Modeling air quality impact of pollutants emitted by an oil/gas plant in complex terrain in view of a health impact assessment

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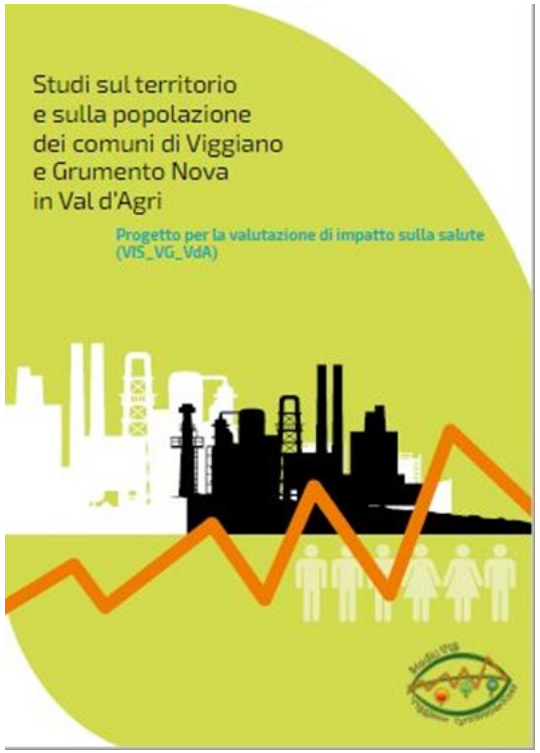
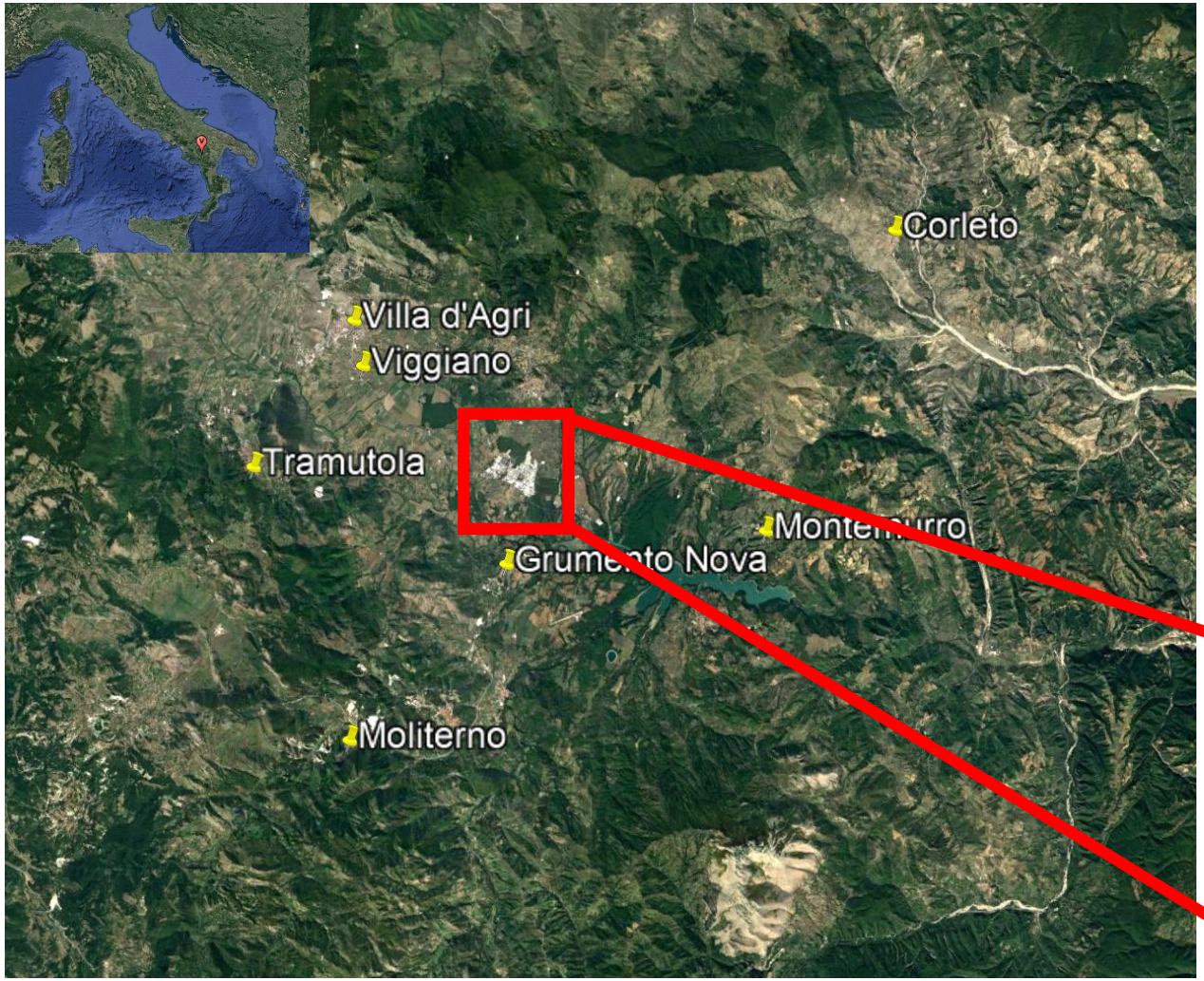
Aim of the study

Estimation of air quality impact of the oil- gas pre-treatment ”Centro Olio Val d’Agri (COVA) in view of a more comprehensive epidemiological study regarding the inhabitants of two towns settled in the proximity of the plant.



… and so it was done

Area of study: Agri Valley (Basilicata-Italy)

