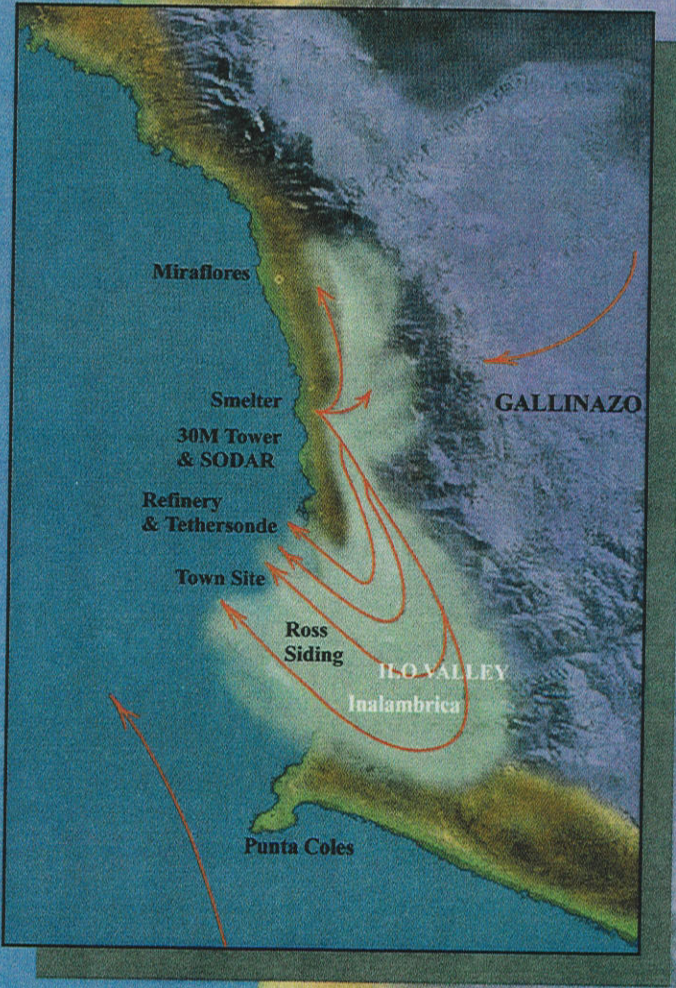
Air Pollution V

Modelling, Monitoring and Management

Editors: H. Power, T. Tirabassi, C.A. Brebbia



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Design and implementation of a supplemental control program for SO_2 episodes in the region of Ilo, Peru

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Abstract

Preliminary results of a research & development study conducted in the region of Ilo, Peru are presented. In this region, large SO_2 emissions from a copper smelter plant affect the local air quality and sometimes cause elevated SO_2 concentration values in the City of Ilo.

SO_2 emissions are expected to be drastically reduced in the next decade. To alleviate the present situation, a Supplemental Control Program (SCP) has been implemented. The SCP includes our interactive Intermittent Control System (ICS) software which is based on a large set of data (emission, meteorology, and air quality) collected in the region and transmitted in real time to a central computer system. These on-line data allow the application of numerical forecasting techniques which provide decision makers with reliable tools for temporarily reducing SO_2 emissions during unfavorable meteorological conditions. Forecasting is based upon both statistical methods (e.g., time series analysis) and deterministic modeling (e.g., a Monte Carlo-Lagrangian Particle [MCLP] model).

We present a description of the SCP, the design of the full ICS, expected to be implemented by the end of 1997, and a description of the preliminary ICS which has been in operation since April 1997.

1. Introduction

The Southern Peru Limited (SPL) smelter, refinery, rail, and port facilities are located near the City of Ilo in the southern coastal deserts of Peru. Following SPL commitments with the Republic of Peru, SPL initiated an environmental program which included the construction of an acid plant and the engineering of an 800 million dollar state-of-the-art smelter with sulfur dioxide and particulate controls that meet or exceed Peruvian and international standards. During the interim engineering and construction phases, SPL is committed to minimize SO_2 impact from the existing smelter on human and agricultural interests.

