DEVELOPING CASE STUDIES I

Workshop on the use of the SIMPACTS model for estimating human health and environmental damages from electricity generation

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How identified a Study Case

- Health and environmental situation
- Current facilities, technologies, fuels
- Selection of candidates (technologies, fuels, location)
- Identifying impact pathways

Identifying impact pathways

Air Pollution

Water Pollution

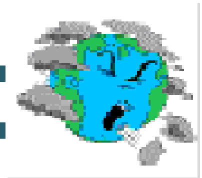
Solid Waste

- Public Health
- Agricultural Crops
- Materials
- Ecosystems

HOW TO STRUCTURE A STUDY CASE?

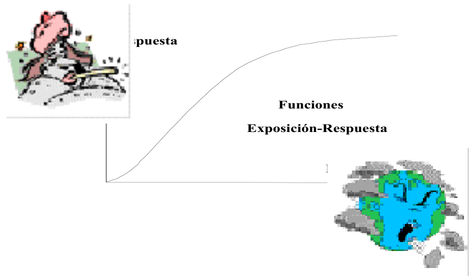
- Case study description

- Stack parameters
- Pollutant Inventory



- Meteorological Data
- Receptor Data

- Exposure Response Function



- Monetary Unit Cost

STACK PARAMETERS

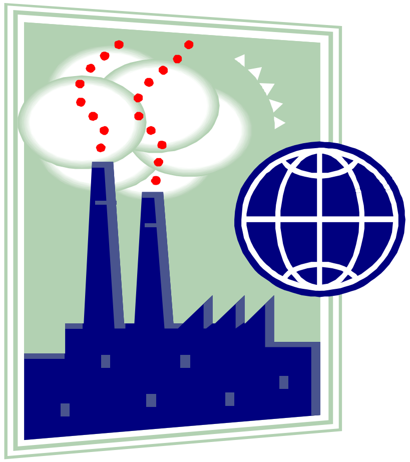
- **Mandatory Input**
  - Source geographical coordinates
  - Source Location
- **Optional Input**
  - Stack height
  - Stack diameter
  - Flue gas velocity
  - Flue gas temperature

STACK PARAMETERS: Options

- **Only Mandatory Input**
- **Mandatory Input plus:**
  - **One, two, three or four optional Input**
    - Stack height
    - Stack diameter
    - Flue gas velocity
    - Flue gas temperature

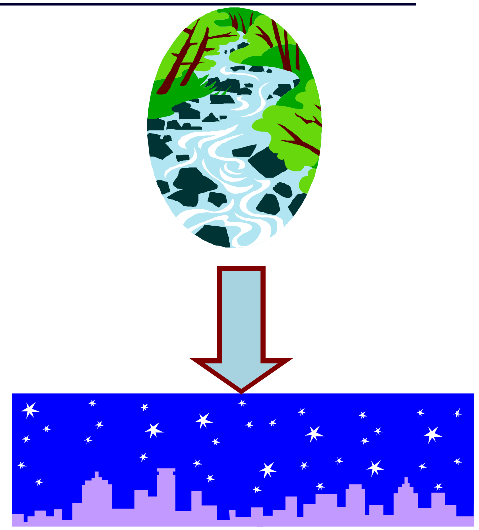
Source geographical coordinates

- Source Latitude and Longitude (mandatory input)
  - ***Latitude:*** (-90 to +90 degrees about equator);
  - ***Longitude***: 0 to 360 degrees, clockwise West of Greenwich



Source Location

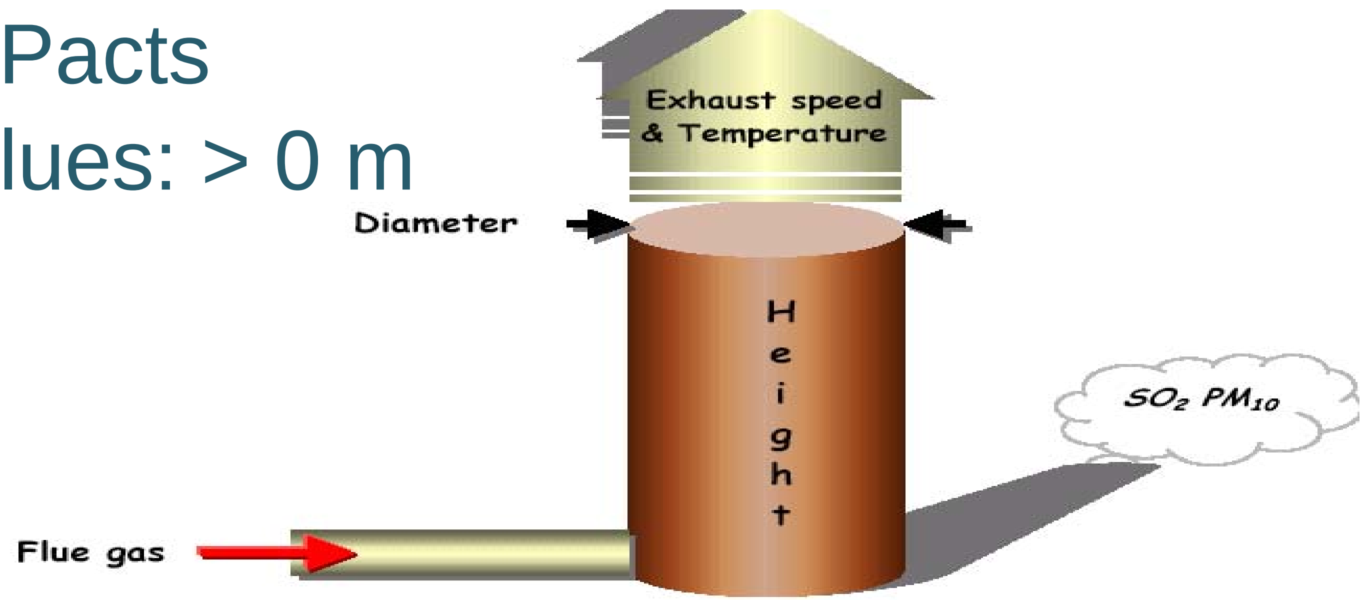
• ID	• Description of site	∀ ρ_{Local} / ρ_{Reg}
• 0	• Rural,	• < 2
• 1	• Small City Ex : Stuttgart in Germany	• < 6
• 2	• Medium City Ex : Milan in Italy	• < 10
• 3	• Large City Ex: Paris in France	• > 10
• 4	• within 25 km from large city	
• 5	• within 40 km from large city	
• 6	• more than 40 km from large city	



0 or 1 Source located on a small island, ex. Crete in Greece,
or near a large water body (ocean or lake),
or close to a city surrounded mostly by unpopulated areas, ex. Finland in Europe

Stack height and Stack diameter (m)

- Physical height at which pollutants are released into the atmosphere. AirPacts acceptable range: 25 to 300 m
- Inner stack diameter at point of release. AirPacts acceptable values: > 0 m



Flue gas velocity and temperature

- Velocity of exhaust gases, AirPacts acceptable values: > 0 m/s

$$Velocity(m/s) = \frac{Flow(m^3/s) x T(K)}{Stack\_Area(m^2)273}$$

- Temperature of exhaust gases:
  - AirPacts acceptable range: 300 to 600 K
  - ΔT between escape gases and ambient > 20
  - For fossil fuel power plant, in most case could be used the exit temperature from regenerative heaters

POLLUTANT INVENTORY

- Primary species
  - Particulate Matter, PM_{10}
  - Sulfur Dioxide, SO_2
  - Nitrogen Oxides, NO_X
  - Carbon Monoxide, CO
  - Other pollutant
- Secondary species
  - Nitrate aerosols (precursor pollutant NO_X)
  - Sulfate aerosols (precursor pollutant SO_2)

Pollutant Inventory

- Mandatory Input
  - Emission rate (ton/year)
  - Depletion velocity (cm/second)
- Options
  - Pollutants selected
  - ☑ SUWM for primary pollutants
  - ☐ SUWM and then it run the corresponding models at the level that data allow

Emission rate

- Pollutant emission rate
  - value > 0 tons per year
- Most current Agency models for energy planning: ENPEP, WASP-IV, DECADES, MESSAGE
- U.S. EPA, Compilation of Air Pollutant Emission Factors, AP-42, Volume I: Stationary Point and Area Sources http://www.epa.gov/ttn/chief/ap42/
- USA, Office of Transportation and Air Quality (OTAQ), Compilation of Air Pollutant Emission Factors, AP-42, Volume II: Mobile Sources, Highway Vehicles and Non road Mobile Sources, http://www.epa.gov/otaq/ap42.htm
- [1] GEMIS, Global Emission Model for Integrated Systems, Version 4.03, Oko Institut, Copyright 1995-2001

Emission rate from DECADES

Combustion and Emission Factors

Plant: 250 | Fuel Used: FC900 | Flue Gas Volume: 12.93 m3/kg

Flue Gas @: 5.5 % vol O2 | Plant Efficiency: 34.75 % | Specific Weigth: kg/m3

FGV: 829,716.29 m3/h | V : 6.498 m/seg | FC: 17.826 kg/seg

Emission Factors

Pollutant	Raw Gas mg/Nm3	Inherent Control %	Abatement %	Clean Gas mg/Nm3	E-Factor g/kg	E-Factor g/GJ	E-Factor g/kWh	E-Factor g/kWh	E-Factor g/seg
CO_2	233598.69	0		233598.69	3020.31	79273.24	821.27	792.73	53839.07
SO_2	7170.1	0	0	7170.1	92.706	2,433.219	25.208	24.332	1,652.541
NO_x	614.38	0	0	614.38	7.944	208.493	2.16	2.16	141.6
Ash	177.89	50	0	88.94	1.15	30.18	0.313	0.604	20.5
HCl	0	0	0	0	0	0	0	0	0
HF	0	0	0	0	0	0	0	0	0
CO	170.66	0	0	170.66	2.207	57.915	0.6	0.6	39.333
CH_4	0	0	0	0	0	0	0	0	0
NMVOC	0	0	0	0	0	0	0	0	0
N_2O	7.96	0	0	7.96	0.103	2.703	0.028	0.028	1.836

