PROJECT:

EastMed Pipeline Project

Document Title:	EastMed Greek Section – Environmental and Social Impact Assessment
Document Subtitle:	Annex9A.1- Air dispersion model for Atherinolakkos Compressor Stations
Project Document No:	PERM-GREE-ESIA-A09_0003_0_Annex9A1

Document details	
Document title	EastMed Greek Section – Environmental and Social Impact Assessment
Document subtitle	Annex9A.1 - Air dispersion model for Atherinolakkos Compressor Stations
Company	IGI Poseidon
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Project	EastMed Pipeline Project
Project Document No.	PERM-GREE-ESIA-A09_0003_0_Annex9A1
Date	03/06/2022
Version	00

Document history

Revision	Author	Reviewed by	Approved by	Date	Status
00	DEMOKRITOS	ASPROFOS	IGI POSEIDON	03/06/2022	For submission to Authorities

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External cooperation

This document was drafted with the cooperation of:

- National Center for Scientific Research "Demokritos"

ANNEX 9A.1 AIR DISPERSION MODEL FOR ATHERINOLAKKOS COMPRESSOR STATIONS

9A.1.1 INTRODUCTION

9A.1.1.1 SUMMARY

The Environmental Research Laboratory (EREL) of the National Centre for Scientific Research "Demokritos" performed the modelling study of the atmospheric dispersion of NOx, and CO concentrations from the future installation of the Compression of Natural Gas Stations, CS2 and CS2N, part of the EastMed Pipeline Project, at a southeast location of Lasithi (eastern Crete).

The study was carried out for ASPROFOS Engineering S.A. by the following EREL personnel:

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9A.1.1.2 AIM OF THE REPORT

The scope of this study is to investigate the impact of the dispersion of Nitrogen Oxides (NOx) and Carbon Monoxide (CO) on the air quality generated by the future installation of the gas Compression Stations (CS2 and CS2N), at the south-eastern near coast corner of Lasithi, (regional unit of Crete, Greece), aimed at providing additional compression required, in the Natural Gas transmission system of the EastMed pipeline. During the operation of the onshore installation of the pipeline, pollutant gases are emitted to the atmosphere as a result of the combustion of natural gas in the compression station through Gas Turbines (GT) according to the standard of the European Association for the Streamlining of Energy Exchange – gas (EASEE-gas). Consequently, emissions of particulate matter (PM) and sulfur dioxide (SO_2) are negligible. According to the European Best available techniques Reference document (BREFs) developed under the IPPC Directive for large combustion installations, CO and NOx are the only gas pollutants emitted that should be taken into account in air dispersion modelling studies.

In the current modelling study, the 3-dimensional computer modelling tools were used with appropriate methodology[2] developed by the Environmental Research Laboratory (EREL) of the NCSR "Demokritos". The position and geometry of data on stacks, emission rates of NOx and CO were provided to EREL by Asprofos S.A. based on construction information.

The meteorological data for the area of interest were retrieved by EREL. The data related to the topography of the area were extracted from the Geographic Information System (ARC GIS) available at EREL. The basic computational and analysis steps followed are listed below:

- Processing of the available data, preparation of the input files for the dispersion model regarding the topography (ARC.GIS) and the meteorology of the area.
- Meteorological computational calculations to obtain the characteristic weather types of the area of interest and the respective 3-Dimensional meteorological fields (WRF model).
- Modelling calculations of the atmospheric dispersion of the emissions of NOx and CO from the gas compression stations (HYSPLIT model).
- Analysis and evaluation of the model results on the near ground distribution of the NOx and CO concentrations.
- Modelled near ground concentrations of the pollutants were compared against European air quality standards (2008/50/EC), adopted by Greek legislation, considering ambient background levels and potential receivers (populated places).

9A.1.2 PREPARATION OF THE INPUT DATA

This part involves the preparation of the input data files for the atmospheric dispersion model. For the specific study, the necessary data include the topography and meteorological fields of the area of interest.

9A.1.2.1 TOPOGRAPHY AND MODELLING DOMAIN

The geographical coordinates of the emission sources of the gas compression stations CS2 and CS2N of natural gas at the location of Lasithi (regional unit of eastern Crete) on Greek Geodetic Reference System GGRS87 (X,Y) and latitude /longitude are shown on Table A1- 1.

[2] D. Vlachogiannis, A. Sfetsos, N. Gounaris and A. Papadopoulos," Investigation of atmospheric dispersion of gas compounds from an industrial installation over a realistic topography", 17th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 9-12 May 2016, Budapest.

Table A1- 1 Geographic coordinates of the centroid of the industrial field and each stack of GS2 and GS2N.

UNIT	X (m)	Ψ (m)	Longitude (°)	Latitude (°)
Centroid of industrial field	693854.146634	3875437.94213	26.126000	35.0055805556
CS2 _1	693931.0090	3875625.9220	26.126886	35.007260
CS2 _2	693881.4860	3875619.0320	26.126342	35.007207
CS2 _3	693831.9630	3875612.1420	26.125798	35.007155
CS2_spare	693782.4400	3875605.2520	26.125254	35.007102
CS2 N_1	693733.0720	3875598.3830	26.124711	35.007050
CS2 N_2	693683.5490	3875591.4930	26.124167	35.006997
CS2 N_3	693633.8730	3875584.5820	26.123622	35.006944

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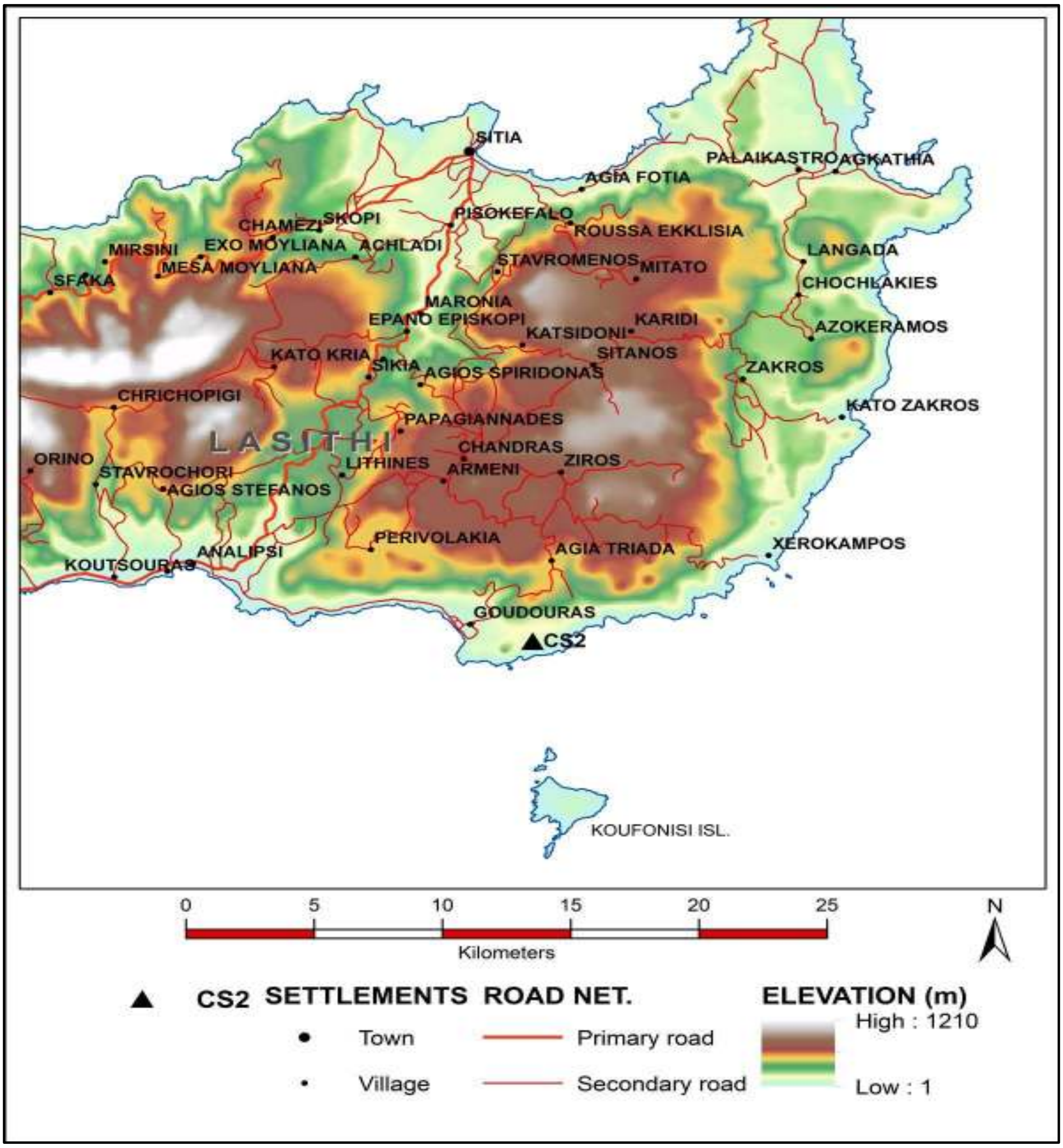
The computational domain extent was set to 40 x 40 km^2 to include as many as possible neighbouring urban areas of the eastern part of the Lasithi regional unit (see Figure A1- 1). The topography of the area includes two major mountainous areas (~1500 m) that smooth down to low levels towards the coasts.



