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Black carbon ageing in the Canadian Centre for Climate modelling and analysis atmospheric general circulation model

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Abstract. Black carbon (BC) particles in the atmosphere have important impacts on climate. The amount of BC in the atmosphere must be carefully quantified to allow evaluation of the climate effects of this type of aerosol. In this study, we present the treatment of BC aerosol in the developmental version of the 4th generation Canadian Centre for Climate modelling and analysis (CCCma) atmospheric general circulation model (AGCM). The focus of this work is on the conversion of insoluble BC to soluble/mixed BC by physical and chemical ageing. Physical processes include the condensation of sulphuric and nitric acid onto the BC aerosol, and coagulation with more soluble aerosols such as sulphates and nitrates. Chemical processes that may age the BC aerosol include the oxidation of organic coatings by ozone. Four separate parameterizations of the ageing process are compared to a control simulation that assumes no ageing occurs. These simulations use 1) an exponential decay with a fixed 24h half-life, 2) a condensation and coagulation scheme, 3) an oxidative scheme, and 4) a linear combination of the latter two ageing treatments. Global BC burdens are 2.15, 0.15, 0.11, 0.21, and 0.11TgC for the control run, and four ageing schemes, respectively. The BC lifetimes are 98.1, 6.6, 5.0, 9.5, and 4.9 days, respectively. The sensitivity of modelled BC burdens, and concentrations to the factor of two uncertainty in the emissions inventory is shown to be greater than the sensitivity to the parameterization used to represent the BC ageing, except for the oxidation based parameterization. A computationally efficient parameterization that represents the processes of condensation, coagulation, and oxidation is shown to simulate BC ageing well in the CCCma AGCM. As opposed to the globally fixed ageing time scale, this treatment of BC ageing is responsive to varying atmospheric composition.

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