LOTUS: Current ozone profile data sets, regression analyses and trend

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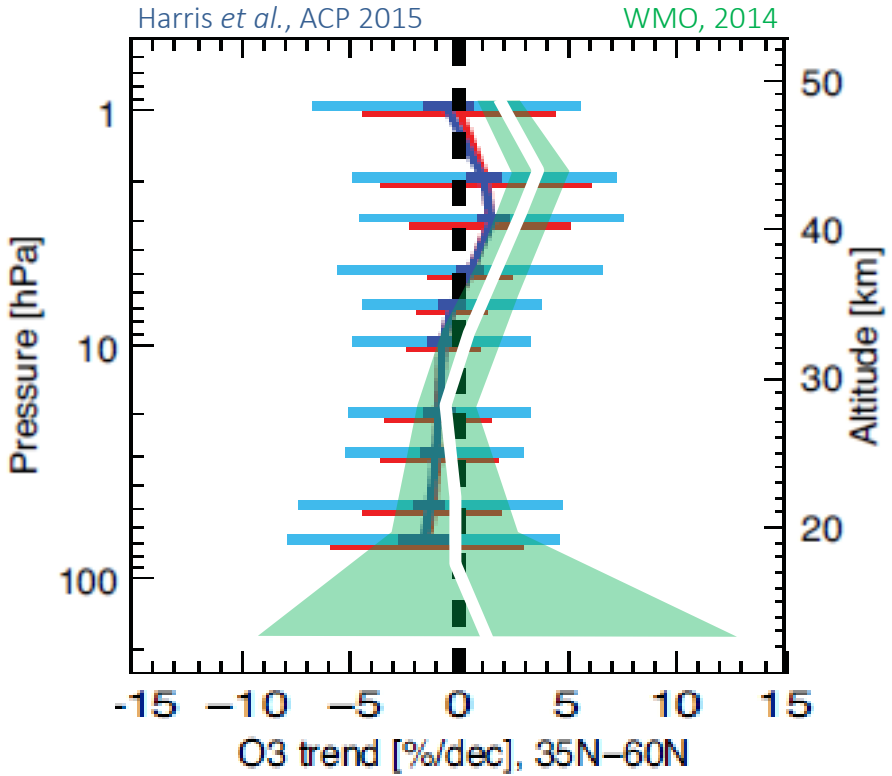
and 30 participants

