The Pope's Encyclical, Climate Science, and the President's Climate Action Plan

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Outline of these remarks

- The Encyclical's embrace of climate science
- From science to policy
- The President's Climate Action Plan
- The path forward…
  - in the United States
  - internationally

The Encyclical's embrace of climate science

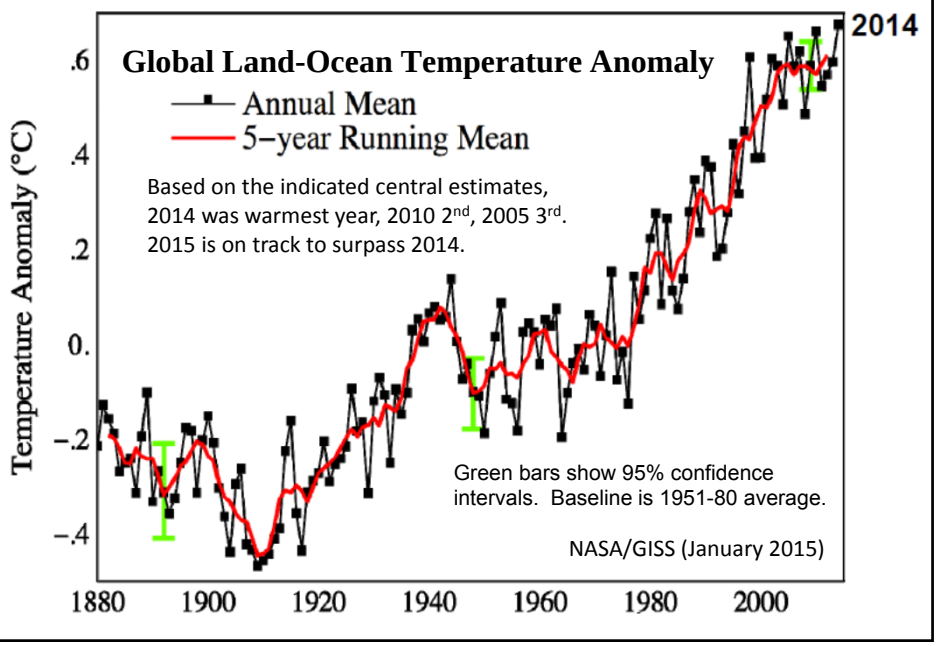
ENCYCLICAL:

"A very solid consensus indicates that we are presently witnessing a disturbing warming of the climatic system." (§23)

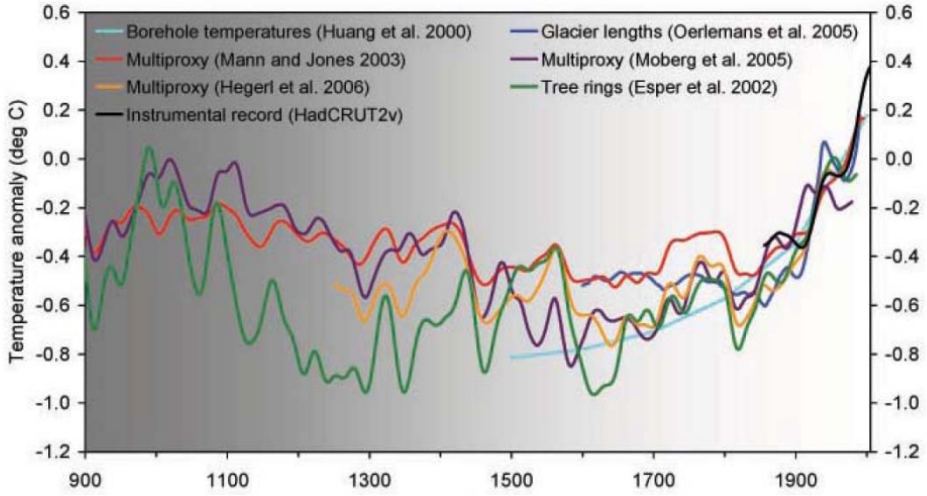
THE RELEVANT SCIENCE:

- The warming is described by the Intergovernmental Panel on Climate Change (IPCC) as "unequivocal". The national academies of science of every major country have agreed.
- The warming is manifest in the near-surface air temperatures over every continent, in sea-surface temperatures across the globe, in the shrinkage of Arctic sea ice, in the retreat of the great majority of the world's coastal and mountain glaciers, and in the loss of ice from the Greenland & Antarctic ice sheets.

Near-surface air temperature as directly measured



Near-surface air temperature inferred from paleo evidence (last 1100 years)



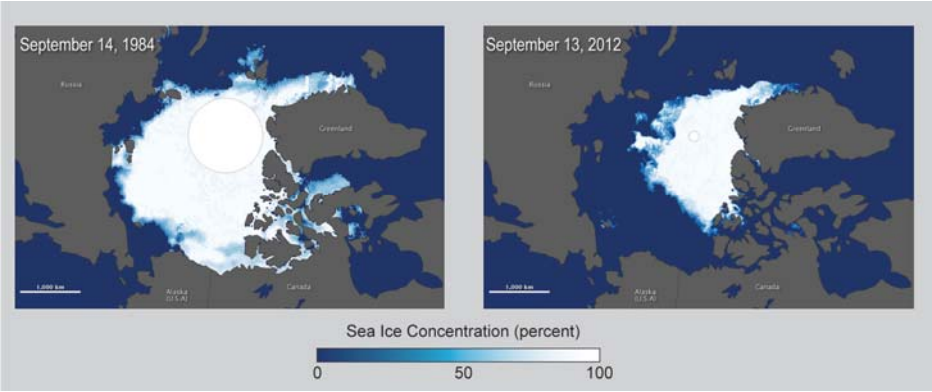
Source: National Academy of Sciences 2006

Declining mass of the world's glaciers

Average cumulative mass loss from a global set of reference glaciers, with 1945 as the starting point and baseline.

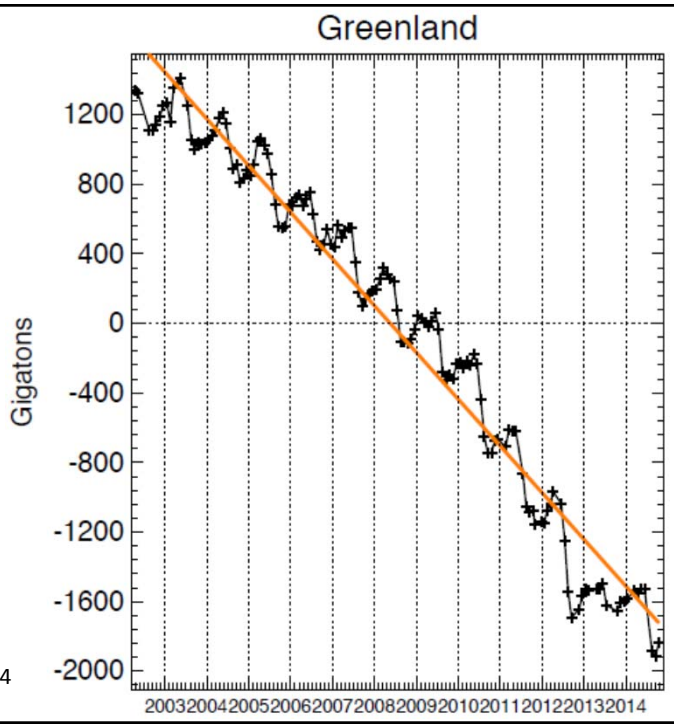
Source: EPA Climate Change Indicators

Decline in summer extent of Arctic sea ice



GlobalChange.gov
U.S. Global Change Research Program

Mass of ice sheet on Greenland, 2002-2014



Waleed Abdalati, from GRACE, December 2014

Embrace of climate science (continued)

ENCYCLICAL:

