Our Changing Climate
Climate change is...

Simple

Serious

Solvable
Simple
Simple

Burning fossil fuels

More CO₂ in the atmosphere

Temperature rises
99% nitrogen and oxygen, with important trace amounts of greenhouse gases:

- Water vapor
- Carbon dioxide
- Methane
- Nitrous oxide
The Greenhouse Effect
The Greenhouse Effect

Some energy is reflected back into space.
The Greenhouse Effect

Some is absorbed and re-radiated as heat
Most of the heat is absorbed by greenhouse gases and then radiated in all directions, warming the Earth.
Evidence That CO2 Is A Greenhouse Gas

Joseph Fourier (1820s)
Eunice Foote (1850s)
Svante Arrhenius (1890s)
Guy Stewart Callendar (1930s)
Burning fossil fuels puts carbon dioxide into the atmosphere

By burning coal, oil, and natural gas, humans are warming the planet
GLOBAL TEMPERATURE & CARBON DIOXIDE

Global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910)
Global annual average carbon dioxide
Source: NASA GISS, NOAA NCEI, ESRL
Global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910)
Global annual average carbon dioxide
Source: NASA GISS, NOAA NCEI, ESRL
OKLAHOMA CITY
DECADES OF WARMING

Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
THE NEW NORMAL
30-Year Temperature Averages Are Rising


Normal is based on 30-year average temperature, adapted from NOAA
Source: RCC/ACIS.org
FUTURE WARMING
Projections (°F) Based on Emissions Decisions

Current Path
Emission Cuts

Current path represents RCP8.5, Emission cuts represents RCP4.5
Source: 4th National Climate Assessment 2018

CLIMATE CENTRAL
Serious
Serious:
- Rising seas
- Wild weather
SMALL CHANGE IN AVERAGE
BIG CHANGE IN EXTREMES
UNITED STATES RECORDS SET BY DECADE

HOT  COLD

100%

80%

60%

40%

20%

0%

1920s  1960s  2010s

Maximum daily temperature & minimum daily temperature for POR through 2018.
Produced 8/30/2019
Source: Guy Walton & NOAA/NCEI
Snowfall Patterns Changing Regionally And Seasonally

- Globally—less snow and shorter snow seasons
- Locally—potential for bigger snow events in snowy areas
93% of extra heat is going into the oceans.

OCEANS HEATING UP
Change in sea surface temperature (°F) since 1901:

Data through 2015. Gray indicates insufficient data.
Source: IPCC, NOAA: Merged Land-Ocean Surface Temp Analysis

SERIOUS
SEA LEVEL RISE
BY CENTURY

Inches:
+6
+3
0
-3

1ST  5TH  10TH  15TH  20TH

Central reconstruction shown
Source: Kopp et al. 2016 (PNAS)
HIGHER TIDES, MORE FLOODING

PEAK # OF CONCURRENT U.S. COASTAL FLOODS YEARLY

Annual maximum number of NOAA tide gauges exceeding a minor flood threshold in a single day, 1970 to September 2020
Charleston, SC Sea Level Rise Projection
Warmer air leads to:
- More evaporation
- More precipitation

1°F increase = 4% more water vapor

Temperature

Available water
MORE DOWNPOURS
Increase in Heaviest Precipitation Events

Heaviest events defined as top 1% of events
Source: USGCRP Climate Science Special Report 2017
DAILY DELUGE
RAIN ON THE WETTEST DAY EACH YEAR

Amount of precipitation on the wettest calendar day observed each year
Source: RCC-ACIS.org
SERIOUS

HURRICANES & CLIMATE CHANGE
What we know

- Warmer water = more fuel
- Heavier rain
- Higher storm surge

CLIMATE CENTRAL
Western U.S. Drought Index

Mild
Moderate
Severe
Extreme

1900 1920 1940 1960 1980 2000 2020

Palmer Hydrological Drought Index 24 month average. NCEI West U.S. climate region (CA and NV).
Source: NCEI
HOTTER YEARS, HIGHER FIRE RISK
ACRES BURNED ACROSS WESTERN STATES

(THOUSANDS OF ACRES)

Serious

Rising seas

Nature

Wild weather

Health

Economy
Impacts from extreme weather
2019 BILLION-DOLLAR DISASTERS
WEATHER AND CLIMATE EVENTS SINCE 1980

Source: NOAA/NCEI
Data as of 3/15/2019

2020 BILLION-DOLLAR DISASTERS
WEATHER AND CLIMATE EVENTS

Cumulative billion-dollar disaster frequency 1980-2019 average.
Source: NOAA/NCEI

