SPARC General Assembly, Bologna 2008, Poster Session C, Poster #00331:

A transient simulation for 1960-2003 with the chemistry climate model ECHAM5/MESSy1: First results on solar variability effects

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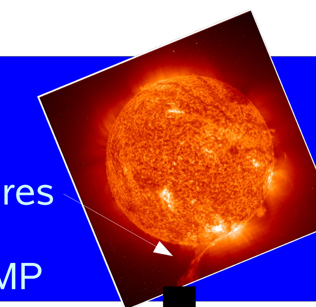
MAX-PLANCK-GESELLSCHAFT

MPI for Chemistry — Modular Earth Submodel System

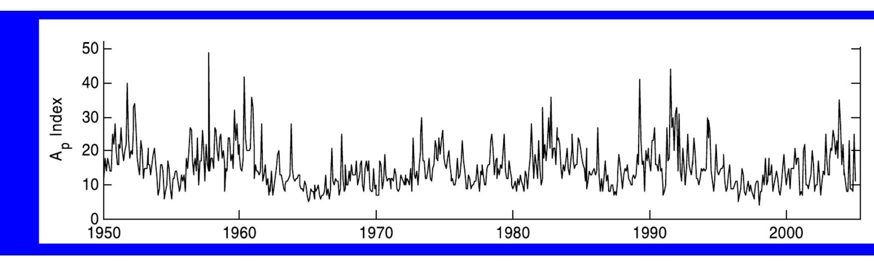
SOLAR FORCING

Solar irradiance variations at 49 wavelengths

Particle flux enhanced during solar flares measured by the satellite instruments GOES and IMP



Geomagnetic activity (monthly A_p index)



THE MODEL

ECHAM5/MESSy1 (EMAC)

Resolution: spectral T42 → 2.8° x 2.8°

90 vertical layers up to 0.01 hPa (80 km)

see Jöckel et al., 2006

JVAL
online calculation of photolysis rates
(Landgraf & Crutzen, 1998)

FUBRad
High-resolution shortwave radiative heating computation
(Nissen et al., 2007)

SPE
Parameterizes NOx and HOx production in the stratosphere and mesosphere by Solar Proton Events
(Baumgaertner et al., 2008b)

SPACENOX
parameterizes NOx produced by low-energy-electrons in the upper atmosphere
(Baumgaertner et al., 2008c)

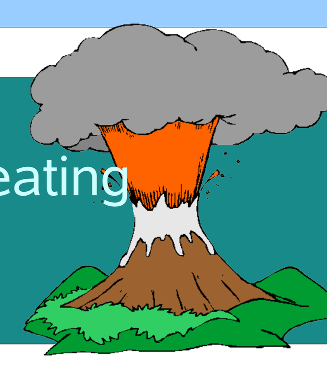
Galactic cosmic ray production of NOx
maximises during solar minimum

For all other submodels
see e.g. Jöckel et al., 2006

SURFACE FORCING

Sea Surface Temperatures (HadISST1)

