Professor, University of Maryland
Department of Atmospheric & Oceanic Science
2419 Computer & Space Science
College Park, Maryland 20742-2425
Phone: (301) 405-7567, Fax: (301) 314-9482

Email: xliang@umd.edu
Earth System Science Interdisciplinary Center
5825 University Research Court, Suite 4001
College Park, Maryland 20740-3823
Phone: (301) 405-6300, Fax: (301) 405-8468

EDUCATION:

Ph.D. *Atmospheric Dynamics* September 1983 – January 1987
The Graduate School of the Chinese Academy of Sciences and Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences, Beijing, China

Dissertation: The Design of IAP General Circulation Model (GCM) and the Simulation of Climate and Interseasonal Variability

B.S. *Meteorology* September 1979 – July 1983
Hangzhou University (now part of Zhejiang University), Hangzhou, China

EMPLOYMENT AND RESEARCH EXPERIENCE:

Professor January 2011 – Present
Department of Atmospheric & Oceanic Science and Earth System Science Interdisciplinary Center
University of Maryland at College Park (UMCP)

Professor February 2010 – December 2010
Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign (UIUC)

Senior Professional Scientist January 2006 – December 2010
Professional Scientist May 2001 – December 2005
Associate Professional Scientist January 1999 – April 2001
Illinois State Water Survey, Prairie Research Institute, UIUC

NCSA Faculty Fellow March 2002 – January 2004
National Center for Supercomputing Applications, UIUC

- Global and regional climate, hydrology, air quality, water quality, and impact modeling. The lead investigator to develop and apply an integrated Earth modeling system, which currently incorporates global general circulation models (CESM, CFS), global chemical transport models (MOZART, CAM-Chem), mesoscale multi-nested regional climate models (CMM5, CWRF), advanced air quality models (CMAQ, WRF-Chem), a detailed emission inventory model (SMOKE), a state-of-the-art terrestrial hydrology model for conjunctive surface and subsurface processes (CSSP), a comprehensive water quality model (SWAT), and dynamic ecosystem models (GOSSYM, DSSAT).
- The lead investigator to develop and apply (CMM5, CWRF) for dynamic downscaling to improve seasonal climate prediction, climate change and impact modeling, climate-hydrology-crop interaction, air-sea-land interaction, convection-cloud-radiation interaction, quantitative precipitation forecast…

Senior Research Scientist May 1993 – January 1999
Research Scientist October 1990 – April 1993
Atmospheric Sciences Research Center, State University of New York at Albany

- Development of GCM treatment for cloud-radiation interaction including subgrid variability
- Improvement and application of IAP/SUNY, GENESIS, NCAR CCM1-3 and CSM GCMs
- Investigation on climate change modeling – anthropogenic forcing of CO_2, CH_4, N_2O, CFCs and O_3
- Study on seasonal to interannual climate variability and predictability – monsoon, ENSO, LFO

Research Associate January 1987 – September 1990
Institute for Terrestrial and Planetary Atmospheres, State University of New York at Stony Brook

- Development of the IAP/SUNY global atmospheric GCM, with the entire new physics package
- Improvement and application of IAP, OSU and IAP/SUNY GCMs

- Research on climate feedbacks and GCMs' analysis

EDITORSHIPS:

- Editorial Advisory Board Member, *the Open Atmospheric Science Journal*, 2007-
- Editorial Board Member, *Frontiers of Environmental Science & Engineering*, 2009-
- Editorial Advisory Board Member, *Eos, Transactions, American Geophysical Union*, 2010-

SELECT PANELS AND COMMITTEES:

- WRF (Weather Research and Forecasting model) National-wide Development Teams & Working Groups: Model Physics (WG5) and Regional Climate Modeling (WG16), 2001-
- AGU (American Geophysical Union) GEC (Global Environmental Change) Focus Group, 2013-
- U.S. CLIVAR (Climate Variability and Predictability) Program, PPAI (Predictability, Prediction, and Applications Interface) Panel, 2014-2017

TEACHING EXPERIENCE:

- AOSC621: Physics and Chemistry of the Atmosphere (II) – a comprehensive course designed to help students in mastering the fundamental principles, quantitative analysis, and numerical modeling of atmospheric radiation and chemistry. Topics include solar and terrestrial radiative transfer processes, specifically the absorption, scattering and emission resulting from interactions with atmospheric constituents (gases, aerosols, clouds) and the Earth's surface, as well as how radiation drives atmospheric chemistry and climate dynamics. Department of Atmospheric and Oceanic Science, University of Maryland; Spring 2012, 2014, and every spring onward.
- AOSC347: Computing and Data Analysis – a comprehensive introductory course designed to prepare students to identify, interpret, and visualize Earth's climate variations observed in the past and projected into the future. The class emphasizes real-world applications, providing students with essential hands-on experience using MATLAB for data analysis and visualization, developing analytical skills for observational and modeling data, and performing virtual experiments to distinguish data contributing factors. Students will gain an understanding of the scientific issues concerning the modern global warming debate on detection and attribution including: signal vs noise, trend vs periodicity, natural vs anthropogenic forcing, local vs remote response, mean vs extreme changes, and accuracy vs uncertainty. Department of Atmospheric and Oceanic Science, University of Maryland; Fall 2012, Spring 2014, and every spring onward.
- ATMS305: Computing and Data Analysis – a comprehensive introduction to the statistical treatment and graphical representation of atmospheric and geophysical sciences data both in space and time. It emphasizes applications and real-world examples, and discusses relevant data statistics. Students will gain hands-on experience using MATLAB for data analysis, develop analytical skills for observational and modeling data, and perform virtual experiments to identify, interpret and understand the major signals in the data. Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Fall 2010.

MAJOR SCIENTIFIC ACHIEVEMENTS:

MODEL DEVELOPMENT

- Global General Circulation Models (GCMs): A lead investigator to develop China's 1st and 2nd generations of GCMs, which are widely used in China for operational seasonal-interannual climate predictions, future climate change projections, as well as major research and higher educational tools. Major improvements to NCAR GCMs include parameterizations for convection, cloud, radiation and their interactions.
- Regional Climate Models (RCMs): A lead investigator to develop CMM5 and CWRF, which becomes the fundamental tools for realistic downscaling of USA regional climate variations, focusing on precipitation and surface temperature. They are used in numerous federal and state funded research projects, national and regional climate change assessments, as well as graduate and Ph.D. thesis studies. In particular, the public release of the most recent CWRF is highly demanded, scheduled in this summer. New development of unique physics representations in the CWRF includes cloud-aerosol-radiation interactions, land surface albedo parameterization, optimized ensemble cumulus parameterization, conjunctive surface-subsurface terrestrial hydrology module, ensemble crop growth module and interactive upper ocean module. The

CWRF currently contains over 10^{24} physics configurations representing cloud, aerosol, radiation, surface, planetary boundary layer, cumulus, and microphysics processes and their nonlinear interactions. This number is expanding as addition of new schemes continues. The CWRF is the most ever complete regional climate modeling system that provides an unprecedented pathway to develop an optimized physics ensemble approach for tackling major roadblocks in weather and climate prediction at regional-local scales. The developed physics ensemble system is readily transferable to any global or regional model for weather forecast and climate prediction at high spatial resolution.