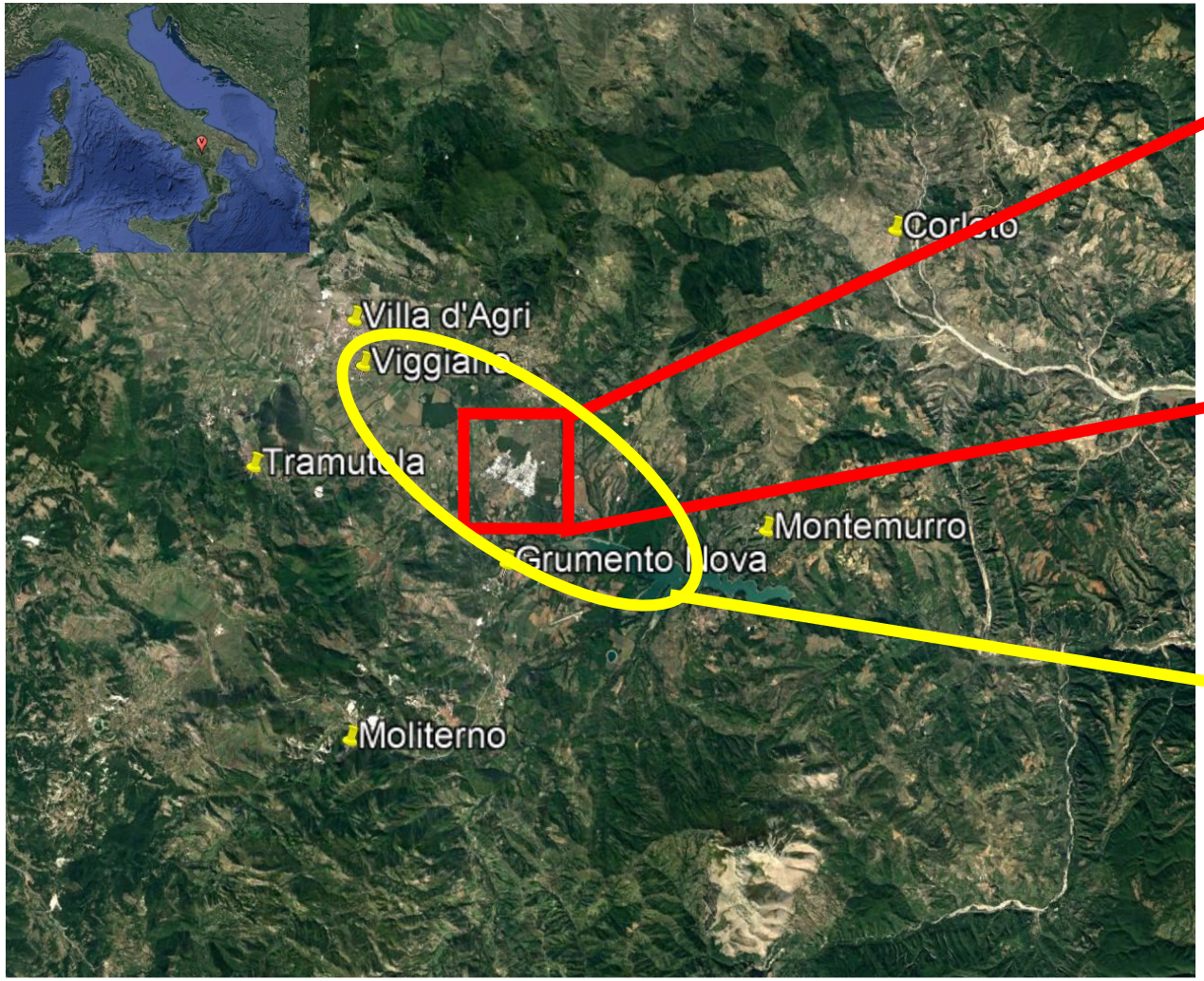


Agri Valley (Southern Italy)
30 km long 12 km wide
its bottom at 600 m.s.l
Bordered by Appennine Mountains

It hosts:

- **The largest European oil on-shore reservoir**
- **Pre-treatment plant -Centro Olio Val d'Agri (COVA)**

Area of study: Agri Valley (Basilicata-Italy)



Area of the epidemiological study:

- ❑ **Viggiano**
- ❑ **Grumento Nova**

Pre-treatment Oil-gas Centro Olio

Nominal treatment capacity of the entire plant

- **16 500 m^3 d^{-1} crude oil**
- **3 100 000 Sm^3 d^{-1} associated gas**

The processes imply different kind of atmospheric emissions:

- ❑ **incineration of residues and electric and thermic power generation (i.e.stationary combustion)**
- ❑ **flaring and venting activities**
- ❑ **fugitive emissions from oil tanks.**

The modelling system

RAMS

Atmospheric Regional Atmospheric Modeling System ***Pielke et al., 1992; Cotton et al, 2003)***

MIRS

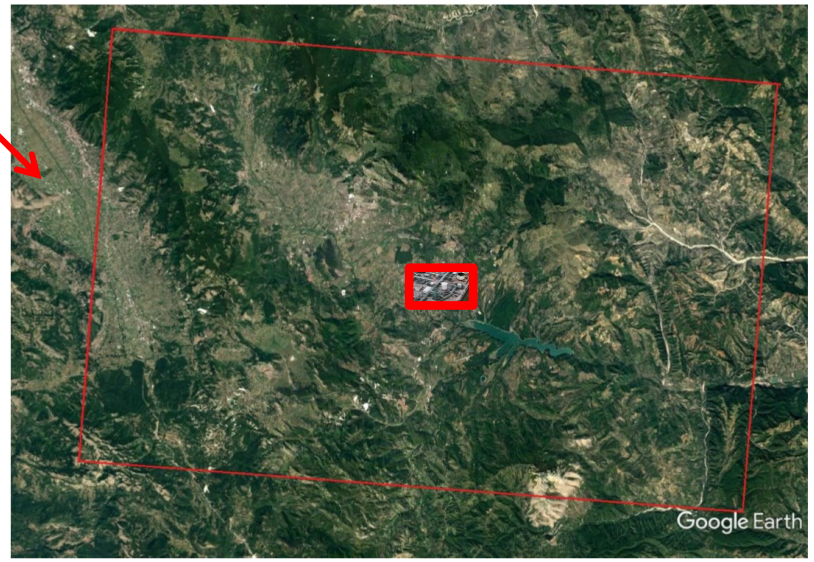
Method for Interfacing RAMS and SPRAY ***Trini Castelli and Anfossi, 1997, Trini Castelli, 2000***

SPRAY

Lagrangian particle dispersion model (***Brusasca et al., 1989, Anfossi et al., 1998, Tinarelli et al, 2000, Ferrero et al. 2001)***

The modelling system setup

	grid1	grid2	grid3	grid4
Lx,Ly (km)	4272 , 3696	1452 , 1596	136,136	45,30
Dx, Dy (km)	48 , 48	12, 12	4 , 4	1 , 1
Nx,Ny,Nz,	90,78,25	122,134,35	35,35,35	46,30,35



The simulations were carried out for the year 2013 as both meteorology and emission scenario were representative of the typical conditions of the area. 2013 had also the highest number of valid data on emission and concetration data.

Speed up meteorological simulations

In order to reduce the time needed to perform the yearly simulation, the RAMS analysis fields from previous runs over Italy were acquired for the two coarse domains of 48 and 12 km resolution.

These analyses were then used as input and nudging on hourly basis for the two nested domains at 4 and 1 km resolution.

