

Observed free tropospheric ozone changes and their attribution through model simulations

Ground-Based Observations: W. Steinbrecht, D. Kubistin, C.

Plass-Dülmer, J. Davies, D.W. Tarasick, P. von der Gathen, H. Deckelmann, N. Jepsen, R. Kivi, N. Lyall, M. Palm, J. Notholt, B. Kois, P. Oelsner, M. Allaart, A. Piters, M. Gill, R. Van Malderen, A.W. Delcloo, R. Sussmann, E. Mahieu, C. Servais, G. Romanens, R. Stübi, G. Ancellet, S. Godin-Beekmann, S. Yamanouchi, K. Strong, B. Johnson, P. Cullis, I. Petropavlovskikh, J. Hannigan, J.-L. Hernandez, A. Diaz Rodriguez, T. Nakano, F. Chouza, T. Leblanc, C. Torres, O. Garcia, A. Röhling, M. Schneider, T. Blumenstock, M. Tully, C. Paton-Walsh, N. Jones, R. Querel, S. Strahan, R.M. Stauffer, A.M. Thompson, A. Inness, R. Engelen, K.-L. Chang, O.R. Cooper, GRL paper:
<https://doi.org/10.1029/2020GL091987>

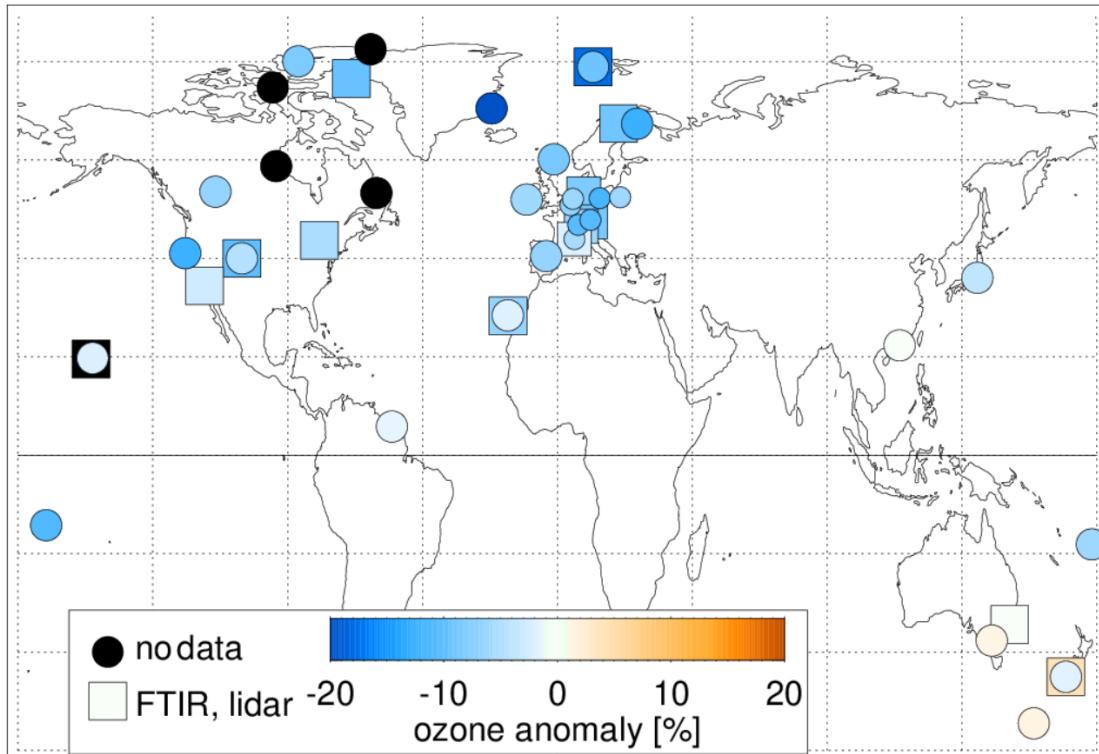
Satellite Observations: Ziemke et al., Miyazaki et al.

