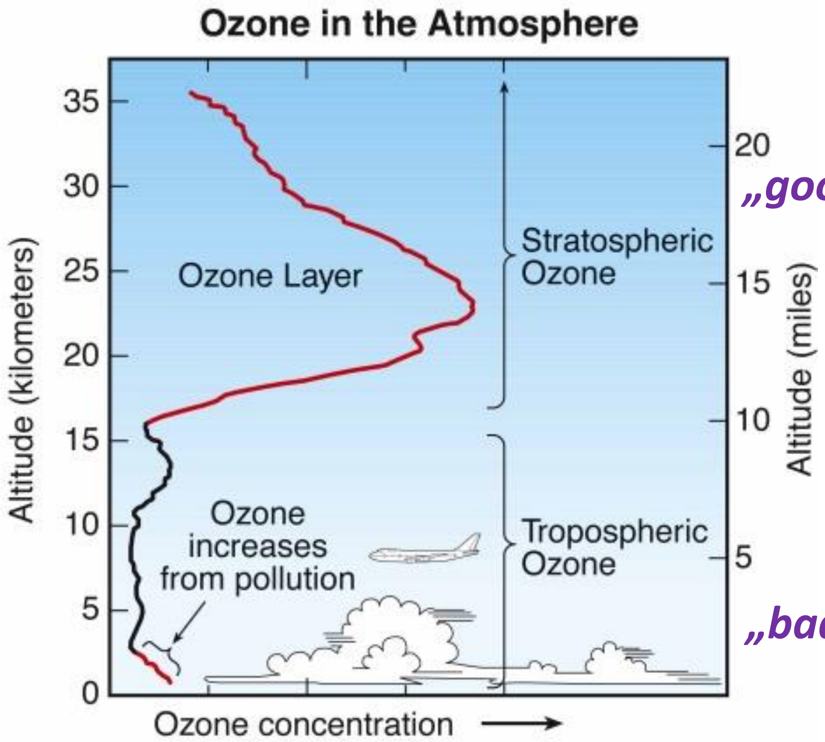
TROPO3-MIDLAT

Tropospheric Ozone at Middle Latitudes from S5P/TROPOMI Satellite Data



„good ozone“

„bad ozone“

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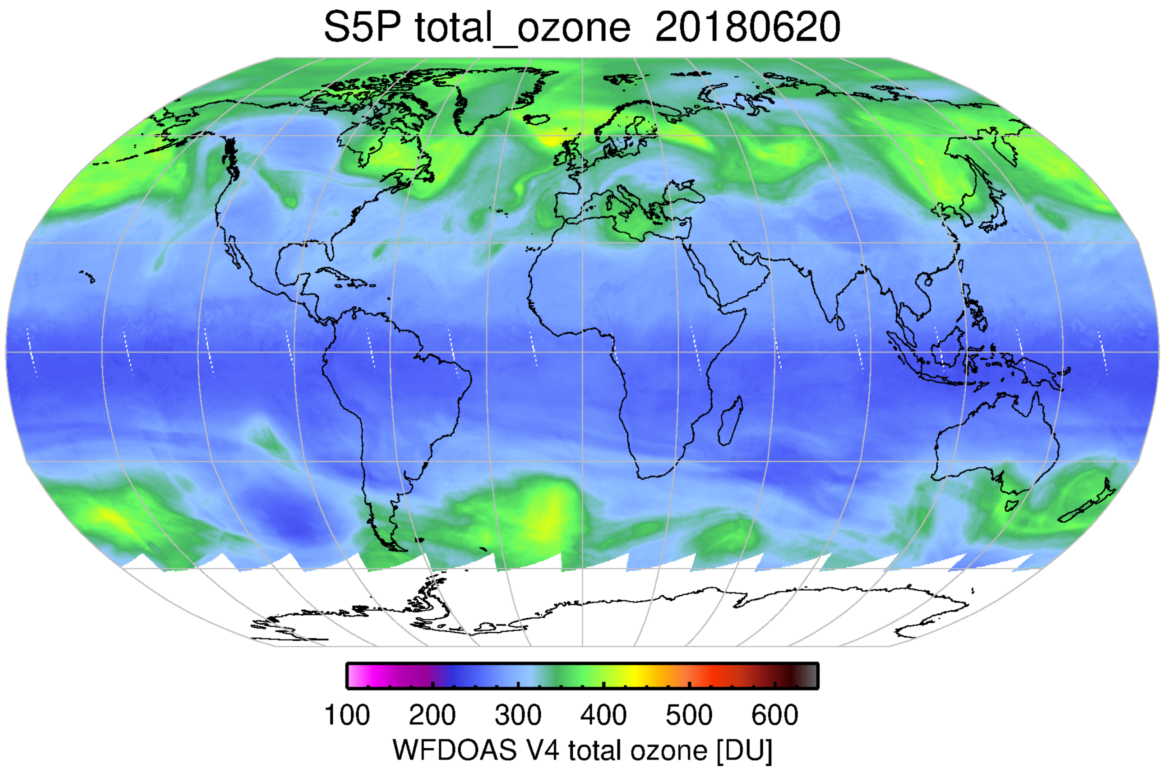
Project goals

