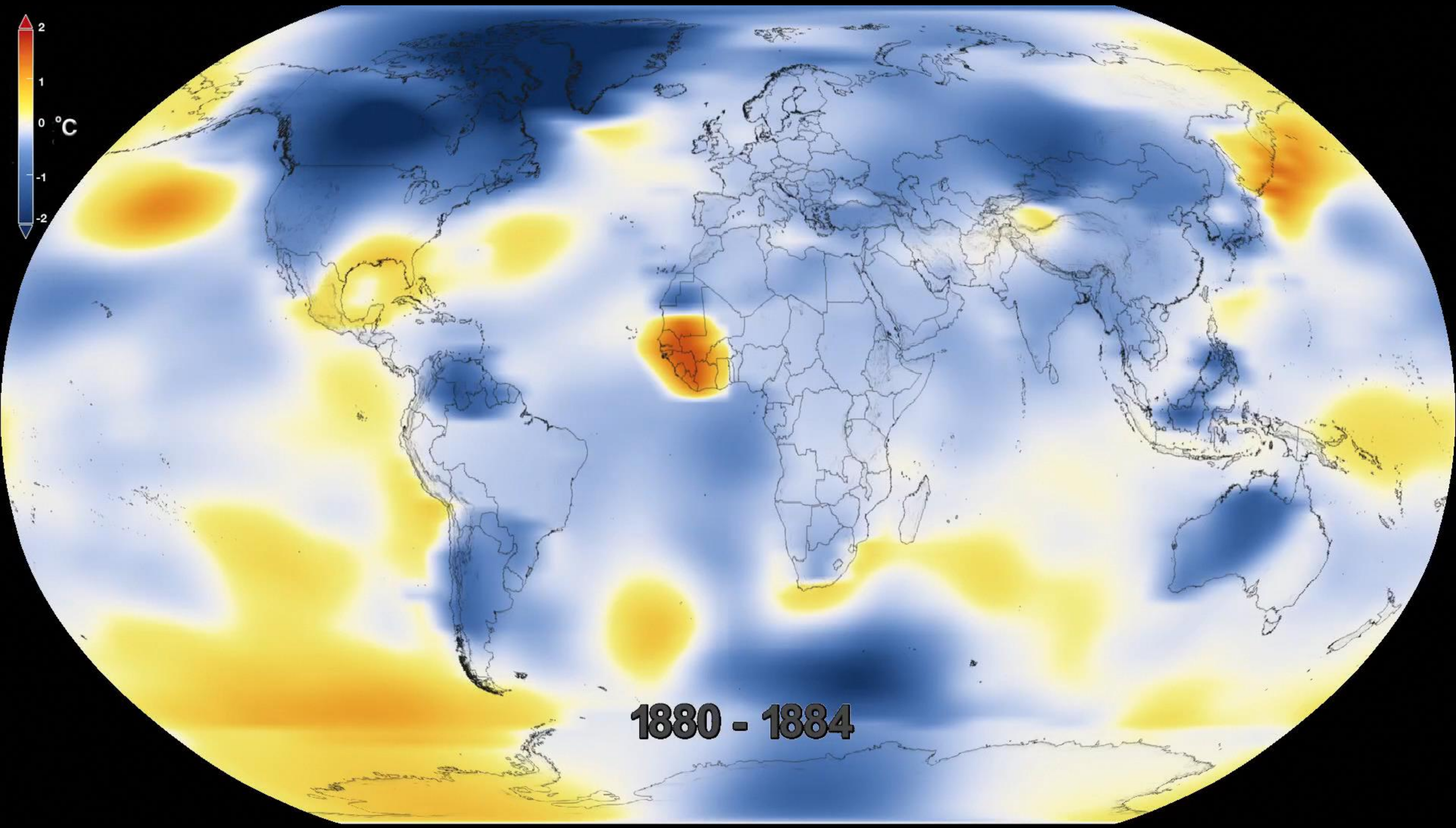
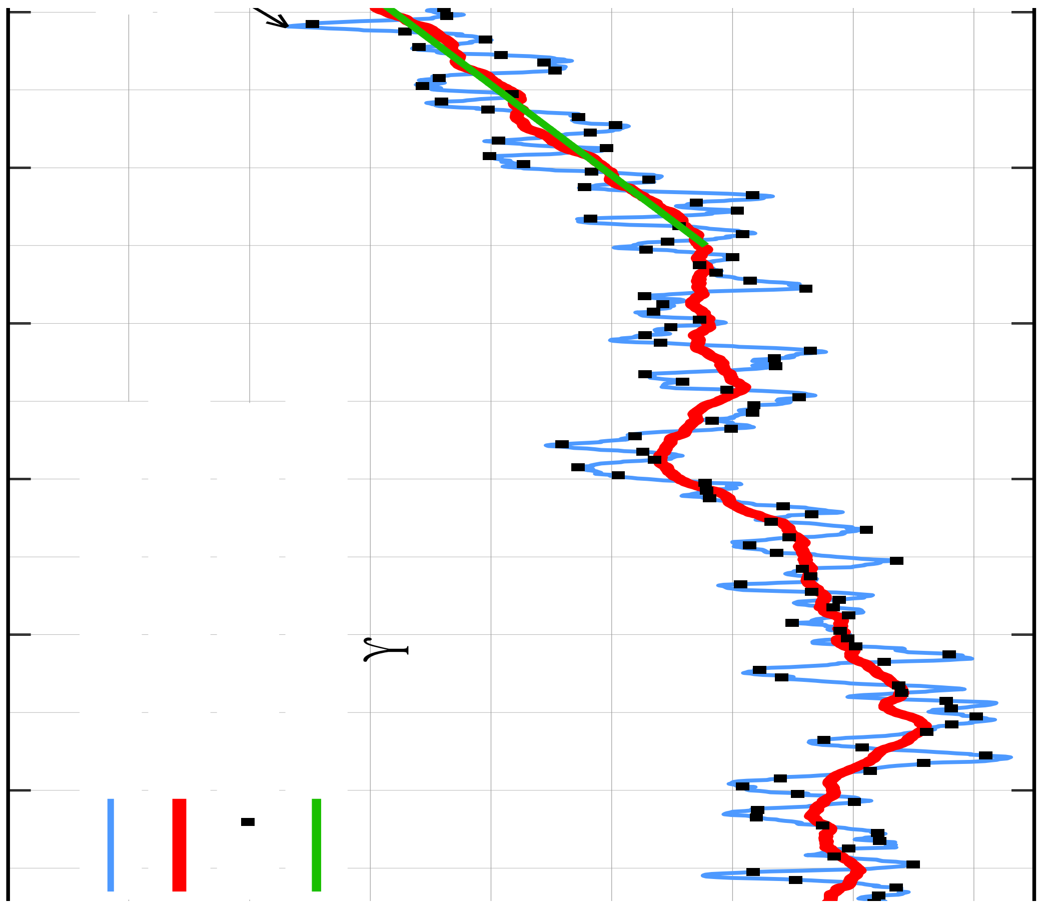
The Climate Crisis

Dr. Chip Fletcher, SOEST, University of Hawai'i at Mānoa

The world is now 1^{o}C (1.8^{o}F) warmer



Global Surface Temperature relative to 1880-1920 mean

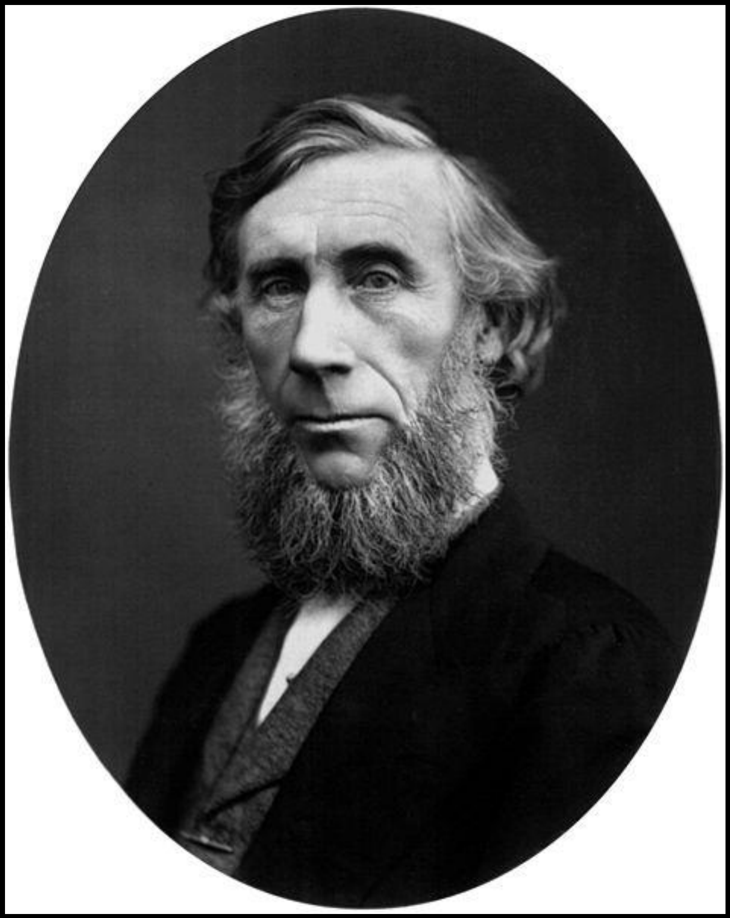


Jim Hansen: http://www.columbia.edu/~mhs119/Temperature/

Jean-Baptiste Joseph Fourier (1768-1830)

French mathematician, physicist

- Calculated that Earth should be considerably colder than it is.
- He considered that Earth's atmosphere might act as an insulator.
- First recognition of Greenhouse Effect



John Tyndall (1820–1893) *Irish physicist*

- First to measure heat trapping by atmospheric gases
- Identified the role of CO_2 in absorbing heat
- Proved what Greenhouse Effect was real

Svante Arrhenius (1859–1927) *Swedish chemist/physicist*

- F rst to conclude that ng coal could cause rming.
- Sugg t human emissio ould be strong enou vent the world from ent w ice age, and that a Earth would be neede feed the rapidly increasin population

“Arrhenius Effect”

Guy Stewart Callendar (1897–1964) *English engineer*

“Callendar Effect”

- vered temperature
  i rom nineteenth
  centu
- Correlateu
  measurement
- Concluded that CO_2
  causing climate change.

Charles David Keeling (1928-2005) *American chemist*

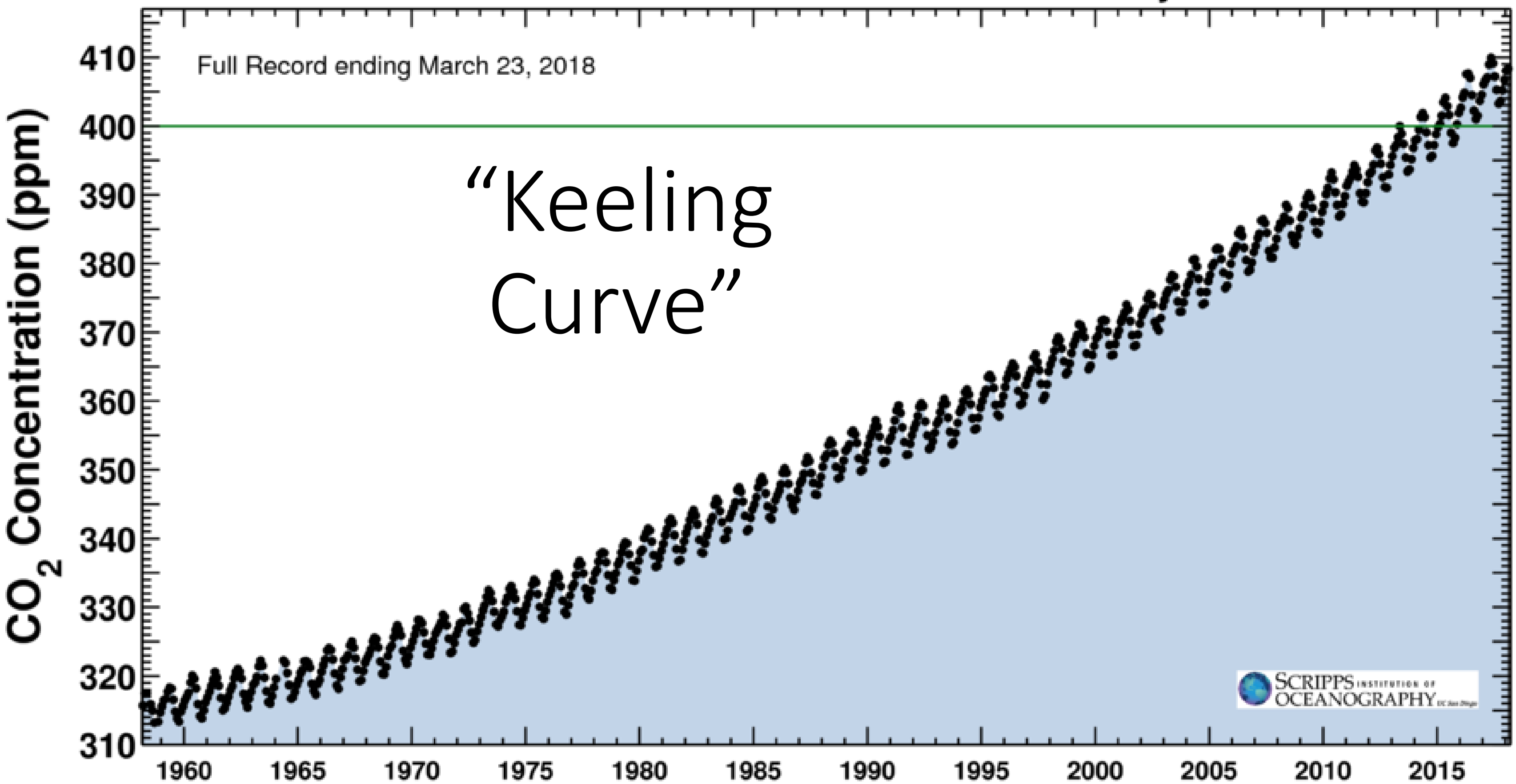
- 1961 showed that CO_2 levels w... ising steadily.
- Nov... continuous record ... the world showing tha... grown from 315 ppm i... 409 ppm in 2018.

“Keeling Curve”

Latest CO_2 reading
March 23, 2018

409.53 ppm

Carbon dioxide concentration at Mauna Loa Observatory




60% of the warming is
due to human
greenhouse gas
emissions

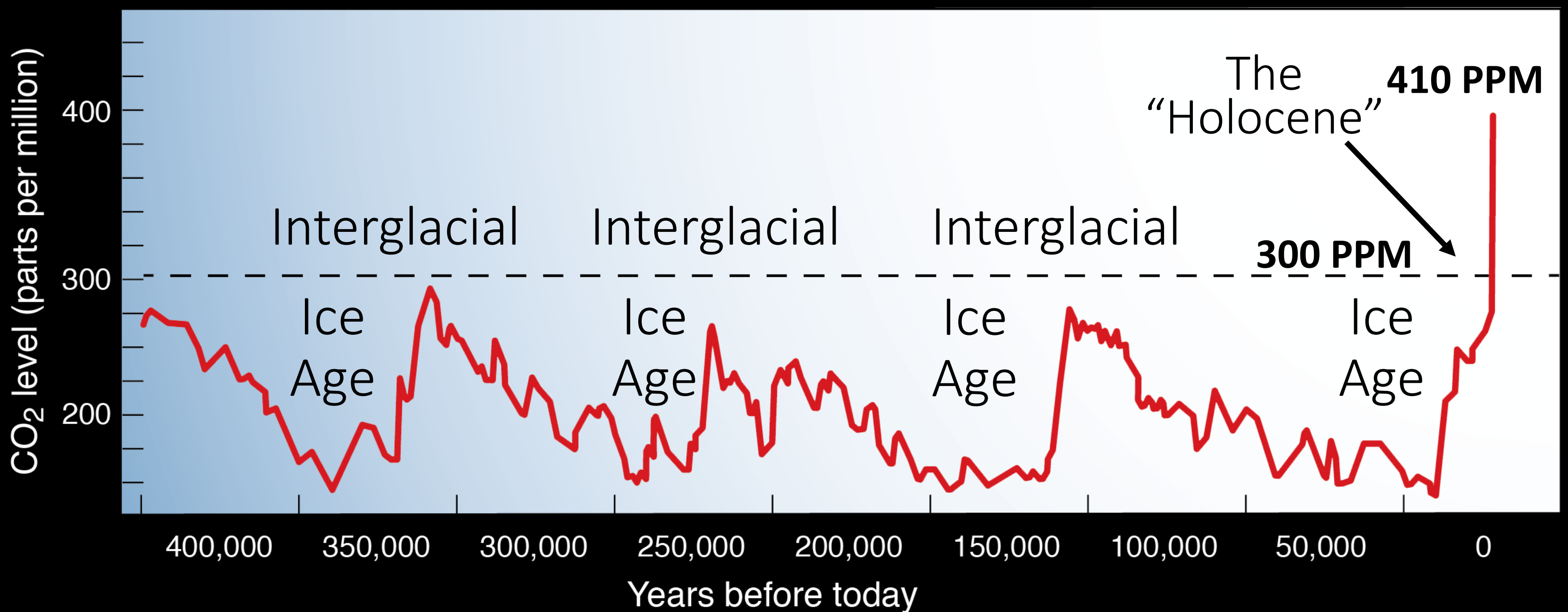

18% results from deforestation


18-22% of global warming comes from industrial meat production

0.5 to 1.1^{o}C warmer if not for aerosols

https://e360.yale.edu/features/air-pollutions-upside-a-brake-on-global-warming

We have exceeded natural levels of carbon dioxide by 45%, highest in millions of years



