Characteristics of Black Carbon Aerosol from a Surface Oil Burn During the Deepwater Horizon Oil Spill

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Citation: Perring et al., GRL, 38 (L17809), 2011

Photo: Dan Lack

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- To assess the yield of black carbon (BC) particles produced from surface oil burning

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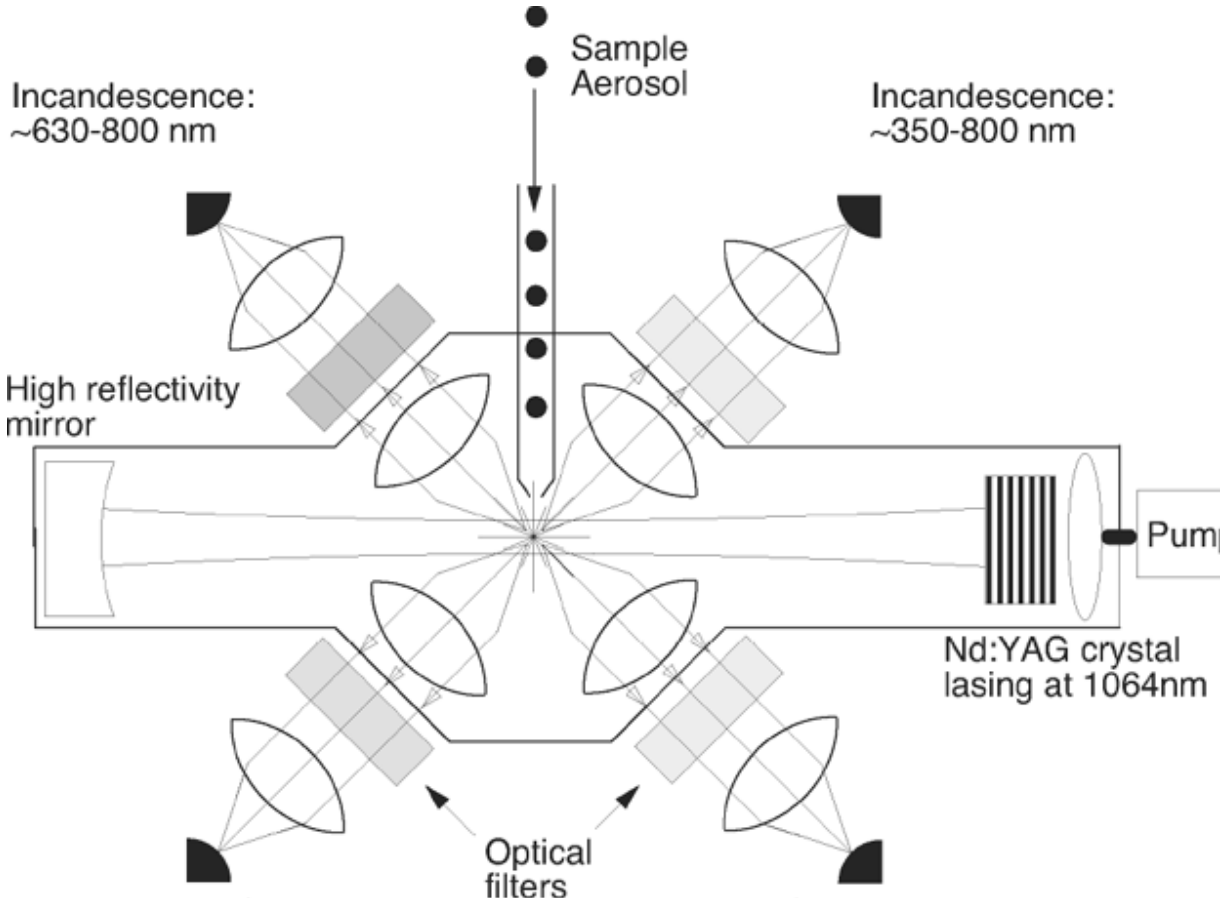
This is not meant to be a commentary on the relative harms and benefits of surface burning as an oil spill remediation strategy

