MACRO TRACER MODEL AS A TECHNIQUE FOR SOURCE APPORTIONMENT OF PARTICULATE MATTER IN KRAKOW AGGLOMERATION – AN OPTIMIZATION APPROACH

Katarzyna Szramowiat-Sala[1], Katarzyna Styszko[1], Magdalena Kistler[2], Anne Kasper-Giebl[2], Janusz Gołaś[1]

[1]AGH University of Science and Technology, Al. Mickiewicza 30, 30-059 Krakow, Poland
[2]TU Wien, Institute of Chemical Technologies and Analytics, Vienna Austria

24th ETH-Conference on Combustion Generated Nanoparticles
22-24 June 2021

ATMOSPHERIC AEROSOLS

→Dispersion of liquid or solid particles suspended in the air

→PM is present both in the troposphere and the stratosphere; the particles vary in size and chemical composition

→PM has an impact on the global climate, ecosystems and human health as well

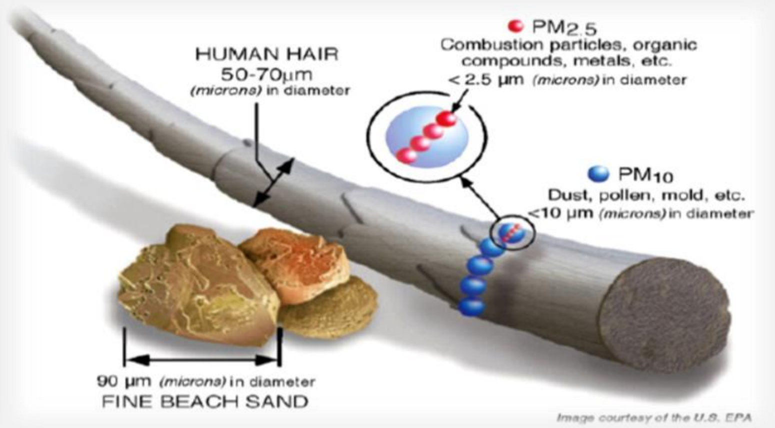


Fig. 1. Comparison of particles $PM_{2,5}$ and PM_{10} sizes to the size of the hair or sand.

PM classification due to the aerodynamic diameter (AD) size:

- ✓ $PM_{2,5}$ – with AD ≤ 2,5 um;
- ✓ PM_{10} – with AD ≤ 10 um;
- ✓ TSP (Total Suspended Particles) – all aerosols, even with AD larger than 10 um.