The SCP was voluntarily implemented by SPL on December 20, 1995 to manage smelter emissions. The SCP was originally called the "Intermittent Control Plan" and began as a proactive environmental control plan which included a series of air quality evaluations, scientific studies, and ambient monitoring activities aiming at the development of a defensible program consistent with international expectations of environmental quality management.

The SCP focuses on reducing the exposure from the Ilo smelter SO_2 emissions in the populated areas around the City of Ilo until successful completion and operation of the new smelter and gas cleaning system. In order to be effective in this endeavor, sufficient ambient data must be acquired to consistently refine and improve projections and procedures of SO_2 emission curtailment. In January 1997, a new expanded monitoring network involving real-time data acquisition and modeling became operational for prognostic microscale meteorological analyses. As the new SCP database grows, the system's ability to recognize and predict elevated SO_2 events is improving. This allows timely process adjustments to effectively control ambient SO_2 concentrations.

2. Southern Peru Limited, Ilo Facilities

Though located in a marine air environment, the climate in the Ilo region of Peru is quite dry with negligible annual reported precipitation. Temperatures typically range between 13 to 28 degrees Celsius. The predominant wind direction is from the south to southeast, nearly parallel to the coastline occupied by SPL operations and the primary populations of Ilo. This southeasterly flow is the controlling factor in the dispersion of gaseous effluents from the SPL operations.

Approximately 30 kilometers of the Pacific Ocean coastline are of principal interest to the SPL Supplemental Control Program. This segment of coastal plane is bordered by a rocky, uneven shoreline to the west and a sharply rising mountain range or "cerros" 3.5 to 4 kilometers inland. The coastal plane includes a gradual rise to approximately 50 meters in elevation, then an abrupt rise to 100 meters, creating a mesa or "pampa" which extends eastward to the base of the mountain range. This pampa runs along the base of the cerros and is intersected by widely separated river valleys and quebradas. The cerros along the eastern edge of the coastal plane rise rapidly to nearly 1,200 meters marking the western edge of a much more expansive elevated pampa and creating a barrier between the inland elevated planes and the marine layer.

The SPL smelter is located 16 kilometers north of the Port and City of Ilo, in a location where the coastal pampa tapers into rocky foot hills. The 10-

acre smelter complex is set back 140 meters east of the shoreline, at an elevation of approximately 15 meters above sea level.

The smelter is of conventional design. It uses two reverberatory furnaces to produce copper matte, which is then blown in one of seven Pierce-Smith converters to produce blister copper. A Teniente Modified Converter (CMT) operates with oxygen-enriched air supplied by an oxygen plant. The CMT produces white metal (75% copper) which is also blown in the Pierce-Smith converters. To comply with an agreement with the Peruvian government, SPL installed an acid plant in 1995 to capture sulfur dioxide. The acid plant produces165,000 tons per year of sulfuric acid. Part of the acid produced by the smelter is used in the leaching and solvent extraction and electrowinning (SX/EW) facilities at the mine while the rest is sold on the open market. Expansion of the acid plant will be completed in early 1998 as a further interim effort to control SO_2. The new smelter being engineered will virtually eliminate significant ambient SO_2 impact in the region.

3. Ambient Air Monitoring Network

A real-time monitoring system (RTMS; Campbell Scientific, Inc.) has been installed in the region under a contract with TRC Environmental Corporation. The monitoring network includes eleven stations, strategically placed in order to provide atmospheric measurements in the area of influence of the SPL smelter. SO_2 is measured at six of the eleven stations, as indicated by a small rectangle in Figure 1. The arrows in Figure 1 indicate the typical flow pattern in the region. The SO_2 and meteorological measurements from each station are transmitted via an automated radio system to a central control room where the data are displayed, analyzed, and used for planning. Additional meteorological stations have been linked to the RTMS via radio telemetry from the elevated pampas inland for purposes of future environmental analyses.

