



AASC Mesonet Recognition Program Requirements and Procedures

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1. Introduction

The U.S. Weather, Water, and Climate Enterprise is supported by a dense observational infrastructure: an array of independent observing networks owned and operated by a mix of federal and state governments, academia, and private sector companies. Mesonets in particular play a critical role in the weather and climate observational space¹. These observational networks are functionally diverse and are designed and deployed for varying purposes, including agriculture, air pollution monitoring, aviation, education, energy applications, emergency management, and transportation. While data from all networks are of some value, not all data are of equal quality or value for all weather applications. In addition, not all weather observing systems are maintained with the same degree and frequency of care as most mesonets across the United States.

To aid users of weather and climate data in need of high-quality observations, the American Association of State Climatologists (AASC) has designed this recognition program to recognize those data providers that can be relied upon to provide high-quality, timely (near real-time), and relevant weather and climate data. These data providers are so recognized for their (1) consistently high level of excellence for data quality and maintenance and (2) their efforts to follow and adopt the latest scientific best practices and guidelines in the collection, processing, archival and dissemination of environmental data.

This document outlines the goals, criteria and procedures of the AASC Mesonet Recognition Program.

2. Program Goals

The goals of the Recognition Program are to:

- Promote a standard of excellence for the collection, processing, archiving, and dissemination of high-quality weather and climate data.
- Recognize mesonets adhering to high-quality data standards and best practices.
- Provide an independent assessment of the quality and maintenance of mesonets used for public service.
- Provide users of weather and climate information with a list of research-quality networks.
- Provide mesonets with constructive ideas to improve performance.

¹ Mahmood, R., and Coauthors, 2017: Mesonets: Mesoscale Weather and Climate Observations for the United States. *Bull. Amer. Meteor. Soc.*, **98**, 1349–1361, <https://doi.org/10.1175/BAMS-D-15-00258.1>.

3. Recognition Criteria

AASC Mesonet Recognition is provided to those mesonets that, to the best of their ability, follow the principles and guidelines described in the AASC's *Recommendations and Best Practices for Mesonets*². The recognition criteria are based upon five general categories: (1) station siting; (2) sensor performance; (3) station maintenance; (4) quality assurance and quality control; and (5) end-to-end services. These categories contain recognition criteria that are structured in a 5-level system. The meaning of each level generally represents the following:

Level 1: Network has demonstrated little or no evidence that it is following the ideals set forth in the *Recommendations and Best Practices for Mesonets* guide.

Level 2: Network has provided substantial evidence of operational excellence but is lacking in some areas that are necessary for recognition.

Level 3: Network has demonstrated a satisfactory level of operational excellence in order to be recognized by the AASC.

Level 4: Network has exceeded the required level of operational excellence and has implemented systems and procedures that go above and beyond what is required for recognition.

Level 5: Network is on the forefront of developing operational standards and best practices and has demonstrated a capability that far exceeds what is required for recognition.

Networks will be reviewed and scored based on their abilities to satisfy the recognition criteria outlined in each of the categories defined below. Level 3 is considered passing for each category and subcategory. All categories and subcategories must be passed in order to be recognized.

² AASC *Recommendations and Best Practices for Mesonets*. American Association of State Climatologists. (2019, June 19). <https://stateclimate.org/best-practices/>

3.1 Siting

Mesonet stations should be sited in a way that are broadly representative of the surrounding mesoscale environment while limiting local obstructions and microscale effects. Ideally, each station should be located on a flat, or nearly flat, natural surface at least 100 m² in area and deployed on a natural (likely grass) surface (no rooftops, walls, vehicles). Nearby obstructions or artificial surfaces, such as tall trees, buildings, and parking lots, should be avoided where possible. General guidance is that obstructions should be no closer than 10 times their height from the station. However, this guideline should not be viewed as an obstacle to monitoring conditions on the mesoscale. Where this guideline cannot be achieved, siting metadata are extremely important and should be well documented. Large bodies of water, irrigation, and complex topography should be avoided. In general, the site area should be as homogenous as possible. Differences in topography, land cover, and land use type should be limited across the site domain.

