

Role of Biogenic Hydrocarbon on the Variability of Total Rainfall Amount over Sundarban, Kaziranga and Gir Forests

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ABSTRACT

TA critical analysis of the yearly variation of rainfall with tropospheric ozone for three Indian forest zones, namely, Sundarban in West Bengal, Gir in Gujarat and Kaziranga in Assam has been carried out from 1979 to 2009. The Analysis shows that low temperature of troposphere, presence of sufficient water vapor, and CCN (Cloud Condensation Nuclei) are not sufficient for generating rainfall. From the study the following important results are obtained:

i) The amount of rainfall showed an overall increasing trend with increasing tropospheric ozone concentration for three forest zones of India, over 30 year period.

ii) A few anomalous results are obtained over Gir and Sundarban forest zones, for the years 1982, 1983, 2001, while no such opposite trend has been observed for Kaziranga.

Possible explanation of such varied trend in rainfall amount with tropospheric ozone concentration is presented.

INTRODUCTION

Tropospheric ozone concentration is influenced by the biogenic hydrocarbons (biogenic organic compounds, BVOC) emitted by the trees. Emission of hydrocarbons by the trees has become a topic of concern recently, especially if the trees are located closer to an urban zone and are potent for high rate of BVOC emission. It is a well established fact that hydrocarbon flux emitted by biogenic sources is greater than that emitted by anthropogenic sources. Singh et al. (1992) showed that global estimate of hydrocarbon flux emitted by anthropogenic sources is about 1×10^{14} gC per year and Guenther et al. (1995) showed that global estimate of hydrocarbon flux emitted by biogenic sources is about 1.2×10^{15} gC per year. The only forms of BVOCs emitted by trees are the isoprene and monoterpene. Out of these two hydrocarbons, isoprene dominates the biosphere-atmosphere carbon exchange process as shown by Sharkey et al. (2008). It is experimentally proved that emission of these two hydrocarbons by plants is to fulfill their biological purposes, which include protection of leaves from damage due to extreme heat shock and oxidative stresses (Fares et al. 2007 and Francesco et al. 2001). This emission helps plant to maintain its photosynthesis rate to the required biological level.

These hydrocarbons react with the anthropogenic volatile organic compounds to produce ozone, a green house pollutant. It is already a reported fact by Wiedinmyer (2006) that tropospheric ozone affects human health as well as agricultural productivity. Production of ozone is enhanced in presence of nitrogenous oxide of the form NO_x (NO + NO₂) which takes part in the chemistry of ozone production.

Nitrogen dioxide itself produces ozone by reacting with the atmospheric oxygen $\{2\text{NO}_2 + 2\text{O}_2 = 2\text{NO} + 2\text{O}_3\}$. But it does not decide the total available ozone in the atmosphere. In the absence of isoprene, only the reaction given above could have dominated and estimation of ozone due to the presence of these oxides in the atmosphere would have been an easy task. But the presence of the isoprene makes the tropospheric ozone chemistry much complicated. Ganguly (2006) reported that the increase in ozone is being enhanced by the increase in the NO_x concentration in the nearby cities, suggesting a faster transportation of the NO_x to the surroundings from its sources. In another communication, she also mentioned that the ozone concentration on the Indian forests is increasing year by year (Ganguly, 2007). However, exact estimation of ozone arising out of known concentration of NO_x is almost not possible. One of the many factors responsible for such an uncertainty, as reported by Fiore et al. (2005), may be due to the extremely complex and multidimensional tropospheric chemistry and decadal change in the meteorology. In this context, it is high time to investigate the trends of major meteorological parameters over the decades in the background of tropospheric ozone. Many studies have been carried out on the radiative forcing effect of the green house gases, as a whole, along with tropospheric ozone and their indirect effect on the meteorology. In an earlier communication Midya et al. (2012) have shown that anthropogenic volatile organic compounds are causing an increase in rainfall over urban areas, with respect to the corresponding non urban areas. The purpose of the present paper is to verify the direct relationship between the tropospheric ozone and the rainfall over three forest zones. We opine that this