- Cloud-Aerosol-Radiation ensemble modeling system (CAR): A lead investigator to develop the system that consists of 10^{18} free choices of alternative parameterizations for cloud properties (cover, water, radius, optics, geometry), aerosol properties (type, profile, optics), and radiation transfers (solar, infrared) and their interactions currently available in the literature, including those used by the world leading GCMs at NCAR, GFDL, NCEP, NASA, ECMWF, CCCMA, CSIRO, and UKMO. The CAR is the unprecedented collection of most available numerical representations of cloud-aerosol-radiation interactions that are fully selectable and exchangeable. It has been built in the CWRF and is being coupled with the NCAR CESM to embody the most ever complete range of climate sensitivities in existing GCMs. The system has broad, unique applications in physical process understanding, new parameterization development, remote sensing retrieval, climate sensitivity analysis, climate projection uncertainty, optimized physics ensemble design, and inverse physics modeling.
- Integrated Earth modeling system: A lead investigator to develop the system, which currently incorporates global general circulation models (CESM, CFS), global chemical transport models (MOZART, CAM-Chem), mesoscale multi-nested regional climate models (CMM5, CWRF), advanced air quality models (CMAQ, WRF-Chem), a detailed emission inventory model (SMOKE), a state-of-the-art conjunctive surface and subsurface process model (CSSP), a comprehensive water quality model (SWAT), and dynamic ecosystem models (GOSSYM, DSSAT). It has been used as the principal tool to support the national assessments on the impacts of global climate and emissions changes on air quality (ozone, particulate matter, mercury) and water quality (nutrients, pathogens, bacteria, sediments) and the associated projection uncertainty by USEPA, and on agricultural and invasive plant distributions by USDA. The system is continuously expanding and subject to an increasing scope of applications, including seasonal-interannual climate prediction, regional climate and environment change projection and impact assessment, as well as critical interdisciplinary research.

RESEARCH ADVANCE

- The developed or improved GCMs have been applied to study seasonal-interannual-decadal climate variability and predictability (East Asian and North American monsoons, El Niño-Southern Oscillation), climate feedbacks, climatic effects of anthropogenic emissions.
- The developed RCMs (CMM5, CWRF) have been applied to improve regional weather forecast and climate prediction in USA and China, focusing on precipitation and surface temperature; to downscale climate change projections and reduce the corresponding uncertainties.
- The developed integrated Earth modeling system has facilitated interdisciplinary research on climate change and environmental issues. In particular, the study of the impacts of global climate and emissions changes on USA air quality has been well recognized, taking the lead to conduct a national assessment of the challenges facing the future pollutant control.
- The developed new model physics representations of key significance include mosaic treatment of cloud overlap effects on radiation, dynamic-statistical parameterization of land surface albedo, conjunctive surface-subsurface terrestrial hydrology modeling with a scalable parameterization of subgrid topographic control, optimization of ensemble precipitation prediction, interactive climate-crop growth modeling, and grand cloud-aerosol-radiation ensemble modeling system.
- The developed "optimized physics ensemble (OPE)" approach, currently statistical, has been demonstrated to significantly improve model skill in weather forecast and climate predication, especially for precipitation that is most challenging. The dynamical OPE approach being developed is anticipated to be more powerful.
- The core research is interdisciplinary across a wide range of sciences, including atmosphere/ocean/land physics and chemistry, climate dynamics, terrestrial hydrology, ecosystem, agriculture, numerical prediction and supercomputing. This is well reflected by the numerous research grants from multiple federal agencies (EPA, NOAA, NSF, USDA, DOE, NASA) focusing on different fields.

PUBLICATIONS:

- *Over 100 publications in reviewed literature in the following journals and books:*

  Science, Nature, Geophysical Research Letters, Journal of Climate, Bulletin of the American Meteorological Society, Journal of Geophysical Research, Journal of Atmospheric Sciences, Atmospheric Chemistry and Physics, Climate Dynamics, Quarterly Journal of the Royal Meteorological Society, Agronomy Journal, Atmospheric Environment, Environmental Health Perspectives, Monthly Weather Review, Journal of Applied Meteorology and Climatology, Journal of Applied Meteorology, Journal of Hydrometeorology, Water Resources Research, Journal of Hydrologic Engineering, Climate Research, Atmospheric Research, Earth Interactions, Tellus, Global and Planetary Change, Climatic Change, Mitigation and Adaptation Strategies for Global Change, Journal of Water Resources Planning and Management, Journal of Great Lakes Research, EOS, Frontiers of Earth Sciences, Chinese Journal of Atmospheric Sciences, Advances in Atmospheric Sciences, Advances in Natural Sciences, Acta Meteorologica Sinica, Acta Oceanologica Sinica, Plateau Meteorology, Open Atmospheric Science Journal, NATO Advanced Science Institutes Series, Future Climates of the World, Climate-Biosphere Interactions.

- *Over 50 preprints and other proceedings in non-reviewed literature.*

REFEREED JOURNAL AND BOOK ARTICLES

[125] Chen, L., X.-Z. Liang, D. DeWitt , A.N. Samel, and J.X.L. Wang, 2014: Seasonal prediction of U.S. precipitation and temperature by the nested CWRF-ECHAM system. *Climate Dynamics* (submitted).

[124] Liu, S., J.X.L. Wang, X.-Z. Liang, V. Morris, and S.S. Fine, 2014: A hybrid approach to improve U.S. seasonal climate outlook skills at the regional scale. *Climate Dynamics* (submitted).

[123] Lei, H., D.J. Wuebbles, and X.-Z. Liang, 2014: Physical dust aerosol modeling by CAM-Chem: Model formulation and evaluation. *Geoscientific Model Development* (submitted).

