Regional assessment of dry and wet deposition of reactive nitrogen in East Asia

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Introduction

Asia has been identified as a high-risk area for nitrogen deposition effects on ecosystems (Bleeker et al., 2011). It is therefore extremely important to carry out a measurement-based assessment of nitrogen deposition on regional scale in Asia. Recently, the state of wet deposition of reactive nitrogen such as NO_3^- and NH_4^+ in East Asia have been investigated by using data from the Acid Deposition Monitoring Network in East Asia (EANET).
Ban et al. (2016) estimated dry deposition of reactive nitrogen in Japan using inferential method and showed the spatial distributions and the 10-year trend together with the wet deposition. In this study, we expand the area of the assessment from Japan to East Asian region by means of modified inferential method.

Estimation of N dry and wet deposition

We applied the modified inferential method using monthly mean inputs to the estimations of annual dry depositions of HNO_3, NH_3, particle-NO_3^- and particle-NH_4^+ at 20 sites in 7 countries in 2010. We estimated total N deposition.

Components: HNO_3, NH_3, particle-NO_3^-, particle-NH_4^+,wet- NO_3^-, wet-NH_4^+
Location: EANET 7 countries 20 sites (total deposition(wet and dry))
& China 6 sites (wet deposition)
Period: Jan. to Dec. in 2010

Table 1 Location of EANET sites used in this study.

Country	Site	Class.	Latitude	Longitude
Total deposition (wet and dry)				
China	Hongwen	Urban	24°28' N	118°08' E
Indonesia	Serpong	Rural	6°15' S	106°34' E
Japan	Rishiri	Remote	45°07' N	141°13' E
Japan	Ochiishi	Remote	43°10' N	145°30' E
Japan	Tappi	Remote	41°15' N	140°21' E
Japan	Sado-seki	Remote	38°15' N	138°24' E
Japan	Ijira	Rural	35°34' N	136°42' E
Japan	Oki	Remote	36°18' N	133°11' E
Japan	Banryu	Urban	34°41' N	131°48' E
Japan	Yusuhara	Remote	33°23' N	132°56' E
Japan	Hedo	Remote	26°52' N	128°15' E
Japan	Ogasawara	Remote	27°06' N	142°13' E
Mongolia	Ulaanbaatar	Urban	47°55' N	106°55' E
Mongolia	Terelj	Remote	47°59' N	107°27' E
Russia	Listvyanka	Rural	51°51' N	104°54' E
Russia	Irkutsk	Urban	52°14' N	104°15' E
Thailand	Bangkok	Urban	13°47' N	100°32' E
Thailand	Nakhon Ratchasima	Rural	14°28' N	101°54' E
Vietnam	Hanoi	Urban	21°01' N	105°51' E
Vietnam	Hoa Binh	Rural	20°49' N	105°20' E
Wet depostion				
China	Haifu	Urban	29°37' N	106°30' E
China	Jinyunshan	Rural	29°49' N	106°22' E
China	Shizhan	Urban	34°14' N	108°57' E
China	Xiaoping	Remote	24°51' N	118°02' E
China	Xiang Zhou	Urban	22°16' N	113°34' E
China	Zhuxiandong	Urban	22°12' N	113°31' E

【Results and discussion】

- The highest amount in each site classification (urban, rural, and remote) was found at Chinese site (Fig. 2).
- The total (dry and wet) nitrogen depositions (Fig. 3a) at 20 sites in 7 countries in East Asia were in the range of 2.8 - 37 kg N ha^{-1} year^{-1}, and high total nitrogen deposition amounts over 10 kg N ha^{-1} year^{-1} were found in wide areas of the region. That indicate that the amount of nitrogen deposition on East Asia is high in global scale.
- The ratios of dry deposition to total deposition were high in the inland areas due to the low precipitation (Fig. 3b). And the ratios of reduced nitrogen to total nitrogen deposition were relatively high in southern part of East Asia (Fig. 3c).

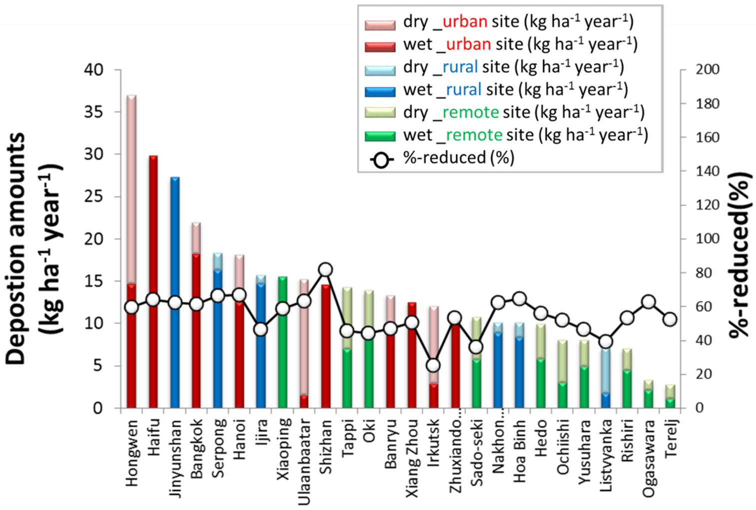

Fig 2 N deposition (kg N ha^{-1} year^{-1}) and %-reduced(%) of EANET 20 sites (total deposition(wet and dry)) and Chinese 6 sites (wet deposition) in 2010

Method of dry deposition estimation (Inferential method)

F(deposition) = C(atmospheric concentration) × V_d(deposition velocity)

Biweekly sampling

Input data: hourly meteorological data

THE PROBLEM

Only monthly mean data are available in EANET sites of all the participating countries except Japan.

