VALIDATION OF GAUSSIAN PLUME MODEL AEROPOL AGAINST CABAUW FIELD EXPERIMENT

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THE PURPOSE of revisiting the classical dispersion experiment in Cabauw (Agterberg et al., 1983) is a better understanding of dispersion from elevated (buoyant) accidental releases, such as 2011 in Moerdijk, and preparation for fast response. A project to implement a mesoscale dispersion model for the Dutch emergency response has since been launched.

Here we investigate the validation and verification of the dispersion model, based on the experiments at the Cabauw mast: is the quality of these older measurements up to par for the present state of art dispersion models?

THE DISPERSION EXPERIMENT was carried out at Cabauw atmospheric measurement site in 1977-1978, using the facilities of a 213 m high mast (**Figure 1**). The data set consists of 28 half-hourly runs – two sequential half hours per day, thus 14 days in total. The SF_6 tracer was released from the height either at 80 or 200 m depending on pre-estimated dispersion conditions, and measured at surface level on an arc 2 – 5 km downwind. The data set includes on-site evaluated meteorological parameters, which were used for modelling: temperature, wind speed and direction at different heights in the mast, surface turbulent heat flux.

MODELS AND METHODS. The synoptic weather reanalysis ERA40 is used. Based on the 3D-wind information from the ERA40 reanalysis dataset, the trajectory model TRAJKS (Stohl et al., 2001) calculated the advection of the centre of the plume. **Figure 2** shows whether the trajectories are ascending (in red), descending (in blue) or move at a constant height (in black).

AEROPOL (Kaasik & Kimmel, 2003) is a stationary Gaussian plume model developed in University of Tartu, Estonia. Two alternative parameterisations for dispersion parameters are enabled:

- classical Pasquill-Gifford stability classification (further referred as Pasquill scheme);
- a scheme based on Lagrangian time scales, developed by Gryning et al. (1987) and validated against the Copenhagen dispersion experiment (further referred as Gryning scheme).

The validated output parameters are cross-wind integrated, maximal arc-wise and near-centreline concentrations. Validation is based on correlation (COR), fractional bias (FB), fractional sigma (FS), normalised mean square error (NMSE) and fraction of measured vs. modelled values in factor of two (FA2). The near-centreline concentration is defined as average of concentrations between $-0.67\sigma_y$ and $0.67\sigma_y$, where σ_y is the horizontal standard deviation of the plume in Gaussian approximation (Olesen, 2000).

RESULTS. It was found that average wind direction and speed between the lowest measurement level and the source height is a better guess for Gaussian plume, than those at release level (for an example, see **Figure 3**). For all results reported in **Table 1** and further, the average values are applied. The compared concentrations in **Figures 4 - 6** are normalised with source release rate.

The effect of too wide Gaussian spread of Gryning scheme (see also Figure 3) is seen in plots of the arc-wise maximum and the near-centreline concentrations, as the reason of underestimation. But wider spread makes the fit less sensitive to the exact position of the Gaussian peak and thus, the scatter of data points is lower than with Pasquill scheme.

In contrary, the fit of arc-wise integrated concentrations is almost perfect with Gryning scheme and much looser with Pasquill-Gifford scheme, i.e. the latter one is not that precise to reproduce the vertical transport of the tracer. However, both schemes are within 10% range from one-to-one relation by trendline, thus handling the vertical dispersion rather well.

