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Articles, Letters and other Contributions
for the EURASAP Newsletter since 2008
to
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May 2008

⇐
Summer sunshine in Svalbard

⇒
Winter sunshine in Lapland

European association for the science of air pollution

EURASAP GOVERNING BODIES 2005-2007

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The printed newsletter series started in 1986 and was registered (ISSN-1026-2172) in 1996 with issue 27. Newsletter issues 27 to 64 were printed with registration ISSN-1026-2172.

Editorial

Dear EURASAP members,

The transition from printed to online EURASAP newsletter publication took some time, but our future success depends on how well we shall manage to use the new media to intensify contacts.

You are welcome to share your opinions and ideas sending e-mails to:
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Scientists' Contributions

EVALUATION OF AN OPERATIONAL ENSEMBLE PREDICTION SYSTEM FOR OZONE CONCENTRATIONS OVER BELGIUM USING THE CTM CHIMERE

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Abstract

In the framework of operational air quality forecasts in Belgium, an ensemble prediction system based on the chemical transport model (CTM) Chimere has been implemented. The Chimere model was forced by ECMWF meteorological fields and by the EMEP emission database. The simulation domain covers Western Europe with a spatial resolution of 0.5 degree.

The objective of these ensemble simulations consists of evaluating the impact of uncertainties from emission and meteorological data on the simulated concentrations of pollutants. Such evaluations are important in the operational context, since they contribute to reduce the risk of false alarm and inappropriate broadcast of information to the public. Indeed the forecaster has at its disposal more information to better judge to what extent a change in one or more particular input parameters can influence the modelled pollutant concentrations.

1. INTRODUCTION

A first assessment of the ensemble prediction system has been performed for ozone forecasts during summertime 2006. Currently,

the Chimere model is run considering 16 different scenarios in which some variables influencing pollutant dispersion and ozone chemistry (e.g. temperature, wind velocity, cloud cover) are perturbed. The treatment of all these simulations allows defining a confidence interval around the concentrations simulated by the reference (i.e. without change in input parameters) simulation, which contributes also to improve the accuracy of the ozone forecast. Considering physical aspects, the ensemble prediction system contributes to point out – for each specific situation – the most sensitive input parameters that influences ozone concentrations.

The observations, used to validate the Chimere model are deduced from an advanced interpolation method (kriage). This "RIO-algorithm", developed by VITO (Hooyberghs et al., 2006), provides every hour an ozone value which takes into account the representativeness of the location the user is interested in. The ozone maps created with this algorithm have a spatial resolution of 5 km^2. An overview of the Belgian monitoring network is shown in Figure 1 with the grid points plotted of the interpolated observation maps.

Figure 2 shows the maximum ozone concentrations, simulated with Chimere for the 26^{th} of July, 2006.

2. METHODOLOGY

Since a CTM is very depended on the meteorological fields, it is interesting for the forecaster to know what will be the outcome of a sudden change in these meteo fields for the next day (D+1).

Therefore we roughly changed (in a first stage) 3 parameters in a symmetric way:

- Cloud cover (0 or 1) (CLO, CL1), +50% (Cp5), -50% (Cm5)
- Temperature (+2 ºC (Tp2), +4 ºC (Tp4), -2 ºC (Tm2), -4 ºC (Tm4))
- Wind speed (-1 m/s (Wm1), -2 m/s (Wm2), +1 m/s (Wp1), +2 m/s (Wp2))

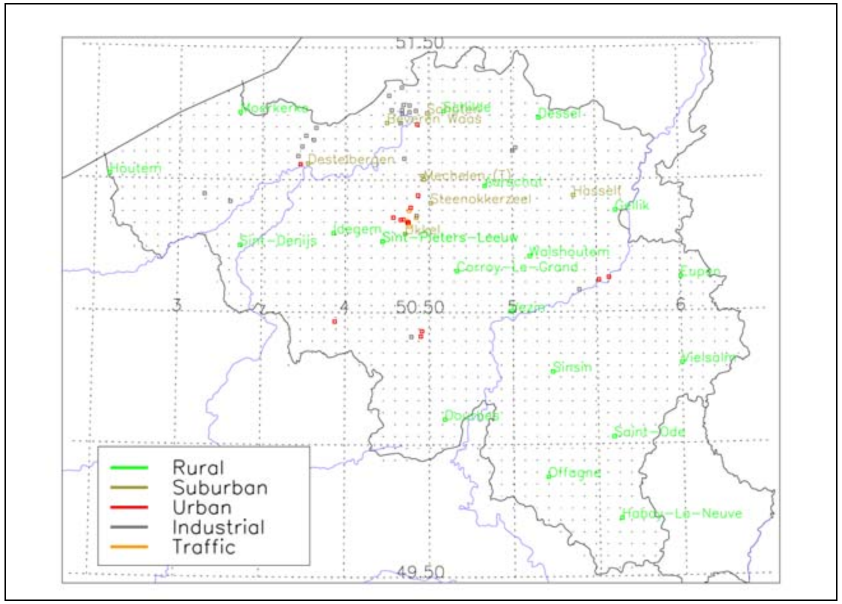

Figure 1. Belgian monitoring network

The reason why we have chosen these values can be derived from Figure 3 which shows an example of an EPS Meteogram for Brussels.

