The Madison Automatic Weather Station:
Next-Generation Development and Operational Successes

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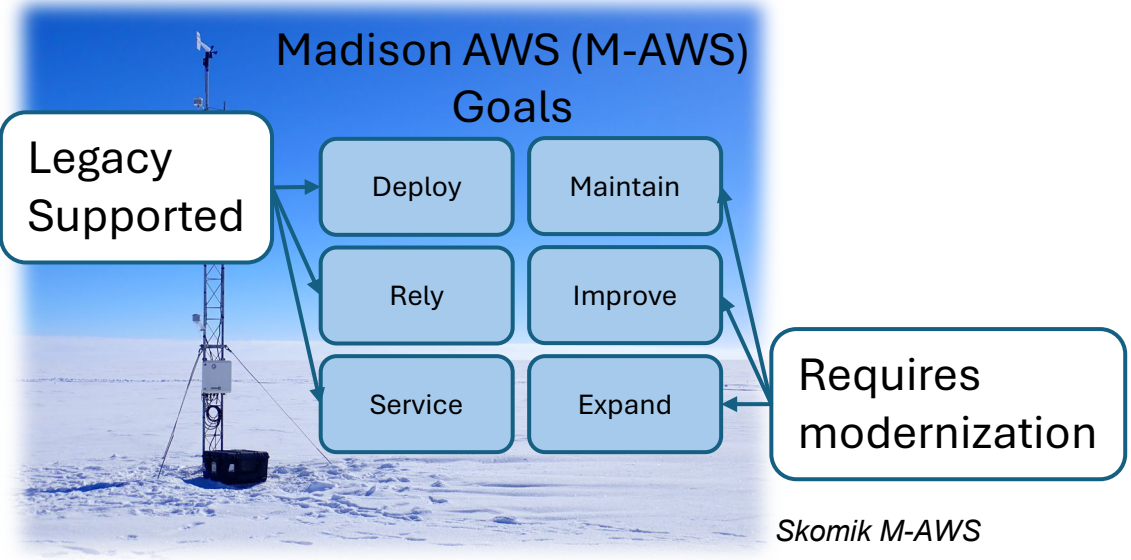
Madison AWS Motivation & Goals

- AWS Program supports Antarctic observations
- The AWS is a valuable community asset
- Need for modernization (continual)
- Evolving measurement suite and requirements
- Student involvement at every level of AWS project, proposal/design -> manufacturing/assembly -> testing/validation -> support/deployment



Skomik M-AWS

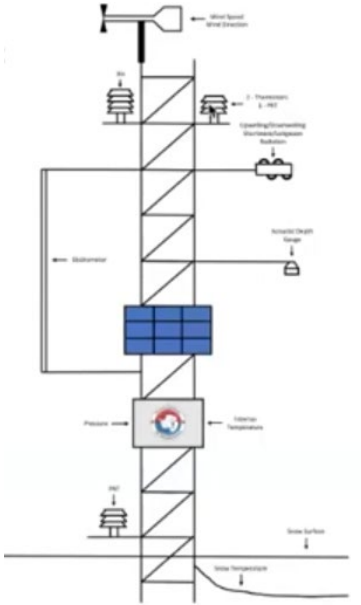
Some MATC students that have worked on the AWS project – clockwise from top: Jordan Gehrking, Andres Perez, Maija Balts, Jake Zimmerman, Justin Widen (center), Ryan November, Barkwende Nikiema, Caleb Hudson, Grace Zongo

System Overview & Expanded Instrument Suite

- 3-meter tower – convenient to service
- Transmit real-time data every 10 minutes – Iridium network
- As good or exceeding WMO measurement standards
- Low power draw – must preserve a power system over winter
- Focus on modular sensor integration

- Temperature
  - Apogee PRT & thermistors
- Pressure
  - Paroscientific Digiquartz 215A
- Relative Humidity
  - Campbell Scientific HMP155A
- Wind speed + direction
  - RM Young 05103
  - Taylor WS3 + WD3 (high wind)
- Distance to surface
  - Campbell Scientific SR50A
- Snow drift
  - ISAW FlowCapt IC4
- Charge controller
  - Flexcharge PV7D
- Network
  - Iridium 9602-NAL

