Julian Mak

Associate Professor
Department of Ocean Sciences
Hong Kong University of Science and Technology

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Research interests

Geophysical and astrophysical fluid dynamics

- Wave/eddy-mean flow interaction
- Baroclinic dynamics/turbulence
- Development of numerical ocean models
- Applied and computational mathematics (particularly optimisation problems)
- Magnetohydrodynamics

Education

PhD Applied Mathematics, University of Leeds (Oct 2009 – Sep 2013)

- Thesis title: *Shear instabilities in shallow-water magnetohydrodynamics*
  supervised by David W. Hughes and Stephen D. Griffiths
  examined by David G. Dritschel and Chris A. Jones

MMath Mathematics, University of Durham, (First class; Oct 2005 – Jul 2009)

- MMath dissertation: *Hydrodynamic stability of Newtonian and non-Newtonian fluids*
  supervised by Miguel A. Moyers-Gonzalez

Research experience

Associate professor (Jul 2025 – to date)
Department of Ocean Science, Hong Kong University of Science and Technology

Senior NOC fellow (visiting position; Sep 2023 – to date)
National Oceanography Centre, UK

Assistant professor (cf. lecturer in the UK system; Jul 2019 – Jun 2025)
Department of Ocean Science, Hong Kong University of Science and Technology

Post-doctoral researcher (Oct 2017 – May 2019)
AOPP, Department of Physics, University of Oxford
– working primarily with David P. Marshall (PI) and James R. Maddison (Co-I)

Post-doctoral researcher (Sep 2014 – Sep 2017)
School of Mathematics, University of Edinburgh
– working with James R. Maddison (PI) and David P. Marshall (Co-I)

Post-doctoral researcher (Oct 2013 – Sep 2014)
Department of Geophysics & Planetary Sciences, Tel Aviv University
– working with Nili Harnik and Eyal Heifetz

PhD student (Oct 2009 – Sep 2013)
Department of Applied Mathematics, University of Leeds

ISIMA 2010 student research fellow (Jul – Aug 2010)
University of California, Santa Cruz
– *Geostrophic turbulence under the influence of a magnetic field*, supervised by Patrick H. Diamond

EPSRC vacation studentship (Jul – Sep 2008)
Department of Mathematical Sciences, University of Durham
– *Hydrodynamic stability of Kolmogorov flows on the sphere*, supervised by Djoko Wirosoetisno

Publications

Journal Articles

(§ denotes corresponding author(s), bold denotes group members/visitors for the relevant period)

* R. Torres§, R. Waldman, G. Madec, C. de Lavergne, R. Séférian & **J. Mak** (submitted to J. Adv. Model. Earth Syst.)
Energetically constrained mesoscale parameterisations in ocean global circulation models

28. **H. S. Lee**§, J. R. Maddison, **J. Mak**§, D. P. Marshall & Y. Wang (2025)
Negative sensitivity of Southern Ocean circumpolar transport to increased wind stress controlled by residual overturning
Tellus A, **77**(1), 199–220

27. **F. E. Yan**§, H. Frezat, J. Le Sommer, **J. Mak**§ & K. Otness (2025)
Adjoint-based online learning of two-layer quasi-geostrophic baroclinic turbulence
J. Adv. Model. Earth Syst., **17**(7), e2024MS004857

26. R. Liu, Y. Wang§, X. Zhai, D. Balwada & **J. Mak** (2025)
Improved theoretical estimates of the zonal propagation of global nonlinear mesoscale eddies
J. Geophys. Res. Oceans, **130**(6), e2025JC022518

25. J. R. Maddison§, D. P. Marshall, **J. Mak** & K. Maurer-Song (2025)
A two-dimensional model for eddy saturation and frictional control in the Southern Ocean
J. Adv. Model. Earth Syst., **17**(4), e2024MS004682

