COMPLEX TERRAIN AND SPECIFIC METEOROLOGICAL CONDITIONS A STRATEGY TO OVERCOME THE APPLICATION LIMITS OF THE DISPERSION MODEL OF THE UPDATED TA LUFT BY COUPLING THE PROGNOSTIC FLOW MODEL FITNAH

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INTRODUCTION

In 2002, the German legal regulation guideline TA Luft, which defines the procedure of dispersion modelling in licensing processes, has been updated. In appendix 3, a Lagrangian particle model has been introduced, which makes use of wind and turbulence information calculated by a diagnostic flow model.

Due to the physical limits of the diagnostic approach when it comes to steeper terrain, in section 11 of appendix 3, criteria have been verbalized which rule the applicability of the model system defined by the TA Luft:

Within a circle of radius 50 times the stack height, slopes of terrain must be lower than 1:5 (based on a grid with spacing two times the stack height). Otherwise, a suitable flow model – here: a prognostic model – has to be applied. Similar directives have to be followed if special meteorological conditions, e.g. drainage flows, are likely to occur.

This regulation does not apply only in a few locations with extraordinary steep terrain, but already in numerous cases in low mountain ranges with altitude difference lower than 200 m or 300 m (Figure 1).

Figure 1. Examples of terrain, where the German TA-Luft procedure cannot be used.

In consequence, to prepare a legally correct dispersion simulation, a prognostic flow model should be incorporated into the dispersion calculation in many cases.

But prognostic models are known as very time-consuming programs. It would hardly be possible to efficiently run such a model for 8.760 situations (the TA Luft requires the simulation of one year with an accuracy of meteorological input data of one hour). So, a strategy has to be developed which guarantees a professional and scientific handling on the one hand, on the other hand an applicable, affordable and in due time operable procedure.

DIAGNOSTIC AND PROGNOSTIC FLOW CALCULATION - DIFFERENCES

Since the prognostic flow model consist of complete 3D-physics, whereas the diagnostic one only solves a mass continuity equation, the prognostic results can be considered the more realistic ones, a fact that has been proven numerously during the last 25 years.

The following Figure 2 shows schematically, what different flow might be calculated by using diagnostic models or prognostic models. Perpendicular to the valley floor, a complete reverse wind direction occurs, which of course leads to severe consequences in dispersion simulations.

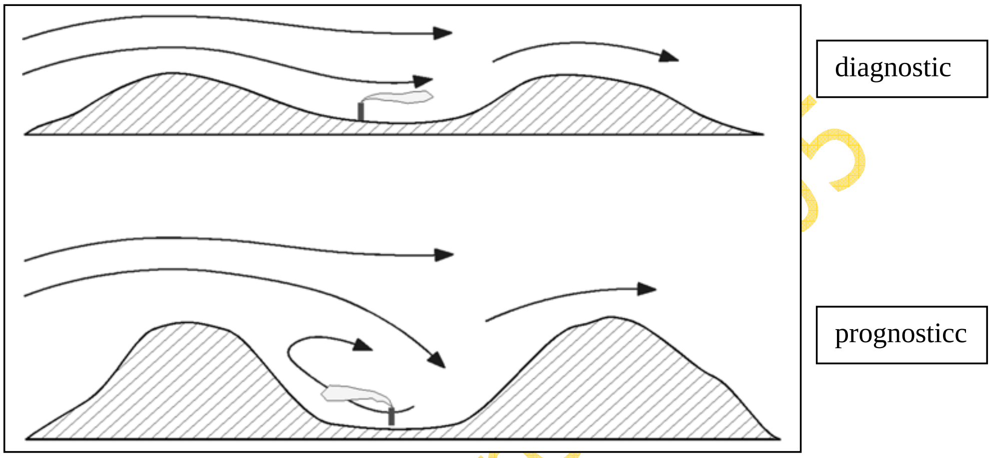

Figure 2. Difference between diagnostic and prognostic flow calculation in hilly terrain.

APPROACH

The philosophy to incorporate prognostic flow simulation into dispersion modelling along TA Luft is a calibration-technique for the TA Luft model system.

First, relevant weather situations have to be identified, which are able to represent a large number of situations in a year. For the relevant situations, single-case model runs are performed. One simulation is carried out with FITNAH-coupling, another with the diagnostic module.

A comparison shows the quality of the stand-alone-use of the TA Luft system. If the latter doesn't calculate the concentration in a pessimistic (slightly overestimating) way, the calibration takes place:

Calibration-aim is to find the combination of meteorological input data (usually measurements at one site in the model domain), which lead to a comparable concentration field with respect to the one of the FITNAH coupling.

The obtained calibration information is finally incorporated into the input data and thus, a realistic dispersion calculation with consideration of steep terrain and specific meteorological situations can be performed with the standard model.

The approach has been applied on several very controversial licensing procedures, e.g. for waste incineration plants or cement works and has been fully accepted and even been ordered by several supreme authorities in Germany.

NUMERICAL MODELS

The numerical models used in this study are the Lagrangian dispersion model **LASAT** (**LA**grange **S**imulation von **A**erosol **T**ransport, see e.g. *Janicke, L. (1983)*), and the prognostic, non-hydrostatic mesoscale model **FITNAH** (**F**low over **I**rregular **T**errain with **N**atural and **A**nthropogenic **H**eat-Sources, e.g. *Groß, G, (1993)* or *Nielinger, J. and W.-J. Kost, (2001), Nielinger, J., W.-J. Kost and W. Kunz (2004)*).

