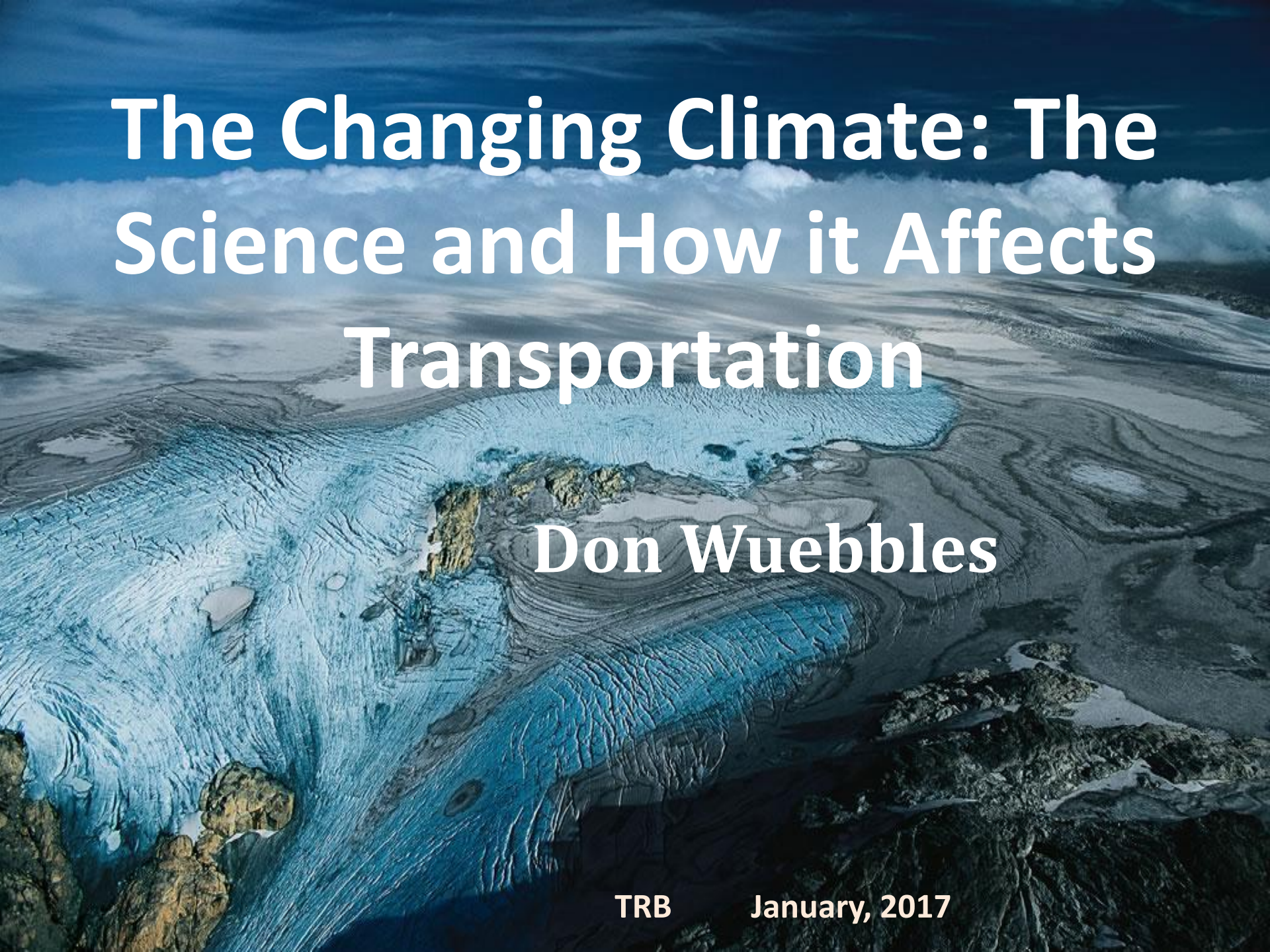
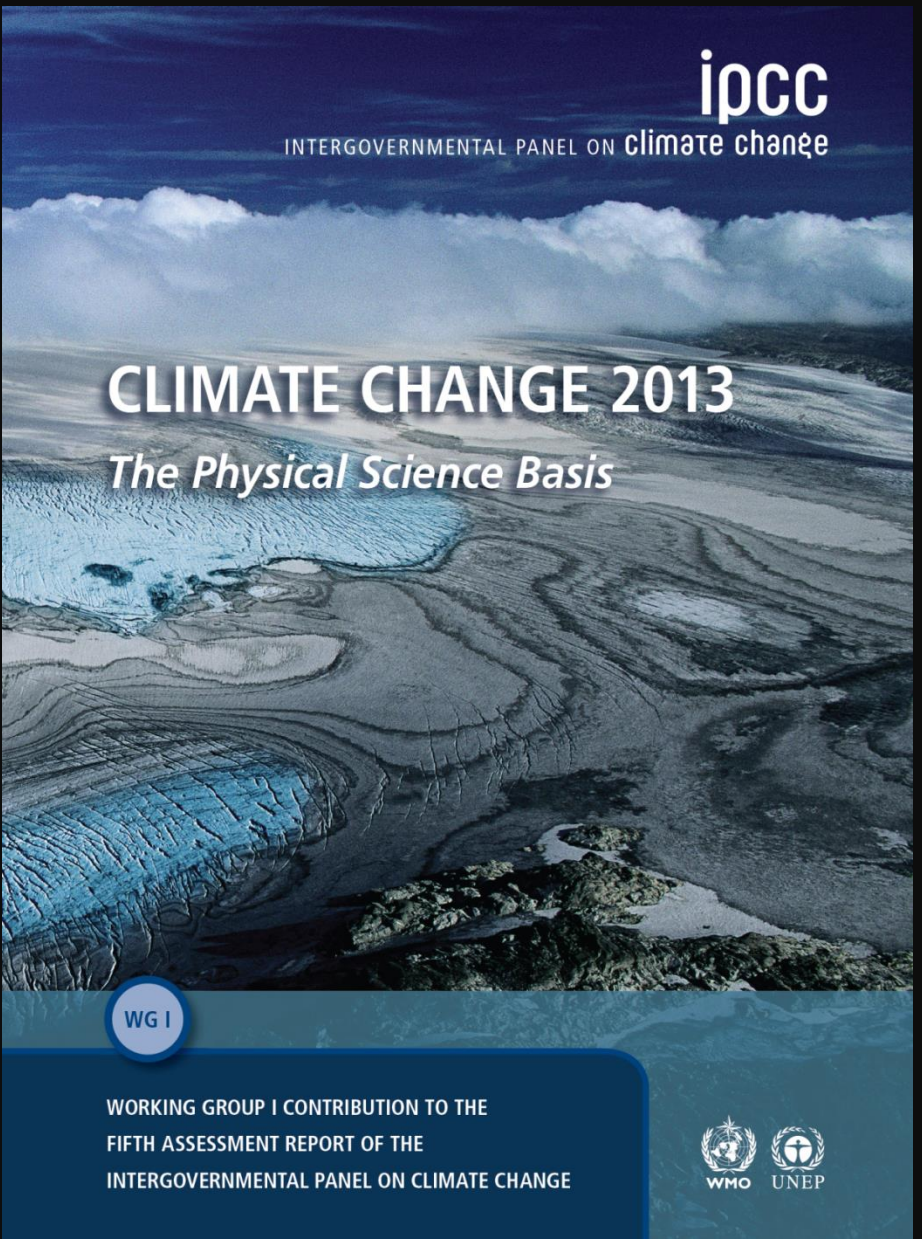