The EPS-gram is a probabilistic interpretation of the forecasts from the Ensemble Prediction System (EPS) for a given location. It displays the time evolution of the distribution of several meteorological parameters in the ensemble (currently 50 members, each starting from slightly perturbed initial conditions) every 6 hours throughout the 10-day forecast period. The unperturbed EPS control and the high resolution deterministic forecast are also shown (by red and blue curves respectively).

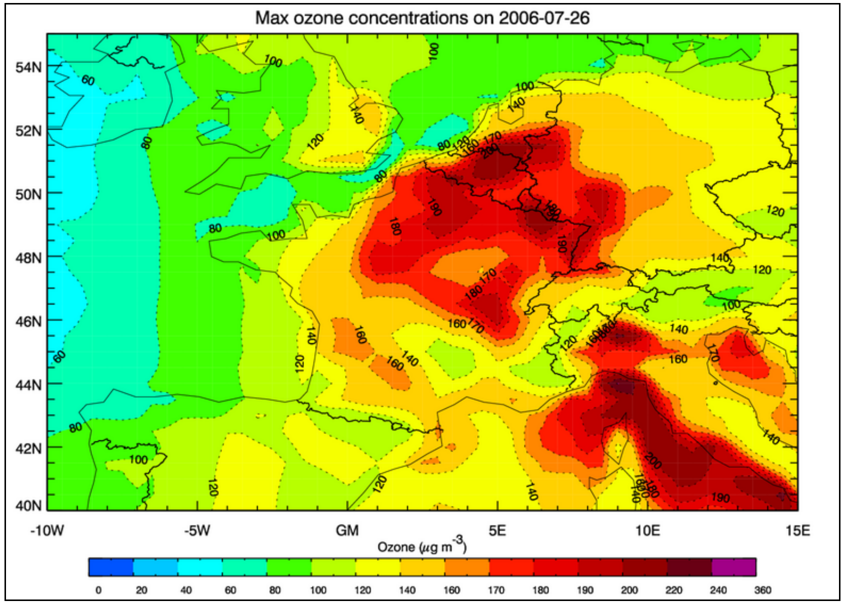

Figure 2. Simulation of maximum ozone concentrations with the CTM Chimere

Also a change in emission scenarios has been taken into consideration. Therefore we have three scenarios:

- Emission (-50 %(EM1), +50% (EM2), +100 %(EM3))

For the emissions we didn't take into consideration a split up into different compounds, i.e. NMVOC and NO_x emissions. It's a general increase or decrease in total emissions we applied.

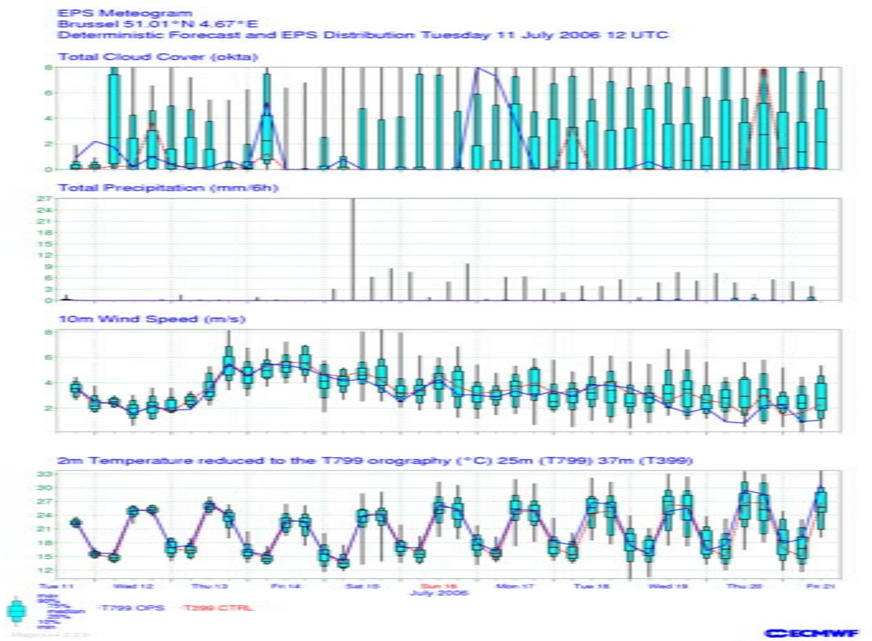

Figure 3: EPS meteogram fro Brussels

3. RESULTS

As an example results are shown for Latitude 51 and Longitude 3.0 (Figure 4). To validate the results, some general statistics (bias, rmse, correlation) are calculated on this different runs for the forecasted day +1 (D+1) (Table 1).

