Measurement at low carbon concentration with a semi-continuous OCEC thermo-optical analyzer

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Carbonaceous aerosols are composed of light-scattering organic carbon (OC) and light-absorbing elemental carbon (EC). The behavior of these aerosol particles are still not very well-understood while they have an important influence on the climate due to their optical properties, their ability to act as cloud condensation or ice nuclei and their long lifetime.

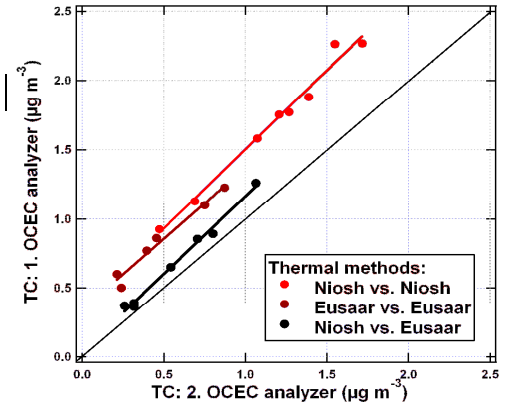

Fig. 1 Total Carbon (TC) concentration measured with two OCEC analyzers

Our OC and EC measurements were performed at Jungfraujoch located in the Swiss Alps at 3580m asl. The fact that the site is weakly influenced by local anthropogenic sources makes it interesting to investigate carbonaceous, continental background aerosols. The average aerosol mass concentration of the fine mode is very low: < ~3 µg m^{-3} (Cozic et al., 2008) therefore special foresight is needed for the measurements.

After 23 h collection of carbon particles on a quartz filter at 6 l min^{-1} flow the loaded filter was heated to different temperatures in different gas atmosphere (He or He+O_2) to release all the carbon into the gas phase that is oxidized into CO_2 which was detected by a Non-Dispersive Infrared Detector (NDIR).

In 2007 August an intercomparison between two OCEC analyzers were carried out. In Fig. 1 the non zero intercept is an indication of instrument and thermal method dependent background. Therefore an offset study with performing series of blank filter analyses was performed. The gained values obtained in the laboratory are 0.021 +/- 0.026 µg m^{-3} and at Jungfraujoch: 0.053 +/- 0.063 µg m^{-3}, which have to be considered at low concentration measurements.

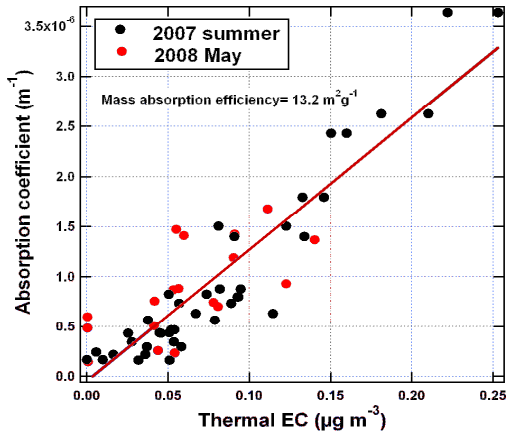

Fig. 2 Comparison of the Multi-Angle Absorption Photometer (MAAP) derived absorption coefficients and the OCEC analyzer derived

The comparison of the EC concentration was compared with the Multi-Angle Absorption Photometer (MAAP) derived absorption coefficients (Fig. 2), showing quite high correlation and resulting in a mass absorption efficiency of 13.2 m^2g^{-1}. Literature values range between 2 and 25 m^2g^{-1} (Bond and Bergstrom, 2006).

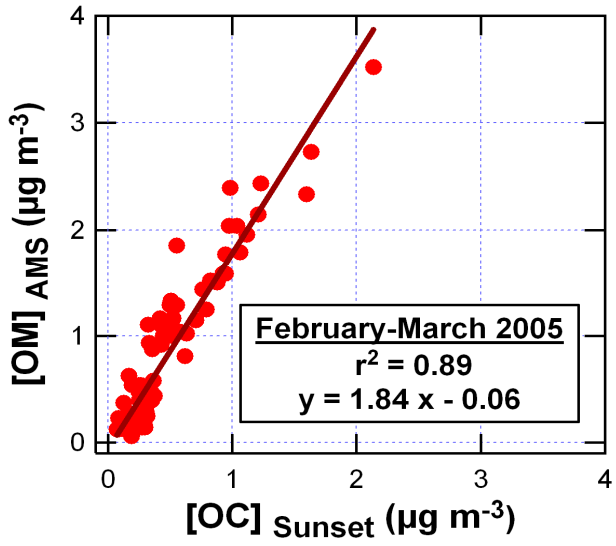

Fig. 3 Comparison of the Aerosol Mass Spectrometer (AMS) derived organic mass (OM) with the OCEC analyzer derived OC concentration in February-March 2005. (Cozic et al., 2008)

High correlation was found when Aerosol Mass Spectrometer (AMS) derived Organic Mass (OM) was compared with OC measurements (Fig. 3). In this case conversion factor of OC to OM = 1.84 was found, which is in agreement with literature data where values are between 1.6 to 2.1 (Turpin and Lim, 2001).

Our results show that the semi-continuous OCEC thermo-optical analyzer is applicable and reliable at low concentration measurement sites but special care has to be taken because of the background problem.