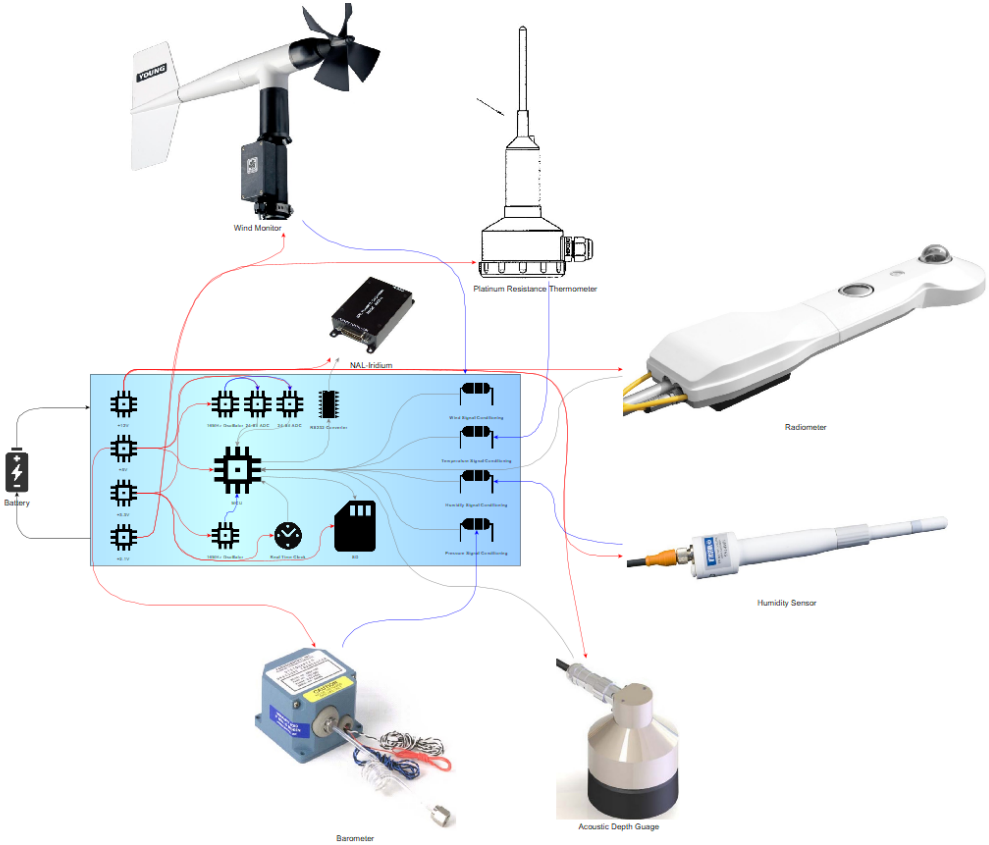
M-AWS concept



Courtesy Carol Costanza

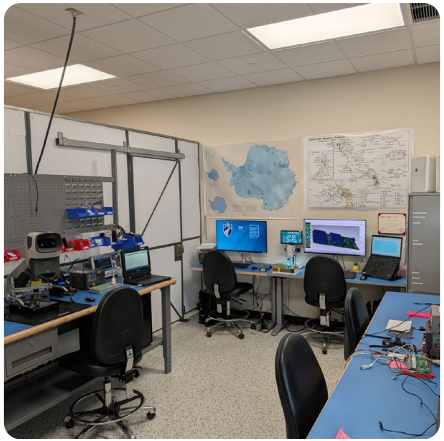
Madison AWS Development Overview

- Electronics architecture
  - Highly integrated precision ADC – 24-bit!!
  - Supports many kinds of instruments
    - Time-based, resistive, voltage, serial data
  - Non-volatile flash memory for long-term data storage
  - v0.1, v1.0, v2.0, v2.1, v2.2, v2.3, v3.0…
- Embedded software
  - C++, state machines
  - Bare-metal, fast, deterministic
  - On-board data processing
- Power system
  - Lead acid battery bank with efficient solar charging
  - Multiple regulated voltage levels
  - Exhaustive on-board load switching – alternative to relays
- Communications
  - Satellite modem – Iridium NAL
  - RS-232, SDI-12, UART, I2C, SPI
  - JTAG, ICSP (debugging tools – don't talk to instruments)
- Mechanical design
  - 3-meter AWS tower design
  - Mil-spec plugs for harsh environmental installations
  - Inexpensive, robust data logger enclosure – built in house
- Modular subsystems
  - Removable data card
  - Sensor suite



