RUBEL CHANDRA DAS, Ph.D.

Mechanical Engineering | Computational Fluid Dynamics | HPC Solver Development | Thermo-Fluids | Turbulence | Transport Modeling | Scientific Software | Model–Measurement Integration

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Professional Summary

Mechanical engineer and computational thermo-fluid researcher with Ph.D., M.Sc., and B.Sc. training in Mechanical Engineering and specialized expertise in high-fidelity CFD, turbulence, thermo-fluids, heat/mass transfer, numerical methods, HPC scientific software, verification/validation, uncertainty-aware modeling, and model–measurement integration. My technical background directly supports research and development-fluids, heat/mass transfer, numerical methods, HPC scientific software, verification/validation, uncertainty-aware modeling, and model–measurement integration. My technical work involving physics-based computational modeling of complex transport problems across aerospace, environmental, energy, and thermal-fluid systems.

I developed and validated a research-grade, massively parallel DNS/LES solver in C/MPI (~30,000 lines) for wind-farm wakes, wall-bounded turbulence, atmospheric-boundary-layer-type flows, and internal thermo-fluid transport. This work included solver architecture, turbulence modeling, boundary-condition implementation, domain decomposition, MPI communication, parallel I/O, grid/time-step refinement, benchmark and experimental validation, and large-scale simulation campaigns. I also bring experience in thermal-hydraulics/corrosion-relevant modeling, Fortran-based CFD development in Incompact3D, HPC benchmarking/scalability, Python-based scientific data pipelines, OpenMP/CUDA, and ongoing work in node-centered, edge-based finite-volume methods on unstructured grids.

In my current postdoctoral role at the National Institute of Aerospace, in collaboration with NASA Langley, I apply this computational thermo-fluid, transport-equation, V&V, uncertainty-aware, and reproducible-computing background to aerospace and environmental transport research. My work includes HAPS/balloon trajectory modeling, wildfire/pyroCb smoke transport, volcanic aerosol plume evolution, UTLS/stratospheric transport, SAGE III/ISS retrieval and classification algorithm development, NASA Disasters geospatial products, and multi-sensor model–measurement integration using satellite, balloon/in-situ, model, and reanalysis datasets. This experience supports my qualifications for specialized research duties involving CFD/numerical methods, atmospheric and aerospace transport modeling, HPC scientific software, verification/validation, and model–measurement integration.

Research Expertise and Core Capabilities

CFD, Numerics, and Solver Development: DNS/LES/RANS; FVM/FDM/FEM; compressible and incompressible flows; turbulence modeling; solver implementation; structured and unstructured-grid methods, including node-centered, edge-based finite-volume methods.

Turbulence, Wakes, Transition, and Flow Control: Wall-bounded turbulence; atmospheric-boundary-layer flows; boundary-layer transition, stability, and control-theoretic flow-control concepts; coherent wake structures; turbine modeling; wind-turbine/wind-farm wakes; yaw control; wake recovery; layout/inflow sensitivity; power/performance trends; and validation against wind-farm wind-tunnel measurements.

Verification, Validation, and Uncertainty Quantification: CFD and transport-model credibility through canonical benchmarks, wind-tunnel

High-Fidelity CFD/HPC Implementation: Developed and validated a research-grade C/MPI DNS/LES solver (~30,000 lines) for turbulent wakes, wall-bounded flows, atmospheric-boundary-layer-like simulations, wind-farm arrays, and internal thermo-fluid transport; experience includes solver architecture, domain decomposition, MPI communication, halo/ghost exchange concepts, turbulence closures, parallel I/O, restart workflows, post-processing, and large LES campaigns.

HPC Scientific Software and Reproducible Workflows: C/C++, Fortran, Python, MATLAB, MPI, OpenMP, CUDA, Linux clusters, Slurm/PBS, profiling/scaling, compiler/MPI environments, memory management, parallel I/O, scientific data formats, scalable data-analysis workflows, workflow automation, traceable data-processing workflows, version control, automated post-processing,

validation, model-experiment comparison, grid/time-step studies, convergence checks, sensitivity analysis, uncertainty-aware interpretation, traceable inputs-to-results workflows, and defensible simulation-to-evidence reasoning.

Multiphysics Software: COMSOL Multiphysics, ANSYS Fluent, STAR-CCM+, WRF, GEOS-Chem.

Aerospace/Environmental Transport as Applied Thermo-Fluids: Conservation-law and transport-equation analysis of buoyant plume rise, lofting, entrainment, stratified mixing, aerosol sedimentation/growth, long-range advection/dispersion, residence time, vertical exchange, UTLS/stratospheric transport, pyroCb smoke, volcanic aerosols, dust/plume events.

