



Monitoring of PM_{10} , $PM_{2.5}$ and Black Carbon concentrations at Urban Environments in Bangladesh

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Background

Scenario

- Rapid urbanization*
- Increased economic activity*
- High population density*
- Increasing number of motor vehicles and industries*
- Traffic congestion*
- Transboundary transport*





Air Quality Parameters

- **PM (PM₁₀, PM_{2.5})**
 - **SO_x**
 - **NO_x**
 - **CO**
 - **Ozone**
 - **Trace elements in PM's etc.**
-
- *The most serious pollutant of concern in Bangladesh, especially in cities, is the particulate matter (PM)*

Adaptation of policies taken by the Government to reduce the PM emission from motor vehicle

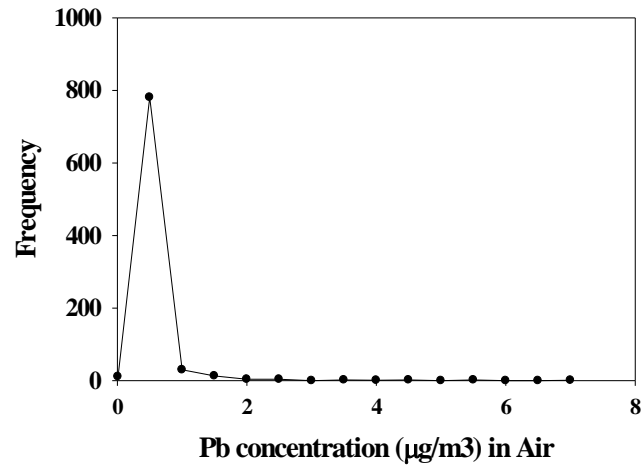
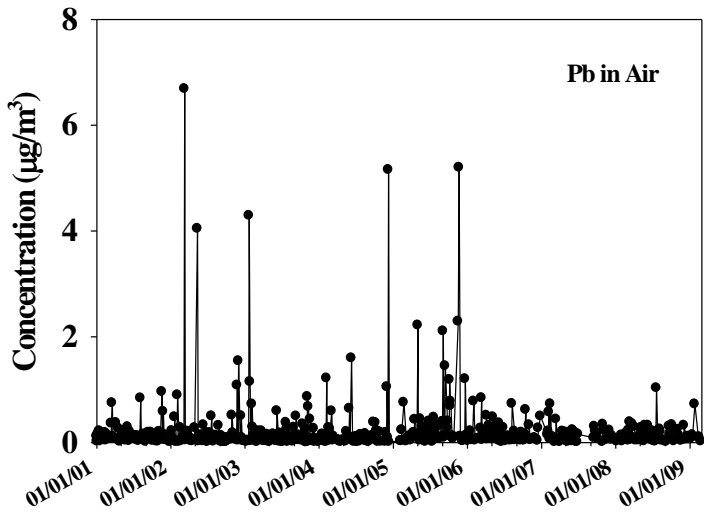
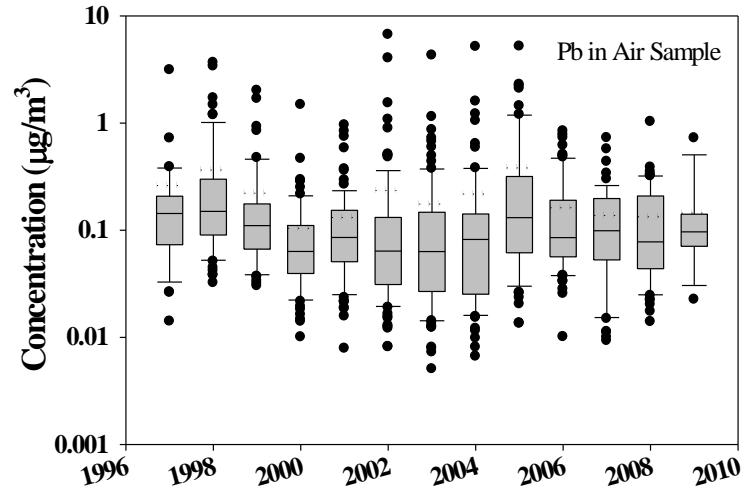
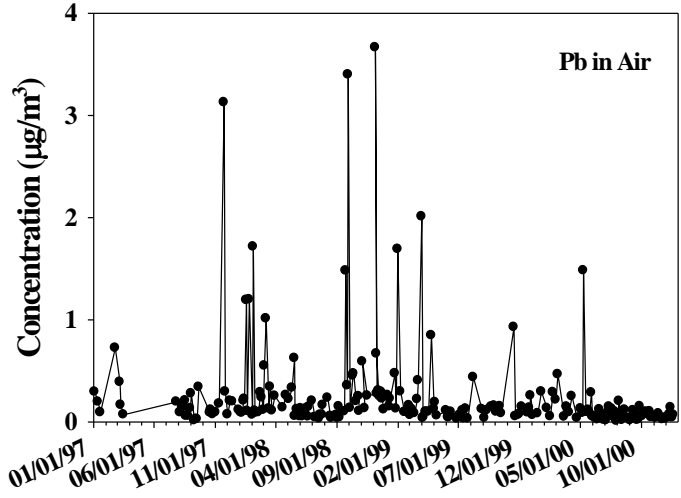


These are

- **banning of use leaded gasoline from July 1999**
- **improved training of engine mechanics, import and marketing of mineral oil without additives and set minimal standards for lubricants**
- **banning of two-stroke three-wheel taxis from January 2003 and removal of trucks and buses that were more than 20 years old**
- **a phased reduction of gasoline-powered by introducing CNG, &**
- **electronic traffic signals to increase the mobility of vehicles.**

