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Tracing local natural gas oxidation by means of oxygen to carbon dioxide ratio measurements

Markus Leuenberger, Chiara Uglietti and Peter Nyfeler

Climate and Environmental Physics, Physics Institute, University of Bern, Switzerland

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Talk layout

- Measuring system for combined CO_2 and O_2 measurements
- Selected time intervals with high carbon oxidation factors (COFs)
- Carbon isotope signature of corresponding CO_2
- Methane budget for Berne city
- Conclusions and Outlook

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Combined CO_2 and O_2 system at Berne city (46°57’05’’N, 7°26’19’’E, 575 m.a.s.l.)

CO_2: Licor 7000 instrument

CO_2: Fuel cells (Oxzilla) and paramagnetic cell

Control: CO_2 and O_2 measurements on IRMS (DELTA^{plus}XP)

Combined CO_2 and O_2 records

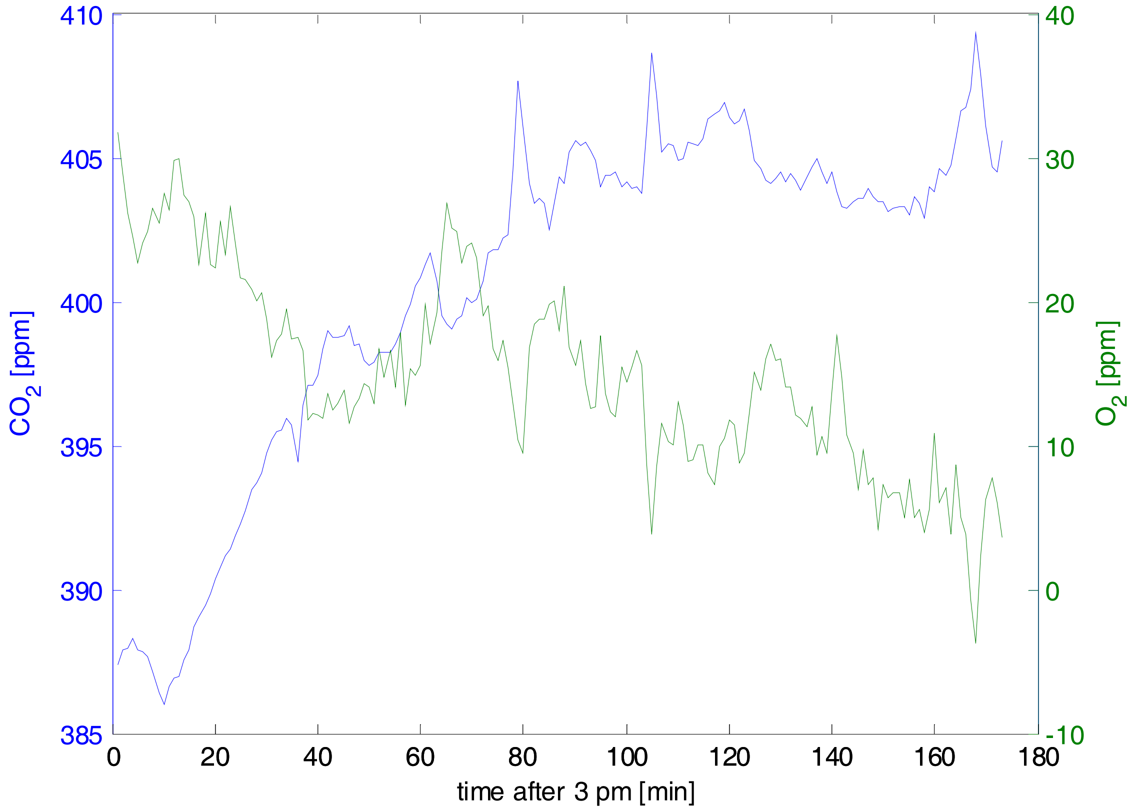

Fig. 1: Three hour interval of CO_2 and O_2 recordings (one minute averages) on the 1st of September 2008 at Berne

