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Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

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Royal Meteorological Institute

Assessment of the homogenization of the EU ozonesonde time series

06/10/2023

Deniz Poyraz[1], Roeland Van Malderen[1], Herman Smit[2]

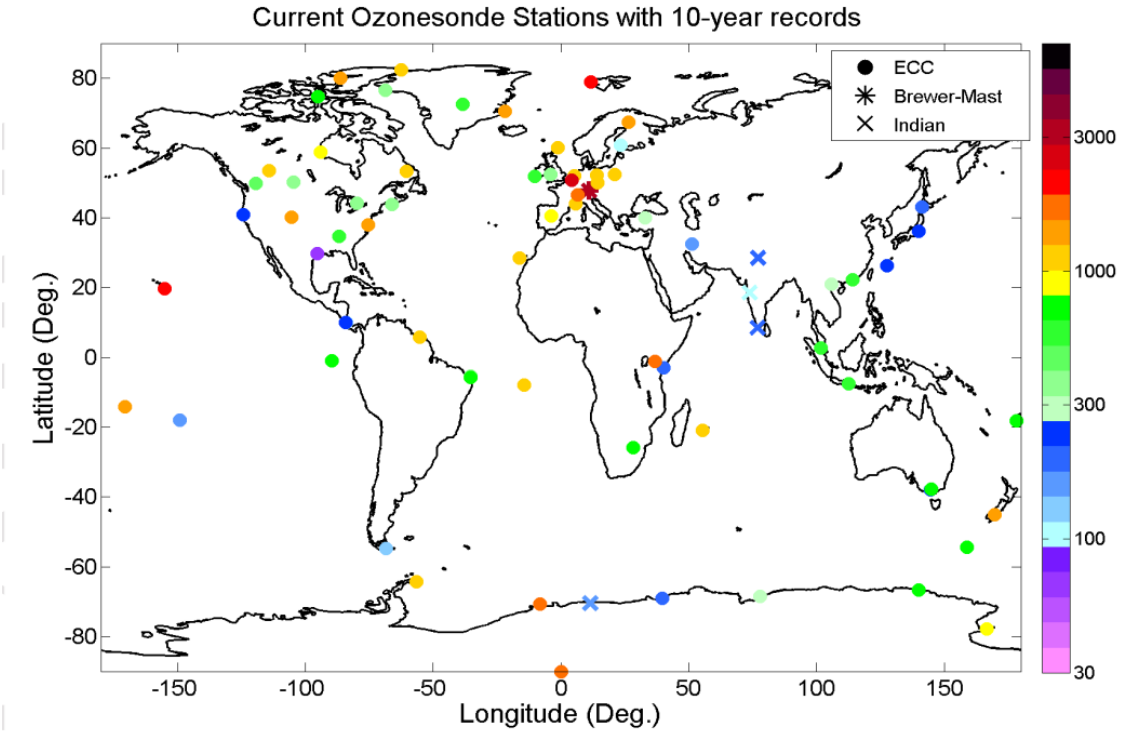
[1] Royal Meteorological Institute

[2] Research Centre Jülich GmbH

- Ozonesondes
- Homogenization of the EU stations
- Assessment of the homogenized data
- TRCC method
- Outlook and conclusions

Ozonesondes

- lightweight and compact balloon-borne instruments
- provide vertical profile of the ozone from
- the surface through the mid-stratosphere (35 km)
- since 1970s



- *Uccle for more than 50 years, since 1969*
- *One of the most frequent time-series around the world*

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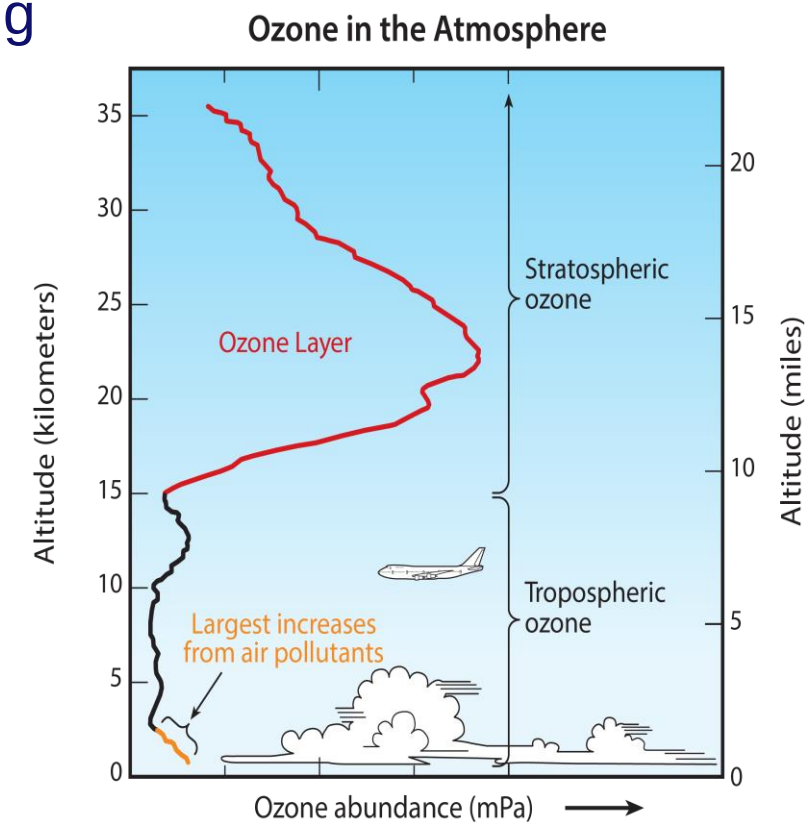
Ozonesondes

- the most important data source with long-term data coverage *with sufficient vertical resolution*
- to validate and evaluate satellite observations and their long term stability
- Important for ozone layer and tropospheric ozone monitoring

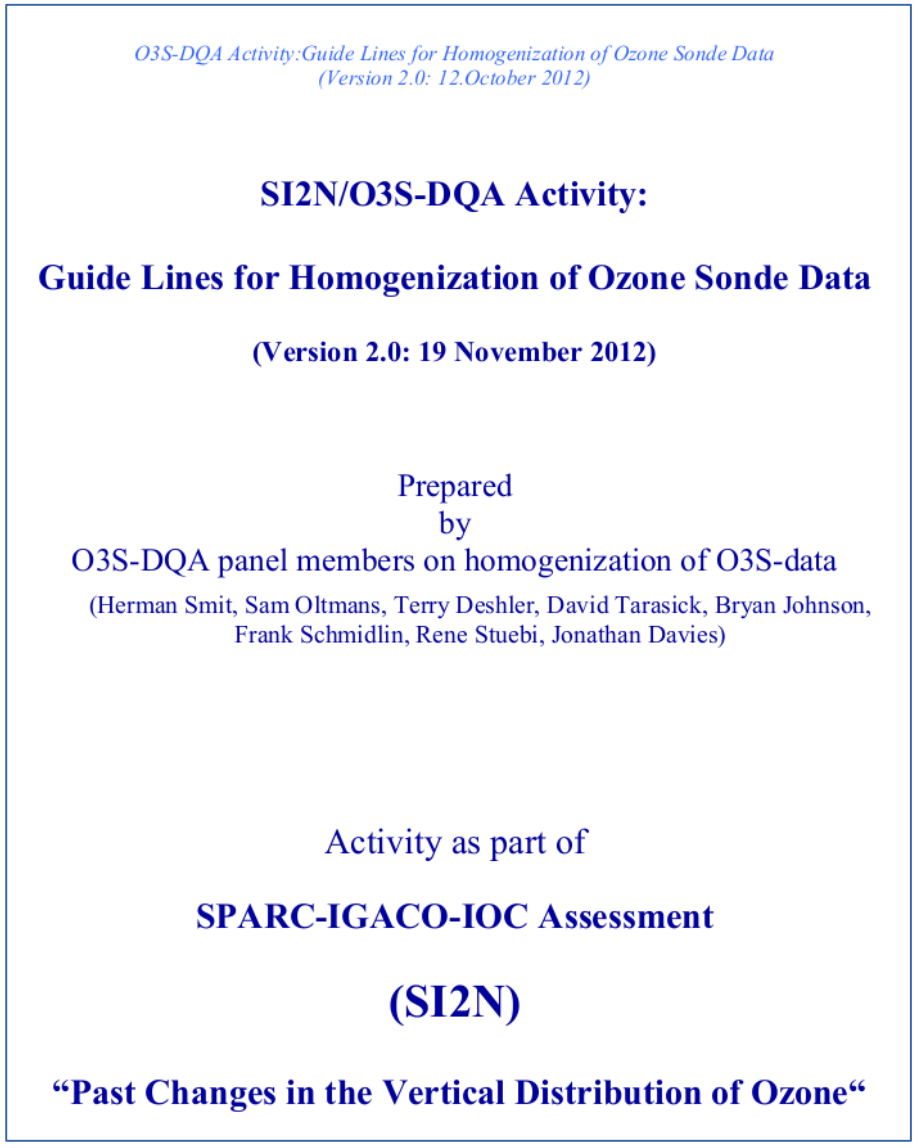
But...

- Different sonde manufacturer and chemical concentrations
- Changes in the preparation procedures and manufacturers

Cause non-homogeneity in the time series !!



Homogenization



O3S-DQA Activity:Guide Lines for Homogenization of Ozone Sonde Data
(Version 2.0: 12.October 2012)

SI2N/O3S-DQA Activity:

Guide Lines for Homogenization of Ozone Sonde Data

(Version 2.0: 19 November 2012)

Prepared
by
O3S-DQA panel members on homogenization of O3S-data
(Herman Smit, Sam Oltmans, Terry Deshler, David Tarasick, Bryan Johnson, Frank Schmidlin, Rene Stuebi, Jonathan Davies)

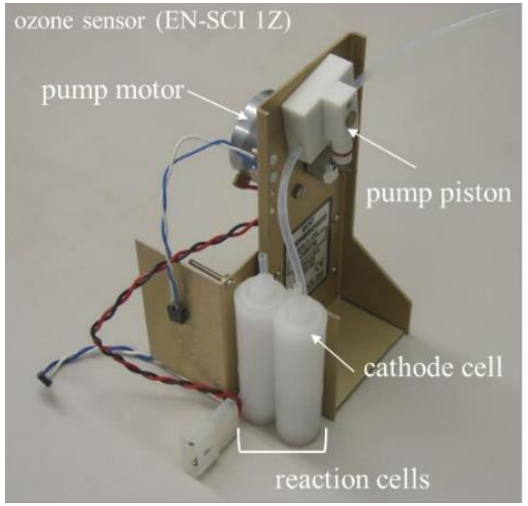
Activity as part of

SPARC-IGACO-IOC Assessment

(SI2N)

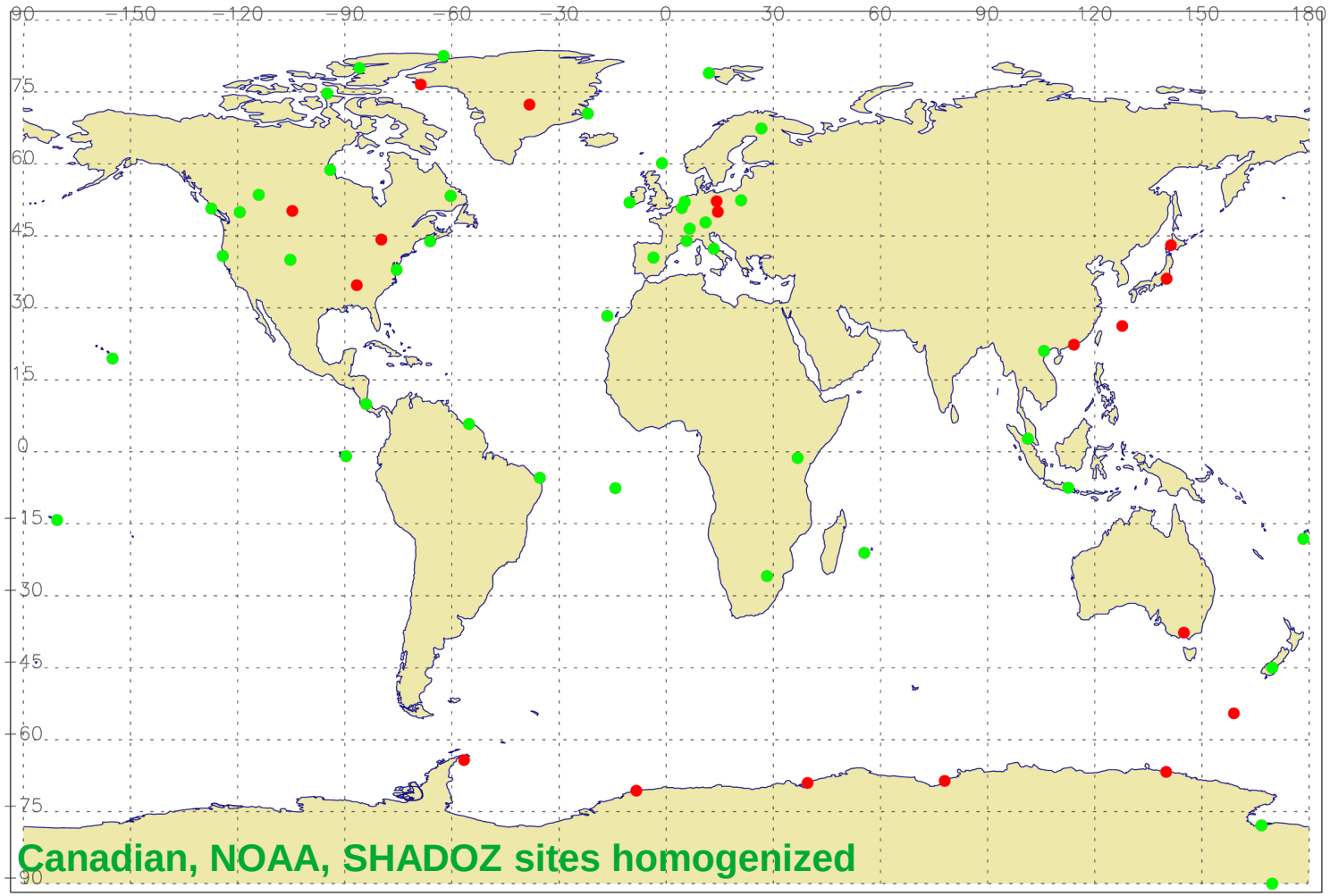
"Past Changes in the Vertical Distribution of Ozone"

$$P_{O3} = \frac{R}{2F} \cdot \frac{T_P}{(\eta_c \cdot \Phi_p)} \cdot (I_M - I_B)$$



- Standard Operating Procedures of Ozone Sonde Data Quality Assessment activity
  → applying to ozonesonde time-series
- Harmonization and Evaluation of Ground-based Instruments for Free Tropospheric Ozone Measurements within the TOAR-II Focus Working Group "HEGIFTOM"
- Homogenized ozonesonde data is also provided to HEGIFTOM

Status of the Ozonesonde Sites



For a detailed view of the stations: https://hegiftom.meteo.be/datasets/ozonesondes

Status of the European Sites

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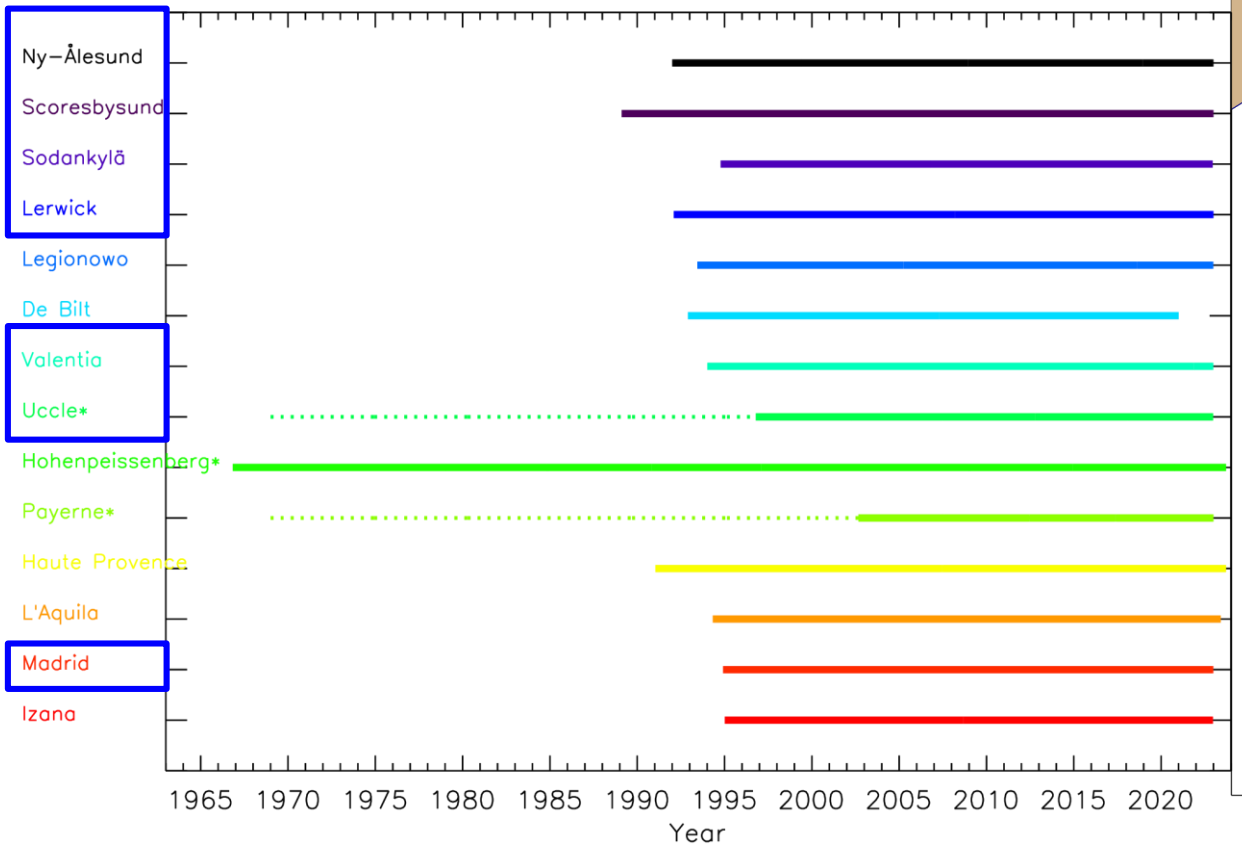
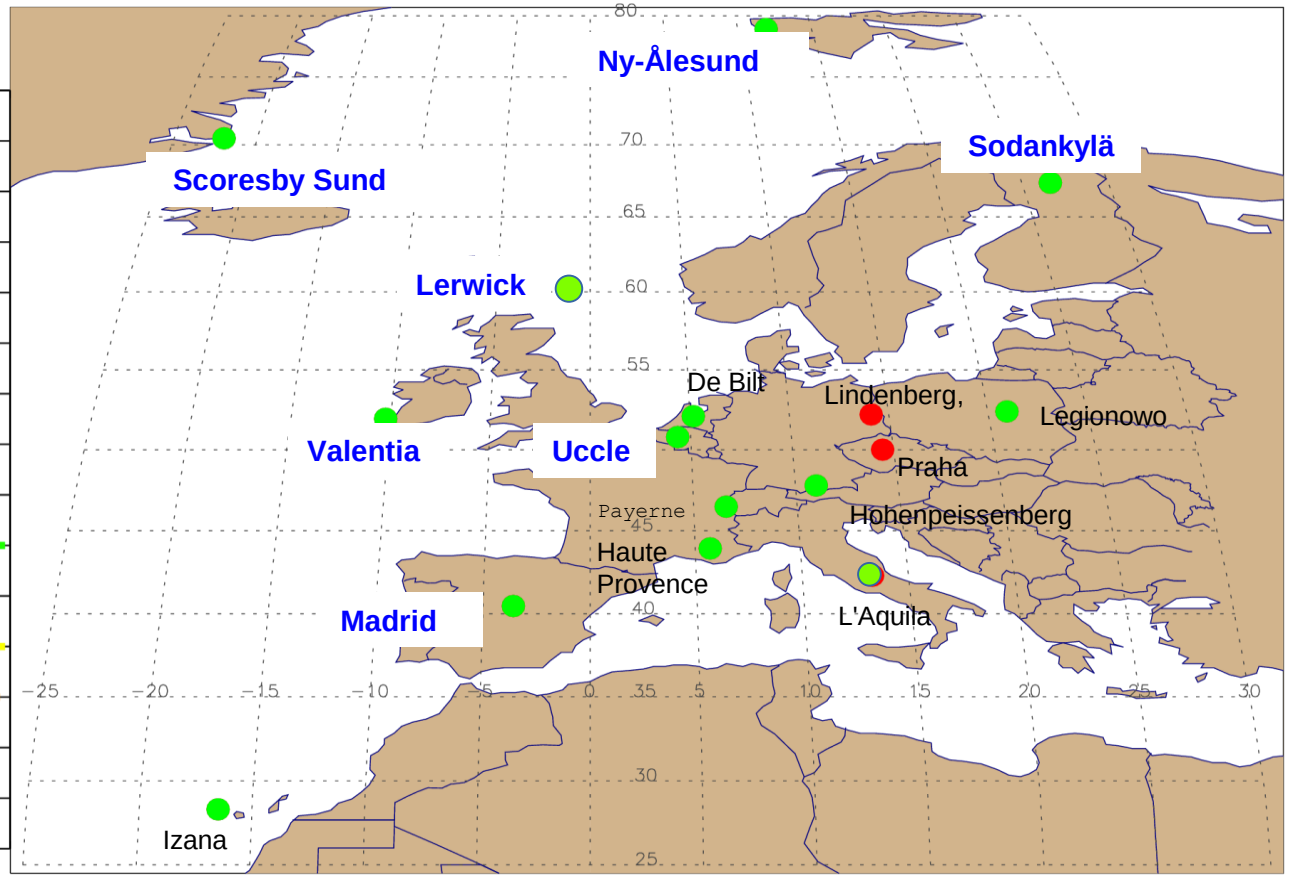
Available Homogenized EU Sites





non EU Lauder (New Zealand)

