Chih-Lun Liu

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Education

- **College of Earth, Ocean, and Atmospheric Sciences, Oregon State University** — Corvallis , OR, USA
  Ph.D.; GPA: 3.95/4.0; Thesis Advisor: Bill Smyth — *Sep 2019 - Dec 2023*
  Dissertation: *Kelvin-Helmholtz Turbulence in Complex Environments*
- **Institute of Oceanography, National Taiwan University** — Taipei, Taiwan
  MSc; GPA: 3.48/4.0; Thesis Advisor: Ming-Huei Chang — *Aug 2015 - Sep 2017*
  Master's thesis: *Numerical Studies of Small Island Wakes in the Kuroshio*
- **Griffith University** — Gold Coast, Australia
  Exchange Program; Grade: 7/7 — *Feb 2015 - Jul 2015*
  Courses: *Fluid Mechanics and Hydraulics, Comp & Programming with MATLAB, Marine Ecosystem*
- **Marine Environmental Informatics, National Taiwan Ocean University** — Keelung, Taiwan
  BSc; GPA: 3.6/4.0 — *Sep 2011 - Jan 2015*
  Dean's Award *1

Experiences

- **Postdoctoral Scholar** — Feb 2024 - present
  Supervised by Henri Drake
  Earth System Sciences, University of California, Irvine
  – Understanding the primary steady energy pathway from barotropic tides to the internal wave continuum, ultimately to small-scale irreversible mixing.
  – Developing a parametrization method that accounts for the spatial variation of internal wave breaking efficiency and irreversible mixing efficiency.
- **AI Unlocked: Empowering Higher Ed through Research and Discovery Workshop** — Apr 2-3 2025
  The National Artificial Intelligence Research Resource (NAIRR), Denver, Colorado
  – Gain practical experiences with AI tools and processes
  – Prepare and use datasets for AI applications, along with hands-on practice in submitting data workflows to computational resources
- **Fluid Dynamics of Sustainability and the Environment Summer School** — Sep 4-15 2023
  Department of Applied Mathematics and Theoretical Physics, University of Cambridge
  – Intense two-week fluid dynamical related lectures and laboratory/numerical experiments followed by a research project
- **Graduate Research Assistant** — Sep 2019 - Dec 2023
  Supervised by Bill Smyth
  College of Earth, Ocean, and Atmospheric Sciences, Oregon State University
  – Used computer model and theories to simulate the effects of a neighboring stratified shear layer
  – Studied the changes in instability, turbulence and mixing when boundary proximity impacts on shear instability
  – Assessed sensitive dependence on initial conditions in a stratified shear instability and recommended an appropriate ensemble size for conducting direct numerical simulation studies
- **Faculty Research Assistant** — Oct 2018 - Sep 2019
  Supervised by Ming-Huei Chang
  Institute of Oceanography, National Taiwan University
  – Developed 3D nested model to simulate oil spill pollution east of Taiwan
  – Utilized numerical model to investigate the interactions between the Kuroshio current and the I-Lan Ridge, east of Taiwan
  – Participated in research cruises focused on measuring ocean turbulence. Responsibilities included crafting the experimental design and deploying instruments.

Academic Involvement

Journal Publications

- **Liu, C. L.**, H. F. Drake, Internal tide-driven mixing and energy pathways at rough seafloor topography: insights from large eddy simulation in the Brazil Basin. (In prep)
- **Liu, C. L.**, A. K. Kaminski, W. D. Smyth, Turbulence and mixing from neighboring stratified shear layers (2024), *J. Fluid Mech.* 987, A8, doi:10.1017/jfm.2024.387

- **Liu, C. L.**, A. K. Kaminski, W. D. Smyth, The effects of boundary proximity on Kelvin-Helmholtz instability and turbulence (2023), *J. Fluid Mech.*, 966, A2, doi.org/10.1017/jfm.2023.412
- **Liu, C. L.**, A. K. Kaminski, W. D. Smyth, The butterfly effect in stratified shear flow (2022), *J. Fluid Mech.*, 953, A43, doi.org/10.1017/jfm.2022.985
- Chang, M. H., Y. H. Cheng, Y. Y. Yeh, Y. J. Yang, **C. L. Liu**, T. Matsuno, T. Endoh, E. Tsutsumi, J. L. Chen, and X. Guo, Internal hydraulic transition and turbulent mixing observed in the Kuroshio over the I-Lan Ridge off northeastern Taiwan (2022), *J. Phys. Oceanogr.*, 52(12), 3179-3198, doi.org/10.1175/JPO-D-21-0245.1
- Chang, M. H., S. Jan, **C. L. Liu**, Y. H. Cheng, and V. Mensah, Observations of island wakes at high Rossby numbers: evolutions of submesoscale vortices and free shear layers (2019), *J. Phys. Oceanogr*, 49(11), 2997-3016, doi.org/10.1175/JPO-D-19-0035.1
- **Liu, C. L.**, and M. H. Chang (2018), Numerical studies of submesoscale island wakes in the Kuroshio, *J. Geophys. Res. Oceans.*, 123(8), 5669-5687, doi.org/10.1029/2017JC013501

