

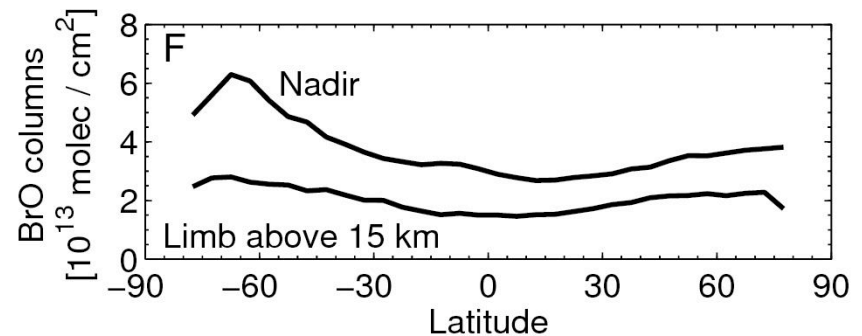
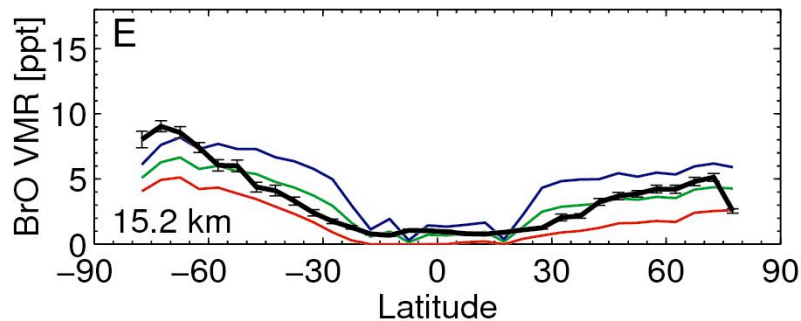
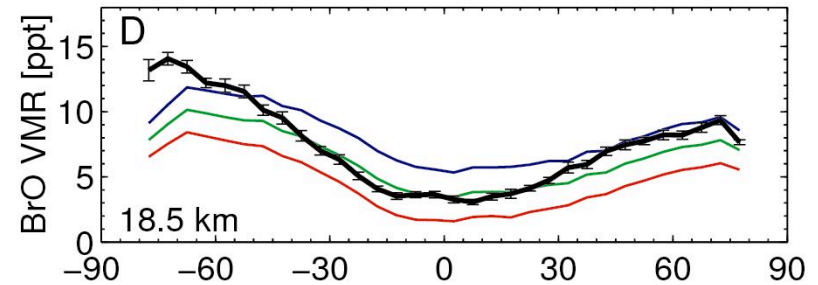
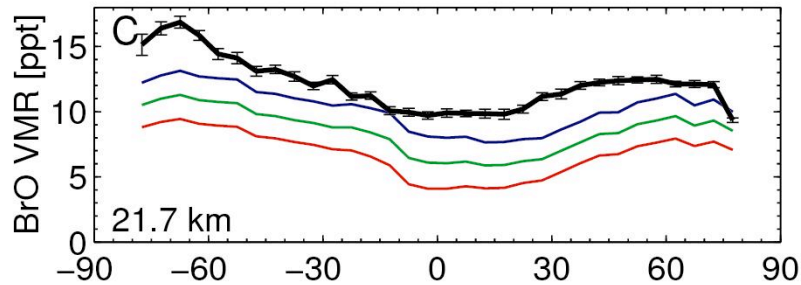
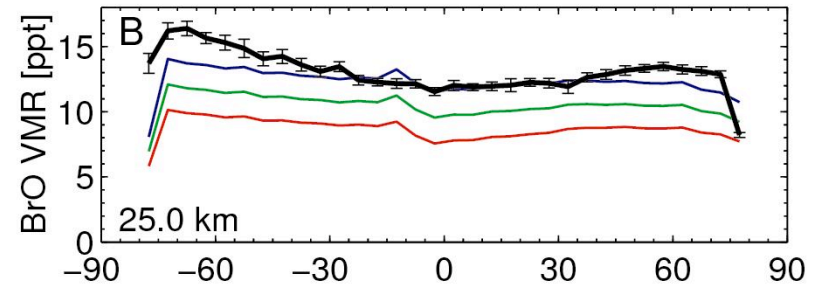
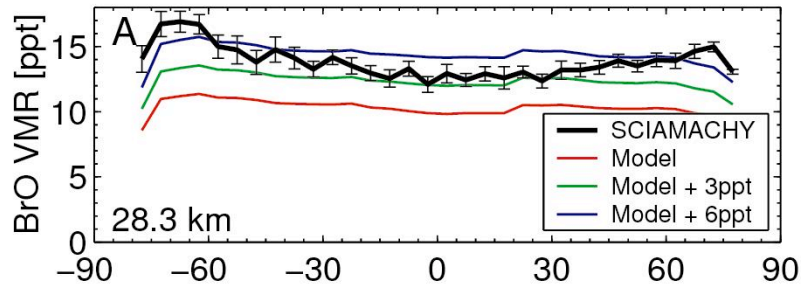
**Observations of BrO in the stratosphere  
and TTL from SCIAMACHY / ENVISAT:**  
*Implications for the transport of  
very short-lived source gases into the  
stratosphere*

Björn-Martin Sinnhuber, Alexei Rozanov, Gregor Kieseewetter,  
Nadine Wieters and John P. Burrows  
Institute of Environmental Physics  
University of Bremen