[122] *He, H., X.-Z. Liang, H. Lei, and D.J. Wuebbles, 2014: Attribution of future U.S. ozone pollution to regional emissions, long-range transport, climate change, and model deficiency. *Atmos. Chem. Phys.* (submitted).

[121] **Qiao, F., and X.-Z. Liang, 2014: Effects of cumulus parameterizations on predictions of summer flood in the Central United States. *Climate Dynamics* (accepted).

[120] Shafiee-Jood, M., X. Cai, L. Chen, X.-Z. Liang, and P. Kumar, 2014: Assessing the value of seasonal climate forecast information through an end-to-end forecasting framework: Application to U.S. 2012 drought in central Illinois. *Water Resources Research* (accepted).

[119] Xu, M., X.-Z. Liang, A. Samel, and W. Gao, 2014: MODIS consistent vegetation parameter specifications and their impacts on regional climate simulations. *J. Climate* (accepted).

[118] *Liu, S., X.-Z. Liang, W. Gao, and T.J. Stohlgren, 2013: Regional climate model downscaling may improve prediction of alien plant species distribution. *Frontiers of Earth Sciences*, 1-15, DOI 10.1007/s11707-014-0457-4.

[117] Lei, H., D.J. Wuebbles, X.-Z. Liang, Z. Tao, S. Olsen, R. Artz, X. Ren, and M. Cohen, 2014: Projections of atmospheric mercury levels and their effect on air quality in the United States. *Atmos. Chem. Phys.*, **14**, 783-795.

[116] Barsugli, J.J., G. Guentchev, R.M. Horton, A. Wood, L.O. Mearns, X.-Z. Liang, J.A. Winkler, K. Dixon, K. Hayhoe, R.B. Rood, L. Goddard, A. Ray, L. Buja, and C. Ammann, 2013: "The Practitioner's dilemma" – How to assess the credibility of downscaled climate projections? *EOS*, **94**, 424-425.

[115] **Lei, H., X.-Z. Liang, D.J. Wuebbles, Z. Tao, and S. Olsen, 2013: Model analyses of atmospheric mercury: Present air quality and effects of transpacific transport on the United States. *Atmos. Chem. Phys.*, **13**, 10807-10825.

[114] *Zhang, F., X.-Z. Liang, J. Li, and Q.-C. Zeng, 2013: Dominant roles of subgrid-scale cloud structures in model diversity of cloud radiative effects. *J. Geophys. Res.*, **118**, 7733-7749, DOI: 10.1002/jgrd.50604.

[113] Liang, X.-Z., and F. Zhang, 2013: The Cloud-Aerosol-Radiation (CAR) ensemble modeling system. *Atmos. Chem. Phys.,* **13**, 8335-8364, doi:10.5194/acp-13-8335-2013.

[112] Li, J., K. von Salzen, Y. Peng, H. Zhang, and X.-Z. Liang, 2013: Evaluation of black carbon semi-direct radiative effect in a climate model. *J. Geophys. Res.*, **118**, 1-14, doi:10.1002/jgrd.50327

[111] *Zhang, F., X.-Z. Liang, Q.-C. Zeng, Y. Gu, and S. Su, 2013: Cloud-Aerosol-Radiation (CAR) ensemble modeling system: Overall accuracy and efficiency. *Adv. Atmos. Sci.*, **30**, 955-973.

[110] Hejazi, M.I., X. Cai, X. Yuan, X.-Z. Liang, and P. Kumar, 2013: Incorporating short-term forecasts from a regional climate model in an irrigation scheduling optimization problem. *Journal of Water Resources Planning and Management*, 10.1061/(ASCE)WR.1943-5452.0000365.

[109] Choi, H.I., X.-Z. Liang, and P. Kumar, 2013: A conjunctive surface-subsurface flow representation for mesoscale land surface models. *J. Hydrometeorology*, **14**, 1421-1442.

[108] **Chen, Q., X.-Z. Liang, M. Xu, T. Lin, and J.X.L. Wang, 2013: Improvement of cloud radiative forcing and its impact on weather forecasts. *Open Atmospheric Science Journal*, **7**, 1-13, DOI: 10.2174/1874282301307010001.

[107] *Zhu, J., and X.-Z. Liang, 2013: Impacts of the Bermuda high on regional climate and air quality over the United States. *J. Climate*, **26**, 1018-1032. doi:10.1175/JCLI-D-12-00168.1.

[106] *Liu, S., W. Gao, and X.-Z. Liang, 2012: Regional climate model downscaling projection of China future climate change. *Climate Dynamics,* **41**, 1871-1884, doi:10.1007/s00382-012-1632-5.

[105] **Lei, H., D.J. Wuebbles, and X.-Z. Liang, 2012: Domestic versus international contributions on 2050 ozone air quality: How much is convertible by regional control? *Atmospheric Environment*, **68**, 315-325, doi:10.1016/j.atmosenv.2012.12.002.

[104] **Lei, H., D.J. Wuebbles, and X.-Z. Liang, 2012: Projected risk of high ozone episodes in 2050. *Atmospheric Environment*, **59**, 567-577.

[103] Post, E.S., A. Grambsch, C.P. Weaver, P. Morefield, J. Huang, L.-Y. Leung, C. Nolte, P. Adams, X.-Z. Liang, J.-H. Zhu, and H. Mahoney, 2012: Variation in estimated health impacts of climate change via ambient ozone concentration changes due to modeling choices and assumptions. *Environmental Health Perspectives*, **120**(11), 1559-64, doi: 10.1289/ehp.1104271.

[102] Liang, X.-Z., M. Xu, W. Gao, K.R. Reddy, K.E. Kunkel, D.L. Schmoldt, and A.N. Samel, 2012: A distributed cotton growth model developed from GOSSYM and its parameter determination. *Agronomy Journal*, **104**, 661-674.

[101] Liang, X.-Z., M. Xu, W. Gao, K.R. Reddy, K.E. Kunkel, D.L. Schmoldt, and A.N. Samel, 2012: Physical modeling of U.S. cotton yields and climate stresses during 1979 to 2005. *Agronomy Journal*, **104**, 675-683.

