KODYACS How well do models represent the observed variance of stratospheric ozone and temperature on interannual and decadal time scales?

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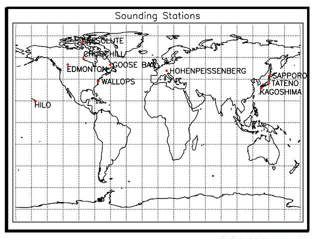
Objectives:
• analyse time series (> 30 years) of monthly mean ozone and temperature profiles
• compare models and observations
• attribute variations to natural and anthropogenic sources
• find+quantify interactions between troposphere, lower, upper stratosphere

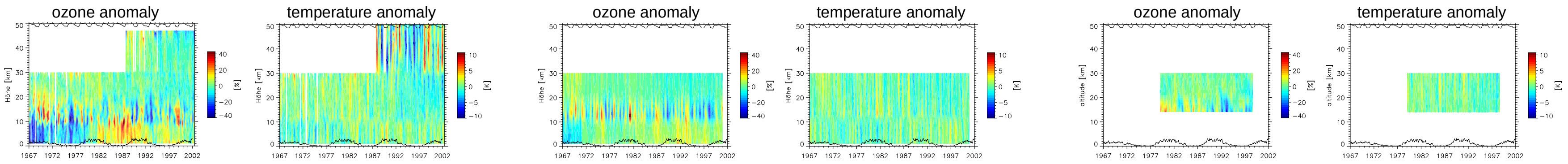
Data:
• ozone-sonde and lidar data from WMO-WOUDC and NDSC
• model results from interactively coupled chemistry climate models (So far: ECHAM-DLR 20 year time slice experiments, greenhouse and ozone depleting gases at 1960s, 1980s and 1990s levels. Future: ECHAM-DLR and ECHAM-MPI transient experiments with varying source gases, QBO and solar cycle)
• model results from chemical transport model SLIMCAT, transport driven by ECMWF meteorological analyses



sounding profiles data sources:

Summary and Outlook:
• long time series from measurements, met. analyses+chemical transport models, and fully coupled free running chemistry-climate model show generally very good agreement
• models show too high ozone and shifted annual cycle in the lower stratosphere
• models show correct/ very realistic interannual variability and trends. SLIMCAT reproduces observed ozone very well
• sonde data show inhomogeneities in ozone (Canada, Japan) and temperature (Japan), that need to be fixed (additional information available, can be done in near future).
• Transient runs that include source gas increases, QBO, solar-cycle, from ECHAM-DLR (1000 to 10 hPa) and ECHAM-MPI (1000 to 0.1 hPa), will be analysed as soon as data are available.
• Upper stratospheric results (lidar, 30 to 50 km) are available for Hohenpeissenberg, analysis needs to be done for available other stations.

