Black Carbon and Organic Carbon during SMOCC: The Absorbing Fraction of Biomass Burning Aerosols in the Amazon Basin

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Problems in the determination of BC (EC) and OC

- Conceptual and technical differences (BC, EC, BC_{app}, BC_e, C_{soot}, C_{brown}, LAC,…)
- Artifacts during sampling and measurements
- Discrimination between particulate OC and black/elemental carbon (BC/EC), particularly for biomass burning (BB) samples
- Determination of the size-resolved BC and OC in BB particles

Novakov and Corrigan, 1995; Mayol-Bracero et al., 2002; Decesari et al., 2006; Andreae and Gelencser, 2006; Fuzzi et al., 2007.

SMOCC

Smoke Aerosols, Clouds, Rainfall and Climate: Aerosols from Biomass Burning Perturb Global and Regional Climate (SMOCC):

- European Union (EU) project in collaboration with the Large-Scale Atmosphere-Biosphere Experiment in Amazonia (LBA) and the Cooperative LBA Airborne Experiment (LBA-CLAIRE), coordinated by the Max Planck Institute of Chemistry
- August – November 2002 (**dry**, transition, and wet periods)
- Rondonia, Brazil (Fazenda Nossa Senhora, pasture site)
- Sampler – 13-stage Dekati low-pressure impactor, (D_p = 30 nm to 18 μm)
- **Main interest**: size-resolved carbonaceous composition

Results presented here are part of the manuscript,

Soto-García, L. L.; O. L. Mayol-Bracero, M. O. Andreae, P. Artaxo, W. Maenhaut, T. Kirchstetter and T. Novakov, Evaluation of different methods for the determination of BC and OC during biomass burning in the Brazilian Amazon, in preparation, 2008.

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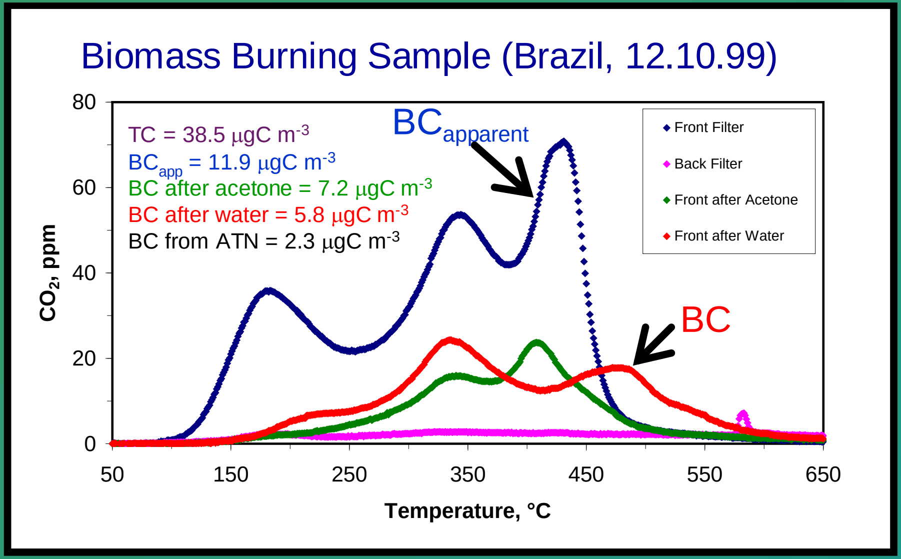
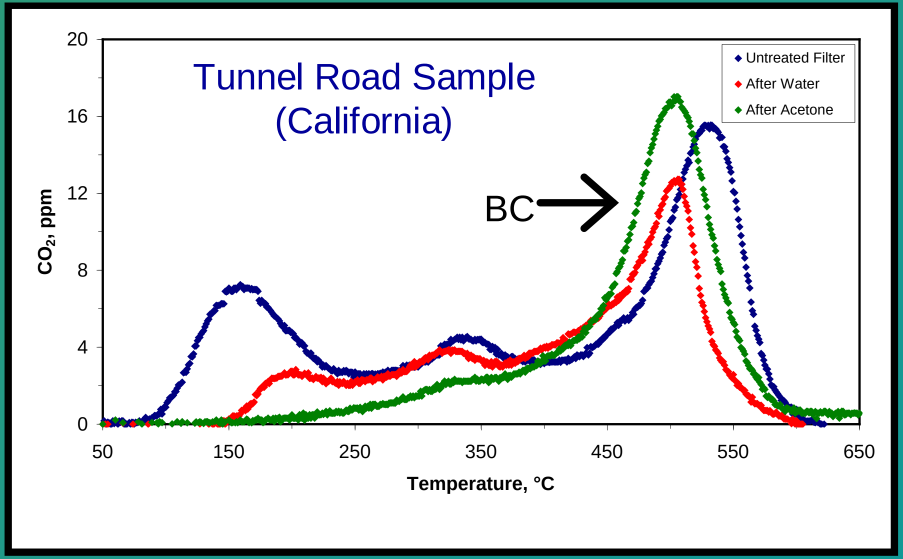
Methods for the determination of BC and OC during SMOCC

