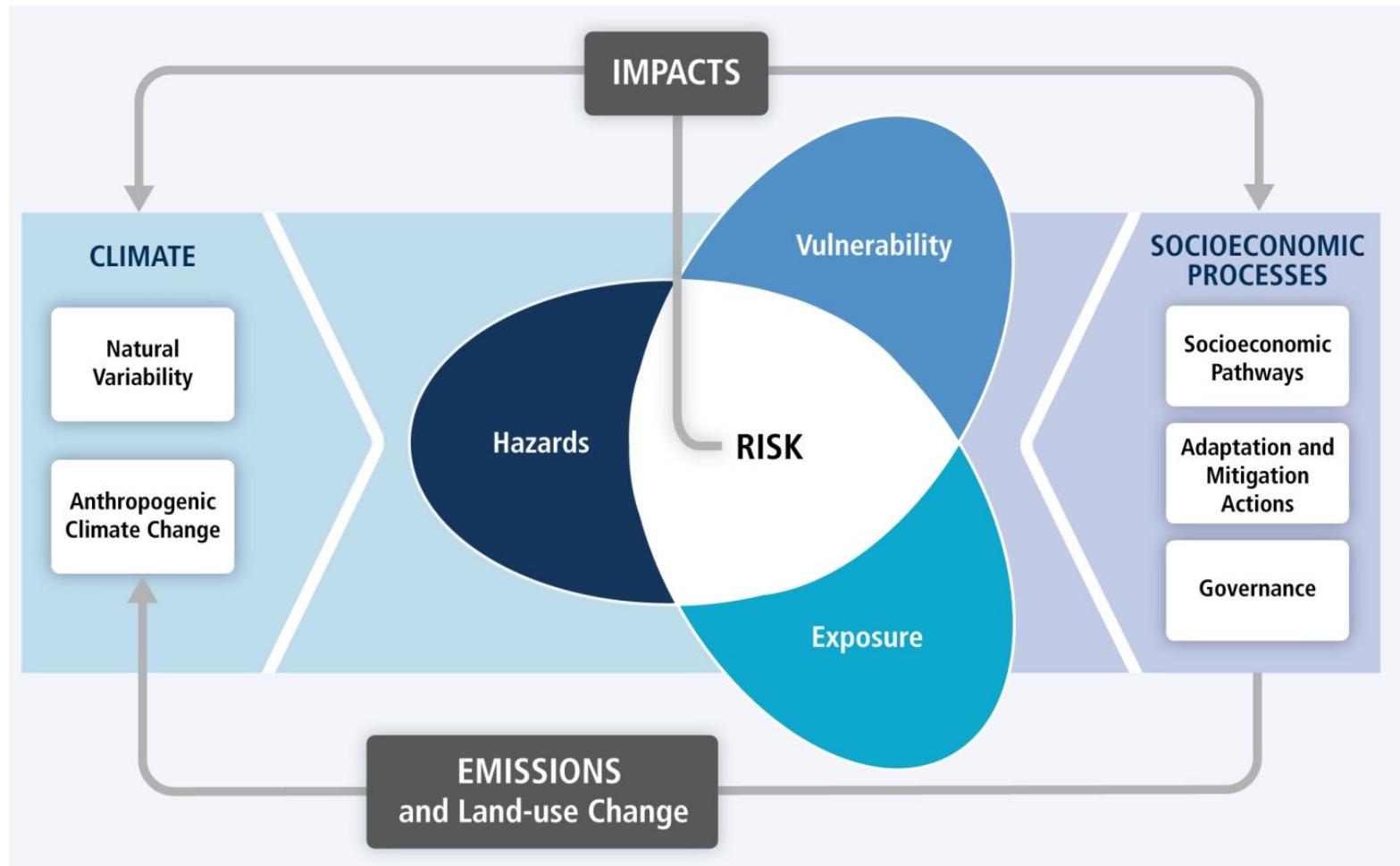
Example: CA Drought (2011-15) due to Climate Change?