EMISSION SOURCES OF ATMOSPHERIC AEROSOLS

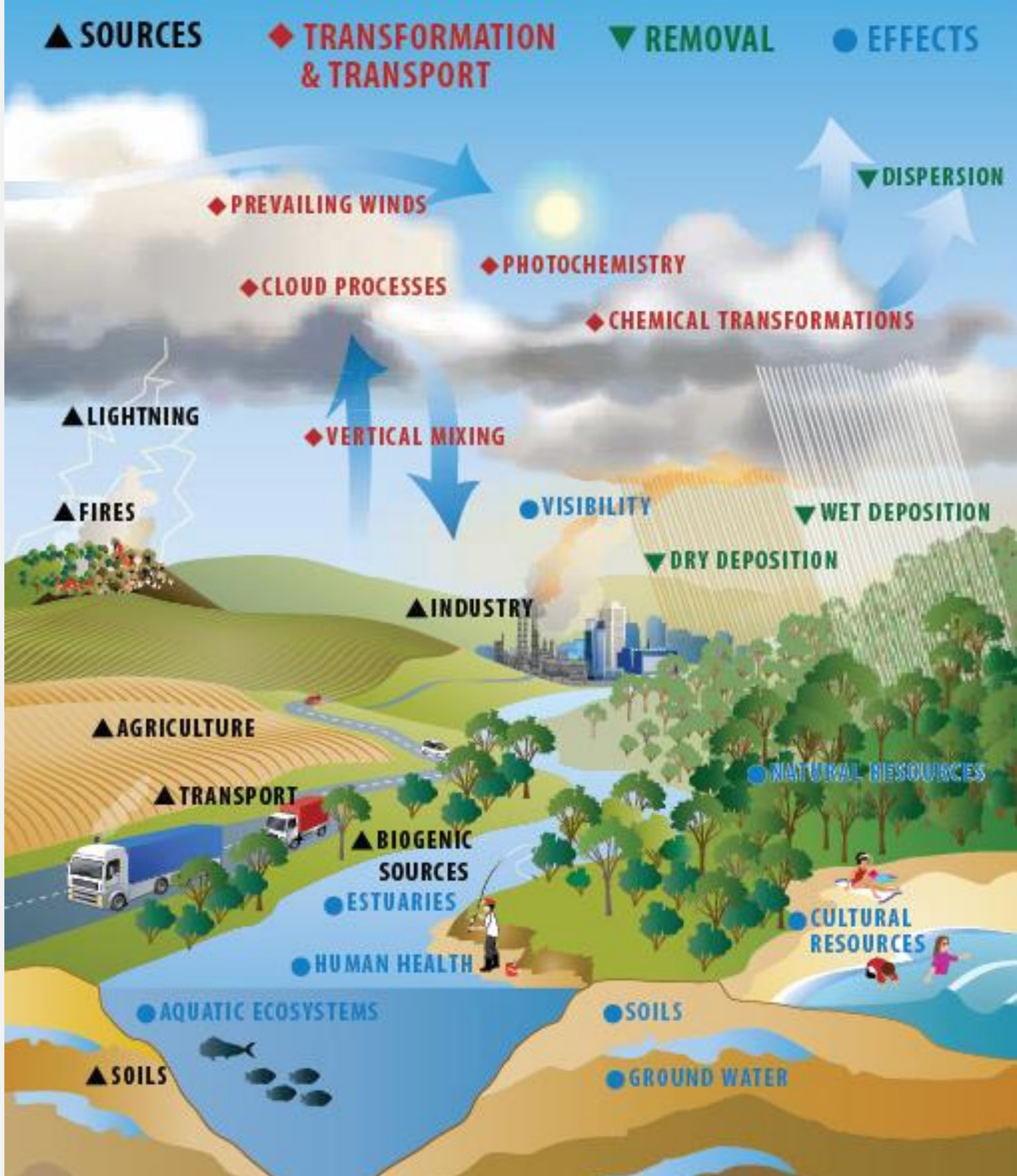


Fig.2.
http://www.epa.nsw.gov.au/air/

RECEPTOR MODELS

Receptor models are mathematical procedures used to identify the sources of pollutant emissions and to estimate their contribution in the overall balance of atmospheric aerosol emissions based on measurements of the concentrations of aerosol components, without the need to carry out an inventory of emission sources or data describing meteorological conditions. The concept of a macro tracer model consists in determining a chemical compound - an indicator or tracer, which is specific to a given source.

I. Positive matrix factorisation

II. Chemical mass balance

III. Macro tracer

THE BASIS OF *MACRO TRACER* MODEL

$$PM_{grav} = \sum_{k=1}^{p} F_{jk} c_{jk} + c_{N/A}$$

k	numer of emission sources
***F*$_{jk}$**	the coefficient of k^{th} emission source correcting the concentration of j^{th} PM component
***c*$_{jk}$**	the concentration of j^{th} PM component being the tracer of k^{th} emission source
***c*$_{N/A}$**	the concentration of the non-identified PM fraction.

IS IT POSSIBLE TO IDENTIFY THE EMISSION SOURCES OF PM ON THE BASIS OF ITS CHEMICAL COMPOSITION?

yes.