Instruments which measure vertical temperature gradient, stability, and turbulence statistics are: a 30 meter tower, a SODAR (Doppler System), and a Tethersonde. The 30 meter tower, located atop the coastal pampa, above the smelter, offers continuous temperature and wind measurements at 10 meters and 30 meters above ground level (AGL). The SODAR, located near the 30 meter tower, provides continuous profiles of wind speeds and direction at 30 meter intervals up to 600 meters AGL. Twice a day, the Tethersonde offers wind and thermodynamic information from the surface to nearly one kilometer in elevation, generally including the top of the marine layer in which the smelter is located.

Concerns with blocking or stabilization affects of drainage flows near the mouth of the Ilo Valley has prompted SPL to purchase a mobile SODAR. This added SODAR System will be available to study numerous micro-meteorological phenomena in the 1997 and 1998 monitoring seasons.

The present number and location of monitoring stations appears to be adequate for the area of interest. However, the area of study may be expanded in the future, following regulatory requirements.

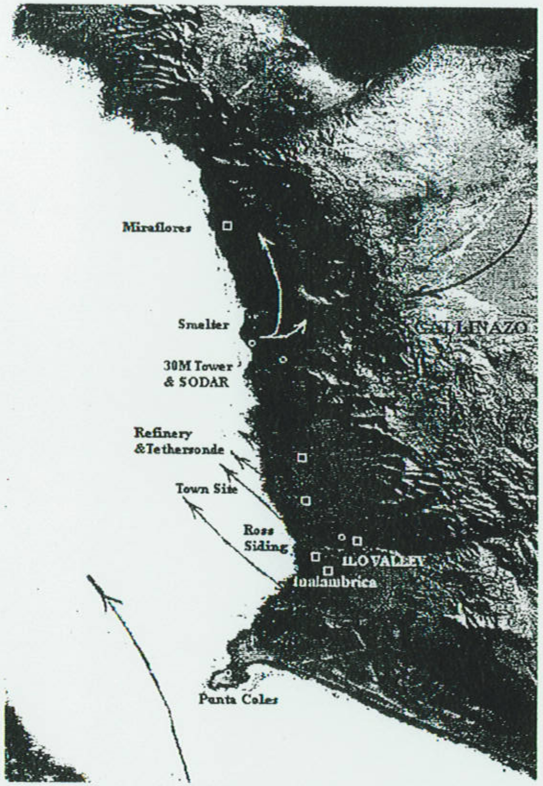

Figure 1. SCP Monitoring Network

In order to support and maintain the data quality of this system, a Quality Assurance Program has been developed using US EPA-recommended procedures for instrumentation maintenance and operation, and data management. These procedures meet or exceed the quality standards defined by the Peruvian Ministry of Energy and Mine's "Protocolo de Monitoreo de Calidad de Aire y Emisiones".

4. General Meteorology

The Ilo climate is dominated by a persistent marine layer which ranges in depth from 600 to 1,200 meters. The limit of this near neutral layer is often defined

by a distinct temperature inversion aloft. Emissions from the Ilo smelter are generally contained inside this layer, in which dispersion is limited by the depth of the layer and the persistence of horizontal winds following a typical, diurnal sea breeze cycle. Cloud cover is not common but is a factor affecting the depth, duration, and suppression of differential heating.

The inland elevated pampa, east of Gallinazo, is located between the tops of the coastal range (cerros) and the Andean foothills to the east. This very large plane drains exclusively into the Ilo Valley and eventually into the City of Ilo and Ciudad Nueva. This night-time drainage flow probably has a blocking or stabilizing effect on the air near the mouth of the river, but its significance has yet to be determined. These phenomena will be evaluated as additional instrumentation is acquired.

The typical night-time air flow in the Ilo area is structured as indicated by Figure 1. This flow was inferred from available wind measurements and meteorological interpretations. An easterly wind direction is observed at Gallinazo (at or above the marine layer); a south to southeast direction is present over the ocean; and a slow, opposing northwesterly flow is seen along the foothills and coastal pampa. In particular, we have observed three common flow patterns, and numerous variations of each pattern, causing elevated SO_2 concentrations in the Ilo/Pacocha area.

