Ship emissions and source apportionment: comparison of receptor and chemical transport models in the framework of the APICE project

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Mar Viana et al., Atmospheric Environment 90 (2014) 96e105

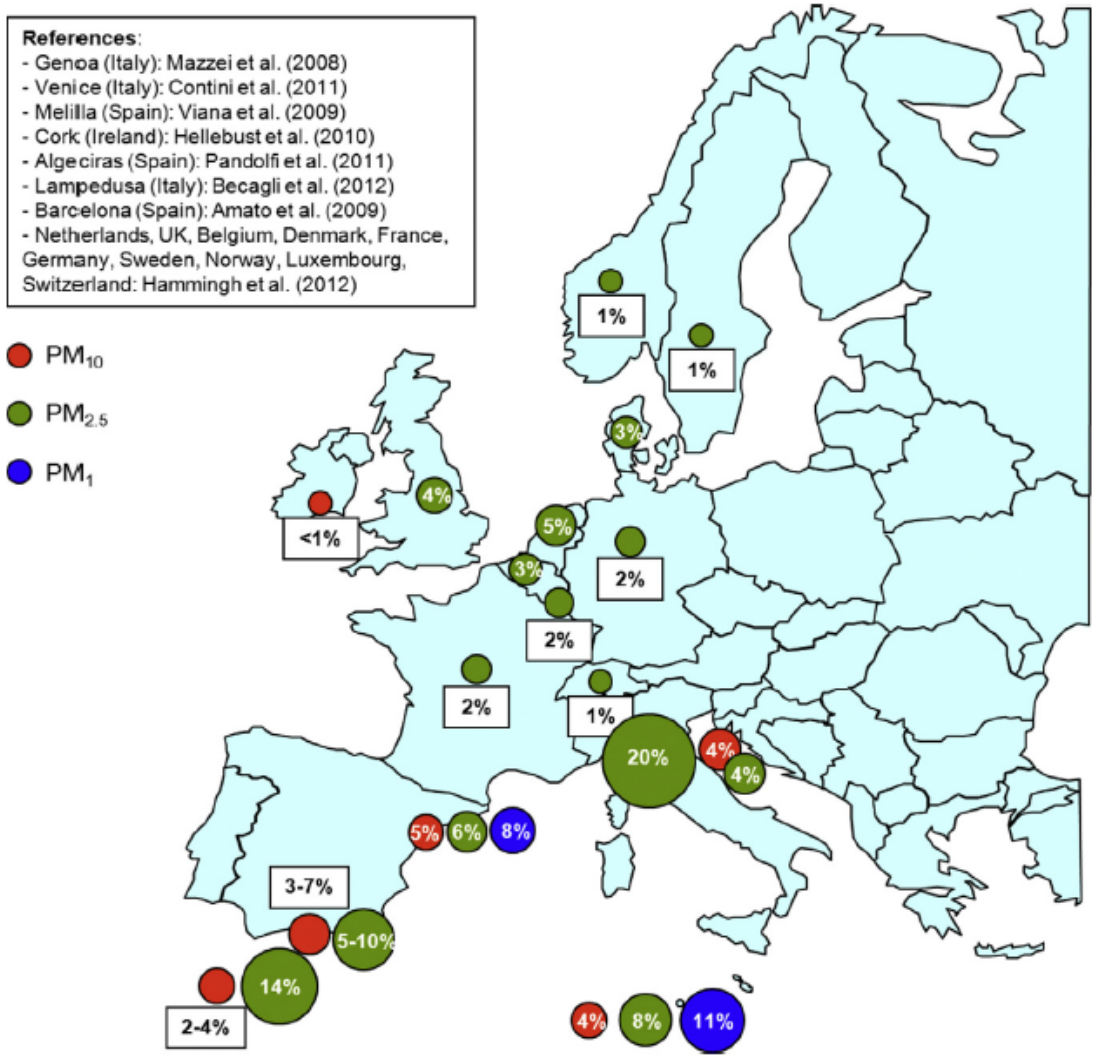

Fig. 1. Contribution from shipping emissions to air quality (PM_{10}, $PM_{2.5}$ and PM_1) across Europe.

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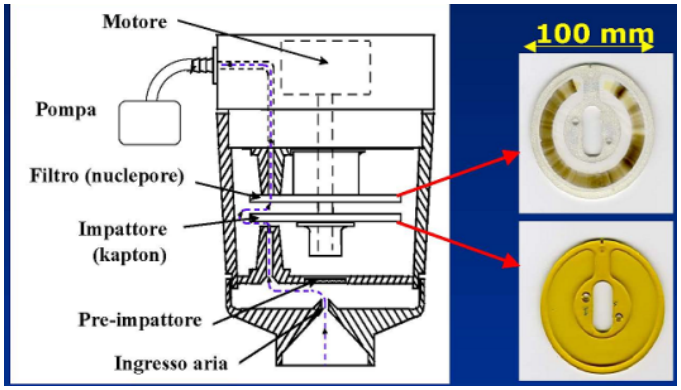
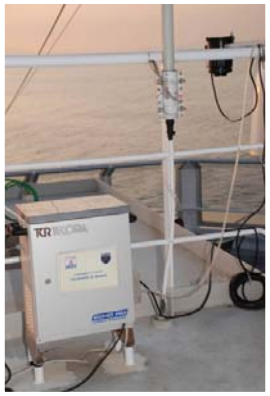
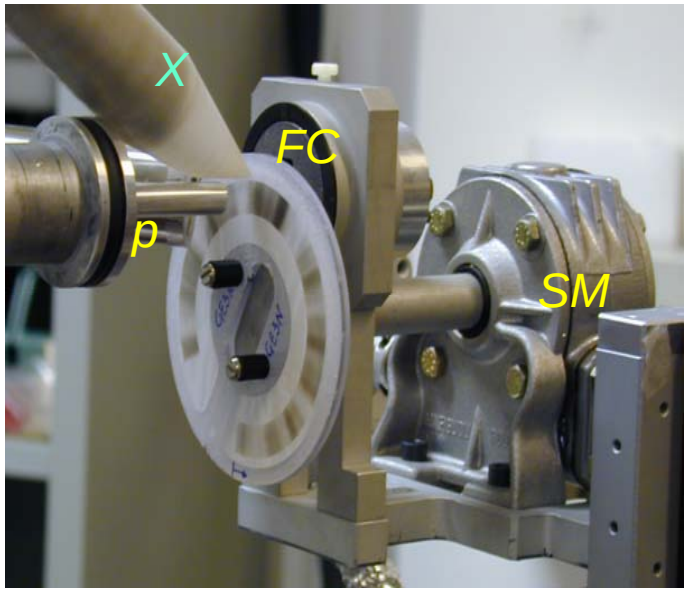
M-PMF → «Moving» PMF

JRC monitoring station on Deck 14

2009-2010







streaker + PIXE (Time Resolution: 1 hour)

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Western Mediterranean PMF2 - Analysis

Input

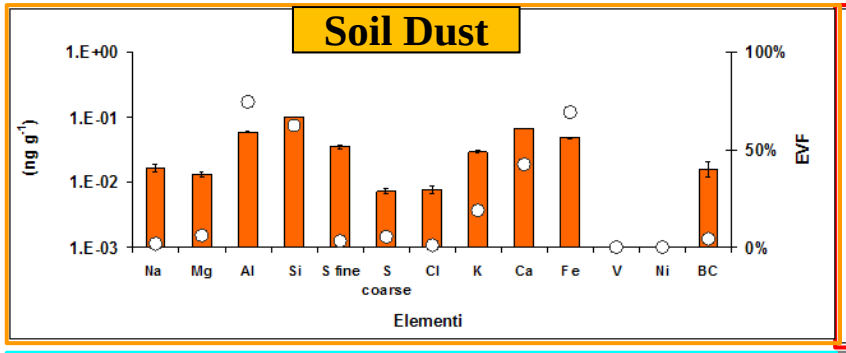
2 datasets (2009 and 2010)
(~ 4 weeks, 600 x2 hourly samples)

