University of Bremen, IUP

Fachbereich 01

Extension of the S5P/TROPOMI CCD tropospheric ozone retrieval to middle latitudes

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Trop. O_3 - Sources and impacts

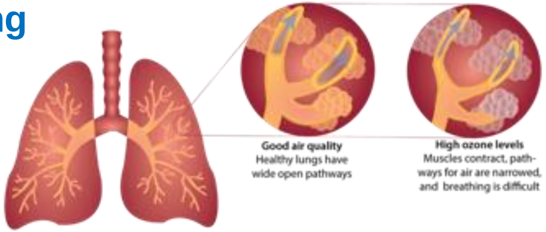
- One of the important pollutant and greenhouse gas
- **Bad ozone :** Contains 10% of atmospheric ozone

Sources:

- Stratosphere-troposphere exchange.
- The photochemical reactions of precursors, hydrocarbons and nitrogen oxides from natural and anthropogenic sources.

Impacts:

- **Contributes to global warming**



- **Causes health issues**

Millions of pollution related deaths and chronic diseases, in every year

- **Toxic to plants**

Adversely affects plant photosynthesis, doubling the climate impact.

Ref : https://www.ccacoalition.org/en/slcps/tropospheric-ozone

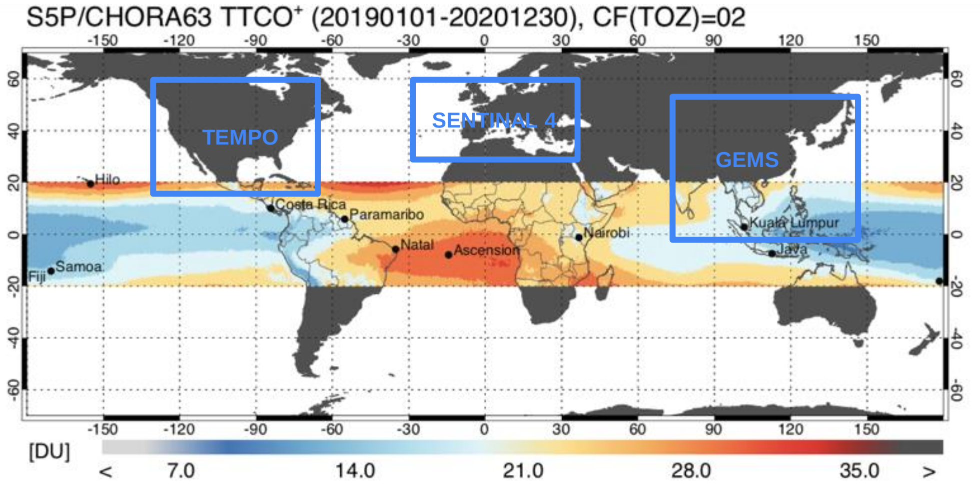
Trop. O_3 retrievals and satellite retrieval algorithms

- **Crucial understanding**:
  - Essential to understand and regulate tropospheric ozone levels.
- **Measurement techniques**:
  - Ozonesondes and LIDARs: Accurate TCO measurements.
  - Satellites: Needed for broad daily coverage.
- **Challenges**:
  - The high spatio-temporal variability complicates satellite measurements.
- **Solutions**:
  - Satellite retrieval algorithms improve accuracy.

