UNIVERSITÀ DEGLI STUDI FIRENZE

L'aerosol atmosferico a Lampedusa: composizione chimica, sorgenti e processi di deposizione

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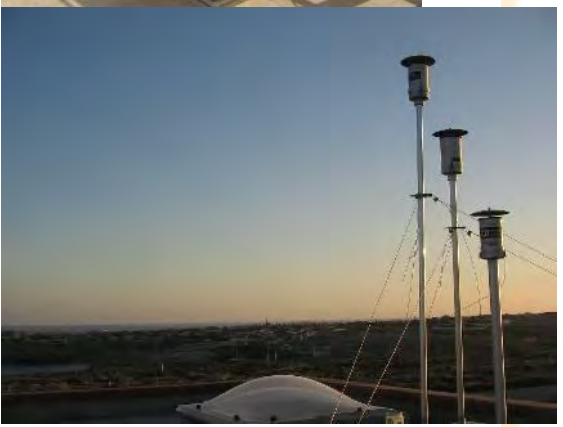
25 ANNI DELL'OSSERVATORIO CLIMATICO ENEA DI LAMPEDUSA
Ricerca scientifica e contributo allo sviluppo sostenibile sul territorio

Roma, 6 dicembre 2022

Il tutto iniziò nel 2004….



- ✓Giu. 04 – Dic. 06: PM_{10} - $PM_{2.5}$ - PM_1 in modo alternato
- ✓Gen. 2007- oggi: PM_{10}
- ✓Gen. 2011- Nov. 2016: campionamento PM_{10} teflon/quarzo in parallelo
- ✓Nov. 2016 ad oggi PM_{10} e PTS in parallelo

Raccolta dei campioni PTS e PM_{10}

da Marzo 2015…..

