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Emissions to the atmosphere by power plants in Baja California Sur, Mexico

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Abstract: Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) emissions to the atmosphere released by three power plants located in Baja California Sur, Mexico, were quantified using mini-DOAS instruments. In La Paz municipality, the Punta Prieta Power Plant released 65.67±77.80 tons/day of SO_2 and 6.66±12.57 tons/day of NO_2, while the Internal Combustion Power Plant Baja California Sur released 44.72±5.37 tons/day of SO_2 and 8.27±1.72 tons/day of NO_2. In the municipality of Comondú, the Internal Combustion Power Plant Agustín Olachea released 18.17±8.00 tons/day of SO_2 and 0.67±0.32 tons/day of NO_2. Comparisons of our measurements with emissions inventories and annual operating reports for the Punta Prieta Power Plant are in good agreement, however, we found differences for the Internal Combustion Power Plant Baja California Sur and the Internal Combustion Power Plant Agustín Olachea. Our analyses show that the Punta Prieta Power Plant has increased its SO_2 and NO_2 emissions between 2013 and 2022. The Internal Combustion Power Plant Baja California Sur has increased its SO_2 emissions, while NO_2 emissions have declined between 2013 and 2022. The Internal Combustion Power Plant Agustín Olachea has been decreasing its SO_2 and NO_2 emissions between 2010 and 2022, albeit in 2018, there was a considerable increase of NO_2 emissions.

Keywords: power plants, SO_2, NO_2, atmospheric emissions, inventory emissions.

Introduction

Baja California Sur (BCS) Mexico is well known as one of the most natural beauty-rich states. It is situated on the Baja California Peninsula and extends to over 73,909 km^2 (SETUES, 2020). The state is divided into five municipalities: Comondú, Mulegé, La Paz, Los Cabos and Loreto.

From an energetic perspective, the state of BCS is isolated from the rest of the nation. Due to its geographic location, Baja California Sur electrical system is not connected to the National Interconnected System (NIS) (SENER, 2019). Instead, the state has its own isolated electrical system: the Baja California Sur Electrical System (BCSES), which covers the area from Loreto to Los Cabos. The electricity generated by the BCSES comes mainly from the municipalities of La Paz and Comondú, which provide the majority (90%) of all the electrical demand for the four municipalities of the state that are connected to the BCS electrical system (CERCA, 2021b).

In Mexico, 72.15% of power generation is based on fossil fuels (SENER, 2021), being natural gas the leading energy source (Bonetto and Storry, 2010). Over the years, the Mexican Federal Electricity Commission has been converting the currently operating combined-cycle power plants from running on fuel oil to running on natural gas (Bonetto and Storry, 2010).

The fuel used by power plants in Mexico depends upon the installed technologies in each facility. However, regardless of the type of fuel, its use implies a series of advantages and disadvantages. Among its advantages, it could be mentioned its low cost and national legal provision. But despite its benefits, the fuel used by power plants in Mexico contains a high content of sulfur and heavy metals. Higher quality fuels, with a lower concentration of these pollutants, involve a higher cost.

Currently, there are two power plants in the municipality of La Paz: Internal Combustion Power Plant Baja California Sur (CCI BCS) and the Punta Prieta Power Plant (CT PP). Additionally, there is the Internal Combustion Power Plant Agustín Olachea (CCI AO), located in the municipality of Comondú.

Internal combustion engine plants are commonly used in remote areas, where the access to fuel used for electricity production is limited, as is the case of Baja California Sur (CENACE, 2018). Even though less water is used for operational processes, the costs of producing electricity by internal combustion engines are higher than those of other forms of electricity, exceeding 100 USD per MWh. In addition to this, the average emissions generated by internal combustion power plants are 688 kg of CO_2 per MWh, which is above the average emissions among other electricity producing technologies (CENACE, 2018; SENER, 2018).

Oil-fired electricity generation also accounts for a large portion of North American electricity production (Miller and van Atten, 2005). In Mexico, electricity generation is primarily based on fossil fuels (CEPAL, 2019; Sosa *et al.*, 2020). In 2019, 66% of Mexico's energy production came from non-renewable thermal power plants (CEPAL, 2019).

One of the main sources of electricity production in Baja California Sur is the CT PP, run by the Federal Electricity Commission (CFE), which produces electricity by burning fuel oil. The CT PP is an old plant that supplies electricity to several suburbs of the city of La Paz and other municipal delegations (INECC, 2020).

Approximately 90% of the sulfur in oil-based fuels is released to the atmosphere during the combustion process. Annual sulfur dioxide emissions could be reduced by using fuels that have lower sulfur contents. In some countries, such as the United States, reductions in pollutant emissions have been achieved through the use of alternative fuels (Sosa *et al.*, 2020; EPA, 2023). However, the fuel used in Mexico for electricity generation is of low quality and has a high sulfur content (CERCA, 2021a).

Emissions of pollutants due to combustion processes may have adverse effects on public health and ecosystems (EPA, 2023; Sosa *et al.*, 2020). Nitrogen and sulfur gaseous pollutants contribute to tropospheric ozone and particulate matter formation (Seinfeld and Pandis, 2016), which could cause complications in respiratory and cardiovascular diseases, and the development of such types of diseases (EPA, 2023). In addition, vulnerable groups, such as the low-income population, the elderly, and people with chronic health conditions, are more likely to experience the negative effects of the pollutants emissions released by thermal power plants (ICM, 2021; EPA, 2023).

In order to quantify the sulfur dioxide and nitrogen dioxide emissions from the CT PP, CCI BCS and CCI AO, in this study we used mobile mini-DOAS instruments. These devices have been previously used to measure volcanic gas emissions (Galle *et al.*, 2002; Garzón *et al.*, 2008; Johansson *et al.*, 2009a), as well as pollutant emissions generated by industries and cities (Johansson *et al.*, 2009b; Rivera *et al.*, 2013).

