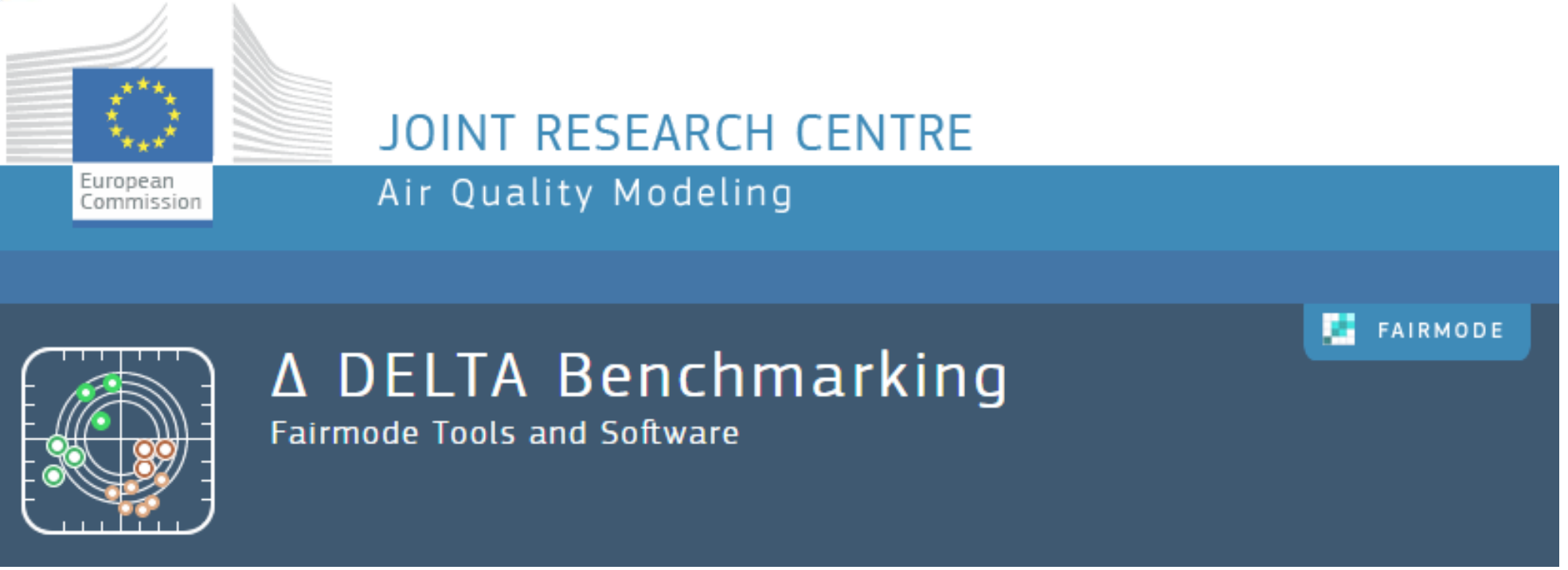


DELTA_Emis tool

ARPA FVG – CRMA
Centro Regionale di Modellistica Ambientale
crma@arpa.fvg.it

Anna Chiara Goglio
Palmanova, Luglio 2017

Index

Motivations

Atmospheric emission inventories

Datasets concerning the amount of air pollutants emitted to the atmosphere

- caused by an economic, social or natural activity
- at a certain geographical location
- for a given period of time

Emission = Emission Factor x Activity Data

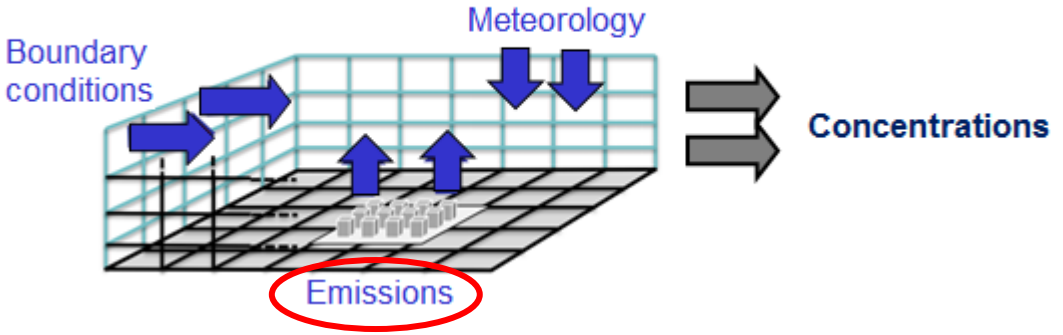
e = rate of emission of a pollutant per activity unit

A = measure of the scale of activity causing the emissions

Motivations

Atmospheric emission inventories

Represent one of the main sources of uncertainty in air quality modeling chains

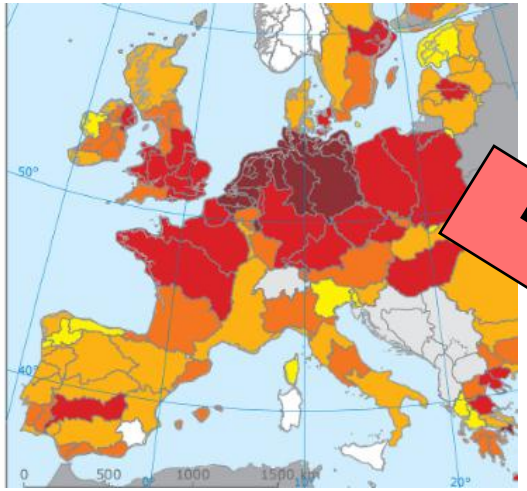


Motivations

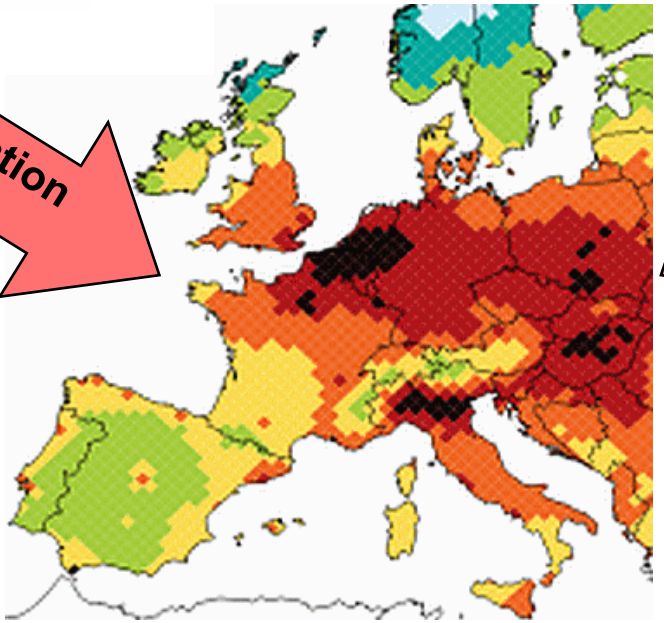
Atmospheric emission inventories estimating approaches

Top-down

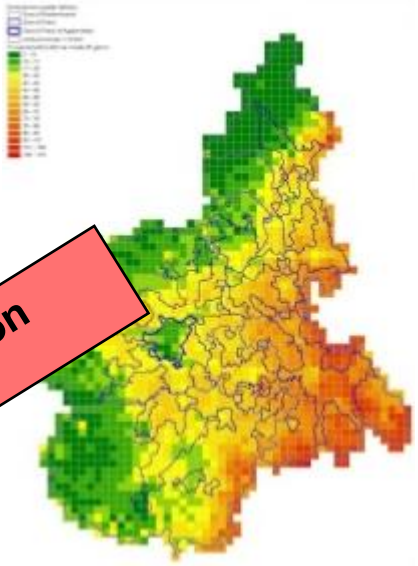
Bottom-up



Disaggregation



Integration



Global/continental/national inventories:

X Low spatial and temporal resoluton

✓ Small amount of data

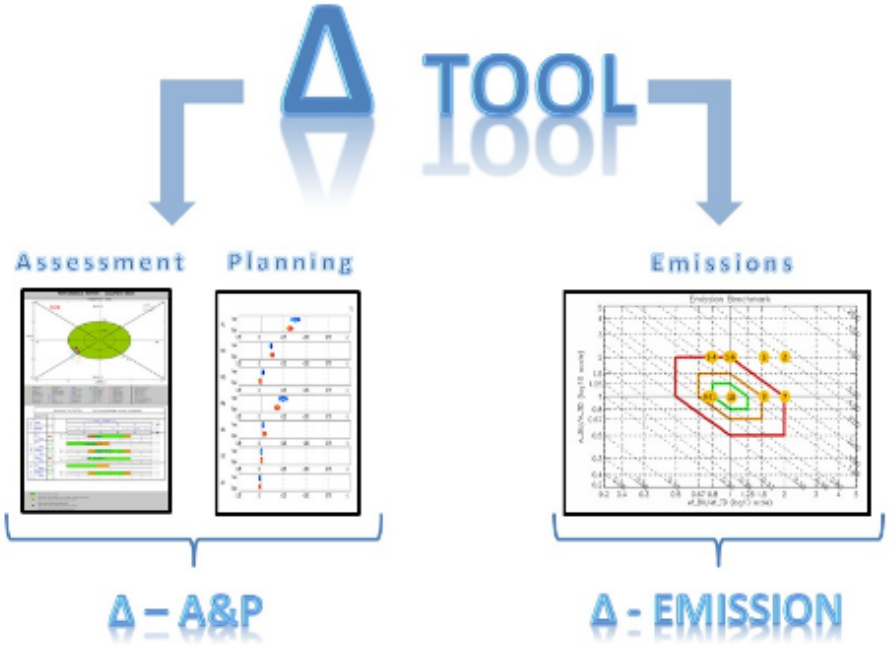
Local inventories:

✓ High spatial and temporal resoluton

X Huge amount of data

The FAIRMODE Δ tool

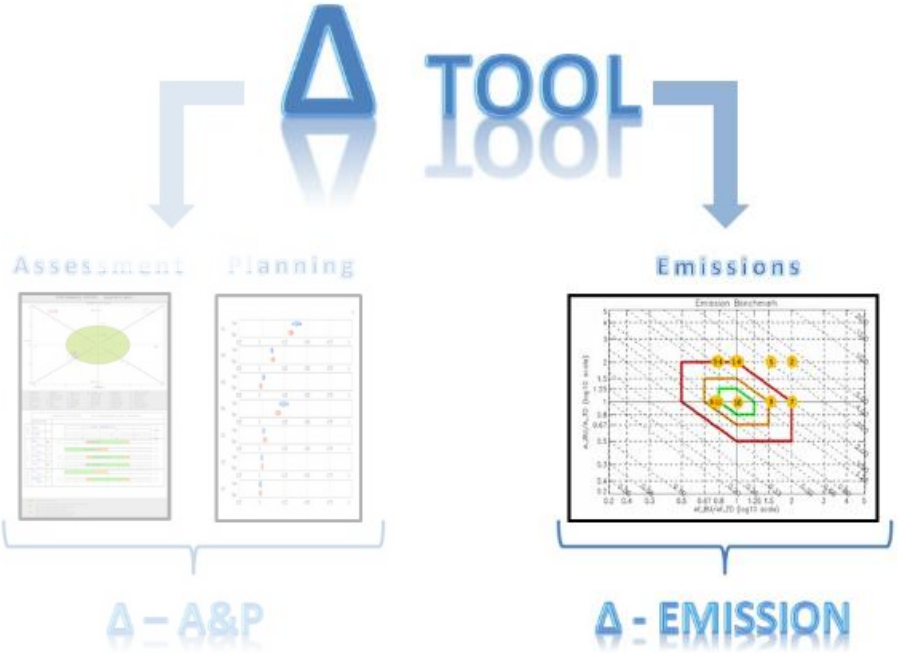
The DELTA software is an IDL-based model evaluation software developed in the framework of the FAIRMODE procedure for benchmarking of Air Quality Directive (AQD) modelling applications.



The tool is structured around two main components: The first (A&P) is dedicated to assessment (comparison of model results with measurements) and planning whereas the second focus on the benchmarking of emission inventories.

The FAIRMODE Δ-EMIS tool

A benchmarking tool to screen and compare atmospheric emission inventories



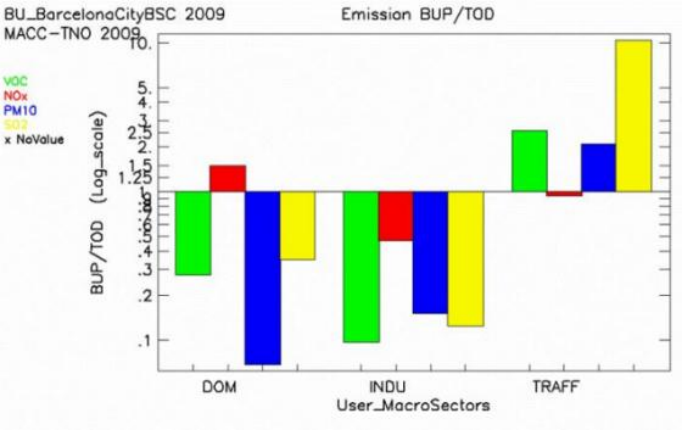
TOD *VS* BUP

TOD *VS* TOD

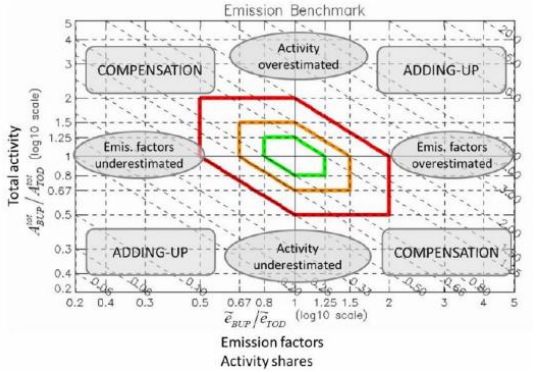
(BUP *VS* BUP)

Index

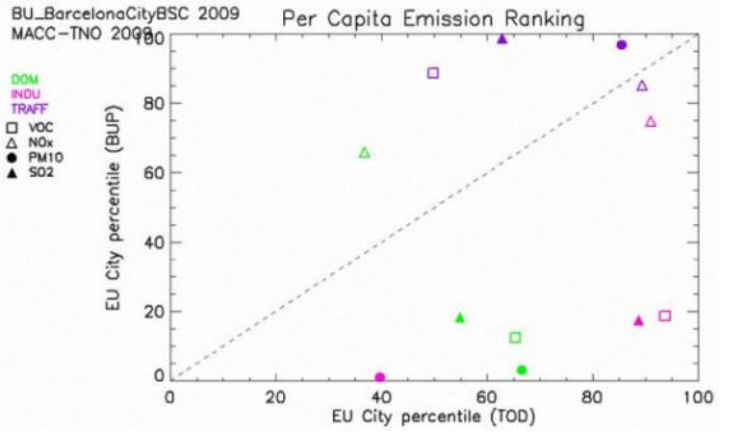
Benchmarking methodology



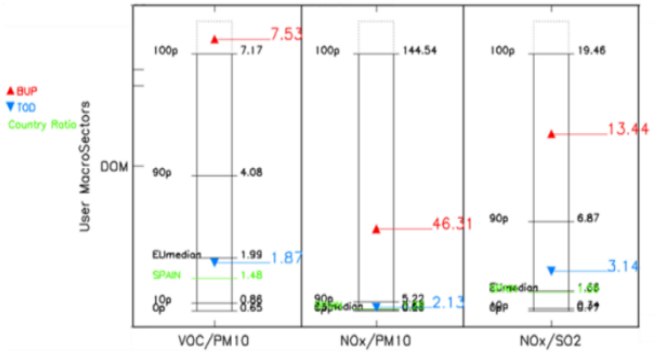
❖ **BAR-PLOT**: total emission comparisons per sector and pollutant



❖ **DIAMOND DIAGRAM**: identification of the different factors causing the discrepancies between total emissions

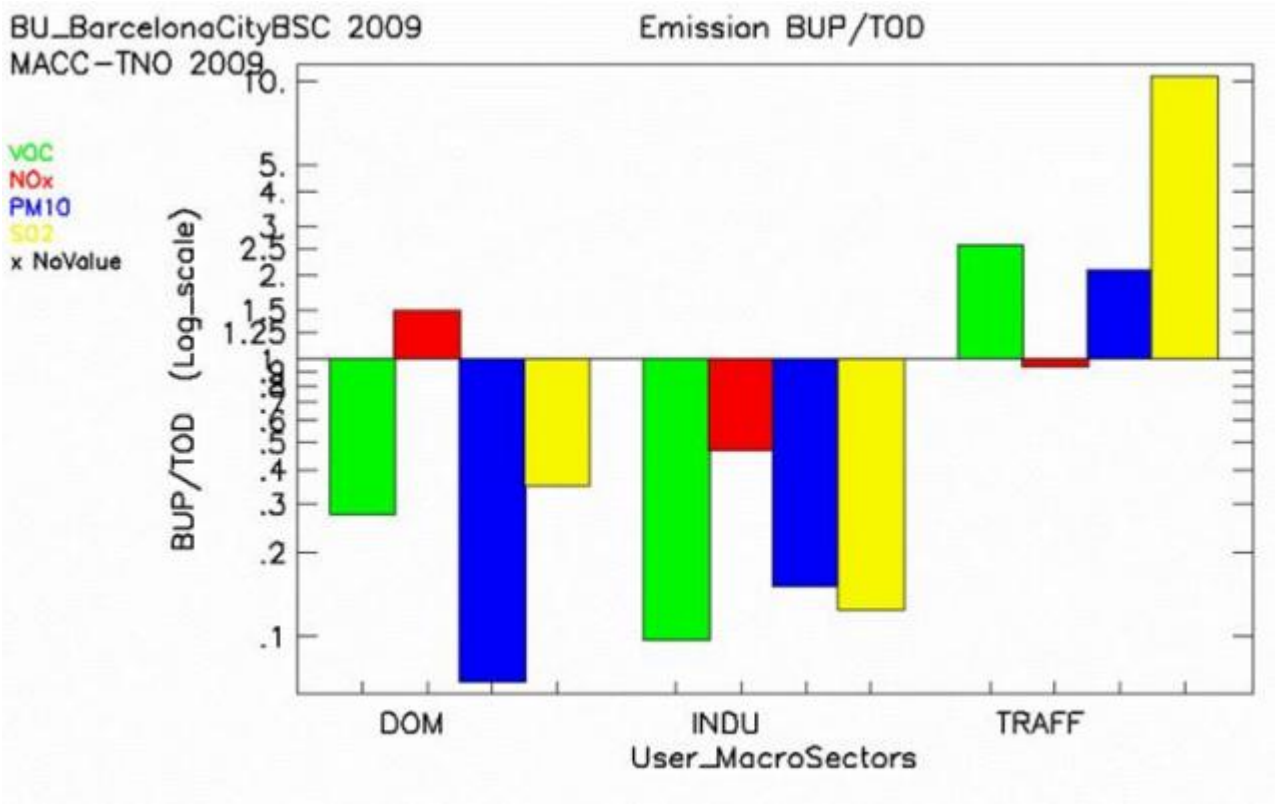


❖ **PER-CAPITA DIAGRAM**: Evaluation of per-capita emissions scaled with respect to the overall EU variability



❖ **RATIO DIAGRAM**: Comparison of pollutant ratios (information about underlying processes)

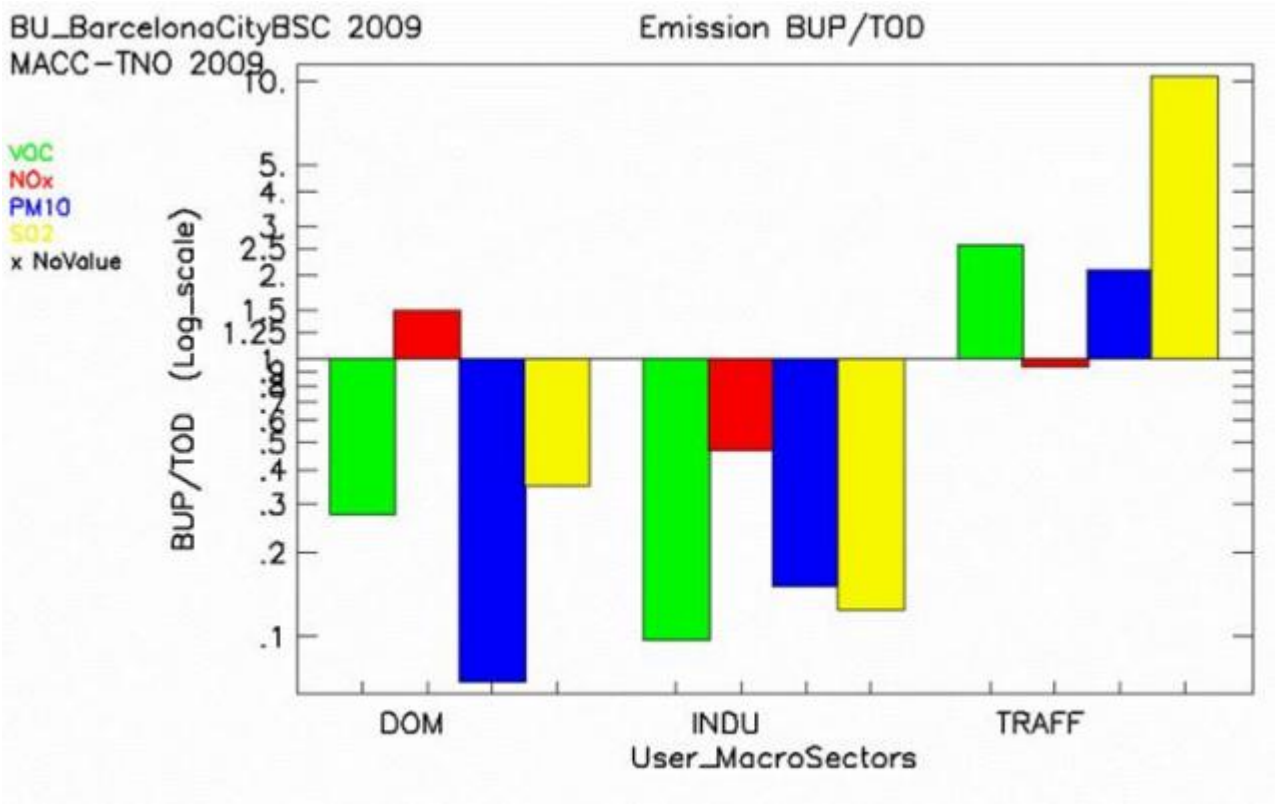
The BAR-PLOT



- Bottom-up total emission ***/*** top-down total emission
- Logarithmic scale

$$\log \frac{{E_{BUP}}^{t,p}}{{E_{TOD}}^{t,p}} \quad \forall \text{ pollutant p, } \forall \text{ technology t} \in \text{macro-sector m}$$

The BAR-PLOT



1) Discrepancies of total emissions per sector and pollutant
Magnitude: bar size
Sign: bar direction

2) Information about the emission factors ratios
Bar size comparison

$$\frac{E_{BUP}{}^{m,p}}{E_{TOD}{}^{m,p}} = \sum_t \frac{E_{BUP}{}^{t,p}}{E_{TOD}{}^{t,p}} = \sum_t \frac{A_{BUP}{}^{t,p} * e_{BUP}{}^{t,p}}{A_{TOD}{}^{t,p} * e_{TOD}{}^{t,p}} \quad \forall \text{ macro-sector m, } \forall \text{ pollutant } \mathbf{p}$$

