Constraining the aerosol direct radiative effect in the framework of the ACROSS campaign held during the June-July 2022 intense summer heatwave period

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Outline

- CONTEXT AND OBJECTIVES
- METHODS
- THE ACROSS CAMPAIGN - MODELLING
- CONCLUSION

CONTEXT AND OBJECTIVES

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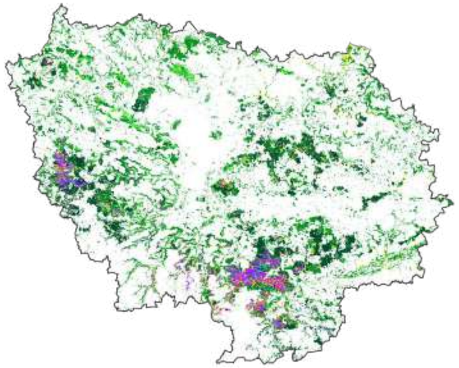
Objectives and strategy

Ile De France



ACROSS CAMPAIGN June-July 2022

Direct Radiative Effect (DRE)

AOD, SSA, G

Chimere

Aerosol Mass

Complex Refractive Index

Size Distribution

Observations constraint on model input/output

Why the IDF?

- one of the most dense populated and polluted region in Europe
- dense polluted agglomeration, surroundend by forests anthropogenic/biogenic aerosol mixing
- ideal situation to test model capacities to reproduce such mixings – still not extensively investigated
- The ACROSS campaign JJ 2022

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METHODS

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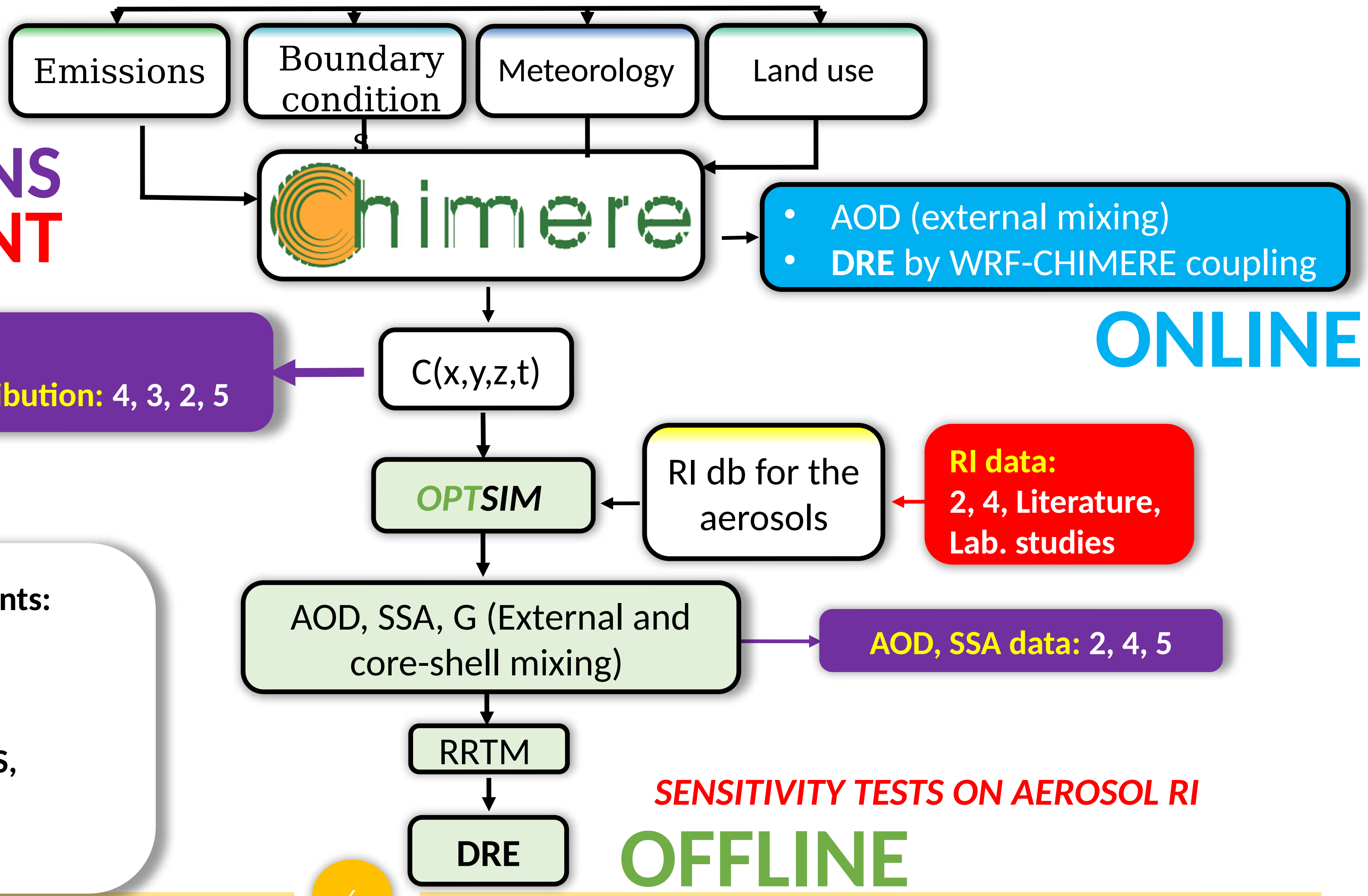
Tools and methods

COMPARISONS
CONSTRAINT

Gas species: 4, 1, 3,
Aerosols mass and size distribution: 4, 3, 2, 5



1. **Continuous measurements:** EEA, AIRPARIF, EBAS
2. **AERONET**
3. **Ballon de Paris**
4. **Field Campaign: ACROSS,** Aircraft vertical profiles
5. **Sirta observatory**

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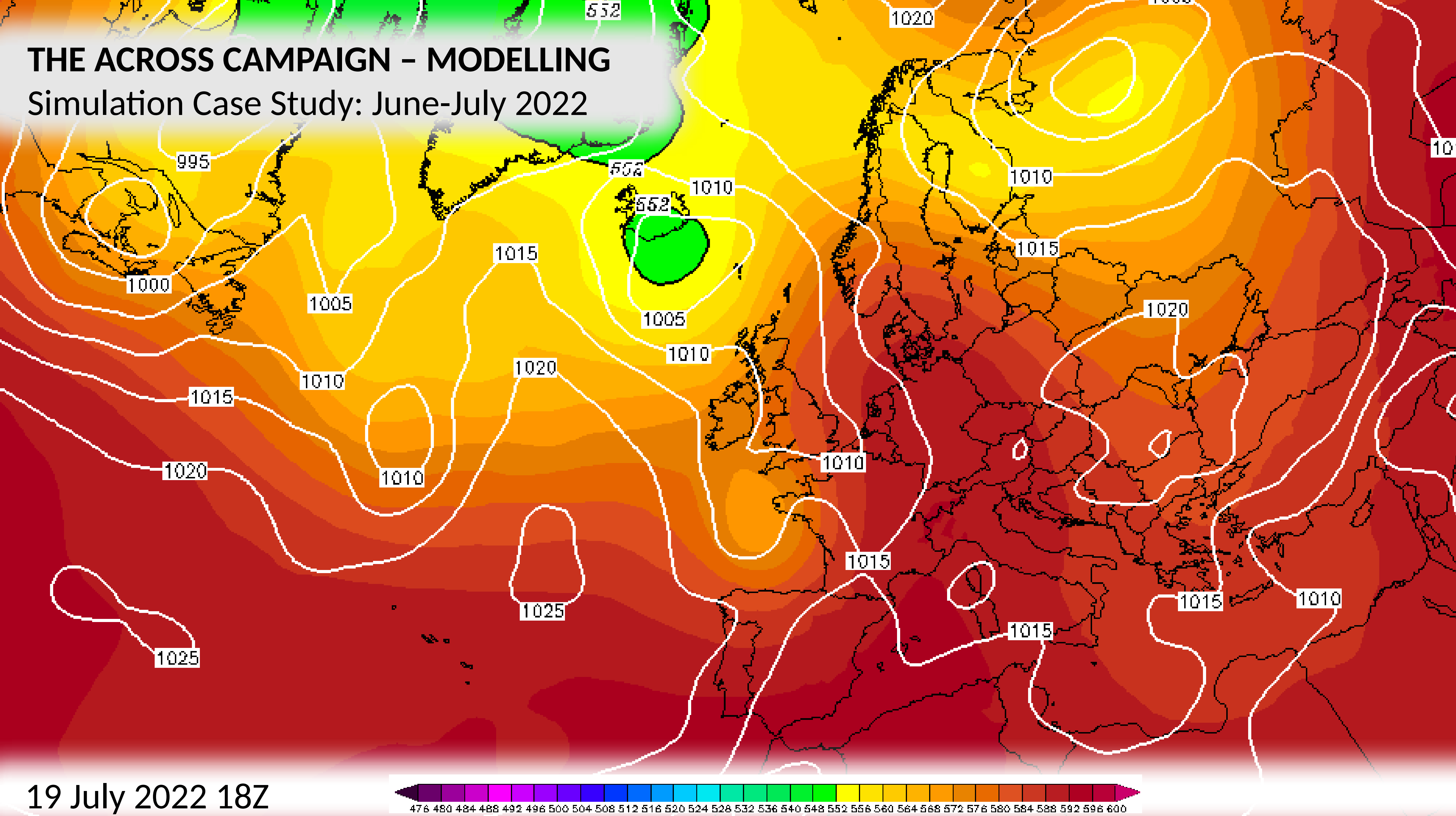
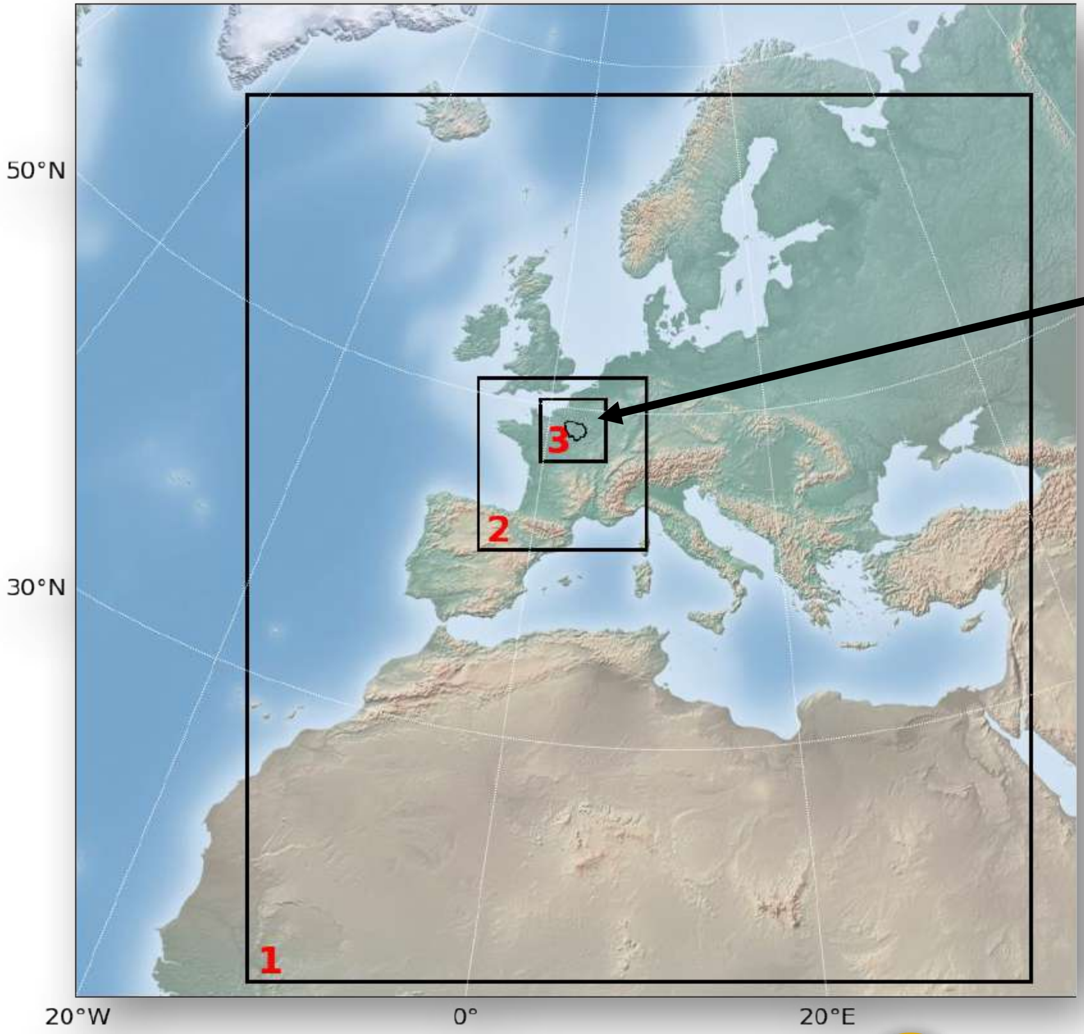
THE ACROSS CAMPAIGN – MODELLING

