



Valutazione modellistica della dispersione in atmosfera delle emissioni relative allo smaltimento di residui agricoli e verdi

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Consiglio Nazionale delle Ricerche





- Contesto della collaborazione nel LCA WG in DISMI
- Inte(g)razione modelli di dispersione LCA
- Caso di studio
- Considerazioni finali



Media centre

WHO releases country estimates on air pollution exposure and health impact

New interactive maps highlight areas within countries that exceed WHO air quality limits

News release

27 SEPTEMBER 2016 | GENEVA - A new WHO air quality model confirms that 92% of the world's population lives in places where air quality levels exceed WHO limits*. Information is presented via interactive maps, highlighting areas within countries that exceed WHO limits.

THE INVISIBLE KILLER

Air pollution may not always be visible, but it can be deadly.



36%
OF DEATHS FROM
LUNG CANCER



34%
OF DEATHS FROM
STROKE



27%
OF DEATHS FROM
HEART DISEASE

BREATHE LIFE.
Clean Air. Healthy Future.



IL 92% DELLA POPOLAZIONE MONDIALE VIVE IN LUOGHI OVE I LIVELLI DI QUALITA' DELL'ARIA SUPERANO I LIMITI INDICATI DALL'OMS



IL 92% DELLA POPOLAZIONE MONDIALE VIVE IN LUOGHI OVE I LIVELLI DI QUALITA' DELL'ARIA **SUPERANO** I LIMITI INDICATI DALL'OMS