# SCIAMACHY BrO: Evidence for contribution from VSLs

Zonal Mean 18–27 Sep 2002

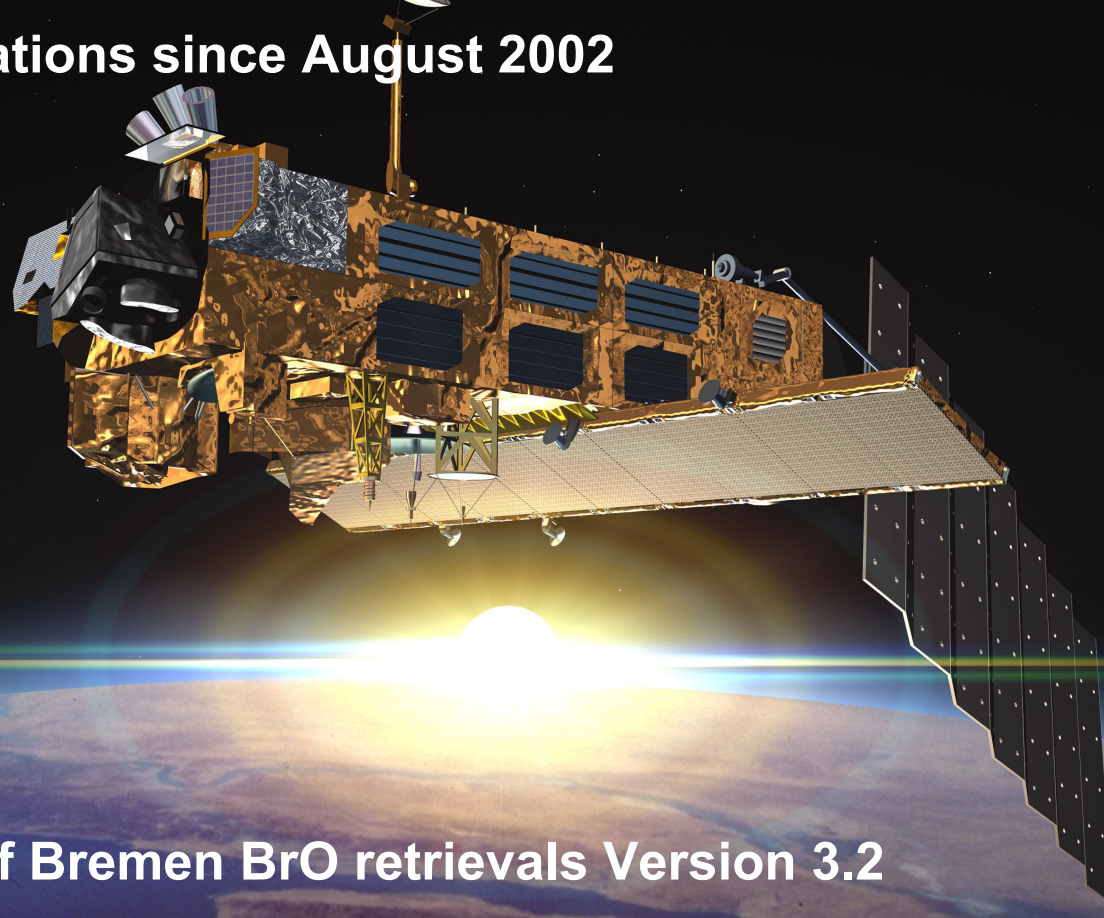


**SCIAMACHY BrO  
Version 3.0**

**updated from Sinnhuber et al., GRL (2005);  
WMO (2007)**

# SCIAMACHY on ENVISAT

- ENVISAT launched in March 2002  
BrO observations since August 2002



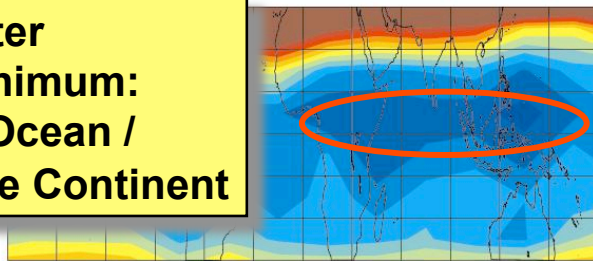
- University of Bremen BrO retrievals Version 3.2  
now with much improved pointing knowledge  
(currently available for 2005; full reprocessing under way)

# SCIAMACHY BrO: Tropical Lowermost Stratosphere

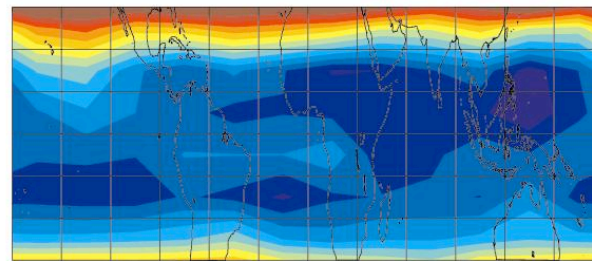
## SCIAMACHY BrO 18 km [pptv]

**NH winter  
BrO minimum:  
Indian Ocean /  
Maritime Continent**

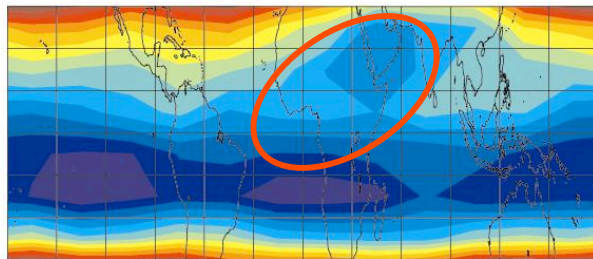
Jan/Feb



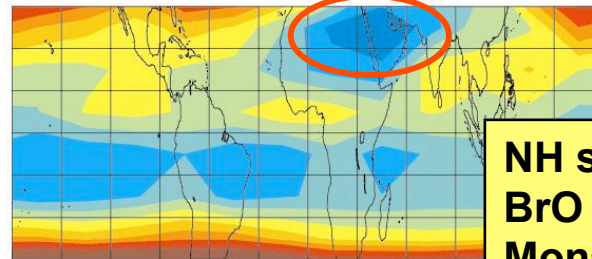
Mar/Apr



May/Jun

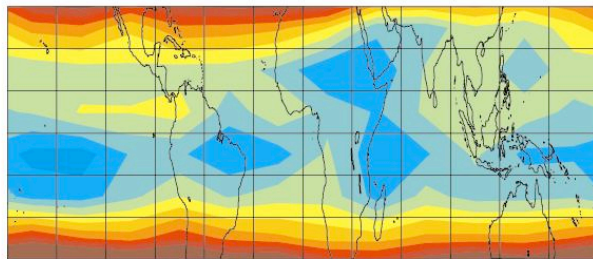


Jul/Aug

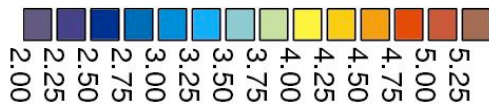
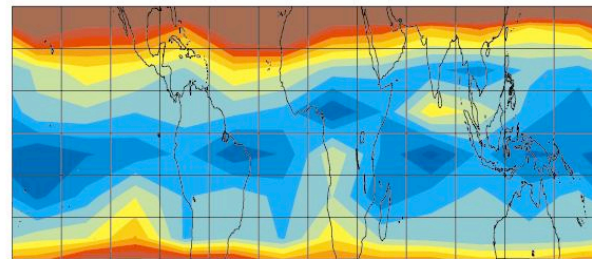


