Harmonization of tropospheric ozone data for TOAR II

Roeland Van Malderen

Royal Meteorological Institute of Belgium, Brussels, Belgium

with inputs from Owen Cooper, Daan Hubert, Arno Keppens, Kazuyuki Miyazaki

Outline and key messages

Outline

- Tropospheric ozone
- From TOAR-I to TOAR-II
- Harmonization activities:

Key Points:

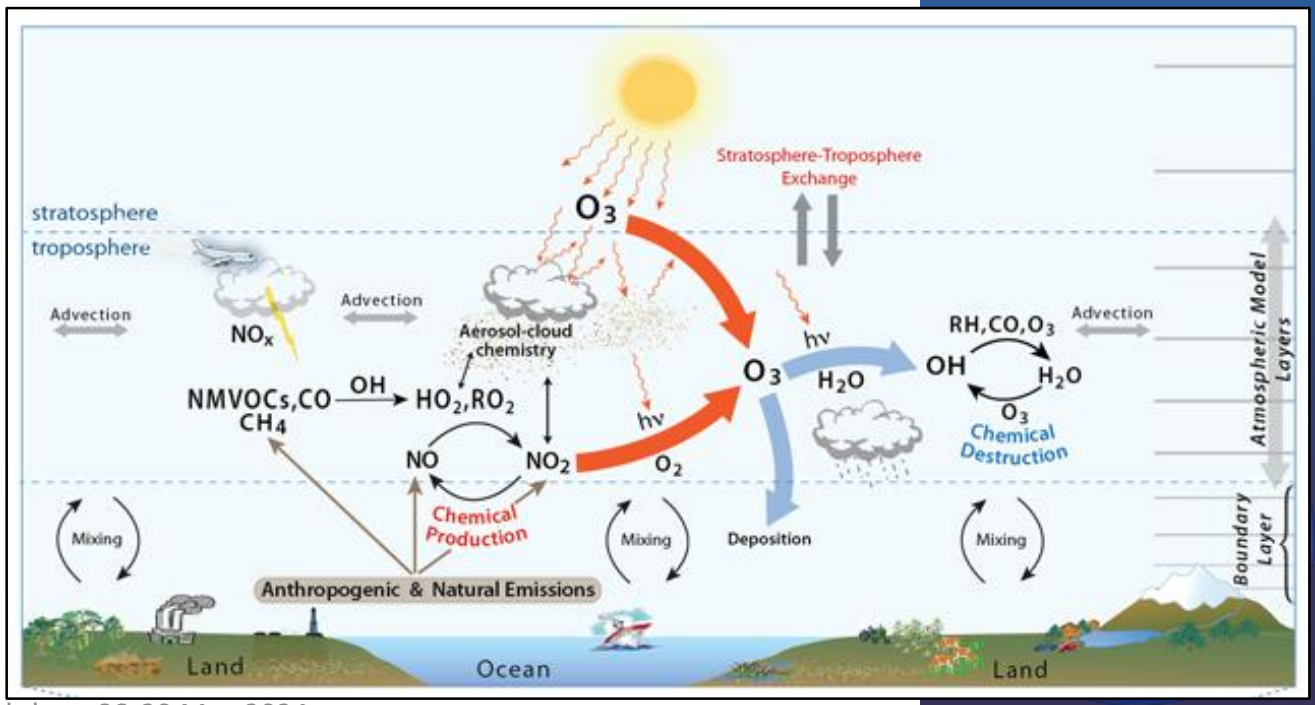
1) surface ozone data harmonization ➔ TOAR-I
2) Tropospheric ozone satellite retrieval ➔ TOAR-II Satellite Ozone Focus Working Group
3) Harmonization of ozone profiles from ground-based or in-situ measurements ➔ TOAR-II HEGIFTOM Focus Working Group

- Outlook

Tropospheric ozone

- 10 % of atmospheric ozone
- strong oxidant detrimental to human health (smog!), crops and ecosystems
- important for tropospheric chemistry as the primary source of the OH radical, the so-called "detergent" of the atmosphere
- greenhouse gas: contributes to global warming (climate)

- **formation/destruction of tropospheric ozone by**
  - ✓ stratosphere-troposphere exchange
  - ✓ photochemical formation: sun + precursors (NO_x, CO and VOC)
  - ✓ photochemical destruction in low NO_x conditions (OH-HO_2 cycle)
  - ✓ dry deposition on the ground



From Young et al., *Elementa*, 2018

Tropospheric Ozone Assessment Report

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.

Deliverables:

1) The first tropospheric ozone assessment report based on all available surface observations, the peer-reviewed literature and new analyses.

Stakeholders:

WMO GAW World Health Organization NOAA LRTAP Task Force on Hemispheric Transport of Air Pollution

TOAR-I publications

https://
collections.elementascience.org/toar

ELEMENTA Science of the Anthropocene

Young, PJ, 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. Young[*,†,‡], V. Naik[§], A. M. Fiore[‖,¶], A. Gaudel[**,††], J. Guo[‖], M. Y. Lin[§,‡‡], J. L. Neu[§§], D. D. Parrish[**,††], H. E. Rieder[¶,‖‖], J. L. Schnell[¶¶], S. Tilmes[***], O. Wild[*], L. Zhang[†††], J. Ziemke[‡‡‡,§§§], J. Brandt[‖‖‖], A. Delcloo[¶¶¶], R. M. Doherty[****], C. Geels[‖‖‖], M. I. Hegglin[††††], L. Hu[‡‡‡‡], U. Im[‖‖‖‖], R. Kumar[§§§§], A. Luhar[‖‖‖‖], L. Murray[¶¶¶¶], D. Plummer[*****], J. Rodriguez[‡‡‡], A. Saiz-Lopez[†††††], M. G. Schultz[‡‡‡‡‡], M. T. Woodhouse[‖‖‖‖] and G. Zeng[§§§§§]

ELEMENTA Science of the Anthropocene

Schultz, MG, 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

Martin G. Schultz[1,82], Sabine Schröder[1], Olga Lyapina[1], Owen R. Cooper[2,3], Ian Galbally[4], Irina Petropavlovskikh[2,3], Erika von Schneidemesser[5], Hiroshi Tanimoto[6], Yasin Elshorbany[7,8], Manish Naja[9], Rodrigo J. Seguel[10], Ute Dauert[11], Paul Eckhardt[12], Stefan Feigenspan[11], Markus Fiebig[12], Anne-Gunn Hjellbrekke[12], You-Deog Hong[13], Peter Christian Kjeld[14], Hiroshi Koide[15], Gary Lear[16], David Tarasick[17], Mikio Ueno[15], Markus Wallasch[18], Darrel Baumgardner[19], Ming-Tung Chuang[20], Robert Gillett[4], Meehye Lee[21], Suzie Molloy[4], Raeesa Moolla[22], Tao Wang[23], Katrina Sharps[24], Jose A. Adame[25], Gerard Ancellet[26], Francesco Apadula[27], Paulo Artaxo[28], Maria E. Barlasina[29], Magdalena Bogucka[30], Paolo Bonasoni[31], Limseok Chang[32], Aurelio Colomb[33], Emilio Cuevas-Agulló[34], Manuel Cupeiro[35], Anna Degorska[36]

ELEMENTA Science of the Anthropocene

Archibald, A. T., et al. 2020. Tropospheric Ozone Assessment Report: A critical review of changes in the tropospheric ozone burden and budget from 1850 to 2100. *Elem Sci Anth*, 8: 1. DOI: https://doi.org/10.1525/elementa.2020.034

