NO_2 distributions by SCIAMACHY across stratospheric transport barriers in comparison with the general circulation model EMAC

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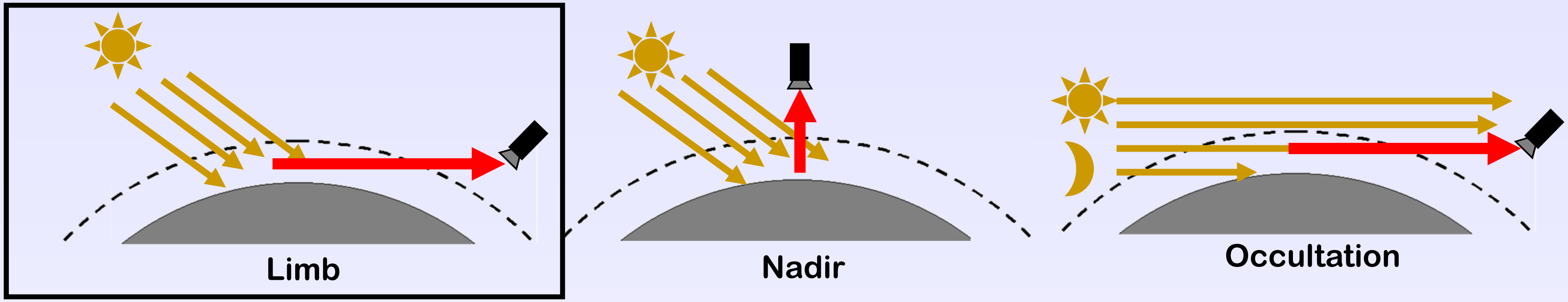
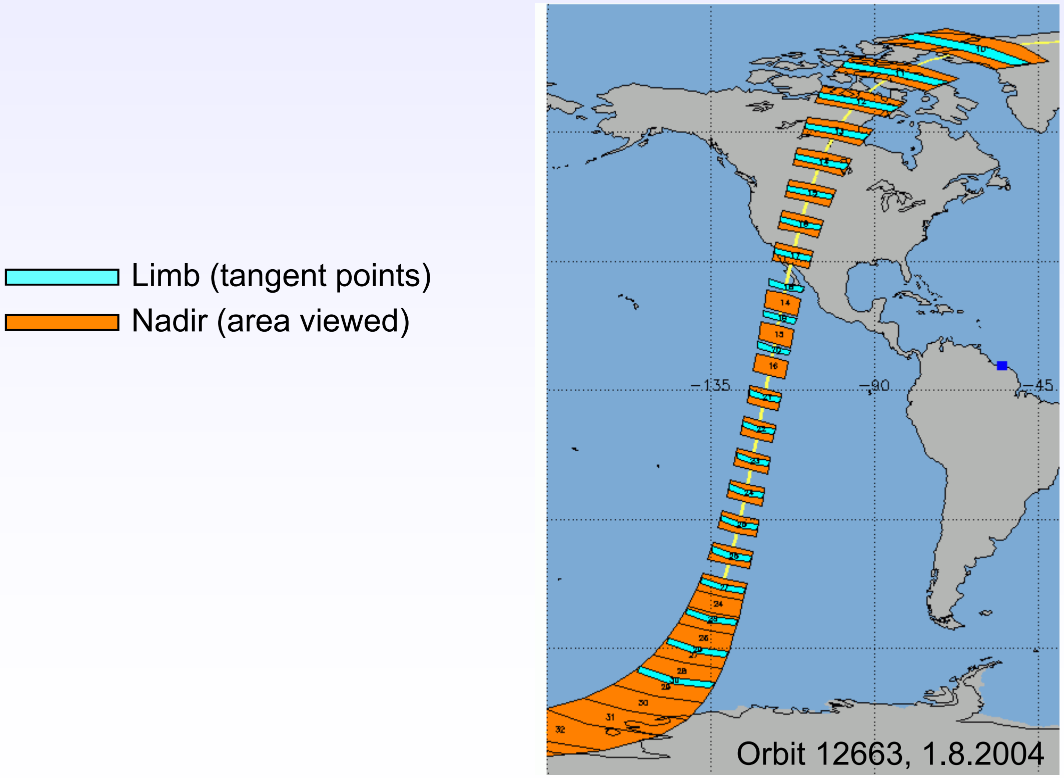
SCIAMACHY: 2002 – April 2012



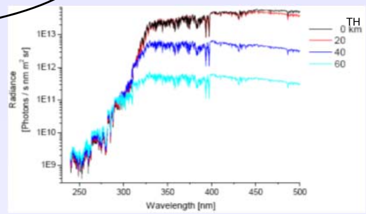


Limb:

- Tangent height range: 0 to 100 km
- Scan width 960 km
- Tangent height step size: ~3.3 km
- Vertical FOV: ~2.6 km
- Distance between scanning sequences along track: from ~3.3° – 7.5°

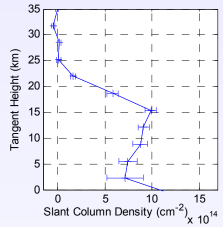
Retrieval: 2 step approach

Measured spectra



Differential optical absorption spectroscopy

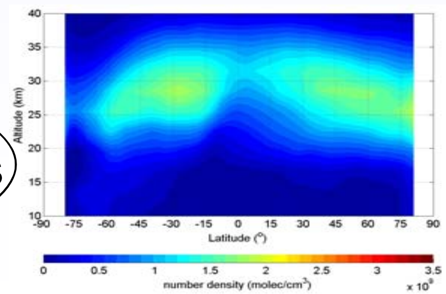
Slant column densities



box air mass factors (RTM)

Inversion (optimal estimation or least squares approach)

Concentration profiles

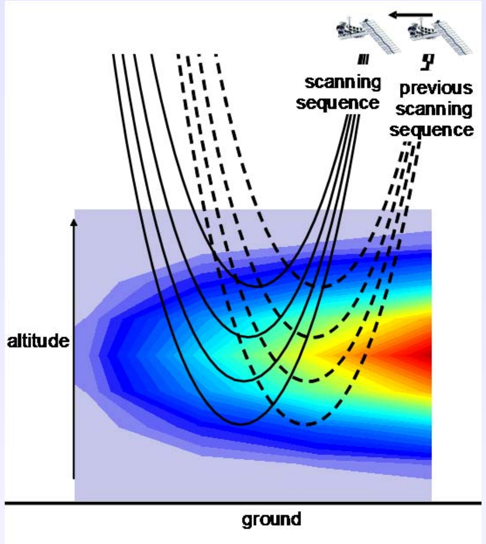


Kühl et al., 2008;

Pukīte et al., 2008

Retrieval: Limb 2D tomography

Partial overlap: tomographic principle

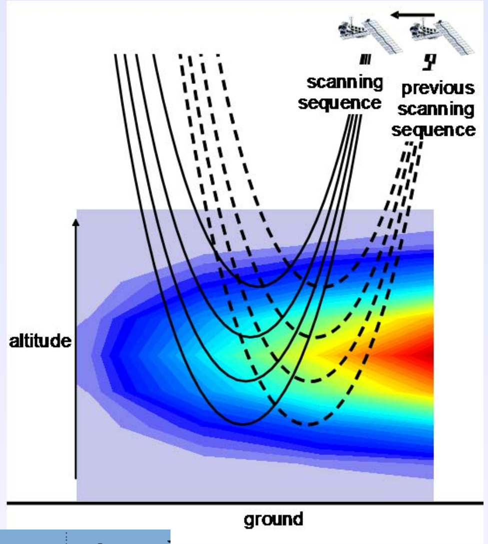


Acquiring 2D distribution fields of stratospheric trace gases along the orbit in one inversion step

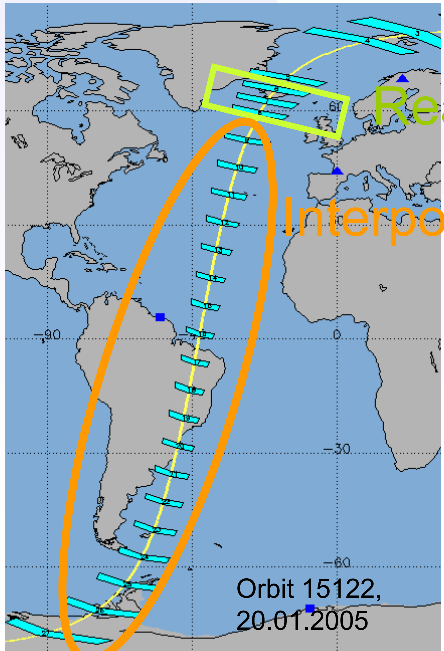
Puķīte et al., 2008; 2010

Retrieval: Limb 2D tomography

Partial overlap: tomographic principle



Acquiring 2D distribution fields of stratospheric trace gases along the orbit in one inversion step



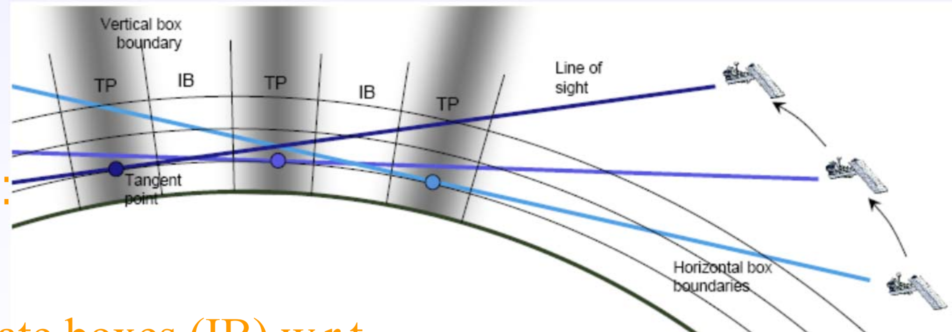
Real overlap

Interpolation approach:

-Constraint

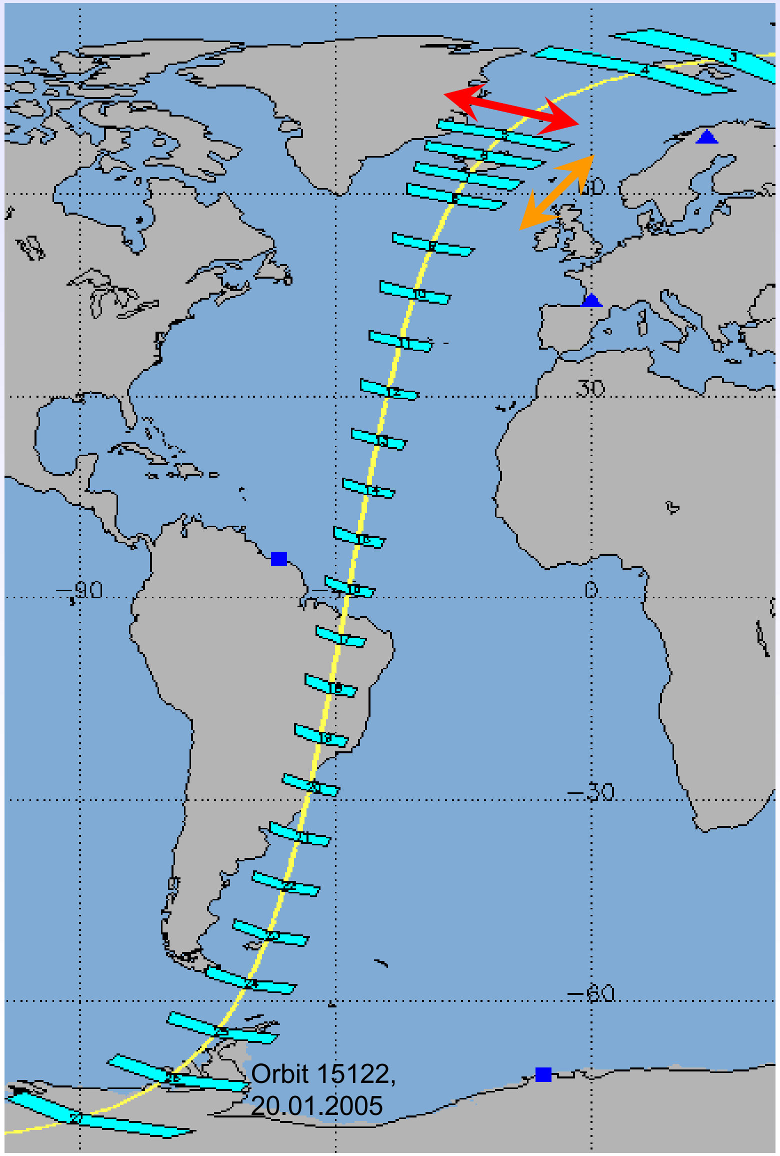
for intermediate boxes (IB) w.r.t.

boxes at tangent point (TP)



Pukīte et al., 2008; 2010

Aim: Retrieval: Limb 3D tomography

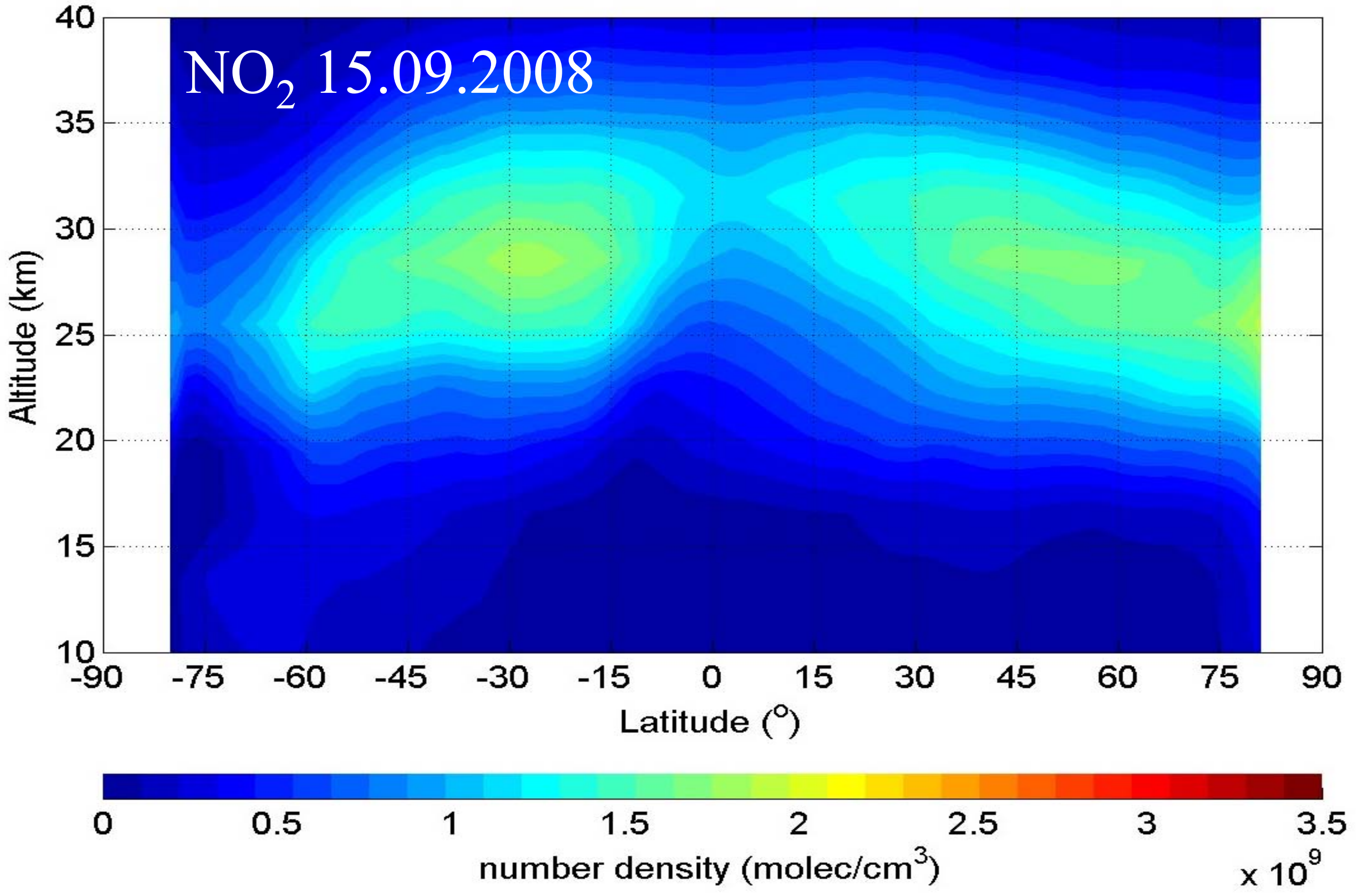


Resolving both along and across the orbit track in one inversion step

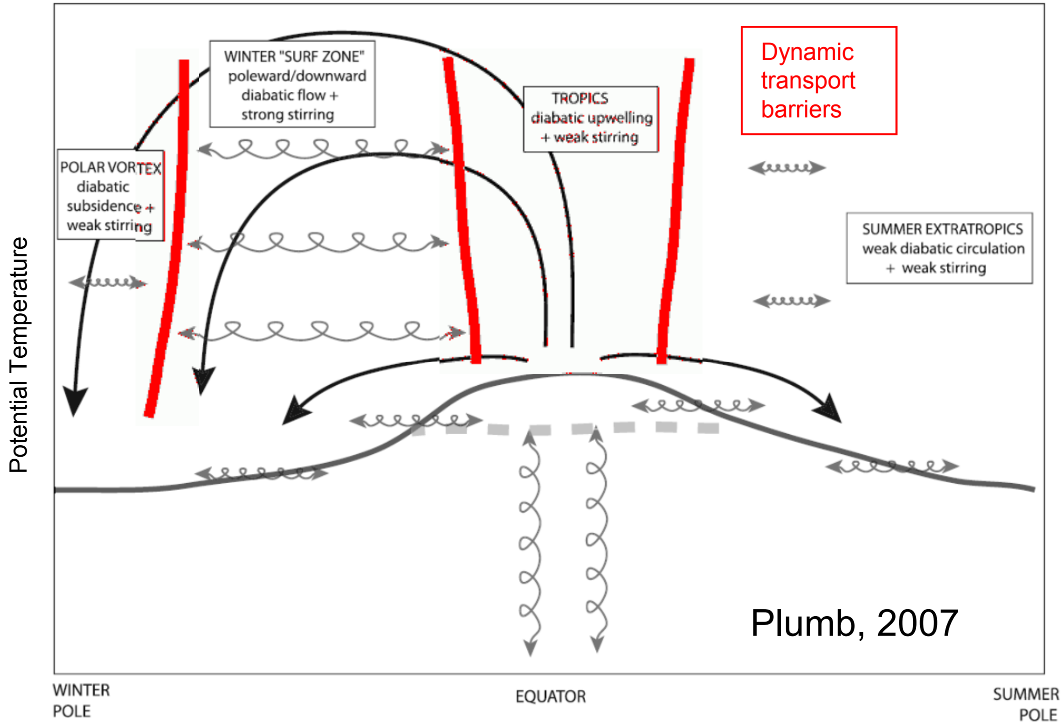
Poster:

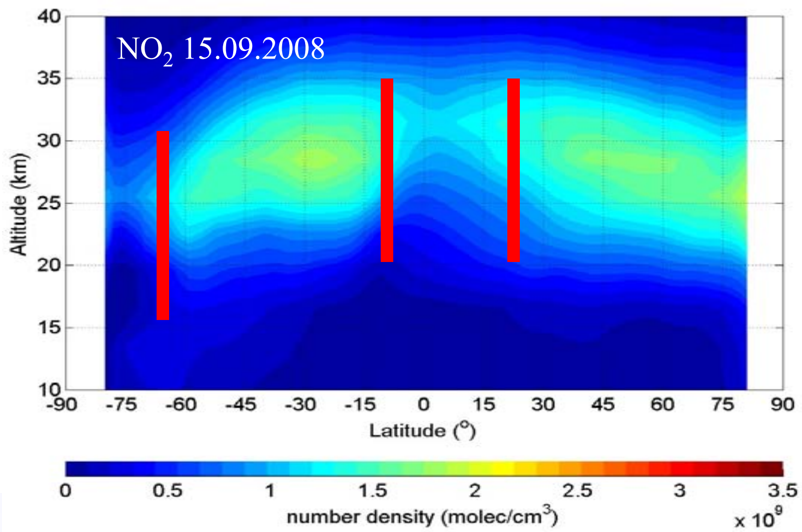
Optimizing grid definition for 3D limb tomographic retrieval: effect on viewing geometry and box AMFs

NO_2 distribution (2D)



