Unidata Community Equipment Awards Proposal Cover Sheet

Proposal Title: AI-Met Lab at UHM

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Project Summary

This proposal requests funds for the purchase of a multi-core GPU-accelerated workstation that will serve as the core of a new Artificial Intelligence (AI) and Machine Learning (ML) - Lab (Met-AI Lab) in the Department of Atmospheric Sciences (ATMO) at the University of Hawaii at Manoa (UHM). This server will facilitate a number of exciting new research initiatives in ATMO that specifically employ artificial intelligence (AI) and machine learning (ML) approaches to meteorological problems (See Table 1 below).

Met-AI Lab will also provide a critical resource for a new course dedicated to application of AI and ML in meteorology that is under development. Met-AI Lab will also enhance educational resources for PhD students, foster collaboration with the Department of Computer Science to train a new generation of remote sensing scientists skilled in Artificial Intelligence and provide valuable data streams resulting from Met-AI research endeavors to benefit the broader Unidata community.

Project Description

This project aims to significantly enhance the computational facilities in ATMO at UHM by providing computational infrastructure specifically designed to run advanced artificial intelligence methods for meteorological applications. The acquisition of a dedicated GPU-accelerated computing server will directly support ongoing high-impact research projects and new initiatives, such as those listed in Table 1 below.

This first project listed in Table 1 addresses the critical challenge of early detection, monitoring, and forecasting of atmospheric rivers over the North-East Pacific region. By leveraging advanced retrieval methods known as Transformed Retrievals (Rodgers 2000; Migliorini 2011; Antonelli et al., 2017, 2020), the project uses hyperspectral infrared (IR) and microwave satellite data to produce highly accurate and computationally efficient atmospheric state estimates explicitly designed for assimilation into Numerical Weather Prediction (NWP) models (Cherubini et al., 2023) in a new transformative approach. The ability to effectively integrate these transformed retrievals sourced from both IR and MW spectral data into NWP systems promises significant advancements in predicting atmospheric rivers, extreme rainfall, and associated flooding hazards, directly enhancing forecasting accuracy, disaster preparedness, and risk mitigation in vulnerable coastal communities. This potentially transformative project is undertaken in collaboration with Dr. Paolo Antonelli, formerly with Cooperative Institute for Meteorological Satellite Studies and Space Science Engineering Center CIMSS/SSEC at the University of Wisconsin - Madison.

This first project redefines satellite data processing by translating raw observations from hyperspectral infrared, microwave, and visible sensors into a unified and compact latent space representation. By employing advanced AI architectures such as variational autoencoders and convolutional neural networks, the project promises to significantly improve atmospheric retrieval accuracy, while efficiently generating valuable atmospheric state information critical for extreme weather forecasting. This innovative approach not only facilitates more precise weather prediction and climate analyses but also establishes a novel data-processing paradigm with broader applications that extend to planetary exploration.

Table 1 outlines many other very promising applications of AI and ML to meteorological problems. Space precludes providing details regarding the source data and methods for each of these applications.

Additionally, this infrastructure investment will improve educational opportunities within the Department of Atmospheric Sciences by fostering interdisciplinary collaboration with the Department of Computer Science (Dr. Peter Sadowski) and providing critical hardware support for a new course entitled, “AI and ML applications in

Meteorology." Through this partnership, the project will cultivate a new generation of atmospheric scientists equipped with specialized skills in Deep Learning and broader AI methodologies. Finally, leveraging this advanced computational platform, the project will generate unique open-access datasets, including transformed hyperspectral satellite retrievals over the Pacific Ocean, offering valuable resources to both local and global research communities, and enhancing broader scientific collaboration. Archived datasets derived from Unidata software and data-streams that are currently available to the Unidata community for the North Pacific region can be found at: http://mkwc.ifa.hawaii.edu/archive/index.cgi