The Type I pattern (Figure 2) is the result of a moderate to strong southerly sea breeze which deteriorates intermittently in the early morning hours for periods of one to two hours. This causes elevated SO_2 concentration at the Refinery and Town Site stations, while only light SO_2 concentrations occur at Ross Siding and Inalambrica during the morning diffusion period. There is an infrequent exception to this pattern which occurs when slow morning diffusion is due to overcast or foggy conditions. In this case, SO_2 concentrations may well approach, but rarely exceed air quality standards. The white region in Figure 2 indicates the typical size and extent of the plume.

A Type II pattern (Figure 3) occurs when the south to southeast sea breeze is weakened due to a high pressure over central Peru, leading to a more dominant synoptic northwesterly flow aloft. In these conditions, smelter emissions drive further south before being caught in the light sea breeze and partially recirculated and/or dispersed over the ocean. In the region, clear skies generally prevail and, therefore, a normal break-up period due to a returning sea breeze in the morning can typically be expected before 9:00 AM.

The Type III pattern (Figure 4) is similar in appearance to Type II, but the SO_2 accumulation usually covers the coastline and up to 12 kilometers of ocean. The pattern begins with a suppressed sea breeze, but not necessarily due to an opposing synoptic wind. The marine layer near the shoreline becomes isolated below the coastal mountains by a low marine inversion (400 to 600 meter); thus, precluding the effects of the residual sea breeze. The night-time northwesterly flow is unimpeded as it slowly follows the coast southward. The SO_2 accumulation reaches the surface; thus, resulting in prolonged, elevated

SO_2 concentrations at ground level. The accumulation does not clear until turbulence from surface heating along the shoreline erodes the stable layer and the strength of the elevated inversion diminishes. Overcast or partly cloudy skies may slow this process severely. When the inversion is finally eliminated, the sea breeze once again clears the area. Elevated SO_2 concentrations at ground level may persist until 11:00 AM or 12:00 PM under these conditions.

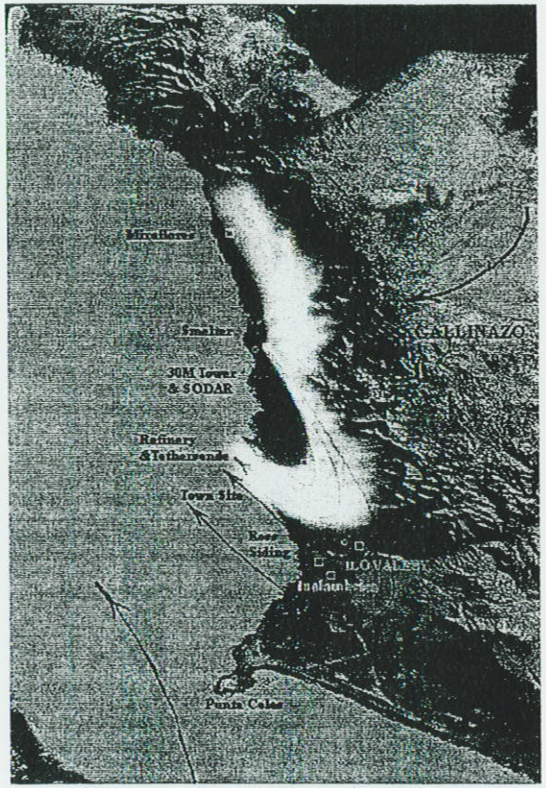

Figure 2. Type I Dispersion Pattern

In the above list of patterns, we do not include a direct flow and impact scenario from the smelter to the City of Ilo. In fact, control under this condition is simple and purely reactive. The direct impact scenario becomes most significant under cloudy skies, when surface heating, required for sea breeze development, is weakened. Synoptically driven northerly flows cause direct impact to the monitored areas. Accumulation is rapidly diffused to the surface; thus, resulting in brief elevated SO_2 concentrations. However, this condition is infrequent.

Figure 3. Type II Dispersion Pattern

5. Intermittent Control Strategy

The strategy for implementing SO_2 intermittent controls depends upon finding ideal curtailment sequences that fit well with the copper production processes and incorporates the best available forecast of SO_2 concentration patterns. Control must be determined with consideration not only of meteorology and dispersion, but also the incremental nature of the curtailments and the impact on the operating units, i.e., reverberatory furnaces, converters, and the CMT.