24. J. Thomy, F. Sanchez, C. Prioux, S. Yau, Y. Xu, **J. Mak**, R. Sun, G. Piganeau§ & C. C. M. Yung§ (2024)
Unveiling Prasinovirus diversity and host specificity through targeted enrichment in the South China Sea
ISME Communications, **4**(1), ycae109

23. **J. Mak**§, N. Harnik, E. Heifetz, **G. Kumar**§ & **E. Q. Y. Ong** (2024)
Edge-wave phase shifts versus normal-mode phase tilts in an Eady problem with a sloping boundary
Physical Review Fluids, **9**(8), 083905

22. **X. Ruan**§, D. Couespel, M. Lévy, **J. Mak**§ & Y. Wang (2024)
Combined physical and biogeochemical assessment of mesoscale eddy parameterisations: eddy induced advection at eddy-permitting resolution
Ocean Modelling, **190**, 102396

21. **F. E. Yan**§, **J. Mak**§ & Y. Wang (2024)
On the choice of training data for machine learning of geostrophic mesoscale turbulence
Journal of Advances in Modeling Earth Systems, **16**(2), e2023MS003915

20. H. Wei, Y. Wang[§] & **J. Mak** (2024)
Parameterizing eddy buoyancy fluxes across prograde shelf/slope fronts using a slope-aware GEOMETRIC closure
Journal of Physical Oceanography, **54**(2), 359–377

19. **J. Mak**[§], J. R. Maddison, D. P. Marshall, **X. Ruan**, Y. Wang & L. Yeow (2023)
Scale-awareness in an eddy energy constrained mesoscale eddy parameterization
Journal of Advances in Modeling Earth Systems, **15**(12), e2023MS003886

18. R. Torres[§], R. Waldman, **J. Mak**, & R. Séférian (2023)
Global estimate of eddy kinetic energy dissipation from a diagnostic energy balance
Geophysical Research Letters, **50**(20), e2023GL104688

17. **X. Ruan**[§], D. Couespel, M. Lévy, **J. Mak**[§] & Y. Wang (2023)
Combined physical and biogeochemical assessment of mesoscale eddy parameterisations: eddy induced advection in non-eddying models
Ocean Modelling, **183**, 102204

16. H. Wei, Y. Wang[§], A. L. Stewart & **J. Mak** (2022)
Scalings for eddy buoyancy fluxes across prograde shelf/slope fronts
Journal of Advances in Modeling Earth Systems, **14**(12), e2022MS003229

15. E. Heifetz[§], L. R. M. Maas, **J. Mak** & I. Pomerantz (2022)
Inertio-gravity Poincare waves and the quantum relativistic Klein-Gordon equation, near-inertio waves and the non-relativistic Schrodinger equation
Physics of Fluids, **34**, 116608

14. **J. Mak**[§], A. Avdis, T. David, **H. S. Lee**, **Y. Na**, Y. Wang & **F. E. Yan** (2022)
On constraining the mesoscale eddy energy dissipation time-scale
Journal of Advances in Modeling Earth Systems, **14**(11), e2022MS003223

13. **J. Mak**[§], D. P. Marshall, G. Madec & J. R. Maddison (2022)
Acute sensitivity of global ocean circulation to eddy energy dissipation time-scale
Geophysical Research Letters, **49**(8), e2021GL097259

12. E. Heifetz[§], L. R. M. Maas, **J. Mak** (2021)
Zero absolute vorticity plane Couette flow as an hydrodynamic representation of quantum energy states under perpendicular magnetic fields
Physics of Fluids, **33** (12), 127120

11. E. Heifetz, L. R. M. Maas, **J. Mak**[§] & I. Pomerantz (2021)
On a formal equivalence between electro-magnetic waves in cold unmagnetized plasma and shallow water inertio-gravity waves
Journal of Physics Communications, **5** (12), 125006

10. Y. Y. Cheung, S. Cheung[§], **J. Mak**, K. Liu, X. Xia, X. Zhang, Y. Yung & H. Liu[§] (2021)
Distinct interaction effects of warming and anthropogenic input on diatoms and dinoflagellates in an urbanized estuarine ecosystem
Global Change Biology, **27** (15), 3463–3473