PM₁₀: 20 µg/m³

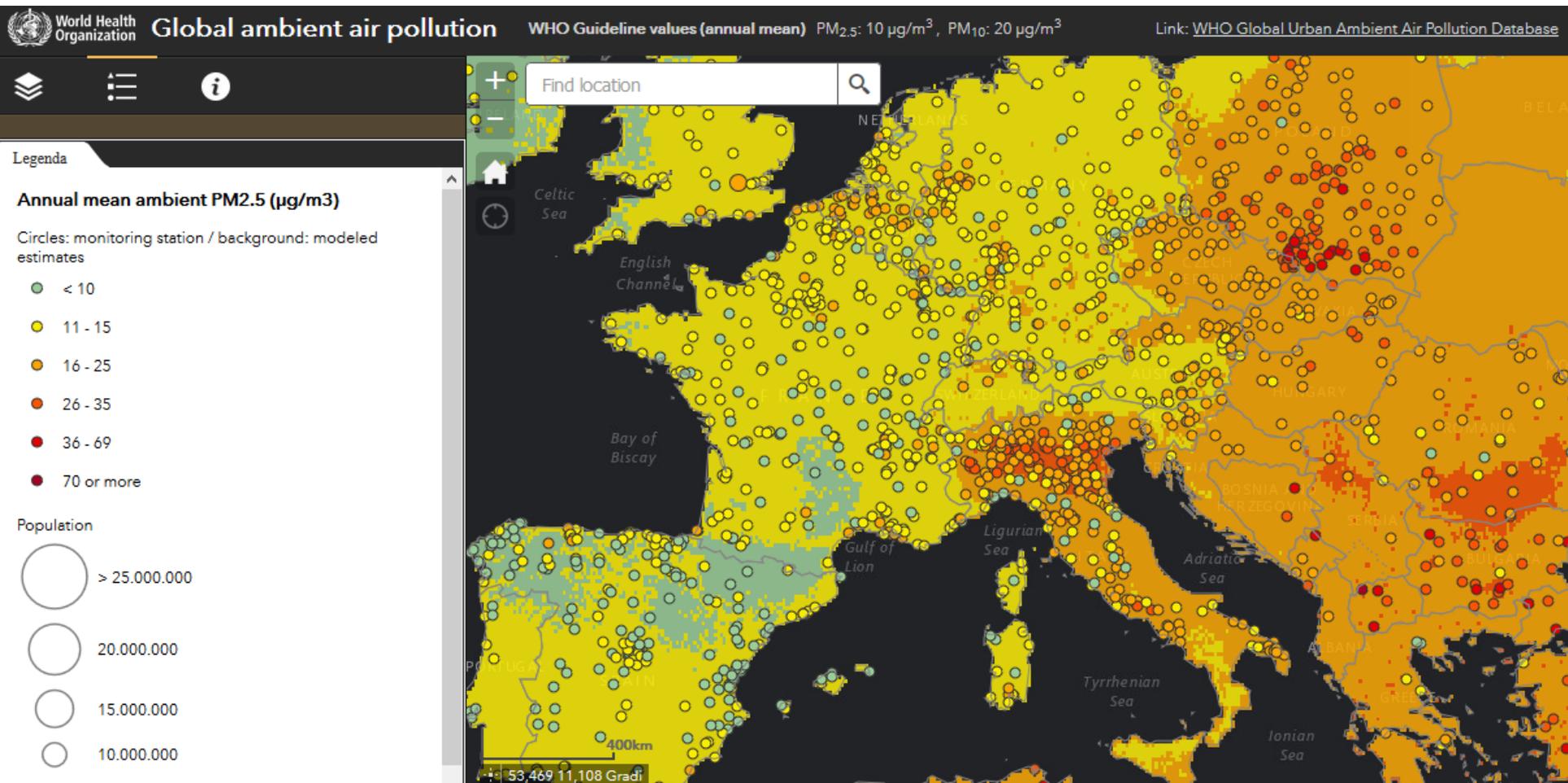
PM_{2.5}: 10 µg/m³

MEDIA ANNUA

	B	D	E	F	G	H	I	J	K	L	M
1	City/Town means										
2	PM10						PM2.5				
3	Regio	Country	City/Town	Annual mean, ug/m3	Year	Number and type of monitoring stations (PM10)	note on converted PM10	Annual mean, ug/m3	Year	Number and type of monitoring stations (PM2.5)	note on converted PM2.5
1563	Eur HI	Italy	MODENA	29	2013	2 stations, traffic	measured data	18	2013	1 station, traffic,	measured data
1583	Eur HI	Italy	PARMA	34	2013	2 stations, backgr	measured data	18	2013	1 station, backgr	measured data
1604	Eur HI	Italy	REGGIO NELL'EMILIA	31	2013	2 stations, traffic	measured data	19	2013	1 station, traffic,	measured data
1629	Eur HI	Italy	SASSUOLO	26	2013	1 station, backgr	measured data	17	2013	-	converted from P
1667	Eur HI	Italy	VILLA MINOZZO	8	2013	1 station, backgr	measured data	5	2013	-	converted from P



Notizia fresca



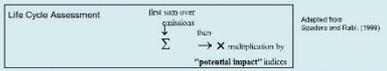


Ambito di ricerca

Local emissions, local impacts: how LCA may evolve to include local detailed damage estimates

Introduction

LCA investigates the life cycle to detect any relevant process and related emission that may impact ecosystems and human health. Weakness: first by summing the emissions over all stages and then multiplying the result by site independent impact indices, spatial and temporal details at the local scale are overlooked.

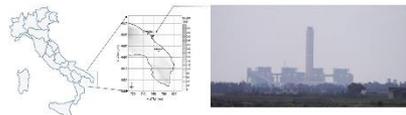


Modeling of pollutants spatio-temporal fate in the actual environment and human populated areas becomes crucial. Dispersion models (in air, but also in soil and water) are required at each stage of investigated processes at which emissions are known and outstanding.

Steps of impact pathway analysis	Emission	Dispersion	Exposure-response function	Economic valuation
Stage of fuel chain				
Fuel collection				
Fuel transport				
Fuel plant			Adapted from Spadaro and Fusi, (1999) for local and remote (2002)	
Transmission of electricity			EXTERNE estimates of energy system	
Management of waste				

Comparison between exposure obtained with two model systems: EcoSenseWeb and Calmet/Calpuff

The coal-fired power plant
4 x 660 MW groups. Emissions (year 2006): 10,175 t/y SO₂, 9,282 t/y NO_x and 730 t/y primary PM.
Stack height 200 m, stack diameter 4 x 6.8 m, flue gas velocity 20 m/s, temperature 358 K, flow rate 4 x 2,400,000 Nm³/h.



Local Orography, Meteorology and Population

