

Methods for Measuring Methane Emissions

The measurement and estimation of methane emissions currently occurs in two primary ways: through “bottom-up” greenhouse gas inventories, which focus on the specific source or activity causing the emissions, and through “top-down” methods that infer emissions from measurements of atmospheric methane concentrations. Each approach has different strengths, weaknesses, and uncertainties, and they play complementary roles. Bottom-up inventories provide the foundation for policy and programs and top-down approaches are utilized for independent validation and overall assessments of the efficacy of national and international efforts to reduce methane in the atmosphere.

Nationally, emissions are tracked by the EPA through a bottom-up inventory, the U.S. Greenhouse Gas Inventory (GHGI), a document all parties to the UN Framework Convention on Climate Change (UNFCCC) are required to produce. A suite of methods for such inventories are published by the Intergovernmental Panel on Climate Change and generally consist of statistical approaches involving activity factors (*e.g.*, number of gas wells, number of landfills), emissions factors (*e.g.*, methane emissions per gas well, methane emissions per landfill), and reductions data (*e.g.*, counts of devices or practices that reduce methane emissions, such as flares and anaerobic digesters). The quality of methane data for some sources in the GHGI can be highly variable, and consequently, emissions estimates for some sources entail considerable uncertainty.

The GHGI is also beginning to be supplemented by new data from the Greenhouse Gas Reporting Program (GHGRP), a congressionally mandated EPA program requiring large emitters of GHGs from many sectors to estimate and report their emissions to EPA. Methane data are now available for several important sectors (*i.e.*, landfills, petroleum and natural gas systems, underground coal mines, and industrial wastewater systems) and are generally consistent with the GHGI, although more analysis is planned.

In addition to estimating human-related emissions using bottom-up statistical approaches, aggregate emissions can be inferred using top-down atmospheric models and measured concentrations of methane in the atmosphere. Atmospheric methane concentrations are sampled in the United States, as well as globally, by a variety of instruments on towers, ships, and aircraft. The network is adequate to estimate average global emissions, but it lacks the density to quantify emissions in all regions or to systematically identify emissions sources.

In sum, bottom-up methods are necessary to characterize emissions sources with precision, which is critical for designing mitigation strategies. Top-down methods, while they cannot generally perform such attribution with high confidence, can help to validate bottom-up estimates using measured values and can help to identify emissions ‘hot spots’ for closer measurement.

Key Actions to Improve Methane Emissions Measurement and Monitoring

Administration efforts to improve U.S. methane measurement support two broad goals: 1) improving the bottom-up emissions data relevant for mitigation; and, 2) advancing the science and technology for monitoring and validating atmospheric concentrations. Within these broad goals, improvement opportunities exist across input data (*i.e.*, emissions factors, activity factors, and reductions data), atmospheric observations data, and the science needed to bridge between

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atmospheric observations and bottom-up emissions data (*i.e.*, monitoring and validation science). Federal agencies are already investing in related enhancements, and this strategy announces several critical new activities to further improve methane emissions measurement. Examples of both include:

- **Encouraging the Development of Cost-Effective Measurement Technologies:** DOE's ARPA-E program is preparing a new methane program that will fund technologies to deliver an order-of-magnitude reduction on the cost of methane sensing, thus facilitating much wider deployment throughout all segments of natural gas systems.
- **Enhancing the US Greenhouse Gas Inventory:** EPA will continue to update and enhance the data published in its annual GHGI as new scientific evidence and data sources emerge. EPA will also continue to use the data collected through the GHGRP to improve the GHGI, particularly for the petroleum, natural gas, coal mining, and landfill sectors. This data will improve as additional reporting of inputs to emissions equations began in 2013 and, in 2015, EPA also plans to make ongoing improvements to the GHGRP regulatory requirements for petroleum and natural gas systems. In March 2014, EPA proposed revisions to GHGRP calculation methods, monitoring and data reporting requirements that would enhance the clarity and consistency of the reported data from petroleum and natural gas systems, such as for liquids unloading, completions and workovers, and compressors. The EPA will continue to review regulatory requirements to address potential gaps in coverage, improve methods, and help ensure high quality data reporting. DOE and USDA will also provide support to improve emissions factors. EPA efforts to improve the GHGI will promote transparency and stakeholder input by means of annual expert, public and international review periods.
- **Building our National Methane Monitoring Network:** National Oceanic and Atmospheric Administration (NOAA) scientists maintain a network of methane monitoring sites in the United States, including tall towers, periodic aircraft measurements, and surface measurements. NOAA has also conducted periodic aircraft-based methane measurements in six major U.S. oil and gas production regions. At its current funding level, this Carbon Observation and Analysis Program provides the minimum needed for climate modeling. To expand capabilities, the President's budget requests \$8 million above current funding of \$6.5 million for this program to:
 - Add 6 tall towers to the network, increasing the network to 14;
 - Enhance the measurement capabilities of all 14 towers;
 - Triple the frequency of aircraft-based observations.
- **Improving Local & Regional Emissions Modeling:** As part of DOE's ongoing unconventional gas program, DOE is funding two projects - one at Pennsylvania State University and one at Carnegie Mellon University - using tracer release methods and tower, automobile, aircraft monitoring, and other methods to measure and model methane emissions from the Marcellus region in Pennsylvania. A regional inventory of other methane sources including landfills, wetlands, water treatment facilities, and agriculture sources will also be obtained. The project is scheduled to begin in 2015 and end in 2017. Additionally, NASA's Jet Propulsion Laboratory JPL, is carrying out a Carbon in Arctic

Reservoirs Vulnerability Experiment, which includes regular monitoring of methane concentrations over Alaska's North Slope.

- **Improving Global Emissions Monitoring and Estimates:** EPA is collecting emissions reduction data through the Global Methane Initiative. EPA will also continue to update and publish detailed estimates and projections of global human-related non-CO₂ greenhouse gas emissions, and the mitigation potential from these sources. DOE's Atmospheric Radiation Measurement Climate Research Facility is making long-term methane flux measurements at multiple permanent locations around the world. NOAA runs the largest global network of GHG measurements and works closely with international partners and the World Meteorological Organization to ensure global measurements of GHG concentrations, including methane, are standardized. NOAA also consolidates data from this global network and releases the data to the public. Other Federal agencies (e.g. NASA and DOE) also contribute to these networks. NASA and the National Institute of Standards and Technology are helping to fund the Megacities Carbon Project, an international research effort to develop and demonstrate a scientifically robust capability to measure multi-year emission trends of CO₂, methane, and carbon monoxide attributed to individual megacities and selected major sectors in those cities. In addition, USDA's Forest Service is working with international partners, universities and the USAID on international efforts that monitor methane on sites in Mexico, Ecuador, Colombia, and Peru.

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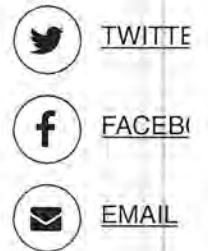
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The White House
Office of the Press Secretary

For Immediate Release

November 06, 2015

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Statement by the President on the Keystone XL Pipeline

Roosevelt Room

11:58 A.M. EST

THE PRESIDENT: Good morning, everybody. Several years ago, the State Department began a review process for the proposed construction of a pipeline that would carry Canadian crude oil through our heartland to ports in the Gulf of Mexico and out into the world market.

This morning, Secretary Kerry informed me that, after extensive public outreach and consultation with other Cabinet agencies, the State Department has decided that the Keystone XL Pipeline would not serve the national interest of the United States. I agree with that decision.

This morning, I also had the opportunity to speak with Prime Minister Trudeau of Canada. And while he expressed his disappointment, given Canada's position on this issue, we both agreed that our close

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friendship on a whole range of issues, including energy and climate change, should provide the basis for even closer coordination between our countries going forward. And in the coming weeks, senior members of my team will be engaging with theirs in order to help deepen that cooperation.

Now, for years, the Keystone Pipeline has occupied what I, frankly, consider an overinflated role in our political discourse. It became a symbol too often used as a campaign cudgel by both parties rather than a serious policy matter. And all of this obscured the fact that this pipeline would neither be a silver bullet for the economy, as was promised by some, nor the express lane to climate disaster proclaimed by others.

To illustrate this, let me briefly comment on some of the reasons why the State Department rejected this pipeline.

First: The pipeline would not make a meaningful long-term contribution to our economy. So if Congress is serious about wanting to create jobs, this was not the way to do it. If they want to do it, what we should be doing is passing a bipartisan infrastructure plan that, in the short term, could create more than 30 times as many jobs per year as the pipeline would, and in the long run would benefit our economy and our workers for decades to come.

Our businesses created 268,000 new jobs last month. They've created 13.5 million new jobs over the past 68 straight months -- the longest streak on record. The unemployment rate fell to 5 percent. This Congress should pass a serious infrastructure plan, and keep those jobs coming. That would make a difference. The pipeline would not have made a serious impact on those numbers and on the American people's prospects for the future.

Second: The pipeline would not lower gas prices for American consumers. In fact, gas prices have already been falling -- steadily. The national average gas price is down about 77 cents over a year ago. It's down a dollar over two years ago. It's down \$1.27 over three years ago. Today, in 41 states, drivers can find at least one gas station selling gas for less than two bucks a gallon. So while our politics have been consumed by a debate over whether or not this pipeline would create jobs and lower gas prices, we've gone ahead and created jobs and lowered gas prices.

Third: Shipping dirtier crude oil into our country would not increase America's energy security. What has increased America's energy security is our strategy over the past several years to reduce our reliance on dirty fossil fuels from unstable parts of the world. Three years ago, I set a goal to cut our oil imports in half by 2020. Between producing more oil here at home, and using less oil throughout our economy, we met that goal last year -- five years early. In fact, for the first time in two decades, the United States of America now produces more oil than we buy from other countries.

Now, the truth is, the United States will continue to rely on oil and gas as we transition -- as we must transition -- to a clean energy economy. That transition will take some time. But it's also going more quickly than many anticipated. Think about it. Since I took office, we've doubled the distance our cars will go on a gallon of gas by 2025; tripled the power we generate from the wind; multiplied the power we generate from the sun 20 times over. Our biggest and most successful businesses are going all-in on clean energy. And thanks in part to the investments we've made, there are already parts of America where clean power from the wind or the sun is finally cheaper than dirtier, conventional power.

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The point is the old rules said we couldn't promote economic growth and protect our environment at the same time. The old rules said we couldn't transition to clean energy without squeezing businesses and consumers. But this is America, and we have come up with new ways and new technologies to break down the old rules, so that today, homegrown American energy is booming, energy prices are falling, and over the past decade, even as our economy has continued to grow, America has cut our total carbon pollution more than any other country on Earth.

Today, the United States of America is leading on climate change with our investments in clean energy and energy efficiency. America is leading on climate change with new rules on power plants that will protect our air so that our kids can breathe. America is leading on climate change by working with other big emitters like China to encourage and announce new commitments to reduce harmful greenhouse gas emissions. In part because of that American leadership, more than 150 nations representing nearly 90 percent of global emissions have put forward plans to cut pollution.

America is now a global leader when it comes to taking serious action to fight climate change. And frankly, approving this project would have undercut that global leadership. And that's the biggest risk we face -- not acting.

Today, we're continuing to lead by example. Because ultimately, if we're going to prevent large parts of this Earth from becoming not only inhospitable but uninhabitable in our lifetimes, we're going to have to keep some fossil fuels in the ground rather than burn them and release more dangerous pollution into the sky.

As long as I'm President of the United States, America

is going to hold ourselves to the same high standards to which we hold the rest of the world. And three weeks from now, I look forward to joining my fellow world leaders in Paris, where we've got to come together around an ambitious framework to protect the one planet that we've got while we still can.

If we want to prevent the worst effects of climate change before it's too late, the time to act is now. Not later. Not someday. Right here, right now. And I'm optimistic about what we can accomplish together.

I'm optimistic because our own country proves, every day -- one step at a time -- that not only do we have the power to combat this threat, we can do it while creating new jobs, while growing our economy, while saving money, while helping consumers, and most of all, leaving our kids a cleaner, safer planet at the same time.

That's what our own ingenuity and action can do. That's what we can accomplish. And America is prepared to show the rest of the world the way forward.

Thank you very much.

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United Nations

FCCC/CP/2015/L.9



Framework Convention on
Climate Change

Distr.: Limited
12 December 2015

Original: English

Conference of the Parties

Twenty-first session

Paris, 30 November to 11 December 2015

Agenda item 4(b)

Durban Platform for Enhanced Action (decision 1/CP.17)

**Adoption of a protocol, another legal instrument, or an
agreed outcome with legal force under the Convention
applicable to all Parties**

ADOPTION OF THE PARIS AGREEMENT

Proposal by the President

Draft decision -/CP.21

The Conference of the Parties,

Recalling decision 1/CP.17 on the establishment of the Ad Hoc Working Group on the Durban Platform for Enhanced Action,

Also recalling Articles 2, 3 and 4 of the Convention,

Further recalling relevant decisions of the Conference of the Parties, including decisions 1/CP.16, 2/CP.18, 1/CP.19 and 1/CP.20,

Welcoming the adoption of United Nations General Assembly resolution A/RES/70/1, "Transforming our world: the 2030 Agenda for Sustainable Development", in particular its goal 13, and the adoption of the Addis Ababa Action Agenda of the third International Conference on Financing for Development and the adoption of the Sendai Framework for Disaster Risk Reduction,


Recognizing that climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions,

Also recognizing that deep reductions in global emissions will be required in order to achieve the ultimate objective of the Convention and emphasizing the need for urgency in addressing climate change,

Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples,

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local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity.

Also acknowledging the specific needs and concerns of developing country Parties arising from the impact of the implementation of response measures and, in this regard, decisions 5/CP.7, 1/CP.10, 1/CP.16 and 8/CP.17.

Emphasizing with serious concern the urgent need to address the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C,

Also emphasizing that enhanced pre-2020 ambition can lay a solid foundation for enhanced post-2020 ambition,

Stressing the urgency of accelerating the implementation of the Convention and its Kyoto Protocol in order to enhance pre-2020 ambition,

Recognizing the urgent need to enhance the provision of finance, technology and capacity-building support by developed country Parties, in a predictable manner, to enable enhanced pre-2020 action by developing country Parties,

Emphasizing the enduring benefits of ambitious and early action, including major reductions in the cost of future mitigation and adaptation efforts,

Acknowledging the need to promote universal access to sustainable energy in developing countries, in particular in Africa, through the enhanced deployment of renewable energy,

Agreeing to uphold and promote regional and international cooperation in order to mobilize stronger and more ambitious climate action by all Parties and non-Party stakeholders, including civil society, the private sector, financial institutions, cities and other subnational authorities, local communities and indigenous peoples.

I. ADOPTION

1. *Decides* to adopt the Paris Agreement under the United Nations Framework Convention on Climate Change (hereinafter referred to as "the Agreement") as contained in the annex;
2. *Requests* the Secretary-General of the United Nations to be the Depositary of the Agreement and to have it open for signature in New York, United States of America, from 22 April 2016 to 21 April 2017;
3. *Invites* the Secretary-General to convene a high-level signature ceremony for the Agreement on 22 April 2016;
4. *Also invites* all Parties to the Convention to sign the Agreement at the ceremony to be convened by the Secretary-General, or at their earliest opportunity, and to deposit their respective instruments of ratification, acceptance, approval or accession, where appropriate, as soon as possible;
5. *Recognizes* that Parties to the Convention may provisionally apply all of the provisions of the Agreement pending its entry into force, and *requests* Parties to provide notification of any such provisional application to the Depositary;
6. *Notes* that the work of the Ad Hoc Working Group on the Durban Platform for Enhanced Action, in accordance with decision 1/CP.17, paragraph 4, has been completed;

7. *Decides* to establish the Ad Hoc Working Group on the Paris Agreement under the same arrangement, mutatis mutandis, as those concerning the election of officers to the Bureau of the Ad Hoc Working Group on the Durban Platform for Enhanced Action;¹
8. *Also decides* that the Ad Hoc Working Group on the Paris Agreement shall prepare for the entry into force of the Agreement and for the convening of the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;
9. *Further decides* to oversee the implementation of the work programme resulting from the relevant requests contained in this decision;
10. *Requests* the Ad Hoc Working Group on the Paris Agreement to report regularly to the Conference of the Parties on the progress of its work and to complete its work by the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;
11. *Decides* that the Ad Hoc Working Group on the Paris Agreement shall hold its sessions starting in 2016 in conjunction with the sessions of the Convention subsidiary bodies and shall prepare draft decisions to be recommended through the Conference of the Parties to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for consideration and adoption at its first session;

II. INTENDED NATIONALLY DETERMINED CONTRIBUTIONS

12. *Welcomes* the intended nationally determined contributions that have been communicated by Parties in accordance with decision 1/CP.19, paragraph 2(b);
13. *Reiterates* its invitation to all Parties that have not yet done so to communicate to the secretariat their intended nationally determined contributions towards achieving the objective of the Convention as set out in its Article 2 as soon as possible and well in advance of the twenty-second session of the Conference of the Parties (November 2016) and in a manner that facilitates the clarity, transparency and understanding of the intended nationally determined contributions;
14. *Requests* the secretariat to continue to publish the intended nationally determined contributions communicated by Parties on the UNFCCC website;
15. *Reiterates* its call to developed country Parties, the operating entities of the Financial Mechanism and any other organizations in a position to do so to provide support for the preparation and communication of the intended nationally determined contributions of Parties that may need such support;
16. *Takes note* of the synthesis report on the aggregate effect of intended nationally determined contributions communicated by Parties by 1 October 2015, contained in document FCCC/CP/2015/7;
17. *Notes* with concern that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2 °C scenarios but rather lead to a projected level of 55 gigatonnes in 2030, and *also notes* that much greater emission reduction efforts will be required than those associated with the intended nationally determined contributions in order to hold the increase in the global average temperature to below 2 °C above pre-industrial levels by reducing emissions to 40 gigatonnes or to 1.5 °C above pre-industrial levels by reducing to a level to be identified in the special report referred to in paragraph 21 below;

¹ Endorsed by decision 2/CP.18, paragraph 2.

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18. *Also notes, in this context*, the adaptation needs expressed by many developing country Parties in their intended nationally determined contributions;
19. *Requests* the secretariat to update the synthesis report referred to in paragraph 16 above so as to cover all the information in the intended nationally determined contributions communicated by Parties pursuant to decision 1/CP.20 by 4 April 2016 and to make it available by 2 May 2016;
20. *Decides* to convene a facilitative dialogue among Parties in 2018 to take stock of the collective efforts of Parties in relation to progress towards the long-term goal referred to in Article 4, paragraph 1, of the Agreement and to inform the preparation of nationally determined contributions pursuant to Article 4, paragraph 8, of the Agreement;
21. *Invites* the Intergovernmental Panel on Climate Change to provide a special report in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways;

III. DECISIONS TO GIVE EFFECT TO THE AGREEMENT

MITIGATION

22. *Invites* Parties to communicate their first nationally determined contribution no later than when the Party submits its respective instrument of ratification, accession, or approval of the Paris Agreement. If a Party has communicated an intended nationally determined contribution prior to joining the Agreement, that Party shall be considered to have satisfied this provision unless that Party decides otherwise;
23. *Urges* those Parties whose intended nationally determined contribution pursuant to decision 1/CP.20 contains a time frame up to 2025 to communicate by 2020 a new nationally determined contribution and to do so every five years thereafter pursuant to Article 4, paragraph 9, of the Agreement;
24. *Requests* those Parties whose intended nationally determined contribution pursuant to decision 1/CP.20 contains a time frame up to 2030 to communicate or update by 2020 these contributions and to do so every five years thereafter pursuant to Article 4, paragraph 9, of the Agreement;
25. *Decides* that Parties shall submit to the secretariat their nationally determined contributions referred to in Article 4 of the Agreement at least 9 to 12 months in advance of the relevant meeting of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement with a view to facilitating the clarity, transparency and understanding of these contributions, including through a synthesis report prepared by the secretariat;
26. *Requests* the Ad Hoc Working Group on the Paris Agreement to develop further guidance on features of the nationally determined contributions for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;
27. *Agrees* that the information to be provided by Parties communicating their nationally determined contributions, in order to facilitate clarity, transparency and understanding, may include, as appropriate, inter alia, quantifiable information on the reference point (including, as appropriate, a base year), time frames and/or periods for implementation, scope and coverage, planning processes, assumptions and methodological approaches including those for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals, and how the Party considers that its nationally determined contribution is fair and ambitious, in the light of its national circumstances, and

how it contributes towards achieving the objective of the Convention as set out in its Article 2;

28. *Requests* the Ad Hoc Working Group on the Paris Agreement to develop further guidance for the information to be provided by Parties in order to facilitate clarity, transparency and understanding of nationally determined contributions for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

29. *Also requests* the Subsidiary Body for Implementation to develop modalities and procedures for the operation and use of the public registry referred to in Article 4, paragraph 12, of the Agreement, for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

30. *Further requests* the secretariat to make available an interim public registry in the first half of 2016 for the recording of nationally determined contributions submitted in accordance with Article 4 of the Agreement, pending the adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement of the modalities and procedures referred to in paragraph 29 above;

31. *Requests* the Ad Hoc Working Group on the Paris Agreement to elaborate, drawing from approaches established under the Convention and its related legal instruments as appropriate, guidance for accounting for Parties' nationally determined contributions, as referred to in Article 4, paragraph 13, of the Agreement, for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session, which ensures that:

(a) Parties account for anthropogenic emissions and removals in accordance with common methodologies and metrics assessed by the Intergovernmental Panel on Climate Change and adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;

(b) Parties ensure methodological consistency, including on baselines, between the communication and implementation of nationally determined contributions;

(c) Parties strive to include all categories of anthropogenic emissions or removals in their nationally determined contributions and, once a source, sink or activity is included, continue to include it;

(d) Parties shall provide an explanation of why any categories of anthropogenic emissions or removals are excluded;

32. *Decides* that Parties shall apply the guidance mentioned in paragraph 31 above to the second and subsequent nationally determined contributions and that Parties may elect to apply such guidance to their first nationally determined contribution;

33. *Also decides* that the Forum on the Impact of the Implementation of response measures, under the subsidiary bodies, shall continue, and shall serve the Agreement;

34. *Further decides* that the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation shall recommend, for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session, the modalities, work programme and functions of the Forum on the Impact of the Implementation of response measures to address the effects of the implementation of response measures under the Agreement by enhancing cooperation amongst Parties on understanding the impacts of mitigation actions under the Agreement and the exchange of information, experiences, and best practices amongst Parties to raise their resilience to these impacts;

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35. *Decides* that the guidance under paragraph 31 above shall ensure that double counting is avoided on the basis of a corresponding adjustment by both Parties for anthropogenic emissions by sources and/or removals by sinks covered by their nationally determined contributions under the Agreement;

36. *Invites* Parties to communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Agreement, and *requests* the secretariat to publish on the UNFCCC website Parties' low greenhouse gas emission development strategies as communicated;

37. *Requests* the Subsidiary Body for Scientific and Technological Advice to develop and recommend the guidance referred to under Article 6, paragraph 2, of the Agreement for adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session, including guidance to ensure that double counting is avoided on the basis of a corresponding adjustment by Parties for both anthropogenic emissions by sources and removals by sinks covered by their nationally determined contributions under the Agreement;

38. *Recommends* that the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement adopt rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Agreement on the basis of:

- (a) Voluntary participation authorized by each Party involved;
- (b) Real, measurable, and long-term benefits related to the mitigation of climate change;
- (c) Specific scopes of activities;
- (d) Reductions in emissions that are additional to any that would otherwise occur;
- (e) Verification and certification of emission reductions resulting from mitigation activities by designated operational entities;
- (f) Experience gained with and lessons learned from existing mechanisms and approaches adopted under the Convention and its related legal instruments;

39. *Requests* the Subsidiary Body for Scientific and Technological Advice to develop and recommend rules, modalities and procedures for the mechanism referred to in paragraph 38 above for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

40. *Also requests* the Subsidiary Body for Scientific and Technological Advice to undertake a work programme under the framework for non-market approaches to sustainable development referred to in Article 6, paragraph 8, of the Agreement, with the objective of considering how to enhance linkages and create synergy between, inter alia, mitigation, adaptation, finance, technology transfer and capacity-building, and how to facilitate the implementation and coordination of non-market approaches;

41. *Further requests* the Subsidiary Body for Scientific and Technological Advice to recommend a draft decision on the work programme referred to in paragraph 40 above, taking into account the views of Parties, for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

ADAPTATION

42. *Requests* the Adaptation Committee and the Least Developed Countries Expert Group to jointly develop modalities to recognize the adaptation efforts of developing

country Parties, as referred to in Article 7, paragraph 3, of the Agreement, and make recommendations for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

43. *Also requests* the Adaptation Committee, taking into account its mandate and its second three-year workplan, and with a view to preparing recommendations for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session:

(a) To review, in 2017, the work of adaptation-related institutional arrangements under the Convention, with a view to identifying ways to enhance the coherence of their work, as appropriate, in order to respond adequately to the needs of Parties;

(b) To consider methodologies for assessing adaptation needs with a view to assisting developing countries, without placing an undue burden on them;

44. *Invites* all relevant United Nations agencies and international, regional and national financial institutions to provide information to Parties through the secretariat on how their development assistance and climate finance programmes incorporate climate-proofing and climate resilience measures;

45. *Requests* Parties to strengthen regional cooperation on adaptation where appropriate and, where necessary, establish regional centres and networks, in particular in developing countries, taking into account decision 1/CP.16, paragraph 13;