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: A critical review of changes in the tropospheric ozone burden and budget from 1850 to 2100

A. T. Archibald[1,2,*], J. L. Neu[3], Y. F. Elshorbany[4], O. R. Cooper[5,6], P. J. Young[7,8,9], H. Akiyoshi[10], R. A. Cox[1], M. Coyle[11,12], R. G. Derwent[13], M. Deushi[14], A. Finco[15], G. J. Frost[6], I. E. Galbally[16,17], G. Gerosa[15], C. Granier[5,6,18], P. T. Griffiths[1,2], R. Hossaini[7,8], L. Hu[19], P. Jöckel[20], B. Josse[21], M. Y. Lin[22], M. Mertens[20], O. Morgenstern[23], M. Naja[24], V. Naik[25], S. Oltmans[26], D. A. Plummer[27], L. E. Revell[28], A. Saiz-Lopez[29], P. Saxena[30], Y. M. Shin[1], I. Shahid[31], D. Shallcross[32], S. Tilmes[33], T. Trickl[34], T. J. Wallington[35], T. Wang[36], H. M. Worden[33], and G. Zeng[23]

ELEMENTA Science of the Anthropocene

Lefohn, AS, et al. 2018 Tropospheric ozone assessment report: Global metrics for climate change, human health, and crop/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 crop/ecosystem research

Allen S. Lefohn[*], Christopher S. Malley[†,‡,§], Luther Smith[‖], Benjamin Wells[¶], Milan Hazucha[**], Heather Simon[¶], Vaishali Naik[††], Gina Mills[‡‡], Martin G. Schultz[§§], Elena Paoletti[‖‖], Alessandra De Marco[¶¶], Xiaobin Xu[***], Li Zhang[†††], Tao Wang[†††], Howard S. Neufeld[‡‡‡], Robert C. Musselman[§§§], David Tarasick[‖‖‖], Michael Brauer[¶¶¶], Zhaozhong Feng[****], Haoye Tang[††††], Kazuhiko Kobayashi[‡‡‡‡], Pierre Sicard[§§§§], Sverre Solberg[‖‖‖‖] and Giacomo Gerosa[¶¶¶¶]

ELEMENTA Science of the Anthropocene

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.291

RESEARCH ARTICLE

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

A. Gaudel[1,2], O. R. Cooper[1,2], G. Ancellet[3], B. Barret[4], A. Boynard[3,5], J. P. Burrows[6], C. Clerbaux[3], P.-F. Coheur[7], J. Cuesta[8], E. Cuevas[9], S. Doniki[7], G. Dufour[8], F. Ebojie[10], G. Foret[8], O. Garcia[11], M. J. Granados-Muñoz[12,13], J. W. Hannigan[14], F. Hase[15], B. Hassler[1,2,16], G. Huang[17], D. Hurtmans[7], D. Jaffe[18,19], N. Jones[20], P. Kalabokas[21], B. Kerridge[22], S. Kulawik[23,24], B. Latter[22], T. Leblanc[12], E. Le Flochmoën[4], W. Lin[25], J. Liu[26,27], X. Liu[17], E. Mahieu[27], A. McClure-Begley[1,2], J. L. Neu[23], M. Osman[29], M. Palm[6], H. Petetin[4], I. Petropavlovskikh[1,2], R. Querel[28], N. Rahpoe[23], A. Rozanov[23], M. G. Schultz[31,32], J. Schwab[33], R. Siddans[22], D. Smale[20], M. Steinbacher[34], H. Tanimoto[35], D. W. Tarasick[36], V. Thouret[4], A. M. Thompson[37], T. Trickl[38], E. Weatherhead[1,2], C. Wespes[39], H. M. Worden[40], C. Vigouroux[40], X. Xu[41], G. Zeng[30], J. Ziemke[42]

ELEMENTA Science of the Anthropocene

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

David Tarasick[*], Ian E. Galbally[†,‡], Owen R. Cooper[§,‖], Martin G. Schultz[¶], Gerard Ancellet[**], Thierry Leblanc[††], Timothy J. Wallington[‡‡], Jerry Ziemke[§§], Xiong Li, Martin Steinbacher[¶¶], Johannes Staehelin[***], Corinne Vigouroux[†††], James W. Hannigan, Omaira García[§§§], Gilles Foret[‖‖‖], Prodromos Zanis[¶¶¶], Elizabeth Weatherhead[§,‖], Irina Petropavlovskikh[§,‖], Helen Worden[‡‡‡], Mohammed Osman[****,††††,‡‡‡‡], Jane Liu[§§§§,‖‖‖‖], Kai-Lan Chang[§,‖], Audrey Gaudel[§,‖], Meiyun Lin[¶¶¶¶,*****], Maria Granados-Muñoz[†††††], Anne M. Thompson[§§], Samuel J. Oltmans[‡‡‡‡‡], Juan Cuesta[‖‖‖‖], Gaelle Dufour[‖‖‖‖], Valerie Thouret[§§§§§], Birgit Hassler[‖‖‖‖‖], Thomas Trickl[¶¶¶¶¶] and Jessica L. Neu[******]

ELEMENTA Science of the Anthropocene

Fleming, ZL, 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

Zoë L. Fleming[*], Ruth M. Doherty[†], Erika von Schneidemesser[‡], Christopher S. Malley[§,****,††††], Owen R. Cooper[‖,‖‖‖], Joseph P. Pinto[¶], Augustin Colette[**], Xiaobin Xu[††], David Simpson[‡‡,¶¶¶], Martin G. Schultz[§§,‖‖], Allen S. Lefohn[¶¶], Samera Hamad[***], Raeesa Moolla[†††], Sverre Solberg[‡‡‡] and Zhaozhong Feng[§§§]

ELEMENTA Science of the Anthropocene

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 tropospheric ozone distribution and trends relevant to vegetation

Gina Mills[*,†], Håkan Pleijel[†], Christopher S. Malley[†,§,‖], Baerbel Sinha[¶], Owen R. Cooper[**], Martin G. Schultz[††], Howard S. Neufeld[‡‡], David Simpson[§§,‖‖], Katrina Sharps[*], Zhaozhong Feng[¶¶], Giacomo Gerosa[***], Harry Harmens[*], Kazuhiko Kobayashi[†††], Pallavi Saxena[‡‡‡], Elena Paoletti[§§§], Vinayak Sinha[¶] and Xiaobin Xu[‖‖‖]

ELEMENTA Science of the Anthropocene

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 from monitoring networks in eastern North America, Europe and East Asia

Kai-Lan Chang[*], Irina Petropavlovskikh[*,†], Owen R. Cooper[*,†], Martin G. Schultz[‡] and Tao Wang[§]

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

ELEMENTA Science of the Anthropocene

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

RESEARCH ARTICLE

Long-term changes of regional ozone in China: implications for human health and ecosystem impacts

Xiaobin Xu[*], Weili Lin[†,‡], Wanyun Xu[*], Junli Jin[†], Ying Wang[*], Gen Zhang[*], Xiaochun Zhang[†], Zhiqiang Ma[§], Yuanzhen Dong[‖], Qianli Ma[¶], Dajiang Yu[**], Zou Li[††], Dingding Wang[‡‡] and Huarong Zhao[§§]

Tropospheric Ozone Assessment Report

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.