Bartoli, G., B. Hönisch, and R. E. Zeebe (2011), Atmospheric CO_2 decline during the Pliocene intensification of Northern Hemisphere glaciations, Paleoceanography, 26, PA4213, doi:10.1029/2010PA002055.
Tripati, A.K., et al., 2009, Coupling of CO_2 and Ice Sheet Stability Over Major Climate Transitions of the Last 20 Million Years, Science, 04 Dec 2009 : 1394-1397

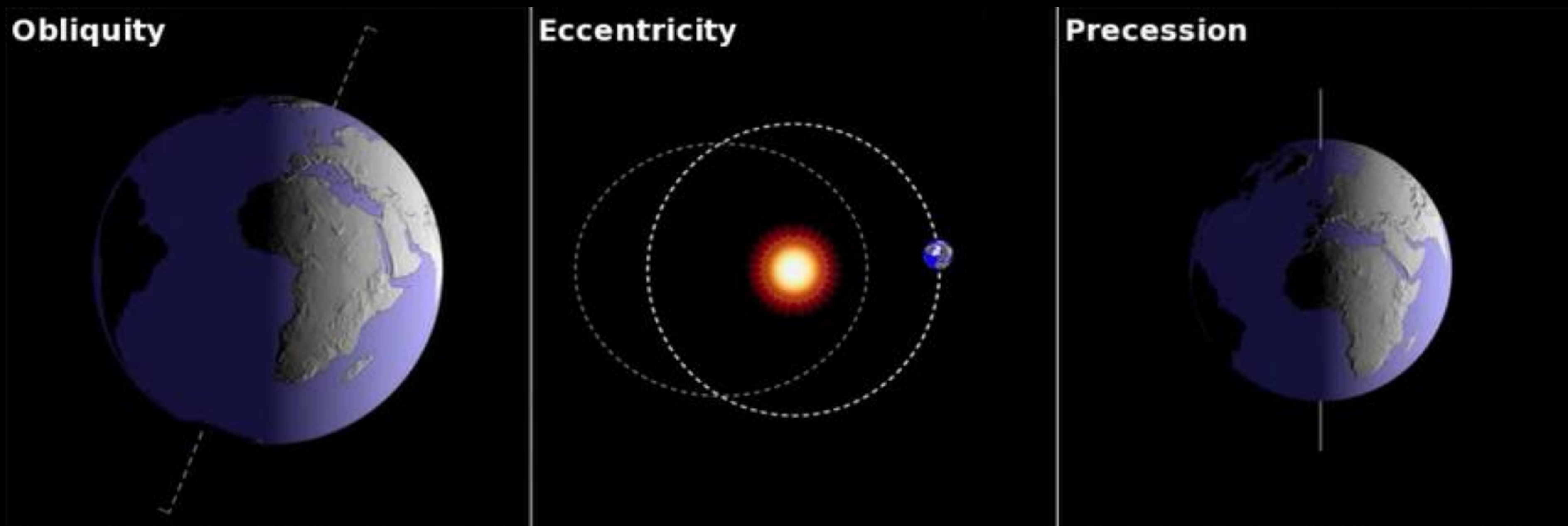
Natural Climate Change is fairly well understood

***Orbital parameters** determine the intensity and duration of **Arctic summer** and lead to **ice ages** and **interglacials**.*

Axial Obliquity– 41,000 yrs

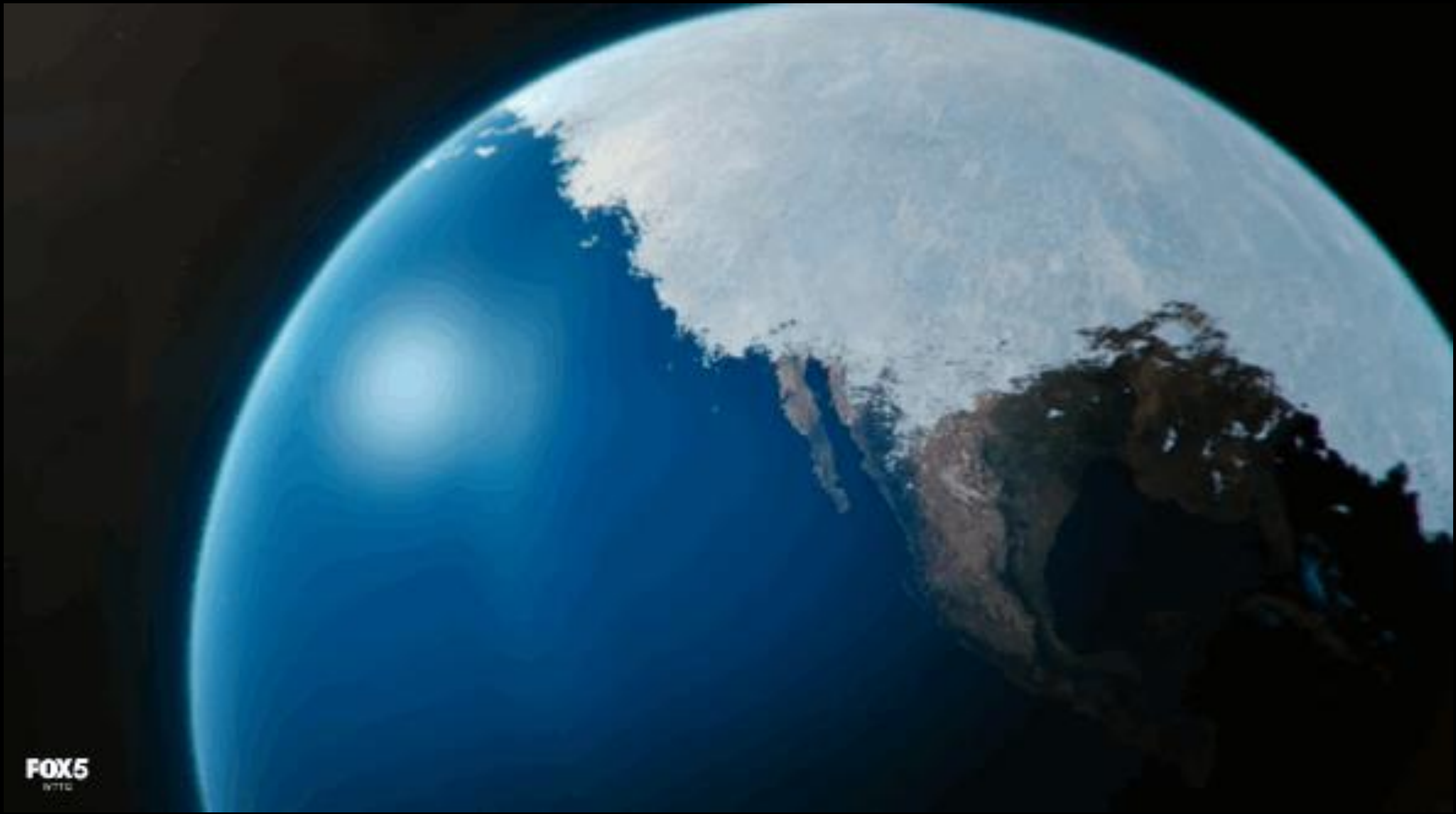
Eccentricity
100,000 and 400,000 yrs

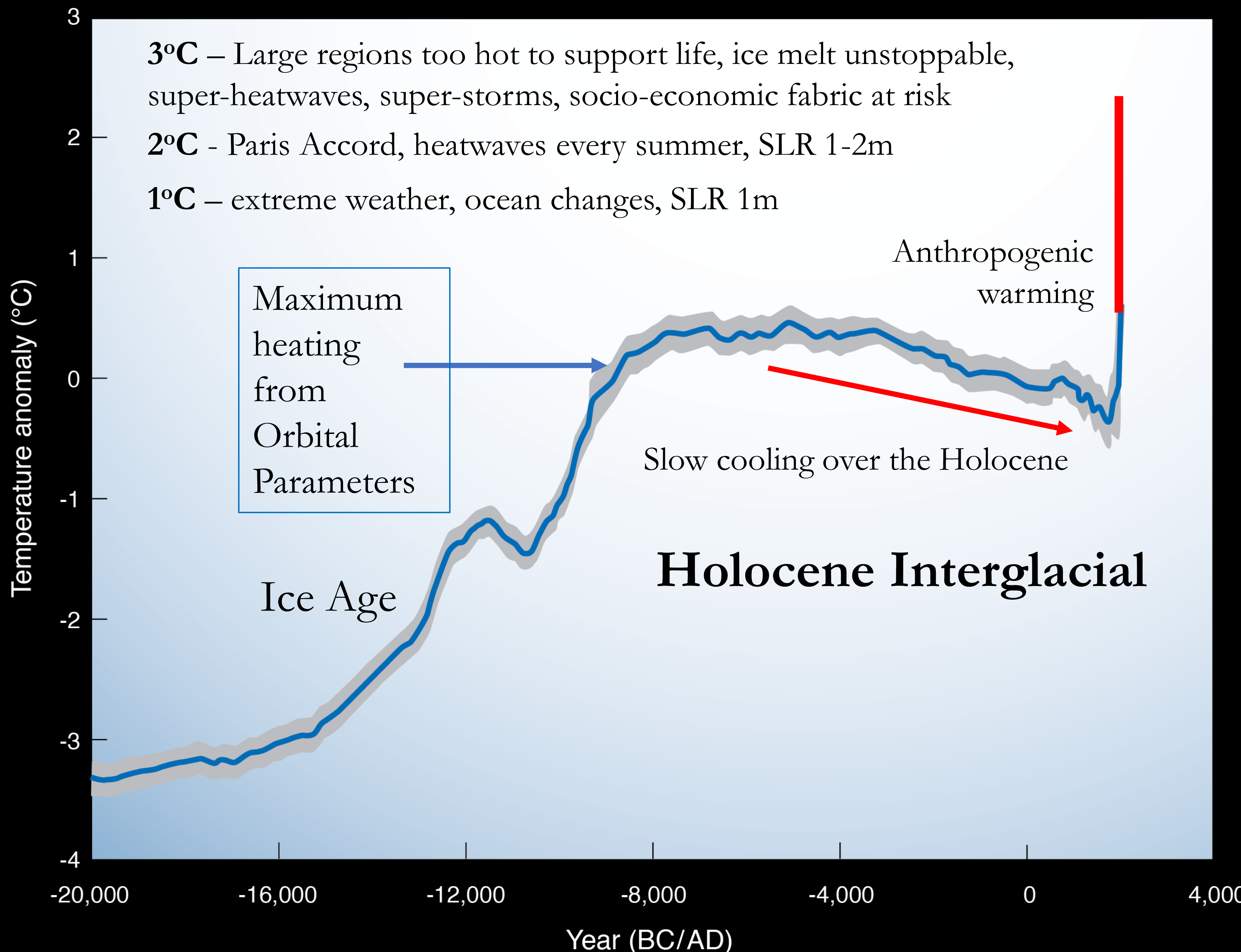
Axial Precession – 26,000 yrs



Ice Age

Interglacial





Marcott, S.A., 2013, A Reconstruction of Regional and Global for the Past 11,300 Years, *Science,* 08 Mar: 1198-1201Temperature

Global Warming is changing our world.

Mora, C., et al. (2017) **Global risk of deadly heat.** *Nature Climate Change*; DOI: 10.1038/NCLIMATE3322

les **THINKPROGRESS**

Water shortages will put 5 billion people at risk by 2050, U.N. warns

Climate change, pollution, and growing demand will put increased pressure on the world's water supplies.

KYLA MANDEL MAR 19, 2018, 1:47 PM

SHARE

IN MARCH, THE KENYAN GOVERNMENT DECLARED THE REGION A 'NATIONAL EMERGENCY' AS THE SEVERE DROUGHT TAKES HOLD. CREDIT: GILES CLARKE/GETTY IMAGES FOR UNOCHA

Almost half of the world's population — some 3.6 billion people — currently live in areas vulnerable to water scarcity. By 2050, this is expected to increase to around 5 billion people, a new United Nations report warns

Half of human population live with water scarcity.

By 2050 this will increase to 5 billion people

Bloomberg Markets

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BREAKING NEWS 9:35 AM **U.K. Watchdog Gets Warrant to Search Cambridge Analytica Offices**

Food Crises Intensifying Because of Climate Change and Conflict

By **Agnieszka De Sousa**
March 22, 2018, 2:17 AM HST

- More lives at risk from lack of food, according to UN and EU
- Food crises set to become more acute, EU commissioner warns

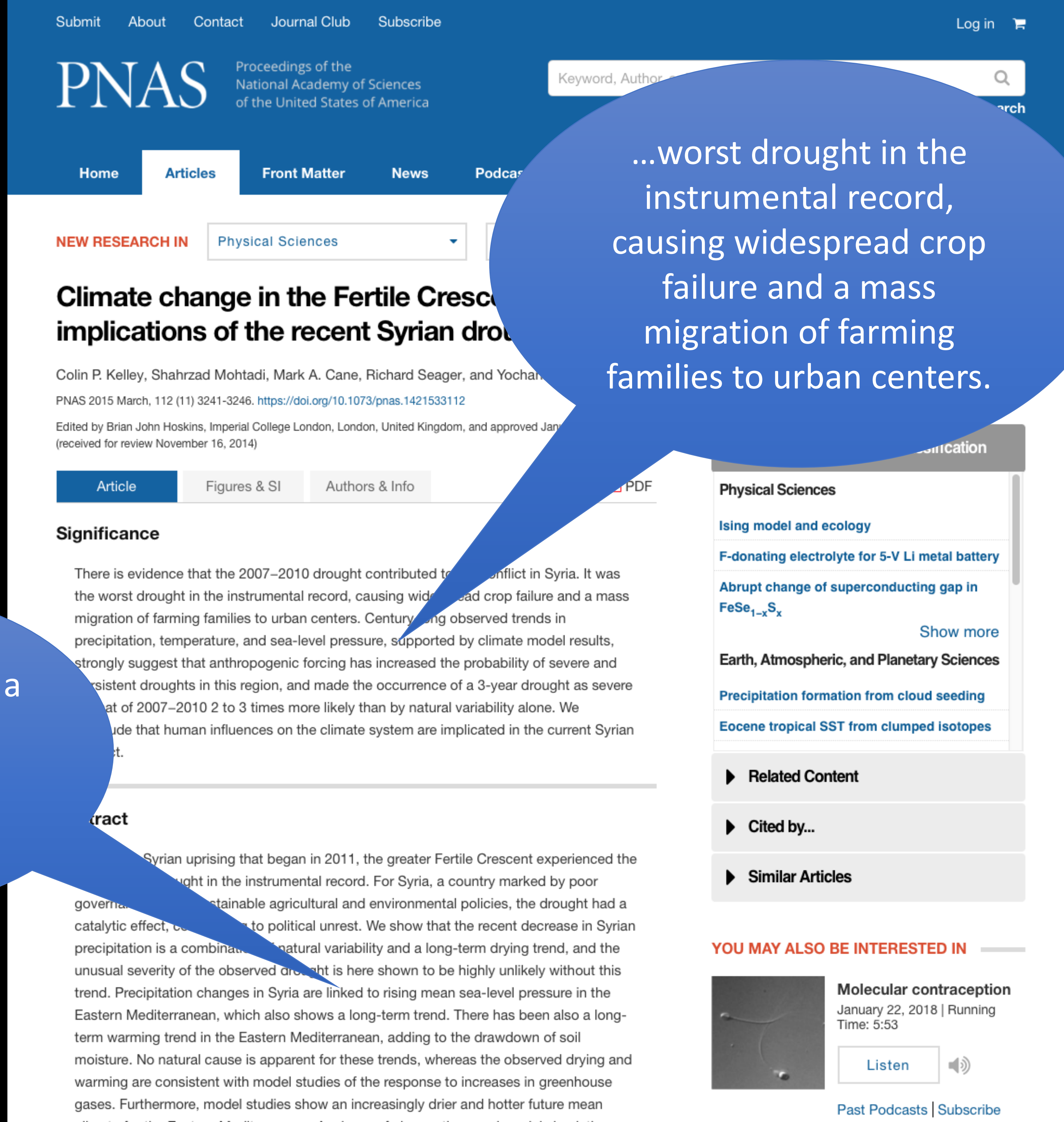
Global food crises are poised to worsen in some areas as conflict and climate

2017 - 124 million in 51 countries faced acute food insecurity

- Increase of 11 million from 2016
- Triggered by extreme climate events –- mainly drought
- In 18 countries, these conditions drove rising conflict, leading to further hunger

Extreme heat leads to drought and famine – driving people from their homelands

Drought in Syria led to civil war and terrorism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NEW RESEARCH IN Physical Sciences

Climate change in the Fertile Cresc… implications of the recent Syrian dro…

Colin P. Kelley, Shahrzad Mohtadi, Mark A. Cane, Richard Seager, and Yochan…

PNAS 2015 March, 112 (11) 3241-3246. https://doi.org/10.1073/pnas.1421533112

Edited by Brian John Hoskins, Imperial College London, London, United Kingdom, and approved Jan… (received for review November 16, 2014)

Article | Figures & SI | Authors & Info | PDF

Significance

There is evidence that the 2007–2010 drought contributed t… …nflict in Syria. It was the worst drought in the instrumental record, causing wid… …ead crop failure and a mass migration of farming families to urban centers. Century… …ng observed trends in precipitation, temperature, and sea-level pressure, supported by climate model results, strongly suggest that anthropogenic forcing has increased the probability of severe and …sistent droughts in this region, and made the occurrence of a 3-year drought as severe …at of 2007–2010 2 to 3 times more likely than by natural variability alone. We …ude that human influences on the climate system are implicated in the current Syrian …t.

