Tuesday Dec 2nd
TOPIC # 13 Global Warming Wrap Up
TOPIC #14 IMPACTS & ISSUES

SIT WITH YOUR GROUP TODAY

ANNOUNCEMENTS:

LINKING-TO-LIFE PROJECT

PART A – Your Ecological Footprint DUE in class TODAY!

PART B – GC Film & Video Commentaries - Due TONIGHT before midnight – or at the latest no later than Dec 3rd

PART C – Project SLIDE & REPORT

Slide: Due Tue Dec 9th in the dropbox before class.

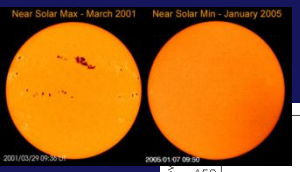
Report: Due Wed Dec 10th in the dropbox before Midnight

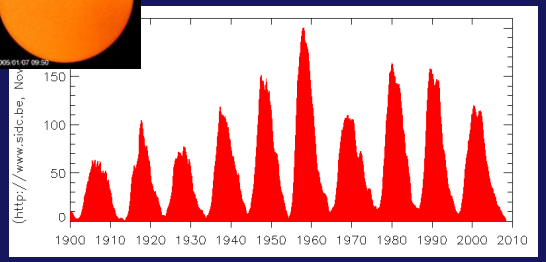
TOPIC # 13
GLOBAL WARMING & ANTHROPOGENIC FORCING

WRAP UP!

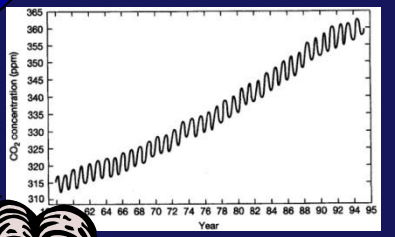
Class Notes pp 85

NATURAL FORCING

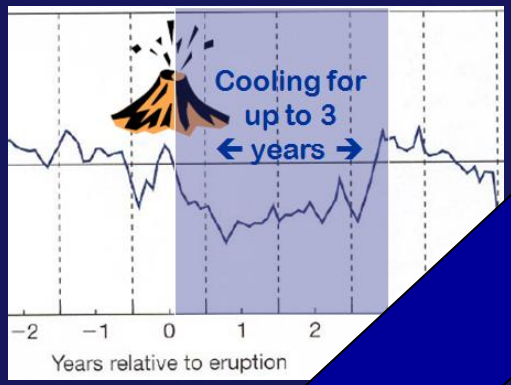




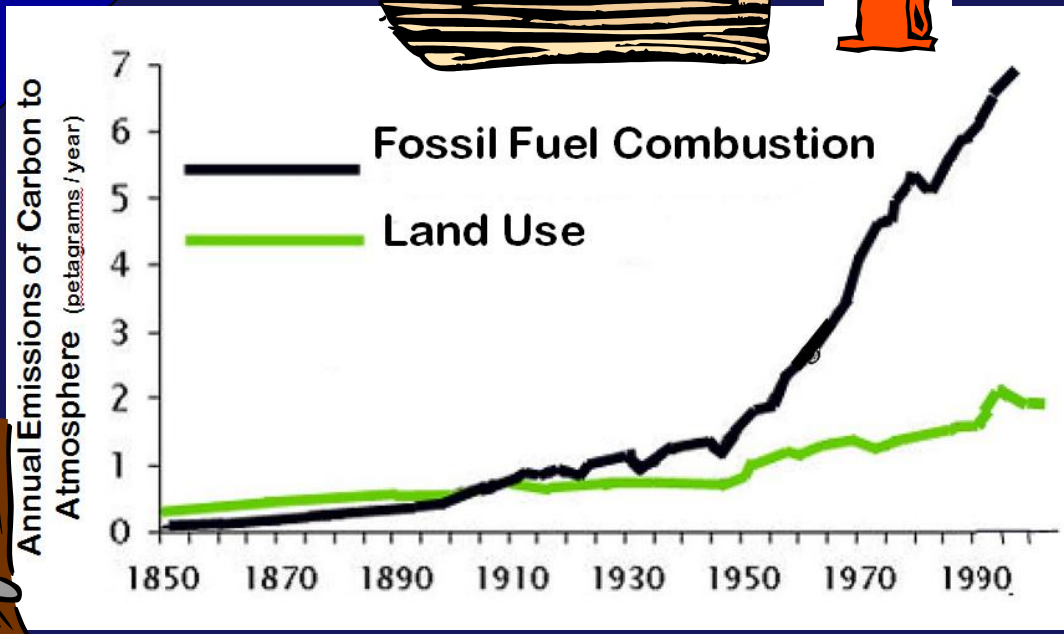
Solar output variations, sunspots

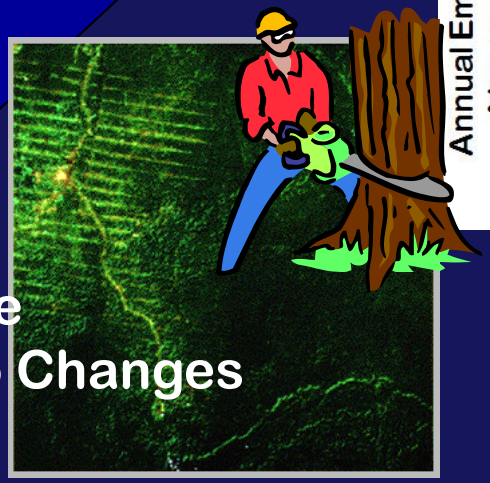


GHG's, soot, SO_2



Volcanic eruptions





Surface Albedo Changes

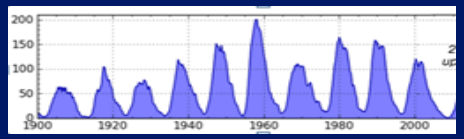
ANTHROPOGENIC FORCING

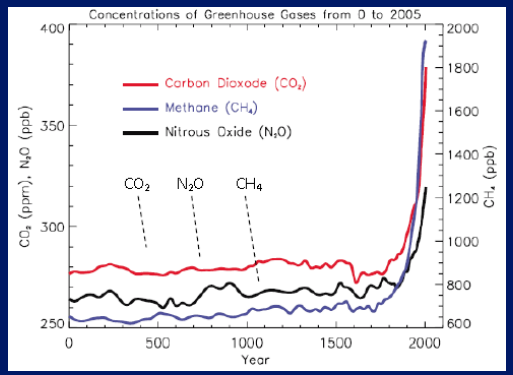
In addition to the "Natural - Archive – Paleo" Approach, **COMPUTER MODELS** have been created to estimate the radiative forcings of the PAST!

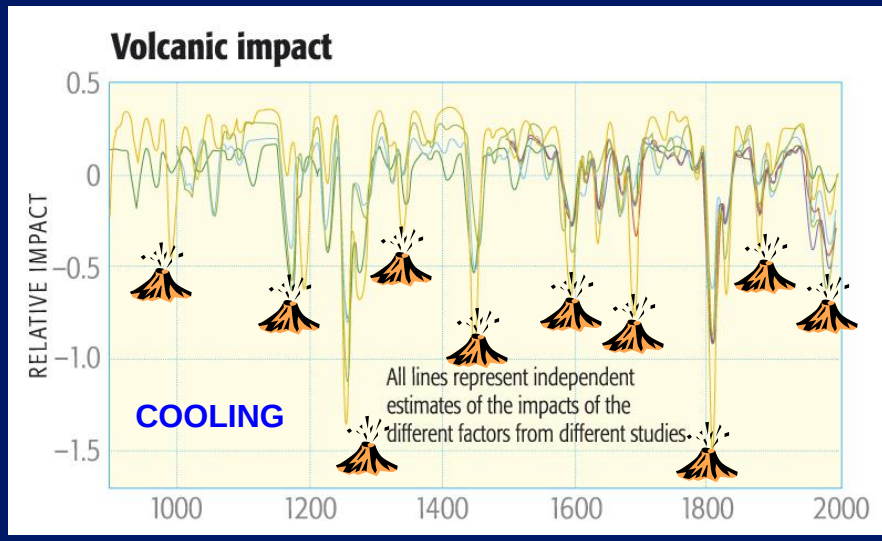
Estimates Of Natural & Human Impacts On Climate Over The Past 1000 Years

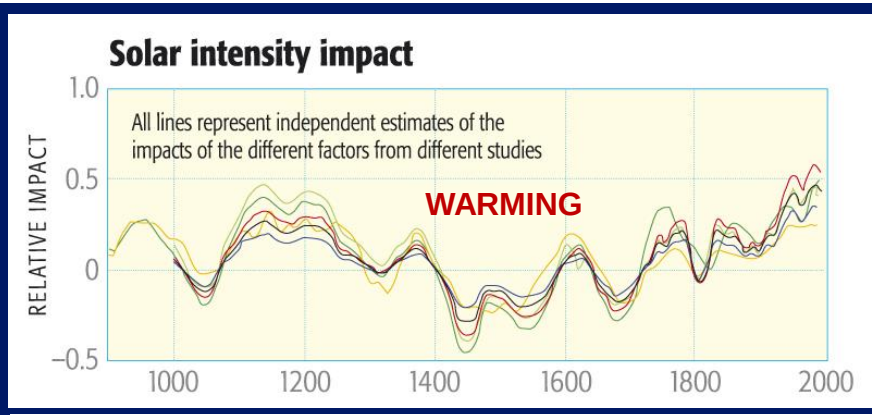
[graphs from *Dire Predictions* p 81]

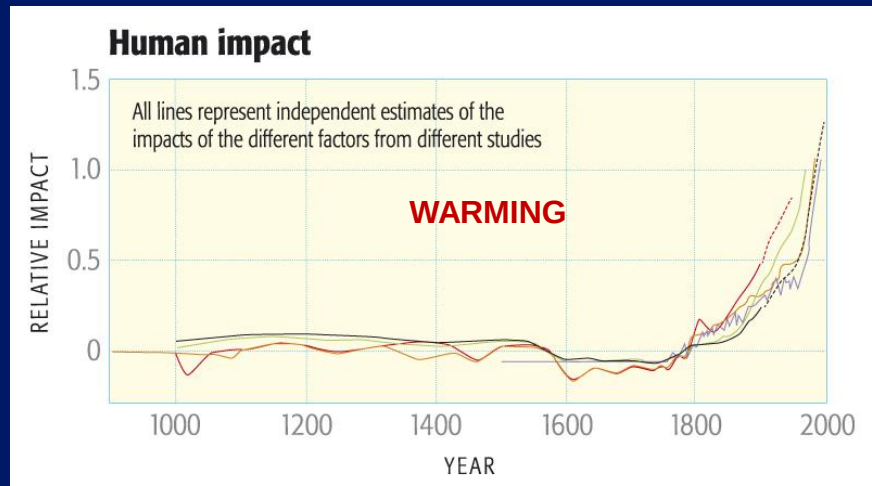
On top of p 89 in Class Notes



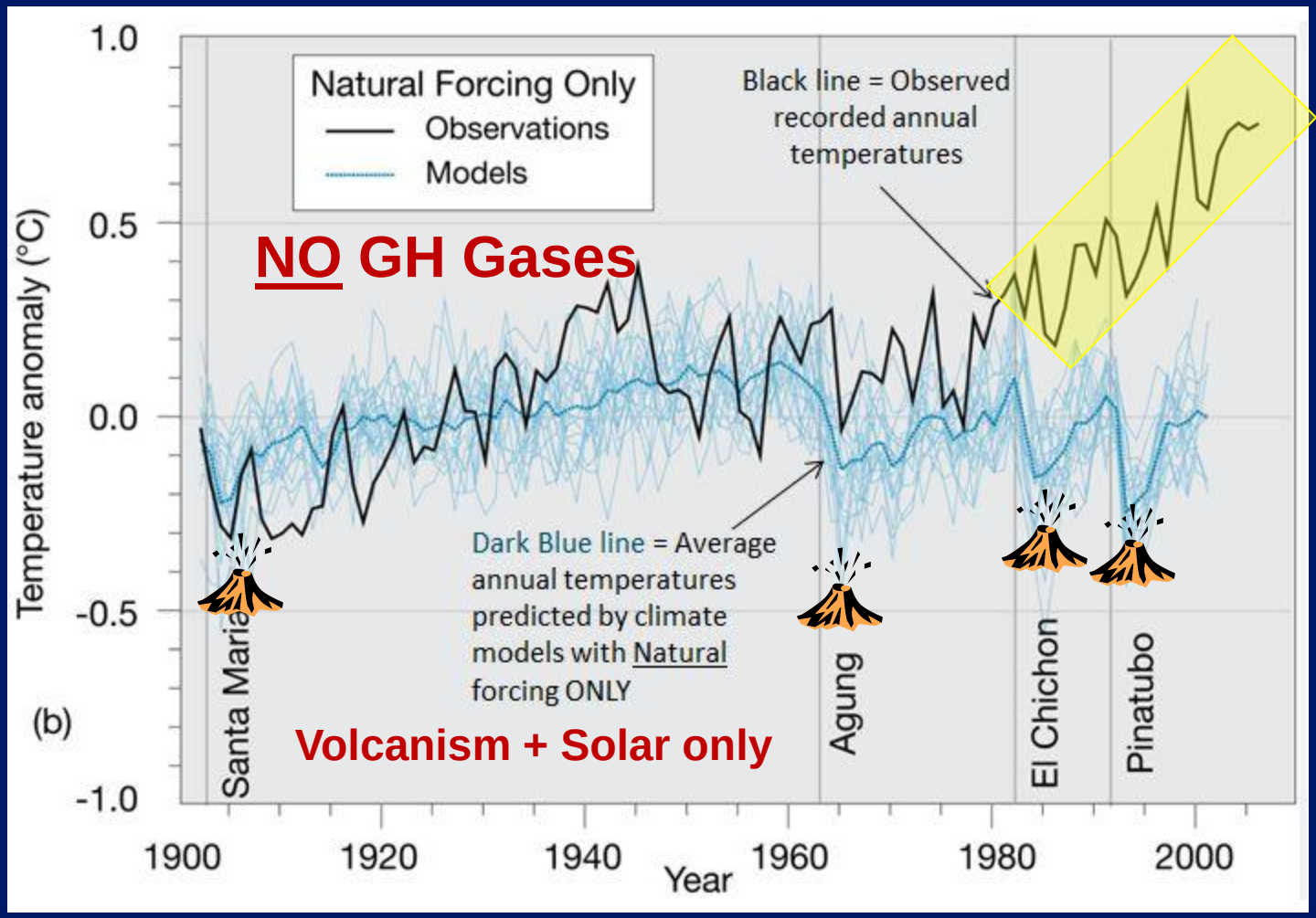






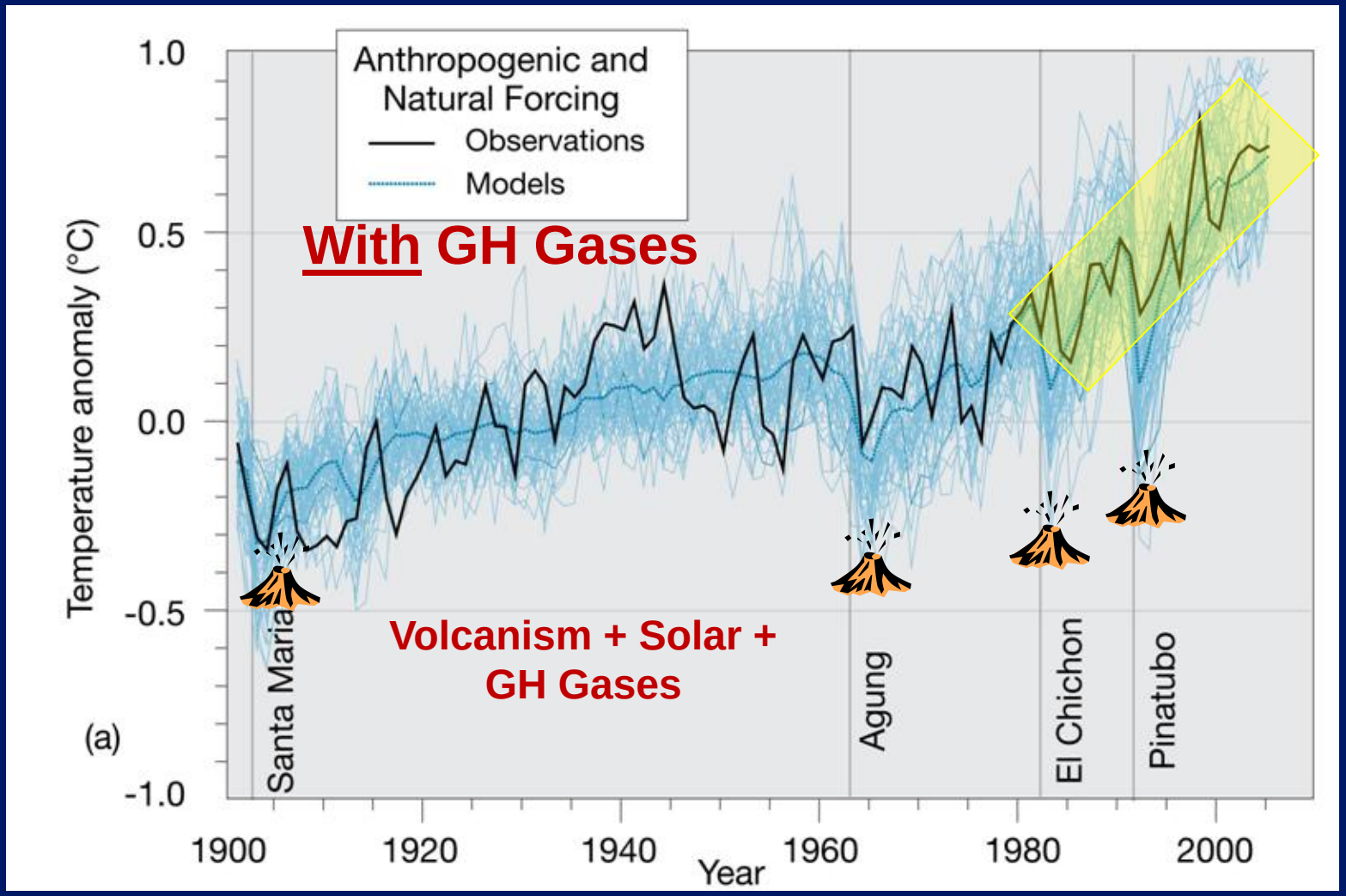


MODELED TEMPERATURE based on NATURAL FORCING ONLY:

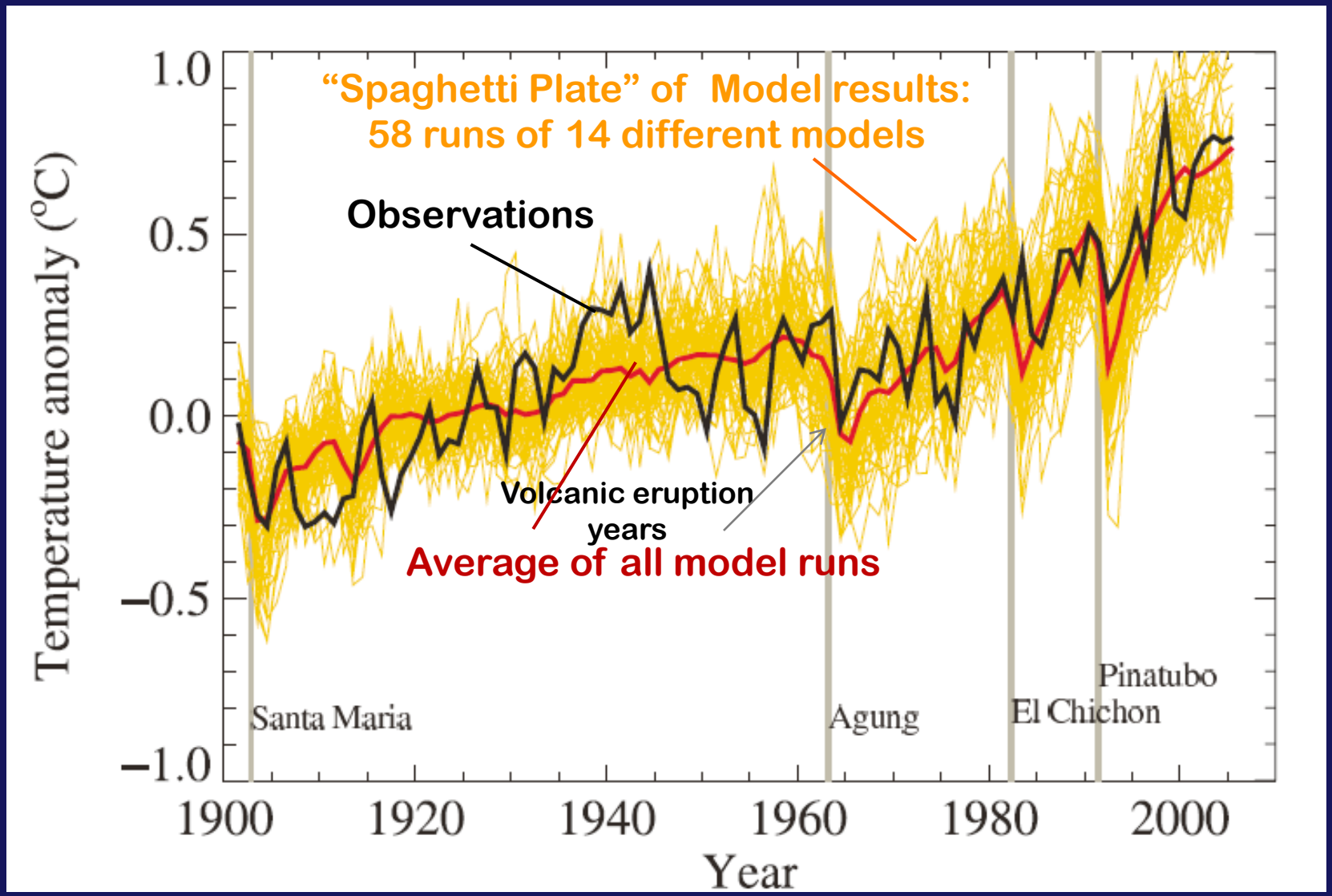


Models cannot reproduce the observed temperature trend since ~ 1980

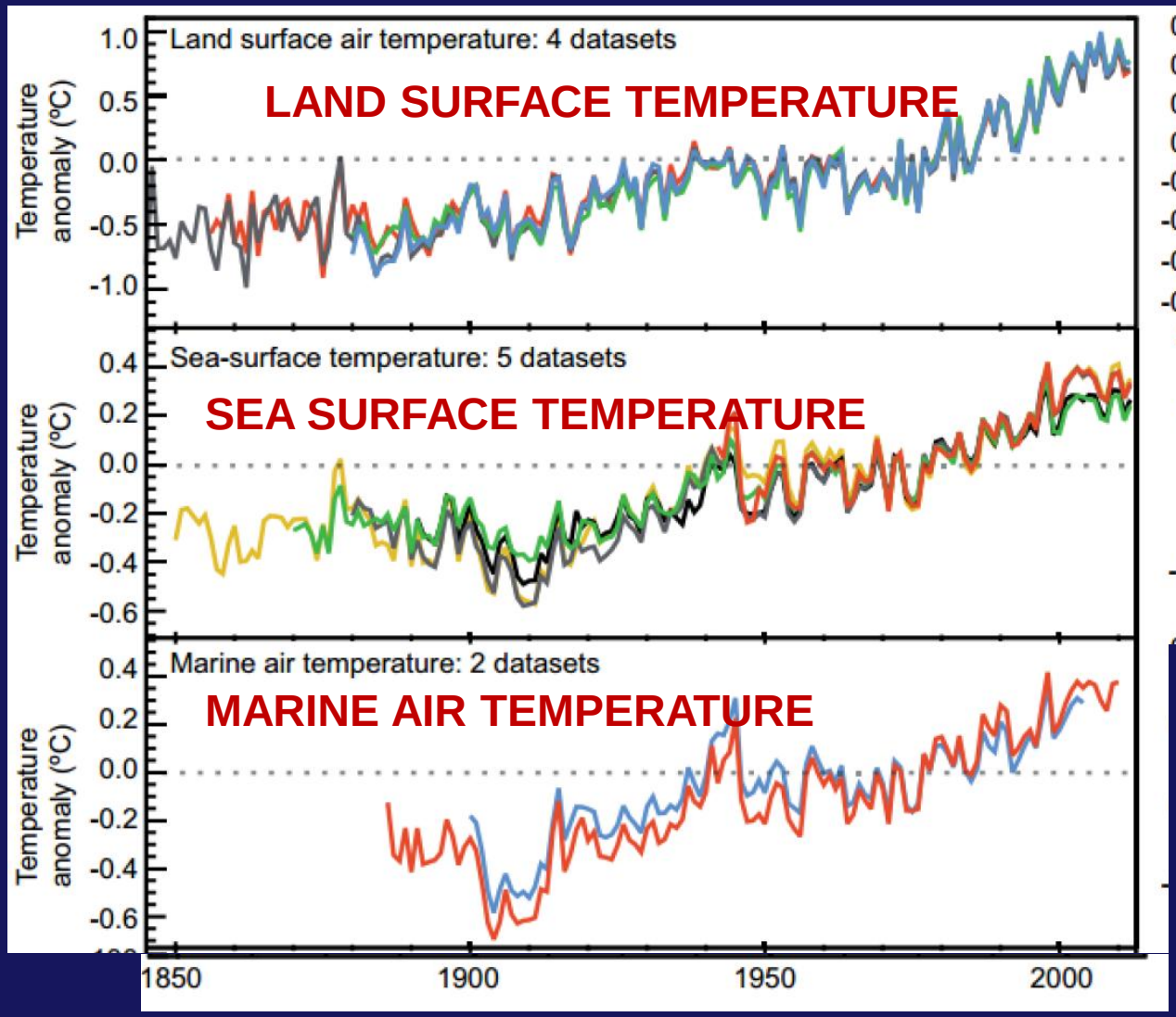
MODELED TEMPERATURE based on NATURAL + ANTHROPOGENIC FORCING

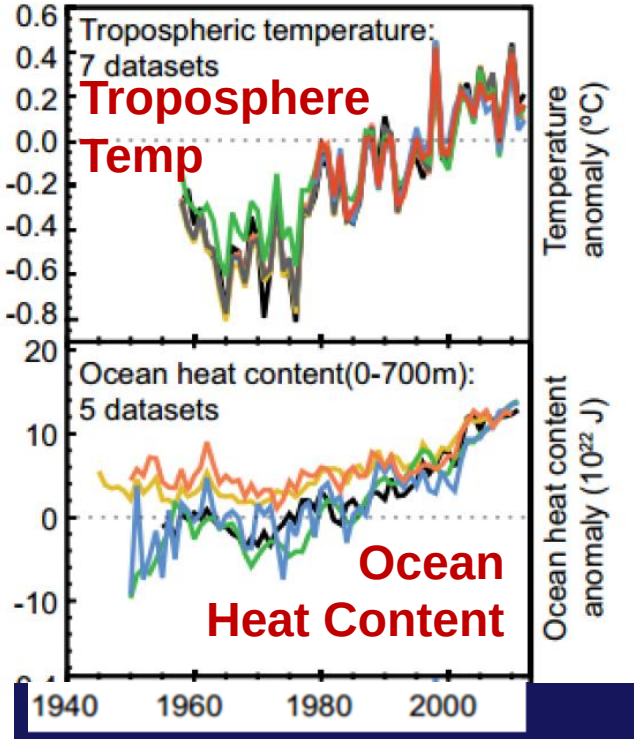


MODELED TEMPERATURE based on NATURAL + ANTHROPOGENIC FORCING



That's what the COMPUTER MODELS say . . . .
What is the EARTH ITSELF
telling us about how it s TEMPERATURE is changing?



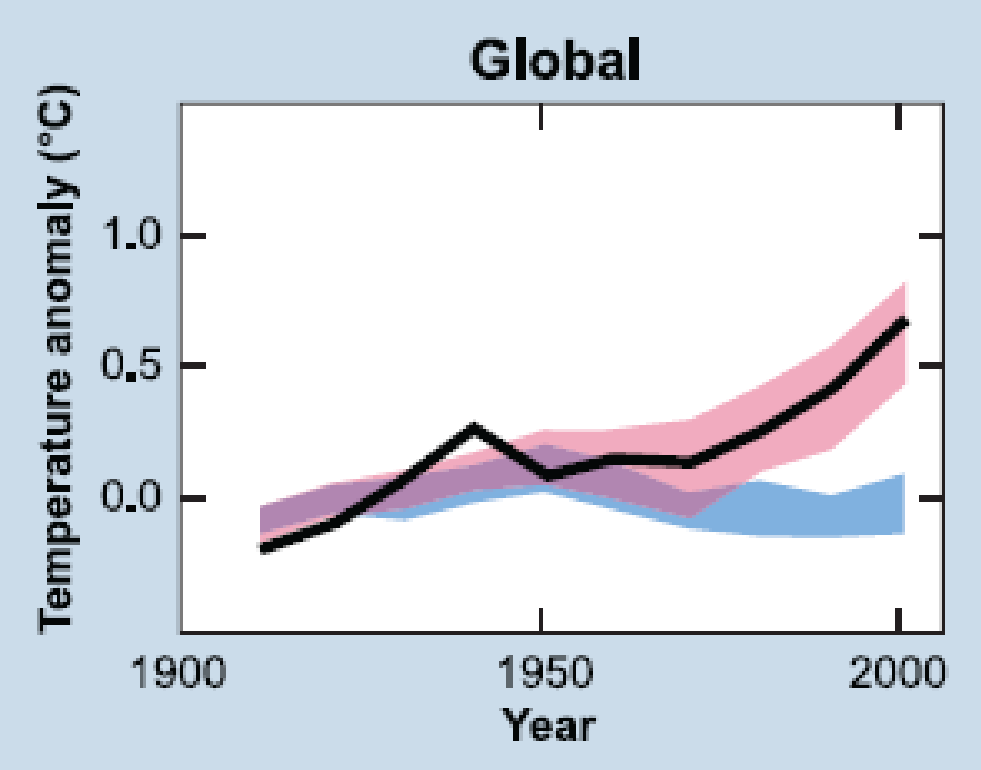


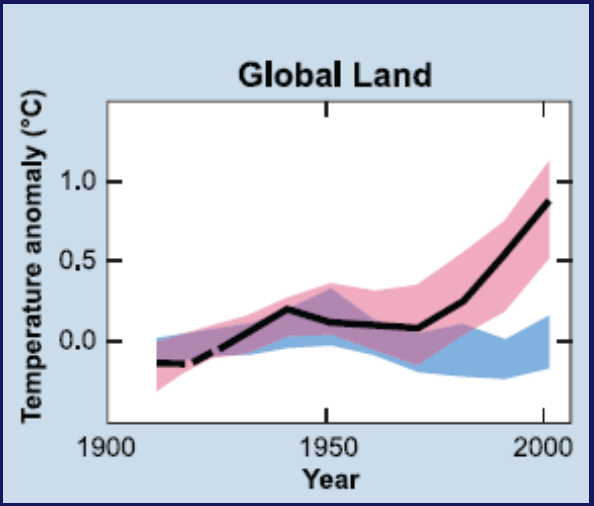
models using only natural forcings

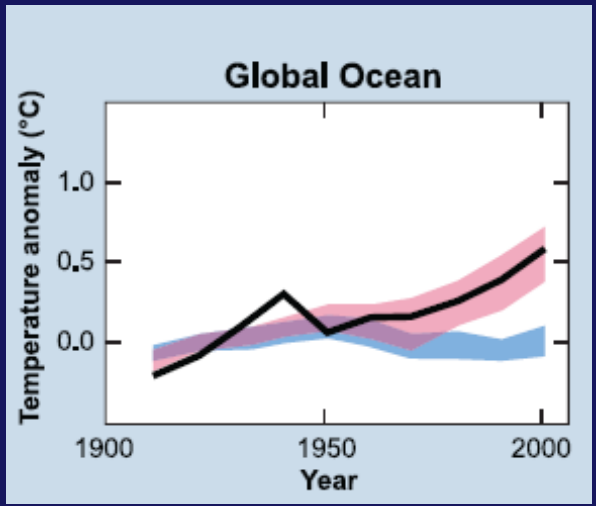
models using both natural and anthropogenic forcings

observations

2007 IPCC Report

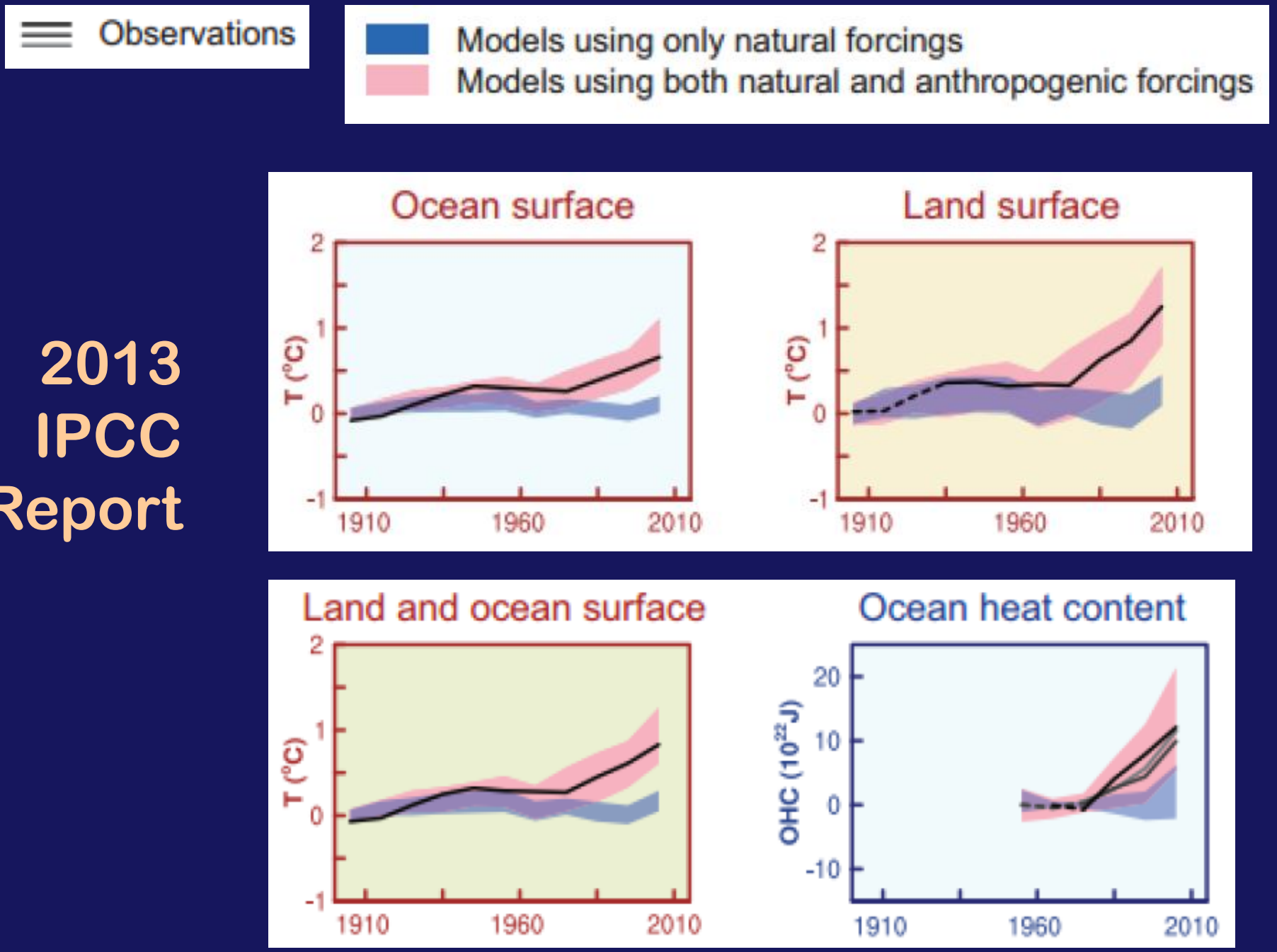






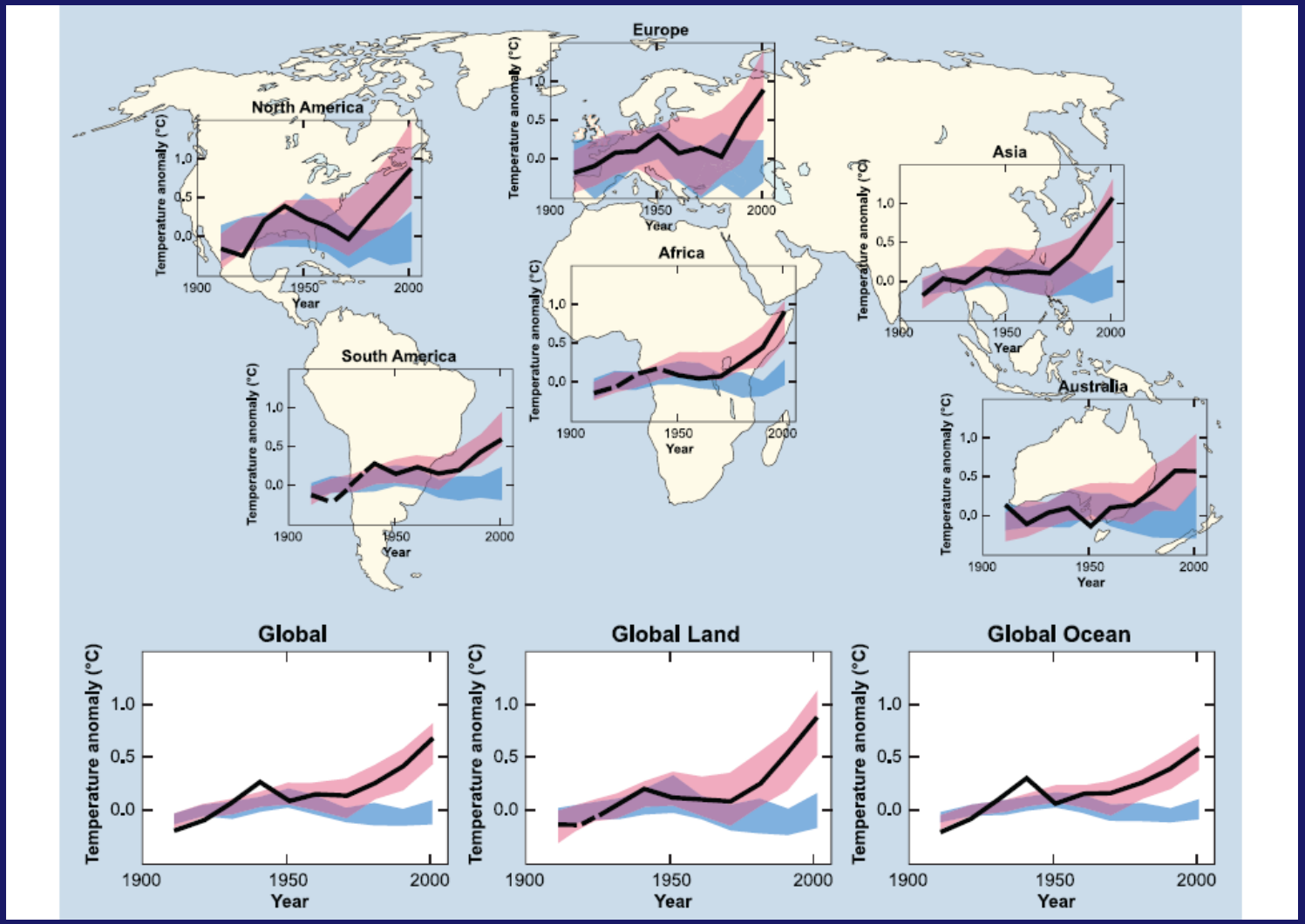
SOURCE: IPCC 2007 WG-1 Synthesis Report Summary for Policymakers

2013 IPCC Report



Individual Region Model Runs showed the same results!