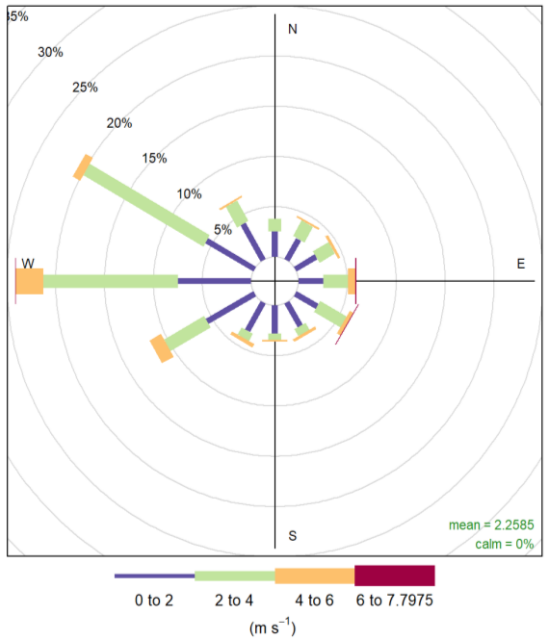
Speed up meteorological simulations

- This approach allowed reducing the simulation time to more than **one-tenth** of a full prognostic run over four nested domains. This is an important aspect when dealing with time restricions in environmental impact studies.
- The drawback is that the two-way nesting cannot work from the two finest to the two coarsest grids.
- However, based on a preliminary assessment comparing this ”nudging” approach with a full 4-grids run, it was shown that the outputs are very similar and the quality of the simulation holds.

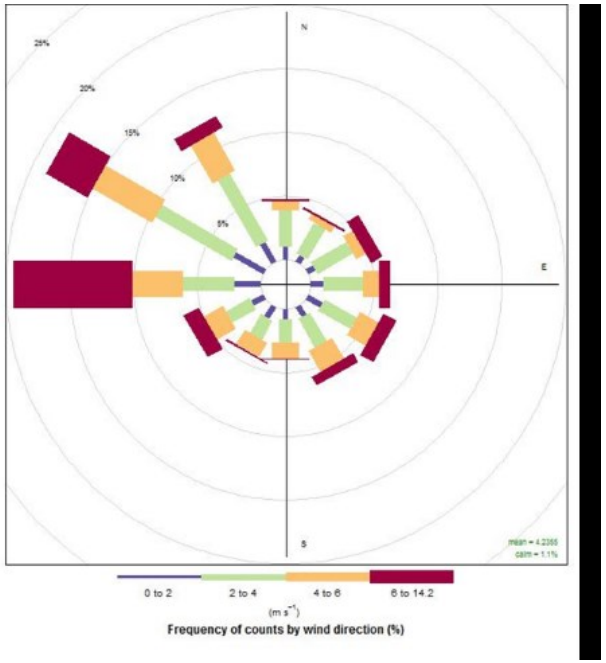
Meteorology: comparison with data

Due to some anomalies in the observed data for several months in 2013, it was not possible to make a quantitative and scientifically significant comparison between observations and predictions throughout the year 2013

