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Education

- **National Taiwan University**, Department of Atmospheric Sciences, Taipei, Taiwan
Ph.D. Atmospheric Sciences (2009). Advisor: Jen-Ping Chen

Appointments

- Associate Research Fellow, Academia Sinica, Research Center for Environmental Changes, Taipei, Taiwan (2023- present)

Honors & Awards

- National Science Council's Postdoctoral Fellow Publication Award (2013)

Research Interests

- Aerosol Parameterization and Modeling
- Aerosol-Cloud-Climate interactions
- Cloud Physics
- Atmospheric Physical Chemistry

Major Achievements and Contributions (2020-present)

- Enhancing Climate Predictions in Taiwan: The Role of Aerosol and Cloud in the Taiwan Earth System Model

Using a locally developed aerosol parameterization scheme, the Taiwan Earth System Model (TaiESM) has been validated against reanalysis and observational data, demonstrating strong performance in simulating circulation, precipitation, and aerosol distributions. TaiESM contributed to CMIP6 and was further used to assess aerosol impacts on the East Asian winter monsoon. Results indicate that anthropogenic aerosols intensify the Siberian High, weaken the Aleutian Low, and suppress monsoonal flow, particularly over extratropical regions. These changes lead to a southward shift of the tropical rain belt and reduced precipitation in southern Asia, reflecting aerosol-induced modifications to the local Hadley circulation.

- Assessing the Multifaceted Impacts of Climate Change on Taiwan: Urban Vulnerability, Air Quality, and Agricultural Productivity

We performed high-resolution simulations to evaluate the impacts of climate change across Taiwan, uncovering critical regional vulnerabilities in urban climate, air quality, and agriculture. Urban areas exhibit a more rapid increase in heatwave frequency than other land-use types, highlighting their elevated exposure to climate stress, while forested regions remain comparatively resilient. Warming

also weakens near-surface winds, contributing to more frequent air pollution episodes. Agricultural assessments indicate declining yields of key crops such as wheat, tomatoes, and potatoes under warming scenarios—primarily driven by ozone stress at +2°C and direct thermal stress becoming dominant at +4°C. These findings underscore the complex and spatially differentiated impacts of climate change in Taiwan, reinforcing the urgency of tailored mitigation and adaptation strategies.

- **Advanced Traffic Data Integration for Improved Air Quality Modeling in the Greater Taipei Area:**

Our study focuses on the Greater Taipei Area, which aims to refine transportation emissions inventories by incorporating web-based traffic data and a vision-based traffic analysis system. The findings reveal that sedans and scooters represent approximately 90% of the traffic, with notable spatial variations: sedans are more common in rural areas, whereas scooters dominate urban and suburban regions. We also identified distinct traffic patterns for weekdays versus weekends, which significantly improved the accuracy of our air quality models, especially in predicting concentrations of carbon monoxide and particulate matter. This research addresses a significant gap in the literature by providing a comprehensive spatial and temporal analysis of scooter traffic, a crucial factor in urban transportation. The insights gained from this study illuminate the impact of vehicle types on air quality and highlight the potential of advanced traffic data integration for developing more effective urban air quality management strategies, underscoring the importance of targeted interventions based on vehicular behaviors and preferences.

Publications

1. Chen, Y.-Y., Y.-T. Hung, C.-T. Cheng, and **I-C. Tsai***, 2025: The interplay of regional urbanization and global climate warming in shaping fog patterns in Taiwan's mountainous area. (Accepted by J. Geophys. Res. Atmos.)
2. **Tsai, I-C.***, P.-R. Hsieh, C.-W. Lin, C.-C. Chou, C.-Y. Tu, C.-T. Cheng, and H.-H. Hsu, 2025: Integrated Assessment of Wind Energy's Emission and Meteorological Effects on PM_{2.5} in Taiwan. *Journal of Environmental Management*, 394, 2025, 127320, <https://doi.org/10.1016/j.jenvman.2025.127320>.
3. **Tsai, I-C.**, Chein-Jung Shiu, Cheng-An Chen, Huang-Hsiung Hsu, You-Yu Mao, and Wei-Chyung Wang, 2025: Investigating the Causes of Cloud Diurnal Variation Biases in Global Climate Models Using the TaiESM1. *Atmospheric Research*, 316, 107976. <https://doi.org/10.1016/j.atmosres.2025.107976>.
4. **Tsai, I-C.**, C.-W. Lin, S.-H. Su, C.-W. Chang, C.-W. Su, and S.-C. C. Lung, 2024: Spatial and Temporal Analysis of Scooter-Induced Traffic Patterns and Their Environmental Implications. *Atmospheric Environmental: X*, <https://doi.org/10.1016/j.aeaoa.2024.100291>
5. **Tsai, I-C.**, S.-W. Yang, C.-J. Shiu, Y.-Y. Chen, Chen-An Chen, W.-L. Lee, and H.-H. Hsu, 2024: Aerosol Impacts on the East Asian Winter Monsoon: Insights from TaiESM1 and CMIP6 Simulations. *International Journal of Climatology*, 44(9), 2816–2832. <https://doi.org/10.1002/joc.8483>
6. **Tsai, I-C.**, P.-R. Hsieh, H.-H. Hsu, Y.-S. Tung, Y.-M. Chen, and C.-T. Cheng, 2024: Climate Change-induced Impact on PM_{2.5} in Taiwan under 2 and 4 °C Global Warming. *Atmospheric*

Pollution Research, <https://doi.org/10.1016/j.apr.2024.102106>.

