

Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I

U.S. Climate Change Science Program
Synthesis and Assessment Product 4.7

March 2008

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Report by the U.S. Climate Change Science Program
And the Subcommittee on Global Change Research

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Acknowledgments

We wish to thank the following for their contributions to this report.

This report has been peer reviewed by the individual members of the Federal Advisory Committee (FAC) to this study. FAC members were chosen for their diverse perspectives and technical expertise. The selection of reviewers and the expert review followed the OMB's Information Quality Bulletin for Peer Review. We gratefully acknowledge the Committee members for their dedicated and generous contribution of their time, expertise, and thoughtful review. They are: **Vicki Arroyo**, Director of Policy Analysis, Pew Center on Global Climate Change; **Philip B. Bedient**, Professor of Engineering, Rice University; **Leigh B. Boske**, Associate Dean and Professor of Public Affairs, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin; **Alan Clark**, Director of Transportation Planning, Houston-Galveston Area Council (HGAC); **Fred Dennin**, Regional Administrator, Region 3, Federal Railroad Administration; **Paul S. Fischbeck**, Professor of Social and Decision Sciences, Carnegie Mellon University; **Anthony Janetos**, Director, Joint Global Change Program Research Institute, University of Maryland; **Thomas R. Karl**, Director, National Climatic Data Center, National Oceanic and Atmospheric Administration; **Rob Lempert**, Senior Scientist, RAND; **Gilbert Mitchell**, Chief, Geodetic Services Division, National Geodetic Survey, National Oceanic and Atmospheric Administration (NOAA); **Chris C. Oynes**, Gulf of Mexico Regional Director, Minerals Management Service (MMS); **Harold "Skip" Paul**, Director of Research, Louisiana Department of Transportation and Development; **Tom Podany**, Assistant Chief, Planning, Programs, and Project Management Division, U.S. Army Corps of Engineers, New Orleans District; **Burr Stewart**, Strategic Planning Manager, Port of Seattle; **Elaine Wilkinson**, Executive Director, Gulf Regional Planning Commission; and **John Zamurs**, Air Quality Section Head, Environmental Analysis Bureau, New York State Department of Transportation. We also want to thank **Pasquale Roscigno**, MMS; and **David Levinson**, National Climatic Data Center, NOAA; for their input and technical support. We thank **Ashby Johnson**, HGAC, and **Diana Bauer**, EPA, for their invaluable reviews and suggestions. The public review comments and peer review comments received on drafts of this report, along with responses to these comments, are publicly available at: <http://www.climate-science.gov/Library/sap/sap4-7/default.php>.

We gratefully acknowledge past and present representatives from the U.S. Geological Survey and the U.S. DOT Center for Climate Change and Environmental Forecasting who helped fund, plan, scope and review technical information that led up to the final report. Special thanks go to **Greg Smith**, Director, and the staff of the USGS National Wetlands Research Center (NWRC) for hosting the research team, and for providing technical and staff support to the research effort. We are deeply indebted to **Connie Herndon** and **Beth Vairin**, NWRC technical editors, whose edits improved the readability and cohesiveness of the final manuscript. We thank the many people who helped over the course of this multiyear study, and wish to explicitly recognize **Jane Bachner**, **Paul Marx**, **Kay Drucker**, **Karrigan Bork**, **Clare Sierawski**, **Brigid DeCoursey**, **Donald Trilling**, **Jan Brecht-Clark**, **April Marchese**, and **James Shrouds** for their assistance.

We wish to acknowledge **Michael MacCracken** whose drive and steady encouragement helped to propel us in the early years.

A number of public and private agencies generously lent their time and insights to this report. We thank the Houston-Galveston Area Council and the City of Galveston for hosting the Advisory Committee meetings. We are very grateful to the many individuals from the private sector and local and state governments who were interviewed or who otherwise shared their perspectives on the significance of climate change to their work. Their insights and perspectives of how climate change considerations may affect their decisions are reflected in this report.

Finally, we also wish to thank our University and agency co-authors whose lives were impacted by Hurricanes Katrina and Rita – for their persistence in delivering material for this study and for their timely responses to reviews, despite tremendous personal challenges and losses.

Recommended Citations

For the Report as a Whole:

CCSP, 2008: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA, 445 pp.

For the Chapters:

For the Executive Summary

Potter, J.R., V.R. Burkett, and M.J. Savonis, 2008: Executive Summary. In: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA.

For Chapter 1

Hyman, R.C., J.R. Potter, M.J. Savonis, V.R. Burkett, and J.E. Tump, 2008: 1.0 Why Study Climate Change Impacts on Transportation? In: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA.

For Chapter 2

Burkett, V.R., R.C. Hyman, R. Hagelman, S.B. Hartley, M. Sheppard, T.W. Doyle, D.M. Beagan, A. Meyers, D.T. Hunt, M.K. Maynard, R.H. Henk, E.J. Seymour, L.E. Olson, J.R. Potter, and N.N. Srinivasan, 2008: Why Study the Gulf Coast? In: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA.

For Chapter 3

Keim, B.D., T.W. Doyle, V.R. Burkett, I. Van Heerden, S.A. Binselam, M.F. Wehner, C. Tebaldi, T.G. Houston, and D.M. Beagan, 2008: How is the Gulf Coast Climate Changing? In: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA.

For Chapter 4

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For Chapter 5

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For Chapter 6

Savonis, M.J., V.R. Burkett, J.R. Potter, T.W. Doyle, R. Hagelman, S.B. Hartley, R.C. Hyman, R.S. Kafalenos, B.D. Keim, K.J. Leonard, M. Sheppard, C. Tebaldi, J.E. Tump, 2008: What are the Key Conclusions of this Study? In: *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Savonis, M. J., V.R. Burkett, and J.R. Potter (eds.)]. Department of Transportation, Washington, DC, USA.