…ract

…Syrian uprising that began in 2011, the greater Fertile Crescent experienced the …ught in the instrumental record. For Syria, a country marked by poor governa… …stainable agricultural and environmental policies, the drought had a catalytic effect, c… …to political unrest. We show that the recent decrease in Syrian precipitation is a combina… …natural variability and a long-term drying trend, and the unusual severity of the observed dro…ht is here shown to be highly unlikely without this trend. Precipitation changes in Syria are linked to rising mean sea-level pressure in the Eastern Mediterranean, which also shows a long-term trend. There has been also a long-term warming trend in the Eastern Mediterranean, adding to the drawdown of soil moisture. No natural cause is apparent for these trends, whereas the observed drying and warming are consistent with model studies of the response to increases in greenhouse gases. Furthermore, model studies show an increasingly drier and hotter future mean

…ication

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…worst drought in the instrumental record, causing widespread crop failure and a mass migration of farming families to urban centers.

…the drought had a catalytic effect, contributing to political unrest.


JUST

Syrian refugees flooded into Europe by the millions

… creating a backlash among residents

Our basic socio-economic system, and core humanitarian principles are at risk

Sebastian Kurz…..campaigned on the need for tougher immigration controls, quickly

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October 19,

N

By

PHOTO ILLUSTRATION: 731; PHOTOS: BLOOMBERG (1), GETTY IMAGES (2)

As Europeans assess the fallout from the U.K.'s Brexit referendum, they face a series of elections that could equally shake the political establishment. In the coming 12 months, four of Europe's five largest economies have votes that will almost certainly mean serious gains for right-wing populists and nationalists. Once seen as fringe groups, France's National Front, Italy's Five Star Movement, and the Freedom Party in the Netherlands have attracted legions of followers by

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Austria likely takes a right turn as 31-year-old minister declares victory in election

's

ent.

Gallup | Getty Images

n Foreign Minister and leader of the conservative Austrian Peoples Party (OeVP) n Kurz speaks to media as he arrives to cast his ballot in Austrian parliamentary n October 15, 2017 in Vienna, Austria.

Austria year-old foreign minister declared victory for his party Sunday in tional election that set him up to become Europe's youngest lea and puts the country on course for a rightward turn.

Foreign Minister Se astian Kurz claimed the win as final results announced by the Interior Ministry showed his People's Party had a comfortable lead with almost all the ballots counted.

Noting that his center-right party had triumphed over the rival Social Democrats only twice since the end of World War II, Kurz called it a

Wild fires have increased 9-fold

Kitzberger T, et al.(2017) Direct and indirect climate controls predict heterogeneous early-mid 21st century wildfire burned area across western and boreal North America. PLoS ONE 12(12). https://doi.org/10.1371/journal.pone.0188486
Abatzoglou, J.T., Williams, A.P. (2016) Impact of anthropogenic climate change on wildfire across western U.S. forests. *Proceedings of the National Academy of Sciences*; 201607171 doi: 10.1073/pnas.1607171113

Centre for Research on the Epidemiology of Disasters, UN International Strategy for Disaster Reduction: http://reliefweb.int/report/world/human-cost-weather-related-disasters-1995-2015

Extreme rainfall has increased 12%

Lehmann, J., et al. (2015) Increased record-breaking precipitation events under global warming, *Climatic Change*, doi: 10.1007/s10584-015-1434-y

Food is less nutritious.

Decreased zinc, iron, and protein

nature
International journal of science

Letter

Increasing CO_2 threatens human nutrition

Samuel S. Myers, Antonella Zanobetti, Itai Kloog, Peter Huybers, Andrew D. B. Leakey, Arnold J. Bloom, Eli Carlisle, Lee H. Dietterich, Glenn Fitzgerald, Toshihiro Hasegawa, N. Michele Holbrook, Randall L. Nelson, Michael J. Ottman, Victor Raboy, Hidemitsu Sakai, Karla A. Sartor, Joel Schwartz, Saman Seneweera, Michael Tausz & Yasuhiro Usui

Nature **510**, 139–142 (05 June 2014)
doi:10.1038/nature13179
Download Citation
Environmental health

Received: 25 November 2013
Accepted: 24 February 2014
Published online: 07 May 2014

Abstract

Dietary deficiencies of zinc and iron are a substantial global public health problem. An estimated two billion people suffer these deficiencies[1], causing a loss of 63 million life-years annually[2,3]. Most of these people depend on C_3 grains and legumes as their primary dietary source of zinc and iron. Here we report that C_3 grains and legumes have lower concentrations of zinc and iron when grown under field conditions at the elevated atmospheric CO_2 concentration predicted for the middle of this century. C_3 crops other than legumes also have lower concentrations of protein, whereas C_4 crops seem to be less affected. Differences between cultivars of a single crop suggest

Editorial Summary

Crop nutrient loss in high CO_2

It has been suggested that the conce
of important nutrients such as zinc a
in food crops will decrease with incr
atmospheric CO_2 levels. However, so
studies have not found this, and som
those that have relied on non-field c
or did not focus on edible crop parts
Myers *et al.* have assembled the large
set to date from free-air CO_2 enrichm
experiments and find that C_3 crops (
and grasses) do indeed have reduced
iron levels under the elevated CO_2 co
predicted for the middle of this cent
Crops using the C_4 photosynthetic p
are less affected. These findings sugg
breeding cultivars for reduced sensit
elevated CO_2 may be an important p
health priority in many parts of the w
show less

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Scientific Data | Data Descriptor | OPEN

Impacts of elevated atmospher
on nutrient content of importa
crops

Lee H. Dietterich, Antonella Zanobetti [...]
Myers

RESEARCH ARTICLE

Climate-Related Local Extinctions Are Already Widespread among Plant and Animal Species

John J. Wiens

Published: December 8, 2016 • http://dx.doi.org/10.1371/journal.pbio.2001104

Abstract

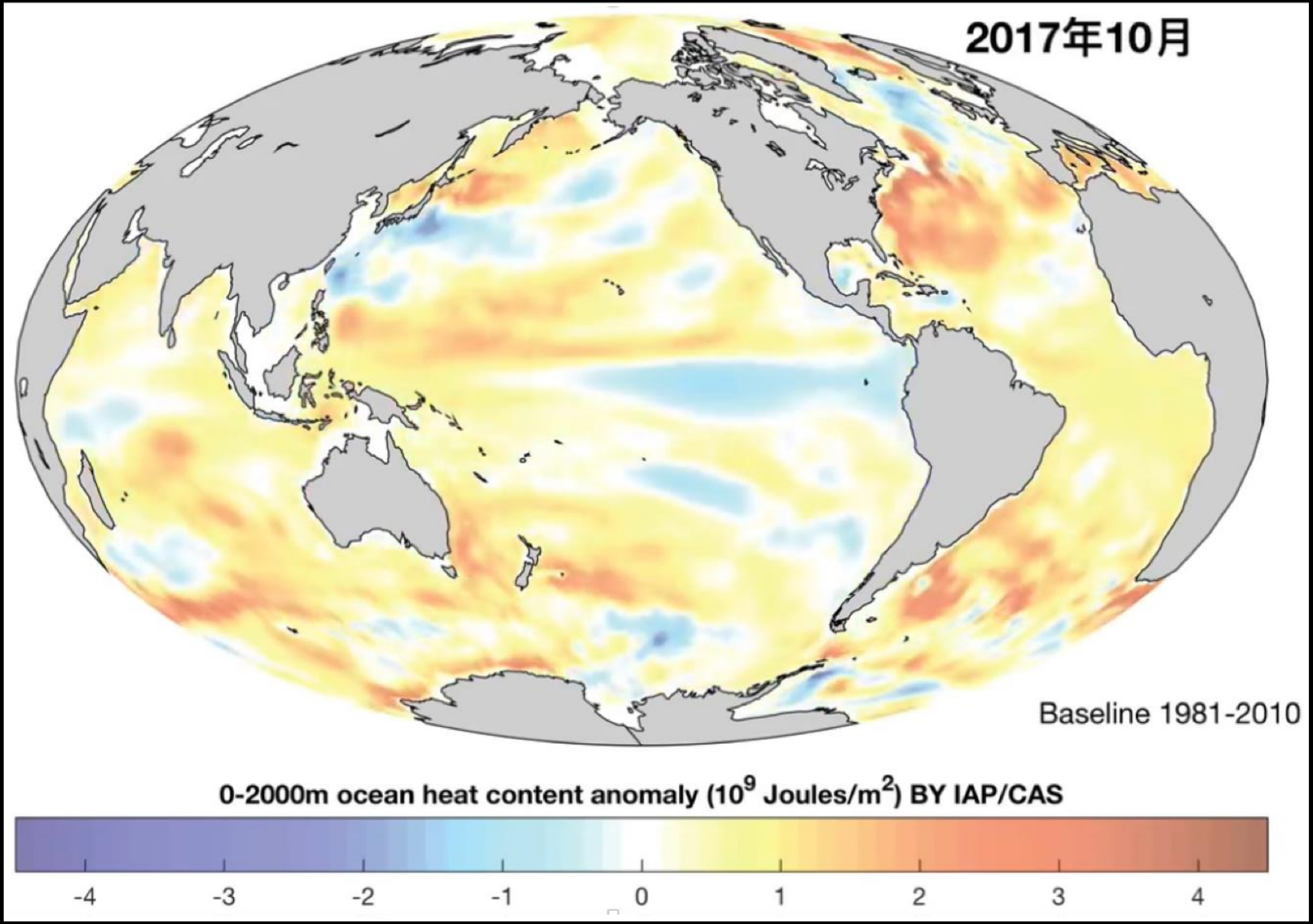
Current climate change may be a major threat to global biodiversity, but the extent of species loss will depend on the details of how species respond to changing climates. For example, if most species can undergo rapid change in their climatic niches, then extinctions may be limited. Numerous studies have now documented shifts in the geographic ranges of species that were inferred to be related to climate change, especially shifts towards higher mean elevations and latitudes. Many of these studies contain valuable data on extinctions of local populations that have not yet been thoroughly explored. Specifically, overall range shifts can include range contractions at the "warm edges" of species' ranges (i.e., lower latitudes and elevations), contractions which occur through local extinctions. Here, data on climate-related range shifts were used to test the frequency of local extinctions related to recent climate change. The results show that climate-related local extinctions have already occurred in hundreds of species, including 47% of the 976 species surveyed. This frequency of local extinctions was broadly similar across climatic zones, clades, and habitats but was significantly higher in tropical species than in temperate species (55% versus 39%), in animals than in plants (50% versus 39%), and in freshwater habitats relative to terrestrial and marine habitats (74% versus 46% versus 51%). Overall, these results suggest that local extinctions related to climate change are already widespread, even though levels of climate change so far are modest relative to those predicted in the next 100 years. These extinctions will presumably become much more prevalent as global warming increases further by roughly 2-fold to 5-fold over the coming decades.

Author Summary

Climate change is an important threat to the world's plant and animal species, including species on which humans depend. However, predicting how species will respond to future climate change is very difficult. In this study, I analyze the extinctions caused by the climate change that has already occurred. Numerous studies find that species are shifting their geographic ranges in response to climate change, typically moving to higher elevations and latitudes. These studies also contain valuable data on local extinctions, as they document the loss of populations at the "warm edge" of species' ranges (lower elevations and latitudes). Here, I use these data to show that recent local extinctions related to climate change have already occurred in hundreds of species around the world. Specifically, among 976 species surveyed, local extinctions occurred in 47%. These extinctions are common across climatic zones, habitats, and groups of organisms but are especially common in tropical regions (which contain most of Earth's species), in animals (relative to plants), and in freshwater habitats. In summary, this study reveals local extinctions in hundreds of species related to the limited

…climate-related local extinctions have already occurred in hundreds of species, including 47% of the 976 species surveyed.

2017 record highest ocean heat content since records began in 1958



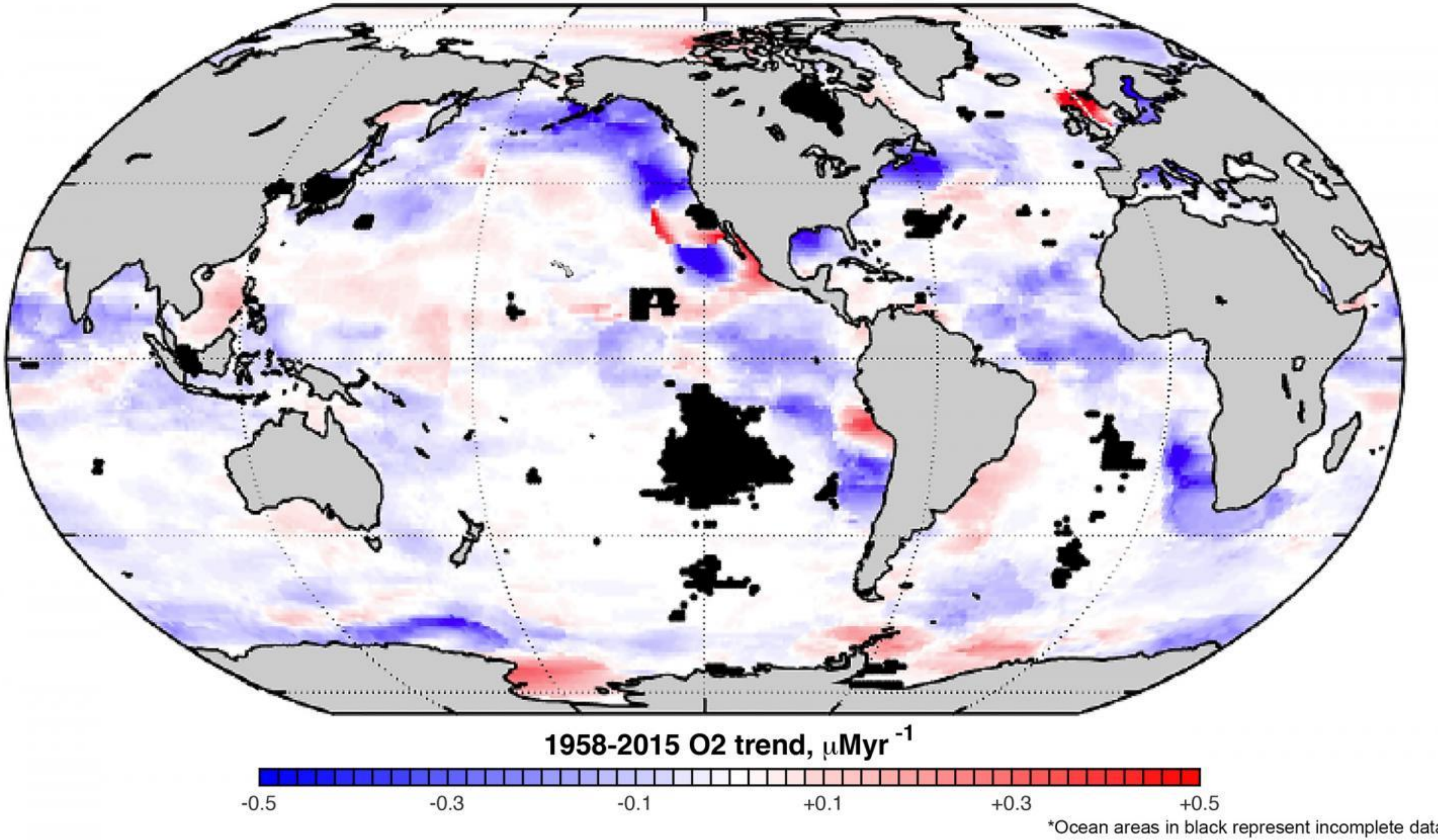
Cheng, L. J., and J. Zhu, 2018: 2017 was the warmest year on record for the global ocean. Adv. Atmos. Sci., 34(3), 261–263, https://doi.org/10.1007/s00376-018-8011-z.

Oceans are more acidic

…West Coast waters dissolving shells of *pteropods* food for pink salmon, mackerel and herring.

