

Mukesh Rai

RESEARCH ASSOCIATE

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Experience

Baylor University

USA

RESEARCH ASSOCIATE

Aug. 2025 - Present

- Developed the Process-Based On-Road Emissions for California (POREC) dataset, creating a high-resolution (1 km × 1 km, hourly) inventory that explicitly isolates non-exhaust brake and tire wear (BTW) alongside exhaust and evaporative emissions.
- Coupled CARB's EMFAC and ESTA models to spatially allocate county-level emissions across grid cells using seven surrogates and perform chemical speciation on BTW particles for atmospheric transport modeling.

NASA-Jet Propulsion Laboratory/Caltech

USA

POSTDOCTORAL FELLOW

Jan. 2023 - May. 2025

- Adapted the water vapor atmospheric river detection algorithm to develop the Trace Gas Atmospheric River (TGAR) algorithm, quantifying extreme long-range transport pathways of key trace gases including CO, tropospheric ozone, and peroxyacetyl nitrate (PAN).
- Identified the intensity and frequency of major TGAR transport pathways globally, quantifying their contributions to air quality degradation in megacities.
- Collaborated with a research scientist, engineer, state, and local-level authority while performing algorithm automation and optimization; data validation obtained from assimilation system, satellite data (i.e., Cross-track Infrared Sounder (CrIS) instrument, and in-situ observation.

The International Centre for Integrated Mountain Development (ICIMOD)

Nepal

AIR QUALITY MODELER

Sep. 2022 - Dec. 2022

- Supported incorporating NASA/SERVIR Hindu Kush Himalaya project air quality model and satellite products in the atmospheric watch initiative (AWI) program.
- Validated transport models (WRF-Chem and GEOS-Chem) model outputs against TROPOMI satellite and ground-based observations for trace gases (SO₂, NO₂, CO) and particulate matter (PM, Black Carbon).

ICIMOD

Nepal

RESEARCH ASSISTANT

Oct. 2017 - Mar. 2018

- Organized and contributed to a workshop on Science Policy Dialogue: Air Pollution, Climate, and Health in South Asia and the Hindu Kush Himalaya.
- Contributed to the establishment of a high-altitude real-time measurement black carbon observation station in the Himalayas.
- Used real-time black carbon data to study source and sink study and radiative forcing

Education

Department of Geography, University of Chinese Academy of Sciences

China

PH.D. IN ATMOSPHERIC PHYSICS AND ATMOSPHERIC ENVIRONMENT

Sep. 2018 - May 2022

- Tracing atmospheric aerosol distribution, transport mechanism, and their radiative effects over Third Pole region using WRF-Chem simulation

Department of Environmental Science And Engineering [DESE], Kathmandu University

Nepal

M.S BY RESEARCH IN GLACIOLOGY

Sep. 2015 - Aug. 2017

- Aerosol radiative forcing estimation over a remote high-altitude location (4900 masl) near yala glacier, Nepal

Center Department of Environmental Science [CDES], Tribhuvan University

Nepal

MASTER IN ENVIRONMENTAL SCIENCE

Feb. 2011 - Jan. 2013

- Climate Change and air pollution control

Skills

Programming

Python, Matlab, bash script

Models/Tools

WRF-Chem, HYSPLIT, SBDART, OPAC, ArcGIS, MOVES, EMFAC, ESTA, SMOKE, MySQL, $\LaTeX$

Others

Linux, Github, High-performance computing, Satellite data, automation, and optimization

Honors & Awards

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|------|---|-------|
| 2022 | NASA-JPL/Caltech, Postdoctoral Fellow | U.S.A |
| 2018 | CAS-TWAS Presidents Fellowship, Ph.D | China |
| 2015 | Cryospheric Monitoring Project, ICIMOD, M.S grant | Nepal |
| 2012 | SEAM-Nepal, Master thesis grant | Nepal |

Membership & Community Services

MEMBERSHIP

- 2026 **The American Geophysical Union**, General Member
- 2010 **Greenhood Nepal**, Team Member

U.S.A
Nepal

COMMUNITY SERVICES

- 2026 **Public Training**, Participate in Portal to Public Training
- 2024 **Panelist Reviewer**, NASA FINESST23 Earth: Air Quality Modeling and Impacts
- 2023 **JPL Exploreer**, Volunteering
- 2015 **Seed to Feed Campaign**, Organized the campaign after the 2015 earthquake

U.S.A
U.S.A
U.S.A
Nepal

Presentation

American Geophysical Union 2024

Washington DC

PRESENTER FOR <AMERICAN GEOPHYSICAL UNION 2024>

Dec 9-13, 2024

- Exploring the role of trace gas atmospheric rivers in extreme air pollution events: Case studies illustrated using TROPES-CrIS products and TCR-2 reanalysis

