Modeling area, line and point sources for ISC model methodology, computer interface and case studies

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topics

- Model application
- Emissions inventory
  - sources categories
  - actual and future emissions evaluation
  - representation of the sources for the model
  - geographic representation of sources
  - temporal disaggregation
- Software
  - Air suite software
  - AIR_ISC interface
- Model performance evaluation
- Case studies
- Conclusions

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Italy Model Application (IMA)

- Industrial Source Complex dispersion model from Environmental Protection Agency has been widely used in the last year in Italy for local air quality management and for environmental impact analysis
- usually, for planning purpose, the model was used in its long term option to evaluate the average pollution on selected areas
- however, in some cases, also the short term behaviours of pollution can be of interest; in these cases the short term model was been used

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IMA - Air Quality Man. Plan

- emissions inventory
- air quality and meteorological data analysis
- emissions projection without emissions reduction measures
- classification of territory and analysis of actions priority
- planning of measures to reduce emissions
- definition of scenarios of reduction
- emissions projection in plan scenarios
- use of air quality models in the actual situation and in future with and without plan application

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IMA - Env. impact analysis

- emissions inventory in the "ante operam" scenario
- meteo data analysis for input to dispersion model
- use of dispersion model in "ante operam" scenario
- comparison between air pollutants monitored concentrations and model results for model validation
- emissions projection of existing sources at project year ("post operam" scenario)
- evaluation of the emission of the project (plant, transport infrastructure, etc.) at project year ("post operam" scenario)
- use of dispersion model in "post operam" scenario

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Emission inventory (EI)

- emission inventory activities in Italy started in 1980 at a national level and has been applied at the local level since 1990
- preparation of air pollutants emissions inventories allows characterization of the different role played by the various emission sources and consequently represents a basic tool to define criteria for air quality management plans
- recent paper reports a balance of air quality management activities in Italy

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EI Sources categories 1

Nomenclature follows the guidelines of the European Commission CORINAIR working group; about 200 activities in 11 groups:

- Combustion in energy and transformation industries
- Non-industrial combustion plants
- Combustion in manufacturing industry
- Production processes
- Extraction and distribution of fossil fuels and geothermal energy
- Solvent and other product use
- Road transport
- Other mobile sources and machinery
- Waste treatment and disposal
- Agriculture

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EI Sources categories 2

The sources are generally split in:

- main/minor point sources: the fixed sources for which the total annual emissions of one pollutant is larger than a fixed threshold value
- linear/nodal sources: the main communication ways (roads, rivers, railways, and seaways) and nodes (ports, airports); generally all the highways, all the main extra-urban roads and all the main ports and airports are included
- area sources: all the other sources

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EI Sources categories 3

Pollutant	Minor point sources	Main point sources
Carbon Monoxide	50 t/year	250 t/year
Other main pollutants	5 t/year	25 t/year
Heavy metals	50 kg/year	250 kg/year

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EI Actual emission

- main point sources: information is gathered through a questionnaire that allows collection of general data (identification, location, etc.), structural data (stacks and units characteristics) and quantitative data (pollutant concentrations at the stacks, pollutant emissions, actual production, fuel consumptions)
- minor point sources: information is gathered through a simplified questionnaire with general data, pollutant emissions and actual production.
- area sources (for instance, domestic solvent use and natural sources): evaluated on a geographical basis, inside each municipal administrative unit, using statistical or survey data on suitable activity indicators (for example: paint consumptions, fuel consumptions) and emission factors

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EI Future emission

- carried out within the realization of the air quality management plan
- future area and line emissions are evaluated from emission at base year, projection parameter for activity indicator and projection parameter for emission factor
- future point sources emissions as in area and line case but projection parameter for the specific unit of a single facility, are also used where applicable

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EI ISC source modeling 1

The methodology for preparing input for EPA ISC model is based on the different modeling of

- **main point sources,**
- **minor point sources,**
- **area and line/nodal sources splitted in:**
  - **not elevated - sources of the following CORINAIR groups: extraction and distribution of fossil fuels and geothermal energy, road transport, other mobile sources and machinery, waste treatment and disposal, agriculture**
  - **elevated - sources of the following CORINAIR groups: non-industrial combustion plants, combustion in manufacturing industry, production processes, solvent and other product use, other sources and sinks**