Combined CO_2 and O_2 records

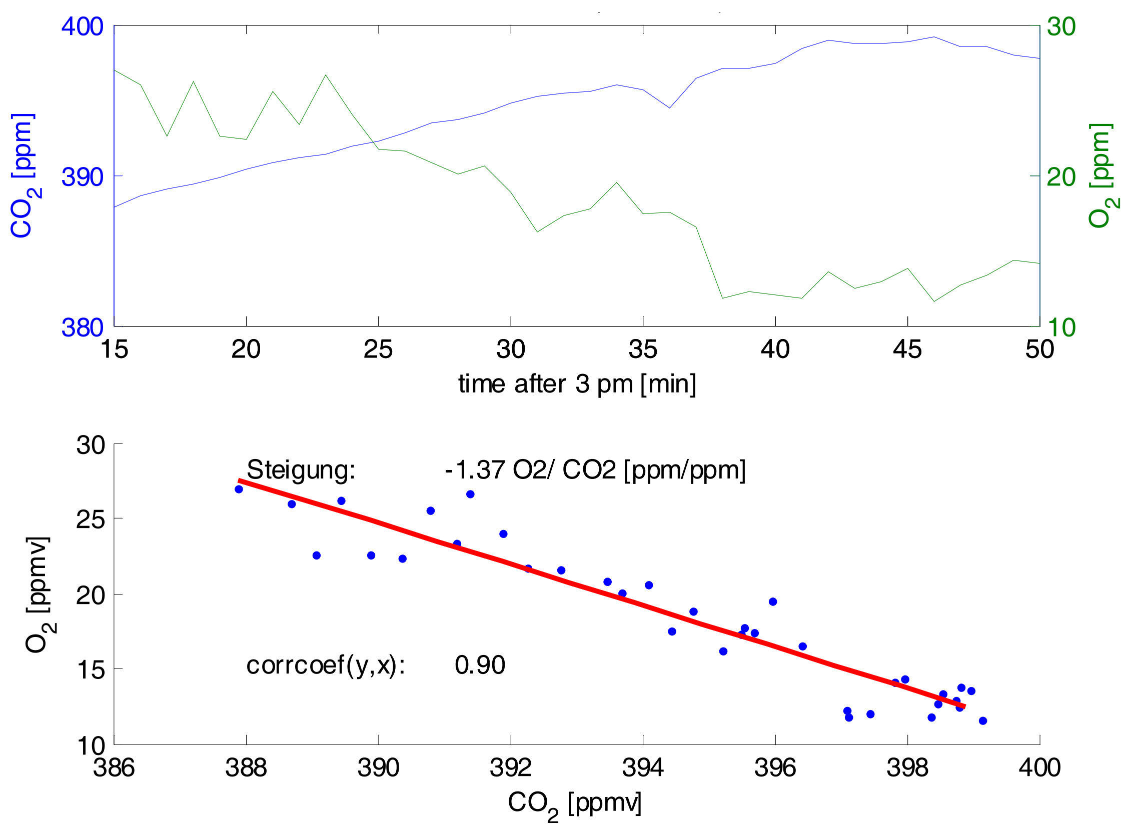

Fig. 2: Top, sectional display of the record given in Fig. 1. Bottom, correlation between O_2 and CO_2 with an apparent slope for normal fossil fuel mix oxidation.