Flat, with small hills (<200 up to 500 m). Area dominated by a north-westerly synoptic wind (> 50% of total wind events). During weak synoptic conditions (< 20% of total wind events), the region may be influenced by complex sea-land breeze systems caused by the diurnal heating cycle. The local area comprises two towns of small size (Brindisi and Lecco) and 120 municipalities. Total population: 1,198,311 individuals. Epidemiological studies have revealed critical situations in terms of high values for mortality and morbidity rates, consistent with environmental and occupational exposure to pollutants. The area comprises industrial facilities such as a steel factory, two more power plants, a petrochemical plant and incinerators.

Modelling systems

EcoSenseWeb, by UNI-Stuttgart, web-based model. Local range analysis runs on the Industrial Source Complex Model (ISC), a Gaussian plume model developed by the US-EPA. The ISC is used for transport modelling of primary air pollutants on a local scale (100 x 100 km² around the source site), at 50 x 50 km² grid space. The user has only to provide longitude and latitude coordinates. The tool used to derive local meteorological data was developed within NEEDS.

Calmet/Calpuff, by Scire et al (2000) is a Lagrangian non-steady state puff model that allows for the handling of three-dimensional winds. It can treat calm wind conditions. It has been applied in a number of power plant exposure studies (Lopez et al. 2005) and in the investigated area (Mangia et al. 2014). Here a 105 km x 135 km² modelling domain with a resolution of 1.5 km x 1.5 km² has been considered.

Yearly averaged fields of primary and secondary PM₁₀ concentration values have been computed with the two models.

References

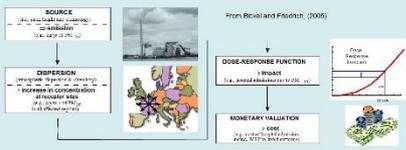
Dieke, P and Friedrich, R. (2005). Externalities of Energy. Methodology Update, 2005. Office for Official Publications of the European Communities. Luxembourg.
WVC International Agency for Research on Cancer (2013). <http://dx.doi.org/10.1182/ncicmonographs221.pdf> (accessed 04/2/13).
Lopez, M. T., Zua, M., Carbal, V., Tardón, O., Iñesta, R., & Fernandez, A. (2005). Health impacts from power plant emissions in Mexico. *Atmospheric Environment*, 39(7), 1191-1200.
Mangia, C., Cosentino, M., and Chiaravito, R.A. (2014). Dispersion models and air quality data for population exposure assessment to air pollution in 22 Italian Power Plants. *Atmospheric Pollution*, 84(2), 119-127.
Neri, J., Rinaldi, D. S., Vianello, R. (2000). A user's guide for the Calpuff-Dispersion Model. Earth Tech, Inc., Concord, MA.
Spadaro, J.V and A. Fusi (1999). Estimates of real damage from air pollution: site dependence and simple impact indices for LCA. *International J. of Life Cycle Assessment*, vol. 4, n. 1, 25-30.



