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USE OF THE CALMET MODEL FOR PREPARATION OF WIND ROSES FOR THE REGULATORY MODELLING PURPOSES

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Abstract: An integrated system for the CALMET model input data preparation, model run and post processing has been developed in order to obtain an objective tool for preparation of wind roses at a specific location where a dispersion study is needed. The system uses a high resolution orography and land cover files to prepare the input terrain data. The surface meteorological input file is based on data from the measurement network database to which the system user is able to connect and interactively select stations suitable for the model run. According to the information given in the input files the system sets up the model control file. The user has the option to change the default setting of the model run and fit it to the specific location. The module for post processing consists of the configuration and run of CALMET post processor PRTMET and further statistical processing of the output data in the form of the final wind rose with stability and wind speed classes. The wind rose can then be used in SYMOS '97 model which is an approved methodology for regulatory modelling purposes in the Czech Republic.

Key words: *wind rose, wind field model, CALMET model, user interface system.*

INTRODUCTION
The software system *CALMET Integrator* is a user interface for calculation of wind roses divided into classes of wind speed and atmospheric stability. The system development is a result of cooperation between Czech Hydrometeorological Institute and a private programming company IDEA-ENVI. This contribution describes the *CALMET Integrator* system components, the methodology of wind rose calculation and presents a few examples of model results comparison with measurements.

The model core of *CALMET Integrator* system is a diagnostic 3-dimensional meteorological model CALMET which is a part of CALPUFF dispersion modelling system (Scire *et al.*, 1990a, 1900b). CALMET model includes diagnostic wind field module which provides hourly wind speed and wind direction data on a predefined 3-dimensional gridded domain. The wind field module contains objective analysis and parameterized treatments of complex terrain effects. Further, the CALMET model is able to calculate micrometeorological characteristics of the boundary over land as well as over water bodies.

For the successful run of the CALMET model it is necessary to prepare three basic input data files. The first file describes the geography of a model domain giving the information about the domain extent, terrain elevation and land cover. The second file provides hourly meteorological data from the surface observation stations in the vicinity of the spot where the wind rose is desired. The third input file needed for the model run is upper air data file with frequency of measurements of at least 12 hours. Optionally, the CALMET model accepts prognostic data from meteorological model MM5 (Mesoscale Model v.5) stepping into the model calculation in several possible stages – as surface observation field, as initial guess wind field in diagnostic mode, as Step 1 field in objective analysis mode.

CALMET INTEGRATOR SYSTEM DESCRIPTION
The *CALMET Integrator* system has been developed in order to serve as an easy-to-use tool for preparation of wind rose in a defined location. The wind rose is created in the way as it is needed for the dispersion study following the national approved methodology SYMOS '97. The *CALMET Integrator* manages creation of input files described in the preceding paragraph, runs CALMET model and, based on the model results and using simple statistics, calculates wind rose with wind speed and stability classes as defined by the Bubnik-Koldovsky classification (Bubnik *et al.*, 1998).

The user interface of the *CALMET Integrator* system is shown in Figure 1. One sheet is assigned to each working step where the user successively defines the model run specifications. In the first sheet (Geo.dat) user inserts the location of the spot for wind rose calculation either by stating the exact geographical coordinates or selects location by clicking on the map. The domain extent and the distance between individual grids needs are inserted as well. *CALMET Integrator* then retrieves orography and land cover data inside the domain from orography and land cover binary data files covering the whole area of the Czech Republic in the resolution of 25 m. The data are recalculated into the model grid and written into the geography input file.

Next sheet (Surf.dat) deals with surface meteorological observations. The *CALMET Integrator* system communicates with the climatological database of the Czech Hydrometeorological Institute which embraces surface measurements from the whole measuring network in the Czech Republic. The system offers the user only those stations which have valid data in the selected time period. User chooses stations for the model calculation either from the list of stations or interactively from the map. The selected hourly meteorological data are then uploaded into *CALMET Integrator* and the user is able to watch and edit the data or use an interpolation utility to fill in missing observations. The data are then written into the data file in the format suitable for CALMET model.