Simulation Case Study: June-July 2022



19 July 2022 18Z

CHIMERE ACROSS CONFIGURATION



CHIMERE Configuration 30, 6, 2 Km

- **CHIMERE v2020r3 version**
- **POA scheme=3** with fragmentation and non-volatile
- **SOA scheme=7** VBS with functionalization, fragmentation, non-volatile

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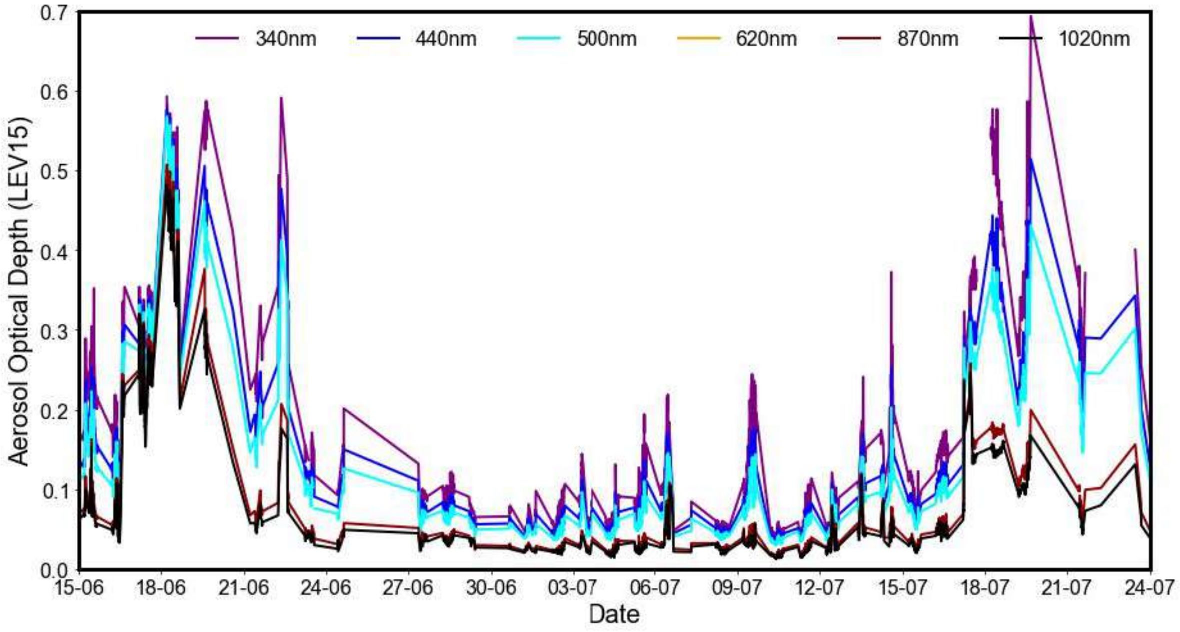
OVERVIEW OF THE ACROSS CAMPAIGN

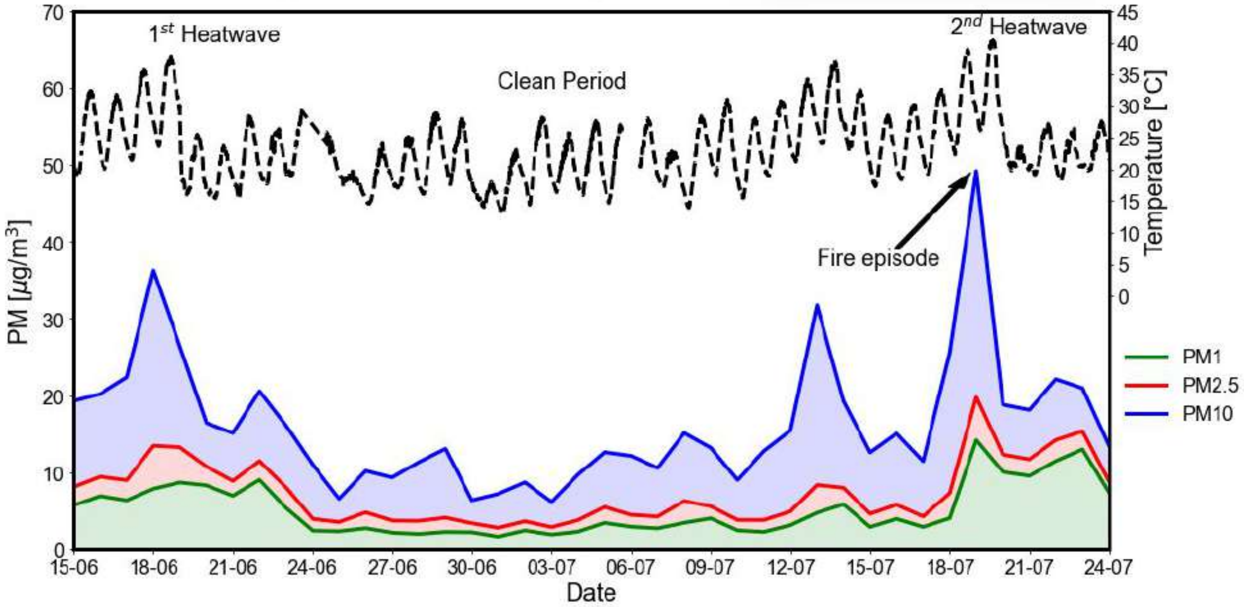
Aerosol Optical Depth from AERONET Sun-photometer

PM Concentrations

Rambouillet

Paris city





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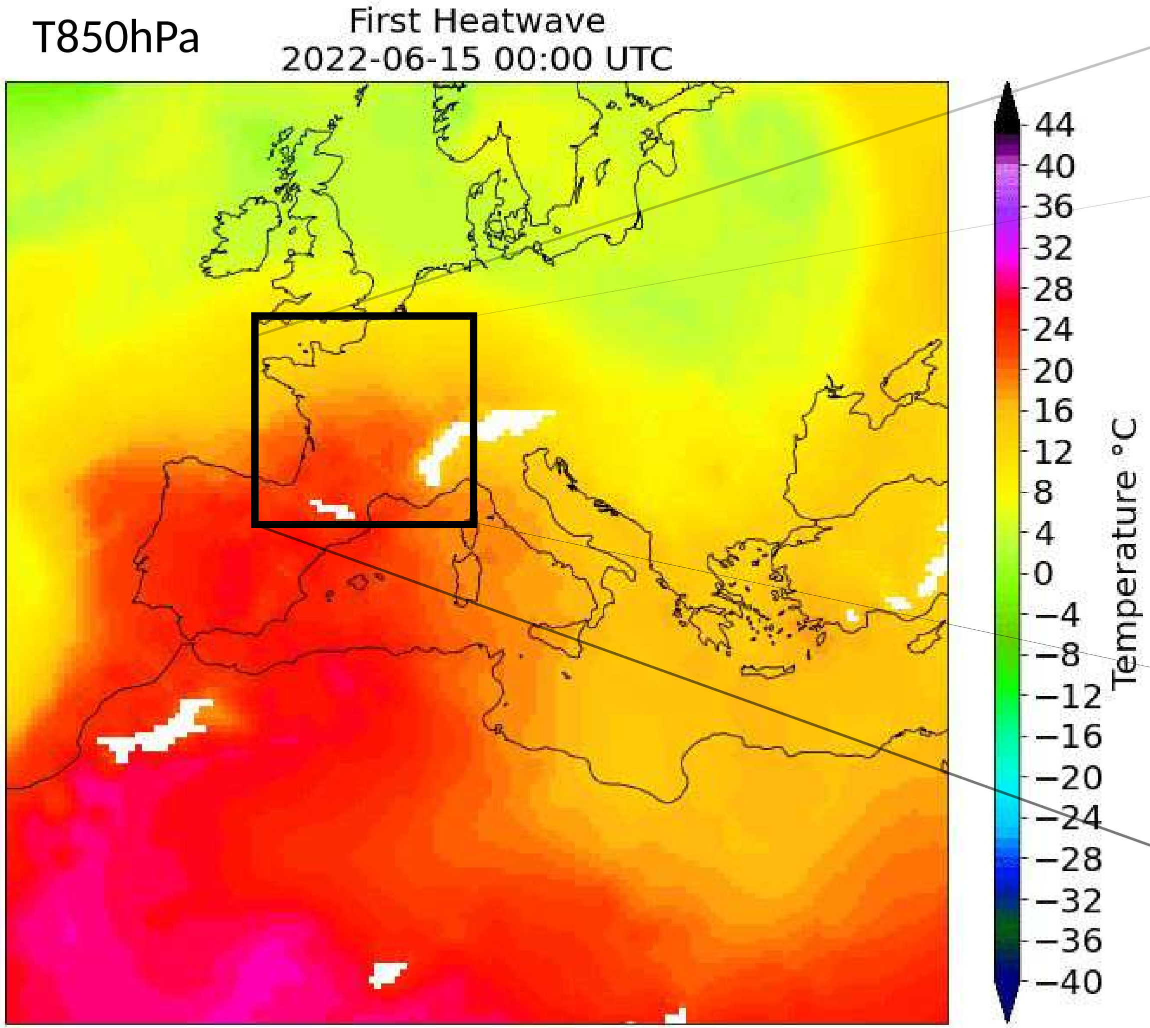
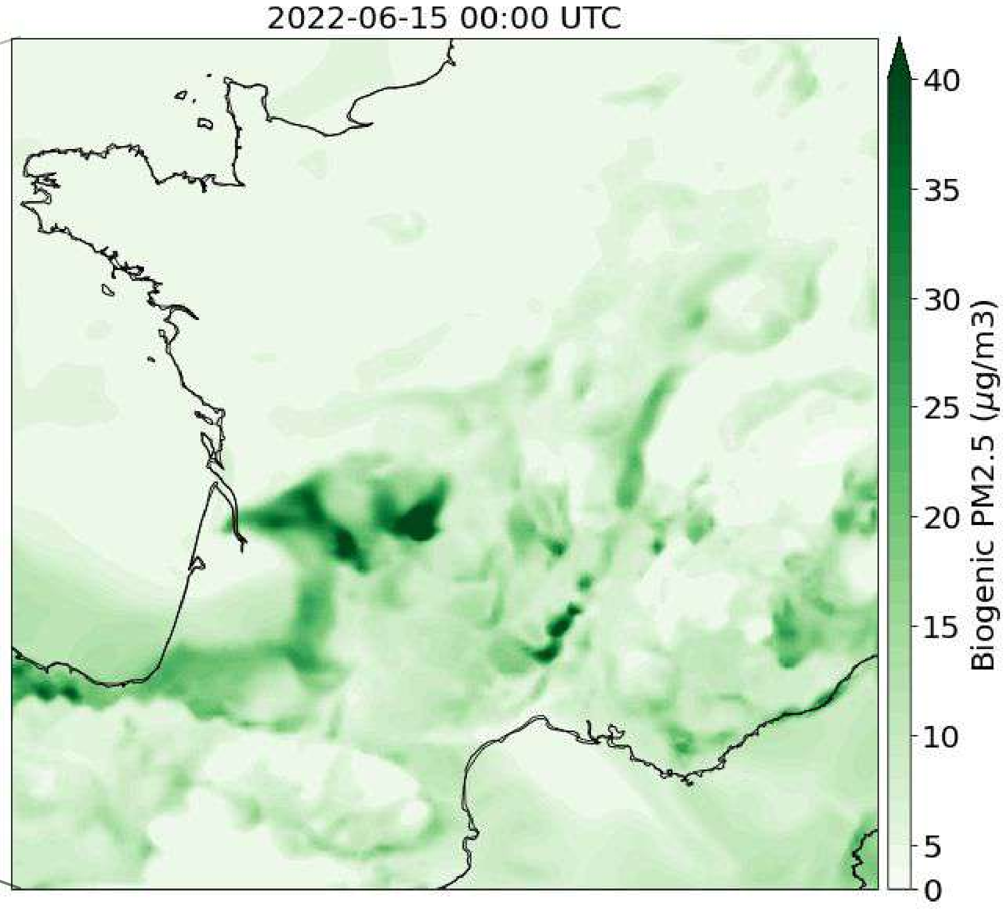
T850hPa and Bio PM2.5 simulation

