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Critical topics in the modeling of noctilucent clouds

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Noctilucent clouds (NLC) can be observed during the summer months at high and polar latitudes. Their most outstanding property is the altitude of their occurrence which falls most commonly in the region 81 to 85 km. NLC are a visible sign of an extreme state of the atmosphere. This state is characterized by air temperatures between 150 and 115 K and large vertical temperature gradients, the latter changing signs at the mesopause (which is located just about one scale height above the NLC layer).

The existence of these rather special summer clouds has attracted the interest of many scientists ever since their initial reported visual observations in 1885. Improved observation methods, new instrumentation for ground-based and space-based observations of NLC, and the rapidly developing capabilities for numerical modeling of NLC and their ambient environment have since led to a basic understanding of the causes for the existence and of the typical life cycle of these clouds. Nevertheless, numerical models of NLC still have to cope with a number of problems to which a perfect solution has not been found yet. Of those we will discuss the following:

NLC observables comprise almost exclusively the optical properties of NLC layers, which depend in highly non-linear fashion on the NLC particle sizes. Another non-linearity is caused by the prominent phase changes of water vapor to ice and back within the NLC layer. In order to model the sizes of cloud particles with the required accuracy, one needs high spatial and temporal resolution of the model calculations. This makes also for critical choices of the initial state of the model atmosphere, of the type of condensation nuclei, and of the way in which these condensation nuclei are introduced into the model domain. Against this background, it seems no wonder that some models have “difficulties” to reach a kind of steady state, even after many model-days. This in turn raises the question what we might learn from a model output which describes a NLC layer which is still rapidly evolving from an unrealistic initial state. Helpful for gaining a deeper insight into the processes controlling NLC aeronomy are sensitivity studies in which the reaction of numerically modeled NLC layers to well-defined changes of input parameters are investigated. For these studies we have to face questions like whether or not the modeled states of the atmosphere need be internally consistent and to what extent we want them to be realistic, that means to resemble somehow the known uncertainties of the input parameters? Obviously, very few, if any, of these questions may have an unique answer. Hence, we will discuss a range of possibilities and express some preferences on how to deal with the situation.