Dr. Sen Zhao

Department of Atmospheric Sciences, University of Hawaii at Mānoa
2525 Correa Road, HIG 350, Honolulu, HI 96822, USA
Email: zhaos@hawaii.edu Website: https://senzhao.netlify.com

Research Interests

Climate Variability and Change, Dynamics and Predictability; Wave Dynamics and Atmospheric Teleconnections; Air-Sea Interactions; ENSO

Education

Ph.D. Meteorology 2011 - 2016

Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China
Dissertation: "*Theory of Cross-Equatorial Propagation of Planetary Wave in Horizontally Non-Uniform Basic Flow and Its Applications in Atmospheric Teleconnections"*. Advisor: Jianping Li

B.S. Atmospheric Sciences 2007 - 2011

College of Atmospheric Sciences, and School of Mathematics and Statistics, Lanzhou University
Thesis: "*Evaluation of WRF microphysics and cumulus schemes in simulating Hurricane Katrina*"

Professional Appointment

Postdoctoral Fellow 2016 - Present

Department of Atmospheric Sciences, SOEST, University of Hawaii at Mānoa
Collaborating advisor: Fei-Fei Jin

Honors, Awards, and Scholarships

- **National Scholarship**, Ministry of Education of China, No. 50257, 2013
- **Outstanding Student Leader**, University of the Chinese Academy of Sciences, 2012, 2013, 2014
- **Outstanding Student**, University of the Chinese Academy of Sciences, 2012, 2013, 2014, 2015
- **Outstanding Graduate**, Lanzhou University, 2011
- **Contemporary Undergraduate Mathematical Contest in Modeling Award,** National Second Prize and Special Prize of Gansu Province**,** CSIAM*,* 2009
- **First Class Scholarship of Lanzhou University**, 2009
- **China National Encouragement Scholarship**, 2008, 2010

Publications

Submitted Papers

Zhao, S., F.-F. Jin, X. Long, and M. Cane (2021): On the Breakdown of ENSO's Relationship with Thermocline Depth in the Central-Equatorial Pacific. *in review.*

Peer-reviewed Journal Articles

1. **Zhao, S.**, M. F. Stuecker, F.-F. Jin, J. Feng, H. Ren, W. Zhang, and J. Li (2020): Improved Predictability of the Indian Ocean Dipole using a Stochastic-Dynamical Model compared to the North American Multi-model Ensemble Forecast. ***Wea. Forecasting***, 35(2), 379–399.

2. **Zhao, S.**, F.-F. Jin, and M. F. Stuecker (2019): Improved Predictability of the Indian Ocean Dipole Using Seasonally Modulated ENSO Forcing Forecasts. ***Geophys. Res. Lett.,*** 46(16), 9980–9990.

3. **Zhao, S.,** J. Li, Y. Li, F.-F. Jin, and J. Zheng (2019): Interhemispheric Influence of Indo-Pacific Convection Oscillation on Southern Hemisphere Rainfall through Southward Propagation of Rossby Waves. ***Climate Dyn.,*** 52(5), 3203–3221.

4. **Zhao, S.,** J. Li, and C. Sun (2016): Decadal Variability in the Occurrence of Wintertime Haze in Central Eastern China Tied to the Pacific Decadal Oscillation. ***Sci. Rep.,*** 6, 27424. (**Top 100 read Scientific Reports articles in 2016**)

5. **Zhao, S.,** J. Li, and Y. Li (2015): Dynamics of an Interhemispheric Teleconnection across the Critical Latitude through a Southerly Duct during Boreal Winter. ***J. Climate***, *28*(19), 7437–7456.

6. Zhang Y., J. Li, **S. Zhao**, F. Zheng, J. Feng, Y. Li, Y. Xu (2020): Indian Ocean tripole mode and its associated atmospheric and oceanic processes. ***Climate Dyn.***, 55(5), 1367-1383

7. Zhou, X., Q. Chen, Z. Wang, M. Xu, **S. Zhao**, Z. Cheng, and F. Feng (2020): Longer duration of the weak stratospheric vortex during extreme El Niño events linked to spring Eurasian coldness. ***J. Geophys. Res.: Atmos.,*** 125(16), e2019JD032331

8. Liu, T., J. Li, Q. Wang, **S. Zhao** (2020): Influence of the Autumn SST in the Southern Pacific Ocean on Winter Precipitation in the North American Monsoon Region. ***Atmosphere***, 11(8): 844

9. Tseng, Y., R. Ding, **S. Zhao**, Y. Kuo, and Y. Liang (2020): Could the North Pacific Oscillation Be Modified by the Initiation of East Asian Winter Monsoon? ***J. Climate***, *33,* 2389–2406.

