Pressure effects on methane emissions from landfills

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Aim of the research

- Field studies report short-term variation of several orders of magnitude in measured CH_4 fluxes from landfills.
- This variation makes discontinuous measurements uncertain, without understanding the influence of meteorological conditions and most importantly barometric pressure.
- This presentation aims at illustrating CH_4 emission dynamics under the influence of barometric pressure changes and develop a concept model that can explain these dynamics.

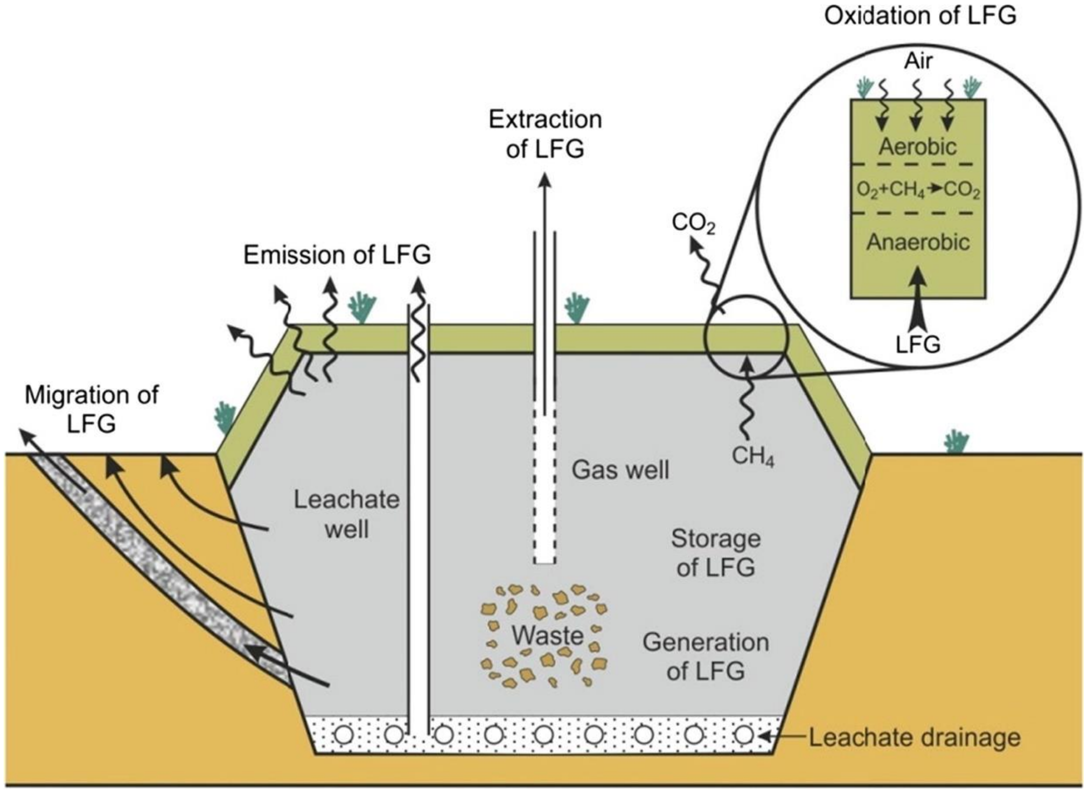

Figure 1. Processes affecting the fate of methane generated in a landfill.

Source: Scheutz, C., & Kjeldsen, P. (2019). Guidelines for landfill gas emission monitoring using the tracer gas dispersion method. *Waste Management*, *85*, 351–360. https://doi.org/10.1016/j.wasman.2018.12.048

Methods

Figure 2. Setup of the eddy covariance instrumentation at Skellingsted landfill. Instruments shown include an open-path CH_4 analyzer, a 3-D sonic anemometer, and an open-path CO_2/H_2O analyzer.

- Investigated site: The study was performed at Skellingsted landfill, located in Western Zealand, Denmark.
- Quantification technique: The eddy-covariance method is used, a micrometeorological method able to measure continuously over long periods.
- Advantage: Cope with temporal variability
- Disadvantage: Partially representative emissions of the whole landfill due to spatial heterogeneity

Results and Discussion

Representation of heterogeneity of the landfill.

