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Investigation of Black Carbon characteristics over southern ocean: Contribution of fossil fuel and biomass burning☆

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A B S T R A C T

Black Carbon (BC) is an absorbing aerosol which has significant impact on the Earth - Atmosphere radiation balance and hence on climate. The variation of BC mass concentration and contribution of fossil fuel and biomass burning have been investigated over the Indian ocean sector of the Southern Ocean during austral summer. BC mass was in the range of 300–500 ng m^{-3} between 23.3°S to 24.5°S followed by decrease in BC to 150 ng m^{-3} as moving to higher southern latitudes till 41°S latitude. An increase in BC mass from 250 to 450 ng m^{-3} was found between 41 and 50°S due to trap of air masses by cyclonic wind and transport of aerosols from the southern part of African and eastern Madagascar regions. Higher BC concentration (250–350 ng m^{-3}) was observed in the latitude range of 57–60°S which can be attributed to convergence of north-westerly and south-easterly winds. The dominant contributor to BC was fossil fuel, which was > 80% during half of the total observations, while > 20% biomass burning contributed to one fifth of observations. The coastal Antarctic region showed higher BC mass concentration with mixed type of contributions of biomass and fossil fuel. Such accumulation of BC near the Antarctic coast can have a crucial impact on the sea-ice albedo which significantly affect the Antarctic climate system locally and global climate in general.

1. Introduction

The Southern Ocean (SO) has significant influence on the atmospheric and oceanic circulations not only in the Southern Hemisphere (SH) but also in the entire globe. There are remarkable differences in the geography and human settlement patterns between the Northern Hemisphere (NH) and SH, which provide a good opportunity to study aerosols and their impact on regional as well as global climate. In the SH, the snow covered Antarctica continent and the unbroken circumpolar expanse of the SO can give rise to strong latitudinal gradients in atmospheric and ocean properties. These affect ocean heat and carbon uptake. SO has a crucial role in modulating the global carbon cycle (Reid et al., 2009), and aerosols in the atmosphere can alter the regional biogeochemical cycles and atmospheric chemistry (Gao et al., 2013). Sea salt and biogenic sulphur are among the major aerosol species in the SO (Berg et al., 1998; Murphy et al., 1998). However, less Black Carbon (BC) concentrations were also reported over the SO region (Moorthy et al., 2005; Hulswar et al., 2020).

Atmospheric aerosols are crucial climate forcing agents which play an important role in regional and global climate change (Stocker et al., 2013). The incomplete combustion of coal, fossil fuel and wood, emit large amount of BC and organic carbon (OC) into the atmosphere. BC aerosols trap radiation and warm the atmosphere, and modify the melting of snow/ice cover (Stocker et al., 2013). BC is the only aerosol which has second strongest contribution to global warming after CO_2 (Ramanathan and Carmichael, 2008). The annual global emissions of BC were suggested as 7500 Gg Yr^{-1} in 2000 (Bond et al., 2013). Diesel emissions and domestic solid-fuel combustion contributed 27% and 25% respectively, while open biomass burning (BB) contributed 40% to BC (Bond et al., 2013). Fossil fuel (FF) contribution to total BC was reported to be ~ 40% (Ramanathan and Carmichael, 2008). On a regional scale, the BB and FF contributions significantly vary between urban, rural or remote regions.

In order to understand the spatio-temporal variability of aerosol properties and their climatic impact over the Polar regions including the southern ocean, Indian POLar AERosol NETwork (POLAERNET) program was started in 2018. Under this network program, BC mass concentrations and aerosol properties are

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