

Caratterizzazione dimensionale e chimica del particolato atmosferico in aree a differente grado di antropizzazione

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Inquinamento Atmosferico - Giornata di studio, CNR Firenze, 28Mar17



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7 Strutturati
2 Dottorandi
2 Assegnisti/Borsisti

Sintesi Attivita' Scientifiche

- Studio dei processi di origine e trasporto di componenti chimici immessi nell'atmosfera da processi naturali o antropici nel Bacino del Mediterraneo e in aree polari (Artide e Antartide).
- Ricostruzione delle paleo-atmosfere e studio delle interazioni tra processi climatici e ambientali nel passato (analisi chimica e isotopica di carote di ghiaccio e di sedimenti marini in Antartide).
- Valutazioni di impatto ambientale e di qualita' dell'aria e dell'ambiente.
- Caratterizzazione chimica di campioni di interesse climatico, ambientale, alimentare, tecnologico e biochimico in matrici complesse (atmosfera, acque, sedimenti, suoli, alimenti, materiali, tessuti biologici).

Strumentazione ed Attrezzature



Cromatografia Ionica



**ICP-AES / ICP-HR-MS
Integrated System**

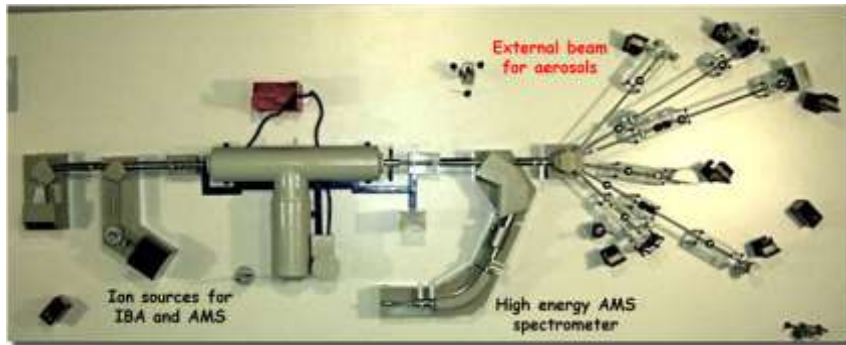


**EC-OC Thermo-Optical
Analyser**



SEM-EDX Analysis

Strumentazione ed attrezzature



INFN-3 MV Tandetron Accelerator
PIXE - Particle Ind. x-ray Emiss.
PIGE - Particle Ind. γ -ray Em.
 ^{14}C Determination



Sistemi campionamento



Gas Analysis



Classificatori di particolato

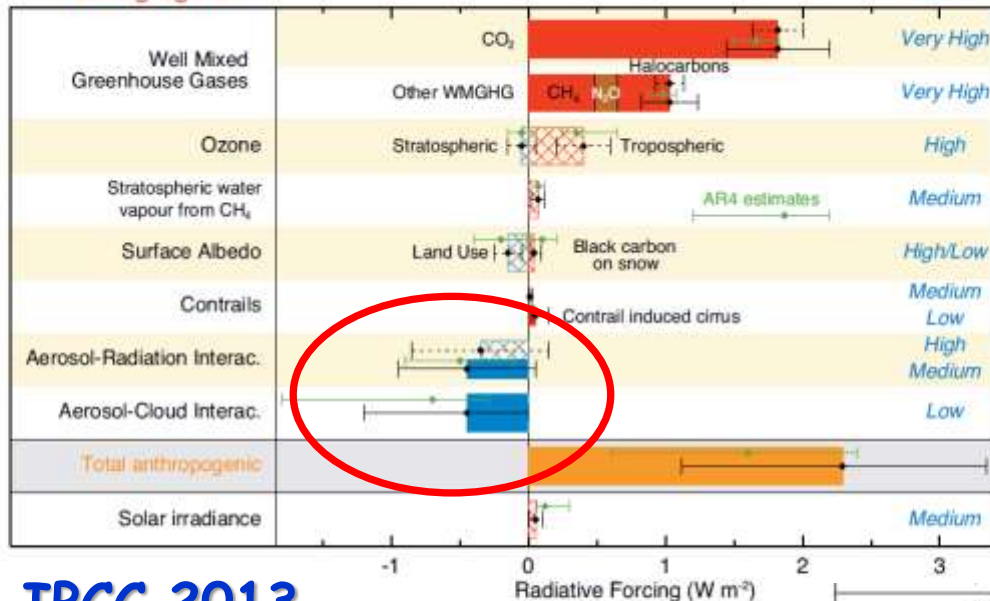
Radiative forcing of climate between 1750 and 2011

Forcing agent

Confidence Level

Anthropogenic

Natural



IPCC 2013

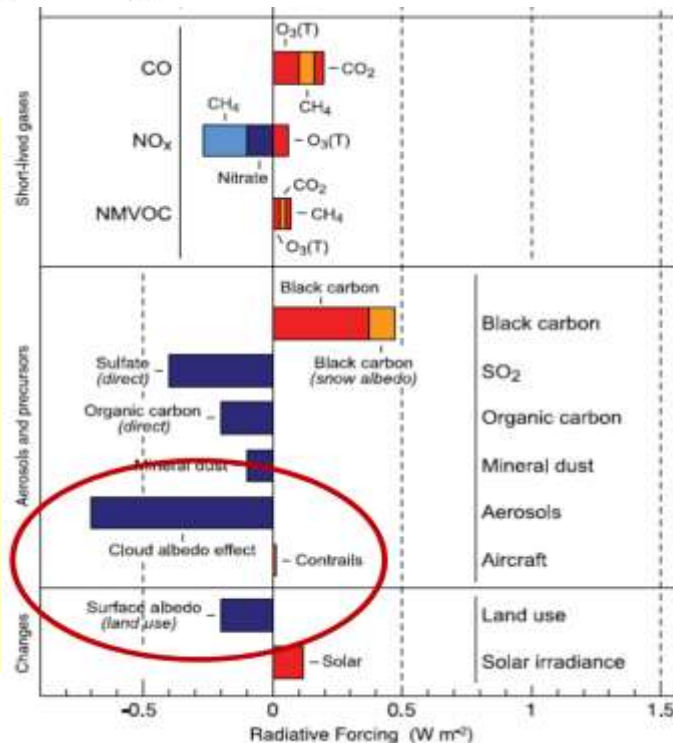
Polar Aerosol

Effective radiative aerosol forcing: cooling

But, large uncertainties, even for the sign, especially for polar aerosols

In the polar areas, the negative forcing of the surface albedo is higher than that of the cloud albedo and of the scattering processes.

→ Aerosol positive forcing!



Climate Forcings
Positive - Negative

NO_x

BC

Sulfate

OC

Dust

Cloud Albedo

Surface Albedo

Automatic Weather Station (AWS) Location Map

See <http://uwamrc.ssec.wisc.edu/aws/>
and <ftp://ice.ssec.wisc.edu/pub/biglist>
for more details

AVHRR Image Mosaic from
USGS Map I-2560
Merge by C.A. Shuman
UMD-ESSIC

★ King Sejong S.

Active AWS
Inactive AWS
Planned AWS

★ DC

★ MZS

★ Jang Bogo S.

Key for McMurdo Area	
1 Cape Bird	11 Mount Erebus
2 Ferrell	12 Nancy
3 Fogle	13 Pegasus
4 Jimmy', Jimmy'	14 Pegasus North
5 Laurie	15 Pegasus South
6 Laurie II	16 Tiffany
7 Linda	17 White Out
8 Manning	18 White Island
9 Meeley	19 Willie Field
10 Minna Bluff	20 Windless Bight'
	21 Windless Bight'

Thule

**Russian
Cap
Baranova
Station
Severnaya
Zemlya Is.**

**Ny Alesund
Svalbard
Islands**



Image NASA

© 2008 Europa Technologies

Since 2010

Ny Ålesund

78°56' N - 11°56' E

Spitsbergen
Svalbard (Norway)

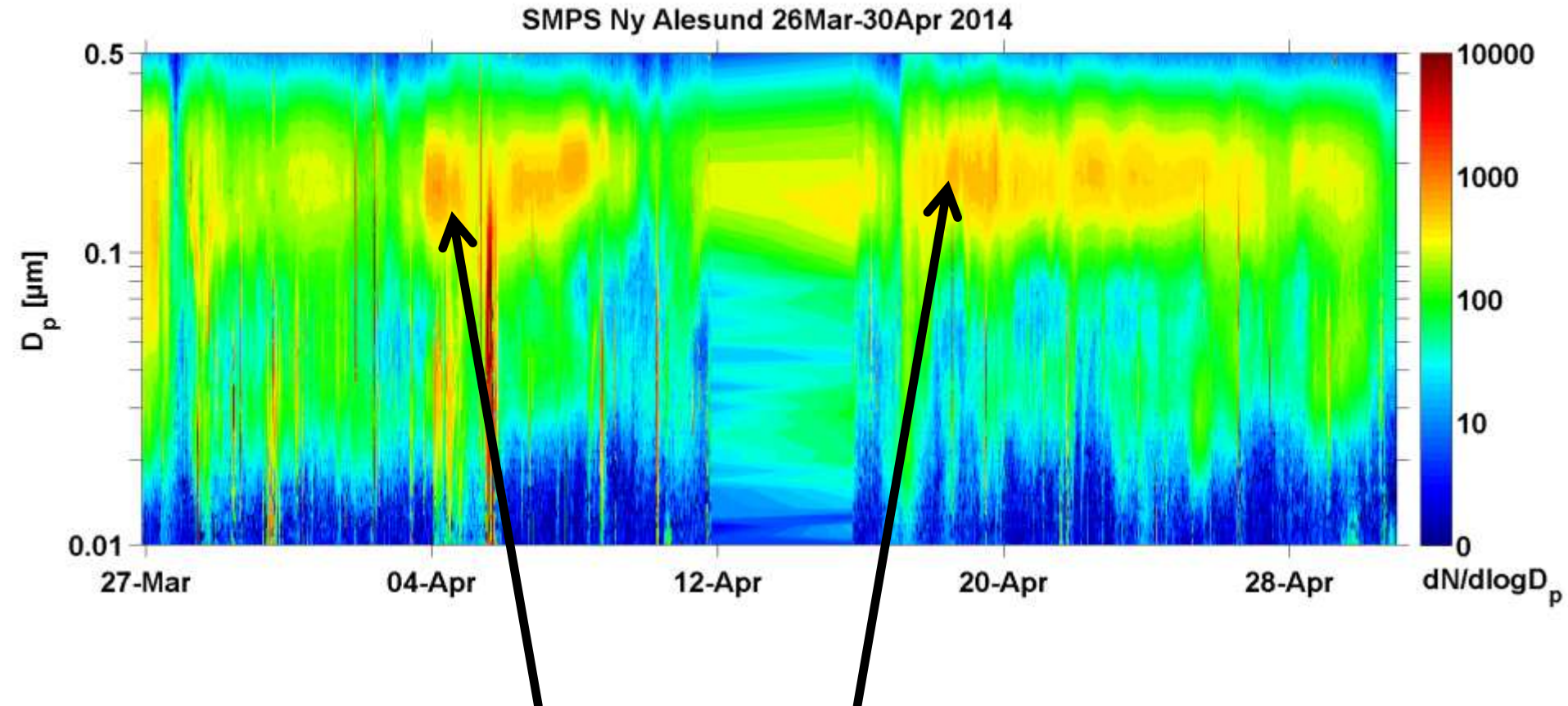
Gruvebadet
Observatory

800 m from Ny Alesund
about 50 m a.s.l.



NyA 2014 - SMPS Size Distribution (6-500 nm)

26 Mar - 30 Apr 2014

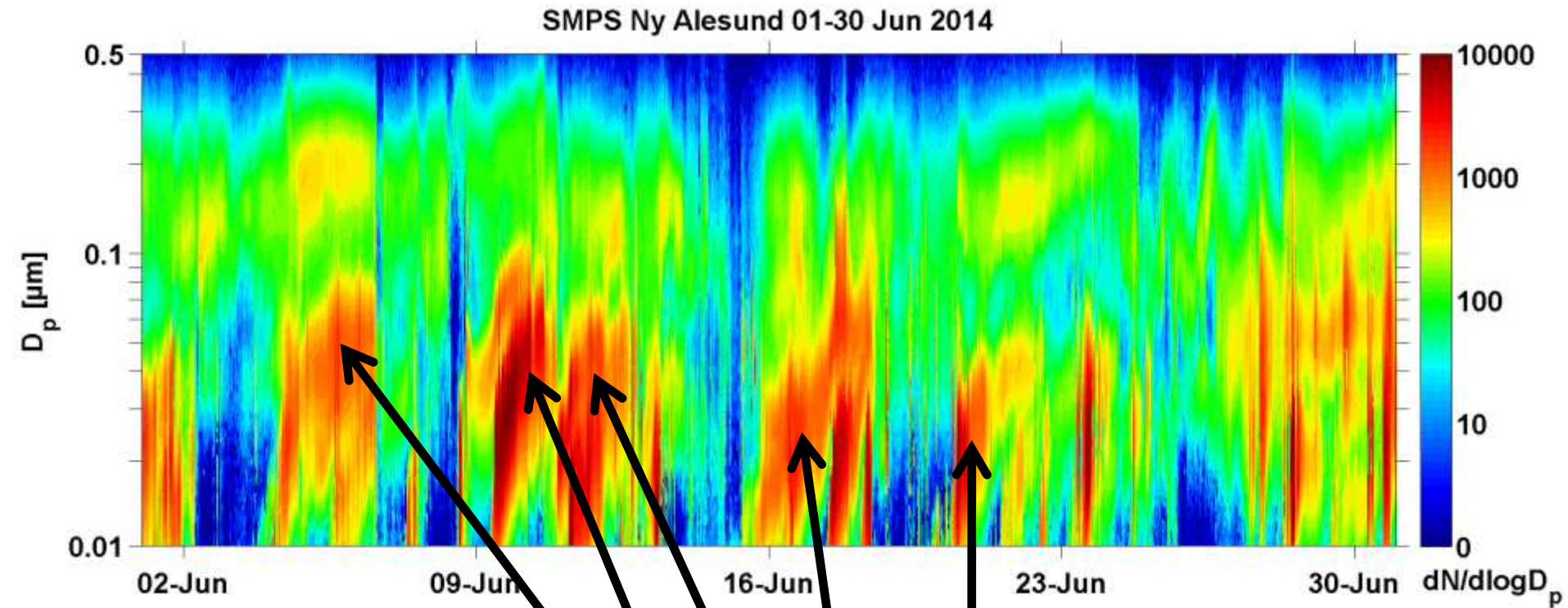


Spring:

Accumulation Mode
Long Range Transport

NyA 2014 - SMPS Size Distribution (6-500 nm)

01 - 30 June 2014

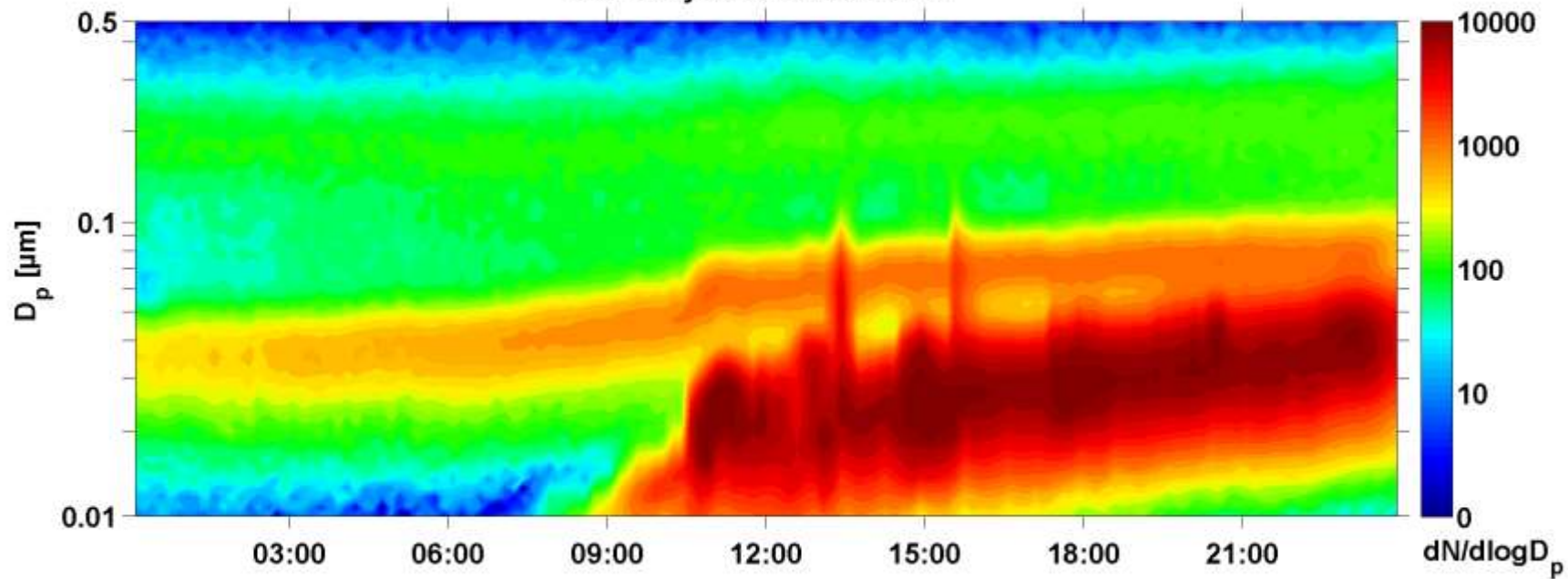


Summer:

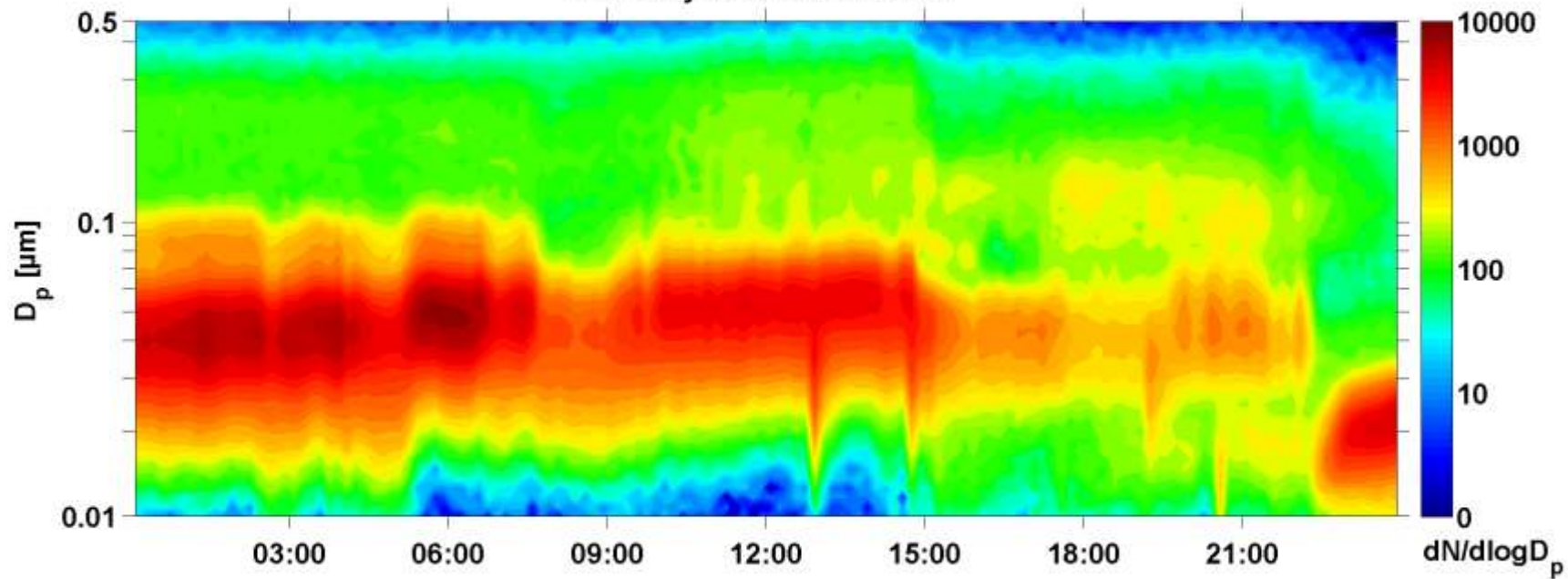
Nucleation events

Nucleation 09 - 10 June

SMPS Ny Alesund 09 Jun 14



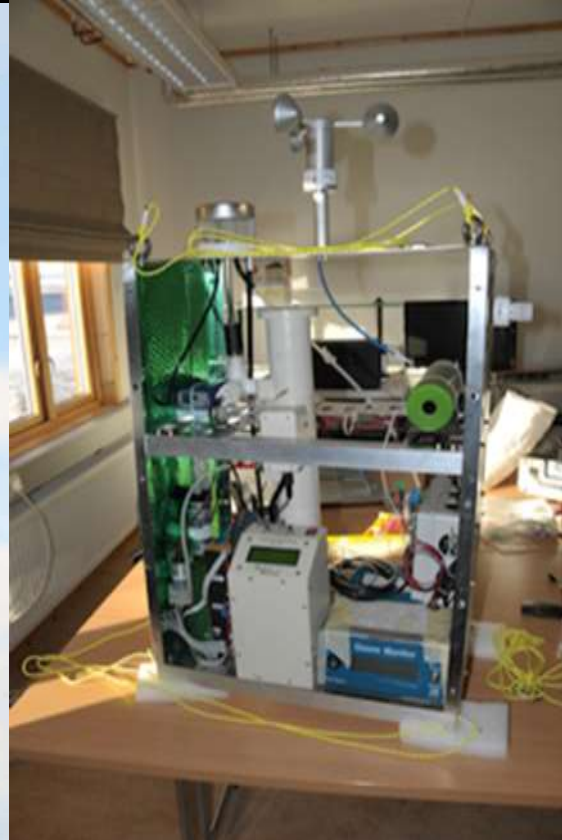
SMPS Ny Alesund 10 Jun 14



2011-2017 Campaigns

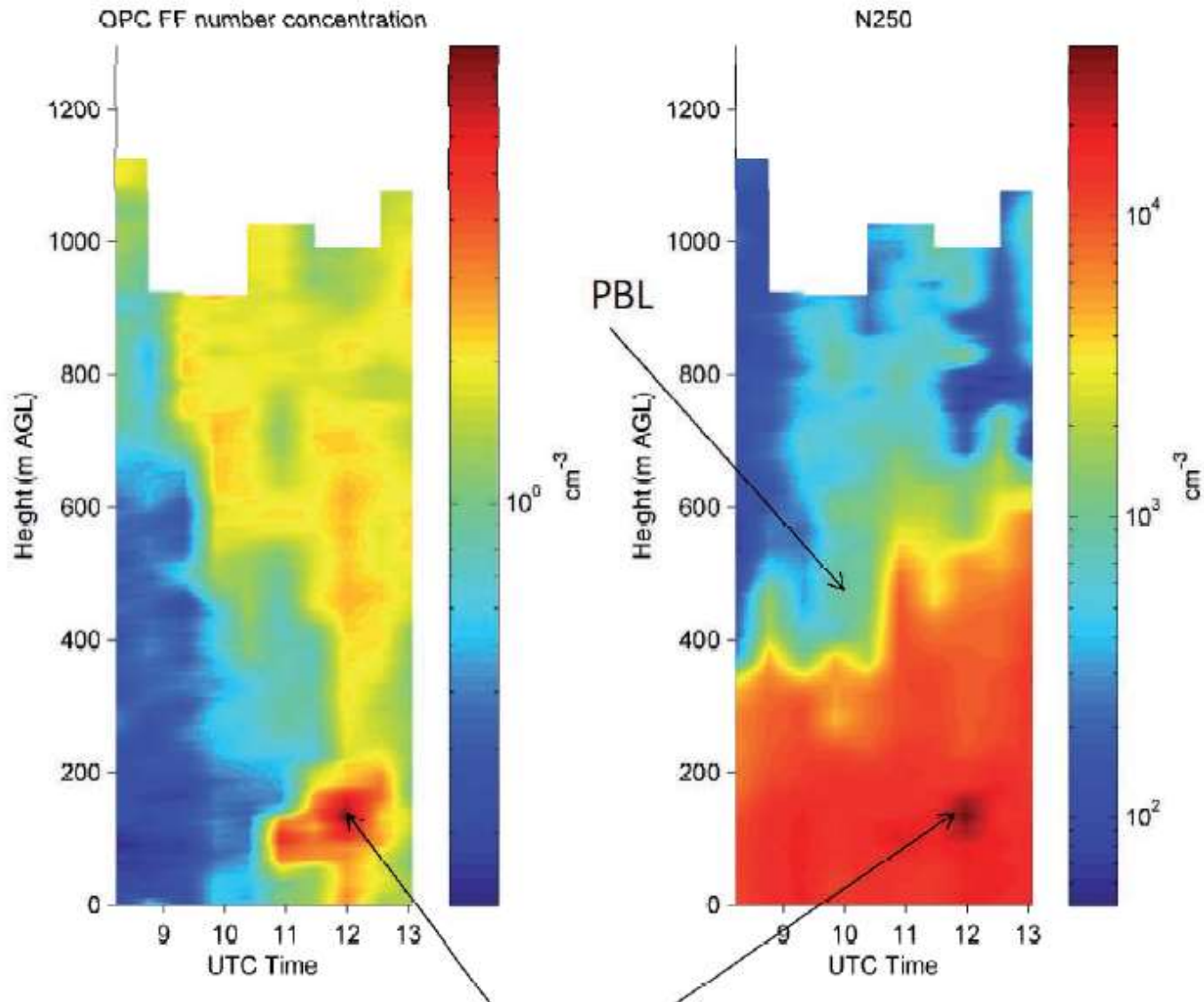
Balloon measurements up to 1000 m altitude

Airship shape
about 15 kg payload



Meteo Probes
OPC measurements
Nano-Particle Count.
Nephelometer
Aerosol sampling
Ozone
Black Carbon
Video-Camera
Data Trasm. (156MHz)

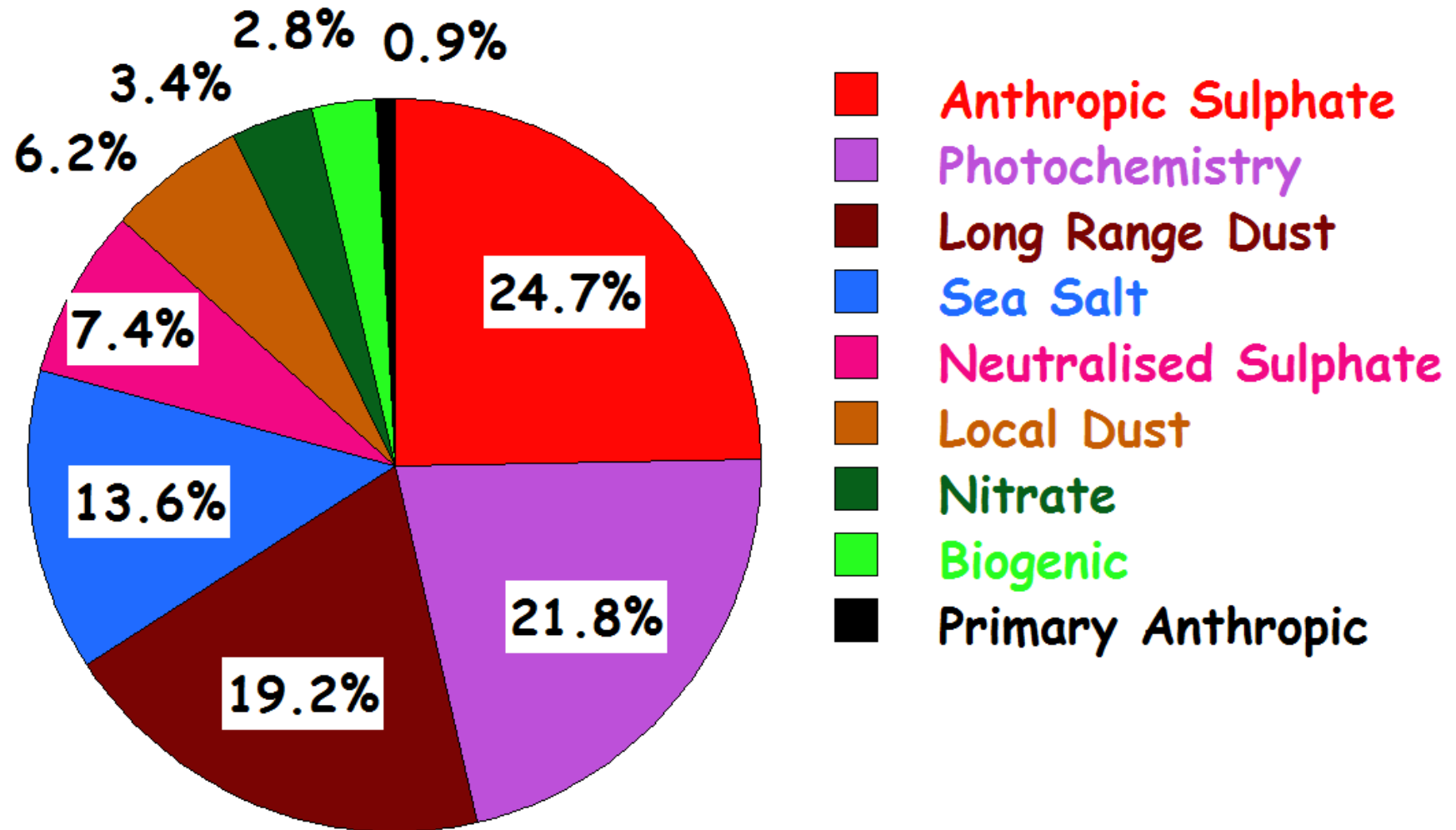
29_06_2012: Aerosol stratification within the PBL and ship plumes



Plumes from tourist ship in the NyA harboor

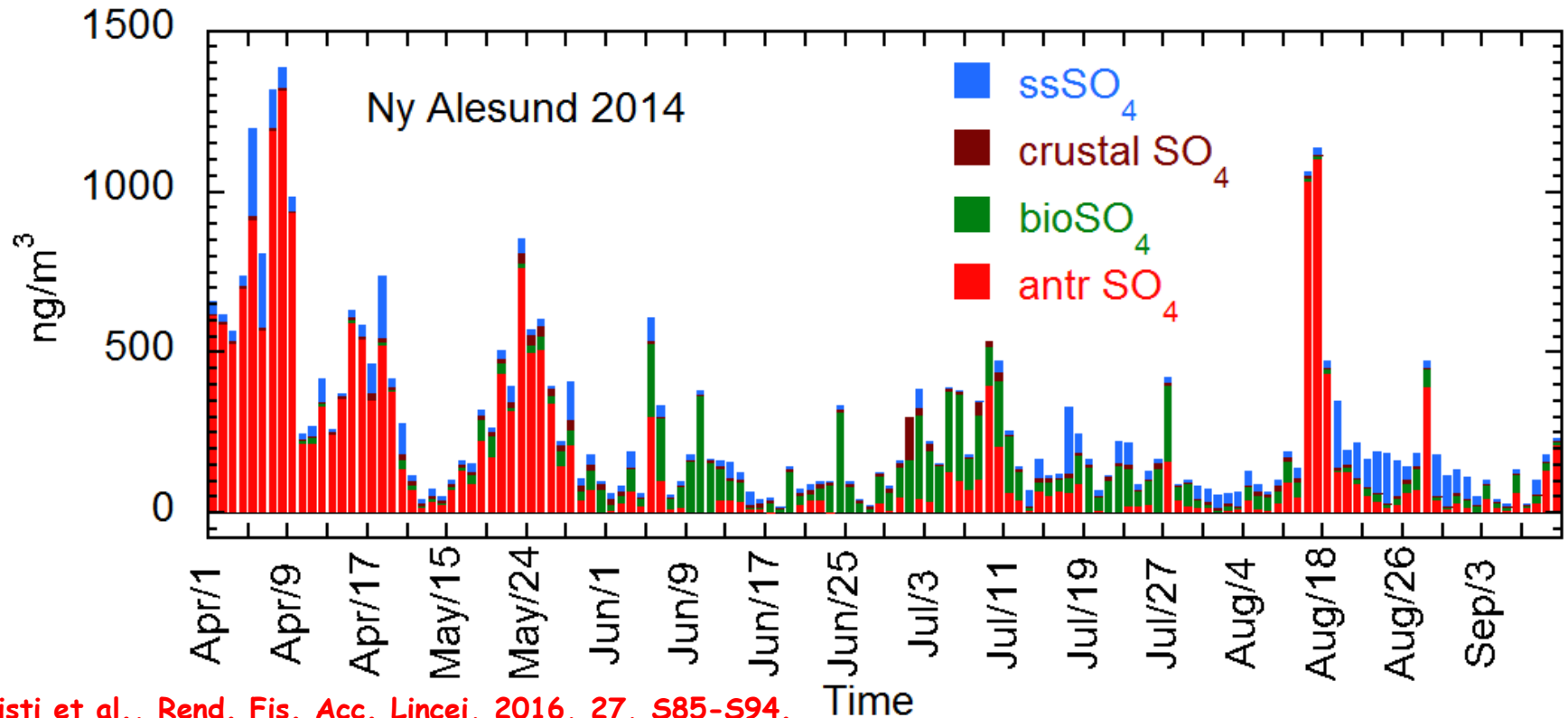
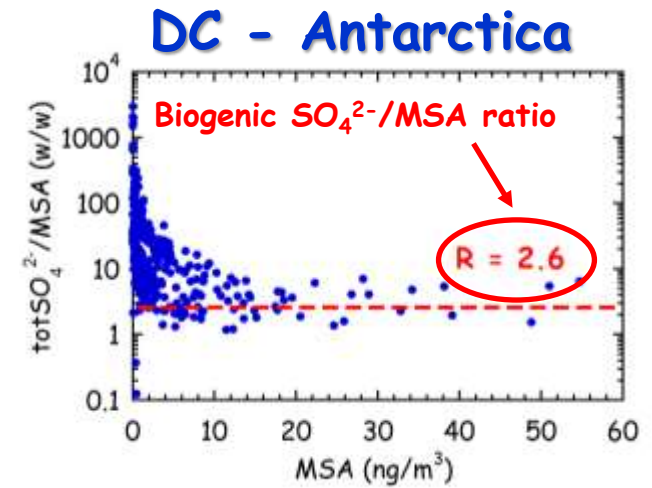
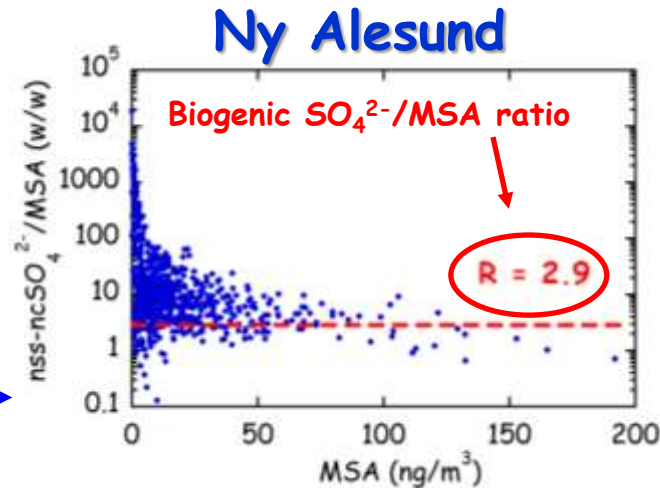
Source Apportionment on the reconstructed mass (74%) (EC-OC measurements cannot be included)

NyA 2010 - PMF Source Apportionment

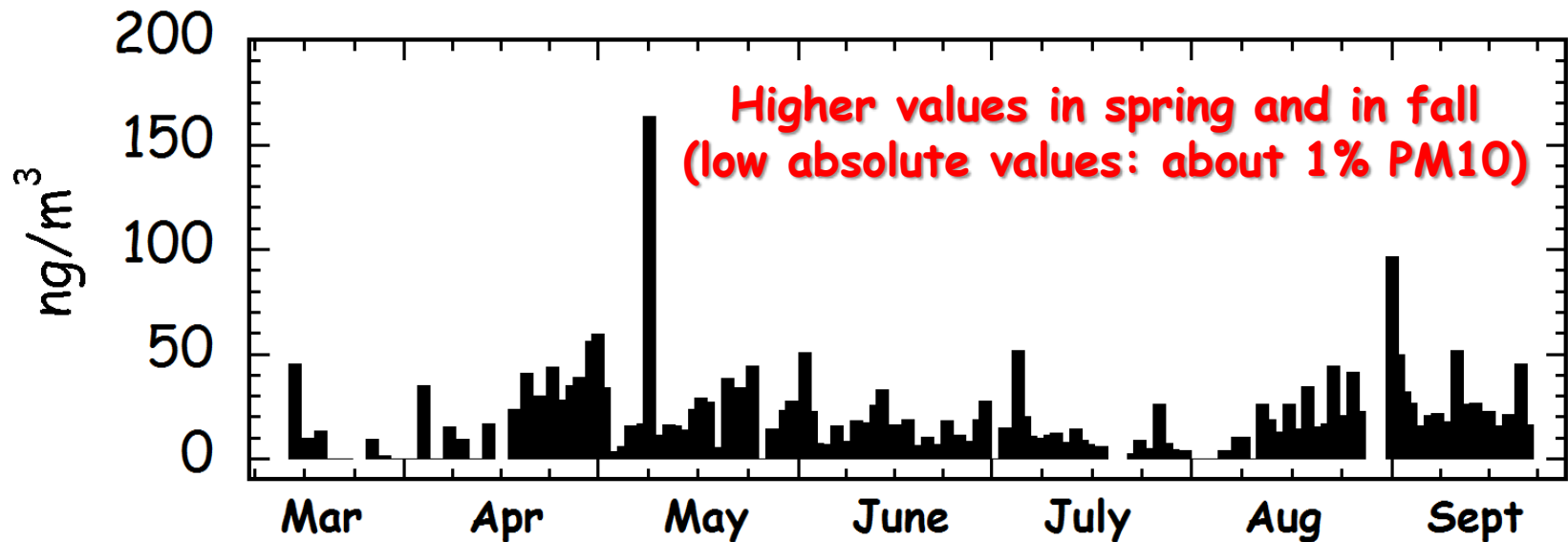
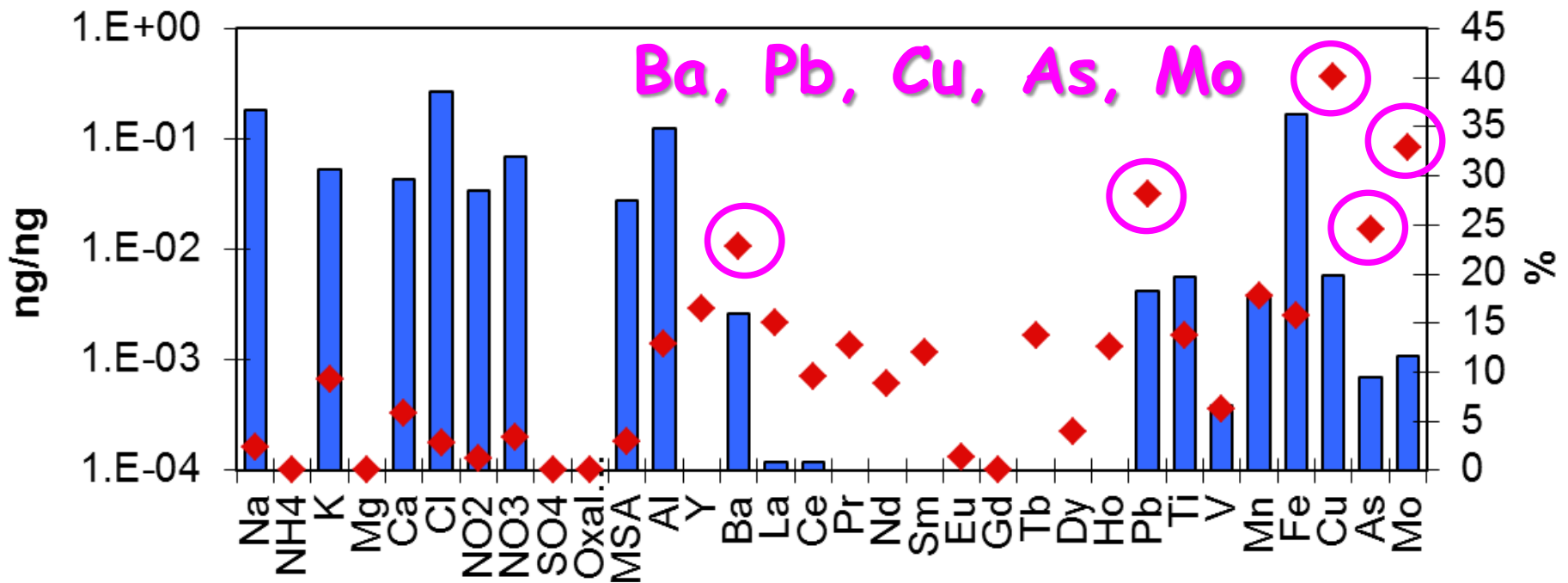