T. Friedrich, et al. (2012) Detecting Regional Anthropogenic Trends in Ocean Acidification against Natural Variability, *Nature Climate Change*, doi: 10.1038/NCLIMATE1372.
https://www.climate.gov/teaching/national-climate-assessment-resources-educators/ocean-region

2% decline in dissolved oxygen since 1950



Takamitsu Ito et al, Upper Ocean O trends: 1958-2015, *Geophysical Research Letters* (2017). DOI: 10.1002/2017GL073613

Article | OPEN

Warming Trends and Bleaching Stress of the World's Coral Reefs 1985–2012

Scott F. Heron, Jeffrey A. Maynard, Ruben van Hooidonk & C. Mark Eakin

Scientific Reports **6**, Article number: 38402 (2016)
doi:10.1038/srep38402
Download Citation

Environmental impact
Physical oceanography

Received: 25 May 2016
Accepted: 07 November 2016
Published online: 06 December 2016

Abstract

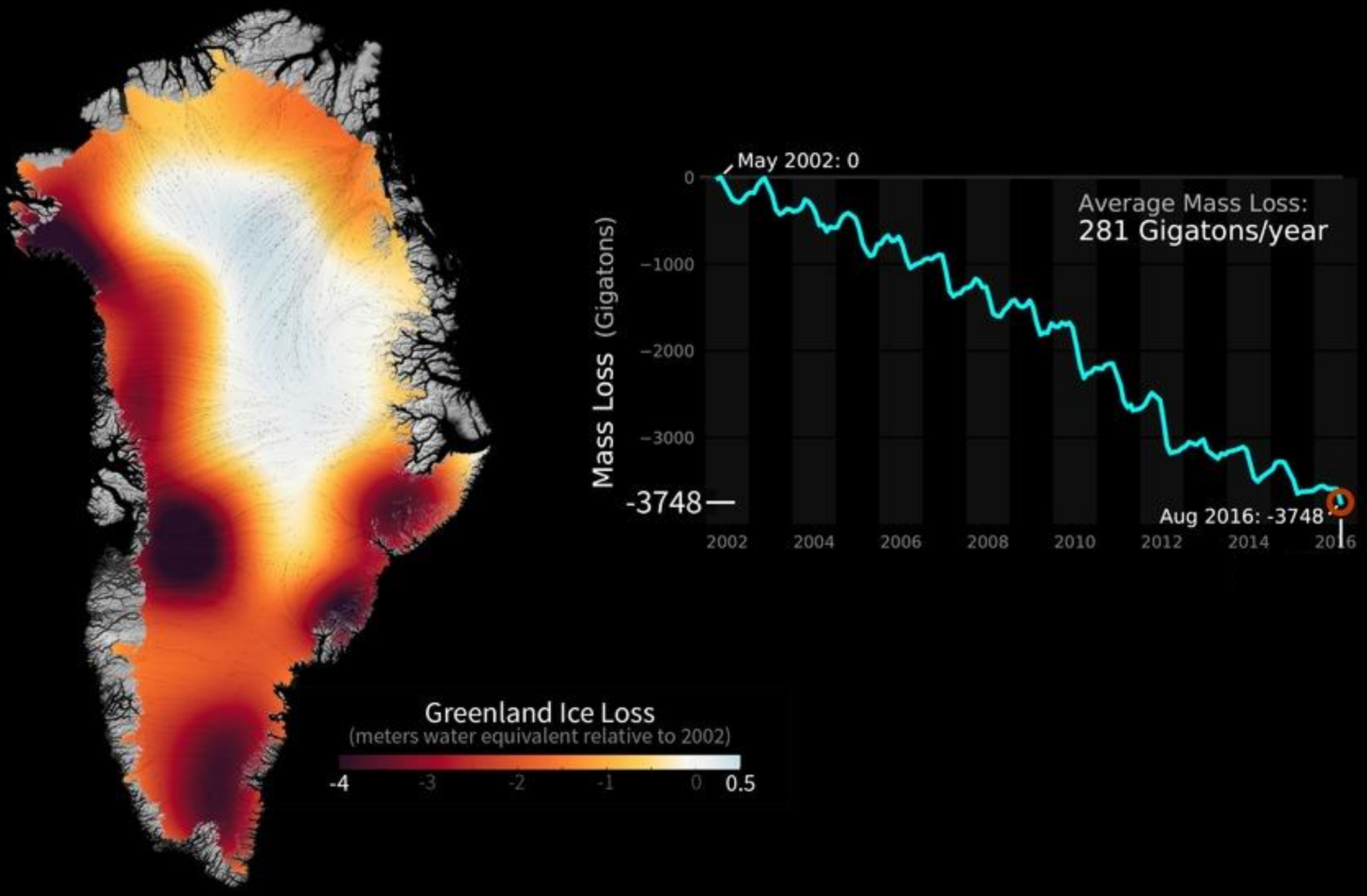
Coral reefs across the world's oceans are in the midst of the longest bleaching event on record (from 2014 to at least 2016). As many of the world's reefs are remote, there is limited information on how past thermal conditions have influenced reef composition and current stress responses. Using satellite temperature data for 1985–2012, the analysis we present is the first to quantify, for global reef locations, spatial variations in warming trends, thermal stress events and temperature variability at reef-scale (~4 km). Among over 60,000 reef pixels globally, 97% show positive SST trends during the study period with 60% warming significantly. Annual trends exceeded summertime trends at most locations. This indicates that the period of summer-like temperatures has become longer through the record, with a corresponding shortening of the 'winter' reprieve from warm temperatures. The frequency of bleaching-level thermal stress

The global percentage of reefs impacted by bleaching tripled through the 28-year record

By 2050 more than 98% of coral reefs will be afflicted by bleaching each year

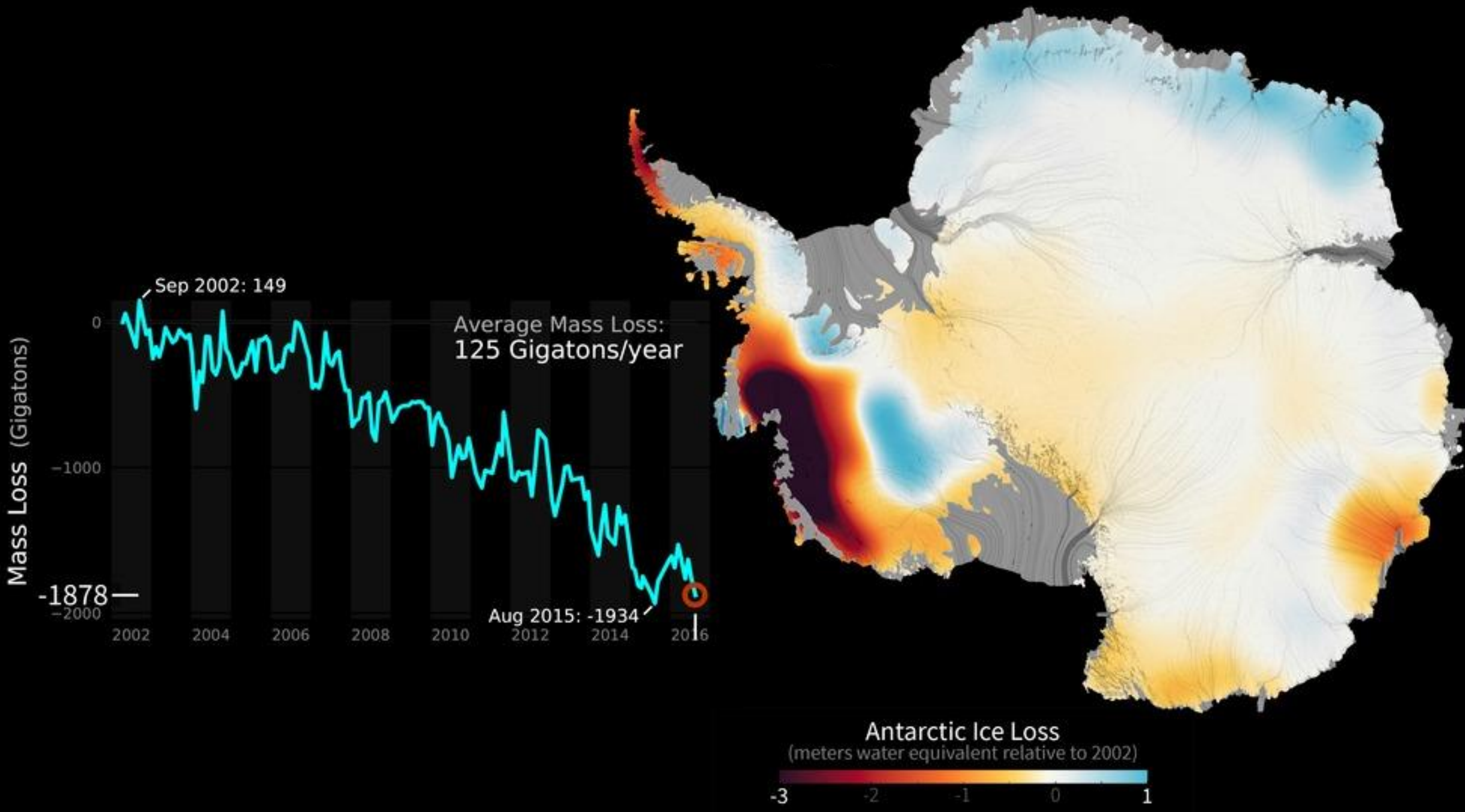
Four global bleaching events since 1998, none prior

Ice is melting – 600 billion tons each year and accelerating



https://climate.nasa.gov

Ice is melting – 600 billion tons each year and accelerating



https://climate.nasa.gov

NBC news West Antarctic collapse

Paris Agreement 2015

nearly every country pledged to keep global temperatures "well below" 2C

and to "pursue efforts to limit the temperature increase even further to 1.5C".

United Nations
Climate Change

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Paris Agreement - Status of Ratification

174

174 Parties have ratified of 197 Parties to the Convention

On 4 November 2016, the Paris Agreement entered into force.
More information

The Paris Agreement entered into force on 4 November 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 % of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depositary.

The list below contains the latest information concerning dates of signature and receipt of instruments of ratification by the Secretary-General of the United Nations, as Depositary of the Paris Agreement. The dates in the third column are those of the receipt of the instrument of ratification, acceptance (A) or approval (AA).

Authoritative information on the status of the Paris Agreement, including information on signatories to the Agreement, ratification and entry into force, is provided by the Depositary, through the United Nations Treaty Collection website, which can be accessed here, and the Depositary Notifications which are available here.

Background information related to the ratification, acceptance, approval or accession of the Paris Agreement, as well as its entry into force can be found here.

Paris Agreement

Paris, 12 December 2015

Entry into force: 4 November 2016

Status: Signatories: **195**. Parties: **174**

Note: The Paris Agreement was adopted on 12 December 2015 at the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change held in Paris from 30 November to 13 December 2015. In accordance with its article 20, the Agreement shall be open for signature at the United Nations Headquarters in New York from 22 April 2016 until 21 April 2017 by States and regional economic integration organizations that are Parties to the United Nations Framework Convention on Climate Change

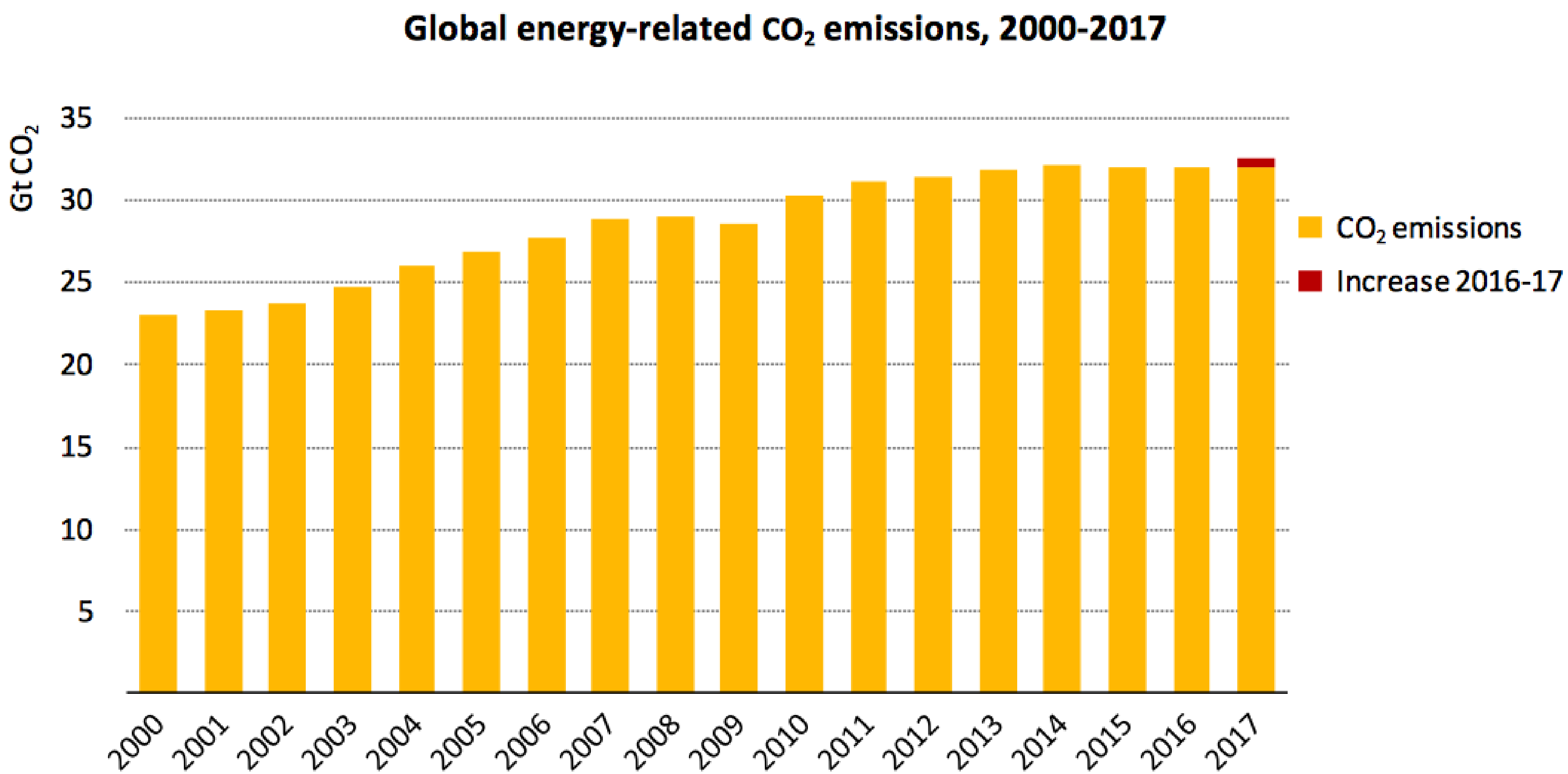
Authentic texts of the Paris Agreement
- Arabic (3595 kB)
- Chinese (3131 kB)
- English (4439 kB)
- French (5194 kB)
- Russian (5397 kB)
- Spanish (5234 kB)

First nationally determined contribution

By decision 1/CP.21, paragraph 22, the COP invited Parties to communicate their first nationally determined contribution (NDC) no later than when the Party submits its respective instrument of ratification, acceptance, approval or accession. If a Party has communicated an intended nationally determined contribution (INDC) prior to joining the Agreement, that Party shall be considered to have satisfied this provision unless that Party decides otherwise. Further information be found here.


Nations Unies
Conférence sur les Changements Climatiques 2015
COP21/CMP11
Paris, France
SECRETAIRE EXECUTIVE CCNUCC
PRESIDENT
SECRETAIRE

After 3 years of flat emissions 1.4% increase in 2017



International Energy Agency, World Energy Outlook, 2017 https://www.iea.org/weo2017/

After 3 years of flat emissions 1.4% increase in 2017

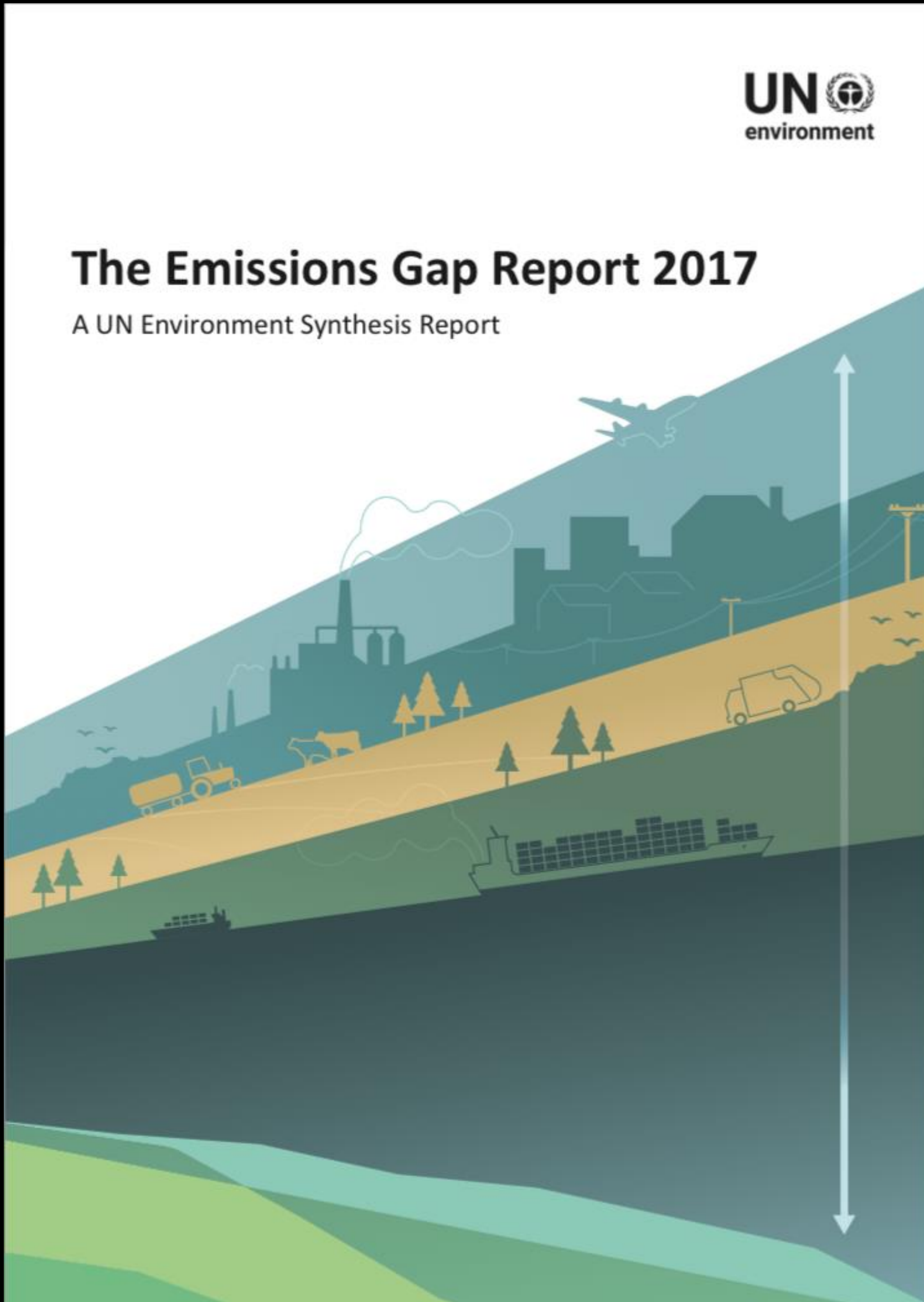
- **Energy**: Global energy demand increased by 2.1% in 2017, compared with 0.9% the previous year and 0.9% on average over the previous five years.
  - More than 40% of the growth was driven by China and India
  - 72% of the new energy demand was met by fossil fuels
  - 25% by renewables and the remainder by nuclear
  - Energy demand was more than twice the annual average seen over the last decade
  - Driven by: increasing share of sport-utility vehicles and light trucks in major economies and
  - Demand from the petrochemicals sector
- **Oil**: World oil demand rose by 1.6% (or 1.5 million barrels a day)
- **Carbon dioxide (CO2)**: Global energy-related CO2 emissions grew by 1.4%
- **Rise**: Most major economies saw a rise in emissions
- **Decline**: United States, United Kingdom, Mexico and Japan.
  - Largest decline came from the United States, mainly because of higher deployment of renewables.

