CCSP Synthesis and Assessment Product 3.3

SAP-3.3

Prospectus for

Weather and Climate Extremes in a Changing Climate

Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands

U.S. Climate Change Science Program

Lead Agency
National Oceanic and Atmospheric Administration

Contributing Agencies
Department of Energy
National Aeronautics and Space Administration
U.S. Geological Survey

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This prospectus has been prepared according to the *Guidelines for Producing Climate Change Science Program (CCSP) Synthesis and Assessment Products*. The prospectus was reviewed and approved by the CCSP Interagency Committee. The document describes the focus of this synthesis and assessment product, and the process that will be used to prepare it. The document does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action.

Prospectus for Synthesis and Assessment Product 3.3

Weather and Climate Extremes in a Changing Climate

Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands

1. Overview: Description of Topic, Audience, Intended Use, and Questions to Be Addressed

The impact of climate extremes can be severe and wide-ranging. Extremes affect all sectors of the economy, including agriculture, utilities, transportation, water resources, and the insurance industry. The costs of weather-related disasters can be considerable. The U.S. National Climatic Data Center maintains a web page (<http://www.ncdc.noaa.gov/oa/reports/billionz.html>) that describes those events that have had the greatest economic impact in the United States since 1980. During the period 1980-2005, the United States experienced 67 weather-related disasters in which overall damages exceeded $1 billion at the time of the event (and subsequently adjusted in terms of constant dollars).

Clearly, the direct impact of extreme weather and climate events on the U.S. economy is substantial. However, the evidence for increases in extreme weather and climate events varies, depending on the event of interest (e.g., changes in heavy and extreme precipitation, frost days, heavy snow events, etc.).

A workshop convened in Bermuda in October 2005 assembled climate scientists and insurers/reinsurers to assess the current state of knowledge of climate extremes. A summary of the meeting is available in EOS (Vol. 87, No. 3, January 17, 2006). The meeting addressed anticipated changes in the frequency of extreme events in response to global warming; whether these changes could be bounded; and the observations needed to improve knowledge (i.e., improve models and the statistics of extremes). Hurricanes were of particular interest because of recent, very active seasons and the large impact on the insurance industry. The workshop recognized the importance of both observations and models to accurately quantify risk. The need to better understand the natural and anthropogenic drivers of changes in climate extremes was underscored.

Recent and ongoing Intergovernmental Panel on Climate Change (IPCC) assessments have evaluated extreme weather and climate events in the context of climate change on a global basis. However, there has not yet been specific focus on those events in North America, where observing systems are among the best in the world.

There is also environmental evidence that changes in weather and climate extremes have important biological impacts for both natural and managed ecosystems. In addition, there are prospects from climate model simulations that a gradually warming world will be accompanied by changes in the variability and frequency of weather and climate extremes. For all these reasons, monitoring changes and variations in weather and climate extremes and assessing what we know and do not know regarding future changes is important for both socio-economic and environmental interests. Therefore, it is timely to undertake an indepth assessment of the state of knowledge for North America, where we live, work, grow much of our food, etc.

Extreme weather and climate events span many weather and climate variables, and an important aspect of this synthesis and assessment report will be to identify those key variables or indices that may provide important information related to socio-economic or environmental impacts. Identifying recent changes and trends in these parameters will be a focus of the report, as well as identifying what can be said about future changes. Examples of some of the key variables include temperature-related parameters (severe freezes, heat waves), precipitation-related parameters (wet spells, heavy precipitation events, droughts), tropical and extra-tropical storm frequency and intensity, ice and hail, snow cover and depth, etc. Since extreme weather and climate events on a global scale are regularly addressed in international assessments, this CCSP synthesis and assessment product will focus on weather and climate extremes primarily across Canada, Mexico, and the United States, including its territories. In accordance with CCSP guidelines, the synthesis and assessment products are intended to support informed discussion and decisionmaking regarding climate variability and change by policymakers, resource managers, stakeholders, the media, and the general public. This report also should have particular value to ongoing free-trade agreements (Canada, United States, and Mexico) and bi-lateral and multi-lateral agreements related to the management of natural resources in North America.

2. Contact Information for Responsible Individuals at the Lead and Supporting Agencies

The National Oceanic and Atmospheric Administration (NOAA) is the lead agency for this synthesis and assessment product. Relevant agency personnel are presented in the following table:

CCSP Agency	Agency Leads
DOC (NOAA)	Thomas Karl, Christopher Miller
DOE	Anjuli Bamzai
NASA	Don Anderson, Tsengdar Lee
USGS	Tom Armstrong

3. Lead Authors: Required Expertise of Lead Authors and Biographical Information for Proposed Lead Authors

The author team for this product will be constituted as a Federal Advisory Committee in accordance with the Federal Advisory Committee Act (FACA) of 1972 as amended, 5 U.S.C. App.2. Each author team member shall be appointed for a term of 2 years, and will serve at the discretion of the Under Secretary of Commerce for Oceans and Atmosphere. Appointments are renewable for additional terms. Committee members will include non-Federal experts and Federal officials who are also experts and who may remain on the committee should they leave Federal service. Non-federal employee committee members will be subject to the ethical standards applicable to Special Government Employees and to Departmental and FACA vetting procedures. The Committee Charter, a list of Committee members, and meeting announcement information will be made available to the public on a dedicated web page. Committee meetings will also be announced in the *Federal Register* at least 15 days in advance and these meetings will be open to the public. All materials made available to the Committee, as well as meeting reports, will be made available to the public unless subject to exemption under the Freedom of Information Act.

The list of author team nominees presented in Appendix A is proposed based on their records of interest and accomplishment in framing the core issues related to changes, trends, and uncertainties in the occurrence of extreme climate events and their impacts, advancing relevant scientific arguments, and contributing to increased understanding of the behavior of respective components of the end-to-end system that provides the required data sets. Past contributions to relevant scientific assessments, publication records in refereed journals, and committee balance and diversity are among the measures used in the selection process. Dr. Thomas Karl, the Director of the National Climatic Data Center, and Dr. Gerald Meehl, of the National Center for Atmospheric Research, are nominated as co-Chairs of the FACA Committee. Once the nominations have been approved and vetting has been completed, the

chapter assignments proposed in Section 5 of this prospectus will be confirmed.

4. Stakeholder Interactions

An initial workshop was held in July 2005 to bring together a number of leading scientists in the area of climate extremes and members of key segments of the stakeholder community. The primary objective of this workshop was to help frame the critical issues related to this synthesis and assessment product. This framework included various aspects of the science, impacts, and stakeholders' concerns related to the changes and variations of weather and climate extremes. A specific outcome was an outline of an action plan to produce the required CCSP product (i.e., an assessment report on weather and climate extremes). A second workshop—one focusing more on the impacts of extreme weather and climate events for a specific stakeholder community—occurred in October 2005. The output from the second workshop was used to help refine critical issues this report will address. The general objectives of these workshops were to: (1) identify a framework to define climate weather and extremes with particular ecological or economic impact; (2) assess the state of the science in the historical and contemporary measurement of weather and climate extremes; (3) examine and clarify our ability to report on observed changes and variations; (4) examine what, if anything, we can say about future changes suggested by climate models or other relevant information, including changes in the frequency, intensity, and duration of extremes; and (5) define the measurements, analyses, and other actions required to improve our understanding of future variations and changes in weather and climate extremes. These issues will be the focus of the CCSP Synthesis and Assessment Product 3.3.

