AIR DISPERSION MODELING APPLICATION FOR AIR IMPACTS AND DEPOSITIONS ASSESSMENT IN THE ANTARCTIC

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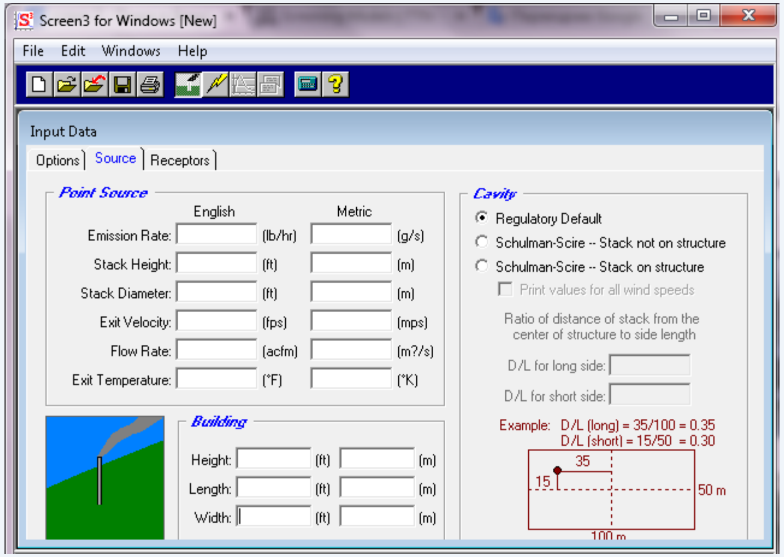
RATIONALE

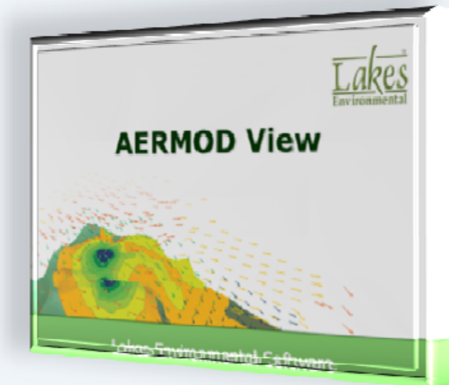
Air emission is among the most important factors of impact onto Antarctic environment taking into account extreme low levels of pollutants in ambient air and sensitivity of vegetation. So, application of dispersion modeling might be an effective instrument of qualitative human impact assessment.



It is reveled that emission dispersion models application for impact assessment in Antarctica is limited: from 12 known cases of CEE of construction activity no dispersion modeling was done in 5 cases; ISC3 model was applied in 2 cases; SYMOS97, OND-86 and AERMOD were applied in other 3 cases. No assessment of deposition fluxes was made.

SYMOS´97

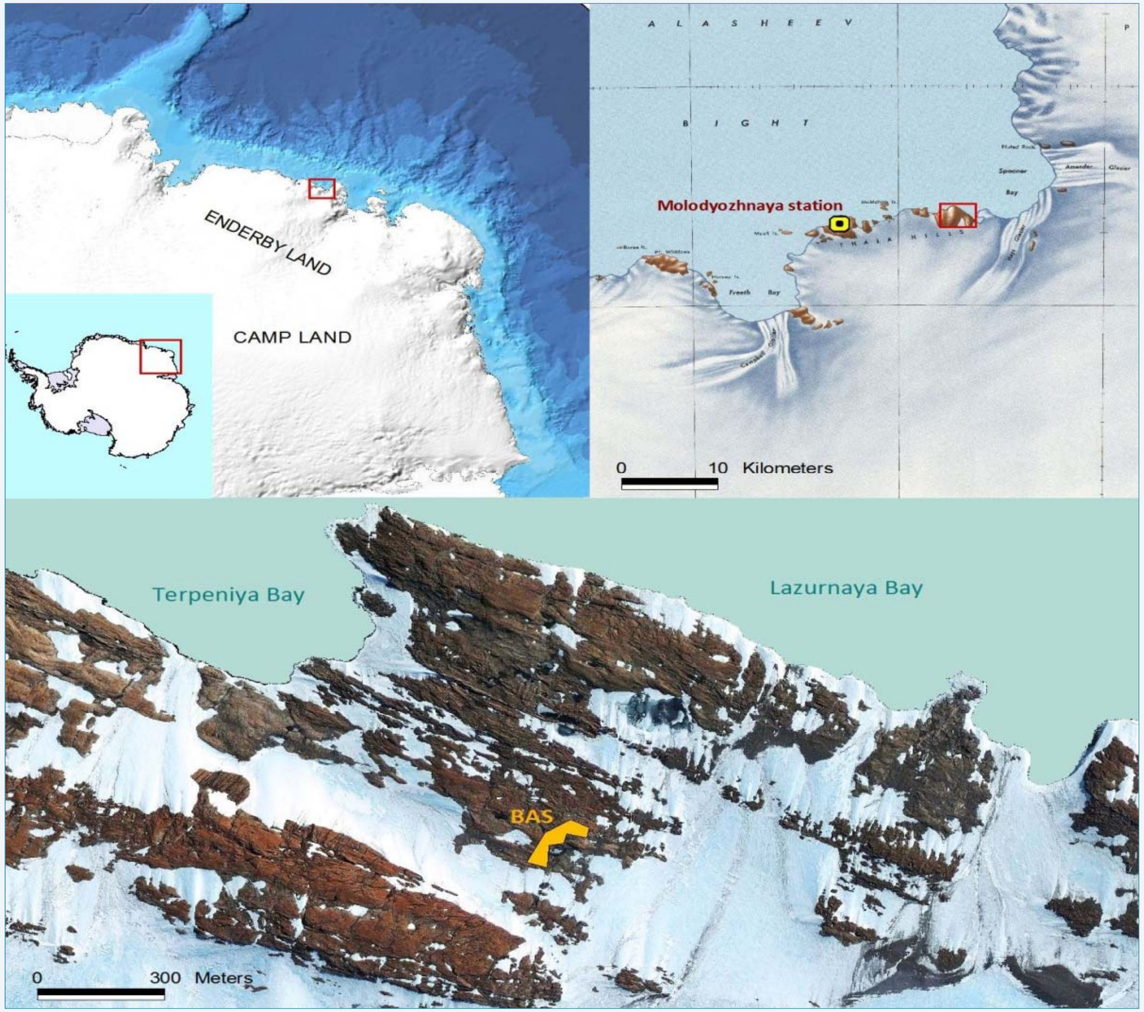
ISC3 model



List of dispersion models used for air impact assessment for construction and operation Scientific Stations in Antarctica

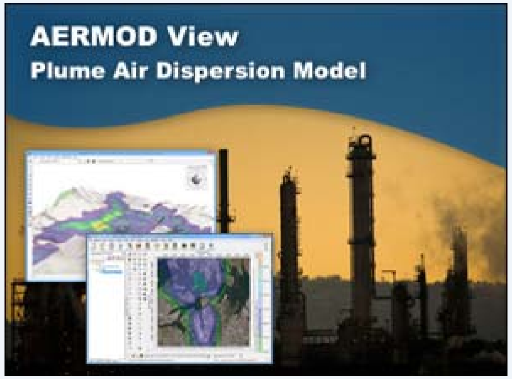
Station or site	Year	Dispersion model
Mendel Polar Station, Czech Republic	2003	SYMOS’ 97
Troll Station, Norway	2004	No
Halley Research Station, United Kingdom	2005	No
Neumayer-Station III, Germany	2005	No
Princess Elisabeth Base, Belgium	2007	No
Kunlun Station, China	2008	No
Zhongshan (Sun Yat-Sen) Station, China	2010	No
Bharati, India	2010	ISCST 3
Jang Bogo Station, South Korea	2012	ISCST 3
Taishan Station, China	2013	No
Vernadsky Station, Ukraine	2006	OND-86
Mount Vechernyaya, Belarus	2014-2015	AERMOD

