

**16th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
8-11 September 2014, Varna, Bulgaria**

**PREPARATION OF INPUT DATA SET FOR DISPERSION MODEL AUSTAL2000
USING OBSERVATIONS AT SYNOPTIC WEATHER STATION**

Dimiter Atanassov, Petio Simeonov, Lilia Bocheva

National Institute of Meteorology and Hydrology, 66 Blvd. Tzarigradsko Chaussee, 1784 Sofia, Bulgaria

Abstract: The German regulatory model AUSTAL2000 is designed to work in two modes: statistical calculations and “time series” calculations. In the second case AUSTAL2000 needs hourly data for wind speed, wind direction in 10-degree batches and stability class according to Klug/Manier (or Obukchov length scale). In many synoptic weather stations measurements are still made manually, by observers. The data are collected in synoptic hours, in 3-hour interval. Often, the wind speed is measured by Wild’s anemometers, where the low threshold is 1 m/s and the wind direction is registered in 22.5-degree batches. Prevailing part of meteorological archives from synoptic stations are collected in this way. A procedure for pre-processing of the data from such a station into the format necessary for the “time series” calculations by AUSTAL2000 is presented. The procedure is applied to the information from the synoptic station “Elhovo” in the Sought-East Bulgaria.

Another issue considered in the present report is determination of the most representative year for dispersion calculations. According to the TA Luft criteria and an additional statistical assessment, the year 2008 was chosen as the most representative among the 10 years record from the “Elhovo” weather station.

Key words: *meteorological pre-processing, dispersion modelling, air quality*

INTRODUCTION

Many dispersion models for regulatory purposes require meteorological information that can not always be met exactly by the available measurements. The automatic meteorological stations satisfy to a great degree the requirements of today dispersion models. Most of these stations have been operating since the last years, while regulatory models usually require data from longer period of time. This make necessary to use data from sites, where measurements are performed by observers, by eye. There is relatively dense network of such stations operating in Bulgaria for many decades. Problem with these stations is that the measurements are performed in discrete time intervals: 3 hours intervals, in the synoptic weather stations, and in 8 hours intervals, in the climatological network of stations, designed for climate researches. The data itself are discrete values, measured by old fashion equipment. For example, the wind speed is measured by the Wild anemometers. The wind velocity takes values 1,2,3,... m/s, and the wind direction is determined in 8- or 16- class scale. More information about these observations and some reasonings on the influence of observer’s subjective factor on the data records, as well as method to avoid them are presented in Tzenkova et al (2002).

The modelling system SELMA-GIS is one of the few tools recommended for use for regulatory purposes in Bulgaria, especially for development of programs for air quality improvement in urban areas (SELMA-GIS, 2012). The system can run different dispersion models. One of them is the advanced Lagrangian model AUSTAL2000 - the official reference model of the German Regulation on Air Quality Control (TA Luft) (AUSTAL2000, 2014). AUSTAL2000 needs the following meteorological information: wind velocity, wind direction in 10-degree batches and stability class according to Klug/Manier (or Obukchov length scale). It can work in statistical mode, producing averaged fields and some extreme values of pollutants concentrations for the considered time period. In the second, “time series” mode, AUSTAL2000 calculates hourly values of the pollutant concentration at some points, for each hour of the considered period. This make possible to assess the number hours and days when the threshold values of some pollutant concentrations have been exceeded. In statistical mode, AUSTAL200 needs a 3-dimensional wind rose of the listed above meteorological parameters for the considered period. In “time series” mode, it needs the values of the listed above meteorological parameters for each hour of the considered period of time - the so called AKTerm file. Often, the calculations of “time series” for long

period of many years is inconvenient. An alternative is to select a representative year among the considered time period and then to perform “time series” calculations for this representative year. For that purpose, the German Weather Service (DWD) developed a method, named AKJahr, for selection of a representative year (Deutschländer T. and J-D. Hessel, 2006).

The present study demonstrates a procedure for selection of a representative year and preparation of AKTerm file from observations at a synoptic weather station. The procedure is applied for the station “Elhovo” in the Sought-East Bulgaria.