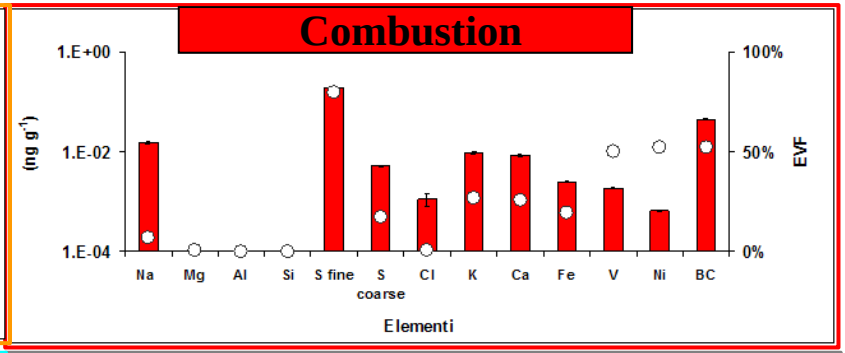
HARBOURS excluded

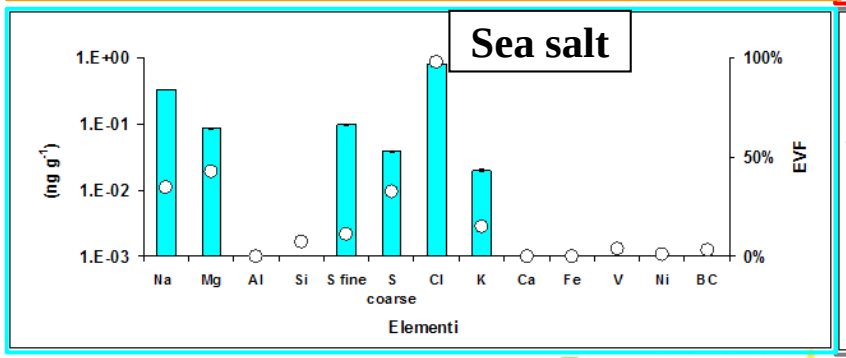
Output

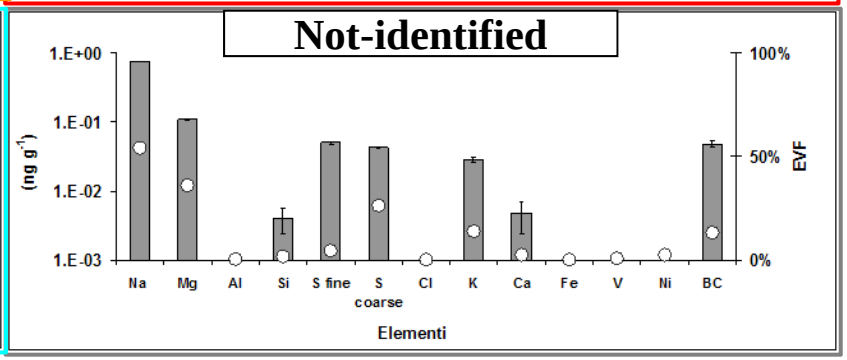
same sources resolved both years

Ships + «secondary sulphates»









Schembari et al., AE, submitted

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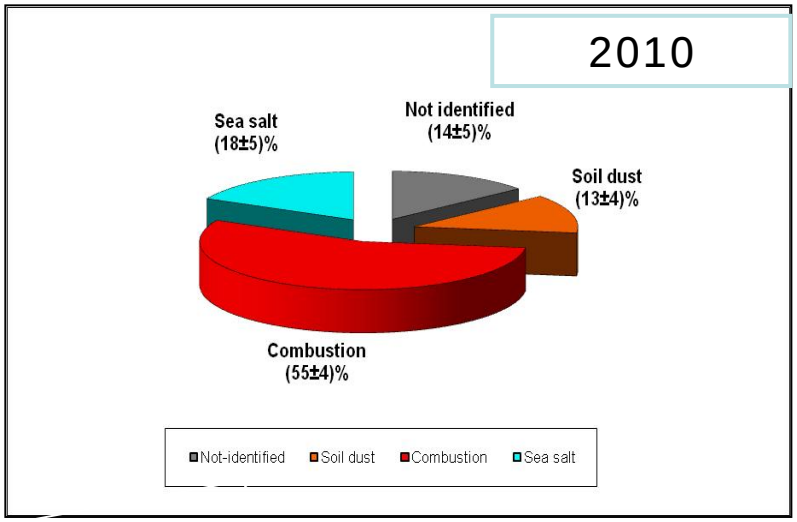
Source apportionment

Source apportionment through a linear regression of the PM10 levels (by an OPC) vs. PMF source trends. **In 2010 only**.



SO_4 (PM10) apportionment by IC		SO_4 (PM10) apportionment by PMF	
Sea salt SO_4	(8±1)%	Sea salt	(9±3)%
Soil dust SO_4	(1±1)%	Soil dust	(4±6)%
Anthropogenic nssSO_4	(66±7) %	Combustion	(81±4)%
Biogenic nnsSO4	(26±3) %	Not-identified	(6±4)%

Schembari et al., AE, submitted

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2011: Costa Concordia….

2011

Civitavecchia-Savona-Barcelona-Palma de Mallorca-Malta (Valletta)-Palermo-Civitavecchia

18-25 July
15-22 August
12-19 September

2 LV PM10 samplers

QUARTZ

- **ED-XRF**
- **IC**
- **TOT**

PTFE

- **EBS/PESA**

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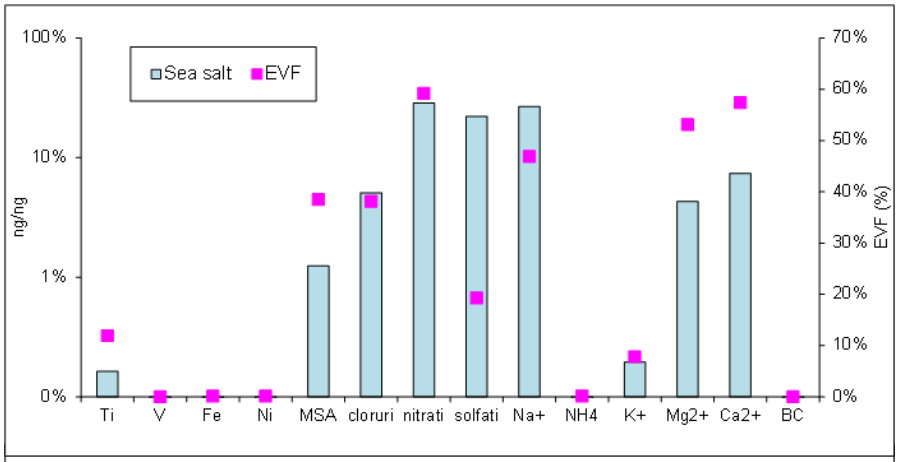
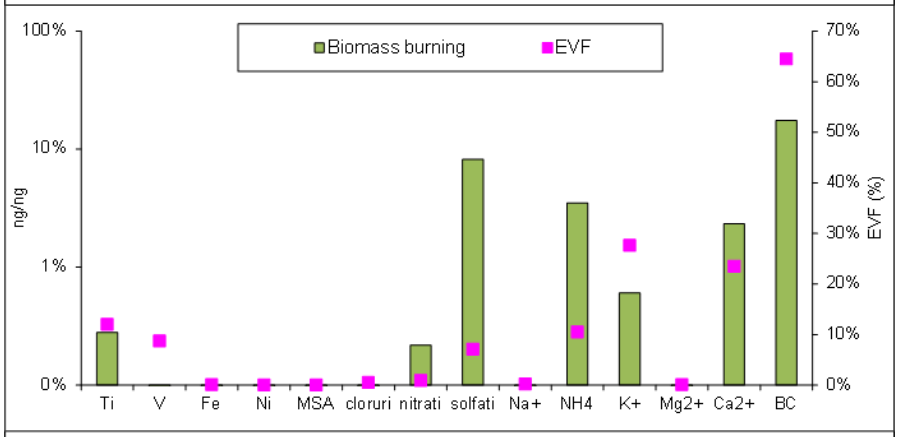
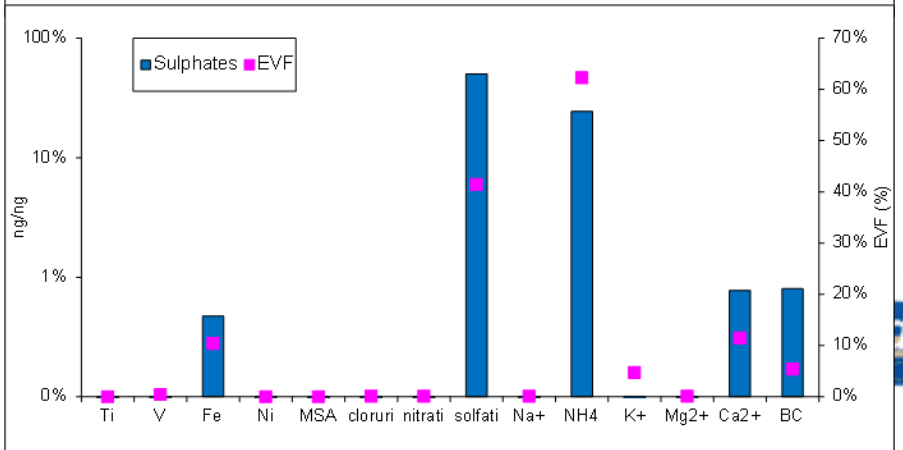
- The samplers were started 1 hour after the departure from each harbor and stopped 1 hour before the arrival in the next port
- Each leg was then divided in periods of **about 4 hours** with one filter sampled per each period