T850hPa





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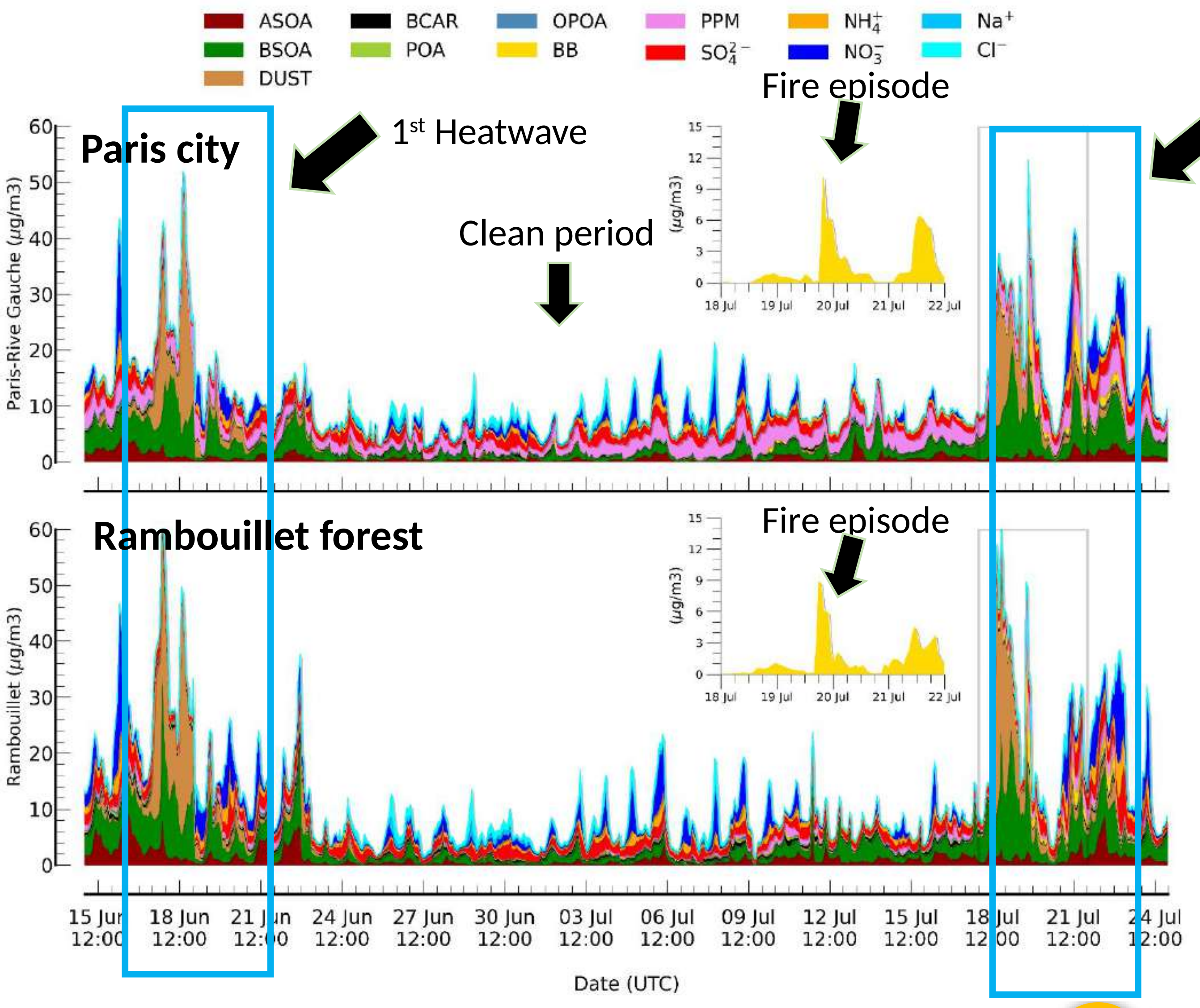
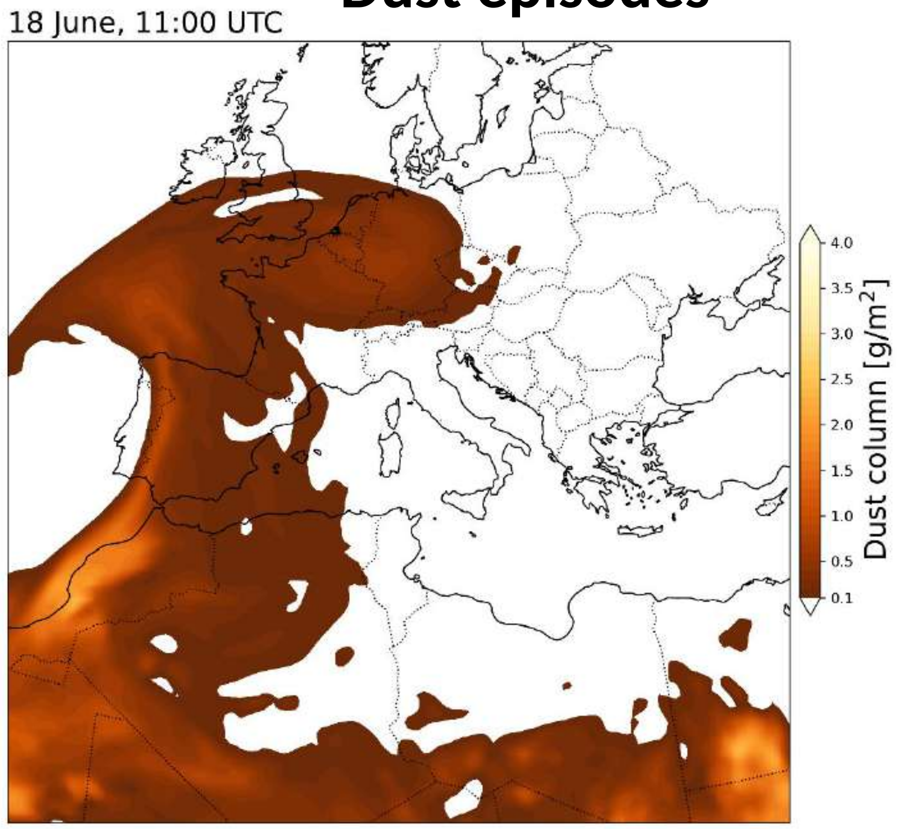
AEROSOL CHEMICAL COMPOSITION SIMULATED (PM_{tot})



Dust episodes



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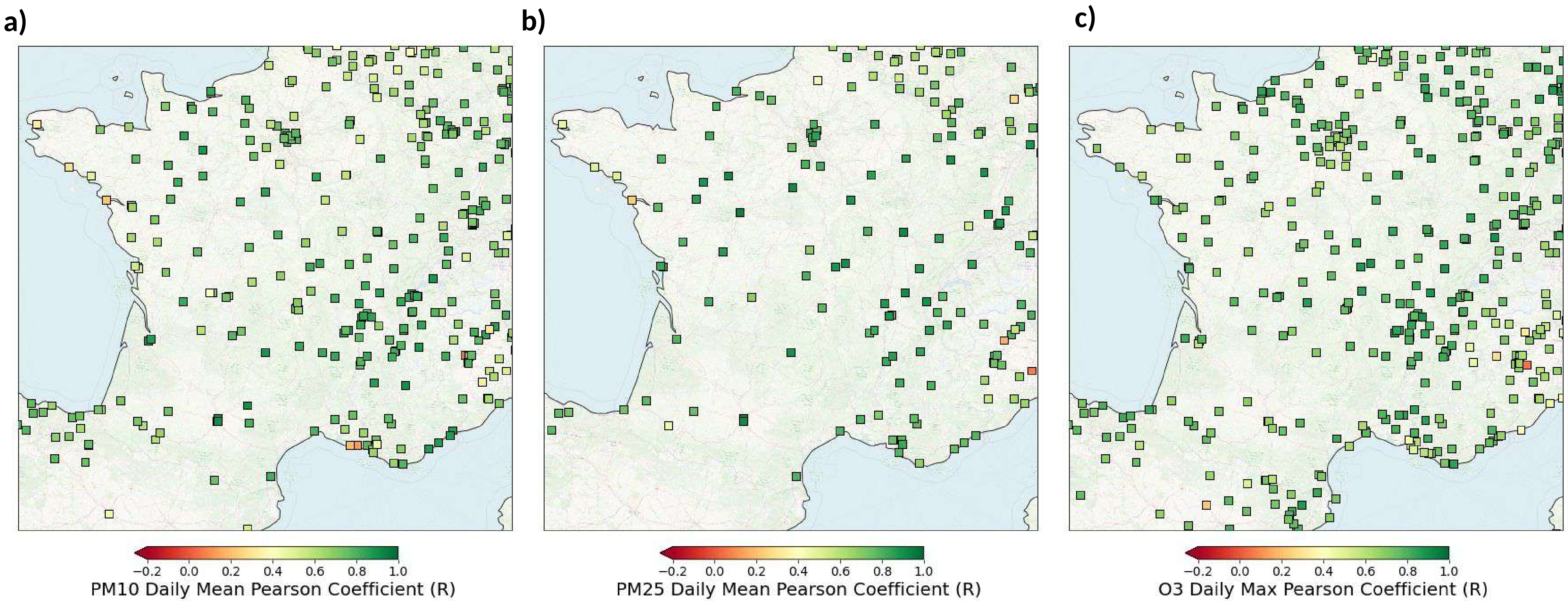
PM10, PM2.5 and O3 validation



PM10, PM2.5 and Ozone Pearson Coefficient for the entire ACROSS campaign 2022. Data Source: EEA

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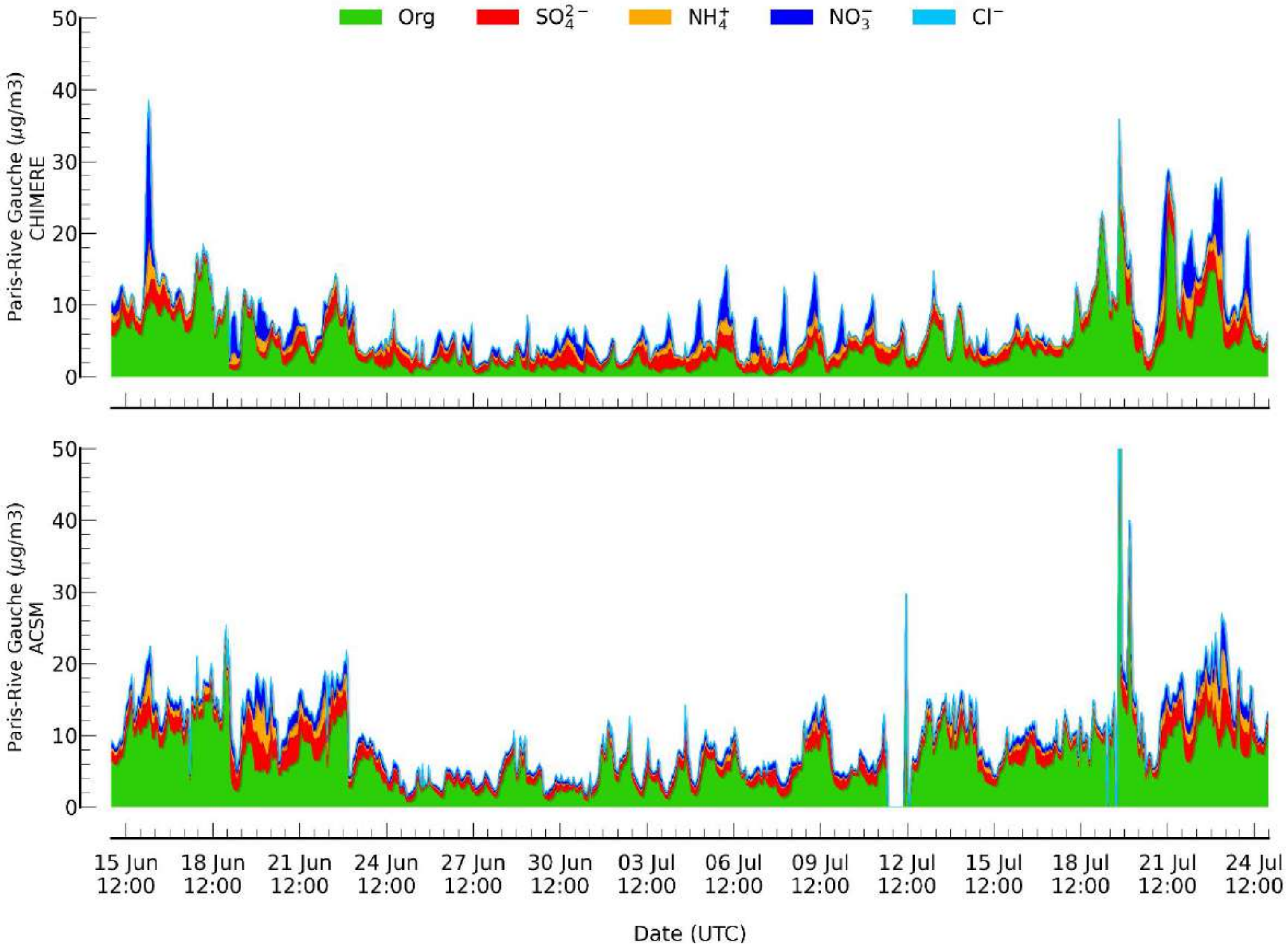
AEROSOL CHEMICAL COMPOSITION (PM_1)



