EPP-climate link by reactive N polar winter descent revisited: MIPAS v8 reprocessing and NOy UBC for climate models

9th International HEPPA-SOLARIS meeting

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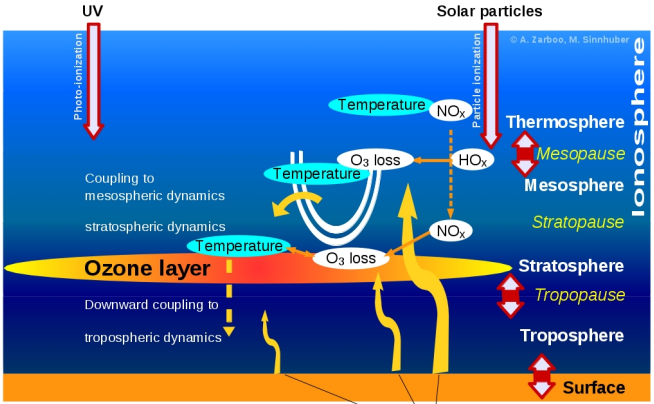
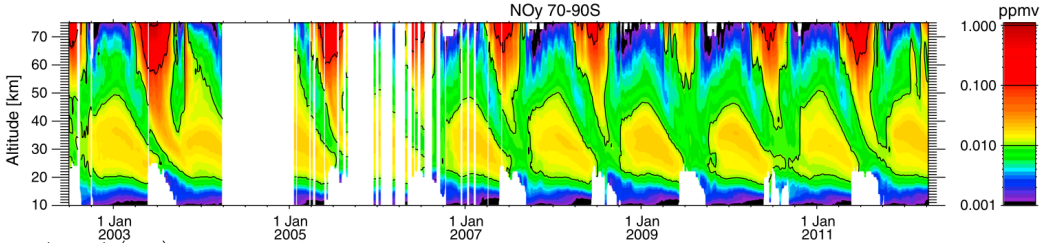
Particle impact on the middle and upper atmosphere

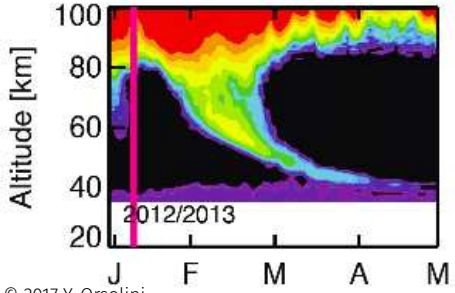
- Particle precipitation (EPP), mainly e^-, p^+ → middle/upper atmosphere ionization
- Chemistry (HOx and NOx) and dynamics (NOx descent winter/spring) → ozone chemistry
- (whole-atmosphere) climate models still struggle to get it right



NOy transport in polar vortex



Funke et al., (2014)



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- NOy descent every winter/spring
- down to the stratosphere
  $\rightarrow$ catalytic desctruction of ozone
- EPP/solar activity-related
  (follows the solar cycle)
- source above $\approx$ 100 km
- Upper boundary condition (UBC)
  for low-top models (Funke et al., 2016)

MIPAS version 8 update

NOy = NO + NO_2 + 2·N_2O_5 + $ClONO_2$ + HNO_3 + HNO_4

Version 8 NO retrieval (Bernd Funke et al., 2023)

- spectra calibration update from ESA
- improved treatment of horizontal gradients (e.g. in Auroral regions)
- apriori update, based on v5 regression model, WACCM, and photochemical box model
  $\Rightarrow$ more accurate NO in low content regions

Other changes affecting EPP-NOy calculation

- CO retrieval updated
- CH_4 retrieval updated (Glatthor et al., 2023)
- all other NOy species

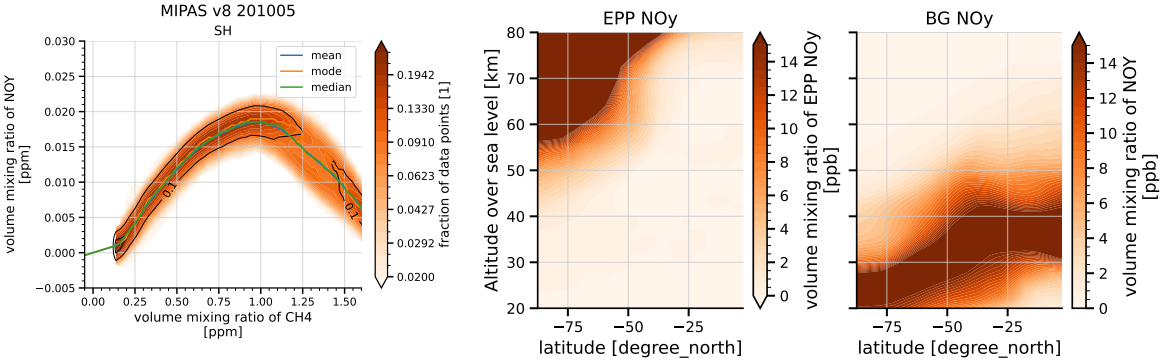
Impact

- higher v8 NOy densities in some areas
- CO threshold indicating thermospheric/mesospheric air
- correlation between NOy and CH_4 without EPP-NOy

