#	Paper	Ref	Model	Summary
1	Ghan et al. 2011: Droplet nucleation: Physically-based parameterizations and comparative evaluation.	2-9	Lit review of 8 droplet nucleation parameterizations, tested in CAM5	Review of assumptions, applications, and performance of most popular parameterizations of droplet nucleation, which estimate CDNC based on aerosol number size distribution, hygroscopicity, and cooling rate. All are found to preform well under common conditions, while more complex schemes do better under varied conditions. Estimates of anthropogenic aerosol indirect effects using two different parameterizations only differ by 10%.
2	Nenes and Seinfeld 2003: Parameterization of cloud droplet formation in global climate models.	3,4,5	Nenes and Seinfeld, Abdul-Razzak and Ghan 2000, parcel model	Iterative (Smax) parameterization based on size and composition. Treat I or E mixed aerosol, effects of surface-active species (organics), insoluble species, slightly soluble species. CCN treated separately for those with size close to their Dc and those not. Treats kinetic (mass transfer) limitations on droplet growth. Compares better than Abdul-Razzak and Ghan against parcel model sims (1000x < expense of parcel) for a variety of conditions.
3	Twomey 1959: The nuclei of natural cloud formation. Part II: The supersaturation in natural clouds and the variation of droplet concentration.		Simplified expression of droplet nucleation	The first expression for time variations of supersaturation during cloud formation, which calculates maximum supersaturation as a function of updraft velocity and nucleus spectra – uses assumption 8. Cloud droplet concentrations of maritime and continental clouds compare with obs. SS ranges from 0.2-0.8%. Power law aerosol size distributions and idealized expressions for condensation rate, can result in more CDNC than CCN.
4	Abdul-Razzak et al. 1998: A parameterization of aerosol activation - 1. Single aerosol type.		Precursor to Abdul-Razzak and Ghan 2000 developed with a cloud parcel model	Parameterization of aerosol particles activated to form cloud droplets. Single lognormal size distribution with uniform chemical composition. Compared to a parcel model 50 discretized sizes. For a wide range of conditions (particle radius, standard deviation, updraft velocity), differences between the parametric equations and parcel model results are less than 10% for most conditions and less than 25% for some extreme conditions.
5	Abdul-Razzak and Ghan 2000: A parameterization of aerosol activation 2. Multiple aerosol types.		Simplified expression of droplet nucleation	Parameterization of activation of a lognormal size distribution of aerosol for multiple externally mixed lognormal modes, with internal mixtures. The Kohler theory and max SS relates aerosol to CDNC. Not only relates droplet activation to aerosol characteristics, but also couples it with a local cooling rate determined by cloud-scale and sub-grid turbulent vertical velocity as well as radiative cooling. The error of the parameterization is less than 10% under a wide variety of conditions. 20–100x faster than Nenes scheme.
6	Gustafson et al. 2007: Impact on modeled cloud characteristics due to simplified treatment of uniform cloud condensation nuclei during NEAQS 2004.		Regional – NE US, WRF-Chem, Abdul-Razzak and Ghan 2000	Prescribed CCN with vertical and temporal fluctuations does better simulating clouds and radiation than a prescribed uniform CCN in a GCM grid size region. Effects on shortwave radiation are between -3 and -11 W/m2 for the fluctuating and uniform, respectively, relative to sims with fully interactive aerosols. The mean cloud optical depth increases by over 25% when using the uniform CCN resulting from a stronger 2nd indirect effect.
7	Luo et al. 2008: Arctic mixed-phase clouds simulated by a cloud- resolving model: Comparison with ARM observations and sensitivity to microphysics parameterizations.		Cloud-resolving – Arctic, NASA CRM, Abdul-Razzak and Ghan 2000	Compares the impact of single (LFO) vs. double (MCK) moment microphysics on Single-layer mixed-phase stratiform Arctic clouds. MCK reproduces the magnitudes and vertical structures of LWC, IWC, CDNC, and Re compared to observations, but under estimates ICNC and overestimates Re of ice. LFO produces LWP and IWP that were about 30% and 4 times, respectively, those produced by MCK.
8	Gettelman et al. 2008: A new two-moment bulk stratiform cloud microphysics scheme in the community atmosphere model, version 3 (CAM3). Single-column and global results.		Global, CAM3, Abdul-Razzak and Ghan 2000	Implementation of a double moment microphysics scheme. Produces reasonable representations of cloud particle size and number concentration compared to observations. A reduction in droplet size using the scheme allows the model to achieve TOA radiation balance with 60% LWP (better agreement with obs). Used fixed aerosol distributions and did not compare cloud ice. The number of ice nuclei is specified as a function of temperature.
9	Wang et al. 2011: The multi-scale aerosol-climate model PNNL-MMF: model description and evaluation.		Global, Multiscale model, Abdul-Razzak and Ghan 2000	Evaluates a MMF aerosol model. The effects of clouds on aerosols are treated by using an explicit-cloud parameterized-pollutant (ECPP) approach that links aerosol and chemical processes on the large-scale grid with statistics of cloud properties and processes resolved by the CRM. Activation uses CRM updraft velocities. The response in LWP to anthropogenic aerosols is smaller than CAM5, leading to smaller IDE (-0.77,-1.79 W/m2).
10	Liu et al. 2007: Inclusion of Ice Microphysics in the NCAR Community Atmospheric Model Version 3 (CAM3).		Global CAM3	ICNC scheme implemented in CAM3 to study the cold indirect effect. Ice nucleation depends on temperature and updraft velocity, number concentration of pure sulfate aerosol acting through homogeneous ice nucleation and number concentration of soot aerosol as heterogeneous ice nuclei. The Re of ice is from predicted mass and number of ice crystals rather than diagnosed from temperature. SW and LW CF increase by 3.9 and 4.3 W/m2.

Parameterization Assumptions:

1. No cloud droplets are present before cooling begins. Although ice crystals might be present, we assume their influence on supersaturation is too slow to affect aerosol activation.
2. Adiabatic conditions.
3. The aerosol population can be represented in terms of the distribution of number with size, which can be described by a power law, by multiple sections, or by lognormal modes, each with a uniform bulk hygroscopicity.
4. Particles are composed of internal mixtures of salts and insoluble components within each section or mode.
5. The volume of particle water at maximum supersaturation is substantially larger than the dry aerosol volume.
6. The number of nucleated droplets is determined by the number of particles with critical supersaturation less than the maximum supersaturation.
7. Particles grow in equilibrium with relative humidity until the supersaturation exceeds the particle critical value for activation.
8. Beyond the point of activation, particle growth rates are not significantly influenced by droplet curvature and solute effects.