Raccolta dei campioni deposizioni

Analisi chimica

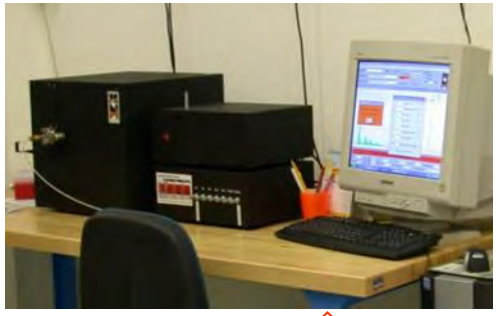
ICP AES

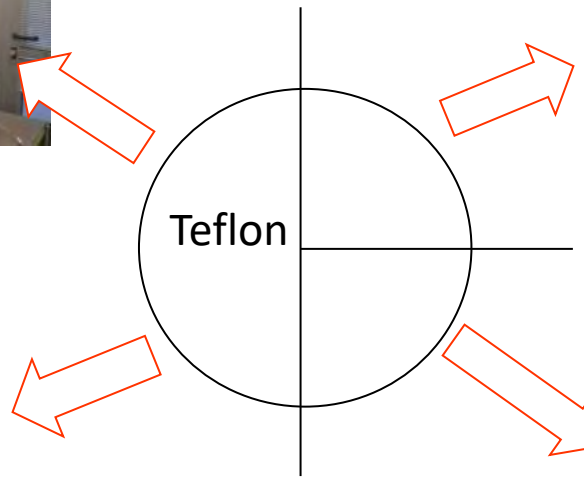
s.b.HNO_3 – H_2O_2

Metals, La, Ce

PIXE: elements total content

Analizzatore Termo-ottico: EC/OC



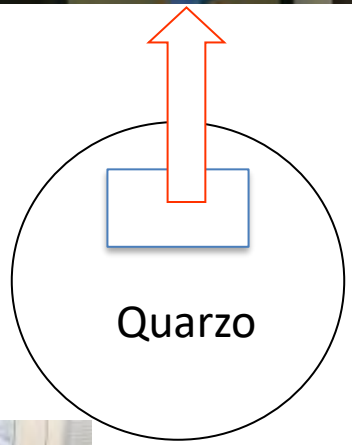


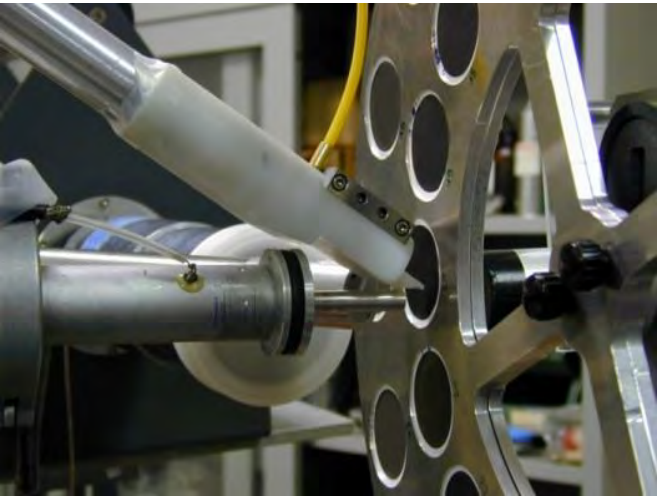
Ions Chromatography

Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+},

Cl^-, NO_3^-, SO_4^{2-}, MSA, Ac,

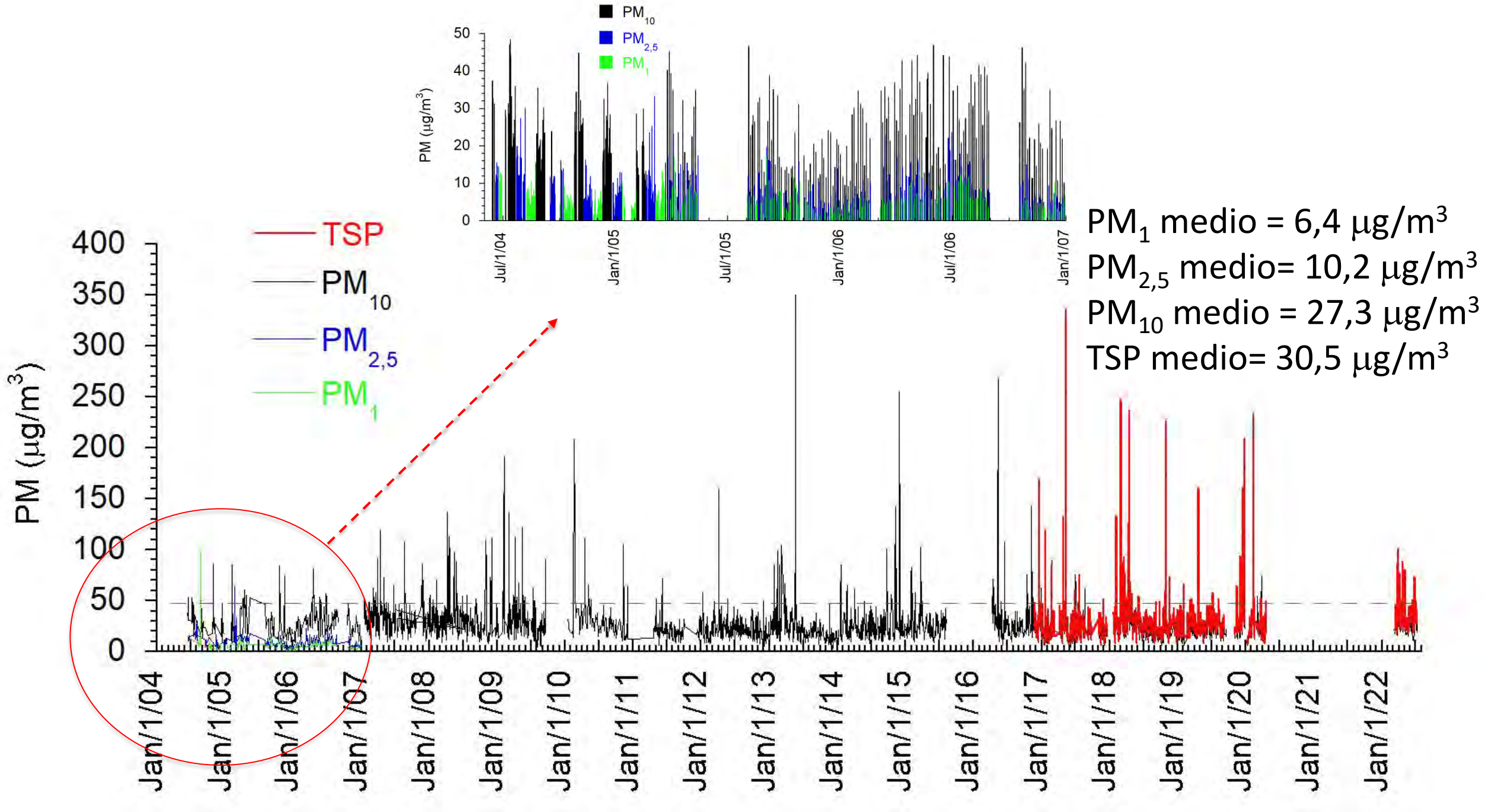
For, Gly, Ox



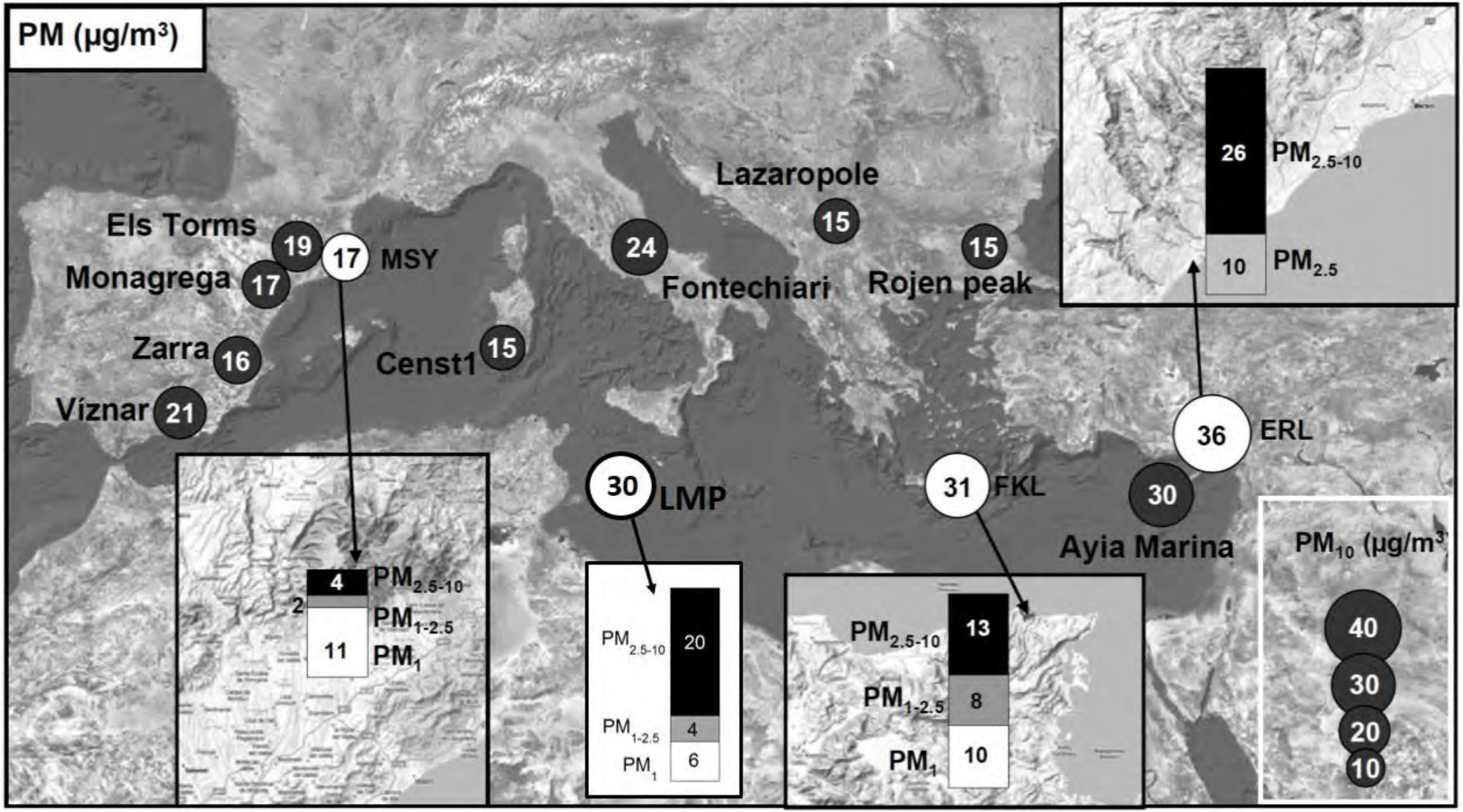


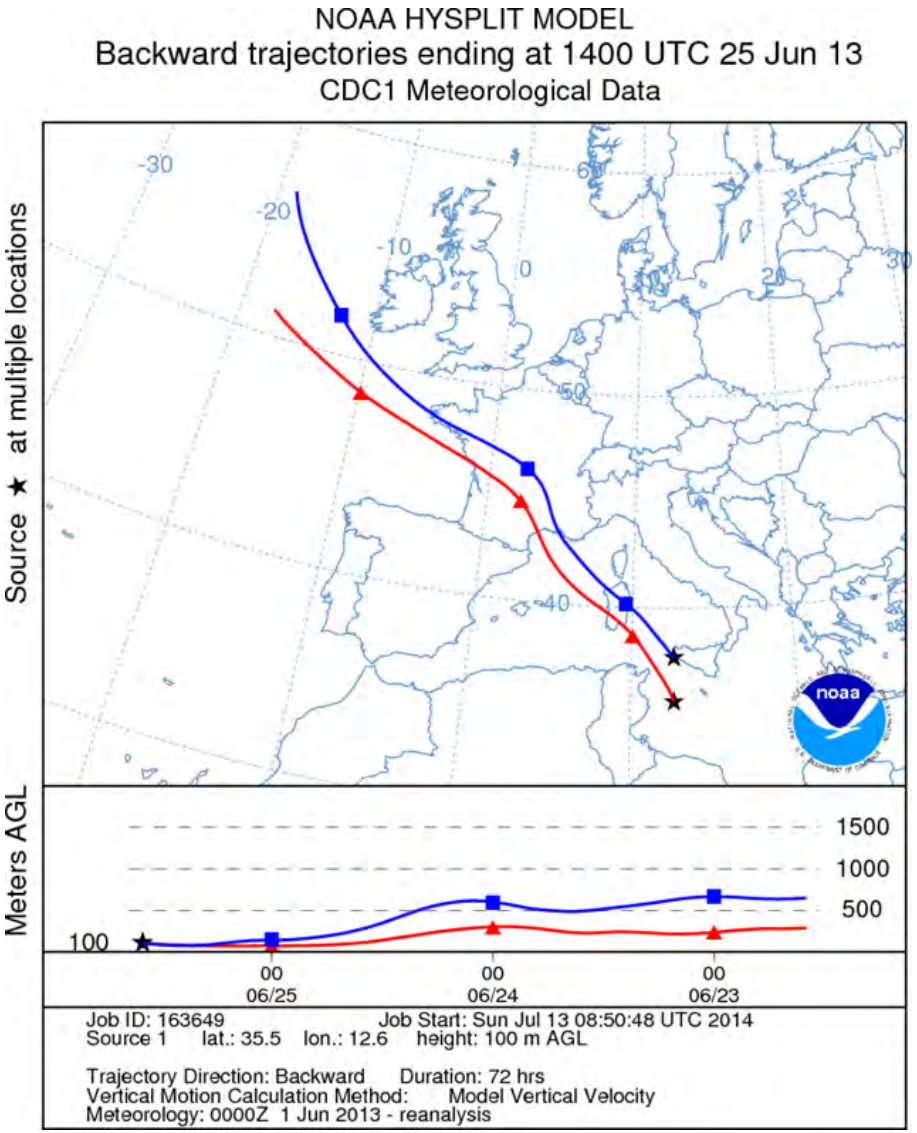
ICP AES

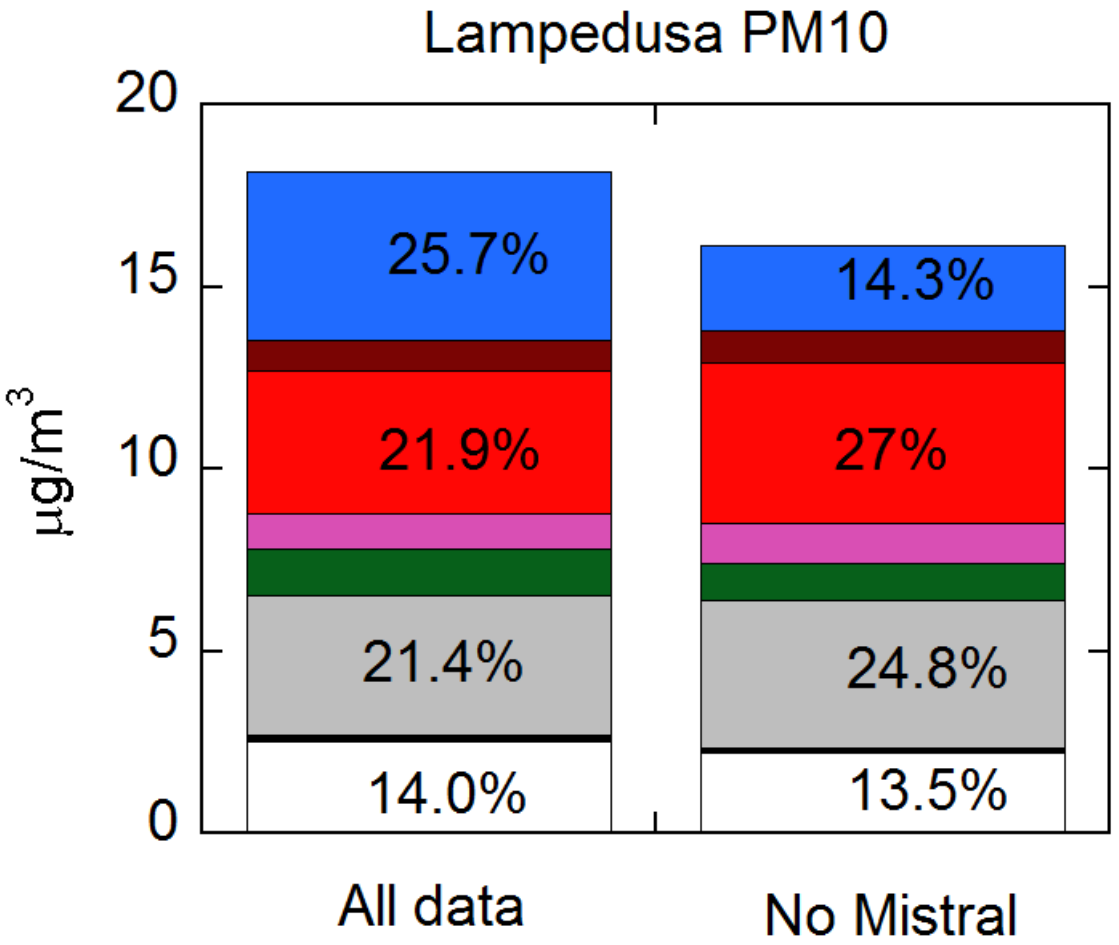
Metals

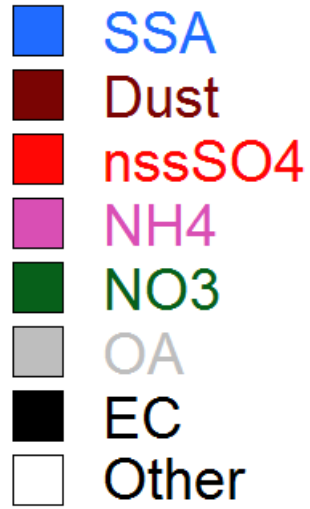


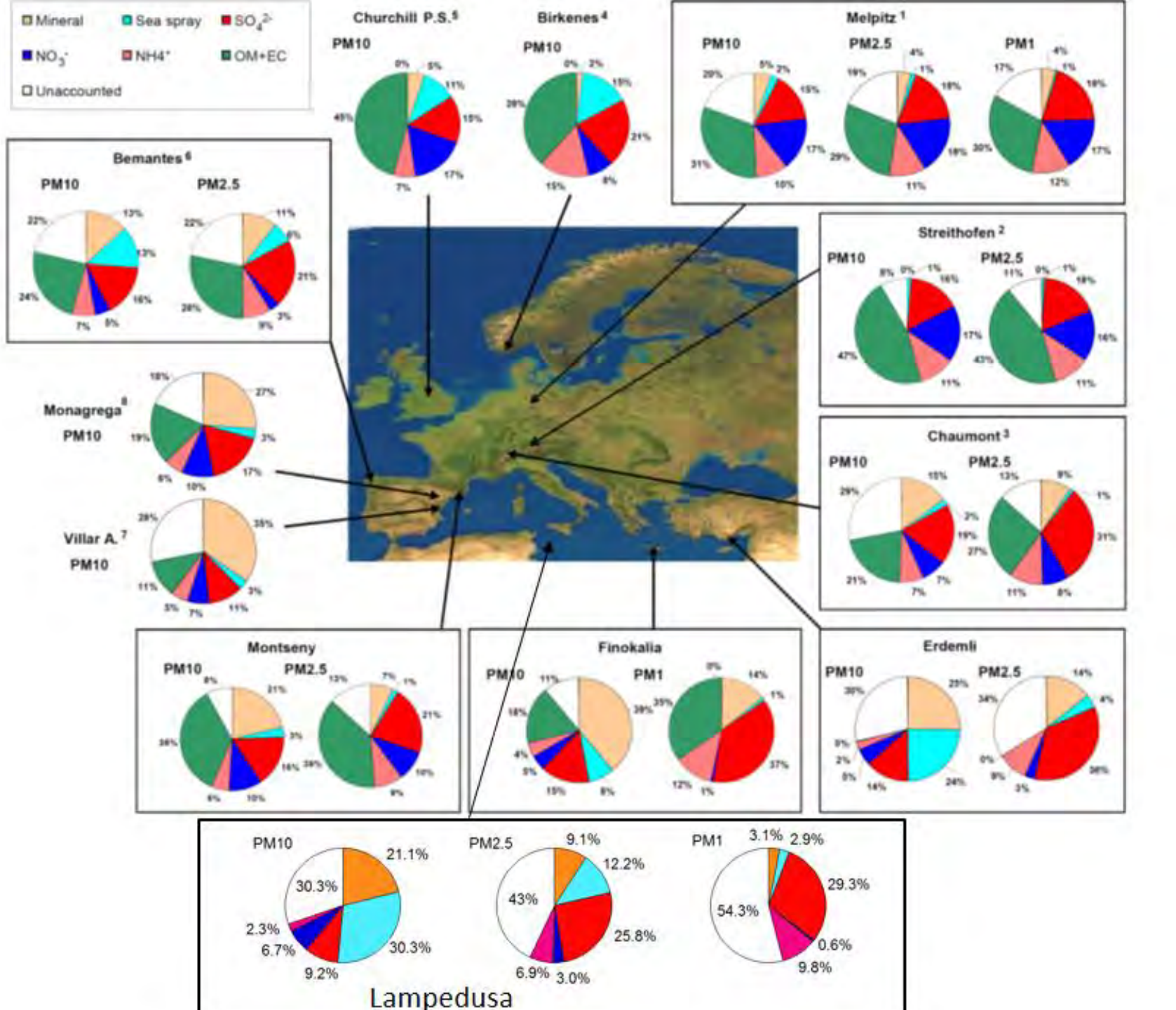
PM_1 medio = 6,4 µg/m³
$PM_{2,5}$ medio= 10,2 µg/m³
PM_{10} medio = 27,3 µg/m³
TSP medio= 30,5 µg/m³


PM (µg/m³)
Els Torms
19
17
MSY
Monagrega
17
Zarra
16
Víznar
21
Censt1
15
24
Fontechiari
Lazaropole
15
15
Rojen peak
26
PM2.5-10
10
PM2.5
36
ERL
30
Ayia Marina
30
LMP
31
FKL
4
2
11
PM2.5-10
PM1-2.5
PM1
PM2.5-10
20
PM1-2.5
4
PM1
6
PM2.5-10
13
PM1-2.5
8
PM1
10
PM10 (µg/m³)
40
30
20
10


NOAA HYSPLIT MODEL
Backward trajectories ending at 1400 UTC 25 Jun 13
CDC1 Meteorological Data
Source ★ at multiple locations
Meters AGL
1500
1000
500
100
00 06/25
00 06/24
00 06/23
Job ID: 163649 Job Start: Sun Jul 13 08:50:48 UTC 2014
Source 1 lat.: 35.5 lon.: 12.6 height: 100 m AGL
Trajectory Direction: Backward Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 1 Jun 2013 - reanalysis


Lampedusa PM10
μg/m3
20
15
10
5
0
25.7%
21.9%
21.4%
14.0%
14.3%
27%
24.8%
13.5%
All data
No Mistral


SSA
Dust
nssSO4
NH4
NO3
OA
EC
Other


Mineral
Sea spray
SO_4^{2-}
NO_3^-
NH4+
OM+EC
Unaccounted
Churchill P.S.[5]
PM10
Birkenes[4]
PM10
Melpitz[1]
PM10
PM2.5
PM1
Bemantes[6]
PM10
PM2.5
Streithofen[2]
PM10
PM2.5
Monagrega[8]
PM10
Villar A.[7]
PM10
Chaumont[3]
PM10
PM2.5
Montseny
PM10
PM2.5
Finokalia
PM10
PM1
Erdemli
PM10
PM2.5
PM10
21.1%
30.3%
2.3%
6.7%
30.3%
9.2%
PM2.5
9.1%
12.2%
43%
25.8%
6.9%
3.0%
PM1
3.1%
2.9%
29.3%
54.3%
0.6%
9.8%
Lampedusa

Calcolo del contributo dell'aerosol crostale

1- Dal PM_{10}

sottraendo il background regionale (Escudero et al., 2007) 30° (o 40°) percentile del PM_{10}. Metodo accettato dalla Commissione Europea attraverso la Direttiva 2008/50/EC sulla qualità dell'aria.

2- Calcolo mediante somma degli ossidi

[Aerosol crostale] = 2.14* Si +1.89*Al + 1.43*Fe + 1.40*Ca + 1.35*nssNa + 1.66*nssMg + 1.21*nssK + 1.67*Ti

ssNa = Na−nssNa

nssNa = nssCa · $(Na/Ca)_{crust}$

nssCa = Ca−ssCa = Ca−ssNa $(Ca/Na)_{sw}$

nssMg = Mg−ssMg = Mg−ssNa $(Mg/Na)_{sw}$

nssK = K−ssK = K−ssNa $(K/Na)_{sw}$

$(Na/Ca)_{crust}$ =0.59 w/w

$(Ca/Na)_{sw}$ = 0.038 w/w

$(Mg/Na)_{sw}$ =0.129 w/w

$(K/Na)_{sw}$= 0.036 w/w

nssNa =7.5%

nssCa= 80.9%

nssMg= 15.1%

nssK= 39.6%

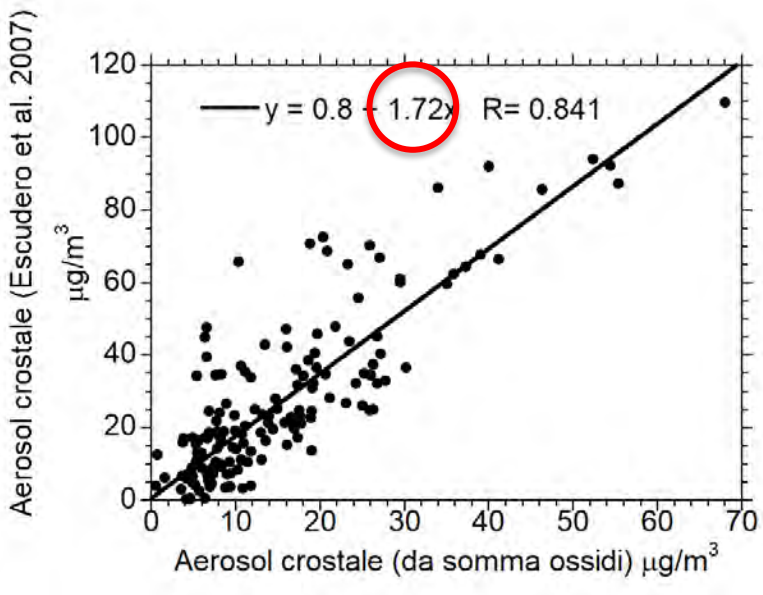
3- Calcolo con singolo tracciante

3A- Al : 8.2% UCC e considerando il recupero Al ottenuto da procedura EN 14902 (2005) , per LMP 68.5%

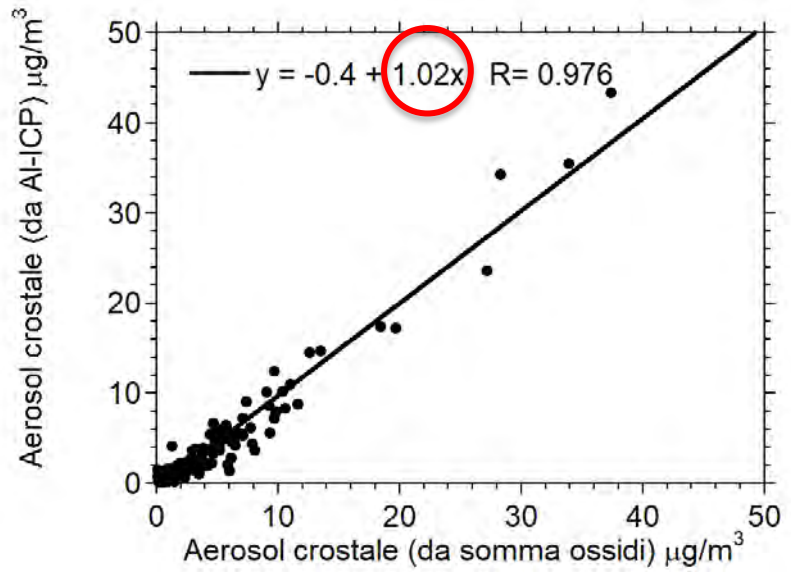
3B- Ca : Aerosol crostale =11* nssCa (Ca determinato con IC) (Marconi et al., 2014)

Confronto fra i vari metodi misure al suolo

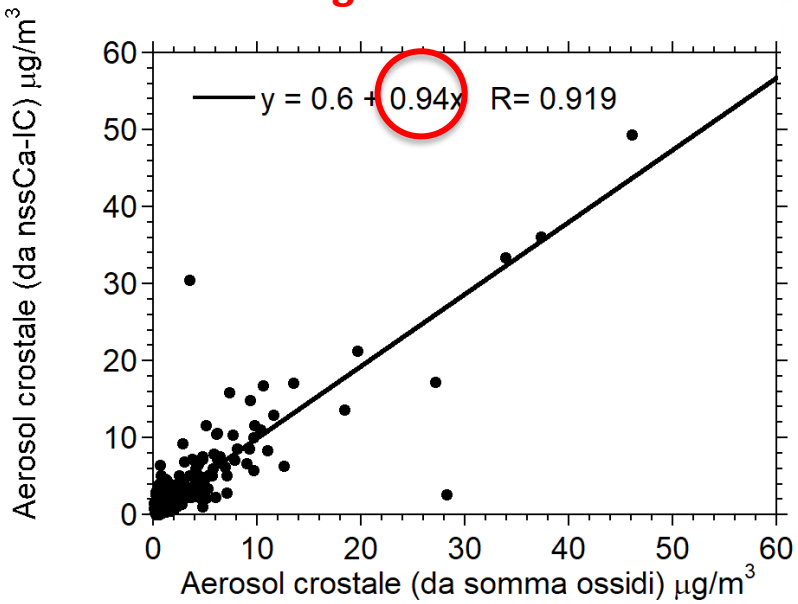
1- Dalla massa del PM_{10}, Escudero et al., 2007