9. **J. Mak**[§], J. R. Maddison, D. P. Marshall & D. R. Munday (2018)
Implementation of a geometrically informed and energetically constrained mesoscale eddy parameterization in an ocean circulation model
Journal of Physical Oceanography, **48**, 2363–2382

8. **J. Mak**§, S. D. Griffiths & D. W. Hughes (2017)
   Vortex disruption by magnetohydrodynamic feedback
   Physical Review Fluids, **2**, 113701

7. **J. Mak**§, D. P. Marshall, J. R. Maddison & S. D. Bachmann (2017)
   Emergent eddy saturation from an energy constrained eddy parameterisation
   Ocean Modelling, **112**, 125–138

6. S. D. Bachman§, D. P. Marshall, J. R. Maddison and **J. Mak** (2017)
   Evaluation of a scalar eddy diffusivity based on geometric constraints
   Ocean Modelling, **109**, 44–54

5. **J. Mak**§, J. R. Maddison & D. P. Marshall (2016)
   A new gauge-invariant method for diagnosing eddy diffusivities
   Ocean Modelling, **104**, 252–268

4. **J. Mak**§ , S. D. Griffiths & D. W. Hughes (2016)
   Shear flow instabilities in shallow-water magnetohydrodynamics
   Journal of Fluid Mechanics, **788**, 767–796

3. E. Heifetz & **J. Mak**§ (2015)
   Stratified shear flow instabilities in the non-Boussinesq regime
   Physics of Fluids, **27**, 086601, 1–15

2. E. Heifetz, **J. Mak**§, J. Nycander & O. M. Umurhan (2015)
   Interacting vorticity waves as an instability mechanism for magnetohydrodynamic shear instabilities
   Journal of Fluid Mechanics, **767**, 199–225

1. M. A. Moyers-Gonzalez§ , T. Burghlea & **J. Mak** (2011)
   Linear stability analysis for plane-Poiseuille flow of an elastoviscoplastic fluid with internal microstructure at large Reynolds Number
   Journal of Non-Newtonian Fluid Mechanics, **166**, 515-531

Reports, proceedings and grey literature

F. NEMO Consortium (2022)
   NEMO Development Strategy 2023-2027 (Version 3)
   Zenodo (`https://doi.org/10.5281/zenodo.7361464`)

E. D. P. Marshall§, J. R. Maddison, **J. Mak**, S. D. Bachman & D. R. Munday (2020)
   GEOMETRIC: Geometry and energetics of ocean mesoscale eddies and their representation in climate models
   CLIVAR exchanges, **77**, 17-22 (joint special edition on "Sources and Sinks of Ocean Mesoscale Eddy energy")

D. E. Heifetz & **J. Mak**§ (2014)
   Magnetohydrodynamic shear instabilities arising from interacting vorticity waves
   Advances in Fluid Mechanics X (Proceedings of AFM2014), 371-381

C. **J. Mak**§ (2013)
   Shear instabilities in shallow-water magnetohydrodynamics
   PhD thesis, Department of Applied Mathematics, University of Leeds

B. **J. Mak**§ (2011)
   Geostrophic turbulence in the MHD regime
   report / proceedings for ISIMA 2010 (see ISIMA website)

A. **J. Mak**[§] (2009)
Hydrodynamic stability of Newtonian and non-Newtonian fluids
MMath dissertation, Department of Mathematical Sciences, University of Durham

Grants

– *Energetically consistent coupling of a mesoscale eddy and lee wave parameterization in an IPCC-class global ocean circulation model*
1st Jul 2025 — 30th Jun 2028 (PI, Co-I: Casimir de Lavergne, LOCEAN-IPSL)
HKD 792,542 (exclusive of overheads), 36 months
HKRGC General Research Fund (16303625)