Model-Measurement Integration: Fuse observations with transport models to support aerosol/plume transport studies.

Data-Driven Modeling and AI/ML: Applied AI/ML and statistical modeling to engineering, CFD, and observational datasets, including preprocessing, feature engineering, regression/classification, SVMs, Gaussian-process models, PCA, scikit-learn/MATLAB/PyTorch workflows, cross-validation, hyperparameter tuning, uncertainty-aware prediction, surrogate/ROM development, and physics-informed feature engineering for thermo-fluid and transport applications.

Mechanical Engineering Breadth: Mechanics, FEA, machine design, CAD/SolidWorks/AutoCAD, materials, manufacturing/process improvement, instrumentation/DAQ, controls/mechatronics, experimental systems, thermal-conductivity measurement, automated sensing/actuation projects, and practical engineering design/fabrication.

publication-quality visualization, and reproducible simulation/data pipelines.

Thermo-Fluids, Heat/Mass Transfer, and Energy Systems: Thermal boundary layers; turbulent convection; internal pipe/duct flows; coupled momentum-heat-species transport; heat/mass transfer; thermal-hydraulics; cooling/corrosion-relevant transport; liquid-metal/lead-loop modeling; experimental heat-transfer and instrumentation foundations.

Postdoctoral NASA/NIA Modeling and Mission Support: LaTM/HYSPLIT forward/back-trajectory modeling; HAPS and scientific balloon campaign support; INSPYRE/BalNeO/BATAL/BRAVO-related analysis; pre-event forecasting; in-flight/near-real-time guidance where applicable; post-event reconstruction; NASA Disasters support; GIS-ready products; uncertainty-aware mission/hazard decision support.

Remote Sensing Retrievals and Algorithm Development: Develop/test Level-1 to Level-2-type aerosol/extinction retrieval workflows and aerosol-cloud/species discrimination methods using multi-wavelength extinction, extinction ratios, QA/QC, collocation, and multi-sensor checks.

Research Communication, Mentoring, and Funding Readiness: NASA/NIA funded deliverables; ROSES/INSPYRE-style proposal-team contributions; Co-I/researcher roles; DOE-affiliated project experience; manuscripts; conference presentations; publication-quality figures; technical reports; stakeholder-facing briefs; interdisciplinary collaboration; student mentoring; teaching-ready translation of CFD/transport workflows.

Education

Ph.D., Mechanical Engineering, University of New Mexico (UNM), Albuquerque, NM — *May 2024*
(Degree conferred May 2024; all requirements completed Dec 2023)
Dissertation: *Wind Farm Optimization and Analysis of Complex Wake Structures*
Supervisors: Prof. Yu-Lin Shen and Prof. Sang Lee | GPA: **3.97/4.00**
Focus: DNS/LES solver development, HPC parallelization, atmospheric boundary layer and wind-farm interactions, turbulence modeling, validation against experiments

M.Sc., Mechanical Engineering, Bangladesh University of Engineering & Technology, Dhaka — *May 2018*
(Result published May 2018; all requirements completed Aug 2017)
Thesis: *Multi-Scale Analysis of Turbulent Thermal Boundary Layers with Zero Pressure Gradient*
Focus: Wall-bounded turbulence, RANS modeling, heat and momentum transport

B.Sc., Mechanical Engineering, Bangladesh University of Engineering & Technology, Dhaka — *Sept 2015*
Thesis: *Design and Construction of a Thermal Conductivity Measurement Setup for Insulating Materials*
Focus: Experimental heat transfer, instrumentation, system design, thermal–fluid sciences.

Professional Appointments

Postdoctoral Research Scholar, National Institute of Aerospace (NIA), VA — *Jan 2024–Present*

➢ **Thermo-fluids transport & dispersion modeling (NASA Langley; environmental & aerospace flows):** Multi-scale modeling of plume rise/lofting, stratified transport, mixing/entrainment, and long-range aerosol dispersion/persistence (PyroCb smoke, volcanic plumes, dust, UTLS/stratospheric aerosols/ATAL) using validated Eulerian–Lagrangian frameworks, conservation laws, and control-volume/energy-balance diagnostics.

➢ **CFD/numerical-methods extension:** Conducting ongoing **CFD** code-development research on node-centered, edge-based finite-volume methods for unstructured grids.

➢ **CFD skill-building & continuum-mechanics extension (transport-focused):** Transfer **CFD** rigor to atmospheric dispersion via budget-style diagnostics (advection–diffusion + sources/sinks), discretization/assumption-aware sensitivity checks, and numerics-informed physical interpretation for decision-relevant conclusions.