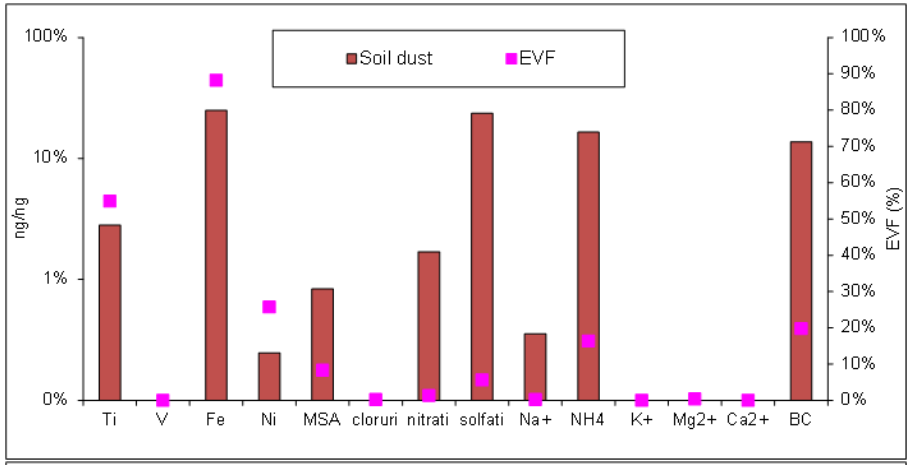
«new» Profiles and EVF - preliminary

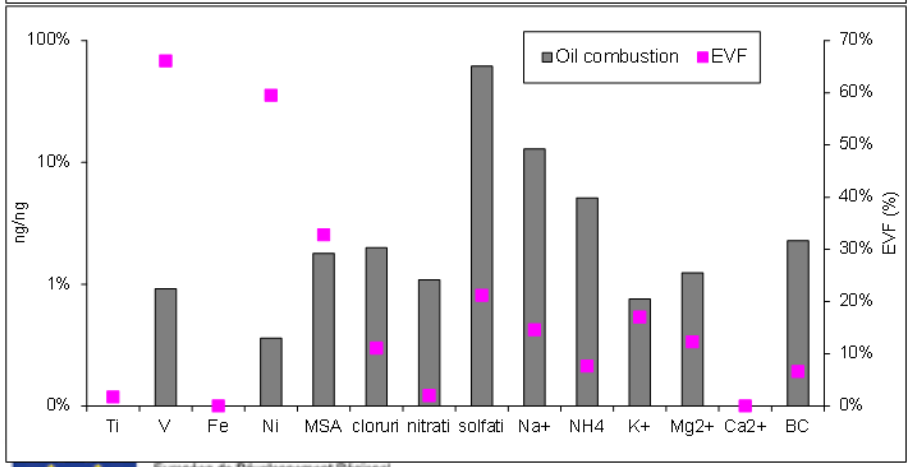






HARBOURS excluded





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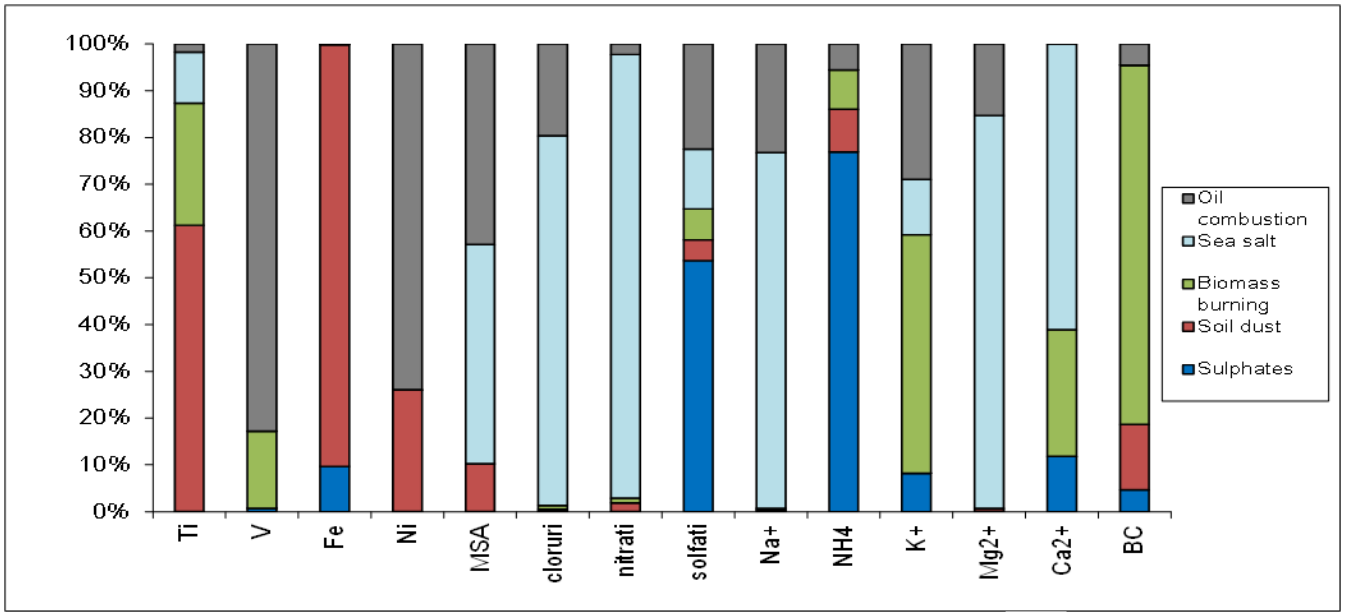
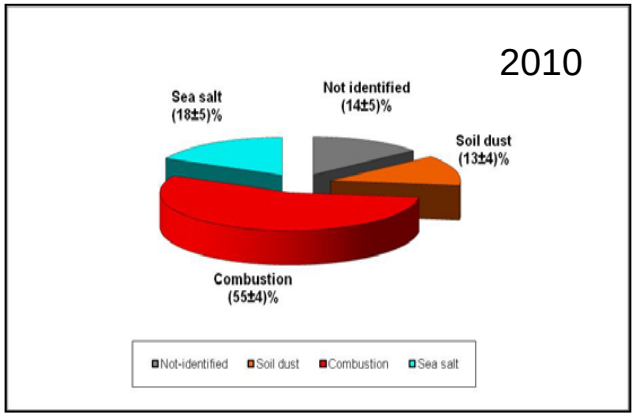
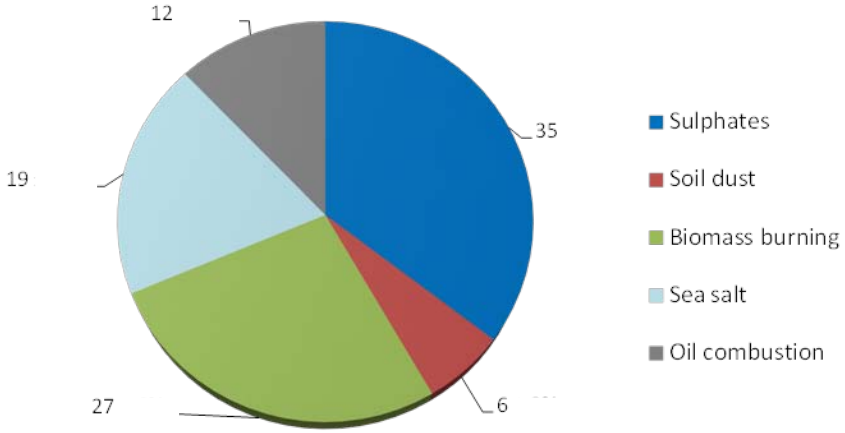
Source apportionment 2011- preliminary







M.C. Bove et al., in preparation

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APICE

Common Mediterranean strategy and local practical **A**ctions for the mitigation of **P**ort, **I**ndustries and **C**ities **E**missions.

EU-MED June 2010 – February 2013 ***http://www.apice-project.eu/***

In each study area: one-year sampling campaign → Source apportionment
air quality simulation by CTM → Source apportionment

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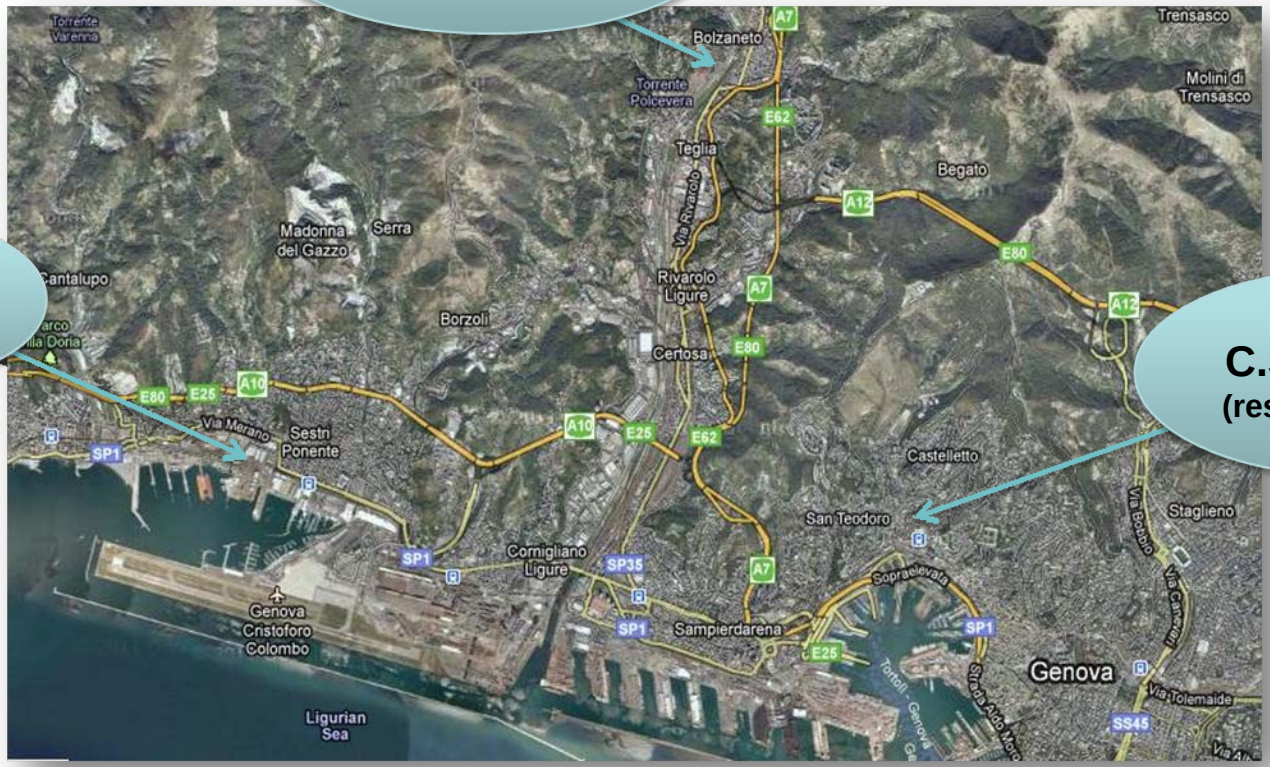
APICE : sampling campaign in Genoa

