Atmogenic NH$_4^+$ derived from agriculture drives N$_2$O emissions in an N-saturated subtropical forest, southwest China

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Why denitrification and N$_2$O emission are important in subtropical forests in south China?

- High N deposition

Atmospheric NH$_4^+$ derived from agriculture drives N$_2$O emissions in an N-saturated subtropical forest, southwest China.
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high N deposition 2/3 as NH$_4^+$

Hypothesis 1: N gaseous emissions remove much N; especially in GDZ

Hypothesis 2: Different landscape elements contribute differently to denitrification and N$_2$O emission.

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Air temperature and precipitation
Soil temperature and moisture

(a) WFPS (%)
- WFPS-T3
- WFPS-B1

(b) Soil temperature (°C)
- T-T3
- T-B1

Lower site
Upper site
Atmogenic NH$_4^+$ derived from agriculture drives N$_2$O emissions in an N-saturated subtropical forest, southwest China.
Interpolation of $N_2O$ flux

Atmospheric $NH_4^+$ derived from agriculture drives $N_2O$ emissions in an N-saturated subtropical forest, southwest China.

May 2009 – Apr. 2010: 0.50 g N m$^{-2}$
Jan. 2010 – Dec. 2010: 0.41 g N m$^{-2}$

$\ln(N_2O_{HS}) = -4.80 + 0.0881 \ WFPS + 0.178 \ T$
R-Sq(adj) = 68.9%
In situ $^{15}$N-NO$_3$ labelling experiment

Two locations: top hillslope (between T1 & T2) & foot hillslope (T5)

Conducted in June, 2010

Two fertilizer loads as one dose:
High load (H): 1 g N/m$^2$ 99 at% KNO$_3$ $\Rightarrow$ 20% annual inorganic N input
Low load (L): 0.2 g N/m$^2$ 99 at% KNO$_3$ $\Rightarrow$ 4% annual inorganic N input

No labeled NH$_4^+$ added
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- High dose of NO$_3^-$ resulted high [NO$_3^-$]
- But lower site had higher N$_2$O emission irrespective of treatment
- High WFPS at lower site $\Rightarrow$ high N$_2$O emission
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- 71% to 100% of N$_2$O were produced from denitrification.
- Pool dilution to estimate nitrification rate.
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- Pool dilution revealed very low *in situ* nitrification rate
- Higher N$_2$O emission from lower site compared to upper site
- Emission factors
  1) calculated as total cumulative N$_2$O flux of added NO$_3^-$-N;
  2) calculated as cumulative $^{15}$N$_2$O flux of added NO$_3^-$-N.

<table>
<thead>
<tr>
<th></th>
<th>Low N at upper site</th>
<th>High N at upper site</th>
<th>Low N at lower site</th>
<th>High N at lower site</th>
</tr>
</thead>
<tbody>
<tr>
<td>gross nitrification rate</td>
<td>µg N g$^{-1}$ dw soil d$^{-1}$</td>
<td>0.17 (0.24)</td>
<td>0.33 (0.33)</td>
<td>0.65 (0.89)</td>
</tr>
<tr>
<td>cumulative N$_2$O flux in 147 hrs</td>
<td>mg N m$^{-2}$</td>
<td>16 (10)</td>
<td>21 (4)</td>
<td>31 (14)</td>
</tr>
<tr>
<td>% cumulative N$_2$O flux of applied N</td>
<td>%</td>
<td>8.0 (4.9)</td>
<td>2.1 (0.3)</td>
<td>15.3 (7.2)</td>
</tr>
<tr>
<td>$^{15}$N recovery from N$_2$O emission</td>
<td>%</td>
<td>1.3 (0.4)</td>
<td>0.6 (0.0)</td>
<td>3.2 (0.3)</td>
</tr>
</tbody>
</table>
Lab incubation: denitrification potential

Soil slurry, 2mM KNO$_3$, +/- 2mM glut, +/- C$_2$H$_2$, anaerobic incubation

- Top soils from HS (O&A horizon: ~5cm) and GDZ (0-20 cm) have similar denitrification potential in spite of low C content at GDZ;
- N$_2$OR activity is much higher for soils from GDZ than from HS; probably due to long-term anoxic condition, low NO$_3^-$ concentration, high dissolved N$_2$O in GDZ and pH;
- Both traits suggested that GDZ soil has high denitrification rate with low N$_2$O/N$_2$ product ratio, whereas HS soil has high denitrification rate with high N$_2$O/N$_2$ product ratio.
Summary

Atmogenic NH$_4^+$ derived from agriculture drives N$_2$O emissions in an N-saturated subtropical forest, southwest China.

- Transient N$_2$O peaks occur in summer after rain episode;
- Denitrification is the major pathway for N$_2$O emission;
- Nitrification rate is low but can be a main pathway for NO emission.
Many Thanks for your attention & for helps from