Image credit : ESA

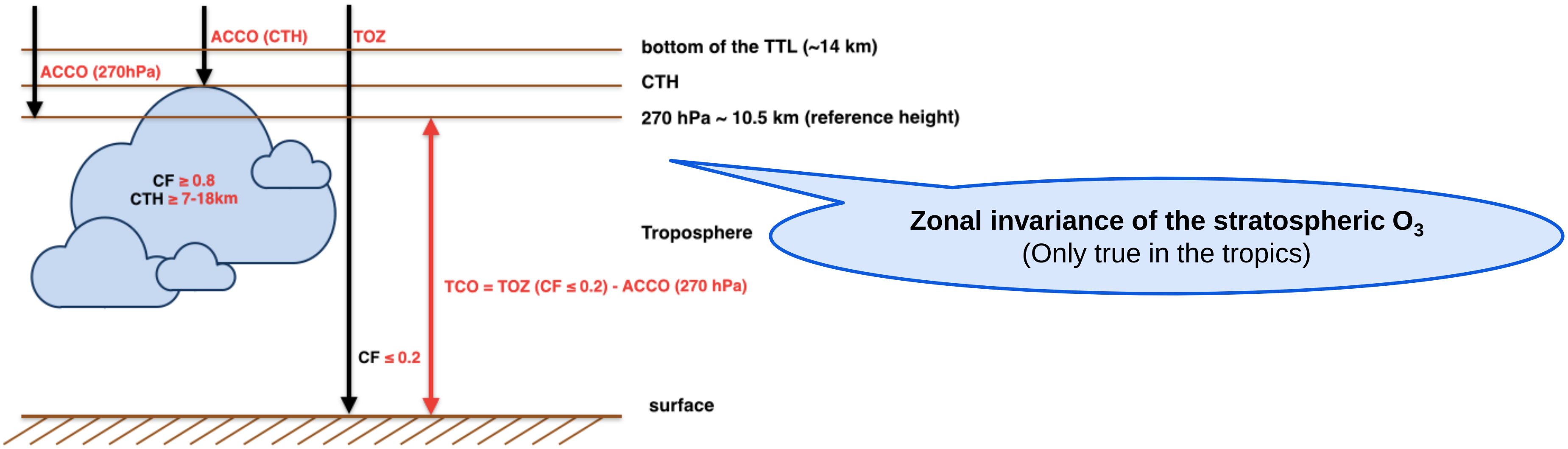
Convective Cloud Differential (CCD) method

- **Standard Method**:
  - Limited to the tropical band (**20°S-20°N**)
  - Not applicable to geostationary satellites (ESA Sentinel-4, NASA TEMPO, and GEMS covering only middle latitudes)
- **Successful Applications**:
  - Applied to satellite sensors: Aura OMI, MetOp GOME-2, **Sentinel-5P TROPOMI.**



Kai-Uwe Eichmann, Universität, Bremen

The standard CCD method



- Stratospheric/Above **C**loud **C**olumn **O**zone (**ACCO**) is measured above deep convective clouds (**Cloud Fraction > 0.8**) over the **Pacific sector (70°E-170°W, 20°S-20°N)**
- Correct ACCO up to reference altitude (e.g**. 270 hPa ~10.5 km**) using a climatology.
- Subtract the ACCO from the total ozone (**CF < 0.2**) to compute Trop. Column Ozone (**TCO**).

Extension of CCD to middle latitudes

- **Challenges**

➢ The lack of high reflective clouds to measure ACCO/stratospheric column ozone.

➢ Large spatio-temporal variability of stratospheric ozone.

- **Proposed solutions and evaluations**

➢ Ziemke et al. (2005) suggested extending CCD to higher latitudes, **focusing on the Pacific** with sufficient cloud cover. Initially used TOMS data (1979-2003) across mid-latitudes **(50°S-60°N**).

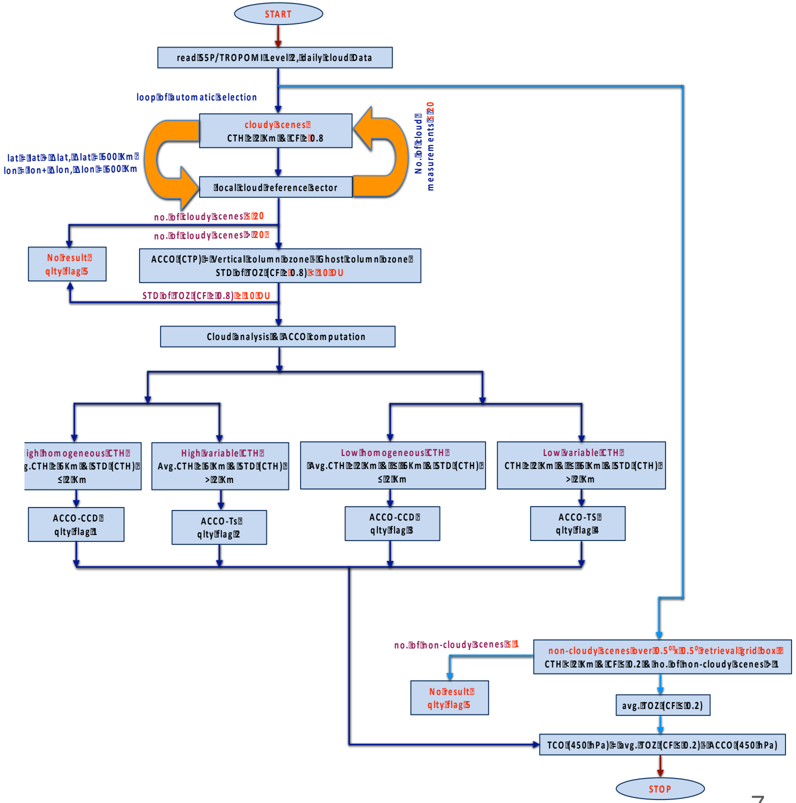
➢ Ziemke et al. (2012) evaluated the CCD method in higher latitudes (**60°S-60°N**) **over the Pacific** using Aura OMI and MLS ozone measurements (2004-2010).

