AN INTEGRATED TOOL TO FORECAST AND REDUCE REFINERY CONTRIBUTION ON SO2 POLLUTION PEAKS.

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INTRODUCTION

For several years, environmental modeling has become a tool systematically used for regulatory purposes, prospective policies on air quality and for impact assessment on air pollution in large emission situations too. For many plants, the annual average impact is significantly lower than regulation limit. Nevertheless, in some critical meteorological conditions, pollution peaks may occur.

The present study describes an original control method for a refinery emissions based on forecast meteorological and dispersion modeling, to avoid SO_2 pollution peaks.

TECHNICAL DESCRIPTION

Context

The Donges refinery is located in the Loire estuary (Atlantic France West coast) near the city of Donges (Localized unless 1 kilometre of houses, see Figure 1). According to the classical wind rose (High speed), the annual impact of the refinery is significantly lower than the annual limit of the European regulation. Unfortunately in some specific meteorological conditions, SO_2 concentration recorded by air quality network (Air Pays de Loire) overtakes the information threshold (300 µg/Nm^3 during one hour, local regulation of the 04/03/01) about 17 times, per year. Analysis of these specific meteorological conditions has been done. It shows that in most part of the events, the passage of an oceanic depression conducts to a brief wind shifts from West / South-West to South / South-East. When the front travels the Donges area, conflict of air masses conducts, in less than one hour, to a fast variation of wind direction and atmospheric turbulence, leading to high SO_2 impact situation on Donges city.

Principal scheme of the modelling system

In one hand, there is a fast meteorological change, and in the other hand, actions on emissions reduction by the refinery need several hours to be effective at stack level. If actions begin when the wind shifts occurs, it's too late to avoid the SO_2 peak. To anticipate these situations, a forecast meteorological and dispersion system has been developed to choose the most efficient strategy for emission reduction. Its aim is to be an help for decision-making. Due to operational constraints (Economic planning, interaction of different refinery units and decision making), forecast must be at least of 24 hours. The decision making principle is summarized in Figure 1; a more complete description is done in *Puel* (2007). The decision rule starts with impact forecasts taking into account meteorology and emissions defined with the operational units program. If the tool forecasts high SO_2 environmental impacts, production schedule is modified (fuels changes or flue reduction) then re-evaluated to reach the optimal impact situation.

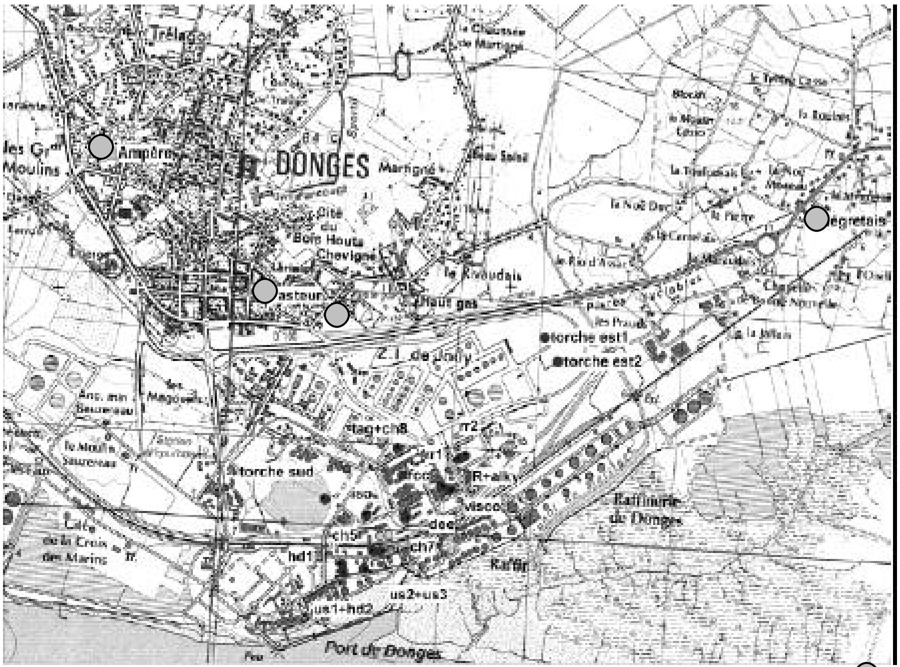

Fig. 1; Donges city, Refinery and airquality monitor implantation (◯) .