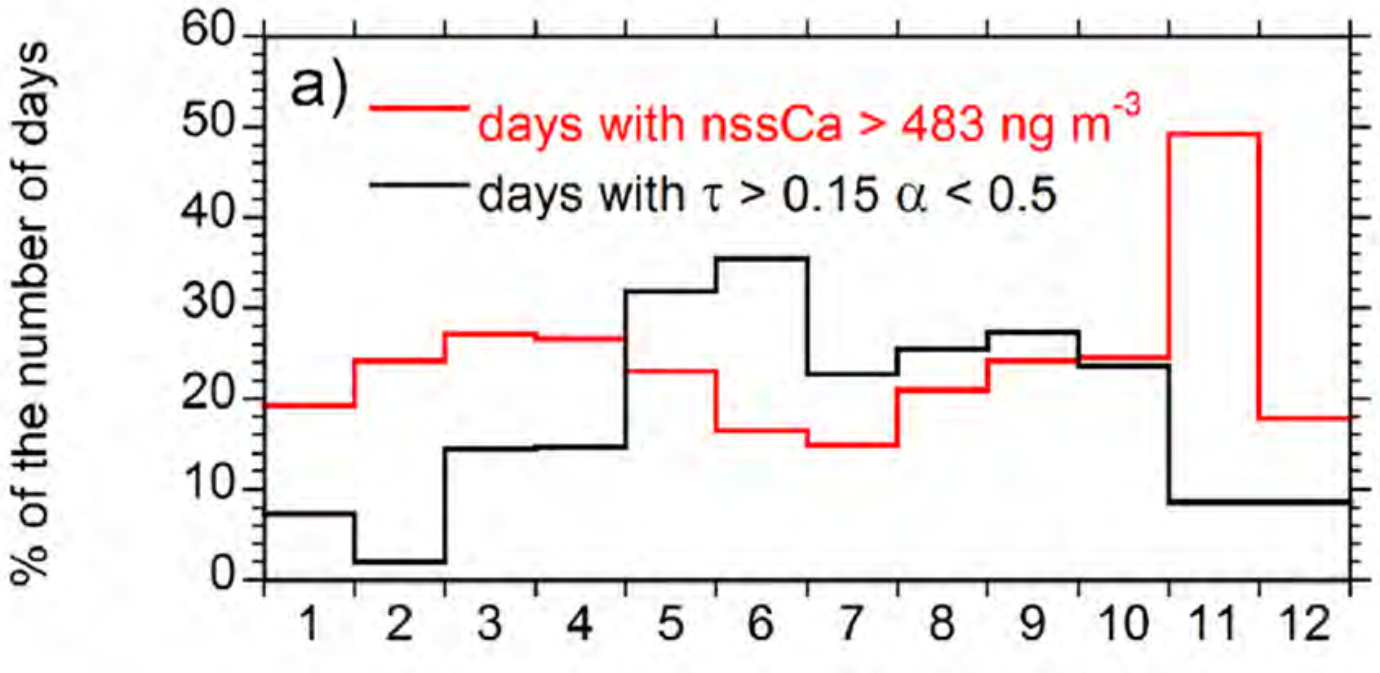
3A - Singolo tracciante Al- ICP-AES

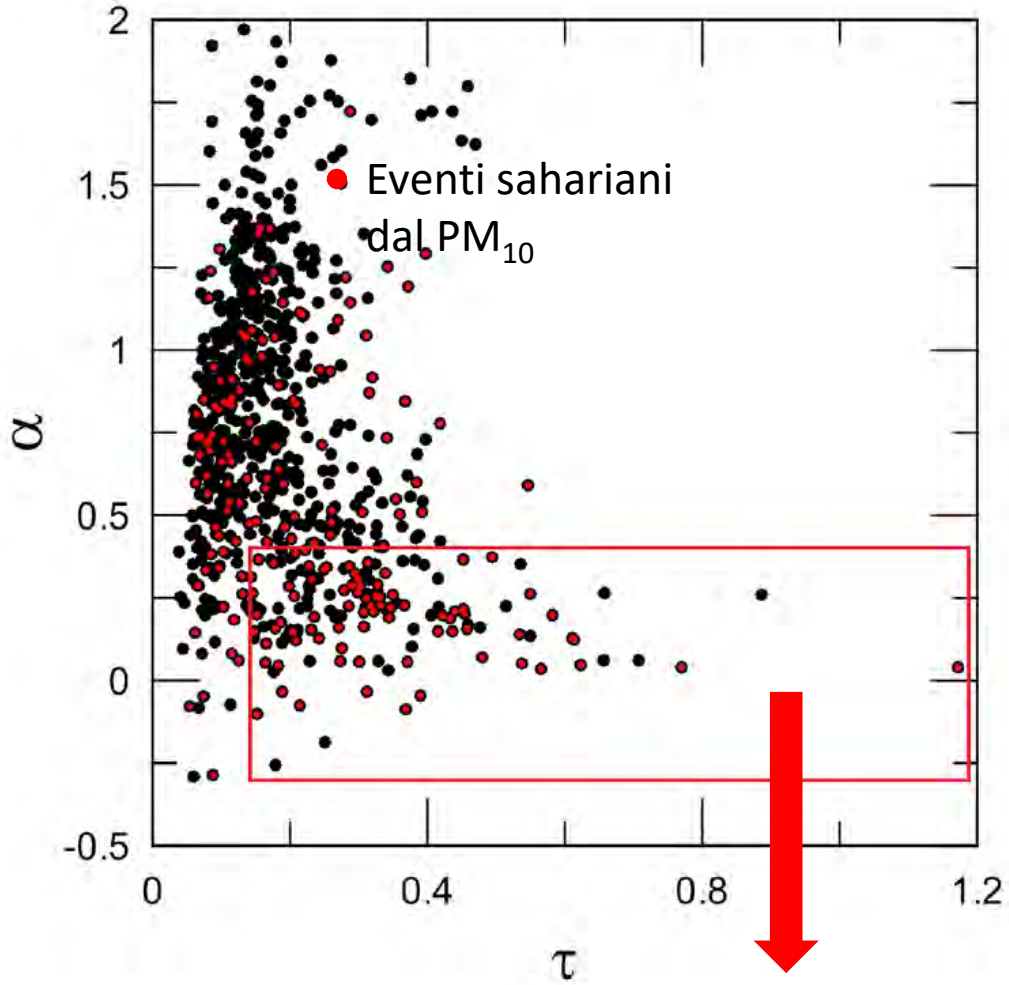


3B - Singolo tracciante Ca- IC



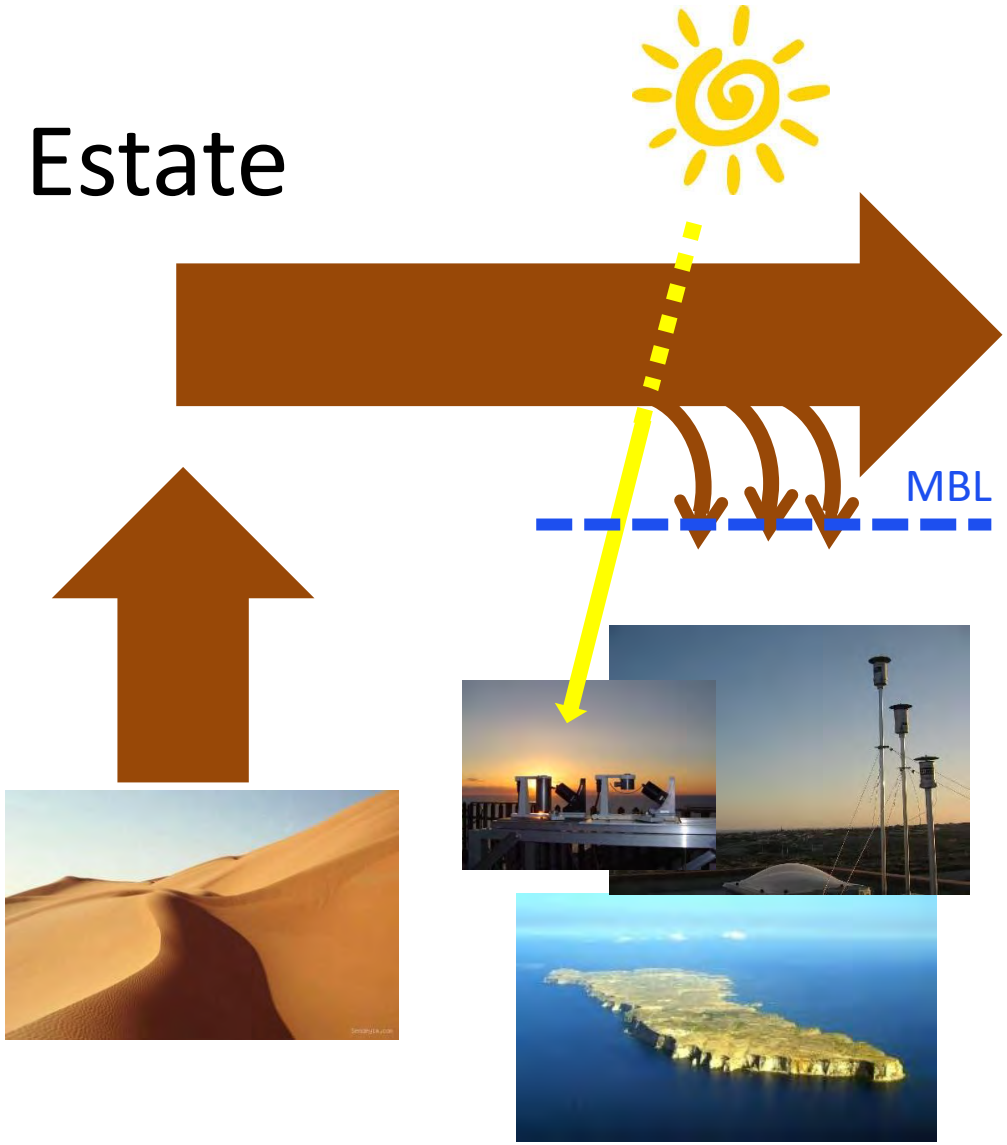
Identificazione eventi Saharan dust da misure ottiche colonnari



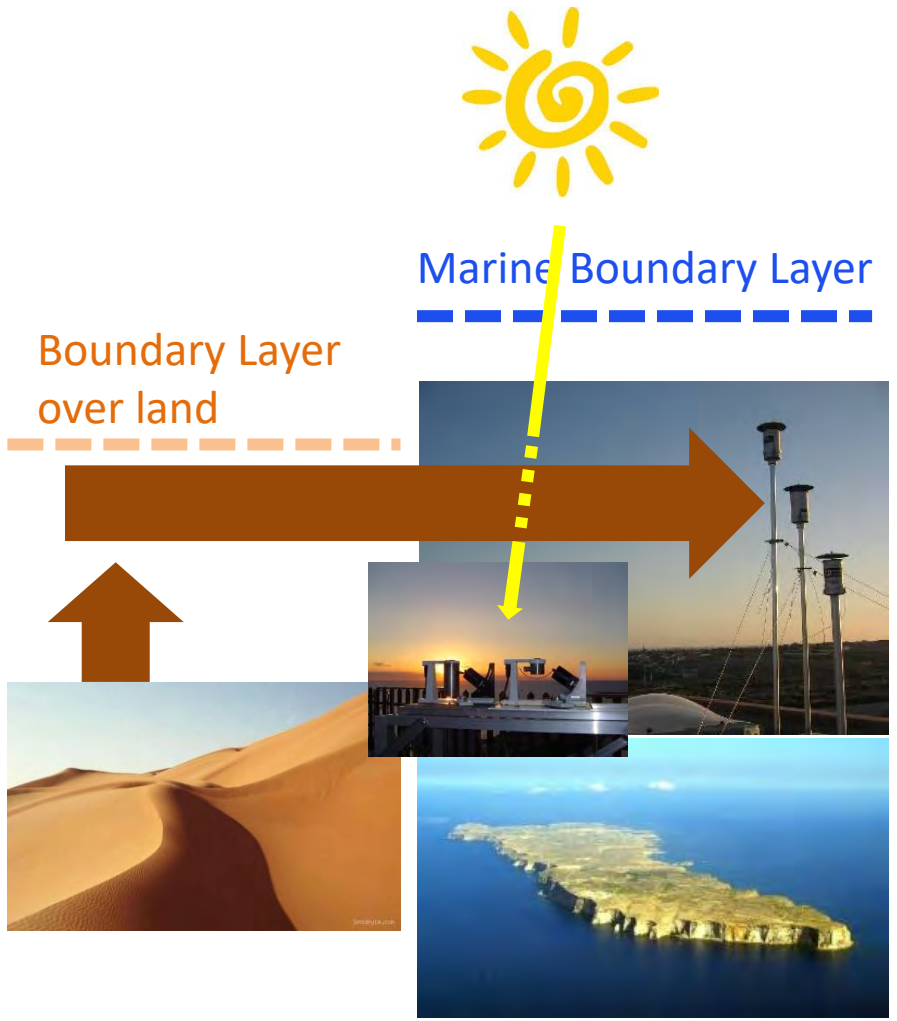


Eventi sahariani
(Pace et al. 2006)

