Examination of aerosol distributions and radiative effects over the Bay of Bengal and the Arabian Sea region during ICARB using satellite data and a general circulation model

R. Cherian1,2, C. Venkataraman1, S. Ramachandran3, J. Quaas2,*, and S. Kedia3

1Department of Chemical Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, 400 076, India
2Max Planck Institute for Meteorology, Hamburg, Germany
3Physical Research Laboratory, Ahmedabad, 380 009, India

*now at: Institute for Meteorology, Universität Leipzig, Germany

Correspondence to: R. Cherian (cherian.ribu@gmail.com)

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Abstract. In this paper we analyse aerosol loading and its direct radiative effects over the Bay of Bengal (BoB) and Arabian Sea (AS) regions for the Integrated Campaign on Aerosols, gases and Radiation Budget (ICARB) undertaken during 2006, using satellite data from the MODerate Resolution Imaging Spectroradiometer (MODIS) on board the Terra and Aqua satellites, the Aerosol Index from the Ozone Monitoring Instrument (OMI) on board the Aura satellite, and the European-Community Hamburg (ECHAM5.5) general circulation model extended by Hamburg Aerosol Module (HAM). By statistically comparing with large-scale satellite data sets, we firstly show that the aerosol properties measured during the ship-based ICARB campaign and simulated by the model are representative for the BoB and AS regions and the pre-monsoon season. In a second step, the modelled aerosol distributions were evaluated by a comparison with the measurements from the ship-based sunphotometer, and the satellite retrievals during ICARB. It is found that the model broadly reproduces the observed spatial and temporal variability in aerosol optical depth (AOD) over BoB and AS regions. However, AOD was systematically underestimated during high-pollution episodes, especially in the BoB leg. We show that this underprediction of AOD is mostly because of the deficiencies in the coarse mode, where the model shows that dust is the dominant component. The analysis of dust AOD along with the OMI Aerosol Index indicate that missing dust transport that results from too low dust emission fluxes over the Thar Desert region in the model caused this deficiency. Thirdly, we analysed the spatio-temporal variability of AOD comparing the ship-based observations to the large-scale satellite observations and simulations. It was found that most of the variability along the track was from geographical patterns, with a minor influence by single events. Aerosol fields were homogeneous enough to yield a good statistical agreement between satellite data at a 1° spatial, but only twice-daily temporal resolution, and the ship-based sunphotometer data at a much finer spatial, but daily-average temporal resolution. Examination of the satellite data further showed that the year 2006 is representative for the five-year period for which satellite data were available. Finally, we estimated the clear-sky solar direct aerosol radiative forcing (DARF). We found that the cruise represents well the regional-seasonal mean forcings. Constraining simulated forcings using the observed AOD distributions yields a robust estimate of regional-seasonal mean DARF of −8.6, −21.4 and +12.9 W m⁻² at the top of the atmosphere (TOA), at the surface (SUR) and in the atmosphere (ATM), respectively, for the BoB region, and over the AS, of, −6.8, −12.8, and +6 W m⁻² at TOA, SUR, and ATM, respectively.

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