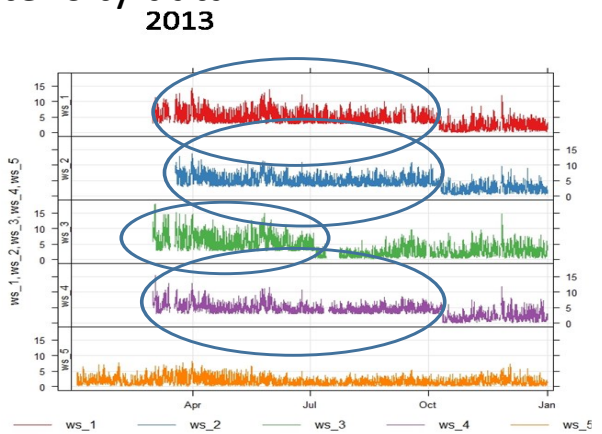
PREDICTED



MEASURED DATA*

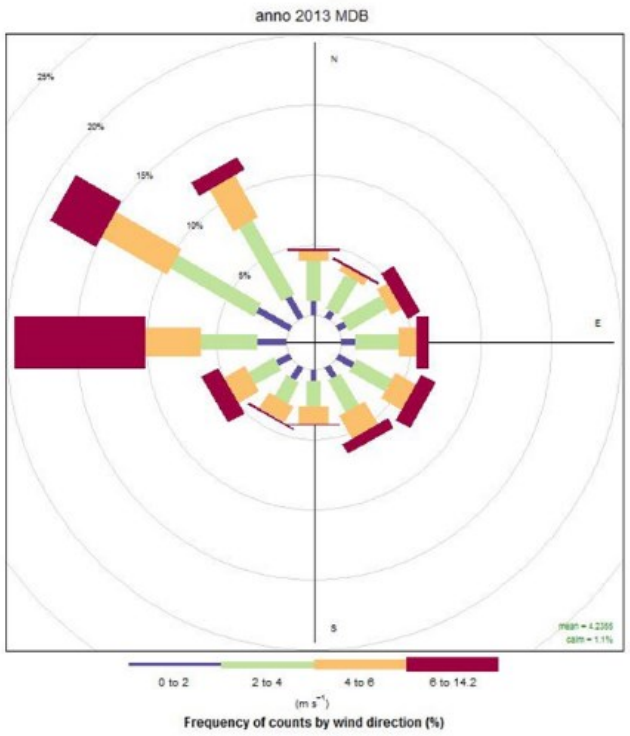


Anomalies in measured wind intensity data

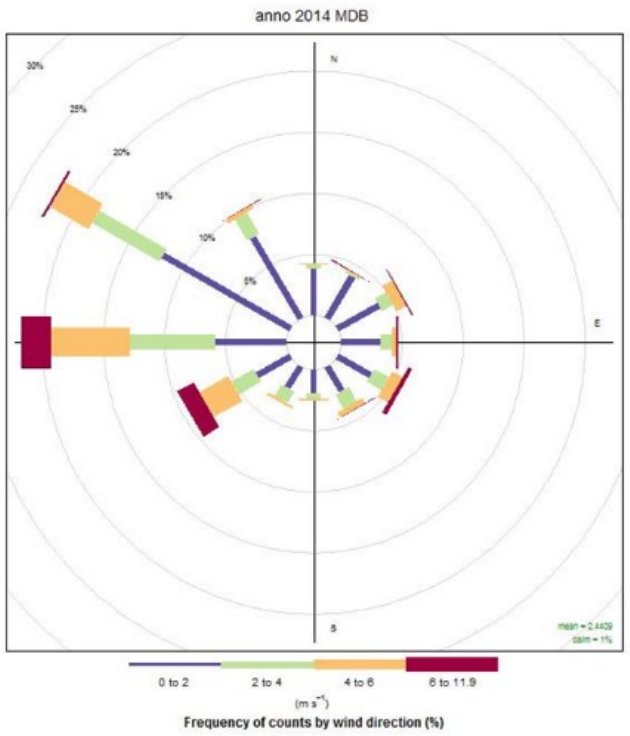


Measured wind data

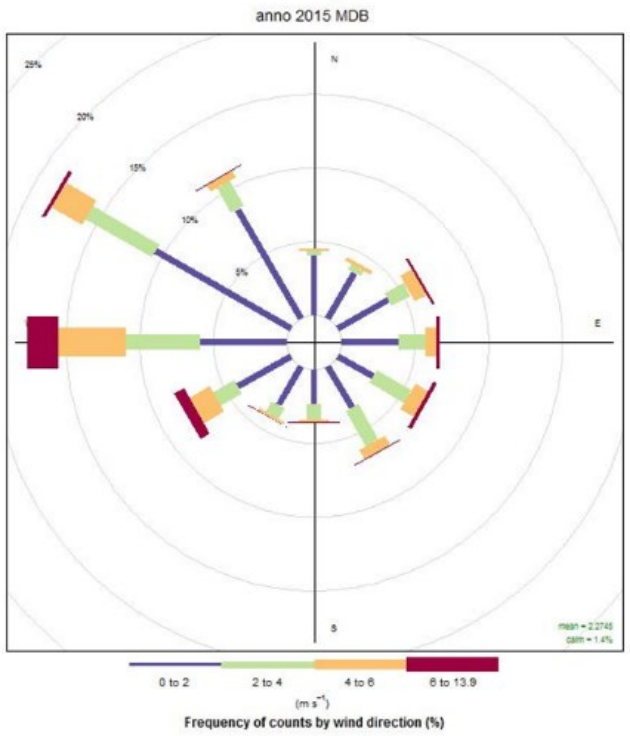
2013



2014



2015



Emissions for simulations

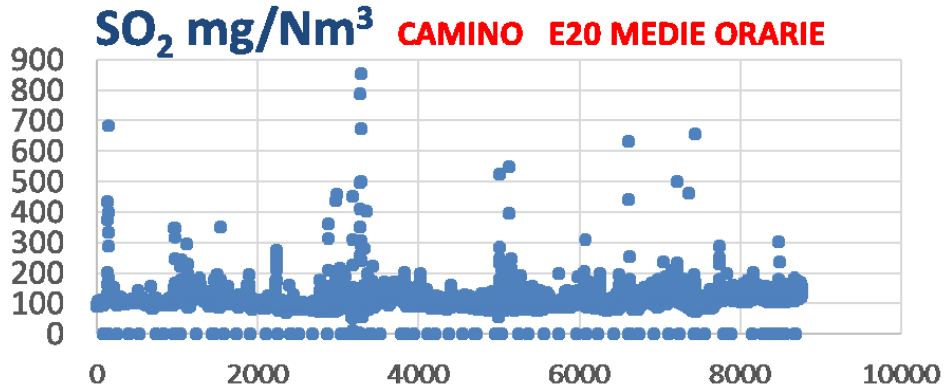
- **Atmospheric emissions**

❑ **Hourly monitored emissions of SO2, NOx, CO, due to the incineration of residues and to electric and thermic power generation (i.e. stationary combustion). Other substances were emitted but not monitored.**

❑ **flaring and venting activities : only some information are available**

❑ **Eventual fugitive emissions from oil tanks.**

Stack	X-UTM(km)	Y-UTM(km)	h(m)	d(m)	t (K)	V (ms^{-1})	SO_2(t)	NOx(t)	CO(t)
E03	576.487	4462.96	12	0.93	395	4.5		4.9	0.2
E04bis	576.537	4462.861	27.5	2.1	826	3.1	5.6	4.4	0.2
E11a			17	2	441	20.5		47.3	4.3
E11b	576.453	4462.861	17	2	447	20.5		23.5	2.6
E11c	576.431	4462.826	17	2	449	21.4		34.5	N.A.
E12b	576.381	4462.81	15	1.2	416	19.3		52.8	1.3
E12c	576.414	4462.794	15	1.2	420	16.3		44.7	1.3
E20	576.045	4463.085	33	2.5	1083	7.2	30.7	47.7	2.7