NCAR / MPI Modelling: G. Brasseur, I. Bouarar, B. Gaubert, ...



free troposphere ozone anomaly 2020

ozone anomaly [%], 2020, Apr to Aug, 1 to 8 km



- ~45 stations / instruments
- Sondes
- 11 FTIRs
- 2 lidars
- reasonably fast data delivery (NILU, WOUDC, NDACC)

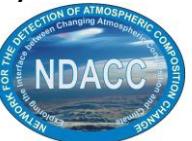


WMO



GAW

Government of Canada
Gouvernement du Canada
World Ozone and Ultraviolet
Radiation Data Centre



06/2021

FEHPC

Satellites saw it too!

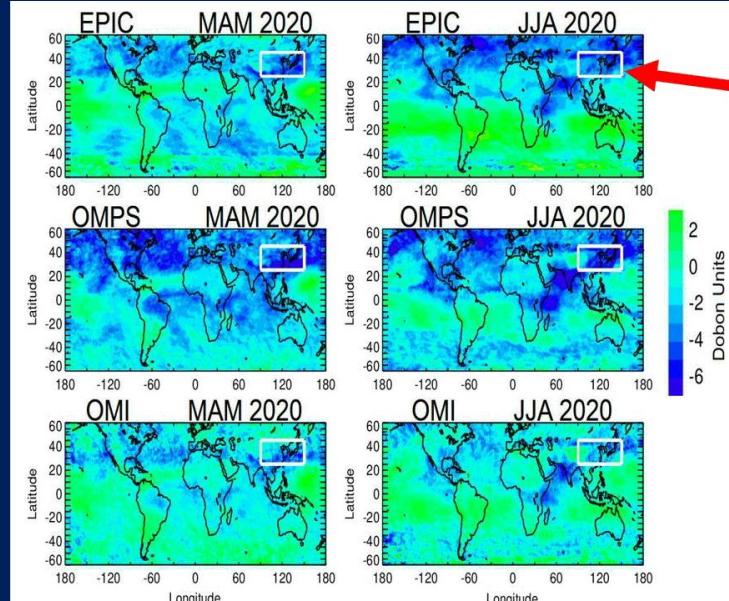
Total O₃ – strat.

EPIC–MERRA2

OMPS-MERRA2

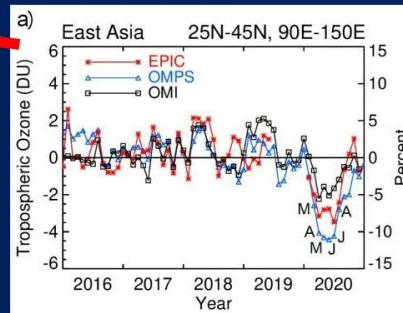
OMI - MLS

Regional Patterns of the NH Tropospheric Ozone Reductions in 2020



(Anomalies: Relative to 2016-2019 Average Fields

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Compare: Steinbrecht et al. (2021, GRL) found about 7% reduction of ozone throughout the NH free troposphere in spring-summer 2020 from ozonesondes and lidar

Ziemke et al.,
CEOS AC-VC 17,
June 9 2021



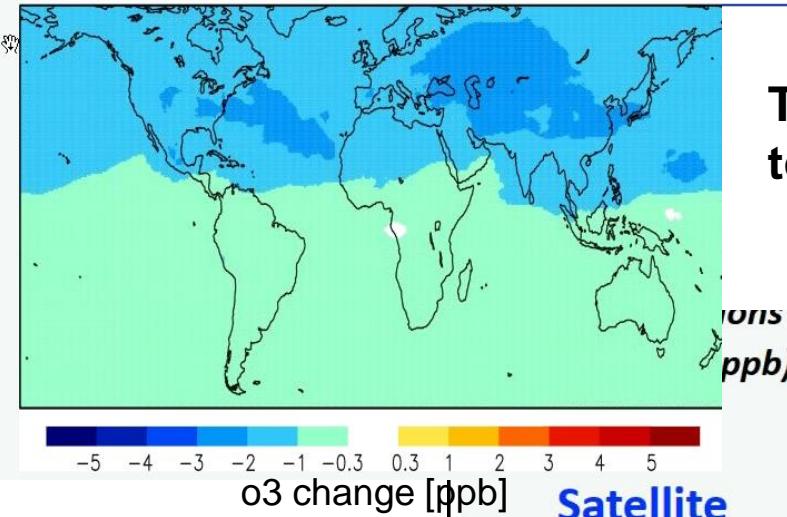
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JPL MOMO model + CrIS

