



Overview of:

## **IGAC's Tropospheric Ozone Assessment Report**

*Global metrics for climate change, human health and crop/ecosystem research*

Written by the TOAR Steering Committee  
Updated February 16, 2017

*Tropospheric Ozone Assessment Report (TOAR): Global metrics for climate change, human health and crop/ecosystem research*, is a new Activity of the International Global Atmospheric Chemistry Project (IGAC), approved by the IGAC Scientific Steering Committee on March 13, 2014 ([www.igacproject.org/TOAR](http://www.igacproject.org/TOAR)).

**Mission:** To provide the research community with an up-to-date scientific assessment of tropospheric ozone's global distribution and trends from the surface to the tropopause.

**Goals:**

- 1) Produce the first tropospheric ozone assessment report based on all available surface observations, the peer-reviewed literature and new analyses.
- 2) Generate easily accessible, documented data on ozone exposure and dose metrics at thousands of measurement sites around the world (urban and non-urban), freely accessible for research on the global-scale impact of ozone on climate, human health and crop/ecosystem productivity.

**Organization:** TOAR is a science effort initiated by IGAC, and developed by an international team of experts. TOAR receives financial and logistical support from IGAC, the US National Oceanic and Atmospheric Administration, and The World Meteorological Organization (an agency of the United Nations).

TOAR is coordinated by a Steering Committee, chaired by Owen Cooper, CIRES, University of Colorado/NOAA ESRL, USA (contact: [owen.r.cooper@noaa.gov](mailto:owen.r.cooper@noaa.gov)).

TOAR has established 7 regional working groups to gather surface ozone time series from around the world, a working group that focuses on free troposphere and satellite ozone observations, and a working group on metrics, statistics, and data analysis tools. In addition, there are writing teams for each paper of the report (see detailed outline below).

Forshungszentrum Jülich has built the world's largest database of surface ozone observations, containing over 9000 time series from ozone monitors located around the world. The publicly available database will provide access to dozens of ozone metrics for each monitoring site, calculated with the same consistent methodology.

The report is being written as a series of eight stand-alone publications to be submitted for peer-review to *Elementa: Science of the Anthropocene*, an open-access, non-profit science journal founded by five US research Universities and published by University of California Press ([www.elementascience.org](http://www.elementascience.org)).

## I. Progress Report

Tropospheric ozone is a greenhouse gas and pollutant detrimental to human health and crop and ecosystem productivity. Since 1990 a large portion of the anthropogenic emissions that react in the atmosphere to produce ozone have shifted from North America and Europe to Asia. This rapid shift, coupled with limited ozone monitoring in developing nations, has left scientists unable to answer the most basic questions: Which regions of the world have the greatest human and plant exposure to ozone pollution? Is ozone continuing to decline in nations with strong emission controls? To what extent is ozone increasing in the developing world? How can the atmospheric sciences community facilitate access to the ozone metrics necessary for quantifying ozone's impact on climate, human health and crop/ecosystem productivity?

TOAR is designed to answer these questions through the development of an assessment report based on expert opinion and analysis, and the generation of a range of ozone metrics (i.e., exposure and dose indices) at thousands of sites around the world. TOAR consists of an eleven-member Steering Committee, which established the project's goals and scope and guides the ongoing development of the assessment report and the ozone metrics database. TOAR membership is open to any scientist actively involved in tropospheric ozone research or data collection; current membership stands at over 220 individuals from 36 nations, representing research on all 7 continents. Interested participants are encouraged to contact the TOAR Chair, Owen Cooper ([owen.r.cooper@noaa.gov](mailto:owen.r.cooper@noaa.gov)). TOAR's achievements include:

- The organization of the largest international group of scientists ever assembled for the purpose of assessing the current state of tropospheric ozone research and observations.
- The world's largest database of ozone metrics, calculated consistently for over 9000 surface ozone time series, created by Forshungszentrum Jülich: <https://join.fz-juelich.de/accounts/login/>
- Four workshops have been hosted in the USA, Spain, Beijing and Germany to develop TOAR and encourage international collaboration.
- The TOAR ozone database is now complete and the writing of the assessment report is well underway.

## II. Timeline

March 14, 2014: IGAC Scientific Steering Committee approves TOAR as a new IGAC Activity.

December 10-11, 2014: TOAR Workshop 1.01, was held at the NOAA Earth System Research Laboratory, Boulder, to develop TOAR's scope, structure and timeline.

February – March, 2015: Preliminary organization of TOAR author teams and working groups, establishment of TOAR database and initiation of ozone data collection period.

April 28-30, 2015: TOAR Workshop 1.02 was held at the Agencia Estatal de Meteorología (AEMET), Madrid, Spain (co-sponsored by WMO) to develop the report outline.