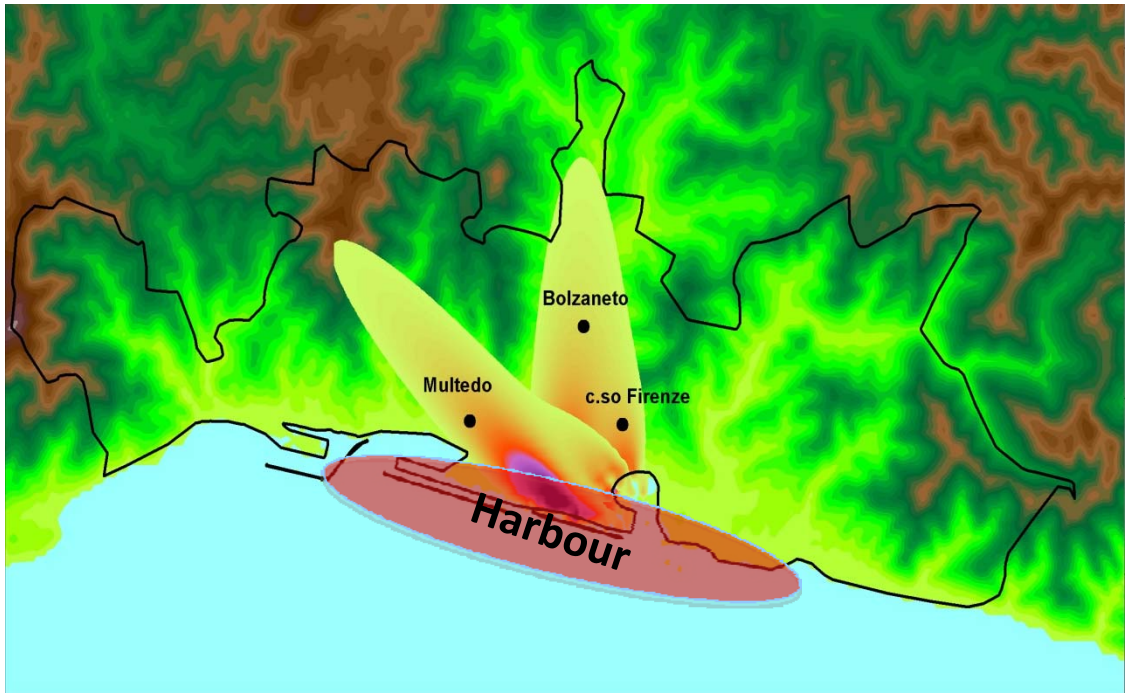
Bolzaneto (suburb – industrial activity - highway)

Multedo (private road)

C.So Firenze (residential area)



APICE : sampling campaign in Genoa



Sites selected through a preliminar analysis of prevailing wind directions

Peculiar “sampling strategy ”

PM2.5 Daily samples
May – October 2011
PTFE and Quartz - alternate days

M.C. Bove et al., AE, in press

- PM2.5
- TC, OC, EC (TOT – EUSAAR2 + MWAA on PFTE → **Massabò et al., JAS 2013**
- Elements: Na, Mg, Al, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Se, Br, Rb, Sr, Zr, Mo, Ba, Pb
- MSA
- Fl^-, Cl^-, NO_3^-, SO_4^-
- Na^+, NH_4^+, K^+, Mg^{2+}, Mn^+, Ca^{2+}

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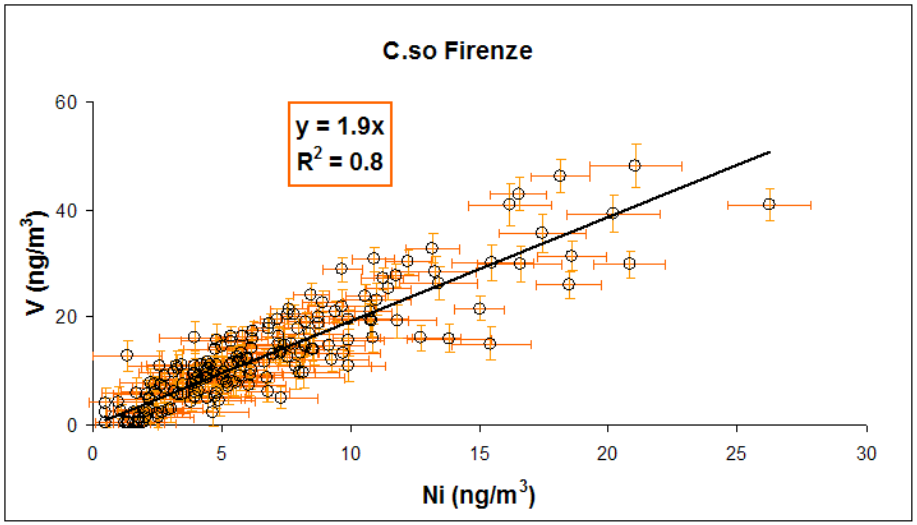
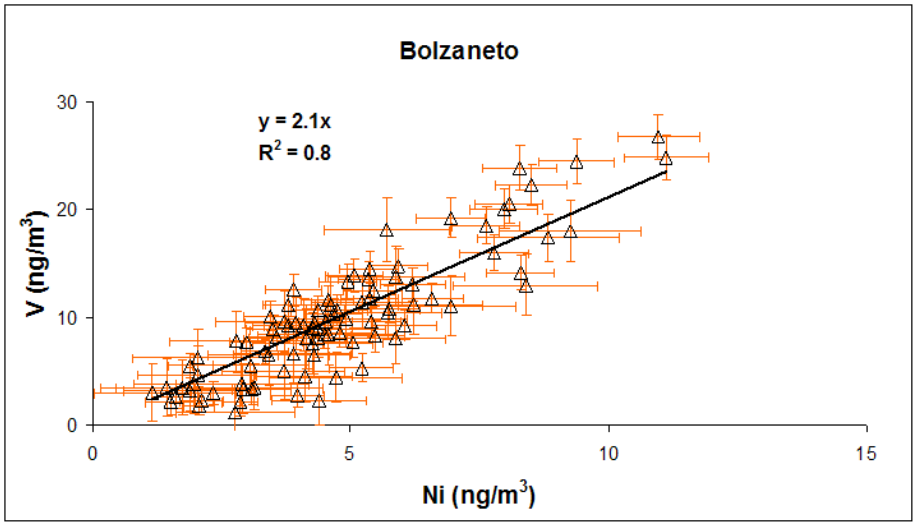
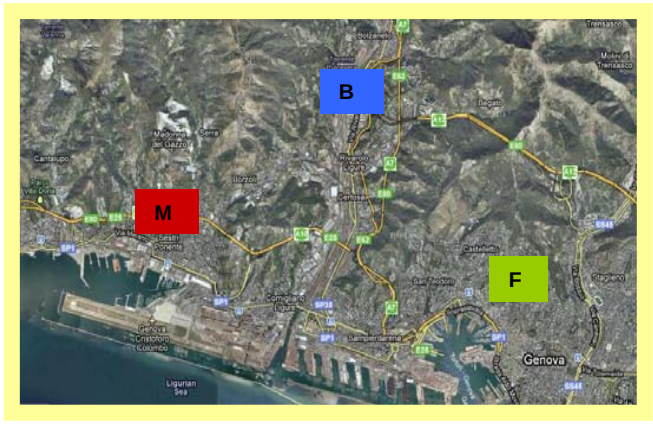
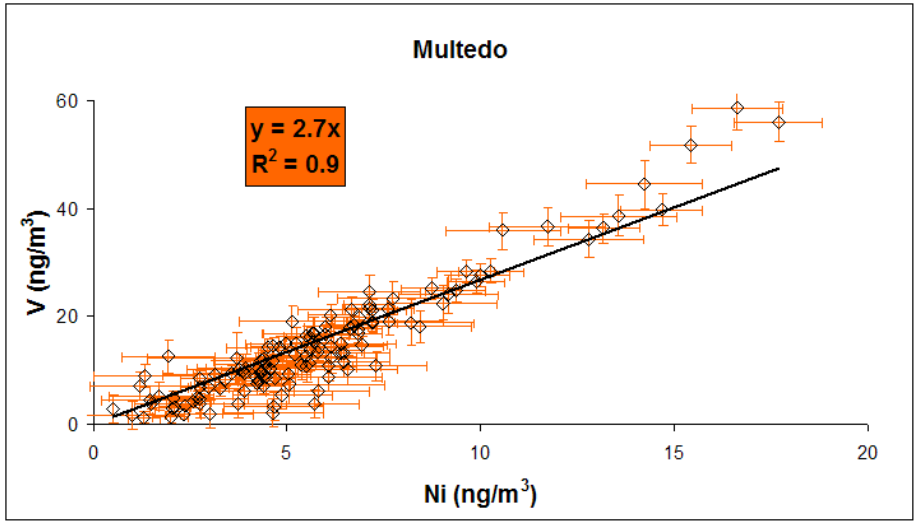
Raw data: V:Ni concentration ratio