Measurements of emissions released to the atmosphere by power plants have been conducted elsewhere. In Veracruz-Mexico, Ayala-Cortés *et al.* (2023) studied the impact of particulate matter (PM_{10} and $PM_{2.5}$) from a thermoelectric power plant on morpho-functional traits of *Rhizophora mangle* L. leaves. In Qatar, Rey-Pommier *et al.* (2023), presented a study where nitrogen dioxide emissions from gas-fired power plants were estimated from 2019 to 2022 using spaceborne retrievals of nitrogen dioxide columns at high spatial resolution using data from the TROPOspheric Monitoring Instrument. Tian *et al.*, (2013) estimated nitrogen oxides emissions from thermal power plants in China, at a national level, using detailed information on unit capacity, boiler and burner patterns, feed fuel types, emission control technologies, and geographical locations. In a more regional study, Dai *et al.*, (2019), reported changes between 2013 and 2017 in total emissions of nitrogen oxides, sulfur dioxide and particulate matter from coal-fired power plants in Anhui, China with the objective to assess the impact of the application of high-efficiency emission control measures (desulfurization, denitration and dust-removing devices and selective catalytic reduction) on atmospheric emissions.

Specific studies conducted in Baja California Sur, Mexico involve modeling the dispersion of the plume of pollution generated by the Baja California Sur internal combustion power plant using a gaussian-type model (Rangel Rodríguez, 2019), the proposal of an information model to strengthen mobile monitoring projects in the City of La Paz, BCS (CERCA, 2019) as well as studying the dispersion of pollutants into the atmosphere for the installation of power plants in La Paz (CFE 2003; 2020d). Despite these previous studies conducted to determine the environmental impacts of power plants in Baja California Sur, Mexico, to our knowledge, this is the first time that emissions of sulfur dioxide and nitrogen dioxide obtained using mobile mini-DOAS measurements are reported for Baja California Sur, Mexico. This study is particularly important because for the municipality of La Paz, the studied power plants represent the second source of emissions of criteria pollutants and, as in the case of the municipality of Comondú, the main source of sulfur dioxide emitted to the atmosphere. These conditions make this study relevant in terms of mitigation, to show its scope and be able to determine assertive reduction measures.

Materials and Methods

Study Area

La Paz, Baja California Sur

Currently, there are two power plants in the municipality of La Paz: 1) CCI BCS (24.20 N, 110.25 W), with an installed capacity of 235.6 MW, providing 42% of the total demand. It consists of five internal combustion units, an aeroderivative gas turbine and multiple mobile power units; and 2) CT PP (24.22 N, 110.30 W), which has three power units and two turbo gas units for emergency conditions, with an installed capacity of 155.5 MW, and covering 26% of the total demand. CCI AO (24.81 N, 112.09 W) is located in Puerto San Carlos, Comondú, has 3 internal combustion units, and covers 20% of the demand (Figure 1) (Bermúdez *et al.*, 2016).

