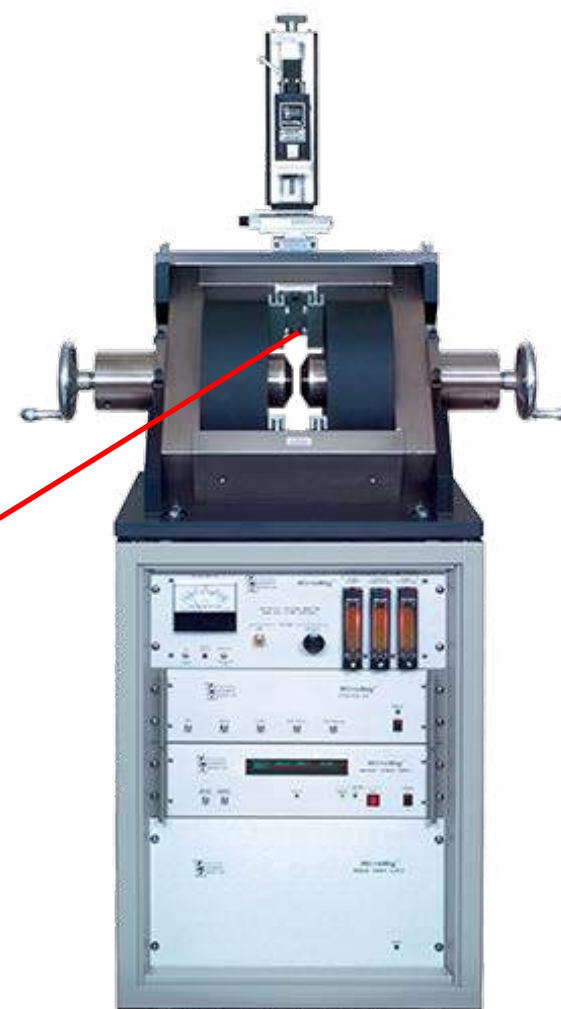


Magnetic monitoring of PM filters from Air Monitoring Stations during the COVID-19 lockdown in Rome, Italy (March 10 th - May 18 th , 2020)

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Magnetic properties of PM filters; they were determined:

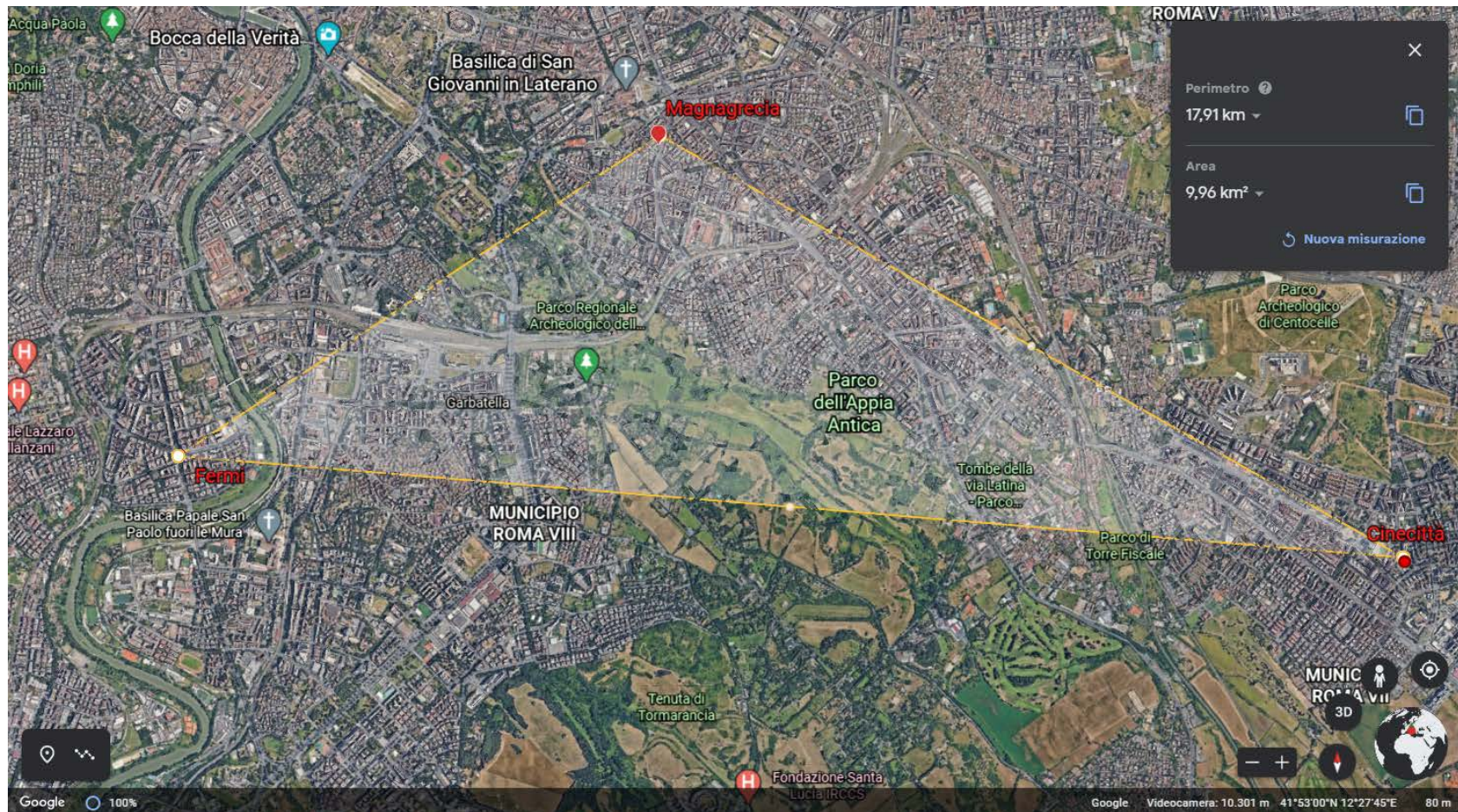
- ✓ **Volume magnetic susceptibility** - as the fastest proxy of the concentration of magnetic minerals in the daily PM filters, assuming the KLY5 standard volume (10 cm^3).
- ✓ **Mass magnetic susceptibility** - dividing the total susceptibility for the daily PM mass, calculated as $\text{PM} (\mu\text{g}/\text{m}^3) \times 55 \text{ m}^3$ (air filtered in a day).
- ✓ **Hysteresis properties** - mass normalized M_s , M_{rs} ; B_c , B_{cr} , (on half filter in a gel cap). Their ratios were plotted in a «Day Plot»; on representative samples
- ✓ **FORC diagrams** - on selected samples

The results shown here are only a selection of an extensive study covering many stations in Latium region (Rome, Fiumicino, Civitavecchia, Valle del Sacco)



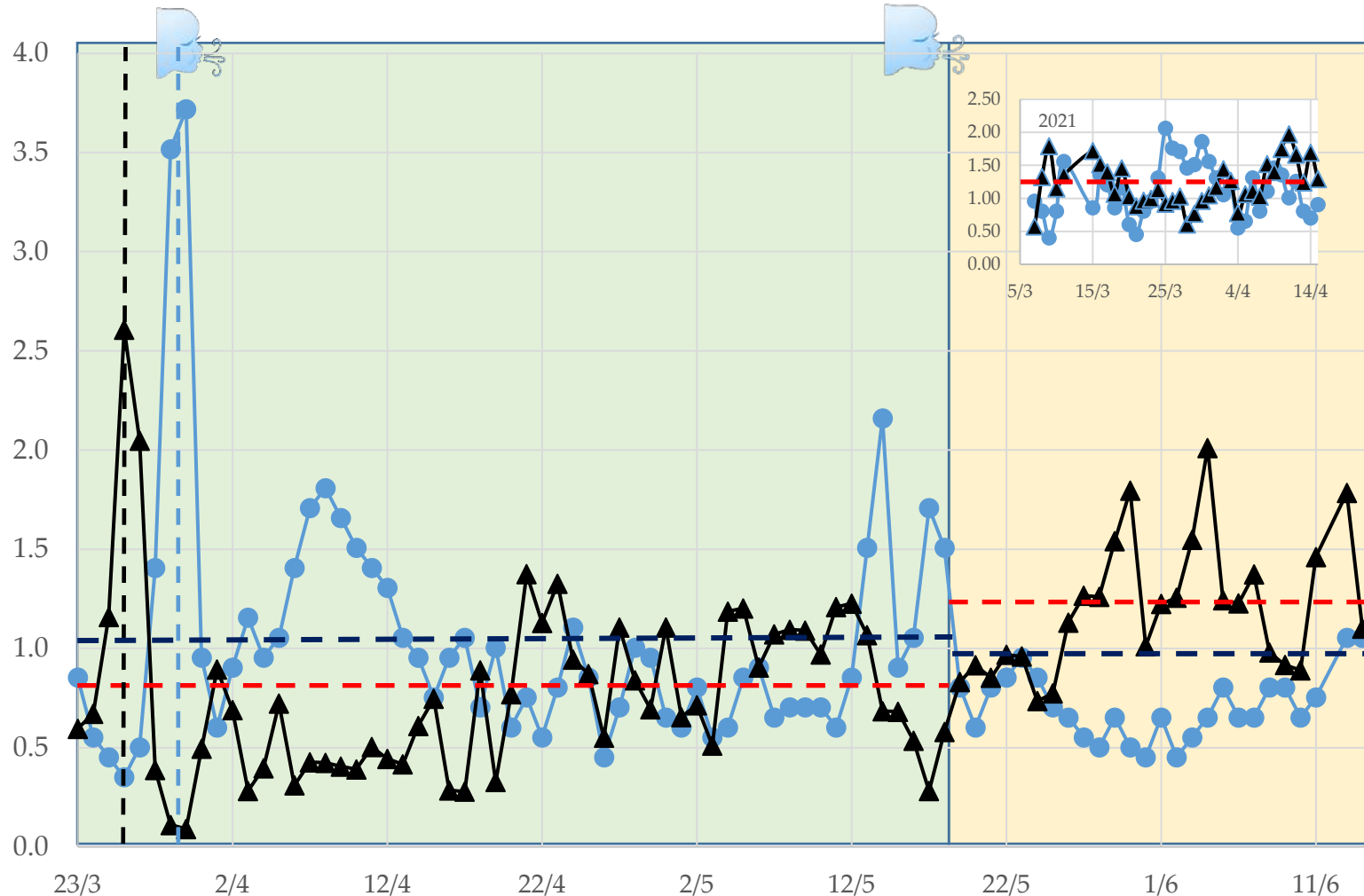
Roma: PM air filter stations

- Fermi (busy road, intense exposure to traffic); March 23, 2020 – April 15, 2021 (uncontinuous sampling after lockdown)
- Cinecittà (internal road, moderate exposure to traffic; March 3, 2020 - June 14, 2020)
- Magnagrecia (busy road, intense exposure to traffic); March 26, 2020 – March 22, 2021 (uncontinuous sampling after lockdown)



ROMA FERMI (March 23, 2020 – April 15, 2021 (uncontinuous sampling after lockdown))

