

Tropospheric Ozone Assessment Report – Phase II and the TOAR-II Satellite O3 Working Group (SOWG)

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on behalf of the TOAR-II SC



CEOS AC-VC-16

Virtual Meeting, June, 2020



TOAR-II in a nutshell

TOAR-II continues the successful work of TOAR-I and lasts until 2024

TOAR-II will provide updated and extended metrics on tropospheric ozone.

TOAR-II will provide an updated state of the science estimate of ozone's global distribution and trends relevant to climate, human health and vegetation

TOAR-II will further enhance the TOAR data portal and web services

TOAR-II will extend the statistical toolbox and trend analyses

TOAR-II will maximize exploitation of the TOAR Surface Ozone Database

TOAR-II reaches out to the international scientific community

TOAR-II Steering Committee



Owen Cooper (co-Chair), CIRES, University of Colorado Boulder/NOAA CSL, USA



Martin Schultz (co-Chair), Forschungszentrum Jülich, Germany



Lisa Emberson, University of York, UK



Yugo Kanaya, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan



Raeesa Moola, University of the Witwatersrand, South Africa



Yinon Rudich, Weizmann Institute of Science, Israel



Erika von Schneidemesser, Institute for Advanced Sustainability Studies, Potsdam, Germany



Rodrigo Seguel, Center for Climate and Resilience Research (CR)2, Universidad de Chile, Sanitago, Chile



Bärbel Sinha, Indian Institute of Science Education and Research (IISER), Mohali, India



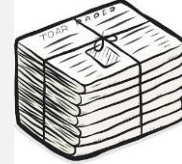
Helen Worden, National Center for Atmospheric Research, Boulder, USA



Lin Zhang, Peking University, Beijing, China

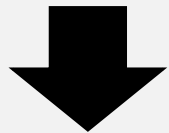
TOAR-I accomplishments

Nine highly-cited journal publications
in Elementa



A database with easily accessible ozone
metrics at 1000s of stations worldwide

A highly motivated community of > 240
scientists from over 35 countries



Uptake of TOAR results in impact
communities (e.g. GBD)

TOAR-I publications in Elementa



Young, P.J. et al. 2018 Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability, and trends. *Elem Sci Anth* 6: 10. DOI: <https://doi.org/10.1525/elementa.265>

REVIEW

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

P. J. Young¹,
D. D. Parr²,
J. Ziemke³,
L. Hu⁴,
A. Saiz-L

Model Assessment

The goal is with an up-to-date assessment of tropospheric ozone models to provide a comprehensive overview of the current state of the science and to identify key research community the tropopause, stratospheric chemistry



Schätz, M.G. et al. 2017 Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations. *Elem Sci Anth* 5: 58. DOI: <https://doi.org/10.1525/elementa.244>

RESEARCH ARTICLE

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

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Surface O3 database and metrics

Ian Galbally⁴,
ckhardt¹²,
Hong¹³,
io Ueno¹⁵,
ett⁴,
ig³²,
s Gheus⁴¹,
H⁶,
bistin⁴²,
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ish^{2,3},
ab⁴³,

Yvonne Scorgie⁴⁴, Irina Senik⁴⁵, Peter Simmonds⁴⁶, Vinayak Sinha⁴⁷,
Andrey I. Skorokhod⁴⁸, Gerard Spain⁴⁹, Wolfgang Spang⁴⁸, Ronald Spoor²⁰,



Lefohn, A.S. et al. 2018 Tropospheric ozone assessment report: Global ozone metrics for climate change, human health, and cropland ecosystem research. *Elem Sci Anth* 6: 28. DOI: <https://doi.org/10.1525/elementa.279>

RESEARCH ARTICLE

Tropospheric ozone assessment report: Global ozone metrics for climate change, human health, and cropland ecosystem research

Global O3 metrics

Zhaozhong Feng^{***}, Haoye Tang^{****}, Kazuhiko Kobayashi^{****}, Pierre Sicard^{****},
Sverre Solberg^{****} and Giacomo Gerosa^{****}



Gaudel, A. et al. 2018. Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation. *Elem Sci Anth* 6: 39. DOI: <https://doi.org/10.1525/elementa.391>

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model

O3 trends for climate and model eval.