Presentations

-2025

- Liu, C. L. & H. F. Drake (2025), Internal Tide-Driven Mixing Above a Rough and Sloping Seafloor. *Southern California Flow Pysics Symposium XVIII*, University of Southern California, CA, USA

-2024

- Liu, C. L. (2024), Applied Fluid Mechanics: GPU-Enabled Turbulence Modeling for Renewable Energy and Defense Applications. *Institute of Applied Mechanics, National Taiwan University*, Taipei, Taiwan (Invited)
- Liu, C. L. & H. F. Drake (2024), Internal Tide-Driven Mixing Above a Rough and Sloping Seafloor. *American Physics Society Division of Fluid Dynamics*, Salt Lake City, Utah, USA (poster)
- Liu, C. L. & H. F. Drake (2024), Internal Tide-Driven Mixing at Rough Topography. *Ocean Mixing Gordon Research Conference/Gordon Research Seminar*, South Hadley, Massachusetts, USA (poster)
- Liu, C. L., W. D. Smyth (2024), Kelvin-Helmholtz Turbulence in Complex Environments. *UC Irvine Fluid Dynamics Seminar (Mechanical and Aerospace Engineering)*, Irvine, CA, USA (Invited)
- Liu, C. L., W. D. Smyth (2024), Turbulence and Mixing From Neighboring Stratified Shear Layers. *Southern California Flow Physics Symposium XVII*, Irvine, CA, USA
- Liu, C. L., A. K. Kaminski and W. D. Smyth (2024), Turbulence and Mixing From Neighboring Stratified Shear Layers. *Ocean Sciences Meeting*, New Orleans, USA (poster)

-2023

- Liu, C. L. & W. D. Smyth (2023), Kelvin-Helmholtz Turbulence in Complex Environments. *Ph.D. Defense*, Corvallis, OR, USA
- Liu, C. L., A. K. Kaminski, W. D. Smyth (2023), The effects of boundary proximity on Kelvin-Helmholtz instability and turbulence. *The 28th General Assembly of the International Union of Geodesy and Geophysics (IUGG)*, Berlin, Germany
- Liu, C. L., A. K. Kaminski and W. D. Smyth (2023), Neighboring Shear Instability and Turbulence. *Fluid Dynamics of Sustainability and the Environment Summer School*, University of Cambridge, UK (poster)

-2022

- Liu, C. L. (2022), Application of Quasi-Realistic Numerical Modeling to Mitigate Ocean Pollution: An Oil Spill Example, *International Conference on UNCLOS 40th Anniversary and Its Implementation of Marine Policy*, virtual (Invited)
- Liu, C. L., A. K. Kaminski, W. D. Smyth (2022), The effects of Boundary Proximity on Kelvin Helmholtz Instability and Turbulence, *International Symposium on Stratified Flows*, University of Cambridge, UK
- Liu, C. L., A. K. Kaminski, W. D. Smyth (2022), The effects of Boundary Proximity on Kelvin Helmholtz Instability and Turbulence, *POA Research Symposium*, Oregon State University, USA
- Liu, C. L., A. K. Kaminski and W. D. Smyth (2022), The effects of Boundary Proximity on Kelvin Helmholtz Instability and Turbulence, *AGU Fall Meeting*, Chicago, USA (poster)
- Liu, C. L., A. K. Kaminski and W. D. Smyth (2022), The effects of Boundary Proximity on Kelvin Helmholtz Instability and Turbulence, *Ocean Sciences Meeting*, virtual

-2019

- Liu, C. L., M. H. Chang, S. Jan, Y. J. Yang, Y. L. T. Matsuno, E. Tsutsumi, T. Endoh, A. Sakai, S. Shimada, X. Guo , J. L. Chen (2019), Numerical Simulation of Kuroshio Topography Interaction Over the I-Lan Ridge, *Forthcoming collaborative meeting*, Kyushu University, Japan
- Liu, C. L and M. H. Chang (2019), Instabilities and Turbulence Mixing in the Strong and Unsteady Flows Over a Sill: A Numerical Study, *Ocean Sciences Conference*, Taipei, Taiwan (poster)
- Liu, C. L and M. H. Chang (2019), Instabilities and Turbulence Mixing in the Strong and Unsteady Flows Over a Sill: A Numerical Study, *Pacific Asian Marginal Seas (PAMS) Meeting*, Kaohsiung, Taiwan (poster)