REGION



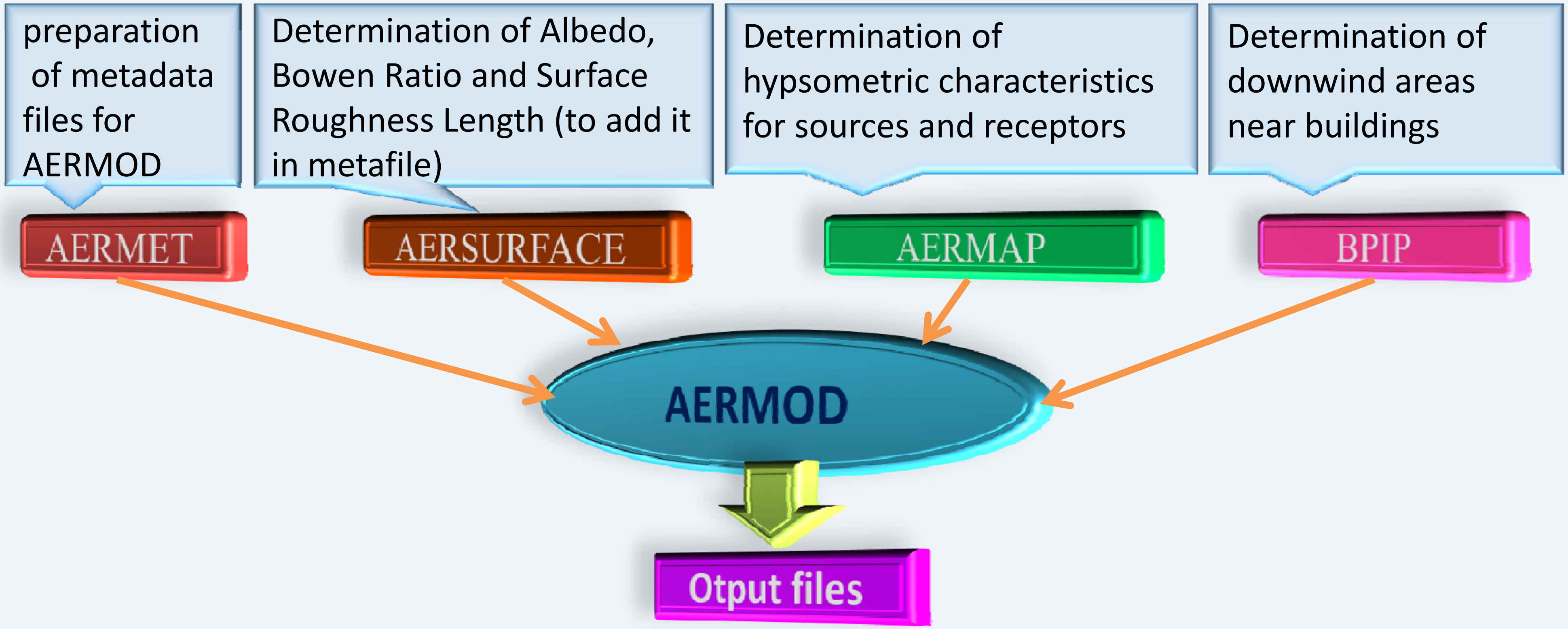
Mount Vechernyaya Belarusian Antarctic station is located at the western part of Enderby Land and eastern part of Tala Hills, at the coastal area of the Alasheeva Gulf, Cosmonaut Sea. It incorporates a series of rocky ridges with a dominant mountain, the Mount Vechernyaya (272.0 m). The area stretched about 8 km along the seacoast; its utmost width is about 2 km.

METHODOLOGY



For ambient air impact assessment simulations of pollutant dispersion in atmosphere from stationary sources were per-formed using US EPA AERMOD model.

Model developed in USA in 2002. Nowadays it is one of the most widely used Gaussian models. It can be used for estimation within zones with diameter up to 50 km. The model consists of the core and preprocessing components for representing input data in the required format. The core program uses data prepared by preprocessors.



DG-60

SOURCES OF EMISSION

KTO-50.K20

As emission sources stationary equipment on the station were accounted: 2 diesel generators and wastes incinerator (planned).

Technical documentation provides information on composition, intensity, temperature and volume of pollutants, heights and diameters of smokestacks.

Also were defined the locations of sources

Source	emission rate, g/s				height, m	tempera-ture, K	exit velo-city, m/c	diameter, m	Zone	X (UTM)	Y (UTM)
	SO_2	PM_{10}	NO_2	CO							
DG-60	0.016	0.011	0.156	0.109	3.5	623.1	39.79	0.05	-38	548681	2494456
DG-100	0.030	0.020	0.283	0.197	3.5	751.1	54.38	0.08	-38	548691	2494456
Incinerator	0.006	0.0004	0.003	0.009	9.0	473.1	12.0	0.3	-38	548678	2494478

SCENARIOS

Two scenarios were taken into
consideration to predict the BAS environmental impacts during the operation phase: seasonal and all-year-round.

SCENARIO 1:

1 source: diesel generator DG-60;

operate daily and continuously at full power during the December-March

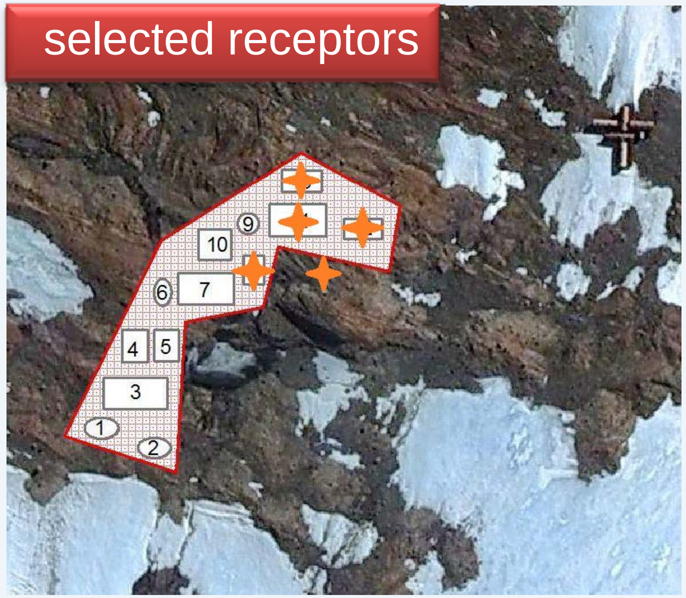
SCENARIO 2:

2 sources: diesel generator DG-100 and wastes incinerator KTO-50.K20

diesel generator full-power operation during all the year

wastes incinerator full-power operation once a week.