Evaluation of the sulfate source fractions

$ssSO_4^{2-}$
from $ssNa^+$
 $Crust-SO_4^{2-}$
from $nssCa^{2+}$
 $bio-SO_4^{2-}$

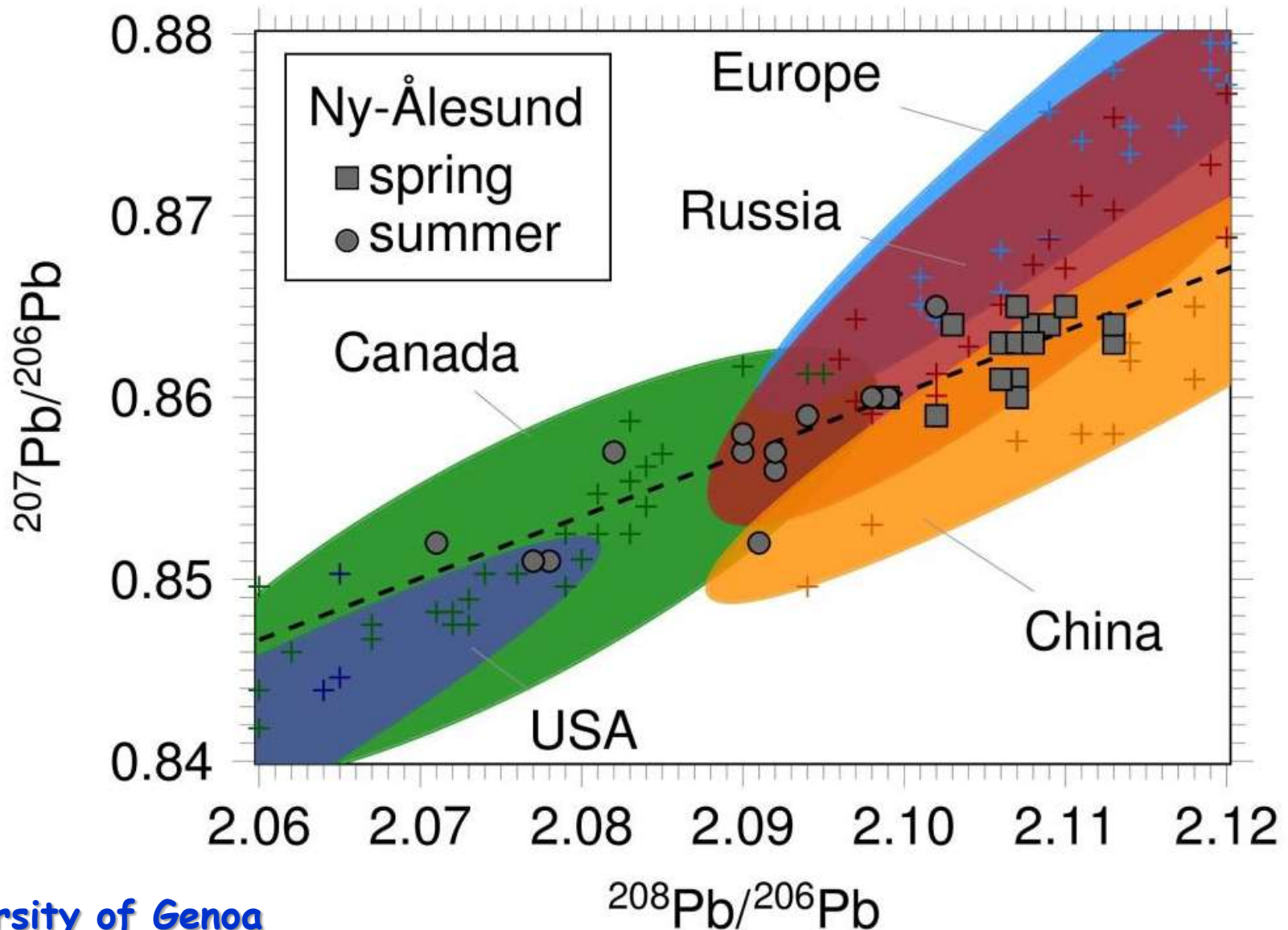


NyA 2010 - PMF - Primary Anthropogenic

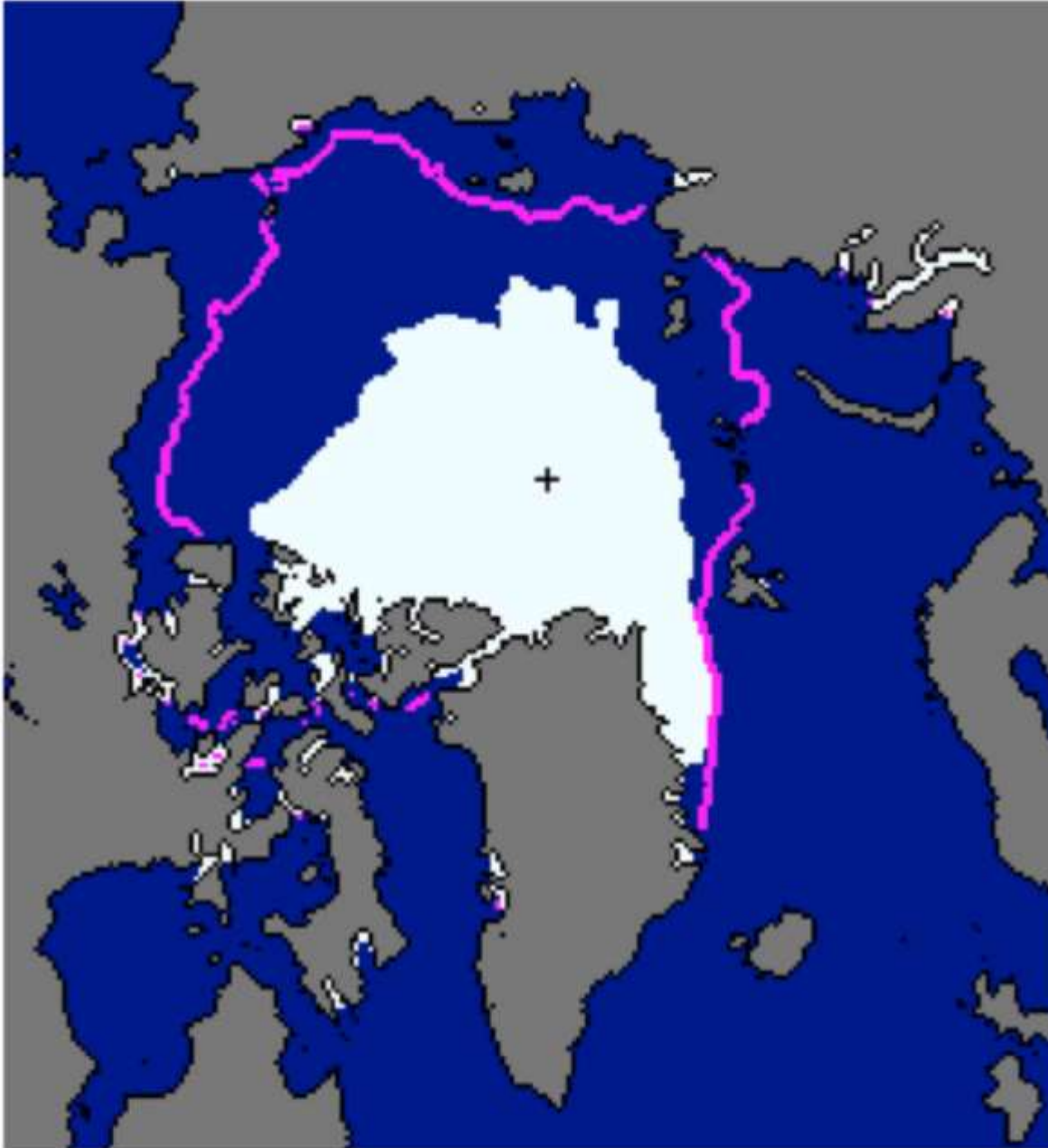


Source assessment of atmospheric lead by isotope ratios

Three-isotopes plot showing potential Pb source areas in spring and summer 2012



Sea Ice Retreat and Future trans-Arctic shipping



Arctic sea ice extent
in Sept. 2012
(3.6 Mkm²)

Magenta line indicates
mean sea ice extent
for 1979-2011.

Sept. 2012
represents a 49%
decline.

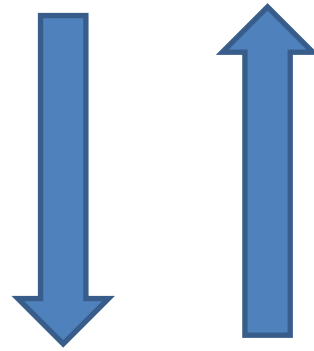
Oceanic DMS Climate Feedback

Global marine primary productivity has been declining during the last century, and is expected to decrease due to global warming. Such a decline was not observed in Arctic waters.

Climate change

Sea water stratification
in temperate regions

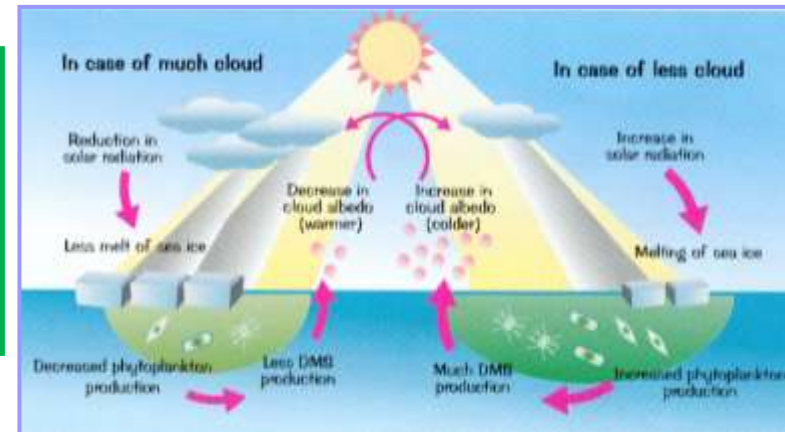
Sea ice extent
(in polar region)



Primary
Productivity
($\text{g C m}^{-2} \text{ d}^{-1}$)

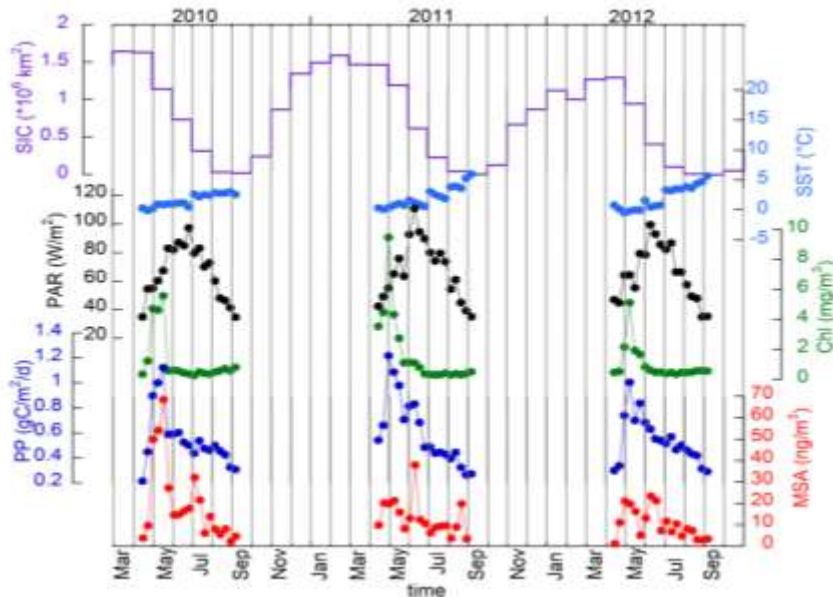
Uptake of atmospheric CO_2
for phytoplanktonic growth

Emission of DMS, precursor
of **MSA** and nssSO_4^{2-}

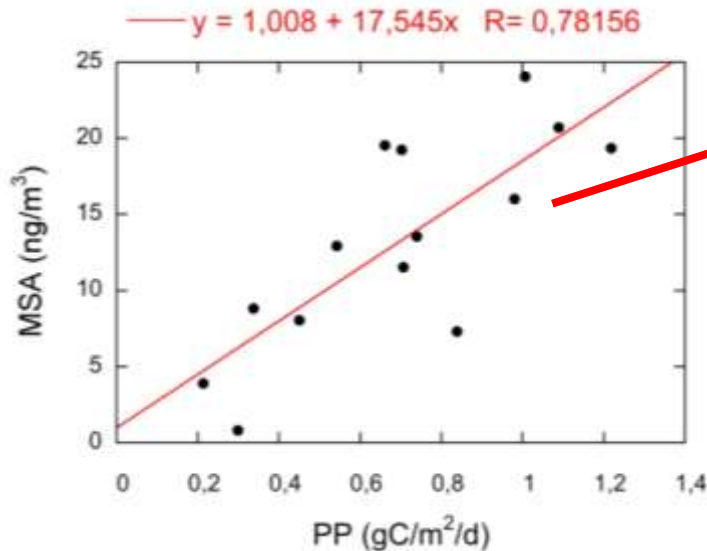
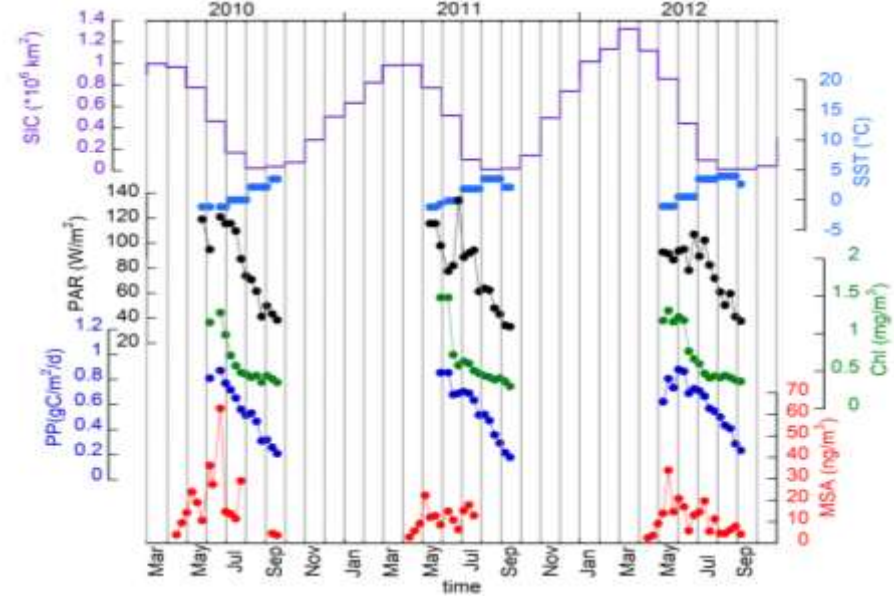


Biogenic Source - MSA vs Primary Productivity

MSA Ny Alesund - PP Barents Sea

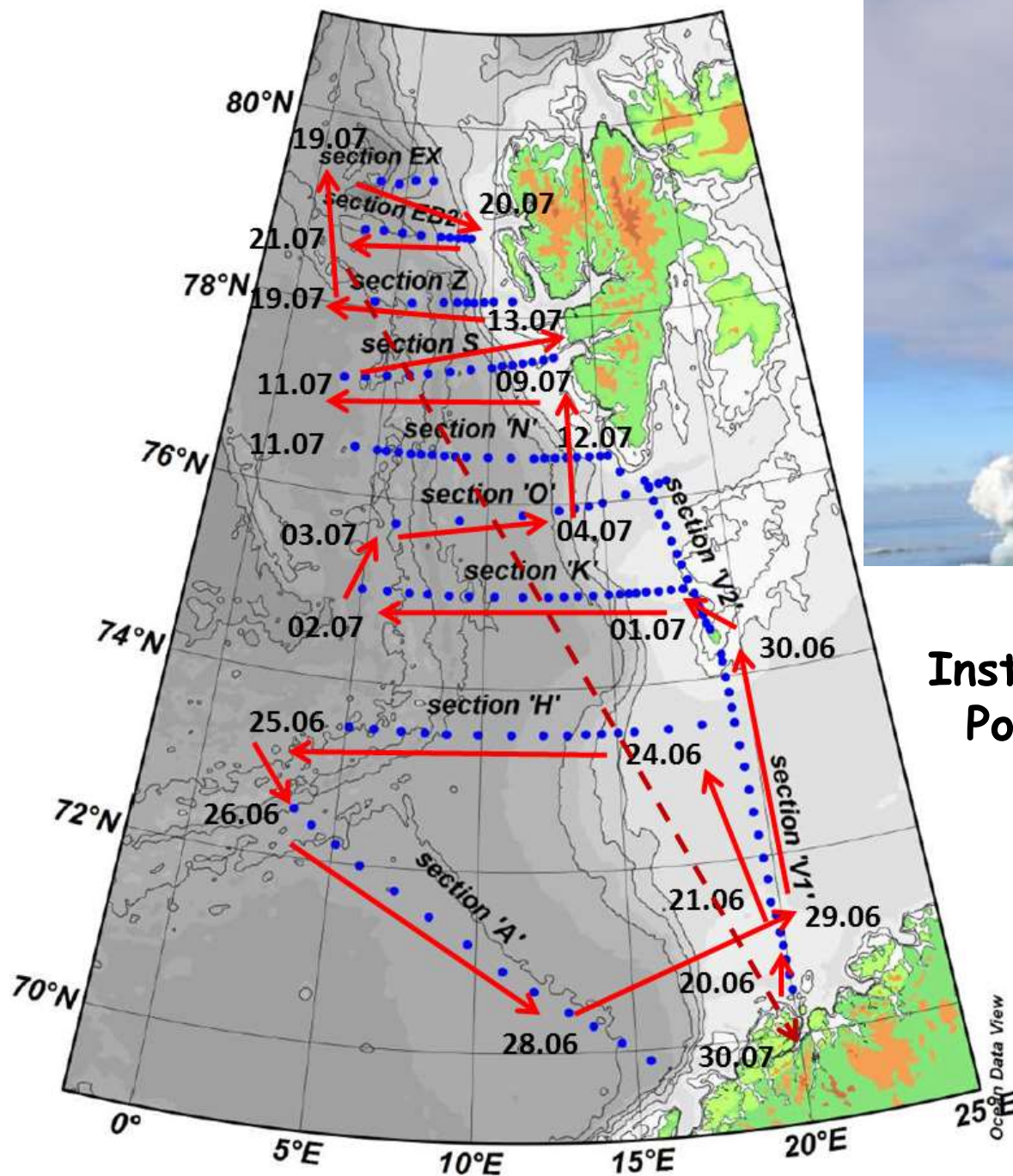


MSA Thule - PP Baffin Bay



Good correlation between MSA and primary productivity, primed by sea-ice melting.

