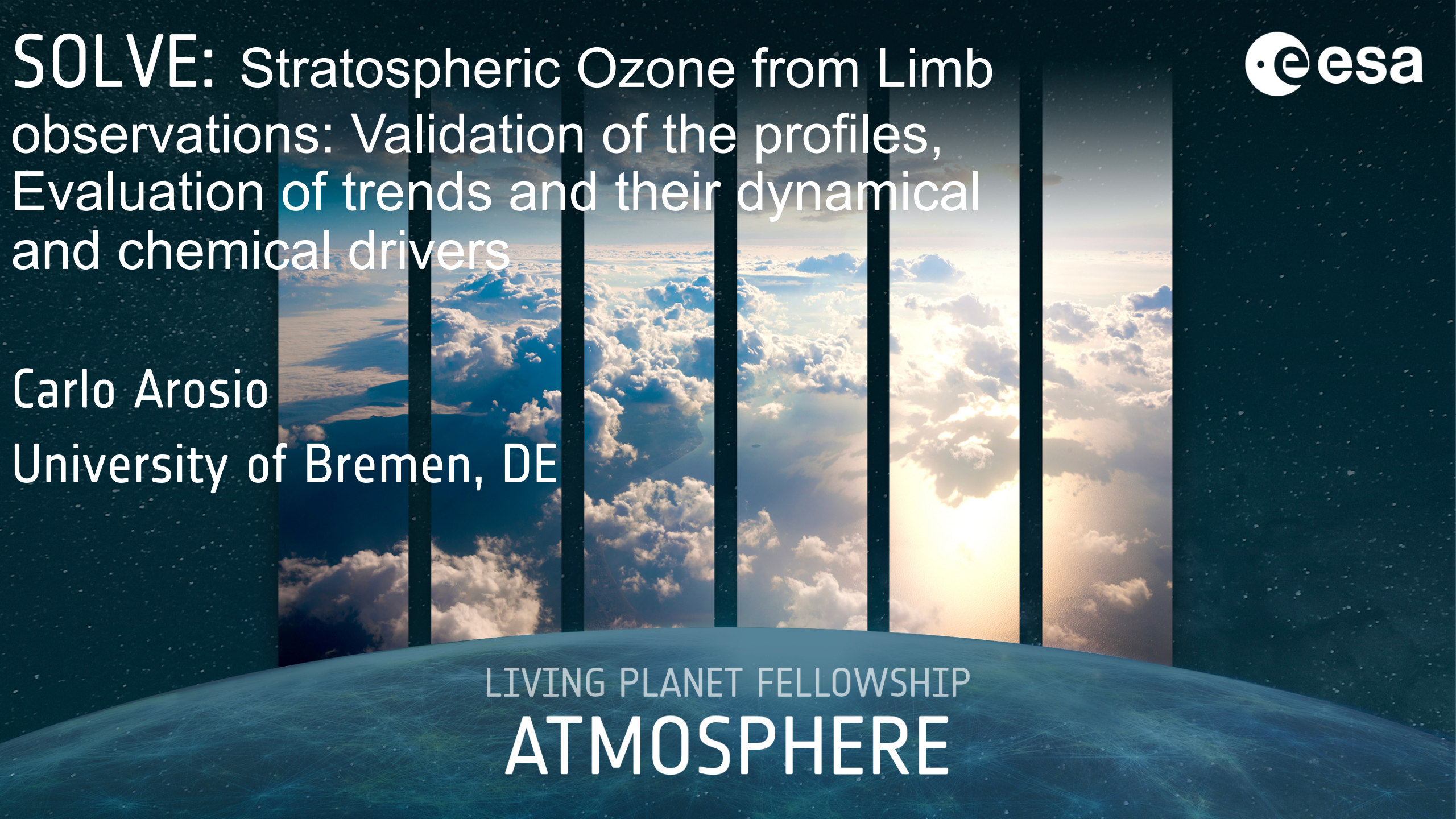
SOLVE: Stratospheric Ozone from Limb observations: Validation of the profiles, Evaluation of trends and their dynamical and chemical drivers

