Large and Small Unmanned Aircraft Systems (UAS) for Trace Gas Measurements in Climate Change Studies

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NOAA and CIRES scientists have used Unmanned Aircraft Systems (UAS) for the measurement of trace gases involved in climate change since 2005, including both high altitude-long endurance (HALE UAS: NASA Altair & Global Hawk) and 1-m wingspan, small UAS (sUAS: SkyWisp, Aero). These gases include nitrous oxide (N₂O), sulfur hexafluoride (SF₆), methane, ozone, carbon monoxide, hydrogen, and water vapor. In particular, atmospheric N₂O is the third strongest greenhouse gas (326 ppb) and is the largest increasing stratospheric ozone depleting gas in terms of future emissions (~4 Tg N₂O-N yr⁻¹), primarily from fertilizer use. Atmospheric SF₆, another potent greenhouse gas, is present globally at 8.2 ppt and growing at a rate of 0.25 ppt yr⁻¹, and is used primarily in electrical power distribution. It is an excellent indicator of transport timescales (e.g., mean age) in the troposphere and stratosphere, because of its source distribution (~95% emitted in the northern hemisphere), long atmospheric lifetime (~600-3200 yr), and large relative atmospheric growth rate (~3%). We have developed atmospheric instrumentation for HALE platforms using a two-channel gas chromatograph with an ozone photometer and a water vapor tunable diode laser spectrometer. We are currently investigating a sUAS glider (SkyWisp) for balloon-assisted high altitude flights (30 km) and propeller driven sUAS (Aero) as a test bed for a new autopilot. Our motivation for utilizing this autopilot is a low cost, open source autopilot alternative that can be used to return AirCore samples from high altitude balloons for quick laboratory analysis. The goal is a monitoring program to understand transport changes as a result of climate change during different seasons at many locations from a balloon-borne package (Moore et al., BAMS, pp. 147-155, Jan. 2014). The glider version of our open source autopilot system is also being considered for a future aerosol and trace gas study, called GOAHEAD.

Figure 1. Collage of UAS platforms used left to right, including NASA Altair during NOAA 2005 Demo, NASA Global Hawk during ATTREX in 2014, SkyWisp (SwRI), and Aero (3DRobotics).