**NH summer  
BrO minimum:  
Monsoon Region**

Sep/Oct



Nov/Dec

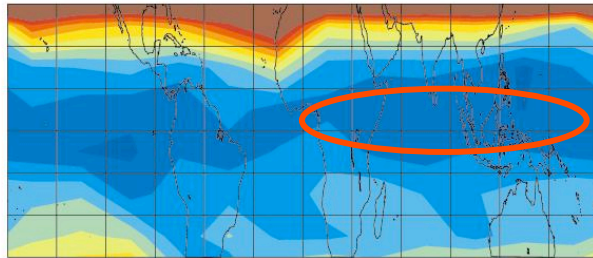


2005

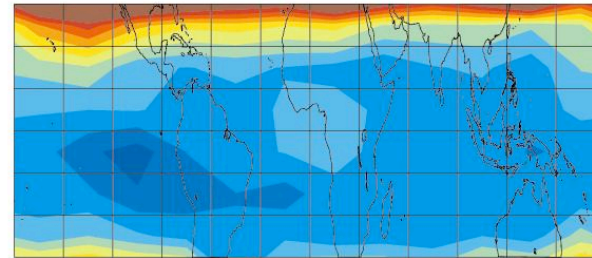
# SCIAMACHY Ozone

## SCIAMACHY O<sub>3</sub> 18 km [ppbv]

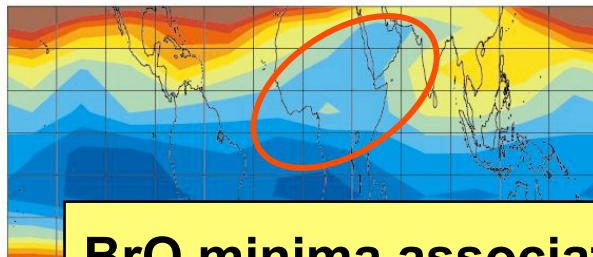
Jan/Feb



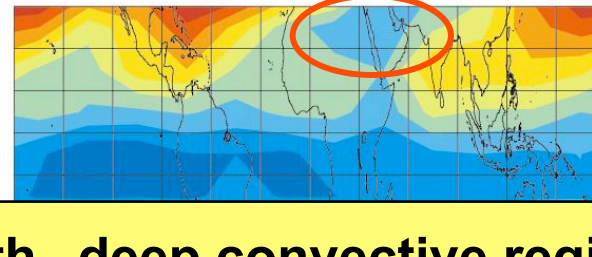
Mar/Apr



May/Jun



Jul/Aug



**BrO minima associated with „deep convective regions“**

- Retrieval artefacts due to high clouds?
- (Convective) transport of BrO poor air?
- Low BrO/Bry-ratio due to low ozone?

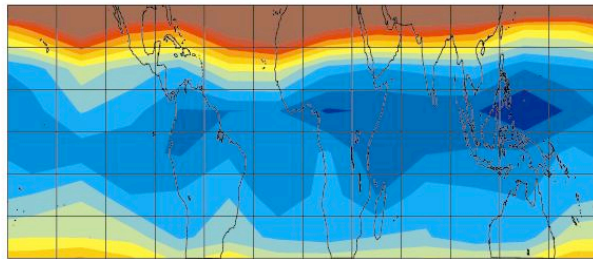
200 250 300 50 00 50 00 50 00 50 00 50 00

# SCIAMACHY BrO: Cloud Free Observations

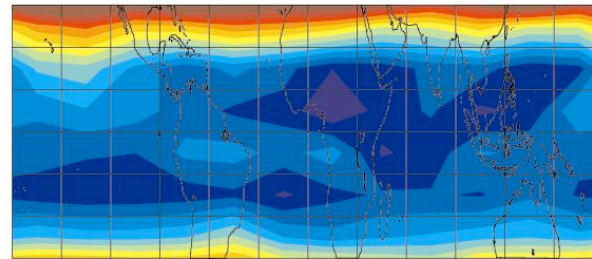
Cloud information from observed colour ratio