Simulated Paris city with the CHIMERE model

Measured by the ACSM at Paris city

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AEROSOL OPTICAL PROPERTIES AND DIRECT RADIATIVE EFFECTS

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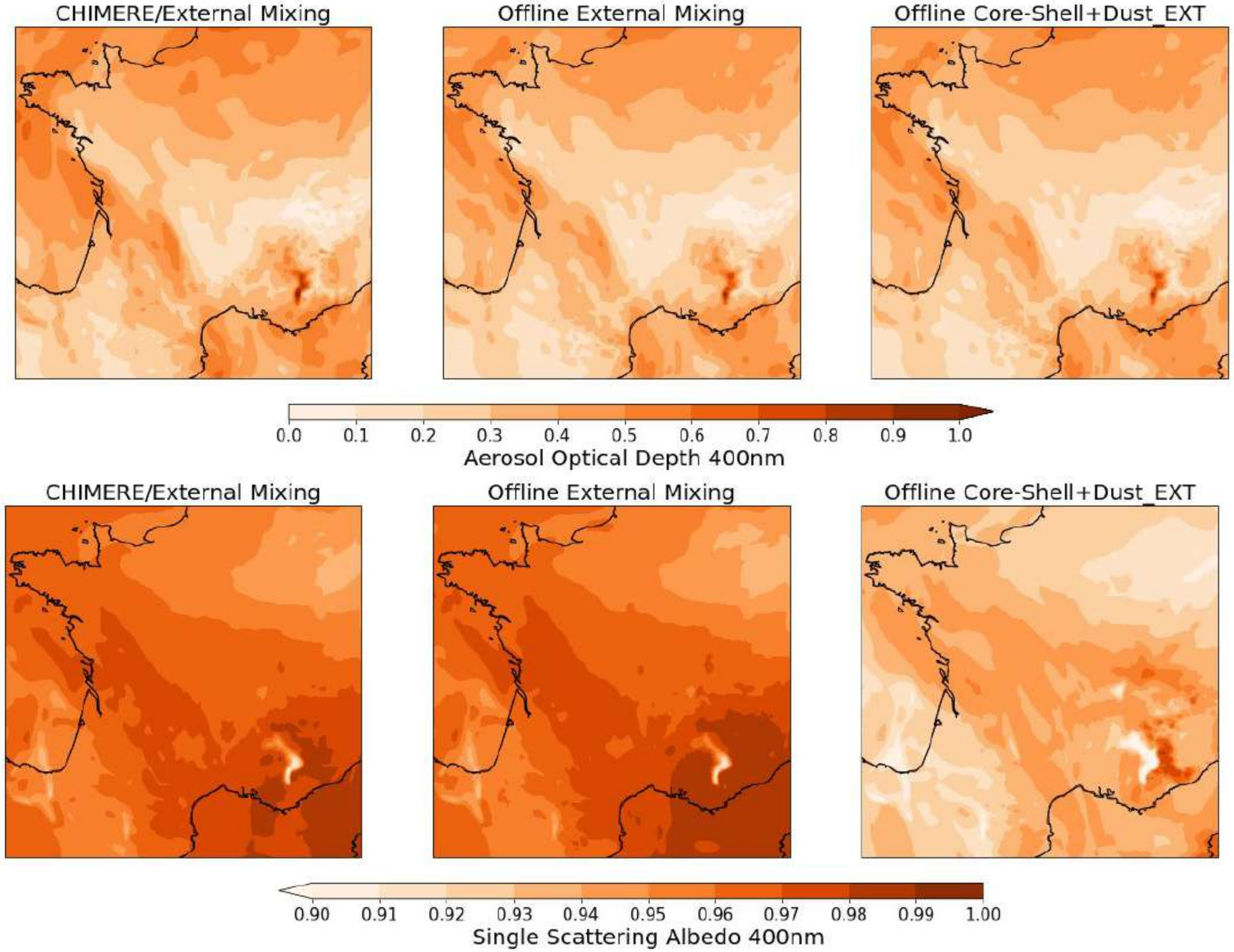
Aerosol optical depth and Single Scattering Albedo

18 June at 12UTC

ONLINE **OFFLINE** **OFFLINE**



Aerosol Optical Depth at 400nm

Single Scattering Albedo at 400nm

OFFLINE External mixing AOD and SSA are in good agreement with the CHIMERE model.

OFFLINE Core-Shell exhibits lower SSA values

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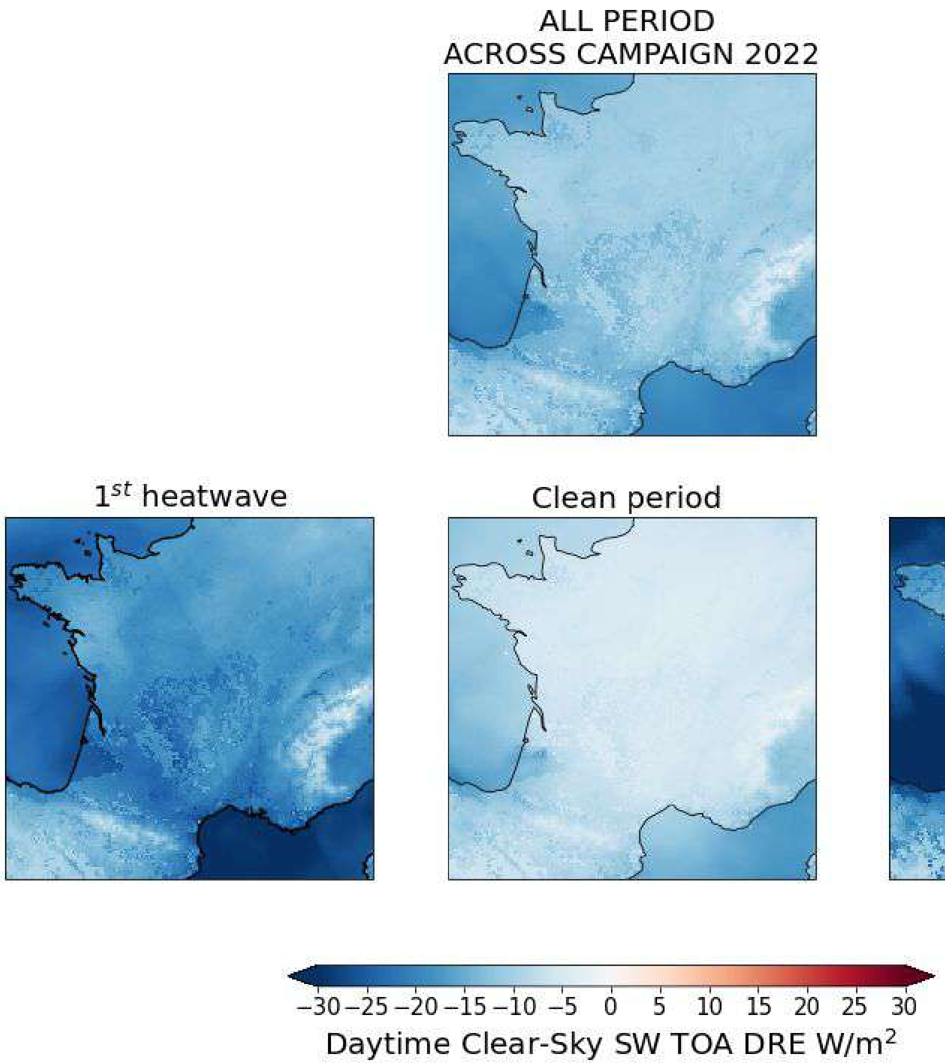
Clear-Sky SW DRE TOA online WRF-CHIMERE coupling



(

Average values over the IDF region

W/m2

W/m2

W/m2

W/m2

Stronger Negative DRE at TOA during the heatwave

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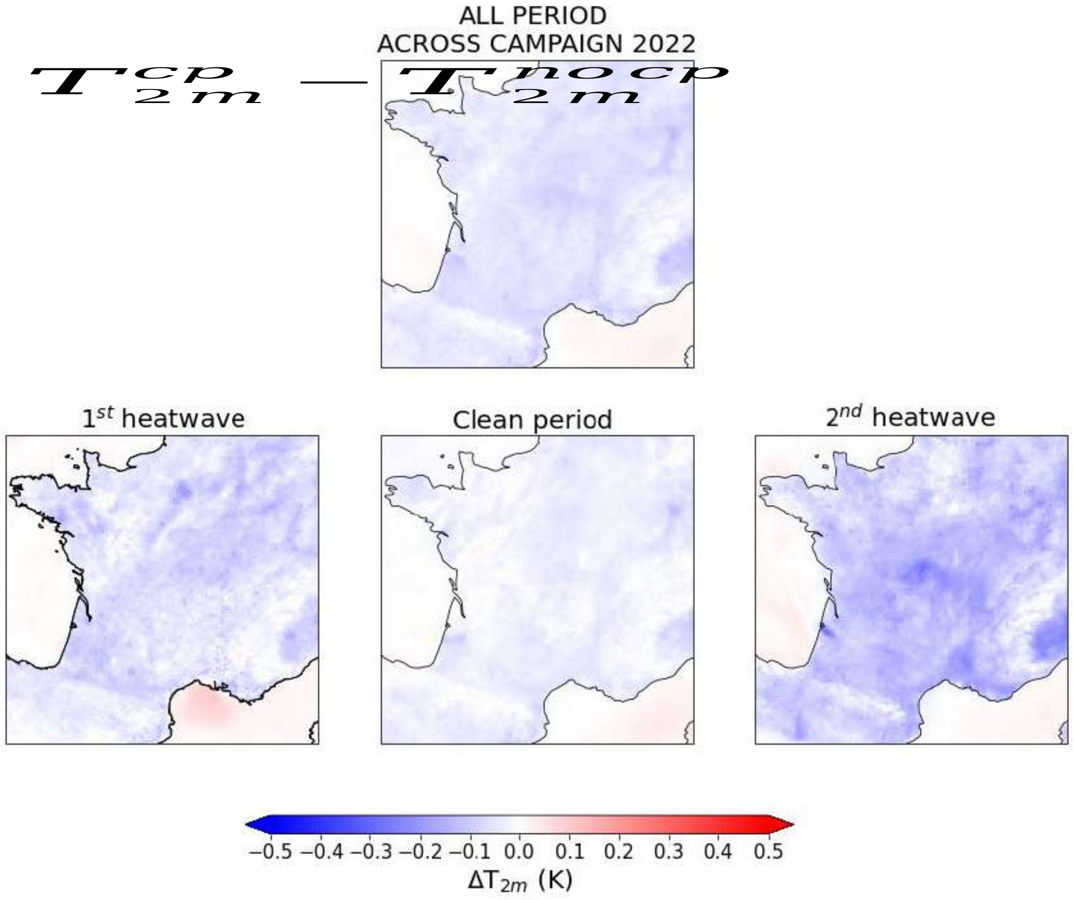
WRF-CHIMERE coupling (,)

Cp =Aerosol properties field sent from CHIMERE to WRF
No Cp = No aerosol properties field sent from CHIMERE to WRF

