Supplement of

Brief Communication: The reliability of gas extraction techniques for analysing \(\text{CH}_4\) and \(\text{N}_2\text{O}\) compositions in gas trapped in permafrost ice wedges

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Figure S1. The site locations of the ground ice samples used in this study are marked in the map of circum-Arctic permafrost (Brown et al., 2002), Yedoma distributions (Strauss et al., 2016), and major rivers.

Figure S2. Images of ground ice outcrops at Churapcha (central Yakutia) site. Locations of the samples used in this study are indicated by yellow dotted circles.
Figure S3. Images of ground ice outcrops at Cyuie (central Yakutia) sites: (a) ice wedge outcrop, (b) CYC and (c) CYB samples. Locations of the samples used in this study are indicated by yellow dotted lines.

Figure S4. Images of ground ice outcrops at Zyryanka sites: (a and b) Zy-A, (c) Zy-B, and (d) Zy-F. Locations of the samples used in this study are indicated by yellow dotted lines.
**Figure S5.** Images of ground ice outcrops at northern Alaskan sites: (a) Bluff03 and (b) Bluff06. Locations of the samples used in this study are indicated by yellow dotted boxes.

**Figure S6.** Schematic diagram of needle-crusher method together with enlarged photographs of crushing needles (left top), and extraction chamber (left bottom). The detailed descriptions about the SNU dry extraction system can be found elsewhere in Ahn et al. (2009) and Shin (2014).
Figure S7. Schematic diagram of melting-refreezing (wet extraction) procedure used in this study. More details about the wet extraction line and GC systems are described in Yang et al. (2017) and Ryu et al. (2018).
Table S1. Comparison of CH₄ and N₂O results from extracted gas from control wet extraction method and the dry (hit5) extraction method plotted in Figures 1(a to d).

| Site Location          | Sample     | soil content wt. % | wet-control CH₄ ppm | dry-hit5 CH₄ ppm | wet-control N₂O nmol/kg | dry-hit5 N₂O nmol/kg |
|------------------------|------------|--------------------|----------------------|------------------|-------------------------|----------------------|
| Zyryanka, Northeastern Siberia | Zy-F-1     | 0.618              | 1080                 | 651              | 655.6                   | 316                  |
|                        | Zy-B-Low-B | 0.107              | 18030                | 23400            | 21010                   | 29900                |
|                        | Zy-A-W1-Low| 0.049              | 4309                 | 5890             | 5073                    | 8390                 |
|                        | Zy-A-W1-D  | 0.155              | 6138                 | 5530             | 3713                    | 2890                 |
| Northern Alaska        | Bluft06-B3 | 0.078              | 558.7                | 678              | 164.2                   | 204                  |
|                        | CYB-04-C   | 0.498              | 20.2                 | 25.5             | 48.4                    | 88.3                 |
|                        | CYB-03-A   | 0.423              | 20.4                 | 24.0             | 21.5                    | 30.5                 |
|                        | CYB-06-A   | 0.387              | 35.0                 | 52.0             | 15.5                    | 21.2                 |
|                        | CYB-05-C   | 1.20               | 19.4                 | 23.4             | 13.1                    | 21.8                 |
|                        | CYB-02-D   | 0.287              | 7.4                  | 13               | 9.2                     | 11                   |
|                        | CYB-04-D   | 0.345              | 10.5                 | 17.7             | 10.3                    | 15.8                 |
|                        | CYB-04-A   | 0.618              | 7.1                  | 12               | 7.1                     | 4.9                  |
|                        | CYC-01-B   | 0.252              | 18.0                 | 20               | 18.3                    | 23.6                 |
|                        | CYC-02-A   | 0.418              | 8.0                  | 13               | 8.3                     | 10                   |
|                        | CYC-03-B   | 0.836              | 14.0                 | 22.6             | 17.8                    | 24.5                 |
|                        | CYC-01-C   | 0.374              | 13.9                 | 19.0             | 17.4                    | 18.1                 |
|                        | CYC-03-C   | 1.08               | 30.9                 | 37.5             | 32.5                    | 32.5                 |
|                        | CYC-02-B   | 1.12               | 30.3                 | 44.0             | 12.1                    | 13.0                 |
|                        | CYC-02-C   | 0.306              | 119.0                | 132              | 5.9                     | 6.2                  |
|                        | CYC-02-D   | 0.572              | 29.4                 | 34.1             | 29.8                    | 18.6                 |
| Churapcha, Central Yakutia | C04       | 1.38               | 7.0                  | 14               | 9.2                     | 14                   |
|                        | C07        | 0.328              | 4.9                  | 10               | 4.8                     | 11                   |
|                        | C08        | 0.620              | 5.3                  | 8.9              | 5.0                     | 7.8                  |
|                        | C10        | 0.269              | 5.5                  | 9.3              | 7.1                     | 14                   |
|                        | C12        | 0.253              | 3.2                  | 5.4              | 4.4                     | 5.5                  |
|                        | C18        | 0.582              | 3.4                  | 4.9              | 4.6                     | 7.9                  |
|                        | C19        | 0.433              | 3.3                  | 4.7              | 4.6                     | 10                   |
|                        | C30        | 1.03               | 4.4                  | 8.2              | 5.7                     | 10                   |
Table S2. Comparison of CH₄ and N₂O results from extracted gas from control wet extraction and HgCl₂-treated wet extraction method plotted in Figures 1(e to f).