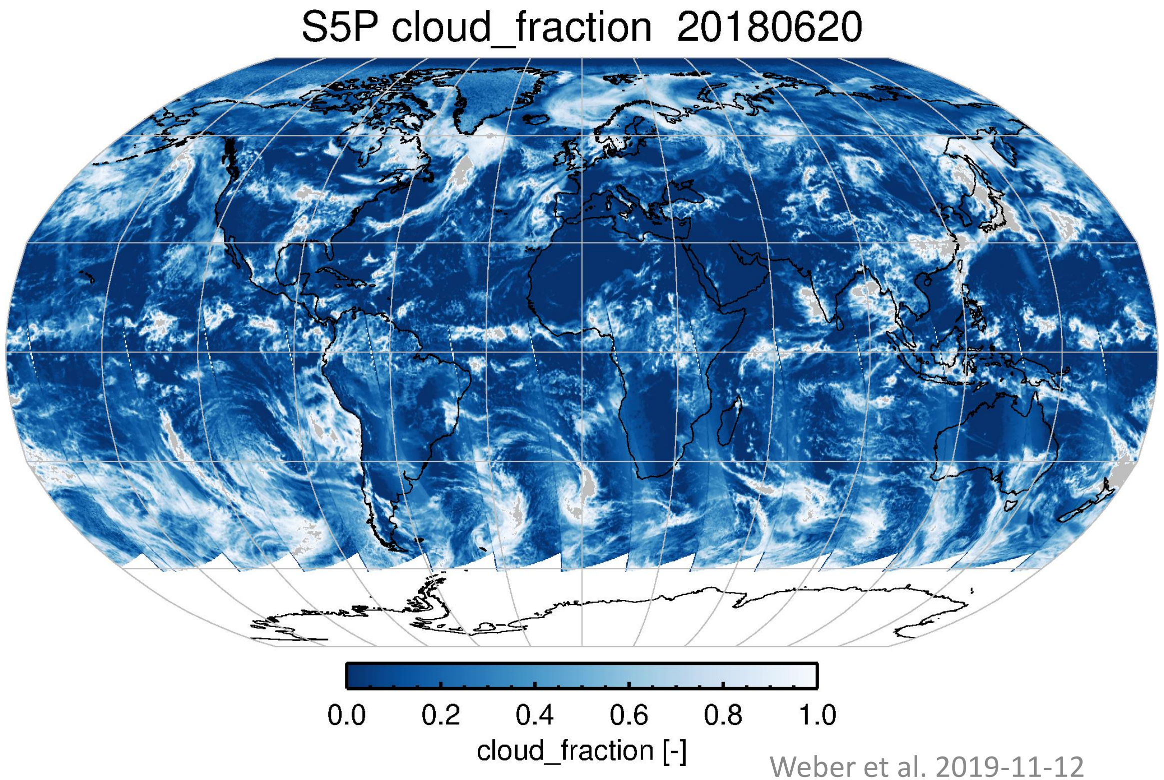
Project goals:

- Extend the applicability of two satellite tropospheric ozone retrievals (cloud slicing, convective cloud differential) from the tropics to middle latitudes

How is that possible:

- Taking advantage of the very high spatial resolution (3.5 × 5.6 km^2) of the Sentinel-5P (S5P) Tropomi satellite instrument (launched in 2017) by combining total ozone column and cloud observations





Motivation

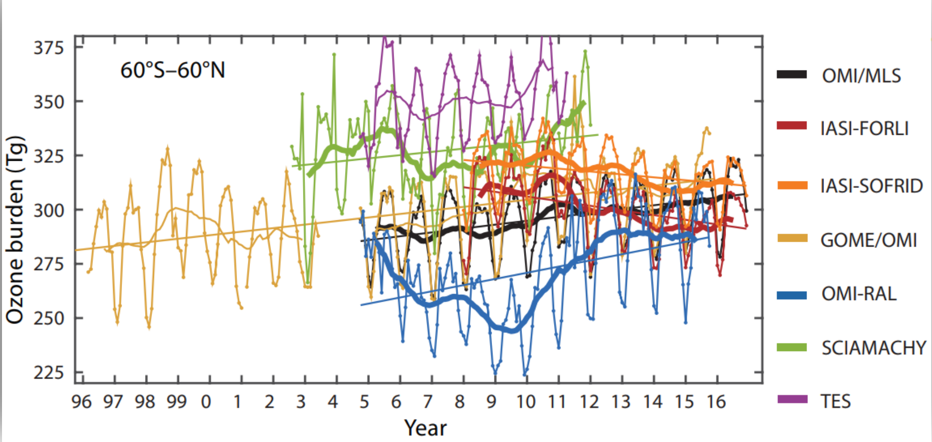
Role of tropospheric ozone (0-15 km):

- air pollution
  →Smog (produced by nitrogen oxides & hydrocarbons)
  →toxic for plants (reduced photosynthetic activity & crop yield)
  →respiratory problems and heart disease (premature mortality)
- climate
  →greenhouse gas
  →modifies lifetimes of other green house gases (methane)

http://www.wsl.ch/info/mitarbeitende/schaub/Mayer_and_Schaub_2010

Changes in tropospheric ozone

- ~13% increase since pre-industrial times (IPCC 2013)
- Uncertainty in current trends (Gaudel et al., 2018)
- Future changes depends on future greenhouse gas scenarios (CO_2 doubled=18% increase in 2100)
- Mean O_3 lifetime ~23d → long-range ozone transport into remote regions



-2.5 to +2.9 Tg/year (Gaudel et al. 2018)

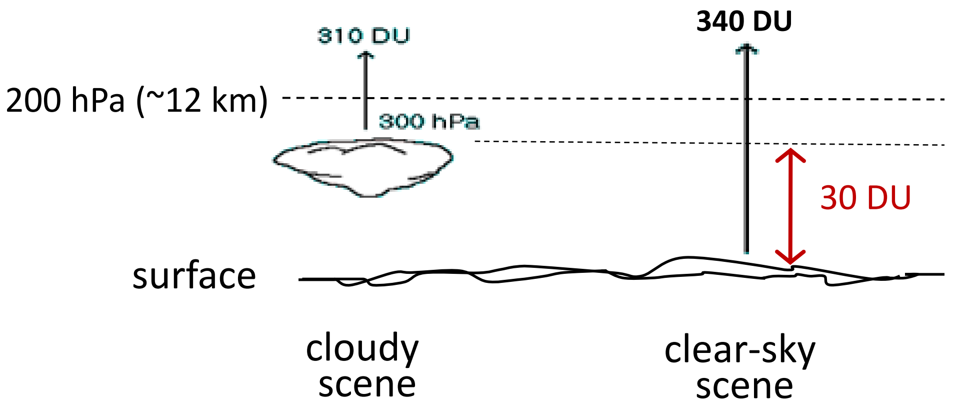
Need for continued and improved global satellite measurements of tropospheric ozone

