EAC 2021 31 August 2021

Camp Fire 2018: Highly time-resolved study of eOC, eBC and BrC aerosols by the TC-BC (total carbon–black carbon) method

M. Ivančič[1], G. Lavrič[1], A. Gregorič[1], B. Alföldy[1], I. Ježek[1], J. Connor[2], C. Garland[2], J. P. Bower[2] and M. Rigler[1]

[1] Aerosol d.o.o., Slovenia, EU

[2] Bay Area Air Quality Management District, CA, USA

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Google photos

CAMP FIRE

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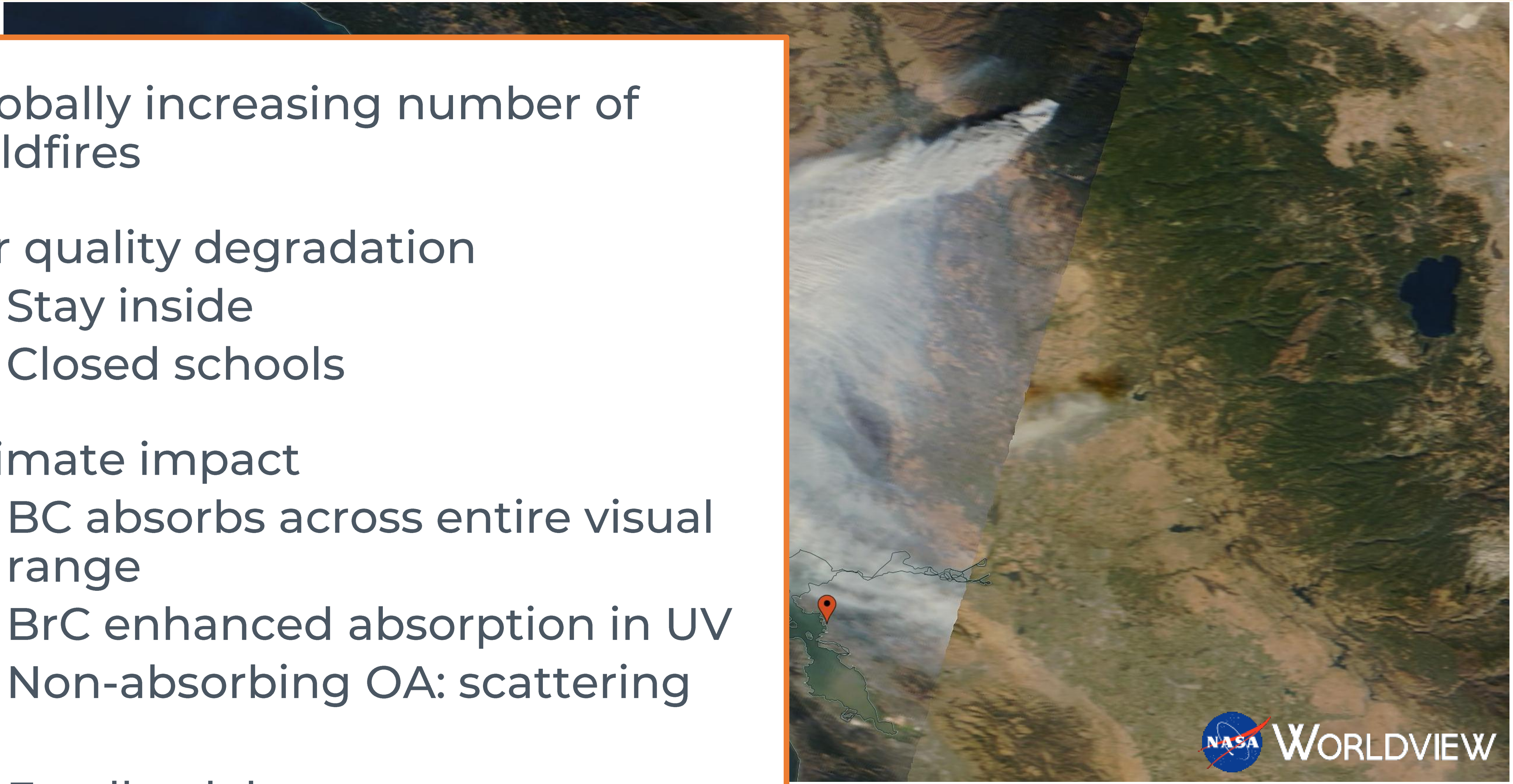
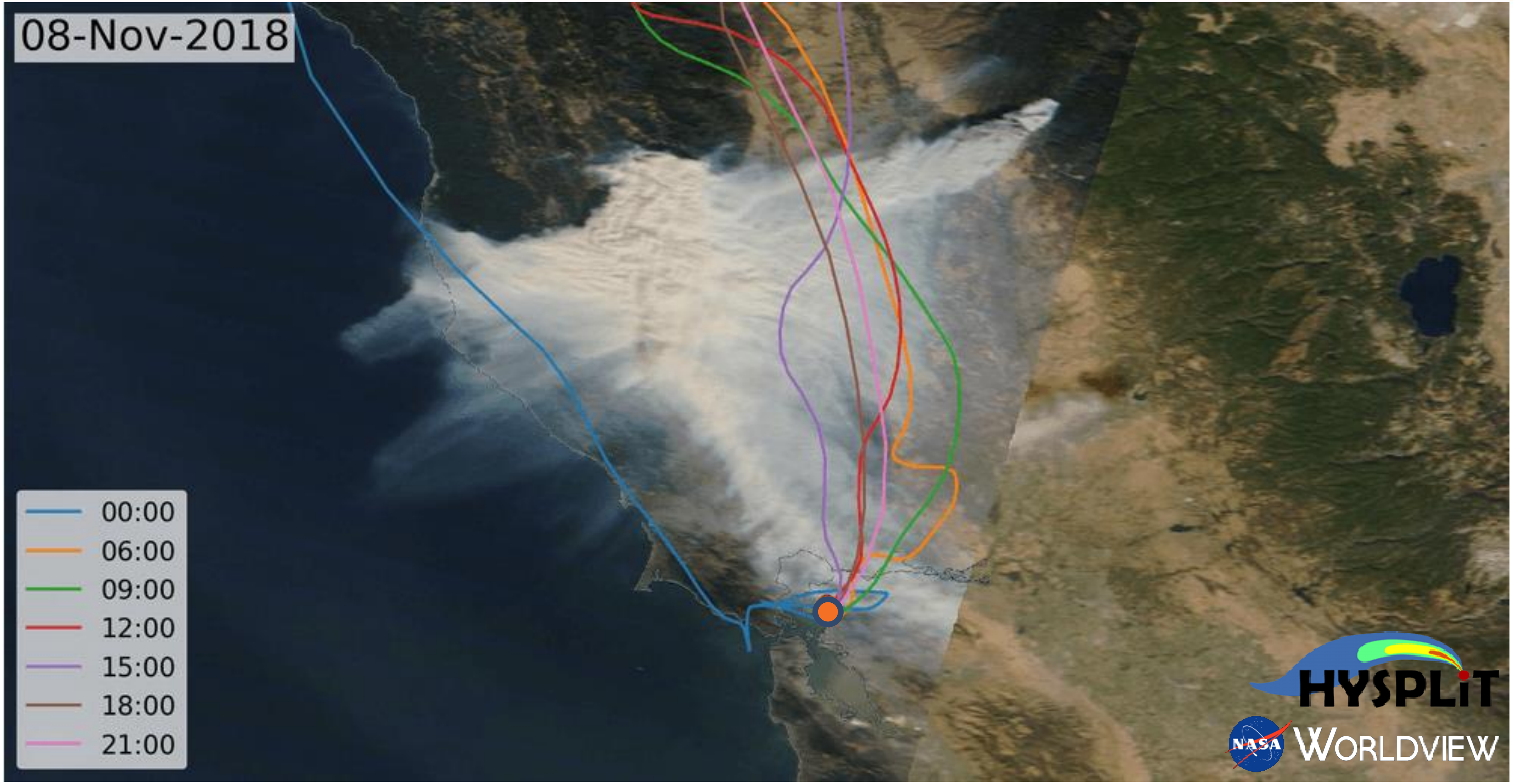
MOTIVATION

- Globally increasing number of wildfires
- Air quality degradation
  - Stay inside
  - Closed schools
- Climate impact
  - BC absorbs across entire visual range
  - BrC enhanced absorption in UV
  - Non-absorbing OA: scattering
  - Feedback loop



Aerosol

CAMP FIRE


08-Nov-2018
00:00
06:00
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15:00
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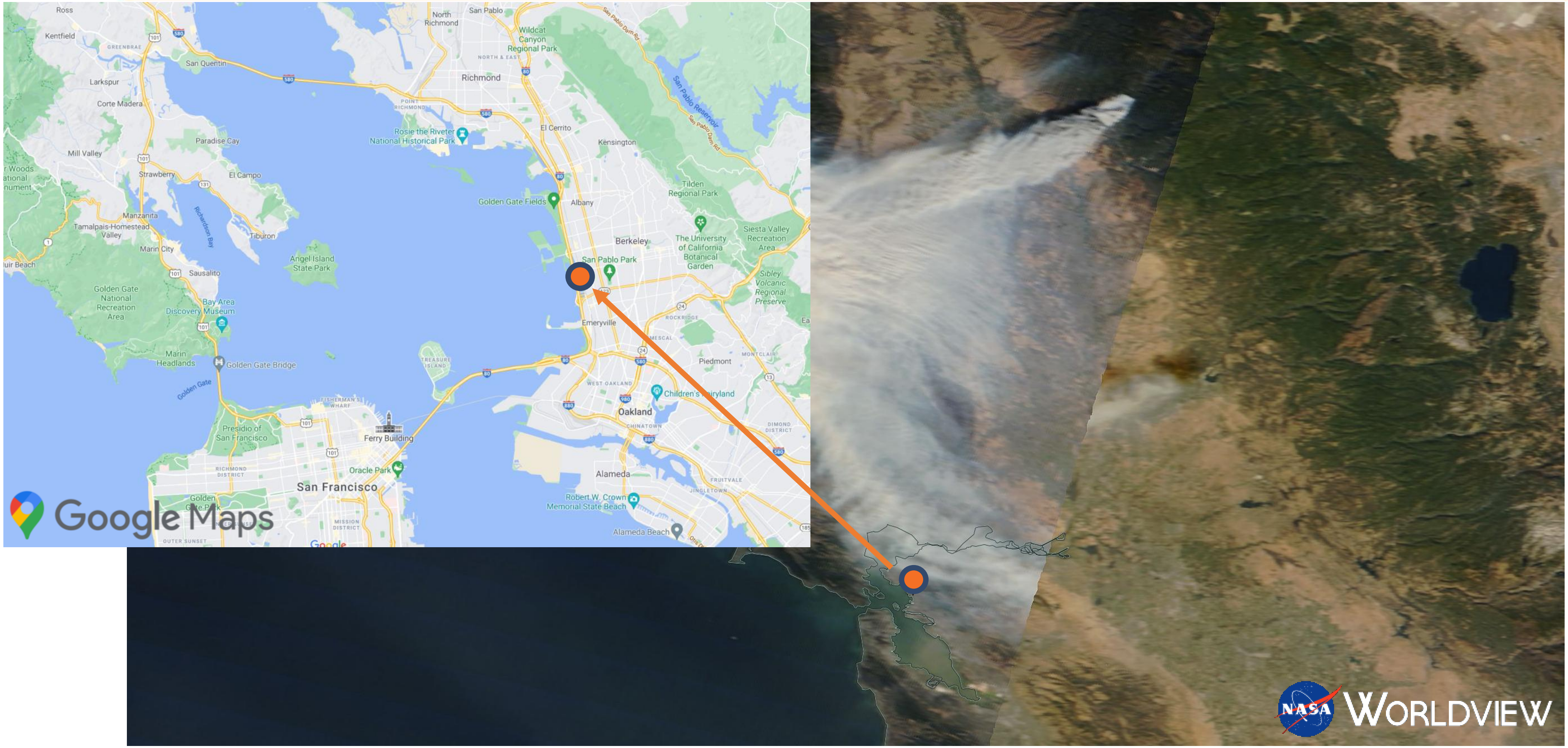
21:00
HYSPLIT
NASA
WORLDVIEW