2007 IPCC Report

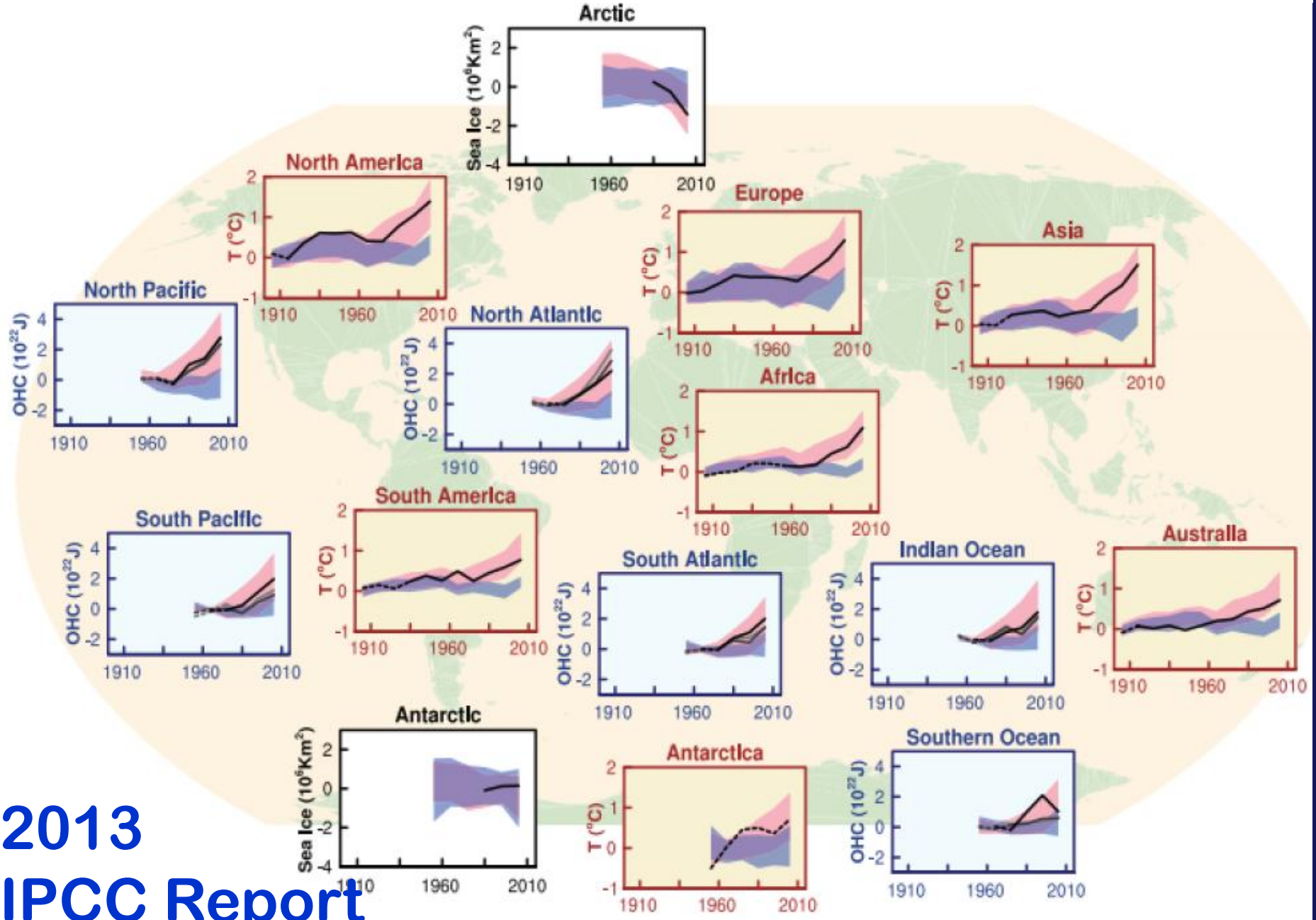


observations

models using only natural forcings

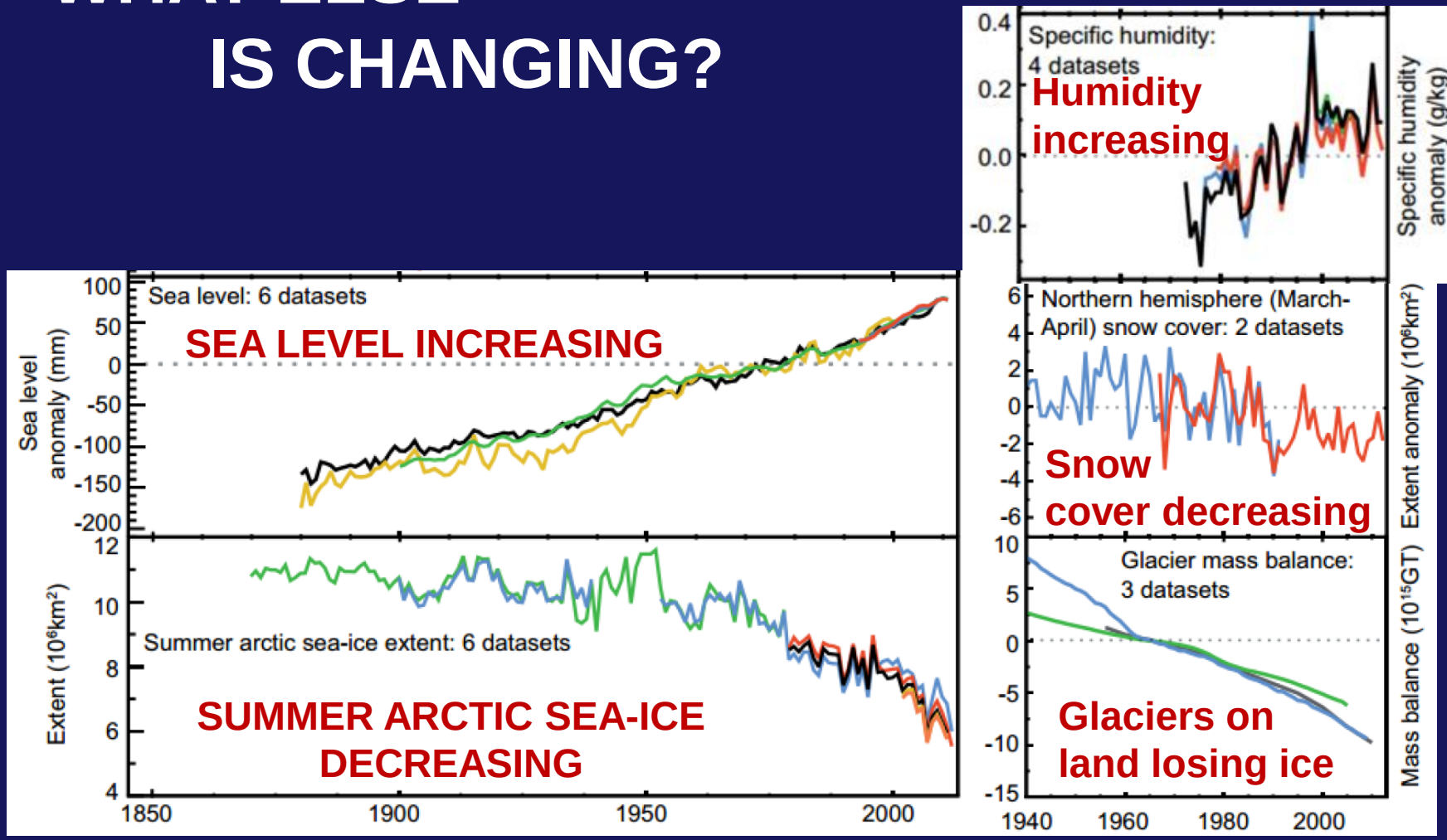
models using both natural and anthropogenic forcings

Model Comparisons of Natural vs. Anthropogenic Forcing on All Continents

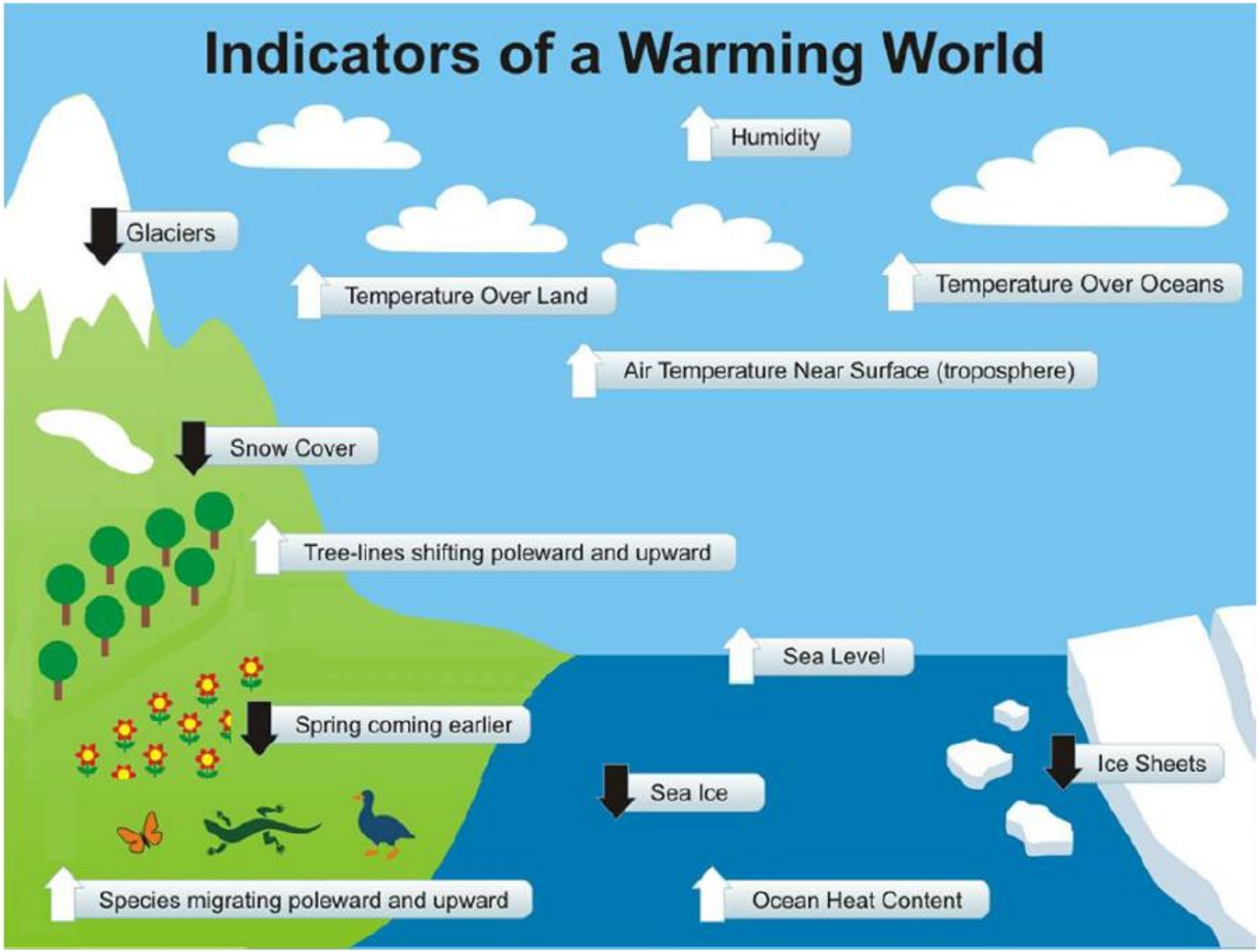


2013 IPCC Report

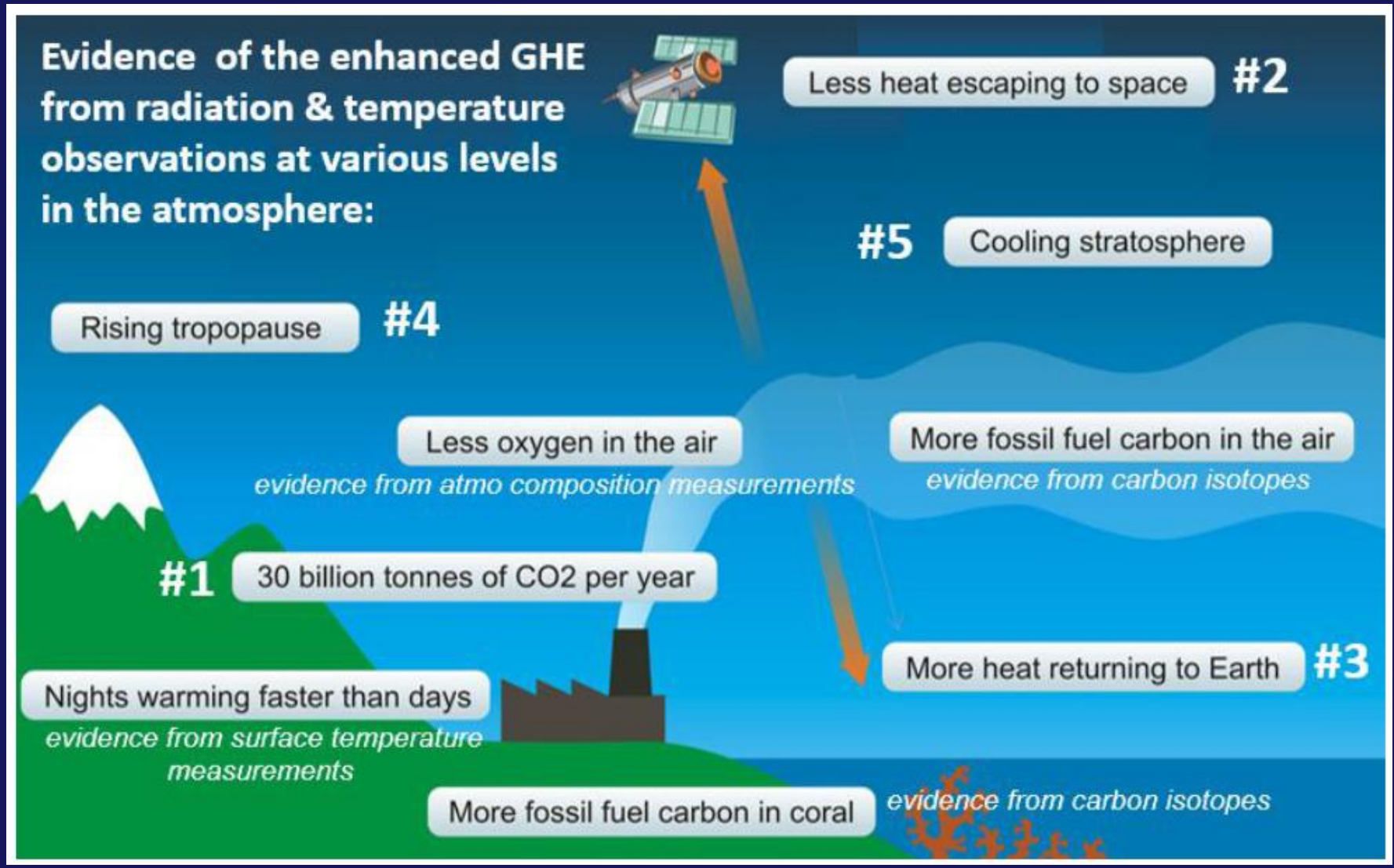
WHAT ELSE IS CHANGING?



THE SUMMARY: INDICATORS RECAP



What else tells us that the Anthropogenically enhanced GreenHouse Effect is responsible for recent change?



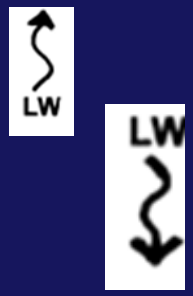
Can you link the indicators in the figure with processes we've covered this semester that are linked to an ANTHROPOGENIC influence?

Can you link the indicators in the figure with processes we've covered this semester that are linked to an Anthropogenic influence?

1. 30 billion tonnes of CO2 emitted into the atmosphere per year: Keeling curve

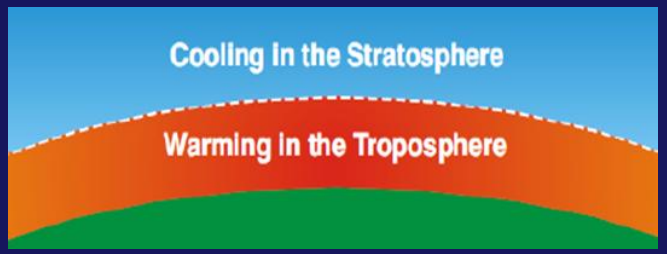
2. Less heat escaping to space at the top of the atmosphere:

3. More heat returning to Earth:



4. Rising tropopause:

5. Cooling stratosphere:



Greenhouse Warming Signature

TOPIC #14

CLIMATE CHANGE: IMPACTS & ISSUES – THE IPCC FINDINGS & WHAT LIES AHEAD

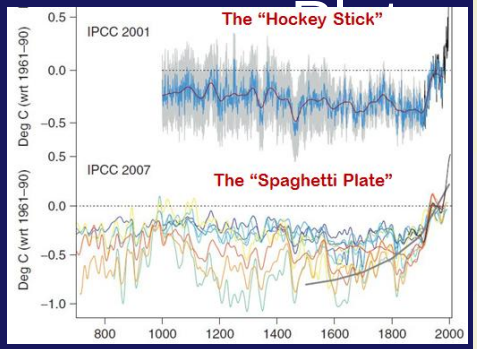
p 93 in Class Notes

There is a paradoxical gulf between the importance of Earth's climate and the level of public interest in it . . . .

We're in the middle of a large uncontrolled experiment on the only planet we have.

