



Supplement of

Assessing methane emissions for northern peatlands in ORCHIDEE-PEAT revision 7020

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Table S1. Prior and posterior uncertainties for parameters at sites for the single site optimization. Prior uncertainties values are indicated in parenthesis.

| | q _{MG} | k _{MT} | M _{rox} | Z _{root} | T _{veg} | wsize | mxr _{CH4} |
|----------------|-----------------|-----------------|------------------|-------------------|------------------|-----------|--------------------|
| Prior | (0.8) | (1.60) | (0.4) | (0.196) | (6.00) | (0.0396) | (0.28) |
| US-Los | 0.80 | 0.00019 | 0.13 | 0.196 | 6.00 | 0.040 | 0.19 |
| DE-spw | 0.80 | 1.56 | 0.40 | 0.196 | 0.012 | 0.0015 | 0.19 |
| DE-Sfn | 0.17 | 0.0023 | 0.00025 | 0.196 | 0.0077 | 0.00023 | 0.089 |
| DE-Zrk | 0.80 | 0.0023 | 0.093 | 0.195 | 5.95 | 0.0043 | 0.19 |
| CA-Wp1 | 0.79 | 0.00019 | 0.084 | 0.151 | 0.77 | 0.0043 | 0.065 |
| US-Bog | 0.00015 | 0.00019 | 0.0000053 | 0.130 | 5.38 | 0.040 | 0.19 |
| FR-Lag | 0.79 | 0.022 | 0.022 | 0.190 | 2.22 | 0.040 | 0.19 |
| DE-Hmm | 0.75 | 2.23 | 0.14 | 0.124 | 3.16 | 0.0038 | 0.19 |
| FI-Lom | 0.0032 | 0.00014 | 0.00017 | 0.067 | 3.04 | 0.0029 | 0.033 |
| PL-Kpt | 0.49 | 0.00019 | 0.092 | 0.00544 | 0.16 | 0.000043 | 0.0021 |
| RU-che | 0.00025 | 0.00019 | 0.000029 | 0.0000109 | 0.00042 | 0.040 | 0.19 |
| Prior(DK-Nuf) | (1.6) | (1.60) | (0.4) | (0.296) | (16.0) | (0.040) | (0.28) |
| DK-NuF | 0.00053 | 0.00021 | 0.0000060 | 0.0000311 | 0.0012 | 0.0000032 | 0.000071 |
| Prior (PL-Wet) | (4.00) | (4.23) | (0.4) | (0.196) | (6.00) | (0.0396) | (0.192) |
| PL-Wet | 0.58 | 0.00019 | 0.0056 | 0.0355 | 5.59 | 0.033 | 0.13 |
| Prior (US-Wpt) | (1.6) | (2.84) | (0.4) | (0.196) | (16.0) | (0.0396) | (0.192) |
| US-Wpt | 0.0083 | 0.00019 | 0.0000010 | 0.196 | 16.00 | 0.0000070 | 0.13 |