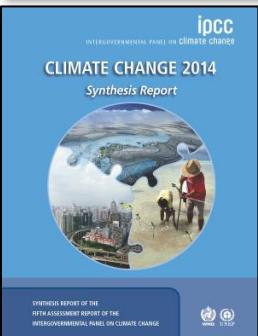
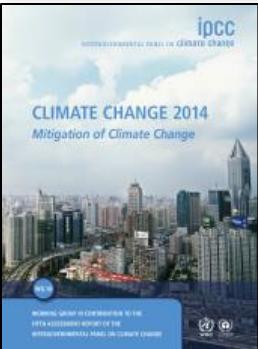
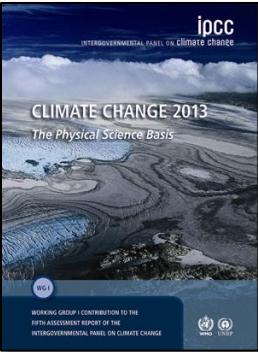
Photo: Lake Piru Ringo Chiu/ZUMA

See: Seager et al. (2014). Causes and Predictability of the 2011-14 California Drought . Available at: <http://cpo.noaa.gov/MAPP/californiadroughtreport/>

The Bigger Issue: Extreme Events + Vulnerability

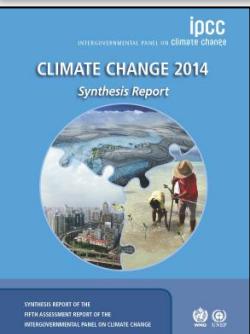
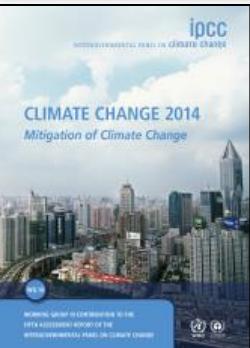
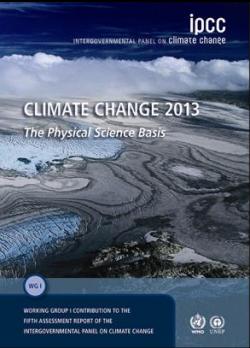


Source: IPCC (2012)



IPCC in 2013-14 (AR5)

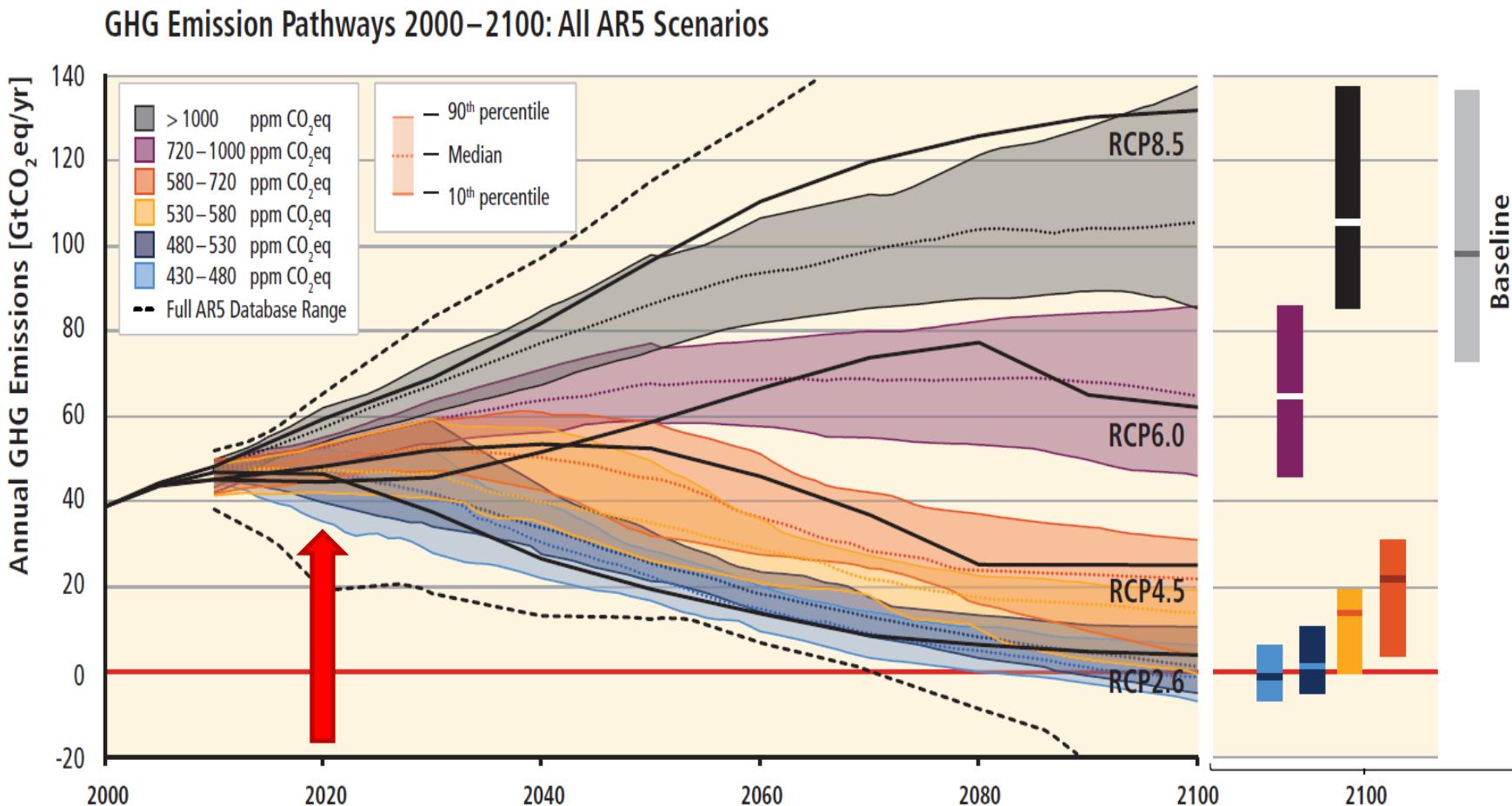
- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of **severe, pervasive and irreversible impacts** for people and ecosystems
- Limiting climate change would require substantial and sustained reductions in **GHG emissions** which, together with adaptation, can limit climate change risks