Deliverables:

1) The first tropospheric ozone assessment report based on all available surface observations, the peer-reviewed literature and new analyses.
2) A database containing ozone exposure metrics at thousands of measurement sites around the world, freely accessible for research on the global-scale impact of ozone on climate, human health and crop/ecosystem productivity.

Stakeholders:

WMO GAW World Health Organization NOAA LRTAP Task Force on Hemispheric Transport of Air Pollution

TOAR-I Database key results

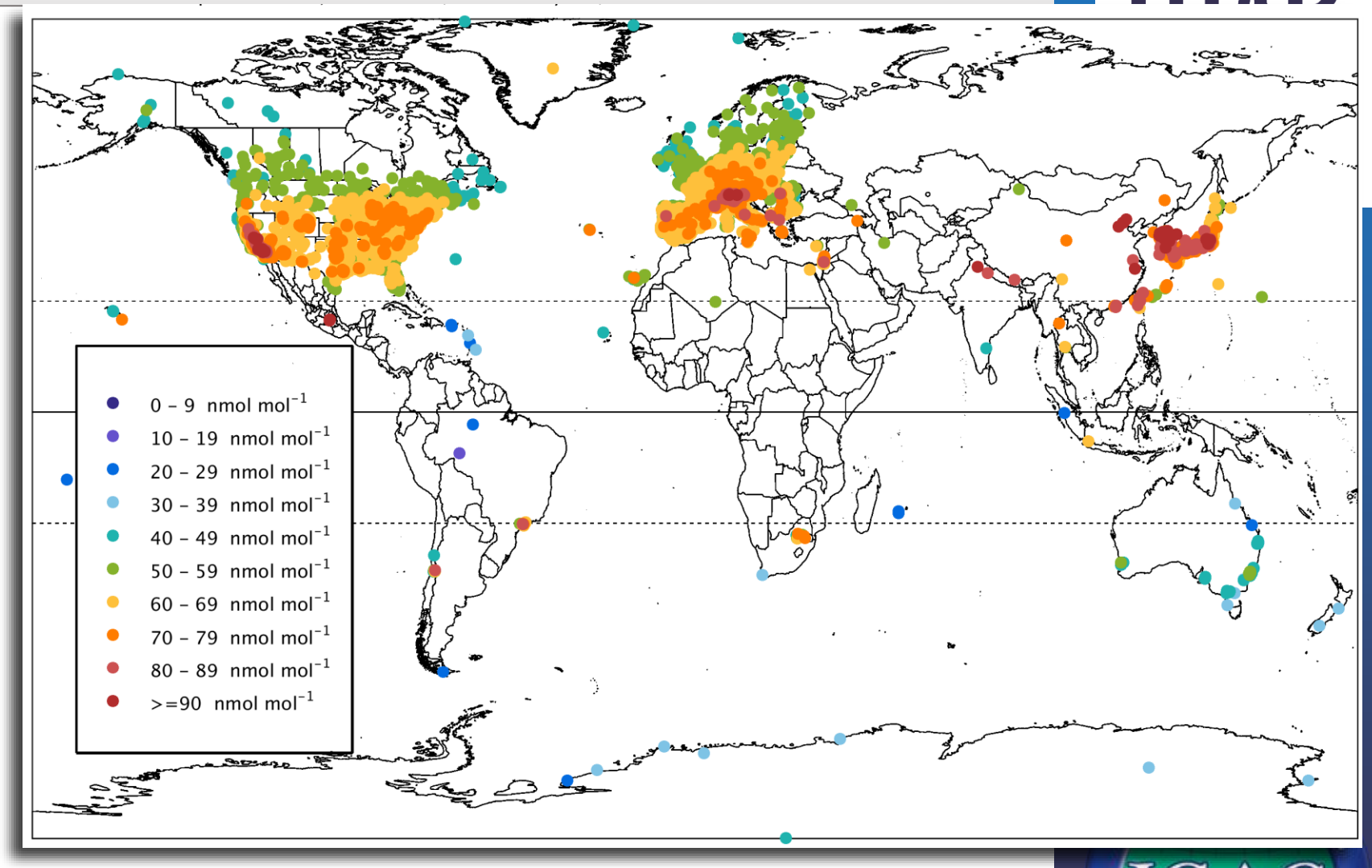
The first global-scale view of all available surface ozone observations

98th percentile

5-year average (2010-2014)

Summertime months

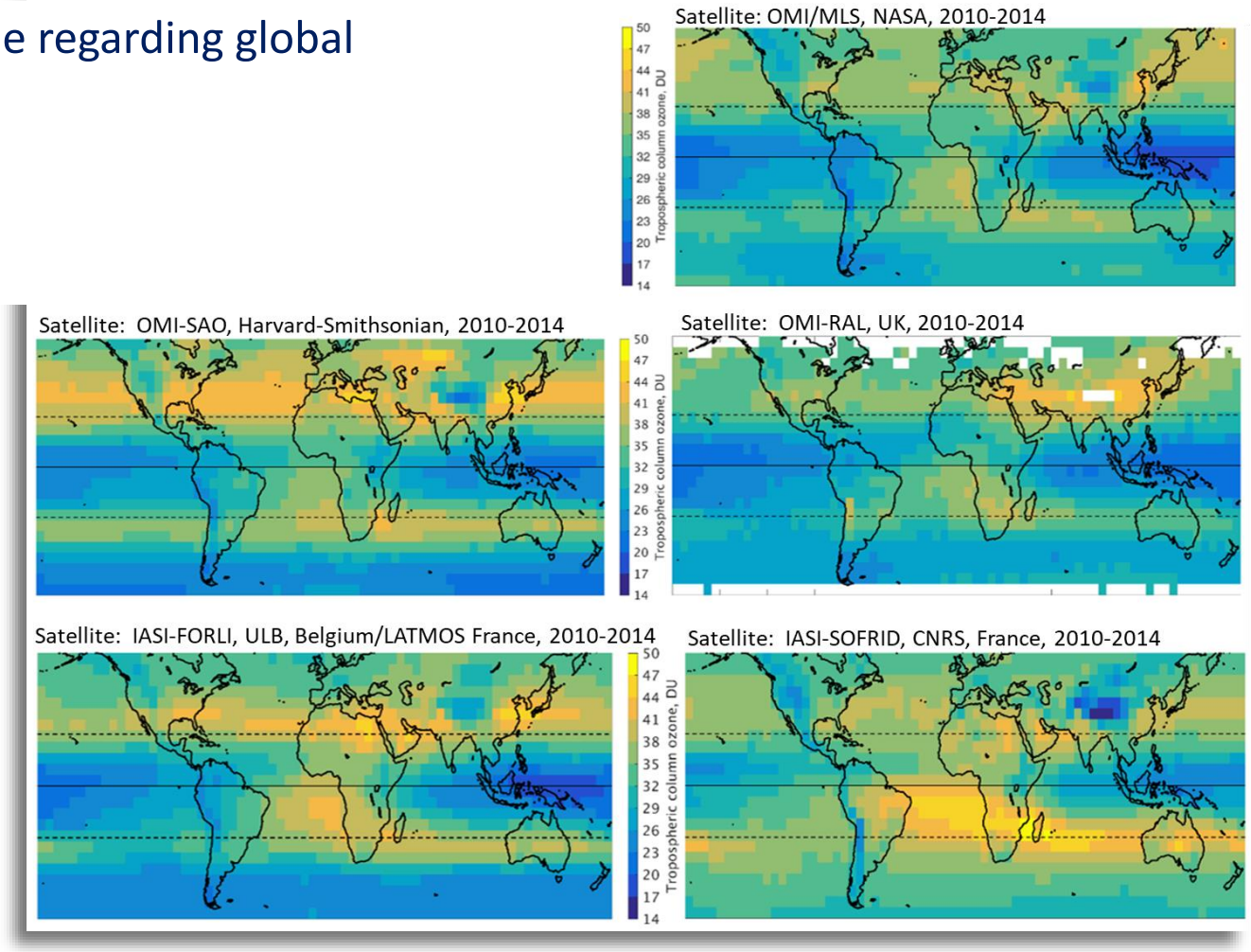
➔ surface O_3 data harmonization: world's largest database of surface ozone observations, with ozone metrics and trends calculated consistently for all time series



TOAR-I key results

The first intercomparison of satellite ozone products

Satellite products generally agree regarding global tropospheric ozone hotspots.