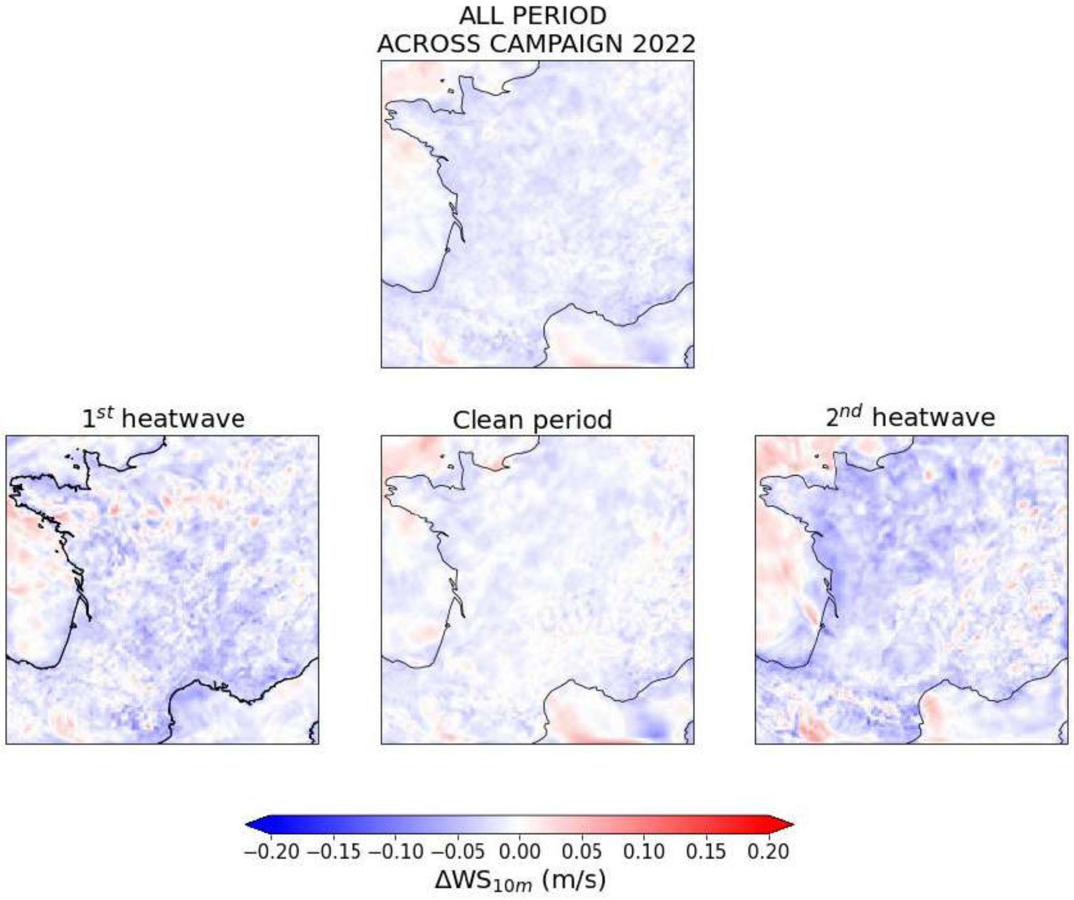
Stronger 2m temperature difference during the heatwave period

$$= T_{2m}^{cp} - T_{2m}^{no\,cp}$$



General reduction of the WS over land

$$\Delta WS_{10m} = WS_{10m}^{cp} - WS_{10m}^{no\,cp}$$



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Black Carbon Daily Clear-Sky DRE (OFFLINE External Mixing) 19 July 2022

Average values over the IDF region

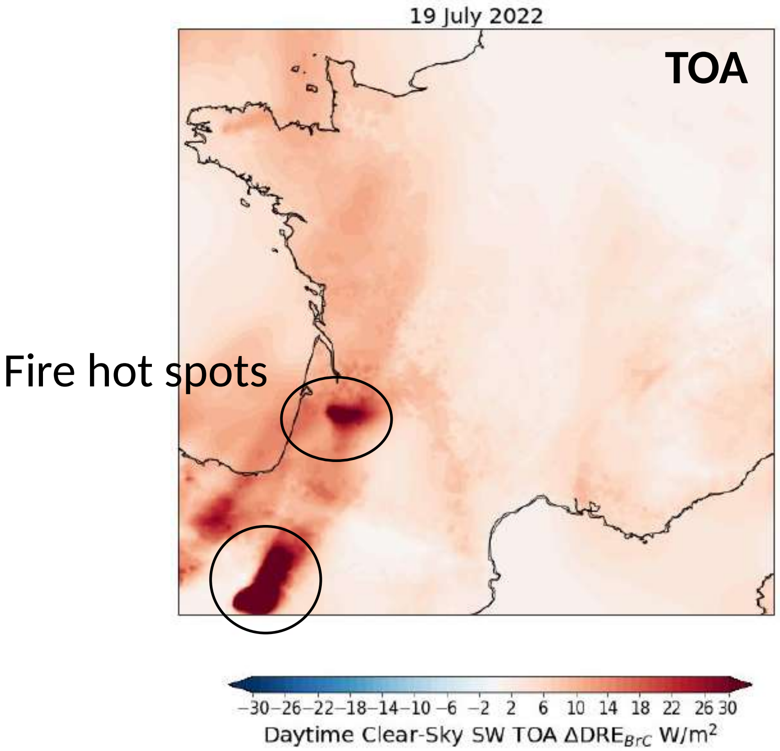
Positive BC DRE at TOA with stronger values over the fire hot spots

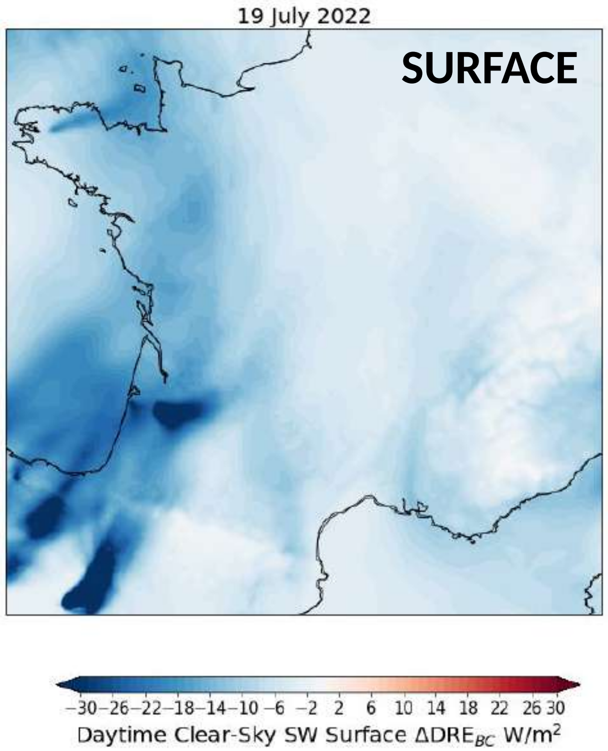
$$\Delta DRE^{BC}_{TOA} = \Delta DRE^{BC}_{TOA} - \Delta DRE^{no\,BC}_{TOA}$$
$$\Delta DRE^{BC}_{SURF} = \Delta DRE^{BC}_{SURF} - \Delta DRE^{noBC}_{SURF}$$
$$\Delta DRE^{BC}_{ATM} = \Delta DRE^{BC}_{TOA} - \Delta DRE^{BC}_{SURF}$$

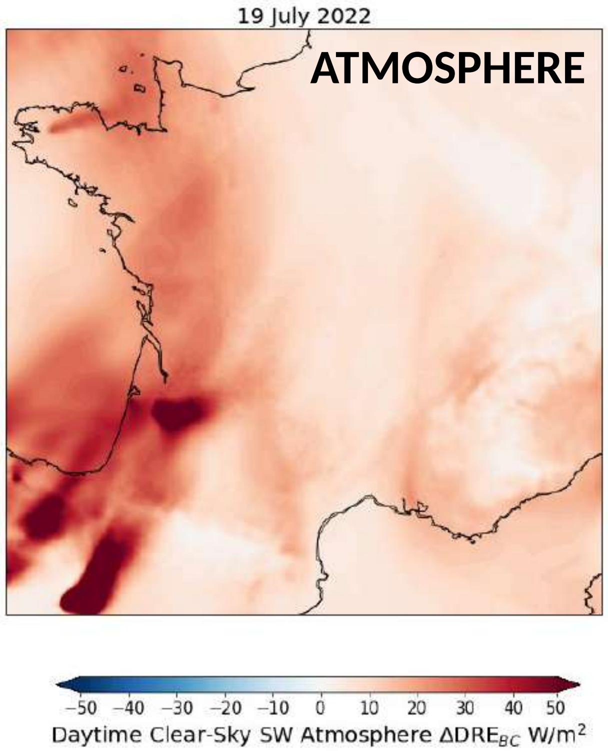
W/m2

W/m2

W/m2







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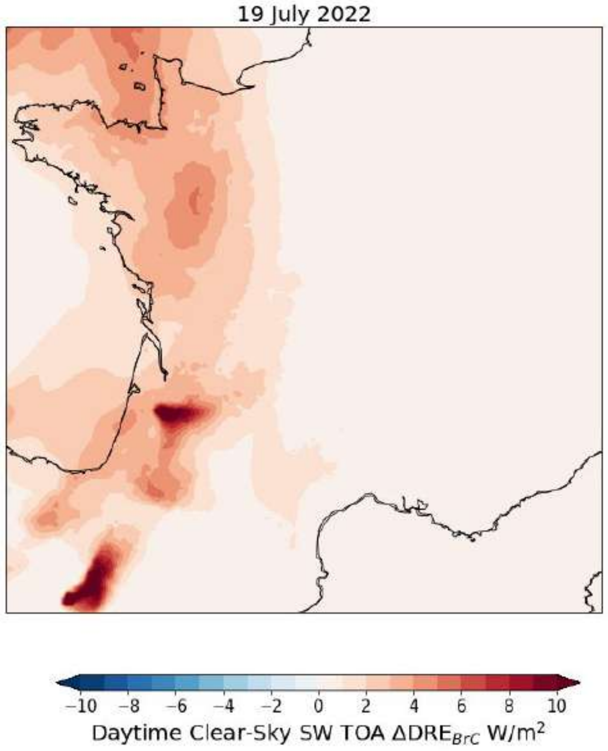
BrC, BSOA absorption contribution to DRE SW TOA

19 July 2022

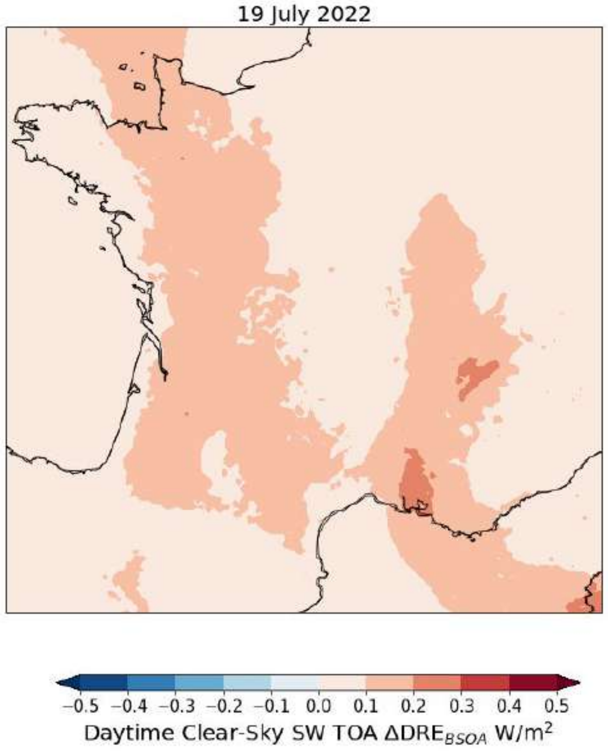
$$\Delta DRE^{X}_{TOA} = \Delta DRE^{X_{absorption}}_{TOA} - \Delta DRE^{X_{sc}}_{TO}$$

