Real-time characterisation of the submicronic aerosol and its atmospheric dynamics at the Marseille-Longchamp supersite

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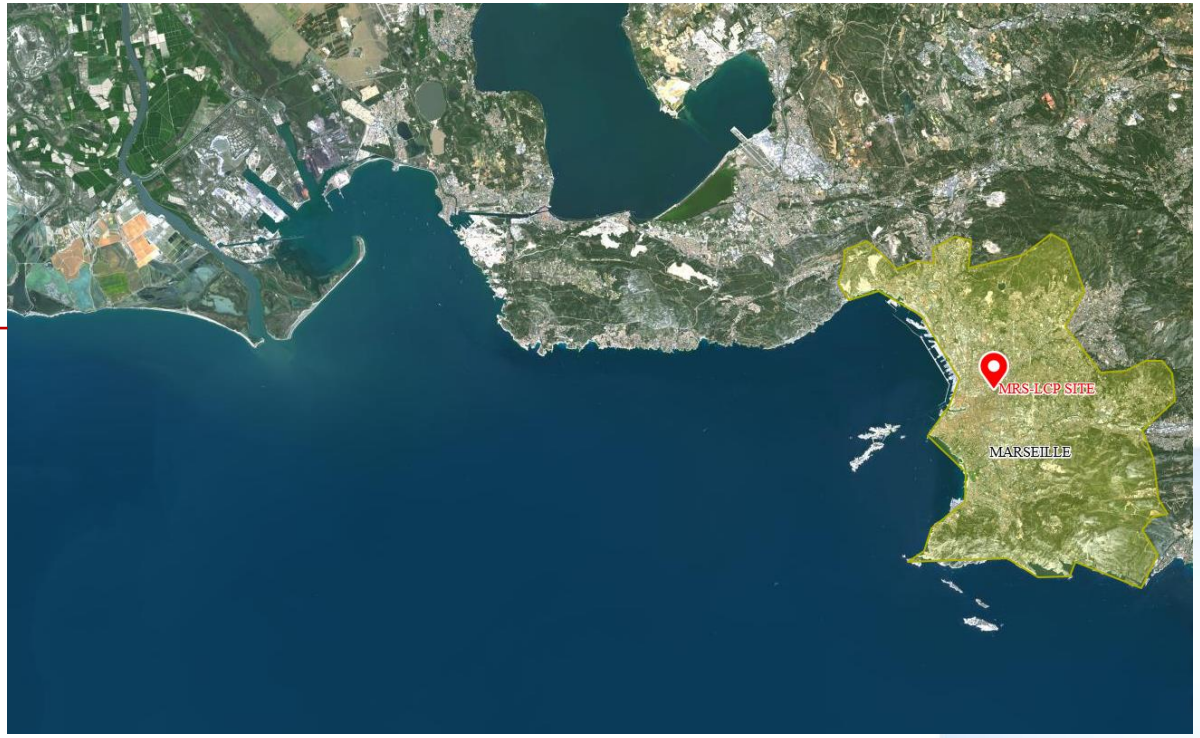
Site description

About MARSEILLE…

- 2nd largest city in France with~870 000 inhabitants
- 3rd largest harbour of mediterranean sea and 1st french harbour



A real **hotspot** in France, where the population is clearly exposed to a complex mixture of pollutants !

Site description

Solar insolation (photo-oxidation)

Specific orography and air mass circulation

Site description

Several sources…

Traffic

Cooking

Wood burning

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Solar insolation (photo-oxidation)

Specific orography and air mass circulation

Industry

Shipping

Some are complex and less described…

Site description: Marseille-Longchamp station

To assess the impact of these sources:

Aerosol super site
Marseille - Longchamp

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To assess the impact of these sources:

Aerosol super site Marseille - Longchamp

- ToF-ACSM
- X-ACT metal analyzer (Since Jul. 2018)
- AETHALOMETER AE33
- SMPS
- Anemometer, temperature sensors, regulated pollutants (NO_x, O_3, SO_2, PM_x,..)

A promising instrument panel for long term measurements 1/ to describe chemical composition of submicron particles and 2/ to apportion their sources

Ultimate goal: **Online Source Apportionment** in order to provide near real time information to the authorities!

