MP-3000A Thermodynamic Profiler Features

Radiometrics continuously improves its patented MP-Series radiometers (MP3000A, MP2500A & MP1500A) and associated accessories to ensure accuracy and long-term reliability, and to assure of set up, calibration, operation, maintenance, repair and transport. This overview provides information on some of the more important improvements, with which clients might not otherwise be familiar. Because MP-Series radiometers have undergone continuous design improvements, existing customers may notice some differences between their units and the units pictured in this document.

Improved Local High-Impact Weather Forecasting

It is widely understood that nearly continuous boundary layer humidity, wind and temperature soundings can be used effectively to improve local high-impact weather forecasting[1]. National and provincial meteorological agencies are operating more than two hundred MP-3000A thermodynamic profilers worldwide to obtain continuous atmospheric soundings for this purpose. Continuous Forecast Indices derived from these soundings are used to improve fog[2], aviation weather[2], lightning and convective storm[3] forecasting. Radiometer data are combined in real time with model gridded analysis via One-Dimensional Variational Analysis (1DVAR)[4], merged with wind radar[5] and lidar[6], and assimilated directly into numerical models[7]. Fifty percent fog forecast improvement[2] and lightning-convection prediction more than two hours in advance[3] have been demonstrated. MP-3000 profiles are also used for weather modification[8], cloud physics and climate research[9], and wind energy forecasting[10].

Flexible Observation Channel Capacity

The MP-3000A is designed to make upper atmospheric observations in up to 800 K-band channels, and 400 V-band channels. These are true independent channel measurements, rather than the pseudo-channels (interpolations between measured channels) in competing radiometer products.

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[1] U.S. National Research Council, 2009.
[2] Thomas, 2009; Barrere et al, 2006; Shaw et al, 2006.
[3] Madhulatha et al, 2013.
[4] Hewison, 2006; Cimini et al, 2011, 2015.
[5] Barrere et al, 2008; Shaw et al, 2008; Thomas, 2009.
[6] Nelson et al, 2013.
[7] Koch et al, 2014.
[8] Bruintjes, 1999; Murakami, 2009; Xue et al, 2013;
[9] Cadeddu et al, 2013; Campos et al, 2013; Serke et al, 2014.
[10] Friedrich et al, 2012.

In practice, as few as five (5) K-band frequencies and seven (7) V-band frequencies are needed to produce accurate atmospheric temperature and humidity profiles under most conditions. Radiometrics normally provides 35 optimized and calibrated channels as standard with the MP-3000A, of which 22 channels (8 K-band and 14 V-band) are used operationally in the proprietary Radiometrics Neural Network retrieval algorithms.

By utilizing more than the minimum required frequencies to generate profiles (hyperspectral retrievals), improved profile accuracy is obtained. The additional channels also provide inherent radio frequency interference (RFI) mitigation capabilities, since the system operator can readily replace RFI contaminated channels with adjacent RFI-free channels.

The MP-3000A proprietary frequency synthesizer architecture allows Radiometrics to provide additional or unique factory calibrated K-or V-Band channels to support user-specified observational requirements, without requiring hardware changes. Please contact us should you have such needs.

Accurate All-Weather Measurements

Previous MP-Series radiometers used heated forced air to melt and evaporate precipitation accumulating on the radiometer radome. However, through extensive operational experience we found that the heated air often degraded the accuracy of nearby surface temperature and humidity measurements. Although the heated forced air reduced precipitation accumulation on the radome, ice accumulation during subfreezing conditions seriously degraded microwave and infrared measurement accuracies.

The current MP-Series design elevates internal cabinet temperature to eliminate dew on the radome. ***Patented Rain Effect Mitigation*** methods deliver accurate measurements during heavy rain, sleet and snow. ***Avoidance of external forced air heating*** and use of patented methods ensures surface meteorological, microwave and infrared measurement accuracy in all weather conditions[11].

Safety and Radiation Certification

The latest MP-Series radiometer has a more robust design with fewer internal assemblies, and has passed the most stringent requirements of Safety and Radiation Certification to **UL/IEC 61010-1** and **MIL-STD-461F** (Conducted Emissions – CE102, Radiated E-field Emissions – RE102, Conducted Susceptibility – CS101, Conducted Susceptibility – CS106, Conducted Susceptibility – CS114, and Radiated Susceptibility – RS103)[12].