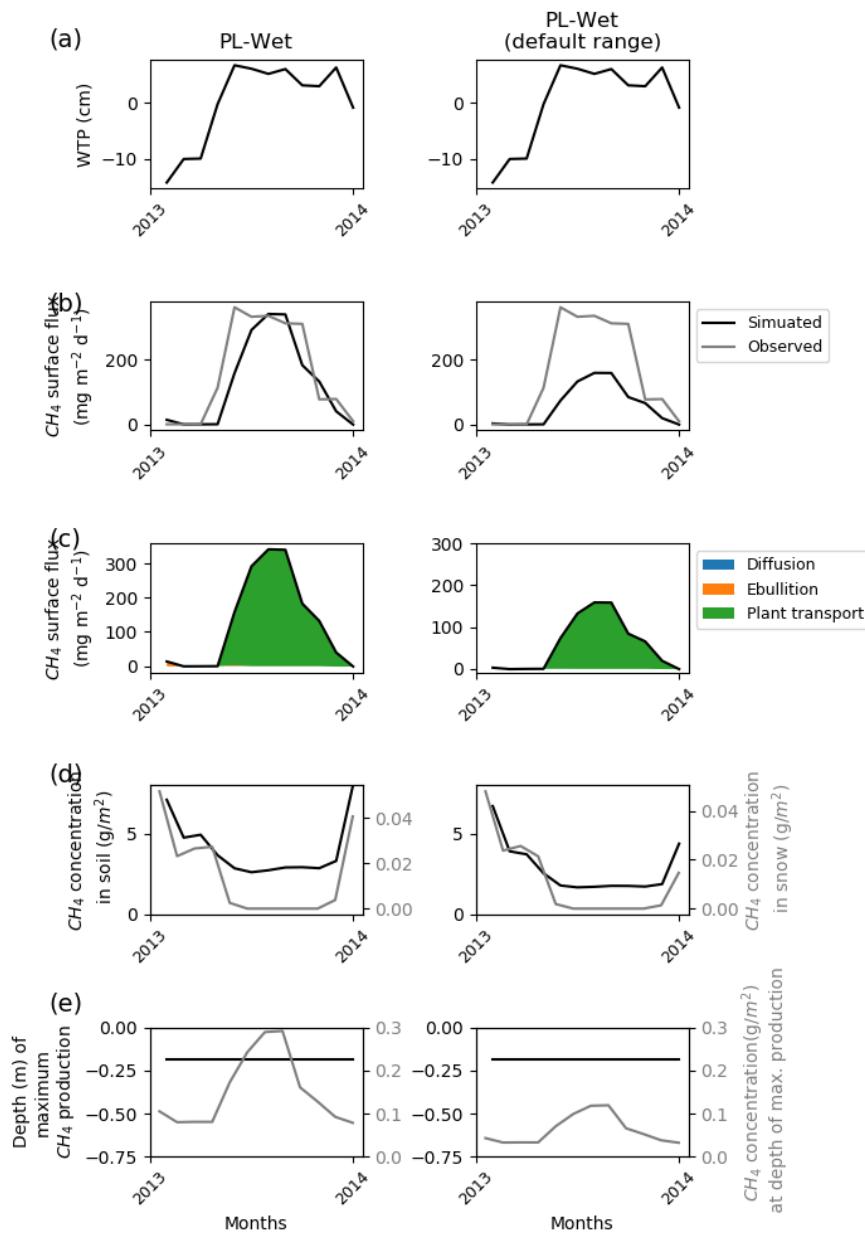


Fig.S1. Temporal distribution of methane at PL-Wet using optimized parameters (see Table S1) defined from an extended range (right) and from the default range (left). (a) Simulated water table position estimated from the soil water content; (b) Simulated (dark line) and observed (gray line) methane emissions released to the atmosphere; (c) Cumulative amount of methane emitted by diffusion, plant mediated transport and ebullition; (d) Methane concentration in the soil layers (dark line) and in the snow layers (gray line); (e) On the left, depth at which methane production is the highest in the soil, scaled to the maximum peat depth. On the right, the amount of methane produced at these depths.

Table S2. Single site prior and optimized values of methane scheme parameters for PL-Wet. Discrepancies between methane emissions observed and simulated are quantified by the root mean square difference (RMSD). Minimization efficiency of each test is indicated by the relationship between the prior using default values and posterior RMSD: (1 - RMSD_{post} / RMSD_{prior})x100.

| Parameters | Units | PL-Wet A | | PL-Wet (default range) | |
|--|------------|------------------|--------|------------------------|--------|
| | | prior | post | prior | post |
| q _{MG} | proportion | 10.0 (1.0, 11.0) | 4.0 | 10.0 | 9.8 |
| k _{MT} | 1/s | 1.3 | 2.0 | 1.3 | 1.5 |
| M _{rox} | fraction | 0.5 | 0.165 | 0.5 | 0.030 |
| Z _{root} | m | 0.3 | 0.328 | 0.3 | 0.330 |
| T _{veg} | proportion | 5.0 | 6.0 | 7.0 | 7.4 |
| wsize | m | 0.01 | 0.0110 | 0.01 | 0.0111 |
| mxrCH ₄ | fraction | 0.15 | 0.136 | 0.25 | 0.244 |
| RMSD | | 183.0 | 80.5 | 267.6 | 227.4 |
| 1-(RMSD _{post} /RMSD _{prior}) | % | | 56.04 | | 15.02 |