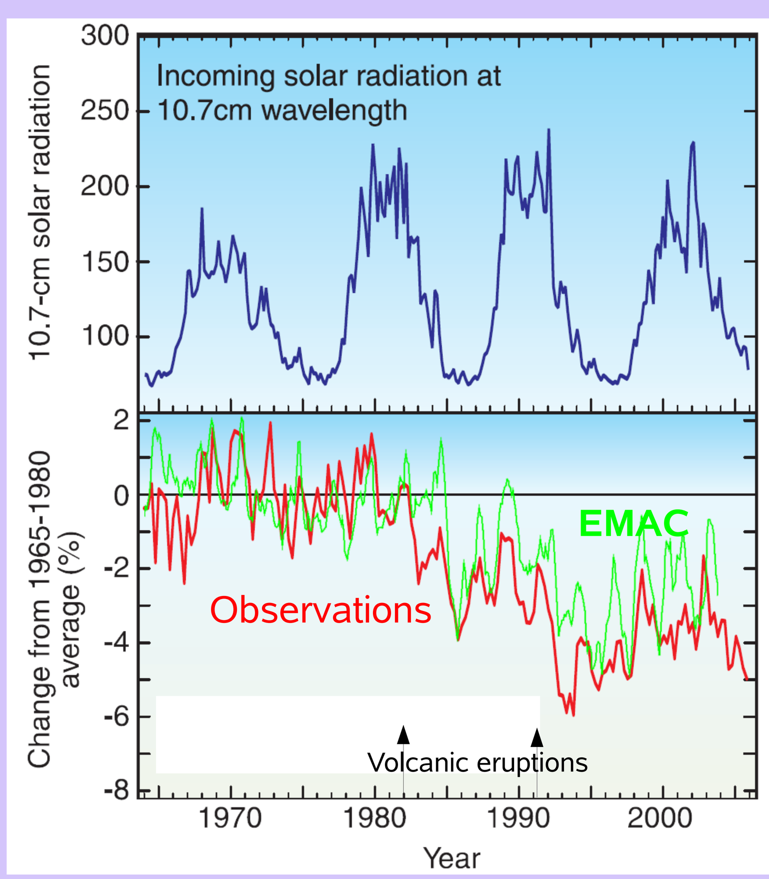
Volcanic aerosol heating
based on data by Gera Stenchikov



GHG and CFC nudging at the surface

Emissions of ozone-precursor gases
(Baumgaertner et al., 2008a)

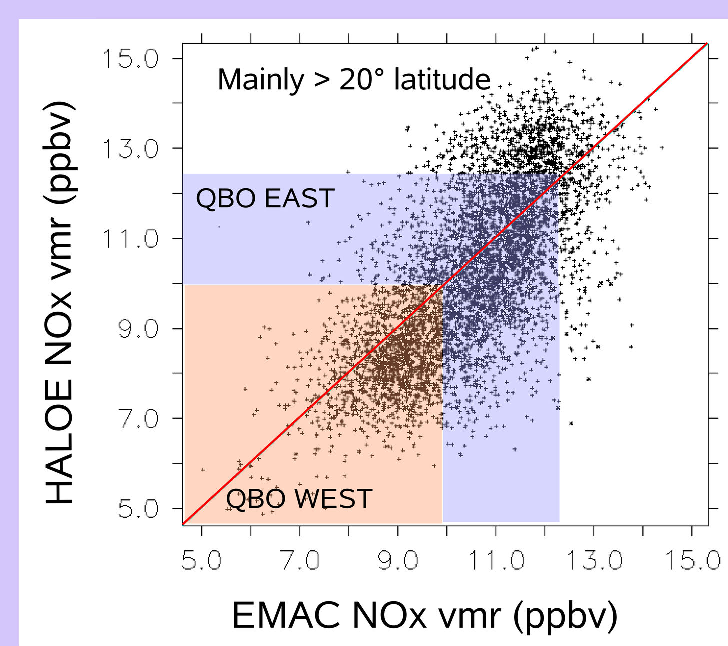
VALIDATION



Modified after WMO, 2006

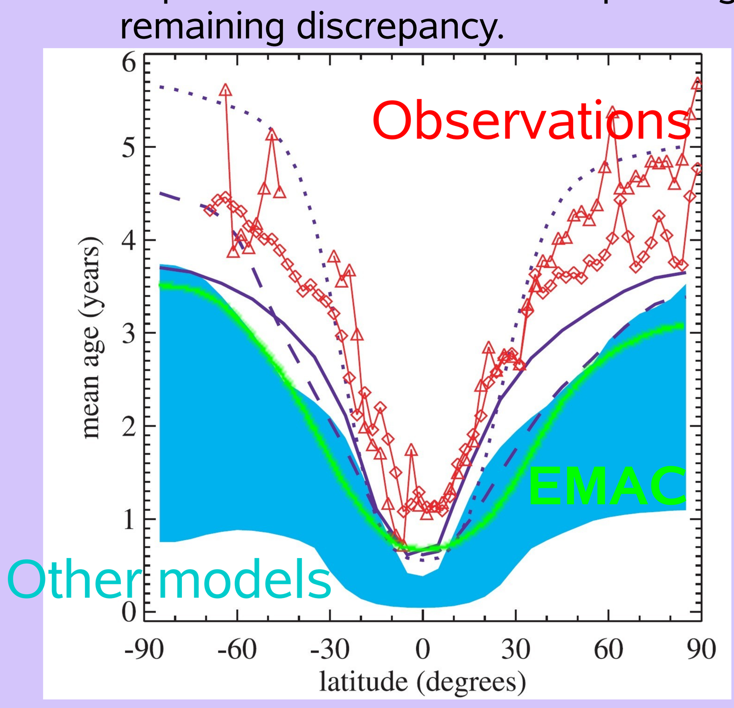
Good agreement with observations of global total ozone. Signatures of the solar cycle as well as from volcanic eruptions can be seen in the model results and the observations.