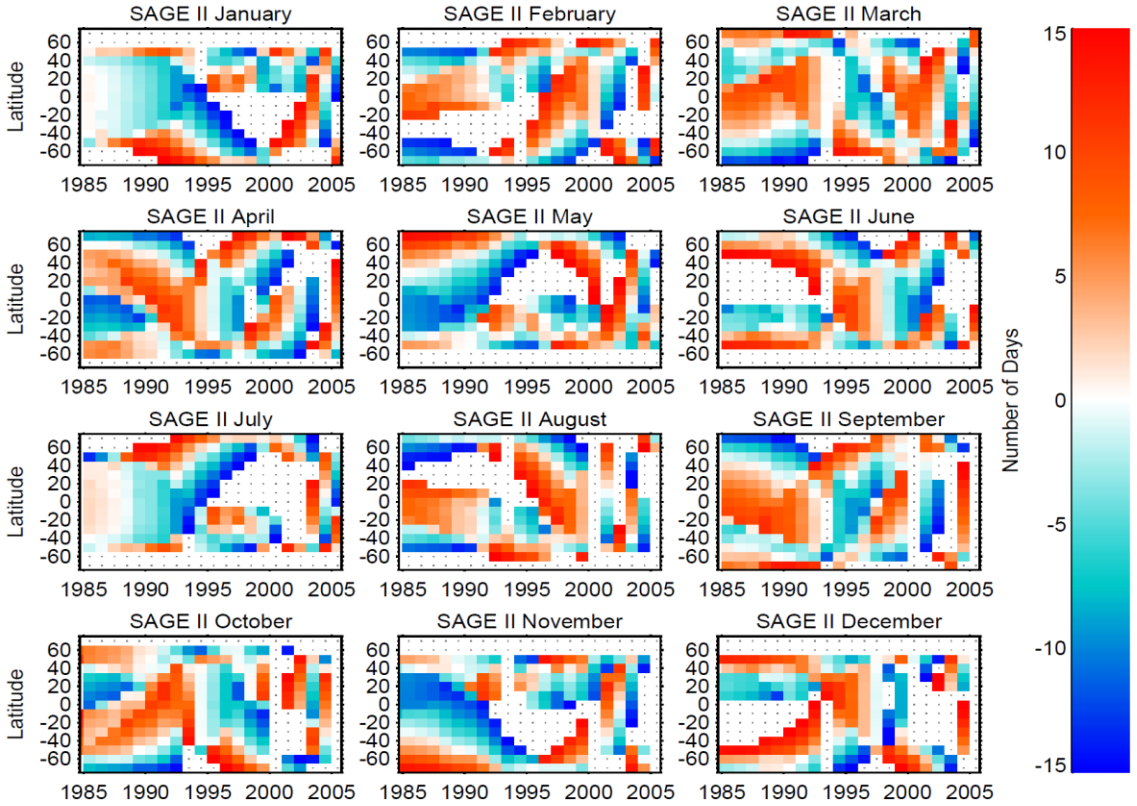
Rationale

- Different ozone profile trend results by WMO/UNEP 2014 Ozone Assessment and by SI2N initiative.
- Evaluation of trend significance is very sensitive to assumptions made, and we don't know which ones are more realistic.
- It is crucial to resolve this issue before the next WMO/UNEP Ozone Assessment (2018).
- WMO/UNEP Ozone Assessments are based on assessed published results.