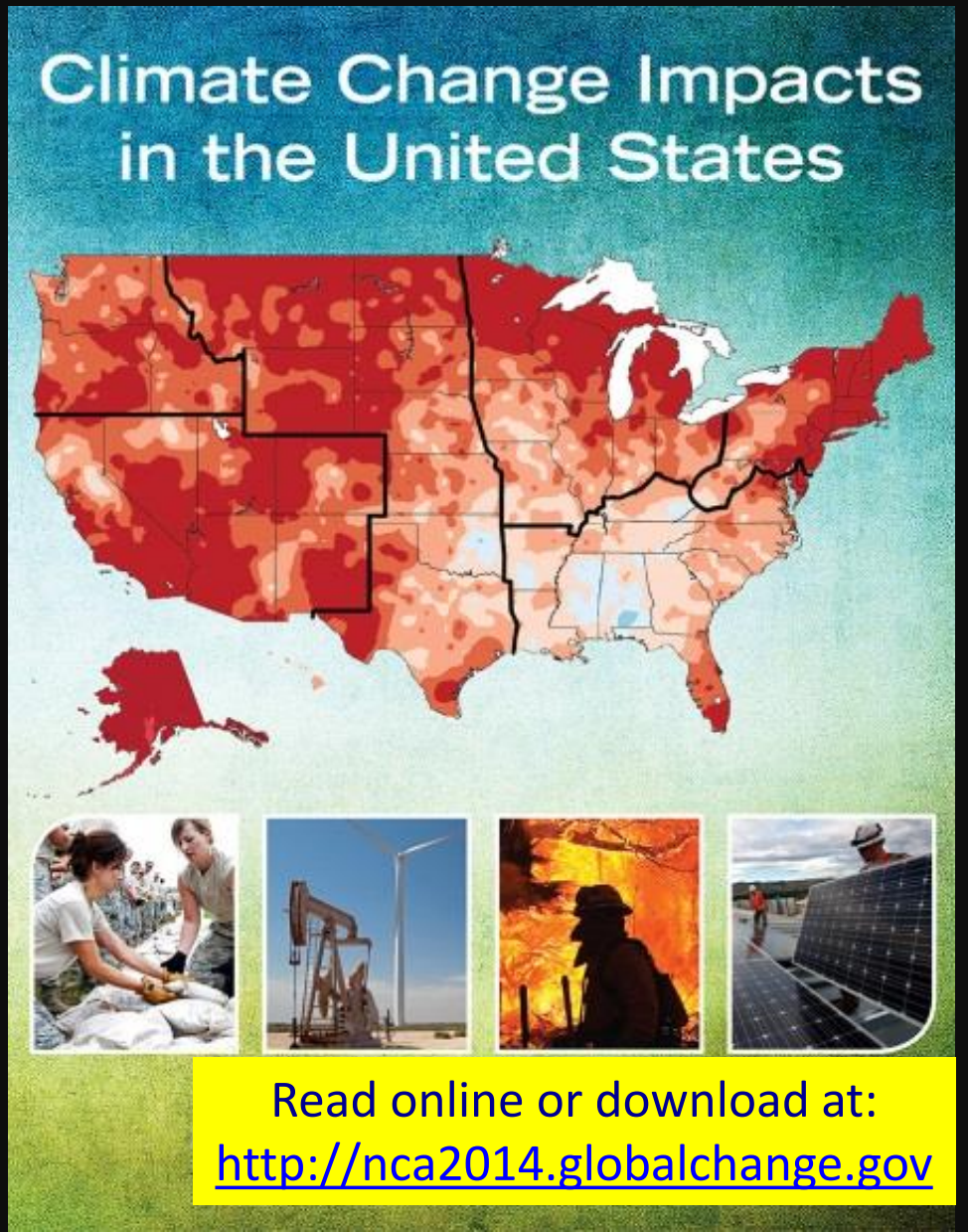
The Changing Climate: The Science and How it Affects Transportation

Don Wuebbles

TRB January, 2017

Assessing the Science of Climate Change





The Key Findings

Our climate is changing,

It is happening now;

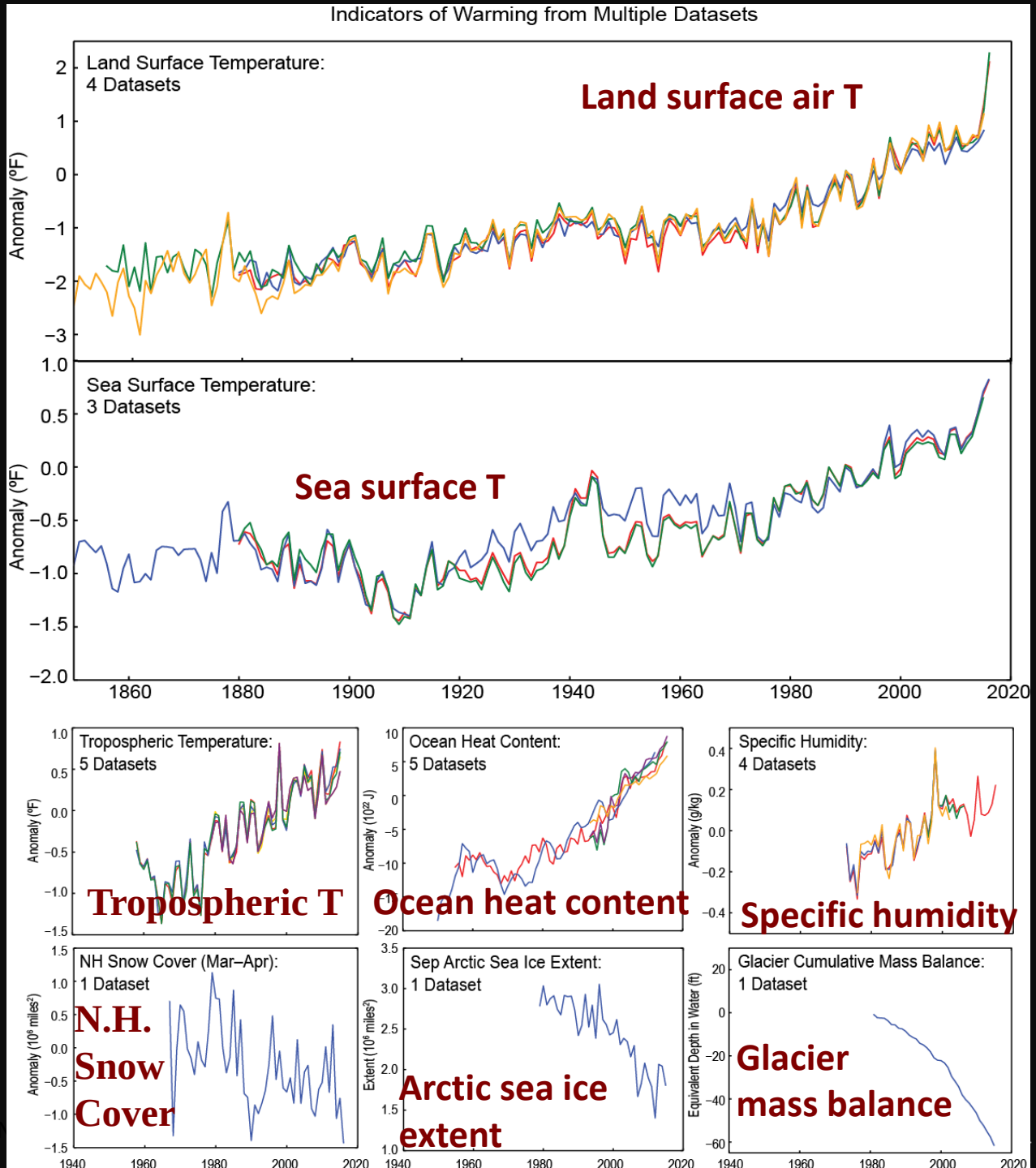
It is happening extremely rapidly;

It is largely happening because of human activities;

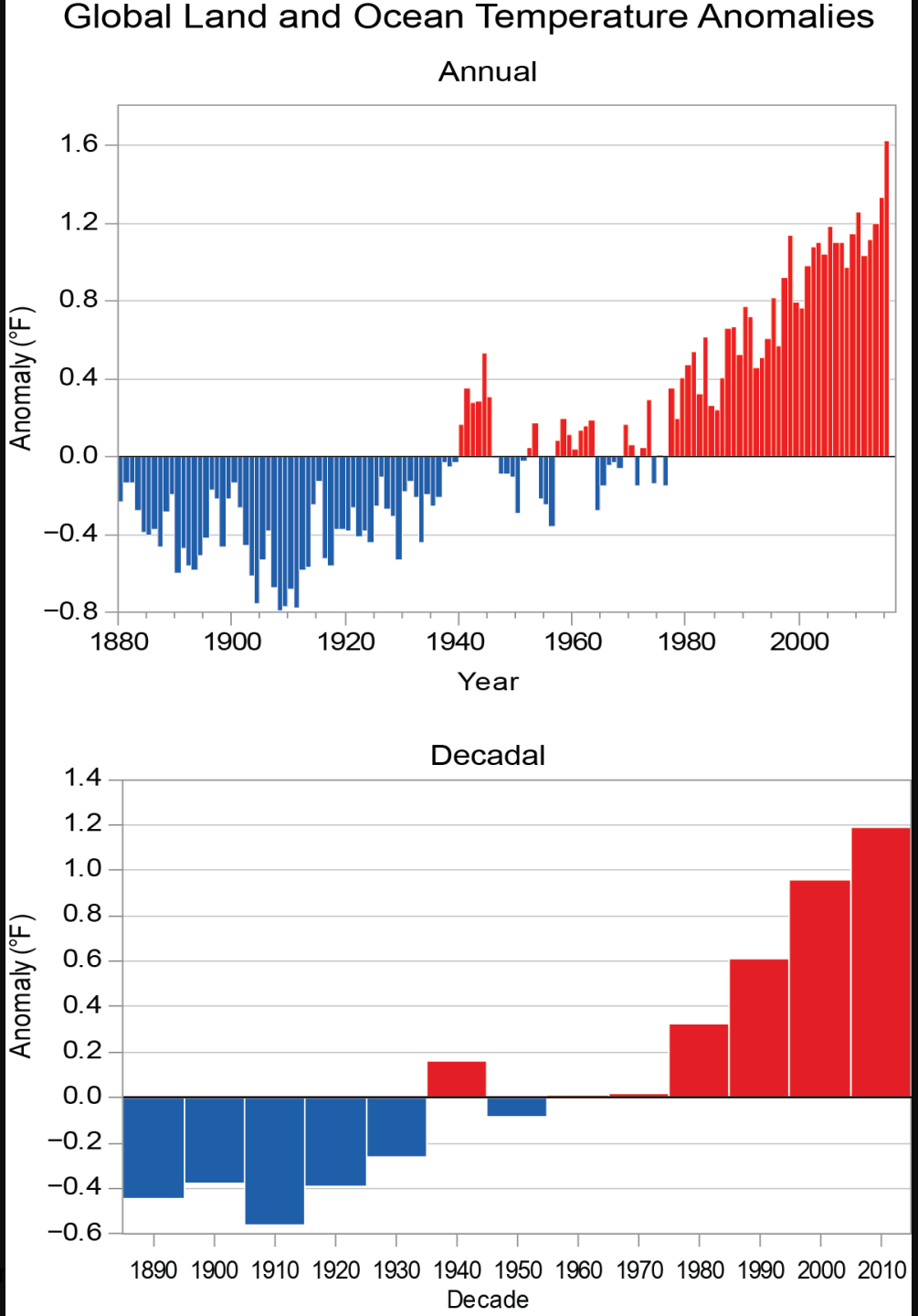
The climate will continue to change over the coming decades.