The DIAMOND DIAGRAM

INVENTORIES ASSUMPTIONS:

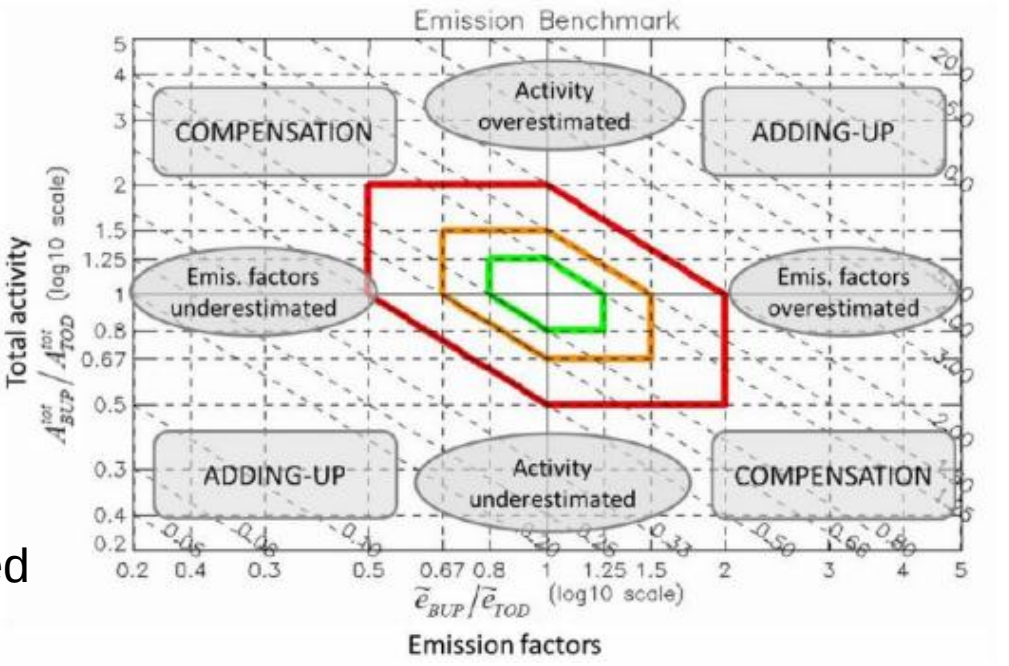
I. Comparable sectors and pollutants

II. Same activity ratio for all pollutants per technology:

$$a^{m,t,p}{}_{BUP} = a^{m,t,p}{}_{TOD}$$
$$where\ a^{m,t,p} = A^{t,p}/_{A^{m,p}}$$

III. Existence of a **reference pollutant** per macrosector characterized by similar weighted (with relative activity) emission factors:

$$\forall m\ \exists p^* \mid \tilde{e}_{BUP}{}^{m,p*} = \tilde{e}_{TOD}{}^{m,p*}$$
$$where\ \tilde{e}^{m,p} = \sum_t a^{m,t,p} * e^{t,p}$$

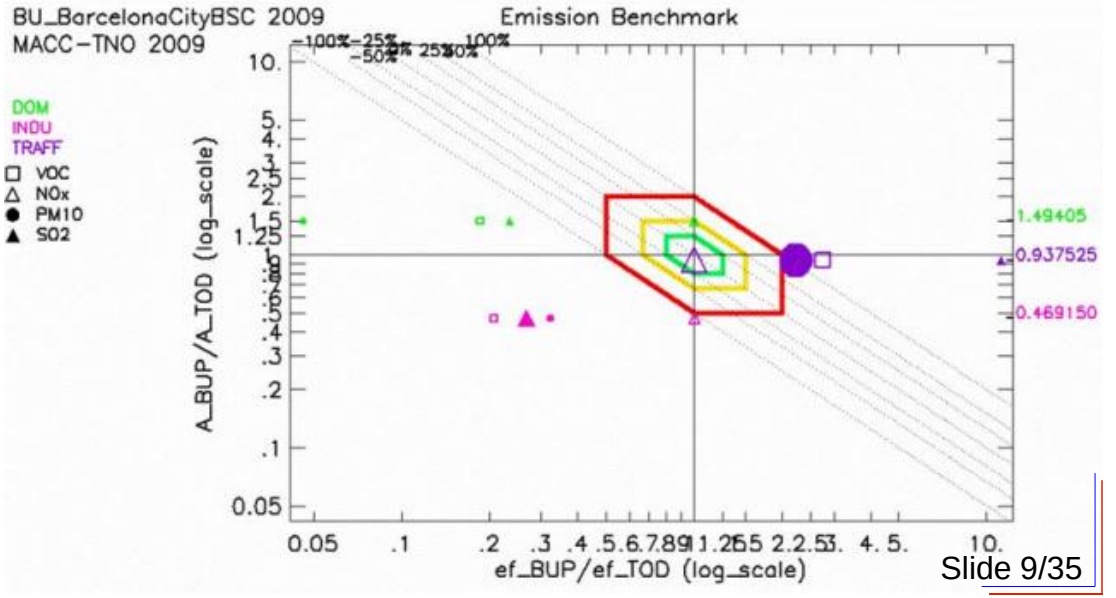


APPROACH LIMITATION:

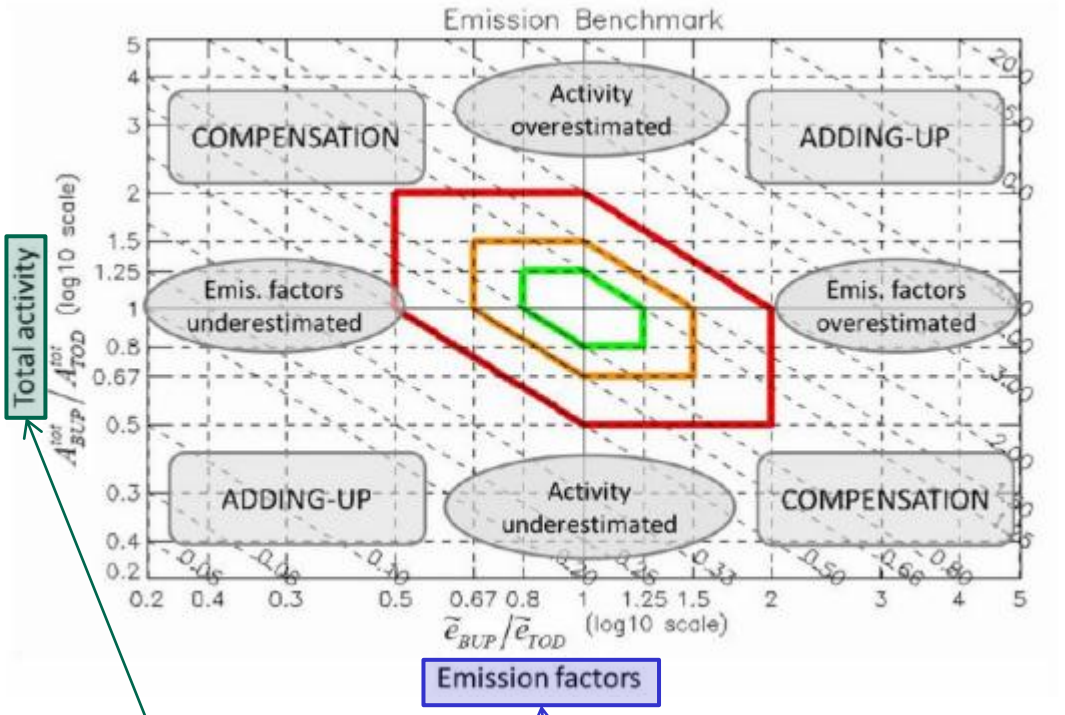
Deviations from expected behaviours are indicative of discrepancies

BUT

agreements do not guarantee matching (because of possible compensations)



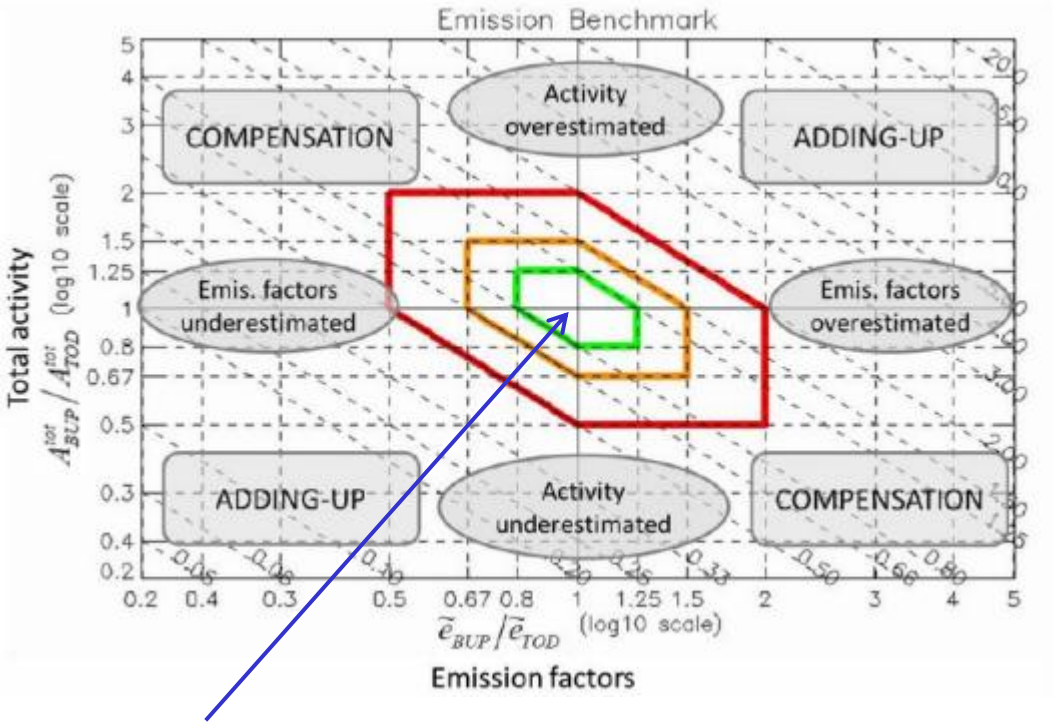
The DIAMOND DIAGRAM



- Activity ratios *Vs* Emission factor ratios
- Logarithmic scale

$$\log\frac{E_{BUP}{}^{m,p}}{E_{TOD}{}^{m,p}} = \log\frac{A_{BUP}{}^{m}}{A_{TOD}{}^{m}} + \log\frac{\tilde{e}_{BUP}{}^{m,p}}{\tilde{e}_{TOD}{}^{m,p}} \qquad \forall \text{ sector}, \forall \text{ pollutant}$$

The DIAMOND DIAGRAM



1) Deviations per sector and pollutant (E/E, e/e, A/A)

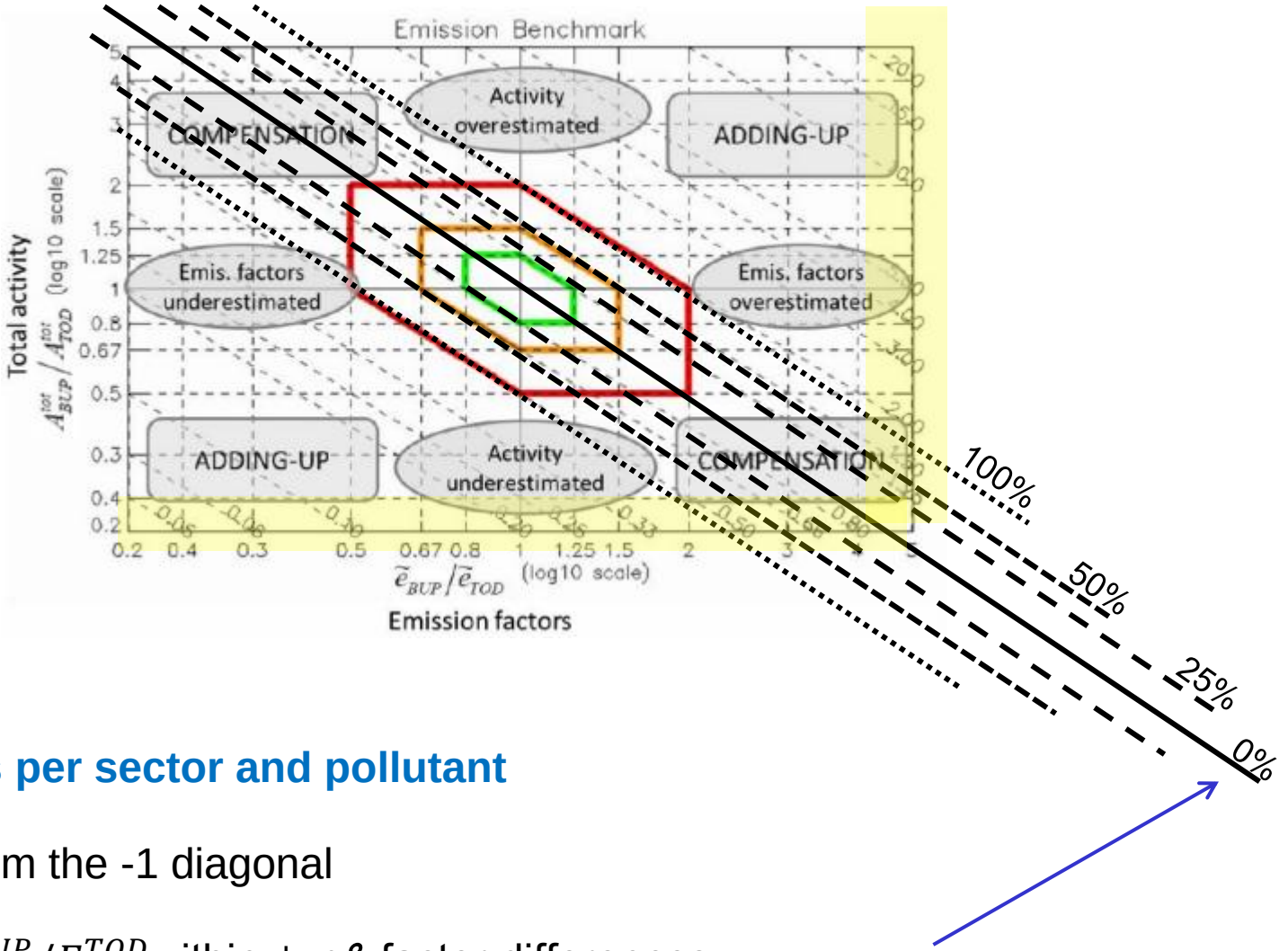
Distance from the origin

red diamond = A^{BUP}/A^{TOD}, e^{BUP}/e^{TOD}, and E^{BUP}/E^{TOD} all within **100%** differences

orange diamond = A^{BUP}/A^{TOD}, e^{BUP}/e^{TOD}, and E^{BUP}/E^{TOD} all within **50%** differences

green diamond = A^{BUP}/A^{TOD}, e^{BUP}/e^{TOD}, and E^{BUP}/E^{TOD} all within **25%** differences

The DIAMOND DIAGRAM

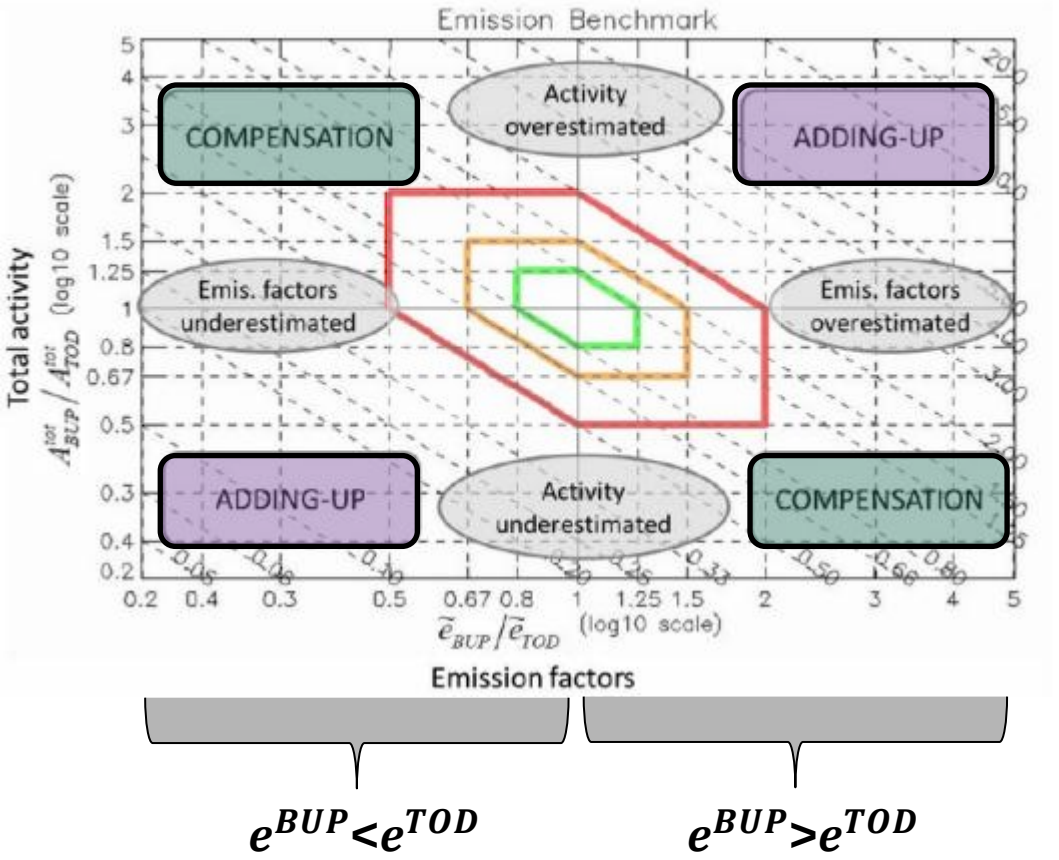


2) E/E analysis per sector and pollutant

Distance from the -1 diagonal

E^{BUP}/E^{TOD} within $\pm$ ***n°*** factor differences

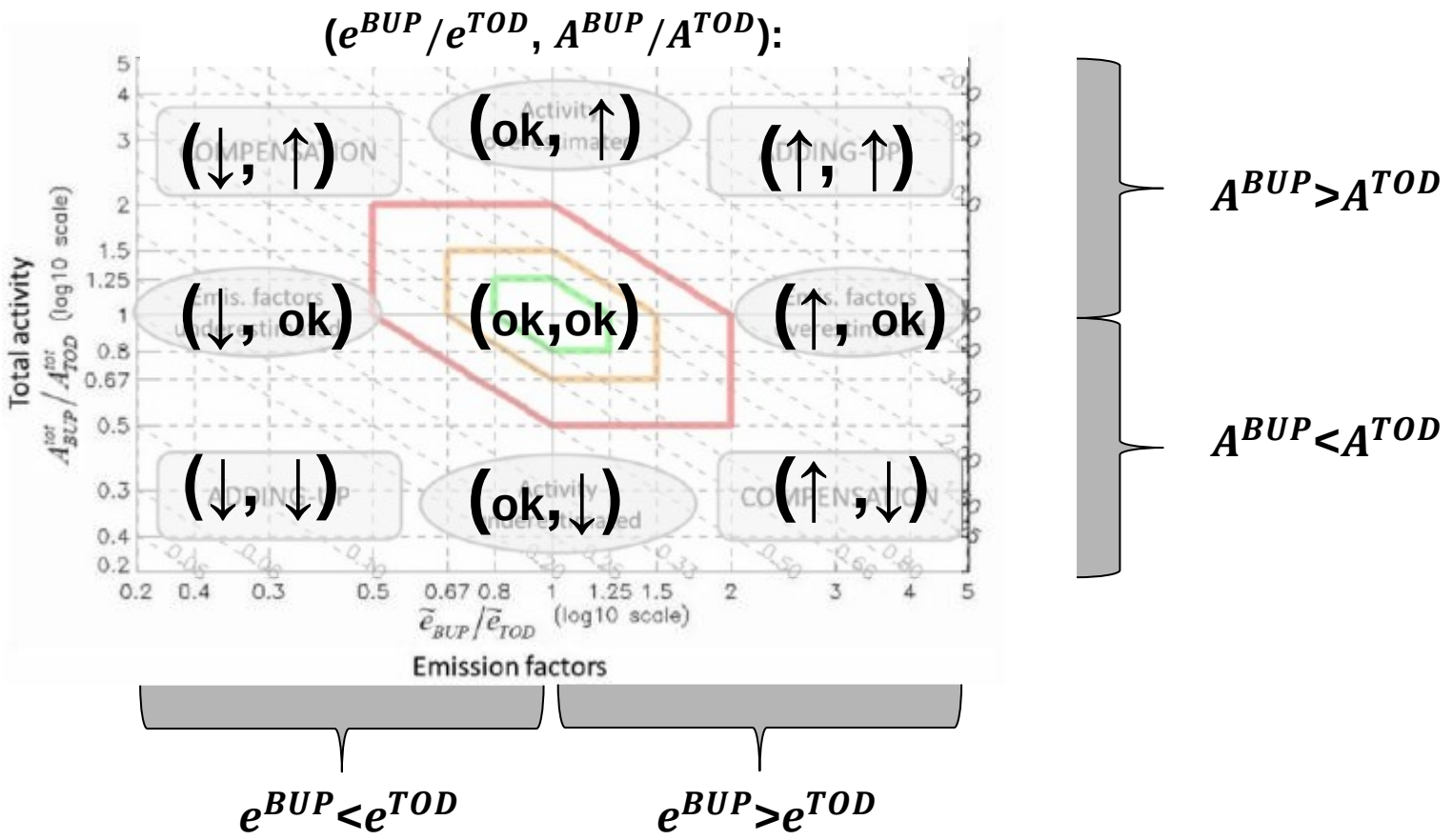
The DIAMOND DIAGRAM



3) Discrepancies analysis: e/e and A/A evaluation

- **COMPENSATION zone (e^{BUP}/e^{TOD}, A^{BUP}/A^{TOD}): (↑,↓);(↓,↑)**
- **ADDING-UP zone (e^{BUP}/e^{TOD}, A^{BUP}/A^{TOD}): (↑,↑);(↓,↓)**

