Project Summary:

Name of project: *Community Open Data and Experimental Mesonet (CODE-M)*
Project lead and contact details: Agbeli Ameko, NCAR, agbeli@ucar.edu, (303) 497-2487
Project partners and contact details:

1) Mike Daniels, NCAR, daniels@ucar.edu, (303) 497-8793,
2) Keith Maull, NCAR, kmaull@ucar.edu, (303) 497-1187,
3) Elliot Foust, NCAR, wefoust@ucar.edu, (303) 497-2458

Proposed start and end date: August 1, 2019 - February 28, 2020

Budget Requested: $7340

Budget Summary:

Cloud-hosting fees: AWS CHORDS instances	Up to 4 AWS EC2 t2.large instances @ $67/mo per instance based on current pricing.	$1340*
Purchase, 3D-print, assemble, test/design modifications as needed, and deploy IoTwx 3D-PAWS weather stations	Purchase and deploy four (4) 3D-print weather station parts and new design to assemble for deployment at three (3) CODE-M pilot program locations.	$4000
Conference travel	Presentation of project findings and outcomes to Winter 2020 meeting.	$3000

Project Outline:

Project description: Real-time sensors are increasingly being used for scientific analysis and discovery in earth science education. The Internet of Things (IoT) concept describes an environment in which small, inexpensive sensors become ubiquitous and stream their data to servers on the Internet in real-time. Recently, a platform called the IoTwx has been developed to expand, explore and bring visibility to low cost, IoT weather sensing. A successful and highly stable, near-professional grade IoTwx platform is the 3D-Printed Automatic Weather Station (3D-PAWS), which will serve as the backbone of this project. Initially designed and developed at UCAR/COMET in 2014, 3D-PAWS is a Raspberry Pi based weather station composed of nearly 70% 3d-printed parts. It has been deployed into dozens of locations around the globe[1] and has recently undergone a series of proposed modifications by partner Maull and PI Ameko to improve its deployability and simplify its construction for students, educators and researchers looking for low-cost, easy-to-deploy weather stations.

Therefore, at the heart of this proposal is the development of tools and capacity to explore building mesonets atop these low-cost sensors. Indeed, dense mesonets to support operational forecasting, research, emergency management, and educational outreach are rare, and

[1] See 3d.chordsrt.com, 3d-kenya.chordsrt.com, 3d-zambia.chordsrt.com and chords.globedata.ws

remarkably, only three US states (Oklahoma, New York, and most recently Texas) have such mesonets. The high costs of building and maintaining the requisite network of weather stations (often between $10,000 - $15,000 per commercial grade system) are the primary factor cited in the slow development of these mesonets, yet their value in improving operational outcomes are obvious. In this project we will test the potential of a community operated mesonet based on the proposed modifications to 3D-PAWS aimed at demonstrating the potential to operationalize more of such mesonets around the country.

To address the IoT as it could be applied to the geosciences, an NSF-funded project called "Cloud-Hosted Real-time Data Services for the Geosciences" (CHORDS, see chordsrt.com) was proposed and funded in 2016 to explore the use of real-time data in a scientific context. We will us CHORDS to store and stream the data real-time produced by our 3D printed stations.

Through the ESIP Lab funding, we would like to 1) test and complete IoT based modifications to 3D-PAWS to demonstrate a Community Open Data and Experimental Mesonet (CODE-M) and, 2) publish and store data from IoTwx on CHORDS to meet FAIR data standards.

Project objectives, significance and impact:

- CODE-M can help communities augment, verify, and compare forecasts to observational data improving user's understanding of inevitable forecast error and bias. This could include comparisons to research models like WRF or NWS operational model forecasts.
- Testing the viability of IoTwx as a platform to build community mesonets which can help more communities across the country adopt mesonet programs.

Description of key project steps and timeline:

FALL 2019

- Announce candidate community that will participate in the CODE-M pilot program.
- Establish project GitHub repository.
- Purchase, print, assemble, and test four (4) IoTwx stations.
- Install and test WRF-pi interfaces on all IoTwx systems.
- Test station deployment time for air sensing (T, P, RH) and communications nodes including hotspot and LoRa operability.
- Test system connectivity and set up Grafana dashboards or other reporting systems to ESIP CHORDS instances.

Winter 2019

- Test station deployment time for Wind, Hydro (WS,WD, Rain and/or soil) and communications nodes including hotspot and LoRa operability making necessary subsystem modifications to insure rapid deployment.
- Visit CODE-M pilot community for IoTwx stations deployments.
- Publish to ESIP CHORDS instances.
- CODE-M wrap up and final report.
- **Present results at ESIP 2020 Summer Meeting**

Outreach:

What groups/audiences will be engaged in the project?
The team will engage select communities in Colorado and/or Wyoming. If this project is approved, we will announce this at the 2019 ESIP Meeting and through ESIP Newsletters.

How will you judge that project has had impact?
Impact will be assessed in terms of deployment to pilot communities and community engagement. Impact will also be measured by the quality and quantity of data generated and the use of that data outside of the project. We will track the use of dataset and other project DOIs through and beyond the lifespan of the project.

How will you share the knowledge generated by the project?
Information about the project will be shared on the ESIP EnviroSensing site and through resulting publications, posters, and presentations given relating to the project. An ESIP GitHub repository will be created to store all project documentation and artifacts. All datasets generated from stations will be minted DOIs via Figshare and indexed directly with NCAR's DASH search portal. A website will be developed on Github to archive project assets and content relevant to ESIP and the public.

Project Partners:

Description of project partners (individuals and/or organizations) and their involvement:

Agbeli Ameko, NCAR Computational and Information Systems Laboratory (CISL), will work on testing, assembling and deploying IoTwx weather stations at select communities.
Keith Maull, NCAR Library, will lead the project and coordinate the activities. He will work with project partners to track deliverables and project priorities.
Mike Daniels, NCAR Earth Observing Laboratory (EOL) and CSU, will assist in IoTwx hardware configuration and CHORDS interfacing, set up ESIP CHORDS instances and reporting dashboard graphics using Grafana. He will also participate in community visits.
Elliot Foust, NCAR Computational and Information Systems Laboratory (CISL), will set up WRF-Pi, a low-cost, Raspberry pi-based experimental forecasting platform.

How will this project engage members of the ESIP community?
The team will promote and engage the ESIP community through inviting ESIP members to work with IoTwx station data on ESIP cluster for analysis, and will promote participation at the ESIP summer and winter meetings.