Figure 5 shows the corresponding observed maximum ozone values derived with the RIO algorithm for the 13th of July 2006 with a horizontal resolution of 5 km^2.

Table 1. Bias (ppb), correlation and rmse (ppb) for the time period 01/06/2006 – 21/07/2006 are shown for some grid points with respect to RIO-observations.

LAT	LON	CL0	CL1	Cm5	Cp5	STD	Tm2	Tm4	Tp2	Tp4	Wm1	Wm2	Wp1	Wp2	EM1	EM2	EM3
51.0	5.0	-0.2	-25.3	-5.3	-8.7	-7.5	-7.6	-8.2	-7.0	-4.6	-7.0	-6.5	-7.9	-8.3	-10.0	-6.4	-6.1
		0.78	0.66	0.84	0.86	0.85	0.85	0.85	0.87	0.87	0.85	0.85	0.86	0.86	0.84	0.85	0.84
		13.9	30.1	13.1	14.3	13.7	13.7	14.2	13.2	12.3	13.6	13.5	13.8	13.9	15.5	14.2	16.0
51.0	3.0	0.6	-18.4	-3.1	-5.4	-4.5	-4.0	-4.0	-6.3	-4.2	-4.6	-4.7	-4.5	-4.6	-5.7	-4.7	-5.4
		0.82	0.56	0.86	0.87	0.87	0.86	0.86	0.82	0.85	0.87	0.87	0.86	0.86	0.87	0.86	0.85
		11.4	24.1	10.4	11.0	10.7	10.4	10.6	12.6	11.3	10.7	10.8	10.7	10.9	11.0	12.0	13.8
50.5	6.0	-0.3	-16.9	-4.2	-7.0	-6.0	-6.1	-6.8	-3.4	0.1	-5.1	-4.3	-6.5	-6.6	-9.9	-3.4	-1.6
		0.66	0.60	0.72	0.73	0.73	0.72	0.72	0.75	0.76	0.74	0.74	0.73	0.73	0.70	0.73	0.72
		13.9	22.1	13.5	14.4	14.0	13.9	14.1	13.0	13.0	13.5	13.0	14.1	14.2	16.0	14.0	15.4
51.0	4.5	-2.3	-27.9	-7.9	-11.4	-10.2	-9.0	-9.2	-8.8	-6.7	-9.8	-9.5	-10.4	-10.6	-11.0	-10.8	-12.0
		0.80	0.65	0.85	0.85	0.85	0.86	0.86	0.87	0.87	0.85	0.85	0.85	0.85	0.85	0.83	0.82
		13.9	32.8	14.4	16.6	15.6	14.5	14.8	14.4	13.6	15.4	15.3	15.8	15.8	16.3	17.4	19.8

The results show that Chimere has a high negative bias for this particular time period. When we reduce the cloud cover, the bias and rmse improves, but the correlation declines. Table 1 shows that in general the changes in wind speed and temperature are less important. Only Tp4 shows significantly better scores for bias, correlation and rmse, compared with the standard run of Chimere.

Changes in emissions are not really improving the forecasts for ozone. This can be related to the non-linear behaviour of ozone. In this study we didn't take into account if the grid cells under consideration are located in a VOC- or NO_x-limited region. This can significantly improve the forecasts, taking different scenarios into account.