▲ Mass susceptibility; ● PM – normalized to average



Mass Susceptibility

Max: 3.36E-05 m³/kg

Min: 1.17E-06 m³/kg

Average: 1. 29E-05 m³/kg

average lock: 9.97E-06 m³/kg

average post: 1. 1.56E-05 m³/kg

p (same mean): 3.3E-08

PM concentration

Max: 74 µg/m³

Min: 7 µg/m³

Average: 19 µg/m³

average lock: 21 µg/m³

average post 19 µg/m³

p (same mean): 0.29

Magnetite average

concentration = 1.11%

Ms data on 15 samples

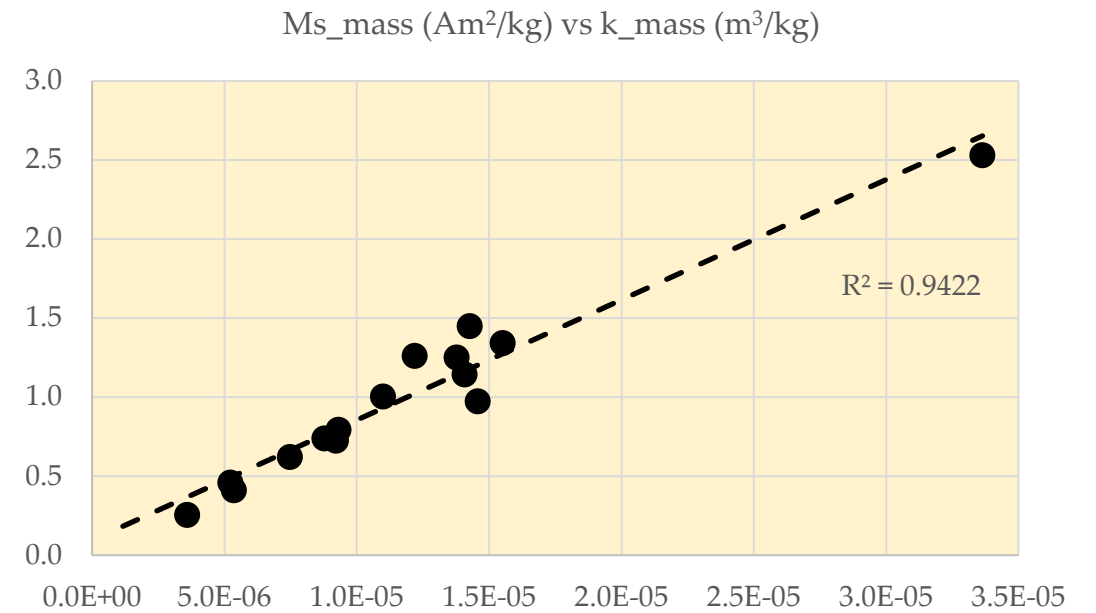
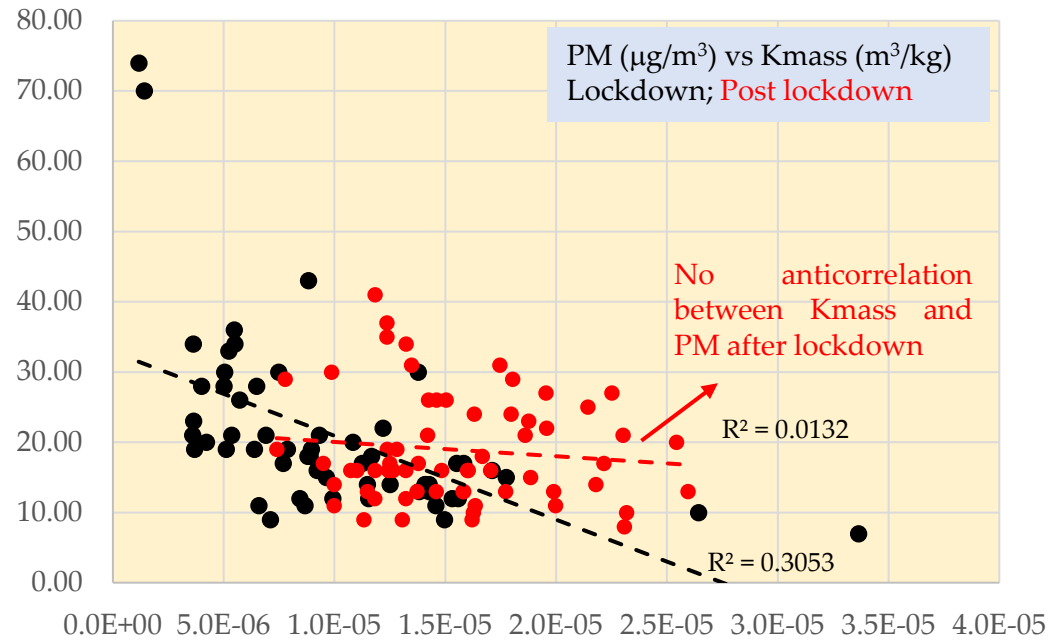
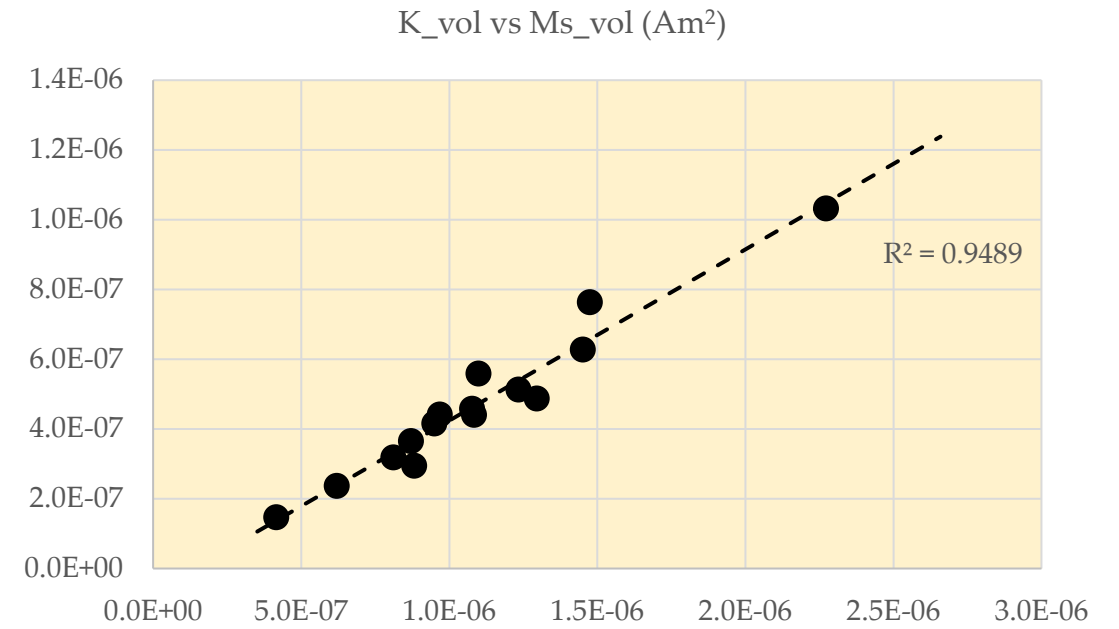
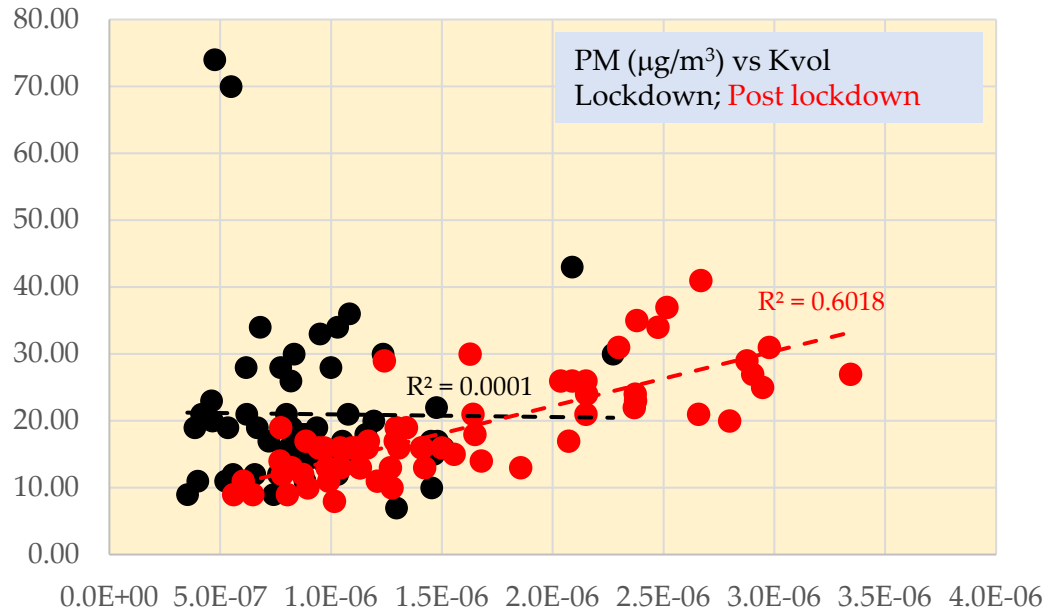
— — — — Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts

— — — — Absolute maximum of mass susceptibility vs PM minimum – highest concentration of magnetic PM

— — — — Average Kmass

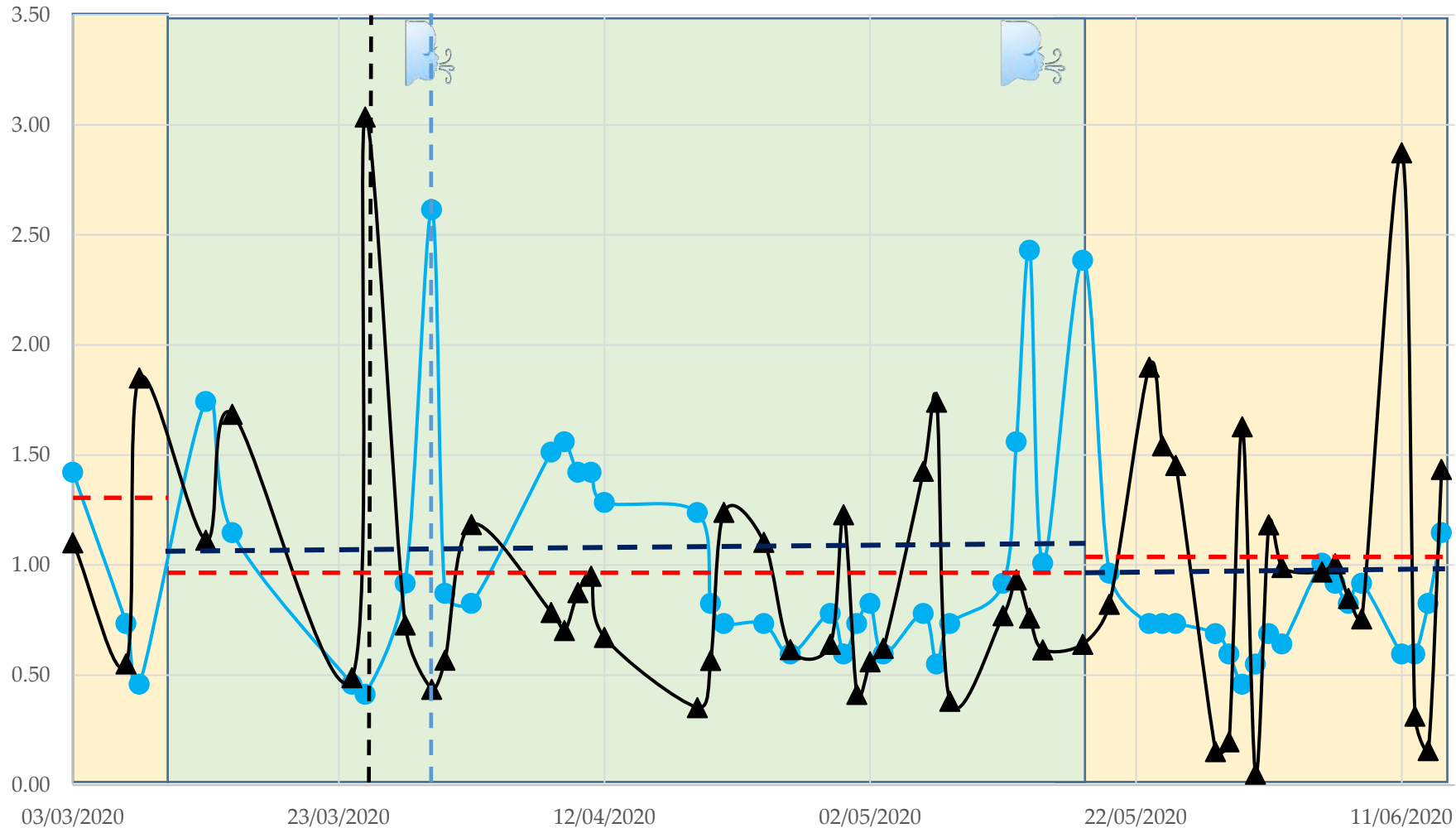
— — — — Average PM

ROMA FERMI: correlations



ROMA CINECITTÀ (March 3, 2020 – June 14, 2020)

▲ Mass susceptibility; ● PM – normalized to average



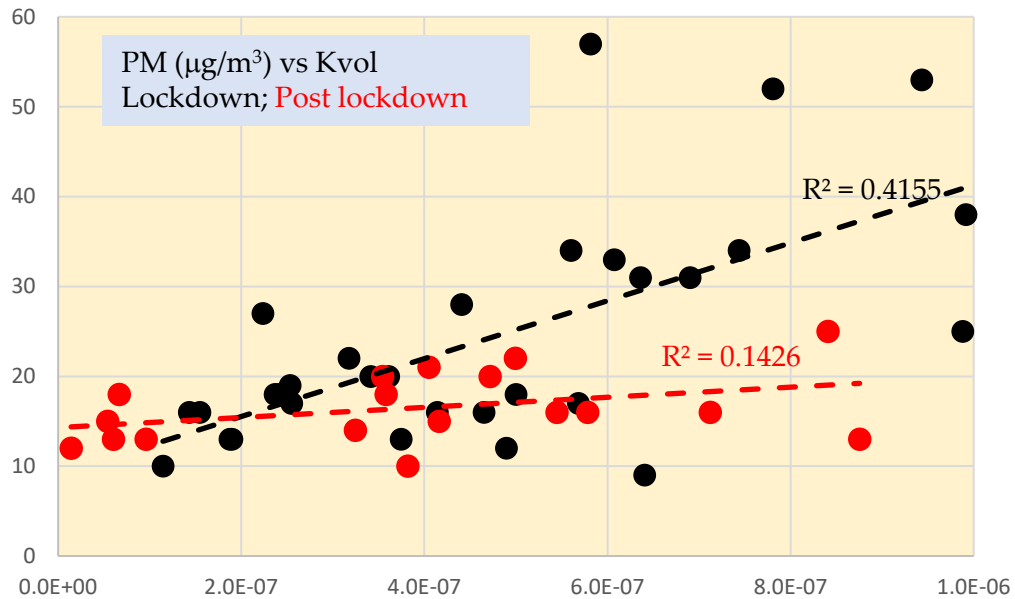
- — — — Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts
- — — — Absolute maximum of mass susceptibility vs PM minimum – highest concentration of magnetic PM
- — — — Average Kmass
- — — — Average PM

