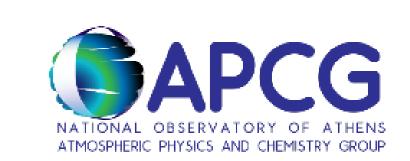


Temporal and spatial variability of black carbon levels in different environments in Greece with emphasis on the role of residential biomass burning



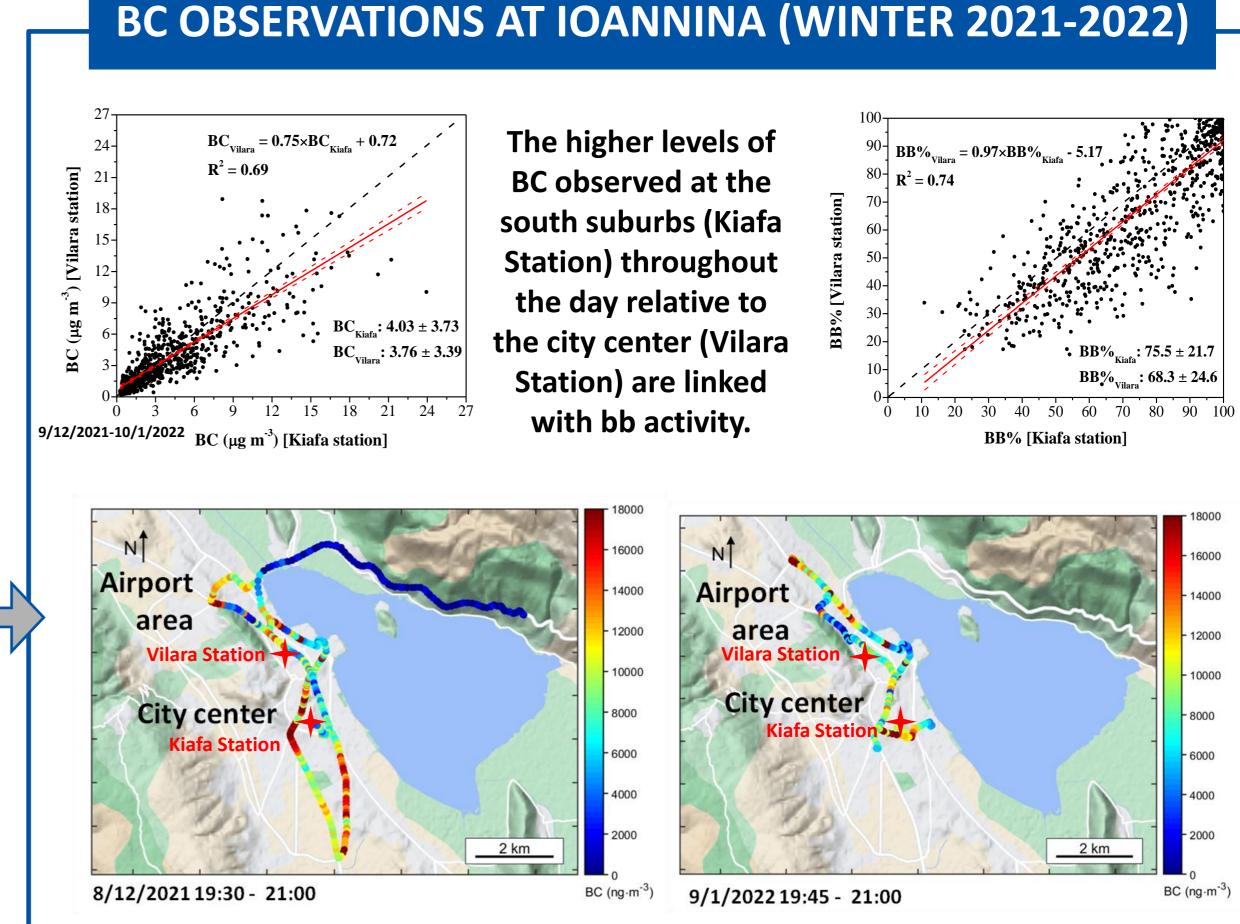
Remarkable variability on the

seasonally averaged spectral bal

E. Liakakou¹, D.G. Kaskaoutis¹, I. Stavroulas¹, G. Grivas¹, A. Bougiatioti¹, N. Kalivitis², G. Kouvarakis², M. Tsagkaraki², M. Gavrouzou³, N. Hatzianastassiou³, K. Michailidis⁴, D. Balis⁴, E. Gerasopoulos¹ and N. Mihalopoulos^{1,2}

¹Institute for Environmental Research and Sustainable Development, National Observatory of Athens, P. Penteli, Athens, 15236, Greece, Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, Heraklion, 70013, Greece, Laboratory of Meteorology, Department of Physics, University of Ioannina, Ioannina, 45110, Greece, Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Thessaloniki, 54124, Greece