In January 1997, after the expanded monitoring network was completed, we initiated the implementation of controls using basic dispersion techniques. SO_2 emissions were estimated from metallurgical analyses and concentration impacts calculated using a straight line dispersion model – the US EPA ISCST3 model. This yielded a worst-case estimate of ambient SO_2 concentration; thus, allowing conservative, but expeditious, curtailment of operations to meet SO_2 compliance targets.

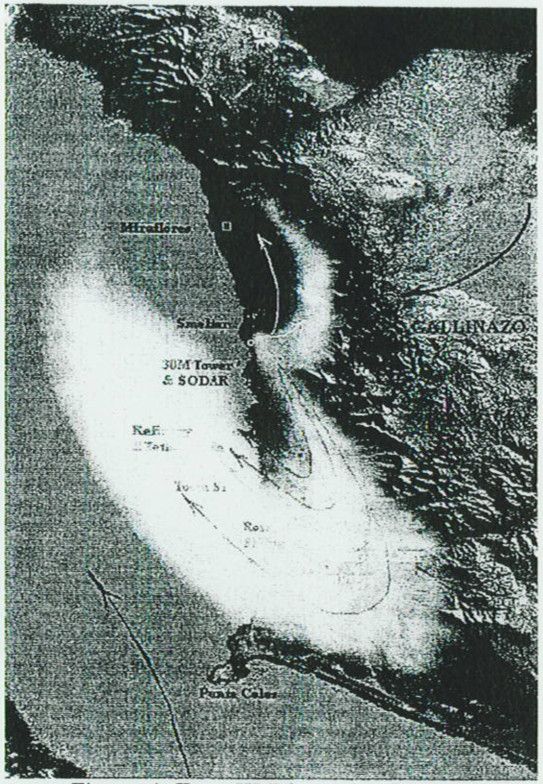

Figure 4. Type III Dispersion Pattern

The next step was the implementation of a set of graphic displays which could be continuously examined by the meteorologists on duty, allowing them to become familiar with diurnal cycles and events, and ultimately classify the events into groups for subsequent computer analysis. Dispersion in Ilo is affected primarily by a very persistent shoreline circulation. With this in mind, persistence and accumulation are our greatest prognostic tools. In this initial phase, it was expected that advanced modeling and statistical techniques would offer insight into effluent movement, greater numerical precision in justifying specific levels of SO_2 curtailment, and a basis for future recognition of pattern variations.

Since the start-up of the new monitoring network, SPL scientists have been working to develop night-time SO_2 curtailment sequences which allow completion of metallurgical operating cycles with the least interruption, while minimizing SO_2 impact to the surrounding communities. When a specific dispersion pattern is recognized, an appropriate sequence of curtailment is

begun. The curtailment plan is also dynamically modified to account for differences from persistence or variation from a previously identified pattern.

6. Smelter Emissions Estimation

The greatest difficulty in developing a curtailment strategy is the incremental nature of the smelter operations. There is no fine adjustment of the SO_2 emission rates. A sequence of curtailments must be manageable and reasonably implemented, i.e., with consideration of both the batch and continuous operations at the smelter, in order to avoid damage to the equipment. When dealing with as many as seven converters, two reverberatory furnaces, and the CMT, these curtailment operations become very difficult. The problem is further complicated by the time delay between SO_2 emission and ground-level impact, and the changing cycles of operation.

To deal with these complexities, a computer program has been developed which allows converter scheduling and scenario testing through the estimation of emissions under expected cycles of production. The program develops a schedule printout which SPL operation specialists may use as a guide for planning industrial production. The program also allows real-time modification of the operations database through a graphical "point and click" screen which also creates and updates a separate emissions database. The following are descriptions of the significant operating units and general emissions handling [Oviedo 1997].

- Reverberatory Furnaces: There are two continuously operated reverb furnaces which function identically. Each furnace burns fuel-oil for smelting concentrated ore, producing two liquid phases plus gasses. The primary materials produced are matte (sulfur phase; Cu_2S and FeS), which is fed to the converters; slag (oxide compounds of Fe, SiO_2, and Al_2O_3), which is discarded; and gasses, resulting from combustion and oxidation of sulfur. The gaseous effluent is simply estimated using heat or fuel input.