Prepared by Demokritos on behalf of ASPROFOS, 2022.

Figure A1- 1 Topography map of the computational domain of size 40 x 40 km^2. The gas compression stations CS2 &CS2N (Lasithi) is located near the south-eastern coast.

9A.1.2.2 METEOROLOGY AND CHARACTERISTIC WEATHER TYPES

The atmospheric dispersion models use as input data meteorological variables such as wind speed and wind direction, temperature, category of atmospheric stability, mixing layer height etc. The more complex models (like the one used in this study named HYSPLIT) use 3-dimensional meteorological fields as input. The discretised meteorological fields are calculated by prognostic and/or diagnostic models.

For the current study, meteorological data (vertical distribution of wind speed and direction, temperature, mixing layer height, humidity, precipitation, cloud cover etc) were extracted from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-5 climate re-analysis dataset, (https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation), available at 3-hourly intervals.

9A.1.2.2.1 Characteristic Weather Types over the study area

To calculate the average levels and the maximum values of the pollutant concentrations from a future installation in the atmosphere on an annual, daily and hourly basis, the procedure of identifying the typical meteorological conditions or else characteristic weather types (CWT) of the area of interest was followed. The prevailing meteorological conditions or in other words characteristic weather types were obtained using the methodology of Sfetsos et al. (2005)[3]. The specific methodology was applied on ERA5 reanalysis data of large scale, as referenced above, covering a period of eleven years (2010-2020). The analysis revealed the prevailing weather conditions in the defined computational domain and the corresponding frequency of occurrence (in percentage) per year. Each weather condition was assigned a characteristic or else typical day (24-hour). The results showed that the area of study is characterised by twelve (12) in total weather types (see Table A1- 2). Table A1- 3, summarises the meteorological conditions from the global reanalysis model, which characterise each typical weather day of the region.

[3] A. Sfetsos, D. Vlachogiannis, N. Gounaris, and A. K. Stubos, (2005). On the identification of representative samples from large data sets with application to synoptic climatology, Theor. Appl. Climatol. 82, 177–182.

Table A1- 2 Characteristic weather types (CWT) and percentage of their frequency of occurrence within a typical year in the area of Lasisthi.

LASITHI	
Typical weather type	Frequency Percentage of occurrence in a year (%)
1	12.2
2	12.8
3	10.8
4	5.9
5	8.5
6	5.9
7	3.6
8	5.7
9	3.7
10	6.3
11	11.6
12	13.1

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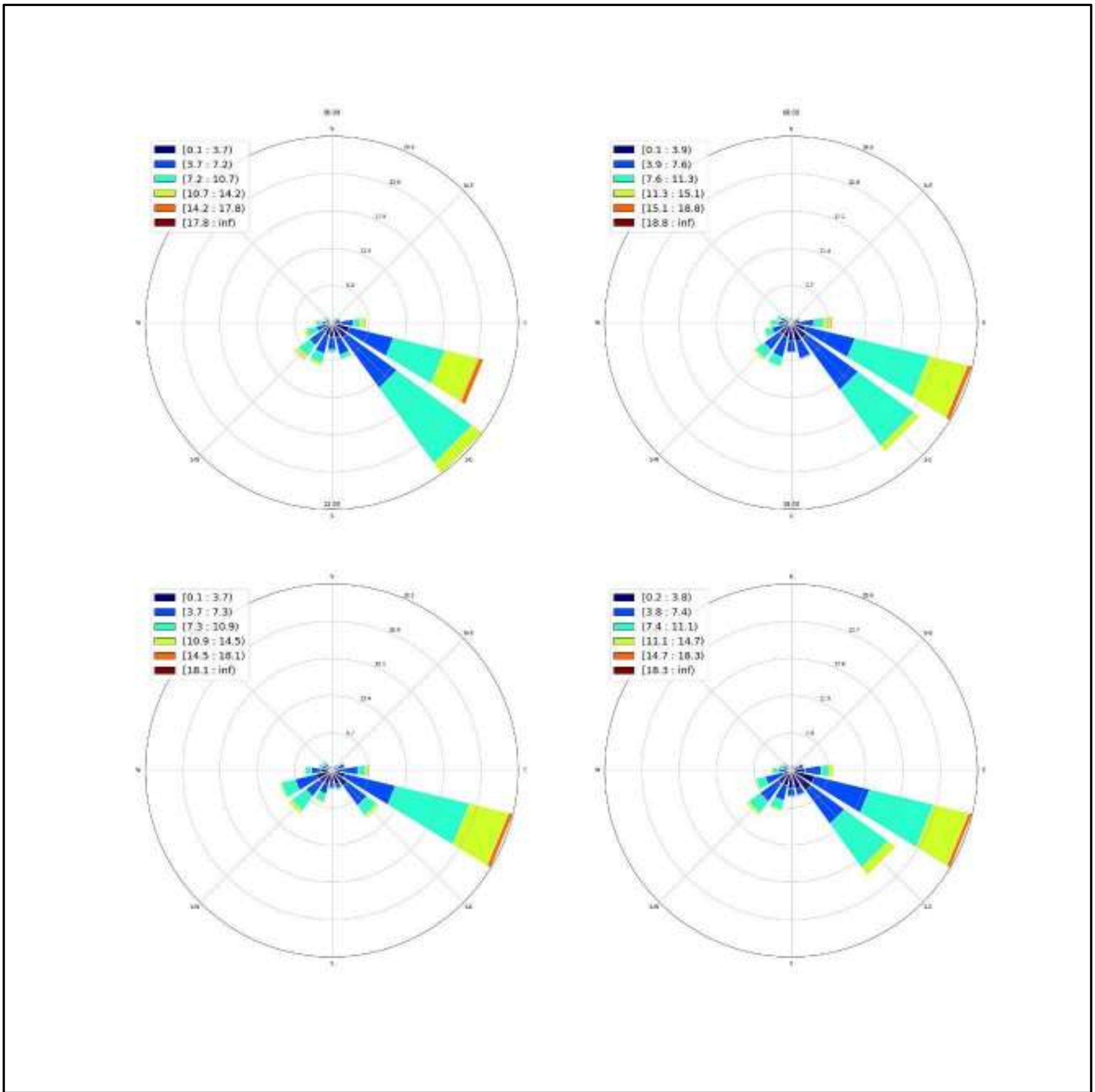
Table A1- 3 Prevailing meteorological conditions during the 12 characteristic weather types (CWT) in the domain of Lasithi: horizontal component of wind speed, u (m/s), vertical component of wind speed v (m/s), (at 850 mb and 10 meters above mean sea level, a.m.s.l