[11] Chan, 2009; Cimini et al, 2011; Ware et al, 2013; Xu et al, 2014.
[12] Greb, 2012.

Cabinet Hood

The MP-Series Cabinet Hood is shown in Figure 1 with field replaceable SuperBlower, radome, GPS and infrared window components.

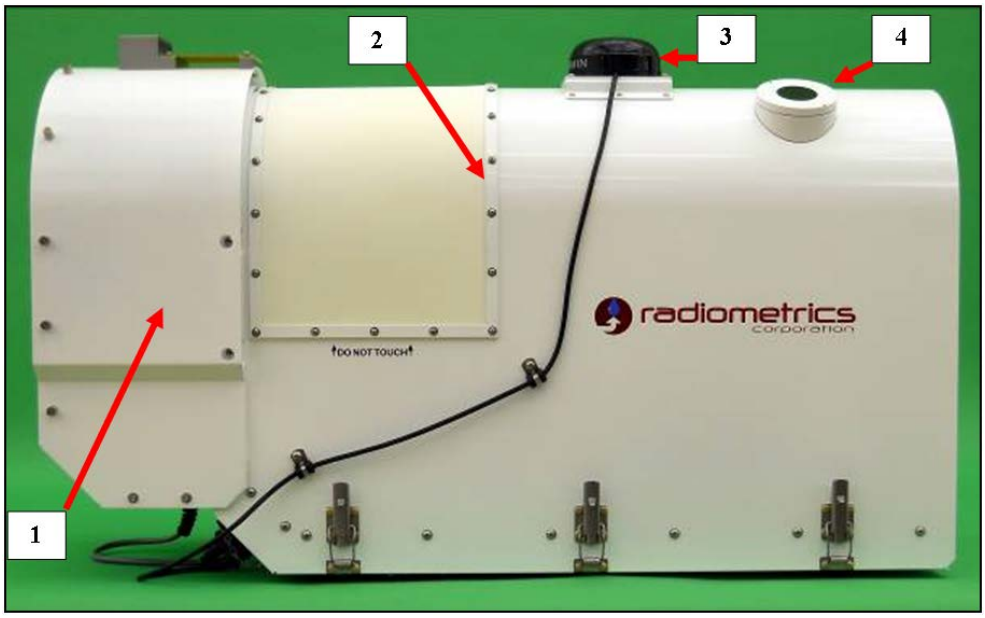

Figure 1. Cabinet Hood (inset numbers are described below).

1. Field replaceable SuperBlower assembly attaches with just four mounting screws.
2. Easy-change Radome Retainer allows the Cabinet Hood to remain in place when the hydrophobic radome is being replaced.
3. Field replaceable GPS assembly attaches with just four mounting screws.
4. Field replaceable IRT Window assembly threads onto the IRT Window Base Mount.
5. The SuperBlower and a properly maintained hydrophobic radome prevent rain, sleet and snow accumulation on the radome (Figure 2).

SuperBlower

The SuperBlower makes significant improvements over older blower designs that incorporated heaters in an attempt to keep the radiometer radome free from dew and precipitation (Figure 2). It uses a high airflow impeller (Figure 3) that is very robust against corrosion from salt spray and pollutants, and provides easy access to the field replaceable air filter and ambient air probe (Figures 4 and 5). Internal airflow design and directional fins concentrate and constrain the flow of air to the entire surface of the hydrophobic radome, across the Rain Sense Board (Figure 6) mounted on top of the SuperBlower, and over the infrared sensor window.