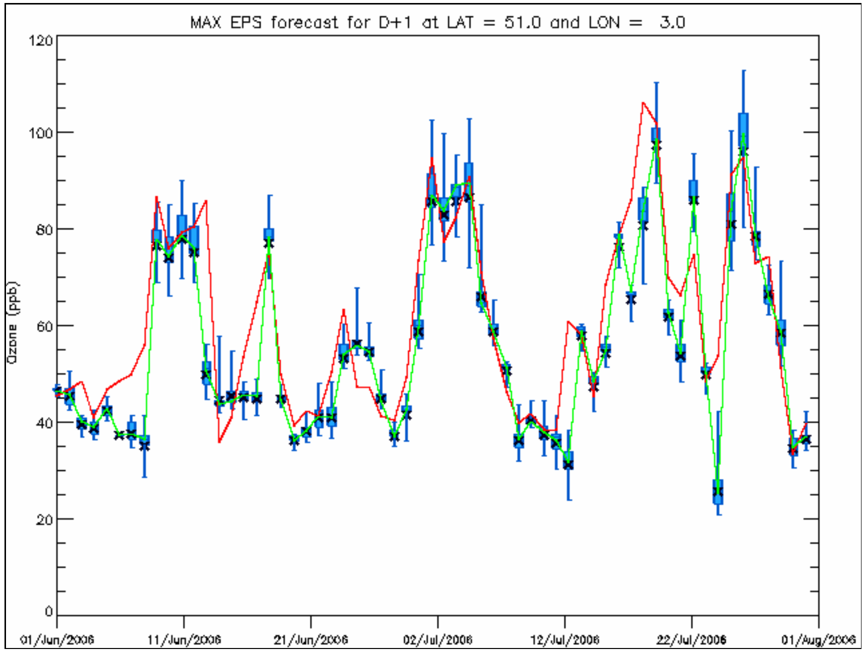

Figure 4. Boxplot of maximum daily ozone concentrations (ppb) for the time period 01/06/2006 – 31/07/2006. The 10, 25, 50, 75, 90 percentiles and the mean value (black cross) are shown. The red lines corresponds to the observed values with RIO, the green line represents the standard run of Chimere

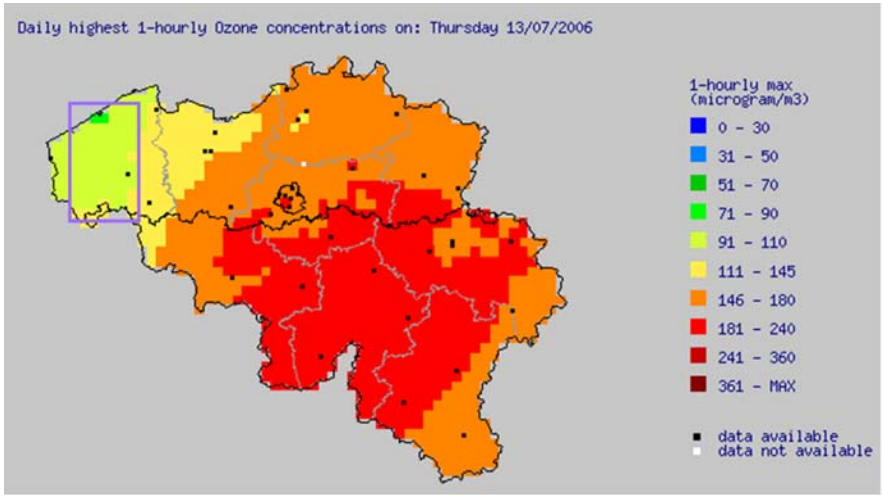

Figure 5: *Daily highest 1-hourly Ozone concentrations*

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HEIGHT OF STACKS WITH LOW POLLUTANT EMISSIONS: ANALYSIS OF DATA FROM A SIGNIFICANT NUMBER OF SMALL AND MEDIUM SIZED INDUSTRIES

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Abstract
Based on data gathered from a significant number of small and medium sized Portuguese industries, a comprehensive study on the need to heighten stacks with low pollutant emissions is presented. This study considers the application of the recent Portuguese legislation for stack height verification and the application of dispersion modeling tools. The main reasons for stack heightening in existing small and medium sized industries with low pollutant emissions are presented and discussed. The benefits and the environmental impact of the recent Portuguese legislation for stack height verification are discussed.
Keywords: Stack height, Legislation, Building downwash, Dispersion modelling.

INTRODUCTION

Atmospheric dispersion modeling has proven its importance in giving a greater insight on the atmospheric distribution of pollutants. The good results obtained in the validation tests made with different dispersion models assure, to some extent, their applicability in the study of different scenarios of atmospheric pollutants emissions and in justifying design options which are unconventional and/or fall out of the legislation scope (Scire, 1999).

Due to the complex nature of the atmospheric dispersion phenomenon, a great deal of caution is yet necessary even in the application of validated dispersion models. A particular example is related with the application of dispersion models when perturbations in the airflow around industrial buildings have a significant impact in the pollutants dispersal, giving origin to building downwash effects. Building downwash problem (Briggs, 1973) is particularly important in existing small and medium industries that did not pay much attention to pollution dispersal in the past and have stacks and building roofs of identical height and roofs of complex geometry, resulting from a seemingly unplanned growth of the productive process.

Since the introduction of the Air Act in 1990 (DR, 1990) in Portugal, several existing Portuguese industries had to review the height of their stacks. Based on the applicable legislation, stacks should have more than 10 m, and, when in the vicinity of a large structure, and are given by equation (1).

$$A_c = a + 1{,}5l \qquad \text{Equation (1)}$$

where, A_c stands for the stack height measured above soil (m), a stands for the nearby structure height measured above soil (m) and l stands for the smallest dimension (height or width) of the nearby structures (m), should be used.

It should be noted that equation (1) is somewhat simplistic as it does not take into account such crucial factors as pollutant mass flow, upward thermal forces, background pollutant concentration. The conservative nature of this equation and the fact that Portuguese industries are generally small and medium sized enterprises with low pollutant emissions to the atmosphere, often led to disproportionate heightening needs that contradicted common sense.