[100] Liang, X.-Z., M. Xu, X. Yuan, T. Ling, H.I. Choi, F. Zhang, L. Chen, S. Liu, S. Su, F. Qiao, Y. He, J.X.L. Wang, K.E. Kunkel, W. Gao, E. Joseph, V. Morris, T.-W. Yu, J. Dudhia, and J. Michalakes, 2012: Regional Climate-Weather Research and Forecasting Model (CWRF). *Bull. Amer. Meteor. Soc.,* **93**, 1363-1387. [Featured in the cover page of the BAMS 2012 September issue]

[99] Yuan, X., X.-Z. Liang, and E.F. Wood, 2012: WRF ensemble downscaling seasonal forecasts of China winter precipitation during 1982-2008. *Climate Dynamics*, **39**, 2041-2058. DOI: 10.1007/s00382-011-1241-8.

[98] *Liu, S., X.-Z. Liang, W. Gao, Y. He, and T. Ling, 2011: Regional climate model simulations of the 1998 summer China flood: Dependence on initial and lateral boundary conditions. *Open Atmospheric Science Journal*, **5**, 96-105.

[97] *Yuan, X., and X.-Z. Liang, 2011: Improving cold season precipitation prediction by the nested CWRF-CFS system. *Geophys. Res. Lett.*, **38**, L02706, doi:10.1029/2010GL046104.

[96] Markus, M., D. J. Wuebbles, X.-L. Liang, K. Hayhoe, and d. A. R. Kristovich, 2011: Diagnostic analysis of future climate scenarios applied to urban flooding in the Chicago metropolitan area. *Climatic Change*, DOI 10.1007/s10584-011-0172-z.

[95] **Ling, T.-J., X.-Z. Liang, M. Xu, Z. Wang, and B. Wang, 2011: A multilevel ocean mixed-layer model for 2-dimension applications. *Acta Oceanologica Sinica*, **33**(03), 1-10.

[94] *Yuan, X., and X.-Z. Liang, 2011: Evaluation of a Conjunctive Surface-Subsurface Process model (CCSP) over the contiguous United States at regional–local scales. *J. Hydrometeorology*, **12**, 579-599, doi: 10.1175/2010JHM1302.1.

[93] *Wang, C., X.-Z. Liang, and A.N. Samel, 2010: AMIP GCM simulation of precipitation variability over the Yangtze River Valley. *J. Climate*, **24**, 2116-2133.

[92] *Drewry, D.T., P. Kumar, S. Long, C. Bernacchi, X.-Z. Liang, and M. Sivapalan, 2010: Ecohydrological responses of dense canopies to environmental variability, Part 1: Interplay between vertical structure and photosynthetic pathway. *J. Geophys. Res. Biogeosciences*, 115, G04022, 25pp, doi:10.1029/2010JG001340.

[91] *Drewry, D.T., P. Kumar, S. Long, C. Bernacchi, X.-Z. Liang, and M. Sivapalan, 2010: Ecohydrological responses of dense canopies to environmental variability, Part 2: Role of acclimation under elevated CO_2. *J. Geophys. Res. Biogeosciences*, **115**, G04023, 22pp, doi:10.1029/2010JG001341.

[90] *Liu, S., and X.-Z. Liang, 2010: Observed diurnal cycle climatology of planetary boundary layer height. *J. Climate*, **23**, 5790-5809, doi:10.1175/2010JCLI3552.1.

[89] *Xu, M., X.-Z. Liang, W. Gao, and N. Krotkov, 2010: Comparison of TOMS retrievals and UVMRP measurements of surface spectral UV radiation in the United States. *Atmos. Chem. Phys.*, **10**, 8669-8683, doi:10.5194/acp-10-8669-2010.

[88] *Choi, H. I., and X.-Z. Liang, 2010: Improved terrestrial hydrologic representation in mesoscale land surface models. *J. Hydrometeorology*, **11**, 797-809.

[87] **Wang, X., X.-Z. Liang, W. Jiang, Z. Tao, J.X.L. Wang, H. Liu, Z. Han, S. Liu, Y. Zhang, G.A. Grell, and S.E. Peckham, 2010: WRF-Chem simulation of East Asian air quality: Sensitivity to temporal and vertical emissions distributions. *Atmos. Environ.*, 44, 660-669, doi:10.1016/j.atmosenv.2009.11.011.

[86] Kunkel, K.E., X.-Z. Liang, and J. Zhu, 2010: Regional climate model projections and uncertainties of U.S. summer heat waves. *J. Climate*, **23**, 4447-4458.

[85] Lin, J.-T., D.J. Wuebbles, H.-C. Huang, Z. Tao, M. Caughey, X.-Z. Liang, J. Zhu, and T. Holloway, 2010: Potential effects of climate and emissions changes on surface ozone in the Chicago area. *J. Great Lakes Research*, **36**, 59-64.

[84] Anderson, B.T., K. Hayhoe, and X.-Z. Liang, 2010: Anthropogenic-induced changes in the twenty-first century summertime hydroclimatology of the Northeastern US. *Climatic Change,* **99**, 403-423.

[83] Weaver, C.P., X.-Z. Liang, J. Zhu, P.J. Adams, P. Amar, J. Avise, M. Caughey, J. Chen, R.C. Cohen, E. Cooter, J.P. Dawson, R. Gilliam, A. Gilliland, A.H. Goldstein, A. Grambsch, D. Grano, A. Guenther, W.I. Gustafson, R.A. Harley, S. He, B. Hemming, C. Hogrefe, H.C. Huang, S.W. Hunt, D.J. Jacob, P.L. Kinney, K. Kunkel, J.F. Lamarque, B. Lamb, N.K. Larkin, L.R. Leung, K.J. Liao, J.T. Lin, B.H. Lynn, K. Manomaiphiboon, C. Mass, D. McKenzie, L.J. Mickley, S.M. O'neill, C. Nolte, S.N. Pandis, P.N. Racherla, C. Rosenzweig, A.G. Russell, E. Salathé, A.L. Steiner, E. Tagaris, Z. Tao, S. Tonse, C. Wiedinmyer, A. Williams, D.A. Winner, J.H. Woo, S. Wu, and D.J. Wuebbles, 2009: A preliminary synthesis of modeled climate change impacts on U.S. regional ozone concentrations. *Bull. Amer. Meteor. Soc.*, **90**, 1843–1863.

[82] *Liu, S., W. Gao, M. Xu, X. Wang, and X.-Z. Liang, 2009: Regional climate model simulation of China summer precipitation using an optimal ensemble of cumulus parameterization schemes. *Frontiers of Earth Science*, **3**(2), 248-257, DOI 10.1007/s11707-009-0022-8.

[81] **Zeng, M.-J., W. Lu, X.-Z. Liang, H. Wu, M. Pu, and D. Yin, 2008: Analysis of temperature structure for persistent disastrous freezing rain and snow over southern China in early 2008. *Acta Meteorologica Sinica*, **66** (6), 1043-1052.