Single Particle Soot Photometer

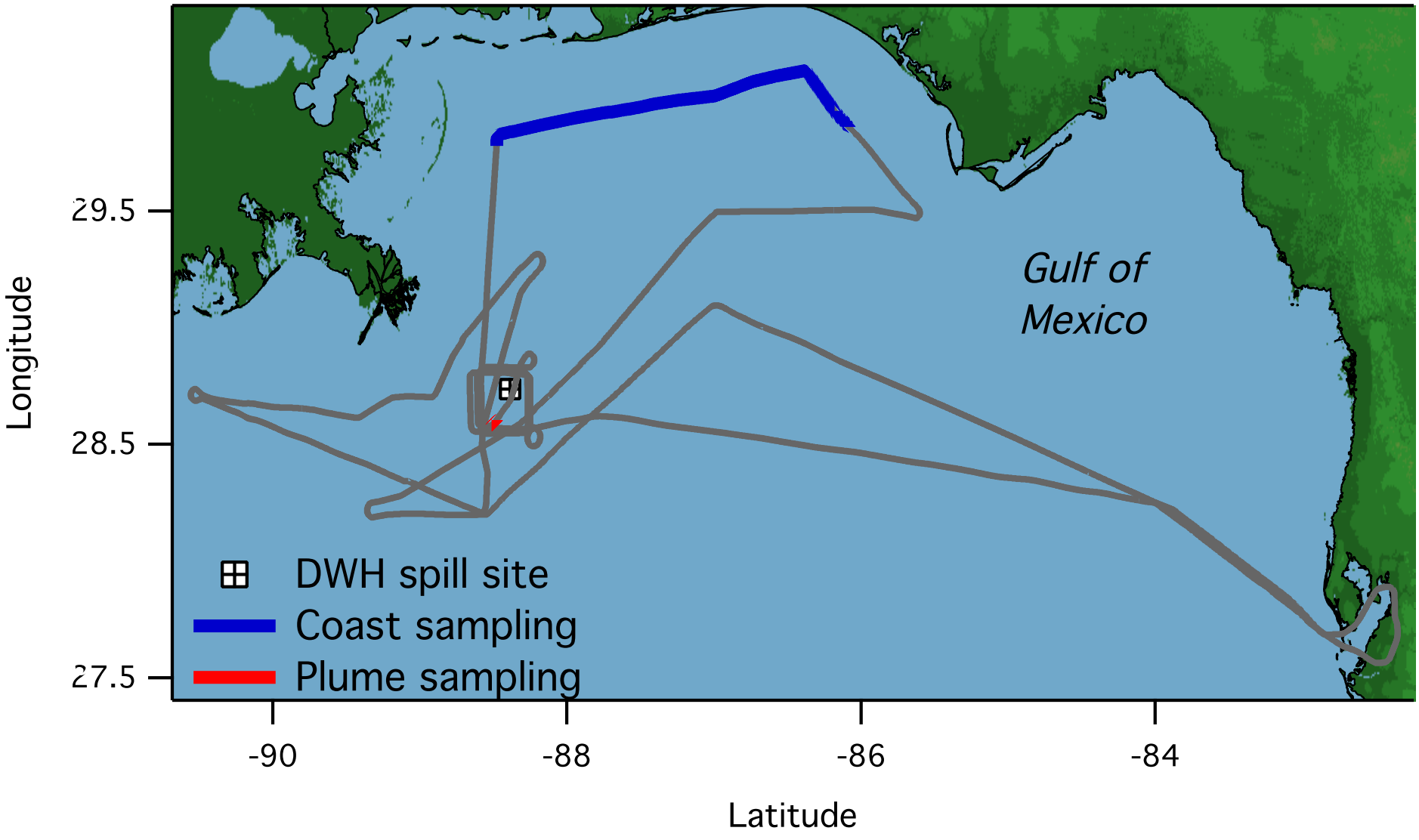


- Laser-induced incandescence technique to measure BC aerosol.
- Detects *individual* BC particles of 0.7-350 fg (~90-700 nm volume equivalent diameter)
- Uncertainty of ~40% due to calibration uncertainties