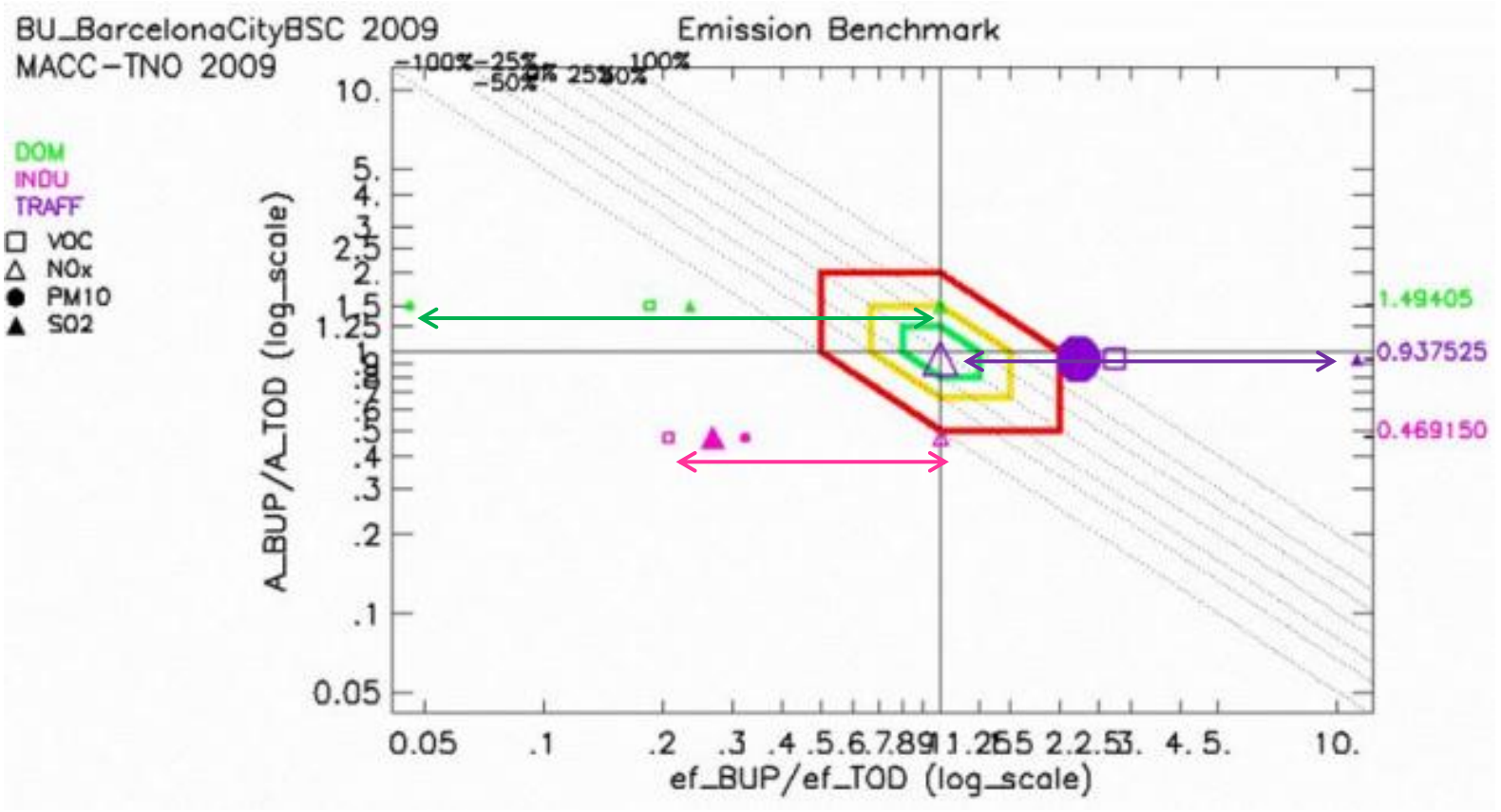
The DIAMOND DIAGRAM



3) Discrepancies analysis: e/e and A/A evaluation

- **COMPENSATION zone (e^{BUP}/e^{TOD}, A^{BUP}/A^{TOD}): (↑,↓);(↓,↑)**
- **ADDING-UP zone (e^{BUP}/e^{TOD}, A^{BUP}/A^{TOD}): (↑,↑);(↓,↓)**

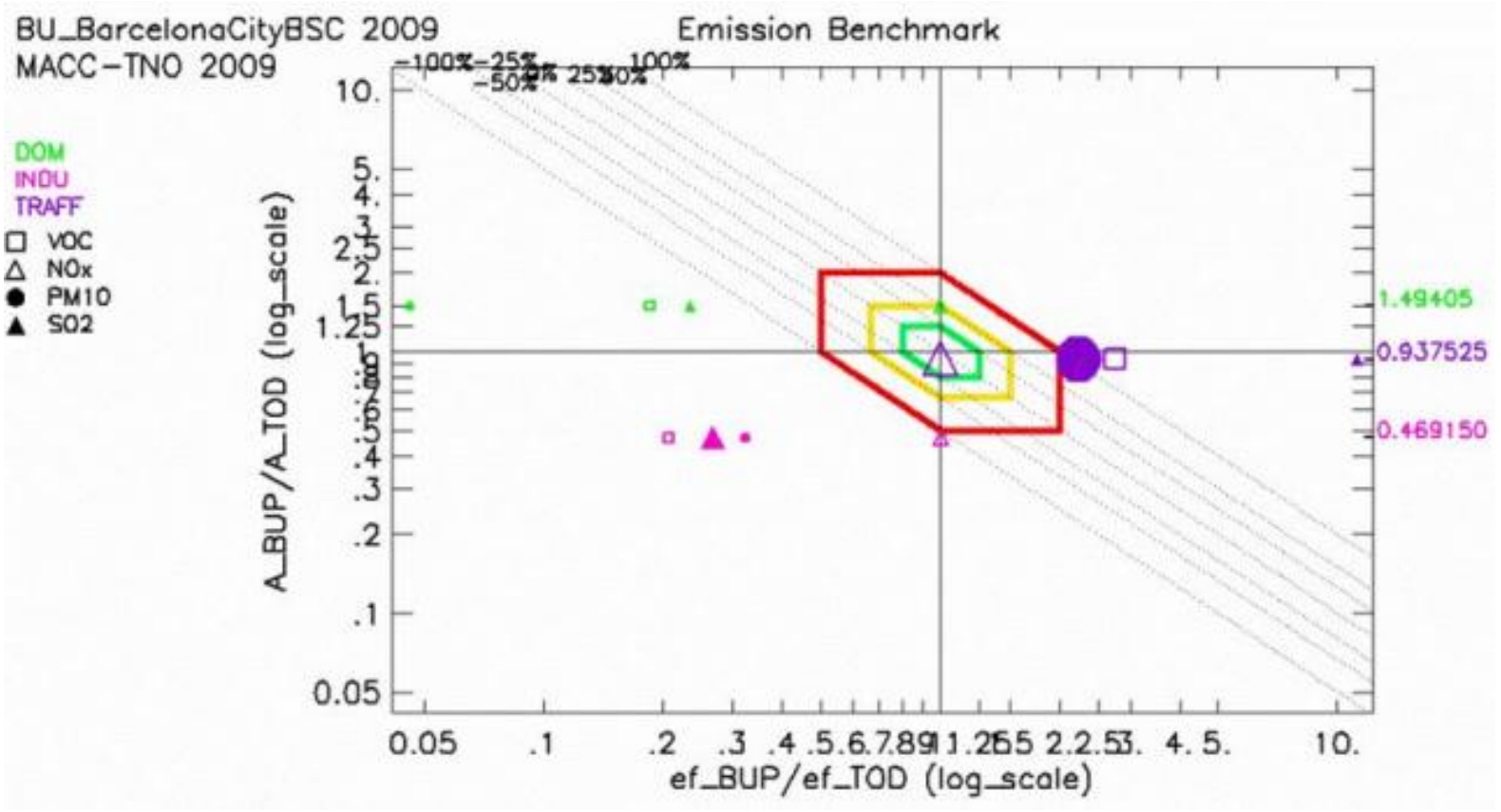
The DIAMOND DIAGRAM



4) Coherence in terms of relative sectorial ratios

- **X-distances**: emission factor ratio coherence per sector
- **Y-distances**: activity factor ratio difference between sectors

The DIAMOND DIAGRAM

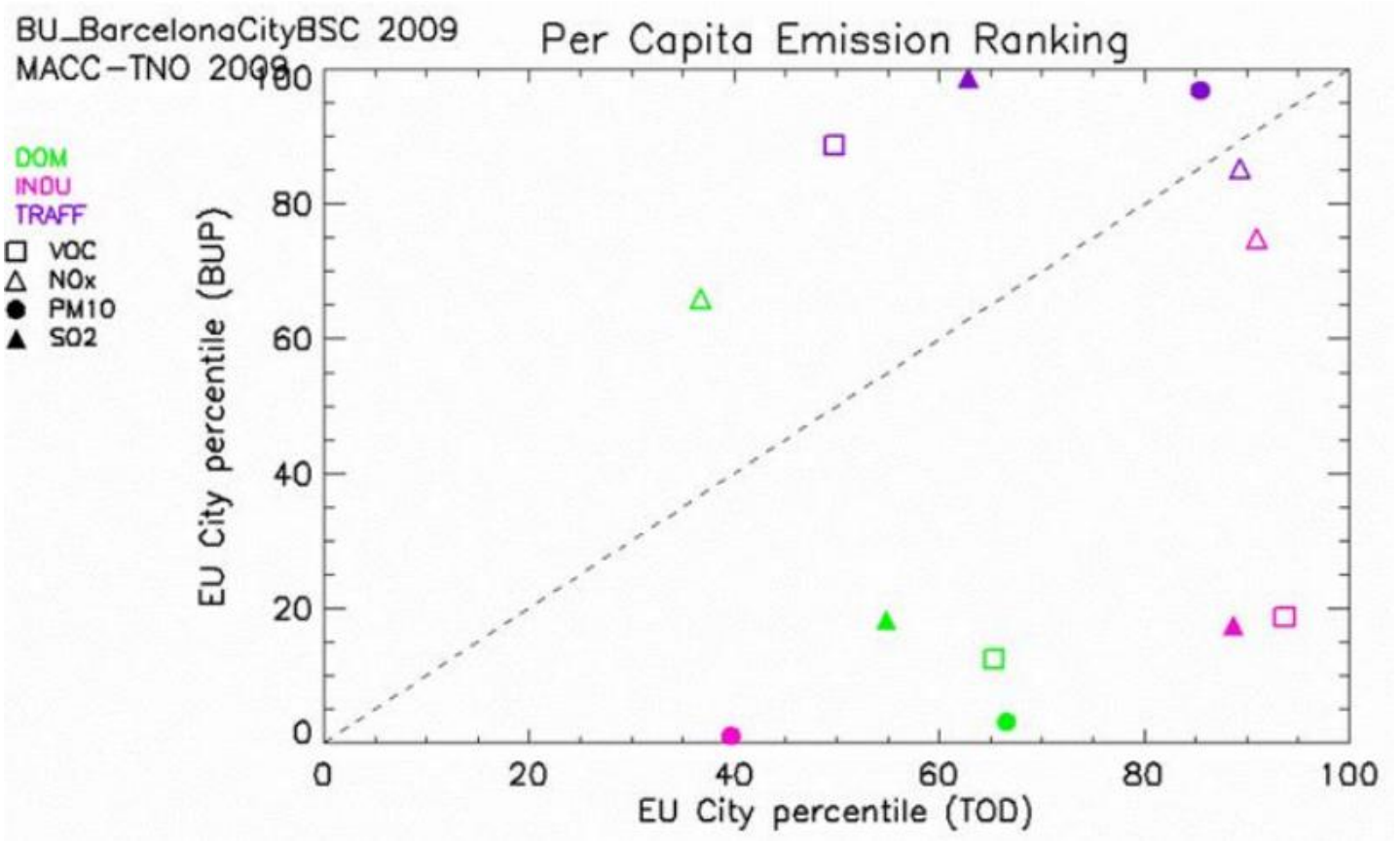


5) Emission magnitude per sector per pollutant

Size of the symbol

- **Large symbol**: big contributor
- **Small symbol**: second order contributor

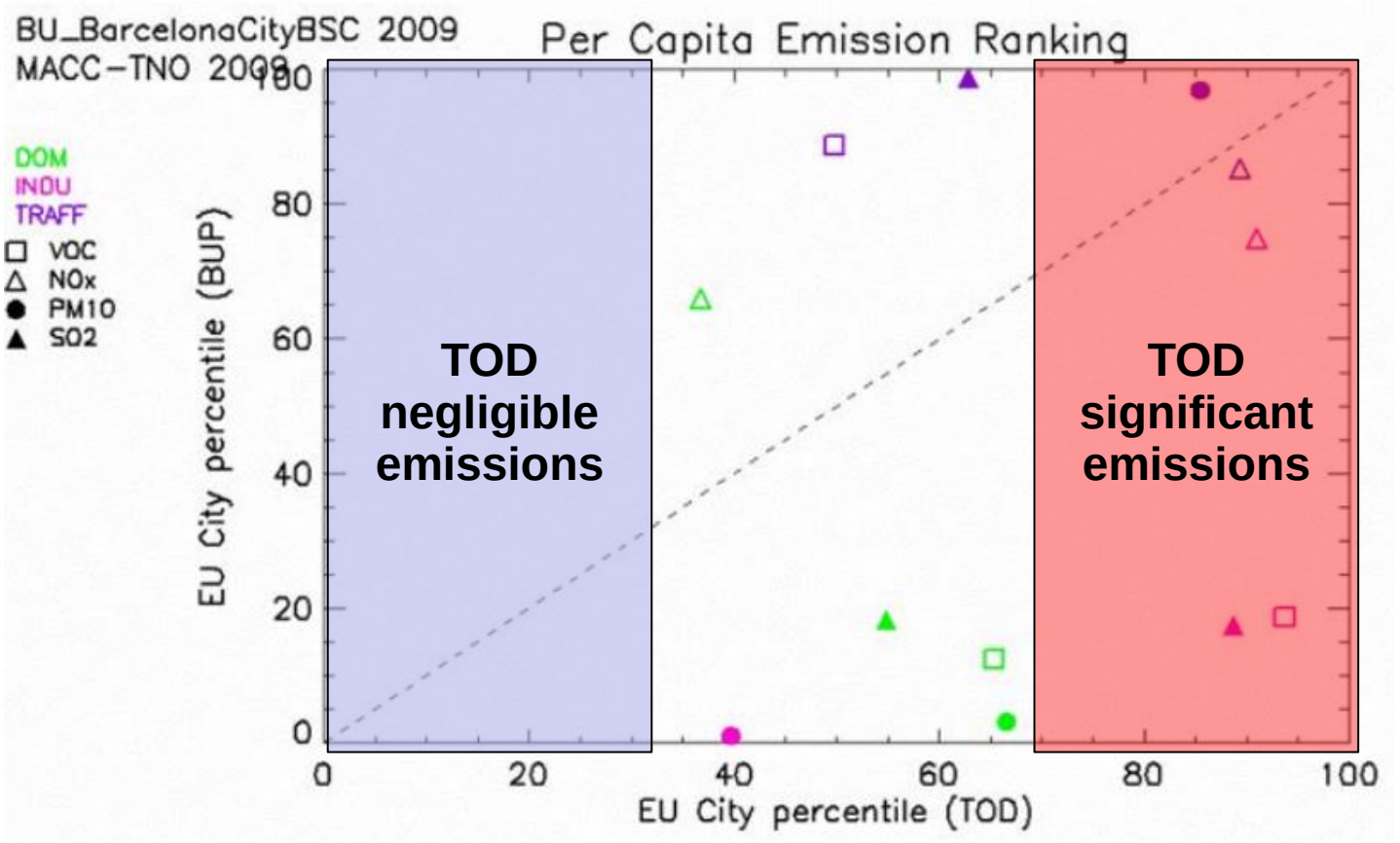
PER-CAPITA DIAGRAM



- EU-Scale:
  - per-capita emissions for each sector/pollutant couple
  - based on top-down values
  - covering a wide spectrum of European locations (megacities - rural regions)
  - ranked and used to scale the axes

- Plot:
  - $\left(\frac{E^{BUP}}{pop}\ ;\frac{E^{TOD}}{pop}\right)$ scaled (EU−Scale percentile)

PER-CAPITA DIAGRAM

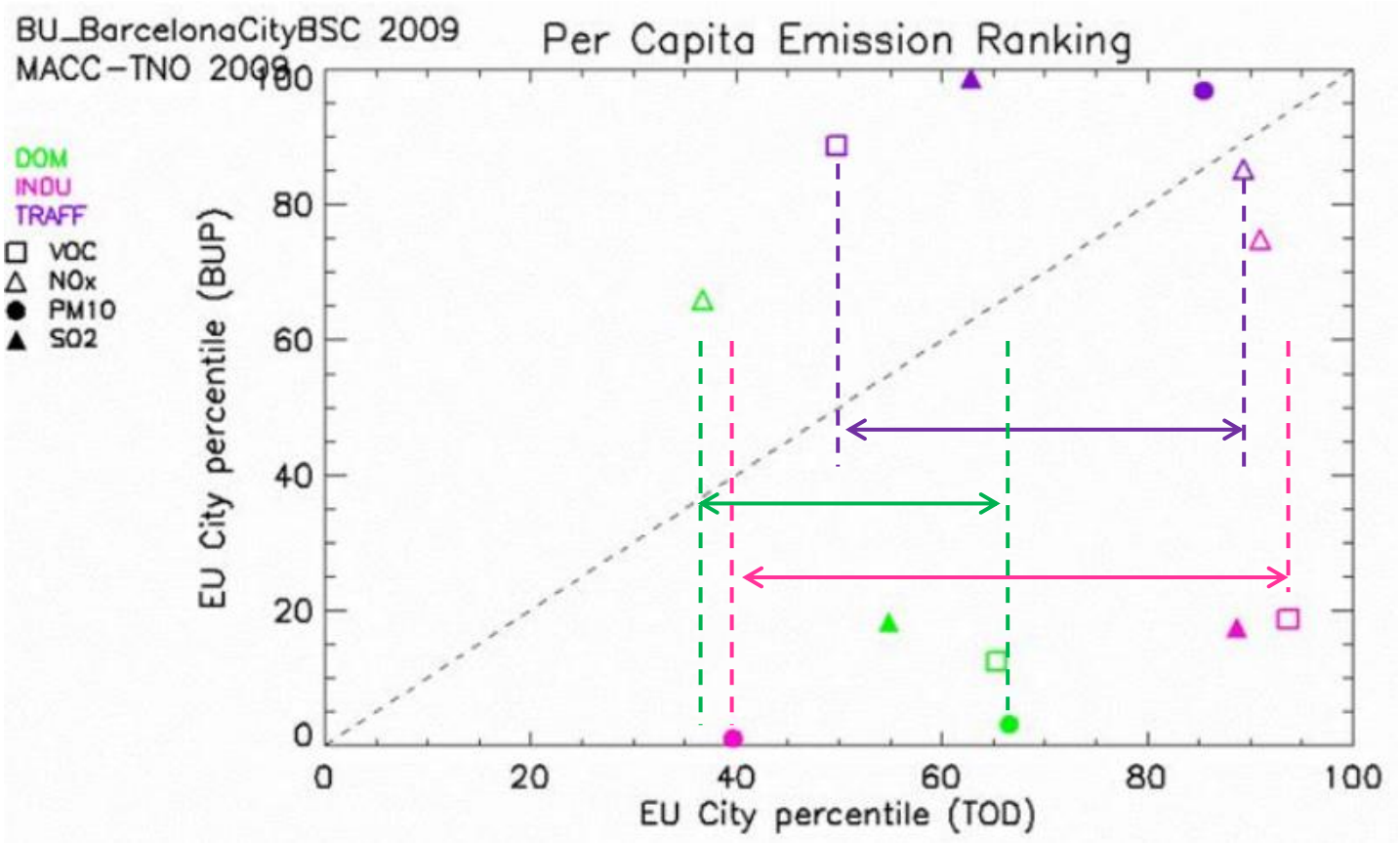


1) How the city/region of interest is considered within the top-down EU inventories

Position along X-axis

- High X-value: significant contribution in respect to EU
- Low X-value: negligible contribution in respect to EU

PER-CAPITA DIAGRAM

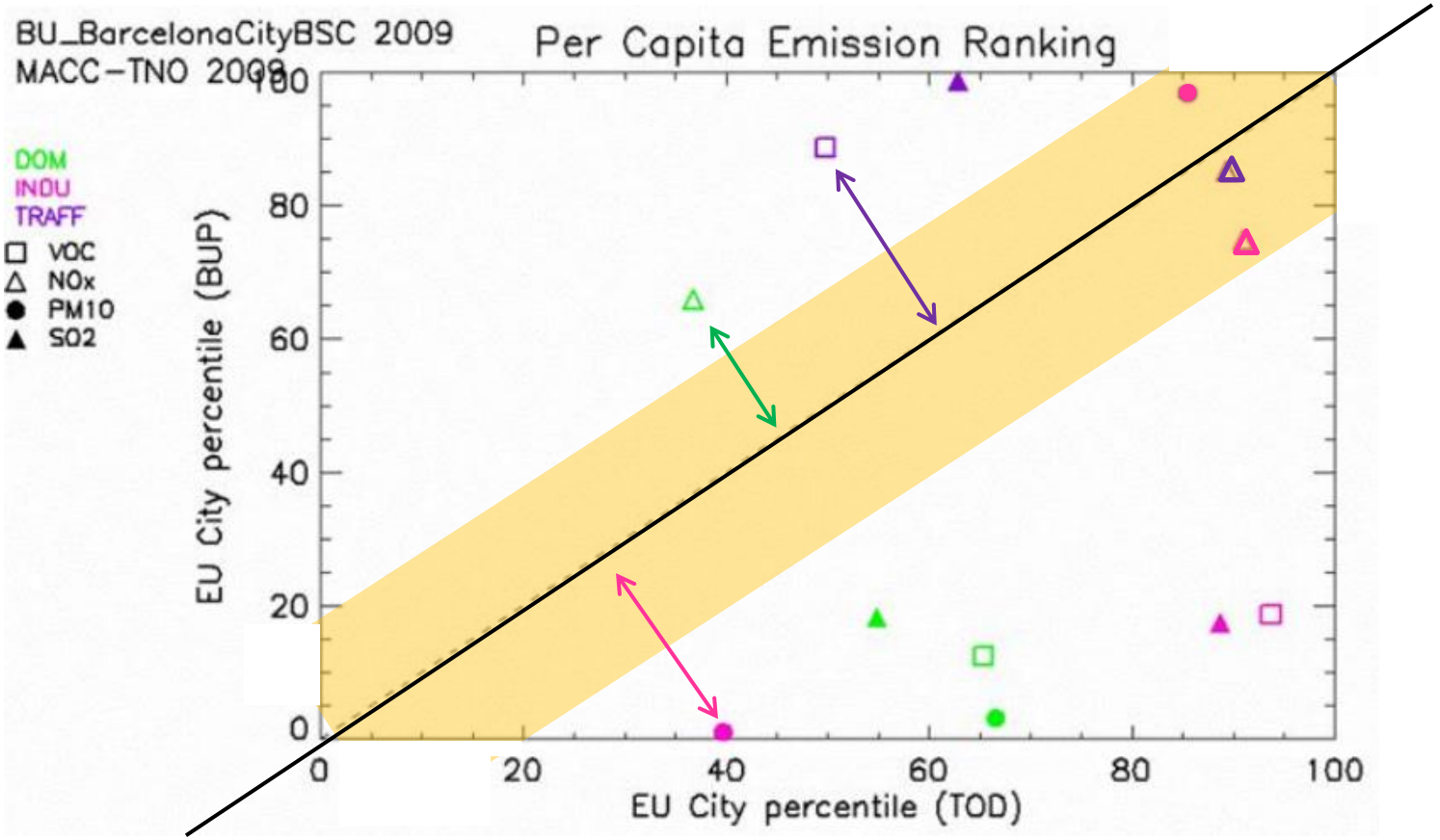


2) Coherence in terms of relative sectorial ratios in TOD inventary

X-distances per sector

- Large X-interval per sector: possible inconsistencies in TOD inventory

PER-CAPITA DIAGRAM

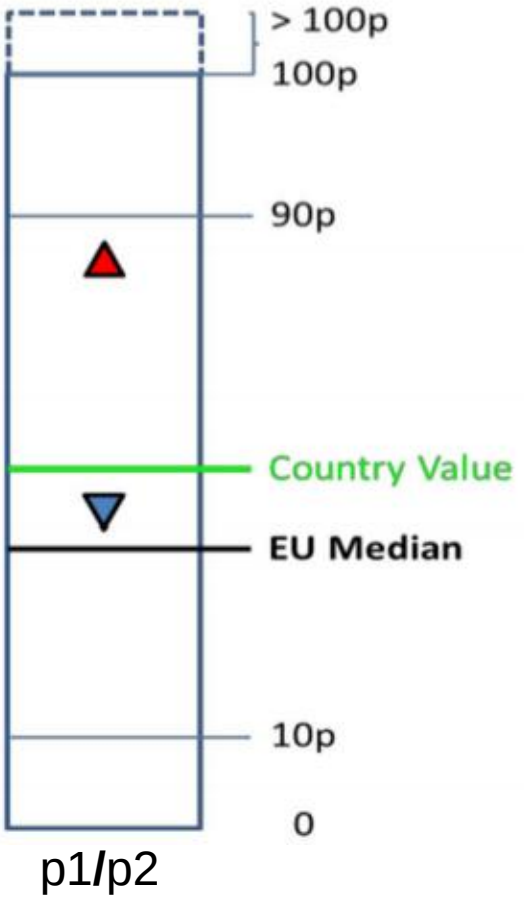


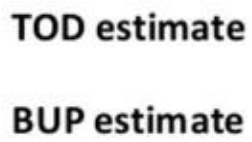
2) Consistency between TOD and BUP inventories