GHG | Update

Legend

Values from DB | Calculated Values | Calculated from DB or Inputed Values

Close

Stack parameters, some considerations

$$FC = NoU\,\frac{\left(HR_B P_B + HR_{AI}\left(P_N - P_B\right)\right)}{860\,NLHV}$$

$$FC = NoU\,\frac{100P_N}{\eta_{eff}\,NLHV}$$

$FGV = V_r * FC,$ $V_r\ \alpha\ ER$ *and Fuel composition*

- Where:
- Vr: Real Volume (Flow of Gases for kg of burned fuel)
- NoU: Number of units unloading for the same stack
- FC: Fuel Consumption
- HRB: Heat Rate- Minimum Load
- ηeff: Net Efficiency
- HRAI: Incremental Average Heat Rate
- PB: Minimum power
- PN: Net power
- ER: Excess of air

Emission rate in ton/year: Er

Era: Available emission rate	
g/kwh	Er=Era x Energy produced during the year Er=Era x Plant Capacity x Load capacity
g/kg_fuel	Er=Era x Fuel consumption during the year
g/s at full load	Er=Era x 8760 x 3600 x Load capacity
mg/m^3	Er=Era x FGV at full load x 8760 x 3600 x Load capacity

Depletion velocity

- Characteristic velocity determining the rate at which a particular pollutant is removed from the atmosphere because of chemical transformation and deposition (dry and wet)
- value > 0 cm/second

Depletion velocity, **Method #1: Regression to atmospheric dispersion calculations**

Primary species

$$C_p = \frac{A_p}{r} e^{B_p r}$$

$$\boxed{k_P = -\frac{Q\ B_P}{2\ \pi\ A_P}}$$

Europe

- PM10 0.67 cm/s
- SO2 0.73 cm/s
- NOx 1.47 cm/s

Secondary species

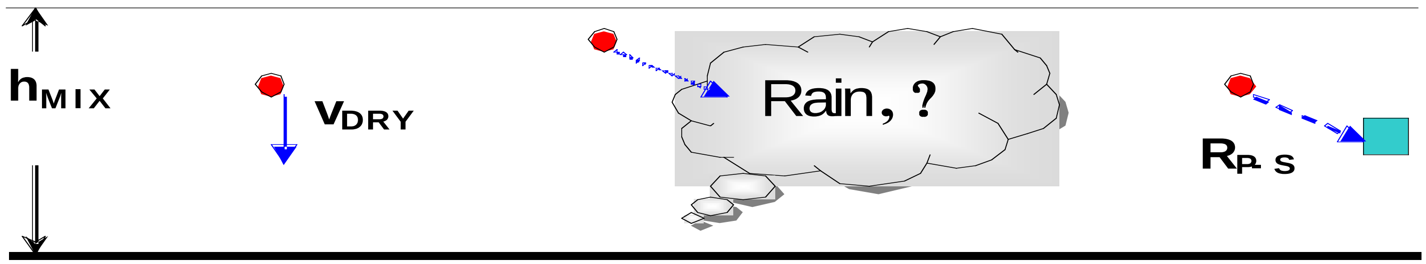
$$C_S = \frac{A_S}{r}\left(e^{B_p r} - e^{B_S r}\right)$$

$$\boxed{k_S = -\frac{Q\ B_P\ B_S}{2\ \pi\ A_S\ (B_S - B_P)}}$$

- Sulfates 1.73 cm/s
- Nitrates 0.71 cm/s

A_P, B_P, A_S, B_S are obtain by regression analysis

Depletion velocity,
Method #2: Atmospheric rate equations



Primary species

$$\frac{k_P}{h_{MIX}} = \left(\frac{v_{DRY}}{h_{MIX}} + \Lambda + R_{P\to S}\right)_P$$

Secondary species

$$\frac{k_{S,EFF}}{h_{MIX}} = \frac{\left(\frac{v_{DRY}}{h_{MIX}} + \Lambda + R_{P\to S}\right)_P \times \left(\frac{v_{DRY}}{h_{MIX}} + \Lambda + R_{S\to T}\right)_S}{R_{P\to S}}$$

Depletion velocity,
Method #3: Atmospheric residence time- τ_{AIR}

$$k\,(cm/s) = \frac{1.2}{\tau_{AIR}^{0.4}\,(days)}$$

$(\tau_{AIR} < 75\ \text{days})$

Meteorological Data: Optional Data

- Options
  - Any meteorological data is available or known
  - Statistical Meteorological Data
  - Hourly Meteorological Data
    - Excluding Pasquill class and mixing height
    - Including Pasquill class and mixing height
- Compilation, processing and consistency checking of the meteorological data of the nearest Meteorological Stations to facility with similar geographical and physical conditions and recommended by the National Climatic Service.

Statistical Meteorological Data

- Anemometer height (Za): Reference height for wind speed
  - value > 0 m (typically 10 m for weather stations located away from large urbanized areas)

$$U_s = U_a \left(\frac{Zs}{Z_a} \right)^P$$

Power-law exponent for wind speed

•Passquill class	•Default value proposed by EPA		•Surface roughness length (Zo)				
	•Urban	•Rural	•0.0002 •Open sea	•0.005 •Open flat terrain	•0.03 •Grass,	•0.1 •Low crops	•0.4 •Forest
•A	•0.15	•0.07	•0.0364	•0.0569	•0.0797	•0.1065	•0.1658
•B	•0.15	•0.07	•0.0406	•0.0638	•0.0896	•0.1193	•0.1824
•C	•0.2	•0.10	•0.0466	•0.076	•0.1092	•0.1438	•0.2178
•D	•0.25	•0.15	•0.086	•0.119	•0.1512	•0.1848	•0.2485
•E	•0.3	•0.35	•0.3933	•0.3059	•0.293	•0.3054	•0.3306
•F	•0.3	•0.55	•0.5971	•0.5702	•0.5376	•0.5149	•0.4861

Statistical Meteorological Data

- Mean Ambient temperature
  - value > 0 Kelvin (=Celsius + 273)
- Mean Wind Speed
  - value > 0 m/s
- Pasquill (stability) class: Atmospheric turbulence classifications;
  - specified as % of occurrence (fraction of time) over the study period in consideration. The sum of Pasquill classes is equal to 100%.
  - A – very unstable B – unstable
  - C – slightly unstable D – neutral
  - E – slightly stable F – stable

Hourly Meteorological Data: Primary data

- Meteorological data measure routinely by meteorological station
  - Mean Ambient temperature
    - value > 0 Kelvin (=Celsius + 273)
  - Mean Wind Speed
    - value > 0 m/s
  - Wind Direction
    - degree from North

Hourly Meteorological Data: Secondary data

- Pasquill (stability) class
  - Default values

•Wind speed at anemometer height (m/s)	•*High Insolation*, $\alpha > 45^{o}$	•*Low Insolation* •a <45	•*Overcast*	•*Night time*
• •0-2	•A	•B	•D	•F
•2-3	•B	•C		•F
•3-5	•C	•D		•E
•> 5	•D	•D		•D

Hourly Meteorological Data: Secondary data

- Pasquill (stability) class
  - Turner´s method starting from:
    - Solar altitude (calculated for every hour using geographical coordinates)
    - Wind speed
    - Ceiling height
    - Cloud cover
  - Solar Radiation´s method:
    - At day: Solar radiation
    - At night:
      - Net radiation
      - Vertical temperature gradient
  - Etc,

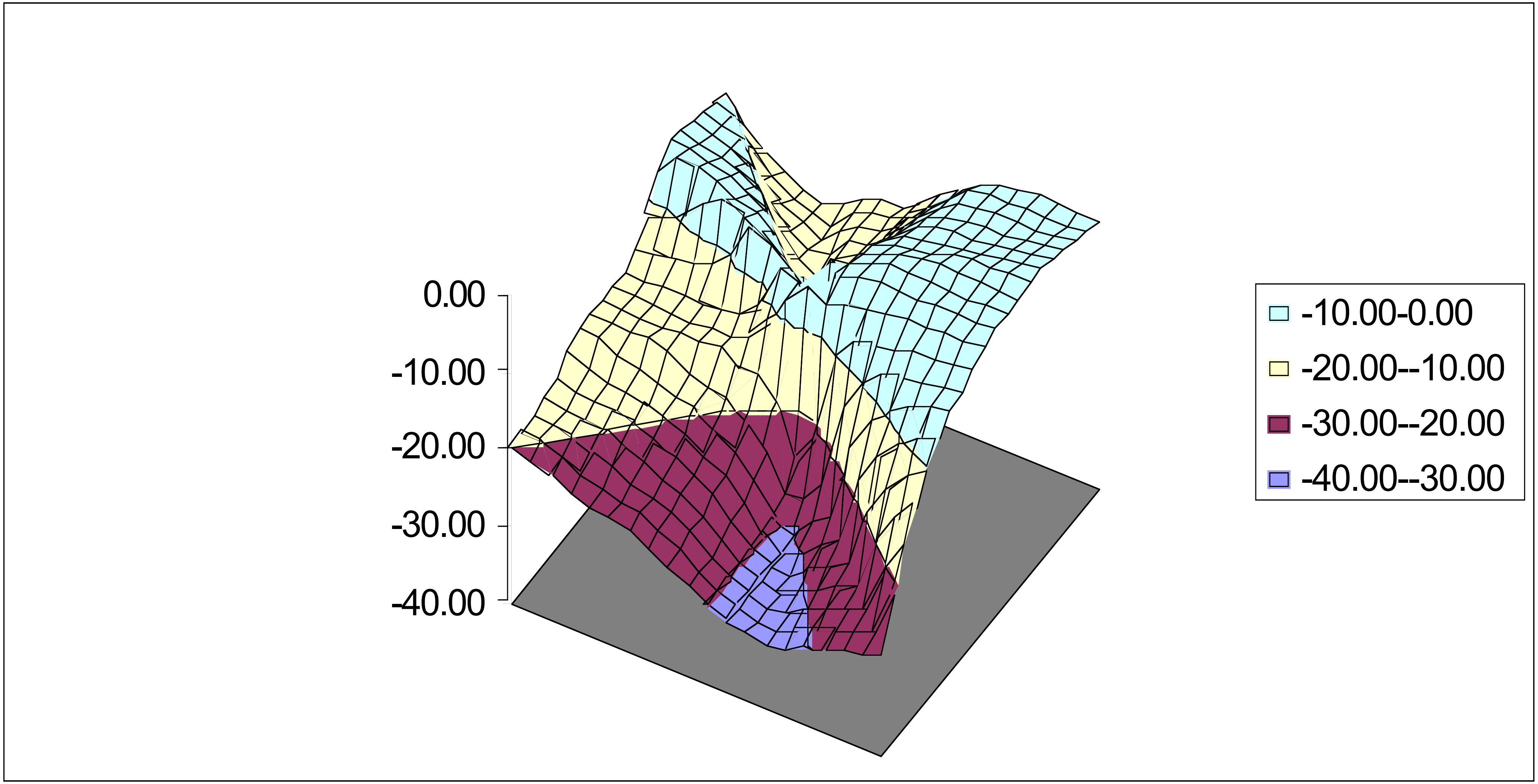
Hourly Meteorological Data: Secondary data