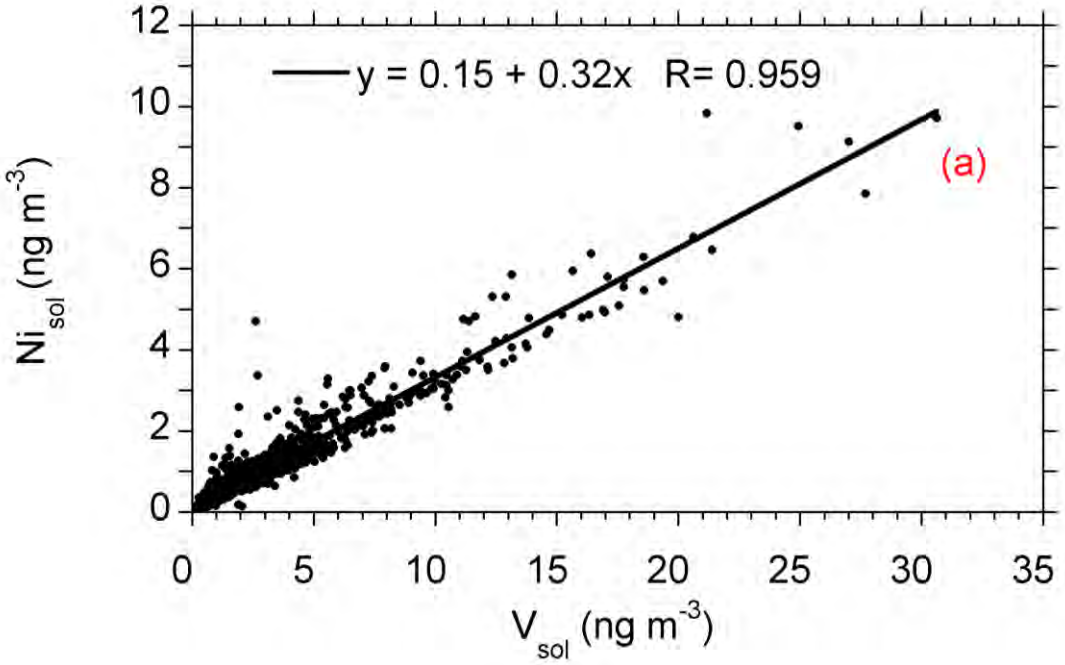
Estate

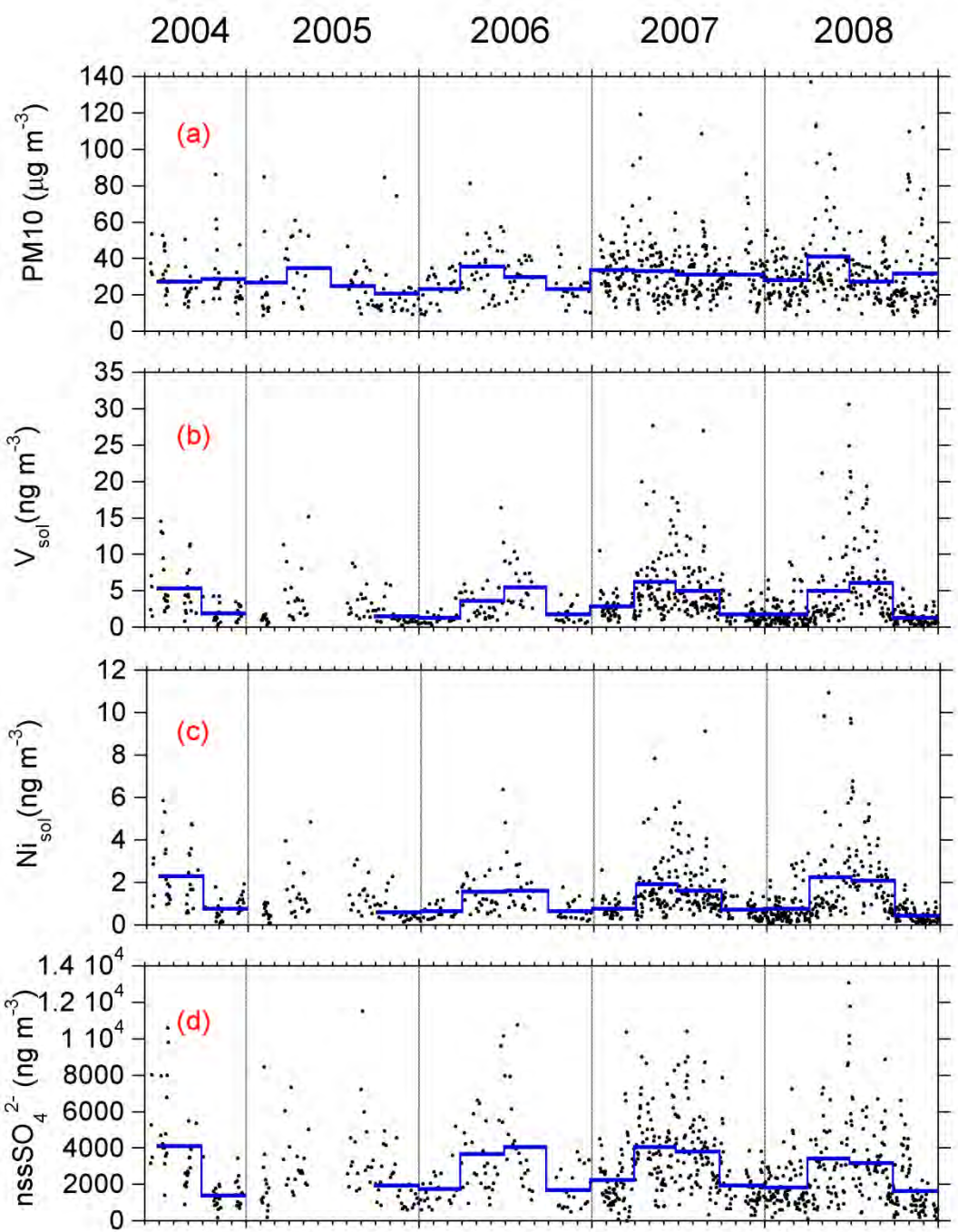


Inverno

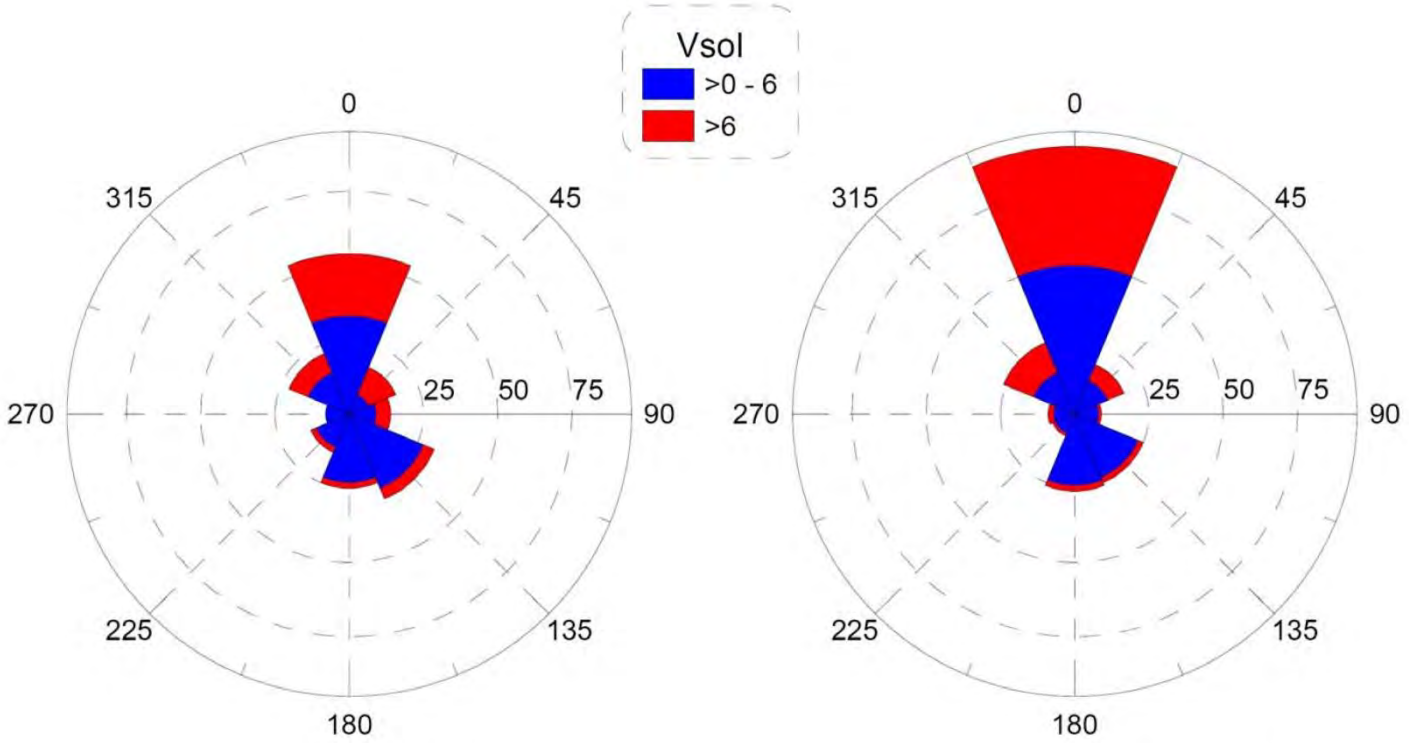


Marconi et al., 2014. www.atmos-chem-phys.net/14/2039/2014/

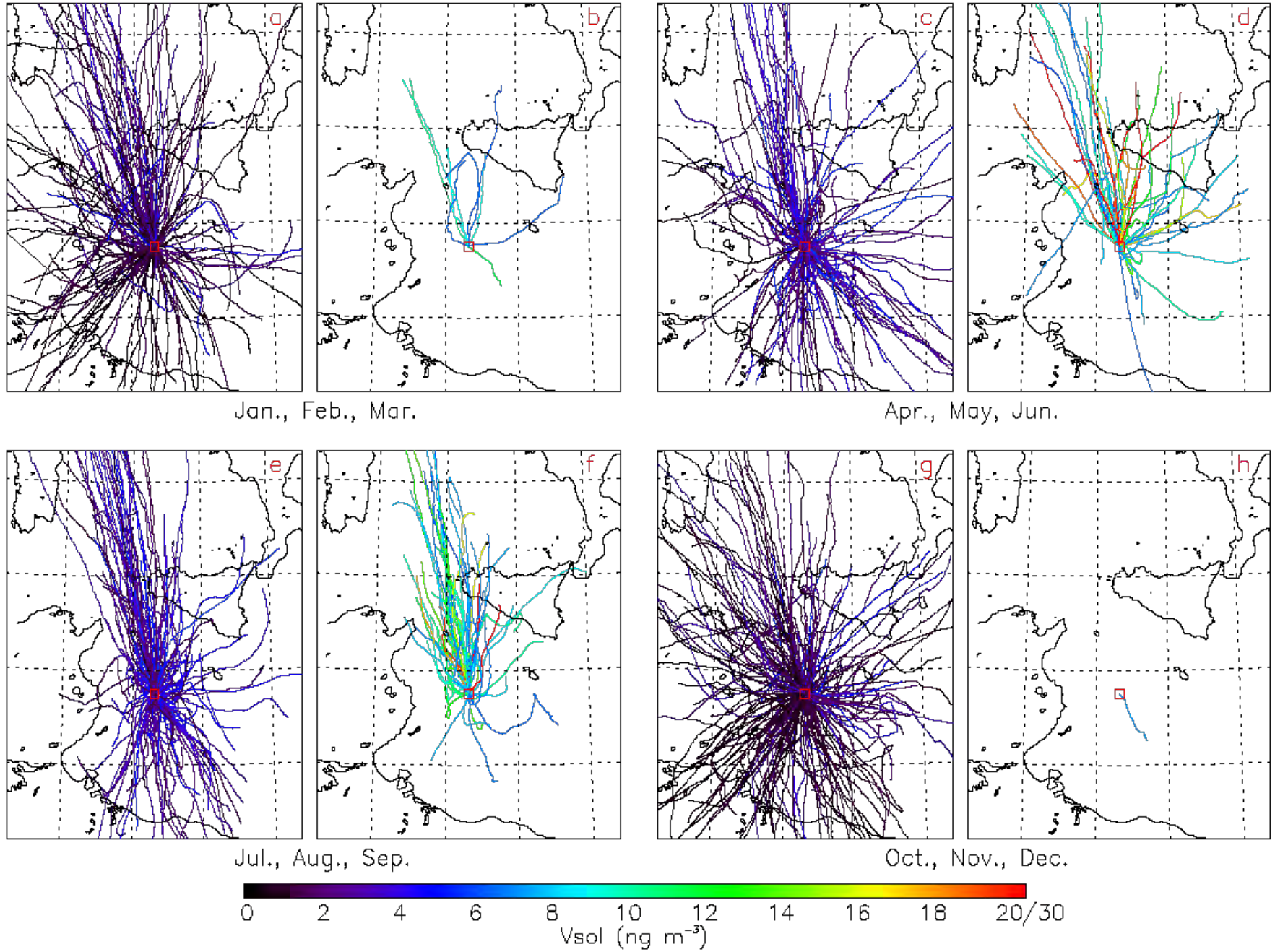




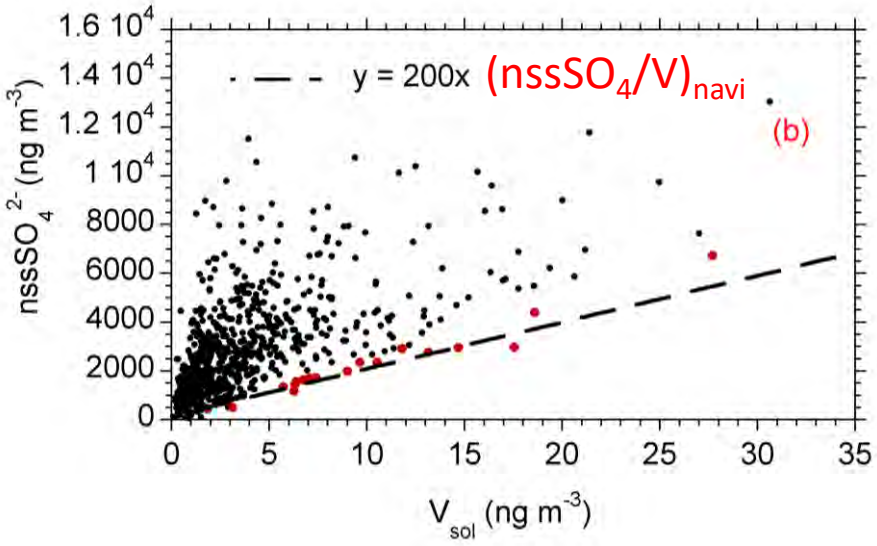
Becagli et al., 2012 www.atmos-chem-phys.net/12/3479/2012/

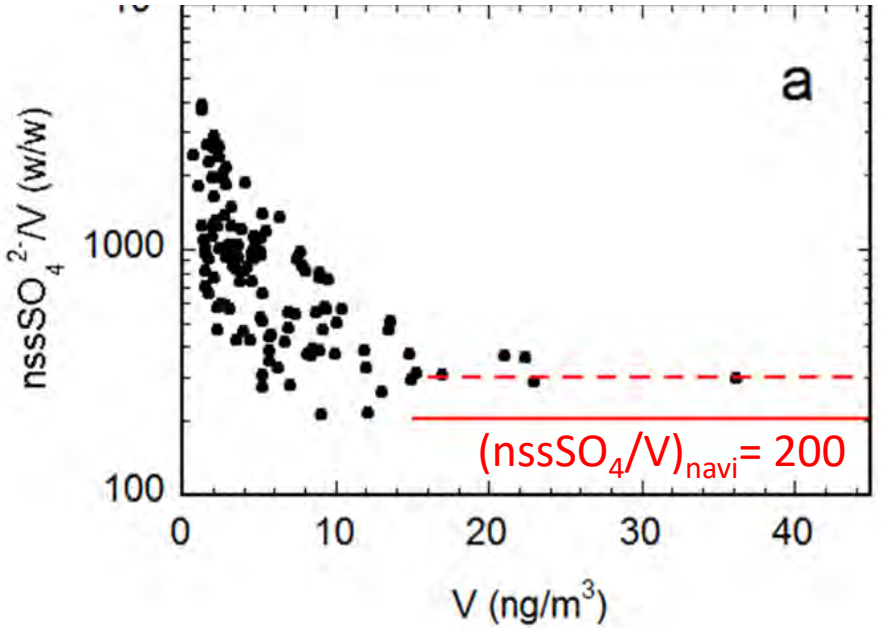

Vsol
>0 - 6
>6
0
45
90
135
180
225
270
315
25
50
75
April, May, June
July, August, September