Tarasick, D. et al. 2019. Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties. *Elem Sci Anth* 7: 39. DOI: <https://doi.org/10.1525/elementa.376>

REVIEW

Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties

O3 Obs./Uncer.

M. Thompson¹⁶, Samuel J. Oltmans^{****}, Juan Cuestas^{****}, Gaelle Dufour^{****},
Thouret^{****}, Birgit Hassler^{****}, Thomas Trick^{****} and Jessica L. Neu^{****}

From the earliest observations of ozone in the lower atmosphere in the 19th century, both measurement



Fleming, Z.L. et al. 2018 Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health. *Elem Sci Anth* 6: 12. DOI: <https://doi.org/10.1525/elementa.273>

RESEARCH ARTICLE

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

O3 trends for human health



Mills, G. et al. 2018. Tropospheric Ozone Assessment Report: Present-day tropospheric ozone distribution and trends relevant to vegetation. *Elem Sci Anth* 6: 47. DOI: <https://doi.org/10.1525/elementa.302>

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Present-day

O3 trends for vegetation

Feng^{***}, Giacomo Gerosa^{****}, Haoye Tang^{****}, Kazuhiko Kobayashi^{****}, Pierre Sicard^{****},
Elena Paoletti^{****}, Vinayak Sinha⁴ and Xiaobin Xu^{****}



Chang, K.-L. et al. 2017 Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia. *Elem Sci Anth* 5: 50. DOI: <https://doi.org/10.1525/elementa.243>

RESEARCH ARTICLE

Regional trend analysis of surface ozone observations

Surface O3 trends

Surface ozone is a greenhouse gas and pollutant detrimental to human health and crop and ecosystem productivity. The Tropospheric Ozone Assessment Report (TOAR) is designed to provide the research community with an up-to-date observation-based overview of tropospheric ozone's global distribution and trends. The TOAR Surface Ozone Database contains ozone metrics at thousands of monitoring sites



Xu, X. et al. 2020. Long-term changes of regional ozone in China: implications for human health and ecosystem impacts. *Elem Sci Anth* 8: 13. DOI: <https://doi.org/10.1525/elementa.409>

China O3 trends

Xiaobin Xu¹, Weili Lin^{2*}, Wanyun Xu¹, Junli Jin¹, Ying Wang¹, Gen Zhang¹,
Xiaochun Zhang¹, Zhiqiang Ma², Yuanzhen Dong¹, Qianli Ma², Dajiang Yu², Zou Li²,
Dingding Wang^{2*} and Huarong Zhao³

TOAR

tropospheric
ozone
assessment
report

Phase II

O3 History & Budget
submitted Mar. 2020

Design of a new TOAR data portal



<https://toar-data.org>

HOME PAGE

EXAMPLE PAGE

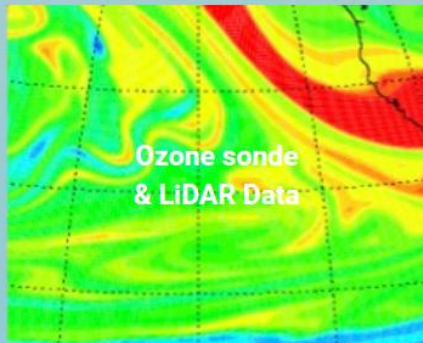
CUSTOM PAGE



Satellite Data



Surface Data



Ozone sonde
& LiDAR Data



Aircraft Data

Latest News:

FAIRNESS in Air Quality and Weather Forecast

27. MARCH 2020 / 0 COMMENTS

News from Jülich

23. MARCH 2020 / 0 COMMENTS

New data from Colombia

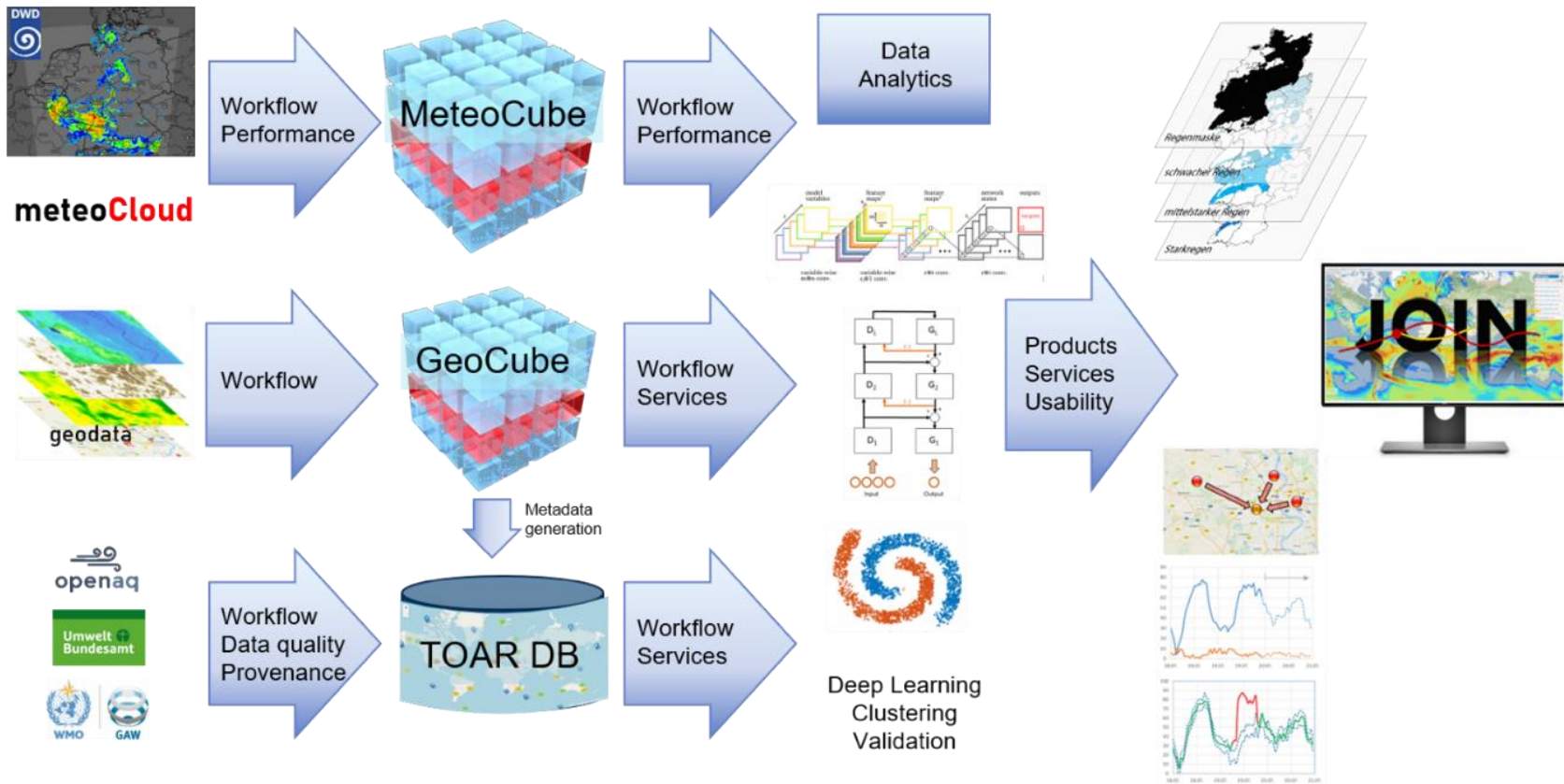
23. MARCH 2020 / 0 COMMENTS

Hallo Welt!