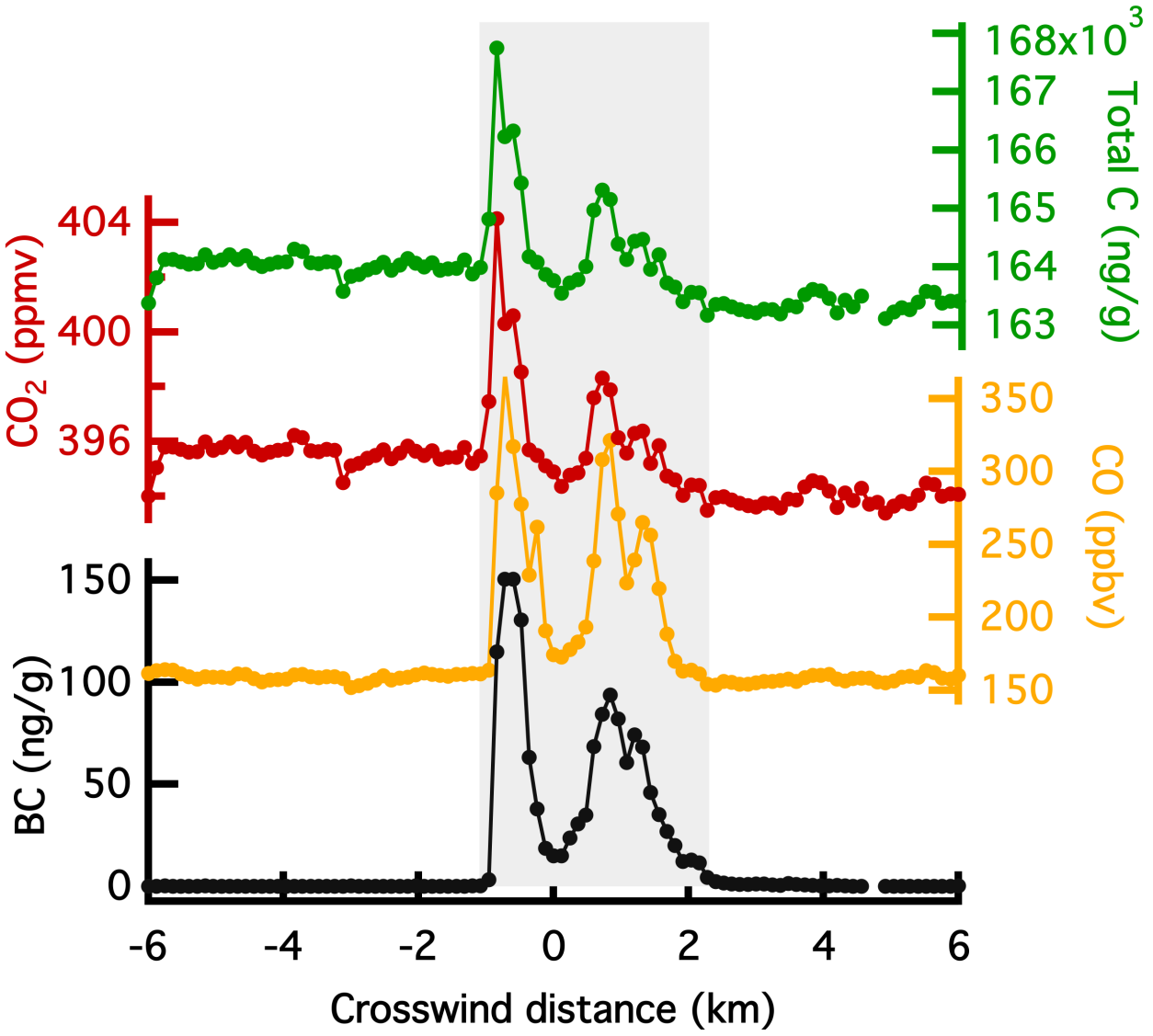
Schwarz et al., JGR-Atm, 2006

Experiment

- Flight of 08 June 2010
- Included sampling of burn plumes as well as gulf background air



Black Carbon Yield



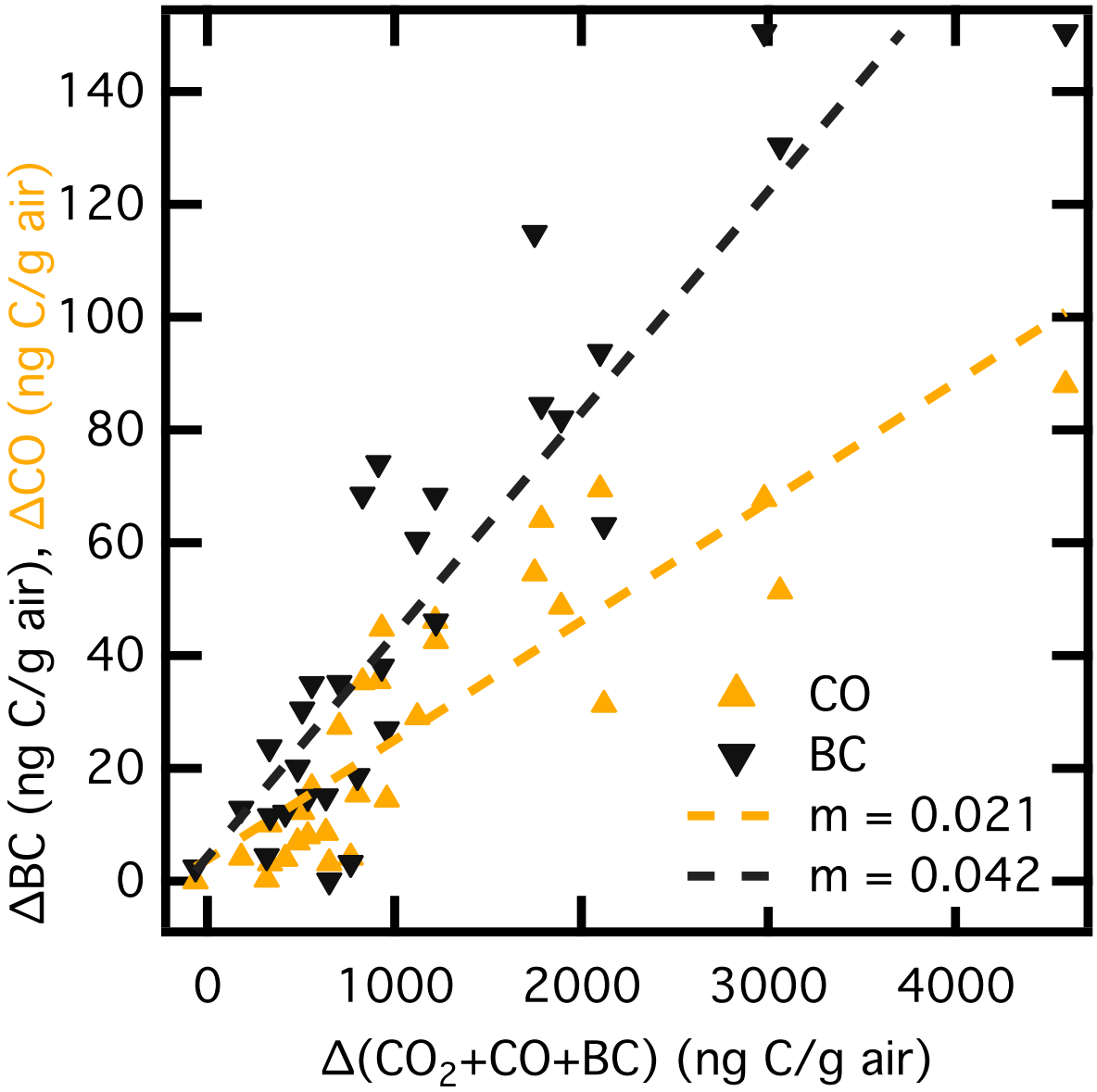
- Requires a plume of sufficient concentration for CO2 levels to be well above background concentrations.

- The P-3 encountered one such plume at ~1000m elevation and sampled it for ~45 seconds

Black Carbon Yield

- Observations show BC and CO yields of 4.2% and 2.1% by mass respectively.