## SCIAMACHY BrO 18 km [pptv] (CLOUD FREE)

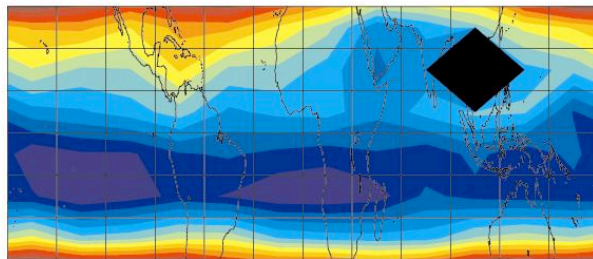
Jan/Feb



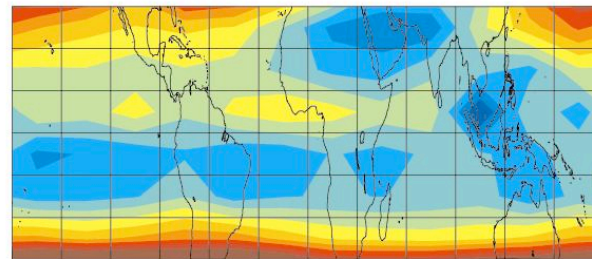
Mar/Apr



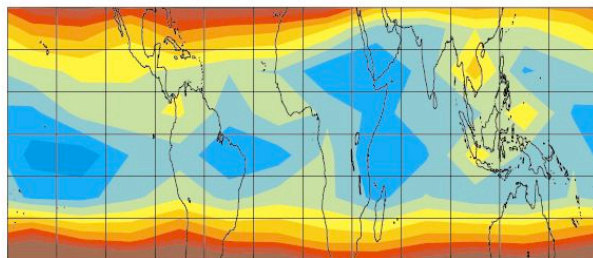
May/Jun



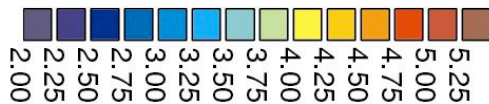
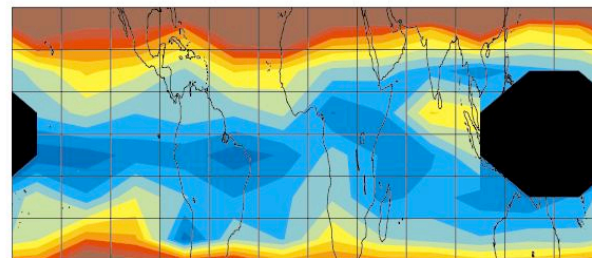
Jul/Aug



Sep/Oct



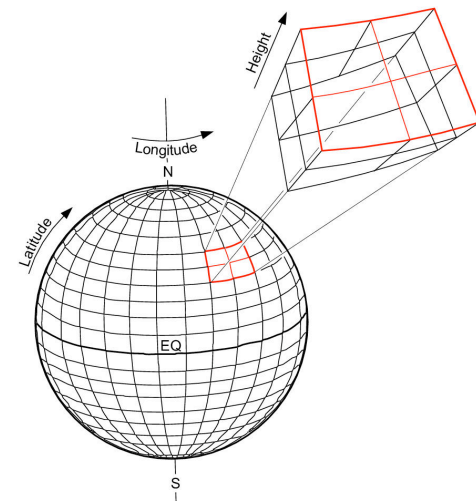
Nov/Dec



2005

## 3D Chemical Transport Model

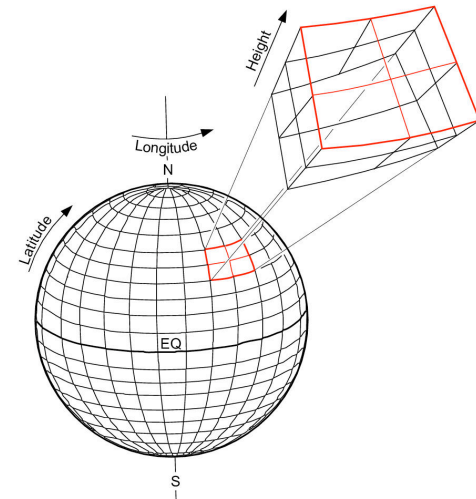
- **Stratospheric isentropic CTM with comprehensive chemistry; driven with UKMO analyses**
- **Output at local time of SCIAMACHY observations**
- **Prescribed lower boundary at 330K isentropic level**
- **No convective transport;  
trace gases set to tropospheric values  
up to 380K level in the tropics**



# 3D Chemical Transport Model: Bromine Loading

- **Model bromine loading only from CH<sub>3</sub>Br and Halons („WMO Bromine“)**  
**Total bromine: 15.6 pptv**
- **Scale modelled BrO to 20pptv total bromine:**

$$\text{BrO}' = (\text{BrO}/\text{Br}_y)(\text{Br}_y + 4.4\text{pptv})$$

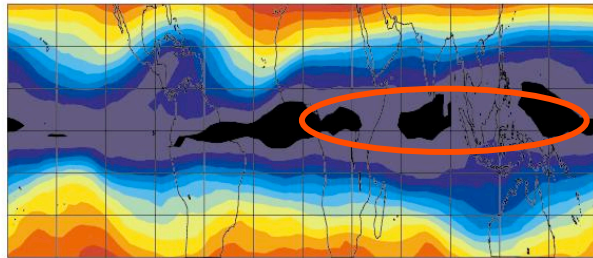




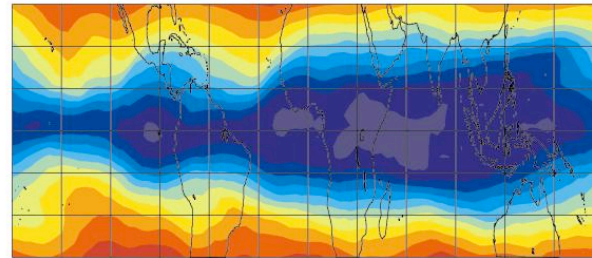
# Chemical Transport Model: BrO

Model BrO 18 km [pptv] (Scaled to 20ppt Br)