Distance from the diagonal

- Large distances: inconsistencies between TOD and BUP inventories

RATIO DIAGRAM



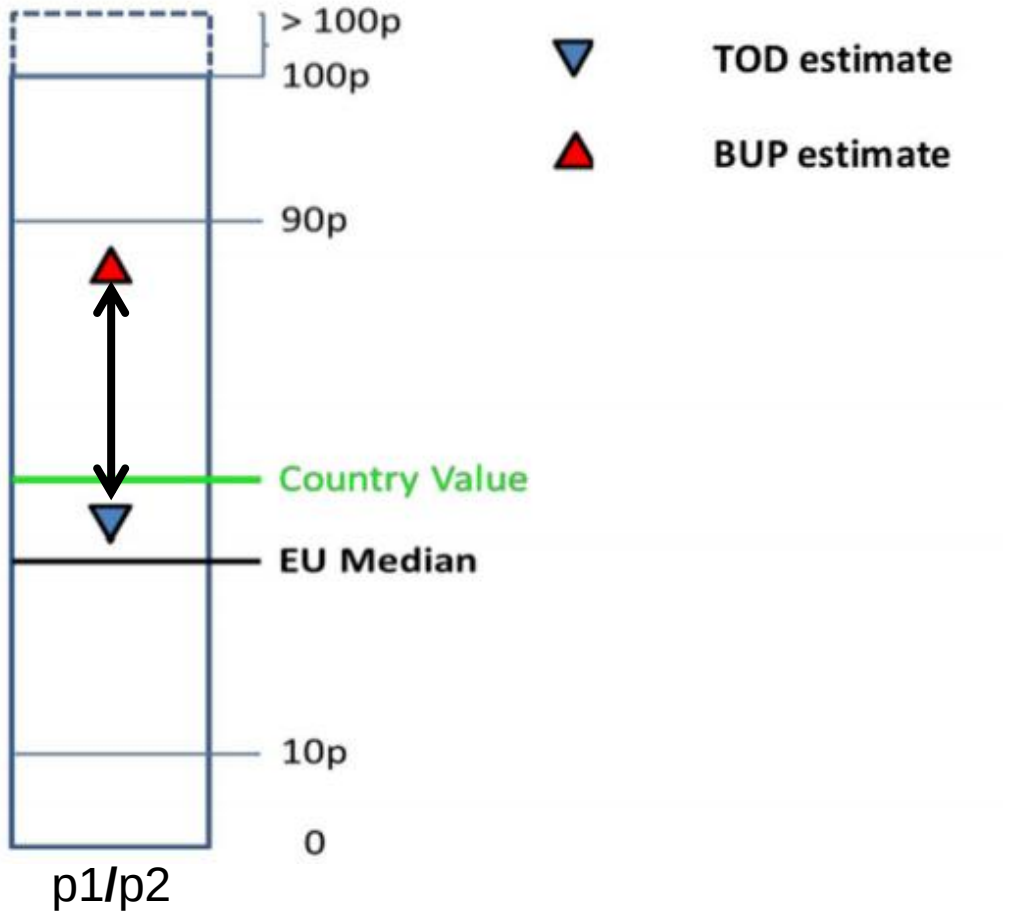


- Scale based on GAINS country values
- Ratio values from TOD and BUP inventories:

$$\blacktriangledown = \frac{E_{p1}{}^{TOD}}{E_{p2}{}^{TOD}} \qquad \blacktriangle = \frac{E_{p1}{}^{BUP}}{E_{p2}{}^{BUP}}$$

- (For TRAFF sector TREMOVE value overlaied)

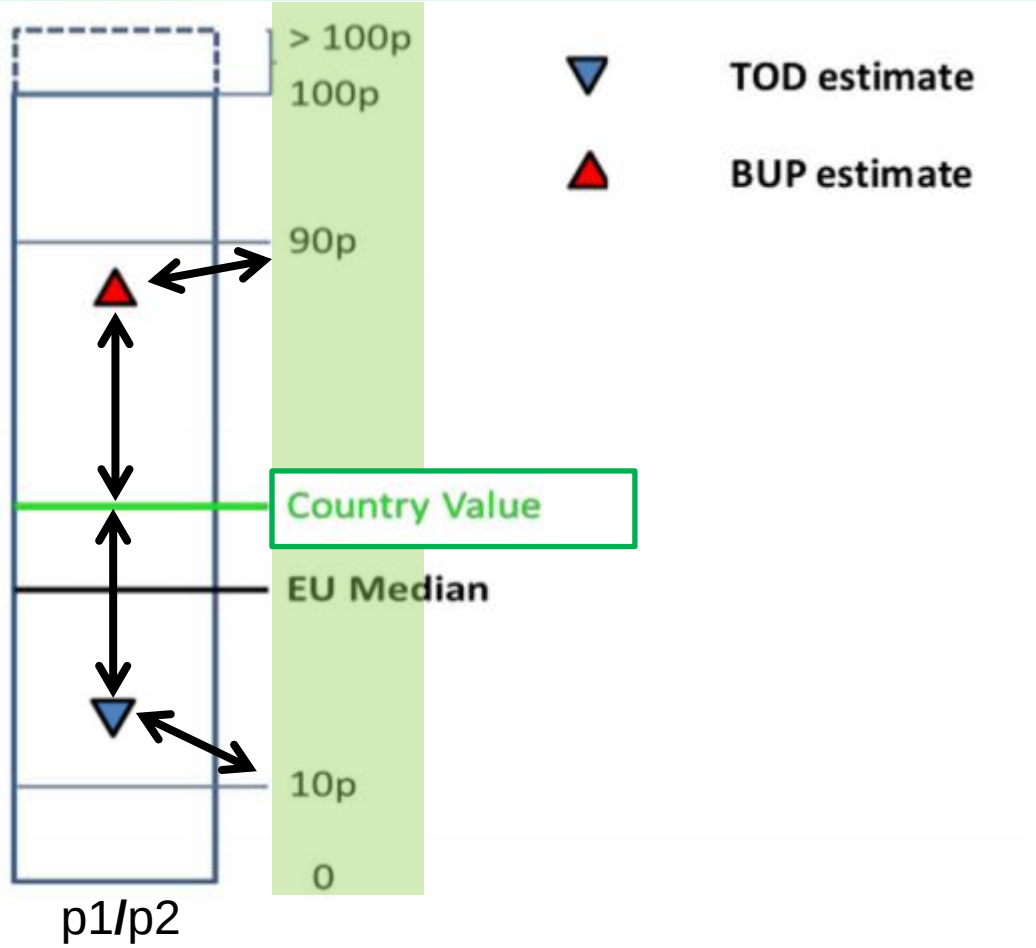
RATIO DIAGRAM



1) Consistency between TOD and BUP inventories

Distance between triangles

RATIO DIAGRAM



2) Plausibility of TOD and BUP inventories with regards to EU reference scale (GAINS)

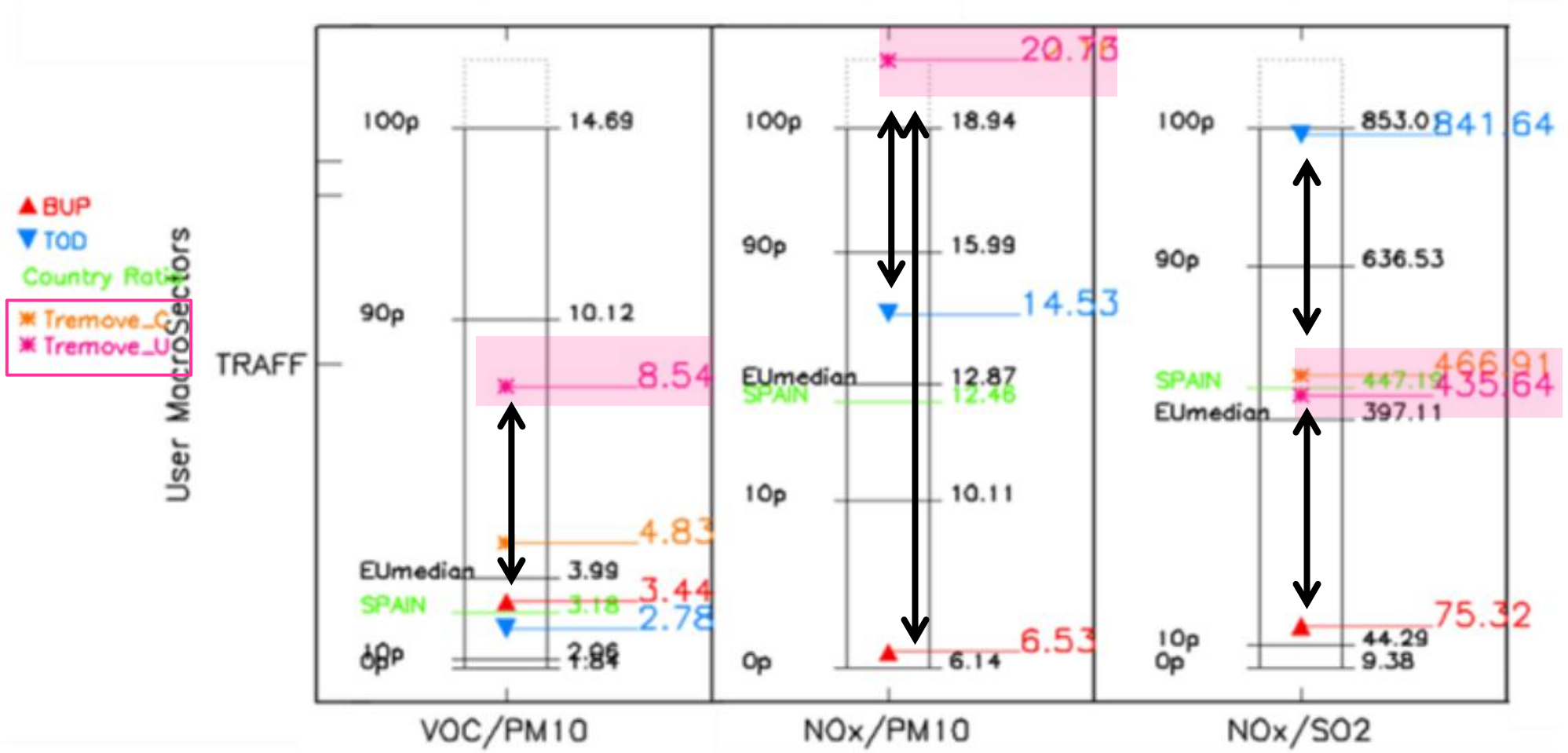
Distance from the country value and percentiles

RATIO DIAGRAM

MS	Ratio	Comment
SNAP01	NO_x/SO_2	Close to 0 for liquid or coal based fuel. Much higher for natural gas
	NO_x/PPM_{10}	
	NOx/NH_3	Low if SCR or SNCR systems are in place. Higher values indicate incomplete reaction of NH_3 additive
	VOC/PPM_{10}	Close to 1 for liquid or coal based fuel and much higher for natural gas
	SO_2/PPM_{10}	Very high for liquid based fuel, high for coal based fuel and close to one for natural gas
SNAP02	SO_2/NO_x	Close to 0 for natural gas. Much higher for liquid or coal based fuel
	PPM_{10}/NO_x	
	PPM_{10}/VOC	Close to 1 for liquid, coal or biomass based fuel and much higher for natural gas
	PPM_{10}/SO_2	Very low for liquid based fuel, low for coal based fuel, close to one for natural gas and higher for biomass
SNAP03	SO_2/NO_x	Close to 0 for natural gas and higher for liquid or coal based fuel
	NO_x/PPM_{10}	Low for liquid or coal based fuel and high for natural gas
	PPM_{10}/VOC	Very high for process furnaces and processes with contact (e.g. iron and steel industries)
	SO_2/PPM_{10}	Very low for biomass, low for coal based fuel, close to 1 for natural gas and much higher for liquid based fuel
SNAP04	SO_2/NO_x	Very high values identify processes in petroleum industries (i.e. sulphur recovery plants) aluminium and sulphuric acid production plants
	PPM_{10}/NO_x	High values identify coke ovens and aluminium and fertilizer production plants
	NH_3/NO_x	High values identify ammonia and fertilizer production
	SO_2/NH_3	Low values identify ammonia and fertilizer production
	PPM_{10}/SO_2	Low values identify refinery, aluminium and sulphuric acid plants and high values identify fertilizer production plants
SNAP07	NO_x/SO_2	High values indicate move to ultra-low sulphur content
	PPM_{10}/SO_2	
	NO_x/PPM_{10}	High values identify gasoline-powered vehicles or modern Euro diesel-powered vehicles equipped with particle filters
	NOx/ NH_3	Values between 10 and 50 indicate SCR systems. Higher values for emerging economies
	NO_x/VOC	High values for gasoline-powered vehicles and much lower for diesel-powered vehicles
SNAP08	SO_2/NO_x	High values for fuels with high sulphur content values, usually related to maritime activities (e.g. residual oil)
	NO_x/PPM_{10}	Values are usually stable (several dozen). Very high values (several hundreds) identify air traffic activities
	VOC/SO_2	Very high values identify industrial or agricultural machinery and low values identify port facilities
	PPM_{10}/SO_2	
SNAP09	PPM_{10}/NO_x	Above means unabated PM low values indicate reverse
SNAP10	PPM_{10}/NO_x	High values identify manure management
	PPM_{10}/VOC	
	NH_3/VOC	Low values for cultures without fertilizers
	NH_3/PPM_{10}	Low values (<15) indicate manure management rather than crop production (>40)

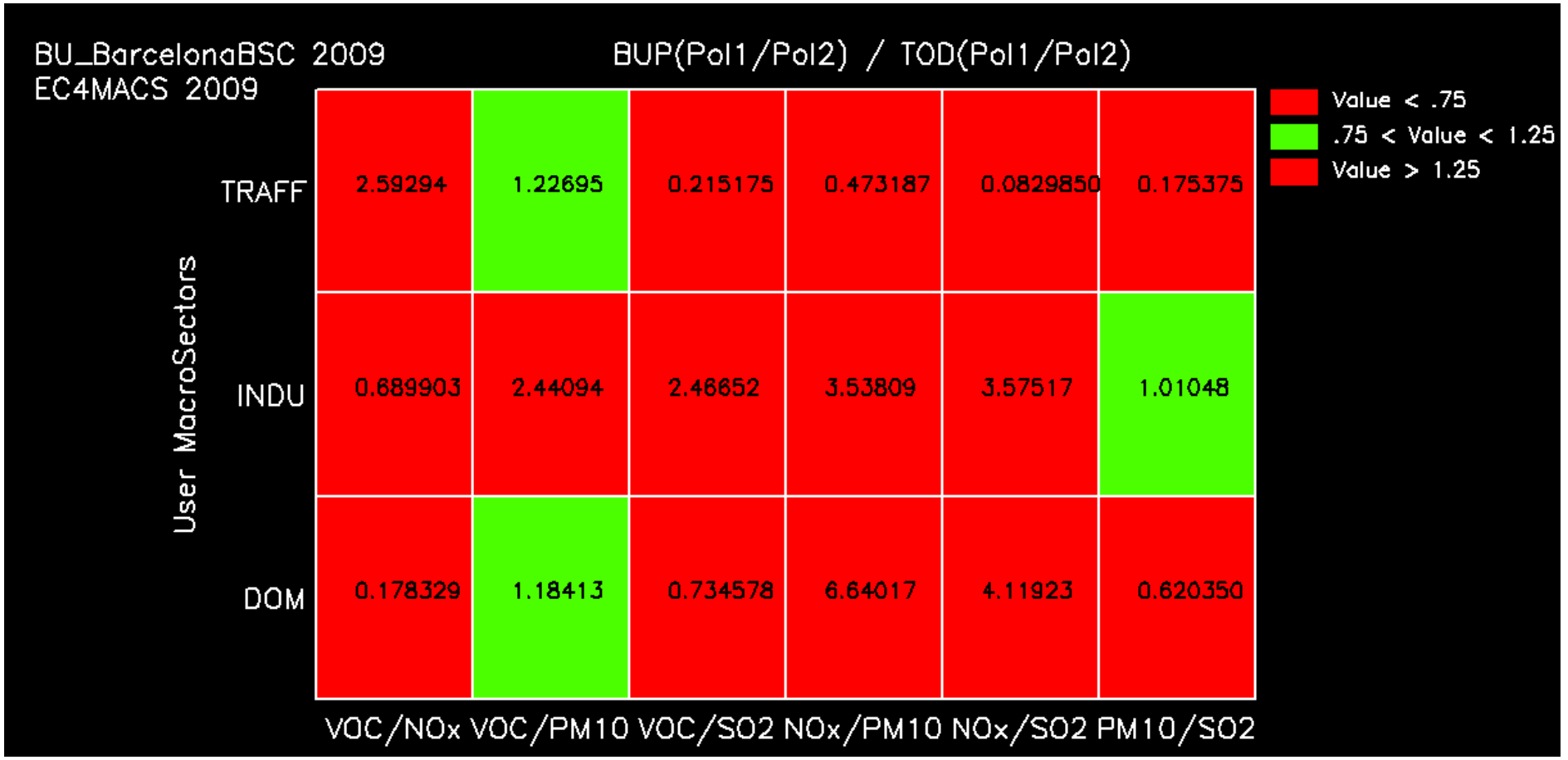
3) Information about the underlying processes

RATIO DIAGRAM



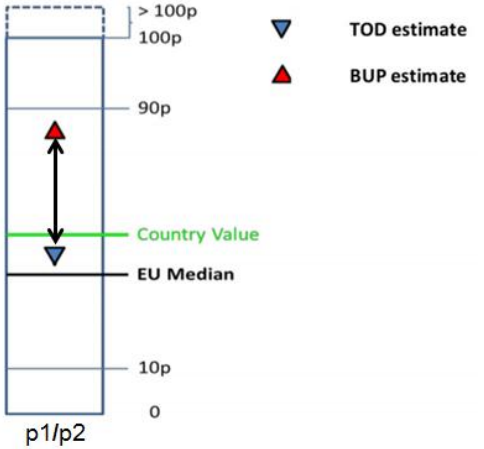
4) Consistency with TREMOVE inventory (TRAFF – SNAP 07 macro-sector)

RATIO2 DIAGRAM

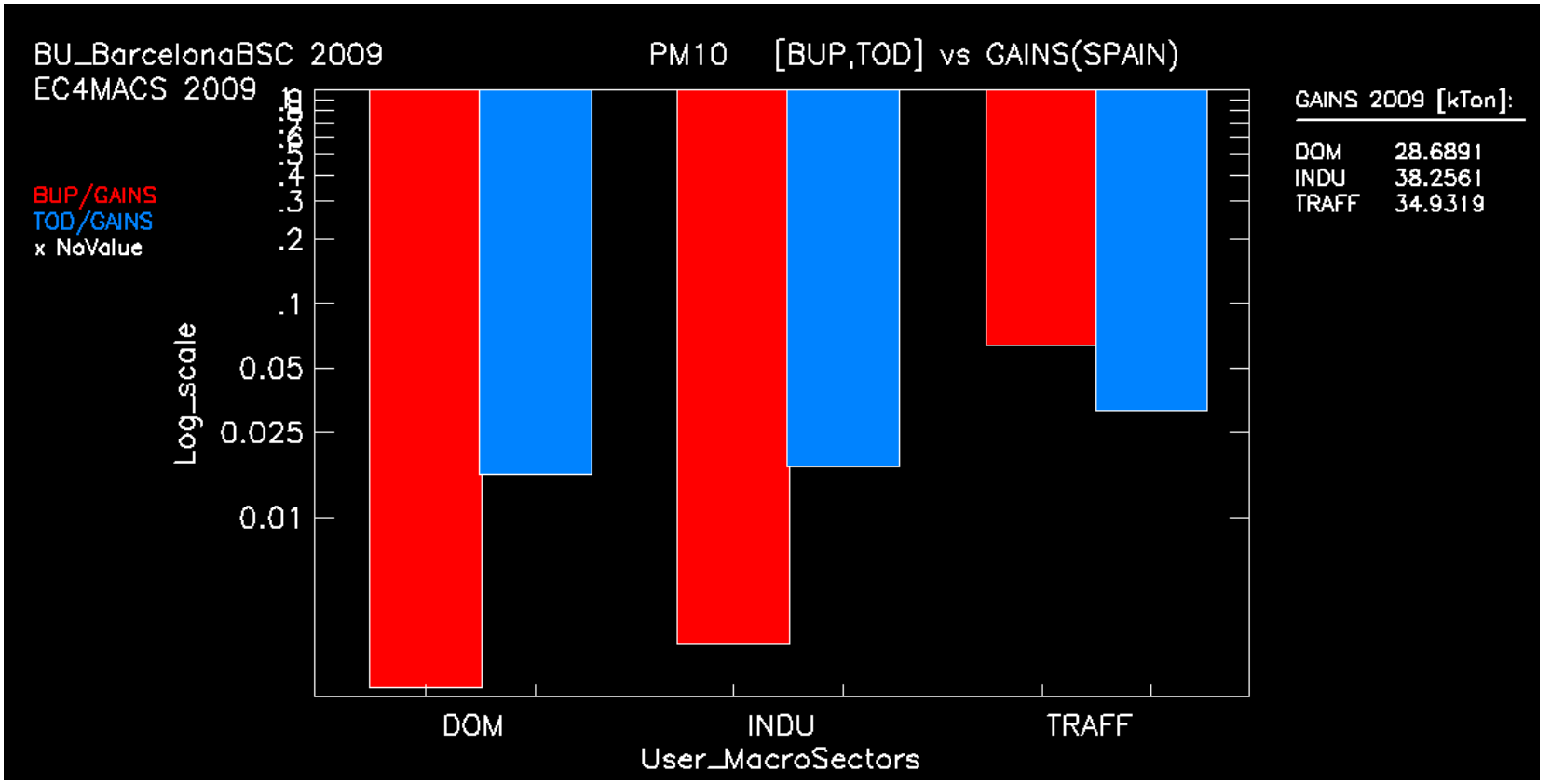


- Ratio of ratios:

$$\frac{E_{p1}{}^{BUP}}{E_{p2}{}^{BUP}} \Big/ \frac{E_{p1}{}^{TOD}}{E_{p2}{}^{TOD}}$$