Stratospheric transport



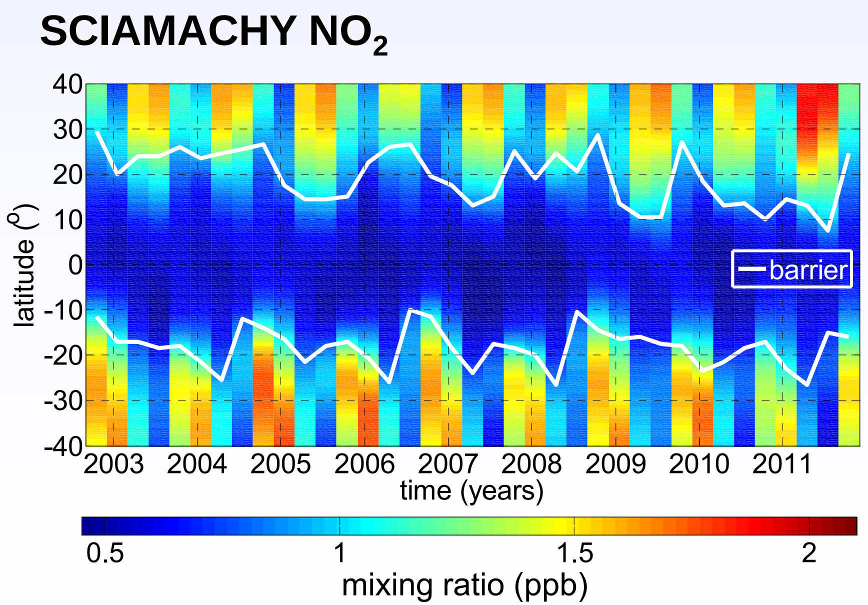


- ➢Barrier can be detected: maximum gradient in a long living trace gas (e.g. N_2O, CH_4) is a proxy
- ➢N_2O decrease -> NO_y increase
- ➢$N_2O+O(^1D)\rightarrow 2NO$ (slowly)
- ➢NO converted to NO_2 and other NO_y species
- ➢Barrier have effect on NO_2 distribution

NO_2 time series

Seasonal (SON, DJF, MAM, JJA)

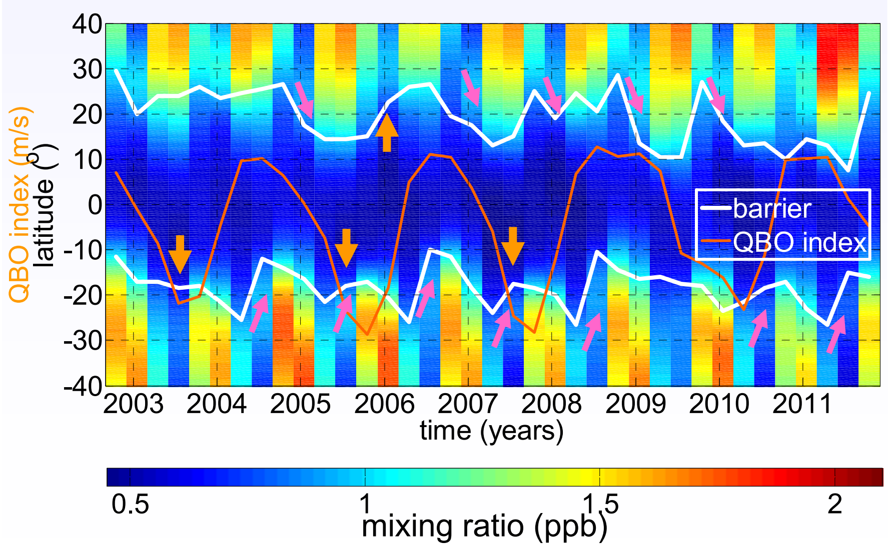
average vs. latitude & time

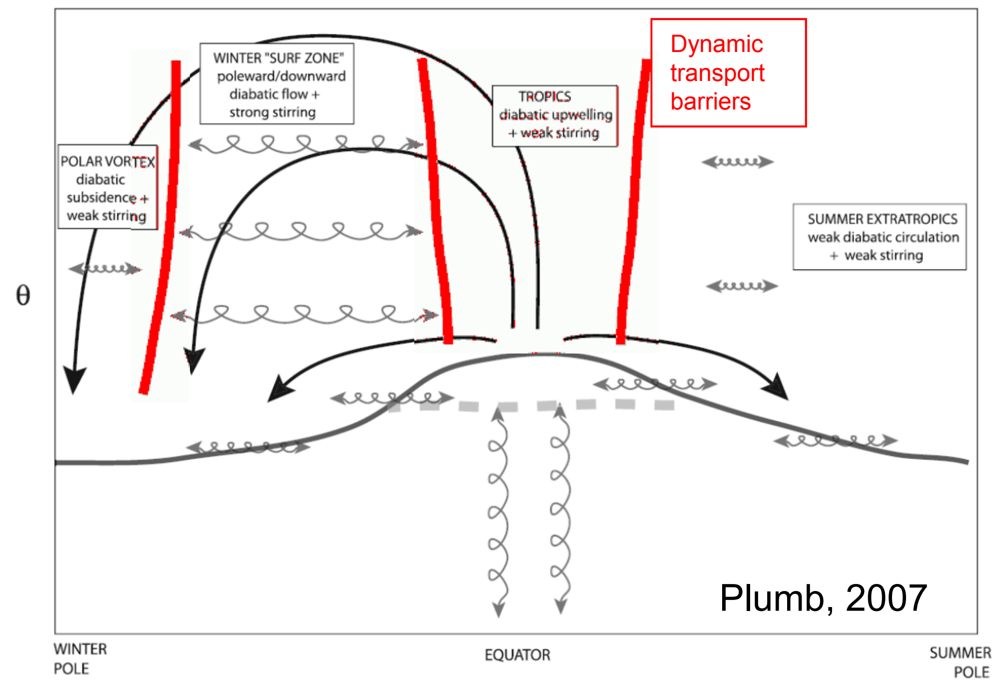


NO_2 and N_2O at 600 K (≈ 25 km)

- Seasonal variation (move towards equator autumn -> winter)
- Biannual variation (QBO): more poleward for easterly

SCIAMACHY NO_2



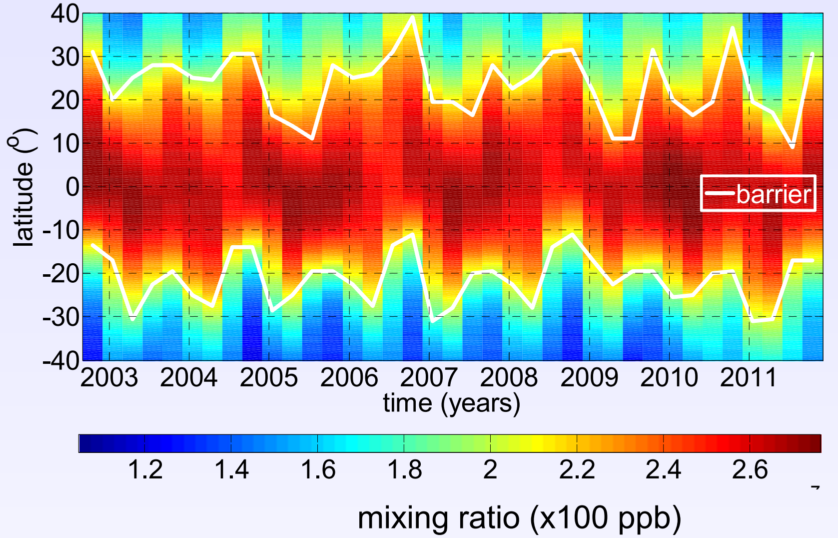


NO_2 and N_2O at 600 K (≈ 25 km)