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EI ISC source modeling 2

Source category	Geographical representation	Physical representation
main point	point	specific of source
minor point	50 m x 50 m squared area	default height 10 m
low line/nodal	1 km x 1 km squared area	default height 0,5 m
high line/nodal	1 km x 1 km squared area	default height 10 m
low area	1 km x 1 km squared area	default height 0,5 m
high area	1 km x 1 km squared area	default height 10 m

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EI Source representation 1

- main point sources are singularly located on territory with plant coordinates
- minor point sources are located, by means of coordinates, at 50 m x 50 m squared areas
- line/nodal sources are allocated to the 1 km x 1 km grid on the basis on topological consideration
- area emissions are allocated on a square grid mesh with the methodology of proxy variables

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EI Source representation 2

when municipal value is known, it is distributed on the square grid mesh according to the two cases:

- **the data to be distributed is an extensive variable and it is proportional to coverage of a thematism on single mesh (for example: urban zones); in this case the weight of the mesh coverage on total municipal coverage is utilized**
- **the data to be distributed is an intensive variable and depends on the presence of the activity estimated at municipal level on the single mesh (for example the presence of a small industry); in this case the weight of the mesh activity on total municipal activity, is utilized**

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EI Source representation 3

emissions on mesh k are obtained as:

$$E_{ik} = S_j (E_j P_{lkj} / S_k P_{lkj})$$

where: i, activity; j, municipality; k, mesh; l, proxy variable appropriate to activity i; E_j, total emission; P_{lkj}, value of the proxy variable

Example of proxy from CORINE Land Cover are: urban; agricultural; industrial and commercial; modeled artificial; mining, permanent crops, arable land, deciduous forests; coniferous forests; airports; landfills

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EI Temporal representation

- annual emissions are at first evaluated
- for short term diffusion models it is necessary to obtain an estimate of hourly, monthly and daily distribution of emissions:
  - main point sources temporal disaggregation may be evaluated directly at the plant
  - other sources disaggregation is estimated through the use of corrective factors that have a similar rule of the proxy variable in the case of spatial distribution (for example: typical working hours, wintertime, temperature, monthly selling of fuels, etc.)

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Software (SW)

- computer interface to ISC models is integrated in the computer models system AIR SUITE developed by Techne consulting
- AIR SUITE has been implemented on a network of Pentium computers with large extended RAM running Windows NT, Oracle or Access, Arc View or MapInfo, and Statistica
- ISC computer interface is available with ORACLE (as regard emission inventory and meteorological data) and ACCESS (as regard model parameters) database and use Arc View or MapInfo and Surfer for geographical output

Modeling area, line and point sources for ISC model: methodolo

Techne srl -Via

PREM : model for emissions projections and to evaluate emission control measures
- **in Windows/ORACLE environment**
- **contains socioeconomic projection factors database**
- **contains technologic projection factors database**
- **contains some tools to project emissions**
- **integrated with the APEX system**

APEX: a
- **i**
- **cont**
- **contair**

municipal

SETS
interf
CALI
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disper

AIR_ISC. computer
inter
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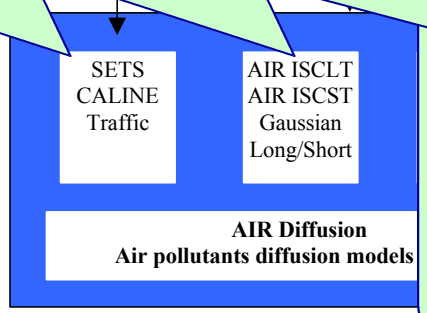
AIR OCD: co
interface to O
integrating da
from APEX an

AIR_GRID, a computer interface to CALMET and CALGRID models integrating data from APEX and QUAR



data manag ment and analysis
- **developed in Windows/ORACLE environment**
- **use Statistica software to analyze data**
- **use ArcView or MapInfo for thematic map**