Table 1 Sample List of Current and Potential Met-AI Projects

1. Atmospheric River Prediction: By leveraging advanced retrieval methods known as Transformed Retrievals (Rodgers 2000; Migliorini 2011; Antonelli et al., 2017, 2020), this research combines hyperspectral infrared (IR) and microwave satellite data to produce highly accurate and computationally efficient atmospheric state estimates explicitly designed for assimilation into Numerical Weather Prediction (NWP) models (Cherubini et al., 2023). The ability to effectively integrate these transformed retrievals into NWP systems promises significant improvement in prediction of atmospheric rivers, extreme rainfall, and associated flooding hazards, providing better guidance to support disaster preparedness and risk mitigation in vulnerable coastal communities.
2. Vog and Smoke Prediction: Use AI to optimize output from ensemble UH vog- and smoke-model runs to produce better probabilistic forecasts (Moisseeva and Businger 2024).
3. Flood Risk: Use AI to analyze rainfall, terrain, and river data in Hawaii to predict flood risks for specific basins more accurately (Corrigan and Businger 2023).
4. Rainfall Estimation and Prediction: Use ML models trained on long-range lightning, satellite and TRMM radar data to provide rainfall estimates over the North Pacific (Pessi and Businger 2009) that will improve NWP in the relatively data sparse North Pacific.
5. Aviation safety: Use ML applied to data from NTSB Reports, ASOS, and sounding data to diagnose the conditions in Hawaii that foster general aviation accidents (Monte and Businger 2025).
6. Aviation Safety: Use AI models to interpret satellite, radar, and long-range lightning data to identify convective activity and potential lightning zones that could impact flight paths over the North Pacific Ocean.
7. Turbulence Prediction: Use ML models to analyze past flight data, PIREPS, weather model output, and sensor inputs to forecast wind shear, clear-air and convective turbulence more accurately and earlier.
8. Fog and Low Visibility Forecasting: Use AI to improve nowcasting of fog at Maunakea and Haleakala observatories by analyzing local sensors, humidity levels, and satellite data.
9. Use of ML to improve optical turbulence and seeing forecasts over Maunakea in support of astronomical observatories (Cherubini et al. 2022).

10. Supercell Prediction: ML models trained on historical radiosonde and ACARS profiles (e.g., CAPE, shear, helicity) can help identify sounding patterns favorable for supercells and flash flooding in Hawaii and elsewhere.

Resources Requested

We propose to acquire a high-performance GPU-accelerated server designed specifically to meet the intensive computational demands of AI-based and ML-based research and education as outlined in Table 1 above. The proposed server configuration balances powerful computational capabilities with budget considerations, providing optimal performance within available funding constraints. The detailed proposed architecture is provided in Table 2.

Table 2 **Component**	**Quoted Cost**
Single Intel Xeon CPU **or** AMD EPYC (32 cores / 64 threads)	$4,500
NVIDIA RTX A6000 GPU (48 GB GPU memory)	$5,500
256 GB DDR4 ECC RAM	$2,400
2 TB SSD NVMe (high-speed working storage)	$500
40 TB Enterprise-grade HDD storage (RAID capable)	$2,000
Server-grade Motherboard & Chassis	$1,500
10-Gigabit Ethernet Networking	$500
Power Supply & Cooling Solution	$1,000
Total Estimated Cost	**$17,900**

The above configuration aims to balance performance and cost-effectiveness, offering:

Ample GPU Computing Power:

A single NVIDIA RTX A6000 GPU provides sufficient capability for developing and running sophisticated deep-learning models essential to AI-based integration tasks.

Robust CPU Performance:

The single multi-core CPU (32 physical cores, 64 logical threads) offers strong parallel-processing capabilities suitable for computationally intensive numerical weather prediction and data processing workflows.

Expanded Memory Capacity (256 GB RAM):

The doubled memory allocation ensures efficient multitasking and handling of large-scale datasets common in satellite remote sensing and atmospheric research applications.

Balanced Storage Strategy:

Combining high-speed NVMe SSD (2 TB) for rapid data access with substantial HDD storage (40 TB, RAID-configured) provides both performance and reliability for active project data and archival needs.

Efficient Data Transfer:

Integrated 10-Gigabit Ethernet ensures rapid, reliable transfer of data from the Direct Broadcast receiving station and to local and external users, essential for timely data dissemination.

Information Technology (IT) Support in ATMO:

ATMO has a dedicated IT Specialist in Michael Gonsalves.

Benefits for Education and Research

The proposed acquisition directly aligns with NSF Unidata's priorities for the 2025 equipment awards by substantially enhancing computing resources in ATMO at UHM. Specifically, the addition of this GPU-accelerated server provides essential capabilities

for advanced AI-based data analysis. This enhancement directly contributes to improved research outcomes and expanded educational opportunities, particularly with interdisciplinary collaboration with the Department of Computer Science.