$$X = BrC\ ,\ BS$$

Biomass burning



Biogenic SOA



Average values over the IDF region

W/m2

W/m2

Stronger BrC DRE at TOA over the fire hot spots

Weak BSOA positive contribution to DRE

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COMPLEX REFRACTIVE INDEX RETRIEVAL DURING THE ACROSS CAMPAIGN

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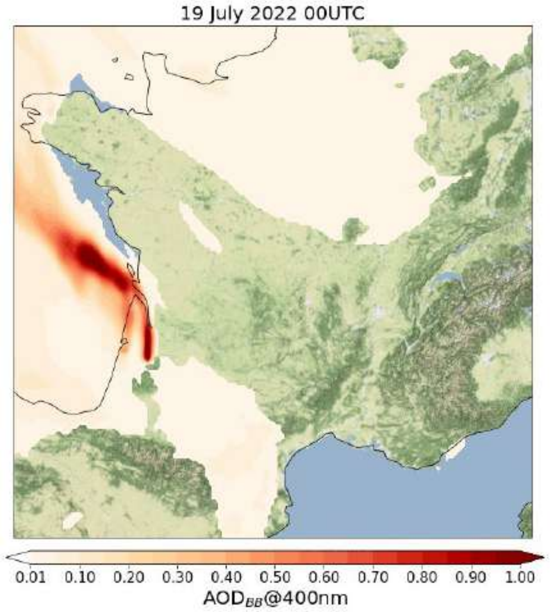
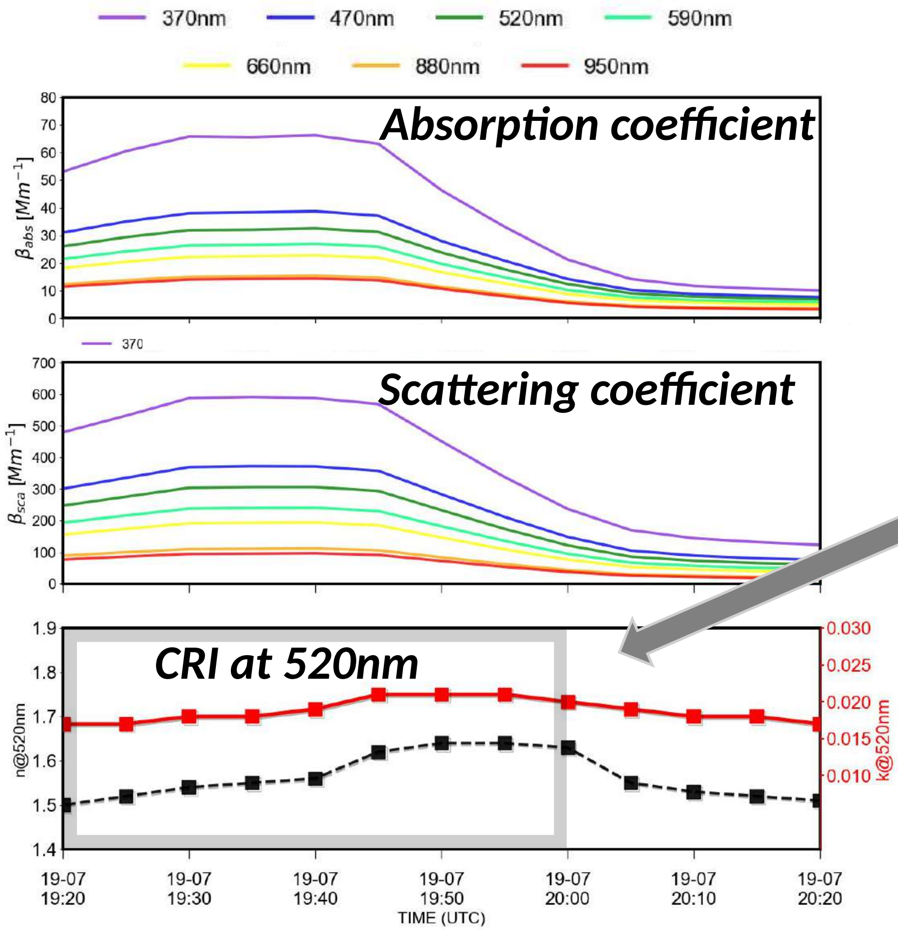
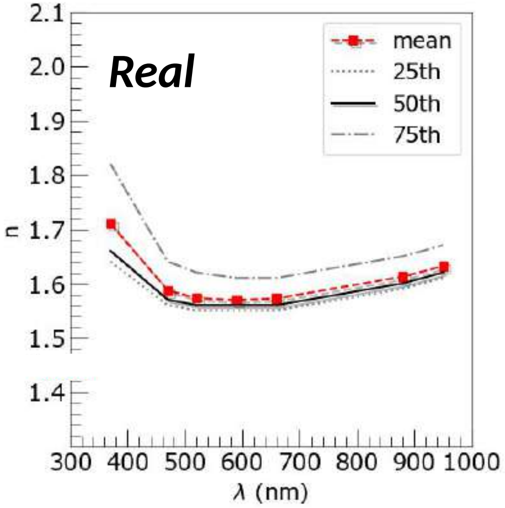
Case study – Paris city: The Fire Episode of 19-20 July

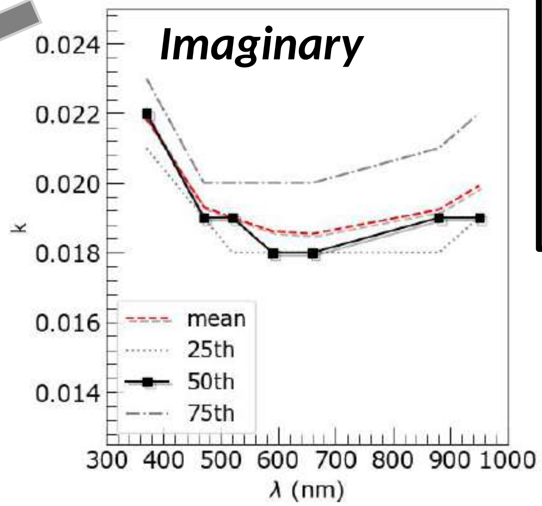


Before and after the fire plume



CRI spectral variability





Increase of UV absorption, suggesting BrC presence in the fire plume

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CONCLUSIONS

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Conclusions and further perspectives

The DRE calculation using the WRF-CHIMERE coupled model shows an average value for the IDF region over the period of −10.4±0.6 W/m2, with stronger values over the two heatwave periods of −16.8±0.8 W/m2 and −18.9±1.5 W/m2 respectively.

A of +2.0±0.6 W/m2 has been estimated at TOA over the IDF region for the 19 July. The absorption contribution to DRE of BB BrC and BSOA has been estimated to be +0.36±0.12 W/m2 and +0.05±0.01 W/m2 respectively over the region.

The spectral complex refractive index (CRI) has been retrieved to characterize the urban and rural sites of the ACROSS campaign 2022. Average values of 1.43+0.04i and 1.48+0.03i at 520nm have been found at the urban and rural site respectively, suggesting a lower but not-negligible absorption at the rural site. This CRI will be used to validate the output of the simulation and constraint the input.

All-sky DRE and the BC, BSOA, ASOA, BrC contribution to DRE will be further investigated.

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THANKS FOR YOUR ATTENTION!!!

CHIMERE - Complex refractive index database update

	Complex refractive index at different wavelength (nm)					
	200	300	400	600	999	
POA	1.53-0.09i	1.53-0.008i	1.53-0.005i	1.53-0.0063i	1.53-0.016i	OPAC
OPOA	1.53-0.0001i	1.53-0.0001i	1.53-0.0001i	1.53-0.0001i	1.53-0.0001i	Non Absorbing
ASOA	1.63-0.04i	1.58-0.02i	1.55-0.005i	1.53-0.0001i	1.52-0.0001i	Liu et al, 2014
BSOA	1.6-0.005i	1.55-0.0012i	1.52-0.0001i	1.5-0.0001i	1.5-0.0001i	Liu et al, 2013
BB	1.7-0.1i	1.7-0.06i	1.7-0.03i	1.7-0.02i	1.7-0.007i	Saleh et al, 2014, Wang et al, 2018

Liu et al, 2013, Complex Refractive Indices of Thin Films of Secondary Organic Materials by Spectroscopic Ellipsometry from 220 to 1200 nm
Liu et al, 2014, Ultraviolet and visible complex refractive indices of secondary organic material produced by photooxidation of the aromatic compounds toluene and m-xylene
Saleh et al, 2014, Contribution of brown carbon and lensing to the direct radiative effect of carbonaceous aerosols from biomass and biofuel burning emissions
Wang et al, 2018, Exploring the observational constraints on the simulation of brown carbon

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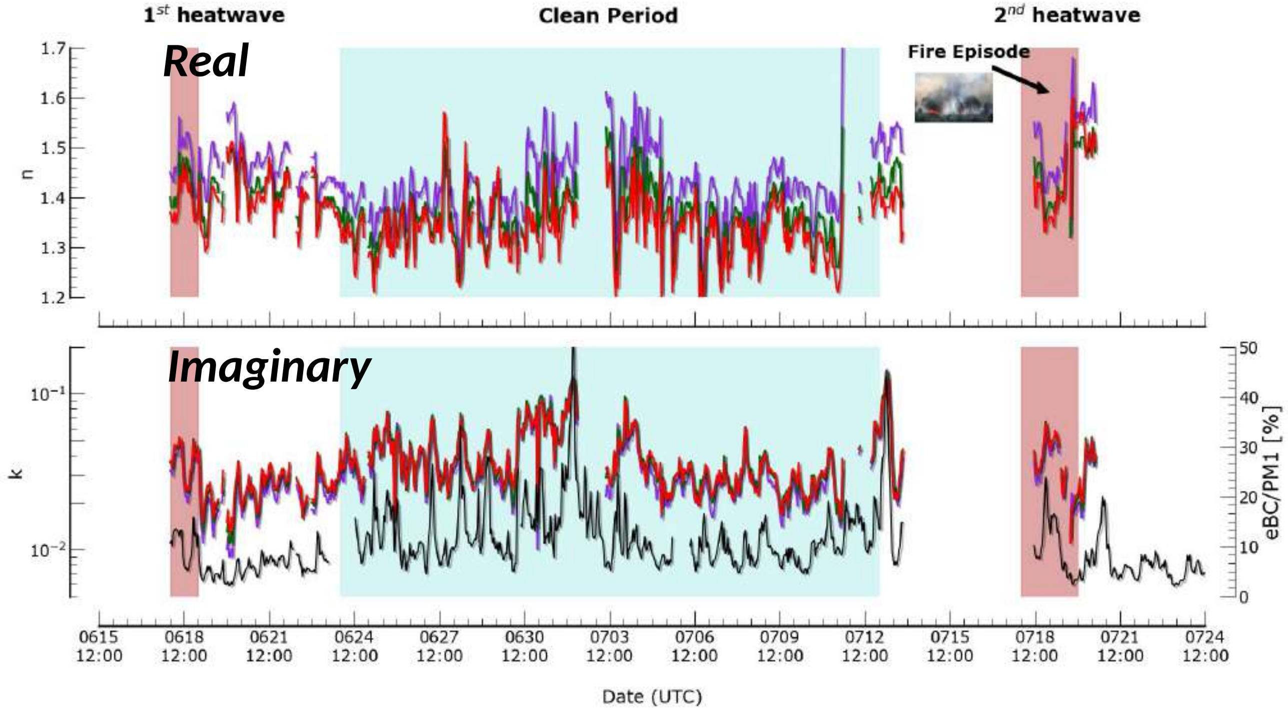
Complex refractive index time series

Real part varying between 1.3-1.8
Imaginary part varying between 0.01 and 0.2

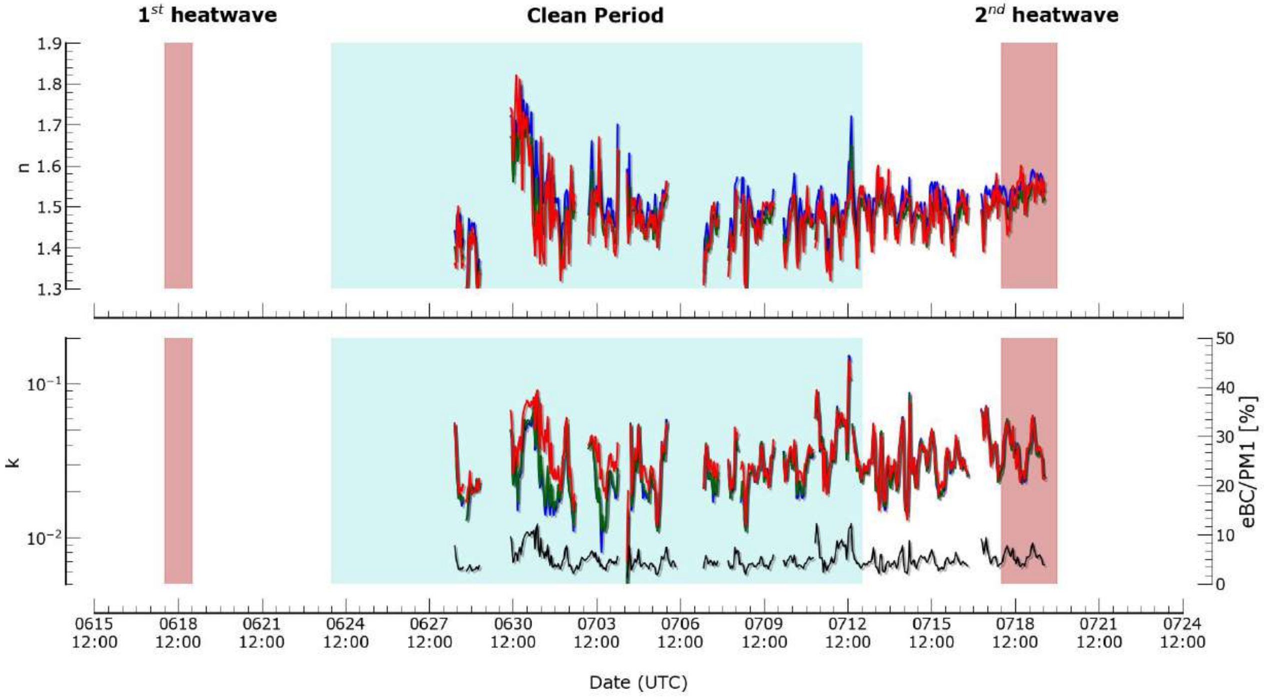
Mean CRI at 520nm=1.43+0.04i

Paris city (PRG)



