An update on the science of climate change

A. E. Dessler
Dept. of Atmospheric Sciences
Texas A&M University

Conclusions

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  - **source: IPCC Third Assessment Report, 2001**

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- **Most of the warming of the last 50 years is likely to be due to human activity**
- **Estimates of 21st century are 1.4 to 5.8°C**
- **Impacts of this are possibly severe**
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Confirming evidence

- surface thermometers
- satellite temperature
- glaciers
- sea ice
- ocean temps
- sea level
- paleoproxy data

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- Like a good detective, we can write down the “suspects” and then determine which one is most likely he culprit

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- *The suspects:*
  - Orbital variations
  - Tectonic
  - Solar
  - Volcano
  - Internal variability
  - Human GHGs

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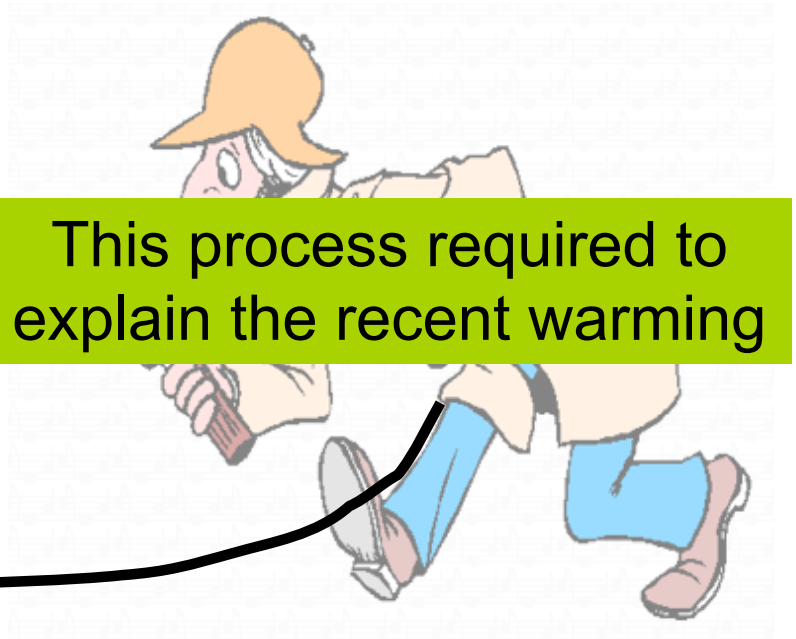


Climate impacts: Temperature

- Temperature increases
  - More hot days and heat waves, fewer cold days and cold waves
  - In Texas, we can expect average temperature increases of 5-10°F by 2100
  - Impacts
    - Direct stress of people and ecosystems
    - Indirect stress: e.g., vector- and water-borne pathogens, air quality

Climate Impacts: Precipitation

- Precipitation in a warmer world:
  - More precipitation
  - A larger fraction will fall in the heaviest downpours
    - Increased run-off, erosion, and flooding
  - Combined with warmer temperatures
    - Decreased soil moisture
    - Increased chance of drought
  - More falling as rain rather than snow
    - Earlier snow melts