There are many actions we can take both to reduce future changes in climate and to adapt to those changes we cannot prevent.

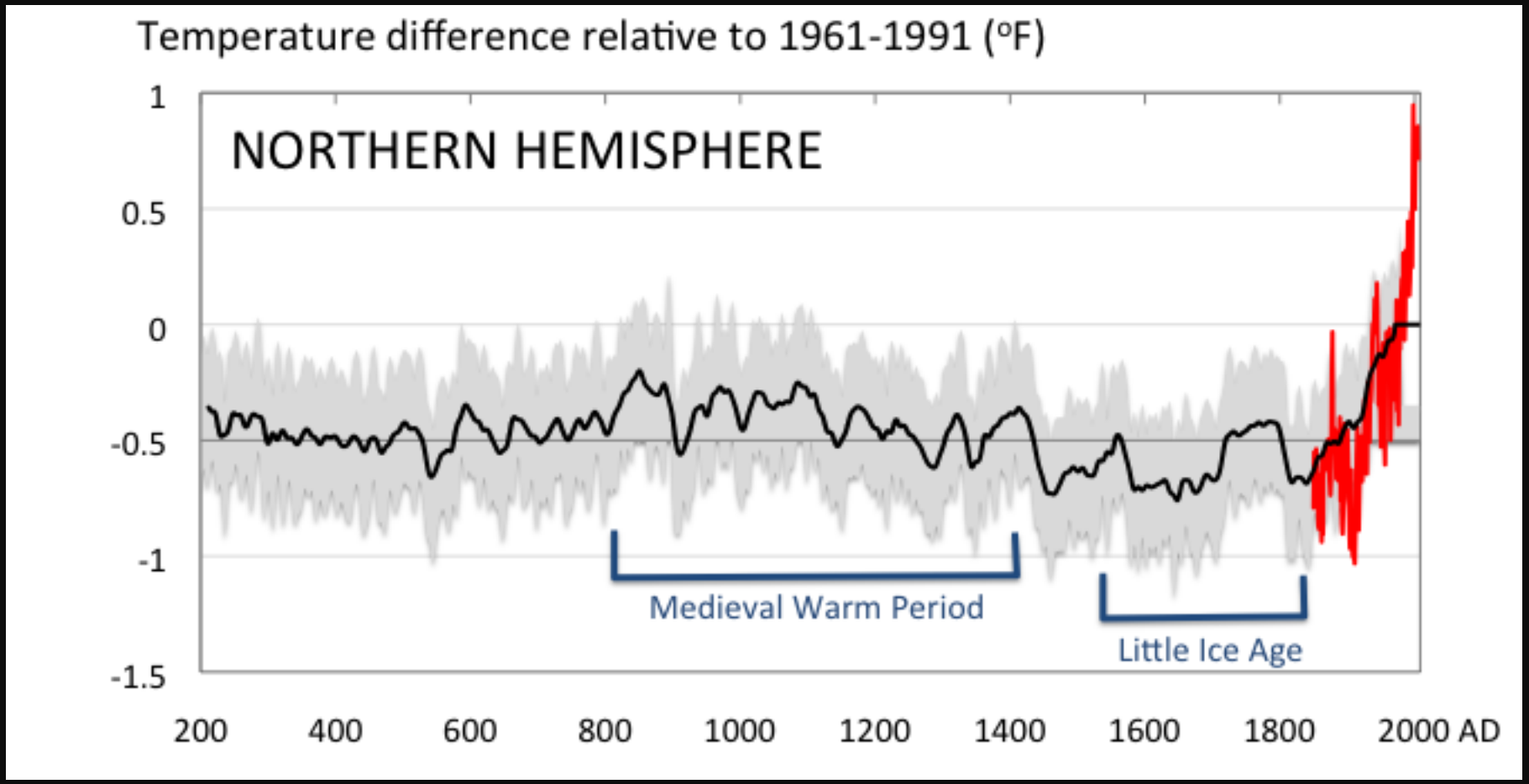
There are Many Observed Indicators of a Changing Climate



Updated global annually averaged Temperature Record (from NOAA through 2015)



Conditions today appear to be unusual in the context of the last 2,000 years . . .