46. *Also requests* the Adaptation Committee and the Least Developed Countries Expert Group, in collaboration with the Standing Committee on Finance and other relevant institutions, to develop methodologies, and make recommendations for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session on:

(a) Taking the necessary steps to facilitate the mobilization of support for adaptation in developing countries in the context of the limit to global average temperature increase referred to in Article 2 of the Agreement;

(b) Reviewing the adequacy and effectiveness of adaptation and support referred to in Article 7, paragraph 14(c), of the Agreement;

47. *Further requests* the Green Climate Fund to expedite support for the least developed countries and other developing country Parties for the formulation of national adaptation plans, consistent with decisions 1/CP.16 and 5/CP.17, and for the subsequent implementation of policies, projects and programmes identified by them;

LOSS AND DAMAGE

48. *Decides* on the continuation of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts, following the review in 2016;

49. *Requests* the Executive Committee of the Warsaw International Mechanism to establish a clearinghouse for risk transfer that serves as a repository for information on insurance and risk transfer, in order to facilitate the efforts of Parties to develop and implement comprehensive risk management strategies;

50. *Also requests* the Executive Committee of the Warsaw International Mechanism to establish, according to its procedures and mandate, a task force to complement, draw upon the work of and involve, as appropriate, existing bodies and expert groups under the Convention including the Adaptation Committee and the Least Developed Countries Expert Group, as well as relevant organizations and expert bodies outside the Convention, to develop recommendations for integrated approaches to avert, minimize and address displacement related to the adverse impacts of climate change;

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51. *Further requests* the Executive Committee of the Warsaw International Mechanism to initiate its work, at its next meeting, to operationalize the provisions referred to in paragraphs 49 and 50 above, and to report on progress thereon in its annual report;

52. *Agrees* that Article 8 of the Agreement does not involve or provide a basis for any liability or compensation;

FINANCE

53. *Decides* that, in the implementation of the Agreement, financial resources provided to developing countries should enhance the implementation of their policies, strategies, regulations and action plans and their climate change actions with respect to both mitigation and adaptation to contribute to the achievement of the purpose of the Agreement as defined in Article 2;

54. *Further decides* that, in accordance with Article 9, paragraph 3, of the Agreement, developed countries intend to continue their existing collective mobilization goal through 2025 in the context of meaningful mitigation actions and transparency on implementation; prior to 2025 the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall set a new collective quantified goal from a floor of USD 100 billion per year, taking into account the needs and priorities of developing countries;

55. *Recognizes* the importance of adequate and predictable financial resources, including for results-based payments, as appropriate, for the implementation of policy approaches and positive incentives for reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks; as well as alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests; while reaffirming the importance of non-carbon benefits associated with such approaches; encouraging the coordination of support from, inter alia, public and private, bilateral and multilateral sources, such as the Green Climate Fund, and alternative sources in accordance with relevant decisions by the Conference of the Parties;

56. *Decides* to initiate, at its twenty-second session, a process to identify the information to be provided by Parties, in accordance with Article 9, paragraph 5, of the Agreement with the view to providing a recommendation for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

57. *Also decides* to ensure that the provision of information in accordance with Article 9, paragraph 7 of the Agreement shall be undertaken in accordance with modalities, procedures and guidelines referred to in paragraph 96 below;

58. *Requests* Subsidiary Body for Scientific and Technological Advice to develop modalities for the accounting of financial resources provided and mobilized through public interventions in accordance with Article 9, paragraph 7, of the Agreement for consideration by the Conference of the Parties at its twenty-fourth session (November 2018), with the view to making a recommendation for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

59. *Decides* that the Green Climate Fund and the Global Environment Facility, the entities entrusted with the operation of the Financial Mechanism of the Convention, as well as the Least Developed Countries Fund and the Special Climate Change Fund, administered by the Global Environment Facility, shall serve the Agreement;

60. *Recognizes* that the Adaptation Fund may serve the Agreement, subject to relevant decisions by the Conference of the Parties serving as the meeting of the Parties to the Kyoto

Protocol and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;

61. *Invites* the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol to consider the issue referred to in paragraph 60 above and make a recommendation to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;
62. *Recommends* that the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall provide guidance to the entities entrusted with the operation of the Financial Mechanism of the Convention on the policies, programme priorities and eligibility criteria related to the Agreement for transmission by the Conference of the Parties;
63. *Decides* that the guidance to the entities entrusted with the operations of the Financial Mechanism of the Convention in relevant decisions of the Conference of the Parties, including those agreed before adoption of the Agreement, shall apply *mutatis mutandis*;
64. *Also decides* that the Standing Committee on Finance shall serve the Agreement in line with its functions and responsibilities established under the Conference of the Parties;
65. *Urges* the institutions serving the Agreement to enhance the coordination and delivery of resources to support country-driven strategies through simplified and efficient application and approval procedures, and through continued readiness support to developing country Parties, including the least developed countries and small island developing States, as appropriate;

TECHNOLOGY DEVELOPMENT AND TRANSFER

66. *Takes note of* the interim report of the Technology Executive Committee on guidance on enhanced implementation of the results of technology needs assessments as referred to in document FCCC/SB/2015/INF.3;
67. *Decides* to strengthen the Technology Mechanism and requests the Technology Executive Committee and the Climate Technology Centre and Network, in supporting the implementation of the Agreement, to undertake further work relating to, *inter alia*:
- (a) Technology research, development and demonstration;
 - (b) The development and enhancement of endogenous capacities and technologies;
68. *Requests* the Subsidiary Body for Scientific and Technological Advice to initiate, at its forty-fourth session (May 2016), the elaboration of the technology framework established under Article 10, paragraph 4, of the Agreement and to report on its findings to the Conference of the Parties, with a view to the Conference of the Parties making a recommendation on the framework to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for consideration and adoption at its first session, taking into consideration that the framework should facilitate, *inter alia*:
- (a) The undertaking and updating of technology needs assessments, as well as the *enhanced* implementation of their results, particularly technology action plans and project ideas, through the preparation of bankable projects;
 - (b) The provision of enhanced financial and technical support for the implementation of the results of the technology needs assessments;
 - (c) The assessment of technologies that are ready for transfer;

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(d) The enhancement of enabling environments for and the addressing of barriers to the development and transfer of socially and environmentally sound technologies;

69. *Decides* that the Technology Executive Committee and the Climate Technology Centre and Network shall report to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, through the subsidiary bodies, on their activities to support the implementation of the Agreement;

70. *Also decides* to undertake a periodic assessment of the effectiveness of and the adequacy of the support provided to the Technology Mechanism in supporting the implementation of the Agreement on matters relating to technology development and transfer;

71. *Requests* the Subsidiary Body for Implementation to initiate, at its forty-fourth session, the elaboration of the scope of and modalities for the periodic assessment referred to in paragraph 70 above, taking into account the review of the Climate Technology Centre and Network as referred to in decision 2/CP.17, annex VII, paragraph 20 and the modalities for the global stocktake referred to in Article 14 of the Agreement, for consideration and adoption by the Conference of the Parties at its twenty-fifth session (November 2019);

CAPACITY-BUILDING

72. *Decides* to establish the Paris Committee on Capacity-building whose aim will be to address gaps and needs, both current and emerging, in implementing capacity-building in developing country Parties and further enhancing capacity-building efforts, including with regard to coherence and coordination in capacity-building activities under the Convention;

73. *Also decides* that the Paris Committee on Capacity-building will manage and oversee the work plan mentioned in paragraph 74 below;

74. *Further decides* to launch a work plan for the period 2016–2020 with the following activities:

(a) Assessing how to increase synergies through cooperation and avoid duplication among existing bodies established under the Convention that implement capacity-building activities, including through collaborating with institutions under and outside the Convention;

(b) Identifying capacity gaps and needs and recommending ways to address them;

(c) Promoting the development and dissemination of tools and methodologies for the implementation of capacity-building;

(d) Fostering global, regional, national and subnational cooperation;

(e) Identifying and collecting good practices, challenges, experiences, and lessons learned from work on capacity-building by bodies established under the Convention;

(f) Exploring how developing country Parties can take ownership of building and maintaining capacity over time and space;

(g) Identifying opportunities to strengthen capacity at the national, regional, and subnational level;

(h) Fostering dialogue, coordination, collaboration and coherence among relevant processes and initiatives under the Convention, including through exchanging information on capacity-building activities and strategies of bodies established under the Convention;

(i) Providing guidance to the secretariat on the maintenance and further development of the web-based capacity-building portal;

75. *Decides* that the Paris Committee on Capacity-building will annually focus on an area or theme related to enhanced technical exchange on capacity-building, with the purpose of maintaining up-to-date knowledge on the successes and challenges in building capacity effectively in a particular area;

76. *Requests* the Subsidiary Body for Implementation to organize annual in-session meetings of the Paris Committee on Capacity-building;

77. *Also requests* the Subsidiary Body for Implementation to develop the terms of reference for the Paris Committee on Capacity-building, in the context of the third comprehensive review of the implementation of the capacity-building framework, also taking into account paragraphs 75, 76, 77 and 78 above and paragraphs 82 and 83 below, with a view to recommending a draft decision on this matter for consideration and adoption by the Conference of the Parties at its twenty-second session;

78. *Invites* Parties to submit their views on the membership of the Paris Committee on Capacity-building by 9 March 2016;²

79. *Requests* the secretariat to compile the submissions referred to in paragraph 78 above into a miscellaneous document for consideration by the Subsidiary Body for Implementation at its forty-fourth session;

80. *Decides* that the inputs to the Paris Committee on Capacity-building will include, inter alia, submissions, the outcome of the third comprehensive review of the implementation of the capacity-building framework, the secretariat's annual synthesis report on the implementation of the framework for capacity-building in developing countries, the secretariat's compilation and synthesis report on capacity-building work of bodies established under the Convention and its Kyoto Protocol, and reports on the Durban Forum and the capacity-building portal;

81. *Requests* the Paris Committee on Capacity-building to prepare annual technical progress reports on its work, and to make these reports available at the sessions of the Subsidiary Body for Implementation coinciding with the sessions of the Conference of the Parties;

82. *Also requests* the Conference of the Parties at its twenty-fifth session (November 2019), to review the progress, need for extension, the effectiveness and enhancement of the Paris Committee on Capacity-building and to take any action it considers appropriate, with a view to making recommendations to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session on enhancing institutional arrangements for capacity-building consistent with Article 11, paragraph 5, of the Agreement;

83. *Calls upon* all Parties to ensure that education, training and public awareness, as reflected in Article 6 of the Convention and in Article 12 of the Agreement are adequately considered in their contribution to capacity-building;

84. *Invites* the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session to explore ways of enhancing the implementation of training, public awareness, public participation and public access to information so as to enhance actions under the Agreement;

² Parties should submit their views via the submissions portal at <<http://www.unfccc.int/5900>>.

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TRANSPARENCY OF ACTION AND SUPPORT

85. *Decides* to establish a Capacity-building Initiative for Transparency in order to build institutional and technical capacity, both pre- and post-2020. This initiative will support developing country Parties, upon request, in meeting enhanced transparency requirements as defined in Article 13 of the Agreement in a timely manner;
86. *Also decides* that the Capacity-building Initiative for Transparency will aim:
- (a) To strengthen national institutions for transparency-related activities in line with national priorities;
 - (b) To provide relevant tools, training and assistance for meeting the provisions stipulated in Article 13 of the Agreement;
 - (c) To assist in the improvement of transparency over time;
87. *Urges and requests* the Global Environment Facility to make arrangements to support the establishment and operation of the Capacity-building Initiative for Transparency as a priority reporting-related need, including through voluntary contributions to support developing countries in the sixth replenishment of the Global Environment Facility and future replenishment cycles, to complement existing support under the Global Environment Facility;
88. *Decides* to assess the implementation of the Capacity-building Initiative for Transparency in the context of the seventh review of the financial mechanism;
89. *Requests* that the Global Environment Facility, as an operating entity of the financial mechanism include in its annual report to the Conference of the Parties the progress of work in the design, development and implementation of the Capacity-building Initiative for Transparency referred to in paragraph 85 above starting in 2016;
90. *Decides* that, in accordance with Article 13, paragraph 2, of the Agreement, developing countries shall be provided flexibility in the implementation of the provisions of that Article, including in the scope, frequency and level of detail of reporting, and in the scope of review, and that the scope of review could provide for in-country reviews to be optional, while such flexibilities shall be reflected in the development of modalities, procedures and guidelines referred to in paragraph 92 below;
91. *Also decides* that all Parties, except for the least developed country Parties and small island developing States, shall submit the information referred to in Article 13, paragraphs 7, 8, 9 and 10, as appropriate, no less frequently than on a biennial basis, and that the least developed country Parties and small island developing States may submit this information at their discretion;
92. *Requests* the Ad Hoc Working Group on the Paris Agreement to develop recommendations for modalities, procedures and guidelines in accordance with Article 13, paragraph 13, of the Agreement, and to define the year of their first and subsequent review and update, as appropriate, at regular intervals, for consideration by the Conference of the Parties, at its twenty-fourth session, with a view to forwarding them to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for adoption at its first session;
93. *Also requests* the Ad Hoc Working Group on the Paris Agreement in developing the recommendations for the modalities, procedures and guidelines referred to in paragraph 92 above to take into account, inter alia:
- (a) The importance of facilitating improved reporting and transparency over time;

(b) The need to provide flexibility to those developing country Parties that need it in the light of their capacities;

(c) The need to promote transparency, accuracy, completeness, consistency, and comparability;

(d) The need to avoid duplication as well as undue burden on Parties and the secretariat;

(e) The need to ensure that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;

(f) The need to ensure that double counting is avoided;

(g) The need to ensure environmental integrity;

94. *Further requests* the Ad Hoc Working Group on the Paris Agreement, when developing the modalities, procedures and guidelines referred to in paragraph 92 above, to draw on the experiences from and take into account other on-going relevant processes under the Convention;

95. *Requests* the Ad Hoc Working Group on the Paris Agreement, when developing modalities, procedures and guidelines referred to in paragraph 92 above, to consider, inter alia:

(a) The types of flexibility available to those developing countries that need it on the basis of their capacities;

(b) The consistency between the methodology communicated in the nationally determined contribution and the methodology for reporting on progress made towards achieving individual Parties' respective nationally determined contribution;

(c) That Parties report information on adaptation action and planning including, if appropriate, their national adaptation plans, with a view to collectively exchanging information and sharing lessons learned;

(d) Support provided, enhancing delivery of support for both adaptation and mitigation through, inter alia, the common tabular formats for reporting support, and taking into account issues considered by the Subsidiary Body for Scientific and Technological Advice on methodologies for reporting on financial information, and enhancing the reporting by developing countries on support received, including the use, impact and estimated results thereof;

(e) Information in the biennial assessments and other reports of the Standing Committee on Finance and other relevant bodies under the Convention;

(f) Information on the social and economic impact of response measures;

96. *Also requests* the Ad Hoc Working Group on the Paris Agreement, when developing recommendations for modalities, procedures and guidelines referred to in paragraph 92 above, to enhance the transparency of support provided in accordance with Article 9 of the Agreement;

97. *Further requests* the Ad Hoc Working Group on the Paris Agreement to report on the progress of work on the modalities, procedures and guidelines referred to in paragraph 92 above to future sessions of the Conference of the Parties, and that this work be concluded no later than 2018;

98. *Decides* that the modalities, procedures and guidelines developed under paragraph 92 above, shall be applied upon the entry into force of the Paris Agreement;

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99. *Also decides* that the modalities, procedures and guidelines of this transparency framework shall build upon and eventually supercede the measurement, reporting and verification system established by paragraphs 40 to 47 and 60 to 64 of decision 1/CP.16 and paragraph 12 to 62 of decision 2/CP.17 immediately following the submission of the final biennial reports and biennial update reports;

GLOBAL STOCKTAKE

100. *Requests* the Ad Hoc Working Group on the Paris Agreement to identify the sources of input for the global stocktake referred to in Article 14 of the Agreement and to report to the Conference of the Parties, with a view to the Conference of the Parties making a recommendation to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for consideration and adoption at its first session, including, but not limited to:

- (a) Information on:
 - (i) The overall effect of the nationally determined contributions communicated by Parties;
 - (ii) The state of adaptation efforts, support, experiences and priorities from the communications referred to in Article 7, paragraphs 10 and 11, of the Agreement, and reports referred to in Article 13, paragraph 7, of the Agreement;
 - (iii) The mobilization and provision of support;
- (b) The latest reports of the Intergovernmental Panel on Climate Change;
- (c) Reports of the subsidiary bodies;

101. *Also requests* the Subsidiary Body for Scientific and Technological Advice to provide advice on how the assessments of the Intergovernmental Panel on Climate Change can inform the global stocktake of the implementation of the Agreement pursuant to its Article 14 of the Agreement and to report on this matter to the Ad Hoc Working Group on the Paris Agreement at its second session;

102. *Further requests* the Ad Hoc Working Group on the Paris Agreement to develop modalities for the global stocktake referred to in Article 14 of the Agreement and to report to the Conference of the Parties, with a view to making a recommendation to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for consideration and adoption at its first session;

FACILITATING IMPLEMENTATION AND COMPLIANCE

103. *Decides* that the committee referred to in Article 15, paragraph 2, of the Agreement shall consist of 12 members with recognized competence in relevant scientific, technical, socio-economic or legal fields, to be elected by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the basis of equitable geographical representation, with two members each from the five regional groups of the United Nations and one member each from the small island developing States and the least developed countries, while taking into account the goal of gender balance;

104. *Requests* the Ad Hoc Working Group on the Paris Agreement to develop the modalities and procedures for the effective operation of the committee referred to in Article 15, paragraph 2, of the Agreement, with a view to the Ad Hoc Working Group on the Paris Agreement completing its work on such modalities and procedures for consideration and adoption by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session;

FINAL CLAUSES

105. *Also requests* the secretariat, solely for the purposes of Article 21 of the Agreement, to make available on its website on the date of adoption of the Agreement as well as in the report of the Conference of the Parties at its twenty-first session, information on the most up-to-date total and per cent of greenhouse gas emissions communicated by Parties to the Convention in their national communications, greenhouse gas inventory reports, biennial reports or biennial update reports;

IV. ENHANCED ACTION PRIOR TO 2020

106. *Resolves* to ensure the highest possible mitigation efforts in the pre-2020 period, including by:

(a) Urging all Parties to the Kyoto Protocol that have not already done so to ratify and implement the Doha Amendment to the Kyoto Protocol;

(b) Urging all Parties that have not already done so to make and implement a mitigation pledge under the Cancun Agreements;

(c) Reiterating its resolve, as set out in decision 1/CP.19, paragraphs 3 and 4, to accelerate the full implementation of the decisions constituting the agreed outcome pursuant to decision 1/CP.13 and enhance ambition in the pre-2020 period in order to ensure the highest possible mitigation efforts under the Convention by all Parties;

(d) Inviting developing country Parties that have not submitted their first biennial update reports to do so as soon as possible;

(e) Urging all Parties to participate in the existing measurement, reporting and verification processes under the Cancun Agreements, in a timely manner, with a view to demonstrating progress made in the implementation of their mitigation pledges;

107. *Encourages* Parties to promote the voluntary cancellation by Party and non-Party stakeholders, without double counting of units issued under the Kyoto Protocol, including certified emission reductions that are valid for the second commitment period;

108. *Urges* host and purchasing Parties to report transparently on internationally transferred mitigation outcomes, including outcomes used to meet international pledges, and emission units issued under the Kyoto Protocol with a view to promoting environmental integrity and avoiding double counting;

109. *Recognizes* the social, economic and environmental value of voluntary mitigation actions and their co-benefits for adaptation, health and sustainable development;

110. *Resolves* to strengthen, in the period 2016–2020, the existing technical examination process on mitigation as defined in decision 1/CP.19, paragraph 5(a), and decision 1/CP.20, paragraph 19, taking into account the latest scientific knowledge, including by:

(a) Encouraging Parties, Convention bodies and international organizations to engage in this process, including, as appropriate, in cooperation with relevant non-Party stakeholders, to share their experiences and suggestions, including from regional events, and to cooperate in facilitating the implementation of policies, practices and actions identified during this process in accordance with national sustainable development priorities;

(b) Striving to improve, in consultation with Parties, access to and participation in this process by developing country Party and non-Party experts;

(c) Requesting the Technology Executive Committee and the Climate Technology Centre and Network in accordance with their respective mandates:

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- (i) To engage in the technical expert meetings and enhance their efforts to facilitate and support Parties in scaling up the implementation of policies, practices and actions identified during this process;
 - (ii) To provide regular updates during the technical expert meetings on the progress made in facilitating the implementation of policies, practices and actions previously identified during this process;
 - (iii) To include information on their activities under this process in their joint annual report to the Conference of the Parties;
- (d) Encouraging Parties to make effective use of the Climate Technology Centre and Network to obtain assistance to develop economically, environmentally and socially viable project proposals in the high mitigation potential areas identified in this process;

111. *Encourages* the operating entities of the Financial Mechanism of the Convention to engage in the technical expert meetings and to inform participants of their contribution to facilitating progress in the implementation of policies, practices and actions identified during the technical examination process;

112. *Requests* the secretariat to organize the process referred to in paragraph 110 above and disseminate its results, including by:

(a) Organizing, in consultation with the Technology Executive Committee and relevant expert organizations, regular technical expert meetings focusing on specific policies, practices and actions representing best practices and with the potential to be scalable and replicable;

(b) Updating, on an annual basis, following the meetings referred to in paragraph 112(a) above and in time to serve as input to the summary for policymakers referred to in paragraph 112(c) below, a technical paper on the mitigation benefits and co-benefits of policies, practices and actions for enhancing mitigation ambition, as well as on options for supporting their implementation, information on which should be made available in a user-friendly online format;

(c) Preparing, in consultation with the champions referred to in paragraph 122 below, a summary for policymakers, with information on specific policies, practices and actions representing best practices and with the potential to be scalable and replicable, and on options to support their implementation, as well as on relevant collaborative initiatives, and publishing the summary at least two months in advance of each session of the Conference of the Parties as input for the high-level event referred to in paragraph 121 below;

113. *Decides* that the process referred to in paragraph 110 above should be organized jointly by the Subsidiary Body for Implementation and the Subsidiary Body for Scientific and Technological Advice and should take place on an ongoing basis until 2020;

114. *Also decides* to conduct in 2017 an assessment of the process referred to in paragraph 110 above so as to improve its effectiveness;

115. *Resolves* to enhance the provision of urgent and adequate finance, technology and capacity-building support by developed country Parties in order to enhance the level of ambition of pre-2020 action by Parties, and in this regard *strongly urges* developed country Parties to scale up their level of financial support, with a concrete roadmap to achieve the goal of jointly providing USD 100 billion annually by 2020 for mitigation and adaptation while significantly increasing adaptation finance from current levels and to further provide appropriate technology and capacity-building support;

116. *Decides* to conduct a facilitative dialogue in conjunction with the twenty-second session of the Conference of the Parties to assess the progress in implementing decision 1/CP.19, paragraphs 3 and 4, and identify relevant opportunities to enhance the provision of financial resources, including for technology development and transfer and capacity-building support, with a view to identifying ways to enhance the ambition of mitigation efforts by all Parties, including identifying relevant opportunities to enhance the provision and mobilization of support and enabling environments;

117. *Acknowledges* with appreciation the results of the Lima-Paris Action Agenda, which build on the climate summit convened on 23 September 2014 by the Secretary-General of the United Nations;

118. *Welcomes* the efforts of non-Party stakeholders to scale up their climate actions, and *encourages* the registration of those actions in the Non-State Actor Zone for Climate Action platform;³

119. *Encourages* Parties to work closely with non-Party stakeholders to catalyse efforts to strengthen mitigation and adaptation action;

120. *Also encourages* non-Party stakeholders to increase their engagement in the processes referred to in paragraph 110 above and paragraph 125 below;

121. *Agrees* to convene, pursuant to decision 1/CP.20, paragraph 21, building on the Lima-Paris Action Agenda and in conjunction with each session of the Conference of the Parties during the period 2016–2020, a high-level event that:

(a) Further strengthens high-level engagement on the implementation of policy options and actions arising from the processes referred to in paragraph 110 above and paragraph below, drawing on the summary for policymakers referred to in paragraph 112(c) above;

(b) Provides an opportunity for announcing new or strengthened voluntary efforts, initiatives and coalitions, including the implementation of policies, practices and actions arising from the processes referred to in paragraph 110 above and paragraph 125 below and presented in the summary for policymakers referred to in paragraph 112(c) above;

(c) Takes stock of related progress and recognizes new or strengthened voluntary efforts, initiatives and coalitions;

(d) Provides meaningful and regular opportunities for the effective high-level engagement of dignitaries of Parties, international organizations, international cooperative initiatives and non-Party stakeholders;

122. *Decides* that two high-level champions shall be appointed to act on behalf of the President of the Conference of the Parties to facilitate through strengthened high-level engagement in the period 2016–2020 the successful execution of existing efforts and the scaling-up and introduction of new or strengthened voluntary efforts, initiatives and coalitions, including by:

(a) Working with the Executive Secretary and the current and incoming Presidents of the Conference of the Parties to coordinate the annual high-level event referred to in paragraph 121 above;

(b) Engaging with interested Parties and non-Party stakeholders, including to further the voluntary initiatives of the Lima-Paris Action Agenda;

³ <<http://climateaction.unfccc.int/>>.