- This indicates relatively inefficient combustion but is comparable to previous measurements of surface oil burns

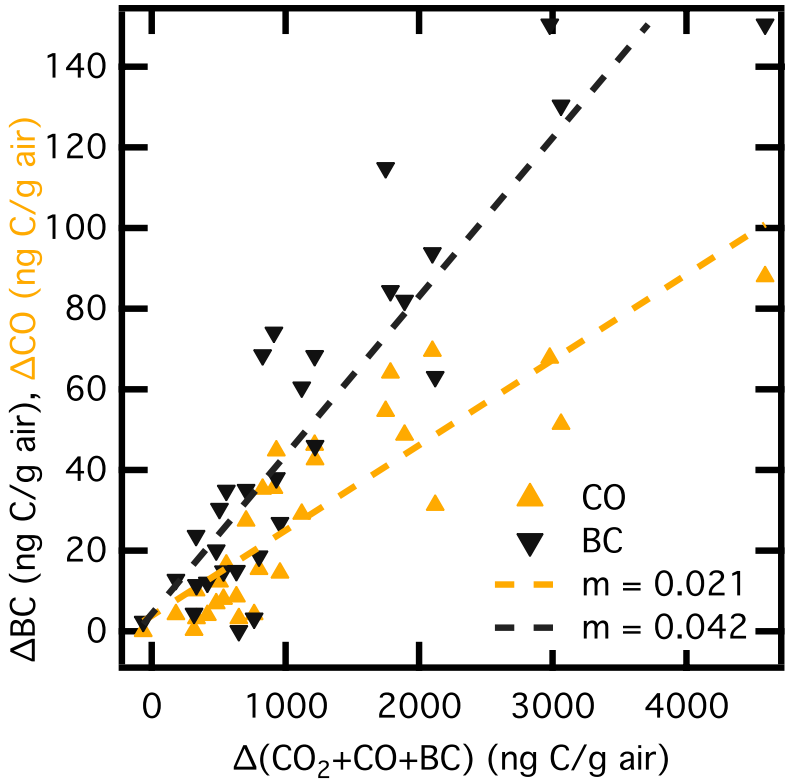


Black Carbon Yield

Calculation

Convert % yield to EF (g-C/kg-fuel)

BC EF = 850 g-C/kg * 0.042 g-BC/g-C
= 36 g-BC/kg-fuel
= 22-50 g-BC/kg-fuel (incl. unc.)



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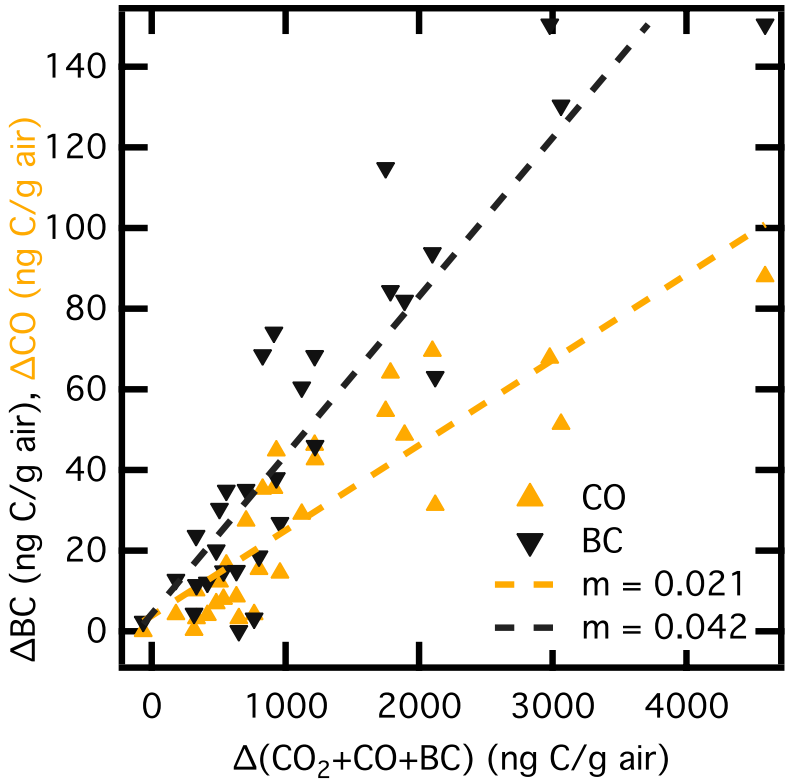

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Oil burned (g) =

(220 - 313 x 10^3 bbls) x (1.6 x 10^5 cm^3/bbl) x (0.9 g/cm^3)