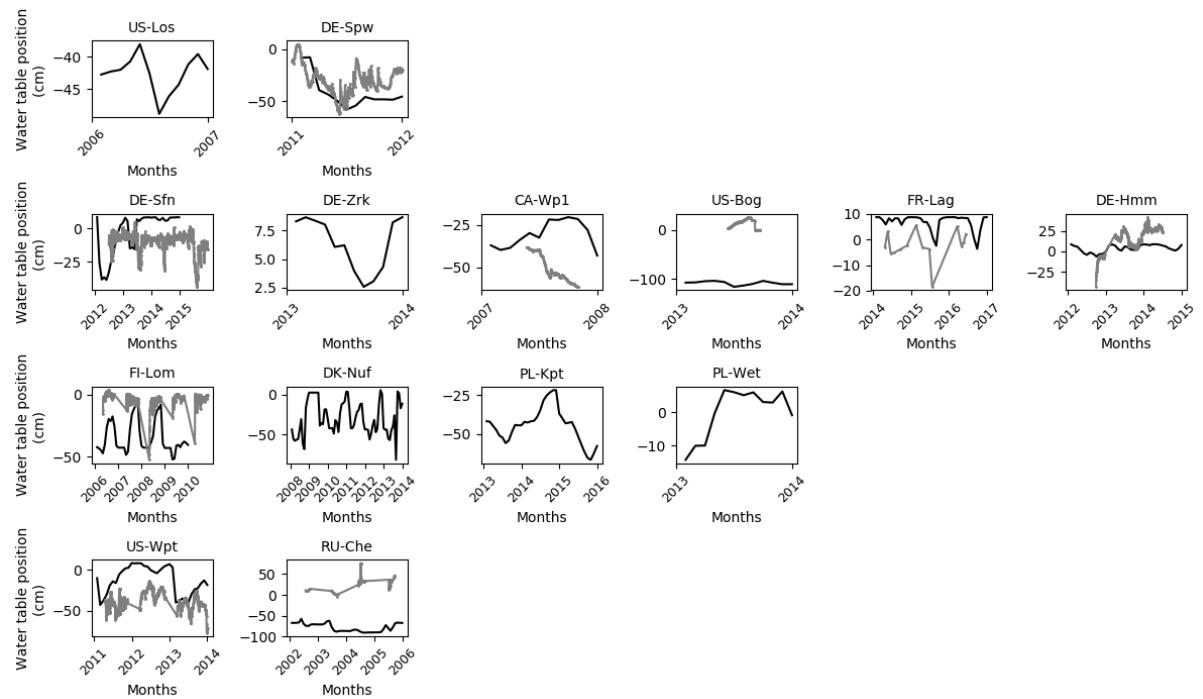


Fig. S2: Simulated (dark line) and observed (gray line) water table position.

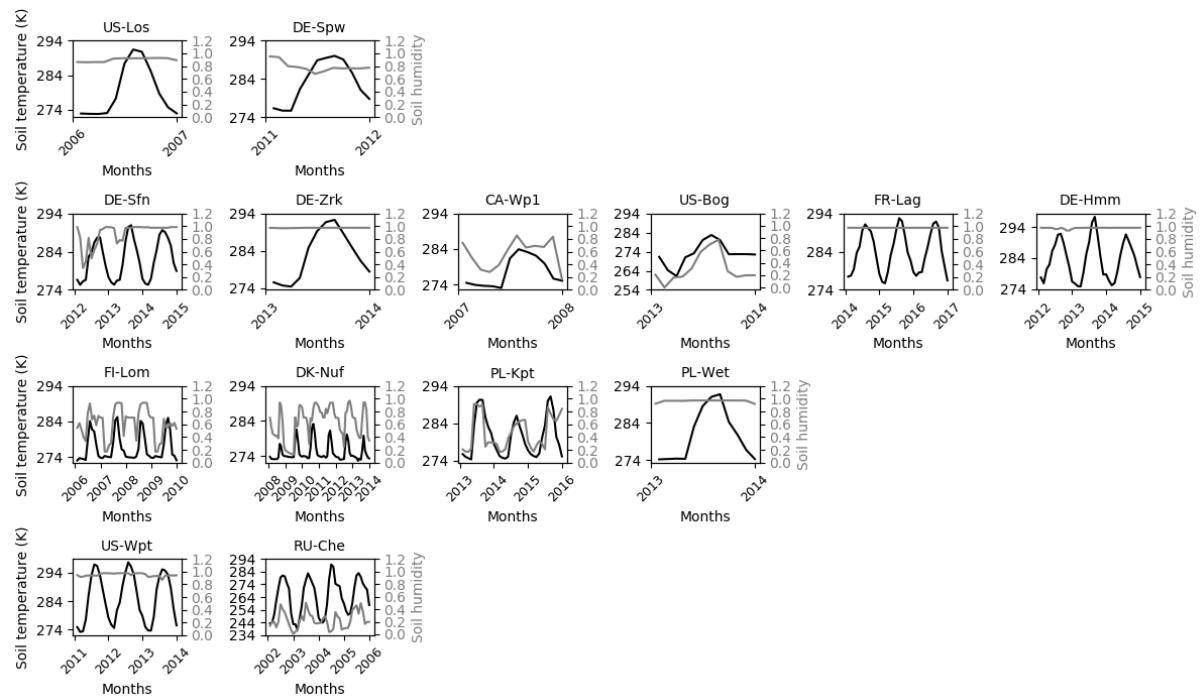


Fig. S3: Soil temperature (dark line) and soil moisture (gray line) at the depth of maximum methane production.