-85C° freezer

Madison AWS lab



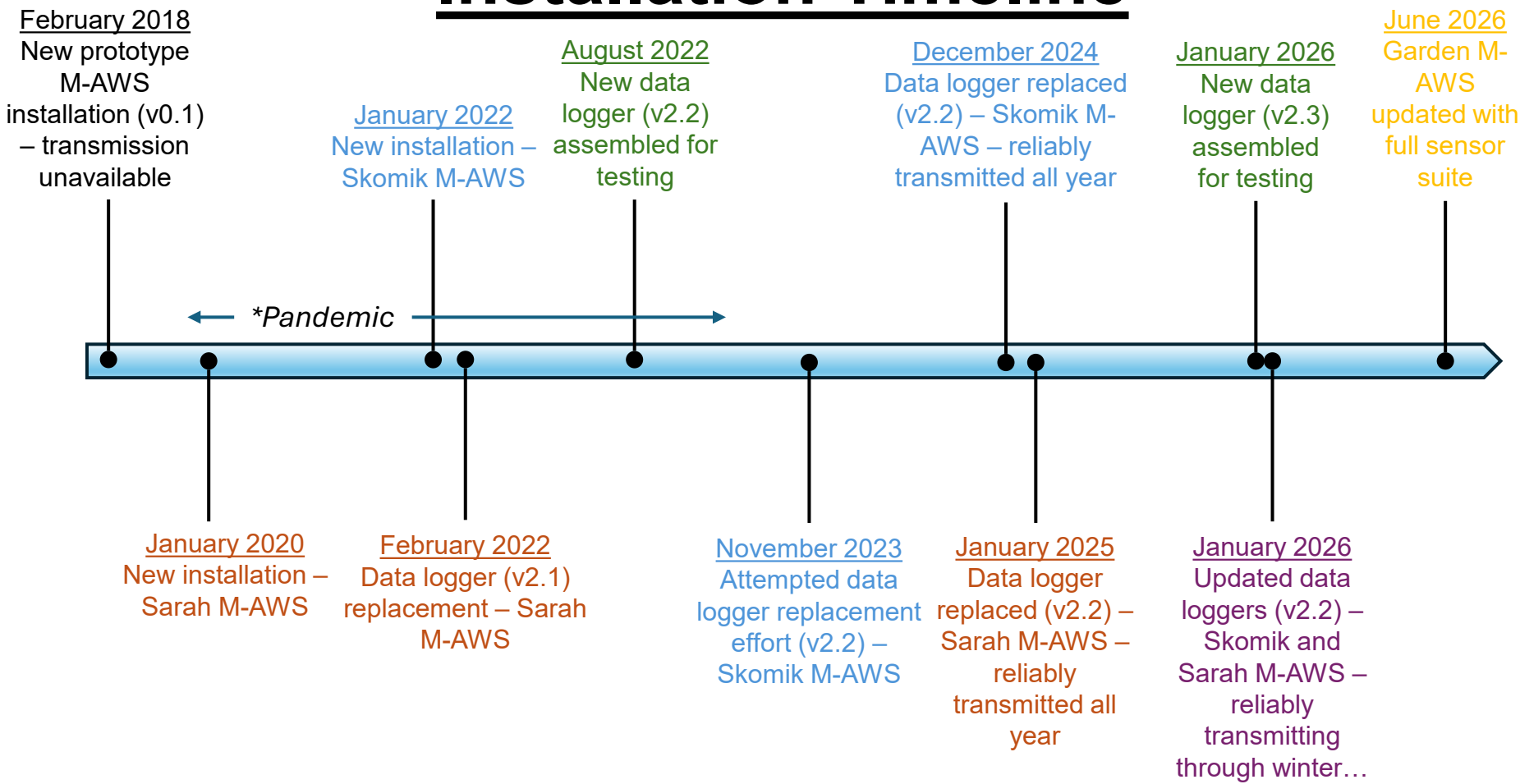
PCB assembly and fab lab

Garden M-AWS site

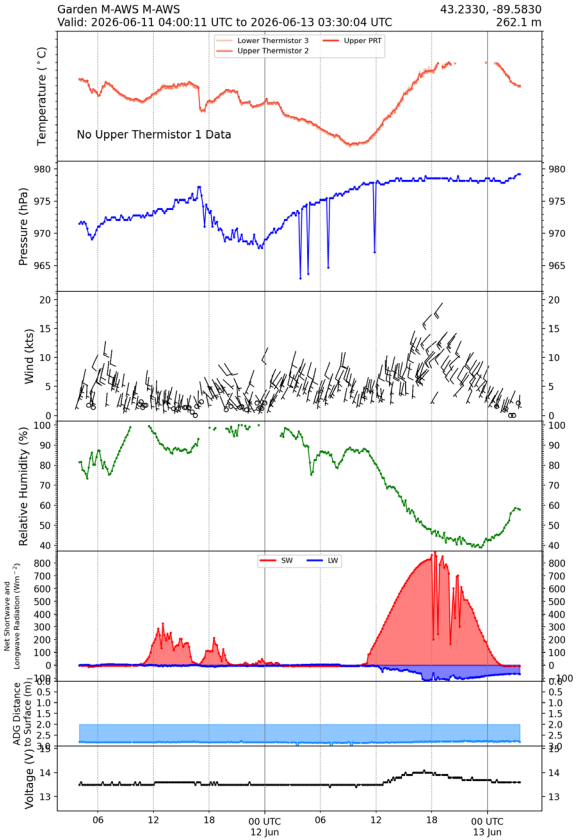
Test Facilities & Validation

- Indoor laboratory testing/prototyping
  - Able to mock M-AWS lab on the bench; Iridium transmissions (rooftop antenna)
  - Scopes, analyzers, meters
  - Enclosed 3D printers
  - Laser engraver/cutter
  - Advanced circuit fab/assembly
- Environmental testing
  - -85C° freezer, web-based remote monitoring
- Outdoor Wisconsin test sites
  - Garden station – now has complete sensor set! https://amrdc.ssec.wisc.edu/web_products/99698.txt
- Long-duration validation