In all cases, thorough site metadata should be collected and regularly updated to accurately reflect the siting conditions of stations.

To summarize, these are the specific siting requirements that ideally should be met:

- Each station should be installed in a location that is broadly representative of the surrounding mesoscale environment.
- Each station should be located on a flat, or nearly flat, natural surface at least 100 m² in area, and deployed on a natural surface, such as grass (i.e. no parking lots, no rooftops, walls, vehicles, etc.).
- Obstructions should be no closer than 10 times their height from the station.
- Large bodies of water, irrigation, and complex topography should be avoided.
- The site area should be as homogenous as possible. Although highly complex terrain may be unavoidable, differences in topography, land cover, and land use type should be minimized across the site area.

These are the specific instrument location requirements that ideally should be met:

- Air temperature and relative humidity should be measured between 1.5 m and 2.0 m above ground level (AGL); air temperature should be housed within an aspirated (or naturally ventilated) shield to minimize solar radiation errors.
- Precipitation should be measured ≤ 2.0 m AGL with an orifice diameter of ≥ 15.24 cm (6 inches).
- Solar radiation sensors should be placed level in an open location with minimal obstructions on the horizon and minimal reflectance on to the sensor.

- Soil moisture data should be collected under natural vegetation cover, and soil temperature can be collected under bare or natural vegetation. The soil type should be as representative as possible of the surrounding area. The specific depths for soil monitoring may vary according to stakeholder needs.
- Wind speed and direction should be measured at 10.0 m AGL, except when satisfying a specific purpose such as fire weather or agricultural needs.

These are the specific siting metadata requirements that ideally should be provided:

- Station name, latitude, longitude, and elevation.
- A paragraph description of site characteristics and/or maps of site properties (this could be digital elevation maps, land-use, soil characteristics, and slope information).
- Aerial imagery (i.e., either satellite or drone-based). Range rings and station location ideally should be marked on the imagery.
- 4 cardinal direction photographs, updated annually.
- A list of obstructions that violate the siting specifics listed above.
- Sensor mounting heights plus explanation if deviating from siting criteria listed above.

Siting should also be reviewed annually to track changes in site exposure and to document and prioritize stations that need to either be relocated or mediate microscale influences (e.g., improve fetch by removing encroaching trees/shrubs in the vicinity of the station).

Criteria:

Category	Station siting	Instrument location	Metadata
Level 1	None of the requirements are met by any station.	None of the requirements are met by any station.	None exist.
Level 2	At least 30% of the stations meet the requirements; Siting variances are well documented.	At least 30% of the stations meet the requirements; Instrument location variances are well documented.	Less than 3 of the 6 required items are included and are not updated on an annual basis.

Level 3	At least 50% of the stations meet the requirements; Siting variances are well documented.	At least 50% of the stations meet the requirements; Instrument location variances are well documented.	Includes 4 of the 6 required items and items are updated annually.
Level 4	At least 70% of the stations meet the requirements; Siting variances are well documented.	At least 70% of the stations meet the requirements; Instrument location variances are well documented.	Includes 5 of the 6 required items and items are updated annually.
Level 5	At least 90% of the stations meet the requirements; Siting variances are well documented.	At least 90% of the stations meet the requirements; Instrument location variances are well documented.	All 6 items are included and are updated annually.

3.2 Sensor Performance

A mesonet station is expected to utilize in-situ meteorological sensors with the ability to accurately record weather and climate data as it occurs. Not all sensors used in weather and climate monitoring are suitable for deployment at a mesonet station due to factors such as cost, ruggedness/reliability, service interval, and accuracy. Meteorological sensor technology is a dynamic industry that will change what is deemed acceptable in a mesonet over time. To address this, some criteria provided below are based on the 2019 version of the AASC publication *Recommendations and Best Practices for Mesonets*, which has an anticipated update frequency of 5 years.