RECEPTORS



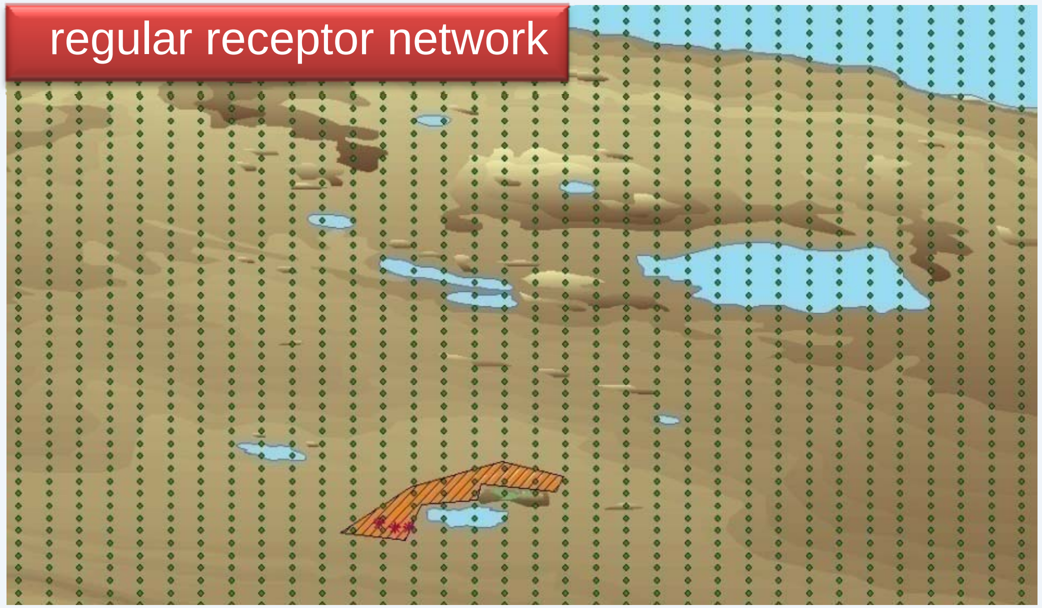
Two types of receptors points were introduced:

(1) Selected receptors: 4 in locations of residential modules, 1 in moss and lichen community;

(2) The regular receptor network encompassing area of 3000 x 1800 m with 20 m grid cells (1350 receprors)

Using preprocessor AERMAP, location of each receptor was used for obtaining hypsometric characteristics.

Each pollution source was characterized in the same manner.



INPUT DATA

EMISSION SOURCES PARAMETERS (emissions rate, stack height, temperature etc.)

RECEPTORS POINTS PARAMETERS (locations, heights)

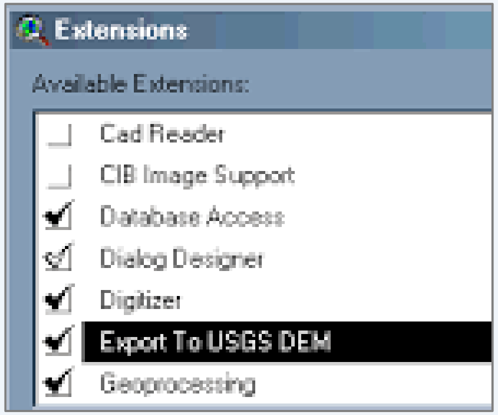
DIGITAL ELEVATION MODEL

SURFACE CHARACTERISTICS

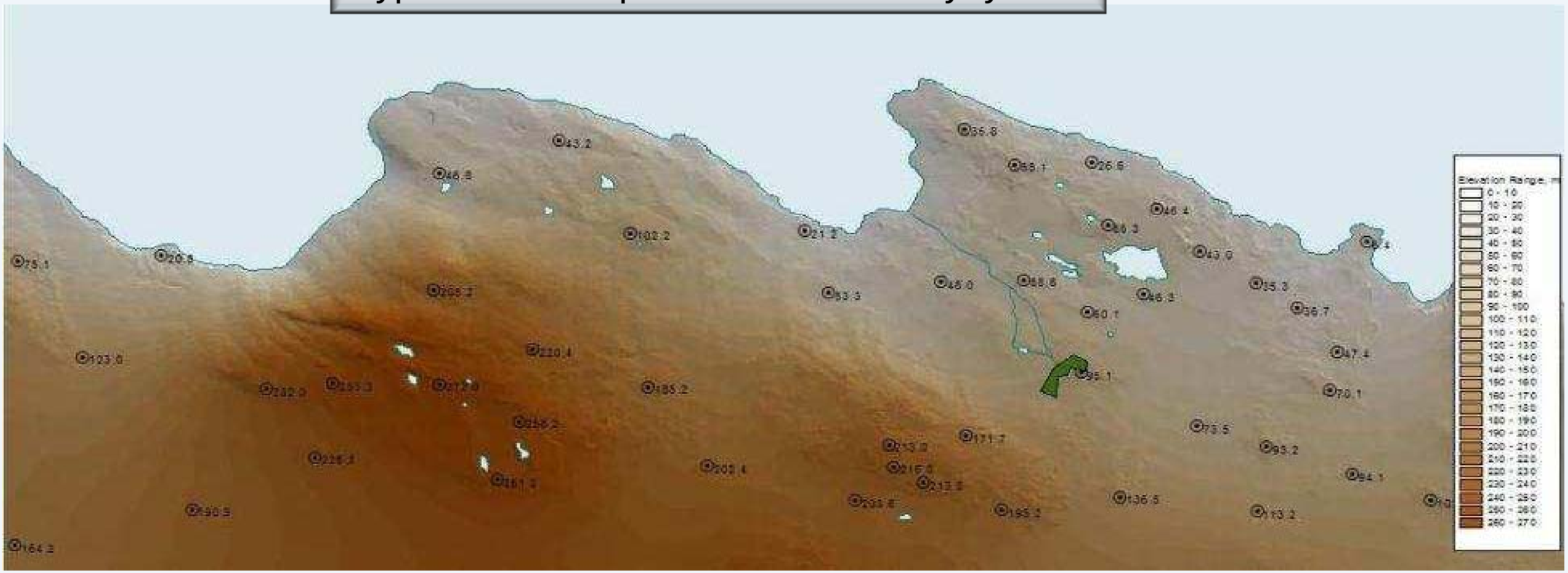
METEOROLOGICAL DATA

DIGITAL ELEVATION MODEL (DEM) FOR BAS

USGS DEM file was received at the base the topographic map 1:25000 using ARC VIEW program.
The obtained file was used in preprocessor AERMAP.



Hypsometric map of Mount Vechernyaya



SURFACE CHARACTERISTICS

It was impossible to find map of Land Cover Classification for our region in Antarctica.
We have used the topographic map for description of terrain types. There are two types of terrain near the station: (12)Perennial Ice/Snow and (31)Bare Rock. The terrain in the vicinity of the station was divided in 4 sectors. For each sector a percentage of both terrain types was determined. Then, using tables in AERMOD User Guide, the following parameters were determined for each sector:

i. Albedo
ii. Surface Roughness Length
iii. Bowen Ratio

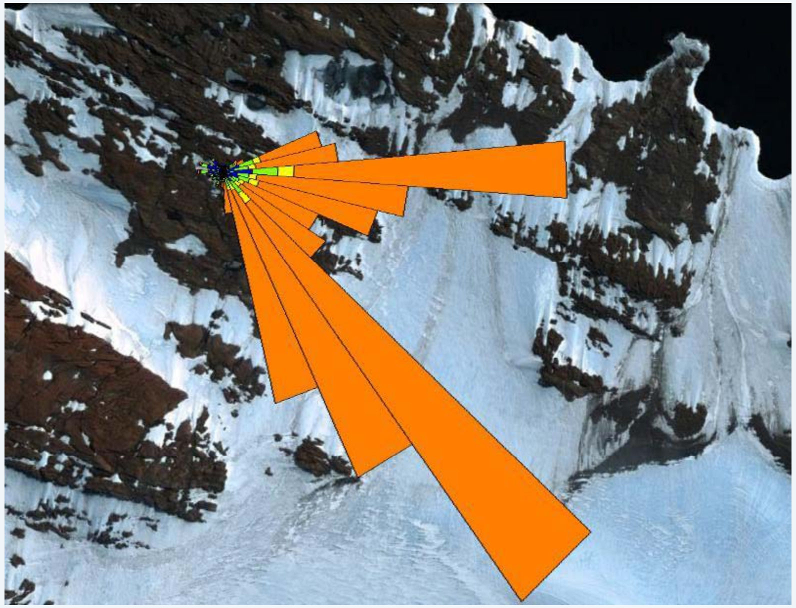
These parameters are inputs for preprocessor AERMET. They are used for making input metafiles for AEMOD.