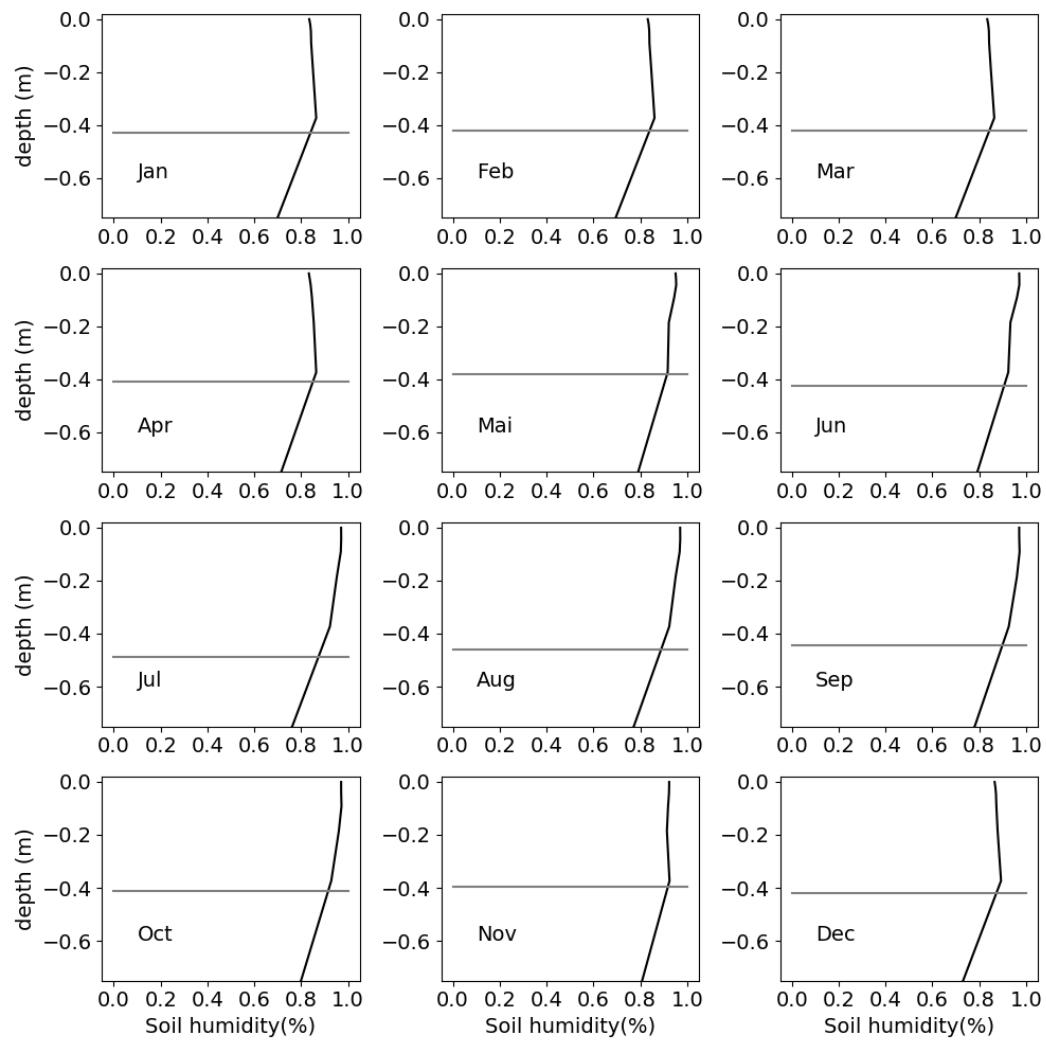


Fig. S4: Monthly soil moisture profiles (solid line) and water table position (grey line) at US-Los.