= 3.2 - 4.6 x 10^{10} g

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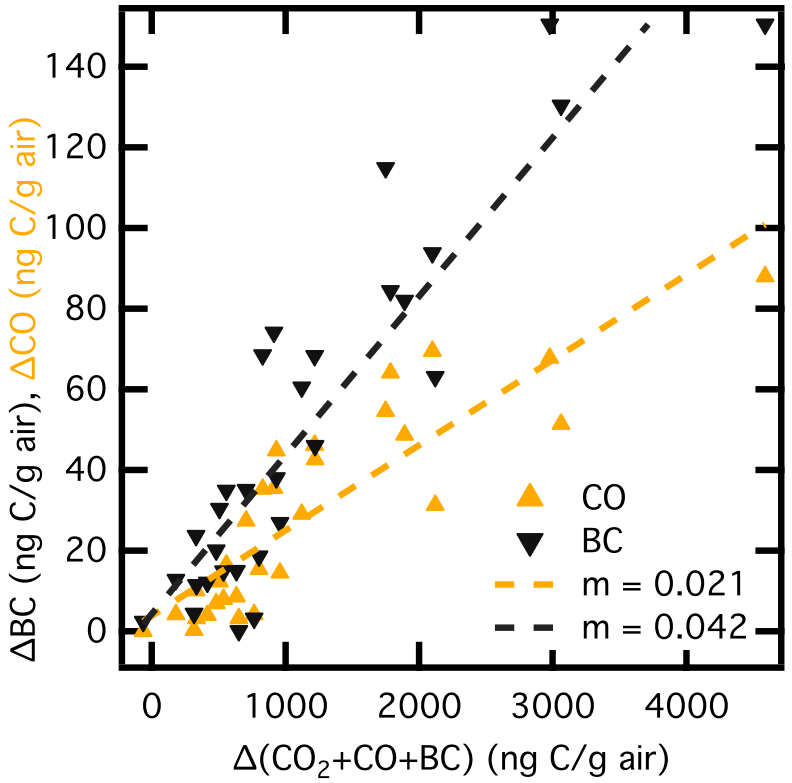

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(3.2 - 4.6 x 10^{10} g) x (0.9) x (0.022-0.050 g-C-as-BC/g-oil)

= 0.63 – 2.07 x 10^6 kg C

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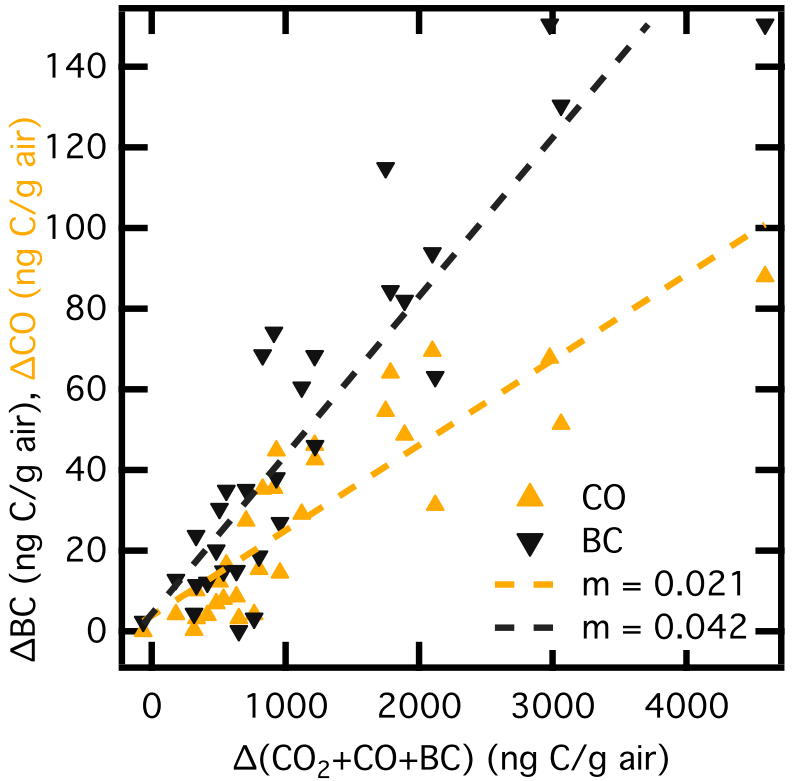