Berkeley, CA - Aquatic Park



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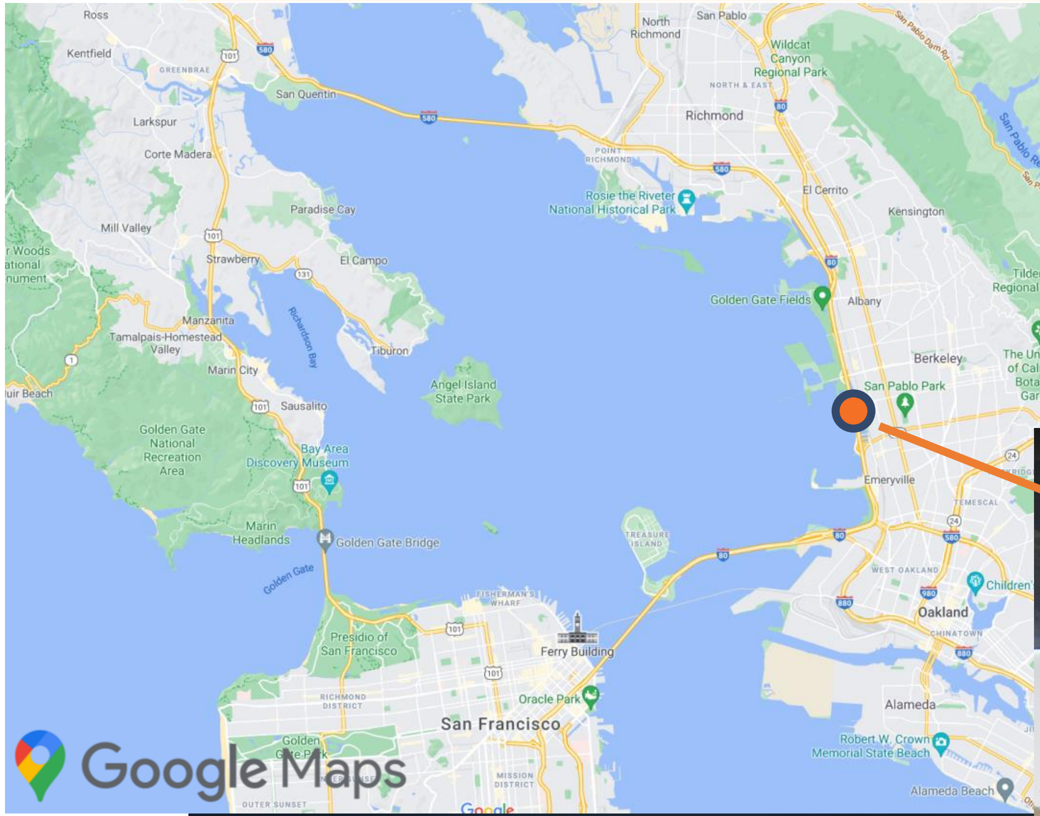
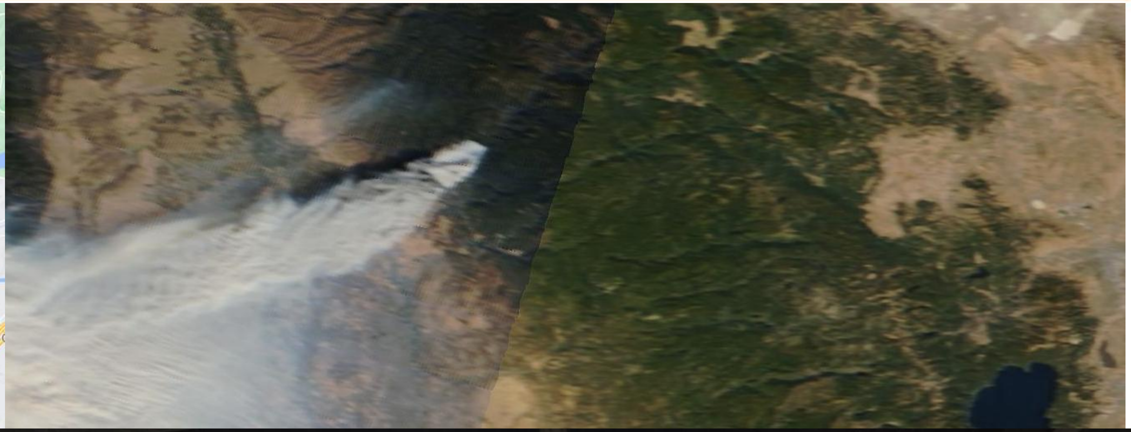
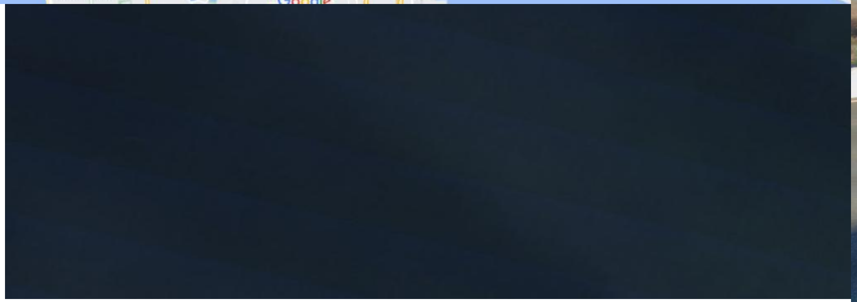
Aerosol

Berkeley, CA - Aquatic Park







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CASS - Carbonaceous Aerosol Speciation System

CASS

TCA08

AE33

Rigler et al., 2020, AMT

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CASS - Carbonaceous Aerosol Speciation System

- TCA08:
  - Simplified thermal protocol for TC
  - Two chambers - continuous data
  - 20 min – 24 h time resolution

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  - eBC ~ EC
  - 1 s – 1 min time resolution

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  OC(t) = TC(t) – BC(t)

- Carbonaceous aerosols (carbonaceous matter)

  CA(t) = BC(t) + OA(t)

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- Carbonaceous aerosols (carbonaceous matter)

$$\mathbf{CA(t) = BC(t) + OA(t)}$$

  - Using OA/OC (OM/OC) ratio

$$\mathbf{CA(t) = TC(t) \cdot \left(\frac{OA}{OC}\right) - BC(t) \cdot \left[\left(\frac{OA}{OC}\right) - 1\right]}$$

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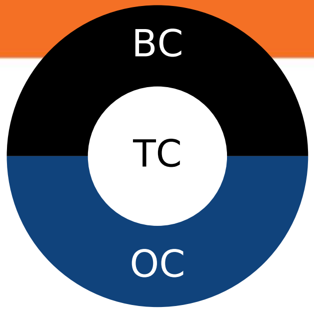
CASS – apportionment models

- CASS measurements (Rigler et al., 2020, AMT):
  - **OC(t) = TC(t) - BC(t)**



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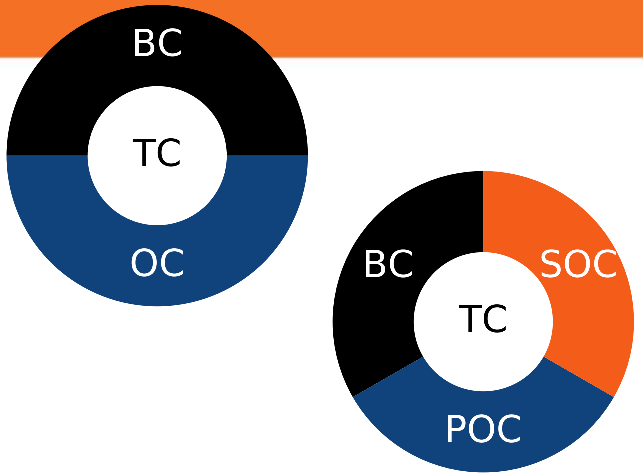

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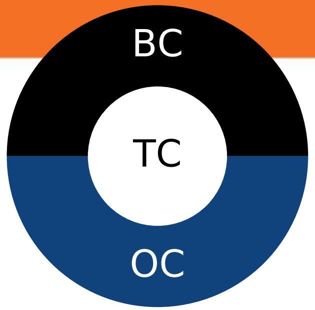

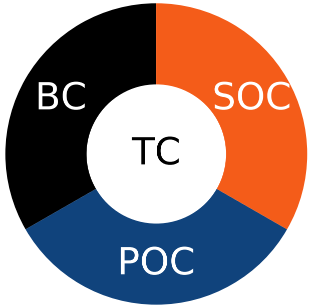

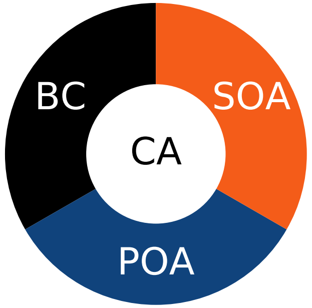

Aerosol

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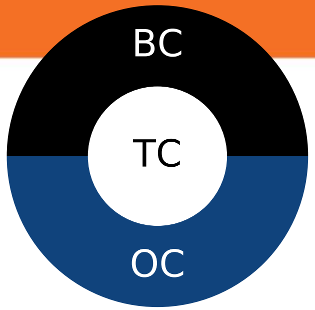