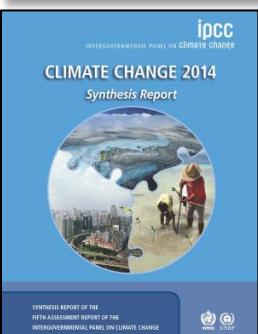
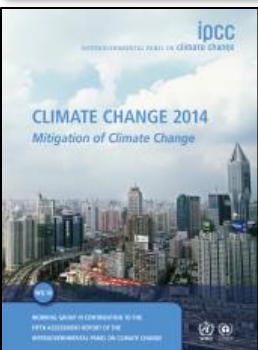


The Outlook

- **Without additional efforts to reduce GHG emissions beyond those in place today ... global mean surface temperature increases in 2100 from 3.7°-4.8°C [6.7-8.6 °F] compared to pre-industrial levels (range 2.5-7.8°C) [4.5-14 °F] (high confidence)**
- Mitigation scenarios in which it is **likely** [>66% chance] that the temperature change ...can be kept to less than 2°C relative to pre-industrial levels are characterized by atmospheric concentrations in 2100 of about **450 ppm CO₂eq (high confidence)**
 - By 2050: 40-70% GHG emission reduction globally
 - By 2100: near 0 (or below)

No Time To Lose

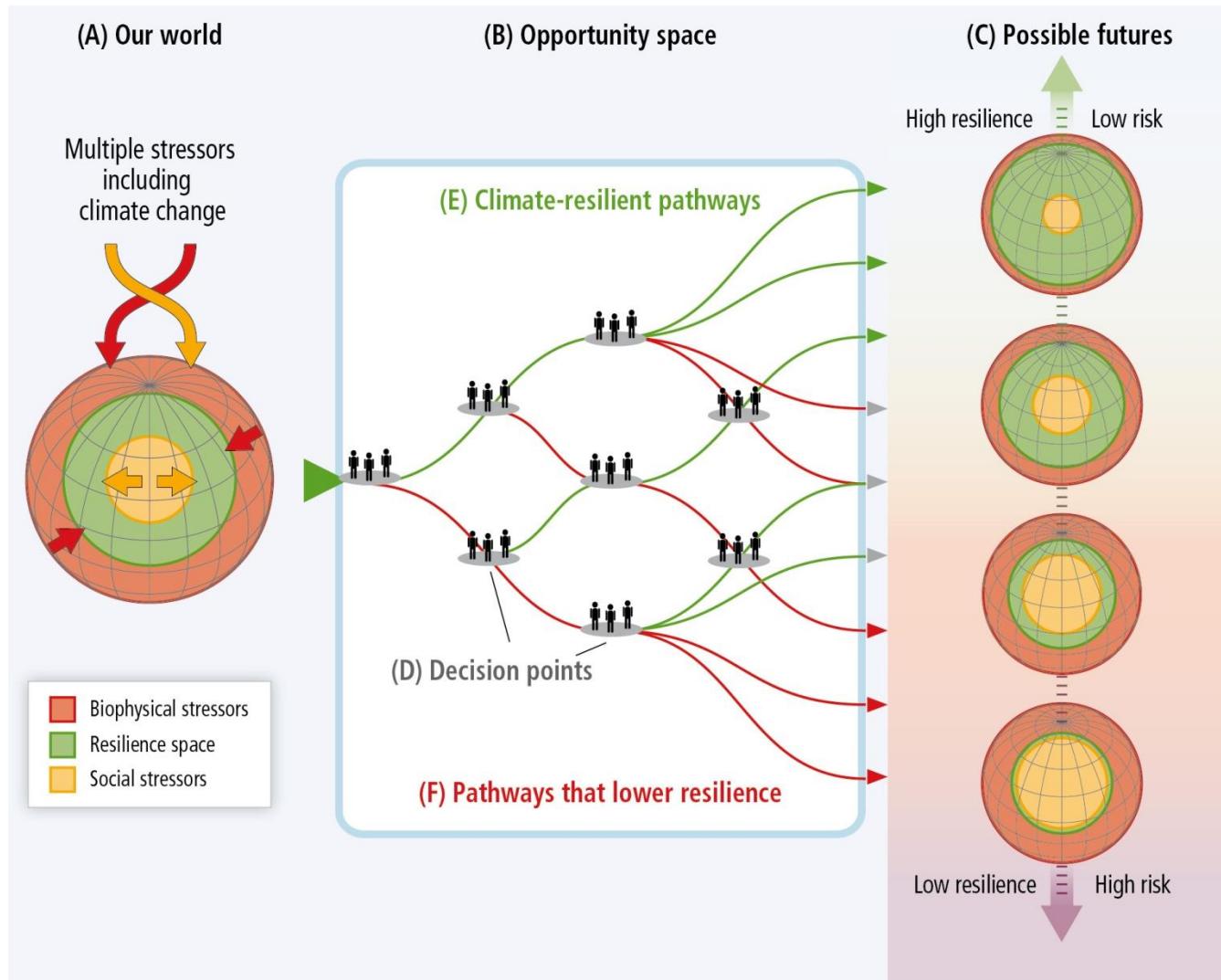




IPCC in 2013-14 (AR5)

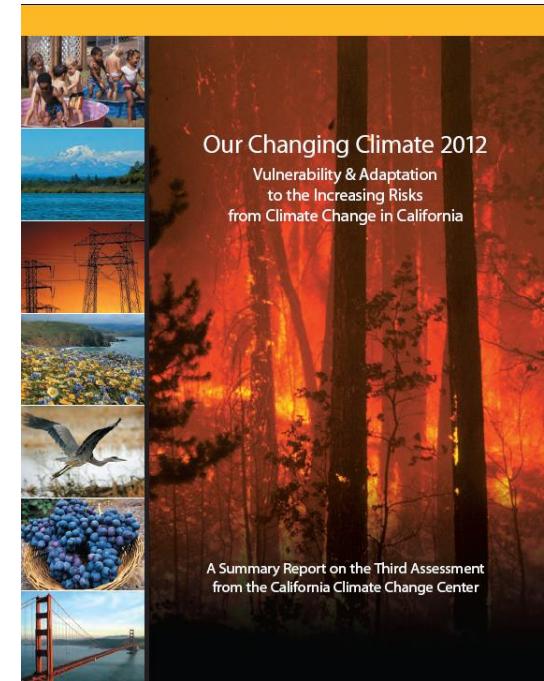
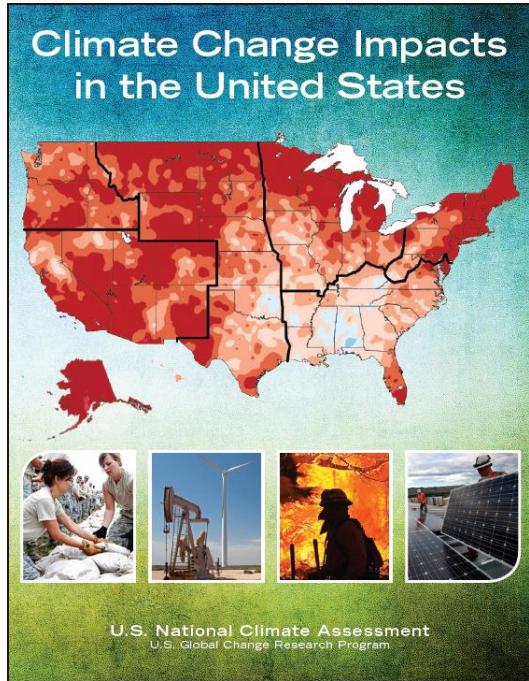
- Many aspects of climate change and associated impacts will **continue for centuries**, even if anthropogenic emissions of greenhouse gases are stopped. The **risks of abrupt or irreversible changes increase as the magnitude of the warming increases**

