Unidata Community Equipment Awards Cover Sheet

Proposal Title: A Data-Proximate Computing Platform for Federated Earth Systems Science Data Access: Integrating Iowa Water Quality Monitoring with NSF Unidate Ecosystem.

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NSF Unidata Community Equipment Award Proposal

Iowa Water Quality Information System 2 (IWQIS 2) and the Marketplace of Innovation (MOI):

A Data-Proximate Computing Platform for Federated Earth Systems Science Data Access: Integrating Iowa Water Quality Monitoring with the NSF Unidata Ecosystem

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1. Project Description

1.1 Overview

IIHR — Hydroscience & Engineering at the University of Iowa operates the Iowa Water Quality Information System (IWQIS), a statewide network of continuous water quality monitoring sensors deployed at approximately 75 sites across Iowa. IWQIS has collected high-frequency measurements of nitrate, dissolved oxygen, temperature, pH, specific conductance, turbidity, phosphate, and related parameters at 15-minute intervals since 2012. The system currently holds more than 240 million individual measurements and grows by approximately 300 observations per hour.

We are building IWQIS 2 — a modern data infrastructure designed to serve this dataset to researchers, educators, policymakers, and the public in real time. IWQIS 2 is built on open standards and applications (PostgreSQL/PostGIS, FastAPI, Celery, Docker) and is designed from the ground up to integrate with NSF Unidata tools, particularly the THREDDS Data Server (TDS). Equipment awarded through this proposal would enable the deployment of IWQIS 2 on dedicated production hardware, unlock THREDDS-based data access for the Unidata community, and support the development of the Marketplace of Innovation (MOI) framework — a novel data abstraction layer designed to make IWQIS data accessible through a generic, Unidata-compatible interface. The MOI, in development, is a federated marketplace that allows trusted users to develop and distribute data access methods, custom models and analytics, visualizations, map views, educational content, and research materials. Users will be able to utilize materials developed by other users in a trusted and verified working environment.

1.2 Current Infrastructure and Limitations

IWQIS 2 is currently in active development on a Windows workstation with resources shared with other projects. The system is not running in production 24/7, and the database (PostgreSQL 16 with PostGIS) is constrained by available memory and computational capabilities. Specifically:

- The IWQIS 2 database contains 240+ million measurements in a range-partitioned PostgreSQL table. Complex aggregation queries (rolling 365-day statistics, all-time percentiles) require dedicated compute resources.
- Real-time ingestion from IWQIS 1 runs on a cron schedule and needs to operate continuously without interrupting research workloads.
- A THREDDS Data Server cannot be deployed without dedicated hardware to host the OPeNDAP/NetCDF interface alongside the database and API.
- AI-assisted anomaly detection and quality flagging — a planned feature — requires GPU inference capability that is not available on the current development hardware.

IT has provisioned a Linux server for IWQIS 2, but the machine is around 8 years old and the hardware is rapidly aging and is untrusted. We will use this as proof of concept for IWQIS 2 and MOI. This proposal requests funding to procure two GPU inference appliances to support IWQIS and the MOI computing environments and a database/web application server for IWQIS 2 and the MOI.

1.3 THREDDS Integration

THREDDS Data Server (TDS) is the primary NSF Unidata technology we plan to deploy. IWQIS 2/MOI will expose its water quality time series data via TDS in two complementary ways:

- Direct NetCDF/OPeNDAP access: IWQIS measurements will be exported to NetCDF-CF format on a daily basis and served via TDS, making Iowa water quality data accessible to any OPeNDAP-compatible client including MATLAB, Python (netCDF4, xarray), IDV, and MetPy.
- MOI node abstraction: The Marketplace of Innovation (MOI) framework will register the THREDDS endpoint as an MOI node, making the data discoverable through a standard query interface regardless of the underlying data format. This allows IWQIS data to be combined with NEXRAD precipitation, NLDAS soil moisture, and other Unidata-served datasets through the same MOI query interface.

The combination of direct THREDDS access and MOI abstraction means that IWQIS water quality data becomes a first-class participant in the Unidata data ecosystem — accessible via OPeNDAP for traditional Earth Systems Science workflows and via the MOI API for modern web-based and AI-assisted workflows.

1.4 The Marketplace of Innovation (MOI) Framework

The MOI framework is the most architecturally significant contribution of this project. An MOI node is a self-describing data access contract that encodes the data source, access protocol, parameter vocabulary, methodology, and provenance chain for any environmental dataset. A generic frontend application queries MOI nodes without needing to know whether the underlying data comes from a sensor network, a THREDDS endpoint, a WaterML2 service, a REST API, or a file download.