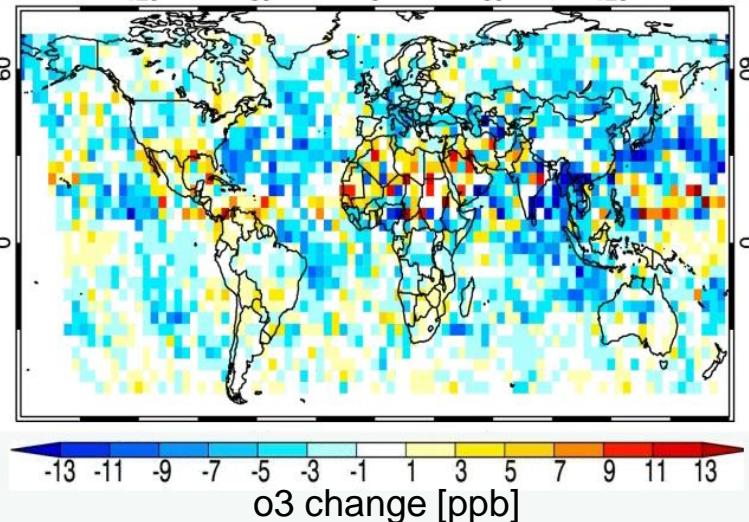
Model
simulation

Figure:
500 hPa ozone
changes due to
COVID-19 NO_x



Tropospheric ozone response
to COVID-19 (May 2020)