- Pasquill (stability) class
  - Turner´s method

•Wind speed at anemometer height (m/s)	•Day: Insolation				•Overcast: •,ceiling height<2133.6 m	•Night: Cloud Cover	
	•Strong a >60°	•Moderate, 35<a<60°	•Slight, a<35°	•Weak, a<15°		• > 4/10	•≤4/10
•0-0.77	•A	•A	•B	•C	•D	•F	•F
•0.77-1.80	•A	•B	•B	•C	•D	•F	•F
•1.80-2.83	•A	•B	•C	•D	•D	•E	•F
•2.83-3.34	•B	•B	•C	•D	•D	•E	•F
•3.34-3.86	•B	•B	•C	•D	•D	•D	•E
•3.86-4.89	•B	•C	•C	•D	•D	•D	•E
•4.89-5.40	•C	•C	•D	•D	•D	•D	•E
•5.40-5.92	•C	•C	•D	•D	•D	•D	•D
•≥ 5.92	•C	•D	•D	•D	•D	•D	•D

+ Effect of ceiling height can change Passquil class

DC using Passquill class from default values and from Turner´s method



Hourly Meteorological Data: Secondary data

- Mixing height
  - Lowest layer of the atmosphere where turbulent transport of mass and energy takes place
  - Typical values vary from a few hundred meters during the night up to 2000 meters above ground for very unstable meteorological conditions, A Passquill Stability class (summertime midday hours).
  - the rural mixing heights < urban due to nocturnal and early morning urban heat "heat island effect"
  - SIMPACTS considered as a first estimate, that the rural and urban mixing height are equals

Hourly Meteorological Data: Secondary data

- Mixing height
  - Default estimation:

Passquill Class	Mixing height (m)
A	1600
B	1200
C	800
D	560
E	320
F	200

Hourly Meteorological Data: Secondary data

- Mixing height
  - Holzworth Method
    - provides twice-per-day (morning and afternoon) mixing heights using upper-air data (sounding)
    - **Morning**: height above ground at which the dry adiabatic extension of the **morning minimum** surface temperature plus **5ºC** intersects the vertical temperature profile observed at 1200 Greenwich Mean Time (GMT).
    - **Afternoon**: height above ground at which the dry adiabatic extension of the **afternoon maximum** surface temperature intersects the vertical temperature profile observed at 1200 Greenwich Mean Time (GMT).
    - EPA’s MIXHT software
  - Hourly Interpolation
    - Meteorological preprocessor software: EPA: PCRAMMET, MPRM

Hourly Meteorological Data: Secondary data

- Mixing height
  - Parametrization of surface data:
    - Vertical temperature gradient
    - Boundary Layer Parameters
      - Friction velocity.
      - Monin-Obukhov Length
    - Meteorological preprocessor software: EPA, AERMET

$$\frac{dh}{dt} = (1 + 2A)\frac{S}{\rho C_P \gamma_\theta h} + 2B\frac{u_*^3 T}{g\gamma_\theta h^2}$$

For convective mixing layer: during the day

$$h = \frac{\alpha U^*}{f}$$

For mechanical mixing layer: during the night

Hourly Meteorological Data: Excluding Pasquill class and mixing height

Year of data

Month (1-12)

Day (1-31)

Hour (1-24)

1÷8760 Hours per year

Recommended 90%

Wind direction

Wind speed (m/s)

Ambient temperature (K=^{o}C+273)

93	1	1	1	110	0.60	295.0
93	1	1	2	110	1.10	294.9
93	1	1	3	110	0.60	294.7
93	1	1	4	100	0.60	294.6
93	1	1	5	100	0.60	294.3
93	1	1	6	120	0.60	294.3
93	1	1	7	110	0.60	294.1

Hourly Meteorological Data: Including Pasquill class and mixing height

Year of data

Month (1-12)

Day (1-31)

Hour (1-24)

1÷8760 Hours per year

Wind direction (degree from North)

Wind speed (m/sec)

Ambient temperature (K=^{o}C+273)

Pasquill (stability) class (1 to 6)

Mixing height, m

89	1	1	1	.0	2.0	279.0	3	800
89	1	1	2	.0	2.0	279.0	3	800
89	1	1	3	.0	2.0	279.0	6	200
89	1	1	4	20.0	1.0	278.0	6	200
89	1	1	5	20.0	1.0	278.0	6	200
89	1	1	6	20.0	1.0	278.0	6	200
89	1	1	7	20.0	2.0	278.0	6	200

Receptor Data

- Anything that is affected by the presence of a particular pollutant (human health, agricultural crops and building materials)
- Mandatory Input
  - Regional population density, $\rho_{Regional}$, persons/km^2
- Optional Input
  - Local population density, ρ_{Local}, persons/km^2
  - Size local domain, km
  - Gaussian distribution for urban area
  - Details local population distribution
    - Resolution of 5 x 5 square km

Receptor Data

- Options
  - Regional population density, $\rho_{Regional}$, persons/km^2
  - Local population density, ρ_{Local}, persons/km^2
    - Size of local domain, km
  - Gaussian distribution for urban area
  - Details local population distribution
    - Resolution of 5 x 5 square km

Regional population density, $\rho_{Regional}$

- Regional domain: Size of regional scale,
  - Default value: 1000 km from emission source
- Regional population: Number of persons living inside the regional domain
  - value > 0 persons per km2
- Regional population density: Number of persons living per km^2 inside the regional domain,
  - Regional Population/Area of the Regional Domain
  - value > 0 persons/km

Regional population density, $\rho_{Regional}$

- The Regional population (people per square km) is the number of persons affected by air pollution normalized by the impact area. The impact domain is a circle centered at the source with radius R_{Impact}. The impact area (πR^2_{Impact}) includes both land and water surfaces.
  - u = wind speed (2 to 4 m/s);
  - hmix = mixing height (500 to 1000 m);
  - kp = depletion velocity (0.5 to 3 cm/s);
  - _ = receptor density
- When the value of RImpact is greater than 1000 km, a value of a 1000 km should be used in the analysis.

$$R_{Impacto} = -\frac{u\,h_{mix}}{k_p} Ln\left[0.05\left(\frac{\rho_{Local}}{\rho_{Reg}}\left(1 - e^{\left(\frac{-50000k_p}{u\,h_{mix}}\right)}\right) + e^{\left(\frac{-50000k_p}{u\,h_{mix}}\right)}\right)\right]$$

Regional domain

Local population density

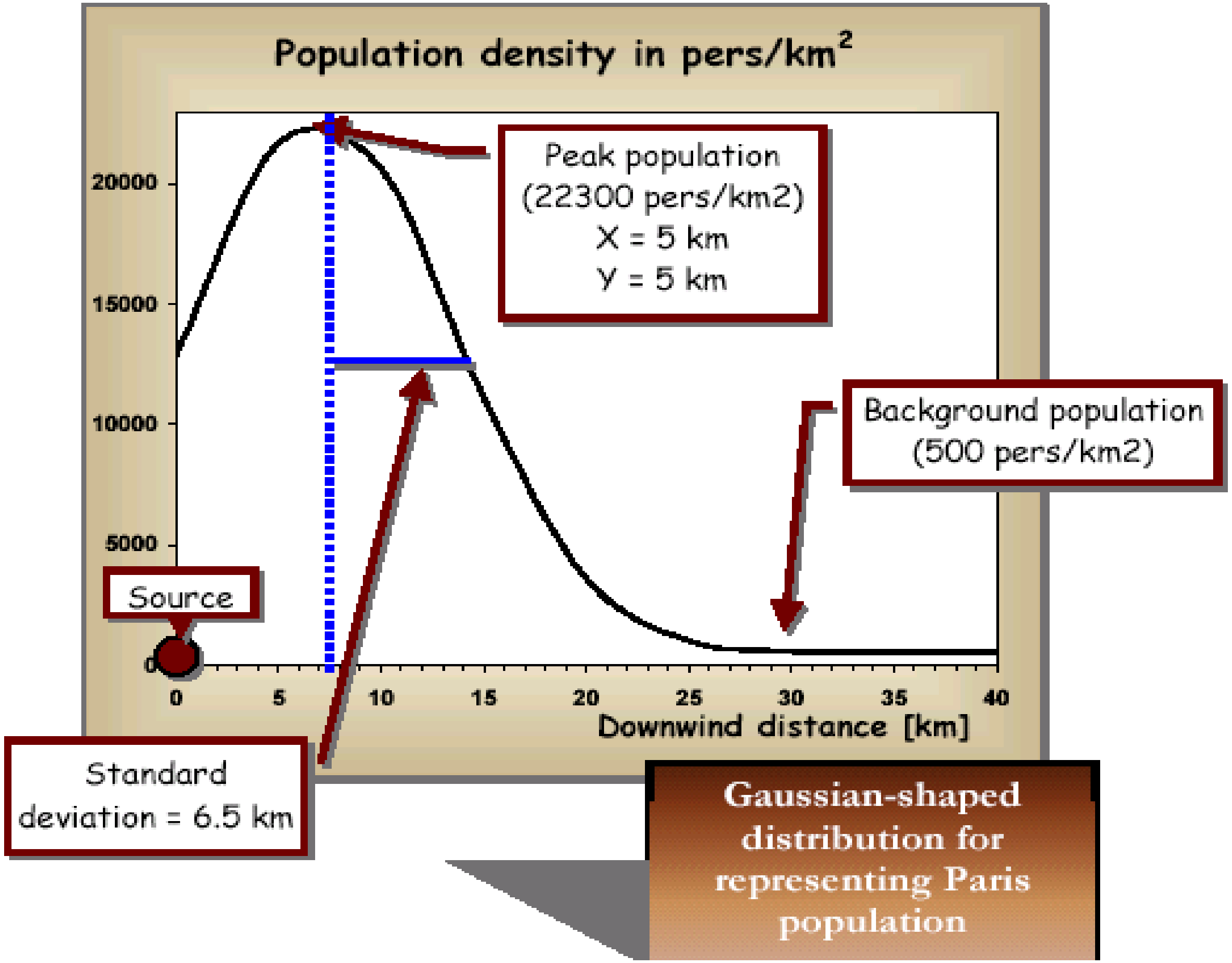
- Local domain: Size of local domain centered at the emission source
  - Up to 50 km from emission source
- Local radius: Radius of local domain
  - For default 56 km (Equivalent of a circle with the same area that an square of 100 x 100 km)
- Local population: Number of persons residing in the local domain
  - value > 0 persons per km2
- Local population density: Number of persons living per km^2 within the local domain
  - Local Population/Area of the Local Domain
  - value > 0 persons per km^2

