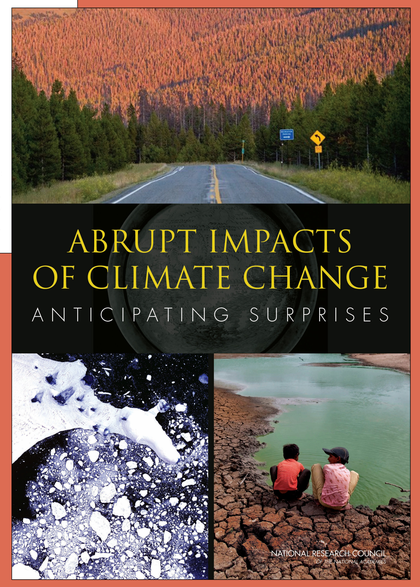
Abrupt Impacts of Climate Change: Anticipating Surprises

James W. C. White, Chair, University of Colorado, Boulder
Edward Dunlea, Study Director, National Research Council
Amanda Purcell, Research Associate, National Research Council

Reference: National Research Council, 2013. Abrupt Impacts of Climate Change: Anticipating Surprises. National Academies Press, Washington, D.C.

COMMITTEE MEMBERSHIP: **James W.C. White** (Chair), University of Colorado Boulder; **Richard B. Alley**, Pennsylvania State University; **David Archer**, The University of Chicago; **Anthony D. Barnosky**, University of California, Berkeley; **Jonathan Foley**, University of Minnesota, St. Paul; **Rong Fu**, The University of Texas at Austin; **Marika Holland**, National Center for Atmospheric Research; **Susan Lozier,** Duke University; **Johanna Schmitt**, University of California, Davis; **Laurence C. Smith**, University of California, Los Angeles; **George Sugihara**, University of California, San Diego; **David Thompson**, Colorado State University; **Andrew J. Weaver**, University of Victoria; **Steven C. Wofsy**, Harvard University; Edward J. Dunlea (Senior Program Officer); Amanda Purcell (Research and Financial Associate); Rob Greenway (Program Associate), National Research Council.



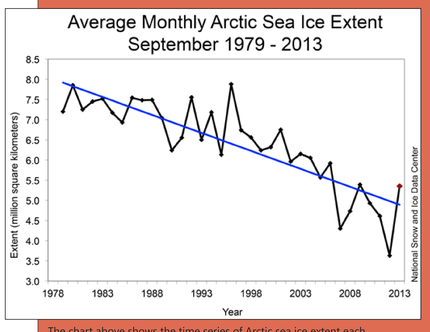
Abrupt Climate Changes Already Occurring

The abrupt changes that are already underway are of most immediate concern for societal decisions. These include the disappearance of late-summer Arctic sea ice and increases in extinction rates of marine and terrestrial species

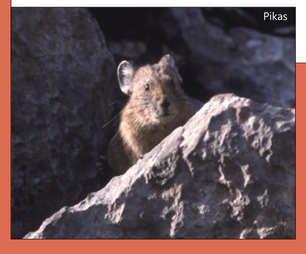
Disappearance of Late-Summer Arctic Sea Ice. Recent dramatic changes in the extent and thickness of the ice that covers the Arctic sea have been well documented. Satellite data for late summer (September) sea ice extent show natural variability around a clearly declining long-term trend (see figure to the right).

Potential impacts include: disruptions in the marine food web, shifts in the habitats of some marine mammals, and erosion of vulnerable coastlines. possible shifts in climate and weather around the northern hemisphere.

Increased Extinction Threat. Biologically important climatic attributes—such as number of frost-free days, length and timing of growing seasons, and the frequency and intensity of extreme events (such as number of extremely hot days or severe storms)—are changing so rapidly that some species can neither move nor adapt fast enough. Specific examples of species at risk for include pikas (below) and endemic Hawaiian silverswords, which are restricted to cool temperatures at high altitudes.



The chart above shows the time series of Arctic sea ice extent each September from 1979 to 2013 derived from satellite data. Late summer Arctic sea ice extent has shown a substantial decrease since the satellite data record began in 1979, in particular the most recent seven summers have shown much lower sea ice cover. Source: NSIDC.


Pikas


Disappearance of summer time Arctic sea ice has impacts on Arctic ecosystems and causes changes to shipping routes.