5. Drafting, Including Materials to Be Used in Preparing the Product

The lead NOAA focal point, Dr. Thomas Karl, is the Editor-in-Chief. The assistant NOAA focal point, Dr. Christopher Miller, serves as the Associate Editor. This report will be prepared in compliance with the Federal Advisory Committee Act and the report development team will be constituted and operated under FACA guidelines. The report will be written in a style consistent with major international scientific assessments [e.g., IPCC assessments and the Global Ozone Research and Monitoring Project (WMO, 1999)].

The main body of this report will be presented in four chapters, the contents of which will be summarized in an Executive Summary (ES):

- Chapter 1. Why Weather and Climate Extremes Matter
  - Why are extremes important?
  - Defining extremes in relation to social, economic and environmental impacts
  - Measures of weather and climate extremes and their data limitations

  Proposed Convening Lead Author (CLA): Thomas Peterson

  Proposed Lead Authors (LAs): David Phillips, Camille Parmesan, John Stone (also ES), David Anderson, Miguel Cortez, Richard Murnane (also ES), Roger Pulwarty, Stewart Cohen (also ES)
- Chapter 2. Observed Changes of Weather and Climate Extremes
  - Observed changes and variations in weather and climate extremes
  - Key uncertainties related to measuring specific variations and changes

  Proposed Convening Lead Author (CLA): Kenneth Kunkel

  Proposed Lead Authors (LAs): David Levinson, Tereza Cavazos, Arthur Douglas, Harold Brooks, David Easterling, Kerry Emanuel, Charles Watson, Pavel Groisman, Richard Smith, Peter Bromirski, Paul Komar
- Chapter 3. Do We Understand the Causes of Observed Changes in Extremes and What are the Projected Future Changes?
  - What are the physical mechanisms of observed changes in extremes?
  - Attributing observed changes to external forcing

  - Projected future changes in extremes, their causes, mechanisms and uncertainties

  Proposed Convening Lead Author (CLA): William Gutowski
  Proposed Lead Authors (LAs): Linda Mearns, Greg Holland, Gabriele Hegerl, Francis Zwiers, Ronald Stouffer, Peter Webster, Thomas Knutson (also ES)
- Chapter 4. Recommendations for Improving Our Understanding
  Proposed Convening Lead Author (CLA): David Easterling
  Proposed Lead Authors (LAs): Thomas Peterson (also ES), Kenneth Kunkel (also ES), William Gutowski (also ES)
- Executive Summary
  Proposed Convening Lead Authors (CLAs): Gerald Meehl, Thomas Karl
  Proposed Lead Authors (LAs): Thomas Peterson, Kenneth Kunkel, William Gutowski, David Easterling, Rick Murnane, Stewart Cohen, Thomas Knutson, John Stone

Under the leadership of the CLA for each of the main report chapters, the LAs and contributors will prepare the scientific/technical analysis section of the synthesis and assessment product. They will draw upon published, peer-reviewed scientific literature in the drafting process—complemented, if necessary and if approved by the CCSP Principals, with information that has not yet been published in the peer-reviewed literature.

The synthesis and assessment product will include an Executive Summary that will present key findings from each of the report chapters. It will be written by a team consisting of the Executive Summary CLAs assisted by the CLAs from each of the chapters. The synthesis and assessment product will strive to reach consensus on the issues covered and will seek to avoid the need to include disparate views in the report chapters and in the Executive Summary. It also will include a recommendation on steps to better understand the frequency and severity of future climate extremes and improve the predictions and projections of those extremes.

The strategy for proceeding from the initiation of the effort, through the sequence of draft versions, to the final version will be in accordance with the *Climate Change Science Program Guidelines for Producing CCSP Synthesis and Assessment Products* as presented on the U.S. Climate Change Science Program web site.

6. Review

The CCSP Synthesis and Assessment Products are classified as "highly influential" under the terms of the Office of Management and Budget's Final Information Quality Bulletin for Peer Review (issued 16 December 2004). The review process will be conducted in accordance with the OMB guidelines, which include making the peer review plan web accessible.

NOAA, the lead agency for this product, plans to present Synthesis and Assessment Product 3.3 to the National Research Council (NRC) for scientific review. The reviewers, who will be selected by the NRC, will be charged to focus on the scientific and technical content of the draft report to ensure that the report adequately answers the questions posed in the approved prospectus; that the report is objective, unbiased, and does not contain policy recommendations; and that the report is written at a level appropriate for the intended audience that will include government and private sector managers and decisionmakers.

Upon receipt of the expert review comments, all comments will be considered and addressed. The lead agency will disseminate the peer review report, including the agency's response to the review, on the agency's web site. A second draft of the product will be prepared and released for a 45-day public comment period. The lead authors will prepare a third draft of the product in response to the public comments, incorporating changes, as appropriate.

The third draft of the document will be submitted to the CCSP Principals for final review and subsequent submission to the National Science and Technology Council (NSTC) for approval for release.

7. Related Activities: Coordination with Other National or International Assessment Processes

This CCSP synthesis and assessment product will be coordinated internationally through the planned direct involvement of international participants in the author and stakeholder groups. In addition, the synthesis and assessment product is expected to complement the IPCC Fourth Assessment Report, which is also due for release in 2007. The IPCC report will focus on the behavior of extremes from the global perspective, while the CCSP report will emphasize extremes as experienced primarily on the North American continent.

8. Communications

The first (peer review version), second (public comment version), and third (post-public comment version) drafts of the product will be posted on the CCSP web site. Once NSTC approval has been obtained and the product is finalized, NOAA, the lead agency, will produce and release the completed product using a standard format for all CCSP synthesis and assessment products. The final product, the comments received during the expert review (without attribution unless specific reviewers agree to attribution), the responses to the expert review comments, and the comments received during the public comment period will be posted on the CCSP web site.

In addition to the formal dissemination requirements listed above, the lead authors will be encouraged to publish their findings in the scientific literature.

9. Chronology

CY 2005

1) Aspen Workshop: "North American Weather and Climate Extremes – Progress in Monitoring and Research" – July 15-21
2) CCSP Stakeholder Workshop – November 14-16

CY 2006

3) Draft Prospectus Submitted to CCSP Interagency Committee for Approval – March 3
4) Draft Prospectus Approved – April 4
5) Draft Prospectus Released for Public Comment – April 12
6) Public Comment Period Completed – May 12
7) Draft FACA Charter Submitted for Approval – May 20
8) Revised Prospectus Submitted to CCSP Interagency Committee for Approval – July 1
9) Prospectus Approved by CCSP Interagency Committee – July 15
10) Draft Prospectus, Public Comments, and Final Prospectus Posted on CCSP Website – July 20

CY 2007

11) First Draft of the Synthesis and Assessment Product Report Submitted for Expert Review – February 15
12) Expert Review of the Synthesis and Assessment Product Report Completed – May 15
13) Second Draft of the Synthesis and Assessment Product Report Released for Public Comment –August 15
14) Second Draft Public Comment Period Completed – October 1
15) Third Draft of the Synthesis and Assessment Product Report Completed and Submitted to CCSP for posting and Interagency Committee Review – December 20

CY 2008

16) CCSP Interagency Committee Review of Third Draft Completed - January 15
17) Third Draft Report Submitted to NSTC for Final Review and Approval – January 31
18) Web Version of the Synthesis and Assessment Product Report Posted on CCSP Website – February 28
19) Hardcopy of the Synthesis and Assessment Product Report Published – April 15

APPENDIX A - List of Lead Authors

David M. Anderson is the head of the Paleoclimatology Branch of NOAA's National Climatic Data Center and the Director of the World Data Center for Paleoclimatology, and an Associate Professor Adjoint at the Institute of Arctic and Alpine Research at the University of Colorado. He serves on the International Past Global Changes Project Data Board, and is the NOAA representative for the CCSP Report on Risks of Global Abrupt Climate Change. His research interests include the marine geologic records of ENSO and the monsoons, and role of the oceans in the global carbon cycle and past changes in carbon dioxide in the atmosphere.