Anthropic activities
Sampling site
N

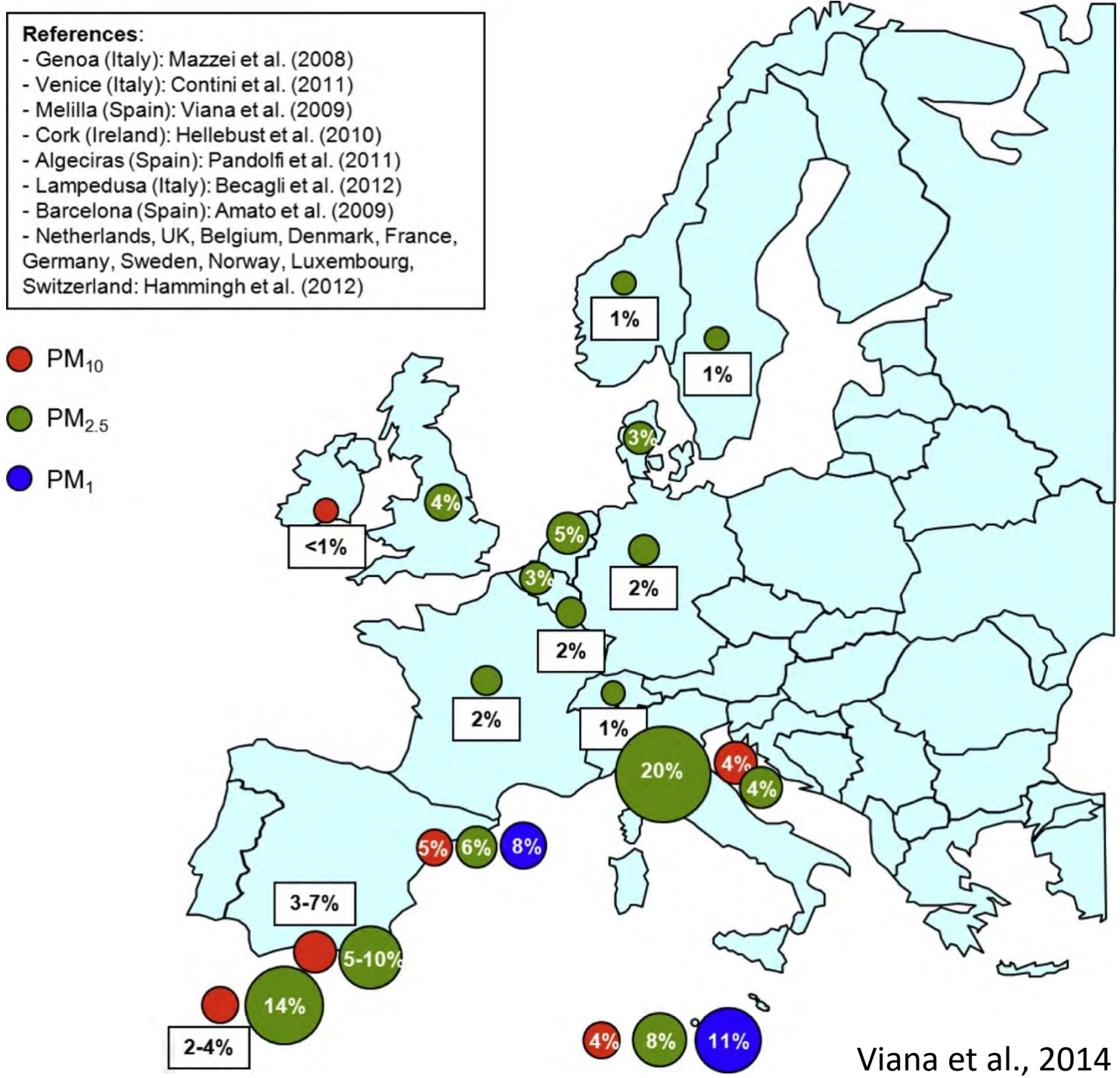


Becagli et al., 2012 www.atmos-chem-phys.net/12/3479/2012/





References:
- Genoa (Italy): Mazzei et al. (2008)
- Venice (Italy): Contini et al. (2011)
- Melilla (Spain): Viana et al. (2009)
- Cork (Ireland): Hellebust et al. (2010)
- Algeciras (Spain): Pandolfi et al. (2011)
- Lampedusa (Italy): Becagli et al. (2012)
- Barcelona (Spain): Amato et al. (2009)
- Netherlands, UK, Belgium, Denmark, France, Germany, Sweden, Norway, Luxembourg, Switzerland: Hammingh et al. (2012)

