CLIMATE CHANGE
CONNECTING GLOBAL CHANGE TO LOCAL RESPONSE

KATHARINE HAYHOE
Climate Science Center, Texas Tech University
Building codes
Water supply
Crop yields
National security
Planning for the future based on the past is like driving down the road looking in the rear-view mirror.
Is there a curve in the road?

PART ONE
The U.S. is getting warmer
Heat waves are stronger and more frequent
Growing season has lengthened.
How climate change is killing the aspen forests of the American Southwest

Ryan Cooper
Will climate change ruin Aspen’s economy?
Readers React

Ski towns like Aspen should do more than just adapt to climate change

Aspen, at nearly 8,000 feet elevation, now averages 23 fewer days below freezing each year than it did before 1980, making snowfall more unreliable. (John Moore / Getty Images)
• Warmer temperatures and reduced snowfall
• Greater risk of water shortages
• Fire size and frequency will increase
• Aspen’s environment will start looking more like the mid-Roaring Fork Valley
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• If the world follows a higher emissions pathway it will spell the end for skiing in Aspen
Around the world, not just here
How can science help?

PART TWO
Is climate changing?

Global Average Temperature (degrees F relative to 1961-1990 mean)
Yes, it really is
Science can tell us climate is changing.
Air temperature is the tip of the iceberg of global warming
Air temperature is the tip of the iceberg of global warming.
Science can explain WHY it’s changing

Can’t be the sun
  
  we’d be getting cooler

Can’t be natural cycles
  
  the entire planet is warming

Can’t be the earth’s orbit
  
  next thing coming is an ice age!
We’ve been producing a lot of this!
Burning coal, gas and oil produces carbon dioxide.
The NATURAL greenhouse effect
The NATURAL greenhouse effect
The NATURAL greenhouse effect
The NATURAL greenhouse effect
The ARTIFICIAL greenhouse effect

+43% more
(we’ve known this for a really long time)

Joseph Fourier
(French, 1768-1830)

John Tyndall
(English, 1820-1893)

Svante Arrhenius
(Swedish, 1859-1927)

2014 U.S. National Climate Assessment
Science can tell us HOW MUCH of present-day warming is due to us.
Science can quantify the impact of our choices today.
Science can show us what will happen depending on the choices we make.
The ultimate objective of the UN Framework Convention on Climate Change is ... to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

WHAT IS THAT LEVEL?
Some would say we’ve reached it

Most of >200 native Alaskan villages at risk

12 out of 31
Turn Down the Heat
Why a 4°C Warmer World Must be Avoided
Even more split the difference

False Hope
The rate of global temperature rise may have hit a plateau, but a climate crisis still looms in the near future
By Michael E. Mann

Earth Will Cross the Climate Danger Threshold by 2036
The rate of global temperature rise may have hit a plateau, but a climate crisis still looms in the near future
Mar 18, 2014 | By Michael E. Mann

(dashed orange). Ironically, the reduction in coal burning needed to lower CO₂ emissions also lessens aerosols, sending temperatures across the danger line (dotted orange). The same is true if the sensitivity is 2.5 degrees C (gold).
These data therefore indicate that to reliably avoid two degrees C of warming, CO₂ levels should be held to 405 ppm (blue)—barely above the 395 to 400 ppm levels observed in the past year.
We basically have three choices:

**MITIGATE**  **ADAPT**  **SUFFER**
We’re going to do some of each. The question is what the mix is going to be.

The more mitigation we do, the less adaptation will be required, and the less suffering there will be.

John Holdren
President’s Science Advisor; Harvard University
Who is driving the problem?

Cumulative carbon emissions: 1900-2005

low  high
Who is experiencing most impacts?
How can science inform this choice?

PART THREE
Science cannot define a single threshold or level for greenhouse gas stabilization or global mean temperature target to prevent dangerous impacts.

Science can quantify the impacts of a specific level or target and this information can be used by policymakers to assess what they consider to be ‘dangerous’.

The primary challenge to this task is the uncertainty in future projections.
Why are future projections uncertain?

1. Natural variability is chaotic
2. Climate sensitivity is unknown
3. Climate models are imperfect
4. Future scenarios are driven by human activities
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The importance of each different source of uncertainty varies in time.

Hawkins & Sutton 2009, 2011
Use scenarios and global climate models that cover the range of known uncertainty.
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Global Average Temperature (degrees F)
NATURAL VARIABILITY

Global Average Temperature (degrees F)

-0.4 -0.2 0 0.2 0.4 0.6 0.8 1

Develop projections over appropriate time scales
What is downscaling?

DOWNSCALING introduces new information into global climate model output to generate high-resolution climate projections.
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Where does this new information come from?

Observations (weather stations, weather balloons, satellites, radar)
Higher-resolution modeling of physical processes
What does downscaling do?

Average Temperature of the Earth
(degrees F relative to 1961-1990 average)
Average DC Summer (JJA) Max Temperature (°F)

Average of 3 Washington DC weather stations
Days over 95°F

- Higher Scenario - Range
- Lower Scenario - Range
- Lower Scenario - Mean
- Higher Scenario - Mean
- OBS

Reagan National Airport
Days over 1" precipitation

Average of 3 Washington DC weather stations
Temperature increases in California

Source: 2009 U.S. National Climate Assessment
GLOBAL TEMPERATURE -> LOCAL CHANGE

Summer in New Hampshire could feel like the typical summer in North Carolina by the end of the century unless we take action to reduce heat-trapping emissions today.

**Lower-Emissions Scenarios:** a shift away from fossil fuels in favor of clean energy technologies, causing heat-trapping emissions to decline by mid-century

**Higher-Emissions Scenarios:** continued heavy reliance on fossil fuels, causing heat-trapping emissions to rise rapidly over the century

Hayhoe, for NECIA 2007
Projected northward expansion of the Hemlock Woolly Adelgid.

Currently limited by cold winter temperatures.

Source: Paradis et al. MITI (2008)
GLOBAL TEMPERATURE -> LOCAL IMPACTS

Source: Hayhoe et al. JGLR (2010)
As climate is changing, **science** can help us **define the outcomes of our choices and prepare for a different future**

Key to informing mitigation is connecting impacts with human choices. Even qualitative information (direction of trend) or awareness of vulnerabilities can be useful.

Key to informing adaptation is integrating climate preparedness into existing planning frameworks and mechanisms, not treating it like something new.
SUMMARY

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and the less suffering there will be.

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Both of these are key to limiting suffering.
We CAN mitigate
Fossil Fuels Just Lost the Race Against Renewables

The race for renewable energy has passed a turning point. The world is now adding more capacity for renewable power each year than coal, natural gas, and oil combined. And there's no going back.
We CAN adapt
We CAN adapt
We CAN adapt
We CAN limit suffering
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?

- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.
THANK YOU!

www.katharinehayhoe.com
@KHayhoe