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IPA (Impact Pathway Analysis) developed under the EXTERNE project aimed to track the fate of a pollutant from where it is emitted to the affected receptors (population, crops, forests, buildings, etc.)

Some elements of EXTERNE and following projects might require an update, like the local area dispersion modeling system.

Objective

Detailed space-time exposure fields to estimate actual damage response may be improved by using state-of-the-art dispersion modeling system.

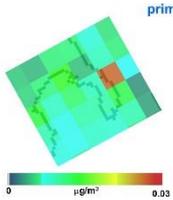
Example for a sizeable local emitter activity, one of the biggest European coal-fired power plant located in Apulia, Italy.

Results

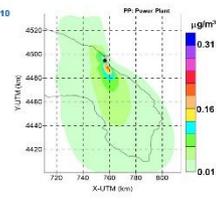
Differences between model results in both impacted area extent and concentration values.

EcoSenseWeb

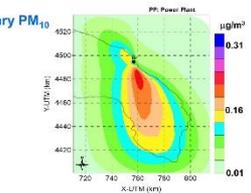
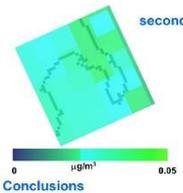
Primary PM₁₀, keeping in mind the different spatial resolution of the two model, the impacted area extent are comparable, close the emission source. EcoSenseWeb showed a lower maximum concentration value.



Calmet/Calpuff



Secondary PM₁₀: EcoSenseWeb showed concentration values < 0.05 over the entire local area. Besides showing higher concentration values (the all continental and populated area showed concentration values < 0.1 µg/m³), Calmet/Calpuff generated a different spatial pattern, with a local maximum concentration near the source and a rate of reduction by half in 60 km in the direction N-S, that is the prevalent wind direction.



Conclusions

Sizeable emissions of fine primary PM and gaseous precursors of secondary PM requires state-of-the-art models to compute the fate of pollution.

This is also becoming clear in LCA thinking, whereas accuracy as best as achievable is needed in estimating human health damages. It is the case for atmospheric PM that is already known to increase risks for a wide range of diseases, such as respiratory and heart diseases, as well as cancer (IARC, 2013). In this work a better accuracy has been achieved especially for secondary PM evaluation. This allows for a more precise pinpointing the most exposed population. Atmospheric PM formation is not so far from the source and as diluted as one would think. Such a computation will be used to estimate the impact of primary and secondary PM on adverse health outcomes, by using adequate concentration-response functions.