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(c) Providing guidance to the secretariat on the organization of technical expert meetings referred to in paragraph 112(a) above and paragraph 130(a) below;

123. *Also decides* that the high-level champions referred to in paragraph 122 above should normally serve for a term of two years, with their terms overlapping for a full year to ensure continuity, such that:

(a) The President of the Conference of the Parties of the twenty-first session should appoint one champion, who should serve for one year from the date of the appointment until the last day of the Conference of the Parties at its twenty-second session;

(b) The President of the Conference of the Parties of the twenty-second session should appoint one champion who should serve for two years from the date of the appointment until the last day of the Conference of the Parties at its twenty-third session (November 2017);

(c) Thereafter, each subsequent President of the Conference of the Parties should appoint one champion who should serve for two years and succeed the previously appointed champion whose term has ended;

124. *Invites* all interested Parties and relevant organizations to provide support for the work of the champions referred to in paragraph 122 above;

125. *Decides* to launch, in the period 2016–2020, a technical examination process on adaptation;

126. *Also decides* that the technical examination process on adaptation referred to in paragraph 125 above will endeavour to identify concrete opportunities for strengthening resilience, reducing vulnerabilities and increasing the understanding and implementation of adaptation actions;

127. *Further decides* that the technical examination process referred to in paragraph 125 above should be organized jointly by the Subsidiary Body for Implementation and the Subsidiary Body for Scientific and Technological Advice, and conducted by the Adaptation Committee;

128. *Decides* that the process referred to in paragraph 125 above will be pursued by:

(a) Facilitating the sharing of good practices, experiences and lessons learned;

(b) Identifying actions that could significantly enhance the implementation of adaptation actions, including actions that could enhance economic diversification and have mitigation co-benefits;

(c) Promoting cooperative action on adaptation;

(d) Identifying opportunities to strengthen enabling environments and enhance the provision of support for adaptation in the context of specific policies, practices and actions;

129. *Also decides* that the technical examination process on adaptation referred to in paragraph 125 above will take into account the process, modalities, outputs, outcomes and lessons learned from the technical examination process on mitigation referred to in paragraph 110 above;

130. *Requests* the secretariat to support the technical examination process referred to in paragraph 125 above by:

(a) Organizing regular technical expert meetings focusing on specific policies, strategies and actions;

(b) Preparing annually, on the basis of the meetings referred to in paragraph 130(a) above and in time to serve as an input to the summary for policymakers referred to in paragraph 112(c) above, a technical paper on opportunities to enhance adaptation action, as well as options to support their implementation, information on which should be made available in a user-friendly online format;

131. *Decides* that in conducting the process referred to in paragraph 125 above, the Adaptation Committee will engage with and explore ways to take into account, synergize with and build on the existing arrangements for adaptation-related work programmes, bodies and institutions under the Convention so as to ensure coherence and maximum value;

132. *Also decides* to conduct, in conjunction with the assessment referred to in paragraph 120 above, an assessment of the process referred to in paragraph 125 above, so as to improve its effectiveness;

133. *Invites* Parties and observer organizations to submit information on the opportunities referred to in paragraph 126 above by 3 February 2016;

V. NON-PARTY STAKEHOLDERS

134. *Welcomes* the efforts of all non-Party stakeholders to address and respond to climate change, including those of civil society, the private sector, financial institutions, cities and other subnational authorities;

135. *Invites* the non-Party stakeholders referred to in paragraph 134 above to scale up their efforts and support actions to reduce emissions and/or to build resilience and decrease vulnerability to the adverse effects of climate change and demonstrate these efforts via the Non-State Actor Zone for Climate Action platform⁴ referred to in paragraph 118 above;

136. *Recognizes* the need to strengthen knowledge, technologies, practices and efforts of local communities and indigenous peoples related to addressing and responding to climate change, and *establishes* a platform for the exchange of experiences and sharing of best practices on mitigation and adaptation in a holistic and integrated manner;

137. *Also recognizes* the important role of providing incentives for emission reduction activities, including tools such as domestic policies and carbon pricing;

VI. ADMINISTRATIVE AND BUDGETARY MATTERS

138. *Takes note* of the estimated budgetary implications of the activities to be undertaken by the secretariat referred to in this decision and requests that the actions of the secretariat called for in this decision be undertaken subject to the availability of financial resources;

139. *Emphasizes* the urgency of making additional resources available for the implementation of the relevant actions, including actions referred to in this decision, and the implementation of the work programme referred to in paragraph 9 above;

140. *Urges* Parties to make voluntary contributions for the timely implementation of this decision.

⁴ <<http://climateaction.unfccc.int/>>.

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Annex

PARIS AGREEMENT

The Parties to this Agreement,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as “the Convention”,

Pursuant to the Durban Platform for Enhanced Action established by decision 1/CP.17 of the Conference of the Parties to the Convention at its seventeenth session,

In pursuit of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances,

Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge,

Also recognizing the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, as provided for in the Convention,

Taking full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology,

Recognizing that Parties may be affected not only by climate change, but also by the impacts of the measures taken in response to it,

Emphasizing the intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty,

Recognizing the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change,

Taking into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities,

Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity,

Recognizing the importance of the conservation and enhancement, as appropriate, of sinks and reservoirs of the greenhouse gases referred to in the Convention,

Noting the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognized by some cultures as Mother Earth, and noting the importance for some of the concept of “climate justice”, when taking action to address climate change,

Affirming the importance of education, training, public awareness, public participation, public access to information and cooperation at all levels on the matters addressed in this Agreement,

Recognizing the importance of the engagements of all levels of government and various actors, in accordance with respective national legislations of Parties, in addressing climate change,

Also recognizing that sustainable lifestyles and sustainable patterns of consumption and production, with developed country Parties taking the lead, play an important role in addressing climate change.

Have agreed as follows:

Article 1

For the purpose of this Agreement, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
2. "Conference of the Parties" means the Conference of the Parties to the Convention.
3. "Party" means a Party to this Agreement.

Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
 - (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
 - (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
 - (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.
2. This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

Article 3

As nationally determined contributions to the global response to climate change, all Parties are to undertake and communicate ambitious efforts as defined in Articles 4, 7, 9, 10, 11 and 13 with the view to achieving the purpose of this Agreement as set out in Article 2. The efforts of all Parties will represent a progression over time, while recognizing the need to support developing country Parties for the effective implementation of this Agreement.

Article 4

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.
2. Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures with the aim of achieving the objectives of such contributions.
3. Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.
4. Developed country Parties shall continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances.
5. Support shall be provided to developing country Parties for the implementation of this Article, in accordance with Articles 9, 10 and 11, recognizing that enhanced support for developing country Parties will allow for higher ambition in their actions.

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6. The least developed countries and small island developing States may prepare and communicate strategies, plans and actions for low greenhouse gas emissions development reflecting their special circumstances.
7. Mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans can contribute to mitigation outcomes under this Article.
8. In communicating their nationally determined contributions, all Parties shall provide the information necessary for clarity, transparency and understanding in accordance with decision 1/CP.21 and any relevant decisions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
9. Each Party shall communicate a nationally determined contribution every five years in accordance with decision 1/CP.21 and any relevant decisions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement and be informed by the outcomes of the global stocktake referred to in Article 14.
10. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall consider common time frames for nationally determined contributions at its first session.
11. A Party may at any time adjust its existing nationally determined contribution with a view to enhancing its level of ambition, in accordance with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
12. Nationally determined contributions communicated by Parties shall be recorded in a public registry maintained by the secretariat.
13. Parties shall account for their nationally determined contributions. In accounting for anthropogenic emissions and removals corresponding to their nationally determined contributions, Parties shall promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting, in accordance with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
14. In the context of their nationally determined contributions, when recognizing and implementing mitigation actions with respect to anthropogenic emissions and removals, Parties should take into account, as appropriate, existing methods and guidance under the Convention, in the light of the provisions of paragraph 13 of this Article.
15. Parties shall take into consideration in the implementation of this Agreement the concerns of Parties with economies most affected by the impacts of response measures, particularly developing country Parties.
16. Parties, including regional economic integration organizations and their member States, that have reached an agreement to act jointly under paragraph 2 of this Article shall notify the secretariat of the terms of that agreement, including the emission level allocated to each Party within the relevant time period, when they communicate their nationally determined contributions. The secretariat shall in turn inform the Parties and signatories to the Convention of the terms of that agreement.
17. Each party to such an agreement shall be responsible for its emission level as set out in the agreement referred to in paragraph 16 above in accordance with paragraphs 13 and 14 of this Article and Articles 13 and 15.
18. If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization which is itself a Party to this Agreement, each member State of that regional economic integration organization individually, and together with the regional economic integration organization, shall be responsible for its emission level as set out in the agreement communicated under paragraph 16 of this Article in accordance with paragraphs 13 and 14 of this Article and Articles 13 and 15.
19. All Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

Article 5

1. Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases as referred to in Article 4, paragraph 1(d), of the Convention, including forests.
2. Parties are encouraged to take action to implement and support, including through results-based payments, the existing framework as set out in related guidance and decisions already agreed under the Convention for: policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon

stocks in developing countries; and alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests, while reaffirming the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches.

Article 6

1. Parties recognize that some Parties choose to pursue voluntary cooperation in the implementation of their nationally determined contributions to allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity.
2. Parties shall, where engaging on a voluntary basis in cooperative approaches that involve the use of internationally transferred mitigation outcomes towards nationally determined contributions, promote sustainable development and ensure environmental integrity and transparency, including in governance, and shall apply robust accounting to ensure, inter alia, the avoidance of double counting, consistent with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
3. The use of internationally transferred mitigation outcomes to achieve nationally determined contributions under this Agreement shall be voluntary and authorized by participating Parties.
4. A mechanism to contribute to the mitigation of greenhouse gas emissions and support sustainable development is hereby established under the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement for use by Parties on a voluntary basis. It shall be supervised by a body designated by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, and shall aim:
 - (a) To promote the mitigation of greenhouse gas emissions while fostering sustainable development;
 - (b) To incentivize and facilitate participation in the mitigation of greenhouse gas emissions by public and private entities authorized by a Party;
 - (c) To contribute to the reduction of emission levels in the host Party, which will benefit from mitigation activities resulting in emission reductions that can also be used by another Party to fulfil its nationally determined contribution; and
 - (d) To deliver an overall mitigation in global emissions.
5. Emission reductions resulting from the mechanism referred to in paragraph 4 of this Article shall not be used to demonstrate achievement of the host Party's nationally determined contribution if used by another Party to demonstrate achievement of its nationally determined contribution.
6. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall ensure that a share of the proceeds from activities under the mechanism referred to in paragraph 4 of this Article is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.
7. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall adopt rules, modalities and procedures for the mechanism referred to in paragraph 4 of this Article at its first session.
8. Parties recognize the importance of integrated, holistic and balanced non-market approaches being available to Parties to assist in the implementation of their nationally determined contributions, in the context of sustainable development and poverty eradication, in a coordinated and effective manner, including through, inter alia, mitigation, adaptation, finance, technology transfer and capacity-building, as appropriate. These approaches shall aim to:
 - (a) Promote mitigation and adaptation ambition;
 - (b) Enhance public and private participation in the implementation of nationally determined contributions; and
 - (c) Enable opportunities for coordination across instruments and relevant institutional arrangements.
9. A framework for non-market approaches to sustainable development is hereby defined to promote the non-market approaches referred to in paragraph 8 of this Article.

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Article 7

1. Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2.
2. Parties recognize that adaptation is a global challenge faced by all with local, subnational, national, regional and international dimensions, and that it is a key component of and makes a contribution to the long-term global response to climate change to protect people, livelihoods and ecosystems, taking into account the urgent and immediate needs of those developing country Parties that are particularly vulnerable to the adverse effects of climate change.
3. The adaptation efforts of developing country Parties shall be recognized, in accordance with the modalities to be adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session.
4. Parties recognize that the current need for adaptation is significant and that greater levels of mitigation can reduce the need for additional adaptation efforts, and that greater adaptation needs can involve greater adaptation costs.
5. Parties acknowledge that adaptation action should follow a country-driven, gender-responsive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems, and should be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, with a view to integrating adaptation into relevant socioeconomic and environmental policies and actions, where appropriate.
6. Parties recognize the importance of support for and international cooperation on adaptation efforts and the importance of taking into account the needs of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change.
7. Parties should strengthen their cooperation on enhancing action on adaptation, taking into account the Cancun Adaptation Framework, including with regard to:
 - (a) Sharing information, good practices, experiences and lessons learned, including, as appropriate, as these relate to science, planning, policies and implementation in relation to adaptation actions;
 - (b) Strengthening institutional arrangements, including those under the Convention that serve this Agreement, to support the synthesis of relevant information and knowledge, and the provision of technical support and guidance to Parties;
 - (c) Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making;
 - (d) Assisting developing country Parties in identifying effective adaptation practices, adaptation needs, priorities, support provided and received for adaptation actions and efforts, and challenges and gaps, in a manner consistent with encouraging good practices;
 - (e) Improving the effectiveness and durability of adaptation actions.
8. United Nations specialized organizations and agencies are encouraged to support the efforts of Parties to implement the actions referred to in paragraph 7 of this Article, taking into account the provisions of paragraph 5 of this Article.
9. Each Party shall, as appropriate, engage in adaptation planning processes and the implementation of actions, including the development or enhancement of relevant plans, policies and/or contributions, which may include:
 - (a) The implementation of adaptation actions, undertakings and/or efforts;
 - (b) The process to formulate and implement national adaptation plans;
 - (c) The assessment of climate change impacts and vulnerability, with a view to formulating nationally determined prioritized actions, taking into account vulnerable people, places and ecosystems;
 - (d) Monitoring and evaluating and learning from adaptation plans, policies, programmes and actions; and
 - (e) Building the resilience of socioeconomic and ecological systems, including through economic diversification and sustainable management of natural resources.

10. Each Party should, as appropriate, submit and update periodically an adaptation communication, which may include its priorities, implementation and support needs, plans and actions, without creating any additional burden for developing country Parties.
11. The adaptation communication referred to in paragraph 10 of this Article shall be, as appropriate, submitted and updated periodically, as a component of or in conjunction with other communications or documents, including a national adaptation plan, a nationally determined contribution as referred to in Article 4, paragraph 2, and/or a national communication.
12. The adaptation communications referred to in paragraph 10 of this Article shall be recorded in a public registry maintained by the secretariat.
13. Continuous and enhanced international support shall be provided to developing country Parties for the implementation of paragraphs 7, 9, 10 and 11 of this Article, in accordance with the provisions of Articles 9, 10 and 11.
14. The global stocktake referred to in Article 14 shall, inter alia:
 - (a) Recognize adaptation efforts of developing country Parties;
 - (b) Enhance the implementation of adaptation action taking into account the adaptation communication referred to in paragraph 10 of this Article;
 - (c) Review the adequacy and effectiveness of adaptation and support provided for adaptation; and
 - (d) Review the overall progress made in achieving the global goal on adaptation referred to in paragraph 1 of this Article.

Article 8

1. Parties recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.
2. The Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement and may be enhanced and strengthened, as determined by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
3. Parties should enhance understanding, action and support, including through the Warsaw International Mechanism, as appropriate, on a cooperative and facilitative basis with respect to loss and damage associated with the adverse effects of climate change.
4. Accordingly, areas of cooperation and facilitation to enhance understanding, action and support may include:
 - (a) Early warning systems;
 - (b) Emergency preparedness;
 - (c) Slow onset events;
 - (d) Events that may involve irreversible and permanent loss and damage;
 - (e) Comprehensive risk assessment and management;
 - (f) Risk insurance facilities, climate risk pooling and other insurance solutions;
 - (g) Non-economic losses;
 - (h) Resilience of communities, livelihoods and ecosystems.
5. The Warsaw International Mechanism shall collaborate with existing bodies and expert groups under the Agreement, as well as relevant organizations and expert bodies outside the Agreement.

Article 9

1. Developed country Parties shall provide financial resources to assist developing country Parties with respect to both mitigation and adaptation in continuation of their existing obligations under the Convention.
2. Other Parties are encouraged to provide or continue to provide such support voluntarily.
3. As part of a global effort, developed country Parties should continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of public funds,

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through a variety of actions, including supporting country-driven strategies, and taking into account the needs and priorities of developing country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts.

4. The provision of scaled-up financial resources should aim to achieve a balance between adaptation and mitigation, taking into account country-driven strategies, and the priorities and needs of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change and have significant capacity constraints, such as the least developed countries and small island developing States, considering the need for public and grant-based resources for adaptation.
5. Developed country Parties shall biennially communicate indicative quantitative and qualitative information related to paragraphs 1 and 3 of this Article, as applicable, including, as available, projected levels of public financial resources to be provided to developing country Parties. Other Parties providing resources are encouraged to communicate biennially such information on a voluntary basis.
6. The global stocktake referred to in Article 14 shall take into account the relevant information provided by developed country Parties and/or Agreement bodies on efforts related to climate finance.
7. Developed country Parties shall provide transparent and consistent information on support for developing country Parties provided and mobilized through public interventions biennially in accordance with the modalities, procedures and guidelines to be adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, at its first session, as stipulated in Article 13, paragraph 13. Other Parties are encouraged to do so.
8. The Financial Mechanism of the Convention, including its operating entities, shall serve as the financial mechanism of this Agreement.
9. The institutions serving this Agreement, including the operating entities of the Financial Mechanism of the Convention, shall aim to ensure efficient access to financial resources through simplified approval procedures and enhanced readiness support for developing country Parties, in particular for the least developed countries and small island developing States, in the context of their national climate strategies and plans.

Article 10

1. Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions.
2. Parties, noting the importance of technology for the implementation of mitigation and adaptation actions under this Agreement and recognizing existing technology deployment and dissemination efforts, shall strengthen cooperative action on technology development and transfer.
3. The Technology Mechanism established under the Convention shall serve this Agreement.
4. A technology framework is hereby established to provide overarching guidance for the work of the Technology Mechanism in promoting and facilitating enhanced action on technology development and transfer in order to support the implementation of this Agreement, in pursuit of the long-term vision referred to in paragraph 1 of this Article.
5. Accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Such effort shall be, as appropriate, supported, including by the Technology Mechanism and, through financial means, by the Financial Mechanism of the Convention, for collaborative approaches to research and development, and facilitating access to technology, in particular for early stages of the technology cycle, to developing country Parties.
6. Support, including financial support, shall be provided to developing country Parties for the implementation of this Article, including for strengthening cooperative action on technology development and transfer at different stages of the technology cycle, with a view to achieving a balance between support for mitigation and adaptation. The global stocktake referred to in Article 14 shall take into account available information on efforts related to support on technology development and transfer for developing country Parties.

Article 11

1. Capacity-building under this Agreement should enhance the capacity and ability of developing country Parties, in particular countries with the least capacity, such as the least developed countries, and those that are particularly vulnerable to the adverse effects of climate change, such as small island developing States, to take

- effective climate change action, including, inter alia, to implement adaptation and mitigation actions, and should facilitate technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information.
2. Capacity-building should be country-driven, based on and responsive to national needs, and foster country ownership of Parties, in particular, for developing country Parties, including at the national, subnational and local levels. Capacity-building should be guided by lessons learned, including those from capacity-building activities under the Convention, and should be an effective, iterative process that is participatory, cross-cutting and gender-responsive.
 3. All Parties should cooperate to enhance the capacity of developing country Parties to implement this Agreement. Developed country Parties should enhance support for capacity-building actions in developing country Parties.
 4. All Parties enhancing the capacity of developing country Parties to implement this Agreement, including through regional, bilateral and multilateral approaches, shall regularly communicate on these actions or measures on capacity-building. Developing country Parties should regularly communicate progress made on implementing capacity-building plans, policies, actions or measures to implement this Agreement.
 5. Capacity-building activities shall be enhanced through appropriate institutional arrangements to support the implementation of this Agreement, including the appropriate institutional arrangements established under the Convention that serve this Agreement. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall, at its first session, consider and adopt a decision on the initial institutional arrangements for capacity-building.

Article 12

Parties shall cooperate in taking measures, as appropriate, to enhance climate change education, training, public awareness, public participation and public access to information, recognizing the importance of these steps with respect to enhancing actions under this Agreement.

Article 13

1. In order to build mutual trust and confidence and to promote effective implementation, an enhanced transparency framework for action and support, with built-in flexibility which takes into account Parties' different capacities and builds upon collective experience is hereby established.
2. The transparency framework shall provide flexibility in the implementation of the provisions of this Article to those developing country Parties that need it in the light of their capacities. The modalities, procedures and guidelines referred to in paragraph 13 of this Article shall reflect such flexibility.
3. The transparency framework shall build on and enhance the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries and small island developing States, and be implemented in a facilitative, non-intrusive, non-punitive manner, respectful of national sovereignty, and avoid placing undue burden on Parties.
4. The transparency arrangements under the Convention, including national communications, biennial reports and biennial update reports, international assessment and review and international consultation and analysis, shall form part of the experience drawn upon for the development of the modalities, procedures and guidelines under paragraph 13 of this Article.
5. The purpose of the framework for transparency of action is to provide a clear understanding of climate change action in the light of the objective of the Convention as set out in its Article 2, including clarity and tracking of progress towards achieving Parties' individual nationally determined contributions under Article 4, and Parties' adaptation actions under Article 7, including good practices, priorities, needs and gaps, to inform the global stocktake under Article 14.
6. The purpose of the framework for transparency of support is to provide clarity on support provided and received by relevant individual Parties in the context of climate change actions under Articles 4, 7, 9, 10 and 11, and, to the extent possible, to provide a full overview of aggregate financial support provided, to inform the global stocktake under Article 14.
7. Each Party shall regularly provide the following information:

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- (a) A national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;
 - (b) Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4.
8. Each Party should also provide information related to climate change impacts and adaptation under Article 7, as appropriate.
9. Developed country Parties shall, and other Parties that provide support should, provide information on financial, technology transfer and capacity-building support provided to developing country Parties under Article 9, 10 and 11.
10. Developing country Parties should provide information on financial, technology transfer and capacity-building support needed and received under Articles 9, 10 and 11.
11. Information submitted by each Party under paragraphs 7 and 9 of this Article shall undergo a technical expert review, in accordance with decision 1/CP.21. For those developing country Parties that need it in the light of their capacities, the review process shall include assistance in identifying capacity-building needs. In addition, each Party shall participate in a facilitative, multilateral consideration of progress with respect to efforts under Article 9, and its respective implementation and achievement of its nationally determined contribution.
12. The technical expert review under this paragraph shall consist of a consideration of the Party's support provided, as relevant, and its implementation and achievement of its nationally determined contribution. The review shall also identify areas of improvement for the Party, and include a review of the consistency of the information with the modalities, procedures and guidelines referred to in paragraph 13 of this Article, taking into account the flexibility accorded to the Party under paragraph 2 of this Article. The review shall pay particular attention to the respective national capabilities and circumstances of developing country Parties.
13. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall, at its first session, building on experience from the arrangements related to transparency under the Convention, and elaborating on the provisions in this Article, adopt common modalities, procedures and guidelines, as appropriate, for the transparency of action and support.
14. Support shall be provided to developing countries for the implementation of this Article.
15. Support shall also be provided for the building of transparency-related capacity of developing country Parties on a continuous basis.

Article 14

1. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall periodically take stock of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals (referred to as the "global stocktake"). It shall do so in a comprehensive and facilitative manner, considering mitigation, adaptation and the means of implementation and support, and in the light of equity and the best available science.
2. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall undertake its first global stocktake in 2023 and every five years thereafter unless otherwise decided by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
3. The outcome of the global stocktake shall inform Parties in updating and enhancing, in a nationally determined manner, their actions and support in accordance with the relevant provisions of this Agreement, as well as in enhancing international cooperation for climate action.

Article 15

1. A mechanism to facilitate implementation of and promote compliance with the provisions of this Agreement is hereby established.
2. The mechanism referred to in paragraph 1 of this Article shall consist of a committee that shall be expert-based and facilitative in nature and function in a manner that is transparent, non-adversarial and non-punitive. The committee shall pay particular attention to the respective national capabilities and circumstances of Parties.

3. The committee shall operate under the modalities and procedures adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its first session and report annually to the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.

Article 16

1. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to this Agreement.
2. Parties to the Convention that are not Parties to this Agreement may participate as observers in the proceedings of any session of the Conference of the Parties serving as the meeting of the Parties to this Agreement. When the Conference of the Parties serves as the meeting of the Parties to this Agreement, decisions under this Agreement shall be taken only by those that are Parties to this Agreement.
3. When the Conference of the Parties serves as the meeting of the Parties to this Agreement, any member of the Bureau of the Conference of the Parties representing a Party to the Convention but, at that time, not a Party to this Agreement, shall be replaced by an additional member to be elected by and from amongst the Parties to this Agreement.
4. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall keep under regular review the implementation of this Agreement and shall make, within its mandate, the decisions necessary to promote its effective implementation. It shall perform the functions assigned to it by this Agreement and shall:
 - (a) Establish such subsidiary bodies as deemed necessary for the implementation of this Agreement; and
 - (b) Exercise such other functions as may be required for the implementation of this Agreement.
5. The rules of procedure of the Conference of the Parties and the financial procedures applied under the Convention shall be applied mutatis mutandis under this Agreement, except as may be otherwise decided by consensus by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
6. The first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall be convened by the secretariat in conjunction with the first session of the Conference of the Parties that is scheduled after the date of entry into force of this Agreement. Subsequent ordinary sessions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall be held in conjunction with ordinary sessions of the Conference of the Parties, unless otherwise decided by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
7. Extraordinary sessions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall be held at such other times as may be deemed necessary by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement or at the written request of any Party, provided that, within six months of the request being communicated to the Parties by the secretariat, it is supported by at least one third of the Parties.
8. The United Nations and its specialized agencies and the International Atomic Energy Agency, as well as any State member thereof or observers thereto not party to the Convention, may be represented at sessions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement as observers. Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by this Agreement and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure referred to in paragraph 5 of this Article.