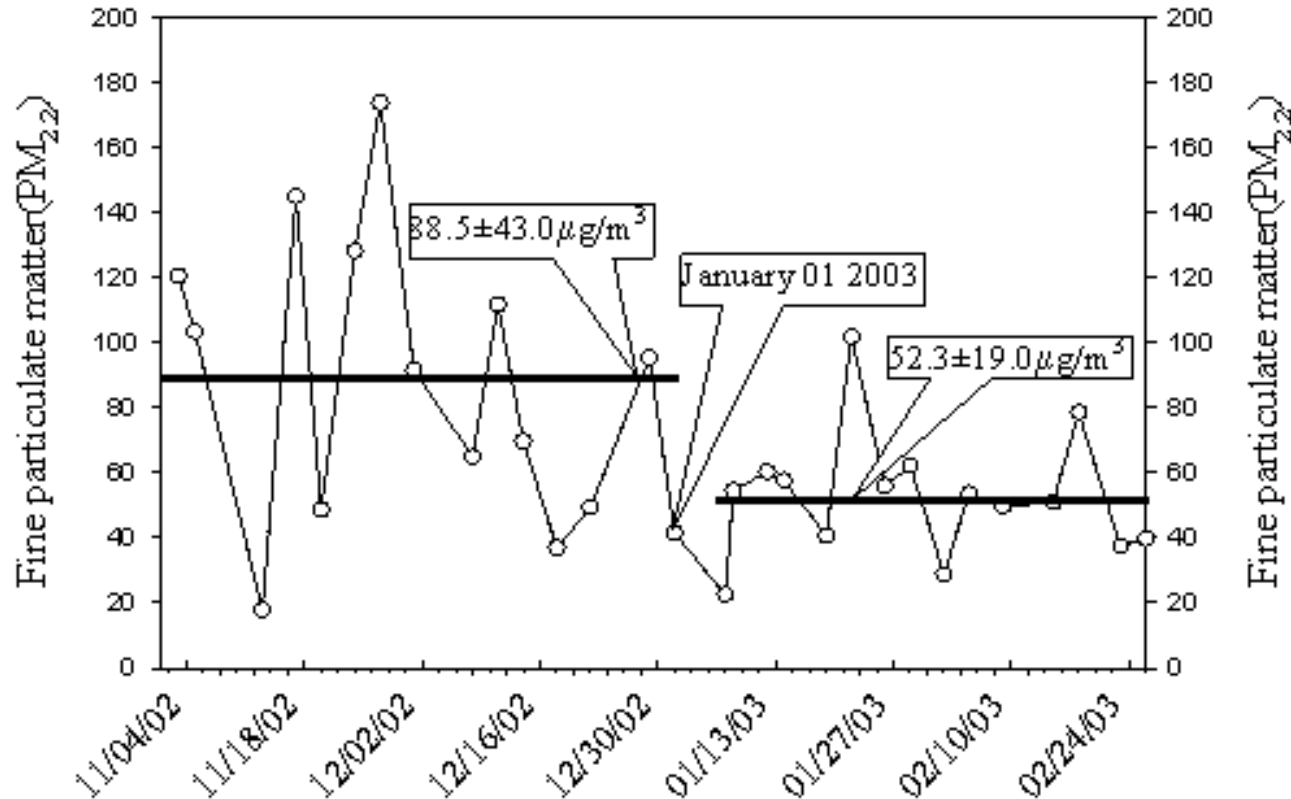


Concentration ($\mu\text{g}/\text{m}^3$) of Pb (Fine PM) in ambient air

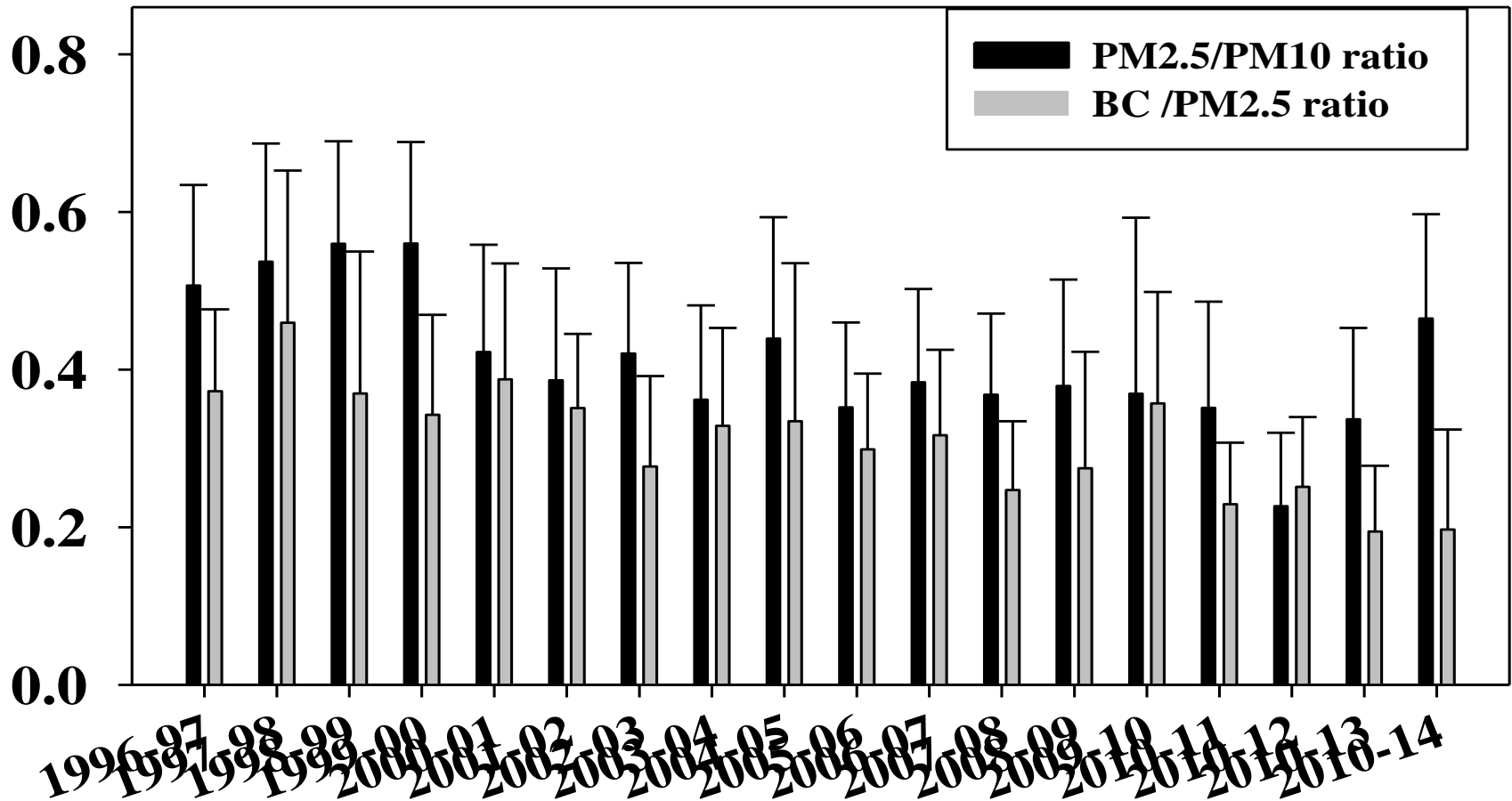




Fine PM concentrations as a function of time showing the likely effect of banning two-stroke engine on air quality in Dhaka



PM_{2.2}/PM₁₀ and BC/PM_{2.2} ratios in different years SR sites



Hence, control of emission from the combustion sources is good achievement of policies adaptation

Average source contributions derived from the PMF modeling



Source	Fine PM samples ($\mu\text{g}/\text{m}^3$)					
	2001-2002		2005-2006		2007-2009	
	Mass	BC	Mass	BC	Mass	BC
Motor vehicle	<i>7.16</i>	<i>2.50</i>	<i>5.62</i>	<i>0.38</i>	<i>12.1</i>	<i>0.02</i>
Brick kiln	<i>2.23</i>	<i>1.37</i>	<i>11.1</i>	<i>4.14</i>	<i>7.59</i>	<i>7.41</i>
Metal smelter	<i>1.87</i>	<i>0.00</i>	<i>1.94</i>	<i>0.53</i>	-	-
Sea salt	<i>0.19</i>	<i>0.00</i>	<i>0.60</i>	<i>0.00</i>	<i>2.12</i>	<i>0.00</i>
Two Stroke/Zn	<i>1.75</i>	<i>1.11</i>	<i>1.94</i>	<i>1.07</i>	<i>1.49</i>	<i>0.62</i>
Soil dust	<i>1.92</i>	<i>0.0</i>	<i>2.74</i>	<i>0.18</i>	<i>3.21</i>	<i>0.02</i>
Road dust	<i>3.63</i>	<i>1.63</i>	<i>5.14</i>	<i>1.09</i>	<i>4.97</i>	<i>0.57</i>
Fugitive Pb			-	-	<i>2.22</i>	<i>0.01</i>
<i>RM</i>	<i>18.7</i>	<i>6.61</i>	<i>29.1</i>	<i>7.38</i>	<i>33.7</i>	<i>8.12</i>
<i>MM</i>	<i>22.1</i>	<i>7.90</i>	<i>30.5</i>	<i>9.23</i>	<i>37.3</i>	<i>8.21</i>



The question is whether we are responsible for all pollutants or it has other sources