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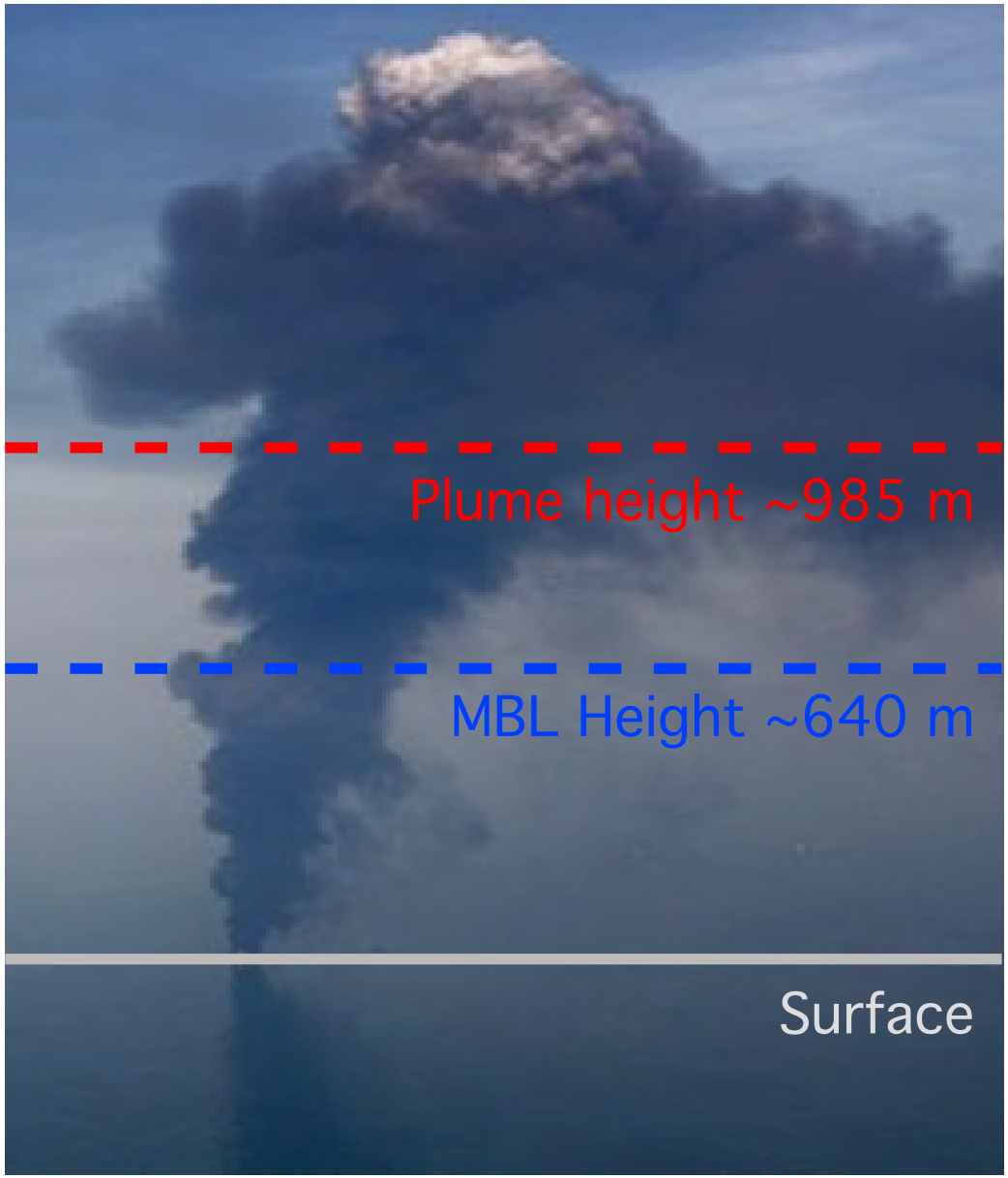
This amount is similar to the BC produced from shipping in the Gulf region during the time period of active burning.

Plume injection height

- One marked difference between the oil burn plume and ship plumes is the plume injection height

