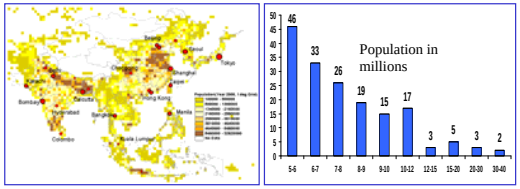
Impact of Asian Megacity Emissions on Regional and Global Tropospheric Chemistry

Sarath Guttikunda[1], Youhua Tang[1], James Yienger[1], Gregory Carmichael[1], Hiram Levy II[2]and James Dorwart[1]

1. Center for Global and Regional Environmental Research, The University of Iowa, Iowa City, IA
2. NOAA Geophysical Fluid Dynamic Laboratories, Princeton University, NJ

URBAN ENVIRONMENTS IN ASIA

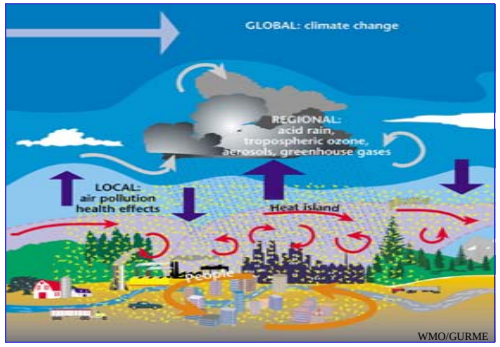
By 2020, over half of the Asia's population is expected to live in the cities. Unplanned and rapid urbanization in cities is taking its toll on human health due to increasing air pollution and exposure to pollutants such as particulates and ozone, a situation driven by increased demand for industrialization, and vehicle use in the urban environments. With an estimated 3 billion urban residents in Asia by 2020 in <5% of the Asia's land cover and human health effects as a primary measure, urban environments are the first to react to any of the pollution control regulations.



Changing standards of living in the urban centers have fueled increased industrial and transportation needs, often associated with unchecked emissions from automobiles, domestic heating, and small-scale industries. Every year, Asian urban centers, prone to indoor and outdoor air pollution, incur hundreds of millions of dollars in health and economic damages.

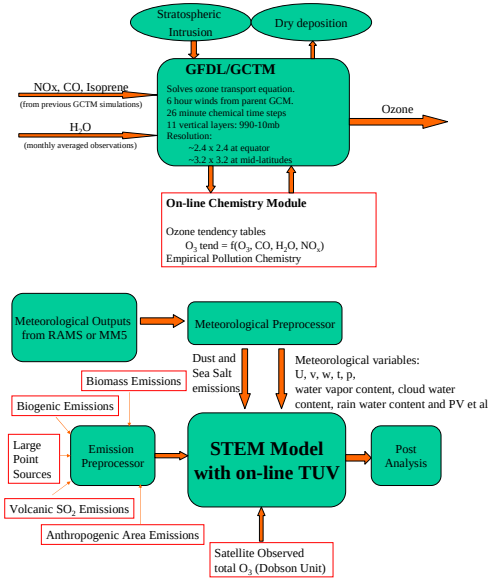
LOCAL TO GLOBAL EFFECTS

Presently, the urban air pollution problems in Asia are continuing to increase and air pollutants originating from urban regions are now recognized as increasing sources of regional- and global- scale pollution.

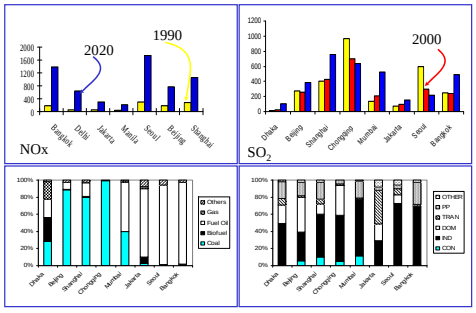


This study employees the GFDL GCTM and the STEM-III model coupled with RAMS to understand the nature of growing emissions from the urban centers of Asia, to characterize the impact of these emissions on trace gas species at urban, regional and global scale. And finally, results of cost-benefit analysis of implementing emission reduction techniques for sulfur, particulates and NO_x for Asian megacities are presented.

MODEL OVERVIEW



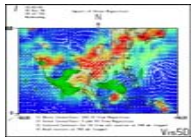
- 27 megacities with population more than 10 million and major urban centers are included in this study
- Emissions for year 2000 are based on Streets (2001) study conducted as part of the TRACE-P and ACE-Asia field experiments (http://www.cgrer.uiowa.edu/ACESS/acess_index.htm)
- Asian megacity anthropogenic emissions accounted for 16% for SO_2 (5.5 Tg SO_2/year), 17% for NO_x (1.54 Tg N/yr), 11% for CO (18.7 Tg CO/yr), and 15% for VOC's (6.68 Tg/yr) in 2000.