"…a number of scientific studies indicate that most global warming in recent decades is due to the great concentration of greenhouse gases (carbon dioxide, methane, nitrogen oxides, and others) released mainly as a result of human activity." (§23)

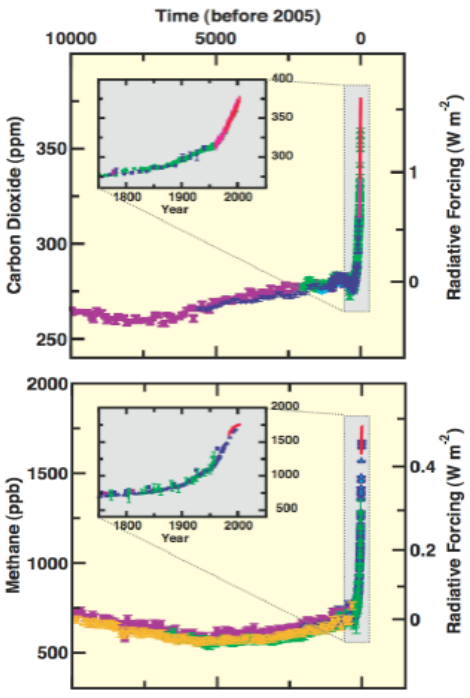
THE RELEVANT SCIENCE:

- The IPCC concluded in 2013 that "it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century".
- That's because the observed warming matches with great fidelity what science predicts would result from the greenhouse-gas build-up that is known for certain to have resulted mainly from human activity.

The key greenhouse-gas increases were caused by human activities.

Compared to natural changes over the past 10,000 years, the spike in concentrations of CO_2 & CH_4 in the past 250 years is extraordinary.

We know humans are responsible for the CO_2 spike because fossil CO_2 lacks carbon-14, and the drop in atmospheric C-14 from the fossil-CO_2 additions is measurable.



IPCC AR4, WG1 SPM, 2007

Recent human-imposed changes on Earth's energy balance far exceed natural ones

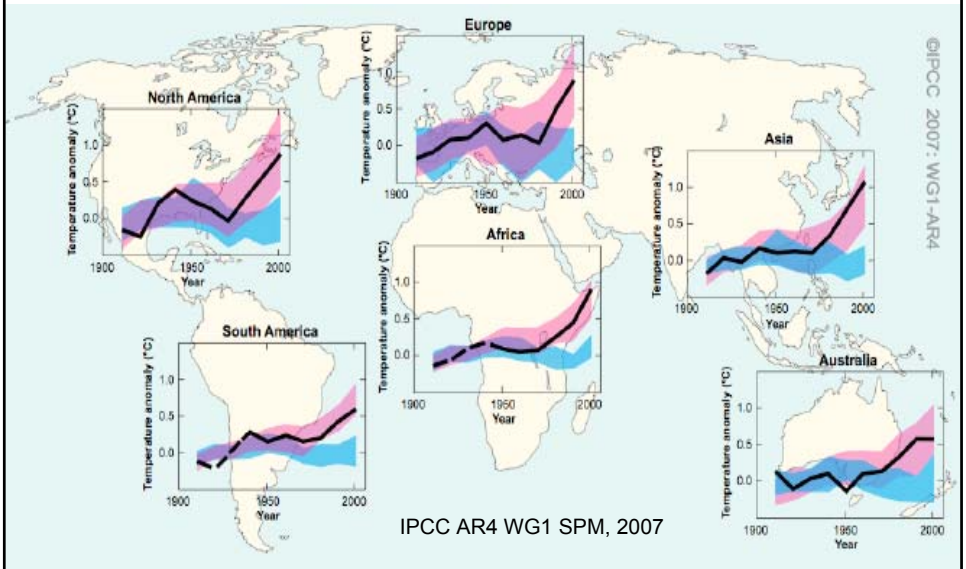
Human vs natural influences 1750-2011 (watts/m^2)

Human emissions leading to increases in…	
atmospheric carbon dioxide	+ 1.7
methane (and resulting constituents)	+ 0.97
halocarbons (incl. stratospheric O3↓)	+ 0.18
nitrous oxide	+0.17
short-lived gasses (CO,NMVOC,NOX)	+0.18
particles (net of reflective + absorptive)	- 0.27
indirect (cloud forming) effect of particles	- 0.55
Human land-use change increasing reflectivity	- 0.15
Natural changes in sunlight reaching Earth	+ 0.05

The warming influence of anthropogenic GHG is ~60x the warming influence of the estimated change in input from the Sun.

IPCC AR5, WG1 SPM, 2013

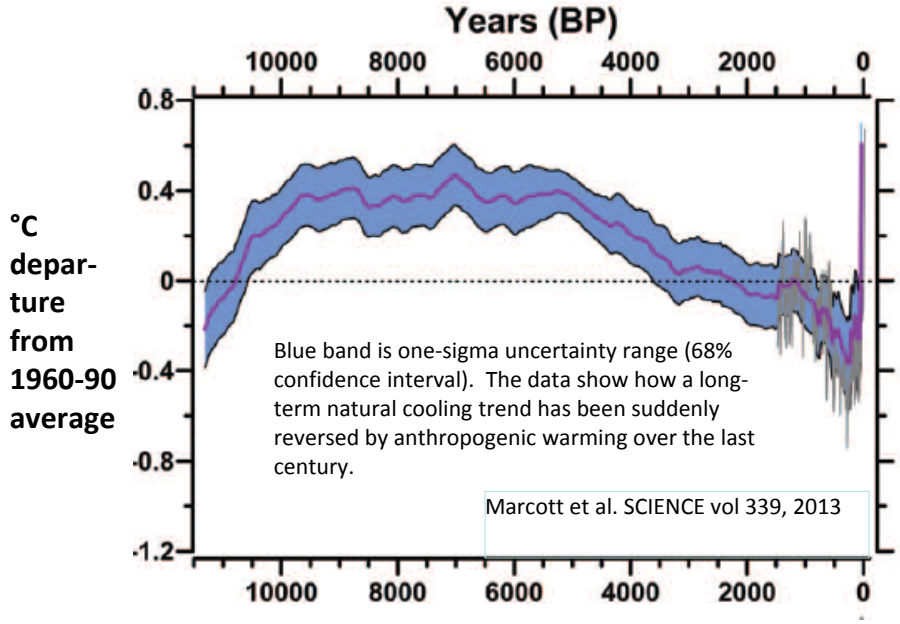
Human influences explain observed T increase on every continent, not just on global average.



IPCC AR4 WG1 SPM, 2007

Black lines are decadally averaged observations. Blue bands are computer models with natural forcings only. Pink bands are computer models with human + natural forcings.

The human-caused GHG increases overcame long-term cooling from natural causes



Embrace of climate science (continued)

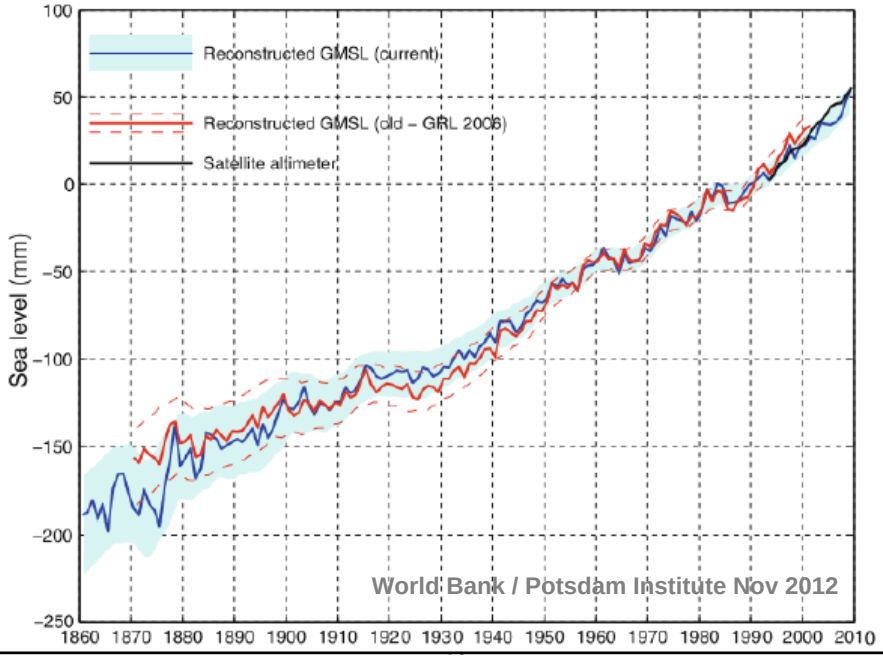
ENCYCLICAL:

"In recent decades this warming has been accompanied by a constant rise in sea level and, it would appear, by an increase in extreme weather events, even if a scientifically determined cause cannot be assigned to each particular phenomenon." (§23)

THE RELEVANT SCIENCE:

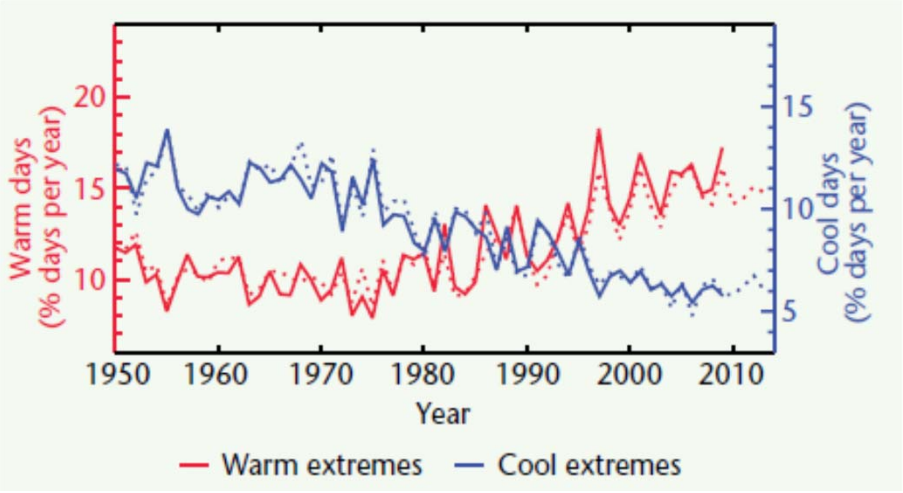
- Here the Encyclical actually understates the reality a bit:
  - The rate of sea-level rise lately has not been constant but growing; it's now 2X the 20th century average.
  - The increase in extremes—especially but not only extremely hot days, heat waves, and extreme downpours—has been documented beyond question.

Global mean sea level 1860-2010



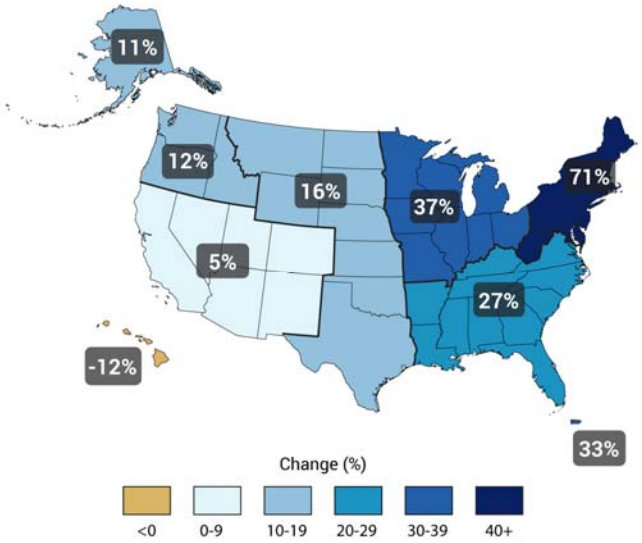
Global average frequency of hot & cold days from 1950-2013

Hot days are those above 90th percentile for 1961-1990 base period; cold days are those below 10th percentile.



Hadley Center, UK Met Office, *Climate Risk: An Update on the Science*, 2014

Downpours increasing nearly everywhere



Percentage increase, between 1958 and 2012, in the amount of precipitation falling in the heaviest 1% of precipitation events in each region.

Global pattern is similar.

Source: USGCRP, Assessment of Climate Change Impacts in the United States, May 2014

NATURE CLIMATE CHANGE | VOL 4 | DECEMBER 2014 | www.nature.com/natureclimatechange

Rapid increase in the risk of extreme summer heat in Eastern China

Ying Sun[1], Xuebin Zhang[2]*, Francis W. Zwiers[3], Lianchun Song[1], Hui Wan[2], Ting Hu[1], Hong Yin[1] and Guoyu Ren[1]

NATURE CLIMATE CHANGE | VOL 5 | JANUARY 2015 | www.nature.com/natureclimatechange

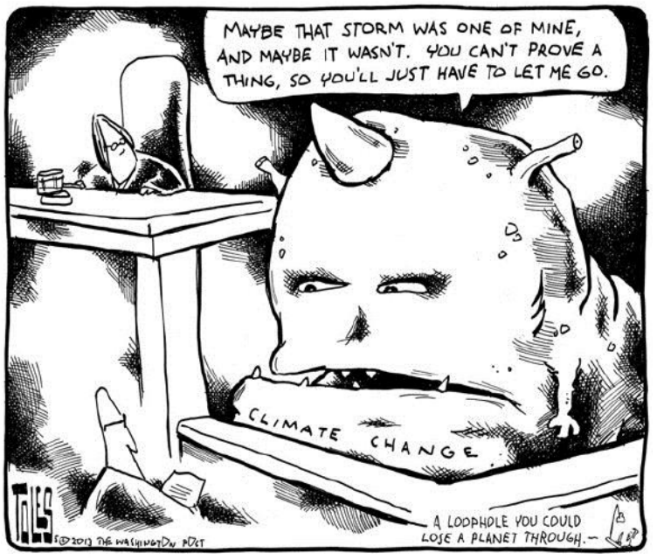
Dramatically increasing chance of extremely hot summers since the 2003 European heatwave

Nikolaos Christidis*, Gareth S. Jones and Peter A. Stott

NATURE CLIMATE CHANGE | VOL 4 | SEPTEMBER 2014 | www.nature.com/natureclimatechange

Stormiest winter on record for Ireland and UK

Powerful storms are caused by the interaction of multiple factors, so one can't say climate change caused a particular one. But climate change is increasing the power of some of the strongest storms.



Embrace of climate science (continued)

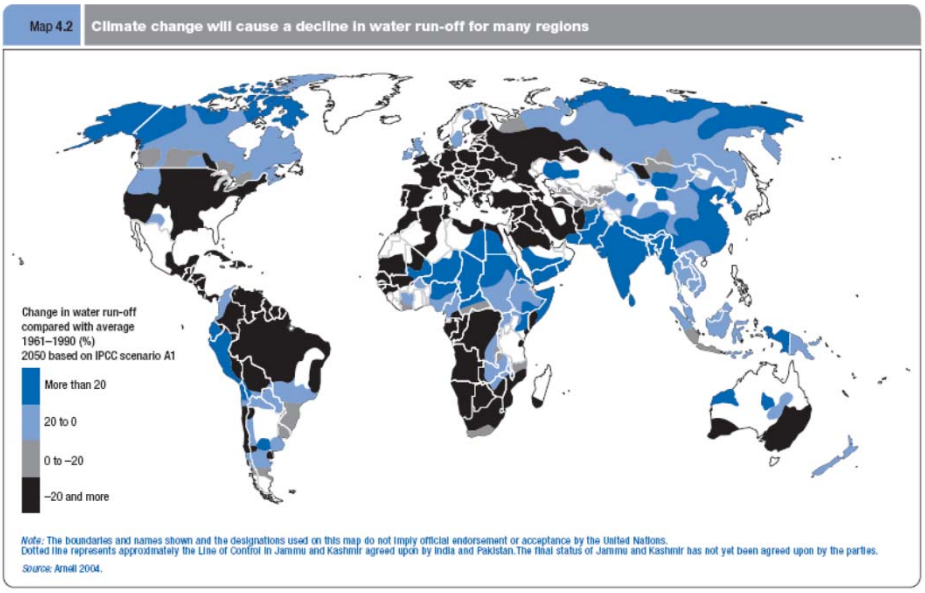
ENCYCLICAL:

"[Warming] creates a vicious cycle…affecting the availability of essential resources like drinking water, energy and agricultural production in warmer regions, and leading to the extinction of part of the planet's biodiversity." (§24)

THE RELEVANT SCIENCE:

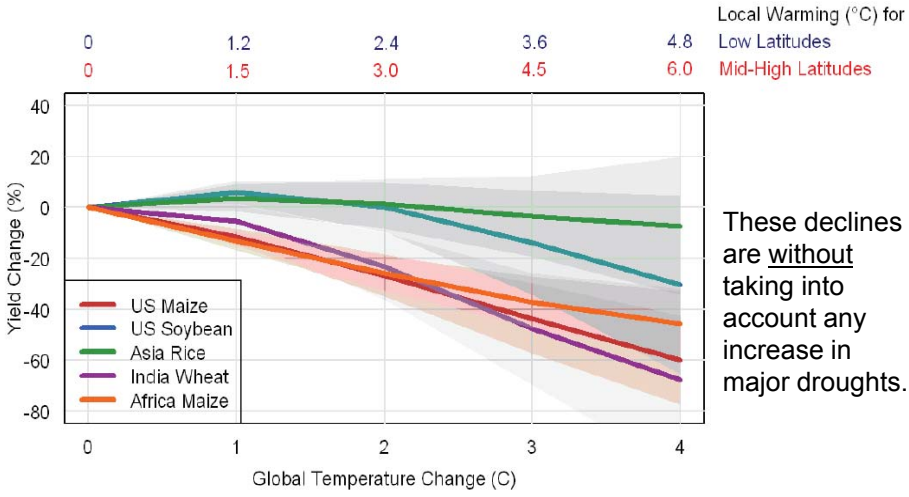
- It is well established scientifically that climate change is adversely affecting and will continue to adversely affect: the availability of water in many regions, the productivity of farms and forests, energy supply and demand, and the distribution and abundance of species (those we need, those we love, and those we hate).

Climate change and water availability



UNDP Human Development Report 2006

Yields of staple crops decline with warming

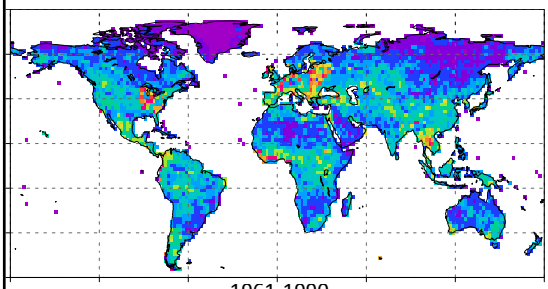


These declines are <u>without</u> taking into account any increase in major droughts.

National Academies, Stabilization Targets, 2010

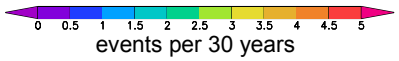
But droughts are expected to worsen

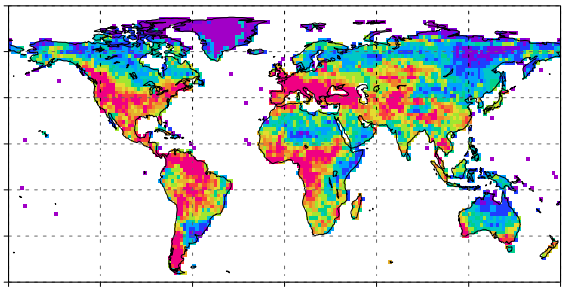
Frequency of 4-6 month duration droughts (events per 30 years)



1961-1990

Drought defined as soil moisture below historical 10th percentile value for that calendar month.





2070-2099, IPCC A2 scenario

Results shown are the mean of 8 global climate models

Source: Sheffield and Wood 2008 Climate Dynamics (2008) 31:79–105
DOI 10.1007/s00382-007-0340-z

Extinction risk from climate change

NATURE | VOL 427 | 8 JANUARY 2004 | www.nature.com/nature

"[W] e predict, on the basis of mid-range climate-warming scenarios for 2050, that 15–37% of species in our sample of regions and taxa will be 'committed to extinction'."

Climate Change 2014: Impacts, Adaptation, and Vulnerability

Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

"A large fraction of both terrestrial and freshwater species faces increased extinction risk under projected climate change during and beyond the 21st century, especially as climate change interacts with other stressors, such as habitat modification, overexploitation, pollution, and invasive species (*high confidence*)."

Embrace of climate science (continued)

ENCYCLICAL:

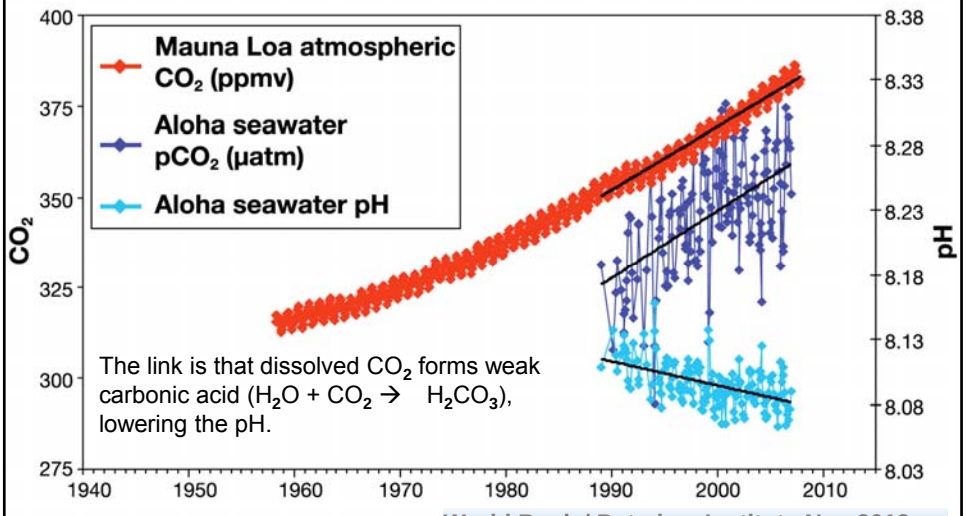
"Carbon dioxide pollution increases the acidification of the oceans and compromises the marine food chain." (§24)

THE RELEVANT SCIENCE:

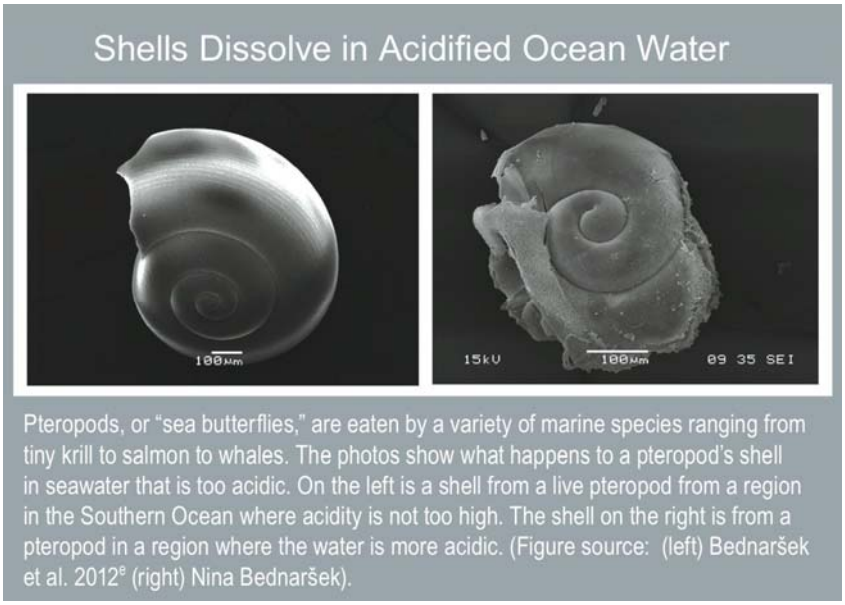
- The impact of climate change on the productivity of the oceans is one of the biggest "sleepers" in the climate challenge.
- Not only does increased atmospheric CO_2 lead to increased acidification of the ocean; global warming also changes ocean circulation patterns, and temperature and currents combined affect the geographic ranges and abundance of species important to both commercial and subsistence fisheries.