Article 17

1. The secretariat established by Article 8 of the Convention shall serve as the secretariat of this Agreement.
2. Article 8, paragraph 2, of the Convention on the functions of the secretariat, and Article 8, paragraph 3, of the Convention, on the arrangements made for the functioning of the secretariat, shall apply mutatis mutandis to this Agreement. The secretariat shall, in addition, exercise the functions assigned to it under this Agreement and by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.

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Article 18

1. The Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation established by Articles 9 and 10 of the Convention shall serve, respectively, as the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Agreement. The provisions of the Convention relating to the functioning of these two bodies shall apply *mutatis mutandis* to this Agreement. Sessions of the meetings of the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Agreement shall be held in conjunction with the meetings of, respectively, the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of the Convention.
2. Parties to the Convention that are not Parties to this Agreement may participate as observers in the proceedings of any session of the subsidiary bodies. When the subsidiary bodies serve as the subsidiary bodies of this Agreement, decisions under this Agreement shall be taken only by those that are Parties to this Agreement.
3. When the subsidiary bodies established by Articles 9 and 10 of the Convention exercise their functions with regard to matters concerning this Agreement, any member of the bureaux of those subsidiary bodies representing a Party to the Convention but, at that time, not a Party to this Agreement, shall be replaced by an additional member to be elected by and from amongst the Parties to this Agreement.

Article 19

1. Subsidiary bodies or other institutional arrangements established by or under the Convention, other than those referred to in this Agreement, shall serve this Agreement upon a decision of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall specify the functions to be exercised by such subsidiary bodies or arrangements.
2. The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement may provide further guidance to such subsidiary bodies and institutional arrangements.

Article 20

1. This Agreement shall be open for signature and subject to ratification, acceptance or approval by States and regional economic integration organizations that are Parties to the Convention. It shall be open for signature at the United Nations Headquarters in New York from 22 April 2016 to 21 April 2017. Thereafter, this Agreement shall be open for accession from the day following the date on which it is closed for signature. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.
2. Any regional economic integration organization that becomes a Party to this Agreement without any of its member States being a Party shall be bound by all the obligations under this Agreement. In the case of regional economic integration organizations with one or more member States that are Parties to this Agreement, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under this Agreement. In such cases, the organization and the member States shall not be entitled to exercise rights under this Agreement concurrently.
3. In their instruments of ratification, acceptance, approval or accession, regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by this Agreement. These organizations shall also inform the Depositary, who shall in turn inform the Parties, of any substantial modification in the extent of their competence.

Article 21

1. This Agreement shall enter into force on the thirtieth day after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 percent of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession.
2. Solely for the limited purpose of paragraph 1 of this Article, "total global greenhouse gas emissions" means the most up-to-date amount communicated on or before the date of adoption of this Agreement by the Parties to the Convention.
3. For each State or regional economic integration organization that ratifies, accepts or approves this Agreement or accedes thereto after the conditions set out in paragraph 1 of this Article for entry into force have been fulfilled,

this Agreement shall enter into force on the thirtieth day after the date of deposit by such State or regional economic integration organization of its instrument of ratification, acceptance, approval or accession.

4. For the purposes of paragraph 1 of this Article, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by its member States.

Article 22

The provisions of Article 15 of the Convention on the adoption of amendments to the Convention shall apply mutatis mutandis to this Agreement.

Article 23

1. The provisions of Article 16 of the Convention on the adoption and amendment of annexes to the Convention shall apply mutatis mutandis to this Agreement.
2. Annexes to this Agreement shall form an integral part thereof and, unless otherwise expressly provided for, a reference to this Agreement constitutes at the same time a reference to any annexes thereto. Such annexes shall be restricted to lists, forms and any other material of a descriptive nature that is of a scientific, technical, procedural or administrative character.

Article 24

The provisions of Article 14 of the Convention on settlement of disputes shall apply mutatis mutandis to this Agreement.

Article 25

1. Each Party shall have one vote, except as provided for paragraph 2 of this Article.
2. Regional economic integration organizations, in matters within their competence, shall exercise their right to vote with a number of votes equal to the number of their member States that are Parties to this Agreement. Such an organization shall not exercise its right to vote if any of its member States exercises its right, and vice versa.

Article 26

The Secretary-General of the United Nations shall be the Depositary of this Agreement.

Article 27

No reservations may be made to this Agreement.

Article 28

1. At any time after three years from the date on which this Agreement has entered into force for a Party, that Party may withdraw from this Agreement by giving written notification to the Depositary.
2. Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.
3. Any Party that withdraws from the Convention shall be considered as also having withdrawn from this Agreement.

Article 29

The original of this Agreement, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

DONE at Paris this twelfth day of December two thousand and fifteen.

IN WITNESS WHEREOF, the undersigned, being duly authorized to that effect, have signed this Agreement.

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Exhibit 7

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Office of the Press Secretary

For Immediate Release

October 05, 2016

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Remarks by the President on the Paris Agreement



Rose Garden



**Please see below for a correction, marked with an asterisk.

3:30 P.M. EDT

THE PRESIDENT: Good afternoon, everybody. Today is a historic day in the fight to protect our planet for future generations.

Ten months ago, in Paris, I said before the world that we needed a strong global agreement to reduce carbon pollution and to set the world on a low-carbon course. The result was the Paris Agreement. Last month, the United States and China -- the world's two largest economies and largest emitters -- formally joined that agreement together. And today, the world has officially crossed the threshold for the Paris Agreement to take effect.

Today, the world meets the moment. And if we follow through on the commitments that this agreement embodies, history may well judge it as a turning point for our planet.

Of course, it took a long time to reach this day. One of the reasons I ran for this office was to make America a leader in this mission. And over the past eight years, we've done just that. In 2009, we salvaged a chaotic climate summit in Copenhagen, establishing the principle that all nations have a role to play in combating climate change. And at home, we led by example, with historic investments in growing industries like wind and solar that created a steady stream of new jobs. We set the first-ever nationwide standards to limit the amount of carbon pollution that power plants can dump into the air our children breathe. From the cars and trucks we drive to the homes and businesses in which we live and work, we've changed fundamentally the way we consume energy.

Now, keep in mind, the skeptics said these actions would kill jobs. And instead, we saw -- even as we were bringing down these carbon levels -- the longest streak of job creation in American history. We drove economic output to new highs. And we drove our carbon pollution to its lowest levels in two decades.

We continued to lead by example with our historic joint announcement with China two years ago, where we put forward even more ambitious climate

targets. And that achievement encouraged dozens of other countries to set more ambitious climate targets of their own. And that, in turn, paved the way for our success in Paris -- the idea that no nation, not even one as powerful as ours, can solve this challenge alone. All of us have to solve it together.

Now, the Paris Agreement alone will not solve the climate crisis. Even if we meet every target embodied in the agreement, we'll only get to part of where we need to go. But make no mistake, this agreement will help delay or avoid some of the worst consequences of climate change. It will help other nations ratchet down their dangerous carbon emissions over time, and set bolder targets as technology advances, all under a strong system of transparency that allows each nation to evaluate the progress of all other nations. And by sending a signal that this is going to be our future -- a clean energy future -- it opens up the floodgates for businesses, and scientists, and engineers to unleash high-tech, low-carbon investment and innovation at a scale that we've never seen before. So this gives us the best possible shot to save the one planet we've got.

I know diplomacy *can be [isn't always] easy, and progress on the world stage can sometimes be slow. But together, with steady persistent effort, with strong, principled, American leadership, with optimism and faith and hope, we're proving that it is possible.

And I want to embarrass my Senior Advisor, Brian Deese -- who is standing right over there -- because he worked tirelessly to make this deal possible.

He, and John Kerry, Gina McCarthy at the EPA, everybody on their teams have done an extraordinary job to get us to this point -- and America should be as proud of them as I am of them.

I also want to thank the people of every nation that has moved quickly to bring the Paris Agreement into force. I encourage folks who have not yet submitted their documentation to enter into this agreement to do so as soon as possible.

And in the coming days, let's help finish additional agreements to limit aviation emissions, to phase down dangerous use of hydrofluorocarbons -- all of which will help build a world that is safer, and more prosperous, and more secure, and more free than the one that was left for us.

That's our most important mission, to make sure our kids and our grandkids have at least as beautiful a planet, and hopefully more beautiful, than the one

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that we have. And today, I'm a little more confident that we can get the job done.

So thank you very much, everybody.

END

3:35 P.M. EDT



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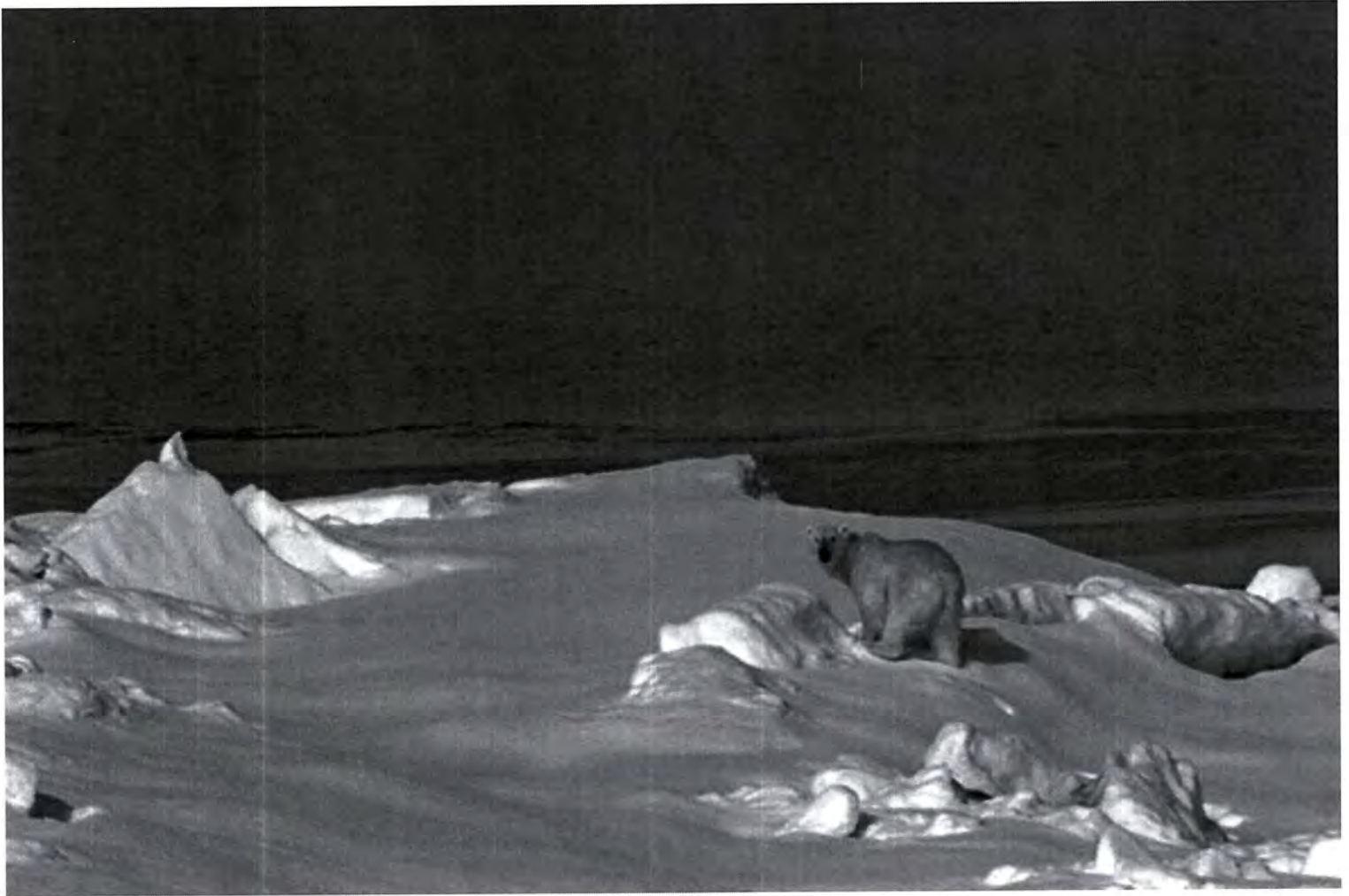
SUSTAINABILITY

Have We Passed the Point of No Return on Climate Change?

Greenhouse gas cuts must begin soon or it could be too late to halt global warming

By EarthTalk on April 13, 2015 23

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If we don't get our carbon emissions in check soon, it could be too late for the polar bear and many other species impacted by global warming. *Credit: Gregory "Slobirdr" Smith, FlickrCC*

Dear EarthTalk: What is the best way to measure how close we are to the dreaded "point of no return" with climate change? In other words, when do we think we will have gone too far? — *David Johnston, via EarthTalk.org*

While we may not yet have reached the “point of no return”—when no amount of cutbacks on greenhouse gas emissions will save us from potentially catastrophic global warming—climate scientists warn we may be getting awfully close. Since the dawn of the Industrial Revolution a century ago, the average global temperature has risen some 1.6 degrees Fahrenheit. Most climatologists agree that, while the warming to date is already causing environmental problems, another 0.4 degree Fahrenheit rise in temperature, representing a global average atmospheric concentration of carbon dioxide (CO₂) of 450 parts per million (ppm), could set in motion unprecedented changes in global climate and a significant

increase in the severity of natural disasters—and as such could represent the dreaded point of no return.

Currently the atmospheric concentration of CO₂ (the leading greenhouse gas) is approximately 398.55 parts per million (ppm). According to the National Oceanic and Atmospheric Administration (NOAA), the federal scientific agency tasked with monitoring the health of our oceans and atmosphere, the current average annual rate of increase of 1.92 ppm means we could reach the point of no return by 2042.

Environmental leaders point out that this doesn't give us much time to turn the tide. Greenpeace, a leading environmental advocacy group, says we have until around 2020 to significantly cut back on greenhouse gas output around the world—to the tune of a five percent annual reduction in emissions overall—if we are to avoid so-called “runaway” climate change. “The world is fast approaching a 'point of no return' beyond which extremely dangerous climate change impacts can become unavoidable,” reports the group. “Within this time period, we will have to radically change our approach to energy production and consumption.”

In a recent lecture at Georgetown University, World Bank president Jim Yong Kim reported that whether we are able to cut emissions enough to prevent catastrophe likely depends on the policies of the world's largest economies and the widespread adoption of so-called carbon pricing systems (such as emissions trading plans and carbon taxes). International negotiators meeting in Paris next December are already working to hammer out an agreement mandating that governments adopt these types of systems to facilitate emissions reductions. “A price on carbon is the single most important thing we have to get out of a Paris agreement,” Kim stated. “It will unleash market forces.”

While carbon pricing will be key to mitigating global warming, Greenpeace adds that stemming the tide of deforestation in the world's tropical rainforests and beyond and adapting our food systems to changing climatic conditions and increasingly limited resources will also be crucial to the health of the planet.

“Without additional mitigation, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally,” reports the Intergovernmental Panel on Climate Change (IPCC), an international group of leading climate experts convened by the United Nations to review and assess the most recent scientific, technical and socio-

economic information on global warming. Indeed, there's no time like the present to start changing our ways.

CONTACTS: NOAA, www.noaa.gov; World Bank, www.worldbank.org; Greenpeace, www.greenpeace.org; IPCC, www.ipcc.ch.

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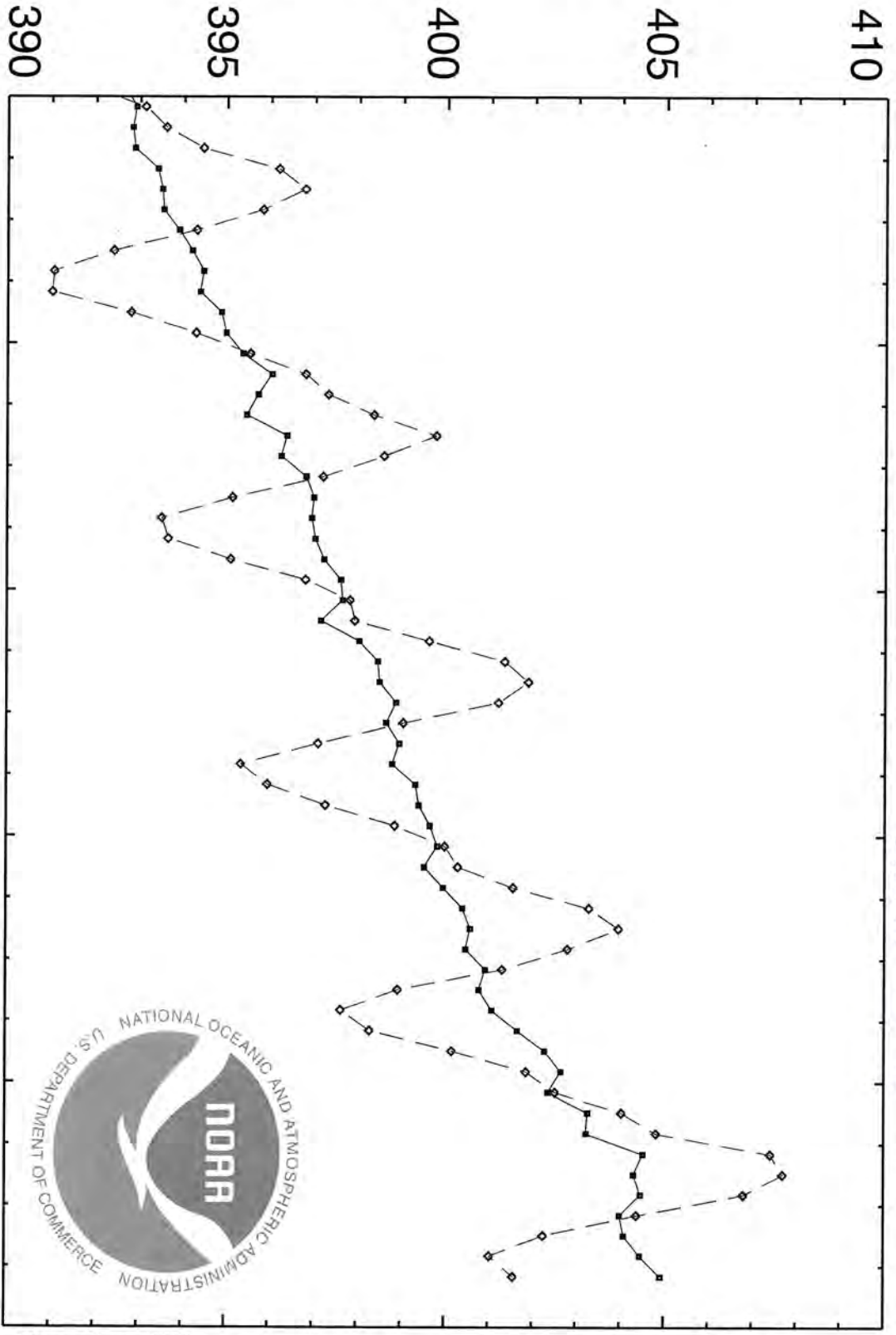
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PARTS PER MILLION



November 2016



2012 2013 2014 2015 2016 2017
YEAR

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Global Analysis - August 2016

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Maps and Time Series

Temperature and Precipitation Maps

August 2016 | June - August 2016

Temperature Anomalies Time Series

August | June - August | Year-to-Date

Introduction | Temperatures | Precipitation | References



August 2016 Selected Climate Anomalies and Events Map

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Introduction

Temperature anomalies and percentiles are shown on the gridded maps below. The anomaly map on the left is a product of a merged land surface temperature (Global Historical Climatology Network, GHCN) and sea surface temperature (ERSST.v4) anomaly analysis as described in Huang et al. (2016). Temperature anomalies for land and ocean are analyzed separately and then merged to form the global analysis. For more information, please visit NCEI's Global Surface Temperature Anomalies page. The percentile map on the right provides additional information by placing the temperature anomaly observed for a specific place and time period into historical perspective, showing how the most current month, season or year compares with the past.

Supplemental August 2016 Information



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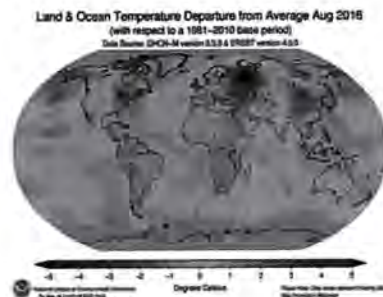
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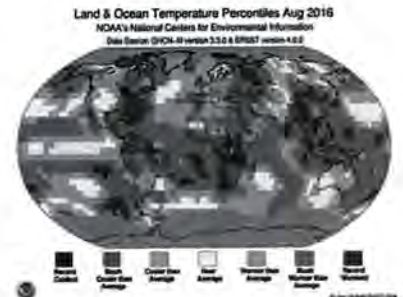
Department of Commerce > NOAA > NESDIS > NCEI > NCDC

In the atmosphere, 500-millibar height pressure anomalies correlate well with temperatures at the Earth's surface. The average position of the upper-level ridges of high pressure and troughs of low pressure—depicted by positive and negative 500-millibar height anomalies on the August 2016 and June–August 2016 maps—is generally reflected by areas of positive and negative temperature anomalies at the surface, respectively.

August



August 2016 Blended Land and Sea Surface Temperature Anomalies in degrees Celsius



August 2016 Blended Land and Sea Surface Temperature Percentiles

The combined average temperature over global land and ocean surfaces for August 2016 was the highest for August in the 137-year period of record, marking the 16th consecutive month of record warmth for the globe. The August 2016 temperature departure of 0.92°C (1.66°F) above the 20th century average of 15.6°C (60.1°F) surpassed the previous record set in 2015 by 0.05°C (0.09°F). August 2016 was also the highest monthly land and ocean temperature departure since April 2016 and tied with September 2015 as the eighth highest monthly temperature departure among all months (1,640) on record. Fourteen of the 15 highest monthly land and ocean temperature departures in the record have occurred since February 2015, with January 2007 among the 15 highest monthly temperature departures.

The average global temperature across land surfaces was 1.29°C (2.32°F) above the 20th century average of 13.8°C (56.9°F)—the highest August global land temperature on record, besting the previous record set in 2015 by 0.19°C (0.34°F). This was also the highest monthly global land temperature departure since April 2016.

Warmer- to much-warmer-than-average conditions were present across much of the world's land surface, with record warmth across the northeastern U.S., northern South America, central and southern Africa, and across parts of western Russia, southern India, China, Southeastern Asia and Indonesia, according to the Land & Ocean Temperature Percentiles map above. Near- to cooler-than-average conditions were observed across the central U.S., northern Mexico, Scandinavia, central and north-central Asia, and western Australia. No land areas experienced record cold temperatures during August 2016. According to NCEI's Global Regional analysis, five of the six continents had at least a top ten warm August, with Africa and Asia observing a record high average temperature for August since continental records began in 1910.

Select national information is highlighted below. Please note that different countries report anomalies with respect to different base periods. The information provided here is based directly upon these data:

- Spain 🇪🇸 had its fifth warmest August since 1961, with an average temperature of 25.2°C (77.4°F) or 1.3°C (2.3°F) above the 1981–2010 average.
- The Kingdom of Bahrain had its second highest mean August temperature since national records began in 1902, with a mean temperature of 36.4°C (97.5°F) or 2.4°C (4.3°F) above average. The nationally-averaged daytime (maximum) and nighttime (minimum) August temperatures were second highest and the highest on record, respectively, since 1946.
- The United Kingdom had a mean temperature of 15.5°C (59.9°F) during August 2016, which is

0.6°C (1.1°F) above the 1981–2010 average. This was the highest August temperature since 2013.

- According to El Centro Internacional para la Investigación del Fenómeno del Niño (CIIFEN), the average monthly temperature across much of South America was predominantly above normal, with temperature departures from average as high as 2.0°C (3.6°F) in eastern Brazil, western Argentina and on the border between Bolivia and Argentina.
- Ontario, Canada, experienced warmer-than-average temperatures during August 2016 with temperature departures ranging between 2°–3°C (3°–5°F).

For the oceans, the August globally-averaged sea surface temperature was 0.77°C (1.39°F) above the 20th century average of 16.4°C (61.4°F), the second highest for August on record, behind 2015 by 0.02°C (0.04°F). August 2016 tied with June 2016 as the 11th highest temperature departure from average among all 1,640 months in the record.

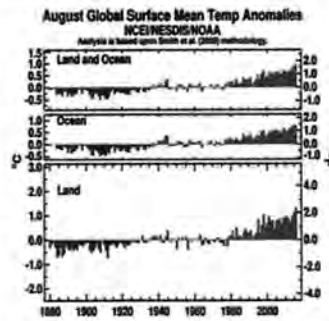
Most of the world's oceans experienced warmer- to much-warmer-than-average temperatures during August 2016, with record warmth present across the northwestern Atlantic Ocean (along the U.S. East coast), the central southern Atlantic Ocean, and across parts of western Indian Ocean and the western and southeastern Pacific Ocean. Cooler-than-average conditions were limited to small areas across the north, central, and southern Pacific Ocean, the southern Atlantic Ocean (southeastern of Argentina), and southeastern Indian Ocean (off the southwestern coast of Australia).

ENSO neutral conditions prevailed during August 2016 even though sea surface temperatures were below-average across the eastern tropical Pacific Ocean. According to NOAA's Climate Prediction Center, ENSO neutral (neither El Niño nor La Niña) is slightly favored, with a 55–60 percent chance, to continue during late Northern Hemisphere fall and winter 2016. This forecast focuses on the ocean surface temperatures between 5°N and 5°S latitude and 170°W to 120°W longitude, called the Niño 3.4 region.