Gupta, A. K., Das, M., and D. M. Anderson, 2005. Solar influence on the Indian summer monsoon during the Holocene, Geophysical Research Letters, 32(7), L17703, 10.1029/2005GL022685.

Moy, C. M., Seltzer, G. O., Rodbell, D. T., and D. M. Anderson, 2002. Oscillation in ENSO Activity at Millennial Time Scales During the Holocene. Nature, 420:162-165.

Anderson, D. M., and Overpeck, J. T., and A. K. Gupta, 2002. Increase in the Asian SW Monsoon During the Past Four Centuries. Science, 297:596-599.

Anderson, D. M., and Archer, D. 2002. Glacial-intergacial stability of ocean pH inferred from foraminifer dissolution rates. Nature, 416:70-73.

Peter D. Bromirski is an Assistant Project Scientist at the Integrated Oceanography Division at Scripps Institution of Oceanography, UCSD, La Jolla, California. As a member of the California Climate Action Team, he recently co-authored an analysis of historical and projected waves and sea levels along the California coast. His current research includes reconstruction of the wave climatology along the central California coast from inversion of archived seismograms at UC Berkeley from 1930 onward, coastal impacts of extreme waves and sea levels, their decadal variability, and the decadal variability of sea levels along the U.S. West Coast. Relevant publications include:

Cayan, D.R., P.D. Bromirski, K. Hayhoe, M. Tyree, M. Dettinger, and R.E. Flick (2006). *Projecting Future Sea Level*, California Climate Change Center, Scripps Institution of Oceanography, La Jolla, CA, publication #CEC-500-2005-202-SF, 53pp, http://www.climatechange.ca.gov/climate_action_team/reports/index.html.

Bromirski, P.D., D.R. Cayan, and R.E. Flick (2005). Wave spectral energy variability in the northeast Pacific, *J. Geophys. Res.*, **110**, C03005, doi:10.1029/2004JC002398.

Bromirski, P.D., R.E. Flick, and D.R. Cayan (2003). Storminess variability along the California coast: 1858 - 2000, *J. Clim.*, **16**, No. 6, 982-993.

Bromirski, P.D., R.E. Flick and N. Graham (1999). Ocean wave height determined from inland seismometer data: Implications for investigating wave climate changes in the NE Pacific, *J. Geophys. Res.*, **104** (C9), 20,753 - 20,766.

Harold Brooks is a research meteorologist and Head of the Mesoscale Applications Group of NOAA's National Severe Storms Laboratory. He was an invited speaker on severe thunderstorms at the Intergovernmental Panel on Climate Change (IPCC) Extreme Weather and

Climate Change Workshop in Beijing in 2002 and was a contributing author to "Climate Change 2001: The Scientific Basis", produced as a contribution of Working Group 1 to the Third Assessment Report of the IPCC. His current research interests include understanding the historical record of severe thunderstorms in the US, and estimation of the distribution of severe thunderstorms around the world and projections of future changes in that distribution. Relevant publications include:

Brooks, H. E., and C. A. Doswell III, 2001: Normalized damage from major tornadoes in the United States: 1890-1999. /Wea. Forecasting/, *16*, 168-176.

Brooks, H. E., J. W. Lee, and J. P. Craven, 2003: The spatial distribution of severe thunderstorm and tornado environments from global reanalysis data. /Atmos. Res./, *67-68*, 73-94.

Verbout, S. M., H. E. Brooks, L. M. Leslie, and D. M. Schultz, 2006: Comparing daily U.S. tornado reports over the period 1954-2003. /Wea. Forecasting/, *21*, in press.

Tereza Cavazos is an Assistant Professor at the Department of Physical Oceanography, CICESE, Ensenada, Baja California, Mexico. She was a Co-convener of the Workshop on The North American Monsoon Experiment (NAME): Oceanographic Component, Baja California, April 2003, a Co-convener: 2004 Ocean Sciences Meeting, Oceanographic and Meteorological Processes in the Gulf of California (OS20), Portland, February 2004, a Special Session co-convener: Climate Modeling in Mexico, Annual Meeting of the Mexican Geophysical Union, Puerto Vallarta, Mexico October 2005. She has served as a Reviewer for: Journal of Climate, Monthly Weather Review, Journal of Hydrometeorology, Journal of Atmospheric Sciences, Journal of Applied Meteorology, International Journal of Climatolology, Climate Research, Geophysical Research, Letters, Theoretical and Applied Climatology, Atmospheric Science Letters, Annals Geographicae, Geofisica Internacional, Ingeniería Hidráulica, Ciencias Marinas and has been the author or co-author of 15 peer-reviewed articles including Journal of Climate, International Journal of Climatology, Climate Research, Geophysical Research, Letters, Journal of Hydrometeorology. Her current research interests include climate variability and downscaling, extreme events, and the North American monsoon. Relevant publications on climate extremes:

Cerezo-Mota, R., T. Cavazos, and L. M. Farfan, 2005: Numerical simulation of heavy precipitation in northern Baja California and southern California. J. Hydrometeor. (in press).

Cavazos, T. and D. Rivas, 2004: Variability of extreme precipitation events in Tijuana, Mexico. Climate Res., 25, 229-243.

Cavazos, T., A. C. Comrie, and D. M. Liverman, 2002: Intraseasonal variability associated with wet monsoons in southeast Arizona. J. Climate, 15, 2477-2490.

Cavazos, T., 1999: Large-scale circulation anomalies conducive to extreme events and simulation of daily precipitation in northeastern Mexico and southeastern Texas. J. Climate, 12, 1506-1523.

Stewart J. Cohen is a research scientist with Adaptation and Impacts Research Group (AIRG), Environment Canada, and an Adjunct Professor of the Sustainable Development Research

Institute (SDRI) at University of British Columbia (UBC), Vancouver, Canada. Dr. Cohen received Ph.D. in Geography from the University of Illinois. He has served as a Lead Author for the IPCC Fourth Assessment Report, an Adviser to the Canadian Climate Impacts & Adaptation Research Network, a Coordinating Lead Author for the IPCC Third Assessment Report, and as an adviser/reviewer/contributor to climate impacts programs at United Nations Environment Programme (1995-8), and in the following countries: United Kingdom (1996-7, 2004), Netherlands (1994), Norway (2001, 2004), Brazil - ARIDAS (1995), United States (1989). Relevant publications include:

Cohen, S., D. Neilsen, S. Smith, T. Neale, B. Taylor, M. Barton, W. Merritt, Y. Alila, P. Shepherd, R. McNeill, J. Tansey, and J. Carmichael (in press, Climatic Change). Learning with Local Help: Expanding the Dialogue on Climate Change and Water Management in the Okanagan Region, British Columbia, Canada.

Cohen, S., D. Neilsen and R. Welbourn (eds.). 2004. Expanding the dialogue on climate change & water management in the Okanagan Basin, British Columbia. Final Report, Project A463/433, submitted to Climate Change Action Fund, Natural Resources Canada, Ottawa, 230 pp.

