A Unified Approach for Reporting ARM Measurement Uncertainty

Doug Sisterson, Edwin Campos
Argonne National Laboratory, Environmental Science Division, Argonne, IL 60491

THE STUDY

A comprehensive inventory of the current ARM uncertainty estimates was constructed from inputs by each ARM Instrument Mentor for all instruments and for important variables.

The uncertainty estimate provided was classified as either instrument resolution, precision, accuracy, or none (information not provided or not available).

THE SPECIFICS

For those cases where uncertainty was reported as accuracy, the method of traceability of the calibration was classified as a traceable standard, consensus procedure, or expert judgment.

Although the results of this study are contained in a spreadsheet, due to the number of instruments and measured variables, there is far too much information to be displayed here.

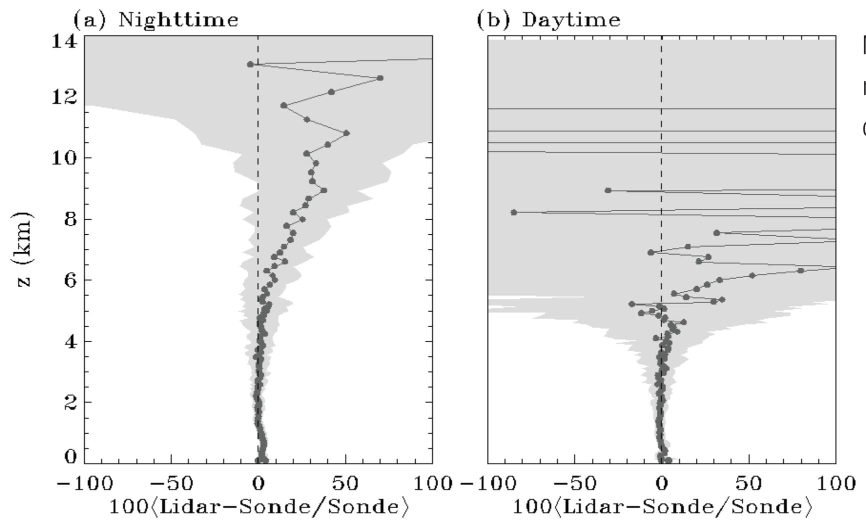
The results presented here indicate the families of instruments and measured variables that have common attributes of uncertainty type.

REPORTING UNCERTAINTIES

Not all of information about instrument uncertainties is complete, so iterations with the ARM Instrument Mentors will be needed.

Uncertainty estimates can have dependencies on environmental factors and therefore a non-linear component. For example, there is a range dependence on water-vapor mixing ratios from Raman Lidar, which is based on the dryness of the atmosphere.

Displaying instrument measurement uncertainties will be a challenge!



Newsom: ARM Raman Lidar water-vapor mixing ratio error estimates based on comparisons with radiosondes.

Contact the authors:
dlisisterson@anl.gov, ecampos@anl.gov

STUDY RESULTS

The best representation of uncertainty for the ARM instrument measurements would be precision. Precision estimates are generated using statistics from a set of repeated readings using calibrated instruments in the field.

However, results of this study show that most of the ARM measurement uncertainties are based only accuracy, and only 7% are based on precision.