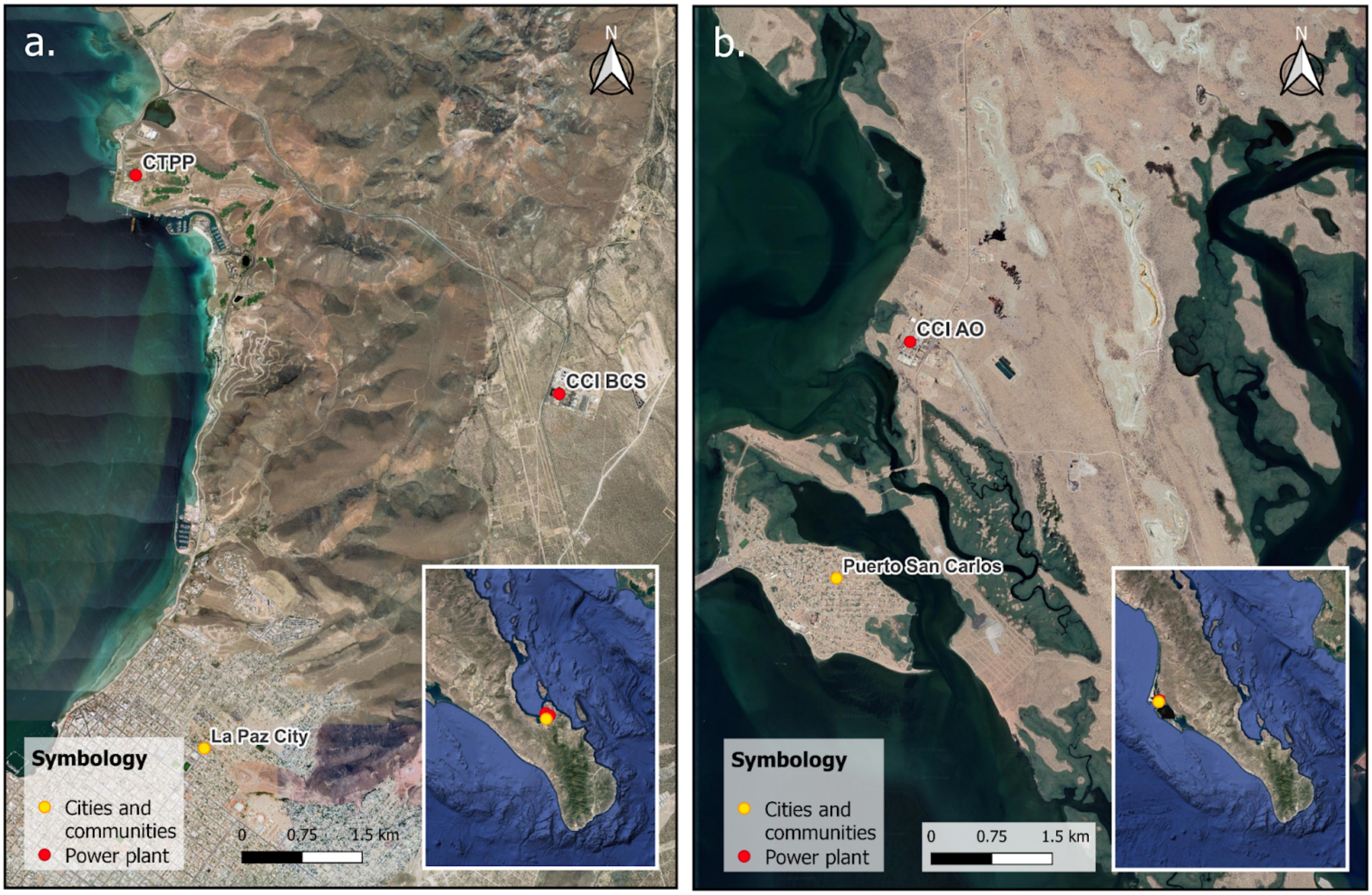

Figure 1. Study area of Baja California Sur: (a) two power plants in the municipality of La Paz: CCI BCS and CT PP, and (b) one power plant in Puerto San Carlos CCI OA. Image from Google Satellite: Map data ©2015 Google.

According to Bermúdez *et al.* (2016), the Emissions Inventory for La Paz, BCS, with the base year being 2013, estimates that La Paz power plants generated 30,546 tons of emissions, which include the criteria pollutants: SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and VOCs. An estimate of 12% of these emissions are generated by the CT PP, and 88% come from the power generation of the CCI BCS (Table 1).

Table 1. Pollutant emissions reported in the environmental impact assessment (MIA) for the CCI BCS, (CIBNOR & CFE, 2004; 2008a; 2008b; 2013, n.d.).

Central	Unit	Operational Considerations	Emissions as per operational conditions (g/s)		
			NO_x	SO_2	PM_{10}
CCI BCS	48 CCI BCS I	1U of 37,5 MW National fuel oil	141.4	116.5	9.12
	107 CCI BCS II	1U total capacity 36,06 ± 10 % MW, in summer design conditions	125.3	135.5	10.7
	236 CCI BCS III	1U of 43 MW, in summer design conditions	176.7	171.5	10.9
	235 CCI BCS IV	1U of 43 MW, in summer design conditions without SCR system*	176.7	171.5	10.9
	286 CCI BCS V	1U of 43 MW, in summer design conditions, without SCR system*	176.7	171.5	10.9

*Selective Catalytic Reduction (SCR)

San Carlos, Comondú, Baja California Sur

Puerto San Carlos is a fishing community located in the southwest area of the municipality of Comondú, Baja California Sur, Mexico. The town faces Magdalena Bay, and is located 60 km west of Ciudad Constitución, the capital city of Comondú. The climate of Puerto San Carlos is mainly warm, with cool or cold winds, low humidity and low cloud cover. However, the first months of the year are characterized by low temperatures and occasional morning fog layers (SEMAR, n.d.; SETUES, 2020).

The CCI AO is located 5 km from Puerto San Carlos. This power plant is composed of three internal combustion units, with an installed capacity of 41.125 MW, and two units with a capacity of 31.5 MW. This plant started operating in 1991 with a single unit, incorporating the second and third units in 1992 and 2021, respectively.

Emissions Inventories and Annual Operating Reports

The emission data reported for CCI BCS and CT PP were obtained from an Emission Inventory for La Paz, Baja California Sur (Bermúdez *et al.*, 2016). The numbers presented in the Emission Inventory were calculated using INECC and SEMARNAT methodologies (SEMARNAT *et al.*, 2005; SEMARNAT and INECC, 2013) for use of inventories and estimations of emissions from stationary sources, using 2010 as base year.

The emissions estimated in the inventory are based on emission factors, which relate the amount of a pollutant released, with activities related to the generation of the same pollutant in a certain period of time. For this study, in the estimation of emissions of the power plants, were used activity data, emission factors and the efficiency of emission reduction in case of any system for such effect. In the case of power plants, the activity data correspond to the fuel consumption of each of the generation units as well as other equipment. These data were obtained from the annual operating reports (COA, for its acronym in spanish) of both plants.

Mobile mini-DOAS measurements

Mobile mini-DOAS measurements were conducted between the 16th and 19th of June 2022 at each site, either transecting the plume downwind or by circling the source. The mini-DOAS instruments are composed of a spectrometer with different wavelength ranges, depending on the trace gas to quantify (274-432 nm for SO_2 and 357-510 nm for NO_2), an optical fiber, a telescope and a GPS. The software MobileDOAS (Zhang *et al.*, 2021) was used to acquire spectra in real time along with information about the time and location (latitude and longitude) of each measurement. Further details of the instrument can be found in Galle *et al.* (2002).

Spectra were re-evaluated using the QDOAS software version 3.2 (Danckaert *et al.*, 2017) using the 307-317 nm wavelength interval for SO_2 and the 405-465 wavelength interval for NO_2. Details about the used retrieval settings are presented in Table 2.

Table 2. Description of the wavelength interval used, and the cross sections included in the retrievals.

Species	**SO_2**	**NO_2**
Wavelength interval	**307 - 317 nm**	**405 - 465 nm**
Cross sections included	SO_2 (Vandaele *et al.*, 2009) O_3 (Bogumil *et al.*, 2003) Ring spectrum	NO_2 (Vandaele *et al.*, 1998) O_3 (Bogumil *et al.*, 2003) O_4 (Hermans *et al.*, 2003) H_2O (Rothman *et al.*, 2010) Ring spectrum

Afterwards, the software MobileDOAS (Zhang *et al.*, 2021) was used to calculate SO_2 and NO_2 fluxes using wind direction and wind speed obtained from the Air Resources Laboratory (ARL, 2022).

Wind data

Meteorological stations

Meteorological data (wind speed, wind direction, temperature, relative humidity and pressure), were obtained from a DAVIS Vantage Pro 2 weather station, located at 24.19 N, 110.26 W, installed at a height of ≈8m. Data was collected during 2021.

