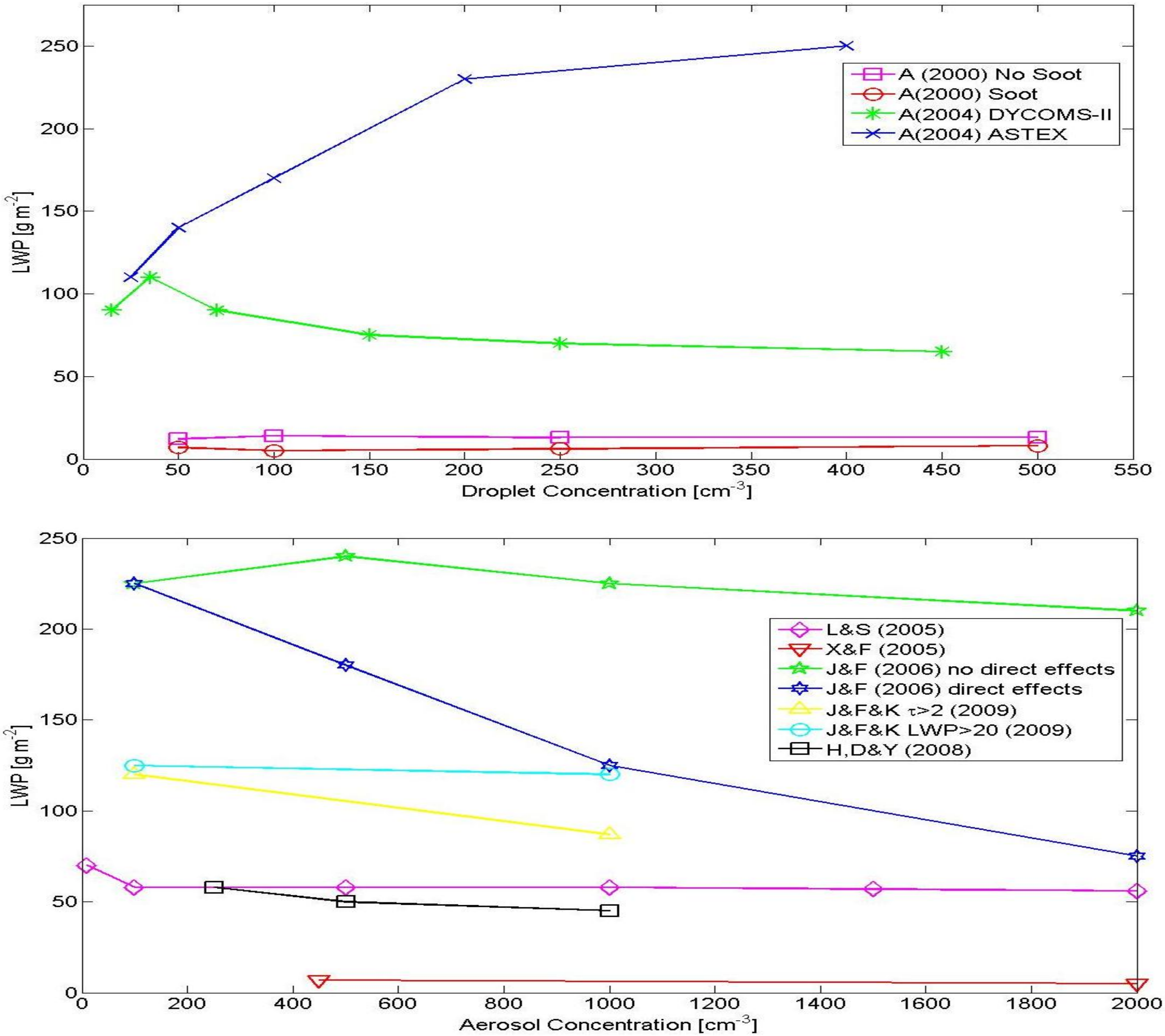
Paper Author (s)	LES Model description and Location/ Cloud type	Key Points
Twomey (1974) Grassl (1975) Albrecht (1989)		**First Indirect Effect:** For constant LWP, increase aerosols leads to smaller cloud droplets and higher cloud albedo. **Semi-Indirect Effect:** absorption of solar radiation by aerosols leads to changes in cloud cover and liquid water path **Second Indirect Effect:** an increase in aerosol suppresses precipitation, and increases cloud liquid water path LWP, cloud fraction CF, and cloud lifetime
Ackerman et al. (2000)	Dynamics LES model (Stevens et al 1997) coupled with two stream radiative transfer model. Incorporated Soot into model. INDOEX field experiment. Focused on Daytime. Trade Cumulus clouds	Increasing the amount of Soot in the atmosphere increases solar absorption which increases temperature which reduces relative humidity which decreases LWP due to reduction in flux of water vapor into the polluted Cloud
Ackerman et al (2004)	LES model coupled with microphysics model. Particle size dist.: dry condensation nuclei (0.01 -5μm) and activated cloud droplets(1 -500μm). **Stratiform clouds.** **Drizzling clouds over the northeastern Atlantic (ASTEX)** **Marine Stratocumulus clouds off the coast of southern California (DYCOMS-II)** Northeastern Pacific marine stratocumulus clouds (FIRE-1)	Response of LWP due to increasing droplet concentration is influenced by precipitation at the surface and near clout-top. Only when overlying air is humid does sufficient precipitation reach the surface of the cloud to increase LWP. Otherwise, entrainment of dry air reduces LWP.
