A commercial ground-based atmospheric profiler

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INTRODUCTION

Ground-based atmospheric profilers are used to remotely measure the concentration of atmospheric constituents as well as other important parameters as a function of altitude. These instruments can be used in several fields of application including:

- Meteorological sounding
- Greenhouse gases studies
- Pollution transport and assessment

Fourier-transform spectrometers have been used and studied in the last three decades by the research community for the remote sensing of atmosphere constituents. With recent advances in infrared technologies and data processing techniques, ground-based atmospheric profilers are becoming mature instruments and are ready to enter the commercial market.

OBJECTIVES

Operational ground-based profilers have to meet requirements of:

- Accuracy,
- Ease of use and
- Reliability.

The accuracy is the fundamental performance criterion of any sensing equipment. It is the system's ability to measure the parameters of interest with low error. This is obtained with low random and systematic instrumental errors. Accuracy requirements vary according to the application. For example for weather sounding, a temperature error less than 1K is required at all measured wavelengths in order to perform useful predictions. The LR-Tech ASSIST was designed to meet these requirements as shown in Figure 1.

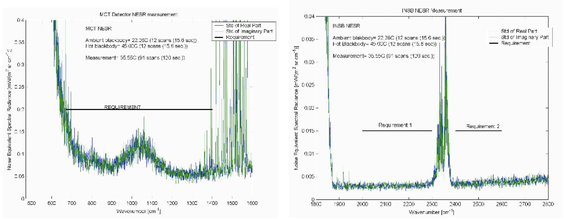

Figure 1. The ASSIST low noise noise performance is adequate to achieve an atmospheric temperature profiling error of less than 1 K within the Planetary Boundary Layer

Ease of use and reliability are also critical for a commercial product. When they are deployed in atmospheric sensing networks, each profiler must operate 24/7 without user physical intervention. The profiler hardware must be designed for the rigors of field operation, for detailed remote health monitoring and diagnostics, as well as easy and rapid field maintenance.

INSTRUMENTATION AND METHODS

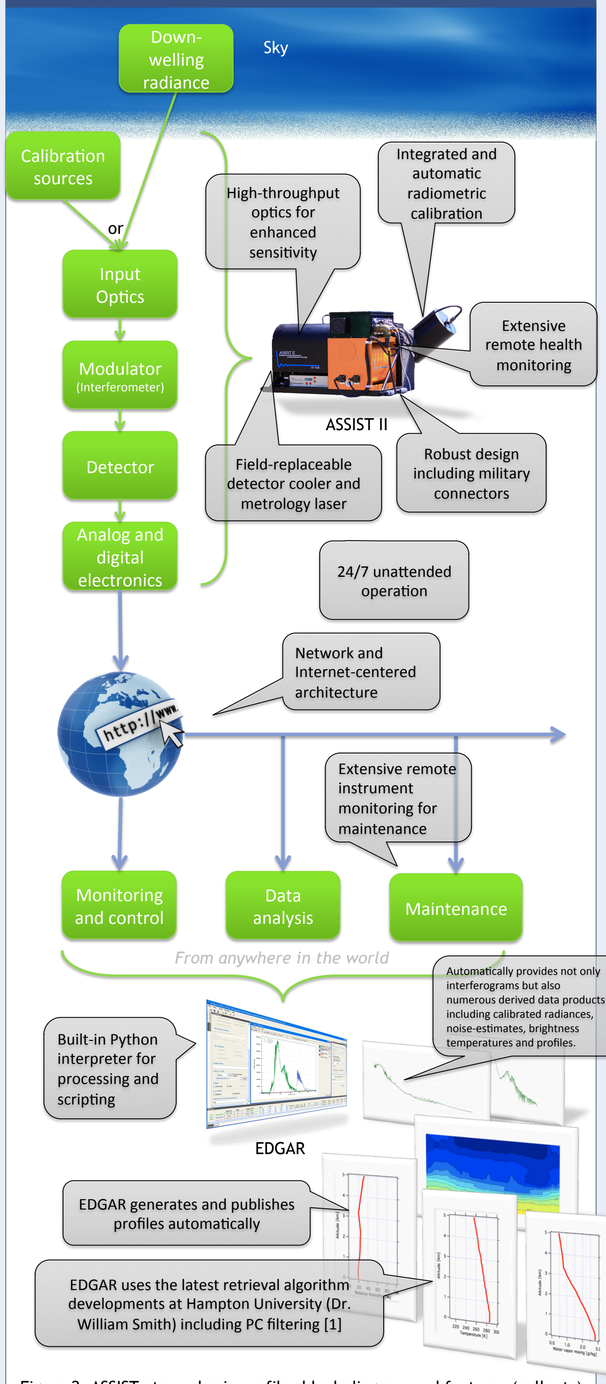

Figure 2. ASSIST atmospheric profiler block diagram and features (callouts)

EXPERIMENTAL RESULTS

The ASSIST system has been validated in several sites and scientific campaigns. Figure 3 shows the ASSIST deployed in the U.S. DOE's ARM Mobile Facility #2 installed on Mount Werner (Colorado) at an elevation of 3220m [2]. This instrument has been operating unattended and remotely from PNNL since August 2010.