➢ **Verification/validation mindset + quality engineering (model–data credibility):** Apply engineering-grade QA/QC (flags, unit/consistency checks, sensitivity tests, traceability, reproducibility) and first-order uncertainty/error analysis to deliver defensible model–data inference aligned with thermo-fluids **CFD**/experimental V&V and safety-margin thinking.

➢ **Trajectory modeling & operational mission support (LaTM/HYSPLIT; HAPS & balloon campaigns):** Build and operate ensemble forward/back-trajectory pipelines (NASA LaTM, HYSPLIT) for HAPS/balloon campaigns (INSPYRE, BalNeO, BATAL, BRAVO), providing forecasts, in-flight updates, and reconstructions; convert winds/shear/stability/dispersion envelopes into uncertainty-aware, risk-informed guidance for mission design and sampling/operations.

➢ **Model–measurement integration (multi-sensor, multi-platform):** Fuse trajectory/transport interpretation with satellite + in-situ/balloon observations and meteorological reanalysis to create traceable, analysis-ready datasets for event reconstruction and climatology, using cross-validation/compositing and vertical/transport diagnostics (injection height, layer thickness, persistence, pathway statistics) with uncertainty-aware interpretation.

➢ **Remote-sensing retrieval/algorithm development & aerosol–cloud classification (SAGE III/ISS Science Team):** Develop/evaluate aerosol–cloud discrimination/clearing and classification with robust QA/QC and uncertainty characterization; run multi-sensor consistency checks and quantify how screening/clearing choices affect derived aerosol/transport metrics, supporting science-team products and publication-ready analyses. Develop Level-1 to Level-2 retrieval/inversion workflows.

➢ **Extreme-event case studies → event-to-climatology analytics:** Analyze major volcanic/wildfire plume events and extend to climatologies to quantify variability, anomalies, persistence, and pathways; diagnose injection/lofting, mixing/stratification, sedimentation, and impacts on UTLS/stratospheric aerosol loading, translating spatiotemporal complexity into interpretable, publication-ready metrics for intercomparison/model assessment.

➢ **Hazard products, coordination & response support (NASA Disasters Program):** Deliver rapid-response, GIS-ready hazard products and interpretation during events; coordinate with partners/ground contacts to align outputs with operational needs, enable rapid dissemination, and capture lessons learned for workflow improvement.

➢ **Reproducible scientific software + HPC data pipelines:** Engineer scalable, version-controlled Python/HPC workflows for large NetCDF/HDF and legacy archives; automate processing/visualization, debug numerical/I/O issues, and maintain end-to-end traceability from raw inputs to publication-quality figures/results with QA/QC.

➢ **Multi-model transport interpretation:** Use working familiarity with **WRF** and **GEOS/GEOS-Chem** to interpret species transport across PBL–UTLS/stratosphere regimes, with attention to physical mechanisms, assumptions, limitations, and uncertainty.

➢ **ML-ready datasets & data-enabled modeling (surrogates/AI-ready; uncertainty-aware):** Curate labeled ensembles and feature tables into ML-ready datasets for clustering/classification, regression, and surrogate/reduced-order/physics-guided ML, with uncertainty-aware evaluation, documented provenance, and reproducible benchmarking.

➢ **Funded research, proposal development & collaborations:** Contribute to funded deliverables/manuscripts and ROSES-style proposal/reporting cycles (science framing, workflow design, preliminary analyses) in cross-institution teams (NASA Langley, NIA, NRL, university partners) delivering integrated observation–model–data products.

➢ **Research mentoring and teaching translation:** Mentor graduate and undergraduate researchers in transport modeling, scientific Python, reproducible data workflows, uncertainty-aware analysis, and research communication; translate NASA/NIA model–measurement workflows into teaching-ready datasets, notebooks, and modules for thermo-fluids, **CFD**/numerical methods, validation, and engineering data analysis.

Graduate Research Assistant, Department of Mechanical Engineering, UNM — *Aug 2017–Dec 2023*

➢ **High-fidelity solver development & numerics for thermal-fluid science (HPC CFD):** Developed a research-grade, ~30k-LOC massively parallel DNS/LES code in C/MPI (domain decomposition, halo/ghost exchange, scalable parallel I/O) with modular numerics/turbulence options for wall-bounded turbulence and atmospheric boundary-layer flows; maintained verification-minded, reproducible workflows suitable for multi-user research and externally funded deliverables.