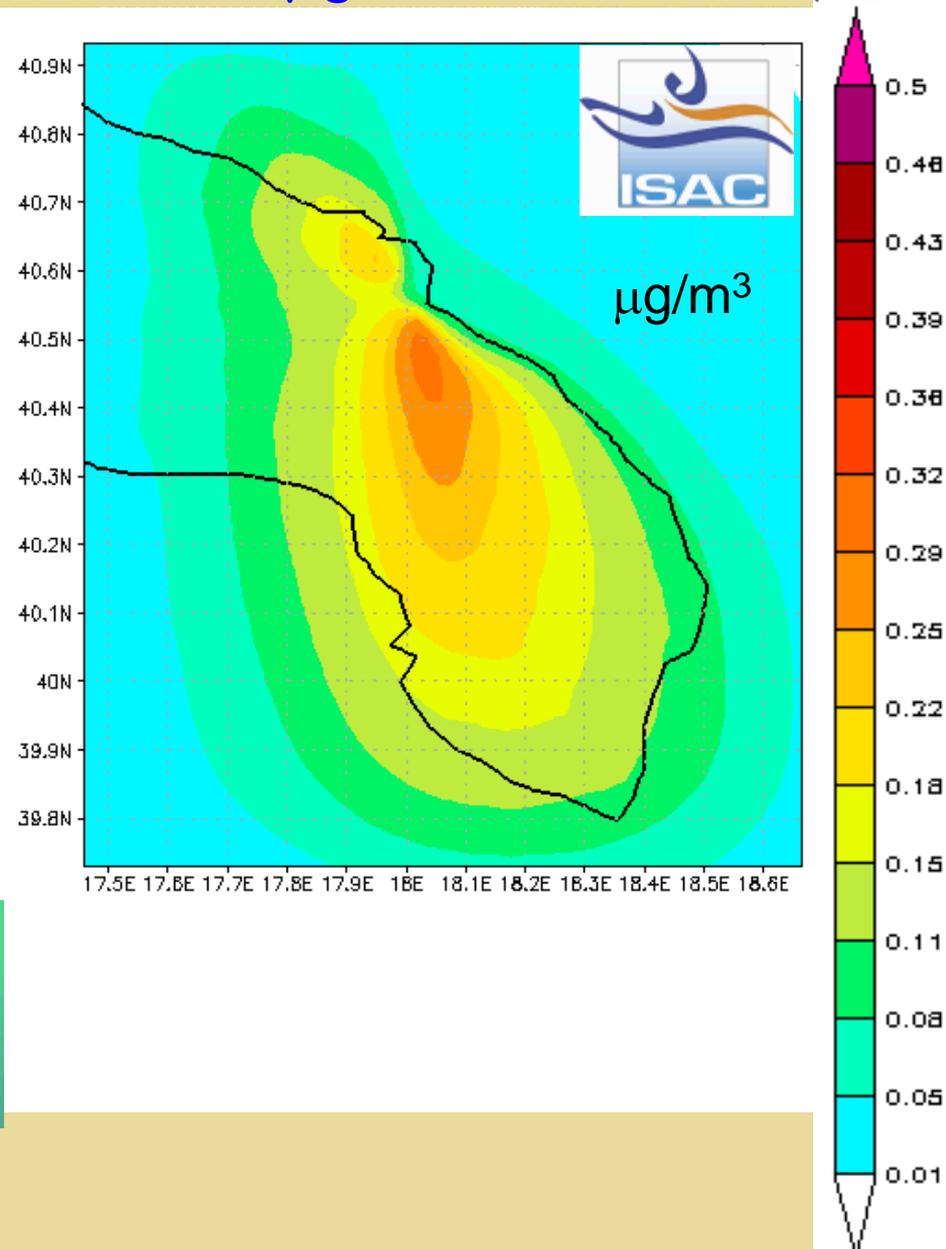
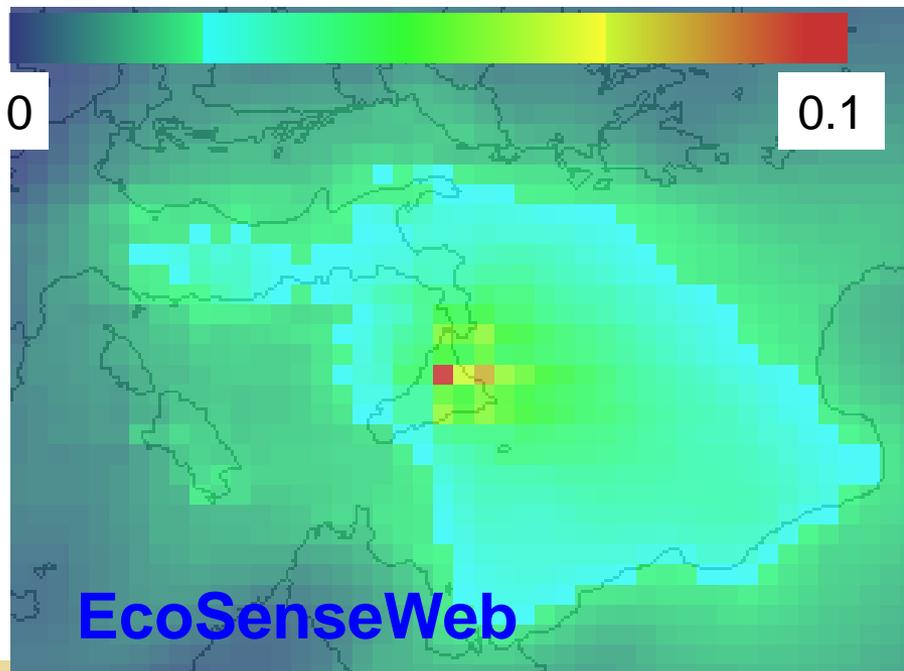
Cervino M., Ferrari A.M., Neri P., Pini M., Mangia C.

Local emissions, local impacts: how LCA may evolve to include local detailed damage estimates

SETAC Europe 25^o Annual Meeting 3-7 Maggio 2015, Barcellona.