Mann et al., 2008 PNAS

Temperature trends (change in °F) for the period 1986-2015 relative to 1901-1960

Data from NOAA NCEI

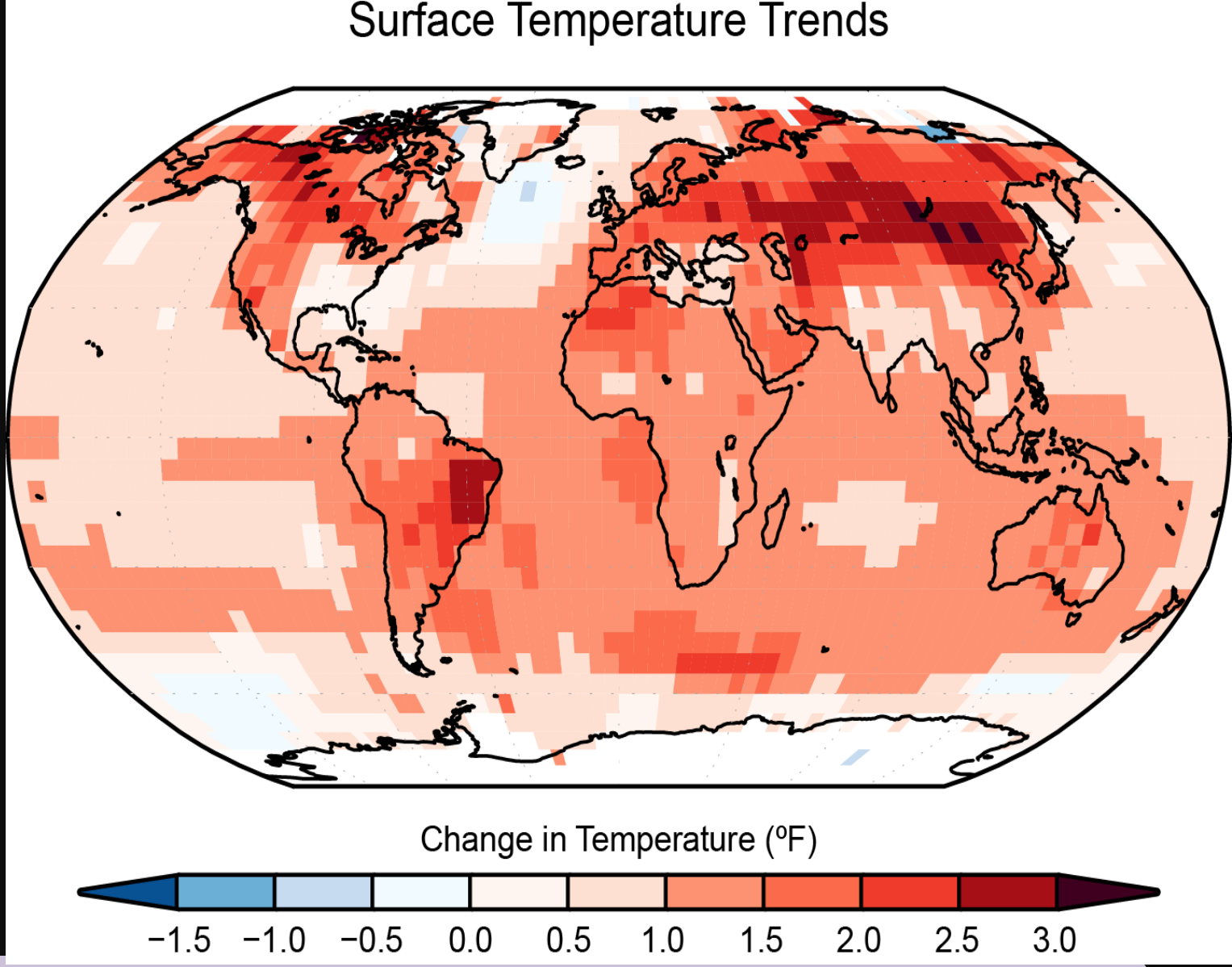
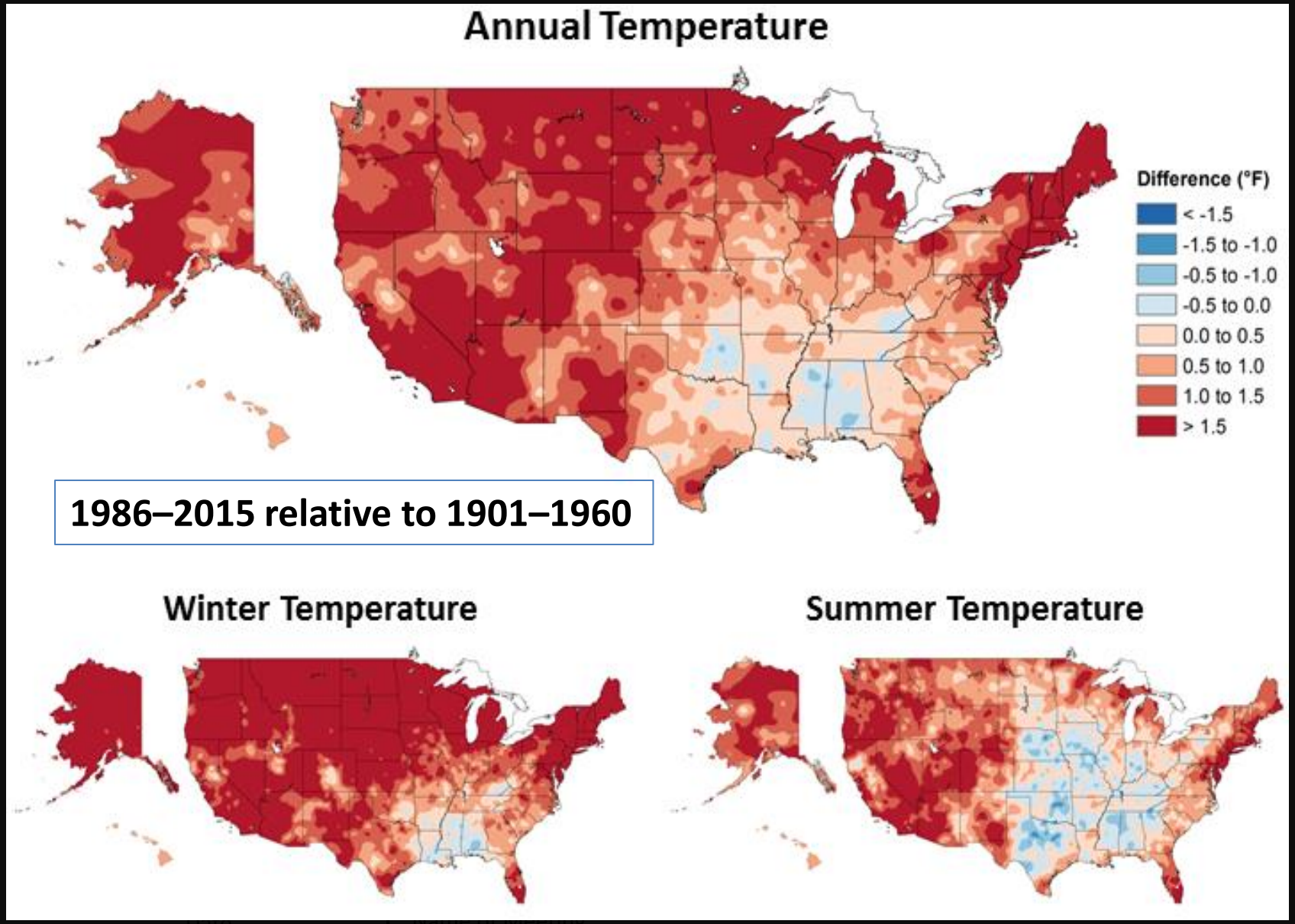


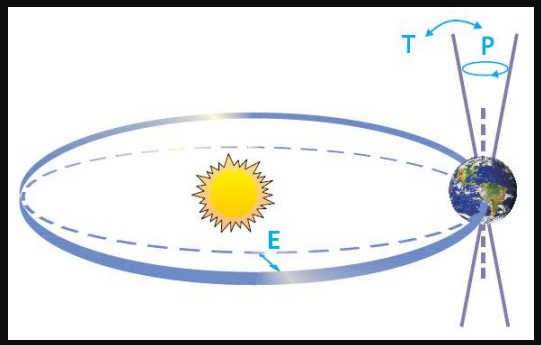
Fig. SPM

Warming of the climate system is unequivocal

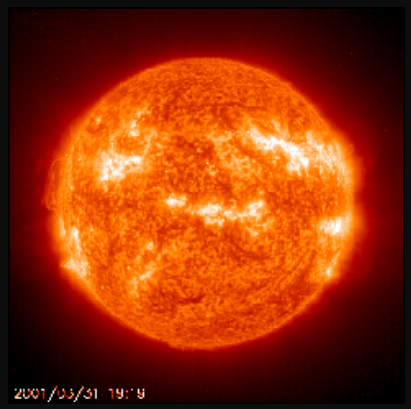
Observed U.S. Temperature Change



Natural Drivers of Climate



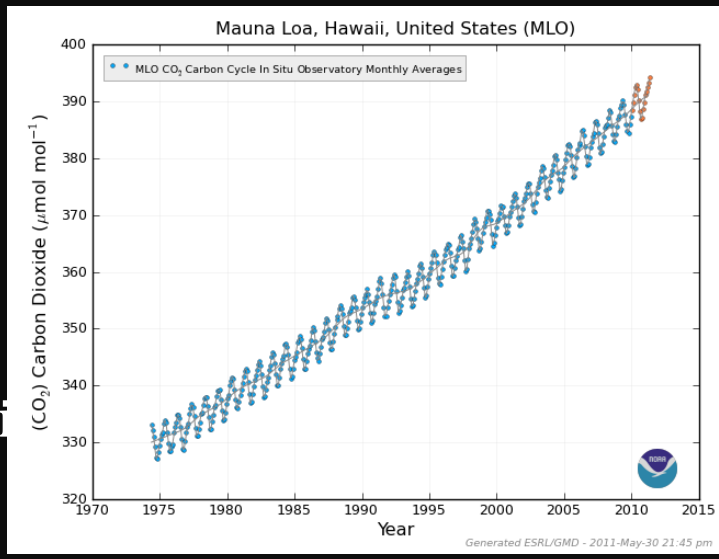
Variations in the Earth's orbit (Milankovitch effect)



Variations in energy received from the sun

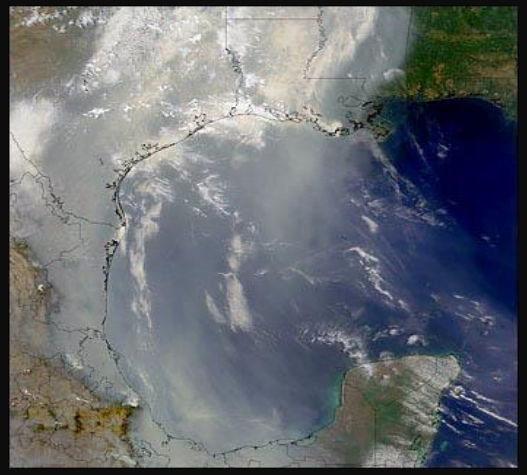
Stratospheric aerosols from energetic volcanic eruptions