Combined CO_2 and O_2 records

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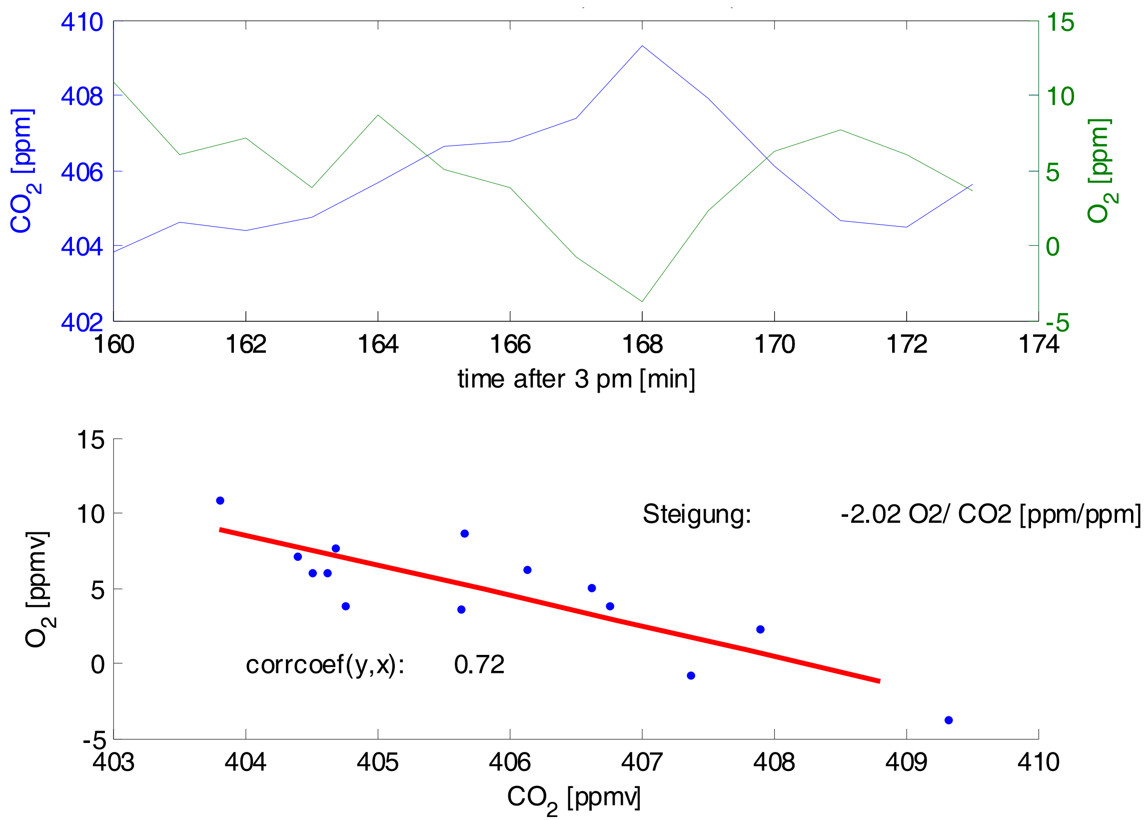

Fig. 3: Top, sectional display of the record given in Fig. 1. Bottom, correlation between O_2 and CO_2 with an apparent slope for methane oxidation.