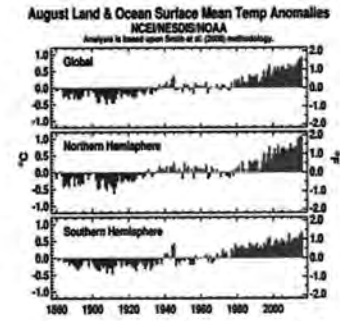
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AUGUST	ANOMALY		RANK (OUT OF 137 YEARS)		RECORDS		
	°C	°F			YEAR(S)	°C	°F
Global							
Land	+1.29 ± 0.22	+2.32 ± 0.40	Warmest	1 st	2016	+1.29	+2.32
			Coollest	137 th	1911	-0.43	-0.77
Ocean	+0.77 ± 0.14	+1.39 ± 0.25	Warmest	2 nd	2015	+0.79	+1.42
			Coollest	136 th	1907	-0.33	-0.59
Land and Ocean	+0.92 ± 0.16	+1.66 ± 0.29	Warmest	1 st	2016	+0.92	+1.66
			Coollest	137 th	1887, 1890, 1893, 1913	-0.33	-0.59
Northern Hemisphere							
Land	+1.28 ± 0.21	+2.30 ± 0.38	Warmest	1 st	2016	+1.28	+2.30
			Coollest	137 th	1875	-0.43	-0.77
Ocean	+0.92 ± 0.13	+1.66 ± 0.23	Warmest	3 rd	2015	+1.03	+1.85
			Coollest	135 th	1890, 1910	-0.44	-0.79
Land and Ocean	+1.06 ± 0.17	+1.91 ± 0.31	Warmest	1 st	2016	+1.06	+1.91
			Coollest	137 th	1890	-0.40	-0.72
Southern Hemisphere							
Land	+1.33 ± 0.17	+2.39 ± 0.31	Warmest	2 nd	2009	+1.43	+2.57

			Coolest	136 th	1924	-0.54	-0.97
Ocean	+0.66 ± 0.15	+1.19 ± 0.27	Warmest	1 st	2016	+0.66	+1.19
			Coolest	137 th	1909	-0.33	-0.59
Land and Ocean	+0.77 ± 0.14	+1.39 ± 0.25	Warmest	1 st	2016	+0.77	+1.39
			Coolest	137 th	1902, 1923	-0.31	-0.56



August Global Land and Ocean plot

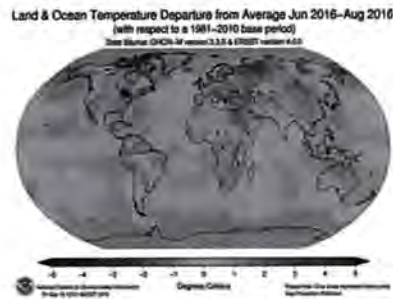


August Global Hemisphere plot

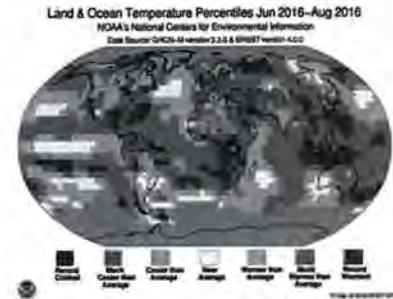
The most current data can be accessed via the Global Surface Temperature Anomalies page.

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Seasonal (June–August)



June–August 2016 Blended Land and Sea Surface Temperature Anomalies in degrees Celsius



June–August 2016 Blended Land and Sea Surface Temperature Percentiles

The June–August seasonal global land and ocean temperature was 0.89°C (1.60°F) above the 20th century average of 15.6°C (60.1°F)—the highest temperature departure from average for June–August in the 1880–2016 record, surpassing the previous record set in 2015 by 0.04°C (0.07°F). June–August 2016 also marks the tenth highest three-month departure for any three-month period on record. The 10 highest three-month temperature departures in the record have all occurred since August–October 2015, when a strong El Niño episode was in place in the tropical Pacific Ocean.

The globally-averaged temperature across land surfaces for June–August was also the highest on record for June–August, at 1.21°C (2.18°F) above the 20th century average of 13.8°C (56.9°F). This surpasses the previous record set in 2015 by 0.11°C (0.20°F). Across the world's oceans, the June–August average sea surface temperature was 0.77°C (1.39°F) above the 20th century average of 16.4°C (61.5°F)—the highest for June–August on record, besting the previous record set in 2015 by only 0.01°C (0.02°F). This was also the tenth highest three-month ocean temperature departure from average for any three-month period on record. The ten highest three-month departures from average in the record have occurred since July–September 2015, when a strong El Niño episode was in place in the tropical Pacific Ocean.

The three-month period was characterized by warmer- to much-warmer-than-average temperatures across much of the global land and ocean surfaces. Record warmth was scattered across parts of

western and southern Atlantic Ocean, the Gulf of Mexico, western Alaska, northern South America, central and southern Africa, the Middle East, northwestern and Far East Russia, China, Indonesia, New Zealand and the oceans surrounding New Zealand. Meanwhile, very limited land and ocean areas experienced cooler-than-average conditions, including northeastern Russia and the southern Oceans. No land areas observed record cold temperatures for the June–August period, however, the only ocean area with record cold temperatures was east of the Drake Passage off the southern tip of South America. According to NCEI's Global Regional analysis, all six continents had at least a top seven warm June–August period, with Africa and Asia observing a record high average temperature for June–August and North America having its second warmest June–August period since continental records began in 1910.

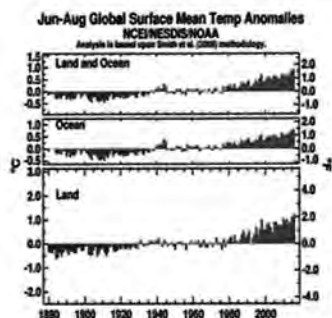
Select national information is highlighted below. (Please note that different countries report anomalies with respect to different base periods. The information provided here is based directly upon these data):

- Australia's mean temperature during June–August 2016 (Southern Hemisphere winter) was 0.91°C (1.64°F) above the 1961–1990 average—tying as the sixth highest June–August period. The region with the highest temperature departure was the Northern Territory with a temperature departure for the three-month period of 1.34°C (2.41°F) above average and the eighth highest since records began in 1910. Queensland, New South Wales, and Tasmania had a top ten June–August period. Nighttime (minimum) temperatures were unusually warm, resulting in the nation experiencing its fourth warmest June–August minimum temperature at 1.49°C (2.68°F) above average. All regions, with the exception of South Australia, had a top seven warm minimum temperature for the three-month period, with New South Wales tying 1973 as the highest minimum temperature on record.
- The United Kingdom had its warmest summer since 2013, with an average temperature for June–August 2016 of 14.9°C (58.8°F) or 0.6°C (1.1°F) above the 1981–2010 average.
- Most of Ireland experienced above average June–August conditions, with temperature departures ranging between -0.4°C (-0.7°F) to 1°C (1.8°F). The Dublin Airport had its warmest summer since 2006 with a temperature of 15.1°C (59.2°F) or 0.4°C (0.7°F) above average.

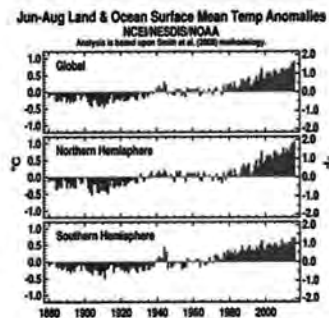
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JUNE-AUGUST	ANOMALY		RANK (OUT OF 137 YEARS)	RECORDS			
	°C	°F		YEAR(S)	°C	°F	
Global							
Land	+1.21 ± 0.18	+2.18 ± 0.32	Warmest	1 st	2016	+1.21	+2.18
			Coolest	137 th	1908	-0.42	-0.76
Ocean	+0.77 ± 0.15	+1.39 ± 0.27	Warmest	1 st	2016	+0.77	+1.39
			Coolest	137 th	1907, 1916	-0.31	-0.56
Land and Ocean	+0.89 ± 0.16	+1.60 ± 0.29	Warmest	1 st	2016	+0.89	+1.60
			Coolest	137 th	1892	-0.33	-0.59
Northern Hemisphere							
Land	+1.26 ± 0.17	+2.27 ± 0.31	Warmest	1 st	2016	+1.26	+2.27
			Coolest	137 th	1895	-0.41	-0.74
Ocean	+0.92 ± 0.14	+1.66 ± 0.25	Warmest	2 nd	2015	+0.93	+1.67
			Coolest	136 th	1890, 1912	-0.36	-0.65

Land and Ocean	+1.05 ± 0.17	+1.89 ± 0.31	Warmest	1 st	2016	+1.05	+1.89
			Coollest	137 th	1884	-0.37	-0.67
Southern Hemisphere							
Land	+1.06 ± 0.15	+1.91 ± 0.27	Warmest	2 nd	2015	+1.14	+2.05
			Coollest	136 th	1925	-0.51	-0.92
Ocean	+0.67 ± 0.16	+1.21 ± 0.29	Warmest	1 st	2016	+0.67	+1.21
			Coollest	137 th	1903, 1910, 1916	-0.30	-0.54
Land and Ocean	+0.73 ± 0.15	+1.31 ± 0.27	Warmest	1 st	2016	+0.73	+1.31
			Coollest	137 th	1922	-0.30	-0.54



June-August Global Land and Ocean plot



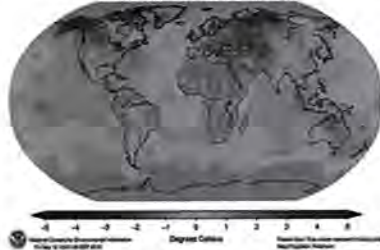
June-August Global Hemisphere plot

The most current data can be accessed via the [Global Surface Temperature Anomalies](#) page.

[top]

Year-to-date (January-August)

Land & Ocean Temperature Departure from Average Jan-Aug 2016
(with respect to a 1951-2010 base period)
Data Source: GPCP-M version 3.3.3 & ERA-Interim version 4.0.0



January-August 2016 Blended Land and Sea Surface Temperature Anomalies in degrees Celsius

Land & Ocean Temperature Percentiles Jan-Aug 2016
NOAA's National Centers for Environmental Information
Data Source: GPCP-M version 3.3.3 & ERA-Interim version 4.0.0



January-August 2016 Blended Land and Sea Surface Temperature Percentiles

The first eight months of the year were characterized by much-warmer-than-average conditions across much of the globe's surface, resulting in the highest January-August period on record at 1.01°C (1.82°F) above the 20th century average of 14.0°C (57.3°F). This value exceeded the previous record set in 2015 by 0.16°C (0.29°F).

Much-warmer-than-average conditions engulfed the vast majority of the world's land surfaces, resulting in a record warm January-August period at 1.62°C (2.92°F) above the 20th century average of 9.0°C (48.1°F), besting the previous record set in 2015 by 0.33°C (0.59°F). Record warmth during the first eight months was present across Alaska, western Canada, northern South America, central and southern Africa, southern Europe, Indonesia, and across parts of Central America, the Caribbean, northern and central Asia and Australia. According to NCEI's Global Regional analysis, all six continents had at least a top three warm January-August period, with North America, Asia, and Oceania experiencing a record high average temperature for January-August since continental

records began in 1910. No land areas experienced cooler-than-average conditions during January–August 2016.

Select national information is highlighted below. (Please note that different countries report anomalies with respect to different base periods. The information provided here is based directly upon these data):

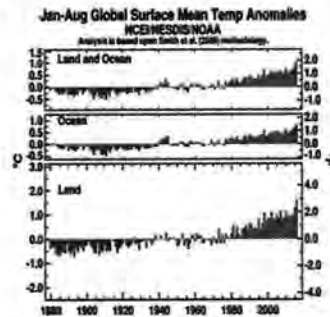
- The January–August 2016 average temperature for New Zealand was the highest such period since national temperature records began in 1909, at 1.1°C (2.0°C) above the 1981–2010 average.

The average global sea surface temperature for the year-to-date was the highest for January–August in the 137-year period of record, at 0.79°C (1.42°F) above average, surpassing the previous record set in 2015 by 0.11°C (0.20°F). Record warm sea surface temperature during January–August 2016 was present across much of the Indian Ocean and Southwest Pacific Ocean, with scattered areas across the Atlantic Ocean and the tropical Pacific Ocean. The only ocean area with record cold temperatures was east of the Drake Passage off the southern tip of South America.

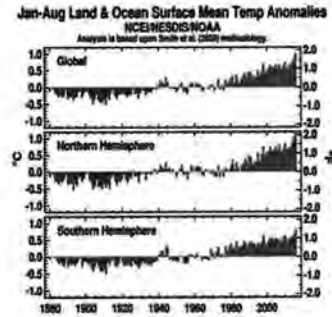
JANUARY-AUGUST	ANOMALY		RANK (OUT OF 137 YEARS)		RECORDS		
	°C	°F			YEAR(S)	°C	°F
Global							
Land	+1.62 ± 0.16	+2.92 ± 0.29	Warmest	1 st	2016	+1.62	+2.92
			Coollest	137 th	1888	-0.57	-1.03
Ocean	+0.79 ± 0.18	+1.42 ± 0.32	Warmest	1 st	2016	+0.79	+1.42
			Coollest	137 th	1890, 1894, 1929	-0.28	-0.50
Land and Ocean	+1.01 ± 0.17	+1.82 ± 0.31	Warmest	1 st	2016	+1.01	+1.82
			Coollest	137 th	1905, 1910, 1917	-0.35	-0.63
Northern Hemisphere							
Land	+1.78 ± 0.18	+3.20 ± 0.32	Warmest	1 st	2016	+1.78	+3.20
			Coollest	137 th	1886, 1888	-0.61	-1.10
Ocean	+0.87 ± 0.17	+1.57 ± 0.31	Warmest	1 st	2016	+0.87	+1.57
			Coollest	137 th	1903	-0.30	-0.54
Land and Ocean	+1.22 ± 0.18	+2.20 ± 0.32	Warmest	1 st	2016	+1.22	+2.20
			Coollest	137 th	1895	-0.38	-0.68
Southern Hemisphere							
Land	+1.20 ± 0.15	+2.16 ± 0.27	Warmest	1 st	2016	+1.20	+2.16
			Coollest	137 th	1909	-0.53	-0.95
Ocean	+0.73 ± 0.18	+1.31 ± 0.32	Warmest	1 st	2016	+0.73	+1.31
			Coollest	137 th	1890, 1921, 1928	-0.27	-0.49
Land and Ocean	+0.81 ± 0.17	+1.46 ± 0.31	Warmest	1 st	2016	+0.81	+1.46
			Coollest	137 th	1890, 1898, 1917, 1925	-0.29	-0.52

The most current data can be accessed via the Global Surface Temperature Anomalies page.

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January–August Global Land and Ocean plot



January–August Global Hemisphere plot

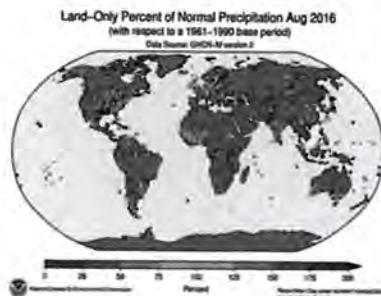
Precipitation

August

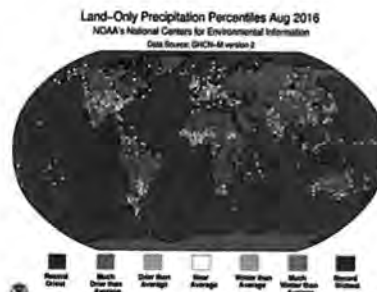
The maps below represent precipitation percent of normal (left, using a base period of 1961–1990) and precipitation percentiles (right, using the period of record) based on the GHCN dataset of land surface stations. As is typical, precipitation anomalies during August 2016 varied significantly around the world. August precipitation generally was drier than normal across parts of the western contiguous U.S., northern, northeastern and southern South America, central Europe, southern Africa, and central, eastern and southern Asia. Wetter than normal conditions were present across the contiguous U.S. Midwest and Lower Mississippi Valley, northern Mexico, southern Brazil, southern Argentina, the Scandinavia region, western Africa, northern Russia, northern Japan, northwestern India, and across parts of Australia.

Select national information is highlighted below. (Please note that different countries report anomalies with respect to different base periods. The information provided here is based directly upon these data):

- According to El Centro Internacional para la Investigación del Fenómeno del Niño (CIIFEN), precipitation was above normal in eastern Colombia and southern Chile, with 30–40% above-average precipitation. A stretch from the northeastern region of Bolivia to south-central Brazil received as much as 150% above-average precipitation. In contrast, Venezuela, central Chile, and central Argentina had rainfall deficits during the month.
- Drier-than-average conditions were present across much of Ireland ¹ during August 2016, with the exception of several stations across parts of the West, Southwest, and East that had near- to above-average precipitation. Belmullet, Co Mayo had its driest August in a decade at 55% of average, meanwhile Shannon Airport, Co Clare had its wettest August in seven years.
- Precipitation totals across the Island of Fiji were above- to much-above-average. According to Fiji's Meteorological Service ², 18 out of 26 stations recorded twice their normal monthly precipitation total during August 2016, with five stations receiving triple the amount and four stations receiving as much as four times their monthly normal. The much needed precipitation helped provide relief from the dry conditions that plagued the region in the past months. The much-above-average amounts of precipitation received in several stations were not enough to set new rainfall records.



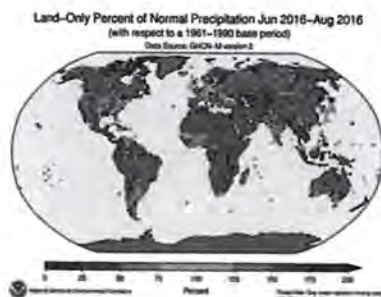
August 2016 Land-Only Precipitation Percent of Normal



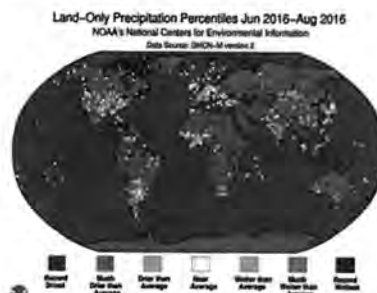
August 2016 Land-Only Precipitation Percentiles

Seasonal (June–August)

As is typical, precipitation anomalies during June–August 2016 varied significantly around the world. During June–August 2016, above-average precipitation was observed across much of the contiguous U.S. Midwest and Lower Mississippi Valley, Alaska, British Isles, central Europe, northern Argentina, Asia, and across Australia. Drier-than-average conditions were present across the western contiguous U.S., northern, northeastern, and southern South America, western Europe, and central Asia.



June – August 2016 Land-Only Precipitation Percent of Normal



June – August 2016 Land-Only Precipitation Percentiles

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References

Peterson, T.C. and R.S. Vose, 1997: An Overview of the Global Historical Climatology Network Database [DOI](#), *Bull. Amer. Meteorol. Soc.*, **78**, 2837-2849.

Huang, B., V.F. Banzon, E. Freeman, J. Lawrimore, W. Liu, T.C. Peterson, T.M. Smith, P.W. Thorne, S.D. Woodruff, and H-M. Zhang, 2016: Extended Reconstructed Sea Surface Temperature Version 4 (ERSST.v4). Part I: Upgrades and Intercomparisons. *J. Climate*, **28**, 911-930.

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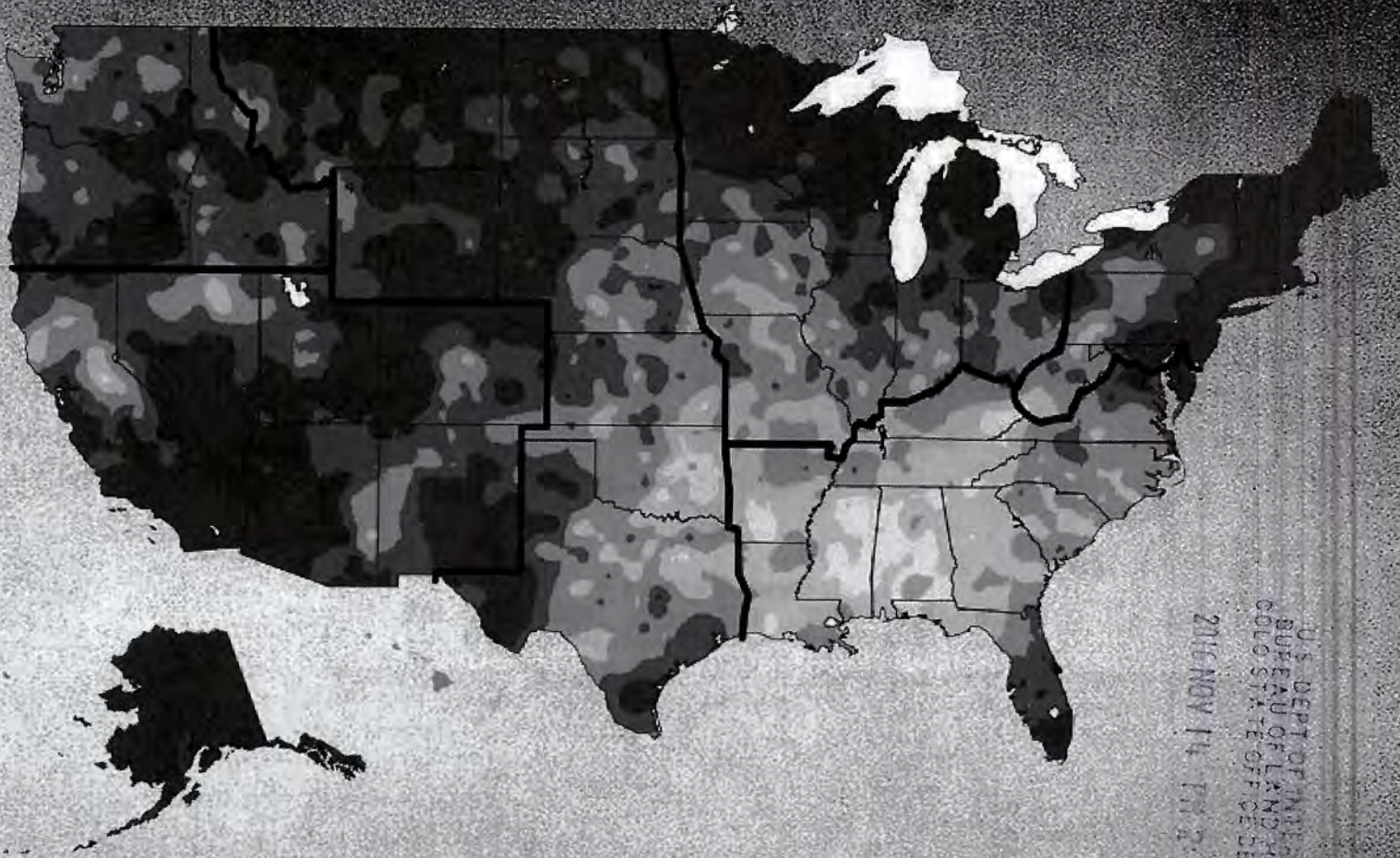
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Exhibit 11

Climate Change Impacts in the United States



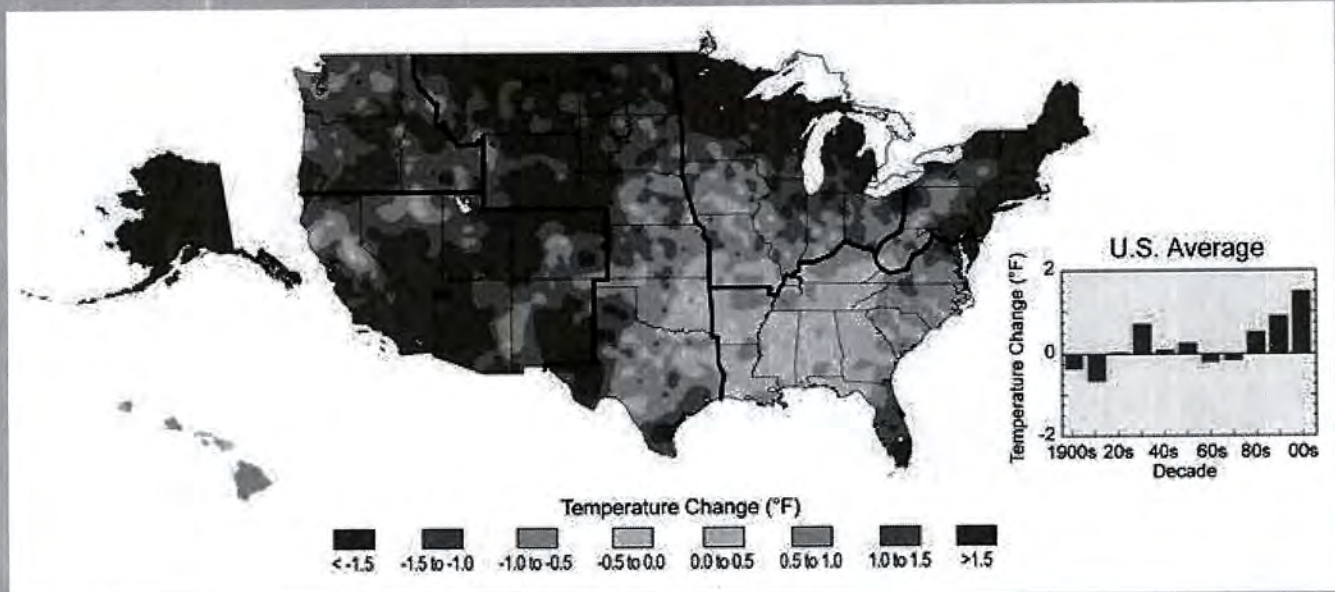
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U.S. National Climate Assessment
U.S. Global Change Research Program

Climate Change Impacts in the United States

Observed U.S. Temperature Change



The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for the contiguous U.S., and to the 1951-1980 average for Alaska and Hawaii. The bars on the graph show the average temperature changes for the U.S. by decade for 1901-2012 (relative to the 1901-1960 average). The far right bar (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region. (Figure source: NOAA NCDC / CICS-NC).



