Curriculum Vitae

Family Name: Zhao   First Name: Biao   Gender: Male

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PERSONAL STATEMENT

As a researcher with a background in both atmospheric sciences and physical oceanography, my work focuses on the intricate dynamics of air-sea interactions and their role in extreme weather systems, particularly tropical cyclones (known as hurricanes and typhoons). Recognizing that the energy driving hurricane development originates from the ocean, I leverage numerical models to explore the role of small-scale air-sea coupled and boundary layer processes in the development of hurricanes. To achieve this, I independently developed an air-sea-wave coupled model FIO-AOW. By introducing representative wave-coupled processes, the model shows potential for reducing hurricane intensity forecast errors. This model is currently being applied to the hurricane operational forecasting system at the Center for Earth System Modeling and Prediction. Committed to knowledge sharing, I have made the FIO-AOW available to the research community on GitHub (https://github.com/Biao-Zhao/FIO-AOW). Building on my expertise in small-scale air-sea interactions and my skills in simulation and coding, I am interested in enhancing our understanding of coupled air-sea interactions and their impact on both atmospheric and oceanic processes, aspiring to contribute to more accurate weather forecasting and climate predictions while supporting societal resilience to environmental hazards.

EDUCATION

Tsinghua University   Beijing, China

Ph.D. in Ecology, Specialization: Atmospheric Science   April 2023
- Dissertation: Numerical Research on the Effects of Air-Sea Coupling on Tropical Cyclone Intensity
- GPA: 3.8/4.0
- University Ranking: 1st in China, 12th globally (Times Higher Education Rankings 2024)

The First Institute of Oceanography   Qingdao, China

M.S. in Physical Oceanography   June 2012
- Ranked 1st in the admission examination for the Master's program

Ocean University of China   Qingdao, China

B.S. in Marine Science, Specialization: Physical Oceanography   June 2008
- Key Coursework: Physical Oceanography, Fluid Dynamics, Dynamical Meteorology, Ocean Circulation, Coastal Oceanography, Fortran (Grade A in all)
- University Ranking: 1st in China, 3rd globally in Oceanography (2024 ARWU ranking by subject)

RESEARCH EXPERIENCE

Princeton University   Princeton, USA

Postdoctoral Research Associate, AOS   July 2025-present
- Improving the wave coupling of SHiELD-MOM6-WW3 coupled model
- Investigating the impacts of small-scale air-sea processes on weather forecasting skills

Uppsala University   Uppsala, Sweden

Postdoctoral Researcher, Department of Earth Sciences   September 2023-July 2025
- Implemented modifications to WW3 to enable double-periodic boundary conditions, ensuring rapid wave growth and significantly reducing computational demands
- Developed a wave diffraction theory-based parameterization that accounts for wind turbine–induced wave scattering, within a conserved wave energy framework

The First Institute of Oceanography   Qingdao, China
Researcher, Key Lab of Marine Science and Numerical Modeling   April 2014-September 2023
- Developed the FIO-AOW air-sea-wave coupled model tailored for tropical cyclones
- Introduced wave-coupled processes into FIO-AOW, achieving a 40% reduction in forecast errors for tropical cyclone intensity.
- Proposed a sea state-dependent air-sea momentum flux for high winds and improved the wind-pressure relationship of tropical cyclone

National Marine Environmental Forecasting Center   Beijing, China
Researcher, Key Lab of Marine Hazards Forecasting   July 2012-April 2014
- Built the operational Arctic ice-ocean coupled forecasting system based on the ROMS (Regional Ocean Modeling System).

Ohio State University   Columbus, USA
Visiting Scholar, Byrd Polar and Climate Research Center   May 2013-June 2013

TEACHING

Tsinghua University   Beijing, China
Guest Lecturer, Numerical Experiments of Earth Systems   April 2018 and 2021

UNESCO/IOC ODC Training Program   Qingdao, China
Guest Lecturer, Development of Coupled Regional Ocean Models   Jul 2017

PROFESSIONAL SKILLS

Numerical Models

Ocean：ROMS, POM, MOM6	Atmosphere: WRF, SHiELD	Ocean Wave: MASNUM, WW3

Programming Languages

Fortran, MATLAB	Linux/Unix Shell	GitHub & GitLab for version control

Data Analysis

EOF, EMD and Spectral Analysis	Statistical Analysis	Satellite, SFMR, CTD, Argo, AXBT and Dropsonde data Manipulation

SELECTED PUBLICATIONS

[1]   **Zhao, B**., Sahlée, E., Du, J., Wu, L.
      A subgrid-scale parameterization of wave-structure interactions for spectral wave models: Idealized simulations in offshore wind farm conditions
      Journal of Advances in Modeling Earth Systems, 18, e2025MS005603

[2]   **Zhao, B.**, Wu, L., Wang, G., Zhang, J. A., Liu, L., Zhao, C., Zhuang, Z., Xia, C., Xue, Y., Li, X., Qiao, F.
      A numerical study of tropical cyclone and ocean responses to air-sea momentum flux at high winds
      Journal of Geophysical Research: Oceans, 2024, 129(7), e2024JC020956.