7. Wu, C.-H., S.-Y. Lee, **I-C. Tsai**, C.-J. Shiu, Y.-Y. Chen, 2023: Volcanic contribution to the 1990s North Pacific climate shift in winter. *Scientific Reports*, 13 (1), 5672.
8. Wu, C.-H., C.-J. Shiu, Y.-Y. Chen, **I-C. Tsai**, S.-Y. Lee, 2023: Climatological changes in East Asian winter monsoon circulation in a warmer future, *Atmospheric Research*, 284, 106593, <https://doi.org/10.1016/j.atmosres.2022.106593>.
9. **Tsai, I-C.***, P.-R. Hsieh, C.-T. Cheng, Y.-S. Tung, L.-Y. Lin and H.-H. Hsu, 2023: Impacts of 2 and 4 °C global warmings on extreme temperatures in Taiwan, *International Journal of Climatology*. 43(2), 702-719, <https://doi.org/10.1002/joc.7815>.
10. Chen, Y.-C., P.-H. Lin, W.-N. Chen, **I-C. Tsai**, S. Laplace, C.-C. Ting, C. Fu, Charles, C.-K. Chou, 2022: Decade long-term measurement for investigating vertical thermodynamic of urban boundary layer, *Urban Climate*, 46, 2022, 101301, <https://doi.org/10.1016/j.uclim.2022.101301>.
11. **Tsai, I-C.**, L.-S. Shu, J.-P. Chen, P.-R. Hsieh, and C.-T. Cheng, 2022: Projecting ozone impact on crop yield in Taiwan under climate warming, *Science of the Total Environment*, 846 (2022), 157437, <https://doi.org/10.1016/j.scitotenv.2022.157437>.
12. Lee, S.-Y., S.-C. C. Lung, P.-G. Chiu, W.-C. Wang, **I-C. Tsai**, T.-H. Lin, 2022: Northern hemisphere urban heat stress and associated labor hour hazard from ERA5 reanalysis. *Int. J. Environ. Res. Public Health*. 2022, 19, 8163. <https://doi.org/10.3390/ijerph19138163>
13. Su, S.-H., C.-W. Chang, **I-C. Tsai**, J.-L. Chu, Y.-L. Chen, and T.-S. Yo, 2022: Taiwan Atmospheric Event Database. <https://doi.org/10.17605/OSF.IO/4ZUTJ>
14. **Tsai, I-C.***, P.-R. Hsieh, H. C. Cheung, and C. C.-K. Chou, 2021: Aerosol impacts on fog microphysics over the western side of Taiwan Strait in April from 2015 to 2017, *Atmospheric Environment*, 118523, <https://doi.org/10.1016/j.atmosenv.2021.118523>.
15. **Tsai, I-C. ***, C.-Y. Lee, S.-C. C. Lung, C.-W. Su, 2021, Characterization of the vehicle emissions in the Greater Taipei Area through vision-based traffic analysis system and its impacts on urban air quality, *Science of the Total Environment*, 782(2021), 146571, ISSN 0048-9697, <https://doi.org/10.1016/j.scitotenv.2021.146571>.
16. Lee, W.-L., Y.-C. Wang, C.-J. Shiu, **I-C. Tsai**, C.-Y. Tu, Y.-Y. Lan, J.-P. Chen, H.-L. Pan, and H.-H. Hsu, 2020, Taiwan Earth System Model Version 1: description and evaluation of mean state, *Geosci. Model Dev.*, 13, 3887–3904, <https://doi.org/10.5194/gmd-13-3887-2020>.
17. Zhang, L., T.-M. Fu, H. Tian, Y. Ma, J.-P. Chen, T.-C. Tsai, **I-C. Tsai**, Z. Meng, X. Yang. 2020: Anthropogenic Aerosols Significantly Reduce Mesoscale Convective System Occurrences and Precipitation over Southern China in April, *Geophysical Research Letters*. 47, e2019GL086204. <https://doi.org/10.1029/2019GL086204>.
18. Wu, C.-H., **I-C. Tsai**, P.-C. Tsai and Y.-S. Tung, 2019, Large-Scale Seasonal Control of Air Quality in Taiwan, *Atmospheric Environment*, 214, 116868, [doi:https://doi.org/10.1016/j.atmosenv.2019.116868](https://doi.org/10.1016/j.atmosenv.2019.116868).
19. Huang C.-C., S.-H. Chen, Y.-C. Lin, K. Earl, T. Matsui, H.-H. Lee, **I-C. Tsai**, J.-P. Chen, C.-T. Cheng, 2019, Impacts of Dust-Radiation versus Dust-Cloud Interactions on the Development of a Modeled Mesoscale Convective System over North Africa. *Monthly Weather Review*, 147, 3301–3326, <https://doi.org/10.1175/mwr-d-18-0459.1>.