– *The role of symmetries in fluid and plasma systems*
1st Apr 2025 — 31st Mar 2026 (PI; RIAM host: Yusuke Kosuga and Yohei Onuki)
JPY 200,000 (travel grant), 12 months
RIAM international joint research (2025S2-CD-5)

– *Implementing a slope- and scale-aware mesoscale eddy parameterization in global ocean models*
1st Sep 2024 — 31st Aug 2027 (Co-I, PI: Yan Wang, HKUST)
HKD 783,478 (exclusive of overheads), 36 months
HKRGC General Research Fund (16307324)

– *Multi-sensor monitoring, geophysical interpretation and prediction of sea level rise in Hong Kong*
1st Jun 2024 — 30th May 2027 (Co-I, PC: Jianli Chen, PolyU)
HKD 6,567,108 (exclusive of overheads), 36 months
HKRGC Collaborative Research Fund (C5013-23GF)

– *Inferring ocean eddy energy dissipation timescale from observations using an inverse method*
1st Nov 2023 — 31st Oct 2024 (Co-I, PI: Xiaoming Zhai, UEA)
GBP 3,000 (travel grant), 12 months
The Royal Society Kan Tong Po International Fellowship (KTP\R1\231008)

– *Numerical modelling of the influence of secondary surface roughness on urban turbulence and ventilation*
1st Jul 2021 — 30th Jun 2024 (Co-I, then PI)
HKD 391,015 (exclusive of overheads), 36 months
HKRGC General Research Fund (11308021)

– *Inferring South China Sea abyssal upwelling via a consistent regional state estimate*
1st Jul 2021 — 30th Jun 2024 (PI, Co-I: Matt Mazloff)
HKD 598,015 (exclusive of overheads), 36 months
HKRGC General Research Fund (16304021)

– *Parameterization in grey zone ocean general circulation models*
1st Nov 2020 – 31st Oct 2022 (PI)
HKD 400,000 (exclusive of overheads)
Center for Ocean Research in Hong Kong and Macau

– *Probing circulation influences on pollution dispersion*
1st Jan 2020 – 31st Dec 2022 (PI)
HKD 700,000 (exclusive of overheads)
Hong Kong Branch Collaborative Research Fund and Operation Fund

– *Constraining uncertain parameters in IPCC-class global ocean circulation models using inverse methods*
1st Jul 2020 – 30th Jun 2023 (PI)
HKD 705,710 (exclusive of overheads), 36 months
HKRGC Early Career Scheme (26300020)

Selected conference/seminar presentations

– *Relaxation and equilibration of baroclinic flows*
(Invited plenary) AAPPS-DDP 2025, Fukuoka, Sep 2025

– *Machine learning of geostrophic turbulence*
Machine Learning for Ocean Modelling, NCAS, Reading, Jun 2025

– *The modified geostrophic Eady problem revisited*
CGAFD Seminar, School of Mathematics, Exeter, Jun 2025

– *Influences on biogeochemical responses from mesoscale eddy parameterisations*
NEMO Hackathon, UK Met Office, Exeter, Jun 2025

– *Combined physical and biogeochemical assessment of mesoscale eddy parameterisations in ocean models: Eddy-induced advection at eddy-permitting resolutions*
JpGU, Chiba, Japan, Jun 2025

– *Influences on biogeochemical responses by representations of fluid turbulence*
ESS Seminar, CUHK, HK, May 2025

– *Machine learning of geostrophic turbulence*
(Invited talk) AAPPS-DDP 2024, Melaka, Nov 2024

– *Scale-awareness in an energetically constrained eddy parameterisation*
Speaker and organiser, Physical Oceanography Day, HKUST, HK, Jun 2024

– *Hands-on session on Machine Learning techniques*
(Invited tutorial 3 hours) TAPGFD, ICTS, Bangalore, May 2024

– *The geostrophic Eady problem revisited*
(Invited lecture 2 hours) TAPGFD, ICTS, Bangalore, May 2024

Selected professional activities

– Editor: EGU Ocean Sci. (Aug 24 onwards)

– Reviewer for: J. Fluid Mech.; Phys. Fluids; Phys. Lett. A; J. Phys. Oceanogr.; Phys. Plasmas; Astrophys. J.; J. Geophys. Res: Oceans; Ocean Modell.; J. Adv. Model. Earth Syst.; IPCC AR6 WG1 (second draft); EGU Ocean Sci.; Geophys. Res. Lett.