Air resources laboratory (ARL) Archived Meteorology

For each measurement day, wind data (wind speed and direction) were downloaded from the ARL Archived Meteorology webpage (ARL, 2022). First the latitude and longitude of each site was fed into the website. A sounding was requested using the North American Mesoscale Forecast System (NAM) meteorological data with a 12 km horizontal resolution and a 3-hour temporal resolution ([dataset] DOC/NOAA/NWS/NCEP/EMC, 2019). Wind direction and wind speed obtained from the soundings was used for SO_2 and NO_2 flux calculations.

Results and Discussion

Mobile mini-DOAS measurements

A total of 74 emission fluxes were calculated (37 for SO_2 and 37 for NO_2) from measurements conducted at the three power plants between the 16th and 19th of June 2022. A summary of the SO_2 and NO_2 calculated fluxes from measurements conducted during the field campaign is presented in Table 3.

Table 3. Summary of SO_2 and NO_2 calculated fluxes from measurements conducted during the field campaign.

Site	**Date**	**SO_2**			**NO_2**		
		Flux emissions (tons/d)	**Stdev (tons/d)**	**Number of measurements**	**Flux emissions (tons/d)**	**Stdev (tons/d)**	**Number of measurements**
CCI BCS	16th June	44.72	5.37	4	8.27	1.72	4
CT PP	16th-17th June	65.67	77.80	6	6.66	12.57	6
CCI AO	18th-19th June	18.17	8.00	27	0.67	0.32	27

An example of a measurement conducted surrounding the CT PP on June 17th 2022 between 18:13 and 18:35 UTC (12:13 and 12:35 Local Time (LT)) is presented in Figure 2, while Figure 3 shows SO_2 columns quantified during the same measurement.

Figure 2. Example of a measurement conducted surrounding the CT PP on June 17th 2022 between 18:13 and 18:35 UTC, where SO_2 columns are depicted. Images from Google Earth: Data SIO, NOAA, U.S. Navy, NGA, CEBCO. Image Landsat / Copernicus.

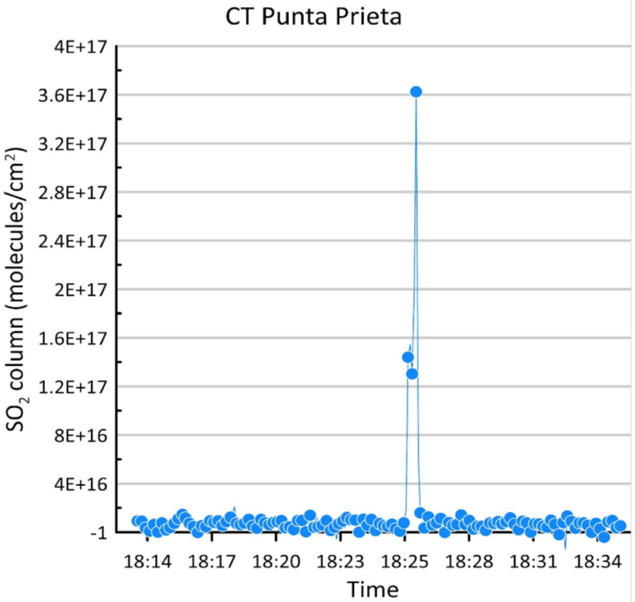

Figure 3. SO_2 columns quantified during a measurement conducted on June 17th 2022 between 18:13 and 18:35 UTC surrounding the CT PP, corresponding to the measurement route presented in Figure 2, circles represent SO_2 columns quantified from each measured spectrum.

Figure 4 shows an example of a measurement conducted downwind of CCI AO on June 19th 2022 between 17:43 and 17:49 UTC (11:43 and 11:49 LT), where SO_2 columns are depicted. In Figure 5, we present quantified SO_2 (a) and NO_2 (b) columns corresponding to the measurement route presented in Figure 4.

A recent study published by Beirle *et al.*, (2023) reports NOx emissions released to the atmosphere between 2018 and 2021 from point sources (such as power plants) using TROPOspheric Monitoring Instrument (TROPOMI) measurements of NO_2 to derive them. For the detected point sources, the NOx to NO_2 ratio of 1.38 was used and a 15 km radius considered for emission quantification.

Figure 4. Example of a measurement conducted downwind of CCI AO on June 19th 2022 between 17:43 and 17:49 UTC, where SO_2 columns are depicted. Image from Google Earth: Image © 2023 CNES / Airbus.