Koshida, G., M. Alden, S.J. Cohen, R. Halliday, L.D. Mortsch, V. Wittrock and A.R. Maarouf, 2004, "Drought Risk Management in Canada-U.S. Transboundary Watersheds: Now and in the Future" in Drought and Water Crises: Science, Technology and Management Issues, D. A. Wilhite (ed.), CRC Press, Boca Raton, Florida, pp. 287-317.

Cohen, S., B. Bass, D. Etkin, B. Jones, J. Lacroix, B. Mills, D. Scott and G.C. van Kooten. 2004. Regional adaptation strategies. In H. Coward and A. Weaver (eds.), Hard Choices: Climate Change in Canada, Wilfrid Laurier University Press, 151-178.

Choices: Climate Change in Canada, Wilfrid Laurier University Press, 151-178.

Miguel Cortez is a climatologist and the lead of the Climate Section at the Mexican National Meteorological Service and lecturer at the Department of Geography, National University of Mexico. His current research interests include climate variability, climate extremes and drought monitoring activities. Miguel also serves as the Mexican principal author for the North American Drought Monitor. Relevant publications include:

Cortez-Vázquez, M., 1999: The annual cycle of the convective activity in Mexico (in Spanish). *Atmósfera*, **12**, 101-110.

Cortez-Vázquez, M., 2000: Intraseasonal variability of the convective activity over Mexico and Central America (In Spanish). *Atmósfera,* **13**, 95, 108.

Cortez-Vázquez, M., and J. Matsumoto, 2001. Intraseasonal changes in the regional circulation over Mexico. *Investigaciones Geográficas*, **46**, 30-44.

Farfán L. M., and M. Cortez, 2005: An observational and modeling analysis of the landfall of hurricane Marty (2003) in Baja California, Mexico. *Mon. Wea. Rev*., **133**, 2069-2090.

Arthur Douglas is a Professor and Chair, Environmental and Atmospheric Sciences, at Creighton University. He is an elected member of NOAA's Office of Global Programs North American Monsoon Experiment Science Working Group. For the past 8 years he has served as a

WMO consultant for Mexico specializing in Climate Change and Prediction. In this position he coordinates the issuance of seasonal climate outlooks for the Mexican Government and he helps to formulate strategies for detecting climate change in Mexico. In the 1980s he developed the GHCN network for Mexico and through current work with OGP's Climate Change Data and Detection Program he continues to update and add new stations to this network. In the late 1990s as part of the North America Drought Monitoring Initiative, Dr. Douglas helped to establish a network of operational long-term stations in Mexico for drought monitoring. Relevant climate publications include:

Easterling, D. R., H. F. Diaz, A. V. Douglas, W.D. Hogg, K. E. Kunkel, J. C. Rogers, and J. F. Wilkinson, 1999: Long-Term Observations for Monitoring Extremes in the Americas.

Englehart, P.J. and A.V. Douglas, 2002e: Mexico's summer rainfall patterns: an analysis of regional modes and changes in their teleconnectivity. Atmósfera Vol. 15, No.2: 147-164.

Englehart, P.J. and A.V. Douglas, 2003a: Assessing warm season drought episodes in the central United States. Journal of Climate Vol. 16, No. 11: 1831-1842.

David Easterling is currently Chief of the Scientific Services Division at NOAA's National Climatic Data Center in Asheville, NC. He received his Ph.D. from the University of North Carolina at Chapel Hill in 1987 and served as an Assistant Professor in the Climate and Meteorology Program, Department of Geography, Indiana University-Bloomington from 1987 to 1990. In 1990 he moved to the National Climatic Data Center as a research scientist, was appointed Principal Scientist in 1999, and Chief of Scientific Services in 2002. He has authored or co-authored more than sixty research articles in journals such as ***Science, Nature*** and the ***Journal of Climate***. Dr. Easterling was also a contributor to the Intergovernmental Panel on Climate Change (IPCC) Second and Third Assessment Reports, and is currently a Lead Author for the IPCC Fourth Assessment Report. His research interests include the detection of climate change in the observed record, particularly changes in extreme climate events. Relevant publications include:

Easterling, D.R. J.L. Evans, P. Ya. Groisman, T.R. Karl, K.E. Kunkel, and P. Ambenje, 2000: Observed variability and trends in extreme climate events: A brief review, Bull. Amer. Meteor. Soc., Special Section on Climate Extremes. 81, 417-426.

Easterling, D.R., G. Meehl, S. Changnon, C. Parmesan, T.R. Karl, and L.O. Mearns, 2000: Climate extremes: observations, modeling, and impacts, Science, 289, 2068-2074.

Easterling, D.R., 2002: Recent changes in frost days and the frost-free season in the United States, Bull. Amer. Meteor. Soc., 83, 1327-1332.

Kunkel, K.E., D.R. Easterling, K. Redmond, and K. Hubbard, 2003: Temporal variations of extreme precipitation events: 1895-2000, ***Geophys. Res. Letts.***, **30** (17), 1900, doi: 10.1029/2003GL018052, 2003, 4pp.

Kerry Emanuel is a professor of atmospheric science at the Massachusetts Institute of Technology, where he has been on the faculty since 1981, after spending three years as a faculty member at UCLA. Professor Emanuel's research interests focus on tropical meteorology and climate, with a specialty in hurricane physics. His interests also include cumulus convection, and

advanced methods of sampling the atmosphere in aid of numerical weather prediction. He is the author or co-author of over 100 peer-reviewed scientific papers, and two books, including Divine Wind: The History and Science of Hurricanes, recently released by Oxford University Press and aimed at a general audience. Relevant publications include:

Emanuel, K.A., 1997: Climate variations and hurricane activity: Some theoretical considerations. Hurricanes, Climate and Socioeconomic Impacts. H.F. Diaz and R.S. Pulwarty (eds.), Springer Verlag (Heidelberg), 55-65.

Emanuel, K., C. DesAutels, C. Holloway and R. Korty, 2004: Environmental control of tropical cyclone intensity. J. Atmos. Sci., 61 <ftp://texmex.mit.edu/pub/emanuel/PAPERS/emanuel_et_al2004.pdf>, 843-858

Emanuel, K. A., 2005: Increasing destructiveness of tropical cyclones over the past 30 years. Nature, 436, 686-688

Pavel Ya. Groisman is a UCAR Project Scientist at the NOAA/NESDIS National Climatic Data Center. During the past three years he has been a Northern Eurasia Earth Science Partnership Initiative (NEESPI) Project Scientist and editor of the NEESPI Science Plan (http://neespi.org). During the past two decades, Dr. Groisman has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. He has been a contributing author to all four IPCC Assessment Reports and to the recently completed Arctic Climate Impact Assessment focusing on climatic changes during the period of instrumental observations. His current research interests include studying changes in extreme events frequency and intensity over North America and Eurasia. Relevant publications include:

Groisman, P.Ya. Karl, T.R., Easterling, D.R., Knight, R.W., Jamason, P.B., Hennessy, K.J., Suppiah, R, Page, Ch.M., Wibig, J., Fortuniak, K., Razuvaev, V.N., Douglas, A., Førland, E., and Zhai, P.-M. 1999: Changes in the probability of heavy precipitation: Important indicators of climatic change. Climatic Change, 42, No.1, 243-283.

Groisman, P.Ya. R.W. Knight, and T.R. Karl, 2001: Heavy precipitation and high streamflow in the contiguous United States: Trends in the 20th century. Bull. Amer. Meteorol. Soc., 82, 219-246.