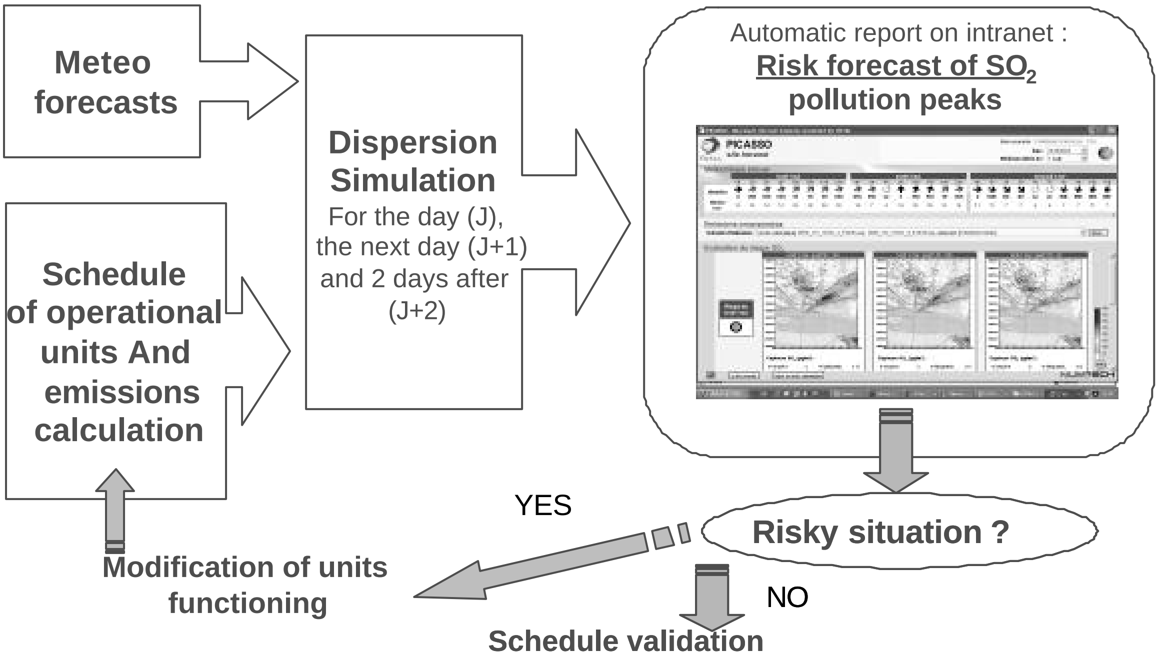

Fig. 2; operational tool scheme for SO_2 Risk forecast.

Meteorological forecast system

A comparative evaluation of 3 meteorological forescast models performance (RAMS *Pielke & all* (1992), 2 configurations of MM5 *Dudhia* (1993)) has been carried out during 3 months. Daily forecast (direction and wind speed, temperature) were compared with more than 60 000 data measurements on site. The statistics report in table 1 focuses on the risky situations: SO_2 peaks on the sensors of Donges corresponding to a windfall phenomenon with a wind direction range of 145-175°. It shows the percentage of good prediction according different tolerances in terms of wind speed, wind direction and temperature. Performance results have been calculated by accepting a shift of prediction in an interval of time of 4 hours. It is observed that the precise prediction of the windfall hour is less important than the good modeling of depression arrival. Between the 3 evaluated configurations RAMS was the best one. We retained a nesting approach (3 grids, finest resolution with cells of 4 km x 4 km), with large scale GFS forecast model nudging. There is an automatic update (twice a day) of the weather forecast in the operational tools.

Table 1. Percentage of good prediction of different meteorological forecast models according different tolerances .

	Wind Direction	**Wind Speed**	**Temperature**
Tolerance	***20°***	***1m/s***	***1°C***
MM5-conf1	**66 %**	**69** %	**82%**
MM5-conf2	45 %	67 %	77 %
RAMS	59 %	67 %	56 %
Tolerance	***30°***	***2m/s***	***2°C***
MM5-conf1	72 %	**94** %	87 %
MM5-conf2	58 %	83 %	**88 %**
RAMS	**76 %**	89 %	75 %
Tolerance	***40°***	***3m/s***	***3°C***
MM5-conf1	67 %	**99 %**	96 %
MM5-conf2	70 %	95 %	91 %
RAMS	**81 %**	95%	**98 %**

Dispersion model

Operational time response, site configuration and separated stack analysis made us choose the Gaussian model ADMS, see *Carruthers* (1994). Dispersion modeling needs meteorological information on one specific point defined as the top of 50 meters stack. Some theses parameters are directly extracted from the RAMS 3D fields (wind direction & speed, temperature, humidity, rainfall) and other are recalculated (boundary layer height, representation of turbulence by Monin Obukov length).

To take into account the tolerance range of the forecast meteorological system, a series of three calculations is performed and gives a representation of the global uncertainty for the final SO_2 modelled impact. The Figure 3 illustrates reports of final SO_2 concentration as 2D impact maps (Percentile 100 for a period with an associate “alert signal”), and time series at a specific location (such as sensor) with the contribution of each stack.

Interface of the operational tool.

All simulation results are on an intranet report, available 24h a day, 7 every 7 days and automatically updated twice a day. Through this report, the decision-maker has all information in terms of meteorology and simulated concentrations maps to validate the refinery functioning or modify the process to avoid pollution peaks.