SAMPLING OF PARTICULATE MATTER ON QUARTZ FIBRE FILTERS IN REPRESENTATIVE AREAS

THE QUALITATIVE IDENTIFICATION OF PARTICULATE MATTER ORIGIN ON THE BASIS OF ITS CHEMICAL COMPOSITION - *MASS CLOSURE* MODEL

THE CHEMICAL CHARACTERISATION OF SOLID PARTICLES EMITTED FROM DIFFERENT SOURCES

THE QUANTITATIVE IDENTIFICATION OF PM ORIGIN IN KRAKOW AGGLOMERATION WITH AN APPLICATION OF OPTIMIZED *MACRO TRACER* MODEL

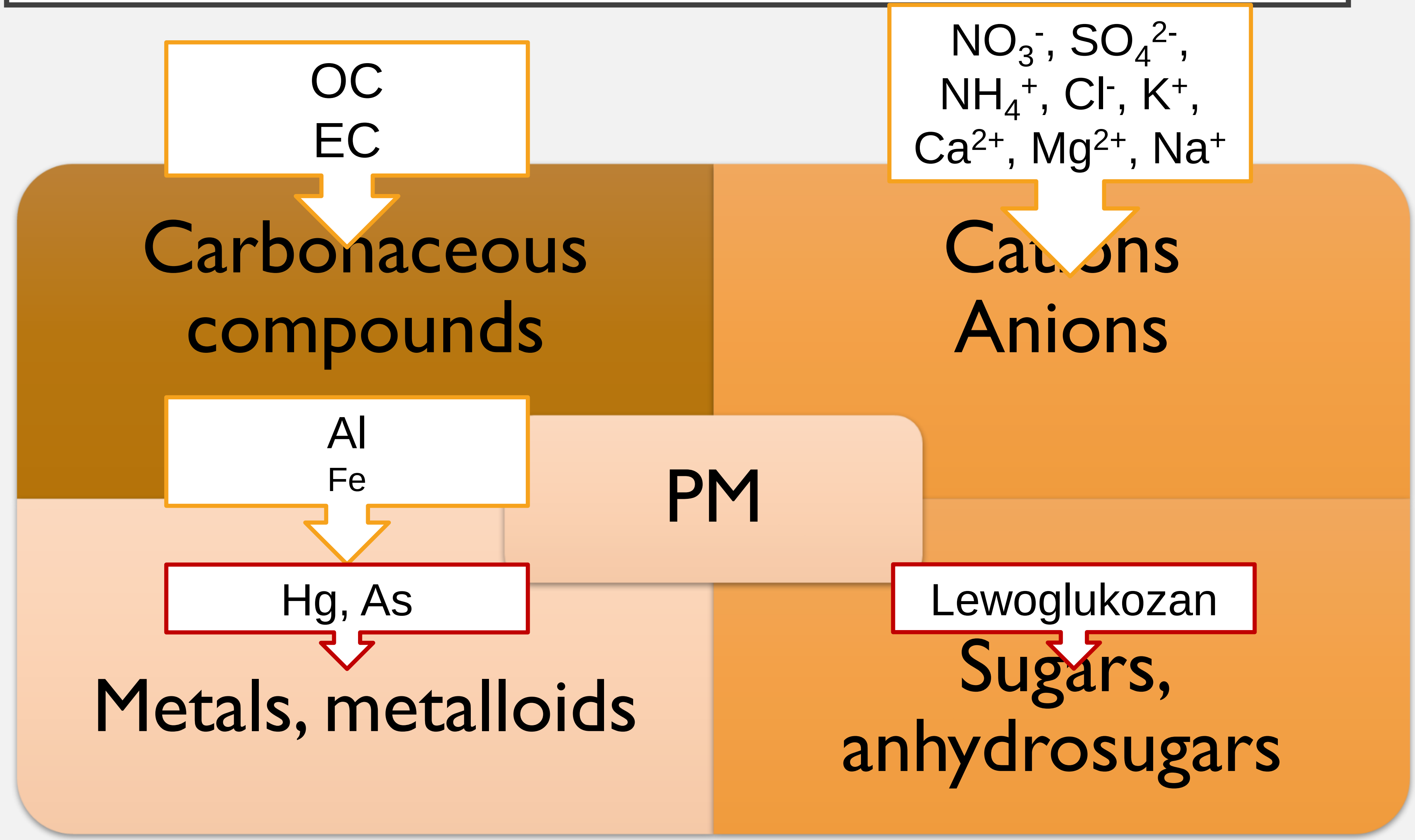
WHAT WAS NECESSARY TO PROCEED?