10. Xue, A., F.-F. Jin, W. Zhang, J. Boucharel, **S. Zhao**, and X. Yuan (2020): Delineating the Seasonally Modulated Nonlinear Feedback onto ENSO from Tropical Instability Waves. ***Geophys. Res. Lett.***, *47*(7), e2019GL085863.

11. Feng, J., J. Li, F.-F. Jin, Z. Liu, and **S. Zhao** (2019): Effect of El Niño on the Response Ratio of Hadley Circulation to Different SST Meridional Structures. ***Climate Dyn.***, *53,* 3877–3891.

12. Shi, F., H. Goosse, F. Klein, **S. Zhao**, T. Liu, and Z. Guo (2019): Monopole mode of precipitation in East Asia modulated by the South China Sea over the last four centuries. ***Geophys. Res. Lett.***, *46*(24), 14713–14722.

13. Wang, Q., J. Li, Y. Li, J. Xue, **S. Zhao**, Y. Xu, Y. Wang, Y. Zhang, D. Dong, and J. Zhang (2019): Modulation of tropical cyclone tracks over the western North Pacific by intra-seasonal Indo-western Pacific convection oscillation during the boreal extended summer. ***Climate Dyn.***, *52*(1-2), 913–927.

14. Feng, J., J. Li, F. Jin, **S. Zhao**, and J. Zhu (2018): Relationship between the Hadley circulation and different tropical meridional SST structures during boreal summer. ***J. Climate***, *31*(16), 6575–6590.

15. Li, Y., J. Feng, J. Li, and **S. Zhao** (2018): The Circle Diagram in the Group Velocity Domain for Rossby Wave under the Horizontally Non-Uniform Flow. ***SOLA***, *14,* 121–125.

16. Li, Y., J. Li, F. Kucharski, J. Feng, **S. Zhao**, and J. Zheng (2018): Two Leading Modes of the Interannual Variability in South American Surface Air Temperature during Austral Winter. ***Climate Dyn.***, *51*(5-6), 2141–2156.

17. Liu, T., J. Li, Y. Li, **S. Zhao**, F. Zheng, J. Zheng, and Z. Yao (2018): Influence of the May Southern Annular Mode on the South China Sea Summer Monsoon. ***Climate Dyn.***, *51*(11-12), 4095–4107.

18. Stuecker, M. F., C. M. Bitz, K. C. Armour, C. Proistosescu, S. M. Kang, S.-P. Xie, D. Kim, S. McGregor, W. Zhang, **S. Zhao**, W. Cai, Y. Dong, and F.-F. Jin (2018): Polar Amplification Dominated by Local Forcing and Feedbacks. ***Nature Climate Change***, *8*(12), 1076–1081.

19. Xue, J., J. Li, C. Sun, **S. Zhao**, J. Mao, D. Dong, Y. Li, and J. Feng (2018): Decadal-Scale Teleconnection between South Atlantic SST and Southeast Australia Surface Air Temperature in Austral Summer. ***Climate Dyn.***, *50*(7-8), 2687–2703.

20. Zhou, X., J. Li, F. Xie, R. Ding, Y. Li, **S. Zhao**, J. Zhang, and Y. Li (2018): The Effects of the Indo-Pacific Warm Pool on the Stratosphere. ***Climate Dyn.***, *51*(11-12), 4043–4064.

21. Feng, J., J. Li, F. Jin, **S. Zhao**, and F. Xie (2017): The responses of the Hadley circulation to different meridional SST structures in the seasonal cycle. ***J. Geophys. Res.: Atmos.***, *122*(15), 7785–7799.

22. Huyan, L., J. Li, **S. Zhao**, C. Sun, D. Dong, T. Liu, and Y. Zhao (2017): The Impact of Layer Perturbation Potential Energy on the East Asian Summer Monsoon. ***J. Climate***, *30*(17), 7087–7103.

23. Qin, J., R. Ding, Z. Wu, J. Li, and **S. Zhao** (2017): Relationships between the extratropical ENSO precursor and leading modes of atmospheric variability in the Southern Hemisphere. ***Adv. Atmos. Sci.***, *34*(3), 360–370.

24. Shi, F., **S. Zhao**, Z. Guo, H. Goosse, and Q. Yin (2017): Multi-proxy reconstructions of May–September precipitation field in China over the past 500 years. ***Clim. Past***, *13*(12), 1919–1938.