Combined CO_2 and O_2 records

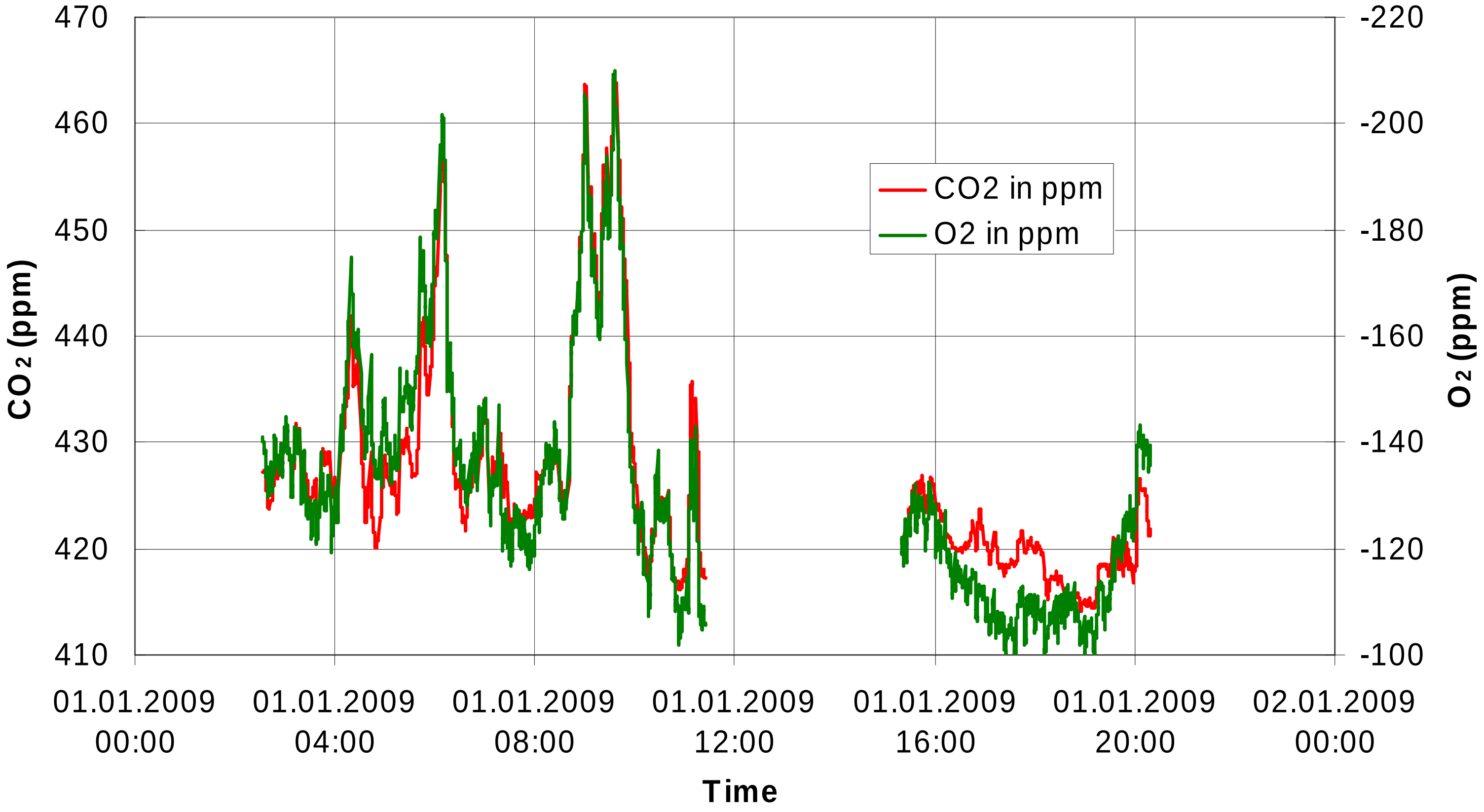

Fig. 4: A day interval of CO_2 and O_2 recordings (one minute averages) on the 1st of January 2009 at Berne

