

	Paper	Cites	Model or Obs	Species	Forcing	Summary
1	Leaitch et al. 1992: The relationship between CDNC and anthropogenic pollution: obs and climatic implications		SO <sub>4</sub> , NO <sub>3</sub> <sup>-</sup> , CDNC, & LWC in Ontario CA & New York US	S	(-2 to -3) Eastern US	Measurements of SO <sub>4</sub> and CDNC and LWC are used to determine relationship between pollution and stratiform/cumuliform clouds (1982-1988). Found a positive correlation between SO <sub>4</sub> & CDNC (56% increase), no change in LWC. Simple model calculates RF.
2	Jones et al. 1994: A climate model study of indirect radiative forcing by anthropogenic sulphate aerosol	1	Hadley Centre GCM and Langner and Rodhe CTM	S	(-1.26) (-1.25)	Used sulphate concentrations from a chemical transport model as input to a GCM to evaluate aerosol indirect radiative forcing on stratiform and shallow convective clouds. Tested both the Leaitch et al. 1992 and Martine and Johnson 1992 relationship between CDNC and aerosol.
3	Boucher & Lohmann 1995: The sulfate-CCN-cloud albedo effect	1, 2	LMD and ECHAM GCMs	S	(-1)	An empirical aerosol-CDNC relationship is used in 2 GCMs to find aerosol indirect effect. Highest off the coast of NH continents. Uncertainty associated with aerosol-CDNC relationship is ±0.5. GCM differences (-0.5 and -1.5) attributed to modeled water budget.
4	Jones et al. 2001: Indirect sulphate aerosol forcing in a climate model with an interactive sulphur cycle	2, 3	Hadley Centre GCM - 6 experiments	S, SS (E)	(-1.34) -1.89	Update of GCM used in Jones et al. 1994 with interactive sulphur cycle, sea salt, and autoconversion (first and second indirect effects). Assumptions about natural sulphate can reduce the forcing by over 25%, and different parameterizations of autoconversion can double it.
5	Ming et al. 2005: GFDL GCM investigation of the indirect radiative effects of anthropogenic sulfate aerosol	3, 4	GFDL GCM and MOZART CTM	S	(-1.5) -2.3	First and second aerosol indirect effects are estimated by altering which parameterizations respond to PD and PI aerosol concentrations. 77 % of the forcing is in the NH, which is only significant in the NH low-mid lats. Separates TOA forcing from flux change (includes LW).
6	Dufresne et al. 2005: Contrasts in the effects on climate of anthropogenic sulfate aerosols between the 20th and the 21st century.	3	IPSL-CM4 (LMDZ) and satellite (POLDER)	S	(-0.22)	Simulated (1860-2100) the first aerosol indirect effect using aerosol-CDNC relationship of Boucher & Lohmann 1995. Found lower value when parameters are adjusted to match POLDER and when a couple land model is used. Aerosol cooling decreases over time into the 21C.
7	Lohmann and Feichter 2005: Global indirect aerosol effects: a review		Multi-model comparison	S	(-0.5 to -1.9)	A review of aerosol effects in general with model comparison, much of which IPCC AR4 is based on. Inverse simulations bound the combined aerosol effect from 0 to -2, but models predict up to -1.9 from first effect alone, so there must be cancellation or over prediction.
8	Ming et al. 2007: Modeling the interactions between aerosols and LW clouds with a self-consistent cloud scheme in a GCM		GFDL GCM	S, SS, OC	-1.8	Simulated aerosol indirect effect using a prognostic scheme to calculate CDNC rather than the empirical fit previously used. The new scheme improves comparison of LWP and cloud forcing with observations. 73% of the forcing is in the NH. Sulfate alone is 1.1.
9	Quaas et al. 2009: Aerosol indirect effects – general circulation model intercomparison and evaluation with satellite data	4,7	Ten GCMs and satellite (MODIS, ATSR-2, CERES)	S, OC, D, BC, SS (E&I)	-0.7	Evaluated relationships between aerosol optical depth - albedo, CDNC, CF, and LWP, found to be good predictors for aerosol indirect forcing. Correlation between aerosol optical depth and CDNC is good, LWP is too strong, and CF is too weak in models compared to satellite.
10	Wang et al. 2011: Aerosol indirect effects in a multi-scale aerosol-climate model PNNL-MMF		NCAR CAM5 and PNNL MMF GCMs	S, OC, D, BC, SOA, SS (I)	-1.79 CAM5 -0.77 MMF	Used an MMF (4km CRM) to simulate aerosol indirect effects, compared to conventional GCM and obs. Smaller value is attributed to weaker increase in LWP with increased CCN and smaller increase in CCN, which are in better agreement with obs and high res models.