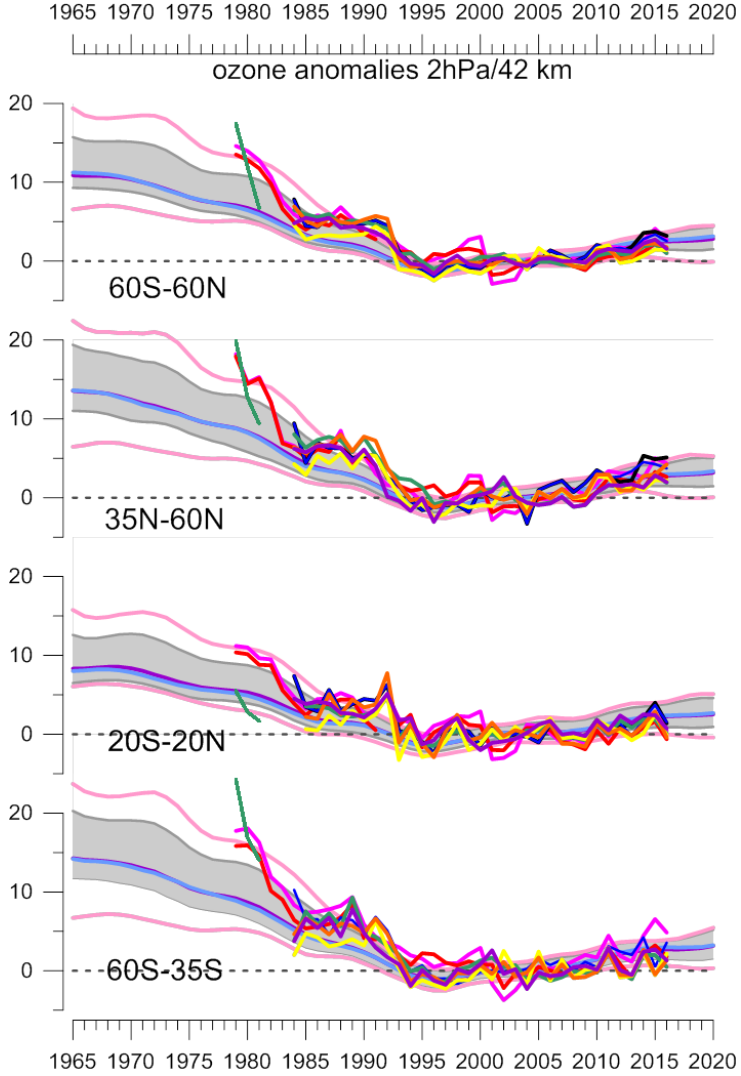
Changes in individual data sets

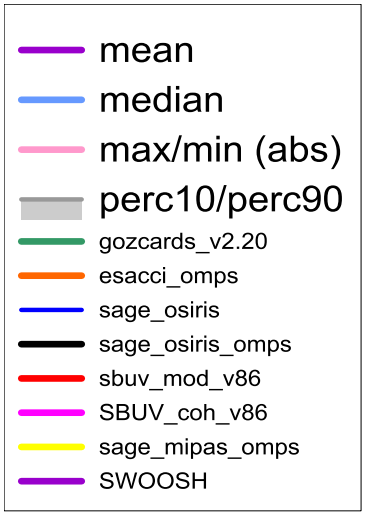
- SBUV v8.6 : no changes
- SAGE II v7 : correction for sampling bias correction
- OSIRIS v5.10 : correction for drift in absolute pointing
- GOMOS ALGOM : improved screening, aerosol model
- MIPAS v7, SCIAMACHY v3.5: updated Level-1 data, …
- Aura MLS v4.2, ACE-FTS v3.6: no major changes
- OMPS-LP, NASA v2.5, USASK 2D v1.02: new data sets
- …



Damadeo et al., in reviews

Time series





CCMI models

Satellite merged datasets

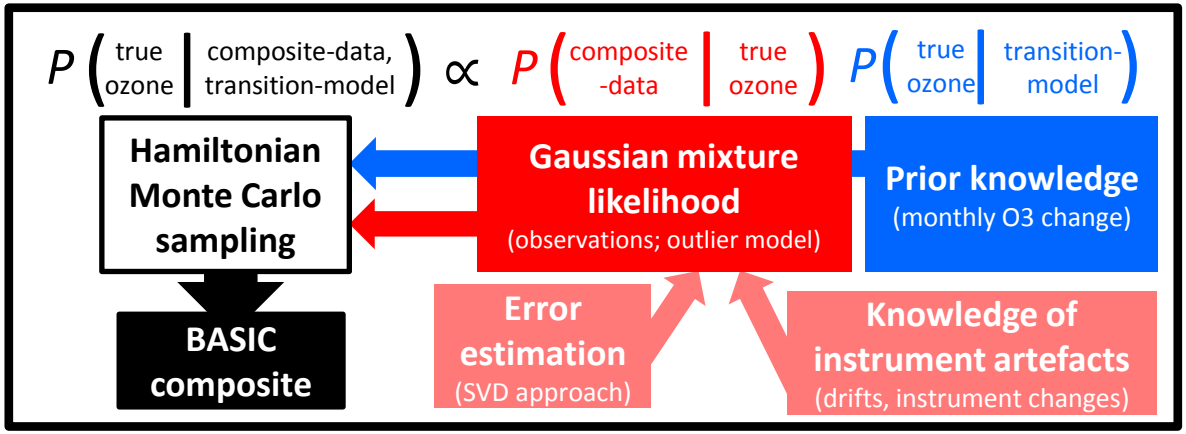
de-seasonalized data at 2hPa (45 km) for wide latitude bands.
QBO signal is seen in the data, but models are averaged out

BASIC Composite

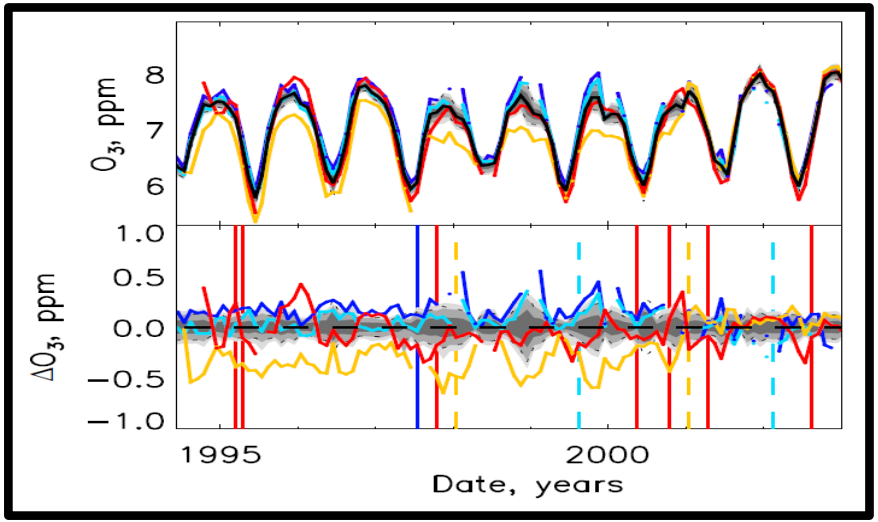
BAyeSian Integrated and Consolidated

Algorithm *follows Bayesian inference*

$$P\left(\begin{matrix}\text{true}\\ \text{ozone}\end{matrix}\,\middle|\,\begin{matrix}\text{composite-data,}\\ \text{transition-model}\end{matrix}\right) \propto P\left(\begin{matrix}\text{composite}\\ \text{-data}\end{matrix}\,\middle|\,\begin{matrix}\text{true}\\ \text{ozone}\end{matrix}\right) P\left(\begin{matrix}\text{true}\\ \text{ozone}\end{matrix}\,\middle|\,\begin{matrix}\text{transition-}\\ \text{model}\end{matrix}\right)$$



