

189 **Preface**
190 **Motivation and Guidance for Using This Report**

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194 A primary objective of the U.S. Climate Change Science Program (CCSP) is to provide
195 the best possible scientific information to support public discussion, as well as
196 government and private sector decision making, on key climate-related issues. To help
197 meet this objective, the CCSP has identified an initial set of 21 Synthesis and Assessment
198 Products (SAPs) that address its highest priority research, observation, and decision
199 support needs.

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201 This report, CCSP SAP 2.4, addresses Goal 2 of the CCSP Strategic Plan: Improve
202 quantification of the forces bringing about changes in the Earth's climate and related
203 systems. The Atmospheric Composition chapter of the CCSP Strategic Plan describes a
204 vision to produce a Synthesis and Assessment Product (SAP) on "Trends in emissions of
205 ozone-depleting substances, ozone layer recovery, and implications for ultraviolet
206 radiation (UV) exposure–SAP 2.4." The report provides a synthesis and integration of
207 the current knowledge of the stratospheric ozone layer, ozone-depleting substances, and
208 ultraviolet radiation reaching the Earth's surface.

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210 **P.1 CONTEXT FOR THIS SYNTHESIS AND ASSESSMENT PRODUCT**

211 SAP 2.4 contributes to the ongoing and iterative international process of producing and
212 refining climate-related assessments and decision support tools. SAP 2.4 integrates

213 findings from the World Meteorological Organization (WMO) / United Nations
214 Environment Programme (UNEP) 2006 assessment on the ozone layer (*Scientific*
215 *Assessment of Ozone Depletion: 2006*) and the 2005 Special Report of the
216 Intergovernmental Panel on Climate Change (IPCC) and the Technology and Economic
217 Assessment Panel (TEAP) on *Safeguarding the Ozone Layer and the Global Climate*
218 *System – Issues Related to Hydrofluorocarbons and Perfluorocarbons*. Both of these
219 assessments have been extensively reviewed prior to their publication. SAP 2.4 discusses
220 these assessments from both the global perspective and in the specific context of the
221 United States of America; this SAP 2.4 gives the U.S.-specific perspective of a global
222 issue for decision-makers in the United States. The SAP discusses ozone changes over
223 North America, the contributions of the United States to ozone-depleting substances, and
224 the UV changes due to the ozone layer changes over the North American continent. This
225 SAP takes advantage of these thoroughly vetted scientific assessments to prepare a
226 product that can be used to inform domestic and international decision makers in
227 government and industry, scientists, and the public. This SAP was planned and initiated
228 in August 2005, before the release of the Fourth Assessment Report (AR4) of the
229 Intergovernmental Panel on Climate Change (*Climate Change 2007: The Physical*
230 *Science Basis*). Therefore, this report does not rely on the IPCC AR4; however, some key
231 pertinent issues from the IPCC report are used in a few instances where updated
232 information was essential. They are noted as such in the chapters.

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236 P.2 AUDIENCE AND INTENDED USE

237 The audience for SAP 2.4 includes scientists, decision makers in the public sector
238 (federal, state, and local governments), the private sector (chemical industry,
239 transportation, and agriculture; and climate policy and health-related interest groups), the
240 international community, and the general public. This broad audience is indicative of the
241 diversity of stakeholder groups interested in knowledge of the stratospheric ozone layer,
242 ozone-depleting substances, and ultraviolet radiation, and of how such knowledge might
243 be used to inform decisions. The primary users of SAP 2.4 are intended to include, but
244 are not limited to, officials involved in formulating climate and environmental policy,
245 individuals responsible for managing emissions of ozone-depleting substances, and
246 scientists involved in assessing and/or advancing the frontier of knowledge. The plan for
247 this SAP was presented at the CCSP workshop, “U.S. Climate Change Science Program,
248 Climate Sciences in Support of Decision Making,” held in Arlington, Virginia, during 14-
249 16 November 2005, where it was well received.