Tropospheric ozone retrieval methods (1)

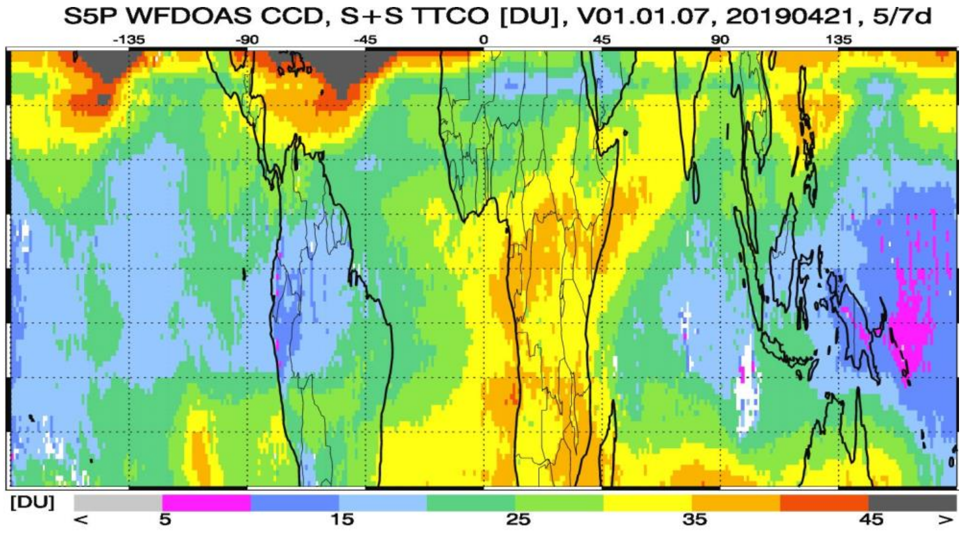
- **Converctive Cloud Differential (CCD)**
  → Standard method
  - ❑ Determine mean above cloud ozone columns above convective clouds in the Pacific (~ stratospheric ozone column
  - ❑ Subtract above cloud ozone columns from total column amounts under clear-sky condition (all longitudes) to obtain tropospheric ozone column amounts up to cloud-top height in a grid box
  - ❑ Correct tropospheric column up to reference altitude (e.g. 200 hPa ~12 km)

  → assumption
  - ❑ stratospheric ozone is invariant (approximately only true in the tropics)

  → S5P/TROPOMI
  - ❑ smaller grid boxes
  - ❑ more full cloud and clear-sky scenes
  - ❑ statistics possible over fewer days (instead of month)
  - ❑ above cloud columns from nearby regions instead from the Pacific alone
  - ❑ **extension into middle latitude possible**



- Tropospheric ozone column = 340 -310 DU =30 DU (up to 300 hPa)
- Climatological correction to extend column amount up to 200 hPa (reference altitude): 31 DU



S5P 5-day mean around 2019-04-21

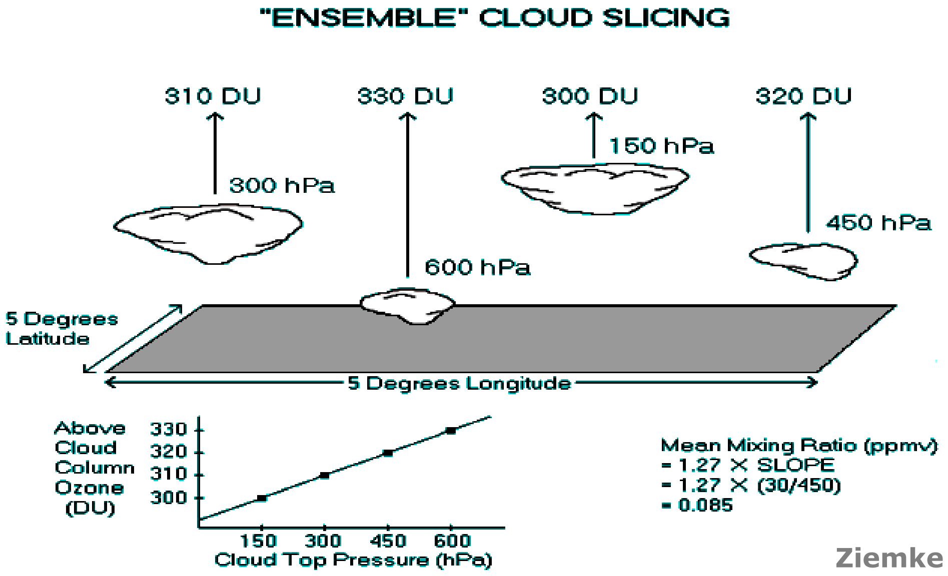
Tropospheric ozone retrieval methods (2)