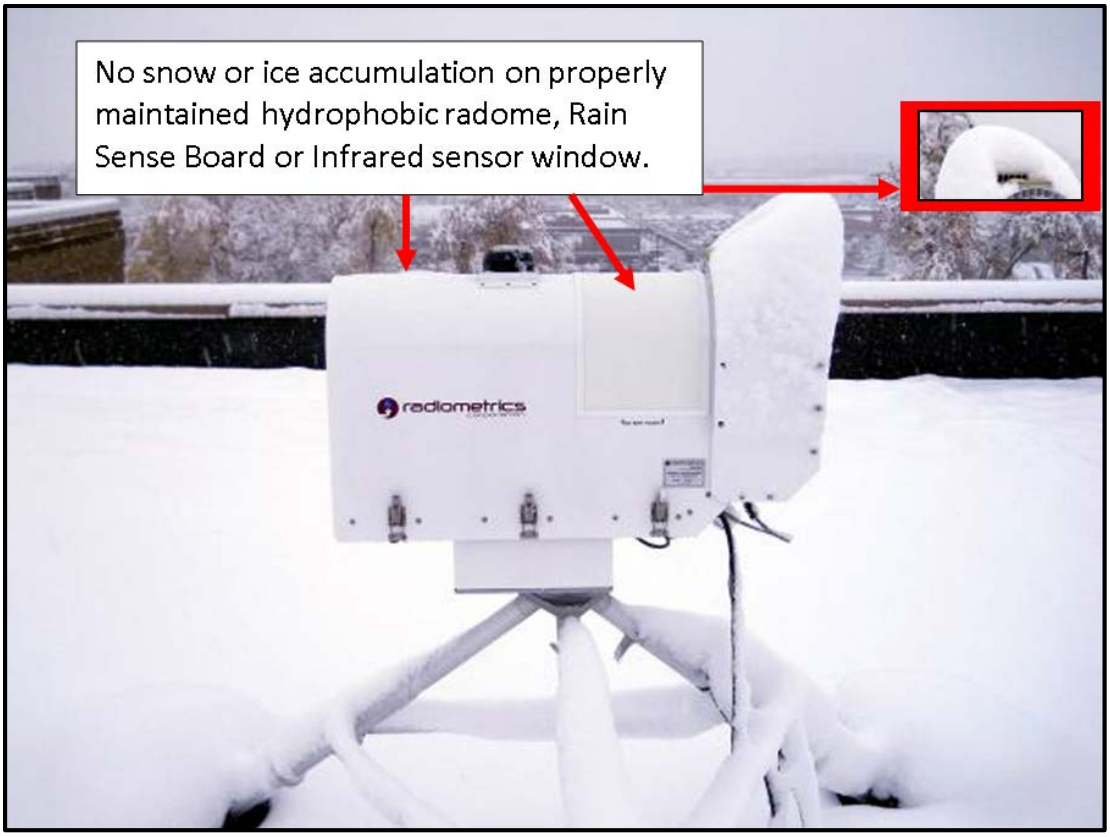

Figure 2. A Superblower keeps the Radome, Rain Sensor and Infrared Window snow-free.

The SuperBlower makes significant improvements over older blower designs that incorporate heaters in an attempt to keep the radiometer radome free from dew and precipitation (Figures 3-6).

Figure 3. New SuperBlower with high airflow impeller (left) and old blower with heater (right).