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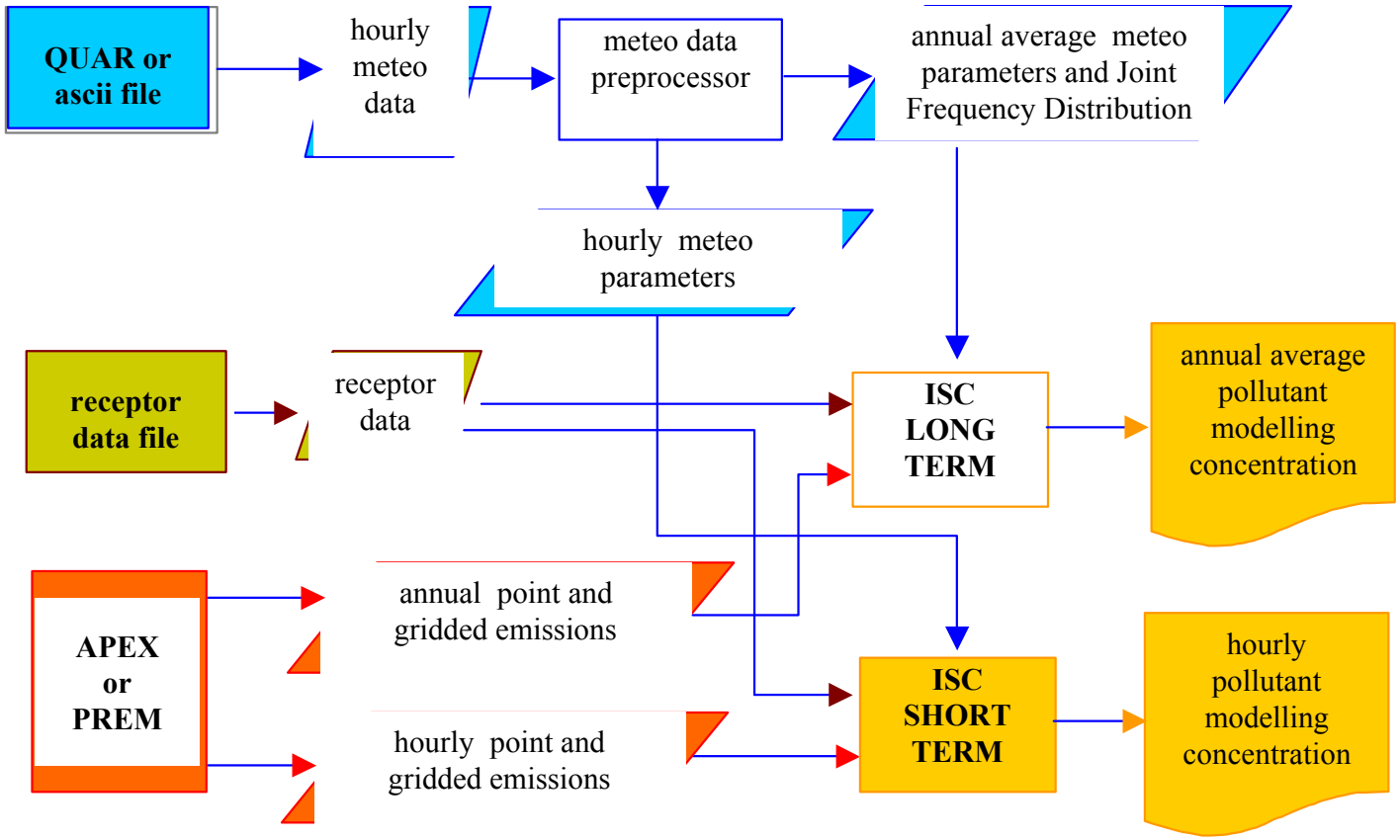
SW – Air ISC interface 1