The performance of a sensor is one of the hallmarks of whether or not it can be considered ‘research-grade’. Ruggedness and reliability are key to sensor survival while exposed to the outdoor environment. To ensure long-term performance, regular maintenance should be performed on sensors to mitigate external elements that may impact sensor performance, such as pests, dust, salt/minerals, etc. Additional information regarding sensor performance, including accuracy and range, can be found in *Recommendations and Best Practices for Mesonets*.

Acceptable sampling rates of sensors will vary from 3-second for dynamic variables such as wind to 5-minute for slowly changing variables such as soil temperatures. Reporting intervals are 5 minutes in nearly all cases. One-second sampling and 1-minute reporting are starting to be adopted by some mesonets, but delivery of data should still conform to applicable standard sampling and averaging periods found in *Recommendations and Best Practices for Mesonets*. The standard definition for wind gust, for example, is the highest 3-second average over 5 minutes.

Mesonets operate stations with many types of reported parameters, but the essential ones are provided in the Primary Sensing list below. Additionally, mesonets are known for their ability to add instrumentation to respond to their stakeholders' particular needs (e.g., solar radiation for evapotranspiration or cloud cover estimates, 10-cm bare soil temperature for agriculture, etc.) Examples are provided in the Expanded Sensing list below.

Primary Sensing (complete list):

- Air Temperature
- Relative Humidity
- Wind Speed
- Wind Direction
- Wind Gust
- Rainfall (liquid-only precipitation)

Expanded Sensing (examples):

- Barometric pressure
- Solar Radiation
- Snow Depth
- Soil Moisture
- Soil Temperature
- Precipitation (solid and liquid)

Criteria:

Category	Primary Parameters	Expanded Parameters
Level 1	Temperature and rainfall instrumentation is either not deployed or fails to meet standards* at all stations.	None are measured.
Level 2	Temperature and rainfall instrumentation is deployed and meets standards* at all stations. Near real-time reporting at sub-hourly intervals or better at all stations.	None are measured.
Level 3	All instrumentation is deployed and meets standards* at all stations. Near real-time reporting at 5-minute intervals or better at all stations.	None are measured.
Level 4	Same as Level 3.	Expanded monitoring sensors are deployed and meet standards* at most stations.
Level 5	More advanced sensors for higher accuracy (e.g., heated sensors, shielded precipitation gauges, aspirated temperature sensor shields, etc.) at the majority of stations.	Pioneering new measurements, (e.g. precipitation type, net radiation, PAR and other specialized spectrum radiometers, weighing precipitation gauges, etc.) at any number of stations. Web cameras mounted on/near the station for ground-truthing weather events and anomalous data at any number of stations.

* Standards of sensor performance and sampling/reporting as outlined in the most current version of the AASC publication *Recommendations and Best Practices for Mesonets* using equipment of appropriate ruggedness and reliability to serve in the elements and in meteorological situations where the data is relied on to protect life and property.

3.3 Maintenance

One of the key distinguishing characteristics of an AASC recognized mesonet is its high maintenance standards. The ability to respond quickly to failed sensors (within days) minimizes data gaps, and attention to sensor quality and calibration ensures confidence in the data record. A well-maintained network should have proactive, preventive maintenance, with routine site visits scheduled for regular cleaning, calibration, and inspection of sensors. Technicians should also be available for unscheduled trips to sites to respond to system problems such as failed equipment and/or communications. All site visits and sensor maintenance should be recorded in appropriate metadata.

Criteria:

Category	Scheduled Maintenance	Emergency Maintenance	Documentation	Sensor Metadata	Site Upkeep
Level 1	None.	No protocol exists to respond to emergency sensor/station maintenance issues.	None.	None.	None.
Level 2	Average ≤ 1 visit per station per year.	No protocol exists to respond to emergency sensor/station maintenance issues.	Sparse documentation. Infrequent.	Only done on initial install. No updates.	None.
Level 3	Average ≥ 1 visit per station per year. Sensor calibration or function check performed on a schedule.	A defined protocol exists to respond to emergency sensor/station maintenance issues.	Done each visit. List of items done.	Updated as needed. Includes photos of station and serial numbers of sensors.	Occasional spraying and management of vegetation