Groisman, P. Ya., R.W.Knight, D. R. Easterling & T. R. Karl, G. C. Hegerl, and V.N. Razuvaev, 2005: Trends in intense precipitation in the climate record. J. Climate, 18, 1343-1367.

William J. Gutowski, Jr., is a Professor of Meteorology at Iowa State University. Prof. Gutowski was a contributing author to "Climate Change 2001: The Scientific Basis", produced as a contribution of Working Group 1 to the Third Assessment Report of the IPCC, and is also a contributing author to the upcoming Fourth Assessment Report's chapter on regional climate. He is a member of a National Academy/Transportation Research Board panel to study impacts of climate change on transportation. His current research interests include regional climate change and the water cycle. Relevant publications include:

Pan, Z., R. W. Arritt, E. S. Takle, W. J. Gutowski, Jr., C. J. Anderson, and M. Segal, 2004: Altered hydrologic feedback in a warming climate introduces a "warming hole". Geophys. Res. Lett., 31, L17109, doi:10.1029/2004GL020528.

Gutowski, W. J., F. Otieno, R. W. Arritt, E. S. Takle and Z. Pan, 2004: Diagnosis and attribution of a seasonal precipitation deficit in a U.S. regional climate simulation. J. Hydrometeor., 5, 230-242, doi: 10.1175/1525-7541(2004)005<0230:DAAOAS>2.0.CO;2

Gutowski, W. J., S. G. Decker, R. A. Donavon, Z. Pan, R. W. Arritt and E. S. Takle, 2003: Temporal-spatial scales of observed and simulated precipitation in central U.S. climate. J. Climate, 16, 3841-3847.

Gabriele Hegerl is an Associate Research Professor at Duke University. She has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. Prof. Hegerl is a Coordinating Lead Author of the chapter "Understanding and Attributing Climate Change" of "Climate Change 2007: The Scientific Basis", produced as a contribution of Working Group 1 to the Fourth Assessment Report of the IPCC, and was a Lead Author of the Third Assessment Report. Her current research interests include detection and attribution of climate change, and variability and changes in climate extremes. Three relevant publications:

Hegerl, G. C., F. Zwiers, S. Kharin and Peter Stott (2004): Detectability of anthropogenic changes in temperature and precipitation extremes. J. Climate, 17, 3683-3700.

Hegerl G. C., T. Karl, M. Allen, N. Bindoff, N. Gillett, D. Karoly and F. Zwiers (2005): Climate Change detection and attribution: Beyond mean temperature signals. J. Climate, invited contribution through CLIVAR, in press.

Christidis, N., P.A. Stott, S. Brown, G. C. Hegerl and J. Caesar (2005): Detection of changes in temperature extremes during the 20th century. Geophys. Res. Let., accepted.

Greg Holland is director of the Mesoscale and Microscale Meteorology Division at the National Center for Atmospheric Research. He is a fellow of the American Meteorological Society as well as the Australian Meteorological and Oceanographic Society. He is an active member of the WMO Commission for Atmospheric Science Working Group on Tropical Meteorology Research and a current member of the NOAA Hurricane Intensity Review Working Group. Dr. Holland has several areas of research interests which have carried through to applications and include improved forecasting of tropical cyclone motion, scale interactions associated with cyclogenesis, establishment of field facilities, establishment of programs on coastal impacts of tropical cyclones and the development of Unmanned Aerial Vehicles (UAVs). He is a lead author of the recently published, "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment", Science, Vol 309, Issue 5742, 1844-1846, 16 September 2005. Other relevant publications include:

Holland, G.J., 1995: Scale interaction in the western Pacific monsoon. Met. Atmos. Phys., 56, 57-79.

Henderson-Sellers, A., Zhang, H., Bertz, G., Emanuel, K., Gray, W.M., Landsea, C., Holland, G.J., Lighthill, J., Shieh, S.L., Webster, P. and McGuffie, K., 1998: Tropical Cyclones and Climate Change: A Post-IPCC Assessment. Bull. Amer. Met Soc., 79, 19-38.

Thomas R. Karl is the Director of NOAA's National Climatic Data Center, Program Manager for NOAA's Climate Observations and Analysis Program, and Director of NOAA's Climate Change Data and Detection Applied Research Center. Dr. Karl is author of many climatic atlases and has nearly 200 published articles and technical reports in various scientific journals on topics related to changes and variations of a variety of extreme climate and weather events. He has served as Editor of the *Journal of Climate* and as Lead Author of several scientific assessments completed by the Intergovernmental Panel on Climate Change (IPCC), Chief Editor of the CCSP Product and Synthesis Report 1.1, and served as Co-Chair of the US National Assessment of Climate Variability and Change. Selected relevant publications include:

Karl, T.R. and K. E. Trenberth, 2003: Modern global climate change. Science, 302, 1719-1723.
Karl, T.R. and D. R. Easterling, 1999: Climate extremes: Selected review and future research directions. Climatic Change, 42, 309-325.
Karl, T.R. and R. W. Knight, 1998: Secular trends of precipitation amount, frequency, and intensity in the United States. Bulletin of the American Meteorological Society, 79, 2, 231-241.

Thomas Knutson is a Research Meteorologist at NOAA's Geophysical Fluid Dynamics Laboratory. His current research interests include the potential impact of climate change on hurricanes and climate change detection. He was invited to organize a special session on "Global Warming and Hurricanes" at the WMO 4th International Workshop on Tropical Cyclones in Cairns, Australia. He has presented invited lectures on this topic at a National Research Council Roundtable; an IPCC Special Workshop on Climate Extremes; a special session at an American Meteorological Society annual meeting;
and other professional meetings, workshops, and universities. Relevant publications include:

Knutson, T. R., and R. E. Tuleya, 2004: Impact of CO2-induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization. Journal of Climate, 17(18), 3477-3495.
Knutson, T. R., R. E. Tuleya, W. Shen, and I. Ginis, 2001: Impact of CO2-induced warming on hurricane intensities as simulated in a hurricane model with ocean coupling. Journal of Climate, 14(11), 2458-2468.
Knutson, T. R., R. E. Tuleya, and Y. Kurihara, 1998: Simulated increase of hurricane intensities in a CO2-warmed climate. Science, 279(5353), 1018-1020.

Paul Komar is emeritus Professor of Oceanography at Oregon State University, where he has been on the faculty since 1970. He received a M.S. degree in Geology at the University of Michigan, and a Ph.D. in Oceanography from the Scripps Institution of Oceanography. Professor Komar's research interests have focused primarily on coastal processes, including investigations of wave-induced nearshore currents and the resulting transport of beach sediments. His recent research has centered on the climate controls on U.S. West Coast processes and the resulting erosion problems, including those associated with occurrences of major El Niños and a progressive increase in North Pacific wave

heights. As well as having undertaken research along the West Coast of the United States, Professor Komar's investigations have included the Nile Delta of Egypt and the coast of New Zealand. He is author or co-author of over 100 peer-reviewed scientific papers, and two books including Beach Processes and Sedimentation published by Prentice-Hall (1976 and1998). Relevant publications include:

Ruggiero, P., P.D. Komar, W.G. McDougal, J.J. Marra, and R.A. Beach, 2001: Wave runup, extreme water levels and the erosion of properties backing beaches: Journal of Coastal Research, v. 17, no. 2, p. 407-419.

Komar, P.D., and J.C. Allan, 2002: Nearshore-process climates related to their potential for causing beach and property erosion: Shore & Beach, v. 70, n. 3, p. 31-40.