Relevant result in studying the impact of climate change on marine biogenic activity in the past

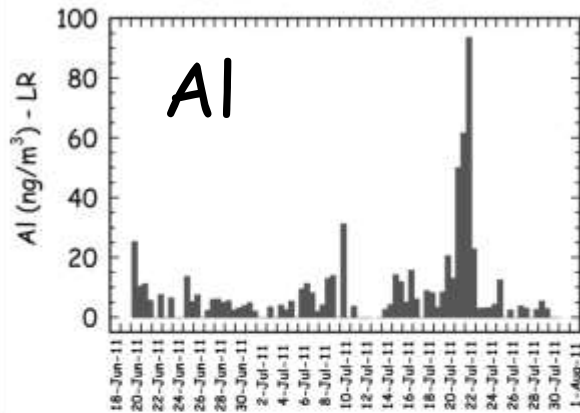


Polish Ship
Oceania

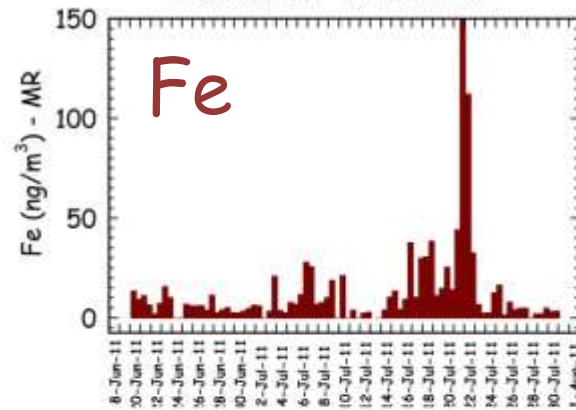
Collaboration with
Institute of Oceanology of the
Polish Academy of Sciences

**Longitudinal and
Latitudinal transects
from Tromsø to
Svalbard Islands
during the
AREX 2011 Cruise**

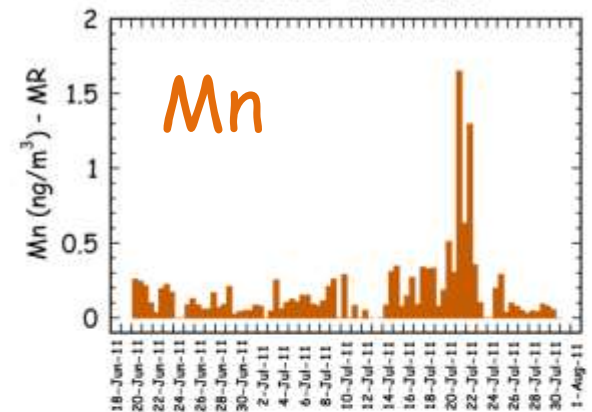
Oceania 2011 - PM10 Data



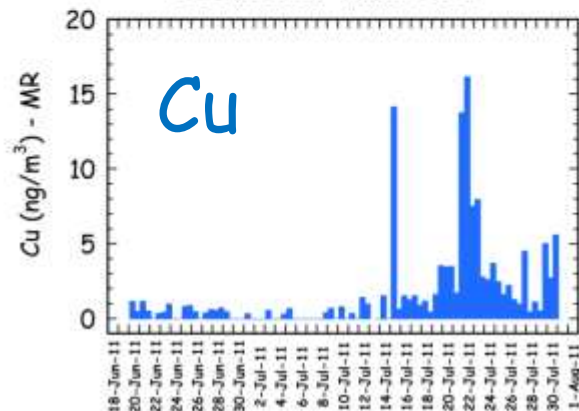
Oceania 2011 - PM10 Data



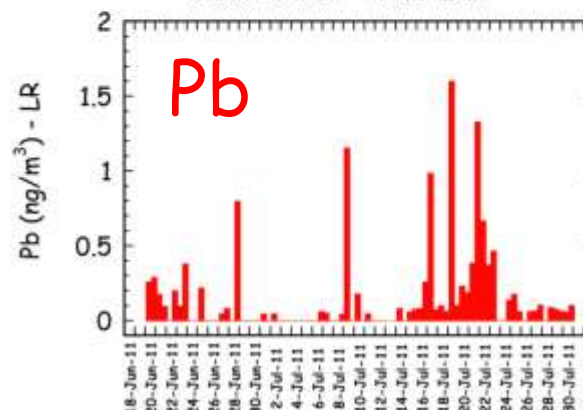
Oceania 2011 - PM10 Data



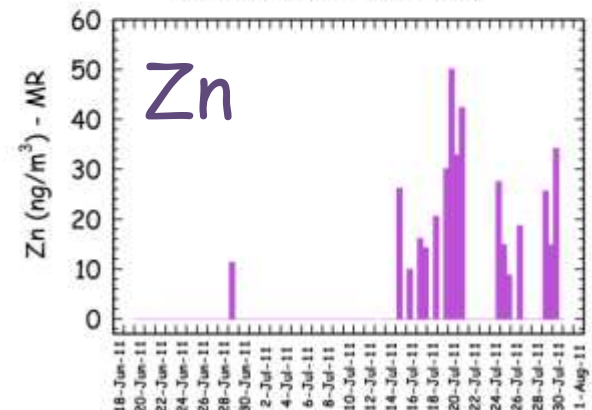
Oceania 2011 - PM10 Data



Oceania 2011 - PM10 Data



Oceania 2011 - PM10 Data



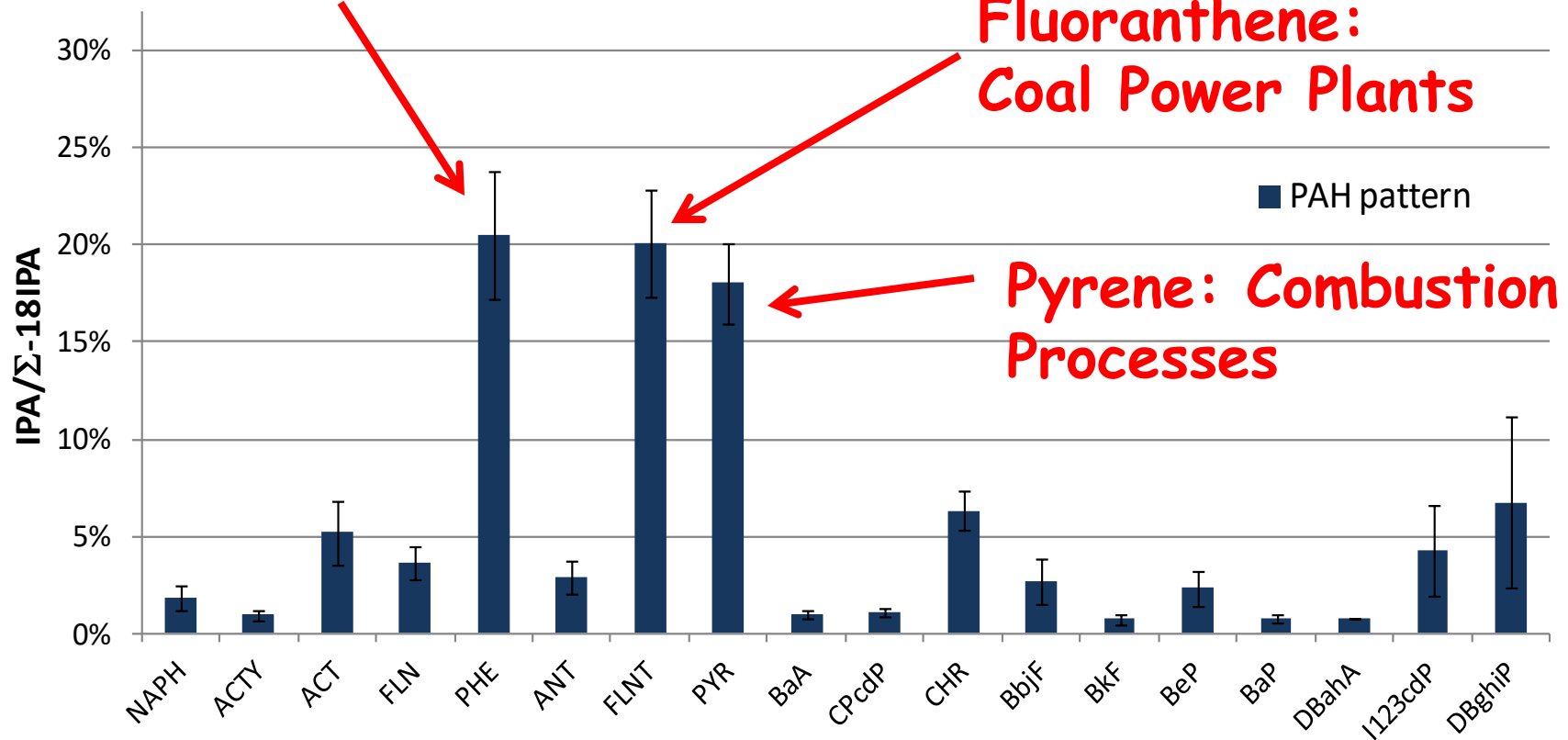
Crustal (Al, Fe, Mn) and anthropic (Cu, Pb, Zn) metals show larger contributions in Western Coastal Areas of Svalbard Islands (especially near Longyearbyen)

Percentage contribution of PAH species

Phenanthrene: Heavy Fuel Oil

Fluoranthene: Coal Power Plants

Pyrene: Combustion Processes



Phenanthrene, Fluoranthene and Pyrene constitute 58% of the PAHs sum



NASA/MODIS

Isola di Lampedusa

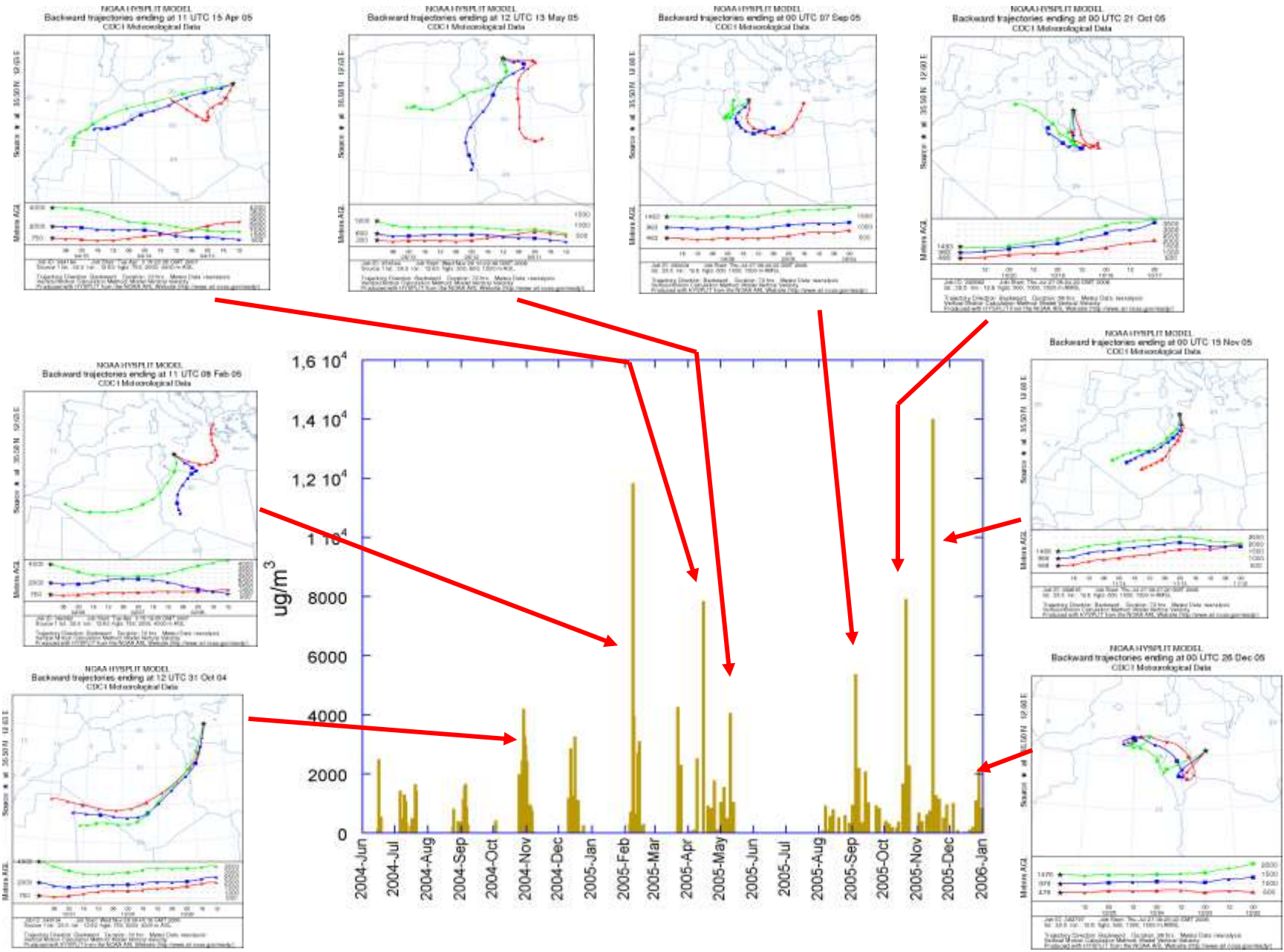
Studio della
frequenza e
dell'origine degli
eventi di trasporto
delle polveri
sahariane

Relazione tra
produttività marina
primaria e marker
biogenici nell'aerosol
nel Mediterraneo
Meridionale

Valutazione
dell'impatto sulla
qualità dell'aria
delle emissioni da
traffico navale nel
Canale di Sicilia

35.5°N, 12.6°E

Identificazione Aree Sorgenti Saharan Dust da Back-Trajectory



Identificazione Aree Sorgenti Saharan Dust da Geochimica

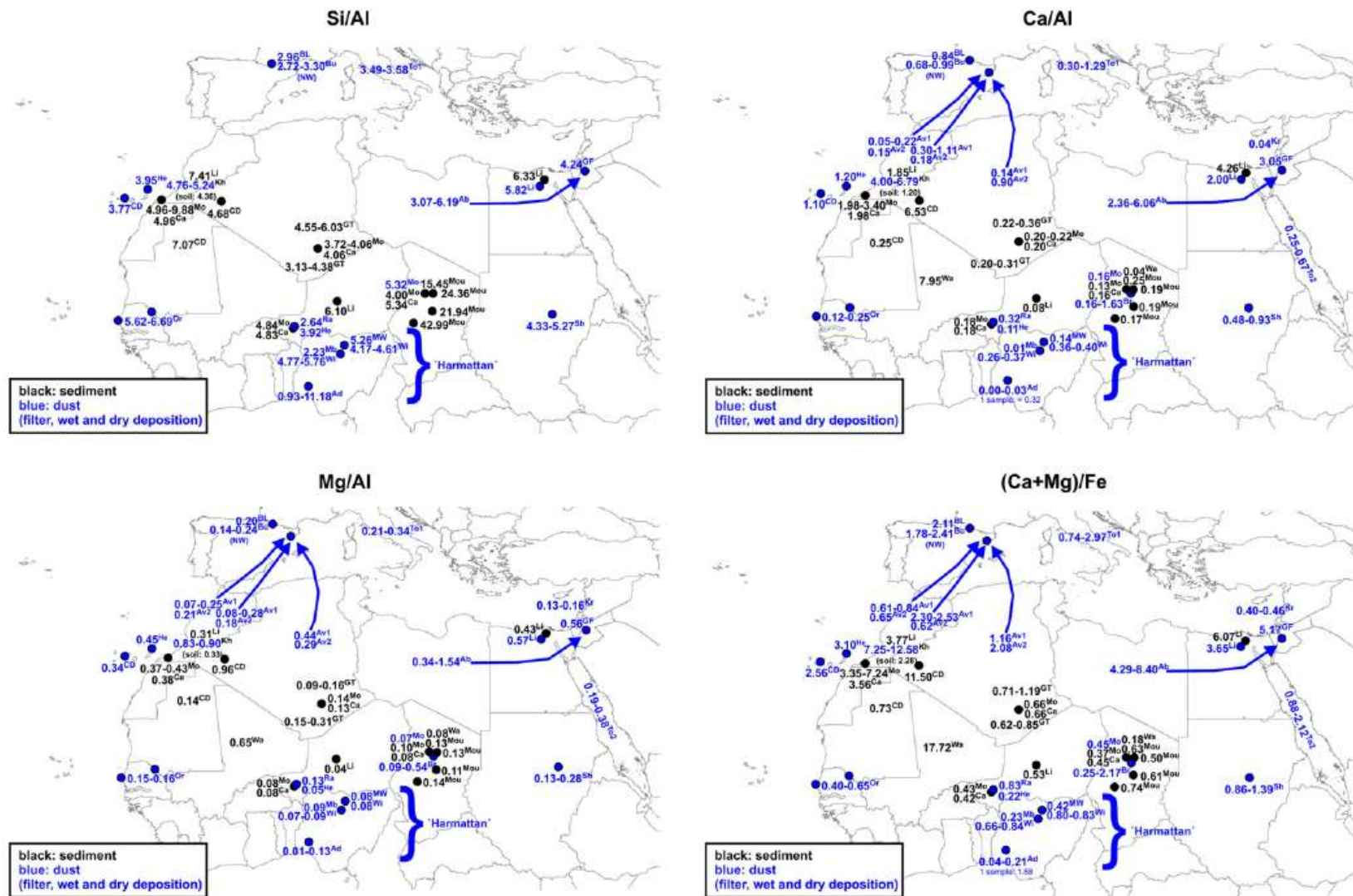
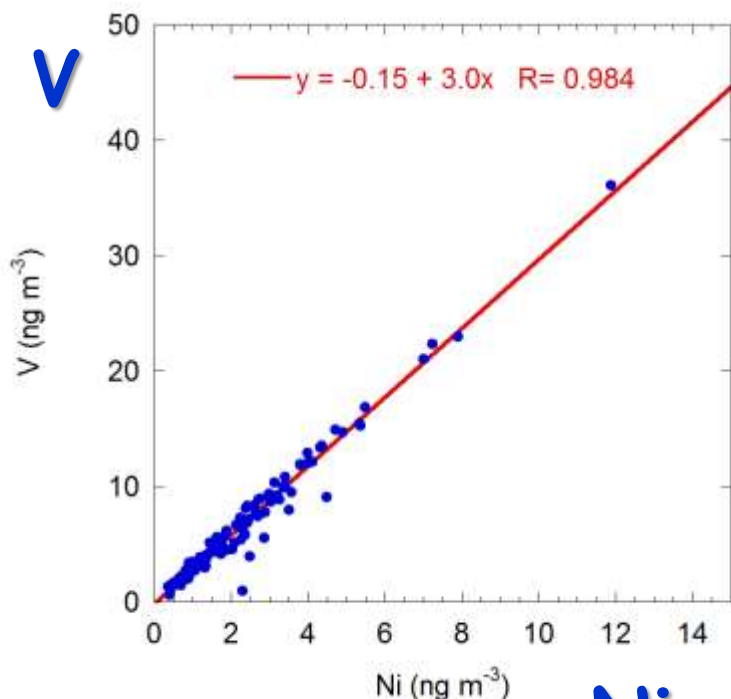


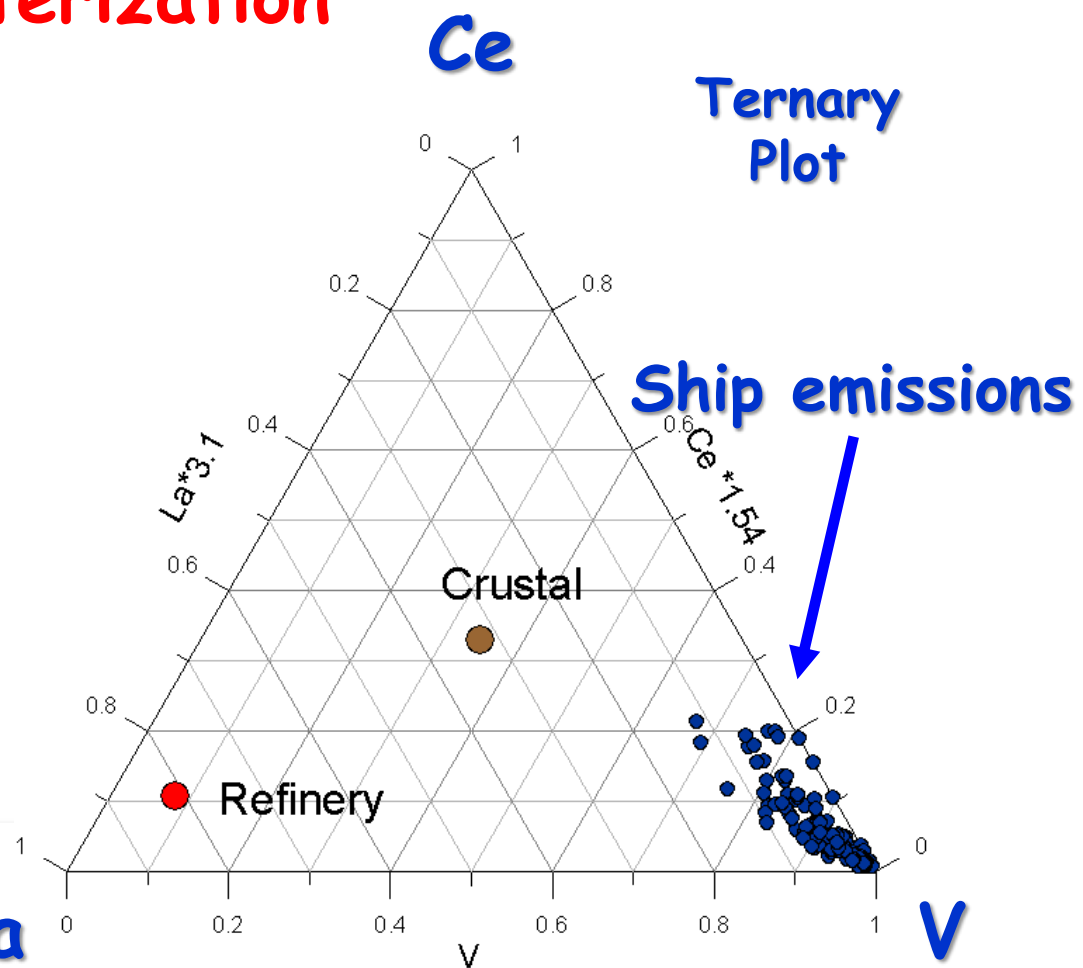
Fig. 2. Maps of northern Africa with elemental ratios of Si/Al, Ca/Al, Mg/Al, and (Ca + Mg)/Fe indices (bulk chemical analyses in wt.%) for dust and sediment samples; arrows show transport directions of mineral dust of selected studies. References: MW: McTainsh and Walker (1982), BL: Bücher and Lucas (1984), To1: Tomadin et al. (1984), Wit: Willke et al. (1984), Ad: Adedokun et al. (1989), Bu: Bücher (1989), To2: Tomadin et al. (1989), Mb: Moberg et al. (1991), Or: Orange et al. (1993), Sh: Sharif (1995), GF: Ganor and Foner (1996), GT: Guieu and Thomas (1996), He: Herrmann et al. (1996), Av1: Avila et al. (1998), Kr: Krom et al. (1999), Gu: Guieu et al. (2002a), CD: Criado and Dorta (2003), Si: Singer et al. (2003), Kh: Khiri et al. (2004), Li: Linke et al. (2006), Mo: Moreno et al. (2006), Mou: Mounkaila (2006), Av2: Avila et al. (2007), Ca: Castillo et al. (2008), Ra: Rajot et al. (2008), Ab: Abed et al. (2009), Wa: Washington et al. (2009), and Br: Bristow et al. (2010).