- Pierce-Smith Converters: The converters are cylindrical reactors in which air is blown through matte, produced by the reverbs, in a batch process. This process involves two cycles: the slag-blow, in which FeS is removed as a slag and returned to the reverbs; and the copper-blow, in which the remaining Cu_2S (white-metal) is further "blown" to remove the sulfur. Both cycles produce a significant level of SO_2 which may be estimated through metallurgical analyses.

- Modified Teniente Converter: The "CMT" is a continuous feed reactor to which both matte and concentrate may be fed and blown with oxygen-enriched air to produce white metal (Cu_2S). The white metal is fed to the Pierce-Smith converters to complete sulfur removal. SO_2 emission is calculated similarly as the Pierce-Smith converters.

- Emissions from less significant sources, such as the acid plant tail gas and fugitives, are estimated from operations specification and sulfur mass balances, respectively. Once the new smelter is operational, these sources will become the primary sources and require greater attention.

7. Design of the ICS

This section presents the general design of the computerized Intermittent Control System (ICS) and its functions, as seen by the user. The ICS provides advanced tools to decision makers for a full implementation of the SCP.

7.1 The ICS

The user sits in front of a high-end PC running Microsoft Win97/NT (actually, the final system could be installed on several parallel PCs, if parallel computing is needed to reduce the simulation time in real-time mode). On the desktop, there is an icon called ICS. By double-clicking on the ICS icon, the program starts and opens a window with the following items:

Title: Intermittent Control System (ICS) for Application to the Region of Ilo, Peru

Buttons:

About ICS
Tutorial
Data Analysis (DA)
Statistical Modeling (SM)
- Past Episodes (with all data)
- Past Episodes (simulated forecasting)
- Real-Time Forecasting

Air Pollution Modeling (APM)
- Past Episodes (with all data)
- Past Episodes (simulated forecasting)
- Real-Time Forecasting

Integrated Forecasting (IF)

Each button opens a new window and a series of interactive functions (i.e., a subsystem) for the user. Each subsystem contains utilities to allow the user to perform analyses and simulations. Results are automatically visualized and animated in three-dimension (3D) over the region. The functionality of each button is discussed.

- **About ICS**
  A new window is displayed with information about the project, the sponsors, and the development team. The information is presented in a hyper-text format with links to Internet Web sites using Netscape.

- **Tutorial**
  A brief tutorial is presented with hyper-text and animations illustrating the use of the ICS.

- **Data Analysis (DA)**
  This feature provides the user with a set of functions to perform statistical data analysis of the collected data (emission, meteorology, and air quality) and visualize the results.

- **Statistical Modeling (SM)**
  This feature provides the user with a set of functions to perform statistical modeling – mostly time-series analysis – and forecast air quality trends. The air quality forecast can be done in three modes: 1) simulating past episodes using all available emission and meteorological data (i.e., an "optimum" forecasting); 2) simulating past episodes using only the information available at the starting time (i.e., a simulated forecasting mode which provides a "realistic" forecasting); or 3) simulating air quality at present time (i.e., a real-time forecasting mode).
  For past episodes, the simulated air quality forecasts can be compared with the actual observations; thus, providing a way of evaluating the performance of the statistical predictors.
  For real-time forecasting, the system can operate either in manual mode (i.e., with the user actually requesting to perform a forecast at the present time) or in automatic mode (i.e., a mode in which a new forecast is automatically performed at a specified time interval).

- **Air Pollution Modeling (APM)**
  This feature provides the user with a set of functions to perform meteorological modeling and air pollution dispersion modeling. As with the SM function, this simulation can be done in three modes: optimum forecasting, realistic forecasting, and real-time forecasting.
  As before, for past episodes, the simulated air quality forecasts can be compared with the actual observations. Also, for real-time forecasting, the APM System can operate either in manual mode or in automatic mode.