Mass susceptibility
 max 1.29E-05 m³/kg
 min 2.15E-07 m³/kg
 average 4.07E-06 m³/kg
 average lock. 3.83E-06 m³/kg
 average post 4.24E-06 m³/kg
p (same mean): 0.55

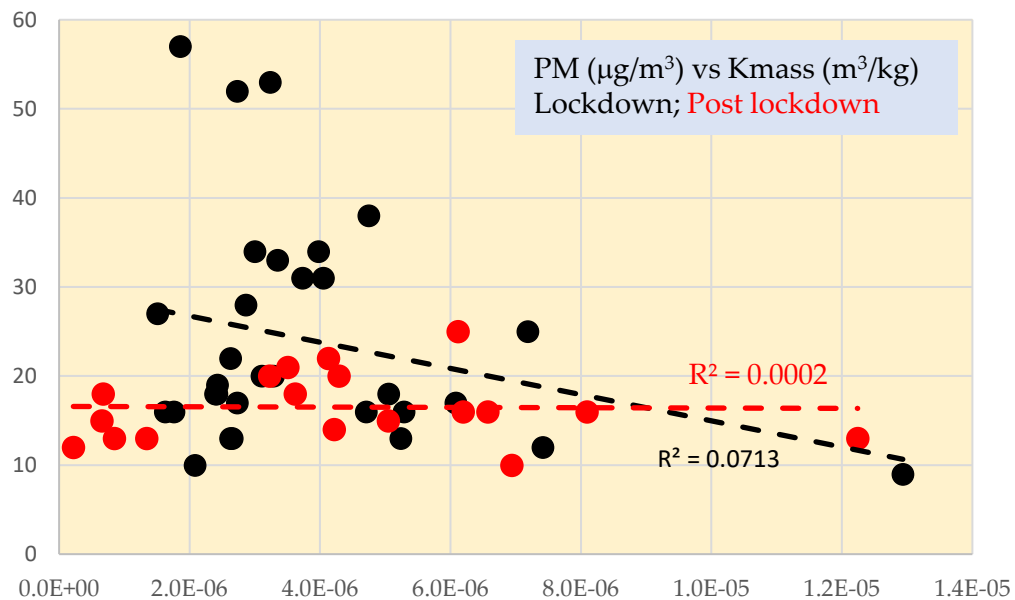
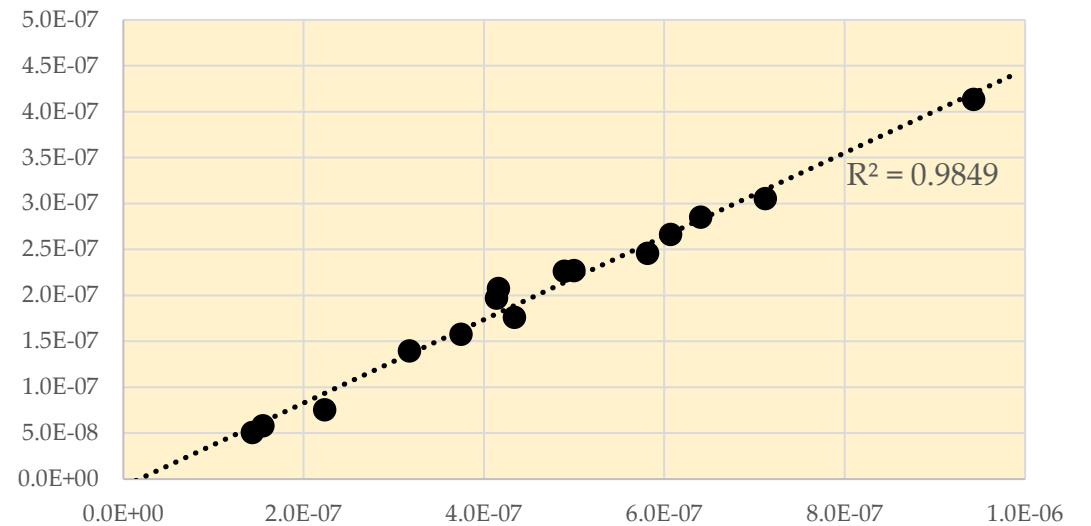
PM concentration
 Max: 57 µg/m³
 Min: 9 µg/m³
 Average: 21 µg/m³
 average lock: 23 µg/m³
 average post 18 µg/m³
p (same mean): 0.01

Magnetite average concentration = 0.47% (Ms data on 15 samples)

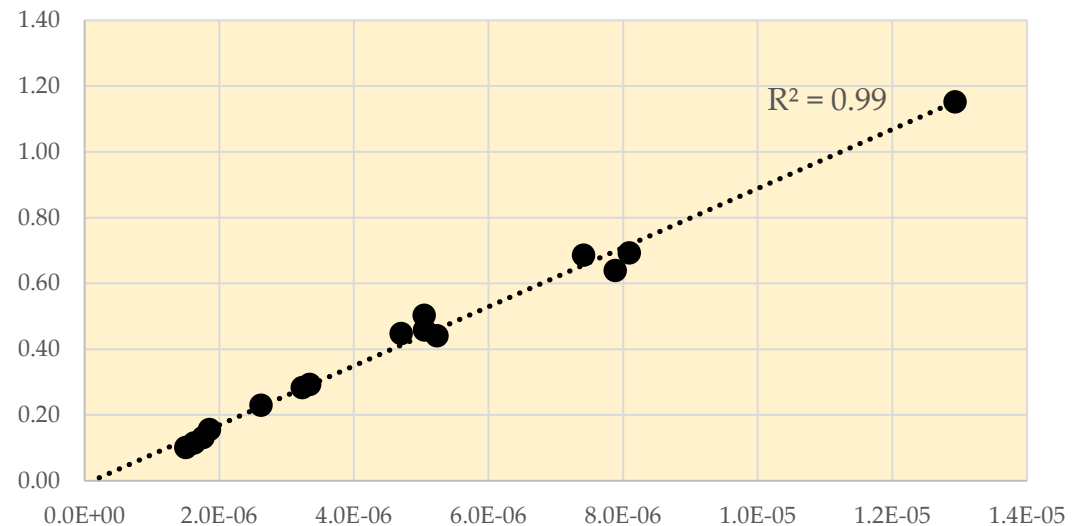
ROMA Cinecittà: correlations



Cinecittà Ms (Am^2) vs k_vol

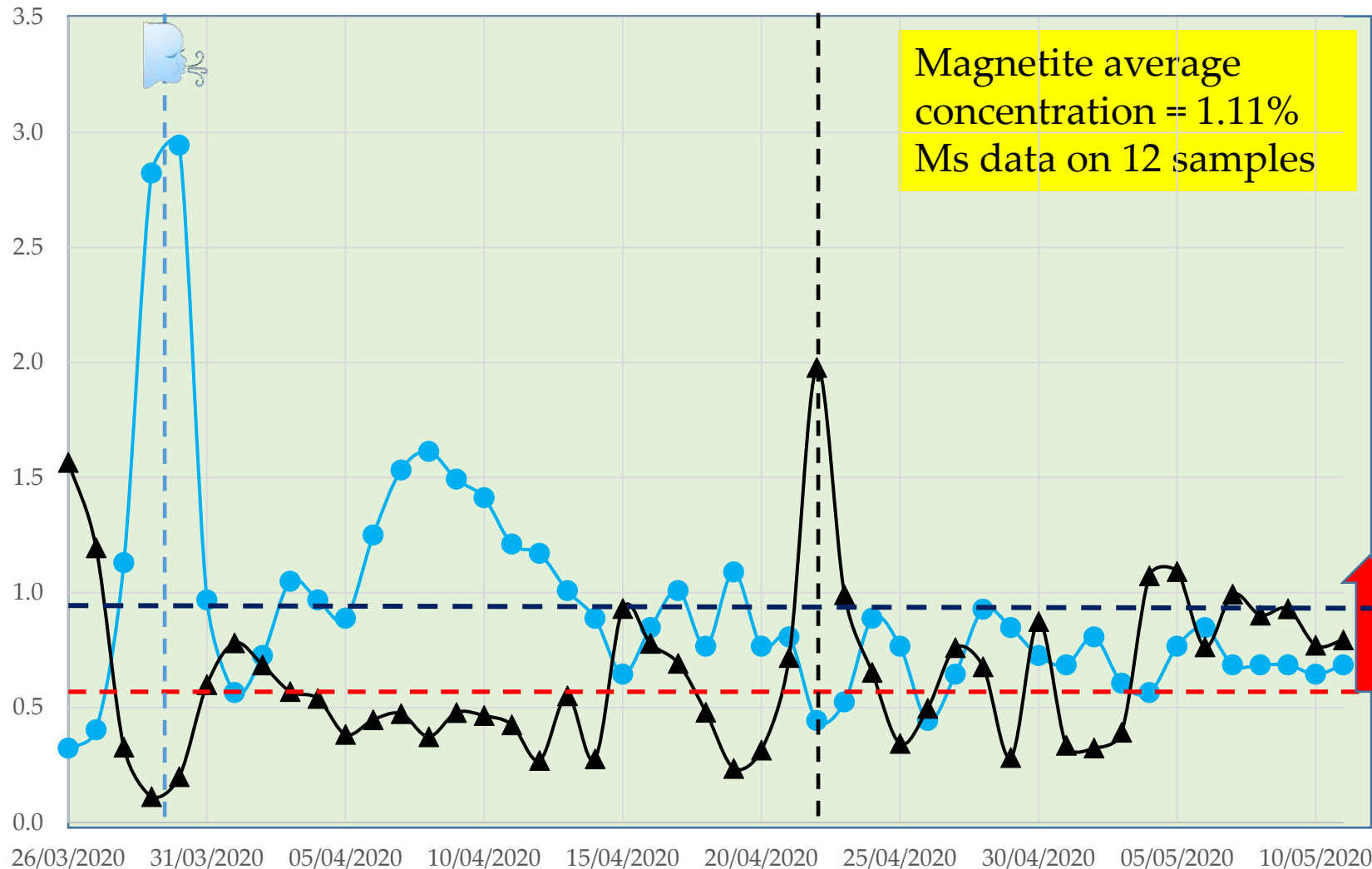


Cinecittà Ms_mass (Am^2/kg) vs k_mass (m^3/kg)



ROMA MAGNAGRECIA (March 26, 2020 – March 22, 2021)

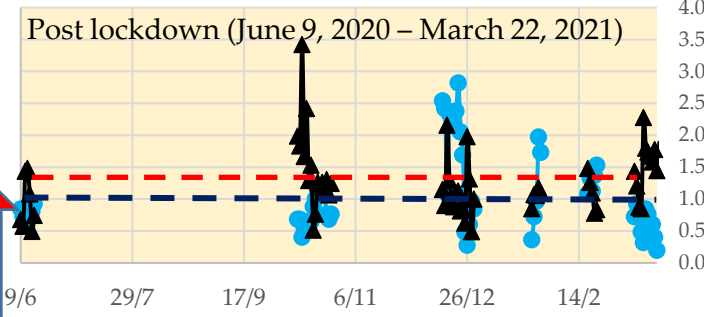
▲ Mass susceptibility; ● PM – normalized to average



Magnetite average concentration = 1.11%
Ms data on 12 samples

Mass susceptibility
max 5.14E-05 m³/kg
min 1.69E-06 m³/kg
average 1.50E-05 m³/kg
average lockd. 9.67E-06 m³/kg
average post 1.91E-05 m³/kg
p (same mean): 6.6E11