2 < V:Ni < 3

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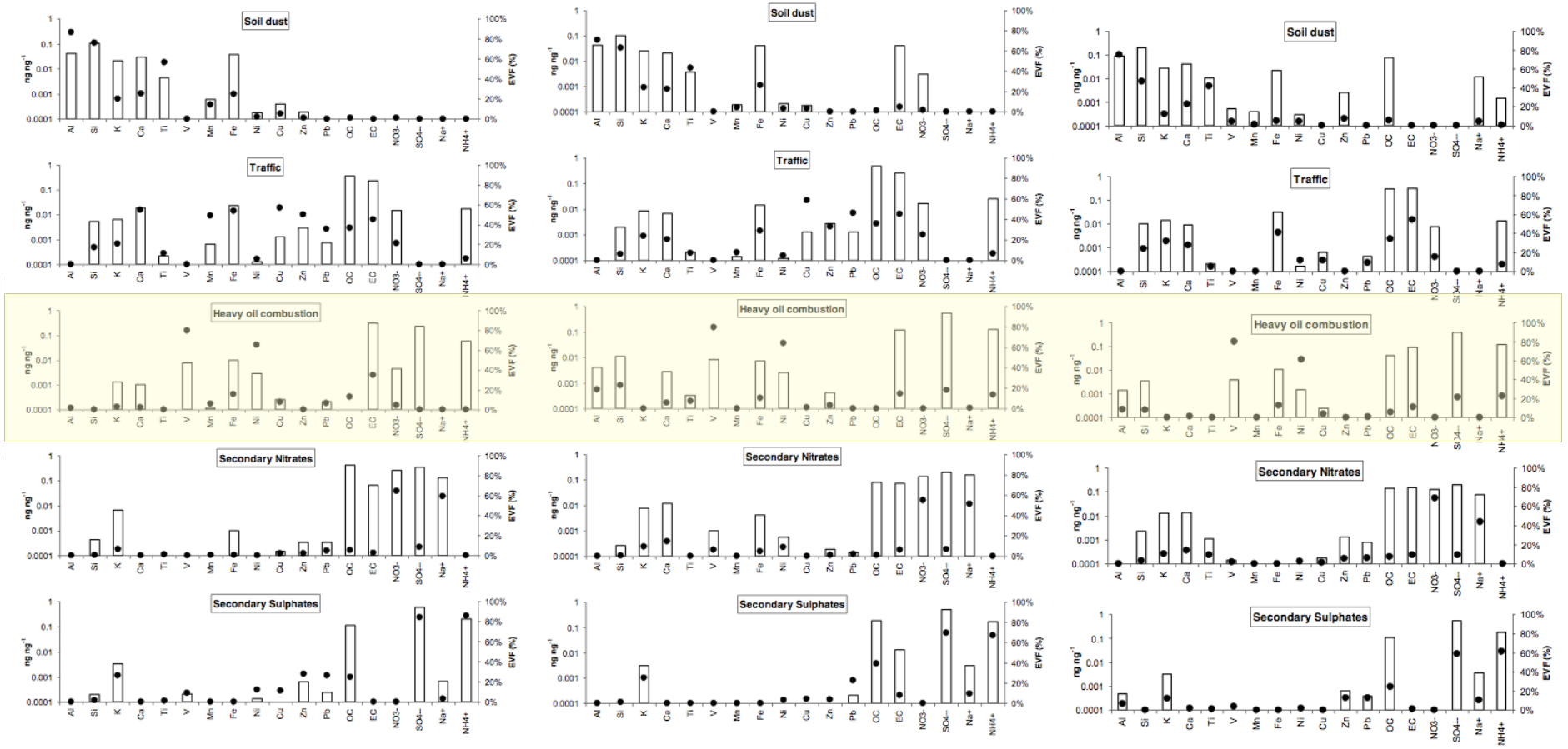
APICE – Genoa: Source profiles by PMF2

C. Firenze (coast) | Multedo (coast) | Bolzaneto (inland)



Plus some other minor «local» sources/factors, **M.C. Bove et al., AE, in press**

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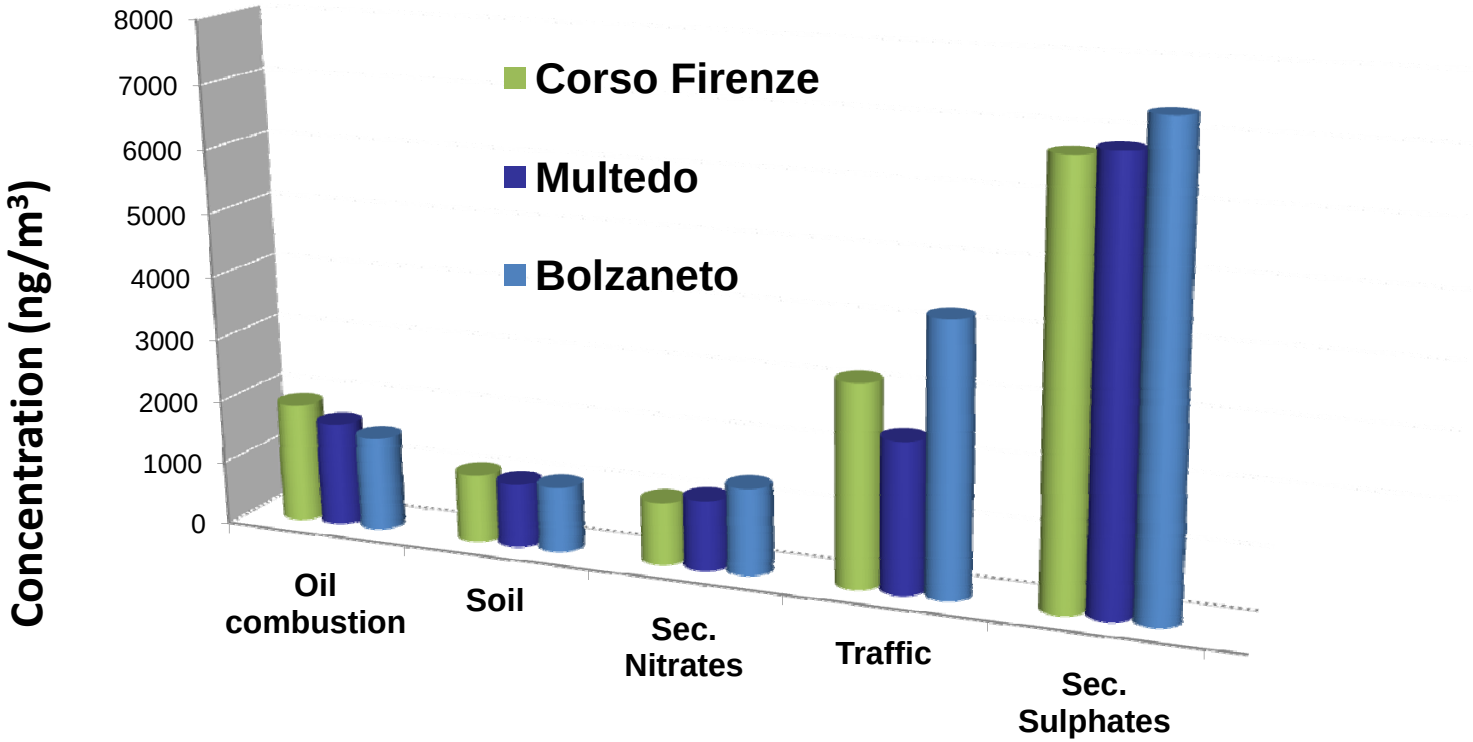
APICE – Genoa: Source apportionment by PMF2



- ✓ Secondary inorganic compounds identified as the major $PM_{2.5}$ components
- ✓ Traffic everywhere results the major primary source
- ✓ Heavy oil combustion higher in the sites near the harbour (ship emissions predominant source)

