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PM over summertime India: Sources and trends investigated using long term measurements and multi-receptor site back trajectory analysis

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We apply multi-receptor site residence-time weighted concentration back trajectory analysis to a ten year data set (1991-2003) of PM10 and TSP measurement data from four Indian megacities Delhi, Mumbai, Kolkata and Chennai. The dataset was sourced from the published and peer reviewed work of Gupta and Kumar (2006). Sources and trends of PM10 and TSP during the pre-monsoon season (March-June) were investigated. Residence-time weighted concentration maps were derived using 72 hour HYSPLIT back trajectory ensemble calculations. Trajectory runs were started 100 m AGL and the observed PM monthly averages were attributed to all trajectory runs in a month and each trajectory of the ensemble runs with equal probability. For investigating trends the dataset was further subdivided into two groups of four year durations each (1992-1995 and 2000-2003).

We found a linear correlation with a slope of 1.0 (R^2=0.9) between estimated seasonal average TSP (2000-2003) using our approach and the measured seasonal averages (2006-2007) for Kanpur, Ahmedabad, Pune and Bangalore. A linear fit between predicted and measured PM10 concentration for 19 sites with PM10 observations of at least one seasonal average between 1999-2009 shows a slope of 1.4 (R^2=0.4). For the observation period 2000-2003, the Thar Desert and Taklimakan Desert emerged as largest sources for both PM10 ($>$180 μg/m^3 and $>$200 μg/m^3 respectively) and TSP ($>$650 μg/m^3 and $>$725 μg/m^3 respectively). In-situ observation at Bikaner (central Thar Desert) and in Jhunjhunu (semi-arid site at the border of the Thar Desert) indicate that both TSP and PM10 inside the desert source region are underpredicted by a factor of 10 compared to in-situ observations while for the semi arid area bordering the desert PM10 and TSP are underpredicted by a factor of 5 and 3 respectively. This indicates that strong sources are underpredicted by a receptor site centred approach.

The entire North-Western Indo-Gangetic Basin (NW-IGB), where crop residue burning is practiced during harvesting months (April-May) displays enhanced seasonal average PM10 loadings. Average PM10 loadings are approximately 40 μg/m^3 higher compared to average PM10 loadings in the Eastern IGP, where crop residue burning is not practiced. PM10 loading in Patiala (Central Punjab) are underpredicted by a factor of 1.8 with respect to the seasonal average and a factor of 2.5 for the harvesting season only.

A comparison between 1992-1995 and 2000-2003 shows that PM10 loadings over entire India decreased with the strongest decrease (-150 μg/m^3) over the mining areas in Madhya Pradesh and in Chhattisgarh, providing confidence in environmental protection norms put in place by government regulatory authorities. TSP mass loadings decreased over Central India, the Eastern IGB and the Bay of Bengal (-300 μg/m^3) but increased over the Southern Indus plains (+ 200 μg/m^3) and the Thar Desert. In general there is an increase of TSP from windblown desert dust which is most apparent over the dust source regions but also impacts TSP loadings over the NW-IGB.

References: Gupta and Kumar: Trends of particulate matter in four cities in India. Atmospheric Environment 40 (2006) 2552–2566.

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