

# TOPAS Ozone Profile Retrieval for TROPOMI/S5P Ultraviolet Spectral Range and Improvements by Combining with CrIS Infrared Measurements

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# Introduction

- TOPAS: Tikhonov regularized Ozone Profile retrieval with SCIATRAN
- Ozone profile retrieval from UV TROPOMI spectral range with precision of  $\pm 5\%$  in the stratosphere validated with MLS and stratospheric lidar measurement
- Vertical resolution  $< 10$  km in the stratosphere, but worse in the troposphere

Atmos. Meas. Tech., 14, 6057–6082, 2021  
<https://doi.org/10.5194/amt-14-6057-2021>  
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## Ozone profile retrieval from nadir TROPOMI measurements in the UV range

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Received: 8 February 2021 – Discussion started: 17 March 2021

Revised: 25 June 2021 – Accepted: 9 August 2021 – Published: 16 September 2021

(Mettig et al., 2021)

→ combined retrieval approach: UV TROPOMI and IR CrIS measurements

→ high vertical resolution in the stratosphere from UV and high vertical resolution in the troposphere from IR

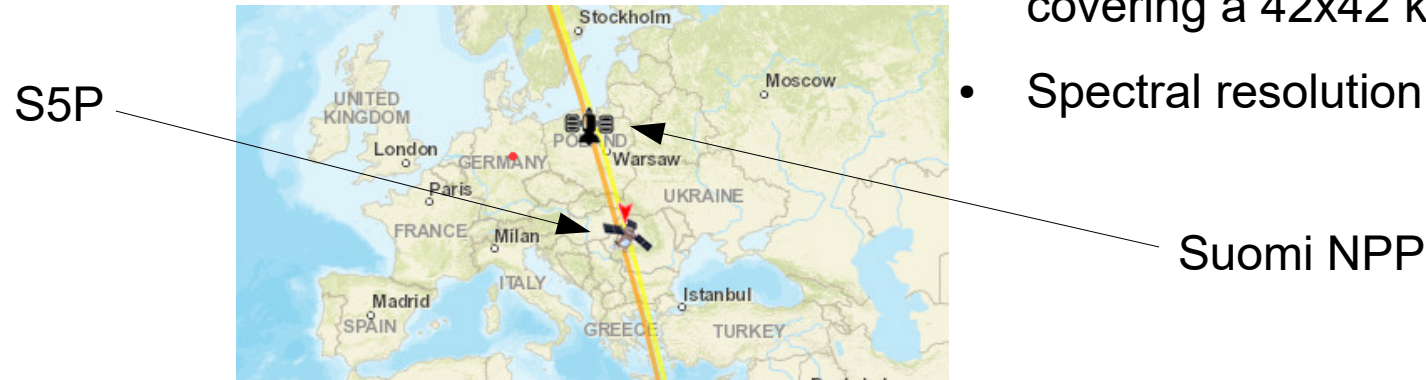
# TROPOMI and CrIS data

## TROPOMI (UV)

- L1B version 2: test data set
- Spectral segments: 270 – 329 nm from UV1 and UV2 bands
- Spatial binning to 48x48 km or to spatial sampling from CrIS pixels
- Spectral re-calibration with simulations using MLS ozone profiles