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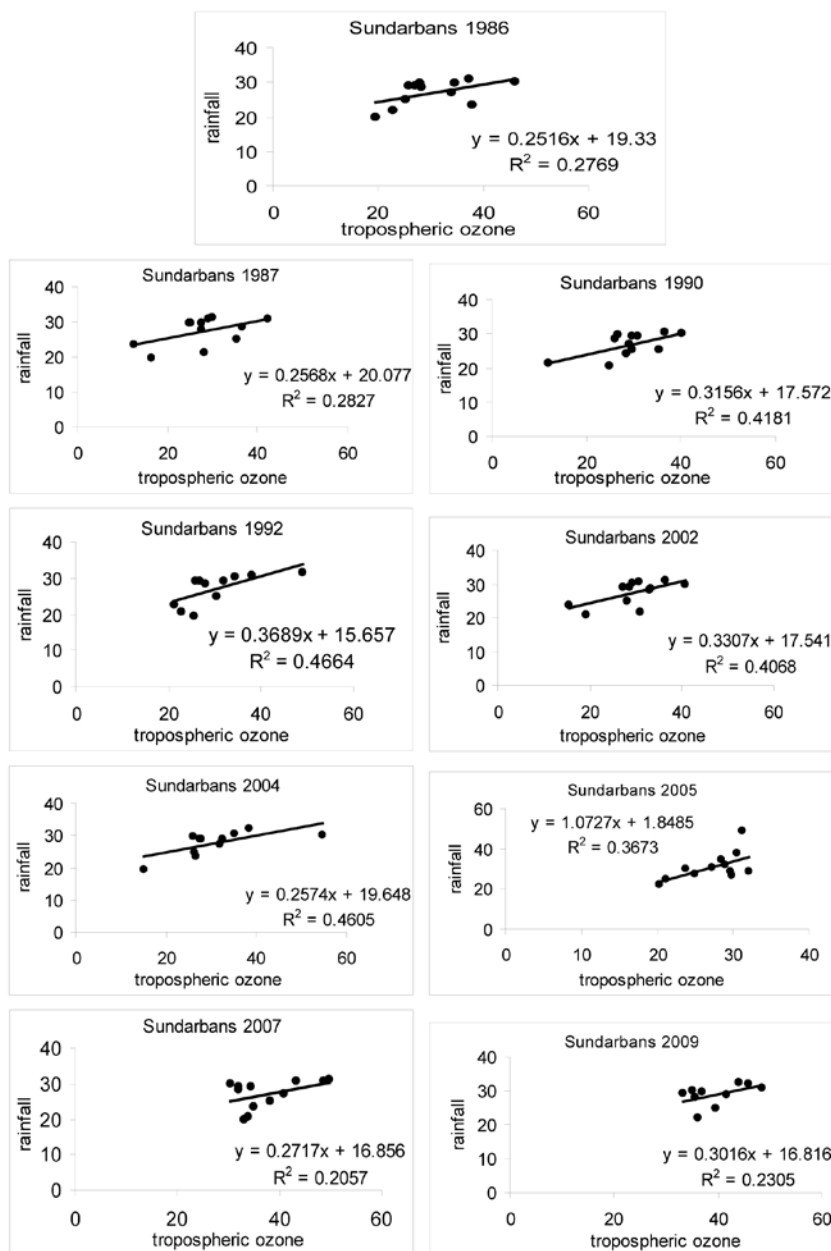


Figure 1. Variation of rainfall pattern with tropospheric ozone over Sundarbans.

will automatically indicate the relationship between rain and biogenic hydrocarbon.