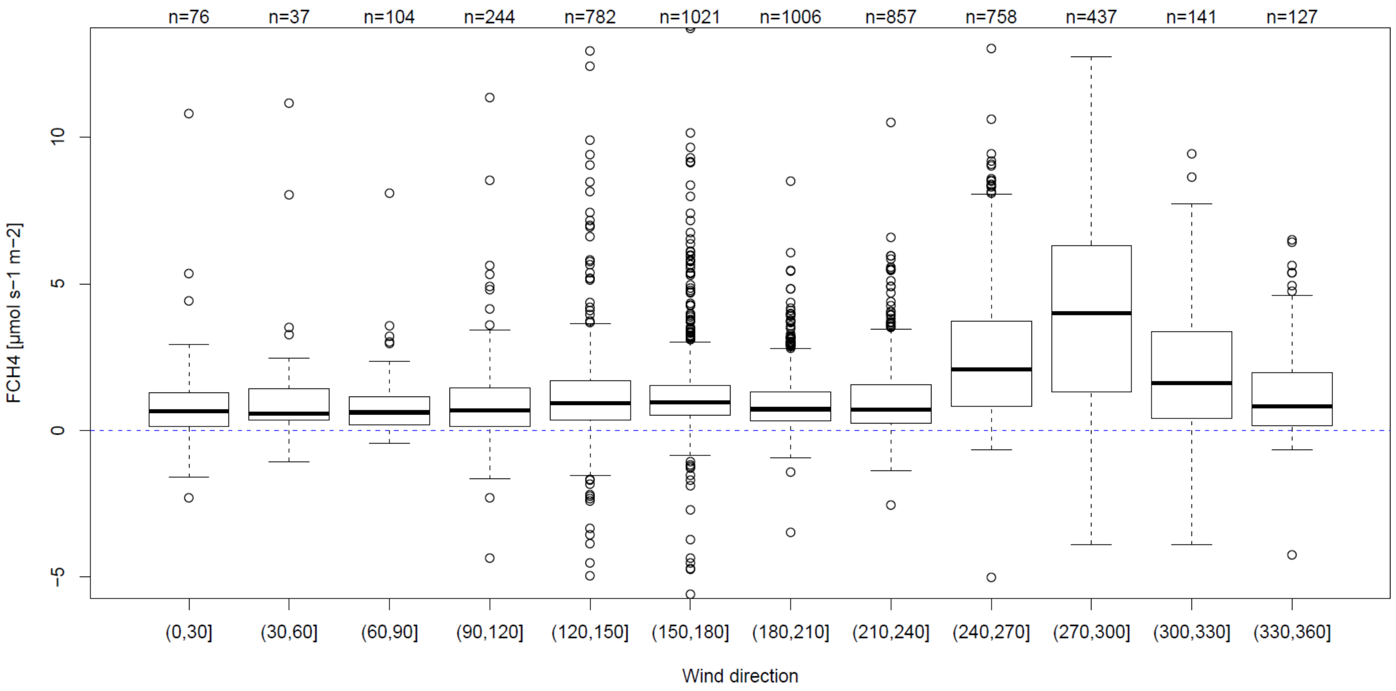

Figure 3. Wind direction measurements plotted against average CH_4 emission fluxes binned by wind direction.