As this legislation (Gomes, 2004a) considers the possibility of justifying heightening needs based on dispersion modeling tools, this became the way used by several industries to avoid the conservativeness of equation (1). As a result, some lack of standardization in the stack height verification methodology occurred, and in some cases the importance of building downwash phenomena may have been neglected, as shown previously by the authors (Gomes, 2004b).

With the introduction in 2006 of a new Portuguese legislation (DR, 2005) for stack height verification, pollutant mass flow, upward thermal forces and pollutant background concentration are now considered, and a more reasonable way of dealing with the influence of nearby large structures is also considered. This constitutes a significant improvement towards the standardization of stacks height verification methodology and towards better environmental conditions.

Based on data gathered from approximately 100 stacks of more than 20 different Portuguese small and medium sized industries, and considering different methodologies to verify/compute stack height - recent Portuguese legislation; building downwash analysis and dispersion modeling, it is possible to assess the main reasons for stack heightening needs in existing small and medium sized industries. By comparing different methodologies for verifying and computing stack height, it is also possible to discuss the benefits and the environmental impact of the recent Portuguese legislation for stack height verification.

CHARACTERIZATION OF THE INDUSTRIES CONSIDERED IN THE STUDY

The data used to assess the stack heightening needs in small and medium sized industries was collected since 1998, from over 20 Portuguese enterprises. These enterprises included glass manufacturers, chemical industries, combustion facilities, paper mills, and many other small and medium sized factories. Overall, more than 100 stacks were analyzed.

Different pollutant emissions were studied. However, the major pollutant mass flows emitted to the atmosphere were PM10 and NO_x. For these stacks, Figure 1 presents the relative frequency of different classes of PM10 mass flows emitted to the atmosphere, m_{PM10}. From Figure 1 it can be concluded that more than 50% of the PM10 emissions were smaller than 100 g/h. Over 90% of the PM10 emissions were smaller than 1000 g/h.

Figure 2 presents the relative frequency of different classes of NO_x mass flows emitted to the atmosphere, m_{NOx}. From Figure 2 it can be concluded that 45% of the NO_x emissions were smaller than 100 g/h; 65% of the NO_x emissions were smaller than 1000 g/h.

Figures 1 and 2 show that the majority of the stacks studied emitted low mass flows of pollutants.

STACK HEIGHTENING NEEDS CONSIDERING THE USE OF THE RECENT PORTUGUESE LEGISLATION

According to the recent Portuguese legislation (DR, 2005), stack height verification depends on a minimum 10 m stack height and on: i) the magnitude of pollutants mass flow; ii) the presence of large structures in the vicinity of stacks; and, iii) the height of the stack above the top of the buildings roof where the stack is located (should be greater than 3 m).

The actual value of each stack is chosen as the higher value between Hp and Hc. Hp is the minimum height of a stack considering the pollutant emission aspects, as given by equation (2).

$$Hp = \sqrt{S} \, (1 / Q \, \Delta T)^{1/6} \qquad \text{Equation (2)}$$

where, Q is the flow rate of emitted gases (m^3/h), ΔT is the difference between the outlet gas temperature and the average annual air temperature in the location (K), and S is given by equation (3), as follows:

$$S = F \, q / C \qquad \text{Equation (3)}$$

where, C is the difference between a reference concentration for each pollutant and its background concentration in location (mg/m^3), F is a correction factor (F=340 for gases and F=680 for particles) and q is the maximum pollutant flow rate (kg/h).

Hc is the minimum height of a stack considering the presence of obstacles, as given by equation (4).

$$Hc = h_0 + 3 - 2D/5h_0 \qquad \text{Equation (4)}$$

where, D is the distance between the obstacle and the stack (m) and h_0 is the height of the obstacle (m).

