Synergetic use of MATCH-MPIC and GOME Satellite data for the study of Tropospheric NO_x over Asia

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INTRODUCTION

The tropics play a key role in the chemistry of the global troposphere. The region is chemically very active due to high levels of solar insolation and humidity. Tropical anthropogenic emissions of O_3 precursor trace gases such as NO_x and hydrocarbons are significant and rapidly growing, especially in Asia. There is a significant uncertainty in these emissions, as well as in natural sources of NO_x such as the production by microbial processes in soils and by lightning.

MATCH-MPIC

(Model of Atmospheric Transport and Chemistry- Max Planck Institute for Chemistry version.)

Horizontal resolution : T63 (1.875 °) & T21 (5.625°)

Vertical resolution: 28 levels, surface-2.7 hPa

Model time step: 30 minutes.

Meteorology component simulates advection, convection, dry turbulent mixing and full tropospheric hydrology cycle. Photochemistry component represent the major sources, transformations and sinks of O_3 related gases.

OBJECTIVES

1. **To understand tropospheric NO_x over south Asia, especially India and the Indian Ocean, by using MATCH-MPIC & GOME satellite observations.**
2. **To analyse the uncertainties in the estimation of regional NO_x emission strength from GOME.**

GOME

(Global Ozone Monitoring Experiment)

Spatial resolution : 40 km lat. × 320 km lon.

Wavelength region : 240-790 nm

Spectral resolution : 0.2-0.4 nm

Cloud screening : Pixels with a cloud cover < 0.1

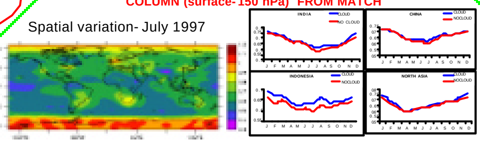
Column densities of NO_2 absorption : DOAS method

Air mass factors for the NO_2 column : GOMETRAN

Assumptions: Clear sky, a maritime aerosol, a surface albedo= 0.05, Constant mixing ratio of NO_2 < 1.5 km

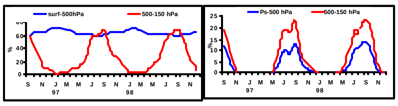
RATIO OF 10:30 to 24 HOUR AVERAGE TROPOSPHERIC NO_2 COLUMN (surface-150 hPa) FROM MATCH

Spatial variation- July 1997



Figures show that the ratio varies with respect to space and time. Test runs without cloud in the photolysis indicate that the difference in the ratio compared to base run is small for India, China & N.Asia. This indicates that a proper cloud screening will only make a minor improvement.

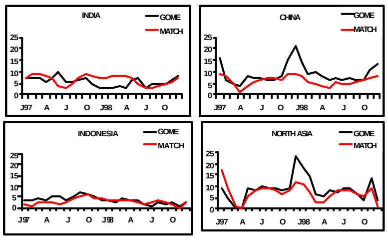
SCALED SENSITIVITY OF NO_x TO LOCAL SOURCE & LIGHTNING OVER INDIA



Scaled sensitivity of NO_x emission to local source (left) and lightning (right) over India computed from sensitivity run (10% reduction in regional NO_x source with/without changing lightning.The change is multiplied by 10 to determine the scaled sensitivity) for lower (surface-500 hPa) and upper (500-150 hPa) troposphere.

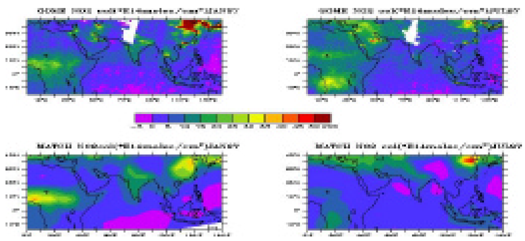
The figures indicate that most of the lower tropospheric NO_x (60-70%) is sensitive to local emissions. In the upper troposphere in winter, nearly all of the NO_x comes from remote sources, while in summer about 40-50% is sensitive to convective transport of surface emissions and 10-20% to lightning

AERAL AVERAGES OF MATCH & GOME NO_2 COLUMNS FOR ASIAN REGIONS



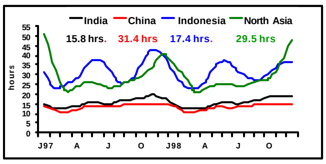
Comparision of areal average of NO_2 column (in 10^{14} molecules/cm^2) from MATCH and GOME for India, Indonesia, North Asia and China. The general magnitude of NO_2 is generally in agreement in all the regions. Over India the month-to-month variations are not very well reproduced, while over the other regions the seasonal cycles and interannual variability are in much better agreement, although MATCH tends to underestimate the pronounced maxima during the biomass burning periods, especially over North Asia and China.