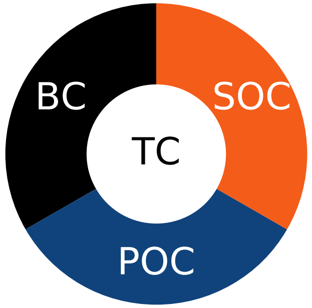

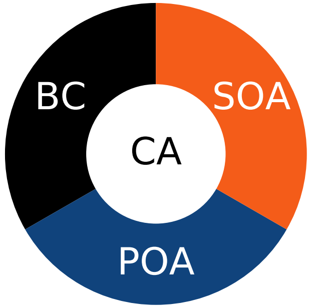

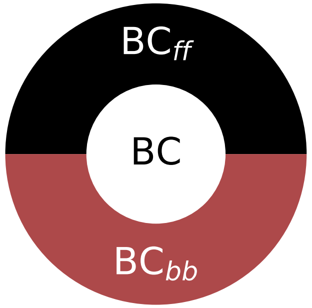

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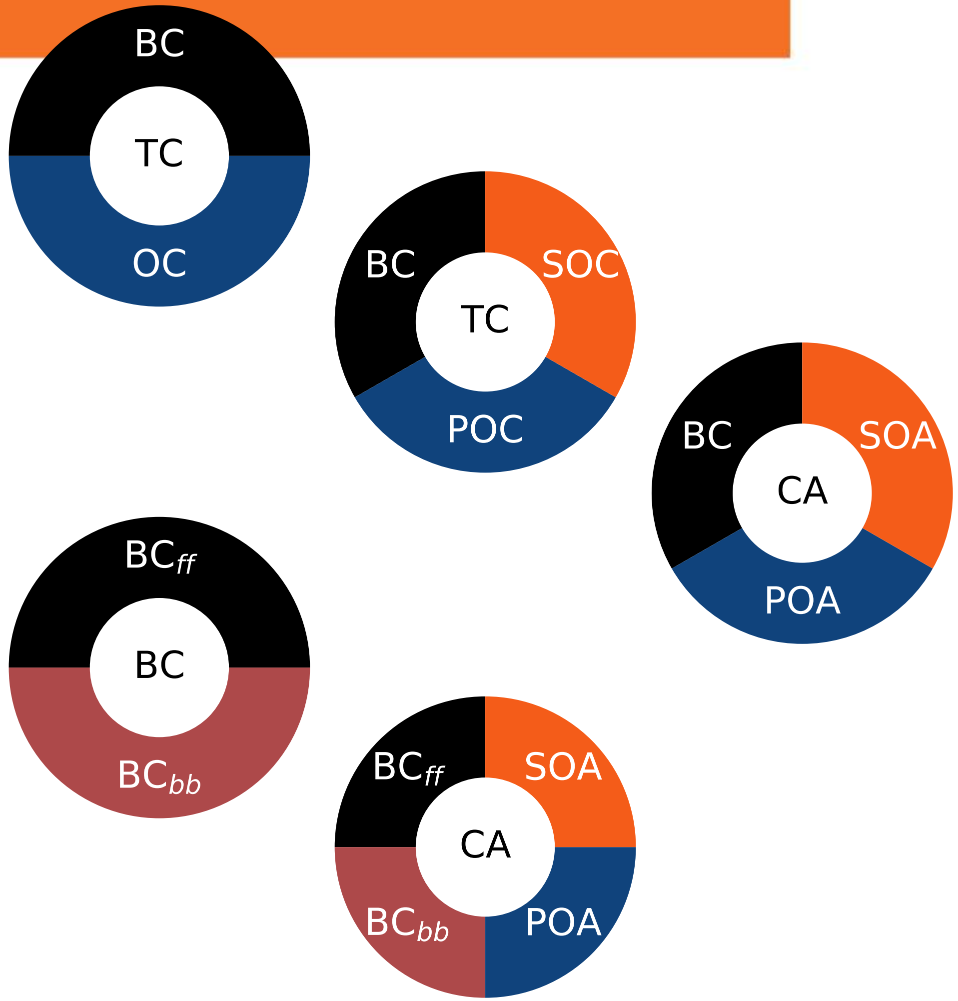
  - **$CA(t) = BC_{ff}(t) + BC_{bb}(t) + POA(t) + SOA(t)$**



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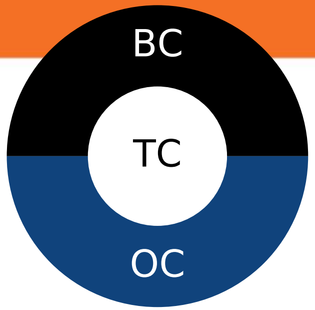
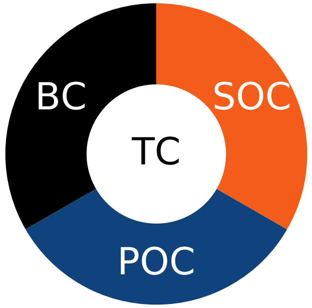
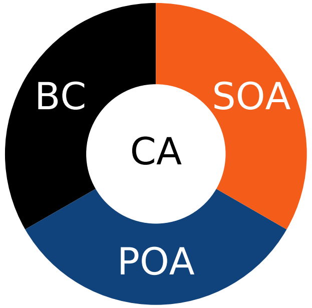
- Apportionment of light-absorbing CA
  - Brown carbon model

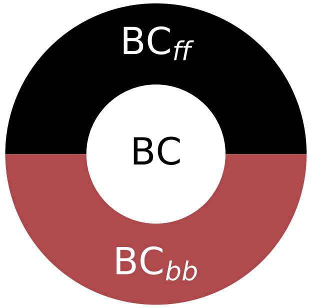
$$b_{abs}^{BrC}(880nm) = 0, b_{abs}^{BC}(880nm) = b_{abs}(880nm)$$

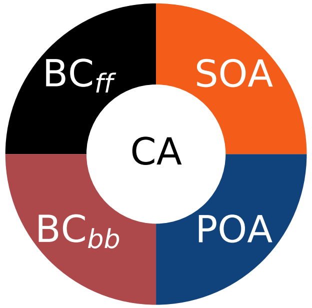
  - AAE_{BC}=1.15 -> $\mathbf{b_{abs}^{BrC}(\lambda,t) = b_{abs}(\lambda,t) - b_{abs}^{BC}(\lambda,t)}$