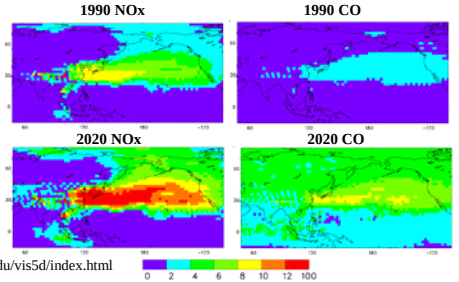
The Figures above presents total anthropogenic emissions of NO_x and SO_2 (ktons/year) from 7 megacities in Asia for period of 1990-2020 and fuel consumption mix in the cities for year 2000 extracted from the RAINS-Asia (Version 7.52) integrated assessment model.

GCTM Simulations

Two sets of GCTM simulations were conducted for the present and year 2020 emission levels compared to a reference run excluding the Asian megacities. Figures to the right present percentage contribution from megacities at 500mb for the month of March.

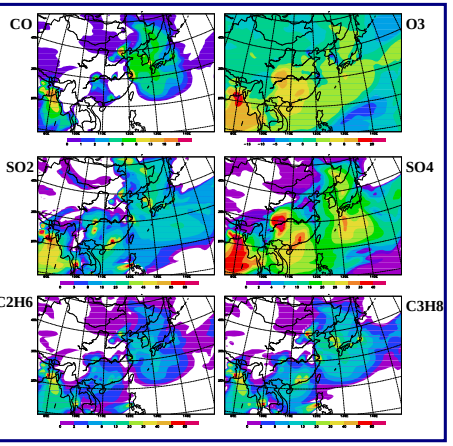


Animations can also be viewed at http://www.cgrer.uiowa.edu/vis5d/index.html

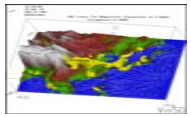


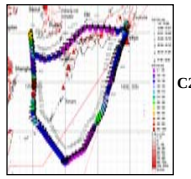
STEM/RAMS Simulations

The STEM model simulations were conducted for year 2000 emission levels compared to a reference run excluding all trace gas emissions from the Asian megacities using meteorological inputs from Regional Atmospheric Modeling System (RAMS). Model includes SAPRC-99 chemical mechanism coupled with TUV for photochemistry. Figures to the right present percentage contribution from the Asian megacities to photochemical activity in the region averaged between March 1st-March 15th, 2001 at 500m.



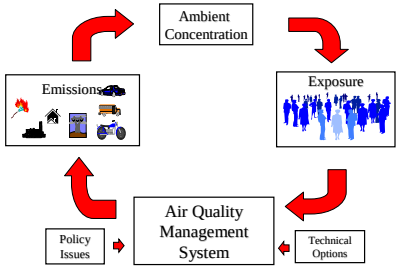
STEM-RAMS results for megacity tracers were utilized for TRACE-P and ACE-Asia mission planning





TRACE-P DC-8 Flight #13 March 21st 2001

INTEGRATED ASSESSMENT



Scenario ==>	C1	C2
% Emission Reduction	Industrial	Power Sector
Sulfur	14	41
NOx	6	13
TSP	9	3
PM10	12	4
PM2.5	13	4

Scenario ==>	C1	C2
Total # of Deaths Avoided	1771	2789
Total # of Chronic Bronchitis Cases Avoided	1106	1740
Total # of Hospital Visits Avoided	60752	95619
Total # of Emergency Hospital Visits Avoided	30603	48166
Total # of Hospital Admissions Avoided	27433	43177
Total Control Costs (US $ in millions)	94	395
Total Benefits Due to Human Impacts Avoided (in millions US $)	106 - 887	168 - 1, 396
Median	265	419
Health Benefit to Scenario Cost Ratio	1.1 - 9.4	0.4 - 3. 5

The table above presents cost-health benefit analysis due to particulate pollution control in 2020 for the city of Shanghai, China

The modeling framework proved to be a useful method in understanding local and regional air quality trends in Asian megacities and the realization of possible future scenarios. Further study includes detailed comparisons with observational data from field experiments and local monitoring stations and integrated assessment of urban air pollution. For further information please contact Sarath Guttikunda (sguttiku@cgrer.uiowa.edu) or Prof. Carmichael (gcarmich@engineering.uiowa.edu)