The input file with upper air data is not yet part of the *CALMET Integrator* system. Since there are only two locations in the Czech Republic which provide the upper air measurements, the CALMET input files are now prepared by the external utility. Incorporation of the upper air data preparation tool into the *CALMET Integrator* system is one of the future steps in the system development.
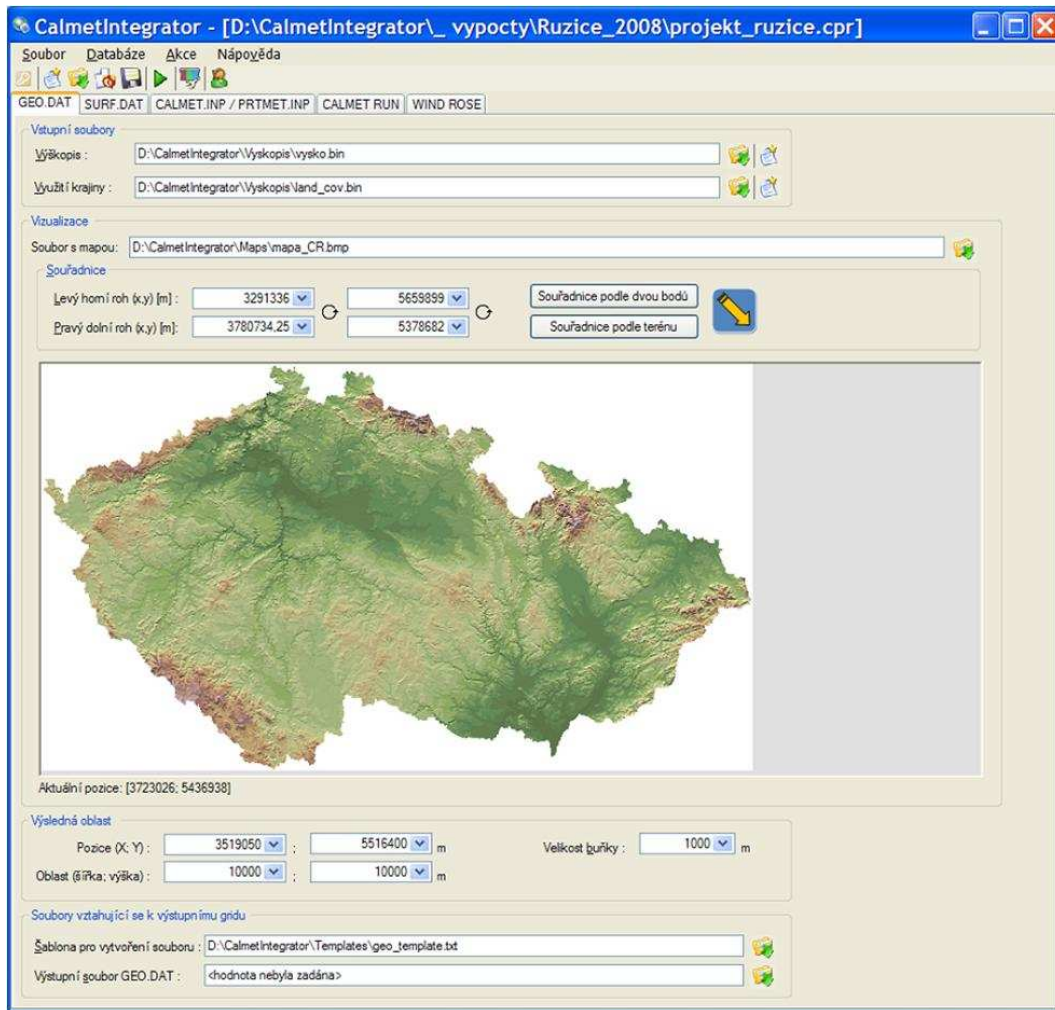
Figure 1. User interface of *CALMET Integrator* system. Example of the first sheet for preparation of geographical input file.

The two following sheets cover the set up of the CALMET model control file and run of the model. Parts of the CALMET control file which have already been defined in the preceding sheets such as domain definition, number and locations of surface stations, etc. are inserted into the control file automatically by *CALMET Integrator*. The user is asked to define parameters usually specific to each calculation (e.g. terrain dependent parameters). Part of the *CALMET Integrator* is also run of the CALMET model postprocessor – PRTMET model. Control file creation and run of PRTMET model is also integrated into these two sheets.

The last sheet is assigned to calculation of the wind rose. As an output from the postprocessor PRTMET a simple data file is produced including hourly data of wind speed and direction in 10 m above ground and temperature in 10 vertical layers for the desired spot and for the selected time period. Based on this data *CALMET Integrator* creates statistical wind rose for 8 directions. The vertical temperature data are used to calculate vertical temperature gradient which serves as a base parameter for atmospheric stability classes. Beside the overall wind rose, *CALMET Integrator* creates wind rose divided into 3 wind speed classes and into 5 classes of atmospheric stability as well.