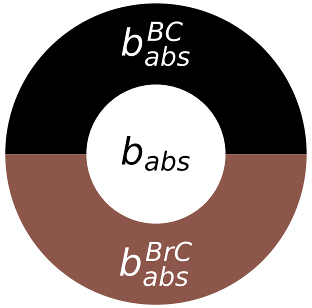


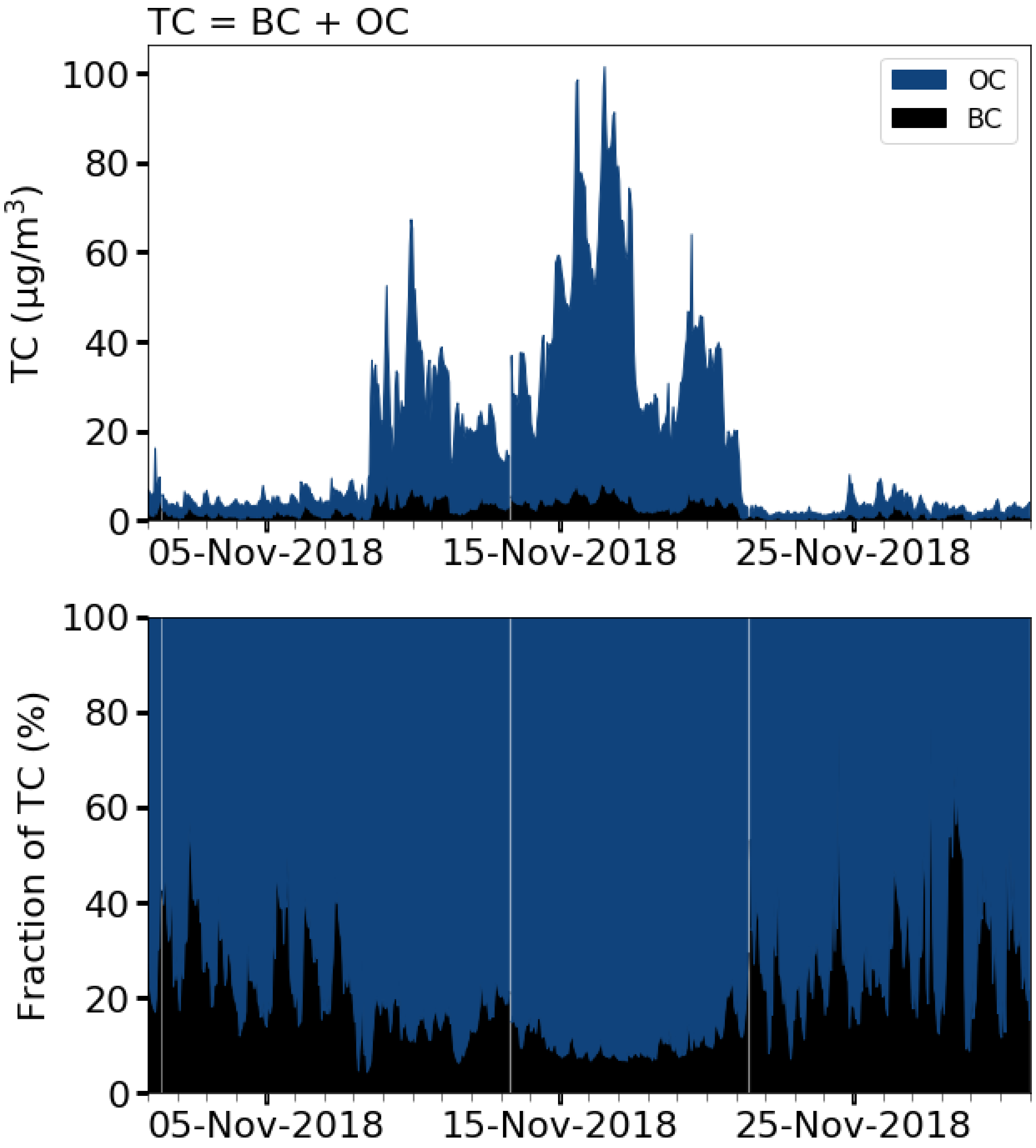




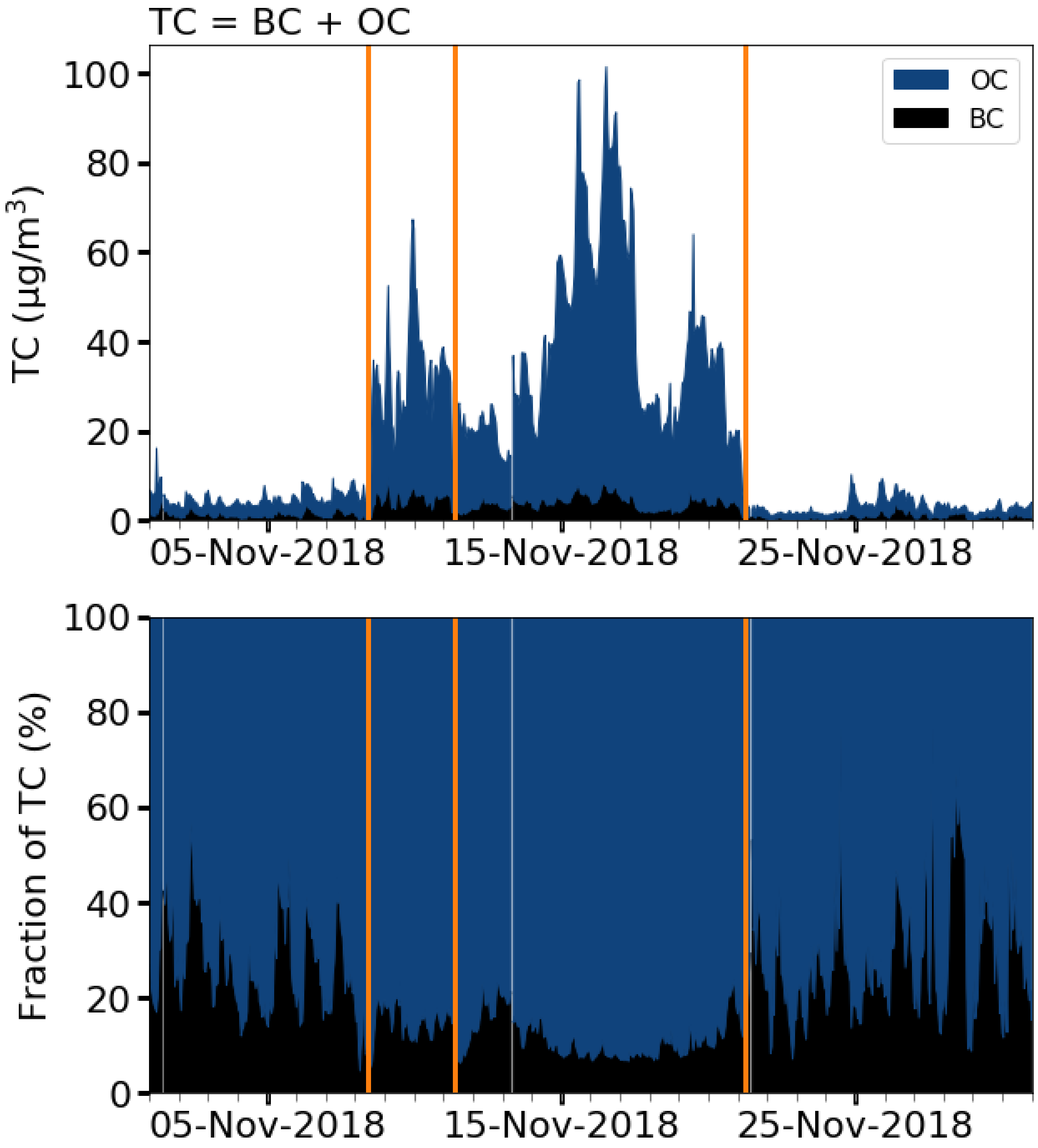




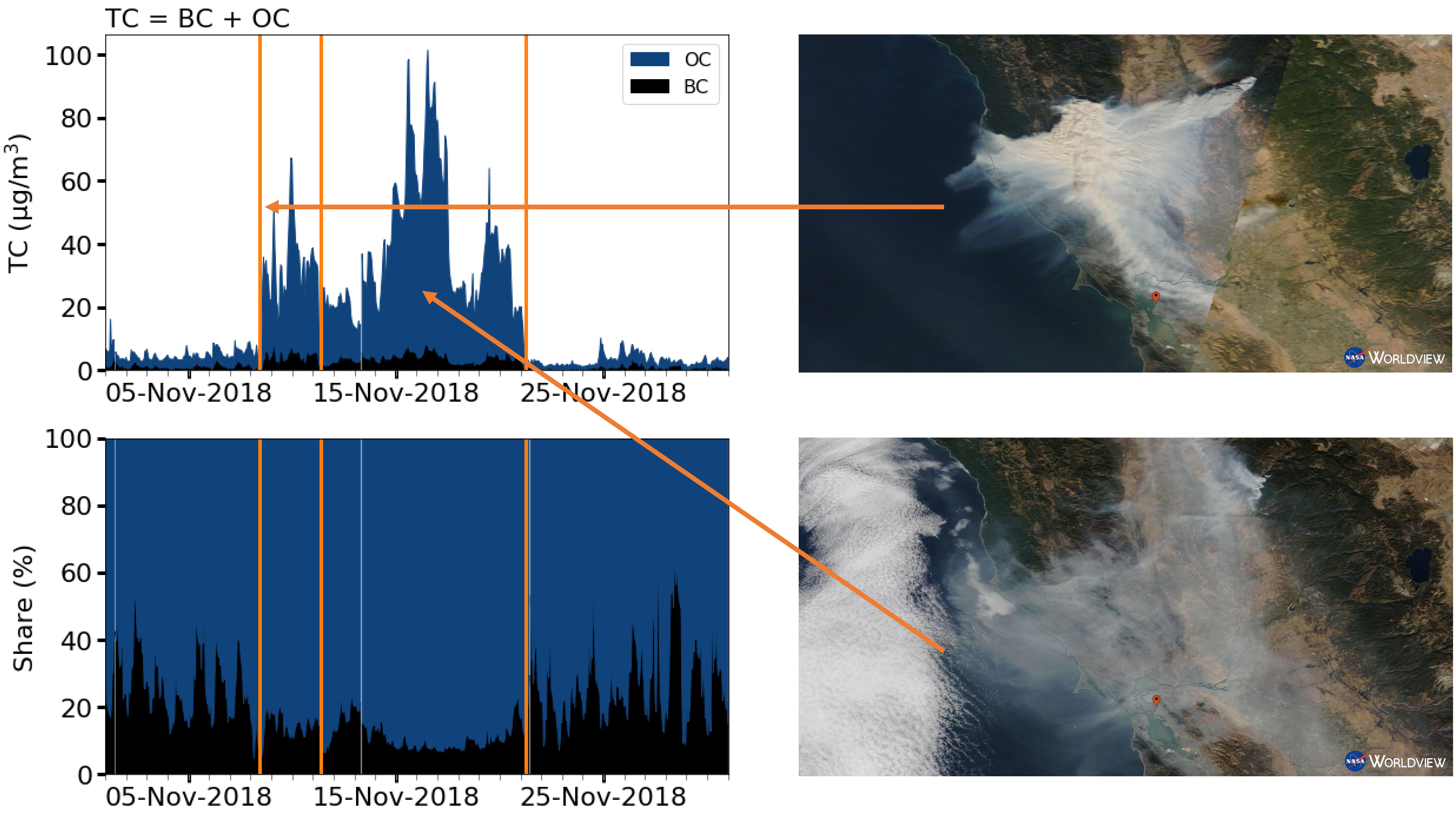




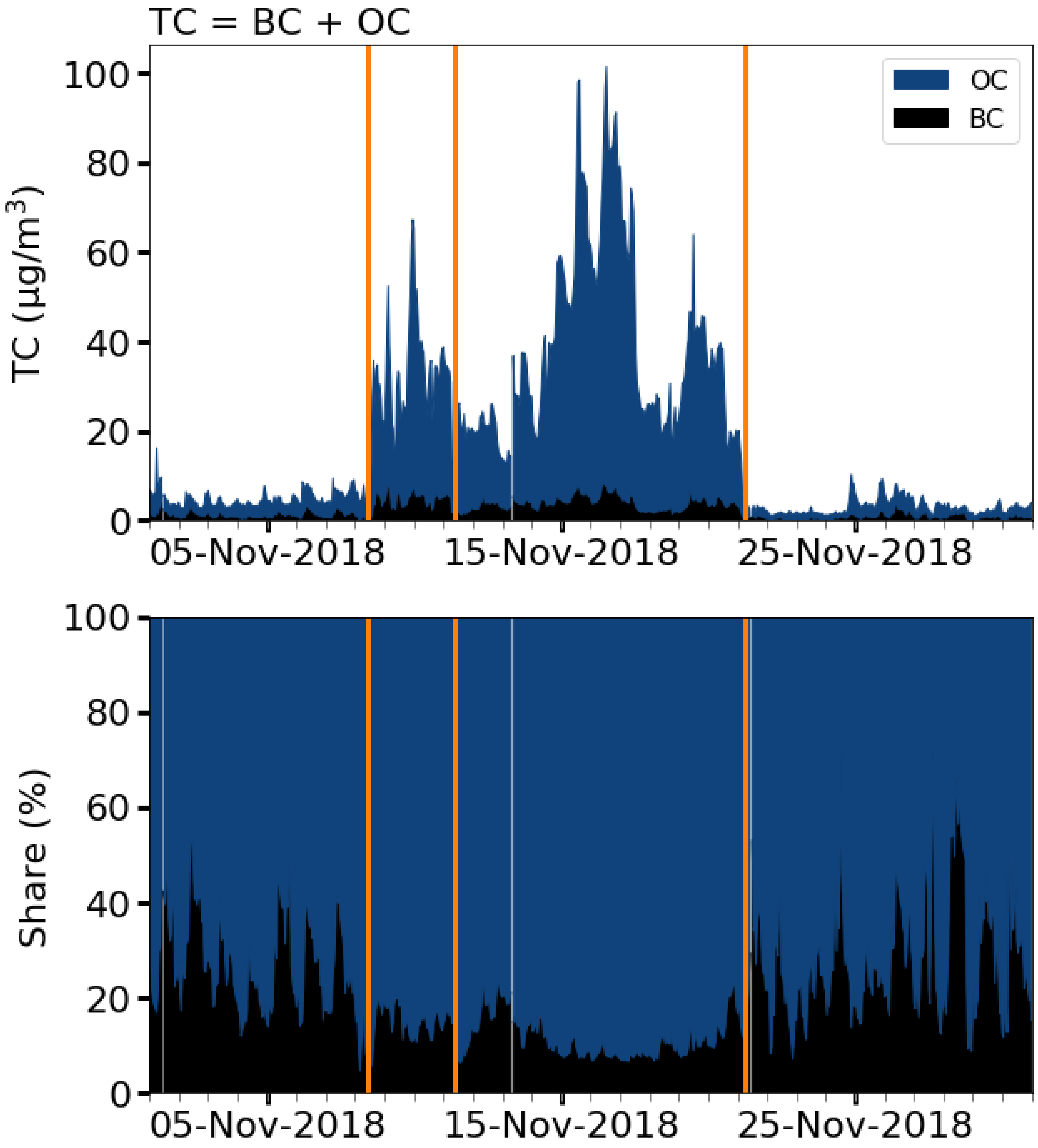
TC = BC + OC
OC
BC
TC (µg/m3)
100
80
60
40
20
0
05-Nov-2018
15-Nov-2018
25-Nov-2018
Fraction of TC (%)
100
80
60
40
20
0
05-Nov-2018
15-Nov-2018
25-Nov-2018