Furthermore, the equipment will enable the generation and dissemination of unique locally created datasets over the North Pacific region, such as AI derived physical and transformed retrievals from satellite radiance data (see Table 1). This proposal leverages unique datasets available in Hawaii and over the North Pacific Ocean, including those obtained from the Direct Broadcast receiving station located on Oahu. These datasets will become accessible not only to local researchers and students but also to broader Unidata communities, helping those involved in numerical weather prediction efforts, such as the WRF and MPAS modeling community, through our Pacific THREDDS data server. Thus, the project facilitates greater scientific collaboration and broadens the impact of locally produced research data on a national and international scale.

Met-AI Lab will provide a critical resource for a new course dedicated to application of AI and ML in meteorology that is under development. Met-AI Lab will also enhance educational resources for undergraduate and graduate students, foster collaboration with the Department of Computer Science to train a new generation of atmospheric scientists skilled in Artificial Intelligence and provide valuable data streams resulting from Met-AI research endeavors to benefit the broader Unidata community.

Institutional Context and Benefits

The Atmospheric Sciences Department at the University of Hawai‘i at Mānoa offers various computational resources to its faculty, staff, and students. Below is a summary of these resources:

Resource	Description
VisionLab (HIG 310)	Equipped with 14 Dell G5 Gaming Desktops and one instructional Windows 10 computer connected to a SmartBOARD display.
Student Lounge (HIG 376)	Contains three general-use computers: a Windows 10 system, a Linux CentOS system, and a MacBook Pro connected to a 65-inch television monitor for presentations.
Home Directory Servers	Two servers, 'uila' and 'kahi', provide home directory services accessible remotely via SOEST accounts.
Pacific THREDDS Data Server	Provides archive and historical data serving capacity that facilitates automated remote access to custom and operational Pacific data sets for research and education.

In summary, the proposed equipment will substantially expand existing resources to enable novel AI-driven scientific research and educational opportunities for undergraduate and graduate students.

New AI sourced datasets and methods will be shared with the broader Unidata community through our Pacific THREDDS data server. Scientific data that result from this project will be developed in or converted to the Unidata-standard NetCDF format allowing for easy remote access to our data and products via a THREDDS server housed in the Atmospheric Sciences Department at UHM.

Collaboration with the Department of Computer Science, with the help of Dr. Peter Sadowski, and the development of an ATMO course dedicated to AI applications in meteorology, support interdisciplinary training and the development of advanced AI competencies.

Budget and Justification

This proposal requests $17,900 for the acquisition of a high-performance GPU-accelerated server for AI and ML applications and education. A detailed quoted budget breakdown of the components is provided in **Table 1** above. Cost Match: All costs above the requested total above, including taxes, shipping, inflation, minor accessories, etc. will be covered by the ATMO Department as a cost match. These additional costs could reach ~$3,000-$5,000.

Project Milestones

The workstation will be purchased during Summer 2025 with software installation and testing completed by Fall Semester. During Fall Semester 2025, AI-Met Lab will be fully operational for student project access and for educational demonstrations. During Spring Semester 2025 the AI-Met Lab will be integrated into the into lower and upper division Atmospheric Science courses. Summer 2026 and beyond, software developed by students and faculty and new data sets in the context of the AI-Met Lab will be shared with the broader community.

References Cited

Antonelli, P., Cherubini, T., Businger, S., de Haan, S., Scaccia, P., & Moncet, J. (2020). Regional Assimilation System for Transformed Retrievals from Satellite High-Resolution Infrared Data, Journal of Applied Meteorology and Climatology, 59(7), 1171-1193.

Antonelli, P., H.E. Revercomb, G. Giuliani, T. Cherubini, S. Businger, R. Lyman, S. Tjemkes, R. Stuhlmann, and J. Moncet, 2017: Regional Retrieval Processor for Direct Broadcast High-Resolution Infrared Data. J. Appl. Meteor. Climatol., 56, 1681 1705, https://doi.org/10.1175/JAMC-D-16-0144.1

Cherubini, T., R. Lyman, S. Businger, 2022: Forecasting seeing for the Maunakea observatories with machine learning, *Monthly Notices of the Royal Astronomical Society*, Volume 509, Issue 1, Pages 232–245, https://doi.org/10.1093/mnras/stab2916

Cherubini, T., S. Businger, P. Antonelli, T., and P. Scaccia, 2023: Assimilation of Transformed Retrievals from Satellite High-Resolution Infrared Data over the Central Pacific Area, MWR, in press: DOI:10.1002/essoar.10512882.1

Corrigan, T. J. and S. Businger, 2021: Anatomy of a Series of Cloud Bursts that Eclipsed the US Rainfall Record, Mon. Wea. Rev., *DOI: 10.1175/MWR-D-21-0028.1*

Migliorini, S. (2011). On the Equivalence between Radiance and Retrieval Assimilation. Monthly Weather Review, 140(1), 258–265.

