

Theodore J. Boutrous, Jr. (SBN 132099)
tboutrous@gibsondunn.com
Andrea E. Neuman (SBN 149733)
aneuman@gibsondunn.com
William E. Thomson (SBN 187912)
wthomson@gibsondunn.com
Ethan D. Dettmer (SBN 196046)
edettmer@gibsondunn.com
Joshua S. Lipshutz (SBN 242557)
jlipshutz@gibsondunn.com
GIBSON, DUNN & CRUTCHER LLP
333 South Grand Avenue
Los Angeles, CA 90071
Telephone: 213.229.7000
Facsimile: 213.229.7520

Neal S. Manne (SBN 94101)
nmanne@susmangodfrey.com
Johnny W. Carter (*pro hac vice*)
jcarter@susmangodfrey.com
Erica Harris (*pro hac vice* pending)
eharris@susmangodfrey.com
Steven Shepard (*pro hac vice*)
sshepard@susmangodfrey.com
SUSMAN GODFREY LLP
1000 Louisiana, Suite 5100
Houston, TX 77002
Telephone: 713.651.9366
Facsimile: 713.654.6666

Herbert J. Stern (*pro hac vice*)
hstern@sgklaw.com
Joel M. Silverstein (*pro hac vice*)
jsilverstein@sgklaw.com
STERN & KILCULLEN, LLC
325 Columbia Turnpike, Suite 110
Florham Park, NJ 07932-0992
Telephone: 973.535.1900
Facsimile: 973.535.9664

Attorneys for Defendant Chevron Corporation

**UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION**

THE PEOPLE OF THE STATE OF
CALIFORNIA, acting by and through Oakland
City Attorney BARBARA J. PARKER,

Plaintiff and Real Party in
Interest,

v.

BP P.L.C., a public limited company of
England and Wales, CHEVRON
CORPORATION, a Delaware corporation,
CONOCOPHILLIPS COMPANY, a Delaware
corporation, EXXON MOBIL
CORPORATION, a New Jersey corporation,
ROYAL DUTCH SHELL PLC, a public
limited company of England and Wales, and
DOES 1 through 10,

Defendants.

First Filed Case: No. 3:17-cv-6011-WHA
Related Case: No. 3:17-cv-6012-WHA

NOTICE OF SUBMISSION

Case No. 3:17-cv-6011-WHA

1 THE PEOPLE OF THE STATE OF
2 CALIFORNIA, acting by and through the San
3 Francisco City Attorney DENNIS J.
4 HERRERA,

5
6 Plaintiff and Real Party in
7 Interest,

8 v.

9 BP P.L.C., a public limited company of
10 England and Wales, CHEVRON
11 CORPORATION, a Delaware corporation,
12 CONOCOPHILLIPS COMPANY, a Delaware
13 corporation, EXXON MOBIL
14 CORPORATION, a New Jersey corporation,
15 ROYAL DUTCH SHELL PLC, a public
16 limited company of England and Wales, and
17 DOES 1 through 10,

18 Defendants.
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Case No. 3:17-cv-6012-WHA

NOTICE OF SUBMISSION

Defendant Chevron Corporation hereby respectfully submits copies of the slides it used during its Climate Change Tutorial presentation to the Court on March 21, 2018. True and correct copies of the slides presented in Part I of the Tutorial are attached hereto as Exhibit A, and true and correct copies of the slides presented in Part II of the Tutorial are attached hereto as Exhibit B.

In response to the Court's request in its February 27, 2018 Order, Chevron also submits a timeline of major developments in climate science, attached hereto as Exhibit C. Chevron is providing a hyperlinked version of this timeline to Plaintiffs and the Court.

March 21, 2018

Respectfully submitted,

By: /s/ Theodore J. Boutrous

Herbert J. Stern (*pro hac vice*)
 Joel M. Silverstein (*pro hac vice*)
 STERN & KILCULLEN, LLC
 325 Columbia Turnpike, Suite 110
 Florham Park, NJ 07932-0992
 Telephone: (973) 535-1900
 Facsimile: (973) 535-9664
 E-mail: hstern@sgklaw.com
 E-mail: jsilverstein@sgklaw.com

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 GIBSON, DUNN & CRUTCHER LLP
 333 South Grand Avenue
 Los Angeles, CA 90071
 Telephone: (213) 229-7000
 Facsimile: (213) 229-7520
 E-mail: tboutrous@gibsondunn.com
 E-mail: aneuman@gibsondunn.com
 E-mail: wthomson@gibsondunn.com
 E-mail: edettmer@gibsondunn.com
 E-mail: jlipshutz@gibsondunn.com

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 SUSMAN GODFREY LLP
 1000 Louisiana, Suite 5100
 Houston, TX 77002
 Telephone: (713) 651-9366
 Facsimile: (713) 654-6666
 E-mail: nmanne@susmangodfrey.com
 E-mail: jcarter@susmangodfrey.com
 E-mail: eharris@susmangodfrey.com
 E-mail: sshepard@susmangodfrey.com

Attorneys for Defendant
CHEVRON CORPORATION

Exhibit A

TUTORIAL: PART I

“The first part will trace the history of scientific study of climate change, beginning with scientific inquiry into the formation and melting of the ice ages, periods of historical cooling and warming, smog, ozone, nuclear winter, volcanoes, and global warming.”

Notice Re: Tutorial (Feb. 27, 2018)

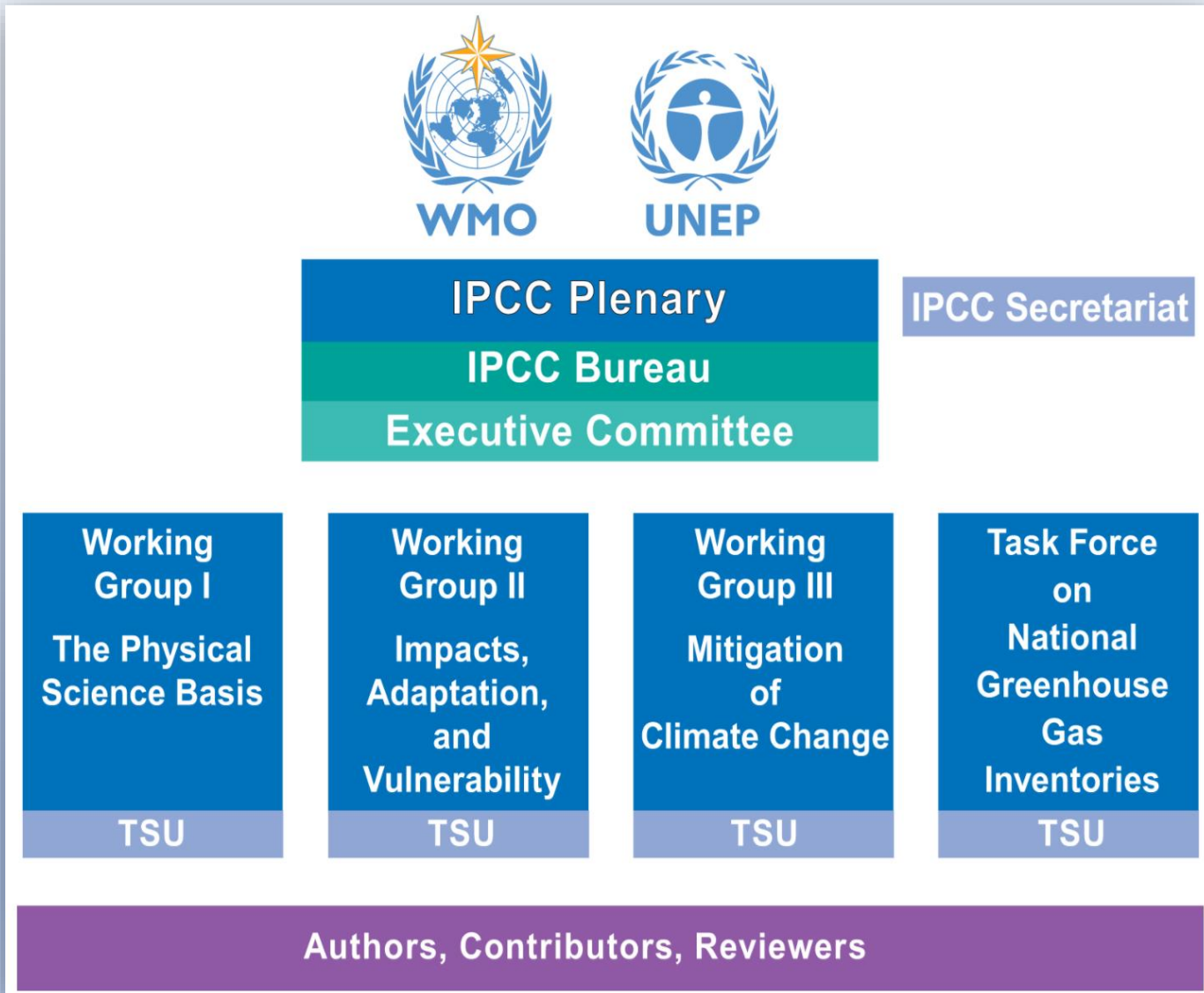
“It is **extremely likely** that human influence has been the dominant cause of the observed warming since the mid-20th century.”

IPCC WORKING GROUP III
12TH SESSION
IPCC PLENARY
39TH SESSION
Berlin, 7–12 April 2014

are a key mitigation strategy in scenarios reaching atmospheric CO₂eq concentrations of about 450 or 500 ppm by 2100 (robust evidence, high agreement). Near term reductions in energy demand are an important element of cost effective mitigation strategies, provide more flexibility for decarbonizing the energy supply sector, hedge against related supply side risks, avoid lock-in to carbon-intensive infrastructures, and are associated with important co-benefits. Integrated and sectoral studies provide similar estimates for energy demand reductions in the transport,



IPCC Structure



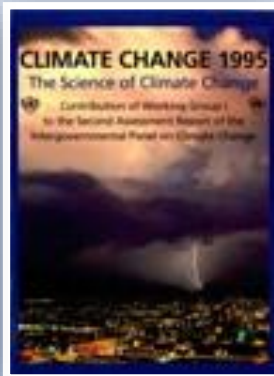
IPCC Reports

“FAR”



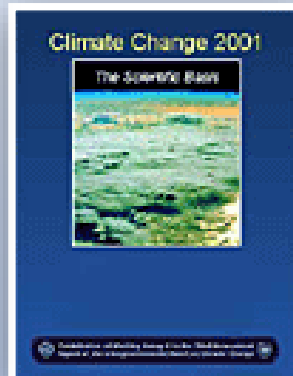
1990

“SAR”



1995

“TAR”



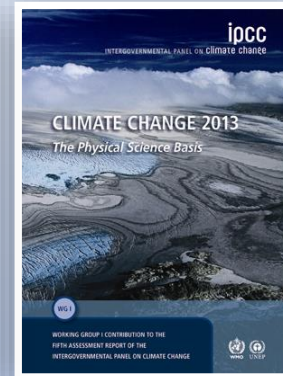
2001

“AR4”



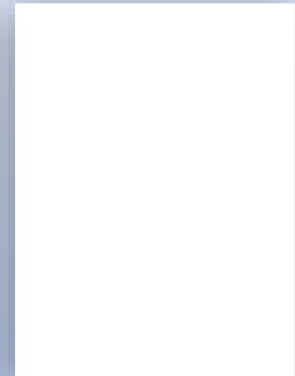
2007

“AR5”



2013

“AR6”



~2021

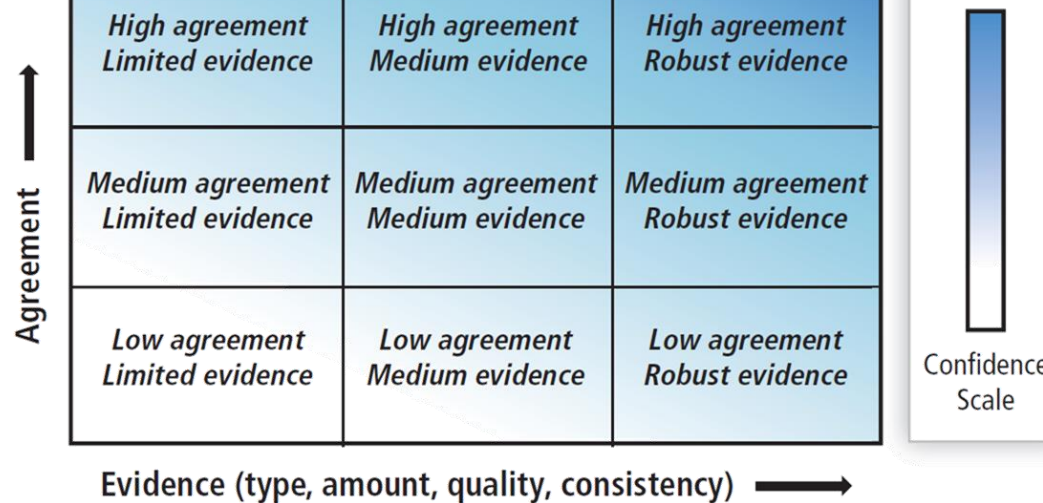
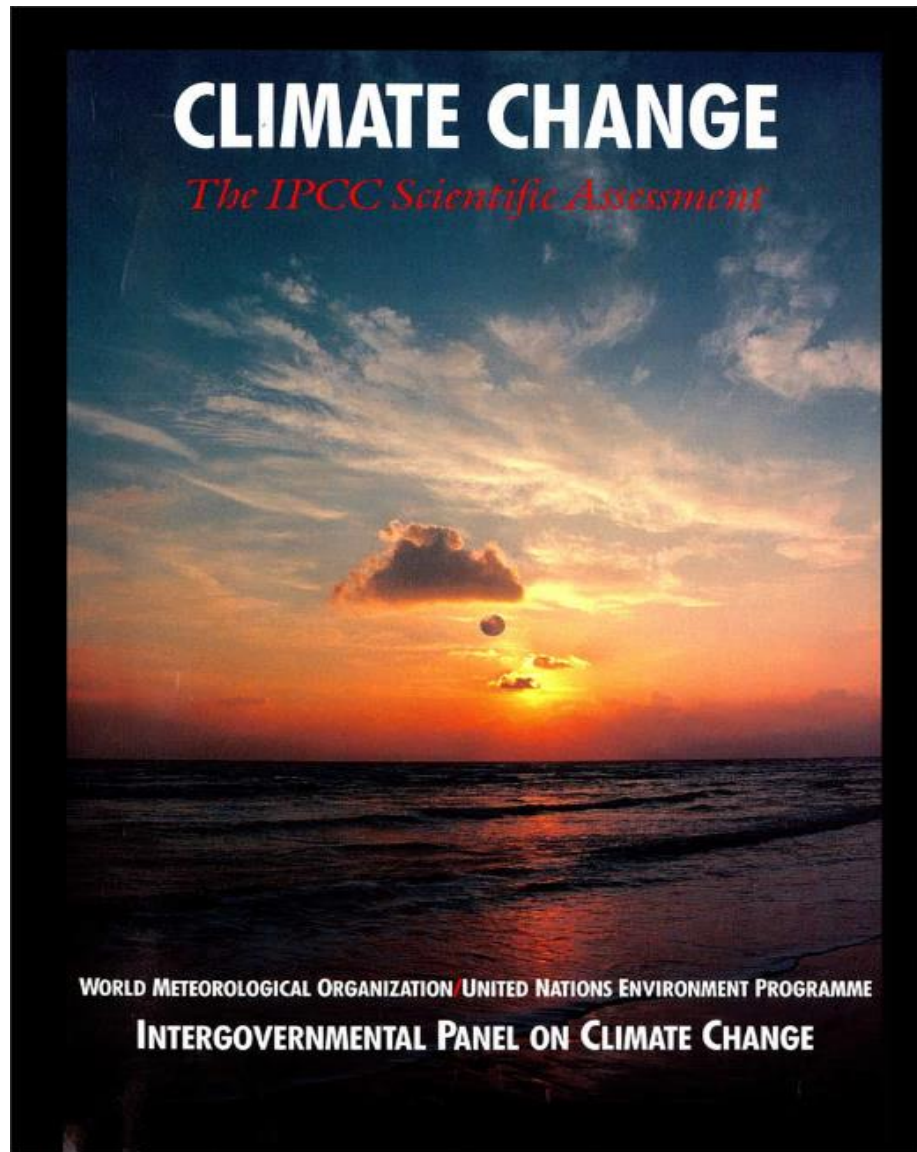


Table 1.2 | Likelihood terms associated with outcomes used in the AR5.

Term	Likelihood of the Outcome
<i>Virtually certain</i>	99–100% probability
<i>Very likely</i>	90–100% probability
<i>Likely</i>	66–100% probability
<i>About as likely as not</i>	33–66% probability
<i>Unlikely</i>	0–33% probability
<i>Very unlikely</i>	0–10% probability
<i>Exceptionally unlikely</i>	0–1% probability

** Additional terms (extremely likely: 95–100% probability, more likely than not: >50–100% probability, and extremely unlikely: 0–5% probability) may also be used when appropriate. (IPCC AR5, WG1, 36)*

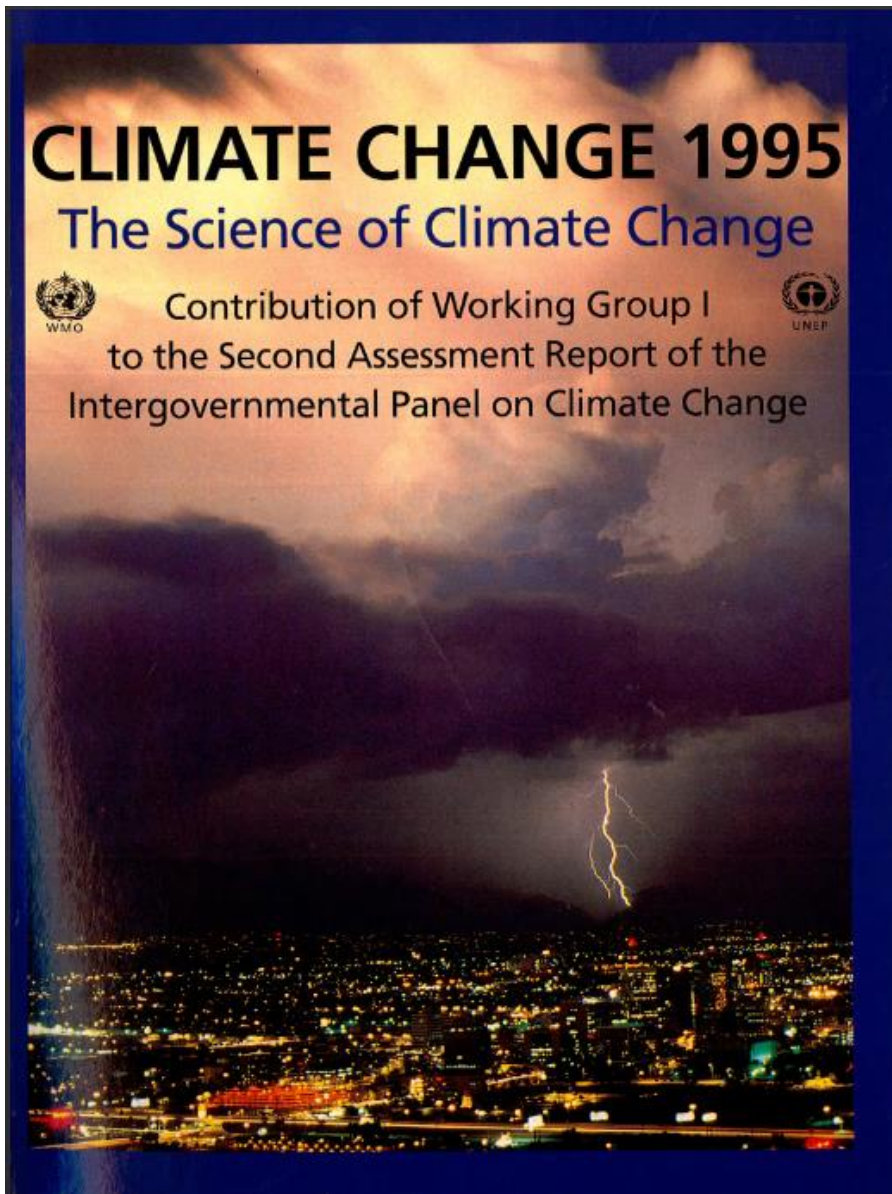
“This final section of the Technical Summary provides readers with a short overview of key uncertainties in the understanding of the climate system and the ability to project changes in response to anthropogenic influences. The overview is not comprehensive and does not describe in detail the basis for these findings. These are found in the main body of this Technical Summary and in the underlying chapters to which each bullet points in the curly brackets.”



FAR, 1990 IPCC

“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. **Thus the observed increase could be largely due to this natural variability**; alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.”