25. Stuecker, M. F., A. Timmermann, F.-F. Jin, Y. Chikamoto, W. Zhang, A. T. Wittenberg, E. Widiasih, and **S. Zhao** (2017): Revisiting ENSO/Indian Ocean Dipole Phase Relationships. ***Geophys. Res. Lett.***, *44*(5), 2481–2492. (**AGU Editor's Highlight**)

26. Tian, W., Y. Li, F. Xie, J. Zhang, M. P. Chipperfield, W. Feng, Y. Hu, **S. Zhao**, X. Zhou, Y. Yang, and X. Ma (2017): The relationship between lower-stratospheric ozone at southern high latitudes and sea surface temperature in the East Asian marginal seas in austral spring. ***Atmos. Chem. Phys.***, *17*(11), 6705–6722.

27. Xie, F., J. Li, J. Zhang, W. Tian, Y. Hu, **S. Zhao**, C. Sun, R. Ding, J. Feng, and Y. Yang (2017): Variations in North Pacific Sea Surface Temperature Caused by Arctic Stratospheric Ozone Anomalies. ***Environ. Res. Lett.***, *12*(11), 114023.

28. Ding, R., J. Li, Y.-h. Tseng, K.-J. Ha, **S. Zhao**, and J.-Y. Lee (2016): Interdecadal change in the lagged relationship between the Pacific–South American pattern and ENSO. ***Climate Dyn.***, *47*(9-10), 2867–2884.

29. Kazmi, D. H., J. Li, C. Ruan, **S. Zhao**, and Y. Li (2016): A Statistical Downscaling Model for Summer Rainfall over Pakistan. ***Climate Dyn.***, *47*(7–8), 2653–2666.

30. Yang, F., N. Wang, F. Shi, F. C. Ljungqvist, **S. Zhao**, and T. Liu (2016): The spatial distribution of precipitation over the West Qinling region, China, AD 1470–2000. ***Palaeogeogr. Palaeoclimatol. Palaeoecol.***, *443,* 278–285.

31. Zheng, F., J. Li, Y. Li, **S. Zhao**, and D. Deng (2016): Influence of the Summer NAO on the Spring-NAO-Based Predictability of the East Asian Summer Monsoon. ***J. Appl. Meteor. Climatol.***, *55*(7), 1459–1476.

32. Zheng, J., Q. Wu, Y. Guo, and **S. Zhao** (2016): The Impact of Summertime North Indian Ocean SST on Tropical Cyclone Genesis over the Western North Pacific. ***SOLA***, *12,* 242–246.

33. Li, Y., J. Li, F. F. Jin, and **S. Zhao** (2015): Interhemispheric Propagation of Stationary Rossby Waves in a Horizontally Nonuniform Background Flow. ***J. Atmos. Sci.***, *72*(8), 3233–3256.

34. Shi, F., Q. Ge, B. Yang, J. Li, F. Yang, F. C. Ljungqvist, O. Solomina, T. Nakatsuka, N. Wang, **S. Zhao**, C. Xu, K. Fang, M. Sano, G. Chu, Z. Fan, N. P. Gaire, and M. U. Zafar (2015): A Multi-Proxy

Reconstruction of Spatial and Temporal Variations in Asian Summer Temperatures over the Last Millennium. ***Climatic Change***, *131*(4), 663–676.

35. Sun, C., J. Li, and **S. Zhao** (2015): Remote Influence of Atlantic Multidecadal Variability on Siberian Warm Season Precipitation. ***Sci. Rep.***, *5,* 16853.
36. Zhu, G., W. Lin, **S. Zhao**, and Y. Cao (2015): Spatial and temporal variation characteristics of ocean waves in the South China Sea during the boreal winter. ***Acta Oceanol. Sin.***, *34*(1), 23–28.

Peer-reviewed Book Chapters

1. Jin F.-F., H.-C. Chen, **S. Zhao**, M. Hayashi, C. Karamperidou, M. F. Stuecker, R. Xie, and L. Geng (2020) Simple ENSO Models. In: Santoso A, Cai W, McPhaden MJ (eds) El Niño Southern Oscillation in a Changing Climate, 119-151.

Papers in Preparation

Zhao, S., J. Li, F.-F. Jin, M.F. Stuecker, J. Feng, and Y. Li: Rossby wave phase tracing theory on a horizontally non-uniform flow with application to understand the structure of the Pacific-Japan teleconnection. to be submitted

Zhao, S., and F.-F. Jin: A Robust Assessment of the Bjerknes-Wyrtki-Jin Indices for ENSO Linear Stability and Periodicity. Part I: Ensemble of Ocean Reanalyses. to be submitted.

Zhao, S., and F.-F. Jin: A Robust Assessment of the Bjerknes-Wyrtki-Jin Indices for ENSO Linear Stability and Periodicity. Part II: CMIP5 and CMIP6 models. in preparation.