| Site Location | Sample   | Soil content | Wet-control CH₄ | Wet-HgCl₂ CH₄ | Wet-control N₂O | Wet-HgCl₂ N₂O |
|---------------|----------|--------------|-----------------|---------------|-----------------|---------------|
| Zyryanka, Northeastern Siberia | Zy-A-W1-D | 0.155 wt. % | 6138 ppm | 2605 ppm | 11.37 ppm | 15.25 ppm |
|               | Zy-B-Low-D | 0.251 wt. % | 10620 ppm | 7355 ppm | 2.14 ppm | 1.447 ppm |
|               | Zy-A-W1-Low | 0.049 wt. % | 4309 ppm | 4449 ppm | 2.07 ppm | 2.261 ppm |
|               | Zy-F-1 | 0.618 wt. % | 1080 ppm | 1427 ppm | 1.57 ppm | 2.069 ppm |
|               | Zy-B-Low-B | 0.107 wt. % | 18030 ppm | 22780 ppm | 5.37 ppm | 5.331 ppm |
| Northern Alaska | Bluff06-B3 | 0.078 wt. % | 558.7 ppm | 422.1 ppm | 3.74 ppm | 10.26 ppm |
|               | Bluff06-B1 | 0.077 wt. % | 2003 ppm | 1741 ppm | 1.13 ppm | 1.248 ppm |
|               | Bluff03-IW1 | 2.07 wt. % | 44160 ppm | 18540 ppm | 5.58 ppm | 1.788 ppm |
|               | Bluff06-B2 | 0.007 wt. % | 589.2 ppm | 808.1 ppm | 1.32 ppm | 2.026 ppm |
| Cyuie, Central Yakutia | CYB-01-A | 0.700 wt. % | 17.3 ppm | 16.97 ppm | 0.94 ppm | 0.842 ppm |
|               | CYB-04-A | 0.618 wt. % | 7.1 ppm | 7.52 ppm | 0.81 ppm | 0.799 ppm |
|               | CYB-04-C | 0.498 wt. % | 20.2 ppm | 16.71 ppm | 0.71 ppm | 0.767 ppm |
|               | CYC-01-B | 0.252 wt. % | 18.0 ppm | 4.76 ppm | 1.55 ppm | 0.544 ppm |
|               | CYC-02-C | 0.306 wt. % | 119.0 ppm | 9.83 ppm | 0.66 ppm | 0.791 ppm |
|               | CYC-02-D | 0.572 wt. % | 29.4 ppm | 29.30 ppm | 1.53 ppm | 1.193 ppm |
References not cited in main text

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