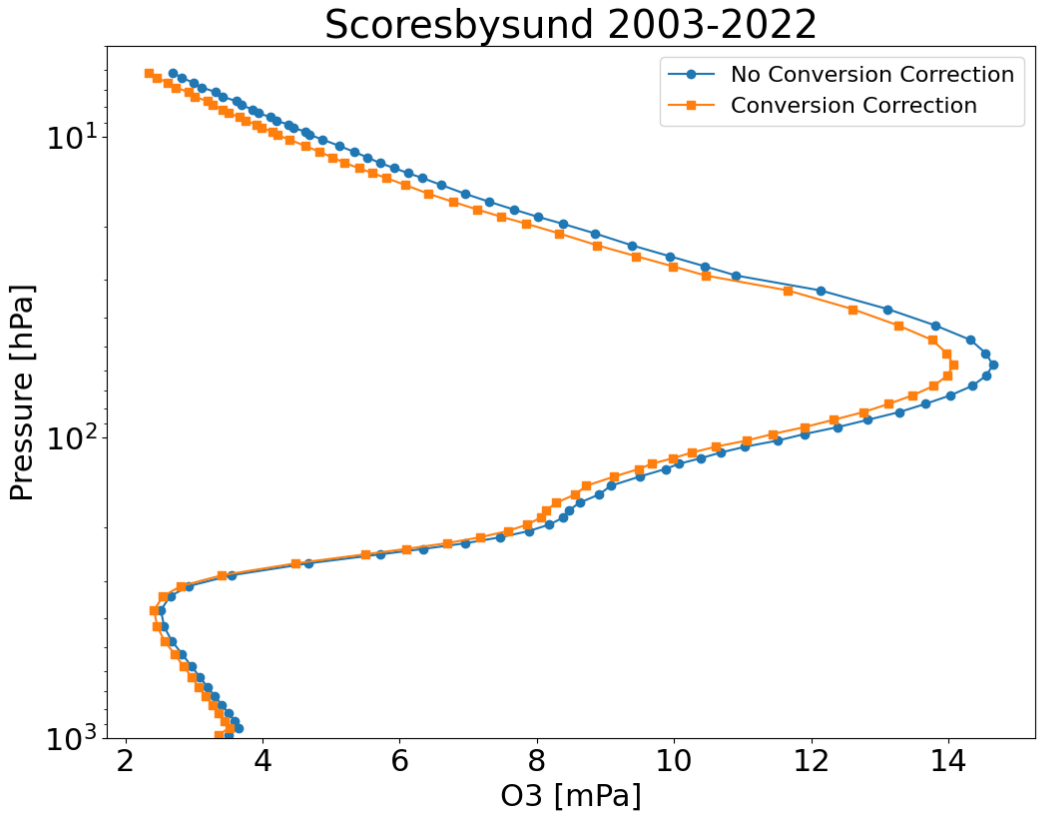
Canadian, NOAA, SHADOZ sites homogenized

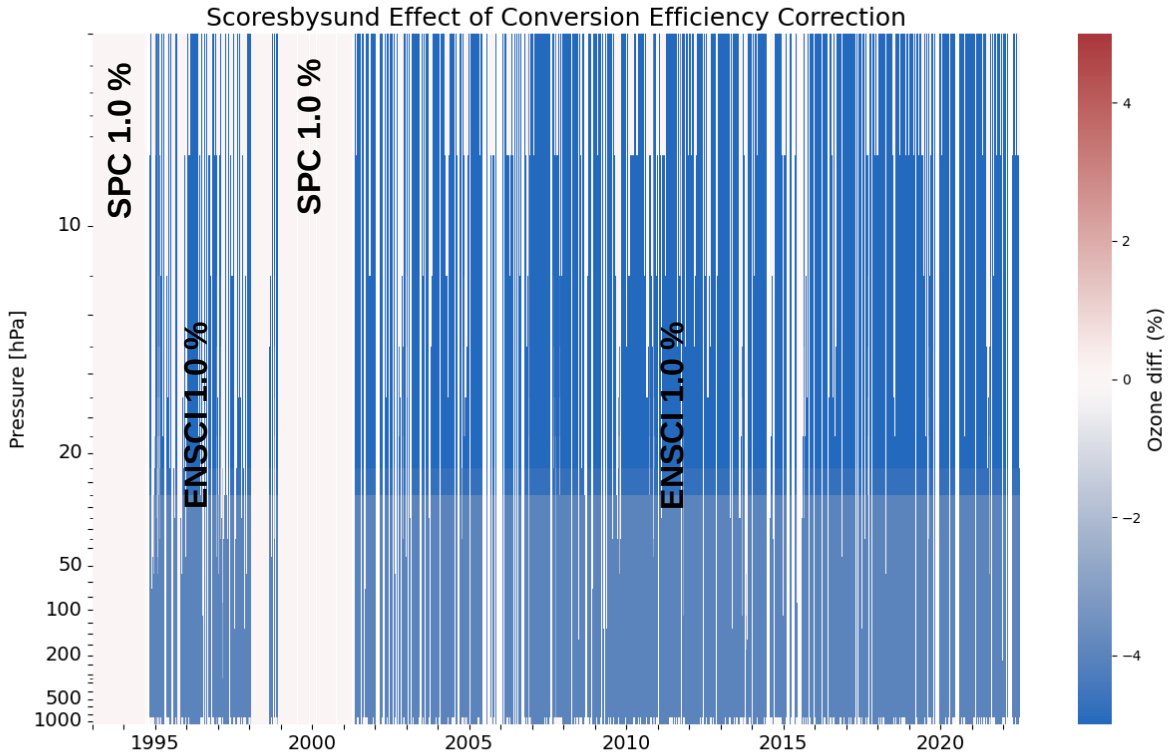
➔ Data-processing by RMI :https://github.com/denizpoyraz/o3s-dqa-homogenization

➔ Data availability: https://hegiftom.meteo.be/datasets/ozonesondes

Principles of homogenization

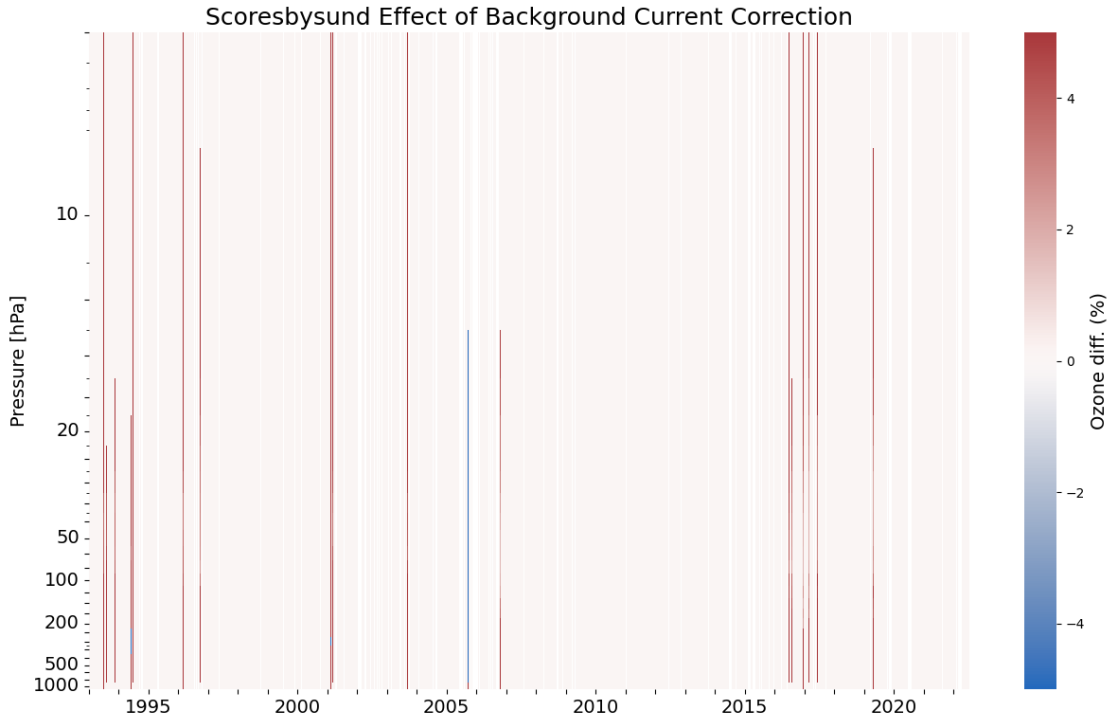
- **correcting for changes in**
  - ECC ozonesonde type (SPC, EN-SCI) and sensing solution strength/volume

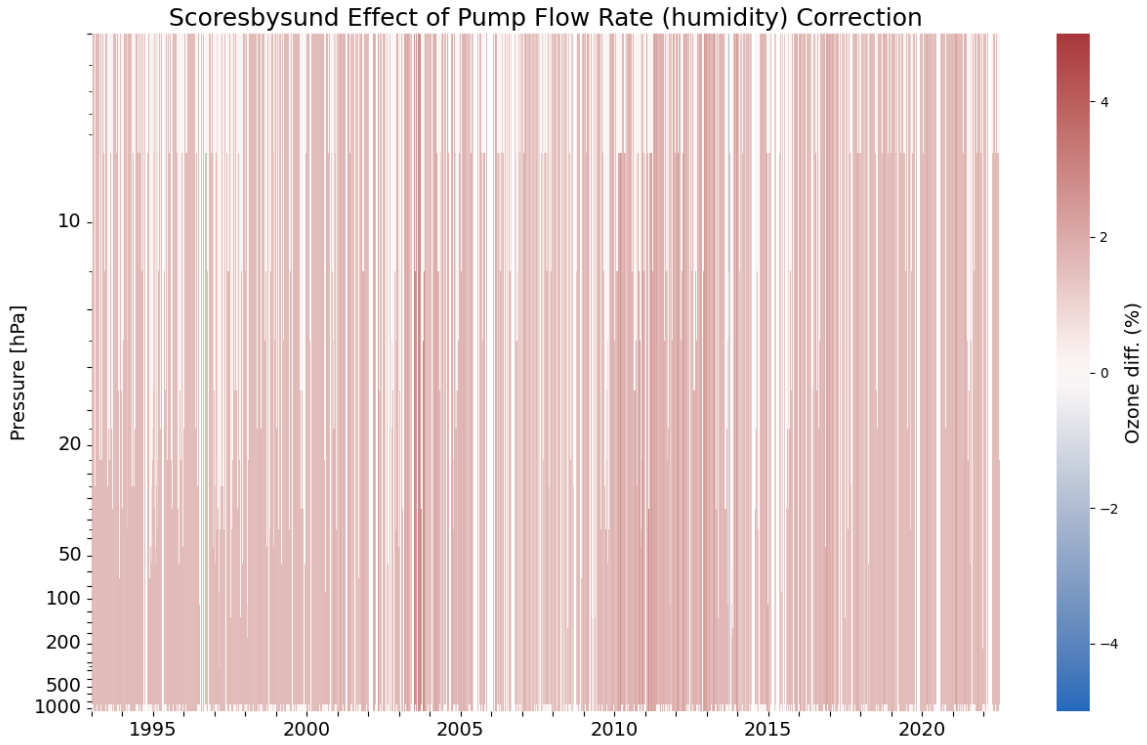




Principles of homogenization

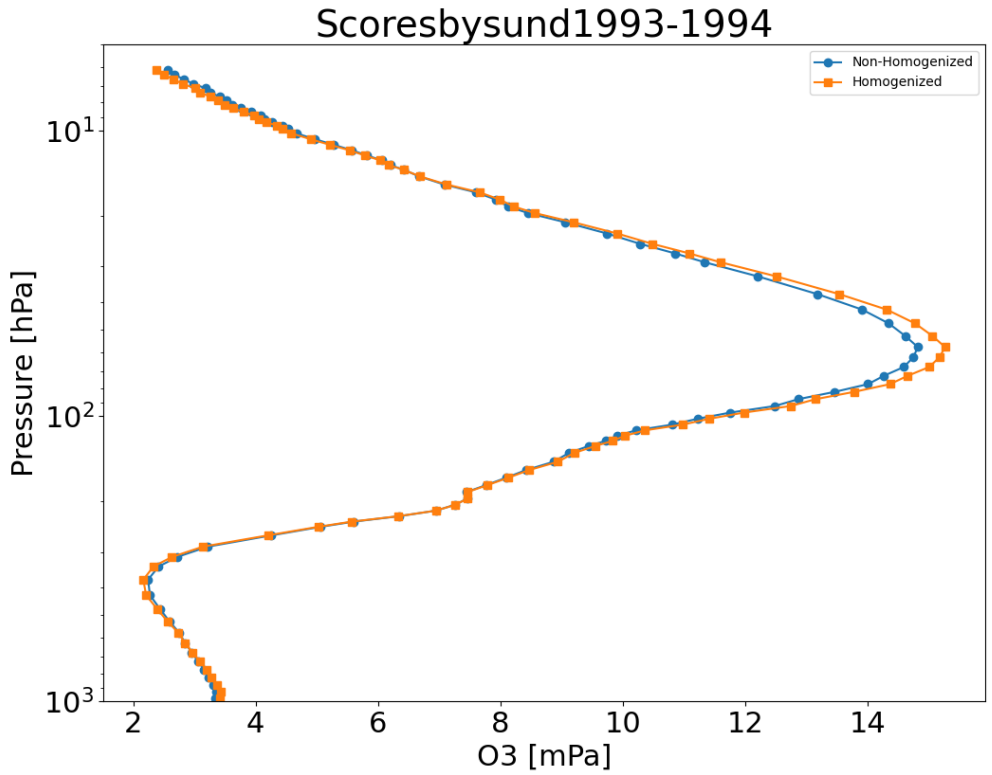
- **correcting for changes in**
  - pre-flight procedures (background current, pump flow rate)

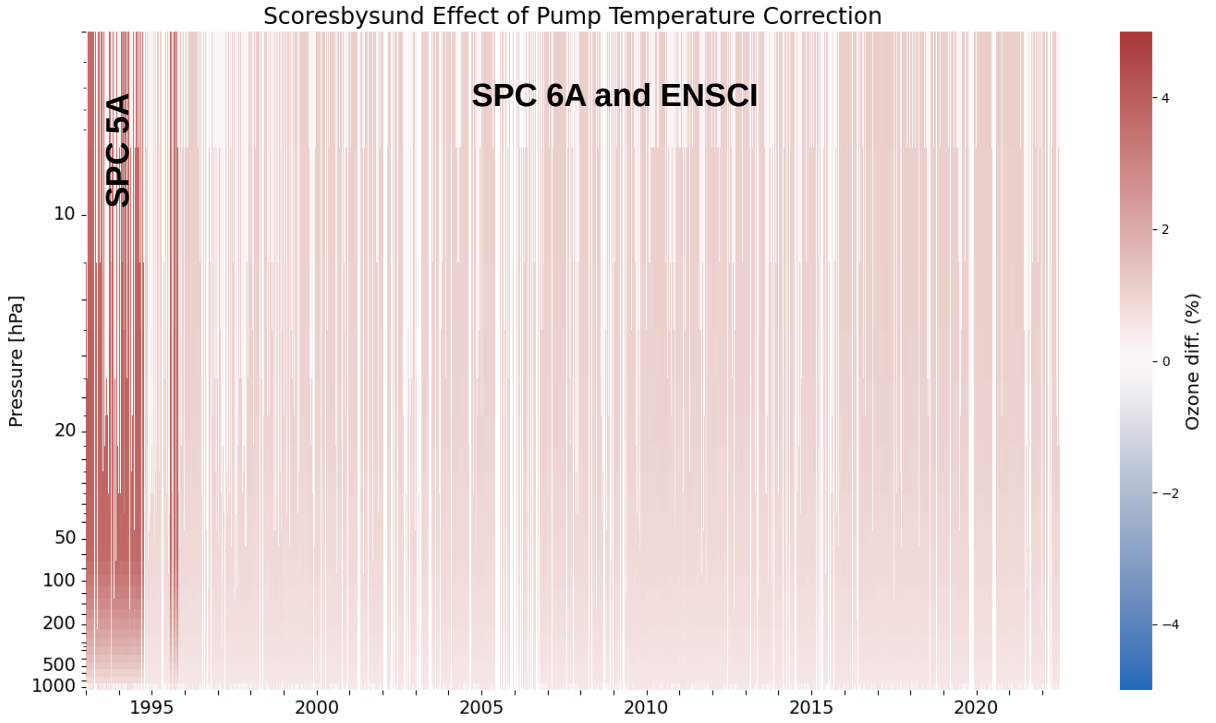




Principles of homogenization

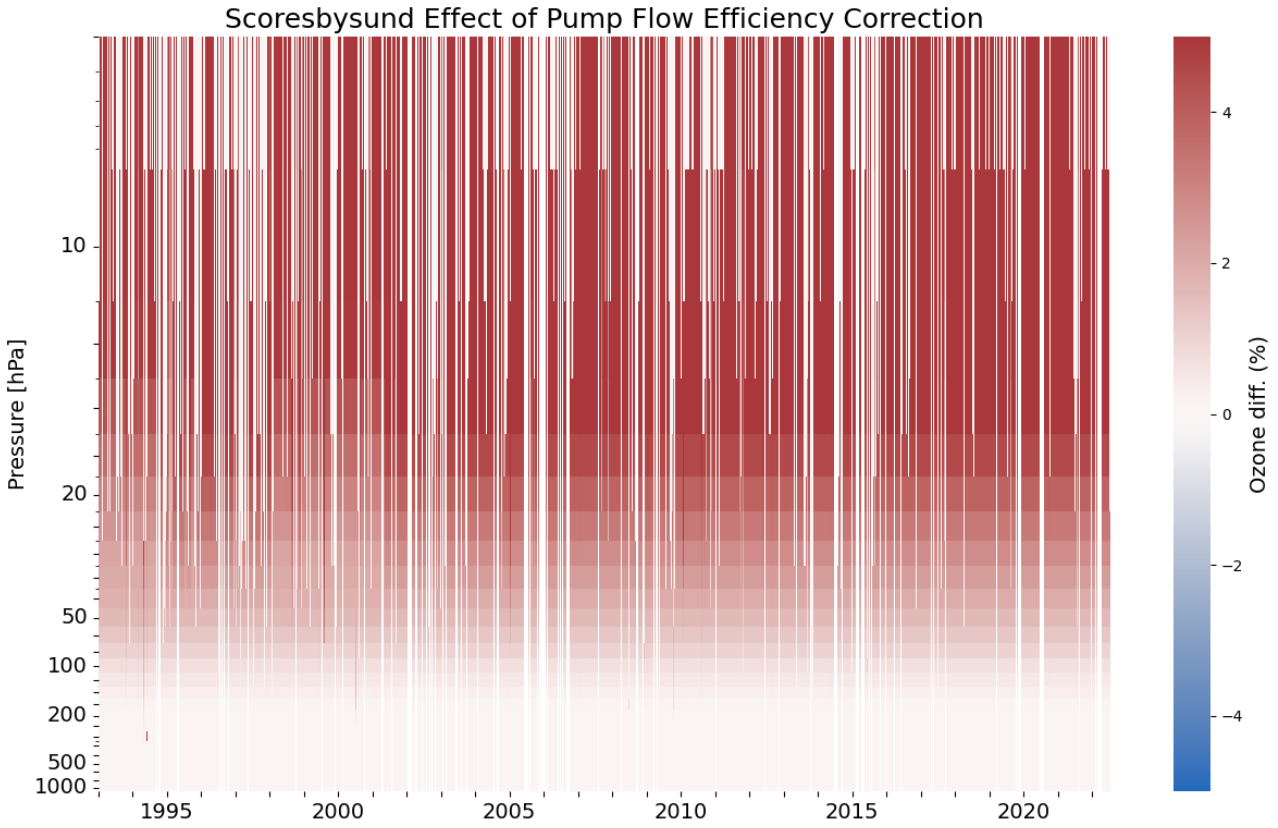
- **correcting for changes in**
  - Location of the pump temperature measurements