THE QUALITATIVE IDENTIFICATION OF PARTICULATE MATTER ORIGIN – *MASS CLOSURE*

- Combustion processes
- Secondary inorganic aerosols
- Resuspension dust
- Road salt

Styszko, K., Kistler, M., Szramowiat, K., Nowak, M., Kasper-Giebl, A., Gołaś, J., Seasonal variations of chemical composition of two aerosol size fractions at urban and rural site in South Poland. (Unpublished).

MAIN COMPONENTS OF PM



MACRO TRACER MODEL OPTIMISATION TO THE REGION WITH DOMINATING ROLE OF COAL AS AN ENERGY SOURCE

MASS CLOSURE MODEL

THE CHEMICAL CHARACTERISATION OF SOLID PARTICLES EMITTED FROM DIFFERENT SOURCES

THE QUANTITATIVE IDENTIFICATION OF PM ORIGIN IN KRAKOW AGGLOMERATION WITH AN APPLICATION OF OPTIMIZED *MACRO TRACER* MODEL

- Macro tracer assumptions
- Estimation of new F coefficients
- Correlation of obtained results PM_{grav} vs. PM_{MT}

Emission source	Tracer
INDUSTRIAL COAL COMBUSTION	**As**
OTHER INDUSTRIAL PROCESSES	**Ca, Fe_{ind}**
WOOD COMBUSTION	**Lewoglukozan**
COAL COMBUSTION	**Hg/OC**
CULM COMBUSTION	**K^+**
ECO-PEA COMBUSTION	**K^+**
TRANSPORT	**EC**
ROAD DUST	**EC**

EMISSION SOURCE	TRACER
SECONDARY INORGANIC AEROSOLS	NH_4^+, SO_4^{2-}, NO_3^-
ALUMINOSILATES, CARBONATES	Ca, Al, Si, Fe_{rest}
ROAD SALT	Na^+, Cl^-
NON-IDENTIFIED ORGANIC MATTER	OC

