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Multi-scale Shipping Emission Inventory and its Air Quality Impacts

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Asia's share of world seaborne trade reached 41% and 60% for goods loaded and unloaded in 2015, and nine of the top ten global container ports as well as eight of the top ten leading ports by total volume are located in East Asia. These areas also have the highest population density, poor air quality and the fastest developing rate. China government has set up three domestic emission control areas (DECA) to reduce the shipping emissions. The ships were required to switch to 0.5% diesel fuel when at berth in 10 key ports in China since January 1, 2017.

To estimate air quality impacts from shipping emissions, five scales of shipping emission inventories based on AIS data including East Asia, China, Chinese DECA, port-scale and port berthing area scale were established.

Shipping emissions in East Asia accounted for 14-19% of global shipping emissions compared to 4-7% in 2002-2005. 18000±8600, 1100±400, 3600±1200,800±300, 600±200 premature deaths per year in China-Mainland, China-Taipei + Hong Kong + Macau area, Japan, South Korea, Viet Nam were attributed to East Asian shipping emission, respectively. In term of climate change impact, shipping emissions showed a short-term cooling and long-term warming effect.

In China, the total emissions of NO_x, PM, SO_2, and CO_2 were 1.91 ± 0.01, 0.164 ± 0.001, 1.30 ± 0.01, and 86.3 ± 0.3 Tg•yr^{-1} in 2013. Compared with on-road mobile source emissions, NO_x and PM emissions from ships were equivalent to about 34% and 29% of the total mobile vehicle emissions.

Chinese DECA in Bohai Rim Area (JJJ), Yangtze River Delta (YRD), and Pearl River Delta (PRD) were three shipping emission hotpots in China, accounting for only 8% of the ocean area but contributing 37% to the total shipping emissions in China in 2013.

In port-scale level, The resulting total port SO_2 emissions in JJJ, the YRD, and the PRD are 23.9 kt, 37.3 kt, and 15.3 kt, and the total port PM emissions are 2.4 kt, 3.7 kt, and 1.5 kt, respectively. Shipping emissions in Dalian, Shanghai, Ningbo-Zhoushan and Hong Kong ports were 23-147 times higher than that of Port of Los Angeles.

Berthing area in ports were distinguished to evaluate the effect of DECA. According to shipping emission results of port berthing area scale, Chinese DECA policy would result in a 20-70% reduction in shipping emissions in port berthing area.

A field campaign was taken place in a key port - Tangshan Port in Bohai Bay to observe the impact of Chinese DECA in shipping emissions during December 2016 to January 2017. In the field campaign in Bohai Bay, a higher SO_2/NO_x ratio in shipping plume which was 10.51 after switching fuel compared to 1.96 before switching fuel.