MODELLING SYSTEM FOR DISPERSION CALCULATIONS DURING ACCIDENTAL RELEASES

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Abstract: An operational model system for calculating dispersion during accidental releases is presented. The operational model system is designed so it can be used by non-specialists and with presentation of the results in graphical form. Applications of the model system include: 1) Air pollution calculations in now-casting mode to obtain concentrations in real time and 2) Prognosis of air pollution during accidental releases. The prognoses show quite good agreement with measured data.

Key words: *Accidental release, measurements, model, prognosis.*

1. INTRODUCTION

There is a large need for people leading a rescue in an area after an accident after e.g. a track accident or a train accident. They need answer within a couple of minutes of the dispersion situation and a prognosis of the situation for the nearest hours. In part of Sweden the ALARM-system has been implemented to the Swedish Rescue Service dispersion model.

2. THE MODELLING SYSTEM

The modelling system (ALARM-system – Advanced Local And Regional Modelling-system) includes:

- **Regional model (COAMPS®) with 12 km resolution to get influence of terrain on regional scale (half Scandinavia).**

A regional model (COAMPS®) is used to make a regional prognosis over southern Scandinavia. This model uses a 12 km grid resolution Every 6 hours, a 30 hours prognosis is performed. As input (initial and lateral conditions), forecasts from the Global Forecast System (GFS) run by NOAA is used.
The synoptic model and the regional models are working continuously.

- **Meso-scale model (the MIUU model) with 1 km resolution to get prognosis over the accidental area by taking into account the local terrain.**

In case of an accident a local model (the MIUU model, see e.g. Tjernström, M. et al., 1988, Enger, L. 1990a, Enger, L. et al., 1993, Koračin, D. and L. Enger, 1994, Grisogono, B., 1995, and Enger, L. and B. Grisogono, 1998, Söderberg, S. and M. Tjernström, 2001, Söderberg, S. and M. Tjernström, 2002, Brooks et al., 2003) is used to get prognosis over the actual area with 1 km resolution to take care the local terrain into consideration. The length of the prognosis can be up to 24 hours. In the actual area there are three sodar instruments to get wind and wind direction at higher elevations. There are also ten 10 m high towers with wind speed, wind direction and temperature profile measurements in the area. The measurements in the area are used to correct the input data from the regional model (COAMPS®) to the meso-scale model (MIUU) at start of the prognosis.

The local model (the MIUU-model) is used only during the accidental release. The MIUU model provides a 12-hour prognosis of wind, stability, turbulence etc. within less than 10 minutes for a limited area.

- **Model database (a large library of simulated fields of wind components, potential temperature, specific humidity, and turbulence kinetic energy) to get meteorological data over a larger local area.**

In an area with complex terrain it is too time consuming to simulate the meteorological fields of wind and turbulence for every situation. Instead the higher-order closure dynamic model is used for simulations of the local dynamics in the area for many different meteorological situations.

These simulations are stored in a database. Typical thermal conditions – or typical profiles of potential temperature and humidity – are used for the initialisation of the dynamic model. These typical profiles can be derived from e.g. synoptic models and/or radio-soundings. By using surface energy balance equation at the surface, simulations are made for the entire diurnal cycle in order to incorporate the diurnal variation of wind, temperature, and turbulence. Simulations are made for 3 classes of magnitude of the geostrophic wind (e.g. 4, 8, and 14 ms^{-1}), for every 12.5 degrees of azimuth and for four different “seasons”, to include differences in water body temperatures.

The creation of the database is performed in three steps. In the first step needed data for the model is created: terrain height, roughness length, albedo, emissivity etc. Furthermore, one need temperature, humidity, and geostrophic wind profiles. The temperature, humidity and geostrophic wind profiles have to be split up according to geostrophic wind direction, as the stability can be quite different if one has southerly or northerly wind directions. In the second step simulations are performed for a large area to take into account the influence of surrounding terrain in and around

Sweden by using a grid solution of 5 km. In the last step simulations are made with 1 km resolution for a smaller area, but now using the results from the first step as boundary conditions for the high-resolution simulations (the model is nested). The calculations are made from surface up to around 15 km. The resolution is much finer closer to surface than higher up. The results of wind speed and direction, temperature, and humidity will be on the following heights: 0.0 m, 2.0 m, 6.5 m, 12.5 m, 21 m, 33 m, 49 m, 72 m, 103 m, 146 m, 206 m, 289 m, 402 m etc up to 15 km. The turbulent energy will be saved in heights between these heights. The same heights are used in both the 5-km resolution simulations and the 1-km resolution simulations. Simulations are done over 36 hours, but only the 24 last hours are used. A model has to come in to balance; therefore one needs around 12 hours for initialisation. The terrain (orography, surface roughness, ground temperature, seawater temperature etc) influences the wind over an area. The ground temperature is calculated through the energy balance at the surface, which is dependent on the albedo, emissivity, vegetation type etc. All this is taking care of in the model. A large library of simulation results, a so-called "model output database", is created by this procedure.