Effective Mitigation + Adaptation Will Create Possibility for Climate-Resilient, Low-Risk Futures



Source: IPCC, WG2 (2014)

The Third National Climate Assessment



NCA3 available at: <http://nca2014.globalchange.gov>
CCA available at: <http://www.climatechange.ca.gov/>

Key Findings for the Southwest

Sierra Snowpack



January 2013



January 2014

Source: NASA

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems

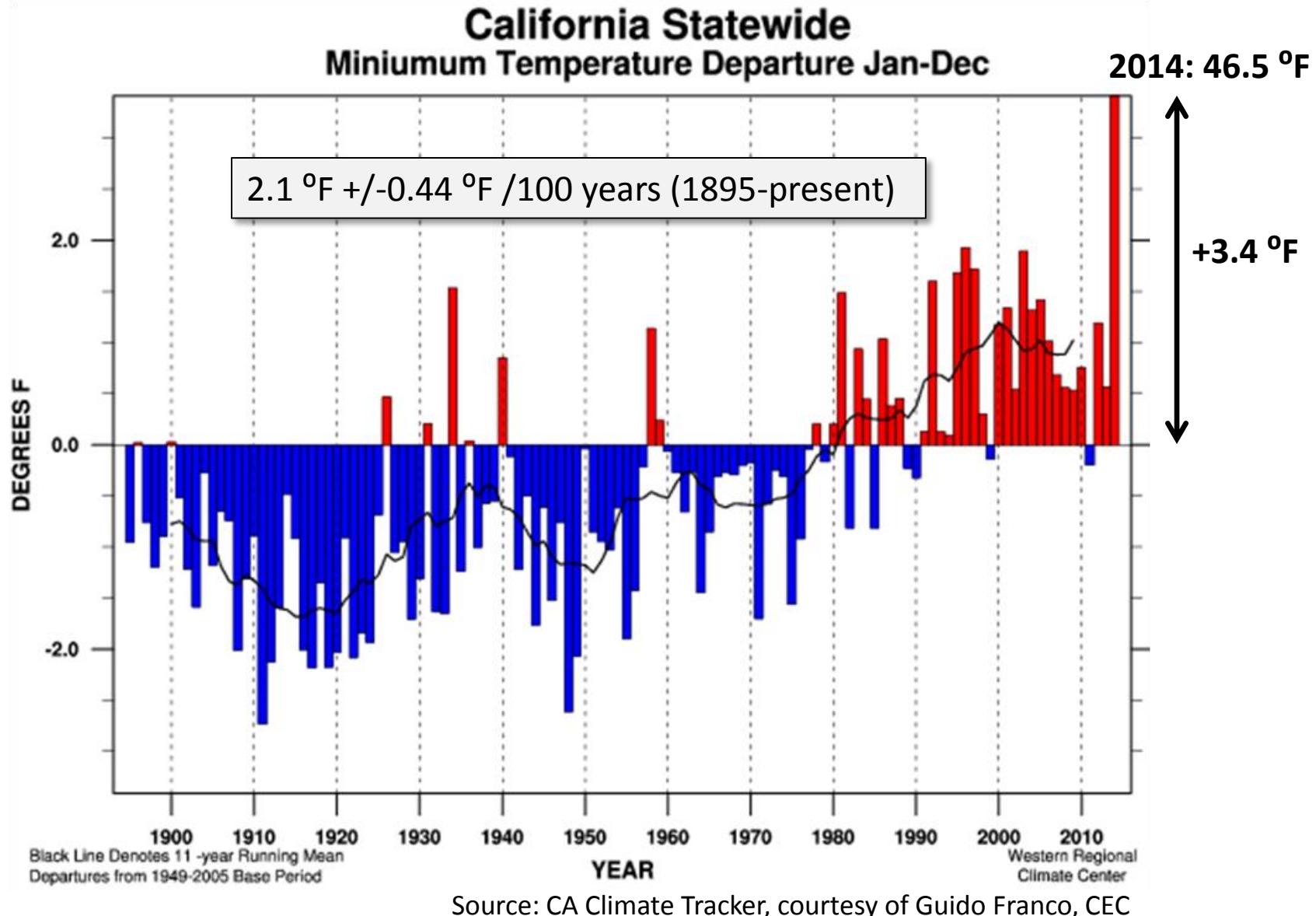
Key Findings for the Southwest



Source: inhabitat.com

- **The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat**
- **Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities**

2014: Also Warmest Year in California



Key Findings for the Southwest



Wildfire in Yosemite National Park
Source: Justin Sullivan, Getty Images

- **Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest**
- **Fire models project more wildfire and increased risks to communities across extensive areas**

12 of California's 20 largest wildfires have occurred since 2000

Key Findings for the Southwest

- Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides
- Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland



Source: USGS



Source: SFGate

Key Findings for the Southwest

Source: www.flickr.com



Source: wikipedia



- **Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population.**
- **Disruptions to urban electricity and water supplies will exacerbate these health problems.**

Outlook: The Fourth California Climate Assessment

- **Start in 2014, due 2017:** Combination of state-identified, state-funded, use-inspired research with externally identified, partner-funded research priorities
 - Led by Natural Resources Agency in collaboration with other State agencies
 - Tier 1: Priority research areas identified and supported by State agencies (heavily dominated by phys./nat./eng. topics)
 - Tier 2: Priority research areas identified through external input, pursued through partnerships/external funding
 - CEC-EPIC Program will contribute energy-sector focused studies