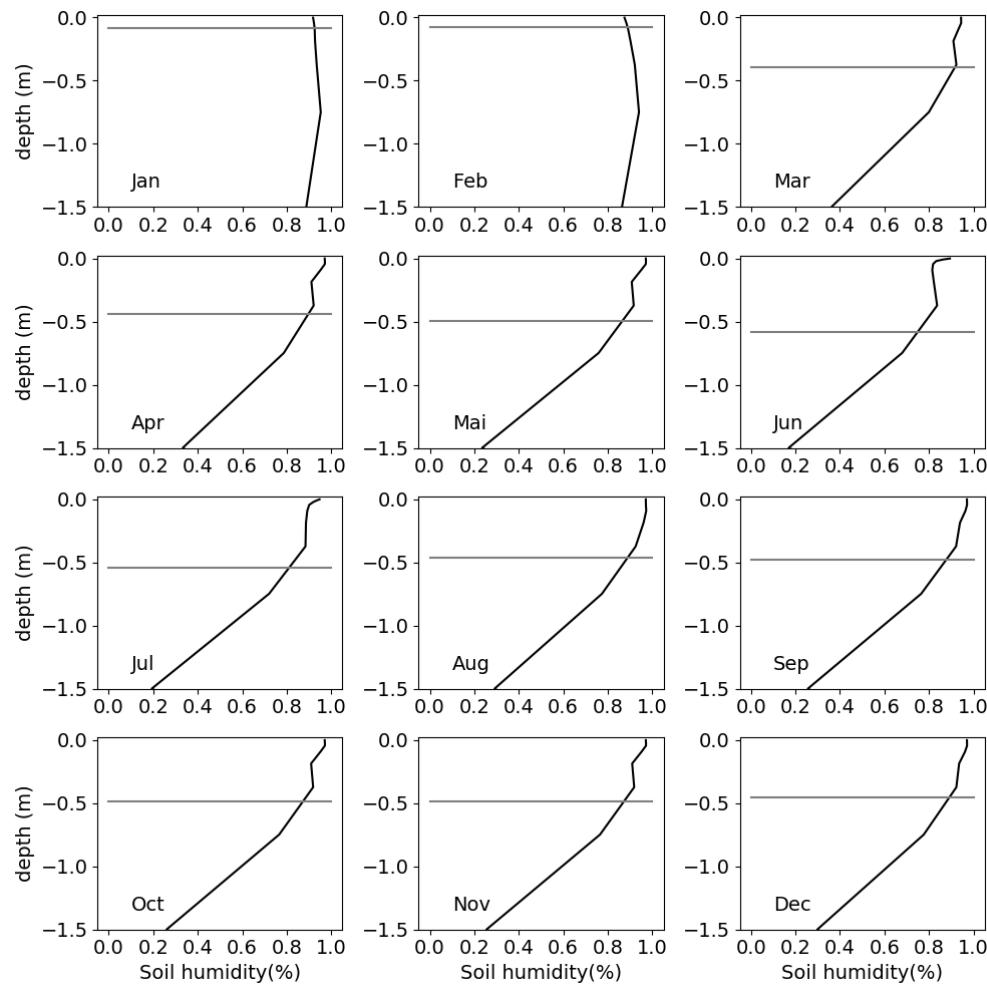


Fig. S5: Monthly soil moisture profiles (solid line) and water table position (grey line) at DE-Spw.

Table S3. Root mean square difference (RMSD) of the first optimization prior and the last optimization posterior. The relationship between the prior using default values and posterior RMSD: $(1 - \text{RMSD}_{\text{post}} / \text{RMSD}_{\text{prior}}) \times 100$ indicates minimization efficiency of the successive optimization runs.

| Sites identification | RMSDprior | RMSDpost | $1 - (\text{RMSD}_{\text{post}} / \text{RMSD}_{\text{prior}})$ % |
|----------------------|-----------|----------|---|
| US-Los | 69.6 | 1.1 | 98.44 |
| DE-spw | 687.9 | 9.5 | 98.62 |
| DE-Sfn | 263.3 | 9.2 | 96.50 |
| DE-Zrk | 16.2 | 4.6 | 71.44 |
| CA-Wp1 | 73.6 | 11.8 | 84.03 |
| US-Bog | 33.0 | 6.7 | 79.82 |
| FR-Lag | 91.4 | 23.0 | 74.86 |
| DE-Hmm | 34.4 | 25.3 | 26.34 |
| FI-Lom | 44.0 | 38.3 | 12.93 |
| DK-NuF | 44.6 | 40.1 | 9.97 |
| PL-Kpt | 146.5 | 54.6 | 62.70 |
| PL-Wet | 181.3 | 80.5 | 55.63 |
| US-Wpt | 265.5 | 249.0 | 6.21 |
| RU-che | 157.4 | 139.7 | 11.25 |

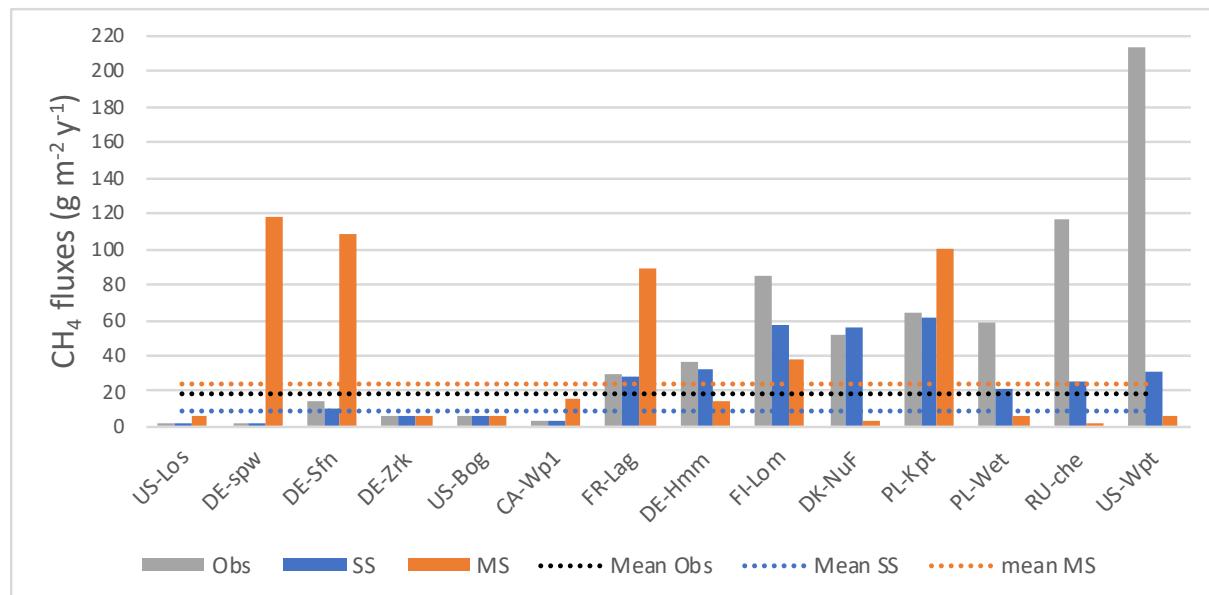


Fig. S6: Annual methane emissions defined from the observed data (Obs in grey), from simulations employing optimized parameters obtained by the single site optimization (SS in blue) and by multi-site optimization (MS in orange). Dotted lines indicate the mean values of annual methane fluxes across sites.