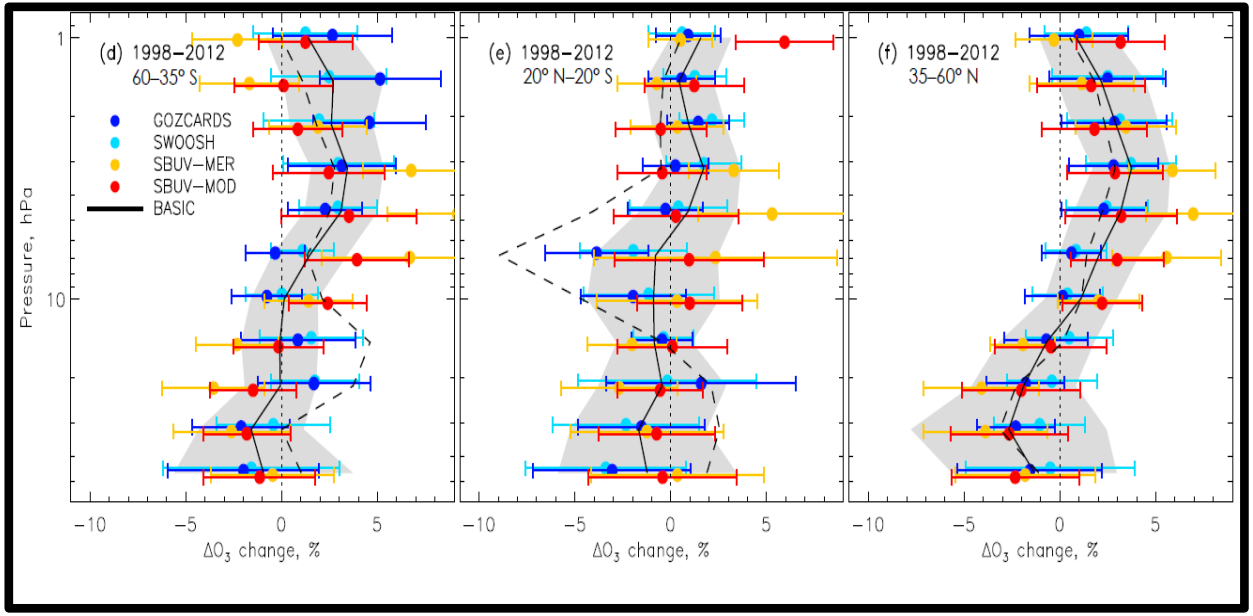
Example timeseries *at 7 hPa and 40-50S*



BASIC
GOZCARDS
SWOOSH
SBUV-NASA
SBUV-NOAA

Ball et al., 2017, ACP

Profile Ozone change, %; *1998-2012*



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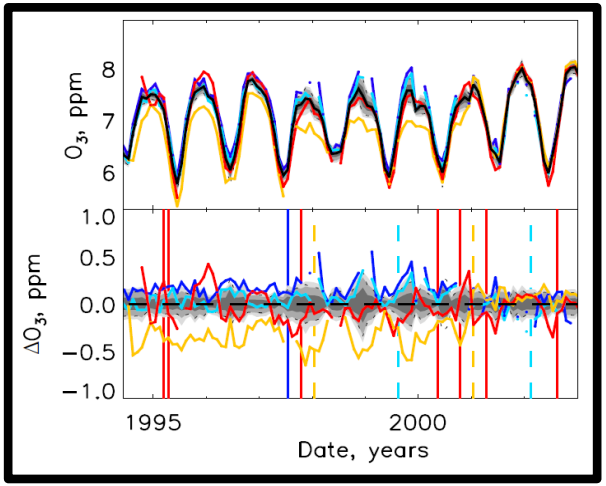