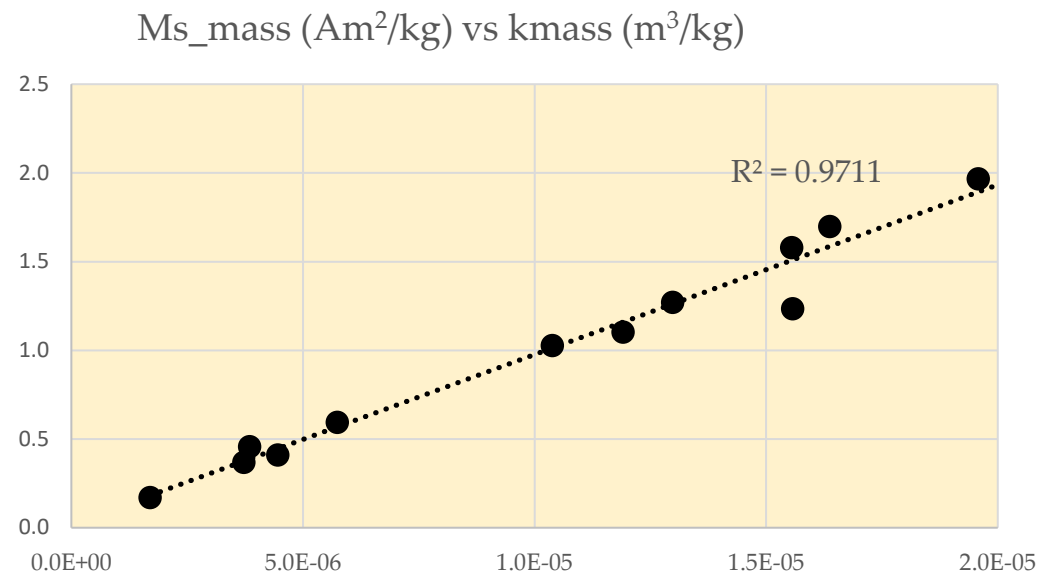
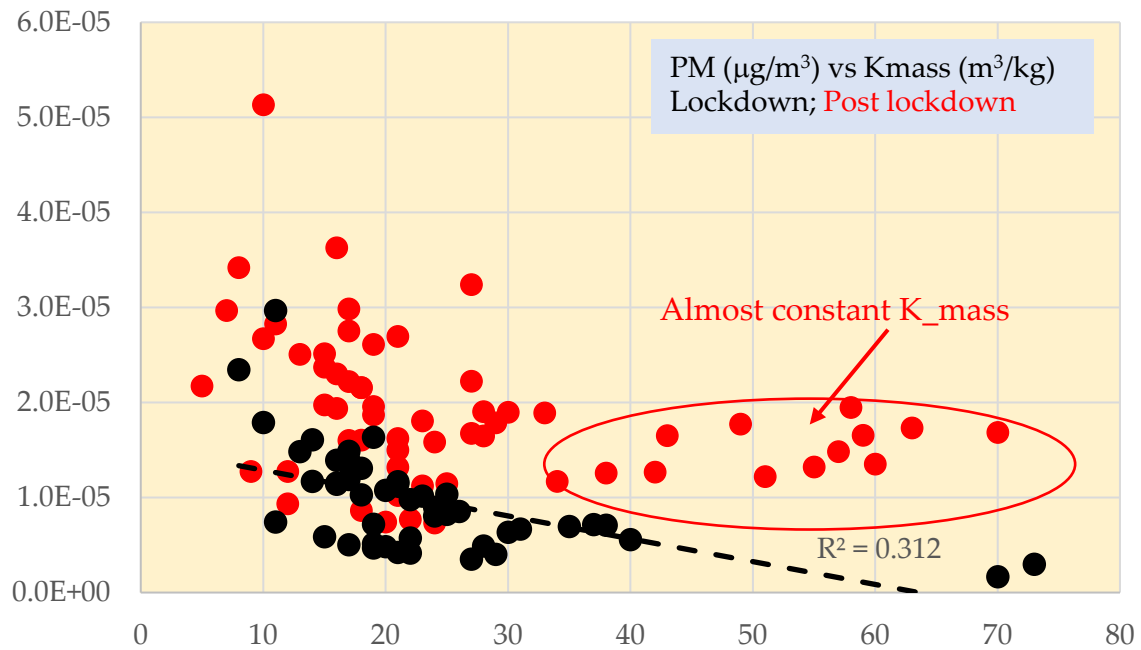
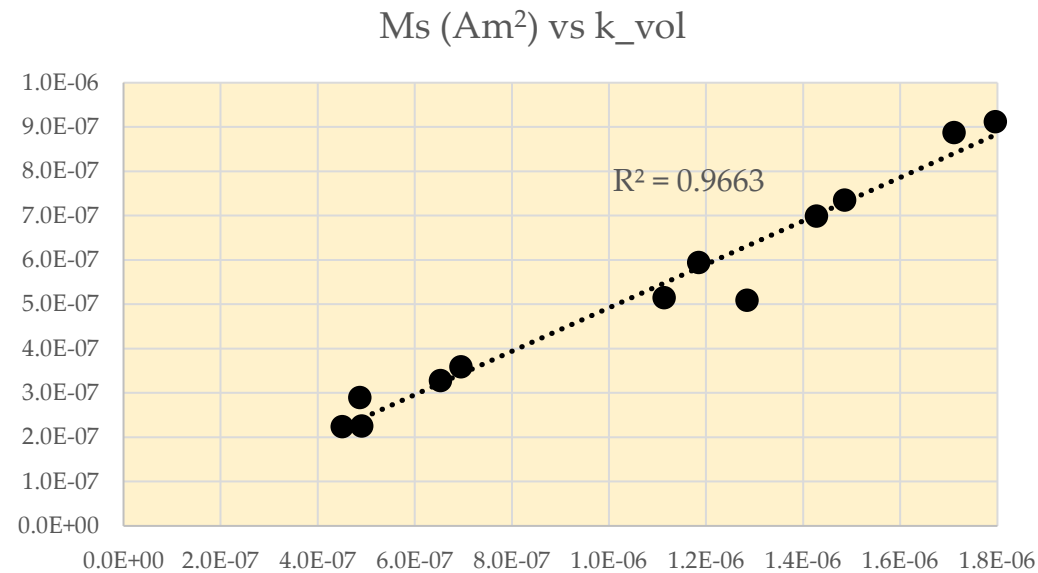
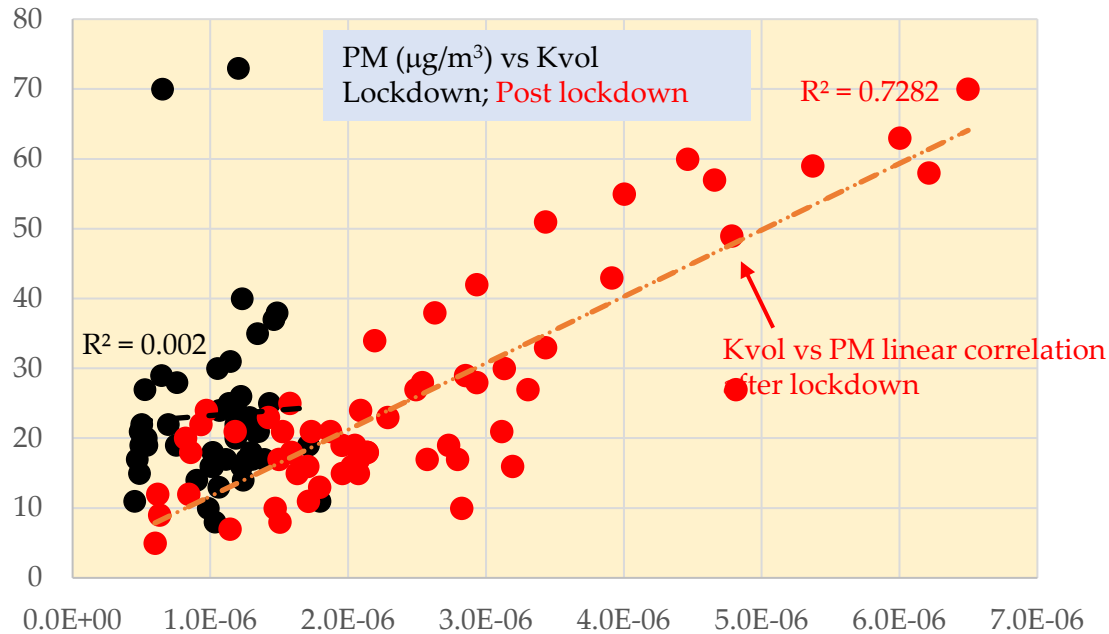
Sagnotti et al., 2006
average 2.12E-05 m³/kg



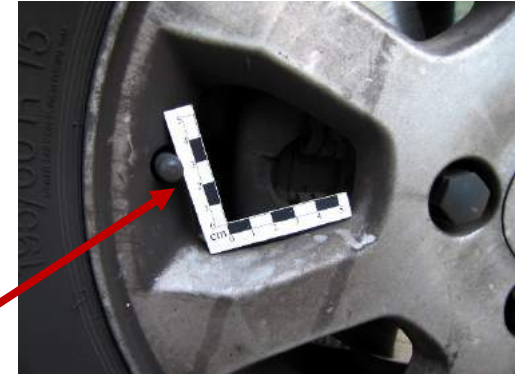
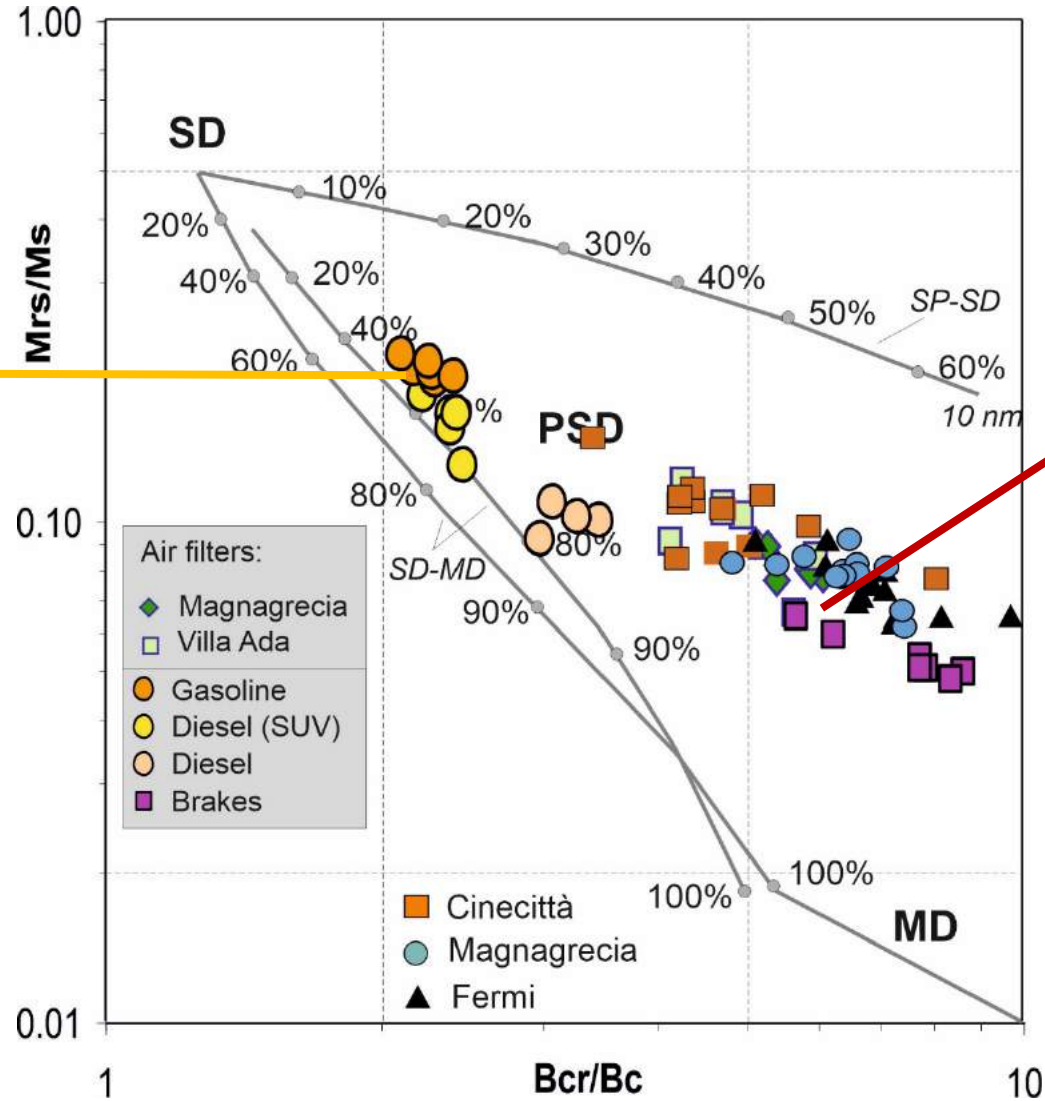
PM concentration
Max: 73 μg/m³
Min: 5 μg/m³
Average: 25 μg/m³
average lock: 23 μg/m³
average post 26 μg/m³
p (same mean): 0.34

- — — — Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts
- — — — Absolute maximum of mass susceptibility vs PM minimum – highest concentration of magnetic PM
- — — — Average Kmass
- — — — Average PM