IPCC FAR, WG1 at p. xii (1990) (emphasis added)

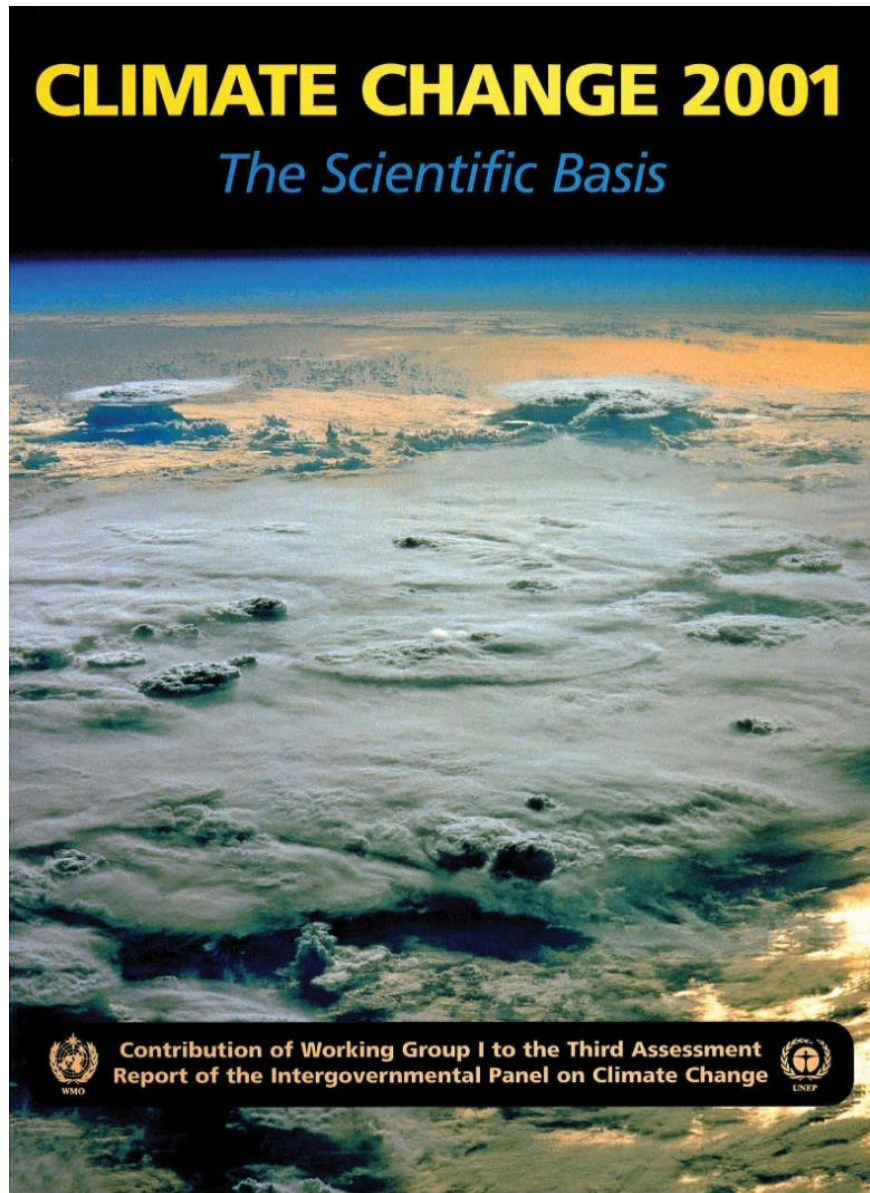


SAR, 1995 IPCC

“Our ability to quantify the human influence on global climate is currently limited **because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. . . .**

Nevertheless, the balance of evidence suggests that there is a discernible human influence on global climate.”

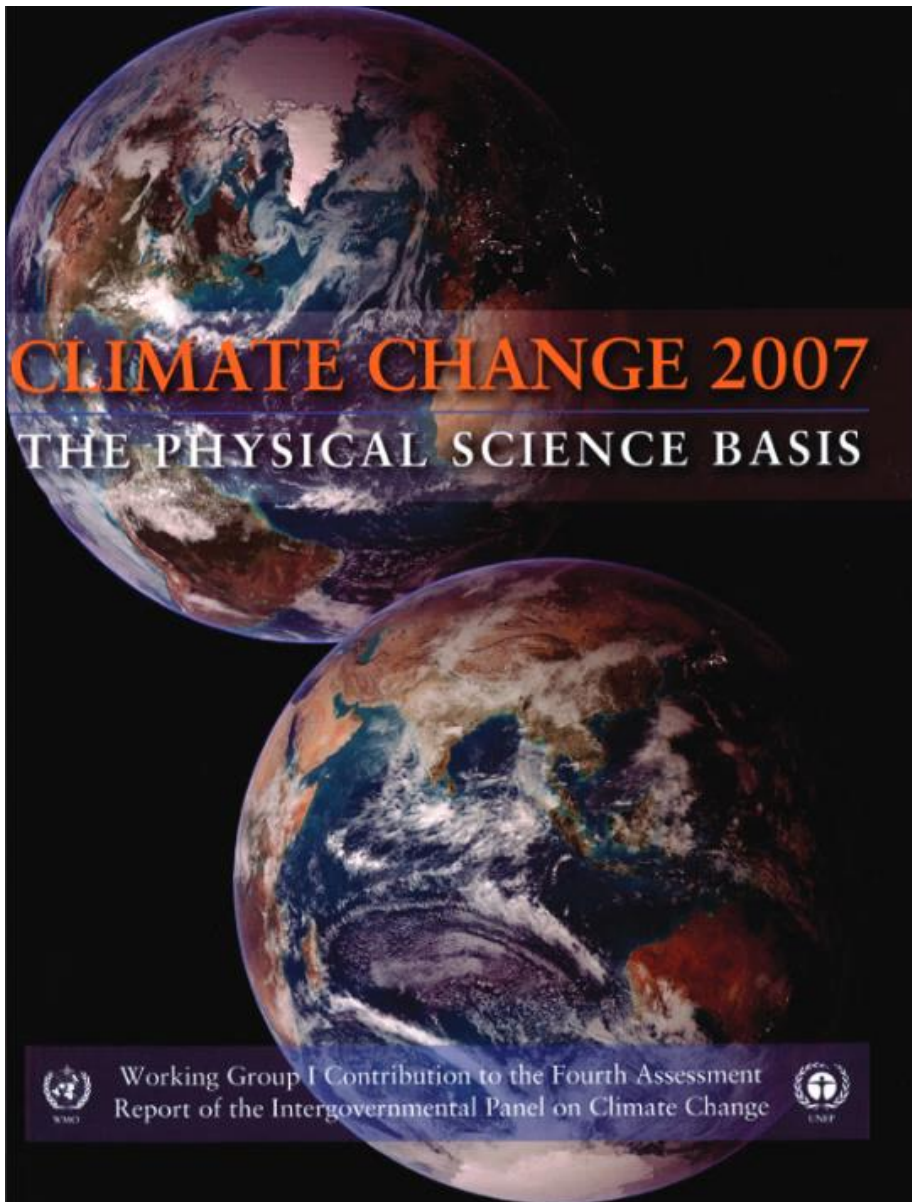
IPCC SAR, WG1 at p. 5 (1995) (emphasis added)



TAR, 2001 IPCC

“There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities. . . . There is a longer and more scrutinized temperature record and new model estimates of variability. Reconstructions of climate data for the past 1,000 years indicate this warming was unusual and is unlikely to be entirely natural in origin. The warming over the past 100 years is **very unlikely to be due to internal variability alone[.]**”

IPCC TAR, WG1 at p. 10 (2001) (emphasis added)
 (“likely” as described in the
 TAR is a 66-90% chance)



AR4, 2007 IPCC

“Most of the observed increase in global average temperatures since the mid-20th century is **very likely due to the observed increase in anthropogenic greenhouse gas concentrations.**

Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.”

IPCC AR4, WG1 at p. 10 (2007) (emphasis added)
 (“very likely” as described in
 AR4 as a greater than 90% chance)



AR5, 2013 IPCC

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

IPCC, AR5, WG1 at p. 17 (2013)
 (“extremely likely” as described
 in AR5 as a 95-100% chance)

“Globally, economic and population growth continued to be the most important drivers of increases in CO₂ emissions from fossil fuel combustion.”

IPCC AR5, SYR at p. 5 (2014)

International Cooperation Required

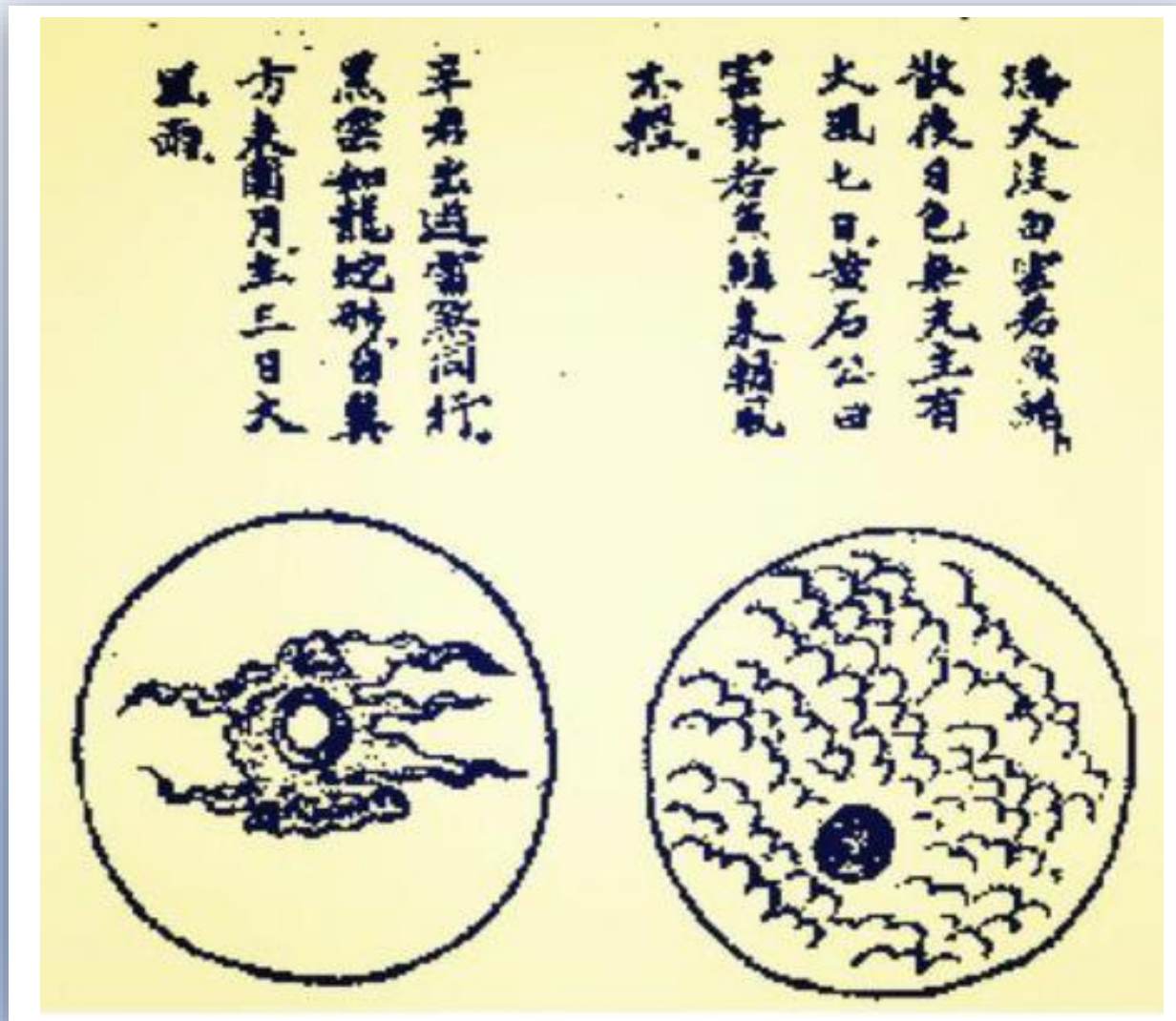
“Climate change has the characteristics of a collective action problem at the global scale, because most greenhouse gases (GHGs) accumulate over time and mix globally, and emissions by any agent (e.g., individual, community, company, country) affect other agents. International cooperation is therefore required to effectively mitigate GHG emissions and address other climate change issues.”

Climate As A Static System



Apiano, *Cosmographia*, 1575, fol. 5r, John E. Oliver, *Climate Zones*, in *Encyclopedia of World Climatology* 270 (John E. Oliver ed., 2005).

Cloud Records



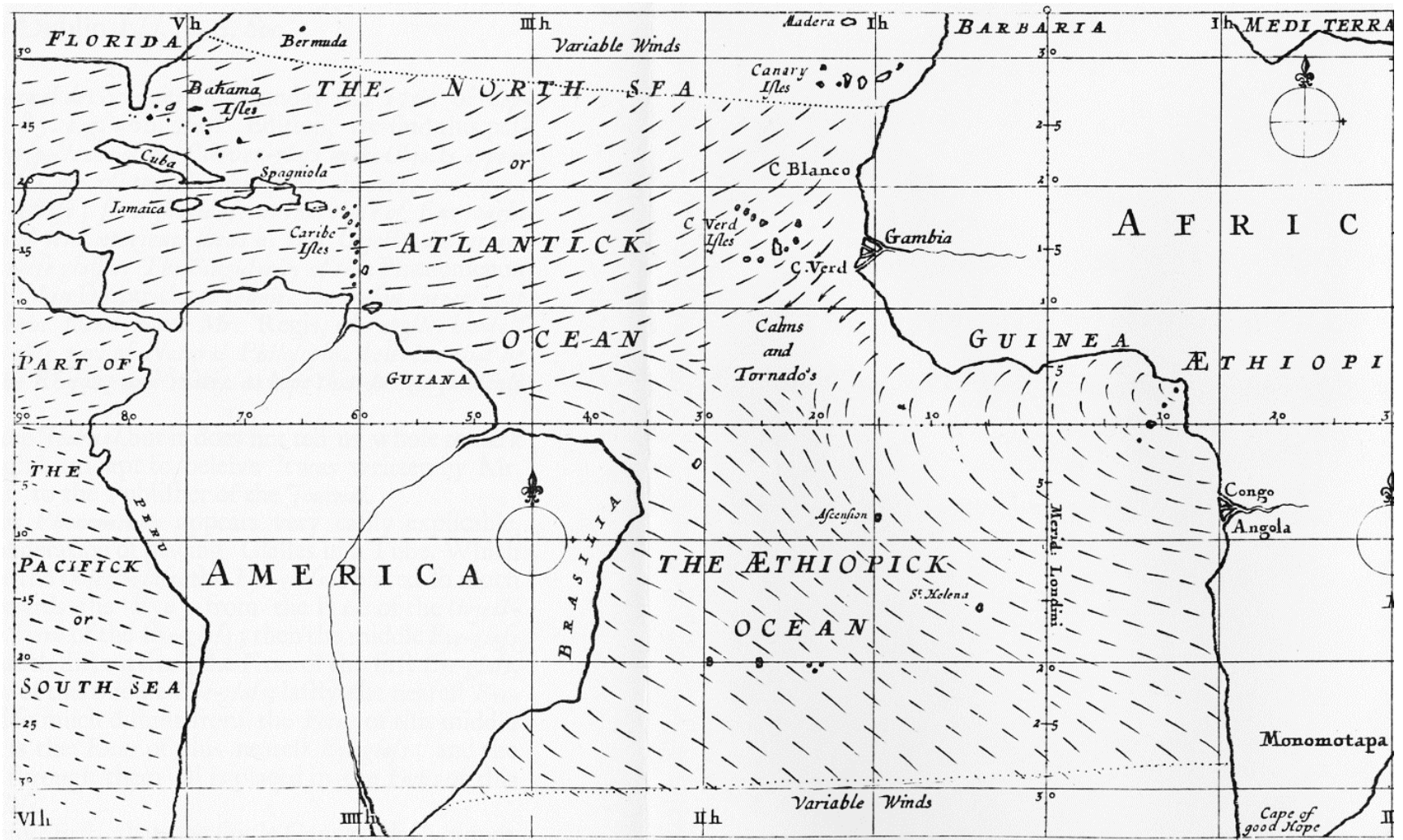
Ming Dynasty in the 1300s, David H. Miller, *History of Climatology*, in *Encyclopedia of World Climatology* 283 (John E. Oliver ed., 2005)

Temperature Records

Observations on the weather
Philadelphia 1776

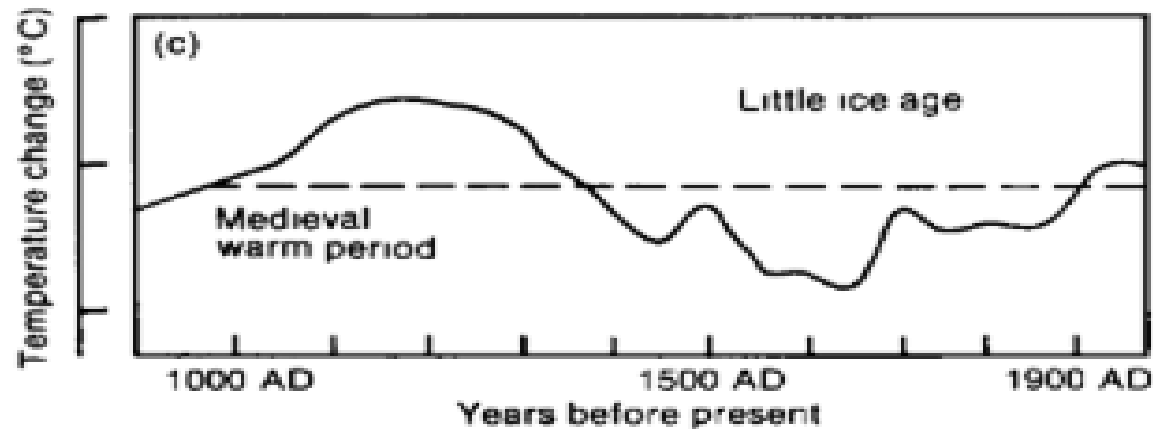
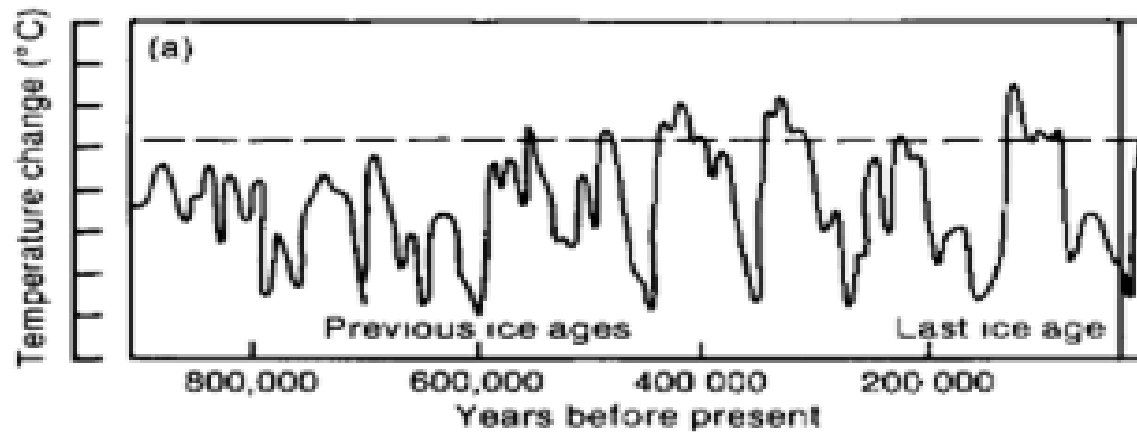
<i>July.</i>	<i>hour.</i>	<i>thermom.</i>	<i>day</i>	<i>h. m.</i>	<i>°</i>
1.	9-0 A.m.	81½	9	5-30 A.m.	75°
	7- P.m.	82.		9	77½
2.	6. A.m.	78.		6-30 P.m.	81½
	9-40' A.m.	78		9-45	78.
	9. P.m.	74	10.	8. A.m.	75.
3.	5-30' A.m.	71½		9-15.	76½
	1-30. P.m.	76		2-0. P.m.	80.
	8-10.	74.		4-45'	82.
4.	6. A.m.	68.		6-30	81½
	9.	72½		9-30.	78.
	1. P.m.	76	11.	5-30. A.m.	74.
	9.	73½		8.	76½

Trade Winds Map



Edmond Halley, 1686, John E. Oliver, *Climate Zones*, in *Encyclopedia of World Climatology* 270 (John E. Oliver ed., 2005).

The Ice Ages

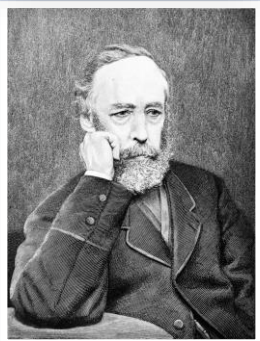


What Caused the Ice Ages?



Milutin Milankovitch: Orbital Variations

"[T]here is strong evidence that these [ice ages] are linked to regular variations in the Earth's orbit around the [s]un, the so-called Milankovitch cycles."



James Croll: Albedo Feedback Loop

"[M]any studies suggest that the amount of summer sunshine on northern continents is crucial: if it drops below a critical value, snow from the past winter does not melt away in summer and an ice sheet starts to grow as more and more snow accumulates."