[3]   **Zhao, B.**, Wang, G., Zhang, J. A., Liu, L., Liu, J., Xu, J., Yu, H., Zhao, C., Yu, X., Sun, C., Qiao, F.
      The effects of ocean surface waves on tropical cyclone intensity: numerical simulations using a regional atmosphere-ocean-wave coupled model.
      Journal of Geophysical Research: Oceans, 2022, 127, e2022JC019015.

[4]   **Zhao, B.**, Qiao, F., Cavaleri, L, Bertotti, L., Liu, L.
      Sensitivity of typhoon modeling to surface waves and rainfall.
      Journal of Geophysical Research: Oceans, 2017, 122(3), 1702-1723.

[5]   **Zhao, B.**, Qiao, F., and Wang, G.
      The effects of the non-breaking surface wave-induced vertical mixing on the forecast of tropical cyclone tracks.
      Chinese Science Bulletin, 2014, 59(24), 3075-3084.

[6] **Zhao, B**., Sahlée, E., Du, J., Wu, L.
Wind stress modification by offshore wind turbines: A numerical study of wave blocking impacts.
Ocean Engineering, 2024, 33, 119651.

[7] **Zhao, B**., Qiao, F., and Wang, G.
The impacts of SST on the track and intensity of Typhoon JANGMI.
Acta Oceanologica Sinica (in Chinese), 2008, c34(4), 41-52.

[8] Li, S., **Zhao, B.**, Ma, S., Yin, X., Ji, D., Qiao, F.
Effects of Sea Spray on Extreme Precipitation Forecasting: A case study in Beijing of China.
Geophysical Research Letters, 2024, 51, e2024GL109923.

[9] Wang, G., **Zhao, B.**, Qiao, F., Zhao, C.
Rapid intensification of Super Typhoon Haiyan: the important role of a warm-core ocean eddy.
Ocean Dynamics, 2018, 68(12), 1649-1661.

[10] Wang, G., **Zhao, B**., and Zhao, C.
Study on the Relationship between Super Typhoon Intensity and the Upper Ocean Thermal Structure in the Passing Area.
Advances in Marine Science (in Chinese), 2018, 36(3).

[11] Chen, S., Qiao, F., Huang, C. J., **Zhao, B.**
Deviation of wind stress from wind direction under low wind conditions.
Journal of Geophysical Research: Oceans, 2018, 123, 9357-9368.

[12] Wang, G, Ma, H., Babanin, AV., **Zhao, B.**, Huang, C., Dai, D., Qiao, F.
Estimating sea spray volume flux with a laser gauge in a self-consistent system.
Frontiers in Marine Science, 2023, 9, 1102631.

[13] Xu, X., Voermans, J. J., Zhang, W., **Zhao, B.**, Qiao, F., Liu, Q., Moon, I., Janekovic, I., Waseda, T., Babanin, A.
Tropical Cyclone modeling with the inclusion of wave-coupled processes: Sea spray and wave turbulence.
Geophysical Research Letters, 2023, 50, e2023GL106536.

[14] Zhanpeng Zhuang, Yang Y., Shu Q., Song Z., **Zhao B.**, Yuan Y.
Variability of non-breaking surface-wave induced mixing and its effects on ocean thermodynamical structure in the Northwest Pacific during Typhoon Lekima (2019).
Deep Sea Research Part I, 2023, 202, 104178.

[15] Liang, X., Yang, Q., Nerger, L., Losa, S. N., **Zhao, B.**, Zheng, F., Zhang, L., Wu, L.
Assimilating Copernicus SST Data into a Pan-Arctic Ice-Ocean Coupled Model with a Local SEIK Filter.
Journal of Atmospheric and Oceanic Technology, 2017, 34, 1985-1999.

[16] Sun, C., Liu, L., Li, R., Yu, X., Yu, H., **Zhao, B**., Wang, G., Liu, J., Qiao, F., and Wang, B.
Developing a common, flexible and efficient framework for weakly coupled ensemble data assimilation based on C-Coupler2.0
Geoscientific Model Development, 2021, 14, 2635-2657.

[17] Yu, X., Liu, L., Sun, C., Jiang, Q., **Zhao, B.**, Zhang, Z., Yu, H., and Wang, B.
CIOFC1.0: a common parallel input/output framework based on C-Coupler2.0.
Geoscientific Model Development, 2023, 16, 6285-6308.

MANUSCRIPT

The superscript † indicates co-first authorship
[1] Li, S†., **Zhao, B†.,** Shu, Q., Ryabinin, V., Ji, D., Qiao, F., Tung, KK.
Incorporating Ocean Waves Improves Forecasts of Strong Tropical Cyclones.
Submitted to Communications Earth & Environment.

PRESENTATIONS

[1]   A Wave Diffraction Theory-Based Wave Scattering Parameterization for Spectral Wave Models and Idealized Simulations, *Seminar,* April 2025, DHI, Denmark, online (Invited Talk).