Carlo Arosio

University of Bremen, DE



Background

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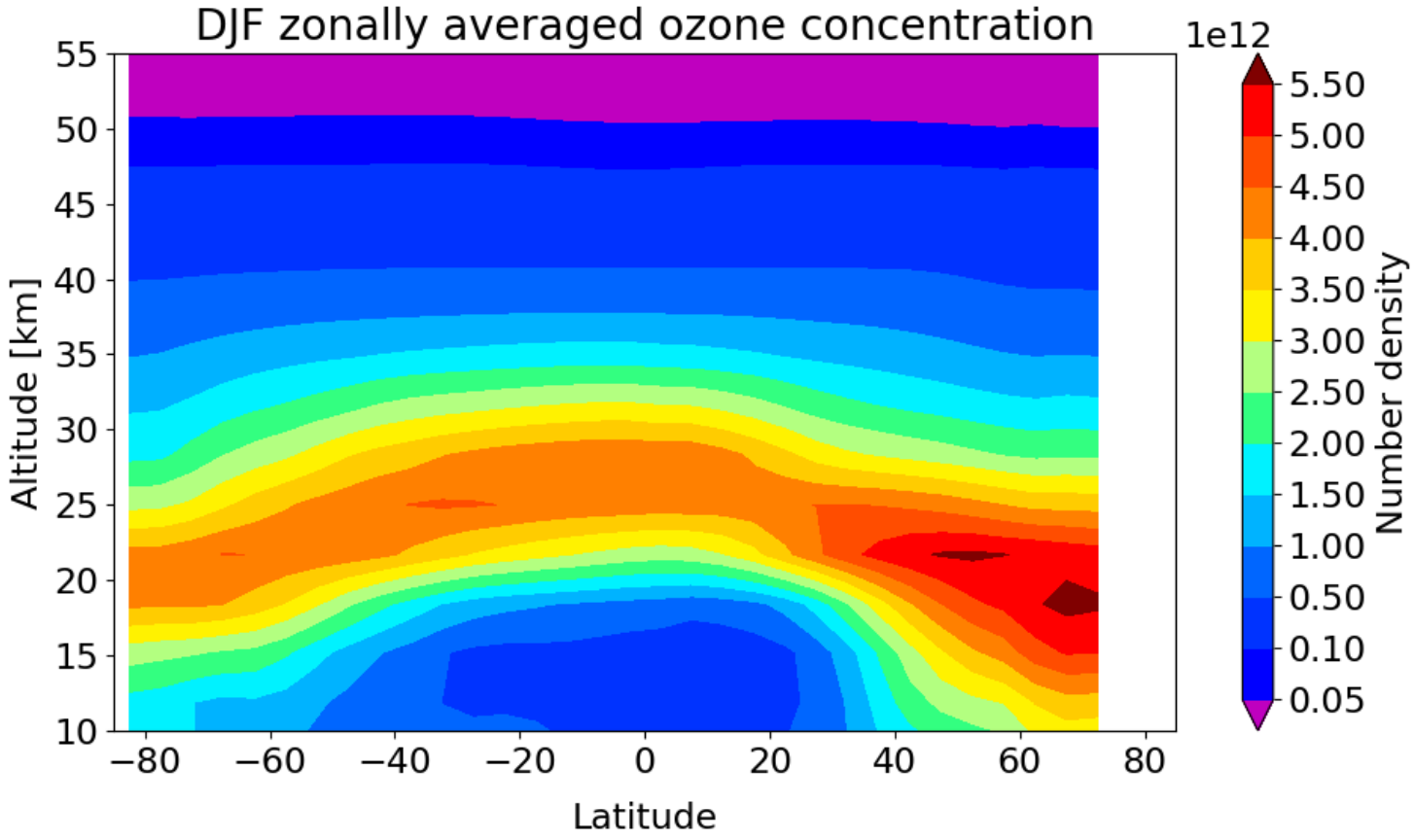

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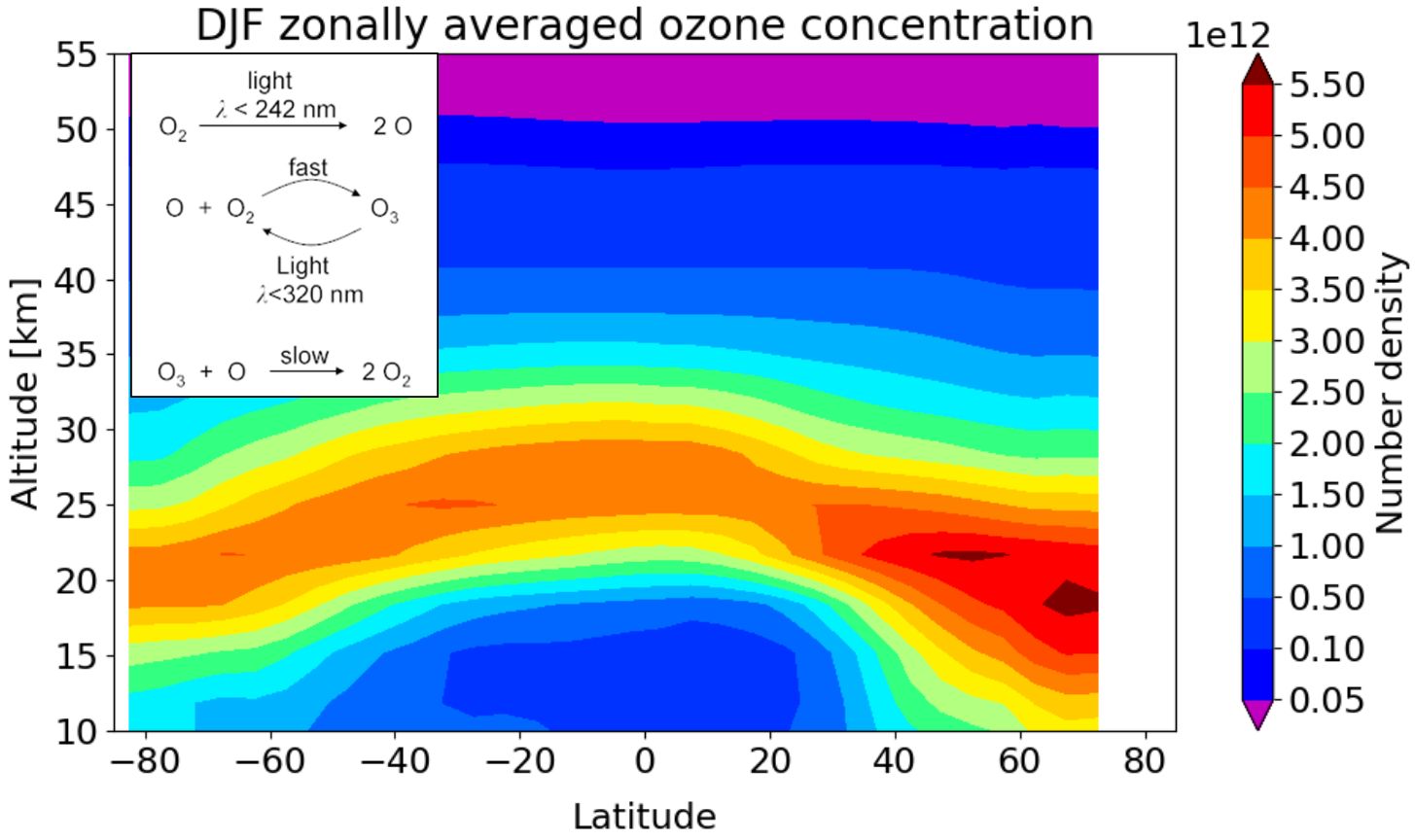