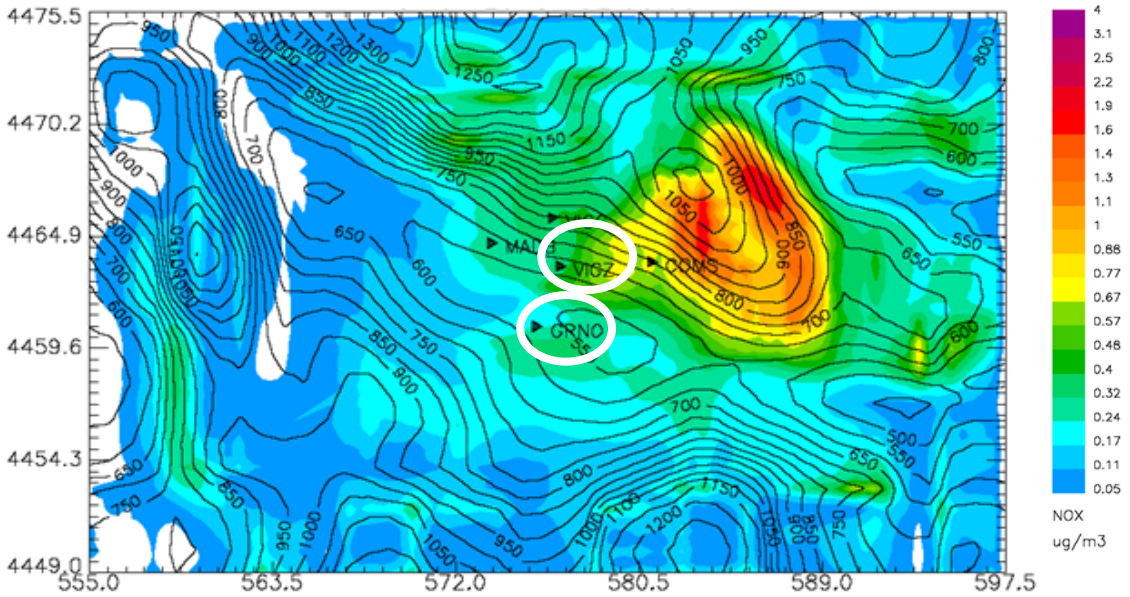


Modelling results

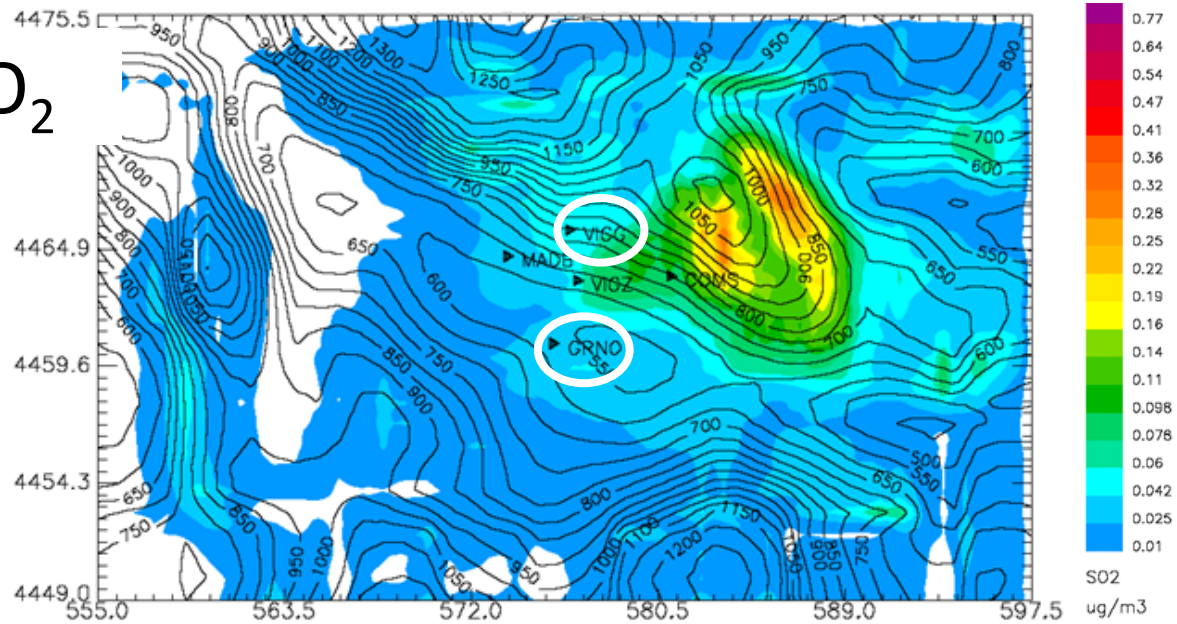
The spatial distribution of pollutants shows: a larger impact of the plant in the eastern-north-eastern sector; the two towns are differently impacted by the plant; and the highest concentration values beyond the two towns' sites.

The orography drives the distribution of pollutants at the ground, where maximum values are found on the slopes. This also is related to the height of the release points and to the additional strong plume rise, originated by the high temperature and exit velocity of the plumes.

NOx



SO_2

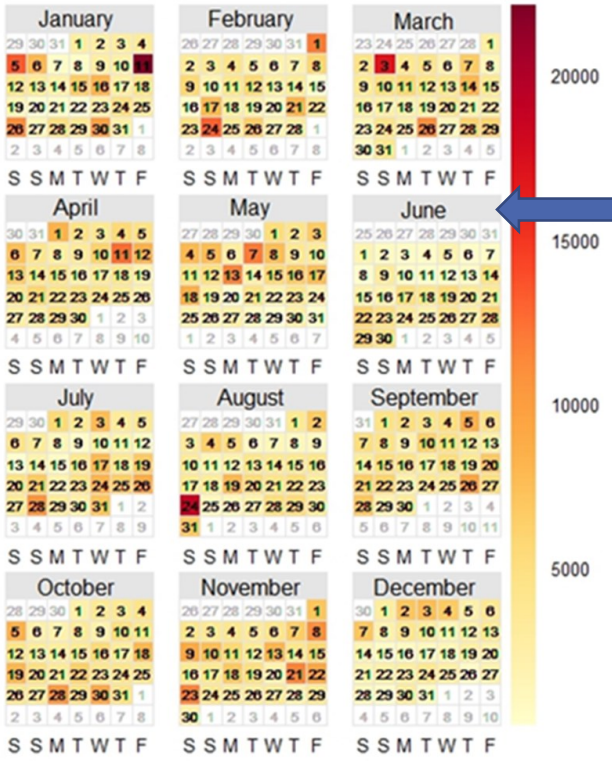


Flares emissions: how to consider their impact?

- Only flow rate data are available
- No information on gas composition
- No information on single flare stack characteristics (ground and elevated)

Flares emissions: how to consider their impact?