CLIMATE CENTRAL
Moving northward and to higher elevation
Mismatched timing between animals and food sources
Increasing vulnerability to invasive species & extinction
Global decline in coral reefs
Health

Worsening air quality

More heat-related illnesses

Longer, stronger allergy seasons

Increasing risk of insect and food-borne diseases
Food & Farming
Stress from increased weather extremes (droughts & floods)
Shifting planting zones
Increased crop diseases and pests
Ways Of Life

- Sports
- Outdoor activities and recreation
- Coffee and Beer
<table>
<thead>
<tr>
<th>1.5°C (2.7°F)</th>
<th>VS</th>
<th>2°C (3.6°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5-30 inches of sea level rise by 2100</td>
<td><strong>Sea Level Rise</strong></td>
<td>Additional 4 inches of sea level rise and 10.4 million more people exposed</td>
</tr>
<tr>
<td>Loss of 70-90% of coral reefs</td>
<td><strong>Ecosystems</strong></td>
<td>Loss of 99% of coral reefs</td>
</tr>
<tr>
<td>350 million people in urban areas exposed to severe drought</td>
<td><strong>Extreme Weather</strong></td>
<td>410 million people in urban areas exposed to severe drought</td>
</tr>
<tr>
<td>At least one sea-ice-free Arctic summer after 100 yrs</td>
<td><strong>Arctic Ice</strong></td>
<td>At least one sea-ice-free Arctic summer after 10 yrs</td>
</tr>
</tbody>
</table>
Solvable
We Need to Make Big Cuts, Fast

CO₂ EMISSIONS

Past  Today  2100

Continued Emissions

Emission cuts

+4°C

+1.5°C
GREENHOUSE GAS SOURCES
UNITED STATES EMISSIONS BY SECTOR

9% AGRICULTURE
12% COMMERCIAL & RESIDENTIAL
22% INDUSTRY
28% ELECTRICITY
29% TRANSPORTATION

Source: U.S. EPA 2017 (released 2019)
## California Solar Electricity Generation

<table>
<thead>
<tr>
<th></th>
<th>Yesterday</th>
<th>Today</th>
<th>Tomorrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Generated (MWH)</td>
<td>84,000</td>
<td>69,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Equivalent Homes Powered</td>
<td>34%</td>
<td>28%</td>
<td>31%</td>
</tr>
<tr>
<td>Home Energy Savings</td>
<td>110%</td>
<td>95%</td>
<td>104%</td>
</tr>
</tbody>
</table>

Electricity Generated (MWH): Approximate electricity generated in megawatt-hours.
Equivalent Homes Powered: Electricity generated divided by the number of homes in the area, assuming average daily electricity usage.
Home Energy Savings: Percentage of daily electricity cost saved by an average household with an average-sized solar array who does not have previously power sold from the grid.
Source: Climate Central / WeatherFlower tool

## California Wind Electricity Generation

<table>
<thead>
<tr>
<th></th>
<th>Yesterday</th>
<th>Today</th>
<th>Tomorrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Generated (MWH)</td>
<td>54,000</td>
<td>3,300</td>
<td>2,800</td>
</tr>
<tr>
<td>Equivalent Homes Powered</td>
<td>22%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Smartphones Charged</td>
<td>4.9 billion</td>
<td>298.6 million</td>
<td>258.8 million</td>
</tr>
</tbody>
</table>

Electricity Generated (MWH): Approximate electricity generated in megawatt-hours.
Equivalent Homes Powered: Electricity generated divided by the number of homes in the area, assuming average daily electricity usage.
Smartphones Charged: Charged (approximated) - the number of typical smartphones that could be charged using the amount of electricity generated.
Source: Climate Central / WeatherFlower tool
Electrifying Transport
Better Buildings

- Dynamic Glass
- Insulation
- Electric heating & cooling
BUILDING BETTER SOILS
Farming practices that increase soil carbon

- Apply compost
- Grow a cover crop
- Reduce tilling

Source: Paustian et al. 2017
Maintain Natural Carbon Sinks & Flood Buffers

- Coastal Wetlands
- Peatlands
- Grasslands
- Forests
UNITED STATES
THE POWER OF TREES

1,438.2
MILLION TONS
CO₂ EQUIVALENT REMOVED

398,810
MILLION GALLONS
STORM RUNOFF AVOIDED

35,429
MILLION POUNDS
AIR POLLUTION ABSORBED

Source: U.S. Forest Service - Tree County Tool
We Have Done Big Things Before
[Insert who/what inspires you to combat climate change here]
- **Simple**
  - Well-understood science that goes back to 1800s
- **Serious**
  - Impacts are already being felt & will only accelerate
- **Solvable**
  - We have what we need to make changes
Special thanks to Scott Denning at Colorado State for the Simple, Serious, Solvable framing
ADDITIONAL SLIDES
For those wanting to go deeper into some topics