PM_1 chemical composition

Concentrations of non-refractory species: Organic aerosol (OA), Sulfate (SO_4^{2-}), Nitrate (NO_3^-), Ammonium (NH_4^+), Chloride (Cl^-)

ToF-ACSM

Aethalomètre AE33

*Concentrations of **Black Carbon (BC)***

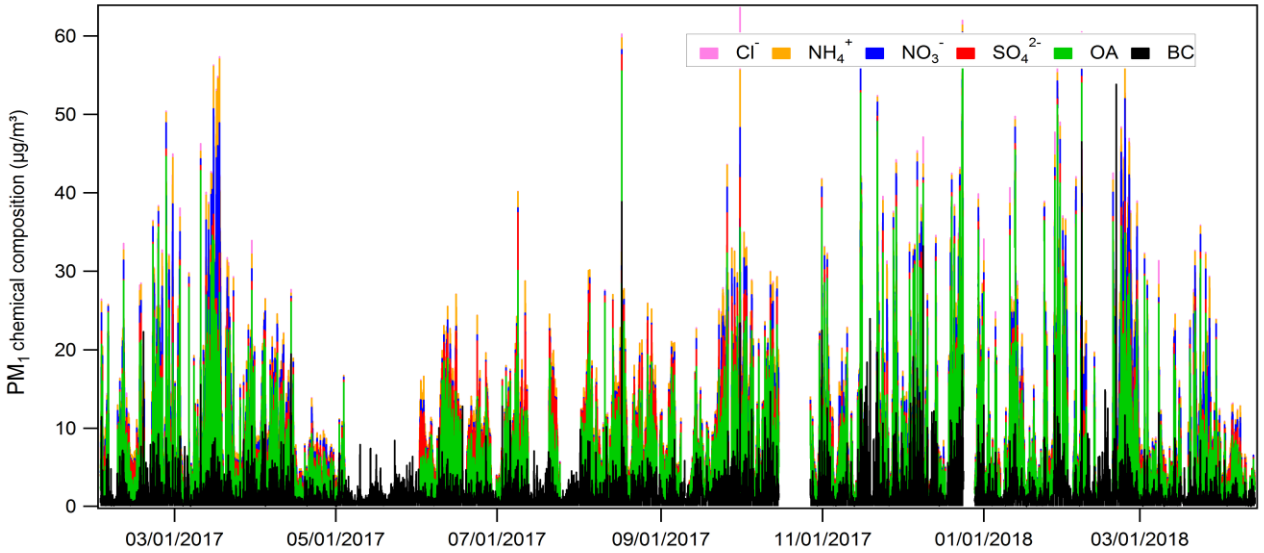
Total chemical composition of PM_1

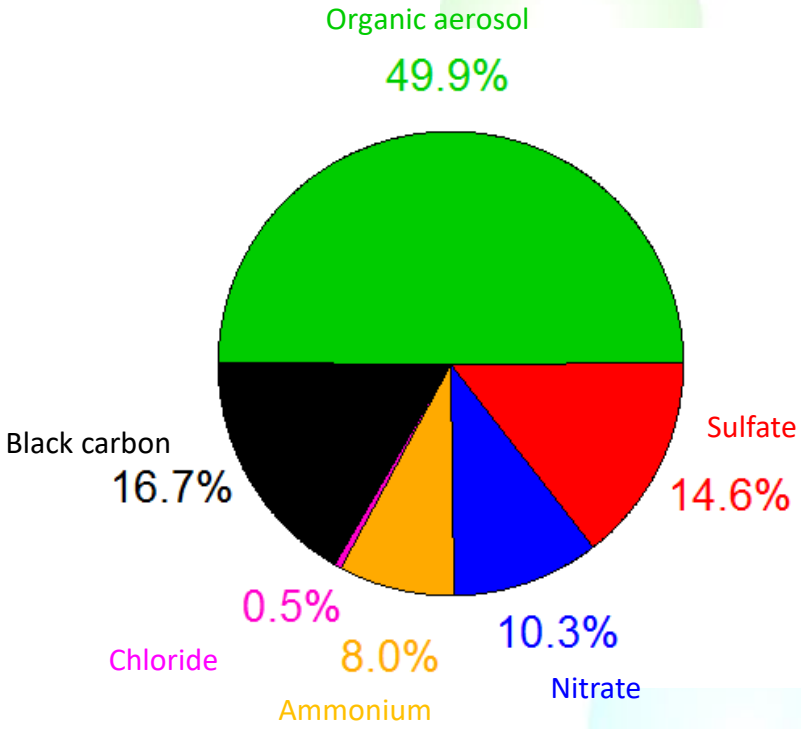
Account for 80-90% of $PM_{2.5}$

Also metals to include…
→ **concentrations << ACSM+BC**

PM_1 chemical composition and sources

Chemical species of PM_1 from **febuary 2017 to April 2018 (14 months)**