Category	Scheduled Maintenance	Emergency Maintenance	Documentation	Sensor Metadata	Site Upkeep
Level 4	Average ≥ 2 visits per station per year. Sensor calibration or function check performed on a schedule.	A defined protocol exists to respond to emergency sensor/station maintenance issues.	Done each visit. List of items done, time of visit, name of technician(s) at site.	Updated once a year. Includes photos of station and serial numbers of sensors.	Routine management of vegetation and removal of pests, nests etc.
Level 5	Average ≥ 2 visits per station per year. Sensor calibration or function check performed on a schedule.	A defined protocol exists to respond to emergency sensor/station maintenance issues.	Done each visit. List of items done, nature of visit, time of visit, name of technician(s) at site. Centralized location of historical maintenance visits.	Updated each visit. Station photos taken each visit. Serial numbers updated when sensors change. Documentation of maintenance on sensor.	Routine management of vegetation and removal of pests, nests, etc.

3.4 Quality Assurance and Quality Control

In addition to its field maintenance, mesonets should apply data quality control (QC) and quality assurance (QA) to more readily identify biases and errors. Automated quality control may include: (i) physical range tests; (ii) seasonal range tests; (iii) sensor intercomparison tests; (iv) temporal consistency tests; and (v) spatial coherence tests. A data quality flag structure is recommended to identify periods of data that are good, suspect, or bad. Additionally, data flags should be shareable with data users alongside observational data. Both automated QC and manual QA are recommended in order to more thoroughly identify subtle errors within the data, and these processes should be well documented in network metadata.

Criteria:

Category	Document QAQC Procedures	Flagging Information	Manual Review Process	Automated QAQC Procedures
Level 1	No procedures defined.	No flag information defined.	No process in place.	No procedures exist.
Level 2	QAQC procedures exist for at least air temperature, relative humidity, precipitation, and wind data, but are not documented in a way that can be shared with data users.	Flagging structures or logs of flagged data exist but are not documented in a way that can be shared with data users.	Manual review process may exist but is not implemented in any regular fashion.	No procedures exist.
Level 3	All manual and/or automated QAQC procedures for all variables measured are documented and available in a format that can be shared with data users.	One or both of the following items is documented and is available in a format that can be shared with data users: 1) list of all quality control flags along with their definitions, or 2) a log of data quality issues.	Manual review process may exist but is not implemented in any regular fashion.	No procedures exist.
Level 4	All manual and/or automated QAQC procedures for all variables measured are documented and available in a format that can be shared with data users.	A list of all quality control flags along with their definitions are available in a format that can be shared with data users.	Manual review QAQC process is defined and is implemented on at least a weekly basis.	Automated QAQC limit tests are implemented with automated flagging procedures.

Category	Document QAQC Procedures	Flagging Information	Manual Review Process	Automated QAQC Procedures
Level 5	All manual and/or automated QAQC procedures for all variables measured are documented and available in a format that can be shared with data users.	A list of all quality control flags along with their definitions are available in a format that can be shared with data users; Flag values are capable of being provided with observation data to data users, if requested.	Manual review QAQC process is defined and implemented on a daily basis.	Automated QAQC procedures for limit tests, temporal and spatial consistency checks are implemented; Automated QAQC procedures to detect long-term problems (e.g., sensor drift) with sensors or siting conditions are implemented; Automated QAQC procedures flag data automatically.

3.5 End-to-End Data Processing

The climate data record should be complete and accurate. According to the *Recommendations and Best Practices for Mesonets*, mesonets should “meet or exceed an operational reliability threshold of 95% or higher data completeness for any 60-minute period, for all stations in the network”. All derived statistics should use the base 5-minute observations, and a 75% completeness minimum threshold should be used when computing averages.