Climate Impacts: Sea Level

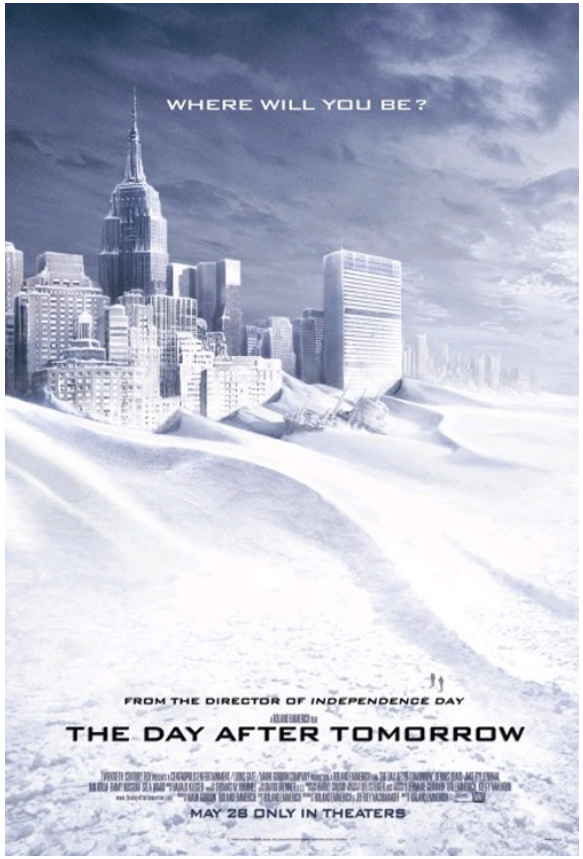
- One of the most certain impacts of climate change
- Thermal expansion, melting of grounded ice
- 10-90 cm over 21st century
- Loss of land
  - For half-meter rise, 10% of Bangladesh inundated
  - Displacing 5 million people
- Indirect effects
  - e.g., damage to coastal infrastructure
- Extreme events
  - e.g., levees become less effective as sea level increases, making you more vulnerable to storms like Katrina

Climate impacts: Extreme Events

- Severe storms
  - e.g., Hurricanes
  - Theoretically, we expect GW to increase hurricane strength
  - Some evidence that their intensity has been increasing in response to global warming, although the evidence is weak
  - In the future, it is likely that hurricanes will become more intense (combined with sea level rise, that's bad news for coastal cities)

Climate Impacts: Abrupt Changes

- Low probability, high impact events
  - Abrupt changes:
    - e.g., sudden collapse of West Antarctic Ice Sheet
    - e.g., reorganization of the ocean circulation



Climate Impacts: Surprise!

The upshot

- Significant climate change would be a **bad thing**
- We are adapted to our present climate
- There is a very real risk of significant climate change