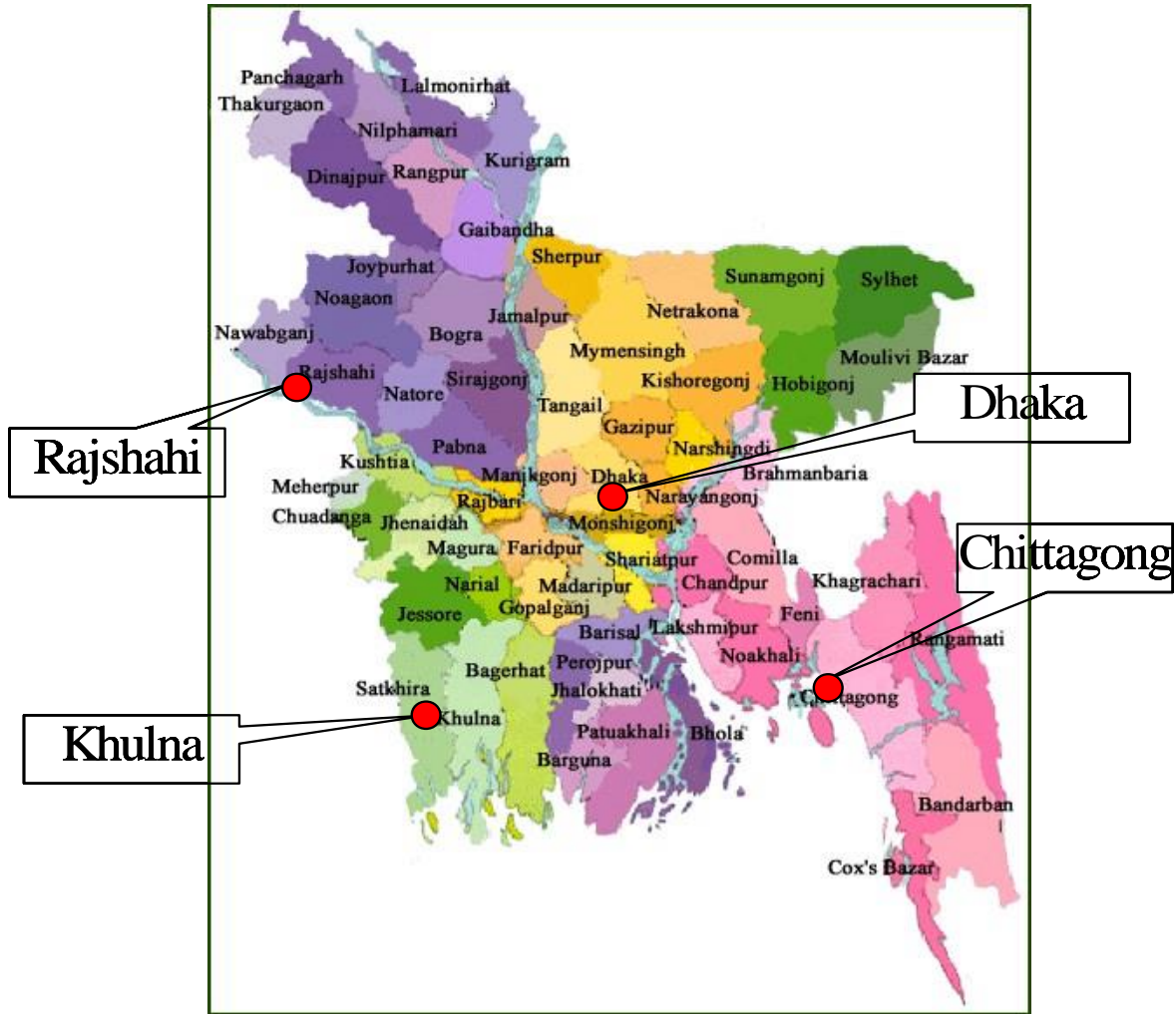


Long Range Transport

30 May 2016



Map of sampling locations in Bangladesh



Sample collection (*DoE*)



Location of sampling site at Dhaka

City	Location	Lat/Lon	Monitoring capacity
Dhaka	Farm Gate (CAMS-2)	23.76°N, 90.39°E	PM _{2.5-10} , PM _{2.5} , CO, SO ₂ , NO _x , O ₃ , and HC with meteorological parameters.
Chittagong	TV station, Khulshi (CAMS-3)	22.36°N, 91.80°E	PM _{2.5-10} , PM _{2.5} , CO, SO ₂ , NO _x , O ₃ , and HC with meteorological parameters.
Rajshahi	Sapura, Rajshahi Cantonment area (CAMS-4)	24.38°N, 88.61°E	PM _{2.5-10} , PM _{2.5} , CO, SO ₂ , NO _x , O ₃ , and HC with meteorological parameters.
Khulna	Baira (CAMS-5)	24.38°N, 88.61°E	PM _{2.5-10} , PM _{2.5} , CO, SO ₂ , NO _x , O ₃ , and HC with meteorological parameters

The summary of PM and BC concentration ($\mu\text{g}/\text{m}^3$) during the sampling periods



Parameter	Rajshahi			Dhaka			Khulna			Chittagong		
	PM10	PM2.5	BC	PM10	PM2.5	BC	PM10	PM2.5	BC	PM10	PM2.5	BC
Min	24.3	14.9	3.07	21.1	14.3	1.05	10.3	6.20	1.44	13.2	9.34	0.84
Max	1526	842	46.1	419	212	17.2	579	371	23.0	345	211	11.4
Mean	244	155	131	130	65.1	7.20	112	64.7	5.84	117	73.3	4.32
STD	172	112	7.05	74.2	41.2	3.31	88.4	56.8	3.58	78.5	50.7	2.67
Median	204	121	10.8	119	56.0	7.40	95.6	52.0	5.2	111	74.2	3.32
Sample Size	211			185			145			114		
Sampling Period	01/09/10 to 31/07/12			23/08/10 to 01/07/12			16/09/10 to 23/02/12			03/12/10 to 29/02/12		