Atmospheric CO_2 and ocean pH

About 1/3 of CO_2 added to atmosphere is quickly taken up by the surface layer of the oceans (top 80 meters).



The impact of acidification



Pteropods, or "sea butterflies," are eaten by a variety of marine species ranging from tiny krill to salmon to whales. The photos show what happens to a pteropod's shell in seawater that is too acidic. On the left is a shell from a live pteropod from a region in the Southern Ocean where acidity is not too high. The shell on the right is from a pteropod in a region where the water is more acidic. (Figure source: (left) Bednaršek et al. 2012[e] (right) Nina Bednaršek).

NCA Highlights 2014

The future of ocean acidification

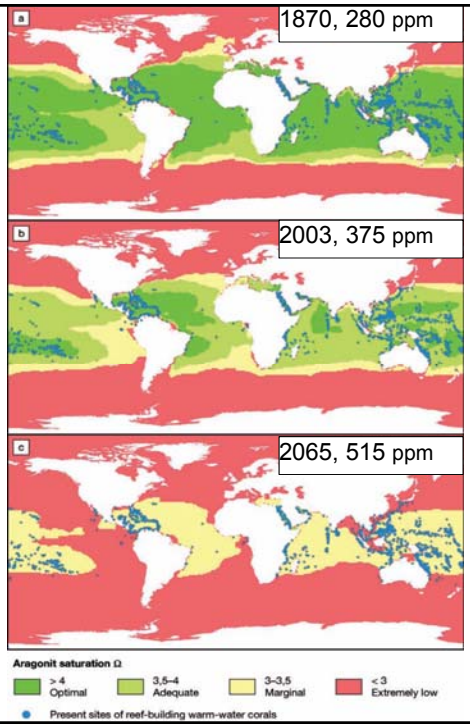
Widespread adverse effects of acidification were already being observed in the early 2000s.

The expanding yellow and red ocean areas are marginal and unsuitable, respectively, for supporting coral reefs.

Blue denotes current areas of reef-building warm-water corals.

Such reefs could be dead or in peril over most of their range by mid to late 21st century.

Steffen et al., 2004



Embrace of climate science (continued)

ENCYCLICAL:

"If present trends continue, this century may well witness extraordinary climate change and an unprecedented destruction of ecosystems, with serious consequences for all of us. A rise in the sea level, for example, can create extremely serious situations, if we consider that a quarter of the world's population lives on the coast or nearby, and that the majority of our megacities are situated in coastal areas." (§24)

THE RELEVANT SCIENCE:

- The magnitude of anthropogenic climate change is already extraordinary, with significant impacts on society and ecosystems; continuation of present trends through this century would almost certainly mean disaster.

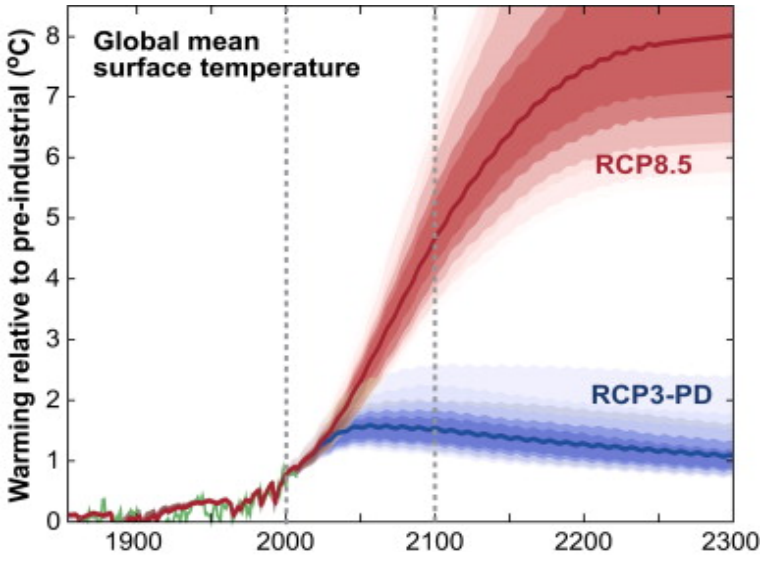
Harm from climate change is already widespread

Around the world we're seeing, variously, increases in

- floods
- wildfires
- droughts
- heat waves
- pest outbreaks
- coral bleaching events
- power of typhoons & hurricanes
- geographic range of tropical pathogens

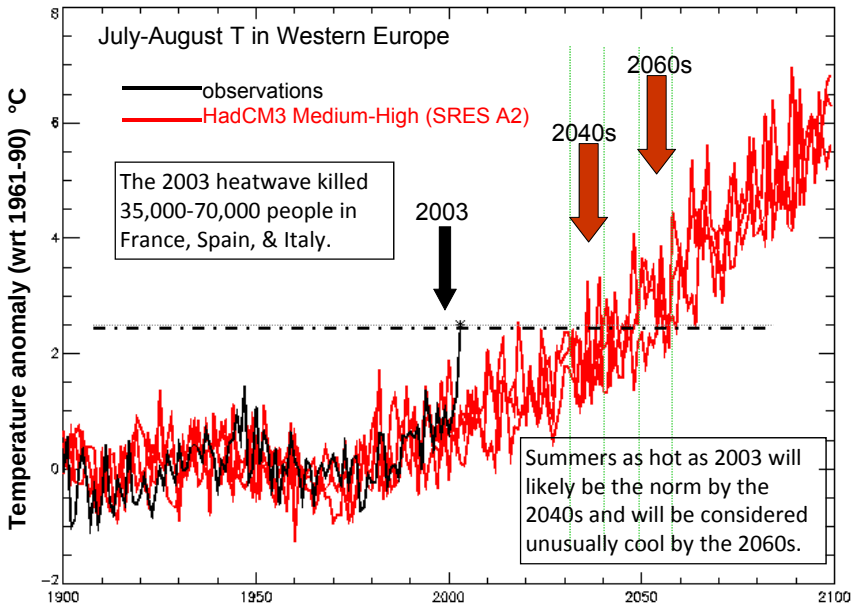
All plausibly linked to climate change by theory, models, observed "fingerprints"