Rambouillet

Mean CRI=1.48+0.03i at 520nm



BC-correlated absorption

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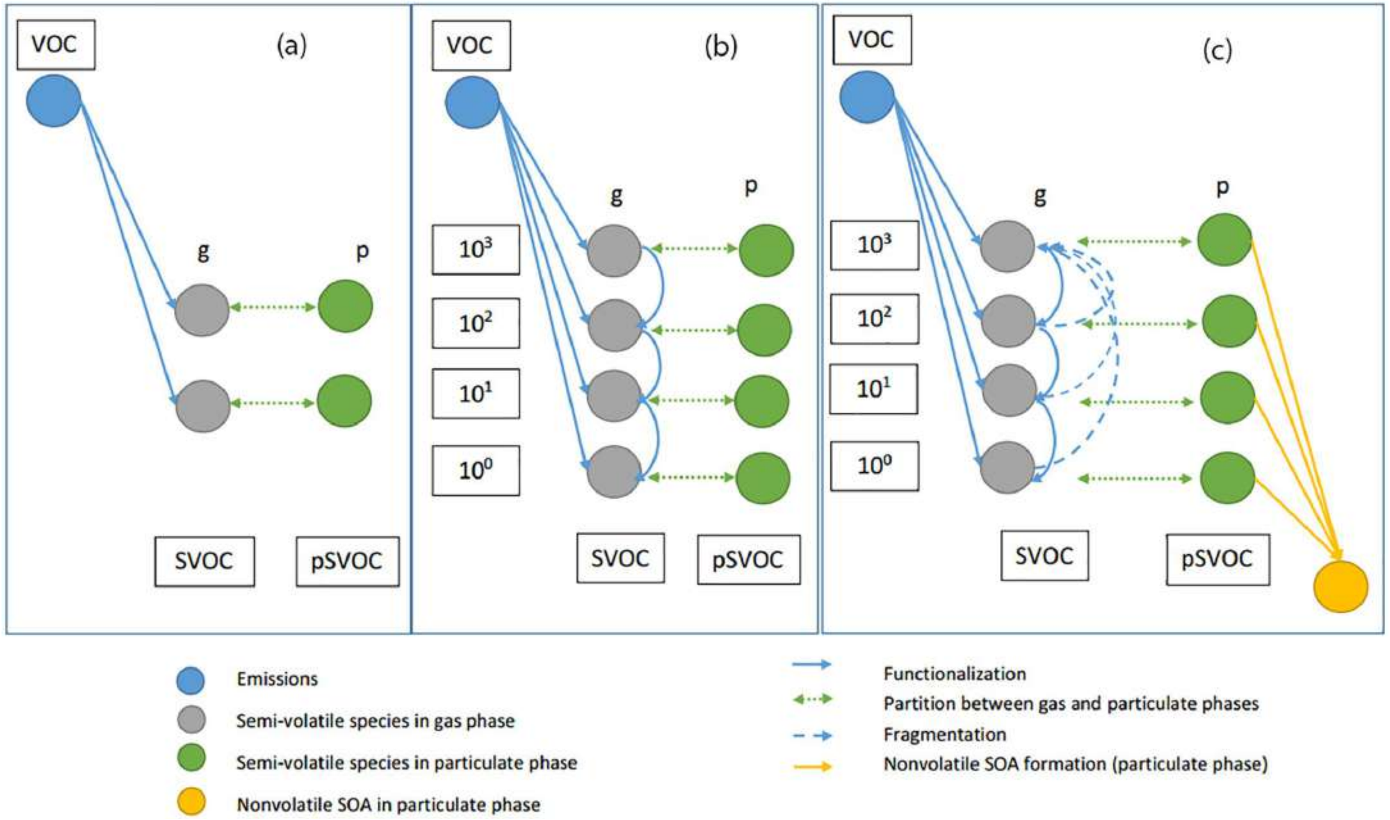
The VBS scheme

Single step oxidation | Standard VBS (SVBS) | Modified VBS (SVBS+Fragmentation and non-volatile SOA production)



The Volatility Basis Scheme (VBS) introduces the volatility of the aerosol species depending on their saturation concentration:

9 bins: 1-1e6 ug/m3 for SVOC and IVOC

4 bins: 1,10,100,1000 ug/m3 for BSOA and ASOA

Functionalization: transfer to lower volatile bins

Fragmentation: transfer of species to higher volatility bins

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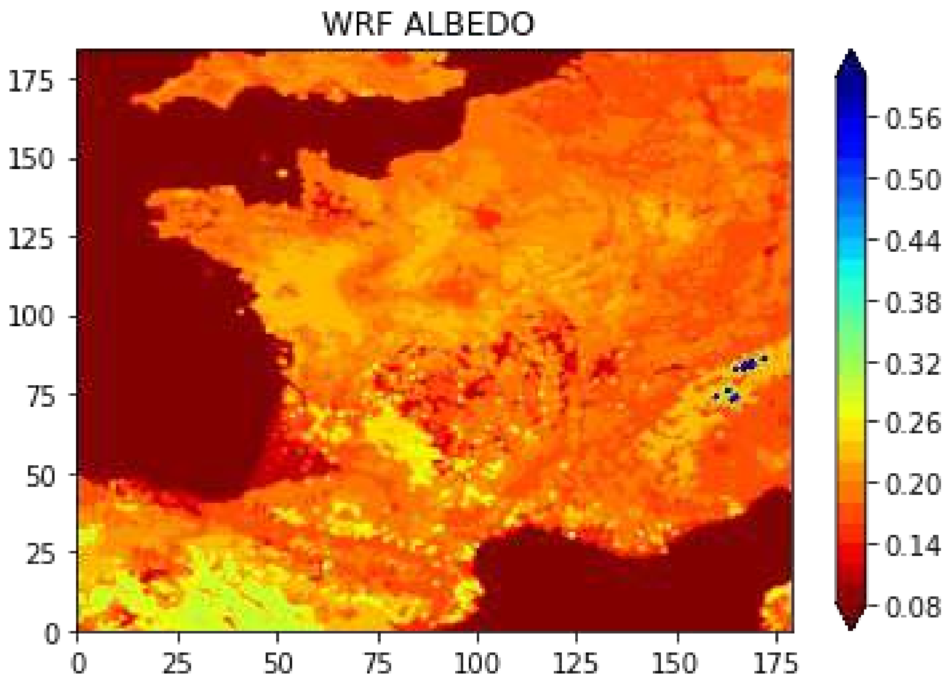
ALBEDO



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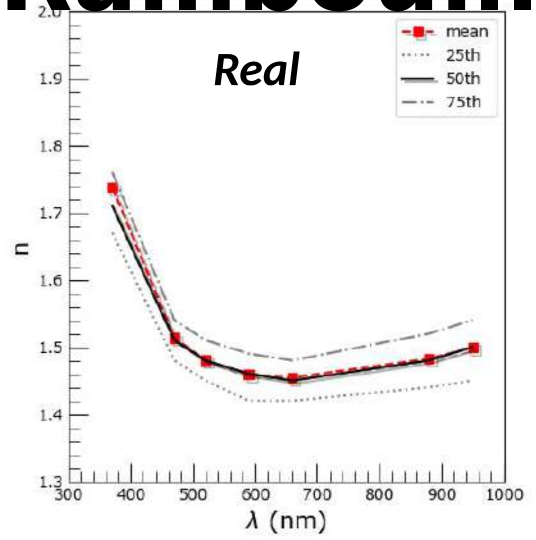
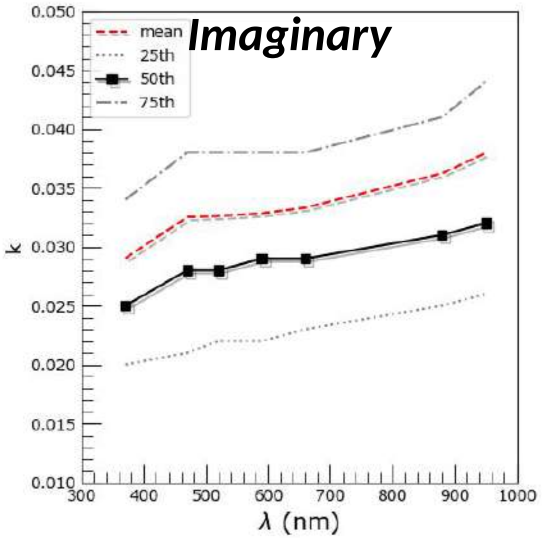
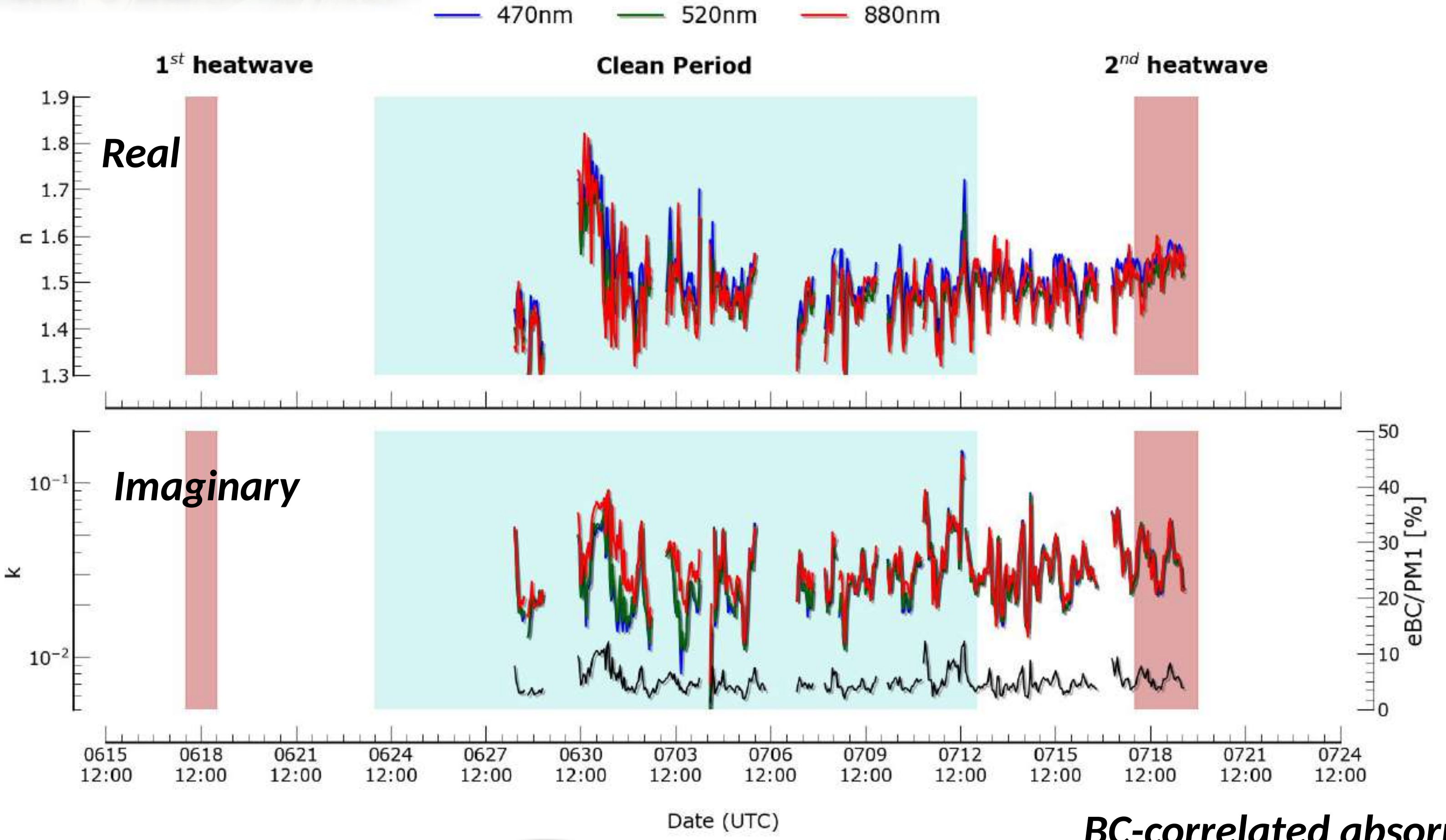
Complex refractive index retrieval-Rambouillet forest