Daily maximum flow rate (kg/hour) from all torchs

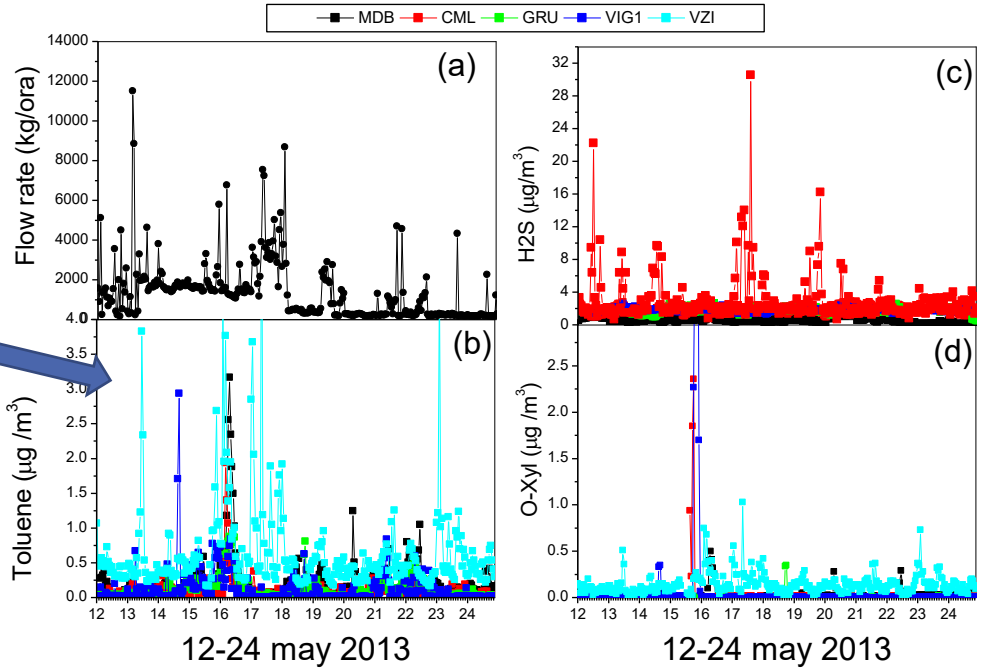


-Irregular emissions

-High ground level measued concentration data

Ground level measured concentration during a flare event

12-24 may 2013

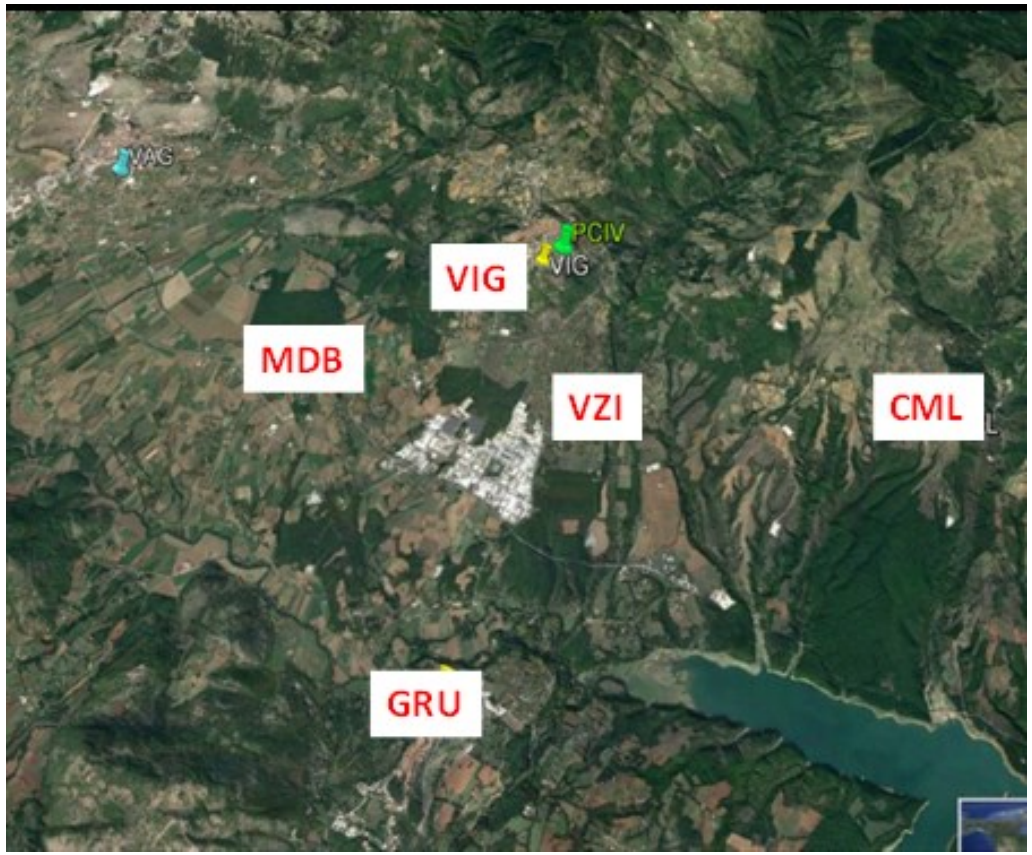


12-24 may 2013

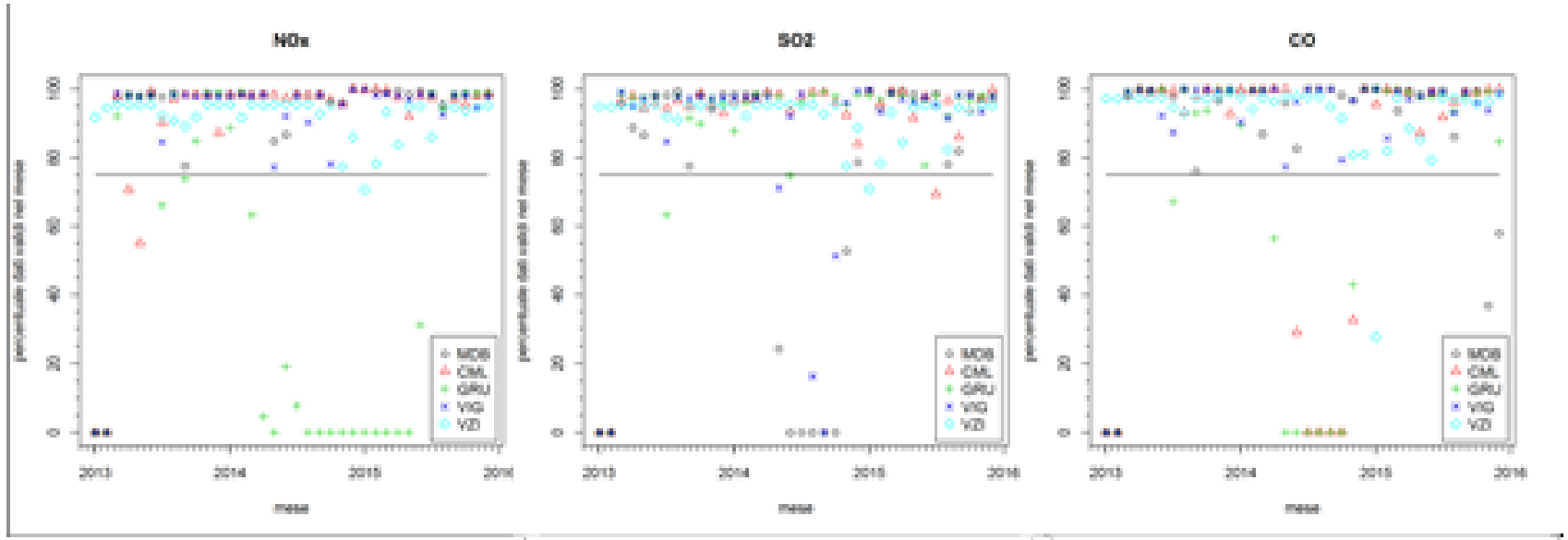
12-24 may 2013

..looking at measured concentration data

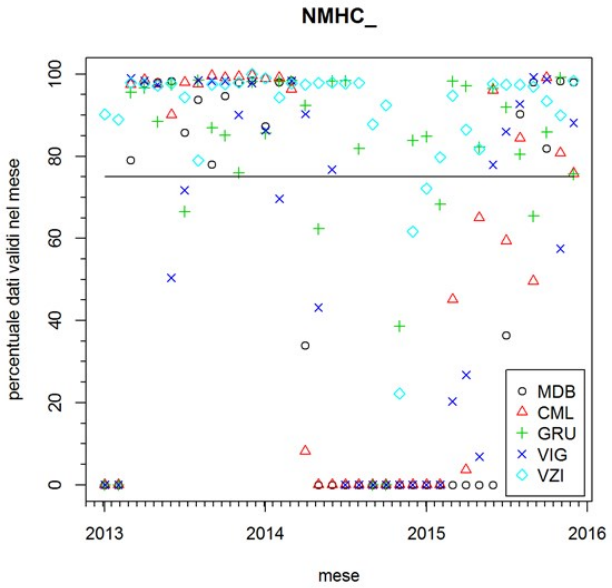
Monitoring network

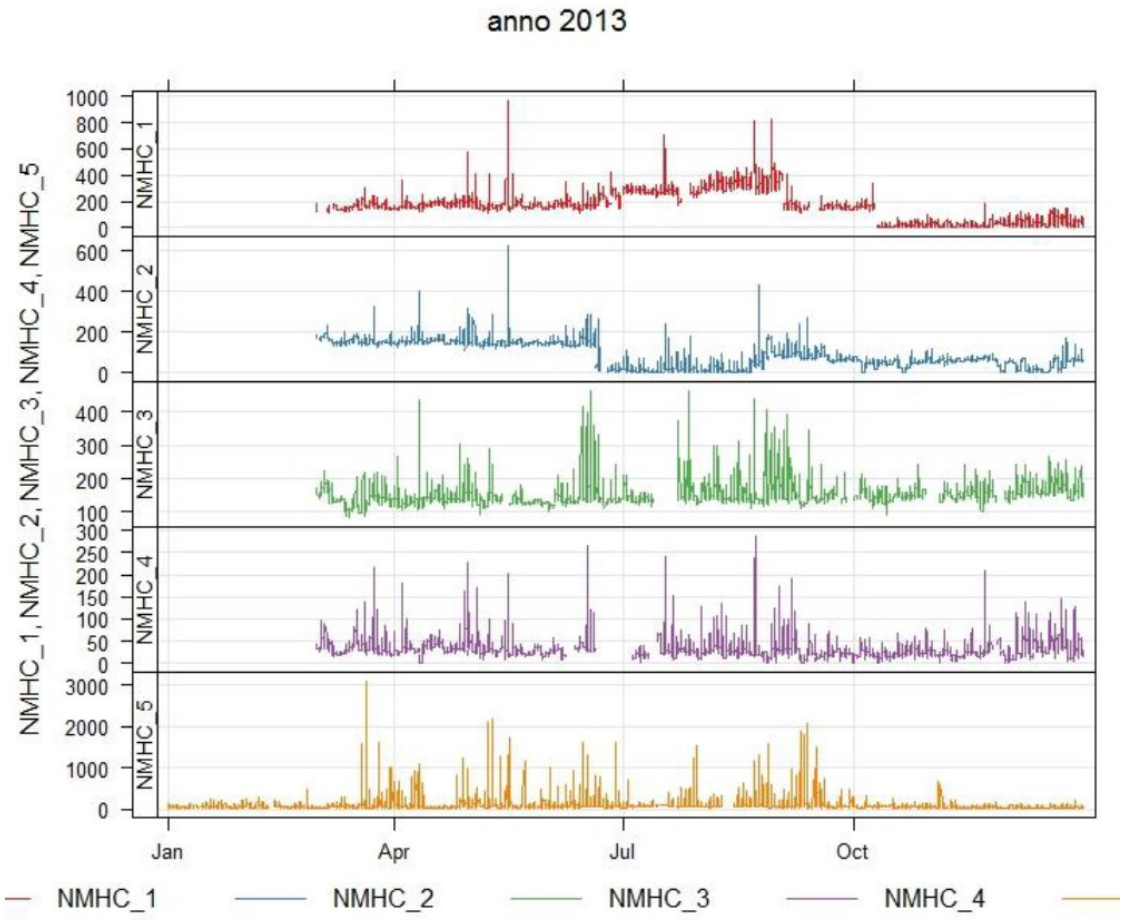