Lu and Seinfeld (2005)	RAMS LES coupled with explicit bin resolving warm cloud microphysics model. Loosely based on FIRE. Stratocumulus clouds and ASTEX	Cloud optical depth is positively correlated with LWP LWP is strongly dependent on external dynamic forcing parameters such as SST and large scale divergence rate. Largest aerosol indirect effect occur during night time
Xue and Feingold (2005)	Stevens at al (1999) LES model. with microphysical model (Feingold 1996). Barbados (BOMEX). Trade Wind Cumuli	Increase in aerosol concentration results in more efficient droplet evaporation and entrainment. Also leads to suppression of drizzle. Two mechanisms that act in opposite direction.
Jiang and Feingold (2006)	RAMS LES model coupled with microphysical model (Feingold 1996) and Land-Ecosystem-Atmospheric feedback (LEAF). Amazon, Warm continental Cumulus Clouds	For no Aerosol Direct Effects: Increase in aerosol concentration does not cause significant changes in LWP, cloud fraction. For Aerosol Direct Effects: Increase in aerosol concentration causes a decrease in LWP due to weaker convection and reduction in surface flux.
Jiang, Feingold and Koren (2009)	RAMS LES model coupled with microphysical model (Feingold 1996) and Land-Ecosystem-Atmospheric feedback (LEAF). Based on sounding from the RICO campaign in Barbuda. Trade Cumulus clouds.	Increasing aerosols increase number and decreases size of small clouds. LWP response to increase in aerosol depends on the criterion used to defined a cloud (LWP vs τ). LWP does not detect smaller clouds that form as a result of aerosols due to their lower LWP.
Hill, Dobbie and Yin (2008)	UK Met Office LES. Model coupled with size-bin-resolved cloud microphysics. Loosely based on FIRE. Stratocumulus.	Reduction in LWP with increasing CCN
Kogen, Mechem, and Choi (2011)	(CIMMS) large-eddy simulation (LES) with 34 cloud-drop bins ranging in size from 1 mm up to 2 mm. The CCN particles are considered to be of NaCl origin. Based on sounding from the RICO campaign in Barbuda. Shallow Cumulus clouds.	Addition of large (small) sea-salt nuclei tends to accelerate (suppress) precipitation formation
Petters at al. (2012)	RAMS LES model, coupled with bulk microphysics scheme (Meyers et al. 1997) Stratiform clouds over the Pacific Ocean, off the coast of Southern California	Low LWP stratiform clouds are particularly sensitive to initial thermodynamic profiles and model configurations.



A (2000) No Soot
A(2000) Soot
A(2004) DYCOMS-II
A(2004) ASTEX
LWP [g m^-2]
Droplet Concentration [cm^-3]
L&S (2005)
X&F (2005)
J&F (2006) no direct effects
J&F (2006) direct effects
J&F&K τ>2 (2009)
J&F&K LWP>20 (2009)
H,D&Y (2008)
LWP [g m^-2]
Aerosol Concentration [cm^-3]