Presentations

Talks

- Improved Predictability of the Indian Ocean Dipole Using Seasonally Modulated ENSO Forcing, *AOGS 15th Annual Meeting*, Honolulu, USA, June 03–08, 2018
- Decadal Variability in the Occurrence of Wintertime Haze in Central Eastern China Tied to the Pacific Decadal Oscillation, *AOGS 15th Annual Meeting*, Honolulu, USA, June 03–08, 2018

Posters

- A robust assessment of the Bjerknes-Wyrtki-Jin indices for ENSO growth rate and periodicity, *AGU Fall Meeting 2019*, San Francisco, USA, December 9–13, 2019
- Interhemispheric influence of the Indo-Pacific convection oscillation on Southern Hemisphere rainfall, *AOGS 13th Annual Meeting*, Beijing, China, July 31–August 5, 2016
- Interhemispheric influence of the Indo-Pacific convection oscillation on Southern Hemisphere rainfall, *The 13th General Circulation Model Simulations of the East Asian Climate (EAC) workshop*, Beijing, China, March 24–25, 2016
- The Hemispheric Propagation of Stationary waves in Atmosphere, *EGU General Assembly 2013*, Vienna, Austria, April 7–12, 2013
- The Hemispheric Propagation of Stationary waves in Atmosphere, *ICDM Workshop 2012*, Kunming, China, August 6–9, 2012

Teaching

- **Guest Lecturer,** "Applied Atmospheric Dynamics" (ATMO 402), Instructor: Fei-Fei Jin, UH Mānoa spring semester 2020
- **Co-Instructor**, "Dynamics of El Niño–Southern Oscillation Phenomenon" (ATMO 752), Instructor: Fei-Fei Jin, UH Mānoa spring semester 2019
- **Guest Lecturer,** "Applied Atmospheric Dynamics" (ATMO 402), Instructor: Fei-Fei Jin, UH Mānoa spring semester 2019

Other Professional Experience

Academic and Professional Activities

- **Participant:** *Joint US-Japan Workshop on Climate Change and Variability*, Honolulu, USA, 03/2019
- **Participant:** *International Symposium on Tropical Ocean and Climate*, Qingdao, China, 06/2015
- **Participant:** *The International Commission on Climate (ICCL) Expert Assessment Workshop on "Decadal Climate Variability and Cross-Scale Interactions"*, Beijing, China, 04/2013

Journal reviewer

Geophysical Research Letters, Journal of Climate, Climate Dynamics, Scientific Reports, Journal of Geophysical Research-Atmosphere, Atmosphere, Theoretical and Applied Climatology, Earth and Space Science

Scientific Societies

American Geophysical Union (AGU), Asia Oceania Geosciences Society (AOGS), European Geosciences Union (EGU)

Contributed Projects

- **U.S. National Science Foundation:** "Further Studies of Dynamics for El Nino-Southern Oscillation (ENSO) Diversity and Complexity" (PI: Fei-Fei Jin), 2018-2021
- **U.S. Department of Energy:** "Understanding ENSO Diversity and Changes in Climate Models and Observations" (PI: Fei-Fei Jin), 2018-2021
- **National Science Foundation of China:** "Temporal and Spatial Characteristics of Interhemispheric Atmospheric Teleconnections in the Boreal Summer and Mechanism on the Theory of Cross-Equatorial Propagation of Planetary Wave" (PI: Yanjie Li), 2016-2019
- **National Science Foundation of China**: "New theory of the planetary wave propagation in divergent atmosphere and its characteristics over the Asian-Australian Monsoon region" (PI: Yanjie Li), 2013-2015
- **National Science Foundation of China**: "On the new theory of planetary wave on non-uniform basic flow and interactions between Asian and Australian monsoon systems" (PI: Jianping Li), 2011-2014

Self-Development Toolkits and Models

- **Rossby wave ray and phase tracing,** A software package for investigating the Rossby wave propagation and its phase evolution in a horizontally non-uniform basic flow
- **A simple stochastic-dynamical IOD prediction system**. The system exhibits generally higher skill and longer lead times for predicting IOD events than current operational forecast systems
- **An intermediate tropical ocean model (iTOM).** This is a linear continuously stratified ocean model extended to all tropical oceans with a more realistic coastline and a space dependent background stratification, show much improved performance than Zebiak-Cane type ocean model

Skills

- **Languages**: Mandarin Chinese and English
- **Coding**: Python, Fortran, Matlab, CDO, NCO, NCL, Ferret, Gnuplot, R, Linux Shells, LATEX
- **Numerical Models:** CESM, GFDL CM2.1, SPEEDY, WRF
- **Simple Models**: Linear Baroclinic Models, Zebiak-Cane ENSO Model, Shallow Water Model for Global Ocean, Linear Primitive Models, Barotropic Model, Recharge Oscillator Model, Gill-Matsuno Model
- **Misc**. Academic research, teaching, training, consultation, and publishing.