➢ **Wind-farm wakes, yaw control & energy optimization (renewables-focused thermo-fluids):** Performed turbulence-resolving LES of wind-turbine arrays using actuator-based models (ADM/actuator disk); implemented yaw-control and layout/inflow variations; quantified wake interactions/recovery and array power/efficiency trends, linking turbulent-flow physics to control/design trade-offs for energy systems.

➢ **Experimental validation: compared miniature-scale wind-farm simulations using actuator-disk methods against EPFL wind-tunnel data (Chamorro & Porte-Agel):** Validated actuator-based wake/array predictions against EPFL miniature wind-farm measurements, emphasizing defensible model–data comparison, scaling awareness, and uncertainty-informed interpretation.

➢ **Turbulent heat transfer, internal flows & cooling systems (thermal management + energy systems):** Built an axisymmetric/cylindrical-coordinate pipe-flow solver for coupled heat + species transport and developed verification-style post-processing for friction/pressure-drop and heat-transfer (e.g., Nusselt/HTC) diagnostics; extended analysis capability toward thermal-management/cooling-system problems and related datasets/materials used in presentations and collaboration.

➢ **Verification, validation & uncertainty (VVUQ; model–data reasoning):** Benchmarked against canonical turbulence/heat-transfer cases; executed grid/time-step sensitivity and convergence checks; performed uncertainty/sensitivity analyses to bound key outputs (pressure drop, heat-transfer metrics, power/efficiency proxies) and support decision-relevant conclusions.

➢ **HPC performance, scalability & scientific software engineering:** Improved throughput and robustness via MPI tuning, profiling-driven optimization, load-balancing considerations, and campaign management on HPC systems; strengthened software practices (Git/version control, documented configs, traceable runs, reproducible post-processing, regression-style checks where appropriate).

➢ **Parametric studies, optimization mindset & ML-ready datasets (data-driven modeling foundation):** Designed systematic simulation campaigns (yaw, layout, inflow, Reynolds number, thermal/flow parameters) and curated structured outputs to enable sensitivity analysis, optimization thinking, and reduced-order/surrogate/AI-ready dataset creation.

➢ **Nuclear-thermal-hydraulics-adjacent project (DOE lead-loop; NURETH 2019):** Contributed to a DOE-affiliated lead-loop modeling effort on flow-accelerated corrosion with thermal-hydraulics coupling; co-authored and presented results at **NURETH (2019)**, supporting safety-oriented transport/thermal analysis framing.

➢ **Open-source CFD code development:** Implemented wind-turbine modeling features in **Incompact3D** (Fortran; 2D pencil decomposition) and gained cross-code development/testing perspective (including **REEF3D** workflow and related numerical-analysis coding), strengthening portability and validation instincts, also familiarity with OpenFOAM.

➢ **CFD mentoring and instructional translation:** Mentored graduate and undergraduate researchers in CFD workflows, solver/code development, verification, post-processing, and technical communication; translated solver-validation and internal-flow studies into reusable teaching-scale cases and mini-projects connecting hand analysis, CFD, and benchmark/experimental comparison.

Graduate Research Assistant, Center for Advanced Research Computing — *Jan 2018–Jul 2018*

➢ **HPC support, scalability, and reproducible research computing:** Supported researchers running CFD, FEA, and data-intensive workloads on HPC systems by troubleshooting batch jobs, modules, MPI/compiler environments, and I/O issues; conducted benchmarking and profiling, advised on MPI/OpenMP layouts and resource requests, and developed reusable job-script templates, documentation, and run checklists for reliable, portable, and repeatable simulation campaigns.

Graduate Teaching Assistant – Mechanical Engineering, UNM — Aug 2017–Dec 2021

➢ Supported instruction in Thermodynamics, Wind Energy Systems, Energy Storage and Conversion Systems, Dynamic System Analysis, and Aerospace Structures and Materials through grading, office hours, recitation/problem-solving support, and student mentoring.

Industry Intern, Avery Dennison Bangladesh Ltd. — *Jun 2015–Aug 2015*

➢ Analyzed manufacturing and distribution workflows, identified process bottlenecks, and proposed practical improvements to support production efficiency, quality control, and operational decision-making.

Selected Projects

□ Portable thermal-conductivity measurement setup for insulating materials, B.Sc. thesis

– Designed and constructed a bench-scale experimental apparatus to measure the thermal conductivity of locally available insulating materials; achieved less than 5% deviation from manufacturer-reported values using a brass disc, thermocouple-based temperature measurement, brass steam chamber, and stainless-steel steam generator.

□ Automatic color-based product sorting machine, undergraduate project

– Developed an automated product-sorting system using RGB and IR sensors, a conveyor mechanism, servo actuation, and microcontroller-based control logic to classify and sort objects by color.