Svante Arrhenius: CO₂ Feedback Loop

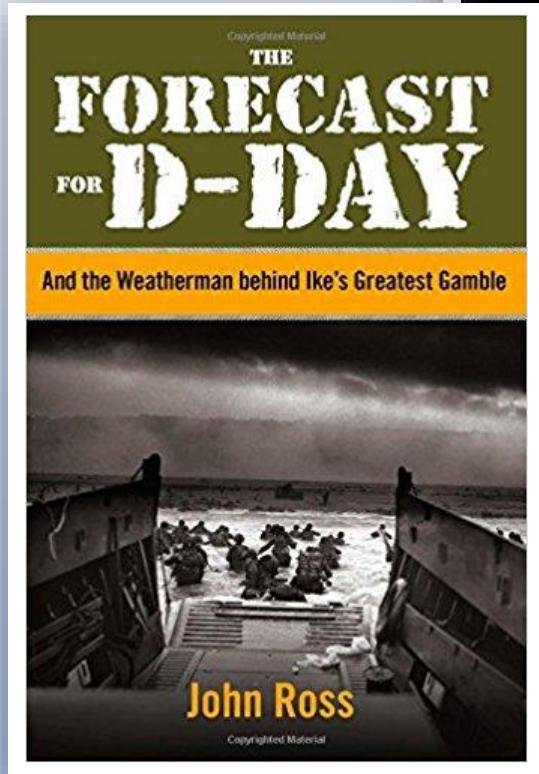
"Although it is not their primary cause, atmospheric carbon dioxide (CO₂) also plays an important role in the ice ages. . . . [A] small initial cooling due to the Milankovitch cycles is subsequently amplified as the CO₂ concentration falls."

The “Little Ice Age”



“The combined influence of volcanism, solar forcing [variation in the sun’s energy output] and a small drop in greenhouse gases (GHGs) *likely* contributed to Northern Hemisphere cooling during the LIA [Little Ice Age].”

World War II



Military applications for climate science

Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* (Jan. 2017), <https://history.aip.org/climate/Govt.htm>

Expansion of U.S. Government-Funded Research

1960

1970

1980

1990

NCAR

National Center
for Atmospheric
Research



The President's
Science Advisory
Committee


NOAA

National Oceanic
and Atmospheric
Administration


CIAP

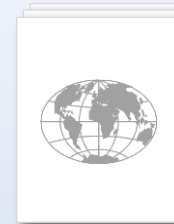
"Climatic Impact
Assessment
Program"


WCRP

The World Climate
Research
Programme



Global Climate
Protection Act


USGCRP

"United States
Global Change
Research Program"


ESSA

Environmental
Science Services
Administration


GARP

The Global
Atmospheric
Research Project


EPA


National Climate
Program Office
within NOAA



Expansion of U.S. Government-Funded Research

1960

1970

1980

1990



“This generation has altered the composition of the atmosphere on a global scale through radioactive materials and a steady increase in carbon dioxide from the burning of fossil fuels.”

Lyndon B. Johnson, Special Message to the Congress on Conservation and Restoration of Natural Beauty (Feb. 8, 1965)

ESSA

Environmental
Science Services
Administration



GARP

The Global
Atmospheric
Research Project



EPA

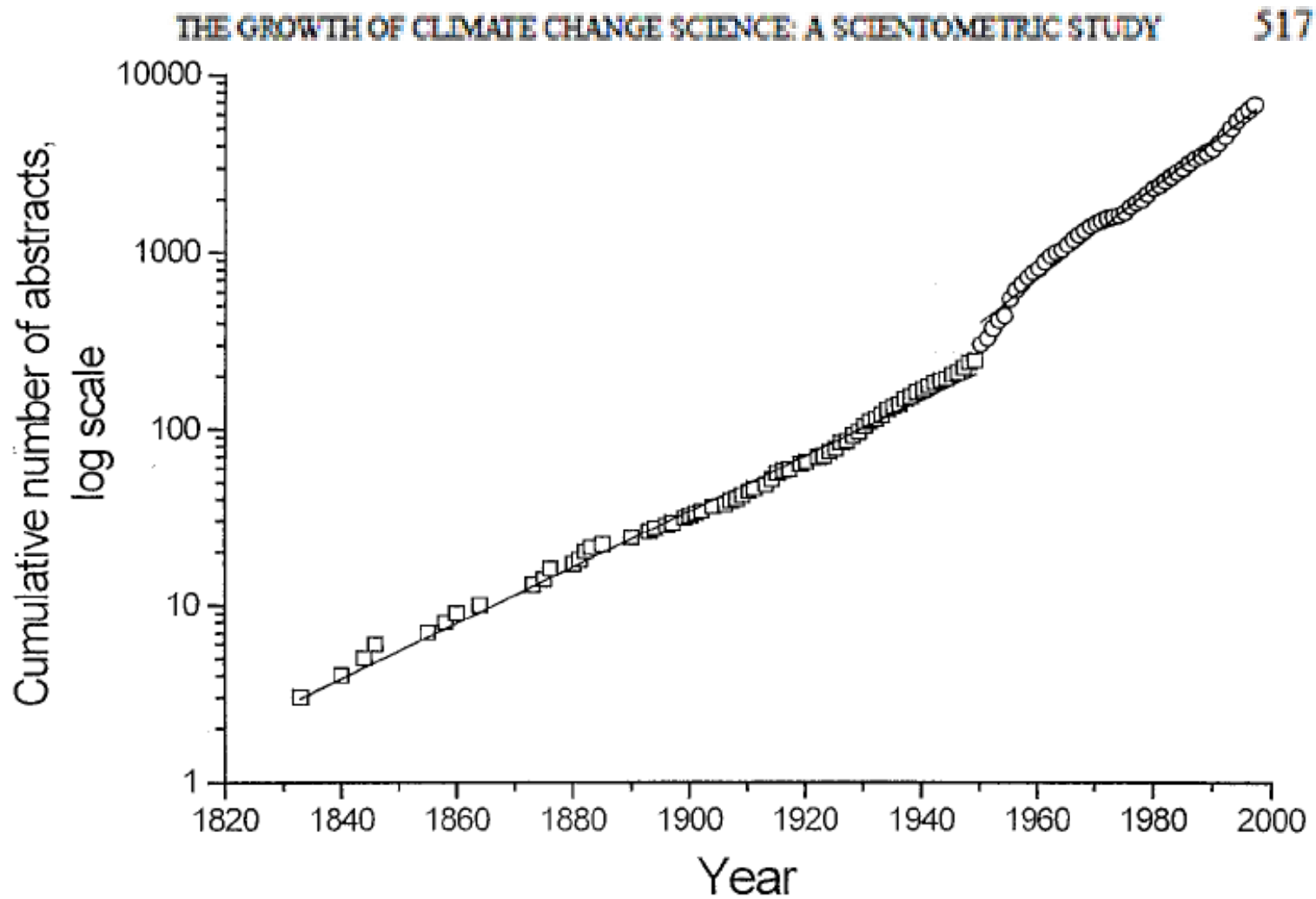


National Climate
Program Office
within NOAA



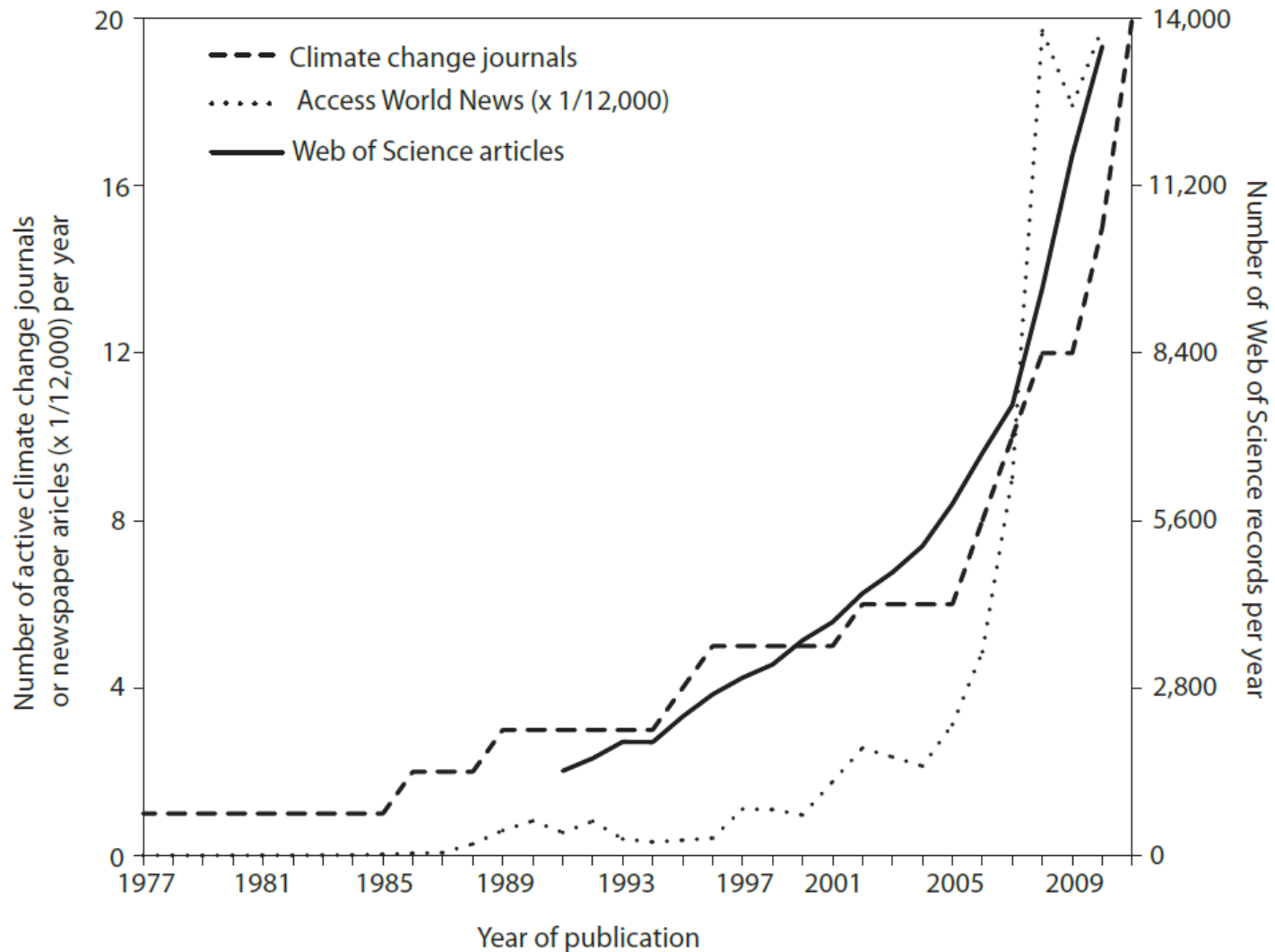
Climate Science Publishing

Case 3:17-cv-06011-WHA Document 179-1 Filed 03/21/18 Page 25 of 41



1820s-1999 (Gerald Stanhill, *The Growth of Climate Change Science: A Scientometric Study*, 48 Climatic Change 515 (2001))

Climate Science Publishing



Through 2010 (Michael L. Griensen & Minghua Zhang, *The Current Status of Climate Change Research*, 1 Nature Climate Change 72, 72-73 (2011))

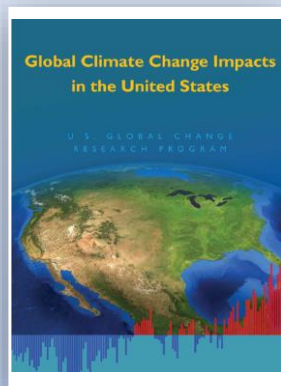
USGCRP Climate Assessments

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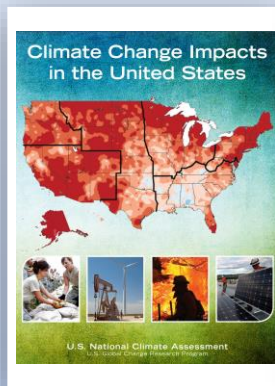
2000



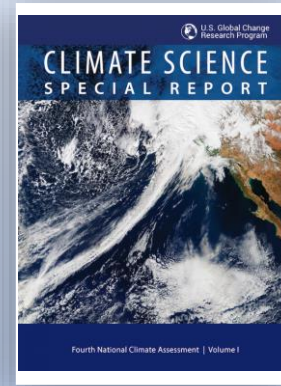
2009



2014



2017



2000

2005

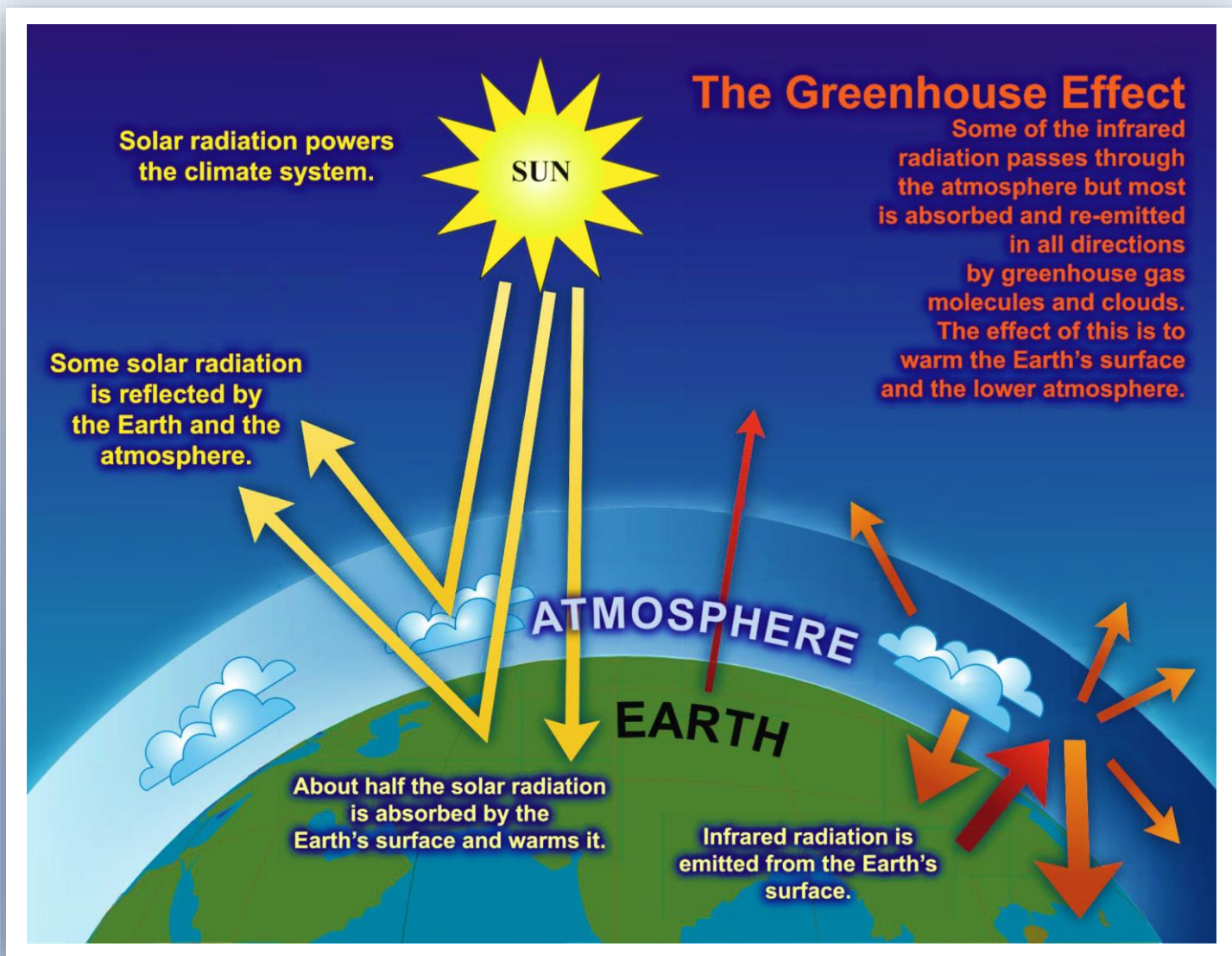
2010

2015

2020

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Basic Climate Processes



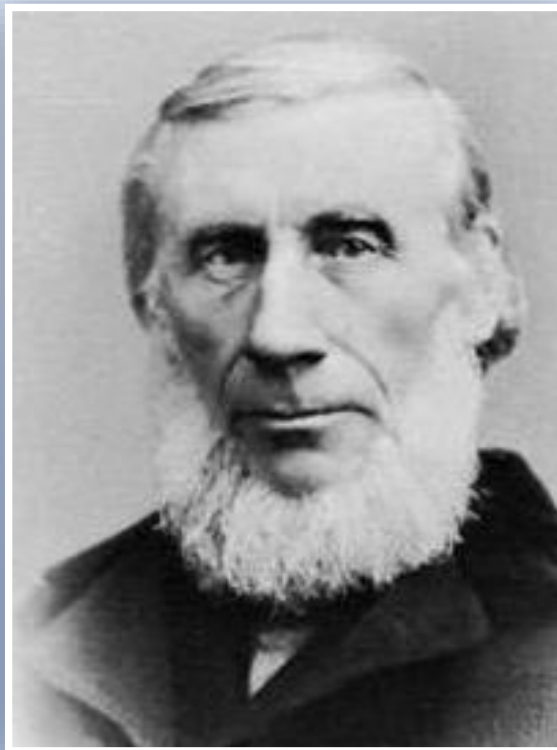
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Greenhouse Effect: Early Science

**Jean-Baptiste
Joseph Fourier**
(1766-1830)



John Tyndall
(1820-1893)



Svante Arrhenius
(1859-1927)





“The remainder of Angstrom’s paper is devoted to a destructive criticism of the theories put forth by the Swedish chemist, S. Arrhenius, in which the total absorption of CO_2 is quite inadmissibly inferred from data which include the combined absorption of CO_2 and the vapor of water.”

Knut Armstrong on Atmospheric Absorption, Monthly Weather Rev., June 1901, at 268

1900-1950s

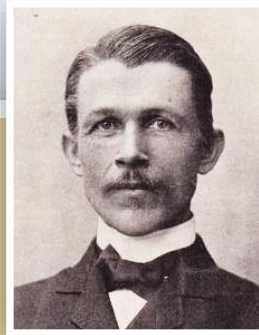
COMPENDIUM OF METEOROLOGY

Prepared under the Direction of the
Committee on the Compendium of Meteorology
H. R. BYERS H. E. LANDSBERG H. WEXLER
B. HAURWITZ A. F. SPILHAUS H. C. WILLETT
H. G. HOUGHTON, Chairman

Edited by
THOMAS F. MALONE



AMERICAN METEOROLOGICAL SOCIETY
BOSTON, MASSACHUSETTS
1951



“[Arrhenius] saw in this a cause of climactic changes, but **the theory was never widely accepted and was abandoned** when it was found that all the long-wave radiation absorbed by CO₂ is also absorbed by water vapor.”

C.E.P. Brooks, *Geological and Historical Aspects of Climate Change*, in *Compendium of Meteorology* 1004, 1016 (Thomas F. Malone ed., Am. Meteorological Soc’y 1951)

Benedict and Plyler

Journal of Research of the National Bureau of Standards

Vol. 46, No. 3, March 1951

Research Paper 2194

Absorption Spectra of Water Vapor and Carbon Dioxide in the Region of 2.7 Microns

W. S. Benedict and Earle K. Plyler

The absorption due to atmospheric H₂O and CO₂ in the region of 2.7 μ has been remeasured under higher resolution than previously reported. By using a 15,000-line grating and a lead sulfide photoconductive cell, some 450 lines have been measured between 2.43 microns (4,090 cm⁻¹) and 2.87 μ (3,500 cm⁻¹). A rotational analysis may be given for nearly all the lines. In addition to the known ν_2 fundamental of H₂O which causes the strongest absorption in the region, a number of lines due to the ν_1 fundamental of H₂O, and the $\left\{ \begin{smallmatrix} 02^+ \\ 10^+ \end{smallmatrix} \right\}$ combination bands of CO₂ may be recognized. The ν_1 analysis does not agree with one suggested previously. The following are the principal molecular constants derived from the new analyses:

Molecule	ν_1	ν_2	ν_3	ν_0	A	B	C
				cm ⁻¹	cm ⁻¹	cm ⁻¹	cm ⁻¹
H ₂ O.....	0	0	1	3755.79	26.64	14.40	9.16
H ₂ O.....	1	0	0	3657.65	27.13	14.29	9.11
CO ₂	0	2	1	3612.91	-----	0.3875 ₃	-----
CO ₂	1	0	1	3714.59	-----	.3872 ₃	-----

I. Introduction

Since the beginning of infrared spectroscopy, the existence of a region of strong atmospheric absorption near 2.7 μ has been recognized. With each advance in experimental techniques, permitting higher resolving power, more and more fine structure has been observed in the absorption band. The lines have the highly irregular spacing characteristic of an asymmetric rotator, and it has long been recognized that the strongest absorption is due to the H₂O molecule, in a fundamental vibration-rotation band. The first rotational analysis of this molecule was achieved by Mecke [1],¹ who was able to assign the strongest lines, as resolved by Plyler and Slesor [2], to transitions of low J in the asymmetrical valence vibration, ν_3 . Nielsen, [3], with improved resolution, made a more extensive analysis of the ν_3 band, and also attributed some of the weaker lines at longer wavelength to the symmetrical valence vibration, ν_1 , which appears strongly in the Raman effect.