- **Integrated Forecasting (IF)**
  This feature provides the user with a series of functions to perform forecasting of air quality trends by combining both statistical (SM) and deterministic (APM) tools. This is done, for example, by running a deterministic APM model with the capability of "filtering" or "assimilating" incoming measurements. This is the analog of a "predictor-corrector" scheme in which the APM model gives an initial forecast which is then corrected based upon the information provided by incoming new data.

7.2 Real-Time Forecasting

SM, APM, and IF can operate in a real-time forecasting mode, which can be either manual or automatic.

In manual mode, the user can require a real-time forecast to be performed immediately. In automatic mode, the forecast is performed automatically every N minutes (e.g., N = 30 minutes). In both cases, the system loads from the databases all the recent measurements, reads any available forecast of meteorological trends, reads the emission data expected in the next few hours, and performs an air pollution forecasting using either SM, APM, or IF techniques, as requested by the user.

7.3 Exceedance

If real-time air quality forecasts exceed pre-defined concentration values (e.g., air quality standards in Ilo), then the ICS provides the user with quick tools (automatic or semi-automatic) to assess the necessary reduction in SO_2 emission from the copper smelter in the next few hours, in order to avoid excess concentrations.

8. Implementation of the Preliminary ICS

We installed a preliminary ICS for use by SPL in Ilo, Peru. The system provides SPL with a preliminary set of tools to help SPL decision makers in their intermittent SO_2 emission control strategies.

The main goal of the preliminary ICS is to provide reliable real-time information to decision makers, so that they can make better decisions on emission reduction strategies to avoid excess SO_2 in Ilo.

More specifically, the preliminary ICS provides a display in real time of all available information, including:

- SO_2 emissions by the copper smelter
- SO_2 emission forecasts

- meteorological measurements
- SO_2 concentration measurements

The preliminary ICS includes the following modules.

- The Data Grabber System
- The Visualization of the Ilo Topography
- The Data Analysis System
- The Real-Time Forecasting Modeling System
- The Monte Carlo-Lagrangian Particle Model
- The Emission Modeling System

These systems/modules are discussed below, with the exception of the EM System which was described in Section 6.

8.1 The Data Grabber System

The Data Grabber (DG) System extracts the measurements collected in the field by the local monitoring network and organizes them into two databases: main and hourly.

The DG System collects 5-minute average meteorological data, 5-minute average concentration data, and 15-minute average Sodar data (i.e., data from remote sensing of wind at different altitudes using Doppler acoustic sounding techniques). The system also collects the 5-minute average SO_2 emission data and forecasts calculated by the EM System.

The DG System calculates hourly averages of all the collected data and appends them into the hourly database. The DG System runs continuously, independent from other uses of the preliminary ICS.

8.2 The Visualization of the Ilo Topography

This module provides a 3D visualization of the topography in Ilo from any selected viewpoint, using the software package "savi3D" (www.ssesco.com). In future versions of the ICS, 3D visualization will become the standard user interface.

8.3 The Data Analysis System

The "Data Analysis (DA)" option provides a map of the region around the City of Ilo, Peru. In the map, all sites in which data are collected are highlighted. A "configuration" table allows the system to know how many monitoring sites are available, the data collected at each site, and the time periods in which these data are available in the database.

By clicking on any data collection site in the map, a new window opens, displaying the site characteristics (with a picture of the site) and information about the data available in the database: measured variables, time resolution, collection period, units, special codes (e.g., missing values), etc. Three types of time-series data are provided: emission data (e.g., SO_2 emission rates at the copper smelter), meteorological data (e.g., wind speed), and concentration data (e.g., SO_2 concentrations measured in the City of Ilo). In each site window, the user can view subsets of available data measured at that site during any selected time period.

In addition to the map, the DA window contains a "Perform DA" button. By clicking this button, the user is provided with information and utilities to perform data analysis on selected subsets of data. For example, the user can search the hourly database, extract information, and display selected data.