ROMA MAGNAGRECIA: correlations

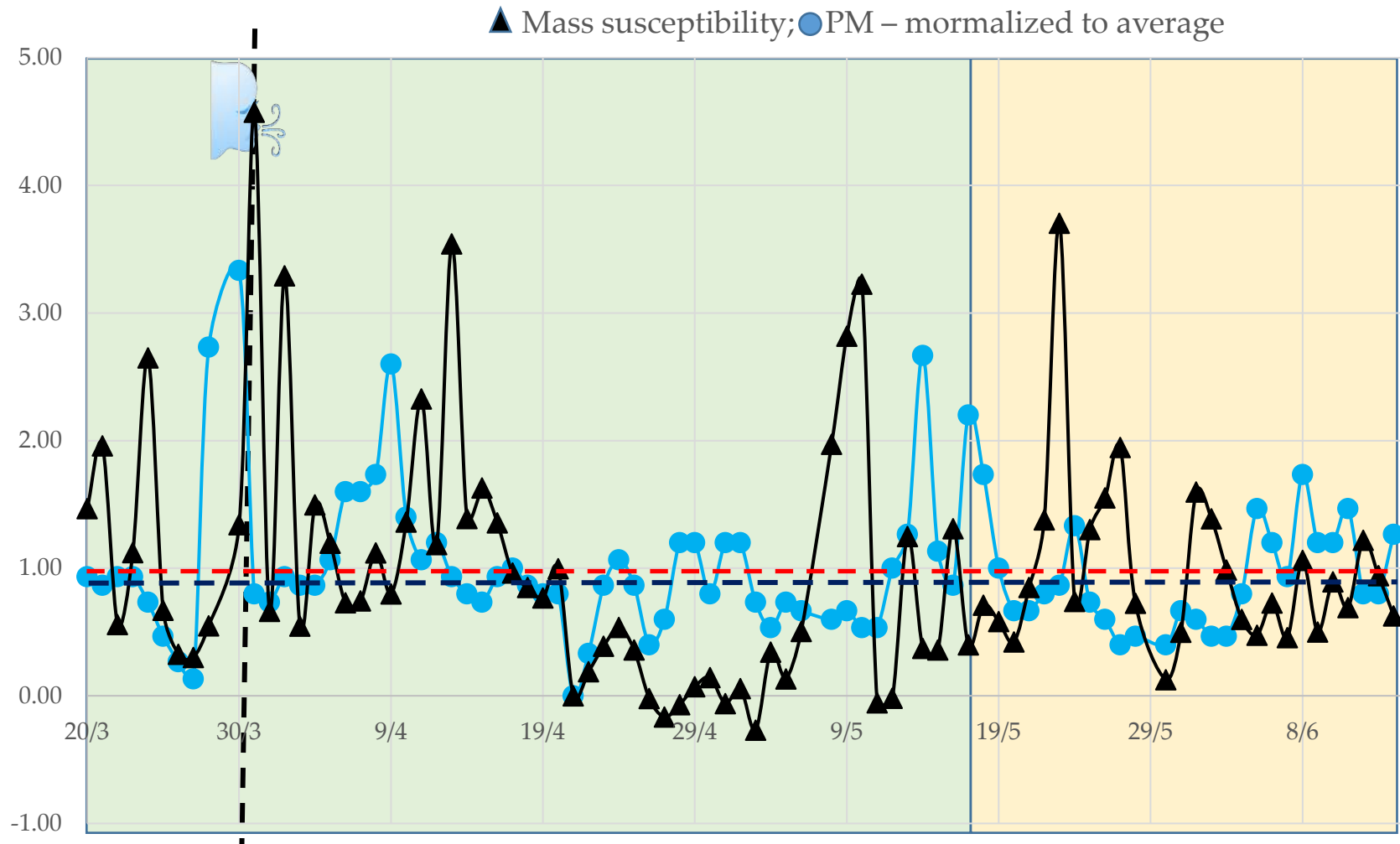


Day Plot - Roma



- Prevailing Brake Emissions in Fermi and Magnagrecia (busy roads)
- Cinecittà points (distant to busy roads) move towards natural and fuel sources

Civitavecchia (rural background): Sant'Agostino (March 20, 2020 – June 14, 2020)

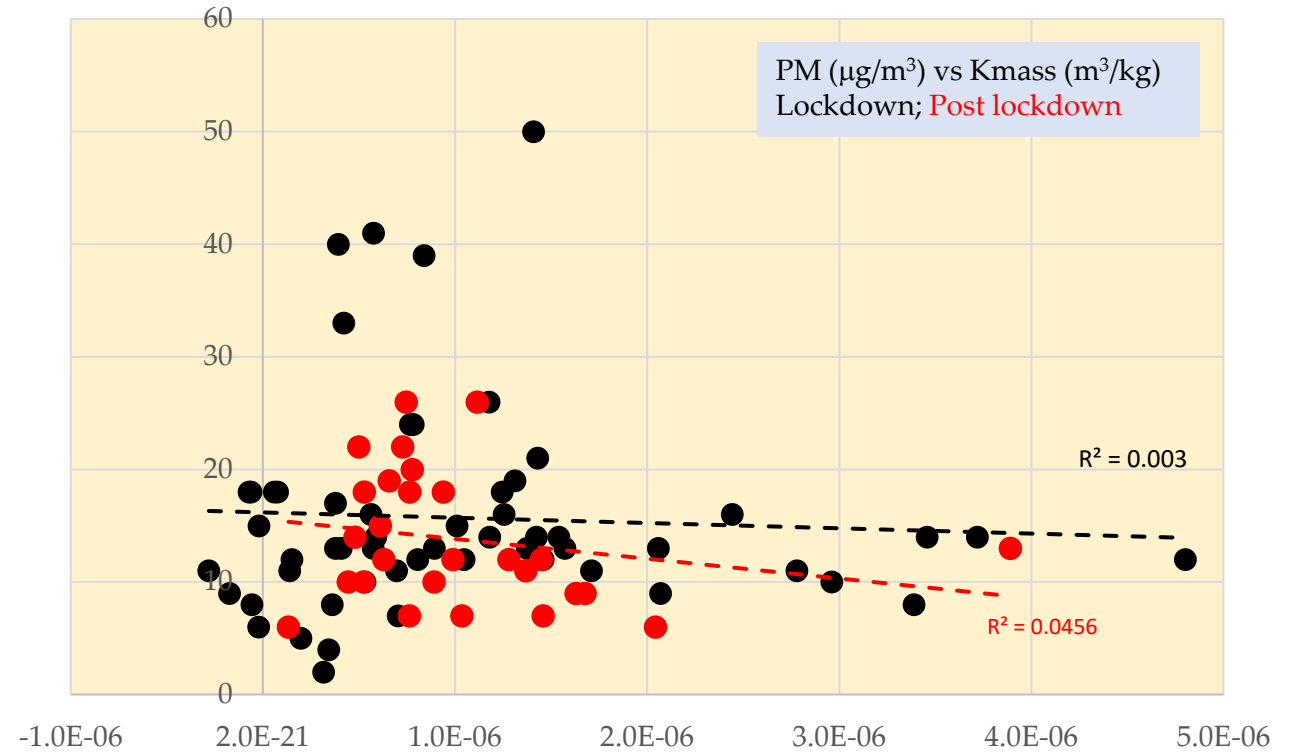
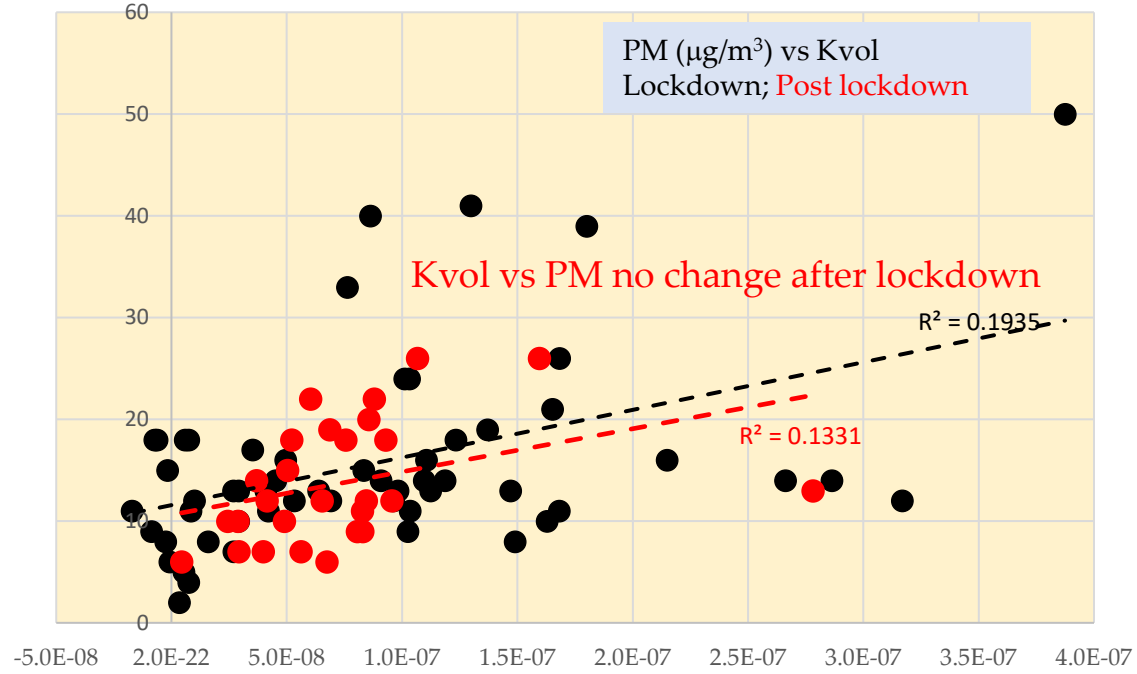


Mass susceptibility
 max 4.80E-06 m³/kg
 min -2.82E-07 m³/kg
 average 1.05E-06 m³/kg
 average l. 1.05E-06 m³/kg
 average p.l. 1.06E-06 m³/kg
p (same mean): 1.00

PM concentration
 Max: 50 µg/m³
 Min: 2 µg/m³
 Average: 15 µg/m³
 average lock: 16 µg/m³
 average post 14 µg/m³
p (same mean): 0.20

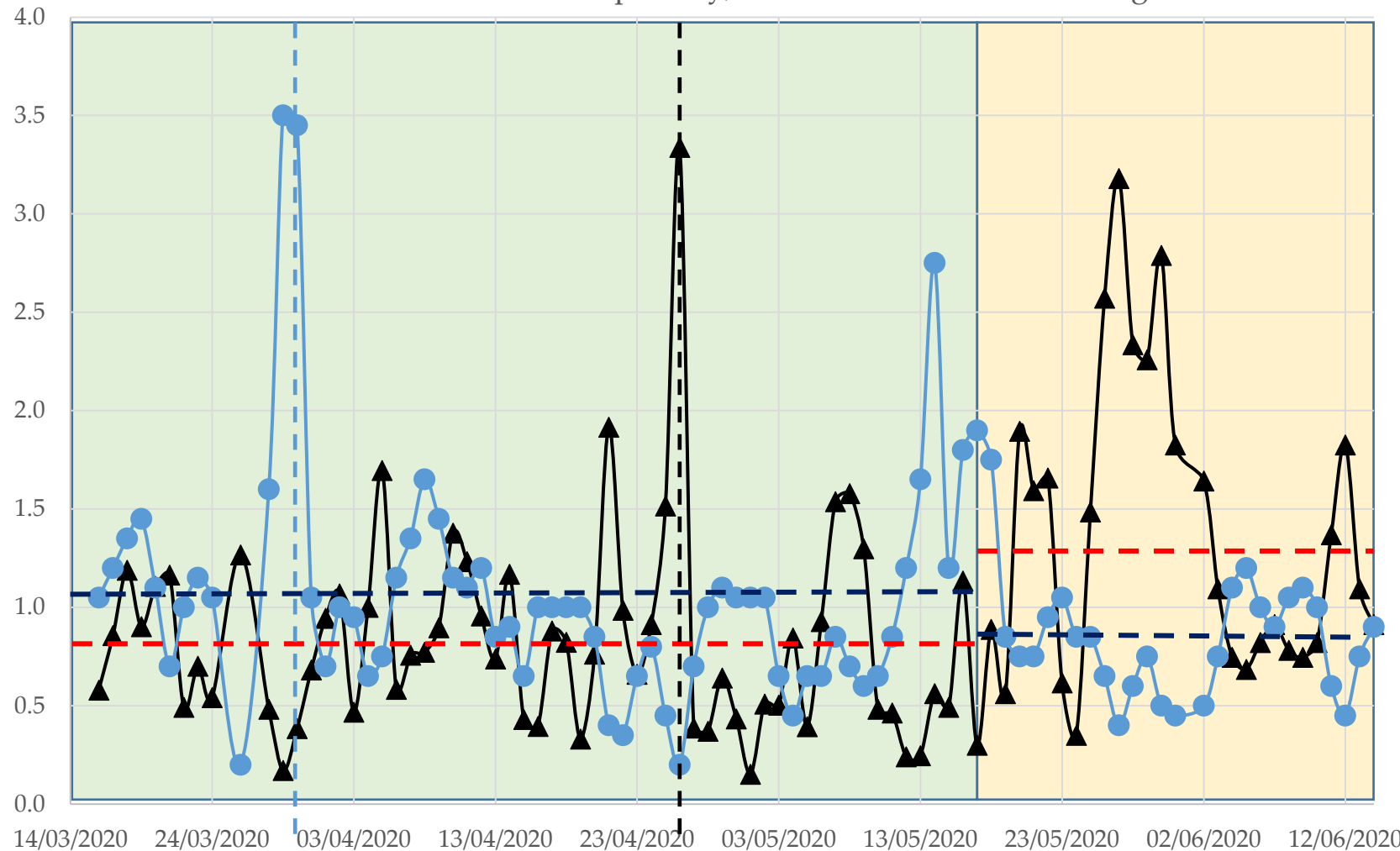
- — — — Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts
- — — — Absolute maximum of mass susceptibility vs PM minimum – highest concentration of magnetic PM
- — — — Average Kmass
- — — — Average PM

SANT'AGOSTINO: correlations



Civitavecchia (urban): Villa Albani (March 16, 2020 – June 14, 2020)

▲ Mass susceptibility; ● PM – normalized to average



Mass susceptibility

max 1.73E-05 m³/kg
 min 7.89E-07 m³/kg
 average 5.18E-06 m³/kg
 average lckd. 4.30E-06 m³/kg
 average p.lckd. 7.19E-06 m³/kg
p (same mean): 0.0003

PM concentration

Max: 70 µg/m³
 Min: 4 µg/m³
 Average: 20 µg/m³
 average lock: 22 µg/m³
 average post 16 µg/m³
p (same mean): 0.06