BC MEASUREMENTS - PANACEA CAMPAINGS Atmospheric Pollution and Population Exposure THESSALONIKI URBAN STATION (LAP) **THESSALONIKI** 40.63N, 22.95E, 50m ASL Assessment of the role of residential biomass burning during wintertime Campaign Period STATION, ATHENS Jul. 2019 – Aug. 2019 Summer 1^{rst} 37°58'24"N 23°43'05"E, 105m ASL KIAFA STATION, IOANNINA Winter 1^{rst} Dec. 2019 - Feb. 2020 39°39'12"N 20°51'15"E, **520m ASL** Winter 2nd **Emphasis** on Dec. 2021 – Jan. 2022 Ioannina High resolution measurements of **Black Carbon** (BC) by means of the 7- λ Aethalometers AE33 or AE31 (Magee Scientific, 1 and 5 min **FINOKALIA STATION, CRETE** 35° 20' N, 25° 40' E, 250m ASL resolution, respectively) at three urban centers The overarching goal of PANACEA is the integration of all existing in Greece (Athens, Thessaloniki & Ioannina) national facilities to create a single harmonized high-class and at the regional background station of innovative distributed RI to serve and provide access to all <u>Finokalia, Crete</u>. PM_{2.5} sampling also academic/research institutions and the private sector in the wide performed on 24-hr basis. scientific range covered by PANACEA.



Increased BC levels close to city center, airport and at the north lakeside area due to traffic. The enhancement at the south suburbs could be linked heating emissions (e.g. fireplaces).

SPATIO-TEMPORAL VARIABILY OF BC FRACTIONS

BC (μg m ⁻³)	ug m ⁻³) Finokalia Athens Thessaloniki Ioannina 1 ^{rst} Ioannina 2 nd				_	lline with the findin	1-	during winter in loan increased wood burn				
Winter	0.31 ± 0.23	2.61 ± 3.49	1.37 ± 1.12	4.92 ± 4.69	3.86 ± 3.68	i.e. high BC levels at both the city center and the suburban residential area.				270 90 120	to Athens and Finological to Iater presenting	kalia, with the the the lower
Summer	0.57 ± 0.24	0.66 ± 0.46	0.76 ± 0.45	1.05 ± 0.67	-		Winter Car	mpaigns		210 150	contribution of Bro	
300 300 300 240	BC _{ff} (morning) (µg m ⁻³) 0,3 0,6 0,9 1,2 1,5 1,8		(Athens, Tound (Finokal	hessaloniki, lo ia) environme	ions in urban pannina) and nts in Greece er and winter.		December '21 10 10 10 10 10 10 10 10 10	January '22 0.58 \pm 0.69 3.28 \pm 3.69 Date	February '22 BC _{ff} BC _{wb}	9 aver. ~81%, max. ~98% 7 BC	Winter 300 Winter 250 BC BrC BrC BrC Winter 250 BC BrC BrC BrC BrC BrC BrC BrC BrC BrC	BrC Abs ~9.1% 600 700 800 900 BrC Abs ~ 37.2%
Uniformity of local trate at loannina during summering, with BC _{ff} averagely at about 2 during wints	mmer in the $\frac{m}{2}$ peaking $\frac{m}{2}$ $\frac{1.5}{1.0}$ $\frac{1.5}{2}$ $\frac{1.0}{2}$ $\frac{m}{2}$ $\frac{m}{2}$ $\frac{1.5}{2}$	aver. ~15%, max.	20 22 September 10	July '19 0.90 ± 0.59 0.15 ± 0.10	August '19 BC BC wb	loannina	December '19 0.75 ± 0.98 4.17 ± 4.46 December '19 0.75 ± 0.98 4.17 ± 4.46	January '20	February '20 BC _{ff} BC _{wb}	9 aver. ~82%, max. ~97% 80 80 90 80 90 80 90 80 90 90 80 90 90 90 90 90 90 90 90 90 90 90 90 90	Summer 300 Winter Property of the property o	Athens BrC Abs ~ 14.4% 600 700 800 900 BrC Abs
Bimodal diu variability in urban environ regardless the s followed l	ments Season,	aver. ~4%, max. ~	30 wo minipalition (%) 3- 3- 3- 3- 3- 3- 3- 3- 3- 3- 3- 3- 3-	July '19 0.73 ± 0.44 0.03 ± 0.03	August '19 BC _{mb} BC _{wb}	Thessaloniki	December '19 1.07 ± 1.02 0.30 ± 0.27 1.00 1	January '20 BC _{ff} BC _{wb}	February '20	A	wavelength (nm) 40 Vinter BC BC BrC BrC BrC BrC BrC Winter Winter BC BrC BrC BrC BrC BrC BrC Br	~ 23.0% Finokalia BrC Abs
enhancement bb fraction d winter nig	of the uring $\frac{2.5}{1.5}$	aver. ~21%, max. ~	222% 40	July '19 0.52 ± 0.37 0.14 ± 0.24	August '19 BC _{ff} BC _{wb}	Athens	35 30 December '19 1.57 ± 2.00 1.04 ± 1.75 20 50 10 50 0	January '20	February '20 BC _{ff} BC _{wb}	9 8 6 60 8 10 12 14 16 18 20 22 10 60 80 10 10 10 10 10 10 10 10 10 10 10 10 10	Wavelength (nm) * mean BrC Abs at 370-660 n	~ 10.5% BrC Abs ~ 17.5% m BC wb

Finokalia

Mean diurnal variability of BC fractions in urban (Athens, Thessaloniki, Ioannina) and

background (Finokalia) environments in Greece during summer and winter.