Gaussian distribution for urban area

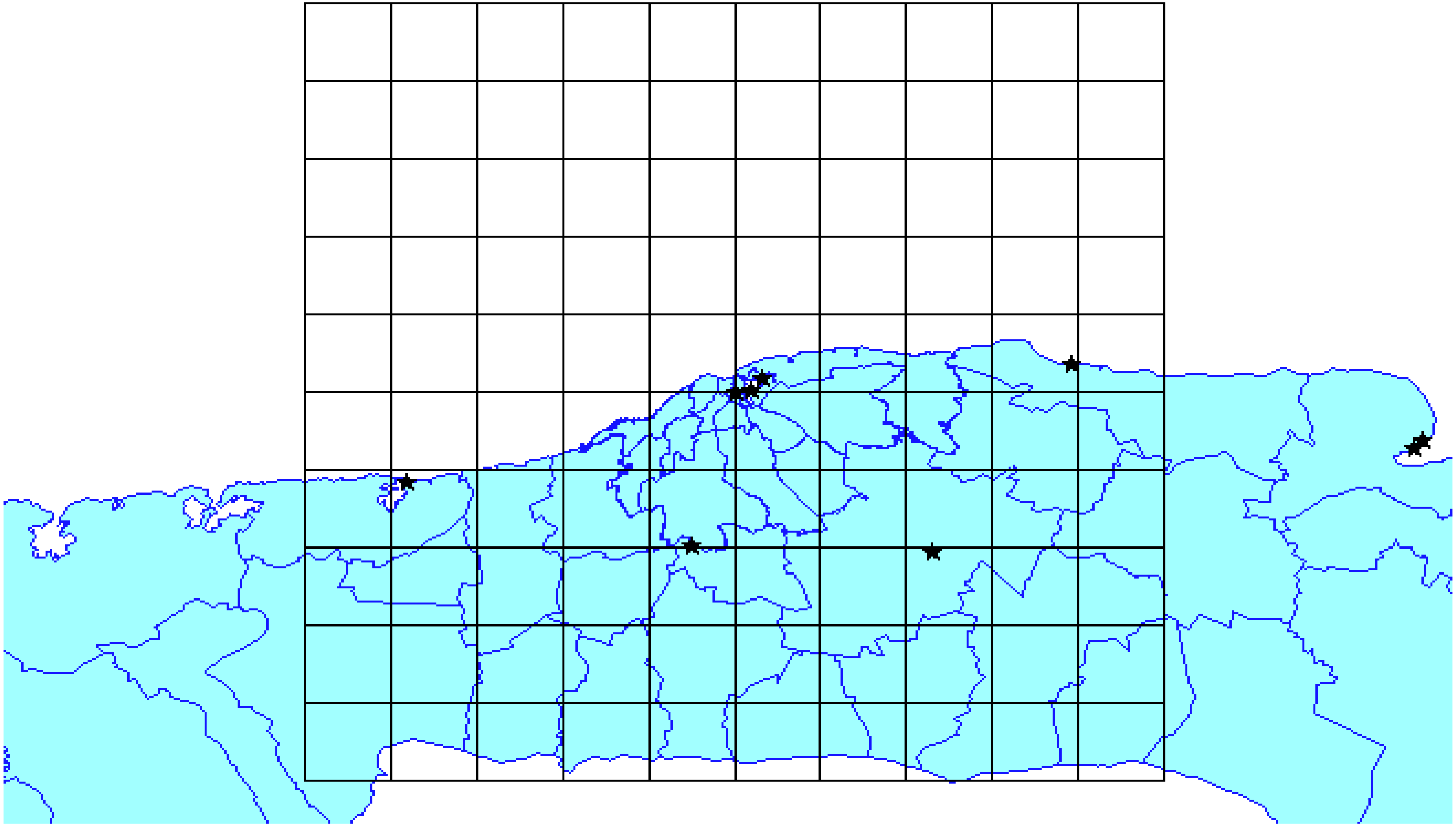
Approximating the population distribution of a city to a Gaussian-shaped function using the variables:

- Peak population,
  - value > 0 persons/km2,
- X and Y coordinates: Position of the peak of the population relative to the location of the source, or the origin of the coordinate system,
  - value > 0 km,
- Background population: The receptor density sufficiently far from the city,
  - value > 0 persons per km2,
- Standard deviation: Roughly half of the size of the city
  - value > 0 km

Gaussian distribution for urban area



Details local population distribution
Resolution of 5 x 5 square km



Details local population distribution Resolution of 5 x 5 square km

•X direction in km, -50 to 50 km, step of 5 km
•Longitud

	-47.5	-42.5	-37.5	-32.5	-27.5	-22.5	-17.5	-12.5	-7.5	-2.5	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5
47.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	2740	2740	5516	5516	2349	2349	366	366	0	0	0	0	0	0	0	0	0	0
2.5	0	0	2740	2740	5516	5516	2349	2349	366	366	0	[illegible]	0	0	0	0	0	0	0	0
-2.5	227981	227981	72564	72564	23385	23385	18910	18910	2263	2263	1986	1986	1723	1723	3023	3023	8893	8893	2679	2679
-7.5	227981	227981	72564	72564	23385	23385	18910	18910	2263	2263	1986	1986	1723	1723	3023	3023	8893	8893	2679	2679
-12.5	53920	53920	50952	50952	10915	10915	4486	4486	2484	2484	2094	2094	1810	1810	6317	6317	7645	7645	6568	6568
-17.5	53920	53920	50952	50952	10915	10915	4486	4486	2484	2484	2094	2094	1810	1810	6317	6317	7645	7645	6568	6568
-22.5	15158	15158	13878	13878	2761	2761	2712	2712	2852	2852	2358	2358	1745	1745	2150	2150	1314	1314	1421	1421
-27.5	15158	15158	13878	13878	2761	2761	2712	2712	2852	2852	2358	2358	1745	1745	2150	2150	1314	1314	1421	1421
-32.5	2681	2681	2971	2971	2578	2578	2755	2755	3830	3830	3374	3374	1719	1719	1365	1365	1246	1246	1361	1361
-37.5	2681	2681	2971	2971	2578	2578	2755	2755	3830	3830	3374	3374	1719	1719	1365	1365	1246	1246	1361	1361
-42.5	2691	2691	3113	3113	2559	2559	2612	2612	3622	3622	2272	2272	1589	1589	1187	1187	1240	1240	1392	1392
-47.5	2691	2691	3113	3113	2559	2559	2612	2612	3622	3622	2272	2272	**1589**	1589	1187	1187	1240	1240	1392	1392

•y direction in km, -50 to 50 km, step of 5 km
•Latitud

•Number of persons in 400 cells of 25 km^2 (5 x 5 km)

Exposure Response Function

for health impacts

- ***Fer(r,C(r,Q))=fer(r) ×C(r,Q)*, where *fer=∂Fer /∂C is the slope of the function***
- mandatory input
- relates the pollutant ambient concentration to the resulting impact on a receptor or sub-group at risk (adults, children, crop, etc.)
- **straight lines with no threshold**, the line passes through the origin at zero concentration.
- slope is always positive and numerically less than 1 if expressed as annual cases/(year-receptor-µg/m3)
- **IRR: Increased Risk Ratio** is the % change in the natural rate of occurrence of a particular disease (morbidity) or mortality in the population at risk relative to the **Baseline rate** per unit change in ambient concentration
  - typically expressed in %/µg/m3
- **Baseline** or nominal rate of occurrence of a particular disease in annual cases per receptor (adult, child, etc.)
  - mandatory input if selecting AirPacts built-in ERFs
  - cases/(year-receptor)
- IRR and Baseline are positive numbers.

Exposure Response Function
for health impacts

- **For Morbidity Impacts**

ERF slope = IRR x Baseline = IRR x Incidence x f_{POP}

  - **f_{POP}:**fraction of the population affected (for ex., % adults in the exposed population):

- **For Mortality Impacts:**
  - Baseline=Mortality rate YOLL/ /(year-receptor)
  - ERF slope = IRR x Mortality Rate x YOLL/death
  - YOLL: Years of Life Lost or Life Loft Expectancy
  - Acute Mortality 1 death~0.5 YOLL
  - Chronic Mortality 1 death~10 YOLL

Monetary Unit Cost

- Cost factor for monetizing the physical impacts and environmental burdens. For example,
  - the cost per asthma attack or
  - the cost per year of life lost (YOLL).
- For health impacts include:
  - the cost-of-illness (medicines and hospitalization),
  - wage and productivity losses
  - and non-market considerations that take into account the person's willingness to pay to avoid the pain and suffering accompanying disease.
  - Number > 0 US$ per case

Monetary Unit Cost

$$Unit\_Cost\ in\ a\ country = Unit\_Cost\ REf\_Study\ \frac{PPP\ GNP_{Country}}{PPP\ GNP_{REF\ \ STUDY}}$$

- *PPPGNP:* Purchasing Power Parity of the Gross National Product normalized per capita
- **Reference Study:**
  - **ExternE**
  - **US studies**

Geographical Information System: Processing input data

Source geographical coordinates
Latitud: 23.13
Longitud: -82.36

d_{Lat}: distance in km per latitude degree
d_{Long}: distance in km per longitude degree