International Energy Agency, World Energy Outlook, 2017 https://www.iea.org/weo2017/

Carbon Budget – in climate models, there is strong relationship between cumulative emissions, and temperatures

- 1.5^{o}C – 593 billion tons of Carbon (66%)
- 2019
- 2.0^{o}C – 790 billion tons of Carbon (66%)
- 2033 to 2037 (15 to 19 yrs.)

Gillett, N.P., V.K. Arora, D. Matthews, and M.R. Allen, 2013: Constraining the ratio of global warming to cumulative CO2 emissions using CMIP5 simulations, *J. Climate,*26, 6844–6858, https://doi.org/10.1175/JCLI-D-12-00476.1



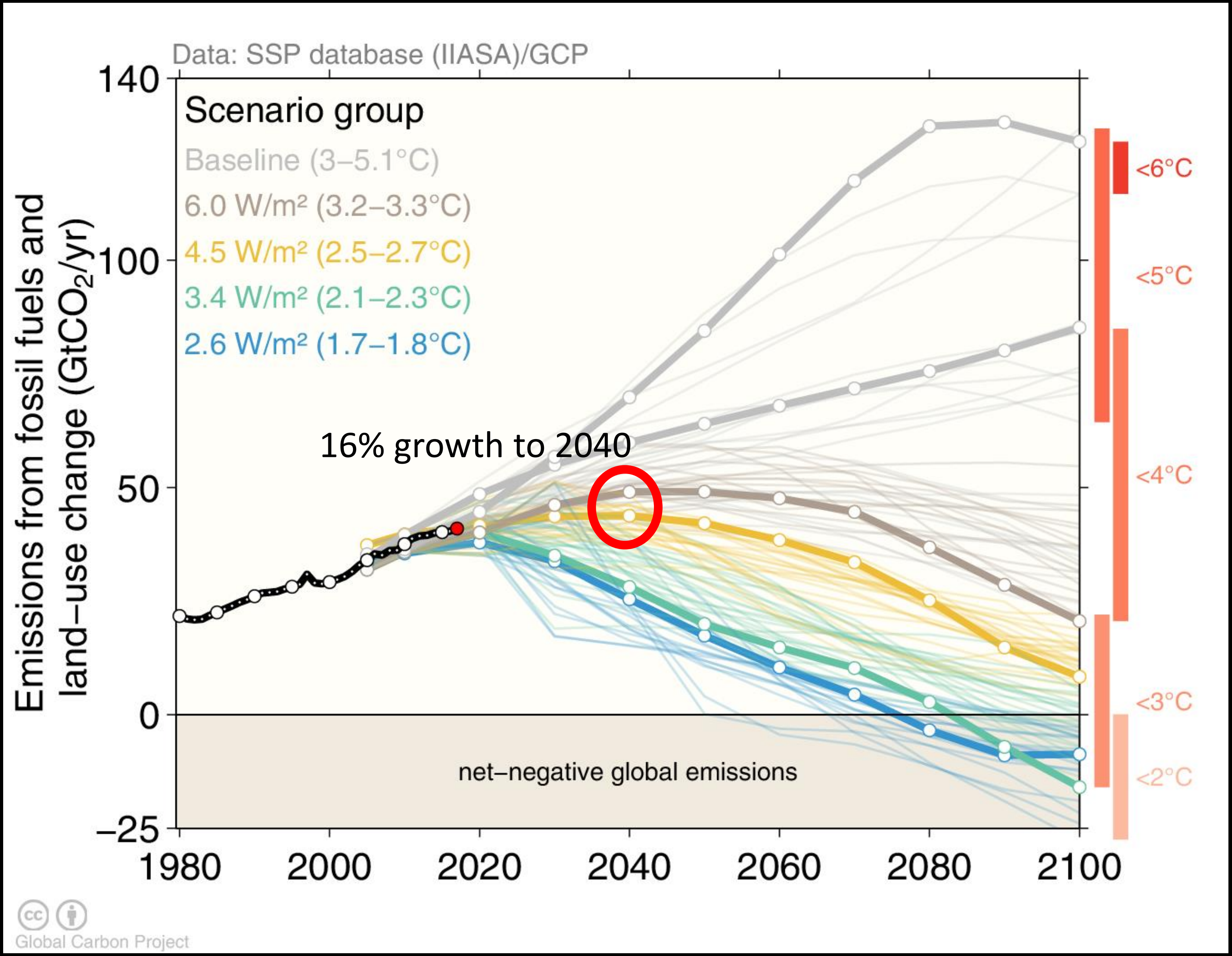
Paris pledges are only 1/3 of what is needed to stop at 2°C

Global energy use to the year 2040

- Global economy grows at 3.4% per year
- Energy demand expands by 30%
  - Global population grows to 9 billion in 2040
  - One-third of growing demand comes from India
  - Urbanization adds a city the size of Shanghai (24 million) every 4 months
- Renewable energy meets 40 percent of the increase
- Oil demand continues to grow at a steadily decreasing pace. Natural gas use rises by 45%
- Fossil fuels hold a steady 75 to 80% market share
- **Global emissions of CO2 from fossil fuels alone grows 16% by the year 2040**

International Energy Agency, World Energy Outlook, 2017 https://www.iea.org/weo2017/

Negative Emissions



The likely range of warming is 2.0–4.9∘C, with median 3.2∘C

nature climate change

LETTERS

PUBLISHED ONLINE: 31 JULY 2017 | DOI: 10.1038/NCLIMATE3352

Less than 2 °C warming by 2100 unlikely

Adrian E. Raftery[1]*, Alec Zimmer[2], Dargan M. W. Frierson[3], Richard Startz[4] and Peiran Liu[1]

The recently published Intergovernmental Panel on Climate Change (IPCC) projections to 2100 give likely ranges of global temperature increase in four scenarios for population, economic growth and carbon use[1]. However, these projections are not based on a fully statistical approach. Here we use a country-specific version of Kaya's identity to develop a statistically based probabilistic forecast of CO_2 emissions and temperature change to 2100. Using data for 1960–2010, including the UN's probabilistic population projections for all countries[2-4], we develop a joint Bayesian hierarchical model for Gross Domestic Product (GDP) per capita and carbon intensity. We find that the 90% interval for cumulative CO_2 emissions includes the IPCC's two middle scenarios but not the extreme ones. The likely range of global temperature increase is 2.0–4.9 °C, with median 3.2 °C and a 5% (1%) chance that it will be less than 2 °C (1.5 °C). Population growth is not a major contributing factor. Our model is not a 'business as usual' scenario, but rather is based on data which already show the effect of emission mitigation policies. Achieving the goal of less than 1.5 °C warming will require carbon intensity to decline much faster than in the recent past.

The IPCC has issued projections of climate change based on four different pathways for emissions and land use up to 2100, each one in turn based on a different socioeconomic scenario for the world's future and developed by a different research group[1,5]. They are called representative concentration pathways (RCPs) and were selected so as to represent the scientific literature as of 2007 and to span a range of radiative forcings by 2100. The RCP2.6 scenario was designed to represent very low greenhouse gas concentration levels[6], RCP4.5 and RCP6 are stabilization scenarios[7,8], and RCP8.5 represents rising radiative forcing[9]. The RCPs were not to be interpreted as forecasts[5].

The two key socioeconomic driving forces of the RCPs are population and GDP, and the RCPs drew on population information up to 2012[10]. The UN has recently issued new population projections to 2100, reflecting data up to 2015[2]. These are probabilistic projections based on a Bayesian model[3,4,11]. The UN's predictive distribution for world population in 2100 has a median of 11.2 billion and a 90% interval from 9.7 to 12.9 billion. Three of the four RCPs are based on population in 2100 below the lower fifth percentile of the UN's predictive distribution (9.7 billion); the only one higher is the high-emissions RCP8.5. This raises the question of the impact of the higher projected future population on climate.

The availability of probabilistic population projections now (unlike when the RCPs were formulated) makes it more feasible to develop a statistical forecasting model for the key drivers, as advocated by Moss and Schneider[12]. We use a simple form of the Kaya identity, which expresses future emission levels in a country as a product of three components: population, GDP per capita, is a specific version of the IPAT equation, Impact = Population × Affluence × Technology. We use data from 1960 to 2010 on GDP per capita and carbon intensity for most countries. We build a joint Bayesian hierarchical statistical model for GDP per capita and carbon intensity in most countries, and combine it with the UN probabilistic population projections to produce a predictive distribution of quantities of interest to 2100. We develop a probabilistic forecast of global temperature increase by combining them with the relationship between cumulative CO_2 emissions and temperature used by the IPCC[15].

For GDP per capita we use a Bayesian hierarchical model for all countries based on the idea of a world technology frontier (represented by the US for the period of our data), towards which countries may converge[16]; see Supplementary Fig. 1. The frontier is modelled by a random walk model with constant drift[17,18]. This allows countries with high current growth rates to continue growing fast in the short to medium term, while avoiding unrealistically high long-term forecasts.

To model carbon intensity, we note that most countries have reached a peak intensity; subsequently their carbon intensity has been trending downwards, as illustrated in Fig. 1. Note that we posit a peak and subsequent decline in CO_2 emissions per unit of GDP; this is different from the Environmental Kuznets Curve hypothesis that CO_2 emissions per person rise and then decline, which has not been established despite much research[19]. We model carbon intensity using a Bayesian hierarchical model for most countries estimated using the post-peak data. For each country, intensity is modelled as a linear trend plus an autoregressive random process.

Our model incorporated a within-country correlation between model errors in GDP per capita and carbon intensity, estimated to be −0.16. We found no significant correlation between model errors in population and either of the other two components.

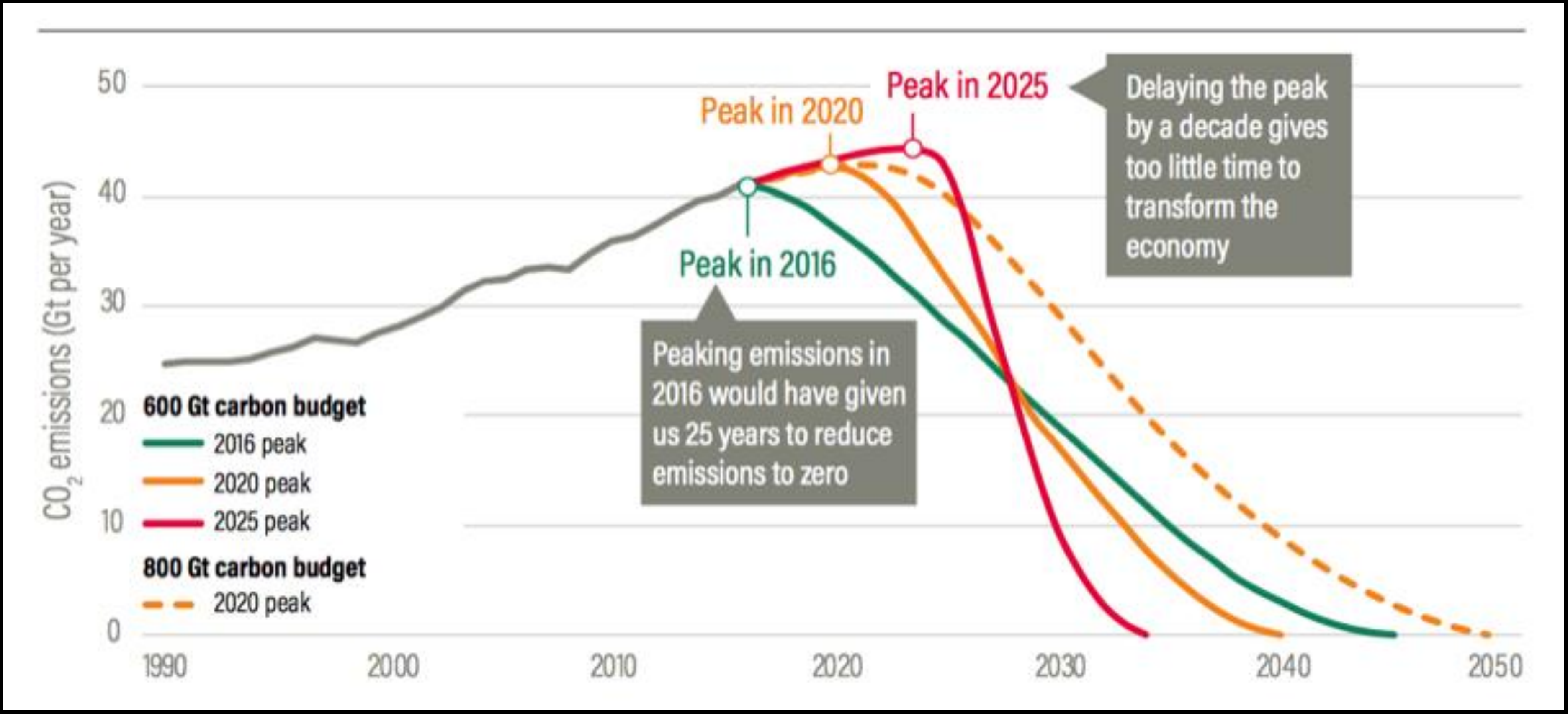
An advantage of a fully statistical model is that it can be assessed by prediction validation experiments; we carried out several. In the first one, we fitted the model using only data from 1950 to 1980, generated predictive distributions for the following 30 years, and compared them with what actually happened. We repeated forecasts through 2010 for data up to 1990 and 2000, respectively. Illustrative results for world CO_2 emissions are shown in Fig. 2. The results showed the model to be reasonably well calibrated. The largest deviation from our median forecast in these validation experiments is in prediction of the rapid uptick in CO_2 emissions from 2000 to 2010. This decade of rapid emissions, driven largely by China's exceptionally rapid growth, nevertheless lies within our 90% intervals for all three predictive validation experiments.

The results of these calibration exercises by country are shown in Supplementary Table 1, while the results for the five IPCC regions are shown in Supplementary Fig. 2. These indicate that the model is

- Global scale refugee crisis as the equatorial continents marginally habitable
- Sea level, 10-15m (30-50 ft)
- 2100, 50% more people to feed, 50% less grain to give them.
- Extreme weather disasters, massive floods, heat waves, great tropical cyclones, mega-drought, and torrential rainfall.
- Ironically, this is all taking place in a world of solar panels, wind mills, electric cars, and cleaner air.