COMPARISON OF MODEL RESULTS WITH MEASUREMENTS
The comparison of model experiments with meteorological measurements in four different locations in the Czech Republic is presented in this section. The model results were obtained by applying the *CALMET Integrator* system. Shown are annual average wind roses calculated by the CALMET model and annual average wind roses calculated from the observations. In cases shown in Figures 2 to 4, the meteorological station has been selected as a spot for the calculation. However, measurements from this station were not included in the model simulations and are therefore used only for the comparison. Wind rose in Figure 5 has been calculated using two different input data sets. In the first calculation, the observations from the station were not used, but in the second model run the observations were included. Both model runs are again compared with measurements. A simple map demonstrating the terrain of the model domain is given for each location. The spot of wind rose calculation is marked with red dot.
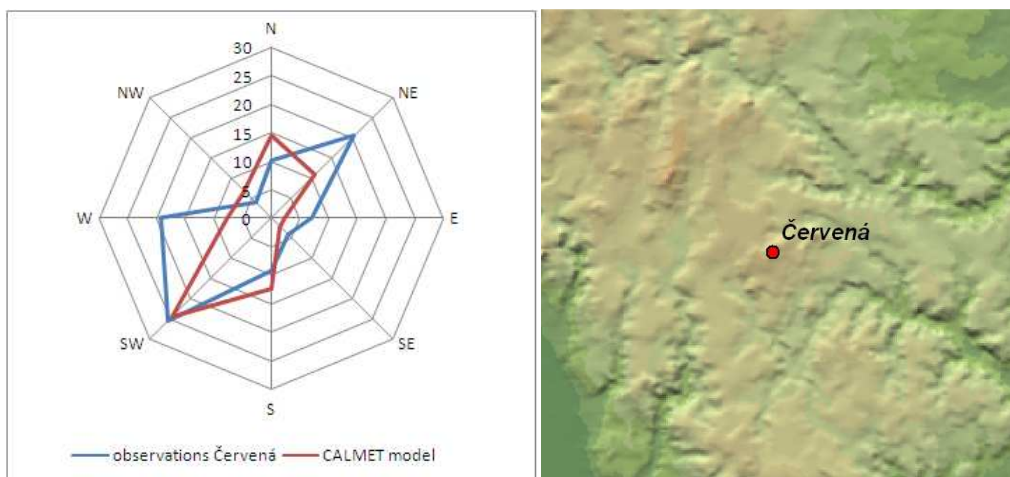
Figure 2. Annual average wind rose for year 2006 calculated with CALMET model compared with annual average wind rose based on observations from Červená station; terrain map of the model domain.
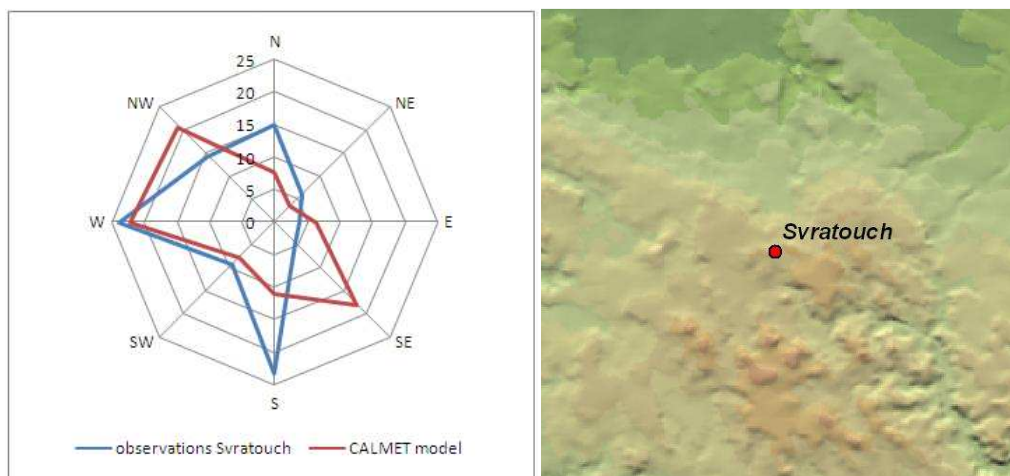