## CrIS (IR)

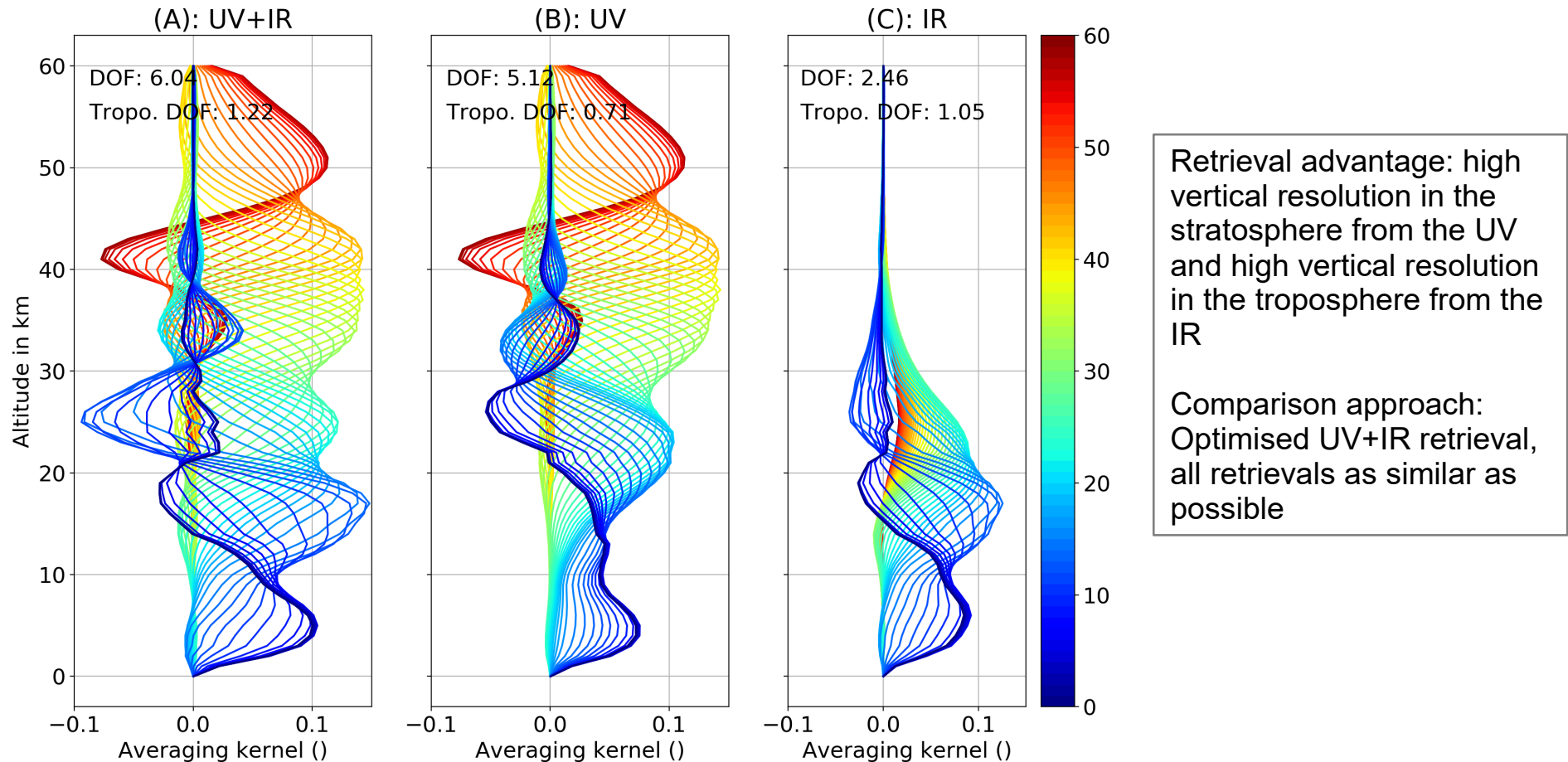
- Fourier transform spectrometer on Suomi-NPP launched 2011
- Flying in loose formation with S5P
- Spectral range: 9350 – 9900 nm, L2 product: cloud cleared radiances, surface temperature
- Spatial resolution (nadir): 3x3 14 km FOV covering a 42x42 km cell
- Spectral resolution: 0.625 cm<sup>-1</sup>



<https://www.n2yo.com/>

Nora Mettig, 23.11.21, ATMOS conference

# Combined UV+IR retrieval: information content



TROPOMI+CrIS pixels: 27.11.2018, 34.2° latitude and -117.9° longitude (Table Mountain),  
SAZ: 42°, VA: 34°

# Retrieval results for UV+IR, UV-only and IR-Only

TROPOMI+CrIS pixels:  
27.11.2018,  
34.2° latitude and -117.9°  
longitude (Table  
Mountain)

For comparison in the  
stratosphere (A and B):