Human Factors in Climate



Changes in atmospheri gases

Changes in particles from burning fossil fuels and biomass



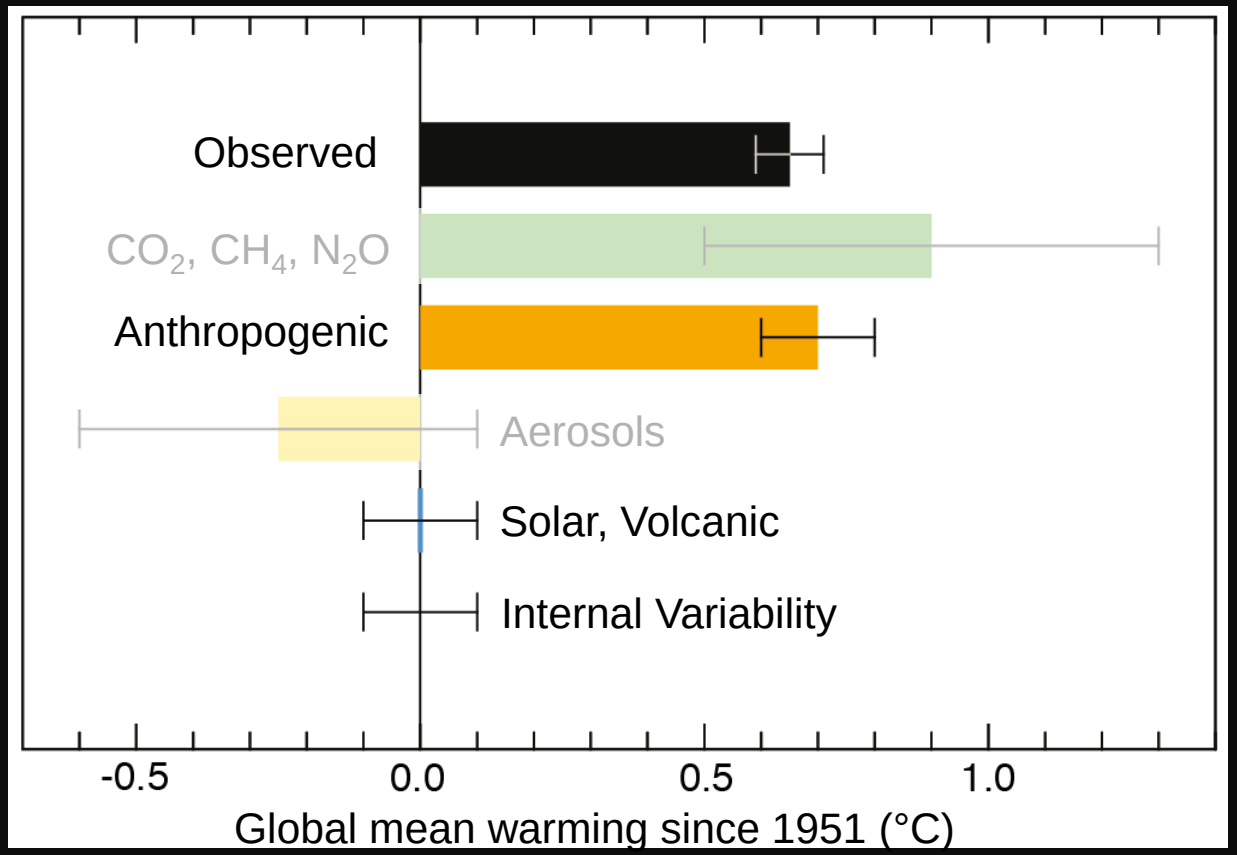


Fig. TS.10

The observed warming 1951–2010 is approximately 0.6°C to 0.7°C.

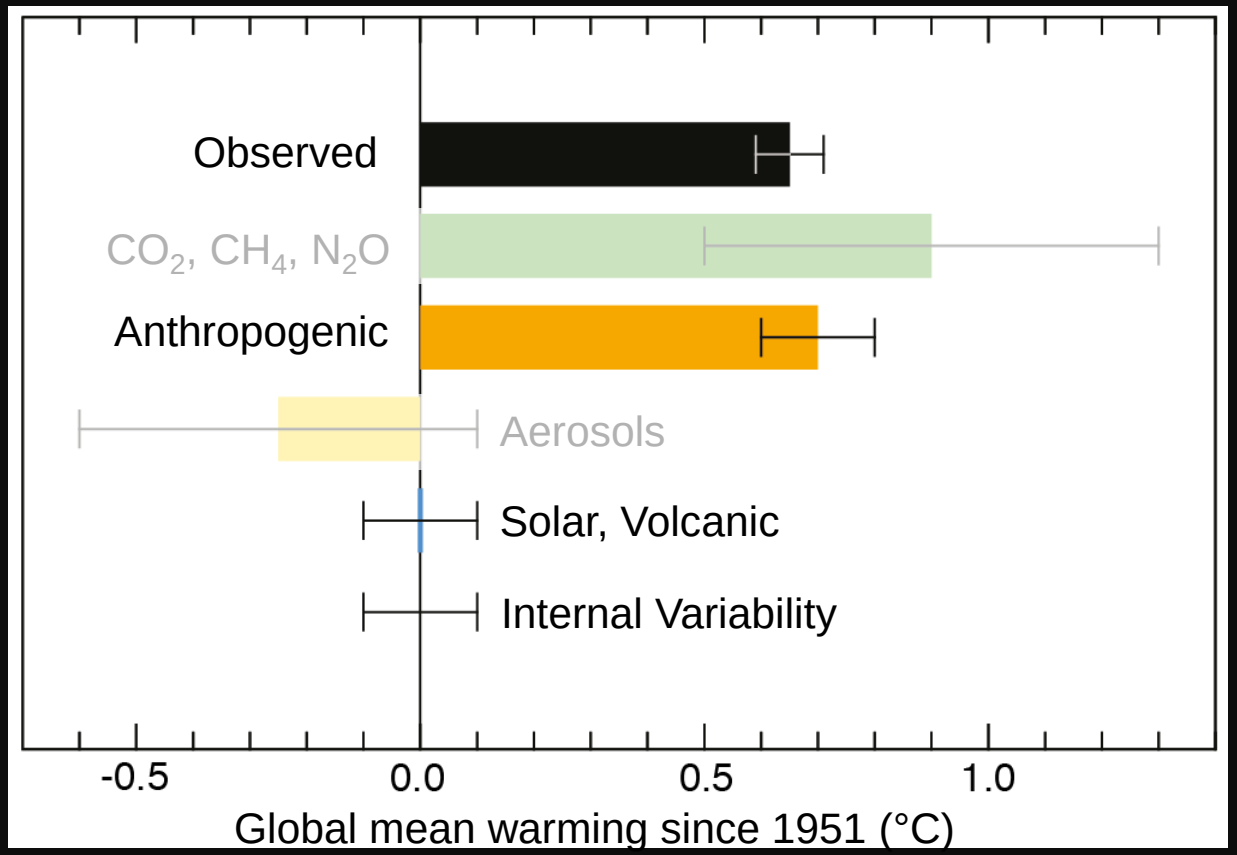
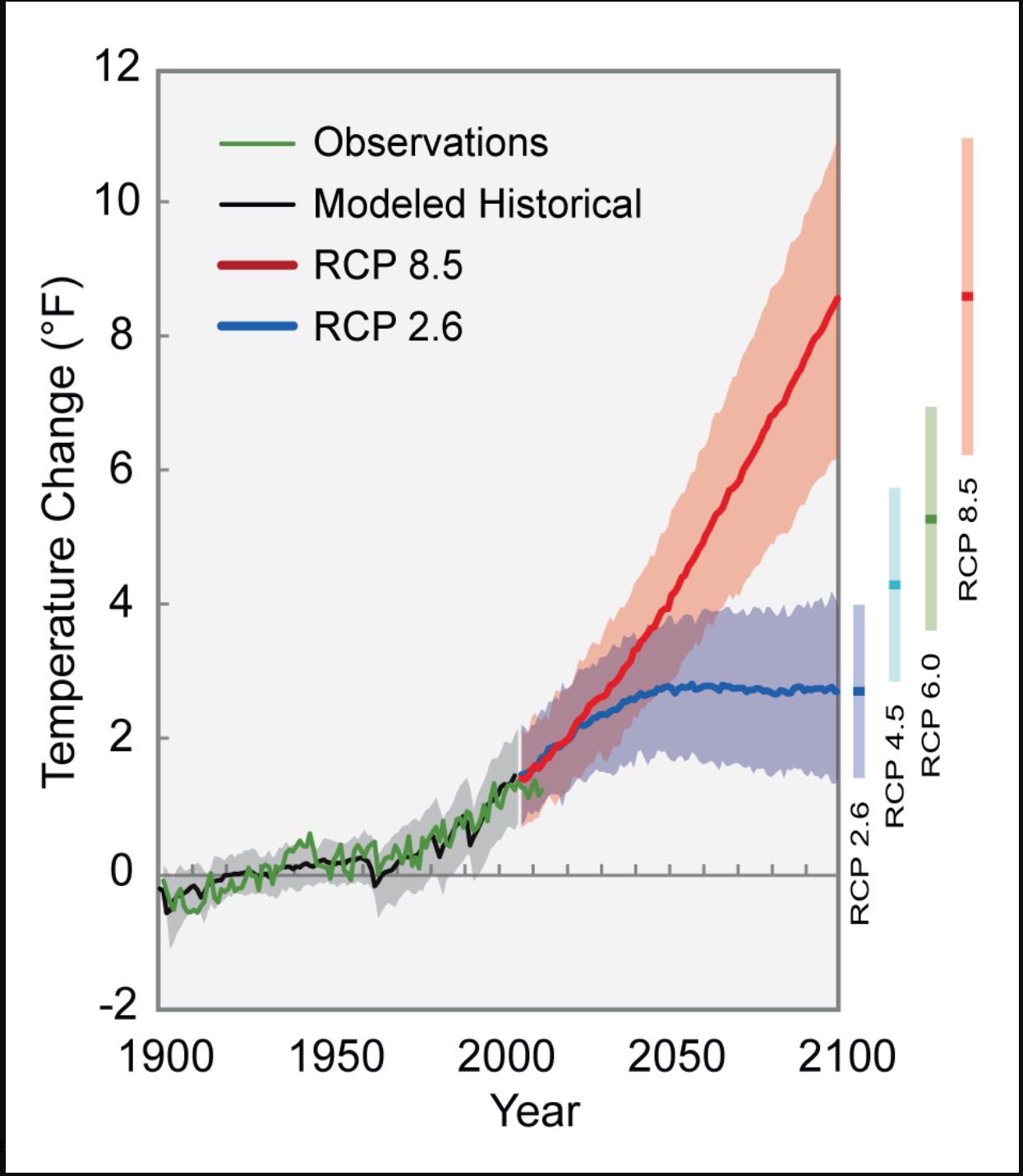