Poor quality of measured data



Poor quality of NMHC measured data

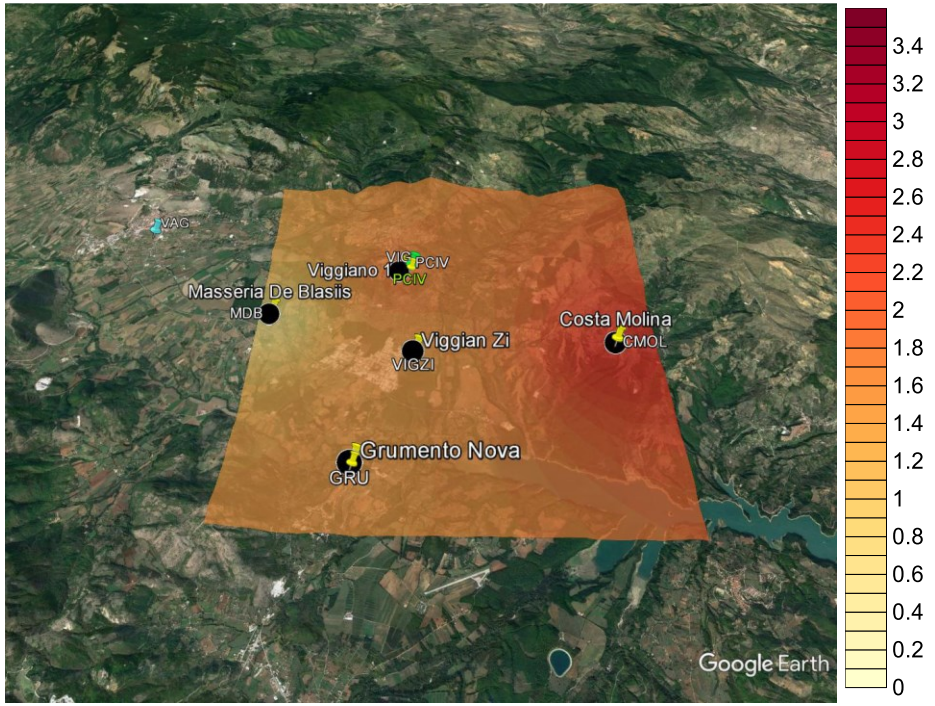




Impact of other type of emissions…

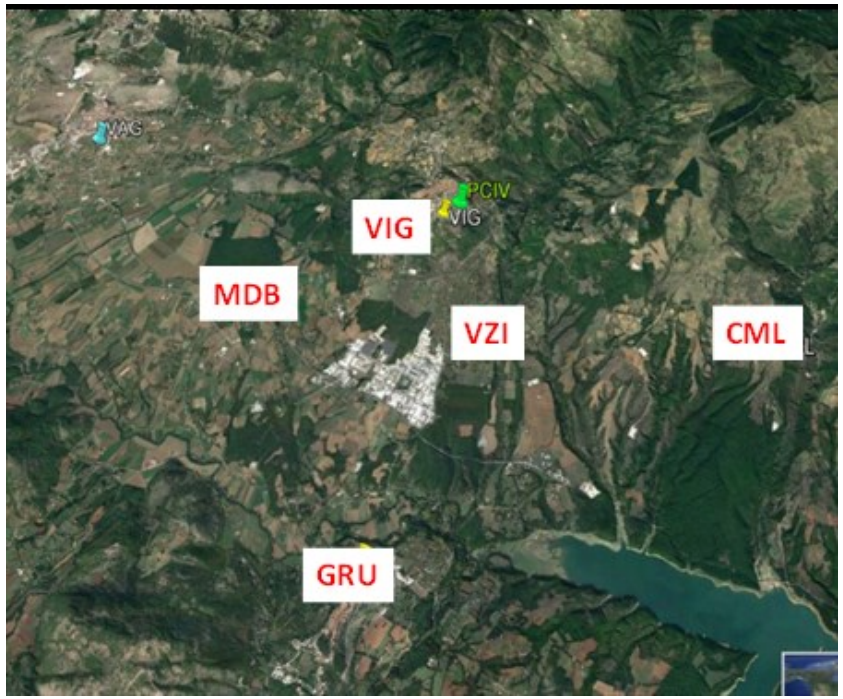
- The spatial pattern of H_2S concentrations averaged over the years 2013-2015 obtained by interpolation of data measured at the 5 monitoring stations.
- As well as for simulated concentration a spatial gradient is evident with highest values found in the eastern sector