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Ball et al., 2017, ACP

Further development of regression analyses

USASK team developed a **regression toolset** that is being used for

- **Sensitivity tests**
  - Choice of regression terms
  - Choice of proxies
  - Start/end period
  - Treatment of autocorrelation
  - Use regression uncertainties (or not)
  - (MLR versus DLM)
- **All trend analyses using final set-up(s)**
  - One code to obtain consistent results

MLR regression (Python code)

Full period data record (1979/1984-2015/20

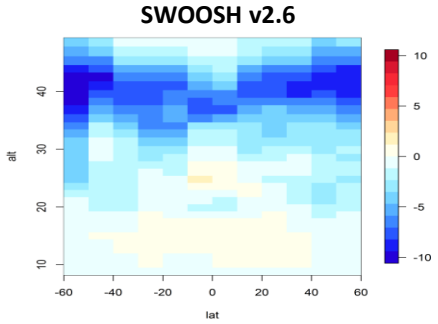
Native representation data record

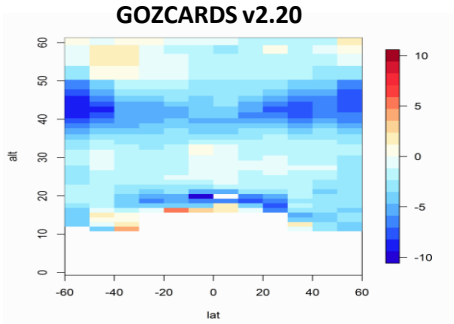
Model : trend, solar f10.7, QBO PCA A+B, ENSO lag-0, GISS AOD (+seasonal)

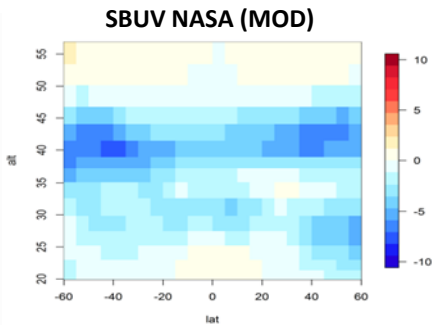
Plot

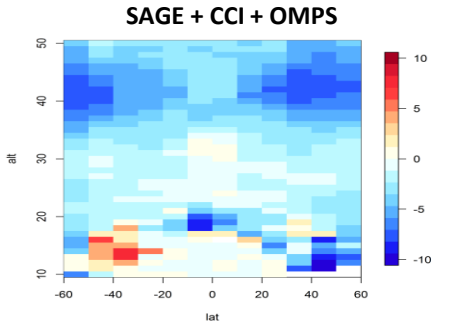
All scales equal, except vertical

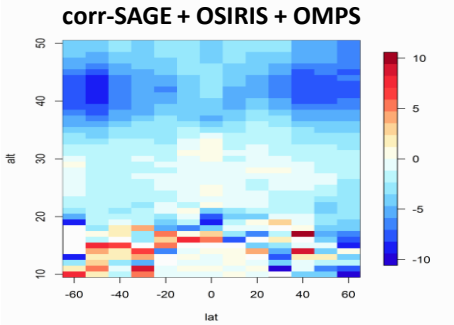
Colour scale increment = 1.18 % per decade