Principles of homogenization

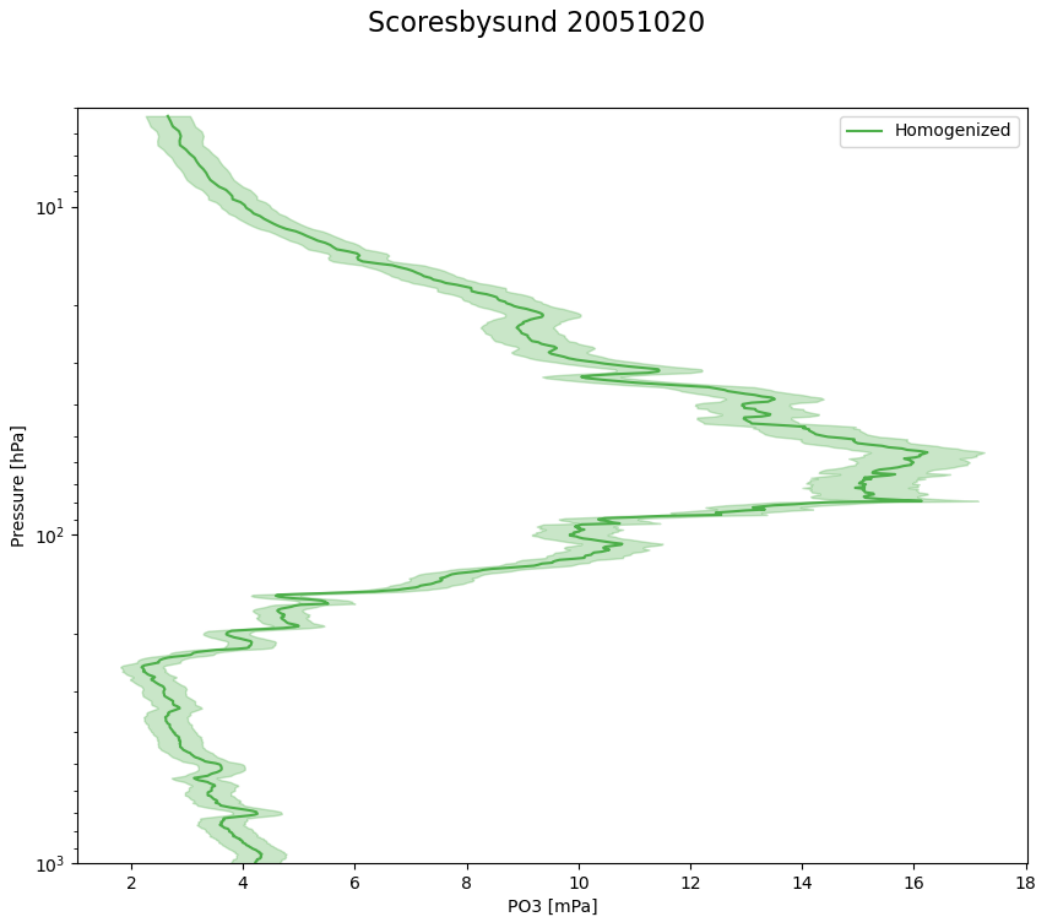
- **correcting for changes in**
  - post-processing (pump efficiency correction tables, total ozone normalization, etc.)



- Pump Flow efficiency correction is (almost) always applied, but needs to be corrected if sonde manufacturer changes

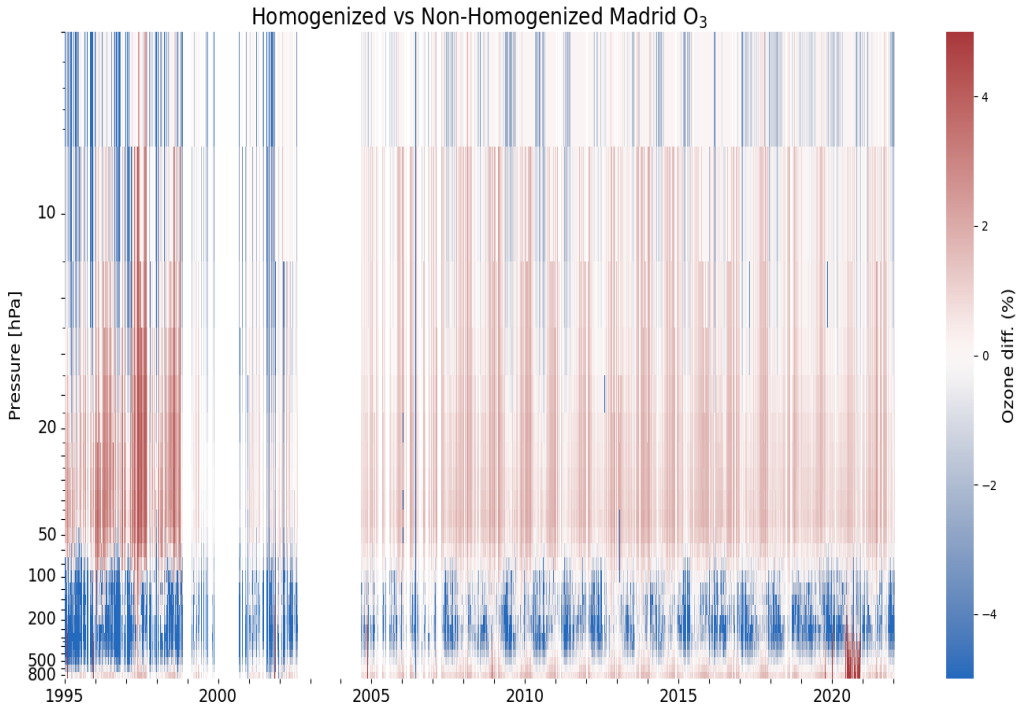
Principles of homogenization

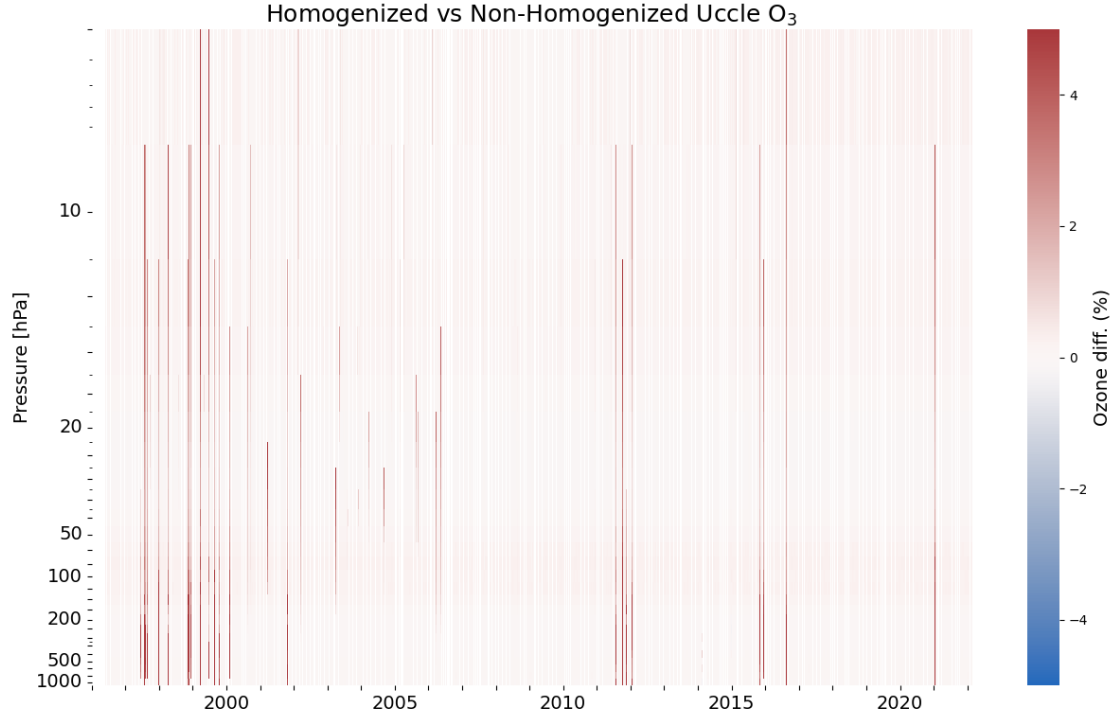
- providing uncertainties for ozone partial pressure measurement
- providing raw observations (“currents”) needed for re-processing
- → like time response correction (TRC)



Effect of homogenization on data

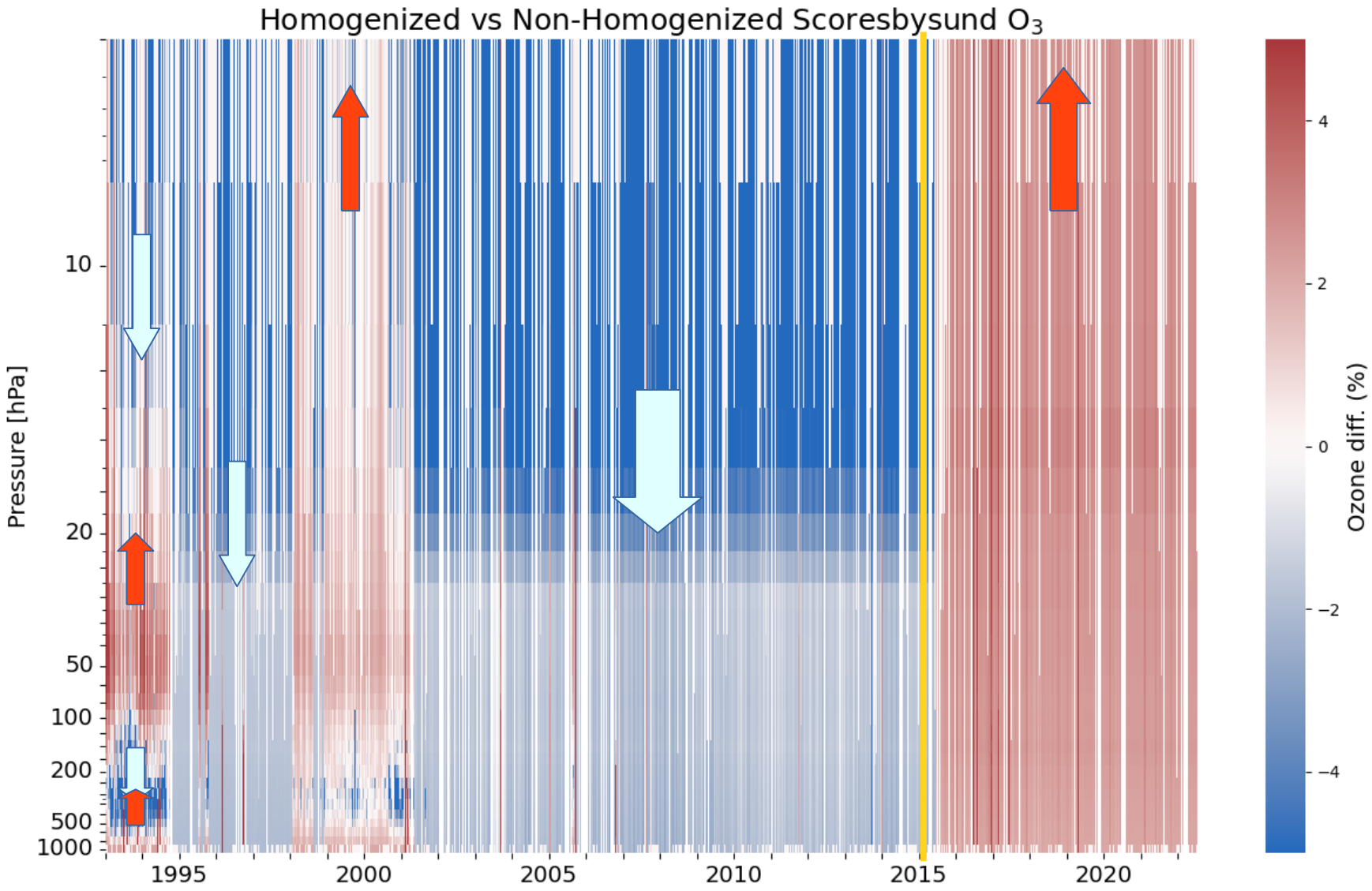
- ECC ozonesonde type (SPC, EN-SCI) and sensing solution strength/volume
- pre-flight procedures (background current, pump flow rate)
- location of the pump temperature measurements
- post-processing (pump efficiency correction tables, total ozone normalization, etc.)





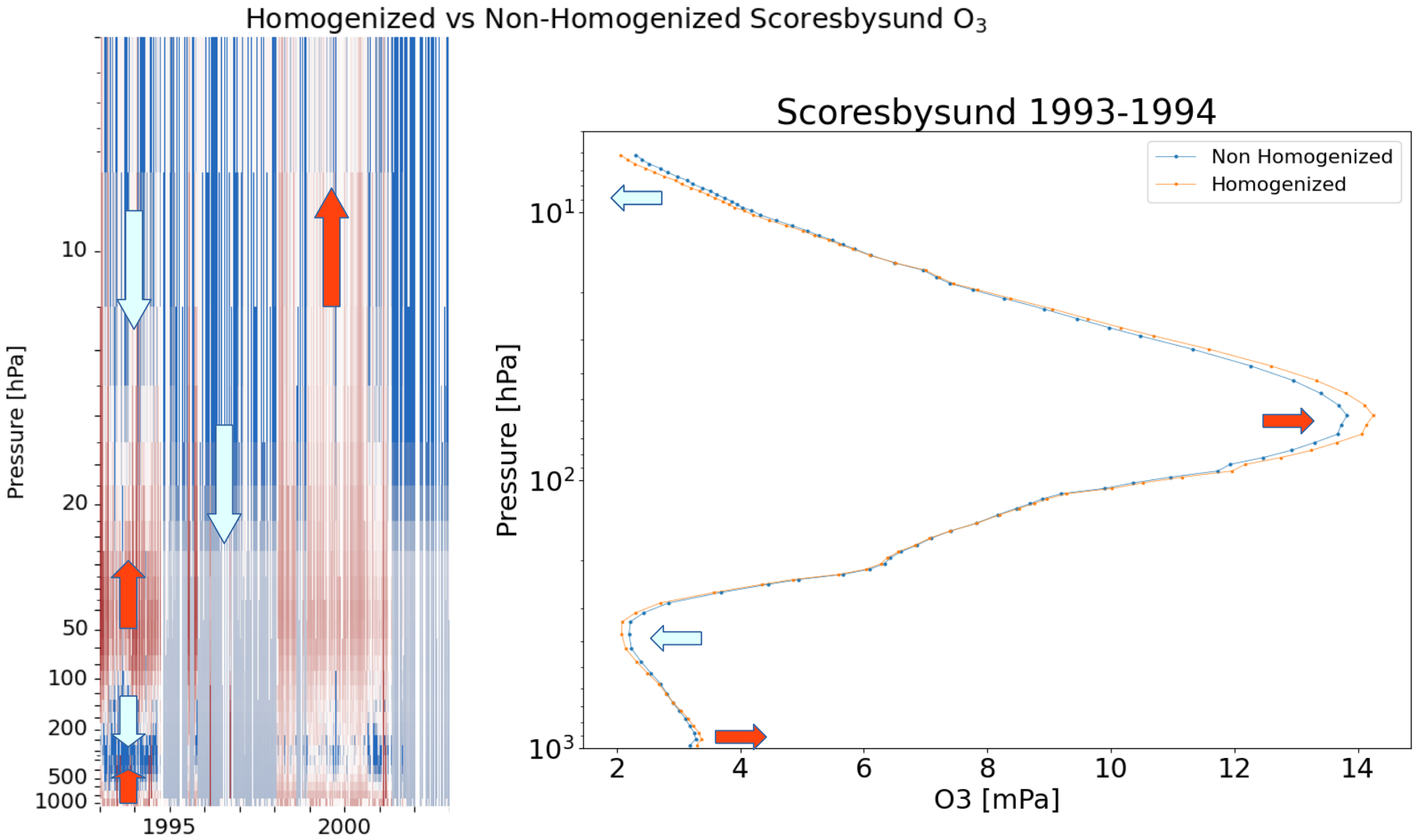
***Non-Homogenized: Data from WOUDC, NDACC, nilu**

Effect of homogenization on data



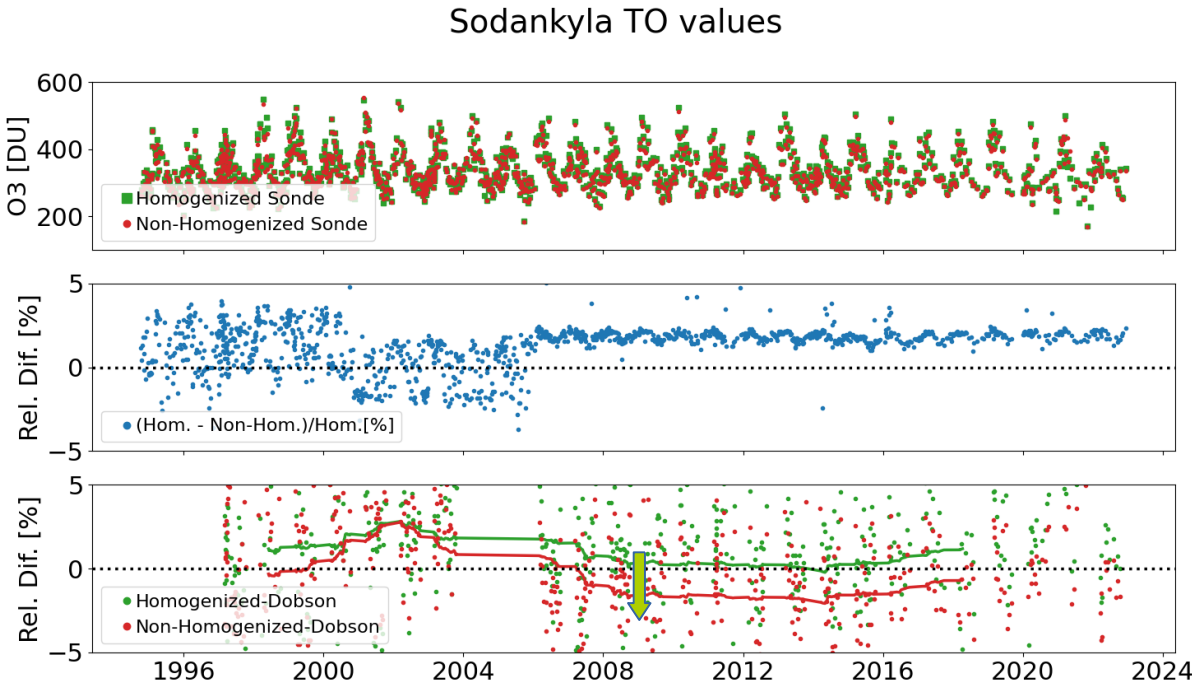
conversion eff. applied in original data
ENSCI 1.0 % to SPC 1.0%

Effect of homogenization on data

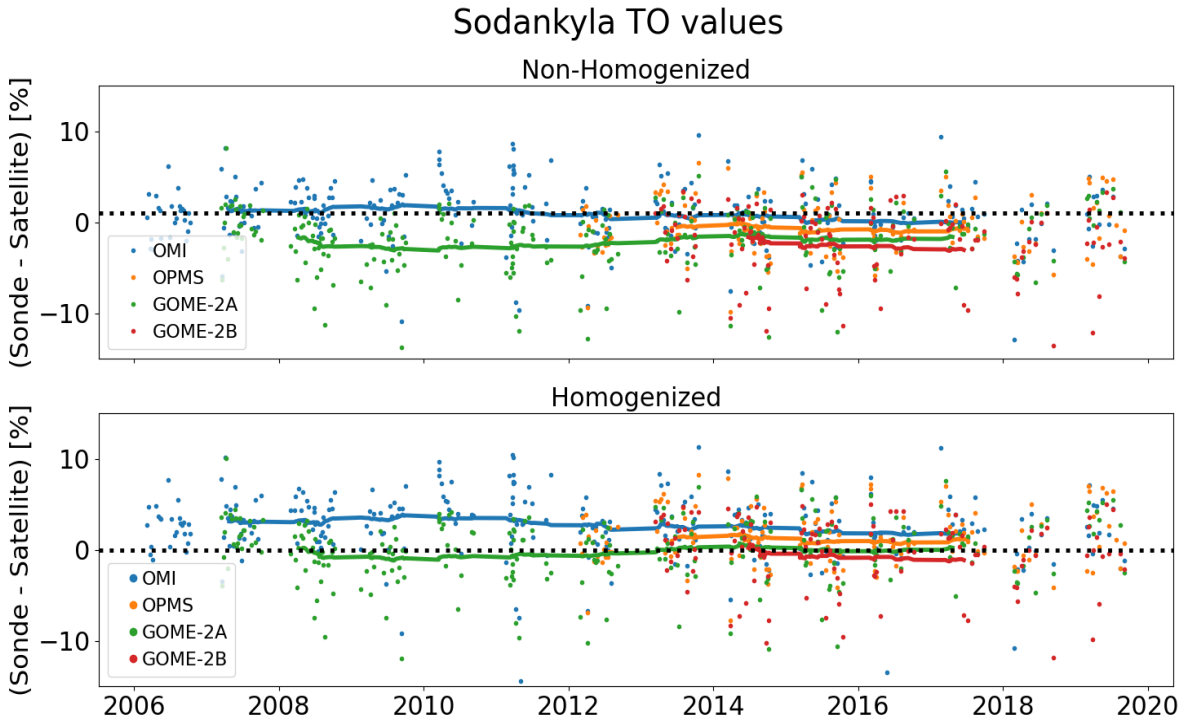


Inter-Comparison of Homogenized data:

- Total ozone values with respect to co-located Dobson and to satellite measurements



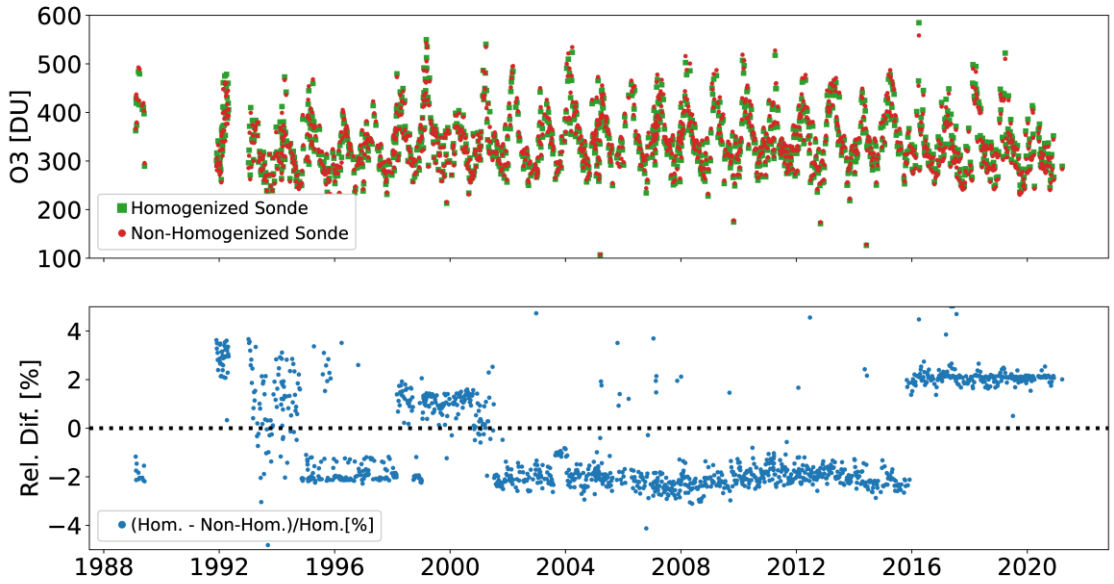
Better agreement with Dobson after 2007



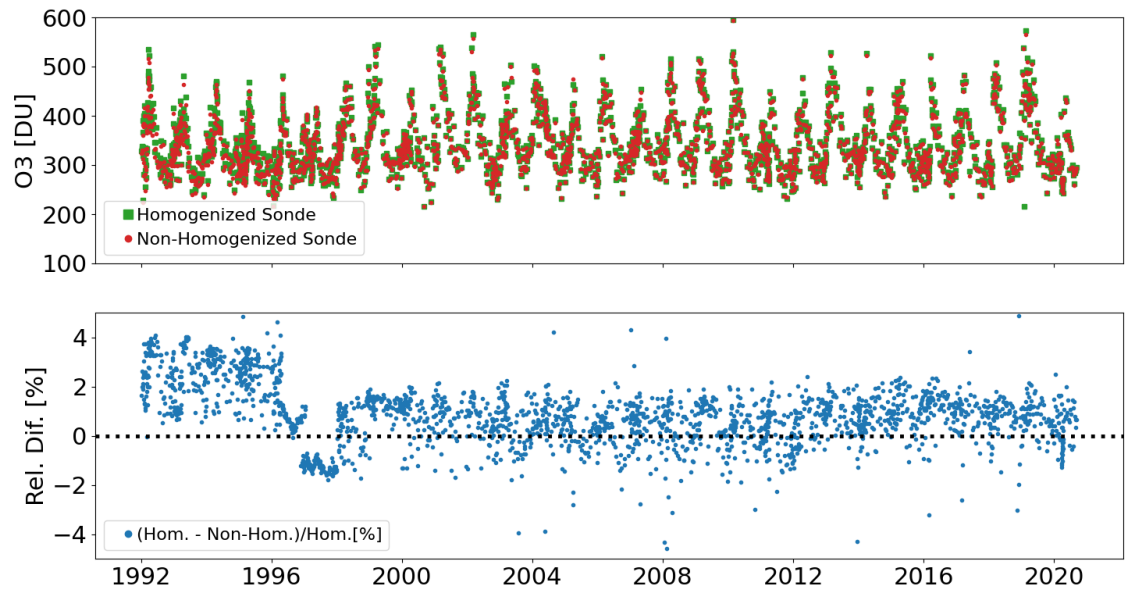
Overall not a better agreement

**TO values from satellites: R. Stauffer*

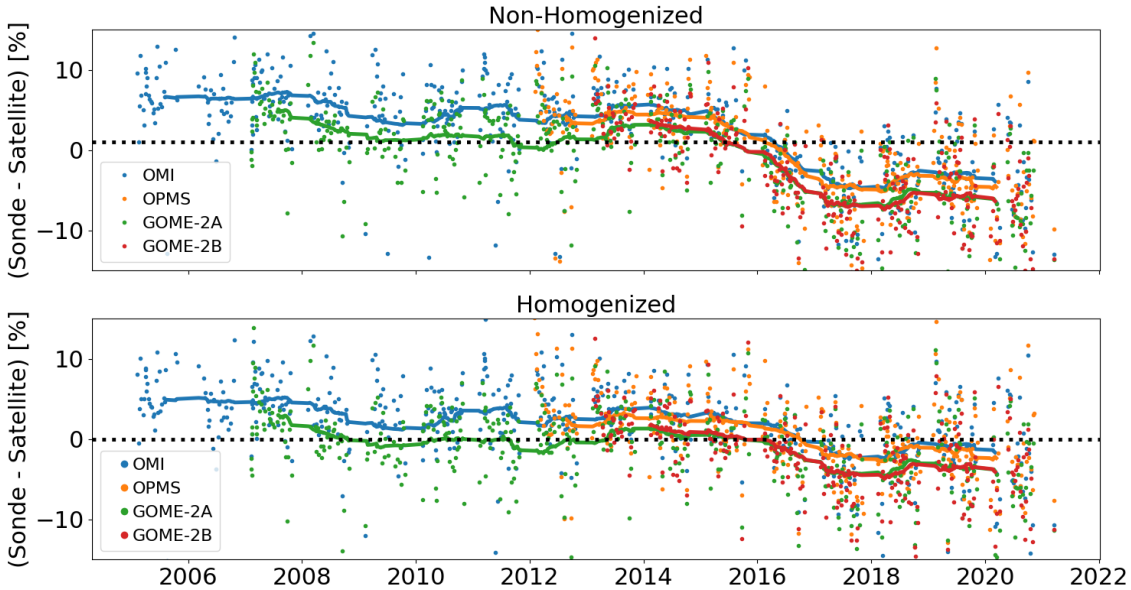
Scoresbysund TO values



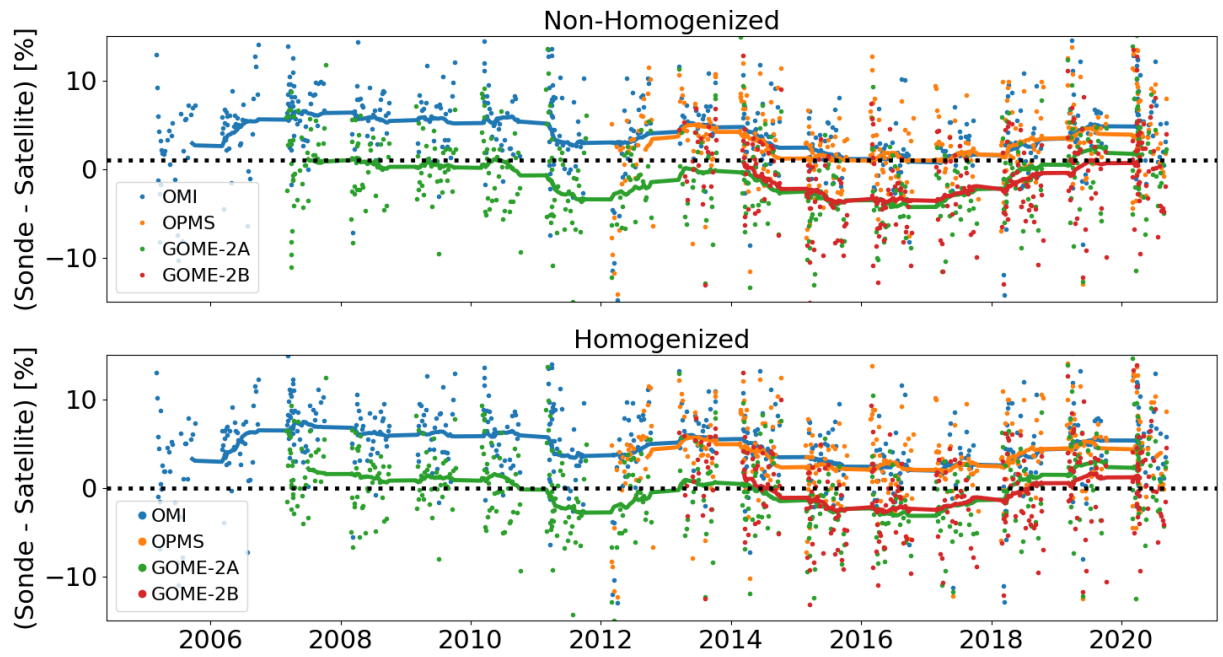
Ny-Alesund TO values



Scoresbysund TO values

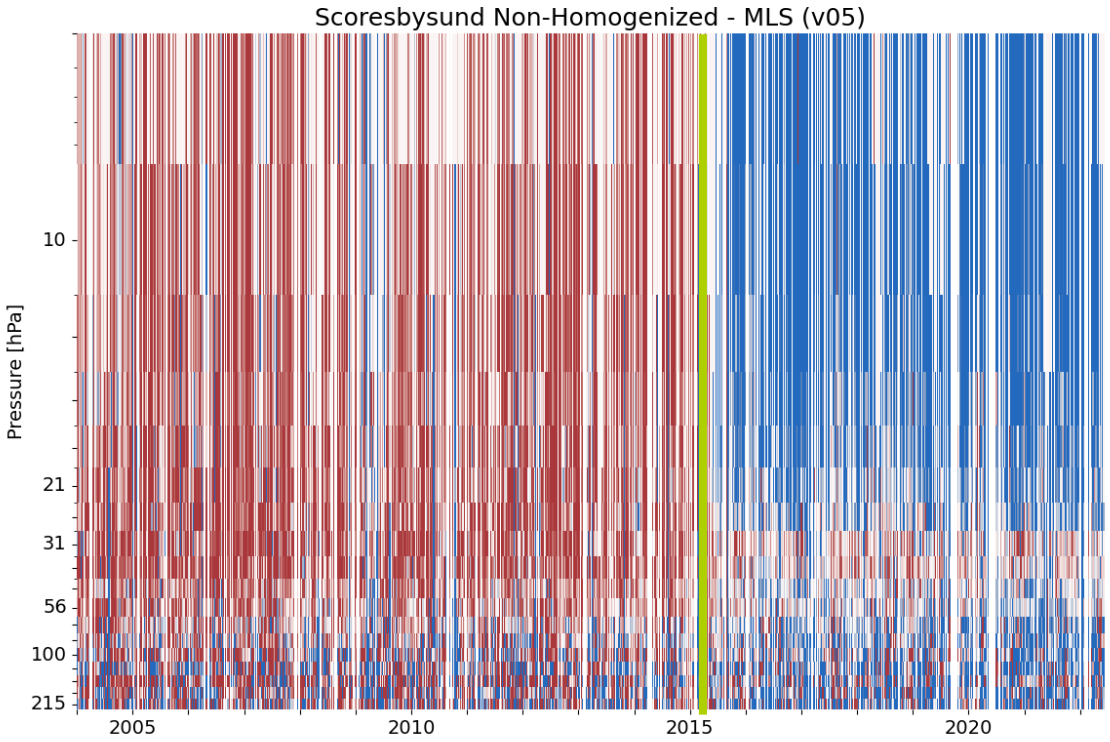


Ny-Alesund TO values

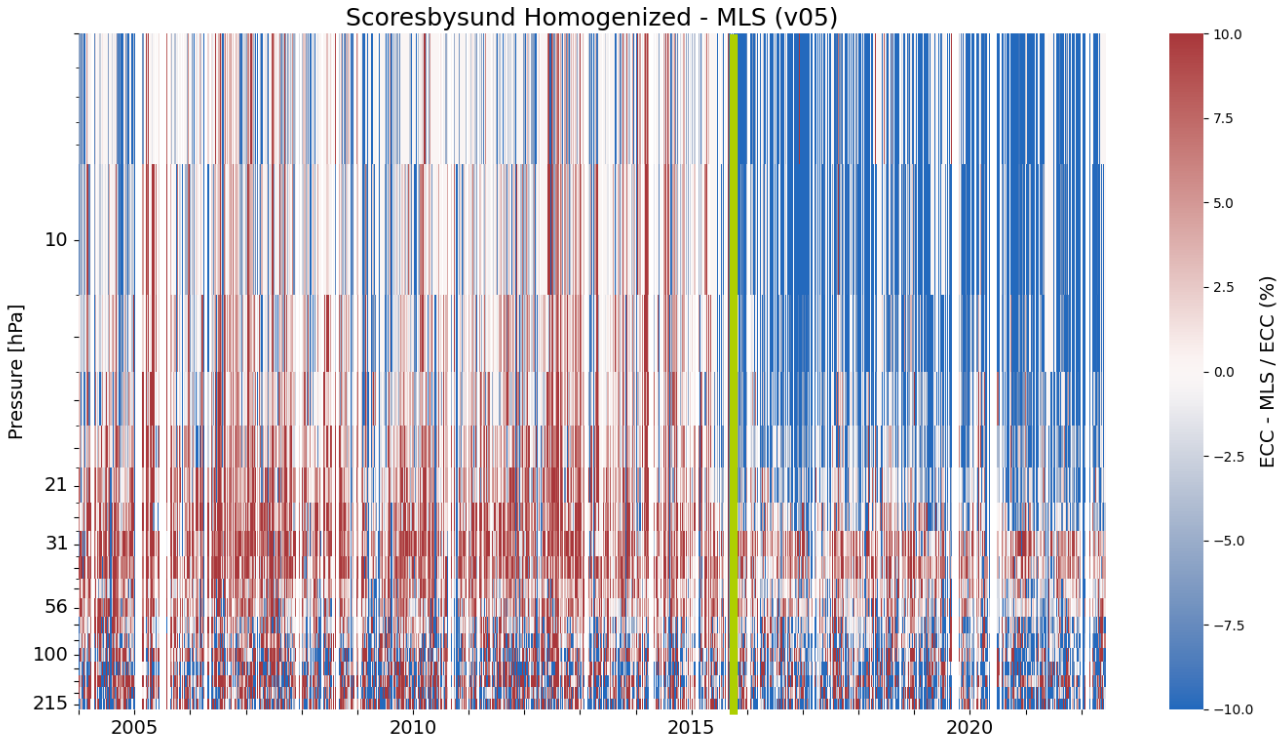


Inter-Comparison of Homogenized data:

- Stratospheric ozonecomparison with respect to AURA-MLS



→ after 2015 ?

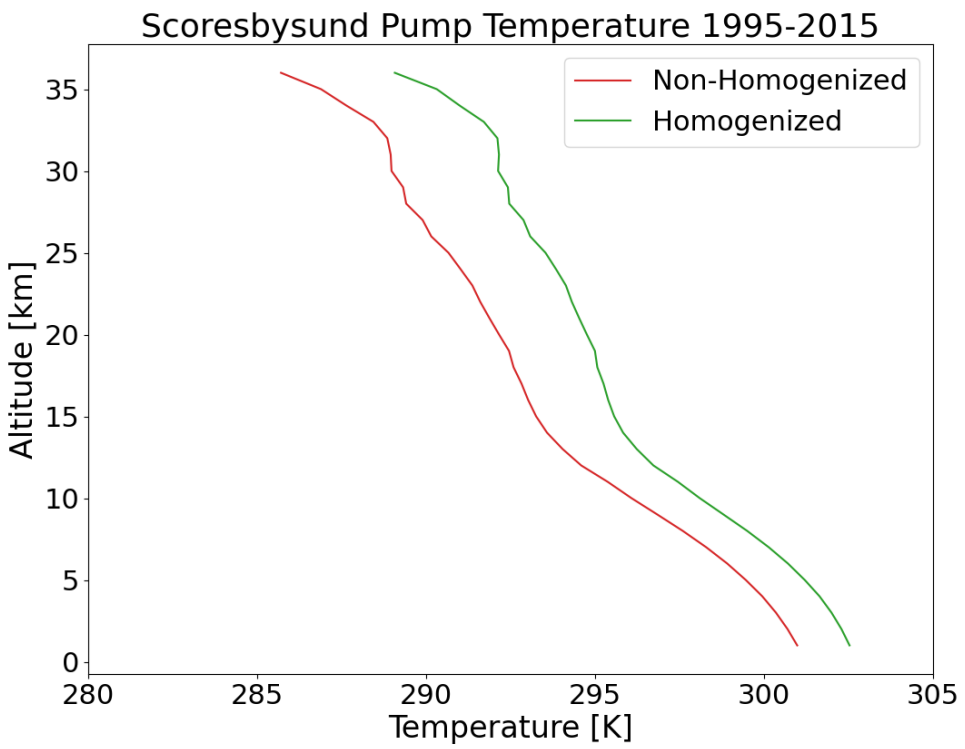


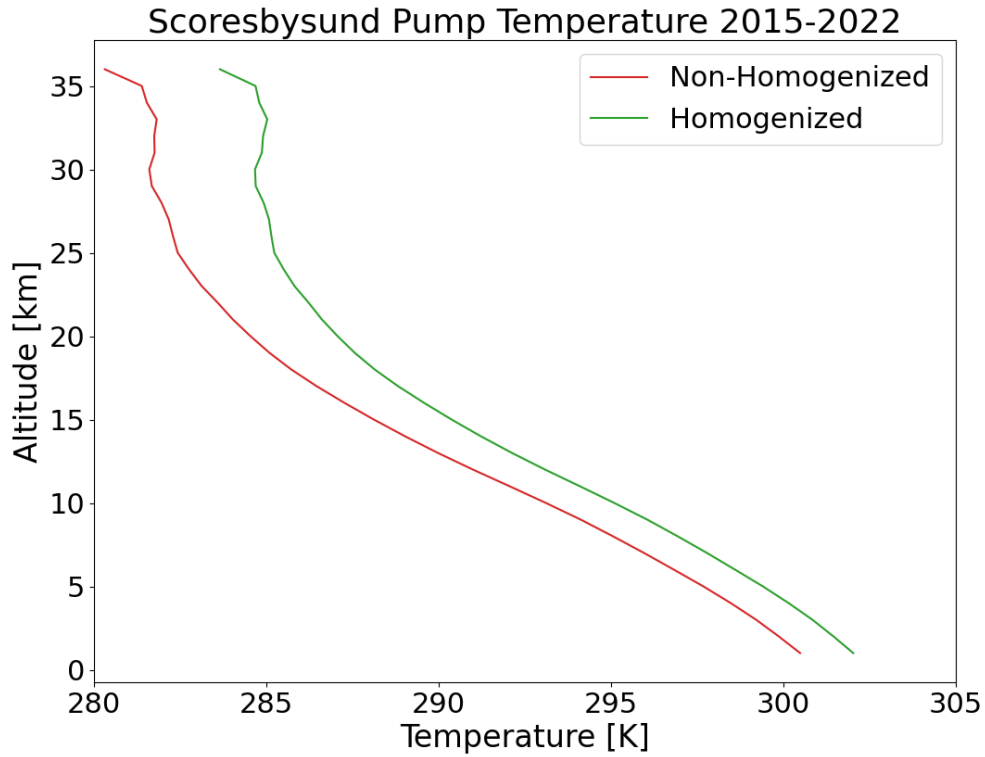
→ after 2015 ?