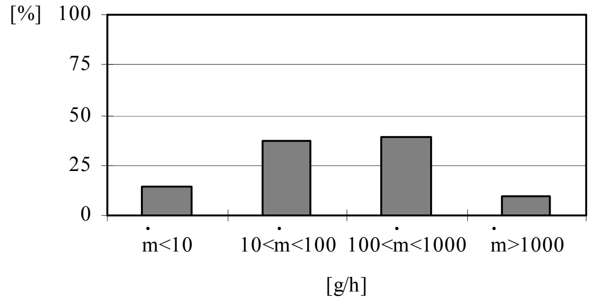

Figure 1. Relative frequency of different classes of PM10 mass flows

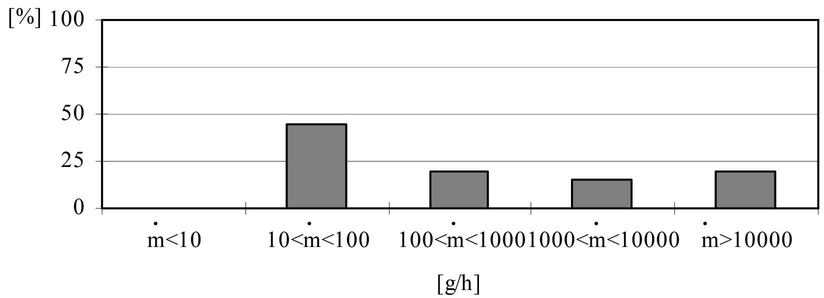

Figure 2. Relative frequency of different classes of NOx mass flows

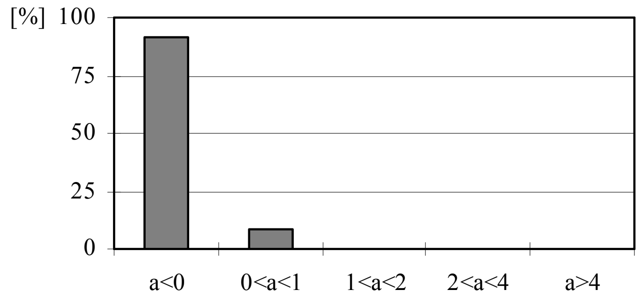

Figure 3. Relative frequency of different classes of stack heightening needs, a_m , when only the magnitude of the pollutant mass flow is analysed

For the studied stacks, Figure 3 presents the relative frequencies of different stack heightening needs, when only the magnitude of the pollutants mass flow is analyzed (note that heightening needs are presented as a percentage of heightening when compared to the actual stack height). From Figure 3 it can be concluded that, if the magnitude of pollutant mass flow emitted to the atmosphere was the only factor determining stack height, the majority of the actual stacks could in fact be lowered (a_m<0). Only 8,5% of the stacks studied had to be raised from its actual height (a_m =0) up to twice the actual stack height (a_m =1).

Figure 4 presents the relative frequencies of different heightening needs, when only the presence of large structures in the vicinity of stacks is analyzed. From Figure 4 it can be concluded that, if the presence of obstacles was the only factor in determining stack height, the majority (74%) of the actual stacks had to be raised to a height from its actual height ($a_{\text{Obst.}}$ =0) up to twice the actual stack height ($a_{\text{Obst.}}$=1).

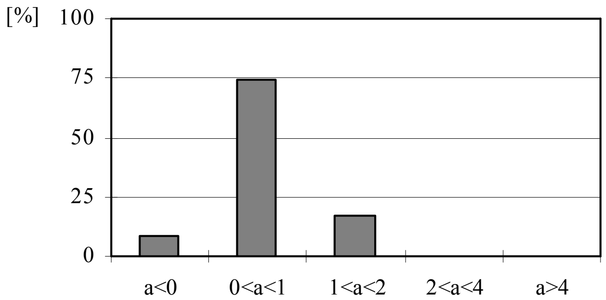

Figure 4. Relative frequency of different classes of stack heightening needs, $a_{\text{Obst.}}$, when only the presence of large structures in the vicinity of stacks is analysed

Figure 5 presents the relative frequencies of different stack heightening needs, when only the distance between the stack top and the top of the buildings roof where the stack is located is analyzed (should be greater than 3 m). From Figure 5 it can be concluded that only 30% of the stacks are 3 m (or more) taller than the roof top. The majority of the stacks studied (70%) should, however, be heightened, since their height above the roofs top is lower than 3 m.

Considering the three factors studied above, that determine the stack heightening needs, according to the new Portuguese legislation, Figure 6 presents the percentage of stacks that should be heightened due to: i) the magnitude of pollutant mass flow (m); ii) the presence of large structures in the vicinity of stacks (Obst.); and, iii) the height of the stack above the top of the buildings roof where the stack is located (Roof). From Figure 6 it can be concluded that the main reason for the heightening of stacks of small and medium sized industries, with low pollutant emissions, is the presence of obstacles in the vicinity of stacks. Heights of stacks above the roofs top lower than 3 m are also a common reason for stack heightening needs.

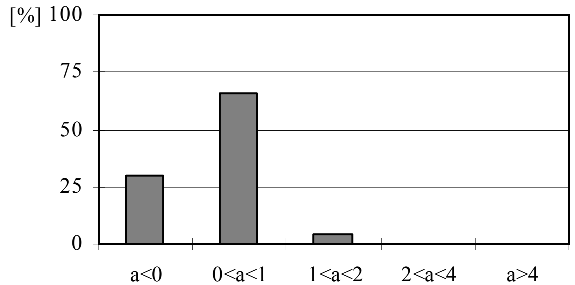

Figure 5. Relative frequency of different classes of stack heightening needs, a_{Roof}, when only the distance between the stack top and the top of the buildings roof where the stack is located is analysed