- 8 November
  - Fire started at 6:20
  - Plume reached BAAQD site 4 hours later
- 11 November
  - Over 70 % of the final area was burned by the end of November 10, three days after ignition.
- 21 November - Heavy rain
  - Helped to fully contain the fire
  - Washed out atmosphere of all pollution



TC = BC + OC
TC (µg/m3)
OC
BC
100
80
60
40
20
0
05-Nov-2018
15-Nov-2018
25-Nov-2018
Share (%)
100
80
60
40
20
0
05-Nov-2018
15-Nov-2018
25-Nov-2018
WORLDVIEW
WORLDVIEW



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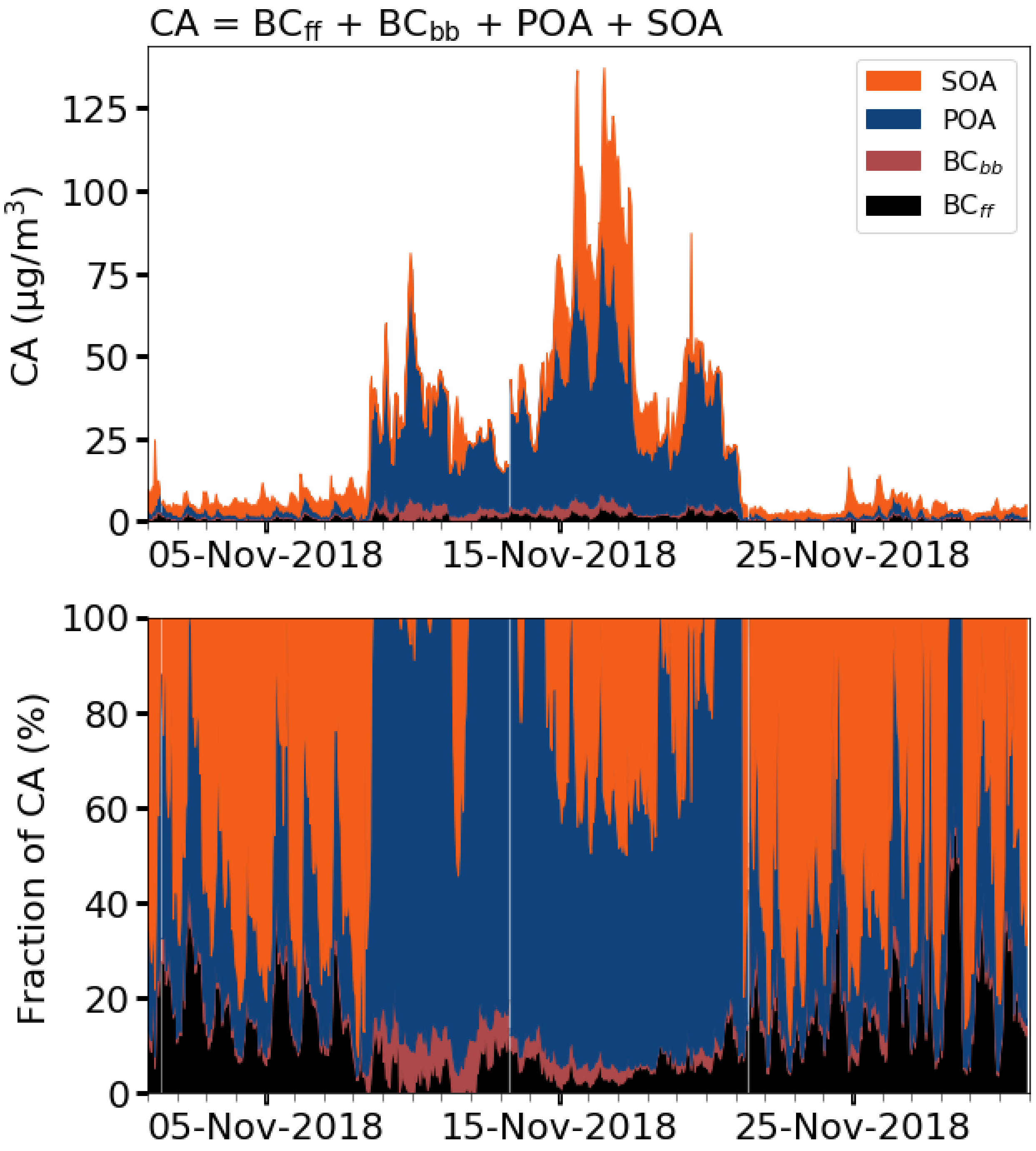
TC (during) = 9.5 x TC (before/after)

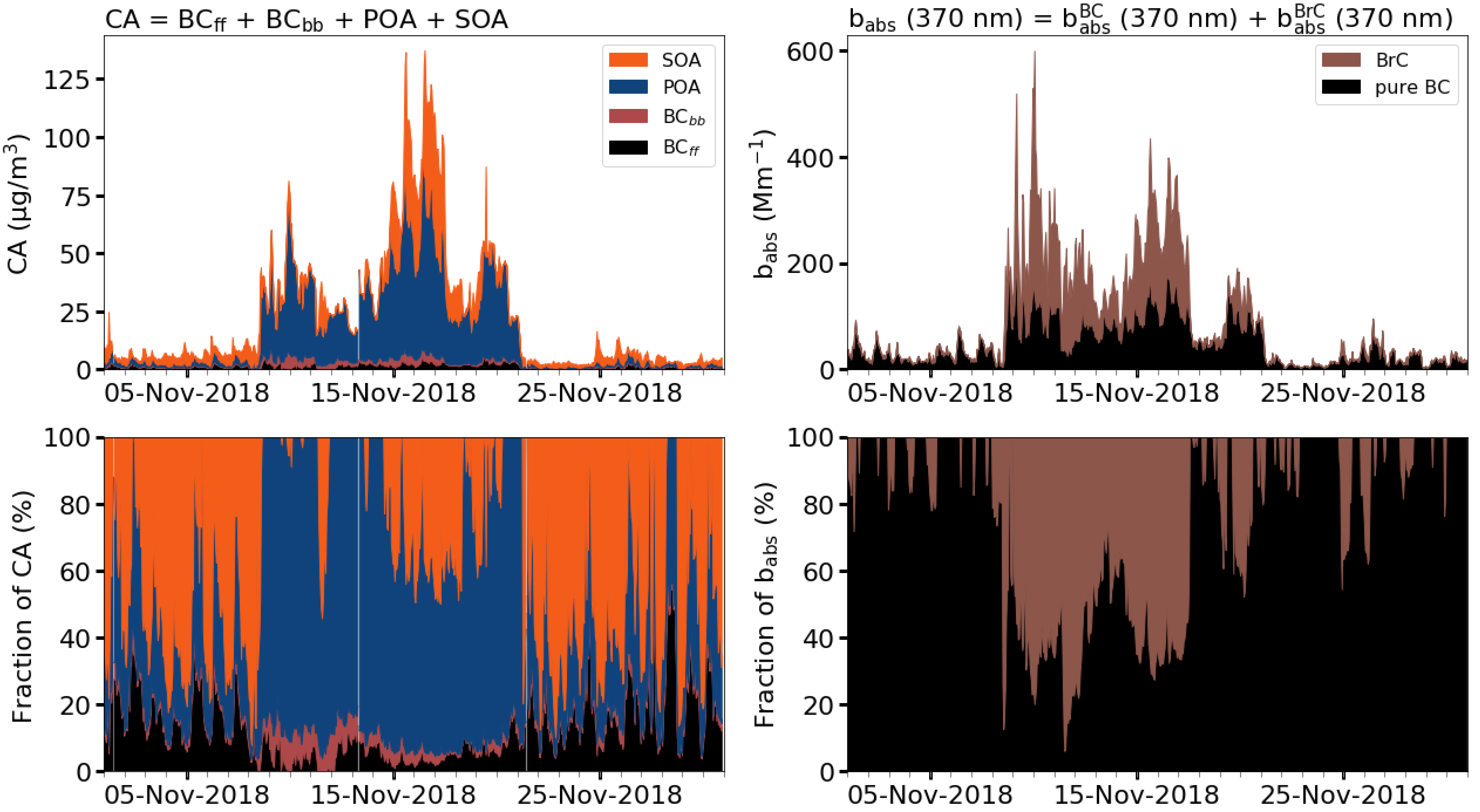
BC(during) = 3.8 x BC (before/after)

OC(during) = 11.8 x OC (before/after)

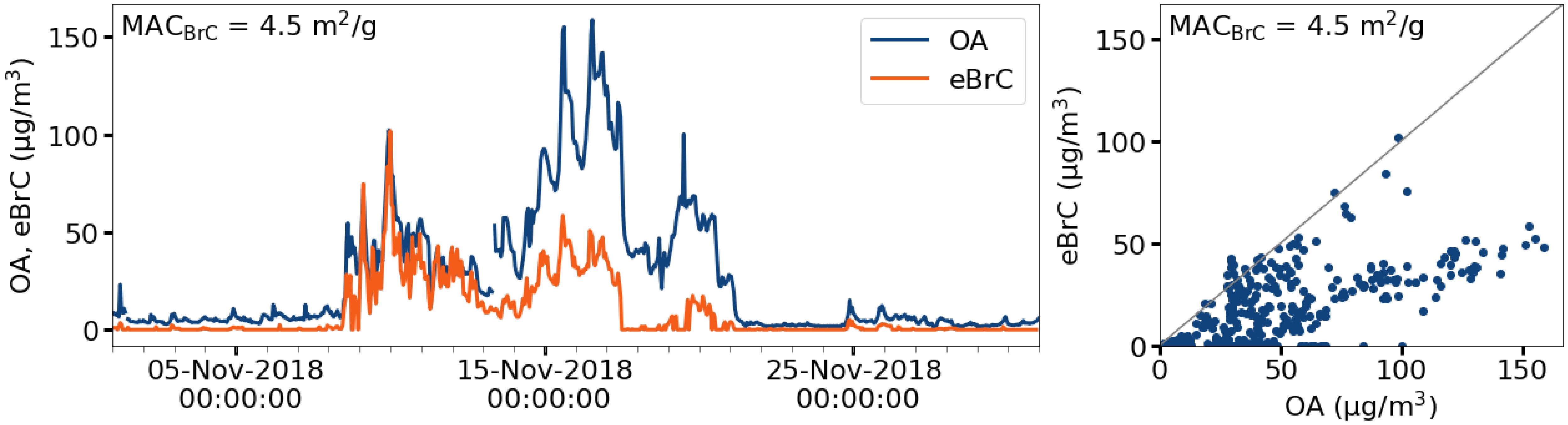


- Daily cycle before and after fire event
  - High morning primary CA (BC+POC) contribution due to morning rush hour
  - High secondary CA during afternoons and nights
  - Negligible BB contribution

