Ice nucleation is an important microphysical process for mixed-phase and ice clouds. Unfortunately, our current understanding of nucleation mechanisms is poor. Model simulations indicate a strong dependency of cloud properties on ice nucleation parameterizations, but to consider aerosol effects on ice-containing clouds, ice nucleation processes must be described in terms of aerosol properties. Classical Nucleation Theory (CNT) can be used to do that if its key parameters are properly constrained. In this study, we analyze the relationships between ice nucleation and dust properties, such as contact angle (a parameter in CNT to represent the ice nucleating ability of aerosols), using new laboratory data for deposition nucleation on mineral dust collected at the Pacific Northwest National Laboratory Atmospheric Measurements Laboratory (AML) together with published data from other laboratories. A lognormal probability distribution of contact angle for each dataset (different dust types, temperature and particle sizes) is derived and the temperature- and size-dependent distribution is investigated to improve the parameterization of CNT. Using cloud-resolving model simulations, we evaluated the sensitivity of cloud properties to changes in the parameters for contact angle distribution. We find that with the derived lognormal distribution of contact angle, the observed freezing probability can be well reproduced. Simulated cloud microphysical properties, cloud onset time, thickness, and lifetime are shown to be very sensitive to changes in contact angle distribution. By comparing with effects of aerosol (IN) concentration on cloud properties, we find that the contact angle distribution is more critical in modifying cloud properties.