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Key Points:

- Mean pH was about 6.2 and was lower than observed in cities in China
- pH, deposition of SO_4^{2-} , and NO_3^- in rainfall differed among regions
- Acid deposition is closely related to regional GDP and rainfall amount

Supporting Information:

- Supporting Information S1

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Wet acid deposition in Chinese natural and agricultural ecosystems: Evidence from national-scale monitoring

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Abstract Acid deposition in precipitation has received widespread attention. However, it is necessary to monitor the acid deposition in Chinese agricultural and natural ecosystems because data derived from traditional urban/suburban observations might overestimate it to some extent. In this study, we continuously measured the acid deposition through precipitation (pH, sulfate (SO_4^{2-}), and nitrate (NO_3^-)) in 43 field stations from 2009 to 2014 to explore the spatial patterns and the main influencing factors of acid deposition in Chinese agricultural and natural ecosystems. The results showed that the average precipitation pH at the 43 stations varied between 4.10 and 8.25 (average: 6.2) with nearly 20% of the observation sites being subjected to acid precipitation (pH < 5.6). The average deposition of SO_4^{2-} and NO_3^- was 115.99 and 32.93 kg ha⁻¹ yr⁻¹, respectively. An apparent regional difference of acid deposition in Chinese agricultural and natural ecosystems was observed, which was most serious in south and central China and less serious in northwest China, Inner Mongolia, and Qinghai-Tibet. The level of economic development and amount of precipitation could explain most of the spatial variations of pH, SO_4^{2-} , and NO_3^- depositions. It is anticipated that acid deposition might increase further, although the current level of acid deposition in these Chinese agricultural and natural ecosystems was found to be less serious than projected from urban/suburban data. The control of energy consumption should be strengthened in future to prevent an increase of acid deposition in China.

1. Introduction

Emissions of sulfur and nitrogen into the atmosphere have increased considerably following the rapid increases in fossil fuel consumption and vehicle emissions accompanying the industrial and agricultural development during past decades [Dentener et al., 2006; Jia et al., 2014; Kuribayashi et al., 2012]. Atmospheric sulfur and nitrogen oxides produced by human activities can be changed into nitrate (NO_3^-) and sulfate (SO_4^{2-}) through complex physical and chemical processes such as oxidation. Increasing levels of atmospheric NO_3^- and SO_4^{2-} can change the pH of precipitation, which could result in serious acid deposition [Kulp, 1990; Singh and Agrawal, 2008; Jia et al., 2016]. There is evidence to show that a decrease in acid deposition has been achieved in some parts of Europe and America through effective control of pollution emissions. Therefore, the effects of acid deposition and methods for its control are of interest to the public and policy makers [Stoddard et al., 2000].

Increased acid deposition through precipitation has led to serious acidification in some regions, which has even become an international environmental problem in some areas [Krug and Frink, 1983]. Acid deposition via precipitation can lead to the accumulation of acid substances (mainly H^+ , SO_4^{2-} , and NO_3^-) on leaf surfaces that can cause serious damage to plants by affecting the permeability of leaf cells, destroying pore structure, and even reducing enzyme activity [Driscoll et al., 2003; Schwartz, 1989; Singh and Agrawal, 2008; Vasat et al., 2015]. Furthermore, acid deposition can lead to soil acidification, indirectly resulting in greater impact on terrestrial ecosystems [Krug and Frink, 1983; Qiu et al., 2015]. Serious acid deposition can activate toxic heavy metals in soils (soil toxicity). For example, H^+ deposition to soils through acid deposition via precipitation can release Al^{3+} as an active aluminum ion, which can be absorbed directly by plants, causing aluminum toxicity [Driscoll et al., 2003; Kulp, 1990; Rosseland et al., 1986].