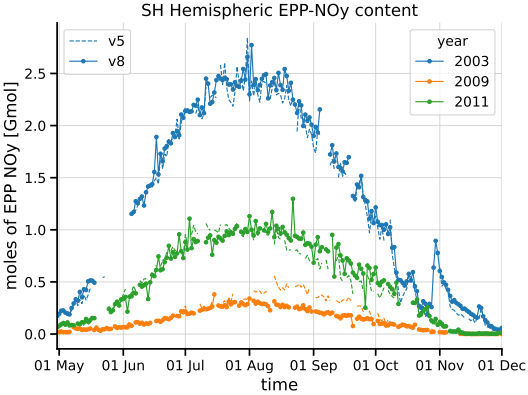
MIPAS EPP-NOy

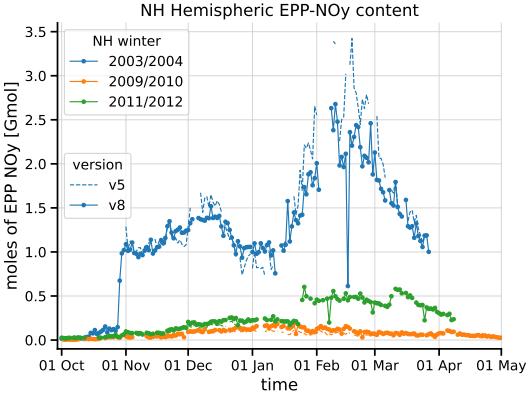
v8 EPP-NOy based on B. Funke et al. (2014)

- Correlation between **background NOy** and CH_4 in regions without expected EPP-NOy, 0–45° latitude, 30–70 km
- CO as tracer for mesospheric air ⇒ low CO = low mesospheric air
  → CO threshold to exclude descended air possibly containing EPP-NOy
- MIPAS: monthly correlations + interpolation in time



MIPAS hemispheric EPP-NOy





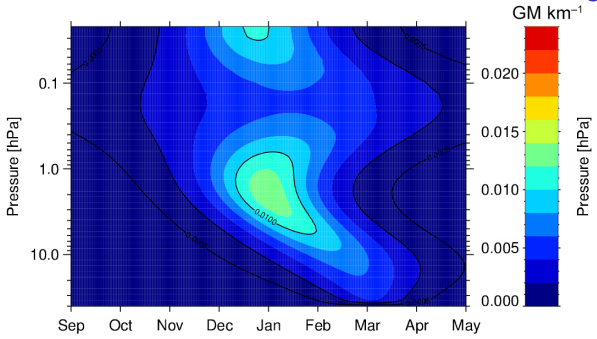
- integrated EPP-NOy from 0–90°, ~25 km to 70 km
- monthly correlated background NOy interpolated to daily frequency
- zonal-mean CO threshold for lower boundary
- not exactly same processing for v5 and v8, e.g. different CO thresholds

MIPAS NOy UBC model

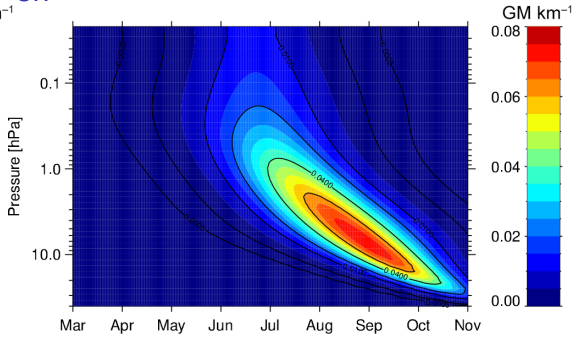
Upper-Boundary-Condition NOy model (B. Funke et al., 2016)

- semi-empirical model for “low”-top climate models ($\lessapprox$ 80 km)
- EPP-NOy driven by Ap
- background NOy driven by seasonal variations
- NOy flux or density