Point-to-point comparison with HALOE NOx measurements at 10 hPa, 45°S- 45°N for 1992 – 2000
Features of NOx variability in the tropical and mid-latitude stratosphere are well captured.



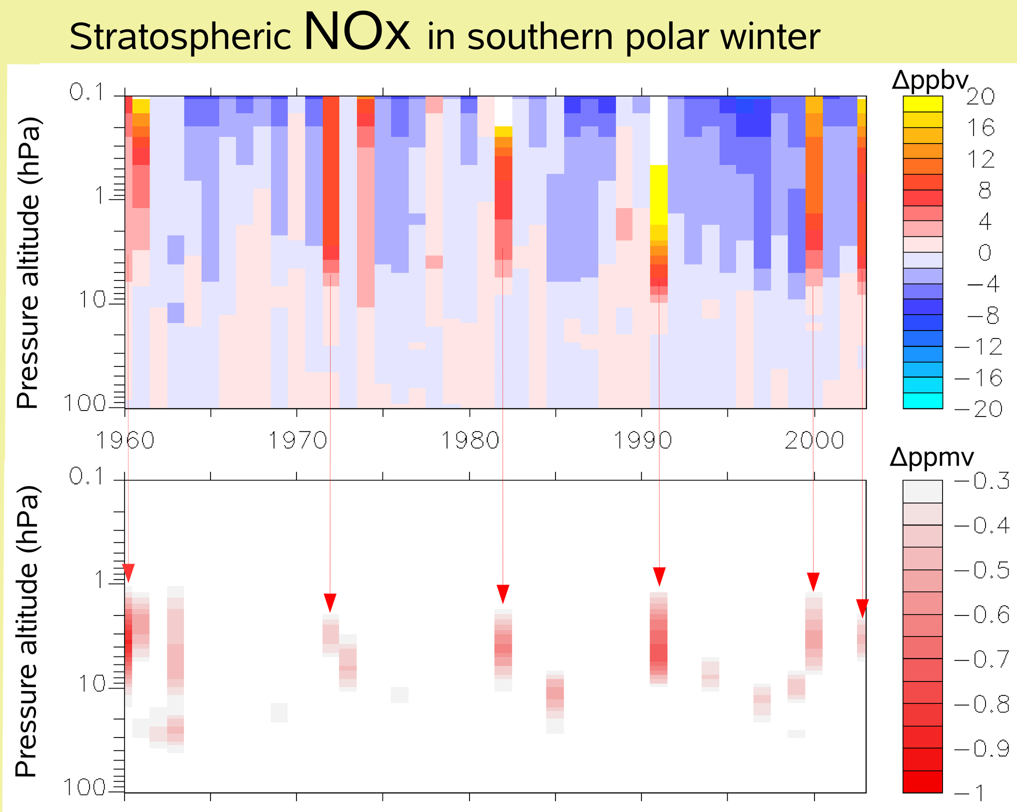
Dynamics: Age of air at 20 km

For age of air, EMAC performs better than most other models. However, air is still up to one year too young. Improvements in tracer transport might reduce the remaining discrepancy.