Members of the National Guard lay sandbags to protect against Missouri River flooding.



Energy choices will affect the amount of future climate change.



Climate change is contributing to an increase in wildfires across the U.S. West.



Solar power use is increasing and is part of the solution to climate change.

Online at:
nca2014.globalchange.gov

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May 2014

Members of Congress:

On behalf of the National Science and Technology Council and the U.S. Global Change Research Program, we are pleased to transmit the report of the Third National Climate Assessment: *Climate Change Impacts in the United States*. As required by the Global Change Research Act of 1990, this report has collected, evaluated, and integrated observations and research on climate change in the United States. It focuses both on changes that are happening now and further changes that we can expect to see throughout this century.

This report is the result of a three-year analytical effort by a team of over 300 experts, overseen by a broadly constituted Federal Advisory Committee of 60 members. It was developed from information and analyses gathered in over 70 workshops and listening sessions held across the country. It was subjected to extensive review by the public and by scientific experts in and out of government, including a special panel of the National Research Council of the National Academy of Sciences. This process of unprecedented rigor and transparency was undertaken so that the findings of the National Climate Assessment would rest on the firmest possible base of expert judgment.

We gratefully acknowledge the authors, reviewers, and staff who have helped prepare this Third National Climate Assessment. Their work in assessing the rapid advances in our knowledge of climate science over the past several years has been outstanding. Their findings and key messages not only describe the current state of that science but also the current and future impacts of climate change on major U.S. regions and key sectors of the U.S. economy. This information establishes a strong base that government at all levels of U.S. society can use in responding to the twin challenges of changing our policies to mitigate further climate change and preparing for the consequences of the climate changes that can no longer be avoided. It is also an important scientific resource to empower communities, businesses, citizens, and decision makers with information they need to prepare for and build resilience to the impacts of climate change.

When President Obama launched his Climate Action Plan last year, he made clear that the essential information contained in this report would be used by the Executive Branch to underpin future policies and decisions to better understand and manage the risks of climate change. We strongly and respectfully urge others to do the same.

Sincerely,

Dr. John P. Holdren
Assistant to the President for Science and Technology
Director, Office of Science and Technology Policy
Executive Office of the President

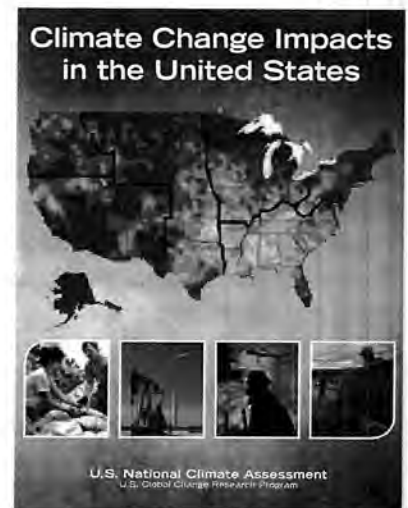
Dr. Kathryn D. Sullivan
Under Secretary for Oceans and Atmosphere
NOAA Administrator
U.S. Department of Commerce

About the NATIONAL CLIMATE ASSESSMENT

The National Climate Assessment assesses the science of climate change and its impacts across the United States, now and throughout this century. It documents climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels.

A team of more than 300 experts (see page 98), guided by a 60-member National Climate Assessment and Development Advisory Committee (listed on page vi) produced the full report – the largest and most diverse team to produce a U.S. climate assessment. Stakeholders involved in the development of the assessment included decision-makers from the public and private sectors, resource and environmental managers, researchers, representatives from businesses and non-governmental organizations, and the general public. More than 70 workshops and listening sessions were held, and thousands of public and expert comments on the draft report provided additional input to the process.

The assessment draws from a large body of scientific peer-reviewed research, technical input reports, and other publicly available sources; all sources meet the standards of the Information Quality Act. The report was extensively reviewed by the public and experts, including a panel of the National Academy of Sciences, the 13 Federal agencies of the U.S. Global Change Research Program, and the Federal Committee on Environment, Natural Resources, and Sustainability.



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About the HIGHLIGHTS

The *Highlights* presents the major findings and selected highlights from *Climate Change Impacts in the United States*, the third National Climate Assessment.

The *Highlights* report is organized around the National Climate Assessment's 12 Report Findings, which take an overarching view of the entire report and its 30 chapters. All material in the *Highlights* report is drawn from the full report. The Key Messages from each of the 30 report chapters appear in boxes throughout this document.

A 20-page *Overview* booklet is available online.



Online at:
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CLIMATE CHANGE AND THE AMERICAN PEOPLE

Climate change, once considered an issue for a distant future, has moved firmly into the present. Corn producers in Iowa, oyster growers in Washington State, and maple syrup producers in Vermont are all observing climate-related changes that are outside of recent experience. So, too, are coastal planners in Florida, water managers in the arid Southwest, city dwellers from Phoenix to New York, and Native Peoples on tribal lands from Louisiana to Alaska. This National Climate Assessment concludes that the evidence of human-induced climate change continues to strengthen and that impacts are increasing across the country.

Americans are noticing changes all around them. Summers are longer and hotter, and extended periods of unusual heat last longer than any living American has ever experienced. Winters are generally shorter and warmer. Rain comes in heavier downpours. People are seeing changes in the length and severity of seasonal allergies, the plant varieties that thrive in their gardens, and the kinds of birds they see in any particular month in their neighborhoods.

Other changes are even more dramatic. Residents of some coastal cities see their streets flood more regularly during storms and high tides. Inland cities near large rivers also experience more flooding, especially in the Midwest and Northeast. Insurance rates are rising in some vulnerable locations, and insurance is no longer available in others. Hotter and drier weather and earlier snowmelt mean that wildfires in the West start earlier in the spring, last later into the fall, and burn more acreage. In Arctic Alaska, the summer sea ice that once protected the coasts has receded, and autumn storms now cause more erosion, threatening many communities with relocation.

Scientists who study climate change confirm that these observations are consistent with significant changes in Earth's climatic trends. Long-term, independent records from weather stations, satellites, ocean buoys, tide gauges, and many other data sources all confirm that our nation, like the rest of the world, is warming. Precipitation patterns are changing, sea level is rising, the oceans are becoming more acidic, and the frequency and intensity of some extreme weather events are increasing. Many lines of independent evidence demonstrate that the rapid warming of the past half-century is due primarily to human activities.

The observed warming and other climatic changes are triggering wide-ranging impacts in every region of our country and throughout our economy. Some of these changes can be beneficial over the short run, such as a longer growing season in some regions and a longer shipping season on the Great Lakes. But many more are detrimental, largely because our society and its infrastructure were designed for the climate that we have had, not the rapidly changing climate we now have and can expect in the future. In addition, climate change does not occur in isolation. Rather, it is superimposed on other stresses, which combine to create new challenges.



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This National Climate Assessment collects, integrates, and assesses observations and research from around the country, helping us to see what is actually happening and understand what it means for our lives, our livelihoods, and our future. This report includes analyses of impacts on seven sectors – human health, water, energy, transportation, agriculture, forests, and ecosystems – and the interactions among sectors at the national level. This report also assesses key impacts on all U.S. regions: Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawai'i and the Pacific Islands, as well as the country's coastal areas, oceans, and marine resources.



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Over recent decades, climate science has advanced significantly. Increased scrutiny has led to increased certainty that we are now seeing impacts associated with human-induced climate change. With each passing year, the accumulating evidence further expands our understanding and extends the record of observed trends in temperature, precipitation, sea level, ice mass, and many other variables recorded by a variety of measuring systems and analyzed by independent research groups from around the world. It is notable that as these data records have grown longer and climate models have become more comprehensive, earlier predictions have largely been confirmed. The only real surprises have been that some changes, such as sea level rise and Arctic sea ice decline, have outpaced earlier projections.

What is new over the last decade is that we know with increasing certainty that climate change is happening now. While scientists continue to refine projections of the future, observations unequivocally show that climate is changing and that the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases. These emissions come mainly from burning coal, oil, and gas, with additional contributions from forest clearing and some agricultural practices.

Global climate is projected to continue to change over this century and beyond, but there is still time to act to limit the amount of change and the extent of damaging impacts.

This report documents the changes already observed and those projected for the future. It is important that these findings and response options be shared broadly to inform citizens and communities across our nation. Climate change presents a major challenge for society. This report advances our understanding of that challenge and the need for the American people to prepare for and respond to its far-reaching implications.



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ABOUT THIS REPORT

This report assesses the science of climate change and its impacts across the United States, now and throughout this century. It integrates findings of the U.S. Global Change Research Program (USGCRP)^a with the results of research and observations from across the U.S. and around the world, including reports from the

U.S. National Research Council. This report documents climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels.

REPORT REQUIREMENTS, PRODUCTION, AND APPROVAL

The Global Change Research Act¹ requires that, every four years, the USGCRP prepare and submit to the President and Congress an assessment of the effects of global change in the United States. As part of this assessment, more than 70 workshops were held involving a wide range of stakeholders who identified issues and information for inclusion (see Appendix 1: Process). A team of more than 300 experts was involved in writing this report. Authors were appointed by the National Climate Assessment and Development Advisory Committee (NCADAC),^b the federal ad-

visory committee assembled for the purpose of conducting this assessment. The report was extensively reviewed and revised based on comments from the public and experts, including a panel of the National Academy of Sciences. The report was reviewed and approved by the USGCRP agencies and the federal Committee on Environment, Natural Resources, and Sustainability (CENRS). This report meets all federal requirements associated with the Information Quality Act (see Appendix 2: IQA), including those pertaining to public comment and transparency.

REPORT SOURCES

The report draws from a large body of scientific, peer-reviewed research, as well as a number of other publicly available sources. Author teams carefully reviewed these sources to ensure a reliable assessment of the state of scientific understanding. Each source of information was determined to meet the four parts of the IQA Guidance provided to authors: 1) utility, 2) transparency and traceability, 3) objectivity, and 4) integrity and security (see Appendix 2: IQA). Report authors made use of technical input reports produced by federal agencies and other interested parties in response to a request for information by the NCADAC;² oth-

er peer-reviewed scientific assessments (including those of the Intergovernmental Panel on Climate Change); the U.S. National Climate Assessment's 2009 report titled *Global Climate Change Impacts in the United States*;³ the National Academy of Science's *America's Climate Choices* reports;⁴ a variety of regional climate impact assessments, conference proceedings, and government statistics (such as population census and energy usage); and observational data. Case studies were also provided as illustrations of climate impacts and adaptation programs.

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^aThe USGCRP is made up of 13 Federal departments and agencies that carry out research and support the nation's response to global change. The USGCRP is overseen by the Subcommittee on Global Change Research (SGCR) of the National Science and Technology Council's Committee on Environment, Natural Resources and Sustainability (CENRS), which in turn is overseen by the White House Office of Science and Technology Policy (OSTP). The agencies within USGCRP are: the Department of Agriculture, the Department of Commerce (NOAA), the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of the Interior, the Department of State, the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Smithsonian Institution, and the U.S. Agency for International Development.

^bThe NCADAC is a federal advisory committee sponsored by the National Oceanic and Atmospheric Administration under the requirements of the Federal Advisory Committee Act.

A GUIDE TO THE REPORT

The report has eight major sections, outlined below:

- **Overview and Report Findings:** gives a high-level perspective on the full National Climate Assessment and sets out the report's 12 key findings. The Overview synthesizes and summarizes the ideas that the authors consider to be of greatest importance to the American people.
- **Our Changing Climate:** presents recent advances in climate change science, which includes discussions of extreme weather events, observed and projected changes in temperature and precipitation, and the uncertainties associated with these projections. Substantial additional material related to this chapter can be found in the Appendices.
- **Sectors:** focuses on climate change impacts for seven societal and environmental sectors: human health, water, energy, transportation, agriculture, forests, and ecosystems and biodiversity; six additional chapters consider the interactions among sectors (such as energy, water, and land use) in the context of a changing climate.
- **Regions:** assesses key impacts on U.S. regions – Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, and Hawai'i and the U.S. affiliated Pacific Islands – as well as coastal areas, oceans, and marine resources.
- **Responses:** assesses the current state of responses to climate change, including adaptation, mitigation, and decision support activities.
- **Research Needs:** highlights major gaps in science and research to improve future assessments. New research is called for in climate science in support of assessments, climate impacts in regions and sectors, and adaptation, mitigation, and decision support.
- **Sustained Assessment Process:** describes an initial vision for and components of an ongoing, long-term assessment process.
- **Appendices:** Appendix 1 describes key aspects of the report process, with a focus on engagement; Appendix 2 describes the guidelines used in meeting the terms of the Federal Information Quality Act; Appendix 3 supplements the chapter on Our Changing Climate with an extended treatment of selected science issues; Appendix 4 provides answers to Frequently Asked Questions about climate change; Appendix 5 describes scenarios and models used in this assessment; and Appendix 6 describes possible topics for consideration in future assessments.

OVERARCHING PERSPECTIVES

Four overarching perspectives, derived from decades of observations, analysis, and experience, have helped to shape this report: 1) climate change is happening in the context of other ongoing changes across the U.S. and the globe; 2) climate change impacts can either be amplified or reduced by societal decisions; 3) climate change related impacts, vulner-

abilities, and opportunities in the U.S. are linked to impacts and changes outside the United States, and vice versa; and 4) climate change can lead to dramatic tipping points in natural and social systems. These overarching perspectives are briefly discussed below.

Global Change Context

Climate change is one of a number of global changes affecting society, the environment, and the economy; others include population growth, land-use change, air and water pollution, and rising consumption of resources by a growing and wealthier global population. This perspective has implications for assessments of climate change impacts and the design of research questions at the national, regional, and local scales. This assessment explores some of the consequences of interacting factors by focusing on sets of crosscutting issues in a series of six chap-

ters: Energy, Water, and Land Use; Biogeochemical Cycles; Indigenous Peoples, Lands, and Resources; Urban Systems, Infrastructure, and Vulnerability; Land Use and Land Cover Change; and Rural Communities. The assessment also includes discussions of how climate change impacts cascade through different sectors such as water and energy, and affect and are affected by land-use decisions. These and other interconnections greatly stress society's capacity to respond to climate-related crises that occur simultaneously or in rapid sequence.

Societal Choices

Because environmental, cultural, and socioeconomic systems are tightly coupled, climate change impacts can either be amplified or reduced by cultural and socioeconomic decisions. In many arenas, it is clear that societal decisions have substantial influence on the vulnerability of valued resources to climate

change. For example, rapid population growth and development in coastal areas tends to amplify climate change related impacts. Recognition of these couplings, together with recognition of multiple sources of vulnerability, helps identify what information decision-makers need as they manage risks.

International Context

Climate change is a global phenomenon; the causes and the impacts involve energy-use, economic, and risk-management decisions across the globe. Impacts, vulnerabilities, and opportunities in the U.S. are related in complex and interactive ways with changes outside the United States, and vice versa. In order for U.S. concerns related to climate change to be addressed comprehensively, the international context must be

considered. Foreign assistance, health, environmental quality objectives, and economic interests are all affected by climate changes experienced in other parts of the world. Although there is significantly more work to be done in this area, this report identifies some initial implications of global and international trends that can be more fully investigated in future assessments.

Thresholds, Tipping Points, and Surprises

While some climate changes will occur slowly and relatively gradually, others could be rapid and dramatic, leading to unexpected breaking points in natural and social systems. Although they have potentially large impacts, these breaking points or tipping points are difficult to predict, as there are many uncertainties about future conditions. These uncertainties and potential surprises come from a number of sources, including insufficient data associated with low probability/high consequence events, models that are not yet able to represent all

the interactions of multiple stresses, incomplete understanding of physical climate mechanisms related to tipping points, and a multitude of issues associated with human behavior, risk management, and decision-making. Improving our ability to anticipate thresholds and tipping points can be helpful in developing effective climate change mitigation and adaptation strategies (Ch. 2: Our Changing Climate; Ch. 29: Research Needs; and Appendices 3 and 4).

RISK MANAGEMENT FRAMEWORK

Authors were asked to consider the science and information needs of decision-makers facing climate change risks to infrastructure, natural ecosystems, resources, communities, and other things of societal value. They were also asked to consider opportunities that climate change might present. For each region and sector, they were asked to assess a small number of key climate-related vulnerabilities of concern based on the risk (considering likelihood and consequence) of impacts. They were also asked to address the most important information needs of stakeholders, and to consider the decisions

stakeholders are facing. The criteria provided for identifying key vulnerabilities in each sector or region included magnitude, timing, persistence/reversibility, scale, and distribution of impacts, likelihood whenever possible, importance of impacts (based on the perceptions of relevant parties), and the potential for adaptation. Authors were encouraged to think about these topics from both a quantitative and qualitative perspective and to consider the influence of multiple stresses whenever possible.

RESPONDING TO CLIMATE CHANGE

While the primary focus of this report is on the impacts of climate change in the United States, it also documents some of the actions society is taking or can take to respond. Responses to climate change fall into two broad categories. The first involves "mitigation" measures to reduce future climate change by reducing emissions of heat-trapping gases and particles, or increasing removal of carbon dioxide from the atmosphere.

The second involves "adaptation" measures to improve society's ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. At this point, both of these response activities are necessary to limit the magnitude and impacts of global climate change on the United States.

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More effective mitigation measures can reduce the amount of climate change, and therefore reduce the need for future adaptation. This report underscores the effects of mitigation measures by comparing impacts resulting from higher versus lower emissions scenarios. This shows that choices made about emissions in the next few decades will have far-reaching consequences for climate change impacts throughout this century. Lower emissions will reduce the rate and lessen the magnitude of climate change and its impacts. Higher emissions will do the opposite.

While the report demonstrates the importance of mitigation as an essential part of the nation's climate change strategy, it does not evaluate mitigation technologies or policies or undertake an analysis of the effectiveness of various approaches. The range of mitigation responses being studied includes, but is not limited to, policies and technologies that lead to more ef-

ficient production and use of energy, increased use of non-carbon-emitting energy sources such as wind and solar power, and carbon capture and storage.

Adaptation actions are complementary to mitigation actions. They are focused on moderating harmful impacts of current and future climate variability and change and taking advantage of possible opportunities. While this report assesses the current state of adaptation actions and planning across the country in a general way, the implementation of adaptive actions is still nascent. A comprehensive assessment of actions taken, and of their effectiveness, is not yet possible. This report documents some of the actions currently being pursued to address impacts such as increased urban heat extremes and air pollution, and describes the challenges decision-makers face in planning for and implementing adaptation responses.

TRACEABLE ACCOUNTS: PROCESS AND CONFIDENCE

The "traceable accounts" that accompany each chapter: 1) document the process the authors used to reach the conclusions in their key messages; 2) provide additional information to reviewers and other readers about the quality of the information used; 3) allow traceability to resources; and 4) provide the level of confidence the authors have in the main findings of the chapters. The authors have assessed a wide range of information in the scientific literature and various technical reports. In assessing confidence, they have considered the strength and consistency of the observed evidence, the skill, range, and consistency of model projections, and insights from peer-reviewed sources.

When it is considered scientifically justified to report the likelihood of particular impacts within the range of possible outcomes, this report takes a plain-language approach to expressing the expert judgment of the author team based on the best available evidence. For example, an outcome termed "likely" has at least a two-thirds chance of occurring; an outcome termed "very likely" has more than a 90% chance. Key sources of information used to develop these characterizations are referenced.

1 OVERVIEW AND REPORT FINDINGS

Climate change is already affecting the American people in far-reaching ways. Certain types of extreme weather events with links to climate change have become more frequent and/or intense, including prolonged periods of heat, heavy downpours, and, in some regions, floods and droughts. In addition, warming is causing sea level to rise and glaciers and Arctic sea ice to melt, and oceans are becoming more acidic as they absorb carbon dioxide. These and other aspects of climate change are disrupting people's lives and damaging some sectors of our economy.

Climate Change: Present and Future

Evidence for climate change abounds, from the top of the atmosphere to the depths of the oceans. Scientists and engineers from around the world have meticulously collected this evidence, using satellites and networks of weather balloons, thermometers, buoys, and other observing systems. Evidence of climate change is also visible in the observed and measured changes in location and behavior of species and functioning of ecosystems. Taken together, this evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity.

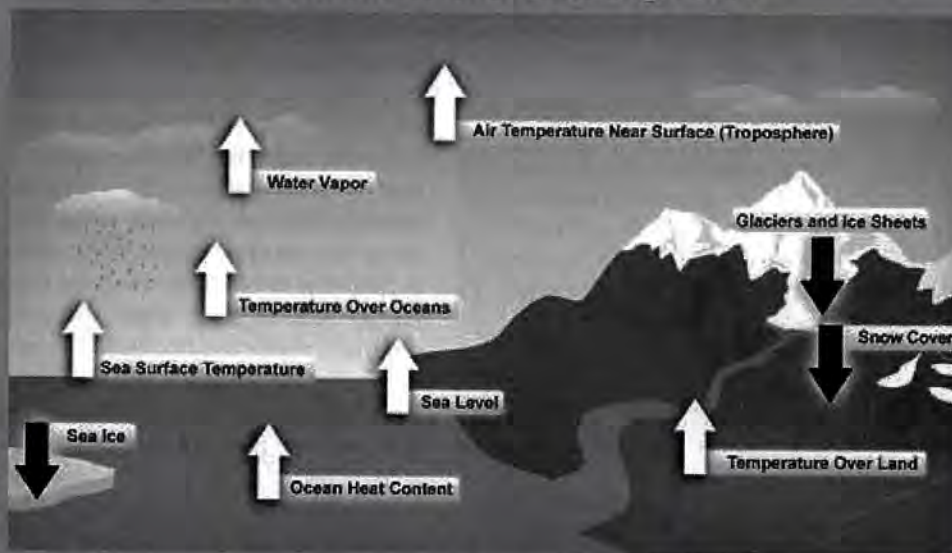


Coal-fired power plants emit heat-trapping carbon dioxide to the atmosphere.

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. Data show that natural factors like the sun and volcanoes cannot have caused the warming observed over the past 50 years. Sensors on satellites have measured the sun's

output with great accuracy and found no overall increase during the past half century. Large volcanic eruptions during this period, such as Mount Pinatubo in 1991, have exerted a short-term *cooling* influence. In fact, if not for human activities, global climate would actually have cooled slightly over the past 50 years. The pattern of temperature change through the layers of the atmosphere, with warming near the surface and cooling higher up in the stratosphere, further confirms that it is the buildup of heat-trapping gases (also known as "greenhouse gases") that has caused most of the Earth's warming over the past half century.

Ten Indicators of a Warming World

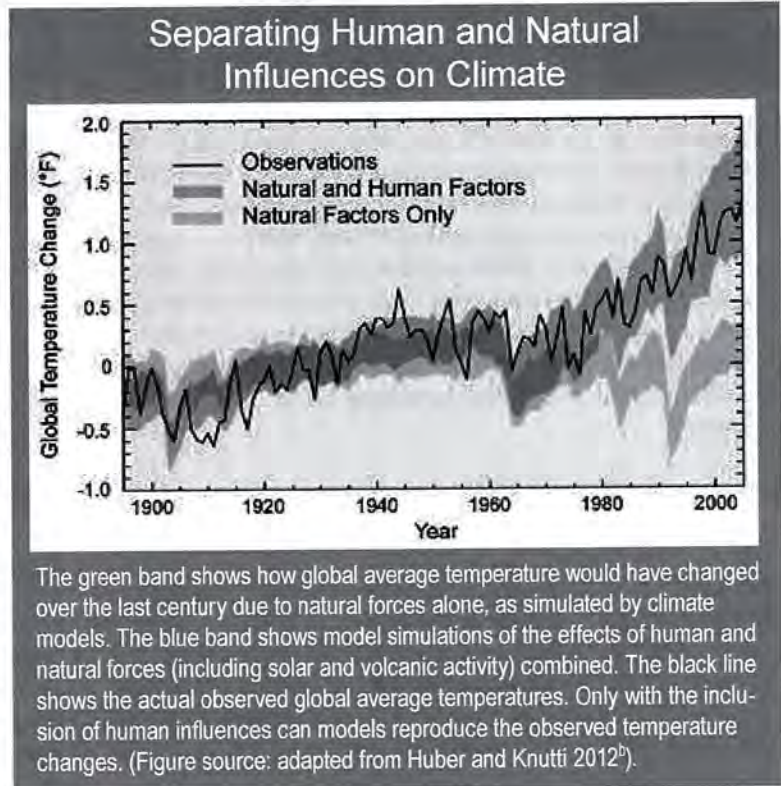


These are just some of the indicators measured globally over many decades that show that the Earth's climate is warming. White arrows indicate increasing trends; black arrows indicate decreasing trends. All the indicators expected to increase in a warming world are increasing, and all those expected to decrease in a warming world are decreasing. (Figure source: NOAA NCDC, based on data updated from Kennedy et al. 2010³).