The ozone distribution in the stratosphere depends on the interplay between:

Chemistry: Chapman cycle and catalytic cycle involving several species

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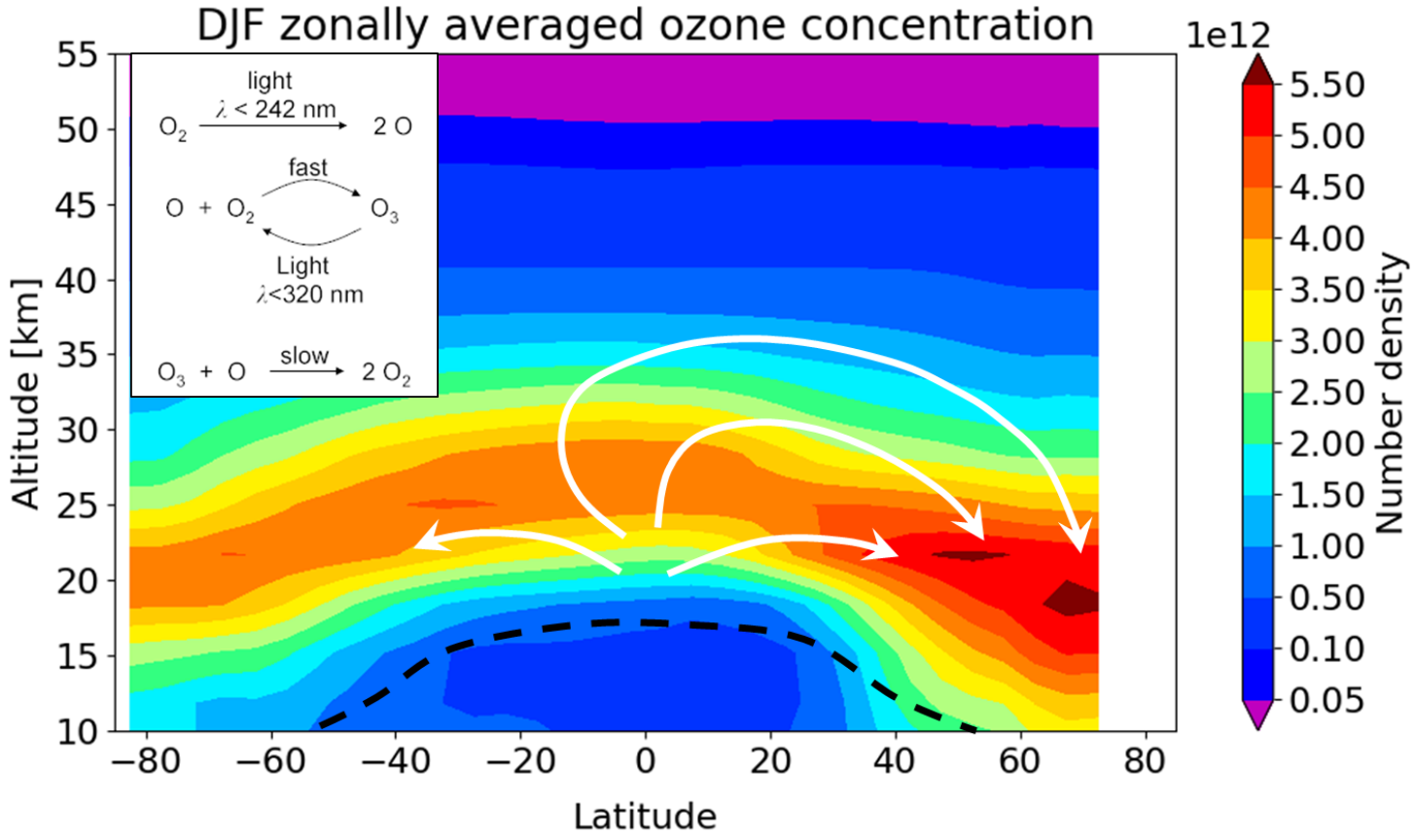


The ozone distribution in the stratosphere depends on the interplay between:

Chemistry: Chapman cycle and catalytic cycle involving several species

and

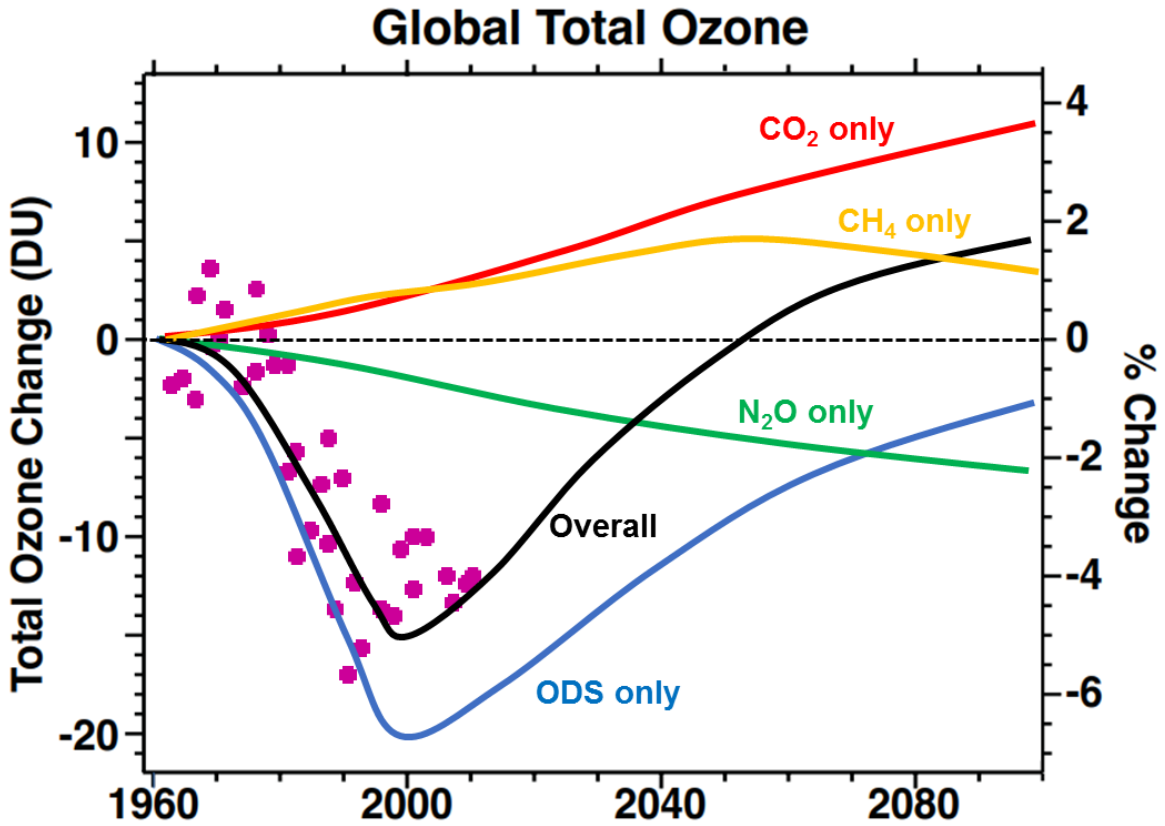
Dynamics: mixing and transport

Which change with time

Background

Ozone depletion was observed at the end of the last century due to the emission of chlorine-containing ozone-depleting substances (ODS).

What is expected in the current century?



Adapted from WMO, 2014

- The ban of chlorine-containing **ODS** (Montreal Protocol and amendments) led to a decrease of their concentration BUT illegal emissions of CFC-11 detected;
- Increasing **GHG** leads to a stratospheric cooling, which dampens ozone-destroying catalytic cycles;
- **N_2O** is expected to become the most important ODS at the end of 21st century;
- **Overall** effect: an ozone **recovery**, or a super-recovery, is expected during the current century.

Instruments and Data

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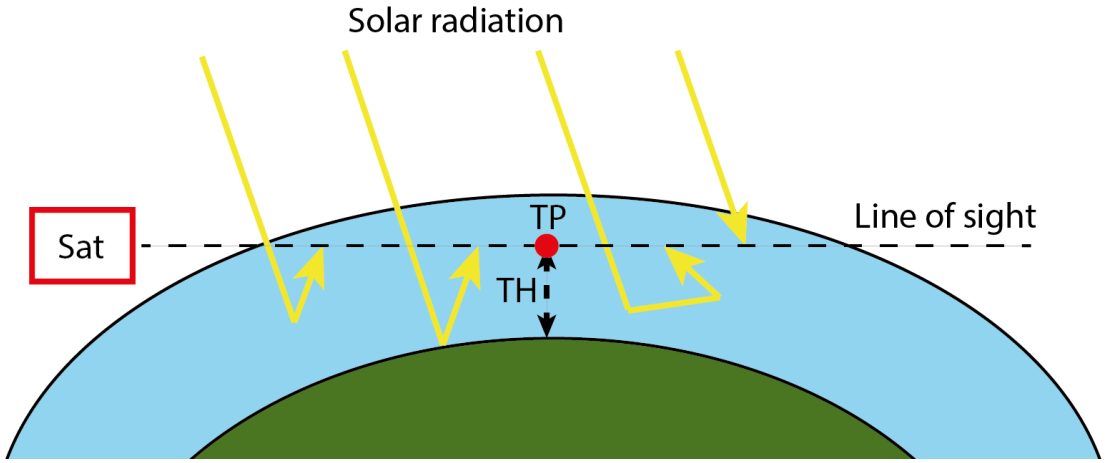