EFFECTS OF SOLAR VARIABILITY

Stratospheric NOx in southern polar winter

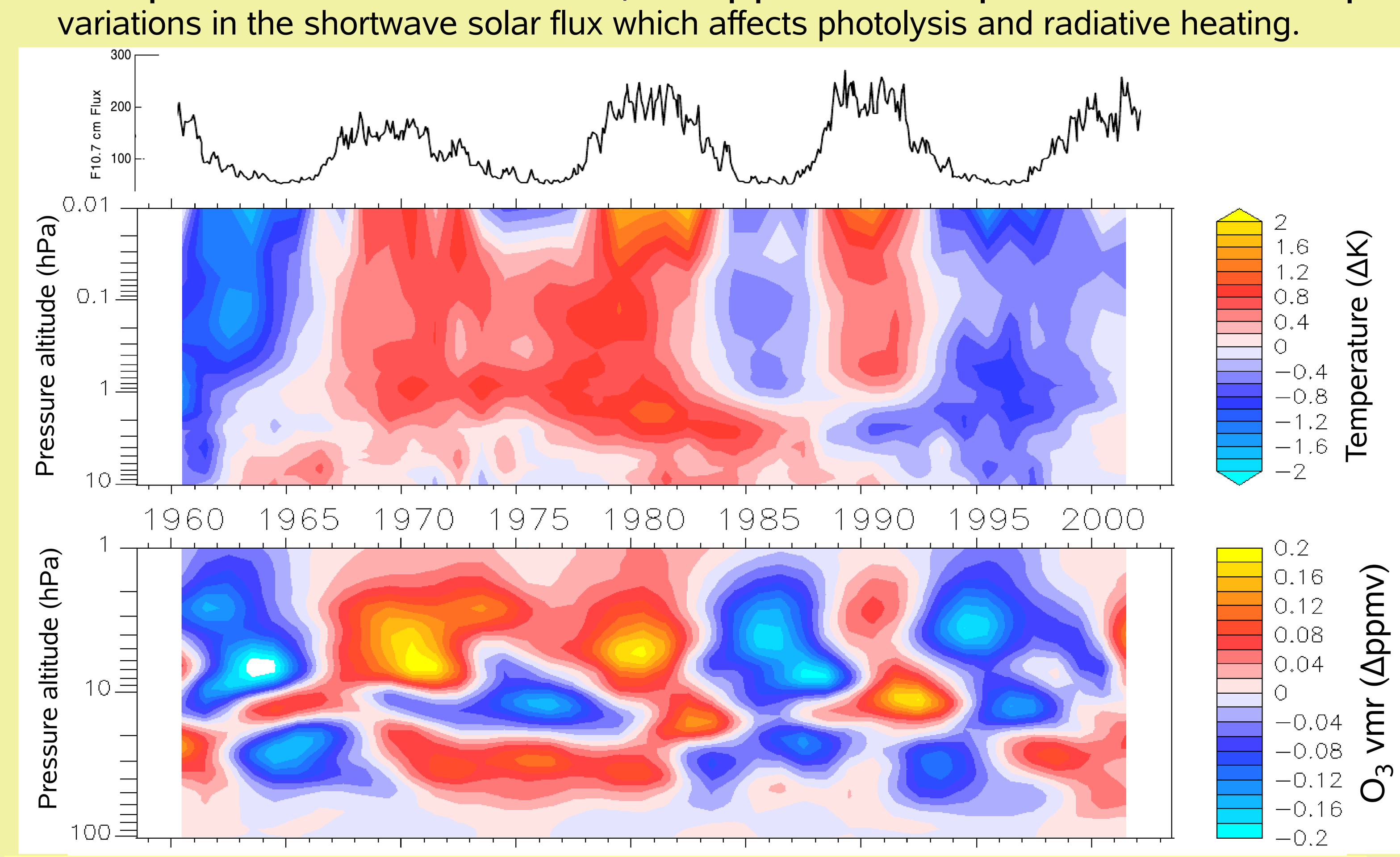


July-September average NOx mixing ratio, mean and trend subtracted

July-September average ozone mixing ratio, mean and trend subtracted (only negative values shown for clarity)

NOx produced in the upper atmosphere maximises during the declining phase of the solar cycle and is transported down into the stratosphere in the polar vortex where it can lead to significant ozone depletion of up to 1 ppmv.