Satellite
CrIS ozone



Miyazaki et al.,
CEOS AC-VC 17,
June 9 2021

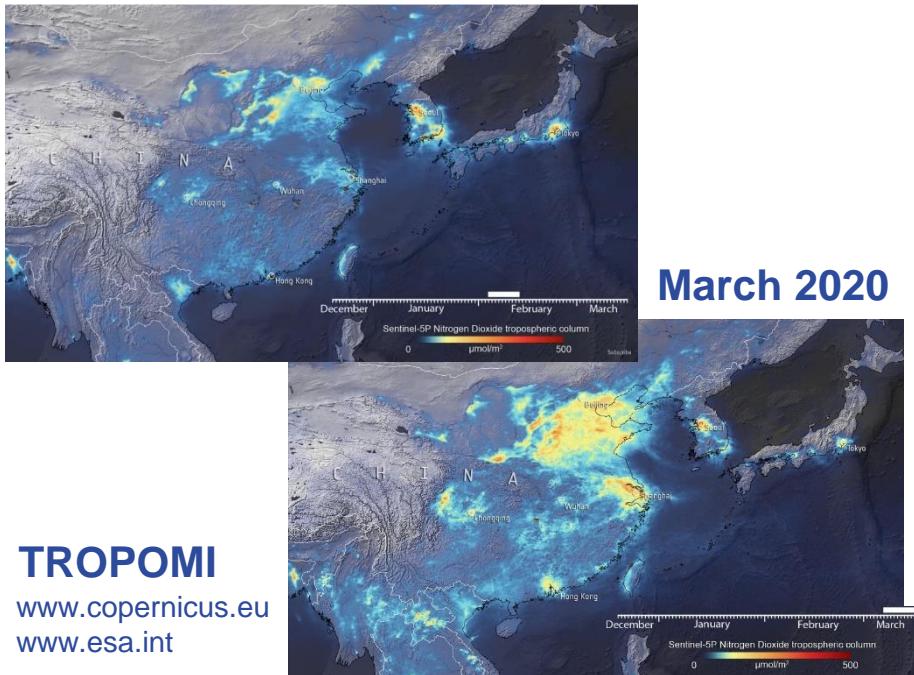


06/2021

Miyazaki et al., Sci. Adv. 2021; 7 : eabf7460, 2021

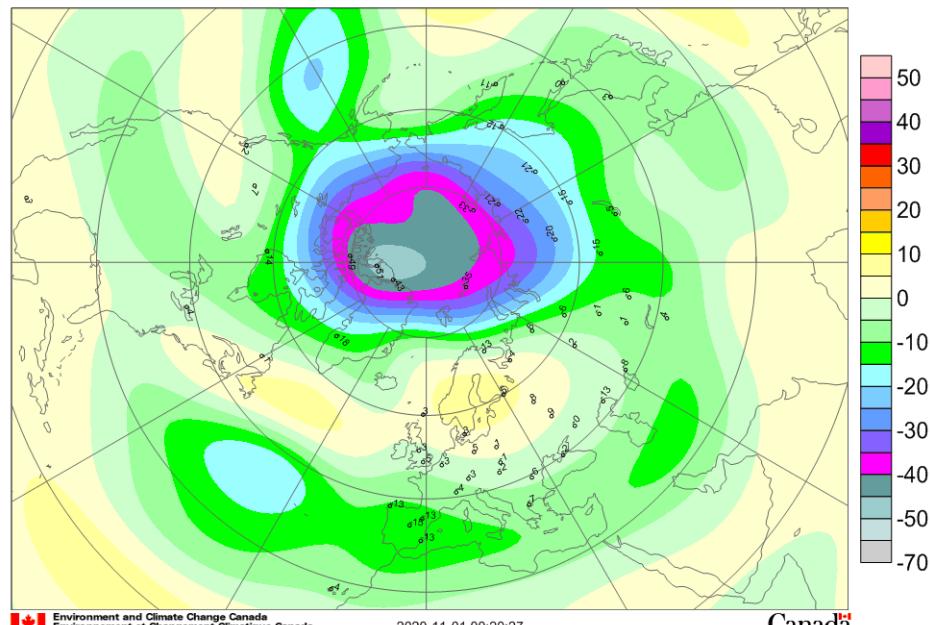
Different in 2020

1.) reduced emission due to COVID-19 NO₂ over China, Feb. 2020 (lockdown)