□ Turbulence-model and grid-sensitivity analysis for laminar/turbulent boundary-layer flows, graduate course project

– Evaluated the effects of turbulence models and grid resolution on planar laminar and turbulent boundary-layer simulations in STAR-CCM+, with emphasis on near-wall behavior, mesh sensitivity, and model comparison.

□ Verification and validation of zero-pressure-gradient boundary-layer flow, graduate course project

– Performed verification and validation of zero-pressure-gradient boundary-layer simulations using ANSYS Fluent and an in-house 2D boundary-layer code, comparing numerical predictions with canonical boundary-layer behavior.

□ Finite element analysis of pressure-driven Couette flow, graduate course project

– Developed finite element simulations of Couette flow under varying pressure-gradient conditions to analyze velocity-field behavior, numerical accuracy, and the influence of boundary/forcing conditions.

□ Optimization and error analysis using machine-learning methods, graduate course project

– Applied Support Vector Machines (SVMs) and Gaussian Process Networks/Models (GPN/GPR) for classification, regression, uncertainty estimation, and error analysis in engineering datasets.

Publications & Theses (selected)

CFD, Thermal-Fluids & Energy Systems in Mechanical Engineering

- Das, R. C., & Shen, Y.-L. (2023). Analysis of wind farms under different yaw angles and wind speeds. Energies, 16(13), 4953.
- Das, R. C. (2024). Wind Farm Optimization and Analysis of Complex Wake Structures. Ph.D. Dissertation, University of New Mexico.
- Talaat, K., Das, R., Romero, B., Cakez, C., Anderoglu, O., Lee, S., Lee, Y., Ban, H., Woloshun, K., Kim, S. J., Rao, D., & Unal, C. (2019). Development of a numerical framework to model flow accelerated corrosion in a lead loop. 18th International Topical Meeting on Nuclear Reactor Thermal Hydraulics, NURETH 2019.
- Das, R., & Lee, S. (2019). Numerical perspectives on wind turbine wakes. 72nd Annual Meeting of the APS Division of Fluid Dynamics.
- Das, R. C. (2017). Multi-scale analysis of turbulent thermal boundary layer with zero pressure gradient. M.Sc. Thesis, Bangladesh University of Engineering and Technology.
- Das, R. C. (2015). Design and construction of a thermal conductivity measurement setup for insulating materials. B.Sc. Project and Thesis, Bangladesh University of Engineering and Technology.