Satellite observations in limb geometry: collecting solar light scattered into the satellite line of sight

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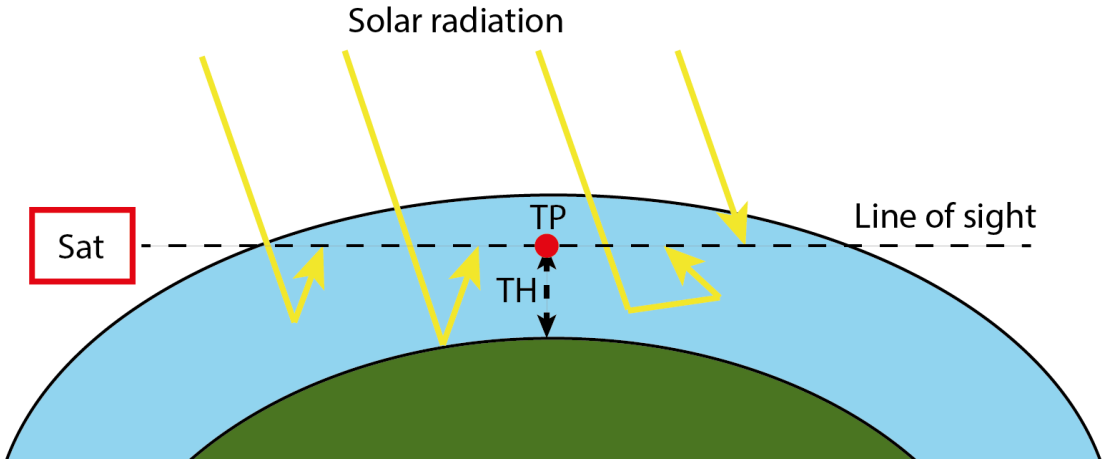
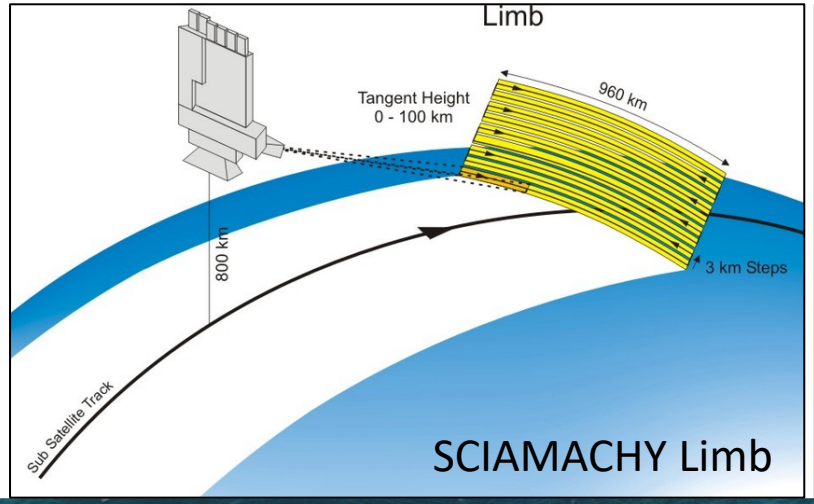
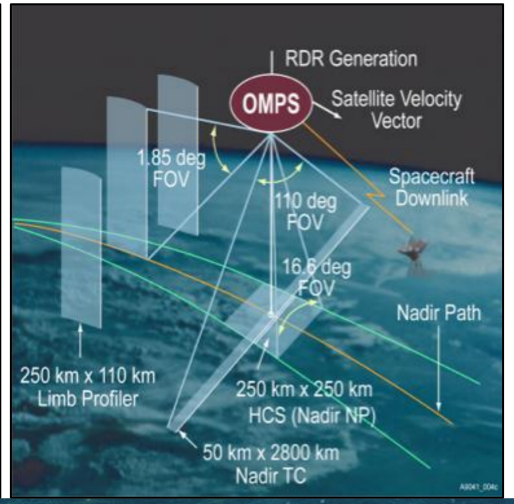






Satellite observations in limb geometry: collecting solar light scattered into the satellite line of sight

Satellite instruments involved:

- SCIAMACHY (2002-2012)
- OMPS Limb Profiler (LP) (2012-present)

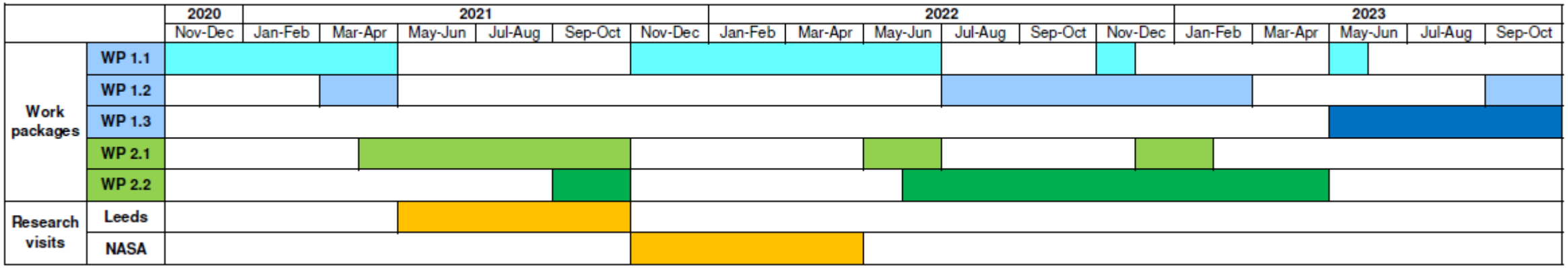
A **merged** monthly mean SCIAMACHY/OMPS-LP data set longitudinally resolved is available and will be used to study long-term ozone changes.

