Confronting UKCA with MIPAS Observations

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Structure

- What is UKCA?
- Validation of zonal mean quantities
  - Age-of-air zonal mean
- Validation beyond the zonal mean
  - Age-of-air maps (Monsoon and planetary wave patterns)
  - Tropical N2O PDFs (existence of sub-tropical barrier, strength of tropical upwelling)
- Summary and Outlook
What is UKCA?

- UKCA is a community chemistry-climate model based on the Met Office’s new dynamics Unified Model.
- It is a joint development between the Met Office, University of Cambridge (chemistry) and University of Leeds (aerosol), with many contributing partners, e.g. University of Reading and University of Oxford (L60).
- UKCA will be part of the forthcoming Joint Climate Research Programme (JCRP).

http://www.ukca.ac.uk/
Model Setups

- Tropospheric UKCA
  - Resolutions: N48L38, N48L60, (N96L38)
  - Tropospheric chemistry

- Stratospheric and “Whole Atmosphere”
  - Resolutions: N48L60, (N96L60)
  - Stratospheric chemistry with tropospheric background

- Future: all resolutions supported by the underlying Met Office model.
Nudged UKCA

Timescales:
6 hourly ECMWF data
15-30 minutes model time step

Telford et al., ACP, 2008

Model is constrained in zonal wind, meridional wind and potential temperature. The vertical velocity in the UM is a *prognostic* (and not a diagnostic) quantity!

\[ X: \text{modelled quantity} \]
\[ X' : \text{analysed quantity} \]
\[ X' = (1-b)*X'[t] + b*X'[t+dt] \]

\[ a(y,z) > 0 \]
\[ dX = a(y,z)*(X'(x,y,z,t)-X(x,y,z,t)) \]
\[ X = X + dX \]

Dt: model time-step
Dt: time between analyses fields

Read data for t and t+dt

Read data for t+dt and t+2dt
Age-of-air at 17km

Annual Mean Age-of-Air (17km)

Model
Observations

MIPAS SF6, Stiller et al., ACP, 2008

Latitude [deg.]

Age [years]
Caveat: Observations of SF6 still sparse! Model results are from equilibrated 10 year integrations.
Age-of-air map: Model

Monsoon signature over Indian sub-continent
Age-of-air map: Observations

Strong El Nino in 2003 is "visible" in the tropics
Longitudinal varying age
Age-of-air cross-sections

Age-of-Air Deviation at 90E

Latitude [deg.]

Altitude [km]

[years]

-0.3 -0.1 0.1 0.3 0.5

[years]

-0.3 -0.1 0.1 0.3 0.5
Recent N2O PDFs

N2O at 600K - DJF

N2O at 600K - JJA

- Probability
- Mixing Ratio Anomaly [ppmv]

MIPAS (July 2002 - March 2004)
UKCA "2000" Conditions
QBO during N2O observations

QBO u[m/s] for MIPAS+MLS obs. period

Pressure [hPa]

MIPAS

MLS

~800K

~600K

~450K
N2O JJA QBO Modulation

MIPAS N₂O
JJA - MIPAS at 600K - 2002-2004

UKCA N₂O
JJA - UKCA at 600K - 1980-2001

Changes in upwelling!

Snapshot versus 22 year climatology!
Summary and Outlook

- UKCA produces good agreement with observations.
- Nudging improves the meridional age gradient.
- Zonal asymmetries in age are reproduced.
- Snapshot $N_2O$ PDFs compare well.
- QBO modulation of $N_2O$ PDFs remains an issue.

- Improved UKCA simulations of the recent past.
- Hopefully more complete satellite data base:
  - Improved age observations?
  - Merged $N2O$ climatology?
Thank You!
Age-of-Air:
Nudged compared to climate UKCA

Mean climate model age (isolines)
Age difference between nudged and climate model
QBO?

N2O Observation: Sampling Issues?
PV Gradients

Regions of strong PV gradients

Pressure [hPa]

60S 30S EQ 30N 60N

Release Region

Dyn. Tropopause
Global O3 after Pinatubo

Averaged over 60S - 60N

Pinatubo Eruption!
Tropical O3 after Pinatubo

Averaged over 10S - 10N

- Time [years]
- DO3 [DU]

Best Guess - Background
Observations - (BG-B)
QBO based ozone proxy (5 months)
Pinatubo in higher latitudes

**NH (30N-60N)**

- **Time [years]**: 1988 to 1998
- **DO3 [DU]**: -20 to 20

**SH (30S-60S)**

- **Time [years]**: 1988 to 1998
- **DO3 [DU]**: -20 to 20

- **Legend**:
  - Blue: Best Guess - Background
  - Black: Observations - (BG-B)
  - Red: QBO (advanced by 5 months)