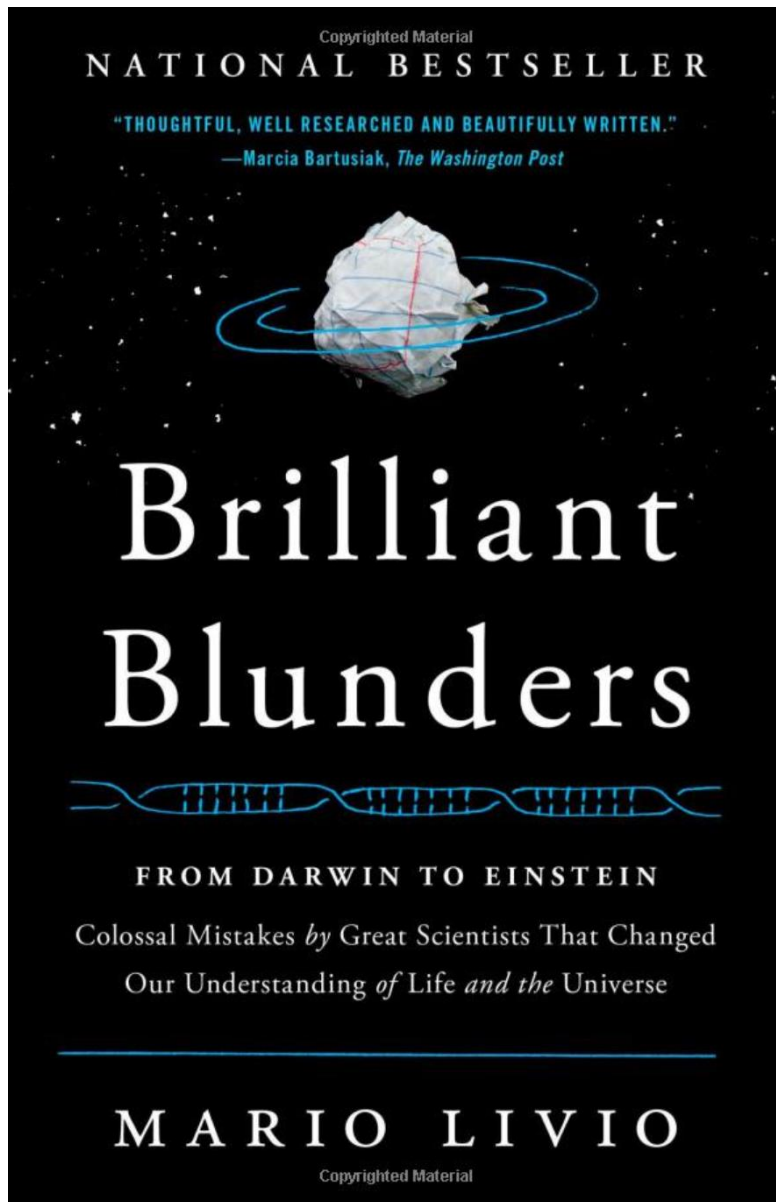
In the course of a study [4] of the structure of a large number of the overtone and combination bands of H₂O, it appeared that the reported identification of ν_1 in the infrared was questionable. We have accordingly reinvestigated the atmospheric absorption in the 2.7- μ region, making use of a recently developed grating spectrograph of high resolution [5]. In the course of the present investigation, we have arrived at a new identification of ν_1 , have extended the analysis of ν_3 to higher values of J , and in addition have identified a number of lines of two combination bands of CO₂ [6], which had not previously been studied under high resolution. The present

analysis of the spectrum accounts for nearly all of the more than 450 lines that have been observed between 2.43 μ (4,090 cm⁻¹) and 2.87 μ (3,500 cm⁻¹). The resulting energy levels are in good agreement with theoretical considerations and with the observations on the overtone and combination bands.

II. Experimental Procedure

The spectrometer, which uses a 15,000-line, 7 $\frac{1}{2}$ -in. ruled surface as the dispersing element and a lead-sulfide photoconductive cell as the receiver, has been described [5]. In order to reach the longest wavelengths desired in this study, it was necessary to use the grating at its extreme angle, thus reducing the intensity of radiation. The sensitivity of the PbS detector also falls off at the longest wavelengths, so that relatively wide slits were required beyond 2.8 μ . However at wavelengths shorter than 2.75 μ ($\nu > 3,640$ cm⁻¹) the instrument could be operated at its maximum resolving power. Under these conditions records with good signal-to-noise ratios were obtained with spectral slit widths of 0.12 cm⁻¹. This is comparable to, or less than the width of the H₂O lines, when the water-vapor content of the optical path in the room and the spectrometer was that prevailing on a dry February day. It is often possible to distinguish the presence of two components in lines separated by 0.15 cm⁻¹, and lines 0.30 cm⁻¹ apart are clearly resolved. Further lowering of the water-vapor content might result in some further improvement in resolution, but as the present resolution was adequate, and as it was desired to record as many of the weaker lines as possible, this was not attempted.

¹ Figures in brackets indicate the literature references at the end of this paper.



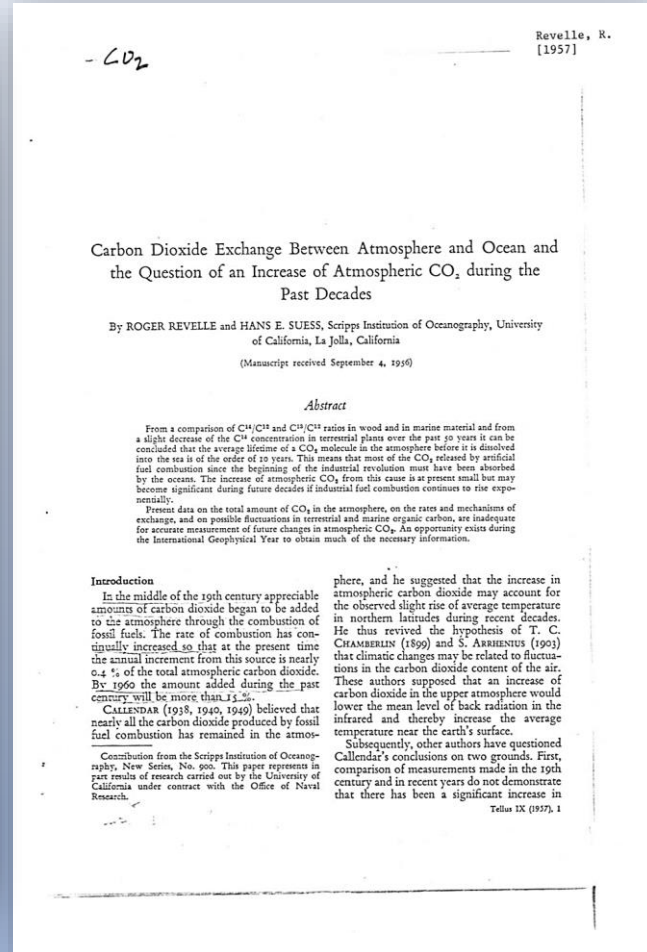
Brilliant Blunders (2013)

“[T]he road to discovery and innovation can be constructed even through the unlikely path of blunders.”

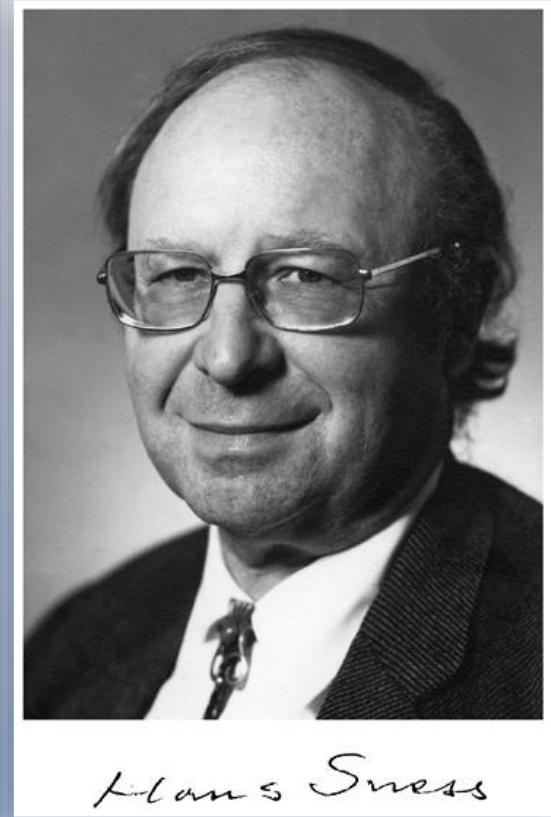
Mario Livio, *Brilliant Blunders* (2013)

Revelle and Suess

Roger Revelle

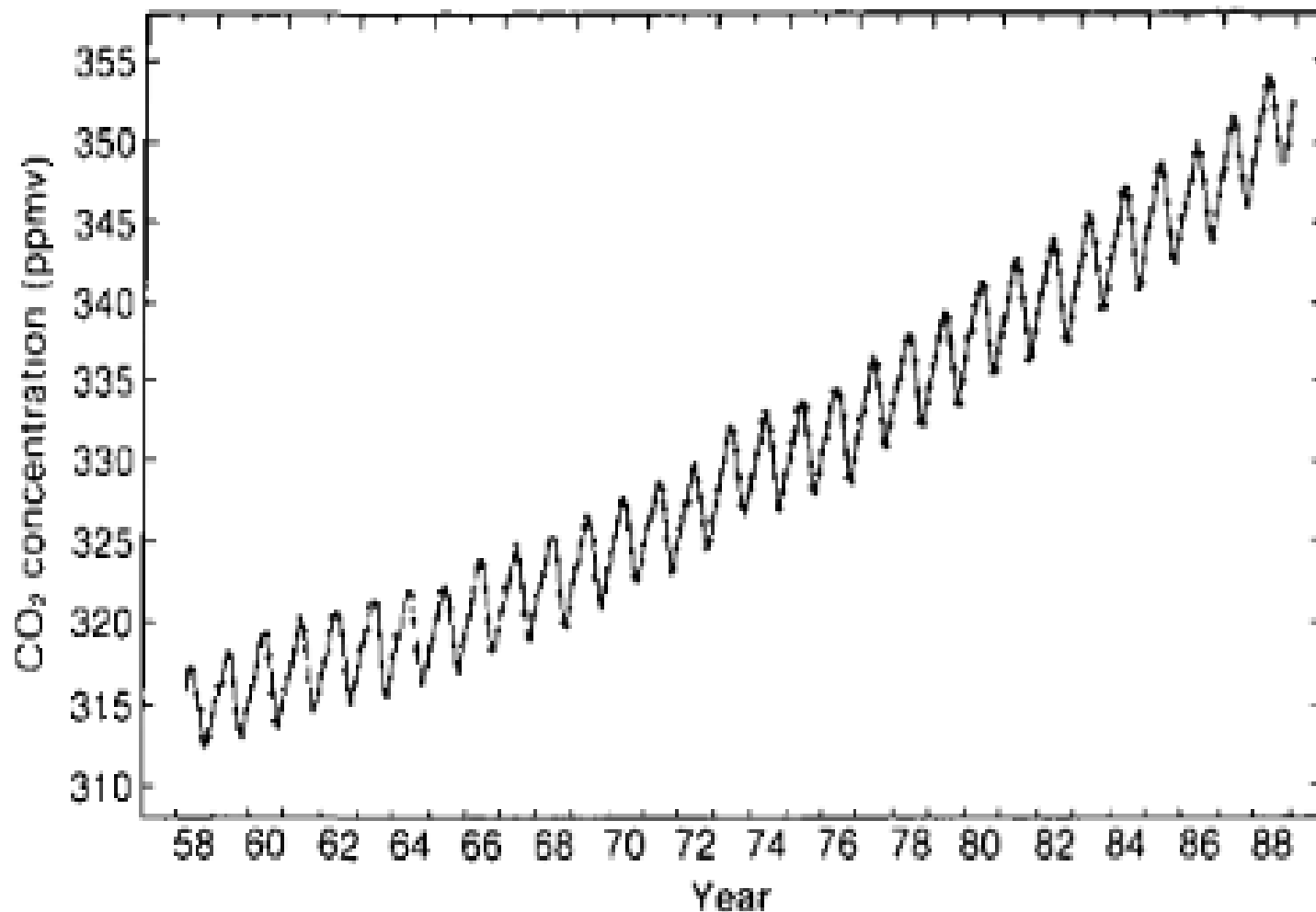


Hans Suess



Roger Revelle & Hans Suess, *Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase in Atmospheric CO₂ During the Past Decades*, 9 Tellus 18 (1956); see also Spencer Weart, *The Carbon Dioxide Greenhouse Effect, The Discovery of Global Warming* (Jan. 2017), <https://history.aip.org/climate/co2.htm>

Keeling Curve

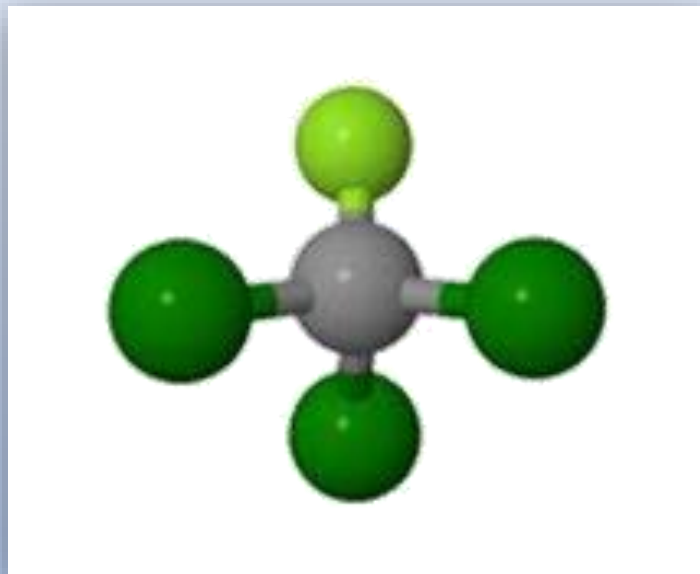


The Ozone Layer



CFCs

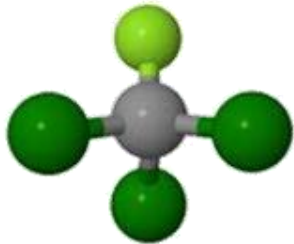
CFC



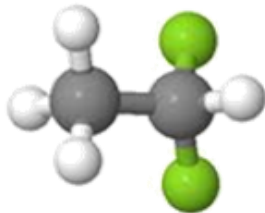
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Other Greenhouse Gases

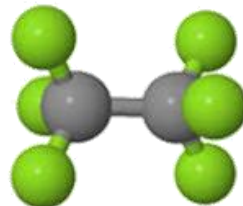
CFC



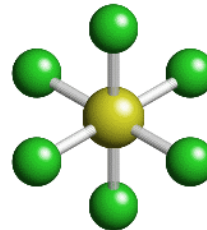
HFC



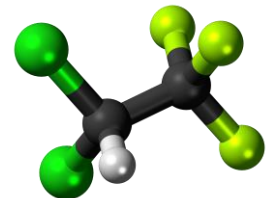
PFC



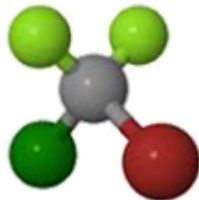
SF6



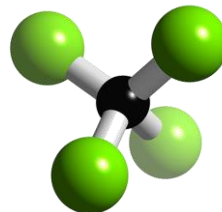
HCFC



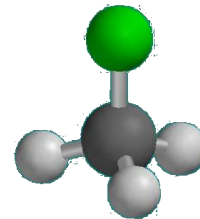
Halons



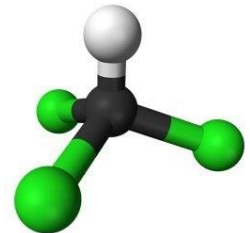
CCl4



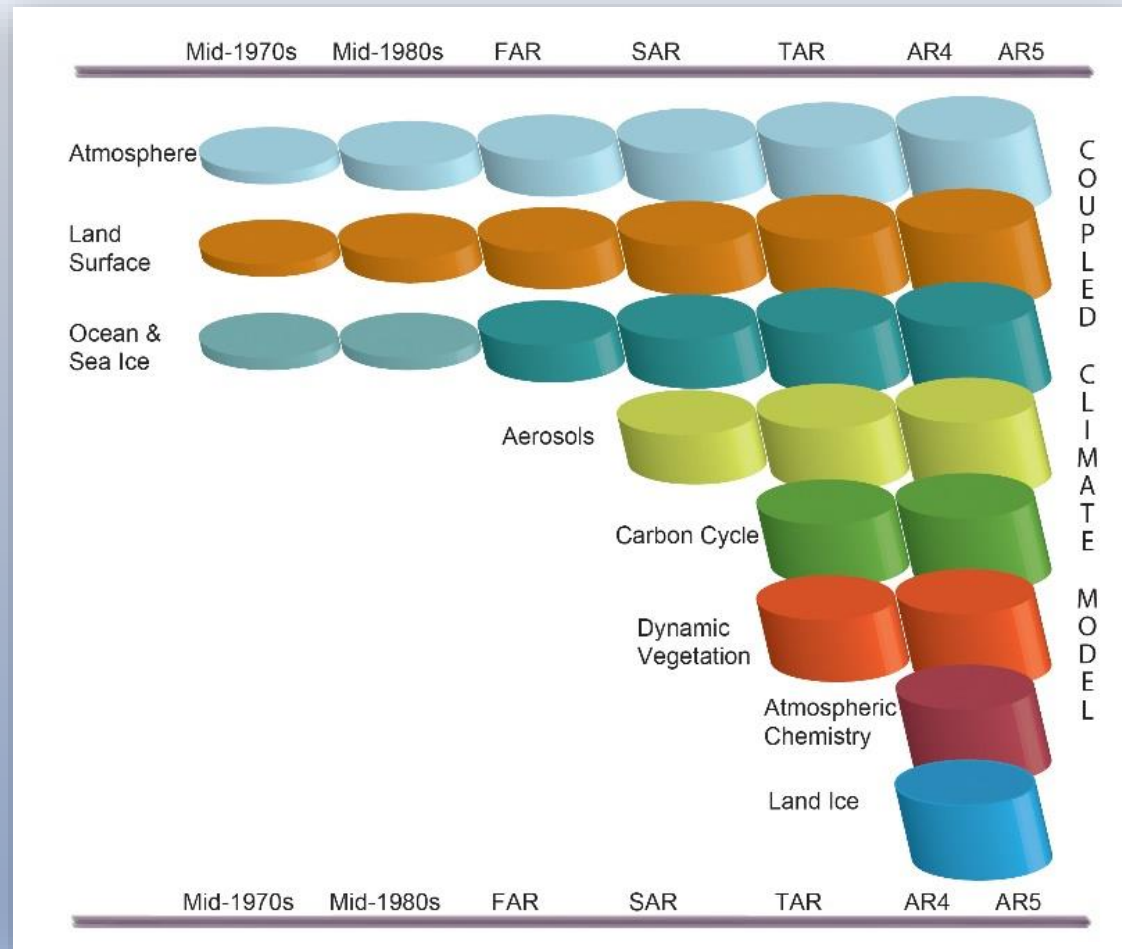
CH3Br



CH3Cl



Climate Modeling: 1970s-Today



“Inevitably, some models perform better than others for certain climate variables, but no individual model clearly emerges as ‘the best’ overall.”

Complexities in Climate Modeling

“Climate models of today are, in principle, better than their predecessors. However, **every bit of added complexity, while intended to improve some aspect of simulated climate, also introduces new sources of possible error** (e.g., via uncertain parameters) and new interactions between model components that may, if only temporarily, degrade a model’s simulation of other aspects of the climate system. Furthermore, despite the progress that has been made, scientific uncertainty regarding the details of many processes remains.”