Ship emission characterization



Ni

La



Mediterranean Sea measurements (Lampedusa Island):

Average % nssSO₄²⁻ from ship : 32.5%

Max value: 7.2 µg/m³ (66.3% of total nssSO₄²⁻ – 32.4% of PM10 mass)

Becagli et al., Atmos. Chem. Phys., 2012, 12, 3479-3492

Becagli et al., Atmos. Chem. Phys., 2017, 17, 2067-2084

Caratterizzazione Chimica Aerosol Urbano

- Identificazione delle principali fonti emissive del particolato atmosferico (PM_x);
- Determinazione nel PM_x dei livelli di elementi le cui concentrazioni atmosferiche sono regolate dalle norme sulla qualità dell'aria (IPA, Metalli pesanti)
- Valutazione degli effetti delle condizioni meteorologiche sulla concentrazione del PM_x

Progetto PATOS I - 2004-05



Lucca

Urban background



Prato

urban traffic



Firenze

urban background



Arezzo

urban traffic



Livorno

Sub-urban background



Grosseto

urban background



PM10 in 6 siti in
Toscana,
rappresentativi di
aree di differente
tipologia
(differenti fonti
emissive e
topografia)



Progetto PATOS 2 - 2008-2009

PM_{2.5} - 3 siti

Firenze Urbana Traffico
Viale Gramsci

Firenze Urbana Fondo
Via Bassi

Livorno Periferica Fondo
Villa Maurogordato



Caratterizzazione chimica del PM_{2.5}

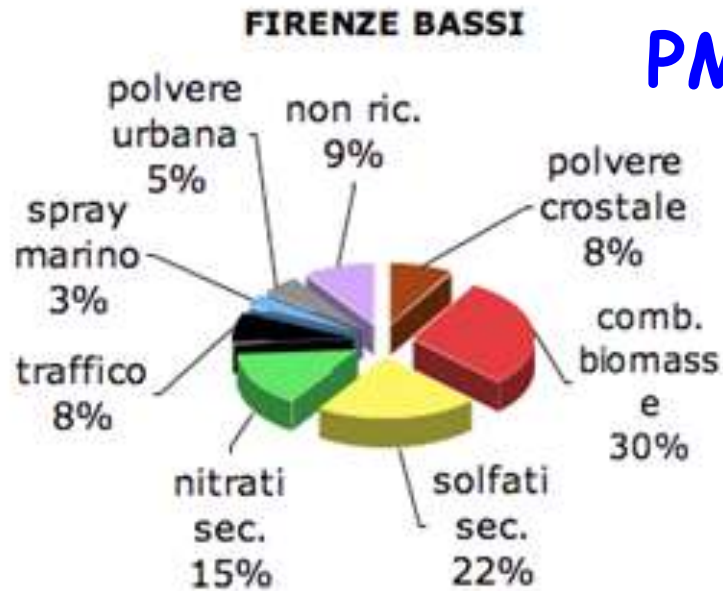
Monitoraggio del carico atmosferico

Monitoraggio livelli degli inquinanti "normati"

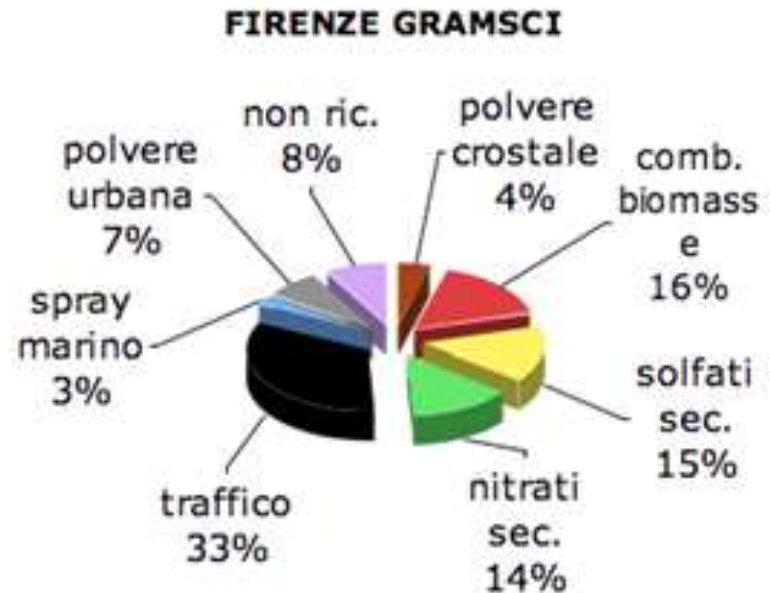
Ricostruzione e quantificazione delle sorgenti per
individuazione strategie di mitigazione

PM_{2.5} Source Apportionment

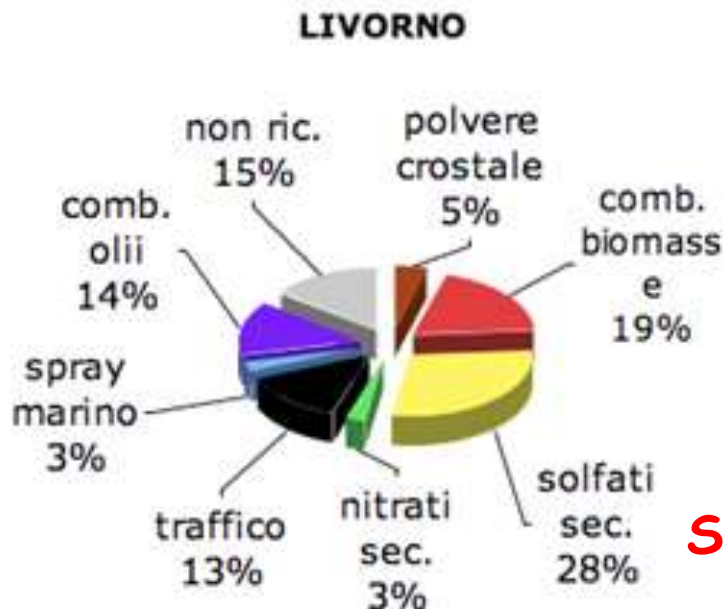
Analisi Statistica Multivariata
Positive Matrix Factorization (PMF)