Business as usual (RCP8.5) → roasted world



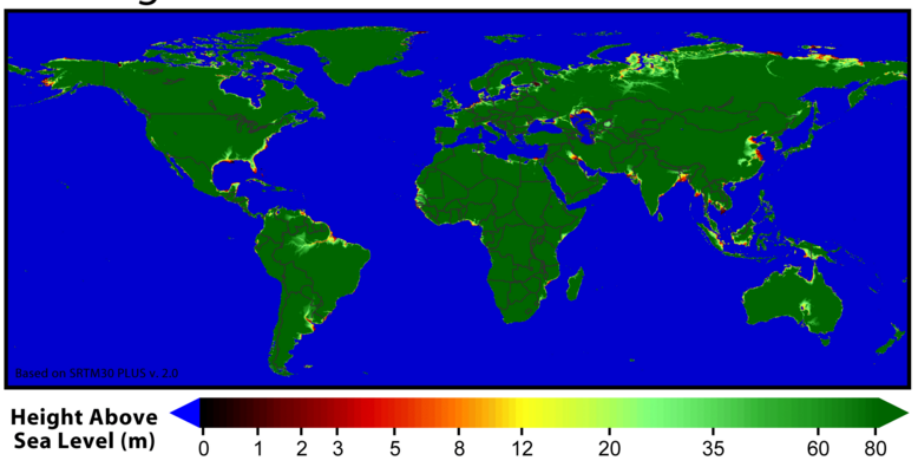
Rahmstorff et al. 2014

Under BAU, severe heat waves multiply

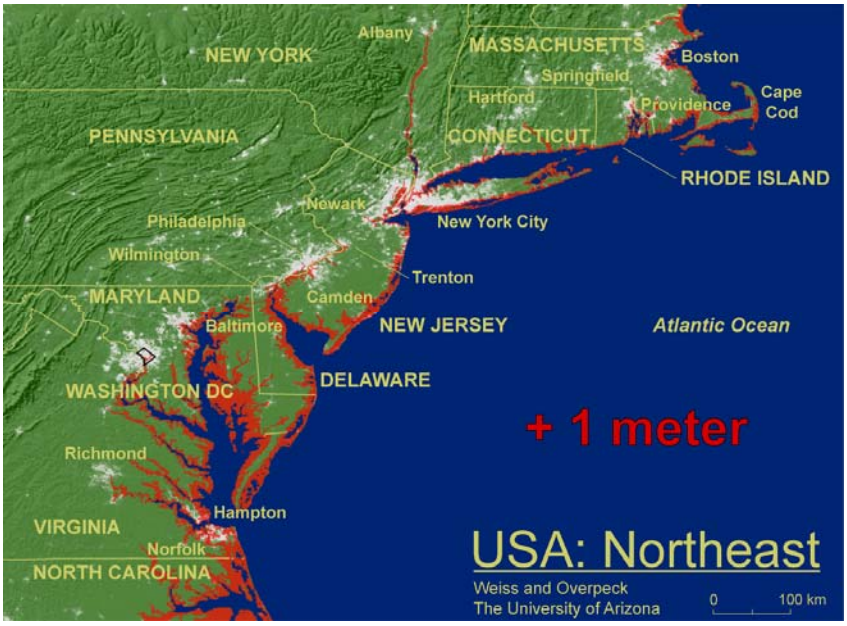


The risk to the world's coastal cities is real

Regions Vulnerable to Sea Level Rise



Sea level: Flooded area with 1 meter rise



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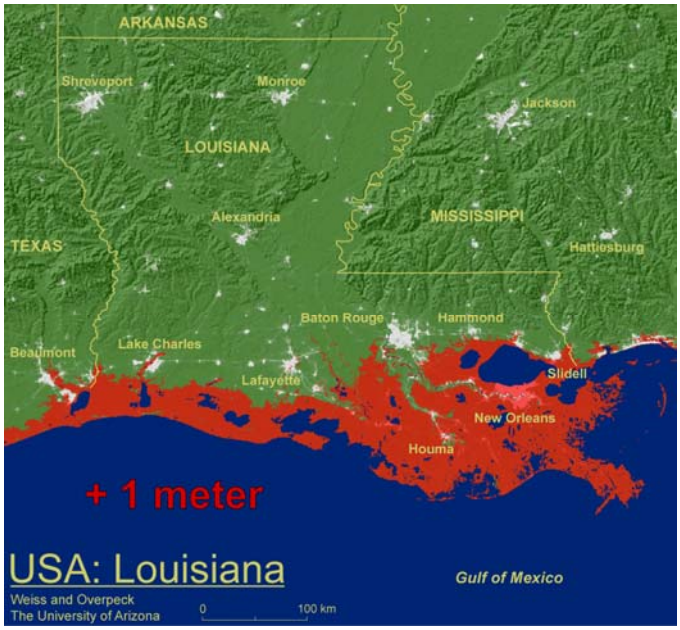


From science to policy

It is hard to quarrel with the Encyclical's account of the science of climate change. Agreement on every aspect of policy is more difficult.

In my opinion, on matters related to policy, the Encyclical, in some passages, is too dismissive of…

- the potential of technological approaches to emission reduction;
- the usefulness of market-based approaches in driving emission reduction and positive technological change;
- the importance of investing in adaptation to changes in climate that can no longer be avoided; and
- the role of the size of the human population in adding to emissions, complicating solutions, and crowding out the rest of creation.

From science to policy (continued)

On the other hand, I can happily applaud the Encyclical's emphasis on…

- the particular vulnerability of the poor to the impacts of climate change
- the particular obligation of the rich…
  - to lead in embracing the needed measures to limit those impacts
  - to assist the poor with both mitigation and adaptation
- the need for an expanded dialogue on
  - fashioning an adequate and equitable global response to the challenge of climate change
  - the relation of human society to the rest of creation

Policy options: What are our choices?

There are only three:

- Mitigation, meaning measures to reduce the pace & magnitude of the changes in global climate being caused by human activities.
- Adaptation, meaning measures to reduce the adverse impacts on human well-being resulting from the changes in climate that do occur.
- Suffering the adverse impacts and societal disruption that are not avoided by either mitigation or adaptation.

Concerning the three…

- We're already doing some of each.
- What's up for grabs is the future mix.
- Minimizing the amount of suffering in that mix can only be achieved by doing a lot of mitigation and a lot of adaptation.
  - Mitigation alone won't work because climate change is already occurring & can't be stopped quickly.
  - Adaptation alone won't work because adaptation gets costlier & less effective as climate change grows.
  - We need enough mitigation to avoid the unmanage-able, enough adaptation to manage the unavoidable.

Adaptation possibilities include…

- Developing heat-, drought-, and salt-resistant crop varieties
- Strengthening public-health & environmental-engineering defenses against tropical diseases
- Preserving & enhancing "green infrastructure" (ecosystem features that protect against extremes)
- Preparing hospitals & transportation systems for heat waves, power outages, & high water.
- Building dikes and storm-surge barriers against sea-level rise
- Avoiding further development on flood plains & near sea level

Many are "win-win": They'd make sense in any case.

Mitigation possibilities include…

(CERTAINLY)

- Reduce emissions of greenhouse gases & soot from the energy sector
- Reduce deforestation; increase reforestation & afforestation
- Modify agricultural practices to reduce emissions of greenhouse gases & build up soil carbon

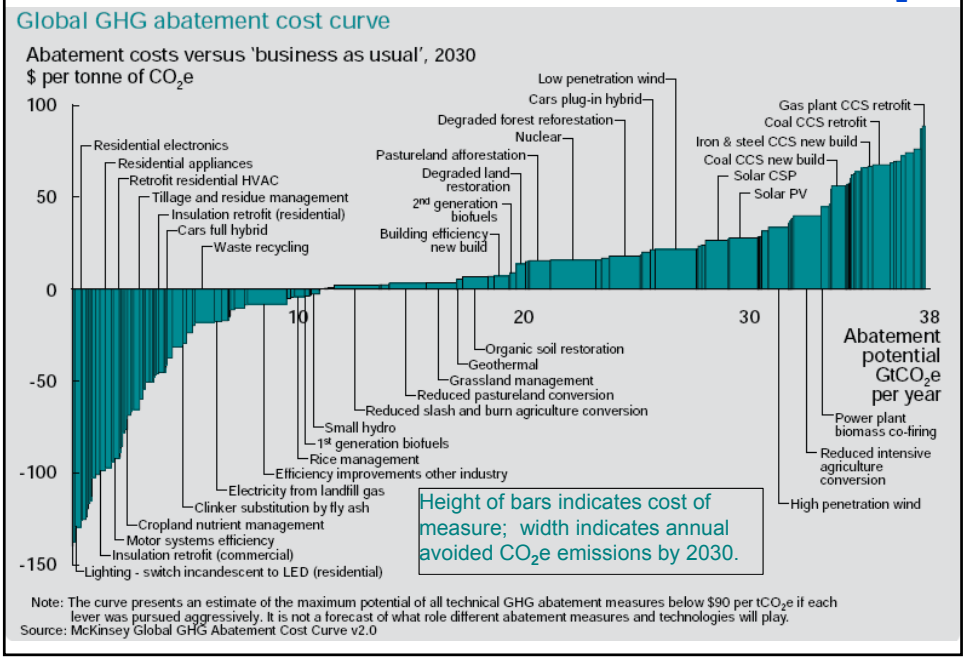
(CONCEIVABLY)