[80] **Zeng, M.-J., W.-S. Lu, X.-Z. Liang, and X.-L. Wang, 2008: Ensemble forecast experiment on precipitation in summer by CWRF numeric model. *Plateau Meteorology*, **27** (6), 1-11.

[79] **Lin, J.-T., D. Youn, X.-Z. Liang, D.J. Wuebbles, 2008: Global model simulation of summertime U.S. ozone diurnal cycle and its sensitivity to PBL mixing, spatial resolution, and emissions. *Atmospheric Environment*, **42**, 8470-8483.

[78] Liang, X.-Z., K.E. Kunkel, G.A. Meehl, R.G. Jones, and J.X.L. Wang, 2008: Regional climate models downscaling analysis of general circulation models present climate biases propagation into future change projections. *Geophys. Res. Lett.,* **35**, L08709, doi:10.1029/2007GL032849.

[77] Liang, X.-Z., J. Zhu, K.E. Kunkel, M. Ting, and J.X.L. Wang, 2008: Do CGCMs simulate the North American monsoon precipitation seasonal-interannual variability? *J. Climate*, **21**, 4424-4448.

[76] *Huang, H.-C., J. Lin, Z. Tao, H. Choi, K. Patten, K.E. Kunkel, M. Xu, J. Zhu, X-Z. Liang, A. Williams, M. Caughey, D.J. Wuebbles, and J.X.L. Wang, 2008: Impacts of long-range transport of global pollutants and precursor gases on US air quality under future climatic conditions. *J. Geophys. Res.*, **113**, D19307, doi:10.1029/2007JD009469.

[75] *Tao, Z., A. Williams, H.C. Huang, M. Caughey, and X.-Z. Liang, 2008: Sensitivity of surface ozone simulation to cumulus parameterization. *J. Appl. Meteor. Climatol.*, **47**, 1456–1466.

[74] **Lin, J.-T., D.J. Wuebbles, and X.-Z. Liang, 2008: Effects of intercontinental transport on surface ozone over the United States: Present and future assessment with a global model. *Geophys. Res. Lett.*, **35**, L02805, doi:10.1029/2007GL031415.

[73] **Lin, J.T., K.O. Patten, K. Hayhoe, X.-Z. Liang, and D.J. Wuebbles, 2008: Effects of future climate and biogenic emissions changes on surface ozone over the United States and China. *J. Appl. Meteor. Climatol.*, **47**, 1888–1909.

[72] **Liu, S., X.-Z. Liang, W. Gao, and H. Zhang, 2008: Climate-Weather Research and Forecasting Model (CWRF) Application in China: Domain Optimization. *Chinese J. Atmos. Sci.*, **32**, 457-468.

[71] Yang, F., K. Mitchell, Y.T. Hou, Y. Dai, X. Zeng, Z. Wang, and X.-Z. Liang, 2008: Dependence of land surface albedo on solar zenith angle: Observations and model parameterization. *J. Appl. Meteor. Climatol.*, **47**, 2963–2982.

[70] Kunkel, K.E., H.-C. Huang, X.-Z. Liang, J.-T. Lin, D.J. Wuebbles, Z. Tao, A. Williams, M. Caughey, J. Zhu, and K. Hayhoe, 2008: Sensitivity of future ozone concentrations in the Northeast U.S. to regional climate change. *Mitig. Adapt. Strat. Glob. Change,* **13**, 597-606, DOI 10.1007/s11027-007-9137-y.

[69] Hayhoe, K., C. Wake, B. Anderson, X.-Z. Liang, E. Maurer, J. Zhu, J. Bradbury, A. DeGaetano, A.M. Stoner, and D. Wuebbles, 2008: Regional climate change projections for the Northeast USA. *Mitig. Adapt. Strat. Glob. Change*, **13**, 425-436, DOI 10.1007/s11027-007-9133-2.

[68] *Tao, Z., A. Williams, H.-C. Huang, M. Caughey, and X.-Z. Liang, 2007: Sensitivity of U.S. surface ozone to future emissions and climate changes. *Geophys. Res. Lett.,* **34**, L08811, doi:10.1029/2007GL029455.

[67] Vrac, M., M.L. Stein, K. Hayhoe, and X.-Z. Liang, 2007: A general method for validating statistical downscaling methods under future climate change. *Geophys. Res. Lett.*, **34**, L18701, doi:10.1029/2007GL030295.

[66] Liang, X.-Z., M. Xu, K.E. Kunkel, G.A. Grell, and J. Kain, 2007: Regional climate model simulation of U.S.-Mexico summer precipitation using the optimal ensemble of two cumulus parameterizations. *J. Climate*, **20**, 5201-5207.

[65] Wu, X., X.-Z. Liang, and S. Park, 2007: Cloud-resolving model simulations over the ARM SGP. *Mon. Wea. Rev.*, **135**, 2841-2853.

[64] *Zhu, J., and X.-Z. Liang, 2007: Regional climate model simulation of U.S. precipitation and surface air temperature during 1982-2002: Interannual variation. *J. Climate*, **20**, 218-232.

[63] Borah, D.K., J.G. Arnold, M. Bera, E.C. Krug, and X.-Z. Liang, 2007: Storm event and continuous hydrologic modeling for comprehensive and efficient watershed simulations. *J. Hydrologic Engineering*, ASCE, **12**, 605-616, DOI: 10.1061/(ASCE)1084-0699(2007)12:6(605).

[62] Morris, V., T.-W. Yu, E. Joseph, R. Armstrong, R. Fitzgerald, R. Karim, X.-Z. Liang, and Q. Min, 2007: The NOAA Center for Atmospheric Sciences (NCAS): Programs and Achievements. *Bull. Amer. Met. Soc.*, **88**, 141-145.

[61] *Huang, H.-C., X.-Z. Liang, K.E. Kunkel, M. Caughey, and A. Williams, 2007: Seasonal simulation of tropospheric ozone over the Midwestern and Northeastern United States: An application of a coupled regional climate and air quality modeling system. *J. Appl. Meteor. Clim.*, **46**, 945-960.

[60] **Choi, H. I., P. Kumar, and X.-Z. Liang, 2007: Three-dimensional volume-averaged soil moisture transport model with a scalable parameterization of subgrid topographic variability. *Water Resour. Res.*, **43**, W04414, doi:10.1029/2006WR005134, 15 pp.