DATA AND METHODOLOGY

The data used in the complete study for the analysis of the role of biogenic hydrocarbon on the variability of rainfall amount over Sundarban, Kaziranga and Gir is listed below:

[a] Monthly mean rainfall over Alipore - Sundarban, Gauhati – Kaziranga, Veraval-Gir has been downloaded from the link <http://www.cru.uea.ac.uk/cru/data/temperature/>

station-data/

[b] Tropospheric ozone data has been collected from <http://acd-ext.gsfc.nasa.gov/>

In the absence of stations over exact forest zones, data of the nearby IMD stations are used in our analysis. Graphs showing tropospheric ozone versus total rainfall have been plotted for each year over each of the forests. The tropospheric ozone has been plotted along x-axis and the monthly rainfall of year along the y-axis. From the trend analysis, conclusions are drawn with the help of the graphical method.

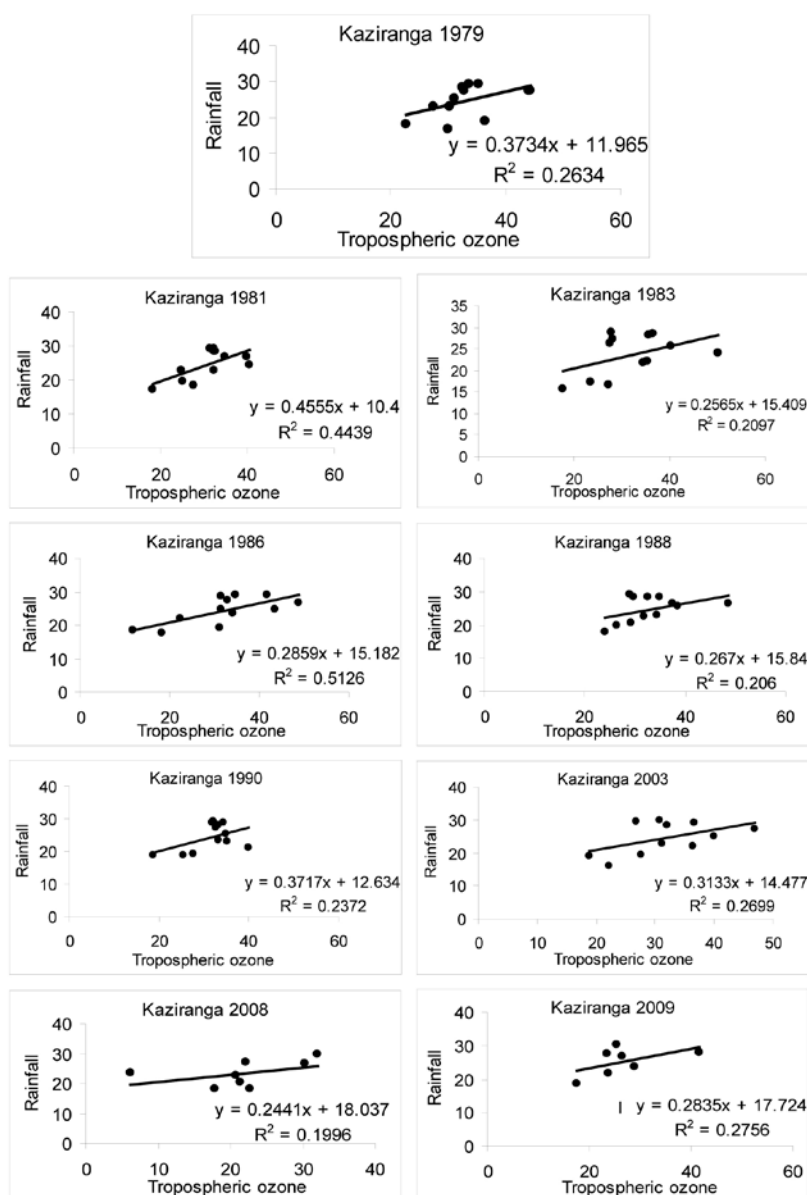


Figure 2. Variation of rainfall pattern with tropospheric ozone over Kaziranga

RESULTS AND DISCUSSIONS

The trend analysis of the graphs (Fig.1-Fig.3) for all of the three forests shows an increasing trend of total rainfall with increasing tropospheric ozone concentration, over a period of 30 years from 1979 to 