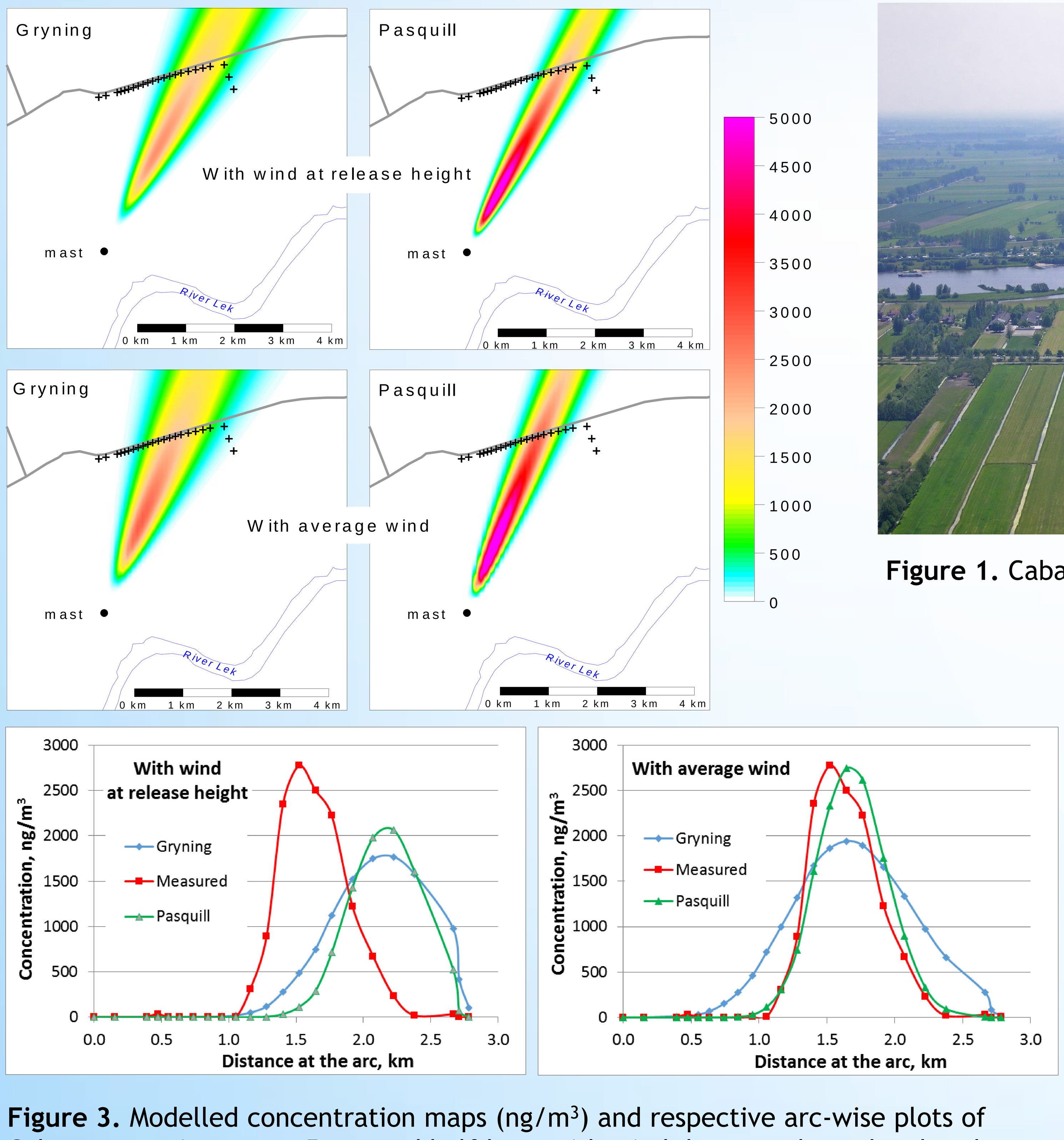

Figure 3. Modelled concentration maps (ng/m^3) and respective arc-wise plots of Cabauw experiment run 5, second half-hour with wind data at release level and averaged wind between release height and low level.