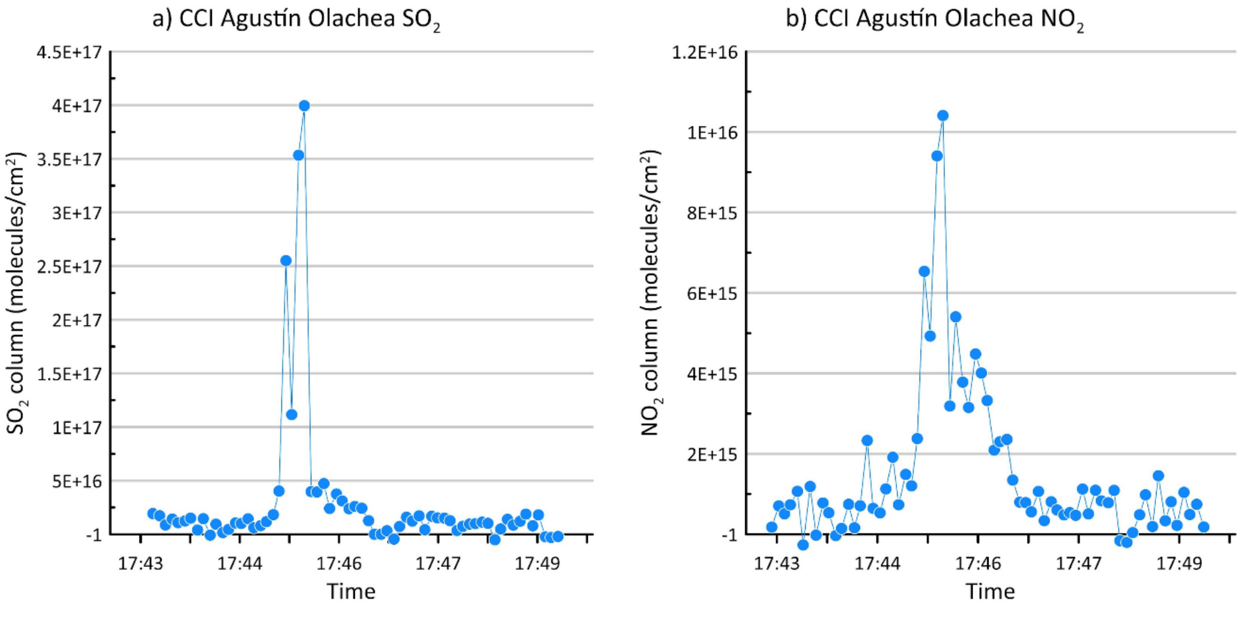

Figure 5. SO_2 (a) and NO_2 (b) columns quantified during a measurement conducted on June 19th 2022 between 18:13 and 18:35 UTC downwind of CCI AO, corresponding to the measurement route presented in Figure 4, circles represent SO_2 and NO_2 columns quantified from each measured spectrum and for each traverse.

Comparing our results with the Beirle *et al.*, (2023) study, we find good agreement for La Paz. Since the distance between CT PP and CCI BCS is less than 15 km, we have considered that NOx emissions reported in Beirle *et al.*, (2023) for CT PP include emissions from CCI BCS as well. NOx emissions reported in Beirle *et al.* (2023) for La Paz (CT PP and CCI BCS) between 2018 and 2021 are 0.455±0.120 kg/s, while our measurements (conducted during June 2022) yielded NOx emissions (using the same NOx to NO_2 ratio as Beirle *et al.*, (2023)) of 0.238±0.151 kg/s. For CCI AO, Beirle *et al.* (2023) report 0.137±0.077 kg/s of NOx emissions between 2018 and 2021, while our measurements (June 2022) yielded 0.011±0.005 kg/s, an order of magnitude lower than the satellite-based estimations.

Analyzing our results with data available from other studies from other parts of the world (Beirle *et al.*, 2023), NO*x* emissions from CCI BCS and CT PP (0.238±0.151 kg/s) are comparable with emissions from the Samra Combined Cycle Gas Turbine Power Plant in Jordan (0.239±0.063 kg/s), the Ladyzhyn power station in Ladyzhyn, Vinnytsia, Ukraine (0.239±0.036 kg/s), the Anuppur Thermal Power Project in Jethari, Jaithari, Annupur, Madhya Pradesh, India (0.236±0.071 kg/s) and the Agios Dimitrios power station in Kozani, Greece (0.236± 0.052kg/s).

Comparison between emission inventories, annual operating reports and conducted measurements

In Table 4 emissions of criteria pollutants due to electricity generation for La Paz and Comondú are presented. Calculations were made for base year 2010. In Table 5 emissions of criteria pollutants, for base year 2013, released to the atmosphere by the two power plants located in the La Paz municipality: CT PP and CCI BCS, are presented.

Table 4. Emissions of criteria pollutants by electricity generation of La Paz, base year 2010 (SETUES, 2018).

Electric generation municipality	Emissions (tons/year)			
	PM_{10}	$PM_{2.5}$	SO_2	NO_x
La Paz	17,809.81	699.74	11,786.37	5,902.94
Comondú	7,041.09	556.21	6,909.25	5,724.06

Table 5. Emissions of criteria pollutants released by the two power generation plants located in La Paz, base year 2013 (Bermúdez *et al.*, 2016).

Power plant	Emissions (tons/year)					
	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	VOC
CT PP	2,428.08	987.37	108.68	30.78	17.54	16.19
CCI BCS	11,916.43	11,493.35	2,473.07	808.39	266.28	0.00
TOTAL	14,344.51	12,480.72	2,581.76	839.17	283.82	16.19

To complement the information retrieved from emissions inventories, the information provided in the COAs for each power plant were analyzed.

A comparison was made between data extracted from the emissions inventories (when available), the emissions extracted from the COAs that were released by the studied sources and the extrapolated yearly emissions from our measurements. Table 6 shows results for CCI AO, Table 7 shows results for CCI BCS and Table 8 shows results for PP CT.

Table 6. Emissions extracted from the COAs released by CCI AO and our measurements. Note that our measurements only report NO_2 and the COAs report NO_x.

Year	Emissions SO_2 (tons/year)	Emissions NO_X (tons/year)	Source	Reference
2010	16,028.89	0.41	COAs	CFE, 2010
2013	8,704.90	—	COAs	CFE, 2013
2014	6,786.13	5,688.34	COAs	CFE, 2014
2018	7,988.00	6,855.00	COAs	CFE, 2018b
2019	6,431.64	—	COAs	CFE, 2019b
2020	6,490.20	5,231.97	COAs	CFE, 2020b
2021	4,913.19	3,930.34	COAs	CFE, 2021a
2022	6,633.84	245.14*	DOAS	This study

* Reported as NO_2.

Table 7. Emissions extracted from the COAs released by CCI BCS and our measurements. Note that our measurements only report NO_2 and the COAs report NO_x.

Year	**Emission SO_2 (tons/year)**	**Emission NO_X (tons/year)**	**Source**	**Reference**
2013	11,916.43	11,493.35	Emissions inventory	Bermúdez *et al.*, 2016.
2018	17,183.73	—	COAs	CFE, 2018a
2019	15,359.78	—	COAs	CFE, 2019a
2020	17,649.01	12,845.96	COAs	CFE, 2020a
2021	14,398.96	14,398.96	COAs	CFE, 2021b
2022	16,322.60	3,019.39*	DOAS	This study

* Reported as NO_2.

Table 8. Emissions extracted from the COAs released by CT PP and our measurements. Note that our measurements only report NO_2 and the COAs report NO_x.

