IMPROVEMENT OF ODOUR DISPERSION MODELLING PERFORMANCE AND CAPABILITIES USING ADVANCED CONTINUOUS MONITORING

J. Piñón[1], R. Arasa[1], M. Riquer[1], D. Almarcha[2], M. Almarcha[2], M. Aleixandre[3] and E. Baquerizo[4]
[1]Technical Department, Meteosim S.L. / [2]ATMOS-TEK / [3]Sociedad de Fomento Agrícola Castellonense, S.A (FACSA) / [4]Empresa Municipal de Aguas de Sevilla S.A (EMASESA)
jpinon@meteosim.com

ABSTRACT

Dispersion modelling is currently an acknowledged technological resource for a better understanding of the impact range generated by odour-emitting sources in Wastewater Treatment Plants (WWTP). As dispersion modelling tools can be fed with continuous emission monitoring information, the combine effect of modelling, good emissions and meteorological data can provide useful methods to manage local complaints and nuisance events. To reduce the uncertainty of odour dispersion modelling results and its subsequent complaint management capabilities a different model-monitoring device integration approach has been implemented. A high-resolution forecasting dispersion system, based on CALPUFF and Weather Research and Forecast (WRF-ARW) system, has been coupled to a gas chromatography (GC) based multi-parametric emission monitoring system at San Jeronimo WWTP (Seville, Spain). Vigi e-Nose (Amiet and Vivola, 2014) monitoring system has been configured to chronological sample and analyse multiple compounds streamed from 5 of the most relevant WWTP emission sources for subsequent CALPUFF modelling. The integration of Vigi e-Nose analytic results to the WRF-CALPUFF dispersion system has enabled not only to implement a near-real time odour dispersion modelling system, but to build an extensive emission database that enables to define WWTP sources specific emission profiles later integrated into an odour impact forecasting system. A set of 2 independent sampling and analysis campaigns, considering dynamic olfactometry as well as different VOC and H_2S analytical techniques, have been implemented to validate the modelling system. The results of these independent campaigns, implemented across different climatic seasons, have been integrated to the operational modelling system for San Jeronimo's WWTP odour impact forecasting and related complaint management purposes. Results show an improvement of the predictions and subsequent local impact range analysis when comparing predefined olfactometric-characterized emission profiles and the use of this specific Vigi e-Nose monitoring-based profiles.

INTRODUCTION

Sulphur compounds, primarily hydrogen sulphide (H_2S), are considered the main cause of odour emissions in WWTP (Sauco et al., 2017), generated mainly in the anaerobic phases of the purification process. It is therefore important to principally monitor the hydrogen sulphide (H_2S) to know in real time the concentration of this pollutant in the areas close to the plant and to establish an odour impact evaluation strategy and a plan of action and improvements in the procedures and activities of the plant to mitigate its odoriferous impacts. Odour dispersion modelling is necessary to evaluate the impact of emissions at any point in space (not only where we have measurements) and in a broader time window, providing estimates in the past, present and future time. Dispersion models have proven to be an indispensable tool for odour management given the difficulty of obtaining reliable values of odour concentrations (Luciano et al., 2017 and Carrera-Chapela et al., 2014).

The objective of this project is to provide a hybrid solution that feeds the odour dispersion models with continuous emission monitoring information to handle local complaints and annoying events and mitigate the impacts on the atmosphere of the San Jerónimo WWTP (Seville, Spain). Before implementing this innovative solution, it is necessary to perform a validation of the modelling results where H_2S will be considered the odour indicator. To undertake this validation, two measurement campaigns have been carried out with the following objectives: to estimate more reliable emission factors and to measure the H_2S concentrations at different points near the plant and compare them with the modelling results.

MATERIALS AND METHODS

Vigi e-Nose (from Chromatotec in France) is a Gas Chromatography (GC) based system. The Vigi e-Nose, installed at the San Jerónimo WWTP, analyses gas flows from six different points. Five of them analyse emission sources and one of them measures in a place not directly affected by emission sources (immission point). The emissions are used to feed the CALPUFF dispersion model. The following image (Figure 1) shows the different emission sources in the WWTP also indicating those measured by the chromatograph.