Seasonal variation of PM_{2.5} ($\mu\text{g}/\text{m}^3$) in four stations



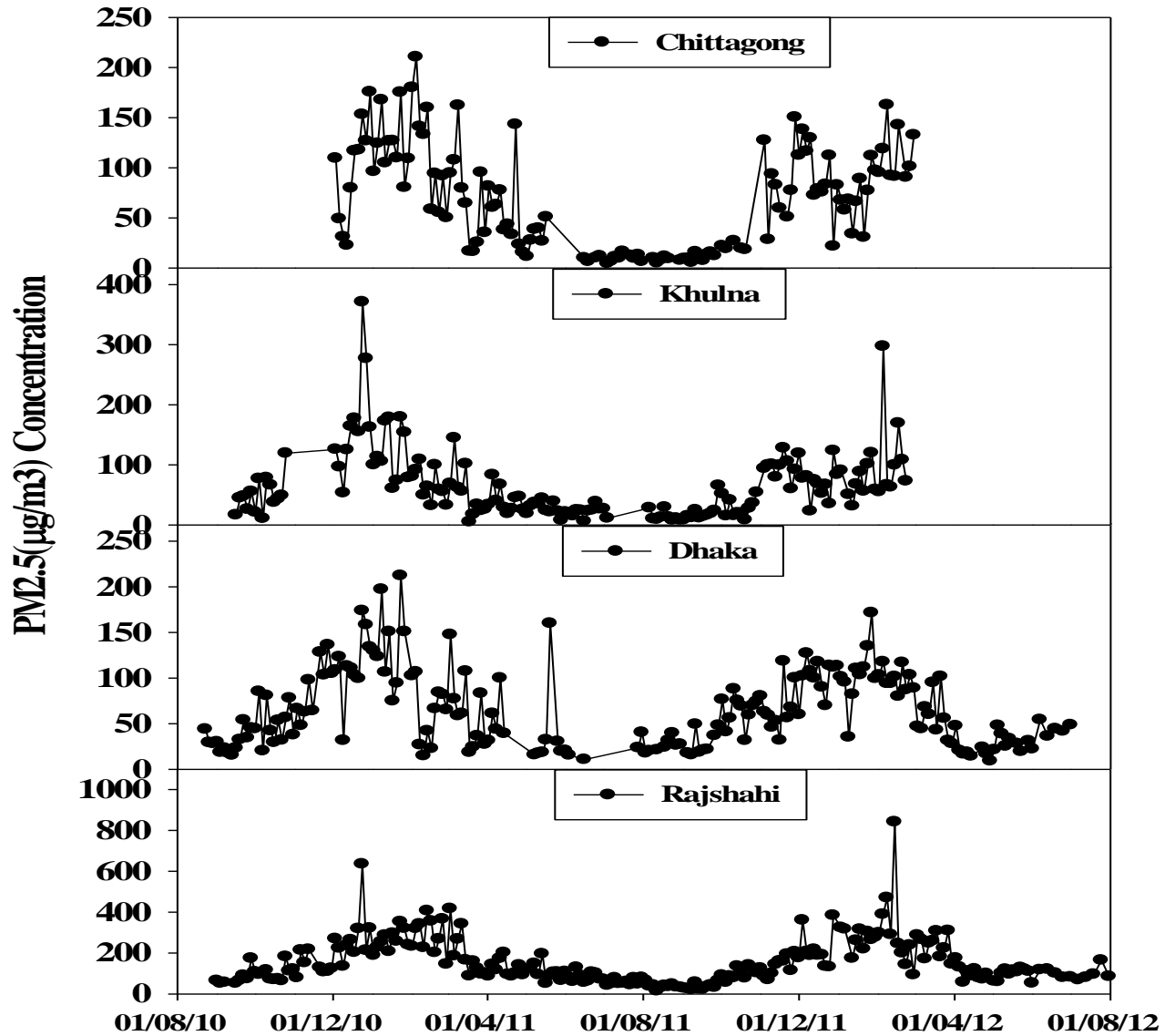
Year	Season	Rajshahi	Dhaka	Khulna	Chittagong
		Mean \pm STD	Mean \pm STD	Mean \pm STD	Mean \pm STD
2010-11	Monsoon	-	30.3 \pm 11.6	-	-
	Post-monsoon	127 \pm 66.4	68.6 \pm 32.7	51.3 \pm 29.3	-
	Winter	277 \pm 94.0	104 \pm 49.8	120 \pm 72.9	113 \pm 47.4
2011-12	Pre-monsoon	143 \pm 79.6	50.0 \pm 35.5	42.5 \pm 28.9	56.6 \pm 39.4
	Monsoon	55.4 \pm 26.5	26.8 \pm 10.5	19.6 \pm 11.8	11.7 \pm 2.32
	Post-monsoon	109 \pm 31.8	65.8 \pm 21.4	63.1 \pm 37.8	60.5 \pm 45.9
	Winter	271 \pm 140	101 \pm 23.6	84.6 \pm 52.6	33.7 \pm 0.71
2012	Pre-monsoon	151 \pm 77.5	39.1 \pm 23.1	-	-
	Monsoon	100 \pm 28.2	41.3 \pm 11.1	-	-

The mean, standard deviation and threshold value of fine PM and BC concentrations ($\mu\text{g}/\text{m}^3$) during sampling period



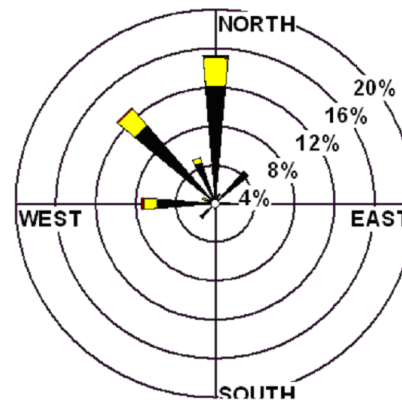
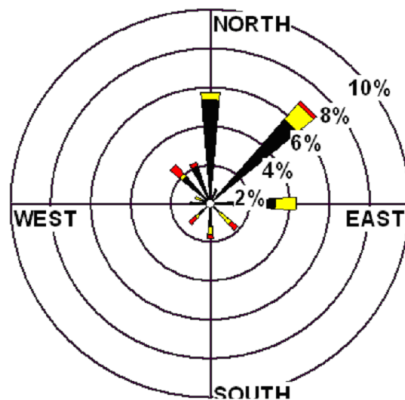
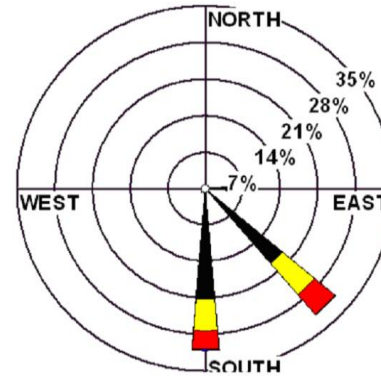
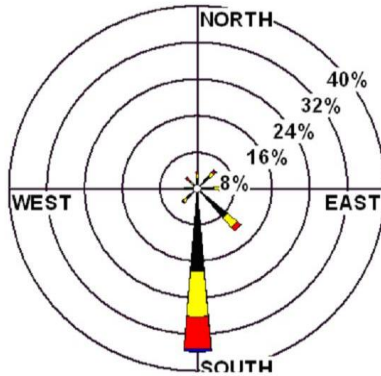
Parameter	Statistics	Rajshahi	Dhaka	Khulna	Chittagong
Fine PM	Mean	155	65.1	64.7	73.3
	Median	121	56.0	52.0	74.2
	STD	112	41.2	56.8	50.7
	Threshold Value	379	147	178	175
BC	Mean	13.1	7.20	5.84	4.32
	Median	10.8	7.40	5.20	3.32
	STD	7.05	3.31	3.58	2.67
	Threshold Value	27.2	13.8	13.0	9.66