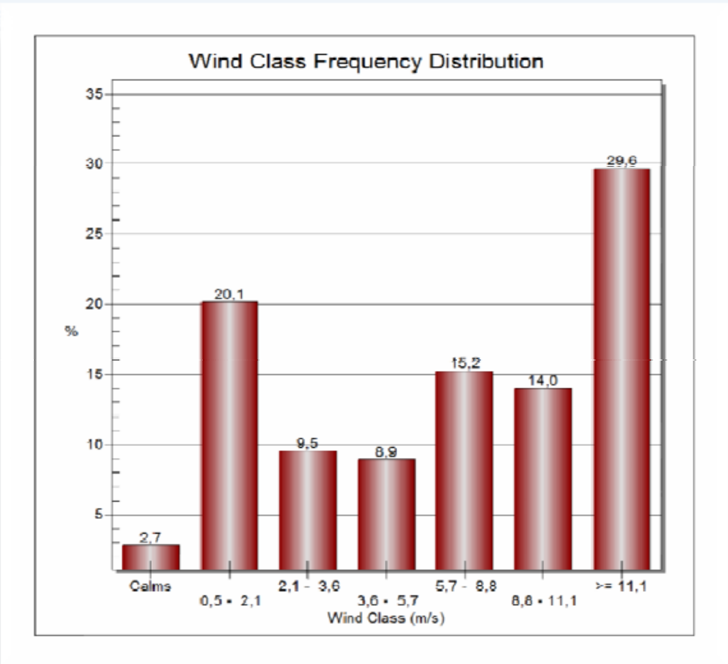
METEOROLOGICAL DATA

For preparing meteorological files observation data from two stations were used:

(1) Surface monitoring data of Molodyozhnaya station (WMO 895420)

(2) Upper air sounding level data from Japanise station SYOWA (WMO 895320)





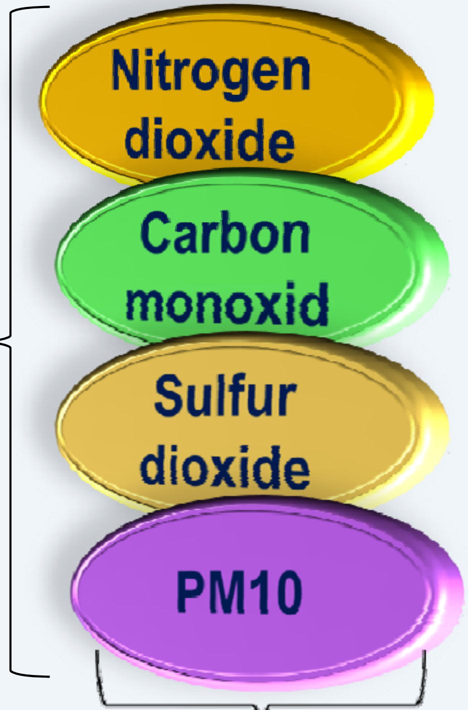
SURFACE DATA
http://www.ncdc.noaa.gov/oa/climate/isd/,

UPPER AIR SOUNDING DATA
http://esrl.noaa.gov/raobs/

POLLUTANS AND AVERAGING PERIODS

- Max 1-hour
- Max 24-hour
- Max month

concentrations



1-hr, 24-hr, month
PM 10 **depositions**

For regular net receptors there were calculated only maximum concentrations averaged over the following time periods: 1 hour, 1 day and 1 month.
For particulate matter we have also estimated deposition
From results of calculations for regular net receptors we have developed maps of concentration distributions for all substances.

For selected receptors were estimated other parameters else:

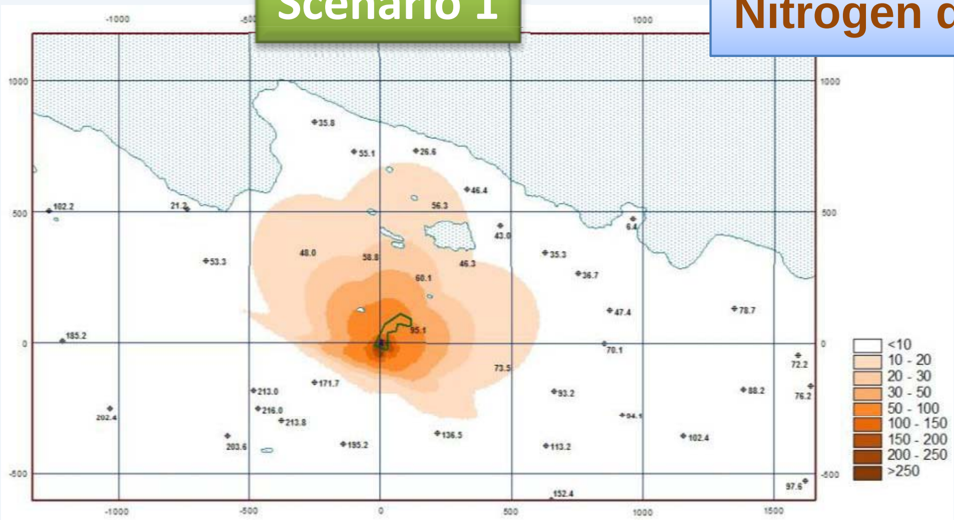
i. Average concentrations
ii. 98 percentile of max concentrations
iii. Frequency of reaching the highest concentrations

RESULTS

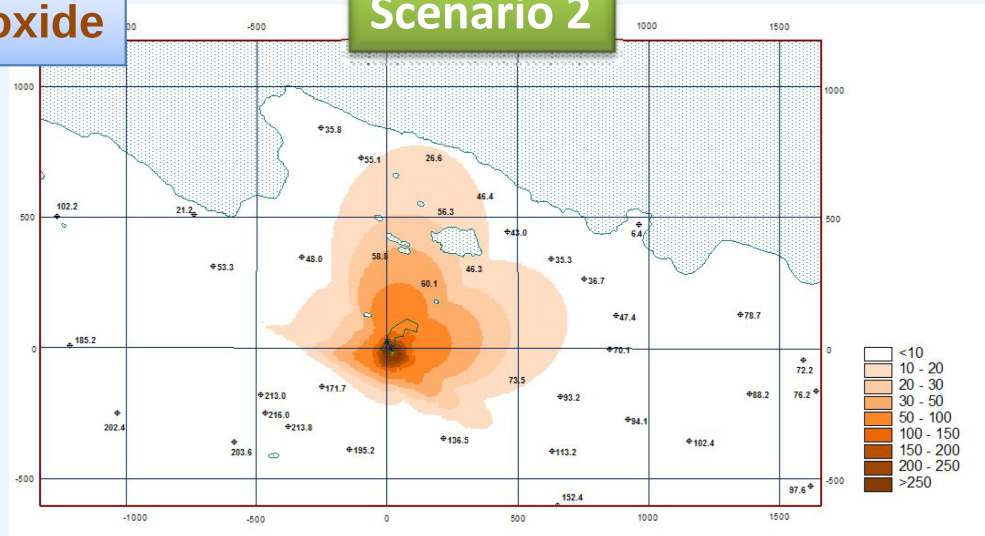
Distribution of max 1-hour concentrations from operation of stationary sources at Mount Vechernyaya station, mkg/m^3