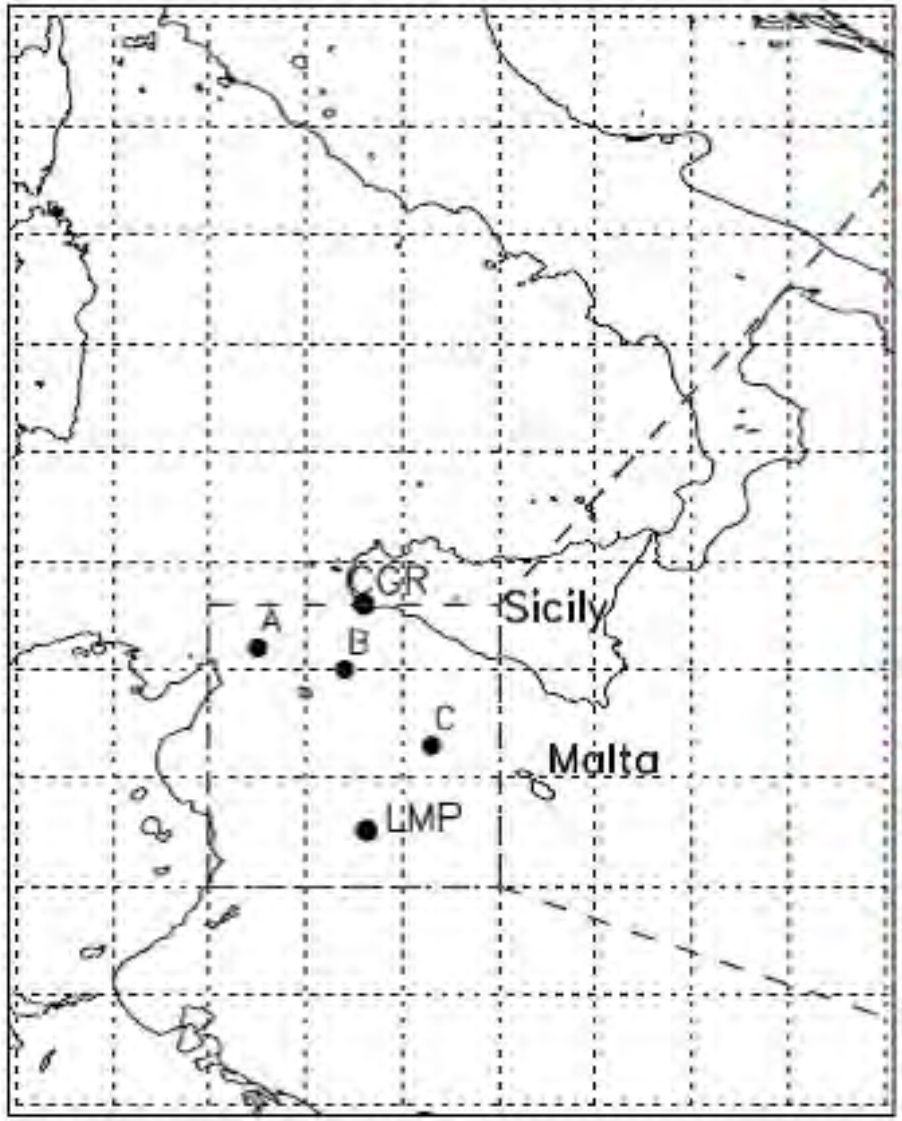


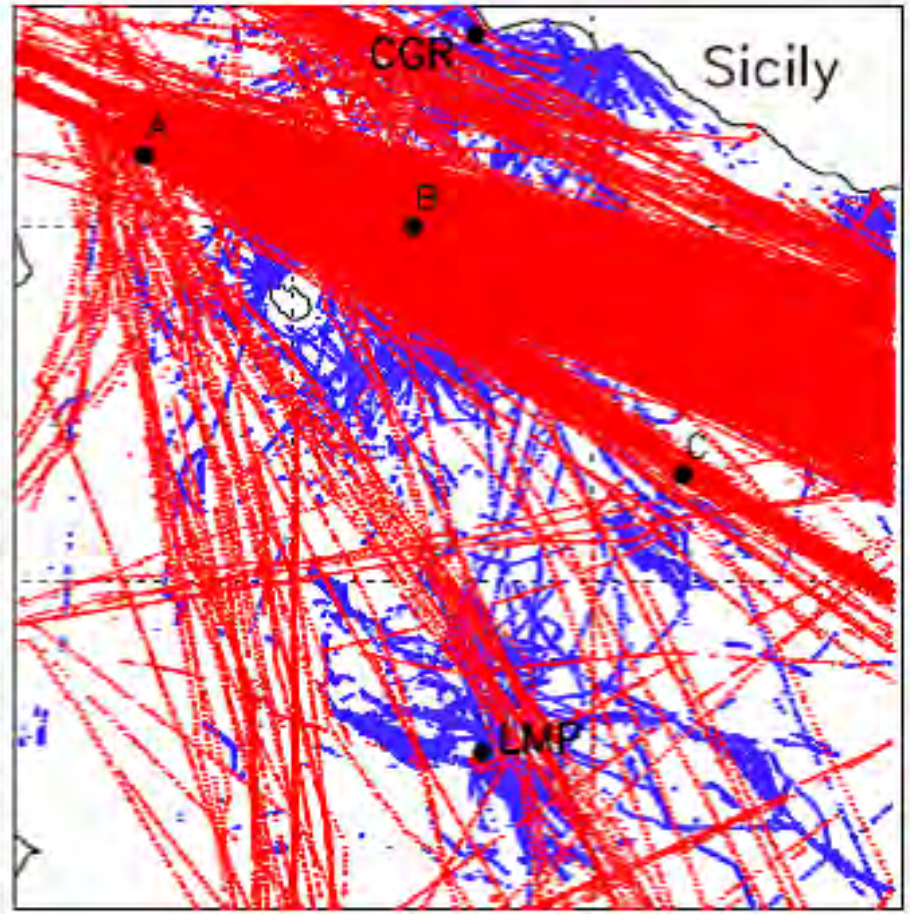
Viana et al., 2014

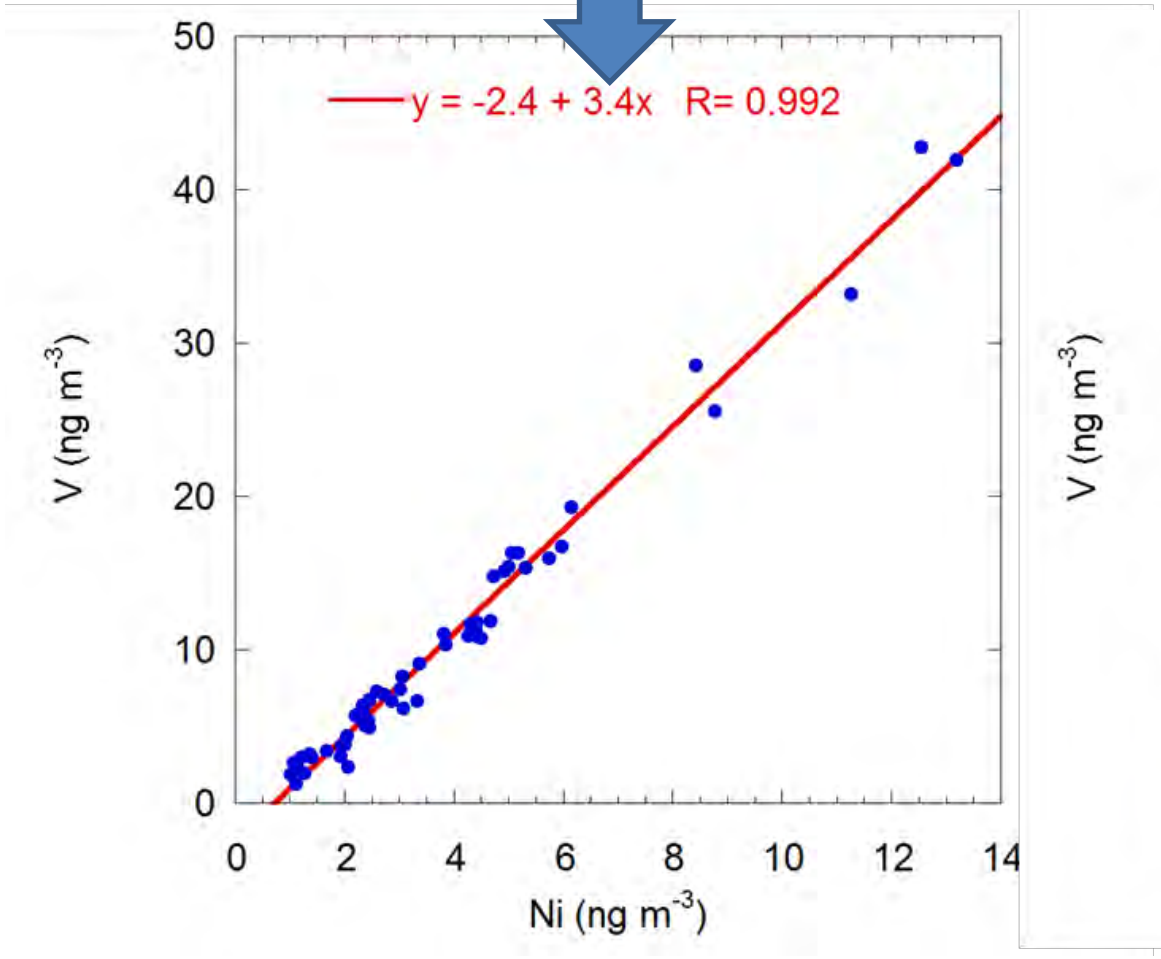
June-July 2013

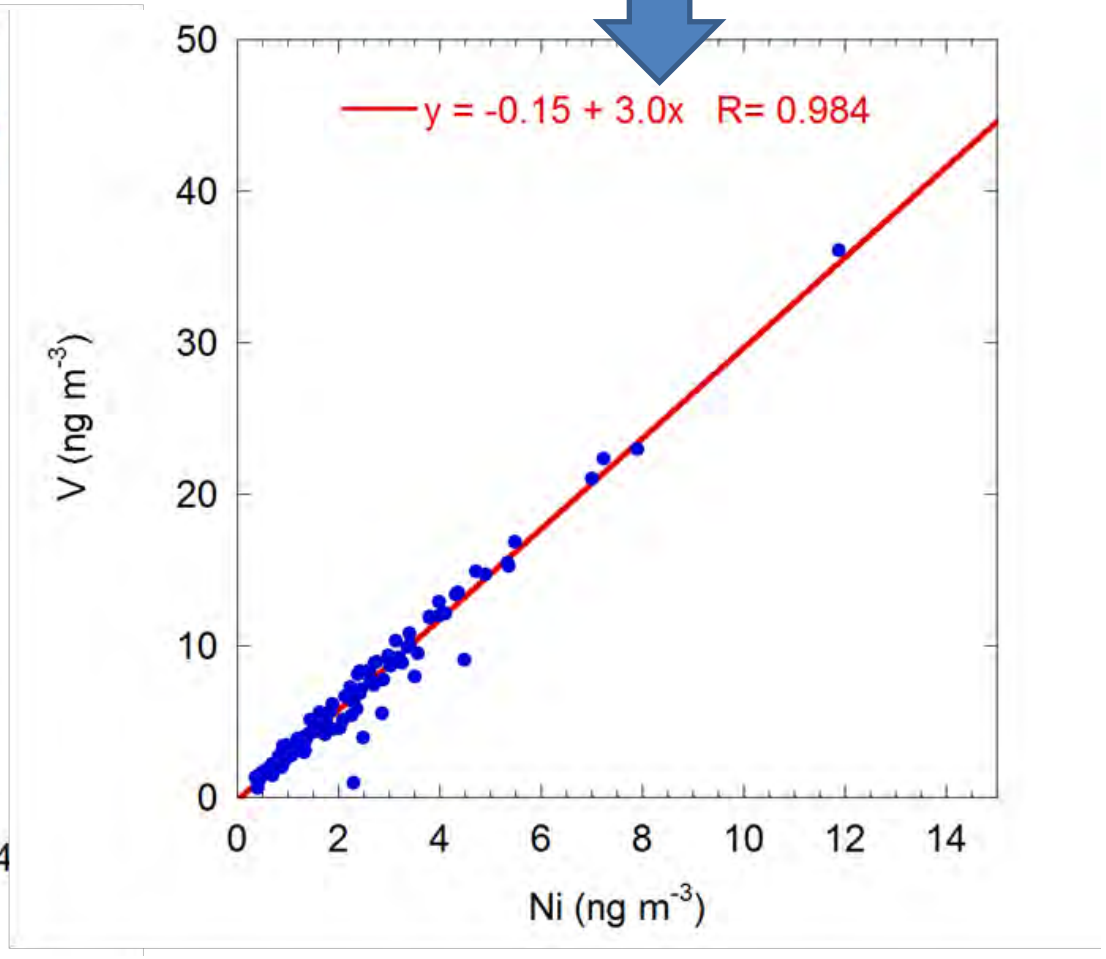
Capo Granitola

Lampedusa


CGR
Sicily
A
B
C
Malta
LMP


CGR
Sicily
A
B
C
LMP

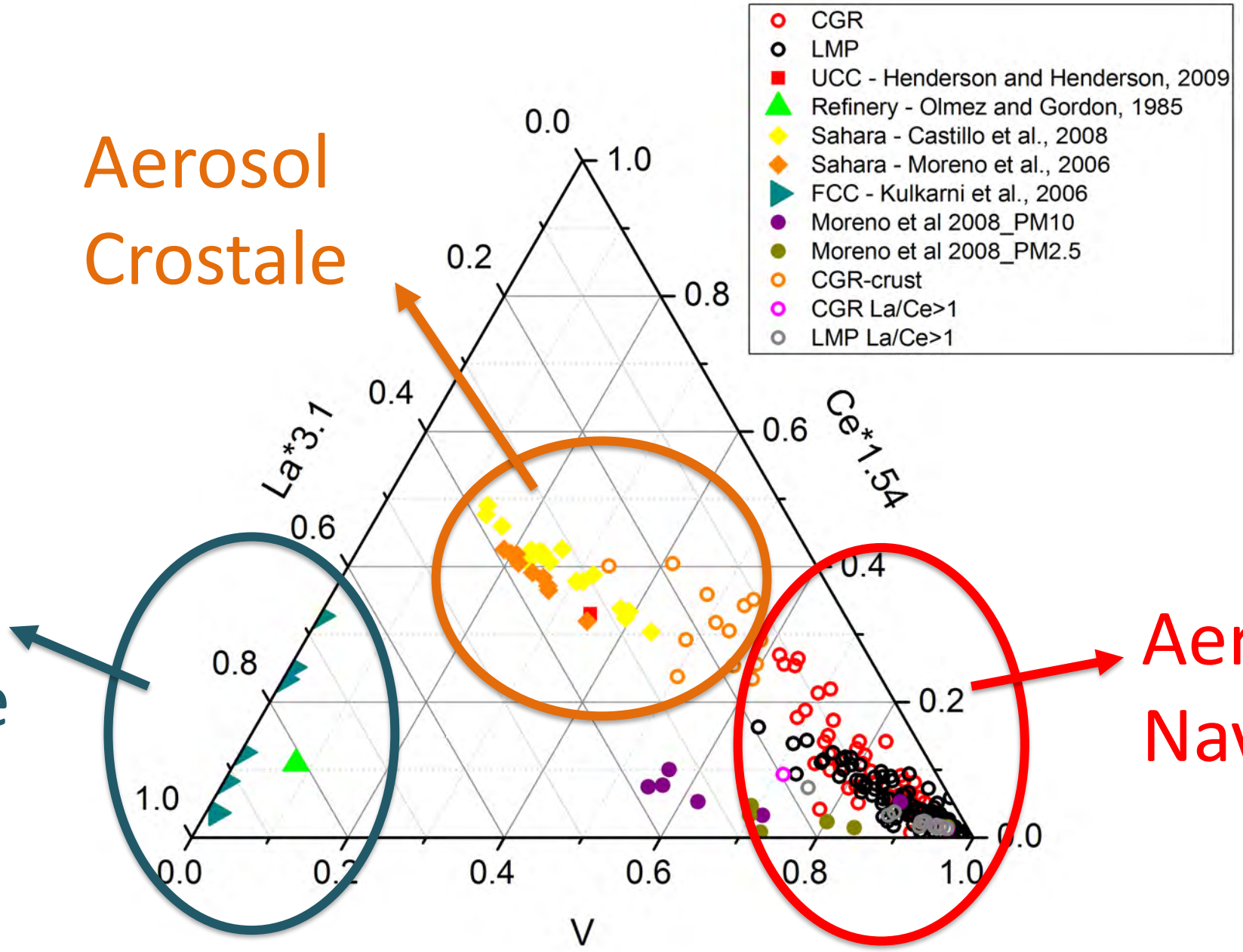

y = -2.4 + 3.4x R= 0.992
V (ng m-3)
Ni (ng m-3)
0
10
20
30
40
50
0
2
4
6
8
10
12
14


y = -0.15 + 3.0x R= 0.984
V (ng m-3)
Ni (ng m-3)
0
10
20
30
40
50
0
2
4
6
8
10
12
14

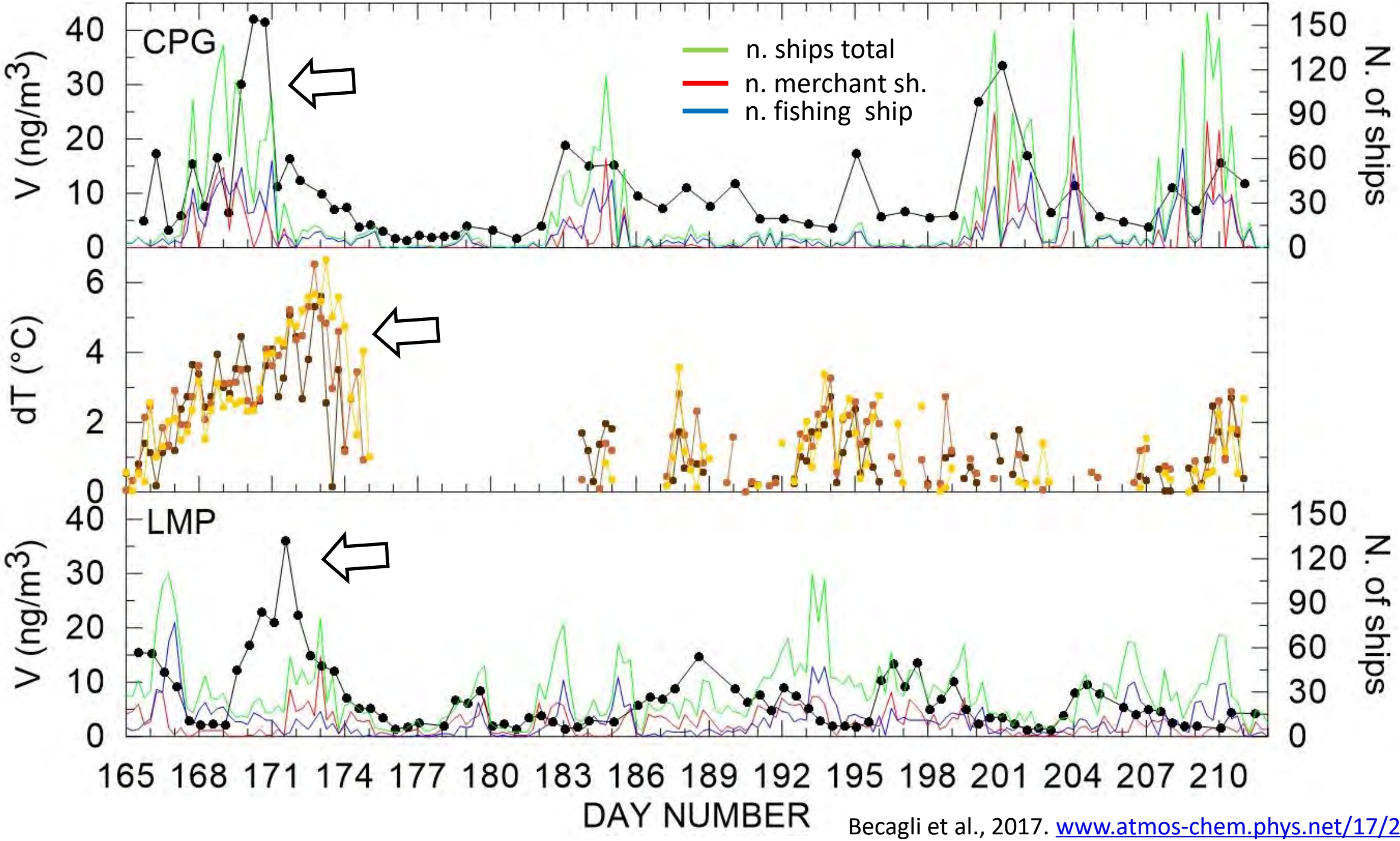
Aerosol Crostale

Aerosol Raffinerie

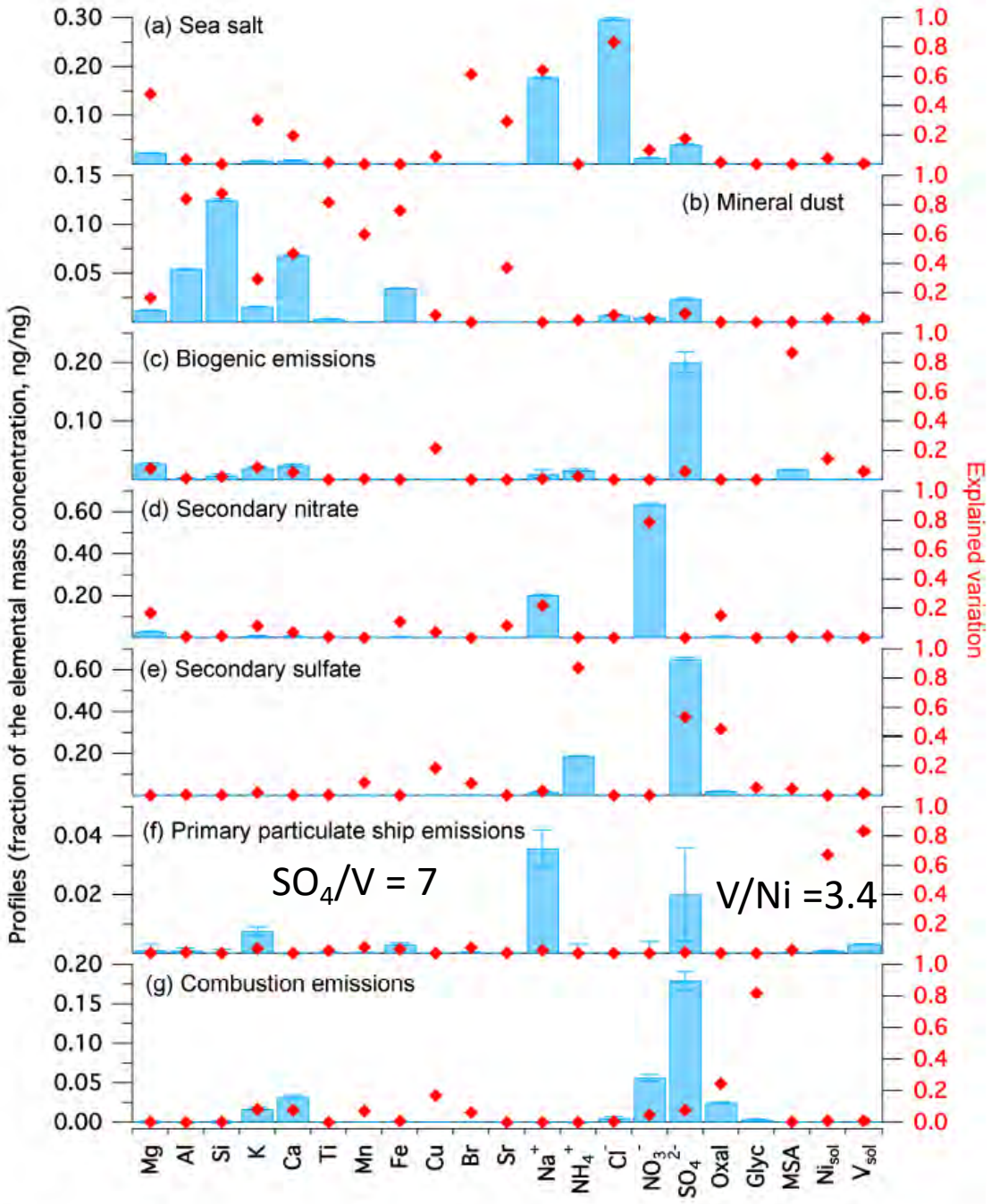
Aerosol Navale



Becagli et al., 2017. www.atmos-chem.phys.net/17/2067/2017/



Becagli et al., 2017. www.atmos-chem.phys.net/17/2067/2017/



Part of the ship source is whithin this factor

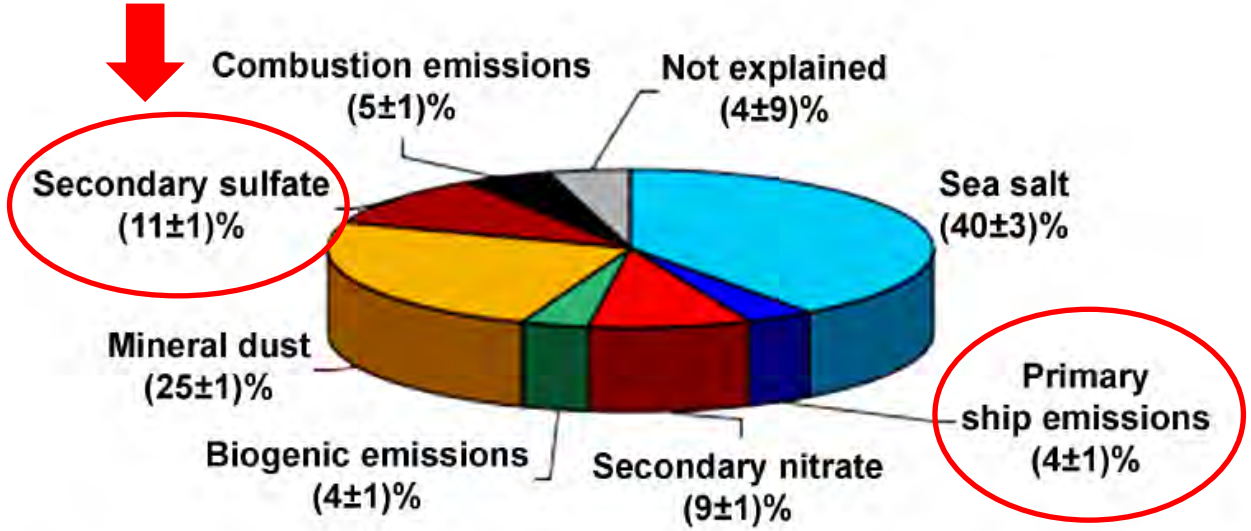
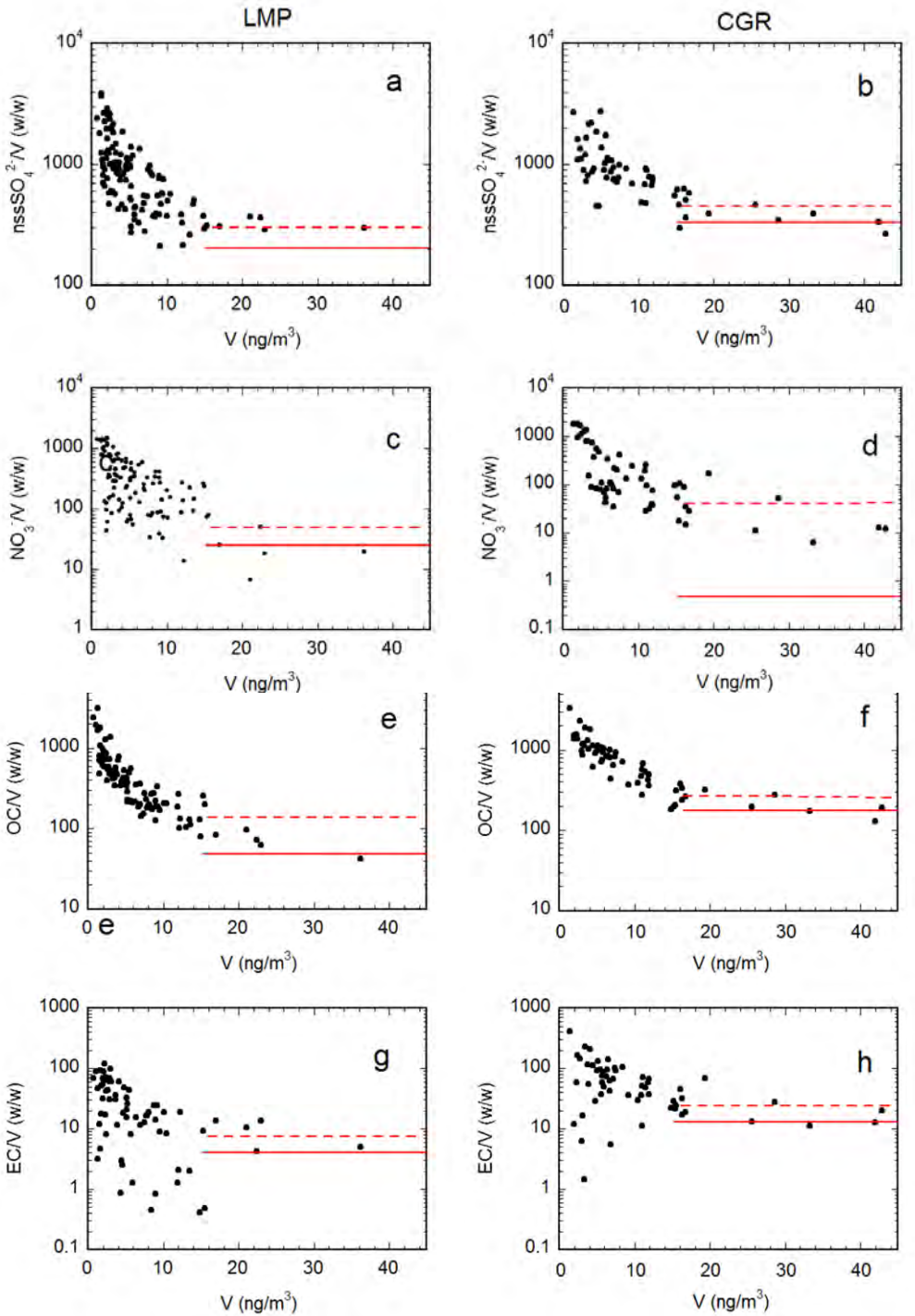


Figure 10. Relative annual contributions to the PM_{10} concentration (average over the years 2007–2008).