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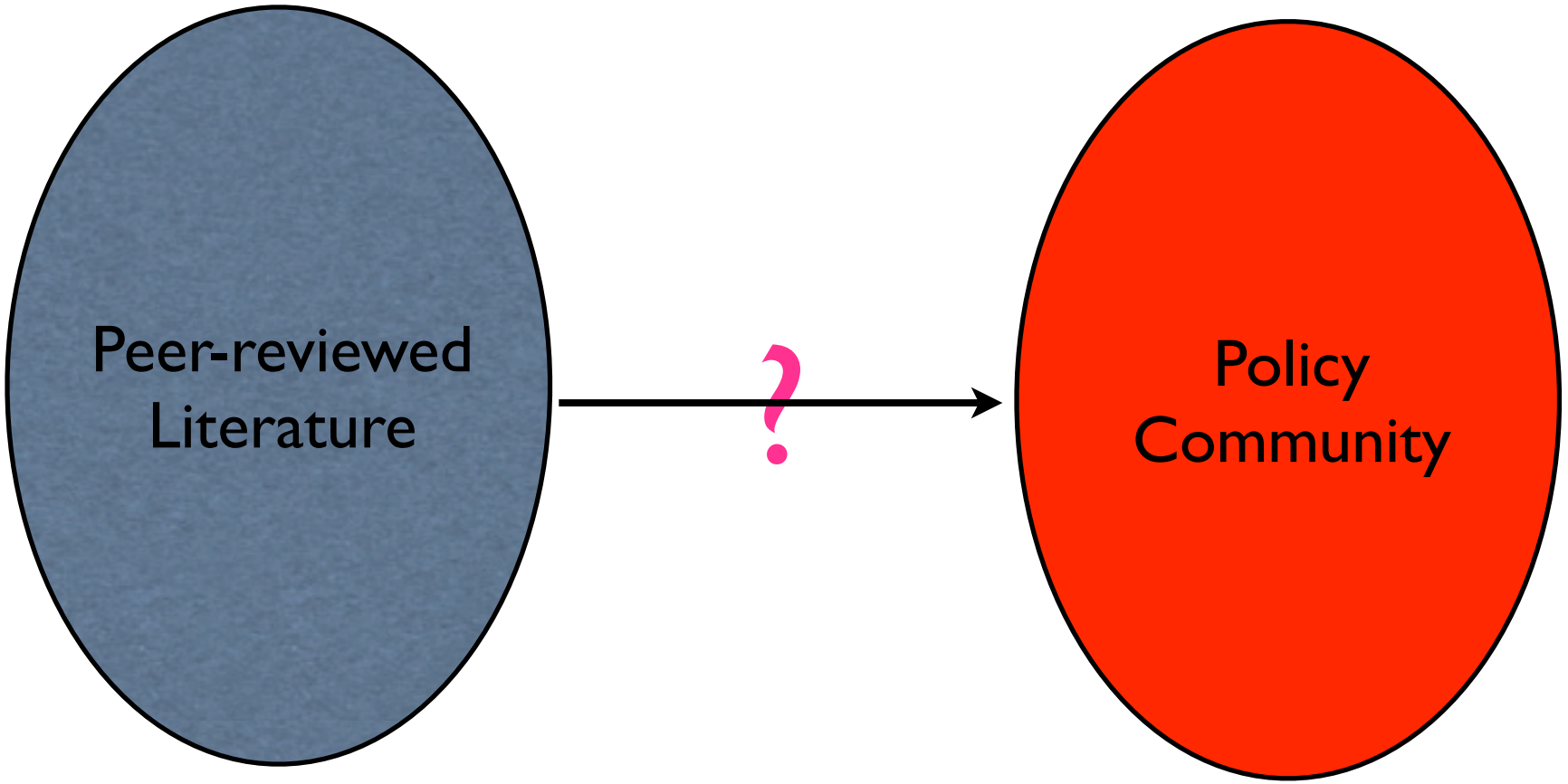
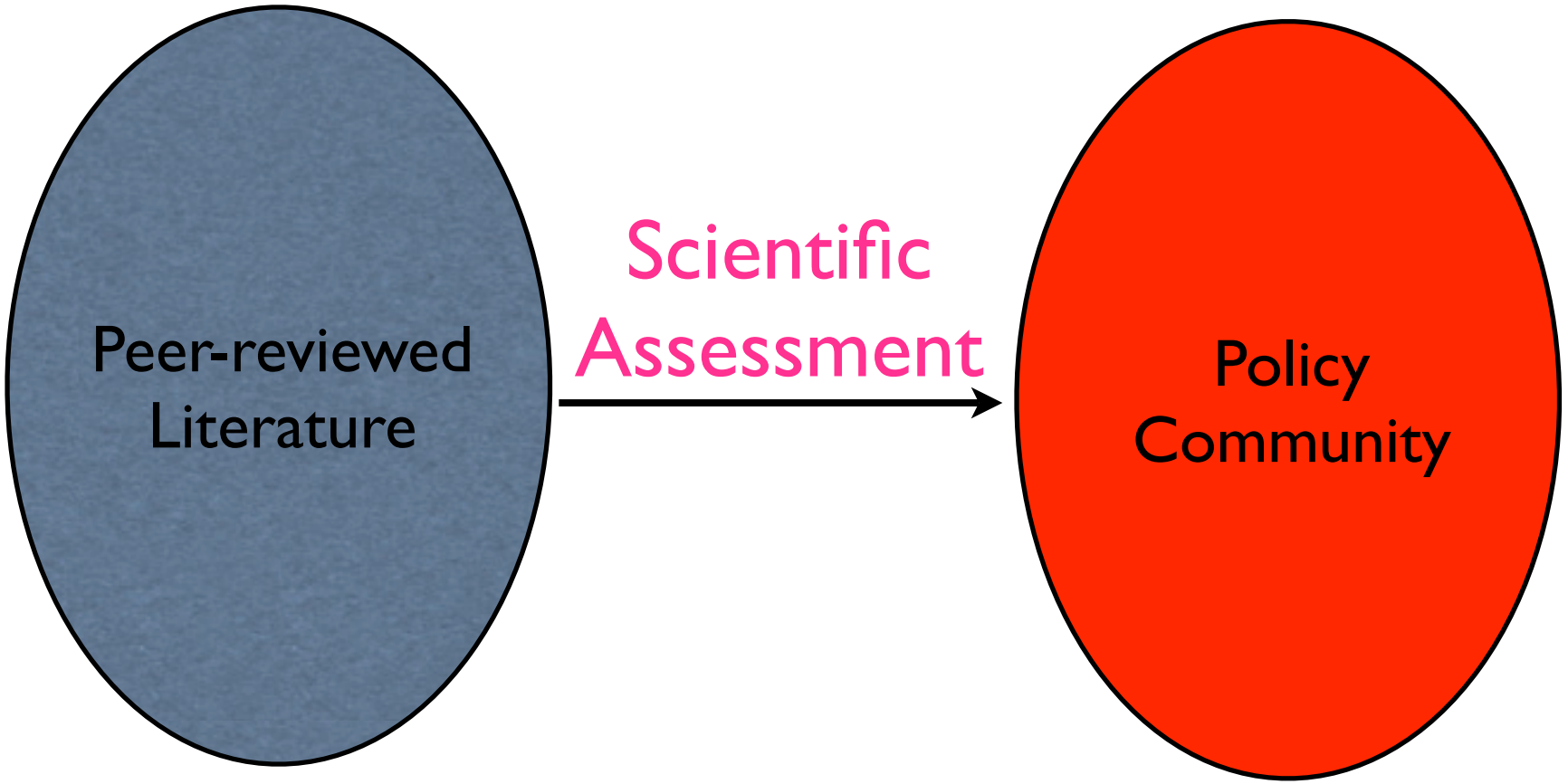
✓ **Eventually, the claim is accepted**