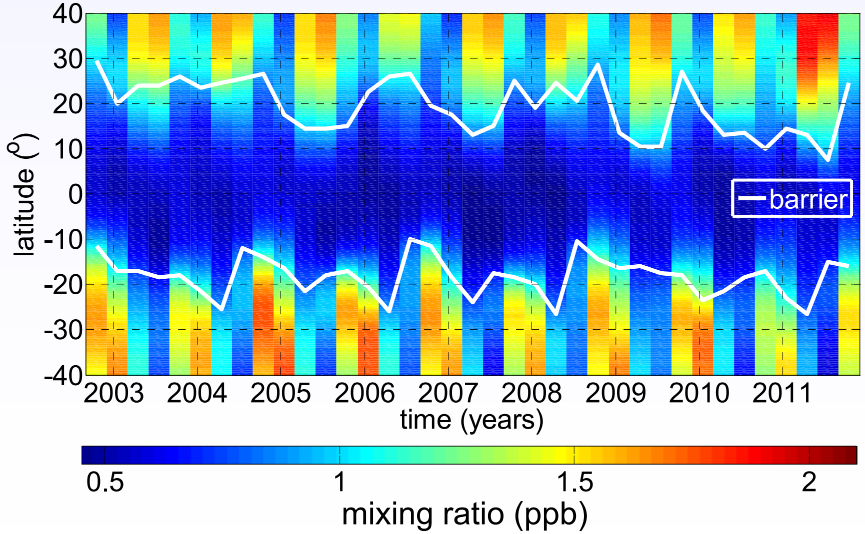
Measurement vs. Model

EMAC: Jöckel et al., 2010

EMAC N_2O



SCIAMACHY NO_2



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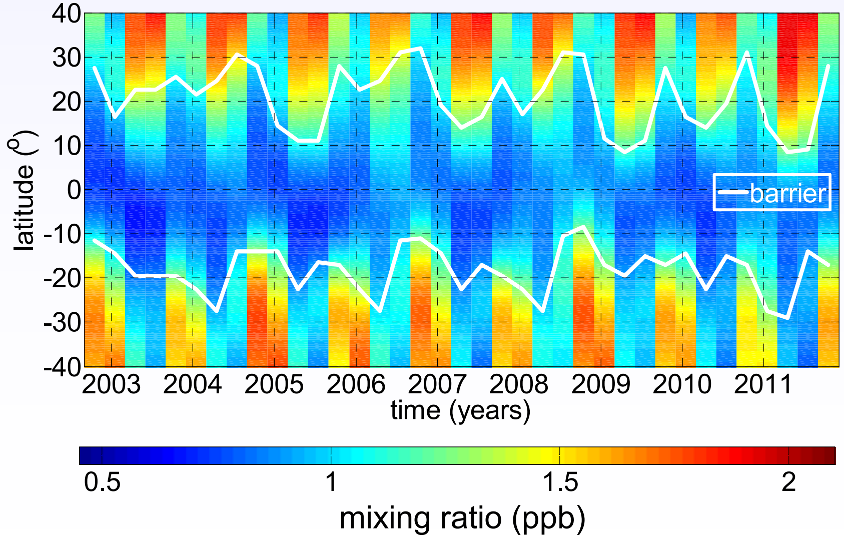
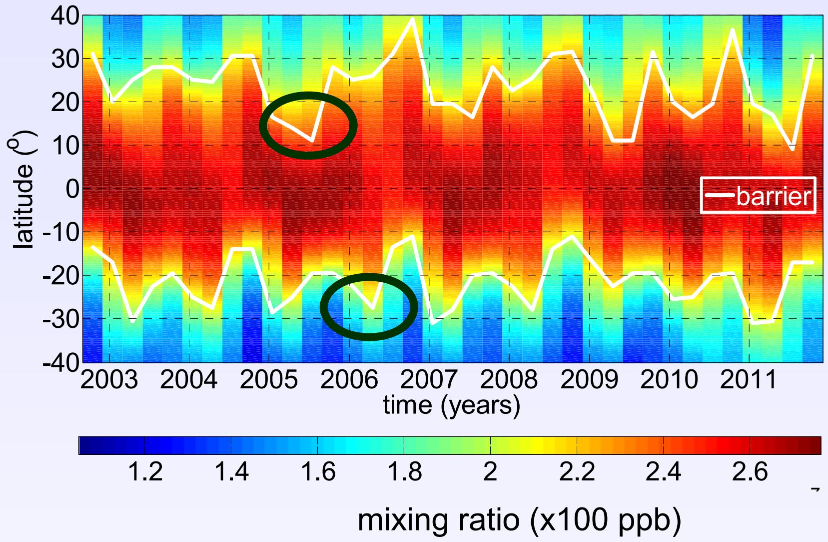


NO_2 and N_2O at 600 K (≈ 25 km)

Measurement vs. Model

- **Overall good agreement; seasonal & QBO paters visible**

EMAC N_2O EMAC: Jöckel et al., 2010



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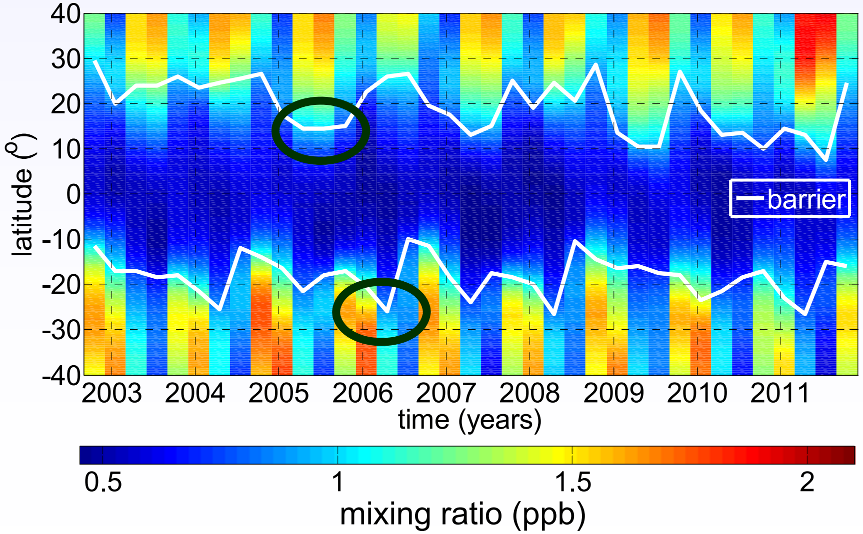
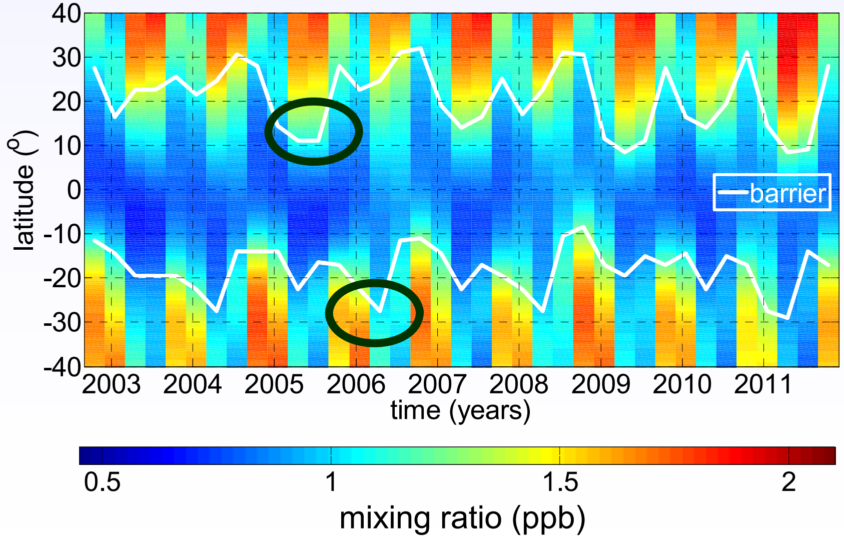


EMAC NO_2

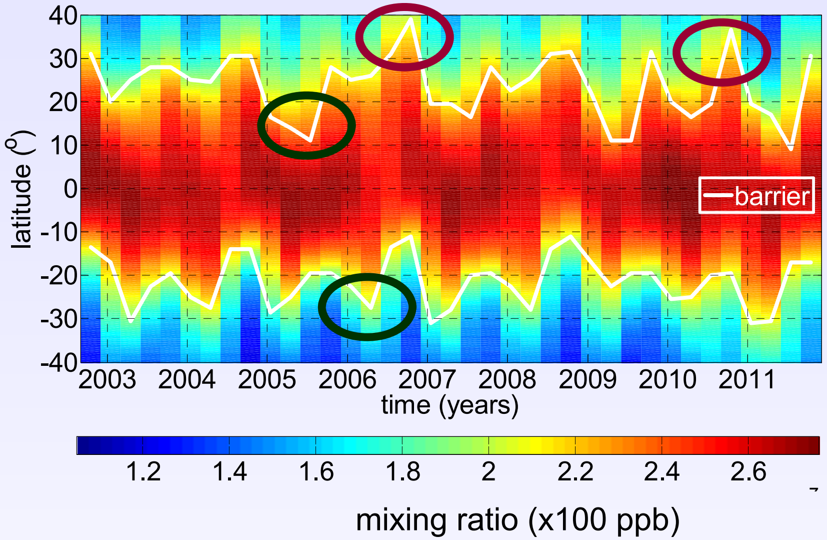


NO_2 and N_2O at 600 K (≈ 25 km)

Measurement vs. Model

- ➢Overall good agreement; seasonal & QBO paters visible
- ➢**Largest discrepancies in autumn**
- ➢**and at higher latitudes (denoxification increases)**

EMAC N_2O EMAC: Jöckel et al., 2010



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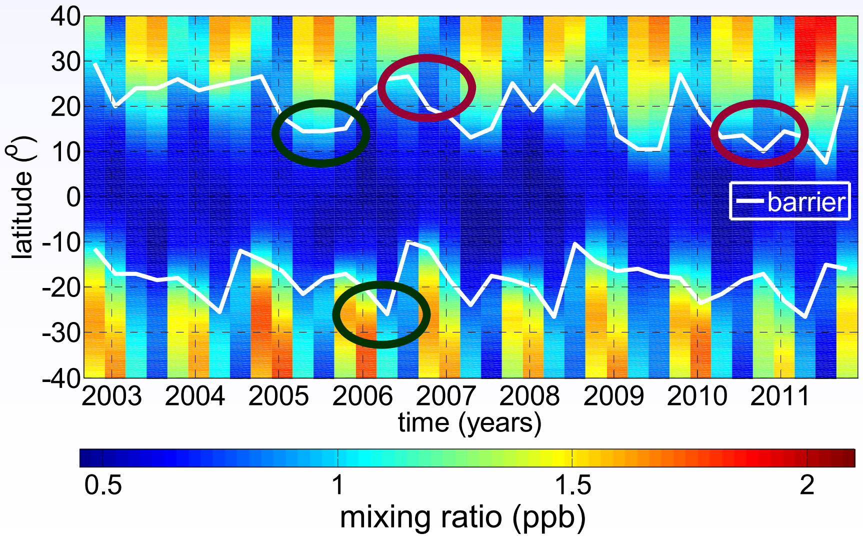

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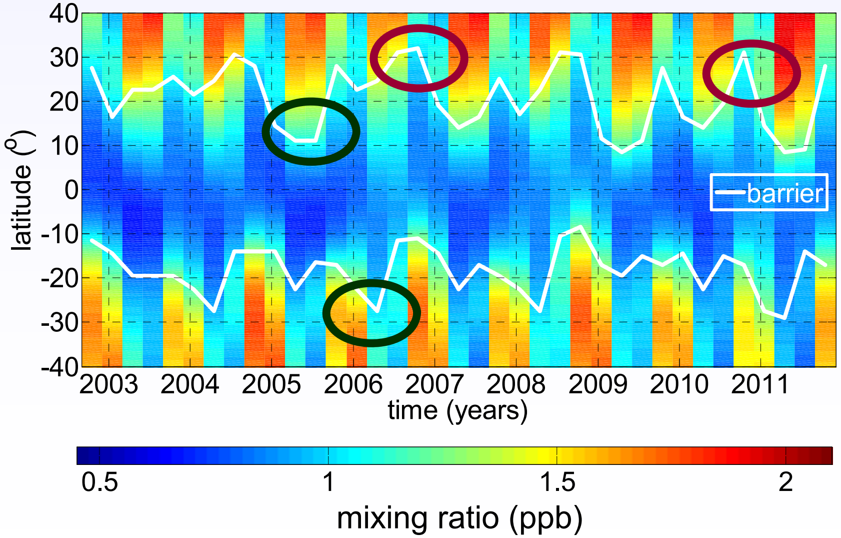