As reviewed by Zhang et al. [2010], Chinese scientists have established a national acid-rain-monitoring network, and they have conducted systematic monitoring of the chemical properties of precipitation in different regions of China since 1980s. They have found that the southern region of China has the most serious acid deposition and that acid deposition in the northern region has been increasing [Dong, 2003; Xiang, 2012;

Zhong and Yuan, 2002]. However, the monitoring sites in these studies were mainly distributed in urban/suburban areas and were concentrated in south China, which has a relatively highly developed economy. Acid deposition through precipitation might be highest in areas closest to city centers, especially for megalopolises [Chan and Yao, 2008]. Du *et al.* [2015] reported the existence of urban “acid islands” within a critical radius of approximately 70 km of urban centers in southern China. We speculated that the agricultural and natural ecosystems of China, which occupy 95% of the total land area, would have lower levels of acid deposition than areas in or near cities because of their lower level of local industrial development and greater distance from urban centers. We further assumed that the level of acid deposition in Chinese agricultural and natural ecosystems might be overestimated when based on data derived only from traditional urban/suburban observations. Therefore, it is very important to determine the real level of acid wet deposition in these agricultural and natural ecosystems by direct measurements, in order to evaluate the potential hazard posed by acid deposition.

Here we measured the acid deposition of precipitation (pH, SO_4^{2-} and NO_3^- concentrations) at 43 field ecological stations from 2009 to 2014 (most of the stations were incorporated in the Chinese Ecosystem Research Network (CERN)). Based on these information, we explored the spatial patterns of acid deposition through precipitation in Chinese agricultural and natural ecosystems and investigated the main influencing factors. Specifically, there were two principal objectives for this study: (1) to establish quantitatively the status of acid deposition in Chinese agricultural and natural ecosystems and (2) to reveal the spatial patterns of acid deposition in Chinese agricultural and natural ecosystems and their main influencing factors. This study has provided baseline data for understanding the influences of acid deposition on the structure and function of typical terrestrial ecosystems.

2. Materials and Methods

2.1. Site Description

The 43 field ecological stations used in this study were mainly from Chinese Ecosystem Research Network (CERN). CERN was established in 1988, and it has become a very important field platform for long-term monitoring and field-controlled experiments in China [Fu *et al.*, 2007; Zhu *et al.*, 2015]. CERN is equivalent to the Long-Term Ecological Research Network in the U.S. and the Environmental Change Network in the UK. As shown in Figure 1, the selected 43 field ecological stations are distributed across 23 Chinese provinces, covering farmlands, forests, water areas, wetlands, grasslands, and desert ecosystems. Those farmlands in CERN are far from urban centers, and they are areas with low industrial development in which levels of precursor substances of acid deposition are low.

2.2. Sampling and Analysis

As a routine procedure of CERN, the effective monthly precipitation was collected by monitors from the field stations [Zhu *et al.*, 2015]. In practice, samples from each site were normally collected three or five times a month using three plastic buckets (diameter 30 cm) installed 1.5 m above ground level only during rainfall events, then the samples were stored in polyethylene plastic bottles at -20°C in order to prevent the possible transformation by microbes [He *et al.*, 2015] and mixed evenly to obtain a monthly sample.

In the Beijing laboratory (Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science), we monthly measured the pH of the precipitation samples using a pH meter (MP-6p, HACH, USA) at $20\text{--}25^\circ\text{C}$ (i.e., room temperature). Then we used a $0.45\text{ }\mu\text{m}$ membrane filter to remove all insoluble particulates from the samples. Subsequently, a continuous flow analyzer (FUTURA, Alliance Instruments, France) was used to measure the concentration of NO_3^- , and inductively coupled plasma optical emission spectroscopy was used to measure the concentration of SO_4^{2-} .

The data of energy consumption and gross domestic product (GDP) at province level from 2009 to 2011 were derived from the “Statistical Yearbook of China” and the web of “National Bureau of Statistics of China” (<http://data.stats.gov.cn>) to substitute for the values of each site. The precipitation data were measured manually using rain gauges at each station. For some missing precipitation data, we extracted values using the ANUSPLIN interpolation software from the data of 740 climate stations of the China Meteorological Administration during 1961 and 2007 [Zhu *et al.*, 2015].

$$D_{\text{sul}} = \sum_{i=1}^n \frac{C_i(\text{SO}_4^{2-}) \times P_i}{100}, \quad (4)$$

$$D_{\text{nit}} = \sum_{i=1}^n \frac{C_i(\text{NO}_3^-) \times P_i}{100} \quad (5)$$

where $C_i(\text{SO}_4^{2-})$ and $C_i(\text{NO}_3^-)$ are the monthly concentration of SO_4^{2-} (mg L^{-1} of SO_4^{2-}) and NO_3^- (mg L^{-1} of NO_3^-) (ppm), respectively, D_{sul} ($\text{kg ha}^{-1} \text{yr}^{-1}$) is the annual wet deposition of SO_4^{2-} , and D_{nit} ($\text{kg ha}^{-1} \text{yr}^{-1}$) is the annual wet deposition of NO_3^- (100 is the conversion factor). For SO_4^{2-} deposition, $1 \text{ keq ha}^{-1} \text{yr}^{-1}$ is equal to $96 \text{ kg ha}^{-1} \text{yr}^{-1}$, and for NO_3^- deposition, $1 \text{ keq ha}^{-1} \text{yr}^{-1}$ is equal to $62 \text{ kg ha}^{-1} \text{yr}^{-1}$.