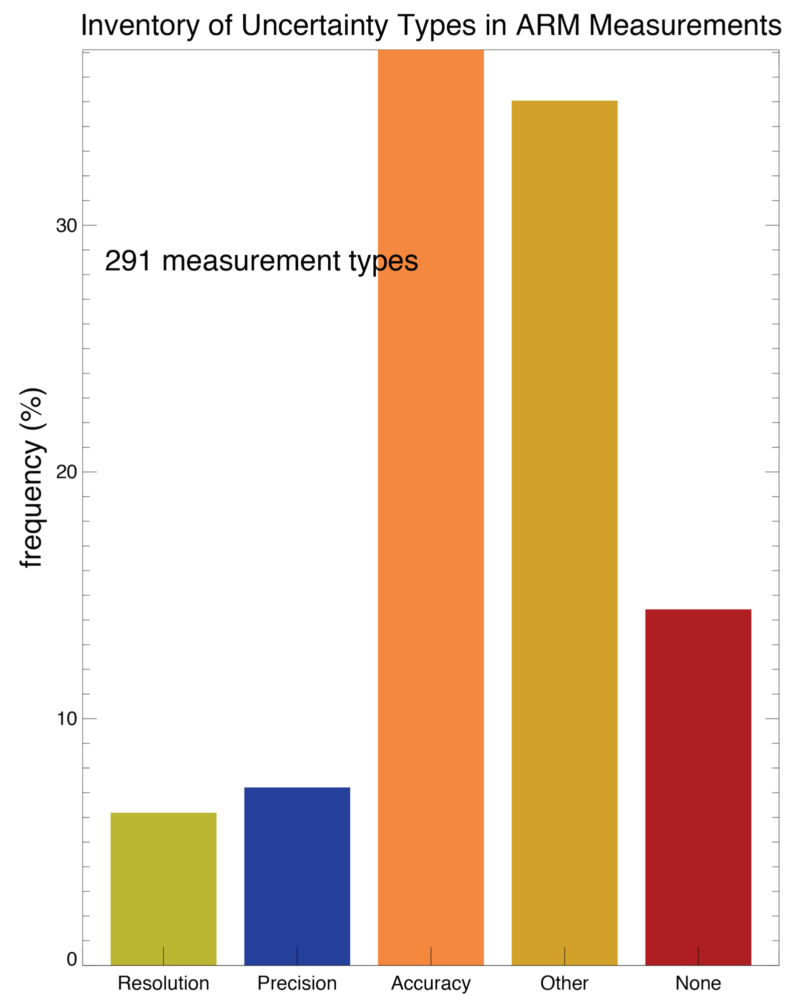
	Instrument	Measurement	Uncertainty Estimate	Uncertainty Type
	Normal Incidence Pyrheliometer **(NIP)**	Direct beam normal irradiance	± 3% (>700 Wm^{-2})	Precision: GUM Combined Uncertainty, after calibrations with traceable standard (NIST) and concensus procedure (WISG)
	Multifilter Rotating Shadowband Radiometer **(MFRSR)**	Clear Skies total horizontal irradiance	± 2.1 %	Accuracy: Calibrations using traceable standards (NIST) and consensus procedure (Langley plots)
	C-band Scanning Precipitation Radar **(C-SAPR)**	Reflectivity	4 dB	Other: Combination of calibration of components, literature, and expert opinion. Calibration is highly idealized, assumes no atmospheric losses, a known target in the far field, the return is from the target only, and no multi-path to the target.
	Rain Gauge – Belfort Model AEPG 600 Weighing Bucket	Rainfall amount (accumulation)	+/- 0.25mm (0.01 inches)	Resolution (minimum detectable signal)

GUM: JCGM 100:2008. Evaluation of measurement data - Guide to the expression of uncertainty in measurement. *Working Group 1 of the Joint Committee for Guides in Metrology First Edition*, Sept. 2008, 134 pp.

NIST: National Institute of Standards and Technology. See for example *http://www.nist.gov/*

WISG: World infrared standard group of Pyrgeometers. See for example *http://www.pmodwrc.ch/pmod.php?topic=irc*

Langley Plots: (See for example)
E. G. Dutton, P. Reddy, S. Ryan, and J. DeLuisi: 1994. Features and effects of aerosol optical depth observed at Mauna Loa, Hawaii: 1982–1992. *J. Geophys. Res.* 99, 8295–8306.



Accuracy Corresponds to instrument calibrations to address known measurement errors.

Resolution Corresponds to minimum detectable signals of measurement.

Precision Corresponds to the variance from repeated calibrated measurements under field conditions.

Other Corresponds to theoretical and/or empirical arguments and/or expert judgment.

None Corresponds to measurements of unknown uncertainty (no estimates were provided).