M.C. Bove et al., AE, in press

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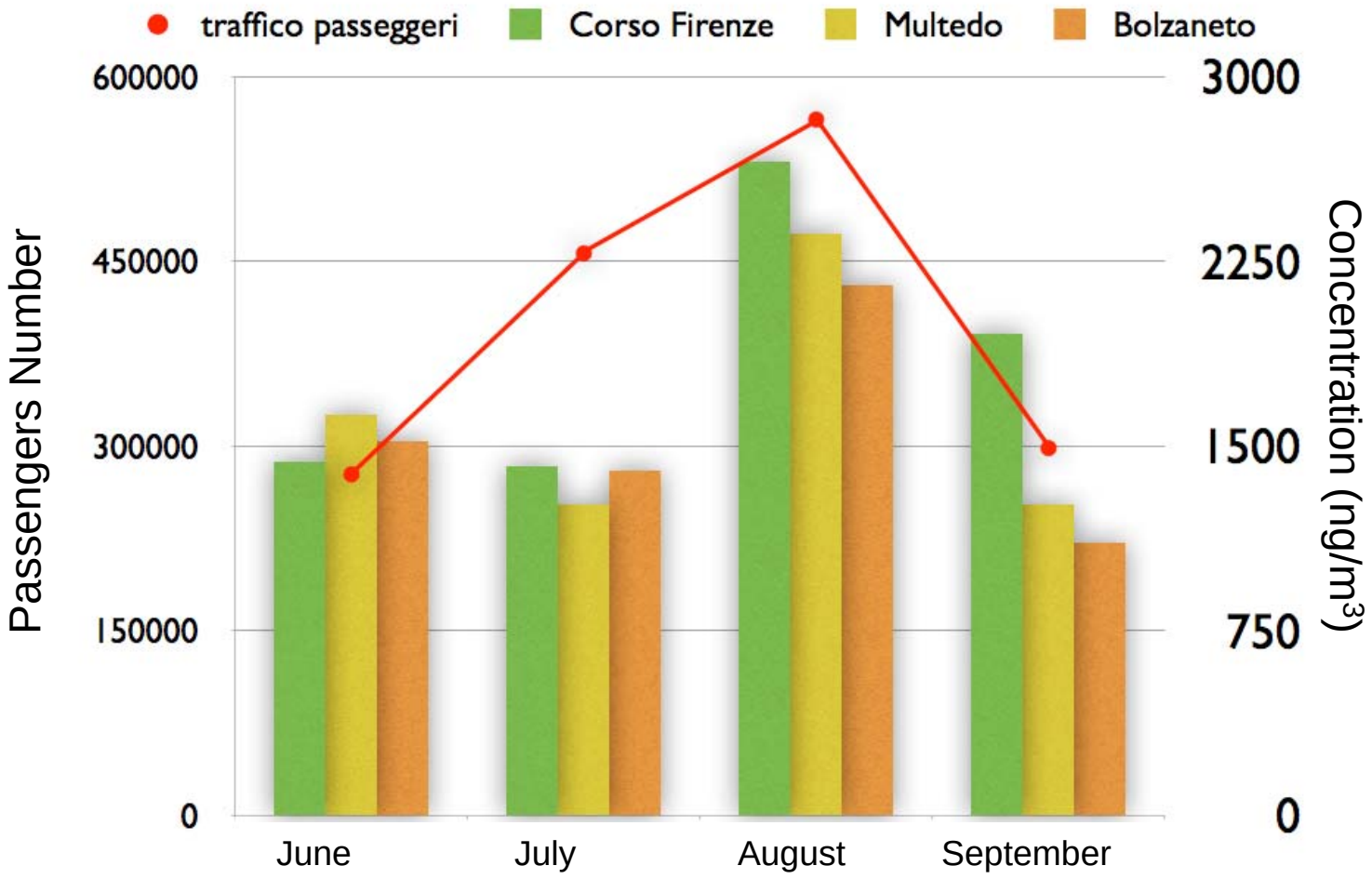
Seasonal trend of «oil Combustion/Ship Emissions» according to PMF2



M.C. Bove et al., AE, in press

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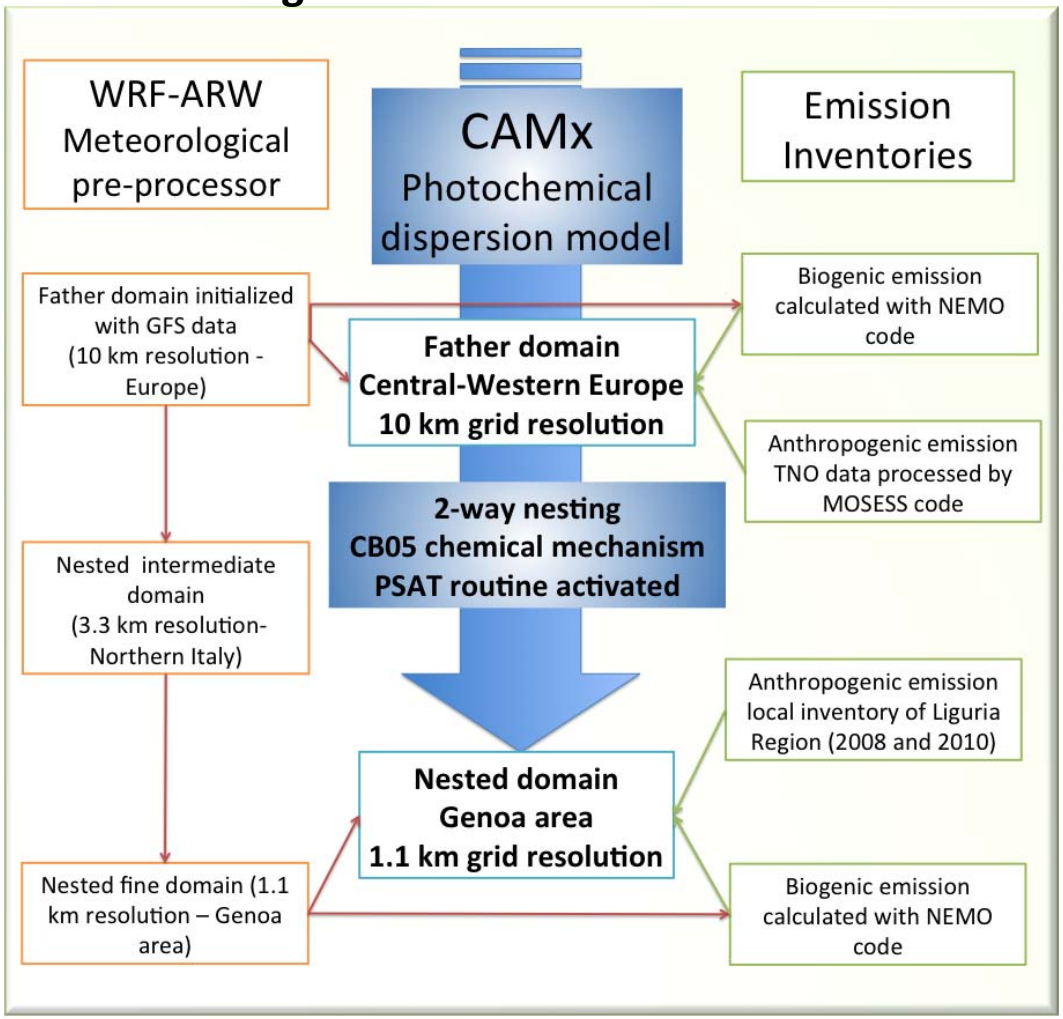
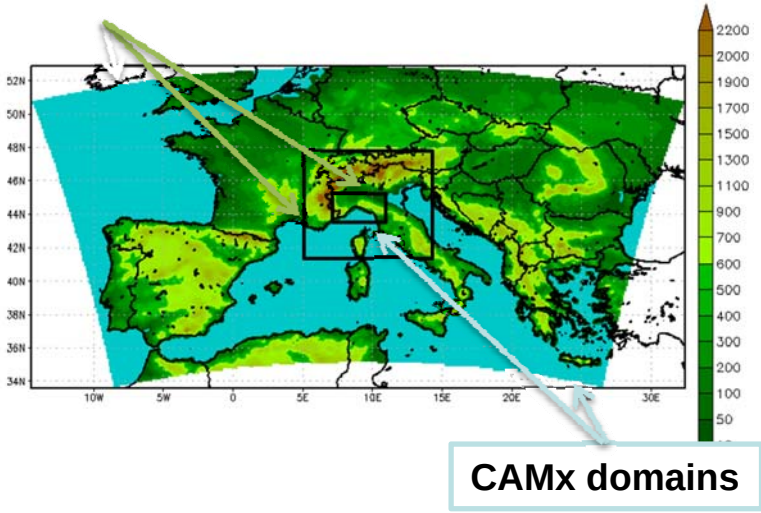
CTM – Model set up