[59] Liang, X.-Z., J. Pan, J. Zhu, K.E. Kunkel, J.X.L. Wang, and A. Dai, 2006: Regional climate model downscaling of the U.S. summer climate and future change. *J. Geophys. Res.*, **111**, D10108, doi:101029/2005JD006685.

[58] Kunkel, K.E., X.-Z. Liang, J. Zhu, and Y. Lin, 2006: Can CGCMs simulate the Twentieth Century "warming hole" in the central United States? *J. Climate*, **19**, 4137-4153.

[57] Dominguez, F., P. Kumar, X.-Z. Liang, and M. Ting, 2006: Impact of atmospheric moisture storage on precipitation recycling. *J. Climate*, **19**, 1513-1530.

[56] *Zhu, J., and X.-Z. Liang, 2005: Regional climate model simulation of U.S. soil temperature and moisture during 1982-2002. *J. Geophys. Res.*, **110**, D24110, doi:10.1029/2005JD006472.

[55] Wu, X., and X.-Z. Liang, 2005: Effect of subgrid cloud-radiation interaction on climate simulations. *Geophys. Res. Lett.*, **32**, L24806, doi:10.1029/2005GL024432.

[54] Amenu, G.G., P. Kumar, and X.-Z. Liang, 2005: Inter-annual variability of deep-layer hydrologic memory and its influence on surface energy fluxes. *J. Climate*, **18**, 5025-5045.

[53] Liang, X.-Z., H. Choi, K.E. Kunkel, Y. Dai, E. Joseph, J.X.L. Wang, and P. Kumar, 2005: Surface boundary conditions for mesoscale regional climate models. *Earth Interactions*, **9**, 1-28.

[52] Liang, X.-Z., M. Xu, W. Gao, K.E. Kunkel, J. Slusser, Y. Dai, Q. Min, P.R. Houser, M. Rodell, C.B. Schaaf, and F. Gao, 2005: Development of land surface albedo parameterization bases on Moderate Resolution Imaging Spectroradiometer (MODIS) data. *J. Geophys. Res.*, **110**, D11107, doi:10.1029/2004JD005579.

[51] Liang, X.-Z., and X. Wu, 2005: Evaluation of a GCM subgrid cloud-radiation interaction parameterization using cloud-resolving model simulations. *Geophys. Res. Lett.*, **32**, L06801, doi:10.1029/2004GL022301.

[50] Wu, X., and X.-Z. Liang, 2005: Radiative effects of cloud horizontal inhomogeneity and vertical overlap identified from a month-long cloud-resolving model simulation. *J. Atmos. Sci.*, **62**, 4105-4112.

[49] Kunkel, K.E., and X.-Z. Liang, 2005: GCM simulations of the climate in the central United States. *J. Climate*, **18**, 1016-1031.

[48] Liang, X.-Z., L. Li, A. Dai, and K.E. Kunkel, 2004: Regional climate model simulation of summer precipitation diurnal cycle over the United States. *Geophys. Res. Lett.*, **31**, L24208, doi:10.1029/2004GL021054.

[47] Liang, X.-Z., L. Li, K.E. Kunkel, M. Ting, and J.X.L. Wang, 2004: Regional climate model simulation of U.S. precipitation during 1982-2002. Part 1: Annual cycle. *J. Climate*, **17**, 3510-3528.

[46] Wu, X., X.-Z. Liang, and G.J. Zhang, 2003: Seasonal migration of ITCZ precipitation across the equator: Why can't GCMs simulate it? *Geophys. Res. Lett.*, **30**, 1824, doi:10.1029/2003GL017198.

[45] **Mao, H., W.-C. Wang, and X.-Z. Liang, 2003: Modeled geographical and seasonal variations of O_3 and NO_2 photodissociation rate coefficients. *J. Geophys. Res.*, **108**, 4216, doi:10.1029/2002JD002760.

[44] Samel, A.N., and X.-Z. Liang, 2003: Understanding relationships between the 1998 Yangtze River flood and northeast Eurasian blocking. *Climate Research*, **23**, 149-158.

[43] Liang, X.-Z., A.N. Samel, and W.-C. Wang, 2002: China rainfall interannual predictability: Dependence on the annual cycle and surface anomalies. *J. Climate*, **15**, 2555-2561.

[42] Kunkel, K.E., K. Andsager, X.-Z. Liang, R.W. Arritt, E.S. Takle, W.J. Gutowski, and Z. Pan, 2002: Observations and regional climate model simulations of heavy precipitation events and seasonal anomalies: A comparison. *J. Hydrometeorology*, **3**, 322-334.

[41] Liang, X.-Z., K.E. Kunkel, and A.N. Samel, 2001: Development of a regional climate model for U.S. Midwest applications. Part 1: Sensitivity to buffer zone treatment. *J. Climate*, **14**, 4363-4378.

[40] Liang, X.-Z., W.-C. Wang, and A.N. Samel, 2001: Biases in AMIP model simulations of the east China monsoon system. *Climate Dynamics*, **17**, 291-304.

[39] Laird, N.F., D.A.R. Kristovich, X.-Z. Liang, R.W. Arritt, and K. Labas, 2001: Lake Michigan lake breezes: Climatology, local forcing, and synoptic environment. *J. Appl. Meteorol.*, **40**, 409-424.

[38] Chou, M.-D., M.J. Suarez, X.-Z. Liang, and M.M.-H. Yan, 2001: A Thermal Infrared Radiation Parameterization for Atmospheric Studies. *Technical Report Series on Global Modeling and Data Assimilation, Vol. 19,* M.J. Suarez (Ed.), NASA/TM-2001-104606*,* 56 pp.

[37] Wang, W.-C., I.S.A. Isaksen, J. Wang, M. Gauss, and X.-Z. Liang, 2000: Atmospheric ozone as a climate gas: Studies concerning aircraft emissions. *Chemistry and Radiation Changes in the Ozone Layer,* NATO ASI Series, Kluwer Academic Publishers, pp. 105-119.

[36] Zhang, R.-H., L.M. Rothstein, A.J. Busalacchi, and X.-Z. Liang, 1999: The onset of the 1991-1992 El Niño event in the tropical Pacific Ocean: The NECC subsurface pathway. *Geophys. Res. Lett.*, **26**, 847-850.

[35] Fuglestvedt, J., T.K. Berntsen, I.S.A. Isaksen, H. Mao, X.-Z. Liang, and W.-C. Wang, 1999: Climate forcing of nitrogen oxides through changes in tropospheric ozone and methane: Global 3-D model studies. *Atmos. Environ.*, **33**, 961-977.