[2]   The Role of Ocean Surface Waves in Modulating Tropical Cyclone Intensity, *Workshop on surface process coupling and its interactions with the atmosphere*, April 2025, ECMWF, Bonn, Germany (Poster).

[3]   The effects of ocean surface waves on tropical cyclone intensity, *Autumn Seminar*, August 2023, Uppsala, Sweden (Talk).

[4]   The effects of ocean surface waves on tropical cyclone intensity, *The 4th Workshop on Waves and Wave-Coupled Processes*, February 2023, Uppsala, Sweden (Talk).

[5]   The development of a regional Atmosphere-Ocean-Wave coupled model for Typhoon, *Eat Asian Workshop on a predicted Ocean*, September 2021, online (Talk).

[6]   The development of an atmosphere-ocean-wave coupled model for tropical cyclones, *The 2nd Workshop on Waves and Wave-Coupled Processes*, October 2017, Qingdao, China (Talk).

[7]   Sensitivity of typhoon modeling to surface waves and rainfall, *The 8th International Workshop on Modeling the Ocean (IWMO)*, June 2016, Bologna, Italy (Poster).

RESEARCH PROJECTS

Improving Offshore Wind Energy Forecast by Exploring the Wave-Air Coupling Processes

2024-2025, 55K USD, grant holder

Funded by Carl Tryggers Stiftelse of Sweden

Ongoing project aimed at improving offshore wind energy forecasts by investigating wave-air coupling processes, focusing on the effects of waves on momentum flux profiles and wind stress misalignment. The project is expected to propose a conserved air-sea momentum flux scheme to enhance the accuracy of offshore wind energy assessments.

Air-Sea-Wave Coupled Model Development for Tropical Cyclone

2023-2024, 15K USD, principal investigator

Funded by the Center for Earth System Modeling and Prediction, China Meteorological Administration

Targeted at integrating a new coupled model framework by integrating the atmospheric model GRAPES, the ocean model POM, and the wave model MASNUM. Through the optimization of air-sea flux schemes, it achieved notable improvements in tropical cyclone intensity simulation. The model has demonstrated reliable performance and is scheduled for operational deployment in tropical cyclone forecasting systems at the China Meteorological Administration.

Developing a Regional Atmosphere-Ocean-Wave Coupled Model System Through a Community Coupler

2016-2021, 120K USD, co-principal investigator

Funded by the National Key Research and Development Program of China

Designed the Atmosphere-Ocean-Wave coupled model FIO-AOW to deepen the understanding of tropical cyclone-ocean interaction mechanisms, particularly the role of small-scale processes (ocean surface waves). By implementing the coupling of component models (WRF, MASNUM, and POM/ROMS) within the C-Coupler framework, and introducing wave-related parameterization schemes, such as sea spray effects, sea-state-dependent momentum flux, and non-breaking wave-induced mixing. This research achieved a 40% reduction in intensity forecast errors, emphasizing the critical role of wave-coupled processes in tropical cyclone simulation and forecasting.

Effect of Rainfall-Induced Horizontal Stress on Air-Sea Momentum Flux

2015-2018, 36K USD, principal investigator

Funded by the National Natural Science Foundation of China

Developed a parameterization scheme to quantify the contribution of rainfall-induced horizontal stress to air-sea momentum flux, based on theoretical analysis and numerical simulations. The results highlighted the overlooked effects of rainfall on air-sea momentum flux, emphasizing its potential role in momentum exchange processes. However, the lack of in-situ observational data limited the ability to fully assess the magnitude of this effect.

AWARD

[Development and Application of the 2nd Generation Earth System Model with Ocean Surface Waves](#)

First Prize of Marine Engineering Science and Technology Award in 2023

Recognized as the top honor in marine science and engineering in China. My contribution involved incorporating ocean surface wave processes, specifically introducing sea spray effects and Stokes drift into this model, which helped reduce uncertainties in climate predictions. I was acknowledged as the 12th-ranked contributor to this work.

OPEN SOURCE CODE

FIO-AOW, an Atmosphere-Ocean-Wave Fully Coupled Model

https://github.com/Biao-Zhao/FIO-AOW

WW3_PBC, WW3 with Double-Periodic Boundary Support

https://github.com/Biao-Zhao/WW3_PBC

WaveF, wave farm parameterization

https://github.com/Biao-Zhao/WaveF

SERVICES

Reviewer for: (1) Bulletin of the American Meteorological Society; (2) Geophysical research letters; (3) Journal of geo physical research, (4) Journal of Climate, (5) Geoscientific Model Development; (6) Water resources research; (7) npj Climate and Atmospheric Science, (8) Ocean Dynamics, (9) Journal of Applied Meteorology and Climatology, (10) Tell us A: Dynamic Meteorology and Oceanography; (11) Acta Oceanologica Sinica; (12) Advances in Marine Science; (13) Journal of Marine Science and Engineering; (14) Atmosphere; (15) Journal of Renewable and Sustainable Energy; (16) Energy; (17) Applied Energy;