Combined CO_2 and O_2 records

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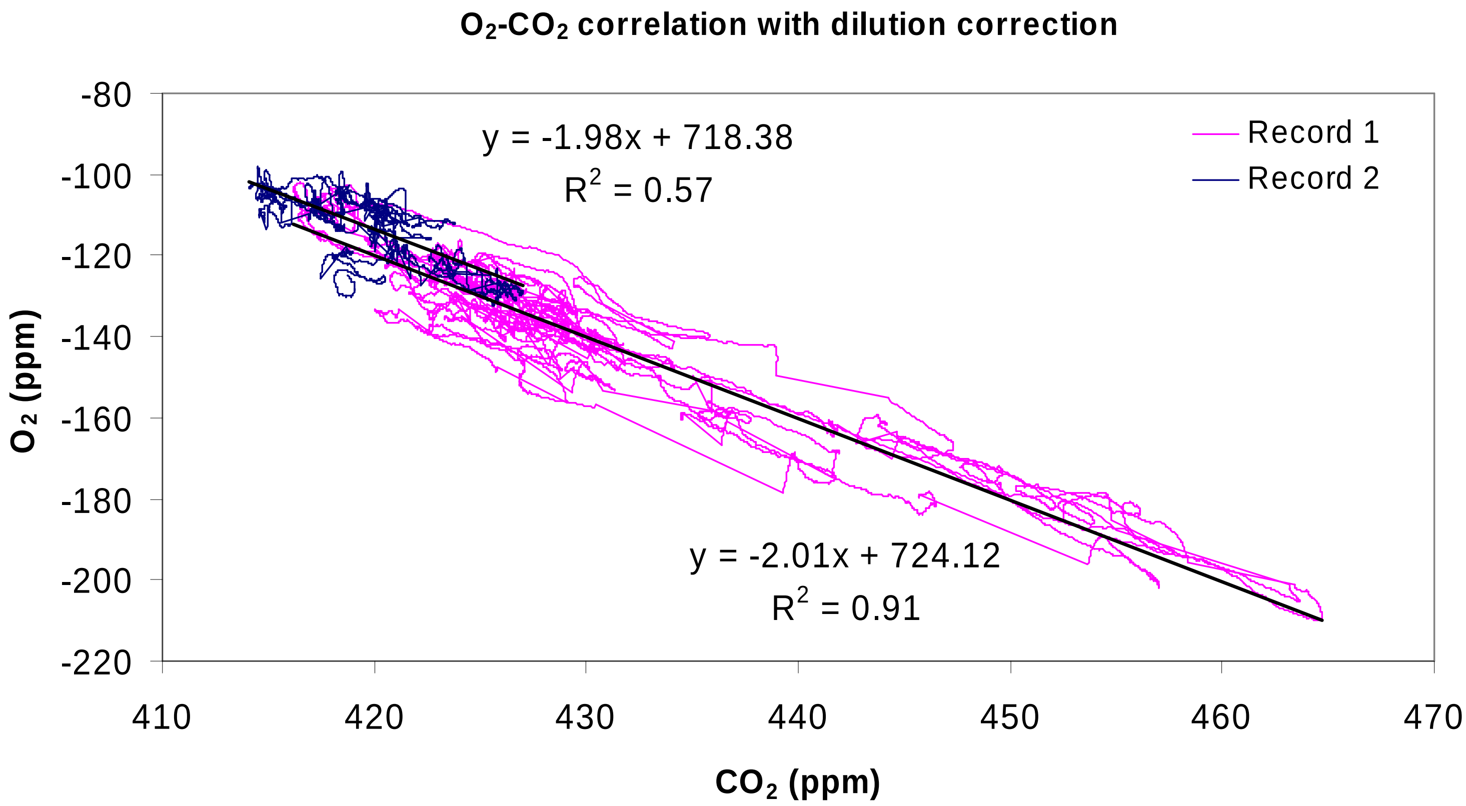