- The surface oil burn plume was encountered at ~1000m, well above the MBL

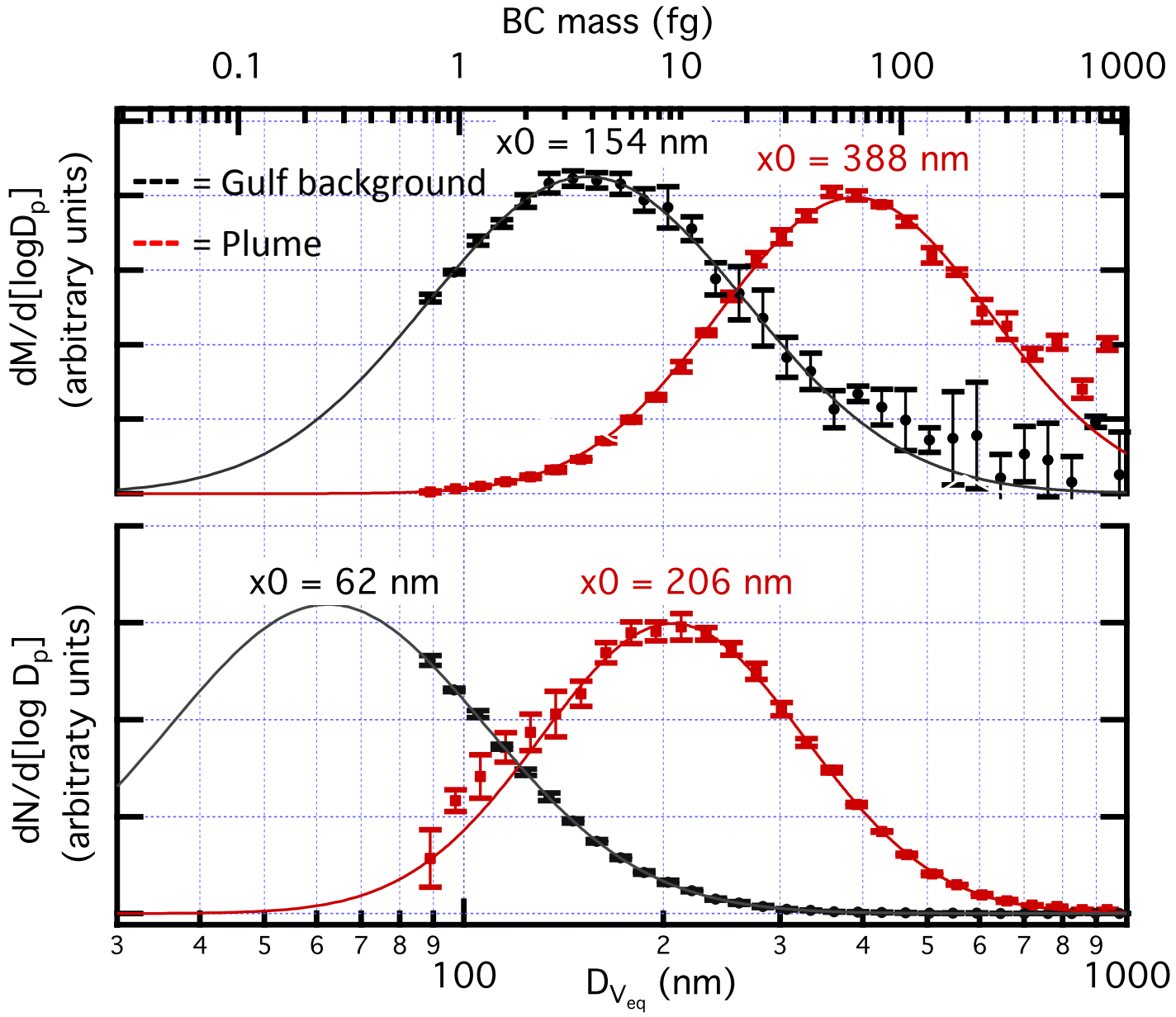
→ ***This will impact lifetime***



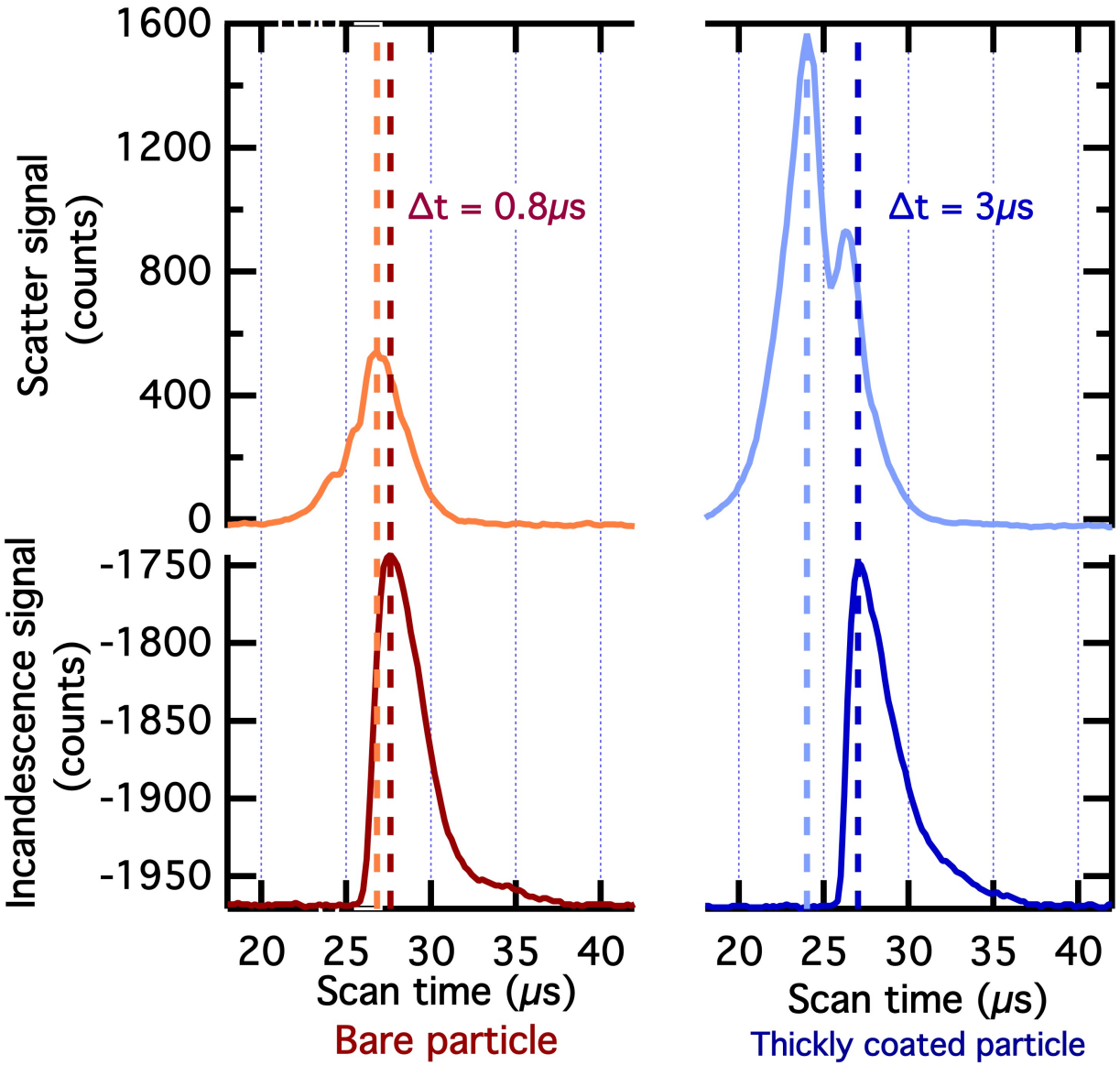
Microphysical Properties I: Particle Size

- Oil burn BC particles are much larger than typically seen elsewhere.