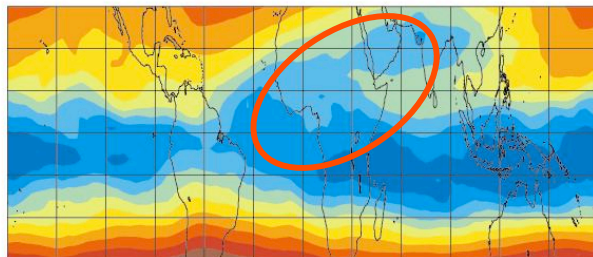
Jan/Feb



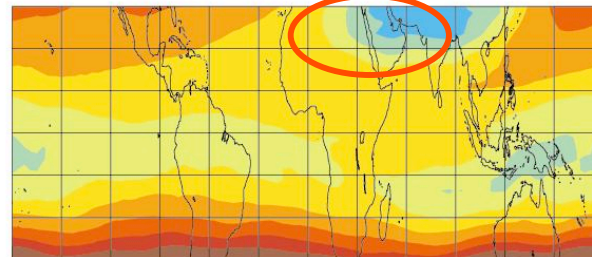
Mar/Apr



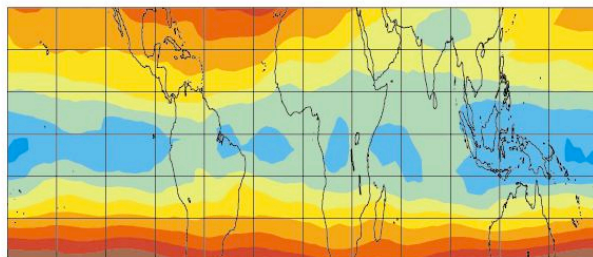
May/Jun



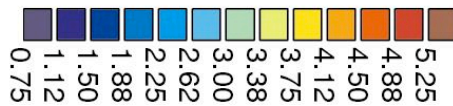
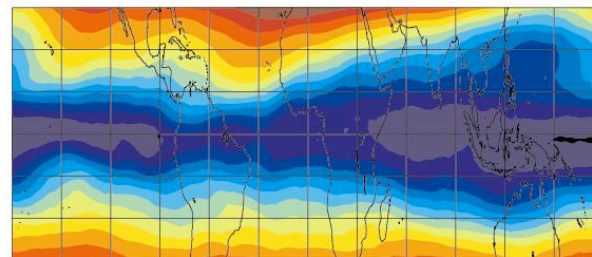
Jul/Aug



Sep/Oct



Nov/Dec

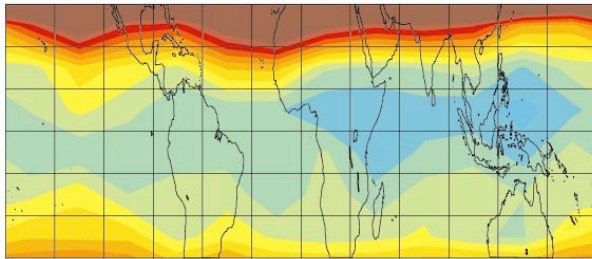


2003/04

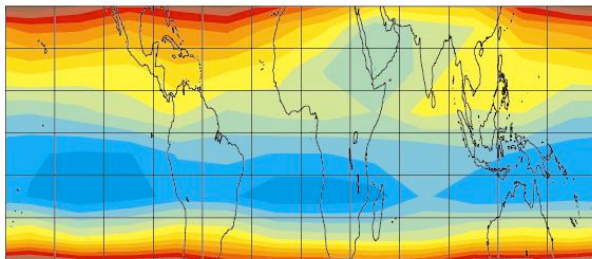
# Tropical BrO: Comparison SCIAMACHY / Model

## SCIAMACHY BrO

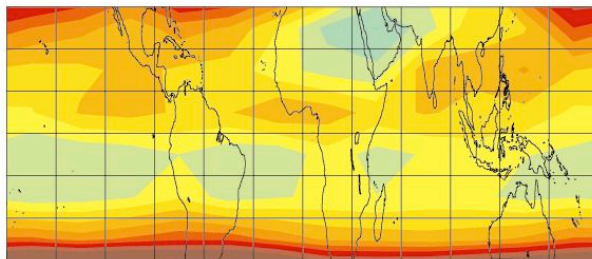
Jan/Feb



May/Jun

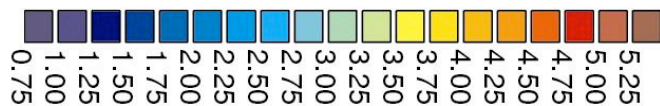


Jul/Aug



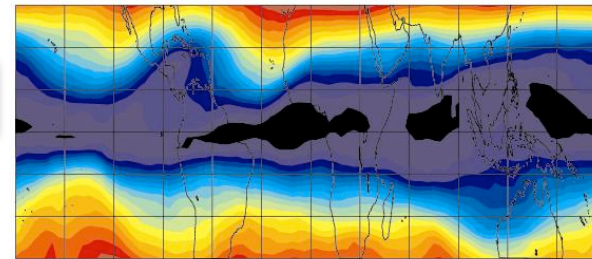
BrO [pptv]