Prevalence of local bb emission sources at Ioannina

during winter night (>10 folded BC..., levels relative to

December '19

 0.24 ± 0.18

 0.07 ± 0.07

February '20

BC-RELATED INDICATIONS ON DOMINANT ATMOSPHERIC PROCESSES

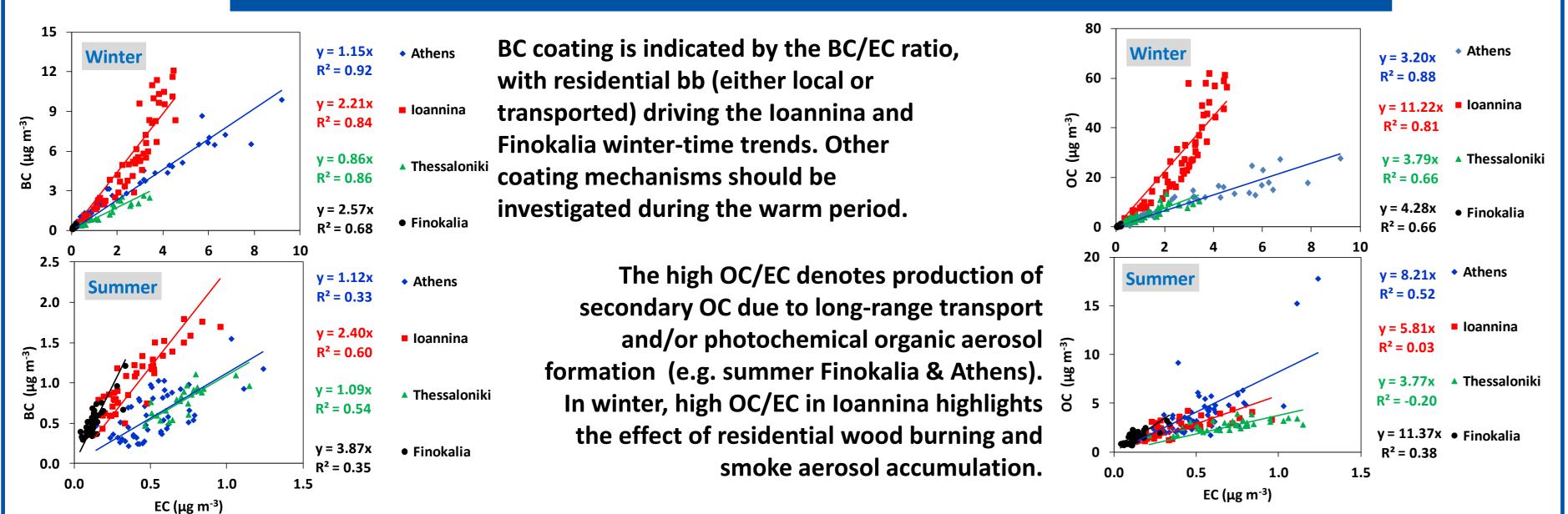
July '19

aver. ~15%, max. ~17%

 0.50 ± 0.20

 0.07 ± 0.09

August '19



in iAC 2022 4-9 SEPT/ATHENS

Low spatio-temporal variability

of the BC_{wb} levels at the remote

site during summer.

We acknowledge support of this work by the project "PANhellenic infrastructure for Atmospheric Composition and climatE change" (MIS 5021516) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).



CONCLUSIONS

The long range transport seems to influence the

BC_{wh} levels at the remote site during winter

relative to the urban ones where the local

sources control the emission of BC.

BC_w

ver. ~26%, max. ~28%

0 2 4 6 8 10 12 14 16 18 20 22 **Hour (UTC+2:00)**

- The study delineates the BC characteristics in contrasted environments in Greece over distinct bb conditions, revealing tremendous differences in the levels and in the day-to day variability.
- The lower mean BC levels were encountered during winter at the background site of Finokalia, Crete and higher at Ioannina by up to one order of magnitude (0.31 μg m⁻³ vs 3.86-4.92 μg m⁻³) whereas Athens and Thessaloniki lie in between.
- During summer, high regional BC levels were observed whereas the city contribution was rather small compared to winter.
- The higher bb impact was encountered in Ioannina with BC $_{wb}$ exceeding frequently the 10 μg m $^{\text{-}3}$ in hourly scale and a remarkable mean nighttime contribution of >90% against the other urban sites of lower than 50%. Both the Ioannina city center and the suburbs were impacted due to heating practices and the intensity of the primary combustion processes was also depicted on the BrC absorption contributions compared to the other sites.
- The enhanced levels of carbonaceous aerosol during winter could be linked with combustion emissions under typical low mixing heights, providing insights of atmospheric transformations.