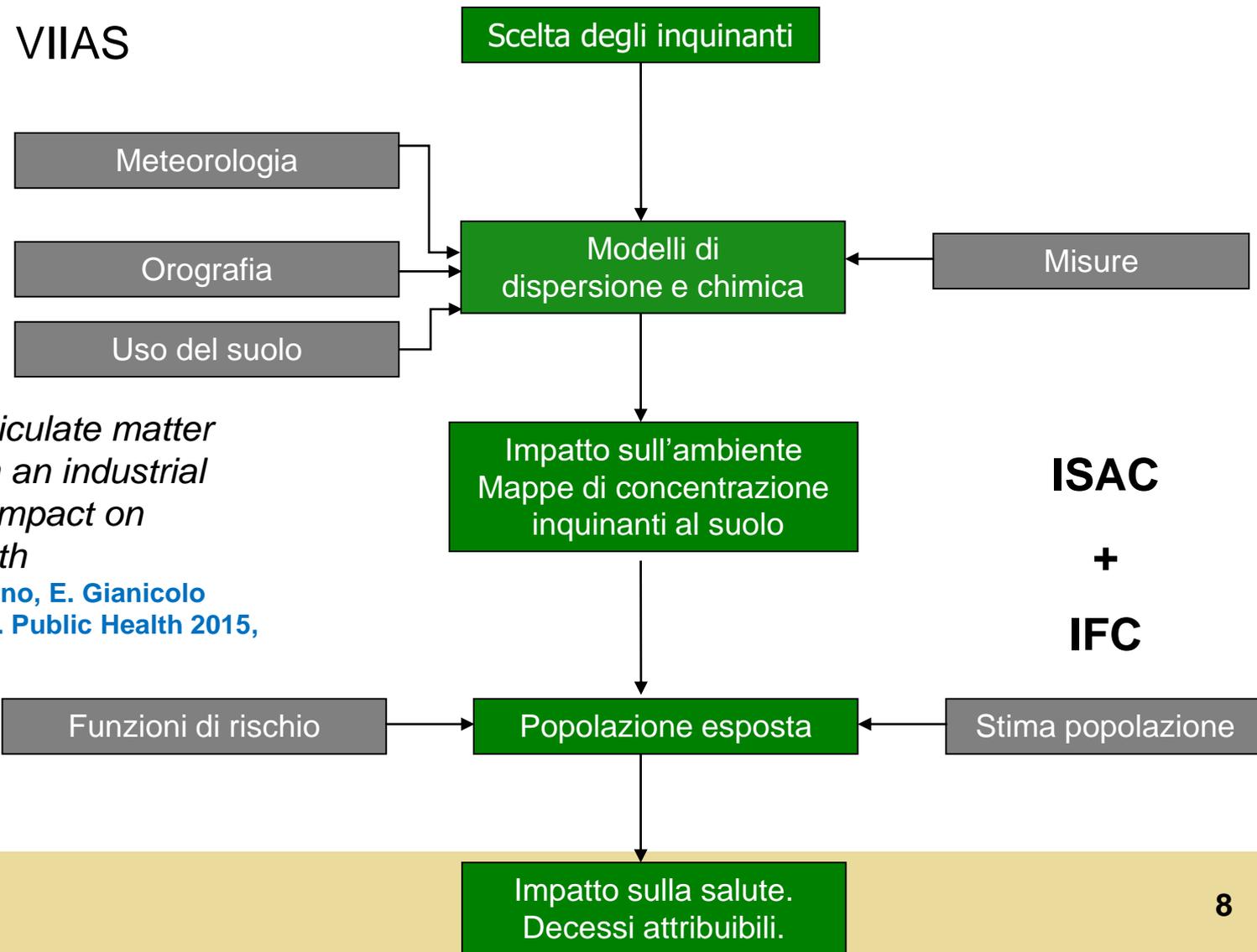


Brindisi: CTE a carbone 2640 MW_e contributo PM₁₀ **secondario** μg/m³





METODO: VIAS



Secondary particulate matter originating from an industrial source and its impact on population health

C. Mangia, M. Cervino, E. Gianicolo
 Int. J. Environ. Res. Public Health 2015,
 12(7), 7667-7681

ISAC
 +
IFC



Risultati: Numero stimato di decessi attribuibili alla centrale (con intervallo di confidenza)



L'area di studio

105 x 135 km²

120 comuni

1,2 milioni di individui

10,000 decessi

Table 4. Estimated number of non-accidental deaths and 95% confidence interval (95% CI) associated with different scenario of modelled exposure to primary and secondary particulate matter (PM_{2.5}) emitted by the coal power plant located in Brindisi (Italy). Year 2006.

Scenario	Absolute number of cases	95% CI		Number of cases per 100,000 inhabitants	95% CI	
		Lower	Upper		Lower	Upper
Primary PM _{2.5}	4	1	7	0.4	0.1	0.6
Secondary and primary PM _{2.5} – run A1	26	9	41	2.2	0.7	3.4
Secondary and primary PM ^{2.5} – run B1	20	7	31	1.7	0.6	2.6
Secondary and primary PM _{2.5} – run C1	19	6	30	1.6	0.5	2.5
Secondary and primary PM _{2.5} – run A2	28	10	44	2.4	0.8	3.7
Secondary and primary PM _{2.5} – run B2	23	8	37	2.0	0.7	3.1
Secondary and primary PM _{2.5} – run C2	21	7	33	1.8	0.6	2.8



Inte(g)razione modelli dispersivi \leftrightarrow LCA



Emissioni outdoor

modelli dispersivi (VIAS)

massa/tempo

$$AC = \frac{(RR - 1) / 5}{\left[1 + \frac{(RR - 1)}{5} \cdot E_{pm} \right]} \cdot \sum_{i=1}^{120} N_i \cdot X_i$$

AC Casi Attribuibili
RR Rischio Relativo
 E_{pm} Conc. Media ambiente
 N_i Casi nell'area i-esima
 X_i Concentrazione *causata*
nell'area i-esima