Komar, P.D., J. McManus and M. Styllas, 2004: Sediment accumulation in Tillamook Bay, Oregon: Natural processes versus human impacts: Journal of Geology, v. 112, p. 455-469.

Allan, J. C., and P.D. Komar, 2006: Climate controls on US West Coast erosion processes: Journal of Coastal Research, v. 22, no. 3, p. 511-529.

Kenneth E. Kunkel is Director of the Center for Atmospheric Sciences of the Illinois State Water Survey, a division of the Illinois Department of Natural Resources and an affiliated agency of the University of Illinois at Urbana-Champaign. He is also an adjunct Professor with the Department of Atmospheric Sciences of the University of Illinois. He is a member of the Advisory Committee of the Program for Climate Model Data and Intercomparison and recently served as a member of the National Academies Committee on "Review of the US Climate Change Science Program's Synthesis and Assessment Product on Temperature Trends in the Lower Atmosphere". Dr. Kunkel was a contributing author to "Climate Change 2001: The Scientific Basis", produced as a contribution of Working Group 1 to the Third Assessment Report of the IPCC. His current research interests include climate variability and extremes, regional climate modeling of extremes, and regional climate applications. Relevant publications include:

Kunkel, K. E., D.R. Easterling, K. Redmond, and K. Hubbard, 2003: Temporal variations of extreme precipitation events in the United States: 1895–2000, Geophys. Res. Lett., 30, 1900, 10.1029/2003GL0180.

Kunkel, K.E., K. Andsager, and D.R. Easterling, 1999: Long-term trends in heavy precipitation events over North America. *J. Climate*, **12**, 2515-2527.

David Levinson is a Physical Scientist in the Climate Monitoring Branch at NOAA's National Climatic Data Center, where he performs research on a variety of topics related to climate extremes and the coastal climate of North America. Before joining NCDC in 2003, Dave worked as a meteorologist for the USDI-Bureau of Land Management in Missoula MT (from 2000-2003), the USDA-ARS Northwest Watershed Research Center in Boise ID (from 1998-2000), and the NOAA/ERL Environmental Technology Laboratory in Boulder CO (from 1991-1998). Dave is a long-standing member of the American Meteorological Society, and is a contributing author to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report. For the past two years Dr. Levinson has been the lead author and editor of

the annual "State of the Climate" assessment that is published each year as a special section in the June issue of the Bulletin of the American Meteorological Society. His current research interests include developing coastal climatologies and studying sea-level rise along coastal areas of the U.S., determining trends in regional and global precipitation extremes, and development of climate indices for tropical cyclone activity. Examples of his relevant publications include:
Levinson, D. H. (ed.), 2005: State of the Climate in 2004. Bulletin of the American Meteorological Society, 86, S1-S86.

Levinson, D. H., and A. M. Waple (eds.), 2004: State of the Climate in 2003. Bulletin of the American Meteorological Society, 85, S1-S72.
Levinson, D. H., 1999: Evaluation of Doppler Lidar Measurements of Momentum Flux and Wind Variability Along an Upwelling Coast. NOAA Technical Memorandum; ERL ETL-294, 105 pp.
Levinson, D. H., and R. M. Banta, 1995: Observations of a terrain-forced mesoscale vortex and canyon drainage flows along the Front Range of Colorado. Monthly Weather Review, 123, 2029-2050.

Linda Mearns is a Senior Scientist at the National Center for Atmospheric Research, and the Director of the Inst. for the Study of Society and the Environment at NCAR. She is a member of the National Research Council Climate Research Committee and Human Dimensions of Global Change Committee, and has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. Dr. Mearns was a convening lead author of "Climate Change 2001: The Scientific Basis", produced as a contribution of Working Group 1 to the Third Assessment Report of the IPCC, as well as a lead author in Climate Change 2001: Impacts, Adaptation, and Vulnerability, a contribution of the IPCC Working Group 2. Her role in these two working groups is continuing in the preparation of the Fourth Assessment Report. Her current research interests include projections of future climate change, analysis of extreme events in climate projections, quantification of uncertainty of region climate change, and agriculture-climate interactions. Relevant publications include:

Wettstein, J. J. and L. O. Mearns, 2002: Simulating the influence of the North Atlantic-Arctic Oscillation on mean, variance, and extremes of temperature in the Northeastern U.S. and Canada. J. of Climate 15:3586--3600 (December).
Mearns, L.O., R.W. Katz, and S.H. Schneider, 1984, Extreme High Temperature Events: Changes in their Probabilities with Changes in Mean Temperature, Journal of Climate and Applied Meteorology, 23(12): 1601-1613.
Mearns, L. O., C. Rosenzweig, R. Goldberg, 1997, Mean and Variance Change in Climate Scenarios: Methods, Agricultural Applications, and Measures of Uncertainty. Climatic Change 35:367--396.

Gerald A. Meehl is a Senior Scientist at the National Center for Atmospheric Research. He is a member of the National Research Council Climate Research Committee and has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. Dr. Meehl was a coordinating lead author of "Climate Change 2001: The Scientific Basis", produced

as a contribution of Working Group 1 to the Third Assessment Report of the IPCC, and is currently a coordinating lead author for the IPCC Fourth Assessment Report. His current research interests include projections of future climate change. Relevant publications include:

Meehl, G.A., and C. Tebaldi, 2004: More intense, more frequent and longer lasting heat waves in the 21st century. Science, 305, 994--997.
Meehl, G.A., C. Tebaldi, and D. Nychka, 2004: Changes in frost days in simulations of 21st century climate. Clim. Dyn., 23, 495--511.
Meehl, G.A., J.M. Arblaster, and C. Tebaldi, 2005: Understanding future patterns of precipitation extremes in climate model simulations. Geophys. Res. Lett., in press.

Richard J. Murnane is an Associate Research Scientist at the Bermuda Biological Station for Research and Program Manager for the Risk Prediction Initiative (RPI). The RPI brings scientists and insurers together with the goal of making science understandable and useable so that insurers can better assess their exposure to risk from natural hazards. He is a Contributing Author for Chapter 7, "Industry, Settlement, and Society," of the Working Group II (Climate Change Impacts, Adaptation, and Vulnerability) contribution to the Fourth Assessment Report of the IPCC. Dr. Murnane's current research interests include understanding how climate variability alters extreme events and their impacts on the insurance industry. Relevant publications include:

Murnane, R. J., The importance of best-track data for understanding the past, present, and future of hurricanes and typhoons, in *Hurricanes and Typhoons: Past, Present, and Future*, R. J. Murnane and K.-b. Liu, eds., Columbia University Press, New York, pp. 249-266, 2004.
Murnane, R. J., Climate research and reinsurance, *Bulletin of the American Meteorological Society*, 85, 10.1175/BAMS-85-5-697, 697-707, 2004.
Murnane, R. J., M. Crowe, A. Eustis, S. Howard, J. Koepsell, R. Leffler, and R. Livezey, The weather-risk management industry's climate forecast and data needs: a workshop report, *Bull. Amer. Meteor. Soc.*, 83, 1193-1198, 2002.