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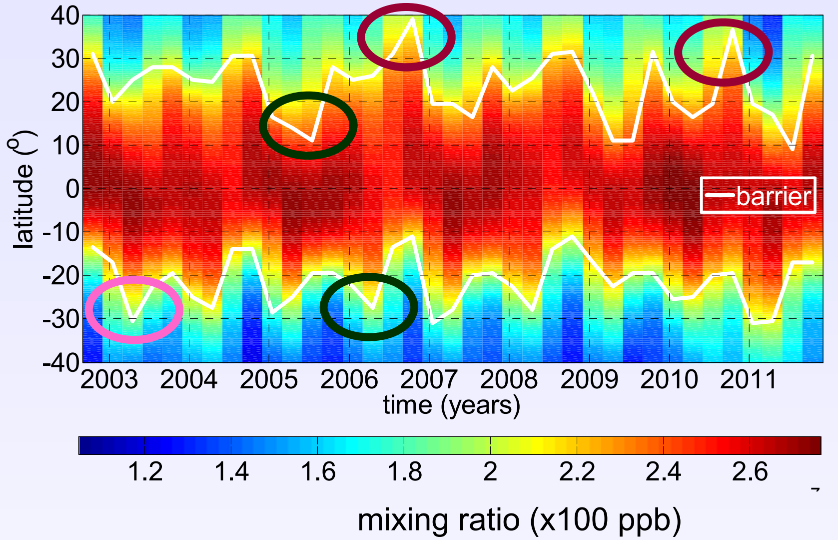

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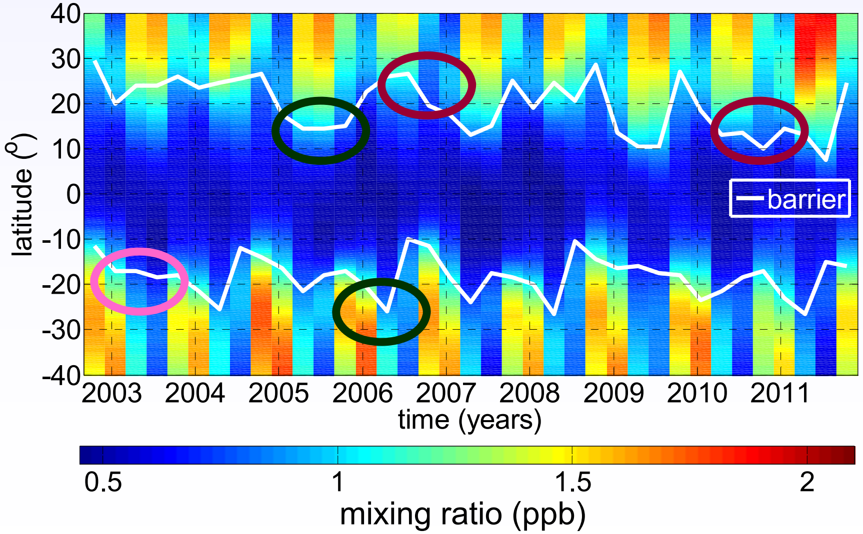

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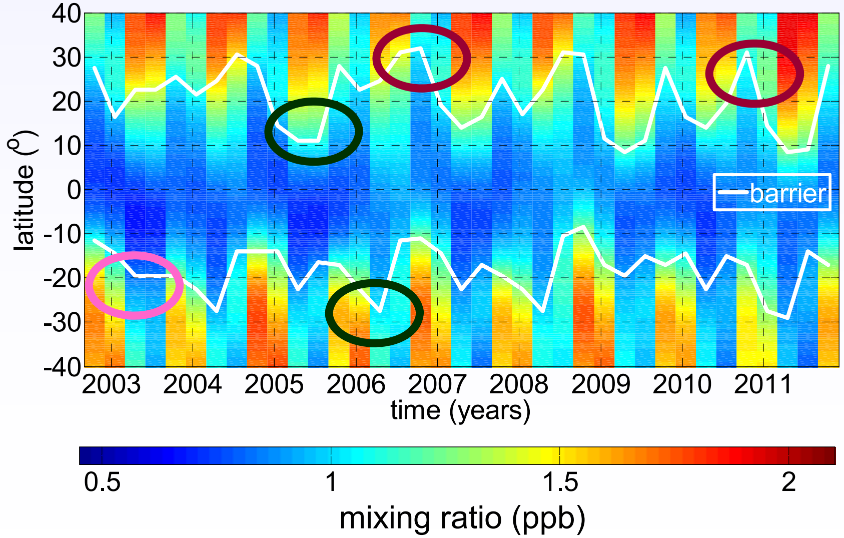
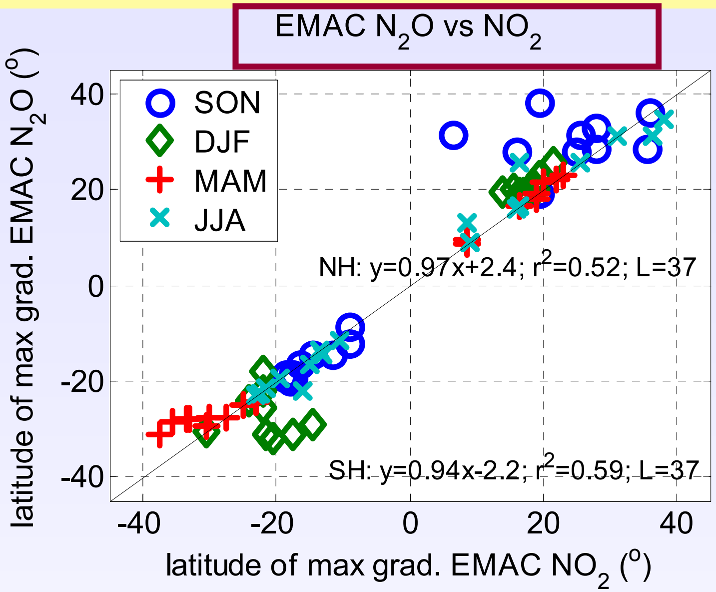
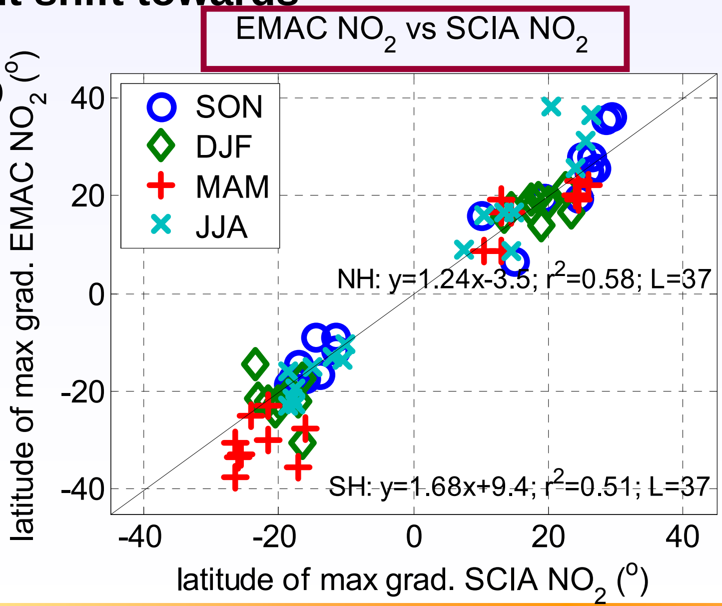


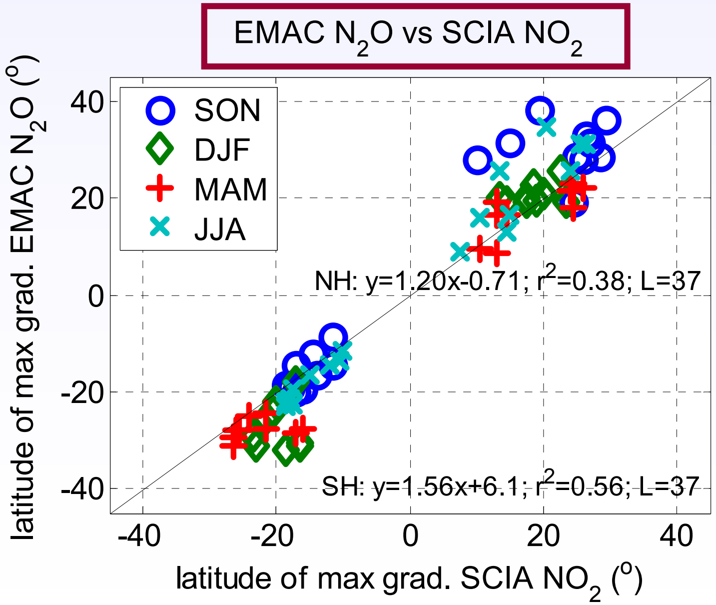
NO_2 and N_2O at 600 K (≈ 25 km)

Measurement vs. Model

- Overall good agreement; seasonal & QBO paters visible
- Largest discrepancies in autumn & **summer**
- and at higher latitudes (denoxification increases)
- **Max gradient shift towards equator for NO_2 w.r.t. N_2O**