TOAR-I key results

The first intercomparison of satellite ozone products

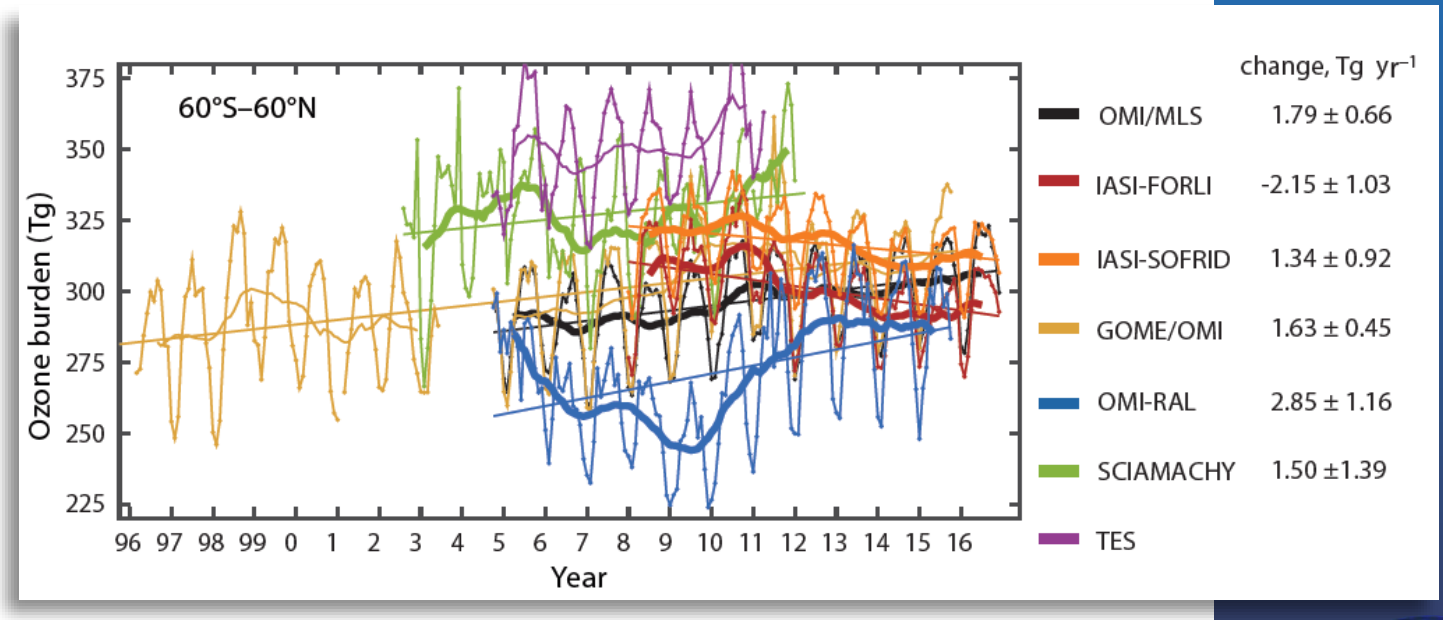
Satellite products generally agree regarding global tropospheric ozone hotspots.

Satellites and IPCC models report similar values for the tropospheric ozone burden.

However, the satellites disagree regarding trends over the past decade (2008-2016).

➔ TOAR-I identified major discrepancies among the ozone trends reported by different satellite products: TOAR-II Satellite Ozone working group.

➔ Tropospheric ozone trends from ground-based and in-situ techniques? TOAR-II GB working group



TOAR-II Primary goals, 2020-2024

Tropospheric Ozone Assessment Report, Phase II

TOAR Database: Updated with all recent ozone observations worldwide; add ozone precursors and meteorological data.

Final Product: An observation-based assessment of tropospheric ozone's distribution and trends on regional, hemispheric and global scales

(modelled after IPCC Working Group I)

Impact studies: will quantify the ***impacts*** of ozone on human health, vegetation and climate

(modelled after IPCC Working Group II)

TOAR-II Focus Working Groups

New research is being led by 16 independent **Focus Working Groups**:

Chemical Reanalysis Focus Working Group
East Asia Focus Working Group
Global and Regional Models Focus Working Group
HEGIFTOM Focus Working Group
Human Health Focus Working Group
Machine Learning for Tropospheric Ozone Focus Working Group
Ozone over the Oceans Focus Working Group
Ozone and Precursors in the Tropics (OPT) Focus Working Group
Ozone Deposition Focus Working Group
Radiative Forcing Focus Working Group
ROSTEES Focus Working Group
Satellite Ozone Focus Working Group
South Asia Focus Working Group
Statistics Focus Working Group
Tropospheric Ozone Precursors (TOP) Focus Working Group
Urban Ozone Focus Working Group

TOAR-II Community Special Issue

Focus Working Group findings submitted to the **Community Special Issue** in 2023-2024

An inter-journal special issue hosted by **Copernicus**

TOAR-II Focus Working Groups

New research is being led by 16 independent **Focus Working Groups**:

Chemical Reanalysis Focus Working Group
East Asia Focus Working Group
Global and Regional Models Focus Working Group
HEGIFTOM Focus Working Group
Human Health Focus Working Group
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Satellite Ozone Focus Working Group
South Asia Focus Working Group
Statistics Focus Working Group
Tropospheric Ozone Precursors (TOP) Focus Working Group
Urban Ozone Focus Working Group

TOAR-II Focus Working Group: HEGIFTOM

Harmonization and Evaluation of Ground-based Instruments for Free Tropospheric Ozone Measurements, *chairs: H. Smit & R. Van Malderen*

Key Objective:
Evaluation and harmonization of the different free tropospheric ozone profiling datasets of the established measuring platforms (in-service aircraft, ozonesondes, Brewer/Dobson Umkehr, FTIR, Lidar).

Major Deliverable:
Quality assessed ozone data sets, whereby each measurement gets also an ***uncertainty*** and a ***quality flag***. Thereby, ***representativeness*** and ***instrumental drifts*** will be characterized and evaluated.