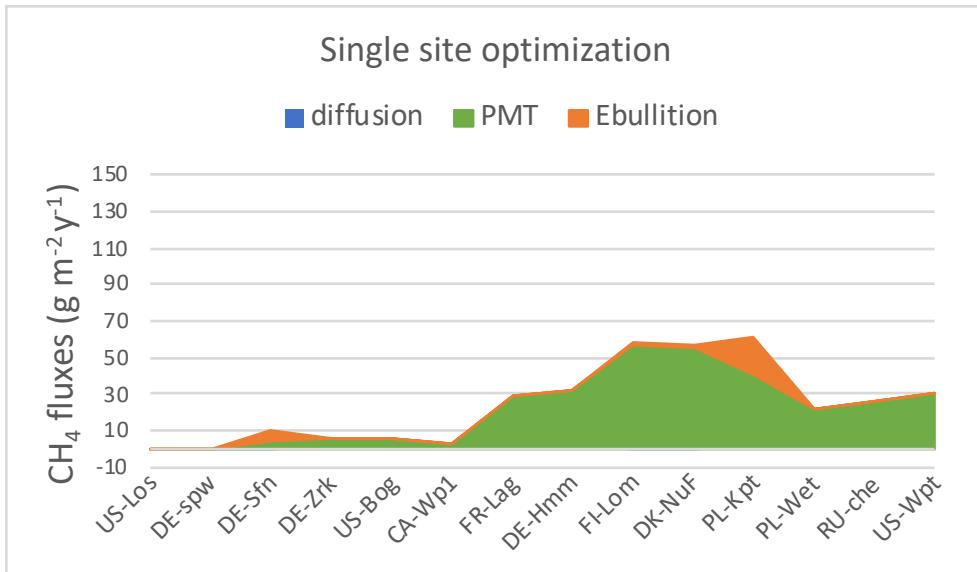


Fig. S7: Stacked area of annual methane fluxes by type of transport process, diffusion, plant mediated transport (PMT) and ebullition for the single site optimization simulations.

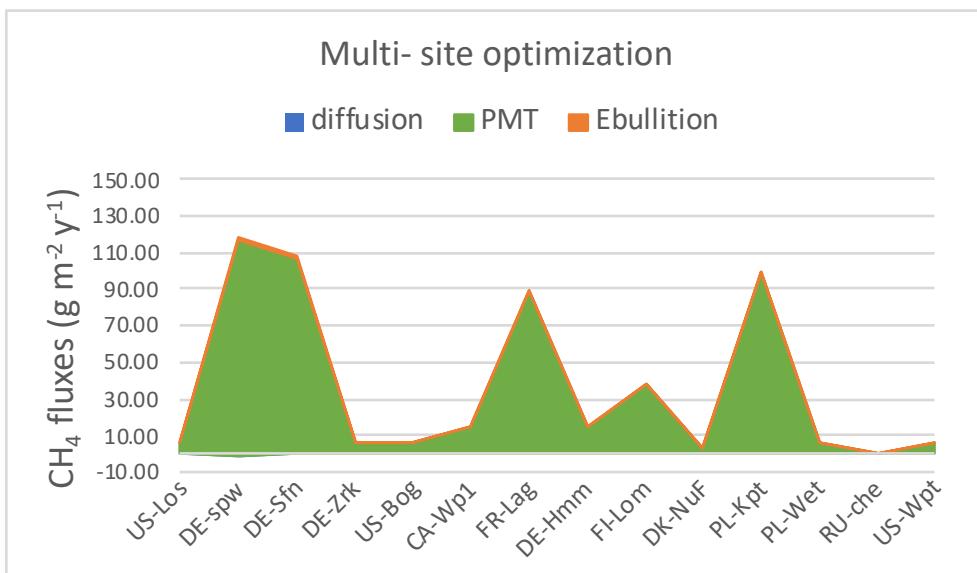


Fig. S8: Stacked area of annual methane fluxes by type of transport process, diffusion, plant mediated transport (PMT) and ebullition for the multi-site optimization simulations.

Table S4. Multi-site prior using extended ranges and optimized values of methane scheme parameters. Parameters description and references are in Table3.

| Parameters | Unit | Prior values | Prior ranges | Posterior values |
|-------------------|------------|--------------|--------------|------------------|
| q _{MG} | proportion | 9.28 | 1.0, 11.0 | 7.63 |
| k _{MT} | 1/d | 2.59 | 1.0, 8.1 | 3.80 |
| M _{rox} | fraction | 0.44 | 0.0, 1.0 | 0.76 |
| Z _{root} | m | 0.27 | 0.01, 0.5 | 0.25 |
| T _{veg} | proportion | 6.99 | 0.0, 40.0 | 12.16 |
| wsize | m | 0.0088 | 0.001, 0.1 | 0.0010 |
| mXRCH4 | fraction | 0.24 | 0.05, 0.75 | 0.25 |