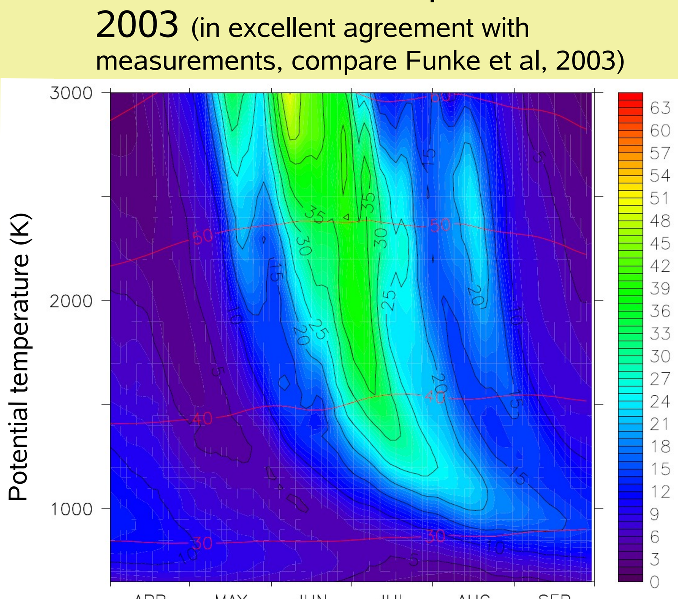
Temperature effects in the tropical upper stratosphere and mesosphere are most likely due to variations in the shortwave solar flux which affects photolysis and radiative heating.

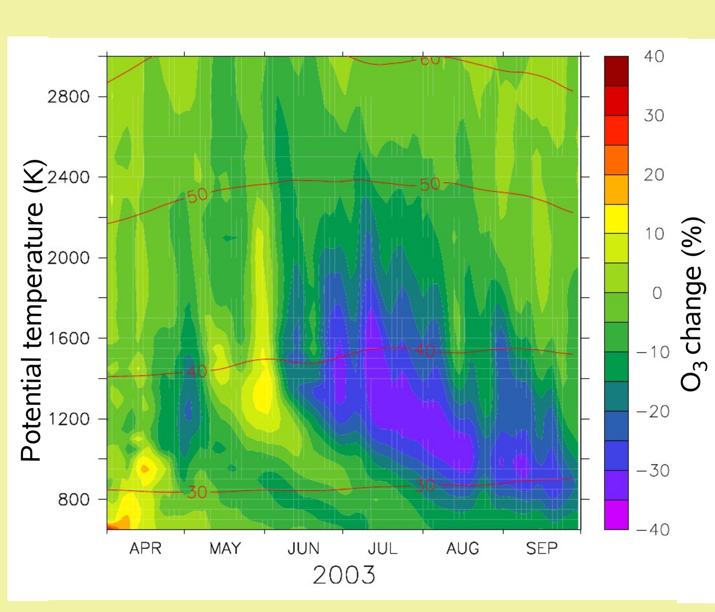


Smoothed and detrended temperature anomalies averaged over 10°S - 10°N.

Smoothed and detrended ozone anomalies averaged over 10°S - 10°N. A solar signal in the upper stratosphere is evident. Above (not shown) and below more complicated variations occur.