Figure 1: Emission sources and connections to the Vigi e-Nose analyser

The capture of environmental pollutants has been performed using passive sensors, a useful system for taking samples and subsequent analytical determination of a wide variety of substances. Two passive collection tubes of the Radiello type have been used, one for the determination of H_2S and the other for mercaptans and thioethers, respectively. In this contribution, only H_2S results will be analysed. Five Radiello tubes were installed during the 3 days of the campaigns in five different locations (see Figure 2). Two sampling and analysis campaigns, considering the Vigi e-Nose and the passive sensors (see Figure 3), have been implemented to validate the modelling system. The campaigns were carried out on November 3, 4 and 5, 2020 (hereinafter referred to as autumn 2020) and on July 21, 22 and 23, 2021 (hereinafter referred to as summer 2021).

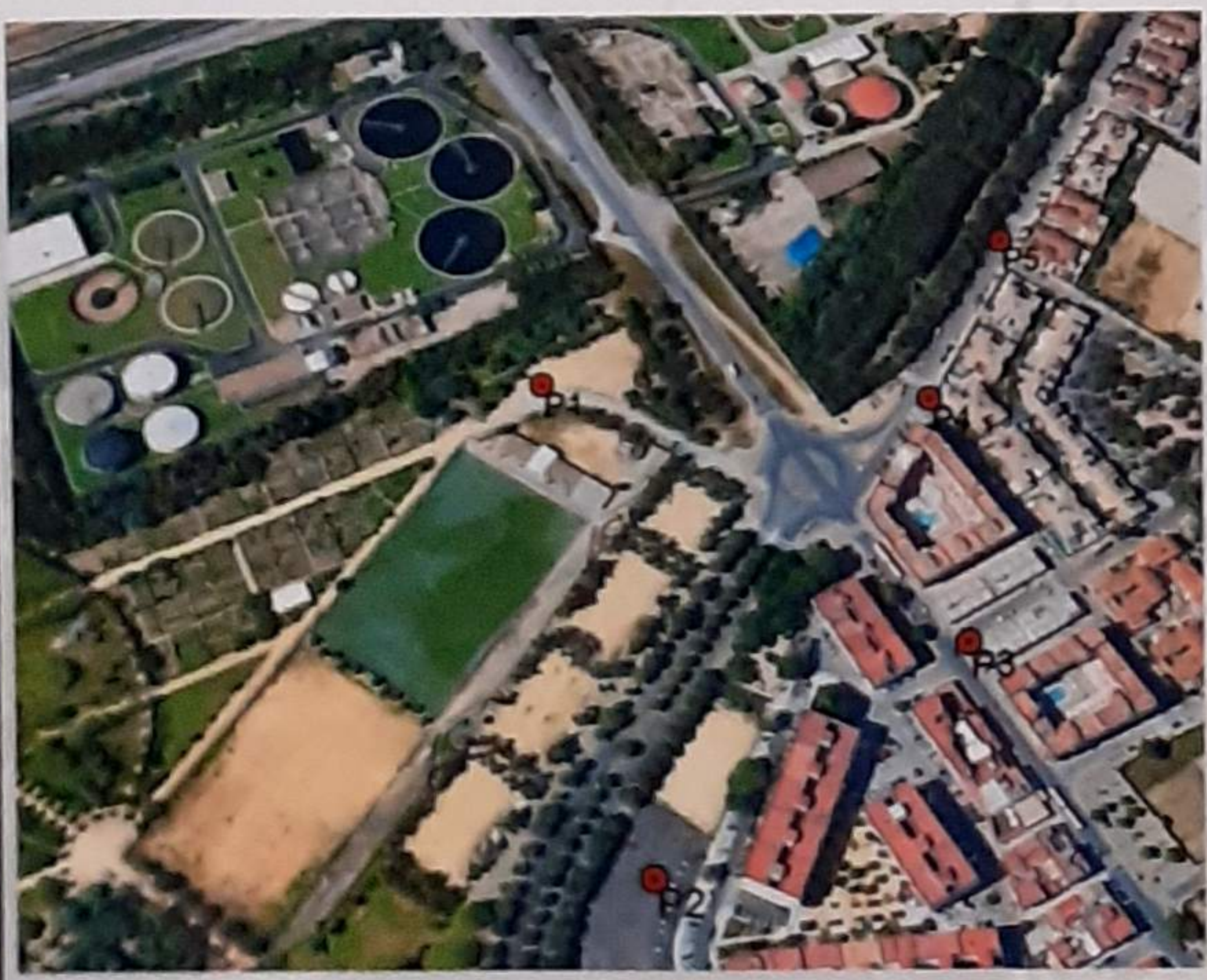

Figure 2: Sampling points

Figure 3: Radiello (up) and Vigi e-Nose (bottom)

RESULTS

The following figures (Figure 4 and Figure 5) show the daily average H_2S concentration values obtained from the modelling carried out with CALPUFF for July 21, 2021, considering different emission factors: the reference emission factors (based on literature review), those obtained after the campaign of autumn 2020 and those of the last campaign developed in summer 2021.

