The World Meteorological Organization (WMO) Central Calibration Laboratory for Carbon Monoxide

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The WMO Central Calibration Laboratory (CCL) for carbon monoxide (CO) provides CO-in-air mixtures for NOAA measurements, WMO/Global Atmosphere Watch (GAW) global and regional networks, and other laboratories which measure CO in the troposphere and lower stratosphere.

The CO scale, designed for measurements in the remote near-surface troposphere (CO ~40 to 300 nmol mol^{-1}), is based on multiple sets of primary reference gases prepared by a gravimetric method [(1)]. Secondary standards were assigned CO by comparison to sets of primary standards prepared in 1989, 1992, 1996/1997, 2000, 2006 and 2011 and differences among the calibration results define the uncertainty of the scale (Figure 1).

Application of a common reference scale among laboratories is a major step towards the both NOAA and WMO/GAW objectives for better comparability of measurements. A serious difficulty for long-term measurements of CO is the fact that when contained in cylinders CO may change with time. Drift rates tend to be quite low (< 1nmol mol^{-1} yr^{-1}) and difficult to detect with the most commonly used measurement methods. The WMO scale has undergone several revisions to account for drift [(2, 3)]. The CCL works closely with the WMO World Calibration Center (WCC) for CO at Empa, Dubendorf, Switzerland to maintain a reliable set of reference gases. As part of their respective Quality Assurance/Quality Control procedures, the CCL and WCC frequently compare measurements to evaluate the scale (Figure 2). Gases assigned CO by the CCL prior to 2004 are referenced to the WMO X2000 scale, standards calibrated after 2004 are referenced to X2004 [(4)]. The differences between the two are largely in their uncertainties: X2004 is more precise and covers a broader range than X2000 (500 nmol mol^{-1} and 300 nmol mol^{-1}, respectively).

In the past decade many GAW sites have adopted the X2004 scale resulting in greater comparability among laboratories. However, other measurement issues, such as different instrument types and drift in standards complicate achieving the WMO/GAW goal for inter-laboratory comparability of 2 nmol mol^{-1}.

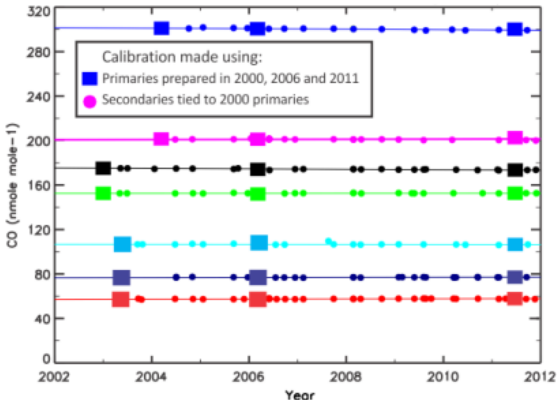

Figure 1. Histories of secondary standards calibrated against: 1) one set of primary/secondary standards or 2) three sets of primaries. All measurements used a CO fluorescence method. The uncertainty of the 2004 scale (μ) determined from regressions of 1 or 2, with μ=2 σ, ranges from 0.6-2.4 nmol mol^{-1}. Higher uncertainties are associated with higher CO.

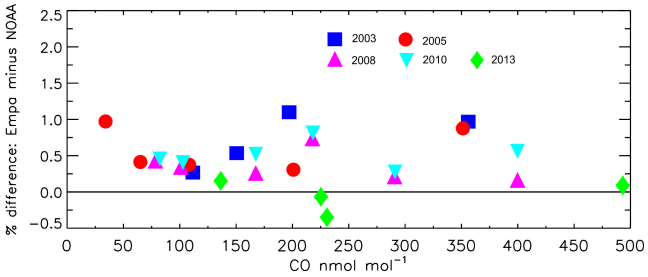

Figure 2. The percent differences in CO assigned air by the WCC (Empa) and the CCL (NOAA).