- Donald Kennedy
editor-in-chief of the journal Science

Continually improving "Hockey Stick" (from 2001 Third Assessment) ➔ Spaghetti



GLOBAL SURFACE TEMPERATURE CHANGE (° C) (compared to 1990 value)

Variations of the Earth's surface temperature: years 1000 to 2100

Departures in temperature in °C (from the 1990 value)

Observations, Northern Hemisphere, proxy data

Global instrumental observations

Projections

Several models all SRES envelope

From 2001 IPCC:

Past & Future Earth's Surface Temperature in one graph (departures from 1990 value)

Bars show the range in year 2100 produced by several models

Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a

6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0

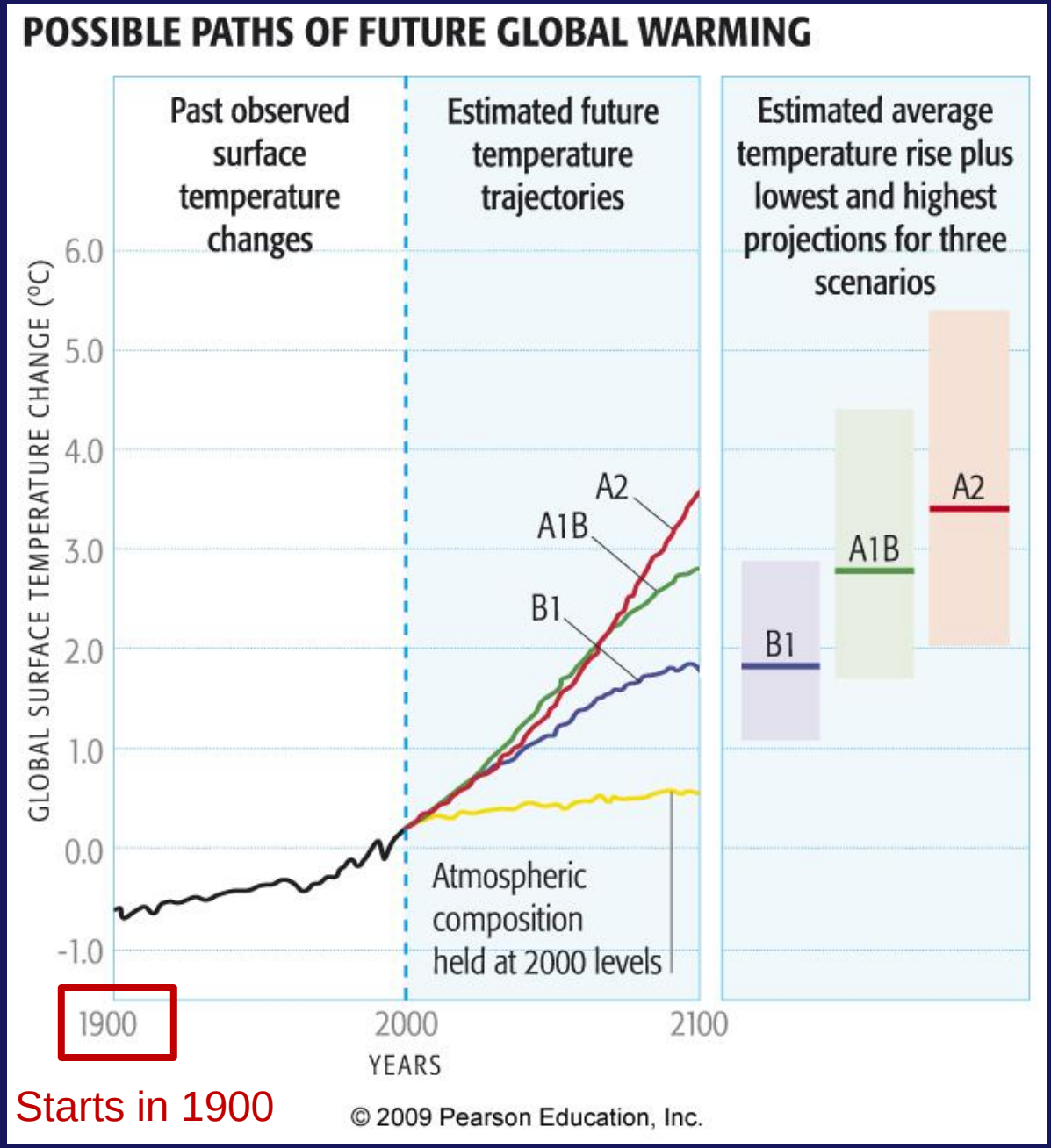
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

From Self test 8

Updated version in AR4:

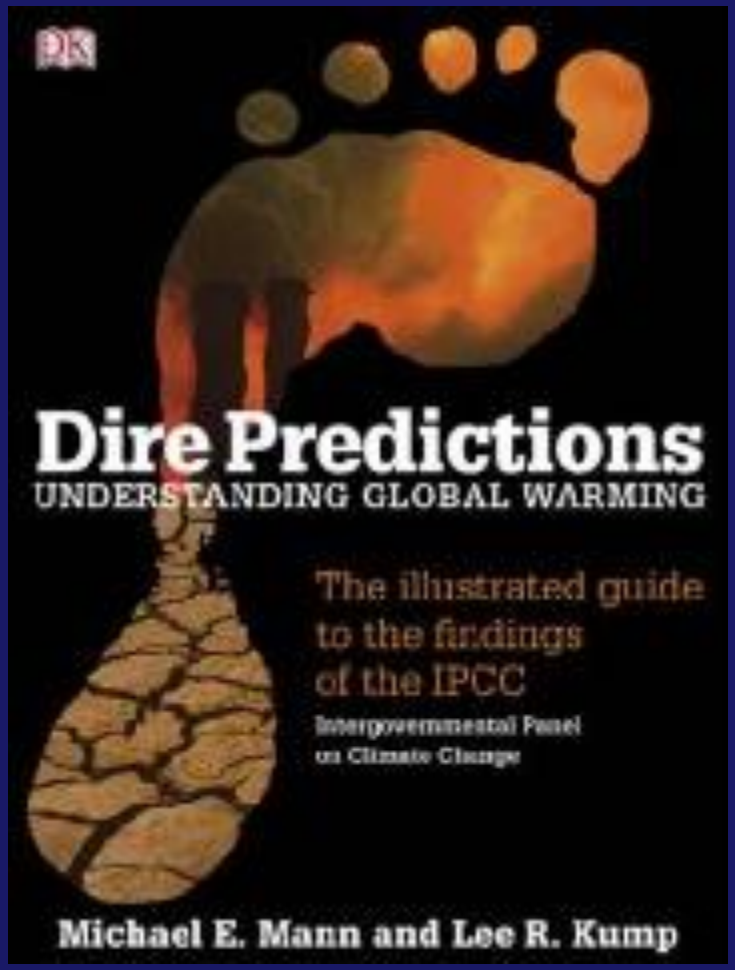
2007 IPCC FOURTH ASSESSMENT REPORT

GLOBAL SURFACE TEMPERATURE CHANGE (° C)
Compared to 1980-1999 period



Starts in 1900

From *Dire Predictions* (p 20)



"The Illustrated Guide to the findings of the IPCC"

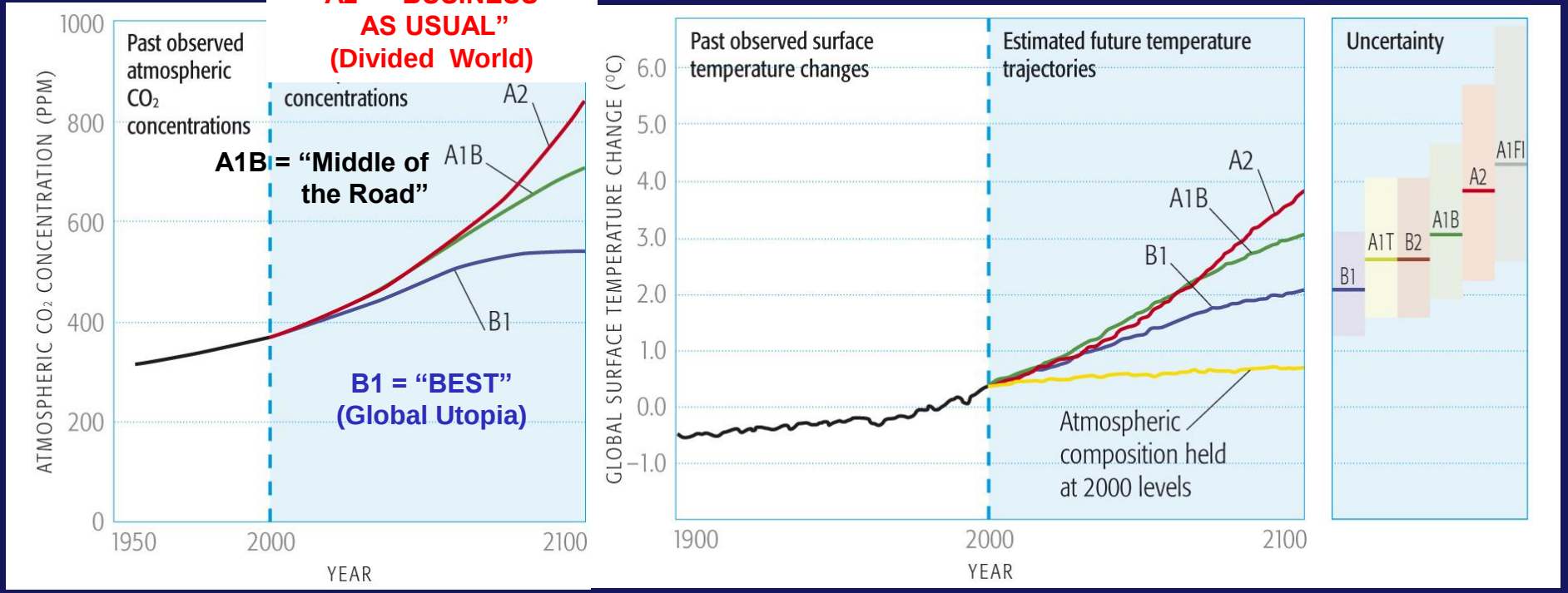
RANGE OF POSSIBLE TRAJECTORIES FOR FUTURE CLIMATE CHANGE

CO2 in ATMOSPHERE
(due to emissions)

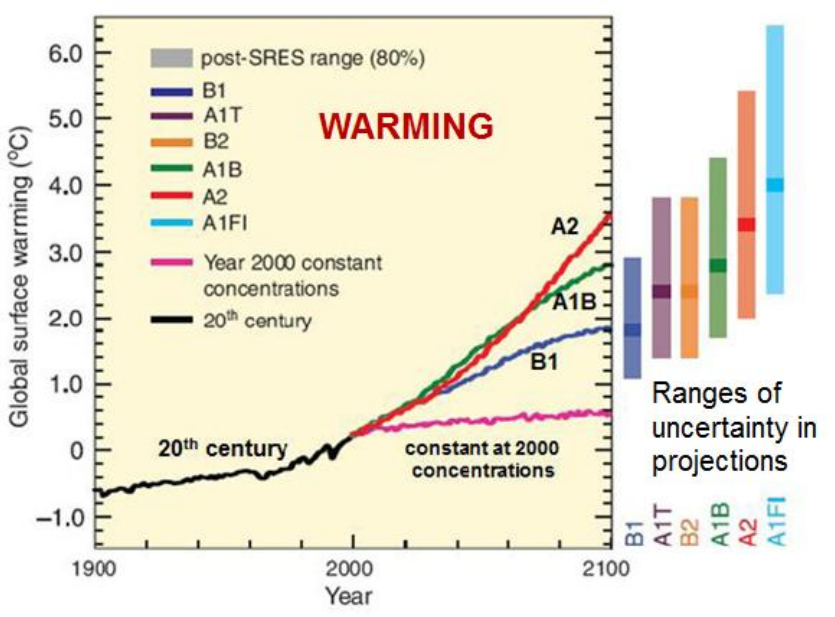
RESULTING WARMING: TEMPERATURE INCREASE

Spread of results due to:

(a) which future emission scenario used
(b) variations among different climate models



From *Dire Predictions* (p 88)



The TABLE below shows the computer model estimates of temperature change for each of the scenarios on ← this graph

Table SPM.1. Projected global average surface warming and sea level rise at the end of the 21st century. {Table 3.1}

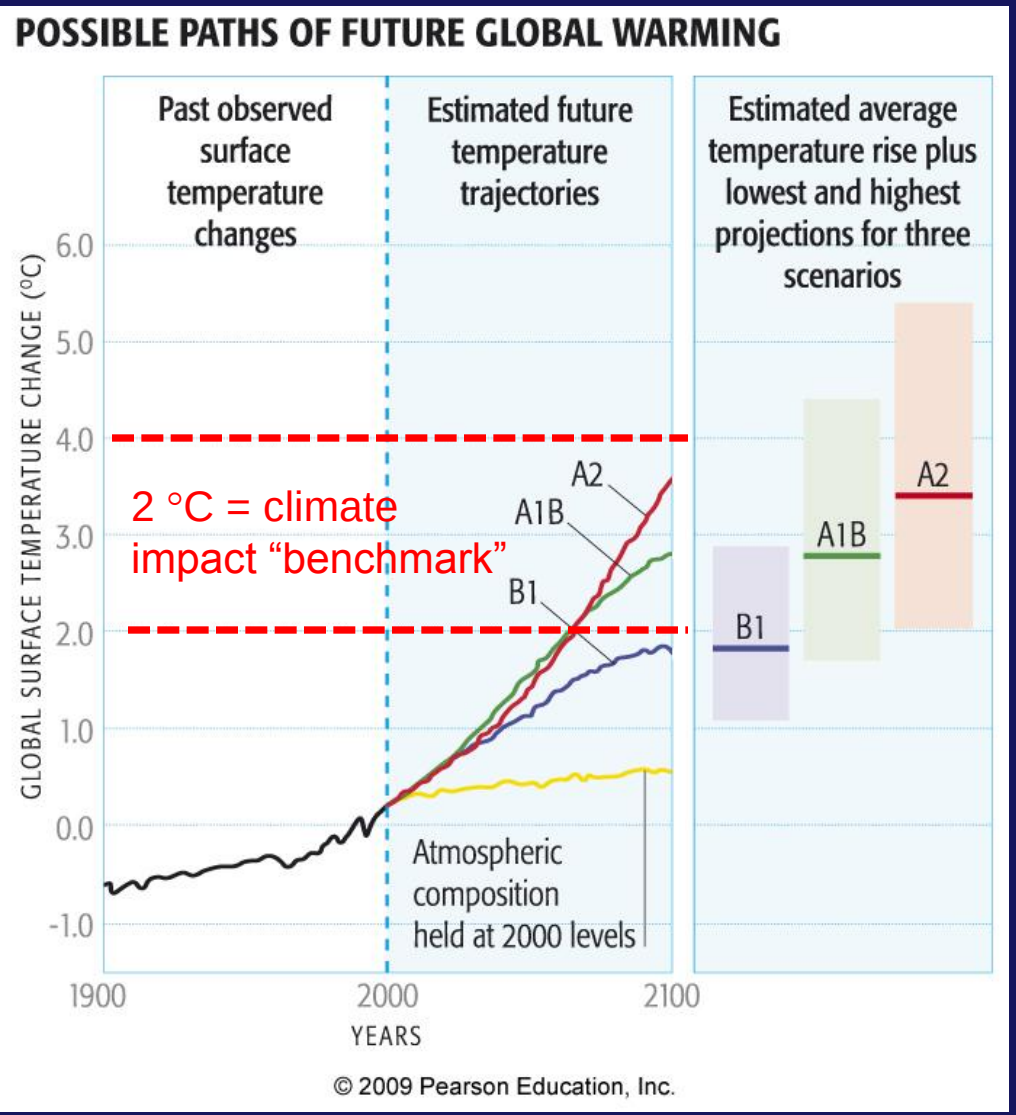
Case	Temperature change (°C at 2090-2099 relative to 1980-1999) [a, d]		Sea level rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant year 2000 concentrations[b]	0.6	0.3 – 0.9	Not available
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

We are already on a path that is close to the A2 scenario or WORSE!!

← This is much faster than was expected when the 2007 IPCC first came out!

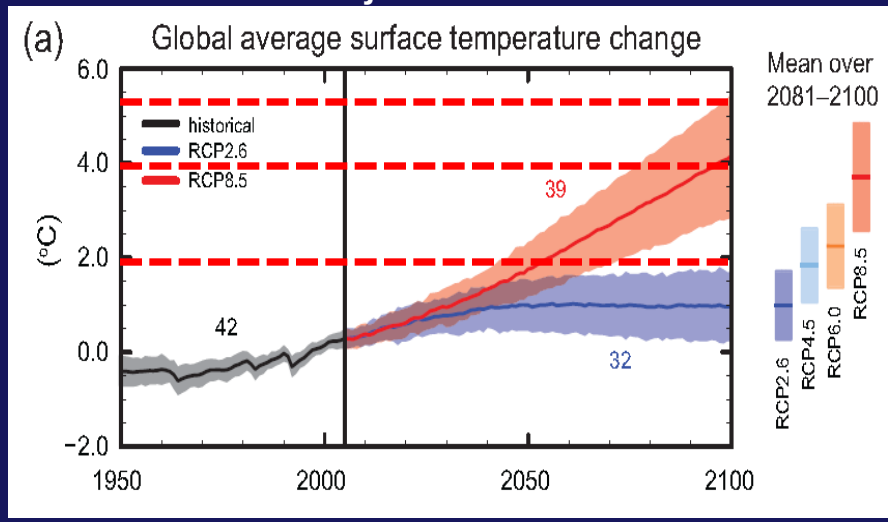
2007 REPORT

From *Dire Predictions* (p 20)



2013 REPORT

Future Temperature Change Projections:



Representative Concentration Pathways (RCPs)

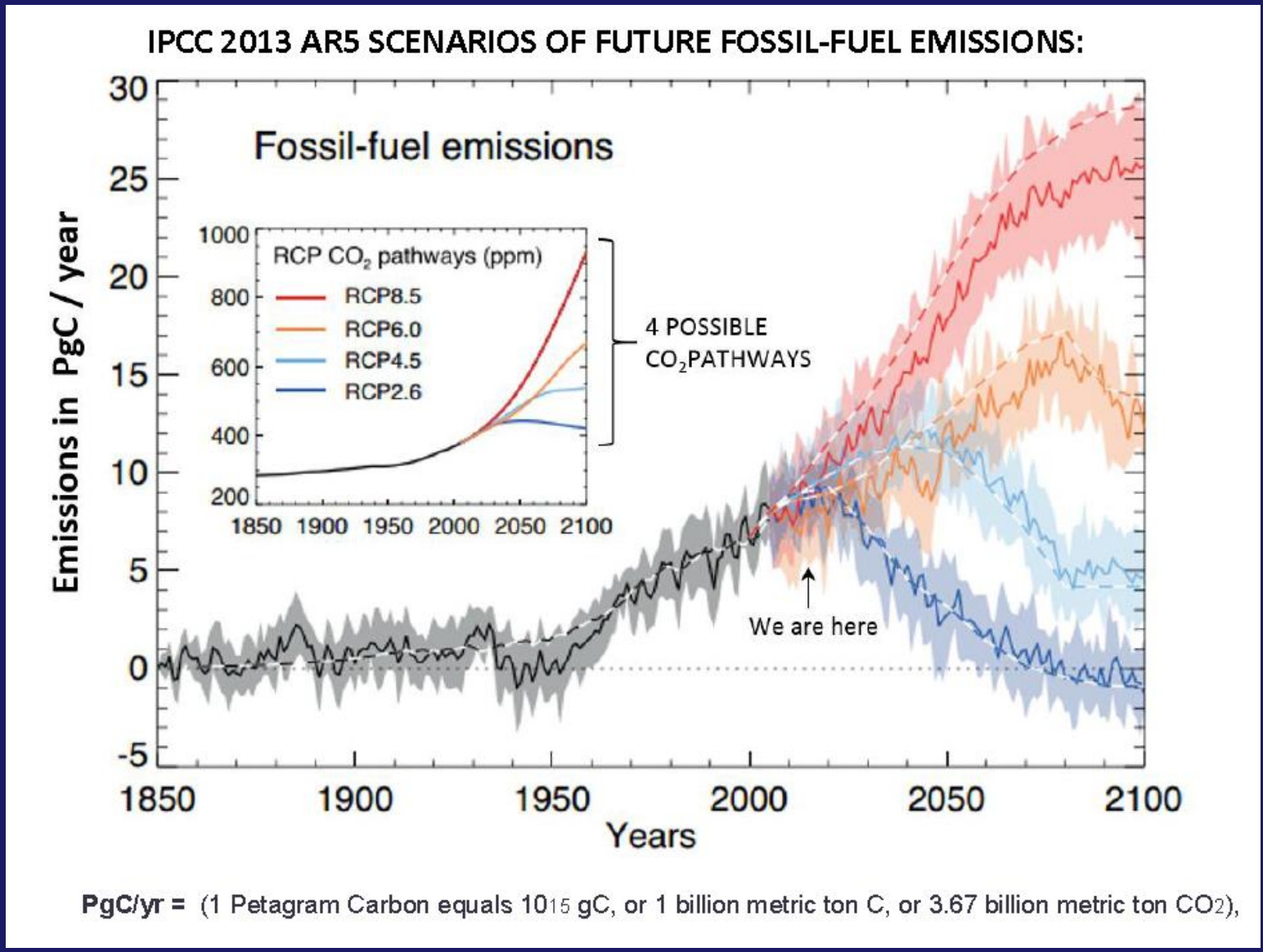
RCPs = future scenarios identified by their approximate total radiative forcing in year 2100 relative to 1750