Year	**Emission SO_2 (tons/year)**	**Emission NO_X (tons/year)**	**Source**	**Reference**
2013	2,428.08	987.37	Emissions inventory	Bermúdez *et al.*, 2016.
2019	14,033.49	—	COAs	CFE, 2019c
2020	13,628.86	—	COAs	CFE, 2020c
2022	23,970.56	2429.57*	DOAS	This study

* Reported as NO_2.

A comparison between our measurements, emissions inventories and annual operating reports is presented in Figures 6, 7 and 8 for CCI AO, CCI BCS and CT PP, respectively.

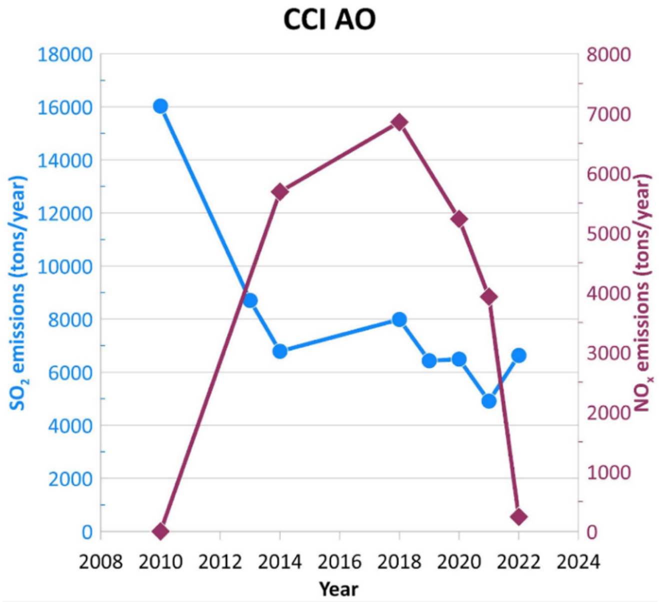

Figure 6. Comparison between our measurements, emissions inventories and annual operating reports for CCI AO.

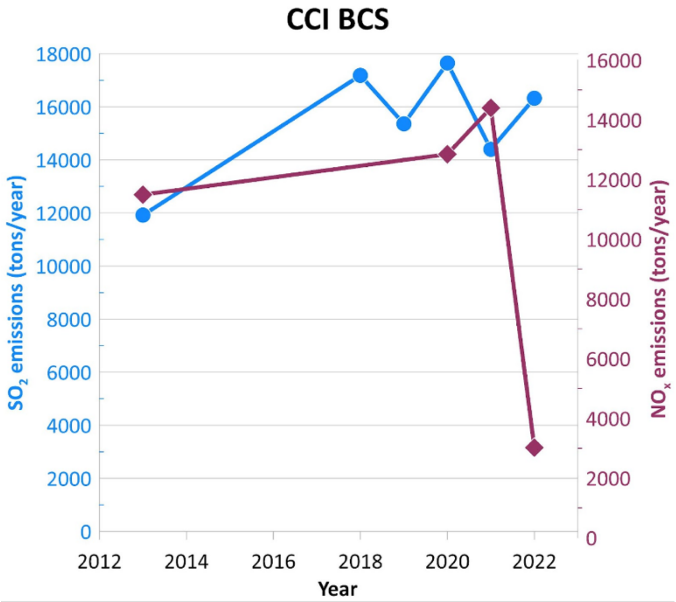

Figure 7. Comparison between our measurements, emissions inventories and annual operating reports for CCI BCS.

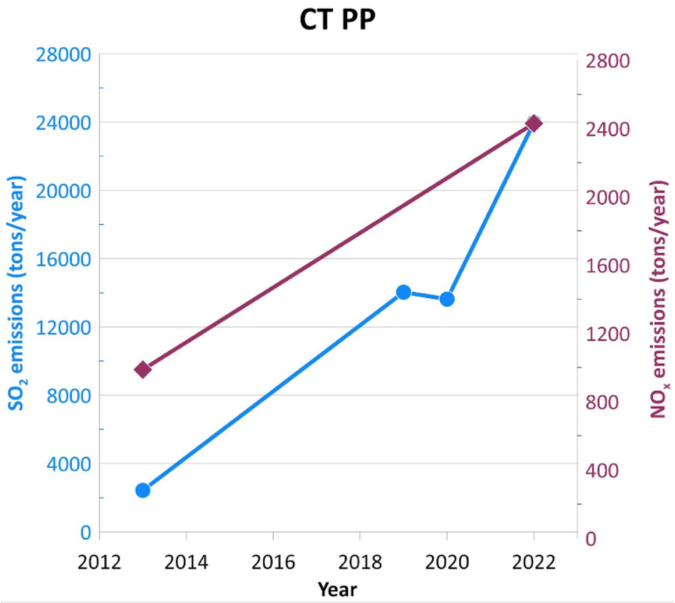

Figure 8. Comparison between our measurements, emissions inventories and annual operating reports for CT PP.

Meteorology

Wind speed and wind direction measured during 2021 are depicted in Figure 9, presented using a wind rose. Results indicate that most of the time, wind speed is between 3 and 5 m/s while wind direction varies between the northwest and southeast directions.

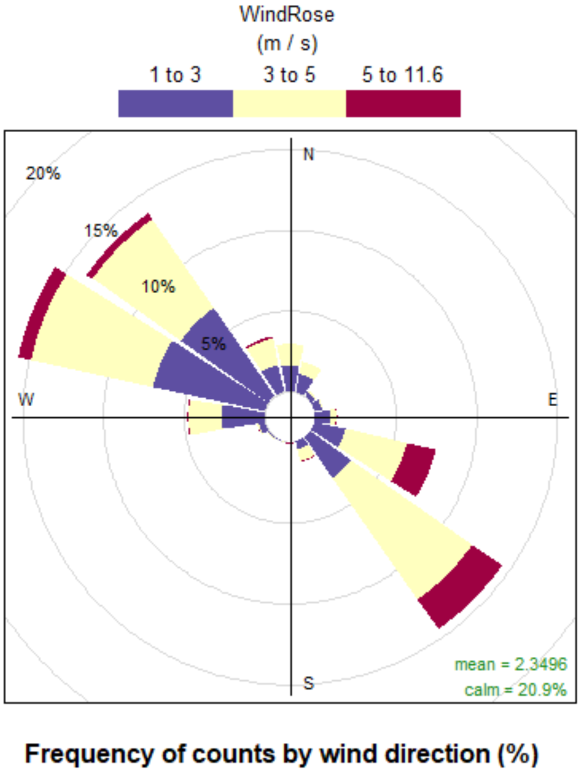

Figure 9. Wind rose for the year 2021 constructed from data collected by the meteorological station located at 24.19 N, 110.26 W.