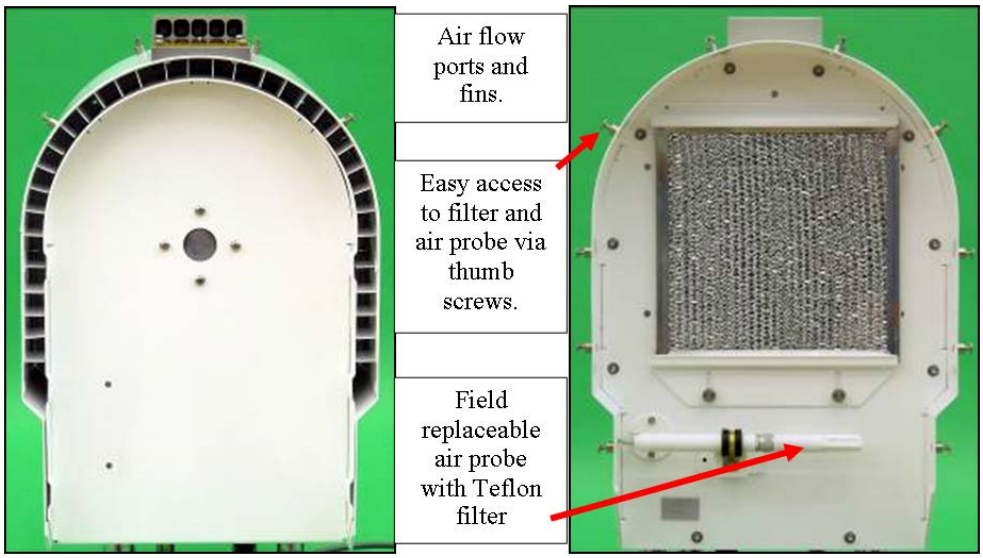

Figure 4. Superblower back and front (with access cover removed).

The back of the SuperBlower has fins and airflow ports that concentrate the flow of air onto the radome and Rain Sense Board (Figure 6). The access panel on the front of the SuperBlower is easily removed (via the thumbscrews) to access the aluminum mesh air filter and field replaceable ambient air probe for periodic maintenance.

Figure 5. Ambient Air Probe.

The HC2-S3 Ambient Air Probe (Figure 5) provides accurate ambient temperature and relative humidity data and comes equipped with a Teflon filter for corrosion resistance and contaminant filtration.

Figure 6. SuperBlower with access cover installed and Rain Sense Board.

Internal Electronic Assembly Features

An internal view of the radiometer is shown in Figure 7.