- During fire event:
  - Significant BC_{bb} contribution
  - First phase: primary OA recognized as major contributor to CA
  - Second phase: up to 50 % OA is formed secondarily

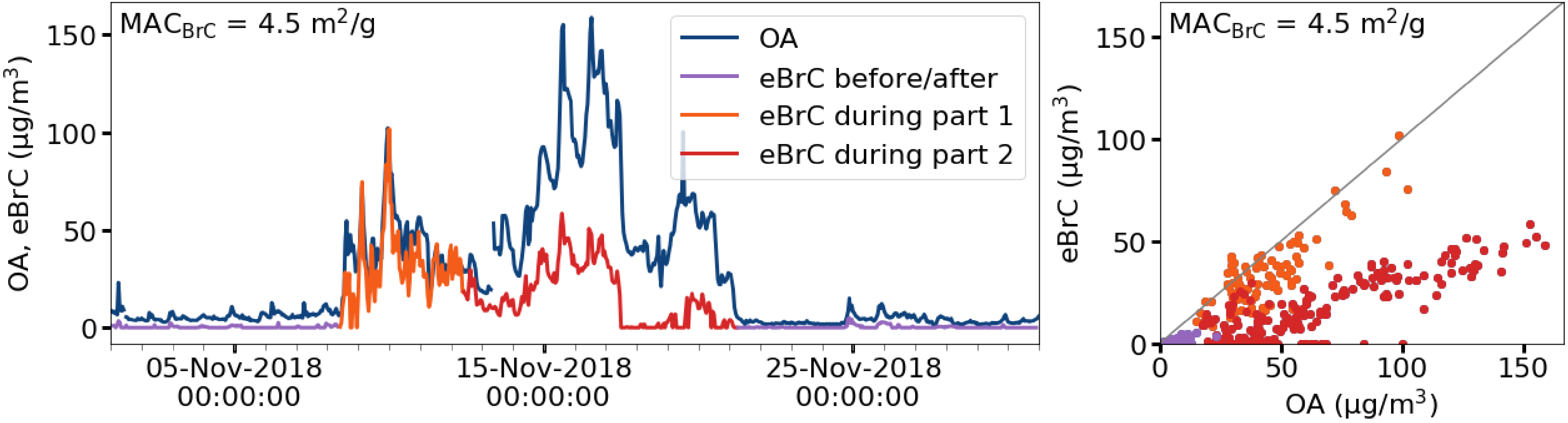


CA = BCff + BCbb + POA + SOA
SOA
POA
BCbb
BCff
CA (µg/m3)
0
25
50
75
100
125
05-Nov-2018
15-Nov-2018
25-Nov-2018
babs (370 nm) = bBCabs (370 nm) + bBrCabs (370 nm)
BrC
pure BC
babs (Mm−1)
0
200
400
600
Fraction of CA (%)
Fraction of babs (%)
0
20
40
60
80
100



Chow et al., 2019, EAC:

Equivalent BrC: $MAC_{BrC} = 4.5\ m^2/g$



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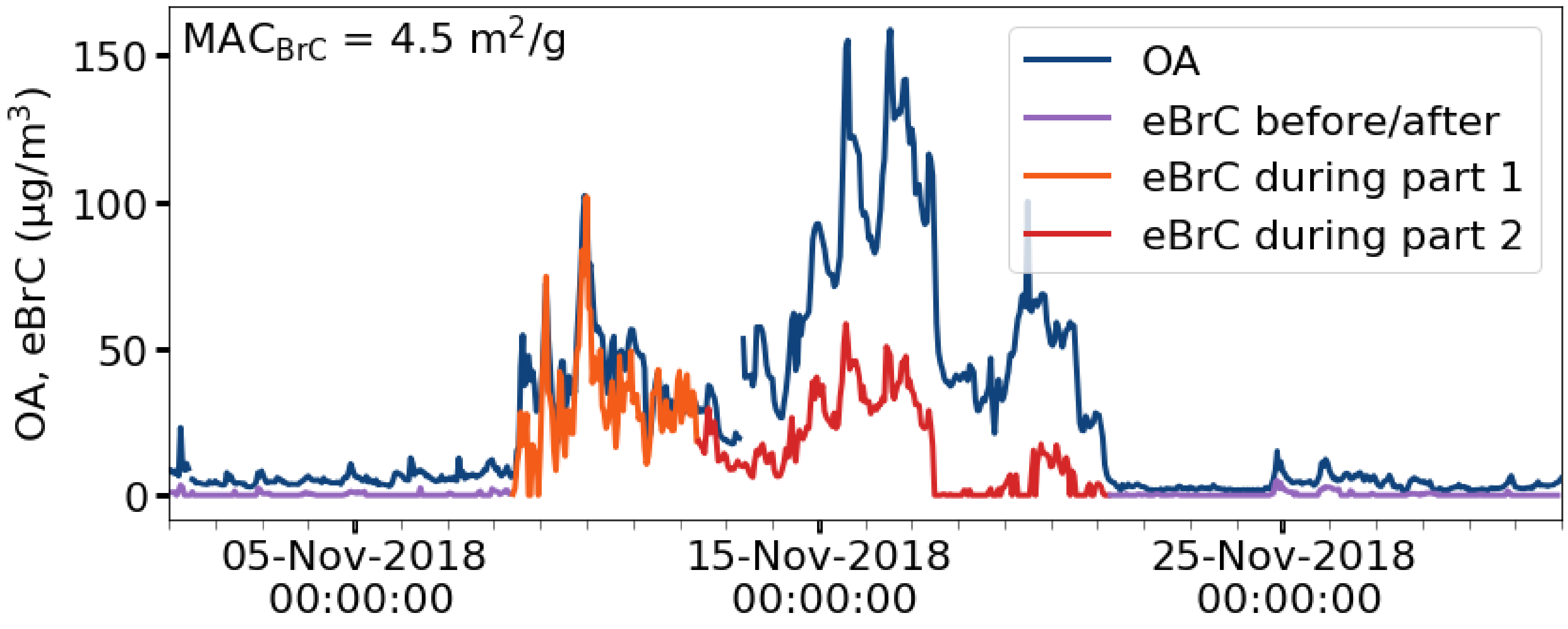