- **Dispersion model**

A semi-Gaussian,trajectory-type dispersion model (Enger, L., 1990b), which is more suitable for longer-term dispersion estimates are used for point source simulations. The model calculates trajectories for the plume from the simulated wind fields, and approximates the concentration fields with a bi-Gaussian distribution. The horizontal and vertical standard deviations for the plume are determined using the simulated turbulence quantities from the dynamic model together with normalized Eulerian spectra.

- **Data of typical emissions during an accidental release (e.g. truck accident) and other source data are provided by the Swedish Rescue Services Agency. They also give information on dangerous concentration limits for the actual substance.**
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The project for accidental release models has been performed in close collaboration with the Swedish Rescue Agency. The model will be implemented on computers and on desktops for the people leading a rescue in the area. They automatically call up a server (through ftp) with indata for the accident (type of substance, location, duration of release etc). In 2 minutes they get back results for a 2 hours prognosis.

Dispersion calculations in now-casting mode are presented within a couple of seconds by using measurements together with the model database. Prognosis of the dispersion is provided for selected times after release by using the meteorological data from the local area prognosis in combination with the model database.

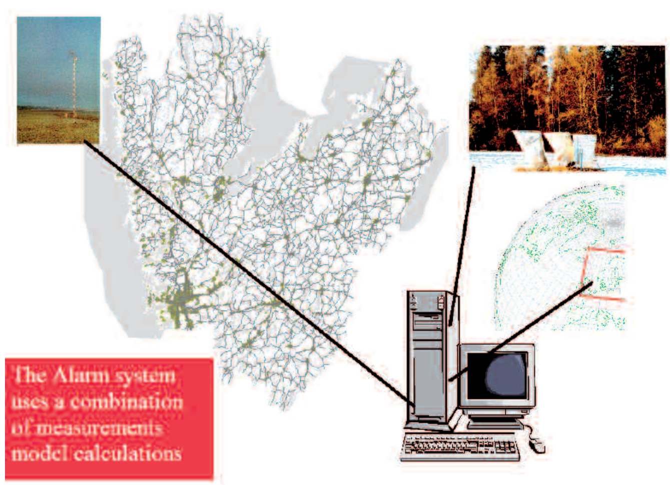

Figure 1. The ALARM-system area located in southwest Sweden. Measurements are collected once per hour and regional prognosis once every 6th hour. The area size is around 200 x 250 km.

3. COMPARISON WITH MEASUREMENTS

The ALARM-system is implemented in the county Västra Götaland in southwest of Sweden. The size of the county is around 200x250 km. Measurements are collected once per hour and regional prognosis every 6th hour.

Comparison of wind speed and wind directions from prognosis and measurements (sodar, and 10-m towers) show quite good agreement. The wind direction is corrected against the sodar measurements every 12th hour.

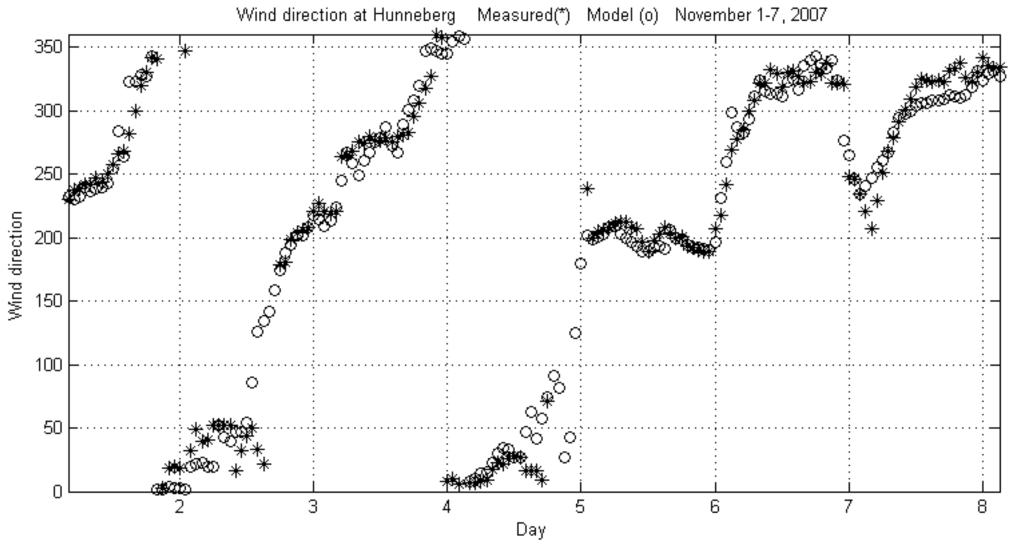

Figure 2. Measured (sodar (*)) and simulated (o) wind directions at site Hunneberg at 175 m.