17. MARCH 2020 / 0 COMMENTS



The new TOAR-II data infrastructure



Funded through

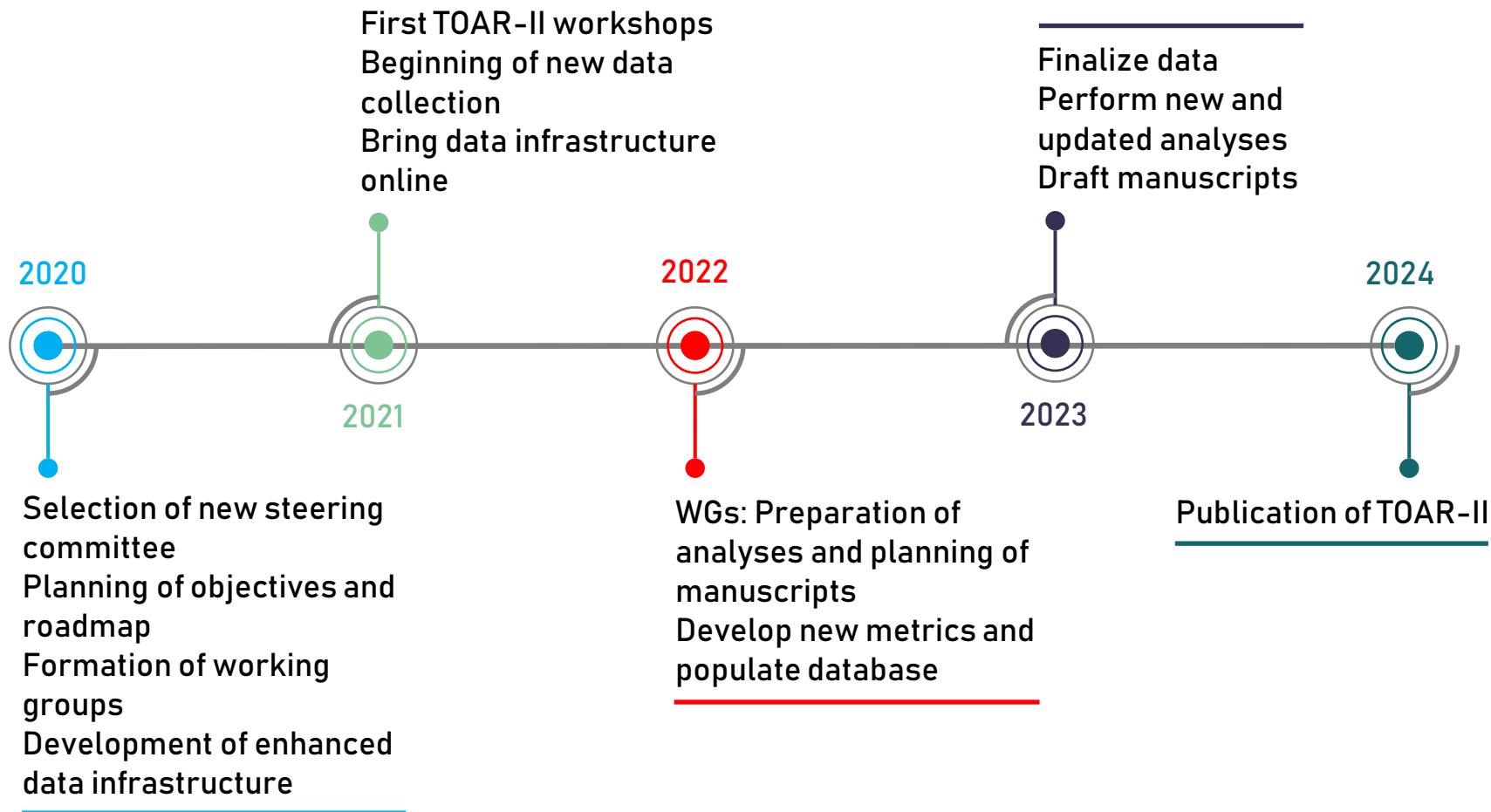


European Research Council
Established by the European Commission

Advanced Grant
ERC-2017-ADG
#787576