This work presents the first successful application of CCD over middle latitudes for global tropospheric ozone retrieval.

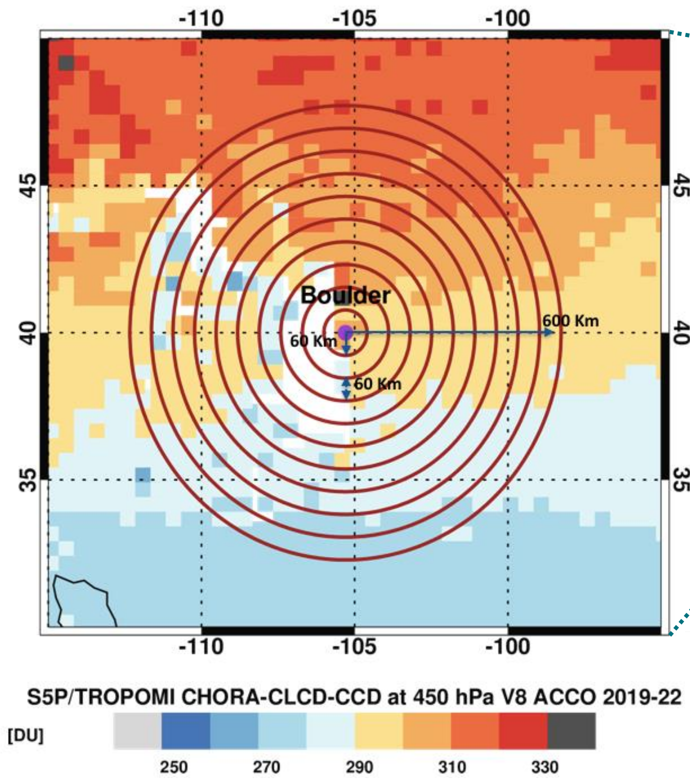
CLCD - CHORA-Local Cloud Decision algorithm