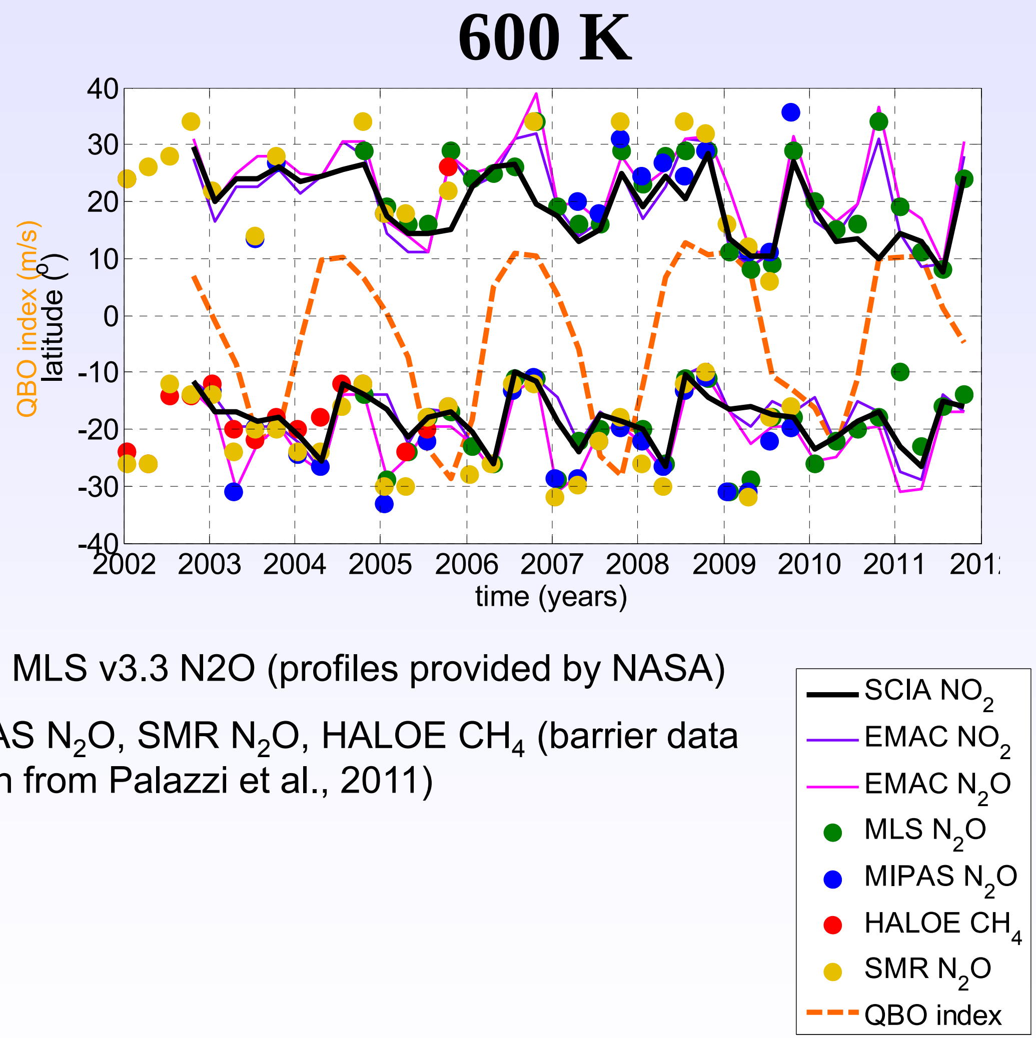




Maximum gradient: different instruments and EMAC

Measurement vs. Model

- ➢Overall good agreement; seasonal & QBO patterns visible
- ➢Largest discrepancies in autumn & **summer**
- ➢and at higher latitudes (denoxification increases)
- ➢Max gradient shift towards equator for NO_2 w.r.t. N_2O
- ➢**Better agreement for SH**

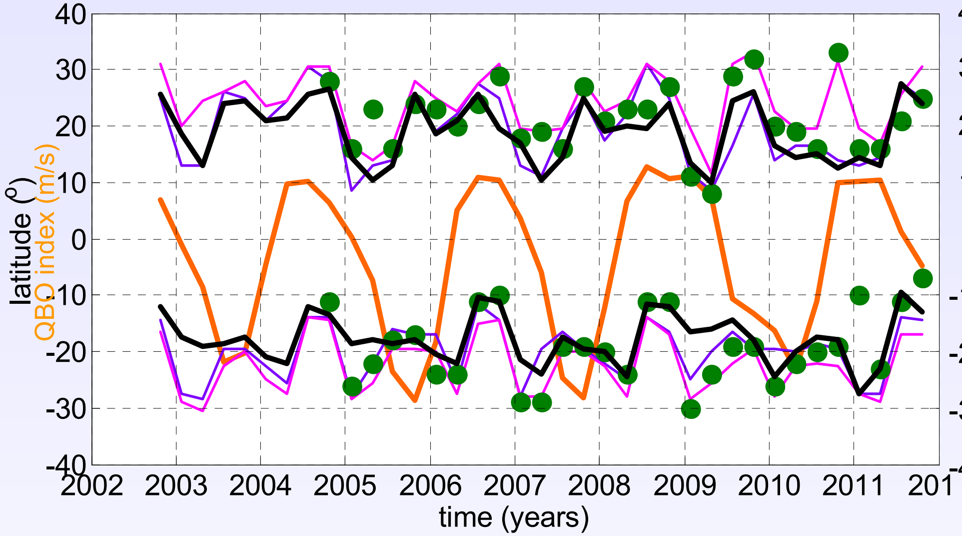


EOS MLS v3.3 N2O (profiles provided by NASA)

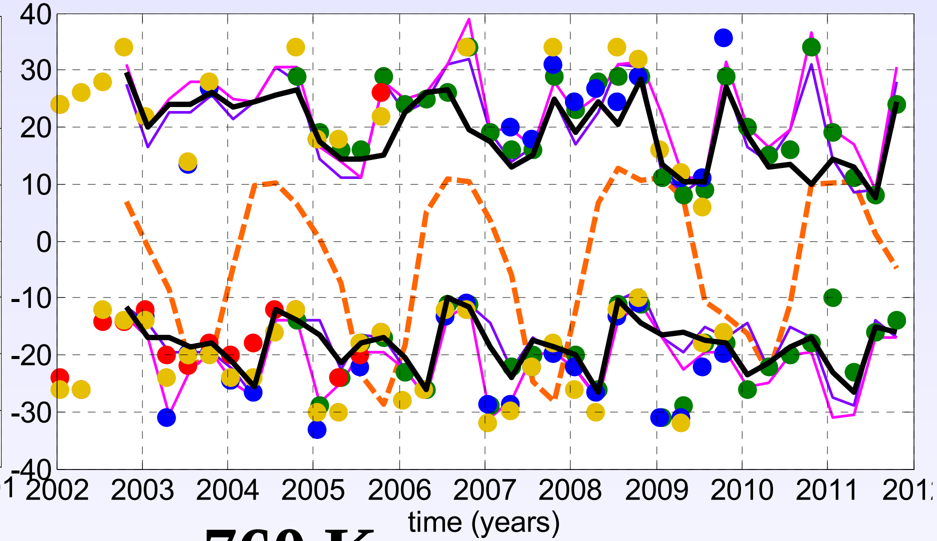
MIPAS N_2O, SMR N_2O, HALOE CH_4 (barrier data taken from Palazzi et al., 2011)

Maximum gradient: different instruments and EMAC

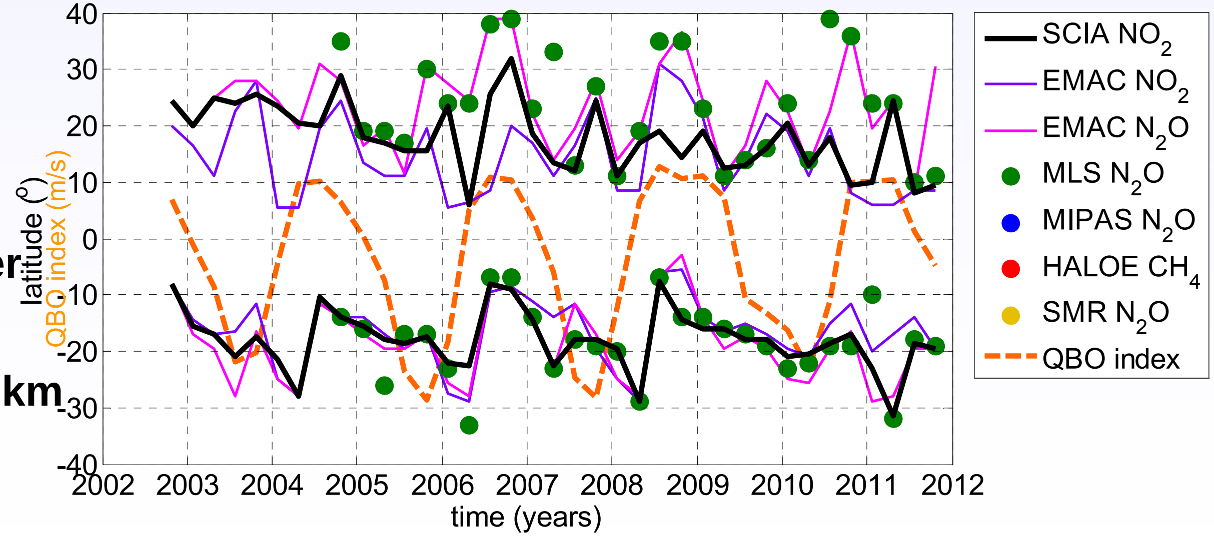
520 K



600 K



760 K

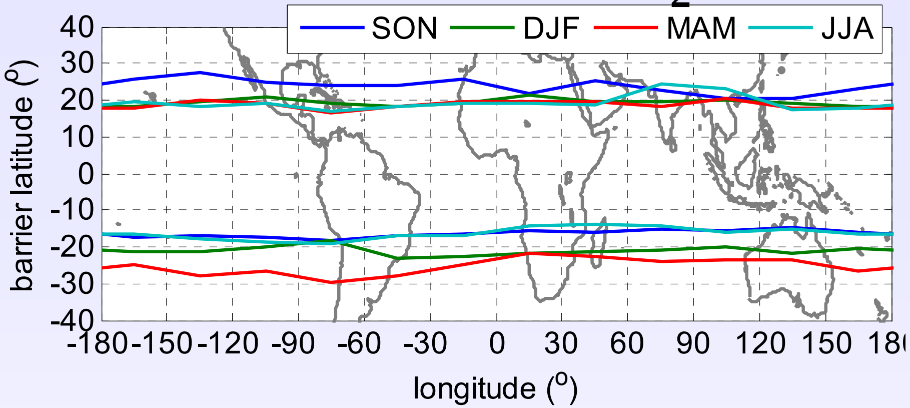


- Max gradient shift towards equator for NO_2 w.r.t. N_2O
- Better agreement for SH
- **Differences larger at higher altitudes (above 30 km)**
- **Best agreement around 25 km**