[34] Samel, A.N., W.-C. Wang, and X.-Z. Liang, 1999: Monsoon rainfall over China and relationships with the Eurasian circulation. *J. Climate*, **12**, 115-131.

[33] Liang, X.-Z., and W.-C. Wang, 1998: The observed fingerprint of 1980-1997 ENSO evolution in the NCAR CSM equilibrium simulation. *Geophys. Res. Lett.*, **25**, 1027-1030.

[32] Liang, X.-Z., and W.-C. Wang, 1998: Associations between China monsoon rainfall and tropospheric jets. *Q. J. R. Meteorol. Soc.*, **124**, 2597-2623.

[31] Wang, W.-C., H.-H. Hsu, W.-S. Kau, X.-Z. Liang, LinHo, C.-T. Chen, A.N. Samel, C.-H. Tsou, P.-H. Lin, and K.-C. Ko, 1998: GCM simulations of the east Asia climate. *Proceedings of the Third East Asia-West Pacific Meteorology and Climate Conference*, C.-P. Chang (Ed.), World Scientific Publication Corp., pp. 473-482.

[30] Liang, X.-Z., and W.-C. Wang, 1997: Cloud overlap effects on general circulation model climate simulations. *J. Geophys. Res.*, **102**, 11039-11047.

[29] Liang, X.-Z., K. R. Sperber, W.-C. Wang, and A. N. Samel, 1997: Predictability of SST forced climate signals in two atmospheric general circulation models. *Climate Dynamics*, **13**, 391-415.

[28] Cess, R.D., M.H. Zhang, G.L. Potter, V. Alekseev, H.W. Barker, S. Bony, R.A. Colman, D.A. Dazlich, A.D. Del Genio, M. Déqué, M.R. Dix, V. Dymnikov, M. Esch, L.D. Fowler, J.R. Fraser, V. Galin, W.L. Gates, J.J. Hack, W.J. Ingram, J.T. Kiehl, Y. Kim, H. Le Treut, X.-Z. Liang, B.J. McAvaney, V.P. Meleshko, J.J. Morcrette, D.A. Randall, E. Roeckner, M.E. Schlesinger, P.V. Sporyshev, K.E. Taylor, B. Timbal, E.M. Volodin, W. Wang, W.C. Wang, and R.T. Wetherald, 1997: Comparison of the seasonal change in cloud-radiative forcing from atmospheric general circulation models and satellite observations. *J. Geophys. Res.*, **102**, 16593-16603.

[27] Liang, X.-Z., 1996: Description of a nine-level grid-point atmospheric general circulation model. *Adv. Atmos. Sci.*, **13**, 269-298.

[26] Liang, X.-Z., W.-C. Wang, and M.P. Dudek, 1996: Northern Hemispheric interannual teleconnection patterns and their changes due to the greenhouse effect. *J. Climate*, **9**, 465-479.

[25] Dudek, M.P., X.-Z. Liang, and W.-C. Wang, 1996: A regional climate model study of the scale-dependence of cloud-radiation interactions. *J. Climate*, **9**, 1221-1234.

[24] Berntsen, T.K., I.S.A. Isaksen, W.-C. Wang, and X.-Z. Liang, 1996: Impacts of increased anthropogenic emissions in Asia on tropospheric ozone and climate: A global 3-D model study. *Tellus*, **48B**, 13-32.

[23] Xue, F., X.-Z. Liang, W. Wang, and Q.-C. Zeng, 1996: A numerical simulation of low frequency oscillation in the atmosphere. *Sci. Atmos. Sinica*, **20**, 655-661.

[22] Liang, X.-Z., and W.-C. Wang, 1995: A GCM study of the climatic effect of 1979-1992 ozone trend. In *Atmospheric Ozone as a Climate Gas*, W.-C. Wang and I.S.A. Isaksen (Eds), NATO ASI Series, Springer-Verlag, Berlin, pp. 259-288.

[21] Graf, H.-F., S. Cox, X.-Z. Liang, H. Mao, G. Myhre, P. Rasch, L.P. Riishøjgaard, K. Shine, I. Thorstensen, G.-X. Wu, I. Yagai, and L. Zetterberg, 1995: Climate modeling. In *Atmospheric Ozone as a Climate Gas*, W.-C. Wang and I.S.A. Isaksen (Eds), NATO ASI Series, Springer-Verlag, Berlin, pp. 39-45.

[20] Liang, X.-Z., W.-C. Wang, and M.P. Dudek, 1995: Interannual variability of regional climate and its change due to the greenhouse effect. *Global and Planetary Change*, **10**, 217-238.

[19] Liang, X.-Z., A.N. Samel, and W.-C. Wang, 1995: Observed and GCM simulated decadal variability of monsoon rainfall in east China. *Climate Dynamics*, **11**, 103-114.

[18] Wang, W.-C., X.-Z. Liang, M.P. Dudek, D. Pollard, and S.L. Thompson, 1995: Atmospheric ozone as a climate gas. *Atmos. Res.*, **37**, 247-256.

[17] Wang, W.-C., M.P. Dudek, and X.-Z. Liang, 1995: Chapter 9: The Greenhouse Effect of Trace Gases. In *Future Climates of the World*, A. Henderson-Sellers (Ed), Elsevier Science Publ. No. 16 of the World Survey of Climatology, pp. 317-346.

[16] Zhang, R.-H., Q.-C. Zeng, G.-Q. Zhou, and X.-Z. Liang, 1995: A coupled general circulation model for the tropical Pacific Ocean and global atmosphere. *Adv. Atmos. Sci.*, **12**, 127-142.

[15] Zeng, Q.-C., C.-G. Yuan, X.-H. Zhang, X.-Z. Liang, R.-H. Zhang, N. Bao, and X.-Q. Bi, 1995: IAP climate models and their applications. *Adv. Natural Sci.*, **5**, 130-138.

[14] Gleckler, P.J., D.A. Randall, G. Boer, R. Colman, M. Dix, V. Galin, M. Helfand, J. Kiehl, A. Kitoh, W. Lau, X.-Y. Liang, V. Lykossov, B. McAvaney, K. Miyakoda, S. Planton, and W. Stern, 1995: Cloud-radiative effects on implied oceanic energy transports as simulated by atmospheric general circulation models. *Geophys. Res. Lett.*, **22**, 791-794. [Correction: X.-Y. should be X.-Z.]

