Geophysical Research Abstracts,
Vol. 11, EGU2009-5836, 2009
EGU General Assembly 2009

Enabling Continuous, Field-Based Isotope and Greenhouse Gas Measurements with WS-CRDS-based Analyzers

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When new instrumentation becomes widely available, it has the power to fundamentally change how measurements are made. In particular, technology developments that enable measurements to be done more simply, at lower cost, by a greater number of scientists, moving information-rich, laboratory-quality measurements from the lab out into the field – these are the innovations that can aid in moving the science forward. Here we describe how the application of a novel cavity-enhanced spectroscopic technique called wavelength scanned cavity ring down spectroscopy (WS-CRDS) has been pivotal in developing gas an isotope analyzers capable of being deployed in the field, unattended, for long periods of time. This particular implementation of the traditional cavity ring down technique employs several additional key aspects of control and design to achieve highly sensitive, highly stable measurements. WS-CRDS owes its high sensitivity to an extremely long optical interaction pathlengh, as well as to its complete immunity to laser noise since the laser is actually off during the measurement. To stabilize the spectroscopic line itself, the temperature and pressure of the gas are tightly controlled. The analyzer's optical cavity, gas handling system and analog electronics are themselves also tightly temperature controlled. The heart of the WS-CRDS technique is, however, the wavelength monitor which further ensures the stability of the measurement by continuously measuring and tightly controlling the laser wavelength. A key design aspect of the WS-CRDS analyzer is its three-mirror, traveling-wave cavity which allows optical backreflections to be avoided and further adds to the inherent stability of the optical train. The analyzer owes its ease of use to the design requirement that it be field-deployable, in locations without personnel, with the ability to restart itself and automatically resume collecting data even after a power failure. Beyond the design aspects of the analyzer are the intensive environmental and performance tests each analyzer must undergo after manufacturing. These include shock, vibration, and temperature stressing to ensure that such stresses in the field do not lead to failures in the field. The combination of technology and its validation has resulted in highly robust, easy to use instruments that provide very sensitive and stable data even in challenging environmental conditions.