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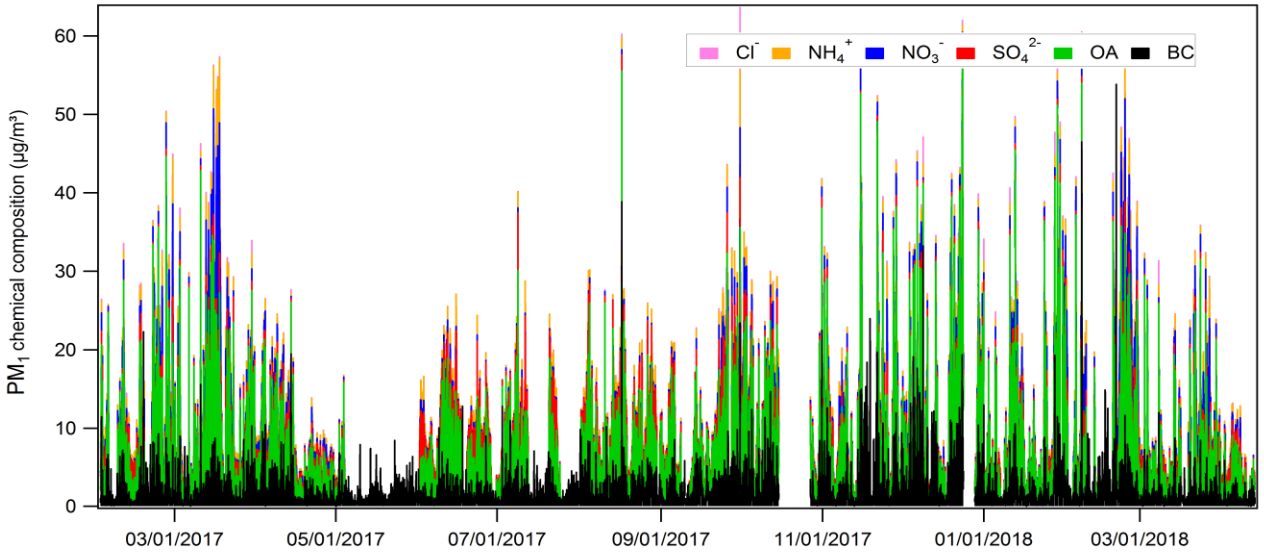


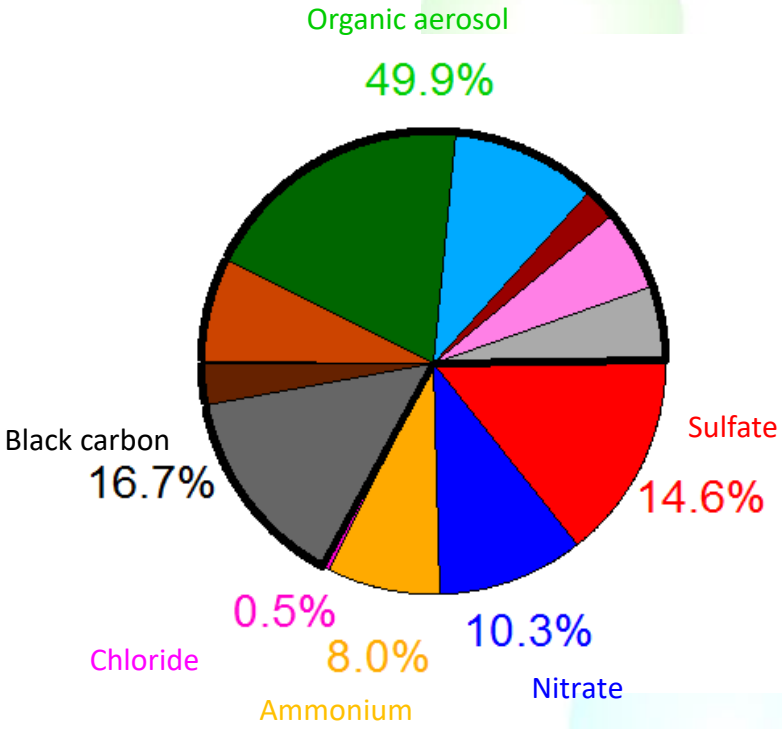
Black Carbon separation:

Fossil fuel = **82%**
Wood burning= **18%**

Source apportionment of OA (based on PMF model):

Road traffic = **11.2%**
Cooking = **11.5%**
Shipping/Industrial = **4.5%**
Oxygenated organic aerosol (less oxydized) = **21.5%**
Oxygenated organic aerosol (more oxydized) = **39.6%**
Biomass burning = **11.7%**

(Chazeau et al., 2021b, in prep.)