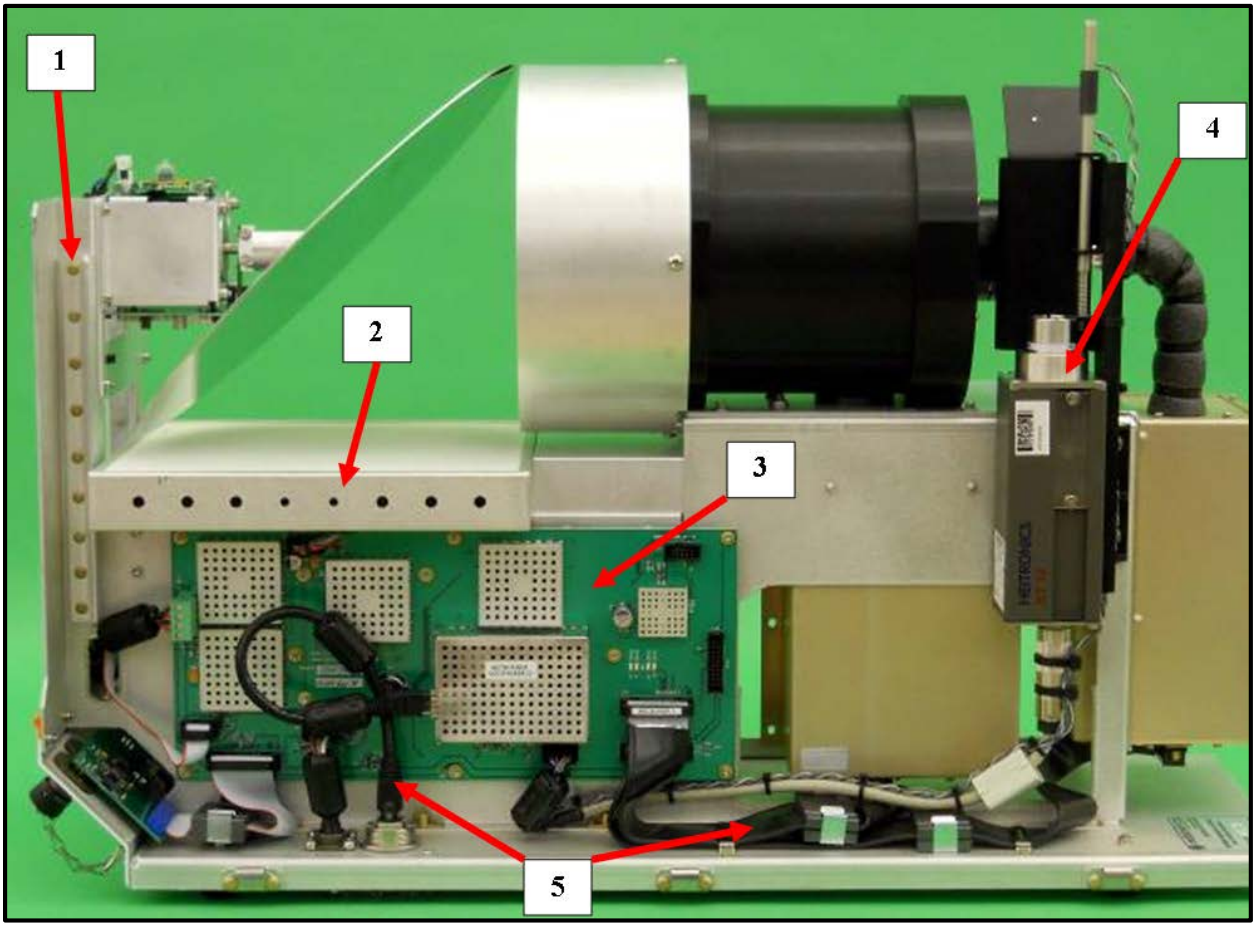

Figure 7. Radiometer internal view -- components are described below.

1. Additional frame supports help to ensure survivability and continued functionality in 1 meter drop tests.
2. Redesigned Black Body Target provides uniform temperature across entire surface, optimizing radiometer measurement accuracy.
3. Field replaceable Main Control Module with embedded extended range/high resolution barometer (which replaces the previous separate Master Control Module, Interconnect Board and standard range barometer configuration).
4. Field replaceable internally mounted IRT assembly ensures functionality in extremely cold temperatures, eliminates all possibility of corrosion on the lens and internal electronics, eliminates the need for a reflective mirror, significantly increases the Infrared Temperature Sensor (IRT) Mean Time Between Failure (MTBF) rating and ensures functionality in all weather conditions.

5. Shielded ribbon cables, and significantly fewer cables throughout the assembly, ensure better performance on both an electrical and mechanical level by making the system more robust against shock, vibration and conducted/radiated susceptibility.

Note: <u>All</u> field replaceable units (FRU), both internal and external, can be removed and replaced in <u>15 minutes or less</u>.

Internal Infrared Temperature Sensor

Cloud base temperature is observed by an Infrared Temperature Sensor (IRT) mounted inside the MP-Series radiometer cabinet to ensure optimum accuracy and reliability. A previous Radiometrics radiometer design included an external mount IRT - front surface gold mirror combination. We found that the external IRT and mirror are subject to severe corrosion in harsh environmental conditions[13]. In addition, the front surface gold mirror electrostatically attracts and accumulates dust. In general, corrosion and dust accumulation inherent in the external IRT design cause unacceptable accuracy degradation and poor reliability. In contrast, the MP-3000A field replaceable internal mount IRT assembly ensures functionality in extremely cold temperatures, eliminates all possibility of corrosion on the lens and internal electronics, eliminates the need for a reflective mirror, significantly increases the IRT MTBF rating, and ensures accurate measurements in all weather conditions.