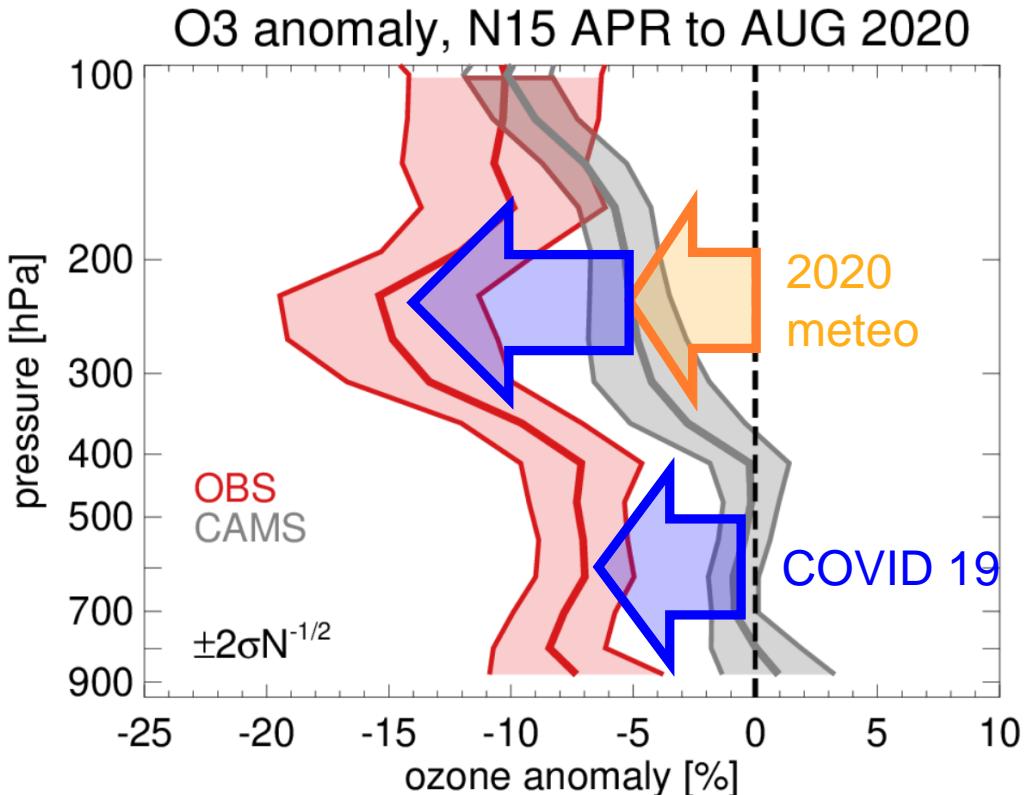


2.) 2020 Arctic “ozone hole”

Mean deviation (%), 2020/03/01-2020/03/31



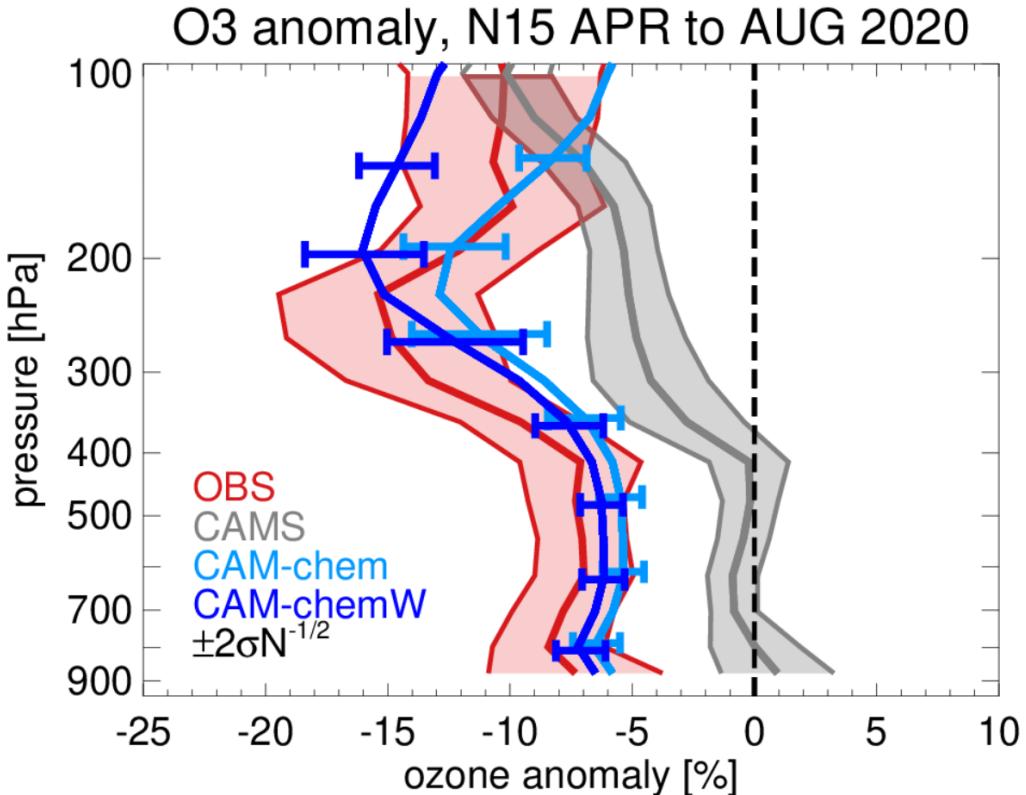
2020 anomalies, vertical profile



- 2020 ozone hole + meteo conditions above 400hPa
- COVID-19 emission reductions below 200 hPa