NASA/AIRS Sounder Meeting

Pasadena, CA

PRESENTER FOR <NASA JOINT AIRS/SOUNDER SCIENCE TEAM MEETING 2024>

Sept 24-June 27, 2024

- Long-range pollution transport and air quality events in Los Angeles: Case studies illustrated using TROPES-CrIS products and TCR-2 reanalysis

NASA Health and Air Quality Applied Sciences Team

MIT - Cambridge, MA

PRESENTER FOR <NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM>

June 3-June 5, 2024

- Poster presentation on exploring the role of atmospheric rivers in extreme air pollution events

104th American Meteorological Society 2024

Baltimore USA

PRESENTER FOR <ATMOSPHERIC COMPOSITION MODELING AND ANALYSIS PROGRAM (ACMAP)>

Jan 28-Feb 01, 2024

- Poster presentation on Trace Gas Atmospheric Rivers: Remote Drivers of Air pollutants

American Geophysical Union 2023

San Francisco USA

PRESENTER FOR <ADVANCES IN THE INTEGRATED GLOBAL OBSERVING SYSTEM FOR AIR QUALITY: SCIENCE AND SOCIETAL BENEFIT>

11, Dec, 2023

- Oral presentation on Trace Gas Atmospheric Rivers: Remote Drivers of Air pollutants

Jet Propulsion Laboratory Postdoc research day 2023

Pasadena, CA, USA

PRESENTER FOR <RESEARCH POSTER DAY 2023>

29, Nov, 2023

- Presented results from my first project on trace gas atmospheric river

International Conference on Mountain and Hydrology and Cryosphere

Kathmandu, Nepal

CONVENER FOR <IAHS CONFERENCE>

09-10, Nov, 2023

- Session chaired on Mountain Hydrology

NASA joint AIRS Sounder Science team meeting 2023

Maryland, USA

PRESENTER FOR <TRACE GAS ATMOSPHERIC RIVERS: REMOTE DRIVERS OF AIR POLLUTANTS>

03-07, Oct, 2023

- Presented on trace gas atmospheric river pollution transport

Meteorology and Climate - Modeling for Air Quality Conference (MAC-MAQ)

UC Davis, USA

PRESENTER FOR <TRACE GAS ATMOSPHERIC RIVERS: REMOTE DRIVERS OF AIR POLLUTANTS>

13-15, Sep, 2023

- Presented lightning talk about the trace gas atmospheric river pollution transport

Atmospheric Composition and the Asian Monsoon (ACAM)

Virtual

PRESENTER FOR <ATMOSPHERIC CHEMISTRY AND AEROSOLS IN THE ASIAN MONSOON REGION USING SATELLITE AND MODEL DATA>

22 Oct. 2021

- Presented on aerosol-climate feedback on regional study

4th Congress of China geodesy and geophysics

Qingdao, China

PRESENTER FOR <MARITIME SILK ROAD AND EARTH SYSTEM SCIENCES>

24 Jul. 2020

- Presented synoptic scale study on trans-boundary air pollution and its driving mechanism

International forum hosted by ICIMOD

Kathmandu, Nepal

PRESENTER FOR <INTERNATIONAL FORUM ON THE CRYOSPHERE AND SOCIETY THE VOICE OF THE HINDU KUSH HIMALAYA>

28-30. Aug. 2019

- Introduced the results on how pollution may impact on cryospheric body and society