Interdisciplinary & Applied Research in Energy, Climate & Environmental Systems

- Kloss, C., Berthet, G., Sellitto, P., Bartolome Garcia, I., Briaud, E., Das, R. C., Chevrier, S., Dumelié, N., Joly, L., Lecas, T., Marbach, P., Ploeger, F., Renard, J.-B., Vernier, J.-P., Wienhold, F. G., & Hegglin, M. I. (2026). Cross-hemispheric transport of the Hunga aerosol plume: In situ evidence and radiative effects from the Northern Hemisphere. Atmospheric Chemistry and Physics, 26, 8981–8997.
- Das, R. C., Vernier, J.-P., Pandit, A. K., Peterson, D. A., Fromm, M. D., Kablick, G., Dumelie, N., Joly, L., & Flaten, J. (2026). Smoke transport and potential impacts from all observed pyroCb events in North America during 2013–2023. Submitted to Atmospheric Chemistry and Physics / EGUsphere.
- Vernier, J.-P., Dumelie, N., Pandit, A. K., Berthet, G., Joly, L., de Souza, G., Landulfo, E., Quintao, D., Biazon, B., Kiran, R., Ratnam, M. V., Flaten, J., Das, R., Paraiseau, D., Wienhold, F., & Li, Y. (2026). A new profiling optical particle counter to study stratospheric aerosols. Submitted to Atmospheric Measurement Techniques.
- Souza, G., Vernier, J.-P., Quintão, D., Biazon, B., Lopes, F., Ricardo, J., Pandit, A. K., Das, R. C., Liu, H., Knepp, T. N., Vernier, H., & Landulfo, E. (2025). Sedimentation and growth of volcanic aerosols within the Hunga plume: Insights from unique tropical in situ and satellite measurements. ESS Open Archive preprint; manuscript under review.
- Vernier, J.-P., Dumelié, N., Pandit, A. K., Souza, G., Das, R. C., et al. (2025). BalNeO: Balloon Network for Stratospheric Aerosol Observations. Manuscript under revision for resubmission to Bulletin of the American Meteorological Society.
- Das, R. C., Vernier, J.-P., Pandit, A. K., Kovilakam, M., Bhatta, S., & Fromm, M. (in preparation). Evaluation of aerosol-cloud clearing techniques and their impacts on SAGE III/ISS data analysis for UTLS studies. Manuscript in preparation.
- Liu, H., Vernier, J.-P., Pandit, A. K., Eastham, S., Luo, G., Choi, H., Zhang, B., Vernier, H., Souza, G., & Das, R. (2025). Transport and evolution of the Hunga Tonga volcanic aerosol plume in the stratosphere simulated with the GEOS-Chem model. 105th Annual Meeting of the American Meteorological Society.
- Vernier, H., Berthet, G., Rastogi, N., Vernier, J.-P., Dumelie, N., Joly, L., Meena, R., Liu, H., Case, P. A., Boone, C. D., Knepp, T. N., & Das, R. (2025). Integrated observation and modeling reveal the 2024 Ruang volcanic plume within the Asian Tropopause Aerosol Layer. AGU Annual Meeting, Abstract V13C-0097.
- Vernier, H., Berthet, G., Rastogi, N., Vernier, J.-P., Ratnam, M. V., Dumelie, N., Joly, L., Meena, R., Liu, H., Boone, C., Colarco, P., Case, P., Das, R. C., & Knepp, T. N. (2025). Impact of the April 2024 Ruang volcanic eruption on the Asian Tropopause Aerosol Layer: Insights from balloon measurements. Poster presentation, VolImpact-SSiRC Workshop, Greifswald, Germany.
- Souza, G., Vernier, J.-P., Quintão, D., Biazon, B., Lopes, F., Ricardo, J., Pandit, A. K., Das, R. C., Liu, H., Knepp, T. N., Vernier, H., & Landulfo, E. (2025). Investigating long-term aerosol plume dynamics from the Hunga eruption with in-situ and satellite observations over Brazil. Presentation, VolImpact-SSiRC Workshop, Greifswald, Germany.
- Vernier, H., Berthet, G., Rastogi, N., Vernier, J.-P., Ratnam, M. V., Dumelie, N., Joly, L., Meena, R., Liu, H., Boone, C., Colarco, P., Case, P., Das, R. C., & Knepp, T. N. (2025). Impact of the April 2024 Ruang volcanic eruption on the Asian Tropopause Aerosol Layer: Insights from balloon measurements. Poster presentation, EGU General Assembly, Vienna, Austria.
- Vernier, H., Berthet, G., Rastogi, N., Vernier, J.-P., Ratnam, M. V., Dumelie, N., Joly, L., Meena, R., Liu, H., Boone, C., Colarco, P., Case, P., Das, R. C., & Knepp, T. N. (2025). Integrated observation and modeling reveal the 2024 Ruang volcanic plume within the Asian Tropopause Aerosol Layer. Oral presentation, ACAM 2025 Meeting, Bali, Indonesia.

- Vernier, J.-P., Pandit, A. K., Das, R., Dumelié, N., Joly, L., Vernier, H., de Souza, G., Landulfo, E., Quintao, D., Biazon, B., & Flaten, J. (2025). The Balloon Measurement Network for Stratospheric Aerosol Observations (BalNeO) for SAI Monitoring. WCRP/SAI Virtual Conference.
- Vernier, J.-P., Liu, H., Pandit, A. K., Ratnam, M. V., Fairlie, T. D., Gadhavi, H., Wienhold, F. G., Kumar, B. S., Berthet, G., Vernier, H., Bian, J., Ziemba, L., Mahnke, C., & Das, R. (2024). ATAL's inter-annual variability derived from satellite observations and airborne measurements. International Workshop on Stratosphere-Troposphere Interactions and Prediction of Monsoon Weather Extremes, STIPMEX 2024.

Peer Review and Professional Service

★ **Reviewer, Journal of Geophysical Research: Atmospheres — 2026**

Grants & Collaborations

Active / Recent Roles

- NASA ROSES — Co-Investigator (Ongoing).
- NASA INSPYRE — Researcher (Ongoing).
- NASA ROSES — Researcher (Ongoing).
- NASA SAGE III/ISS Science Team — Researcher (Ongoing).
- NASA Disasters Program — Researcher.
- DOE Lead-Loop Corrosion Project — Research Contributor.
- PNM Resources Foundation — Renewable Energy Research.

Collaborative Network

- Agencies/Labs: NASA LaRC, NRL.
- Field/Campaigns: INSPYRE, BATAL, BalNeO, BRAVO.
- Universities/Groups: Partners across the U.S., France, Germany, Brazil, and India.