20. **Tsai, I-C.**, W.-Y. Chen, J.-P. Chen, and M.-C. Liang, 2019, Kinetic mass-transfer calculation of water isotope fractionation due to cloud microphysics in a regional meteorological model, *Atmos. Chem. Phys.*, 19, 1753-1766, <https://doi.org/10.5194/acp-19-1753-2019>.
21. Lung, S.-C., S.-W. Chou, J.-P. Chen, P.-C. Wen, H.-J. J. Su, **I-C. Tsai**, and Y.-S. Shen, 2018: Science Plan of “Climate Change and Health Adaptation”, *Journal of Taiwan Land Research*, 21, 2, 209-239 (in Chinese).
22. **Tsai, I-C.***, W.-C. Wang, H.-H. Hsu, and W.-L. Lee, 2016: Aerosol effects on summer monsoon over Asia during 1980s and 1990s, *J. Geophys. Res. Atmos.*, 121, 11761–11776, doi:10.1002/2016JD025388.
23. Chen, J.-P, I.-J. Chen and **I-C. Tsai**, 2016: Dynamic feedback of aerosol effect on the East Asian summer monsoon. *Journal of Climate*, 29(17):6137-6149.
24. Li, N., J.-P. Chen, **I-C. Tsai**, Q. He, S.-Y. Chi, Y.-C. Lin, and T.-M. Fu, 2016: Potential impacts of electric vehicles on air quality in Taiwan. *Science of the Total Environment*, 566-567(2016).
25. **Tsai, I-C.**, J.-P. Chen, C. S.-C. Lung, N. Li, W.-N. Chen, T.-M. Fu, C.-C. Chang, and G.-D. Hwang, 2015: Sources and formation pathways of organic aerosol in a subtropical metropolis during summer. *Atmospheric Environment*, 117, 51-60.
26. **Tsai, I-C.**, J.-P. Chen, Y.-C. Lin, C C.-K. Chou, and W.-N. Chen, 2015: Numerical investigation of the coagulation mixing between dust and hygroscopic aerosol particles and its impacts. *Journal of Geophysical Research: Atmospheres*, 120, 9, 4313-4233, doi:10.1002/2014JD022899.
27. Chen, J.-P., C.-E. Yang and **I-C. Tsai**, 2015: Estimation of foreign versus domestic contributions to Taiwan's air pollution. *Atmospheric Environment*, 112,9-19, doi:10.1016/j.atmosenv.2015.02.022
28. Lin, Y.-C., J.-P. Chen, T.-Y. Ho and **I-C. Tsai**, 2015: Atmospheric Iron deposition in the Northwestern Pacific Ocean and its Adjacent Marginal Seas: the Importance of Coal Burning. *Global Biogeochemical Cycles*, 29, 139–159, doi:10.1002/2013GB004795.
29. Chen, J.-P., **I-C. Tsai**, and Y.-C. Lin, 2013: A statistical–numerical aerosol parameterization scheme, *Atmos. Chem. Phys.*, 13, 10483-10504, doi:10.5194/acp-13-10483-2013.
30. **Tsai, I-C.**, M.-C. Liang, and J.-P. Chen, 2012: Methane-Nitrogen binary nucleation: a new microphysical mechanism for cloud formation in Titan's atmosphere. *Astrophys. J.*, 747.
31. **Tsai, I-C.**, J.-P. Chen, P.-Y. Lin, W.-C. Wang and I. S. A. Isaksen, 2010: Sulfur cycle and sulfate radiative forcing simulated from a coupled global climate-chemistry model. *Atmos. Chem. Phys.*, 10, 3693-3709.
32. Chen, J.-P., Z. Wang, C.-Y. Young, F. Tsai, **I-C. Tsai**, G.-J. Wang, W.-C. Shieh, H.-W. Lin, J.-Y. Huang, and M.-J. Lu, 2004: Simulations of Asian Yellow Dust Incursion Over Taiwan for the Spring of 2002 and 2003, *Terrest. Atmos. Ocean. Vol 15*, No. 5, 949-981.

Book and Chapter in Book

1. Wang, W.-C., J.-P. Chen, I. S. A. Isaksen, **I-C. Tsai**, K. Noone and K. McGuffie, 2012: Climate-chemistry interaction: Future tropospheric ozone and aerosol. In A. Henderson-Sellers and K. McGuffie (eds): *The Future of the World's Climate*. World Survey of Climatology series, Elsevier Science, ISBN: 978-0-12-386917-3, pp. 367-399. (2012 ASLI Choice Award)

2. Chen, J.-P., A. Hazra, C.-J. Shiu, **I-C. Tsai**, and H.-H. Lee, 2008: Interaction between aerosols and clouds: current understanding. In Liou, K.-N., M.-D. Chou and H.-H. Hsu (eds.): *Recent Progress in Atmospheric Sciences: Application to the Asia-Pacific Region*. World Scientific, ISBN-13 978-981-281-890-4, QC861.3.R43, pp. 231-281.