Magnetite average concentration = 0.55%

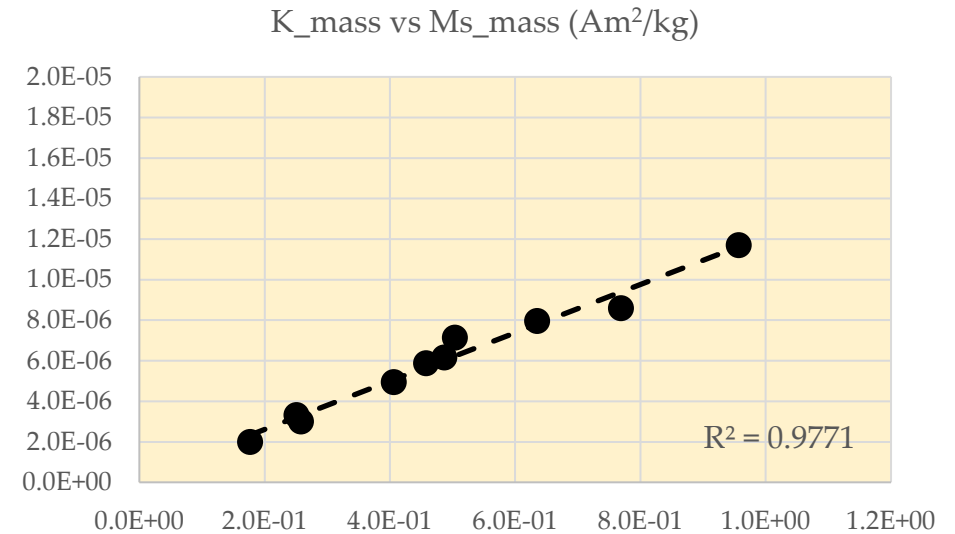
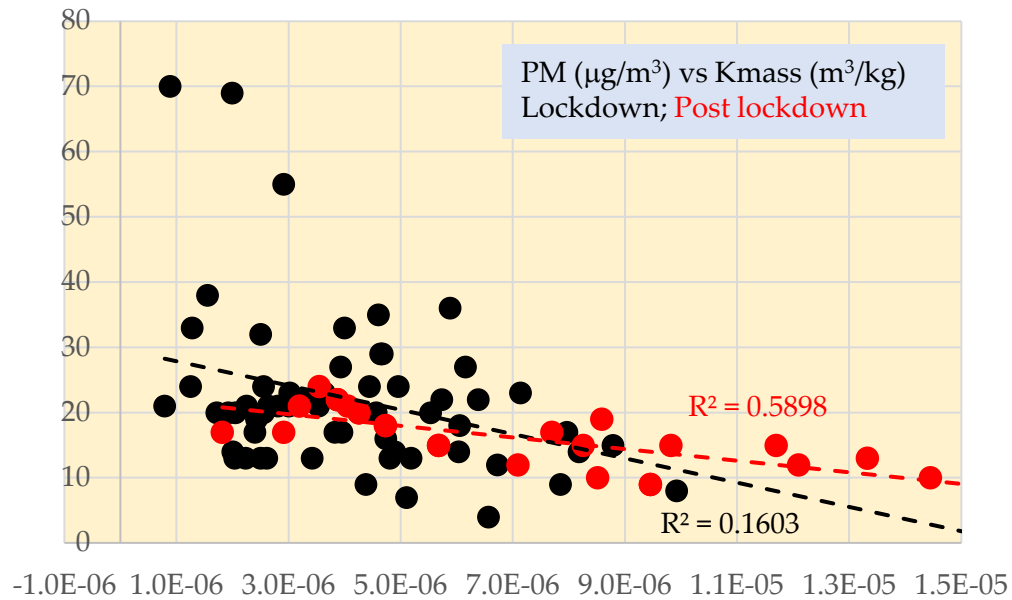
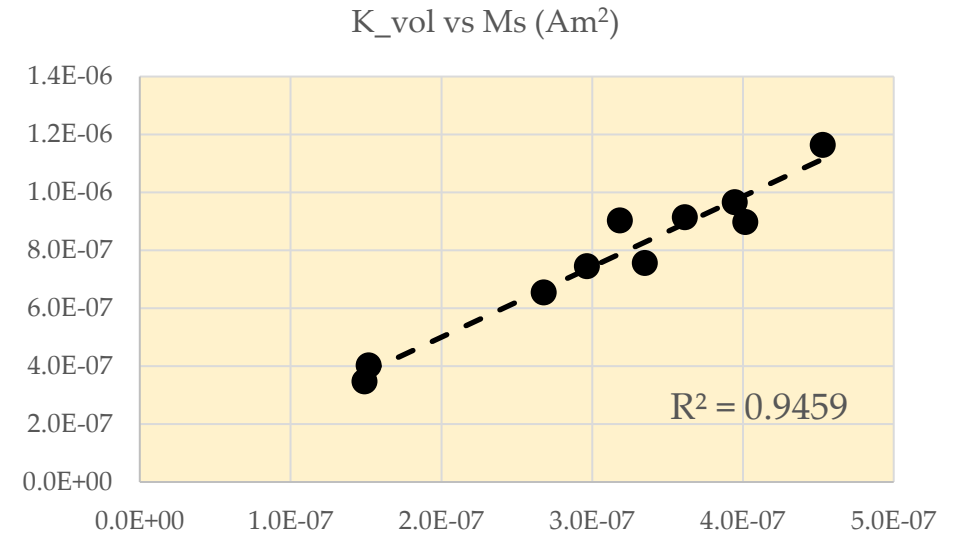
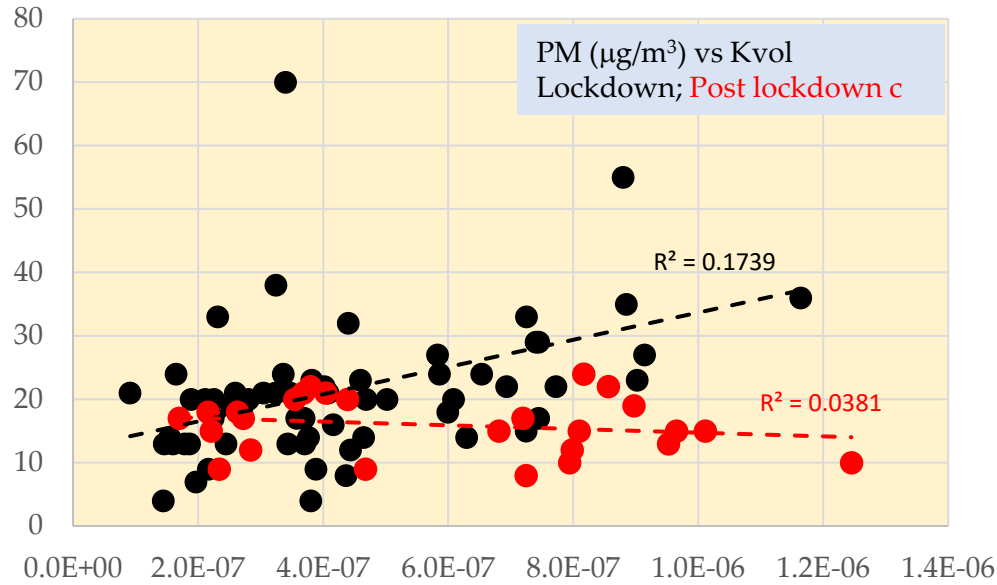
--- Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts

--- Absolute maximum of mass susceptibility vs PM minimum – highest concentration of magnetic PM

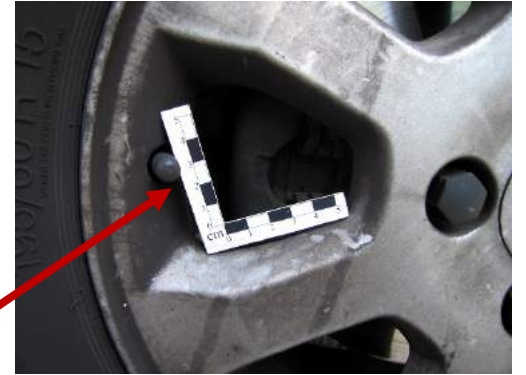
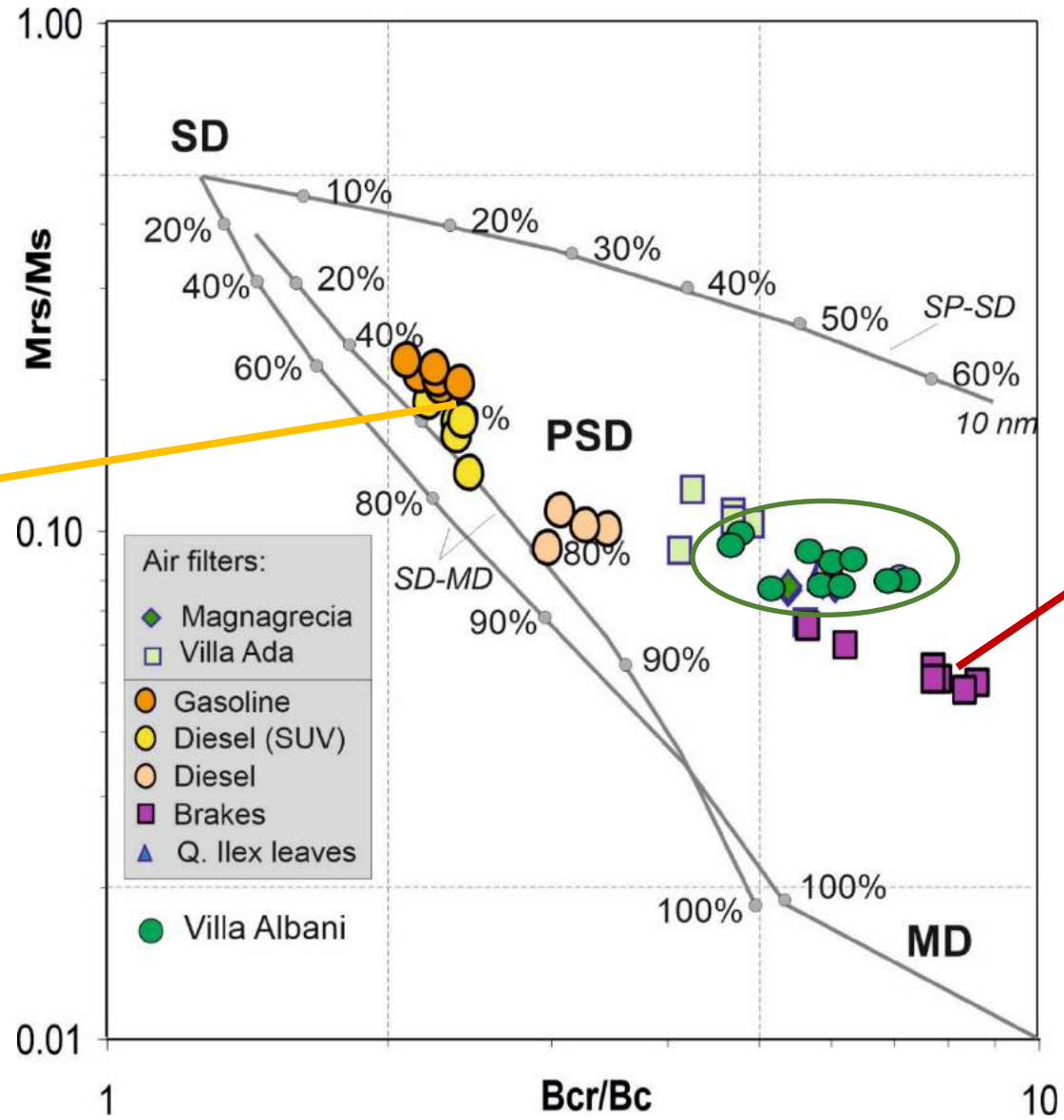
--- Average Kmass