Fig. TS.10

1951−2010: Observed warming 1951−2010 is about 1.1-1.2 °F

It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Global Temperature and Other Changes in Climate Depend on Future Emissions



Global Temperature and Other Changes in Climate Depend on Future Emissions

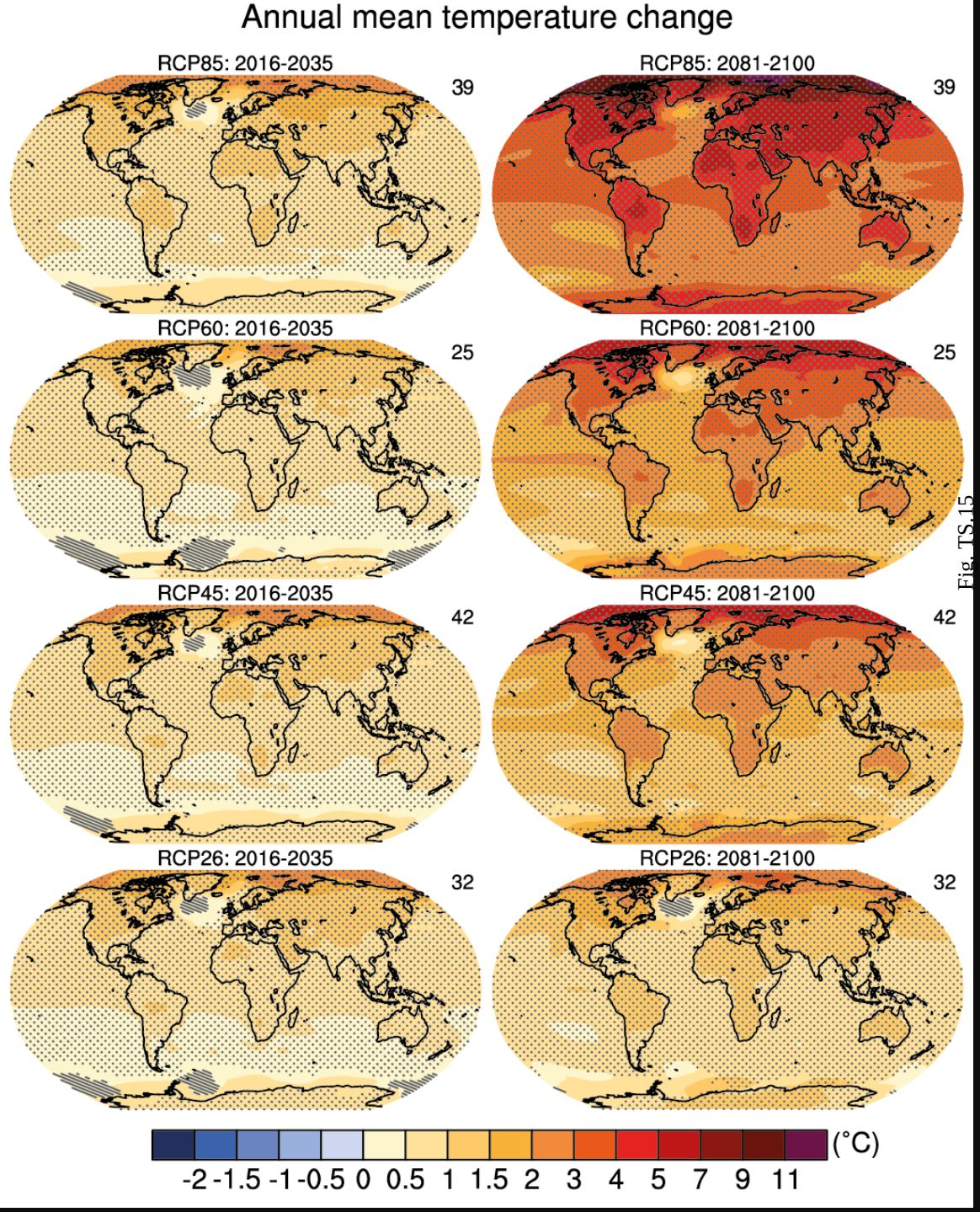
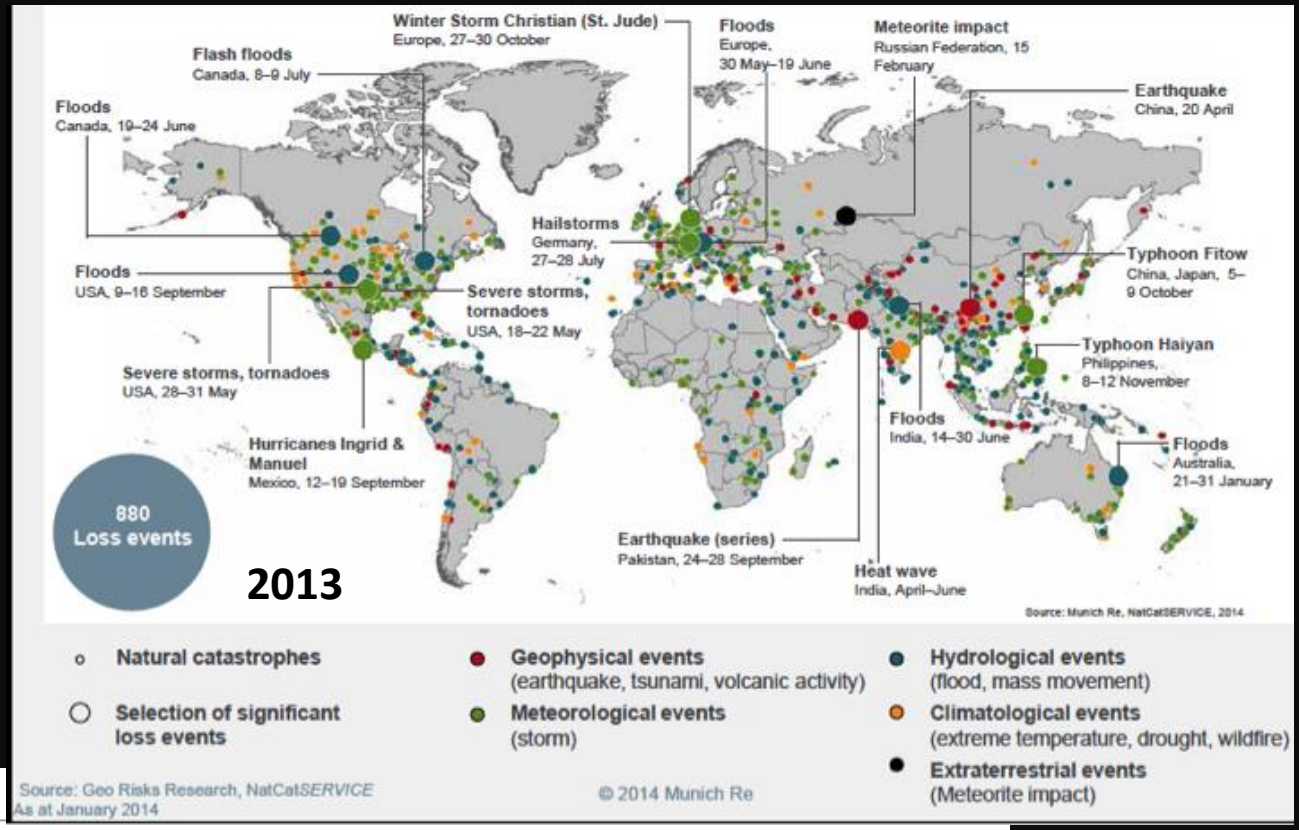
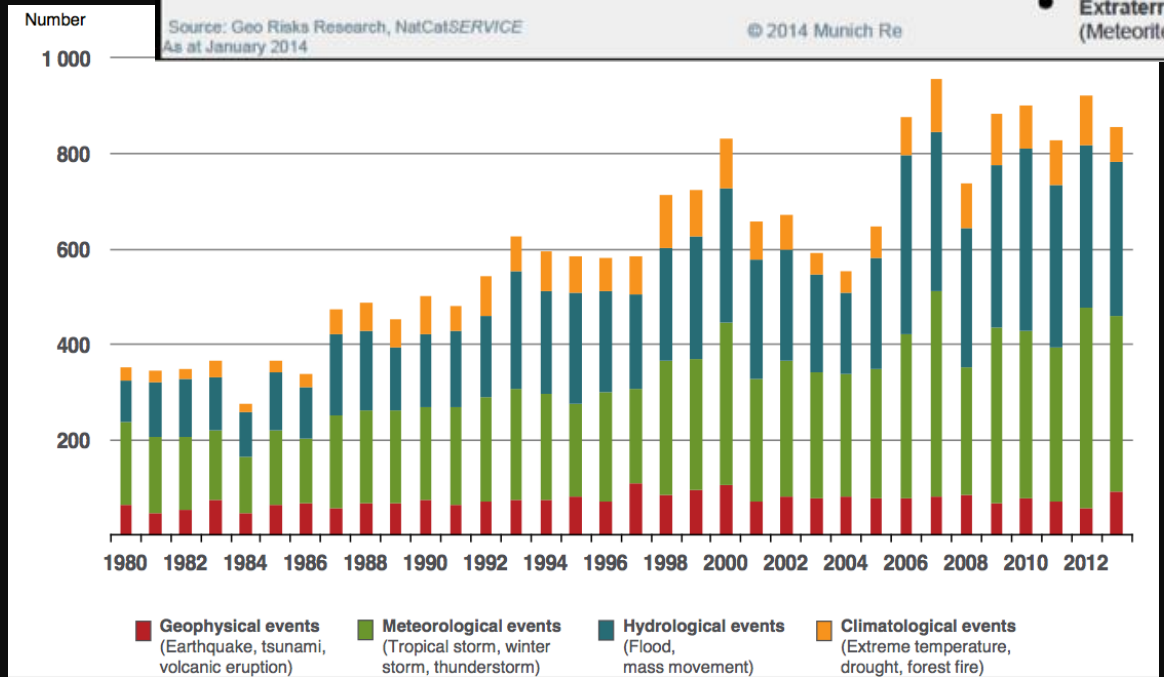