2005

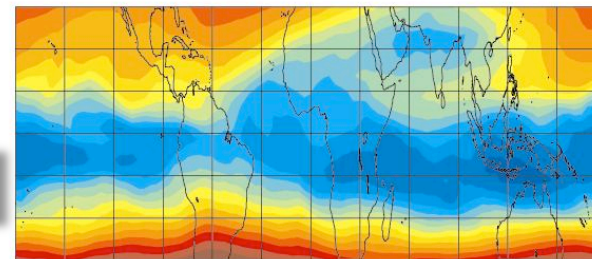


## Model BrO (scaled to 20 ppt)

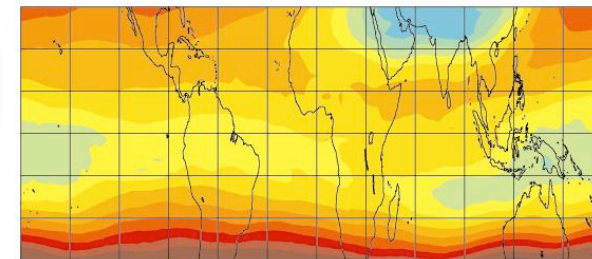
Jan/Feb



May/Jun



Jul/Aug



2004

Jan / Feb

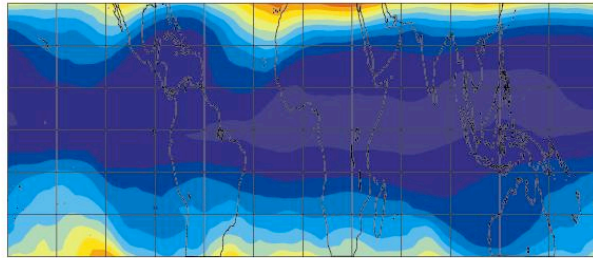
May / Jun

Jul / Aug

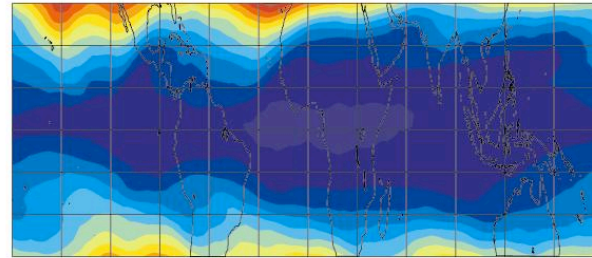
# Chemical Transport Model: Bry

Model Bry [pptv] 18 km

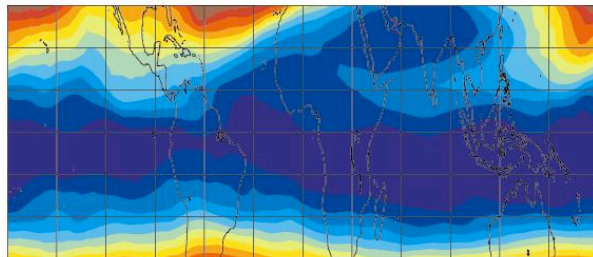
Jan/Feb



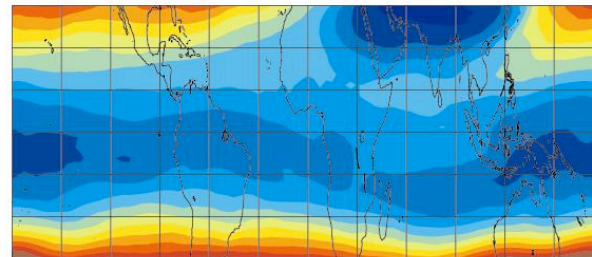
Mar/Apr



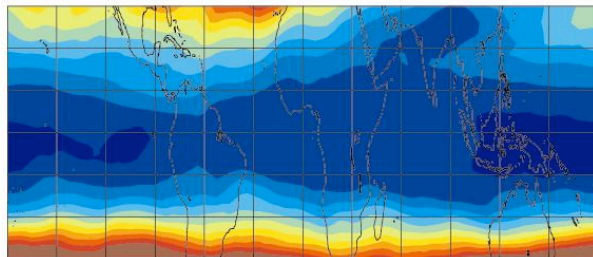
May/Jun



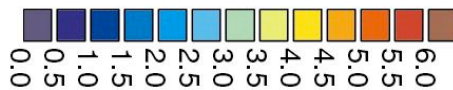
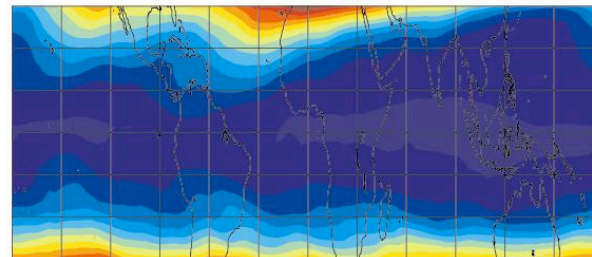
Jul/Aug