CWT	u10 (0 h)	u10 (12 h)	v10 (0 h)	T (0 h)	BLH (12 h)	
1	1.658	3.200	-0.406	293.93	582.75	-
2	3.581	3.563	-6.715	294.04	866.97	-
	u10 (0 h)	u10 (12 h)	v10 (0 h)	T (0 h)	BLH (12 h)	-
3	0.657	0.541	-3.381	289.15	291.50	-
4	6.391	3.649	-7.039	287.41	1070.45	-
5	2.717	3.029	-0.528	291.81	485.27	-
	u10 (0 h)	u10 (12 h)	v10 (0 h)	T (0 h)	BLH (12 h)	-
6	6.037	4.044	-6.844	298.53	669.16	-
7	1.034	0.355	-0.824	297.15	177.12	-

8	2.938	1.266	-5.102	296.94	419.34	-
9	5.993	4.202	-8.137	297.97	765.86	-
10	5.187	2.491	-4.894	297.22	331.41	-
	u10 (0 h)	**u10 (12 h)**	**v10 (0 h)**	**T (0 h)**	**BLH (12 h)**	-
11	2.925	0.460	3.450	287.28	676.93	-
12	4.352	2.951	-5.749	286.22	1203.16	-
CWT	**RH (0 h)**	**RH (12 h)**	**u850 (0 h)**	**u850 (12 h)**	**-**	-
1	75.94	77.01	1.678	4.693	-	-
2	72.73	62.37	1.892	5.473	-	-
	RH (0 h)	**RH (12 h)**	**u850 (0 h)**	**u850 (12 h)**	-	-
3	79.50	74.90	4.688	4.676	-	-
4	66.35	61.22	4.591	5.893	-	-
5	67.78	68.21	6.278	4.243	-	-
	RH (0 h)	**RH (12 h)**	**u850 (0 h)**	**u850 (12 h)**	**v850 (0 h)**	**v850 (12 h)**
6	72.42	66.08	-0.580	3.848	-10.778	-6.761
7	76.09	79.51	5.100	5.399	-1.397	-1.299
8	77.81	75.00	2.769	3.440	-2.669	-2.695
9	67.14	58.34	1.965	1.536	-10.573	-11.697
10	73.34	68.98	0.554	3.452	-5.410	-3.725
	RH (0 h)	**RH (12 h)**	**-**	**-**	**-**	**-**
11	73.95	74.36	-	-	-	-
12	64.07	56.99	-	-	-	-

Prepared by Demokritos on behalf of ASPROFOS, 2022.



Prepared by Demokritos on behalf of ASPROFOS, 2022.

Figure A1- 2 Wind rose diagrams in the area of Lasithi, centred at the location of CS2, at 10 m a.s.l. and 06:00, 12:00, 18:00 and 24:00 h, for a typical year.

Figure A1- 2 presents the calculated wind rose diagrams at the location of the CS2, at 10 meters height for a typical year, calculated using ERA5 data. The concentric circles correspond to the relative frequency of each wind direction and the colour gradation is related to the percentage (%) of the wind speed per direction. It can be concluded that the dominant direction at this location is the South-East (SW). The winds from the other directions have much lower frequency of occurrence.

9A.1.2.2.2 Weather conditions description

The description of the weather conditions prevailing during each characteristic weather type of Table A1- 2 (CWT) is provided below.

- CWT1
  A deep low barometric atmospheric system is moving eastwards, north of Crete, causing cloudiness and rain by night, at the Lasithi region during this autumn type. The winds are blowing from west directions, moderate to strong and the temperature reaches 21-23 degrees Celsius at noon (in the southern areas).
- CWT2
  Smooth barometric field of relatively high pressures is covering the area, with sunny weather and only local clouds over the Lasithi region during this autumn type. The winds blow north-westerlies, strong to near gale and the temperature reaches 22-24 degrees Celsius at noon.
- CWT3
  Smooth barometric field of relatively high pressures is covering the area of interest, with fine spring weather. The winds blow north-westerlies moderate to strong and the temperature up to 24 degrees Celsius at noon.
- CWT4
  A relatively low-pressure barometric field is affecting the weather of the area with fair conditions and few clouds over the area of Crete during this spring type. The winds are north-westerlies strong and the temperature reaches 18-20 degrees Celsius at noon.
- CWT5
  Smooth barometric field of relatively low pressures is covering the area with scattered clouds during this spring type. The winds blow from southwest directions with moderate speeds and the temperature rises to 20-22 Celsius degrees.
- CWT6
  A smooth barometric field is resulting to fine summer weather over the area of interest. The winds blow from northwest with strong intensity and the temperature is reaching 29-31 degrees Celsius over the southern coasts.
- CWT7

Relatively low pressures between Crete and Cyprus are combined with high pressures over north-western Greece, resulting to fine weather conditions over Lasithi region, with light to moderate north-westerly winds and temperature of 30-32 degrees Celsius, during this summer type.

- CWT8

  Relatively low pressures over the central Aegean Sea are resulting to temporary cloudiness over Lasithi region and short rains in the afternoon over mountainous areas. The winds blow from southwest directions strong, veering in the afternoon to northerlies strong, while the temperature reaches 25-27 degrees Celsius, during this summer type.
- CWT9

  Relatively low pressures between Crete and Cyprus are combined with high pressures over central Mediterranean Sea, resulting to fine weather conditions over Crete, with strong to near gale north-westerly winds and temperature of 28-30 degrees Celsius, during this summer type.
- CWT10

  Relatively low pressures over Cyprus are combined with high pressures over north-western Greece, resulting to fine weather conditions over the study area, with strong to near gale north-westerly winds and temperature of 32-34 degrees Celsius, during this summer type.
- CWT11

  An extensive low-pressure system over the Italian peninsula is moving slowly eastwards, resulting to gradual cloudiness over Crete, gradual intense of the south-easterly winds and maximum temperature of 13-15 degrees Celsius over the southern coastal areas, during this winter type.
- CWT12

  Relatively high pressures are covering the Greek area, resulting to good weather over the study area. The winds blow from northwest with strong intensity, veering in the afternoon to westerlies weakening particularly in late hours, while the temperature rises to 16-18 degrees Celsius, during this winter type.

9A.1.2.2.3 Atmospheric model WRF

The prognostic meteorological model Weather Research Forecasting (WRF-ARW) version 3.6.1 (Skamarock et al., 2008)[4] was set-up and used for the calculation of the 3-dimensional meteorological fields. The WRF model calculated the 3-dimensional meteorological fields of the region of interest, in

4 Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G. Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A description of the Advanced Research WRF version 3. NCAR Technical Note 475, http://www.mmm.ucar.edu/wrf/users/docs/arw_v3.pdf.

a domain of 40 ×40 km^2 (Figure A1- 1) and horizontal and temporal resolution of 1 × 1 km^2 and 1-hour, respectively. The ERA-5 data for the determined characteristic weather days were used as initial and boundary conditions to the meteorological model (WRF). The model simulations were performed for the 12 characteristic weather days (CWT).