O3 drop in Scoresybsund

- O3 drop in higher altitudes independent of the homogenization process
- (also no change in sonde type)
- Checking pump temperatures:

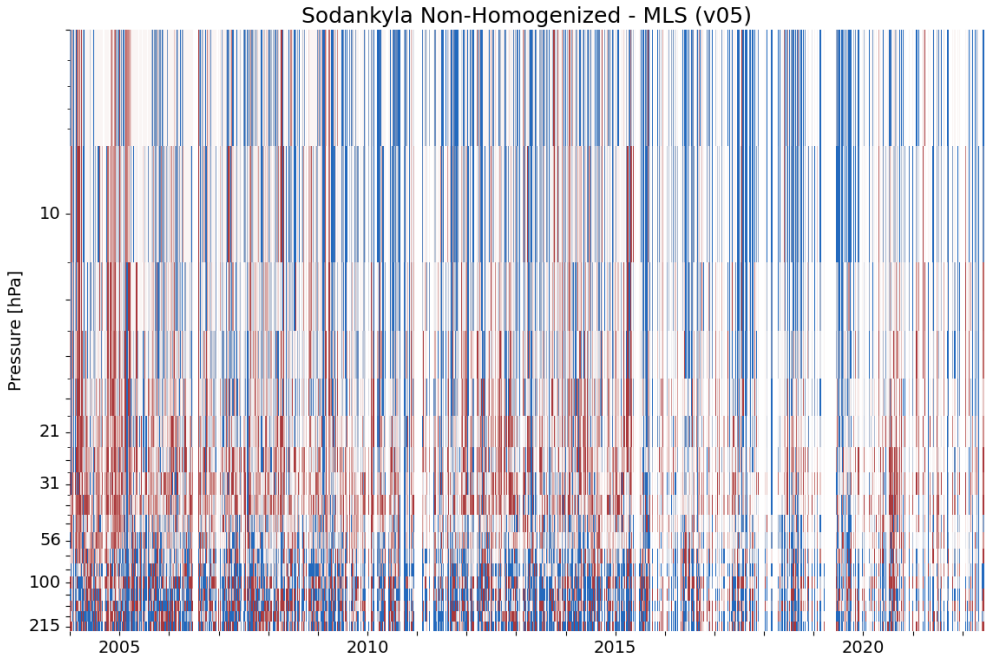
→ lower values after 2015: freezing of the solutions could be an explanation

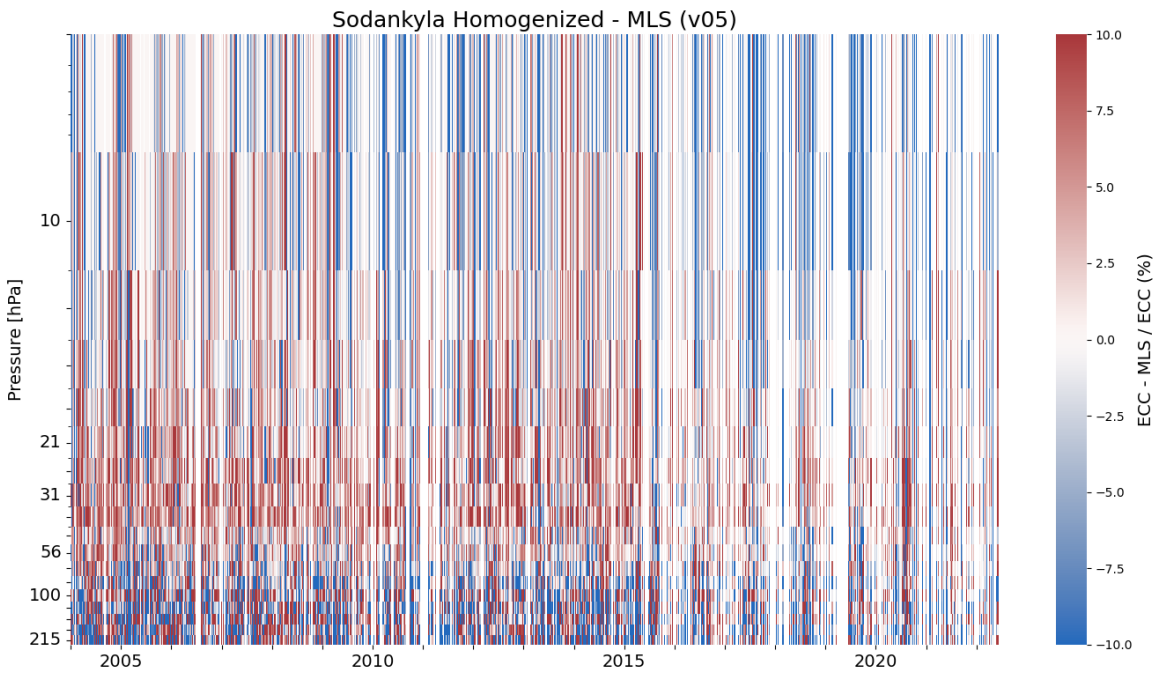




Inter-Comparison of Homogenized data:

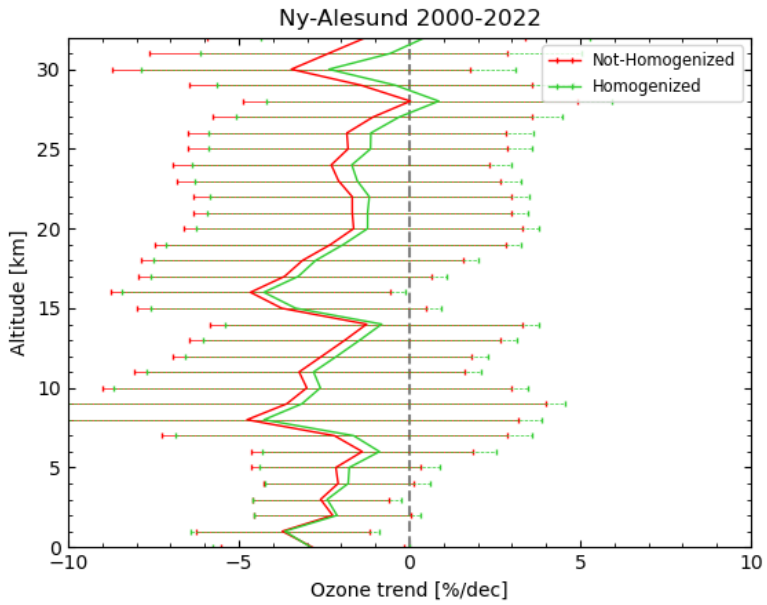
- Stratospheric ozonecomparison with respect to AURA-MLS

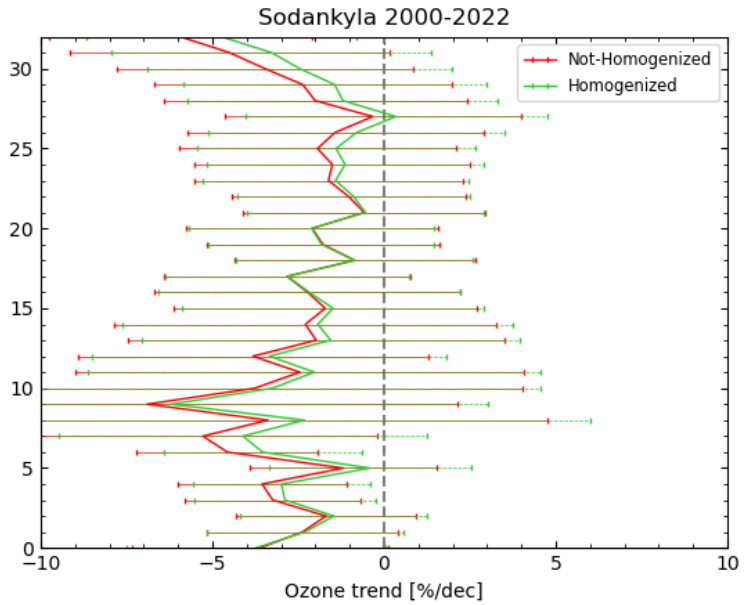


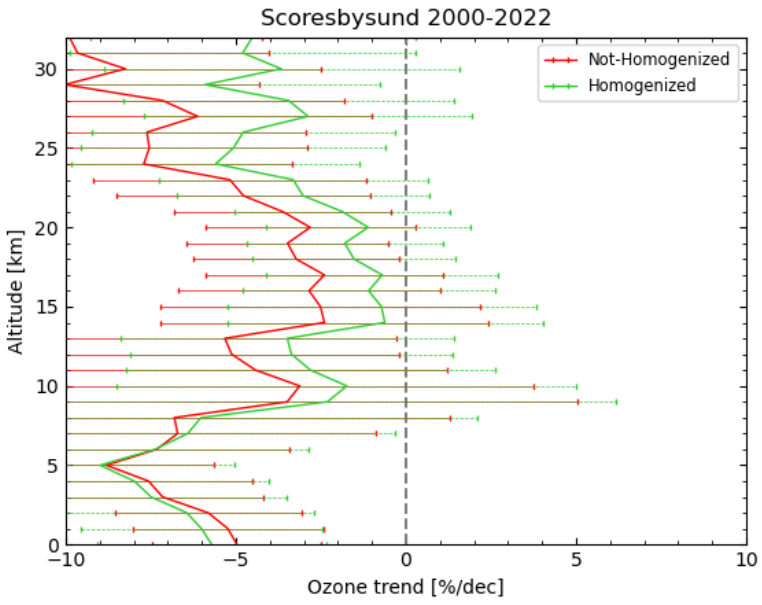


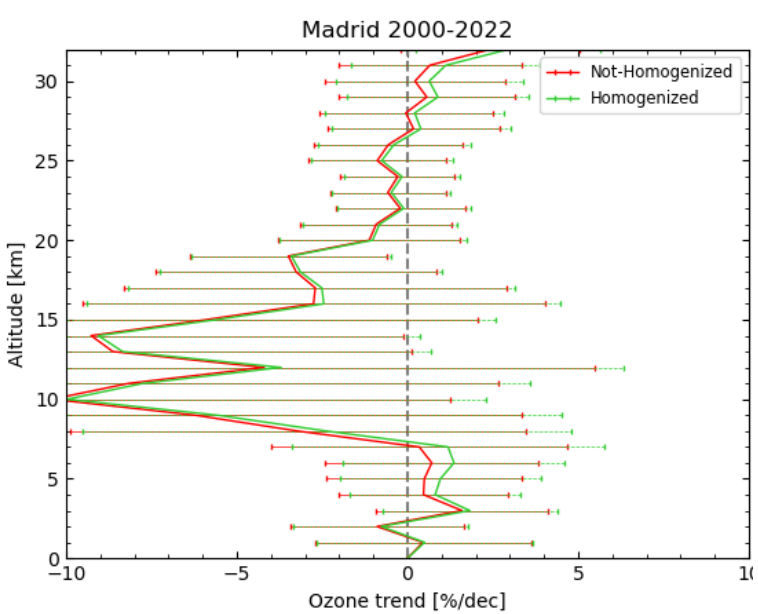
Trends of Homogenized data:

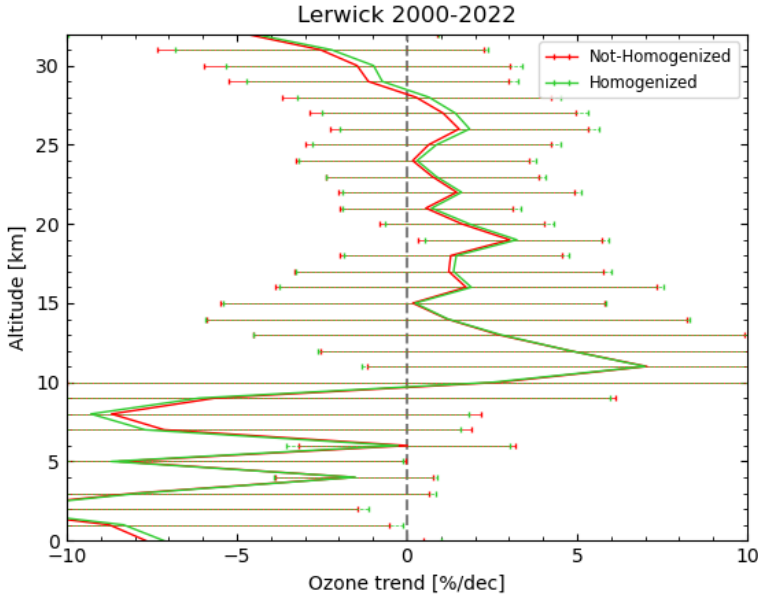
- Long-term Ozone Trends and Uncertainties in the Stratosphere (LOTUS) MLR is used
- O3 time series stars ~1995, looking only post 2000 trends

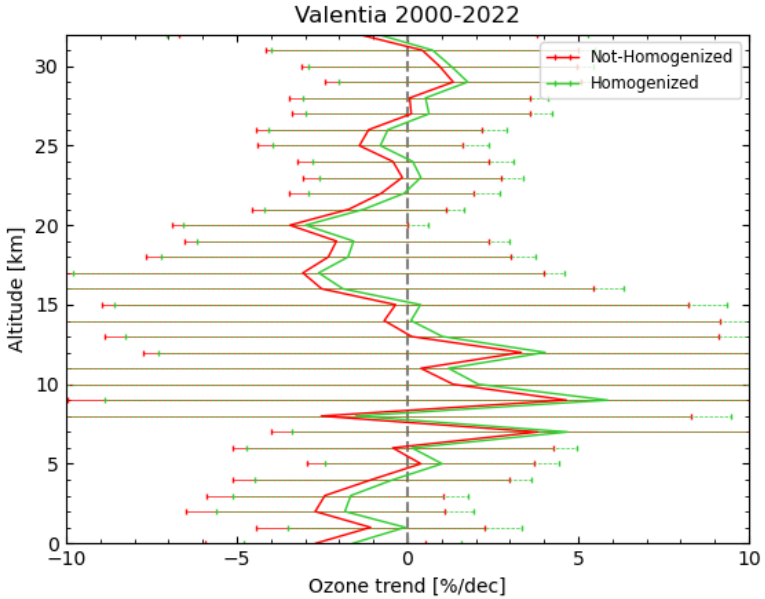


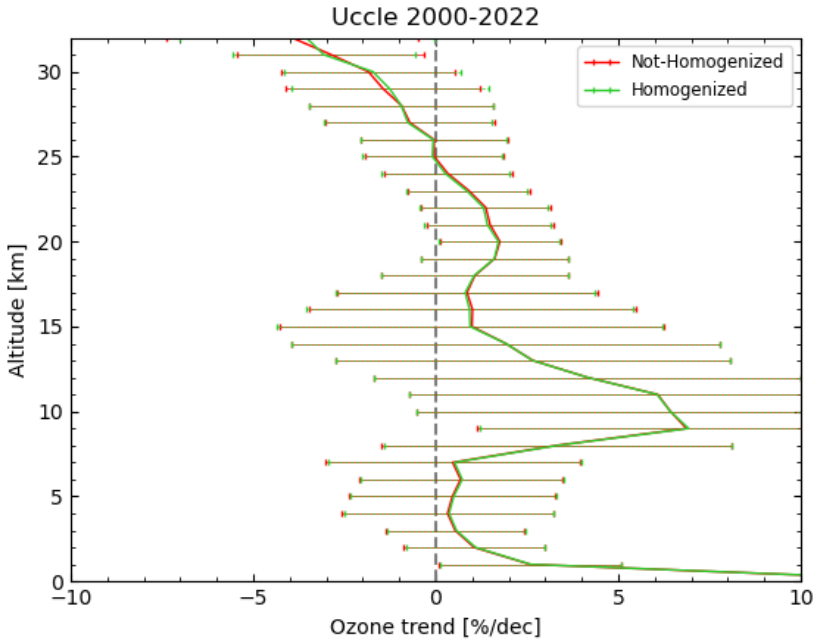


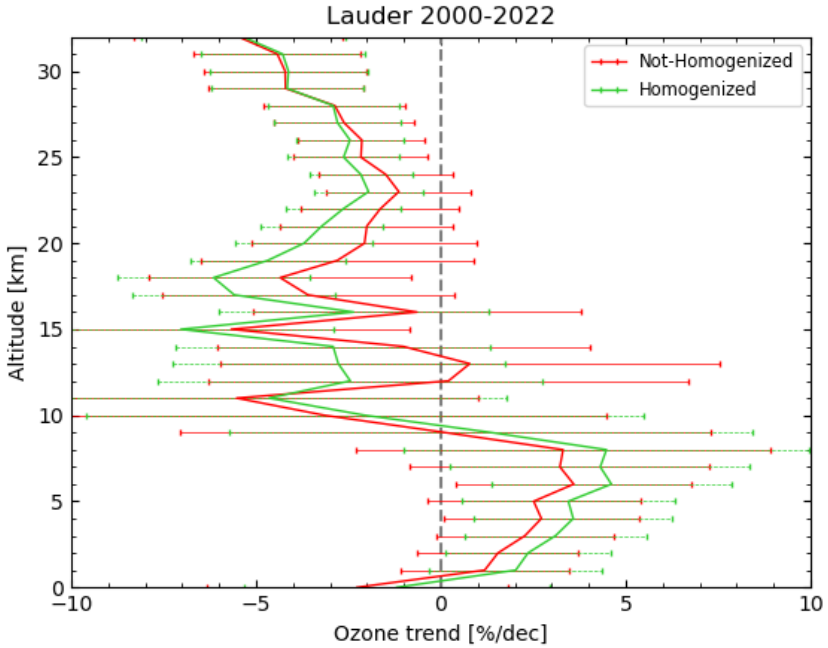



Madrid 2000-2022
Not-Homogenized
Homogenized
Altitude [km]
Ozone trend [%/dec]


Lerwick 2000-2022
Not-Homogenized
Homogenized
Altitude [km]
Ozone trend [%/dec]


Valentia 2000-2022
Not-Homogenized
Homogenized
Altitude [km]
Ozone trend [%/dec]

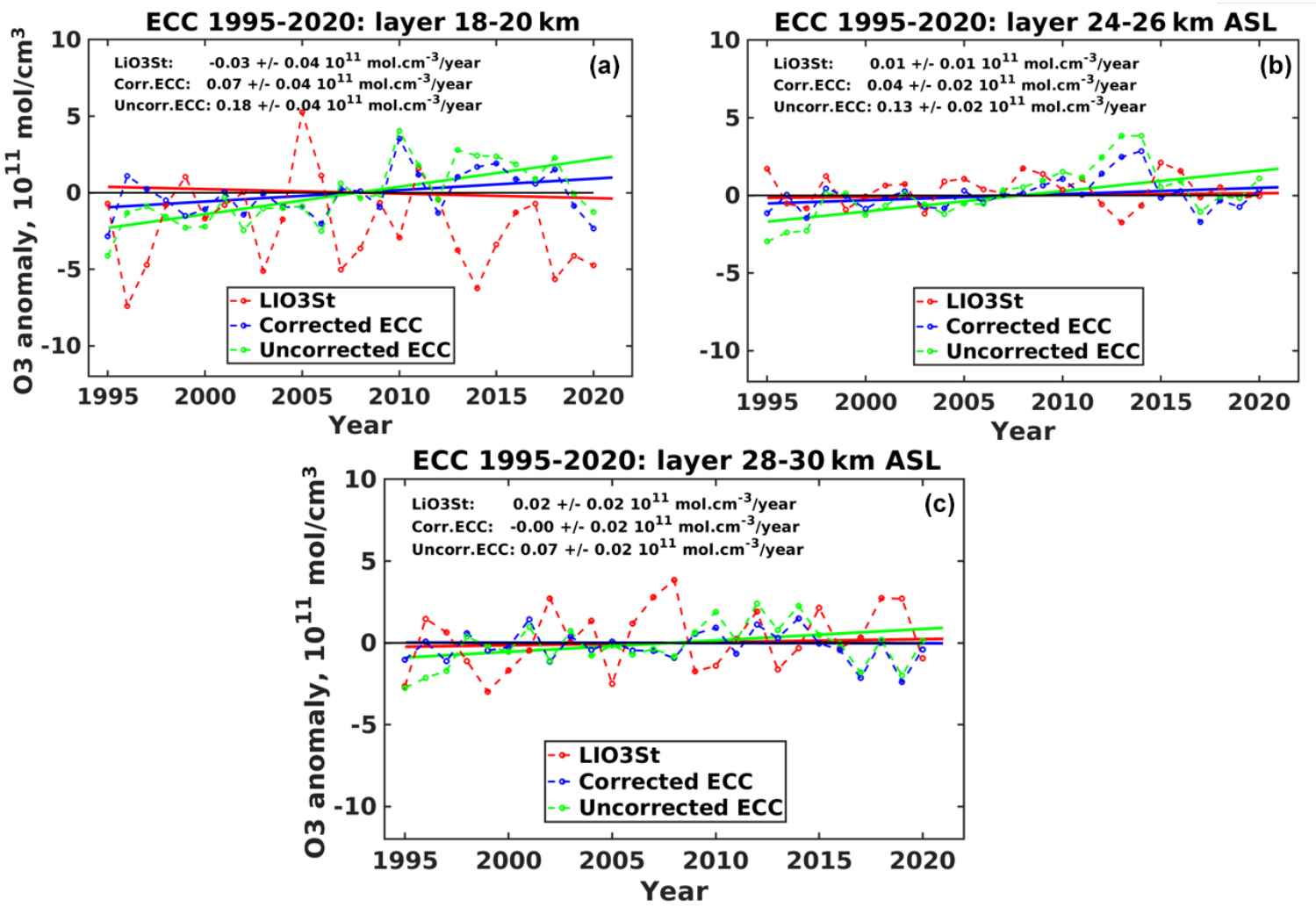

Uccle 2000-2022
Not-Homogenized
Homogenized
Altitude [km]
Ozone trend [%/dec]