January 25-27, 2016: TOAR Workshop 1.03 was held at the Xijiao Hotel, Beijing, to review the first draft of the report and develop the second draft.

April 25-29, 2016: TOAR Workshop 1.04 was held in Jülich, Germany, to conduct the Big Data analysis of the TOAR database to supply the figures and analysis for the report.

April 30, 2016: TOAR database freeze date, no further data submissions.

September 26-30, 2016: IGAC meeting in Breckenridge, Colorado. TOAR Steering Committee and lead authors met to discuss the second draft.

March-June, 2017: Submission period of the TOAR papers to *Elementa*.

July 1, 2017: The TOAR database of ozone metrics will be made publicly available

### III. Scope and outline of the TOAR report

**Purpose of the assessment report:** To provide the scientific community with an up-to-date and comprehensive peer-reviewed, open-access reference that:

- i) Displays the present-day observed ozone distribution and trends for the surface (urban and non-urban), the free troposphere, and the tropospheric column.
- ii) Reviews the ability of global-scale models to replicate the global/regional ozone distribution and trends and identifies future needs for ozone observations.
- iii) Describes the open-access database containing the global ozone metrics produced and archived for the report. Exposure and dose metrics will be calculated from observations that extend through 2014.

TOAR will provide unprecedented information for analyzing the impacts of ozone on human health, vegetation and climate. Because of the focus of the assessment, as stated above, TOAR will not quantify or assess the impacts of ozone on human health, vegetation, or climate change. TOAR encourages researchers around the world, who have an interest in assessing impacts, to access the ozone metrics on the TOAR database and conduct their own analyses.

**Audience:** The report is broadly targeted toward scientists from the Earth and biological sciences. An Executive Summary will highlight the results relevant to policy makers.

**Report Format:** Each paper of the assessment report will be written as a peer-reviewed, stand-alone publication. All papers, documentation on the TOAR database and data products, and the Executive Summary will appear in the same journal and issue, and will be clearly linked.

**Report Authorship:** Each paper will be written by a team of experts. An author contributing to a paper must be an expert in the subject matter covered by that paper, and must have a record of publishing articles in that area in the peer-reviewed literature. Each paper will have a coordinating lead author who will be listed as the first author. All other scientists contributing to the writing of the paper will be listed as co-authors. Each paper will have at least one TOAR Steering Committee member as a co-author.

#### **REPORT CONTENT**

**Tropospheric Ozone Assessment Report: Executive Summary:** A summary (2 pages of text plus several figures) of the key findings from the report, with the goal of being policy-relevant and written in language that is understandable to policy-makers and the general public. Authors: Report lead authors and the TOAR Steering Committee

**Tropospheric Ozone Assessment Report: Critical review of the present-day and near-future tropospheric ozone budget**

*Abbreviated title: TOAR-Ozone Budget*

Lead Authors: A. Archibald and Y. Elshorbany

**Tropospheric Ozone Assessment Report: Tropospheric ozone observations**

*Abbreviated title: TOAR-Observations*  
Lead authors: D. Tarasick and I. Galbally

**Tropospheric Ozone Assessment Report: Global ozone metrics for climate change, human health, and crop/ecosystem research**

*Abbreviated title: TOAR-Metrics*  
Lead Author: A. S. Lefohn

**Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health**

*Abbreviated title: TOAR-Health*  
Lead Authors: Z. L. Fleming and R. Doherty

**Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to vegetation**

*Abbreviated title: TOAR-Vegetation*  
Lead Author: G. Mills

**Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to climate and global model evaluation**

*Abbreviated title: TOAR-Climate*  
Lead Authors: A. Gaudel and O. R. Cooper

**Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability, and trends**

*Abbreviated title: TOAR-Model Performance*  
Lead Authors: P. J. Young and V. Naik

**Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations**

*TOAR-Surface Ozone Database*  
Lead Author: M. Schultz  
SUPPLEMENT 1: Documentation of TOAR surface ozone data products  
SUPPLEMENT 2: Documentation of the Jülich Open Web Interface for accessing TOAR surface ozone data products