As an example of the WRF results, Figure A1- 3, Figure A1- 4 display examples of the WRF calculated 3-dimensional temperature and wind fields for CWT1 (autumn), CWT4 (spring), CWT6(summer) and CWT11 (winter) at 12:00 hr and 24:00 hr. The calculated meteorological fields were consequently used as input to the dispersion model

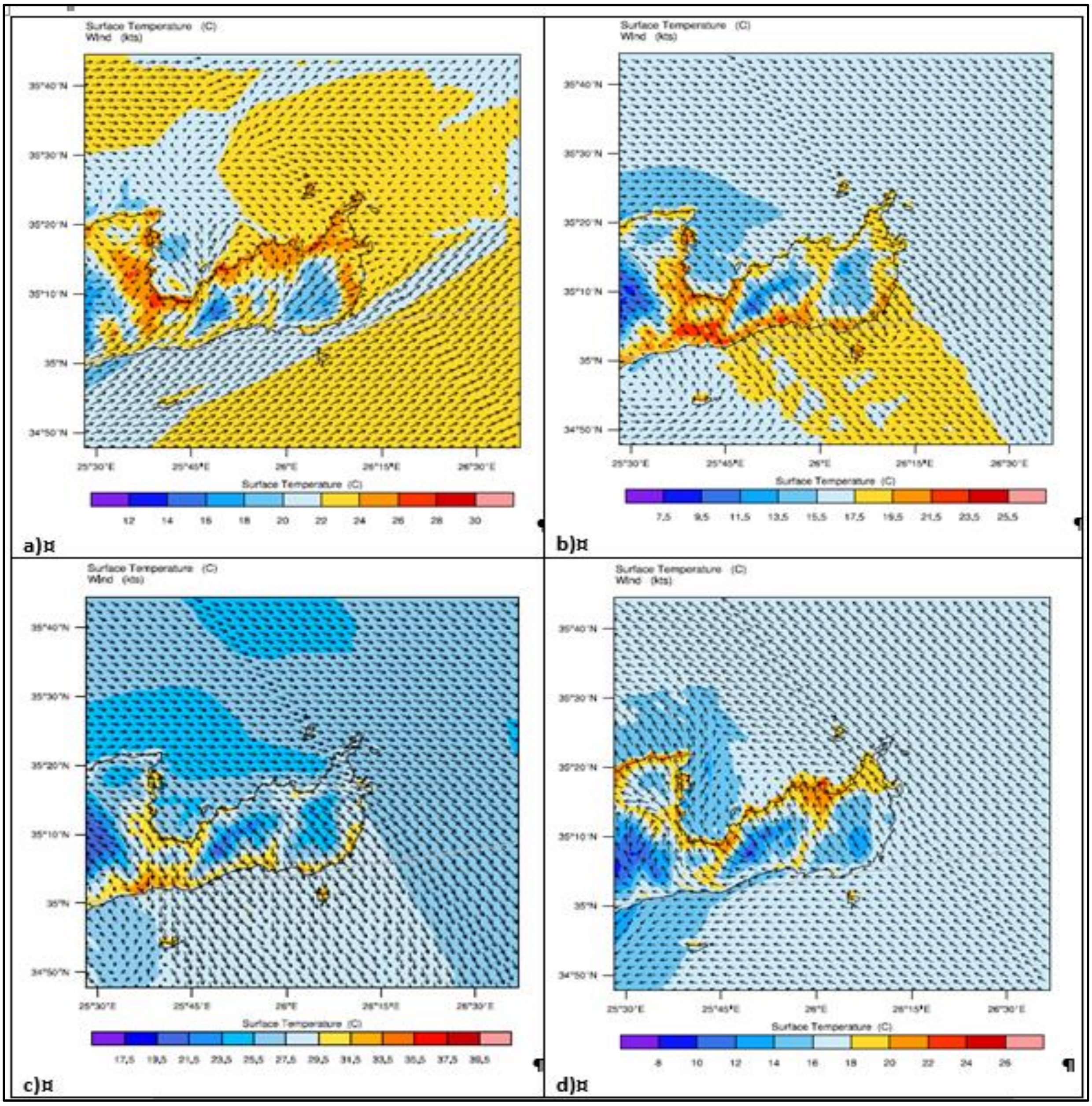


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Figure A1- 3 WRF calculated near surface temperature and wind fields in the area of Lasithi (CS2 & CS2N), at 12:00hr for: a) CWT1(autumn), b) CWT4 (spring), c) CWT6 (summer) and d) CWT11 (winter).

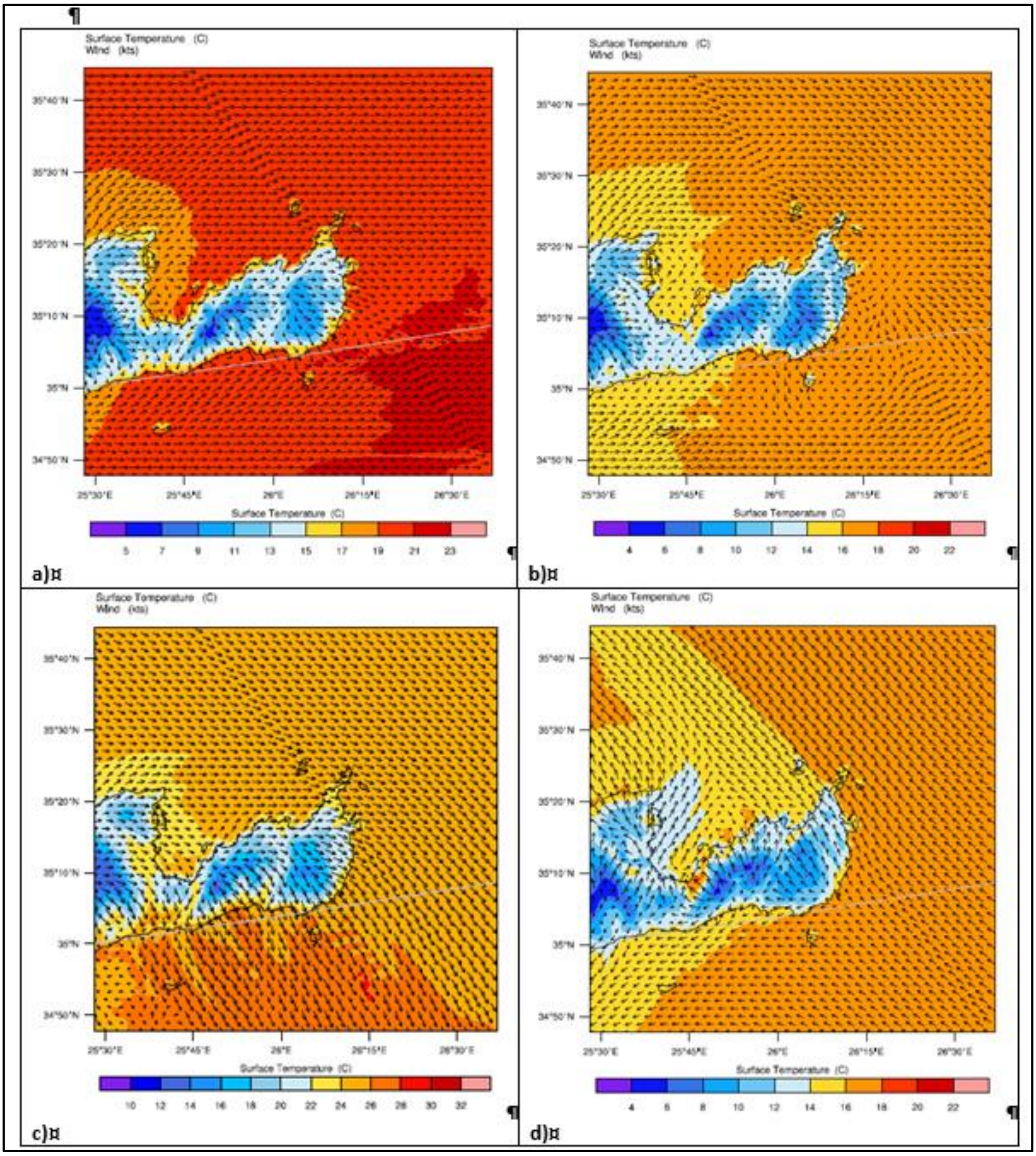

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Figure A1- 4 WRF calculated near surface temperature and wind fields in the area of Lasithi (CS2 & CS2N), at 24:00hr for: a) CWT1(autumn), b) CWT4 (spring), c) CWT6 (summer) and d) CWT11 (winter).

9A.1.2.3 SIMULATION OF THE DISPERSION OF THE POLLUTANTS

This chapter presents the preparation of the input data for the atmospheric dispersion model HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model) used in the present study.

