Chemical Characteristics of Cloudwater and Precipitation at a Representative High-elevation Site in South China: Transboundary Transport of Different Sources

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Outline

1. Objective of this study
2. Samples collection and analysis
3. Chemical compositions
4. Source and transboundary transport
5. Summary
Why Mt. Heng?
(112°42’ E, 27°18’ N, 1269m)

- Within the region of the most acidic rain in southern China
- Frequent clouds/fogs and precipitation
- Good location to study long-range transport

Sample collection and analysis

- **Period**: 2009.2.28-5.29
- **Collector**: CASCC-2
- **pH, EC**: MODEL 6350M
- **Water-soluble ions**: IC-2500(DIONEX)
Acidic precipitation

The precipitation were mostly acidic.

pH range: 3.44~6.91
VWM pH = 4.35
Acidic cloud/fog water

Frequent cloud/fog events occurred.
- 194 samples for 24 events.

The cloud water were mostly acidic.

pH range: 2.91~6.91
VWM pH = 3.80
Chemical composition
Temporal variation of ions

- **Sulfate (SO$_4^{2-}$)**
  - March: 389, 76
  - April: 365, 64
  - May: 357

- **Nitrate (NO$_3^-$)**
  - March: 70.85
  - April: 8.41
  - May: 59.96

- **Calcium (Ca$^{2+}$)**
  - March: 59.96
  - April: 26.06
  - May: 158

- **Ammonium (NH$_4^+$)**
  - March: 21
  - April: 8
  - May: 3/20, 4/01, 4/11, 4/17, 4/29, 5/12, 5/16, 5/29

- **Chloride (Cl$^-$)**
  - March: 21
  - April: 8
  - May: 3/20, 4/01, 4/11, 4/17, 4/29, 5/12, 5/16, 5/29

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Relationships between ions

Cloudwater

γ=0.934

γ=0.978

γ=0.970

Precipitation

γ=0.900

γ=0.931

γ=0.899
## Ionic sources

\[
\%SSF = 100 \left( \frac{X/Na^+}{X/Na^+} \right)_{\text{marine}}/ \left( \frac{X/Na^+}{X/Na^+} \right)_{\text{rain-cloud}} \\
\%CF = 100(\frac{X/Ca^{2+}}{X/Ca^{2+}})_{\text{soil}}/ \left( \frac{X/Ca^{2+}}{X/Ca^{2+}} \right)_{\text{rain-cloud}} \\
\%AF = 100 - \%SSF - \%CF
\]

### Ion Concentration (μeq/l)

<table>
<thead>
<tr>
<th>Ion</th>
<th>Sea salt (%)</th>
<th>Crust (%)</th>
<th>Anthropogenic source (%)</th>
<th>Sea salt (%)</th>
<th>Crust (%)</th>
<th>Anthropogenic source (%)</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>2.1</td>
<td>0.1</td>
<td>97.8</td>
<td>1.4</td>
<td>0.3</td>
<td>98.3</td>
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<tr>
<td>Nitrate</td>
<td>--</td>
<td>0.1</td>
<td>99.9</td>
<td>--</td>
<td>0.1</td>
<td>99.9</td>
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<tr>
<td>Potassium</td>
<td>8.4</td>
<td>91.6</td>
<td>--</td>
<td>4.3</td>
<td>95.7</td>
<td>--</td>
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<tr>
<td>Calcium</td>
<td>4.9</td>
<td>95.1</td>
<td>--</td>
<td>1.4</td>
<td>98.6</td>
<td>--</td>
</tr>
<tr>
<td>Magnesium</td>
<td>21.4</td>
<td>78.6</td>
<td>--</td>
<td>43.3</td>
<td>56.7</td>
<td>--</td>
</tr>
</tbody>
</table>
Air-mass patterns

HYSPLIT4.8 (NOAA/ARL)  5 day 3-D backward Trajectory
Ending point: 1300 m a.s.l.  Cluster analysis with Ward’s method
Summary

• Most of the cloudwater and precipitation events were acidic. Compared with the situation in 1989, in cloudwater the acidity became stronger, but this did not appear in precipitation.

• About 70% ions were $\text{SO}_4^{2-}$, $\text{NH}_4^+$, $\text{NO}_3^-$, and they were mainly from anthropogenic sources. Otherwise organic acids were additional contributors to the acidity.

• Regional transports affected chemical compositions in cloudwater greatly rather than local sources did and this regional transports were associated with ones from East and South China.
Acknowledgements

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Thank you!