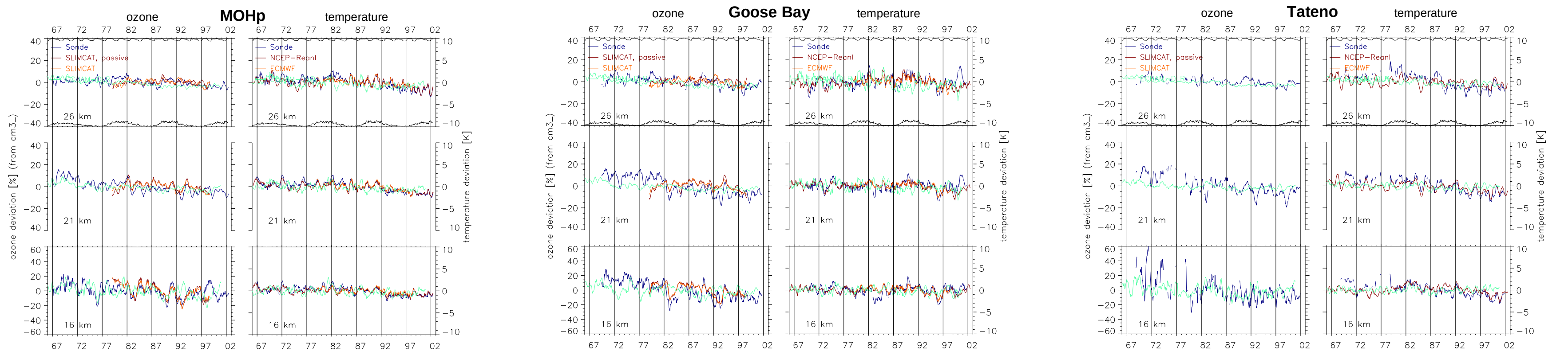
time series



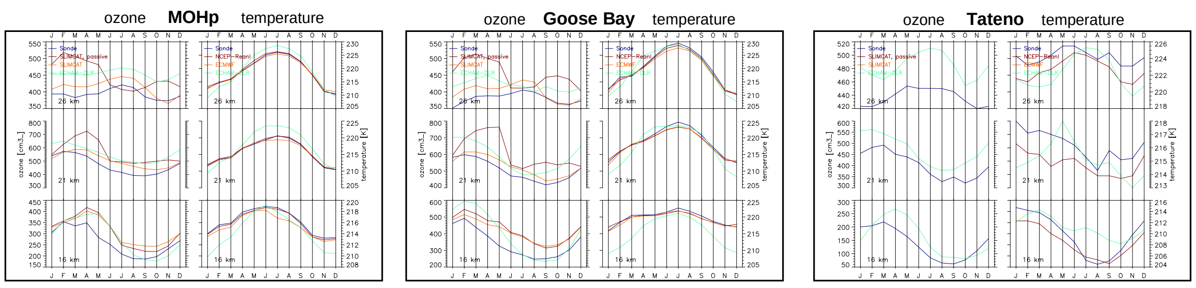
Top: Shaded contour plots showing anomalies at Hohenpeissenberg, measured by sonde and lidar (left, "true" chemistry and climate), modelled by ECHAM (middle, free running "model climate") and SLIMCAT (right, chemistry modelled, transport from ECMWF analyses).

Bottom: Time series at 3 lower stratospheric altitudes for Hohenpeissenberg (left); Goose Bay, Eastern Canada (middle); and Tateno/Tokio, Japan (right).

Highlights: • O_3 and T show clear trends at all altitudes • models reproduce interannual variance and lower stratospheric trends • no model data in upper stratosphere • SLIMCAT spinup from 1979 to 1982 • inhomogeneities (Goose B/M sonde before 1981, Tateno radiation corr. before 1990) • sparse data (Tateno before 1979) • large role of dynamics in interannual variations SLIMCAT O_3 vs SLIMCAT passive tracer shows only minor chemical destruction (mid-latitudes)

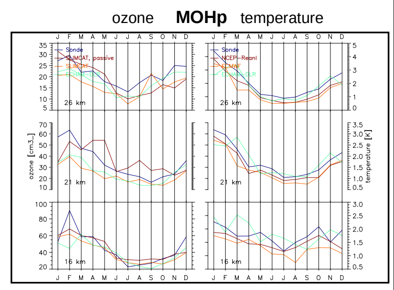


climatology



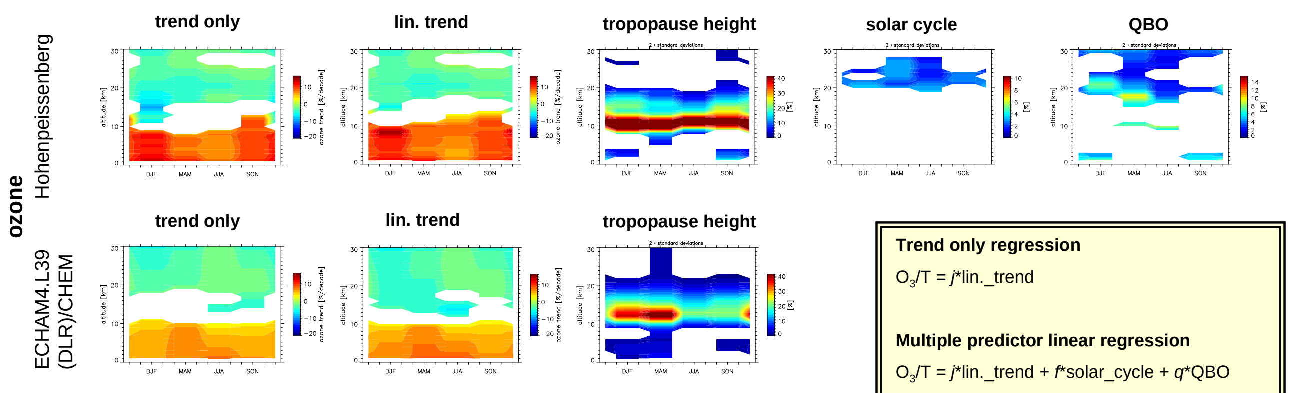
Annual cycle of ozone (left panels) and temperature (right panels) at 3 lower stratospheric altitudes for Hohenpeissenberg (left); Goose Bay, Eastern Canada (middle); and Tateno/Tokio, Japan (right).
• models have 10 to 20% higher ozone; spring/ summer decline too late • ECHAM has winter cold bias at lower levels • Japan has temperature maximum in winter (Aleutian High) - reproduced by model • ECMWF and NCEP-Rean agree well • SLIMCAT O_3 vs SLIMCAT passive tracer shows little O_3 chemistry at 16 km, at 26 km destruction in winter, production in summer