Figure 3. Annual average wind rose for year 2004 calculated with CALMET model compared with annual average wind rose based on observations from Svratouch station; terrain map of the model domain.
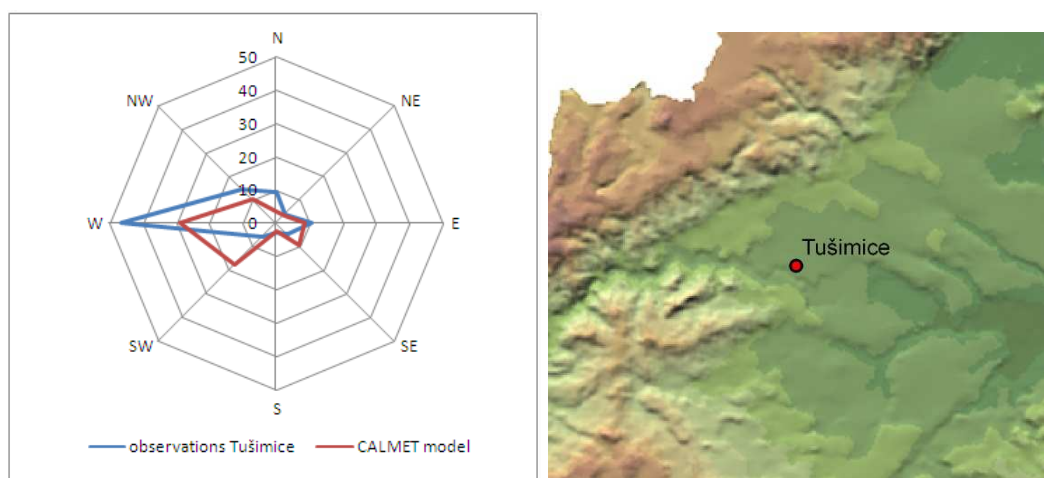

Figure 4. Annual average wind rose for year 2004 calculated with CALMET model compared with annual average wind rose based on observations from Tušimice station; terrain map of the model domain.
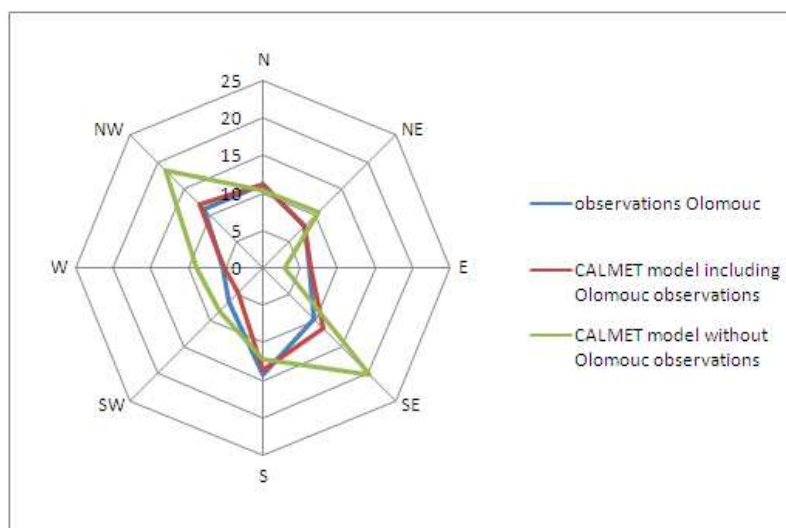
Figure 5. Annual average wind rose for year 2008 calculated with the CALMET model with and without inclusion of observations from the station compared with annual average wind rose based on observations from Olomouc station.

DISCUSSION

From the comparison of model results with measurements it is visible that wind roses produced on the basis of model simulations without inclusion of data from the station differ from those based on the meteorological observations. Although the model is able to capture the mean wind flow (with the exception of Svratouch station), the agreement with observations is not quite as we would expect. The reason for these discrepancies may lie in the insufficiency of the input data, which is even more profound in a complex terrain. The network of measuring stations is regrettably not dense enough and exclusion of one station causes loss in the model input data and it is not possible to compensate this it by another station in the vicinity. Furthermore, Tušimice station is specific for increased westerly winds as a result of the catabatic flows from the surrounding slopes and the model is not able to capture this phenomenon. On the other hand, if the model has the information about the measurements in the location, the agreement between model results and observations is almost absolute, as it is presented in Figure 5.

To improve the model simulations, the next desirable step is to include prognostic meteorological data into model calculations which would simulate increase in surface observations as well as in upper air data owing to relatively dense grid in horizontal as well as in vertical directions. The prognostic wind fields from ALADIN model, which is routinely used in the Czech Hydrometeorological Institute, are being prepared to the format suitable for CALMET model and the test calculations with inclusion of these data will be performed in near future.

REFERENCES
Bubník J., J. Keder, J. Macoun and J. Maňák, 1998: SYMOS'97 Systém modelování stacionárních zdrojů, Metodická příručka, Czech Hydrometeorological Institute, Prague.

Scire, J.S., D.G. Strimaitis and J.R. Yamartino, 1990a: Model formulation and user's guide for the CALPUFF dispersion model. Sigma Research Corp., Concord, MA.

Scire, J.S., D.G. Strimaitis and J.R. Yamartino, 1990b: Model formulation and user's guide for the CALMET meteorological model. Sigma Research Corp., Concord, MA.