– NEMO (Nucleus for European Modelling of the Ocean) working group on eddy parameterisations (22/23 onwards, co-chair from Apr 25); NEMO developer under the NERC group (23/24 onwards)

– (Dept. of Ocean Science, HKUST) Discovering Ocean Science summer school (22/23, 23/24), co-UG co-ordinator (22/23), Departmental seminar organiser (20/21 to 23/24), International Research Enrichment track co-ordinator (20/21 to date), MSc committee (21/22), UG committee (20/21 to date), Teaching Faculty appointment and promotion committee (22/23 to date), Student Mentoring Task Force (19/20 to 22/23), physical oceanography group meeting oragniser (20/21 to date)

– Outreach with the Ocean-3C program in Hong Kong (20/21 placement: Sha Tin College; 21/22 placement: Saint Too Cannan college)

– (School of Mathematics, University of Edinburgh) Reading group member for the Athena Swan Silver application, post-doc wiki administrator, journal club *Waves & Mean Flows* organiser

Teaching Activities

Research mentoring

Floriane Océane SUDRE	PDRA	Aug 2025 – now
RUAN Xi	PDRA	Jul 2025 – now
Virryna WU Yue	PDRA	Feb 2024 – now
Huanhuan WANG	PDRA	Sep 2022 – Feb 2023
Gautam KUMAR	PDRA	Mar 2021 – Sep 2022
LEUNG Wai Hang	MPhil	Sep 2025 – now
YIN Jiahui	MPhil	Sep 2022 – now
Jonathan LEE Ho Ching	PhD	Feb 2024 – now
Dan BARTLEY	MPhil	Sep 2022 – Aug 2024
Kayla LEE	MPhil	Sep 2022 – Aug 2023
YAN Feier	PhD	Feb 2021 – Mar 2025
NA Yongsu	PhD	Sep 2020 – Aug 2025
RUAN Xi	PhD	Sep 2020 – May 2025
LIU Yongqi	MPhil	Sep 2020 – Aug 2022
Floriane Océane SUDRE	PhD	Sep 2020 – May 2021
LEE Han Seul	PhD	Sep 2019 – Sep 2025
Dan BARTLEY	RA	Feb 2022 – Jul 2022
Chinmayee MALLICK	RA	Apr 2020 – Mar 2021
Floriane Océane SUDRE	RA	Mar 2020 – Aug 2020
DONG Zipei	MSc	Sep 2020 – May 2021
JIANG Jinxiao	MSc	Sep 2020 – May 2021
Ellie ONG	Visiting scholar	Oct 2020 – Jan 2021
RUAN Xi	MSc	Feb 2020 – Jul 2020

LEUNG Wai Hang	BSc (Capstone; Ocean Sci.)	Feb 2025 – May 2025
CHAN Chun Ting	BSc (FYP; Physics)	Sep 2024 – May 2025
CHEN Hin Kwan	BSc (FYP; Ocean Sci.)	Sep 2024 – May 2025
HO Chung Yan	BSc (FYP; Ocean Sci.)	Sep 2024 – May 2025
Hayden SO	BSc	Sep 2023 – now
Andersen POON	BSc (UROP; Maths)	Jul 2023 – Sep 2023
Soobeom CHUNG	BSc (FYP; Physics)	Sep 2022 – May 2023
Matthew FONG	BSc (FYP; Physics)	Sep 2022 – May 2023
Tim DU	BSc (FYP; Env. Sci.)	Sep 2021 – May 2022
Anastasia LEUNG	BSc (UROP; Physics)	Jul 2021 – Sep 2021
Rachel TSOI	BSc (FYP; Env. Sci.)	Sep 2020 – May 2021
Jolie NG	BSc (FYP; Env. Sci.)	Sep 2020 – May 2021
Nick KANG	BSc (UROP; Physics)	Jul 2020 – Sep 2020
Haruki SAEGUSA	BSc (UROP, UG helper)	Jul 2020 – Sep 2020
	(Mech. Eng.)	Jun 2021 – Jan 2022
Kathryn CHOW	BSc (Capstone; Env. Sci.)	Feb 2020 – Jul 2020

