Woods Hole Oceanographic Institution

Upper Ocean Processes Group

Technical Note

IMET Sensor Accuracy **September 2005**

In order to better understand the accuracy of the IMET sensor package, an analysis of the literature on the individual IMET sensors and a comparison of the IMET data with other data sources were performed. Full results are detailed in Colbo and Weller (2005). This technical note acts as a short summary of the key points.

What is Accuracy?

Much of the value of the data from sustained mooring deployments is in its use for climate related studies. Thus, we are interested in quantifying the absolute accuracy of the individual sensors and the corresponding absolute accuracy of the fluxes. It is essential to know the inherent "noise level" of the IMET package, so that we can properly interpret inter-annual changes. Errors in the accuracy arise from a number of sources: inherent measurement precision (e.g. the longwave thermopile), laboratory calibration uncertainty, uncorrectable calibration drift and other environmental factors (e.g. low wind errors, solar leakage through the longwave dome, humidity hysteresis near saturation, etc.).

Incoming Longwave Radiation (Eppley PIR)

This is one of the hardest measurements to make, even on a stable, land-based platform. The amplifier boards are still an unresolved issue at the time of this tech note. We have been assuming that the calibration is stable, unless the power is interrupted. Thus *in situ* comparisons with the shipboard sensors are the preferred method of calibration. Fairall et al. (1998) and Payne and Anderson (1999) provide much detail on inherent sensor accuracy and lab calibration. An analysis of all the PIR sensors, which have been recalibrated at WHOI, shows that changes in the two calibration coefficients are weakly correlated (about 30% of the variance). Large amounts of solar leakage would be caught during the burn-in. However, we still think it is likely that a small amount (< 1%) of the shortwave radiation is penetrating the longwave dome.

Inherent Precision	Lab Calibration	Annual Drift	Field Errors	Total
Dome Temp: 0.1 ºC Case Temp: 0.1 ºC Thermopile: 10 μV	Coefficient: 1.5 W/m^2 Noise: 0.5 W/m^2	2 W/m^2	Tilt: < 2 W/m^2 T Gradients: 4 W/m^2 Salt Spray: < 1 W/m^2 Solar: < 1% ↓SW	Instantaneous: 7.5 W/m^2 Daily: 4 W/m^2 Annual: 4 W/m^2

Shortwave Radiation (Eppley PSP)

Because of our calibration method on the roof, it is hard to distinguish between lab calibration errors and instrument calibration drift errors. Salt crystals, dew, guano, etc., on the dome is an open issue (also applies to longwave). Tilt errors should dominate. Mean tilts of 1-2 degrees translate to 1-2% errors in incoming shortwave. Sensors may be level with respect to the superstructure, but is the superstructure level with respect to mean waterline? Wave induced tilts are less important at low latitudes and calm conditions. This might not be true for CLIMODE in winter. In broken cloud, relative clock drift of tens of seconds between the two buoy sensors can result in large discrepancies.

Inherent Precision	Lab Calibration	Drift	Field Errors	Total
0.1 W/m^2	2 W/m^2	<2 W/m^2	Tilt: < 2% T Gradients: 1-2 W/m^2 Salt: 1 W/m^2	Instant: 20 W/m^2 Daily: 6 W/m^2 Annual: 5 W/m^2

Relative Humidity (Rotronic MP100)

The lab calibration procedure sometimes introduces reproducible misfits. Currently these are small (0.3%) but with improved instruments may become more important. Many instruments appear to drift linearly in time. This is good for post-correction. A large number of instruments still break or suffer dramatic calibration shifts during shipment. To improve the chance of obtaining at least one humidity record that behaves in a linear manner throughout its life cycle (i.e. from pre-cal until post-cal), I recommend mounting an additional stand-alone sensor where possible. Ventilation issues are still present in low wind.