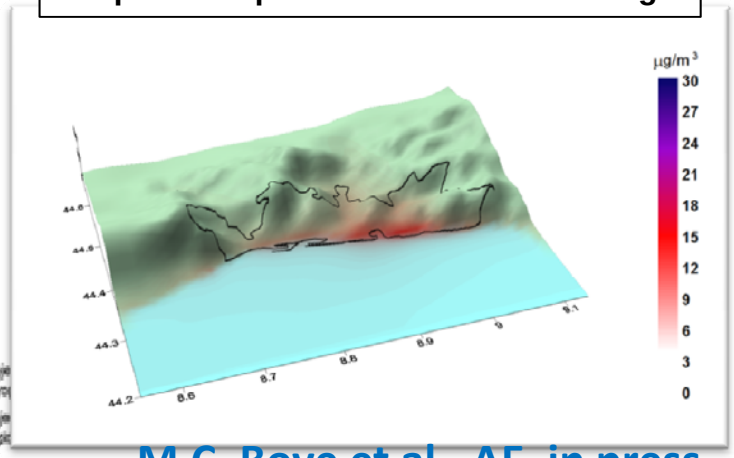
The modelling chain structure



WRF domains



Output example: PM2.5 summer average



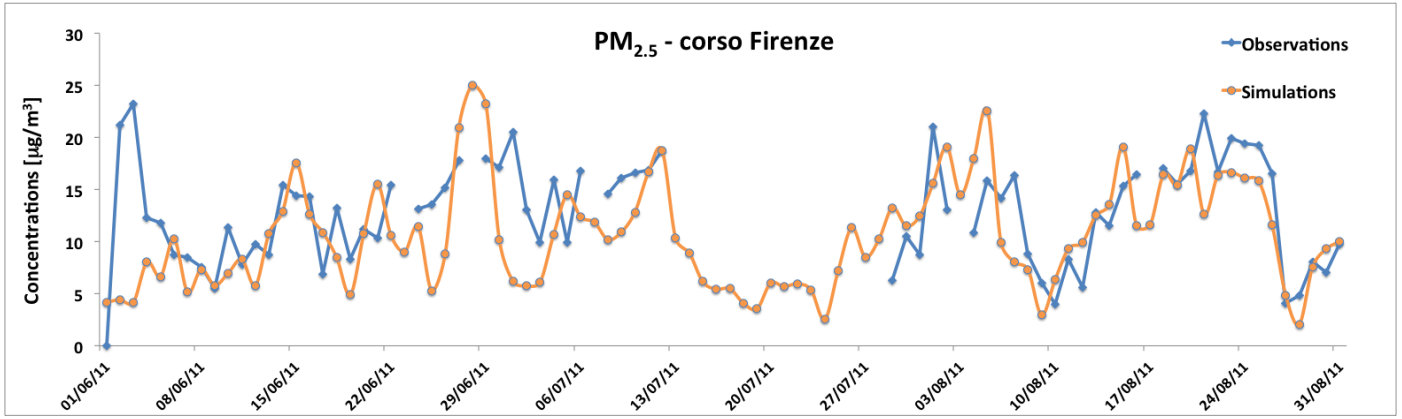
M.C. Bove et al., AE, in press

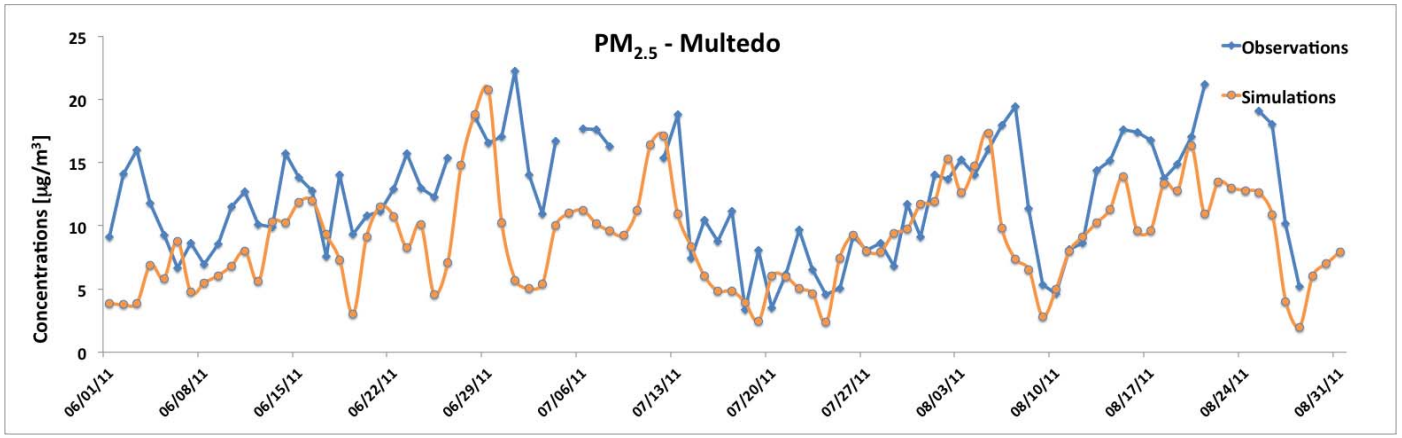
WRF – Skamrock et al NCAR

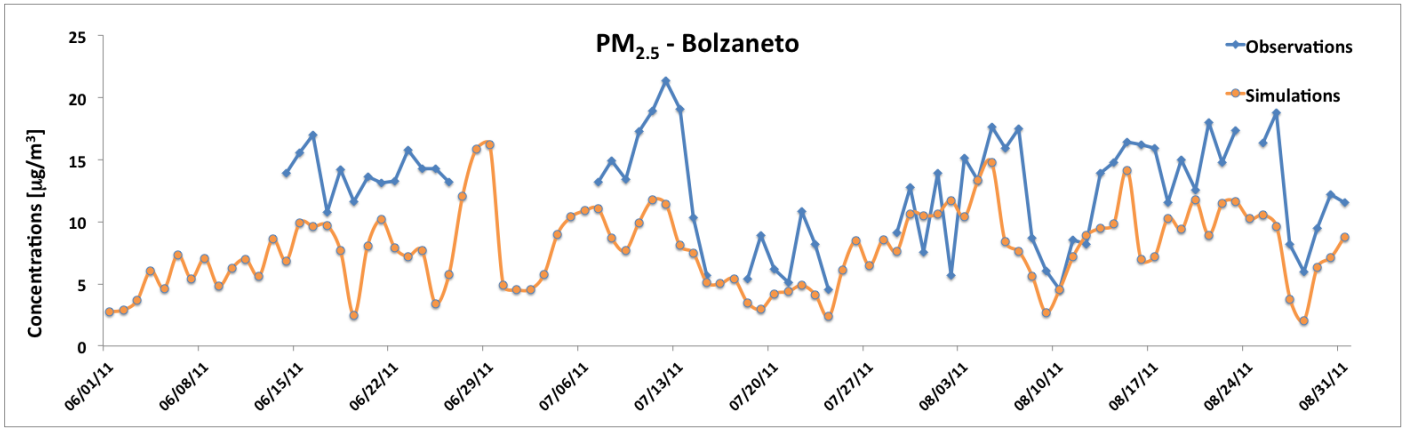
CAMx – Yarwood et al Atm Env 2012

NEMO – Poupkou et al Env Mod Soft 2010

Model validation – $PM_{2.5}$ concentration







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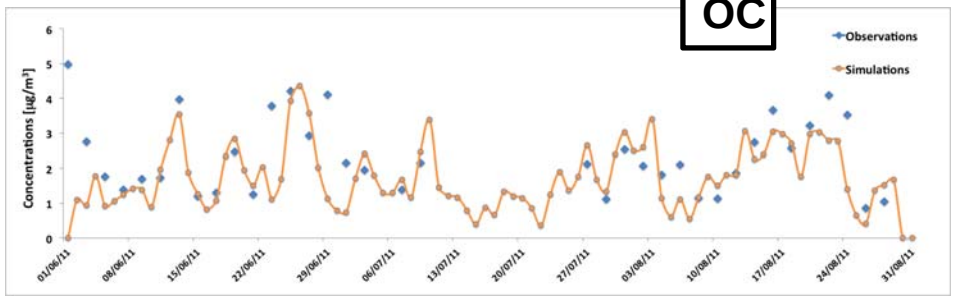
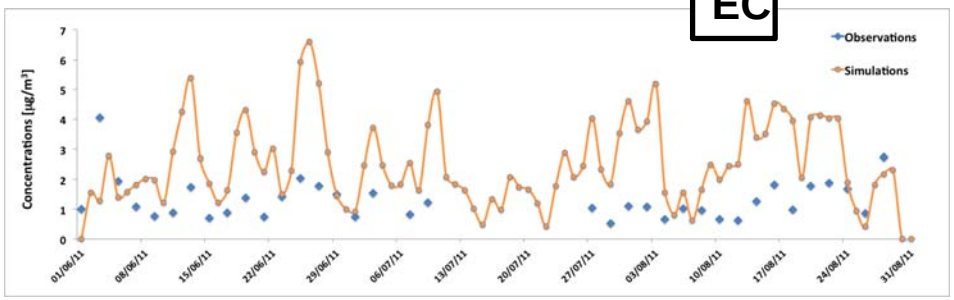
Model validation – $PM_{2.5}$ composition