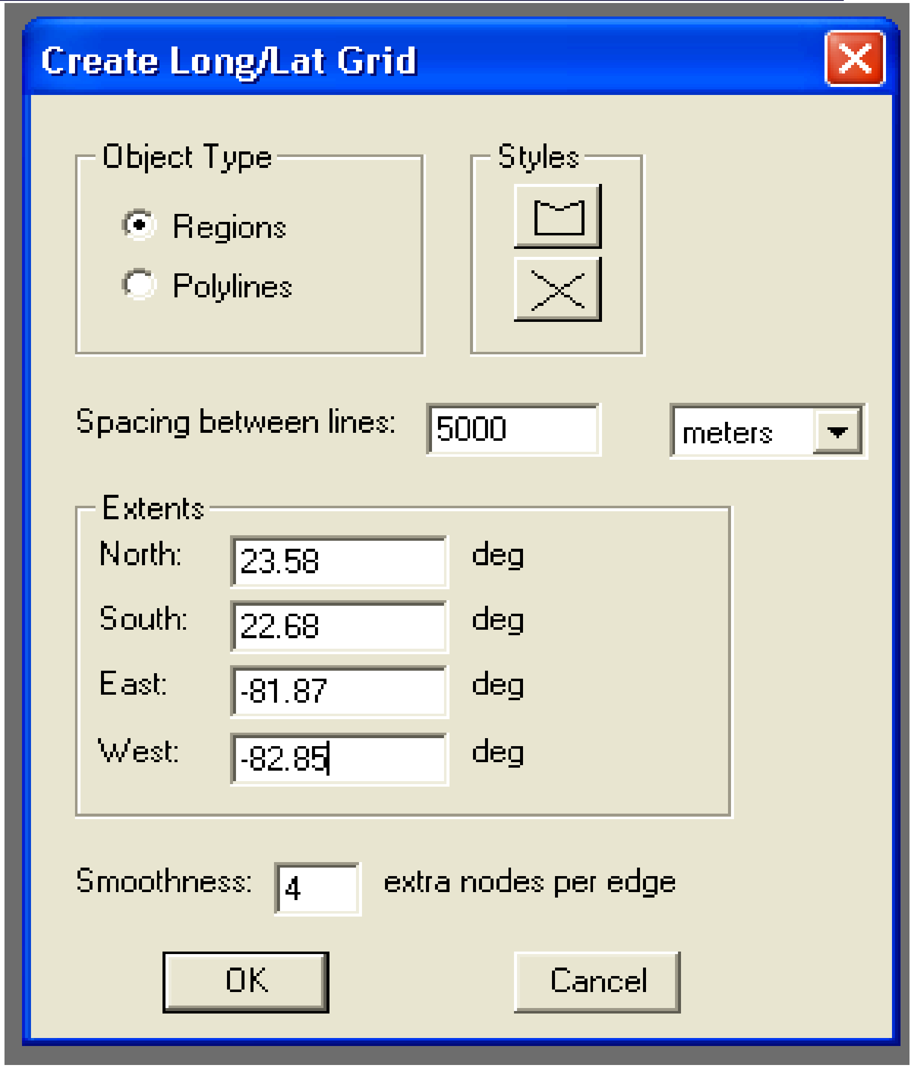
$$North = Latitud + \frac{50}{d_{Lat}}$$

$$South = Latitud - \frac{50}{d_{Lat}}$$

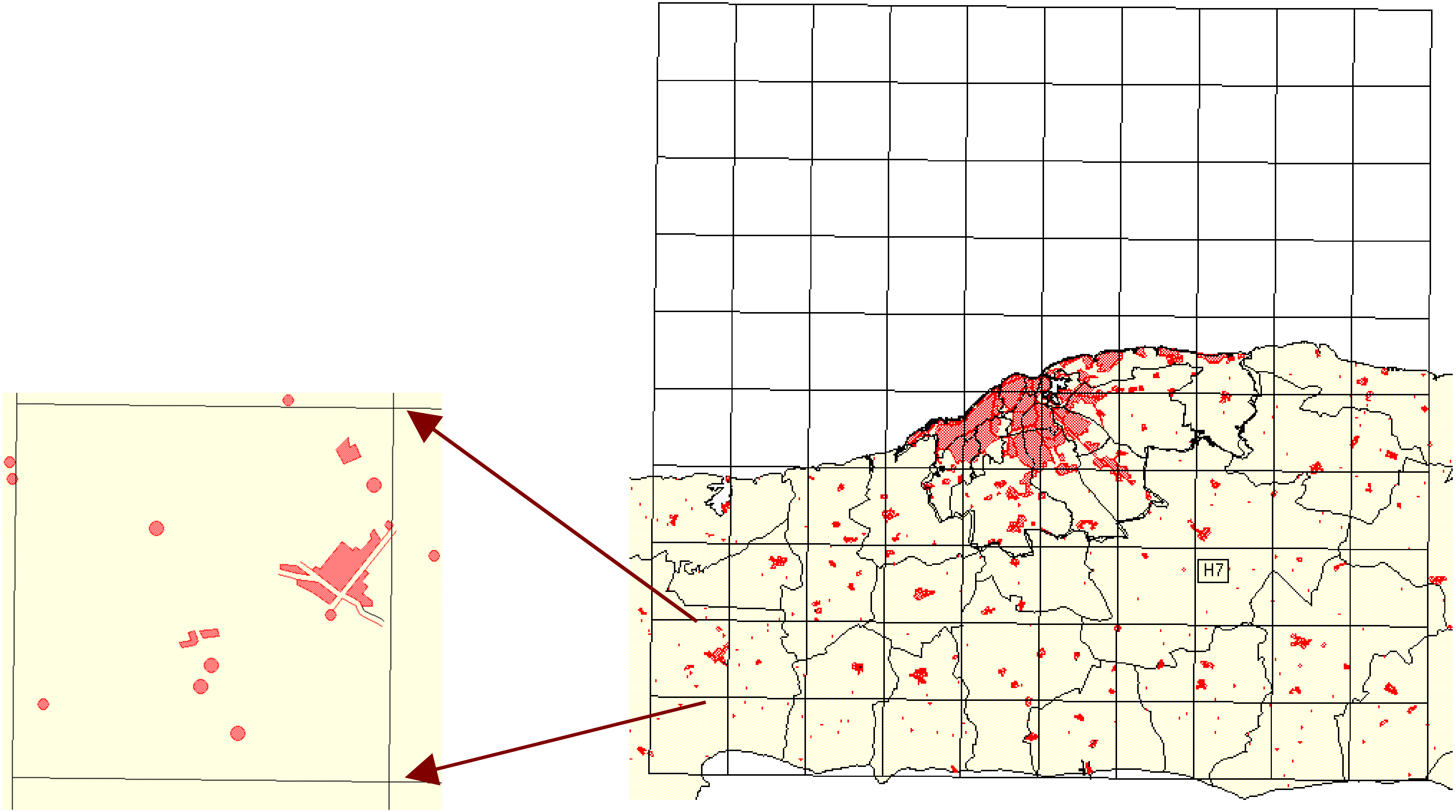
$$East = Longitude + \frac{50}{d_{Long}}$$

$$West = Longitude - \frac{50}{d_{Long}}$$

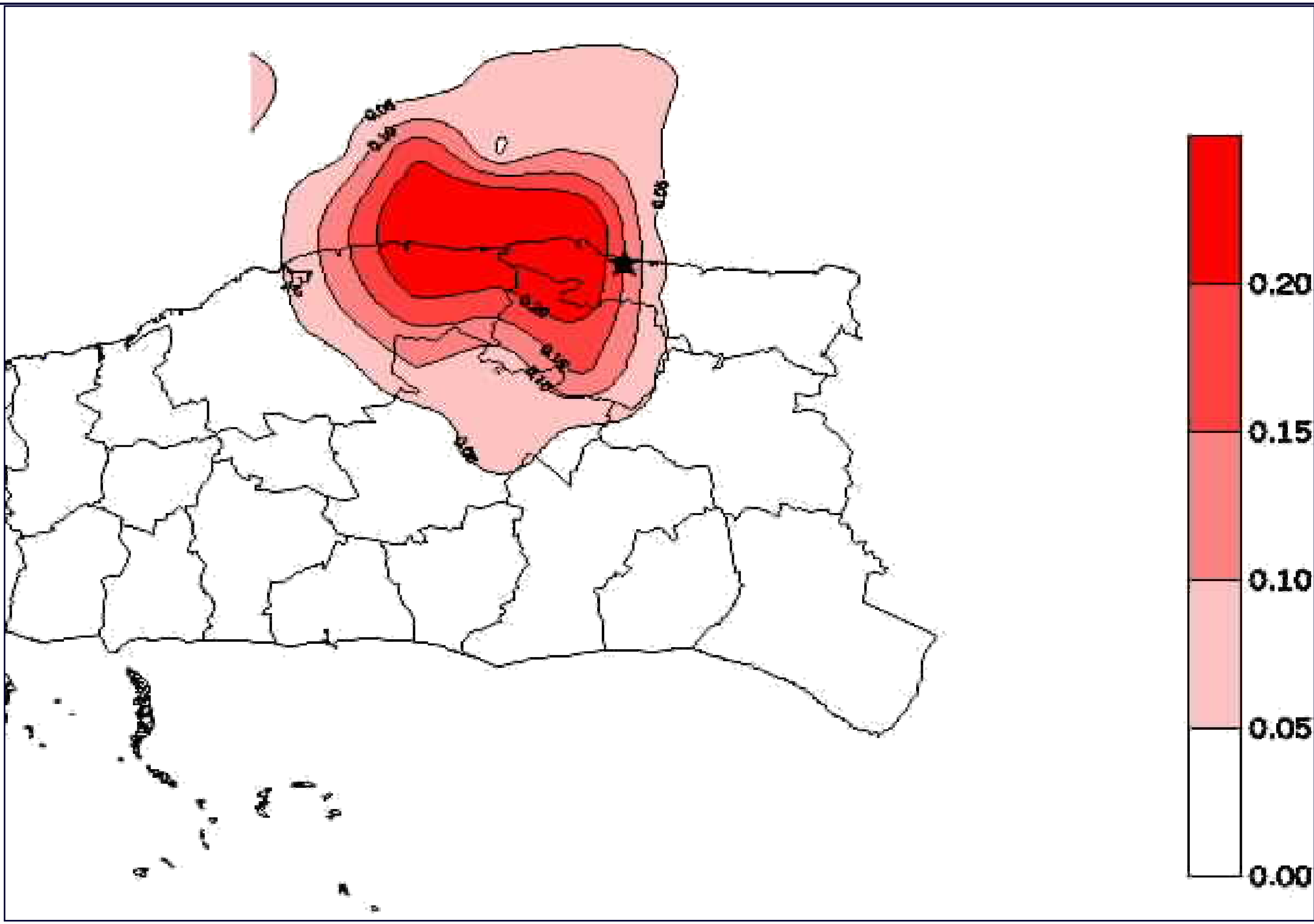
$$d_{Lat} = \frac{2\pi\sqrt{(1 - sen^2 Lat)Lat^2}}{360} \qquad d_{Long} = \frac{2\pi R_{meridians}}{360}$$