Lauder 2000-2022
Not-Homogenized
Homogenized
Altitude [km]
Ozone trend [%/dec]

Other examples

OHP

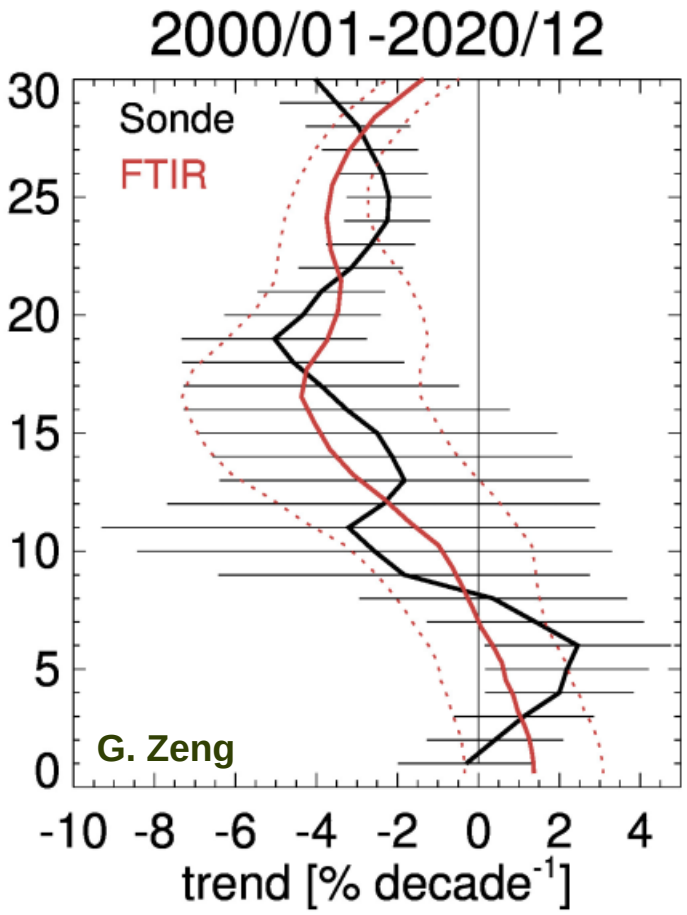
The homogenization greatly improved the stratospheric 30-year trend assessment, with a better agreement with the lidar trend analysis

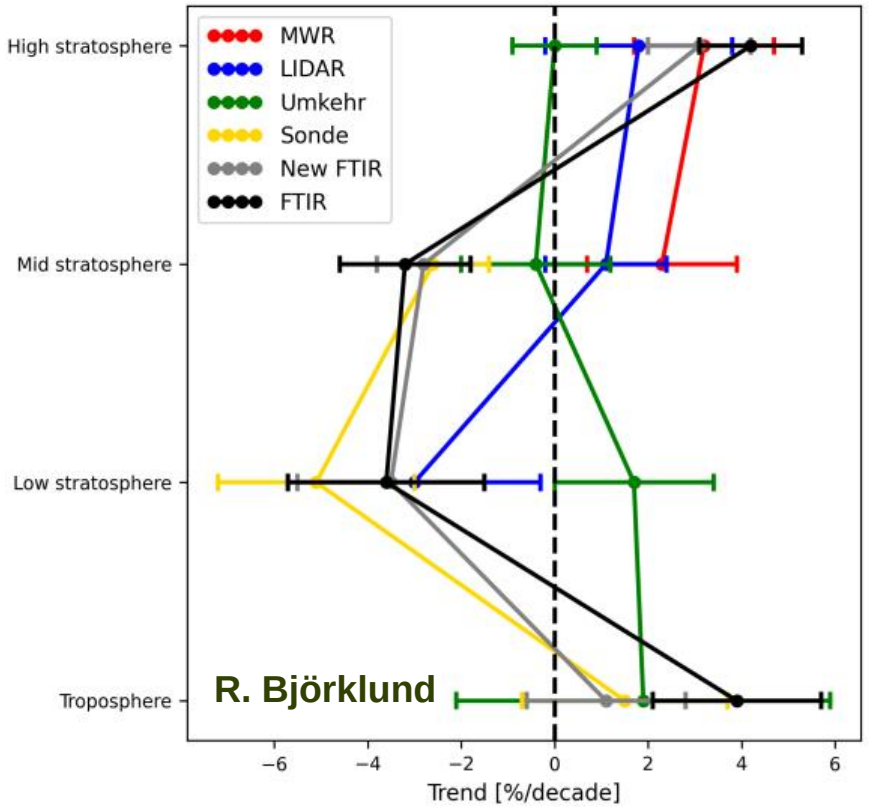


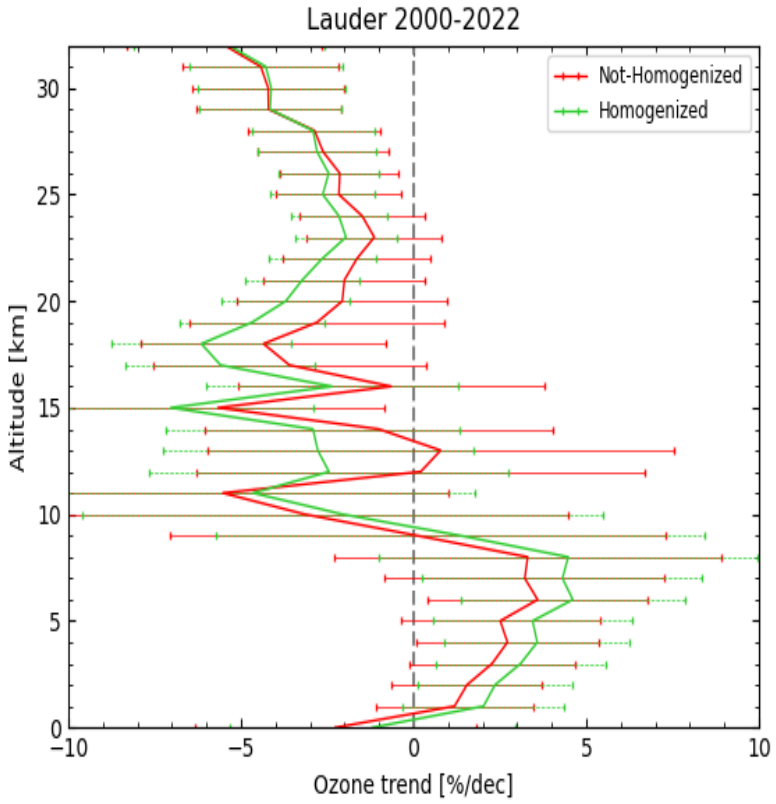
Ancellet et al., AMT, 2022

Other examples

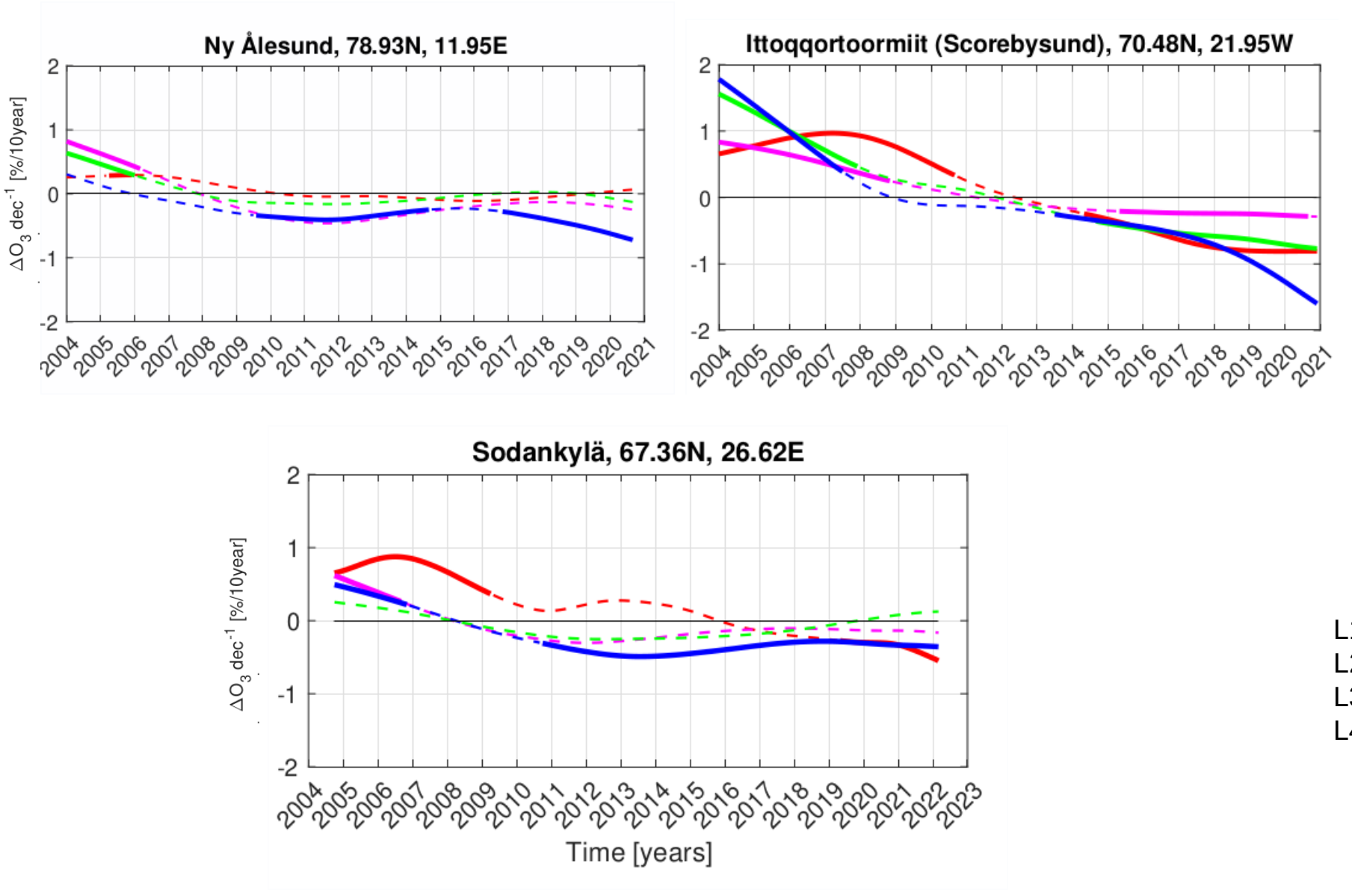
Lauder







Arctic stations

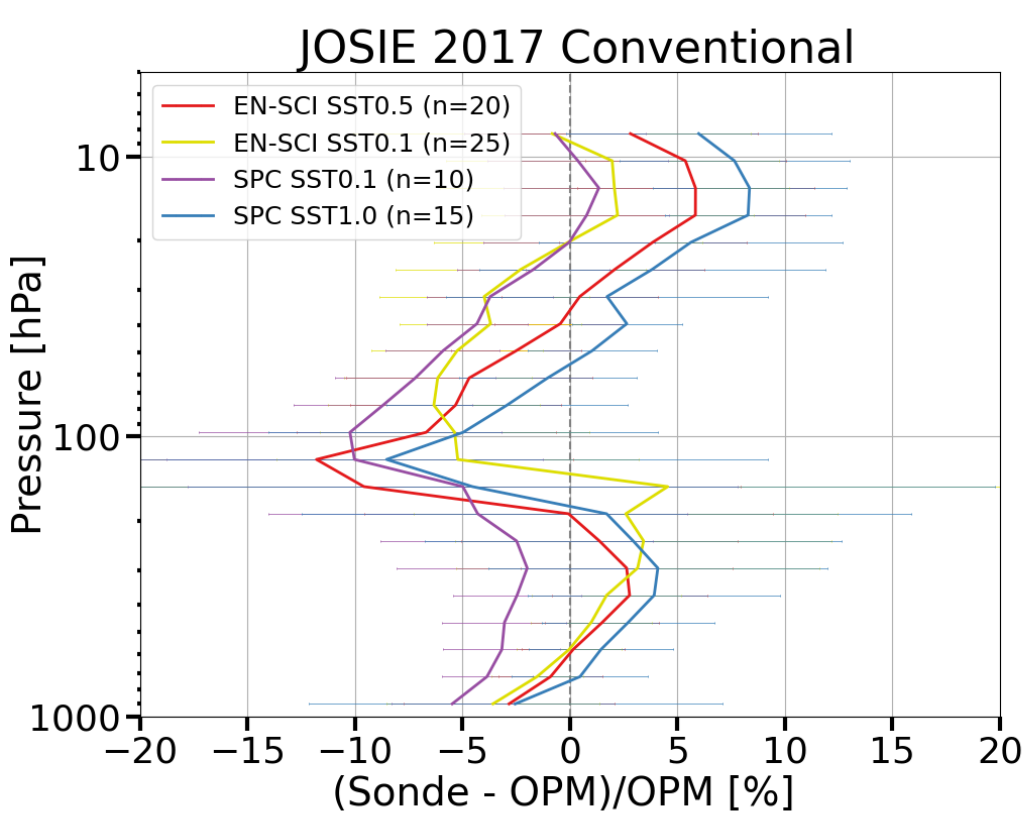


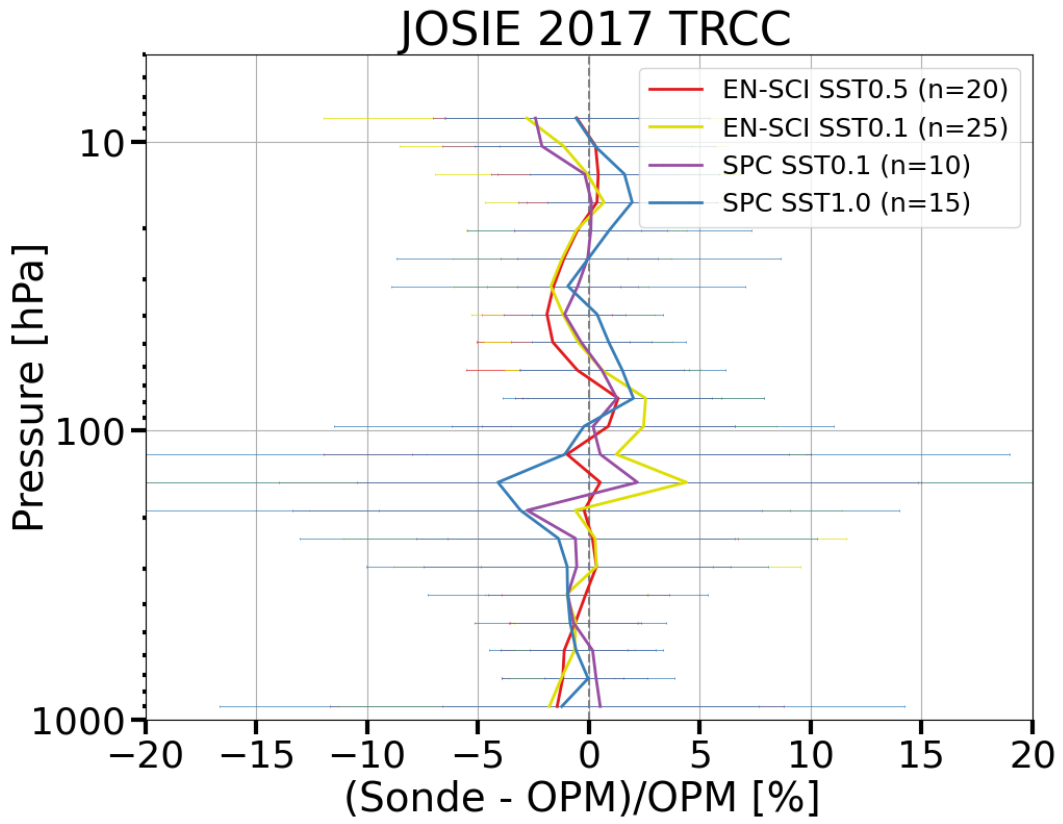
L1: 15 – 40 hPa
L2: 40- 150 hPa
L3: 150 hPa
L4: surface

K. Nilsen et al., submitted

Time Response Correction and Calibration (TRCC) method

- Homogenization → uniqueness among the ozonesonde time series
- TRCC → traceability to one ozone reference instrument: JOSIE ozone UV-photometer (WPM)
- Correcting for the slow and fast time responses of the ECC





Time Response Correction method

- Continuation of the work presented during RMI Seminar on 23/02/2021 :
- **“New insights in measuring ozone with ozonesondes from the Jülich Ozone Sonde Intercomparison Experiments”**

https://doi.org/10.5194/egusphere-2023-1466
Preprint. Discussion started: 14 July 2023

EGUsphere
Preprint repository

1 **New Insights From The Jülich Ozone-Sonde Intercomparison**
2 **Experiments: Calibration Functions Traceable To One Ozone Reference**
3 **Instrument**

4 Herman G.J. Smit[1], Deniz Poyraz[2], Roeland Van Malderen[2], Anne M. Thompson[3,4], David W. Tarasick[5], Ryan M.
5 Stauffer[3], Bryan J. Johnson[6], Debra E. Kollonige[3,7]

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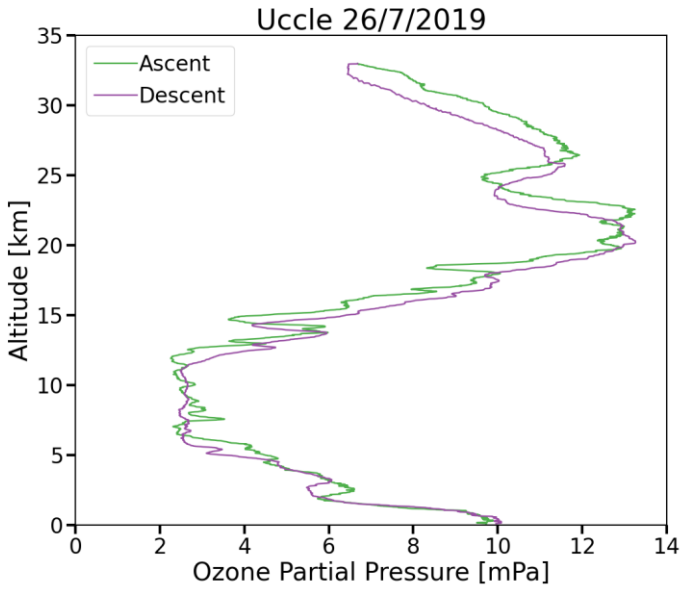
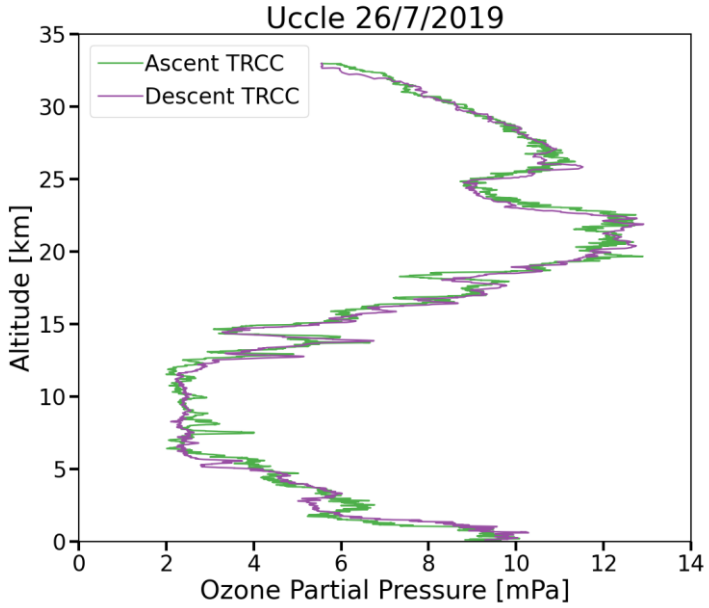
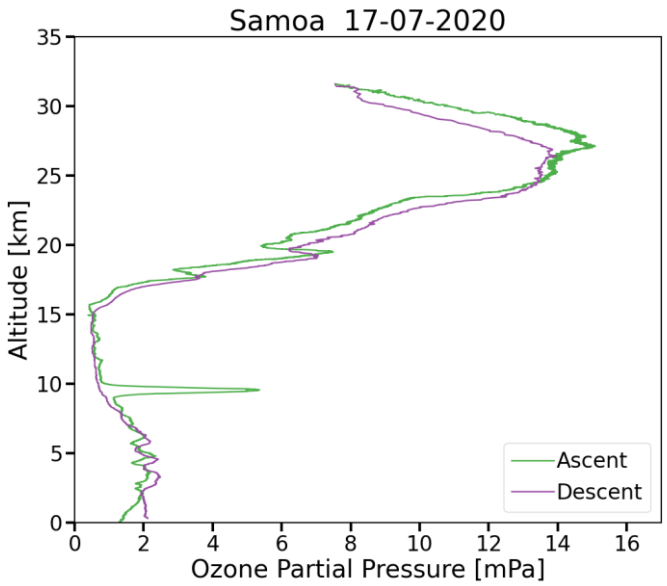
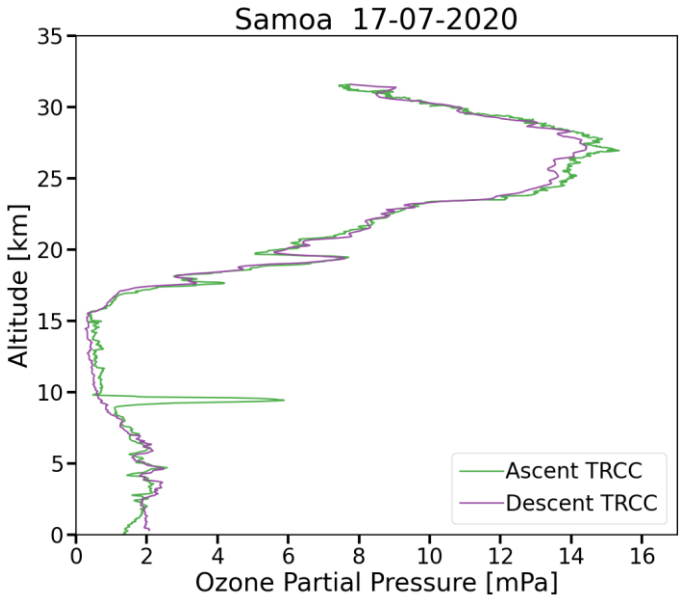
TRCC applied on station data