- evolved gas analysis (EGA) – with/without water extraction
- thermal-optical analysis (TOA) [Hadley et al. presentation of yesterday] – with/without water extraction
- light transmission method (LTM)
- aethalometer

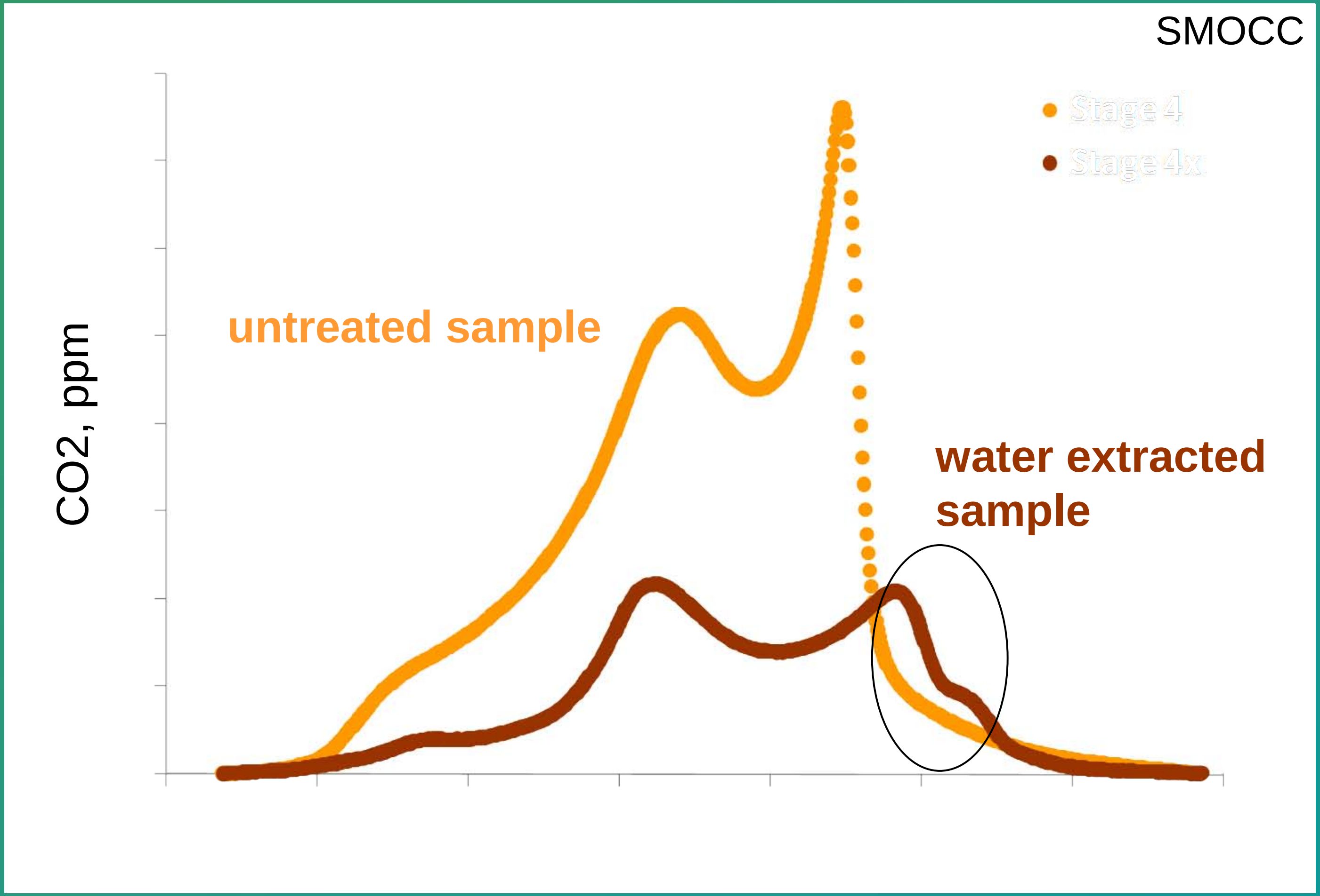
EGA (Thermal Analysis)
Biomass Burning vs Fossil Fuel