Camille Parmesan is an Assistant Professor at the University of Texas at Austin.
She was a Lead Author on the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (2001), and has served as Co-Organizer of the 2004 SCOPE Assessment: "Biodiversity, Global Change and Human Health", as Chair of New Task Force on Climate Change Impacts, the World Conservation Organization (IUCN), and on the NSF Ecology Panel (fall 2001 and spring 2003). Dr. Parmesan assists with the U.S. Fish and Wildlife Service Habitat Recovery Plan for Quino Checkerspot ('98-current), and was a participant and reviewer on the United States National Assessment of the Potential Consequences of Climate Variability and Change for the United States, (2000). Relevant publications include:

Parmesan, C. & H. Galbraith (2004). Observed Impacts of Global Climate Change in the United States. Pew Center on Global Climate Change.
Parmesan, C & G. Yohe. (2003). A globally coherent fingerprint of climate change impacts in natural systems. Nature 421:37-42.

Parmesan, C, N Ryrholm, C Stefanescu, JK Hill, CD Thomas, H Descimon, B Huntley, L Kaila, J Kullberg, T Tammaru, J Tennent, JA Thomas, M Warren (1999). Poleward shift of butterfly species' ranges associated with regional warming. Nature 399:579-583.

Thomas C. Peterson is a research meteorologist at NOAA's National Climatic Data Center in Asheville, NC. He is a lead author on the IPCC Fourth Assessment Report, a member of the GCOS Atmospheric Observation Panel for Climate, lead author on CCSP Product 1.1 *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences,* and chair of the World Meteorological Organization's Commission for Climatology Open Programme Area Group on Monitoring and Analysis of Climate Variability and Change. During 2004 and 2005 he organized four regional workshops that analyzed changes in extremes in Central America, South America, the Middle East, and south-central Asia. He is an author or co-author of eight peer-reviewed papers on observed changes in extremes. The international coordination of a suite of indices of extremes these papers are built on started in 1998 when Dr. Peterson was serving as the WMO Commission for Climatology's "rapporteur on statistical methods for climatology with emphasis on analyses of extreme events." Relevant publications include:

Alexander, L. V. X. Zhang, T. C. Peterson, J. Caesar, B. Gleason, A. Klein Tank, M. Haylock, D. Collins, B. Trewin, F. Rahimzadeh, A. Tagipour, P. Ambenje, K. Rupa Kumar, J. Revadekar, G. Griffiths, L. Vincent, D. Stephenson, J. Burn, E. Aguilar, M. Brunet, M. Taylor, M. New, P. Zhai, M. Rusticucci, and J. L. Vazquez-Aguirre, 2005: Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research – Atmospheres*, in press.

Peterson, Thomas C., Michael A. Taylor, Rodger Demeritte, Donna L. Duncombe, Selvin Burton, Francisca Thompson, Avalon Porter, Mejia Mercedes, Elba Villegas, Rony Semexant Fils, Albert Klein Tank, Albert Martis, Robert Warner, Antonio Joyette, Willis Mills, Lisa Alexander, and Byron Gleason, 2002: Recent Changes in Climate Extremes in the Caribbean Region. *Journal of Geophysical Research*, **107**(D21), 4601, doi: 10.1029/2002JD002251 (Nov. 16, 2002).

Frich, P., L. V. Alexander, P. Della-Marta, B. Gleason, M. Haylock, A. M. G. Klein Tank and T. Peterson, 2002: Observed coherent changes in climatic extremes during the 2nd half of the 20th century, *Climate Research*, **19**, 193-212.

David Phillips has been employed with Environment Canada's weather service for 37 years, and is now a Senior Climatologist. In June 2004 he received an honorary Doctor of Environmental Studies from the University of Waterloo. His work activities relate to the study of the climate of Canada and to promoting awareness and understanding of weather and climate in Canada. He has published several books, papers and reports on the climate of Canada, including several essays in The Canadian Encyclopedia, a book on The Climates of Canada, and two bestsellers: The Day Niagara Falls Ran Dry and Blame It On The Weather. Dr. Phillips is the originator and author of the Canadian Weather Trivia Calendar, the most popular calendar sold in Canada, and now in its 18th year. For nearly ten years he wrote the Weather-wise column in the Canadian Geographic magazine. Further, he is well-known as the expert on The Weather Network. Dr. Phillips is a fellow

of both the Royal Canadian Geographical Society and the Canadian Meteorological and Oceanographic Society. He has been awarded the Patterson Medal for Distinguished Service to Meteorology in Canada, the Commemorative Medal for the 125th Anniversary of the Confederation of Canada, and has twice received the Public Service Merit Award. In 2001, Dr. Phillips was named to the Order of Canada.

Roger S. Pulwarty is a research scientist at the NOAA-CIRES Climate Diagnostics Center at the University of Colorado in Boulder. His interests are on the role of climate and weather in society-environment interactions and in the design of effective responses to address associated risks. From 1998 to 2002 he directed the NOAA/Regional Integrated Sciences and Assessments (RISA) Program. He is a lead and contributing author on the IPCC Fourth Assessment Report Working Group 2 and directs the vulnerability assessment components of the World Bank funded program on Mainstreaming Adaptation to Climate in the Caribbean (jointly administered through an MOU with NOAA/NOS). Relevant publications include:

Pulwarty, R., Jacobs, K., Dole, R., 2005: Drought and critical water problems in the Colorado River Basin. In Wilhite, D., (ed.) 2004: Drought and Water Crises: Science, Technology and Management. Taylor and Francis Press. New York USA

Poveda, G., Waylen, P., and R. Pulwarty, 2005: Modern climate variability in northern South America and northern Mesoamerica: Implications for the interpretation of paleorecords. Palaeogeography, Palaeoclimatology, Palaeoecology (in press)

Pulwarty, R., 2003: Climate and water in the West: Science, Information and Decisionmaking. Water Resources124, 4-12

Pulwarty, R., K., Broad, T., Finan 2003: ENSO, forecasts and decision making. In Bankoff, G., Frerkes, G., and Hilhorst, T., (Eds.) Mapping Vulnerability: Disasters, Development and People. Earthscan pp. 83-98

Richard L. Smith is Mark L. Reed III Distinguished Professor of Statistics at the University of North Carolina, Chapel Hill. He has worked extensively on both the mathematical theory and practical applications of extreme value statistics, and has also numerous collaborations with climate scientists on statistical aspects of climate change. He has been a regular visitor to the Geophysical Statistics Project at NCAR, and has chaired the Advisory Committee for that Project. He is a regular reviewer for geophysical as well as statistics journals, and of grant applications for NSF and other agencies. He has also co-chaired institute programs on environmental statistics and mathematics at the Isaac Newton Institute in Cambridge, UK, and the Statistical and Applied Mathematical Sciences Institute in North Carolina. Recent relevant publications include:

R.L. Smith, T.M.L. Wigley and B.D. Santer (2003), A bivariate time series approach to anthropogenic trend detection in hemispheric time series. Journal of Climate 16, 1228-1240.

R.L. Smith (2003), Statistics of extremes, with applications in environment, insurance and finance. Chapter 1 of, Extreme Values in Finance, Telecommunications and the Environment, edited by B. Finkenstadt and H. Rootzen, Chapman and Hall/CRC Press, London, pp. 1-78.

C. Tebaldi, R.L. Smith, D. Nychka and L.O. Mearns (2005), Quantifying uncertainty in projections of regional climate change: A Bayesian approach to the analysis of multi-model ensembles. Journal of Climate 18 1524-1540.