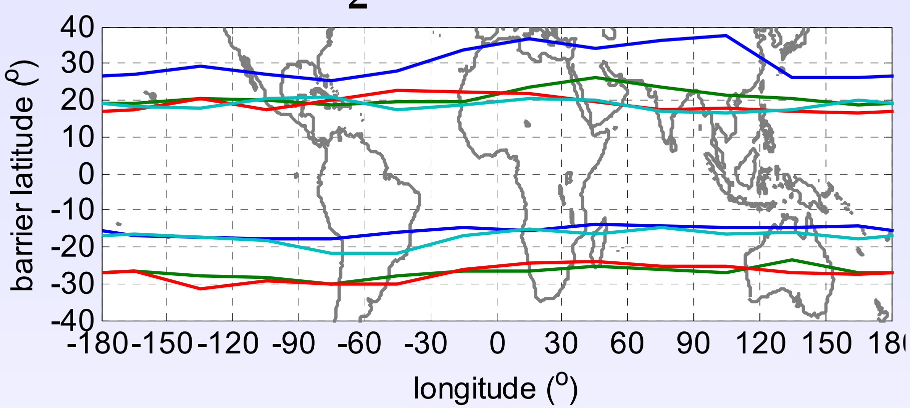
Latitudinal and seasonal variation **600 K**

measured

SCIAMACHY NO_2

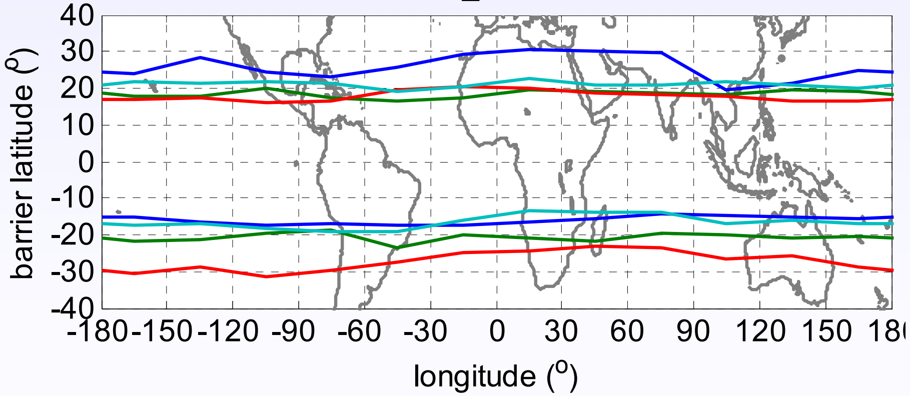


MLS N_2O

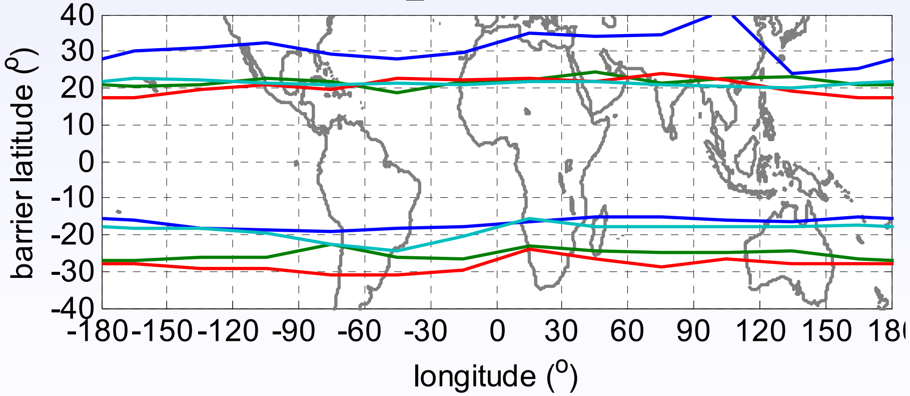


modelled

EMAC NO_2



EMAC N_2O

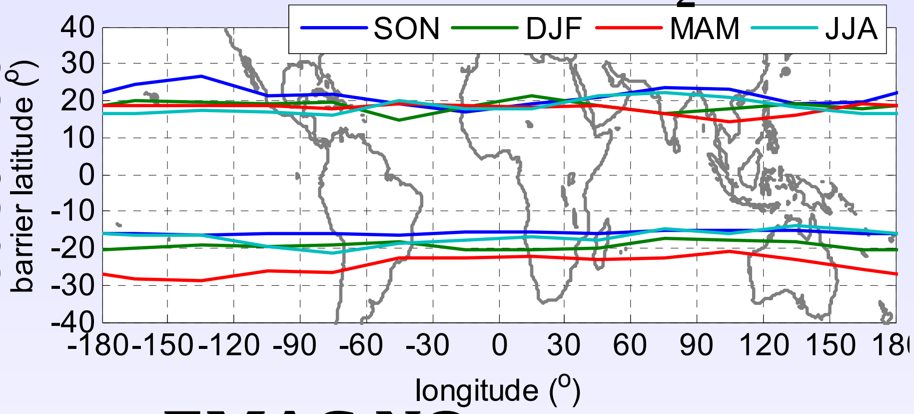


- SCIA & EMAC: average Sep 2002 – Nov 2011; MLS: average Sep 2004 – Nov 2011
- For autumn: barrier movement towards higher latitudes & largest longitudinal variation
- Good agreement (with exception in autumn and SH summer)

Latitudinal and seasonal variation **760 K**

measured

SCIAMACHY NO_2



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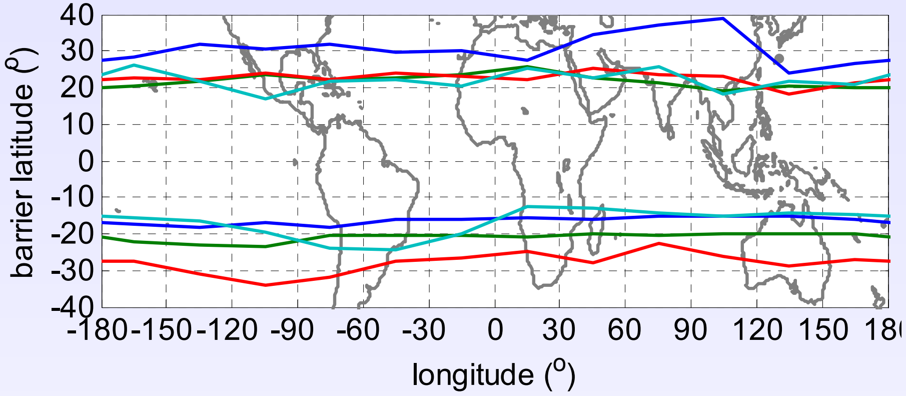
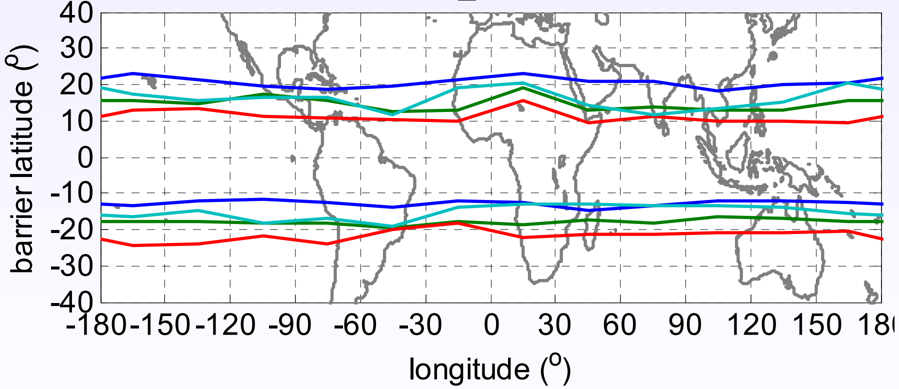
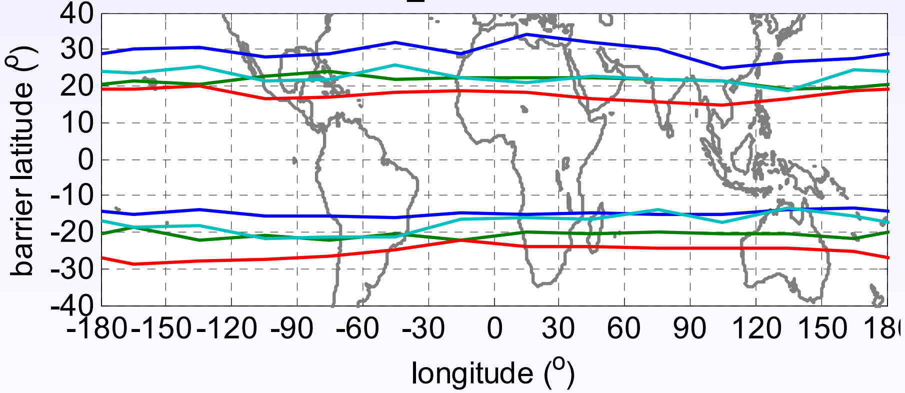


