An Assessment of Tropospheric Ozone Pollution

—A North American Perspective—
About the Cover
The map displays combined distributions of surface O₃ sampling stations and ozonesondes operating on the North American continent. As noted in Chapter 3, the distinction between “rural” and “urban” surface sites is somewhat unclear owing to urban expansion and urban-plume influences in downwind non-urban areas. Sites located in Northern Canada and noncontiguous U.S. regions not shown.
AN ASSESSMENT OF TROPOSPHERIC OZONE POLLUTION:
A NORTH AMERICAN PERSPECTIVE

The Synthesis Team

for the

North American Research Strategy for Tropospheric Ozone
(NARSTO)

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NARSTO OZONE ASSESSMENT

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In 1991, the U. S. National Research Council (NRC) Committee on Tropospheric Ozone Formation and Measurement completed an assessment of the scientific information and data bases relevant to tropospheric O3. Their report, *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, contained specific findings and recommendations related to the trends in O3, the emissions of O3-precursor compounds, the characterization of O3, and its precursors through ambient measurements and models, and the application of science and technology to the management of O3 pollution in the United States. Gaps in our scientific understanding of tropospheric O3 were found to severely hamper our ability to manage O3 pollution, and it was therefore recommended that a coordinated program be established.

The North American Research Strategy for Tropospheric Ozone (NARSTO) was conceived and founded in 1994 in response to the NRC recommendation. NARSTO’s mission is to design and coordinate a coherent, long-term, science-focused, policy-relevant research program emphasizing the atmospheric processes involved in tropospheric O3 and O3-precursor formation, transformation, and transport. Since the formation, accumulation, and transport of tropospheric O3 occur on time scales of many days and spatial scales of thousands of kilometers, NARSTO has adopted a continental perspective (i.e., North America) as opposed to an urban or even regional focus.

The NARSTO strategic plan was developed through a series of workshops culminating in a meeting at Boulder, Colorado in 1994, which drafted the NARSTO Research Strategy and Charter (NARSTO, 1994). This plan established the functional structure of the NARSTO organization, provided the basic rationale for the program, identified the key science and policy questions to be addressed, and outlined the scientific activities required to meet NARSTO goals. In developing this strategic plan, it was recognized that one way of effectively incorporating the rapid scientific developments impacting our understanding of air quality and its management was to conduct periodic assessments aimed at informing and enhancing the decision-making process.

The current Ozone Assessment, the first such effort performed under NARSTO, contains two major components. The first Assessment component — the Critical Review Paper series — is intended to provide a detailed analysis and review of all salient atmospheric aspects of the tropospheric O3 issue. This component now exists in the form of the 24 contributions shown in the accompanying text box, which were prepared by a selected group of North American scientists known for their expertise on various aspects of O3 science. These Critical Review Papers were presented to the scientific and policy-making communities at a NARSTO Science Symposium in West Palm Beach, Florida in the fall of 1997, and subsequently subjected to journal review. Besides providing a stand-alone information resource, these Papers combine with the extended technical literature to serve as the primary information basis for the second Assessment component: this Report.

This report is the product of efforts by a Synthesis Team representing scientists from government agencies, private organizations, and universities in Canada, Mexico, and the United States. This team was formed during October 1996 to address a set of 13 overarching NARSTO policy and science questions, based on a synthesis of the information base provided by the Critical Review Papers as well as the external scientific literature. In contrast to the Critical Review Papers, which are comprehensive in their overall scope and whose audience is the scientific and technical communities, this report attempts to provide a concise, policy-relevant statement of the science of tropospheric O3 for decision-makers and other stakeholders tasked

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* These Science and Policy Questions are listed in Appendix A.
CRITICAL REVIEW PAPERS OF THE NARSTO O3 ASSESSMENT


CR5. Advances in Meteorological Measurement Methods for Application to Air Quality Research and Monitoring  W.D. Neff


CR7. The Method of Photochemical Indicators as a Basis for Analyzing O3-NOx-Hydrocarbon Sensitivity  S. Sillman

CR8. Ozone Process Insights From Field Experiments-Part II: Observation Based Analysis for Ozone Production  L.I. Kleinman


CR11. The Application of Data from Photochemical Assessment Monitoring Stations to the Observation Based Model  C.A. Cardelino, W.L. Chameides


CR14. Atmospheric Chemistry of VOCs and NOx  R. Atkinson

CR15. Chemical Oxidant Mechanisms for Air Quality Modeling: Critical Review  M.C. Dodge

CR16. Heterogeneous Chemistry and Tropospheric Ozone  D.J. Jacob

CR17. Meteorological Modeling for Air Quality Assessments  N.L. Seaman

CR18. A Review of the Current Status of Knowledge on Dry Deposition Processes  M.L. Wesely, B.B. Hicks


CR22. Emissions of Ozone Precursors From Stationary Sources  M. Placet, C. Mann, R.O. Gilbert, M. Niefer


*These papers are published in Atmospheric Environment (Volume 32, Nos. 12-14, 2000). Copies of all papers are posted on the NARTSO website (http://www.cgenv.com/Narsto).
PREFACE

with managing air quality in North America. While critical gaps and shortcomings in our knowledge are identified, the report does not outline the priorities and needed resources for future air quality research; this is a task more properly carried out by the NARSTO Executive Steering Committee and Science and Resource Planning Group on the basis of this report. Moreover, the focus is limited to those aspects of the problem related to the atmospheric sciences, and, as a result, the report does not critically assess issues related to health and ecological effects or to the technology of emission control and prevention.

As will be noted from the frequent citations throughout the text, this report draws heavily from material presented in the Critical Review Papers. However, the Synthesis Team made use of other relevant and accessible information and databases, as well as the input and guidance from a number of experts and policy-makers. These included Dr. Peter Borrell of the International Scientific Secretariat of EUROTRAC and the Fraunhofer Institute in Germany, Mr. John Elston of the New Jersey Department of Environmental Protection, Mr. Grady T. Helms, Jr. of the Office of Air Quality Planning and Standards at the U.S. Environmental Protection Agency, Mr. Jon Heuss of General Motors Corporation, Mr. John Jansen of the Southern Company, Mr. Pierre Pinault of the Transboundary Air Issues Branch of the Environmental Protection Service at Environment Canada, and Dr. Armistead Russell of the Georgia Institute of Technology, all of whom presented their perspectives to the Synthesis Team at one or more meetings. In addition, the assessment report underwent an extensive formal review process that is outlined in Appendix B.

The NARSTO assessment represents one in a series of scientific assessments of tropospheric \( \text{O}_3 \) and its management in North America. These include the aforementioned report of the NRC Committee on Tropospheric Ozone Formation and Measurement, the NRC report *Ozone and Other Photochemical Oxidants* published in 1977, the 1989 report of the U.S. Office of Technology Assessment on *Catching Our Breath – Next steps for reducing urban Ozone*, the Canadian 1996 NO\textsubscript{x}/VOC Science Assessment, the *Primer Informe Sobre la Calidad del Aire en Ciudades Mexicanas 1996*, as well as the periodic U.S. EPA *Criteria Documents for Ozone and Annual Air Quality and Emission Trends Reports*. However, the NARSTO activity represents the first attempt to assess the state of the science of tropospheric \( \text{O}_3 \) from the perspective of the North American continent. Since the atmosphere does not behave in accordance with political borders, such a perspective is critical to the development of comprehensive understanding of tropospheric \( \text{O}_3 \) and, for this reason, the NARSTO assessment provides a unique and critical summary of our current understanding of tropospheric \( \text{O}_3 \) and its relevance to the management of air quality in Canada, Mexico, and the United States.

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