Spectral properties of mesospheric ice clouds require a scattering theory for non-spherical particles

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As a consequence of the global residual circulation, the polar summer mesopause region reaches a thermal state which is $\sim$80 K colder than radiative equilibrium. In the altitude range between 80 and 90 km the temperature falls well below the frost point of water vapor, such that this altitude range is host to the highest ice clouds in the atmosphere. These are known as noctilucent clouds (NLC) or polar mesospheric clouds (PMC) when seen from space. Existing in this extreme thermal environment, it has been argued that even very small changes of the background atmosphere should lead to profound changes of the properties of these ice clouds which could hence act as an indicator for the underlying changes of the atmosphere. However, in order to draw conclusions from the observations of e.g. brightness changes of such clouds, we require a detailed understanding of the microphysical processes governing their properties. In particular, the size distribution and the shape of these ice particles must be known in order to be able to interpret observations of the light scattering or extinction from these clouds. In this paper, we investigate whether ice particle size distributions predicted by state-of-the-art microphysical models can explain observations with lidars and satellite-borne instruments assuming spherical ice particles. We will show that neither lidar, nor satellite observations can be explained under these assumptions. However, using the same particle size distributions, but introducing non-spherical particles allows us to construct a consistent picture for all considered observational data sets.