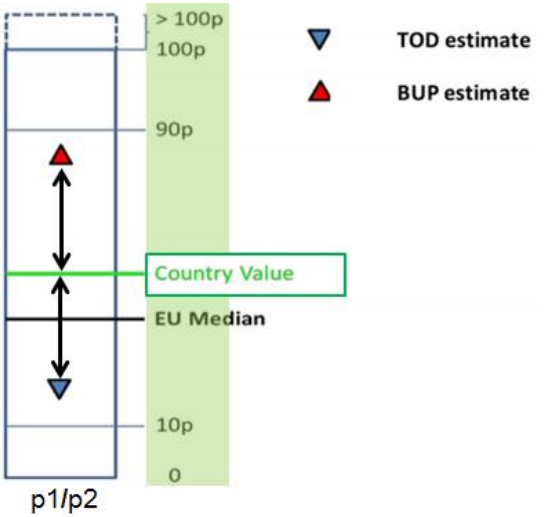
TD-BU-GAINS



- Bottom-up total emission / GAINS
- Top-down total emission / GAINS

- Logarithmic scale

$$\log \frac{Ep,s^{BUP}}{Ep,s^{GAINS}}, \log \frac{Ep,s^{TOD}}{Ep,s^{GAINS}} \forall \text{ pollutant, } \forall \text{ sector}$$



Index

Top-down inventories (file.nc)

EC4MACS inventory

▪POLLUTANTS:
COx, NH3, VOC, NOx, PM10, PM2.5, SO2

▪SNAP sectors:
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10

▪Resolution:
7 km x 7km

▪Reference year:
2009

SNAP macrosectors

- SNAP01 combustion in energy industries
- SNAP02 non-industrial combustion plants
- SNAP03 combustion in manufacturing industries
- SNAP04 production processes
- SNAP05 extraction and distribution of fossil fuels
- SNAP06 solvent use
- SNAP07 road transport

  -S7.1 Exhaust emission of Gasoline road transport
  -S7.2 Exhaust emissions of Diesel road transport
  -S7.3 Exhaust emissions of LPG transport
  -S7.4 non-Exhaust volatilization (Only VOC emissions)
  -S7.5 non-Exhaust Brake wear, Tyre wear, Road wear
  -S7.6 emissions from Natural Gas and H2 fueled vehicles

- SNAP08 other mobile sources
- SNAP09 waste treatment
- SNAP10 agriculture

TNO-MACC inventory

▪POLLUTANTS:
COx, NH3, VOC, NOx, PM10, PM2.5, SO2, **CH4**

▪SNAP sectors:
S1, S2, S3, S4, S5, S6, **S7.1, S7.2, S7.3, S7.4, S7.5**, S8, S9, S10

▪Resolution:
7 km x 7 km

▪Reference year:
2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011

Top-down inventories (file.nc)

➢ JRC7km inventory

▪POLLUTANTS and SNAP sectors:

	CO_x	NH_3	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CH_4
S1	x	x	x	x	x	X	x	
S2	x	x	x	x	x	X	x	
S34	x	x	x	x	x	X	x	
S5			x		x	X		
S6			x					
S8	x	x	x	x	x	X	x	
S9	x	x	x	x	x	X	x	
S10	x	x	x	x	x	X	x	

	CO_x	NH_3	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CH_4
S7.1	x	x	x	x	x	X	x	
S7.2	x	x	x	x	x	X	x	
S7.3	x	x	x	x	x	X		
S7.4			x					
S7.5					x	X		
S7.6	x	x	x	x	x	X	x	

SNAP macrosectors

- SNAP01 combustion in energy industries
- SNAP02 non-industrial combustion plants
- SNAP03 combustion in manufacturing industries
- SNAP04 production processes
- SNAP05 extraction and distribution of fossil fuels
- SNAP06 solvent use
- SNAP07 road transport

  -S7.1 Exhaust emission of Gasoline road transport
  -S7.2 Exhaust emissions of Diesel road transport
  -S7.3 Exhaust emissions of LPG transport
  -S7.4 non-Exhaust volatilization (Only VOC emissions)
  -S7.5 non-Exhaust Brake wear, Tyre wear, Road wear
  -S7.6 emissions from Natural Gas and H2 fueled vehicles

- SNAP08 other mobile sources
- SNAP09 waste treatment
- SNAP10 agriculture

▪Resolution:

7 km x 7km

▪Reference year:

2010

Bottom-up inventories

- **Shapefiles ''*shape_*.dat*''**
  - **Default:**
    - 39 Countries, 428 Regions, 477 Cities
    - Codes (FVG):

      ITALY ITA
      ITA-Region-FVG
      ITA-City-Trieste

```
ITA-Trieste
Nparts          4
lon         11
       13.766194       13.766194       13.776195       13.776195       13.786194
       13.786194       13.796194       13.796194       13.786194       13.776195
       13.766194
lat         11
       45.682251       45.692249       45.692249       45.702251       45.702251
       45.692249       45.692249       45.682251       45.682251       45.682251
       45.682251
lon          5
       13.756194       13.746194       13.746194       13.756194       13.756194
lat          5
       45.682251       45.682251       45.692249       45.692249       45.682251
lon         29
       13.816195       13.806194       13.806194       13.796194       13.796194
       13.786194       13.776195       13.776195       13.776195       13.766194
       13.756194       13.756194       13.766194       13.766194       13.756194
       13.756194       13.756194       13.766194       13.766194       13.776195
       13.786194       13.796194       13.796194       13.806194       13.816195
       13.816195       13.816195       13.816195       13.816195
lat         29
       45.622250       45.622250       45.612251       45.612251       45.622250
       45.622250       45.622250       45.632252       45.642250       45.642250
       45.642250       45.652252       45.652252       45.662251       45.662251
       45.672249       45.682251       45.682251       45.672249       45.672249
       45.672249       45.672249       45.662251       45.662251       45.662251
       45.652252       45.642250       45.632252       45.622250
lon          5
       13.816195       13.826194       13.826194       13.816195       13.816195
lat          5
       45.622250       45.622250       45.612251       45.612251       45.622250
```

- **User defined:**

  Structure: (shape_*zonename*.dat):

  Line 1: *Country Code*

  Line 2: Nparts *Num of subshapes*

  Line 3 and on: Polygonal vertices (for each subshape)

  lon number of vertices
  lon values
  lat number of vertices
  lat values

Bottom-up inventories

➢ Emission file ''*BU_*_info.csv*"

- **Included (examples):**
  - **Cities**: Antwerp (Belgium), Bergen (Norway), Barcelona (Spain), Lisbon (Portugal), London (UK), Milan (Italy), Oslo (Norway), Porto (Portugal), Stockholm (Sweden), Sofia (Bulgaria).
  - **Regions:** Alsace (France), Antwerp (Belgium), Barcelona (Spain), Catalonia (Spain), Flanders (Belgium), Madrid (Spain), **Po Valley (Italy**), Stockholm (Sweden), Strasbourg (France).
  - **Countries:** Bulgaria, Spain

```
Shape,7,Region,dat,
shape_ITA-Region-VDA,,,,
shape_ITA-Region-PMN,,,,
shape_ITA-Region-LMB,,,,
shape_ITA-Region-TAA,,,,
shape_ITA-Region-VEN,,,,
shape_ITA-Region-FVG,,,,
shape_ITA-Region-ERM,,,,
2006,,,,
#Species,BU sectors abbreviation,BU sectors nomenclature,Correspondance with SNAP,Domain Total
NOx,DOM,Domestic,S2,29.3
NOx,TRA,Traffic,S7,184.5
NOx,zOTH,Others,S1+S4+S5+S6+S3+S8+S9+S10,116.2
PM25,DOM,Domestic,S2,10
PM25,TRA,Traffic,S7,11
PM25,zOTH,Others,S1+S4+S5+S6+S3+S8+S9+S10,12
VOC,DOM,Domestic,S2,169.
VOC,TRA,Traffic,S7,83.
VOC,zOTH,Others,S1+S4+S5+S6+S3+S8+S9+S10,165.
END,,,,
```

- **User defined:**

```
Shape,0,Region,,
ESP
lon,0.90,2.7,2.78,1.02
lat,40.75,40.68,42.01,42.09
2009,,,,
#Specie,BU….
…..
END,,,,
```

Structure: (BU_*zonename*_info.csv):

Line 1: Shape, *Num of subshapes* or *coordinates, type of domain, shapefile extension*

Line 2 and on: *sub-shape file names* or 0 *and lon-lat coordinates*

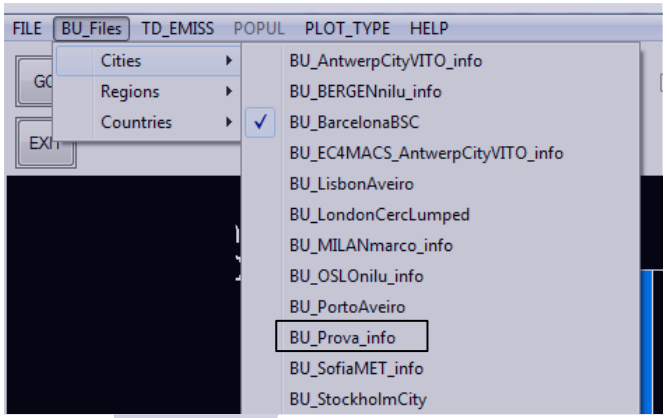
Line 3: *reference year*

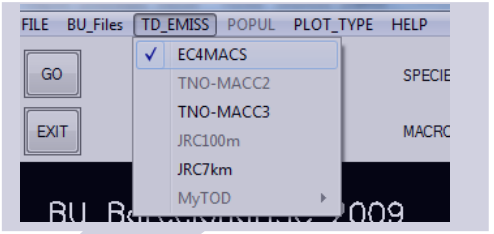
Line 4 and on: species, sector short names, sector description, SNAP sectors correspondance, emissions (kTon/year)

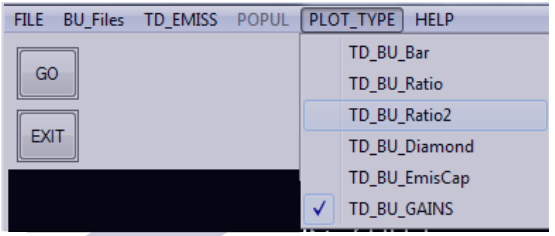
Line 5: END

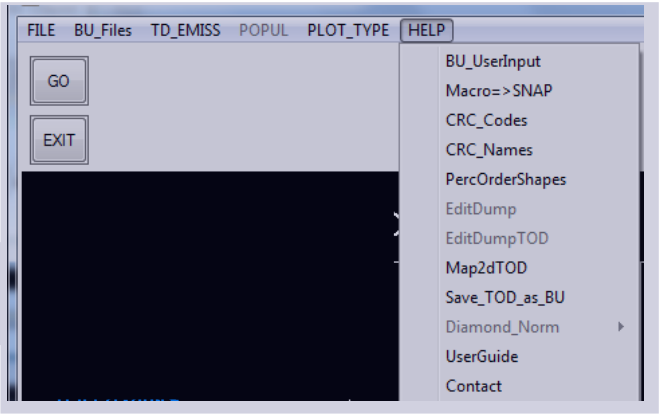
Index

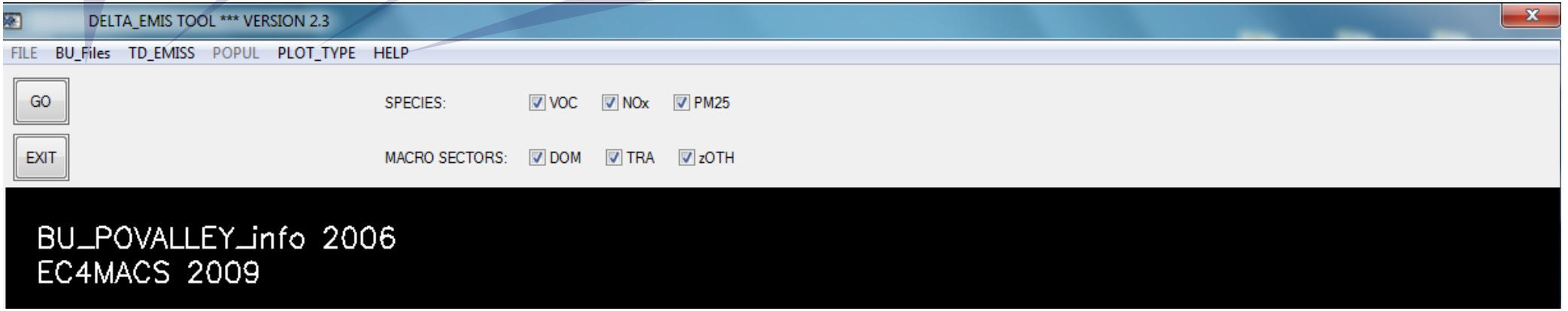
Δ_Emis tool


FILE
BU_Files
TD_EMISS
POPUL
PLOT_TYPE
HELP
Cities
Regions
Countries
BU_AntwerpCityVITO_info
BU_BERGENnilu_info
BU_BarcelonaBSC
BU_EC4MACS_AntwerpCityVITO_info
BU_LisbonAveiro
BU_LondonCercLumped
BU_MILANmarco_info
BU_OSLOnilu_info
BU_PortoAveiro
BU_Prova_info
BU_SofiaMET_info
BU_StockholmCity

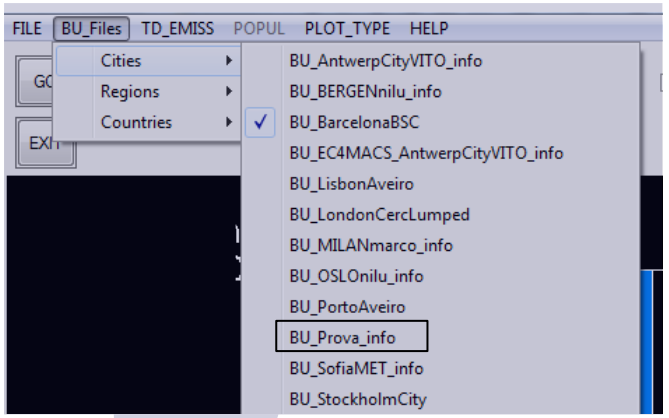

FILE
BU_Files
TD_EMISS
POPUL
PLOT_TYPE
HELP
GO
EXIT
EC4MACS
TNO-MACC2
TNO-MACC3
JRC100m
JRC7km
MyTOD

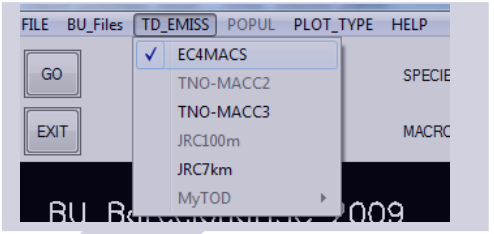

FILE
BU_Files
TD_EMISS
POPUL
PLOT_TYPE
HELP
GO
EXIT
TD_BU_Bar
TD_BU_Ratio
TD_BU_Ratio2
TD_BU_Diamond
TD_BU_EmisCap
TD_BU_GAINS

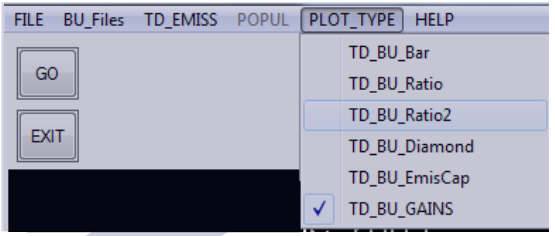

FILE
BU_Files
TD_EMISS
POPUL
PLOT_TYPE
HELP
GO
EXIT
BU_UserInput
Macro=>SNAP
CRC_Codes
CRC_Names
PercOrderShapes
EditDump
EditDumpTOD
Map2dTOD
Save_TOD_as_BU
Diamond_Norm
UserGuide
Contact

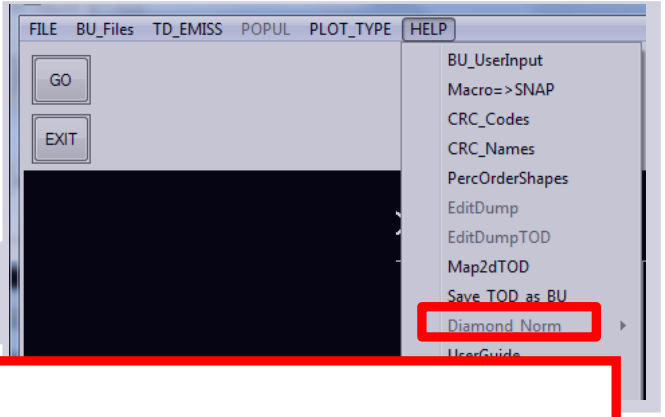

DELTA_EMIS TOOL *** VERSION 2.3
FILE
BU_Files
TD_EMISS
POPUL
PLOT_TYPE
HELP
GO
EXIT
SPECIES:
VOC
NOx
PM25
MACRO SECTORS:
DOM
TRA
zOTH
BU_POVALLEY_info 2006
EC4MACS 2009

Δ_Emis tool



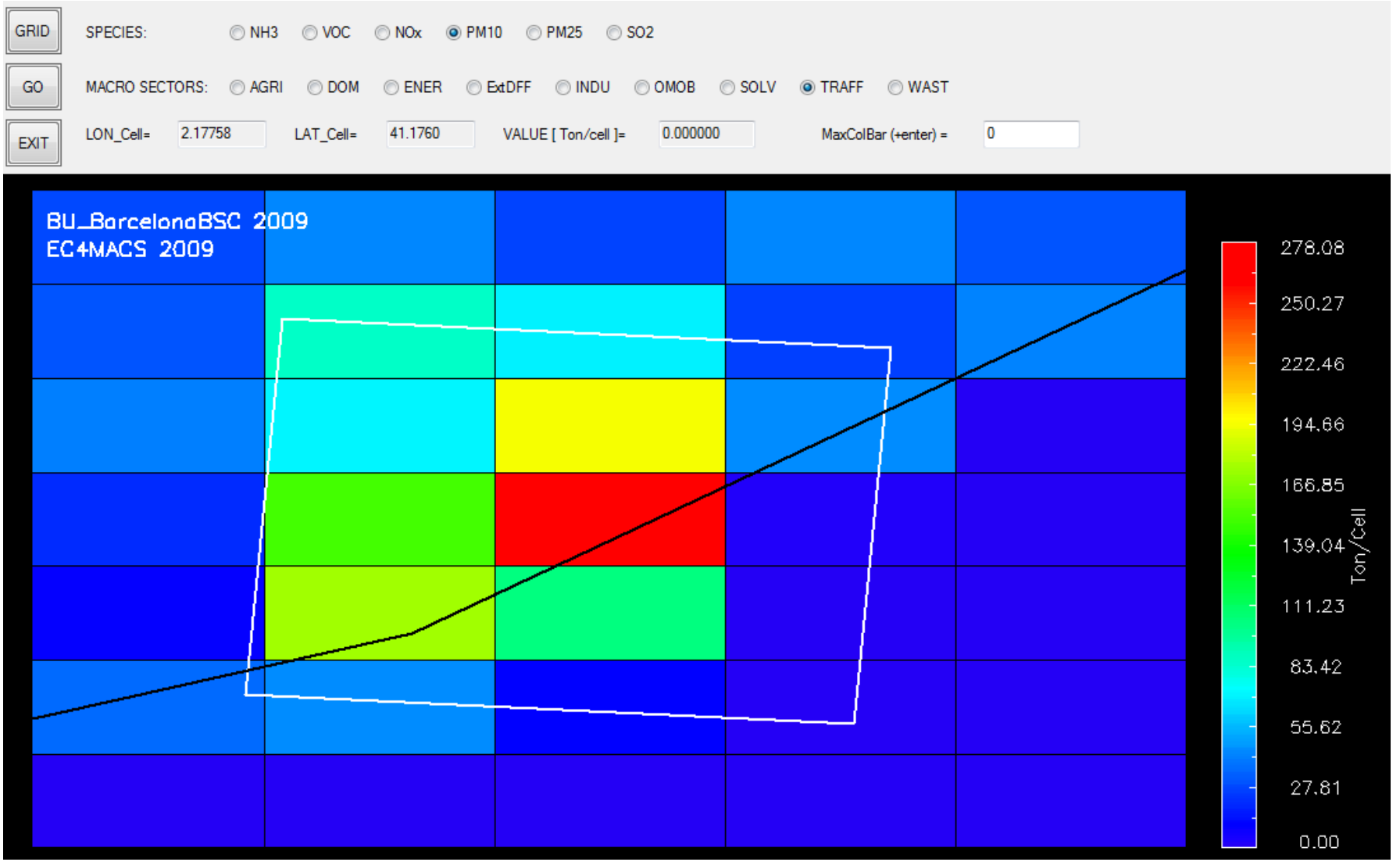






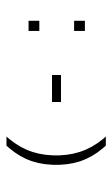

```
# 1  Normalisation by NOx (or an other species if NOx not present).

# 2  Sector specific normalisation:
     if Usect2Snap <-> Snap1  then normalisation by SO2
     if Usect2Snap <-> Snap5  then normalisation by PM10
     if Usect2Snap <-> Snap6  then normalisation by VOC
     if Usect2Snap <-> Snap9  then normalisation by PM10
     if Usect2Snap <-> Snap10 then normalisation by NH3
     else
     normalisation by NOx (or other species if NOx not present).

# 3  Normalisation over Total TOD:
     Yratio(is)=total(BUP(*,is))/total(TOD(*,is),/nan)

# 4  Normalisation of (total TOD + total BUP)/2:
     Yratio(is) = 2.*total(BUP(*,is),/nan)/( total(TOD(*,is),/nan)+total(BUP(*,is),/nan) )

# 5  Sector specific normalisation with respect to the species with the best relative BUP to TOD estimate ( |BUP-TOD|/TOD )

# 6  Normalisation with respect to the mean of two pollutants with smallest X distance.
```

TOD 2D map & shapefile



Index

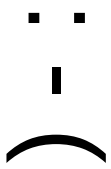
Strengths and limitations



✓ **Simplicity of implementation**: only total emissions for pollutant and macro-sector required

✓ **Coherence** between the various graphs

✓ **Complementarity** between different diagrams



X **Only relative comparisons** are possible (information about the accuracy of emission inventories NOT provided)

X **Additional bias** introduction: TOD inventories downscaled to a 1 km resolution using a uniform sub-grid distribution