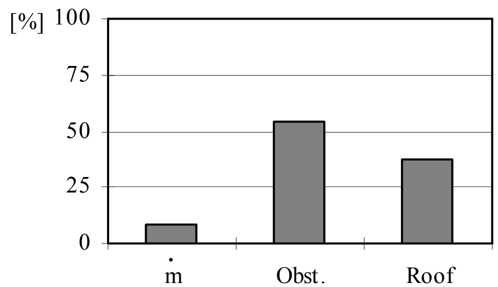

Figure 6. Percentage of stacks heightening needs per factor: pollutant mass flow, presence of obstacles, Obst., distance to roof top, Roof

STACK HEIGHTENING CONSIDERING BUILDING DOWNWASH PHENOMENA AND DISPERSION MODELING

Experience in atmospheric pollutant dispersion modeling applied to Portuguese industrial facilities has been gathered by the authors since 1986. The methodology followed in these dispersion modeling studies is presented in detail by Gomes and Duarte (Gomes, 2004b ; Gomes, 2006). This methodology begins with a site visit and gathering of data. With the plant layout data and the information from the site visit, a preliminary analysis on the airflow patterns around the main buildings can be performed. This analysis intends to identify possible building downwash phenomena. To study the compliance with ambient pollutant concentration limits, the gaussian dispersion model TAPM (Hurley, 2005) was used to determine ambient pollutant concentrations that result from specific maximum emissions, stack geometry and location (near large buildings) and meteorological data. For computing pollutant dispersion in the atmosphere, this model uses previously developed algorithms (Pasquill, 1974 ; Glendening, 1984), and is able to integrate capture effects by the pollutant plume (Schulman, 2000), and calculates different time averages of pollutants in the atmosphere.

For the studied stacks, Figure 7 compares the stack heightening needs when this methodology is used and when the recent Portuguese legislation is followed. This comparison is presented in terms of differences (*d*, in percentage) using both methods. Five classes of differences were considered. From Figure 7 it can be concluded that in 50% percent of the studied cases there is a difference lower than 5% between the stacks heightening need obtained using the author's methodology and that obtained using the recent Portuguese legislation. In 87% of the cases this difference is lower than 10%.

When the recent Portuguese legislation method for determining the stack heightening needs is compared with the method based on equation (1), in 65% of the cases the differences in stack heightening needs between both methods are greater than 25%. This result points out the difference between the recent and old Portuguese methodology for verifying stack height.

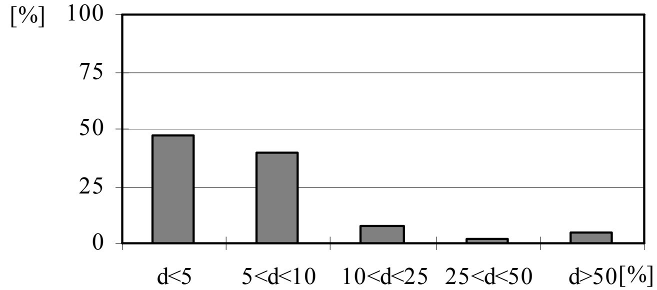

Figure 7. Difference between stack heightening needs using the author's methodology and the recent Portuguese legislation

CONCLUSION

In this paper, data gathered from a significant number of Portuguese small and medium sized industries was analyzed and the issue of heightening needs of low pollutant emitting stacks was addressed. The recent Portuguese legislation on stack height verification was applied to the data gathered. Results showed that for small and medium sized industries stacks usually emit low pollutant mass flows. For these industries the main reason for stack heightening needs is the presence of large obstacles in the vicinity of stacks. Small distances between stacks top and buildings roof top is also a common reason for stack heightening needs. Both results point out the importance of building downwash analysis when studying low pollutant emitting stacks.

A comparison between recent and old Portuguese legislation for verifying stack height showed great differences. When the recent Portuguese legislation was compared with the methodology that has been used by the authors (which considers building downwash phenomena and dispersion modeling tools), very similar stack heightening needs were obtained. This is obviously due to the importance given in both methods to building downwash analysis.

The fact that recent Portuguese legislation justifies reasonable heightening needs for low pollutant emitting stacks contributes to the swift enforcement of the legal requisites. Therefore, it contributes, also, to the reduction of the environmental impact of many small and medium sized Portuguese industries.

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Past events

Harbors08

The 2nd international conference on Harbours, Air Quality and Climate Change, took place in Rotterdam, the Netherlands on 29 and 30 May 2008. The home page of the conference www.haqcc.org is still active. Information on event and contribution of the EURASAP grantees will come in the next newsletter issue.