Technical Skills

➢ Programming & High-Performance Computing

Languages: C, C++, Fortran, Python, MATLAB (incl. Simulink), Bash, IDL.
Parallel & HPC: MPI, OpenMP; GPU/CUDA (2D heat-diffusion kernels, shared-memory tiling); parallel I/O with HDF5/netCDF; environment modules; batch scripting; performance profiling and scaling on Linux clusters (incl. Valgrind; NVIDIA Nsight Systems/Compute).
Schedulers & Systems: Slurm, PBS; Linux and Windows environments; interactive and batch workflows on university and national-class clusters.
Development & Reproducibility: Git/GitHub; Jupyter notebooks; conda/modules; clean, documented scripting for reproducible pipelines; build systems (CMake, Make); containers (Docker).
Practical team workflows: code review / branching practices; issue tracking (GitHub); automated run manifests/config logging for reproducible computational campaigns.

➢ Modeling, CFD/FEA & Numerical Methods

In-house & research codes: Custom DNS/LES solvers in C/MPI for turbulent wakes and internal flows; Incompact3D; familiarity with OpenFOAM; REEF3D.
Commercial / multiphysics tools: ANSYS Fluent, STAR-CCM+, COMSOL Multiphysics; ANSYS Mechanical (intro FEA); ANSYS Meshing.
Methods: Finite-volume, FDM and FEM discretizations, boundary-layer codes, turbulence modeling, conjugate heat transfer, internal-flow heat/mass transfer; reduced-order methods / modal decompositions (POD/SVD/PCA workflows).
V&V & UQ: Verification (grid/time refinement), validation against canonical and experimental data, uncertainty quantification and sensitivity checks.

➢ Trajectory, Atmospheric & Environmental Transport Tools

Models: NASA Langley Trajectory Model (LaTM), HYSPLIT for plume and trajectory analysis (wildfires, volcanoes, dust, HAPS/balloon campaigns); WRF; GEOS-Chem.
Coupling: Integration with reanalyses (MERRA-2, GEOS-FP) and simple dispersion/hazard products; trajectory ensembles and UTLS/stratospheric transport diagnostics.
Reproducibility/ops: ensemble workflow automation (batch/arrays), systematic sensitivity runs, and traceable event reconstruction pipelines (inputs → runs → products).

➢ Data Science, Remote Sensing & Visualization

Python scientific stack: NumPy, SciPy, pandas, xarray, dask, netCDF4, h5py, Matplotlib, Cartopy; robust experience handling large NetCDF/HDF datasets.

Other analysis tools: MATLAB; IDL for legacy satellite/balloon workflows.
Remote sensing & campaign data: Work with multi-sensor datasets (SAGE III/ISS, CALIPSO, OMPS, MLS, in situ and balloon profiles); satellite Level-1/Level-2 products; chemistry-climate and reanalysis output.
Visualization: ParaView, Tecplot, FieldView, Gnuplot; VTK; production of publication-quality plots, vertical profiles, sections, and 3-D flow/aerosol visualizations.
GIS & geospatial: ArcGIS, QGIS; common formats (netCDF, HDF, GeoTIFF, shapefiles); creation of GIS-ready hazard layers, plume maps, and spatial-statistics products.
Research deliverables: publication-ready figure design and reproducible plotting scripts; standardized data products for team handoff (metadata, units, conventions).

➢ Machine Learning & Data-Driven Modeling

Classical ML (tooling + methods): scikit-learn (pipelines, preprocessing/feature scaling, regression/classification, model selection & cross-validation, regularization, PCA; metrics RMSE/MAE/R^2, ROC-AUC); tree-based boosting with XGBoost (as applicable).
Kernel/probabilistic models (uncertainty-aware): SVM (SVR/SVC) and Gaussian Process models (GPR/GPC) for regression/classification with uncertainty estimation (predictive variance/intervals)—applied in course/project contexts on engineering datasets.
Neural networks (intro–intermediate): PyTorch for feed-forward networks, surrogate models, and initial PINN-style experiments (physics-guided NN direction); autograd/custom losses, batching/DataLoader, GPU use (when available).
ML-ready workflows (end-to-end): dataset curation from simulations/observations (cleaning, feature engineering, normalization, train/validation/test splits); generalization checks (residuals/learning curves); hyperparameter tuning with Optuna; experiment tracking with Weights & Biases (as applicable); model + scaler/checkpoint persistence and reproducibility (seeds/configs).
Deep learning ecosystem (as applicable): TensorFlow/Keras (model definition/training); model export ideas (SavedModel/ONNX).
UQ-friendly ML practices (as applicable): bootstrap/ensemble uncertainty, calibration checks, and uncertainty-aware reporting of surrogate predictions.
MATLAB ML workflows (as used): machine learning + statistical analysis workflows in MATLAB for engineering datasets (teaching/research support).
Appropriately scoped: physics-informed feature engineering and error analysis for engineering datasets; responsible use of ML in decision support (limitations, uncertainty, and out-of-distribution awareness).