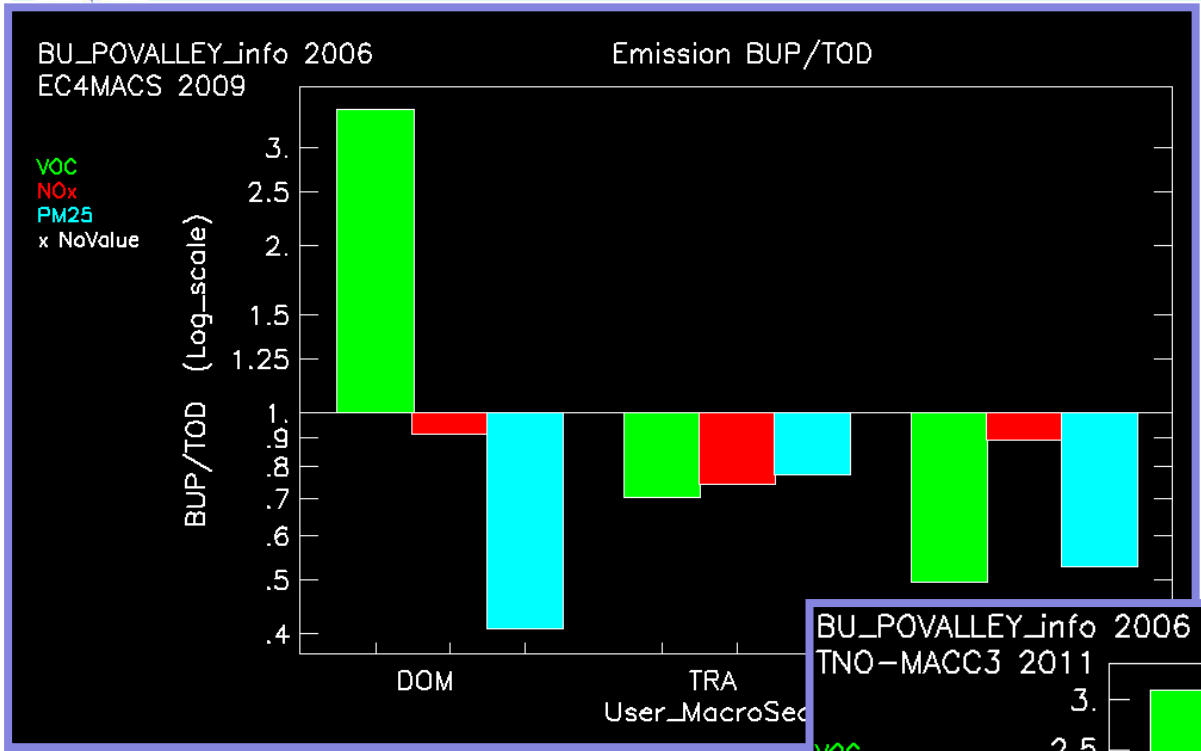
Index

References

- **A benchmarking tool to screen and compare bottom-up and top-down atmospheric emission inventories,** *M. Guevara et al.,* Air Qual Atmos Health DOI 10.1007/s11869-016-0456-6, Springer (December 2016)
- **A novel approach to screen and compare emission inventories,** *P. Thunis et al*., Air Qual Atmos Health DOI 10.1007/s11869-016-0402-7, Springer (March 2016)
- **Delta_Emis Tool Users manual V 2.3,** C. Cuvelier (March 2016)
- **The FAIRMODE Δ-Emis tool - Simplified guide** (slide)

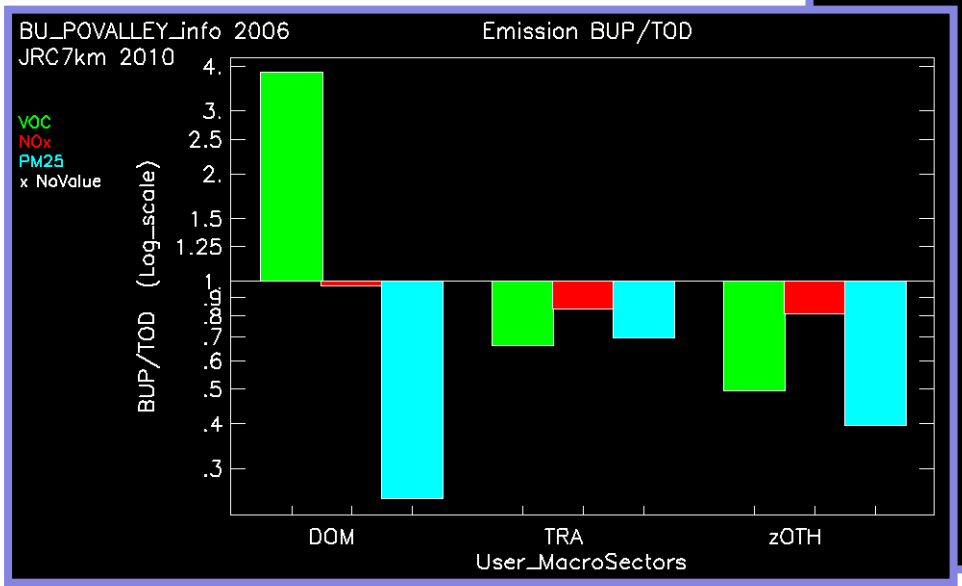
Index

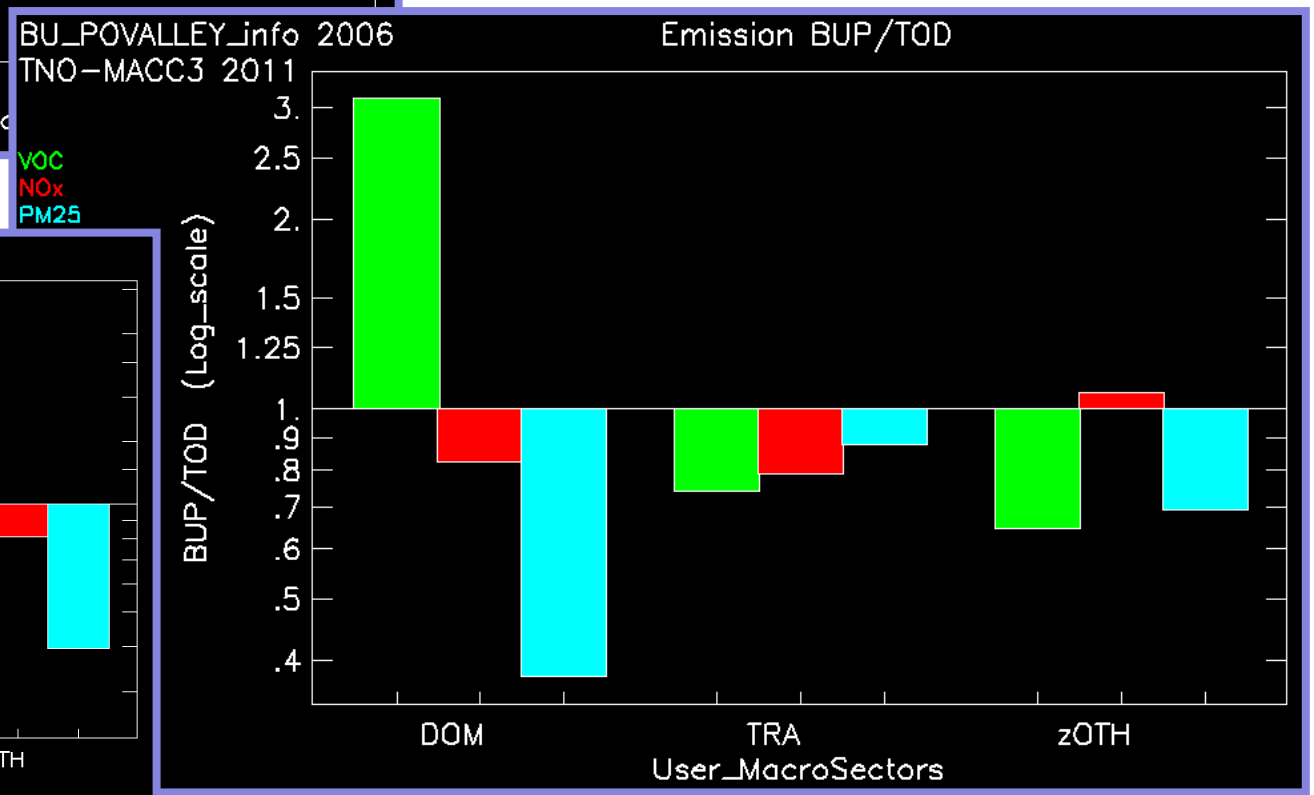
PO VALLEY



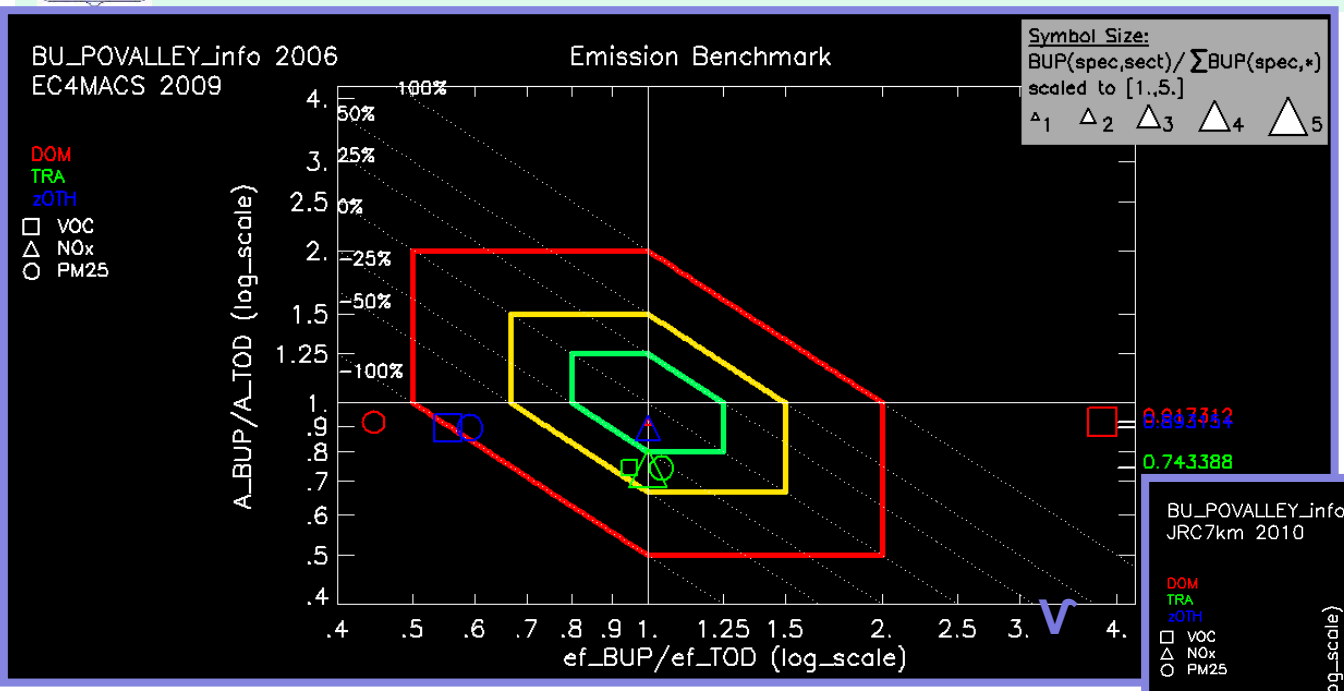

```
EB Input File = BU_POVALLEY_info  2006  (type=Region)
Thu Jul 13 16:19:04 2017
Conversion MacroSectors  => SNAP Sectors
**********************************************************
      DOM  =>   S2
      TRA  =>   S7
      zOTH =>   S1+S4+S5+S6+S3+S8+S9+S10
```

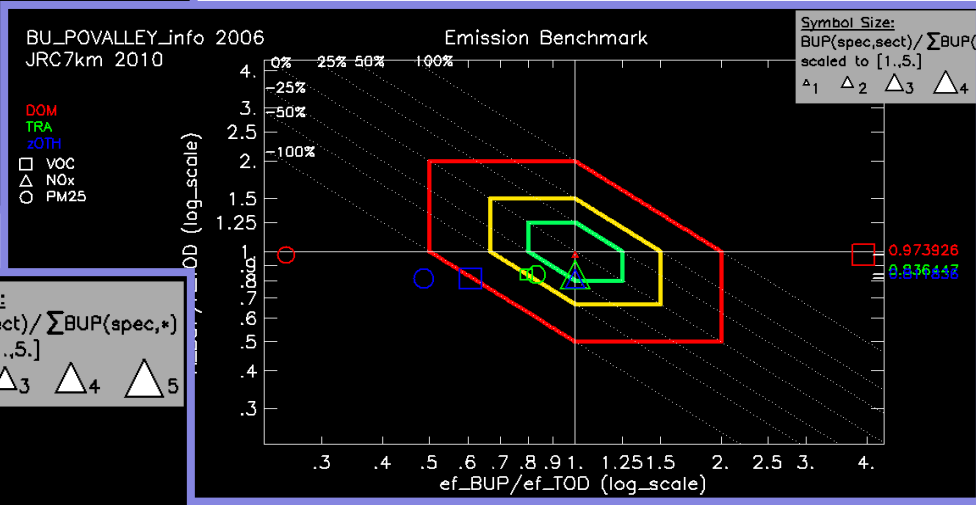
$$\Rightarrow \begin{cases} E^{TRAF} & \checkmark \\ E^{DOM} & \mathbf{x}\ \text{(VOC,PM25)} \\ E^{OTH} & \sim\ \text{(VOC,PM25)} \end{cases}$$

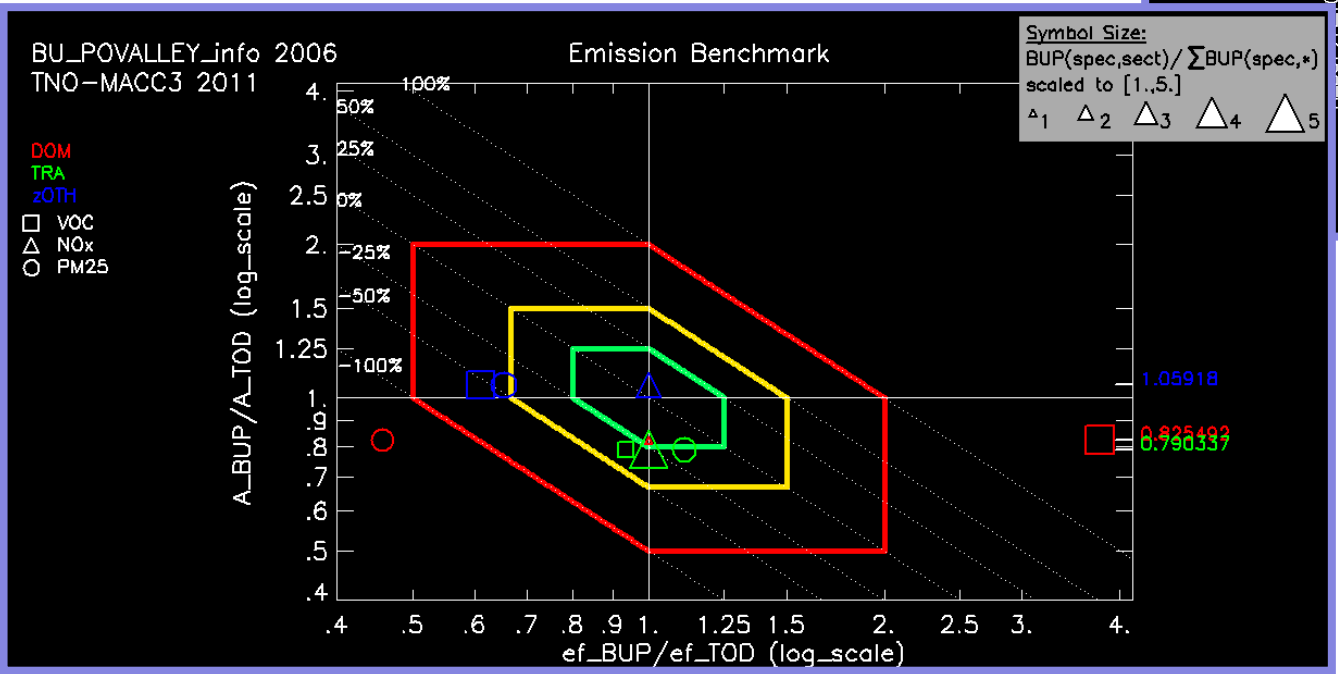




PO VALLEY

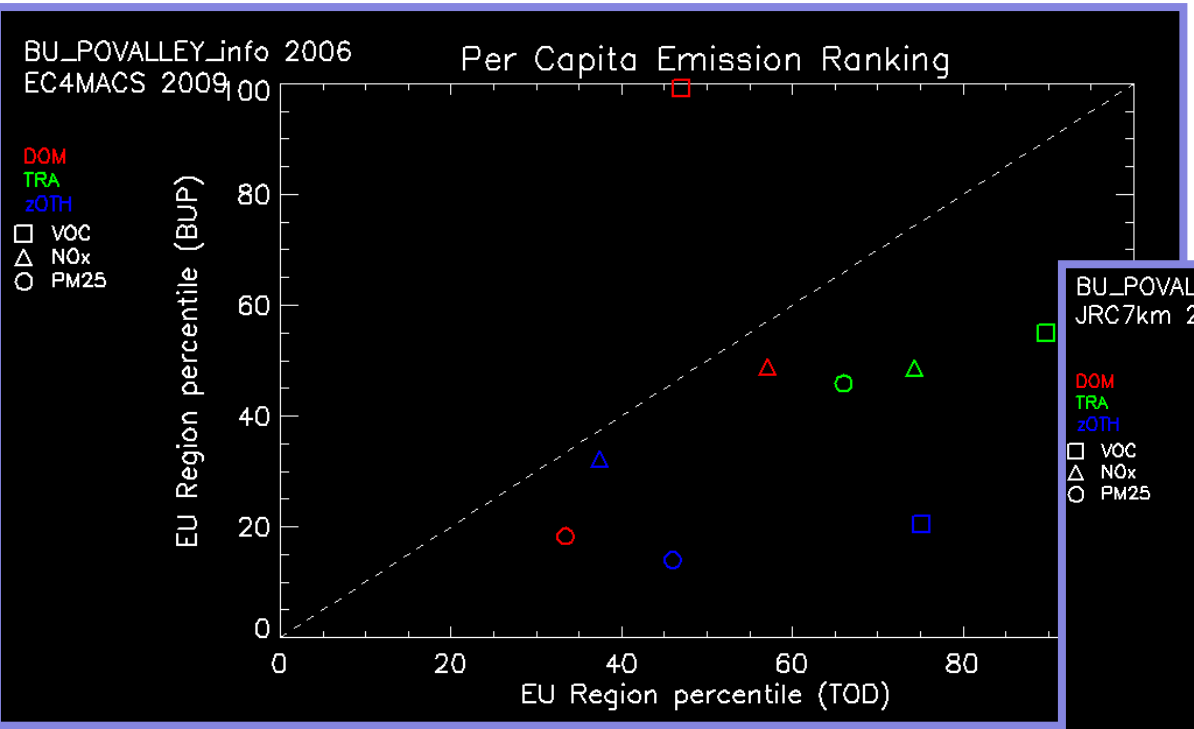


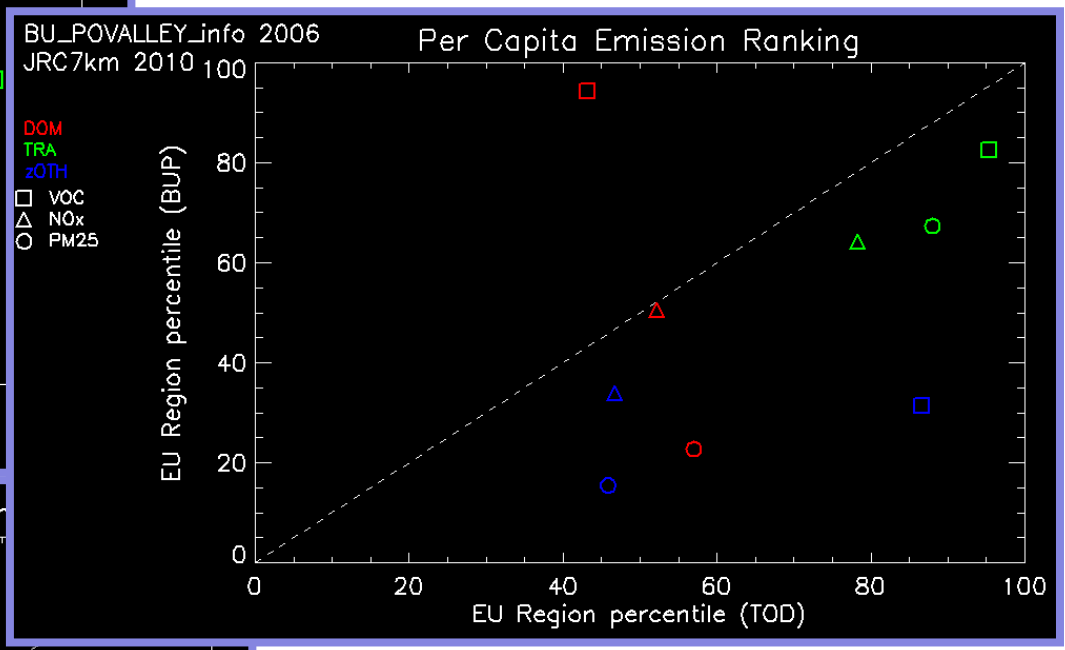


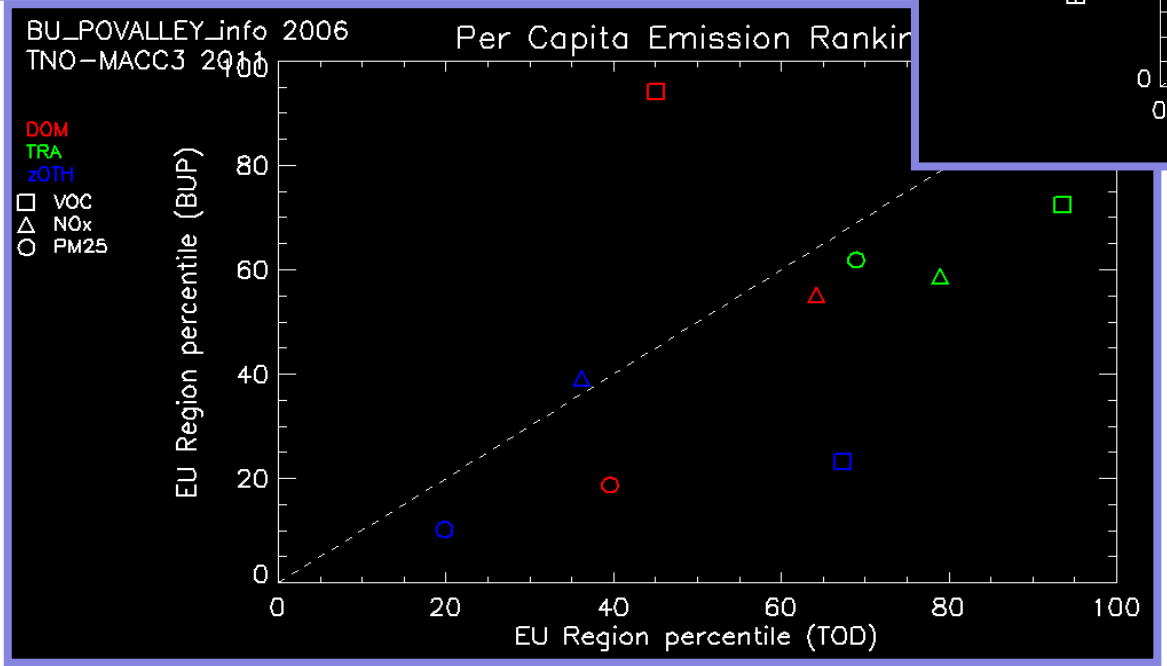


$$\Rightarrow \begin{matrix} (E,e,A)^{TRAF} \checkmark \\ (E,e)^{DOM} \quad \mathbf{X} \\ (E,e,A)^{OTH} \checkmark \end{matrix} \text{ (VOC,PM25)}$$