Table S5. Evaluation of gaps between methane emissions observed and simulated of single site (RMSD_{SS}) and multi-site (RMSD_{MS}) optimizations. Minimization efficiency of each test are indicated by the relationship between the RMSD from the single site simulation and RMSD obtained for the multi-site simulation.

| | RMSD _{SS} | RMSD _{MS} | RMSD _{MS} / RMSD _{SS} |
|--------|--------------------|--------------------|---|
| US-Los | 1.1 | 36.55 | 33.7 |
| DE-spw | 9.5 | 345.9 | 36.4 |
| DE-Sfn | 9.2 | 134.10 | 14.6 |
| DE-Zrk | 4.6 | 4.91 | 1.1 |
| US-Bog | 6.7 | 19.44 | 2.9 |
| CA-Wp1 | 11.8 | 44.12 | 3.8 |
| FR-Lag | 23.0 | 41.22 | 1.8 |
| DE-Hmm | 25.3 | 10.1 | 0.4 |
| FI-Lom | 38.3 | 48.59 | 1.3 |
| DK-NuF | 40.1 | 44.79 | 1.1 |
| PL-Kpt | 54.6 | 65.79 | 1.2 |
| PL-Wet | 80.5 | 174.30 | 2.2 |
| RU-che | 139.7 | 157.80 | 1.1 |
| US-Wpt | 249.0 | 273.10 | 1.1 |

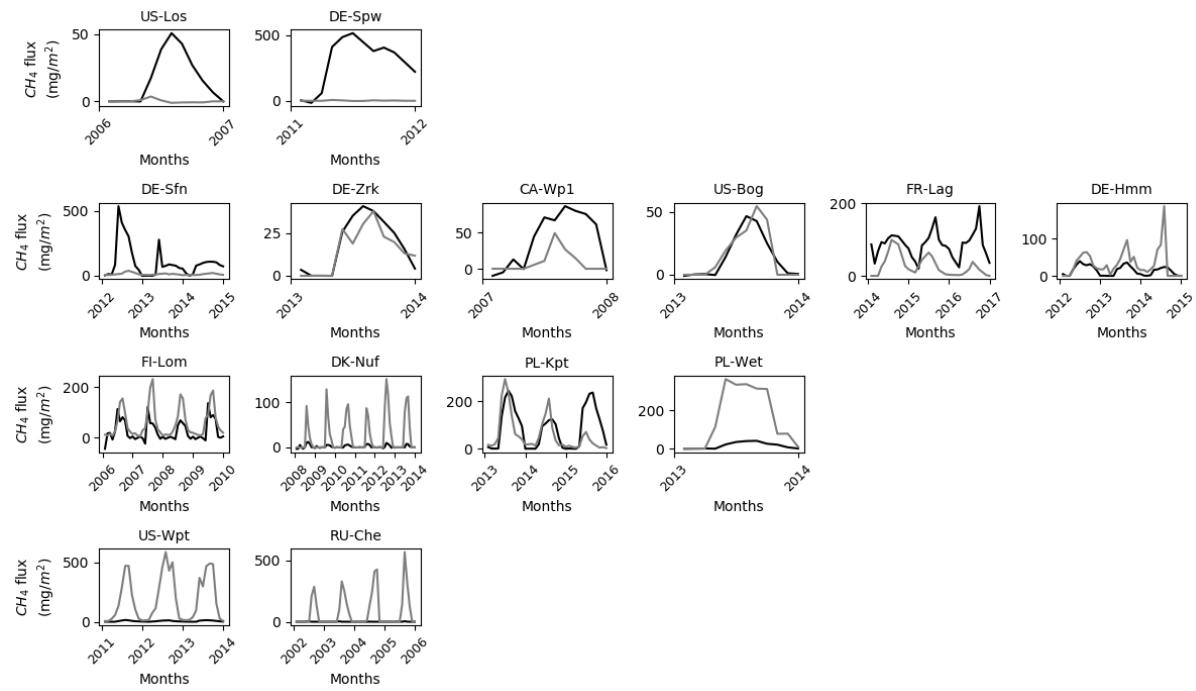


Fig. S9: Simulated (dark line) and observed (gray line) methane emissions using multi-site optimized parameters obtained with extended ranges values defined in Table S3.