Moisseeva, N., Businger, S., & Elias, T., 2023: VogCast: A framework for modeling volcanic air pollution and its application to the 2022 eruption of Mauna Loa volcano, Hawai'i. J. Geophys. Res. Atmos., e2023JD039281. https://doi.org/10.1029/2023JD039281.

Monte, F. and S. Businger, 2024: **I**nvestigation of Weather-related Aviation Accidents in Hawai'i from 2003 – 2022. submitted to Weather and Forecasting.

Pessi, A. T., and S. Businger, 2009: The impact of lightning data assimilation on a winter storm simulation over the North Pacific Ocean. *Mon. Wea. Rev.,* **137,** 3177–3195.

Rodgers, C. D. (2000). *Inverse Methods for Atmospheric Sounding: Theory and Practice*. World Scientific. ISBN: 978-981-02-2740-1.

Preliminary Quote from Thinkmate
https://www.thinkmate.com/system/a+-workstation

A+ Workstation 2115HV-TNRT
Supermicro A+ Workstation 2115HV-TNRT - AMD Ryzen Threadripper PRO 7000WX - 8x NVMe/SATA - AIOM - 2600W (1+1) Redundant
24-Core AMD Ryzen™ Threadripper™ PRO 7965WX Processor - 4.2GHz - 128MB L3 Cache (350W)
8 x 96GB PC5-41600 5600MHz DDR5 ECC RDIMM
Supermicro PWS-1K63A-1R - 1U 1000W/1600W redundant power supply 90-264Vac
3.84TB Micron 7450 PRO Series M.2 PCIe 4.0 x4 NVMe Solid State Drive (110mm)
960GB Micron 7450 PRO Series U.3 PCIe 4.0 x4 NVMe Solid State Drive (15mm)
NVIDIA® L40S ADA GPU Computing Accelerator - 48GB GDDR6 - PCIe 4.0 x16 - Passive Cooling
Supermicro AIOM OCP 3.0 - 2x 1GbE RJ45 - Intel i350 - PCI-E 2.1 x4 - AOC-AG-i2M
Supermicro Update Manager (SUM) (OOB Management Package), included
2 x Supermicro CBL-MCIO-1330M5 - MCIO (x8 to x8), STR, 30cm,G5,32AWG, RoHS,RoHS
Supermicro CBL-MCIO-1332M5 - MCIO (x8 to x8), STR, 32cm,G5,32AWG, RoHS
2 x Supermicro CBL-MCIO-1335M5R - MCIO x8 (RA to STR),35CM,32AWG,RoHS
Supermicro CBL-PWEX-1136YVB-45 - (2x4 to 3 2x2), PH3.0,45cm,8.5A/p,18AWG,RoHS
2 x Supermicro CBL-MCIO-1245M5R - MCIO x8 (RA to STR),45cm,30AWG,RoHS
Supermicro CBL-GNZ4-1227M5YRR16 - GENZ 4C STR to 2 MCIO x8 RA/RA 27/16cm
Supermicro CBL-MCIO-1326M5 - MCIO (x8 to x8) STR,26CM,85 OHM
Supermicro MCP-240-21908-0N - Riser Bracket(4-slot) for RSC-H2-6888G5L in CSE-HS219/HS829
2 x Supermicro MCP-240-21108-0N - Riser Bracket(2-slot) for RSC-H-68G5
Supermicro MCP-120-20118-0N - Middle riser support bracket for 2U Intel and AMD CSE-HS201
3 x Supermicro RSC-H-68G5 - 1U LHS Hyper Riser card with 1x PCIe 5.0 X16 and 1x PCIe 5.0 X8
Supermicro RSC-H-A6G5H - 1U Active LHS Hyper riser card with one PCIe 5.0 X16 slot

Total $17,900