During 2021, pressure varied on average between 29.46 and 29.72 inHg (Figure 10), while humidity varied between 39 and 72% (Figure 11). Average temperature varied between 16 and 30 Celsius degrees (Figure 12).

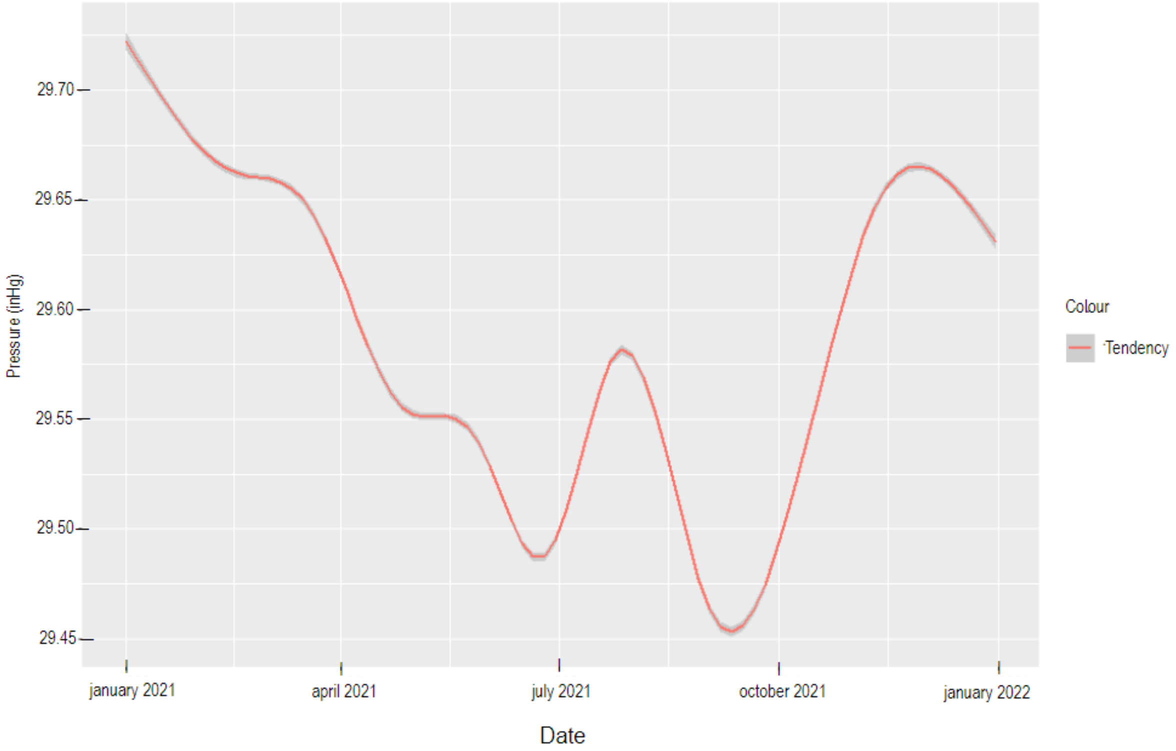

Figure 10. Pressure variability for the year 2021.

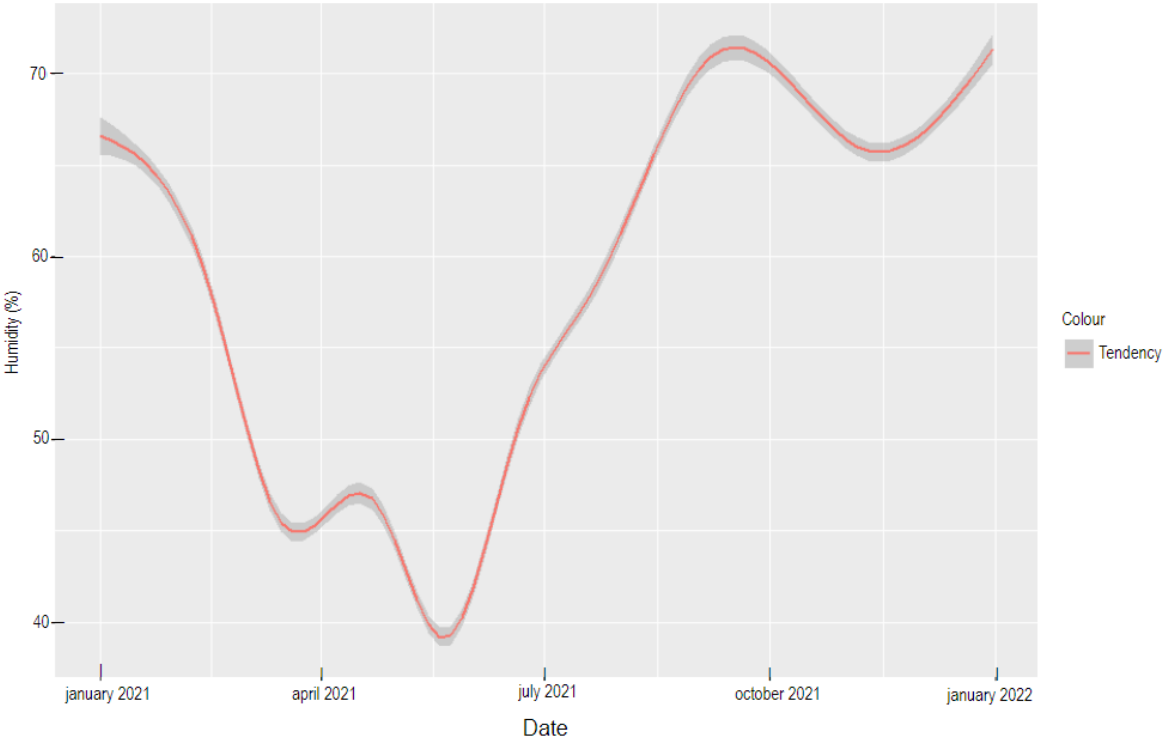

Figure 11. Relative Humidity variability for the year 2021.