Objectives

Goals of the project: investigate ozone changes over the last 20 years at high spatial resolution using satellite observations and simulations from a chemistry transport model to help identifying the driving mechanisms.

- **WP1: Data set assessment and improvement:**
  - establish an extensive uncertainty budget of the SCIAMACHY and OMPS-LP data sets and study the long-term stability of the OMPS-LP time series;
  - validate the profiles using independent satellite and ground-based observations;
  - improve the quality of the data set in the lower stratosphere with a possible synergy with S5P

- **WP2 Geophysical studies:** study long-term trends with the help of TOMCAT chemistry transport model: what is the impact of the ongoing climate change on the ozone recovery? What's the importance of stratospheric dynamics in explaining the zonal asymmetries identified in ozone trends?



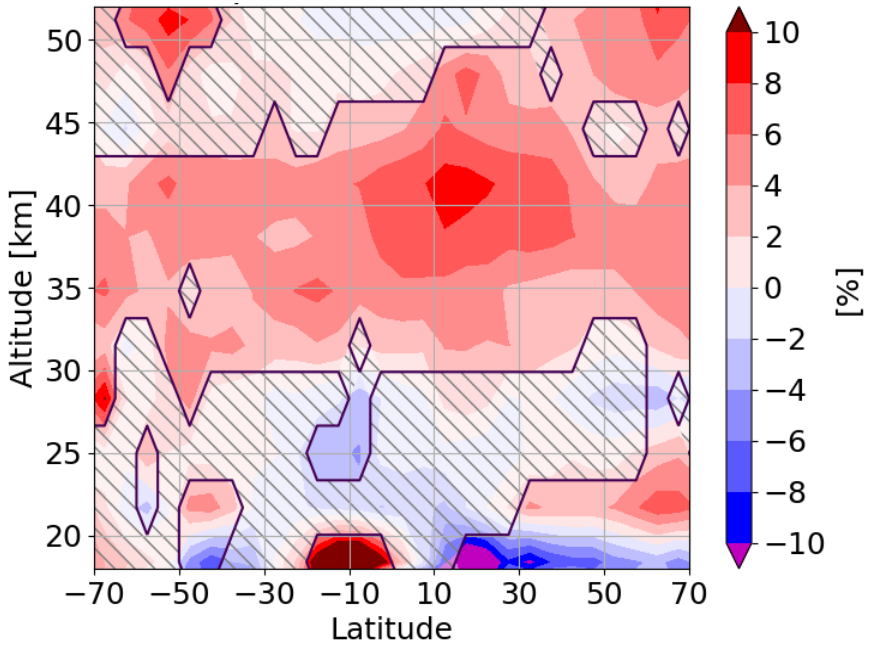
Objectives

WP1 Data set assessment and improvement of the ozone retrieval

1. Assessment of the uncertainty budget for OMPS-LP and SCIAMACHY ozone profiles and propagation into monthly mean and merged data (current work); Investigation of the long-term stability of OMPS-LP time series.

Collaboration with the NASA team responsible for the OMPS-LP Level 1 data; investigation of the long-term **drift** identified in the ozone time series w.r.t. independent observations (MLS satellite observations in the picture).