- MLS: 25min
- stratospheric lidar: 6h

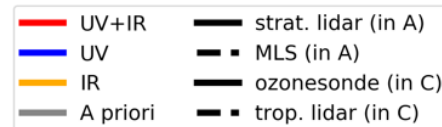
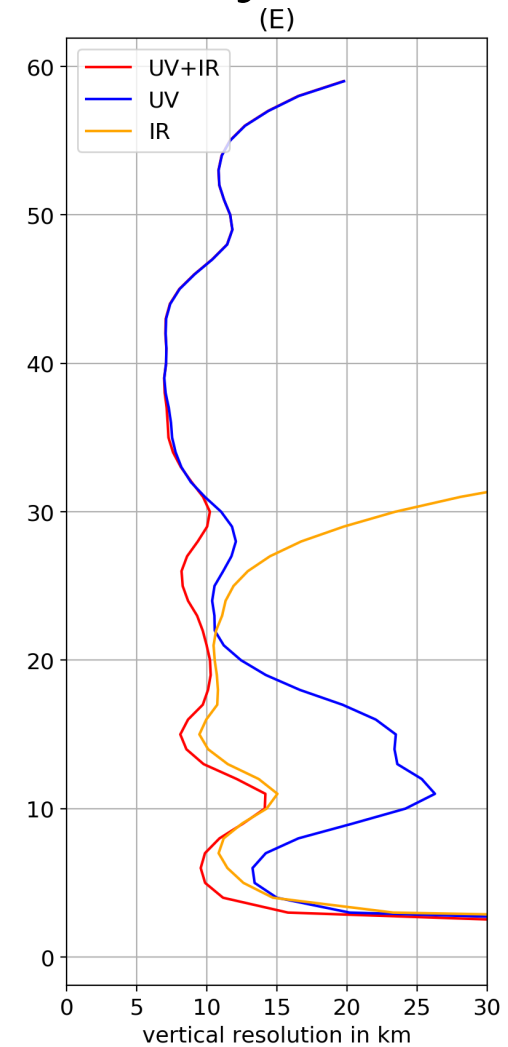
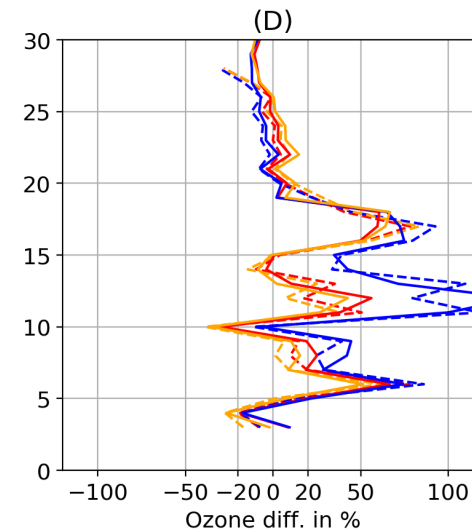
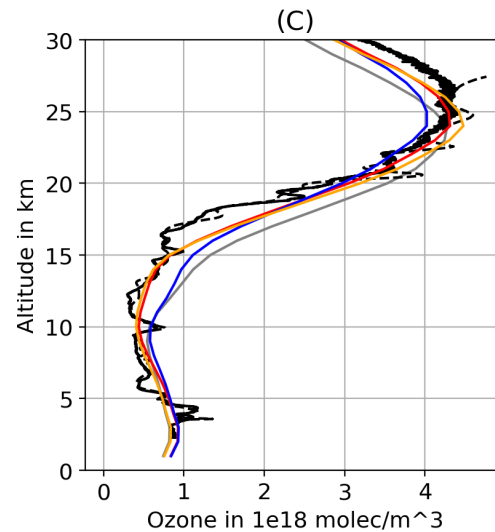
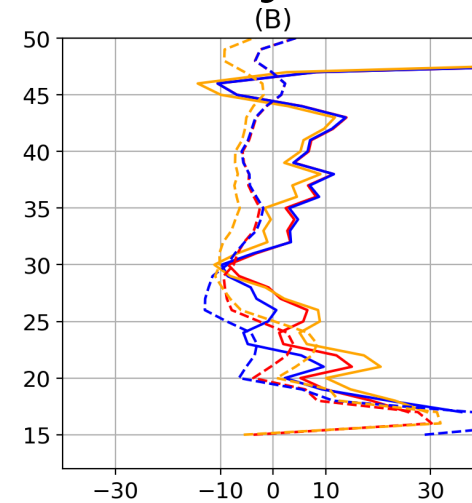
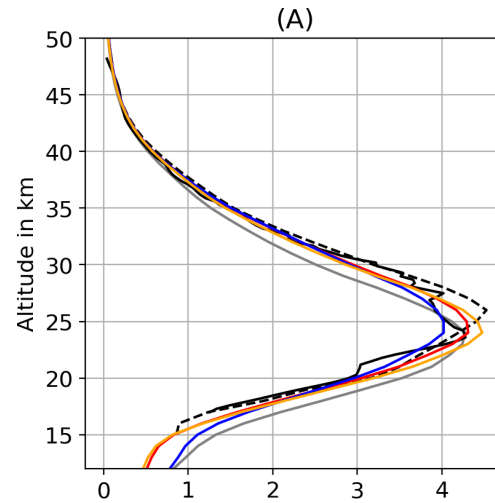
For comparison in the  
troposphere:

- ozonesonde: 8,5h
- tropospheric lidar: 6h

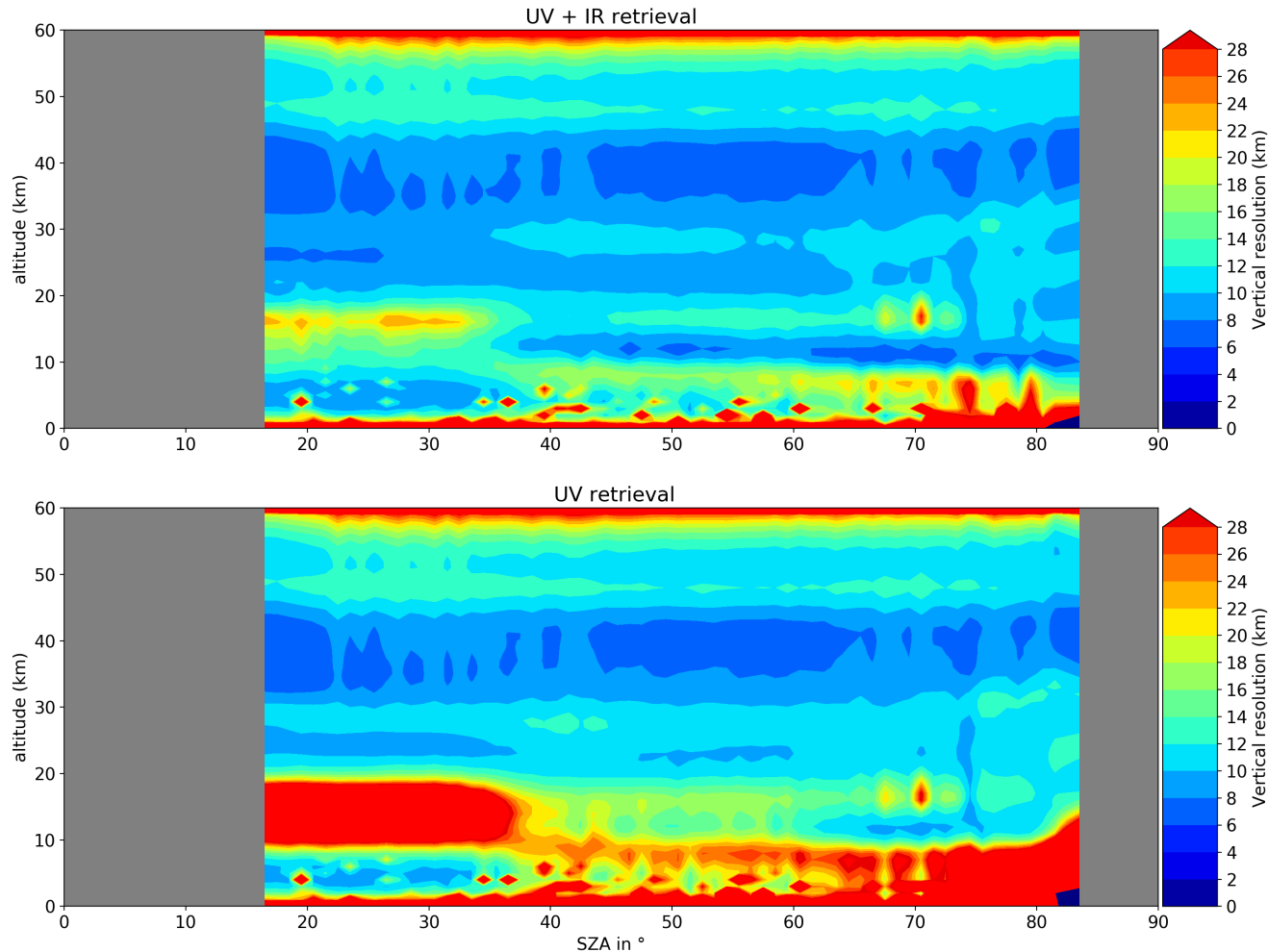
All measurements within  
100 km radius

— strat. lidar  
-- MLS

— ozonesonde  
-- tropos. lidar



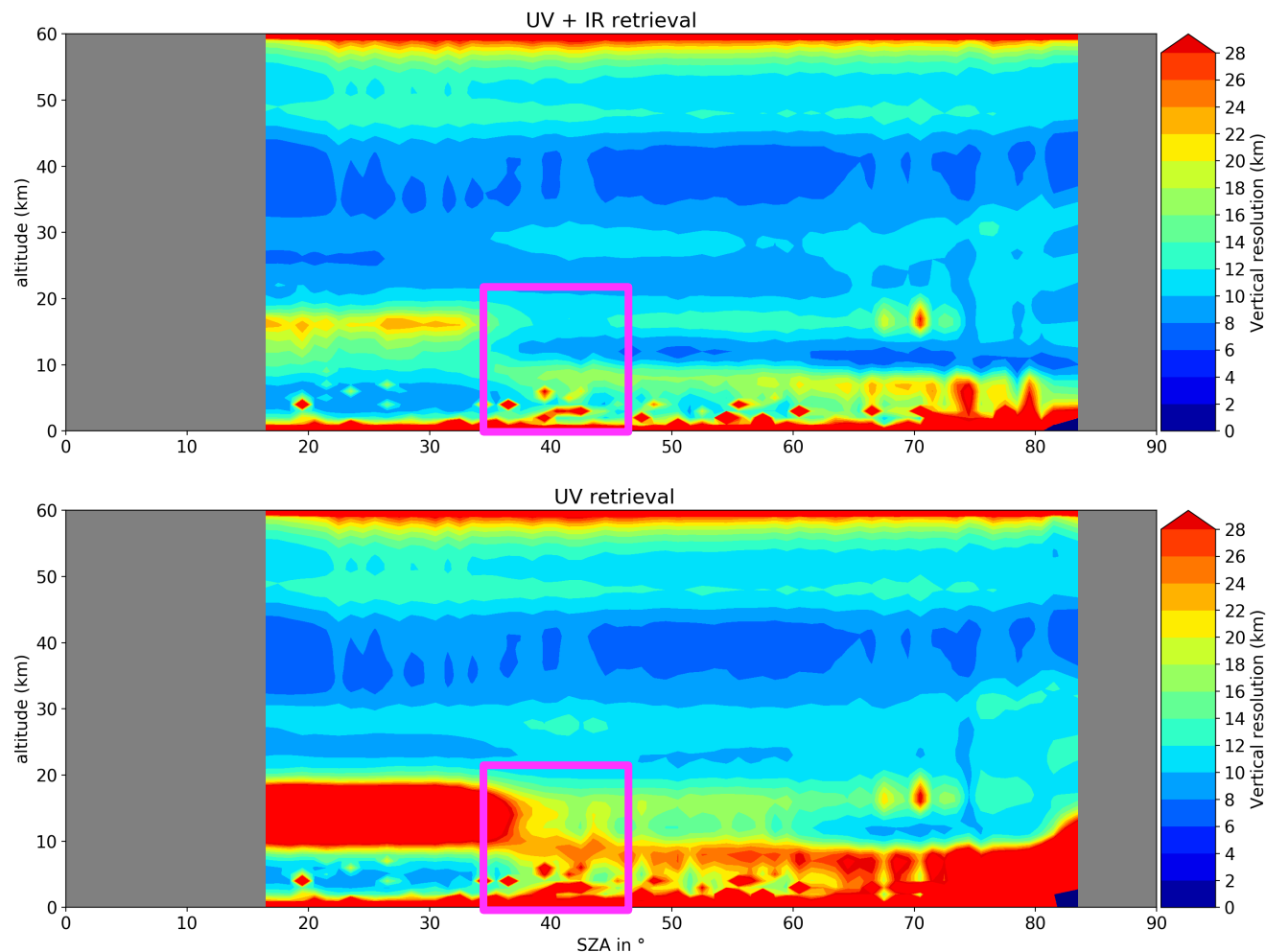
# Improved vertical resolution



Averaged vertical resolution for one day of TOPAS retrieval data (1 October 2018) dependent on SZA

- No changes above 30 km
- great improvements between 10 – 20 km
- in the subtropic region (35° – 45° SZA) potential for tropospheric profiles

# Improved vertical resolution



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# Validation of tropospheric ozone columns (TOC)

