Modeling of Chemical Tracer Transport in the Atmospheric Environment and its Impact on the Global Climate

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Continental regions are experiencing rapid environmental changes due to expansion of industrial activities and land uses in different types of agricultural productions, burning of fossil fuels etc., which lead to the emanation of huge amount of smog aerosol particulates and chemicals in the atmosphere. Information about these chemical tracers has been found from Indian Ocean Experiment (INDOEX) as well as through Intergovernmental Panel for Climate Change (IPCC) assessment reports and from some other sources. In this paper, we have used a global atmospheric model in which the optical properties and the concentrations of the chemical tracers and aerosols have been incorporated. The aerosols and chemicals are transported in the atmospheric environment by the model cumulus convection and through the model semi-Lagrangian advection process. Thus, they are globally distributed along with the wind flow. The model has been used in studying the impact of the tropospheric chemical perturbations on the global environment.

The perturbation in atmospheric trace gases (viz. SO_2 , O_3 , CO, CO_2 , H_2O, CH_4 , NO_2 and CFC etc.) is an important factor in climate change. During INDOEX and IPCC, both satellite and ground based campaigns have been carried out to study the role of aerosols (continental and marine) and trace gas species in the radiative forcing of the atmosphere. The presence of greenhouse gases in the atmosphere and their increasing or decreasing concentrations change the equilibrium point and affect our environment. Atmospheric aerosols and gases are either injected directly into the atmosphere or produced by gas to particle conversion. Emissions of anthropogenic aerosols and gases to the troposphere have increased in recent decades, and the consequent increase in their concentrations may effect the global climate. Modeling the aerosol effects include scattering and absorption of incident solar radiation (direct effect) and modifying the microphysical and optical properties of clouds (indirect effect). Changing optical properties, the chemical tracers modify the radiation field in the atmosphere and determine the scattering losses and absorption of radiative energy and consequently influence the climate and the environment. The model used in this work is based on the NMC (USA) model of Kanamitsu (1989) and Begum (2003, 2020). The tracer transport along with the wind flow are explicitly resolved by the model following the semi-Lagrangian advection scheme.

The results are displayed in Fig. 1 in which we have plotted the change of the temperatures derived from the present model for the years 1996 to 1999 and validated the same with those reported by other workers (Houghton et al., 2001 and Hansen et al., 2000, 2001, 2002). It is found that the model derived values, though slightly differ from the observed values, show similar trend for the temperature change, increasing gradually year after year. The observed global warming trend is therefore thought to be caused by a shifting of the equilibrium conditions of the past, as a result of the build-up of certain gases and perturbations in the atmosphere, especially due to the increase of greenhouse gases. This results in the absorption of the IR radiation by the atmosphere, producing a warming influence in the surface air temperature.

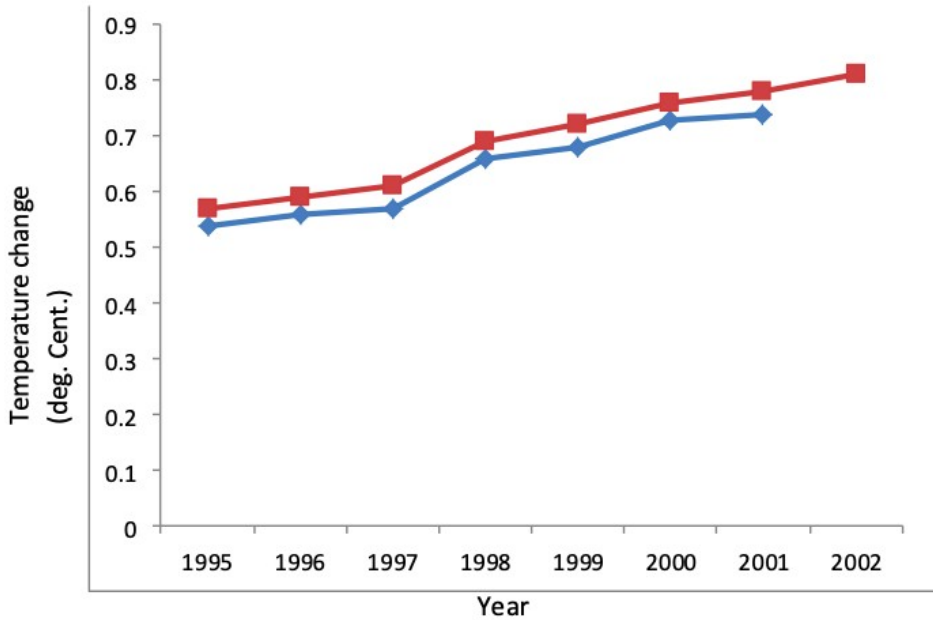

Fig. 1: Plots of Temperature Change versus Year as computed from the Global Circular Model based on: ◆ Kanamitsu. M. (1989) [Original Model]; ■ Begum, Z.N. (2003).

REFERENCES

Begum, Z.N.: 2003, 'A theoretical investigation of the radiative effects and microphysical processes involved in the interaction of aerosol particulates in the atmosphere and validation of the theoretical results with the INDOEX observations', J. Quant. Spect. Rad. Trans. **78**, 99-103.

Begum, Z.N.: (2020), Investigations of the International Experiments, GAME and I-STEP and the Global Atmospheric Model Findings; Res. Activ. Earth System Modell. E.Astakhova (ed.). Rep. No 50. WCRP Rep. No. 6/2020: p. 6-05.

Houghton, J.T, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden and D Xiaosu (eds); Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). New York, Cambridge University Press.

Kanamitsu, M.:1989, 'Description of the NMC global Data Assimilation and Forecast System', Weather and Forecasting, **4** , 335-342.