DETERMINATION OF A REPRESENTATIVE YEAR

Selection of a representative year is performed in several consecutive steps. First of all, an appropriate weather station have to be chosen, taking into account the geographical characteristics of the region, history of the station, completeness and homogeneity of the data records. If possible, the more recent and longer time period have to be considered; the representative year is recommended to be one of the last 5 years. The selection is mainly done on assessment of wind direction and wind velocity. After the weather station and time period have been selected, the next step is to define the average wind direction and wind velocity for the period. Then, the closeness of each individual year to the mean conditions is assessed. Two statistical tests are recommended by DWD for the assessment procedure: chi-squared test (χ^2) and Spearman’s rank correlation analysis (Deutschländer, T. and J-D. Hessel, 2006).

The subject of the next analysis is information from the synoptic station “Elhovo”, from 2002 to 2011. The data are collected at synoptic hours 00:00, 03:00,06:00, 09:00, 12:00, 15:00, 18:00, 21:00 (UTC). The wind velocity is determined with accuracy of 1m/s and low threshold of 1m/s, and the wind direction is determined in 16–class scale. A representative year will be selected by analysis of these raw data. Three groups of meteorological data are analyzed: wind direction for all cases, excluding the cases of no wind (<1m/s); wind velocity for all cases; and wind direction in the cases of calm wind (< 3m/s). At first, the average values of these parameters for the whole 10 years period are determined. In addition to the recommended χ^2 tests and the Spearman’s rank correlation, calculated by StatSoft Inc.(2004), the correlation coefficient, calculated by the MS Exel, is also used. The closeness of each individual year to the mean conditions is ranked according to the three statistical criteria, for the three groups of meteorological data – see Table 1. Only the first 5 places are considered.

Table 1. Years 2002 – 2011 ranked (the first 5 places) according to its closeness to the mean condition.

	rank	groups of meteorological data		
		wind direction, velocity > 1m/s	wind velocity, all cases	wind direction, calm wind (< 3m/s)
χ^2 tests	1	2002	2004	2008
	2	2006	2008	2007
	3	2008	2010	2003
	4	2003	2007	2006
	5	2005	2009	2004
Spearman correlation	1	2003	2007	2007
	2	2005	2003	2009
	3	2008	2006	2004
	4	2004	2008	2005
	5	2002	2010	2008
correlation coefficient	1	2006	2009	2008
	2	2008	2004	2003
	3	2002	2008	2002
	4	2009	2002	2006
	5	2003	2007	2007

The next step is to give score to the years corresponding to their rank: 5 points for the 1st place, 4 points for the 2nd, 3 points for the 3rd, 2 point for the 4th, and 1 point for the 5th place in Table 1. The

summing of the scores is performed separately for each of the three groups of meteorological data; each one of the three statistical criteria brings the same number of points. The results are presented in Table 2. Finally, the average over the three groups of meteorological data, weighted correspondingly by 0.48, 0.32, 0.2 is determined (the last row of Table 2).

Table 2. Score of the years corresponding to their rank

group of data	weight	years									
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
wind direction velocity > 1m/s	0.48	9	8	2	5	9	0	10	2	0	0
wind velocity all cases	0.32	2	4	9	0	3	8	9	6	4	0
wind direction calm wind (< 3m/s)	0.2	3	7	4	2	4	10	11	4	0	0
mean of the all groups weighted		5.6	6.5	4.6	2.8	6.1	4.6	9.9	3.7	1.3	0.0

The conclusion is that the year 2008 is the most representative year for the period 2002 – 2011. A visual demonstration of the selection procedure is shown on Fig. 1.