2009. However, there are a few years of exception (1982, 1983, 2001) to the general increasing trend. During these years decreasing trend has been noticed for Sundarban and Gir forests (Fig.4). However, no such opposite trend is seen for Kaziranga. The results are shown in Table 1. It is clear from the Table 1 that almost all the curves show positive trends, which imply that rainfall increases with the increase of tropospheric ozone. Increase of tropospheric ozone is due

to the increase of biogenic hydrocarbon from forest zones. It agrees fairly well with our previous communication (Midya et al.2012), which shows that rainfall pattern over urban belts is gradually increasing with respect to non-urban belt due to the increase of anthropogenic volatile organic compounds emitted from automobile fuels and industry.

CHEMICAL REACTIONS & CONCLUSIONS

Tropospheric ozone is created from complex chain reactions of biogenic hydrocarbon in the forest zones. The chemistry involving biogenic organic compounds with the NO_x {equations (1) to (6)} enhancing the ozone level has been reported by Sharkey et al. (2008)

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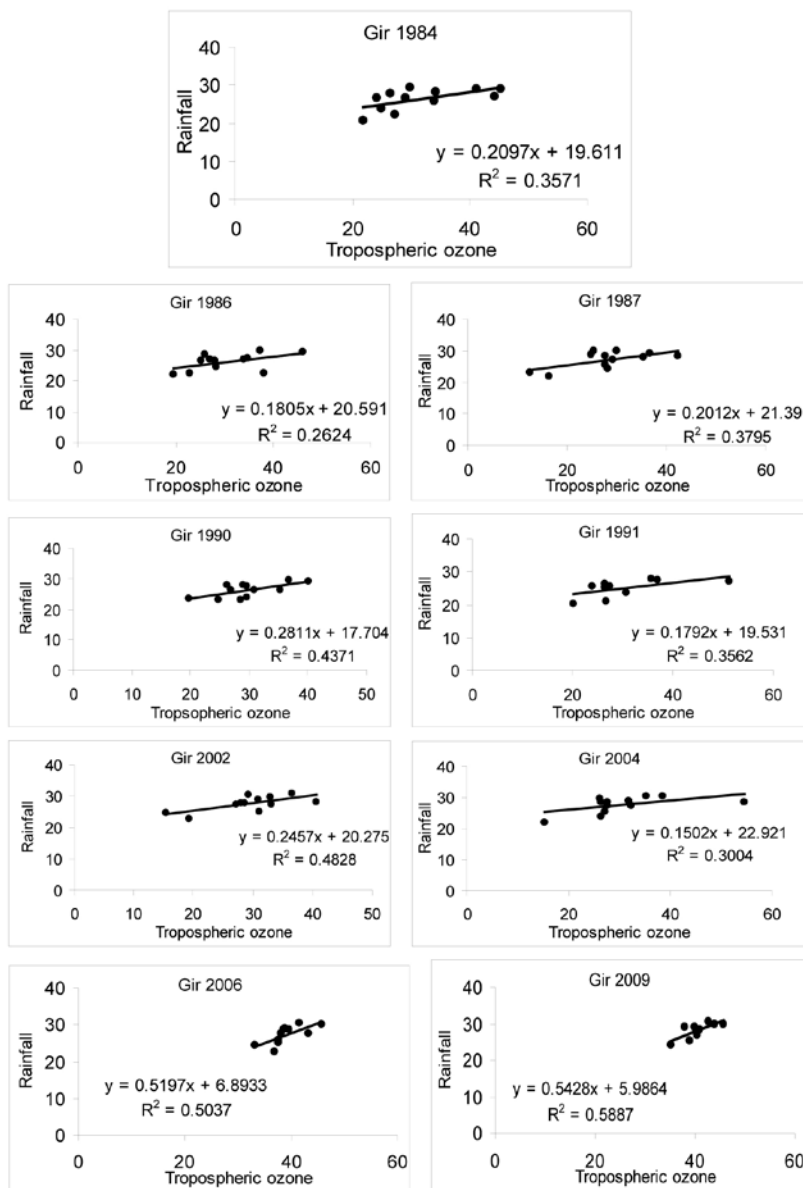
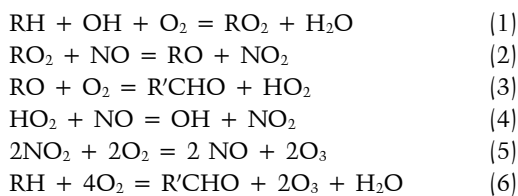