TOC = integrated profile up to the tropopause

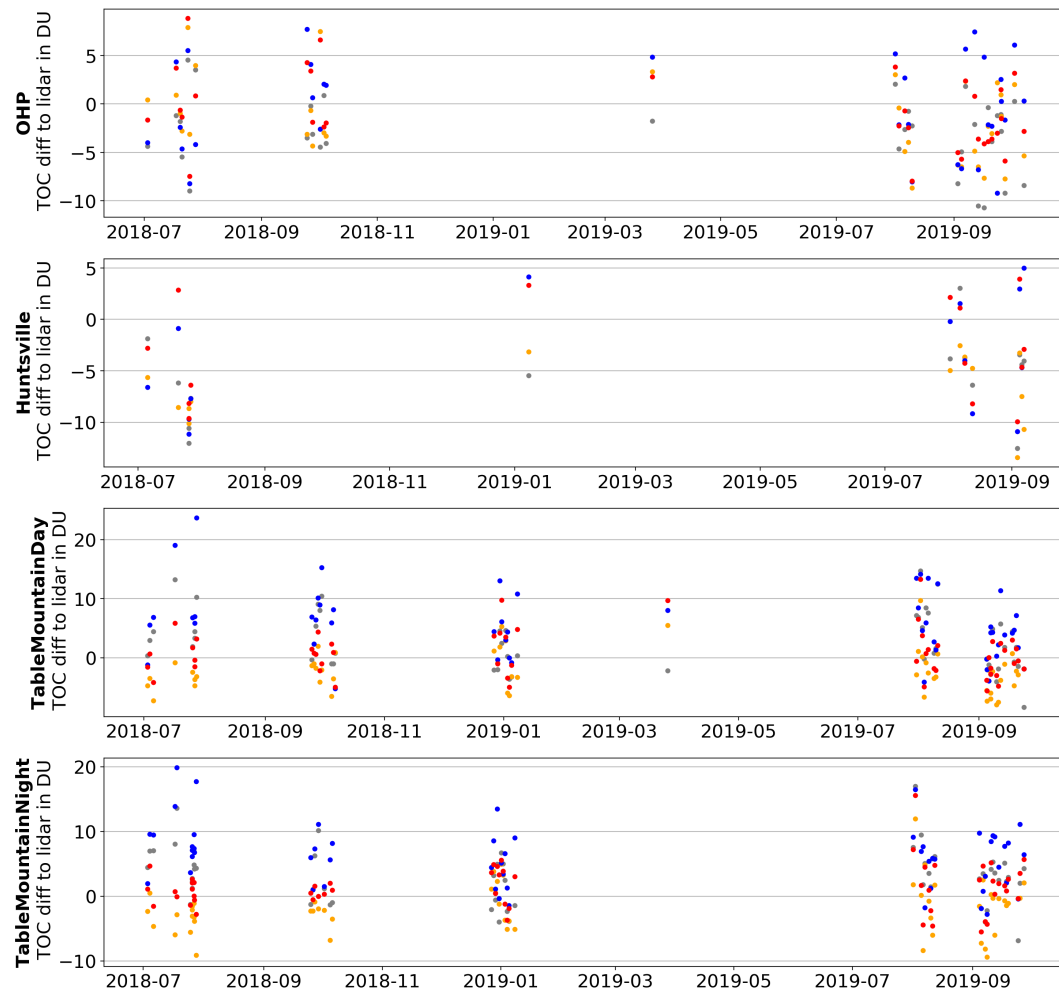
Tropopause taken from ECMWF ERA5 reanalysis (2PV definition)

## Tropospheric lidar:

- 3 sites:
  - Table Mountain Facility, California ( 34.2° lat, -117.9° lon): day and night profiles
  - Huntsville, Alabama, (34.7° lat, -86.6° lon): daylight profiles
  - Observatoire de Haute-Provence (OHP), France (43.9° lat, 5.7° lon): after sunset
- 154 collocated ozone profiles (100 km, 24 h)