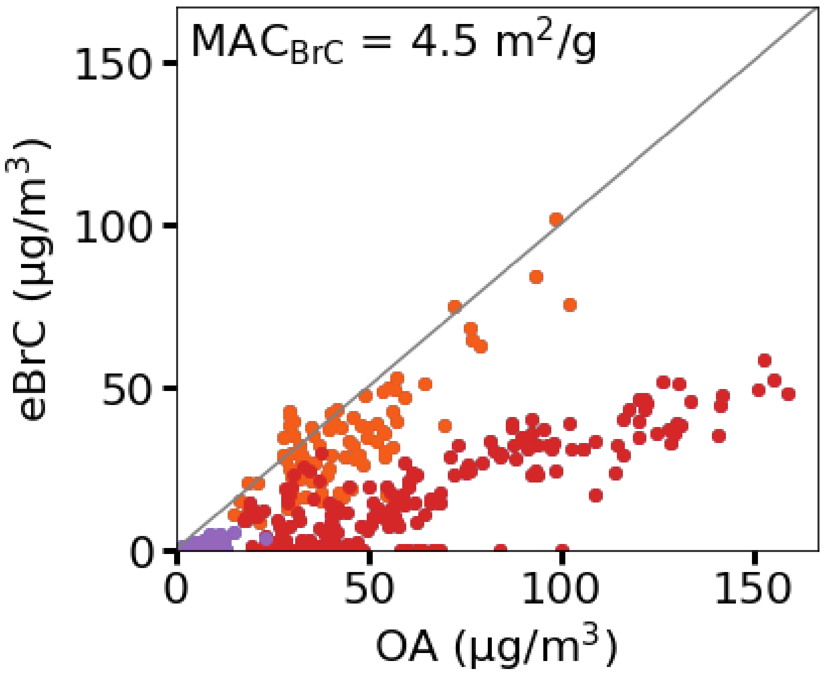

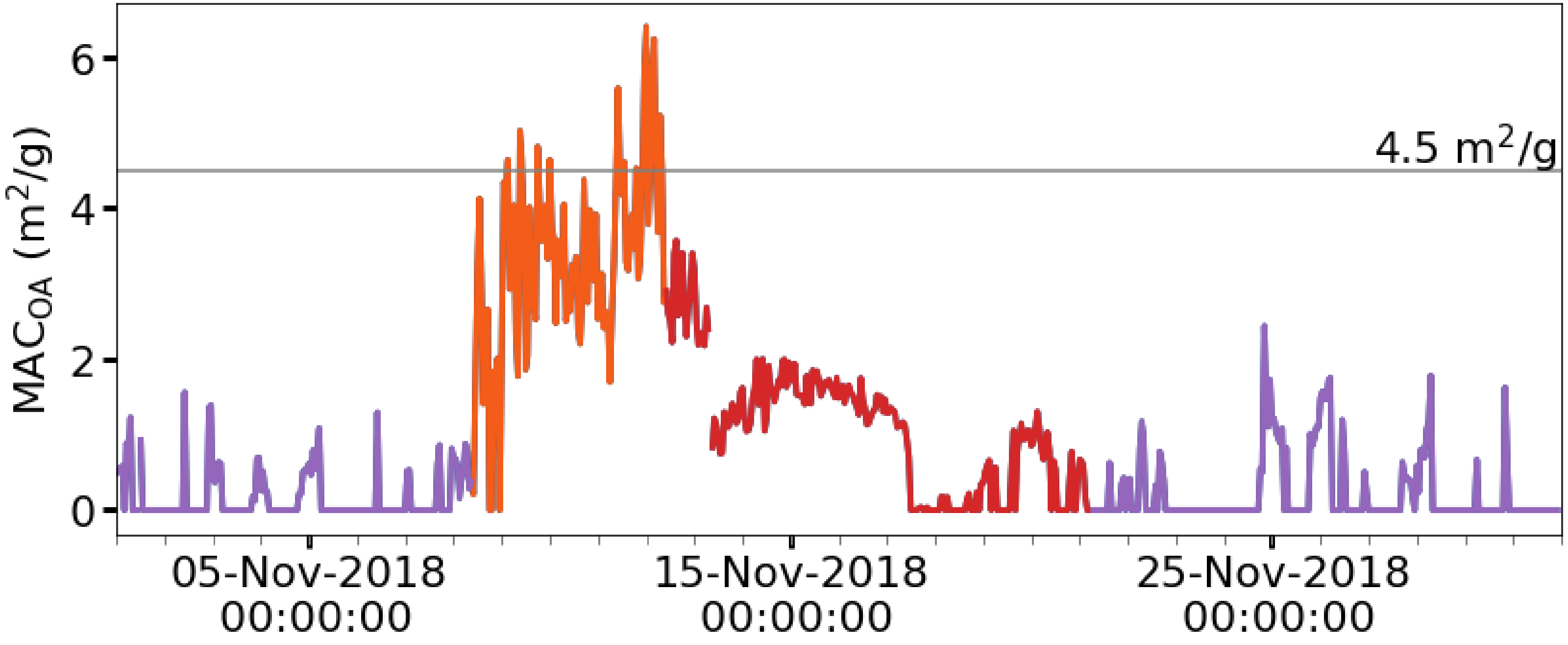

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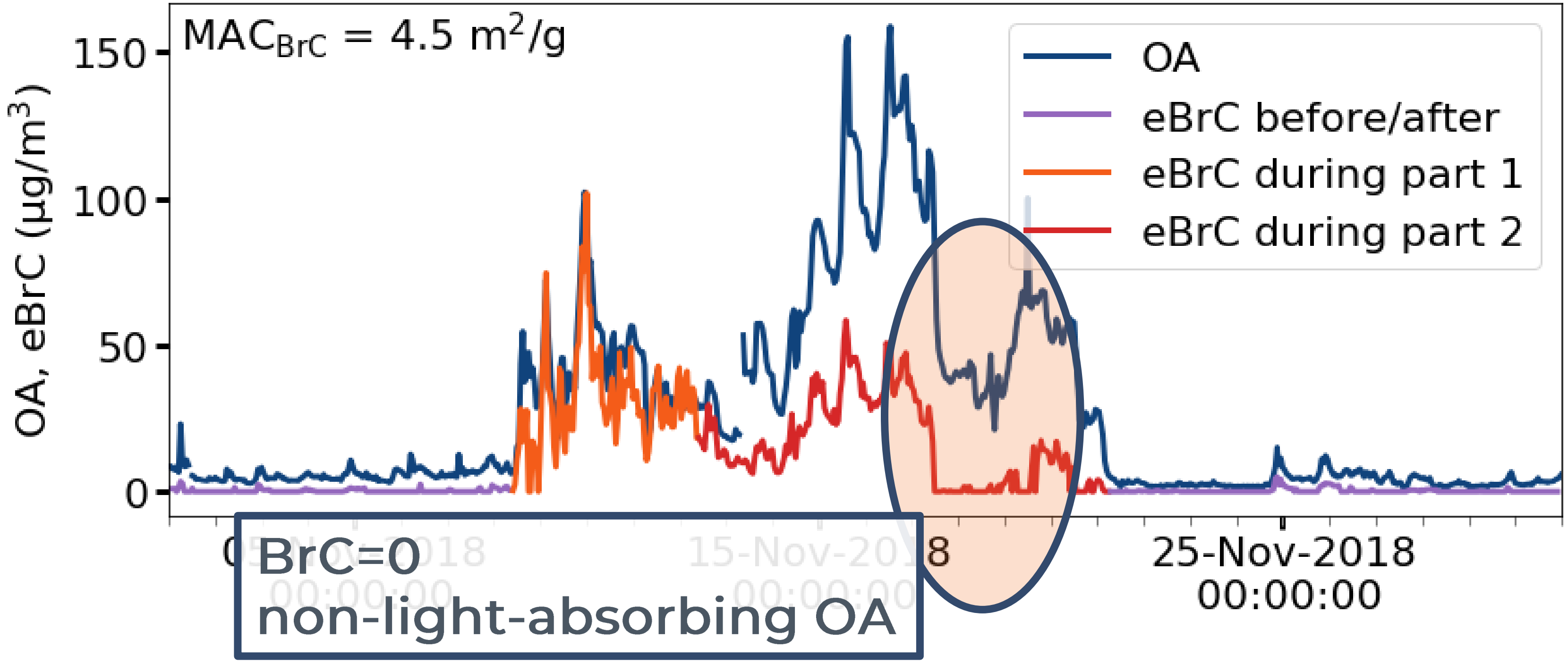