Class Notes p 93

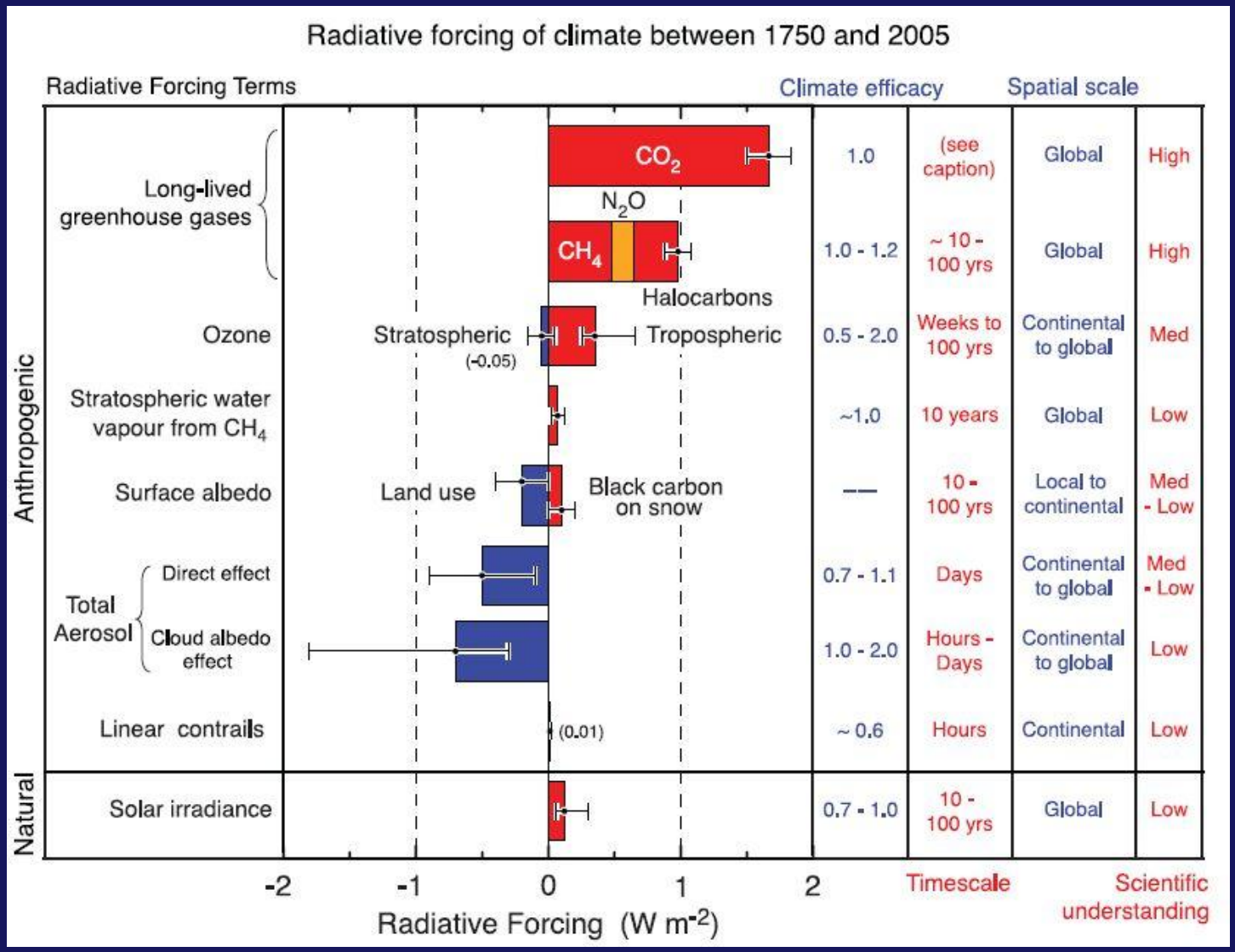
GLOBAL SURFACE TEMPERATURE CHANGE (° C)

How are “FUTURE PROJECTIONS” made?

GHG EMISSIONS ➔ RADIATIVE FORCING ➔ TEMPERATURE



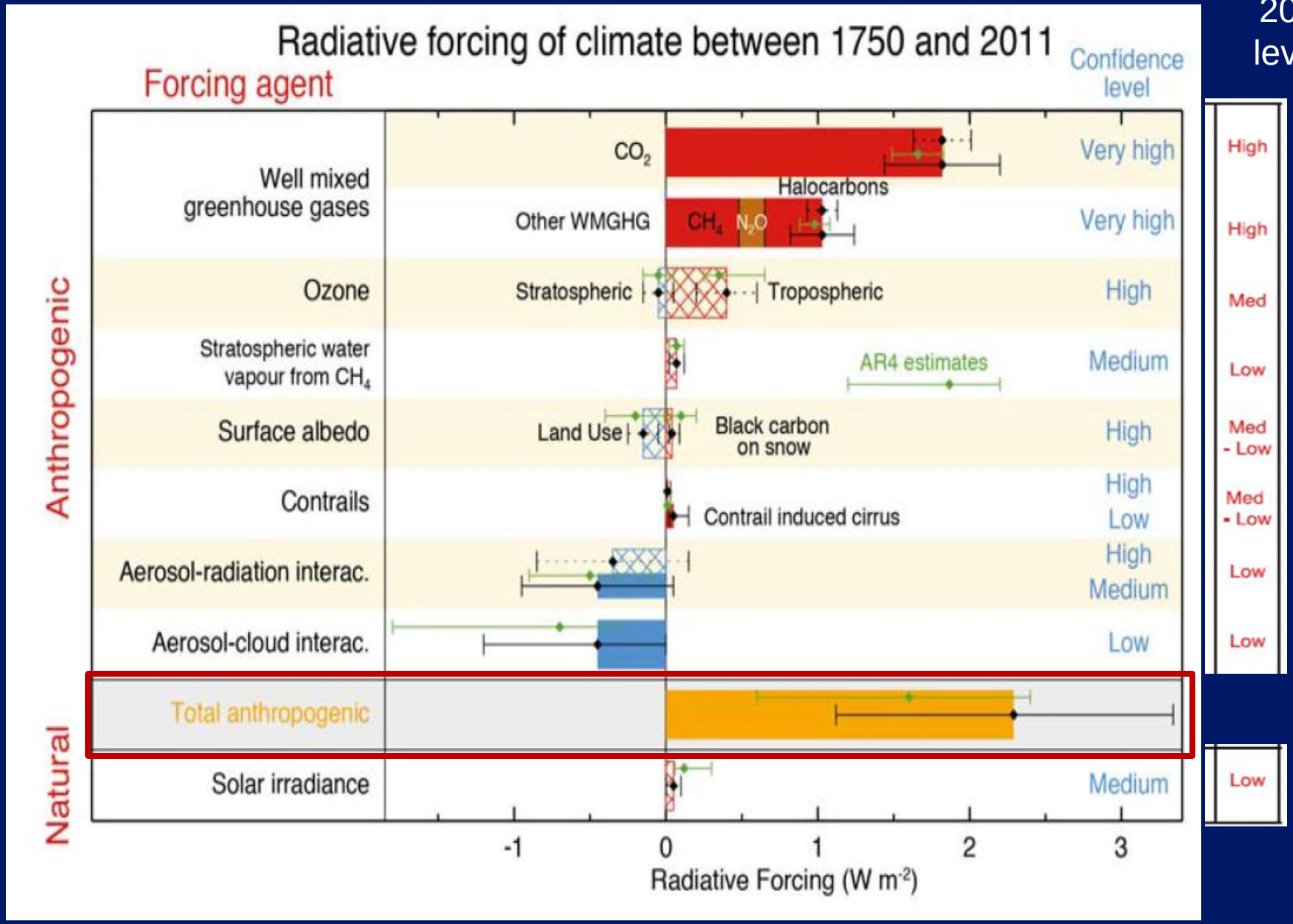
More accurate assessment of magnitude of individual RADIATIVE FORCINGS :



SOURCE: IPCC 2007 WG-1 Synthesis Report Summary for Policymakers

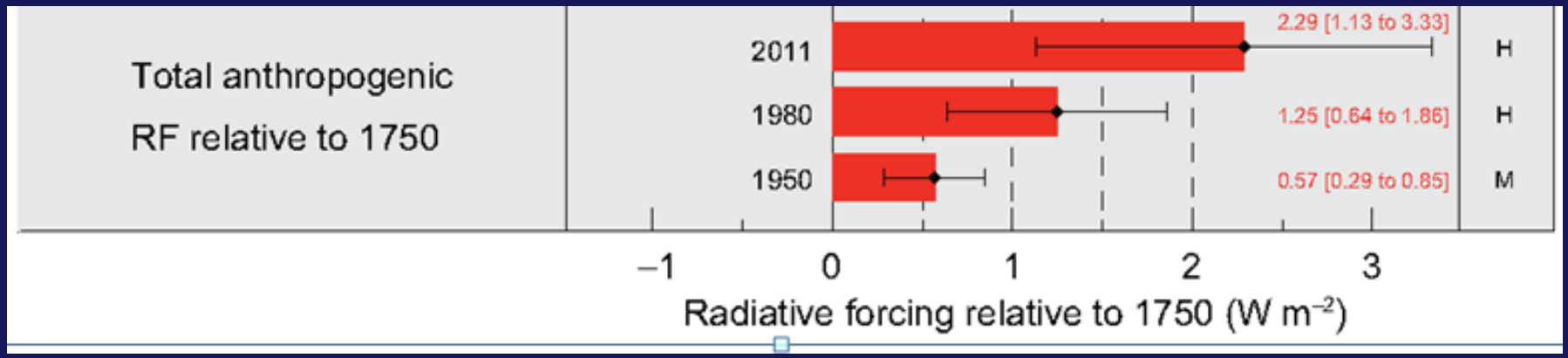
review

IPCC REPORTS 2007 vs 2013

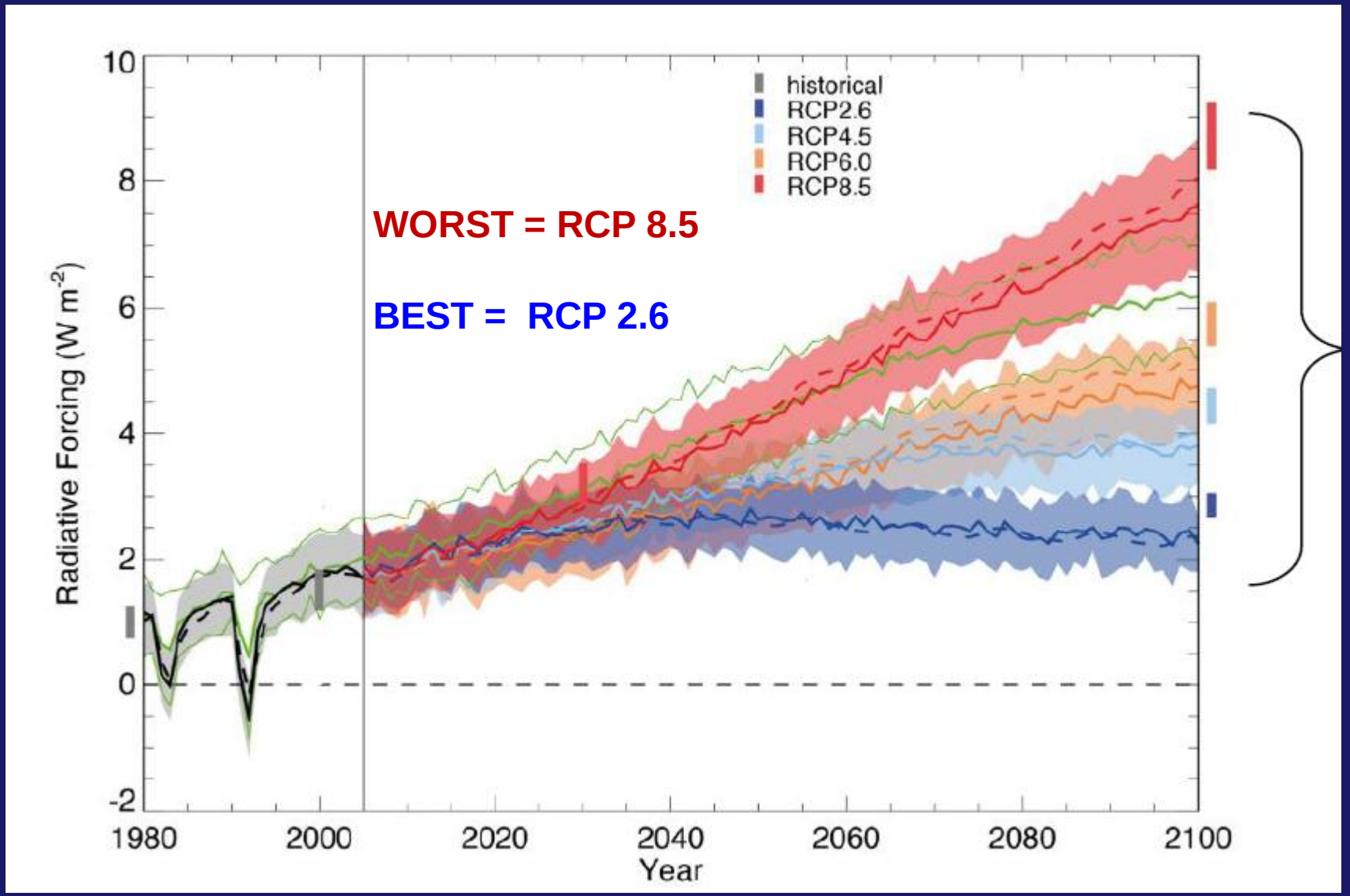


NEW: A time comparison of

TOTAL ANTHROPOGENIC FORCING!



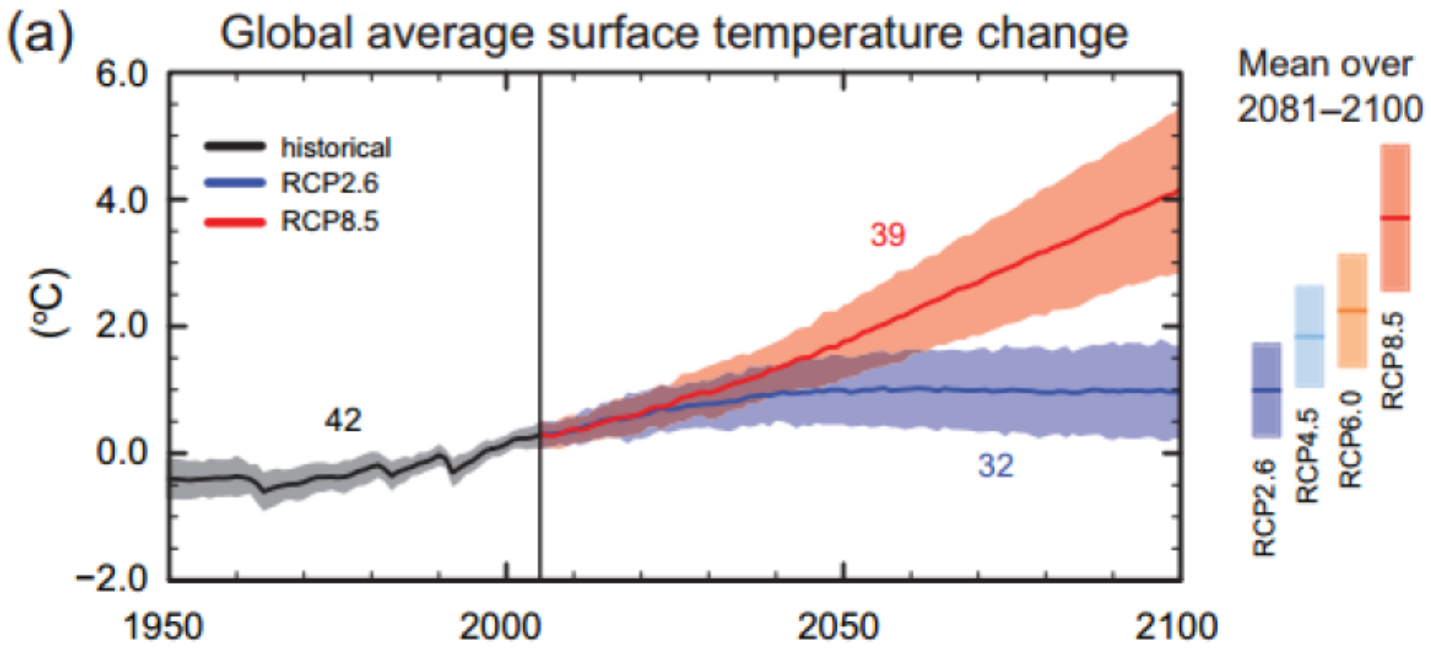
2013 REPORT: Projected RADIATIVE FORCING based on 4 NEW & DIFFFERENT Emissions Scenarios