OMPS relative drift w.r.t MLS, 2012-2017

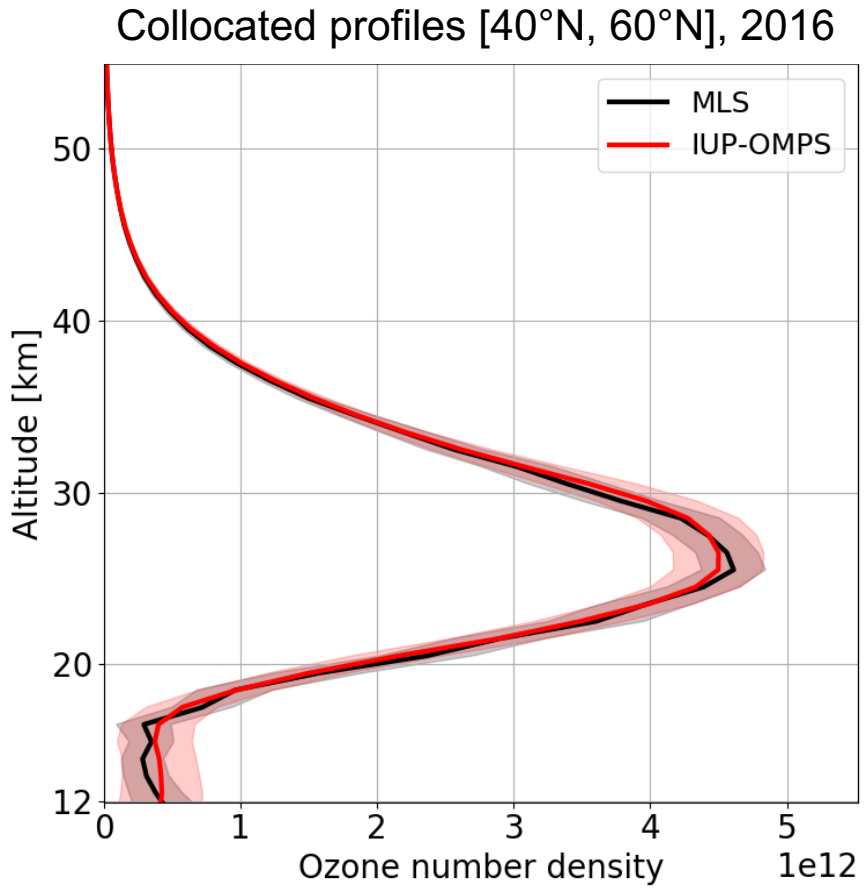


Objectives

WP1 Data set assessment and improvement of the ozone retrieval

2. Validation of the ozone profiles and of the uncertainties, assessment of zonal asymmetries using independent data sets. Interest in validation at so-called “super-sites” where several ground-based observations are available.

3. Study of a new retrieval using the synergy with Sentinel 5P to improve the information content in the lower stratosphere.

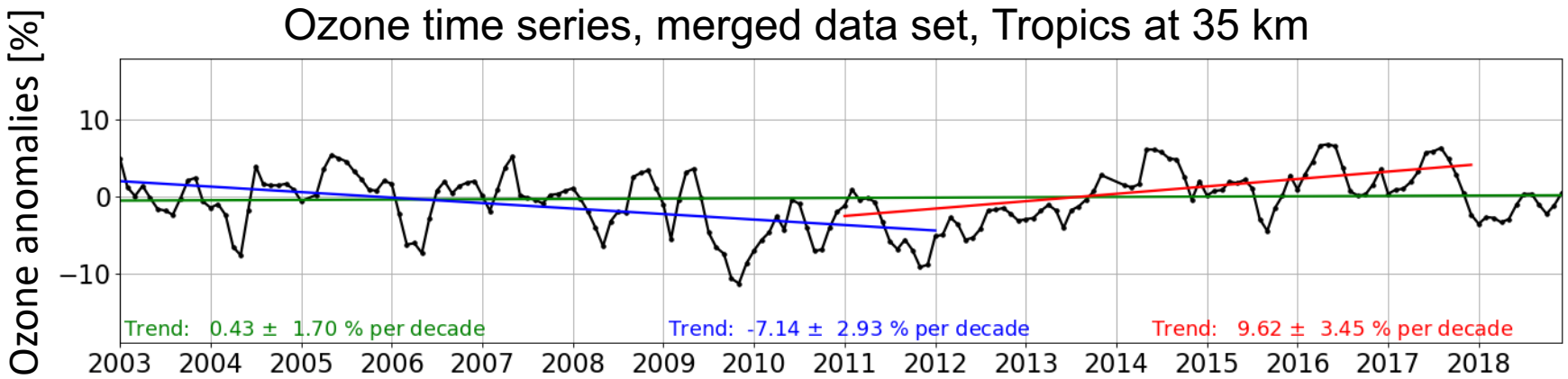


Objectives

WP2 Geophysical studies with a chemistry transport model (CTM)

1. Run simulations with the TOMCAT CTM and investigate the agreement of the model with the merged SCIAMACHY/OMPS-LP data set. Understand differences and compare time series with a focus at interesting atmospheric regions: e.g. tropical mid-stratosphere.

Collaboration with the team at the University of Leeds, School of Earth and Environment, developing the TOMCAT chemistry transport model. Planned visit in next summer.



Objectives

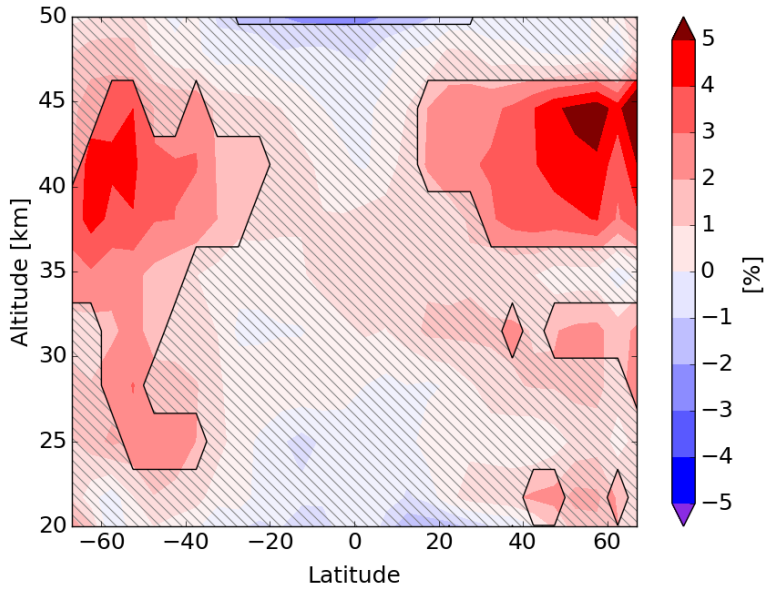
WP2 Geophysical studies with a chemistry transport model (CTM)

2. Geophysical studies using TOMCAT simulations with a focus on:

   - Zonal asymmetries identified in long-term trends, investigate the agreement with the CTM;
   - Atmospheric processes driving the trends in different atmospheric regions.