Verification

V_d calculated from **hourly** meteorological data

VS

V_d calculated from **monthly** meteorological data

Modified inferential method

Components: HNO_3, NH_3, particle-NO_3^-, particle-NH_4^+
Period: Jan. to Dec. in 2012
Location: Japanese EANET sites (Rishiri, Tappi, Sado-seki, Happo, Oki, Yusuhara,Ogasawara, Hedo)

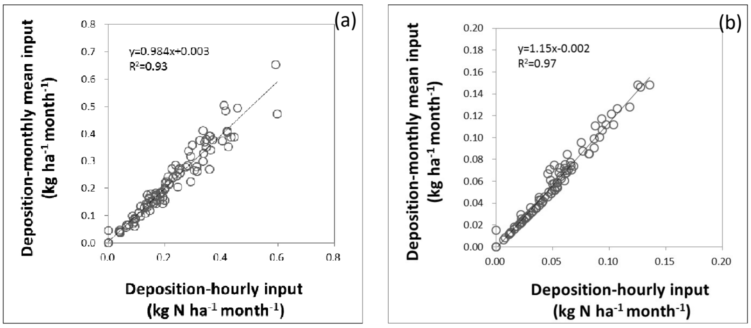

Fig 1 Comparison between monthly dry deposition amounts estimated from high time-resolution inputs (hourly meteorological data) and those estimated from monthly mean inputs (monthly meteorological data) at 8 sites in Japan. (a) and (b) show dry deposition estimated for forest surface and grass surface, respectively.

Dry deposition amounts estimated by the modified inferential method (monthly data input) probably well reproduce those estimated by using high resolution inputs in the case of long-term total dry deposition amounts (e.g. annual deposition).

N deposition = Oxidized N + Reduced N
Oxidized N: HNO_3 (gas) + NO_3^- (aerosol) + NO_3^- (wet)
Reduced N: NH_3 (gas) + NH_4^+ (aerosol) + NH_4^+ (wet)

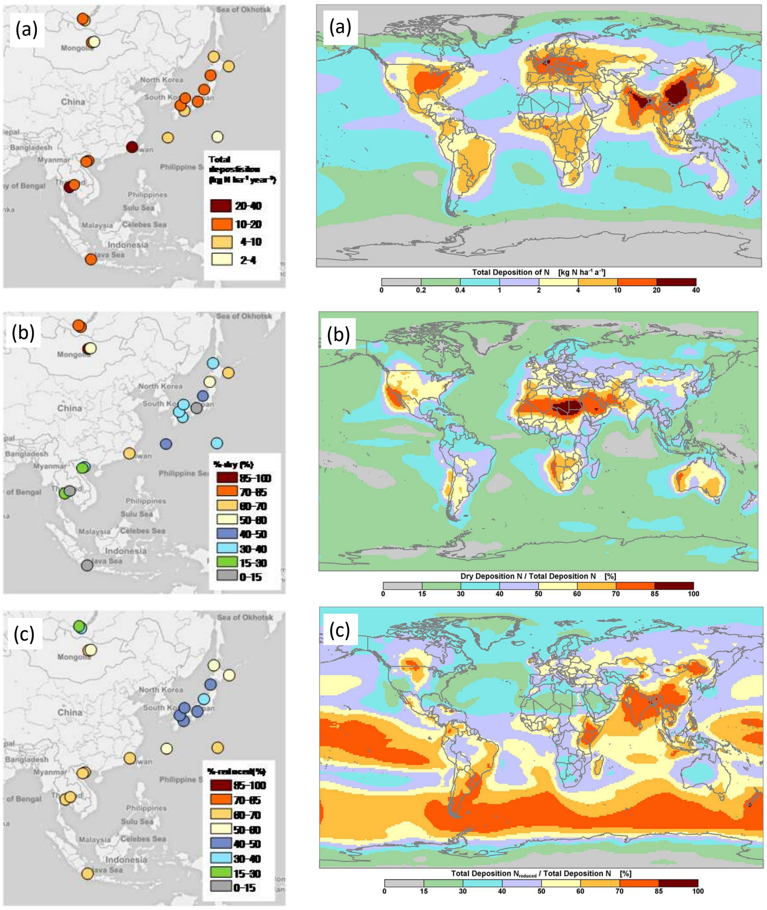

Fig 3 Comparison of estimated N deposition between this study and the model simulations (Vet et al., 2014). (a) Total N deposition (kg N ha^{-1} year^{-1}), (b) %-dry (dry/total) and (c) %-reduced (reduced N/total)

【文献】
Ban, Matsuda, Sato, Ohizumi, Long-term assessment of nitrogen deposition at remote EANET sites in Japan. *Atmospheric Environment*, 146, 70-78 (2016)
Vet et al., A global assessment of precipitation chemistry and deposition of sulfur, nitrogen, sea salt, base cations, organic acids, acidity and pH, and phosphorus *Atmospheric Environment*, 93, 3-100 (2014).