9A.1.2.3.1 The Dispersion Model

The HYSPLIT model is the newest version of a complete system for computing simple air parcel trajectories to complex dispersion and deposition simulations. As a result of a joint effort between NOAA and Australia's Bureau of Meteorology, the model has been used for several applications (https://ready.arl.noaa.gov/HYSPLIT.php). The Air Resources Laboratory's HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model is a complete system for computing both simple air parcel trajectories and complex dispersion and deposition simulations. The model calculation method is a hybrid between the Lagrangian approach, which uses a moving frame of reference as the air parcels move from their initial location, and the Eulerian approach, which uses a fixed three-dimensional grid as a frame of reference. In the model, advection and diffusion calculations are made in a Lagrangian framework following the transport of the air parcel, while pollutant concentrations are calculated on a fixed grid. The model is designed to support a wide range of simulations related to the atmospheric transport and dispersion of pollutants and hazardous materials, as well as the deposition of these materials onto the Earth's surface.

9A.1.2.3.1.1 Data of the pollutant emissions from CS2 and CS2N

Each compression station is designed to comprise three stacks– Gas Turbines of 25.2 MW each (in ISO conditions), 6 in total and identical in characteristics and emission data. The spare turbine of CS2 was not included in the dispersion study. The computational study simulated the maximum operation of the CSs for in total 8,585 hours.

Table A1- 4 presents the data on the geometric characteristics of the stacks and the gas flow properties of the emission source. Table A1- 5 provides the emission values of the pollutants.

Table A1- 4 Technical data on emission sources from the CS2 & CS2N.

Number of stacks	Stack Geometric characteristics		Exit gas Temperature (°C)	Turbine Exhaust gas flow rate (kg/h)	Turbine Exhaust gas density (kg/m^3)
	Height (m)	Size (m)			
6	20	2.6 × 3.8	500.0	260,400	0.65

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Table A1- 5 Data of NOx and CO from each gas turbine.

Pollutant	Pollutant concentration limit in exhaust mg/Nm^3	Emission rates of the pollutants kg/h
NO_x (as NO_2)	30	5.7
CO	50	8.6

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9A.1.3 ATMOSPHERIC DISPERSION CALCULATIONS

This section focuses on the analysis of the HYSPLIT model results of the concentration values of NO_x, and CO from CS2 and CS2N.

The concentrations of NO_x were calculated on an hourly and annual basis to compare the modelled calculated results with the respective air quality limits as set by the legislation in force (MD 14122/549/E.103/2011 "Measures to improve air quality in compliance with the provisions of Directive 2008/50/EC "on the air quality and cleaner air for Europe" the European Parliament and Council of the European Union of 21 May 2008"). According to the current directive, the air quality limit for NO_2 for averaging period of 1 hour is set at 200 μg/m^3, not to be exceeded more than 18 times a calendar. On an annual average basis, the respective limit is 40 μg/m^3. The CO values were calculated as maximum daily 8 hour running mean concentrations for comparison with the respective air quality limit of 10 mg/m^3 (Directive 2008/50/EC).

The modelling approach was performed without the inclusion of the photochemical reactions which could reduce the concentrations of NO_x and CO in the atmosphere for the reason of obtaining the maximum possible values in the domain. Moreover, detailed data on the compounds from high resolution inventories would be needed for a photochemical model, which were not available. Special attention was given to the populated areas around the location of the gas compression stations.

A field survey campaign was carried out during the period of 26/05/2021 - 30/06/2021 to investigate the ambient air quality conditions in the area of interest. Details about the field sampling can be found in the corresponding section of the report.

Figure A1- 5 shows the location of the sampling sites and Table A1- 6 summarises the results from the field measurements. The measured data represent mean hourly concentrations of the period of approximately one month during the summer season. The measurements showed that the hourly average background concentrations of both pollutants of interest were of significant low values compared to those found in more heavily populated areas of the country. In particular, the CO ambient concentrations were lower than the detection limit (0.6 mg/m^3) of the measuring device and analytical method except for the locations of DEH, where the power plant installation is, and for the residential area Asprolithos, which is in close distance from the power plant. In addition, the ambient NOx concentrtions were measured to be very low of an average value of 1.94 μg/m^3 while in the majority of the sampling locations, the concentrations remained below the detection limit 0.7 μg/m^3. Hence, the ambient concentrations of the CO and NOx were not considered in the modelling study.

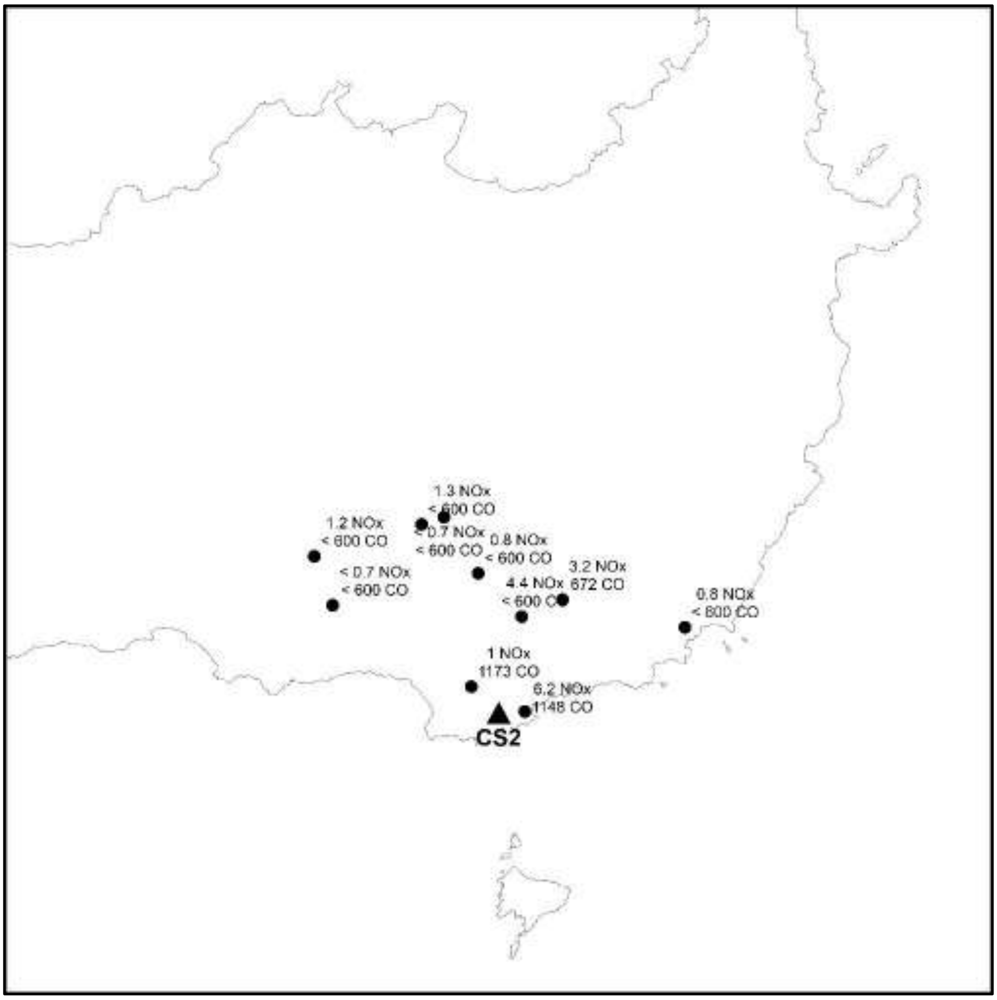

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Figure A1- 5 location of the sampling sites

Table A1- 6 Field campaign concentration measurements of NOx and CO at locations in the vicinity of the CS2 and CS2N.