Nitrogen dioxide

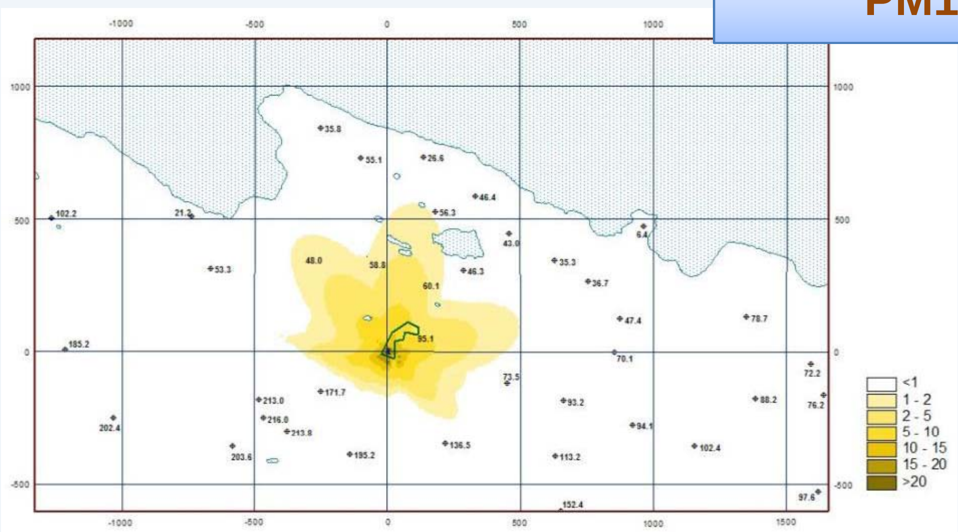
Scenario 1

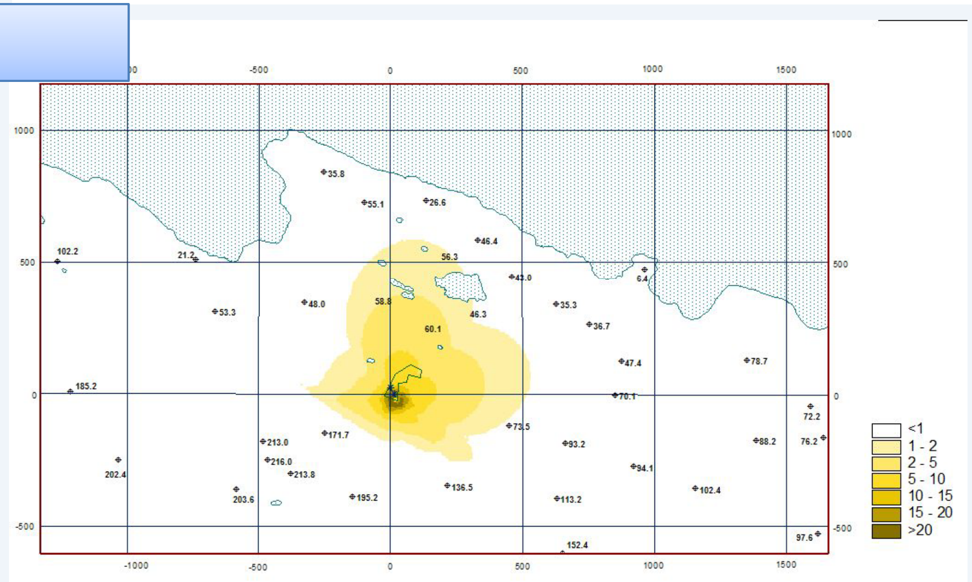


Scenario 2



PM10

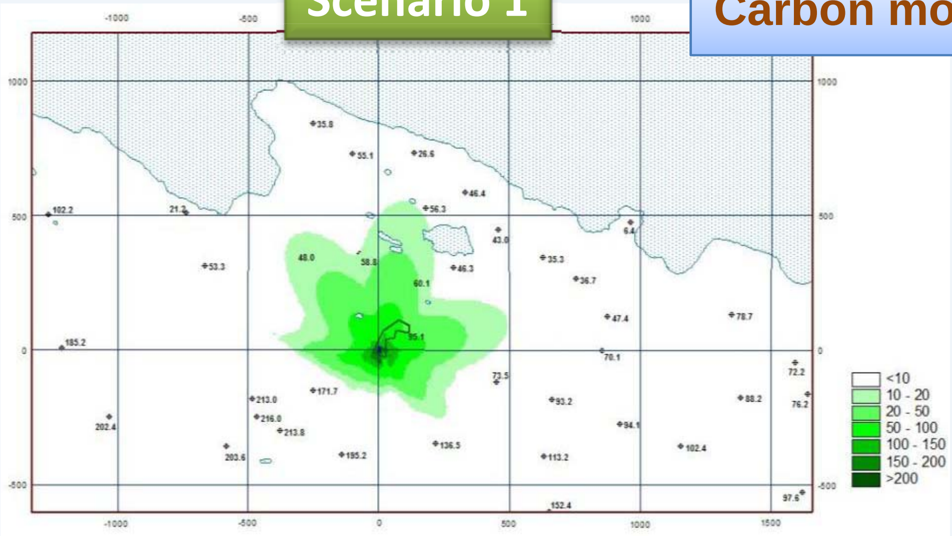


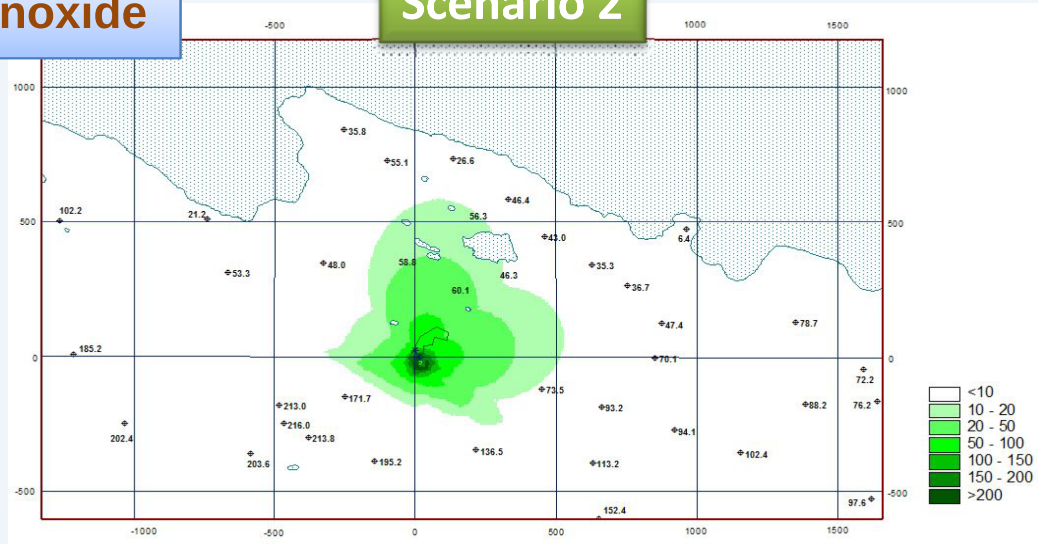


RESULTS

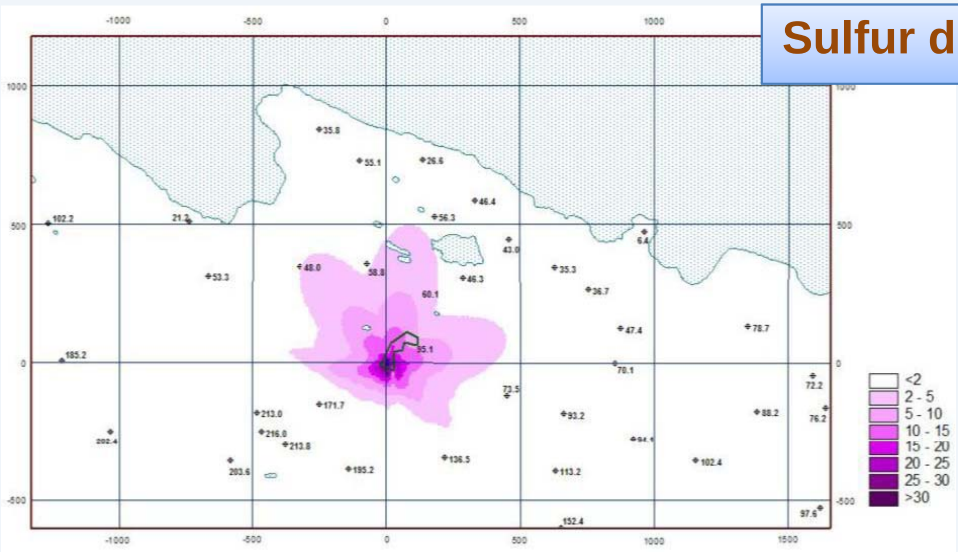
Distribution of max 1-hour concentrations from operation of stationary sources at Mount Vechernyaya station, mkg/m^3