Inherent Precision	Lab Calibration	Drift	Field Errors	Total
0.01%	Linear: 0.16% Cubic: 0.1%	Linear: 0.9% Cubic: 0.9%	@ >95%: ±1% Heating in low wind: 3%	Instant: 1% Low Wind: 3% Daily: 1% Annual: 1%

Air Temperature (Rotronic MP100)

Sensor calibration stability is good. Biggest errors are due to heating in low wind, when natural ventilation of the sensor breaks down. Comparison of buoy and ship sensors shows that the manufacturer's listed specs for low wind are close to the observed values. Leakage of radiation into the sensor cavity and subsequent errors are still an issue. This can cause large ship-buoy discrepancies at times. This appears to be an issue with the ETL sensors more than ours (probably related to higher albedo from the ship).

Inherent Precision	Lab Calibration	Drift	Field Errors	Total
0.02 K	< 0.03 K	0.05 K	0.4 K @ 3 m/s 0.7 K @ 2 m/s >1 K @ 1 m/s Radiation: 0.2 K	Instant: 0.2 K Daily: 0.1 K Annual: 0.1 K

Barometric Pressure (AIR DB1A and DB2A, Heise DXD)

Pressure tends to drift linearly and slowly. Except for rare instances of large drift, linear post-calibration should give a good record.

Inherent Precision	Lab Calibration	Drift	Field Errors	Total
0.01 mb	0.06 mb	0.2 mb (after post-cal)	Temp: 0.1 mb Wind: < 0.1 mb (@ U < 10 m/s)	Instant: 0.3 mb Daily: 0.2 mb Annual: 0.2 mb

Sea Surface Temperature (SBE-39)

This is a very reliable measurement, whose main error arises due to the extrapolation from finite depth up to the sea surface.

Inherent Precision	Lab Calibration	Drift	Field Errors	Total
0.001 K	0.001 K	0.05 K 0.03 K (after correction)	Low Wind: 0.1K Cool Skin: < 0.02 K	Instant: 0.1 K Daily: 0.1 K Annual: 0.04 K

Wind Speed and Direction (R. M. Young 5103)

Wind speed comparisons with height-adjusted ship measurements are very good. The wind speed sensor seems to drift toward higher wind speeds with time. There is not enough data to confirm this hypothesis, but it is consistent with the idea that bearings gradually spin more easily over the course of the deployment. Drift is on the order of +0.1 m/s, which is similar to the change observed in a previous Tech Note. Wind sensors begin to differ below 2 m/s, and are very uncorrelated below 1 m/s. This indicates the vane on the buoy is unable to orient the sensors into the wind effectively at these low wind speeds.

The biggest error on wind direction is presumably in the buoy compass heading. Field comparisons are difficult to make, so an exact quantification is still uncertain. Wind directions on the two vanes can have annual mean differences of 10 degrees. We hypothesize that some of this discrepancy arises from flow distortion around the buoy superstructure. Namely, upstream divergence causes the two wind modules to "toe in" slightly.

Inherent Precision	Lab Cal.	Drift	Field Errors	Total Error
0.002 m/s	1%	+0.1 m/s	Tilt: < 0.3% Sea State: ? Very Low Wind: ± 1m/s	Instant: max(1.5%, 0.1 m/s) more in low wind Daily: max(1%, 0.1 m/s) Annual: max(1%, 0.1 m/s)
0.1°	In lab: 1° buoy spin: 4°	2°	Low Wind: O(1) Flow Distortion: < 5°	Instant: 6° Daily: 5° Annual: 5°

Flux Errors

These stated sensor errors translate into errors in the calculated fluxes. The errors in the annual mean values of the fluxes are listed below. These values are appropriate for Stratus and NTAS deployments, but will be different in more severe environments. Radiative flux errors are dominated by errors in the measurement of the incoming components. Latent and sensible heat fluxes have large uncertainties due to the Dalton and Stanton numbers. However, air temperature is the biggest additional source of error, followed by relative humidity and wind speed.

	Net Longwave	Net Shortwave	Sensible Heat	Latent Heat	Momentum	Net Heat
Percent Error (%)	15	2.5	15	5	10	20
Typical Error	3.9 W/m^2	5 W/m^2	1.5 W/m^2	5 W/m^2	0.007 N/m^2	8 W/m^2

References

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Contributed by Keir Colbo

Published by the Upper Ocean Processes Group, Mail Stop 30, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA. Contact: Jeff Lord. Layout and editing, Penny Foster, Physical Oceanography Department.