Because human-induced warming is superimposed on a background of natural variations in climate, warming is not uniform over time. Short-term fluctuations in the long-term upward trend are thus natural and expected. For example, a recent slowing in the rate of surface air temperature rise appears to be related to cyclic changes in the oceans and in the sun's energy output, as well as a series of small volcanic eruptions and other factors. Nonetheless, global temperatures are still on the rise and are expected to rise further.

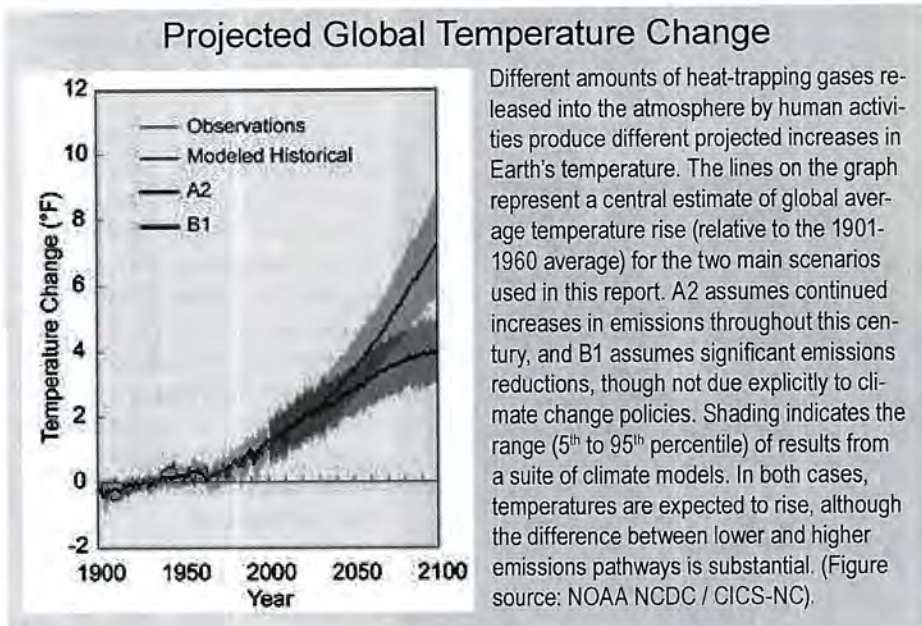
U.S. average temperature has increased by 1.3°F to 1.9°F since 1895, and most of this increase has occurred since 1970. The most recent decade was the nation's and the world's hottest on record, and 2012 was the hottest year on record in the continental United States. All U.S. regions have experienced warming in recent decades, but the extent of warming has not been uniform. In general, temperatures are rising more quickly in the north. Alaskans have experienced some of the largest increases in temperature between 1970 and the present. People living in the Southeast have experienced some of the smallest temperature increases over this period.

Temperatures are projected to rise another 2°F to 4°F in most areas of the United States over the next few decades. Reductions in some short-lived human-induced emissions that contribute to warming, such as black carbon (soot) and methane, could reduce some of the projected warming over the next couple of decades, because, unlike carbon dioxide, these gases and particles have relatively short atmospheric lifetimes.



The amount of warming projected beyond the next few decades is directly linked to the cumulative global emissions of heat-trapping gases and particles. By the end of this century, a roughly 3°F to 5°F rise is projected under a lower emissions scenario, which would require substantial reductions in emissions (referred to as the "B1 scenario"), and a 5°F to 10°F rise for a higher emissions scenario assuming continued increases in emissions, predominantly from fossil fuel combustion (referred to as the "A2 scenario").

These projections are based on results from 16 climate models that used the two emissions scenarios in a formal inter-model comparison study. The range of model projections for each emissions scenario is the result of the differences in the ways the models represent key factors such as water vapor, ice and snow reflectivity, and clouds, which can either dampen or amplify the initial effect of human influences on temperature. The net effect of these feedbacks is expected to amplify warming. More information about the models and scenarios used in this report can be found in Appendix 5 of the full report.¹



Prolonged periods of high temperatures and the persistence of high nighttime temperatures have increased in many locations (especially in urban areas) over the past half century. High nighttime temperatures have widespread impacts because people, livestock, and wildlife get no respite from the heat. In some regions, prolonged periods of high temperatures associated with droughts contribute to conditions that lead to larger wildfires and longer fire seasons. As expected in a warming climate, recent trends show that extreme heat is becoming more common, while extreme cold is becoming less common. Evidence indicates that the human influence on climate has already roughly doubled the probability of extreme heat events such as the record-breaking summer heat experienced in 2011 in Texas and Oklahoma. The incidence of record-breaking high temperatures is projected to rise.²

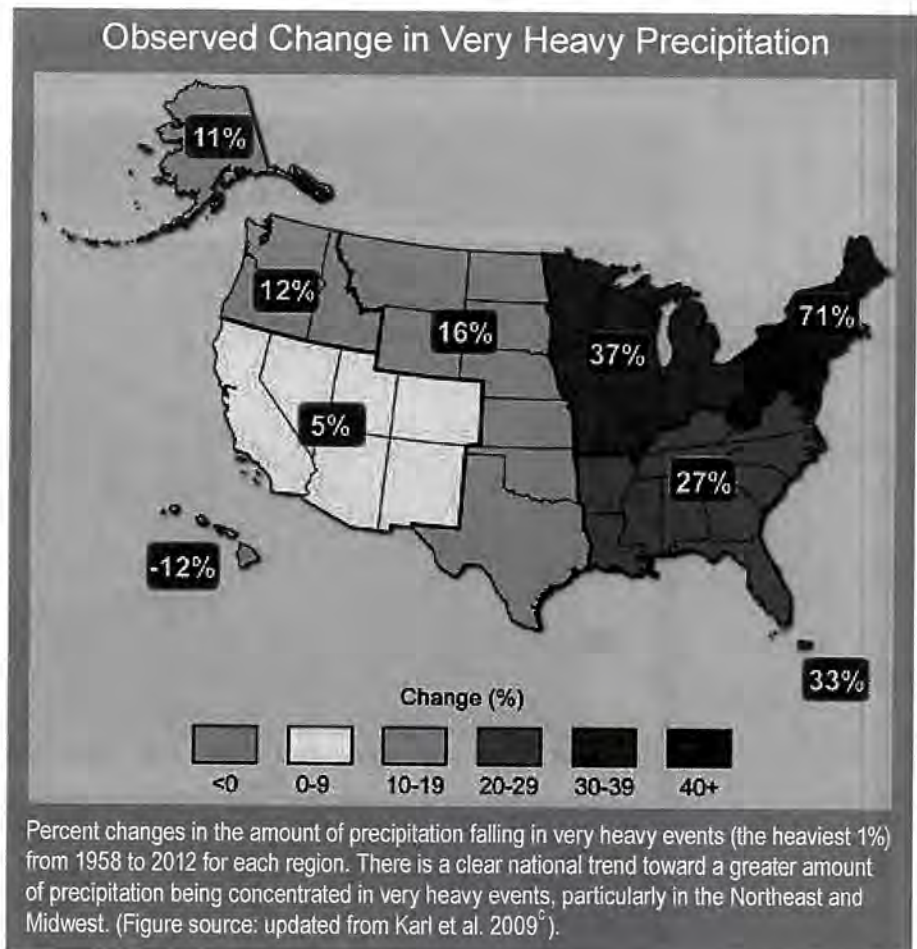
Human-induced climate change means much more than just hotter weather. Increases in ocean and freshwater temperatures, frost-free days, and heavy downpours have all been documented. Global sea level has risen, and there have been large reductions in snow-cover extent, glaciers, and sea ice. These changes and other climatic changes have affected and will continue to affect human health, water supply, agriculture, transportation, energy, coastal areas, and many other sectors of society, with increasingly adverse impacts on the American economy and quality of life.³

Some of the changes discussed in this report are common to many regions. For example, large increases in heavy precipitation have occurred in the Northeast, Midwest, and Great Plains, where heavy downpours have frequently led to runoff that exceeded the capacity of storm drains and levees, and caused flooding events and accelerated erosion. Other impacts, such as those associated with the rapid thawing of permafrost in Alaska, are unique to a particular U.S. region. Permafrost thawing is causing extensive damage to infrastructure in our nation's largest state.⁴

Some impacts that occur in one region ripple beyond that region. For example, the dramatic decline of summer sea ice in the Arctic – a loss of ice cover roughly equal to half the area of the continental United States – exacerbates global warming by reducing the reflectivity of Earth's surface and increasing the amount of heat absorbed. Similarly, smoke from wildfires in one

location can contribute to poor air quality in faraway regions, and evidence suggests that particulate matter can affect atmospheric properties and therefore weather patterns. Major storms and the higher storm surges exacerbated by sea level rise that hit the Gulf Coast affect the entire country through their cascading effects on oil and gas production and distribution.⁵

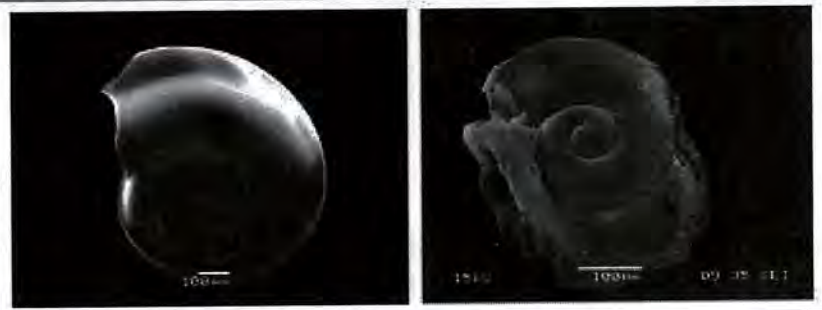
Water expands as it warms, causing global sea levels to rise, melting of land-based ice also raises sea level by adding water to the oceans. Over the past century, global average sea level has risen by about 8 inches. Since 1992, the rate of global sea level rise measured by satellites has been roughly twice the rate observed over the last century, providing evidence of acceleration. Sea level rise, combined with coastal storms, has increased the risk of erosion, storm surge damage, and flooding for coastal communities, especially along the Gulf Coast, the Atlantic seaboard, and in Alaska. Coastal infrastructure, including roads, rail lines, energy infrastructure, airports, port facilities, and military bases, are increasingly at risk from sea level rise and damaging storm surges. Sea level is projected to rise by another 1 to 4 feet in this century, although the rise in sea level in specific regions is expected to vary from this global average for a number of reasons. A wider range of scenarios,



from 8 inches to more than 6 feet by 2100, has been used in risk-based analyses in this report. In general, higher emissions scenarios that lead to more warming would be expected to lead to higher amounts of sea level rise. The stakes are high, as nearly five million Americans and hundreds of billions of dollars of property are located in areas that are less than four feet above the local high-tide level.⁶

In addition to causing changes in climate, increasing levels of carbon dioxide from the burning of fossil fuels and other human activities have a direct effect on the world's oceans. Carbon dioxide interacts with ocean water to form carbonic acid, increasing the ocean's acidity. Ocean surface waters have become 30% more acidic over the last 250 years as they have absorbed large amounts of carbon dioxide from the atmosphere. This ocean acidification makes water more corrosive, reducing the capacity of marine organisms with shells or skeletons made of calcium carbonate

Shells Dissolve in Acidified Ocean Water



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. 2012⁹ (right) Nina Bednaršek).

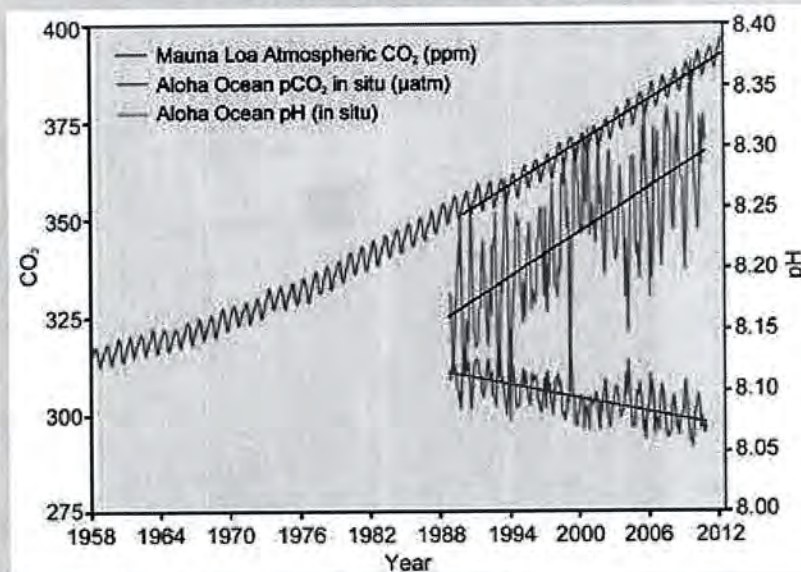
(such as corals, krill, oysters, clams, and crabs) to survive, grow, and reproduce, which in turn will affect the marine food chain.⁷

Widespread Impacts

Impacts related to climate change are already evident in many regions and sectors and are expected to become increasingly disruptive across the nation throughout this century and be-



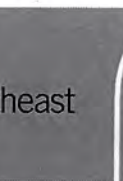

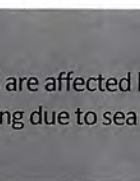
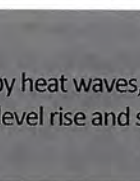
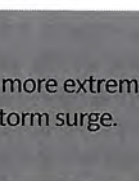
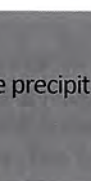
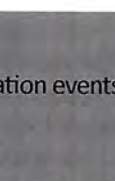
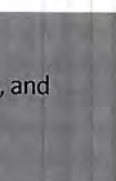
yond. Climate changes interact with other environmental and societal factors in ways that can either moderate or intensify these impacts.

As Oceans Absorb CO₂ They Become More Acidic



The correlation between rising levels of carbon dioxide in the atmosphere (red) with rising carbon dioxide levels (blue) and falling pH in the ocean (green). As carbon dioxide accumulates in the ocean, the water becomes more acidic (the pH declines). (Figure source: modified from Feely et al. 2009⁸).

Observed and projected climate change impacts vary across the regions of the United States. Selected impacts emphasized in the regional chapters are shown below, and many more are explored in detail in this report.

	Northeast	Communities are affected by heat waves, more extreme precipitation events, and coastal flooding due to sea level rise and storm surge.
	Southeast and Caribbean	Decreased water availability, exacerbated by population growth and land-use change, causes increased competition for water. There are increased risks associated with extreme events such as hurricanes.
	Midwest	Longer growing seasons and rising carbon dioxide levels increase yields of some crops, although these benefits have already been offset in some instances by occurrence of extreme events such as heat waves, droughts, and floods.
	Great Plains	Rising temperatures lead to increased demand for water and energy and impacts on agricultural practices.
	Southwest	Drought and increased warming foster wildfires and increased competition for scarce water resources for people and ecosystems.
	Northwest	Changes in the timing of streamflow related to earlier snowmelt reduce the supply of water in summer, causing far-reaching ecological and socioeconomic consequences.
	Alaska	Rapidly receding summer sea ice, shrinking glaciers, and thawing permafrost cause damage to infrastructure and major changes to ecosystems. Impacts to Alaska Native communities increase.
	Hawai'i and Pacific Islands	Increasingly constrained freshwater supplies, coupled with increased temperatures, stress both people and ecosystems and decrease food and water security.
	Coasts	Coastal lifelines, such as water supply infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, and other climate-related changes.
	Oceans	The oceans are currently absorbing about a quarter of human-caused carbon dioxide emissions to the atmosphere and over 90% of the heat associated with global warming, leading to ocean acidification and the alteration of marine ecosystems.

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Some climate changes currently have beneficial effects for specific sectors or regions. For example, current benefits of warming include longer growing seasons for agriculture and longer ice-free periods for shipping on the Great Lakes. At the same time, however, longer growing seasons, along with higher temperatures and carbon dioxide levels, can increase pollen production, intensifying and lengthening the allergy season. Longer ice-free periods on the Great Lakes can result in more lake-effect snowfalls.

Sectors affected by climate changes include agriculture, water, human health, energy, transportation, forests, and ecosystems. Climate change poses a major challenge to U.S. agriculture because of the critical dependence of agricultural systems on climate. Climate change has the potential to both positively and negatively affect the location, timing, and productivity of crop, livestock, and fishery systems at local, national, and global scales. The United States produces nearly \$330 billion per year in agricultural commodities. This productivity is vulnerable to direct impacts on crops and livestock from changing climate conditions and extreme weather events and indirect impacts through increasing pressures from pests and pathogens. Climate change will also alter the stability of food supplies and create new food security challenges for the United States as the world seeks to feed nine billion people by 2050. While the agriculture sector has proven to be adaptable to a range of stresses, as evidenced by continued growth in production and efficiency across the United States, climate change poses a new set of challenges.⁸

Certain groups of people are more vulnerable to the range of climate change related health impacts, including the elderly, children, the poor, and the sick.



Increasing air and water temperatures, more intense precipitation and runoff, and intensifying droughts can decrease water quality in many ways. Here, middle school students in Colorado test water quality.



Climate change can exacerbate respiratory and asthma-related conditions through increases in pollen, ground-level ozone, and wildfire smoke.

Water quality and quantity are being affected by climate change. Changes in precipitation and runoff, combined with changes in consumption and withdrawal, have reduced surface and groundwater supplies in many areas. These trends are expected to continue, increasing the likelihood of water shortages for many uses. Water quality is also diminishing in many areas, particularly due to sediment and contaminant concentrations after heavy downpours. Sea level rise, storms and storm surges, and changes in surface and groundwater use patterns are expected to compromise the sustainability of coastal freshwater aquifers and wetlands. In most U.S. regions, water resources managers and planners will encounter new risks, vulnerabilities, and opportunities that may not be properly managed with existing practices.⁹

Climate change affects human health in many ways. For example, increasingly frequent and intense heat events lead to more heat-related illnesses and deaths and, over time, worsen drought and wildfire risks, and intensify air pollution. Increasingly frequent extreme precipitation and associated flooding can lead to injuries and increases in waterborne disease. Rising sea surface temperatures have been linked with increasing levels and ranges of diseases. Rising sea levels intensify coastal flooding and storm surge, and thus exacerbate threats to public safety during storms. Certain groups of people are more vulnerable to the range of climate change related health impacts, including the elderly, children, the poor, and the sick. Others are vulnerable because of where they live, including those in floodplains, coastal zones, and some urban areas. Improving and properly supporting the public health infrastructure will be critical to managing the potential health impacts of climate change.¹⁰

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Climate change also affects the living world, including people, through changes in ecosystems and biodiversity. Ecosystems provide a rich array of benefits and services to humanity, including habitat for fish and wildlife, drinking water storage and filtration, fertile soils for growing crops, buffering against a range of stressors including climate change impacts, and aesthetic and cultural values. These benefits are not always easy to quantify, but they support jobs, economic growth, health, and human well-being. Climate change driven disruptions to ecosystems have direct and indirect human impacts, including reduced water supply and quality, the loss of iconic species and landscapes, effects on food chains and the timing and success of species migrations, and the potential for extreme weather and climate events to destroy or degrade the ability of ecosystems to provide societal benefits.¹¹

Human modifications of ecosystems and landscapes often increase their vulnerability to damage from extreme weather events, while simultaneously reducing their natural capacity to moderate the impacts of such events. For example, salt marsh-

The amount of future climate change will still largely be determined by choices society makes about emissions.

es, reefs, mangrove forests, and barrier islands defend coastal ecosystems and infrastructure, such as roads and buildings, against storm surges. The loss of these natural buffers due to coastal development, erosion, and sea level rise increases the risk of catastrophic damage during or after extreme weather events. Although floodplain wetlands are greatly reduced

from their historical extent, those that remain still absorb floodwaters and reduce the effects of high flows on river-margin lands. Extreme weather events that produce sudden increases in water flow, often carrying debris and pollutants, can decrease the natural capacity of ecosystems to cleanse contaminants.¹²

The climate change impacts being felt in the regions and sectors of the United States are affected by global trends and economic decisions. In an increasingly interconnected world, U.S. vulnerability is linked to impacts in other nations. It is difficult to fully evaluate the impacts of climate change on the United States without considering consequences of climate change elsewhere.

Response Options

As the impacts of climate change are becoming more prevalent, Americans face choices. Especially because of past emissions of long-lived heat-trapping gases, some additional climate change and related impacts are now unavoidable. This is due to the long-lived nature of many of these gases, as well as the amount of heat absorbed and retained by the oceans and other responses within the climate system. The amount of future climate change, however, will still largely be determined by choices society makes about emissions. Lower emissions of heat-trapping gases and particles mean less future warming and less-severe impacts; higher emissions mean more warming and more severe impacts. Efforts to limit emissions or increase carbon uptake fall into a category of response options known as "mitigation," which refers to reducing the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.¹³

The other major category of response options is known as "adaptation," and refers to actions to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Mitigation and adaptation actions are linked in multiple ways, including that effective mitigation reduces the need for adaptation in the future. Both are essential parts of a comprehensive climate change response strategy. The threat of irreversible impacts makes the timing of mitigation efforts particularly critical. This report includes chapters on Mitigation, Adaptation, and Decision Support that offer an overview of the options and activities being planned or implemented around the country as local, state, federal, and

tribal governments, as well as businesses, organizations, and individuals begin to respond to climate change. These chapters conclude that while response actions are under development, current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.¹⁴

Large reductions in global emissions of heat-trapping gases, similar to the lower emissions scenario (B1) analyzed in this assessment, would reduce the risks of some of the worst impacts of climate change. Some targets called for in international climate negotiations to date would require even larger reductions than those outlined in the B1 scenario. Meanwhile, global emissions are still rising and are on a path to be even higher than the high emissions scenario (A2) analyzed in this report. The recent U.S. contribution to annual global emissions is about 18%, but the U.S. contribution to cumulative global emissions over the last century is much higher. Carbon dioxide lasts for a long time in the atmosphere, and it is the cumulative carbon emissions that determine the amount of global climate change. After decades of increases, U.S. CO₂ emissions from energy use (which account for 97% of total U.S. emissions) declined by around 9% between 2008 and 2012, largely due to a shift from coal to less CO₂-intensive natural gas for electricity production. Governmental actions in city, state, regional, and federal programs to promote energy efficiency have also contributed to reducing U.S. carbon emissions. Many, if not most of these programs are motivated by other policy objectives, but some are directed specifically at greenhouse gas emissions.

These U.S. actions and others that might be undertaken in the future are described in the Mitigation chapter of this report. Over the remainder of this century, aggressive and sustained greenhouse gas emission reductions by the United States and by other nations would be needed to reduce global emissions to a level consistent with the lower scenario (B1) analyzed in this assessment.¹⁵

With regard to adaptation, the pace and magnitude of observed and projected changes emphasize the need to be prepared for a wide variety and intensity of impacts. Because of the growing influence of human activities, the climate of the past is not a good basis for future planning. For example, building codes and landscaping ordinances could be updated to improve energy efficiency, conserve water supplies, protect against insects that spread disease (such as dengue fever), reduce susceptibility to heat stress, and improve protection against extreme events. The fact that climate change impacts are increasing points to the urgent need to develop and refine approaches that enable decision-making and increase flexibility and resilience in the face of ongoing and future impacts. Reducing non-climate-related stresses that contribute to existing vulnerabilities can also be an effective approach to climate change adaptation.¹⁶

Adaptation can involve considering local, state, regional, national, and international jurisdictional objectives. For example, in managing water supplies to adapt to a changing climate, the implications of international treaties should be considered in the context of managing the Great Lakes, the Columbia River, and the Colorado River to deal with increased drought risk. Both “bottom up” community planning and “top down” national strategies may help regions deal with impacts such as increases in electrical brownouts, heat stress, floods, and wildfires.¹⁷

Proactively preparing for climate change can reduce impacts while also facilitating a more rapid and efficient response to changes as they happen. Such efforts are beginning at the federal, regional, state, tribal, and local levels, and in the corporate and non-governmental sectors, to build adaptive capacity and resilience to climate change impacts. Using scientific information to prepare for climate changes in advance can provide economic opportunities, and proactively managing the risks can reduce impacts and costs over time.¹⁸

There are a number of areas where improved scientific information or understanding would enhance the capacity to estimate future climate change impacts. For example, knowledge of the mechanisms controlling the rate of ice loss in Greenland and Antarctica is limited, making it difficult for scientists to narrow the range of expected future sea level rise. Improved understanding of ecological and social responses to climate change is needed, as is understanding of how ecological and social responses will interact.¹⁹

A sustained climate assessment process could more efficiently collect and synthesize the rapidly evolving science and help supply timely and relevant information to decision-makers. Results from all of these efforts could continue to deepen our understanding of the interactions of human and natural systems in the context of a changing climate, enabling society to effectively respond and prepare for our future.²⁰

The cumulative weight of the scientific evidence contained in this report confirms that climate change is affecting the American people now, and that choices we make will affect our future and that of future generations.



Cities providing transportation options including bike lanes, buildings designed with energy saving features such as green roofs, and houses elevated to allow storm surges to pass underneath are among the many response options being pursued around the country.

Report Findings

These findings distill important results that arise from this National Climate Assessment. They do not represent a full summary of all of the chapters' findings, but rather a synthesis of particularly noteworthy conclusions.



1. Global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.

Many independent lines of evidence confirm that human activities are affecting climate in unprecedented ways. U.S. average temperature has increased by 1.3°F to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the warmest on record. Because human-induced warming is superimposed on a naturally varying climate, rising temperatures are not evenly distributed across the country or over time.²¹



2. Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.