Peer-reviewed
Literature
?
Policy
Community


Peer-reviewed Literature
Scientific Assessment
Policy Community

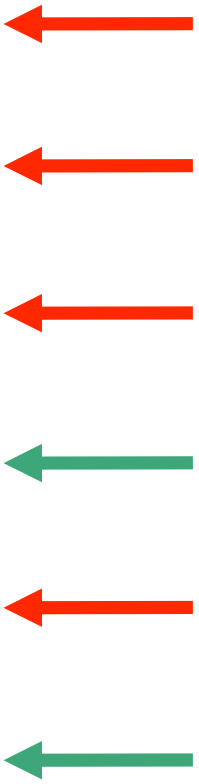
Scientific Assessments

- The peer-reviewed literature contains the scientific consensus
- IPCC reports describe the consensus
- Report written by a team of experts
- Synthesize the peer-reviewed literature
- Focuses on questions of interest to policymakers
- The report is itself peer-reviewed

Positive claims

Normative claims

Claims supporting action
The climate is warming
Greenhouse gas emissions are to blame
The warming over the next century will be 1.4-5.8°C
We have a moral imperative to prevent significant climate change
The costs will not be more than a few tenths of a percent of GDP
Addressing the climate-change problem will be worth the cost



Evolution of our understanding

- 1995: "The balance of evidence suggests that there is a discernible human influence on global climate."
- 2001: "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."
- 2007: ?

Is the debate over?

- Scientifically, there's much we still do not know
- There is overwhelming evidence that climate change carries a *significant risk* of severe impacts

Mitigation Strategies

$$\text{GHG emissions} = ? \quad \times \quad ? \quad \times \quad ?$$

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- To reduce emissions of greenhouse gases, must reduce one or more of the factors:
- Population
- Affluence (GDP/person)
- Technology (GHG emitted/GDP)

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Mitigation

GHG emissions = Population × Affluence × Technology

"My administration is committed to cutting our nation's greenhouse gas intensity -- how much we emit per unit of economic activity -- by 18 percent over the next 10 years."

14-Feb-02

- Technology (GHG emitted/GDP)

Why is SF6 important?

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- Global warming potential

Table 13. Global Warming Potentials (GWP) With CO_2 As a Reference Gas

Gas	Lifetime	20 years	100 years	500 years
CFC-11	50	6600	5300	1900
CFC-12	102	10600	11400	5700
CFC-13	640	10500	15100	17700
CFC-113	85	6400	6400	2900
CFC-114	300	7700	10300	9200
CFC-115	1700	5600	8400	11700
HCFC-22	13.3	4700	1800	570
CCl_4	42	2100	1500	530
CF_4	50000	4200	6500	10100
C_2F_6	10000	8000	12300	18800
SF_6	3200	15600	23700	34700

The results are based on the *ATM*2.5x2.5 case.

from: Myhre and Stordal, JGR, 1997

Why is SF6 important?