2.3.2. Upscaling to Regional or National Level

Considering the complex topography and uneven distribution of the level of economic development in China (Figure S1 in the supporting information), we divided the country into eight regions according to the method of Fu *et al.* [2001]: northeast, Inner Mongolia, central China, north China, south China, northwest, southwest, and Qinghai-Tibet (Figure 1). For each region, we calculated the precipitation pH and concentrations of SO_4^{2-} and NO_3^- based on the sampling sites located within each region. We used Kriging interpolation (ArcGIS 9.3, Environmental Systems Research Institute) to upscale the acid deposition in the Chinese agricultural and natural ecosystems. Commonly, there are three principal methods for upscaling data from individual sites to the national scale: averaging methods [Zhang *et al.*, 2012], geostatistical methods [Zhu *et al.*, 2015], and modeling methods [Gao *et al.*, 2014]. As discussed by He *et al.* [2015], theoretically, the results of the three methods should be consistent if the acid deposition is homogeneous across the different regions of China. That is to say the possible influencing factors of acid deposition, such as the levels of economic development, fossil fuel-based energy consumption and the diffusion of acidic substances within the atmosphere, are relatively balanced in the different regions. However, the level of economic development in the different regions of China varies considerably, which results in considerable spatial heterogeneity of the acid deposition across the country (Figure S1). Furthermore, the latitude extent of China results in different meteorological conditions across the country, which could have considerable influence on the differences of acidic deposition diffusion (Figure S1). Consequently, methods that consider the corresponding area around the observation sites (or the level of development within the area surrounding an observation site), such as modeling methods and Kriging interpolation, should produce more accurate results than averaging methods when upscaling from single site data to the national scale across China. Therefore, we adopted a geostatistical analysis method (Kriging interpolation method) to upscale the data in this study. It should be noted that the data from Hainan Province were not interpolated because of its special island characteristics and Taiwan was not included due to no observation sites of our own. Both of these areas are represented in the figures as shaded areas.

2.4. Statistical Analysis

The normal test was made for our data using the Kolmogorov-Smirnov test in SPSS 18.0, and we found that all three parameters (pH, NO_3^- , and SO_4^{2-}) could be fitted by a normal distribution. Correlation analyses were conducted to explore the relationships of acid deposition (pH, SO_4^{2-} and NO_3^- deposition) with precipitation and economic development parameters (energy consumption per unit area and GDP) both at the sampling site and at the regional scale. During curve estimation, we used the guidelines of the Akaike information criterion (AIC) and Bayesian information criterion (BIC) to screen the optimal models from the fitting function with similar R^2 , and functions with smaller AIC and BIC values were selected [Aho *et al.*, 2014; Murtaugh, 2014]. Furthermore, one-way variation analysis was used to test the differences of acid deposition among the different regions based on the least significant difference test. To quantify the effects of climate and level of economic development on acid deposition, we implemented structural equation modeling using the AMOS software (IBM SPSS AMOS 18.0). We built a factor analysis model in AMOS and only considered the significant correlations. Path coefficients in each model were calculated using the software. And the path coefficients were the standardized regression coefficient, which represented the amount of change in the dependent variable per single unit change in the predictor variable. We used it to evaluate the effect of each influencing factor on the spatial patterns of acidic deposition. A significance level of $P = 0.05$ was used for all tests. All analyses were conducted using the SPSS 18.0 program. And a more detailed discussion of the methodology can be found in the supporting information.

Figure 2. Frequency distributions of pH and SO_4^{2-} and NO_3^- deposition in precipitation. The line in each panel represents the curve of a normal distribution.