Fig. 5: COFs for the record shown in Fig. 4. Slopes indicate CH_4 oxidation

Combined CO_2 and $\delta^{13}C$ records

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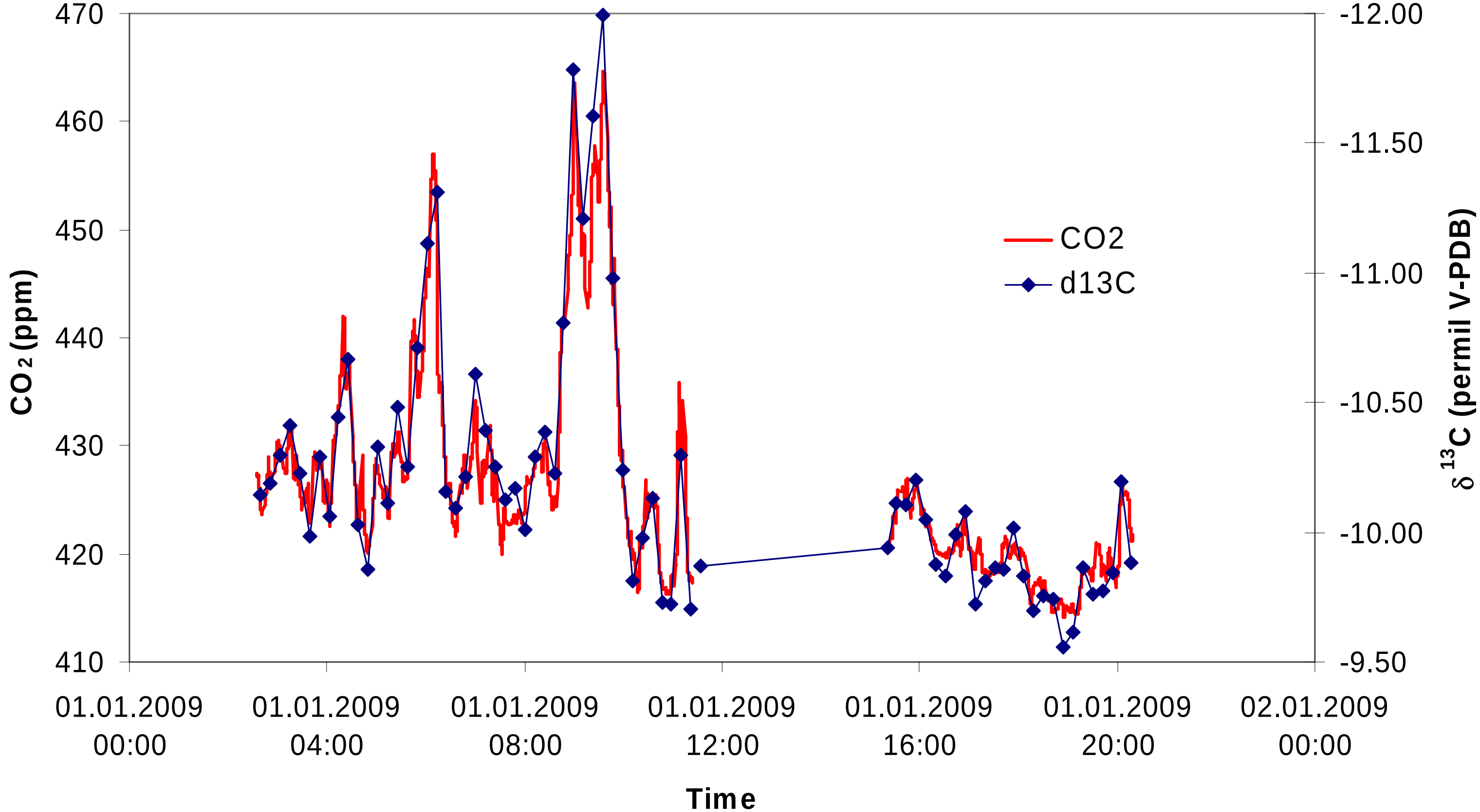

Fig. 6: Carbon isotope composition of measured CO_2.