Table S6. Annual methane emissions defined from the observed data (Obs), from simulations employing optimized parameters obtained by the single site optimization (SSO) and by multi-site optimization (MSO) using the extended range. The methane fluxes combine methane emitted by diffusion, plant mediated transport and ebullition.

| Site | Data | CH ₄ fluxes g m ⁻² y ⁻¹ | Diffusion g m ⁻² y ⁻¹ | Plant mediated transport g m ⁻² y ⁻¹ | Ebullition g m ⁻² y ⁻¹ |
|--------|------|---|--|---|---|
| US-Los | Obs | 0.05 | | | |
| | SSO | 0.01 | 0.003 | 0.01 | 0.0 |
| | MSO | 6.07 | -0.01 | 6.08 | 0.0 |
| DE-spw | Obs | 0.46 | | | |
| | SSO | 0.07 | -0.29 | 0.34 | 0.02 |
| | MSO | 109.51 | -0.50 | 107.32 | 2.70 |
| DE-Sfn | Obs | 14.01 | | | |
| | SSO | 9.63 | -0.22 | 5.03 | 4.82 |
| | MSO | 110.11 | -0.19 | 103.46 | 6.84 |
| DE-Zrk | Obs | 5.60 | | | |
| | SSO | 5.68 | -0.001 | 5.53 | 0.15 |
| | MSO | 6.74 | -0.002 | 6.63 | 0.11 |
| US-Bog | Obs | 5.74 | | | |
| | SSO | 5.48 | 0.05 | 5.44 | 0.0 |
| | MSO | 5.26 | 0.04 | 5.22 | 0.0 |
| CA-Wp1 | Obs | 3.29 | | | |
| | SSO | 3.19 | -0.12 | 3.12 | 0.19 |
| | MSO | 14.74 | -0.11 | 14.84 | 0.01 |
| FR-Lag | Obs | 9.91 | | | |
| | SSO | 9.57 | -0.01 | 9.58 | 0.0005 |
| | MSO | 31.40 | -0.003 | 31.32 | 0.0747 |
| DE-Hmm | Obs | 12.19 | | | |
| | SSO | 10.77 | -0.0015 | 10.68 | 0.09 |
| | MSO | 5.11 | -0.0001 | 5.06 | 0.05 |
| FI-Lom | Obs | 21.15 | | | |
| | SSO | 14.48 | -0.23 | 14.60 | 0.110 |
| | MSO | 9.14 | 0.05 | 9.08 | 0.002 |
| DK-NuF | Obs | 8.69 | | | |
| | SSO | 9.42 | -0.05 | 9.21 | 0.26 |
| | MSO | 1.82 | -0.03 | 1.50 | 0.35 |
| PL-Kpt | Obs | 21.22 | | | |
| | SSO | 20.35 | -0.03 | 13.78 | 6.61 |
| | MSO | 30.95 | -0.04 | 30.89 | 0.10 |
| PL-Wet | Obs | 58.96 | | | |
| | SSO | 21.31 | -0.042 | 21.25 | 0.096 |
| | MSO | 5.82 | 0.001 | 5.81 | 0.002 |
| RU-che | Obs | 38.92 | | | |
| | SSO | 8.46 | -0.0001 | 8.46 | 0.0 |
| | MSO | 0.17 | -0.0006 | 0.17 | 0.0 |
| US-Wpt | Obs | 53.40 | | | |
| | SSO | 7.61 | 0.0 | 7.61 | 0.0 |
| | MSO | 1.45 | 0.0 | 1.45 | 0.0 |

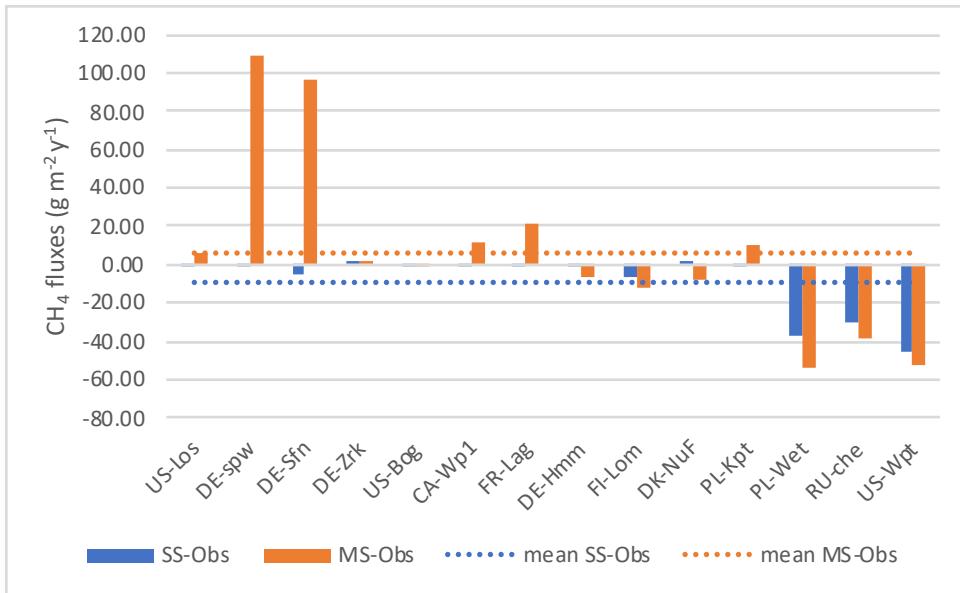


Figure S10: Difference in annual methane emissions between the observed data (Obs), and simulations employing optimized parameters obtained by the single site optimization (SSO) and by multi-site optimization (MSO) using the extended range.