LCA EI99 (RA)

massa

Casi = I * massa
= (UR * PopD * FF) * massa

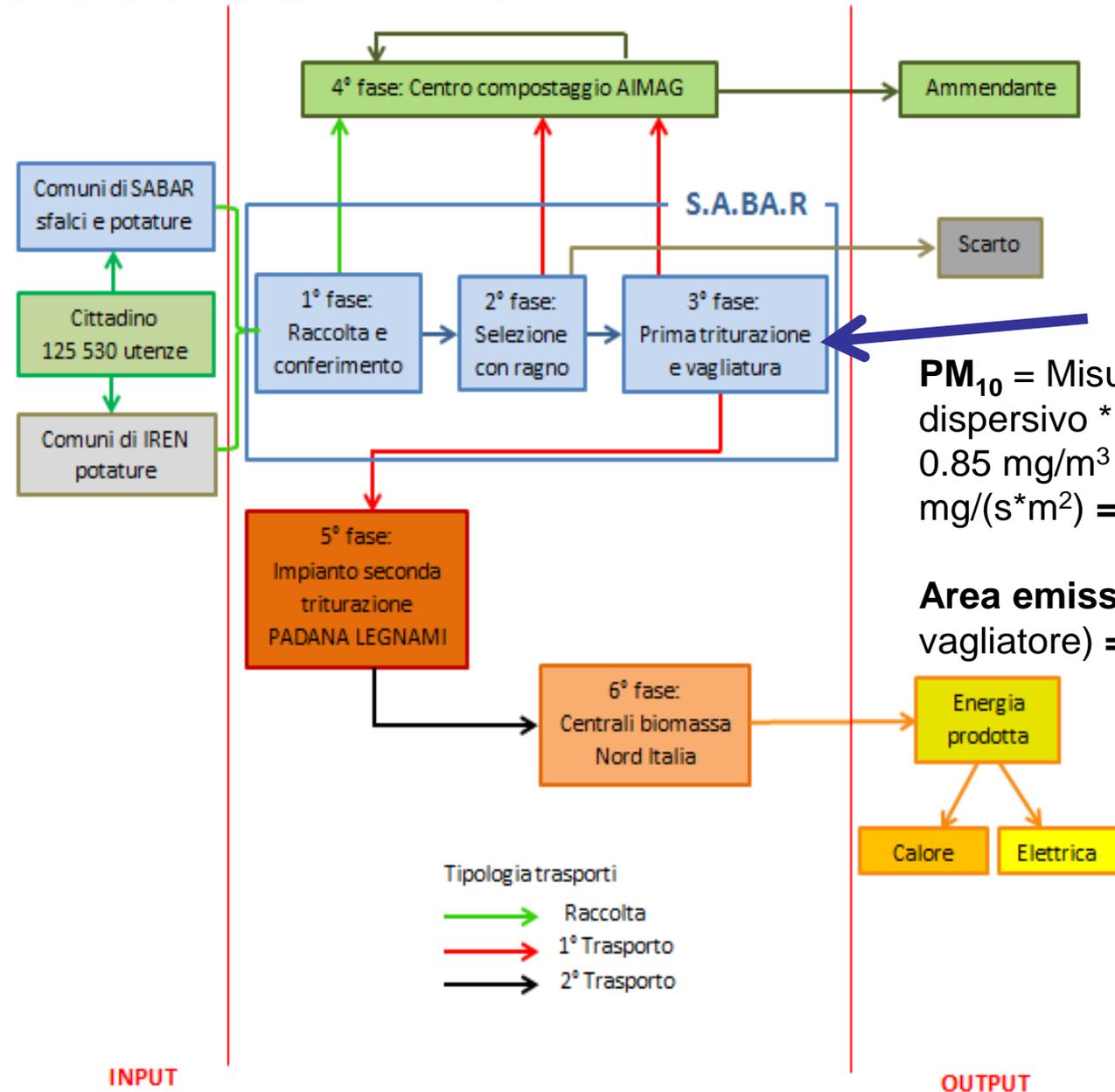
I Incidence

UR Unit Risk

PopD Population Density
FF Fate Factor



A) Emissioni locali diffuse



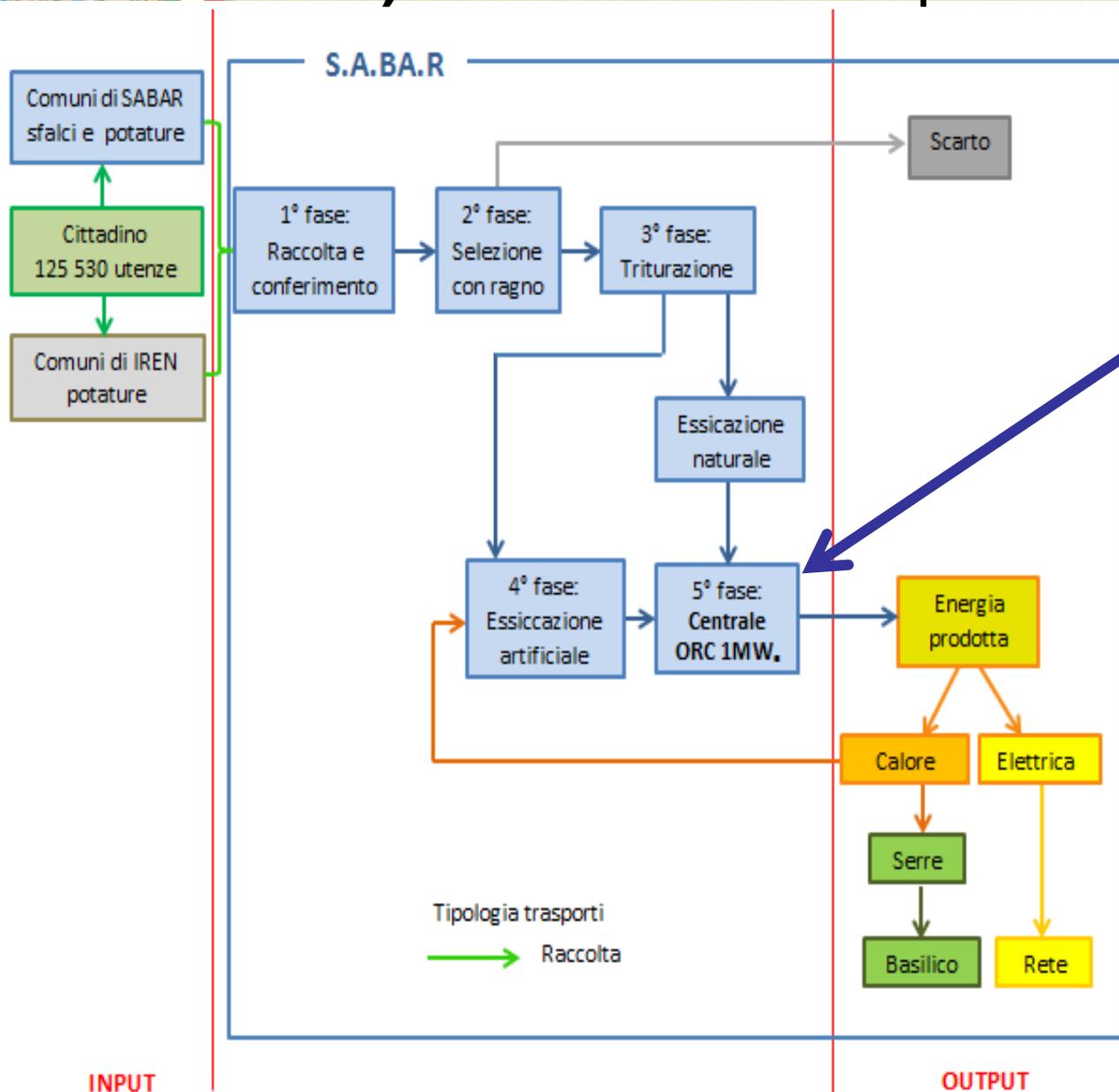
Emissioni locali «stato attuale»:
Polveri durante la triturazione e vagliatura

$$PM_{10} = \text{Misura in ambiente} * \text{fattore dispersivo} * \text{fattore taglio da polveri totali} = 0.85 \text{ mg/m}^3 * 1.667 \text{ m}^3/\text{s} * 0.529 = 0.75 \text{ mg}/(\text{s} * \text{m}^2) = \mathbf{0.75 \cdot 10^{-3} \text{ g}/(\text{s} * \text{m}^2)}$$

Area emissiva totale (prima triturazione+ vagliatore) = **11 m²**



B) Emissione locali puntuale



B) Emissioni locali «stato futuro»:
Polveri al camino
Centrale ORC

PM₁₀ = (by assumption)
PTS = 30 mg/Nm³ =
0.15 g/s



- Scelto dall'EPA per una **discriminazione rapida**, e **cautelativa**, degli impatti di una emissione locale.
- Valido per **emissioni puntuali** (camini) e **areali** (diffusive, senza captazione)
- Sostanzialmente **gaussiano** (no particolato secondario)
- Fornisce **medie orarie massime** in **condizioni meteo** determinate, oppure generiche (sconosciute)
- Può fornire **medie annue massime** (esposizione LT)