- remarkably improved agreement between ascent and descent profiles
- correction for fast time response component with TRCC
- also better agreement in ascent/descent profile shapes with TRCC

Conclusions and Outlook

- Homogenization of the most of the EU sites was missing and this is done by RMI
- 7 EU stations + Lauder
- Data is being use and overall homogenized data agrees better with other measurements
- Homogenization improves the overall data quality but do not solve all the problems
- Next step would be to apply TRCC on ozonesonde time series

Summary of my work at RMI

- Fifty years of balloon-borne ozone profile measurements at Uccle, Belgium: a short history, the scientific relevance, and the achievements in understanding the vertical ozone distribution: https://doi.org/10.5194/acp-21-12385-2021

Roeland Van Malderen, Dirk De Muer, Hugo De Backer, **Deniz Poyraz**, Willem W. Verstraeten, Veerle De Bock, Andy W. Delcloo, Alexander Mangold, Quentin Laffineur, Marc Allaart, Frans Fierens, and Valérie Thouret

- New Insights From The Jülich Ozone-Sonde Intercomparison Experiments: Calibration Functions Traceable To One Ozone Reference Instrument: https://doi.org/10.5194/egusphere-2023-1466

Herman G.J. Smit, **Deniz Poyraz**, Roeland Van Malderen, Anne M. Thompson, David W. Tarasick, Ryan M. Stauffer, Bryan J. Johnson, and Debra E. Kollonige

- Homogenization of the 7 EU stations + Lauder ozone sonde time-series:
  - Time-varying decadal trends from Arctic ozonesonde time series in the years 1994 to 2022

    K. Nilsen, , R. Kivi, M. Laine, R.V. Malderen, **D. Poyraz**, L. Thölix, P. von der Gathen, D. Tarasick, and N. Jepsen
  - Understanding vertically-resolved ozone changes at southern midlatitudes from the Lauder ozonesonde record

    Guang Zeng, Richard Querel, Hisako Shiona, Alex Geddes, Penny Smale, Roeland Van Malderen,**Deniz Poyraz,** Dan Smale, John Robinson, and Olaf Morgenstern
  - Intercomparison of long-term ground-based measurements of tropospheric and stratospheric ozone at Lauder

    Robin Björklund, Corinne Vigouroux, Peter Effertz, Omaira E. García, James Hannigan, Miyagawa Koji, Michael Kotkamp, Bavo Langerock, Gerald Nedoluha, Ivan Ortega, Irina Petropavlovskikh, **Deniz Poyraz**, Richard Querel, John Robinson, Hisako Shiona, Dan Smale, Penny Smale, Roeland Van Malderen, and Martine De Mazière

RMI

THANK YOU

Het Koninklijk Meteorologisch Instituut

L'Institut Royal Météorologique

Das Königliche Meteorologische Institut

The Royal Meteorological Institute

The RMI provides reliable public service realized by empowered staff and based on research, innovation and continuity.

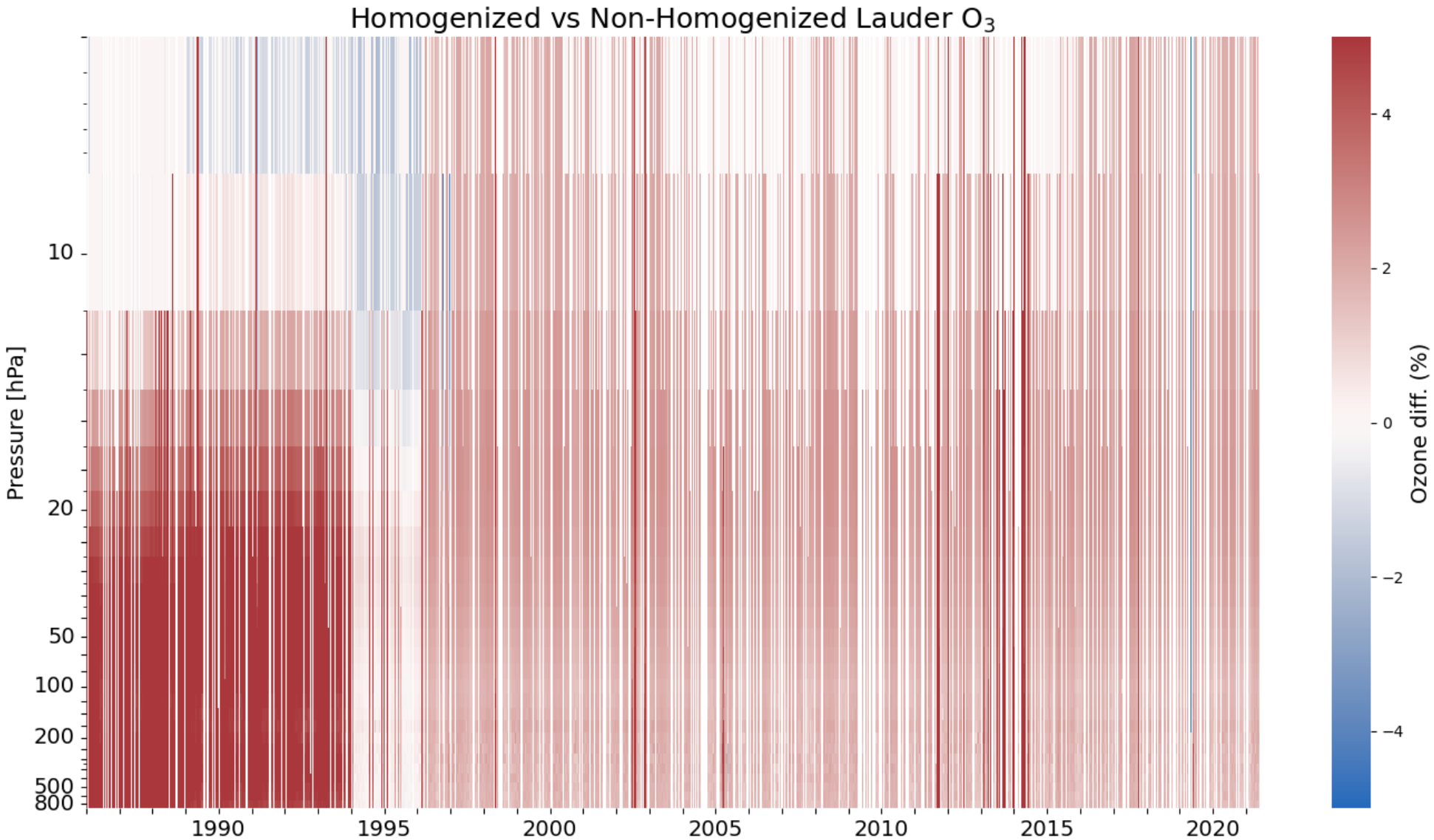
Het KMI verleent een betrouwbare dienstverlening aan het publiek en de overheid gebaseerd op onderzoek, innovatie en continuïteit.

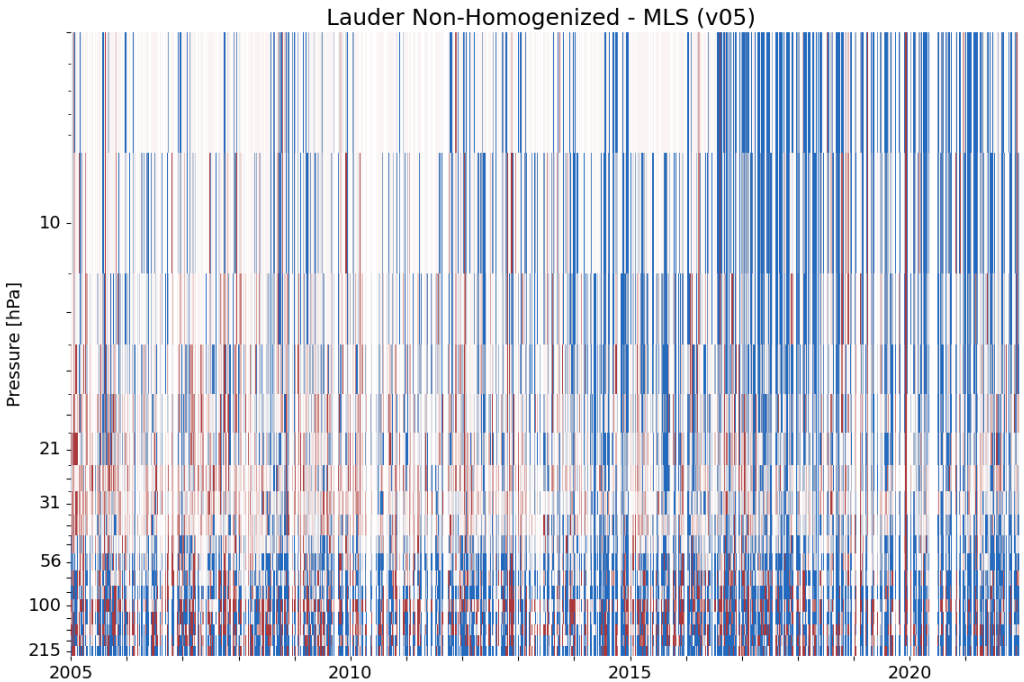
L'IRM fournit un service fiable basé sur la recherche, l'innovation et la continuité au public et aux autorités.

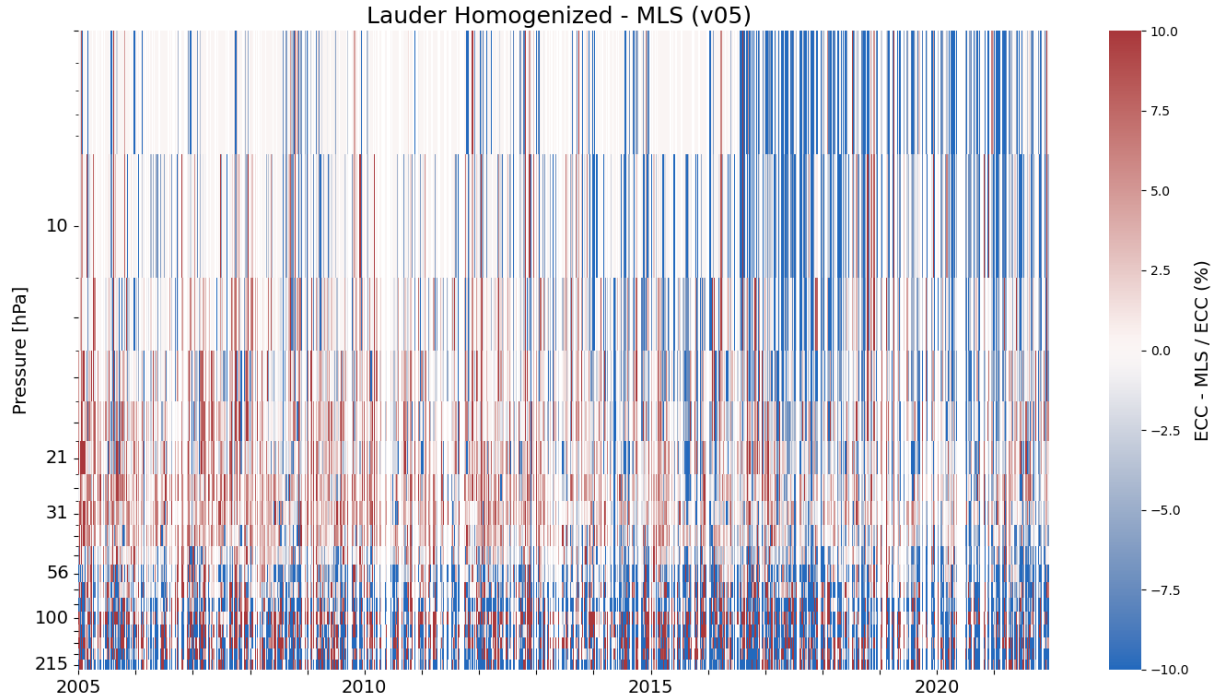
Vertrauenswürdige Dienstleistungen für Öffentlichkeit und Behörden begründet auf Forschung, Innovation und Kontinuität.

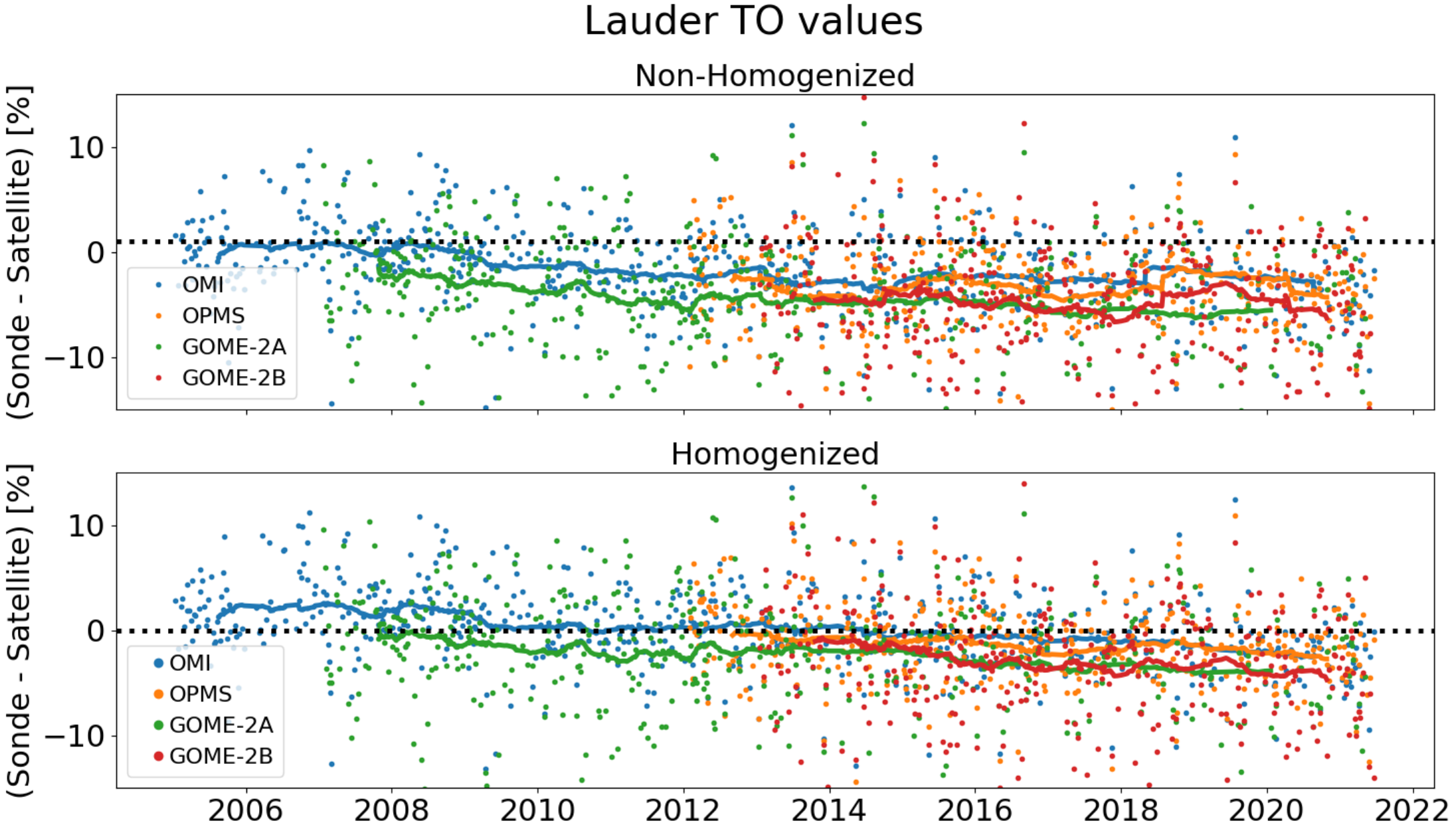
RMI

Extra Plots

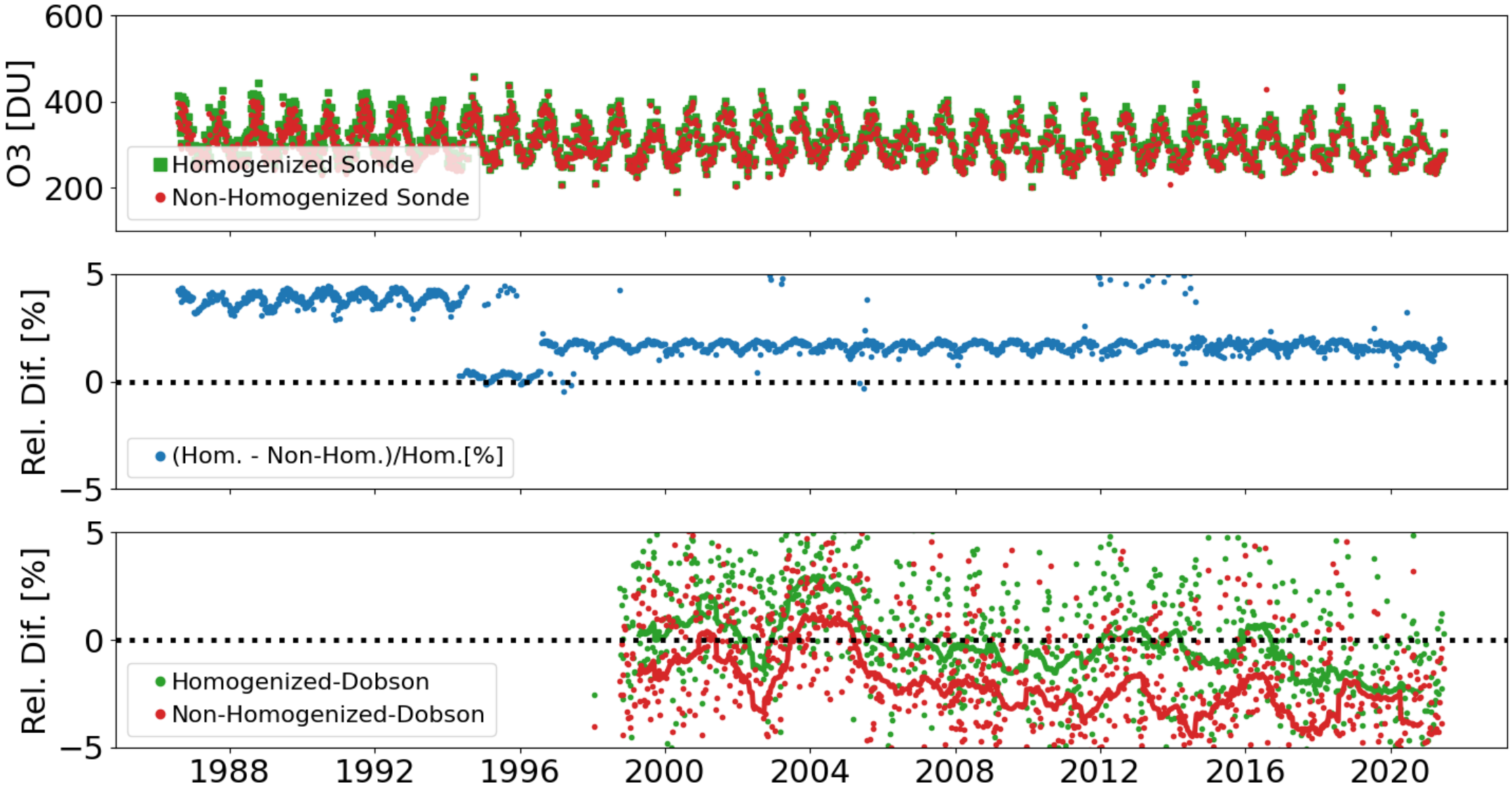

Homogenized vs Non-Homogenized Lauder O_3
Pressure [hPa]
10
20
50
100
200
500
800
1990
1995
2000
2005
2010
2015
2020
Ozone diff. (%)
4
2
0
−2
−4

