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Climate model sensitivity to ice formation processes

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Clouds remain among the largest sources of uncertainty in future climate projections. To accurately describe cloud radiative effects in models, an accurate description of the microphysical structure (the amount of liquid and ice) is required. Ice formation remains among the most poorly understood microphysical processes that profoundly impact clouds and their impact on climate. Ice formation at temperatures above -38^{o}C can occur either *(a)* heterogeneously, with the assistance of aerosols that can act as ice nucleating particles or *(b)* through secondary ice production (SIP). The complexity of the heterogeneous nucleation parameterizations used in numerical models largely varies; some schemes simply diagnose ice formation depending on the thermodynamic conditions, while others explicitly predict ice from cloud-aerosol interactions. Secondary ice production is either not described in models or only accounts for one mechanism, which occurs at a limited temperature range: the Hallett-Mossop process. For this reason, the importance of SIP processes may be largely underappreciated and contribute to predictive uncertainty in climate models. In this study we use the Norwegian Earth System Model (version 2) to quantify the model sensitivity to *(a)* different heterogeneous nucleation schemes (diagnostic vs prognostic) and *(b)* the addition of missing key SIP mechanisms (collisional break-up and drop-shattering). The modeled cloud properties and radiation budget are evaluated against relevant global satellite datasets.