Variation of PM_{2.5} concentrations with time in four cities





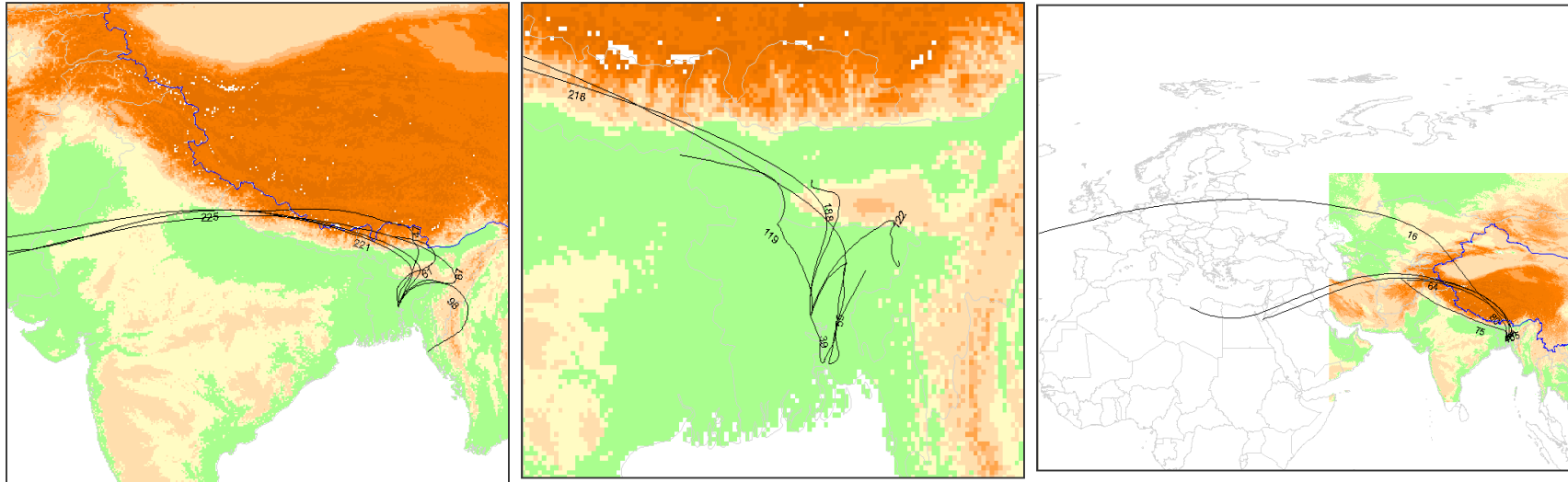
Wind directional pattern



Four season: Pre-monsoon, Monsoon, Post-monsoon, Winter



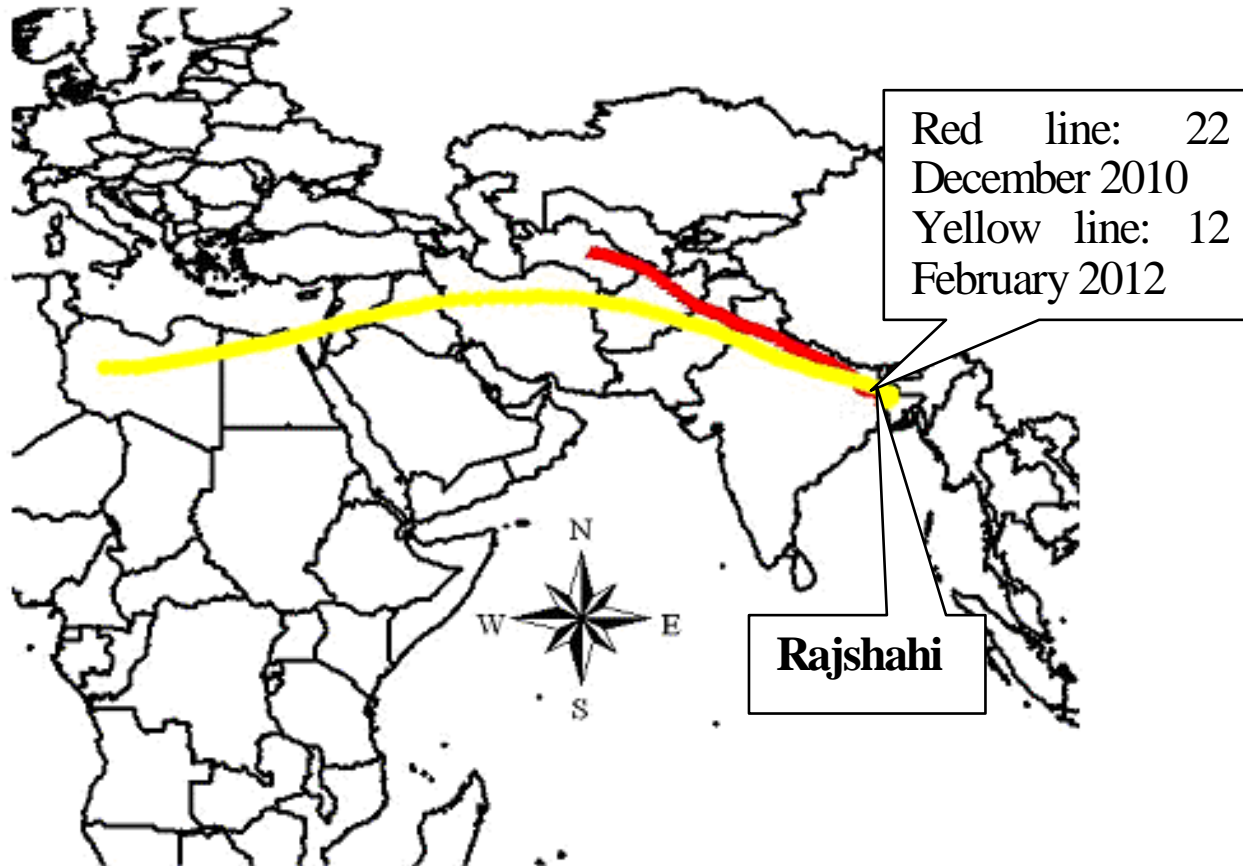
Air parcel movement (Backward trajectory)



Typical wind directional pattern during December, January and February respectively (During the winter time wind mainly comes from northwest direction, e.g. Dhaka)



Air parcel backward trajectories showing the long range transport of fine PM





Pollution and fog mixed at the base of the Himalayas in India in early December 2010

<http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=47742>

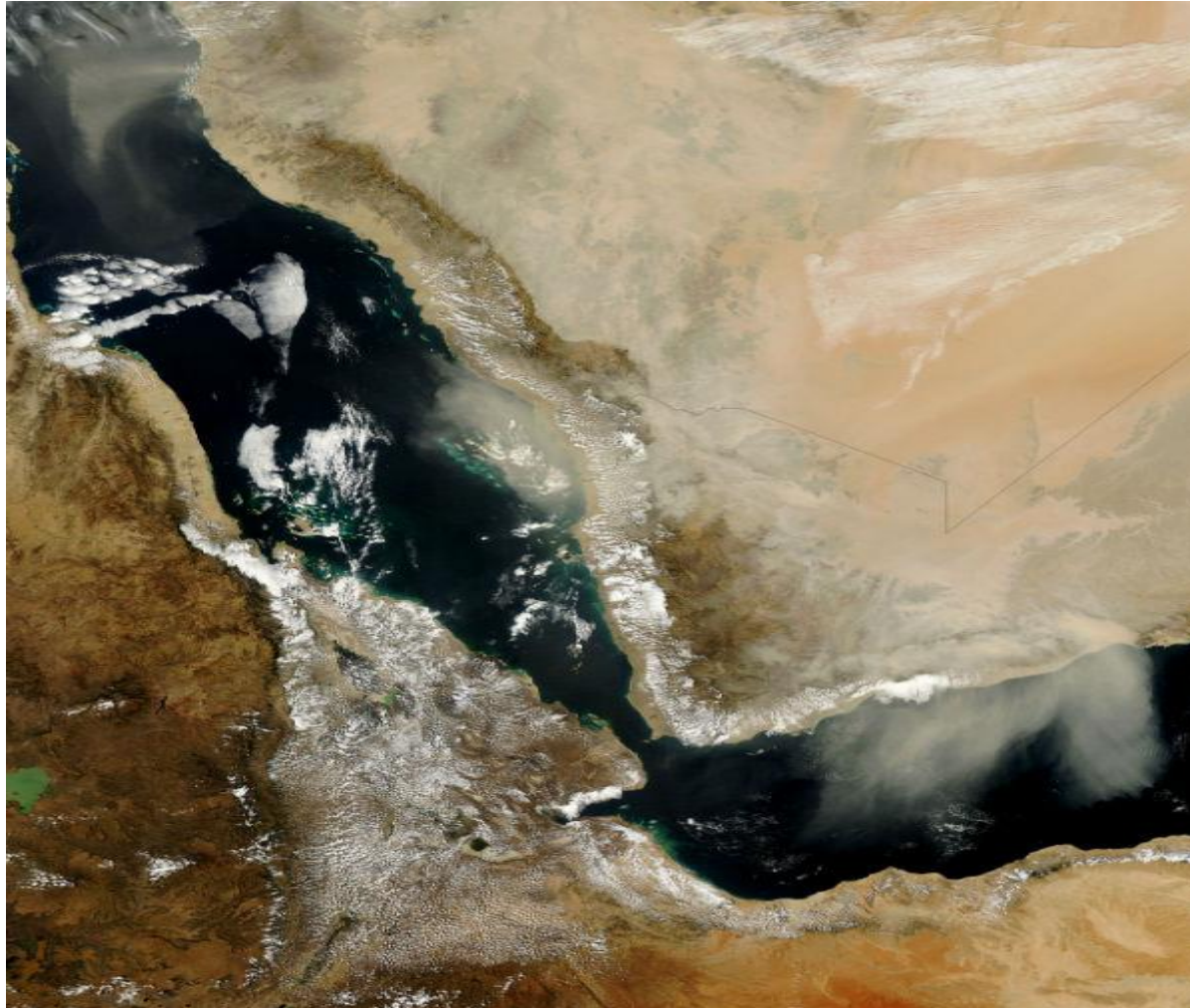


Dull gray haze hovers over northern India and Pakistan, and parts of Bangladesh which results from a combination of agricultural fires, urban and industrial pollution, and a regional temperature inversion.

