**Introduction**

1. BC is a strong aging agent in the atmosphere, so it is important to represent its processes and properties correctly in CTMS. However, current models have large uncertainties and lack of understanding of its aging process is one major source of the uncertainties.
2. There are various treatments of aerosols in models, e.g., bulk, modal aerosol models, partMC method (tracing each particle). Benefits of using modal aerosol model in reducing uncertainties.
3. BC burden/ radiative forcing is very sensitive to the choices of aging criterion.
4. Most model use arbitrary or mechanic aging timescales. Some introduction of the aging process in CAM and PartMC.
5. Hard to compare the accuracy of aging timescales, lack of direct experimental observations. PartMC parameterization can be used to make comparison.
6. In our study.

BC is a product of incomplete combustion of fossil fuel, biofuel and biomass burning. Its particles are emitted to the atmosphere through incomplete burning and have both natural (grass and forest fires) and anthropogenic (agricultural fires, domestic fire places, flaring and combustion engines) sources [Bond et al., 2004; Forsstrom et al., 2013]. BC is a high efficient light absorber, impacting the global atmospheric radiative budget both as an atmospheric aerosol, when internally mixed with other aerosols, and as an impurity in snow and ice after deposition to their surfaces [Zuberi et al., 2005; Flanner et al., 2007]. It strongly absorbs visible light with a mass absorption of 5m2g-1 at a wavelength of 550 nm. The distribution of black carbon after it is emitted can also influence its warming efficacy (global temperature response per unit radiative forcing to carbon dioxide radiative forcing) [Hansen et al., 2005]. Recent research has rank BC as the second most important individual light-absorber for global warming, with a climate forcing of +1.1Wm-2 [Bond et al., 2013].

Understanding of BC sources and transport processes are important in its implications for BC distribution, air quality and climate research. However, Current emission estimates agree on the major sources and emitting regions, but emission estimate from open biomass burning and biofuel combustion lack data of fuel combusted, especially in developing countries, and black-carbon emission factors from this source may be too low. Burden underestimates by factors of 1.75 to 4 are found in Southeast Asia, Latin America and Pacific region, and significant uncertainties also remain in current emission inventories [Bond et al., 2013]. Large uncertainty in BC emission inventories is a major source of significant discrepancies between simulated and observed BC in chemical transport models (CTM), and hinder our understanding of its effect on present climate forcing [Hakami et al., 2005].

In addition, atmospheric BC particles can often mix with other soluble organic materials, and can serve as cloud condensation nuclei [Petters et al., 2006]. The freshly emitted BC are mostly hydrophobic and are gradually turned to hydrophilic through oxidation or coating with sulfate and organics [Langner et al., 1992; Parungo et al., 1994; Liousse et al., 1996], called as aging process. BC particles can be removed by precipitation through deposition freezing and homogeneous freezing below 237K, and through heterogeneous freezing between 237 and 243K, and through accretion of droplets nucleated on BC with ice crystals or raindrops falling from upper levels above 243K [Fan et al., 2012]. BC can also be transported on a global scale once in the free troposphere, because of frequent precipitation [Park et al., 2005]. However, the lack of climatology for BC (e.g. wet deposition via in-cloud and below-cloud scavenging) in most models can lead to large spatial-temperal differences between simulated and observed BC concentrations. Previous studies has implied the general overestimation of BC in the mid-upper troposphere in the mid-latitudes, but underestimation of BC in the lower and middle troposphere at high latitude [Fan et al., 2012].