[13] Wang, W.-C., X.-Z. Liang, and M.P. Dudek, 1994: Effect of global warming on the regional climate in China. In *Climate-Biosphere Interactions: Biogenic Emissions and Environmental Effects of Climate Change*, R.G. Zepp (Ed), John Wiley & Son, Wiley-Interscience, pp. 19-29.

[12] Randall, D.A., R.D. Cess, J.P. Blanchet, S. Chalita, R. Colman, D.A. Dazlich, A.D. Del Genio, E. Keup, A. Lacis, H. Le Treut, X.-Z. Liang, B.J. McAvaney, J.F. Mahfouf, V.P. Meleshko, J.-J. Morcrette, P.M. Norris, G.L. Potter. L. Rikus. E. Roeckner, J.F. Royer, U. Schlese, D.A. Sheinin, A.P. Sokolov, K.E. Taylor, R.T. Wetherald, I. Yagai, and M. -H. Zhang, 1994: Analysis of snow feedbacks in 14 general circulation models. *J. Geophys. Res.*, **99**, 20757-20771.

[11] Cess, R.D. M.-H. Zhang, G.L. Potter, H.W. Barker, R.A. Colman, D.A. Dazlich, A.D. Del Genio, M. Esch, J.R. Fraser, V. Galin, W.L. Gates, J.J. Hack, W.J. Ingram, J.T. Kiehl, A.A. Lacis, H. Le Treut, Z.-X. Li, X.-Z. Liang, J.-F. Mahfouf, B.J. McAvaney, V.P. Meleshko, J.-J. Morcrette, D.A. Randall, E. Roeckner, J.-F. Royer, A.P. Sokolov, P.V. Sporyshev, K.E. Taylor, W.-C. Wang, and R.T. Wetherald, 1993: Uncertainties in carbon dioxide radiative forcing in atmospheric general circulation models. *Science*, **262**, 1252-1255.

[10] Wang, W.-C., M.P. Dudek, and X.-Z. Liang, 1992: Inadequacy of effective CO_2 as a proxy to assess the greenhouse effect of other radiatively active gases. *Geophys. Res. Lett.,* **19**, 1375-1378.

[9] Randall, D.A., D.A. Dazlich, R.D. Cess, M.-H. Zhang, J.P. Blanchet, G.J. Boer, A.D. Del Genio, A.A. Lacis, M. Deque, J.F. Royer, V. Dymnikov, V. Galin, S.J. Ghan, G.L. Potter, K.E. Taylor, H. Le Treut, Z.-X. Li, X.-Z. Liang, B.J. McAvaney, L. Rikus, V.P. Meleshko, D.A. Sheinin, A.P. Sokolov, J.F.B. Mitchell, J.-J. Morcrette, E. Roeckner, U. Schlese, J. Slingo, W.M. Washington, R.T. Wetherald, and I. Yagai, 1992: Intercomparison and interpretation of surface energy fluxes in atmospheric general circulation models. *J. Geophys. Res.*, **97**, 3711-3724.

[8] Wang, W.-C., M.P. Dudek, X.-Z. Liang, and J.T. Kiehl, 1991: Inadequacy of effective CO_2 as a proxy in simulating the greenhouse effect of other radiatively active gases. *Nature*, **350**, 573-577.

[7] Cess, R.D., G.L. Potter, M.-H. Zhang, J.-P. Blanchet, S. Chalita, R. Colman, D.A. Dazlich, A.D. Del Genio, V. Dymnikov, V. Galin, D. Jerrett, E. Keup, A.A. Lacis, H. Le Treut, X.-Z. Liang, J.-F. Mahfouf, B.J. Mcavaney, V.P. Meleshko, J.F.B. Mitchell, J.-J. Morcrette, P.M. Norris, D.A. Randall, l. Rikus, E. Roeckner, J.-F. Royer, U. Schlese, D.A. Sheinin, J.M. Slingo, A.S. Sokolov, K.E. Taylor, W.M. Washington, R.T. Wetherald, and I. Yagai, 1991: Interpretation of snow-climate feedback as produced by 17 general circulation models. *Science*, **253**, 888-892.

[6] Cess, R.D., G.L. Potter , J.P. Blanchet, G.J. Boer, A.D. Del Genio, M. Déqué, V. Dymnikov, V. Galin, W.L. Gates, S.J. Ghan, J.T. Kiehl, A.A. Lacis, H. Le Treut, Z.-X. Li, X.-Z. Liang, B.J. McAvaney, V.P. Meleshko, J.F.B. Mitchell, J.-J. Morcrette, D.A. Randall, L. Rikus, E. Roeckner, J.F. Royer, U. Schlese, D.A. Sheinin, A. Slingo, A.P. Sokolov, K.E. Taylor, W.M. Washington, R.T. Wetherald, I. Yagai, and M.-H. Zhang, 1990: Intercomparison and interpretation of climate feedback processes in 19 atmospheric general circulation models. *J. Geophys. Res.*, **95**, 16601-16615.

[5] Zeng, Q.-C., X.-H. Zhang, X.-Z. Liang, C.-G. Yuan, and S.-F. Chen, 1989: A Documentation of the IAP Two-level Atmospheric General Circulation Model. *U.S. DOE/ER-60314-H1, TR044*, 383 pp.

[4] Zhang, X.-H., and X.-Z. Liang, 1989: A numerical world ocean general circulation model. *Adv. Atmos. Sci.*, **6** (1), 44-61.

[3] Zhang, X.-H., and X.-Z. Liang, 1989: Comparison and examination of dynamic frameworks of IAP and OSU AGCM. *Adv. Atmos. Sci.*, **6** (3), 265-274.

[2] Cess, R.D., G.L. Potter, J.P. Blanchet, G.J. Boer, S.J. Ghan, J.T. Kiehl, H. Le Treut, Z.-X. Li, X.-Z. Liang, J.F.B. Mitchell, J.-J. Morcrette, D.A. Randall, M.R. Riches, E. Roeckner, U. Schlese, A. Slingo, K.E. Taylor, W.M. Washington, R.T. Wetherald, and I. Yagai, 1989: Interpretation of cloud-climate feedback as produced by 14 atmospheric general circulation models. *Science,* **245**, 513-516.

[1] Zeng, Q.-C., X.-Z. Liang, and M.-H. Zhang, 1988: Numerical simulation of monsoons and the abrupt seasonal changing of atmospheric general circulation. *Chinese J. Atmos. Sci.*, **special issue**, 22-42.