



Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions

**U.S. Climate Change Science Program
Synthesis and Assessment Product 5.1**

August 2008

FEDERAL EXECUTIVE TEAM

Director, Climate Change Science Program	William J. Brennan
Director, Climate Change Science Program Office	Peter A. Schultz
Lead Agency Principal Representative to CCSP, Associate Director for Research, Earth Science Division, National Aeronautics and Space Administration	Jack Kaye
Lead Agency Program Director, Associate Director for Applied Sciences, Earth Science Division, National Aeronautics and Space Administration	Teresa Fryberger
Product Lead, Applied Sciences Program, Earth Science Division, National Aeronautics and Space Administration	John A. Haynes
Synthesis and Assessment Product Coordinator, Climate Change Science Program Office	Fabien J.G. Laurier
NASA Point of Contact.....	John Haynes, NASA HQ

EDITORIAL AND PRODUCTION TEAM

Scientific Editor	James Koziana, SAIC
Scientific Editor	Fred Vukovich, SAIC
Scientific Editor	Molly Macauley, RFF
Technical Editor.....	Christy Churchwell, SAIC
Layout/Design.....	Peter Gregory, SAIC

This document, part of the Synthesis and Assessment Products described in the U.S. Climate Change Science Program (CCSP) Strategic Plan, was prepared in accordance with Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) and the information quality act guidelines issued by the National Aeronautics and Space Administration pursuant to Section 515. The CCSP Interagency Committee relies on National Aeronautics and Space Administration certifications regarding compliance with Section 515 and Agency guidelines as the basis for determining that this product conforms with Section 515. For purposes of compliance with Section 515, this CCSP Synthesis and Assessment Product is an “interpreted product” as that term is used in National Aeronautics and Space Administration guidelines and is classified as “highly influential”. This document does not express any regulatory policies of the United States or any of its agencies, or provides recommendations for regulatory action.



Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions

Synthesis and Assessment Product 5.1
Report by the U.S. Climate Change Science Program
and the Subcommittee on Global Change Research

Lead Agency

National Aeronautics and Space Administration

Supporting Agencies

Department of Commerce/National Oceanic and Atmospheric Administration, Department of Energy, Department of Interior/U.S. Geological Survey, National Science Foundation, U.S. Agency for International Development, U.S. Environmental Protection Agency



Members of Congress:

On behalf of the National Science and Technology Council, the U.S. Climate Change Science Program (CCSP) is pleased to transmit to the President and the Congress this Synthesis and Assessment Product (SAP), Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions. This is part of a series of 21 SAPs produced by the CCSP aimed at providing current assessments of climate change science to inform public debate, policy, and operational decisions. These reports are also intended to help the CCSP develop future program research priorities.

The CCSP's guiding vision is to provide the Nation and the global community with the science-based knowledge needed to manage the risks and capture the opportunities associated with climate and related environmental changes. The SAPs are important steps toward achieving that vision and help to translate the CCSP's extensive observational and research database into informational tools that directly address key questions being asked of the research community.

This SAP focuses on the use of climate observations, data, forecasts, and other projections in decision support. It was developed with broad scientific input and in accordance with the Guidelines for Producing CCSP SAPs, the Federal Advisory Committee Act, the Information Quality Act (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554), and the guidelines issued by the National Aeronautics and Space Administration pursuant to Section 515.

We commend the report's authors for both the thorough nature of their work and their adherence to an inclusive review process.

Samuel W. Bodman
Secretary of Energy
Vice Chair, Committee on
Climate Change Science
and Technology Integration

Carlos M. Gutierrez
Secretary of Commerce
Chair, Committee on Climate
Change Science and Technology
Integration

John H. Marburger III
Director, Office of Science
and Technology Policy
Executive Director, Committee
on Climate Change Science and
Technology Integration

Executive Summary 1

Introduction 9

CHAPTER

1 11
Decision Support for Agricultural Efficiency

2 18
Decision Support for Air Quality (Use of CMAQ as a Decision-Support Tool for Air Quality to Climate Change)

3 27
Decision-Support System for Assessing Hybrid Renewable Energy Systems

4 39
Decision Support for Public Health

5 45
Decision Support for Water Resources Management

Appendix A 56
References by Chapter

Appendix B 70
List of Figures and Tables by Chapter

Appendix C 71
Glossary, Acronyms, Symbols, and Abbreviations

AUTHOR TEAM FOR THIS REPORT

Executive Summary

Lead Authors: Fred Vukovich, SAIC; Molly K. Macauley, RFF

Chapter 1

Lead Author: Molly K. Macauley, RFF

Chapter 2

Lead Author: Daewon W. Byun, University of Houston

Chapter 3

Lead Author: David Renne, NREL

Chapter 4

Lead Author: Gregory Glass, Johns Hopkins School of Public Health

Chapter 5

Lead Author: Holly Hartmann, University of Arizona

ACKNOWLEDGEMENT

This report has been peer reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. This document was reviewed via an external review, Public/Federal Agency Review and a NASA Concurrence. The expert review and selection of reviewers followed the OMB's Information Quality Bulletin for Peer Review. The purpose of these independent reviews was to provide candid and critical comments that will assist the Climate Change Science Program in making this published report as sound as possible and to ensure that the report meets institutional standards.