Geographical Information System:
Processing input data



Geographical Information System: Showing results



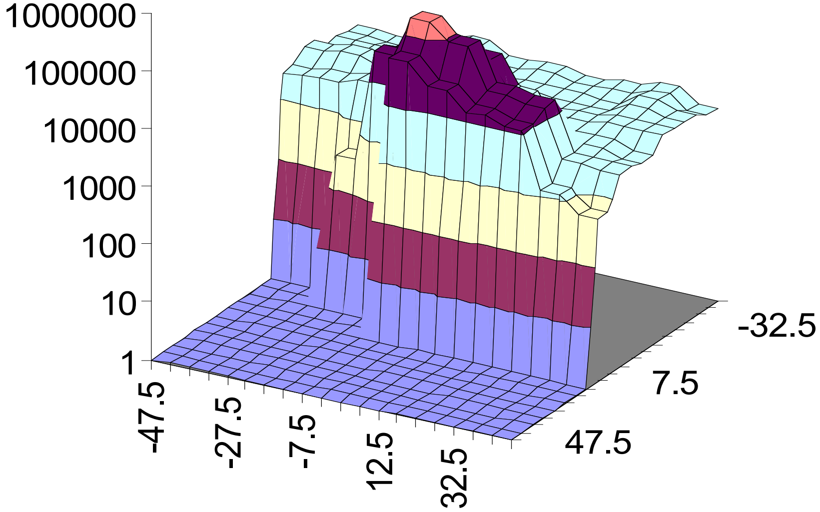
Simplified methodologies:SIMPACTS

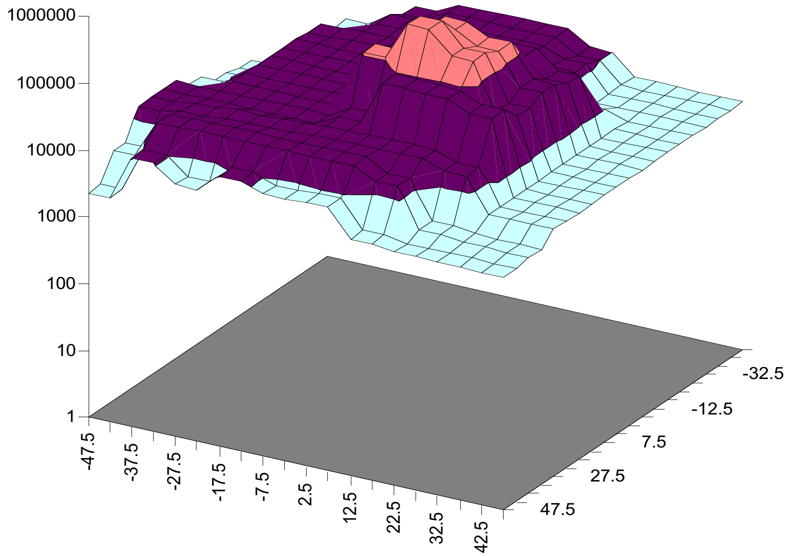
1. AIRPACTS, based in SUWM
   - Human Health:
     - RUWM: Basic, Intermediate and Best Estimations
     - QUERI: Basic, Intermediate and Best Estimations
     - URBAN: Basic and Best Estimations
   - Agricultural Crops and Materials: AGRIMAT
2. NUKPATCTS
3. HYDROPACTS
4. DAM: Decision Analysis Module

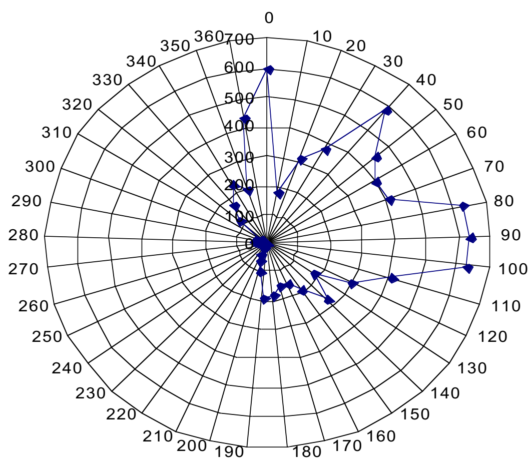
SUWM vs RUWM vs QUERI vs URBAN

- how sensitive is the final result to the input dataset?
- how the results change by not having access to all the number?
- did one really need to know ALL the numbers to get a "reasonable" estimate of the impact?

Inland and coast location
Case 1: Coast, Case 2: Inland

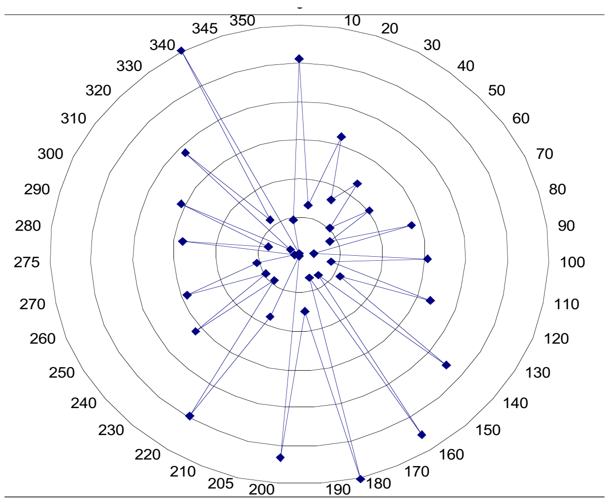






Queri Best Estimate vs Queri Intermediate estimate

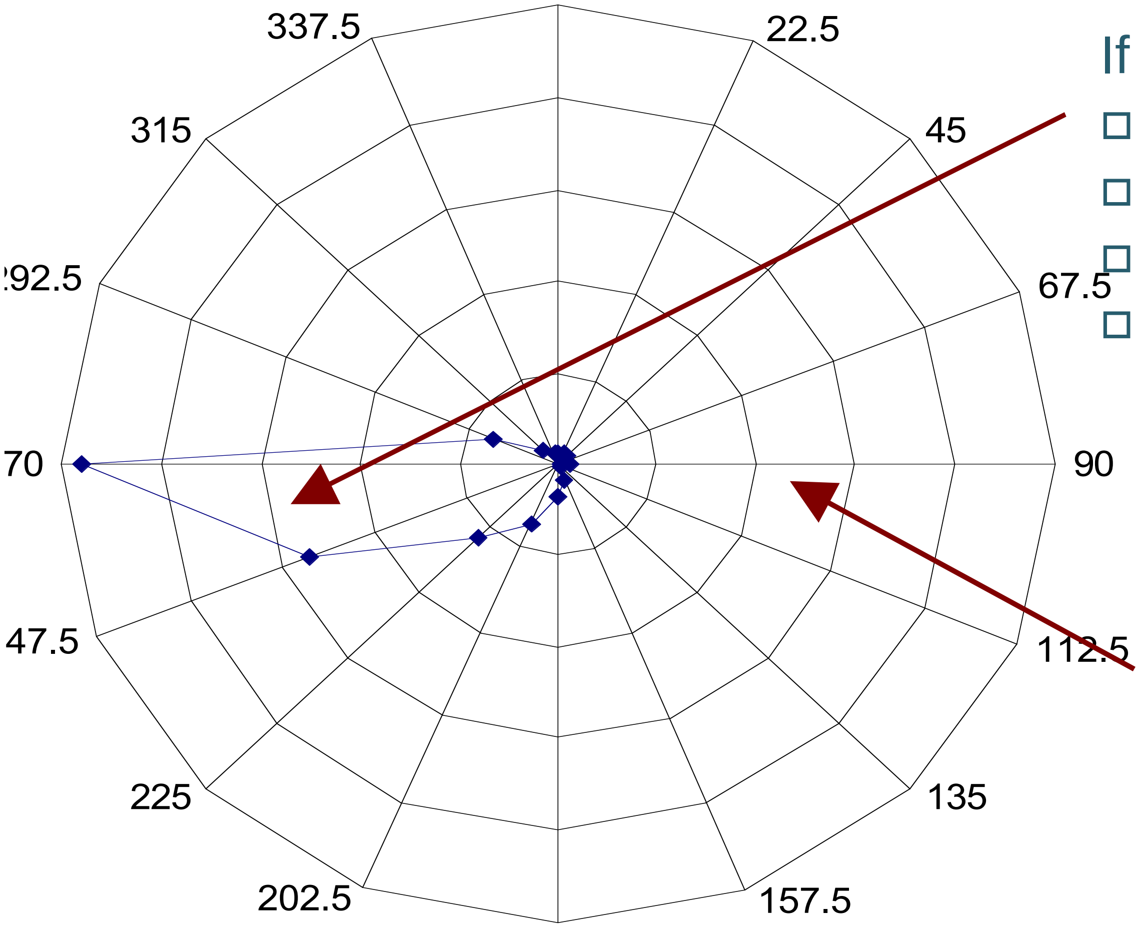
- Case 1: 57.1%
- Case 2: 3.6%



Coast Locations, other considerations

Stack parameters	MD+OD	Mandatory + Optional Data (MD+OD)			
Pollutant inventory					
Receptor data	Local density	5 x 5	5 x 5	5 x 5	5 x 5
Meteorological data	Statistical	Detailed	Detailed + Passquill + hmix	Detailed + Passquill+hmix rotated 180º	Detailed rotated 180º
Model/Estimation	Queri / Intermed.	Queri / Best			
Impacts (cases/year)	123	17.4	17.1	54.8	57.4