- **Supplementary Slides:** *premade slides with main points provided*
  - Greenhouse effect – animation (58)
  - Longer term glacial retreat – Muir Glacier (59)
  - Paleo-climate reconstruction and long term carbon dioxide time series data (60-62)
  - Length of greenhouse gases in the atmosphere (63)
  - Rising Temperatures, US and global (64-66)
  - Astronomical influences (67-68)
  - Ocean temperatures – Time series with ENSO fluctuations (69)
  - Consensus science (70)
  - Projections and pathways (71-73)

- **Local + Extra Slides:** *collection of local and extra graphics organized by topic*
  - Extreme Weather
  - Rising Temperatures
  - Ice & Snow
  - Sea Level Rise & Ocean Warming
  - Health Impacts
Supplementary Graphics

These additional slides can help you further explore a specific topic, if desired.
The Greenhouse Effect
Alaska's Muir Glacier
Reconstructing Past Climates
GREENHOUSE GASES LAST A LONG TIME

- **METHANE**: 10 YEARS
- **NITROUS OXIDE**: 100 YEARS
- **CARBON DIOXIDE**: 1000+ YEARS

Numbers based on lifetime in atmosphere, not their warming potential
10 HOTTEST GLOBAL YEARS ON RECORD

Source: NASA GISS & NOAA NCEI global temperature anomalies averaged and adjusted to early industrial baseline (1881–1910). Data as of 1/14/2021.
GLOBAL DECADES OF WARMING

Average decadal temperature anomalies from 20th century average (°F). Data through October 2019. Source: NOAA
Natural Climate Change - Takes Much Longer

**Axial Precession (Wobble)**
26,000-year cycles

**Changes in Eccentricity (Orbit Shape)**
100,000-year cycles

*Changes in eccentricity exaggerated so the effect can be seen. Earth's orbit shape varies between 0.0034 (almost a perfect circle) to 0.058 (slightly elliptical).*

**Changes in Obliquity (Tilt)**
41,000-year cycles

climate.nasa.gov
Human-caused Climate Change is widely agreed upon...

97% of actively publishing climate scientists agree that human-caused climate change is happening.

99.9% of scientific research studies published in peer-reviewed scientific journals find that human-caused climate change is happening.
FAQ 1.2: How close are we to 1.5°C?

Human-induced warming reached approximately 1°C above pre-industrial levels in 2017.
Data: SSP database (IIASA)/GCP/Riahi et al 2017/Rogelj et al 2018

**Scenario group**

Forcing target and temperature range in 2100

- Baseline (3.0–5.1°C)
- 6.0 W/m² (3.2–3.3°C)
- 4.5 W/m² (2.5–2.7°C)
- 3.4 W/m² (2.1–2.3°C)
- 2.6 W/m² (1.7–1.8°C)
- 1.9 W/m² (1.3–1.4°C)

Net CO₂ emissions (GtCO₂)

- >5°C
- 4–5°C
- 3–4°C
- 2–3°C
- <2°C

net-negative global emissions

Global Carbon Project
Sea Level Rise Projections over a century

The graph shows projections of sea level rise from 1800 to 2100 under different scenarios. The projections are categorized as:
- Historical (geological and tide gauge data)
- Intermediate-High
- Historical (satellite data)
- Intermediate
- Extreme
- Intermediate-Low
- High
- Low

The Y-axis represents the change in sea level (feet) and the X-axis represents the year. The projections are color-coded and the vertical bars indicate the range of sea level rise for each scenario (RCP2.6, RCP4.5, RCP8.5).
Local + Extra Graphics

Directly copy or click on the URL in the slide notes to use the desired graphic

*look for the 🏡 in the upper left of slides to indicate images with local data - URL in slide notes*
Extreme Weather

More Extreme Weather

Power Outages
Rising Temperatures

Not-So-Extreme Cold

Warm Summer Nights

Days Above X

Seasonal Warming
Ice & Snow

Great Lakes Meltdown

Snowfall Trends (Winter, Fall, Spring, Summer)
Sea Level Rise & Ocean Warming

Ocean Heat Waves

Where’s the Heat?

Coastal Flood Days

What’s At Risk?
Health Impacts

Algal Blooms
Poison Ivy
Pollen
Mosquitoes

PM 2.5
Air Pollution
Ticks