We wish to thank the following individuals for their peer review of this report: Frank Muller-Karger (Univ. of South Florida), Roger King (Mississippi State Univ.), Chuck Hutchinson (Univ. of Arizona), Verne Kaupp (Univ. of Missouri), Richard Lawford (GEWEX Project Office), D. Lettenmaier (Univ. of Washington), Pierre-Philippe Mathieu (European Space Agency), Donald Blumenthal (Sonoma Technology, Inc.), Richard Scheffe (US EPA), Gregory Carmichael (Univ. of Iowa), Kelly Chance (Harvard-Smithsonian Center for Astrophysics), Judith Qualters (Centers for Disease Control and Prevention), Robert Venezia, (Armed Forces Medical Intelligence Center) and Jonathan Patz (Univ. of Wisconsin).

In addition, we wish to thank the following individuals for their Public/Federal Agency review of this report: Amy Kaminsky (OMB), Linda Lawson (DOT), Samuel Williamson (NOAA), Derek Parks (NOAA), Kevin Trenberth (NCAR), Thomas Armstrong (USGS), Tom Vonder Harr (Colorado State), and Marta Cehelsky (NSF)

Furthermore, we wish to thank the following individuals for their NASA Concurrence of this report: Teresa Fryberger, Jack Kaye, John Haynes, Michael Freilich, Randy Friedl, Colleen Hartman and Alan Stern

The author wishes to thank Ed Scheffner for his contribution to chapter 1.

The author wishes to thank the following for their contribution to chapter 2.

Tracey Holloway (University of Wisconsin—Madison)

Daniel J. Jacob (Harvard University)

Jennifer A. Logan (Harvard University)

Loretta J. Mickley (Harvard University)

Xin-Zhong Liang (University of Illinois at Urbana-Champaign)

Dr. Zong-Liang Yang (The University of Texas at Austin)

Prof. Armistead (Ted) Russell (Georgia Institute of Technology)

Carey Jang (USEPA/OAQPS)

Alice Gilliland (USEPA/ORD/NERL/AMD)

The author wishes to thank staff members at the National Renewable Energy Laboratory for their many insights and contributions to the area of renewable energy resource assessment, and to this chapter 3 in particular, including Dennis Elliott and Marc Schwartz (wind resource assessments), Ray George, Steve Wilcox, Daryl Myers and Tom Stoffel (solar resource assessments), Donna Heimiller and Anelia Milbrandt (Geographic Information Systems and model input data), and Shannon Cowlin (HOMER applications). The author also wishes to thank Peter Lilienthal (Green Island Power) who developed the HOMER model, and Paul Gilman (HOMER consultant), who reviewed that chapter and provided many useful comments.

The author would like to thank Drs. Durland Fish (Yale University) and Joseph Piesman (U.S. Centers for Disease Control and Prevention) for assistance in characterizing the development of the Lyme Disease Prevention DSS. Dr. John Brownstein was instrumental in providing access to figures in Chapter 4, showing the output of these analyses.

RECOMMENDED CITATIONS

For Chapter 1:

Kanarek, Harold. 2005. “The FAS Crop Explorer: A Web Success Story,” *FAS Worldwide*, June (<http://www.fas.usda.gov/info/fasworldwide/2005/06-2005/Cropexplorer.htm>) (accessed April 2007).

National Research Council, Board on Earth Sciences and Resources. 2007. *Contributions of Land Remote Sensing for Decisions about Food Security and Human Health: Workshop Report* (Washington, DC: National Academies Press).

Reynolds, Curt A. 2001. “CADRE Soil Moisture and Crop Models,” at <http://www.pecad.fas.usda.gov/cropexplorer/datasources.cfm> (accessed April 2007).

United Nations Food and Agriculture Organization. No date. “Agriculture and Climate Change: FAO’s Role” at <http://www.fao.org/News/1997/971201-e.htm> (accessed April 2007).

For Chapter 2:

Hogrefe C, LR Leung, LJ Mickley, SW Hunt, and DA Winner, 2005. “Considering Climate Change in U.S. Air Quality Management,” *EM: Air & Waste Management Association’s magazine for environmental managers* October 2005:19–23.

Jacob, D.J., and A.B. Gilliland, 2005. “Modeling the Impact of Air Pollution on Global Climate Change, Environmental Manager,” pp. 24–27, October 2005, Air and Waste Management Association. Pittsburgh, PA.

Leung LR, Y Kuo, and J Tribbia. 2006. “Research Needs and Directions of Regional Climate Modeling Using WRF and CCSM,” *Bulletin of the American Meteorological Society* 87(12):1747–1751.

LRTAP, 2007b: Task Force on Hemispheric Transport of Air Pollution, 2007 Interim Report. Available at http://www.htap.org/activities/2007_Interim_Report.htm.