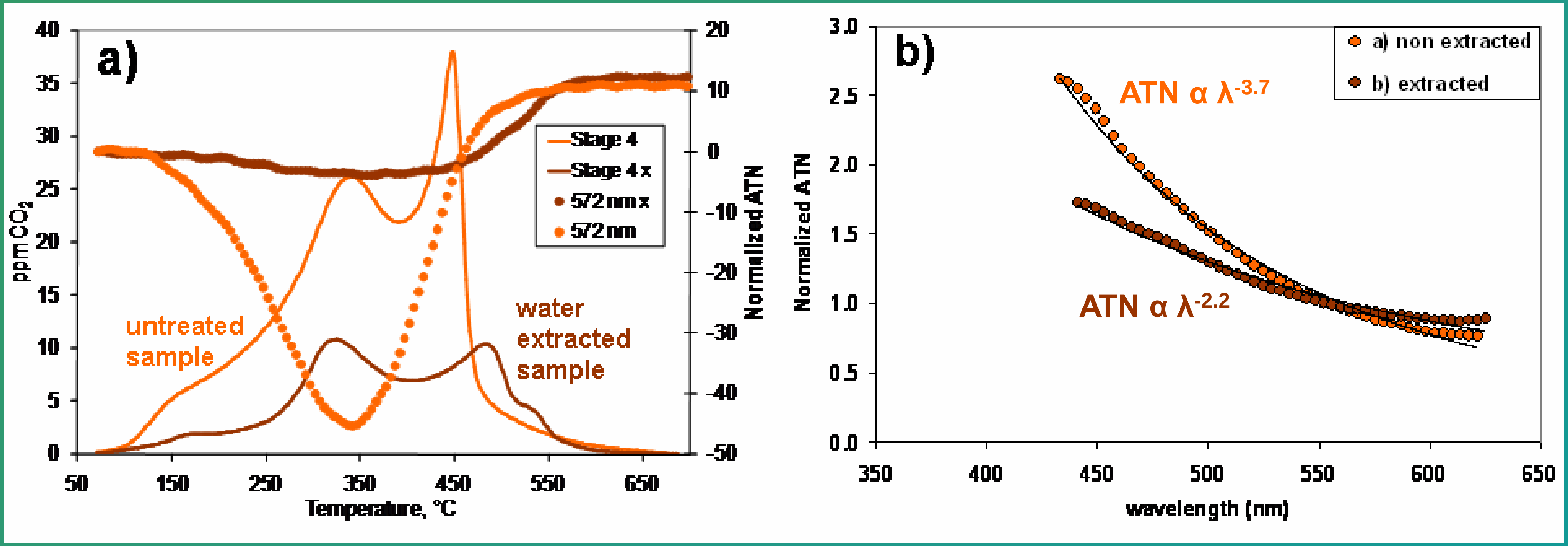
- Discrimination between OC and EC (BC or C_{soot}) with thermal techniques is more difficult for particles coming from BB than for those from the burning of fossil fuel
- Solvent extraction helps in this determination
- The positive artifact was found to be negligible for these BB samples

EGA - DLPI, Stage 4 (D_p 0.2 to 0.3 μm)



