# **Supplemental material**

Sources and sinks of methane in sea ice: insights from stable isotopes

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Table S1. Summary of the sensitivity parameters tested with the one-box model, considering an initial CH4 concentration in bulk ice of 9.1 nM, characterized by a δ13C value of –68.5 ‰ and a δD value of –239 ‰.

|  |  |  |  |
| --- | --- | --- | --- |
| **δ13C-CH4 MOg (‰ vs VPDB)** | **MOg rate/MOx rate** | **εC MOx** | **Figure** |
| –66 | 0.33 | 13 | Fig. S1 |
| 0.66 |
| 1 |
| 0.33 | 30 |
| 0.66 |
| 1 |
| –40 | 0.33 | 13 | Fig. S2 |
| 0.66 |
| 1 |
| 0.33 | 30 |
| 0.66 |
| 1 |
| **δ13C-CH4 S (‰ vs VPDB)** | **S rate/MOx rate** | **εC MOx** | **Figure** |
| –66 | 0.33 | 13 | Fig. S3 |
| 0.66 |
| 1 |
| 0.33 | 30 |
| 0.66 |
| 1 |
| **δD-CH4 MOg (‰ vs VSMOW)** | **MOg rate/MOx rate** | **εD MOx** | **Figure** |
| –239 | 0.33 | 97 | Fig. S4 |
| 0.66 |
| 1 |
| 0.33 | 350 |
| 0.66 |
| 1 |
| –100 | 0.33 | 97 | Fig. S5 |
| 0.66 |
| 1 |
| 0.33 | 350 |
| 0.66 |
| 1 |
| **δD-CH4 S (‰ vs VSMOW)** | **S rate/MOx rate** | **εD MOx** | **Figure** |
| –250 | 0.33 | 97 | Fig. S6 |
| 0.66 |
| 1 |
| 0.33 | 350 |
| 0.66 |
| 1 |



Figure S1. δ13C-CH4 signatures (‰ vs VPDB) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on the April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of in situ CH4 production with a δ13C value of 66 ‰, typical of methanogenesis (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εc = 13 (black) or εc = 30 (grey), with increasing microbial production-to-oxidation ratios (MOg/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).



Figure S2. δ13C-CH4 signatures (‰ vs VPDB) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of in situ CH4 production with an atypically high δ13C value of 40 ‰ (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εc = 13 (black) or εc = 30 (grey), with increasing microbial production-to-oxidation ratios (MOg/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).



Figure S3. δ13C-CH4 signatures (‰ vs VPDB) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of CH4 supply via bubbles or diffusive exchange from underlying seawater with a δ13C value of 66 ‰ (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εc = 13 (black) or εc = 30 (grey), with increasing supply-to-microbial oxidation ratios (S/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).



Figure S4. δ2H-CH4 signatures (‰ vs VSMOW) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of in situ CH4 production with a δ2H value of 239 ‰, typical of methanogenesis (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εH = 97 (black) or εH = 350 (grey), with increasing microbial production-to-oxidation ratios (MOg/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).



Figure S5. δ2H-CH4 signatures (‰ vs VSMOW) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of in situ CH4 production with an atypically high δ2H value of 100 ‰ (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εH = 97 (black) or εH = 350 (grey), with increasing microbial production-to-oxidation ratios (MOg/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).



Figure S6. δ2H-CH4 signatures (‰ vs VSMOW) as a function of ln(f) (where f is the remaining fraction of CH4 ice), measured in Barrow sea-ice cores collected on April 3 (blue), May 8 (orange) and June 5 (red). We tested the impact of CH4 supply via bubbles or diffusive exchange from underlying seawater with a δ2H value of 250 ‰ (dotted lines), on the trend imposed by microbial oxidation (solid lines) with an isotopic fractionation εH = 97 (black) or εH = 350 (grey), with increasing supply-to-microbial oxidation ratios (S/MOx) from the left to the right panel (1/3, 2/3 and 1, respectively).