MATCH versus GOME 2D PLOTS OF NO_2 COLUMN OVER ASIA



Enhanced NO_2 abundances during January and July are seen over China, East Asia and North India. Even small features such as higher values over Bangkok in January and lower values in July are simulated well.

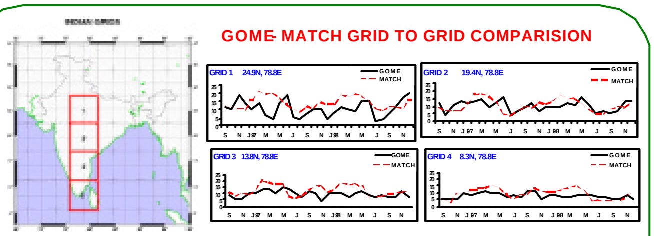
LIFETIME OF NO_x OVER ASIA FROM MATCH



Under steady state, the lifetime of NOx ($\tau(NO_x)$) is the ratio of mass to its emission. Regional lifetime of NO_x for India based on MATCH is 15-23 hours, comparable to $\tau(NO_x)$ over China (14-21hrs), while over Indonesia (23-43 hrs.) & north Asia (21-47hrs.), it is longer and highly seasonal.

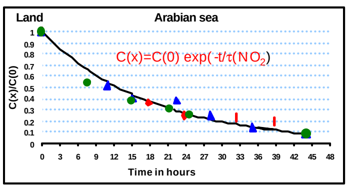
Region	GOME NO_2 Abundance (10^{14} molec/cm^2)			MATCH NO_2 Abundance (10^{14} molec/cm^2)		
	Mean	Maximum	SD	Mean	Maximum	SD
India (5-35° N, 60-95° E)	5.68	9.6	2.0	6.48	12.6	1.82
China (20-70° N, 90-150° E)	9.05	20.8	4.05	6.21	12.8	2.09
Indonesia (10° S-20° N, 95-140° E)	3.49	7.4	1.65	2.84	8.7	1.33
North Asia (30-70° N, 60-90° E)	8.61	23.7	5.17	7.05	23.1	3.72

GOME- MATCH GRID TO GRID COMPARISION



The figures show a better comparison between GOME and MATCH NO_2 column(in 10^{14} molecules/cm^2) over Central Indian grids. Since the ratio of tropospheric to stratospheric NO_2 column is greatest over central India, it is possible that the retrieved tropospheric column might be more accurate over those grids.

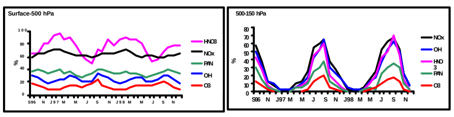
LIFETIME OF NO_2 OVER ARABIAN SEA FROM GOME & MATCH



Chemical decay of NO_2 as a function of time over the Arabian sea during the NE monsoon (when the winds are steadily offshore) along 3 trajectories from the west coast of India. The mean lifetime of NO_2 from GOME computed by using varying offshore wind speed at 850 hpa is 18.2 hours , in good agreement with 3 trajectory angles.

MATCH computes a similar lifetime in the Indian outflow over Arabian sea boundary layer; the lifetime for NO_2 loss to HNO_3 for 6 grid cells is computed to be 16.1 hours, which is close to the GOME estimate.

IMPACT OF NO_x SOURCE PERTURBATIONS ON TRACE GASES OVER INDIAN REGION



Most gases responded to the changes in NO_x in the lower troposphere (surface-500 hPa) with smaller changes, i.e. the scaled sensitivity of O_3, OH and PAN are 30%, 30-50% and 50-60% respectively. HNO_3 is an exception, with a scaled sensitivity of 50-100% with a strong seasonal variability due its high solubility. The variations of all the gases over the upper troposphere are highly seasonal, depending on the convection of surface emission to the upper troposphere during the summer period.

CONCLUSIONS

1. The average NO_2 column from **MATCH & GOME** are comparable in magnitude, although the model shows some discrepancies with **GOME.**
2. Model sensitivity tests for the Indian region indicate that the scaled sensitivity to changes in the local NO_x source is **60-70%** for lower tropospheric NO_x and is only **10-25%** for tropospheric O_3, indicating that moderate reductions or increase in current NO_x emissions are not expected to lead to large changes in regional O_3 levels. In the upper troposphere during winter nearly all of NO_x comes from remote sources, while in summer deep convection and lightning together contribute about **65 %** of NO_x from local sources. This suggests a non-negligible contribution of external NO_x sources, which introduces an uncertainty in to the determination of the regional NO_x source strength using **GOME** data as employed by Leue et al(2001).
3. The regional lifetime of NO_x over India is **15-23** hours, comparable to the lifetime over China(**14-21hrs**.), while over Indoneasia(**23-43 hrs.**) and N.Asia(**21-47 hrs.**), it is longer and highly seasonal. This indicates the importance of using regionally appropriate lifetimes to estimate emissions.

References

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