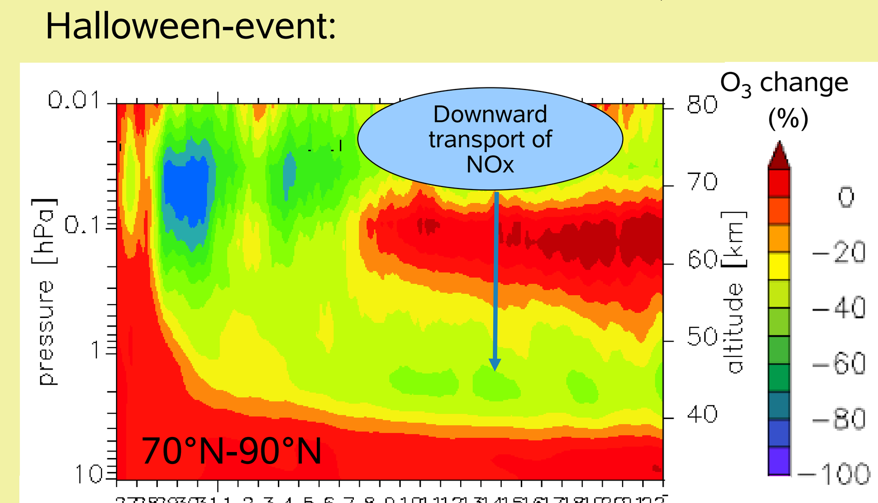
NOx vmr inside the polar vortex in 2003 (in excellent agreement with measurements, compare Funke et al, 2003)





Ozone depletion due to upper atmospheric NOx inside the polar vortex in 2003 (reference year 1996).

Solar Proton Events occur often during solar maximum . Production of NOx and OH at high latitudes leads to severe ozone depletion especially during winter. A very strong event occurred in October/November 2003, the Halloween-event:



Yearly global average 2-meter temperatures (Smoothed with a 7-point Hanning-window)

Is the decadal variation due to solar forcing? Further work required!

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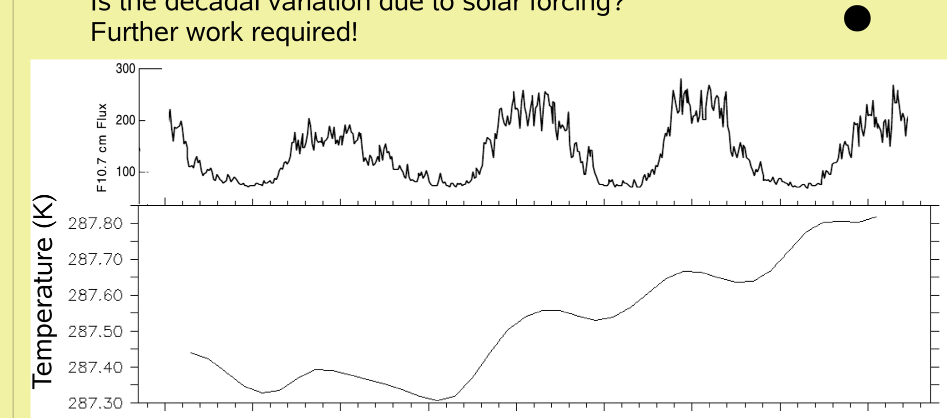

Abstract

Initial results from a transient simulation with ECHAM5/MESSy1 (EMAC) spanning several decades will be presented. The simulation was performed within the framework of the CAWSES/ProSECCO and SCOUT-O3 projects and follows mostly the CCMVal REF1 specifications. The simulation was performed at the resolution of T42L90MA with a model top at 0.01 hPa. The fully interactive model chemistry with approximately 50 species and 130 reactions and an internally generated QBO, which is weakly nudged in order to obtain a realistic phase, will allow to study fundamental questions regarding the 11-year solar signal and the causing mechanisms. Solar variability affects the model atmosphere through a high-resolution short-wave radiation scheme for photolysis and heating rates, solar proton events and downward transport of nitric oxides produced in the thermosphere. Additional variability over the simulation period is caused by varying sea surface temperatures (HadISST1), realistic boundary conditions and emissions of chemical species, as well as volcanic heating rates. An initial comparison between model results and observations will be presented in order to evaluate the model setup. We will then present first results focussing on the effects of solar variability on chemistry and temperature in the middle atmosphere.

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Acknowledgements

This research was funded by DFG SPP 1176 (PROSECCO/CAWSES). We thank all MESSy developers and users for their support, for more information visit http://www.messy-interface.org. UARS/HALOE data were obtained from http://haloe.gats-inc.com/download . CCMVal forcing data are available from http://www.pa.op.dlr.de/CCMVal/