MEMO^2: MEthane goes MObile – MEasurements and MOdelling

Large Eddy Simulation Tools ready for campaign and workshop

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1. Executive Summary

Our tool for the simulation of flow in the near-surface atmosphere MicroHH has been tested and modified in order to introduce point and line sources of methane in it. This extension allows for the use of MicroHH in planning of measurement strategies that is crucial for the success of MEMO^2. We have modified the computer code such that we can prescribe emission fluxes or surface concentrations of methane, and let the model calculate the transport of methane. By incorporating these improvements, we were able to use our Large-Eddy Simulation code MicroHH in the first MEMO^2 school for teaching the students about the complications that arise when observations of methane are made close to the land surface.

2. Background

Estimation of methane emissions from pollution sources, such as landfills or agriculture, is a challenging, but relevant task. The near-surface atmosphere has strong fluctuations in wind speed, due to the turbulent nature of the flow (Figure 1). The turbulent nature of the flow imposes strong fluctuations in the near-surface wind speed, which have a strong effect on the measured concentrations of methane (Figure 1). These fluctuations make the interpretation of observations from measurement stations, cars, and drones challenging.

The increase in computer power of the last decades is making it possible to actually simulate the atmospheric flow in which observations of methane are being made. These simulations can help us to understand turbulent dispersion of methane close to sources, and can help in setting up a measurement strategy.

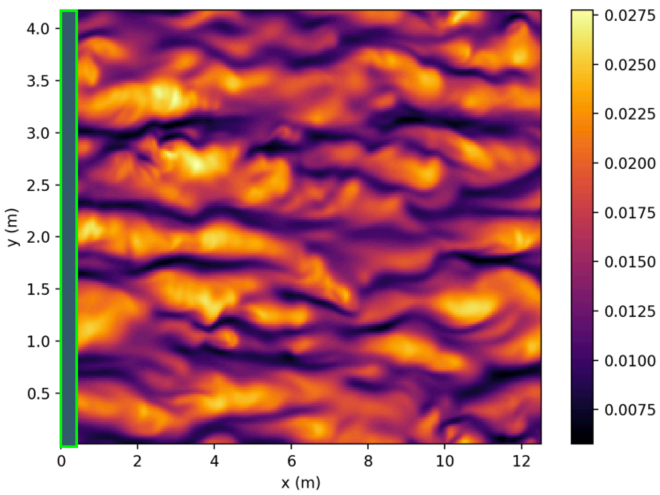

Fig.1: Near-surface wind speed in the vicinity of a line source of methane, as simulated with MicroHH. The velocities are normalized with the mean wind. The mean wind direction is towards the east (to the right).

3. Content

As a first step to prepare MicroHH for simulations of methane dispersion, we have set up the code to run the very well verified simulation case of Moser et al. (1999), which has been fully documented in the reference paper of MicroHH (van Heerwaarden et al., 2017). This case mimics the characteristics of an atmosphere in very windy conditions, which is the typical situation in the northwest of The Netherlands, where the experiments of the MEMO^2 school have been carried out. Taking this case as the basis, we have introduced the option of adding a point- or line source of methane. The user of MicroHH can now choose the exact location of the point and line sources and the surface, and choose between two boundary conditions for methane: fixed concentrations at the surface, or fixed fluxes at the surface.

Fig. 2: Snapshot of the structure of methane concentrations 2 m above the surface. The location of the line source at the surface is indicated in Figure 1.

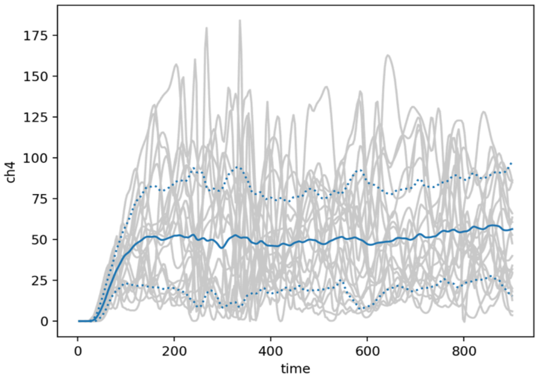

Fig. 3: Point measurements of methane (arbitrary units) taken at 2 m height, parallel to the line source at 0.5 m distance.

Furthermore, we have extended MicroHH to record time series that mimic the observations taken from point measurements (Figure 3). The figure shows recorded concentrations, taken at 20 random y locations at x = 0.5 m (see Figure 1) and 2 m measurement height. The students have discussed these observations among each other and has learned several important aspects of turbulent flows: 1) Observations need to be made under statistically stationary conditions, 2) it always take statistics in order to separate signal from noise.

4. Conclusion and possible impact

Reaching this milestone has marked the finishing of an important first step in the modeling Work Package. We have demonstrated the students the possibilities of turbulence simulation and its benefit in interpreting methane dispersion.

5. Dissemination & Exploitation

By reaching this milestone, we have provided a tool that is readily available to simulate the transport and dispersion of methane close to the land surface. As our tool is open-source software that is freely available (www.microhh.org), it can be used by all students in the MEMO^2 consortium, but also by other interested parties. After the exercises with MicroHH during the MEMO^2 school, project partner Shell already has expressed interest in it for evaluation of measurement techniques. Furthermore, PhD student Barbara Szenasi is currently using our tool during her secondment at Wageningen University and Research to interpret course resolution model outcomes.

6. References

1. Moser, R.D., Kim, J. and Mansour, N.N., 1999. Direct numerical simulation of turbulent channel flow up to Re τ= 590. *Physics of fluids*, *11*(4), pp.943-945.
2. van Heerwaarden, C.C., van Stratum, B.J., Heus, T., Gibbs, J.A., Fedorovich, E. and Mellado, J.P., 2017. MicroHH 1.0: a computational fluid dynamics code for direct numerical simulation and large-eddy simulation of atmospheric boundary layer flows. *Geoscientific Model Development*, *10*(8), pp.3145-3165.

7. History of the document

Version	Author(s)	Date	Changes
1st version	Chiel van Heerwaarden	7 March 2018	First version
Internal review	Maarten Krol	9 March 2018	With track changes
Final version	Sylvia Walter	14 March 2018	Final formatting, submision