- **Cloud slicing (CS)**

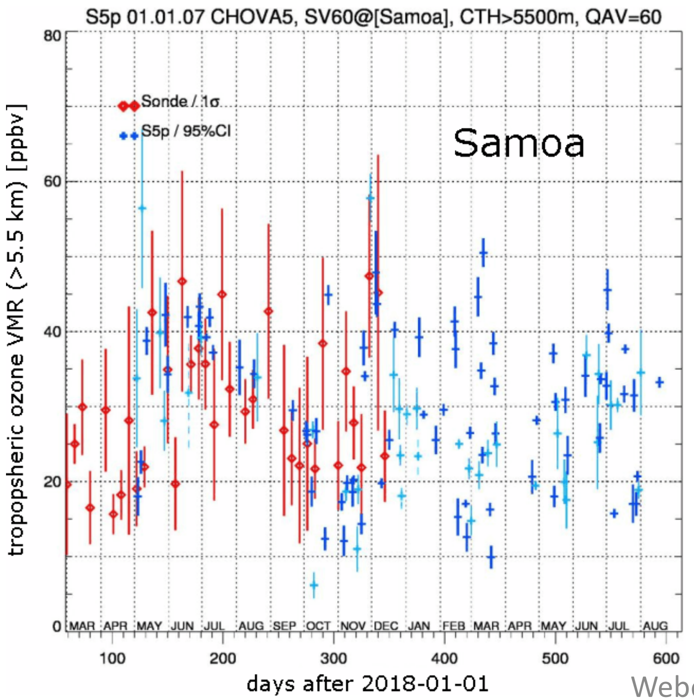
→ standard method
- ❑ Regression of above cloud ozone columns against cloud-top-pressure results in mean ozone volume mixing ratios
- ❑ Statistics in a given grid box (monthly average value)

→ assumptions
- ❑ stratospheric ozone is invariant (approximately only true in the tropics)

→ S5P/TROPOMI
- ❑ smaller grid boxes
- ❑ more cloudy scenes
- ❑ statistics possible over fewer days
- ❑ **extension into middle latitude possible**