Sampling location	NOx (μg/m^3)	CO (μg/m^3)
ASPROLITHOS	1.0	1173
DEH (Power Plant)	6.2	1148
AGIA TRIADA	4.4	<600
KALO CHORIO	3.2	672
XIROKAMPOS	0.8	<600
APIDI	0.8	<600

Sampling location	NOx (μg/m^3)	CO (μg/m^3)
ARMENOI	1.3	<600
CHANDRAS	<0.7	<600
LITHINES	1.2	<600
PERIVOLAKIA	<0.7	<600
PERIVOLAKIA DUPLICATE	<0.7	<600
TRAVEL BLANK	<0.7	<600

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9A.1.3.1 Pollutant concentrations from CS2 and CS2N

Table A1-7 presents the maximum hourly average concentration of NO_x determined for each characteristic weather type. It can be observed that the **maximum hourly average values of NO_x concentrations from the CC2 and CS2N do not exceed the limit of 200 μg/m^3 during any characteristic weather type**. In fact, the maximum hourly average NO_x concentrations remain low and well below the air quality limit. The maximum hourly average concentration of NO_x of 26.11 μg/m^3 was found during CWT3. This value occurred for 1 hour only during the CWT3 in rather stable atmospheric conditions.

Table A1- 8 shows the maximum hourly and annual average concentrations of NO_x as well as the maximum 8-hour running mean value of CO calculated in the domain, for direct comparison with the legislative limits. It can be deduced that these maximum pollutant values are very low compared to the air quality limits (2008/50/EC).

Table A1- 9 summarizes the maximum hourly average and annual NO_x concentrations as well as the CO maximum 8-hour running mean values calculated by the dispersion model over all the residential areas of the domain at a maximum distance of ~25 km from the centroid of the industrial field. The concentrations of the pollutants are negligible above the residential areas compared to the corresponding air-quality limits.

Table A1-7 Maximum calculated near surface values of hourly average NOx concentrations from CS2 and CS2N in the domain per CWT.

CS2 & CS2N	
CWT	Maximum hourly (mean) NOX concentration (μg/m3)
1	16.24
2	1.95

CS2 & CS2N	
CWT	Maximum hourly (mean) NOX concentration (μg/m3)
3	26.11
4	13.91
5	14.03
6	1.11
7	15.55
8	15.47
9	1.33
10	3.26
11	14.36
12	21.17

Prepared by Demokritos on behalf of ASPROFOS, 2022.

Table A1- 8 Maximum calculated average concentration values of NOx and CO in the domain from CS2 and CS2N and air quality limits (2008/50/EC).

Maximum hourly (mean) NO_X concentration ($\mu g/m^3$)	Annual average NO_X concentration ($\mu g/m^3$)	Maximum 8-h mean CO concentration ($\mu g/m^3$)
(limit 200 $\mu g/m^3$)	(limit 40 $\mu g/m^3$)	(limit 10000 $\mu g/m^3$)
26.11 (During CWT 3)	2.83	27.48 (During CWT 12)

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Table A1- 9 Maximum calculated concentration values of NOx and CO from CS2 and CS2N, over the residential areas in the domain of Lasithi, for all CWT.

GS2 and GS2N					
No.	Place of residence	Distance from the centroid (km)	Maximum hourly (mean) NO_X concentration ($\mu g/m^3$)	Annual average NOx concentration ($\mu g/m^3$)	Maximum 8-h mean CO concentration ($\mu g/m^3$)
			(limit200 $\mu g/m^3$)	(limit 40 $\mu g/m^3$)	(limit 10000 $\mu g/m^3$)
1	ACHLADI	18.93	0.27	0.01	0.38

GS2 and GS2N					
No.	Place of residence	Distance from the centroid (km)	Maximum hourly (mean) NO_x concentration ($\mu g/m^3$)	Annual average NOx concentration ($\mu g/m^3$)	Maximum 8-h mean CO concentration ($\mu g/m^3$)
			(limit200 $\mu g/m^3$)	(limit 40 $\mu g/m^3$)	(limit 10000 $\mu g/m^3$)
2	AGIA FOTIA	20.84	0.00	0.00	0.00
3	AGIA TRIADA	3.77	0.00	0.00	0.00
4	AGIOS GEORGIOS	14.20	0.00	0.00	0.00
5	AGIOS SPIRIDONAS	12.56	0.34	0.00	0.42
6	AGIOS STEFANOS	16.02	0.00	0.00	0.00
7	AGKATHIA	24.59	0.00	0.00	0.00
8	ANALIPSI	13.71	0.00	0.00	0.00
9	ARMENI	8.12	0.00	0.00	0.00
10	AZOKERAMOS	17.62	0.00	0.00	0.07
11	CHAMEZI	21.13	0.29	0.00	0.46
12	CHANDRAS	8.78	0.17	0.00	0.04
13	CHOCHLAKIES	18.97	0.02	0.00	0.02
14	CHRICHOPIGI	19.54	0.00	0.00	0.00
15	EPANO EPISKOPI	15.05	0.00	0.00	0.02
16	EXO MOYLIANA	21.88	0.08	0.00	0.19
17	GOUDOURAS	2.56	8.59	0.21	12.99
18	KARIDI	14.73	0.00	0.00	0.00
19	KATO KRIA	16.13	0.00	0.00	0.00
20	KATO ZAKROS	15.85	0.21	0.00	0.18
21	KATSIDONI	13.60	0.00	0.00	0.00
22	KOUTSOURAS	16.57	0.23	0.00	0.07
23	LANGADA	20.36	0.00	0.00	0.00
24	LITHINES	10.64	0.56	0.00	0.39
25	MAKRIS GIALOS	14.59	0.08	0.00	0.07
26	MARONIA	15.66	0.00	0.00	0.00
27	MESA MOYLIANA	22.23	0.05	0.00	0.02
28	MIRSINI	24.11	0.04	0.00	0.05

GS2 and GS2N					
No.	Place of residence	Distance from the centroid (km)	Maximum hourly (mean) NO_X concentration ($\mu g/m^3$)	Annual average NOx concentration ($\mu g/m^3$)	Maximum 8-h mean CO concentration ($\mu g/m^3$)
			(limit200 $\mu g/m^3$)	(limit 40 $\mu g/m^3$)	(limit 10000 $\mu g/m^3$)
29	MITATO	17.11	0.00	0.00	0.00
30	ORINO	21.09	0.00	0.00	0.00
31	PALAIKASTRO	23.99	0.00	0.00	0.00
32	PAPAGIANNADES	10.93	0.32	0.00	0.21
33	PERIVOLAKIA	7.57	0.22	0.00	0.17
34	PISOKEFALO	19.36	0.81	0.01	1.65
35	ROUSSA EKKLISIA	19.25	0.00	0.00	0.00
36	SFAKA	24.70	0.05	0.00	0.08
37	SIKIA	13.70	0.00	0.00	0.00
38	SITANOS	12.90	0.00	0.00	0.00
39	SITIA	22.62	0.62	0.01	1.57
40	SKOPI	20.61	0.17	0.00	0.27
41	STAVROCHORI	18.49	0.00	0.00	0.00
42	STAVROMENOS	17.01	0.20	0.00	0.05
43	TOURLOTI	24.21	0.04	0.00	0.06
44	XEROKAMPOS	10.01	0.59	0.02	0.75
45	ZAKROS	14.55	0.00	0.00	0.03
46	ZIROS	7.83	0.11	0.00	0.11

Prepared by Demokritos on behalf of ASPROFOS, 2022.