CRI spectral variability





Real part varying between 1.3-1.8
Imaginary part varying between 0.01 and 0.2



BC-correlated absorption

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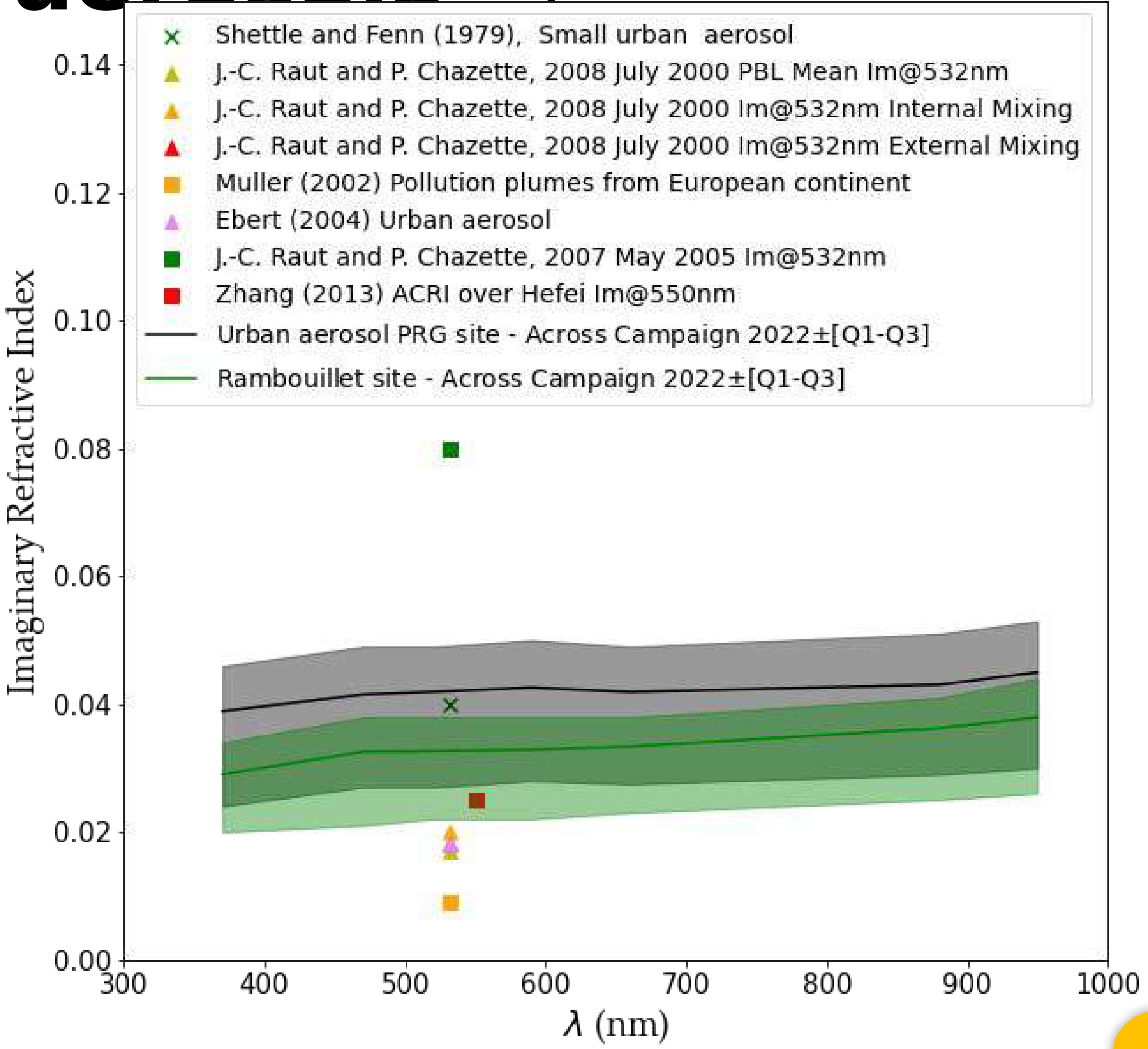
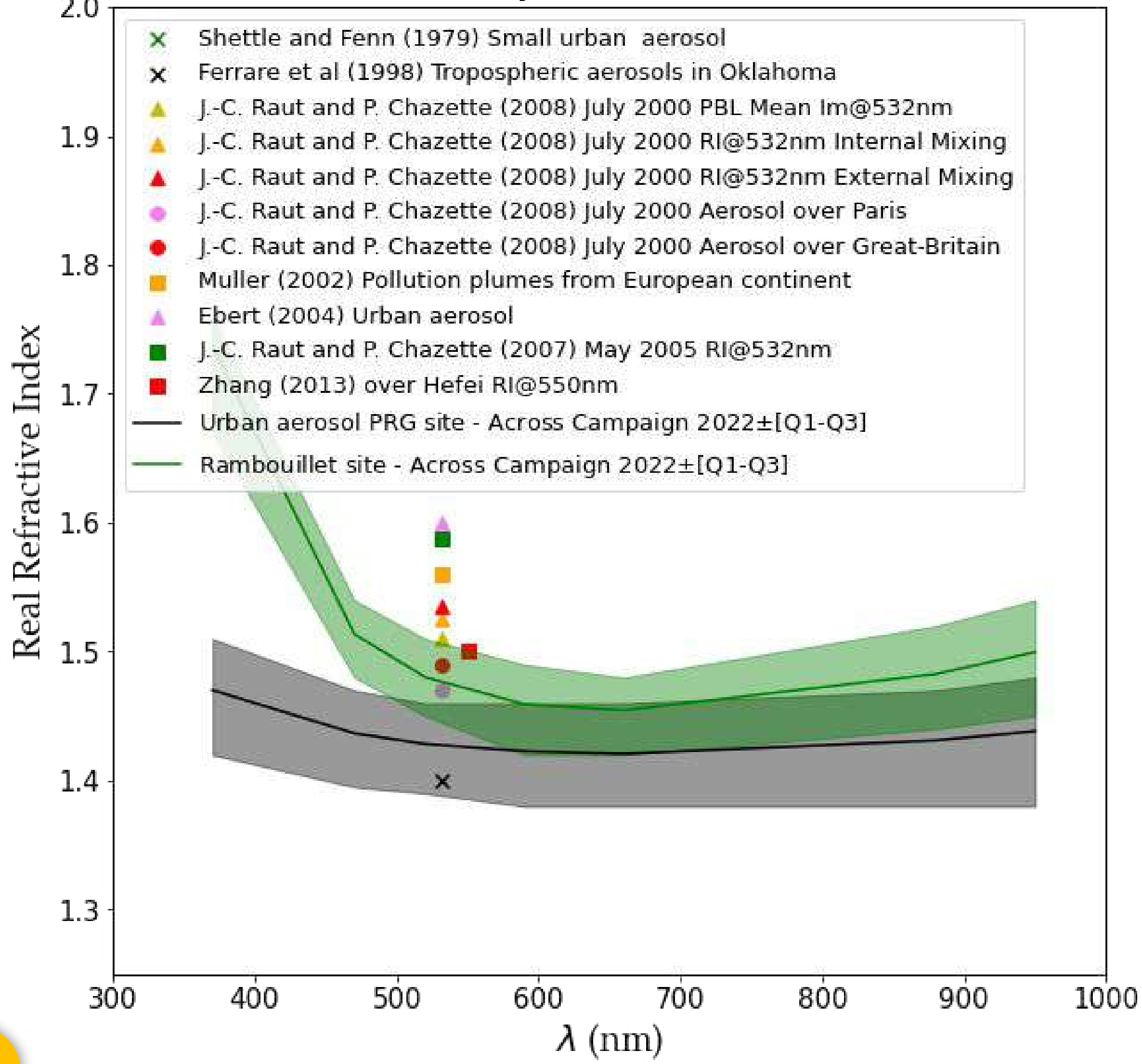
Comparison with the literature for urban aerosols

Imaginary refractive index



Real refractive index



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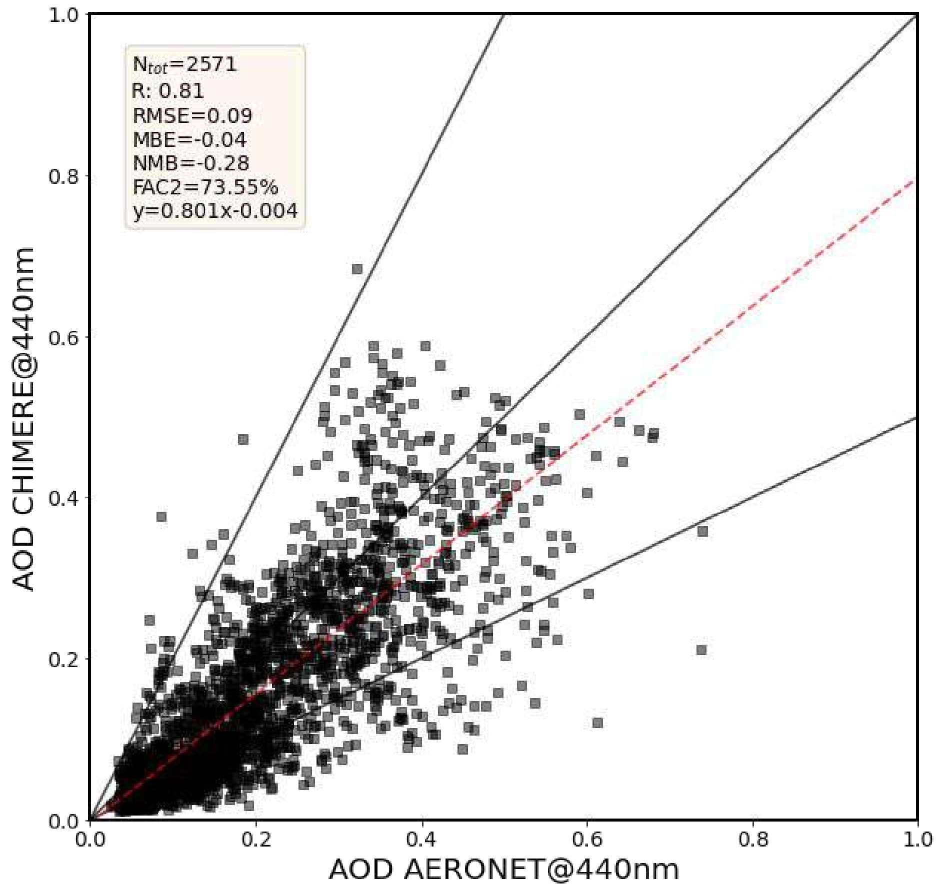
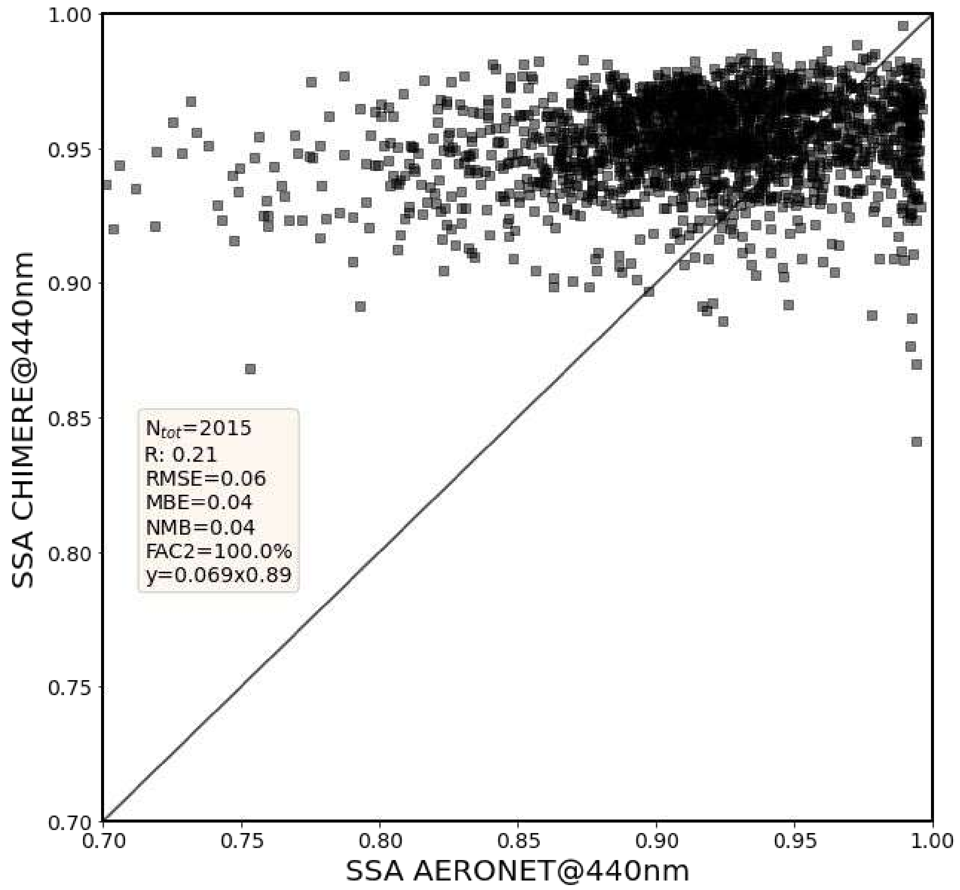
Aerosol Optical Depth /SSA Validation External

LEV2



LEV15/LEV2



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