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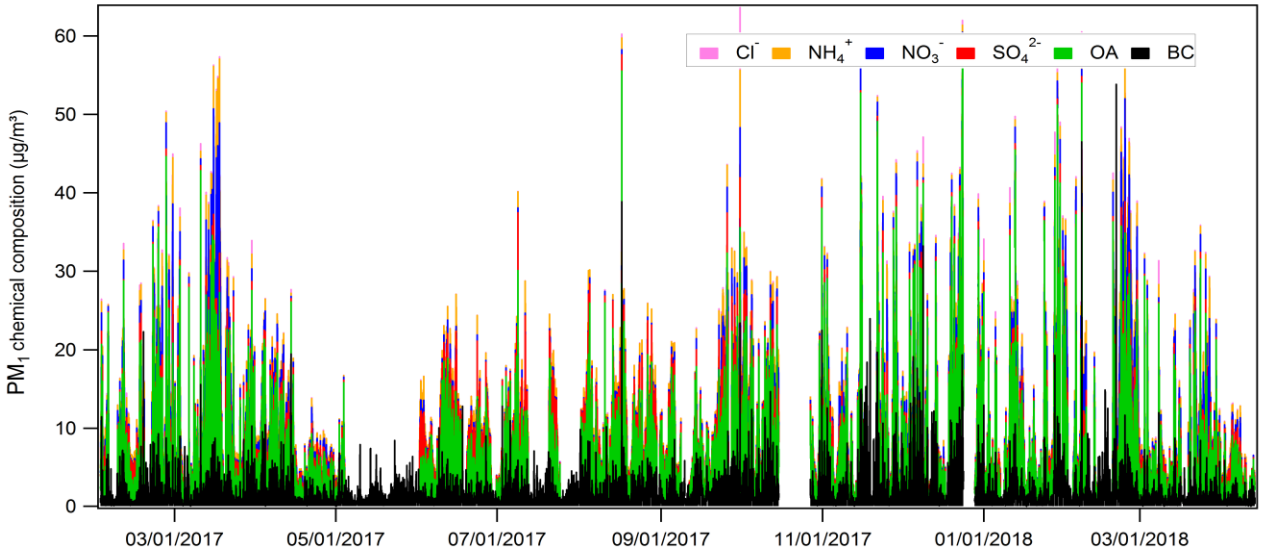
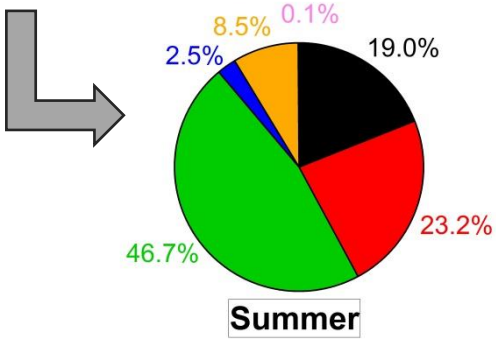
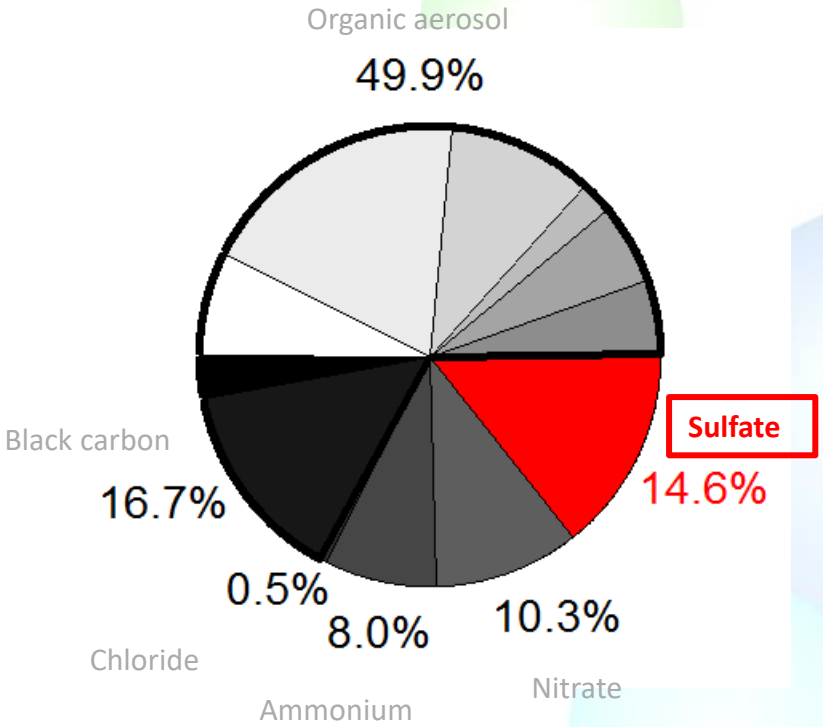