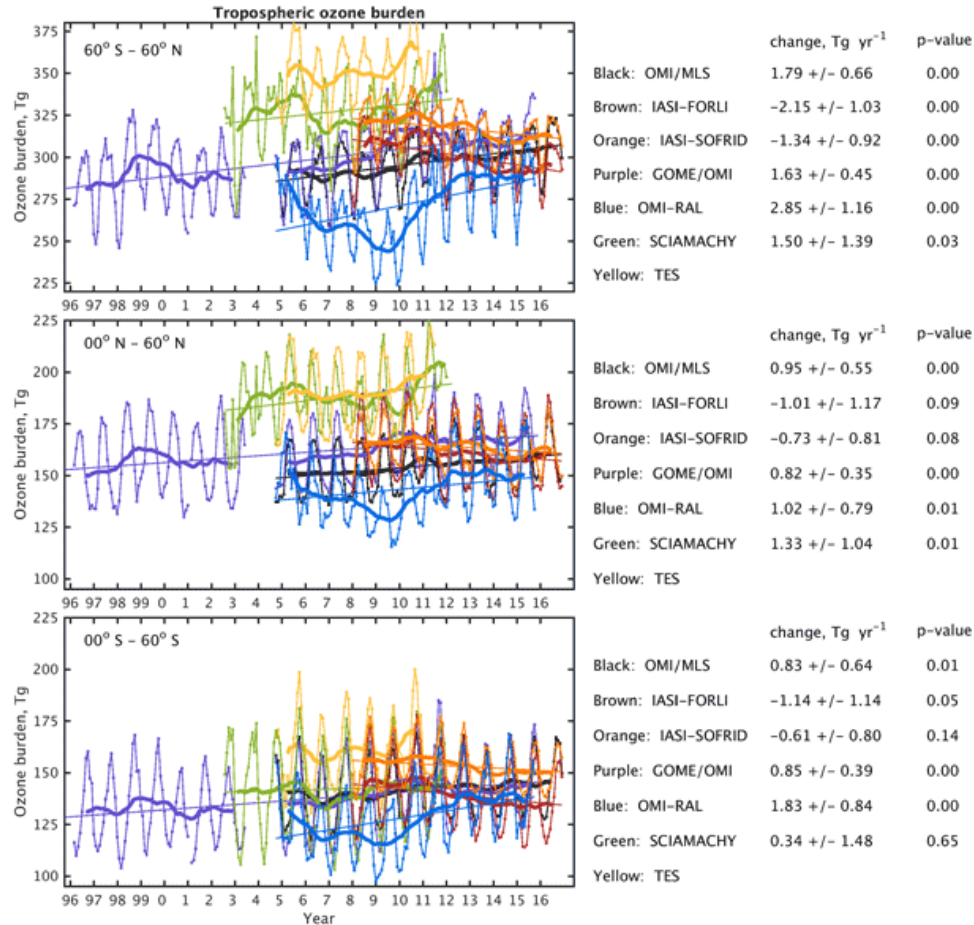
TOAR-II Status and roadmap



Primary goal of the SOWG

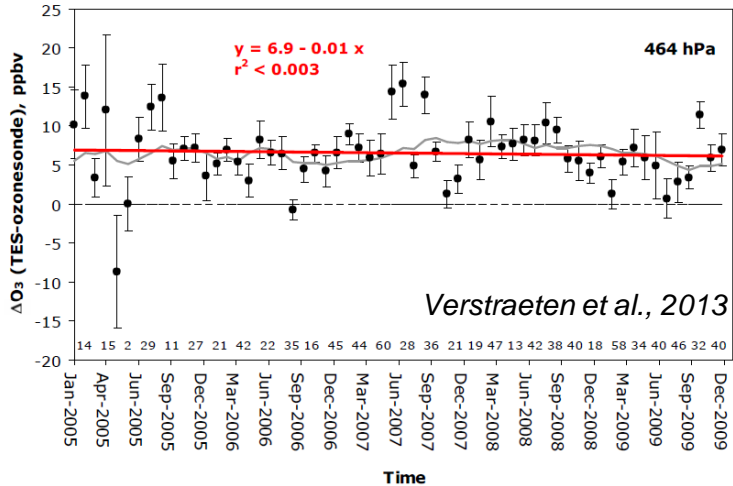
Understand wide variety of trends and variations in tropospheric O_3 (TrO_3) reported by TOAR-I

