1. Introduction & Motivation

Motivation:
- Example of insufficient representation of stratospheric ozone and its impact on tropospheric dynamics.
- Southern hemispheric summer zonal wind trends: Model results

3 approaches to ozone chemistry for GCMs.

- Full Ozone Chemistry Model (with full chemistry)
- SWIFT: Computationally very expensive
- BUT: Computationally dynamic coupling to GCM

2. Chemical regimes in the stratosphere

- Upper Stratosphere: O₃ lifetime < transport timescale
- O₃ is in chemical equilibrium
- Lower Stratosphere: O₃ lifetime >> transp. timescale
- Largest contribution to total ozone column

3. Method: Repro-modeling

Definition: Repro-modeling is the parameterization of complex models by explicit algebraic functions via numerical fitting.

One explicit function for global ozone loss and production rates over 24h:

$$\Delta O_3/24h = F(x_1, x_2, ..., x_9) : \mathbb{R}^9 \rightarrow \mathbb{R}$$

Solving this algebraic equation mimics the behavior of the full system of differential equations.

$\Delta O_3$ can be efficiently described by only 9 variables:

- Geographic and atmospheric variables:
  - Latitude
  - Altitude
  - Temperature
  - Overhead ozone
- Mixing ratios of ozone-depleting chemical families:
  - Chlorine (Cl₂)
  - Bromine (Br₂)
  - Nitrogen-oxide (NOₓ)
  - Water vapor (H₂O)
  - Odd-oxygen (O₃)

4. Training data for polynomials

- Full lagrangian stratospheric chemistry and transport model:
- ATLAS model - training data

- Ozone change rates over 24h and the 9 variables are taken from ATLAS trajectories.
- ATLAS trajectories of one month yield a training data set with approx. 3 to 6 million data points.
- $\Delta O_3$ is fitted with polynomials on training data set.

5. Results & Simulations

$\Delta O_3$ fit of monthly testing data set (July)

- Testing data set: ~1.5 mio. data points (differs from training data).
- Monthly & zonal average
- Very good agreement!

Simulations with $\Delta O_3$ module:

$O_3$ mixing ratios after 5 months of SWIFT model run.

- 1 model month = 1 day on 48 processors
- 1 model month = 10 minutes on single processor

Summary

- The SWIFT extrapol module employs a repro-modeling approach to determine algebraic equations (polynomials) to calculate ozone change rates in the stratosphere.
- Drastical reduction of computing time, in comparison to full CTMs.
- The polynomials are a function of only 9 variables, which are required as a model input.