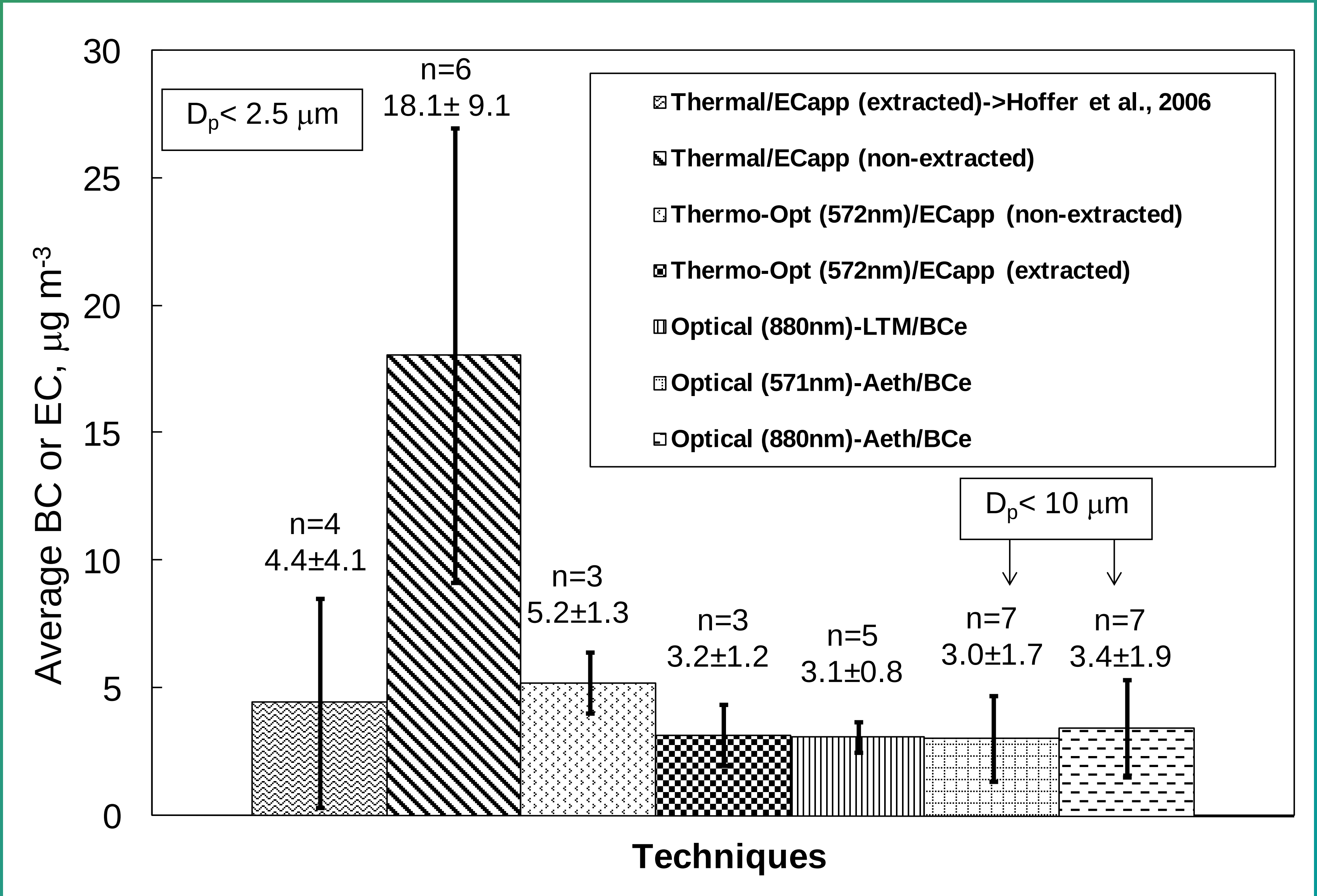
Water extraction removed inorganic ions (e.g., K^+ and Na^+) that catalyze EC combustion, removed the water-soluble organic carbon (about 60% of OC in the fine fraction), and resulted in two “new” peaks coevolving after ~450°C

