IRS2012-485
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Trace gas and AOD retrievals from a newly deployed hyper-spectral airborne sun/sky photometer (4STAR)

M. Segal-Rosenheimer (1), C.J. Flynn (2), J. Redemann (3), B. Schmid (2), S. Dunagan (1), R.R. Johnson (1), Y. Shinozuka (3), J.M. Livingston (4), and P.B. Russell (1)

(1) NASA Ames Research Center, Moffett Field, CA, USA, (2) Pacific Northwest National Lab, Richland, WA, USA, (3) Bay Area Environmental Research Institute, Sonoma, CA, USA, (4) SRI International, Menlo Park, CA, USA

The detailed quantification of atmospheric constituents such as trace gases and aerosols including their spatial and vertical distributions in the atmosphere plays an important role in understanding climate change, radiation budgets, and air pollution. The newly deployed sun/sky photometer 4STAR (Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research) instrument combines both airborne sun tracking capabilities of the Ames Airborne Tracking Sun Photometer (AATS-14) and an AERONET-like sky scanning capability with state-of-the-art monolithic spectrometry. The instrument's relatively wide spectral range, covering much of the UV-VIS-NIR (i.e. 0.4-1.7 um), combined with its hyper-spectral nature and its ability to measure both the direct solar irradiance and the diffuse radiance allows for the parallel retrieval of trace gases (e.g., H_2O, O_3, and NO_2), AOD (aerosol optical depth), and additional aerosol parameters (such as size distribution and SSA) and cloud properties (via the combination of the radiation measurements and RT modeling). Here, we will present the first set of trace gas and AOD data products derived from the sun-tracking component of the instrument during an intensive ground based measurement period at the development site (Mountain View, CA) and from two test-flights (U.S. West coast). Trace gases (i.e. O_3, NO_2) were retrieved using the DOAS method [1], comparing the standard approach of using a clear sky solar noon as the reference spectrum versus the use of a TOA calibrated Langley spectrum, which was derived during one of the test-flights at an altitude of 6 kilometers. The use of the latter was shown to be advantageous in terms of lower slant column uncertainties of the retrieval procedure, especially when measuring at small solar zenith angles (i.e. low airmass factor). Moreover, the use of an airborne Langley spectrum as a reference eliminates the need to derive the amount of trace gases in the reference spectrum, an important quantity in the Direct-Sun DOAS retrieval method [2], and reduces the inherent uncertainty resulting from this procedure. This is especially important for airborne applications, where the spatial location is rapidly changing so that one geo-located reference spectrum might not be appropriate for the whole areal range covered by the aircraft or is actually not representative of the sampled scene (e.g. measurements above ocean). Columnar water vapor amounts were retrieved using the modified Langley approach, as implemented in [3], with adjustments that incorporated the hyper-spectral nature of the instrument. Good agreement was observed between the 4STAR and AATS-14 on co-located measurements. AOD values were derived by subtracting the proper amount of gas contributions for each temporal point. The importance of airborne measurements was demonstrated when an episode of relatively high AOD values was observed above 6 kilometers, confirming recently published ground-based and space-borne Lidar observations of high stratospheric AOD values due to the June 2011 Nabro Volcano eruption[4].

[1] Platt U. Differential Optical Absorption Spectroscopy (DOAS). In: Sigrist MW, editor. Air monitoring by spectroscopic techniques. New York: Wiley; 1994. p. 27–76.

[2] Herman J., Cede A., Spinei E., Mount G.,Tzortziou M., and Abuhassan N., NO_2 column amounts from ground-based Pandora and MFDOAS spectrometers using the direct-sun DOAS technique: Intercomparisons and application to OMI validation, , JGR 114, 2009. D13307

[3] J. Livingston, B. Schmid, J. Redemann, P. B. Russell, S. A. Ramirez, J. Eilers, W. Gore, S. Howard, J. Pommier, E. J. Fetzer, S. W. Seemann, E. Borbas, D. E. Wolfe, and A. M. Thompson., 2007: Comparison of water vapor measurements by airborne Sun photometer and near coincident in-situ and satellite sensors during INTEX/ITCT 2004. J. Geophys. Res., 112, D12S16, doi:10.1029/2006JD007733.

[4] P. Sawamura, J.P. Vernier, J.E. Barnes, T.A. Berko, E J. Welton, L. Alados-Arboledas, F. Navas-Guzm, L. Mona, F. Madonna, D. Lange, M. Sicard, S. Godin-Beekmann, G. Payen, Z. Wang, S. Hu and R.M. Ho, Lidar observations of stratopheric aerosol over the Northern Hemisphere from
the 2011 Nabro Volcano eruption, GRL,2012