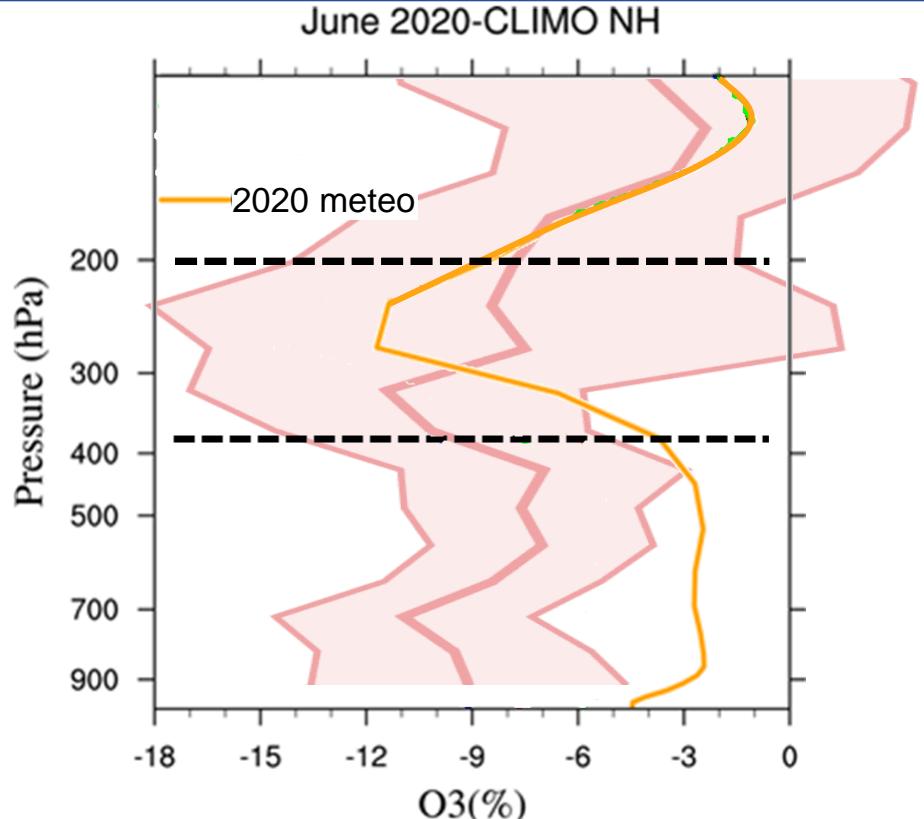
CAMS = Copernicus Atmosphere Monitoring Service = ECMWF + chemistry
2020 meteorology, incl. O₃ hole but “normal” emissions