Again



If there is a City located here

- Plant location is wrong
- Queri/Intermed < Queri/Best
- To improve Queri/Interm results
- Local density=Local density in area over blow the wind

If there is a City located here

- Plant location is OK
- Queri/Intermed > Queri/Best

Again

If there is a City located here

- Plant location is wrong
- Queri/Intermed < Queri/Best
- To improve Queri/Interm results
- Local density=Local density in area over blow the wind

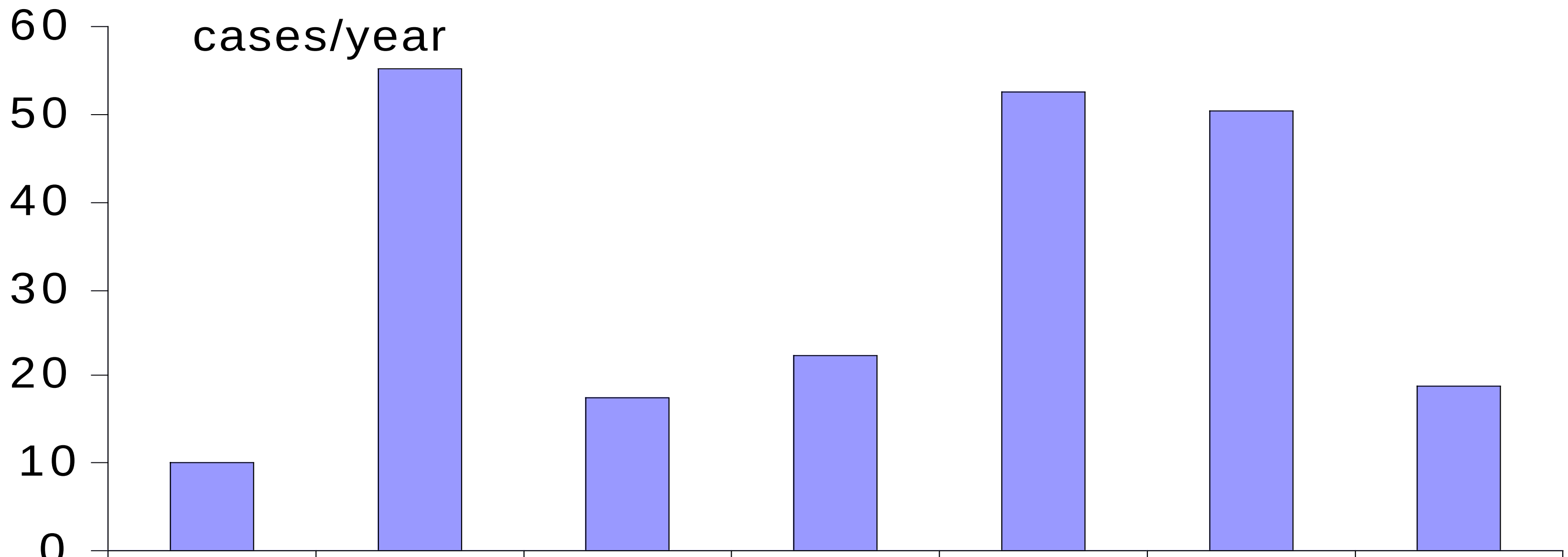
If there is a City located here

- Plant location is OK
- Queri/Intermed > Queri/Best

SUWM vs RUWM vs QUERI vs URBAN

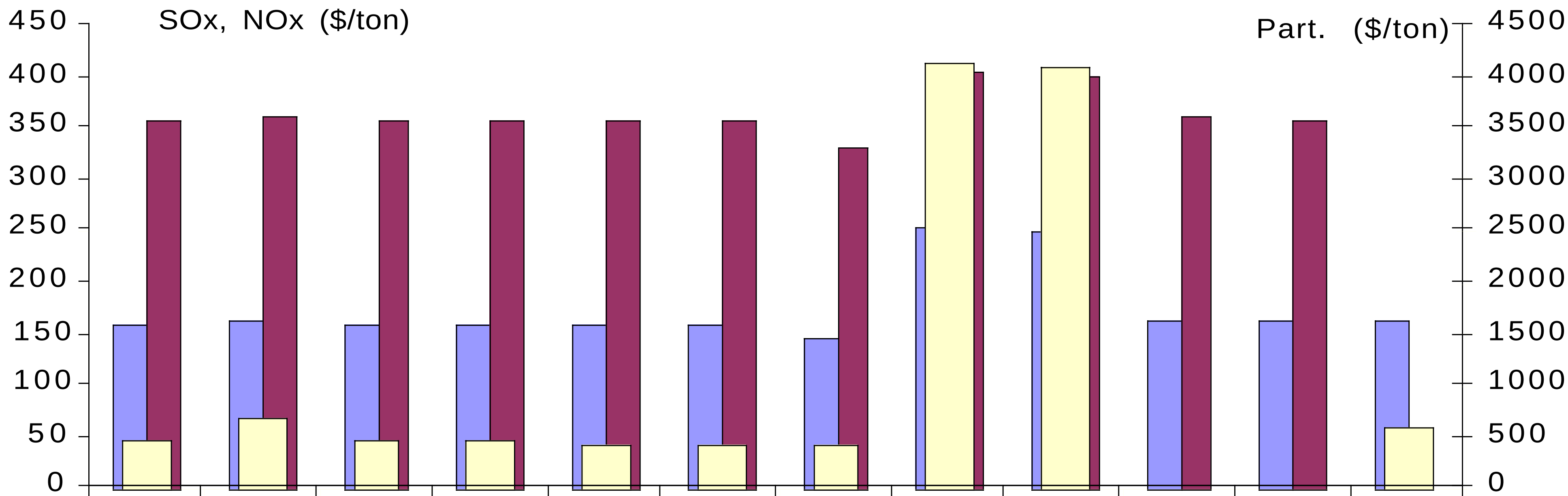
- There are no right or wrong answers, only how appropriate are the assumptions used in a particular model/estimation to describe the existing site/source characteristics
- Different models would give similar answers, despite the different model assumptions that are used , if one were to match more closely the input data with actual site characteristics:
  - if the wind direction is primarily from the North, the population at risk lies to the South of the source. It is this population density or distribution that should be inputted in the RUWM and URBAN models. Then the answers given by QUERI, URBAN and RUWM would be closer to one another.
  - the receptors that matter the most due to exposure to primary pollutants are those located closest to the source, not 40+ km away. The local population density (assuming a radius of 50 km) might, therefore, be "artificially" too high and so the answer is too large.

How to summarize the numbers in tables and figures? Impacts in cases/year



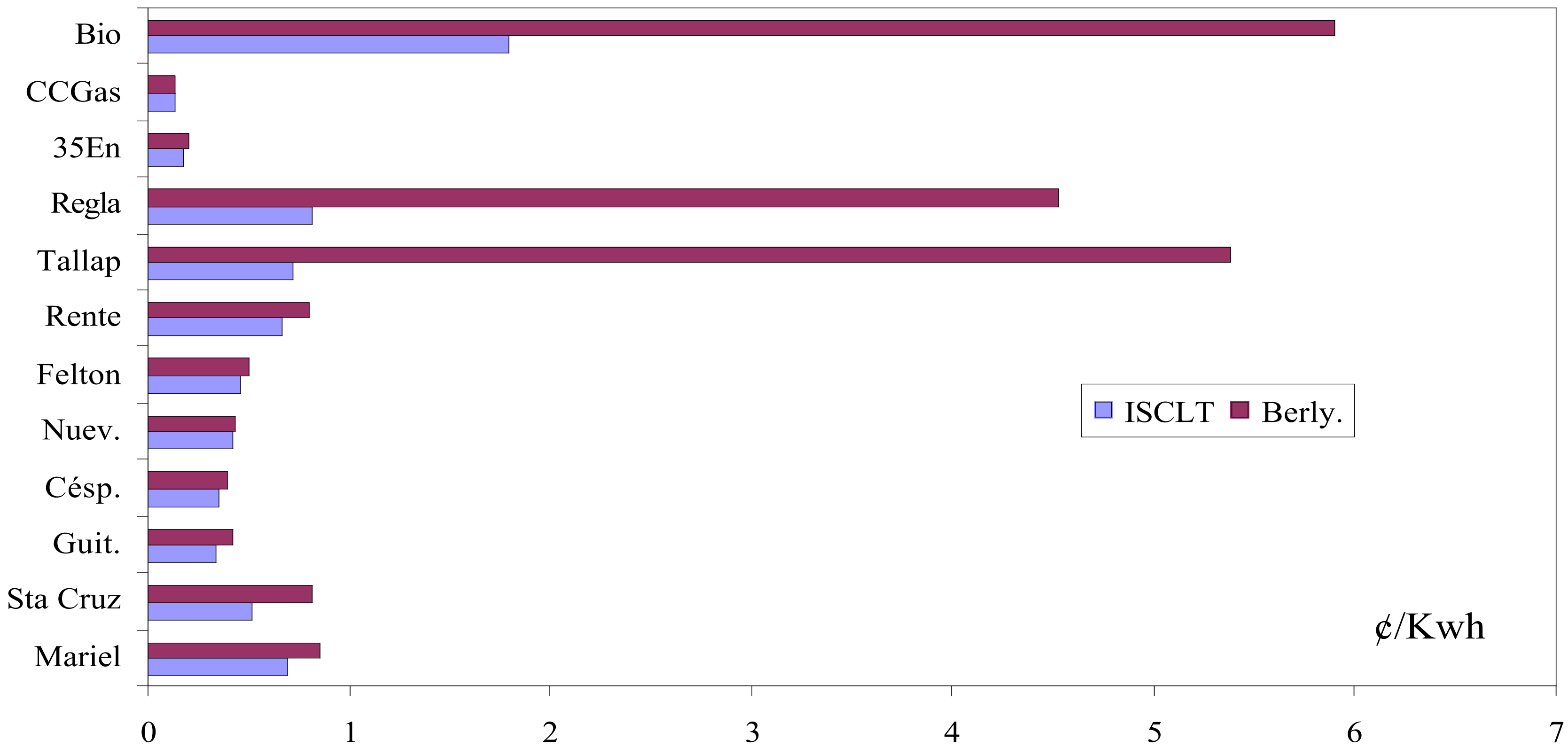
	SUWM	RUWM	RUWM	URBAN	Queri	Queri	Queri
ID=0	10	55	18	22	52	51	19