Focus on the sulfate contribution:

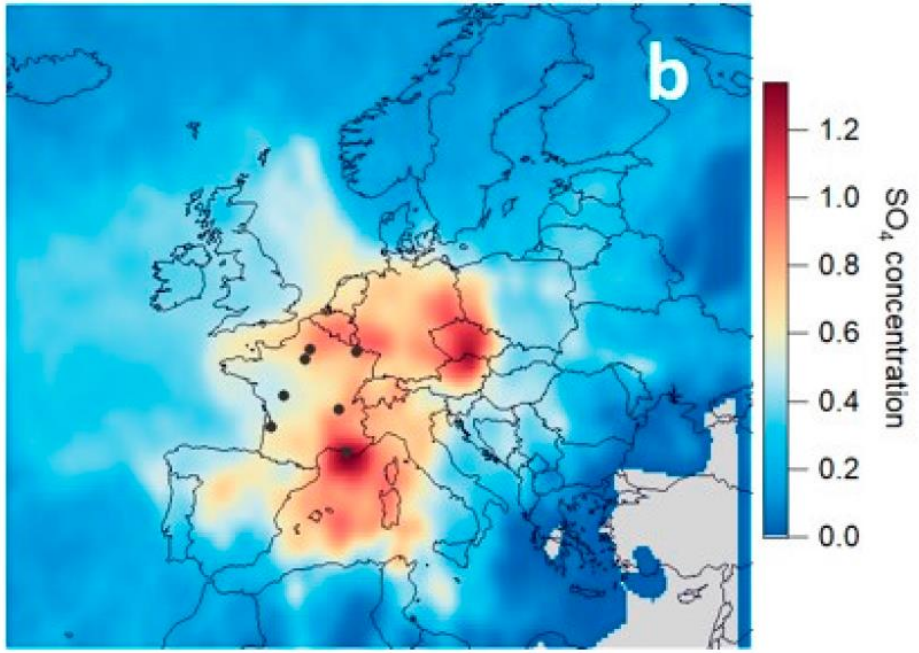
Especially high in summer (23.2%) → Origins ?



(Chazeau et al., 2021a; ACP)



CWT (Concentration-Weighted Trajectory) analysis:
Relates measured concentrations at a receptor site with the localisation of associated air masses.

