Chemical characteristics of cloud and fog water over Mt. Huang, China

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Growing       Mature             issipating

Rosenfeld et al. (2008) found pollutants of anthropogenic emissions could change rainfall, affect the microphysico-chemical properties of the clouds.

High elevation fog, usually formed by orographic clouds or interception of stratus clouds, gives a unique opportunity to study cloud water chemistry without the need of an airborne sampling platform.
Background

- Over the past decade, the chemistry of cloud has become an important topic of investigation at high elevation. Such as Mt. Whiteface, U.S.A. (Anderson, Baumgardner et al. 1999); (2) Mt. Bamboo, Taiwan (LIN and PENG 1998); (3) Mt. Rokko, Japan (Aikawa, Hiraki et al. 2005); (4) Mt. Akagi, Japan (Tago, Kimura et al. 2006); (5) Mt. Haruna, Japan (Tago, Kimura et al. 2006).
Streets et al. (2000) performed analysis of air pollutants, such as sulfur dioxide, NOx, carbon monoxide, found the rapid growth of human activity over China associated with high anthropogenic emissions of pollutants.
Objective

• The purpose of this study is to provide data on fog or cloud and its chemical composition based on observations in mountainous region.
Instruments

Cloud water collector

Fog monitor (drop size spectra)
Sampling Program

- Measurement were conducted during April – July 2008
- More than 120 samples were collected
- Analysis
  - pH
  - Ions: $\text{Cl}^-$, $\text{NO}_3^-$, $\text{SO}_4^{2-}$, $\text{Na}^+$, $\text{NH}_4^+$, $\text{K}^+$, $\text{Mg}^{2+}$, and $\text{Ca}^{2+}$
Results and discussions

• Variation of pH value

pH values: 4.43-6.94
mean: 5.81
The pH is higher than
(1) Mt. Whiteface, U.S.A. (Anderson, Baumgardner et al. 1999);
(2) Mt. Bamboo, Taiwan (LIN and PENG 1998);
(3) Mt. Rokko, Japan (Aikawa, Hiraki et al. 2005);
(4) Mt. Akagi, Japan (Tago, Kimura et al. 2006);
(5) Mt. Haruna, Japan (Tago, Kimura et al. 2006).

It may suggest a quantity of inputs of alkaline species into fog and cloud in the study area

Figure 1. Frequency distribution of pH measured in Mt. Huang from April to July 2008
Origin of chloride ion

• Correlation coefficient of Na\(^+\) versus Cl\(^-\) \((r=0.37)\) was lower, indicating towards different sources.
• \((\text{Cl}^-/\text{Na}^+)=3.55\) mainly originated from non-marine source.

Figure 2 Relationship between chloride ion and sodium ion concentrations in cloud and fog water at Mt.Huang
Major ions in the fog and cloud water

The Huangshan city’s economic and social development of statistical report in 2008 (http://www.huangshan.gov.cn/zjhs/ShowDetails.aspx?ArticleId=25715) :
18,013,000 tourists, increase 17.3%
38,200 ton chemical fertilizer, increase 5.5%

\[ \text{NH}_4^+ > \text{SO}_4^{2-} > \text{NO}_3^- > \text{Ca}^{2+} > \text{Na}^+ > \text{Cl}^- > \text{K}^+ > \text{Mg}^{2+} \]

Figure 3 Cloud and Fog water compositions at Mt. Huang
Correlation analysis

Correlation coefficient of NH$_4^+$ versus NO$_3^-$ (0.848) and SO$_4^{2-}$ (0.895) were higher, showing that NH$_4$NO$_3$, NH$_4$HSO$_4$, (NH$_4$)$_2$SO$_4$ could be more predominant in the atmosphere.

Figure 4 Relationship between concentrations of ammonium ion and major anions (sulfate ion, nitrate ion) in cloud and fog water at Mt. Huang.
4. Conclusions

- An investigation of fog and cloud water at Mt. Huang was performed from April to July 2008. The most of fog and cloud water was typically alkaline as the pH value ranged from 4.43 to 6.94 with a volume-weighted mean value of 5.81.
- Dominant ions in the fog and cloud water were NH$_4^+$, SO$_4^{2-}$, NO$_3^-$, Ca$^{2+}$.
- A good correlation between NH$_4^+$ and SO$_4^{2-}$, as well as NH$_4^+$ and NO$_3^-$, reflected these ions were commonly sources.
- Correlation coefficient of Na$^+$ versus Cl$^-$ (r=0.37) was lower, suggested that most of these ions mainly originated from non-marine source.
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Thank You!