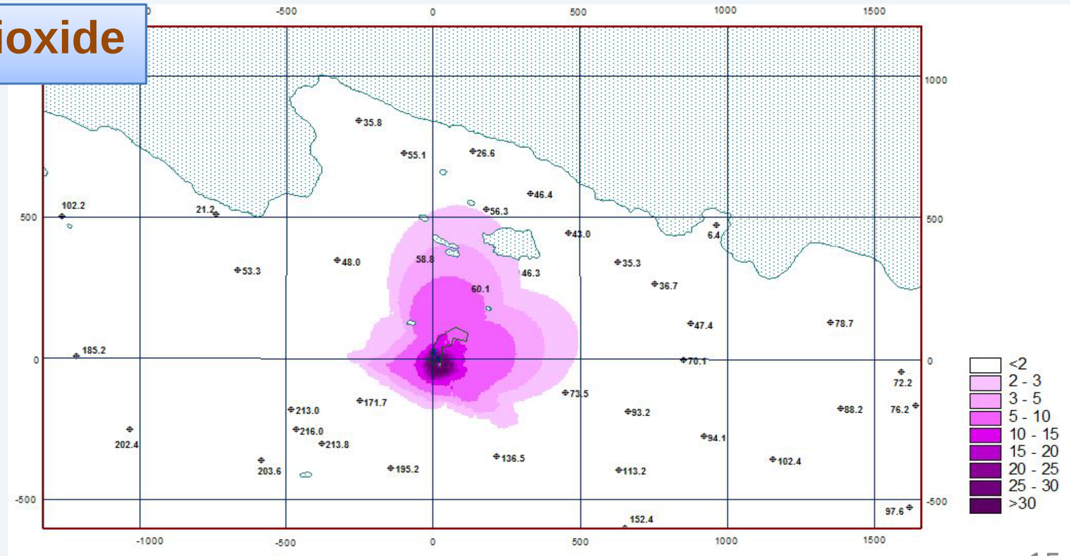
Scenario 1 | **Carbon monoxide** | **Scenario 2**