Hong Kong University of Science and Technology (2019 to date)

Instructor (I), with rough estimate of student numbers

25/26: Data Analysis in Ocean Science (3rd year, I, 40), AI and Machine Learning for Ocean Science (4th year, I, 10), Machine Learning for Ocean Science (PGs, I, 20)

24/25: Descriptive Physical Oceanography (2nd year, I, 40), Data Analysis in Ocean Science (3rd/4th year, I, 8), Physical Oceanography (3rd/4th year, I, 4)

23/24: The Earth as a Blue Planet (1st year, Co-I, 70, both semesters), Descriptive Physical Oceanography (2nd year, I, 40), Data Analysis in Ocean Science (3rd/4th year, I, 12), Physical Oceanography (postgraduates, I, 5)

22/23: Descriptive Physical Oceanography (2nd year, I, 25), Data Analysis in Ocean Science (3rd/4th year, I, 5), Physical Oceanography (3rd/4th year, I, 5)

21/22: Descriptive Physical Oceanography (2nd year, I, 25), Data Analysis in Ocean Science, (3rd/4th year, I, 5)

20/21: Postgraduate Seminar (PG, Co-I, 40), Global Climate Change (3rd year, Co-I, 30), Descriptive Physical Oceanography (2nd year, I, 40)

19/20: Postgraduate Seminar (PG, Co-I, 40), Global Climate Change (3rd year, Co-I, 30)

University of Edinburgh (2014 to 2017)

Instructor (I), Teaching assistant (T), assignment marker (M), with rough estimate of student numbers

16/17: Mathematics in Action : Mathematics of Climate (honours, I, 30)

15/16: Several variable calculus and differential equations (pre-honours, TM, 15), Computing and numerics (pre-honours, TM, 60)

14/15: Computing and numerics (pre-honours, TM, 60)

University of Leeds (2009 to 2013)

Teaching assistant (T), assignment marker (M), with rough estimate of student numbers

12/13: 1H Mathematics 1 (TM, 10), introduction to linear algebra (TM, 10, exam marking, 85); 2H calculus of variations (TM, 30)

11/12: 2H Fourier series, PDEs and transforms (TM, 30), calculus of variations (M, 30), multiple integrals and vector calculus (M, 30)

10/11: 1H numbers and vectors (TM, 20), modelling and investigations (TM, 60 over the semester); 2H Fourier series, PDEs and transforms (TM, 30), mathematics for Geoscience (M, 15), introduction to optimisation (M, 40), calculus of variations (M, 30), multiple integrals and vector calculus (M, 30)

09/10: 1H linear algebra, calculus, differential equations and mechanics (TM, 7); 2H Introduction to optimisation (M, 40); 3/4H Hydrodynamic stability (M, 15).

University of Durham (2008-2009)

Assignment marker

- Single maths courses: complex analysis (2H, 25), analysis in many variables (2H, 25), algebra and number theory (2H, 25)

Training and development agency for schools (2006-2007)

Student associate teachers (for Durham and Lincolnshire county council, UK)

- Government scheme to promote higher education and outreach to secondary school students and to provide teaching experience for student associates. Acted as academic and pastoral mentor at a school listed as 'deprived', as well as a successful school.

Referees

See separate document for referee contact details.