Sep/Oct



Nov/Dec

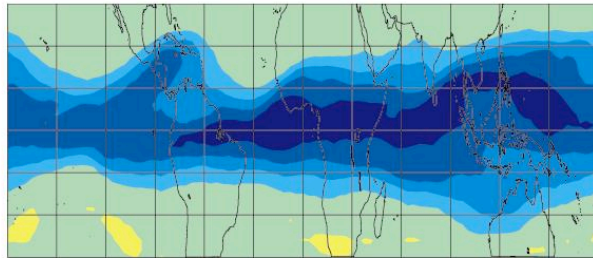


2003/04

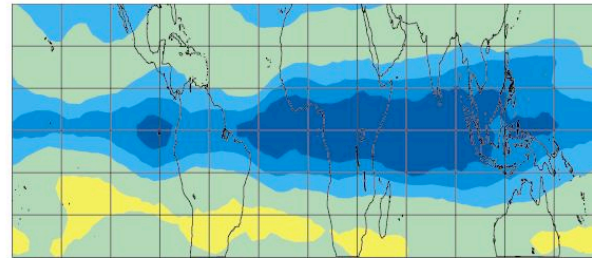
# Calculated BrO / Bry - Ratio

## Model BrO/Bry [%] 18 km

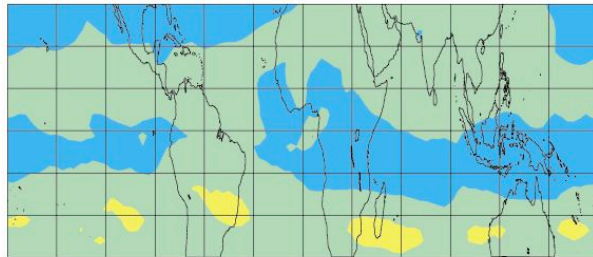
Jan/Feb



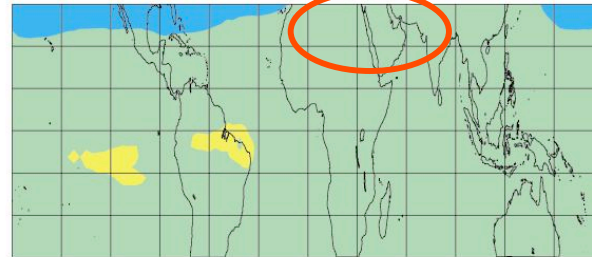
Mar/Apr



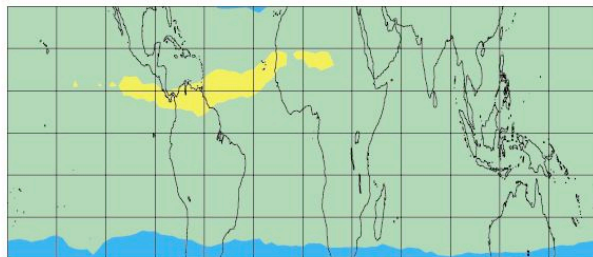
May/Jun



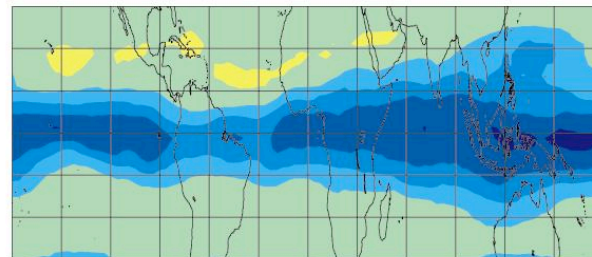
Jul/Aug



Sep/Oct



Nov/Dec

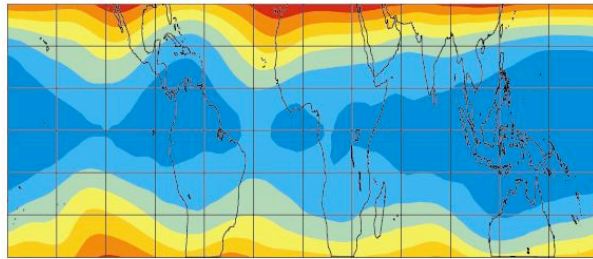


2003/04

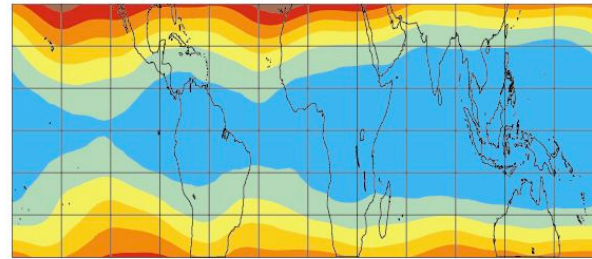
# Potential Temperature

## Potential Temperature 18 km

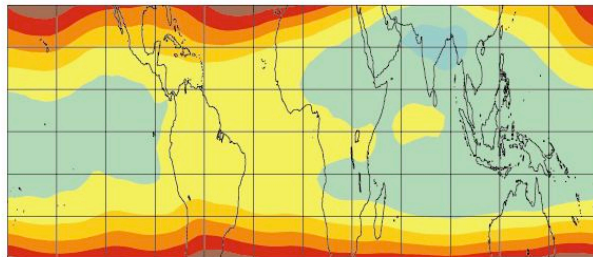
Jan/Feb



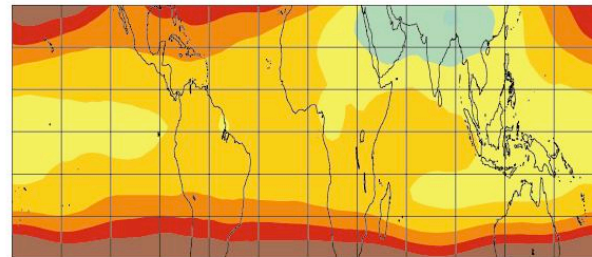
Mar/Apr



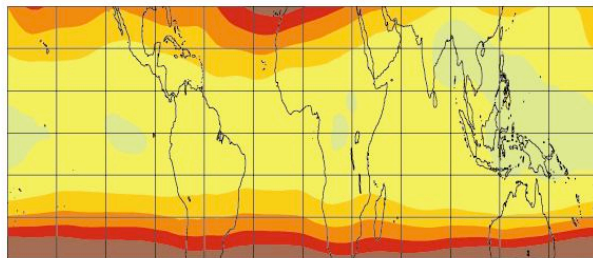
May/Jun



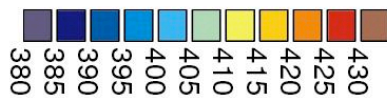
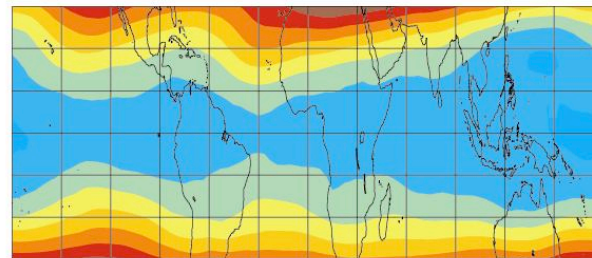
Jul/Aug



Sep/Oct



Nov/Dec



2003/04

## Conclusions

- **SCIAMACHY observations in the tropical tropopause region show lowest BrO above „deep convective regions“**
- **Main features reproduced by CTM:**
  - **BrO minima associated with young age of air:**
    - low  $B_{ry}$
    - low BrO/ $B_{ry}$ -ratio due to low ozone
  - **Model underestimates BrO during NH winter due to low bias in modelled O<sub>3</sub>**
- ***We „see“ the BrO coming out of the source gases***

