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Experimental black and brown carbon heating rate and from mid-latitudes to the Arctic along two years (2018-2019) of research cruises: the energy gradient for the Arctic Amplification

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Black carbon (BC) and Brown Carbon (BrC) absorbs sunlight and heat the atmosphere. The heating rate (HR) can be determined from the divergence of the net radiative flux with altitude (vertical profiles) or from the modelling activity; however, it determination is, up to now, too sparse, does not account for light-absorbing-aerosol (LAA) speciation and for the influence of different cloudy sky conditions on the BC induced heating rate (HR) in the atmospheric layer below clouds. This work applies a new method (Ferrero et al., 2018) to experimentally determine (at high time resolution) the HR induced by the LAA from mid-latidudes to the Arctic along two years (2018-2019, June-August) of oceanographic cruises moving from 54°N to 81°N and from 2°W to 25°E.

The HR was experimentally determined at high time resolution and apportioned in the context of LAA species (BC, BrC), and sources (fossil fuel, FF; biomass burning, BB) as reported in Ferrero et al. (2018) equipping the Oceania vessel of the Polish Academy of Science with the following instrumentation:

1) Aethalometer (AE-33, Magee Scientific, 7-λ), 2) Multiplexer-Radiometer-Irradiometer ROX (diffuse, direct and reflected radiance: 350-1000 nm, 1 nm resolution), 3) a SPN1 radiometer (global and diffuse radiation), 4) High volume sampler (TSP ECHO-PUF Tecora). Samples were analysed for ions (Dionex IC) and by EC/OC by using DRI Model 2015 Multi-Wavelength Thermal/Optical Carbon Analyzer. Radiometers were compensated for the ship pitch and roll by an automatic gimbal. AE33 absorption coefficient accuracy was determined through comparison with a MAAP (Thermo-Fischer).

The HR showed a clear latitudinal behavior with higher values in the harbor of Gdansk (0.29±0.01 K/day) followed by the Baltic Sea (0.04±0.01 K/day), the Norvegian Sea (0.01±0.01 K/day) and finally with the lowest values in the pure Arctic Ocean (0.003±0.001 K/day).

They followed the decrease of both BC concentrations and global radiation from 1189±21 ng/m^3 and 230±6 W/m^2 (Gdansk) to 27±1 ng/m^3 and 111±3 W/m^2 (Arctic Ocean). The latitunal gradient of the HR clearly demonstrate that the warming of the Arctic could be influenced by a heat transport. In this respect, the LAA added about 300 J/m^3 at mid-latitudes and only 3 J/m^3 close to the North Pole. Moreover, above the Arctic circle, 70% of the HR was due to the diffuse radiation induced by cloud presence, a condition that climate models in clear-sky assumption cannot capture. In addition, in the Arctic the BrC experienced an increase of 60% in determining the HR compared to mid-latitudes.

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Reference: Ferrero, L., et al (2018) Environ. Sci Tech., 52, 3546−3555