MACRO TRACER MODEL OPTIMISATION TO THE REGION WITH DOMINATING ROLE OF COAL AS AN ENERGY SOURCE

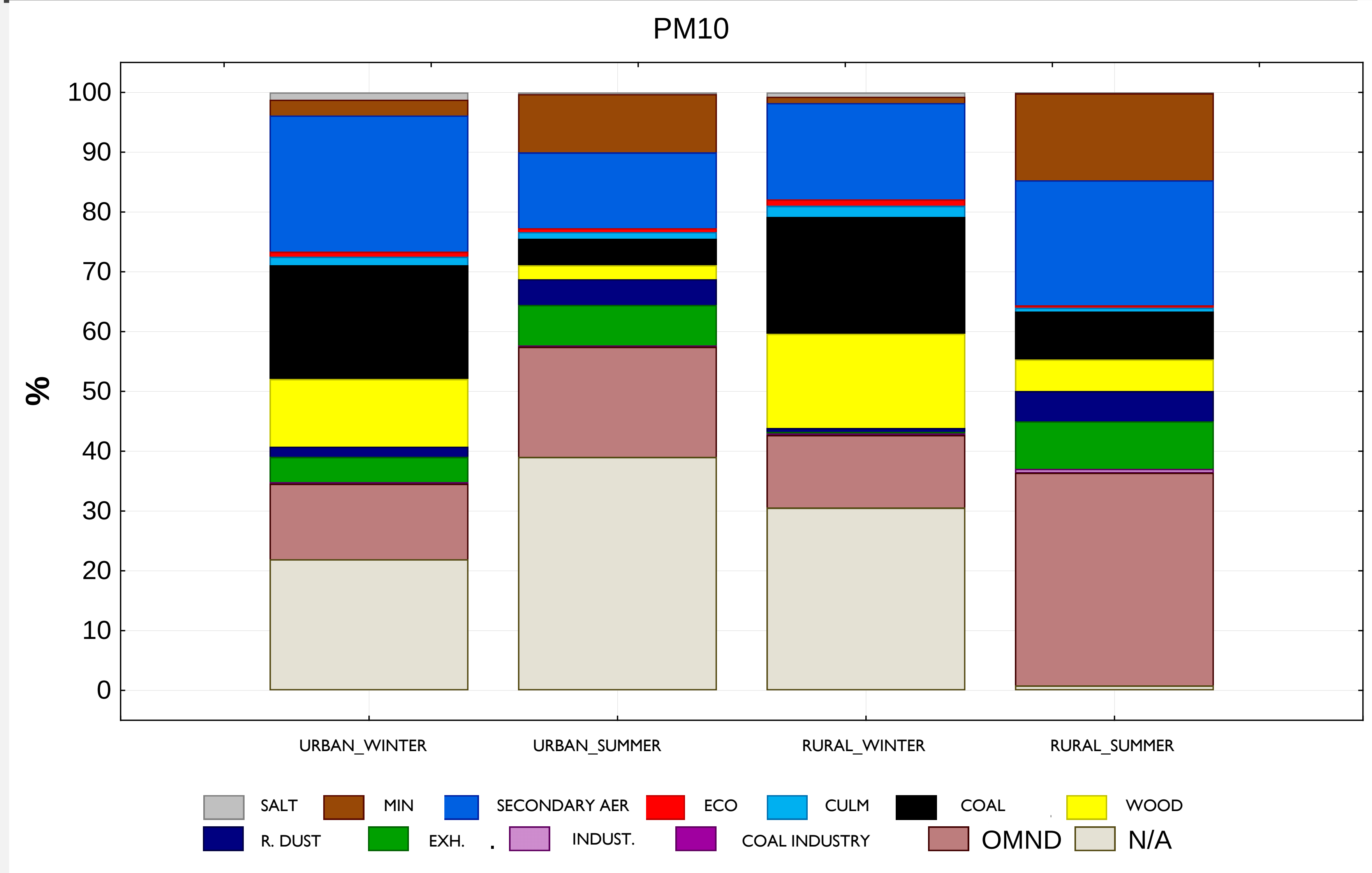
MASS CLOSURE MODEL

THE CHEMICAL CHARACTERISATION OF SOLID PARTICLES EMITTED FROM DIFFERENT SOURCES

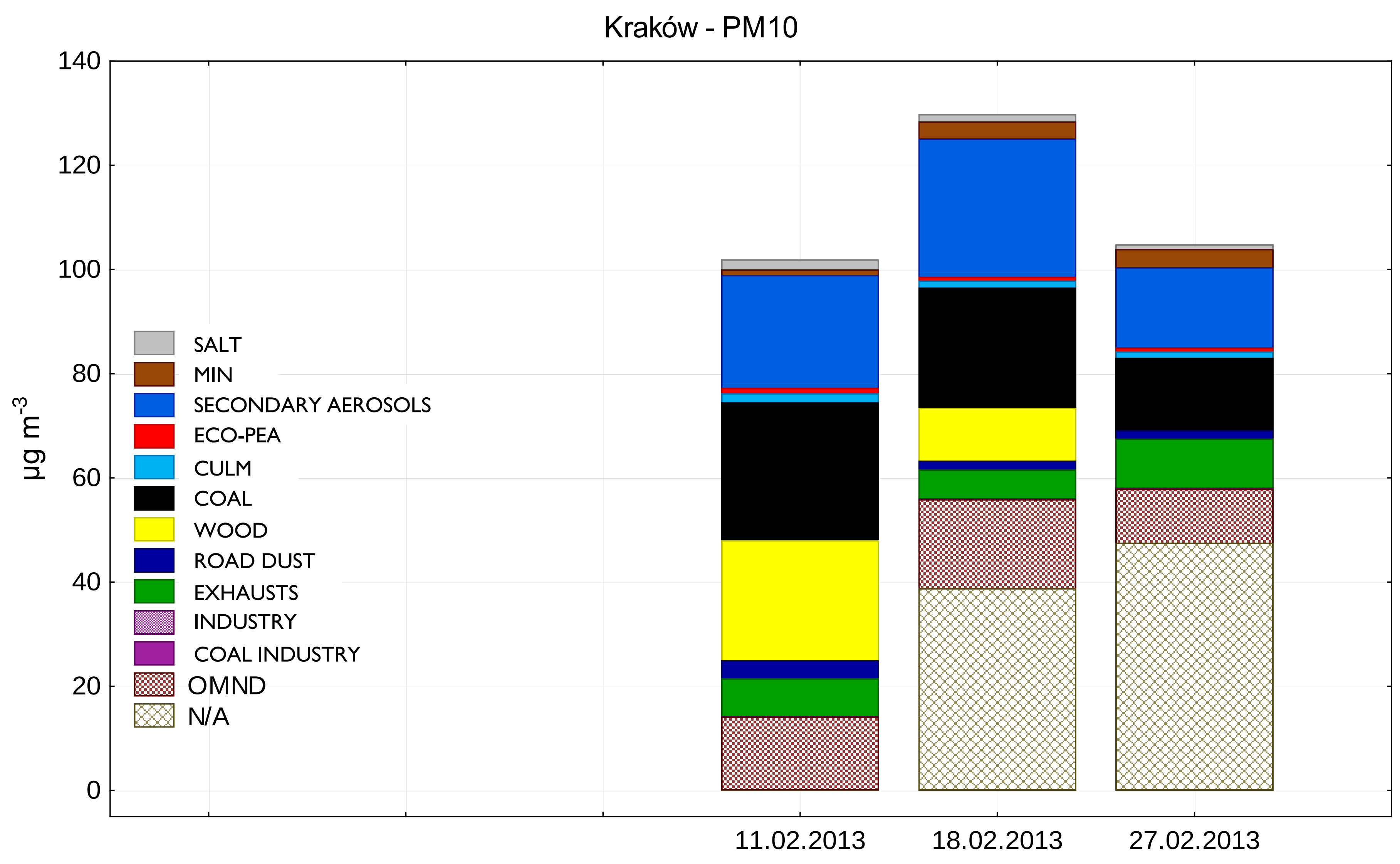
THE QUANTITATIVE IDENTIFICATION OF PM ORIGIN IN KRAKOW AGGLOMERATION WITH AN APPLICATION OF OPTIMIZED *MACRO TRACER* MODEL

- Macro tracer assumptions
- Estimation of new F coefficients
- Correlation of obtained results PM_{grav} vs. PM_{MT}