Climate Model Projections

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Global mean temperature near-term projections relative to 1986–2005

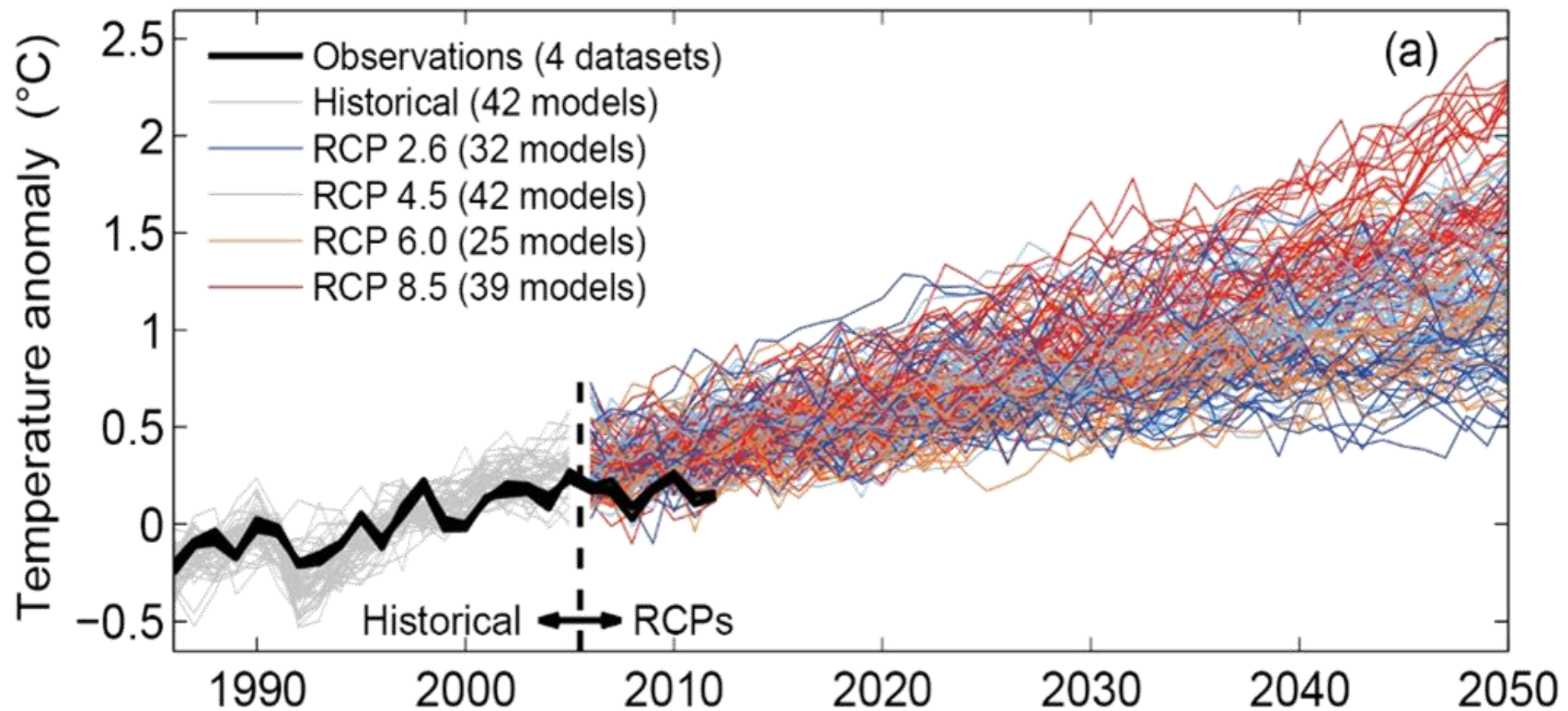


Exhibit B

TUTORIAL: PART II

“The second part will set forth the best science now available on global warming, glacier melt, sea rise, and coastal flooding.”

Notice Re: Tutorial (Feb. 27, 2018)

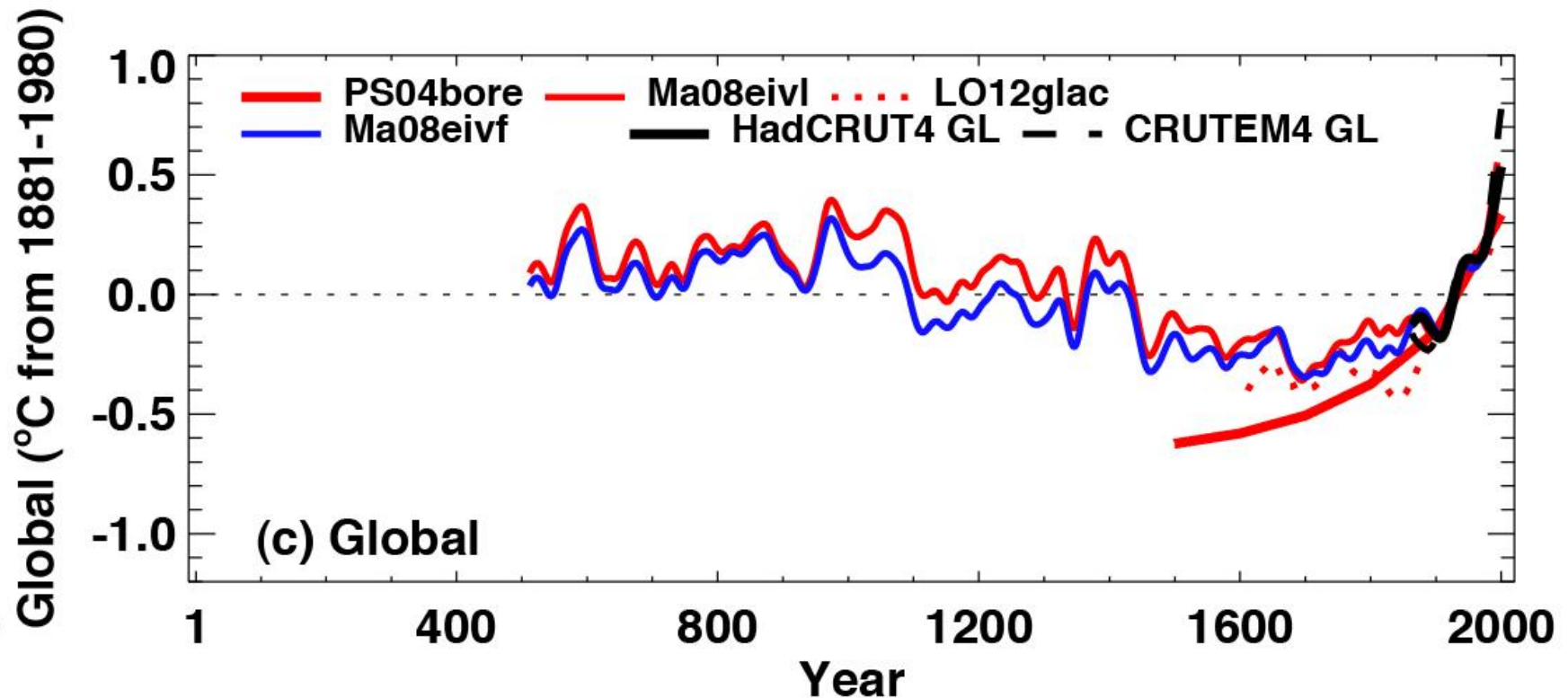
Tutorial Part II

- ▶ **Global Warming**
- ▶ **Glacier Melt**
- ▶ **Sea Level Rise and Coastal Flooding**

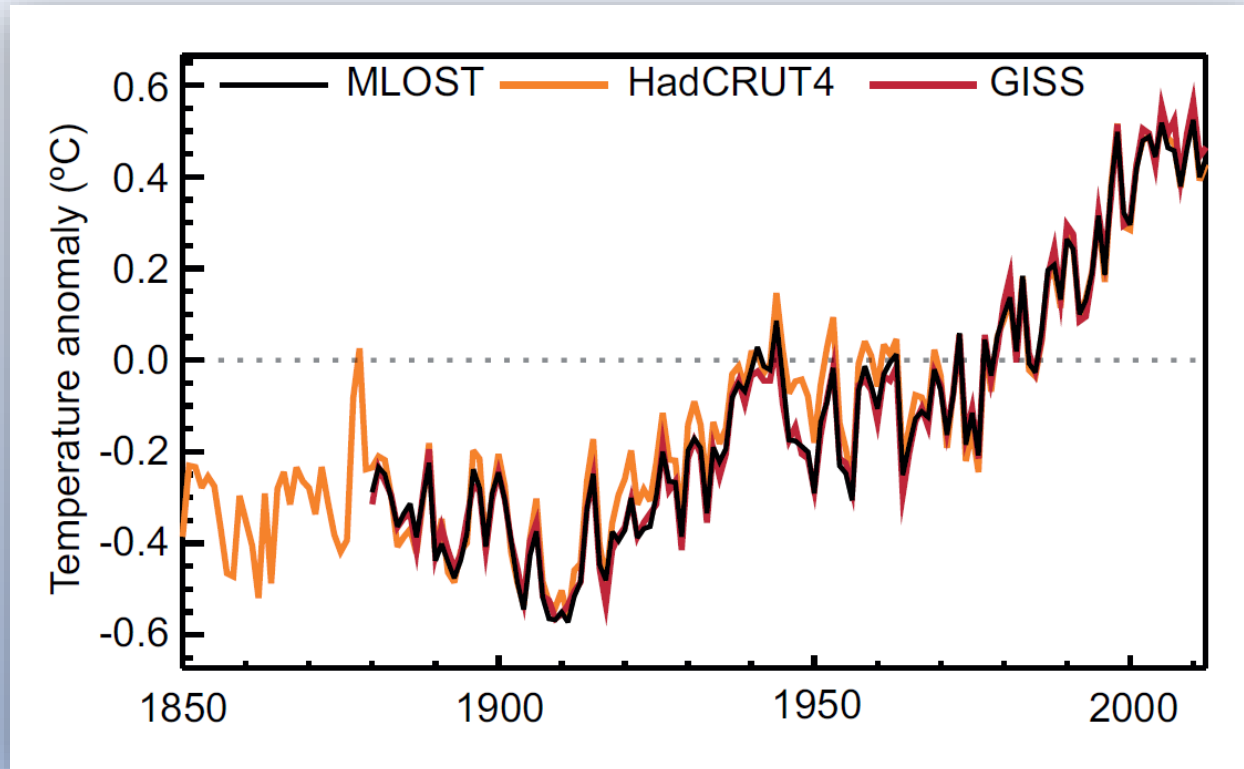
“Temperature Variations During the Last 2000 Years”

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IPCC AR5, WG1 at p. 409 (2013)



Global Temperature Anomalies: 1850 to 2012

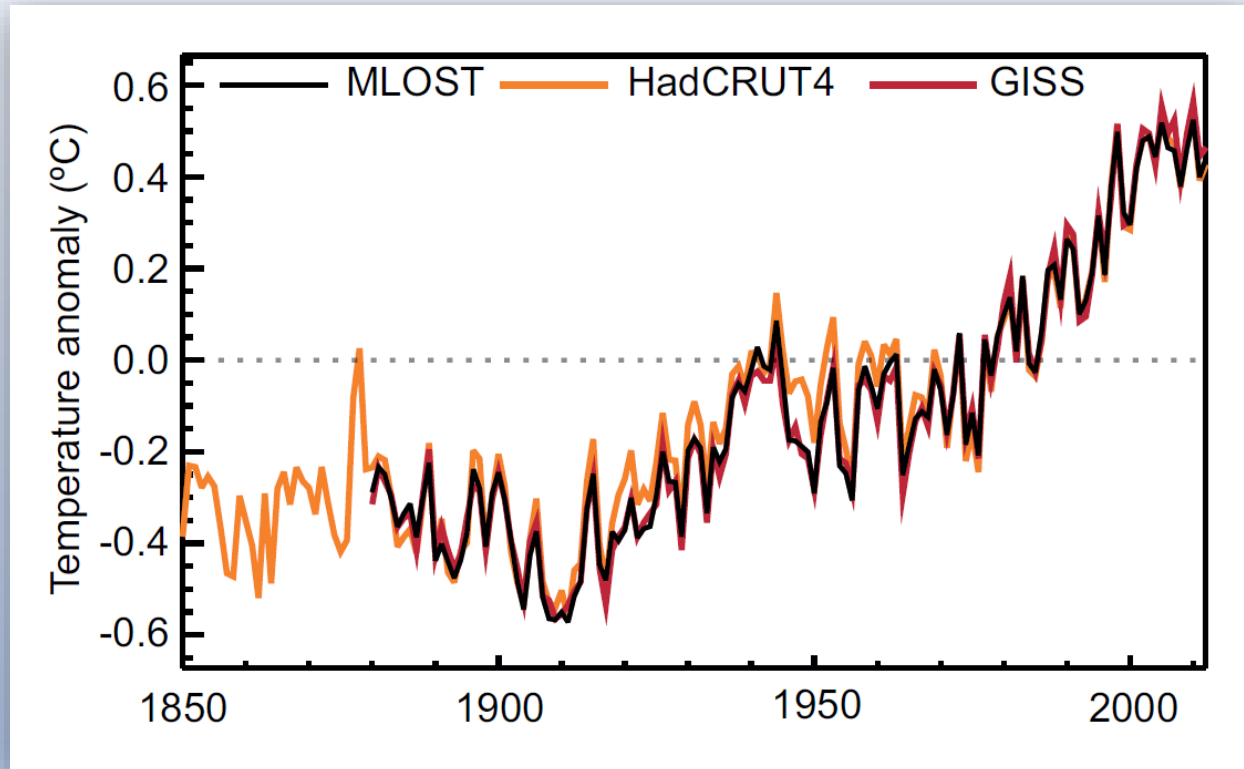


IPCC AR5, WG1, Fig. 2.20 at p. 193 (2013)

“Since 1901 almost the whole globe has experienced surface warming. Warming has not been linear; most warming occurred in two periods: around 1900 to around 1940 and around 1970 onwards.”

IPCC AR5, WG1 at p. 193 (2013) (citation omitted)

Global Temperature Anomalies: Early 20th Century

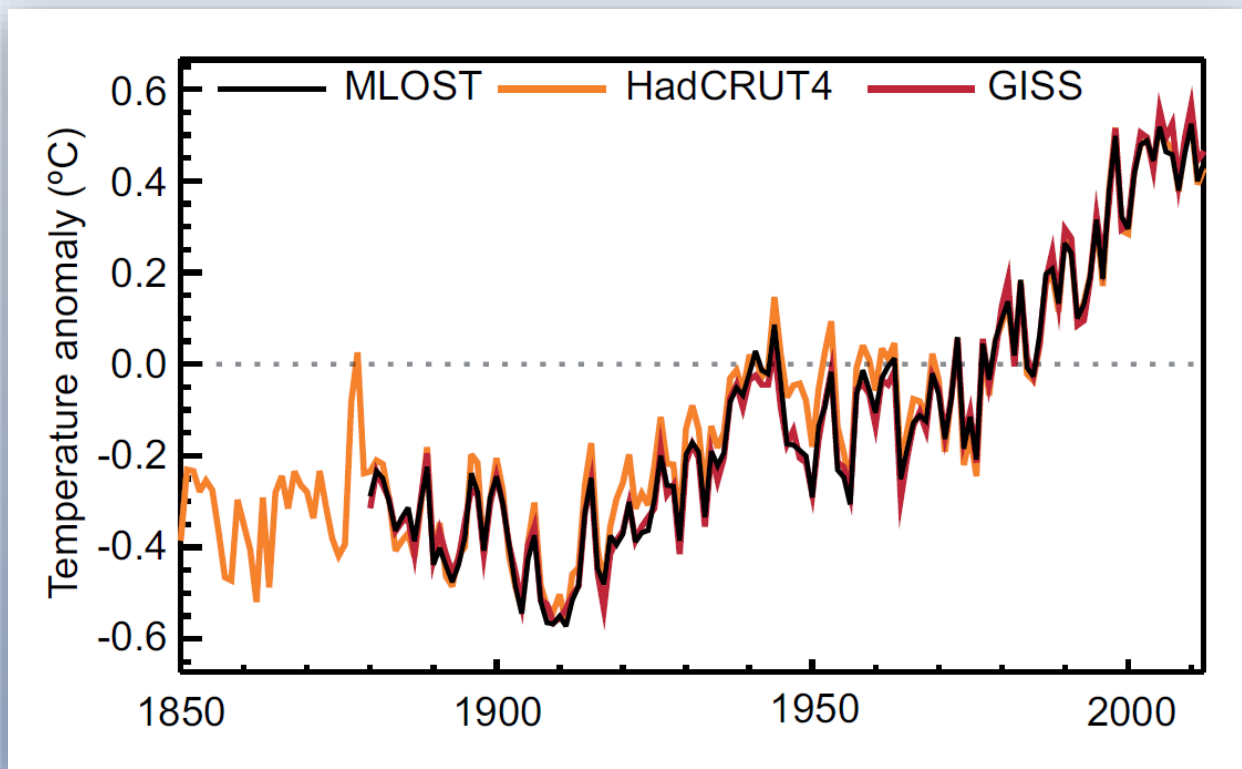


IPCC AR5, WG1, Fig. 2.20 at p. 193 (2013)

“In conclusion, the early 20th century warming is *very unlikely* to be due to internal variability alone. It remains difficult to quantify the contribution to this warming from internal variability, natural forcing and anthropogenic forcing, due to forcing and response uncertainties and incomplete observational coverage.”

IPCC AR5, WG1 at p. 887 (2013)

Global Temperature Anomalies: 1951 to 2012



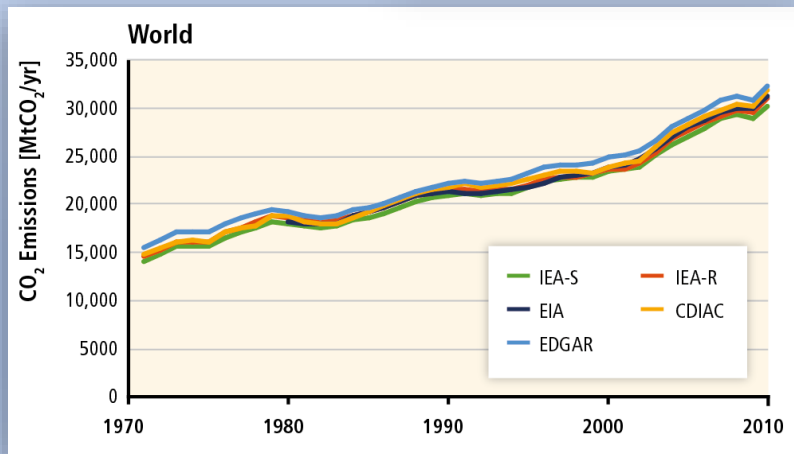
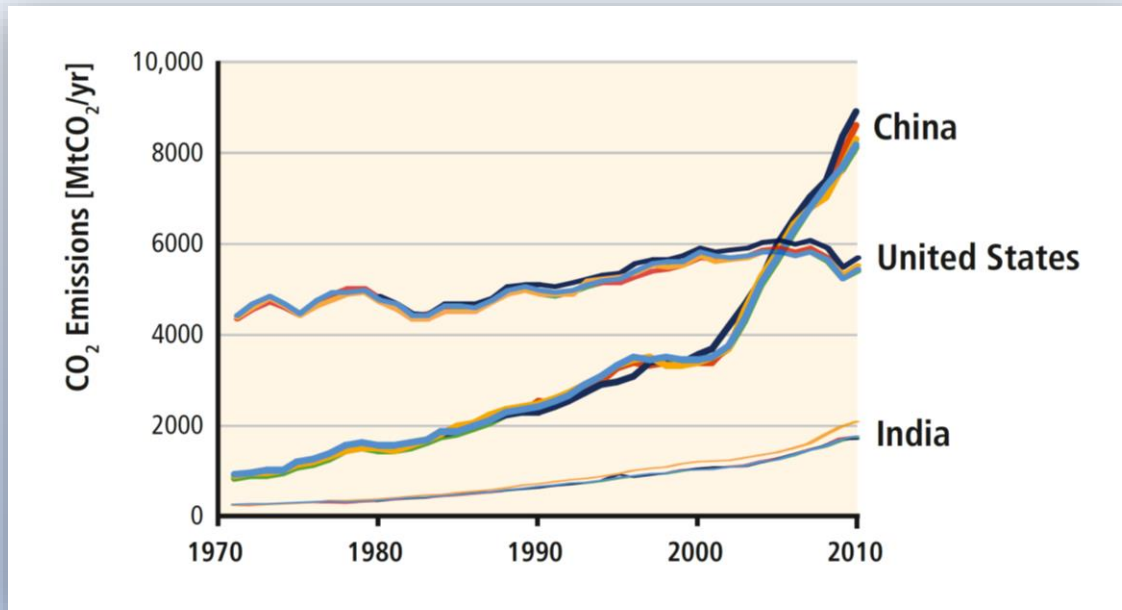
IPCC AR5, WG1, Fig. 2.20 at p. 193 (2013)

“It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.”