Figure 1. Cabauw mast and surrounding landscape

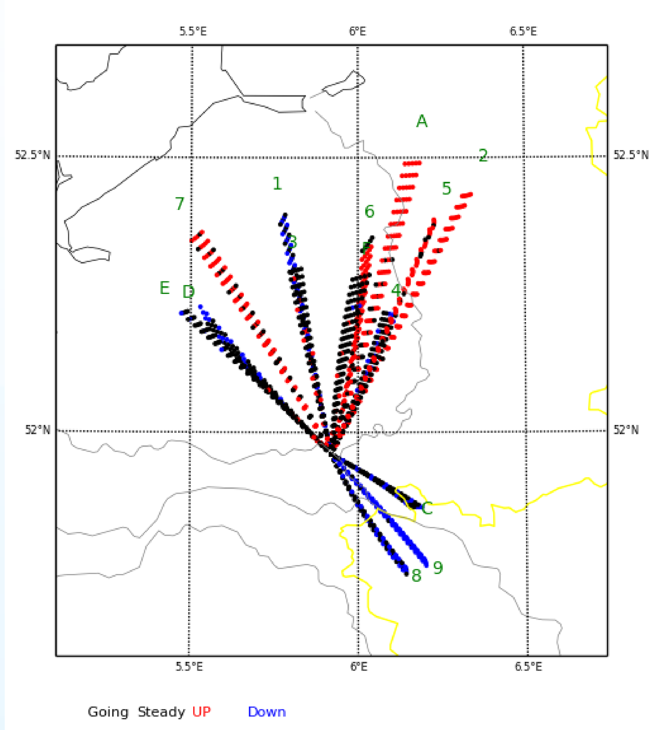

Figure 2. Trajectories with a colour code for a constant height (black), an upward movement (red) or a downward movement (blue) for all experiments.

Table 1. Summary statistics for concentrations and model runs with the Pasquill and the Gyning parameterisation schemes.

	Cross-wind integrated		Maximum arc-wise		Near-centreline	
	Gryning	Pasquill	Gryning	Pasquill	Gryning	Pasquill
CORR	0,92	0,79	0,94	0,74	0,83	0,79
FB	-0,13	-0,25	0,65	0,03	0,46	-0,12
FS	-0,03	-0,07	0,83	0,06	0,75	0,05
NMSE	0,08	0,22	0,65	0,22	0,51	0,18
FA2	0,86	0,86	0,50	0,71	0,71	0,79

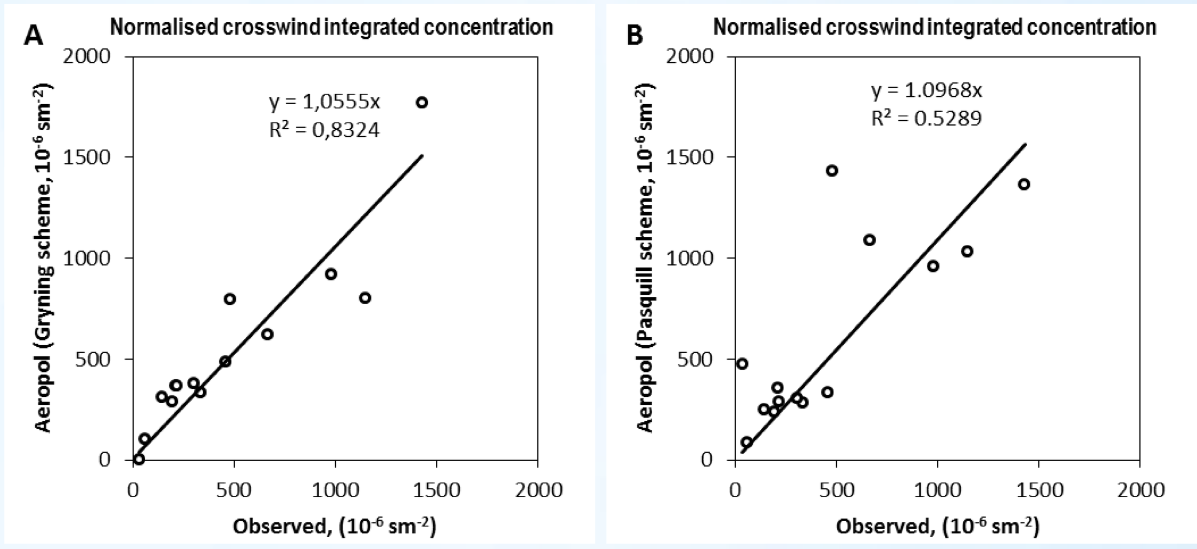

Figure 4. Modelled *vs.* measured cross-wind integrated concentrations.