This design generalizes beyond IWQIS to any environmental monitoring dataset. Institutions that register MOI nodes for their sensor networks — whether air quality, soil moisture, streamflow, or atmospheric observations — make their data immediately accessible through the same API surface as IWQIS. The IWQIS 2 instance at IIHR becomes a reference node in a federated network, with the MOI framework acting as a universal environmental data abstraction layer analogous to how HTTP enables web interoperability.

The dedicated server requested in this proposal will host the first production MOI registry, enabling the framework to be tested and demonstrated with real data before being proposed as a Unidata community standard.

1.5 Educational Components

IWQIS 2 and the MOI framework are designed with education as a primary use case:

- Student access via MOI: The MOI abstraction layer allows students to access Iowa water quality data, THREDDS-served atmospheric data, and other environmental datasets through a single unified query interface, without needing to learn each data service's specific API.
- Gamification: The IWQIS 2 schema includes a gamification layer (badges, points, leaderboards) designed to engage students and citizen scientists in water quality monitoring, anomaly reporting, and data contribution.
- Educational content framework: The MOI system includes provisions for attaching lectures, how-to examples, data summaries, and AI-assisted explanations to any dataset or analysis method. A student querying nitrate data for a watershed can access contextual explanations of what nitrate exceedance means, historical context, and links to relevant publications.
- AI interaction: The dedicated GPU inference appliances will enable real-time AI-assisted anomaly detection and natural language Q&A about water quality data, making the system accessible to students with no programming background.
- Student development: As the system matures and demos become available, undergraduate and graduate students in hydroscience, environmental engineering, and computer science will be recruited to develop MOI widgets, contribute to the frontend, and conduct research using the data infrastructure.
- Broader community: Iowa has ~75 continuous monitoring sites whose data is relevant to agricultural water quality, nutrient management under the Iowa Nutrient Reduction Strategy, and public health. Making this data accessible via THREDDS and the MOI framework extends its educational reach to K-12 educators, community college programs, and citizens interested in local water quality.

1.6 Contribution to the NSF Unidata Community

This project makes several direct contributions to the Unidata community:

- New Earth Systems Science domain: IWQIS represents the first large-scale application of THREDDS to continuous inland water quality monitoring at the watershed scale in Iowa. Water quality and hydrology are disciplines outside Unidata's traditional atmospheric sciences focus, directly advancing Unidata's broadening participation goals.
- Open data: All IWQIS 2 data served via THREDDS will be publicly accessible under a CC-BY 4.0 license, with full provenance metadata. This exposes a 14-year, 240M+ measurement dataset of Iowa water quality to the global research community through standard Unidata interfaces.
- MOI as a community contribution: The MOI framework specification will be documented and published as an open standard, inviting other institutions to register their datasets as MOI nodes. This directly enhances Unidata community capabilities by providing a new mechanism for data sharing and discovery across disciplines.

- Reference implementation: The IWQIS 2 stack (PostgreSQL/PostGIS + THREDDS + MOI API + FastAPI) will serve as a reference implementation for other watershed-scale monitoring programs seeking to join the Unidata community.

2. Equipment Justification

2.1 Production Database and Application Server

The primary equipment need is a dedicated Linux server to host the IWQIS 2 database, API, THREDDS server, and background processing workers. The current development hardware (shared Windows workstation) is insufficient for production deployment. The production server requirements are driven by the IWQIS 2 workload:

- Database: PostgreSQL 16 + PostGIS with 240M+ measurements in a partitioned time-series table. Complex aggregation queries require substantial RAM for in-memory sort and hash operations. We have configured shared_buffers=7.5GB and work_mem=512MB; the production server should support at least 64GB RAM to allow for growth.
- Compute: Celery background workers run parallel statistical recomputation tasks after each hourly ingest. 16 vCPU allows workers and the database to operate without contention.
- Storage: The current database volume is approximately 50GB. With projected growth (5+ years of hourly observations, THREDDS NetCDF archives, export files) we require at least 2TB NVMe SSD storage.
- Network: The server must be reachable from the IWQIS 1 extract server for hourly data pulls, and from the public internet for the API and THREDDS endpoints.