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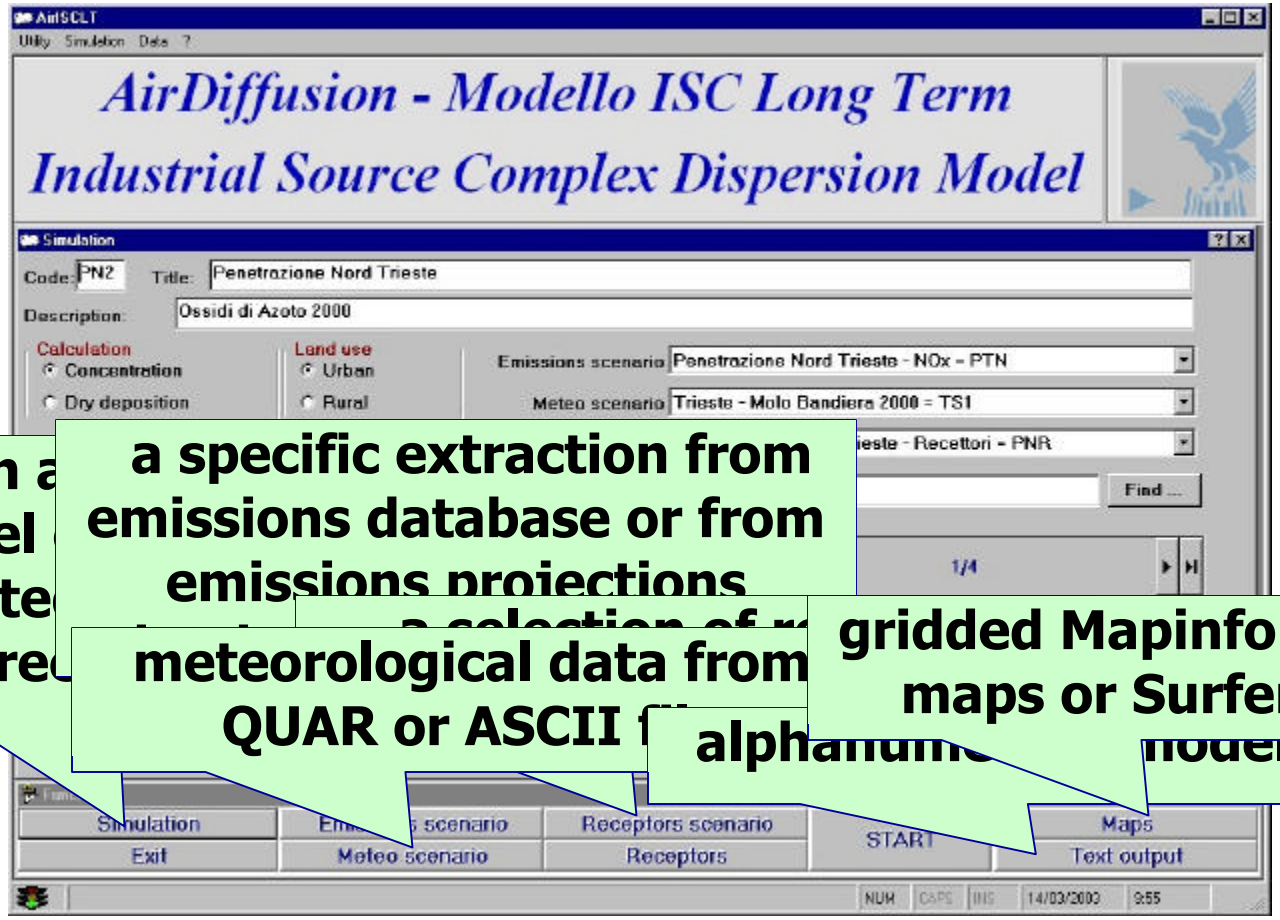
SW – Air ISC interface 2



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Performance evaluat. (PE)

- results of the model are valued on 1 km x 1 km squared grid and in an area of ray 20 meters around the air quality monitoring station
- To evaluate the accuracy of the model the following statistical indicators can be used:
  - Normalized mean standard error

    $NMSE=\langle(C_s-C_m)^2\rangle/\langle C_s\rangle*\langle C_m\rangle$
  - Fractional Bias

    $FB=2\ (\langle C_s\rangle-\langle C_m\rangle)/(\langle C_s\rangle+\langle C_m\rangle)$

  where C_s is the model concentration and C_m the air quality monitoring station concentration.

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Case Studies (CS)

- model was widely used at local level in the frame of environmental impact analysis and at regional level in the frame of emissions inventories and air quality management plans
- meteorological data are elaborate from the data of the meteorological stations
- model application results will be presented and discussed comparing data with monitoring by means of statistical indicators, in the Long Term case

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CS - Trento Alpin area

Monitoring station	Measures 2000 mg/m^3		Model computed mg/m^3					
			2000		2015 do nothing		2015 plan preparatory study	
	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2
Trento – Gardolo	7	49	3	44	2	20	2	18
Trento – Porta Nuova	4	60	6	44	5	24	4	20
Trento – S. Chiara	6	41	6	43	5	25	4	21
Trento – Via Veneto	7	45	6	46	5	25	4	21
Grumo S. Michele	5	44	3	57	2	26	2	22
Borgo Valsugana	4	33	3	22	3	17	3	17
Rovereto – Posta	6	40	11	43	10	23	9	22
Rovereto – Benacense	5	50	12	45	11	24	9	24
Riva del Garda	7	42	12	49	11	34	10	31