-2017

- Liu, C. L. and M. H. Chang (2017), Numerical Studies of Small Island Wakes in the Kuroshio, Thesis Defense National Taiwan University
- Liu, C. L. and M. H. Chang (2017), Numerical Studies of Small Island Wakes in the Kuroshio, *Pacific Asian Marginal Seas (PAMS) Meeting*, Session 02, Jeju, Korea
- Liu, C. L and M. H. Chang (2017), Numerical Studies of Small Island Wakes in the Kuroshio, *Ocean Sciences Conference*, Kaohsiung, Taiwan (winning **1st place** in youth forum competition)

-2016

- Liu, C. L and M. H. Chang (2016), A Preliminary Study on Green Island Wake with Observation and Numerical Modelling, *Ocean Sciences Conference*, Taipei, Taiwan (poster)

Peer Review Service
Journal of Fluid Mechanics (1), *Physical Review Fluids* (1), *Journal of the Atmospheric Sciences* (1), *Monthly Weather Review* (1), Science Advances (1)

Research Cruises

- *R/V Legend*, Underway VMP 250 mapping, on the I-Lan Ridge, Chief Scientist, Ming-Huei Chang, Jul 2019
- *R/V Ocean Research I*, VMP 500 deployment and biological sampling at Kaoping Canyon, SW of Taiwan , Chief scientist, Chih-Lin Wei, Mar 2019
- *R/V Ocean Research III*, Mixing processes in the frontal region of the island wake, North of Green Island, Chief Scientist: Ming-Huei Chang, March 2017
- *R/V Revelle* Submesoscale resolving survey of the region southwest of Taiwan, South China Sea, Chief Scientist: Lou St., Laurant, Feb/March 2017
- *R/V Ocean Research I*, Typhoon buoy deployment; recovery of moorings for recharging ADCP batteries, Philippine Sea, Chief Scientist: Yiing-Jang Yang, Oct 2016
- *R/V Ocean Research II*, Deployed mooring at the north of the Green Island, Philippine Sea, Chief scientist, Ming-Huei Chang, Sep 2016
- *R/V Ocean Research III*, Vertical structure of the Kuroshio, Philippine Sea, Chief scientist, Sen Jan, Jun 2016
- *R/V Ocean Research III*, Observe K-H instability above the ocean ridge, Philippine Sea, Chief scientist, Ming-Huei Chang, May 2016
- *R/V Ocean Research II*, Observe K-H instability above the ocean ridge, Philippine Sea, Chief scientist, Ming-Huei Chang, Mar 2016
- *R/V Ocean Research I*, Kuroshio variability, Philippine Sea, Chief scientist, Yiing Jang Yang, Nov 2015
- *R/V Ocean Research II*, Sea going Internship, Keelung Islet, Convener, Jian-Hua Hu, Sep 2014

Non-Academic Work Experiences

- **Military Service**, Chiayi, Taiwan (Oct/2017 - Oct/2018)
- **Internship**, Taipei, Taiwan (Jul/2012 - Aug/2013)
    1. Asia Environmental Technical Corporation (1 month)
    2. Eastern Media International Corporation (2 months)

Honors and Awards

- Selected to feature on the front cover of Journal of Fluid Mechanics Volume 987
- CEOAS Student Research Fellowship (Outstanding academic performance and engagement in the university community, 1000 USD award) - May 2023
- Wayne V. Burt Award (In recognition of outstanding achievement in the fields of physical oceanography or atmospheric sciences, 3000 USD award) - May 2022
- Ocean Sciences Conference Youth Forum Competition (1^{st} place) - May, 2016
- Dean's Award (1^{st} place in a semester) - June, 2015

Skills

- **Computer Languages**: Julia, MATLAB, Fortran, Python
- **Computational Research Skills**: Numerical Ocean Modeling (MITgcm), Direct Numerical Simulation (DIABLO), Large Eddy Simulation (Oceananigans.jl), High Performance Computing (HPC), Data Visualization (VAPOR), LaTex, git, Unix Shell, Adobe Illustrator, Microsoft Office
- **Preparation, Setups and Operations of Oceanic Instruments**: ADCP, CTD, VMP 250/500 and Mooring deployment and pre-setups
- **Plan Cruise Experiments**: Assist the Chief Scientist to plan a compendium sea-going experiment
- **Platforms**: Extensive experience in Linux, MacOS, and Windows
- **Soft Skills**: Problem-solving and communication, writing, time management
- **Languages**: Fluent Mandarin and English