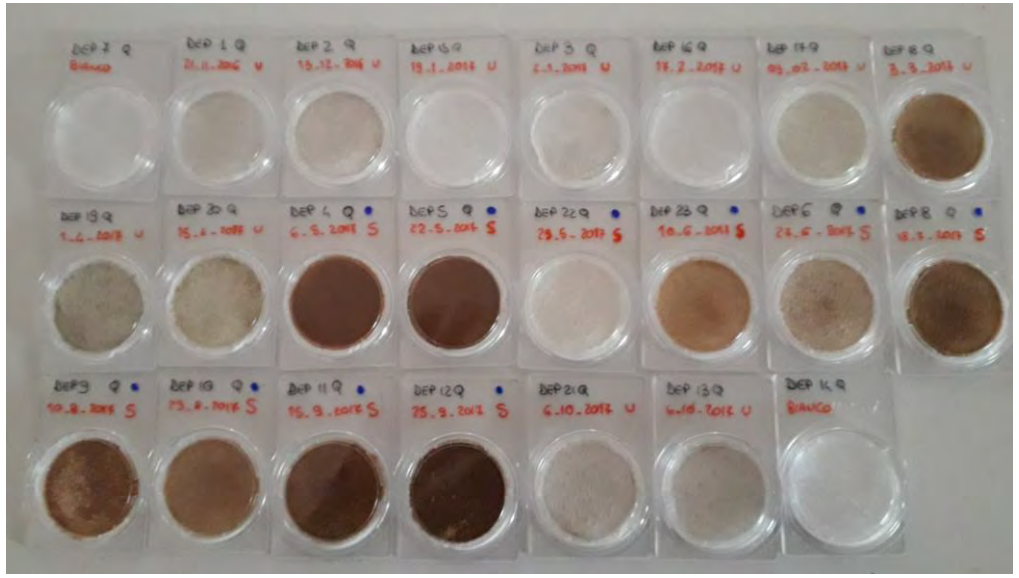
Calzolai et al., 2015. www.atmos-chem-phys.net/15/13939/2015/.



	$nssSO_4^{2-}$ $(nssSO_4^{2-}/V)_{ship}$=207		NO_3^- $(NO_3^-/V)_{ship}$=12.5		OC $(OC/V)_{ship}$=43.1		PM10 LPD OM=2.1*OC CGR OM=1.8*OC	
	LMP	CGR	LMP	CGR	LMP	CGR	LMP	CGR
Mean ship contr. µg/m³ (%)	1.35 (34%)	2.1 (31%)	0.082 (4.5%)	0.13 (9.0%)	0.59 (15%)	0.78 (8.7%)	2.0 (11%)	3.0 (8.6%)
Max ship contr. µg/m³ (%)	7.5 (69%)	8.8 (77%)	0.45 (62%)	0.53 (100%)	3.3 (99%)	3.3 (22%)	11.2 (50%)	12.7 (42%)

Becagli et al., 2017. www.atmos-chem.phys.net/17/2067/2017/

Deposizioni

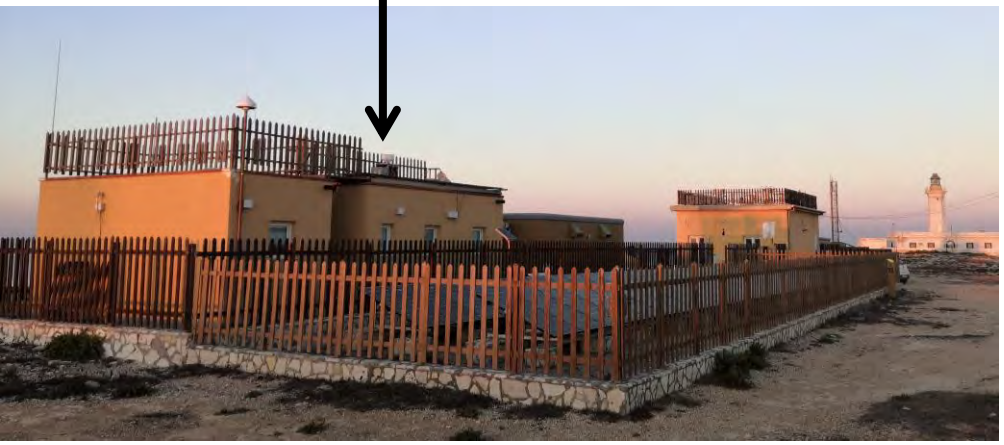


Deposizione secca e/o umida

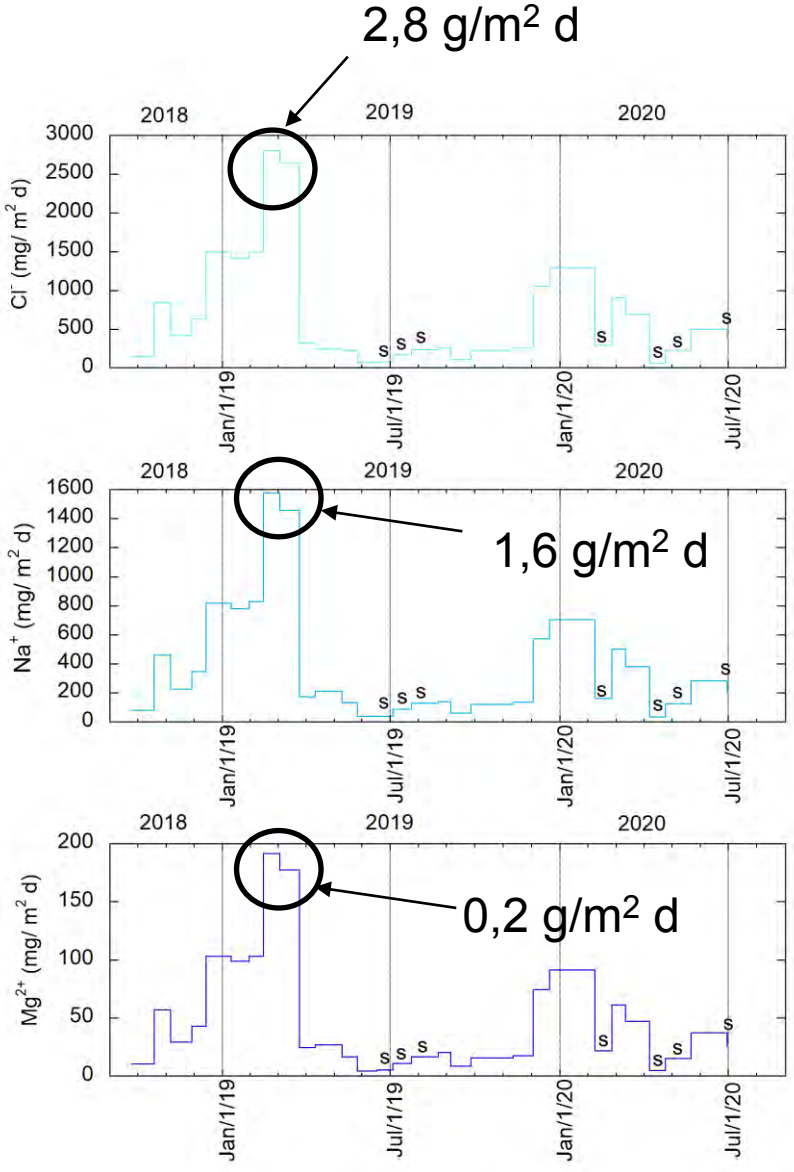
insolubile

solubile

Analisi chimica

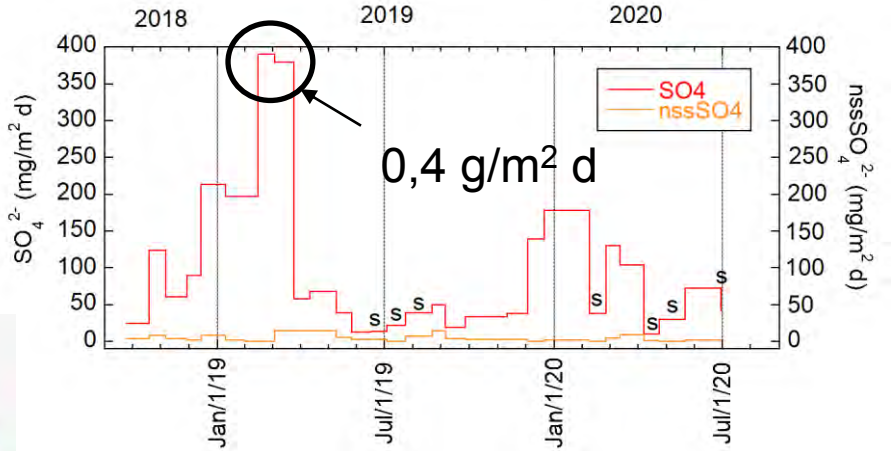


Deposizione di aerosol marino primario

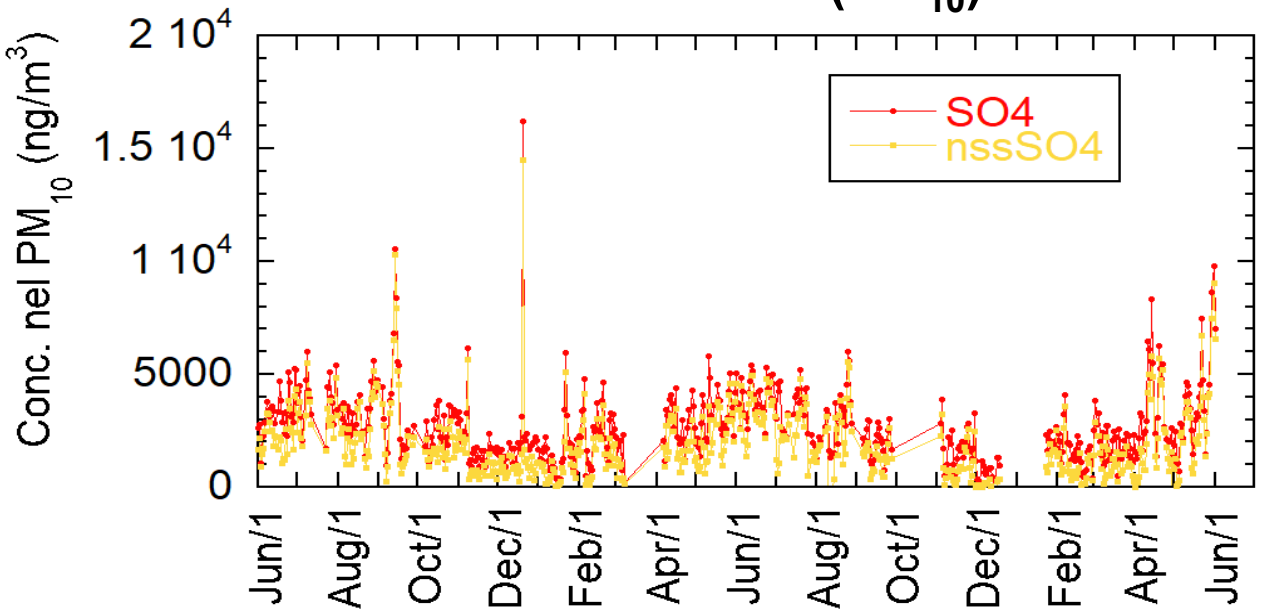


5 g/m² d

Solfati deposizioni

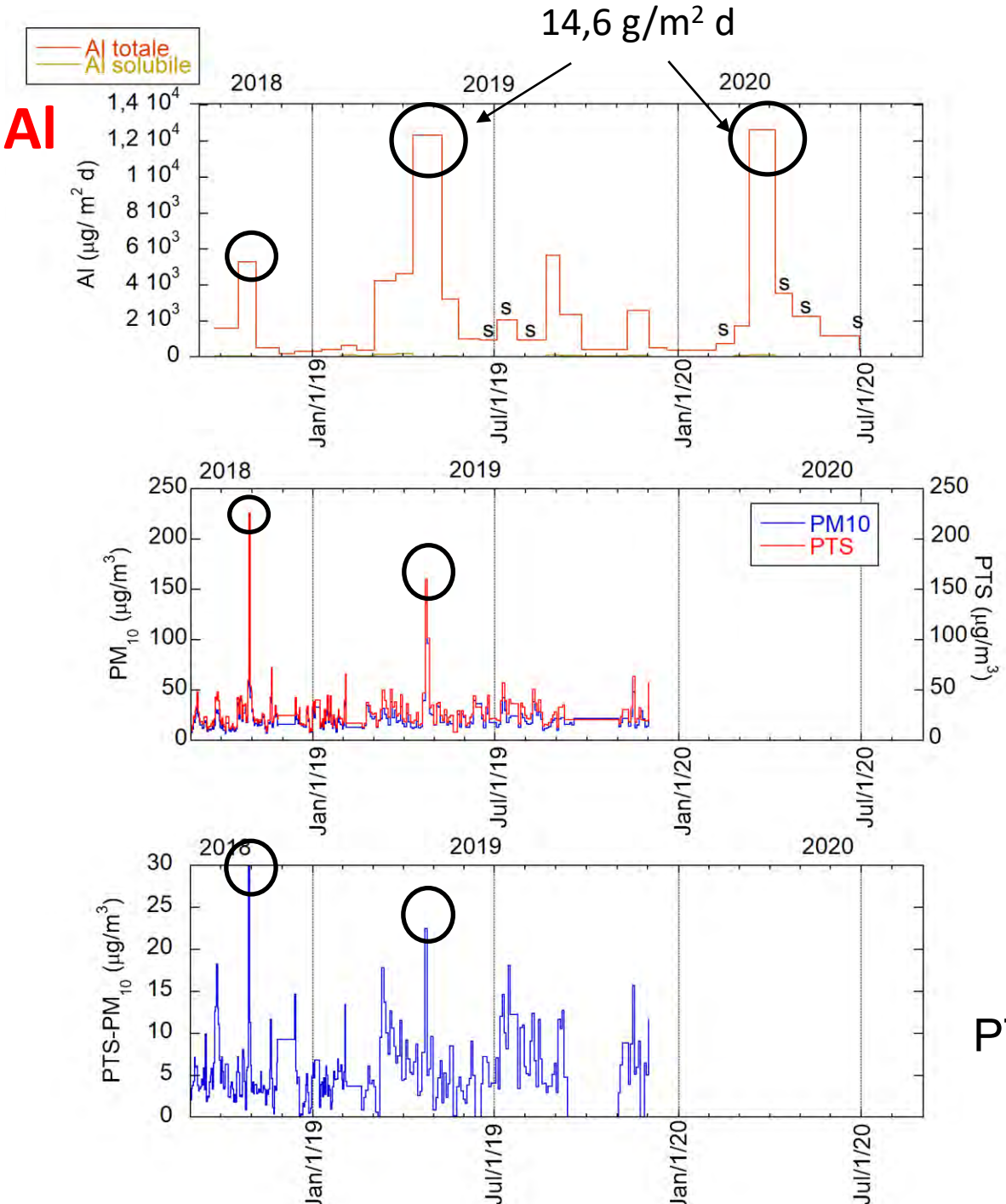


Solfati aerosol (PM_{10})