Combined CO_2 and $\delta^{13}C$ records

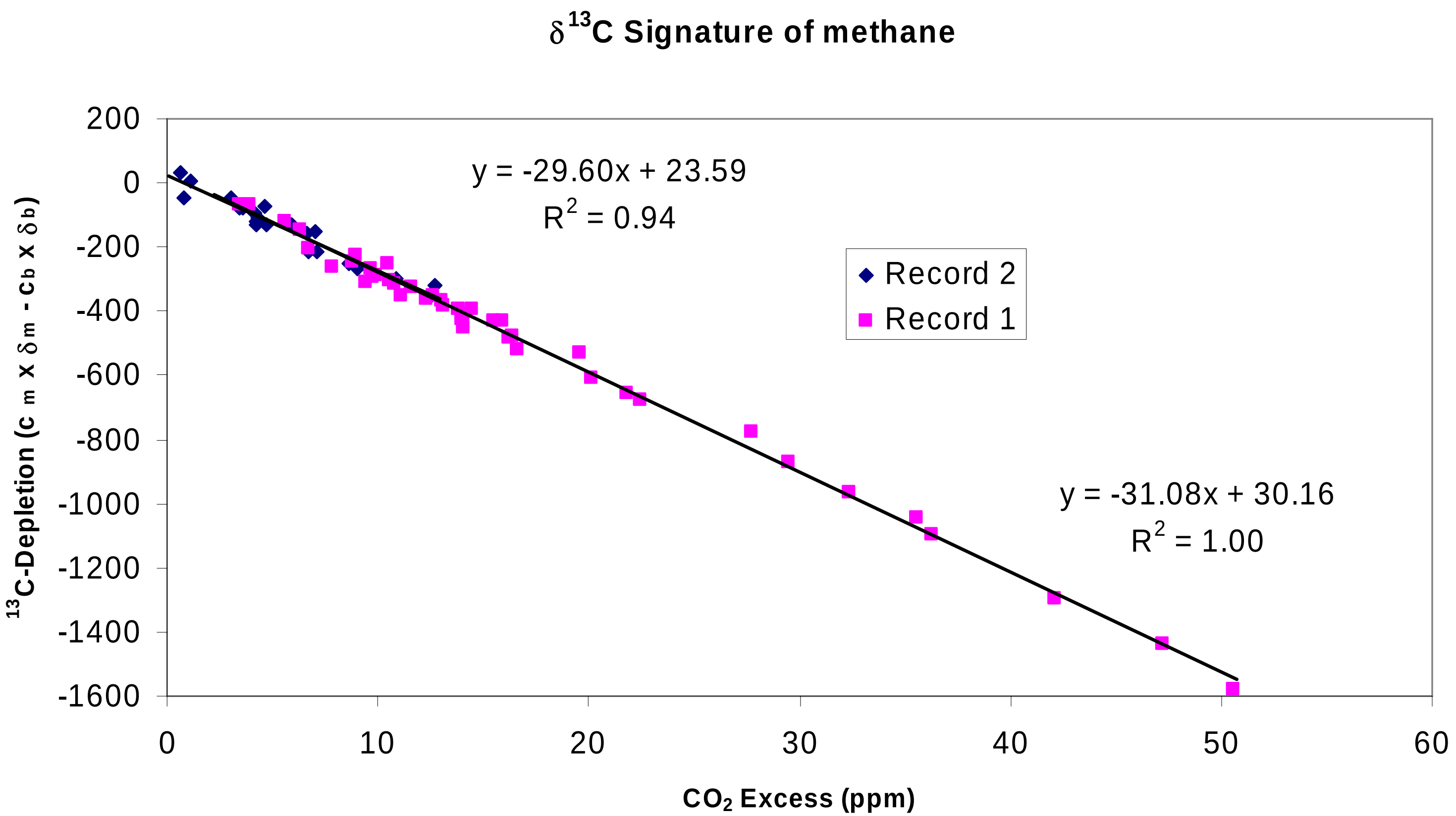

Fig. 6: Carbon isotope signature of CH_4 measured on CO_2.

Methane budget check for Berne city

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More than 20% of the annual energy consumption of Berne city is based on natural gas.

This corresponds to 1'200'000 MWh/yr, i.e. 120 Mm^3/yr CH_4 or 5.36 Gmol/yr CH_4

This corresponds to twice as much mol consumption of oxygen (O_2), i.e. 10.7 Gmol/yr O_2

Assuming a square area of Berne city of 10x10 km^2 with a vertical well mixed air height of 500 m corresponds to a volume of 5×10^{10} m^3, i.e. 2.2×10^{12} mol of air.

Since methane is to more than 80 percent used for heating purposes there is a strong seasonality present. Therefore, during winter months about 8.56 Gmol O_2/120 days, i.e. 70 Mmol O_2/day is consumed.

This corresponds to (70 Mmol O_2/day) / ($0.2095 \times 2.2 \times 10^{12}$ mol of oxygen), 150 permeg change in O_2 and about 15-16 ppm change in CO_2.

Hence, realistic signal strengths are obtained, which are in the range of observed signals.

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Conclusions:

- Short term slopes of O_2/CO_2 ratios (COFs) of -2 mol O_2/mol CO_2 are observed, especially in autumn and spring. In winter such slopes are observed for much longer periods.
- Methane oxidation seems to be reasonable due to high natural gas consumption in Berne city for heating purposes.
- Estimates of signal strengths are compatible with daily consumption rates.

Outlook:

- δ^{13}C signature of natural gas mixtures in Berne is not known, should be determined.

Thank you