2.2 GPU Inference Appliance

GPU inference appliances (NVIDIA DGX Spark or equivalent) will enable AI-assisted quality flagging and anomaly detection without impacting database and API performance. Planned AI applications include:

- LSTM autoencoder for sensor fouling and drift detection
- Isolation forest for point anomaly detection
- Natural language Q&A interface for educational access to water quality data
- Expected value prediction ("what should this site be reading right now?") to contextualize anomalies
- AI assistance for building MOI widgets
- AI summaries for local and regional trends in environmental observations

Dedicated inference appliances keep AI workloads off the primary database server, ensuring query performance is not impacted during model inference. One appliance will also serve as a development platform for the AI capabilities described in the MOI educational framework. The other appliance will be dedicated to IWQIS 2.

3. Proposed Budget

Item	Estimated Cost
Production server: 4 core, Xeon 6 6333P, 64GB RAM, 8TB SATA, Ubuntu 22.04	$7000
2 GPU inference appliance: NVIDIA DGX Spark or equivalent (x2)	$8360
Administration and facilities	$4640
TOTAL REQUEST	$20,000

Note: Exact pricing is pending vendor quotes. Final budget will be submitted upon confirmation of hardware specifications with NSF Unidata Program Center staff as recommended in the Call for Proposals. The total request will not exceed $20,000.

Budget Justification $20,000 total request:
Non Capital Equipment ($8,360)
Funds are requested for specialized computing equipment required to support the development and deployment of a data-proximate computing platform for federated Earth systems science data access. This equipment will support data ingestion, local processing, hosting of data services, and integration with the NSF Unidata ecosystem. The equipment meets NSF's definition of equipment and is not otherwise available through institutional resources.

Capital Equipment ($7,000)
Additional direct costs are requested to support server space required to fully operationalize and maintain the proposed platform.

Facilities and Administrative (F&A) Costs ($4,640)
Facilities and Administrative costs are requested at the institution's federally negotiated rate of 55.5% of Modified Total Direct Costs (MTDC), in accordance with NSF policy.

4. Project Timeline

Timeframe	Milestone
May–June 2026	Procure and deploy production server; migrate IWQIS 2 database from development to production; enable 24/7 automated ingestion
June–July 2026	Deploy THREDDS Data Server; configure OPeNDAP access; export first NetCDF-CF archives of IWQIS water quality data
July–August 2026	Deploy GPU inference appliances; implement AI anomaly detection pipeline; integrate with quality_flag workflow
August–September 2026	Implement initial MOI node specification; register THREDDS endpoint as first MOI node; open MOI API to community

Fall 2026	Student engagement begins; educational content framework developed; demos presented at IIHR seminars and Unidata community meetings
Year 1 report	Submit project report to NSF Unidata; present at AMS or AGU; publish MOI specification as open standard. Expected completion

Project Dependencies: The goals and expectations for the project are straightforward, and development is already on track. The requested hardware will ensure that our objectives will be met without our current computing constraints. In terms of project dependencies, we have very few. The hardware will reside in an IIHR data center eliminating the need for bespoke physical housing. As this is an ambitious project, the main impedance will be in our ability to solve problems that arise. However, we will have support from IIHR personnel who are experienced in developing computational and information systems.

5. Institutional Context

IIHR — Hydroscience & Engineering is a unit of the College of Engineering at the University of Iowa. IIHR has operated the Iowa Water Quality Information System since 2012 in partnership with the Iowa Department of Agriculture and Land Stewardship (IDALS), Iowa State University Extension and Outreach, and the Iowa Nutrient Reduction Strategy. IWQIS data is used by state and federal agencies, researchers, farmers, and the public to understand nutrient loading, track water quality trends, and evaluate conservation practice effectiveness.

The University of Iowa is a land-grant institution with deep engagement with Iowa's agricultural and environmental communities. IIHR's water quality monitoring work directly supports the Iowa Nutrient Reduction Strategy's goal of reducing nutrient loads to the Gulf of Mexico by 45%. IWQIS 2 will make this monitoring data accessible to a far broader audience — including K-12 educators, community colleges, and citizen scientists — through the MOI educational framework and THREDDS data access.

IIHR has not received NSF Unidata Equipment Award funding in recent cycles, and represents a disciplinary expansion of the Unidata community from its traditional atmospheric sciences focus into watershed hydrology and water quality monitoring.

6. Contact Information

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NSF Unidata technologies to be used: THREDDS Data Server (TDS), NetCDF-CF data formats, OPeNDAP protocol, MetPy (for educational examples and analysis widgets).