~~**Including:**~~
~~Testing ozone retrievals from new remote sensing techniques (MAX-DOAS, Pandora) against the established techniques.~~

IAGOS

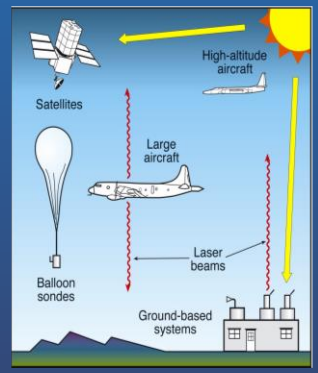

Ozonesondes


Brewer/Dobson Umkehr


FTIR


Lidar


MAX-DOAS & Pandora



http://hegiftom.meteo.be/datasets

HEGIFTOM: Homogenized datasets

Deliverable: Homogenized free tropospheric ozone profile data, described at HEGIFTOM website, with same template for each dataset:

Availability

location (ftp, data archive, website, doi, e-mail address contact person, etc.).

Data field description

Measured data fields (and their units), incl. auxiliary data fields, available metadata. Data format

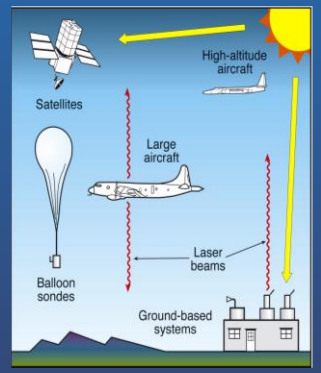
Description of homogenization procedure

short description of the steps taken to make the dataset (more) homogeneous within the network.

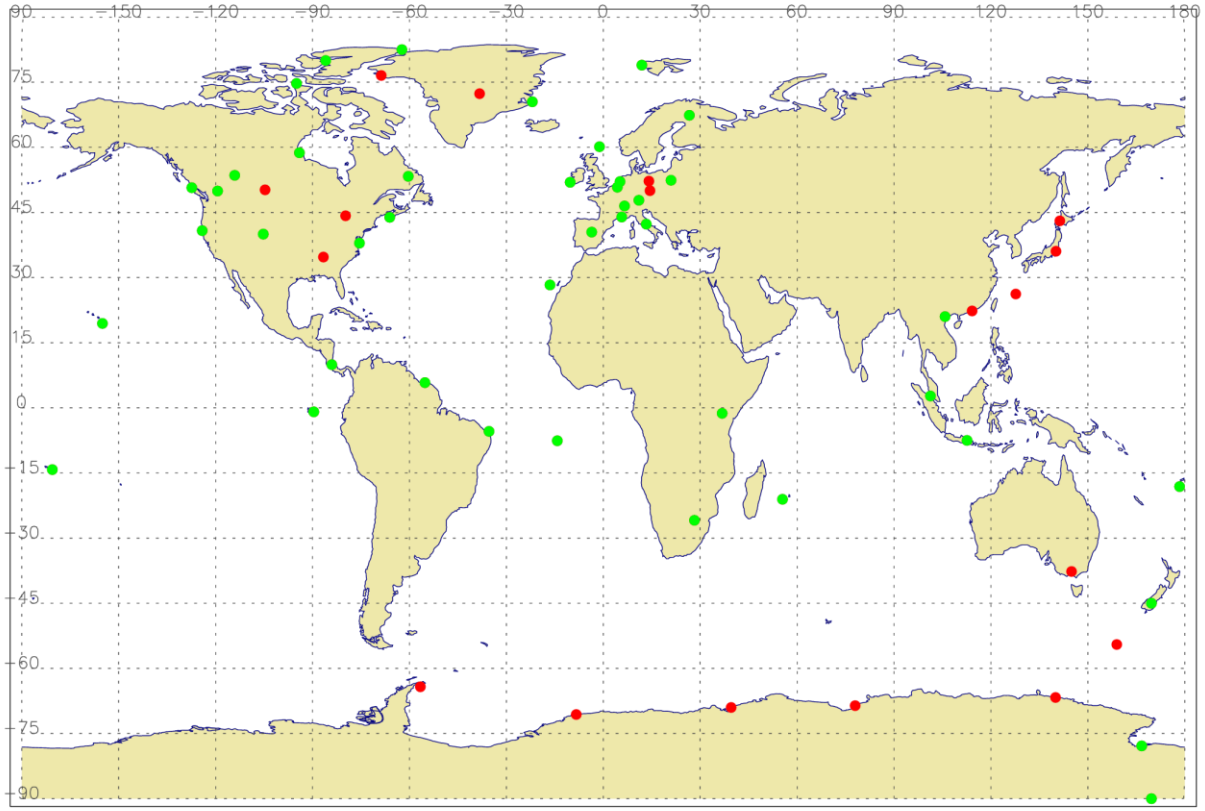
Data management

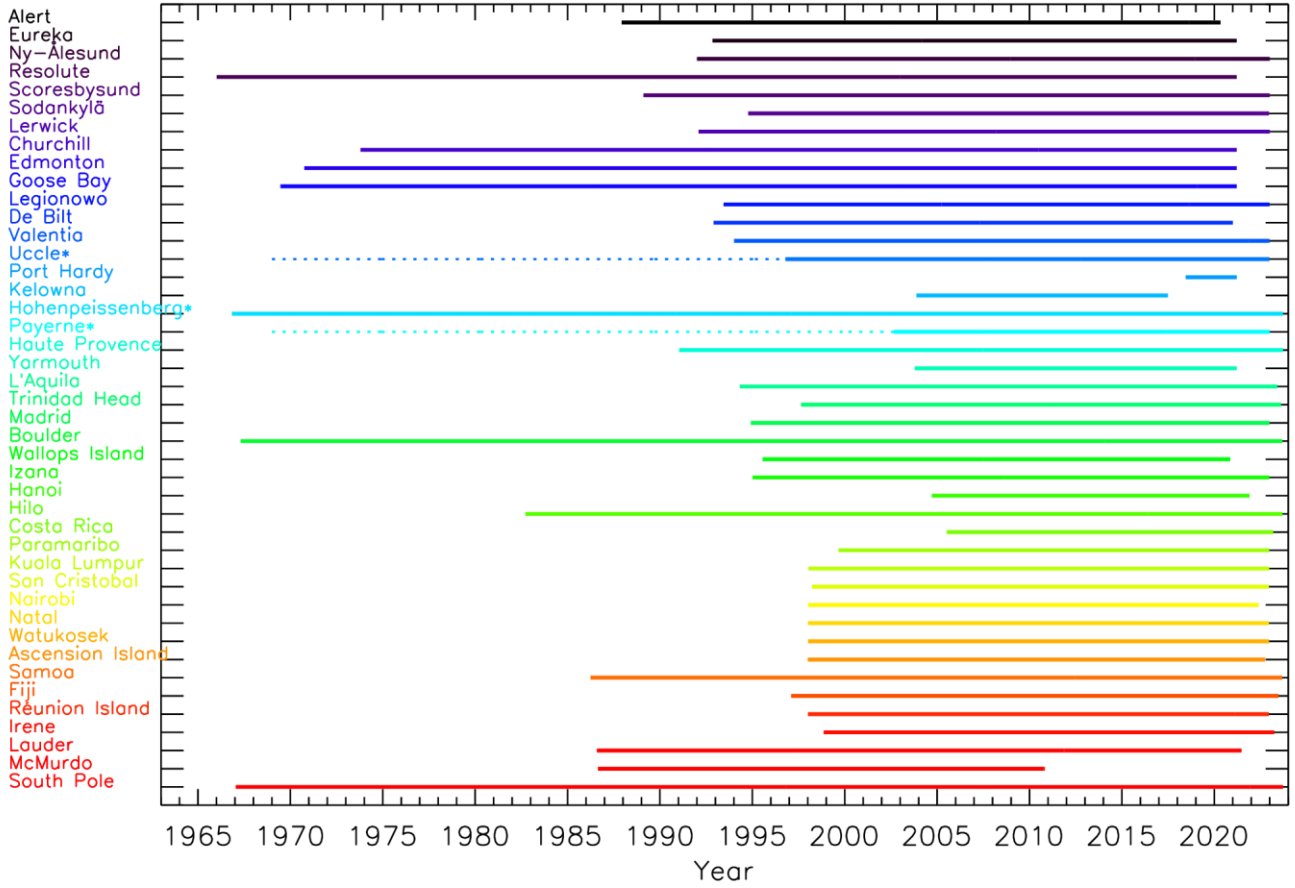
- *Flagging*
- *Uncertainties*
- *Traceability*
- *Internal consistency*
- *External consistency*
- *Data quality indicators*
- *List of homogenized sites (name, geographical location, period of observations)*