Ziemke et al. 2001



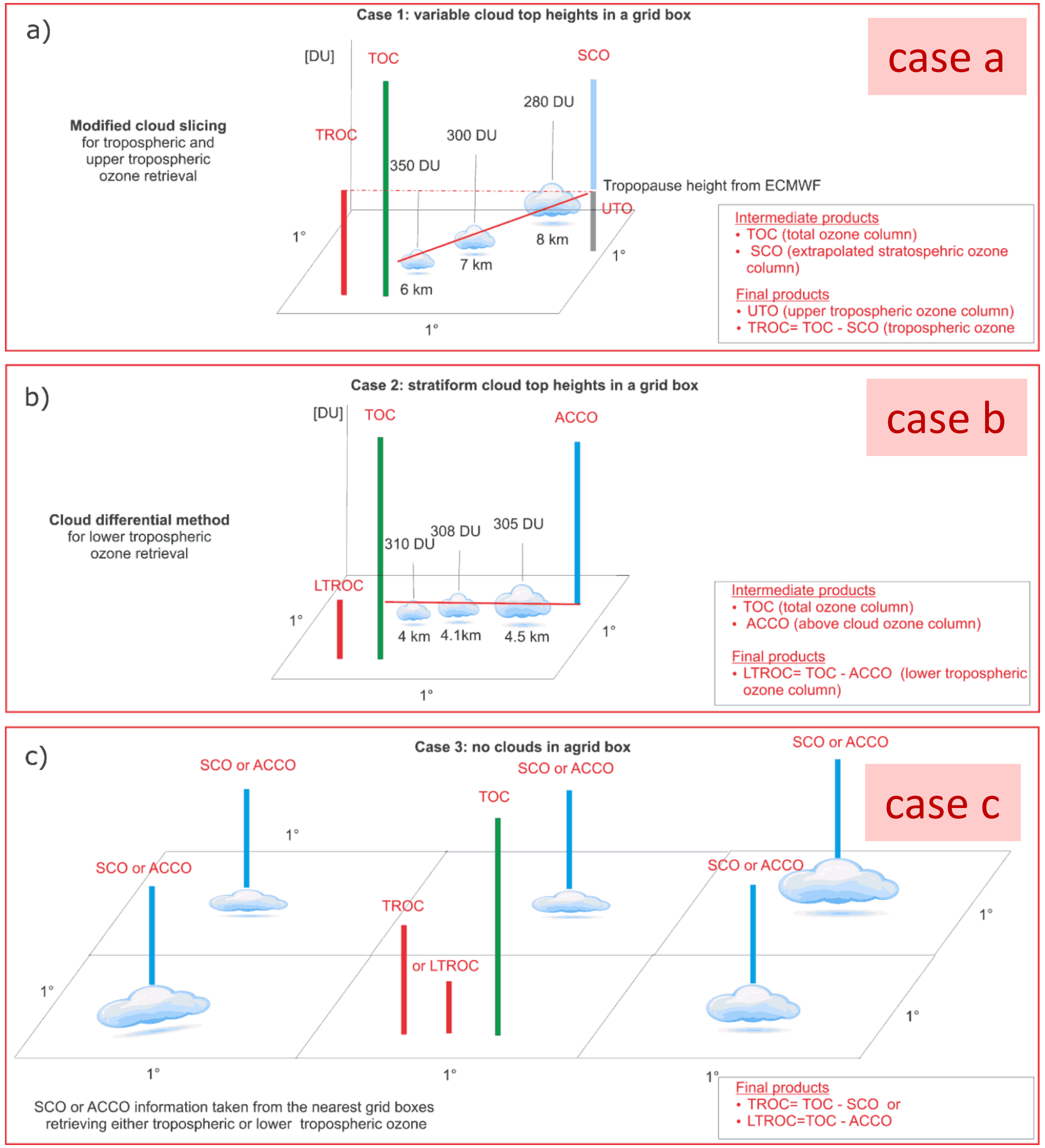
DEMATOR algorithm

***DEcision Making Algorithm for Tropospheric Ozone Retrieval* (DEMATOR)**

- regional total ozone and cloud statistics in each grid box

- case selection if total (stratospheric) ozone is invariant
  - → variable cloud heights (case a) -> apply regional modified CS algorithm
  - → stable cloud height (case b) -> apply regional CCD algorithm

- Case selection when scene is cloud-free
  - → interpolate from neighboring grid boxes (case c)



Work plan & Outlook

Work Plan

- S5P cloud and total ozone statistics (preparation for DEMATOR)
- development of DEMATOR algorithm
- systematic application using TROPOMI data
- validation of DEMATOR results by comparisons with surface and ozone sonde measurements
- 2 peer-review publications
- write an Algorithm Technical Baseline Document (ATBD)
  - → a first step before prototyping the operational algorithm for routine processing (collaboration with DLR and ESA as project follow-up)

Outlook beyond this project

- development into an operational algorithm for Sentinel-5P (and 5)
- adaptation of DEMATOR to geostationary satellites (limited coverage of tropics), e.g. Sentinel-4, GEMS (Korea), and TEMPO (USA)
- consistent long-term multiple satellite tropospheric ozone dataset -> essential climate variable