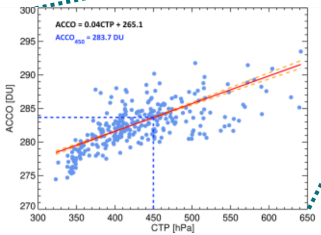
Solutions to the Challenges

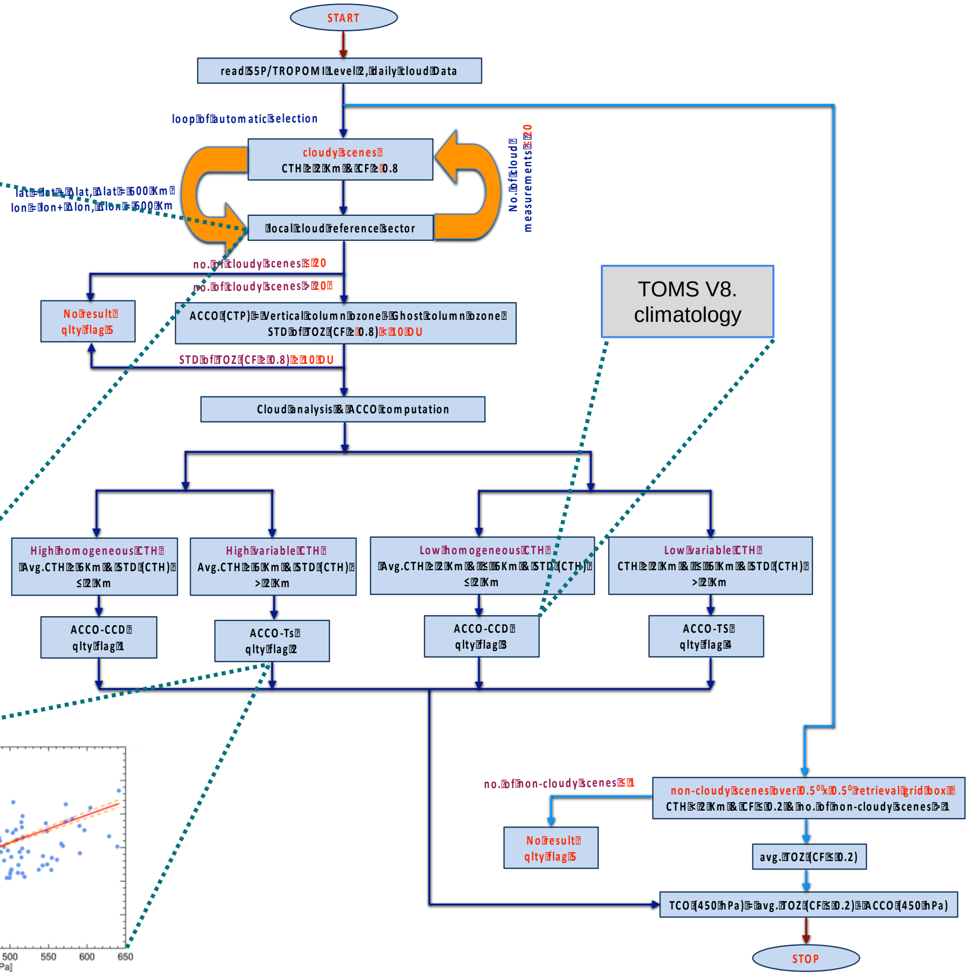
- ➢ **Lack of deep convective clouds reaching 270 hPa**
- ✓ Lowered the reference altitude to **450 hPa ➡ Representative of mid troposphere** (*Worden et al., 2009, Williams et al., 2019, TOAR-II)*
- ➢ **Large Stratospheric ozone variability**
- ✓ Local cloud sector varying both latitudinally and longitudinally
- ✓ High resolution TROPOMI data.
- ✓ Homogeneity criteria