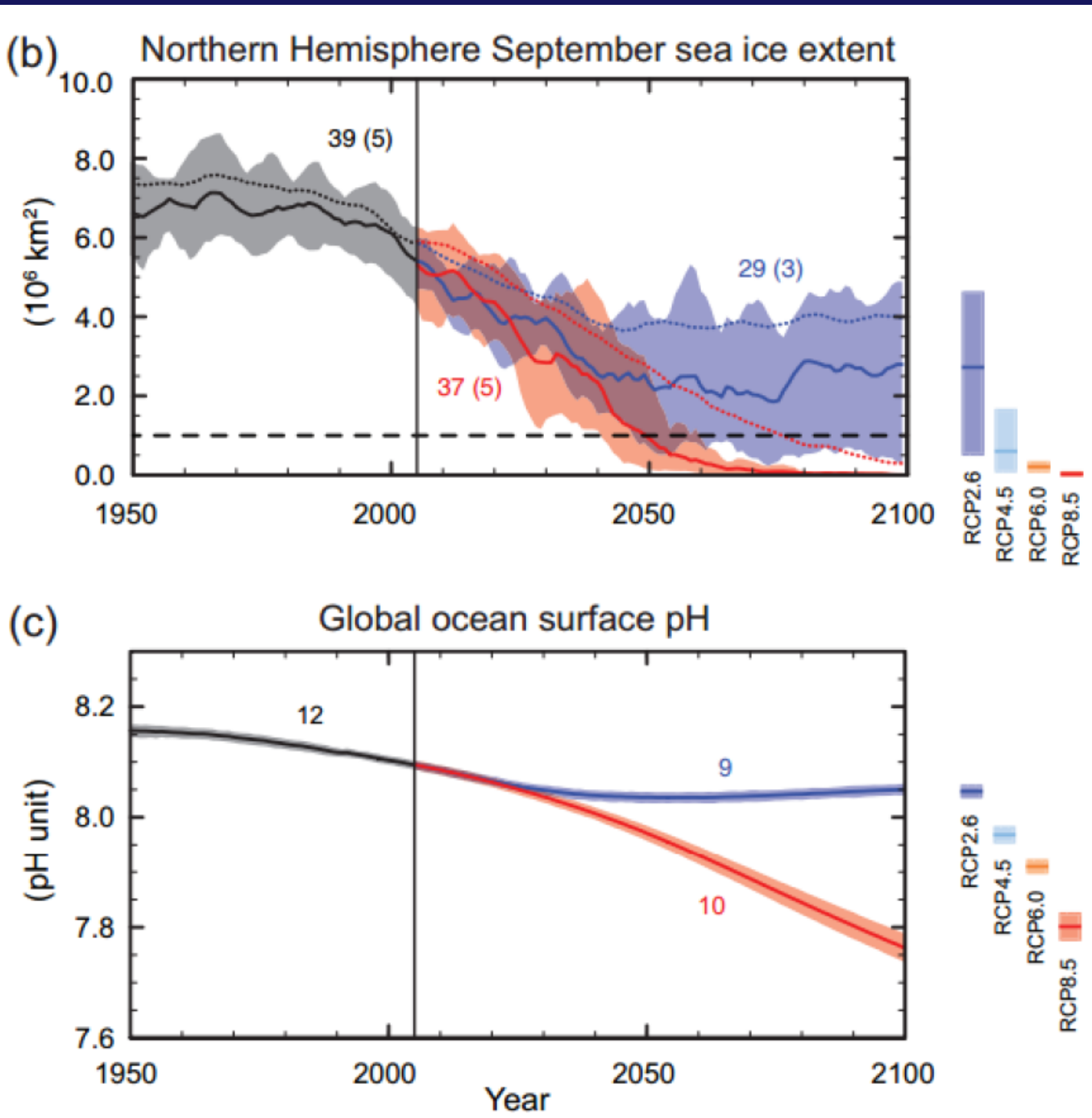


IPCC 2013 (AR5): Projected Climate Change for Different Emissions Scenarios

IPCC 2013 AR5 WG I Summary for Policy Makers Fig SPM.7

http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

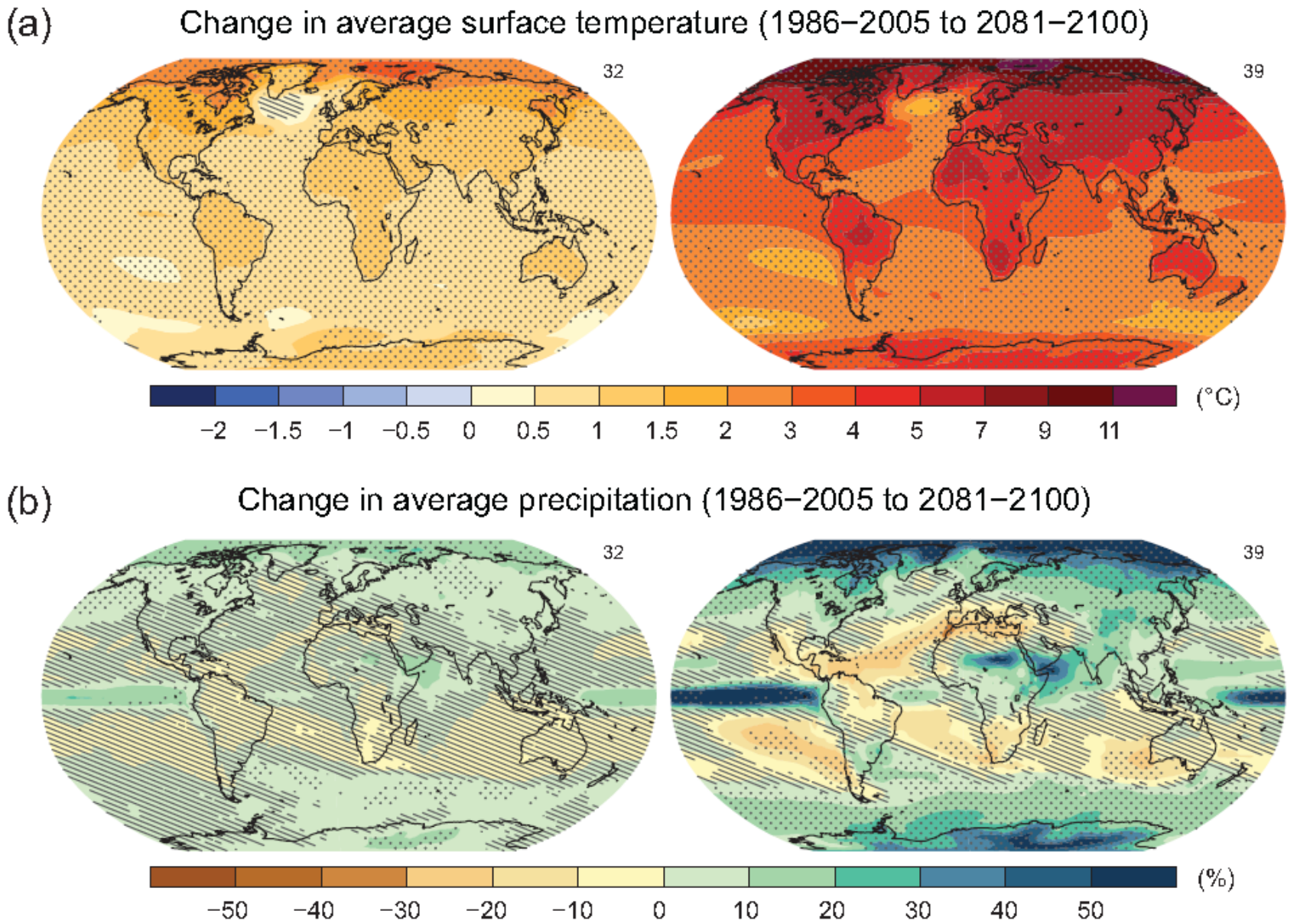



(b)
Northern Hemisphere September sea ice extent
(10⁶ km²)
10.0
8.0
6.0
4.0
2.0
0.0
1950
2000
2050
2100
39 (5)
29 (3)
37 (5)
RCP2.6
RCP4.5
RCP6.0
RCP8.5
(c)
Global ocean surface pH
(pH unit)
8.2
8.0
7.8
7.6
12
9
10
Year

Two FUTURE SCENARIOS FROM THE 2013 REPORT:

very low forcing level

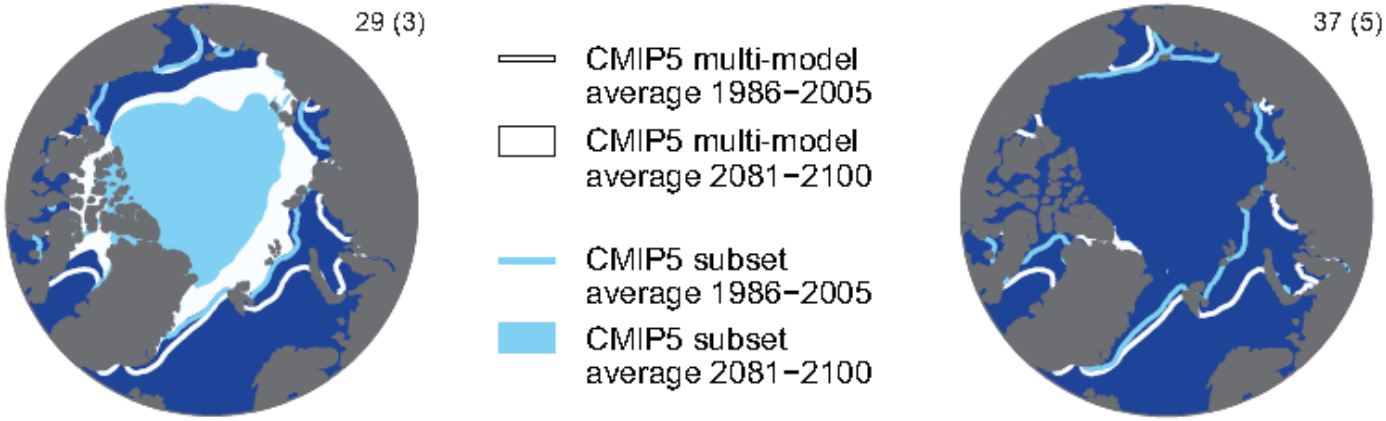
very high greenhouse gas emissions



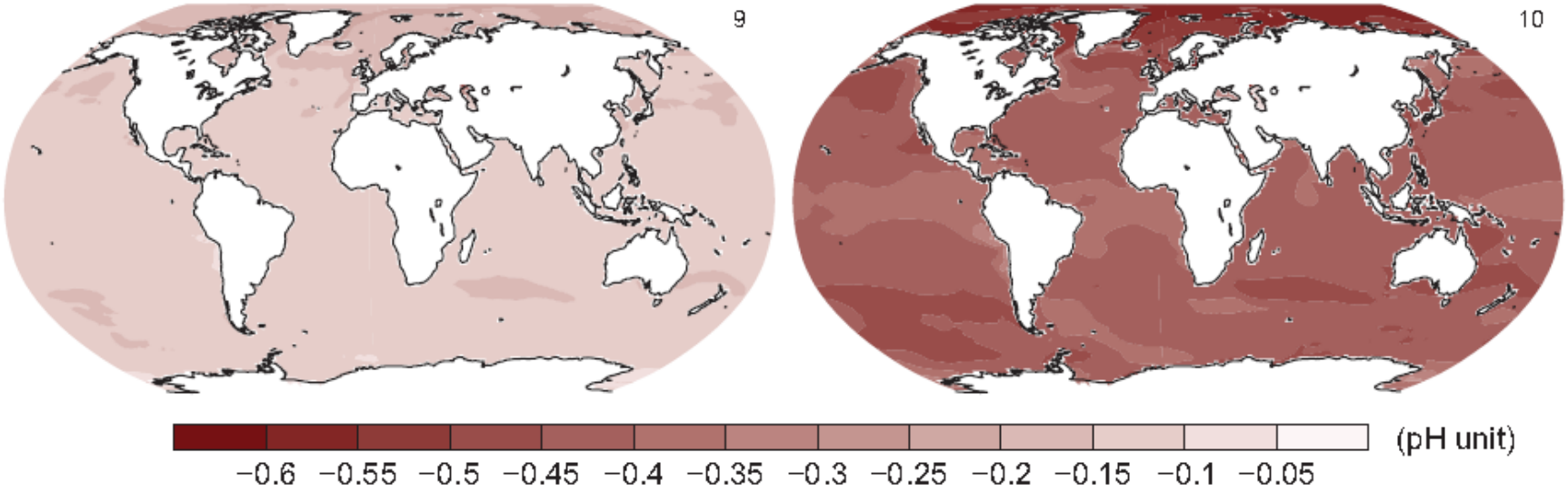
very low forcing level

very high greenhouse gas emissions

(c) Northern Hemisphere September sea ice extent (average 2081–2100)



(d) Change in ocean surface pH (1986–2005 to 2081–2100)



The most comprehensive source of information on Global Climate Change -- the IPCC

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP

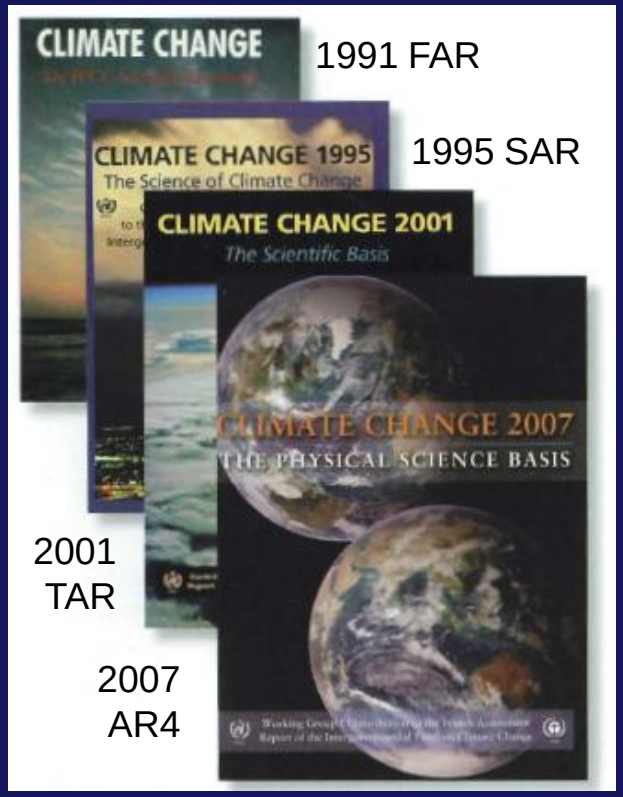
- Established by World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988 as an objective source of information for decision-makers, etc.

"to provide the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences" (IPCC 2007)

- The IPCC does not conduct any research on its own, nor does it monitor climate related data or parameters.

Began with:

The "First Assessment Report" (FAR) in 1991



Most recent:

"Assessment Report 5" (AR5) in 2013

(parts of it are still coming out)

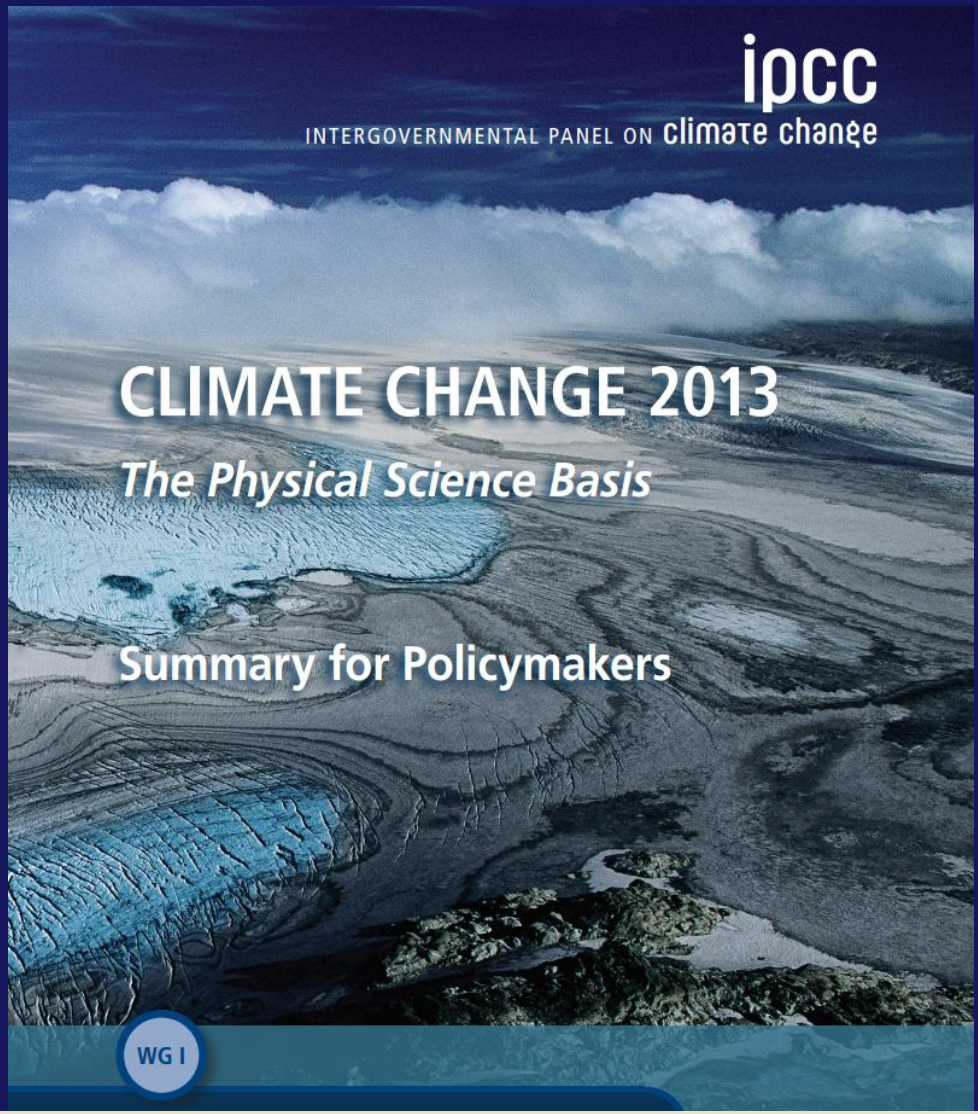
- Its role is **to assess on a comprehensive, objective, open and transparent basis** the latest **scientific**, **technical** and **socio-economic** literature produced worldwide relevant to the understanding of:
  - the **risk** of human induced climate change
  - its **observed and projected impacts** and
  - options for **adaptation and mitigation.**

http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1

http://www.ipcc.ch/

ASSESSMENT REPORT 5
(AR5)

September 2013



Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased

- The **IPCC** is a **scientific body**

- **Thousands of scientists** from all over the world contribute to the work of the IPCC on a voluntary basis.

- **PEER REVIEW** is an essential part of the IPCC process, to ensure an objective and complete assessment of current information.

- **Differing viewpoints** existing within the scientific community are reflected in the IPCC reports.

• **The IPCC is an intergovernmental body,** and it is open to all member countries of UN and WMO.

• Because of its scientific and intergovernmental nature, the IPCC embodies a **unique opportunity to provide rigorous and balanced scientific information to decision makers**.

• By endorsing the IPCC reports, **governments acknowledge the authority of their scientific content.**

• The work of the organization is **therefore policy-relevant and yet policy-neutral, never policy-prescriptive**.

The IPCC has 3 "working groups," a Task Force (and various other subcommittees):

Working Group I (WGI):
Physical Science of climate and climate change.

Working Group II (WGII):
People & Climate – Impacts, Vulnerability of people and natural systems to climate change, & Adaptation options)

Working Group III (WGIII):
Mitigation - options for limiting GHG emissions

Plus: A Task Force that oversees the National Greenhouse Gas Inventories Program

Small, low income, vulnerable people & nations:
They are least responsible,
yet likely to be impacted the most!

What was **NEW** in the most recent reports:

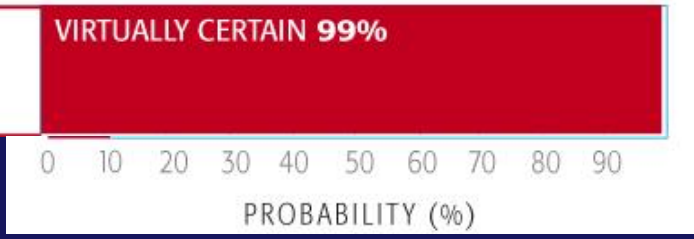
Estimates of confidence in the report's results / conclusions:

- **virtually certain** (greater than 99% chance that a result is true)
- **very likely** (90-99% chance);
- **likely** (66-90% chance);
- **medium likelihood** (33-66% chance);
- **unlikely** (10-33% chance);
- **very unlikely** (1-10% chance);
- **exceptionally unlikely** (less than 1%) chance).