The climate data must also be accessible and useful. More specifically, the *Recommendations and Best Practices for Mesonets* guide concurs with the World Meteorological Organization when it states that weather data should be “credible, available/timely, dependable/reliable, usable, useful, expandable, sustainable, responsive/flexible, and authentic”³. Furthermore, it recommends that the data be both strategic and tactical, meaning that the data should be organized and presented in a way that allows users to make the most of these data for their own applications. Finally, program external partnerships should be “meaningful”. Meaningful

³ World Meteorological Organization (2014), Guide to meteorological instruments and methods of observation. 8th ed. WMO Rep. WMO-8, 569 pp.

partnerships are defined as those partnerships that go beyond simple use of mesonet data; meaningful partnerships may include collaborative research, co-development of value-added products, formerly funded grants or services, collaborative activities defined with an MOU or MOA, and any other formal and informal partnerships that involve mutually-agreed upon active collaborative activities that can be demonstrated to the AASC Recognition Committee.

Criteria:

Category	Archival Access	Display of Data	Value-added Products	External Partnerships
Level 1	None.	None.	None.	None.
Level 2	Manual request of data archive. Staff responds with data when ready to answer the request.	Data is displayed through a website on a per station basis for at least the last 24-hours.	At least one value-added single-station data product available (e.g., calculation of daily or monthly statistics from the sub-hourly data).	A few (1-2) meaningful partnerships with external organizations.
Level 3	Request mesonet data through the web on a per station basis, with a limited date range. Data is delivered via a web request.	Data from multiple stations may be displayed together through a website for at least the previous 24-hours, and the display of multiple station data must include at least $\geq 70\%$ of the network.	At least a few multi-station (e.g. a table), derived (value-added) climate parameters (using at least 70% of the mesonet stations).	At least 3 or more engaged partnerships with external organizations.

Category	Archival Access	Display of Data	Value-added Products	External Partnerships
Level 4	Request text-based data through the web for multiple stations over a limited date range. Data is delivered automatically via the web request.	Data from multiple stations may be displayed together through a website for at least the previous 24-hours, and the display of multiple station data must include at least $\geq 70\%$ of the network.	Multiple multi-station derived products available that aid either long-term climate monitoring and/or supports public/private sector decision making.	Multiple partnerships with external agencies across local, county, and state government agencies, commercial entities, and/or academic institutions.
Level 5	Request text-based data through the web for multiple stations over a limited date range, including all QC/QA codes. Data is delivered automatically via the web request. Partnering agencies may have full access to the archive.	Data from multiple stations may be displayed together through a website for at least the previous 24-hours, and the display of multiple station data must include at least $\geq 70\%$ of the network.	Multiple multi-station derived products available that support multiple users where multi-sector decision making is explicitly stated	Meaningful long-term engagement with external agencies across local, county, and state public, commercial and academic institutions.

4. Evaluation Process and Outcomes

The AASC's Mesonet Recognition Program evaluation process is designed to accomplish two primary goals: 1) determine if the applicant network has met the requirements for recognition by the AASC, and 2) provide recommendations for further improvement and development of the applicant network. In this way, the network seeking recognition not only is able to potentially receive recognition from the AASC for operational excellence but also identify ways to improve their network and meet the ideals set forth in the AASC's *Recommendations and Best Practices for Mesonets* document.

4.1 Applying for Recognition

Applications are accepted anytime and will be reviewed on a first come, first serve basis. No fee is required to apply for recognition. While membership in the AASC is not a requirement for a network to apply for recognition, it is strongly recommended that the individual submitting their mesonet for AASC recognition be a member of the AASC or apply for membership in the AASC if they are not currently a member. The volunteer committee will strive to complete the review within 12 months of receipt of an application but may need longer when the volume of recognition applications is large. Networks that apply and fail to be recognized may apply again as soon as they believe they have addressed all deficiencies identified in the previous review. There is no limit on the number of times a network can apply to be recognized.