PO VALLEY





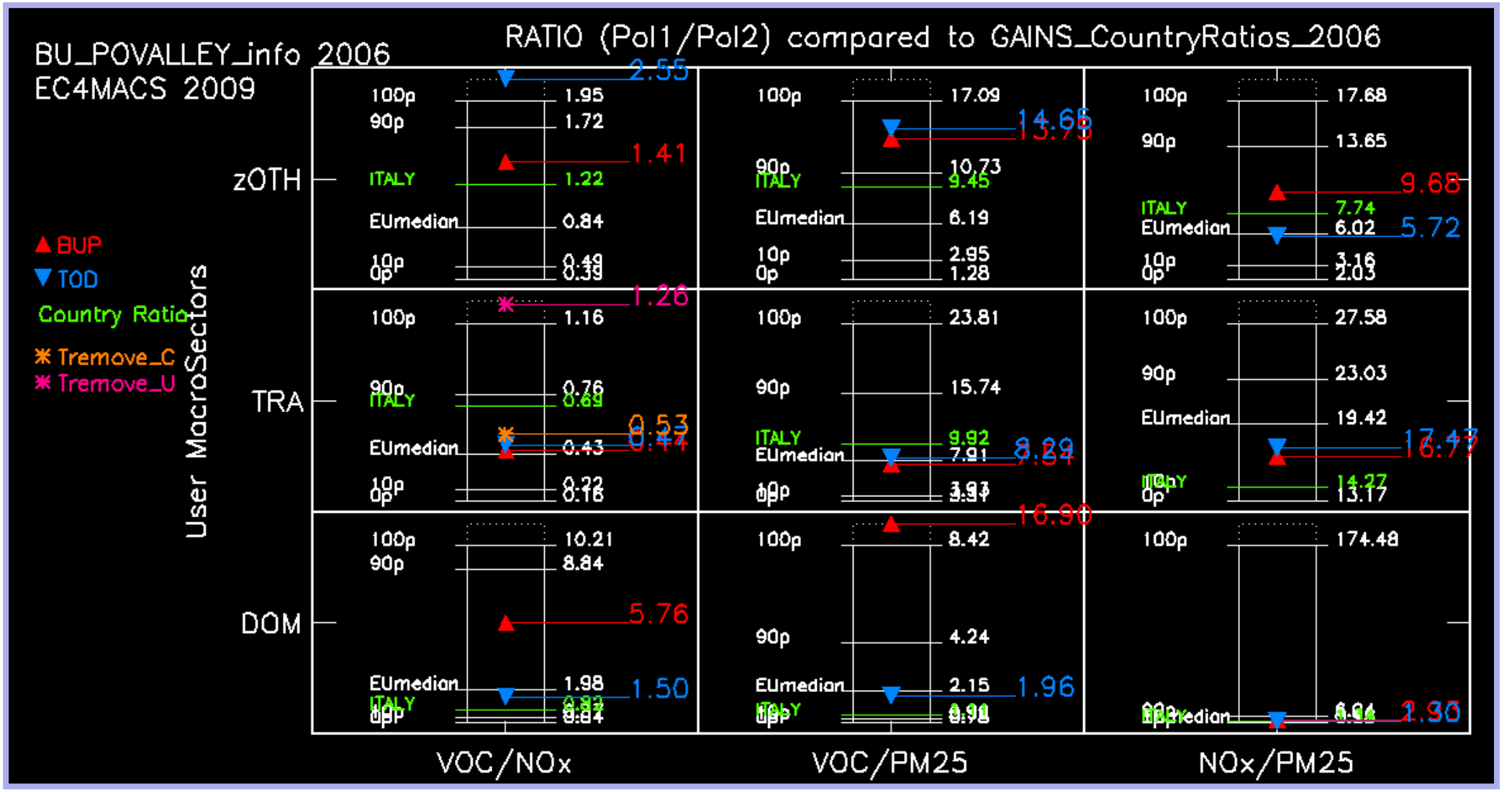


TRAF TOD: ↑,~
BUP: ↓

⇒ DOM TOD: ~
BUP: **X** (VOC,PM25)

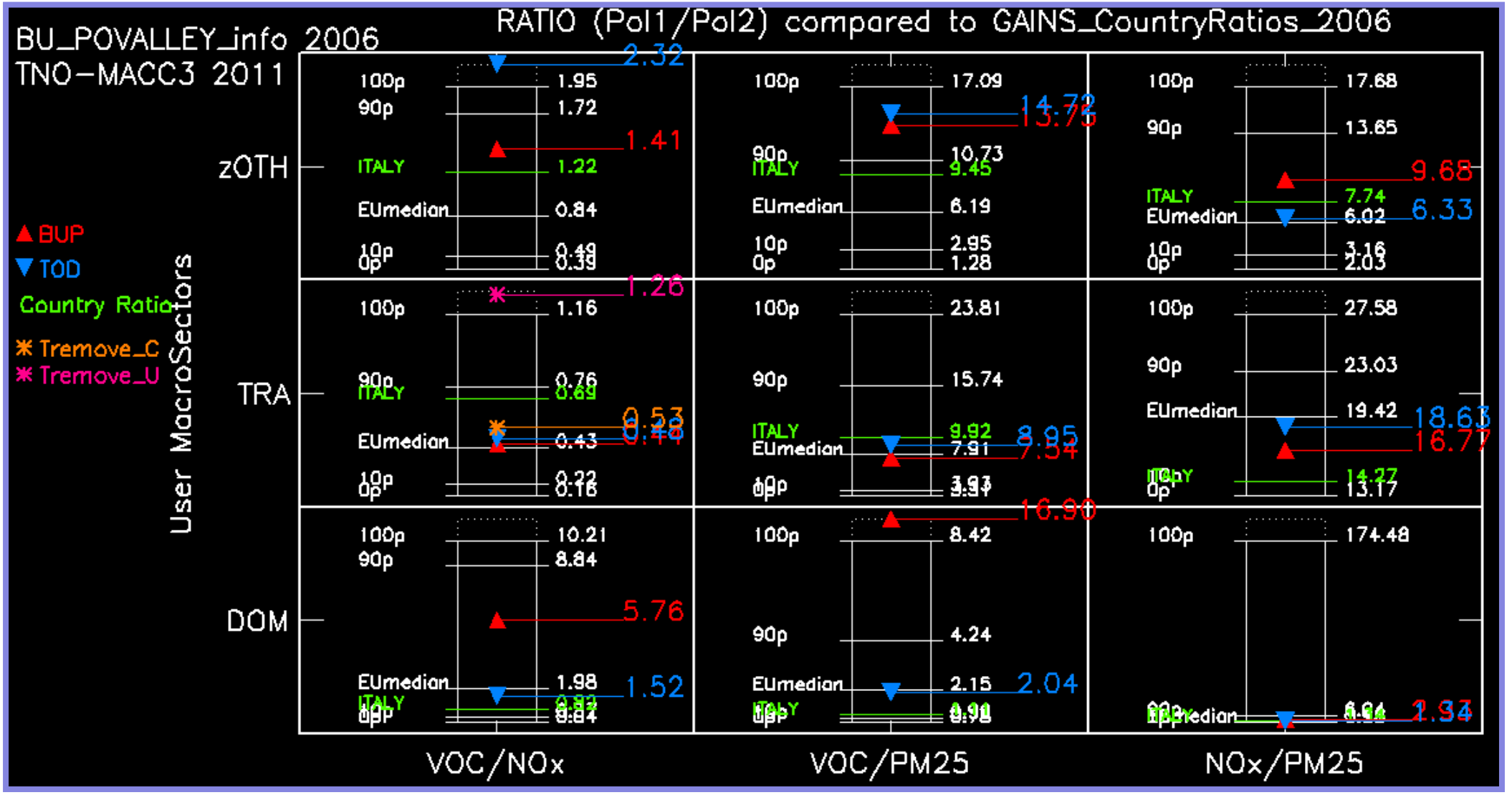
OTH TOD: **X** (VOC)
BUP: **X** (VOC)

PO VALLEY

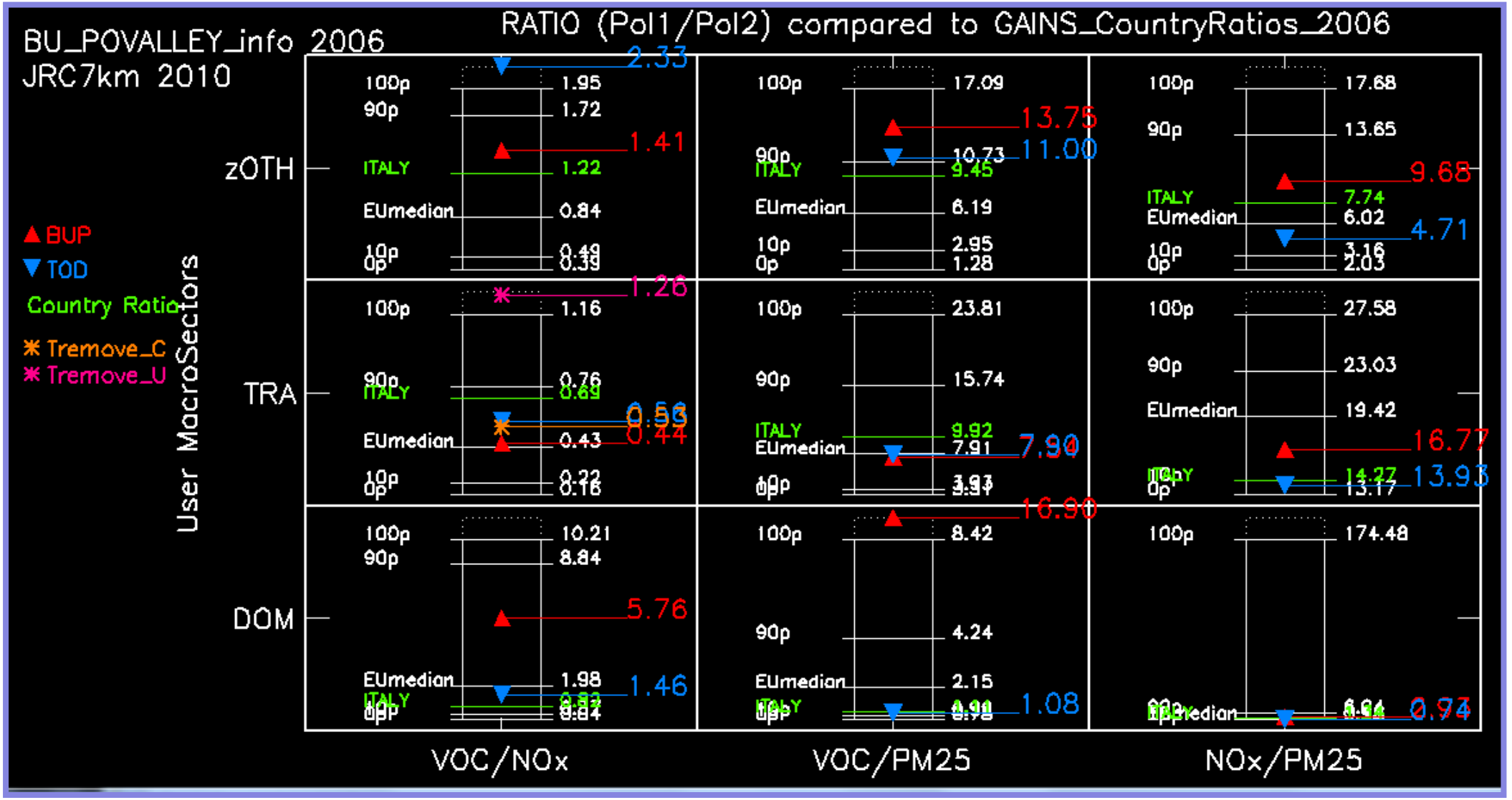


⇒ TRAF **V**
DOM **X** (VOC/PM25, VOC/NOX)
OTH ~ (VOC/NOX)

PO VALLEY


RATIO (Pol1/Pol2) compared to GAINS_CountryRatios_2006
BU_POVALLEY_info 2006
TNO-MACC3 2011
▲ BUP
▼ TOD
Country Ratio
* Tremove_C
* Tremove_U
User MacroSectors
zOTH
TRA
DOM
100p
90p
ITALY
EUmedian
10p
0p
1.95
1.72
1.22
0.84
0.49
0.39
2.32
1.41
17.09
10.73
9.45
6.19
2.95
1.28
14.72
13.75
17.68
13.65
7.74
6.02
3.16
2.03
9.68
6.33
1.16
0.76
0.69
0.43
0.22
0.16
1.26
0.53
0.48
23.81
15.74
9.92
7.91
3.97
3.57
8.95
7.54
27.58
23.03
19.42
14.27
13.17
18.63
16.77
10.21
8.84
1.98
0.82
0.64
5.76
1.52
8.42
4.24
2.15
1.91
0.98
16.90
2.04
174.48
6.94
6.55
1.34
VOC/NOx
VOC/PM25
NOx/PM25

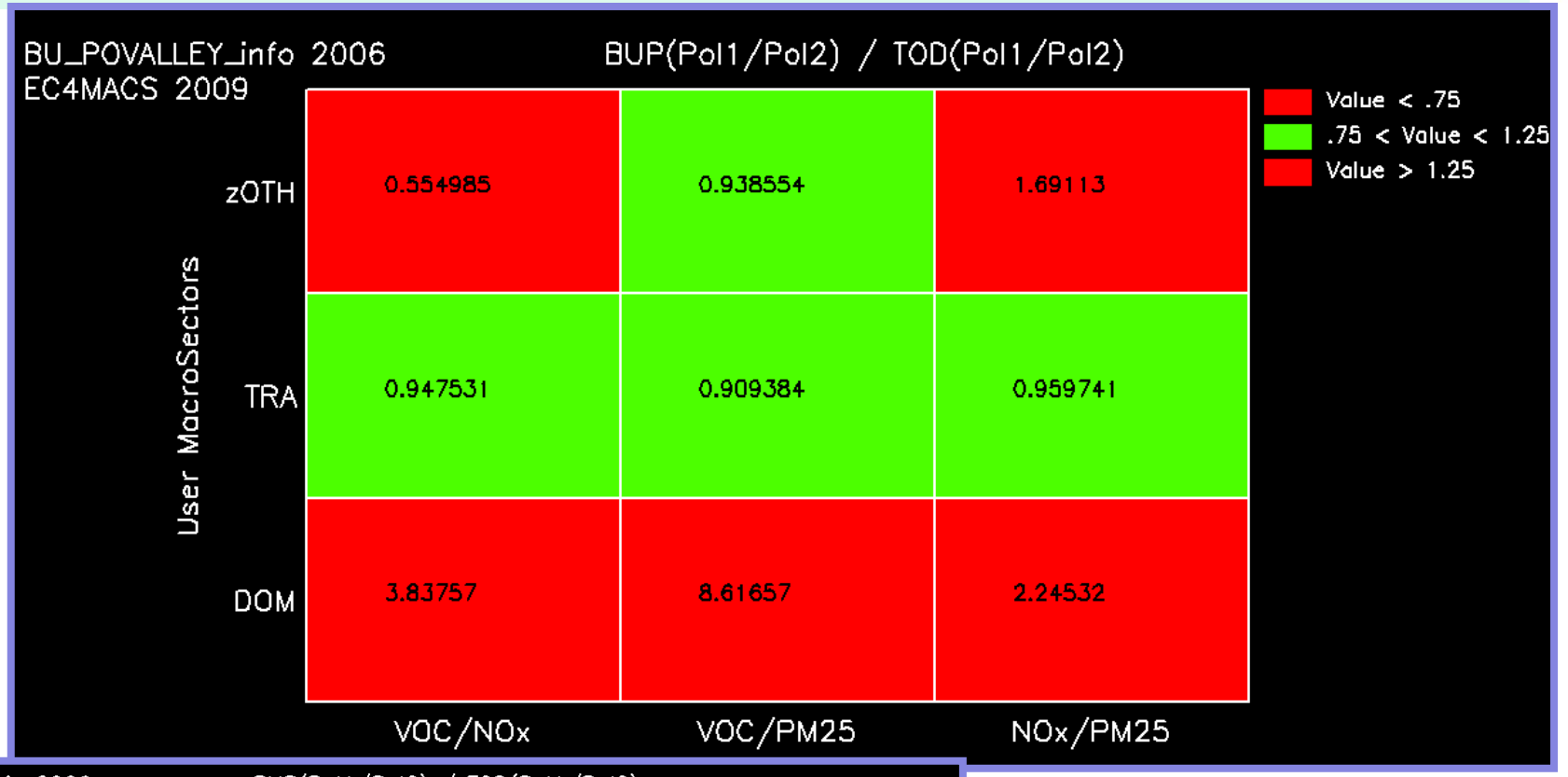
PO VALLEY

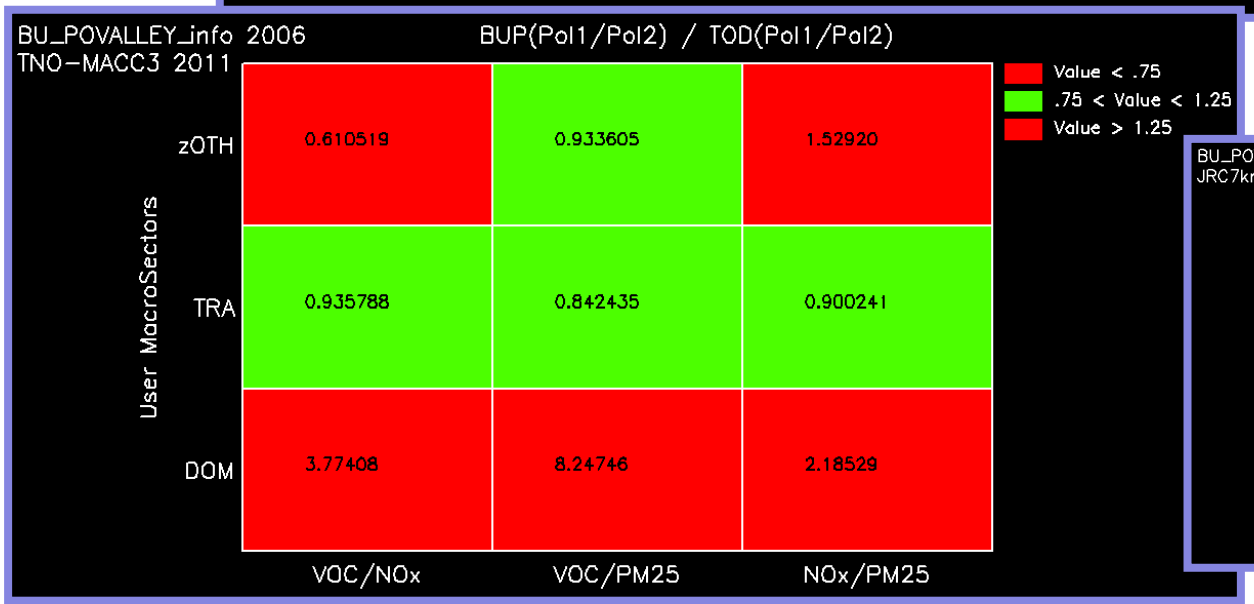

RATIO (Pol1/Pol2) compared to GAINS_CountryRatios_2006
BU_POVALLEY_info 2006
JRC7km 2010
▲ BUP
▼ TOD
Country Ratio
* Tremove_C
* Tremove_U
User MacroSectors
zOTH
TRA
DOM
100p
90p
ITALY
EUmedian
10p
0p
2.33
1.95
1.72
1.41
1.22
0.84
0.49
0.39
17.09
13.75
10.73
11.00
9.45
6.19
2.95
1.28
17.68
13.65
9.68
7.74
6.02
4.71
3.16
2.03
1.26
1.16
0.76
0.69
0.56
0.55
0.44
0.43
0.22
0.16
23.81
15.74
9.92
7.91
7.90
3.93
3.91
27.58
23.03
19.42
16.77
14.27
13.93
13.17
16.90
10.21
8.84
5.76
1.98
1.46
8.42
4.24
2.15
1.08
174.48
0.97
VOC/NOx
VOC/PM25
NOx/PM25

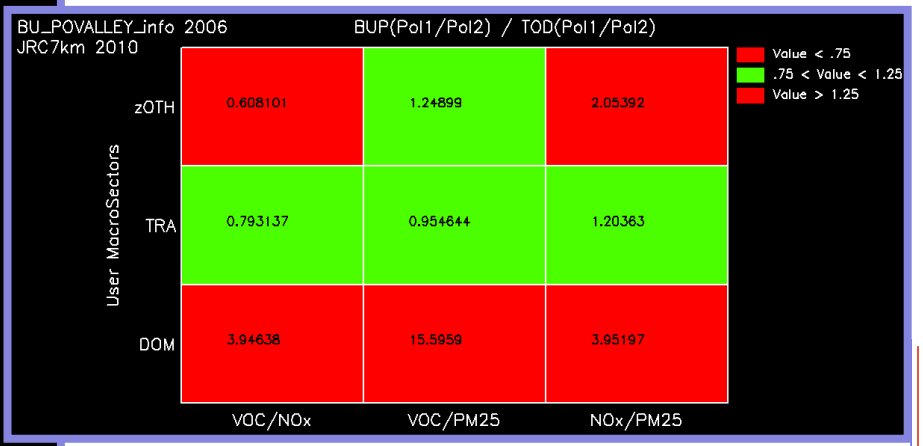
PO VALLEY

MS	Ratio	Comment
SNAP01	NO_x/SO_2	Close to 0 for liquid or coal based fuel. Much higher for natural gas
	NO_x/PPM_{10}	
	NOx/NH_3	Low if SCR or SNCR systems are in place. Higher values indicate incomplete reaction of NH_3 additive
	VOC/PPM_{10}	Close to 1 for liquid or coal based fuel and much higher for natural gas
	SO_2/PPM_{10}	Very high for liquid based fuel, high for coal based fuel and close to one for natural gas
SNAP02	SO_2/NO_x	Close to 0 for natural gas. Much higher for liquid or coal based fuel
	PPM_{10}/NO_x	
	PPM_{10}/VOC	Close to 1 for liquid, coal or biomass based fuel and much higher for natural gas
	PPM_{10}/SO_2	Very low for liquid based fuel, low for coal based fuel, close to one for natural gas and higher for biomass
SNAP03	SO_2/NO_x	Close to 0 for natural gas and higher for liquid or coal based fuel
	NO_x/PPM_{10}	Low for liquid or coal based fuel and high for natural gas
	PPM_{10}/VOC	Very high for process furnaces and processes with contact (e.g. iron and steel industries)
	SO_2/PPM_{10}	Very low for biomass, low for coal based fuel, close to 1 for natural gas and much higher for liquid based fuel
SNAP04	SO_2/NO_x	Very high values identify processes in petroleum industries (i.e. sulphur recovery plants) aluminium and sulphuric acid production plants
	PPM_{10}/NO_x	High values identify coke ovens and aluminium and fertilizer production plants
	NH_3/NO_x	High values identify ammonia and fertilizer production
	SO_2/NH_3	Low values identify ammonia and fertilizer production
	PPM_{10}/SO_2	Low values identify refinery, aluminium and sulphuric acid plants and high values identify fertilizer production plants
SNAP07	NO_x/SO_2	High values indicate move to ultra-low sulphur content
	PPM_{10}/SO_2	
	NO_x/PPM_{10}	High values identify gasoline-powered vehicles or modern Euro diesel-powered vehicles equipped with particle filters
	NOx/ NH_3	Values between 10 and 50 indicate SCR systems. Higher values for emerging economies
	NO_x/VOC	High values for gasoline-powered vehicles and much lower for diesel-powered vehicles
SNAP08	SO_2/NO_x	High values for fuels with high sulphur content values, usually related to maritime activities (e.g. residual oil)
	NO_x/PPM_{10}	Values are usually stable (several dozen). Very high values (several hundreds) identify air traffic activities
	VOC/SO_2	Very high values identify industrial or agricultural machinery and low values identify port facilities
	PPM_{10}/SO_2	
SNAP09	PPM_{10}/NO_x	Above means unabated PM low values indicate reverse
SNAP10	PPM_{10}/NO_x	High values identify manure management
	PPM_{10}/VOC	
	NH_3/VOC	Low values for cultures without fertilizers
	NH_3/PPM_{10}	Low values (<15) indicate manure management rather than crop production (>40)