standard deviations



Annual cycle of standard deviations of ozone (left panels) and temperature (right panels) at 3 lower stratospheric altitudes for Hohenpeissenberg.
• standard deviations very similar • sonde standard deviations are generally higher (lower sampling frequency, smaller scales, measurement errors) • chemistry dampens (SLIMCAT O_3 vs. passive)

sources of variability

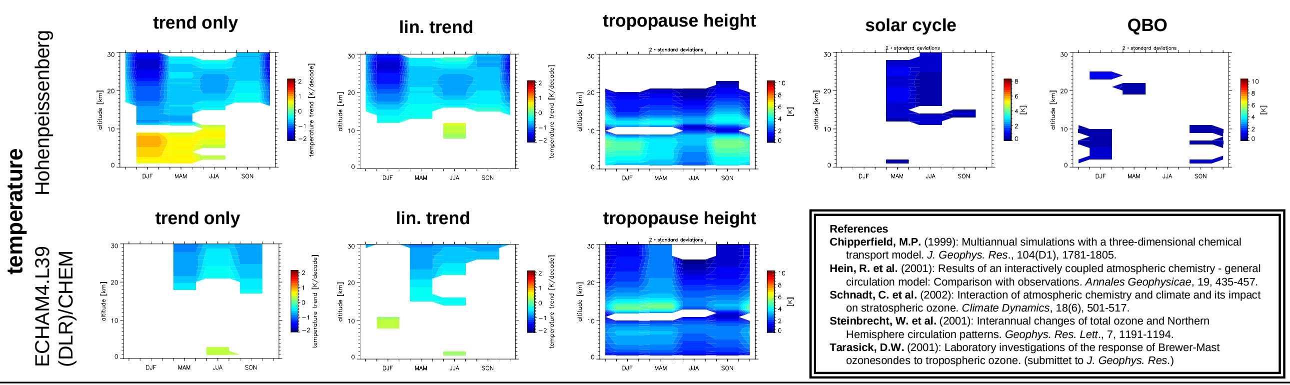


Trend only regression

$O_3/T = j$*lin._trend

Multiple predictor linear regression

$O_3/T = j$*lin._trend + f*solar_cycle + q*QBO + t*tropop._height +... + rest



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Analysis of variance:
• Multiple regression for estimating the influence of various predictors (linear trend, Solar Cycle, QBO etc.) on ozone/ temperature
• Results as function of altitude and for the four seasons
• Non-significant (<90%, white areas in plots) predictors are rejected
• Trends are given in %/decade, other influences are given as standard deviation of their time series (in % or K)
• ECHAM time slice data (lower row s of 3 plots) do not have a solar cycle or QBO influence.

Results:
• Trend only and full regression give very similar trends. "Trend only" trend is slightly higher.
• Agreement between measured data and ECHAM is very good
• SLIMCAT data (not shown) for shorter period (1979-1998): larger trend, otherwise very similar to measured data.
• Variations in lowermost stratospheric ozone largely controlled by meteorology (e.g. tropopause height)
• "chemical" ozone trend in mid and upper stratosphere, "meteorological" ozone trend in lowermost stratosphere
• "radiative" temperature trend in mid-stratosphere (ECHAM: not in winter),
• Very strong coupling between tropospheric temperature, tropopause height, lowermost stratospheric temperature
• sonde changes cause higher ozone (Canada, Japan?) and temperature (Japan) trends.
• Strong meteorological influence at all stations, less in subtropics
• All stations show QBO influence above 20 km