Sito Urbano-Fondo



Sito Urbano-Traffico

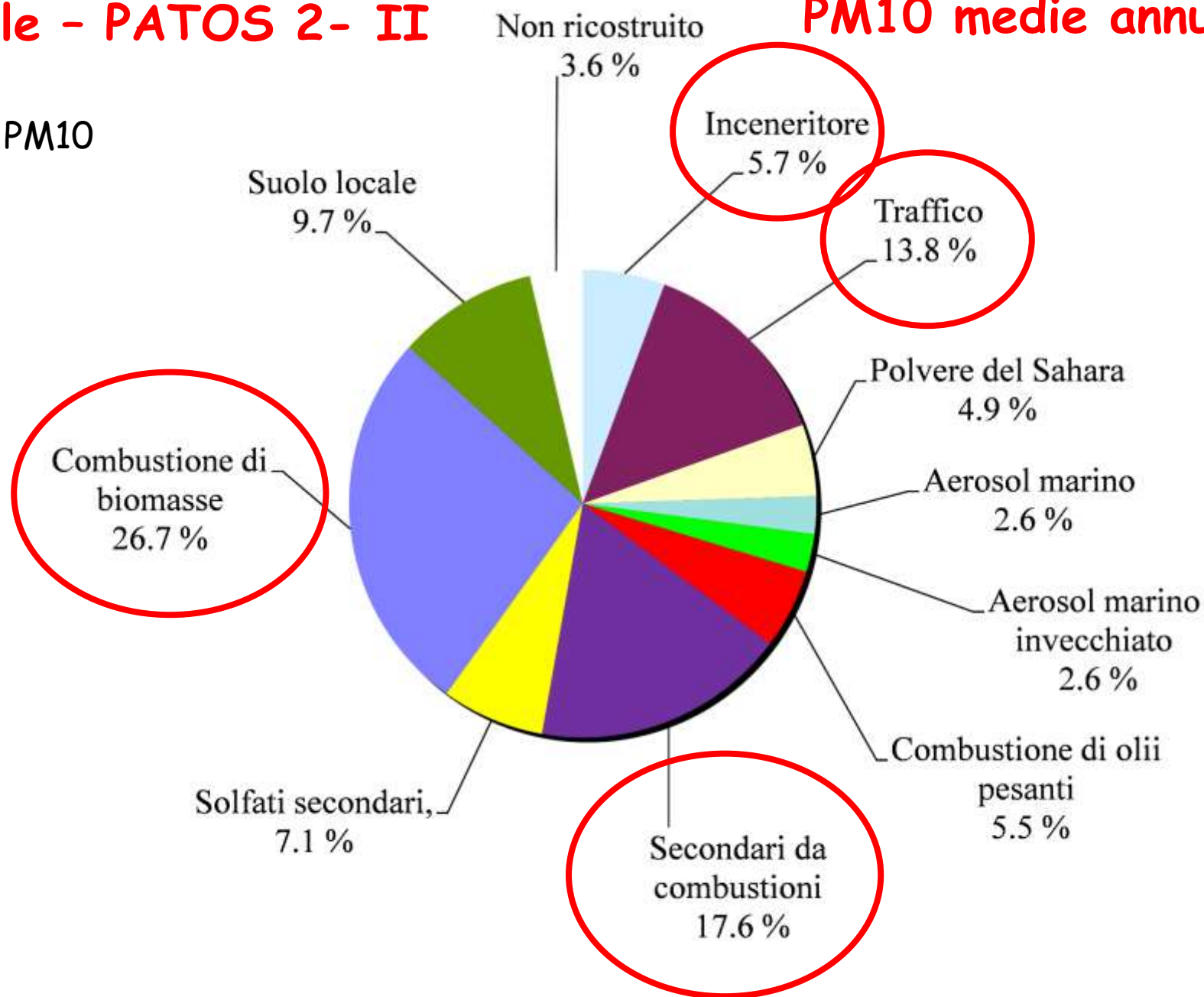


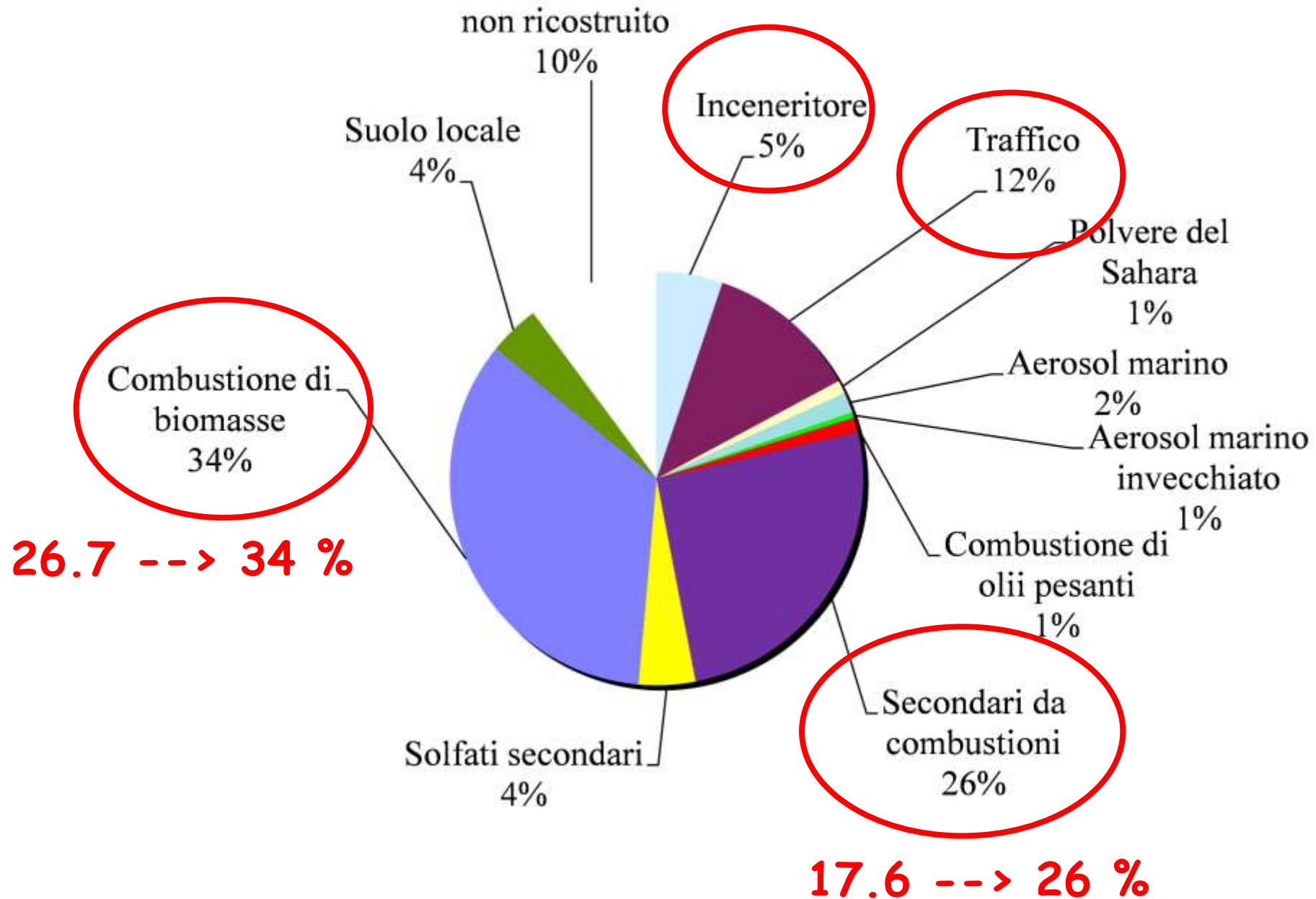
Sito Marino-Fondo

Montale - PATOS 2- II

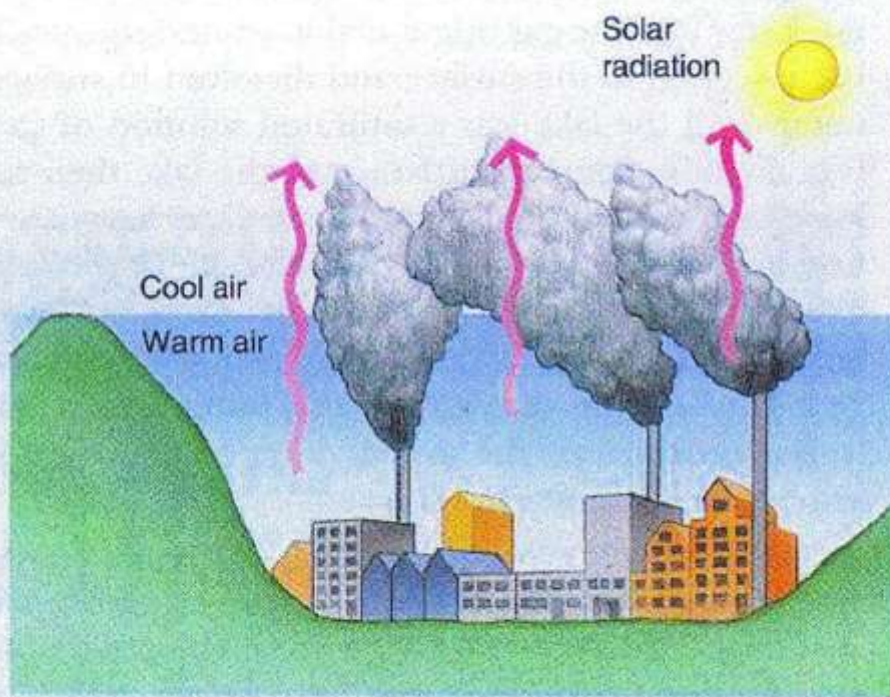
PM10 medie annue

PM10

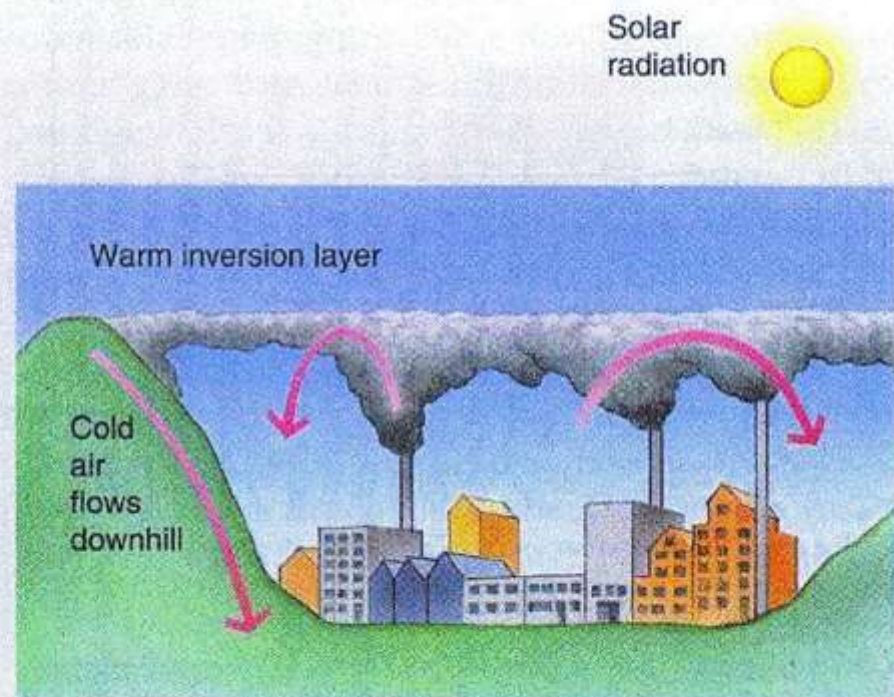




Formazione strato di inversione termica Circolazione verticale

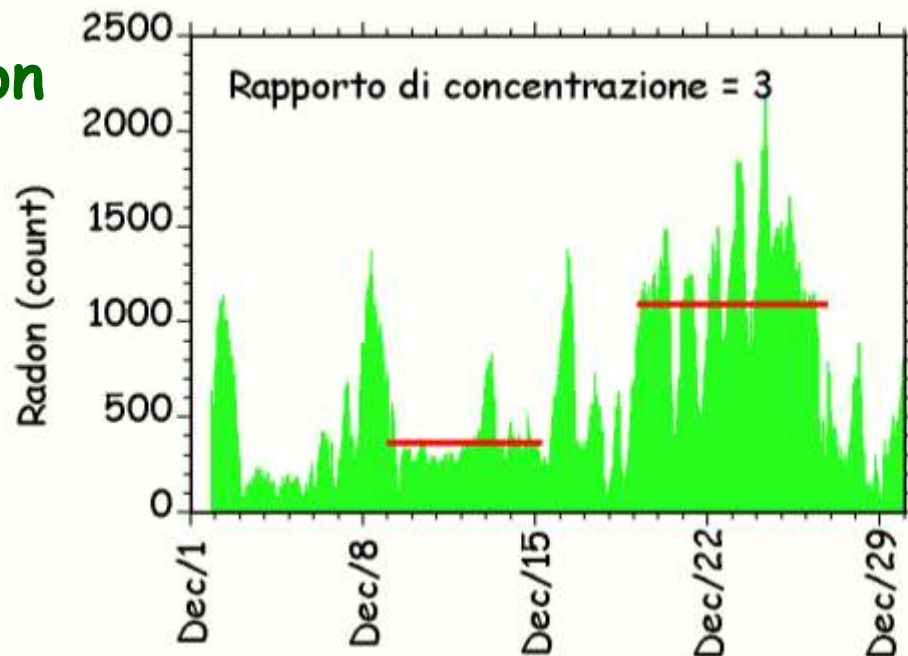


Normal pattern



With a temperature inversion

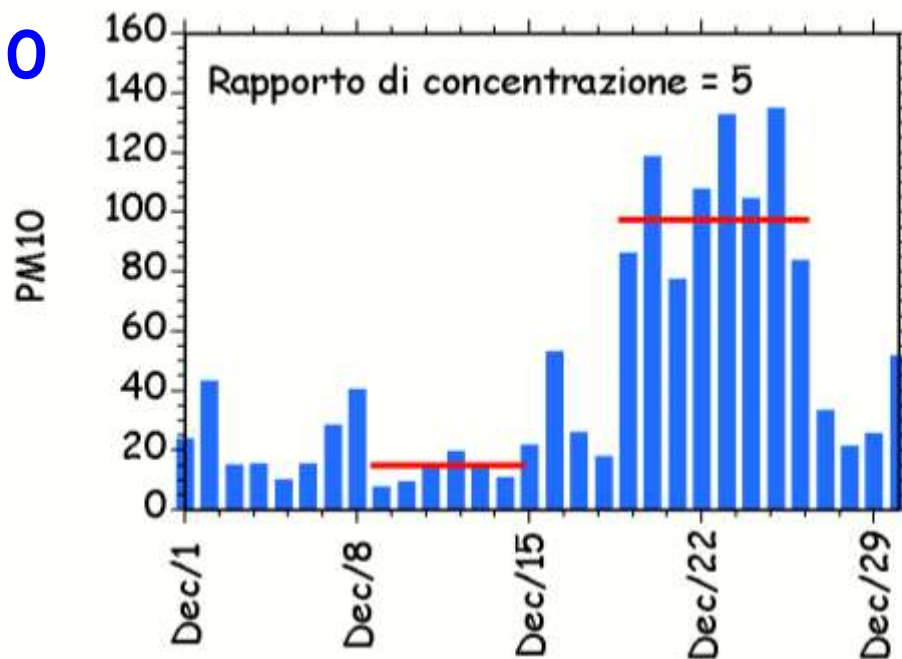
Radon



Dicembre 05

Tutti i
superamenti
osservati sono
attribuibili alla
formazione di
strati di inversione

PM10

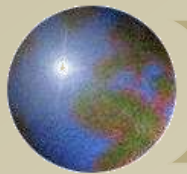


Radon: $R = 3.0$

PM10: $R = 5.0$

**Strato di inversione
spiega almeno il 60%
dell'aumento del PM10**

(talvolta 100%)



Le particelle ultrafini (PUF)

La concentrazione numerica di PUF ($\leq 0.1 \mu\text{m} = \leq 100 \text{ nm}$) **originate dal traffico** gioca un ruolo rilevante negli effetti sanitari.

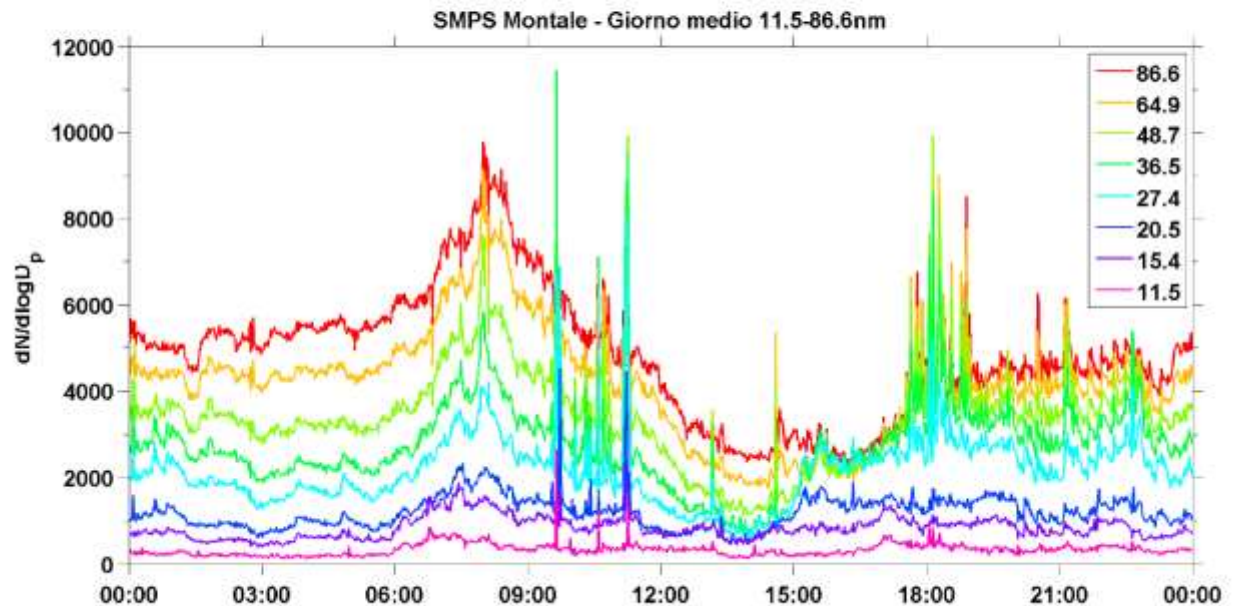
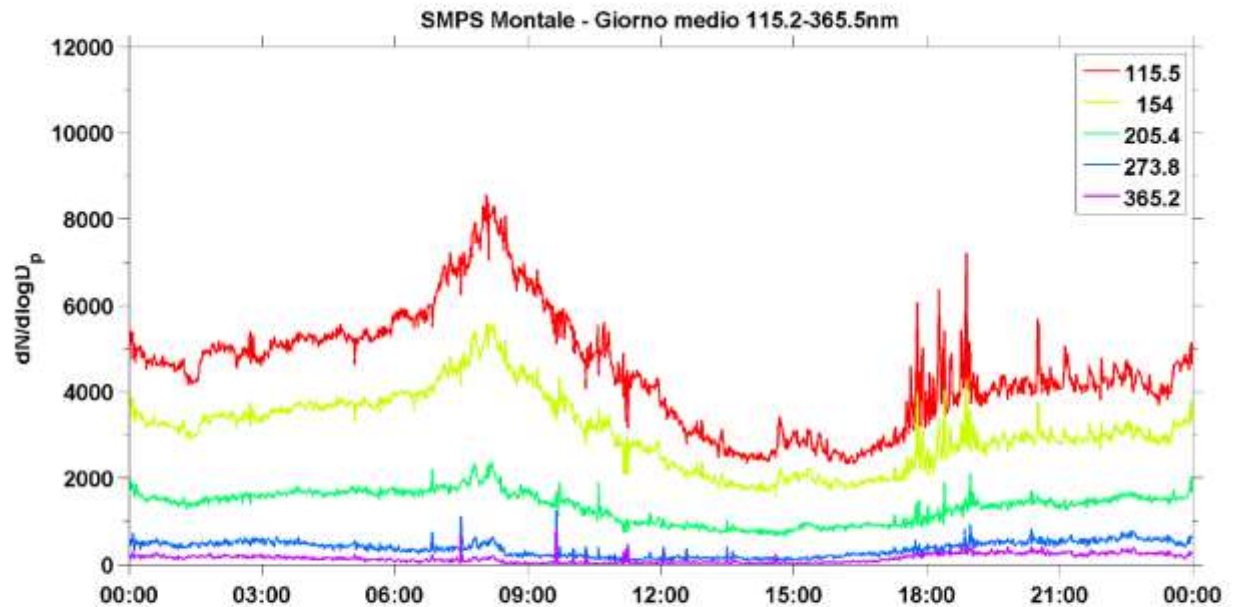
I motori **diesel** sono i maggiori responsabili
Bus/TIR circolanti nelle città forniscono un
significativo contributo alle emissioni di
particelle, specie di PUF (**FE 10 X > benzina**)

**Necessita' di un "bianco" della concentrazione
atmosferica e della composizione chimica di
nano-particelle nella Piana di Firenze anche in
funzione del progetto di costruzione di un
impianto di termovalorizzazione dei rifiuti urbani**

Nano-Particelle Montale 2015

Picchi di particolato intorno alle 8:00 e dalle 18:00 alle 20:00 correlati all'andamento del traffico.

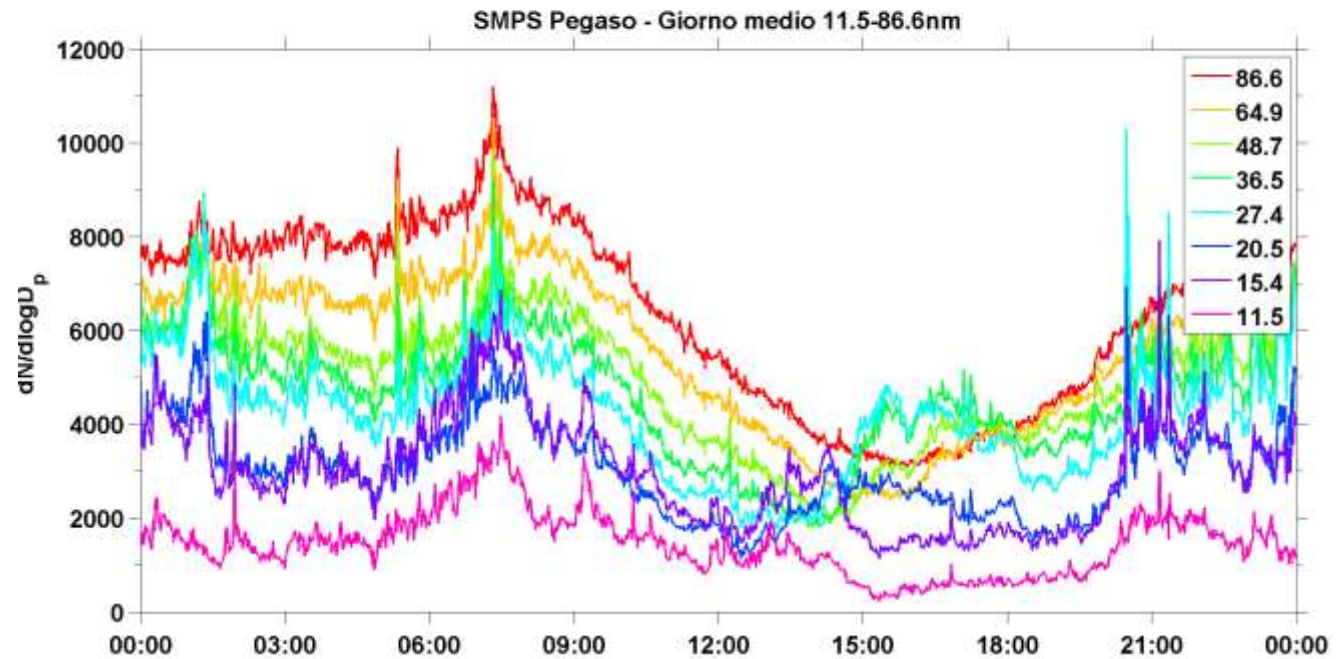
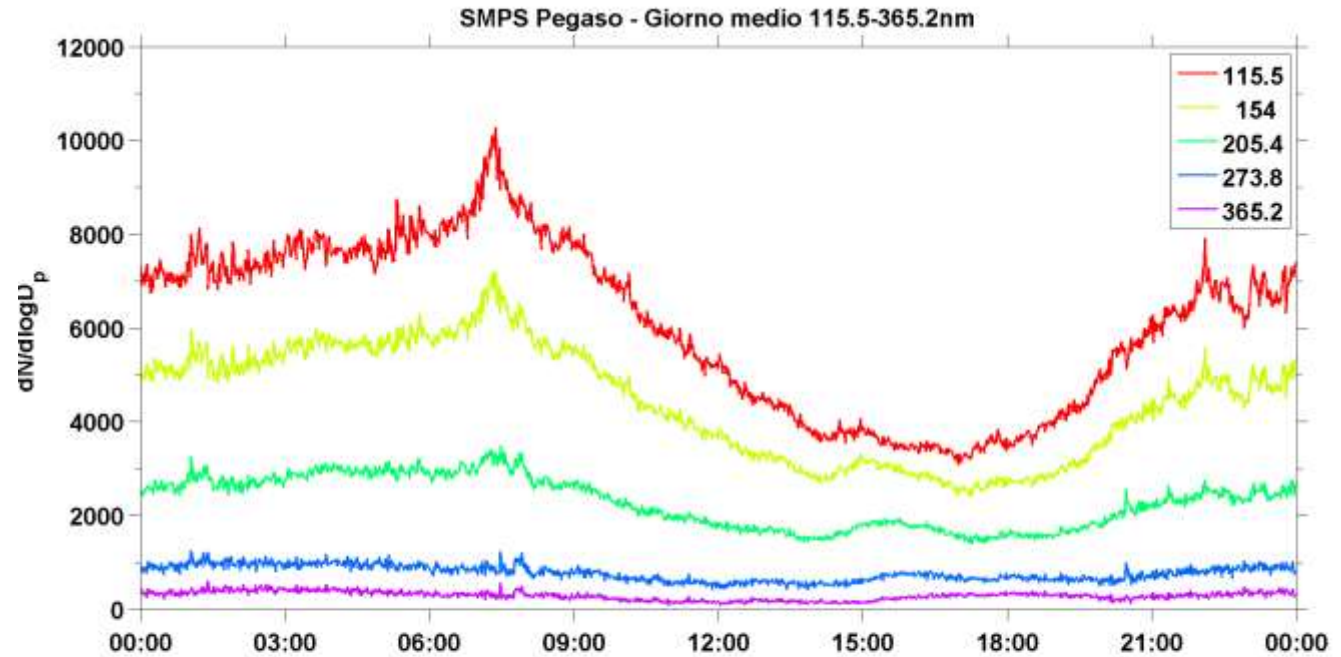
Valori notturni più elevati di quelli delle ore centrali della giornata per effetto della differente efficienza della circolazione verticale



Nano-particelle Osmannoro Giorno Medio

Picchi intorno alle
8:00 e aumento
dalle 18:00
correlati
all'andamento del
traffico.

Valori notturni piu'
elevati di quelli
delle ore centrali
della giornata per
effetto della
differente
efficienza della
circolazione
verticale



Studi pilota aerosol Sesto F.no

PASF-1: PM10 (misure esplorative) - Giu 03 - Giu 05

PASF-2: PM10 e PM2.5 - Nov 05 - Mar 07

PASF-3: PM1 - Mar 07 - Mag 08

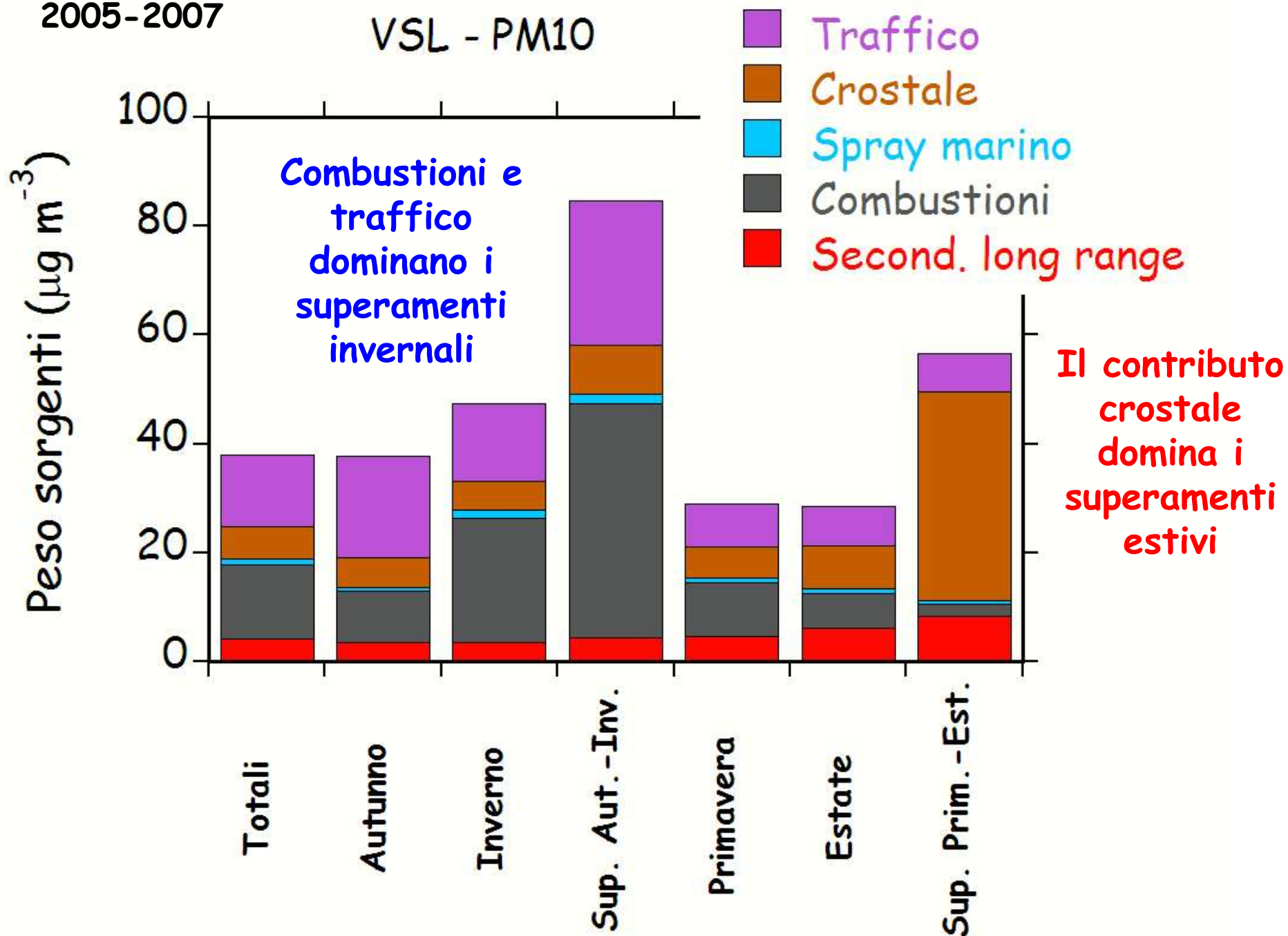
PASF-4: PM2.5 - Mar 10 - Mar 12

- Centro urbano di Sesto Fiorentino
- Area a basso livello di antropizzazione utilizzata come riferimento: Monte Morello (747 m s.l.m.)