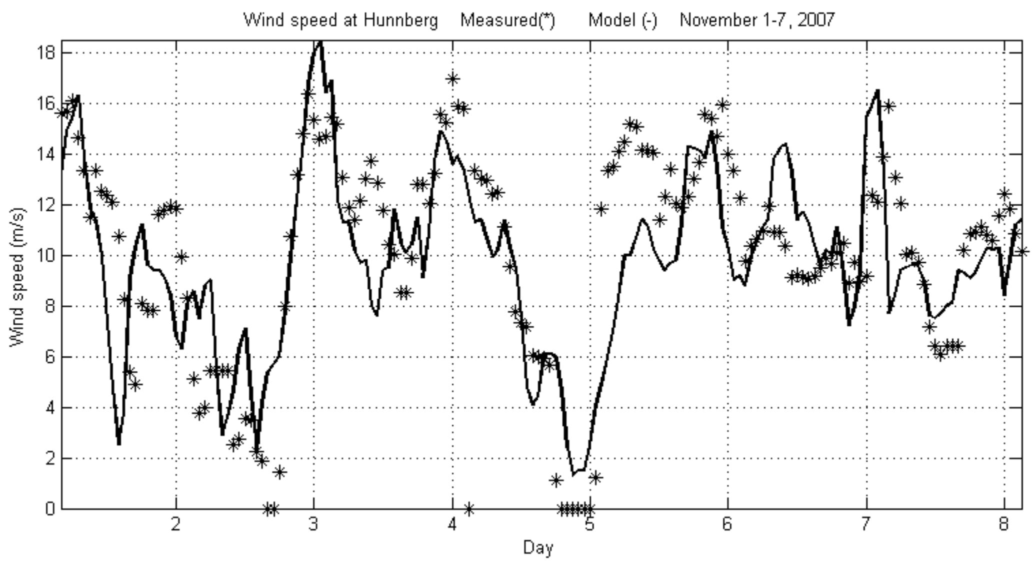

Figure 3. Measured (sodar (*)) and simulated (-) wind speed at site Hunneberg at 175 m.

A good agreement is found between measured and simulated wind direction at site Hunneberg at 175 m height, Figure 2. There is some discrepancies part of day 2 and day 4. During these periods the wind speed at this height are zero or very low, see Figure 3. Also the wind speed shows quite good agreement between measured and simulated wind speed. The simulations capture the main features of increasing and decreasing winds. One also has to remember that measured values are for a point while simulated winds are for an area.

Figure 4 shows the wind direction at 10 m at site Malöga 3 km from the sodar site. This site is situated at quite flat area although influenced by the hill Hunneberg. The agreement is good most of the time. There are some differences during some period of day 2, day 4 and end of day 7. The measured wind speed at these times are very low (1 ms^{-1} or less), see Figure 5. The measured wind directions during these situations are then not reliable.

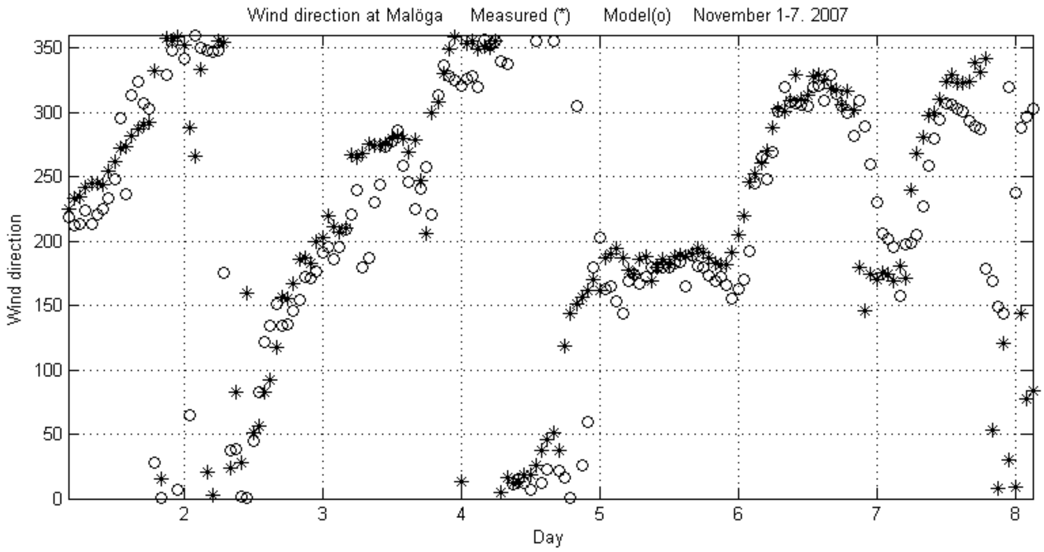

Figure 4. Measured (tower (*)) and simulated (o) wind speed at site Malöga at 10 m.