https://hegiftom.meteo.be/datasets



HEGIFTOM: Homogenized datasets - Ozonesondes



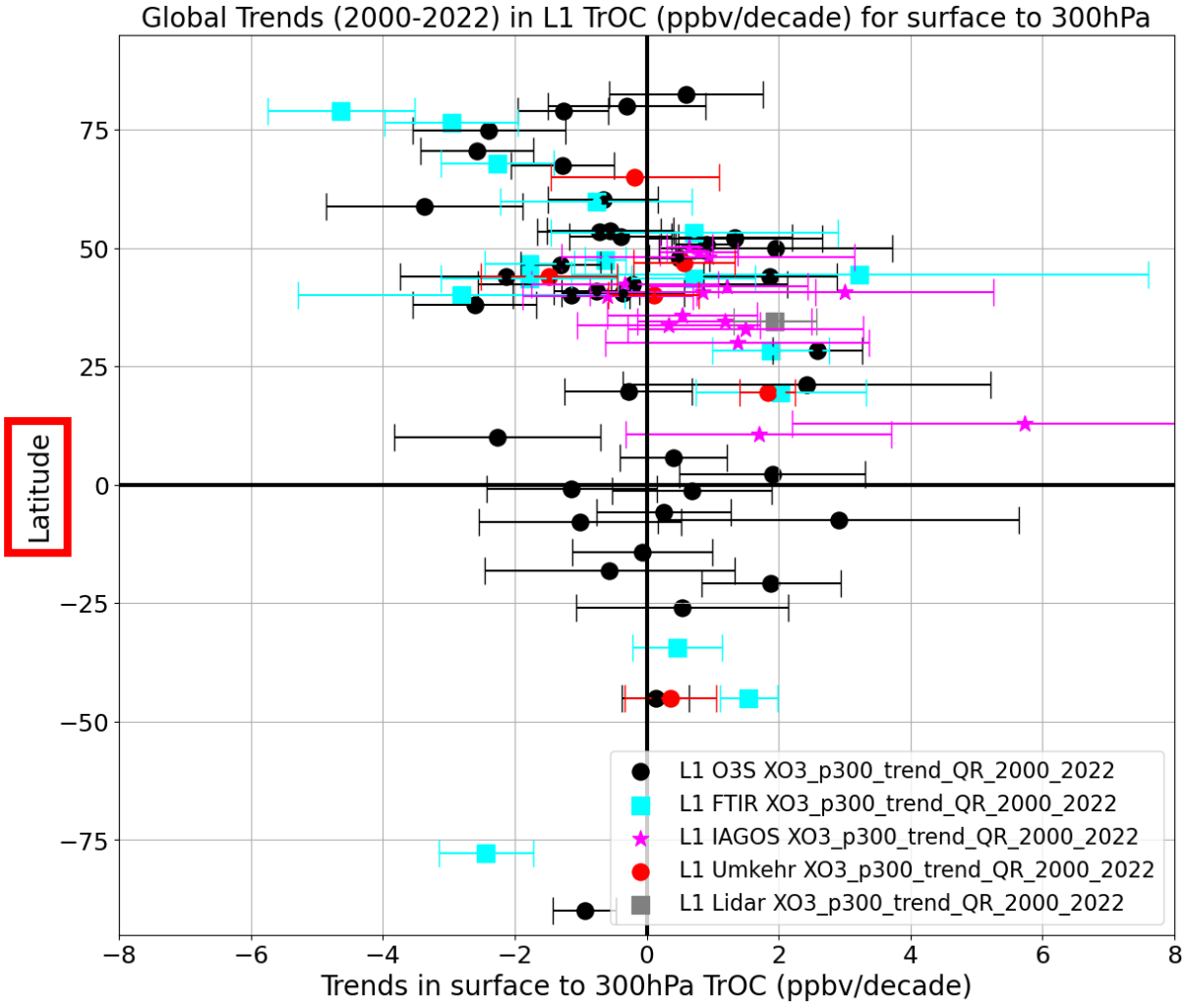


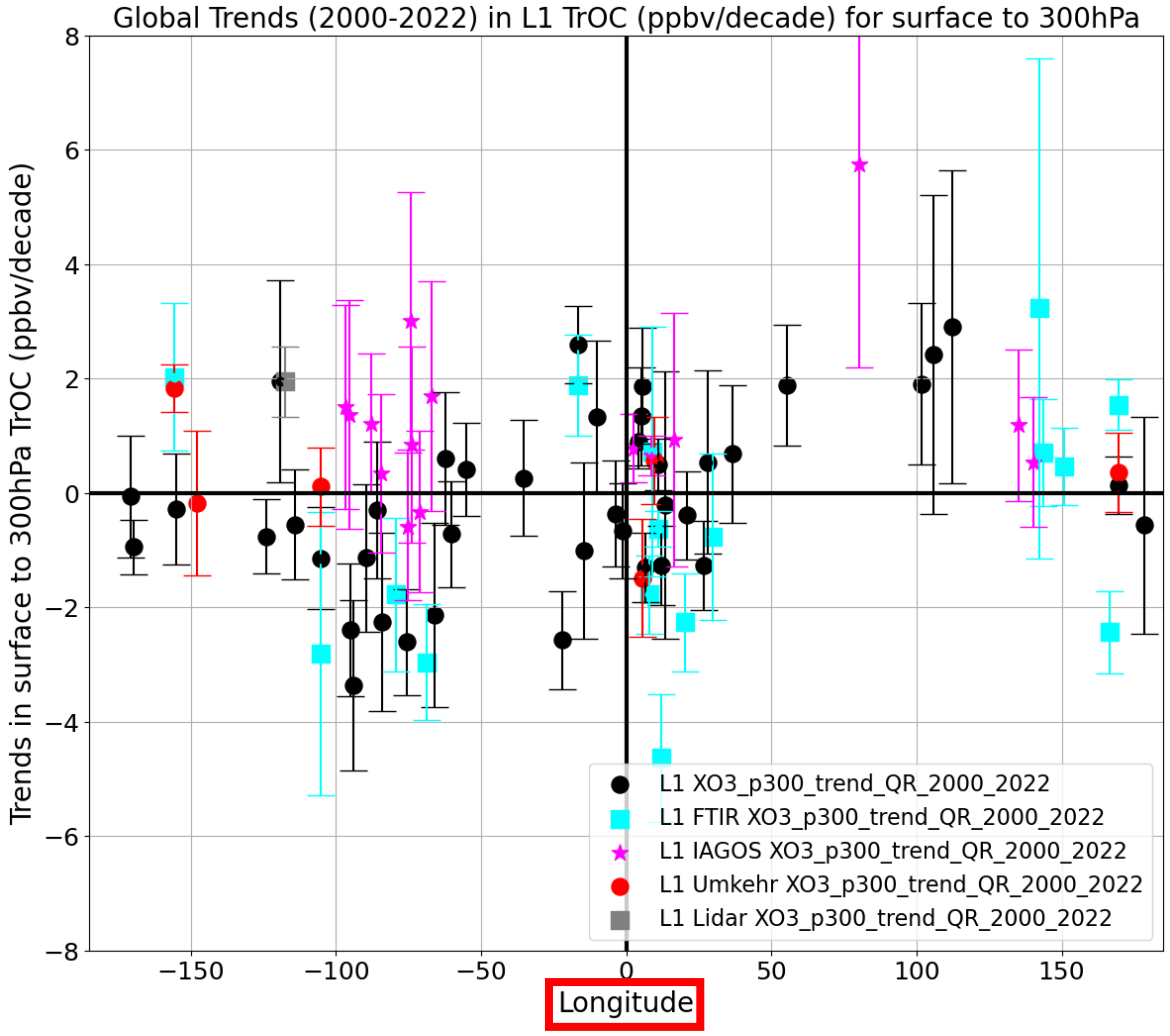
- 43 sites (green dots) with homogenized ozone profile data
- profile data available at ftp-server