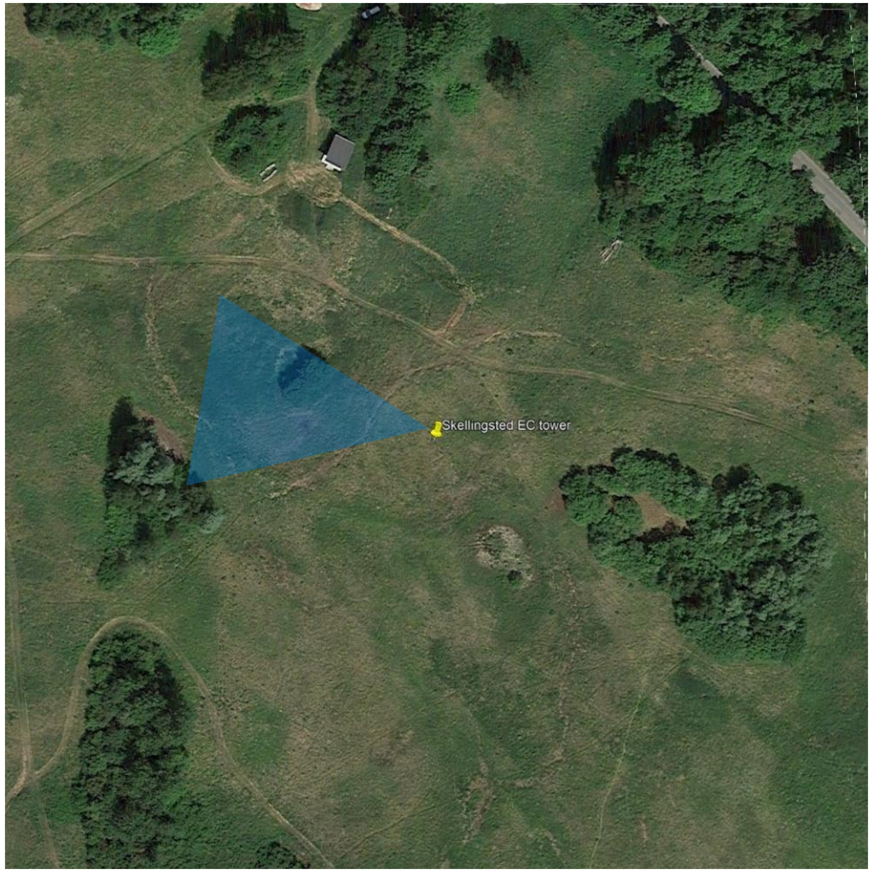

Figure 4. A Google Earth image showing the locations of EC station and the area of elevated CH_4 emission fluxes.

Results and Discussion

- Under <u>increasing</u> barometric pressure CH_4 fluxes suppressed almost to 0.
- Under <u>decreasing</u> barometric pressure the emission rate was greatly increased.
- A delay period was observed in the response of CH_4 fluxes to pressure changes.

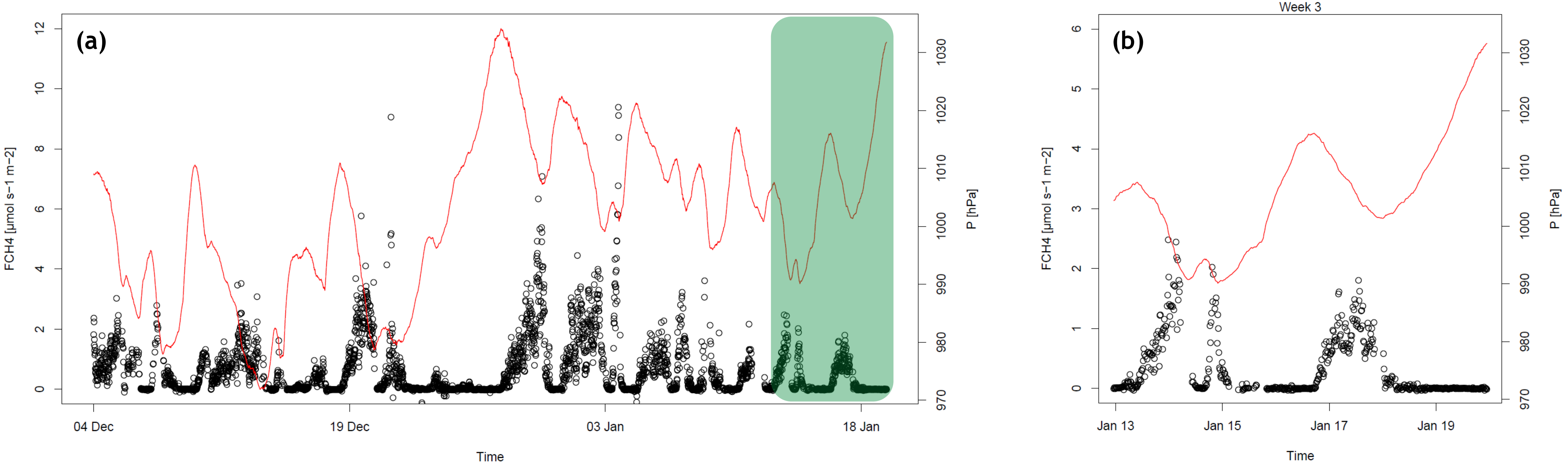

Figure 5. (a) Methane emissions (open circles) time-series from Skellingsted landfill from 4th December 2019 to 19th January 2020 and barometric pressure (red line). (b) Methane emissions time-series during the 3rd week of 2020. Emission data points represent 15-min averaged CH_4 emission fluxes.