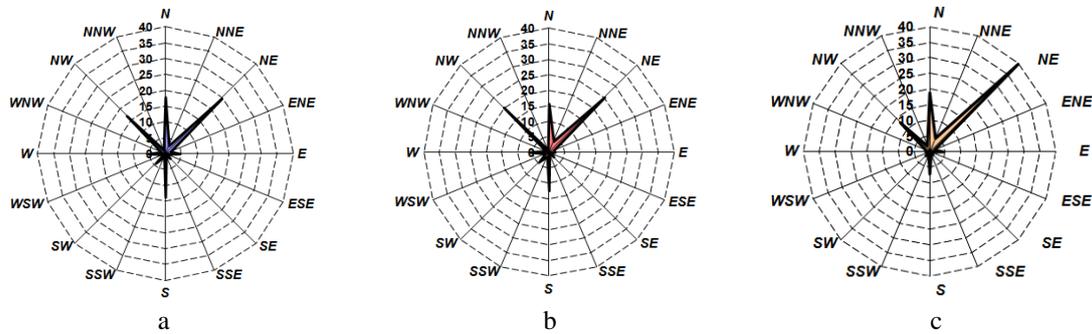


Figure 1. Wind roses of the raw wind measurements at station “Elhovo” for: a) average over 2002-2011, b) the most representative year – 2008, c) the year 2011 - the most different from the average conditions.

PREPARATION OF AKTERM FILE

The AKTerm file contains the hourly values of wind velocity, the wind direction in 10^0 batches and the stability class of Klug/Manier. The format of the numbers in the file is described in (AUSTAL2000, 2014) and will not be discussed here. The data from a synoptic weather station are in 3 hour intervals. Interpolation to 1 hour can be done in different ways. In the present example a simple linear interpolation is used. At most of the synoptic stations, including the “Elhovo” station, the solar radiation is not measured and the stability class of Klug/Manier can not be directly determined. Measurements of wind speed and cloudiness are enough to determine the Pasquill stability class, and then, to determine the corresponding Klug/Manier stability class, according to Foken (2008). This approach is used here.

Focus of the present paragraph is pre-processing of the wind data. The wind velocity records are discrete values of 1,2,3,...m/s. Because of the anemometer threshold of 1m/s, the cases of velocities <1m/s are registered as zero. The wind direction registration is in 22.50 batches, taking the discrete values of: 0° , 22.5° , 45° , 67.5° ,... $360^\circ(0^\circ)$. The preparation of the AKTerm file can not be demonstrated by the AKTerm file itself because of its big size. The preparation procedure will be illustrated by the 3-D wind rose drawn by the SELMA-GIS software from the data in the corresponding AKTerm file. The 3-D rose

summarizes the wind direction, wind velocity and stability class. The main actions in wind data preprocessing are:

1) Random spread of wind direction around its discrete values. In order to study the effect of the interval, in which the random spread is performed, it is done in three different intervals:

–11.25 , +11.25 - 1st example

–15.00 , +15.00 - 2nd example

–22.50 , +22.50 - 3rd example

around its discrete values of: $0^\circ, 22.5^\circ, 45^\circ, \dots$

2) Random spread of wind velocity in the interval $(-0.5,+0.5)$ around its discrete values of 1,2,3,... m/s.

3) In case of wind velocity below the threshold of 1m/s (no wind cases)

a) random spread of wind direction in the interval $(0^\circ, 360^\circ)$,

b) wind velocity is set equal to 0.7m/s.