IPCC AR5, WG1 at p. 17 (2013)

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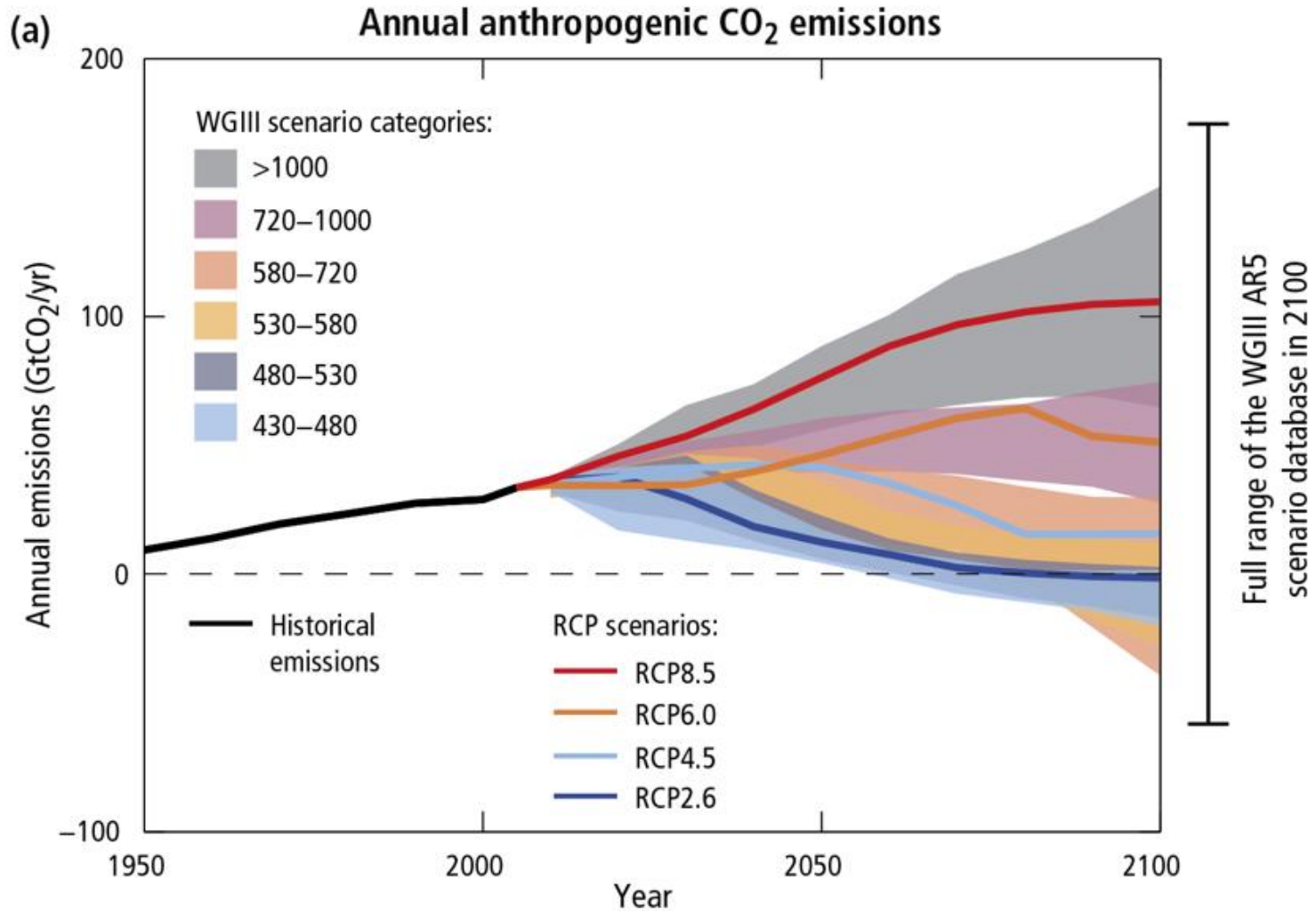
Historic CO₂ Emissions



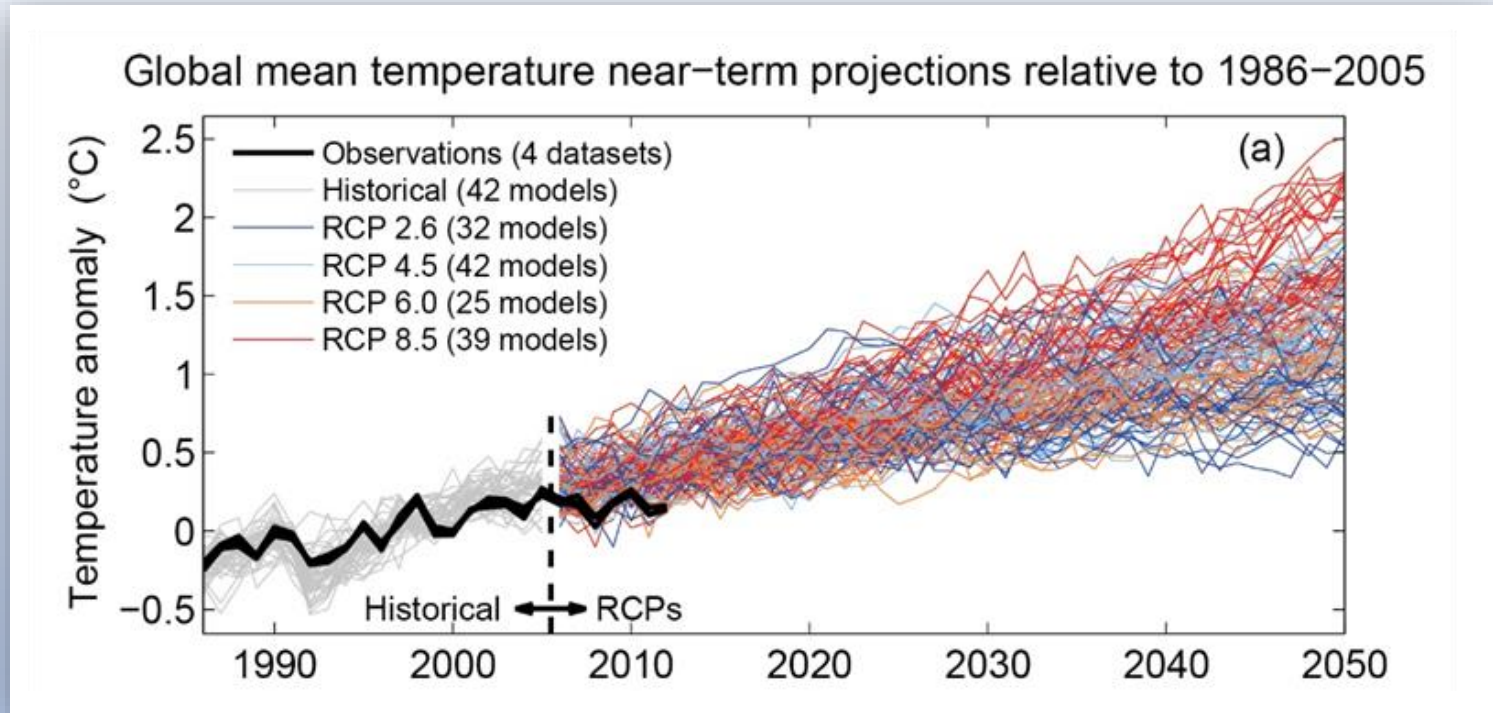
“Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy.”

IPCC AR5, SYR at p. 8 (2014)

IPCC: CO₂ Emission Scenarios



Climate Model Projections



IPCC AR5, WG1, Fig. 11.25(a) at p. 1011 (2013)

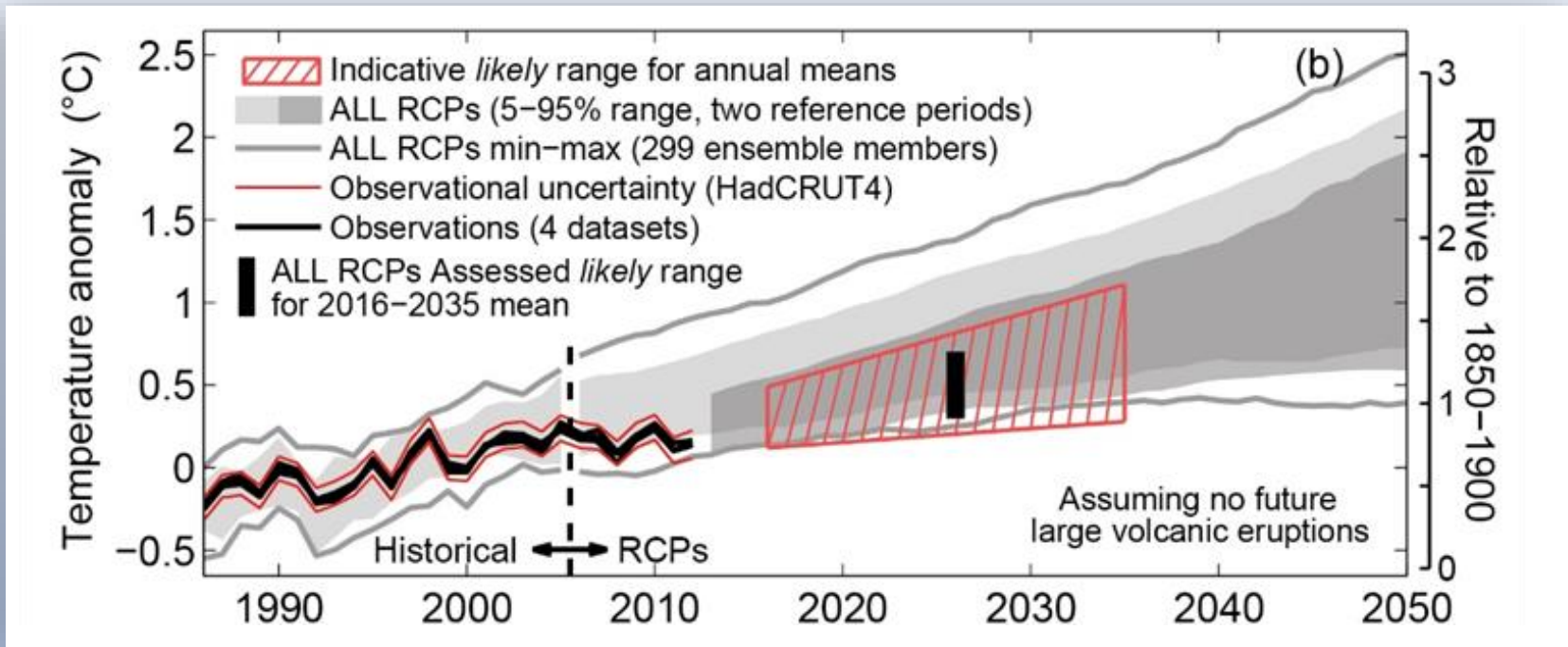
“[S]ome models may be too sensitive to anthropogenic forcing.”

IPCC AR5, WG1 at p. 1010 (2013)

“By mid-21st century, the magnitude of the projected climate change is substantially affected by the choice of emissions scenario.”

IPCC AR5, SYR at p. 10 (2014)

IPCC: Likely Temperature Range, 2016 to 2035



IPCC AR5, WG1, Fig. 11.25(b) at p. 1011 (2013)

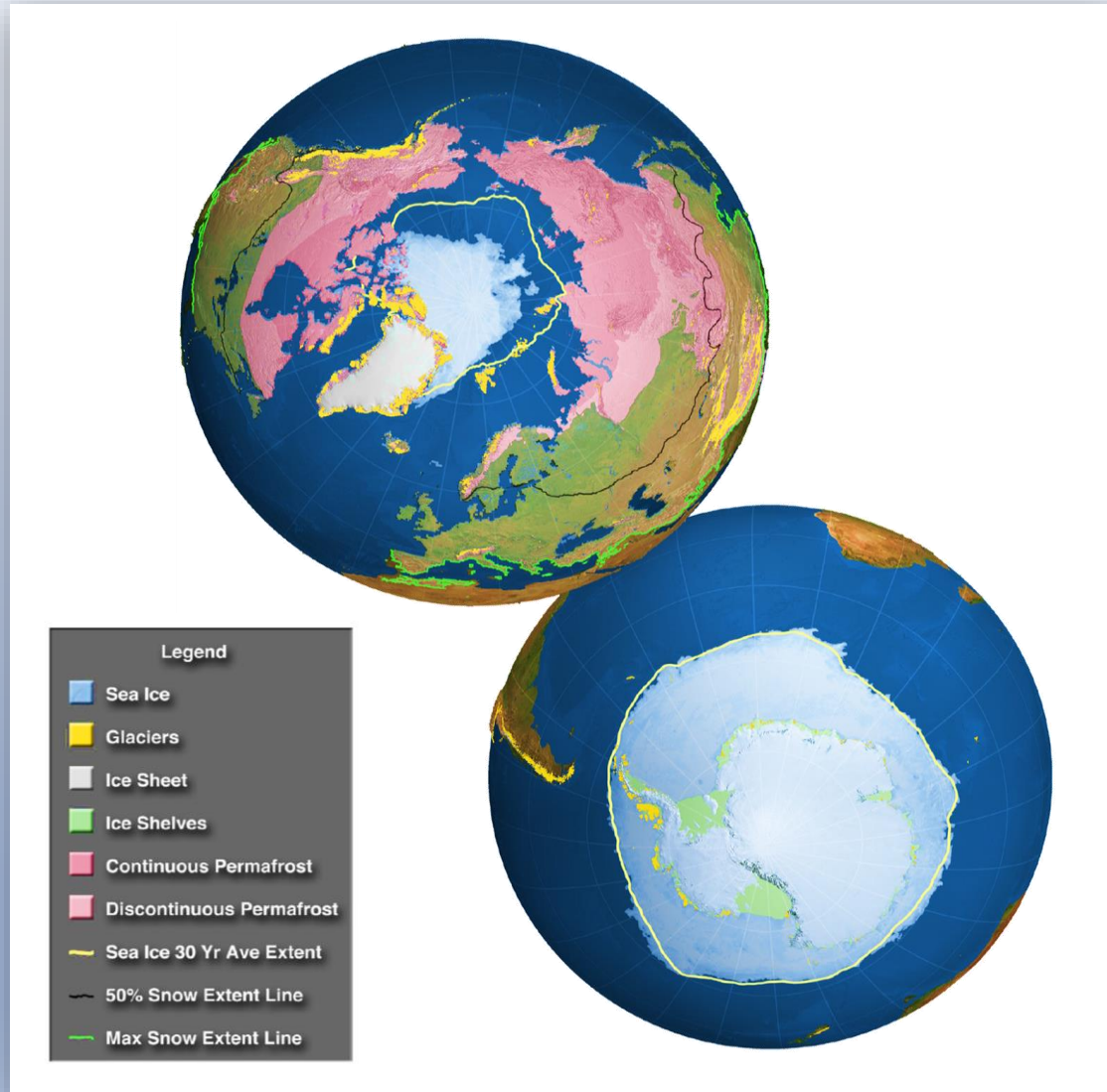
“Overall, in the absence of major volcanic eruptions—which would cause significant but temporary cooling—and, assuming no significant future long term changes in solar irradiance, it is *likely* (>66% probability) that the [Global Mean Surface Temperature] anomaly for the period 2016–2035, relative to the reference period of 1986–2005 will be in the range 0.3°C to 0.7°C (expert assessment, to one significant figure; *medium confidence*).”

IPCC AR5, WG1 at p. 1010 (2013)

Tutorial Part II

- ▶ Global Warming
- ▶ **Glacier Melt**
- ▶ Sea Level Rise and Coastal Flooding

Northern and Southern Views of Cryosphere



Glaciers

“The arithmetic-mean estimate of Leclercq et al. (2011) indicates continuous mass loss from glaciers after about 1850.”

IPCC AR5, WG1 at p. 343 (2013) (citation omitted)

“Overall, there is *very high confidence* that globally, the mass loss from glaciers has increased since the 1960s.”

IPCC AR5, WG1 at p. 344 (2013)

“Anthropogenic influences *likely* contributed to the retreat of glaciers since the 1960s.”

IPCC AR5, WG1 at p. 19 (2013)

Greenland

“Over Greenland, temperature has risen significantly since the early 1990s, reaching values similar to those in the 1930s.”

IPCC AR5, WG1 at p. 353 (2013) (citation omitted)

“There is *very high confidence* that the Greenland ice sheet has lost ice during the last two decades.”

IPCC AR5, WG1 at p. 41 (2013)

“It is *likely* that anthropogenic forcing has contributed to surface melting of the Greenland ice sheet since 1993.”

IPCC AR5, WG1 at p. 909 (2013)

“Since 2007, internal variability is *likely* to have further enhanced the melt over Greenland.”

IPCC AR5, WG1 at p. 870 (2013)

Antarctica

“Overall, there is *high confidence* that the Antarctic ice sheet is currently losing mass.”

IPCC AR5, WG1 at p. 352 (2013)

“There is *low confidence* that the rate of Antarctic ice loss has increased over the last two decades.”

IPCC AR5, WG1 at p. 352 (2013)

“Anthropogenic forcings have *likely* made a substantial contribution to surface temperature increases since the mid-20th century over every continental region except Antarctica.”

IPCC AR5, SYR at p. 5 (2014)

Antarctica: IPCC “Key Uncertainties”

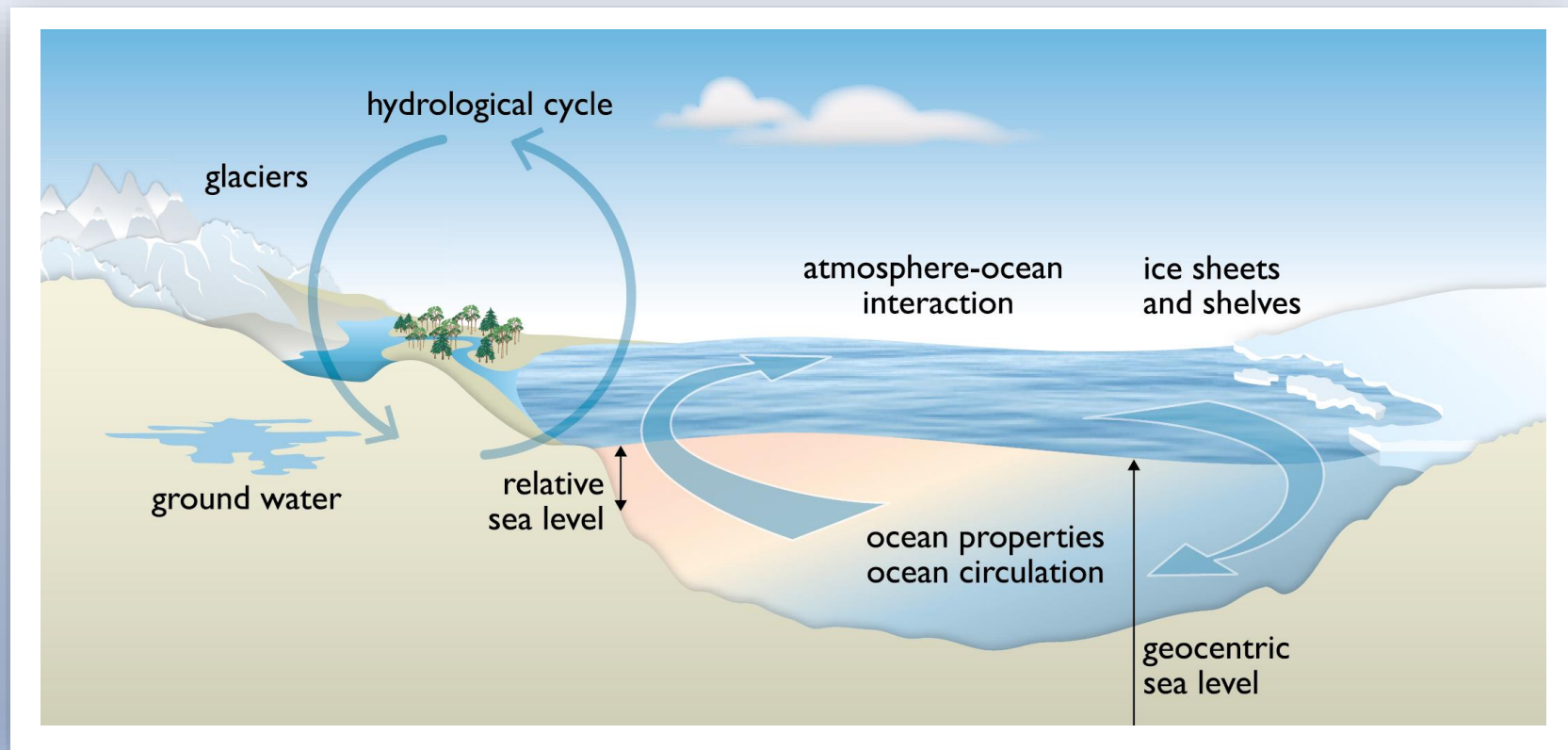
“Key Uncertainties in Understanding the Climate System and Its Recent Changes”

“In some aspects of the climate system, including . . . Antarctic warming, Antarctic sea ice extent, and Antarctic mass balance, *confidence* in attribution to human influence remains *low* due to modelling uncertainties and low agreement between scientific studies.”

Tutorial Part II

- ▶ Global Warming
- ▶ Glacier Melt
- ▶ **Sea Level Rise and Coastal Flooding**

Components of Sea Level

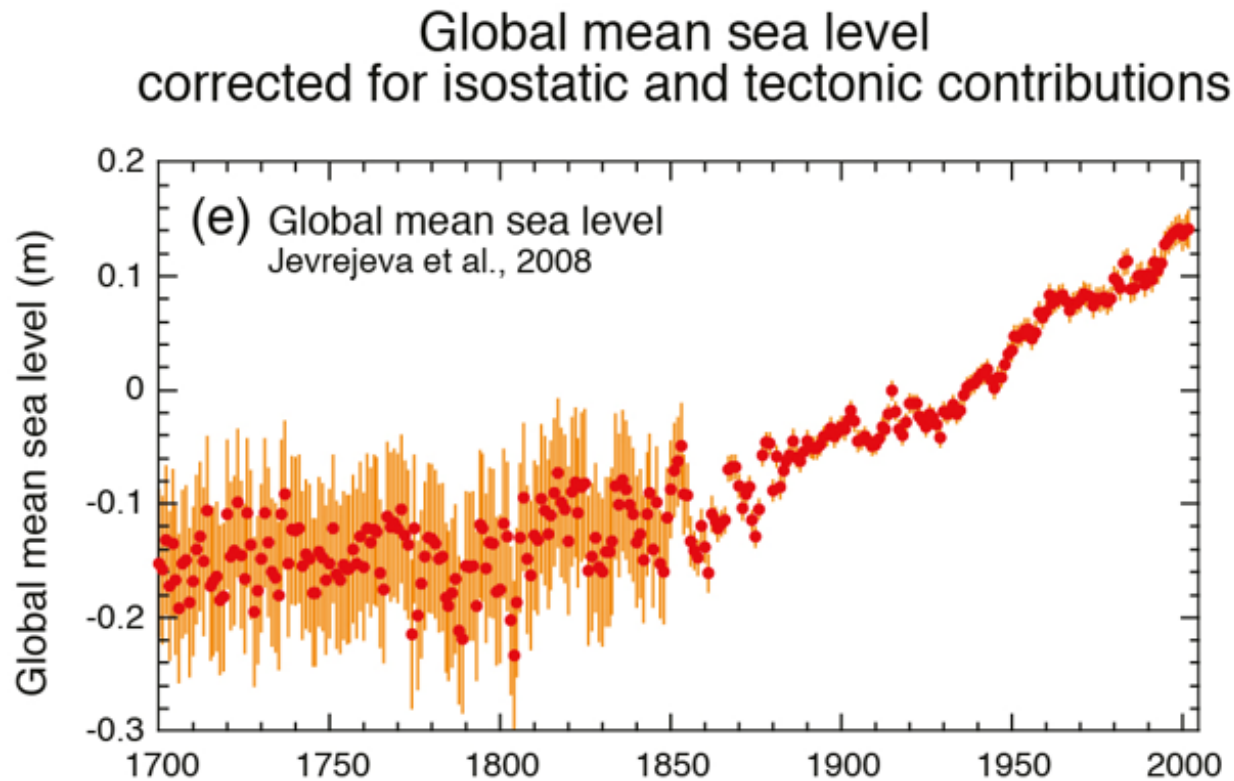


IPCC AR5, WG1, Fig. 13.1 at p. 1143 (2013)

“The primary contributors to contemporary sea level change are the expansion of the ocean as it warms and the transfer of water currently stored on land to the ocean, particularly from land ice (glaciers and ice sheets).”