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Dust storm over the Arabian Peninsula

<http://thewatchers.adorraeli.com/2012/02/06/dust-storm-in-saudi-arabia/>



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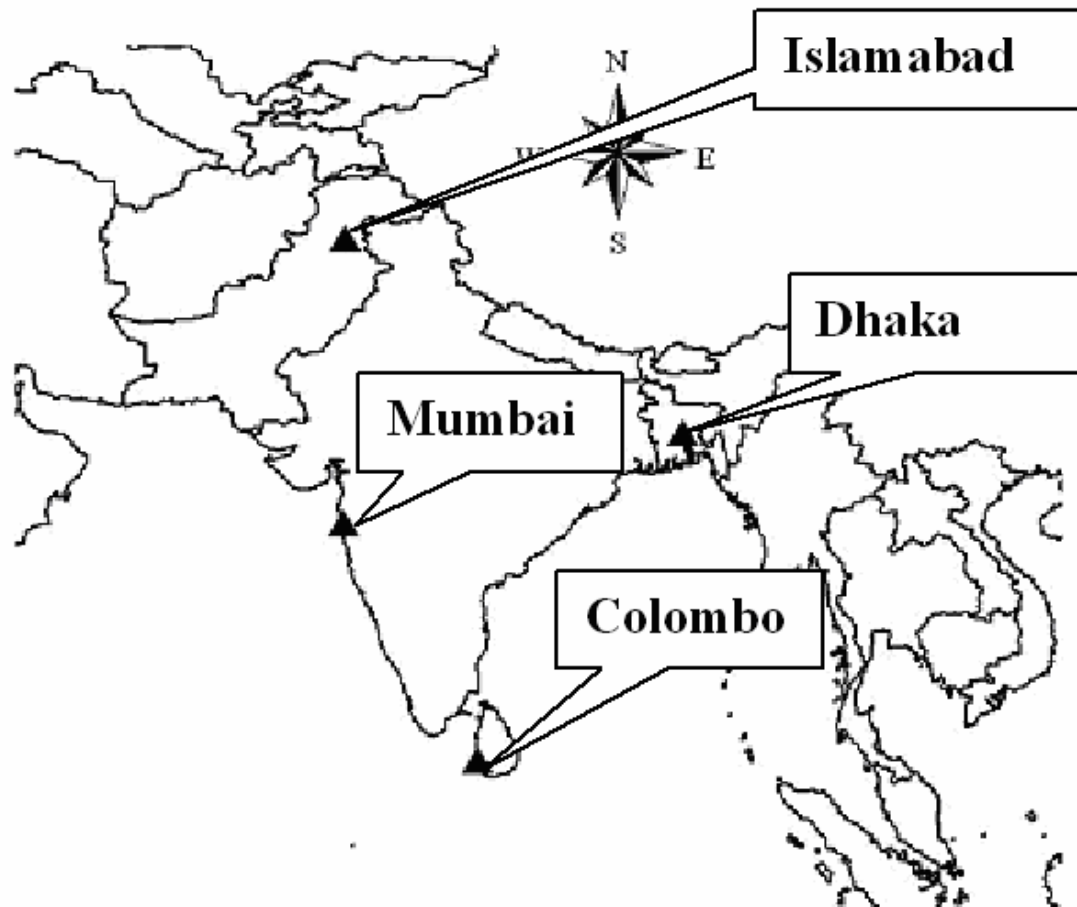


Transboundary Evidence

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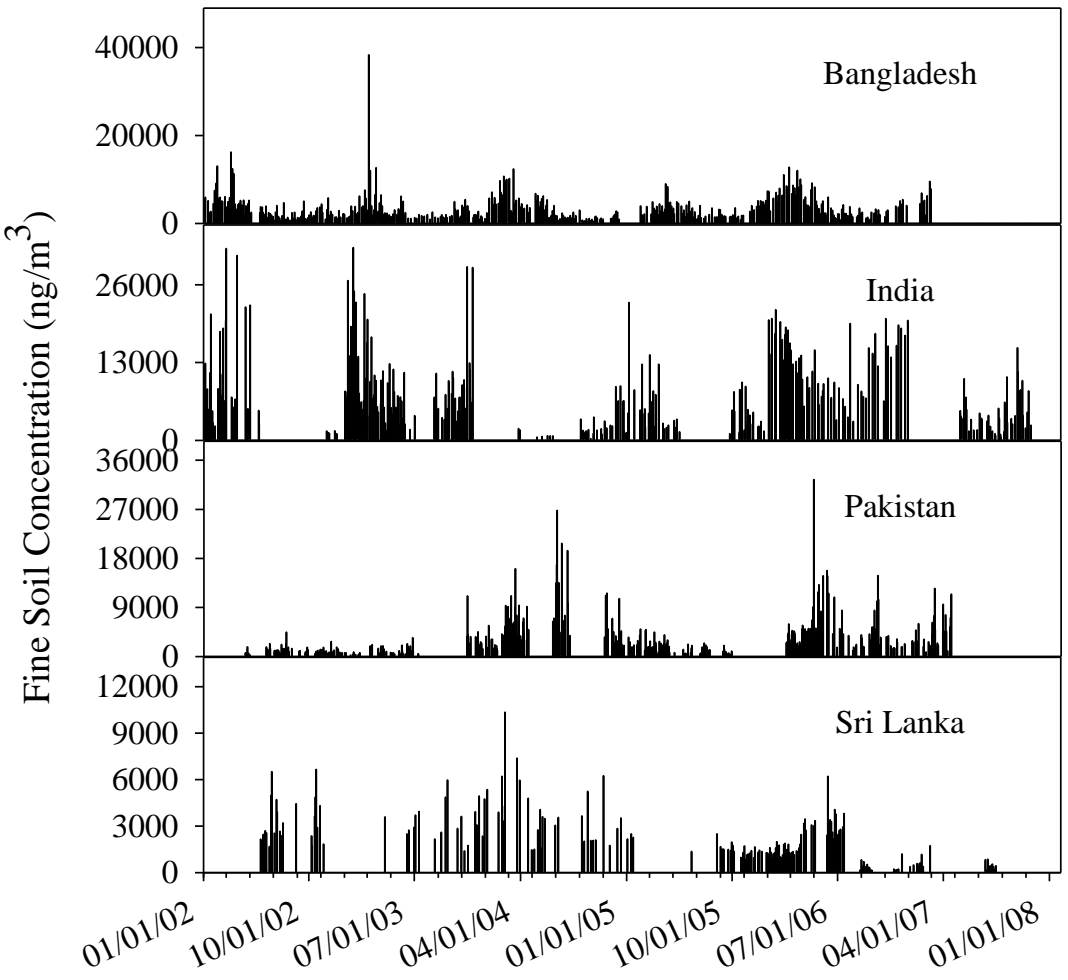