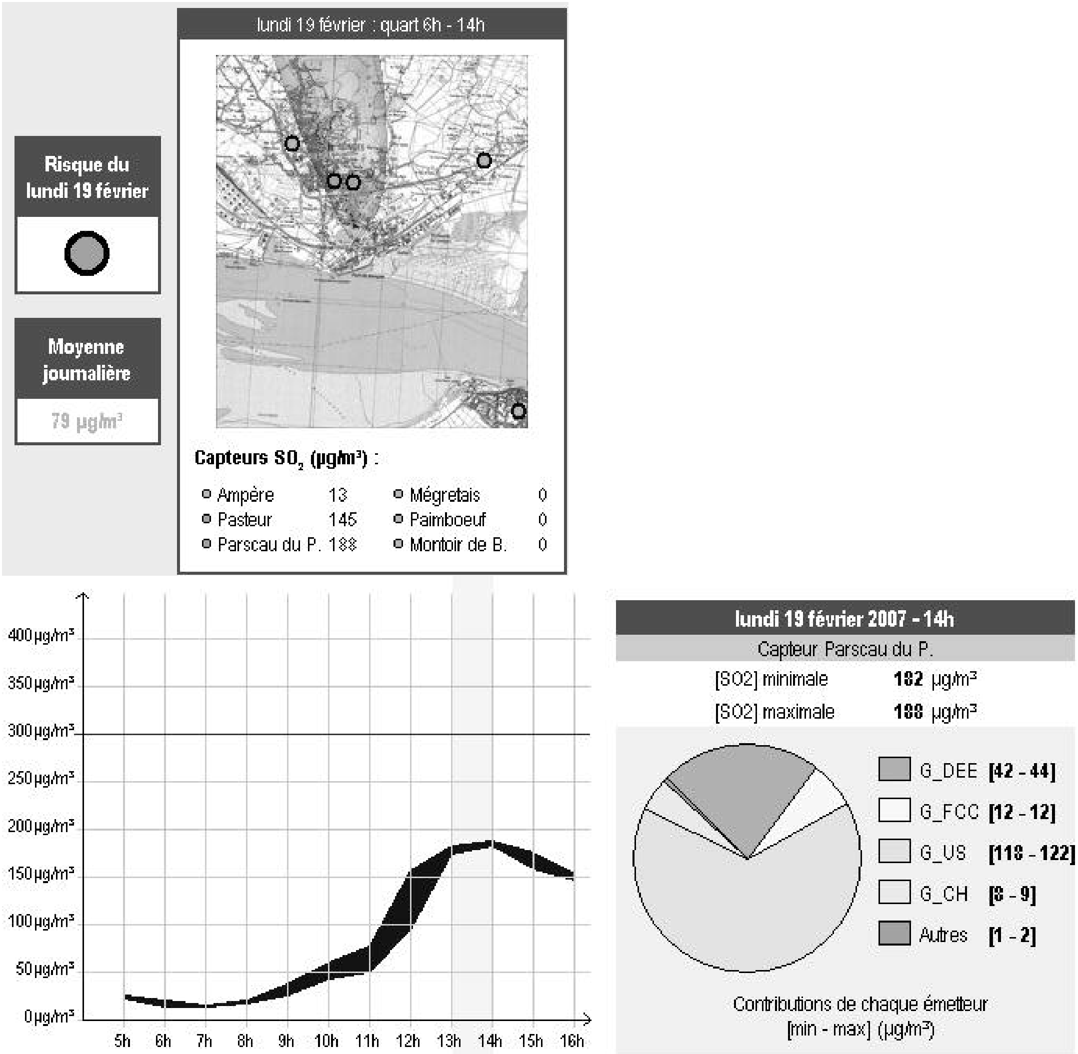

Fig. 3; SO_2 forecasted impact: 2 D maps and time series .

RESULTS

Results are presented in Table 2 in terms of efficiency to avoid peaks. It is shown very good performances of the help decision-making tool with 80% of well-predicted pollution events that have could be avoided. In the remaining 20%, only 8% are not predicted at all whereas 12% are predicted with error on location or time of the event.

Table 2. Modeling tool performances after 18 months of on-line installation.

Period	Well predicted peaks	Unpredicted peaks	Peaks predicted with errors (error of time scaling or on peak intensity)
1	80%	8%	12%

CONCLUSION

Results based on a case study led a French refinery to conduct environmental modeling studies in order to efficiently manage their SO2 emission sources by identifying the ones having the largest impact. An integrated operational tool has been developed to forecast, automatically, twenty four hours a day, the environmental SO2 impact around the plant for the next 2 days. Simulations take into account emissions foreseen by scheduling service and meteorological forecasts. The system has been validated thanks to 10 months measurements/modeling comparison. It is now operational for 18 months and allows the site to avoid the major part of pollution peaks and the associated cost (administrative fines and strong disturbances on the functioning of the industrial units). It is also shown that along the months the system becomes more and more accurate thanks to improvement of RAMS model boundary conditions assimilation and operational integration within the industrial site.

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