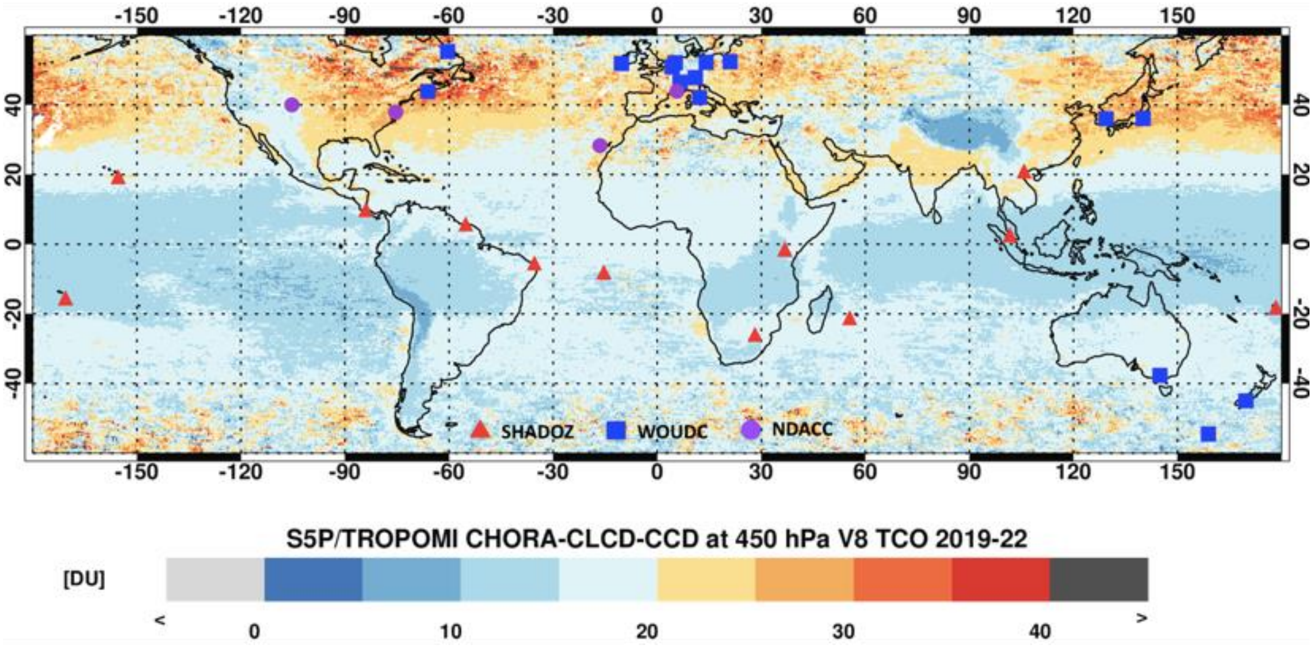
The CLCD algorithm





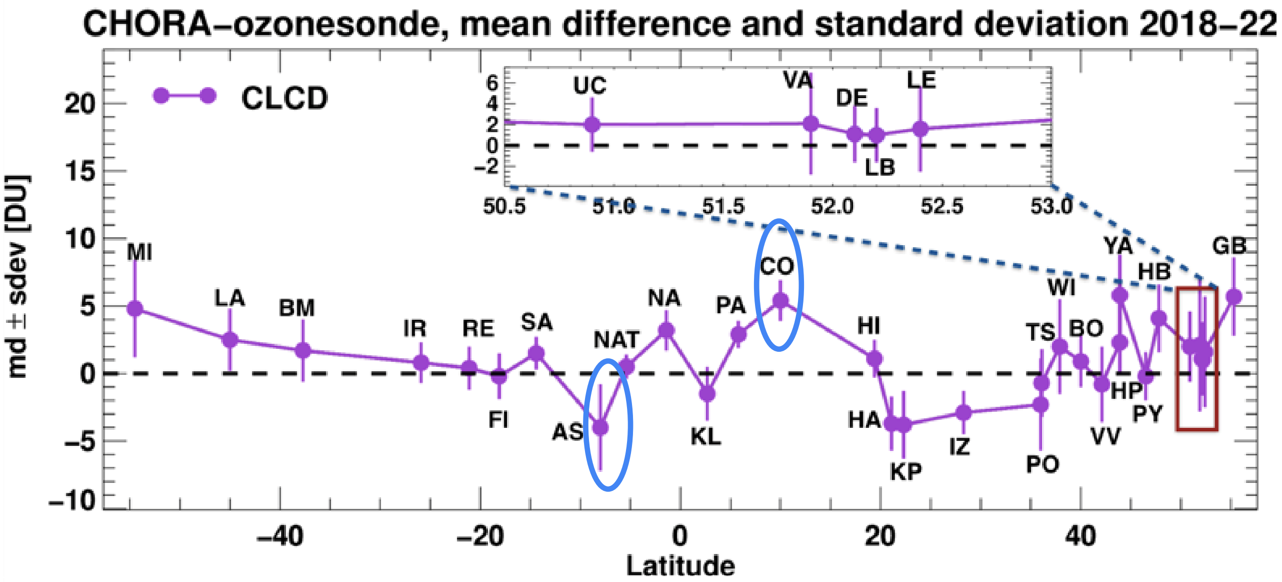


Validation with ozonesondes



- ✓ Monthly averaged **CLCD-TCOs** at **450 hPa** were determined over the middle latitudes (**60°S-60°N**) from TROPOMI for the period from **2018 to 2022**.
- ✓ Validated with spatially collocated **SHADOZ/WOUDC/NDACC** ozonesondes from **31** stations.

Meridional variation of mean bias and scatter



- **Good agreement with ozonesondes at most stations** (max bias below **6 DU** and scatter below **5 DU**).
- **Higher bias and scatter towards higher latitudes. North :** Stronger variability in stratospheric ozone *(Cooper et al., 2014; Williams et al., 2019).*
- **Ascension Island :** Remote low level clouds ➡ Over estimation of ACCO ➡ Underestimation of TCO
- **Costa Rica :** Nearby clouds ➡ Unlikely to miss out pollution events ➡ Sampling errors?

Summary & conclusions

- Monthly averaged **CLCD-TCOs at 450 hPa** were determined over the middle latitudes (**60°S-60°N**) from TROPOMI for **2018-2022**

- The accuracy was validated by comparing with **SHADOZ/WOUDC/NDACC** ozonesondes from **31** stations.

- CLCD-TCOs show good agreement with ozonesondes at most stations, with maximum observed bias and dispersion below **6 DU** and **5 DU**, respectively.

- At three stations from different regions, **Natal [5.4°S, 35.4°W], Irene [25.9°S, 28.2°E],** and **Lindenberg [52.2°N, 14.1°E].** The CLCD method shows excellent agreement with ozonesondes, with minimal bias and scatter: **0.5 ± 0.9 DU, 0.8 ± 1.5 DU, and 1.0 ± 2.6 DU**, respectively

- **These results highlight the benefits of using the local cloud reference sector in mid-latitudes.**


Thank you