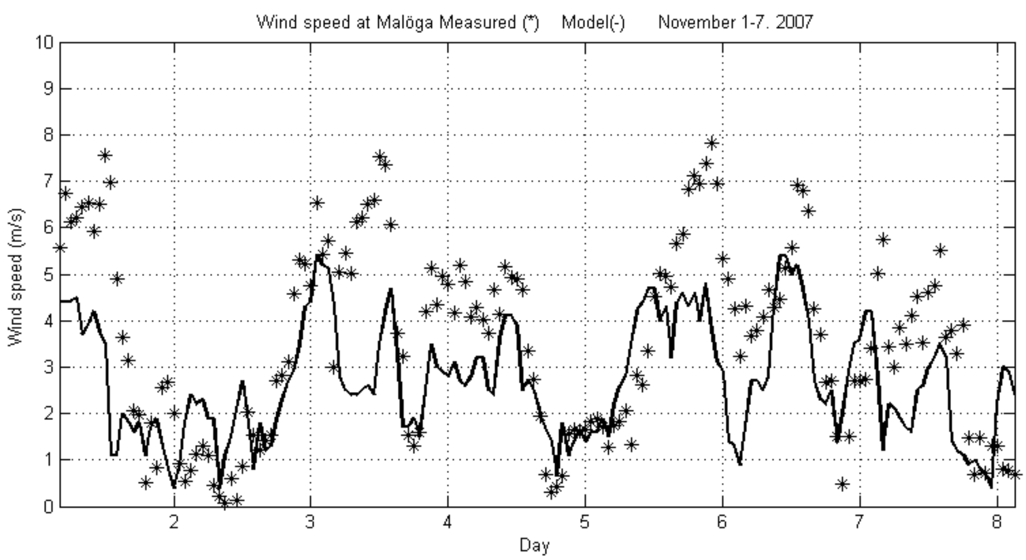

Figure 5. Measured (tower (*)) and simulated (-) wind speed at site Malöga at 10 m.

The wind speed follows the main features but can differ quite much in value during this period. Simulations show that the wind speed can differ quite a lot around the measuring site and as the measurements show the wind at a certain point and the model show a mean for an area the agreement is satisfactory.

The measured and simulated temperature at 2 m height at Malöga, Figure 6, shows also very good agreement. This means that the radiation in the model is good and that the landuse data is good.

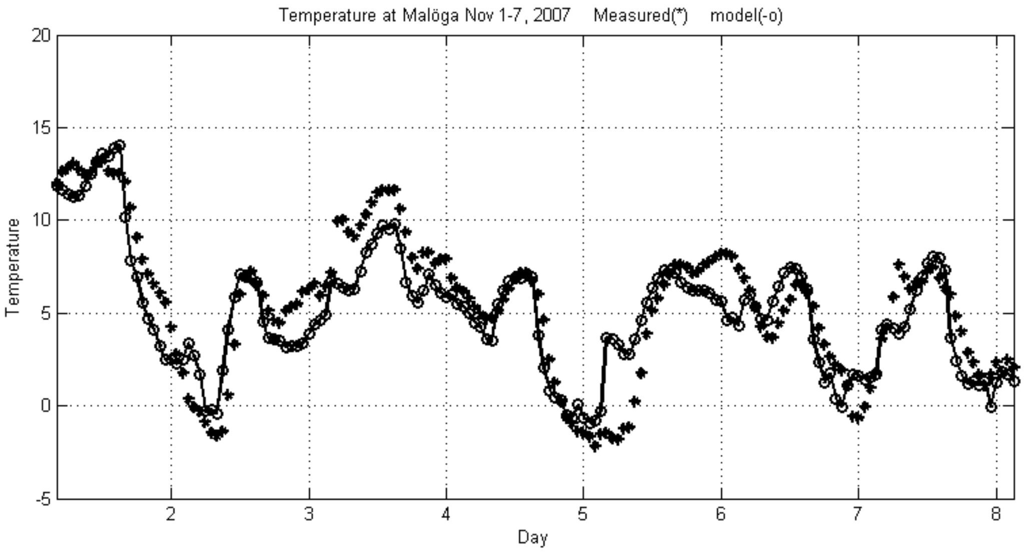

Figure 6. Measured (tower (*)) and simulated (-o-) temperature at site Malöga at 2 m.

4. SUMMARY

A modeling system, including models and measurements, has been presented. The prognosis is corrected against measurements at start of the prognosis. The agreement between prognosis and measurements show quite good agreement both at 175 m and at 10 m.

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