Figure 3. Variation of rainfall pattern with tropospheric ozone over Gir.



where, RH stands for isoprene.

Again tropospheric ozone is one of the important green house gases that act as a heating source of forest zone. As tropospheric ozone data of different forest zones are available, we can assume that tropospheric ozone is the representative of BVOC. Critical analysis shows that rainfall trend of these forest zones is increasing with

tropospheric ozone of that zone as shown in reactions 1-6. So, we can conclude that BVOC plays an important role to control the increasing rainfall pattern of these zones. It is now well established that condensation cannot start without CCN of proper dimension, even though all the favorable conditions for condensation are present. BVOC emitted by the forest zones acts as CCN, which affects the rainfall pattern of forest zones.

A few exceptions of the rainfall pattern in the forest zones are due to special type of meteorological conditions or special type of BVOC emissions of some type of plants that obstruct the rainfall, as revealed by the decreasing trend of rainfall trend for the years 1982, 1983, 2001.

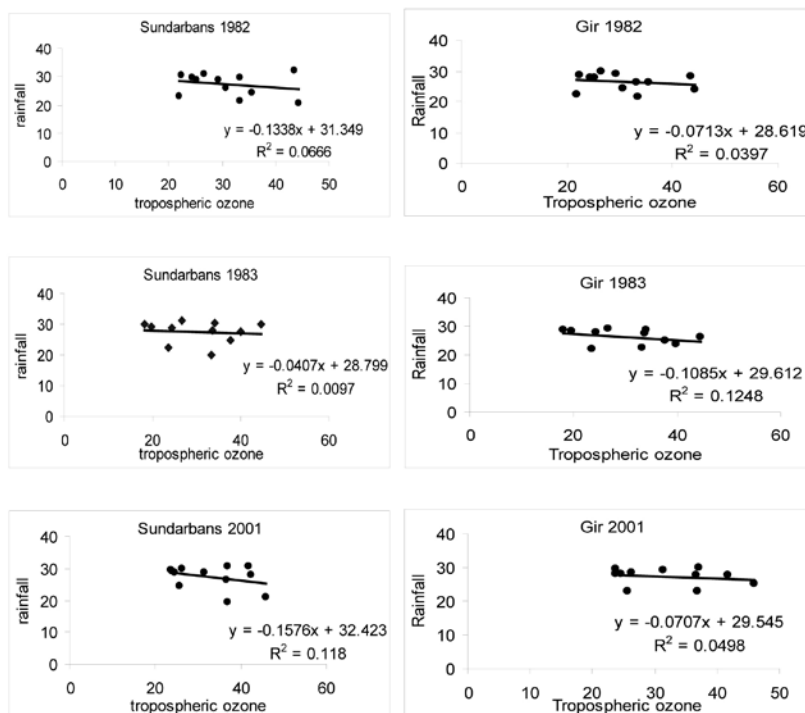


Figure 4. A few abnormal observations over Sundarbans and Gir.