IPCC PROJECTIONS FOR THE 21ST CENTURY

VIRTUALLY CERTAIN 99%

- Cold days and nights will be warmer and less frequent over most land areas
- Hot days and nights will be warmer and more frequent over most land areas



- **Over most land** areas:

HOT DAYS & NIGHTS will be WARMER;
and MORE FREQUENT

Recurrence Interval = measure of frequency

An event happening "once in 50 years"
in the future, might happen "once in 10 years"
(or have a "1 in 10" chance of occurring in any year)

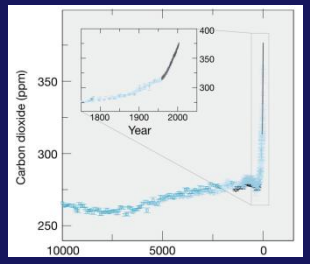
IPCC PROJECTIONS FOR THE 21ST CENTURY

VERY LIKELY 90%

- If the atmospheric CO_2 level stabilizes at double the present level, global temperatures will rise by more than 1.5°C
- The warming over inhabited continents by 2030 will be about double the observed variability during the 20th century
- There will be an observed increase in methane concentration due to human activities
- The rate of increase in atmospheric CO_2, methane, and nitrous oxide will reach levels unprecedented in the last 10,000 years
- The frequency of warm spells and heat waves will increase
- The frequency of heavy precipitation events will increase
- Precipitation amounts will increase in high latitudes
- The ocean's conveyor-belt circulation will weaken or shut down abruptly

VERY LIKELY **90%**

- **the RATE of increase of GHG's will be UNPRECEDENTED in past 10,000 yrs**



- **Frequency of HEAVY PRECIPITATION EVENTS will INCREASE**

IPCC PROJECTIONS FOR THE 21ST CENTURY

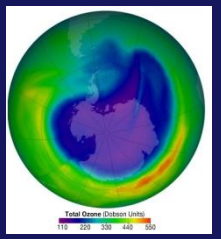
LIKELY 66%

- If the atmospheric CO_2 level stabilizes at double the present level, global temperatures will rise by between 2°C and 4.5°C
- The future increase in global average surface temperature will be between –40% and +60% of the values predicted by climate models
- Areas affected by drought will increase
- The number of frost days will decrease, and growing seasons will lengthen
- Intense tropical cyclone activity will increase, with greater wind speeds and heavier precipitation
- Extreme high-sea-level events will increase, as will ocean wave heights of mid-latitude storms
- Precipitation amounts will decline in the subtropics
- The loss of glaciers will accelerate in the next few decades
- Climate change will promote ozone-hole expansion, despite an overall decline in ozone-destroying chemicals

- **Extreme HIGH SEA LEVEL events will increase**

- **SUBTROPICS (that's us!) will experience PRECIPITATION DECLINE**

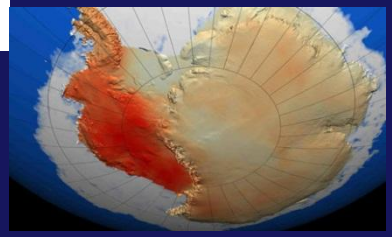
- **Stratospheric cooling ➔ ozone hole persistence even WITH ban of CFC's!**



IPCC PROJECTIONS FOR THE 21ST CENTURY

AS LIKELY AS NOT 35 - 50%

▪ The West Antarctic ice sheet will pass the melting point if global warming exceeds 5°C	ABOUT AS LIKELY AS NOT **35–50%**



- **W. ANTARCTIC ICE SHEET MELTING (if Temp > 5° C)**

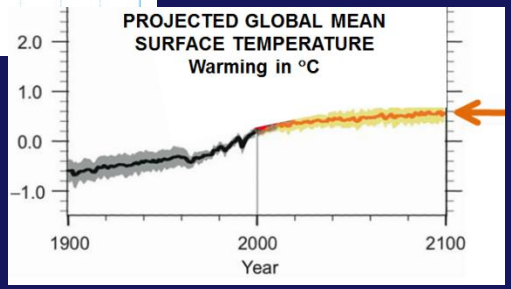
UNLIKELY 35%

▪ Antarctic and Greenland ice sheets will collapse due to surface warming	UNLIKELY

- **ANTARCTIC & GREENLAND ICE SHEETS COLLAPSE**

VERY UNLIKELY10%

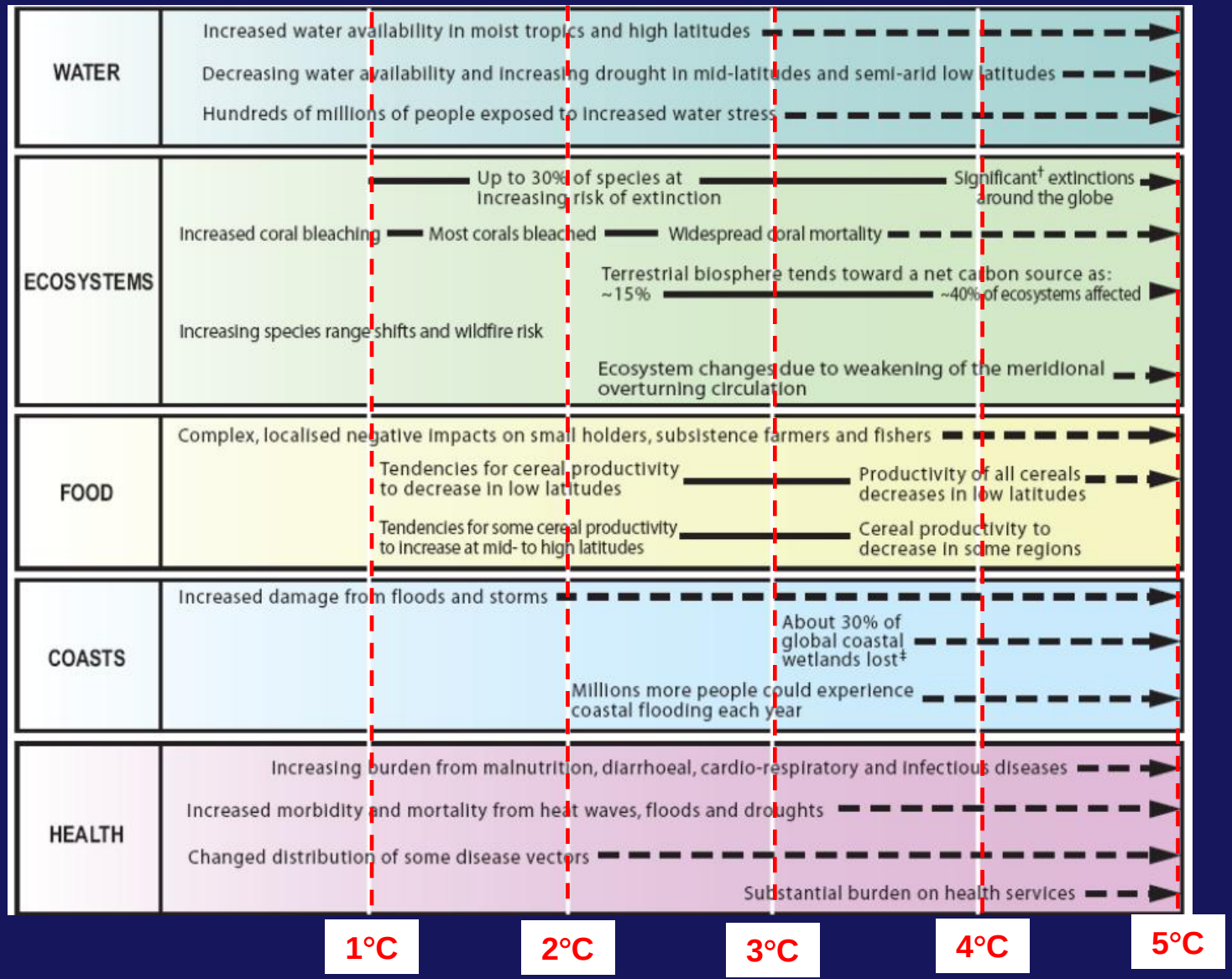
▪ The ocean's conveyer-belt circulation will suffer an abrupt transition ▪ If the atmospheric CO_2 level stabilizes at double the present level, global temperatures will rise by less than 1.5°C	VERY UNLIKELY **10%**



- **GLOBAL TEMPERATURES will rise by LESS than 1.5° C (if CO_2 stabilizes at 2x)**

Examples of IMPACTS associated with global average annual temperature change

(relative to 1980-1999 average temperature)



So what do we do about all of these impacts???

ADAPTATION & MITIGATION SOLUTIONS

POLICIES & POSSIBLE ACTIONS
to SLOW
GLOBAL WARMING . . .
& ADAPT to the warming we
can't prevent!

MITIGATION
VS
ADAPTATION ?

MITIGATION

Mitigation: intervention to reduce anthropogenic Forcing on the climate system through:

(a) strategies to reduce GHG emissions

(b) strategies to enhance GHG sinks

planting trees

ADAPTATION

ADAPTATION: Adjustments made in response to (or anticipation of) **CLIMATIC IMPACTS** in order to:

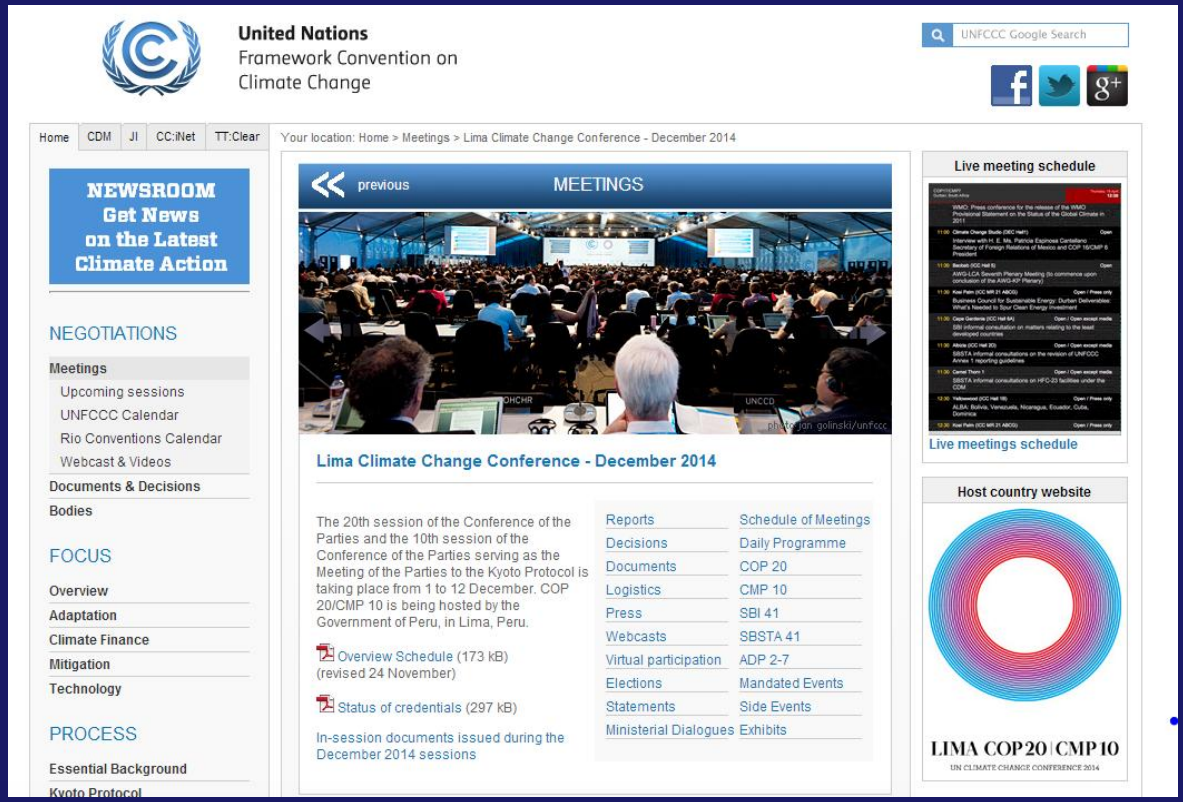
(a) Lessen or reduce harm

(b) take advantage of beneficial opportunities

Should this house be rebuilt?

Going on at this very moment . . .

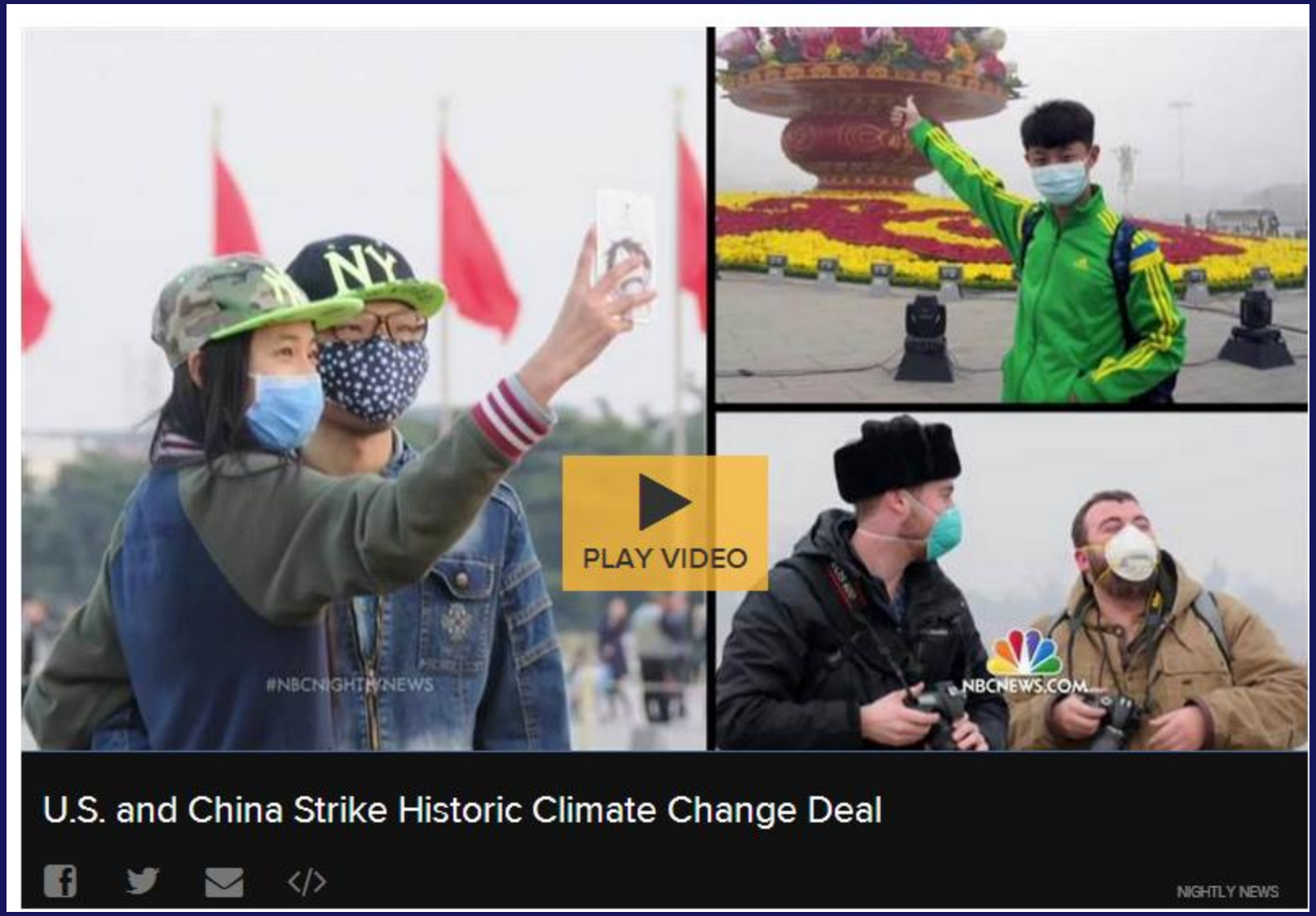
http://unfccc.int/meetings/lima_dec_2014/meeting/8141.php



In fact, that approach is starting to unfold with recent joint pledges by the U.S. and China to ramp up efforts to reduce greenhouse gas emissions: By 2025, the U.S. aims to cut emissions between 26 percent and 28 percent below 2005 levels; China pledged to peak in emissions by 2030.

The pledges were made in the run-up to a climate conference in Lima next month, which will lay the foundation for a climate accord to be reached in Paris in December 2015.

Given such momentum, "one has to hold out hope," Levin said. "On the other hand, we do know that we need very, very aggressive action if we are going to avoid the worst of climate change impacts. We can't lull ourselves into a false sense of security."

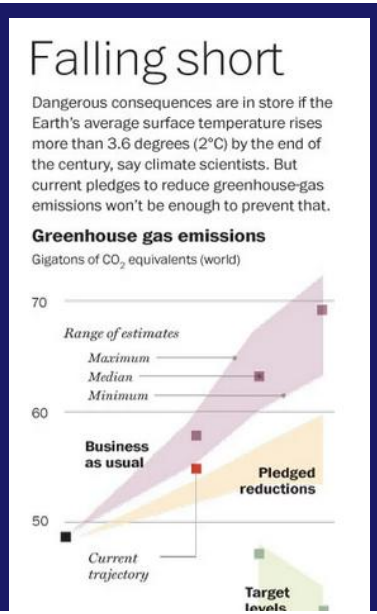


http://www.nbcnews.com/science/environment/were-kidding-ourselves-2-degree-global-warming-limit-experts-n257006

The Washington Post

Diplomats confront stark divide as climate talks begin

http://www.nbcnews.com/science/environment/were-kidding-ourselves-2-degree-global-warming-limit-experts-n257006



WORLD

Optimism Faces Grave Realities at Climate Talks

By CORAL DAVENPORT NOV. 30, 2014

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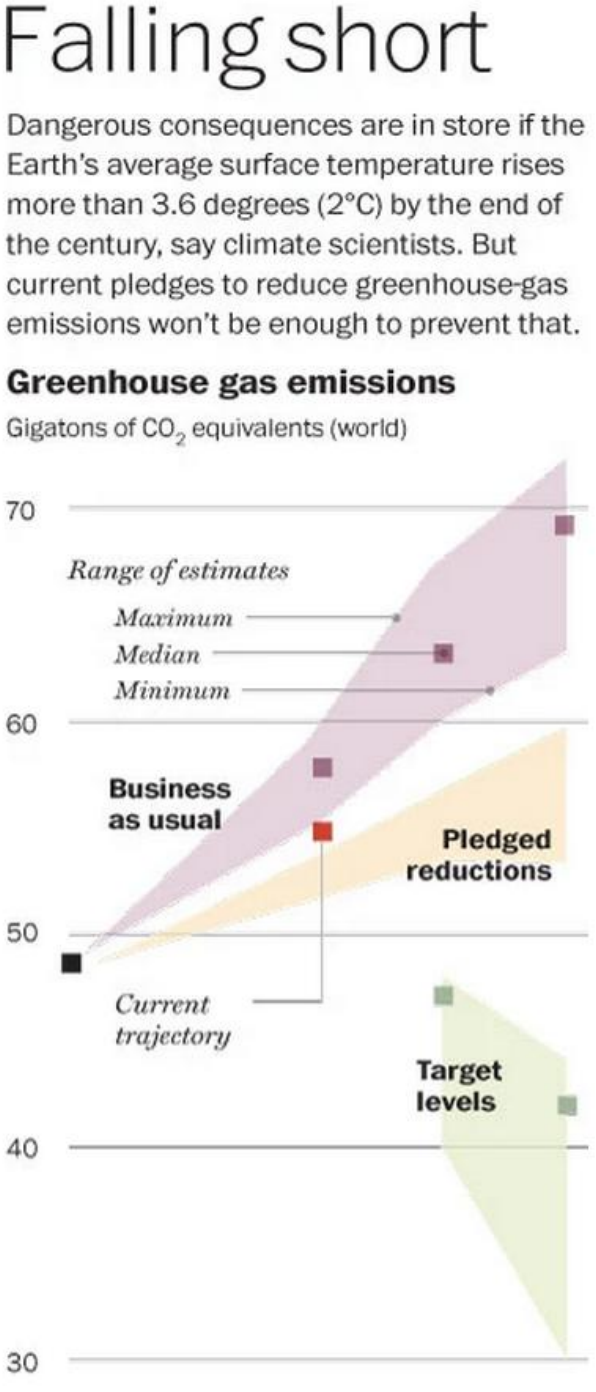
WASHINGTON — After more than two decades of trying but failing to forge a global pact to halt climate change, United Nations negotiators gathering in South America this week are expressing a new optimism that they may finally achieve the elusive deal.

Even with a deal to stop the current rate of greenhouse gas emissions, scientists warn, the world will become increasingly unpleasant. Without a deal, they say, the world could eventually become uninhabitable for humans.



Arizona Daily
tucson.com

HEADING TOWARD WARMEST YEAR ON RECORD

Tucson winter feels more like an invincible summer

Greenpeace Activists Take Pro-Solar Message to the Temple of the Sun in Machu Picchu as Climate Summit in Lima Begins

190-plus nations talk climate change in Lima

By Karl Ritter and Frank Bajak
THE ASSOCIATED PRESS

LIMA, Peru — With this year on track to become the warmest on record, more than 190 nations began talks Monday on new limits for the greenhouse gases that are causing billions of dollars in damage and making life harder to sustain around the world.