1. **Rai, M.**, Kang, S., Yang, J., Chen, X., Hu, Y., & Rupakheti, D. (2022). Tracing atmospheric anthropogenic black carbon and its potential radiative response over the Pan-Third Pole region: A synoptic-scale analysis using WRF-chem. *Journal of Geophysical Research-Atmosphere*, 127, e2021JD035772. <https://doi.org/10.1029/2021JD035772>
 2. **Rai, M.**, Mahapatra, P. S., Gul, C., Kayastha, R. B., Panday, A. K., & Puppala, S. P. (2019). Aerosol radiative forcing estimation over a remote high-altitude location (4900 masl) near yala glacier, nepal. *Aerosol and Air Quality Research*, 19(8), 1872–1891. <https://doi.org/10.4209/aaqr.2018.09.0342>
 3. **Rai, M.**, Kang, S., Yang, J., Rupakheti, M., Rupakheti, D., Tripathi, L., , Hu, Y. Chen (2022). Insight into seasonal aerosol concentrations, meteorological influence, and transport over the Pan-Third Pole region using multi-sensor satellite and model simulation. *Atmospheric Chemistry and Physics Discussion*, 2022, 1–36. <https://doi.org/10.5194/acp-2022-199>
 4. Yang, J., Kang, S., Chen, D., Zhao, L., Ji, Z., Duan, K., Deng, H., Tripathi, L., Du, W., **Rai, M.**, Yan, F., Li, Y., Gillies, R.R (2022), South Asian black carbon is threatening the water sustainability of the Asian Water Tower. *Nature Communication*. 13, 7360. <https://doi.org/10.1038/s41467-022-35128-1>
 5. Hu, Y., Yu, H., Kang, S., Yang, J., **Rai, M.**, Yin, X., Chen, X., and Chen, P. (2024). Aerosol-meteorology feedback diminishes the trans-boundary transport of black carbon into the Tibetan Plateau. 2024. *Atmospheric Chemistry and Physics*. <https://doi.org/10.5194/acp-24-85-2024>
 6. Li, C., Zhang, C., Kang, S., Hu, Y., Yang, F., Liu, Y., **Rai, M.**, Zhang, H., Chen, P., Wang, P., He, C., Wang, S., Slim transport of atmospheric organic carbon into Tibet from South Asia in monsoon season (2024). *Science of The Total Environment*. <https://doi.org/10.1016/j.scitotenv.2024.171321>
 7. Rupakheti, D., Rupakheti, M., **Rai, M.**, Yu, X., Yin, X., Kang, S., Orozaliyev, D.O., Sinyakov, Sinyakov, V.P., Abdullaev, S.F., Sulaymon, I.D., & Hu, J., (2022) Spatio-temporal characteristics of air pollutants over Xinjiang, northwestern China. *Environmental Pollution* 316: 115907. <https://doi.org/10.1016/j.envpol.2022.120501>
 8. Yang, J., Kang, S., Hu, Y., Chen, X., **Rai, M.** (2022). Influence of South Asian Biomass Burning on Ozone and Aerosol Concentrations Over the Tibetan Plateau. *Advances in Atmospheric Sciences* 10(1007): <https://doi.org/10.1007/s00376-022-1197-0>
 9. Rupakheti, D., Aculinin, A., Rupakheti, M., Dahal, S., **Rai, M.**, Yin, X., Yu, X., Abdullaev, SF, Hu, J. (2023). Insights on aerosol properties using two decades-long ground-based remote sensing datasets in Moldova, Eastern Europe. *Environmental Pollution*. <https://doi.org/10.1016/j.envpol.2023.122535>
 10. Hu, Y., Kang, S., Yang, J., Chen, X., Ji, Z., & **Rai, M.** (2022). Transport of black carbon from Central and West Asia to the Tibetan Plateau: Seasonality and climate effect. *Atmospheric Research* 809: 151095. <https://doi.org/10.1016/j.atmosres.2021.105987>
 11. Chen, P., Kang, S., Hu, Y., Pu, T., Liu, Y., Wang, S., **Rai, M.**, Wang, K., Li, C., 2024. South and Southeast Asia controls black carbon characteristics of Meili Snow Mountains in southeast Tibetan Plateau. *Science of The Total Environment* 14: 172262. <https://doi.org/10.1016/j.scitotenv.2024.172262>
 12. Regmi, J., Poudyal, K.N., Pokhrel, A., Malakar, N., Gyawali, M., Tripathi, L., **Rai, M.**, Ramachandran, S., Wilson, K., Aryal, R. (2023). "Analysis of Surface Level PM2.5 Measured by Low-Cost Sensor and Satellite-Based Column Aerosol Optical Depth (AOD) over Kathmandu." *Aerosol and Air Quality Research* 23: 1. <https://doi.org/10.4209/aaqr.220311>
 13. Yang, J., Kang, S., Hu, Y., Chen, X., **Rai, M.** (2023). "Springtime biomass burning impacts air quality and climate over the Tibetan Plateau". *Atmospheric Environment*. <https://doi.org/10.1016/j.atmosenv.2023.120068>
 14. Mehra, M., Shrestha, S., AP, Krishnakumar, Guagenti, M., Moffett, CE., VerPloeg, Coogan, MA., **Rai, M.**, Kumar, R., Andrews, E., Sherman JP, Flynn III, JH., Usenko, S., Sheesley. (2023). "Atmospheric heating in the US from saharan dust: Tracking the June 2020 event with surface and satellite observations". *Atmospheric Environment*. 310:119988. <https://doi.org/10.1016/j.atmosenv.2023.119988>
 15. Chen, P., Kang, S., Li, C., Hu, Z., Tripathi, L., **Rai, M.**, Pu, T., Yin, X., Gustafsson, Ö., 2022. Carbonaceous aerosol transport from the Indo-Gangetic Plain to the Himalayas: Carbon isotope evidence and light absorption characteristics. *Geoscience Frontiers* 14: 101516. <https://doi.org/10.1016/j.gsf.2022.101516>
 16. Dhital, Y.P., Tang, J., Pokharel, A.K., Tang, Q., **Rai, M.** (2022). Impact of aerosol concentration on elevation-dependent warming pattern in the mountains of Nepal. *Atmospheric Science Letter*. <https://doi.org/10.1002/asl.1101>
- Yang, M., Zhongqin, L., Anjum, M. N., Kayastha, R., Kayastha, R. B., **Rai, M.**, Chunhai, X. (2022). Projection of Streamflow Changes Under CMIP6 Scenarios in the Urumqi River Head Watershed, Tianshan Mountain, China. *Frontiers in Earth Science*. 809: 151095. <https://doi.org/10.3389/feart.2022.857854>
17. Li, C., Yan, F., Zhang, C., Kang, S., **Rai, M.**, Zhang, H., & He, C (2022). Spatio-temporal characteristics of air pollutants over Xinjiang, northwestern China. *Science of the Total Environment*. 809: 151095. <https://doi.org/10.1016/j.scitotenv.2021.151095>
 18. Rupakheti, D., Yin, X., Rupakheti, M., Zhang, Q., Li, P., **Rai, M.**, & Kang, S. (2021). Spatio-temporal characteristics of air pollutants over Xinjiang, northwestern China. *Environmental Pollution*. 268: 115907. <https://doi.org/10.1016/j.envpol.2020.115907>