Equipment Quotes

Non Capital Equipment:

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ASUS Ascent GX10

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Overview Tech Specs Review Support

Compact Desktop AI Supercomputer, powered by the NVIDIA® GB10 Grace Blackwell Superchip and NVIDIA DGX™ Spark. Seamless integration and deployment, revolutionizing AI development and research.

- **Extreme AI Performance**: Powered by NVIDIA® GB10 Grace Blackwell Superchip delivering 1 petaFLOP of AI performance and 128GB memory for 200B model fine-tuning.
- **Developer-Optimized Platform**: Tailored for AI researchers and developers with full-stack compatibility and streamlined workflows.
- **Scalable Architecture**: Featuring NVIDIA® NVLink™-C2C for ultra-fast CPU-GPU memory communication and NVIDIA® ConnectX-7 networking to support dual GX10 system stacking, unlocking superior scalability and performance.
- **Advanced Thermal Design**: Engineered cooling ensures sustained high performance and reliability in an ultra small form factor.
- **Minimal Footprint, Maximum Efficiency**: High-density compute power in a compact system designed for labs, offices, and edge environments.
- **Full Stack AI Solution:** The GB10 and NVIDIA AI software stack provide a full stack solution for AI development and deployment.
- **Secure and Scalable Agentic AI:** Empowering the development of safe, long-running autonomous agents by leveraging NVIDIA NemoClaw to establish an agent-ready platform with isolated sandboxes, governed access control, and private on-device inference.

DESIGN AWARD 2026



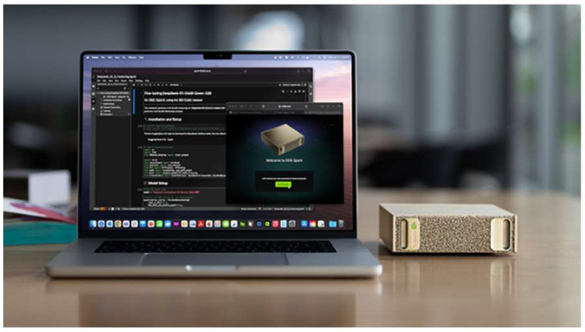
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Components

Base
PowerEdge R360 Server

Trusted Platform Module Edit
No Trusted Platform Module

Chassis Configuration Edit
3.5" Chassis with up to 4 Hot Plug Hard Drives, Front PERC 11

Processor Edit
Intel® Xeon® 6 Performance 6333P 3.1G, 6C/12T, 18M Cache, Turbo, (65W) DDR5-4800

Processor Thermal Configuration
Heatsink

Memory Configuration Type
Performance Optimized

Memory DIMM Type and Speed
5600MT/s UDIMMs

Memory* Edit
32GB UDIMM, 5600MT/s ECC
Qty 2

RAID Configuration Edit
C7, Unconfigured RAID for HDDs or SSDs (Mixed Drive Types Allowed)

RAID Controller Edit
Front PERC H355 Front Load

Storage Edit
8TB Hard Drive SAS ISE 12Gbps 7.2K 512e 3.5in Hot-Plug, AG Drive
Qty 1

BIOS and Advanced System Configuration Settings Edit
Performance BIOS Setting

Advanced System Configurations Edit
UEFI BIOS Boot Mode with GPT Partition
No Energy Star

Fans
No Additional Fan for 3.5" Chassis

Power Supply Edit
Single, (1+0) Non Redundant, Hot-Plug Power Supply, 600W MM (100-240Vac)

Power Cords Edit
NEMA 5-15P to C13 Wall Plug, 125 Volt, 15 AMP, 10 Feet (3m), Power Cord, North America
Qty 2

PCIe Riser Edit
Riser Config 0, No Riser

Bezel Edit
No Bezel

Boot Optimized Storage Cards Edit
No BOSS Card

OS & Software

Operating System Edit
No Operating System

OS Media Kits Edit
No Media Required

Embedded Systems Management Edit
Dell Connectivity Client - Enabled
iDRAC9, Basic 16G

Dell Secure Onboarding Edit
Dell Secure Onboarding Client Disabled

Password Edit
iDRAC,Factory Generated Password, No OMOR

Group Manager Edit
iDRAC Group Manager, Disabled

Accessories

Rack Rails Edit
No Rack Rails or Cable Management Arm

Shipping & Documentation

System Documentation
No Systems Documentation, No OpenManage DVD Kit

Shipping Edit
PowerEdge R360 Shipping

Shipping Material
PowerEdge R350/R360 Shipping Material for 3.5" Chassis

Regulatory Edit
PowerEdge R360 CCC Marking, No BIS or CE Marking