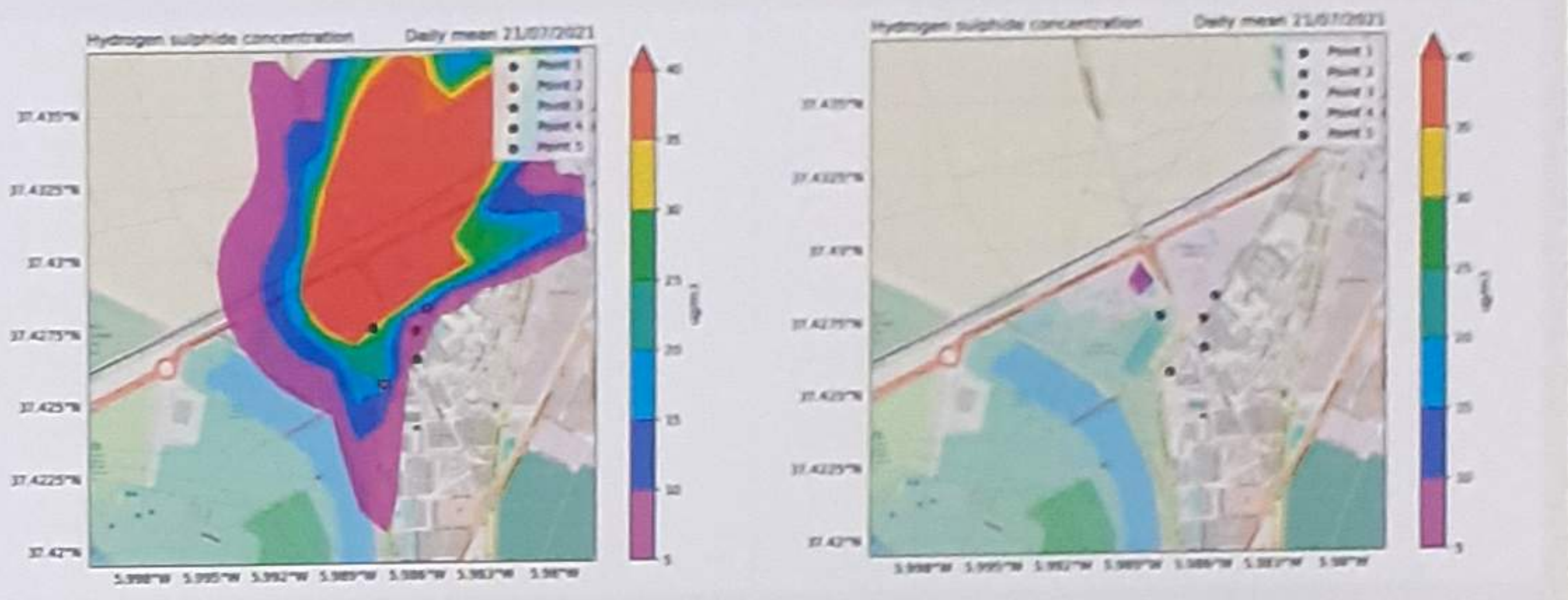

Figure 4: Daily mean H_2S concentration values considering reference (left) and autumn 2020 (right) emission factors

Figure 5: Daily mean H_2S concentration values considering summer 2020 emission factors