- "Scrub" greenhouse gases from the atmosphere technologically
- "Geo-engineering" to create cooling effects offsetting greenhouse heating

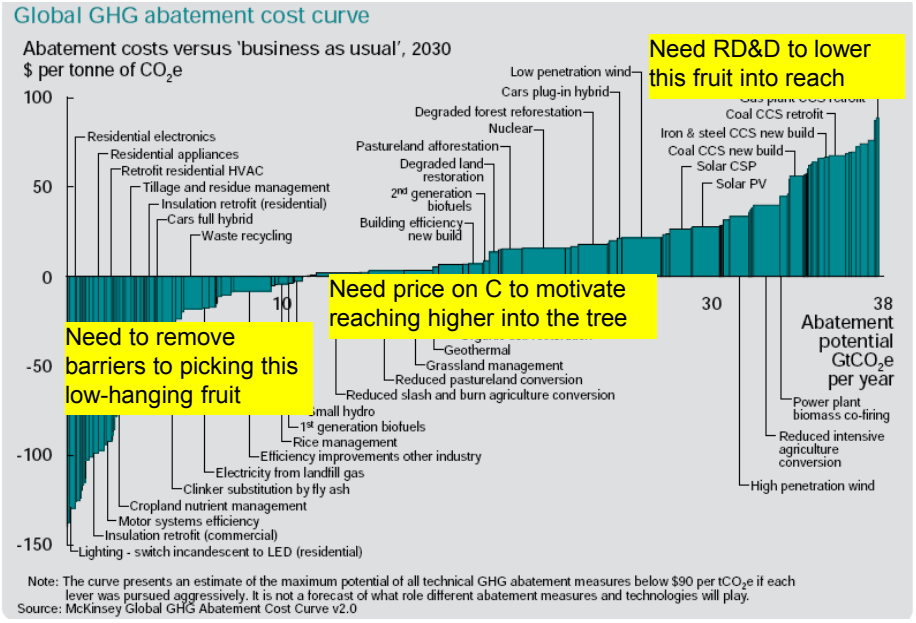
How much mitigation, how soon?

- Limiting ΔT_{avg} to ≤2ºC is now considered by many the most prudent target that still may be attainable.
  - EU embraced this target in 2002, G-8 & G-20 in 2009
- To have a >50% chance of staying below 2ºC:
  - atmospheric concentration of heat-trapping substances must stabilize at around 450 ppm CO_2 equivalent (CO_2e);
  - to get there, developed-country emissions must peak no later than 2015 and decline rapidly thereafter, and
  - developing-country emissions must peak no later than 2025 and decline rapidly thereafter; and
  - global emissions in 2050 must be less than half of those in 2005.

Mitigation supply curve for 2030: aiming for 450 ppm CO_2e

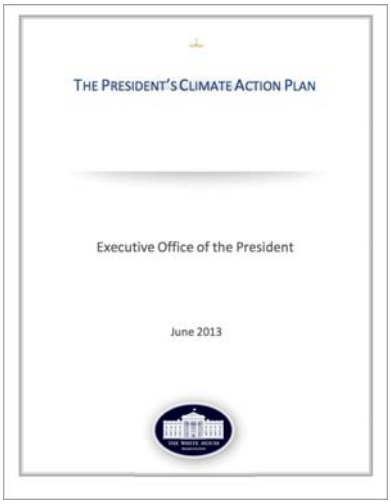


Policies needed if 450 ppm CO_2e is the global goal



Choosing action: President Obama's Plan

Georgetown University, June 2013



- Cutting carbon pollution in America (mitigation)
- Preparing the United States for the impacts of climate change (adaptation)
- Leading international efforts to address climate change

http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

How science underpins the Climate Action Plan

Understanding what climate science is telling us provides:

- the motivation for seeking to develop a cost-effective plan to reduce those impacts;
- the sense of urgency for doing so now rather than waiting;
- the awareness that such a plan must include both mitigation and adaptation;
- the knowledge of the sources of the offending emissions and the character of society's vulnerabilities that allows appropriate specificity in designing a plan; and
- the recognition that any U.S. plan must include a component designed to bring other countries along.

The science basis for the CAP (continued)

Understanding of the technological possibilities for both mitigation and preparedness & resilience…

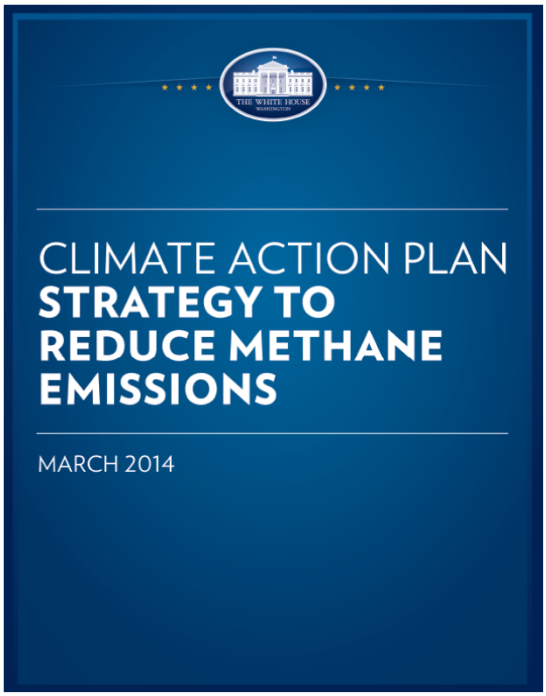
- reveals that there is a wide range of options for cutting the carbon pollution that is driving climate change and for better preparing society to deal with the changes that materialize
- has enabled the CAP to focus specifically on promoting progress on the development and implementation of the most promising options.

Understanding of the results of economic assessments of the costs of taking such actions versus the costs of inaction…

- makes clear that moving ahead now is the right thing to do, because delay would mean bigger damages & costlier action;
- enabled the CAP to focus on those options that are most clearly cost-effective and that bring significant co-benefits.

Progress under the CAP: Mitigation

- Reducing carbon pollution from power plants
  - standards for cutting CO_2 from new power plants (Sept 2013)
  - and from existing power plants (June 2014)
- Reducing other greenhouse gases
  - interagency strategy to reduce methane emissions (March 2014)
  - EPA proposal on hydrofluorocarbons (July 2014)
  - 2025 target to reduce methane emissions form the oil and gas sector by 40-45% from 2012 levels along with various actions to reduce methane emissions going forward, including EPA regulation (January 2015)



Progress under the CAP: Adaptation

- Directing agencies to support climate preparedness/resilience
  - All agencies required to develop & implement plans for integrating climate preparedness/resilience into their missions, policies, programs, investments, and grants.
  - Agency plans were released in 10-14.
- Establishing internal & external task forces on resilience
  - Interagency Council on Climate-Change Preparedness & Resilience (~30 Federal agencies) and Working Groups established (11-13)
  - State, Local, & Tribal Leaders Task Force on Climate Preparedness & Resilience, comprising 26 elected officials from across the country; delivered recommendations to the Administration (11-14)