Abrupt Climate **Change** and Abrupt Climate **Impacts**

This study differs from previous treatments of abrupt changes by discussing both:

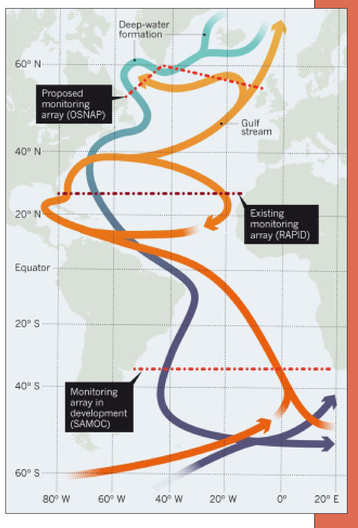
- **abrupt climate change**: abrupt changes in the physical climate system
- **abrupt climate impacts**: abrupt changes in the physical, biological, or human systems that result from steadily changing aspects of the climate system

This report focuses on abrupt climate changes and abrupt climate impacts that have (or were thought to possibly have) the potential to severely affect the physical climate system, natural systems, or humans systems, often affecting multiple interconnected areas of concern. The primary timescale of concern is years to decades. A key characteristic of these changes is that they can come faster than expected, planned, or budgeted for, forcing more reactive, rather than proactive, modes of behavior.

Possible Changes Now Thought to **Not Be an Immediate Threat**

Shutdown of the Atlantic Meridional Overturning Circulation (AMOC). Recent model simulations indicate that the AMOC is currently stable in the face of likely perturbations. An abrupt shutdown of the AMOC is unlikely to occur in this century. Continued and expanded observations (see figure to the right) are required to monitor AMOC for possible changes and improved understanding.

Sudden Release of Methane at High Latitudes. Large amounts of carbon are currently stored in high latitude regions as permafrost soils (below left) and methane-containing ices (below right). According to current scientific understanding, as temperatures rise these carbon stores are poised to play a significant amplifying role in the century-scale buildup of greenhouse gases in the atmosphere—but are unlikely to do so abruptly. Continued and expanded observations and research are required to monitor ongoing methane releases.




Permafrost

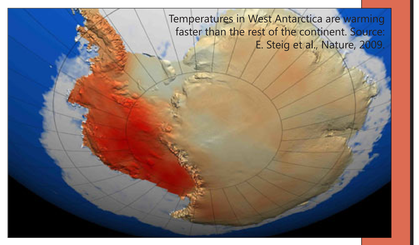

Methane Hydrates

More Research Needed

West Antarctic Ice Sheet WAIS collapse. The disintegration of WAIS would result in rapid sea level rise. The probability of WAIS disintegration during this century is unknown, but probably low.

Improved understanding of key physical processes and inclusion of them in models, together with improved projections of changes in the surrounding ocean, are required to reduce uncertainties and to better quantify worst-case scenarios.


WAIS collapse could endanger coastal infrastructure.


Temperatures in West Antarctica are warming faster than the rest of the continent. Source: E. Steig et al., Nature, 2009.

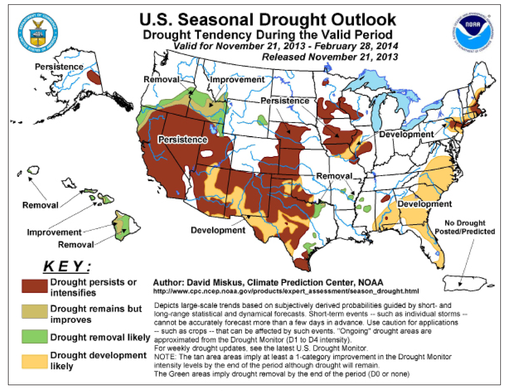
Abrupt Change **Early Warning System** (ACEWS)

Some surprises in the climate system may be inevitable, but with improved scientific monitoring and better understanding of the climate system it could be possible to anticipate abrupt change before it occurs and reduce the potential consequences.

Initial thoughts on what would make such a system successful:

- **Monitor key variables of abrupt change:** Monitoring for an ACEWS should expand upon existing monitoring networks, protect and/or augment important networks that are currently in place, and develop new ones as needed.
- **Modeling to project future abrupt changes:** A successful and adaptive ACEWS must consistently iterate between data collection, model testing and improvement, and model predictions that suggest better data collection.
- **Synthesis of existing knowledge:** A necessary part of an ACEWS is synthesizing knowledge to avoid the trap of data collection without continuing and evolving data analysis and model integration. This will require dedicated teams of researchers, improved collaborative networks, enhanced educational activities, and innovative tools for data analysis and modeling techniques.

Designing and implementing an ACEWS will need to be an iterative process that is revisited and refined as understanding of abrupt climate change, impacts, and social vulnerabilities evolves.



Example warning system: National Integrated Drought Information System (NIDIS).

National Research Council
of the National Academies

The Board on Atmospheric Sciences and Climate (BASC) is a unit within the National Academies. Information about the BASC and other related activities can be found at http://dels.nas.edu/basc/. More information on the study, including a link to download a free PDF of the report, can be found here: http://nas-sites.org/americasclimatechoices/other-reports-on-climate-change/2013-2/abrupt-impacts-of-climate-change/. Paper copies are available for purchase through the National Academies Press at (888) 624-8373.