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251 SAP 2.4 is intended to be used:

- 252 • as a state-of-the-art assessment of our knowledge of the stratospheric ozone layer,
253 ozone-depleting substances, and ultraviolet radiation at the surface;
- 254 • to provide the scientific basis for decision support to guide management and
255 policy decisions that affect the ozone layer and emissions of ozone-depleting
256 substances;
- 257 • as a means of informing policymakers and the public concerning the general state
258 of our knowledge of the stratospheric ozone layer and emissions of ozone-

259 depleting substances with respect to the contributions of and impacts on the
260 United States; and

- 261 • to provide scientific information on the ozone layer to inform important
262 stakeholder groups. Examples of these groups include: the chemical industry that
263 produces ozone depleting substances and substitutes for ozone-depleting
264 substances; agencies in the United States and sectors of the U.S. economy that
265 request exemptions from emissions of substances banned by the Montreal
266 Protocol and its Amendments; and the climate-science community.

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268 Senior managers and the general public may use the Executive Summary of SAP 2.4 to
269 improve their overall understanding of what is known and unknown about the effects of
270 U.S. emissions on the stratospheric ozone layer and ultraviolet radiation at the surface. It
271 will also provide an estimate of the impacts of the ozone layer changes on the country.

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273 **P.3 TOPICS AND CONTENT**

274 The focus of this Report follows the Prospectus guidelines developed by the Climate
275 Change Science Program and posted on its website at (<http://www.climatescience.gov>).

276 SAP 2.4 addresses key issues related to the stratospheric ozone layer, including its
277 changes in the past and expected levels in the future. Also, it takes account of the current
278 abundances and emissions of ozone-depleting substances. Further, it synthesizes the best
279 available information on the past and future levels of ultraviolet radiation at the Earth's
280 surface. Lastly, it explores the interactions between climate change and stratospheric
281 ozone changes. The discussion of these topics is carried out within the context of both the

282 globe and the United States to distill a regional assessment from the global assessments.

283 More specifically, SAP 2.4:

- 284 • Quantifies current information on sources, sinks, and abundances of ozone-
285 depleting substances and associated uncertainties.
- 286 • Discusses levels of ozone in various regions of the stratosphere, including the
287 polar regions. It pays special attention to the Antarctic ozone hole and to ozone
288 above the continental United States.
- 289 • Provides information on the past, current, and future levels of ultraviolet
290 radiation, both generally and for the continental United States.
- 291 • Provides an assessment of the impact of climate and compositional changes on the
292 future of the ozone layer, and provides some qualitative discussion of the impacts
293 of the ozone layer on climate.
- 294 • Describes how these findings relate especially to the United States.
- 295 • Identify the gaps in understanding where research is critical for future
296 assessments of the ozone layer.

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298 The questions addressed by this report include:

- 299 • What is the current state of the stratospheric ozone layer?
- 300 • What are the recorded changes in the emissions and concentrations of ozone-
301 depleting substances?
- 302 • What do the observations indicate about the abundances and trends of
303 stratospheric ozone?

- 304 • What is the trend in the occurrence, depth, duration, and extent of the Antarctic
305 ozone hole?
- 306 • What is the state of ozone depletion in the Arctic region?
- 307 • When can one expect recovery of the global ozone layer and of the Antarctic
308 ozone hole?
- 309 • What are the influences of climate change on the recovery of the ozone layer?
- 310 • How has surface ultraviolet radiation changed in the past and what is expected for
311 the future?
- 312 • What are the findings specific to the United States on the topics of ozone-
313 depleting substances, stratospheric ozone depletion, surface ultraviolet radiation
314 changes, and expectations for the future ozone layer?
- 315 • What are the various possible emission scenarios that can be considered for any
316 further policy actions on emissions of ozone-depleting gases?

