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Yuan Wang

Aerosol-Cloud Interactions from Urban, Regional, to Global Scales

Doctoral Thesis accepted by
Texas A&M University, College Station, USA

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Supervisor's Foreword

Yuan Wang received a B.S. in Computer Science from Fudan University (2007) and a Ph.D. (2013) in Atmospheric Sciences from Texas A&M University. He is presently a postdoc research fellow at the Jet Propulsion Laboratory, California Institute of Technology. His research areas focus on aerosol physics and chemistry, aerosol-cloud interactions and their climate implications, mesoscale and global climate modeling.

This dissertation covers several broad research topics in atmospheric sciences, ranging from development and refinement of the regional Weather Research Forecast (WRF) model and global climate model (GCM) to assessments of the aerosol-cloud-climate interaction. As recognized in the Fifth Assessment Report by the Inter-government Panel on Climate Change (IPCC AR5, 2013), the magnitude of cloud adjustment by aerosols is highly uncertain, representing the largest uncertainty in projections of future climate by anthropogenic activities. Much of the uncertainty in the assessment of the aerosol radiative forcing arises from the difficulty to resolve aerosol and cloud-scale processes in GCMs. Yuan's research involved modeling the aerosol effects on cloud formation and precipitation using the mesoscale cloud-resolving (CR) WRF model. He made key model development that, for the first time, implemented an explicit two-moment bulk microphysical scheme into WRF. Because of its broad application in numerical weather prediction, his improved WRF framework has enabled assessment of aerosol-cloud interaction for variable weather-scale systems, from individual cumulus to mesoscale convective systems. He utilized this model to investigate the aerosol effects on precipitation and lightning over a megacity region in China. He also improved the representation of cloud microphysics in the WRF model and employed the upgraded model to investigate the aerosol effects on stratocumulis over the Southeast Pacific region.

He developed a novel hierarchical modeling approach to assess the impacts of Asian pollution on the Pacific storm track, on the basis of the aerosol forcings calculated from seasonal simulations using the CR-WRF models and incorporation of the derived aerosol forcings to the GCM to predict the associated climatic responses. His novel approach resolved a long outstanding mismatch between simulations by regional mesoscale models and GCMs in the climate research community, allowing a more precise assessment of the global impacts of the cloud-scale processes induced by anthropogenic aerosols. His results from the hierarchical modeling and observational analysis demonstrated unambiguously that Asian pollution has exerted profound climatic impacts on mid-latitude cyclones over the past three decades. In addition, he evaluated the impacts of aerosols over the Pacific storm track on the basis of the results from multi-scale aerosol-climate model simulations, further confirming his results using the hierarchical modeling.

I believe that this dissertation will be of broad interest, not only to the scientific communities in the fields of atmospheric physics and chemistry, but also to those who are interested in global environmental and climate changes and the interface between science and policy.

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This thesis is specially dedicated to my beloved mother, Ruojing Zhang who passed away in 2011.

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