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Modeling methane dispersion using three modeling techniques to prepare a field campaign on methane emissions

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Climate change, as is now well known, is driven by anthropogenic influence on the Greenhouse gases (GHG) concentrations in the atmosphere. One of the most important GHG is methane to which the European emissions are contributing. The quantifications of those emissions is a large challenge for which the Methane goes Mobile – Measurements and Modelling ($MEMO_2$, https://h2020-memo.eu) is initiated. $MEMO_2$ is a Marie Curie International Training Network in which 13 PhD students collaboratively aim to quantify the emissions by by combining different measuring techniques and modeling across scales.

In February 2018, a first field campaign will be organized in the Netherlands, in which the $MEMO_2$ participants will combine their strengths to measure the emissions of a local methane source. The typical type of models used to model the dispersion are are of Gaussian plume type. These are often fitted with empirical relations that are weather-dependent, but also landscape dependent. Such type of models are computationally cheap, but are unable to capture the dynamics of a turbulent plume. More realistic approaches are computationally more expensive. Turbulence resolving models, such as large-eddy simulations or direct numerical simulations (DNS) can simulate the full turbulent behavior of the plumes, but are generally computationally too expensive for practical need. Middle ground between DNS and Gaussian plume models would be to numerically solve Reynolds-averaged Navier-Stokes (RANS) equations, which represent, in theory, the ensemble average of an infinite number of experiments with a turbulence-resolving model. Therefore, they are able to quantify the mean transport, but have limited capabilities to capture fluctuations in the turbulent field.

To prepare for $MEMO_2$'s upcoming field campaign, we compared the three types of models: the Gaussian plume model, a simple Reynolds-averaged advection-diffusion model and a DNS obtained from MicroHH (van Heerwaarden et al., 2017, www.microhh.org) model to find the optimal measurement strategy. We have set up a case in DNS, which resembles the field experiment, in order to test how well the RANS and the Gaussian plume model can estimate the methane emissions. Result of the most appropriate model can aid the experiment design in the presence of turbulence and associated fluctuations and will serve as help in the planning of the experiment.