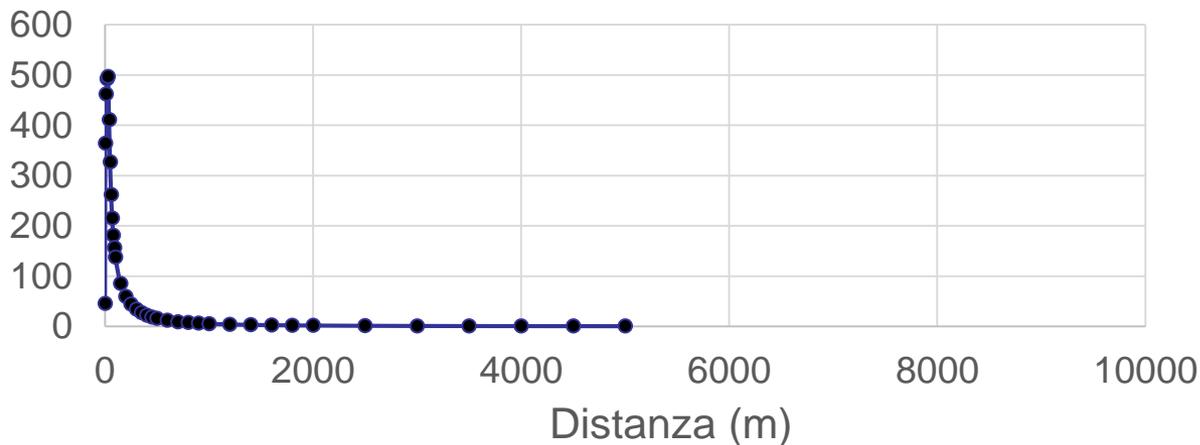


Risultato SCREEN3

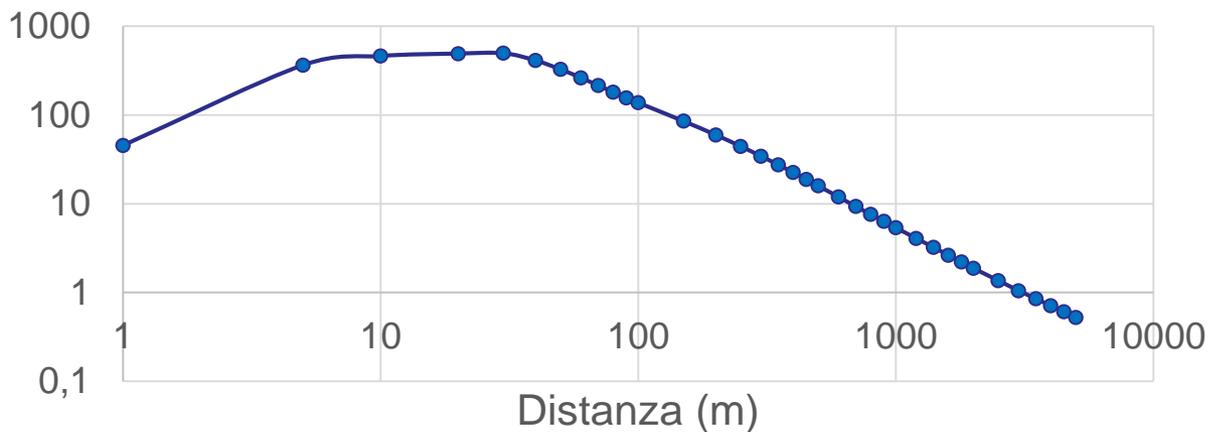
A) emissioni diffuse



PM₁₀ in aria a 2m, ($\mu\text{g}/\text{m}^3$)



PM₁₀ in aria a 2m, ($\mu\text{g}/\text{m}^3$)





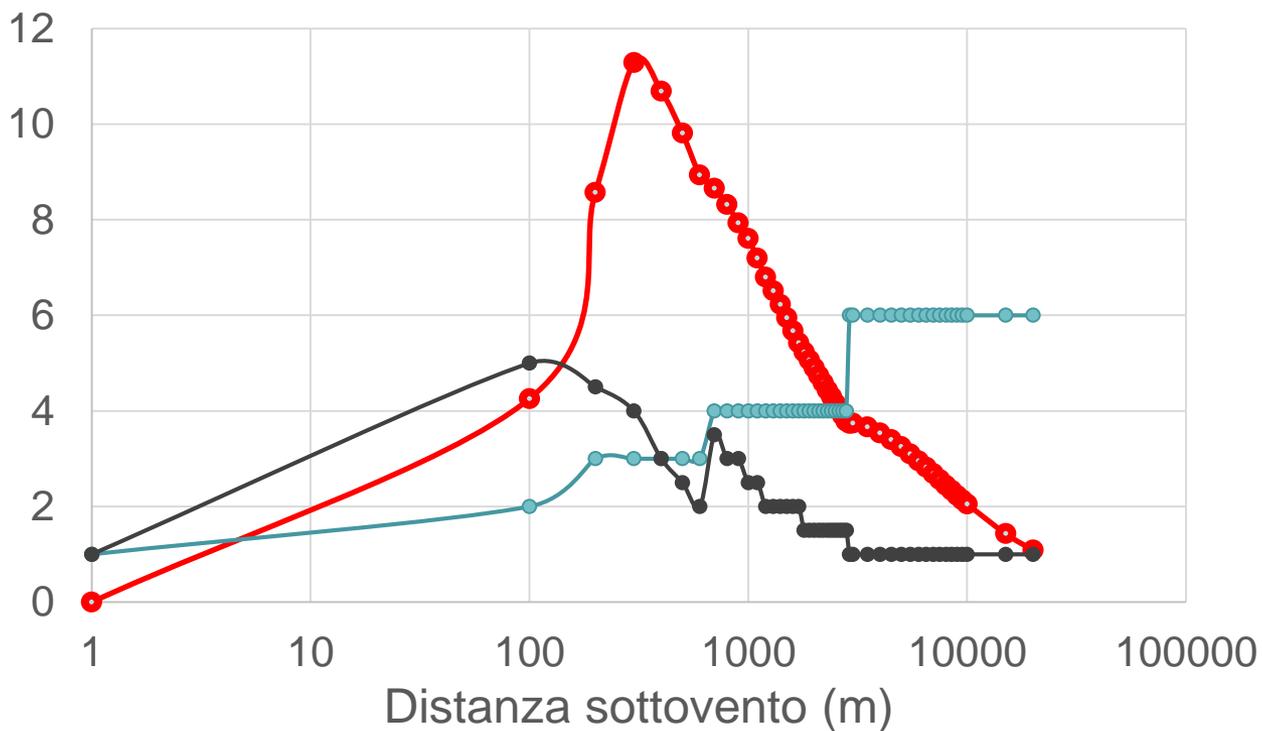
Risultato SCREEN3

B) emissioni al camino

—●— **PM₁₀ in aria, livello suolo (μg/m³)**

—●— classe stabilità

—●— velocità vento (m/s)





- SCREEN3 si mostra utile nel caso in esame, ma non si può generalizzare (no per centrale a carbone, ad es.)
- Serve una meteorologia dettagliata (classi di stabilità; direzione e intensità vento) ?
- Serve una demografia dettagliata (basta il valor medio ... su che area?)
- Serve una geografia dettagliata ?



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Grazie per l'attenzione