https://hegiftom.meteo.be/datasets/ozonesondes

HEGIFTOM: tropospheric ozone column trend estimates

QR trends, ppbv/dec





Quantile regression, 2000-2022, tropospheric ozone column from surface up to 300 hPa

TOAR-II Satellite Ozone FWG: 20+ data sets

Technique	Data record	PI	Level	Period	Resolution	Status	Harmonisation
CCD	**TOMS**	NASA GSFC	L3	1979-2005	5 x 5	Released	No
CCD	**GTTO-ECV**	DLR	L3	1995-2022	1 x 1	2024	BIRA
CCD	**GOME2 CHORA-CPC**	IUP	L3	2006-2023		Q1 2024	
CCD	**TROPOMI CHORA-CPC**	IUP	L3	2017-2023	0.5 x 0.5	Upon request	
LNM	**OMI-MLS**	NASA GSFC	L3	2004-2023	5 x 5	Released	NASA/BIRA
LNM	**GTO-LIMB**	FMI	L3	2002-2022	1 x 1	Q3 2024	BIRA
LNM	**OMI-LIMB**	FMI	L3	2004-2022	1 x 1	Released, improved Q3 2024	BIRA
LNM	**OMPS-LNM**	IUP	L2	2012-2023		Released	
LNM	**OMPS-LNM**	NASA GSFC	L2	2012-			
RNM	**TROPOMI-BASCOE**	DLR	L3	2018-2022	1 x 1	Released	
RNM	**OMI/OMPS/EPIC-MERRA2**	NASA GSFC	L3	2004-2023	1 x 1	Released	BIRA
OEM	**GOME-type L2** (GOME, SCIAMACHY, OMI, GOME-2)	RAL	L2	1995-2021		Released	BIRA
OEM	**GOP-ECV**	DLR	L3	1995-2021	5 x 5	Released	BIRA
OEM	**IASI FORLI CDR**	LATMOS/ULB	L2	2008-2023		Released	BIRA
OEM	**IASI FORLI**	ULB/LATMOS	L3	2008-2023	1 x 1	Q3 2024	BIRA
OEM	**IASI SOFRID**	LAERO	L2	2008-2023		Released / In prep	
OEM	**IASI KOPRA**	LISA	L2	2008-2022		Released	
OEM	**IASI-GOME-2B**	LISA	L2	2016-2023		Released	BIRA
OEM	**Tropess** (AIRS, OMI, AIRS+OMI, CrIS, TROPOMI)	NASA JPL	L2	2004-2023		Released / In prep	JPL/BIRA
OEM	**TROPOMI**	KNMI	L2	2018-2022		Released	BIRA

Tropo column
fixed pressure
~ 100-300 hPa

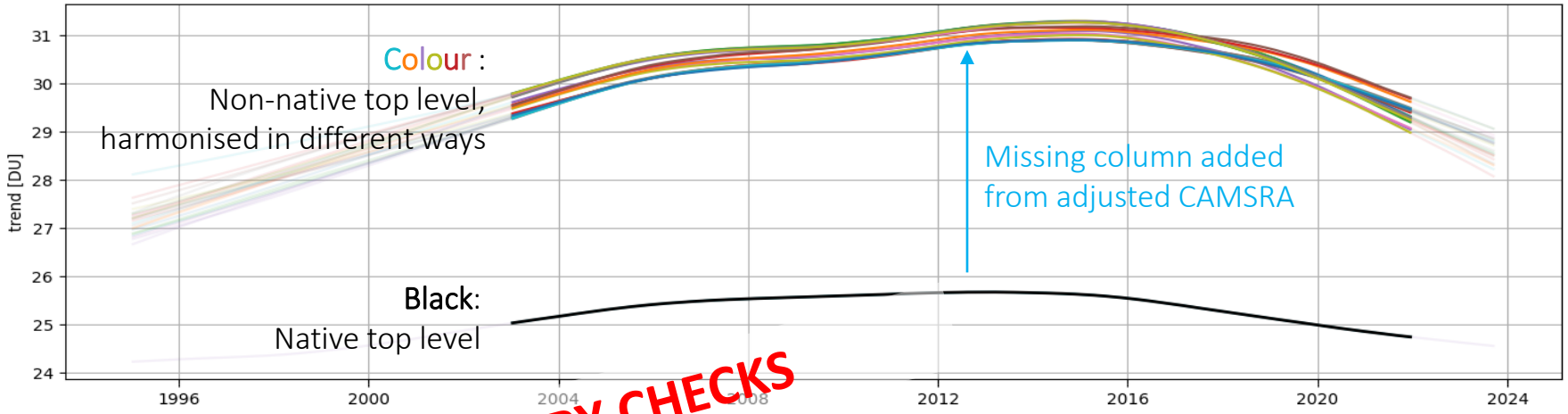
Tropo column
~ thermal / dynamical tropopause

Profile retrieval
~ flexible top level, but different prior information

Courtesy: Hubert & Keppens

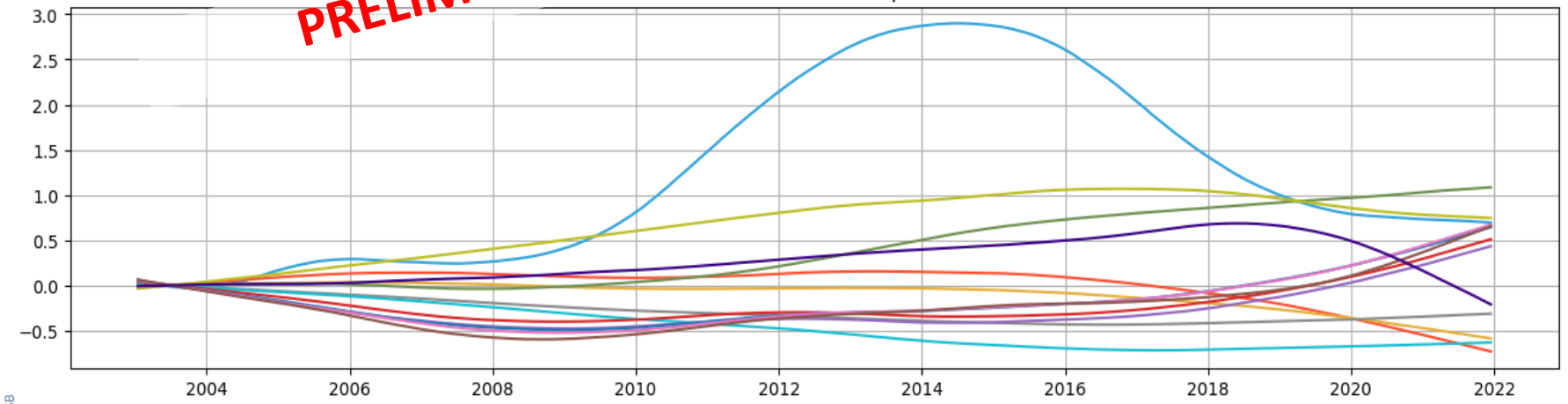
Satellite Ozone FWG: Harmonisation of tropospheric column data