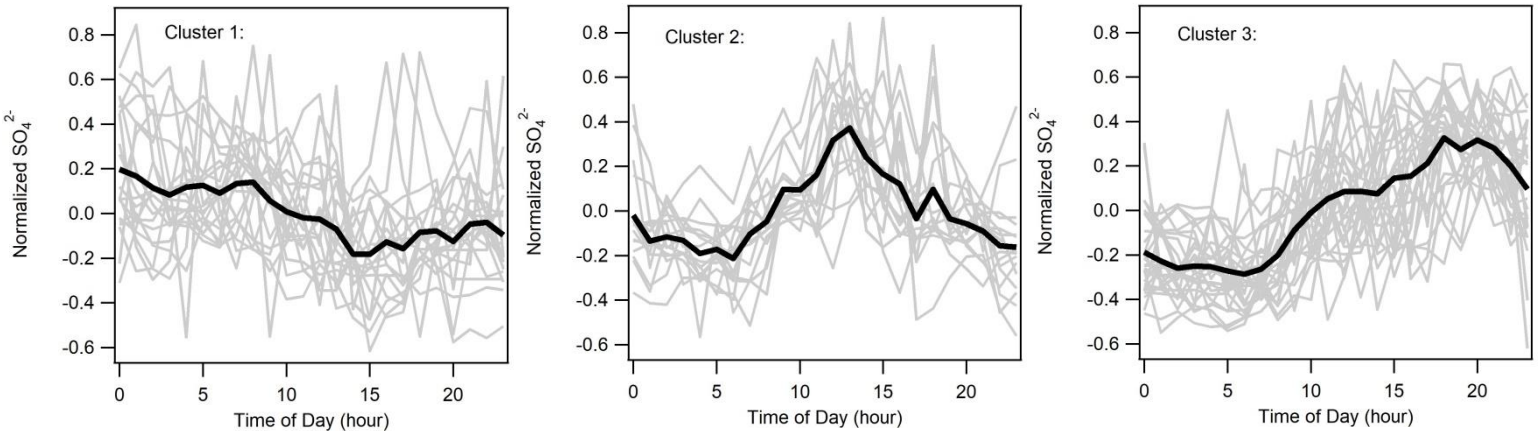


Multi-site **CWT** analysis of sulfate measured by ACSM in 2017 at several CARA stations (Favez et al., 2021)

→ Marseille is a peculiar case with a clear hotspot related to several sources (Shipping, industrial emissions…

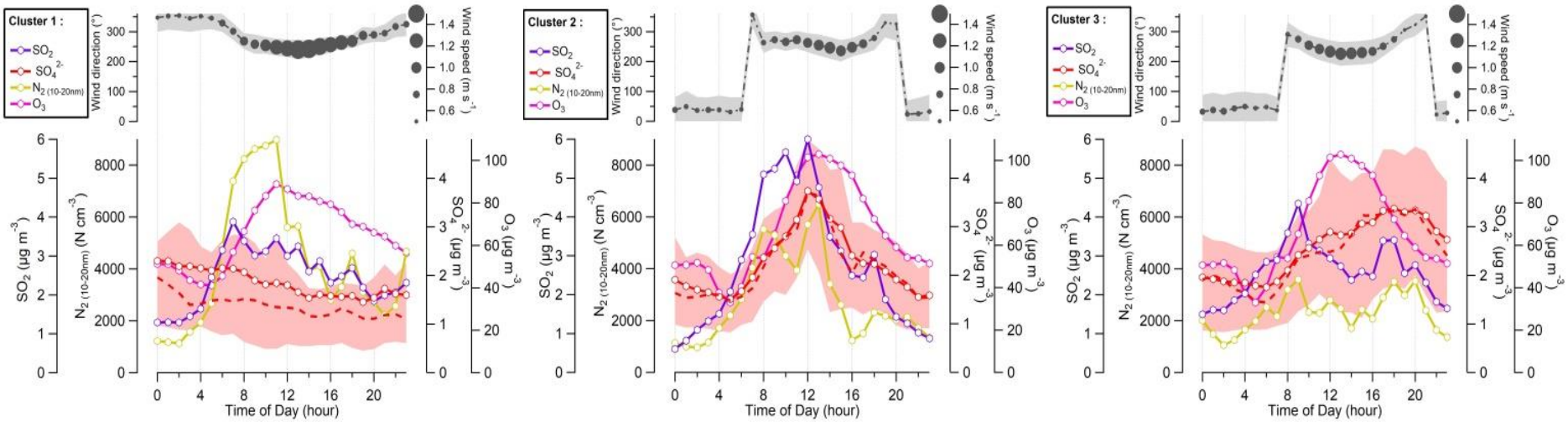
Sulfate origin: K-means clustering analysis

Sulfate origins are inspected based on the diurnal profiles of sulfate concentrations.
Over 63 days in summer 2017, a **K-means clustering analysis** is performed:



3 distinct clusters accounting for 20, 16 and 27 days

Sulfate origin: K-means clustering analysis



- Flat sulfate profile
- Low concentrations, strong winds
- Sulfate decoupled from its precursor (SO_2)

Background level

- Enhanced sulfate under sea breeze advection
- High correlation with SO_2 and $N_{2(10\text{-}20nm)}$

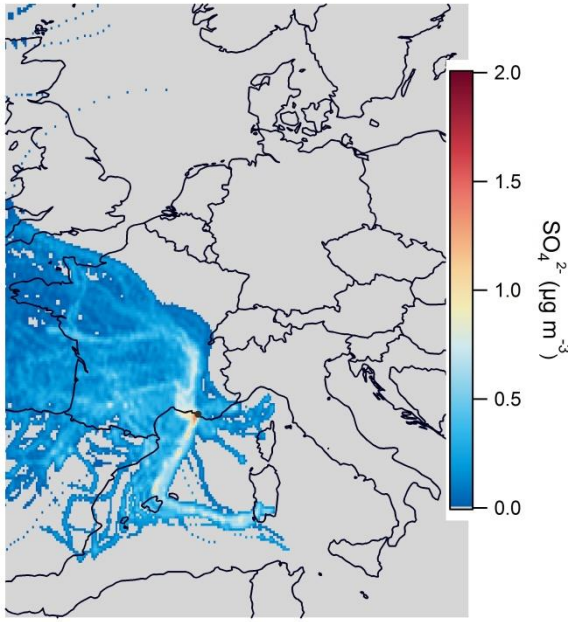
Mixing plumes from local industrial/shipping emissions