Research History

- **Internal Tide-Driven Mixing and Energy Pathways at Rough Seafloor Topography: Insights from Large Eddy Simulation in the Brazil Basin (Postdoc project)**: Turbulent mixing is a crucial process in ocean dynamics, impacting both stratification and circulation. One significant aspect of this mixing is the internal tide-driven mixing that occurs at rough topography. Our research focuses on understanding the energy pathways of the barotropic M2 tide as it interacts with a gently sloping, rough seafloor. The sloping seafloor promotes restratification, which balances with fluid homogenization due to tidal-driven mixing, allowing a non-transient flow development. A large eddy simulation is used with quasi-realistic topography based on the Brazil Basin in the South Atlantic Ocean. Complex topographic features such as abyssal hills, ridges, and canyons are resolved. The energy of the Internal tide is transferred to smaller-scale internal waves, which radiate into the interior of the ocean. Eventually, these internal waves break down into patches of turbulence, driven by either shear instability or convective instability. Additionally, wave-wave interactions play a critical role in mixing and dissipating kinetic energy.
- **Turbulence and Mixing From Neighboring Stratified Shear Layers (3^{rd} PhD project, published in JFM)**: Neighboring stratified shear layers are found in thermohaline density staircases, layers associated with breaking of internal waves. Our goal is therefore to understand the impact of an adjacent shear layer on another shear layer. We found that the results depend non-monotonically on the separation distance, where an abrupt change could be found when the separation distance is similar to the half shear layer thickness. This is largely determined by the dominance of two existing modes. Growth rate, secondary instabilities, as well as the resulting mixing are greatly reduced when
- **Boundary Effects on KH Instability and Turbulence (2^{nd} PhD project, published in JFM)**: Previous studies of KHI have neglected boundary effects. In the atmosphere and oceans, however, instability often occurs near boundaries, e.g., flow over I-Lan Ridge described above. Our goal is therefore to understand the impact of boundary proximity on KHI and turbulent mixing using DNS. We find that boundary effects suppress both vortex pairing and secondary convective instability; it also decreases both the amount and the efficiency of turbulent mixing.
- **The Butterfly Effect in Stratified Shear Flows (1^{st} PhD project, published in JFM)**: Our goal was to understand whether KHI, the transition to turbulence and the overall mixing efficiency are sensitive to the details of the initial conditions. Using ensembles of nearly-identical direct numerical simulations (DNS), we found that with slightly different initial random perturbations, the resulting turbulence and mixing can be drastically different. This has important implications for future DNS studies, as a single simulation may not represent the whole picture, and also broader implications for the predictability of oceanic and atmospheric motions.
- **Interaction Between Kuroshio and I-Lan Ridge (2^{nd} project as a Research Assistant)**: Based on a sequence of field experiments, we employed a two-dimensional model implemented in MITgcm to investigate the mixing processes occurring in the vicinity of the sill. Our primary focus was to comprehend the fundamental mechanisms of mixing, taking into account the energetic passage of the Kuroshio current across the sill and the associated variations induced by the M2 tide. During the flood tide, Lee waves are generated, subsequently undergoing disruption due to the presence of Kelvin-Helmholtz instability (KHI) during various tidal phases. The obtained findings provided valuable insights into the evolution of the flow dynamics and offered anticipations for distinct tidal phases encountered in the field.
- **Model Oil Spill Trajectories (1^{st} project as a Research Assistant)**: We focused on an oil spill incident in the Philippine Sea. A "nested model" was created, where the open boundary conditions for MITgcm are obtained from HYCOM velocity and temperature fields. We also considered modulation by the barotropic tide. A passive tracer was released from the southern boundary where marine traffic is densest. The oil spill was trapped for more than 10 hours near Green Island due to island wakes, which form a reverse flow immediately downstream of the island.

- **Island Wakes (Master's thesis, published in JGR-oceans)**: We used the MIT general circulation model (MITgcm) to resolve wakes downstream of Green Island, east of Taiwan and obtained wake patterns and periods consistent with field observations. We discovered that (i) the wakes exhibit sequentially detached recirculation cells, which contain upwelling of cold water and propagate downstream; (ii) island wakes resemble the von Kármán vortex street but have been modified by inertial and barotropic instabilities; (iii) the hotspot of turbulent mixing is located where horizontal shear is large. Due to the island-shelf effect and tilting of the vertical vorticity, the lateral shear is partly converted to vertical shear resulting in turbulent diapycnal mixing. This was my first research project and has honed my modeling skills and theoretical understanding of oceanography.