Atmospheric deposition fluxes derived from air concentration measurements over Southern Ocean are strongly underestimated: why direct deposition measurement is necessary

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Atmospheric deposition flux can be directly measured using deposition devices such funnels or plates, or calculated from aerosol concentration (C) measurements and some assessments on dry and wet deposition. The total deposition flux F_t is the sum of dry (F_d) and wet (F_w) deposition flux [1]. Dry deposition can be calculated from C, dry deposition velocity V and f the fraction of dry period during the observation duration: $F_d = C\ V\ f$. A scavenging ratio W is introduced to compute F_w, using K, the dust concentration in rain water: $W = K\ \rho / C$ (ρ is the density of air). Then $Fw = W\ P\ C / \rho$ where P is the amount of rainwater falling on the surface.

F_t can be computed from C measurement using deposition velocity and scavenging ratio factors. But conversely one can obtain experimental information on W if both F_d and C are simultaneously measured. This was made during a one year continuous measurement of atmospheric dust deposition flux and atmospheric dust concentration at Kerguelen Island (FLATOCOA experiment, 49°S-70°E). Calculated scavenging ratios varies from 1000 to 46000 [2], far away than used by authors to compute F_t from C measurements. Such high scavenging ratio numbers are produced because C is measured near the surface, which is not the cloud scavenged aerosol. Dust models use W values about 750 but applied on aerosol concentration at the suitable altitude, giving reliable deposition flux results. In highly scavenged regions such Southern Ocean, we suspect a strong positive vertical aerosol concentration gradient where surface based aerosol measurements are without any relationship with those scavenged by clouds at higher altitudes. In the case of our experiment, the underestimation of F_w using C and W reaches a factor of 50 compared to direct measurements. Over the Southern Ocean region and other regions where such situation occurs, all atmospheric flux calculation based on dust concentration in air are subjected to this large underestimation. Consequently biogeochemical models that use such flux calculation to take into account, or not, atmospheric deposition have to be reviewed.

[1] Uematsu & Duce (1985), J. of Atmos. Chem., 3, 123-138.
[2] Heimburger, Losno, Triquet, Dulac & Mahowald, GBC, 26, 10.1029/2012GB004301