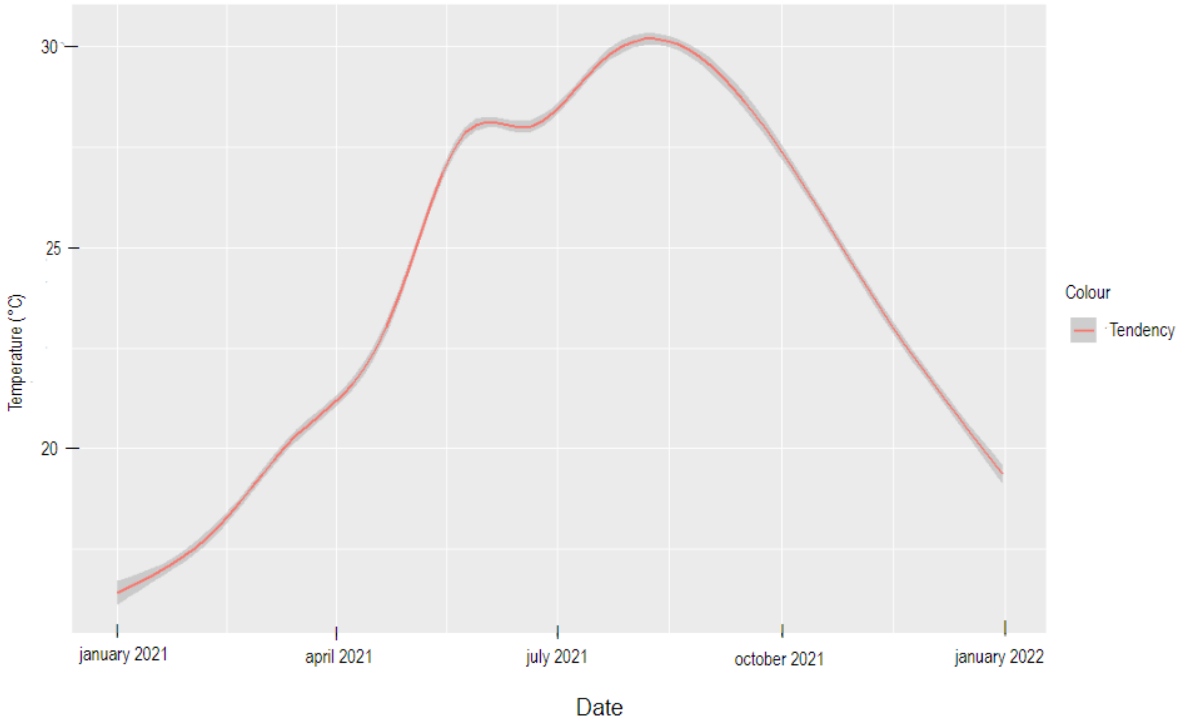

Figure 12. Temperature variability for the year 2021.

Conclusions

Quantification of SO_2 and NO_2 emissions to the atmosphere from power plants located in BCS was possible using mobile mini-DOAS instruments. Emissions to the atmosphere quantified during our field campaign indicate that CT PP released 65.67±77.80 tons/day of SO_2 and 6.66±12.57 tons/day of NO_2, CCI BCS released 44.72±5.37 tons/day of SO_2 and 8.27±1.72 tons/day of NO_2, and CCI AO released 18.17±8.00 tons/day of SO_2 and 0.67±0.32 tons/day of NO_2. From our analyses we were able to determine that CT PP has increased its SO_2 and NO_2 emissions between 2013 and 2022, CCI BCS has increased its SO_2 emissions, while NO_2 emissions have declined between 2013 and 2022 and CCI AO has been decreasing its SO_2 and NO_2 emissions between 2010 and 2022, albeit in 2018, there was a considerable increase of NO_2 emissions.

The drastic drop of NO_2 does not have an exact explanation, although it could be related to the use of different emission control systems, mainly due to the use of additives, electrostatic precipitators, and chemical dosing systems. The units of CT PP have an atmospheric emissions control system, which is made up of electrostatic precipitators (particle retention), a chemical reagent dosing system (magnesium hydroxide and calcium nitrate for the conversion of sulfur trioxide to sulfates) as well as by-product collection and disposal equipment. Electrostatic precipitators were installed between 2006 and 2007, although due to the lifetime of these units, different incidents have arisen that have left these units out of operation, being the most critical period during 2019. It should be noted that the plan for this power plant is its conversion to a combined cycle power plant since its operating limit has been reached.

In addition, it should be mentioned that units IV and V of CCI BCS contemplate the catalytic removal of nitrogen oxides through a selective catalytic reduction system (CERCA, 2021a), and according to CFE reports, a 90% decrease in solids emissions is obtained.

It is important to continue with these types of measurements in a medium-term variability (more than one week) in order to capture changes in the stack emissions from the power plants, as well as in meteorology variability. This can be achieved by carrying out constant monitoring campaigns in the area and continuing with these studies for at least three years to have conclusive results. In the same way, it is important to have networks of regulatory-grade air quality monitoring, and thus have more information that allows generating more robust studies on the impact of electricity generation plants on the air quality of the studied areas. Additionally, it is recommended to compare the DOAS technique versus point sources measurements in the stack simultaneously since the information provided by the power plant is not completely integrated to reduce uncertainty in the emission inventories.

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