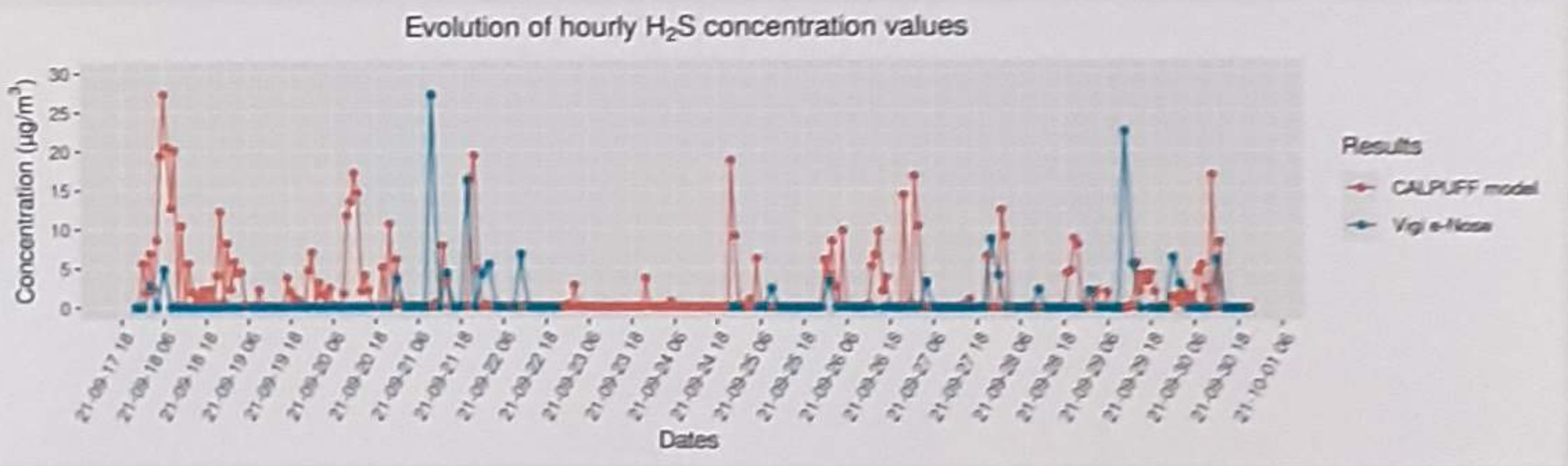

Figure 6: Evolution of hourly H_2S concentration values at the immission point

Table 1 shows the average H_2S concentrations measured from the passive sensor samples at the 4 points and modelled from CALPUFF when considering reference emissions and the emissions obtained as result of the campaigns (autumn 2020 and summer 2021). The average period corresponds to July 21, 22 and 23, 2021. It should be noted that the average H_2S concentration values obtained in the passive capture samples are below the limit of quantification of the method ($2.5\ \mu g/m^3 \pm 0.55 \mu g/m^3$). Results from point 4 could not be analysed.

Table 1: H_2S concentrations ($\mu g/m^3$)

Sampling point	Samples	Reference emissions	Emissions from autumn 2020	Emissions from summer 2021
P1	< 2.50	5.06	0	0.02
P2	< 2.50	0.47	0	0
P3	< 2.50	0.47	0	0
P5	< 2.50	2.06	0.21	0.01

Finally, H_2S concentration values from the immission measurement point of the vigi e-nose have been compared with the results of the CALPUFF model at that same point for some days of September 2021(Figure 6). The results of the model consider the emissions from the last campaign (summer 2021).

CONCLUSIONS

When comparing the daily concentrations of H_2S obtained for the simulations carried out, values from both campaigns show similar results and much lower than the obtained when modelling just with the reference emissions. The analytical results of the H_2S captured passively in the 4 points of the San Jerónimo neighbourhood near the WWTP, show similar results when considering the emission factors obtained from the two campaigns. Both results show very low average concentrations of H_2S. However, at point 1, results obtained when modelling with the reference emission factors show relative higher value than the sample. Furthermore, the CALPUFF model gives values of the same order of magnitude as the measured through the Vigi e-Nose at the immission point. It should be considered that the immission point, as show in Figure 1 is really close to the emission sources from the WWTP where the uncertainty of the model is higher. The CALPUFF modelling has been validated from the comparison with the measurements obtained by the sensors (Radiellos and Vigi e-Nose at the point of immission) and it is considered that the campaigns carried out offer more reliable emission factors than those initially considered. As future work, the implementation of specific emission temporal profiles based on the monitoring of Vigi e-Nose is proposed, in addition to integrating the Vigi e-Nose measures in the emission sources to the model and implementing an odour dispersion modelling system almost in real time.