Figure 3. ASSIST (left) deployed inside the ARM Mobile Facility 2 (right) at the Mount Werner site (Colorado) in support of STORMVEX [2]. The instrument performs measurements 24/7 unless rain or snow are present, in which case the automated hatch mechanism (insert) is closed to protect the equipment. Courtesy of Pacific Northwest National Laboratory

The ASSIST hardware has been validated during field campaigns and found to produce radiance measurements with sub-percent differences compared to well-characterized AERI systems. Such an example is shown in Figure 4 where both the LW and SW spectral ranges are displayed.

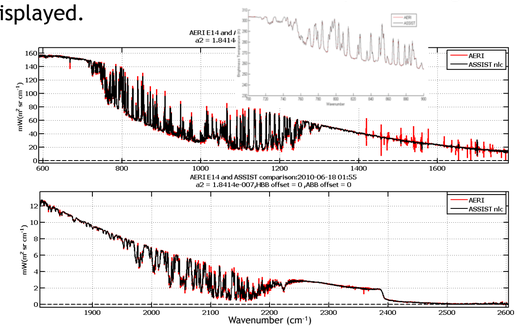

Figure 4. An excellent match is observed between the down welling radiance measured by ASSIST (black curves) and the AERI (red curves). These data have been measured at the U.S. DOE's SGP site. The insert shows the blown-up 11-14μm region for night radiance.

ASSIST does not only produce calibrated spectra, it autonomously generates profiles of temperature, water vapor and ozone in real-time. These retrievals rely on algorithms developed over the past decades of atmospheric research. The ASSIST algorithms incorporate the most recent advances in data processing made at Hampton University [3].

Figure 5. ASSIST (left, blue arrow) during the CAPABLE (Chemistry And Physics Atmospheric Boundary Layer Experiment) held in June – August 2010 at NASA LaRC. NAST-I is visible in the foreground (white arrow).

EXPERIMENTAL RESULTS (Continued)

The accuracy of the retrieved profiles generated by ASSIST has been extensively studied and demonstrated [3]. The left hand graph of Figure 6 shows the excellent agreement obtained between the temperature retrieved from ASSIST plus IASI radiances (black) and radiosonde data (red). The right hand graph of Figure 6 shows the agreement obtained between the ozone profile retrieved by ASSIST(red) with ozoneosonde data (black). ASSIST provides most of the the profile information below 3-km while IASI provides the profile information above 3-km.

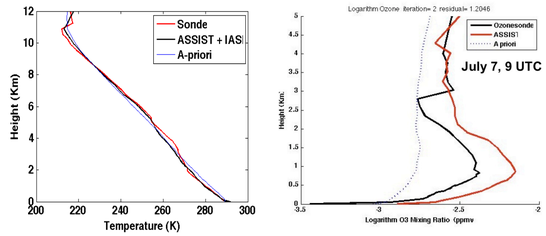

Figure 6. Ground-based ASSIST + satellite IASI retrieved profiles compared with ozonesonde observations. Courtesy of Hampton University [1]

The performance of ASSIST has been already established in weather sounding [3]. ASSIST is now proving its capabilities in other remote sensing applications including greenhouse gases and pollutant profiling as well as sea surface temperature measurements.

CONCLUSIONS

The ASSIST product line was designed from the ground up with the aim of meeting the requirement of commercial atmospheric profiling. This approach has resulted in an optimized and affordable solution, which has now been thoroughly validated in the field. The versatility of the ASSIST instrument has allowed it to be successful not only in traditional weather sounding but also the for the measurement of ozone, greenhouse gases and atmospheric pollutants.

ACKNOWLEDGMENTS AND REFERENCES

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[1] William Smith, Sr., Stanislav Kireev, Elisabeth Weisz, Yongxiao Jian, Melissa Yesalusky, Allen Larar and Henry Revercomb, "IR ultraspectral remote sensing: efficient physical-statistical nonlinear sounding retrieval algorithms", Proc. SPIE 7857, 785703 (2010); doi: 10.1117/12.869425

[2] http://www.arm.gov/publications/backgrounders/docs/doe-sc-arm-10-024.pdf

[3] Smith,W. L. "Global Atmospheric Profiling Techniques for the Improvement and increased Utility of Atmospheric Compensation Methods" University and Industry Technical Interchange (UITI2010) Review Meeting, 7-9 December, 2010 Knoxville TN.