Temporal variation and size distribution of dust-derived Al in northern Taiwan, and implications of dust deposition to the East China Sea biogeochemistry

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Abstract

During a measurement campaign in northern Taiwan from February 2002 to February 2004, PM_{10} ambient aerosols were determined for Al using ICP-MS. Additional nine sets of size-resolved samples also were analyzed for the mass size distribution of Al. By using abnormal Al maxima together with air-mass back trajectory analysis, 12 Asian dust (AD) episodes have been identified to transport southward, crossing the East China Sea (ECS), to northern Taiwan. Atmospheric Al concentrations are variable greatly in time, depending on whether dust plumes reached Taiwan as well as the cleaning effect by frontal rain. During the AD periods dust loadings in air can be abruptly enhanced by three orders of magnitude or more than those in the normal days.

Monthly and seasonal variations of atmospheric Al show a typical pattern with high springtime and low summertime concentrations. Such seasonality is consistent with the frequency distribution of dust storm occurrence in China, and reflects the weakening or lack of AD and removal effects by frequent rainfall in summer. Air mass backward trajectory analyses indicate that Inner Mongolia (i.e. Gobi Desert) and Loess Plateau in northern China are the major source regions for the southward transported AD.

The mass size distribution of airborne Al revealed a monomodal pattern peaking at a size range of 2.5-5.6 μm. The aerodynamically mass median diameters of 4.2±0.7 μm were acquired for dust-derived Al; the corresponding dry deposition velocity was calculated to 2.0±1.5 cm sec^{-1}. Thus the total deposition rates of atmospheric dust were estimated to 12.6 to 18.5 g m^{-2} yr^{-1}. The relative contributions for both dry and wet depositions were 26-38% and 62-74%, respectively. Based on the fact that geographical distribution of dust loadings beyond 30°N is fairly uniform, it allows us to apply the estimates of dust depositions from northern Taiwan to the adjacent southern East China Sea (ECS) to assess the biogeochemical significance of eolian

dust.

Dust inputs to the whole ECS was estimated to about 17 Mt yr^{-1}, which represents ~20% of terrigeneous sediments in the Okinawa Trough where is the most important sink of offshore-transported sediments, because almost all the deposited dust is suggested to be eventually subjected to re-transport seaward. Moreover, by adopting a mean Fe/Al ratio of ~0.68 in aerosols, eolian depositions of total Fe were estimated to 1.25 g m^{-2} yr^{-1}; by assuming the Fe solubility of 2%, the atmospheric input of dissolvable Fe into the entire ECS was then figured out to 0.02 Mt yr^{-1}, comprising of 2-14% of the amount of the whole North Pacific. The additional dust-derived Fe can fertilize the plankton growth, potentially stimulating the primary productivity of ~300 mg C m^{-2} d^{-1}. Briefly, atmospheric inputs of mineral dust, dust-bearing Fe, and other specific nutrient substances may substantially affect the ECS biogeochemistry. Our future works will be focused on the studies of episodic dust and pollution events together with in-situ measurements of biological parameters (such as Chl-a, primary productivity and else) conducted by the LORECS team.