Atmospheric deposition of soluble bioavailable iron in dust aerosols has been widely hypothesized to play an important role in determining the biological productivity in the present and past ocean. However, the impact cannot yet be accurately quantified as a result of the lack of an apparent systematic between the soluble and the total Fe in dust aerosols. In contrast to the previous reports, by using an extensive collection of aerosols over the western Pacific and the adjacent marginal seas and subjecting them to a strictly followed analytical protocol, here we found that the concentration of soluble Fe in dust aerosols does follow a definitive systematic: a robust inverse power–law relationship between the percent soluble iron and the mass ratio of total iron to the sum of the indicators of atmospheric acidic species (non-sea salt sulfate, nitrate and water-soluble organic carbon). This relationship suggests that the amount of soluble bio-available Fe in aerosol dusts is more closely related to the chemical processing than to the total Fe concentration of the dusts. Past extrapolations of the effect of Fe on marine productivity during the high dust glacial time from the present relationship to total Fe as in the iron hypothesis may have grossly overestimated the stimulatory effect of the elevated atmospheric depositional flux of total Fe.