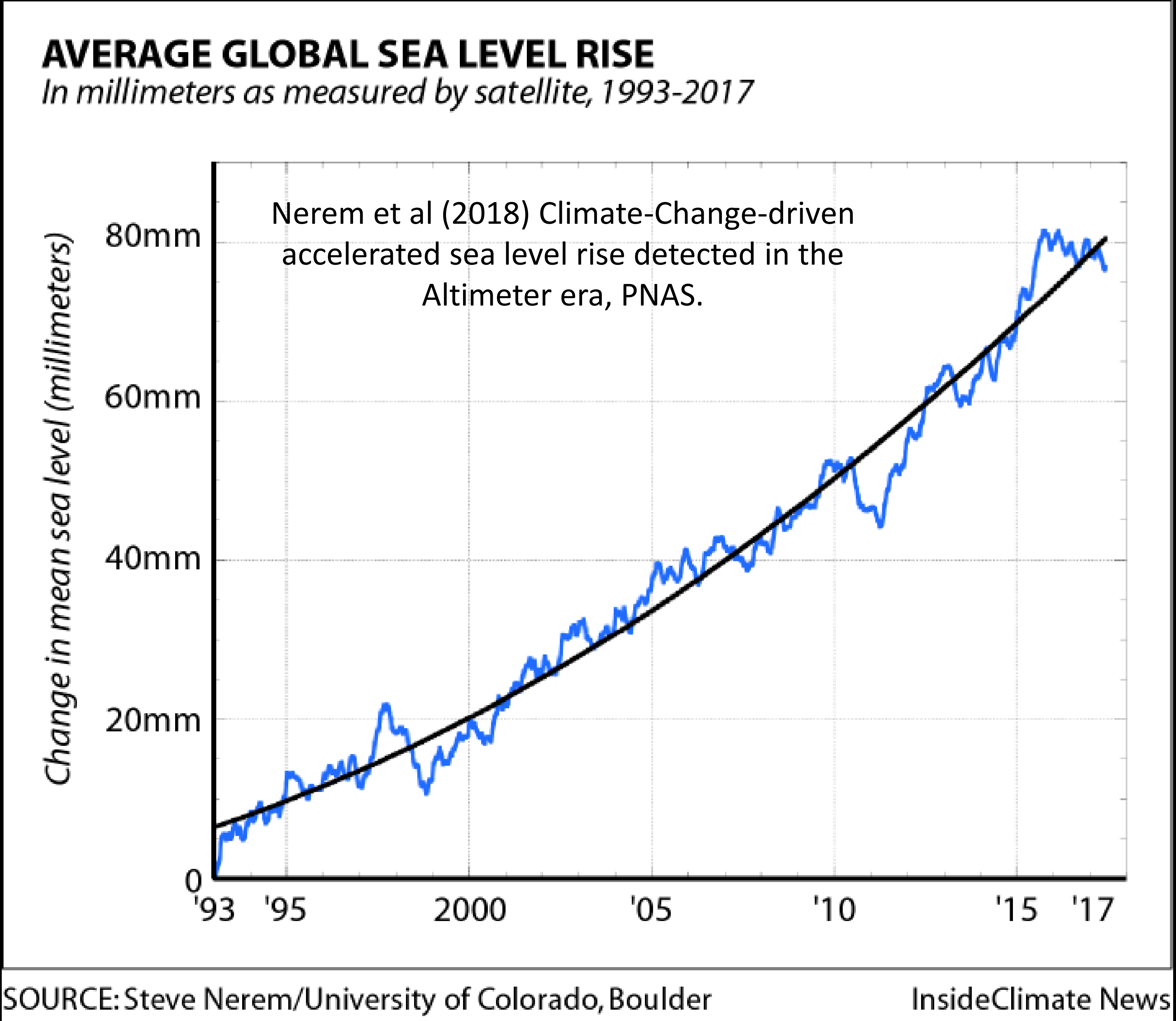
The likely range of global temperature increase is 2.0–4.9∘C, with median 3.2∘C and a 5% (1%) chance that it will be less than 2∘C (1.5∘C)

We need to bend the curve of carbon, and reach zero emissions by 2050.

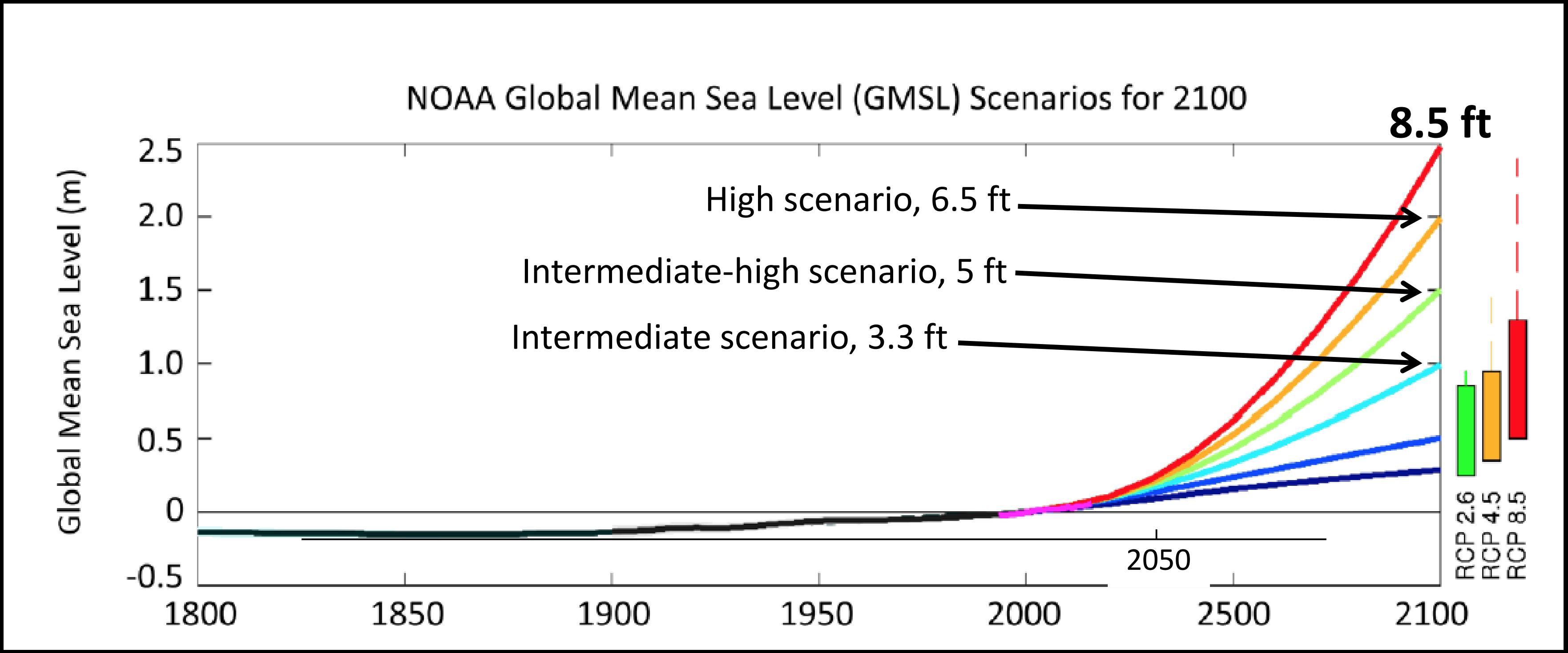


Halving emissions each decade

Sea Level Rise


AVERAGE GLOBAL SEA LEVEL RISE
In millimeters as measured by satellite, 1993-2017
Nerem et al (2018) Climate-Change-driven accelerated sea level rise detected in the Altimeter era, PNAS.
Change in mean sea level (millimeters)
80mm
60mm
40mm
20mm
0
'93
'95
2000
'05
'10
'15
'17
SOURCE: Steve Nerem/University of Colorado, Boulder
InsideClimate News

NOAA – 6 scenarios



NOAA Technical Report NOS CO-OPS 083

GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES

Photo: Ocean City, Maryland

Silver Spring, Maryland
January 2017

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

https://science2017.globalchange.gov

NOAA, 2017 – Scenario Timetable

Table 5. GMSL rise scenario heights in meters for 19-year averages centered on decade through 2200 (showing only a subset after 2100) initiating in year 2000. Only median values are shown.

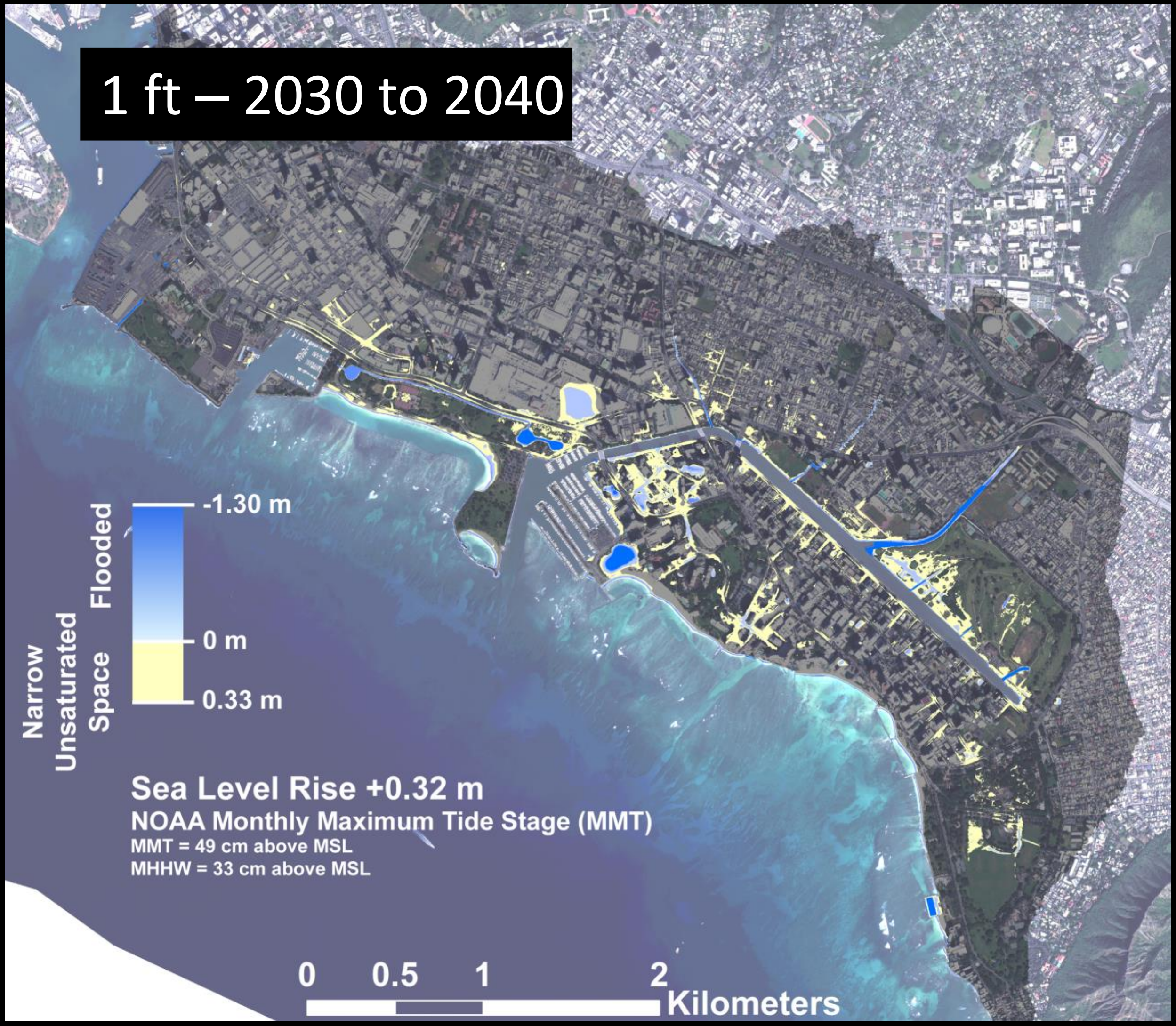
GMSL Scenario (meters)	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	2120	2150	2200
Low	0.03	0.06	0.09	0.13	0.16	0.19	0.22	0.25	0.28	0.30	0.34	0.37	0.39
Intermediate-Low	0.04	0.08	0.13	0.18	0.24	0.29	0.35	0.4	0.45	0.50	0.60	0.73	0.95
Intermediate	0.04	0.10	0.16	0.25	0.34	0.45	0.57	0.71	0.85	1.0	1.3	1.8	2.8
Intermediate-High	0.05	0.10	0.19	0.30	0.44	0.60	0.79	1.0	1.2	1.5	2.0	3.1	5.1
High	0.05	0.11	0.21	0.36	0.54	0.77	1.0	1.3	1.7	2.0	2.8	4.3	7.5
Extreme	0.04	0.11	0.24	0.41	0.63	0.90	1.2	1.6	2.0	2.5	3.6	5.5	9.7