References:

Turpin, B. J., and H. J. Lim (2001), Species contributions to PM2.5 mass concentrations: Revisiting common assumptions for estimating organic mass, Aerosol Science and Technology, 35 (1), 602-610

J. Cozic, B. Verheggen, E. Weingartner, J. Crosier, K. Bower, M. Flynn, H. Coe, S. Henning, M. Steinbacher, M. Collaud Coen, A. Petzold and U. Baltensperger (2008), Chemical composition of free tropospheric aerosol for PM1 and coarse mode at the high alpine site Jungfraujoch, Atmospheric Chemistry and Physics, 8 (2), 407-423

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INTRODUCTION

Atmospheric carbonaceous aerosols

Carbonaceous aerosol is composed of light-scattering organic carbon (OC) and light-absorbing elemental carbon (EC). The behaviour of this aerosol is still not very well-understood while it has an important influence on the climate due to its optical properties, its ability to act as cloud condensation or ice nuclei and its long lifetime.

The measurement site

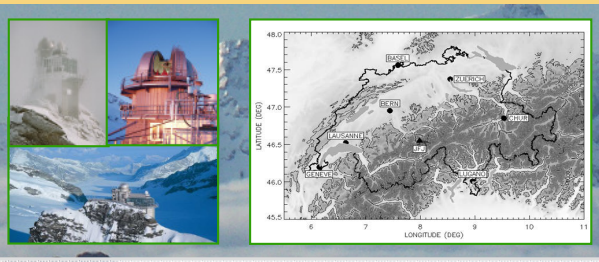


Fig. 1: The high Alpine research station at Jungfraujoch

The measurements were performed at Jungfraujoch located in the Swiss Alps at 3580m. The fact that the site is weakly influenced by local anthropogenic sources makes it interesting to investigate carbonaceous, continental background aerosols. The average aerosol mass concentration of the fine mode is very low: 1.7-2.1 μg m^{-3} (Cozic et al., 2008) therefore special foresight is needed for the measurements.

EXPERIMENTAL

Semi-continuous OCEC thermo-optical analyzer (Sunset laboratory):

use of thermal and optical properties of carbonaceous particles

↳ to measure Elemental and Organic Carbon concentration

Operation of the OCEC instrument:

1. 23 h collection of carbon particles on a quartz filter at 6 lpm flow
2. heating the loaded filter to different temperatures (thermal method) in different gas atmosphere (He or He+O_2)
3. release of all the carbon into the gas phase
4. oxidation into CO_2 gas
5. CO_2 concentration measurement with a Non-Dispersive Infrared Detector (NDIR)
6. separation OC from EC with the help of laser transmittance of filter

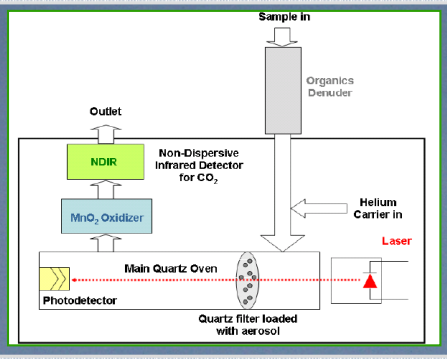
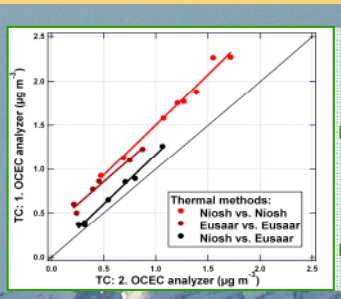


Fig. 2: Operation of the OCEC instrument

RESULTS

OCEC intercomparison



non zero intercept is an indication of instrument and thermal method dependent background

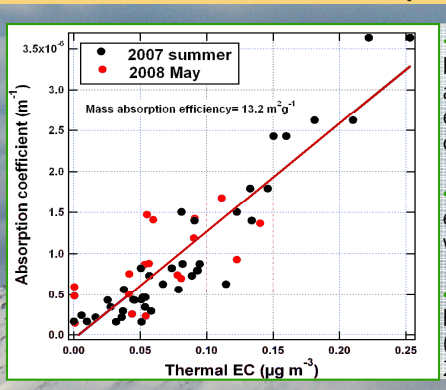
⇨ offset study with performing series of blank filter analyses:
- PSI lab: 0.021 +/- 0.026 μg m^{-3}
- JFJ: 0.053 +/- 0.063 μg m^{-3}

(possible background source: NDIR)

⇨ which has to be considered at low concentration measurements!

Fig. 3: Total Carbon (TC) concentration measured with two OCEC analyzers

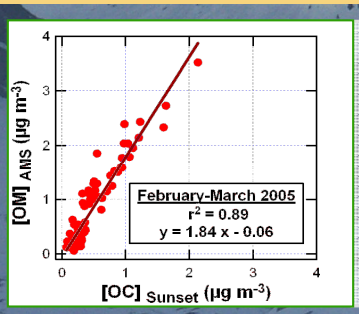
OCEC / MAAP comparison



- quite high correlation between EC and absorption coefficient even at extreme low EC concentrations
- a mass absorption efficiency of 13.2 m^2 g^{-1} was found
- literature values range between 2 and 25 m^2 g^{-1} (Bond and Bergstrom, 2006)

Fig. 4: Comparison of the Multi-Angle Absorption Photometer (MAAP) derived absorption coefficients and the OCEC analyzer derived EC in August 2007 (black) and May 2008 (red). The slope represents the mass absorption efficiency.

OCEC / AMS comparison



- high correlation between OC and OM
- conversion factor of OC to OM = 1.84 which is in agreement with literature data where values are between 1.6 to 2.1 (Turpin and Lim, 2001)

Fig. 5: Comparison of the Aerosol Mass Spectrometer (AMS) derived organic mass (OM) with the OCEC analyzer derived OC concentration in February-March 2005. (Cozic et al., 2008)

CONCLUSION

- the semi-continuous OCEC thermo-optical analyzer is applicable and reliable at low concentration measurement sites
- special care has to be taken because of the background problem

References

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Acknowledgement

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