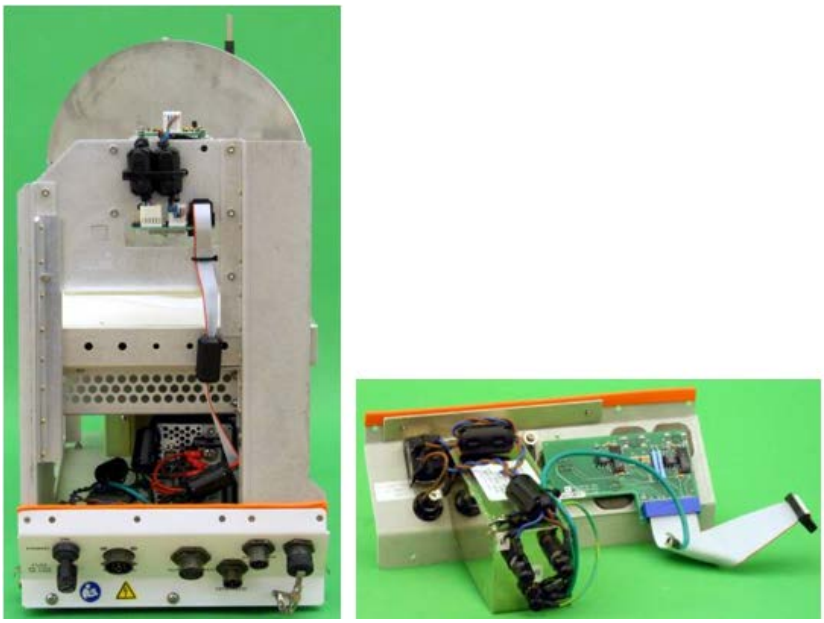

Figure 8. Field replaceable Power Supply and Front Connector Panel Assembly.

[13] Plomondon, 2009.

The field replaceable power supply ensures world-wide operation capability with mains (input) voltages ranging from 85 to 264VAC, 50 or 60Hz (47 to 63Hz capable). The standard power cord supplied is 30m in length and adaptable to any input supply plug configuration. The field replaceable Front Connector Panel assembly now includes AC supply noise filtering and even greater protection against power surges and static shock. The Power Supply and Front Connector Panel Assembly are shown in Figure 8.

Safe and Accurate Calibration

A patented MP-Series closed top-mount Calibration Target (Figure 9) ensures optimum accuracy and safety (a) by eliminating risk of injury from liquid nitrogen spillage and (b) by blocking ambient air entry into the target. The German Weather Service compared multiple MP-3000 cryogenic calibrations and validated its 0.5 K calibration accuracy specification[14].

Figure 9. Patented closed, top-mount Calibration Target ensures optimum accuracy, safety and portability.

In contrast, seriously degraded accuracy and cryogenic spillage hazard is inherent in open side-mount calibration targets sold by a competing radiometer manufacturer[15]. Accuracy is degraded by oxygen and water vapor condensation from ambient air circulation into the open target[16]. Cryogenic spillage and associated safety risk frequently occurs with open side-mount calibration[17].

[14] Güldner, 2015.
[15] Löhnert and Maier, 2012.
[16] Pospichal et al, 2012; Pospichal, 2014.
[17] Nelson et al, 2014.

Azimuth Positioner

The Azimuth Positioner includes a very powerful fine resolution stepper motor coupled with a high ratio minimal backlash gear assembly for fast rotation, maximum torque and incredible holding power for operational wind loads of 30 meters per second and survivable wind loads of 60 meters per second. The Azimuth Positioner is fully operational over a -40 to +50 C temperature range. An internal view of the Azimuth Positioner is shown in Figure 10.

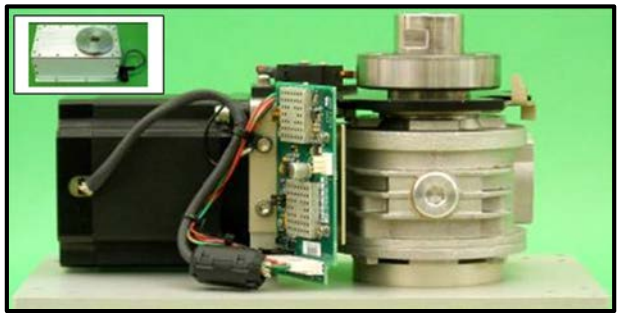

Figure 10. Azimuth Positioner internal view.

Tripod and Shipping Case

The rugged, lightweight Tripod is made from aluminum components and includes versatile mounting and tie-down options (center pull chain, direct foot-to-pad bolting, sandbag), easy leveling and fast assembly. The Tripod packs into a compact container that can be stored (or shipped) inside the radiometer shipping case.