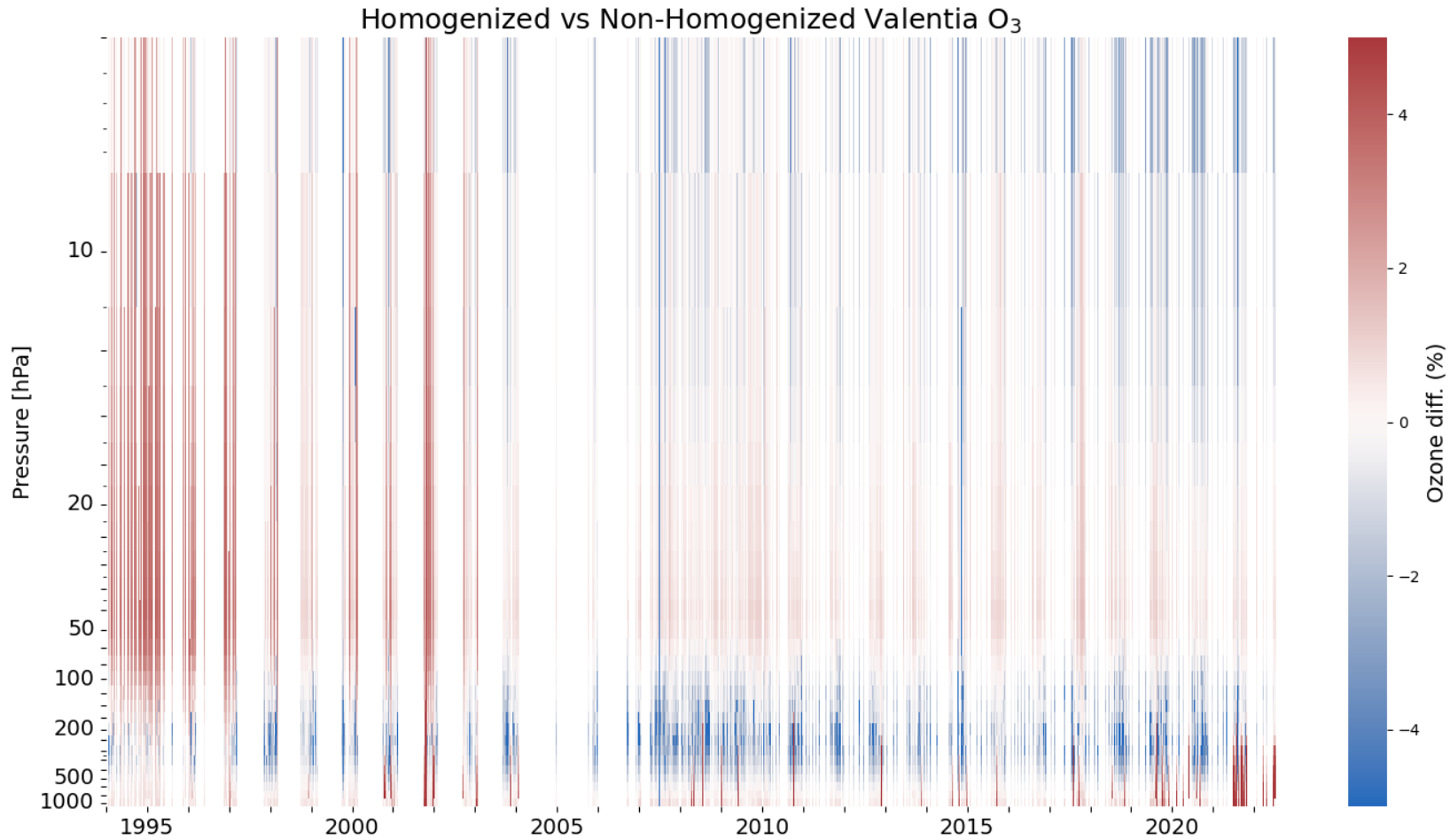

Lauder Non-Homogenized - MLS (v05)
Pressure [hPa]
10
21
31
56
100
215
2005
2010
2015
2020

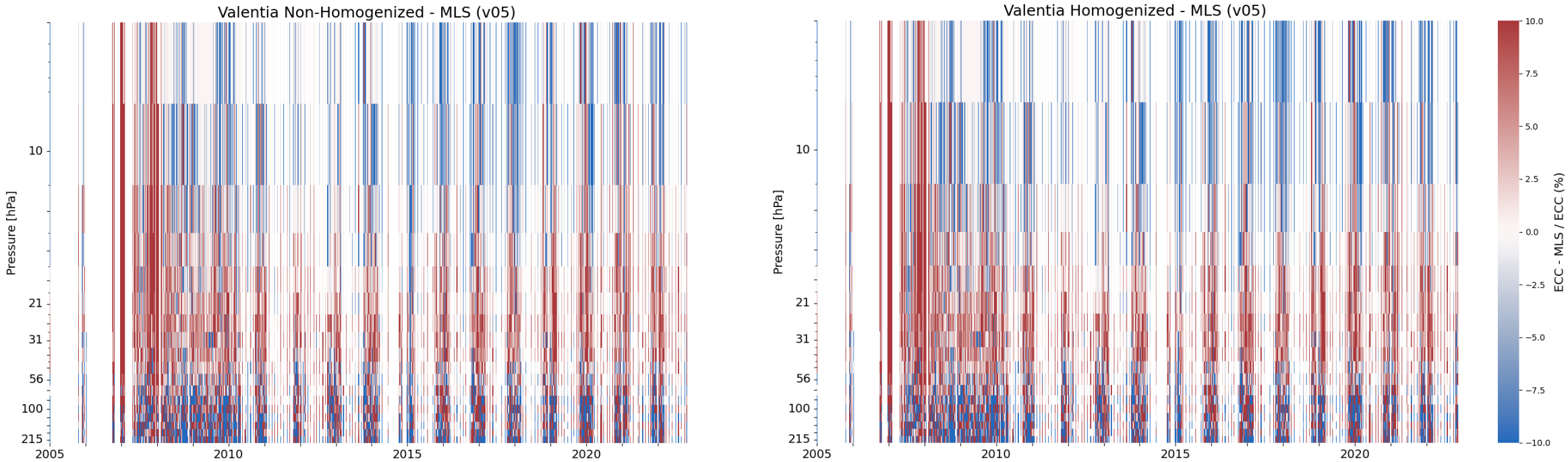

Lauder Homogenized - MLS (v05)
Pressure [hPa]
10
21
31
56
100
215
2005
2010
2015
2020
ECC - MLS / ECC (%)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0

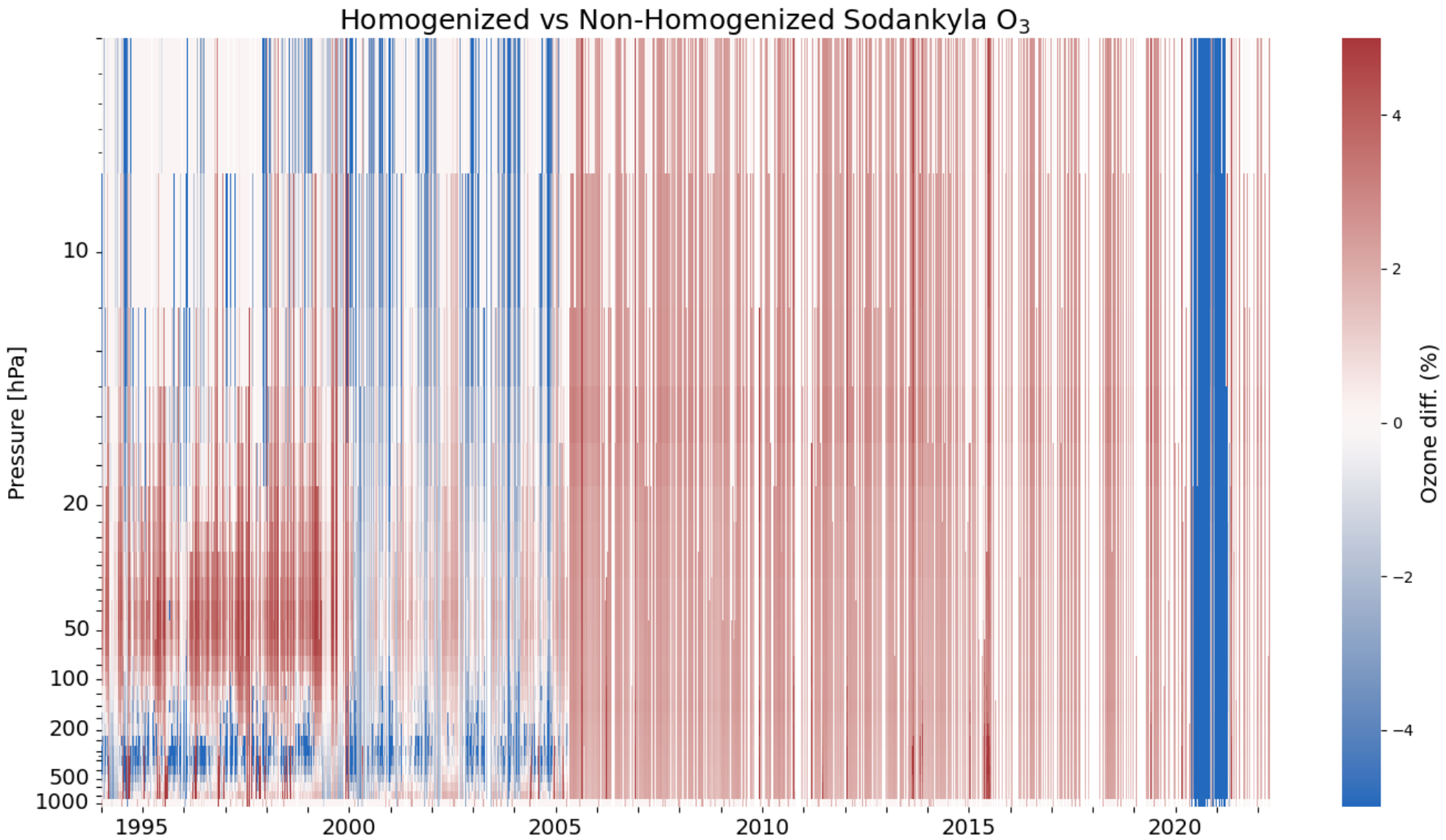

Lauder TO values
Non-Homogenized
Homogenized
(Sonde - Satellite) [%]
10
0
−10
OMI
OPMS
GOME-2A
GOME-2B
2006
2008
2010
2012
2014
2016
2018
2020
2022

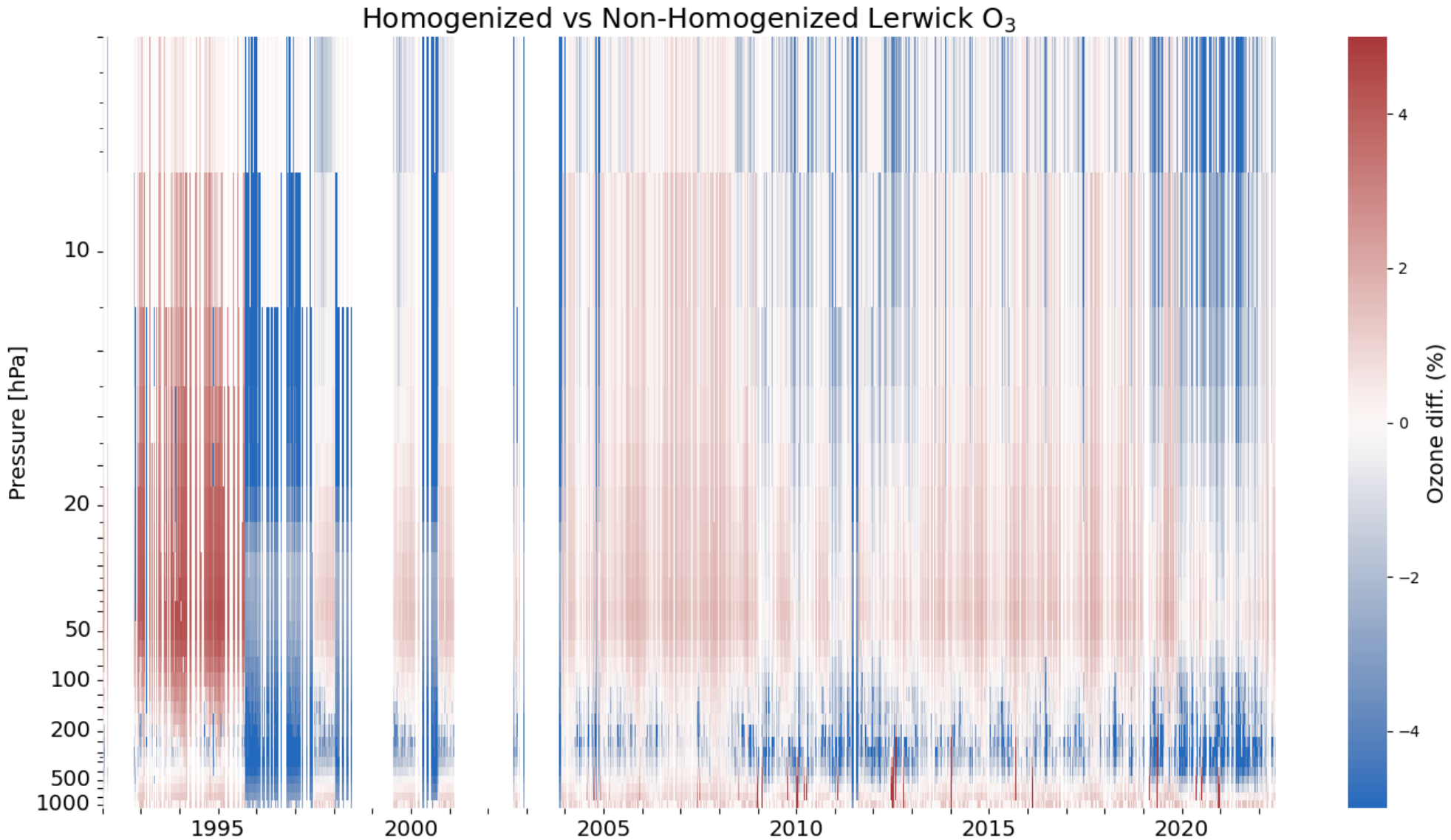
Lauder TO values

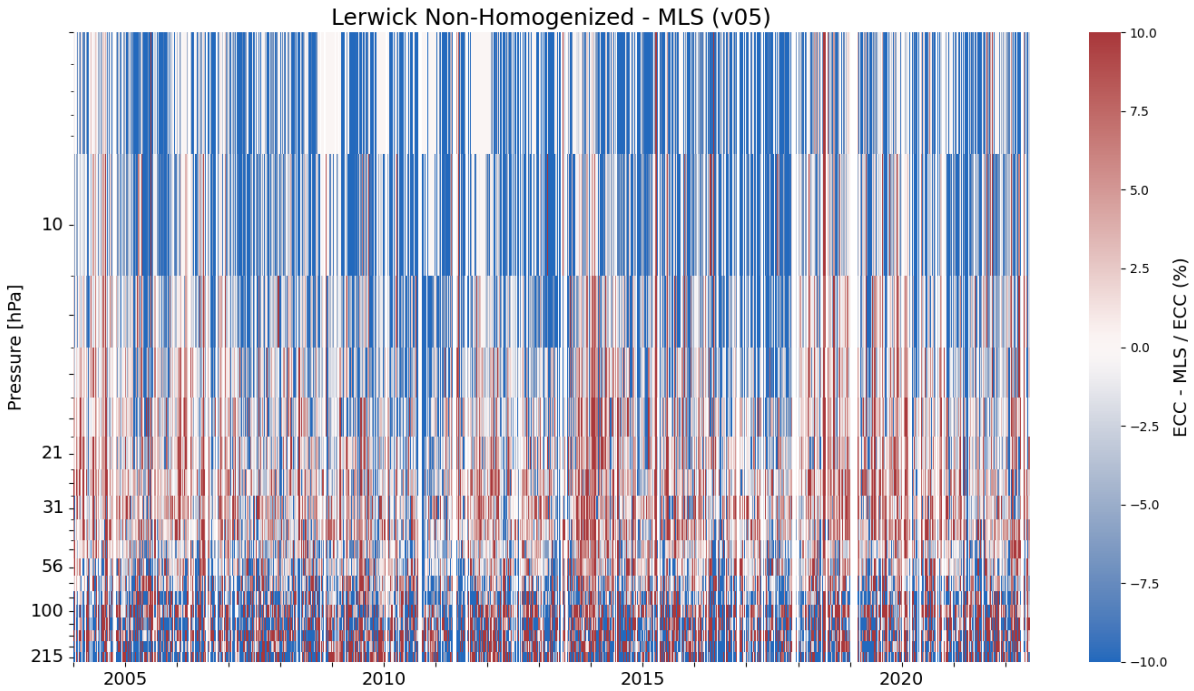


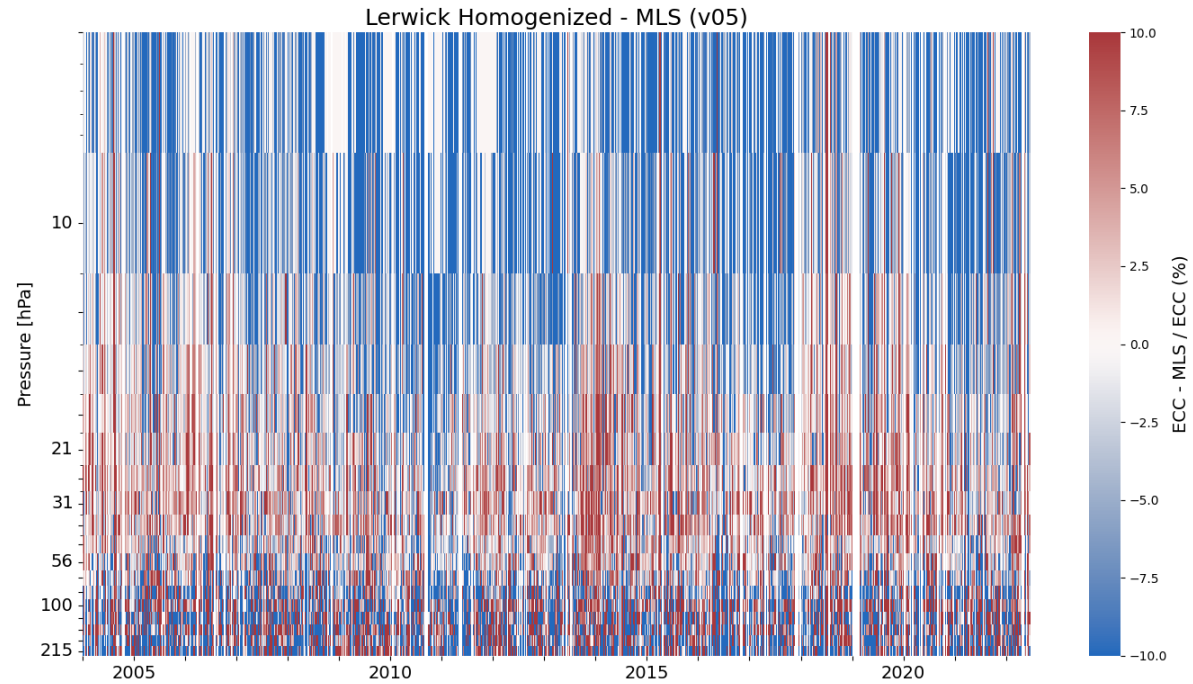

Homogenized vs Non-Homogenized Valentia O_3
Pressure [hPa]
10
20
50
100
200
500
1000
1995
2000
2005
2010
2015
2020
Ozone diff. (%)
4
2
0
−2
−4


Valentia Non-Homogenized - MLS (v05)
Valentia Homogenized - MLS (v05)
Pressure [hPa]
10
21
31
56
100
215
2005
2010
2015
2020
ECC - MLS / ECC (%)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0


Homogenized vs Non-Homogenized Sodankyla O_3
Pressure [hPa]
10
20
50
100
200
500
1000
1995
2000
2005
2010
2015
2020
Ozone diff. (%)
4
2
0
−2
−4


Homogenized vs Non-Homogenized Lerwick O_3
Pressure [hPa]
10
20
50
100
200
500
1000
1995
2000
2005
2010
2015
2020
Ozone diff. (%)
4
2
0
−2
−4


Lerwick Non-Homogenized - MLS (v05)
Pressure [hPa]
10
21
31
56
100
215
2005
2010
2015
2020
ECC - MLS / ECC (%)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0


Lerwick Homogenized - MLS (v05)
Pressure [hPa]
10
21
31
56
100
215
2005
2010
2015
2020
ECC - MLS / ECC (%)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0