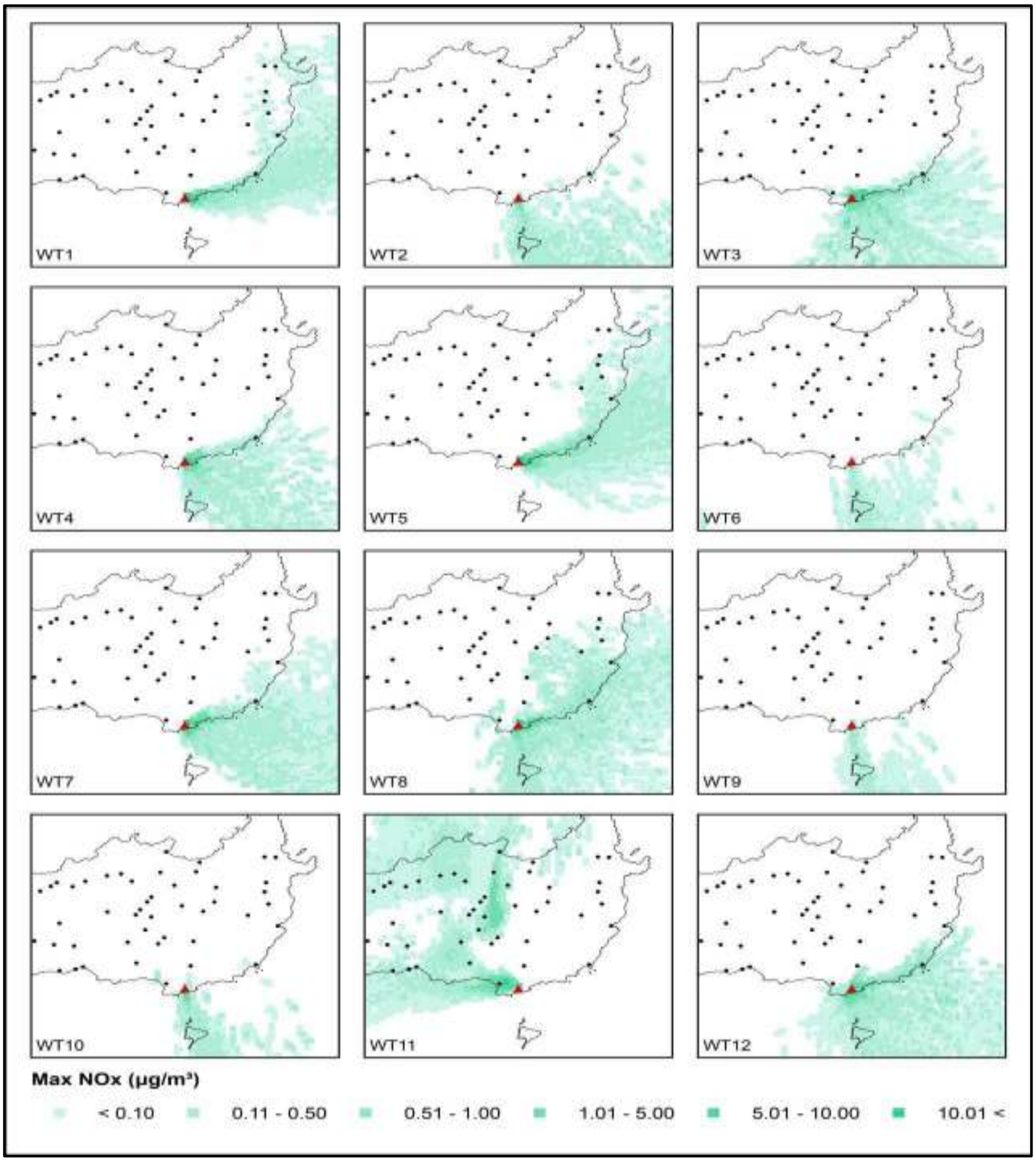
Figure A1- 6 and Figure A1- 7 depict the maximum hourly and annual average concentrations of NO_x from the gas compression stations, calculated by the model taking into account the 12 characteristic weather types of the region and their frequency of occurrence within a typical year (see Table A1- 2). **It can be deduced, that no exceedances of the NO_x and CO respective air quality limits occur over the populated areas within an approximate distance of 20 km from GS2 and GS2N.** In fact, the maximum hourly (for each CWT) and annual NO_x concentrations are found to be very low compared to the legislative limits (2008/50/EC), (see Table A1- 8, Figure A1- 6 and Figure A1- 7).

In particular, the maximum hourly average concentration of NO_x of 8.59 $\mu g/m^3$ is calculated over the residential area of Goudouras, which is at the closest distance from the gas stations (air quality limit

200 μg/m3) (see, Table A1- 9). The maximum hourly NO_x concentrations, dispersed to the more distant populated areas of the domain, are not found to exceed the value of 5.0 *μg/m³,* while over most residential sites the concentrations are equal to zero (Figure A1- 6). The maximum annual NO_x concentration of 2.83 *μg/m³* calculated in the area is also very low compared to the respective air quality limit of 40 μg/m³ (see Figure A1- 7, Table A1- 8).

A similar conclusion is drawn for the maximum 8-hour running mean CO concentrations, which are found to be negligible compared to the air quality limit (10000 μg/m³, 2008/50/EC). The maximum calculated CO concentration is equal to 27.48 μg/m³ during the CWT12 (winter period) (Figure A1-8). The maximum CO concentration calculated over the residential area of Goudouras is equal to 12.99 μg/m³ (Table A1- 9). Overall, the maximum CO concentrations do not exceed the air quality limit anywhere in the domain and during any characteristic weather type.

It can be concluded that the modelled NO_x and CO concentrations from both compression stations (CS2 and CS2N), at the location of Lasithi, emitted from six identical gas turbines are very low and insignificant compared to the air quality limits of the legislation in force.



Prepared by Demokritos on behalf of ASPROFOS, 2022.

Figure A1- 6 Modelled near surface maximum hourly average concentrations of NOx from CS2 & CS2N (only) for the 12 CWT. Black dots indicate residential areas, red triangle indicates the centroid of the industrial field. Air quality limit values for hourly concentration