8.4 The Real-Time Forecasting Modeling System

The Real-Time Forecasting Modeling (RTFM) System includes display modules for visualizing:

- meteorological measurements collected at the local monitoring stations,
- wind measurements collected by the Sodar instrumentation,
- regional meteorological forecast,
- air quality measurements collected at the local monitoring stations, and
- emission data and emission forecasts calculated by the EM System.

8.5 The Monte Carlo-Lagrangian Model

The preliminary ICS includes a particle model for 3D simulation of the plumes emitted from the copper smelter units. Simulations are performed at user's request.

Particle modeling simulations are based upon Monte Carlo techniques [Zannetti, 1981; 1990] and allow a 3D simulation of the plumes in complex terrain. Concentrations are calculated by counting the particles in a pre-defined concentration grid.

The software implementation of the particle model consists of the following steps.

1. The user starts the simulation by clicking the particle model (PM) button in the main window of the preliminary ICS.

2. Through data windows, the user provides the run parameters for the simulation (time, geography, terrain, etc.).

3. The system extracts from the database the emission and meteorological data.

4. The system manipulates the emission data selected in Item 3 in order to create an emission file with the correct sequence of data, as required by the particle model.

5. The system manipulates the meteorological data selected in Item 3 in order to create a meteorological file with the correct sequence of data, as required by the particle model.

6. This step is the actual simulation of the particle model. The model reads the run parameters, the first set of emission data, and the first set of meteorological data. Then it starts a time loop.
   Inside the time loop, the following operations are performed:

   - generate new particles at each source location
   - move all existing particles using local meteorology interpolated at particle's location
   - check for particles outside boundaries (make them inactive, so they will not be used again or saved into the output files)
   - check for particles below terrain or above top of the domain (reflect then inside the domain)
   - save particle locations into a particle file
   - compute and save concentrations into a concentration file

After a simulation run is completed, the user can visualize the results using the software package savi3D and explore particle and concentration dynamics with 3D animations.

9. Conclusions

The ICS implemented in the City of Ilo, Peru, represents a state-of-the-art computer system for providing decision makers with tools to minimize the effects of SO_2 emission in the City of Ilo. The system is designed to be easily portable to other locations and different types of emissions.

For more information on the system and its future developments, the reader is encouraged to contact the authors at their e-mail addresses listed on the first page.

10. Acknowledgements

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Risk evaluation of $S0_2$ emission at Vulcano island (Sicily)

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Abstract

The island of Vulcano (Aeolian Archipelago, north of Sicily) is site of an intense fumarolic and hydrothermal activity. The main fumaroles, located on the northern ridge of La Fossa crater, emit essentially water vapour, carbon dioxide, sulphurous components and other minor compounds. In particular, SO_2 is very dangerous when inhaled (especially when mixed with particles and water vapour). Typical output rates of SO_2 in the last few years oscillate in the order of a few tons/day.

SO_2 concentrations in the air over the island were estimated by numerical codes. Simulations were done using a 3D mesoscale meteorological model for complex terrain. Those were performed for no wind synoptic condition, which is the most significant in terms of hazard. Flow model outputs were then used by a Lagrangian particle model to simulate the dispersion of the gas.

Risk scenarios are estimated in the area of Vulcano Porto where, during the summer, more than 10,000 tourists live. The thresholds considered are 200 ppb for provoking asthma in susceptible people (short term effect over minutes), a few ppm for representing a hazard for the normal people, and 400's ppm as an extreme value potentially leading to death.

1. Introduction

Air pollution is commonly addressed to anthropogenic sources, and natural volcanic hazard is usually associated to volcanic eruptive phase, or to danger in terms of climate global change. On the contrary, soil degassing and fumaroles from volcanoes can threaten the health and safety of the increasing nearby communities. Numerous are in the past, the problems and victims due to this kind of phenomena throughout the world (Baxter[1]).

In this study we focus on the situation at Vulcano island. Activity at Vulcano typically follows a four phase 'Vulcanian' cycle: a quiet phase characterised by fumarolic activity, followed by an explosive eruption beginning with a surge phase, developing into a Vulcanian phase, with surge and fall deposits, ending with a lava effusion phase (Frazzetta et al[2]). Currently, there are gas emissions with magmatic components, temperature anomalies and