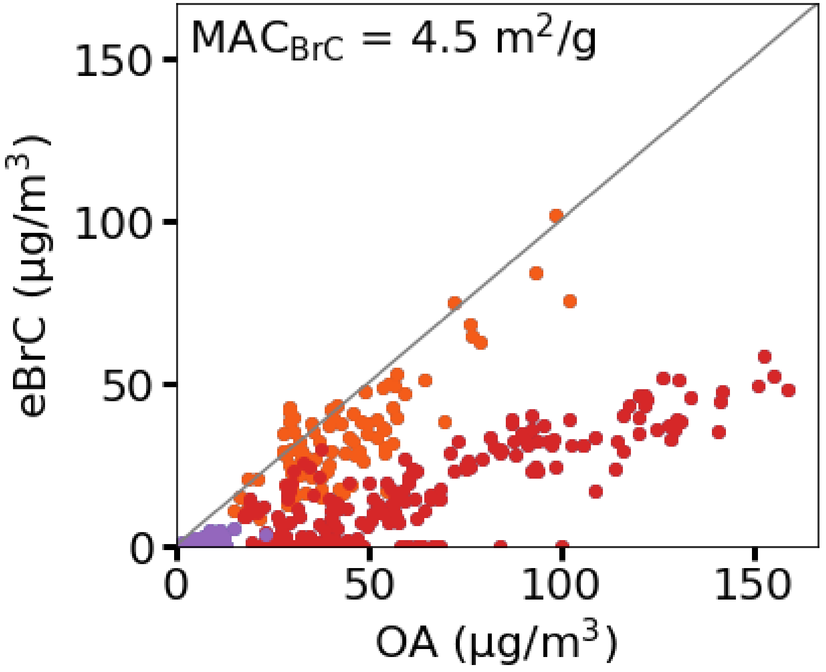

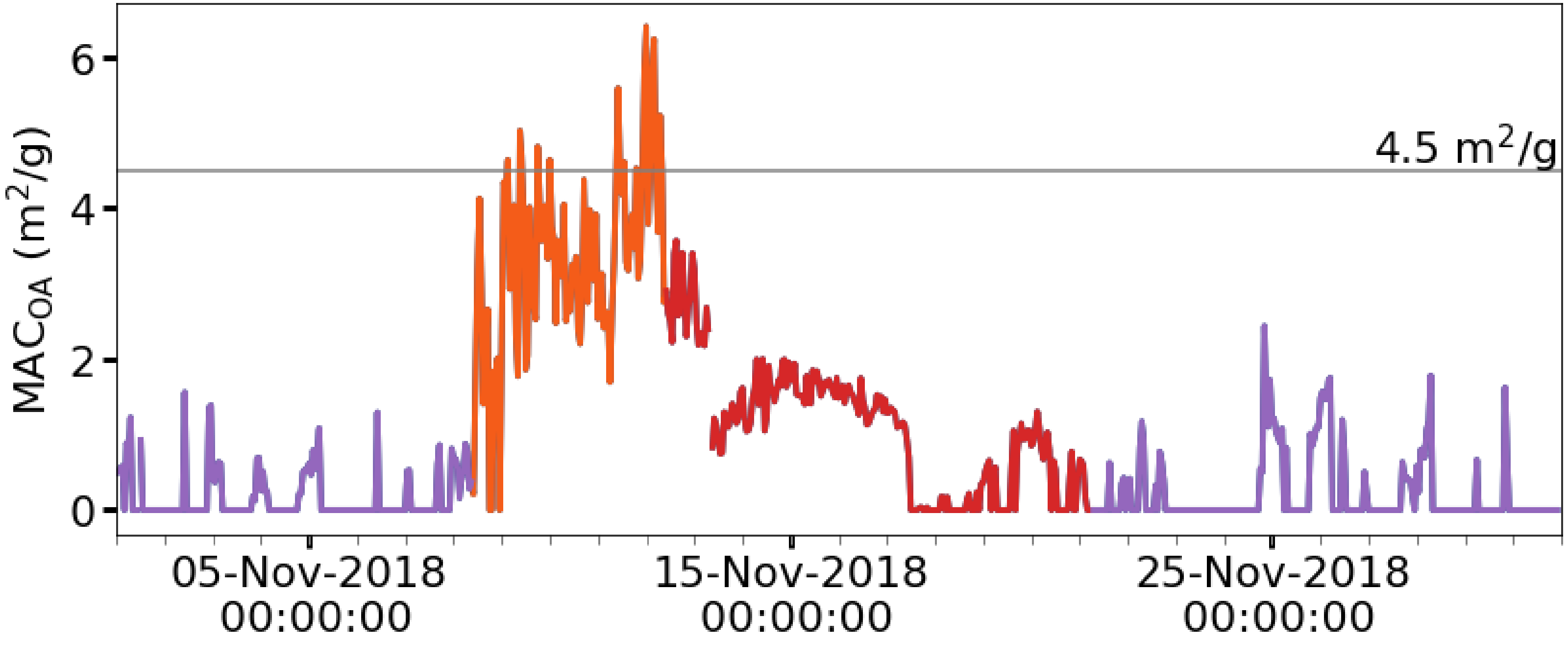

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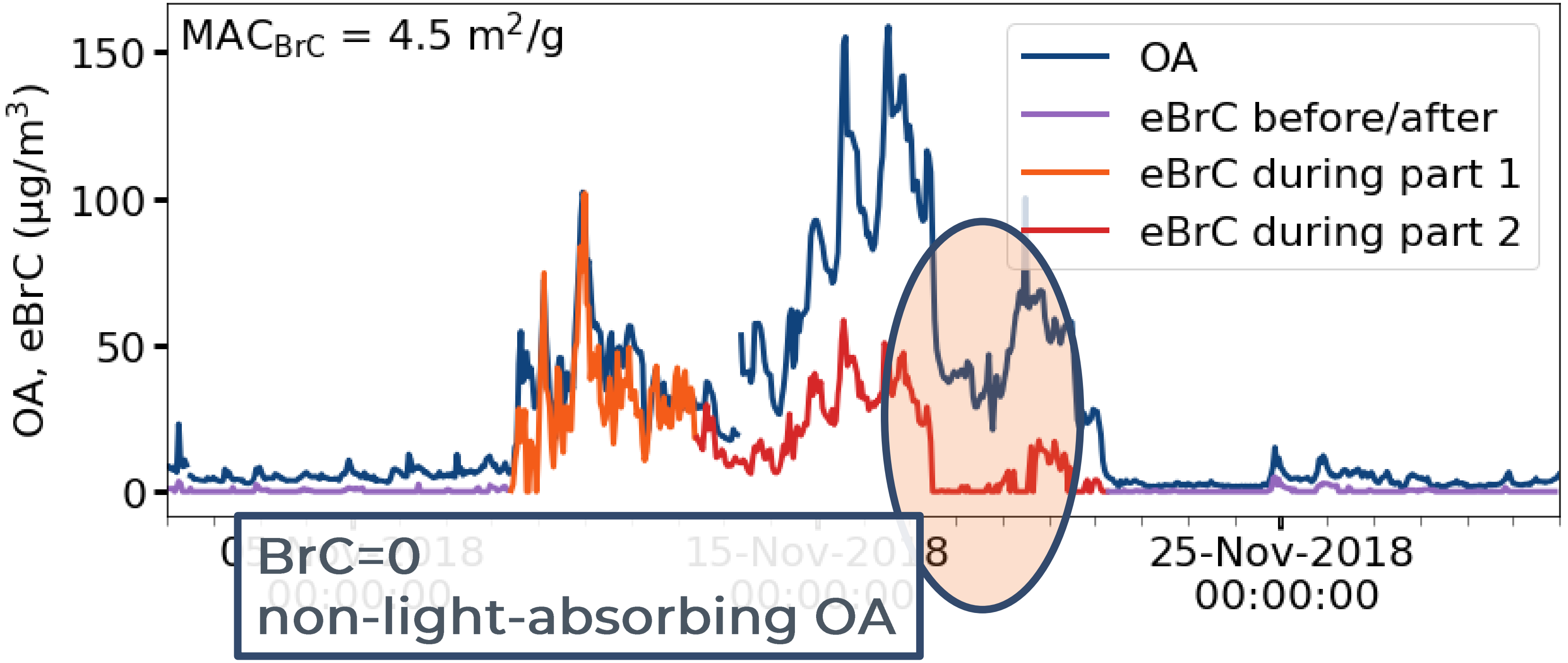
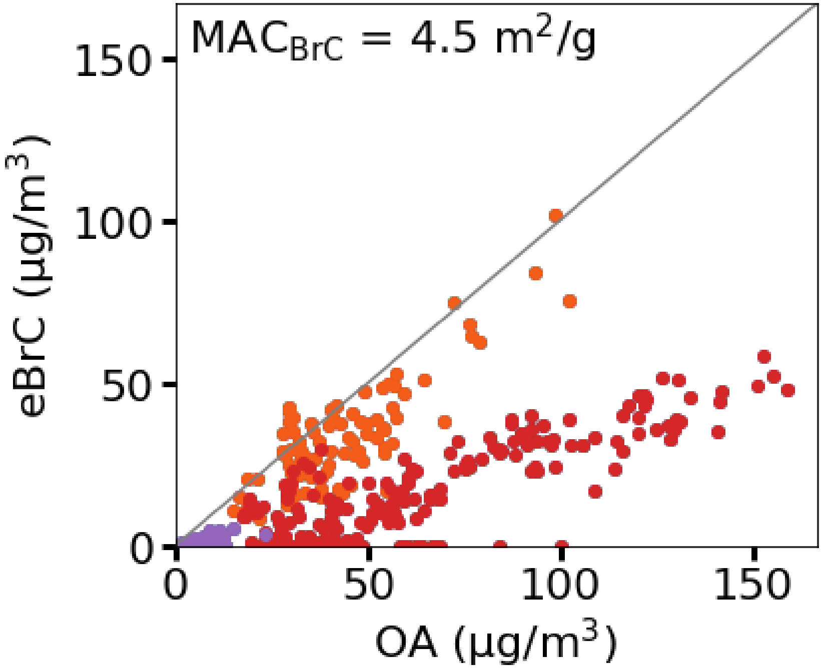
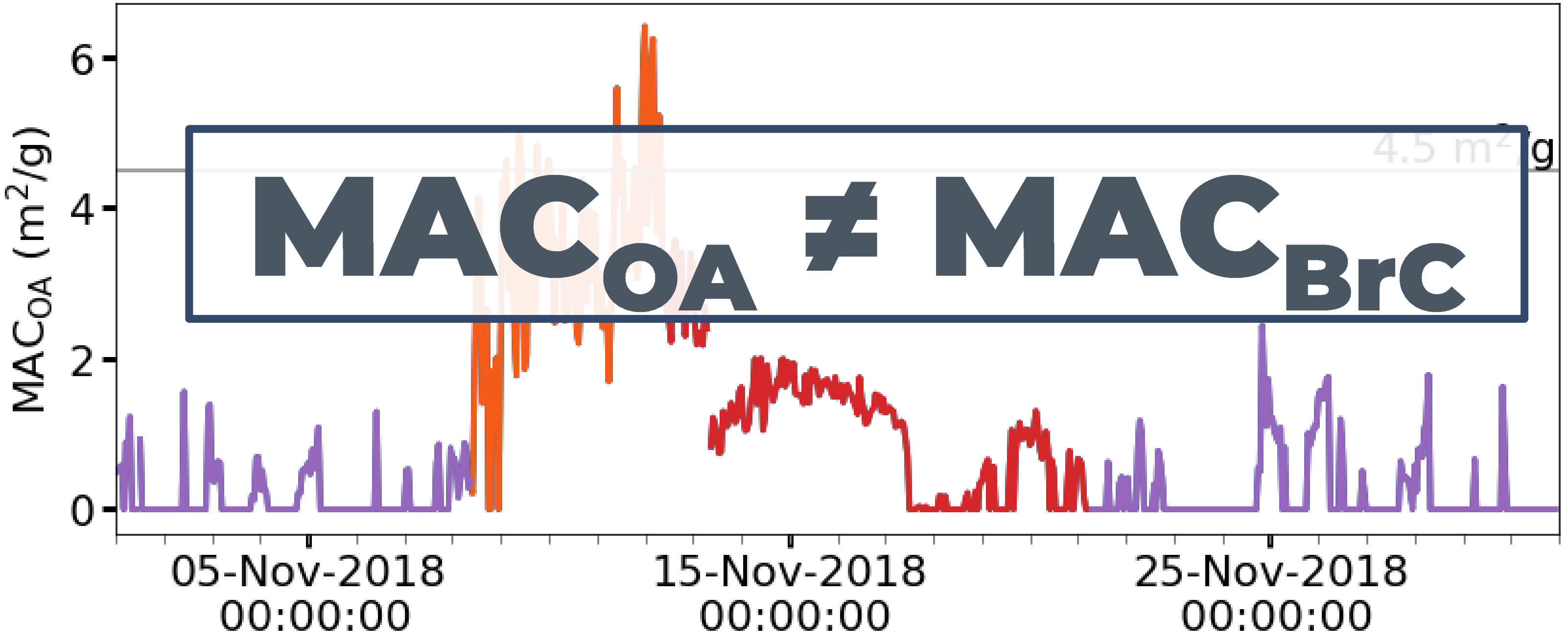
Time variation of MAC
or
non-light-absorbing OA?







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Time variation of MAC
or
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SUMMARY

- Camp fire was deadliest and most destructive fire in CA
- The carbonaceous aerosols from fire plume were characterized with CASS on Berkeley site
  - Details on high time resolution of 1hr
  - Apportionment of CA
    - 4 components
    - 2 optical components light absorbing CA
  - The difference between two fire phases
    - Higher SOC contribution in second phase
    - Higher non-light-absorbing OA in second phase

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Thank you for your kind attention!

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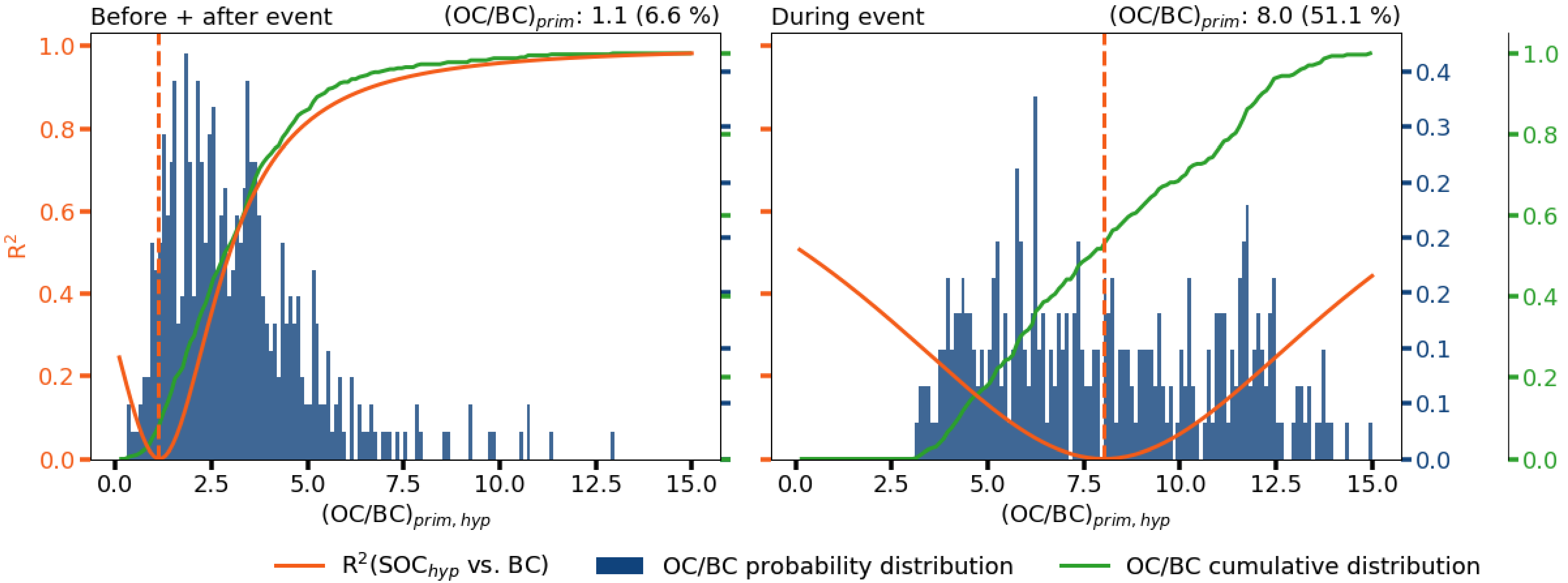
BC tracer model – MRS method (Wu&Yu, 2016, ACP)

$$SOC(t) = OC(t) - POC(t) = OC(t) - BC(t) \cdot \left(\frac{OC}{BC}\right)_{prim}$$



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Uncertainties

• Absorption (Drinovec et al., 2015):	10-15 %
• TC (Rigler et al., 2020):	10 %
▸ OC:	18 %
• Aethalometer model (Zotter et al., 2017):	18 %
• BC tracer – MRS (Wu&Yu, 2016):	20 %
• Carbon content (Aiken et al., 2008):	6 %
• BrC model (Zhang et al., 2020):	11 %
• MAC BrC:	~ 35 %
• Non-light absorbing OA:	~ 40 %

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