Lidar Measurements of Mercury Emissions from the Idrija Mercury Mine

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Abstract: Mercury emission measurements from the Idrija mercury mine in Slovenia were performed during a late October campaign, where the DIAL (DIfferential Absorption Lidar) technique was used to map mercury concentrations and attempts were made to quantify the total mercury flux from the most contaminated area, the abandoned cinnabar roasting oven complex. Lidar concentration data were compared with data recorded with a portable mercur point-monitor, operated from a vehicle equipped with a GPS localization system. Concentrations and fluxes were comparatively low due to low temperature and rainfall.

Key Words: Lidar, Atmospheric mercury flux, Mercury mine

INTRODUCTION

The Idrija mercury mine is the second largest mercury mine in the world, second only to the Almadén mine in Spain. Mercury was found here in 1490 and the mine was in operation for 500 years. With mining operations now stopped the surroundings are still mercury and cinnabar contaminated.

The objectives for the one-week late October lidar (light detection and ranging) measurement campaign were to map the emission sources from the mine and to estimate the total flux of mercury from the site.

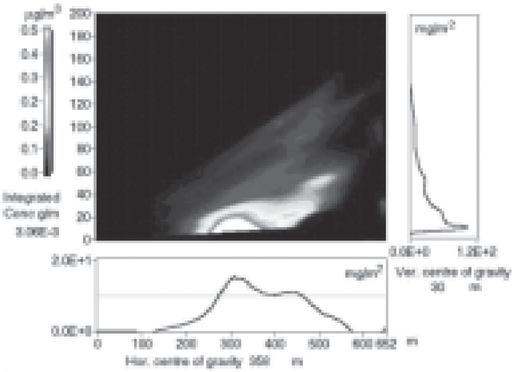
The Lund group has developed differential absorption lidar techniques for three-dimensional mapping of atmospheric atomic mercury[1, 2]. Lidar measurements of the concentrations of mercury utilize the Hg absorption peak at 254 nm and a close-by reference wavelength for differential measurements in the backscattered light. By vertical scanning of the measurement direction, a cross-section of the mercury plume can be found. The total flux can then be obtained by taking the wind speed into account.

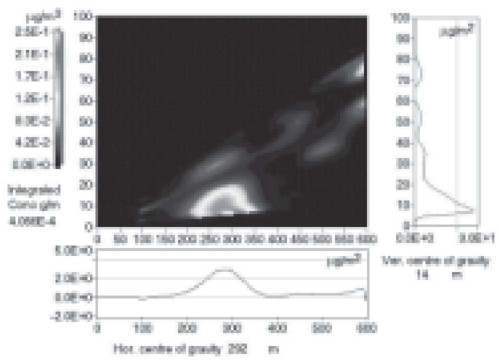
The lidar system has previously been used in measurements at the two other main mercury mining areas, Abbadia San Salvatore (Italy)[3] and Almadén (Spain)[4]. High concentrations, up to 5 μg/m^3 were found and at Almadén a total flux of 600-1200 g/h could be determined in a September measurement campaign. At the Italian site, particularly high concentrations were found around the mercury distillation plant[3, 5]. The present measurements at Idrija were concentratrated to the area around the abandoned distillation plant, where high concentrations were expected from previous point-monitoring measurements.

RESULTS AND DISCUSSION

The Idrija measurements were performed during the time October 30 – November 4, 2003. The terrain in Idrija with a rather narrow valley along the Idrijca river is somewhat complicated in view of positioning lidar scans for flux measurements. Wind conditions were not very favourable for flux measurements: frequently the wind speeds were very low. Heavy rainfall and associated low temperatures during most of the campaign decreased the mercury emission from the ground. Lidar measurements were performed from two locations. The first one was located inside the city of Idrija at an elevation of about 30 meter above the Idrijca river, and close to the present visitors entrance to the mine. From here mostly horizontal scans over the city was made in directions where the beam was not obstructed by vegetation or other structures and all results showed fairly low concentrations. The second location was close to the Idrijca river, about 250 meters downstream of the distillation plant and about 10 meter above the river surface. From here vertical scans downwind from the distillery were made, and also horizontal scans over the valley in the direction towards the city of Idrija.