CO_2	3.48
CH_4	0.08
N2 O	0.16
Tropospheric O_3	0.15
HFC-23	0.003
HFC-125	0.031
HFC-32	0.002
HFC-134a	0.129
HFC-143a	0.026
HFC-152a	0.000
HFC-227ea	0.021
HFC-245ca	0.021
HFC-43-10mee	0.004
CF4	0.021
C2 F6	0.004
C4 F10	0.000
SF6	0.027

Radiative forcing in 2100

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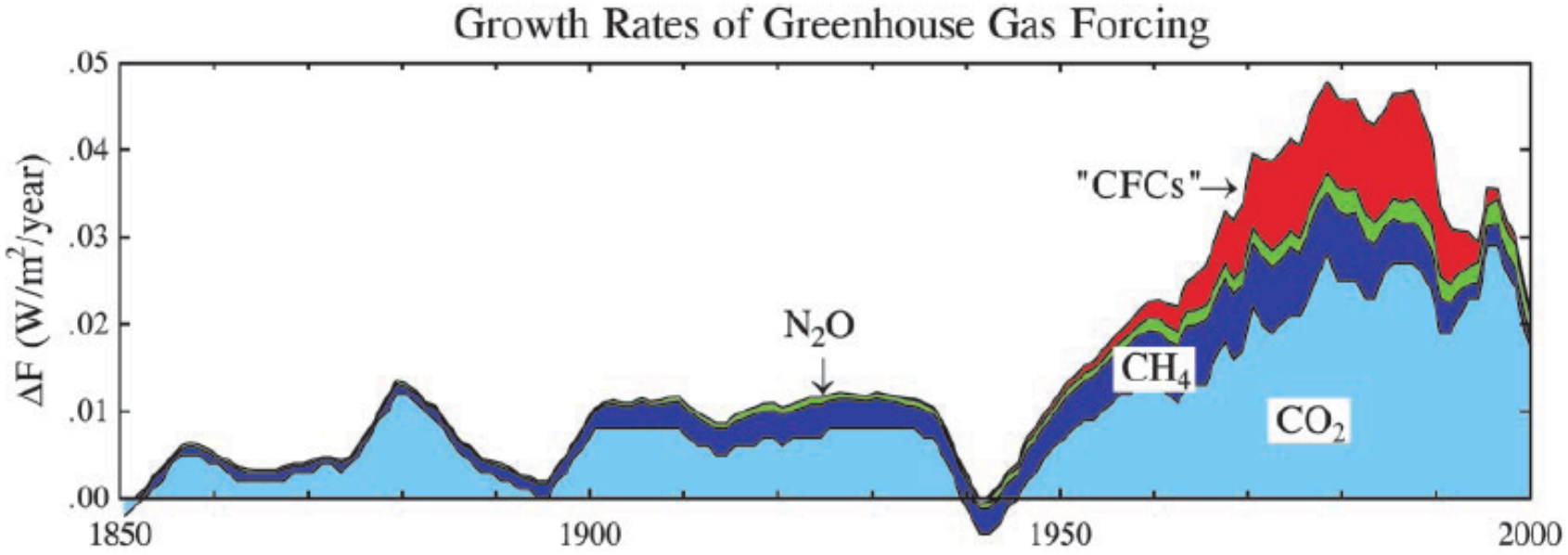

Growth rate of climate forcing by well-mixed greenhouse gases (5-year mean, except 3-year mean for 1999 and 1-year mean for 2000). O_3 pheric H_2O, which were not well measured, are not included.

From: Hansen et al., PNAS, 2001

Conclusions

- There is a very real risk of significant climate change
- While uncertainty exists, a case can be made that we know enough now to begin to take action to reduce emissions of GHGs
- The "best" solution will attack all GHGs, not just CO2