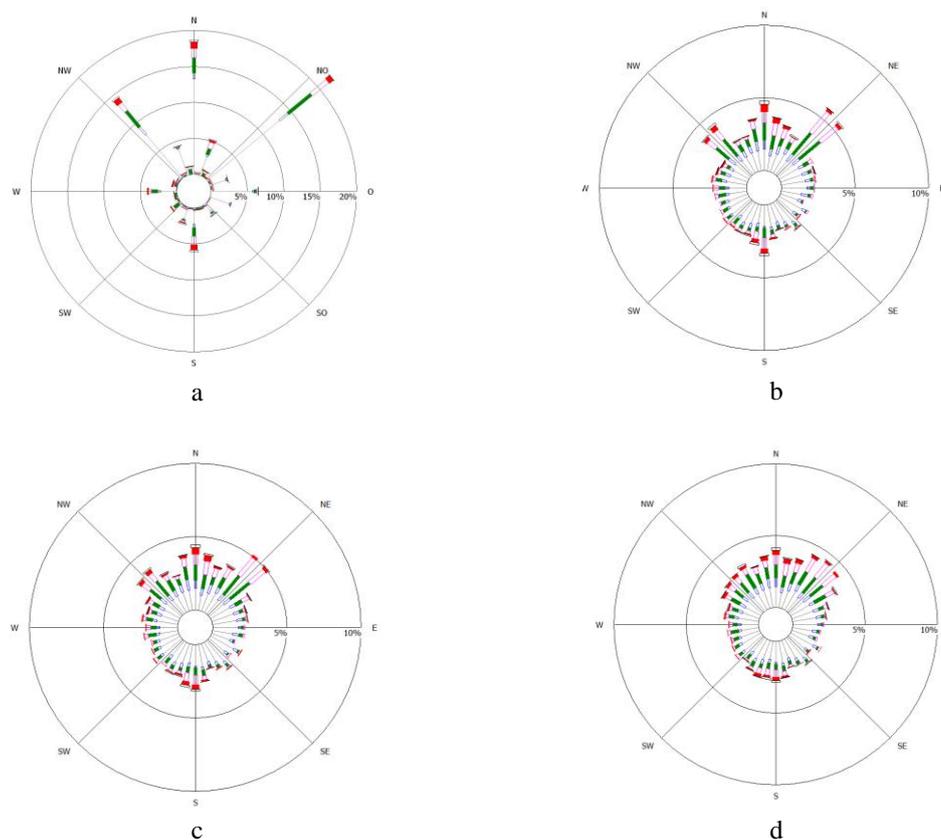


Figure 2. 3-D wind roses obtained by random spread of wind direction in different intervals around the discrete values of $0^\circ, 22.5^\circ, 45^\circ, \dots, 360^\circ$: a) raw data without random spread; b) spread in the interval $(-11.25, +11.25)$, c) spread in the interval $(-15.00, +15.00)$, d) spread in the interval $(-22.50, +22.50)$.

The wind roses for different intervals in which the random spread of the wind direction is done are shown on Fig.2. The Klug/Manier stability class in the AKTerm file are statistically summarized in Table.3.

Table 3. Distribution of the Klug/Manier stability class in the AKTerm file for synoptic station “Elhovo” for 2008.

Klug/Manier class	I	II	III/1	III/2	IV	V
number of cases in %	44.3%	6.9%	16.2%	10.2%	17.1%	5.2%

CONCLUSION

The study demonstrate that the raw data from synoptic weather stations can be successfully preprocessed in the form satisfied the requirements of AUSTAL2000 for the input meteorological information. The described here procedure can be applied to other stations as well as for preparation of meteorological input for other dispersion models.

REFERENCES

AUSTAL2000, 2014, Program Documentation of Version 2.6, 2014, Federal Environmental Agency (UBA), Dessau-Roßlau, Janicke Consulting, Überlingen (Germany),
<http://www.austal2000.de/en/downloads.html>

Deutschländer, T., J-D. Hessel, 2006: Verfahren zur Bestimmung des repräsentativen Jahres aus einer vorgegebenen Zeitreihe der Windrichtung und Windgeschwindigkeit an einer Station,
http://www.dwd.de/bvbw/generator/DWDWWW/Content/Oeffentlichkeit/KU/KU1/KU12/Klimadaten/Ausbreitungen/Details_AKJahr.templateId=raw.property=publicationFile.pdf/Details_AKJahr.pdf

Foken, T., 2008: Micrometeorology, Table 8.2, page 235, Springer-Verlag Berlin, ISBN: 978-3-540-74665-2

SELMA-GIS , 2012, System for Calculating and Representing Air Pollutant Concentrations, Radebeul December 2012, Lohmeyer GmbH,
http://www.lohmeyer.de/de/system/files/content/download/publikationen/Manual_SELMA9.pdf

StatSoft Inc., 2004. STATISTICA (data analysis software system), version 6, www.statsoft.com

Tzenkova, A., J. Ivancheva, D. Syrakov , 2002: Meteorological Preprocessing for Air Pollution Impact assessment, in proc. of 8th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Sofia