Gaudel et al, 2018
<http://doi.org/10.1525/elementa.291>

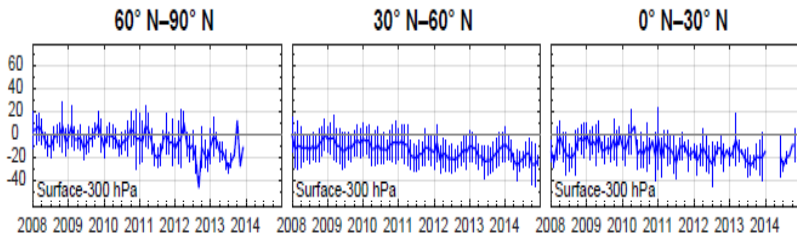


Approach 1: Time series of ozonesonde biases

TES vs Ozonesondes, 464 hPa, Northern Midlatitudes



IASI-FORLI vs Ozonesondes, Sfc-300 hPa, NH



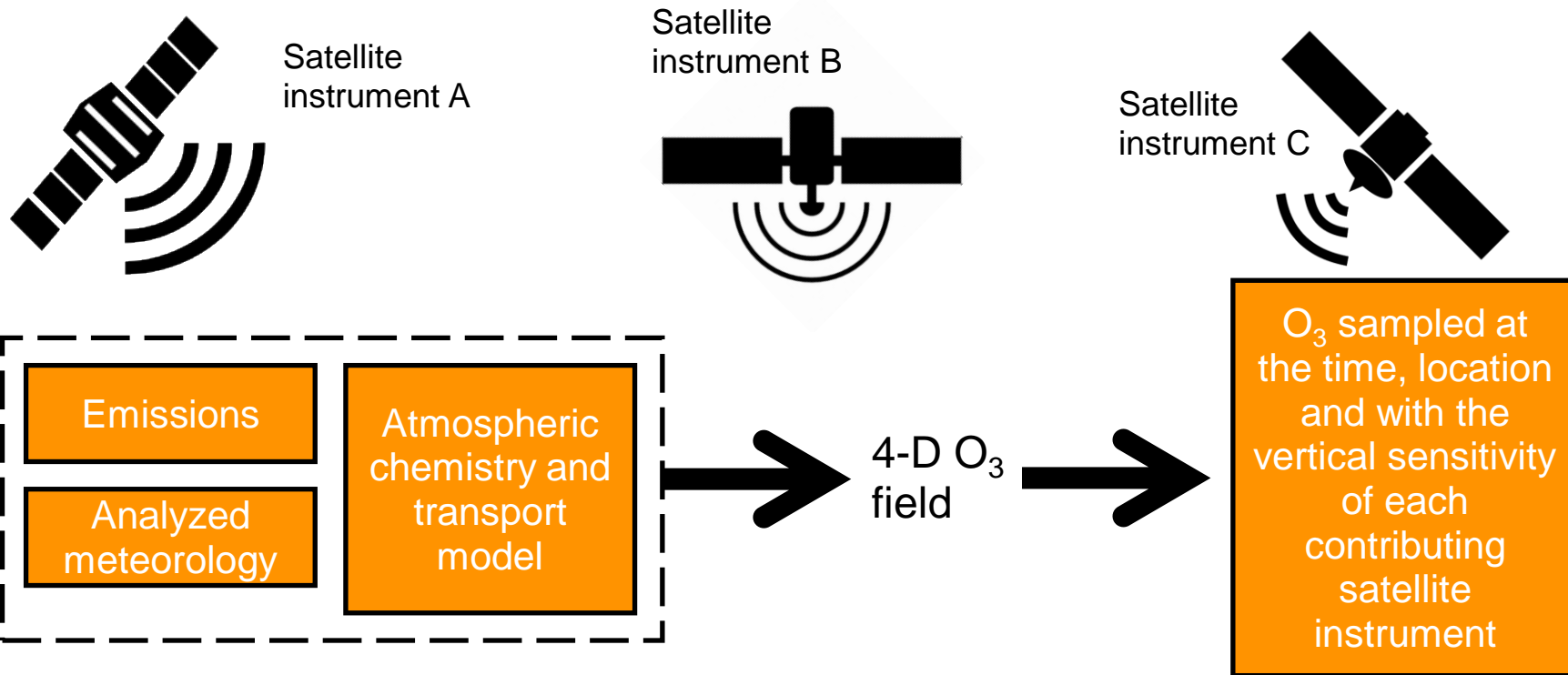
Boynard et al., 2016

We will assess the stability of the satellite ozone measurements as a function of time.

To do so, we will calculate the monthly mean bias of partial column ozone from each instrument relative to ozonesondes (using the weighting function for each profile) for 5-6 latitude bands for the entire length of each satellite record.

We will specify a format for the satellite ozone records. If the instrument groups are able to provide data to the SOWG in this format, we will assess the bias against sondes. If not, we will provide the methodology to the instrument group and ask them to do the sonde comparison.

Approach 2: Sampling patterns and vertical sensitivity



The model acts as an intermediary to help reconcile trends reported by satellites A, B, C... and help us relate and link satellite-observed trends with other TrO₃ data.

Statistical methods

We will use a range of methods to determine corresponding model and observed:

- Non-linear trends
- Atmospheric growth rates
- Step-wise changes, e.g. Covid-19

All taking into consideration data uncertainties so we can investigate robustness of our findings.

Study period: 2004-Spring 2021

An **initial** list (guided by TOAR-I) of relevant data.

| Satellite - Instrument | Time period | Groups |
|-------------------------|----------------|---|
| Metop A,B,C - IASI | 2008 - present | LATMOS (FORLI retrieval) LISA (KOPRAFIT retrieval) U.Toulouse/CNRS (SOFRID) |
| Metop A,B,C - GOME-2 | 2008 - present | U. Bremen |
| Metop - IASI/GOME-2 | 2008 - present | LISA (KOPRAFIT) STFC |