LASAT meets the requirements of the VDI Guideline 3945 Blatt 3 and is the basis for the Lagrangian dispersion model AUSTAL2000, the most distributed implementation of the german legislation TA Luft. FITNAH has been developed in the 1980's and since then permanently enhanced to calculate 3D meteorological fields in complex terrain, especially thermally and dynamically induced flow systems.

EXAMPLE

In Figure 3, it is shown how the scheme works. In this example, a calibration has been performed for a drainage flow situation. During the night, a regional flow system develops which is supplied by higher mountain ranges in the southwest. The small hills in the model domain are incorporated in this flow system and are overflowed.

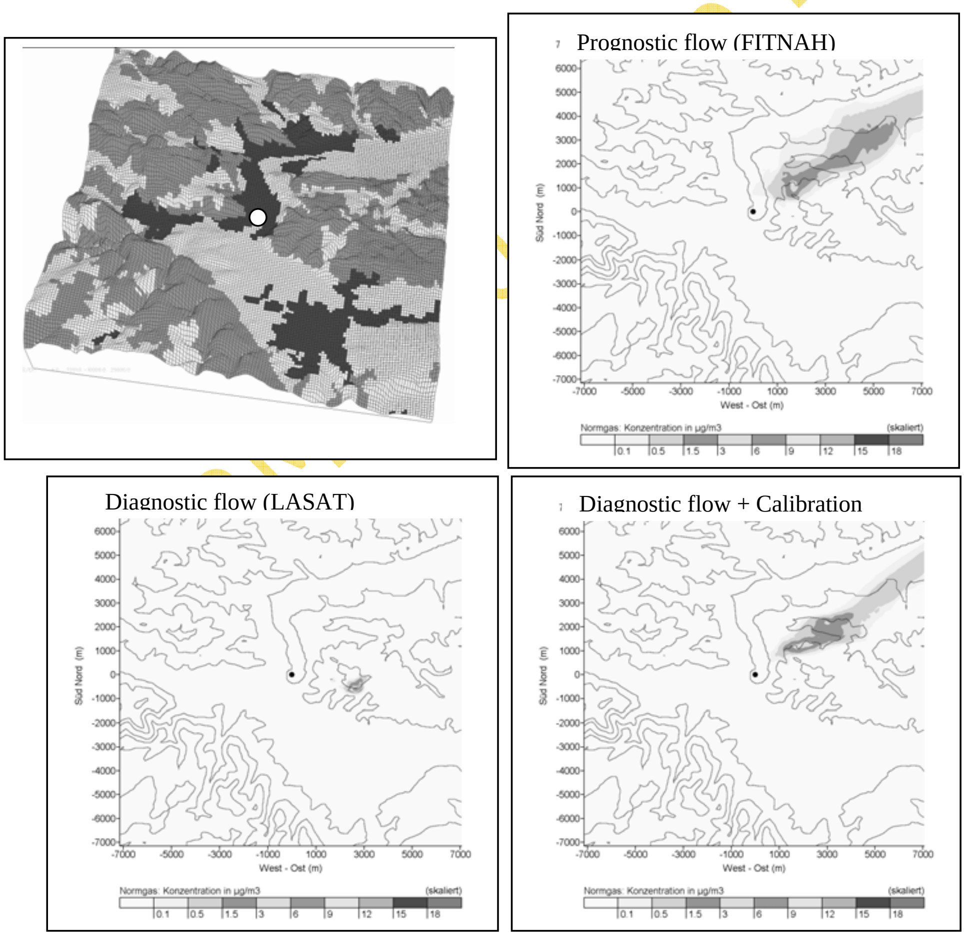

Figure 3. Terrain (top, left), dispersion modelling result with prognostic flow (FITNAH, top, right), results by use of diagnostic model (bottom left) and results after application of calibration technique (bottom, right). Plant is marked as a dot in the centre of model domain.

The use of prognostic flow model results (FITNAH) in dispersion modelling leads to a plume directed to the north-east with maximum concentrations at small hills.

Operating the diagnostic approach (LASAT), the measured meteorological input data (at the plant site) leads to a small area of near surface concentration in the east. This is due to the fact that the measurements at the valley floor show a (correct) slight westerly wind in this drainage flow situation. The measurements are of course not able to detect a drainage flow system which rises up to 200 m above ground. Consequently, the model simulates westerly winds in the whole model domain. As can be seen, this leads to an under-estimation of near-surface concentrations and to a wrong area of touch-down of the plume.

The calibration technique intervenes in the meteorological input data. The calibrated dispersion simulation only makes use of the diagnostic approach, too. But the meteorological input data is modified in a way that the result of prognostic flow simulation can be reproduced. In this example, the wind direction had to be turned by -28°, the turbulence-parameter had to be shifted in the next higher class and wind speed hat to be fixed to 1.9 m/s. Of course these data has ceased to represent a typical drainage flow situation at the measurement site, but by use of this data, the use of the formerly improper model is now possible (Figure 3, comparison of the right pictures).

CONCLUSIONS

The German TA Luft defines a strategy how to perform a correct dispersion simulation in licensing procedures. The strategy makes use of a diagnostic flow model, which is also defined to be not applicable when terrain slopes exceed a ratio of 1:5. This criterion not only applies to alpine terrain, but already in hilly terrain. In such cases, prognostic flow simulations have to be performed.

In this contribution, a strategy to incorporate prognostic flow simulation into dispersion modelling in a very cost-effective and time-efficient way has been presented. The idea is to calibrate the meteorological input data for the diagnostic flow model in such a way, that dispersion field results, generated by use of a prognostic flow model, can be reproduced correctly.

The approach has been applied on several very controversial licensing procedures, e.g. for waste incineration plants or cement works and has been fully accepted and even been ordered by several supreme authorities in Germany.

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