**The Tropospheric Ozone Assessment Report: Key findings and recommendations for future research**

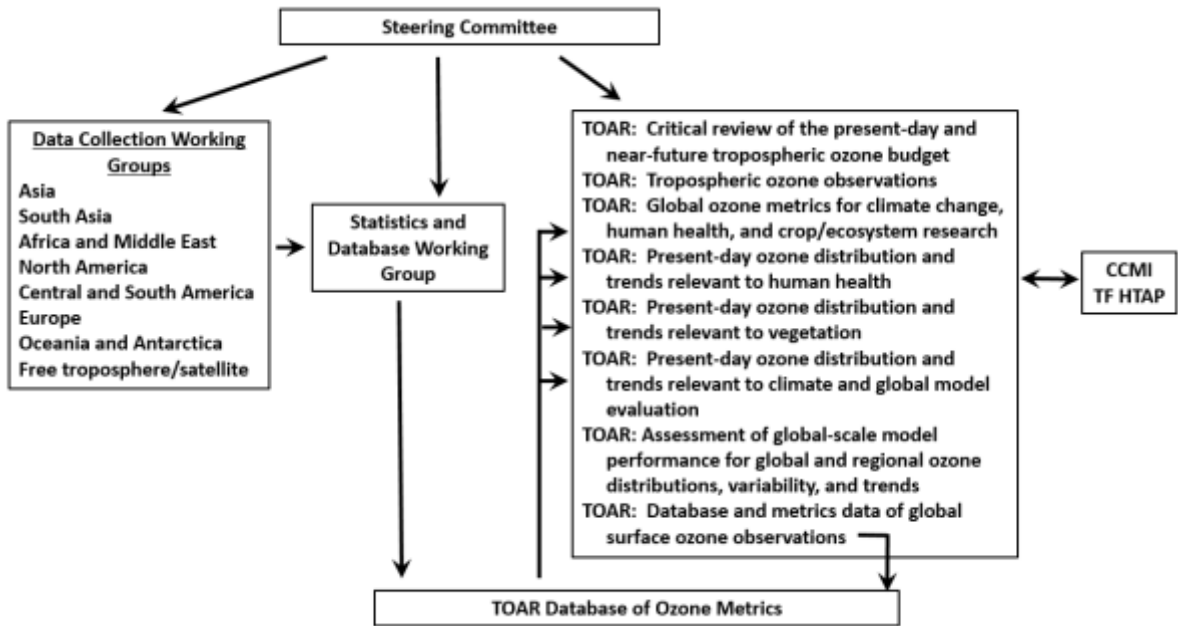
*Abbreviated title: TOAR-Synthesis*  
Lead Author: O. R. Cooper

**Ancillary Papers:** Interested authors may propose to the TOAR Steering Committee additional peer-reviewed papers that can be included in the TOAR special issue. These papers will complement one or more of the TOAR core papers and will allow for greater discussion and analysis of a particular topic e.g. an in-depth analysis of surface ozone's distribution and trends across South Asia. These papers may also be written as relatively short "data papers" which do not provide in-depth analysis but instead focus on the description of new and unique data sets.

**Working Groups:** The eight working groups associated with identifying the most appropriate data for meeting TOAR's goals are comprised of scientists with extensive knowledge of ozone

data quality in their geospatial region of expertise. The working group associated with identifying the appropriate ozone metrics, statistical techniques and database approaches is comprised of scientists with extensive knowledge in these areas. The regional working groups are responsible for preparing and delivering their ozone observations to the Statistics and Database Working Group (Figure 1).

- a) *Asia Working Group*: Covers the region east of the Ural Mountains to the International Dateline, from the North Pole to the Equator, but excluding South Asia/Middle East.
- b) *South Asia Working Group*: India, Pakistan, Nepal, Sri Lanka, Bangladesh, Arabian Sea and Bay of Bengal.
- c) *Africa and Middle East Working Group*: including Cape Verde Islands, Madagascar and La Reunion.
- d) *North America Working Group*: USA, Canada, Greenland, Bermuda, Hawaii
- e) *Central and South America Working Group*: includes Mexico and the Caribbean Sea.
- f) *Europe Working Group*: includes Iceland, Svalbard, the Mediterranean Sea and extends eastward to the Ural Mountains. Excludes the Middle East.
- g) *Oceania and Antarctica Working Group*: Australia, New Zealand, Antarctica and any island sites not allocated to other working groups.
- h) *Free Troposphere and Satellite Working Group*: Global coverage focusing on the following platforms: ozonesondes, aircraft, lidar, FTIR, satellite-detected tropospheric column ozone.
- i) *Statistics and Database Working Group*: Charged with identifying the statistical tests to be applied to the database, and the code that will be used to calculate exposure and dose ozone metrics and statistical tests. The code must be developed and documented such that future updates to the metrics database can be easily conducted by new users. This group will also design the database and will make the ozone metrics openly available to the public.



**Figure 1.** Work flow diagram of the assessment report. TOAR is designed to collaborate with IGAC’s Chemistry Climate Model Initiative (CCMI) and the U.N. Economic Commission for Europe Task Force on Hemispheric Transport of Air Pollution (TF HTAP).

## **TOAR Steering Committee Members:**

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