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318 **P.4 OUTLINE OF THE REPORT**

319 The above questions provide the basis for information presented in the six chapters of
320 SAP 2.4. The chapters are written in a style consistent with major authoritative
321 international scientific assessments (*e.g.*, IPCC assessments, and the reports of the Global
322 Ozone Research and Monitoring Project of WMO). However, additional explanatory
323 material is included both within the Chapters and as an Appendix to aid the diverse
324 readership of this SAP. The Executive Summary, which presents the key findings from
325 the main body of the Report, as well as Chapters 1 and 6, are intended to be useful
326 especially for those involved with policy-related ozone layer issues. Chapter 1 is intended

327 as a background “primer” for those less familiar with the topic of stratospheric ozone
 328 depletion. Chapters 2 through 5 provide the detailed material that supports the findings of
 329 the Executive Summary. Though they are written at a more technical level, they
 330 incorporate material to aid their accessibility to the broad readership of this SAP. The
 331 chapters of SAP 2.4 are:

- 332 • Chapter 1: Introduction
- 333 • Chapter 2: Current Trends, Mixing Ratios, and Emissions of Ozone-Depleting
 334 Substances and Their Substitutes
- 335 • Chapter 3: Ozone and UV Observations
- 336 • Chapter 4: How Do Climate Change and Stratospheric Ozone Loss Interact?
- 337 • Chapter 5: The Future and Recovery
- 338 • Chapter 6: Implications for the United States

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340 For those interested readers who are not specialists on the ozone-layer issue, an Appendix
 341 gives additional scientific background on the topics of this SAP. A glossary and a list of
 342 acronyms are included at the end of the report.

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344 **P.5 THE SYNTHESIS AND ASSESSMENT PRODUCT TEAM**

345 The authors for this SAP were chosen based on their expertise and participation in the
 346 international assessments from which this product derives a great deal of information.

347 The SAP 2.4 Author Team and their roles are:

348	Dr. A. R. Ravishankara, NOAA	Overall Lead
349	Dr. Michael J. Kurylo, NASA	Overall Lead
350	Dr. Richard Bevilacqua, NRL / DoD	Scientific Content
351	Dr. Jeff Cohen, USEPA	Scientific Content

352	Dr. John Daniel, NOAA	Scientific Content
353	Dr. Anne Douglass, NASA	Scientific Content
354	Dr. David Fahey, NOAA	Scientific Content
355	Dr. Jay Herman, NASA	Scientific Content
356	Dr. Terry Keating, USEPA	Scientific Content
357	Dr. Malcolm Ko, NASA	Scientific Content
358	Dr. Stephen Montzka, NOAA	Scientific Content
359	Dr. Paul Newman, NASA	Scientific Content
360	Dr. V. Ramaswamy, NOAA	Scientific Content
361	Dr. Anne-Marie Schmoltner, NSF	Scientific Content
362	Dr. Richard Stolarski, NASA	Scientific Content
363	Dr. Kenneth Vick, USDA	Scientific Content
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365 Those who served as Convening Lead Authors (CLAs) and Lead Authors (LAs) are
 366 shown at the beginning of each chapter. An Editorial Staff managed the assembly,
 367 formatting, and preparation of the Report.

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369 **P.6 DRAFTING AND REVIEWS OF THIS REPORT**

370 This Synthesis and Assessment Product was initiated in August 2005 and the first drafts
 371 prepared during late 2006 and early 2007. It went through many drafts to account for
 372 comments by the SAP 2.4 Authoring Team. The resulting revised draft of this report was
 373 reviewed by a National Academy of Sciences / National Research Council (NRC)
 374 Review Panel in August to November of 2007. This Public Review Draft has made
 375 changes in response to the comments and suggestions of that NRC Review Panel. The
 376 report of the NRC Review Panel is available on the CCSP website. In addition, the
 377 responses of the SAP 2.4 Authoring Team to the NRC Review Panel's report are
 378 itemized in a document that is available on the CCSP website during this Public Review
 379 period.

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