IPCC AR5, WG1 at p. 1142 (2013) (citation omitted)

Global Sea Level Since 1700

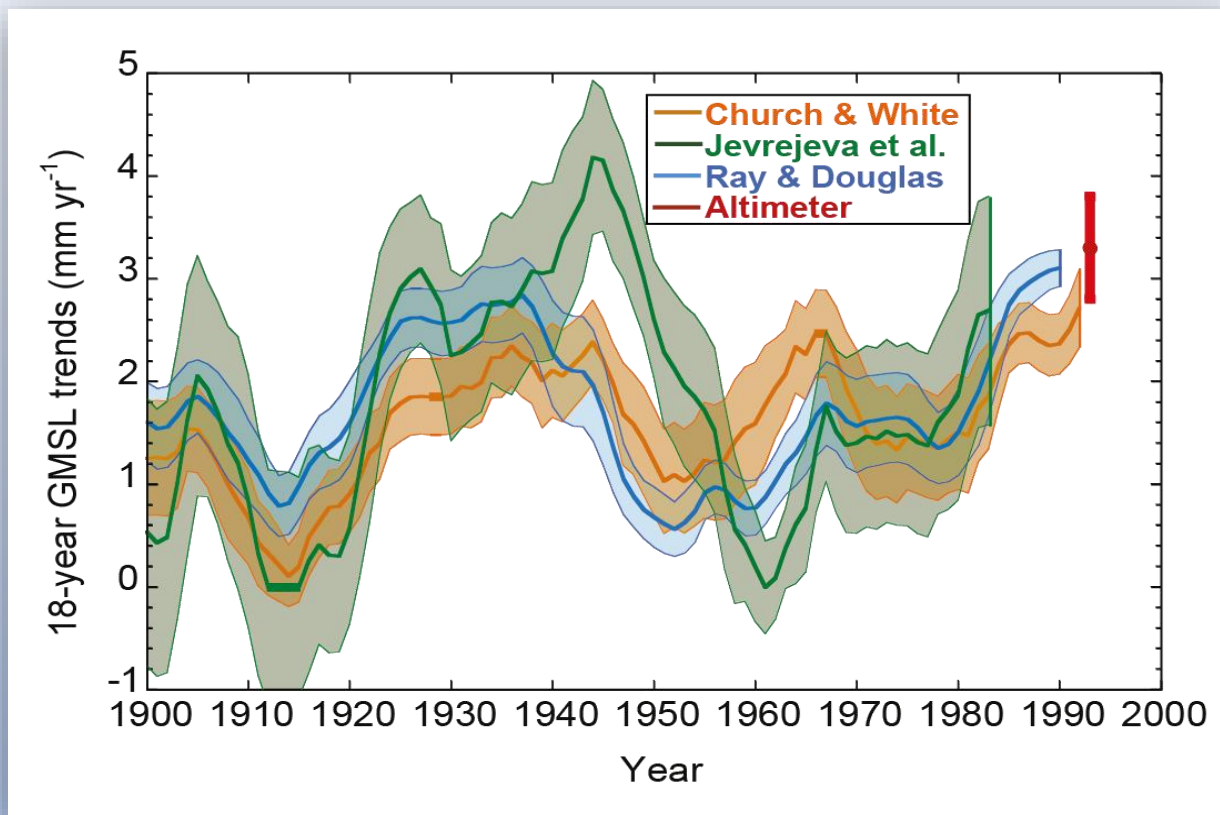


IPCC AR5, WG1, Fig. 5.17(e) at p. 429 (2013)

“[E]vidence indicates that the global mean sea level is rising, and that this is *likely* . . . resulting from global climate change (ocean warming plus land ice melt).”

IPCC AR5, WG1 at p. 136 (2013)

20th Century Rate of Sea Level Change

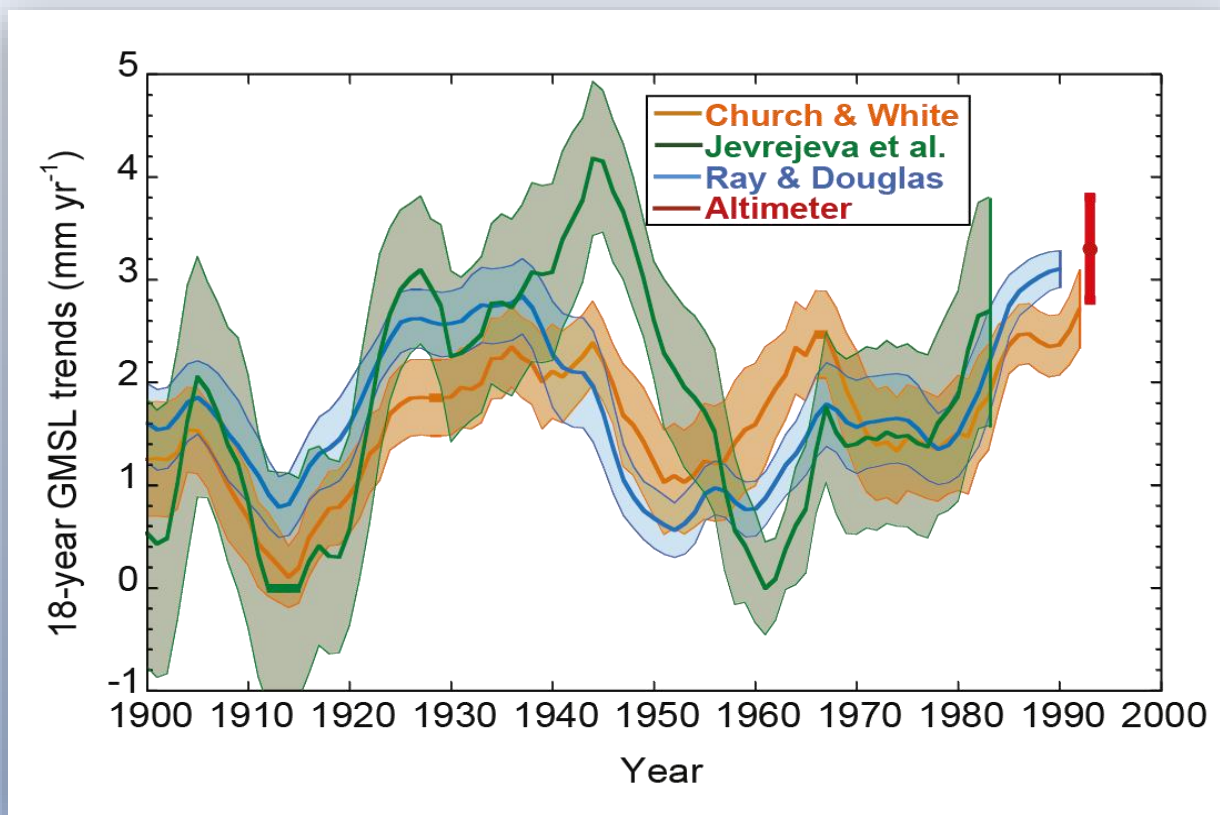


IPCC AR5, WG1, Fig. 3.14 at p. 289 (2013)

“The multi-decadal variability is marked by an increasing trend starting in 1910–1920, a downward trend ... starting around 1950, and an increasing trend starting around 1980.”

IPCC AR5, WG1 at p. 289 (2013)

20th Century Rate of Sea Level Change



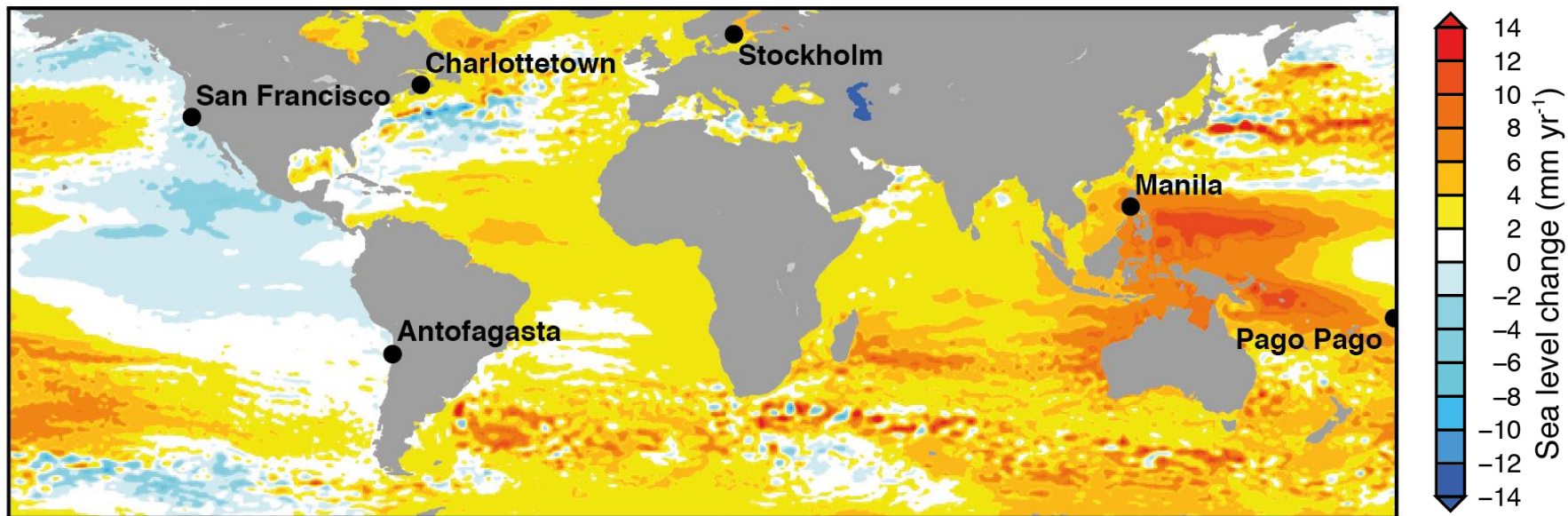
IPCC AR5, WG1, Fig. 3.14 at p. 289 (2013)

“It is *likely* that [Global Mean Sea Level] rose **between 1920 and 1950** at a rate comparable to that observed **between 1993 and 2010.**”

IPCC AR5, WG1 at p. 258 (2013) (emphasis added)

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Geocentric Sea Level Change



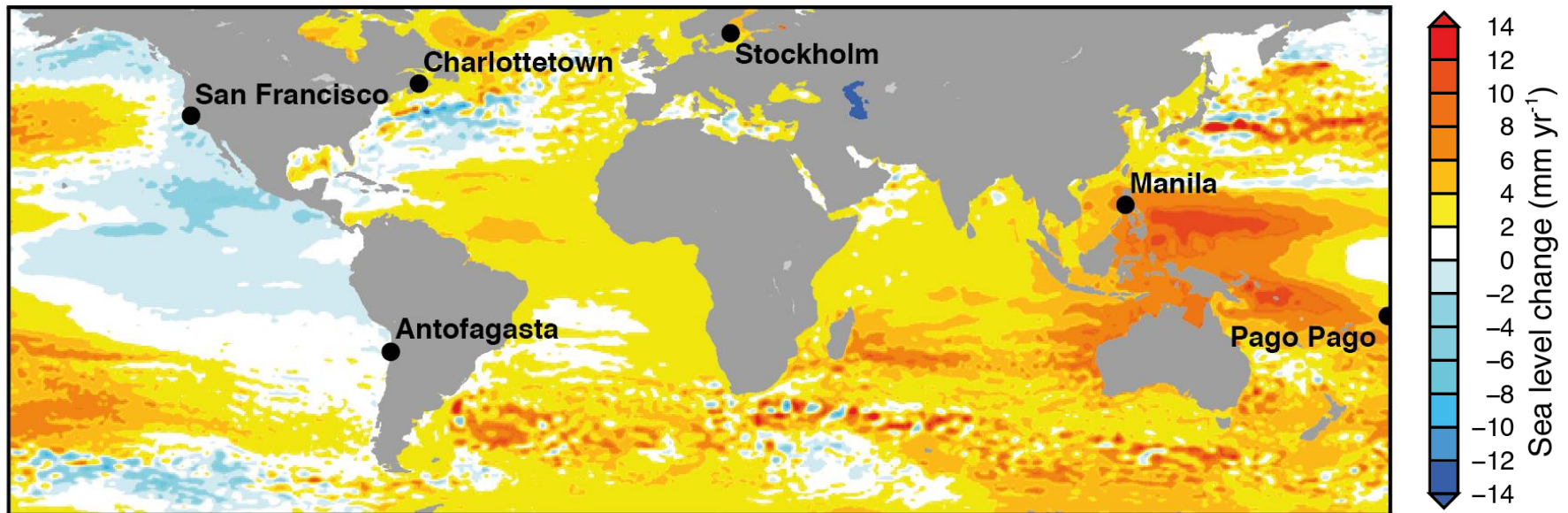
IPCC AR5, WG1, FAQ 13.1, Fig. 1 at p. 1148 (2013)

“Since the late 20th century, satellite measurements of the height of the ocean surface relative to the center of the Earth (known as geocentric sea level) show differing rates of geocentric sea level change around the world. ...”

IPCC AR5, WG1, FAQ 13.1 at p. 1148 (2013)

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Geocentric Sea Level Change



IPCC AR5, WG1, FAQ 13.1, Fig. 1 at p. 1148 (2013)

“Since the late 20th century, satellite measurements of the height of the ocean surface relative to the center of the Earth (known as geocentric sea level) show differing rates of geocentric sea level change around the world. ... **[T]hose in the eastern Pacific Ocean are lower than the global mean value, with much of the west coast of the Americas experiencing a fall in sea surface height over the same period.**”

IPCC AR5, WG1, FAQ 13.1 at p. 1148 (2013) (emphasis added)

IPCC: Sea Level Rise Projections

Table SPM.2 | Projected change in global mean surface air temperature and global mean sea level rise for the mid- and late 21st century relative to the reference period of 1986–2005. {12.4; Table 12.2, Table 13.5}

		2046–2065		2081–2100	
	Scenario	Mean	Likely range ^d	Mean	Likely range ^d
Global Mean Sea Level Rise (m) ^b	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

IPCC AR5, WG1, Table SPM.2 at p. 23 (2013) (only projected change in sea level shown)

“The basis for higher projections of global mean sea level rise in the 21st century has been considered and it has been concluded that there is currently insufficient evidence to evaluate the probability of specific levels above the assessed *likely* range.”

IPCC AR5, WG1 at p. 26 (2013)

Rising Seas in California

Table 4. Probability that sea-level rise at San Francisco, Golden Gate, will meet or exceed a particular height (feet) in a given year under: (a) RCP 8.5, and (b) RCP 2.6.

Estimates are based on Kopp et al., 2014. All heights are with respect to a 1991-2009 baseline; values refer to a 19-year average centered on the specified year. Grey shaded areas have less than a 0.1% probability of occurrence.

(a) RCP 8.5

	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2020										
2030	0.1%									
2040	3.3%									
2050	31%	0.4%								
2060	65%	3%	0.2%	0.1%						
2070	84%	13%	1.2%	0.2%	0.1%					
2080	93%	34%	5%	0.9%	0.3%	0.1%	0.1%			
2090	96%	55%	14%	3%	0.9%	0.3%	0.2%	0.1%	0.1%	
2100	96%	70%	28%	8%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	96%	79%	52%	28%	15%	8%	4%	3%	2%
2200	100%	97%	91%	80%	65%	50%	36%	25%	18%	13%

Coastal Flooding

“Due to sea level rise projected throughout the 21st century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion (*very high confidence*).”

“While it is likely that extreme sea levels have increased globally since the 1970s, mainly as a result of mean sea level rise due in part to anthropogenic warming, local sea level trends are also influenced by factors such as regional variability in ocean and atmospheric circulation, subsidence, isostatic adjustment, coastal erosion, and coastal modification. As a consequence, the detection of the impact of climate change in observed changes in relative sea level remains challenging.”

San Francisco Bond Disclosures (2017)

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“The City is unable to predict whether sea-level rise or other impacts of climate change or flooding from a major storm will occur, when they may occur, and if any such events occur, whether they will have a material adverse effect on the business operations or financial condition of the City and the local economy.”

Oakland Bond Disclosures (2017)

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“The City is unable to predict when seismic events, fires or other natural events, such as searise or other impacts of climate change or flooding from a major storm, could occur, when they may occur, and, if any such events occur, whether they will have a material adverse effect on the business operations or financial condition of the City or the local economy.”

Exhibit C

Theodore J. Boutrous, Jr. (SBN 132099)
tboutrous@gibsondunn.com
Andrea E. Neuman (SBN 149733)
aneuman@gibsondunn.com
William E. Thomson (SBN 187912)
wthomson@gibsondunn.com
Ethan D. Dettmer (SBN 196046)
edettmer@gibsondunn.com
Joshua S. Lipshutz (SBN 242557)
jlipshutz@gibsondunn.com
GIBSON, DUNN & CRUTCHER LLP
333 South Grand Avenue
Los Angeles, CA 90071
Telephone: 213.229.7000
Facsimile: 213.229.7520

Neal S. Manne (SBN 94101)
nmanne@susmangodfrey.com
Johnny W. Carter (*pro hac vice*)
jcarter@susmangodfrey.com
Erica Harris (*pro hac vice* pending)
eharris@susmangodfrey.com
Steven Shepard (*pro hac vice*)
sshepard@susmangodfrey.com
SUSMAN GODFREY LLP
1000 Louisiana, Suite 5100
Houston, TX 77002
Telephone: 713.651.9366
Facsimile: 713.654.6666

Herbert J. Stern (*pro hac vice*)
hstern@sgklaw.com
Joel M. Silverstein (*pro hac vice*)
jsilverstein@sgklaw.com
STERN & KILCULLEN, LLC
325 Columbia Turnpike, Suite 110
Florham Park, NJ 07932-0992
Telephone: 973.535.1900
Facsimile: 973.535.9664

Attorneys for Defendant Chevron Corporation

**UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION**

THE PEOPLE OF THE STATE OF
CALIFORNIA, acting by and through Oakland
City Attorney BARBARA J. PARKER,

Plaintiff and Real Party in
Interest,

v.

BP P.L.C., a public limited company of
England and Wales, CHEVRON
CORPORATION, a Delaware corporation,
CONOCOPHILLIPS COMPANY, a Delaware
corporation, EXXON MOBIL
CORPORATION, a New Jersey corporation,
ROYAL DUTCH SHELL PLC, a public
limited company of England and Wales, and
DOES 1 through 10,

Defendants.

First Filed Case: No. 3:17-cv-6011-WHA
Related Case: No. 3:17-cv-6012-WHA

**TIMELINE OF CLIMATE CHANGE
SCIENCE SUBMITTED BY CHEVRON
CORPORATION**

Case No. 3:17-cv-6011-WHA

HEARING

DATE: MARCH 21, 2018

TIME: 8:00 A.M.

LOCATION: COURTROOM 12, 19TH FL.

THE HONORABLE WILLIAM H. ALSUP

1 THE PEOPLE OF THE STATE OF
2 CALIFORNIA, acting by and through the San
3 Francisco City Attorney DENNIS J.
4 HERRERA,

5
6 Plaintiff and Real Party in
7 Interest,

8 v.

9 BP P.L.C., a public limited company of
10 England and Wales, CHEVRON
11 CORPORATION, a Delaware corporation,
12 CONOCOPHILLIPS COMPANY, a Delaware
13 corporation, EXXON MOBIL
14 CORPORATION, a New Jersey corporation,
15 ROYAL DUTCH SHELL PLC, a public
16 limited company of England and Wales, and
17 DOES 1 through 10,

18 Defendants.
19
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21
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27
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Case No. 3:17-cv-6012-WHA

The People of the State of California v. BP P.L.C., et al.,
Nos. C 17-06011 WHA, C 17-06012 WHA (N.D. Cal.)