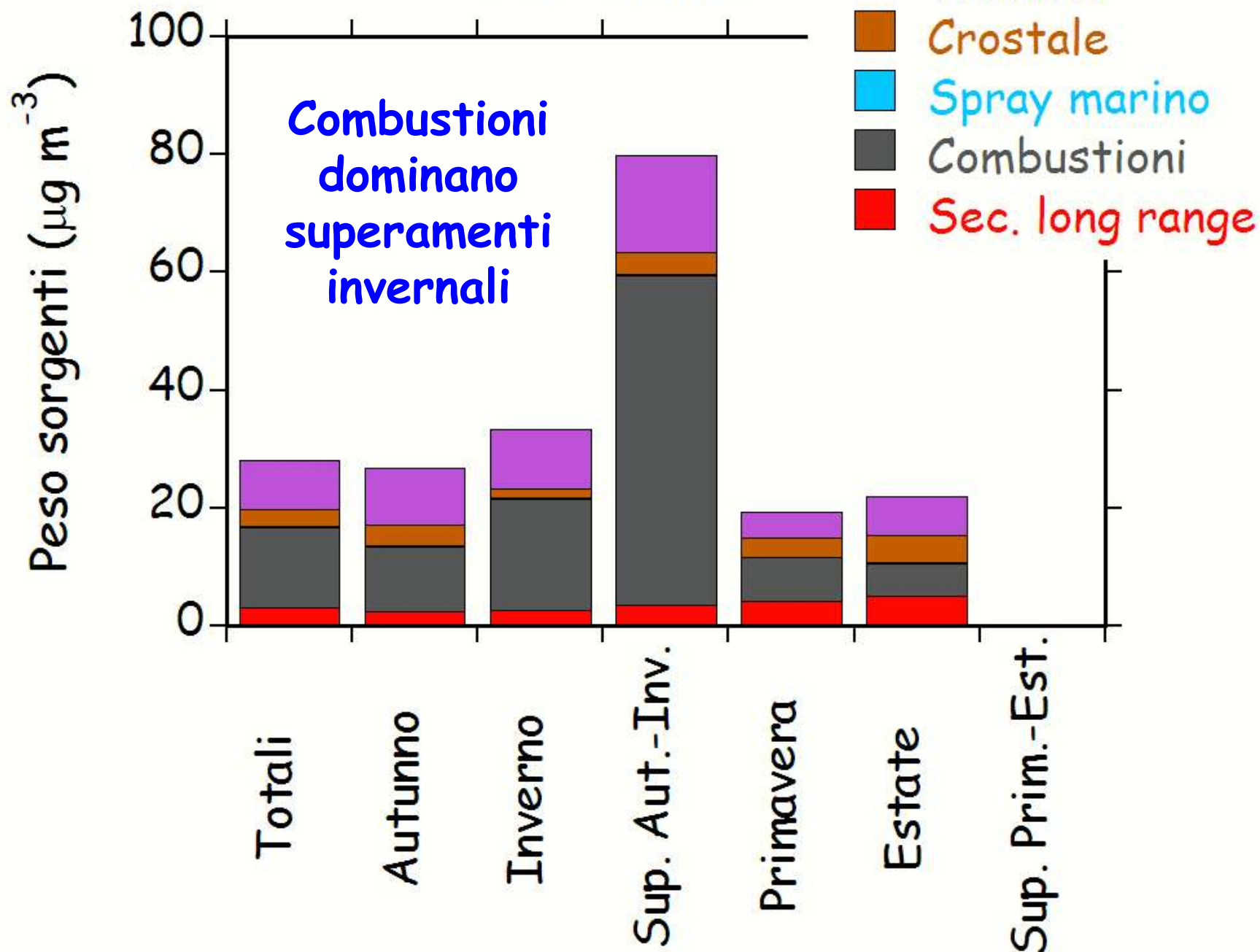
2005-2007

VSL - PM10

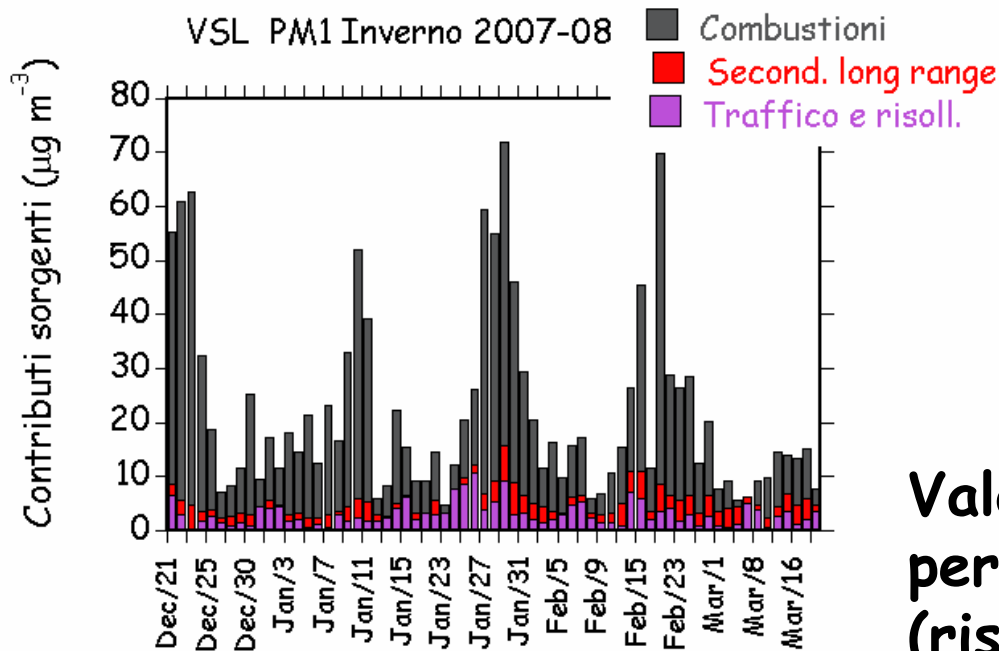


2005-2007

VSL - PM2.5



Villa San
Lorenzo

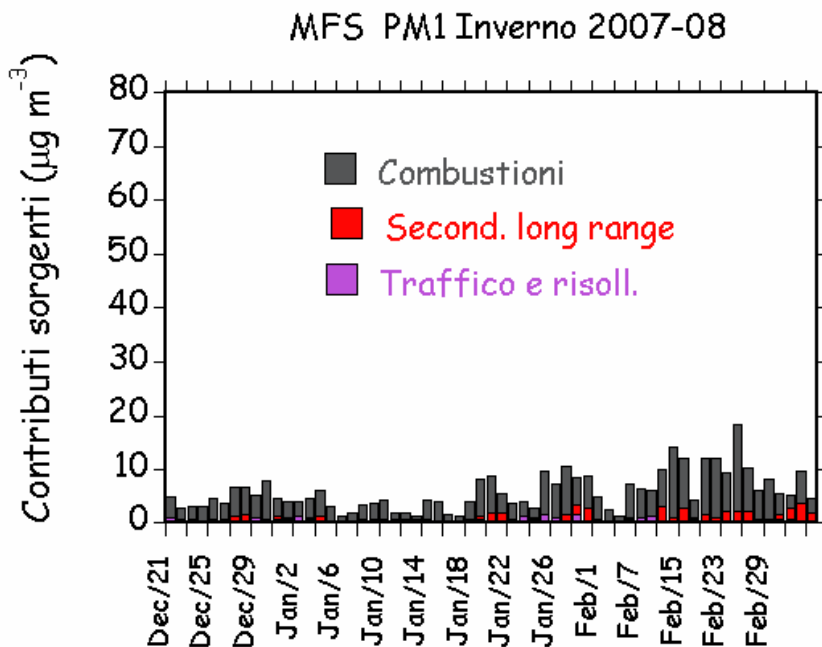


PM1

In inverno

Valori molto piu' alti
per l'abitato di Sesto
(riscaldamento - strati
di inversione termica)

Monte
Morello



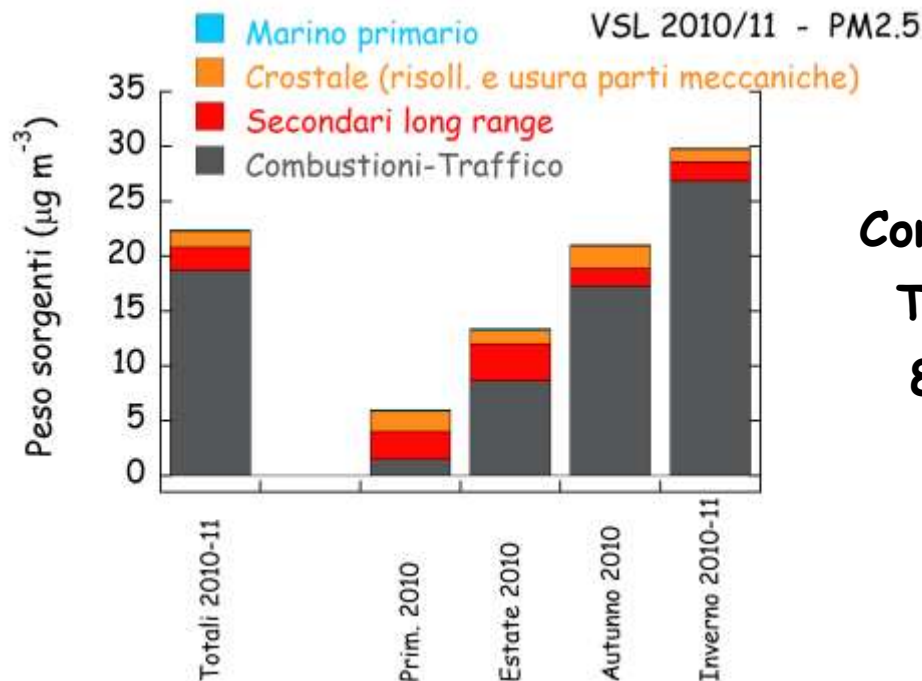
Sorgente prevalente:

Combustioni

Villa San Lorenzo

2010/11

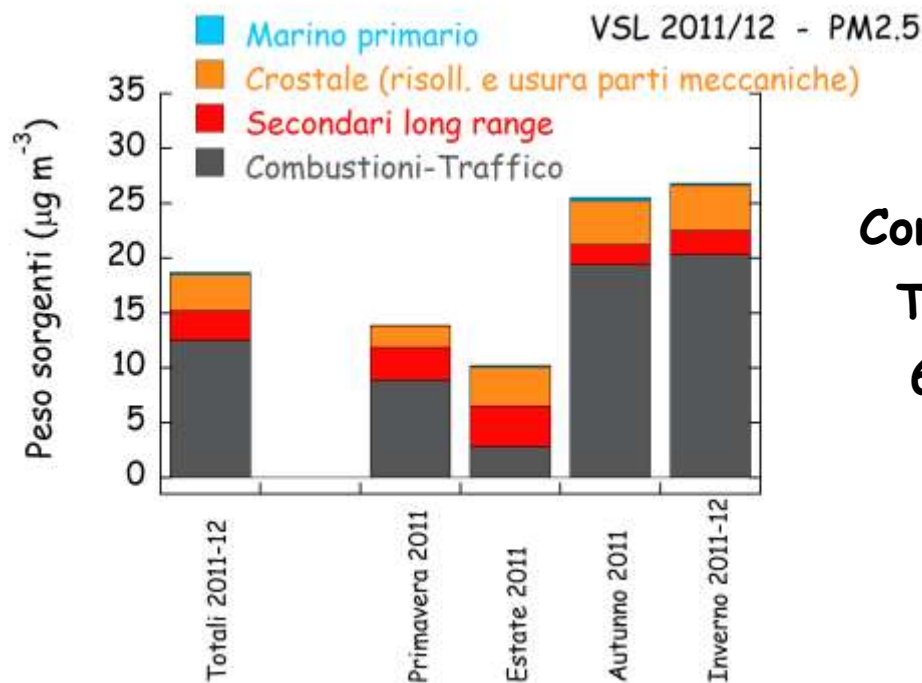
Circolazione verticale
piu' limitata.
Maggiori contributi dei
fattori locali
(Combustioni e
Traffico) soprattutto
in Inverno



**Combustioni
Traffico
83.5 %**

2011/12

Circolazione verticale
piu' energica.
Minori contributi di
inquinanti locali.
Maggiori contributi di
inquinanti secondari
regionali e di polveri
crostali



**Combustioni
Traffico
66.8 %**

Case
Passerini

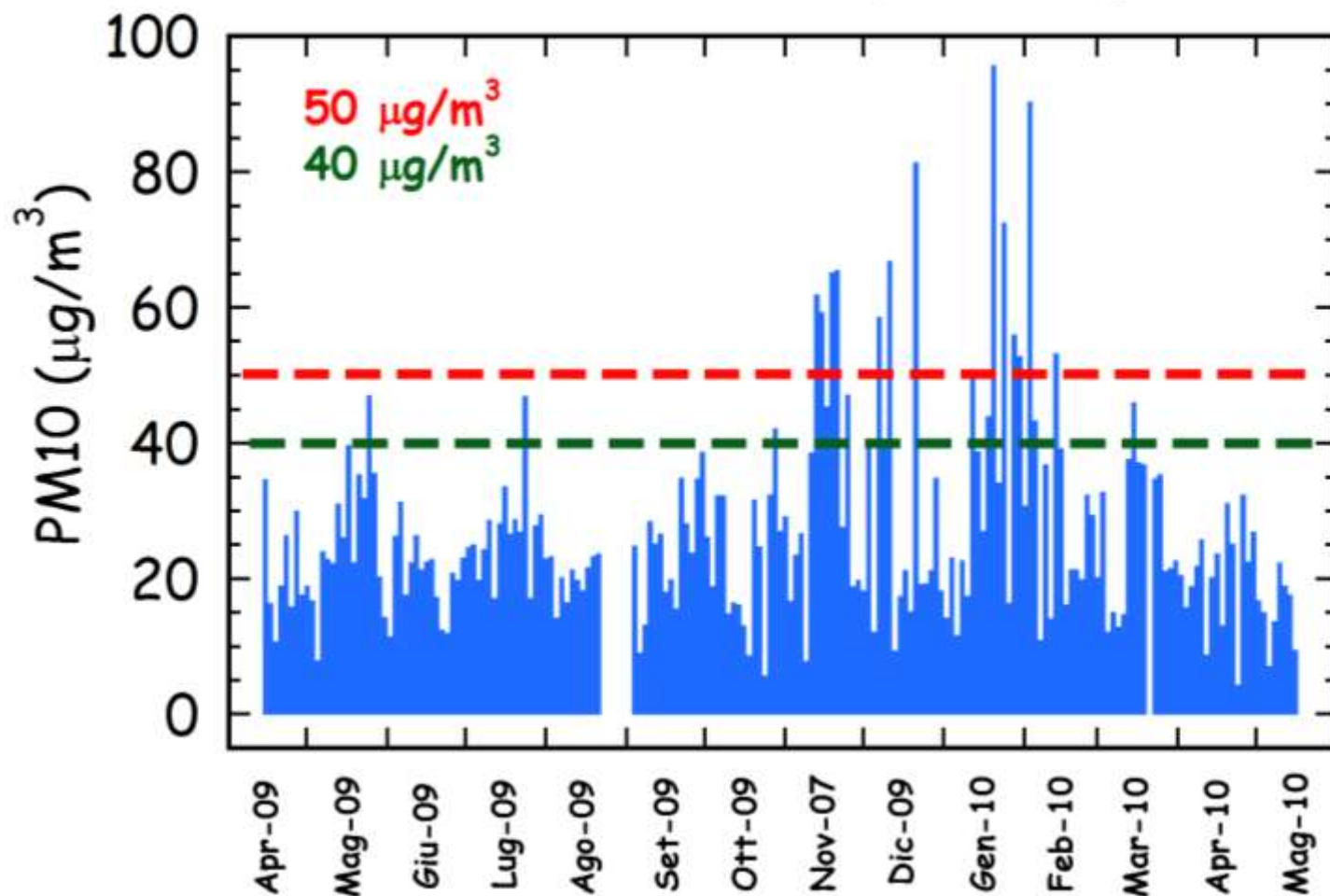
Centralina «Pegaso»
per lo studio e il
monitoraggio qualità dell'aria
Osmannoro - Area ex Longinotti



PM10

Osmannoro 2009-10

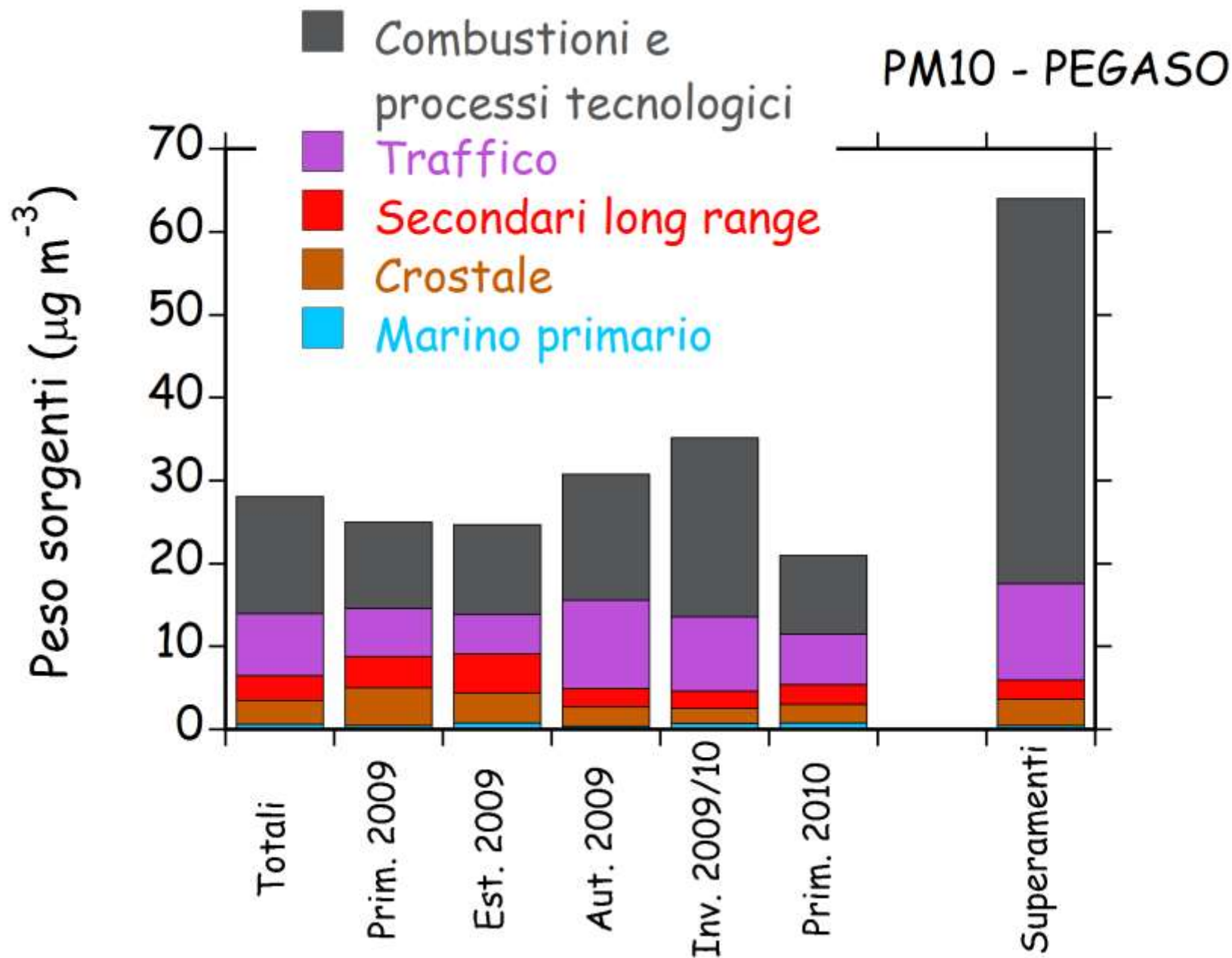
PEGASO - PM10 - Apr09-Mag10



13 superamenti

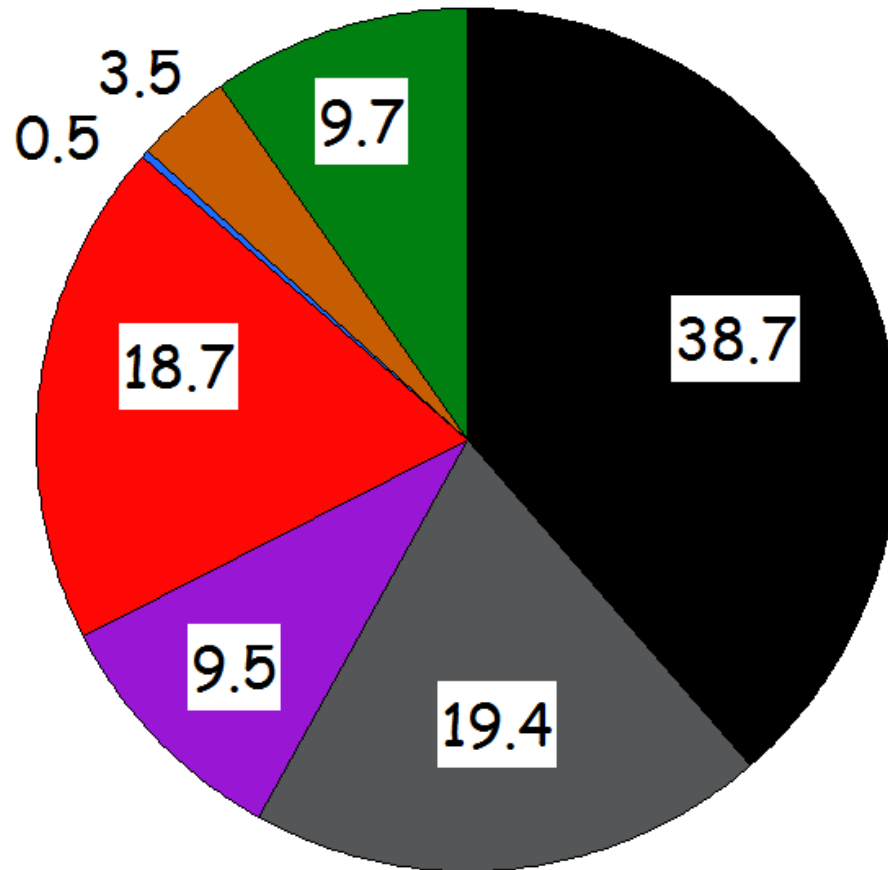
PM10 medio annuo: 28 $\mu\text{g}/\text{m}^3$

