Effects of warming on herbivore-induced plant volatiles in the tundra

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But today we focus on insect herbivory...
What are plant volatiles?
Volatile Organic Compounds, VOCs
Each plant species has different VOC "bouquet" - Vegetation changes alter ecosystem VOC emissions
### The atmosphere

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration (parts per billion, ppb)</th>
<th>Lifetime (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>781 000 000</td>
<td>1.6 x 10^7</td>
</tr>
<tr>
<td>Oxygen</td>
<td>209 000 000</td>
<td>&gt;3000</td>
</tr>
<tr>
<td>CO₂</td>
<td>400 000</td>
<td>not defined (5-200)</td>
</tr>
<tr>
<td>CH₄</td>
<td>1800</td>
<td>12</td>
</tr>
<tr>
<td>N₂O</td>
<td>300</td>
<td>110</td>
</tr>
<tr>
<td>Methanol</td>
<td>1-10</td>
<td>0.02</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.5-2</td>
<td>0.02</td>
</tr>
<tr>
<td>Isoprene</td>
<td>0.5-10</td>
<td>0.00002</td>
</tr>
<tr>
<td>Monoterpenes</td>
<td>0.5-2</td>
<td>0.00000001-0.001</td>
</tr>
</tbody>
</table>
Enclosure measurements, GC-MS analysis in lab
Long-term multifactor experiments
OTC warming causes large increases in arctic tundra VOC emissions, irrespective of the time perspective.

- 240-340%: Lindwall et al. 2016, STOTEN
- 280%: Lindwall et al. 2016, JGR Biogeosciences
- 260%: Kramshøj et al. 2016, Nature Geoscience
- ~100%: Valolahti et al. 2015, Global Change Biology
  Faubert et al. 2010, New Phytologist
  Tiiva et al. 2008, New Phytologist
Are VOC emissions from **alpine tundra** outside the Arctic as temperature sensitive?

Contact me if interested in collaboration!
What about biotic stresses like insect herbivory?

Tao Li
Outbreaks of the geometrids *Operophtera brumata* and *Epirrita autumnata* in subarctic birch forests

Credit: Moritz Klinghardt

Dark brown: severe defoliation during the 2005-2008 outbreak

Post et al. 2009, *Science*
Abisko, Sweden
Comparison of larval feeding and mimicked herbivory effects on *Betula nana* volatiles

*Epirrita autumnata*

Methyl jasmonate (MeJA)

Proton transfer reaction-time of flight-mass spectrometer

Li et al. 2019. *Nature Plants*
Larval feeding and mimicked herbivory (MeJA-treatment) had similar effects on *induced* VOCs.
But MeJa-treatment did not mimic larval feeding effects on compounds released from broken tissue.
Effects of warming and herbivory on *Betula nana* volatiles
Warming amplifies effects of herbivory on *Betula nana* volatiles

![Graph showing the effect of warming and herbivory on Monoterpenes.](image)

Li et al. 2019. *Nature Plants*
Compound composition of *Betula nana* volatiles strongly altered by herbivory

Li et al. 2019. *Nature Plants*
Herbivory drastically increases VOC release especially under warmer climate but how does warming impact herbivory?
Effects of warming on herbivory

Leaf area loss estimated in 3 B. nana twigs per plot

Li, Rinnan et al. unpubl. data
OTC warming strongly increases leaf area loss due to chewing insects

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf area loss (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>W</td>
<td>C</td>
<td>W</td>
</tr>
</tbody>
</table>

Li, Rinnan et al. unpubl. data
Take-home messages

• Biotic stress (insect herbivory) drastically increases VOC release from *B. nana*
  
  Induced production
  
  changed compound composition

• Warming amplifies the herbivory effects

• OTCs increase herbivory damage

Importance on atmospheric chemistry and climate? Implications on ecological interactions?
Thank you!
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