➢ Instrumentation, Measurement & Controls

Instrumentation & DAQ: LabVIEW; NI-style DAQ systems; thermocouples/RTDs; pressure/flow measurement fundamentals; sensor calibration, repeatability, and uncertainty/error awareness.
Embedded / mechatronics (fundamentals): Microcontroller-based sensing and actuation (e.g., conveyor-based color-sorting system); interfacing sensors, simple actuators, and digital I/O/PWM.
Controls (intro level): Modeling first/second-order systems; interpreting time/frequency response; PID concepts; MATLAB/Simulink demos for teaching and labs.
Autonomy-adjacent framing: system identification mindset (fit simple models to data, validate, interpret) and closed-loop "measure → estimate → decide" workflows suitable for student projects.

➢ CAD, Design & Manufacturing

CAD: SolidWorks and AutoCAD for 2D/3D mechanical design, assemblies, detailed drawings, tolerances, and BOMs.
Prototyping: Design of bench-scale experimental rigs (thermal-conductivity apparatus, pipe-flow/heat-transfer setups, flow/thermal test sections) for teaching and research.
Manufacturing: Experience with standard shop tools and processes (drill press, band saw, machining) with strong emphasis on lab and shop safety in instructional settings.
Design communication: documentation for build/test (drawings, BOMs, assembly notes, test plans) and safety-aware lab procedures.

➢ Documentation, Communication & General Tools

LaTeX for technical manuscripts, theses, and reports; MS Office suite for day-to-day communication and documentation.

Selected Coursework (across B.Sc., M.Sc., and Ph.D.)

➢ **CFD, Computational Mechanics, and Numerical Methods:** Introduction to Computational Fluid Dynamics; Computational Mechanics; Numerical Analysis; Advanced Numerical Analysis; Introduction to Verification & Validation in Computational Mechanics; Applied Engineering Mathematics.

➢ **Fluid Mechanics, Turbulence, Boundary Layers, and Compressible Flow:** Theoretical Fluid Mechanics I; Fluid Mechanics I; Fluid Mechanics II; Mechanics of Viscous Fluid; Mechanics of Inviscid Compressible Fluid; Boundary Layers; Turbulent Flows; Fluid Machinery; Fluidics.

➢ **Thermo-Fluids, Heat Transfer, and Energy Systems:** Basic, Advanced, Classical Thermodynamics; Conduction and Radiation Heat Transfer; Advanced Convection Heat Transfer; Convection, Boiling, Condensation and Mass Transfer; Internal

Combustion Engines; Refrigeration and Building Mechanical Systems; Power Plant Engineering; Energy Storage and Conversion Systems; Wind Energy System.

➢ **Mathematics, Programming, Data, and Machine Learning:** Differential Calculus, Solid Geometry and Vectors; Integral Calculus and Differential Equations; Vector Calculus, Matrices, Laplace Transform and Series Solution; Complex Variables, Harmonic Analysis and Partial Differential Equations; Computer Programming Language; Machine Learning.

➢ **Instrumentation, Measurement, Electronics, and Experimental Methods:** Instrumentation and Measurement; Measurement and Quality Control; Fundamentals of Electrical Engineering; Electrical and Electronics Technology.

➢ **Dynamics, Controls, Mechanics, and Systems:** Engineering Mechanics; Applied Dynamics; Control Engineering; Mechanics of Machinery.

➢ **Solids, Continuum Mechanics, and Materials:** Introduction to Continuum Mechanics; Mechanics of Solids; Applied Elasticity; Metallic Materials; Chemistry of Engineering Materials; Composite Materials.

➢ **Design, CAD, Manufacturing, Shops, and Industrial Practice:** Mechanical Engineering Drawing I/II; Machine Design I/II; Production Processes; Machine Tools; Industrial Management.

Service, Leadership & Awards

- **President**, Mechanical Engineering Graduate Association (UNM), 2022–2023
- **President**, Bengal United Sports Club (UNM), 2022–2023
- **Secretary**, Mechanical Engineering Graduate Association (UNM), 2021–2022
- Undergraduate Technical **Scholarship** (BUET) recipient
- **Trilingual**: English, Bengali, Hindi