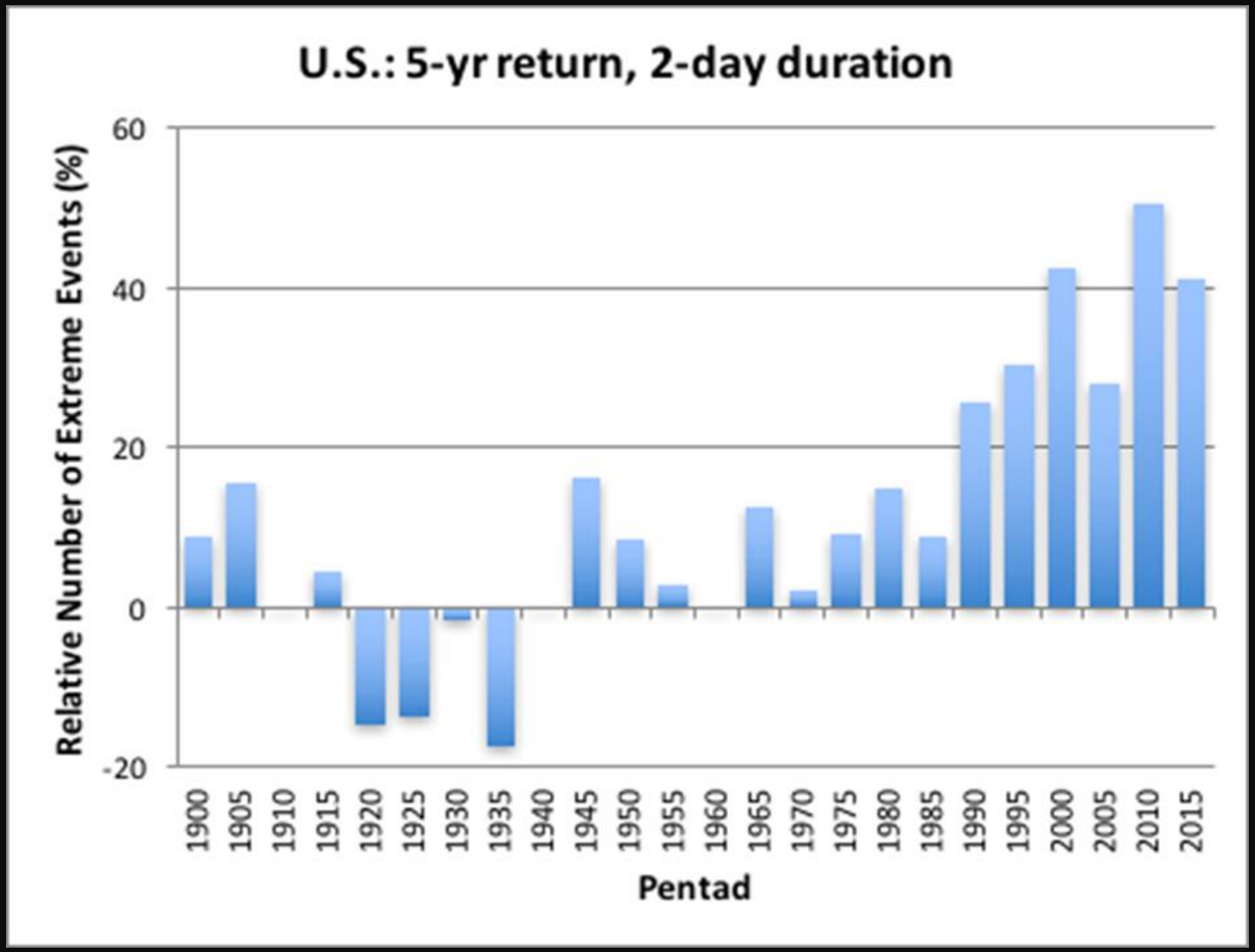
Fig. TS.15

Increasing Tendency for Severe Weather Events in U.S. and Throughout the World





Extreme Precipitation Events are Increasing in Frequency and Intensity

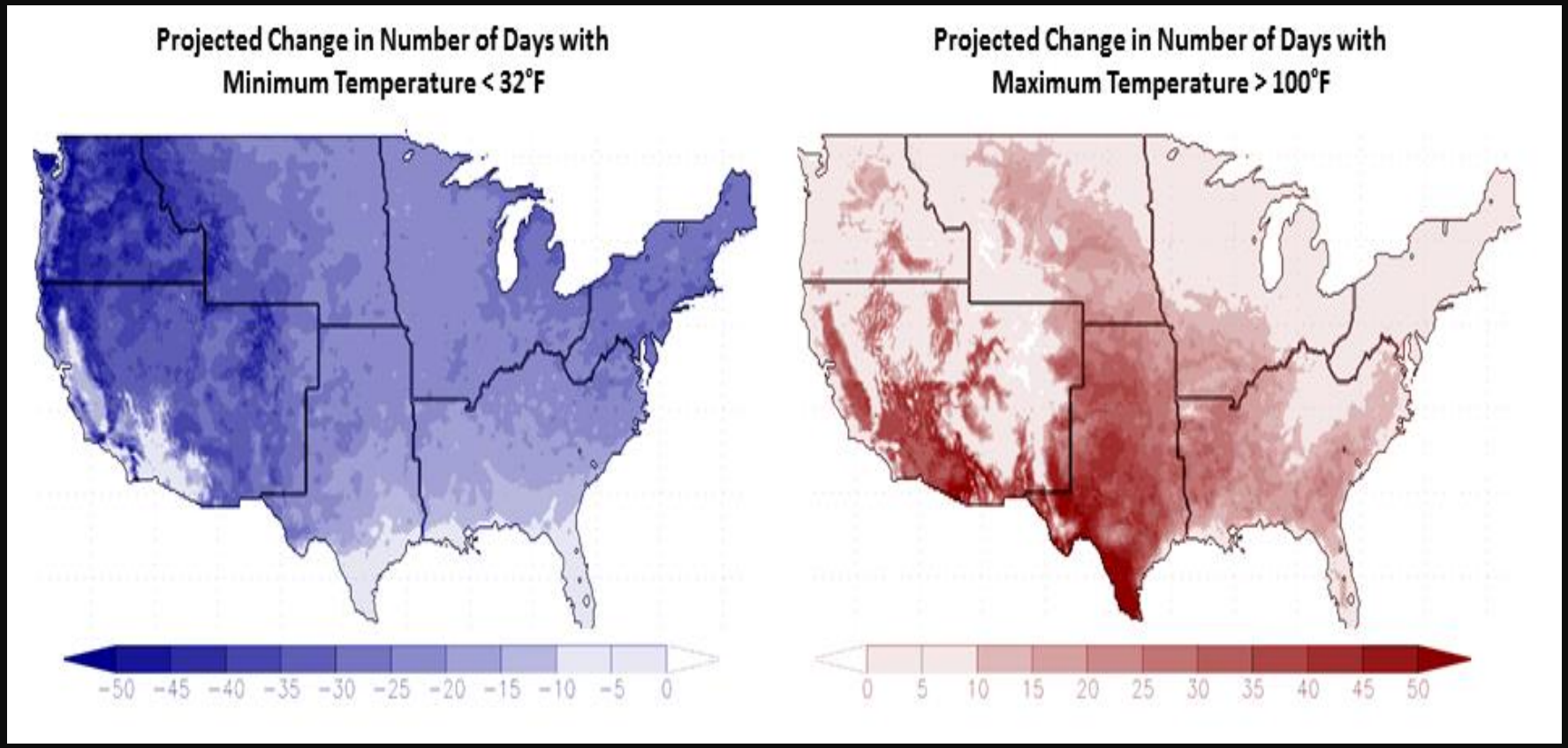


Extreme Events: High Confidence that …

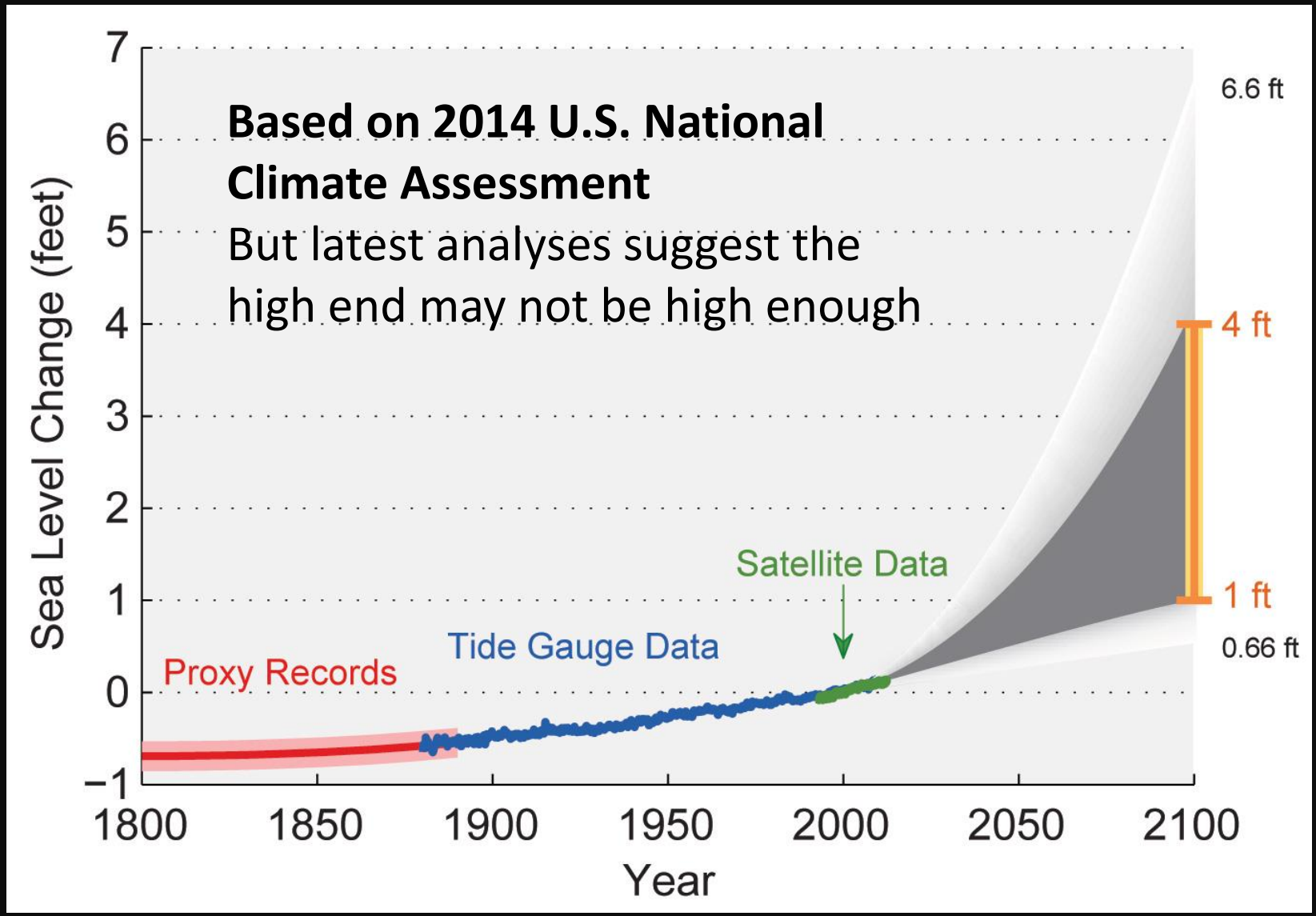
- E**xtreme heat** temperature events are becoming stronger and more frequent
- Risk of **extreme cold** is decreasing
- E**xtreme precipitation events** (including both rain and snow) are becoming more common.
- Risk of **flood in some areas** is increasing
- Severity of **drought** is increasing (as warmer temperatures increase evaporation rates)
- H**urricanes** are becoming more intense

OBSERVED TRENDS : CONSISTENT WITH BASIC PHYSICS, HISTORICAL SIMULATIONS, AND FUTURE PROJECTIONS

Projected Changes in Number of Days for <32°F and >100°F 2036-2065 relative to 1976-2005 for a High Emissions Scenario



Past and Projected Changes in Global Sea Level



Transportation: Reliability and Capacity at Risk

Third U.S. National Climate Assessment:

"Sea level rise and storm surge, extreme weather events, higher temperatures and heat waves, precipitation changes, Arctic warming, and other climatic conditions are already affecting the reliability and capacity of transportation systems in many ways."

"**Extreme weather events** currently disrupt transportation networks throughout the world; projections indicate that such disruptions will increase."

A Sense of Hope

- Our future depends on how we act to limit climate change.
- Adaptation is not a choice – our choice is whether to adapt proactively or respond to the consequences.
- Adaptation requires a paradigm shift, focusing on managing risks.
- We can draw on our long history of responding to changing conditions in facing the challenges of climate change.