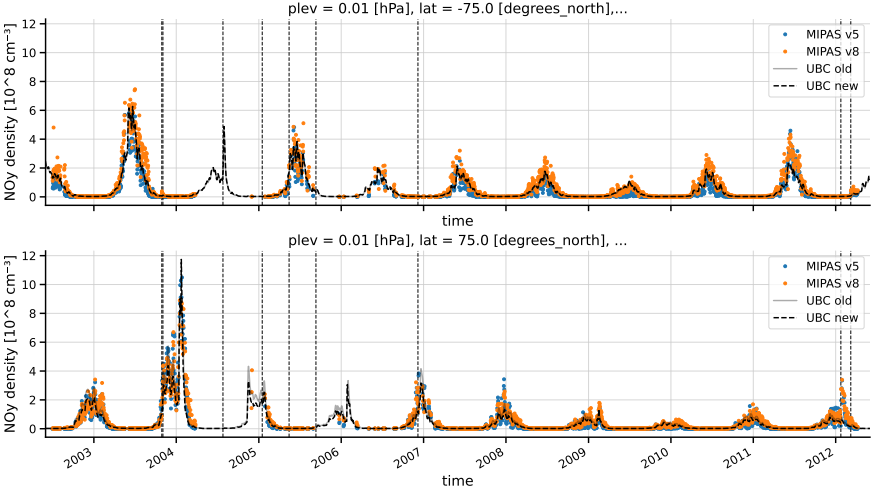
NH



SH

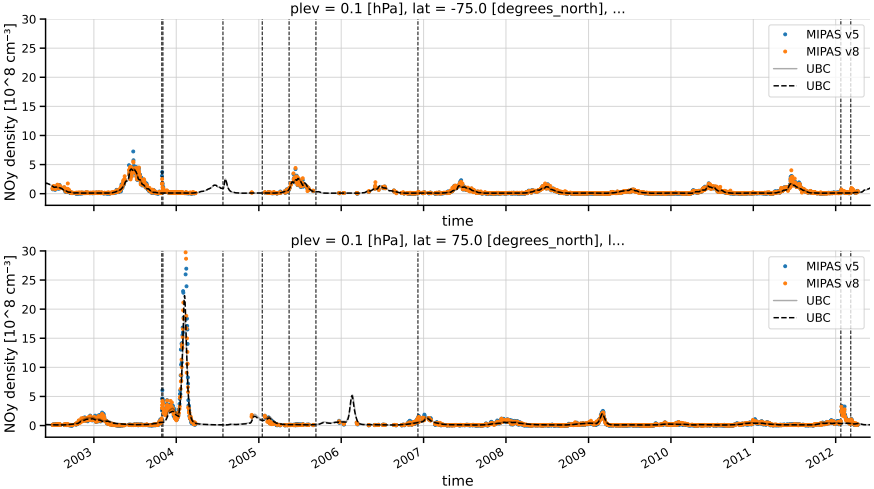


MIPAS v5/v8 NOy and UBC model



- 10° zonal means on pressure levels, upper boundary condition (UBC) (B. Funke et al., 2016)
- differences at low activity, v8 > v5 (e.g. 2009 SH) (changed apriori at higher altitudes)
- v5 and v8 EPP-NOy similar → slight differences → updated UBC

MIPAS v5/v8 NOy and UBC model



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- v5 and v8 EPP-NOy similar ⇒ differences in UBC background(?)

Summary and Outlook

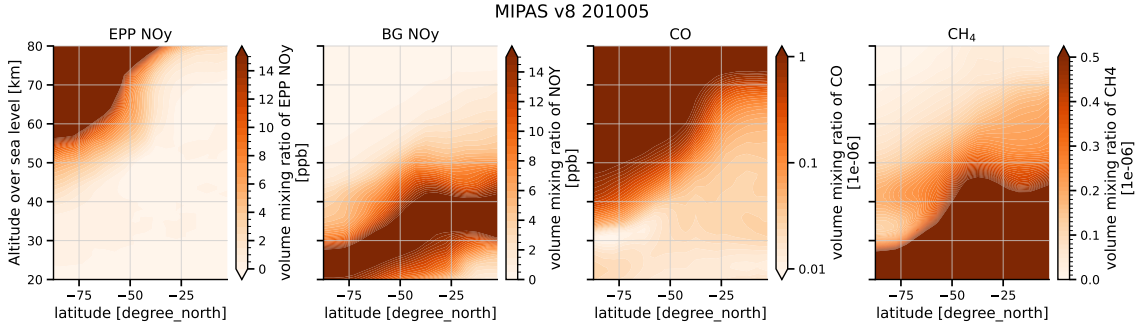
Summary

- NOy MIPAS v5 vs v8
- comparison to SMR, SOFIE (not shown), and UBC
  $\rightarrow$ some differences in low-activity winters (apriori influence at higher altitudes)
- v8 changes in other trace species (CO, CH_4)
  $\Rightarrow$ thresholds and processing changed slightly compared to v5
- EPP-NOy from MIPAS re-processed $\rightarrow$ slight differences in latitudinal distribution
  $\Rightarrow$ updated UBC coefficients

Outlook

- Update UBC model for CMIP7 (partly done)
- ESA's EE-11 candidate CAIRT (IR imaging tomography limb-sounder, phase-A)
  $\rightarrow$ high-resolution observations of NOy (up to 50 km across-track **and** along-track)
- EPP-NOy processing possible, NOy, CH_4, and CO available **daily**

SH zonal mean May 2010



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