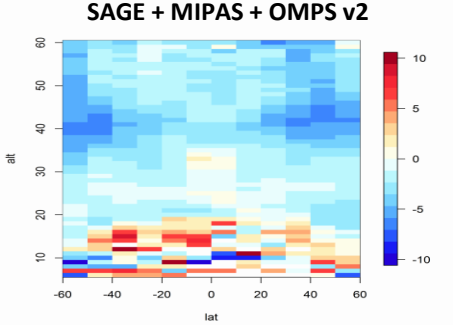


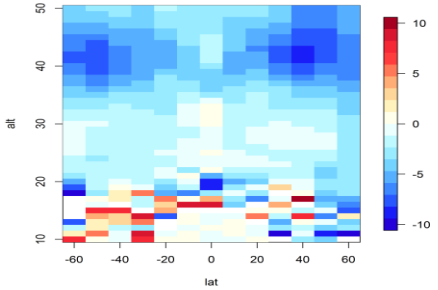


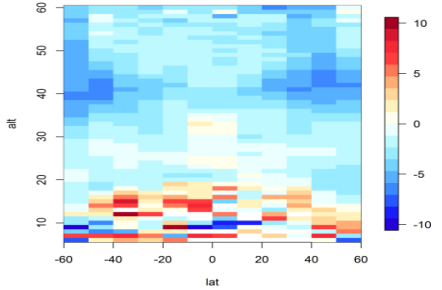


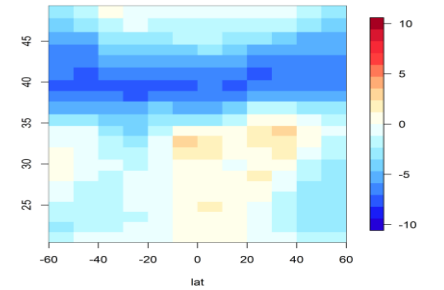






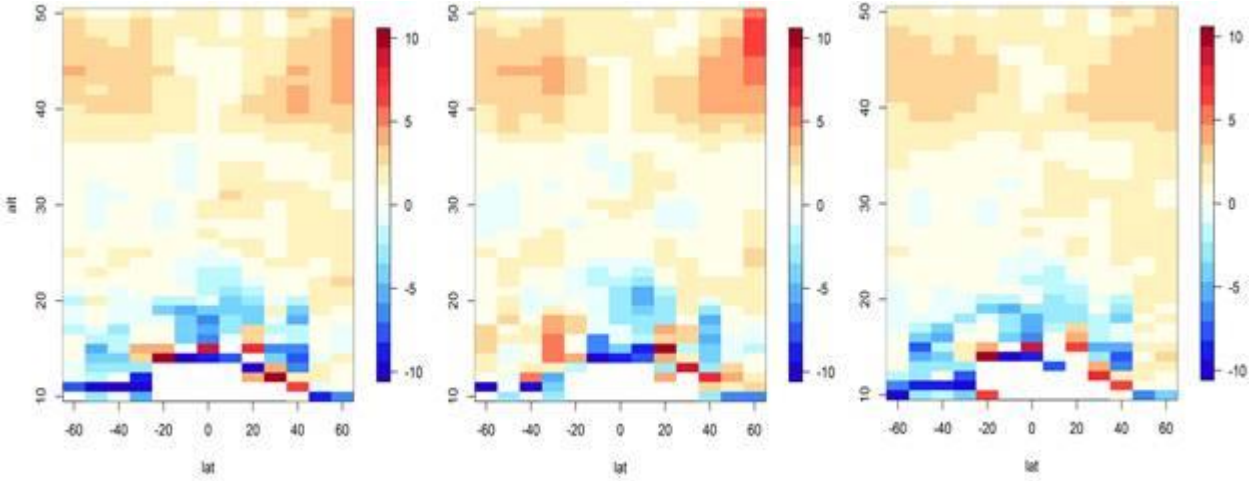






Trend analyses with three MLR models

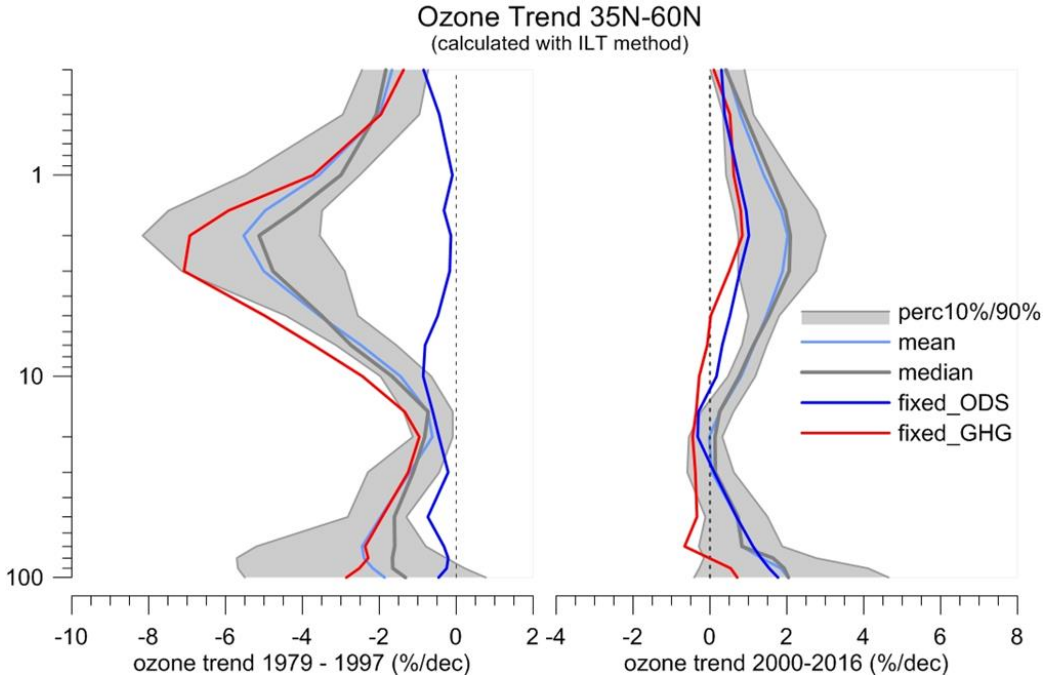
- PWLT – Piece Wise Liner Trend
- EESC-based Trends
- ILT - Independent Linear Trend