- Sulfate progressively increase through the day
- Processed air masses (high sulfate to SO_2 ratio)

Regional influence

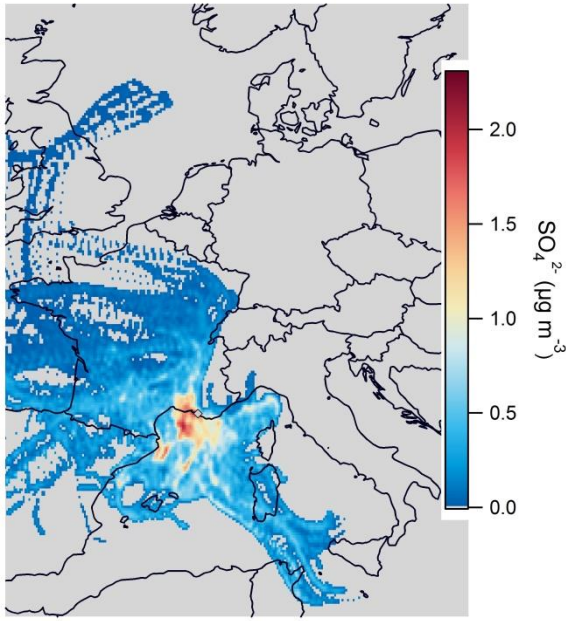
CWT analyses of sulfate clusters

Cluster 1 :
Background sulfate level



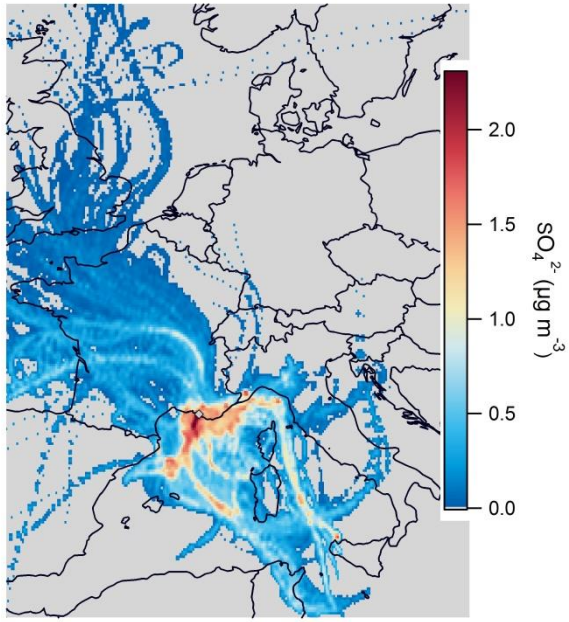
No clear origin

Cluster 2 :
sulfate from local industrial/shipping emissions



« Golfe du Lion » area

Cluster 3 :
Mixed sulfate sources with regional influence



From the north of Spain to the western coast of Italy
→ Main shipping routes ?

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Background sulfate level

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sulfate from local industrial/shipping emissions