## Outlook

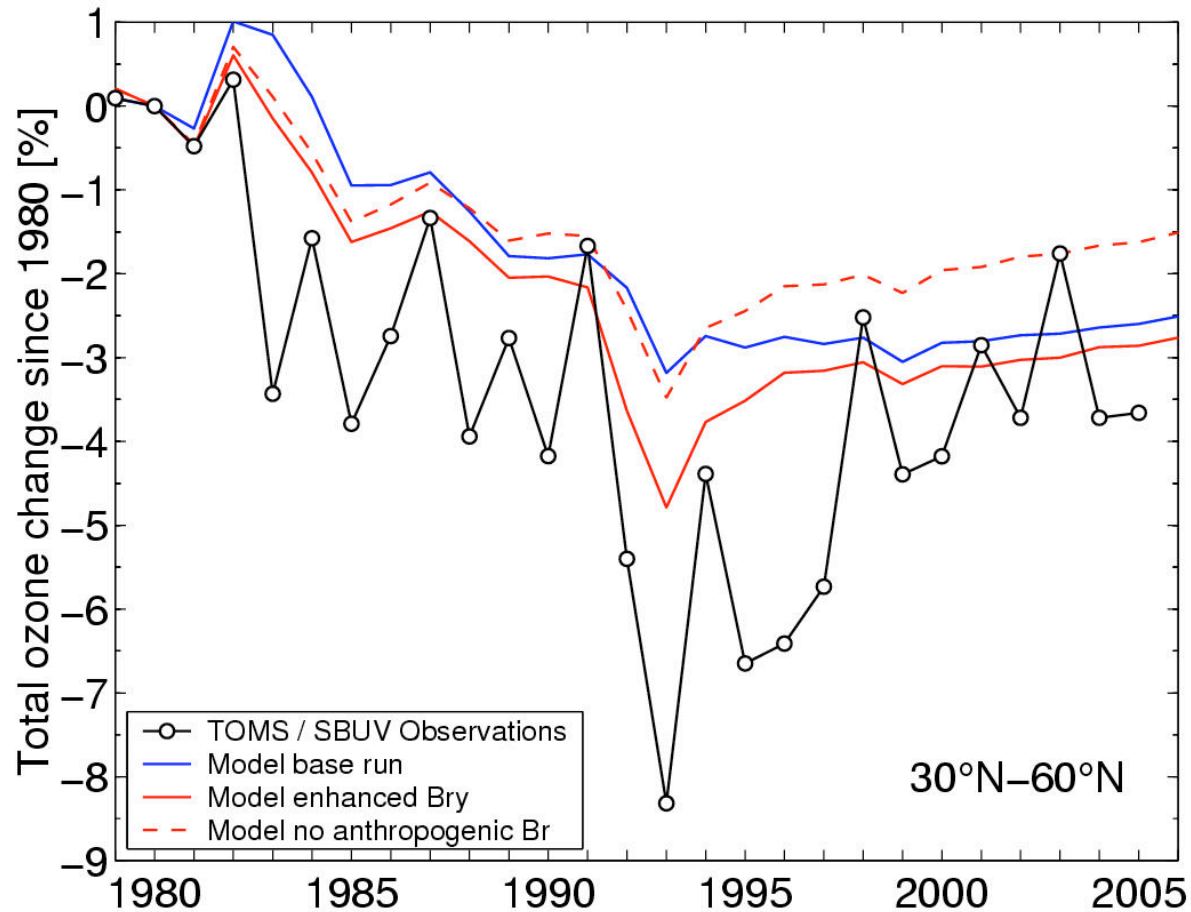
- **Reprocessing of full record of SCIAMACHY BrO observations (2002-present) currently under way**
- **Improve the CTM in the TTL region (including convective detrainment)**
- **Investigate the role of VSLS in a changing climate**



**Thank you!**



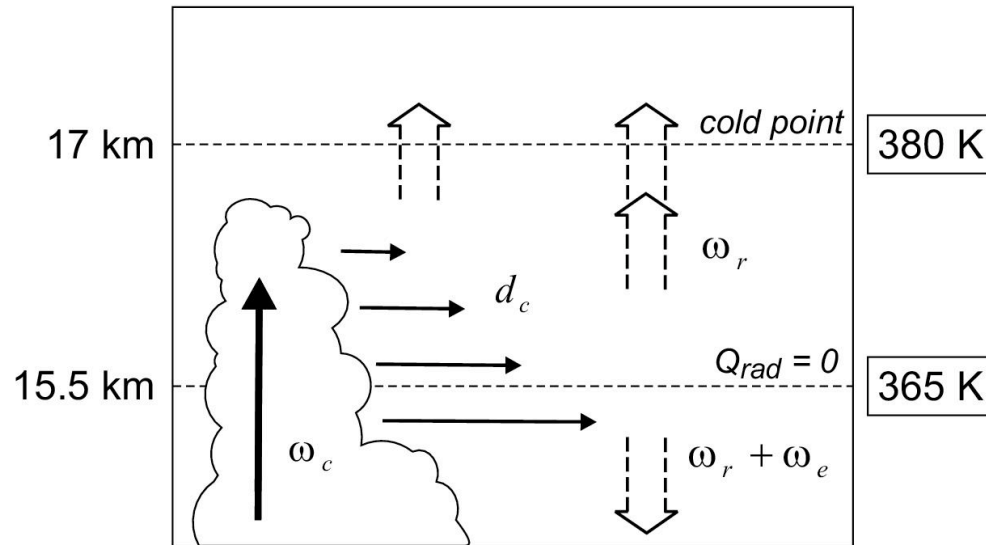
## Modelling studies: Impact of short-lived bromine on ozone trends



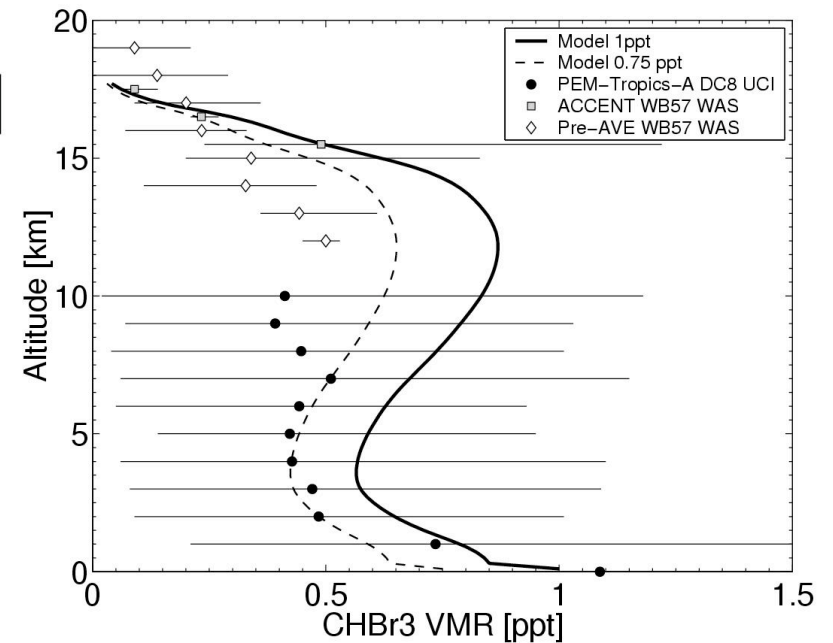
**Additional bromine from very short-lived source gases has significant impact on calculated ozone trends (in particular for periods with enhanced aerosol loading).**

**from Sinnhuber et al.,  
ACPD (2006)**

# Modelling studies: Convective transport into the TTL



## Comparison of modelled and observed tropical mean CHBr<sub>3</sub> profiles



***How will this respond to climate change (e.g. changes in tropical SST and tropospheric temperature) ?***

from Sinnhuber and Folkins, ACP (2006)