Vertical Profile, also NCAR simulations

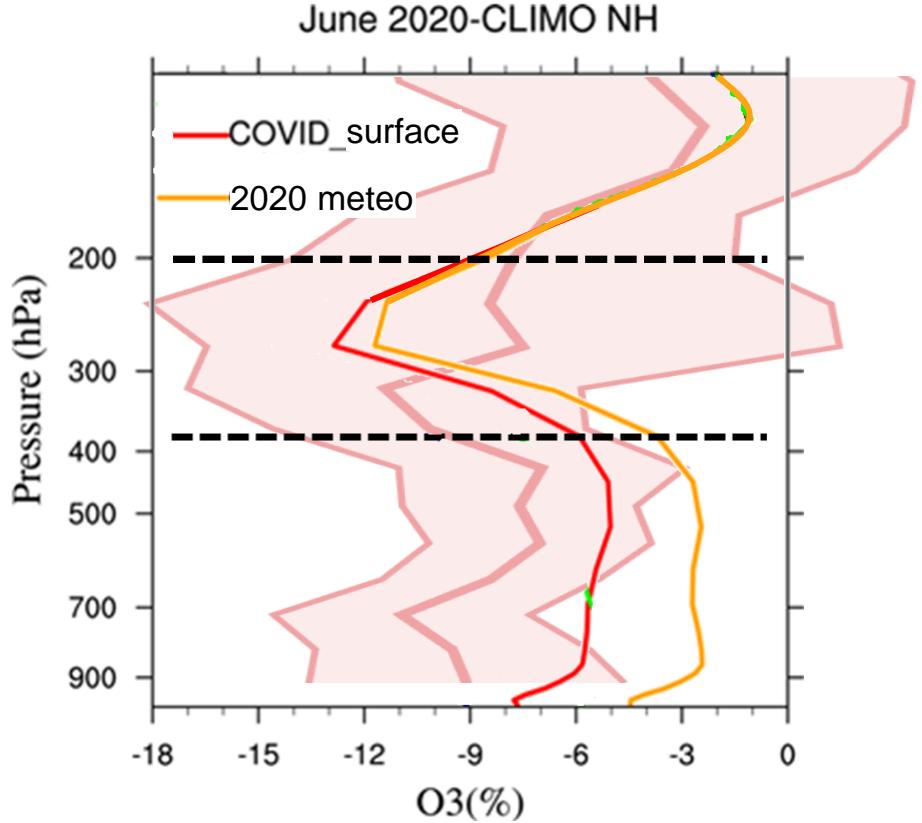


- 2020 ozone hole + meteo conditions above 400hPa
- COVID-19 emission reductions below 200 hPa
- CAM-chem consistent with OBS
- CAM-chemW better ozone hole: -1% trop O3

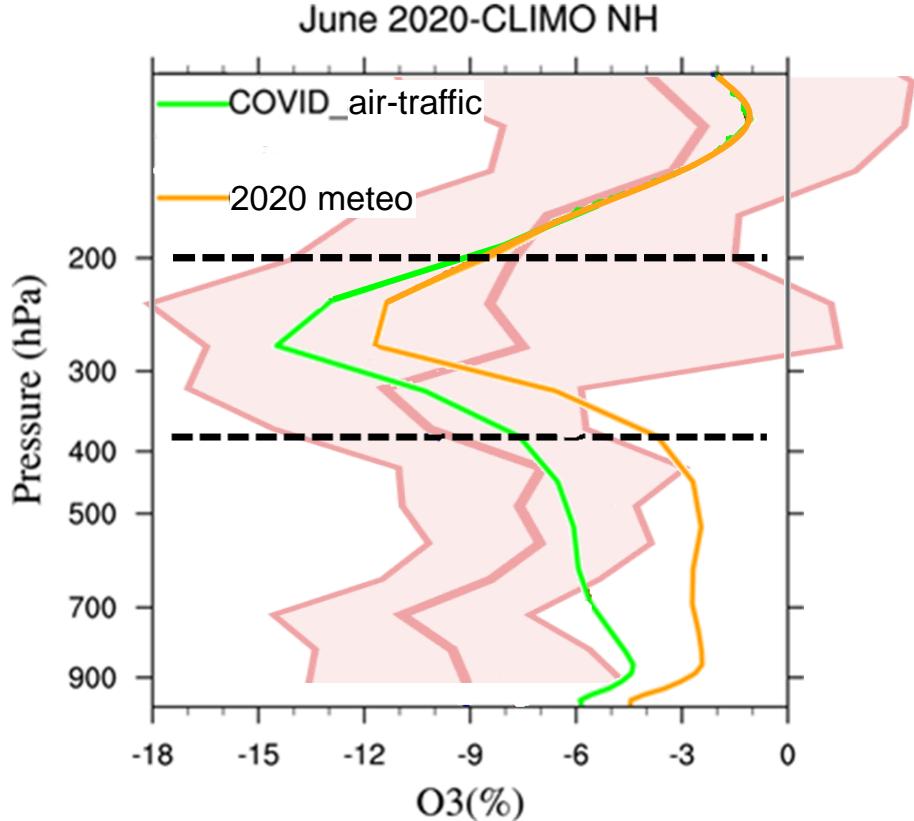
NCAR simulations (June, entire NH)