Sulfur dioxide



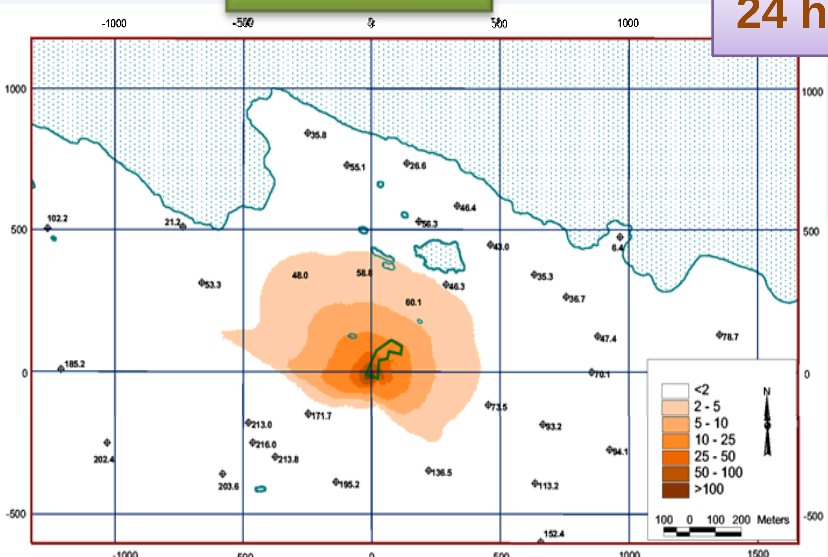


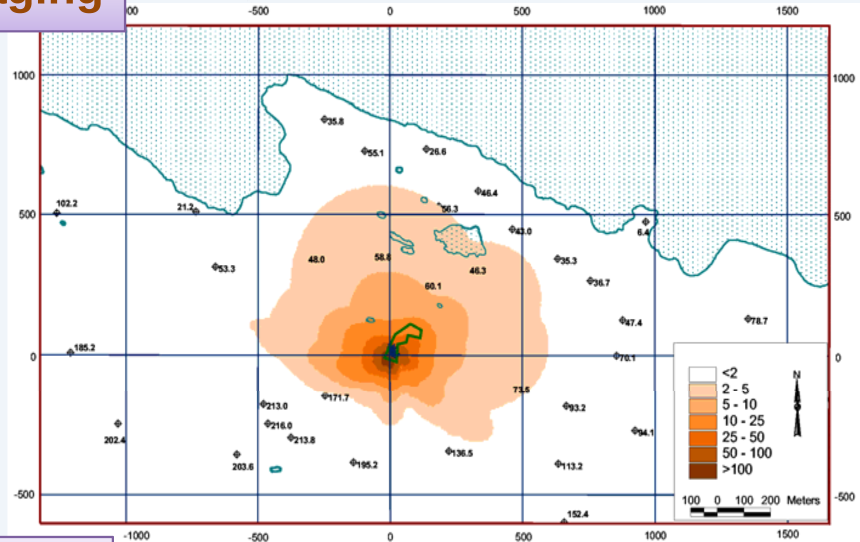
RESULTS

Max 24-hour and month concentrations of NO_2, mg/m^3

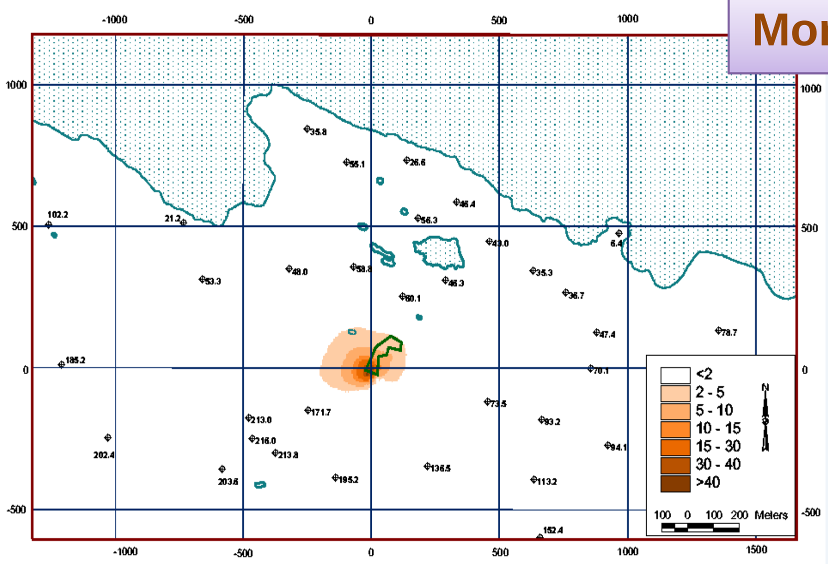
Scenario 1 | **Scenario 2**

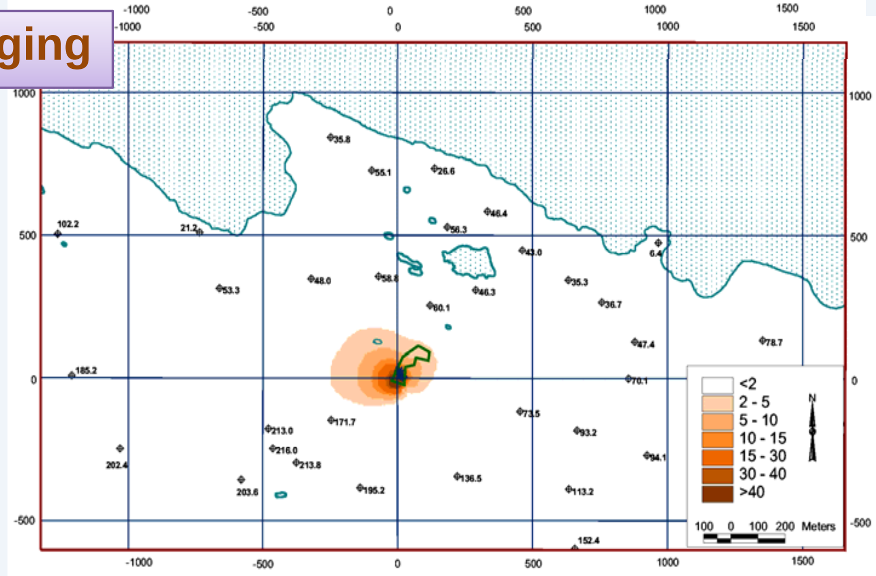
24 hour averaging





Month averaging





MAXIMUM AIR CONCENTRATIONS OF POLLUTANTS IN SELECTED POINTS, MKG/M³

Subst.	Avg	MPC	Country
NO2	20 min	250 mkg/m³	Беларусь
	1 h	200 mkg/m³	ЕС
		100 ppb	США
	24 h	100 mkg/m³	Беларусь
	год	40 мг/м³	ЕС, Беларусь
		53 ppb	США
SO2	20 min	500 mkg/m³	Беларусь
	1 h	350 mkg/m³	ЕС
		75 ppb	США
	24 h	200 mkg/m³	Беларусь
		125 mkg/m³	ЕС
	year	50 mkg/m³	Беларусь
ВЧ10	20 min	150 mkg/m³	Беларусь
	24 h	50 мг/м³	ЕС, Беларусь
		150 ppm	США
	year	40 mkg/m³	ЕС, Беларусь
1 h	20 min	5000 mkg/m³	Беларусь
	1 h	35 ppm	США
	8 h	10000 mkg/m³	ЕС
		9 ppm	США
	24 h	3000 mkg/m³	Беларусь
	year	500 mkg/m³	Беларусь

MAX point

Poll.	Scenario 1			Scenario 2		
	1 h	24 h	Mon	1 h	24 h	Mon
CO	234.0	106.4	42.2	301.1	186.8	92.0
NO_2	**272.0**	**145.4**	**60.3**	**398.7**	**259.0**	**131.8**
SO_2	34.5	15.6	6.2	45.9	28.4	14.0
PM10	23.7	10.7	4.3	30.6	19.0	9.3

Module 1

Poll.	Scenario 1			Scenario 2		
	1 h	24 h	Mon	1 h	24 h	Mon
CO	55.5	13.3	2.8	49.2	17.38	3.0
NO_2	67.0	16.4	4.0	70.6	24.8	4.3
SO_2	8.2	1.9	0.4	7.5	2.6	0.5
PM10	5.6	1.3	0.3	5.0	1.8	0.3

Module 2

Poll.	Scenario 1			Scenario 2		
	1 h	24 h	Mon	1 h	24 h	Mon
CO	55.9	14.8	2.9	43.5	16.9	2.7
NO_2	61.4	15.9	3.5	62.6	24.3	3.8
SO_2	8.2	2.2	0.4	6.6	2.6	0.4
PM10	5.7	1.5	0.3	4.4	1.7	0.3

Moss and lichen community

Poll.	Scenario 1			Scenario 2		
	1 h	24 h	Mon	1 h	24 h	Mon
CO	100.9	23.6	4.6	63.0	26.4	3.9
NO_2	101.2	24.8	5.4	89.6	37.9	5.6
SO_2	14.8	3.5	0.7	9.9	4.0	0.6
PM10	10.2	2.4	0.5	6.4	2.7	0.4

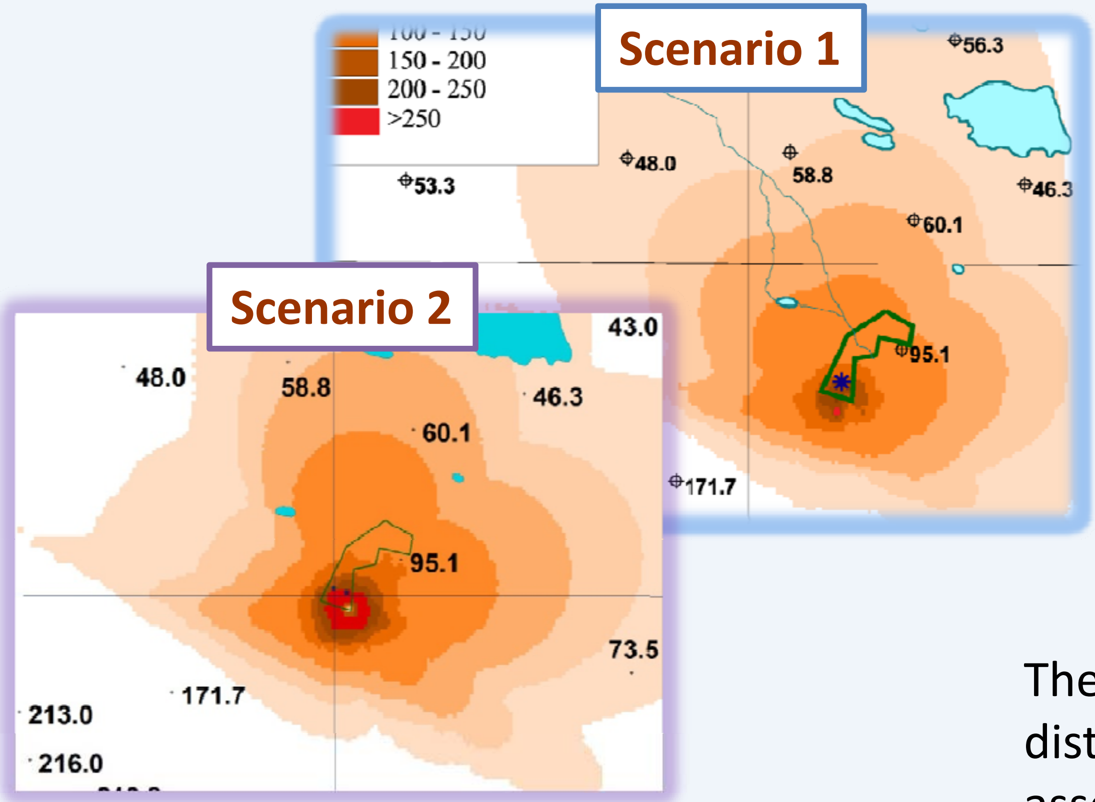
RESULTS

Carbon monoxide (CO)

Sulfur dioxide (SO_2)

PM10

The simulation results of Scenario 1 and Scenario 2 pollutant dispersion demonstrated that under the most adverse weather conditions the stationary sources operation will not result in exceeding the ambient air quality standards



Max hourly NO_2 concentration, mkg/m^3

The Maximum Permissible Concentration values may be exceeded only by nitrogen dioxide