4.2 Application Materials

All mesonets applying to be recognized by the AASC must complete the Mesonet Recognition Program online application. Some portions of the application require support materials. Examples of materials that may be submitted to support a mesonet's application to the program, include (but are not limited to):

- Station and sensor metadata listing.
- Station siting photos and images such as digital elevation maps etc. (Note: These can be provided via a compressed file or via a web URL where the photos and/or images are available).
- Station maintenance procedures document or a link to a website describing station maintenance procedures.
- QAQC procedures document or a link to a website describing the network's QAQC procedures.
- Links to articles (e.g., peer-review articles, white paper, etc.) summarizing various parts of a mesonet's ability to satisfy the recognition program's requirements.
- List of variables collected and value-added products calculated and made available to users.

- List of organization partners, including federal, state, and county governments, NGOs, academic and commercial entities with which the mesonet has an existing research and/or operational collaboration.

Additionally, the Recognition Program Review Committee may conduct interviews, at its discretion, if the committee determines that information is needed beyond what was submitted.

4.3 Review Process

Upon receiving a network applicant's materials, those materials will be independently reviewed by three members of the AASC Mesonet Recognition Review Committee. Following the independent reviews, the full Committee will review the results of the independent reviews to determine if a network has satisfactorily met the requirements (i.e., Level 3 in all categories) for recognition by the AASC. If the independent reviews lack consensus on passing one or more categories, the committee shall deliberate and, if necessary, vote to determine the acceptability of the network's qualifications for that category. In addition, if a committee member's network is being reviewed, that member shall recuse themselves from the review of that application.

4.4 Review Outcomes

Upon completing a review of a network, the AASC Mesonet Recognition Review Committee Chair shall notify the network in writing with the following information:

- A synopsis describing the basis of the committee's final decision (pass or fail) of the network's application to be recognized.
- A copy of each independent reviewer's comments and recognition program scores. Information shall be shared with the applicant network in such a way as to keep each reviewer's identity confidential.

Reviews will only be provided to the applicant and not made public in any form. In addition, if the network passes, the Chair shall provide a digital copy of the "AASC Recognized Mesonet" logo for the mesonet to use in digital and print materials. The AASC will also update its inventory and website with the mesonet's new recognition status.

4.5 Maintaining Recognition Status

Recognized mesonets must reapply to the AASC Mesonet Recognition Program every 5 years to maintain their recognition status. Failure to reapply for recognition status will result in that network's recognition status being revoked unless a request to defer the reapplication process has been made and approved by the AASC Mesonet Recognition Review Committee. If a mesonet fails to have its recognition status renewed during a 5-year review, it may reapply for recognition status per the process described in Section 4.1.

In addition, recognized mesonets are expected to satisfactorily (Level 3 or higher) meet the requirements of AASC Mesonet Recognition Program at all times while it is a recognized

mesonet. Failure to do so could lead the AASC Mesonet Recognition Program Review Committee to call for a special review of the mesonet's status to determine if it still satisfies the criteria required to be recognized by the AASC.

5. Program Review Committee

The AASC Mesonet Recognition Committee shall consist of 5 members, the majority of whom shall be affiliated with a mesonet. Initial membership of the Mesonet Recognition Committee shall be chosen by the AASC Executive Committee.

5.1 Membership Terms

To ensure the continuity of the committee, 2 out of the 5 initial committee members shall serve two year terms, while the other 3 remaining initial members shall serve 3-year terms, including the chair of the committee. All committee members that follow the initial committee members shall serve a three (3) year term from the time they are selected to serve on the committee. A committee member's membership on the committee may be renewed for another three (3) year term at the end of each term with approval from the majority of the remaining committee members.

5.2 Committee Chair

A member of the committee shall be chosen to serve as chair by the committee members. The committee chair shall serve in that role until the end of their term or until they are no longer able to serve as the committee chair. Upon completion of the committee chair's term, the committee may renew the committee chair for another term, or it may select a new committee member to fill the role as chair. If for any reason the committee chair is unable to continue serving as chair, the committee may select another member of the committee to serve as chair.

5.3 Committee Vacancies

Vacancies after the initial creation of the Mesonet Recognition Committee shall be filled by the Committee itself. If a committee member is unable to complete the entirety of their three-year term, the remaining members of the Committee will select another qualified individual to serve on the Committee.