Derived trends in ozone for the SAGE II/OSIRIS/OMPS data set between 2000 and 2016 in units of percent per decade using the PWLT (left), ILT (middle), and EESC EOFs (right) proxies (LOTUS Report, in prep.)

CCMI models for SPARC LOTUS and WMO/UNEP Ozone Assessment

- 15 RefC2 models/modelling groups
- For each model (ensemble) derive:
  - QBO EOFs (from the simulation zonal winds)
  - ENSO index from the simulation SSTs
  - Deseasonalize the data (1998-2008)
- ILT regression analysis at given pressure levels with proxies:
  Trend terms , QBO (2 terms), ENSO, F10.7 (given forcing), AOD forcing
- ODS (SCNfODS) and fixed GHG (SCNfGHG) trends

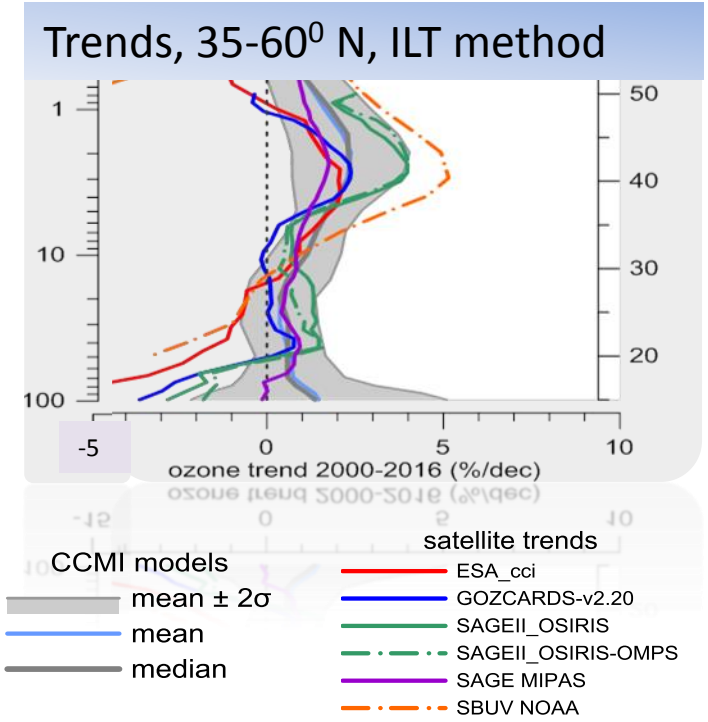


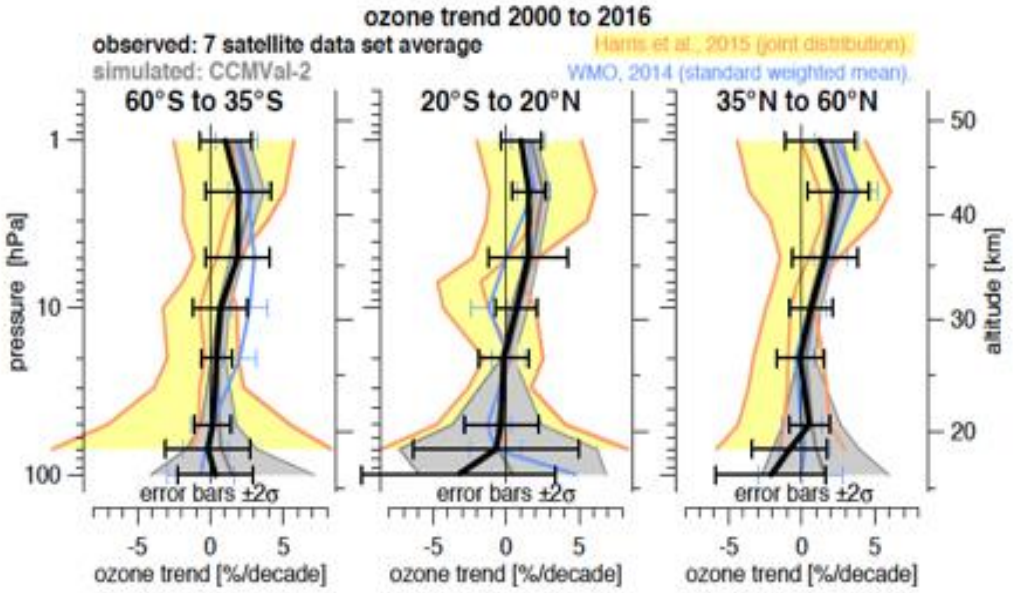
CCMI group permission to use averaged results for the LOTUS Report and the Ozone Assessment