2009-10



PM1

PEGASO 2014-15



- Combustioni Biomassa
- Impianti Riscaldamento
- Traffico
- Sec. Long Range
- Spray Marino
- Crostale
- Fonti Biologiche

**Dati
Preliminari !!!**

Medie Annue

Combustione di bio-masse nel PM1: 38.7 %

Campionatori
SMART
PM10 - 15 gg

Campionamenti:
da Settembre 2016

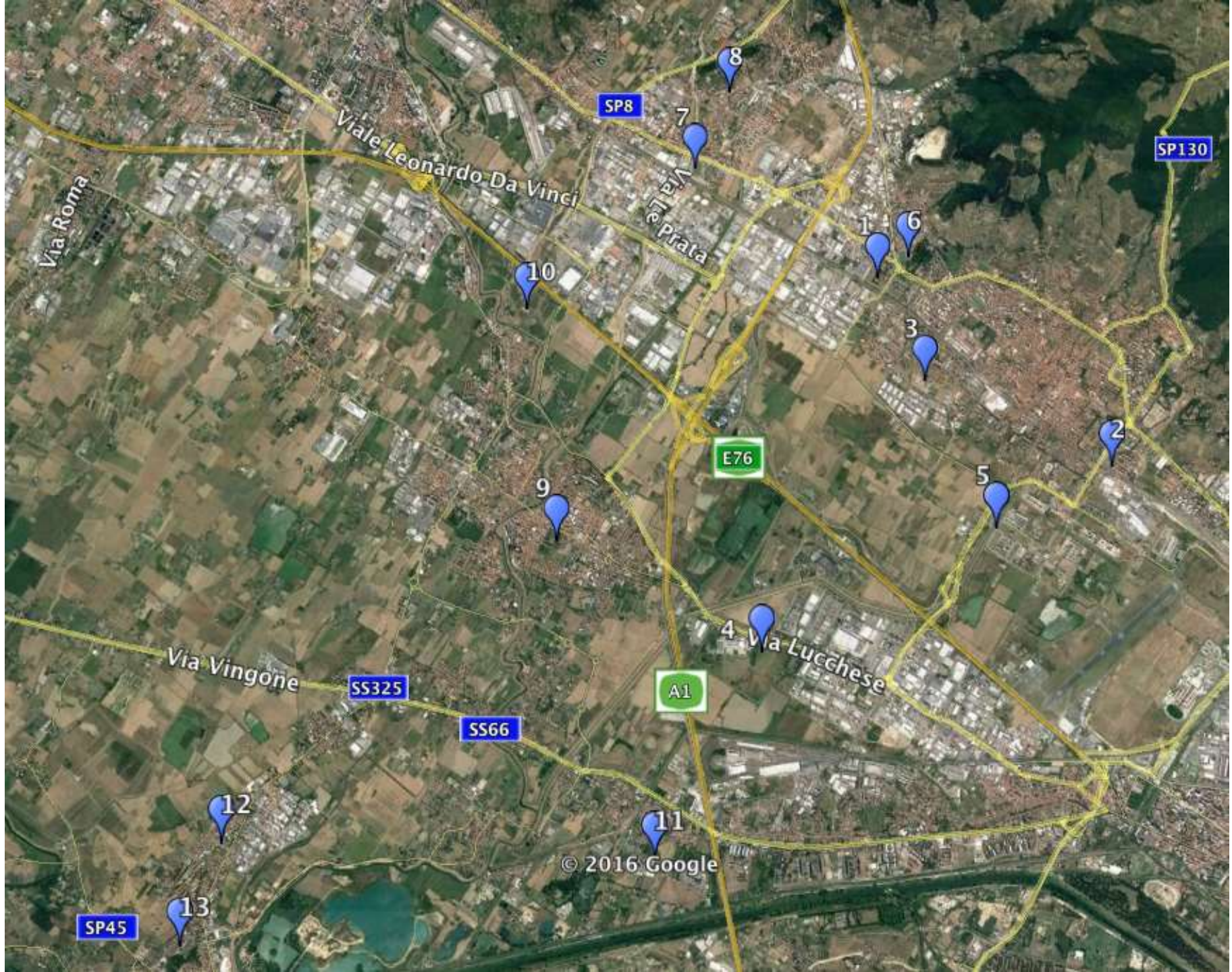


Polo Scientifico



Case Passerini





Via Roma

Viale Leonardo Da Vinci

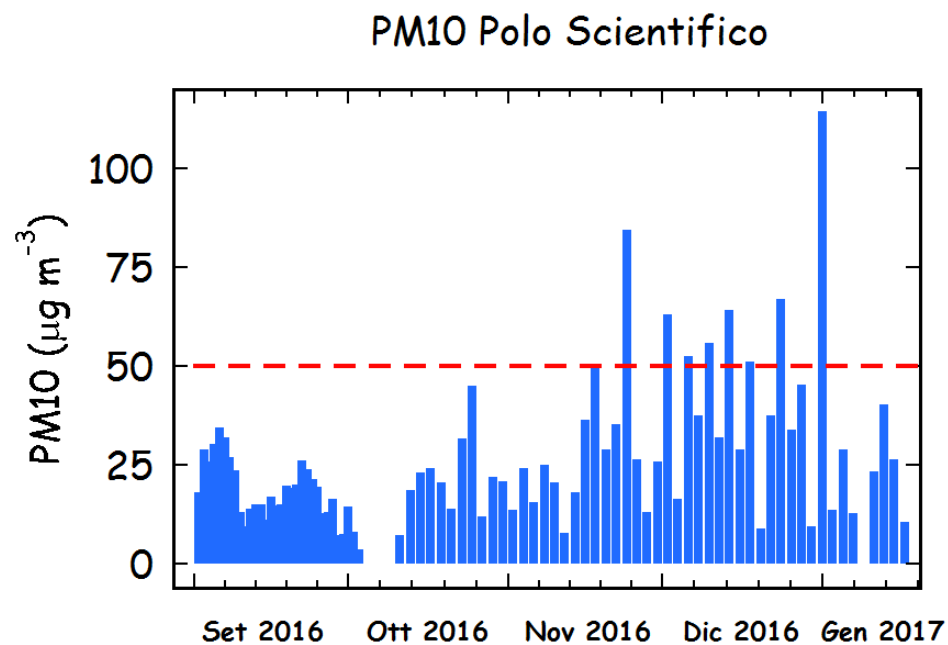
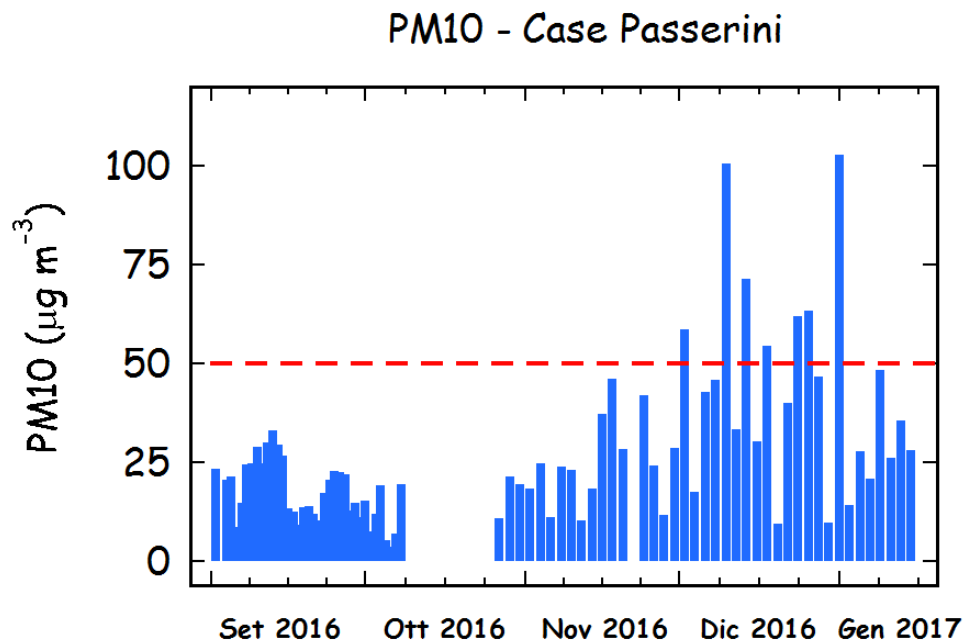
Via Prata

Via Vingone

Via Lucchese

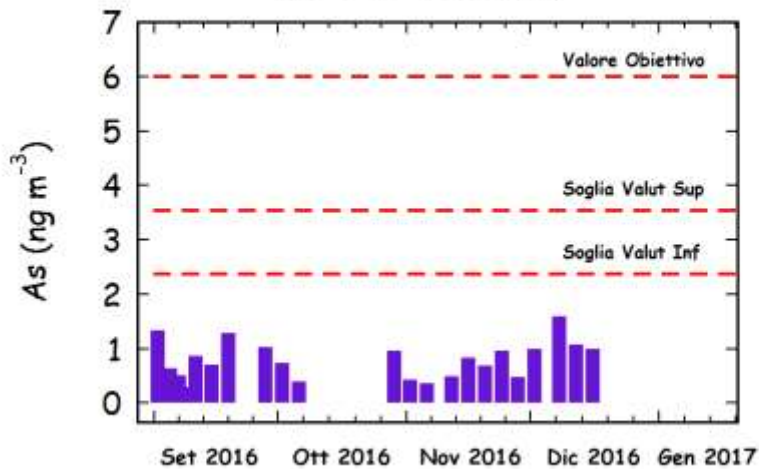
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Campionatori SMART Set16-Gen17

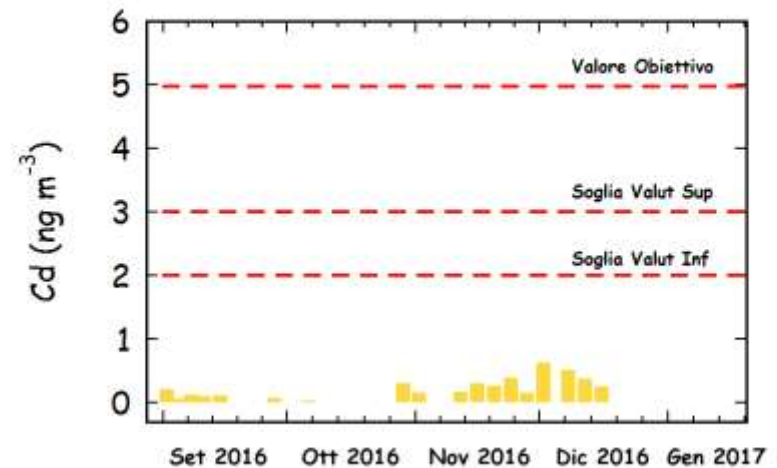


Campionatori SMART - Set16-Gen17

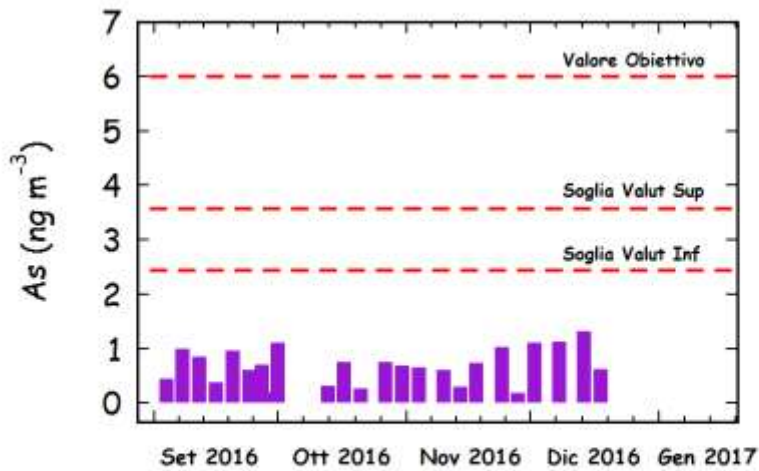
As - Case Passerini



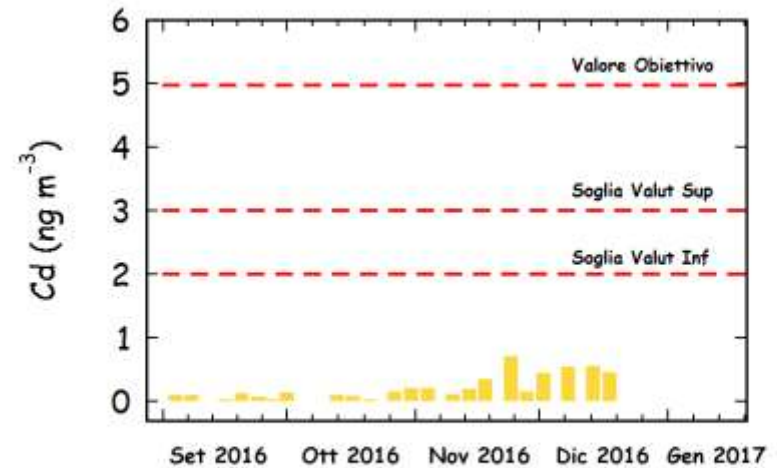
Cd - Case Passerini



As - Polo Scientifico

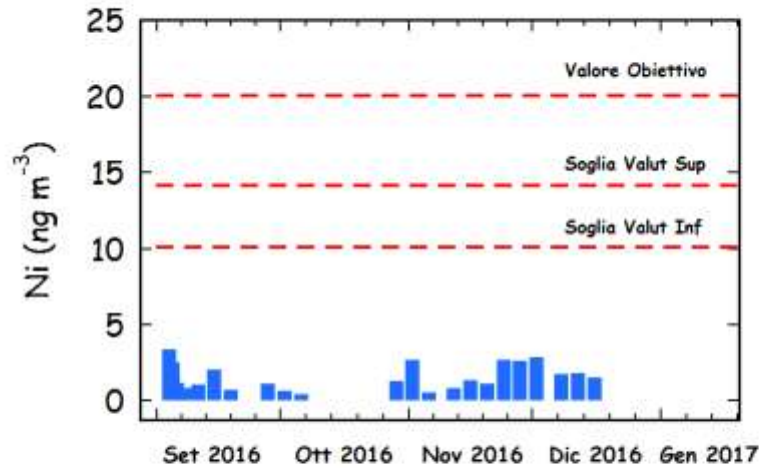


Cd - Polo Scientifico

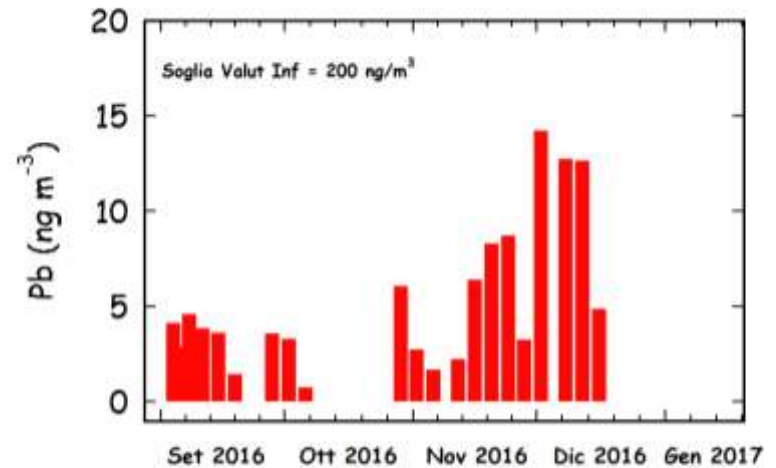


Campionatori SMART - Set16-Gen17

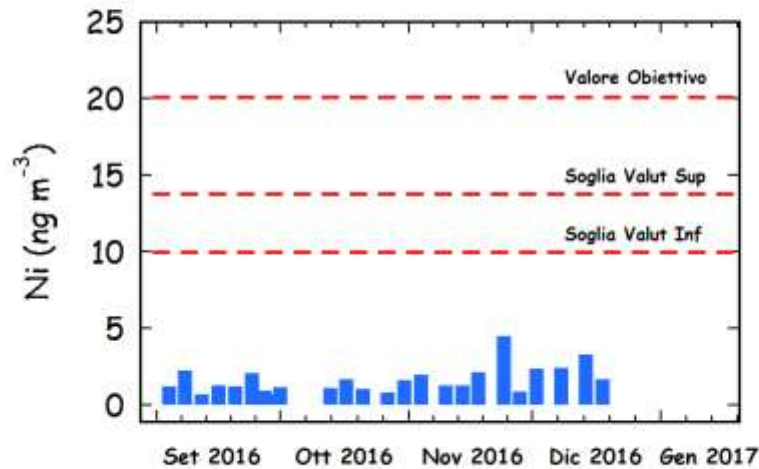
Ni - Case Passerini



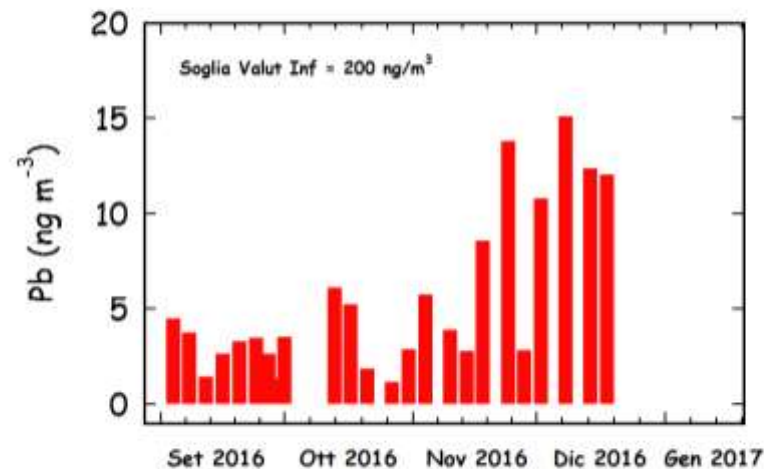
Pb - Case Passerini



Ni - Polo Scientifico



Pb - Polo Scientifico



Conclusioni - Siti Urbani

- PM10, PM2.5 e PM1 nella Piana Fiorentina sono dominati da emissioni da combustioni e traffico
- Meteorologia: ruolo essenziale nei superamenti
- Combustione di biomassa: problema emergente
- Difficoltà/impossibilità di mitigare l'inquinamento atmosferico con interventi locali.
- **Necessita' di una sinergia di interventi tra tutti i soggetti coinvolti: UE, Stato, Regioni, Comuni, utilizzando politiche di risanamento integrate e migliori normative per gli impianti di combustione di biomassa anche domestici.**



Grazie per l'attenzione!

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