Thermal/Optical Analysis and Spectral Absorption

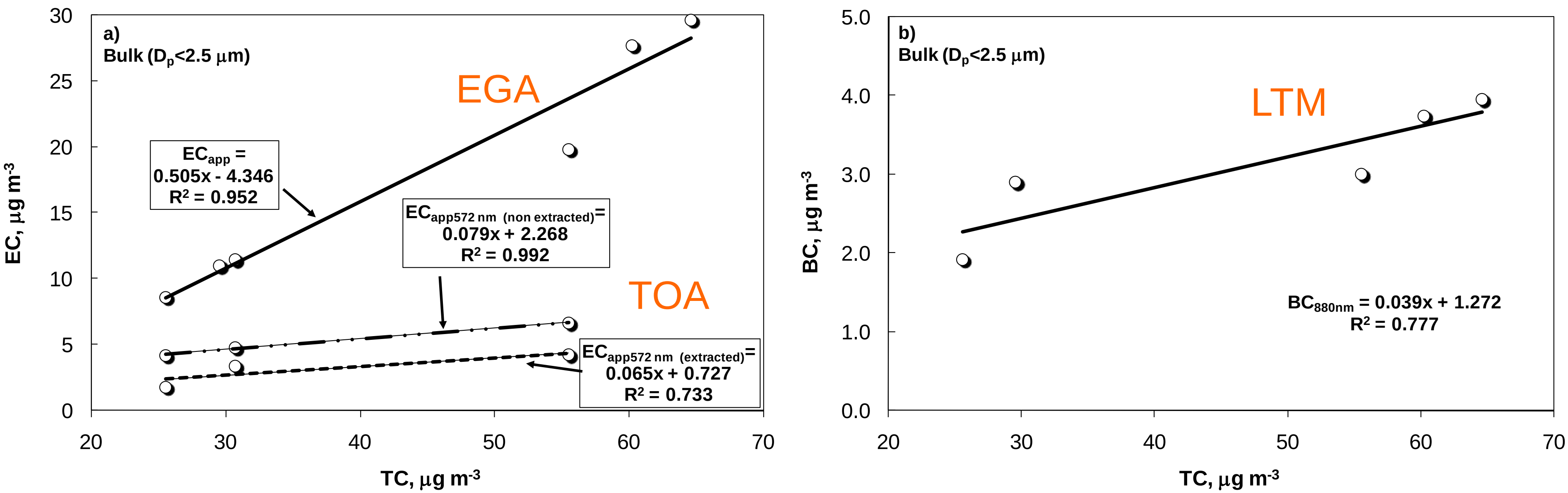


- Water extraction also reduces the charring effect (formation of light absorbing char during the thermal analysis)
- WSOC is pyrolyzed during the thermal analysis
- The absorption Angstrom exponent of ~2.2 (after water extraction) suggests that other species (C_{brown}) in these biomass smoke aerosols are contributing to the absorption of light. Aerosols containing only light-absorbing BC typically exhibit an Angstrom exponent of ~1.0