Ozone trends from merged data set, 2003-2018

Zonally averaged



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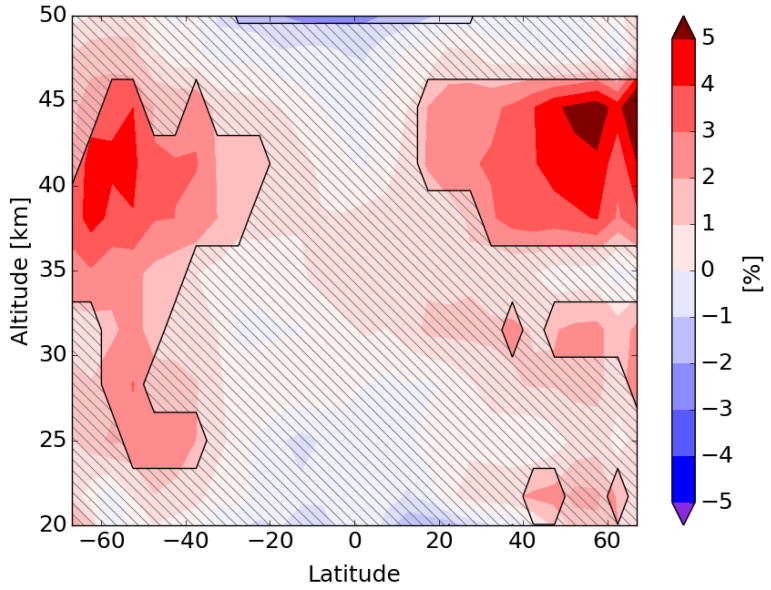
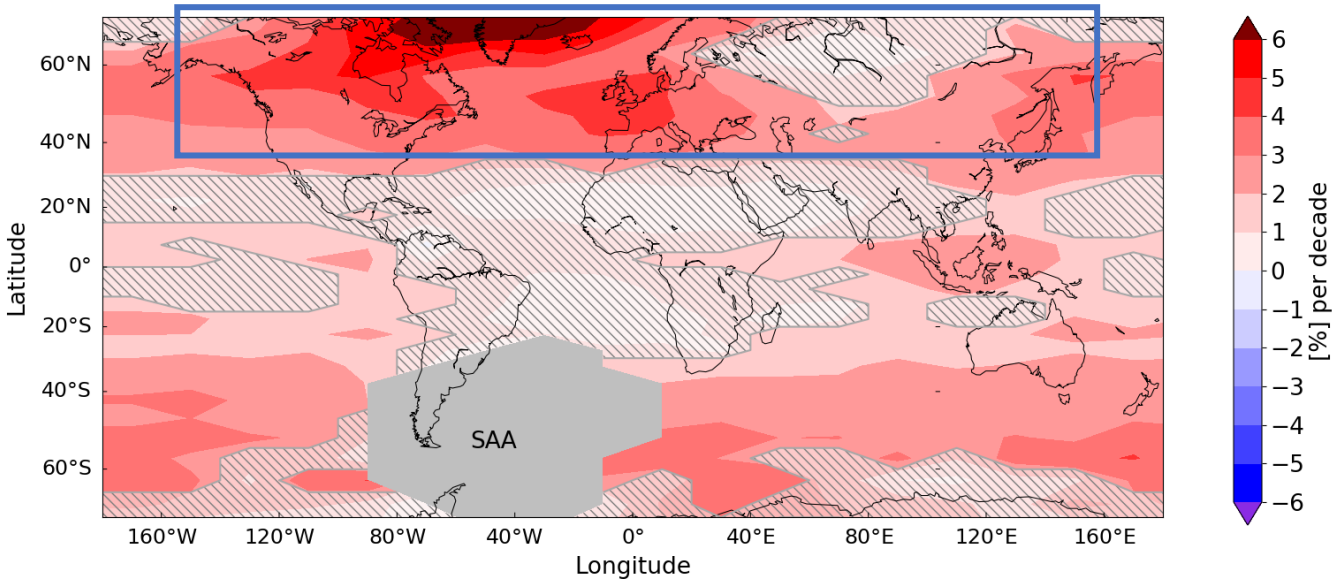


Longitudinally resolved, at 40 km



Conclusions

The project started in November and is expected to result in:

- Improvement and extension of the long-term merged ozone data set, resolved as a function of altitude, latitude and longitude based on SCIAMACHY and OMPS-LP limb observations, covering the period 2002-2022 and the 10-60 km altitude range;
- Extensive assessment of the uncertainties of single satellite data sets and of the merged time series, along with an assessment of its long-term stability;
- Validation of the ozone profiles with independent data sets and at “super-sites”;
- Investigation of long-term ozone changes over the period 2002-2022 and their zonal asymmetries;
- Investigation of the origin of the ozone changes as a function of altitude and atmospheric region (e.g. the oscillation in the middle tropical stratosphere) by exploiting CTM simulations.

Related project: ESA O3 Climate Change Initiative and the LOTUS initiative about ozone trends and merging datasets.