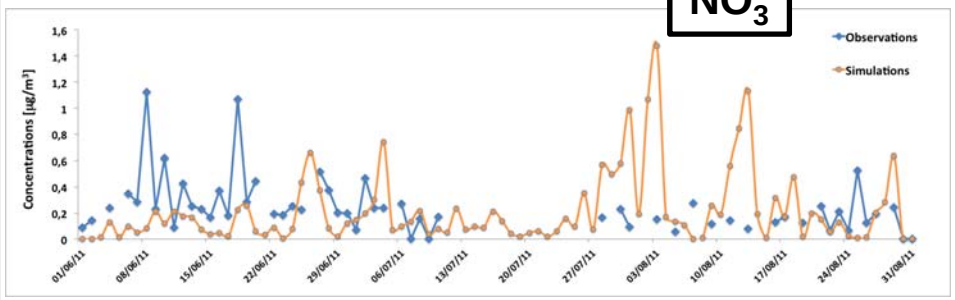
OC



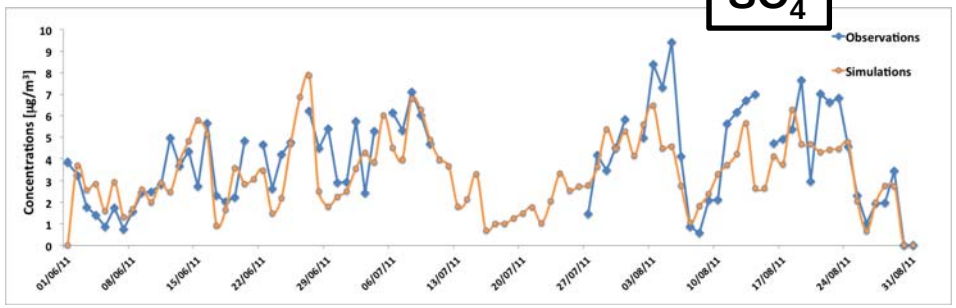
EC



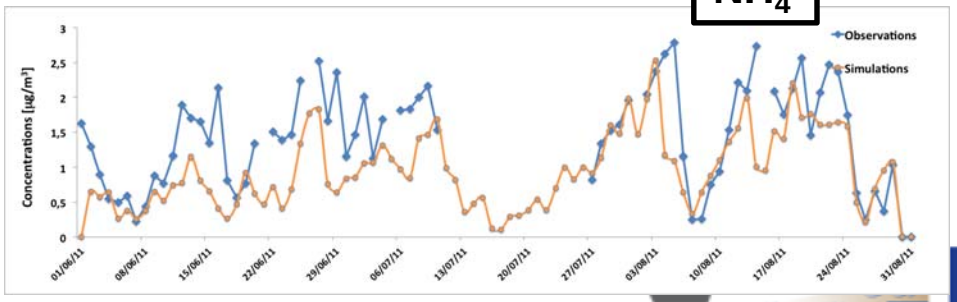
NO_3^-



SO_4^{--}



NH_4^+



- Site: **Corso Firenze**
- Similar pattern observed in the other sites

M.C. Bove et al., AE, in press

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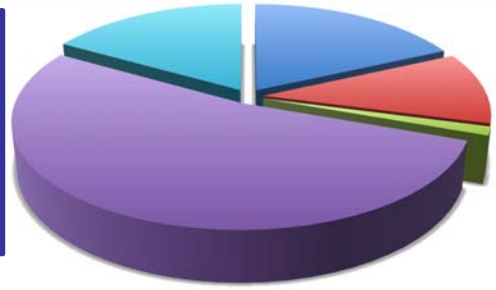
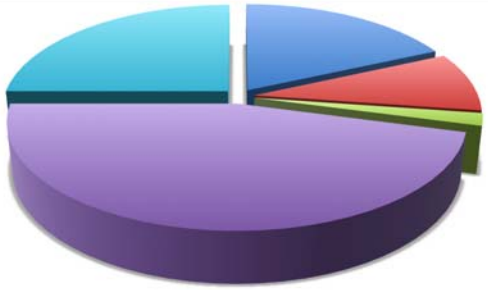
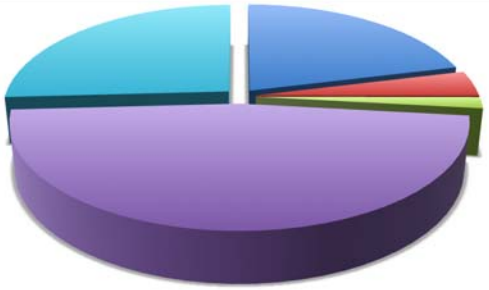
Source apportionment by CAMx-PSAT

coast

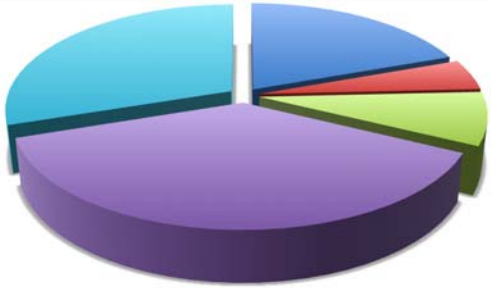
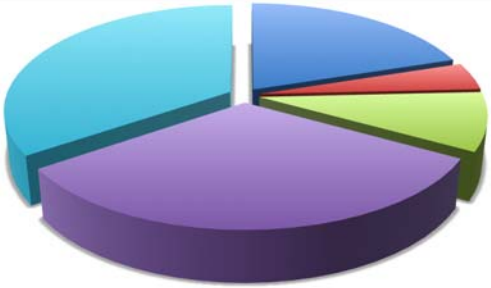
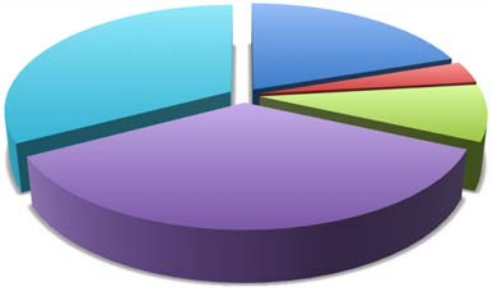
inland

Corso Firenze | **Multedo** | **Bolzaneto**

Summer (06-09/2011)

Winter (11-12/2011)

Industry **Maritime** **Residential** **Traffic** **Others**

- ✓ Traffic identified as the most relevant emission source in both seasons
- ✓ Observed the seasonal trends of maritime and residential activities
- ✓ Observed a higher impact of maritime activities in coastal site

PMF vs CAMx-PSAT – source to source "mapping"

PMF	CTM
A source ("factor") is group of PM components with correlated time trend	Defined via a bottom-up approach based on statistical activity data and emission factors
Secondary components resolved as other primary sources	Both primary and secondary contribution of each source category

A very crude approach !

Critical Analysis of PMF profiles and comparison with raw data on PM composition → e.g. organic «contamination» in PMF secondary sulphates profile redistributed to primary sources (with large uncertainties)

PMF apportionment re-arranged to the set of primary sources categories used by CAMX-PSAT (SNAP sectors)

M.C. Bove et al., AE, in press

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PMF vs CAMx-PSAT - results

M.C. Bove et al., AE, in press

	Cso Firenze %	Multedo %	Bolzaneto %
Road transport	35 ± 10 *53*	38 ± 12 *46*	38 ± 13 *47*
Maritime activities	15 ± 2 *11*	16 ± 3 *9*	14 ± 3 *4*
Residential	NR *1*	NR *2*	NR *2*
Energy production - Industry	36 ± 10 *18*	27 ± 15 *18*	33 ± 12 *21*
Others	15 ± 4 *17*	18 ± 5 *25*	14 ± 4 *26*

PMF

CAMx-PSAT

Sea, Soil dust, minor local sources, boundary conditions etc

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APICE: 5-harbour picture

PM mass attribuited to ship emissions ($\mu g/m^3$)

Barcelona	Marseille	Genoa	Venice	Thessaloniki
PMF	CMB	PMF	PMF	PMF
1.1 ± 0.2	0.20 ± 0.04	1.7 ± 0.5	6.0 ± 0.5	3.0 ± 0.2
higher in town ~ 2.8	highest values in summer	average of coastal sites	including industrial emission – PM10	including part of sea spray

Common «comparative» paper in preparation…meanwhile a technical report is available at:

http://www.apice-project.eu/

Starting from July 2014 a new project:

CAYMANs

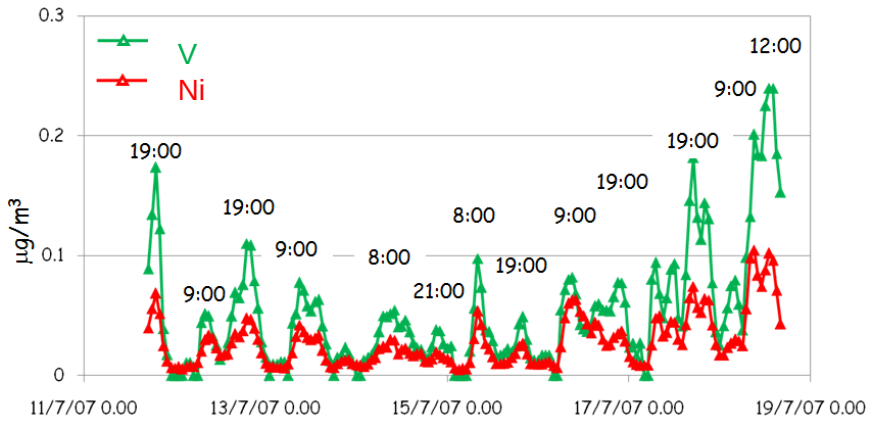
Cruise and passenger ship Air qualitY Mitigation ActioNs

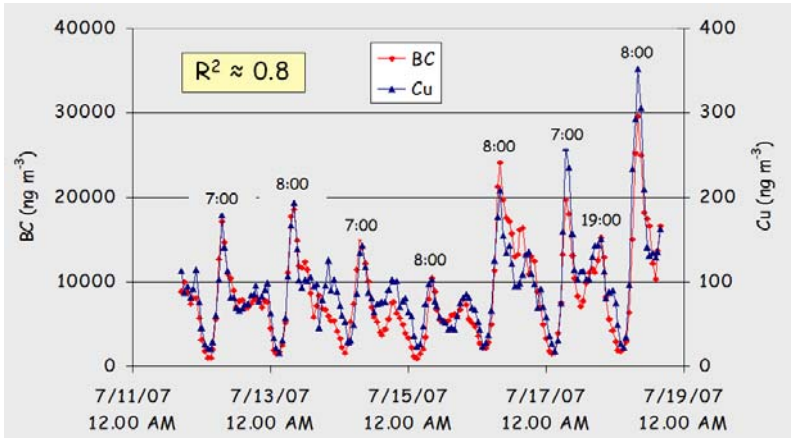
(numerical simulations only, unfortunately)

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Conclusions

- ✓ A source apportionment exercise was performed in the city of Genoa through two different approaches: CTMs and receptor models
- ✓ We tried to overcome difficulties in the comparison between the two results:
  - ✓ different sources grouping/classification;
  - ✓ different treatment of secondary components
- ✓ PMF apportionment (with large uncertainties) showed a fair agreement with CAMx-PSAT estimates
- ✓ The exercise can be considered a preliminary approach to the problem





Signature of ferry-boats and road traffic in the harbour area of Genoa through hourly sampling (streaker) & IBA (PIXE) analysis

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