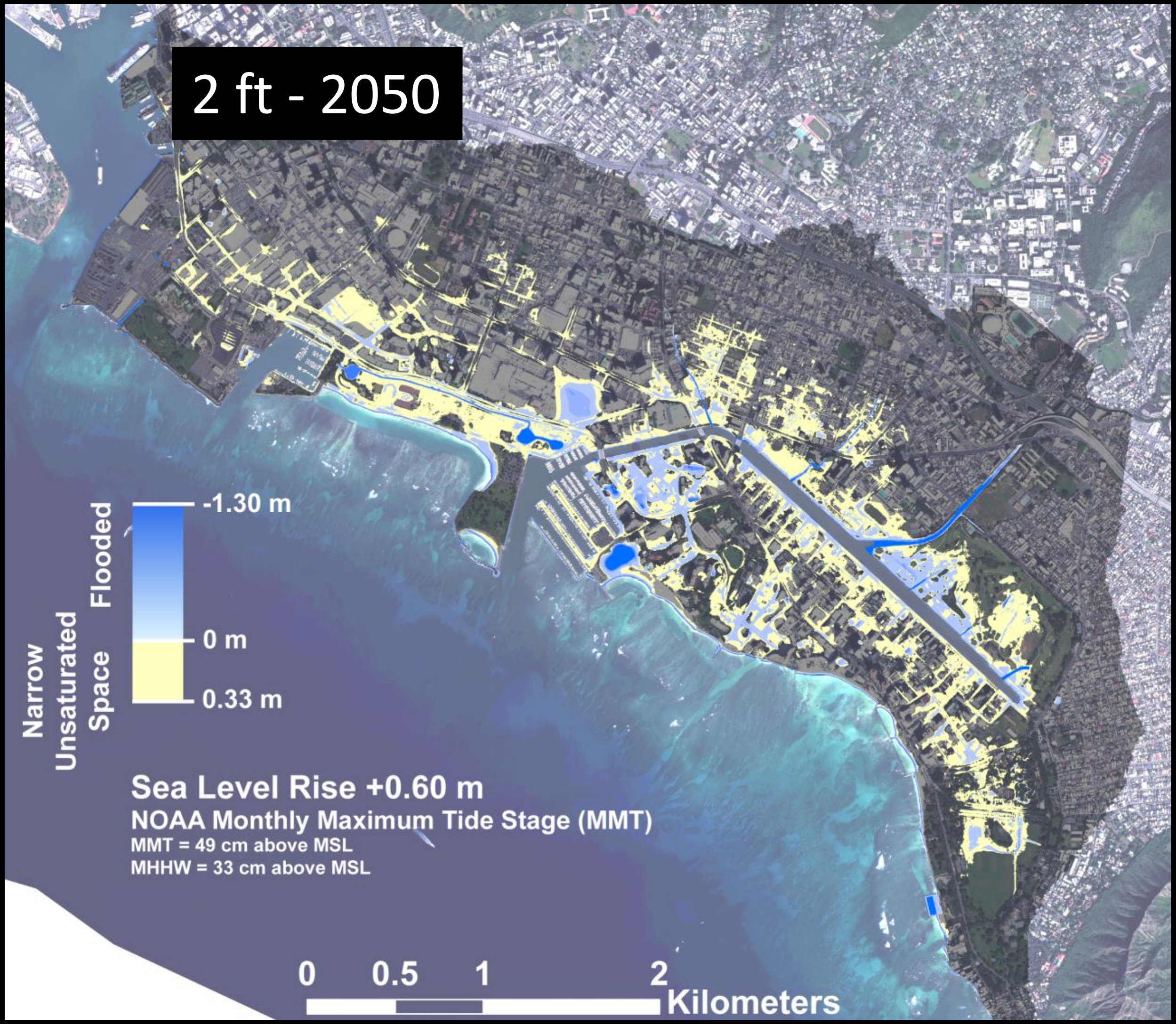
Marine and Groundwater Inundation


2 ft

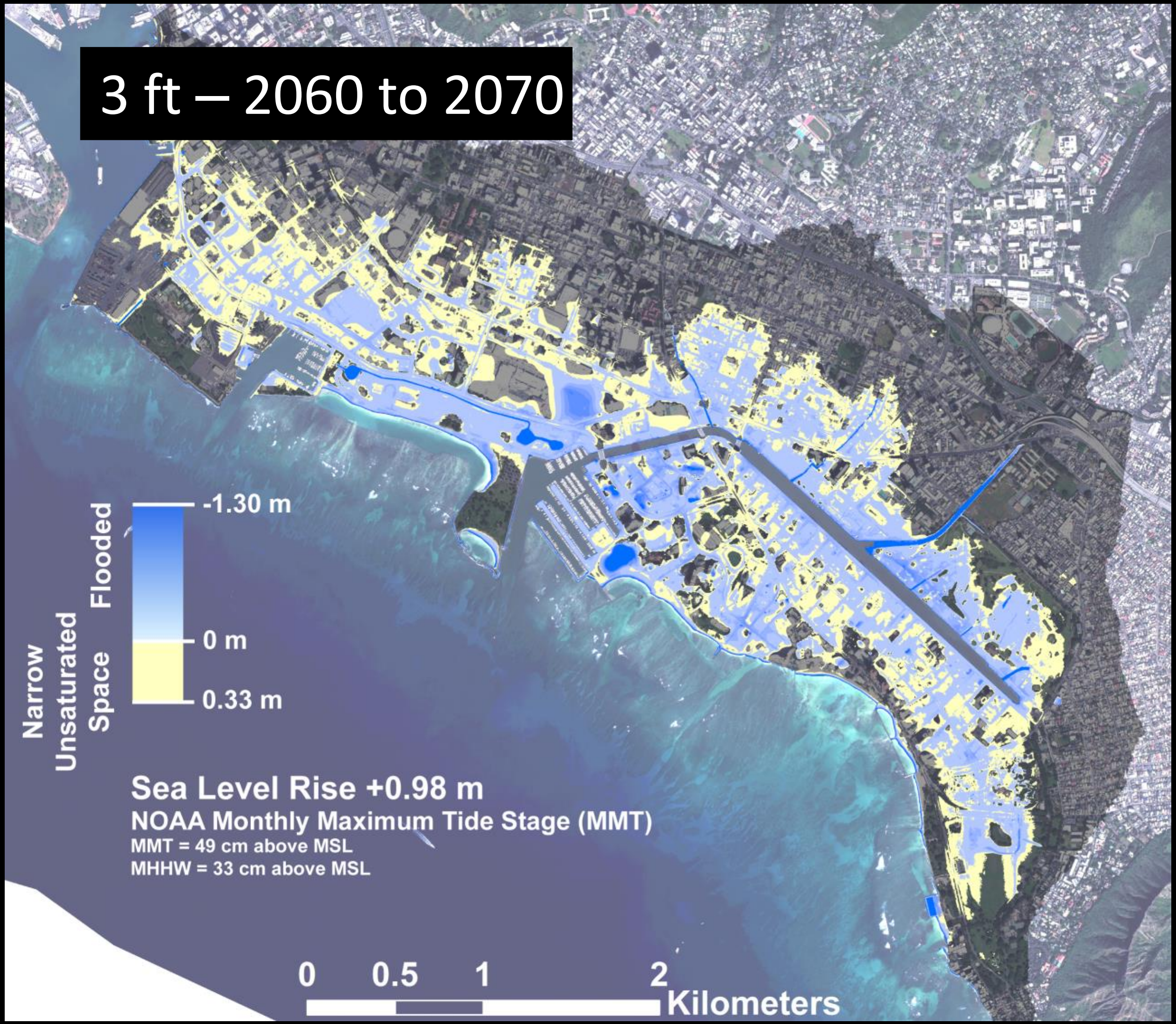

JALPAK
レインボートロリー


HONOLULU ZOO

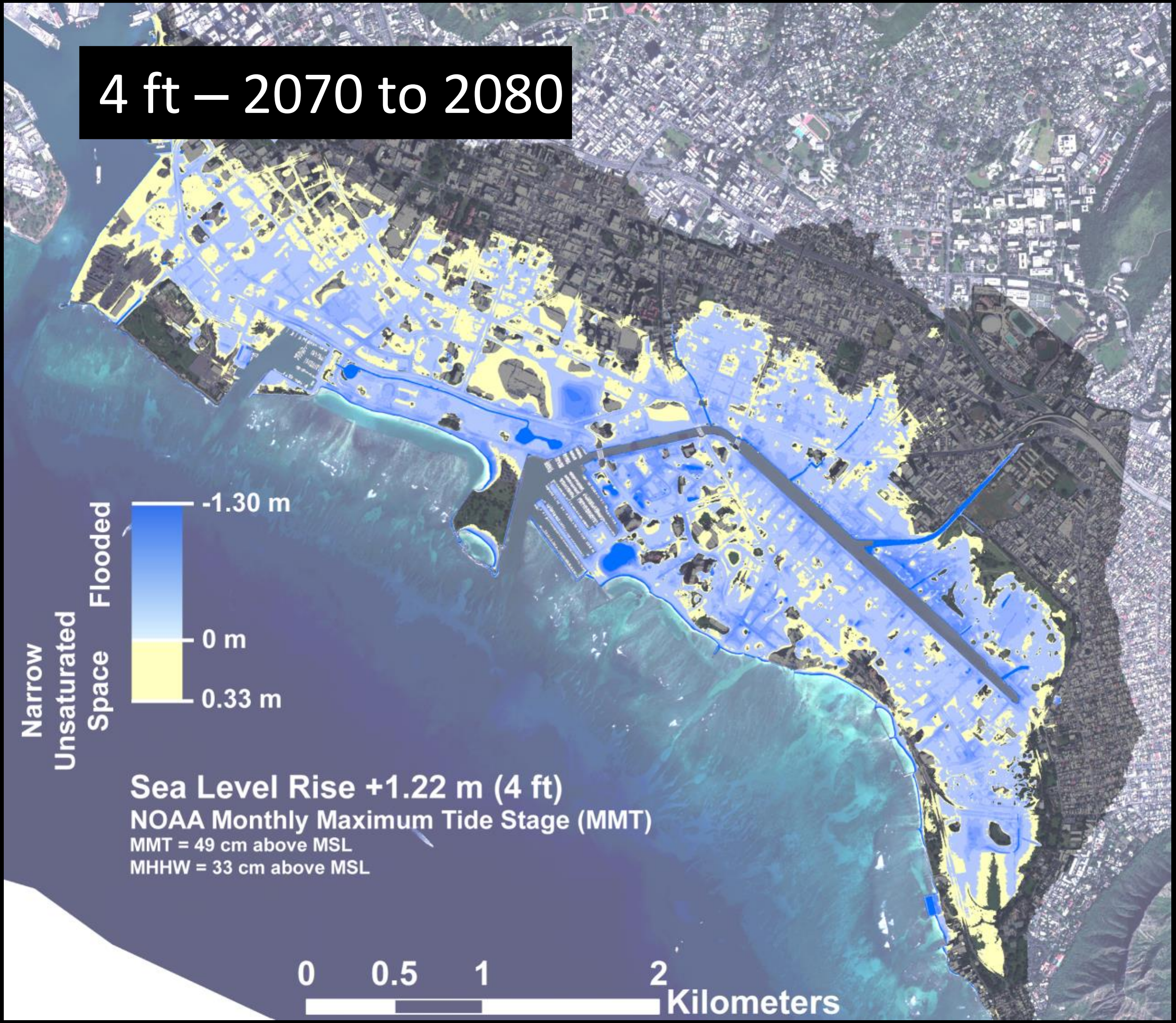

1 ft – 2030 to 2040
-1.30 m
Flooded
0 m
Narrow Unsaturated Space
0.33 m
Sea Level Rise +0.32 m
NOAA Monthly Maximum Tide Stage (MMT)
MMT = 49 cm above MSL
MHHW = 33 cm above MSL
0
0.5
1
2
Kilometers


2 ft - 2050
-1.30 m
Flooded
0 m
0.33 m
Narrow Unsaturated Space
Sea Level Rise +0.60 m
NOAA Monthly Maximum Tide Stage (MMT)
MMT = 49 cm above MSL
MHHW = 33 cm above MSL
0 0.5 1 2
Kilometers