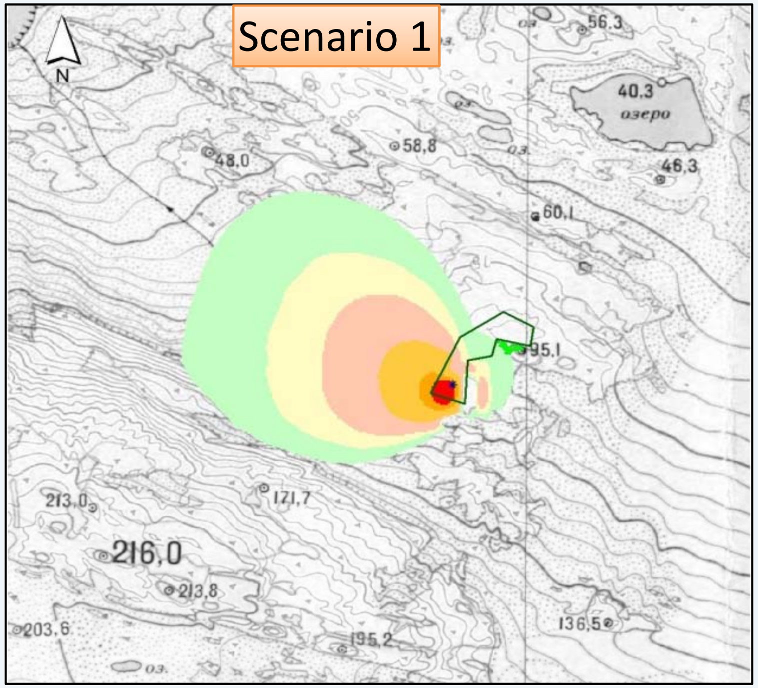
- Such excess will be strictly local
- Its recurrence is assessed to be low
- It might happen no more than for

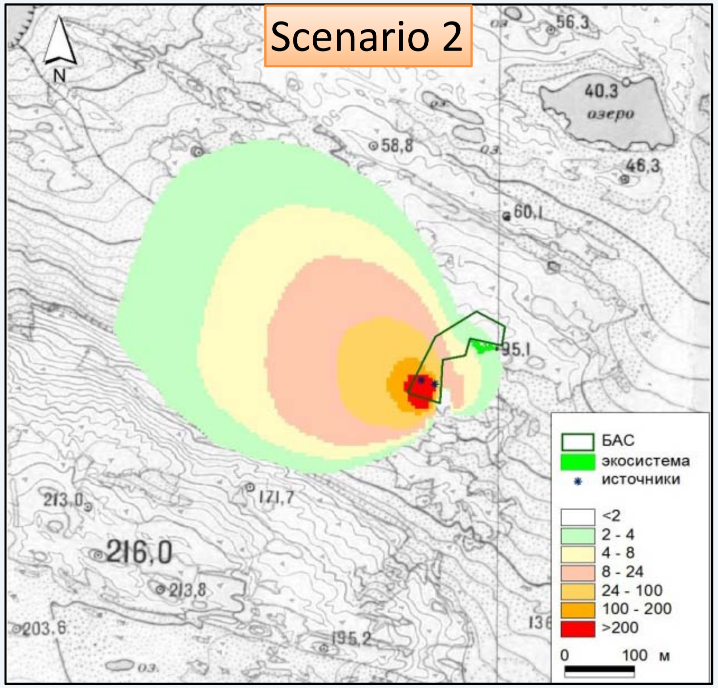
8 hours per year (Scenario 1) and
20 hours per year (Scenario 2)

The emissions will not be transferred at large distance from the station and will be generally assessed as minor.

DRY DEPOSITIONS

Year flux of PM10 at Mount Vechernyaya, mg/m^2

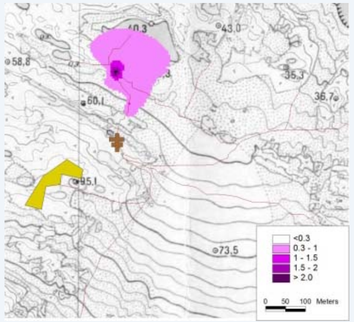


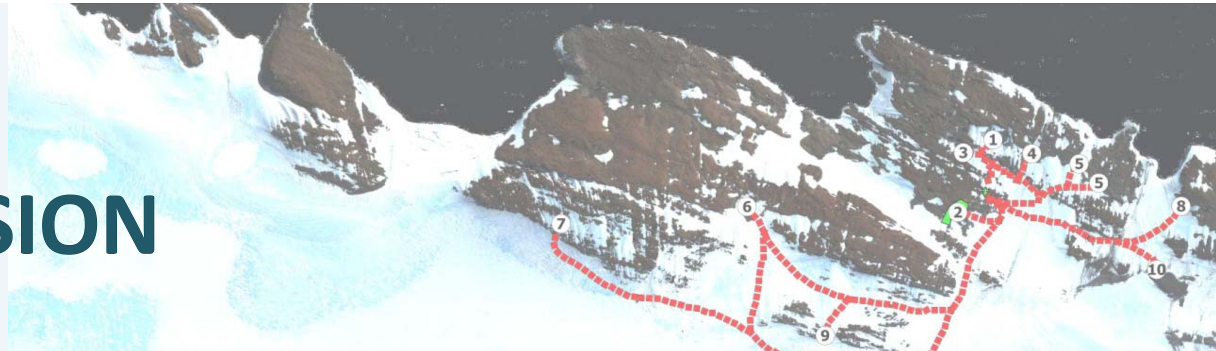


Year flux of PM10 in selected points, mg/m^2

	Module 1	Module 2	Module 3	Module 4	Moss and lichen community	Max point of receptors
Scenario 1	1.65	1.35	2.17	3.46	2.18	399.43
Scenario 2	3.02	2.49	3.96	6.68	4.02	631.14

Over the past two millennia, the background dust flux remained around ***~4 mg m-2 y-1*** *with a modal particle diameter of 5-8 pm. [****Koffman, B.G.,*** *2013. Atmospheric dust deposition in West Antarctica over the past two millennia. PhD Dissertation, University of Maine, 214 pages.]*



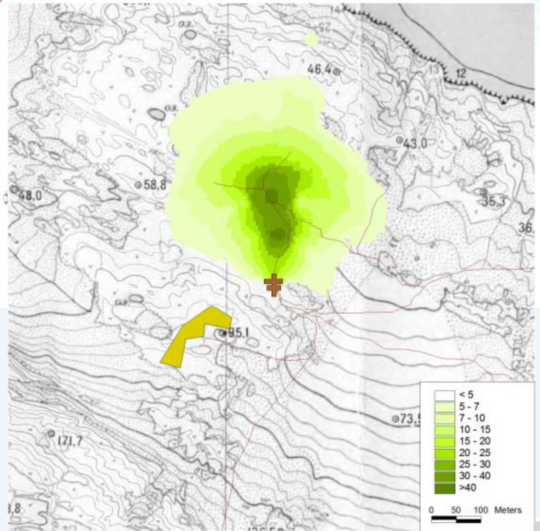


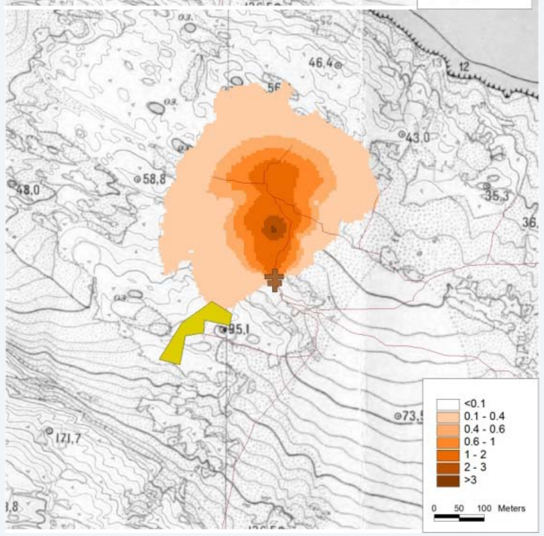
CONCLUSION

Study have shown that taking into account existing limitation of input data it is possible to provide acceptable accuracy of pollution dispersion model results. Air dispersion can be combined with geochemical models for analysis of pollutants migration in soils and waters and estimation of critical loads and thresholds.

Estimation of air and environmental impacts from mobile sources; problems to be solved: obtaining of spatiated emissions accounting routes and vehicles mileage.

Historical emissions and depositions assessment using retrospective modelling for estimation of cumulative impacts.





Thank you for your attention!