Mickley, L.J., D.J. Jacob, B.D. Field, and D. Rind, 2004. “Effects of Future Climate Change on Regional Air Pollution Episodes in the United States,” *Geophys. Res. Lett.*, 30, L24103, doi:10.1029/2004GL021216.

Tagaris, E., K. Manomaiphiboon, K.-J. Liao, L. R. Leung, J.-H. Woo, S. He, P. Amar, A. G. Russell, 2007. “Impacts of Global Climate Change and Emissions on Regional Ozone and Fine Particulate Matter Concentrations over the United States,” *J. Geophys. Res.*, 112 (D14), D14312.

For Chapter 3:

Lambert, Tom, Paul Gilman, Peter Lilienthal., 2006. Micropower System Modeling with HOMER. In Felix A Farret, M Godoy Simoes. *Integration of Alternative Sources of Energy*. John Wiley and Sons, Inc. Hoboken, New Jersey. 379-416

Perez, R., P. Ineichen, K. Moore, M. Kmieciak, C. Chain, R. George, and F. Vignola, 2002: A New Operational Satellite-to-Irradiance Model. *Solar Energy* 73(5), pp. 307–317.

Renné, David S., Richard Perez, Antoine Zelenka, Charles Whitlock, and Roberta DiPasquale, 1999: Use of Weather and Climate Research Satellites for Estimating Solar Resources. Chapter 5 in *Advances in Solar Energy*, Volume 13, Edited by D. YogiGoswami and Karl W. Boer. The American Solar Energy Society, 2400 Central Ave. Suite G1, Boulder, Colorado 80301. Pp.171–240.

The U.S. Climate Change Science Program Appendix A

Schwartz, M., R. George, and D. Elliott, 1999. The Use of Reanalysis Data for Wind Resource Assessment at the National Renewable Energy Laboratory. Proceedings, European Wind Energy Conference, Nice, France, March 1–5, 1999.

For Chapter 4:

Brownstein, J.S., T.R. Holford and D. Fish 2005a: Effect of climate change on Lyme disease risk in North America. *EcoHealth* 2:38–46.

Brownstein, J.S., D. K Skelly, T.R. Holford and D. Fish. 2005b: Forest fragmentation predicts local scale heterogeneity of Lyme disease risk. *Oecologia* 146: 469–475

Glass, G.E. 2007: Rainy with a chance of plague: forecasting disease outbreaks from satellites. *Future Virology* 2:225–229

For Chapter 5:

Carron, J., E. Zagona, and T. Fulp (2006) Modeling Uncertainty in an Object-Oriented Reservoir Operations Model. *J. Irrig. and Drain. Engrg.*, 132(2): 104-111.

Frevrt, D., T. Fulp, E. Zagona, G. Leavesley, and H. Lins (2006) Watershed and River Systems Management Program: Overview of Capabilities. *J. Irrig. and Drain. Engrg.* 132(2):92-97.

Grantz, K., B. Rajagopalan, E. Zagona, and M. Clark (2007) Water management applications of climate-based hydrologic forecasts: case study of the Truckee-Carson River basin, Nevada <<http://cadswes.colorado.edu/PDF/RiverWare/>

GrantzEtAl2006WaterManagementApps_JWRPM.pdf> . *Journal of Water Resources Planning and Management*.

Hartmann, H.C. (2005) Use of climate information in water resources management. In: *Encyclopedia of Hydrological Sciences*, M.G.

Hydrological Sciences Branch (2007) Evaluation Report for AWARDS ET Toolbox and RiverWare Decision Support Tools. NASA Goddard Space Flight Center, Greenbelt, MD, 28pp. (URL: http://wmp.gsfc.nasa.gov/projects/project_RiverWare.php)

Lettenmaier, D.P. (2003) The role of climate in water resources planning and management. In: *Water: Science, Policy, and Management*, R. Lawford, D. Fort, H. Hartmann, and S. Eden (Eds.), American Geophysical Union, Washington, DC, 247-266.

Neumann, D., E. Zagona, and B. Rajagopalan (2006) A decision support system to manage summer stream temperatures. *Journal of the American Water Resources Association* 42, 1275-1284.

U.S. Department of Interior (2007) Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, Draft Environmental Impact Statement, Volume 1, Bureau of Reclamation, Boulder City, NV (URL: <http://www.usbr.gov/> <<http://www.usbr.gov/>> lc/ region/programs/strategies/draftEIS/index.html)

Zagona, E., T.J. Fulp, R. Shane, T. Magee, and H. Morgan Goranflo (2001) RiverWare: A Generalized Tool for Complex Reservoir Systems Modeling. *Journal of the American Water Resources Association*.

Zagona, E., T. Magee, D. Frevrt, T. Fulp, M. Goranflo and J. Cotter (2005) RiverWare. In: V. Singh & D. Frevrt (Eds.), *Watershed Models*, Taylor & Francis/CRC Press: Boca Raton, FL, 680pp.

Blank Page