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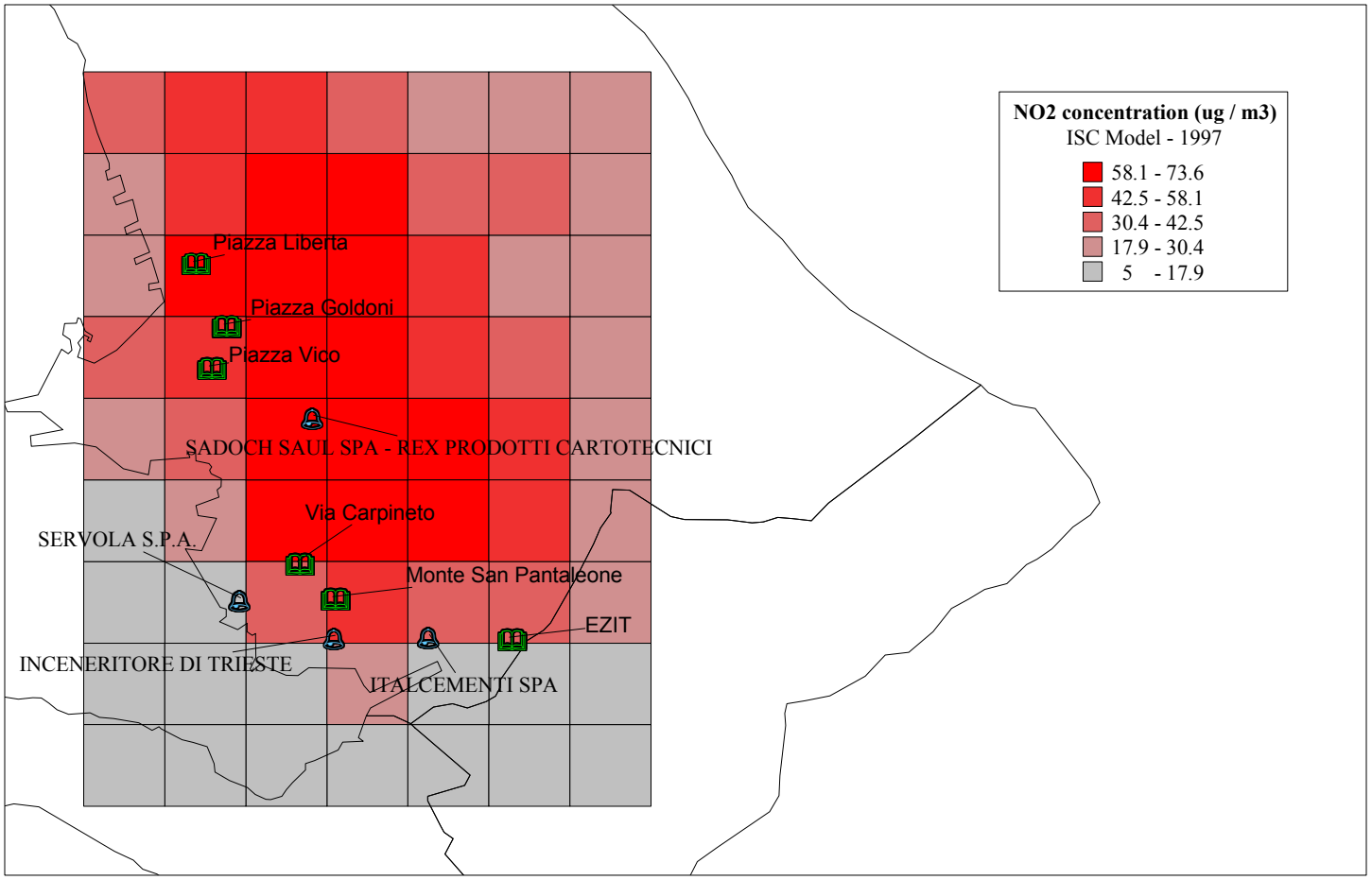
CS – Friuli Venezia Giulia



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CS – Statistical indexes

Index	Trento network 1995		Trento network 2000		Test	
	SO_2	NO_2	SO_2	NO_2	Perfect	Good
NMSE	0.1	0.2	0.36	0.04	0	<1.0
FB	-0.2	-0.2	0.19	-0.03	0	0.5<FB<0.5

in the 1995 case the model use only area (0.5 high sources) and point (stacks height) sources while in 2000 case the methodology of the present paper was used - significant improvement for nitrogen oxides can be noted

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Conclusions

- methodology, computer interface and case studies for modeling area, line and point sources for ISC model are discussed
- the results of the case studies shown as a better representation of sources emissions from air pollutants emissions inventory can significantly improve model results, particularly in complex areas with pollutants emissions from multiple sources categories