→This will also impact lifetime



Microphysical Properties II: Coating State

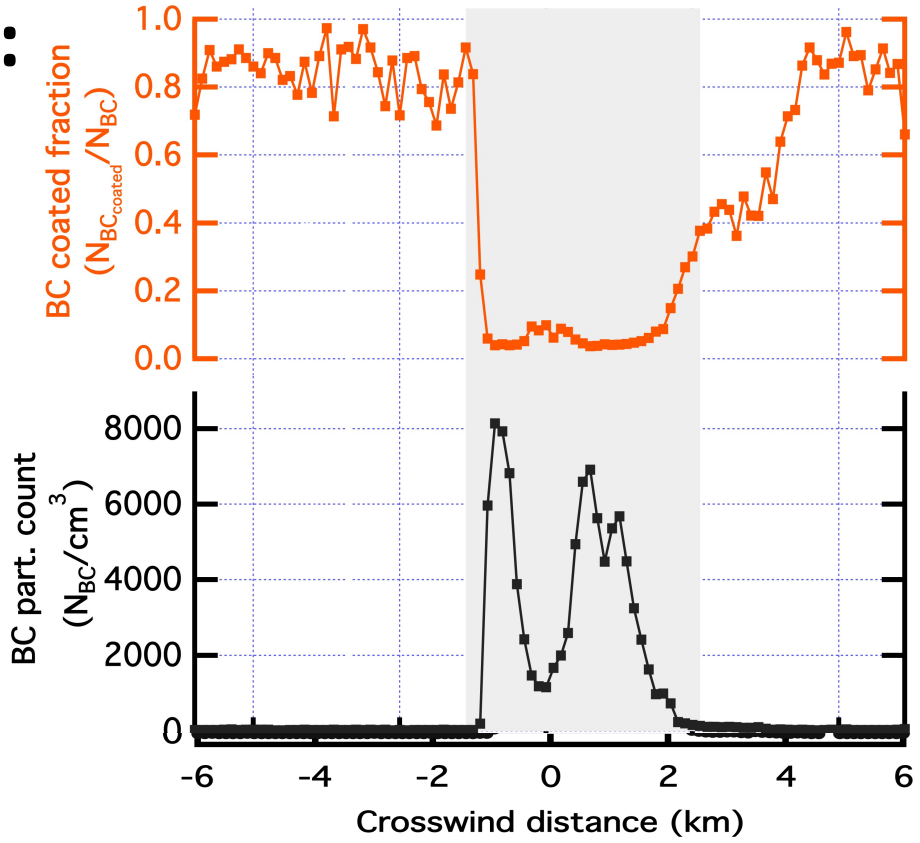


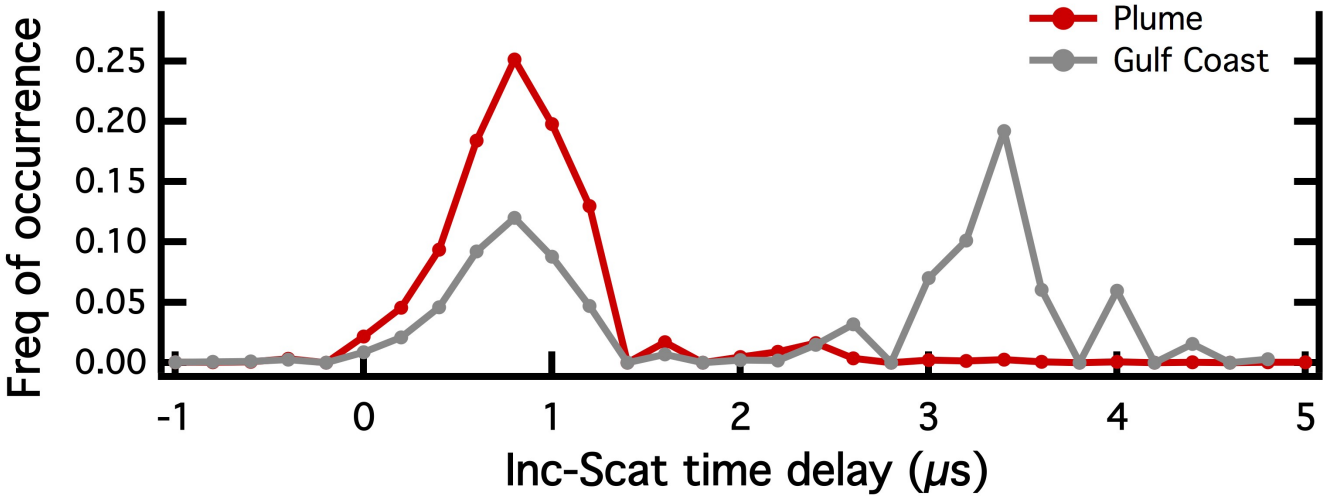
- Coating state is determined from the time delay between the peak incandesence and peak scattering signals.
- Binary determination
- Detection threshold of 15-20nm coating thickness

Microphysical Properties II: Coating State

- Almost none of the particles in the plume were classified as coated as compared to 50-80% coated elsewhere in the gulf.

→ ***Another impact on lifetime***





Main Conclusions

- The black carbon yield from surface burning of oil is determined to be 36 ± 14 g/kg
- The total mass of BC aerosol introduced to the atmosphere over the 9 weeks of active burning was ~ 1.3 x 10^6 kg
- The particles were observed to be larger than the background BC aerosol in the Gulf
- The majority of particles are uncoated and the plume was encountered well above the MBL.

Other Comments

- It is unlikely that the particles arising from surface oil burns had large adverse impacts on population centers along the Gulf coastline
- The climatic impact of this burning was likely small

Acknowledgements

NOAA Climate Program Office and the NOAA Atmospheric Composition and Climate Program

BC Mass Specific Extinction

- When BC dominates total particle mass we can calculate the mass specific extinction

- Using integrated extinction and BC observations in the plume we calculate a BC mass specific extinction of **7.1 ± 2.8 m^2/g**

- This is lower than previously reported literature values and may indicate something about particle morphology