 - Greater focus on multi-sectoral integration, extreme events, adaptation-related information needs at State, regional, local levels



Making Science Accessible to Decision-Makers

The screenshot shows the homepage of the Cal-Adapt website (<http://cal-adapt.org/>). The page has a header with the title "EXPLORING CALIFORNIA'S CLIMATE CHANGE RESEARCH". Below the header are six main sections arranged in a grid:

- Video Tour**: "VIEW THE DIFFERENT TOOLS AND DATA AVAILABLE IN CAL-ADAPT" with a video player icon.
- Explore Climate Tools**: "INTERACTIVE MAPS & CHARTS" with four icons representing different tools.
- About Cal-Adapt**: "WHAT'S NEW?", "WHAT'S TO COME?", and "FAQS".
- Access Data**: "ACCESS THE RAW DATA USED IN CAL-ADAPT" with a download icon.
- Resources**: "INFORMATION, ARTICLES & LINKS" with a document icon.
- Community**: "PARTICIPATE IN COMMUNITY BASED TOOLS AND ACTIVITIES" with three people icons.

At the bottom, it says "Site developed by: Geospatial Innovation Facility" and "Cal-Adapt is a product of the Public Interest Energy Research (PIER) program". There are also social media sharing buttons for Twitter and Facebook.

<http://cal-adapt.org/>

CA Climate Policy Informed by Science (and Unfolding Reality)

The Next Ambitions (Gov and Legislature):

- By 2030:
 - 50% reduction in petroleum use by cars, trucks
 - 50% renewables for utilities
 - doubling energy efficiency in existing buildings
 - reducing Short Lived Climate Pollutants (black carbon, F-gases, methane)
- By 2050:
 - GHG emissions by 80% below 1990 levels
- Improving management of public lands for C sequestration
- Implementing Prop 1 (Water Bond)
- Divestment of the CA pension funds from coal
- Implementing “Safeguarding California” (2nd adaptation strategy)



"This is exciting, it is bold and it is absolutely necessary if we are to have any chance of stopping potentially catastrophic changes to our climate system."

Gov. J. Brown, 5 Jan 2015



Thank you!

Your Questions....

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