# Validation with tropospheric lidars

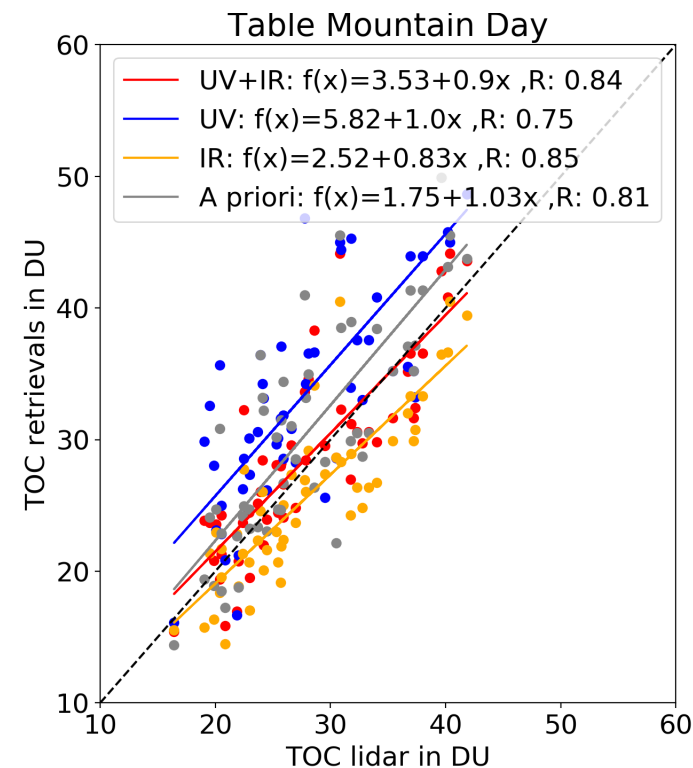


• A priori:  $-3.01\text{DU} \pm 3.79\text{DU}$  ( $1\sigma$ )  
 • IR:  $-1.69\text{DU} \pm 4.15\text{DU}$  ( $1\sigma$ )  
 • UV:  $-0.21\text{DU} \pm 4.86\text{DU}$  ( $1\sigma$ )  
 • UV+IR:  $-0.83\text{DU} \pm 3.9\text{DU}$  ( $1\sigma$ )

• A priori:  $-5.64\text{DU} \pm 3.99\text{DU}$  ( $1\sigma$ )  
 • IR:  $-6.76\text{DU} \pm 3.17\text{DU}$  ( $1\sigma$ )  
 • UV:  $-3.66\text{DU} \pm 5.52\text{DU}$  ( $1\sigma$ )  
 • UV+IR:  $-3.1\text{DU} \pm 4.82\text{DU}$  ( $1\sigma$ )

• A priori:  $2.56\text{DU} \pm 4.82\text{DU}$  ( $1\sigma$ )  
 • IR:  $-2.31\text{DU} \pm 3.53\text{DU}$  ( $1\sigma$ )  
 • UV:  $5.68\text{DU} \pm 5.79\text{DU}$  ( $1\sigma$ )  
 • UV+IR:  $0.69\text{DU} \pm 3.91\text{DU}$  ( $1\sigma$ )

• A priori:  $3.09\text{DU} \pm 4.35\text{DU}$  ( $1\sigma$ )  
 • IR:  $-1.78\text{DU} \pm 3.87\text{DU}$  ( $1\sigma$ )  
 • UV:  $6.28\text{DU} \pm 4.81\text{DU}$  ( $1\sigma$ )  
 • UV+IR:  $1.39\text{DU} \pm 3.5\text{DU}$  ( $1\sigma$ )



University  
of Bremen

# Validation of tropospheric ozone columns (TOC)

TOC = integrated profile up to the tropopause

Tropopause taken from ECMWF ERA5 reanalysis (2PV definition)