Changes in extreme weather events are the primary way that most people experience climate change. Human-induced climate change has already increased the number and strength of some of these extreme events. Over the last 50 years, much of the United States has seen an increase in prolonged periods of excessively high temperatures, more heavy downpours, and in some regions, more severe droughts.²²



3. Human-induced climate change is projected to continue, and it will accelerate significantly if global emissions of heat-trapping gases continue to increase.

Heat-trapping gases already in the atmosphere have committed us to a hotter future with more climate-related impacts over the next few decades. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases that human activities emit globally, now and in the future.²³



4. Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond.

Climate change is already affecting societies and the natural world. Climate change interacts with other environmental and societal factors in ways that can either moderate or intensify these impacts. The types and magnitudes of impacts vary across the nation and through time. Children, the elderly, the sick, and the poor are especially vulnerable. There is mounting evidence that harm to the nation will increase substantially in the future unless global emissions of heat-trapping gases are greatly reduced.²⁴



5. Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water.

Climate change is increasing the risks of heat stress, respiratory stress from poor air quality, and the spread of waterborne diseases. Extreme weather events often lead to fatalities and a variety of health impacts on vulnerable populations, including impacts on mental health, such as anxiety and post-traumatic stress disorder. Large-scale changes in the environment due to climate change and extreme weather events are increasing the risk of the emergence or reemergence of health threats that are currently uncommon in the United States, such as dengue fever.²⁵



6. Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change.

Sea level rise, storm surge, and heavy downpours, in combination with the pattern of continued development in coastal areas, are increasing damage to U.S. infrastructure including roads, buildings, and industrial facilities, and are also increasing risks to ports and coastal military installations. Flooding along rivers, lakes, and in cities following heavy downpours, prolonged rains, and rapid melting of snowpack is exceeding the limits of flood protection infrastructure designed for historical conditions. Extreme heat is damaging transportation infrastructure such as roads, rail lines, and airport runways.²⁶



7. Water quality and water supply reliability are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.

Surface and groundwater supplies in some regions are already stressed by increasing demand for water as well as declining runoff and groundwater recharge. In some regions, particularly the southern part of the country and the Caribbean and Pacific Islands, climate change is increasing the likelihood of water shortages and competition for water among its many uses. Water quality is diminishing in many areas, particularly due to increasing sediment and contaminant concentrations after heavy downpours.²⁷



8. Climate disruptions to agriculture have been increasing and are projected to become more severe over this century.

Some areas are already experiencing climate-related disruptions, particularly due to extreme weather events. While some U.S. regions and some types of agricultural production will be relatively resilient to climate change over the next 25 years or so, others will increasingly suffer from stresses due to extreme heat, drought, disease, and heavy downpours. From mid-century on, climate change is projected to have more negative impacts on crops and livestock across the country – a trend that could diminish the security of our food supply.²⁸



9. Climate change poses particular threats to Indigenous Peoples' health, well-being, and ways of life.

Chronic stresses such as extreme poverty are being exacerbated by climate change impacts such as reduced access to traditional foods, decreased water quality, and increasing exposure to health and safety hazards. In parts of Alaska, Louisiana, the Pacific Islands, and other coastal locations, climate change impacts (through erosion and inundation) are so severe that some communities are already relocating from historical homelands to which their traditions and cultural identities are tied. Particularly in Alaska, the rapid pace of temperature rise, ice and snow melt, and permafrost thaw are significantly affecting critical infrastructure and traditional livelihoods.²⁹



10. Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed.

Climate change impacts on biodiversity are already being observed in alteration of the timing of critical biological events such as spring bud burst and substantial range shifts of many species. In the longer term, there is an increased risk of species extinction. These changes have social, cultural, and economic effects. Events such as droughts, floods, wildfires, and pest outbreaks associated with climate change (for example, bark beetles in the West) are already disrupting ecosystems. These changes limit the capacity of ecosystems, such as forests, barrier beaches, and wetlands, to continue to play important roles in reducing the impacts of these extreme events on infrastructure, human communities, and other valued resources.³⁰



11. Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulation, chemistry, ecosystems, and marine life.

More acidic waters inhibit the formation of shells, skeletons, and coral reefs. Warmer waters harm coral reefs and alter the distribution, abundance, and productivity of many marine species. The rising temperature and changing chemistry of ocean water combine with other stresses, such as overfishing and coastal and marine pollution, to alter marine-based food production and harm fishing communities.³¹



12. Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.

Actions to reduce emissions, increase carbon uptake, adapt to a changing climate, and increase resilience to impacts that are unavoidable can improve public health, economic development, ecosystem protection, and quality of life.³²

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OVERVIEW AND REPORT FINDINGS

REFERENCES

Numbered references for the Overview indicate the chapters that provide supporting evidence for the reported conclusions.

1. Ch. 2.
 2. Ch. 2, 3, 6, 9, 20.
 3. Ch. 2, 3, 4, 5, 6, 9, 10, 12, 16, 20, 24, 25.
 4. Ch. 2, 12, 16, 18, 19, 20, 21, 22, 23.
 5. Ch. 2, 4, 12, 16, 17, 18, 19, 20, 22, 25.
 6. Ch. 2, 4, 5, 10, 12, 16, 17, 20, 22, 25.
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Climate Change Impacts in the United States

CHAPTER 2 OUR CHANGING CLIMATE

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INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

2 OUR CHANGING CLIMATE

KEY MESSAGES

1. Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to human activities.
2. Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions.
3. U.S. average temperature has increased by 1.3°F to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the nation's warmest on record. Temperatures in the United States are expected to continue to rise. Because human-induced warming is superimposed on a naturally varying climate, the temperature rise has not been, and will not be, uniform or smooth across the country or over time.
4. The length of the frost-free season (and the corresponding growing season) has been increasing nationally since the 1980s, with the largest increases occurring in the western United States, affecting ecosystems and agriculture. Across the United States, the growing season is projected to continue to lengthen.
5. Average U.S. precipitation has increased since 1900, but some areas have had increases greater than the national average, and some areas have had decreases. More winter and spring precipitation is projected for the northern United States, and less for the Southwest, over this century.
6. Heavy downpours are increasing nationally, especially over the last three to five decades. Largest increases are in the Midwest and Northeast. Increases in the frequency and intensity of extreme precipitation events are projected for all U.S. regions.
7. There have been changes in some types of extreme weather events over the last several decades. Heat waves have become more frequent and intense, especially in the West. Cold waves have become less frequent and intense across the nation. There have been regional trends in floods and droughts. Droughts in the Southwest and heat waves everywhere are projected to become more intense, and cold waves less intense everywhere.
8. The intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest (Category 4 and 5) hurricanes, have all increased since the early 1980s. The relative contributions of human and natural causes to these increases are still uncertain. Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate continues to warm.
9. Winter storms have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the United States. Other trends in severe storms, including the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds, are uncertain and are being studied intensively.

Continued

KEY MESSAGES (CONTINUED)

10. **Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100.**
11. **Rising temperatures are reducing ice volume and surface extent on land, lakes, and sea. This loss of ice is expected to continue. The Arctic Ocean is expected to become essentially ice free in summer before mid-century.**
12. **The oceans are currently absorbing about a quarter of the carbon dioxide emitted to the atmosphere annually and are becoming more acidic as a result, leading to concerns about intensifying impacts on marine ecosystems.**

This chapter summarizes how climate is changing, why it is changing, and what is projected for the future. While the focus is on changes in the United States, the need to provide context sometimes requires a broader geographical perspective. Additional geographic detail is presented in the regional chapters of this report. Further details on the topics covered by this chapter are provided in the Climate Science Supplement and Frequently Asked Questions Appendices.

Since the second National Climate Assessment was published in 2009,¹ the climate has continued to change, with resulting

effects on the United States. The trends described in the 2009 report have continued, and our understanding of the data and ability to model the many facets of the climate system have increased substantially. Several noteworthy advances are mentioned in the box below.

The 12 key messages presented above are repeated below, together with supporting evidence for those messages. The discussion of each key message begins with a summary of recent variations or trends, followed by projections of the corresponding changes for the future.

WHAT'S NEW?

- Continued warming and an increased understanding of the U.S. temperature record, as well as multiple other sources of evidence, have strengthened our confidence in the conclusions that the warming trend is clear and primarily the result of human activities. For the contiguous United States, the last decade was the warmest on record, and 2012 was the warmest year on record.
- Heavy precipitation and extreme heat events are increasing in a manner consistent with model projections; the risks of such extreme events will rise in the future.
- The sharp decline in summer Arctic sea ice has continued, is unprecedented, and is consistent with human-induced climate change. A new record for minimum area of Arctic sea ice was set in 2012.
- A longer and better-quality history of sea level rise has increased confidence that recent trends are unusual and human-induced. Limited knowledge of ice sheet dynamics leads to a broad range for projected sea level rise over this century.
- New approaches to building scenarios of the future have allowed for investigations of the implications of larger reductions in heat trapping gas emissions than examined previously.

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REFERENCE PERIODS FOR GRAPHS

Many of the graphs in this report illustrate historical changes and future trends in climate compared to some reference period, with the choice of this period determined by the purpose of the graph and the availability of data. The great majority of graphs are based on one of two reference periods. The period 1901-1960 is used for graphs that illustrate past changes in climate conditions, whether in observations or in model simulations. The choice of 1960 as the ending date of this period was based on past changes in human influences on the climate system. Human-induced forcing exhibited a slow rise during the early part of the last century but then accelerated after 1960.² Thus, these graphs highlight observed changes in climate during the period of rapid increase in human-caused forcing and also reveal how well climate models simulate these observed changes. The beginning date of 1901 was chosen because earlier historical observations are less reliable and because many climate model simulations begin in 1900 or 1901. The other commonly used reference period is 1971-2000, which is consistent with the World Meteorological Organization's recommended use of 30-year periods for climate statistics. This is used for graphs that illustrate projected future changes simulated by climate models. The purpose of these graphs is to show projected changes compared to a period that people have recently experienced and can remember; thus, the most recent available 30-year period was chosen (the historical period simulated by the CMIP3 models ends in 1999 or 2000).

Key Message 1: Observed Climate Change

Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to human activities.

Climate is defined as long-term averages and variations in weather measured over a period of several decades. The Earth's climate system includes the land surface, atmosphere, oceans, and ice. Many aspects of the global climate are changing rapidly, and the primary drivers of that change are human in origin. Evidence for changes in the climate system abounds, from the top of the atmosphere to the depths of the oceans (Figure 2.1).³ Scientists and engineers from around the world have compiled this evidence using satellites, weather balloons, thermometers at surface stations, and many other types of observing systems that monitor the Earth's weather and climate. The sum total of this evidence tells an unambiguous story: the planet is warming.

Temperatures at the surface, in the troposphere (the active weather layer extending up to about 5 to 10 miles above the ground), and in the oceans have all increased over recent decades (Figure 2.2). Consistent with our scientific understanding, the largest increases in temperature are occur-

Ten Indicators of a Warming World

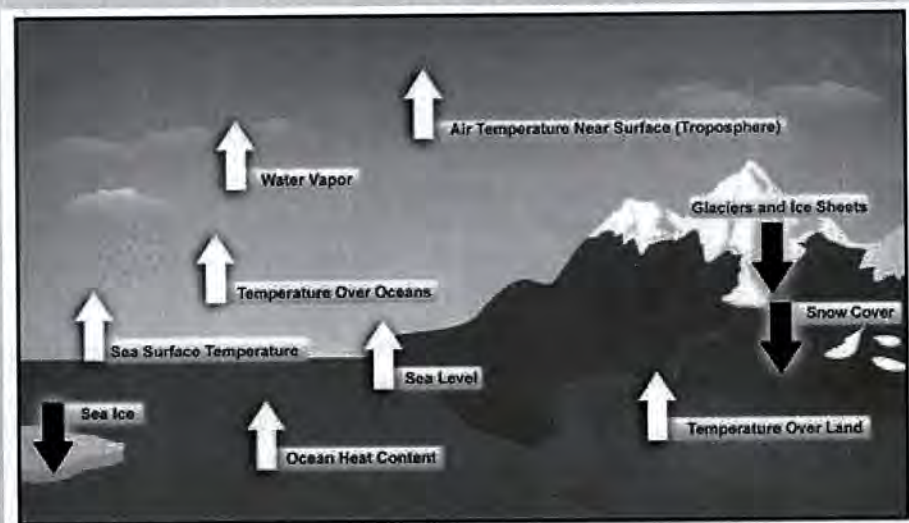


Figure 2.1. These are just some of the indicators measured globally over many decades that show that the Earth's climate is warming. White arrows indicate increasing trends, and black arrows indicate decreasing trends. All the indicators expected to increase in a warming world are, in fact, increasing, and all those expected to decrease in a warming world are decreasing. (Figure source: NOAA NCDC based on data updated from Kennedy et al. 2010³).

ring closer to the poles, especially in the Arctic. Snow and ice cover have decreased in most areas. Atmospheric water vapor is increasing in the lower atmosphere, because a warmer atmosphere can hold more water. Sea levels are also increasing (see Key Message 10). Changes in other climate-

relevant indicators such as growing season length have been observed in many areas. Worldwide, the observed changes in average conditions have been accompanied by increasing trends in extremes of heat and heavy precipitation events, and decreases in extreme cold.⁴

Natural drivers of climate cannot explain the recent observed warming. Over the last five decades, natural factors (solar forcing and volcanoes) alone would actually have led to a slight cooling (see Figure 2.3).⁵

The majority of the warming at the global scale over the past 50 years can only be explained by the effects of human influences,^{5,6,7} especially the emissions from burning fossil fuels (coal, oil, and natural gas) and from deforestation. The emissions from human influences that are affecting climate include heat-trapping gases such as carbon dioxide (CO₂), methane, and nitrous oxide, and particles such as black carbon (soot), which has a warming influence, and sulfates, which have an overall cooling influence (see Appendix 3: Climate Science Supplement for further discussion).^{8,9} In addition to human-induced global climate change, local climate can also be affected by other human factors (such as crop irrigation) and natural variability (for example, Ashley et al. 2012; DeAngelis et al. 2010; Degu et al. 2011; Lo and Famiglietti 2013¹⁰).

The conclusion that human influences are the primary driver of recent climate change is based on multiple lines of independent evidence. The first line of evidence is our fundamental understanding of how certain gases trap heat, how the climate system responds to increases in these gases, and how other human and natural factors influence climate. The second line of evidence is from reconstructions of past climates using evidence such as tree rings, ice cores, and corals. These show that global surface temperatures over the last several decades are clearly unusual, with the last decade (2000-2009) warmer than any time in at least the last 1300 years and perhaps much longer.¹¹

Global Temperature and Carbon Dioxide

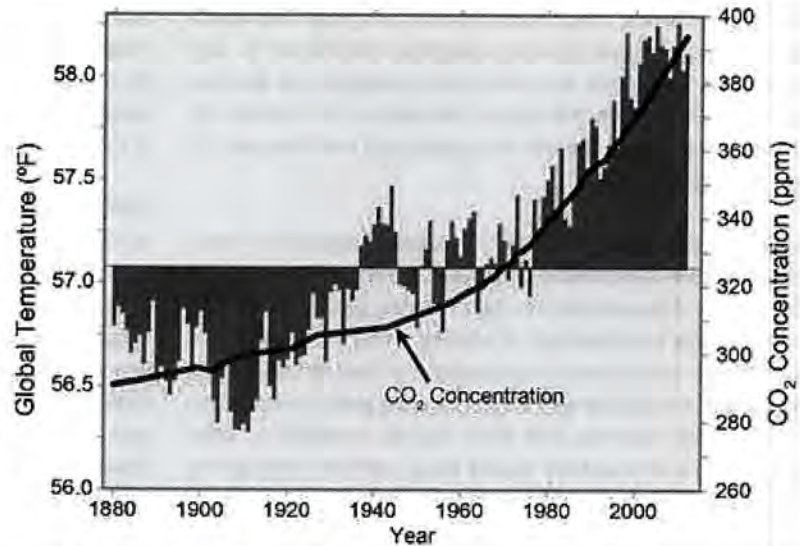


Figure 2.2. Global annual average temperature (as measured over both land and oceans) has increased by more than 1.5°F (0.8°C) since 1880 (through 2012). Red bars show temperatures above the long-term average, and blue bars indicate temperatures below the long-term average. The black line shows atmospheric carbon dioxide (CO₂) concentration in parts per million (ppm). While there is a clear long-term global warming trend, some years do not show a temperature increase relative to the previous year, and some years show greater changes than others. These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and volcanic eruptions. (Figure source: updated from Karl et al. 2009¹).

Separating Human and Natural Influences on Climate

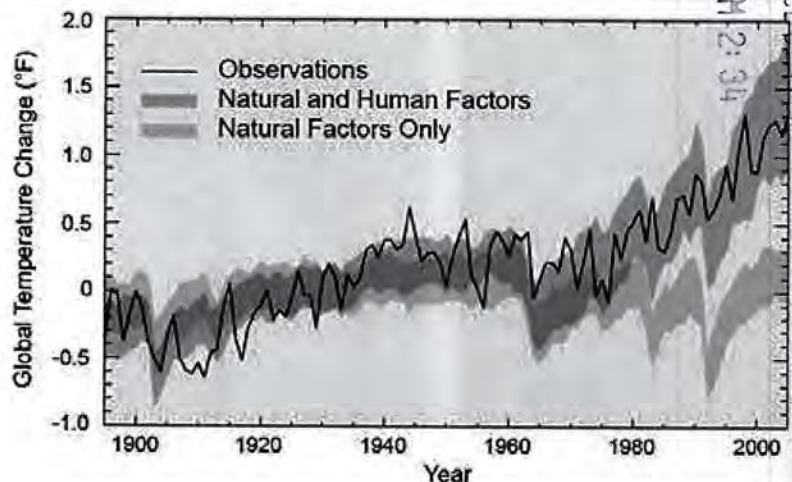


Figure 2.3. Observed global average changes (black line), model simulations using only changes in natural factors (solar and volcanic) in green, and model simulations with the addition of human-induced emissions (blue). Climate changes since 1950 cannot be explained by natural factors or variability, and can only be explained by human factors. (Figure source: adapted from Huber and Knutti²⁹).

The third line of evidence comes from using climate models to simulate the climate of the past century, separating the human and natural factors that influence climate. When the human factors are removed, these models show that solar and volcanic activity would have tended to slightly cool the earth, and other natural variations are too small to explain the amount of warming. Only when the human influences are included do the models reproduce the warming observed over the past 50 years (see Figure 2.3).

Another line of evidence involves so-called “fingerprint” studies that are able to attribute observed climate changes to particular causes. For example, the fact that the stratosphere (the layer above the troposphere) is cooling while the Earth’s surface and lower atmosphere is warming is a fingerprint that the warming is due to increases in heat-trapping gases. In contrast, if the observed warming had been due to increases in solar output, Earth’s atmosphere would have warmed throughout its entire extent, including the stratosphere.⁶

In addition to such temperature analyses, scientific attribution of observed changes to human influence extends to many other aspects of climate, such as changing patterns in precipitation,^{12,13} increasing humidity,^{14,15} changes in pressure,¹⁶ and increasing ocean heat content.¹⁷ Further discussion of how we know the recent changes in climate are caused by human activity is provided in Appendix 3: Climate Science Supplement.

Natural variations in climate include the effects of cycles such as El Niño, La Niña and other ocean cycles; the 11-year sunspot cycle and other changes in energy from the sun; and the effects of volcanic eruptions. Globally, natural variations can be

as large as human-induced climate change over timescales of up to a few decades. However, changes in climate at the global scale observed over the past 50 years are far larger than can be accounted for by natural variability. Changes in climate at the local to regional scale can be influenced by natural variability for multiple decades.¹⁸ This can affect the interpretation of climate trends observed regionally across the U.S. (see Appendix 3: Climate Science Supplement).

Globally averaged surface air temperature has slowed its rate of increase since the late 1990s. This is not in conflict with our basic understanding of global warming and its primary cause. The decade of 2000 to 2009 was still the warmest decade on record. In addition, global surface air temperature does not always increase steadily. This time period is too short to signify a change in the warming trend, as climate trends are measured over periods of decades, not years.^{19,20,21,22} Such decade-long slowdowns or even reversals in trend have occurred before in the global instrumental record (for example, 1900-1910 and 1940-1950; see Figure 2.2), including three decade-long periods since 1970, each followed by a sharp temperature rise.²³ Nonetheless, satellite and ocean observations indicate that the Earth-atmosphere climate system has continued to gain heat energy.²⁴

There are a number of possible contributions to the lower rate of increase over the last 15 years. First, the solar output during the latest 11-year solar cycle has been lower over the past 15 years than the past 60 years. Second, a series of mildly explosive volcanoes, which increased stratospheric particles, likely had more of a cooling effect than previously recognized.²⁵ Third, the high incidence of La Niña events in the last 15 years has played a role in the observed trends.^{20,26} Recent analyses²⁷ suggest that more of the increase in heat energy during this period has been transferred to the deep ocean than previously. While this might temporarily slow the rate of increase in surface air temperature, ultimately it will prolong the effects of global warming because the oceans hold heat for longer than the atmosphere does.

Climate models are not intended to match the real-world timing of natural climate variations – instead, models have their own internal timing for such variations. Most modeling studies do not yet account for the observed changes in solar and volcanic forcing mentioned in the previous paragraph. Therefore, it is not surprising that the timing of such a slowdown in the rate of increase in the models would be different than that observed, although it is important to note that such periods *have* been simulated by climate models, with the deep oceans absorbing the extra heat during those decades.²⁸



Oil used for transportation and coal used for electricity generation are the largest contributors to the rise in carbon dioxide that is the primary driver of observed changes in climate over recent decades.

MODELS USED IN THE ASSESSMENT

This report uses various projections from models of the physical processes affecting the Earth's climate system, which are discussed further in Appendix 3: Climate Science Supplement. Three distinct sets of model simulations for past and projected changes in climate are used:

- Coupled Model Intercomparison Project, 3rd phase (CMIP3): global model analyses done for the Fourth Intergovernmental Panel on Climate Change (IPCC) assessment. Spatial resolutions typically vary from 125 to 187 miles (at mid-latitudes); approximately 25 representations of different models (not all are used in all studies). CMIP3 findings are the foundation for most of the impact analyses included in this assessment.
- Coupled Model Intercomparison Project, 5th phase (CMIP5): newer global model analyses done for the Fifth IPCC assessment generally based on improved formulations of the CMIP3 models. Spatial resolutions typically vary from 62 to 125 miles; about 30 representations of different models (not all are used in all studies); this new information was not available in time to serve as the foundation for the impacts analyses in this assessment, and information from CMIP5 is primarily provided for comparison purposes.
- North American Regional Climate Change Assessment Program (NARCCAP): six regional climate model analyses (and limited time-slice analyses from two global models) for the continental U.S. run at about 30-mile horizontal resolution. The analyses were done for past (1971-2000) and projected (2041-2070) time periods. Coarser resolution results from four of the CMIP3 models were used as the boundary conditions for the NARCCAP regional climate model studies, with each of the regional models doing analyses with boundary conditions from two of the CMIP3 models.

The scenarios for future human-related emissions of the relevant gases and particles used in these models are further discussed in Appendix 3: Climate Science Supplement. The emissions in these scenarios depend on various assumptions about changes in global population, economic and technological development, and choices in transportation and energy use.

Key Message 2: Future Climate Change

Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions.

A certain amount of continued warming of the planet is projected to occur as a result of human-induced emissions to date; another 0.5°F increase would be expected over the next few decades even if all emissions from human activities suddenly stopped,³⁰ although natural variability could still play an important role over this time period.³¹ However, choices made now and in the next few decades will determine the amount of additional future warming. Beyond mid-century, lower levels of heat-trapping gases in scenarios with reduced emissions will lead to noticeably less future warming. Higher emissions levels will result in more warming, and thus more severe impacts on human society and the natural world.

Confidence in projections of future climate change has increased. The wider range of potential changes in global average temperature in the latest generation of climate model simulations³² used in the Intergovernmental Panel on Climate

Change's (IPCC) current assessment – versus those in the previous assessment⁸ – is simply a result of considering more options for future human behavior. For example, one of the scenarios included in the IPCC's latest assessment assumes aggressive emissions reductions designed to limit the global temperature increase to 3.6°F (2°C) above pre-industrial levels.³³ This path would require rapid emissions reductions (more than 70% reduction in human-related emissions by 2050, and net negative emissions by 2100 – see the Appendix 3: Climate Science, Supplemental Message 5) sufficient to achieve heat-trapping gas concentrations well below those of any of the scenarios considered by the IPCC in its 2007 assessment. Such scenarios enable the investigation of climate impacts that would be avoided by deliberate, substantial reductions in heat-trapping gas emissions.

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Projections of future changes in precipitation show small increases in the global average but substantial shifts in where and how precipitation falls. Generally, areas closest to the poles are projected to receive more precipitation, while the dry subtropics (the region just outside the tropics, between 23° and 35° on either side of the equator) expand toward the poles and receive less rain. Increases in tropical precipitation are projected during rainy seasons (such as monsoons), especially over the tropical Pacific. Certain regions, including the western U.S. (especially the Southwest¹) and the Mediter-

anean, are presently dry and are expected to become drier. The widespread trend of increasing heavy downpours is expected to continue, with precipitation becoming less frequent but more intense.³⁴ The patterns of the projected changes of precipitation do not contain the spatial details that characterize observed precipitation, especially in mountainous terrain, because the projections are averages from multiple models and because the effective resolution of global climate models is roughly 100-200 miles.