Work of Kleareti Tourpali (Aristotle University of Thessaloniki), Stergios Misios (Oxford), Bjorn-Martin Sinnhuber (KIT) and Peter Braesicke (KIT)

New trend estimates

SPARC activity report





Steinbrecht et al., ACP (2017)

Publications

- o Three LOTUS leads are –co-authors to WMO/UNEP Chapter 3.
- o Steinbrecht, W, et al., .: An update on ozone profile trends for the period 2000 to 2016, Atmos. Chem. Phys., 17, 10675-10690, doi:10.5194/acp-17-10675-2017, 2017.
- o Damadeo, et al., The Impact of Non-uniform Sampling on Stratospheric Ozone Trends Derived from Occultation Instruments, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2017-575, in review, 2017.
- o Frith, et al..: Estimating Uncertainties in the SBUV Version 8.6 Merged Profile Ozone Dataset, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2017-412, in review, 2017.
- o Ball, W. Tet al..: Reconciling differences in stratospheric ozone composites, ACP ,doi:10.5194/acp-2017-142, 2017.
- o Sofieva, et al., Merged SAGE II, Ozone_cci and OMPS ozone profiles dataset and evaluation of ozone trends in the stratosphere, ACP., 1–28, doi:10.5194/acp-2017-598, 2017.
- LOTUS Report, in preparation for submission, November 2017

To do list:

- The **Final Report** is to be submitted for review to SPARC by the end of October.
- Key results by LOTUS will be part of the WMO/UNEP **Ozone Assessment** to be published in 2018.
- A list of **remaining open issues** relevant to the ozone profile trend study was identified (i.e. UTLS, polar regions, seasonality of trends, trends at upper altitudes).
- LOTUS will continue investigation of the **impact of measurement uncertainties on the derived trends** (in collaboration with the TUNER SPARC activity).
- **AGU Fall meeting** in New Orleans, LA, in December 2017, special LOTUS session "Long-term Ozone Trends and Estimation of their Associated Uncertainties".
- **EGU, April 2018**, LOTUS-focused session "Advances in estimating and attributing long-term ozone and temperature trends in the middle atmosphere". **LOTUS workshop** (planned)
- **Invited talk** on LOTUS at the SPARC Data Assimilation Working Group (SPARC-DA) and SPARC Reanalysis Intercomparison Project (S-RIP) joint workshop in October 2017 in Reading, UK.

The first LOTUS workshop, at LATMOS at the Université Pierre et Marie Curie in Paris, France on March 13-15, 2017. SPARC July 2017 letter has the report.

SPARC
Stratosphere-troposphere Processes And their Role in Climate

WCRP
World Climate Research Programme

WORLD METEOROLOGICAL ORGANIZATION

IUGG

IAMAS
International Association of Meteorology and Atmospheric Sciences

Collaboration with other SPARC activities

- SPARC emerging activity **TUNER** (Towards Unified Error Reporting) - critical information on measurement characteristics and uncertainties needed for combining the multi-platform datasets. .
- The **S-RIP** activities - understanding which models can provide the data for comparisons with observations to characterize past and future ozone trend for attributions to the ODS and climate
- **CCMI** (the Chemistry Climate Model Initiative) - providing assessed ozone datasets and trend attribution products for validation of chemistry climate model.
- The **OCTAV-UTLS** - partner for future trend analyses of ozone in the UTLS region. The new OCTAV-UTLS products help to interpret ozone trends, reduce uncertainties due to dynamical variability in the region and create methods for understanding impacts of the climate changes to ozone levels in UTLS.