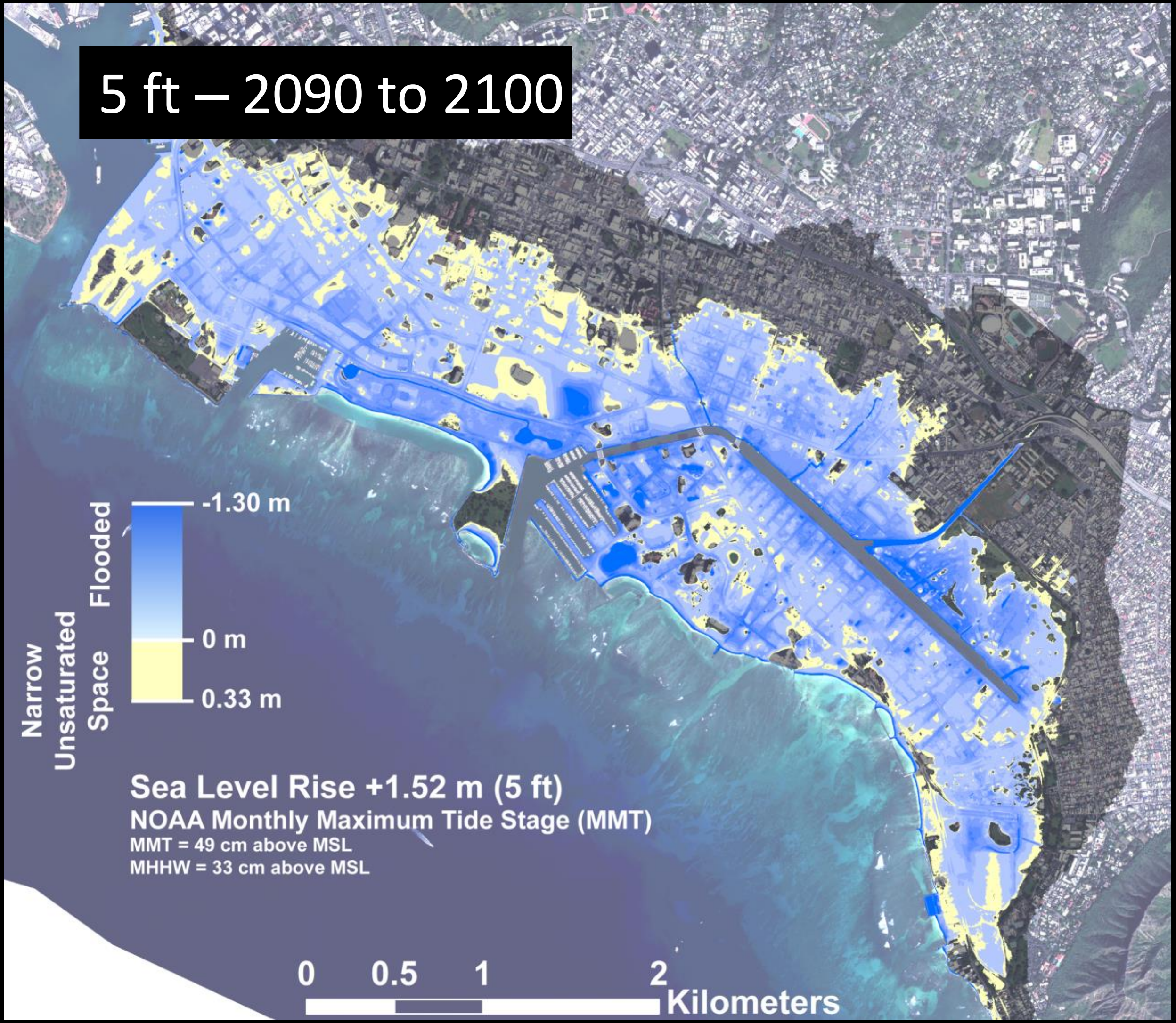
3 ft – 2060 to 2070



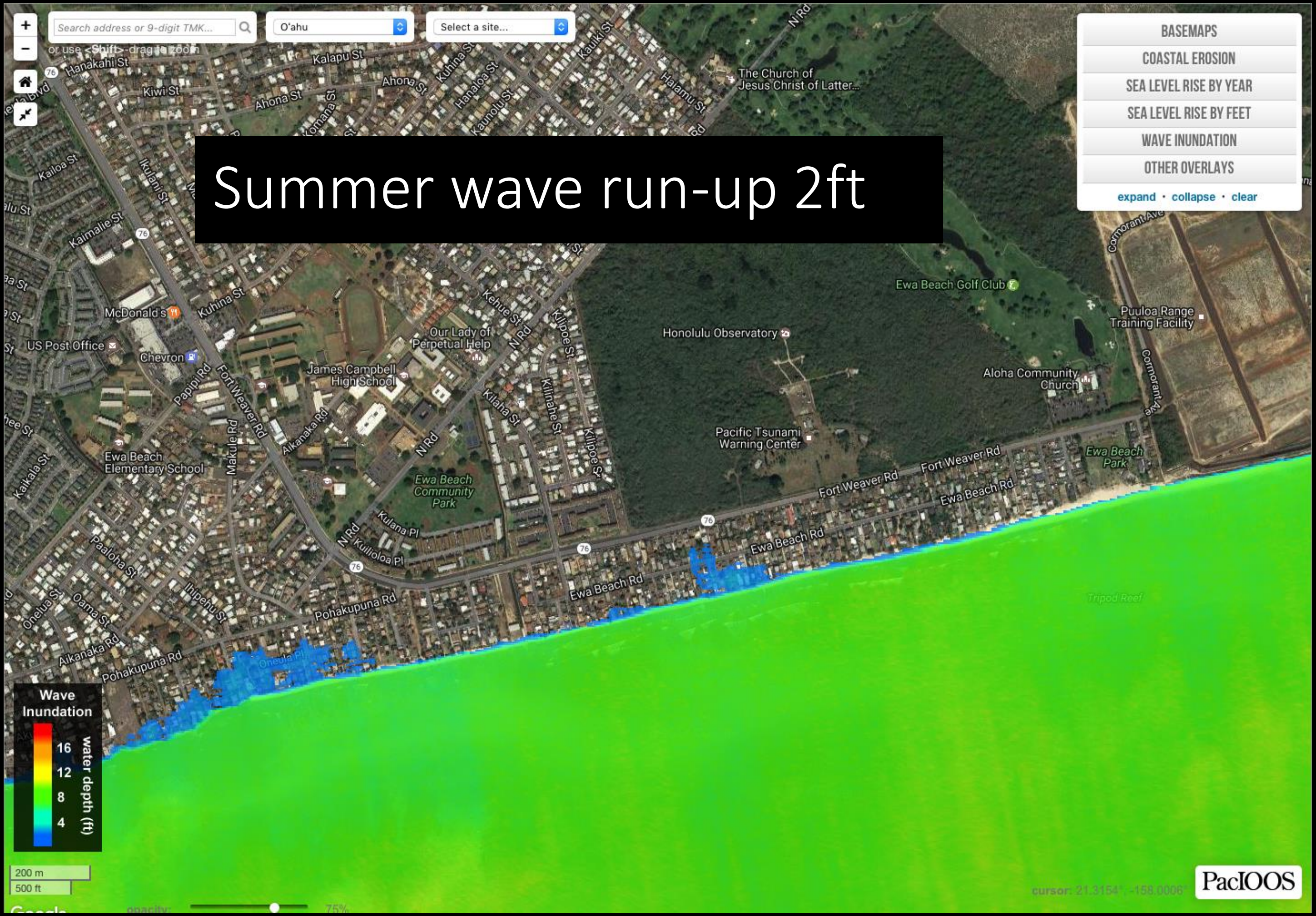
4 ft – 2070 to 2080



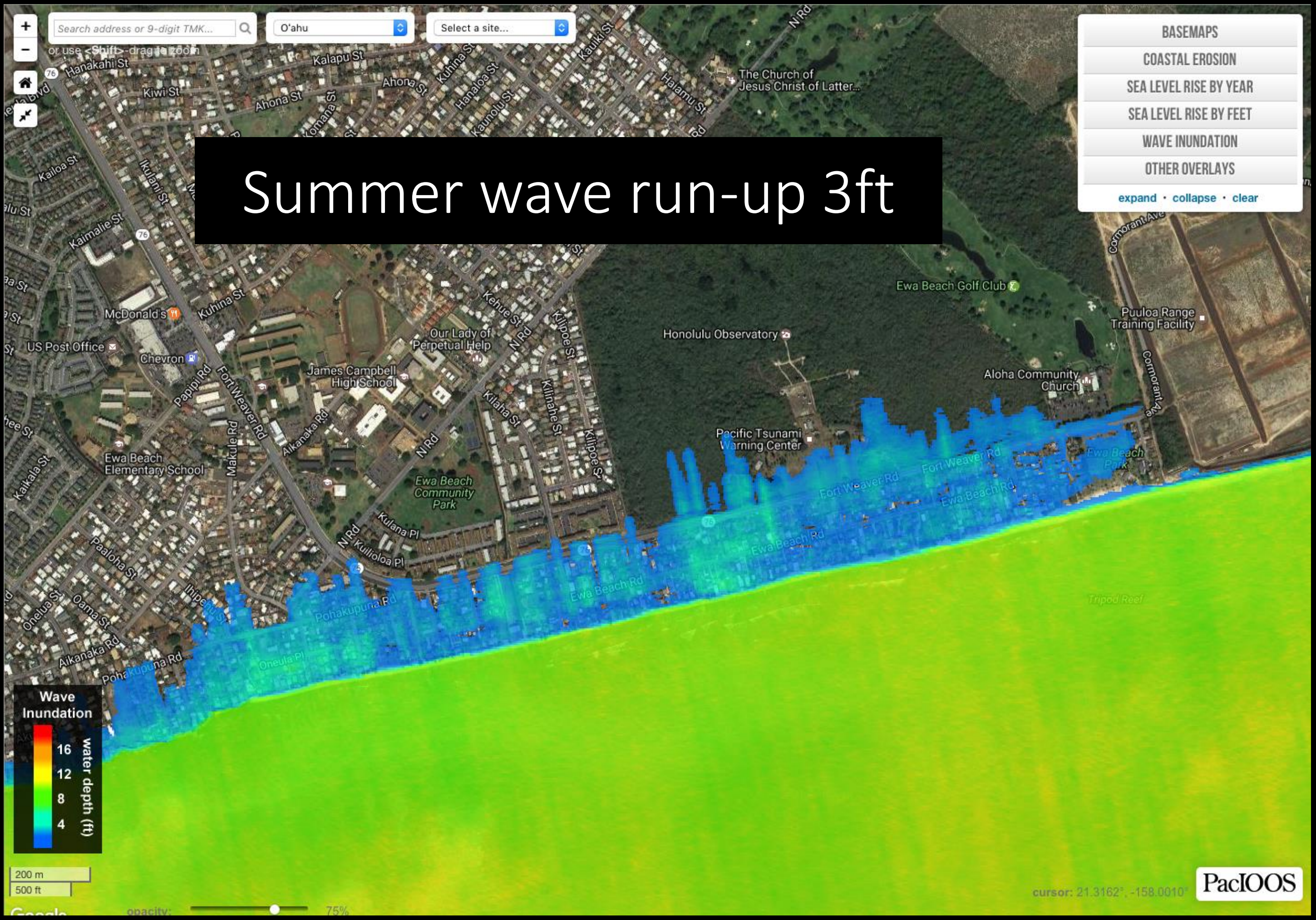
5 ft – 2090 to 2100



Summer wave run-up 2ft



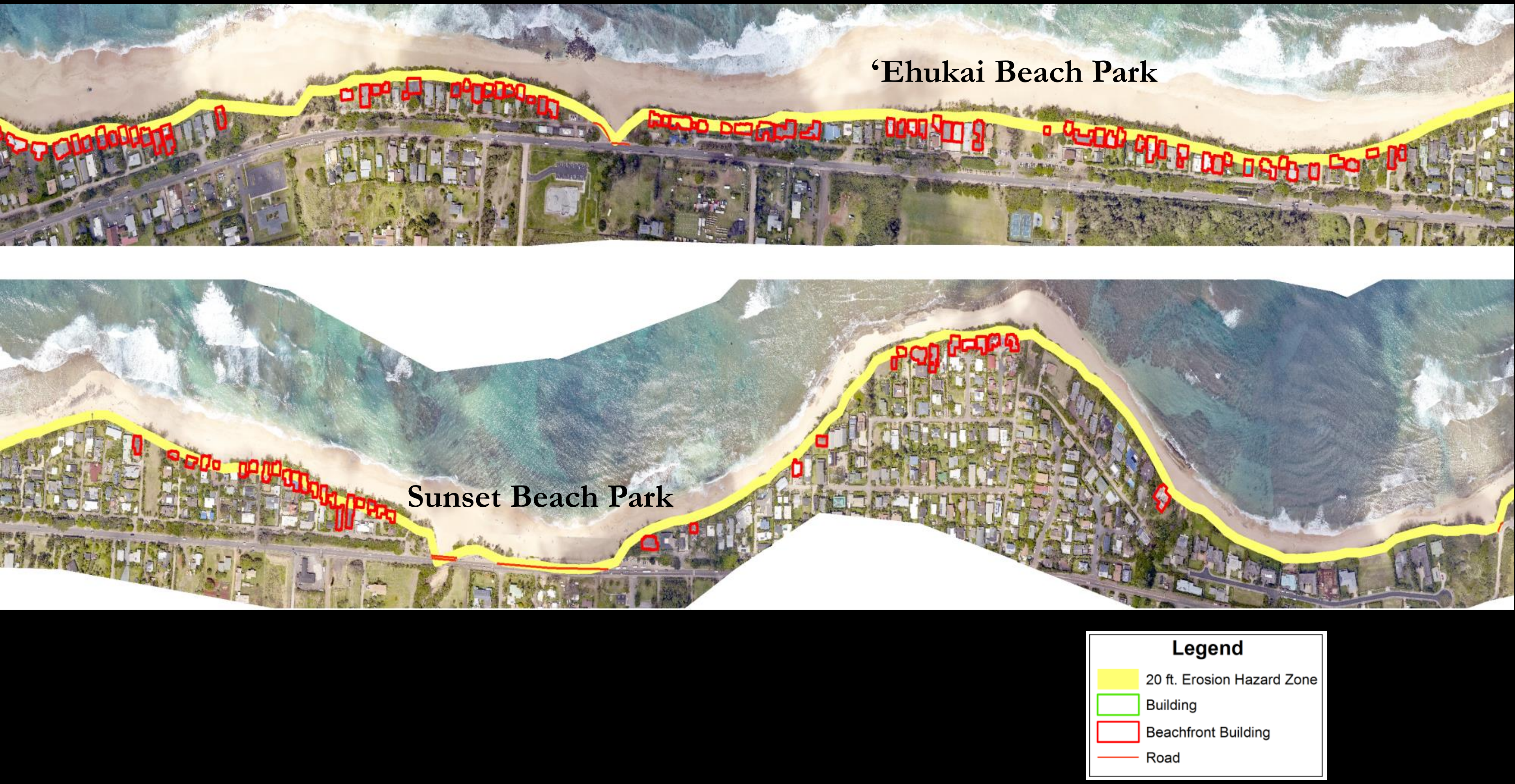
Summer wave run-up 3ft



Coastal Erosion

Today
18 buildings (10%) 0.04 miles of road

1 ft SLR
109 buildings (60%) 0.2 miles of road



Coastal roads are threatened by erosion on every island

Environment

A $15 Billion Price Tag To Protect Hawaii Highways From Climate Change

As the state braces for sea level rise, vulnerable roads could be moved inland — and tunneled through mountains.

By Marcel Honore / About 8 hours ago

In 2016, heavy surf pounding Oahu's Windward Coast tore off two large chunks of Kamehameha Highway near Kaaawa in a three-week period.

Residents had already watched their beach gradually disappear, but they'd never seen the waters claim part of the highway.

Crews rushed to repair the road — a scenic, vital passage that hugs the eastern edge of Hawaii's most populous island. State transportation officials said the fixes would better protect the highway against erosion.

But they acknowledged it wasn't a permanent solution.

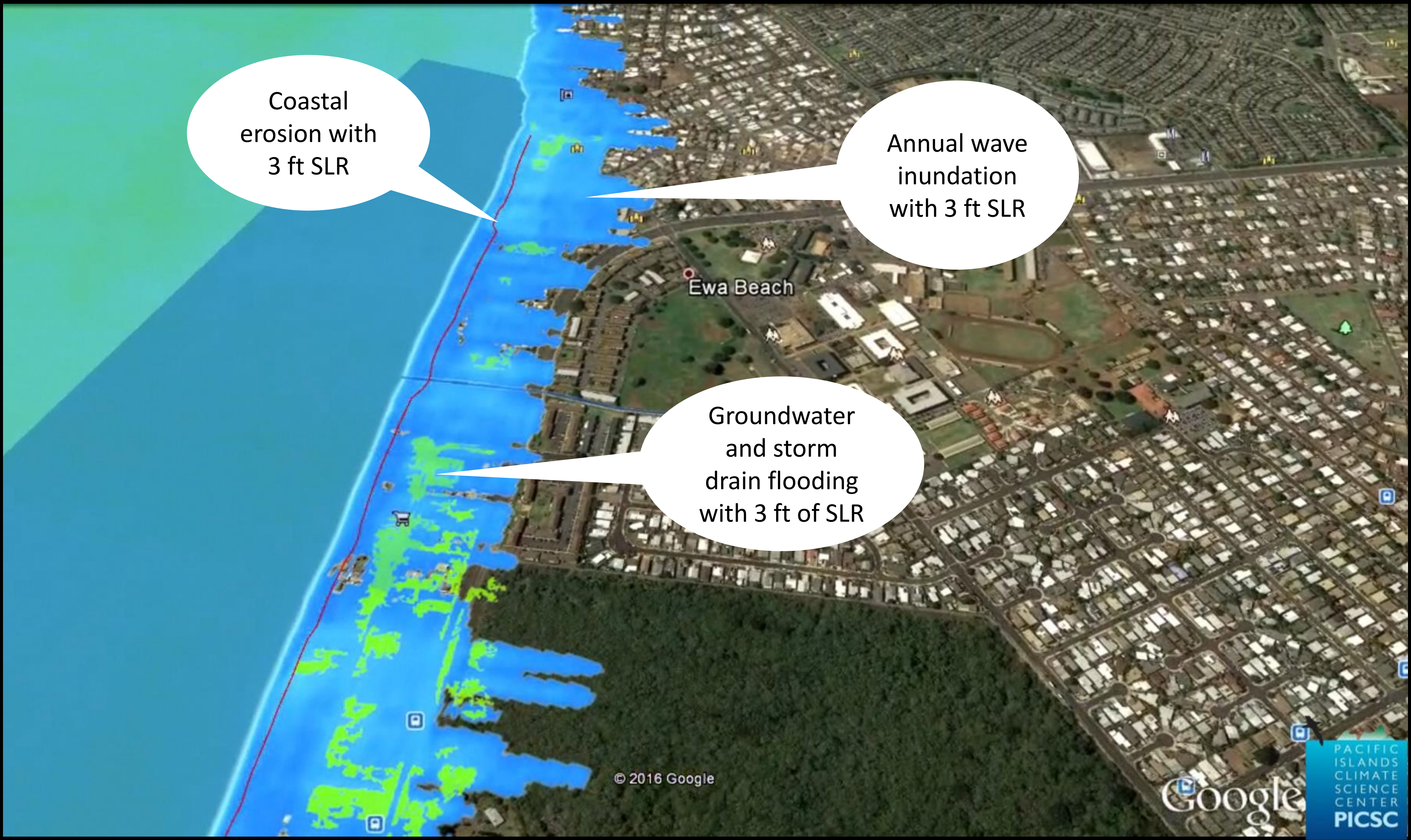
Sandbags were used to protect the Kamehameha Highway near Kaaawa in March.

Hawaii will need $15 billion to protect highways from sea level rise.

$7.5 million for every mile of road that must either be raised, pushed back or relocated in the next 50 to 100 years.

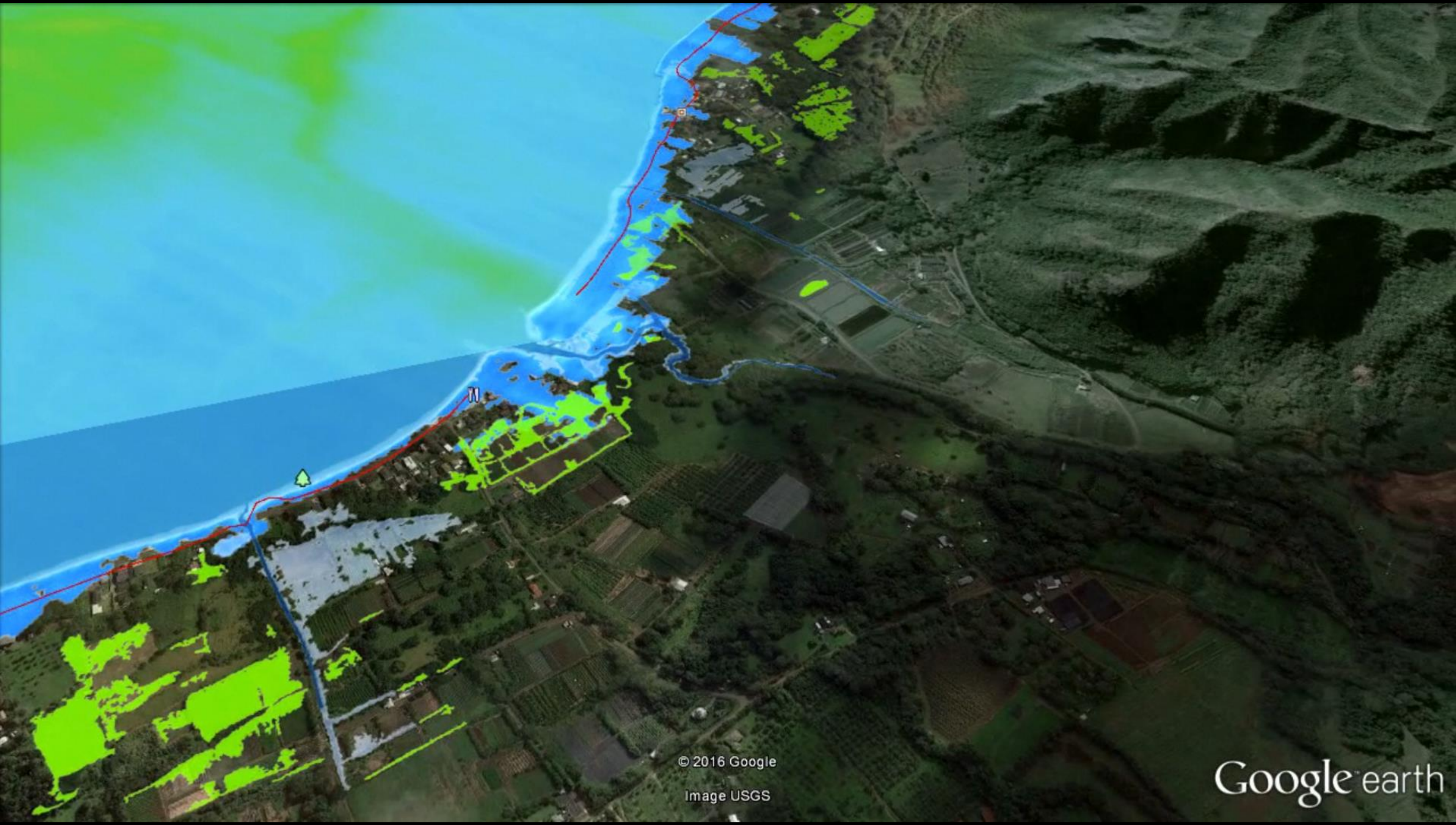
$40 million for every mile of bridge.

Ewa Beach 3.2 ft SLR



Waikiki

Punalu'u



"If you wage war with water, you will lose."

Hope? …… ACTION!

Wind is the most competitively priced technology in most markets

UN Microsites | Adaptation Knowledge Portal | TT Clear | Nairobi Partnership Framework | NAP Expo | More

United Nations
Climate Change

UNFCCC Process | EN

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News

REPORT / 14 FEB, 2018

Global Wind Energy Continues to Gather Momentum

UN Climate Change News, 14 February 2018 – Wind energy continues to grow globally, with wind the most competitively priced technology in many if not most markets.

According to the Global Wind Energy Council (GWEC), the inevitable transition to renewable energy continues to gather momentum with the total global wind energy installation now at almost 540 gigawatts.

The GWEC Secretary General Steve Sawyer says that wind energy is becoming steadily cheaper, and that this benefits consumers and the environment:

"The dramatic price drops for wind technology has put a big squeeze on the profits up and down the whole supply chain", concluded Sawyer. "But we're fulfilling our promise to provide the largest quantity of carbon-free electricity at the lowest price. Smaller profit margins are a small price to pay for leading the energy revolution."

Solar Power fastest-growing source of new energy worldwide

Renewable Energy accounted for two-thirds of new power added to the world's grids in 2016

Time to shine: Solar power is fastest-growing source of new energy

Renewables accounted for two-thirds of new power added to world's grids last year, says International Energy Agency

▲ A rooftop covered with solar panels at the Brooklyn Navy Yard in New York. The US is still the second fastest-growing market for renewables despite Donald Trump's pledge to revive coal. Photograph: Mark Lennihan/AP

Solar power was the fastest-growing source of new energy worldwide last year, outstripping the growth in all other forms of power generation for the first time and leading experts to hail a "new era".

Renewable energy accounted for two-thirds of new power added to the world's

17 states, >36% of US population, >$7 trillion dollars, equivalent to world's third largest country

STATES UNITED FOR CLIMATE ACTION

In response to the U.S. federal government's decision to withdraw the United States from the Paris Agreement, Governors Andrew Cuomo, Jay Inslee, and Jerry Brown launched the United States Climate Alliance – a bipartisan coalition of governors committed to reducing greenhouse gas emissions consistent with the goals of the Paris Agreement. Smart, coordinated state action can ensure that the United States continues to contribute to the global effort to address climate change.

The Alliance has three core principles:

- **States are continuing to lead on climate change**: Alliance states recognize that climate change presents a serious threat to the environment and our residents, communities, and economy.
- **State-level climate action is benefitting our economies and strengthening our communities**: Alliance members are growing our clean energy economies and creating new jobs, while reducing air pollution, improving public health, and building more resilient communities.
- **States are showing the nation and the world that ambitious climate action is achievable**: Despite the U.S. federal government's decision to withdraw from the Paris

News

U.S. CLIMATE ALLIANCE ASKS CONGRESS TO PROTECT CRITICAL FUNDING FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY RESEARCH AND DEVELOPMENT

Feb 16, 2018

JULIE CERQUEIRA NAMED NEW EXECUTIVE DIRECTOR OF THE U.S. CLIMATE ALLIANCE

Jan 30, 2018

The City and County of Honolulu

Office of Climate Change, Sustainability and Resiliency

www.ResilientOahu.org

100 RESILIENT CITIES

RESILIENT O'AHU

Help us draw the line on climate change.

Join Blue Planet Foundation on **Saturday, April 21, 2018**, from 9:00 AM to 12:00 PM for the **Blue Line Project**—a locally powered movement to raise awareness about the impacts of climate change.

DRAW THE LINE

There is something everyone can do

- Volunteer on weekends
- Eat a more vegetable-based diet
- Use cars and airplanes less
- Plant trees and help DLNR with watershed work
- Have smaller families
- Spread the word
- Create art about climate change
- Contact your elected official and ask what they are doing?
- Eat and buy more locally produced foods and goods
- Support urban farming at parks and wetlands (Lo'i Kalo mini-park)
- Tap into climate change news:
    - Climate Progress https://thinkprogress.org/climate/
    - Inside Climate News https://insideclimatenews.org
    - The Daily Climate http://www.dailyclimate.org