Sampling sites of Neighboring Countries



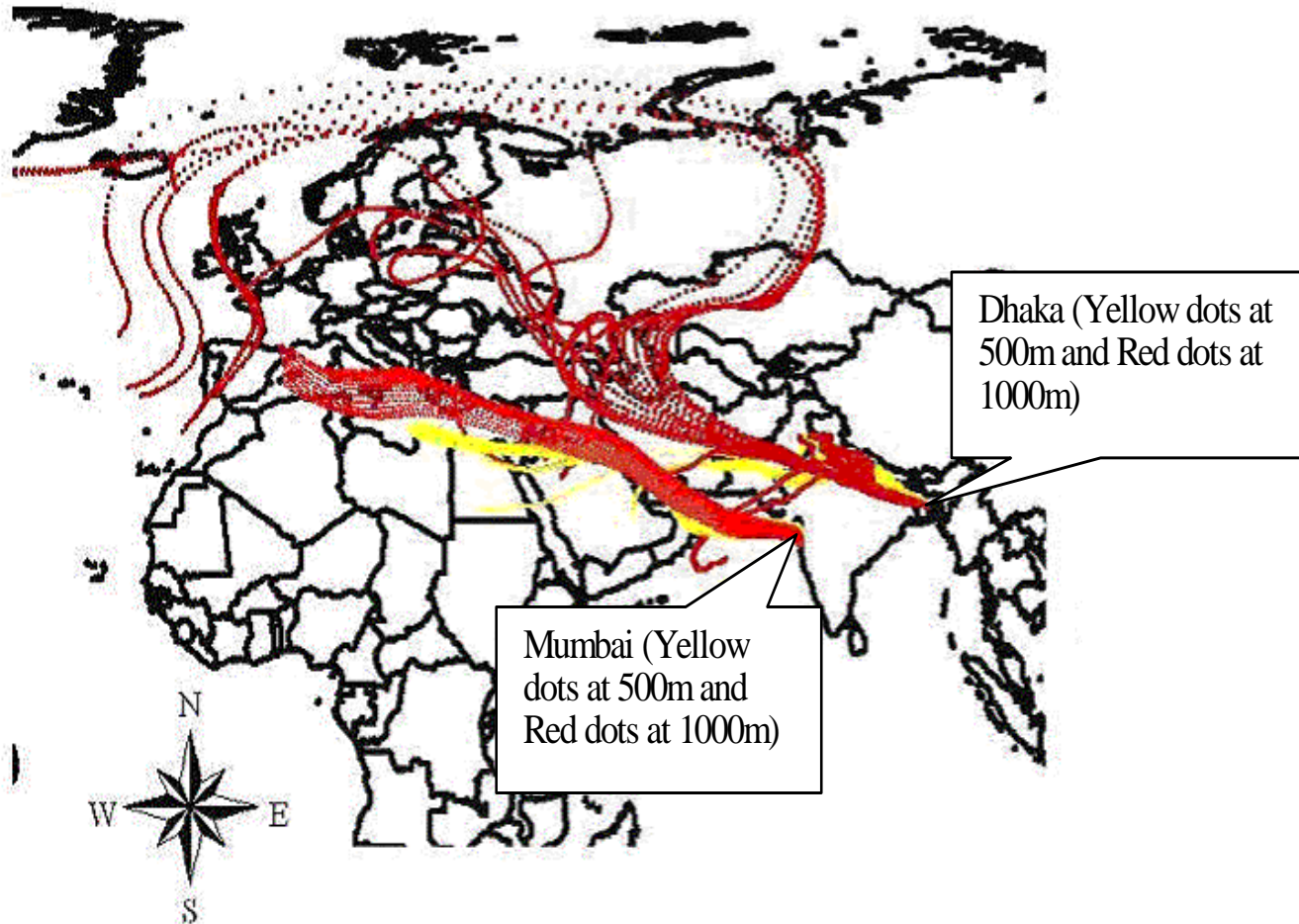


Time series plots of fine soil concentrations in Bangladesh, India, Pakistan and Sri Lanka

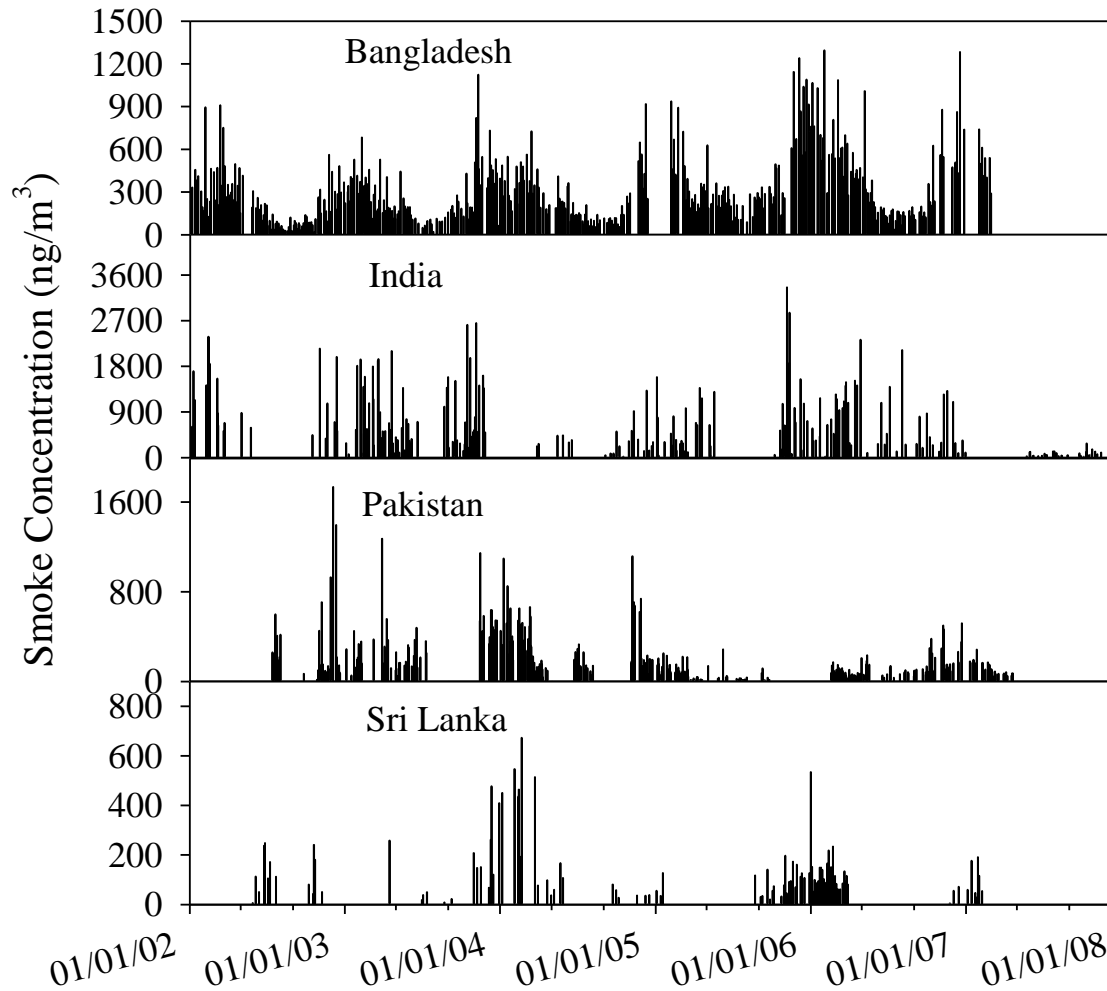




Air parcel back trajectories showing long range transport of soil dust in Bangladesh and India in February 203