--- Average PM

VILLA ALBANI: correlations



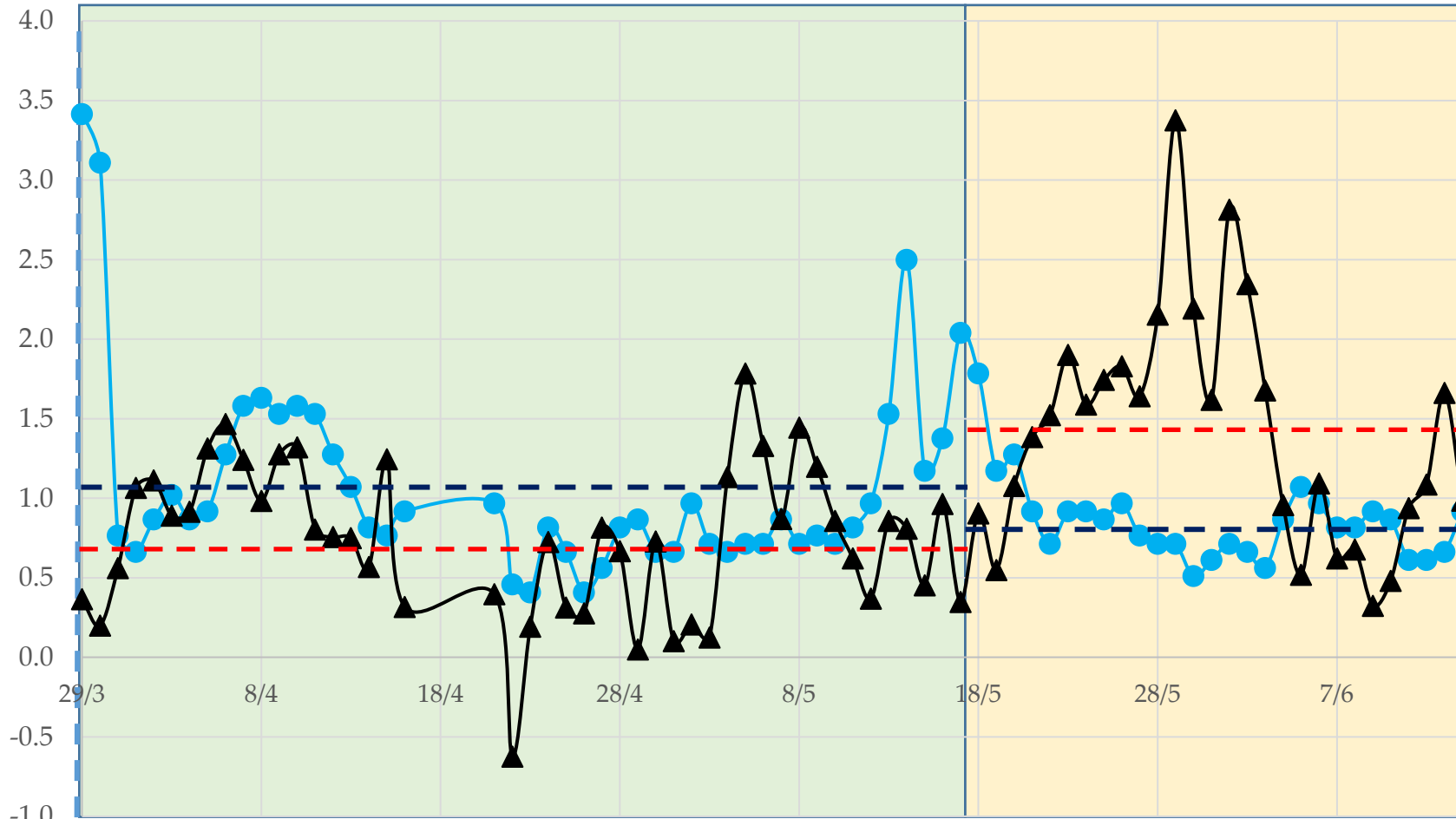
Day plot – Villa Albani



Prevailing Brake Emissions

Intermediate Rural Background: Rome/Fiumicino Castel di Guido (March 20, 2020 – June 14, 2020)

▲ Mass susceptibility; ● PM – normalized to average

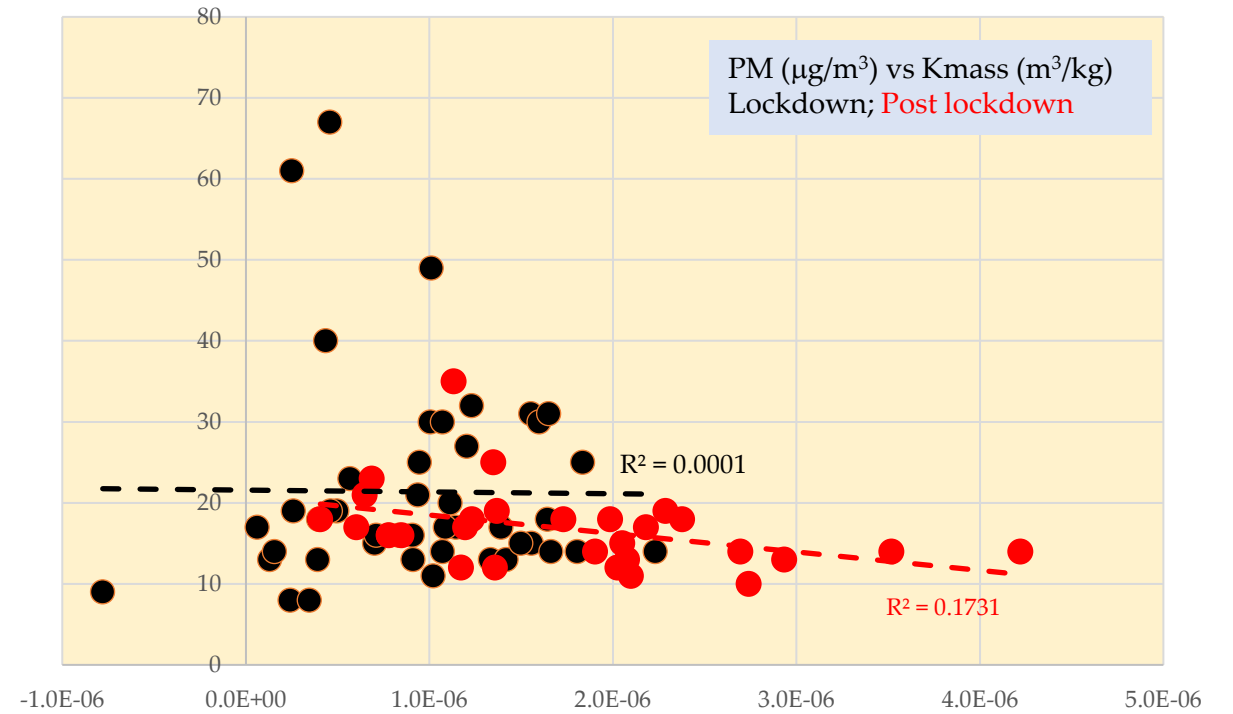
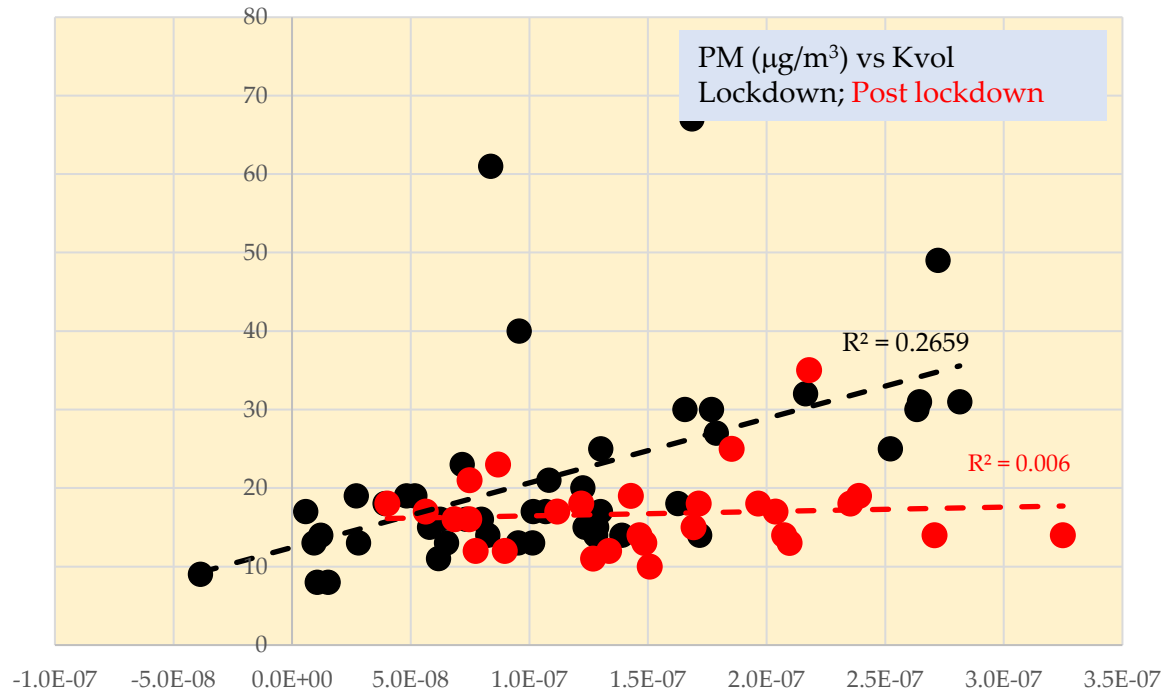


Mass susceptibility
 max 4.22E-06 m³/kg
 min -7.80E-07 m³/kg
 average 1.25E-06 m³/kg
 average lckd. 9.29E-07 m³/kg
 average p.lckd. 1.77E-06 m³/kg
 p (same mean): 5.62E-6

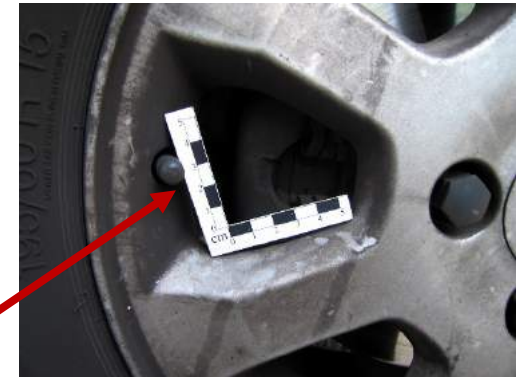
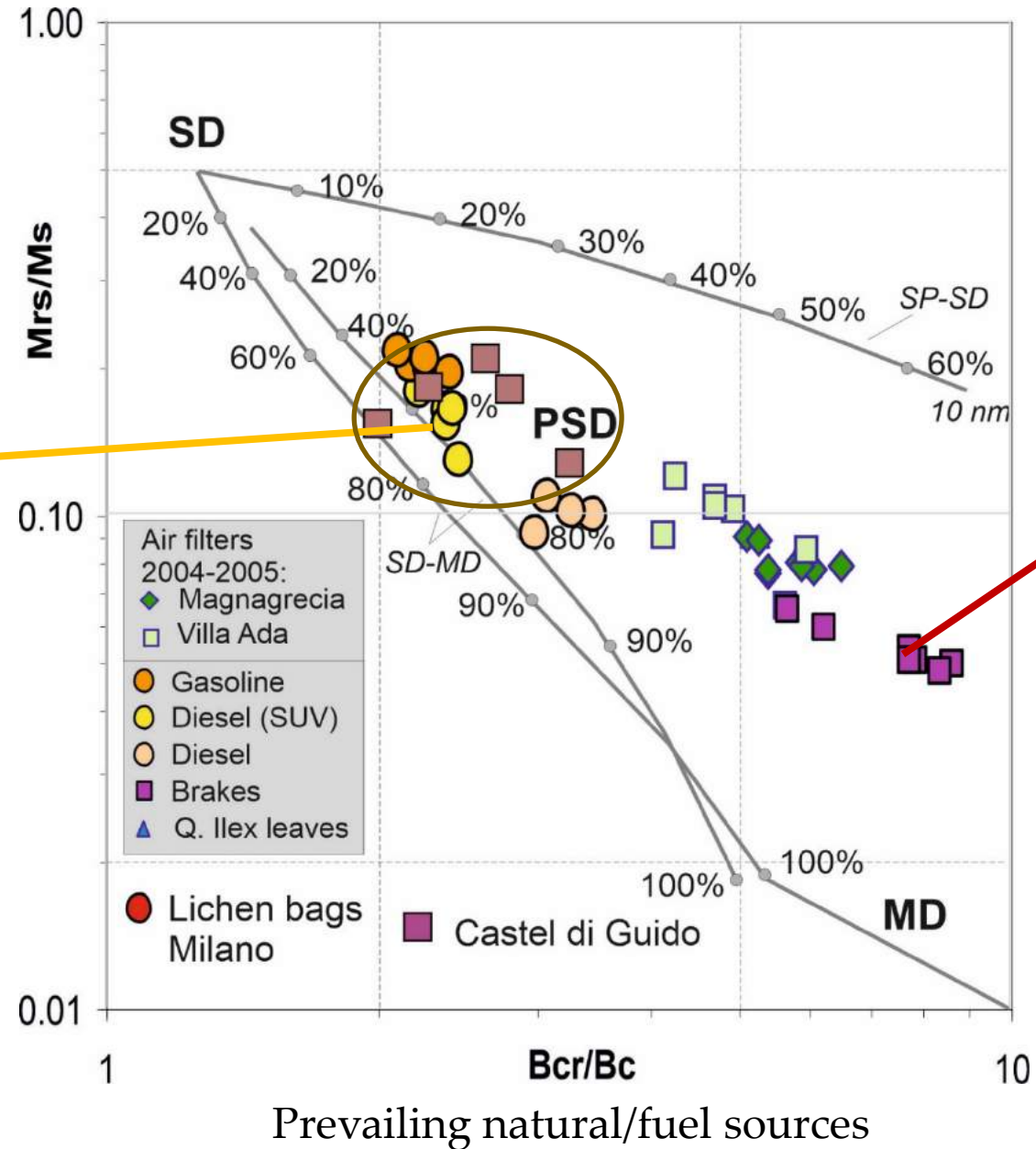
PM concentration
 Max: 67 µg/m³
 Min: 8 µg/m³
 Average: 20 µg/m³
 average lock: 21 µg/m³
 average post 17 µg/m³
 p (same mean): 0.03

- Absolute maximum of PM vs minimum mass susceptibility – input of non magnetic dusts
- Average Kmass
- Average PM