19. Maharjan, L., Kang, S., Tripathee, L., Gul, C., Zheng, H., Li, Q., **Rai, M.**, & Santos, E. Atmospheric particle-bound polycyclic aromatic compounds over two distinct sites in Pakistan: Characteristics, sources and health risk assessment. *Journal of Environmental Science* 112: 1-15. <https://doi.org/10.1016/j.jes.2021.04.024>
20. Rupakheti, D., Rupakheti, M., Yin, X., Hofer, J., **Rai, M.**, Hu, Y. & Kang, S. (2021). Spatio-temporal characteristics of air pollutants over Xinjiang, northwestern China. *Geoscience Frontier* 12:101251. <https://doi.org/10.1016/j.gsf.2021.101251>
21. Neupane, B., Wang, J., Kang, S., Zhang, Y., Chen, P., **Rai, M.**, & Thapa, P. (2021). Black carbon and mercury in the surface sediments of Selin Co, central Tibetan Plateau: Covariation with total carbon. *Science of the Total Environment* 19: 1872-1891. <https://doi.org/10.1016/j.scitotenv.2020.137752>
22. Gul, C., Mahapatra, P.S., Kang, S., Singh, P.K., Wu, X., He, C., Kumar, R., **Rai, M.**, Xu, Y. and Puppala, S.P. (2021). Black carbon concentration in the central Himalayas: Impact on glacier melt and potential source contribution. *Environmental Pollution* 275: 116544. <https://doi.org/10.1016/j.envpol.2021.116544>

SUBMITTED ARTICLE

1. **Rai, M.**, Miyazaki, K., Payne, V., Guan, B., Waliser, D. (2025). Trace gas atmospheric rivers: remote drivers of air pollutants. doi:10.5194/egusphere-2025-399.
2. Neupane, B., Thapa, P., Meadows, M.E., Li, S., **Rai, M.**, Liu, T., Zhang, F., Chen, Minqi., Bao, K. Historical mercury deposition, sources, and ecological risk in a coastal mangrove wetland, southern China, 2026
3. Bhattarai, H., Tripathee, L., Ying, Q., Chen, P., Kang, S., Wu, G., Pani, S.K., **Rai, M.**. Water-soluble brown carbon in fine aerosols over the highly polluted Indo-Gangetic Plain: Chemical compositions, optical properties, and sources, 2026

BOOK CHAPTER

1. Tripathee, L., Gul, C., Kang, S., Chen, P., Huang, J., **Rai, M.** (2021). Transport Mechanisms, Potential Sources, and Radiative Impacts of Black Carbon Aerosols on the Himalayas and Tibetan Plateau Glaciers. In: Tiwari, S., Saxena, P. (eds) *Air Pollution and Its Complications*. Springer Atmospheric Sciences. Springer, Cham. https://doi.org/10.1007/978-3-030-70509-1_2.
2. **Rai, M.**, Tiwari, P., Jaisawal, N., Das, C.N. (2026). Atmospheric Composition: Carbon Monoxide, Ozone, and Water Vapor Sources, Trends, and Climate Impacts. *Encyclopedia of Climate System Science*. Elsevier. (In Press)

REPORT

1. **Rai, M.**, Li, Yang (2026). Generating and Characterizing On-Road Emissions in California: Comparative Analysis of MOVES and EMFAC for Air Quality. Baylor University.