3. Results

3.1. Spatial Variation of Precipitation Acid Deposition

The frequency distribution of pH was normal (Figure 2). The average pH for the 43 field stations was about 6.20 (range: 4.10–8.25). The average SO_4^{2-} and NO_3^- depositions were 115.99 and 32.93 $\text{kg ha}^{-1} \text{yr}^{-1}$, respectively (range: 1.71–821.63 and 0.002–95.22 $\text{kg ha}^{-1} \text{yr}^{-1}$, respectively).

Acid deposition through precipitation was most serious in south China, and the intensity of acid deposition for H^+ , SO_4^{2-} , and NO_3^- decreased from south to north (Figure 3). The precipitation pH and deposition of SO_4^{2-} and NO_3^- were closely correlated with latitude. Specifically, there was significant positive linear correlation between pH and latitude ($R^2 = 0.53$, $P < 0.01$) (Figure 4), and negative linear correlations were observed for SO_4^{2-} and NO_3^- deposition (Figure 4). Furthermore, SO_4^{2-} deposition and NO_3^- deposition might both affect precipitation pH, with P value of 0.03 for the former and 0.027 for the latter (Figure 5).

The precipitation pH and deposition of SO_4^{2-} and NO_3^- through precipitation differed significantly among the eight ecological regions (Figure 6). The average values of pH in south China (4.95) and central China (5.56) were far lower than in other regions. The SO_4^{2-} deposition was also highest in south China with a mean value of 335.12 $\text{kg ha}^{-1} \text{yr}^{-1}$. The NO_3^- deposition was serious in the south China and northwest regions, but it was relatively weak in the regions of southwest, Inner Mongolia, and Qinghai-Tibet.

3.2. Main Factors Influencing Precipitation Acid Deposition

At both sampling site and regional scale, there were significant negative correlations between pH and GDP (Figure 7B, b) and significant negative linear correlations with precipitation (Figure 7C, c). The results of the structural equation modeling showed that GDP and precipitation both contributed considerably to the spatial variation of pH, with path coefficients of 0.29 and 0.35, respectively (Figure 8).

The SO_4^{2-} deposition had significant positive linear correlations with energy consumption, GDP, and precipitation (Figure 7D–7F) at the site scale. At the regional scale, SO_4^{2-} deposition showed significant exponential correlation with energy consumption ($P = 0.046$, $R^2 = 0.513$) (Figure 7d) and no significant correlation with precipitation. Furthermore, the correlation between SO_4^{2-} deposition and GDP was significant at the regional scale ($P = 0.002$, $R^2 = 0.83$) (Figure 7e). GDP contributed most to the variation of SO_4^{2-} deposition, and its path coefficient was 0.74, based on the results of the structural equation modeling (Figure 8c).

At the site scale, NO_3^- deposition showed positive correlations with energy consumption, GDP, and precipitation (Figure 7G–7I), while at the regional scale, it only had significant positive correlation with precipitation ($P = 0.009$) (Figure 7i). Energy consumption, GDP, and precipitation all exerted nearly equal influence on NO_3^- deposition with path coefficients of 0.24, 0.25, and 0.28, respectively (Figure 8b).

4. Discussion

4.1. Precipitation Acid Deposition in Chinese Agricultural and Natural Ecosystems

Our results showed that the average pH of precipitation was approximately 6.20. Among all the 43 field stations, only about one fifth of the sites had average pH < 5.6 (representing acid rain). Through a review of previous studies (Table 1), we obtained 20 records of precipitation pH reported in China, where the data were

Figure 3. Spatial patterns of the (a) pH, (b) SO_4^{2-} deposition ($\text{kg ha}^{-1} \text{yr}^{-1}$), and (c) NO_3^- deposition ($\text{kg ha}^{-1} \text{yr}^{-1}$) through precipitation in China (Taiwan and Hainan Province were not included in the interpolation).

mainly monitored at urban or suburban stations [Wang, 2004; Chen, 2005; Tu et al., 2005; Zheng, 2006; Huang et al., 2010; Niu et al., 2010; Zhao et al., 2011; Zhou, 2011; Wang et al., 2012; Ding et al., 2013; Ou yang et al., 2013; Xu et al., 2013]. The average pH of these collective data was 5.46 with more than half the values <5.6 ; the lowest pH was 3.94, which might indicate serious acid precipitation. These comparisons of pH might support our assumption that acid deposition in Chinese agricultural and natural ecosystems is overestimated when only using data derived from traditional urban/suburban observations. However, the question remains that rain acidification is comprehensive and not only dependent on pH, SO_4^{2-} , and NO_3^- deposition, and further study will be required to address this issue. For the deposition of SO_4^{2-} and NO_3^- , the observed range was 1.71–821.63 and 0.002–95.22 $\text{kg ha}^{-1} \text{yr}^{-1}$, respectively. Some scientists have demonstrated that the critical load values of S and N are very important indicators for the study of soil acidification [Reinds et al., 2015], which is another subject that will require further investigation in the future.