Installation Timeline



Current Project Status



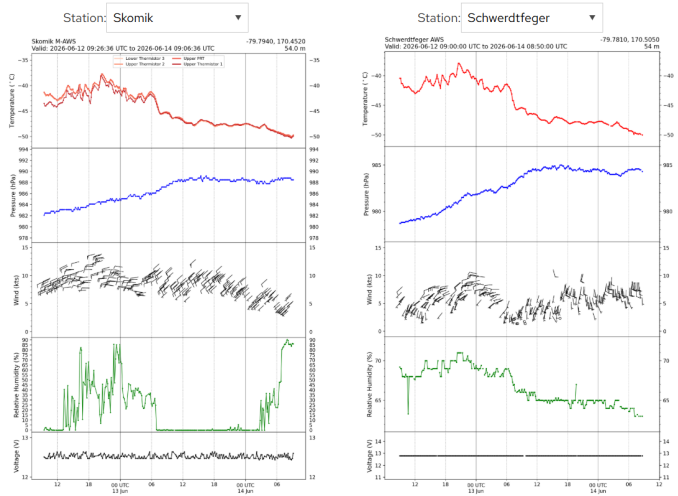
Meteorogram – Garden M-AWS

- Built around 50 data logger systems
  - Over half deprecated – outdated versions
  - Around 15 systems are deployable – depends on available instrumentation
- 2 M-AWS deployments in Antarctica
  - Sarah M-AWS – transmitting reliably
  - Skomik M-AWS – transmitting reliably
- 1 testing/validation site
  - Garden M-AWS – now has full sensor suite
- Development in progress….
  - Data logger v3.0
  - GPS implementation
  - Data storage (e.g., data card, flash memory)
  - On-site station health monitor and reporting