EC and BC Results during SMOCC

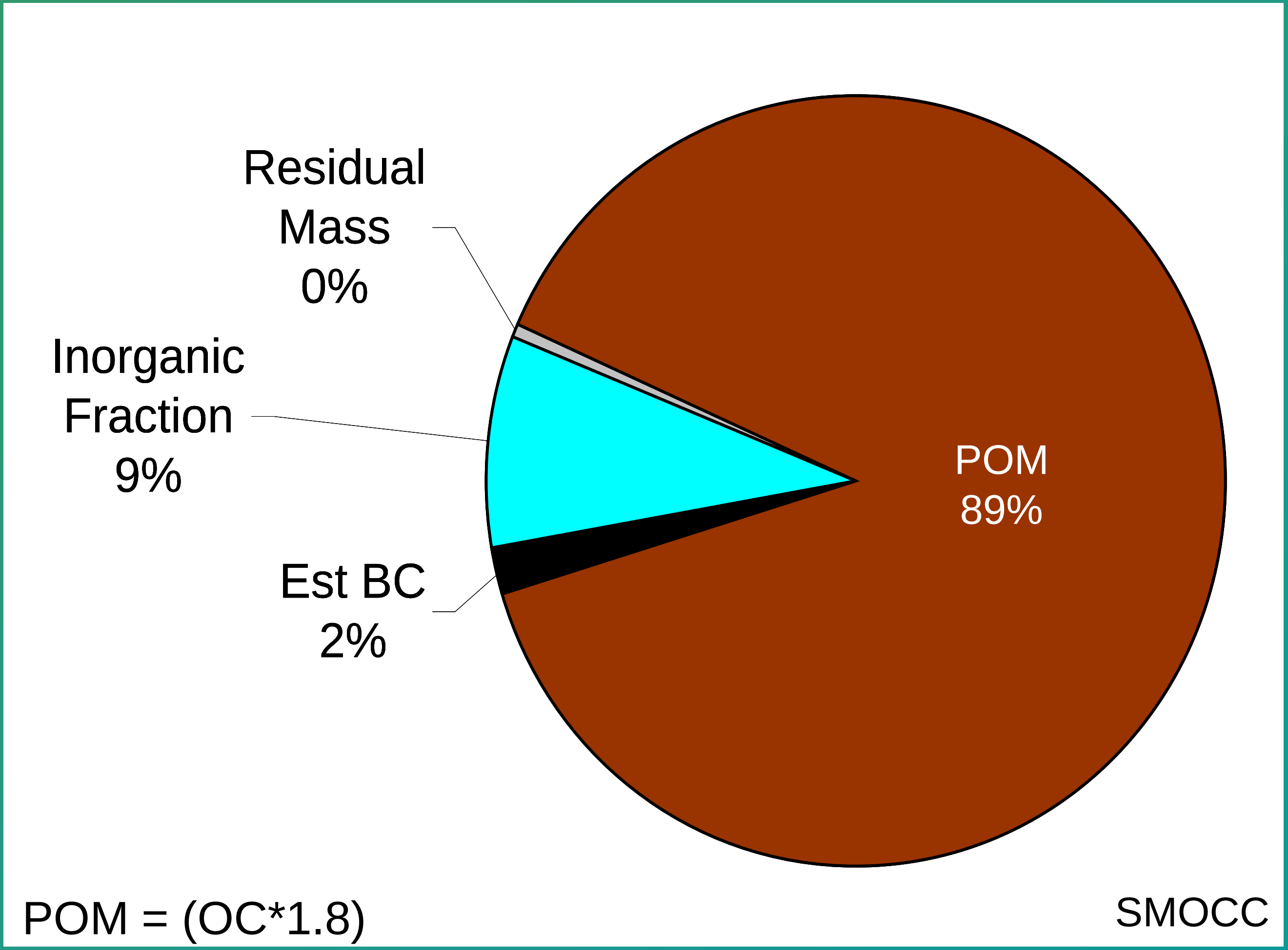


EC and BC Contribution to TC

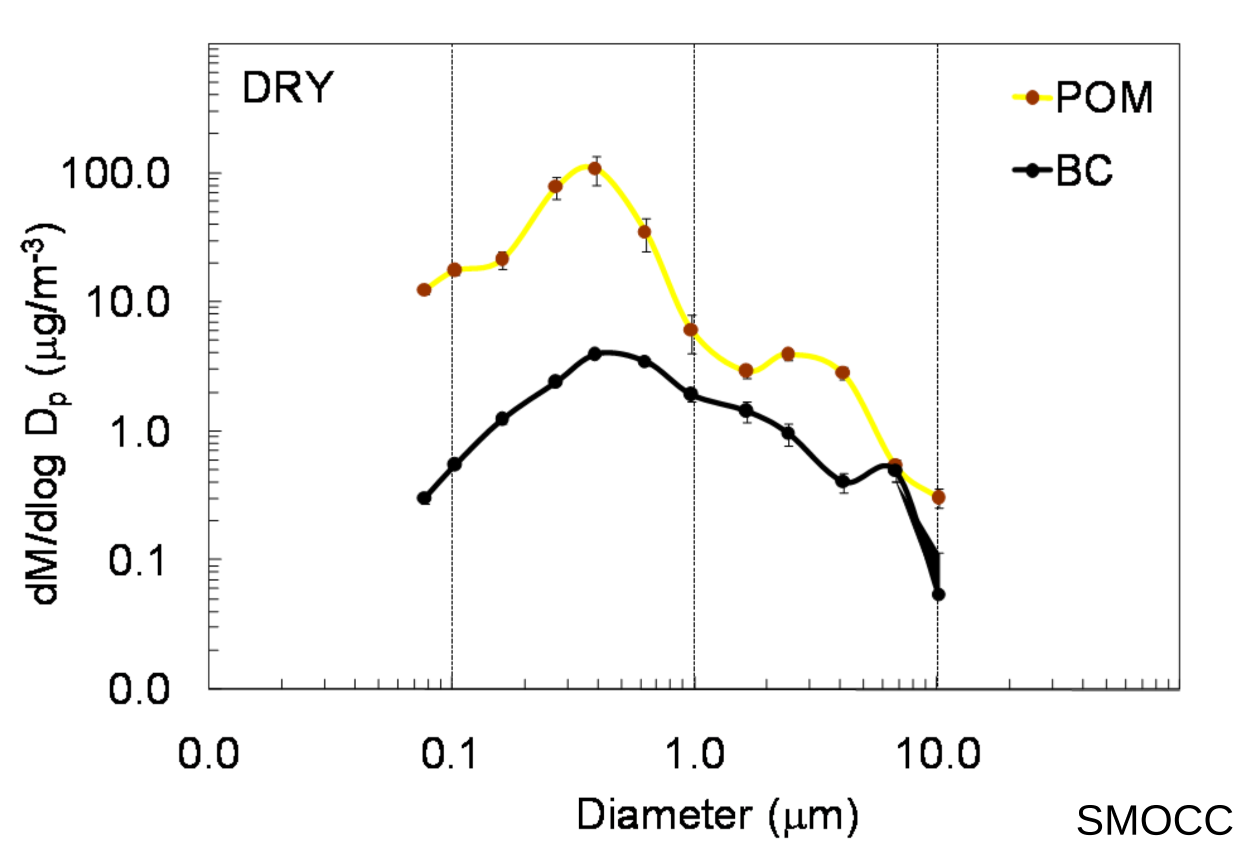


The contribution of EC (EC_{app572} extracted) or BC (C_{soot}) to the TC concentration in BB was between 4 and 7%

Chemical Composition of Smoke Particles in the Fine Fraction ($D_p < 2.5$ µm)



Size-Resolved POM and BC (Dry period)



The majority of the POM and BC in the fine fraction ($D_p < 1\ \mu m$) during the dry period comes from the same source (BB)

BC in the coarse mode is due to the formation of an internal mixture between soot carbon particles and other coarse particles and/or due to absorption of light by large particles (e.g., biogenic)

Summary

- The water-soluble organic carbon is pyrolyzed during the thermal analyses
- Species (i.e., C_{brown}) other than BC contribute to the absorption of light in biomass smoke aerosols
- EC_{app} and BC_e contribute with 4% to 7% to the TC mass concentration
- POM contributes with about 90% to the total aerosol mass
- During the dry period, the majority of the POM and BC in the fine fraction (D_p < 1 μm) comes from the burning of biomass
- BC in the coarse mode is due to the formation of an internal mixture between soot carbon particles and other coarse particles and/or due to absorption of light by large particles (e.g., biogenic)
- Results from the thermal-optical and optical analyses suggest that these are useful techniques for the estimation of atmospheric soot, since the average concentrations of EC and BC were similar for samples measured with the LTM and the EGA after extraction

This study provided a better estimation of the concentration and size distributions of carbonaceous aerosol particles from biomass burning in order to decrease the uncertainties in the estimations of EC or BC, providing in this way reliable data to be used by global and regional climate models that deal with the impact of biomass burning

Acknowledgements

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Thanks for your attention!

