

# The Pandora Spectrometer System: O<sub>3</sub> and Multiple Other Species Measured Using a Small, Inexpensive Package

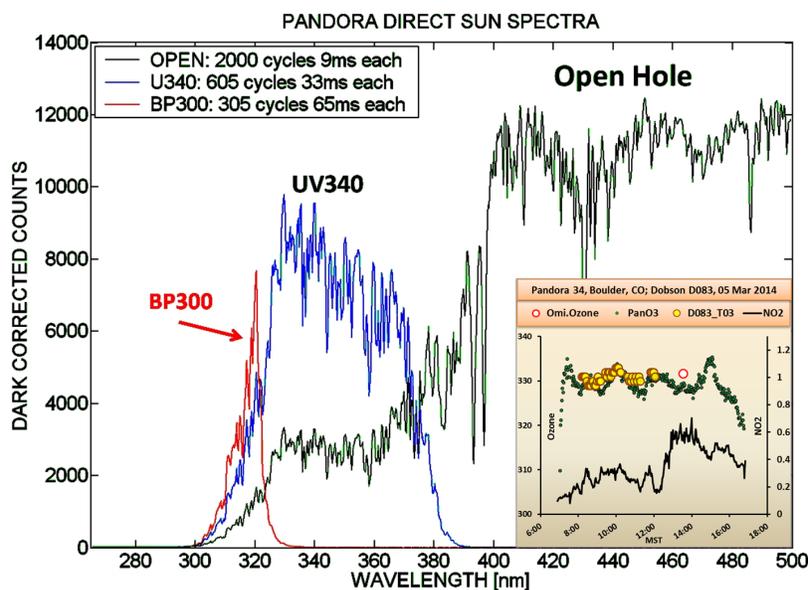
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The measurement of the radiatively important gas ozone in the Earth's Atmosphere has been a part of the Global Monitoring Division mission since its inception in 1972. The primary instrument in NOAA's network to determine total column content (Thickness of the Ozone Layer) is the Dobson Ozone Spectrophotometer, which provides the historic baseline for this measurement. Recent improvements in commercial optical detectors have allowed for the development of small devices that measure surface solar spectra to the detail required to determine the amounts of many atmospheric components, especially Total Ozone Column. One such small spectrometer system (Pandora) was developed at NASA's Goddard Space Flight Center during the last six years. The almost autonomous Pandora system consists of a small commercially available symmetric Czerny-Turner spectrometer optimized for detection of trace gases in the 280 – 525 nm spectral range (0.5 nm resolution, 4.5x oversampling) with a 2048 x 64 Hamamatsu Charge Coupled Device detector. The optimized Avantes spectrometer is connected by a 400 micron fiber optic cable to an optical head (1.6° field of view) mounted on a high precision (0.01°) sun-sky tracker. The laboratory calibrated Pandora O<sub>3</sub> retrieval algorithm uses an external solar reference spectrum derived from the Atlas-3 SUSIM instrument, whereas Dobson and Brewer instruments are calibrated by the means of Langley plots. Recently, the Pandora spectrometer system has been used in three extensive field campaigns (Discover-AQ) in Maryland (2011), California (2013), and Texas (2013). The project involved 12 to 15 Pandoras distributed over a large area for comparison with aircraft and satellite NO<sub>2</sub> and O<sub>3</sub> data. This summer (2014) 15 Pandoras will be deployed in the Denver/Boulder area as part of the final Discover-AQ campaign. One of these Pandoras is currently operating from the NOAA building in Boulder Colorado to both obtain a longer data record and for total column O<sub>3</sub> comparison with NOAA's Dobson instruments. Initial results indicate that total ozone values from the Pandora are well correlated and close in value with the Boulder station Dobson instrument. Pandora's highly resolved spectral measurement allows further processing of the data to determine atmospheric pollutants such as SO<sub>2</sub>.



**Figure 1.** Representative spectra as measured by the Pandora instrument displayed with 5 March 2014 measurement results for the Pandora 34, Dobson D083, and Ozone Monitoring Instrument overpass.