CASTEL DI GUIDO: correlations

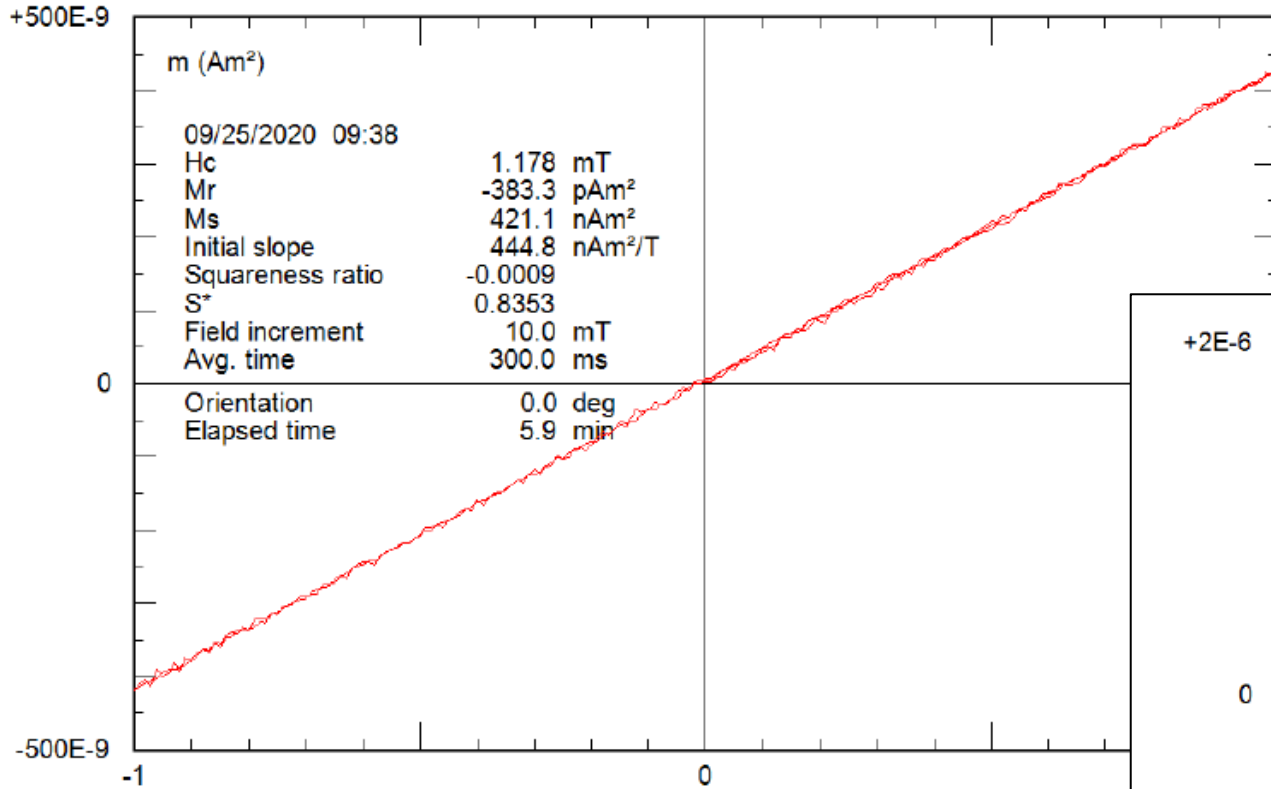


Day plot – Castel di Guido



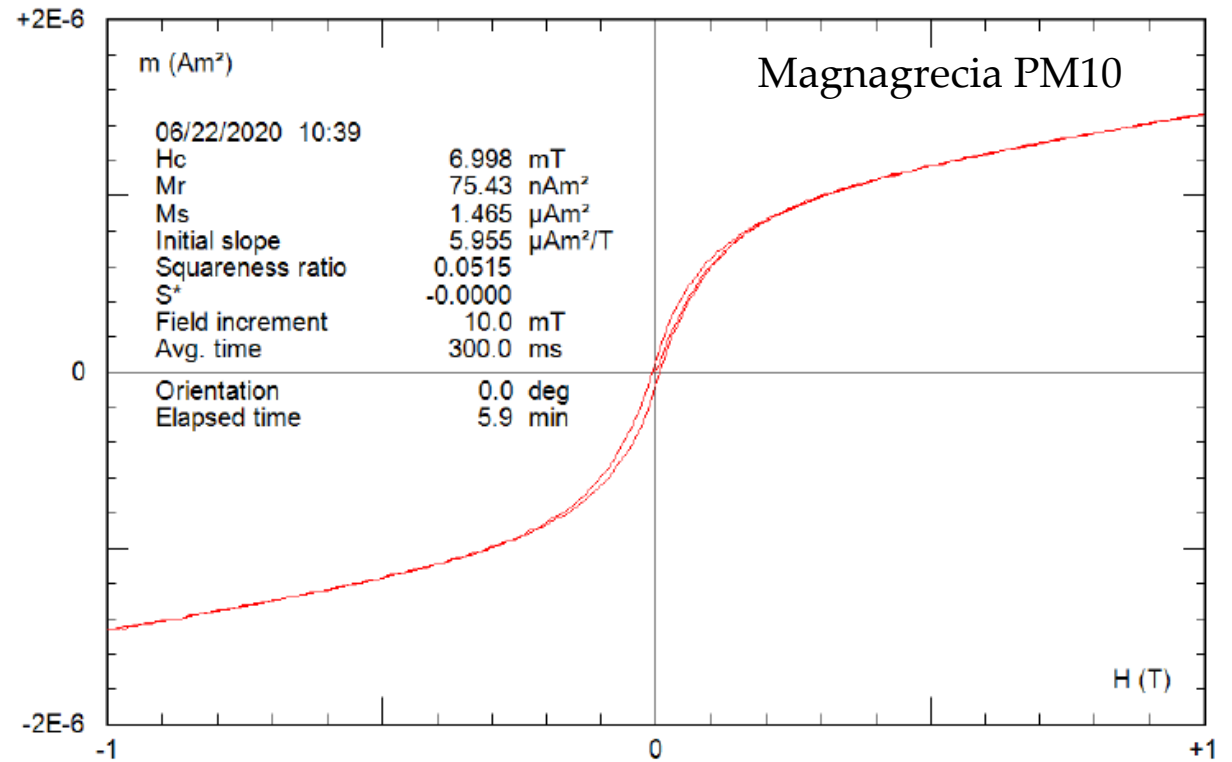
The grainsize: paramagnetism of PM2.5 vs ferromagnetism of PM10

Ferentino PM 2.5



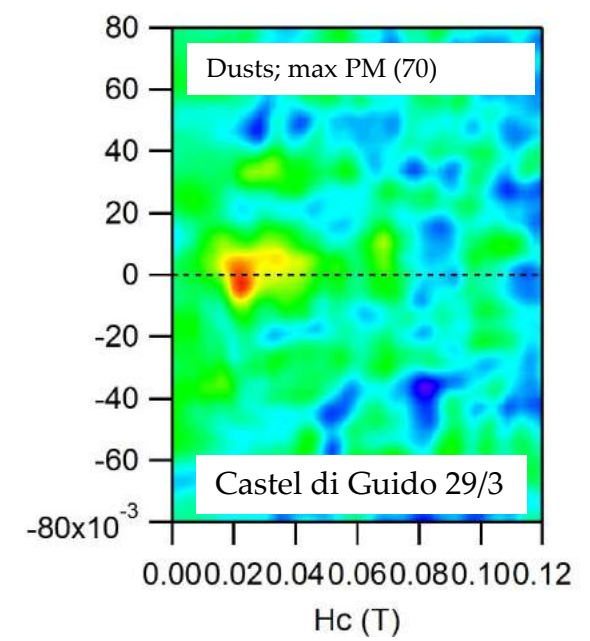
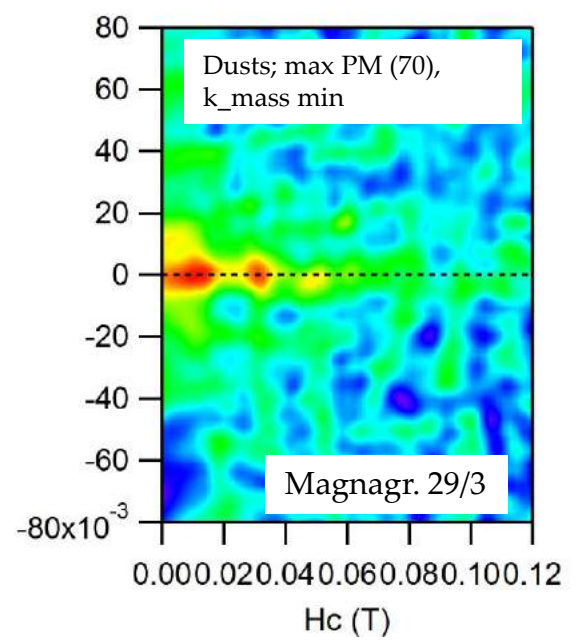
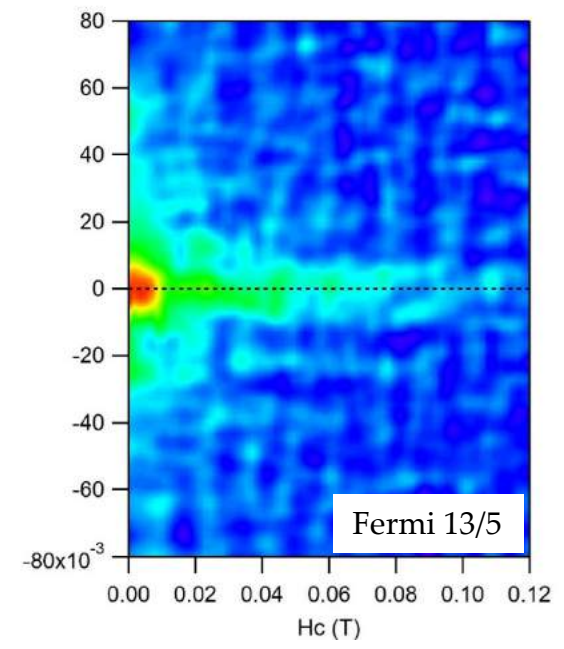
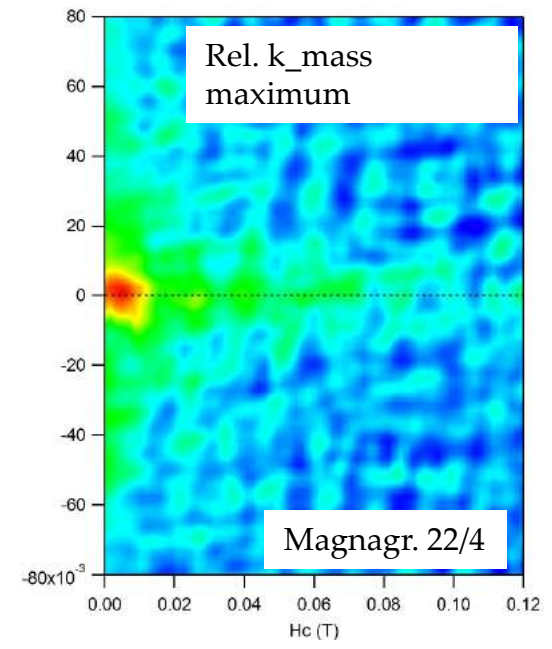
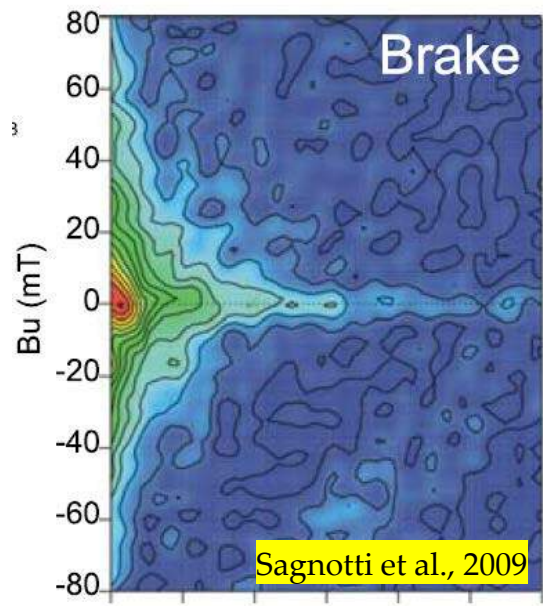
half filter
File: 5_4_hyst(1)

Magnagrecia PM10



Description: [Not assigned]
File: 16_4_hyst

FORC



Conclusions

- ✓ There was a huge debate about the effects of lockdown on PM10 concentration levels: magnetic measurements were successful at understanding the impact of lockdown measures on the abundance and composition of PM10 traffic related dusts.
- ✓ Magnetic measurements highlight persisting high concentration of magnetic minerals in the daily PM filters of busy roads from Latium region during lockdown. Nevertheless, their concentration increases after the strict lockdown and, while the average PM concentration remains the same, the average susceptibility almost doubles.
- ✓ In busy roads, the correlation between PM and volume susceptibility has two distinct regimes during and after the strict lockdown. In general, volume susceptibility is linearly correlated to PM concentration during «end-members» periods, that is prevailing clean (paramagnetic, natural) or heavy polluted (ferrimagnetic, traffic emissions) conditions. An anticorrelation between PM concentration and mass susceptibility emerges during intermediate/mixed conditions.
- ✓ In rural background stations there is no difference between lockdown and post lockdown conditions, for both magnetic susceptibility and PM concentration
- ✓ Non-exhaust PM arising from brakes dominates the magnetic fraction; fuel exhausts and/or natural sources emerge in rural or lower traffic settlements.