| Aura - OMI trop. column | 2004 - present | NASA/GSFC KNMI |
| Aura - OMI/MLS | 2004 - present | NASA/GSFC |
| Aura - OMI profile | 2004 - present | SAO |
| Aqua - AIRS/ Aura - OMI | 2004 - present | NASA/JPL |
| Aura - TES | 2004 - 2010 | NASA/JPL |
| Envisat - SCIAMACHY | 2002 - 2012 | U. Bremen |

- We will also include TROPOMI (as a follow-on to OMI) and GEMS (to provide TrO₃ diurnal cycle).
- We have decided to analyse data to Spring 2021 so we can include the pandemic period and the anticipated return of emissions.

Secondary goal of the SOWG

The broader community is central to the success of the SOWG.

We will coordinate TOAR-related studies of satellite retrievals of TrO_3 .

Data and model output will be made available in a uniform data format for further scientific exploitation.

Indicative timelines

Summer 2020: Solicit participation in working group and set up virtual meetings

Fall 2020: Generate the methodology for direct satellite-sonde comparisons to be distributed to the various groups

Winter 2020: Establish the evaluation period to be used as well as a common definition for the vertical extent of the measurements (e.g. tropospheric ozone column, partial column, individual pressure levels, etc).

Spring 2021: Request data from the satellite groups (updates from TOAR-I contributors).

Summer 2021: Begin analysis using the model output to reconcile difference among the satellite trends up to Spring 2021, taking into account big changes in 2020 due to Covid-19 and expected emission changes in 2021.

Spring 2022: Complete analysis using the model and assess the consistency of the satellite trends with one another and with in situ data

Fall 2022-Winter 2023: Write up results of our analysis for publication

Spring 2024: submit for publication in TOAR II.