How to summarize the numbers in tables and figures?
Damage cost, US$/ton



	Mariel	Sta Crz	Guit.	Césp.	Nuev.	Feltón	Rente	Tallap	Regla	35En	CCG	Bio
SOx	159	165	159	159	158	158	148	254	252	164	162	163
NOx	358	361	358	358	358	358	334	404	403	361	360	0
Part.	465	685	469	462	423	414	408	4130	4087	0	0	610

How to summarize the numbers in tables and figures? Damage cost, ¢/kWh



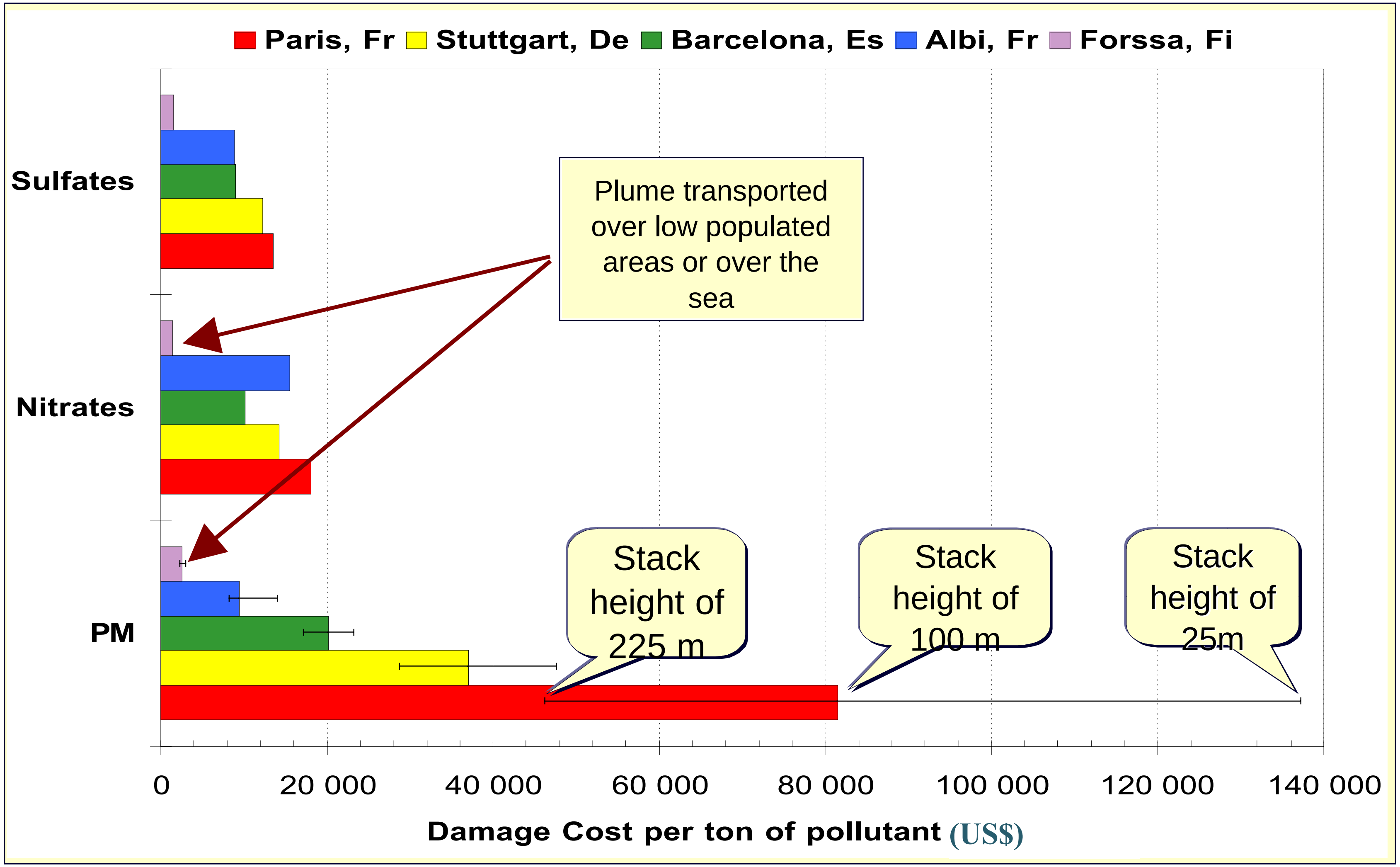
	Mariel	Sta Cruz	Guit.	Césp.	Nuev.	Felton	Rente	Tallap	Regla	35En	CCGas	Bio
Berly.	0.86	0.81	0.42	0.4	0.44	0.5	0.8	5.38	4.53	0.21	0.14	5.9
ISCLT	0.7	0.51	0.34	0.36	0.42	0.46	0.67	0.72	0.82	0.17	0.13	1.8

Strength of SimPacts

- Available and flexible
- Transparent
- Simple to use
- Requires limited input data
- Provides results that are reasonably accurate & reliable as determined by comparison with results calculated by sophisticated environmental impact assessment codes

Possible uses

Geographical sitting of plants

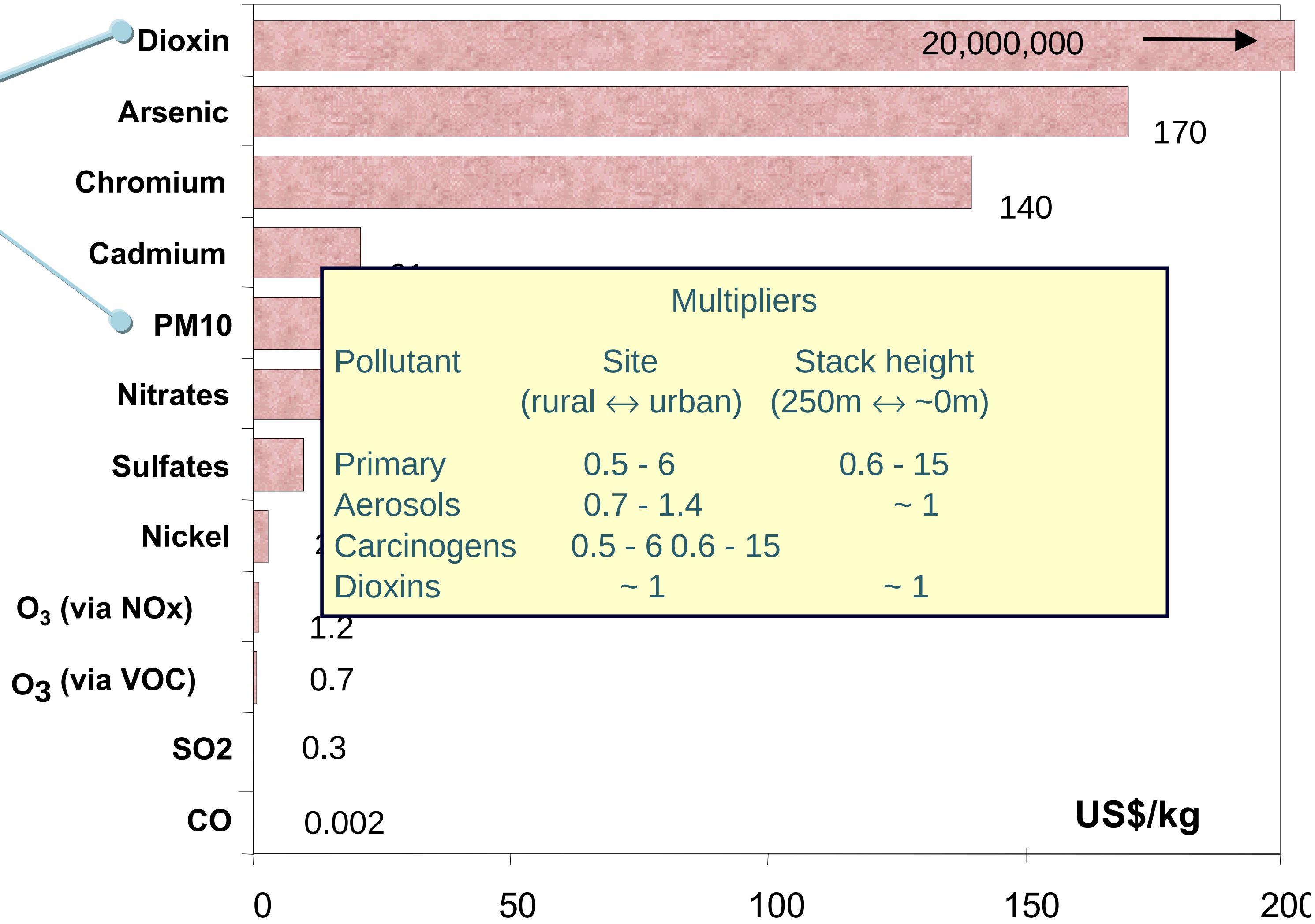


Source: Spadaro 1999

Damage cost per kg

Annual emissions
for typical incinerator
(EC 2000 directive)

Dioxins: 0.00013 kg
PM_{10}: 13,000 kg
PM_{10} / dioxins: 10^8



Multipliers

Pollutant	Site (rural ↔ urban)	Stack height (250m ↔ ~0m)
Primary	0.5 - 6	0.6 - 15
Aerosols	0.7 - 1.4	~ 1
Carcinogens	0.5 - 6	0.6 - 15
Dioxins	~ 1	~ 1

- DAM
- Dispatching decisions
- Mitigation strategies

Process or technology assessment (pollution damages vs. other benefits) Abatement Technologies feasibility

Source: Rabl and Spadaro 2002

Limitations of SimPacts

- ☺ Impacts in Human Healt, Airpacts,
- ☹ Impacts in agricultural crops and building materials, AGRIMAT
- ☹ Applicability to limited number of crops and building materials, no effects from wet deposition
- 😐 Single, elevated, point sources , multi-source analysis requires multiple runs
- 😐 Routine or steady emission rates, no transient or accidental releases
- 😐 Assumption of uniform dispersion conditions along flat terrain but
- 😐 Local precipitation and chemical transformation not considered ✓
- 😐 No impact and damage cost estimates for forests or other ecosystems
- 😐 No multi-media interactions, air ↔ water ↔ soil