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Results and Discussion

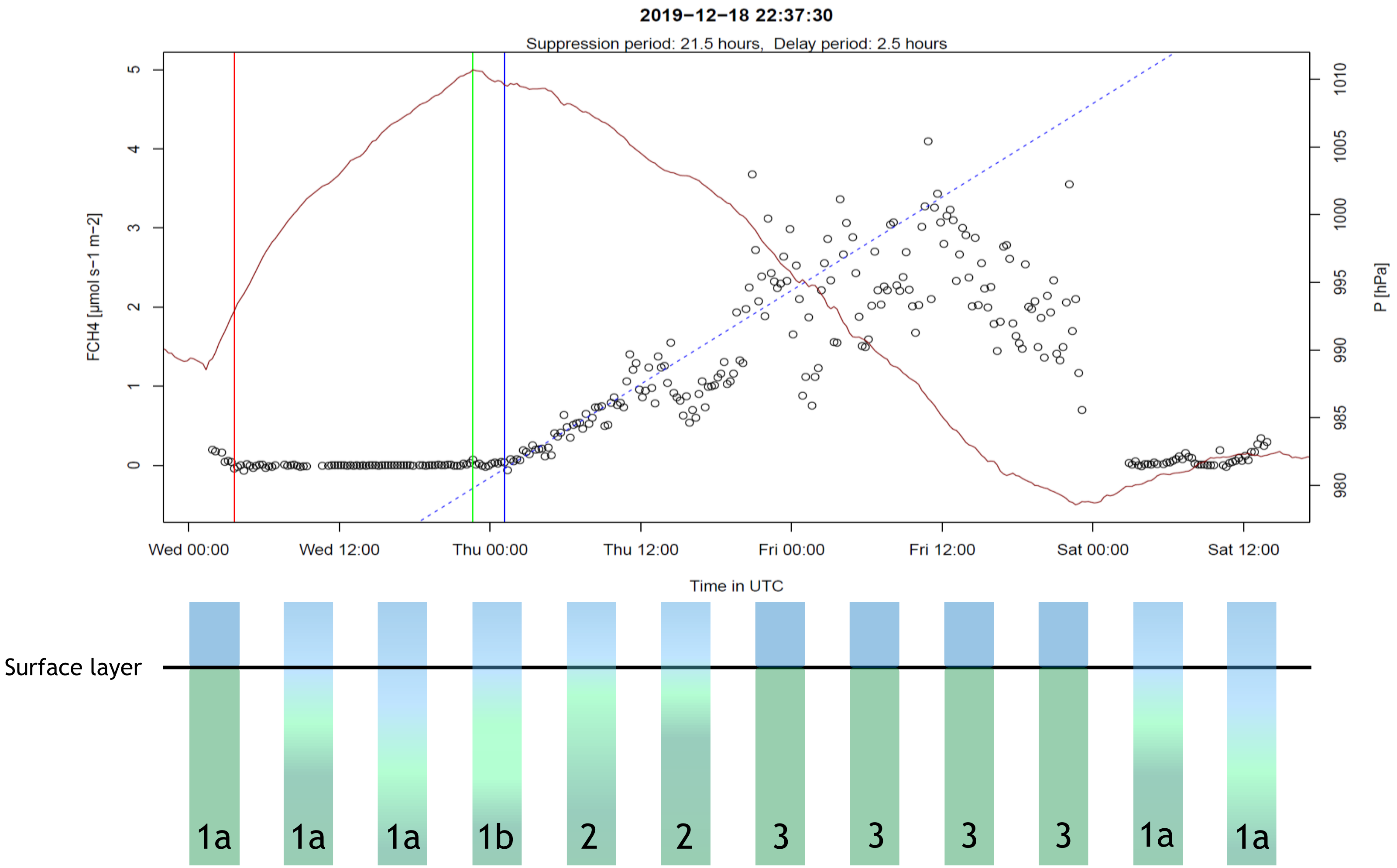

Figure 6. Methane emissions (open circles) time-series and barometric pressure (dark red line). Bars illustrate 1-D landfill columns and the main LFG transport mechanisms.

Conceptual model and hypotheses

- Landfill gas (LFG) advects from the core through the cover layer of the landfill driven by small vertical pressure (*p*) gradients.
- **Phase 1a:** Suppressed CH_4 fluxes $(^{dP}/_{dt} > 0)$
  - Ambient air (blue bars) is pushed into the landfill. (advection and $^{dP}/_{dz} > 0$)
  - LFG-ambient air interface (green/bluish area) increases. (diffusion)
- **Phase 1b:** Suppressed CH_4 fluxes $(^{dP}/_{dt} < 0)$
  - Top layer of air inside the landfill is flushed out. (advection)
  - LFG-ambient air interface increases. (diffusion)
- **Phase 2:** Linear increase of CH_4 fluxes $(^{dP}/_{dt} < 0)$
  - LFG-ambient air interface is flushed out.
- **Phase 3:** Maximum CH_4 fluxes $(^{dP}/_{dt} \leq 0)$
  - a) High fluxes that compensate the built up of LFG under suppressed transport.
  - b) Stationary fluxes that represent the LFG generation rate.

Conclusions

- Eddy-covariance method can adequately illustrate that methane emissions depend strongly on changes in barometric pressure.
- The high-resolution CH_4 fluxes allow us the observation of the underlying LFG transport processes (advection and diffusion) through landfill soil.
- The spatial variability of the landfill should be taken into consideration during the model-based interpretation of methane emission pattern.

Thank you!

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