modelled

EMAC NO_2



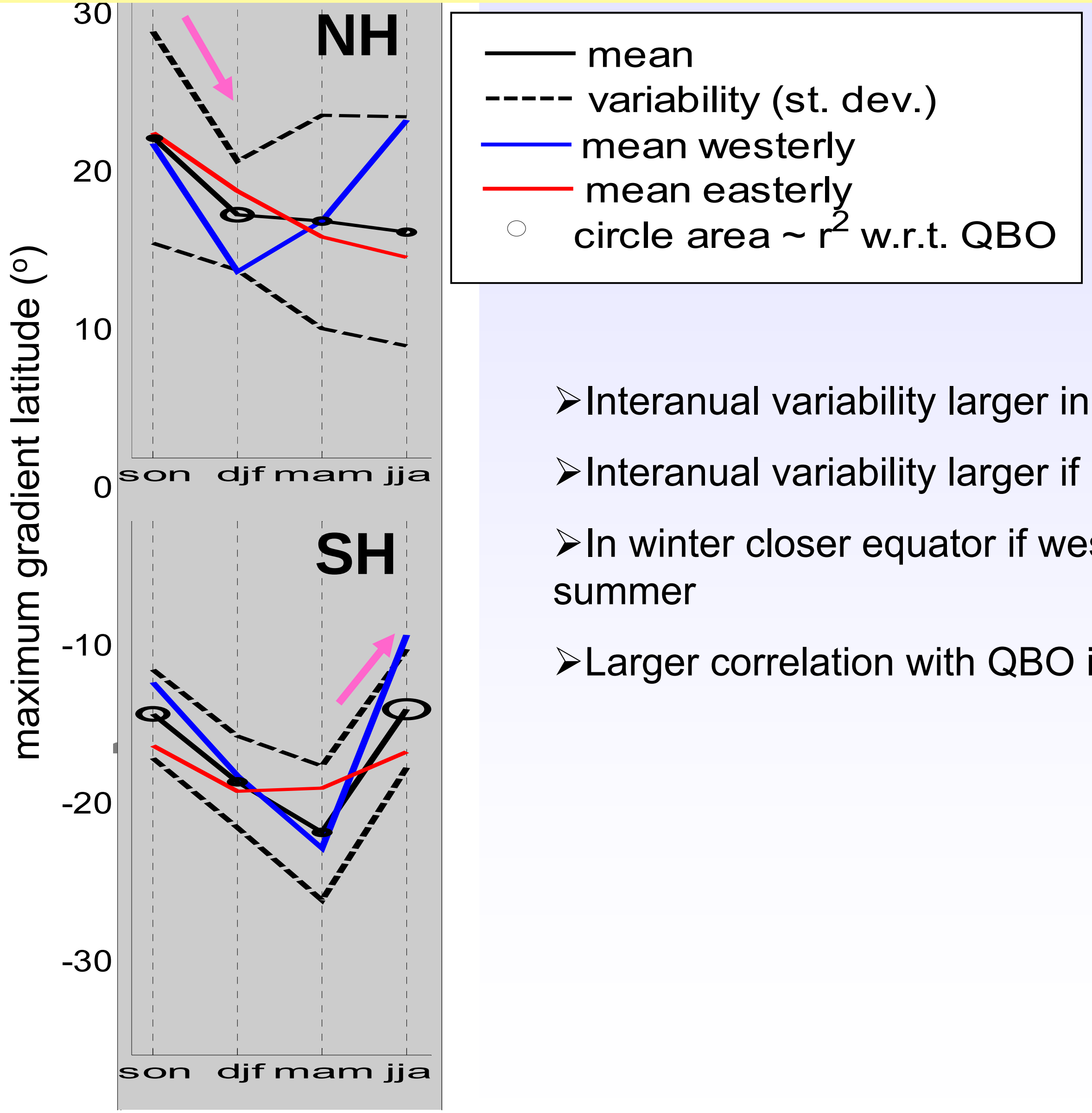
EMAC N_2O



- SCIA & EMAC: average Sep 2002 – Nov 2011; MLS: average Sep 2004 – Nov 2011
- Larger seasonal variations (largest in EMAC)
- Increase for autumn over Asia less prominent in EMAC
- For EMAC larger differences between seasons and shift towards equator

Interannual variability and relation with QBO

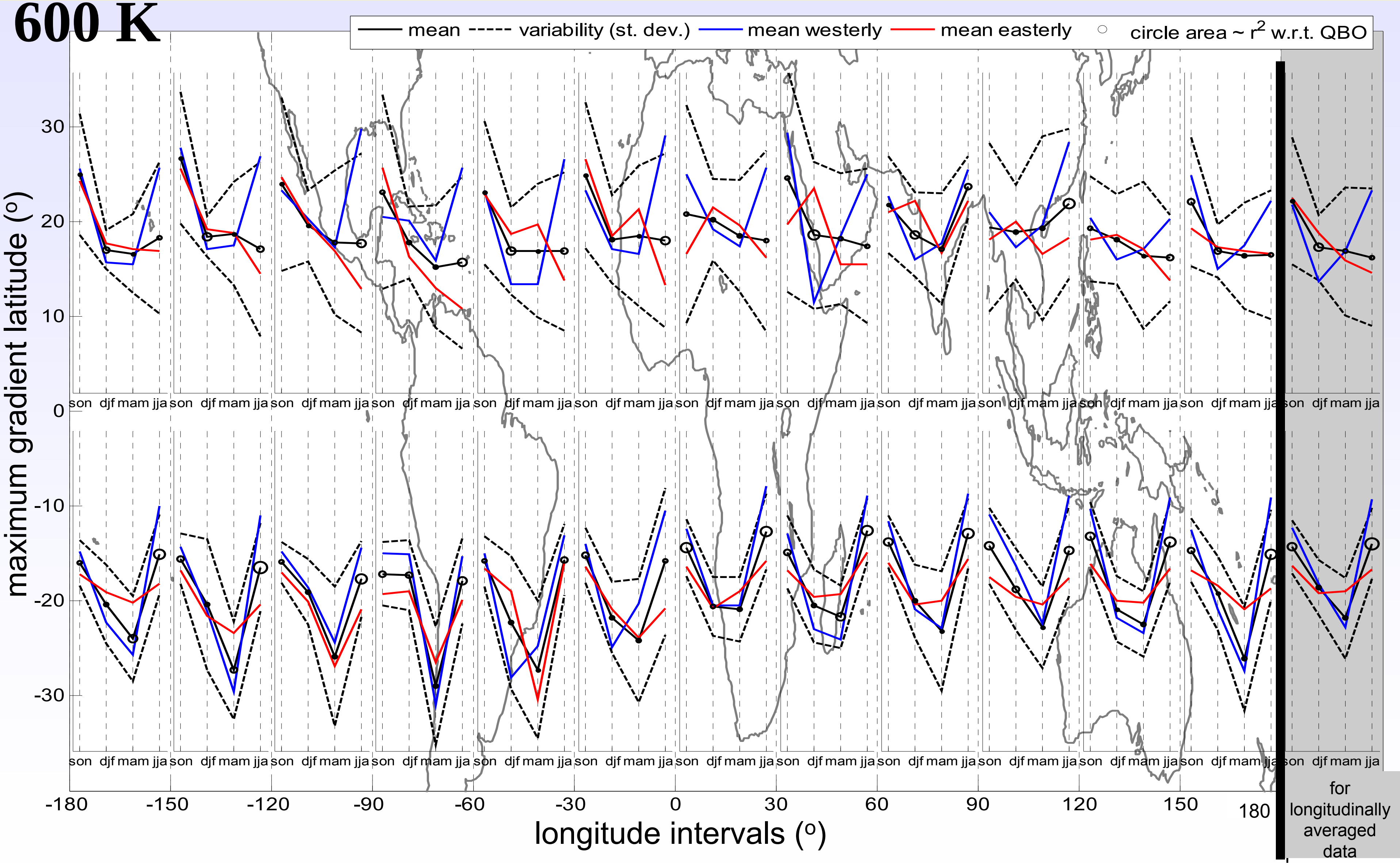
600 K



- Interanual variability larger in NH
- Interanual variability larger if QBO is westerly
- In winter closer equator if westerly, opposite in summer
- Larger correlation with QBO in winter & in SH

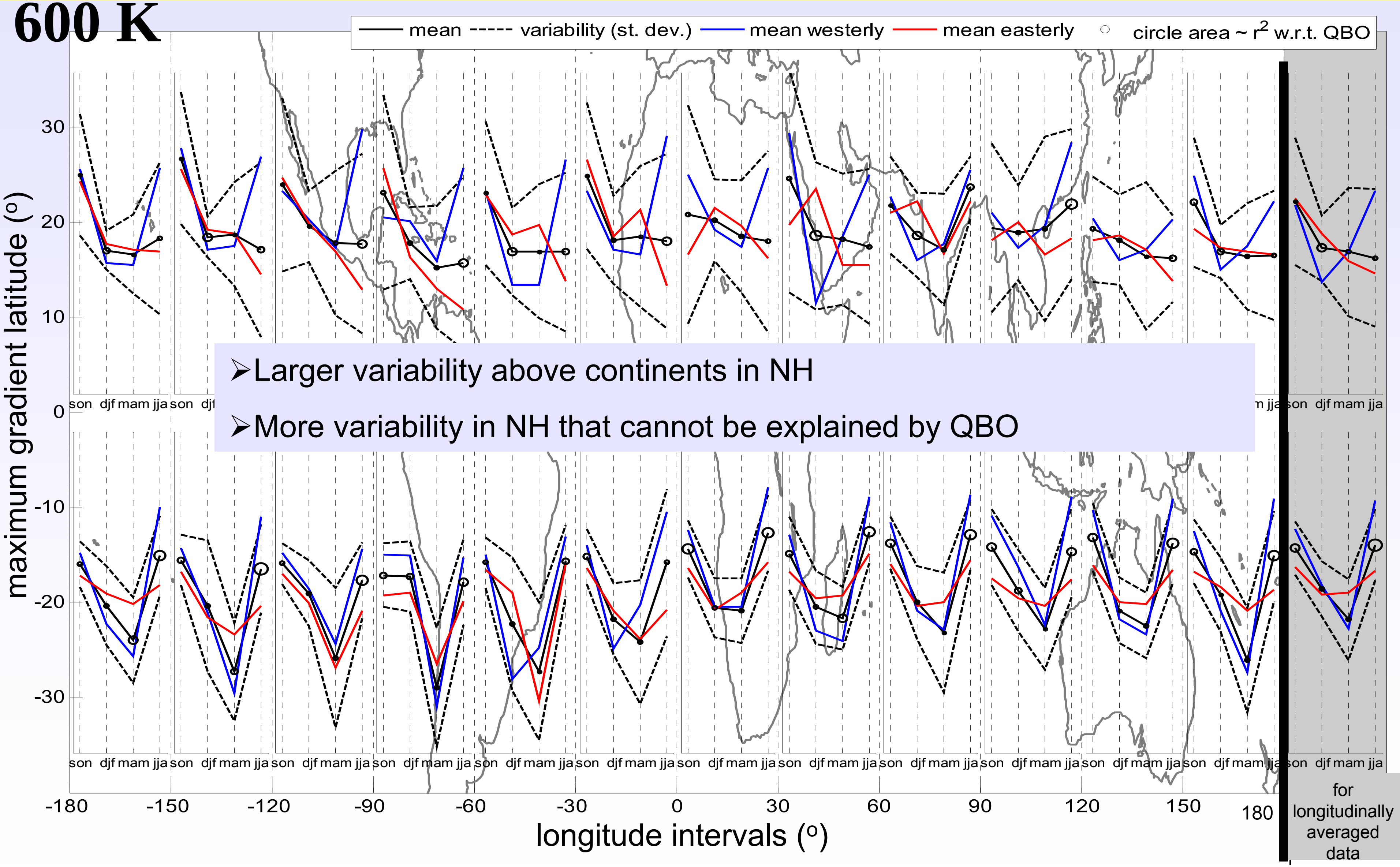
Interannual variability and relation with QBO

600 K



Interannual variability and relation with QBO

600 K



- Larger variability above continents in NH
- More variability in NH that cannot be explained by QBO

Conclusions

- Tropical stratospheric transport barriers affect NO_2 distributions.

- Seasonal and longitudinal variation of the barrier locations investigated; proxy: maximum gradient

- A qualitative agreement between maximum gradient location from NO_2 and from long lived trace gases N_2O (and CH_4) measurements and with EMAC model data

- Larger disagreement between instruments and model in autumn&summer, in the NH, over continents and at higher altitudes

- Largest year to year variation of the barrier location in the NH over continents

- Part of the year to year variation for the same season can be explained by the dependency on QBO— the correlation is higher in the SH, it is lowest over Pacific in the NH

- Opposite effect on QBO for winter and summer. In winter the barrier is nearer to equator if QBO is westerly, for summer the opposite is the case

- Although the correlation with QBO is also lower in summer.