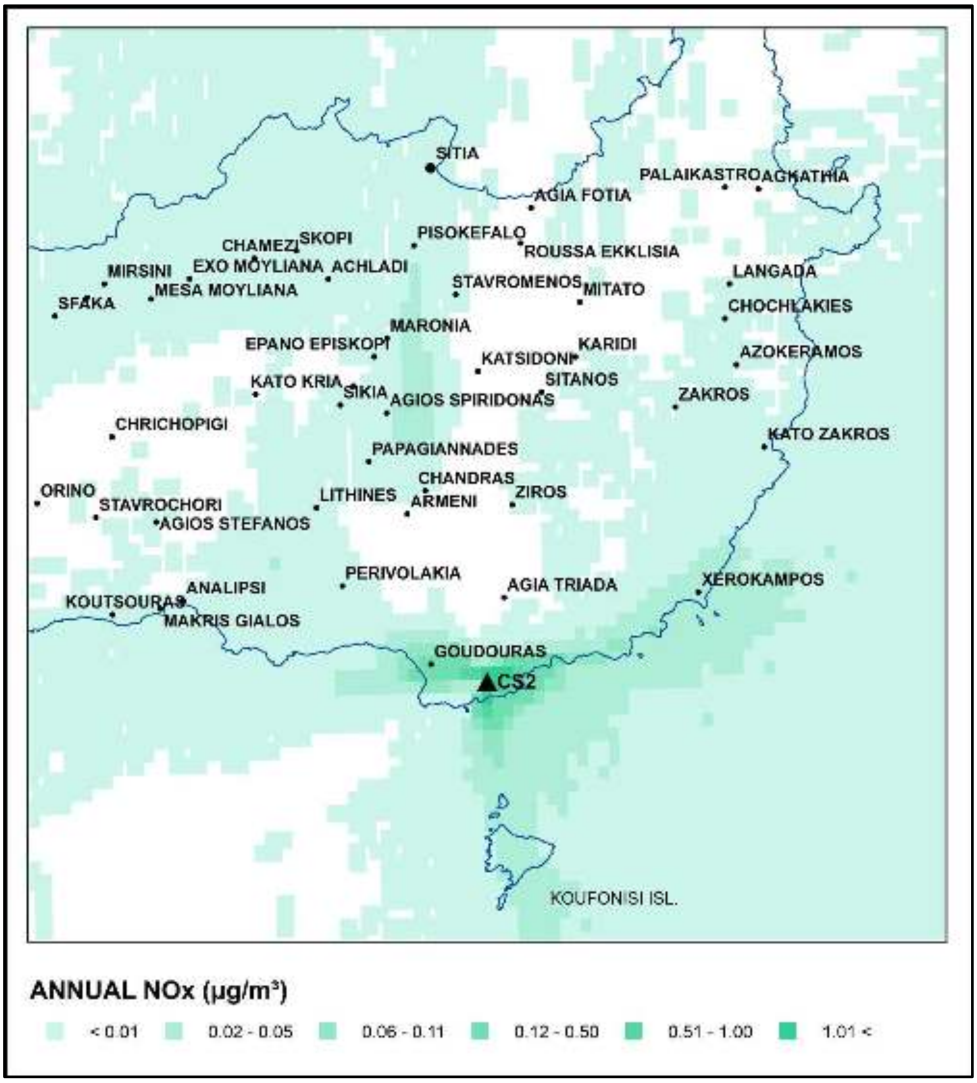


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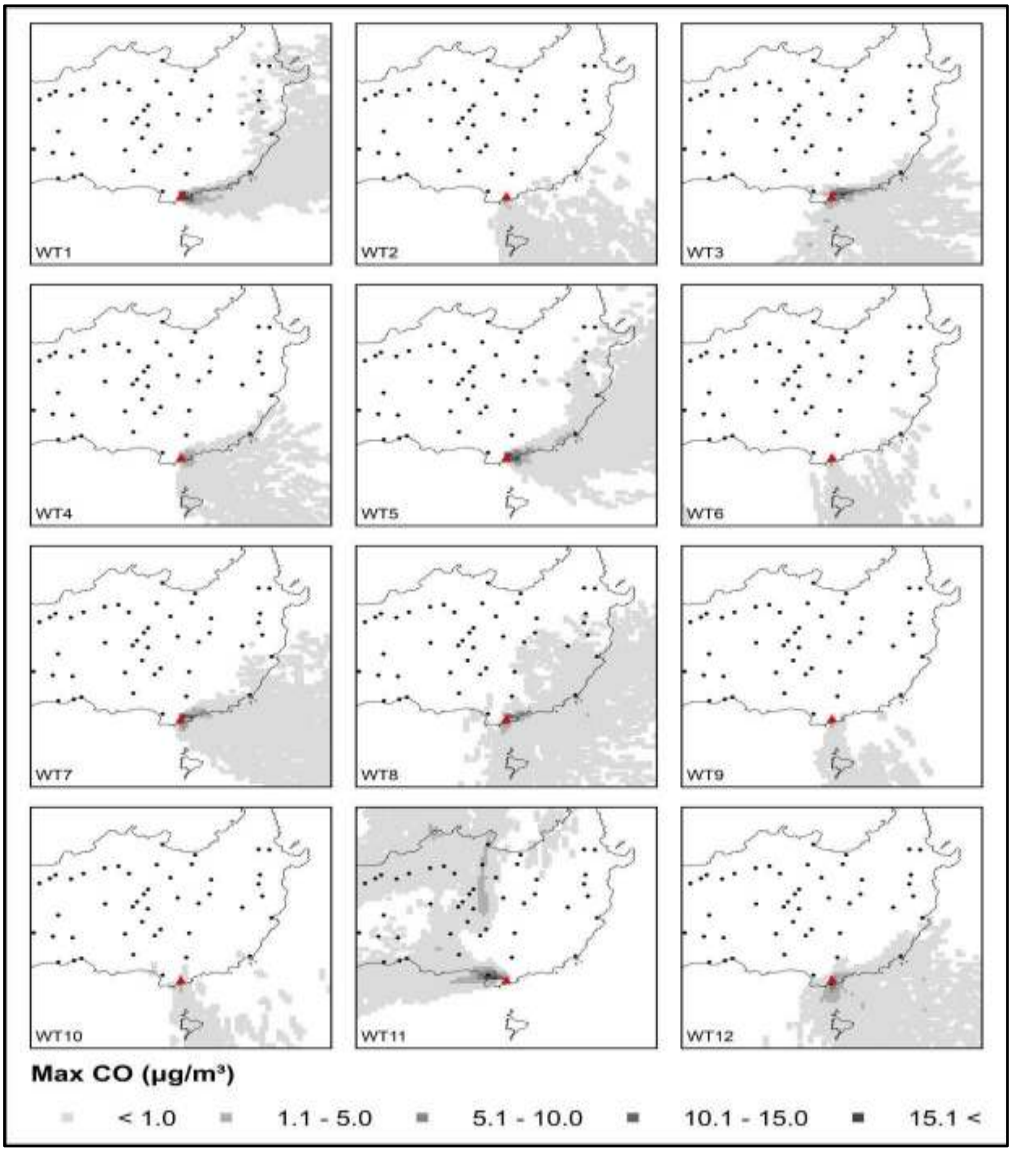
Figure A1- 7 Modelled near surface total average annual NOx concentration contours from CS2 & CS2N (in μg/m3). Annual Air Quality Limit for NO2: 40 (μg/m3).



Prepared by Demokritos on behalf of ASPROFOS, 2022.

Figure A1- 8 Modelled near surface calculated 8-hour running mean concentration values of CO (μg/m3) CS2 & CS2N for the 12 CWT. Red triangle indicates the centroid of the industrial field. Air quality limit for 8-hour concentration: 10000 (μg/m3).

9A.1.4 SUMMARY – CONCLUSIONS

The aim of the current study was to investigate the dispersion of NO_x and CO emissions from the future gas compressor stations CS2 and CS2N in the Lasithi area (Crete). The study was performed with the 3-dimensional computer modelling tools and appropriate methodology used and developed by the Environmental Research Laboratory (EREL) of the NCSR "Demokritos". The contribution of the measured ambient concentrations was also taken into account in the dispersion simulation. The dimensions of the modelling domain were large enough to include sufficiently the residential areas within a reasonable distance from the gas compression stations. Thus, the domain size for the modelling calculations was set to 40 × 40 km^2. For the modelling needs, the initial meteorological data were retrieved from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-5 climate *high-resolution reanalysis* of 3-hours, covering in total eleven (11) years. To calculate the average levels and the maximum values of the pollutant concentrations in the atmosphere from the future installations on an annual, daily and hourly basis, the procedure of identifying the characteristic weather types (CWT) of the area of interest was followed. The analysis revealed twelve (12) characteristic weather types (CWT) in the domain. Using these data as input to the WRF atmospheric model, the 3-d meteorological fields were calculated with a horizontal and temporal resolution of 1 × 1 km^2 and 1-hour, respectively.

For the air dispersion calculations, the atmospheric dispersion model HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model) was employed. The simulations were carried out with a 1-hour resolution. The modelling was based on the technical information available at the stage of the study by ASPROFOS SA. The ambient concentrations of NO_x and CO were not considered in the modelling study as the field measurements in the area surrounding the industrial field were found to be low and negligible for a meaningful assessment.

The near-surface hourly average and annual NO_x concentrations as well as the 8-hour running mean CO values were calculated in order to be comparable to the respective air quality limits as set by the legislation in force (MD 14122/549/E.103/2011 "Measures to improve air quality in compliance with the provisions of Directive 2008/50/EC "on the air quality and cleaner air for Europe" the European Parliament and Council of the European Union of 21 May 2008").

Overall, the hourly mean and annual NO_x concentrations were calculated to be lower than the air quality limits everywhere in the domain and during all CWTs. Similarly, the CO concentrations were calculated to be negligible compared to the air quality legislative limit. The maximum pollutant concentrations were found to occur during specific characteristic weather types (CWT3 and CWT12) due to conditions that resulted from the combination of atmospheric stability and rather weak wind fields, in late night hours. It must also be emphasised that no exceedances of the NO_2 and CO respective air quality limits were found over the populated settlements within a distance of approximately 25 km due to the emissions from the gas compressor stations. Conclusively, the modelling study yielded the following results:

- The maximum mean hourly NO_x concentration was found to be equal to ~13% of the air quality limit 200 $\mu g/m^3$ (during CWT3, spring period).

- The maximum annual NO_x concentration was found to be equal to 7% of the air quality limit 40 μg/m^3.
- The maximum 8-hour running mean CO concentration was found to be equal to 0.27% of the air quality limit of 10000 μg/m^3 (during CWT12, winter period).