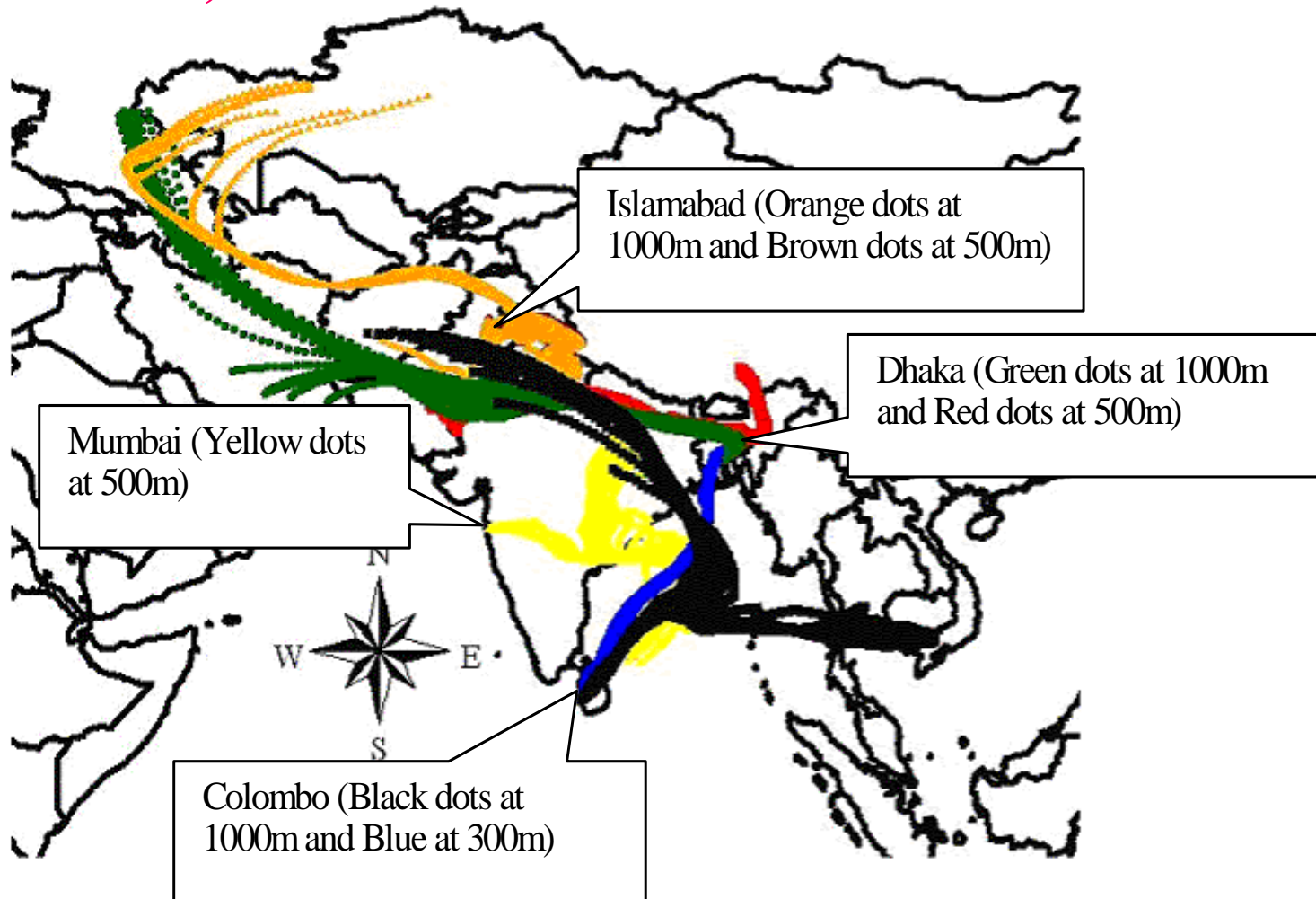
Time series plots of fine Smoke contribution



Air parcel back trajectories showing the likely sources areas for smoke



3 to 15 November, 2003



Crop Residue Burning: A Threat to South Asian Air Quality, *Eos*, Vol. 95, No. 37, 16 September 2014

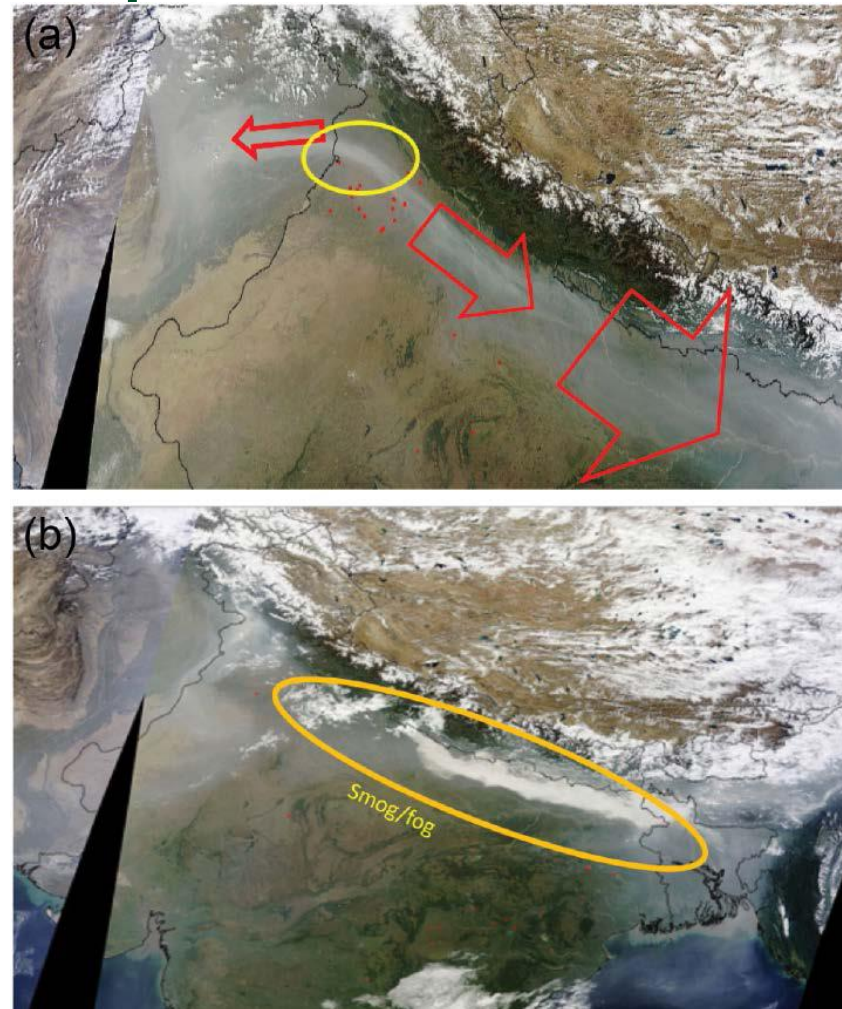


Fig. 1. (a) The Terra satellite's Moderate Resolution Imaging Spectroradiometer (MODIS) image from 30 October 2013, showing transport of plumes from crop residue burning in Punjab (yellow circle shows crop residue burning areas) toward the east of the Indo-Gangetic plain (IGP) and also toward border areas of Pakistan. (b) MODIS image from 1 November 2013, showing the same plume form intense smog and fog over the IGP

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HAZE OCCURRED IN SINGAPORE IN OCTOBER 2006, AND WAS CAUSED BY SMOKE FROM FIRES IN INDONESIA BEING BLOWN BY SOUTH-WESTERLY WINDS.



Conclusions

To address the air pollution issues locally

- a) Emission from Motor vehicles
- b) Reduction of soil dust including road dust and
- c) Replacement of existing brick kiln with energy efficient and environment friendly brick production technology, cook stove and rice parboiling system.

It is also necessary to address the air pollution issues regionally due to Transboundary Effect which increase local air pollution

- a) Coal-fired power plants in India using high S coal in India
- b) Similar problem with BC, biomass/agricultural waste



Thank You

END