Future events

EMS8/ECAC7

The 8th Annual Meeting of the European Meteorological Society (EMS) and the 7th European Conference on Applied Climatology (ECAC) will take place in Amsterdam, The Netherlands on 29 September – 3 October 2008. The scientific programme and abstract submission are now accessible at:
http://meetings.copernicus.org/ems2008
Information on registration, accommodation, travel routes, visa requirements, social events and exhibition opportunities will also become available on this conference web site.
This event has a strong focus on all questions related to mitigation and adaptation to climate change. Sessions discussing climate change and variability are paired with a programme that explicitly addresses adaptation plans in different societal and economic areas.
The programme groups "Forecasting the weather at all time scales – THORPEX studies, developments in NWP, applications and societal impact", "Meteorology and society", and "Atmosphere and the water cycle". It will address a wide spectrum of scientific and application topics in the atmospheric and related sciences, including the challenges to communicate results to society at large.
Contact:
Martina Junge, EMS Executive Secretary, E-mail: ems-sec (at) met.fu-berlin.de
Katja Gänger, Copernicus Meetings ems2008 (at) copernicus.org

Harmo12

The 12th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes will be held from 6 to 9 October 2008 in hotel CROATIA, Cavtat, Croatia.
In order to get all updates on the conference please ensure that you have registered your interest via the website
http://www.meteo.hr/harmo12/PreRegistration.html
Please make a note of the following important dates: One-page abstracts by 10 March 2008; extended abstracts by 4 August 2008; Early registration by 30 June 2008.
Organizing Committee
Research and Development Division-Air Quality Research Unit
Meteorological and Hydrological Service of Croatia

ACCENT/GLOREAM workshop

The next ACCENT/GLOREAM workshop on atmospheric chemistry transport modelling will take place in Antwerp, Belgium. The aim of ACCENT/ GLOREAM is to investigate the processes and phenomena which determine the chemical composition of the troposphere by means of advanced and integrated modelling, both on regional (over Europe) and global scale. The workshop will start on Wednesday, 29 October 2008 at 14.00 p.m. and will end on Friday, 31 October 2008 at 14.00 p.m.
For more information on the workshop venue, call for abstracts, workshop registration, accommodation and contact information, please visit:
http://www.vito.be/accent
Clemens Mensink
VITO - Centre for Integrated Environmental Studies
Boeretang 200, B-2400 Mol, Belgium,
e-mail: clemens.mensink@vito.be

NATO/SPS ITM30

The 30th NATO/SPS International Technical Meeting on Air Pollution Modelling and its Application will take place on 18 – 22 May 2009 at Holiday Inn Gateway, San Francisco, United States of America:
http://www.int-tech-mtng.org/index.html

Deadlines
Abstract Submission: 31 August 2008
Confirmation of acceptance by e-mail: 31 October 2008
Opening of Registration & Hotel Reservations: 31 October 2008
Pre-Registration: 13 February 2009
Manuscript submission deadline: 1 March 2009
Hotel Reservation Deadline: 20 April 2009

Host country: USA
S.T. Rao, Ph.D.
Director, Atmospheric Modeling Division
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The University of British Columbia
Vancouver, BC, Canada V6T 1Z4
e-mail: admin@int-tech-mtng.org, Web: www.int-tech-mtng.org

Air Quality 2009 (UAQ2009)

The 7th International Conference on Air Quality - Science and Application (Air Quality 2009) (formerly known as the Urban Air Quality Conference) will take place on 24-27 March 2008, Istanbul, Turkey.

The conference is being organised by the University of Hertfordshire and the Istanbul Technical University with support from a number of international organizations including World Meteorological Organization (WMO), American Meteorological Society (AMS), Air & Waste Management Association (A&WMA), COST 728, TUBITEK and SHELL.

Important deadlines:

Abstract submission: Friday 26 September 2008
Short paper submission: Friday 9 January 2009
Early bird rate for registration: Friday 6 February 2009

For more information:

Website: **www.airqualityconference.org**
Email: airquality@herts.ac.uk

WMO meetings in September 2009 announced at www.icdc8.org

Please note the following important meetings for September 2009 hosted by MPI Biogeochemie, P.O. Box 10 01 64, 07701 Jena, Germany, Martin Heimann and Willi Brand

1. WMO/IAEA Experts Workshop on Observations of Greenhouse Gases and Related Tracers
Dates: Monday-Thursday, 7-10 September 2009
Location: Volksbad, Jena, Germany
Contact: Dr Willi A. Brand, Max-Planck-Institute for Biogeochemistry, Jena
Email: wbrand@bgc-jena.mpg.de

2. Meeting of the WMO Scientific Advisory Group on GHGs
Date: Friday, 11 September 2009
Location: Max-Planck-Institute for Biogeochemistry, Jena, Germany
Contact: Martin Heimann, MPI for Biogeochemistry
Email: office.bgc-systems@bgc-jena.mpg.de

3. 8th International Carbon Dioxide Conference (ICDC)
Date: 13-19 September 2009
Location: Friedrich-Schiller University of Jena, Ernst-Abbe-Platz (Carl-Zeiss-Str. 3, D-07745 Jena, Germany)
Contact: Martin Heimann, MPI for Biogeochemistry,
Email: office.bgc-systems@bgc-jena.mpg.de,

EUROPEAN ASSOCIATION FOR THE SCIENCE OF AIR POLLUTION

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