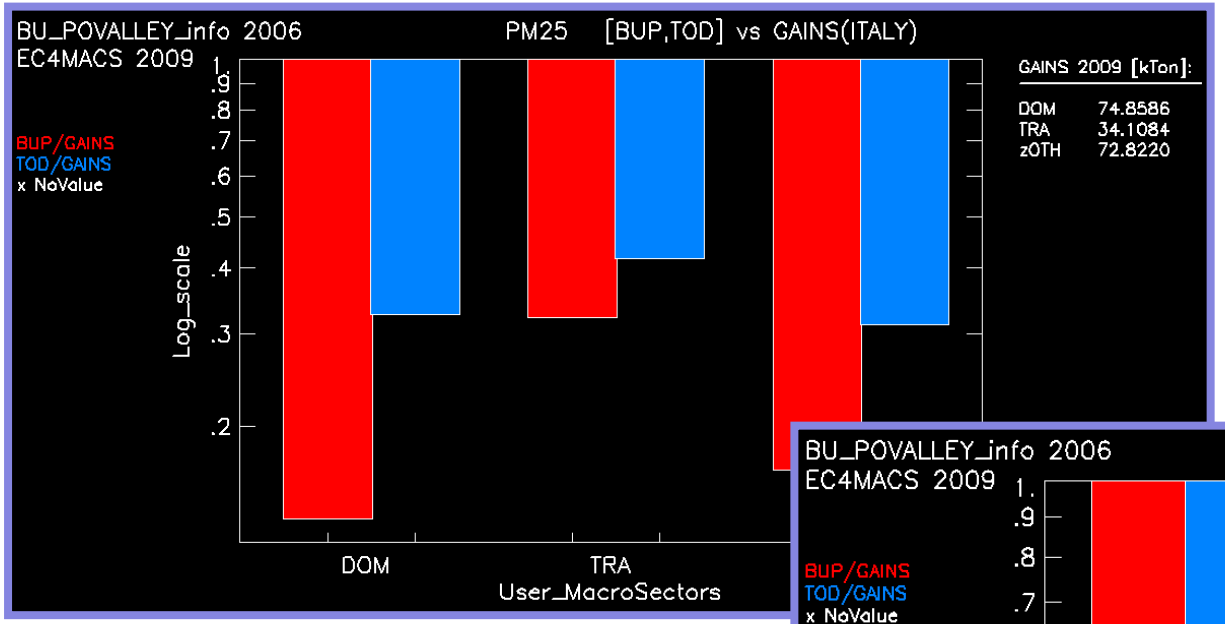
PO VALLEY

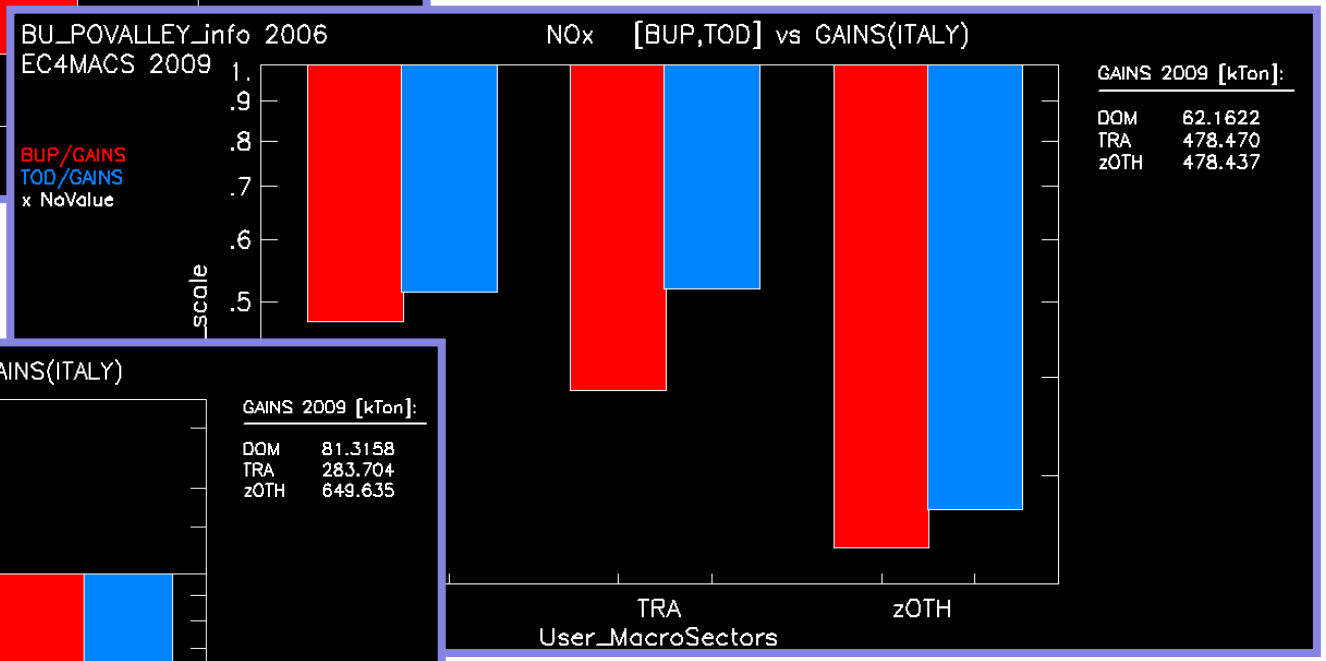

BU_POVALLEY_info 2006
EC4MACS 2009
BUP(Pol1/Pol2) / TOD(Pol1/Pol2)
Value < .75
.75 < Value < 1.25
Value > 1.25
User MacroSectors
zOTH
TRA
DOM
0.554985
0.938554
1.69113
0.947531
0.909384
0.959741
3.83757
8.61657
2.24532
VOC/NOx
VOC/PM25
NOx/PM25

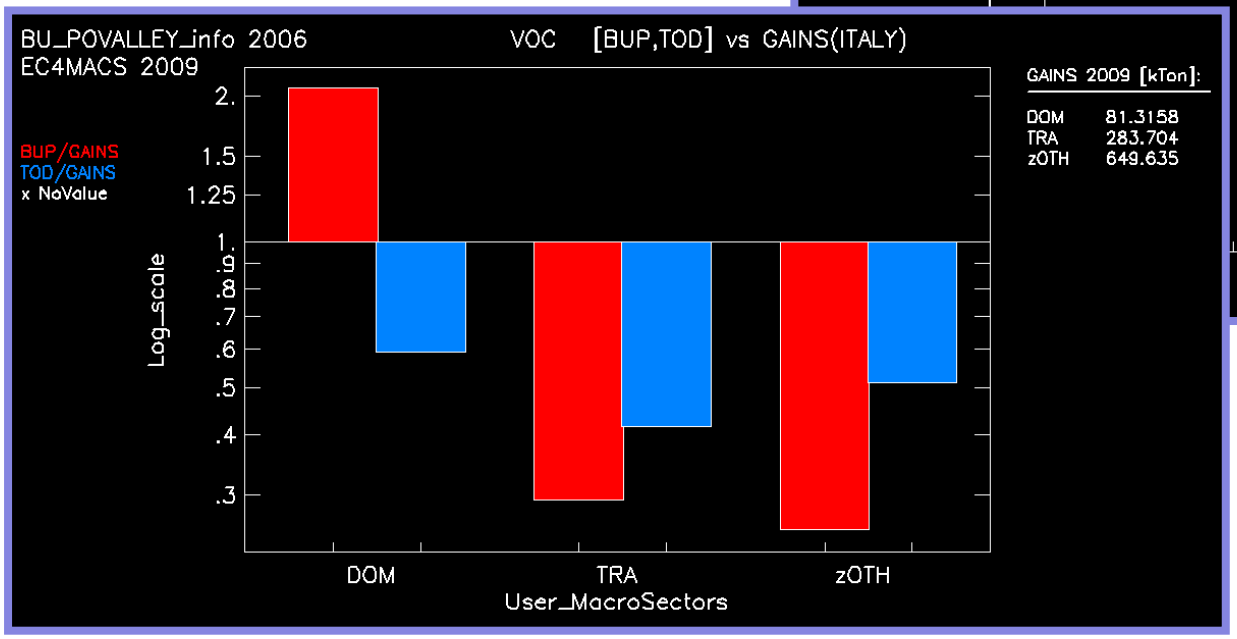

BU_POVALLEY_info 2006
TNO-MACC3 2011
BUP(Pol1/Pol2) / TOD(Pol1/Pol2)
Value < .75
.75 < Value < 1.25
Value > 1.25
User MacroSectors
zOTH
TRA
DOM
0.610519
0.933605
1.52920
0.935788
0.842435
0.900241
3.77408
8.24746
2.18529
VOC/NOx
VOC/PM25
NOx/PM25


BU_POVALLEY_info 2006
JRC7km 2010
BUP(Pol1/Pol2) / TOD(Pol1/Pol2)
Value < .75
.75 < Value < 1.25
Value > 1.25
User MacroSectors
zOTH
TRA
DOM
0.608101
1.24899
2.05392
0.793137
0.954644
1.20363
3.94638
15.5959
3.95197
VOC/NOx
VOC/PM25
NOx/PM25

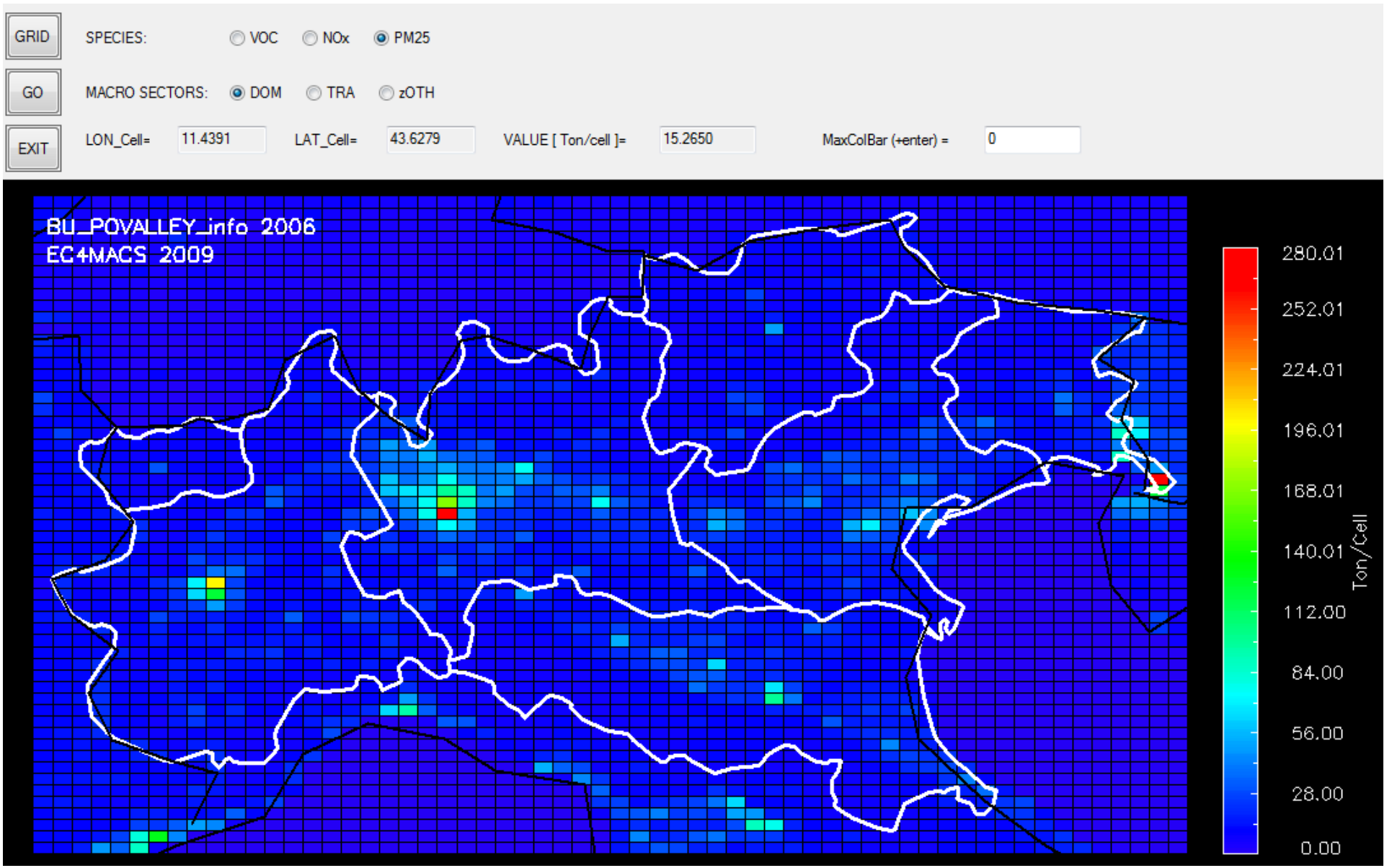
PO VALLEY


BU_POVALLEY_info 2006
EC4MACS 2009
PM25 [BUP,TOD] vs GAINS(ITALY)
BUP/GAINS
TOD/GAINS
x NoValue
Log_scale
1.
.9
.8
.7
.6
.5
.4
.3
.2
DOM
TRA
User_MacroSectors
GAINS 2009 [kTon]:
DOM 74.8586
TRA 34.1084
zOTH 72.8220


BU_POVALLEY_info 2006
EC4MACS 2009
NOx [BUP,TOD] vs GAINS(ITALY)
BUP/GAINS
TOD/GAINS
x NoValue
scale
1.
.9
.8
.7
.6
.5
TRA
zOTH
User_MacroSectors
GAINS 2009 [kTon]:
DOM 62.1622
TRA 478.470
zOTH 478.437


BU_POVALLEY_info 2006
EC4MACS 2009
VOC [BUP,TOD] vs GAINS(ITALY)
BUP/GAINS
TOD/GAINS
x NoValue
Log_scale
2.
1.5
1.25
1.
.9
.8
.7
.6
.5
.4
.3
DOM
TRA
zOTH
User_MacroSectors
GAINS 2009 [kTon]:
DOM 81.3158
TRA 283.704
zOTH 649.635

PO VALLEY

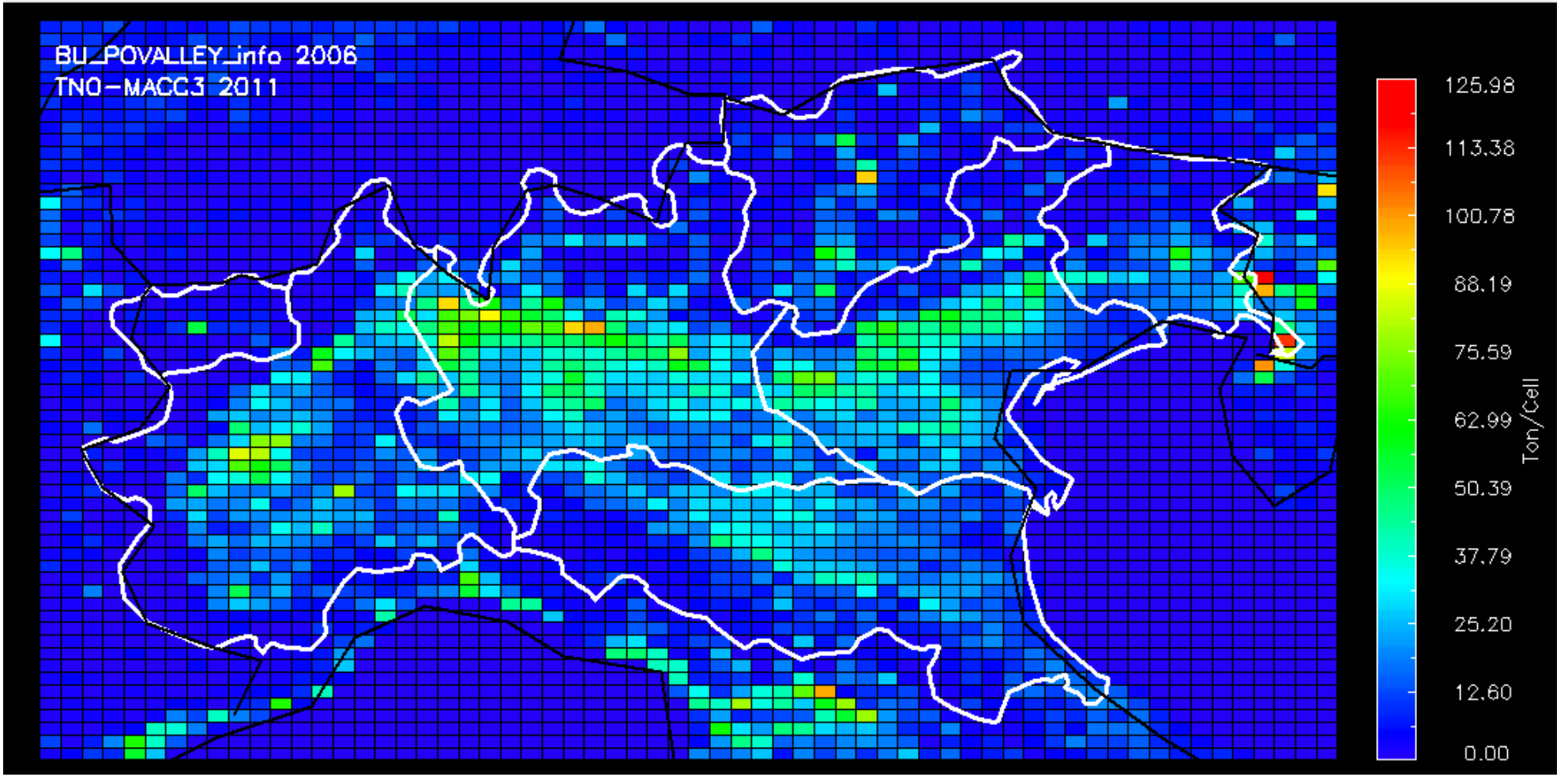

GRID
SPECIES:
VOC
NOx
PM25
GO
MACRO SECTORS:
DOM
TRA
zOTH
EXIT
LON_Cell=
11.4391
LAT_Cell=
43.6279
VALUE [Ton/cell]=
15.2650
MaxColBar (+enter) =
0
BU_POVALLEY_info 2006
EC4MACS 2009
280.01
252.01
224.01
196.01
168.01
140.01
112.00
84.00
56.00
28.00
0.00
Ton/Cell

PO VALLEY

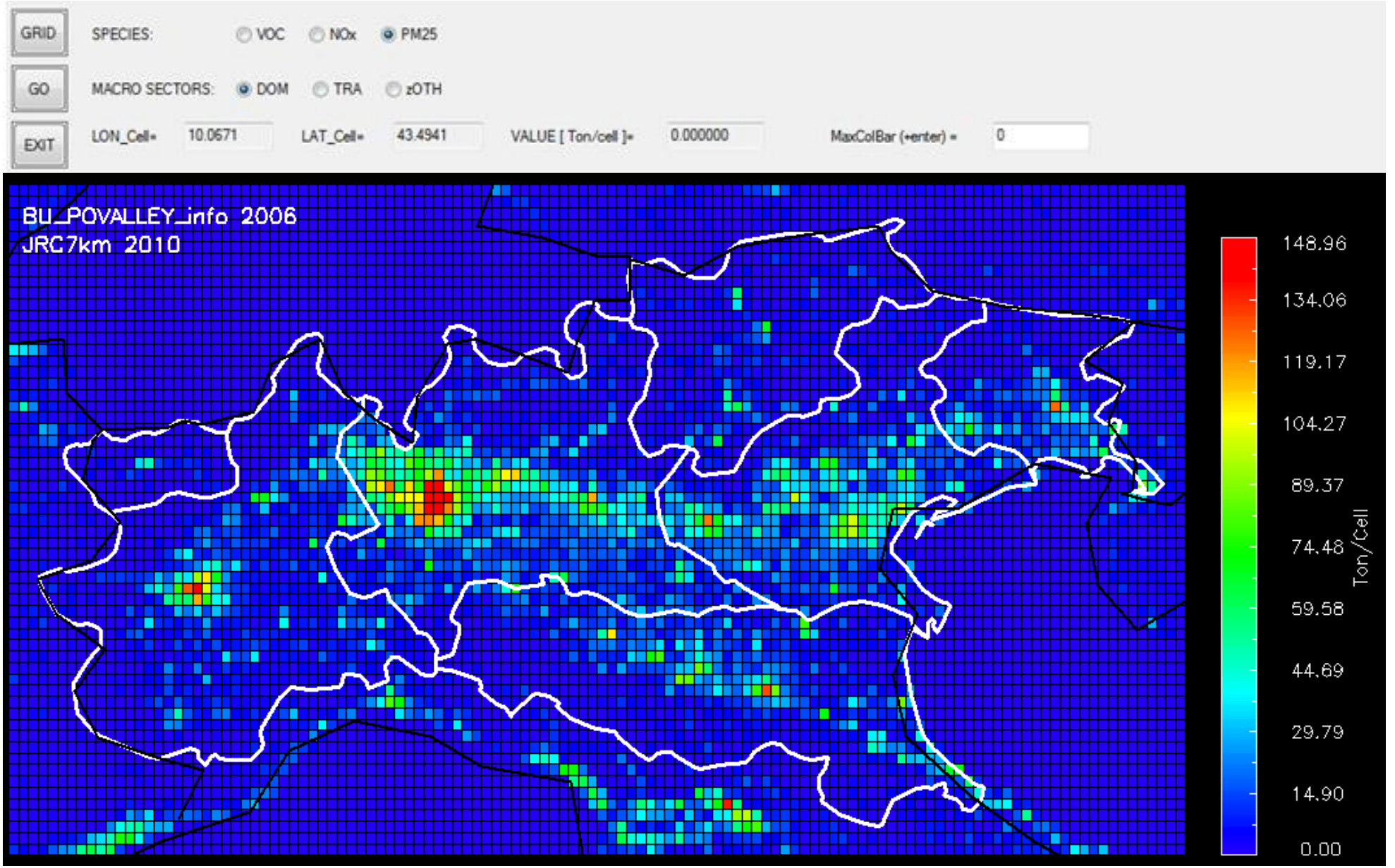
GRID | SPECIES: ○ VOC ○ NOx ◉ PM25

GO | MACRO SECTORS: ◉ DOM ○ TRA ○ zOTH

EXIT | LON_Cell= 10.0671 | LAT_Cell= 43.4941 | VALUE [Ton/cell]= 0.000000 | MaxColBar (+enter) = 0



PO VALLEY


GRID
SPECIES:
VOC
NOx
PM25
GO
MACRO SECTORS:
DOM
TRA
zOTH
EXIT
LON_Cell=
10.0671
LAT_Cell=
43.4941
VALUE [Ton/cell]=
0.000000
MaxColBar (+enter) =
0
BU_POVALLEY_info 2006
JRC7km 2010
148.96
134.06
119.17
104.27
89.37
74.48
59.58
44.69
29.79
14.90
0.00
Ton/Cell