Table 1. The rate of change of rainfall over three forest zones with respect to tropospheric ozone:

Year	Sundarban	Kaziranga	Gir
1979	0.21	0.3734	0.0478
1980	0.06	0.0506	0.0112
1981	0.05	0.4555	0.0726
1982	-0.13	0.3056	-0.713
1983	-0.04	0.2565	-0.1085
1984	0.28	0.1147	0.2097
1985	0.16	0.0488	0.0312
1986	0.25	0.2859	0.1805
1987	0.2568	0.2649	0.2012
1988	0.1083	0.267	0.0495
1989	0.3975	0.2552	0.0748
1990	0.3156	0.3717	0.2811
1991	0.2586	0.1895	0.1792
1992	0.3689	0.2777	
1993	0.0801	0.2669	
1996	0.1072	1.093	0.0441
1997	0.0403	0.1746	0.0283
1998	-0.0366	0.2037	0.01
1999	0.1698	0.1404	0.0109
2000	0.1745	0.1186	0.0185
2001	-0.1576	0.0271	-0.0707
2002	0.3307	0.146	0.2457
2003	0.2243	0.3133	0.1264
2004	0.2574	0.1317	0.1502
2005	1.0727	0.4016	0.2171
2006	0.1785	0.1825	0.5197
2007	0.2717	0.293	0.3265
2008	0.2137	0.2441	0.352
2009	0.3016	0.2835	0.5428

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REFERENCES

- Fares, S., Loreto, F., Kleist, E., and Wildt, J., 2007. Stomatal Uptake and Stomatal Deposition of Ozone in Isoprene and Monoterpene Emitting Plants. *Plant Biology* DOI 10.1055/s-2007-965257, published online ISSN, pp: 1435-8603.
- Fiore, A. M., Horowitz, L. W., Purves, D. W., Levy, II., Hiram, E., Mathew, J., Wang, Y., Li, Q., and Yantosca, R. M., 2005. Evaluating the contribution of changes in isoprene emissions to surface ozone trends over the eastern United States. *Journal of Geophysical Research* 110 [D12303] DOI: 10.1029/2004JD005485.
- Francesco, L., Michela, M., Maris Christophe, M., Pamela, N., Francesco, F., and Stefania, P., 2001. Ozone Quenching Properties of Isoprene and Its Antioxidant Role in Leaves. *Plant Physiology* v.126, pp: 993–1000.
- Ganguly, N. D., 2007. Trend of tropospheric ozone in Indian forests from 1980 to 2000. *Current Science*, v.93, no.12, pp: 1835-1839.
- Ganguly, N. D., and Iyer, K. N., 2006. Effect of forest canopy on the tropospheric ozone concentration of Indian States. *J Ind. Geophys. Union* v.10, no.4, pp: 293-301.
- Guenther, A., Hewitt, C.N., Frickson, D., Fall, R., Geron, C., Graedel, T., Harley, P., and Klinger, L., 1995. A global model of natural volatile organic compound emissions. *J Geophys Res.*, v.100, pp: 8873–8892.
- Midya, S. K., and Ganda, S. C., 2012. Comparison of Long Term Rainfall Trends in Urban and Nonurban Regions of Indian Land Mass and Its Probable Implication. *J Ind Geophys Union*. v.16, no.2, pp: 37-40.
- Sharkey, T. D., Wiberley, A. E., and Donohue, A. R., 2008. Isoprene Emission from Plants :Why and How. *Annals of Botany*, v.101, pp: 5-18.
- Singh, H. B., and Zimmerman, P., 1992. Atmospheric distribution and sources of nonmethane hydrocarbons. *Gaseous Pollutants: Characterization and Cycling*, J. O. Nriagu, Ed., John Wiley and Sons, pp: 235.
- Wiedinmyer, C., Tie, X., Guenther, A., Neilson, R., and Granier, C., 2006. Future Changes in Biogenic Isoprene Emissions: How Might They Affect Regional and Global Atmospheric Chemistry?. *Earth Interactions*, 10,1.



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