New targets for limiting gas emissions blamed on fossil fuels were announced ahead of this conference by the U.S., the European Union and China, the first Asian nation to make such a pledge. This has injected optimism into negotiations that are supposed to climax in Paris next year with the adoption of a long-awaited climate pact.

But India, Russia, Japan and Australia have yet to commit to new limits. Scientists say much sharper emissions cuts are needed in coming decades to keep global warming within 2 degrees C (3.6 F) of preindustrial times, the overall goal of the U.N. talks. Global temperatures have already risen about 0.8 degrees C (1.3 F), and more heat-trapping gases are emitted every year.

Every degree of warming can cause long-lasting impacts, from melting ice caps and rising sea levels to the loss of species.

"Human influence on the climate system is clear," Rajendra Pachauri, who leads the U.N.'s panel of climate-change experts, told delegates at the opening session in Lima.

To have a decent chance of reversing the warming trend before the planet hits the 2-degree mark, the world needs to slash emissions by 40 percent to 70 percent by 2050 and to near-zero by the end of the century, according to the panel's assessments.

Scientists are practically united in warning that there's no way to meet this goal by continuing business as usual.

It would require a sustained, permanent, worldwide shift from fossil fuels to renewable energy sources to power homes, cars and industries. And even then, the transition might not happen fast enough without a large-scale deployment of new technologies to remove greenhouse gases from the atmosphere.

"We call on the world to ensure the opportunity does not slip away," said Nauru's Marlene Moses, representing a group of Pacific island nations threatened by rising seas.

The biggest challenge for the U.N.-sponsored talks is dividing responsibilities between rich Western countries and emerging economies such as China and India. The poorest and most vulnerable nations also need help to develop their economies without aggravating global warming, and to adapt to climate changes that are already causing more violent weather, prolonged droughts and intense flooding.

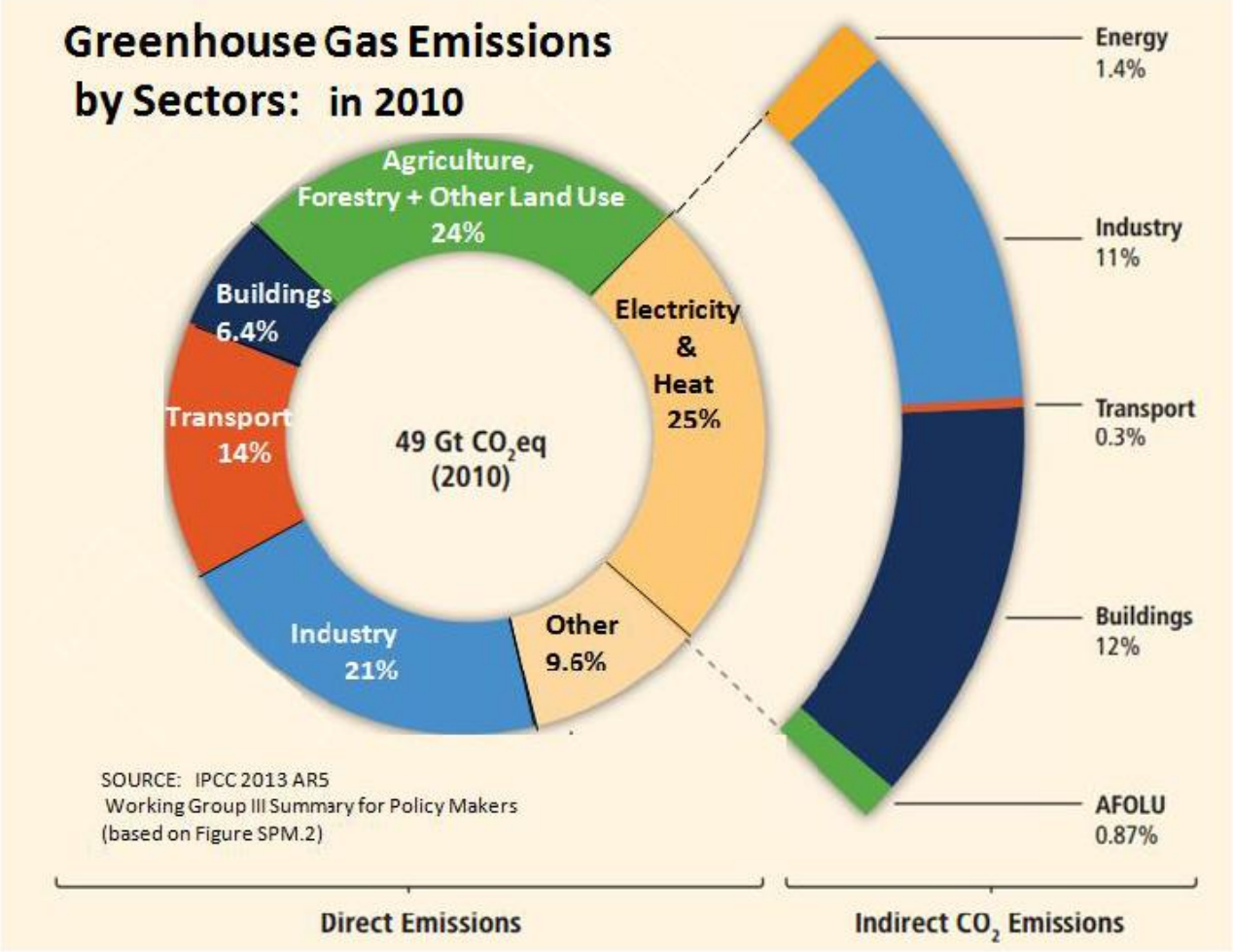
Among them is host country Peru, where glaciers are melting ever-faster, threatening water supplies and food security.

Greenpeace activists met in Copenhagen today to show the way forward for renewables. Courtesy of Greenpeace, 2014

https://greenpeace.app.box.com/s/b0j7gpnlokfn1132p8j9/1/2731042634/23448347971/1

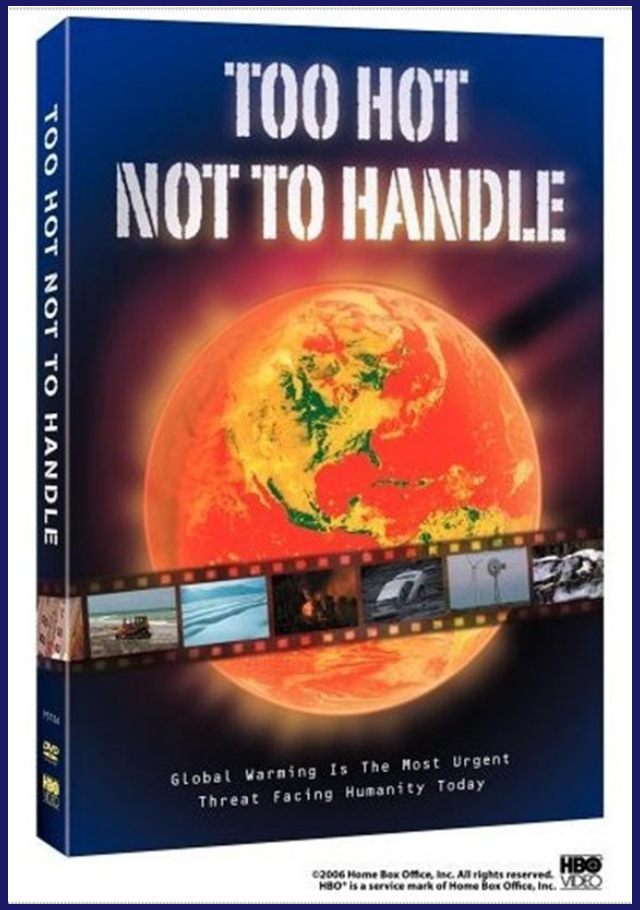
HOW TO MITIGATE FOR FOOTPRINTS!

ANTHROPOGENIC TO GREENHOUSE GAS EMISSIONS BY SECTORS

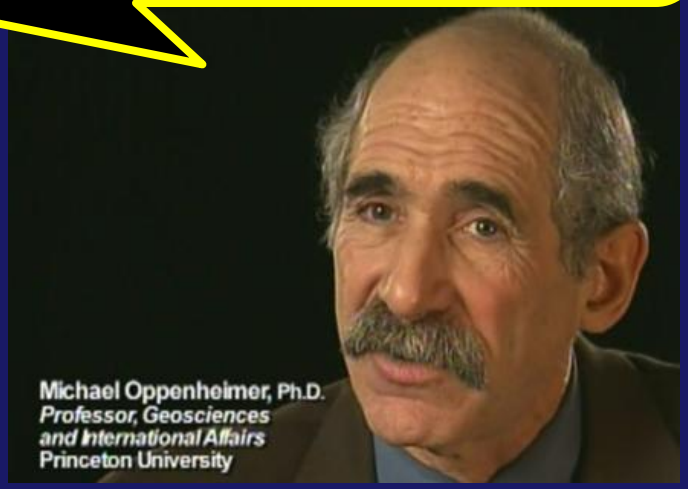


Class Notes pp 85

Several **MITIGATION SOLUTIONS** were described in:



"Let a thousand flowers bloom".

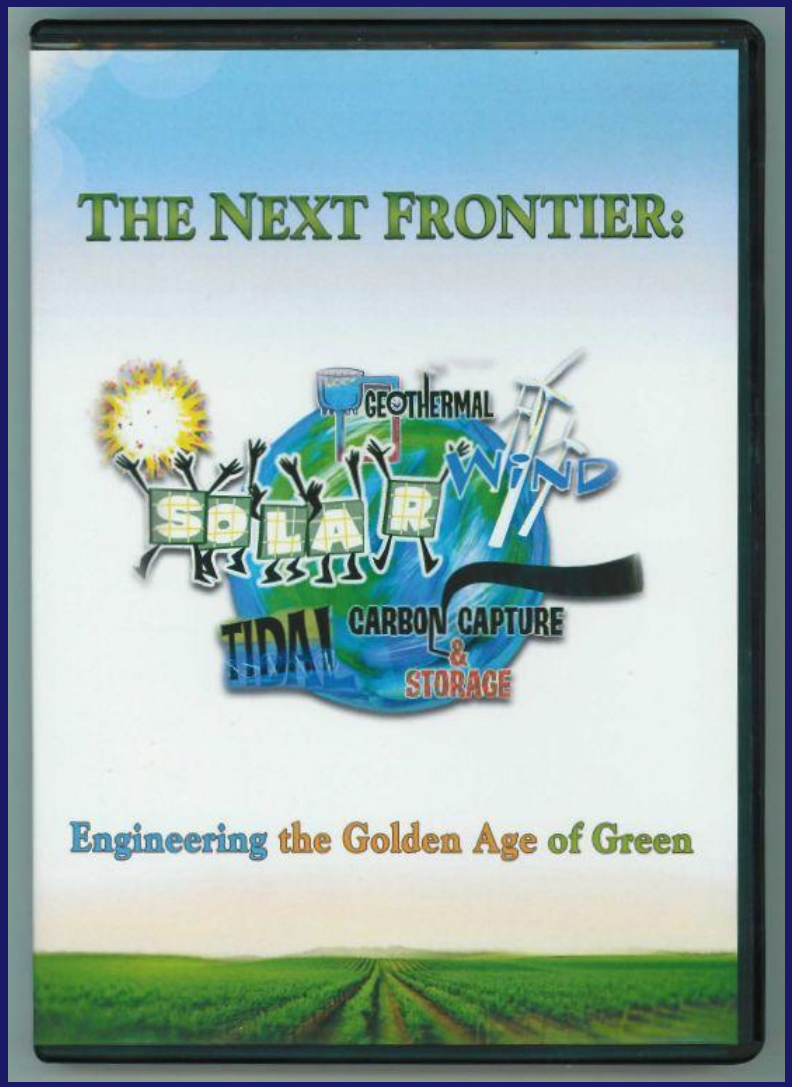


SOLAR

BIOFUELS **WIND**

SUSTAINABLE COMMUNITIES

(Portland, Oregon example)

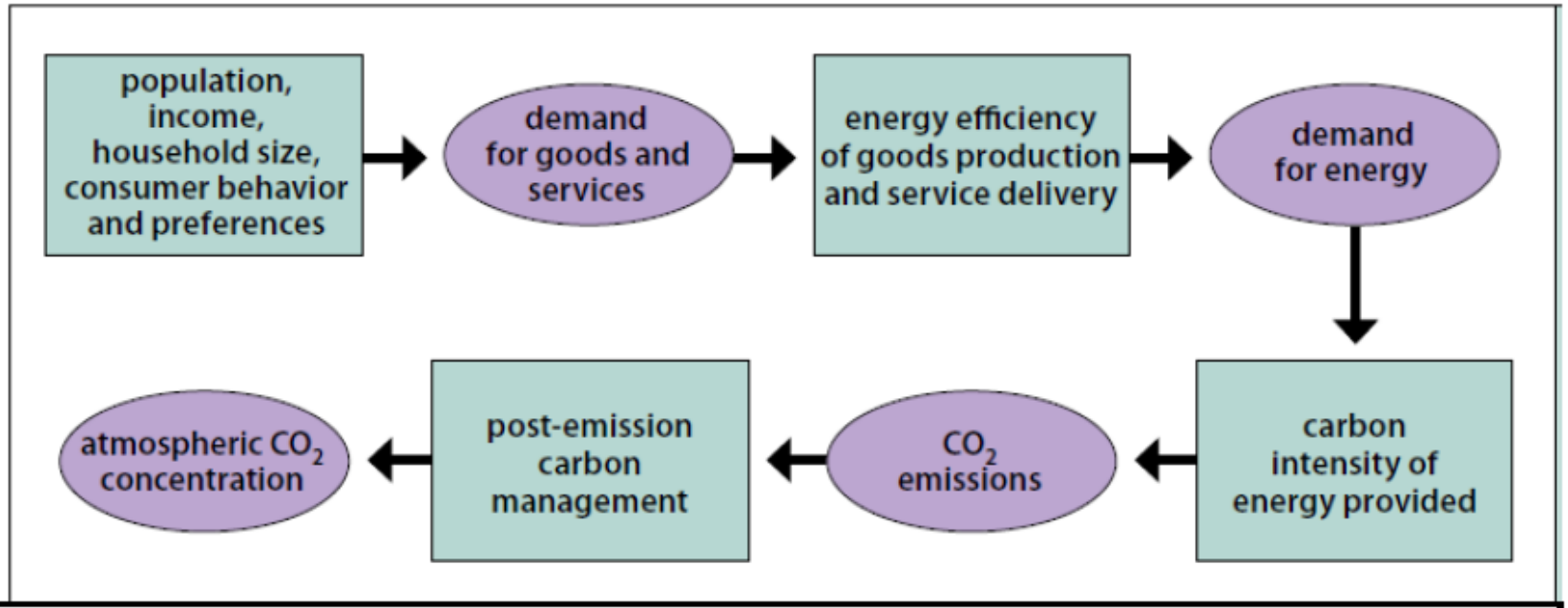


More
MITIGATING
SOLUTIONS
in this film. . .

EXAMPLE OF MITIGATION PROCESS

PROBLEM FACTORS! = factors that lead to increasing accumulation of CO_2 in atmosphere

SOLUTION FACTORS! = factors that HUMANS can adjust to influence the : (oval) factors



The chain of factors that determines how much CO2 accumulates in the atmosphere. The boxes represent factors that can potentially be influenced to affect the outcomes in the circles.

MITIGATION. .

BROOKLYN PIZZA COMPANY®

Welcome to Brooklyn Pizza Company

Brooklyn has gone Solar! The new panels generate 160,000 kWh of electricity per year. Find out how Brooklyn does its part to mitigate environmental impact.

See the PDF.

NOW 100% SOLAR POWERED!

-80,000 gal of water saved each year

-29,700 lbs of CO2 - the biggest contributor to global warming - saved each month

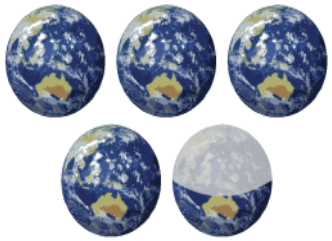
-160,000 lbs of coal saved each year

In TUCSON, on 4th Avenue

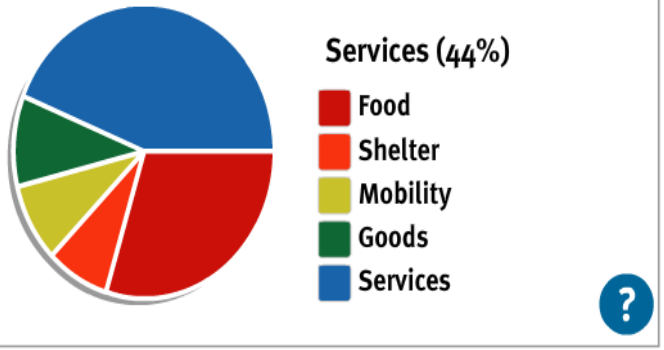
GROUP FOOTPRINT CHALLENGE!!!

YOUR ECOLOGICAL FOOTPRINT

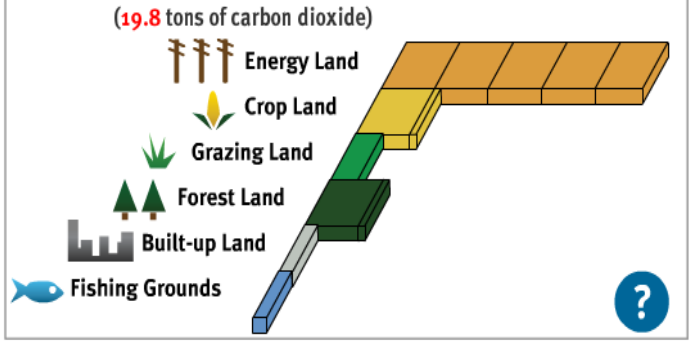
Many activities impact our Footprint. If everyone lived like you, we'd need 4.5 Planet Earths to provide enough resources.



Here is how your Ecological Footprint breaks down:



To support your lifestyle, it takes 20.1 global acres of the Earth's productive area.



Can you reduce your Ecological Footprint?

edit your footprint	go back and retake parts of the quiz
explore scenarios	explore simple actions to change your Footprint
continue	continue without exploring

TASK #1:

REMOVE ALL YOUR GRADED MATERIAL FROM THE FOLDERS!

They are about to burst!

TASK #2:

FILL OUT THE FORM IN YOUR FOLDER & DISCUSS YOUR RESULTS

GROUP CHALLENGE: GROUP FOOTPRINTS & GLOBAL CHANGE

GROUP # _____

PART I. Enter each group member's name & footprint data in the units indicated based on the FOOTPRINT QUIZ everyone took. Then have a different member of your group total each column and enter her/his name at the bottom of that column to indicate this. *(See the example for Stella, but do NOT enter her data into your sum or average)*

If any group members forgot to bring their footprint info to class, enter their name with an asterisk * and use the USA Average in the table below

To calculate **# EARTH's NEEDED** *for each person:* **Your Ecol Footprint** *(in global acres)* **÷ 4.5 ga**

NAME	ECOLOGICAL FOOTPRINT	# EARTHS NEEDED (Ecological Footprint ÷ Global Biocapacity)
	global acres (ga)	Global Biocapacity = 4.5 ga
Stella Student	18.4	4.1
SUM OF EACH COLUMN:		
AVERAGE OF EACH COLUMN:		
First name of student who Computed each column:		

After computing your Group's Average Footprints, fill in this Comparison Table:

based on 2009 data	Ecological Footprint *(global acres)*	Earth's Biocapacity *(global acres)*	# Earth's Needed
GLOBAL Avg	6.4	4.5	1.4
USA Avg	22.3	4.5	5
OUR GROUP Avg		4.5	

Mitigation & Adaption
to be continued . . . .