Main objective : Reduce differences related to different top level of tropospheric column



PRELIMINARY CHECKS

1 satellite data record
DLM trend,
20S-20N mean TrOC [DU]



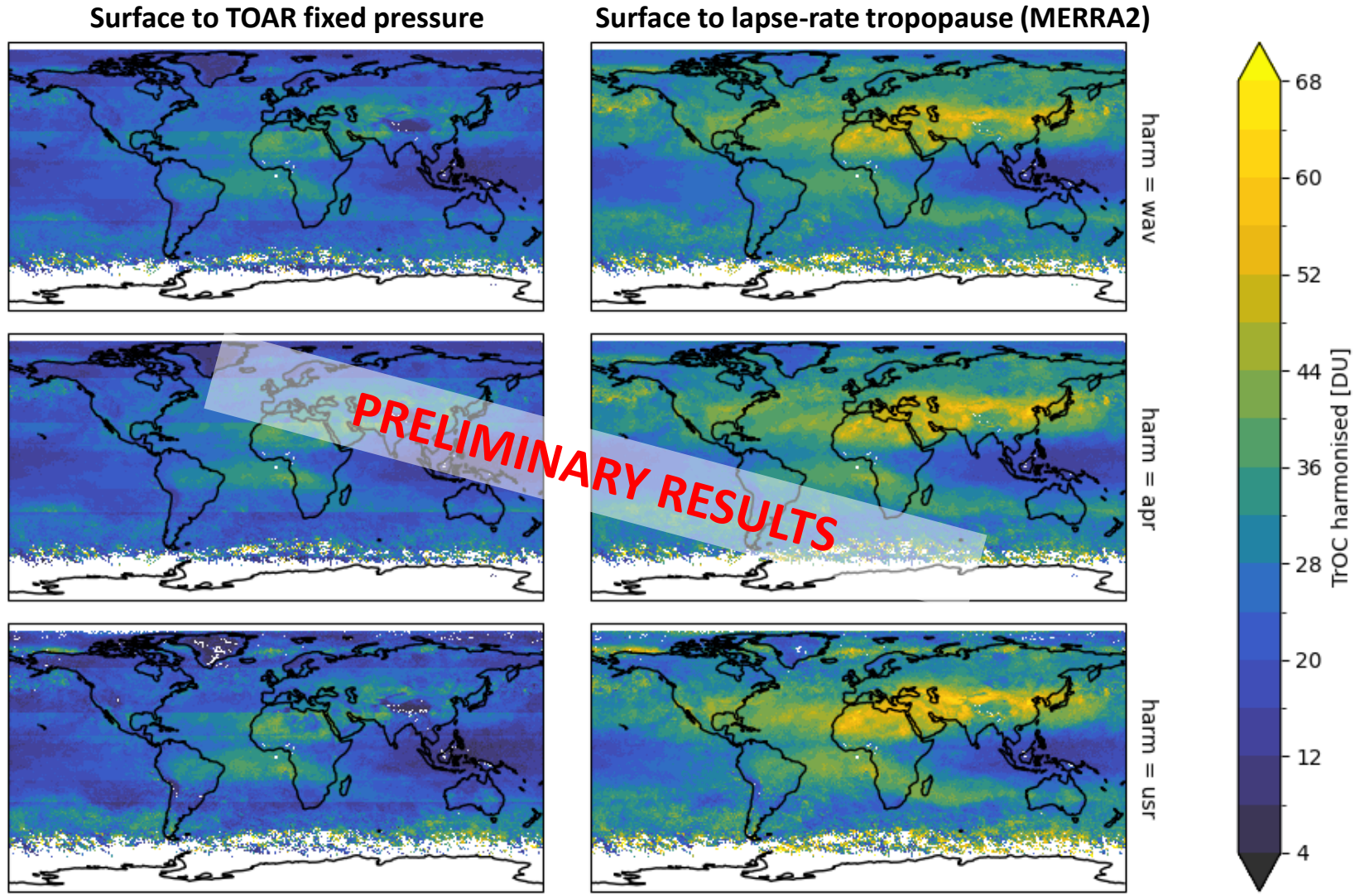
10 harmonised satellite data records
DLM trend offset to 2003 mean,
20S-20N mean TrOC [DU]

Courtesy: Hubert & Keppens

Satellite Ozone FWG: Harmonisation of nadir profile data

Main objective : Reduce differences related to different use of prior information in satellite retrievals

Illustration : IASI-B Aug 2017



Only spatial/temporal aggregation
different prior + prior constraint

Prior harmonization
common prior

Unit-Sensitivity Representation
common prior & prior constraint

Courtesy: Hubert & Keppens

TOAR-II Chemical Reanalysis FWG

This FWG *(chaired by Kazuyuki Miyazaki and Dylan Jones)* is the "glue" between different FWGs:

- Chemical reanalyses have been used as "transfer standards" in the harmonization of satellite ozone retrievals.

- [OBJ1] Evaluation of chemical reanalyses with TOAR-II observations and other data will assess the potential of using reanalysis data for studying tropospheric ozone spatial gradients and trends at regional/global scales.

- [OBJ2] Sensitivity analyses of the impacts of satellite and in-situ observations of ozone and precursors will assess the relative importance of individual observations to improve surface and tropospheric ozone (re)analyses and help design observing systems that better capture the distribution in ozone.

- [OBJ3] Well-validated chemical reanalysis ozone fields will provide an opportunity to study the spatial and temporal representativeness (at seasonal to decadal scales) of free-tropospheric ozone measured with ground-based and in situ techniques.

Conclusions and outlook

- For a reliable tropospheric ozone trends assessment, harmonization of the datasets is a key.
  - ✓ **Surface** ozone → TOAR-I Surface Data https://toar-data.org/surface-data/
  - ✓ **Satellite** tropospheric ozone → TOAR-II Satellite Ozone FWG
  - ✓ **Ground-based + in-situ** tropospheric ozone profiles → TOAR-II HEGIFTOM FWG
- Linkage between those activities by using e.g. ozonesondes and chemical reanalyses
- Finality: tropospheric ozone trends ("TOAR-II guidelines!") & assess impact ("TOAR-II assessment papers") on
  - ✓ Climate
  - ✓ Health
  - ✓ Vegetation
- There will be a TOAR-II Satellite Ozone Assessment Paper as well, led by Daan Hubert & Kazuyuki Miyazaki!