**Large and Small Unmanned Aircarft 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 ($N_2O$), sulfur hexafluoride ($SF_6$), methane, ozone, carbon monoxide, hydrogen, and water vapor. In particular, atmospheric $N_2O$ is the third strongest greenhouse gas (326 ppb) and is the largest increasing stratospheric ozone depleting gas in terms of future emissions (~4 Tg $N_2O$-N $yr^{-1}$), primarily from fertilizer use. Atmospheric $SF_6$, 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.

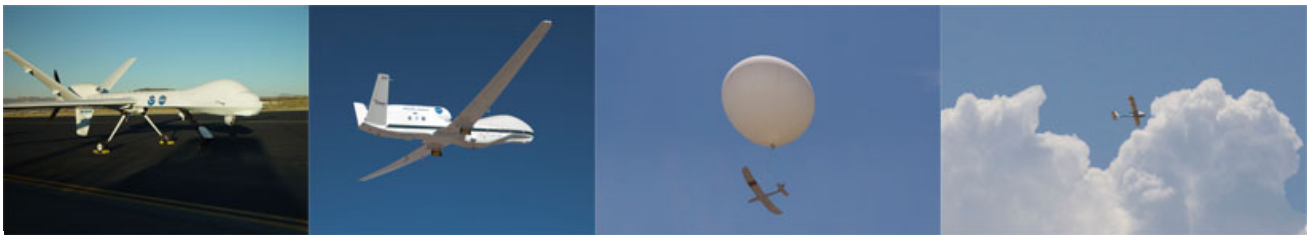

**Figure 1.** Collage of UAS platforms used left to right, including NASA Altair during NOAA 2005 Demo, NASA Global Hawk during ATTREX in 2014, SkyWisp (SwRI), and Aero (3DRobotics).