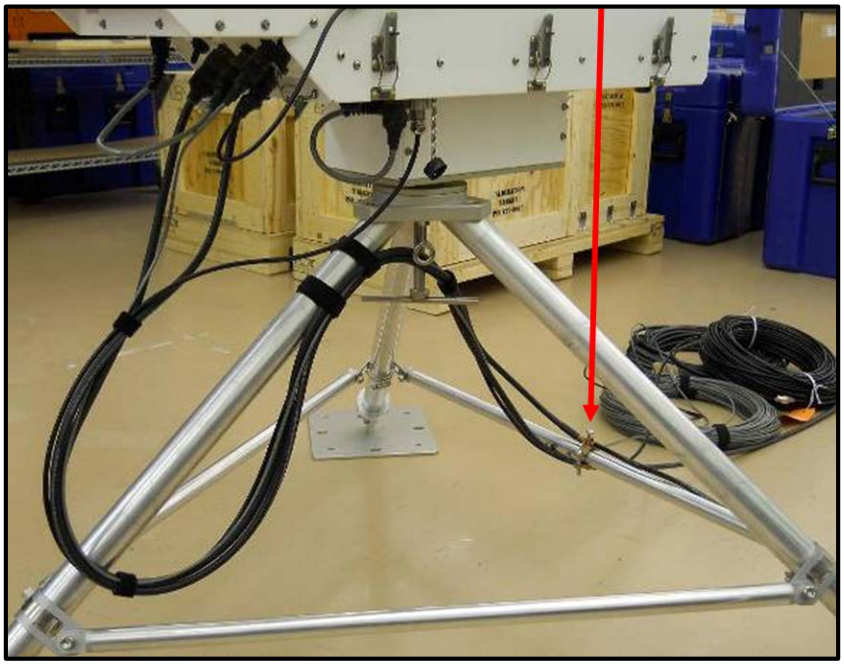

Figure 11. Tripod for cable routing and earth grounding.

The Tripod also serves as a convenient cable routing and tie-in between the radiometer and earth ground, via the cross strut mounted shown in Figure 11.

Figure 12. Radiometer and accessories in shipping case.

The radiometer Shipping Case is designed for international shipments and has multiple packing options. The seal between the hinged lid and lower section ensures that the case is water and air-tight during transit. The case packed with the radiometer, power and communication cables, spare Radomes, laptop computer, LN2 gloves/goggles/funnel, Azimuth Positioner, T-Bolt, Radiometer Mounting Plate, Operator's Manual, Certificates of Compliance and Calibration, spare filter and spare fuses is shown in Figure 12.

Size, Weight and Power

MP-Series radiometers are designed to deliver optimum accuracy atmospheric data from a reliable, minimum size, weight and power sensor package that is easy to transport, set up, calibrate and maintain. Specifically, the MP-3000A dimensions are 28x50x76 cm, weight is 27 kg, and maximum power is 400 W. ***MP-Series radiometers are one-half the size, one-third the weight, and one-fifth the maximum power of competing products***. The entire radiometer package including shipping containers is shown in Figure 13.

Figure 13. MP-Series radiometer systems are easily transported.

Excerpts from a Radiometrics training video demonstrating radiometer system assembly from shipping cases to ***operational in less than 20 minutes*** are shown in Figure 14.

Figure 14. Shipping case to operational in less than 20 minutes.

Field Replaceable Units

The MP-3000A has 21 functionally modular components of which 15 are field replaceable units. This feature, combined with the small size, weight and power of the radiometer system, ensures low transport, set up, maintenance and operation costs.

Long Term Reliability and Support

More than 300 radiometers manufactured by Radiometrics are operating worldwide. A Radiometrics radiometer has been operated aboard the U.S. Research Vessel Ron Brown since 1989 by the National Atmospheric and Oceanic Administration (NOAA). The German Weather Service (Deutscher Wetterdienst – DWD) has been operating a Radiometrics MP-3000 radiometer since 1998, and a second one since 2008. The DWD posts continuous radiometer, 6-hr radiosonde and hourly model sounding comparisons on their website[18]. Their multi-year radiometer-radiosonde comparisons demonstrate radiosonde equivalent observation accuracy[19]. The U.S. Department of Energy (DOE) uses Radiometrics radiometers to calibrate radiosonde humidity soundings in support of its Atmospheric Radiation Monitoring (ARM) program[20]. The DOE currently operates 25 of our radiometers worldwide, with many of them in nearly continuous operation for more than 20 years. We take pride in the long term reliability of our products and are committed to comprehensive and affordable product and customer support.

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