As in the concept of the “acid island,” acid deposition (mainly including pH, SO_4^{2-} , and NO_3^-) decreased with distance from the center of big cities [Beirle et al., 2011; Du et al., 2015]. Du et al. [2015] reported that the critical radius of deposition in the acid island is around 70 km in southern China. As discussed above, those fields of agricultural and natural ecosystems in China, which occupy about 95% of the total land area, might lie beyond the critical radius (70 km) and have lower acid deposition than those sites in or near cities. Their true circumstance cannot be determined based on measurements conducted near large cities. However, as far as we know, this study marked

Figure 4. Relationships between pH and SO_4^{2-} and NO_3^- deposition in precipitation with latitude and longitude.

a most comprehensive investigation of acid deposition via precipitation in Chinese agricultural and natural ecosystems. Therefore, because of the unique regional differentiation in the level of economic development and topography (Figure S1), large uncertainty in the estimation of acid deposition in Chinese agricultural and natural ecosystems should result from the uneven distribution of observation sites, especially in the undeveloped regions of Qinghai-Tibet, Inner Mongolia, and the northwest (Figures 1 and S1).

4.2. Apparent Regional Differences in Acid Deposition in Chinese Agricultural and Natural Ecosystems

The pH and depositions of SO_4^{2-} and NO_3^- through precipitation differed significantly among the eight regions, being most serious in south China and central China and least serious in the northwest, Inner

Figure 5. Relationships between pH and SO_4^{2-} and NO_3^- depositions in precipitation.

Figure 6. Comparison of the pH and SO_4^{2-} and NO_3^- deposition in eight ecological regions of China. SC (south China), CC (central China), NW (northwest), IM (Inner Mongolia), NC (north China), QT (Qinghai-Tibet), NE (northeast), SW (southwest). Data represented as mean ± 1 standard error; data with same lowercase letter indicate no significance in cross-correlation at $\alpha = 0.05$ level.

results of the structural equation modeling showed that GDP and precipitation contribute considerably to the spatial variations of pH, and SO_4^{2-} and NO_3^- deposition in Chinese agricultural and natural ecosystems. It is anticipated that economic development would be accompanied by massive releases of sulfur-nitrogen-containing compounds because of the close relationship between economic growth and energy consumption [Lin and Sun, 2015], and these compounds can be transported some distance in a period [Jing, 1999]. Furthermore, precipitation pH was found closely related to local climate, geographic environment, wind direction, and other factors [Jing, 1999]. The dilution and clearing effects of precipitation are also other important reasons for the observed spatial patterns of acid deposition. Accompanying the higher levels of precipitation in southern China, greater quantities of acidic substances could be washed out of the atmosphere, causing serious acid deposition. According to forecasts of China's economic development and studies of acid

Mongolia, and Qinghai-Tibet regions. The considerable topographic heterogeneity of China and consequent regional differences in resources, population, and other factors also cause huge differences in the level of economic development (Figure S1). For example, Tibet is the largest province in China (about 1,228,000 km²) but its GDP was 453 million RMB per unit area in 2010–2011. In contrast, the area of Jiangsu Province is only 102,600 km² but its GDP per unit area was 441,200 million RMB in 2010–2011. Our results showed that deposition of SO_4^{2-} and NO_3^- was significantly positively correlated with GDP and energy consumption, and precipitation pH was negatively correlated with GDP. Therefore, the huge differences in regional economic development and energy consumption might result directly in the observed spatial patterns of acid deposition in Chinese agricultural and natural ecosystems.