Planning for the future ensures we all get there safely, together.

Climate Effects on Aviation

Turbulence

- Likely will increase, but limited studies at this time.

Climate variability (e.g., jet stream, convection, fog, visibility and ceiling)

- Effects on aviation route decisions

Higher temperatures (and more heat waves)

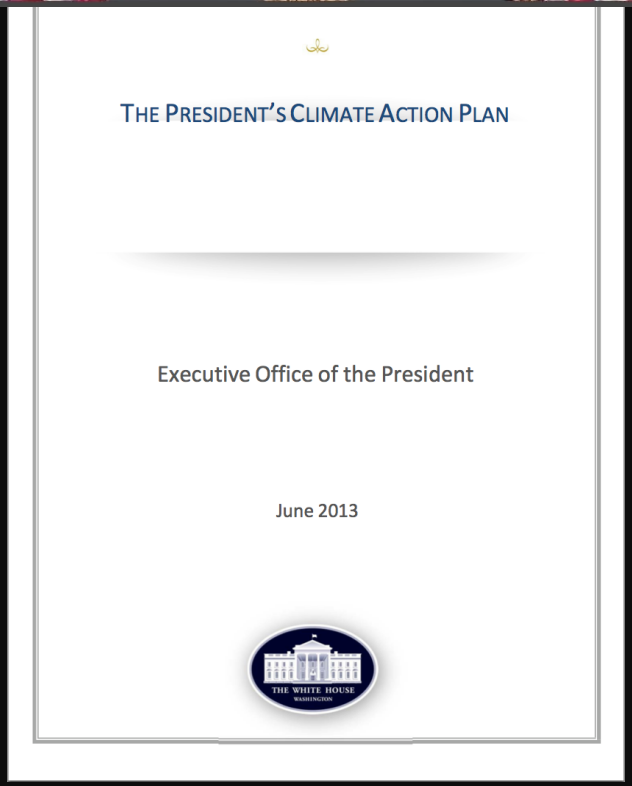
- Effects on lift pavement

Sea Level Rise and storm surge

- Effects on airport facilities and operations

The President's Climate Action Plan

- Released in June 2013 and updated
- Responds to the Science
- Outlines executive actions to address climate change while sparking American innovation and economic growth
- Comprised of three key pillars:
  1. Cutting carbon pollution in America
  2. Preparing the United States for the impacts of climate change
  3. Leading international efforts to address climate change



http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

The Paris Agreement: December 2015

- COP21: 21st Conference of the Parties, held in Paris towards getting a global agreement on climate change
- Resulted in The Paris Agreement
  - National climate action plans called INDCs (Intended Nationally Determined Contributions) submitted.
    - Mitigation and adaptation through 2025-2030
  - Long term goal (2100) is globally-averaged temperature change of 2 degC (or less) relative to pre-industrial
  - Aim at limiting to 1.5 degC if possible
  - Transparency and accountability in national emissions
  - Agreed to help developing countries with impacts
- Agreed to by all 195 countries at COP21

The Paris Agreement: December 2015

The Paris Agreement establishes a bridge between today's policies and climate neutrality before the end of the century.