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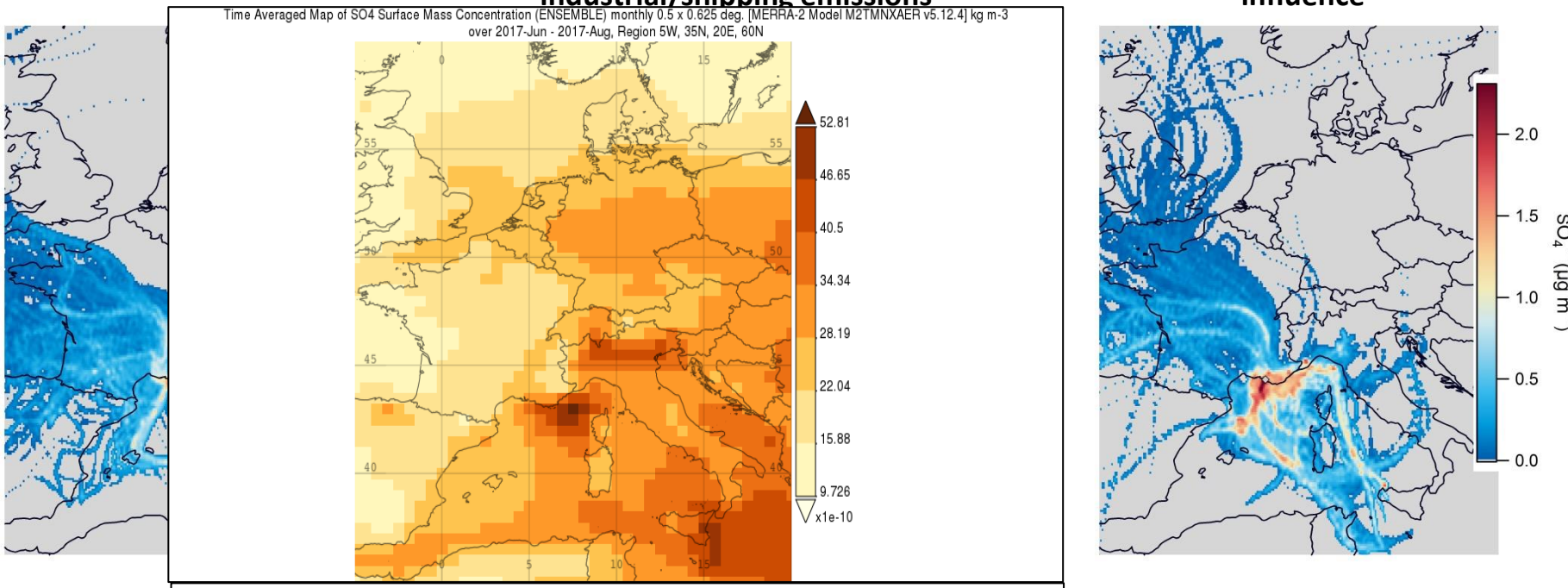

Sulfate distribution from MERRA2 model

No cle

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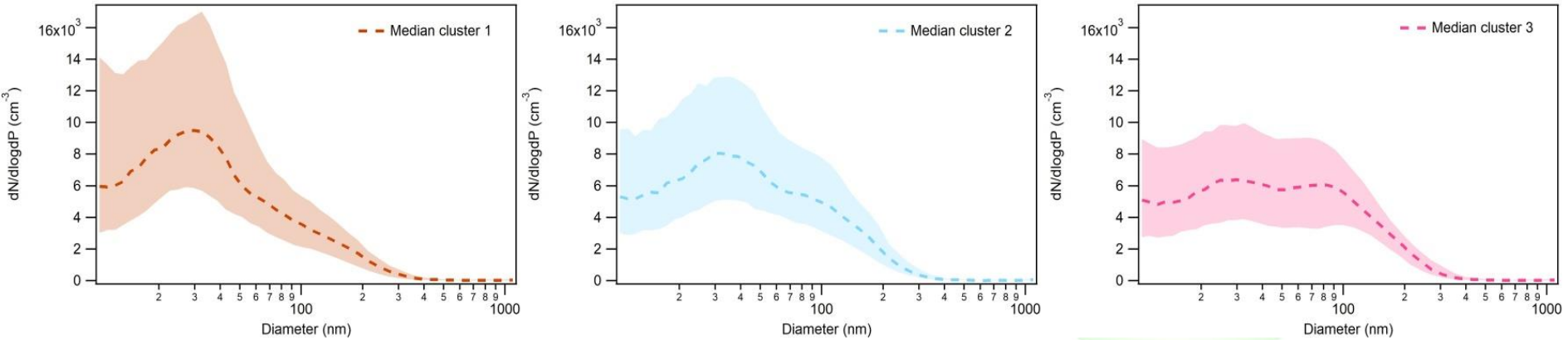
Number size distributions of clusters



More pronounced Aitken mode (20-60 nm) for cluster 2 than for cluster 3.
Accumulation mode (70-200 nm) mostly observed for cluster 3 → aged aerosols

Conclusion

- For ~70% of summer days, the clustering results revealed that sulfate was mainly emitted by **shipping and/or industrial activity (both local and regional origins)**.

- The shipping contribution to sulfate will be further investigated with **PAREA and SCIPPER** campaigns

- To asses the separation between shipping and industrial emissions contributions, **source apportionment models (PMF)** are needed.

- PMF have to be performed over the **entire PM_1 chemical composition** (OA, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, BC and metals).

Thank you for your attention

View from palais Longchamp - Marseille

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