The results of vertical scans downwind from the distillation plant as recorded from the second lidar site are shown in Figures 1 and 2. Strongly elevated concentrations of the order of a few hundred ng/m^3 at a length integration interval of 7.5 m are observed associated with the plant. The wind was blowing down the valley with a quite small and non-optimal angle between the wind and scan directions. This lowers the accuracy in a flow determination. Further, because of buildings blocking the lowest directions of interest some mercury flow escapes under the scan. However, from the two diagrams measured flux values of 2.4 g/h and 5.6 g/h can be evaluated. Horizontal scans starting at the distillery which is quite close to the quickly rising valley side, and extending out over the Idrijca river in a 20 degree sector are shown in Figure 3. Again, it can be seen that the concentrations rapidly fall off away from the plant.





Figures 1. and **2.** Vertical scans downwind from the distillation plant corresponding to elemental mercury fluxes of 2.4 g/h and 5.6 g/h, respectively.

As mentioned above, mercury mapping over the area were also performed using the portable absorption spectrometer installed in a car traversing the roads of the area with the geometry given by GPS recordings. Results from October 30, November 2 and 3, 2003 are given in Figures 4 a, b and c. The concentration values recorded in individual points are here smoothed into a map using a computer routine. The data sampling time varies between about 2 and 7 hours. As can be seen, the distillery completely dominates the emission situation with values reaching above 2 μg/m^3 being observed. It could be noted that such values corresponds to sampling 1 meter above the road surface in direct vicinity to the plant. Average temperatures were 6, 15 and 8 degrees centigrade during the recordings of Fig. 4a, b and c, respectively.

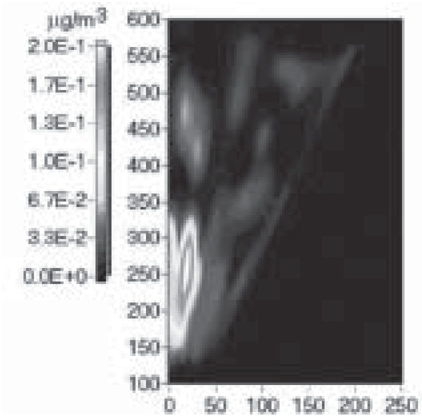
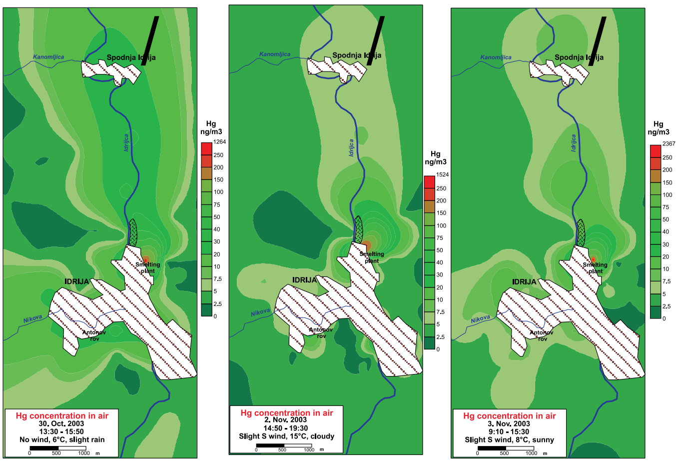


Figure 3. Horizontal scan over the distillation plant and the river valley.



a b c

Figure 4. Concentration maps obtained using a portable mercury point-monitor

CONCLUSIONS

Lidar and point-monitoring data were found to be complementary in mapping the mercury distribution. Lidar provides a fast mapping and the potential for total flux measurements for favourable wind conditions. The mobile point monitor provided powerful large area mapping, but recording times are rather long which may influence mapping accuracy during changing wind and temperature conditions. Generally, comparatively low concentrations and fluxes were observed at Idrija due to reduced ambient temperatures and rainfall during the measurement campaign.

ACKNOWLEDGEMENTS

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