Outline

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  - Black Carbon
  - Problems in the determination of BC (EC) and OC
- SMOCC project
- Methods for the determination of BC (EC) and OC
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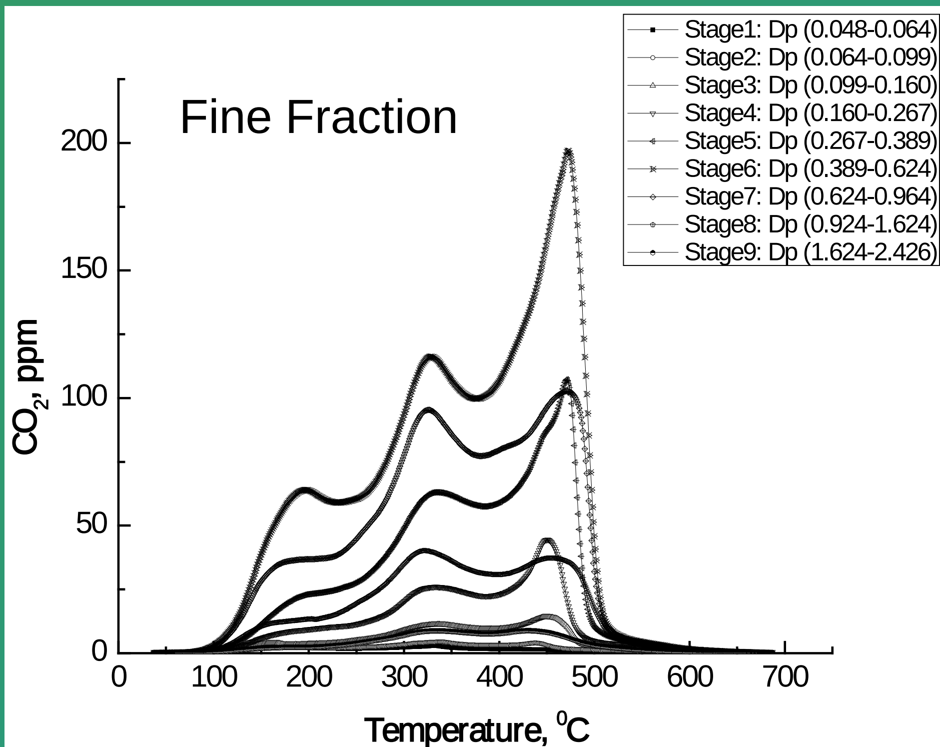
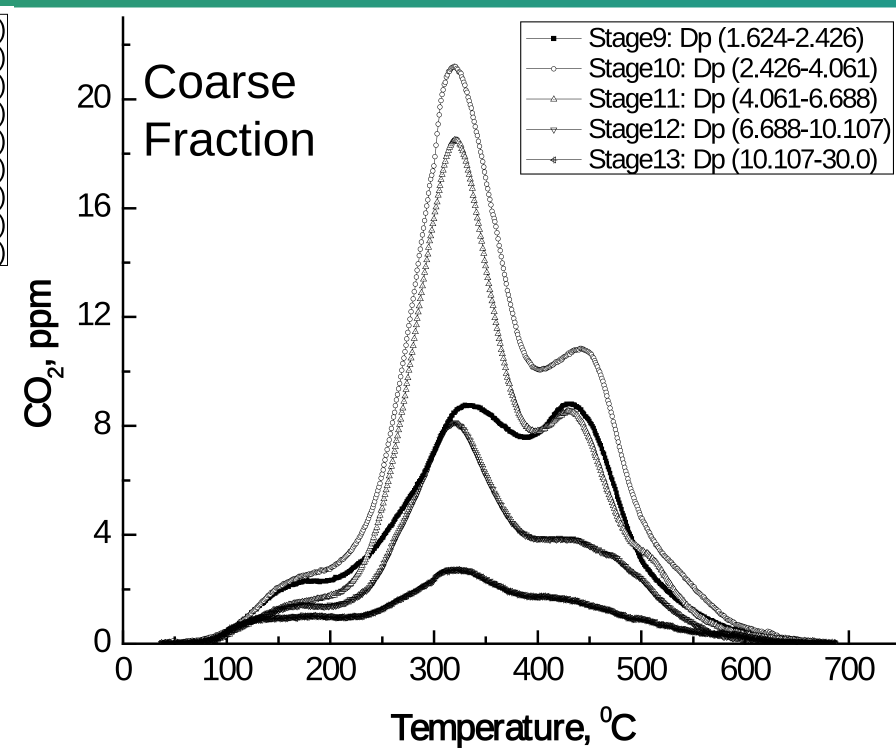
Black Carbon

- Has an impact on public health and on the degradation of structures
- It is a major player in the loss of ice and snow in the polar regions
- Alters regional climate and can be a driver in global warming

"Because the climate effects of "BC" aerosol depend strongly on its physical and chemical properties, as well as on its residence time and distribution in the atmosphere (Jacobson, 2001), a thorough understanding of these properties and accurate techniques for the determination of "BC" in the atmosphere are deemed essential." *Andreae and Gelencser, 2006*

Typical Size-Resolved Thermograms for the Dry period





Fine:

TC concentrations are ~15 times higher than in the coarse fraction.

The last peak (T > 400 °C) is more predominant (less volatile and highly refractory).

Coarse:

The first two peaks (more volatile ones) are more significant.

Less refractory (below 400°C) material.