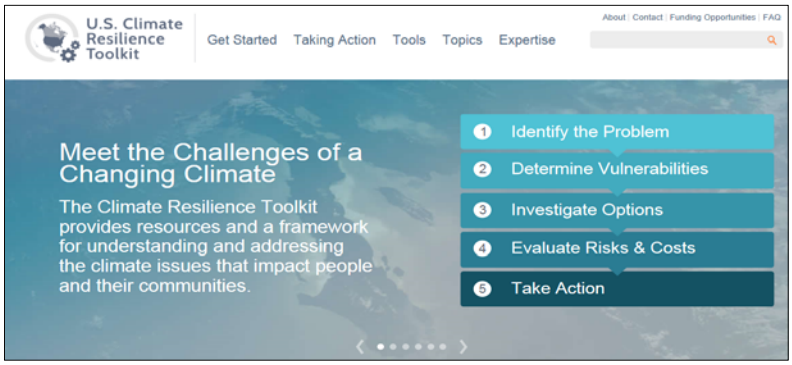
Progress on Adaptation (continued)

- Managing flood, drought, & wildfire risks
  - National Drought Resilience Partnership (11-13)
  - 7 USDA Regional Agricultural Hubs for Climate-Change Mitigation & Adaptation (02-14)
  - USDA/ DOI National Cohesive Wildland Fire Management Strategy (04-14)
  - HUD $1B National Disaster Resilience Competition (06-14)
  - Federal Flood Risk Management Standard (01-15)

Progress on Adaptation (continued)

Mobilizing science and data for climate resilience

- Climate Data Initiative (03-14)
- 3rd U.S. National Climate Assessment (05-14)
- U.S. Climate Resilience Toolkit (11-14)



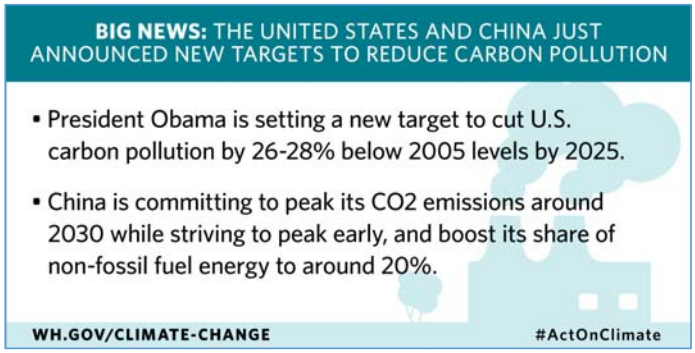
toolkit.climate.gov

Progress under the CAP: International

ENHANCING BILATERAL ENGAGEMENT

- **U.S.-China**

  Joint Announcement in Nov. 2014:



  Also in announcement: Carbon storage demo, new Clean Energy Research Center track on energy-water nexus, new initiative on cities.

- **Mexico, Brazil, India**

  Targets announced or pending

Progress: International (continued)

- Enhancing multilateral engagement

  G-20: Agreement to phase out fossil-fuel subsidies and to develop a methodology for a voluntary peer-review process (09-13).

  UN: Extensive engagement w/ UNFCCC process toward a new global agreement in Paris in December 2015; President Obama speech at UN Climate Summit launched major new U.S. commitments on international assistance for preparedness/resilience (09-14).

- Mobilizing clean-energy and preparedness finance

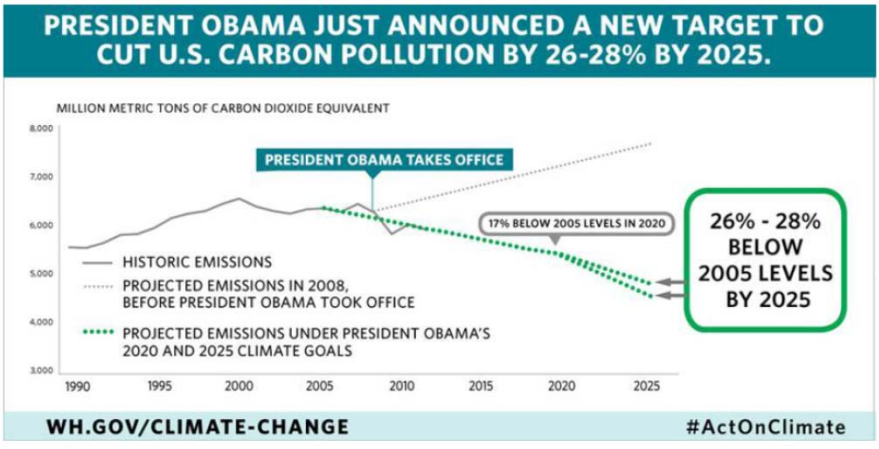
  USA: $3 billion pledge to the Green Climate Fund at G20 (11-14).

  USA/UK/Germany: Global Innovation Lab for Climate Finance - public-private platform to advance next generation of climate finance instruments (06-14).

The path forward in the United States

- Defend the requests for clean-energy RD³ and for Earth observation in the President's FY16 Budget.
- Finalize EPA's Power Plant Rules.
- Improve the coverage, usability, and user base of the Climate Data Initiative and Climate Resilience Toolkit
- Implement the President's Climate Education and Literacy Initiative to ensure continuing public support for all of the above.
- Elect a President in 2016 who will continue and build on President Obama's climate-change program.

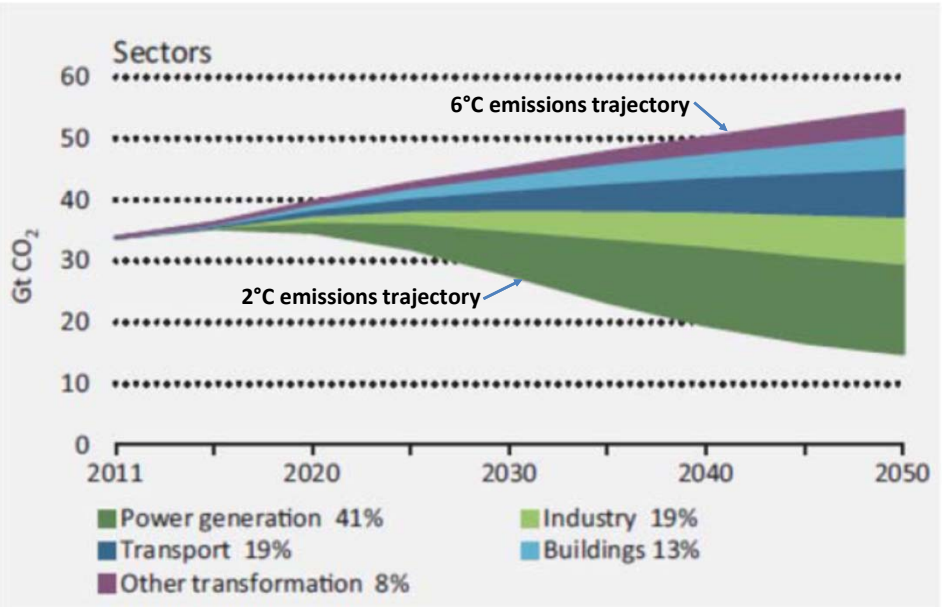
U.S. emission target for 2025



The path forward internationally

- Build the public-private-global partnership for boosting resilience in developing countries announced at the 09-14 UN Climate Summit.
- Continue to push toward a comprehensive, equitable, forward-leaning climate agreement in Paris.
- Begin to plan for the challenges of the steep declines in global emissions that will be needed after 2030.
- To that end, substantially ramp up global research, development & demonstration of the improved and new clean-energy technologies that such cuts will require.

Emissions reductions for a 2°C outcome, by sector



International Energy Agency, Energy Technology Perspectives, 2014

In all of this, leadership will matter!

Some key references

- Vatican, Encyclical Letter Laudato Si' of the Holy Father Francis on Care for Our Common Home, June 2015 http://w2.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf
- The White House, *President Obama's Climate Action Plan: Progress Report*, June 2014, https://www.whitehouse.gov/sites/default/files/docs/cap_progress_report_update_062514_final.pdf
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