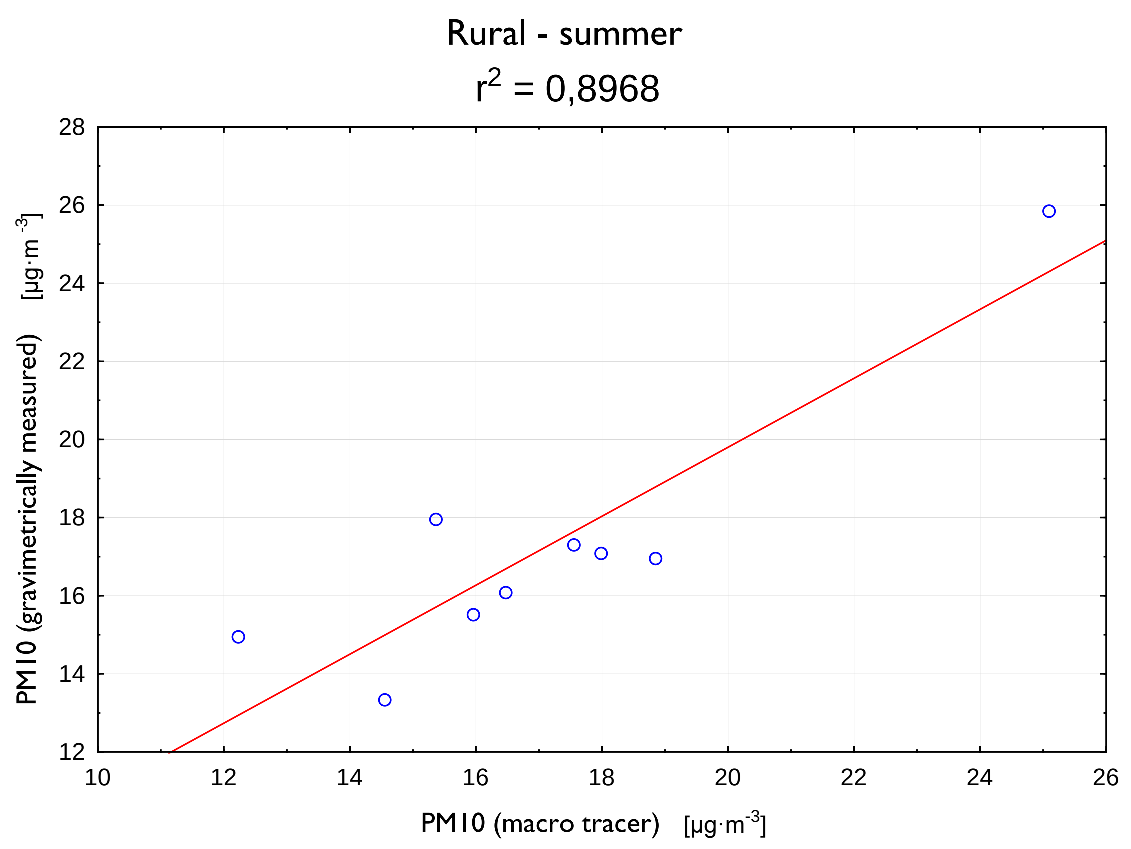
THE QUANTITATIVE IDENTIFICATION OF PM ORIGIN WITH *MACRO TRACER*



THE QUANTITATIVE IDENTIFICATION OF PM ORIGIN WITH *MACRO TRACER*



PM10 GRAVIMETRICALLY MEASURED VS. PM10 ESTIMATED WITH *MACRO TRACER*



Urban	winter: **0,8606**	summer: **0,8899**
Rural	winter: **0,7553**	summer: **0,8968**

CONCLUSIONS

- The Macro Tracer model enables the identification of particulate matter emission sources.
- The application of Macro Tracer model confirmed the so far obtained conclusions that particulate matter mainly originates from combustion processes of different fuels
- The further work is necessary:
  - To characterize particulate matter from higher amount of emission sources or
  - To focus on more specific components, like PAHs, or their nitric or oxygen derivatives
- Macro tracer model is a promising tool for easy and fast identification of particulate matter origin

MACRO TRACER MODEL AS A TECHNIQUE FOR SOURCE APPORTIONMENT OF PARTICULATE MATTER IN KRAKOW AGGLOMERATION – AN OPTIMIZATION APPROACH

Katarzyna Szramowiat-Sala[1], Katarzyna Styszko[1], Magdalena Kistler[2], Anne Kasper-Giebl[2], Janusz Gołaś[1]

THANK YOU FOR YOUR ATTENTION!

For more questions, please contact me at:

Katarzyna.Szramowiat@agh.edu.pl

ORCID: https://orcid.org/0000-0003-2251-3061

ResearchedID: AAI-3380-2021