TIMELINE OF CLIMATE CHANGE SCIENCE

Timeline of Climate Change Science

○ 1824

French mathematician Jean-Baptiste Joseph Fourier discovers the “‘greenhouse effect’: namely, that certain gases in Earth’s atmosphere could trap heat from the sun instead of having it radiate back into space, thereby increasing the surface temperature of Earth.” However, he does not identify what in the atmosphere would cause the effect.

[American Physical Society, *This Month in Physics History: March 21, 1768: Birth of Jean-Baptiste Joseph Fourier* \(last visited Mar. 16, 2018\); IPCC AR4, WG1 at p. 103 \(2007\)](#)

○ 1859

Irish physicist John Tyndall establishes “that molecules of gases, such as water vapour, carbon dioxide and methane, [] absorb more energy than oxygen and nitrogen when radiant heat is passed through them[,] . . . offer[ing] the first public, experimentally based account of what has become known as the *greenhouse effect*.”

[Mike Hulme, *On the Origin of “The Greenhouse Effect”: John Tyndall’s 1859 Interrogation of Nature*, 64 *Weather* 121, 121 \(2009\)](#) (emphasis in original)

1824

1859

1875

○ 1875 - 1890

Scottish physicist James Croll publishes the theory that variations in insolation—the intensity of sunlight hitting the earth—were the likely cause of the ice ages. He concludes that due to different levels of insolation, ice ages would alternate between the northern and southern hemispheres, and that the last ice age was 80,000 years ago. These theories turned out to be wrong—the last ice age was between 10,000 and 14,000 years ago. He also describes the albedo feedback loop, the theory that because the albedo (the fraction of solar energy reflected back into space) over snow and ice is high compared to oceans, increased ice would increase the Earth’s overall albedo and more solar energy would be reflected. Although much of Croll’s work turned out to be incorrect, the notions that insolation could drive some change in global temperature and that albedo influences surface temperature are still accepted.

[IPCC AR4, WG1 at p. 110 \(2007\)](#)

Timeline of Climate Change Science

1880s

The International Meteorological Organization (IMO), a predecessor to the World Meteorological Organization (WMO), begins systematic observations of weather and recording of land surface temperatures at stations around the globe. Scientists later use this data to create a global land surface temperature average time series. Those averages vary significantly depending on how scientists determined what historical data to include and how to account for averaging and gaps.

[IPCC AR4, WG1 at pp. 101–02 \(2007\)](#)

1900

Swedish scientist Knut Angstrom disputes the theory that changes in atmospheric CO₂ concentrations could impact global temperature. He concludes that any radiation that would be absorbed by CO₂ was already being absorbed by water vapor in the atmosphere. This conclusion that CO₂ concentrations were not related to temperature change remained the broad consensus in climate science for much of the 20th century.

[F. W. Very & C. A., *Knut Angstrom on Atmospheric Absorption*, *Monthly Weather Review*, June 1901, at 268;](#)
[Knut Angstrom, *Ueber die Bedeutung des Wasserdampfes und der Kohlensäure der Absorption der Edatmosphäre*, *Annalen der Physik* \(Oct. 1900\);](#)
[Spencer Weart, *The Discovery of Global Warming* 5 & n.1 \(2007\)](#)

1880

1896

1900

April 1896

Swedish scientist Svante Arrhenius's paper, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," is published in the *Philosophical Magazine and Journal of Science*. This paper "is the first to quantify the contribution of carbon dioxide to the greenhouse effect (Sections I–IV) and to speculate about whether variations in the atmospheric concentration of carbon dioxide have contributed to long-term variations in climate (Section V)." Arrhenius also adopts and builds upon the conclusions of Swedish geologist Arvid Högbom that "[t]he world's present production of coal reaches in round numbers 500 millions of tons per annum, or 1 ton per km of the earth's surface. Transformed into carbonic acid, this quantity would correspond to about a thousandth part of the carbonic acid in the atmosphere. . . . This quantity of carbonic acid . . . is supplied to the atmosphere chiefly by modern industry" Arrhenius "considers the radiative effects of carbon dioxide (carbonic acid) and water vapor on the surface temperature of the Earth, and variations in atmospheric carbon dioxide concentrations. . . . His calculations show[] that the 'temperature of the Arctic regions would rise about 8 degrees or 9 degrees Celsius, if the carbonic acid increased 2.5 to 3 times its present value. . . .'"

[Svante Arrhenius, *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*, 41 *Phil. Mag. & J. Sci.* 237, preface, 270 \(1896\);](#)
[NASA, *Svante Arrhenius \(1859-1927\)*, Earth Observatory \(last visited Mar. 16, 2018\)](#)

Timeline of Climate Change Science

1920s

Serbian astrophysicist Milutin Milankovitch “dedicate[s] his career to developing a mathematical theory of climate based on the seasonal and latitudinal variations of solar radiation received by the Earth. Now known as the Milankovitch Theory, it states that as the Earth travels through space around the sun, cyclical variations in three elements of Earth-sun geometry combine to produce variations in the amount of solar energy that reaches Earth[.]” The orbital variations are known as Milankovitch cycles. Milankovitch concludes that these variations resulted in alternating ice ages and warming periods.

[Steve Graham, *Milutin Milankovitch*, NASA Earth Observatory \(Mar. 24, 2000\); Spencer Weart, *The Discovery of Global Warming* 51–52, 59 \(2007\)](#)

1920

1951

1951

The American Meteorological Society’s Compendium of Meteorology notes that Svante Arrhenius’ “theory [that changes in CO₂ could impact global temperature] was never widely accepted and was abandoned when it was found that all the long-wave radiation absorbed by CO₂ is also absorbed by water vapor.”

[American Meteorological Society, *Compendium of Meteorology* 1016 \(1951\)](#)

Mid-1950s

Scientists discover that CO₂ can absorb different wavelengths of radiation than water vapor can, meaning CO₂ may add to the greenhouse effect. The connection between CO₂ and global temperature remains under debate.

[Spencer Weart, *The Carbon Dioxide Greenhouse Effect*, *The Discovery of Global Warming* \(2017\)](#)

Timeline of Climate Change Science

1956

American theoretical meteorologist Norman Phillips develops numerical methods for the prediction of weather and climate changes. His studies lead to the first computer models of weather and climate, as well as to an understanding of the general circulation of the atmosphere, including the transports of heat and moisture that determine the Earth's climate.

[Spencer Weart, *General Circulation Models of Climate, The Discovery of Global Warming* \(2017\); Norman A. Phillips, *The General Circulation of the Atmosphere: A Numerical Experiment*, 82 Q.J. Royal Meteorological Soc. 123 \(1956\)](#)

1956

1957

1957

American scientists Roger Revelle and Hans Suess publish an article in the journal *Tellus*, titled "Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO₂ during the Past Decades." They conclude that "the average lifetime of a CO₂ molecule in the atmosphere before it is dissolved into the sea is of the order of 10 years. This means that most of the CO₂ released by artificial fuel combustion since the beginning of the industrial revolution must have been absorbed by the oceans. The increase of atmospheric CO₂ from this cause is at present small but may become significant during future decades if industrial fuel combustion continues to rise exponentially." Revelle and Suess further explain that "[w]hile CO₂ can be mixed rapidly into the upper layers of the ocean, the time to mix with the deep ocean is many centuries."

[Roger Revelle & Hans E. Suess, *Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO₂ During the Past Decades*, 9 Tellus 18, 19 \(1957\); IPCC AR4, WG1 at p. 105 \(2007\)](#)

Timeline of Climate Change Science

○ 1958

Scientist Charles David Keeling initiates high-accuracy measurements of atmospheric CO₂ concentration in 1958. Decades later, these come to constitute the master time series documenting changing CO₂ concentrations in the atmosphere, and would become known as the “Keeling Curve.”

[IPCC AR4, WG1 at p. 100 \(2007\)](#)

1958

1960

○ 1960

Congress establishes a National Center for Atmospheric Research (NCAR) to provide coordinated global atmospheric research, which eventually includes dozens of universities as members.

[Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

Timeline of Climate Change Science

1965

The government creates the Environmental Science Services Administration (ESSA) to “provide a single national focus for [] efforts to describe, understand, and predict the state of the oceans, the state of the lower and upper atmosphere, and the size and shape of the earth.”

[NOAA, *NOAA's Heritage, A History of NOAA* \(June 8, 2006\); Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

February 8, 1965

In his Special Message to the Congress on Conservation and Restoration of Natural Beauty, President Lyndon Johnson says, “This generation has altered the composition of the atmosphere on a global scale through radioactive materials and a steady increase in carbon dioxide from the burning of fossil fuels.”

[Lyndon B. Johnson, *Special Message to the Congress on Conservation and Restoration of Natural Beauty* \(Feb. 8, 1965\)](#)

1965

1965

The President's Science Advisory Committee forms a panel to address environmental issues, including a sub-panel of climate experts. The report this group issued noted that the burning of coal, oil, and natural gas could lead to a 25% increase in atmospheric CO₂, but that more and better science was needed before the likelihood of potential effects could be ascertained.

[President's Science Advisory Committee, *Restoring the Quality of Our Environment* 1, 3–9, 111–31 \(1965\); Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

1967

1967

The Global Atmospheric Research Project (GARP) is established as the research portion of the World Weather Program (WWP). GARP “is an internationally developed program to study the general circulation of the earth’s atmosphere.”

[National Science Foundation, *Program Activities of the National Science Foundation* 14, 29–30 \(1967\)](#)

Timeline of Climate Change Science

1970

The U.S. government creates the National Oceanic and Atmospheric Administration (NOAA). From the beginning, NOAA is one of the world's chief sources of funding for basic climate studies. NOAA built one of the first computer models of the global climate.

[Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

1971

"Climatic Impact Assessment Program" (CIAP) is established, one of the largest scientific research projects undertaken at that time, involving numerous agencies of the U.S. and foreign governments and more than a thousand scientists. The purpose was to investigate potential atmospheric impacts of the proposed American supersonic transport aircraft.

[Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

1970

1970

EPA is created. The Clean Air Act is passed.

[Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

1971

1975

The Department of Transportation's Climate Impact Assessment Program determines that a proposed high-flying fleet of commercial supersonic aircraft would deplete the stratospheric ozone, increasing the incidence of skin cancer.

[Peter M. Morrisette, *The Evolution of Policy Responses to Stratospheric Ozone Depletion*, 29 Nat. Res. J. 793, 801-02 \(1989\)](#)

1975

1975

The Global Atmospheric Research Program of the National Academy of Sciences (NAS) releases a report entitled *Understanding Climatic Change: A Program for Action* calling for integration of government-sponsored climate research across disciplines and institutions in order to foster a better understanding of atmospheric phenomena and to provide useful data to policymakers and planners to facilitate practical incorporation of climatic effects into planning at local, state, and national levels.

[Global Atmospheric Research Program of NAS, *Understanding Climatic Change: A Program for Action* 9-12 \(1975\)](#)

Timeline of Climate Change Science

June 1975

NASA atmospheric physicist Veerabhadran Ramanathan concludes that “infrared bands of chlorofluorocarbons and chlorocarbons enhance the atmospheric greenhouse effect. This enhancement may lead to an appreciable increase in the global surface temperature if the atmospheric concentrations of these compounds reach values of the order of 2 parts per billion.” In Ramanathan’s biography, he was quoted as explaining that, “Until 1975, we used to think the global warming problem was mainly from carbon dioxide[.] . . . [A]dding one molecule of CFC to the atmosphere would have the same greenhouse effect as adding more than 10,000 molecules of carbon dioxide.”

[V. Ramanathan, *Greenhouse Effect Due to Chlorofluorocarbons: Climatic Implications*, 190 *Science* 50, 50 \(1975\); Regina Nuzzo, *Biography of Veerabhadran Ramanathan*, 102 *Proceedings of the Nat’l Academy of Sci. of the U.S.A.* 5233, 5233 \(2005\)](#)

1975

1977

1978

1977

The Geophysics Research Board of the NAS releases a report, *Energy and Climate: Study in Geophysics*, noting that “finding ways to make reliable estimates of the climatic changes that may result from continued use of fossil fuels could very well require decades.”

[Geophysics Research Board, NAS, *Energy and Climate: Study in Geophysics* 1 \(1977\)](#)

1978

The National Climate Program Act is passed in late 1978 establishing a National Climate Program Office within NOAA to lead a National Climate Program. The Program includes “basic and applied research to improve the understanding of climate processes, natural and man induced, and the social, economic, and political implications of climate change.”

[Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\); National Climate Program Act § 5\(d\)\(2\), 15 U.S.C. § 2904\(d\)\(2\)](#)

1978

NAS releases a comprehensive review of CO₂ and climate research conducted over the previous decade, which predicts that a doubling of atmospheric carbon dioxide would lead to a 1.5–4.5 degree Celsius increase in the global mean temperature.

[Climate Research Board, NAS, *Carbon Dioxide and Climate: A Scientific Assessment* 2 \(1978\)](#)

Timeline of Climate Change Science

1980

The World Climate Research Programme (WCRP) is established “under the joint sponsorship of the International Council for Science (ICSU) and the World Meteorological Organization (WMO)” “to determine the predictability of climate and to determine the effect of human activities on climate.”

[World Climate Research Programme, WCRP History](#)
(last visited Mar. 8, 2018)

1988

The Intergovernmental Panel on Climate Change is “established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.” The UN General Assembly endorses the establishment of the IPCC.

[Principles Governing IPCC Work](#) ¶ 2 (Oct. 1998), as amended Oct. 2013; IPCC, *Organization* (last visited Mar. 8, 2018)

1980

1983

1985

1988

1983

The Carbon Dioxide Assessment Committee of NAS publishes a report indicating that “[c]oncern arises about human activities that release greenhouse gases because . . . increasing the concentration of the gases will continue to affect the net emission or absorption of energy from a given layer of the atmosphere and thus the climate.” William A. Nierenberg, the Chairman of the Carbon Dioxide Assessment Committee, says in an interview that there are “critical gaps in our [scientific] knowledge” that need to be addressed.

[Carbon Dioxide Assessment Committee, NAS, *Changing Climate* 5 \(1983\); Philip Shabecoff, *Haste of Global Warming Trend Opposed*, New York Times, Oct. 21, 1983, at A1](#)

June 20, 1985

Atmospheric physicist Veerabhadran Ramanathan and colleagues publish a study of 30 trace gases that absorb infrared radiation. They conclude that these additional “greenhouse gases” added together could cause as much global warming as CO₂.

[V. Ramanathan, et al., *Trace Gas Trends and Their Potential Role in Climate Change*, 90 J. Geophysical Research 5547, 5562–63 \(1985\)](#)

Timeline of Climate Change Science

1990

Congress codifies and funds the Global Change Research Act, which creates a “United States Global Change Research Program (USGCRP) . . . to understand, assess, predict, and respond to human-induced and natural processes of global change.”

[U.S. Global Change Research Program, *About USGCRP* \(last visited Mar. 8, 2018\); Spencer Weart, *Government: The View from Washington, DC, The Discovery of Global Warming* \(2017\)](#)

1990

1990

The IPCC publishes its First Assessment Report (FAR) stating that “[t]he size of this [global] warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural climate variability. Thus the observed increase could be largely due to this natural variability, alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.”

[IPCC FAR, WG1 at p. xii \(1990\)](#)

Timeline of Climate Change Science

1995

The IPCC publishes its Second Assessment Report (SAR) finding: “Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. . . . Nonetheless, the balance of evidence suggests that there is a discernible human influence on global climate. Simulations with coupled atmosphere-ocean models have provided important information about decade to century timescale natural internal climate variability.”

[IPCC SAR, WG1 at p. 39 \(1995\)](#)

2001

The IPCC publishes its Third Assessment Report (TAR) finding: “There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities. . . . There is a longer and more scrutinized temperature record and new model estimates of variability. The warming over the past 100 years is very unlikely to be due to internal variability alone. Reconstructions of climate data for the past 1,000 years also indicate this warming was unusual and is unlikely to be entirely natural in origin.” The Report defines “unlikely” as a “10–33% chance,” and “very unlikely” as a “1–10% chance.”

[IPCC TAR, WG1 at p. 10 \(2001\) \(footnote and citation omitted\); id. at p. 2 n.7](#)

1995

2000

2001

2000

The U.S. Global Change Research Program publishes its report, *Climate Change Impacts on the United States*, and concludes, “Humans are exerting a major and growing influence on some of the key factors that govern climate by changing the composition of the atmosphere and by modifying the land surface. The human impact on these factors is clear. The concentration of carbon dioxide (CO₂) has risen about 30% since the late 1800s. The concentration of CO₂ is now higher than it has been in at least the last 400,000 years. This increase has resulted from the burning of coal, oil, and natural gas, and the destruction of forests around the world to provide space for agriculture and other human activities. Rising concentrations of CO₂ and other greenhouse gases are intensifying Earth’s natural greenhouse effect.”

[U.S. Global Change Research Program, *Climate Change Impacts on the United States* 12 \(2000\)](#)

Timeline of Climate Change Science

2007

The IPCC publishes its Fourth Assessment Report (AR4) finding that “[m]ost of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations. . . . Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.”

[IPCC AR4, WG1 at p. 10 \(2007\)](#)

2010

At the request of Congress, NAS releases a series of studies titled *America's Climate Choices* comprising four panel reports: *Advancing the Science of Climate Change*, *Limiting the Magnitude of Future Climate Change*, *Adapting to the Impacts of Climate Change*, *Informing an Effective Response to Climate Change*, and a synthesis report published in 2011.

[The Nat'l Academies, Congressional Briefings on America's Climate Choices](#) (last visited Mar. 19, 2018); [Nat'l Research Council, Advancing the Science of Climate Change](#) (2010); [Nat'l Research Council, Limiting the Magnitude of Future Climate Change](#) (2010); [Nat'l Research Council, Adapting to the Impacts of Climate Change](#) (2010); [Nat'l Research Council, Informing an Effective Response to Climate Change](#) (2010); [Nat'l Research Council, America's Climate Choices](#) (2011)

2007

2009

2010

2009

The U.S. Global Change Research Program publishes its report, *Global Climate Change Impacts in the United States*, and concludes, “human activities have been releasing additional heat-trapping gases, intensifying the natural greenhouse effect, thereby changing the Earth’s climate. . . . The increase in the carbon dioxide concentration has been the principal factor causing warming over the past 50 years. Its concentration has been building up in the Earth’s atmosphere since the beginning of the industrial era in the mid-1700s, primarily due to the burning of fossil fuels (coal, oil, and natural gas) and the clearing of forests. Human activities have also increased the emissions of other greenhouse gases, such as methane, nitrous oxide, and halocarbons.”

[U.S. Global Change Research Program, Global Climate Change Impacts in the United States 14](#) (2009)

Timeline of Climate Change Science

2013

The IPCC publishes its Fifth Assessment Report (AR5), finding that “It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.” The IPCC further concludes that, “Globally, economic and population growth continued to be the most important drivers of increases in CO₂ emissions from fossil fuel combustion.” The IPCC further notes that “Climate change has the characteristics of a collective action problem at the global scale, because most greenhouse gases (GHGs) accumulate over time and mix globally, and emissions by any agent (e.g., individual, community, company, country) affect other agents. International cooperation is therefore required to effectively mitigate GHG emissions and address other climate change issues.”

[IPCC AR5, WG1 at p. 17 \(2013\) \(emphasis removed\); IPCC AR5, WG3 at pp. 5, 8 \(2014\) \(footnote and citations omitted\)](#)

2013

2014

2014

The U.S. Global Change Research Program publishes its report, *Climate Change Impacts in the United States*, and concludes, “Multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years. The burning of coal, oil, and gas, and clearing of forests have increased the concentration of carbon dioxide in the atmosphere by more than 40% since the Industrial Revolution, and it has been known for almost two centuries that this carbon dioxide traps heat. Methane and nitrous oxide emissions from agriculture and other human activities add to the atmospheric burden of heat-trapping gases.”

[U.S. Global Change Research Program, *Climate Change Impacts in the United States* 7 \(2014\)](#)

Timeline of Climate Change Science

June 1, 2017

The City and County of San Francisco issue an Official Statement for a municipal bond offering, stating: "The City is unable to predict whether sea-level rise or other impacts of climate change or flooding from a major storm will occur, when they may occur, and if any such events occur, whether they will have a material adverse effect on the business operations or financial condition of the City and the local economy."

[Cty. and Cnty. of S.F., Official Statement for Certificates of Participation, Series 2017A, at 19 \(June 1, 2017\)](#)

2017

August 1, 2017

The City of Oakland issues an Official Statement for two General Obligation Bond offerings, stating: "The City is unable to predict when seismic events, fires or other natural events, such as sea rise or other impacts of climate change or flooding from a major storm, could occur, when they may occur, and, if any such events occur, whether they will have a material adverse effect on the business operations or financial condition of the City or the local economy."

[Cty. of Oakland, Official Statement for General Obligation Bonds, Series 2017A-1 and 2017a-2, at A-48 to -49 \(Aug. 1, 2017\)](#)

2017

The U.S. Global Change Research Program releases its Climate Science Special Report. This report concludes that "it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence."

[U.S. Global Change Research Program, *Climate Science Special Report 12* \(2017\)](#)