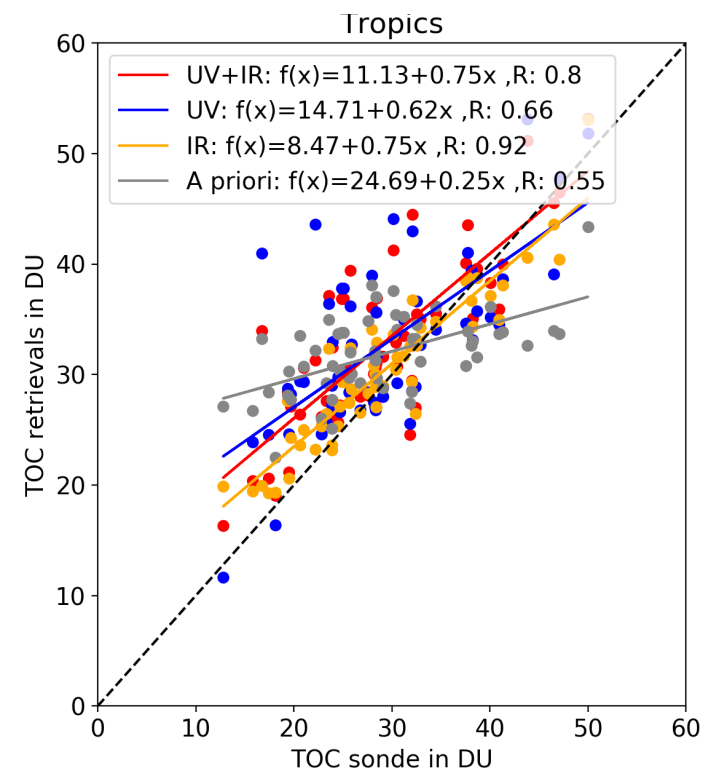
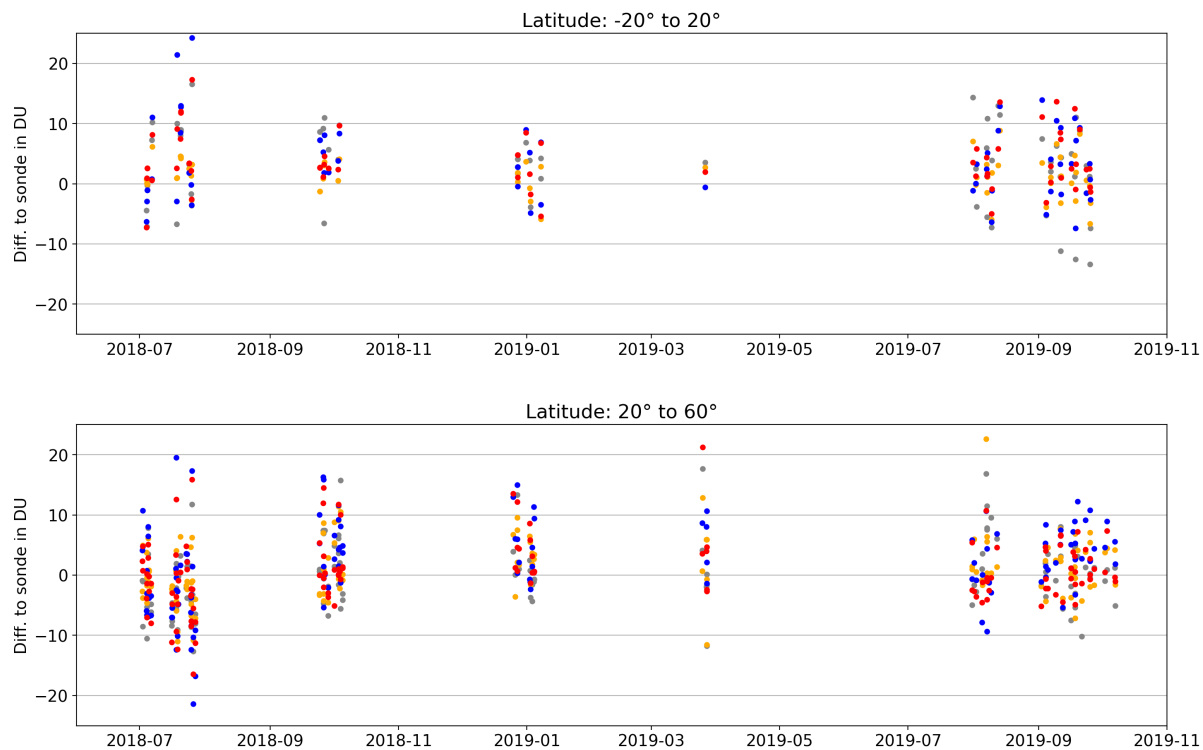
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- 154 collocated ozone profiles (100 km, 24 h)

## Ozonesondes:

- In the tropics: SHADOZ network (8 stations)
- In the northern latitudes: WOUDC network (20 stations)
- 182 collocated ozone profiles (100 km, 24 h)

# Validation with ozonesondes



# Summary

- TOPAS ozone profile retrieval from TROPOMI UV measurements agree well with stratospheric lidar, MLS, and ozonesonde data (Mettig et al., 2021)
- Ozone profiles can also be retrieved from UV (TROPOMI) and IR (CrIS) measurements with TOPAS
- Combined retrieval provides the high vertical resolution in the stratosphere from UV and an improved vertical resolution in the troposphere from IR
- Validation of tropospheric ozone columns and ozone profiles show an improvement of UV+IR over UV-only retrieval in many cases