John Stone has recently retired from the position of Executive Director (Climate Change) with the Canadian government's Department of Environment. Trained in the UK in chemistry, mathematics and physics, he holds a PhD in molecular spectroscopy. He spent over 30 years working for the Canadian government assuming increasing responsibilities first in the Ministry of State for Science and Technology, and later in the Department of Foreign Affairs and International Trade, the National Research Council's Bureau of International Affairs and finally Environment Canada. During the last 15 years of his career he directed research programs on climate and atmospheric sciences as well as developed policy on a range of environmental issues. He has had considerable experience in international science and policy having served Canada through his affiliation with the NATO Science Committee, the International Institute for Applied Systems Analysis, the UN/ECE Senior Advisors on Science and Technology, UN the Framework Convention on Climate Change, the Scientific Steering Committee for the START program and as co-Chair for the Canada-Germany S&T Agreement. In 1997 he was appointed to the Bureau of the Intergovernmental Panel on Climate Change (IPCC), specifically as Vice-Chair of Working Group I, and has since been re-appointed, now as a Vice-Chair of Working Group II. Relevant publications include:

Climate Change: Science, Politics and the Media, Stone JMR, in Statistics, Science and Public Policy IX: Government, Science and Politics, Queens University Press, (2005).
The Science of Changing Climates: Impacts on Agriculture, Forestry and Wetlands - Synthesis Paper, Stone JMR, (in press, 2004).
The Ancillary Benefits of Tackling Climate Change, Stone JMR, (convening lead author), internal Environment Canada policy paper (2002).
Intergovernmental Panel on Climate Change, Climate Change 2001: Synthesis Report, Review Editor.
Intergovernmental Panel on Climate Change, Third Assessment Report, Summary for Policymakers, (2001), member of drafting team and of Working Group I Bureau.

Ronald J Stouffer is a climate scientist at NOAA's Geophysical Dynamics Laboratory (GFDL) in Princeton, NJ. He is a member of the CMIP (Coupled Model Intercomparison Project) panel and PMIP (PaleoModeling Intercomparison Project) panels. He has served on a number of WCRP (World Climate Research Project) committees involving climate modeling. Stouffer has been a lead author in the past 2 Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment reports and is a lead author in the current IPCC report under development. His research interests include projections of future climate change and the study of past and present climates. Relevant publications include:

Braganza, K., D. J. Karoly, A. C. Hirst, M. E. Mann, P. Stott, R. J. Stouffer, and S. F. B. Tett, 2003: Simple indices of global climate variability and change: Part I - variability and correlation structure. Climate Dynamics. 20(5), 491-501.

Hall, Alex, and Ronald J. Stouffer, 2001: An abrupt climate event in a coupled ocean-atmosphere simulation without external forcing. Nature, 409(6817), 171-174.
Knutson, T. R., T. L. Delworth, 1999: Model assessment of regional surface temperature trends (1949-1997). Journal of Geophysical Research, 104(D24), 30,981-30,996.

Charles C Watson Jr. is the Director of Research and Development of Kinetic Analysis Corporation, based in Savannah, Georgia. He is presently an advisor on extreme event climatology and modeling to a wide variety of public and private sector organizations including the states of Florida and North Carolina, the Organization of American States, the Caribbean Development Bank, and numerous engineering firms. Mr. Watson has contributed as an expert reviewer to the IPCC Fourth Assessment Report First Order Draft. His primary research area is incorporating climate variability, especially extreme events, in engineering design criteria, insurance and financial analyses, and mitigation planning. Recent relevant publications include:

Iman, R. L., Johnson, M., and Watson, C. Jr., 2005: Sensitivity Analysis for Computer Model Projections of Hurricane Losses (pt 1), Uncertainty Analysis for Computer Model Projections of Hurricane Losses (pt 2). Risk Analysis, Vol. 25, No. 5, 1277-1312
Watson, C. Jr, and Johnson, M., 2004: Hurricane Loss Estimation Models, Opportunities for Improving the State of the Art, Bulletin of the American Meteorological Society, 85, 1713-1726.
Watson, C., Jr., 2002: Implications of climate change for modeling coastal hazards, Solutions for Coastal Disaster ‘02 (Proceedings), American Society of Civil Engineers, Reston, VA. pp 172-177.

Peter Webster is Professor of Earth and Atmospheric Sciences and Environmental Engineering at Georgia Institute of Technology. For the last 20 years he has concentrated on the investigation of tropical atmospheres and oceans with an emphasis on the monsoons of Asia. In recent years he has directed the Climate Forecast Applications in Bangladesh, which is aimed at producing forecasts of rainfall and floods on time scales from seasonal to daily and at introducing modern predictive techniques to developing countries. Part of the CFAB effort is to forecast hurricanes in regions of low technical resources. Most of Webster's research combines theoretical and modeling techniques although he has organized many field experiments including TOGA Coupled Ocean-Atmosphere Response Experiment (a multinational experiment in the western Pacific Ocean), the Equatorial mesoscale experiment and the Joint Air-Sea Monsoon Interaction Experiment (JASMINE) in the Bay of Bengal. He has received numerous awards including the J. G. Charney and the Carl Gustav Rossby medals from the American Meteorological Society, the two highest research awards presented to an atmospheric scientist in the US. He is a fellow of the American Meteorological Society, the American Geophysical Union, the Royal Meteorological Society and the American Association for the Advancement of Science. Webster has written one textbook, 15 book chapters and in excess of 200 scientific articles. Recent relevant publications include:

Webster, P. J., G. J. Holland, J. A. Curry and H-R. Chang, 2005: " Changes in tropical cyclone number, duration and intensity in a warming environment." 309 (5742), 1844-1846 (September 16).
Hoyos, C. D., P. A. Agudello, P. J. Webster and J. A. Curry, 2005: Deconvolution of the factors contributing to the increase in global hurricane intensity. In Press Science, December 2005.

Francis Zwiers is a Senior Research Scientist and Chief of the Canadian Centre for Climate Modelling and Analysis, and an Adjunct Professor at the University of Victoria. He serves on a number of panels, is co-chair of the CCl/CLIVAR Expert Team on Climate Change Detection, Monitoring and Indices, has served as an Editor of the Journal of Climate and has been prominent in the Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment activities. Dr. Zwiers is a Coordinating Lead Author of the chapter "Understanding and Attributing Climate Change" of "Climate Change 2007: The Scientific Basis", which is being produced as a contribution of Working Group 1 to the Fourth Assessment Report of the IPCC, and was a lead author of the climate change detection chapter of the Third Assessment Report. His current research interests include the analysis of change in climatic extremes, detection and attribution of climatic change, and climate forecasting on seasonal to decadal scales. Recent relevant publications include:

Kharin, V. V., F. W. Zwiers, X. Zhang, and G. C. Hegerl, 2005: Changes in temperature and precipitation extremes in the IPCC ensemble of global coupled model simulations. Journal of Climate, submitted
Kharin, V.V., F.W. Zwiers, and X. Zhang, 2005: Intercomparison of near surface temperature and precipitation extremes in AMIP-2 simulations, reanalyses and observations. Journal of Climate, in press.
Kharin, V.V., and F.W. Zwiers, 2005: Estimating extremes in transient climate change simulations. Journal of Climate, 18, 1156-1173.
Wang, X.L., F.W. Zwiers, and V. Swail, 2004: North Atlantic Ocean wave climate scenarios for the 21st century. Journal of Climate, 17, 2368-2383.
Hegerl, G. C., F. Zwiers, S. Kharin and Peter Stott (2004): Detectability of anthropogenic changes in temperature and precipitation extremes. J. Climate, 17, 3683-3700.
Zhang, X., G. Hegerl, F. Zwiers and J. Kenyon (2005): Avoiding inhomogeneity in percentile-based indices of temperature change. J. Climate, 18, 1641-1651.