Interpolation H2S measured data



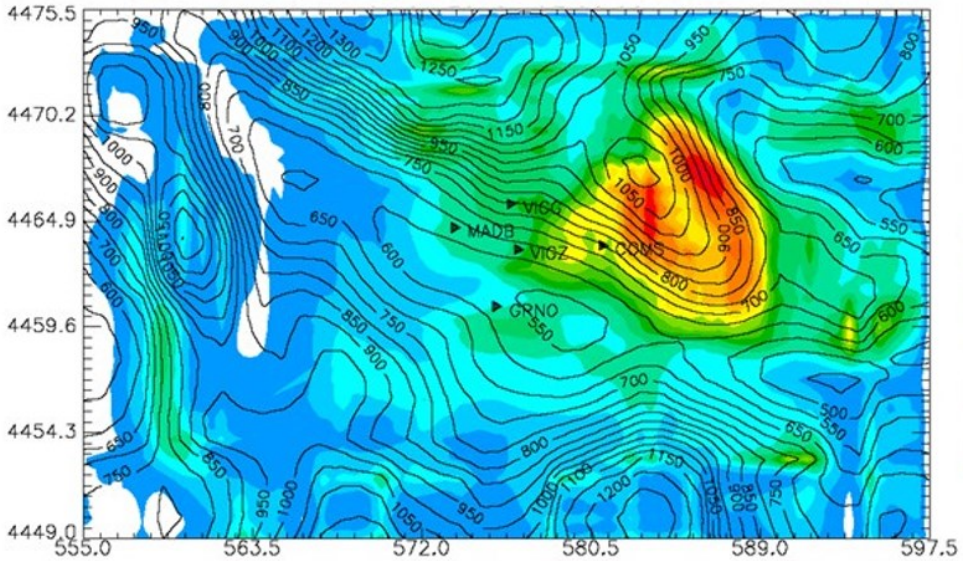
Maps correlation

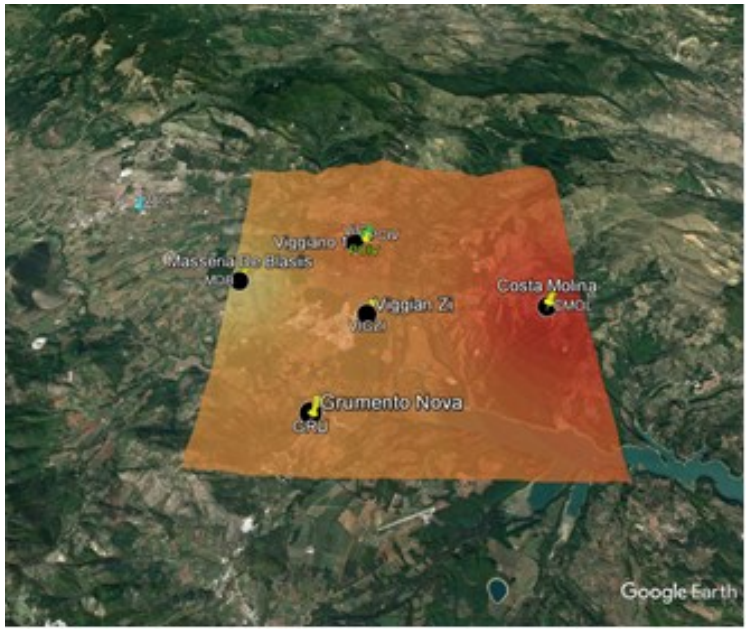
In the domain of epidemiological study the NOx predicted concentrations map and measured H2S data correlate with R2=0.65



Conclusions 1/4

- **Adequate exposure assessment of population needs modelling and measurements due to different emission types from a complex industrial plant**

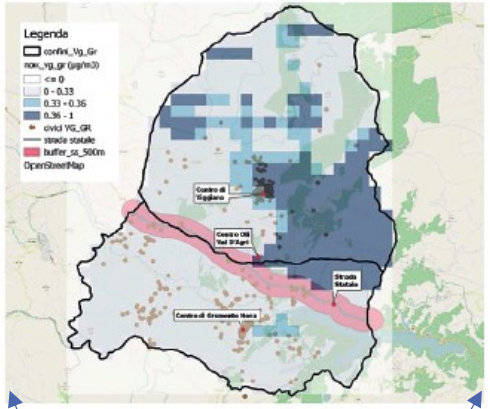




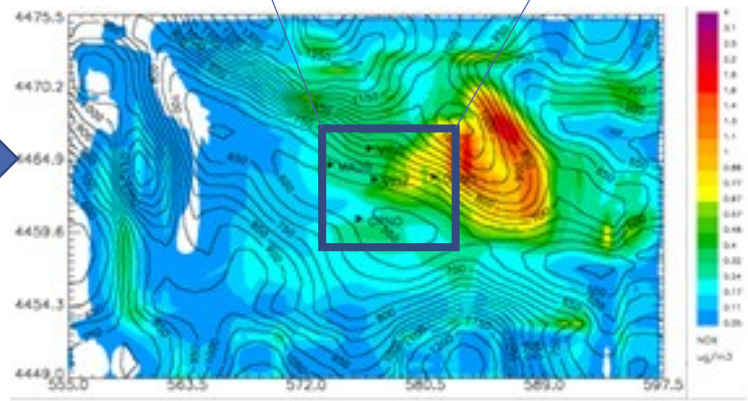
Conclusions 2/4

- **The results suggest that the releases from the plant differently affect the inhabitants of the two towns, involved in the epidemiological study**

Map of exposures categorized in terziles of predicted concentrations



- **The area impacted by the plumes is much larger than that of the 2 towns close to the plant, suggesting the need to extend the air monitoring area and to include in the health study the population living in that area.**



Conclusions 3/4

- **Meteorological simulations allowed to individuate the best performing meteo stations**

- **Furthermore, due to the complexity of the orography, the effective heights of the stacks and risk of relevant accident, model results suggest the need of a meteorological tower close to the plant for emergency reasons**

Conclusion of the epidemiological study 4/4

People living in the more exposed areas have an excess of mortality and morbidity risks.

Aknowledgements

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Conflict of interests: none