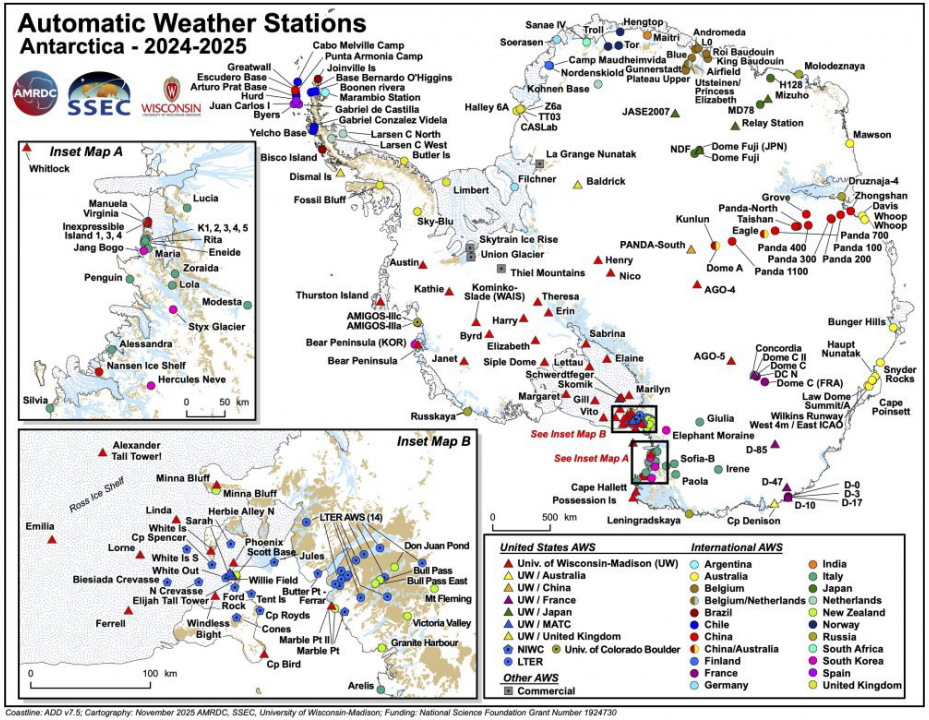
Lessons Learned & Successes

- Successes
  - Antarctic deployments – M-AWS maintained since 2020
  - Comparative data – side-by-side site testing (Sarah v. Willie Field, Skomik v. Schwerdtfeger)
  - Reliable operation – 17 consecutive months (~1.5 winters)
  - Improved efficiency – deep sleep features save battery life
  - Student engagement – since 2017, Madison College has directly worked with 17 2-year technical students on the AWS project, all of which entered STEM industry and/or engineering schools
- Lessons Learned
  - Some instruments are harder to integrate than others
  - Long term field testing is essential to determine when and how things will fail
  - Supply chain for components and service contracts is fickle…need to plan for the worst
  - Large teams of student workers contributing to a complex system require well-designed workflow processes to be successful
  - Engineering results take lots of planning, effort, and patience – failure and success are two sides of the same coin

Courtesy Andy J. Kurth



Skomik/Schwerdtfeger – collocated site comparison



Hoping to add more blue triangles – M-AWS sites – to the map

Future Plans

- 2026–2027
  - Continue expanding instrument suite at current M-AWS sites
  - Update M-AWS data logger to version 3.0, improving hardware and software capabilities to allow for feature expansion and more integrations
- Longer Term
  - Additional site deployments
    - More collocated AWS sites
    - M-AWS sites in extremely cold locations
  - Integrations
    - camera subsystem
    - GPS telemetry
    - Argos network support
    - New high wind speed sensors
  - Improved user interfaces
    - Easier to configure AWS for deployment

Thanks to…

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