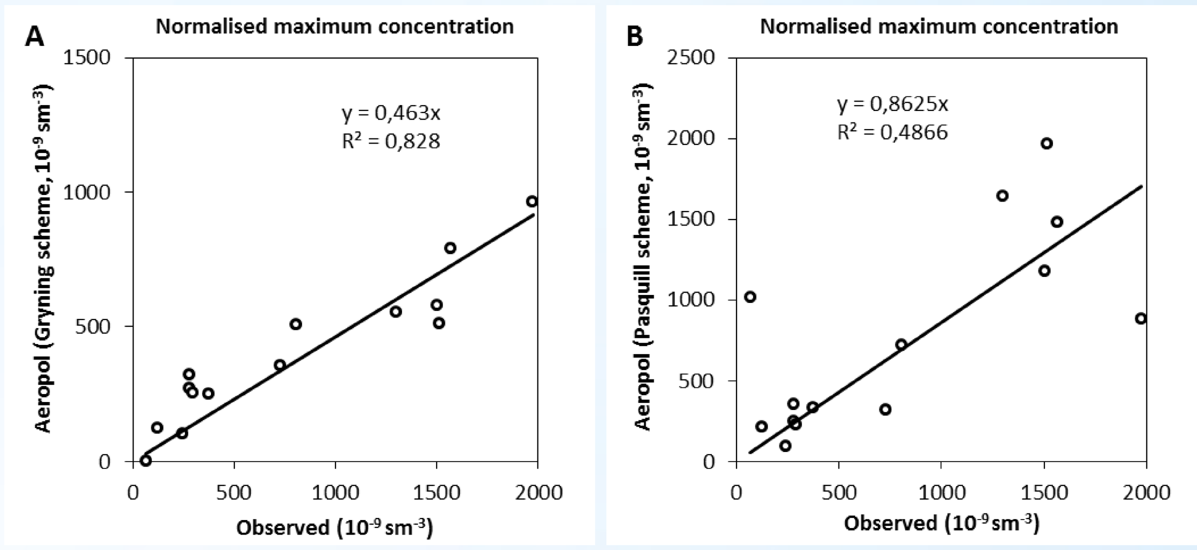

Figure 5. Modelled *vs.* measured arc-wise maximum concentrations.

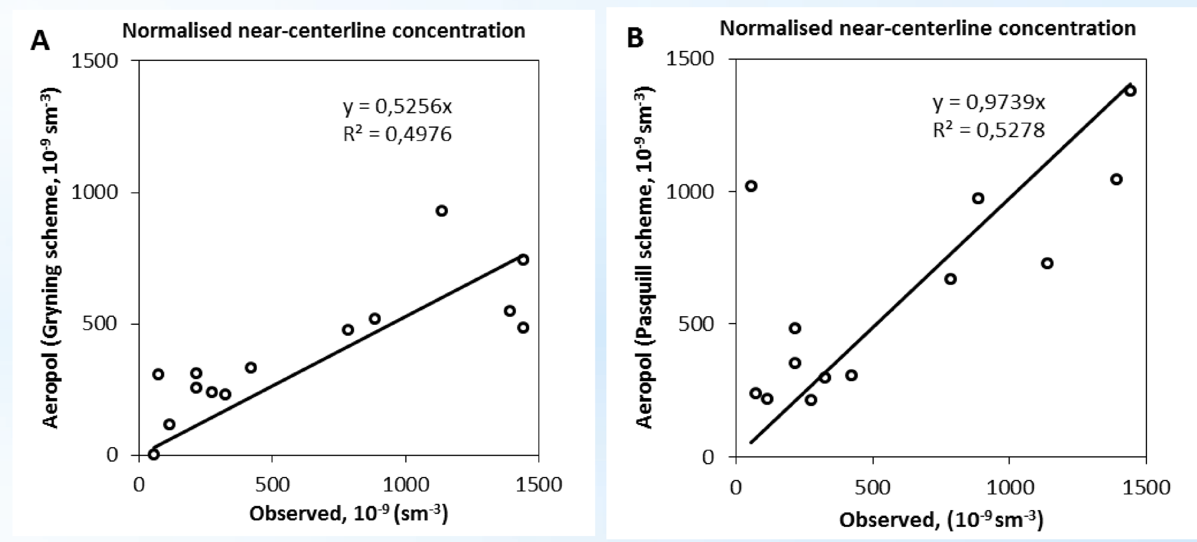

Figure 6. Modelled *vs.* measured near-centreline concentrations.

CONCLUSIONS

1. The Cabauw data set is still useful for model validation.
2. the AEROPOL model is a useful tool for predicting the dispersion of pollutants from elevated releases.
3. The Pasquill-Gifford scheme seems better for predicting the highest concentrations near the surface, but key issue for exact matching is the proper wind direction.
4. The Gryning scheme is somewhat more accurate in predicting the cross-wind integrated concentrations.

Acknowledgement

This study was funded by Estonian Ministry of Education and Research, institutional research funding IUT20-11.

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