4.3. Level of Economic Development and Energy Consumption on Control of Acid Deposition in Chinese Agricultural and Natural Ecosystems

Acid deposition through precipitation showed a clear spatial pattern in Chinese agricultural and natural ecosystems. The reasons for the acidity of precipitation are complex, and many of the primary influencing factors such as sulfide emissions caused by fossil fuel consumption, atmospheric diffusion capacity, and the neutralization capability of atmospheric aerosols have strong regional variations in China [Li, 1998]. The

Figure 7. Relationships between three acid substances (pH, SO_4^{2-} , and NO_3^-) and energy consumption, gross domestic product, and precipitation. (A–I) Data analyzed at site scale. (a–i) Data analyzed at regional scale. Standard errors of regional-scale data are labeled on the figures.

rain [Streets and Waldhoff, 2000; Wang et al., 2004], it is anticipated that acid deposition through precipitation in China will increase further over the coming decades, and for a long time, China may continue to have increased energy consumption accompanying increasing GDP. China has published some related applicable laws and regulations, such as “Renewable Energy Law” and “Cleaner Production Promotion Law”, and implemented a series of coal desulfurization technology. However, the technology in China might not be fully mature and it might require greater investment; besides, the higher-energy costs remain a concern. For these reasons, fossil fuel-based energy consumption in China and the related emissions might not change for a long time. Therefore, we speculate that there is a possibility for acid deposition increasing. The speculation need to be verified in the future or with long-term data. Although the current levels of acid deposition in agricultural and natural ecosystems are perhaps less serious than previously believed, the systematic monitoring of acid deposition (including pH, NO_3^- , NH_4^+ , SO_4^{2-} , and Ca^{2+}) in agricultural and natural ecosystems of China is also urgently required to evaluate the potential hazard posed by acid deposition to the ecosystem structure and function.

Figure 8. Path diagram for the influences of energy consumption, gross domestic product (GDP), and precipitation on (a) pH, (b) NO_3^- deposition, and (c) SO_4^{2-} deposition in precipitation. The path coefficients (standardized regression coefficients) are labeled on figures.

Table 1. Reported Values of Precipitation pH in Different Sites of China from Different Reported Literature

	Sampling Site	Type	pH	Monitoring Year	Resource
1	Nanning	Urban	4.96	2004	Zheng [2006]
2	Beijing	Urban	5.36	2009	Zhou [2011]
3	Chongqing	Urban	5.7	2009	Ou yang et al. [2013]
4	Tianjin	Urban	6.34	2008–2010	Wang et al. [2012]
5	Shenzhen	Urban	4.9	2009	Huang et al. [2010]
6	Liuzhou	Downtown	5.95	2003	Wang [2004]
7	Urumqi	Downtown	6.04	1999	Zhao et al. [2011]
8	Nanjing	Downtown	4.89	2003	Tu et al. [2005]
9	Guangyuan	Suburban	5.41	2011	Xu et al. [2013]
10	JiaYuGuan	Suburban	8.32	2004	Chen [2005]
11	Linan	Suburban	3.94	2008	Niu et al. [2010]
12	Cangzhou	Suburban	5.01	2008–2010	Wang et al. [2012]
13	Yangfang	Suburban	6.27	2008–2010	Wang et al. [2012]
14	Baoding	Industrial district	4.93	2008–2010	Wang et al. [2012]
15	Tanggu	Industrial district	5.63	2008–2010	Wang et al. [2012]
16	Tangshan	Industrial district	5.35	2008–2010	Wang et al. [2012]
17	Luancheng	Agricultural district	4.96	2008–2010	Wang et al. [2012]
18	Yucheng	Agricultural district	5.52	2008–2010	Wang et al. [2012]
19	Huanjiang	Rural	5.1	2007–2008	Ding et al., [2013]
20	Xionglong	Rural	4.71	2008–2010	Wang et al. [2012]

5. Conclusions

This study found that the average pH of precipitation in Chinese agricultural and natural ecosystems was about 6.20, and nearly 20% of the 43 observation sites were subjected to acid rain ($\text{pH} < 5.6$). Our results indicated that acid deposition in Chinese agricultural and natural ecosystems might be overestimated when only using data derived from traditional urban/suburban observations. The deposition of SO_4^{2-} and NO_3^- and the pH of precipitation differed significantly among the eight ecological regions of China, and they were most serious in south China and central China. The level of economic development and amount of precipitation explained most of the spatial variations of pH and SO_4^{2-} and NO_3^- deposition in Chinese agricultural and natural ecosystems. It must be emphasized that it is anticipated that acid deposition in agricultural and natural ecosystems will increase further over the coming decades in association with the continued economic development of China and long-term unchangeable fossil fuel-based energy consumption.

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