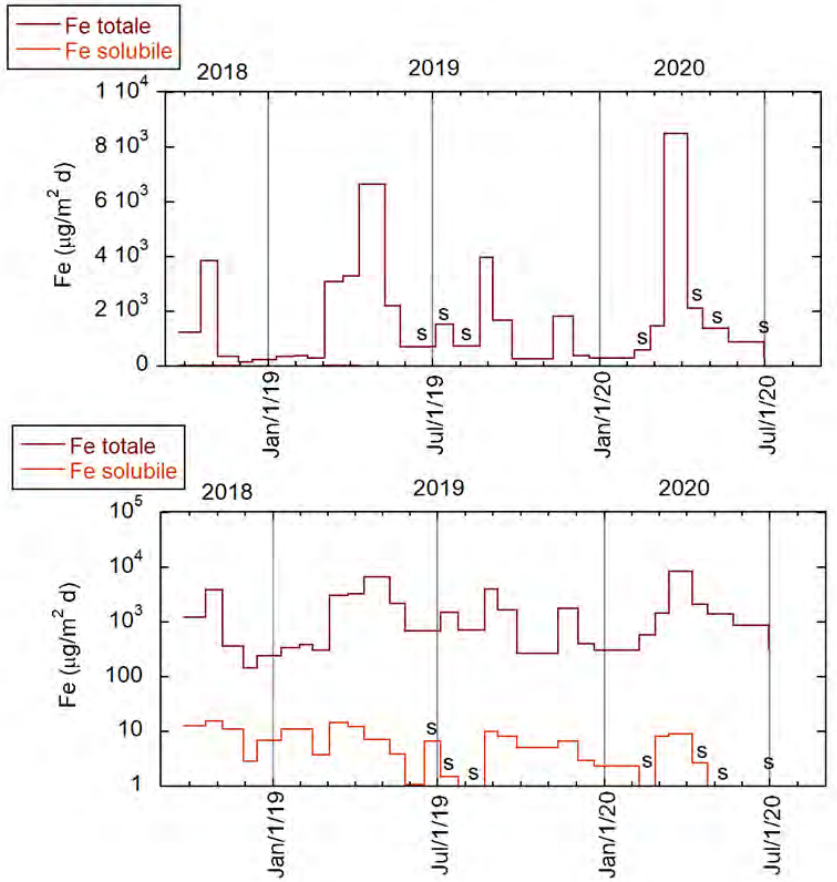
Deposizione di polveri Sahariane

Al

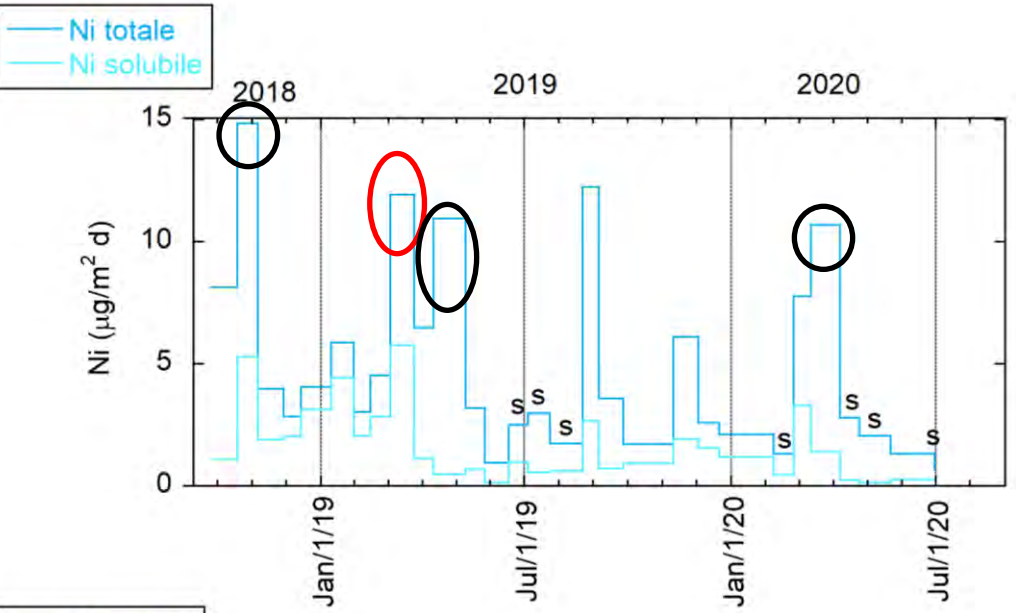


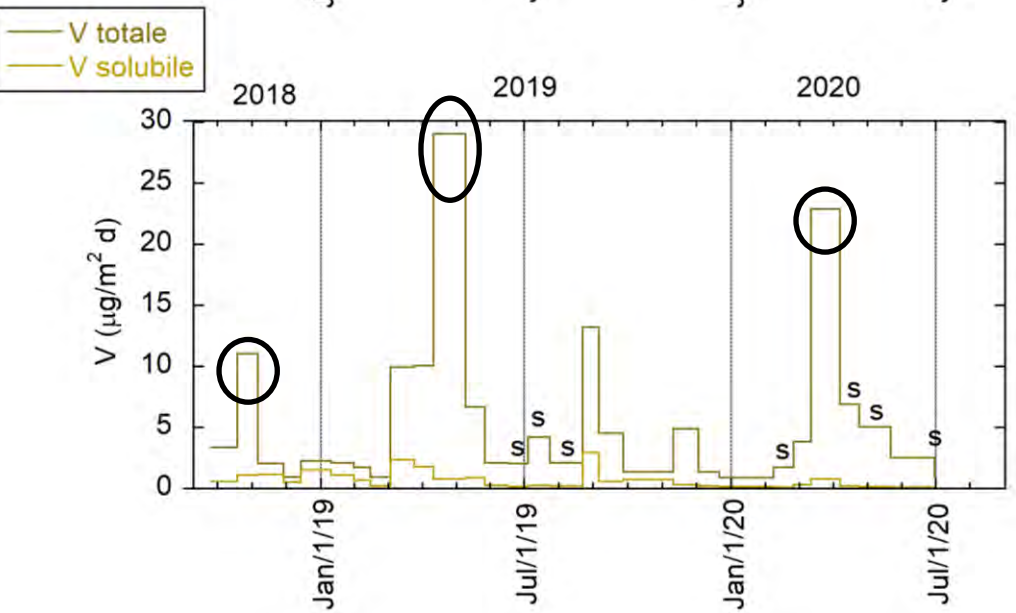
PTS-PM_{10}

Fe

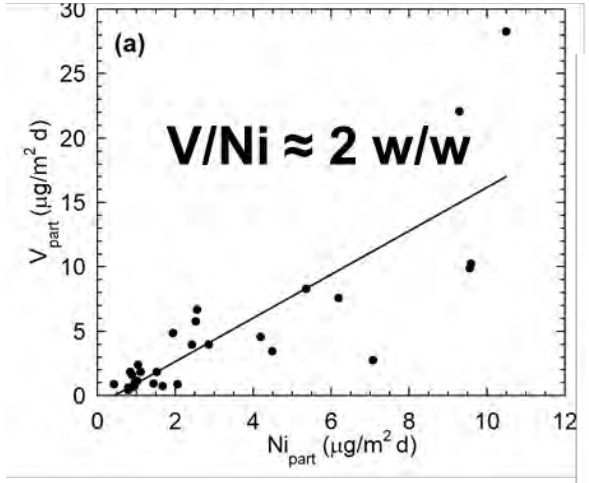


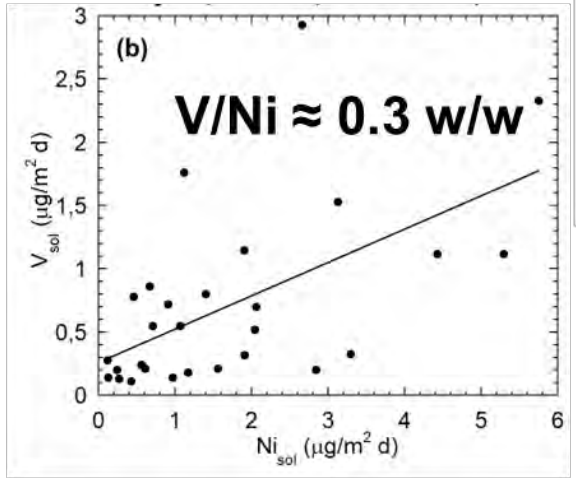
Nichel e Vanadio





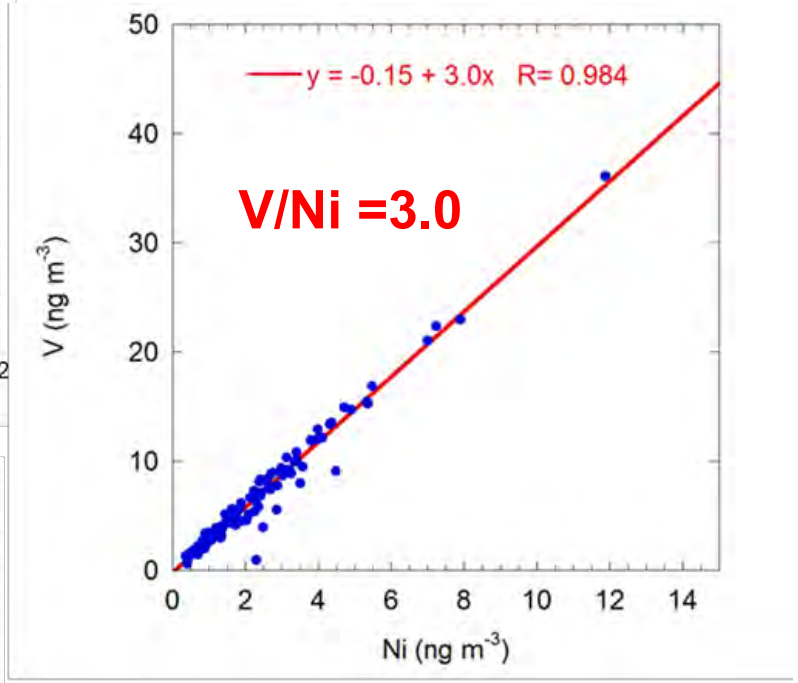
Deposizione-Particolato





Deposizione-Solubile

Aerosol PM_{10} Lampedusa



Aerosol crostale
V/Ni = 2.1 w/w

Aerosol navale
V/Ni= 3-4 w/w

Pubblicazioni

1. Becagli S., D. M. Sferlazzo, G. Pace, A. di Sarra, C. Bommarito, G. Calzolai, C. Ghedini, F. Lucarelli, D. Meloni, F. Monteleone, M. Severi, R. Traversi, and R. Udisti. Evidence for heavy fuel oil combustion aerosols from chemical analyses at the island of Lampedusa: a possible large role of ships emissions in the Mediterranean. Atmos. Chem. Phys., 12, 3479–3492, www.atmos-chem-phys.net/12/3479/2012/. doi:10.5194/acp-12-3479-2012. 2012.

2. Kishcha P., B. Starobinets, R. Bozzano, S. Pensieri, E. Canepa, S. Nickovic, A. di Sarra, R. Udisti, S. Becagli, P. Alpert. Sea-salt aerosol forecasts compared with wave height and sea-salt measurements in open sea. In: "Air Pollution Modeling and its Application XXI". NATO - Science for Peace and Security – Series C: Environmental Security. Springer Netherlands Publisher, 299–303. Print ISBN: 978-94-007-1358-1. Series ISSN 1874-6519. Doi: 10.1007/978-94-007-1359-8_51. 2012.

3. Becagli S., L. Lazzara, F. Fani, C. Marchese, R. Traversi, M. Severi, A. di Sarra, D. Sferlazzo, S. Piacentino, C. Bommarito, U. Dayan, R. Udisti. Relationship between methanesulfonate (MS^-) in atmospheric particulate and remotely sensed phytoplankton activity in oligomesotrophic central Mediterranean Sea. Atmos. Environ., 79, 681-688, http://dx.doi.org/10.1016/j.atmosenv.2013.07.032. 2013.

4. Marconi M., D. M. Sferlazzo, S. Becagli*, C. Bommarito, G. Calzolai, M. Chiari, A. di Sarra, C. Ghedini, J. L. Gómez-Amo, F. Lucarelli, D. Meloni, F. Monteleone, S. Nava, G. Pace, S. Piacentino, F. Rugi, M. Severi, R. Traversi, and R. Udisti. Saharan dust aerosol over the central Mediterranean Sea: PM10 chemical composition and concentration versus optical columnar measurements. Atmos. Chem. Phys., 14, 2039–2054, www.atmos-chem-phys.net/14/2039/2014/ doi:10.5194/acp-14-2039-2014. 2014.

5. Kishcha P., B. Starobinets, R. Udisti, S. Becagli, A. di Sarra, S. Nickovic, P. Alpert. Sea-salt aerosol forecasts over the Mediterranean Sea evaluated by daily measurements in Lampedusa from 2006 to 2010. In: "Air Pollution Modeling and its Application XXII". NATO - Science for Peace and Security – Series C: Environmental Security. Springer Netherlands Publisher, 321-325. Print ISBN: 978-94-007-5576-5. Series ISSN 1874-6519. Doi: 10.1007/978-94-007-5577-2_54. 2014.

6. Calzolai G., S. Nava, F. Lucarelli, M. Chiari, M. Giannoni, S. Becagli, R. Traversi, M. Marconi, D. Frosini, M. Severi, R. Udisti, A. di Sarra, G. Pace, D. Meloni, C. Bommarito, F. Monteleone, F. Anello, and D. M. Sferlazzo. Characterization of PM10 sources in the central Mediterranean. Atmos. Chem. Phys., 15, 13939–13955, www.atmos-chem-phys.net/15/13939/2015/. doi:10.5194/acp-15-13939-2015. 2015.

7. Becagli, S., F. Anello, C. Bommarito, F. Cassola, G. Calzolai, T. Di Iorio, A. di Sarra, J-L Gómez-Amo, F. Lucarelli, M. Marconi, D. Meloni, F. Monteleone, S. Nava, G. Pace, M. Severi, D. M. Sferlazzo, R. Traversi, and R. Udisti. Constraining the ship contribution to the aerosol of the central Mediterranean Atmos. Chem. Phys., 17, 2067–2084, 2017. www.atmos-chem-phys.net/17/2067/2017/doi:10.5194/acp-17-2067-2017.

8. Galletti, Y., S. Becagli, A. di Sarra, M. Gonnelli, E. Pulido-Villena, D. M. Sferlazzo, R. Traversi, S. Vestri, and C. Santinelli. Atmospheric deposition of organic matter at a remote site in the Central Mediterranean Sea: implications for marine ecosystem. Biogeosciences, 17, 3669–3684, 2020. https://doi.org/10.5194/bg-17-3669-2020.

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