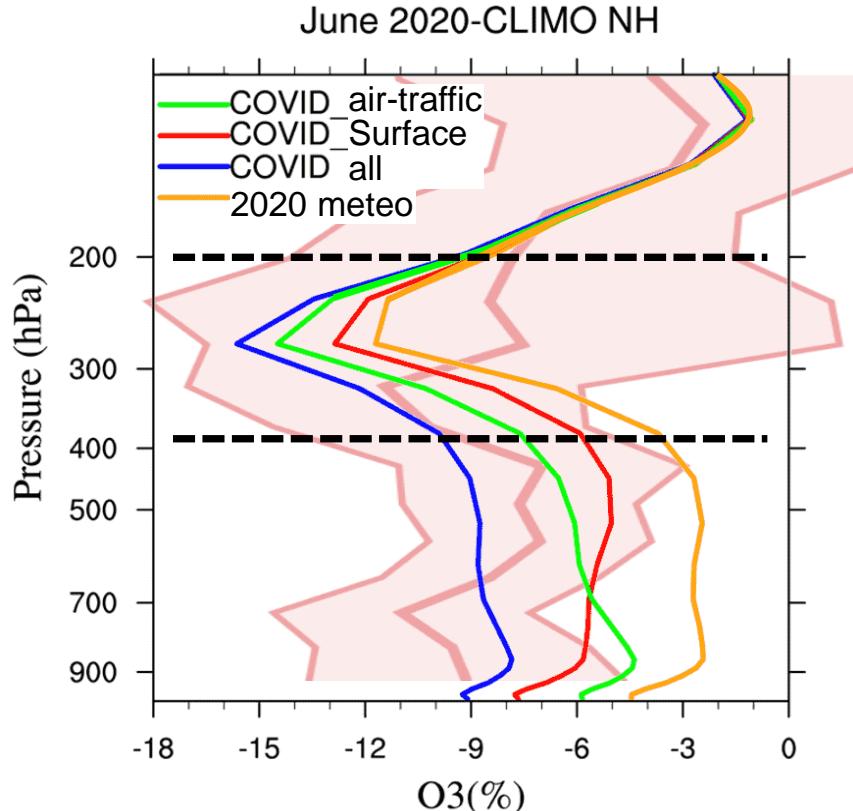
NCAR simulations (June, entire NH)



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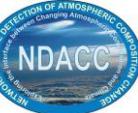
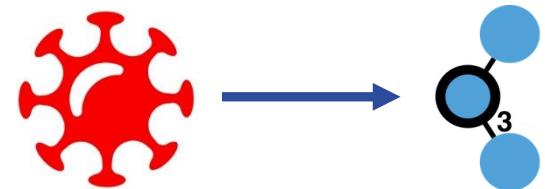
NCAR simulations (June, entire NH)



- above 200hPa:
 - 2020 meteo conditions, including ozone hole
- below 400 hPa:
 - 1/3 meteo conditions
 - 1/3 surface emission reduction
 - 1/3 air-traffic reduction
 - 2/3 COVID-19 reductions

summary

- 7% ozone reduction in NH free troposphere, April to August 2020, 1 to 8 km
- below ~8 km: 2/3 due to COVID-19 emission reductions (NO_x , ...)
 - (1/3 surface emissions, 1/3 air-traffic reduction)
 - 1/3 from 2020 meteorology (incl. Arctic stratospheric ozone hole)
- in SH: (smaller) COVID-19 effect masked by 2020 natural conditions
- accidental “global experiment”, much to be learned
- importance of “monitoring” + data availability
- GRL: obs: paper, simulations: submitted





Environment
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Thank You !



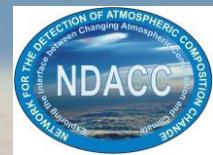
National Center for
Atmospheric Research



MeteoSwiss



Max-Planck-Institut
für Meteorologie



GAW



Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu



Photo: 1.Feb 2016 Ulf Köhler