Climate Instrumentation Calibration for the Tropical Western Pacific Atmospheric Radiation Measurement Program

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Introduction

Climate measurements must be extremely accurate. In fact, estimates of the causes and effects of global warming require measurements that conventional instrumentation is too inherently inaccurate to measure. A 10% inaccuracy in water vapor measurement, for instance, corresponds to a 3.3 K surface air temperature difference at mid-latitudes (Schneider et al. 1999). Los Alamos National Laboratory manages the Tropical Western Pacific (TWP) sites for the Atmospheric Radiation Measurement (ARM) Program. The tropical sites of Manus Island, Papua New Guinea, and the Island of Nauru are ideally located to study the tropical ocean warm pool. It is a challenge to maintain data quality in these remote environments. There are no laboratory facilities nearby, communication is difficult, and the availability of trained personnel is limited. Our work focuses on developing techniques and procedures to calibrate where possible, compare, and test climate instrumentation in the field. We work with ARM Program instrument mentors to continually improve the data quality though hands-on tests during annual remote service team (RESET) visits to the sites.

The priority of calibration is a combination of (1) instrument measurement importance to climate, (2) instrument potential for calibration drift, and (3) practicalities associated with tropical island logistics. The first element focuses us on solar radiation, water vapor, and clouds. The second element puts more emphasis on meteorological measurements and radiation sensors that drift with solar exposure. The third element limits us to calibration comparisons and checks that can be performed in air-conditioned vans and in the field rather than precise laboratory calibrations such as are done for satellite systems (Chen 1997).

The instruments on which routine calibration comparisons are performed by RESET are listed in Table 1. Some of these instruments and others, such as the millimeter cloud radar, have internal calibration checks performed automatically by the instrument and reported with the data. The generic accuracy of each instrument is also listed in Table 1 based on the experience of the manufacturers and instrument mentors. It is our goal to provide more specific bounds for the accuracy of each individual instrument at each location and over specific time intervals. The results of the calibration comparisons are available as calibration reports from each RESET visit. These reports are available from the TWP program office.

Table 1. Instruments on which calibration comparisons are performed during RESET visits to the TWP

Instrument	Measurement	Manufacturer	Sampling Rate (interval)	Accuracy	Height/Range
Thermometer	Temperature	Vaisala	1 min. avgs. (1 sec)	±0.41°C	2 m
R/H Sensor	Relative humidity	Vaisala	1 min. avgs. (1 sec)	±2% RH	2 m
Anemometer	Wind speed	R. M Young	1 min. avgs. (0.5 sec)	±1% for 2.5 to 30 m/s	10 m
Wind Vane	Wind direction	R. M Young	1 min. avgs. (1 sec)	±5 deg.	10 m
Barometer	Air pressure	Vaisala	1 min. avgs. (60 sec)	±0.035 hPa	1 m
Optical Rain Gauge	Rain rate	Scientific Technology	1 min. avgs. (1 sec)	±0.254 mm	1 m
PSP (global)	Solar irradiance	Eppley	1 min. avgs. (1 sec)	±3% irradiance	Vertical integral
PSP (diffuse)	Solar irradiance	Eppley	1 min. avgs. (1 sec)	±3% irradiance	Vertical integral
PIR (global)	Terrestrial irradiance	Eppley	1 min. avgs. (1 sec)	±5% irradiance	Vertical integral
PIR (diffuse)	Terrestrial irradiance	Eppley	1 min. avgs. (1 sec)	±35 irradiance	Vertical integral
IRT	Equivalent blackbody brightness temperature	Heimann	1 min. avgs. (1 sec)	±0.225 K at 20°C	Vertical integral
MFRSR	Aerosol optical depth	Yankee	1 per 20 sec	±0.01 optical depth	Vertical integral at 6 visible and near-infrared wavelengths
MWR	Column water vapor and liquid water	Radiometrics	1 per 20 sec	±0.5 K (about 2 mm H_2O vapor and 0.03 mm liquid H_2O)	Vertical integral
Ceilometer	Cloud height	Vaisala	1 per 15 sec	15 m (resolution)	7.25 km
AERI (Nauru only)	Temperature and water vapor profiles	University of Wisconsin	1 per 7 in. (206 sec)	Better than 1.6°C in temperature and 2.5°C in dewpoint (from comparison with rawinsondes)	Vertical integral

AERI = atmospheric emitted radiance interferometer
IRT = infrared thermometer
MFRSR = multifilter rotating shadowband radiometer
MWR = microwave radiometer
PIR = precision infrared radiometer
PSP = precision spectral pyranometer

Calibrations are performed on data logger reported voltages, comparison reference temperature probes, and comparison chilled-mirror hygrometers for temperature and humidity measurements. The temperature and humidity measurements are used to calibrate the meteorological sensors on towers and balloon sounding systems. Radiometers are calibrated at the National Renewable Energy Laboratory (NREL) in Colorado and once a year the tropical radiometers are replaced. Extensive comparison testing is done before and after replacement. Simple comparisons with a portable blackbody are used to test the infrared thermometers that we use and the atmospheric emitted radiance interferometer in Nauru. Simple tests are also performed on the micropulse lidar, the cloud height ceilometer, and the microwave radiometer for liquid water and water vapor measurements. Our overall goal is to go beyond generic accuracy estimates associated with an instrument type and provide quantitative information to assess the performance of a particular instrument at a specific time during the tropical measurements.

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References

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