Micro-UAS as a tool for observing the Arctic Environment

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Unmanned aircraft systems (UAS) are rapidly becoming a popular tool for scientific measurement of the atmosphere, cryosphere, oceans, and Earth surface. The ability to obtain high-resolution, *in-situ* and remotely sensed datasets without the need for large, expensive manned research aircraft is attractive to scientists across disciplines. In this statement we outline current work on use of "micro" UAS (mUAS) at high latitudes, including information on platforms, recent campaigns, current limitations, regulatory issues and future directions.

Currently the US Federal Aviation Administration (FAA) considers platforms lighter than 55 lbs. as small UAS (sUAS). Within this framework also lies the mUAS category, consisting of platforms with a net weight under 4.4 lbs. These mUAS platforms generally offer a very low-cost platform from which to base measurement operations. Included in this category are the DataHawk (Lawrence and Balsley, 2013) and SUMO (Reuder et al., 2009) UAS. The DataHawk was originally developed at the Unviersity of Colorado – Boulder by Professor Dale Lawrence, and has a ~1.2 m wingspan, a total weight of ~1kg, and a total parts cost of around $950. The SUMO is a modified version of the commercially available Multiplex Funjet, with a wingspan of 0.8 m, a total weight of 580 g and an approximate cost of $5000. These platforms are quite flexible in what quantities they measure, and require very limited infrastructure for operations. Flights generally involve two people, including one pilot and one observer, a laptop ground station, an antenna, and a bungee launcher. Both platforms can be hand-launched, either by throwing the aircraft or using a bungee launcher system. Navigation can be fully autonomous using onboard autopilot systems programmable from the surface both before and during flight. The low cost of these platforms makes them perfect candidates for high-risk operations, where successful recovery of the aircraft is not necessarily guaranteed.

At present, the regulatory bodies of the airspace in which operations take place govern use of these platforms. The Arctic airspace is divided into several different Flight Information Regions (FIRs), overseen by the USA, Canada, Russia, Norway, and Iceland. In the US Arctic the FAA prohibits commercial (including research) use of UAS of any size without authorization through the certificate of authorization (COA) or other exemption pathways. However, several groups have been able to operate in coastal Alaska, either by successfully securing a COA, flying in areas of restricted airspace, or by flying in international waters using "due regard" (definition?). Certain agencies, such as the US Department of Energy (DOE) have provided leadership in the use of UAS in the US Arctic by providing complementary ground-based observational facilities in areas of previously established restricted airspace (e.g. Oliktok Point, Alaska) and by engaging the FAA to find new opportunities for use of UAS, including the newly formed "Warning Area" (W-220) extending from the Alaskan shoreline to 82° N latitude.

Under these provisions, several campaigns using mUAS have been carried out in recent years in the US Arctic and beyond. In the summer of 2013, the interagency Marginal Ice

Figure 1: The DataHawk mUAS making measurements of the lower troposphere over Oliktok Point, Alaska.

Zone Experiment (MIZOPEX) included operation of the DataHawk mUAS from Olitkok Point. For this campaign, the DataHawk was configured as a "Self-Deployable Surface Sensor" (SDSS), carrying a thermistor string to provide information on upper ocean (10 m) temperature for an extended time period. In October of 2014, the DataHawk went back to Oliktok Point to make measurements of atmospheric temperature, humidity and winds during the fall freeze up of near-shore ice. Flights were conducted over a two-week period at very low altitudes (10 m) to evaluate variability of atmospheric conditions over various and changing surface types. Most recently (August, 2015), an updated version of the DataHawk was deployed to Oliktok Point as part of the DOE-funded "Evaluation of Routine Atmospheric Sounding Measurements" (ERASMUS) campaign. During this campaign, the aircraft was used as a recoverable radiosonde, providing frequent, regular profiles of atmospheric temperature and humidity in the lower troposphere over a two-week period. The SUMO was used in a similar manner during a two-week field campaign on the Ross Ice Shelf, Antarctica during January 2014.

At the current time, there are some drawbacks to using these systems for research. First, the small stature and limited power of these aircraft limit the atmospheric conditions in which they can operate. Most noticeably, mUAS are hindered by winds greater than ~15 m s^{-1} and by any sort of icing conditions, since they cannot carry active de-icing equipment. In addition, there is limited availability of commercial sensors small enough to fit on these micro-scale platforms. Where sensors do exist, their performance, in the form of accuracy, response time, or otherwise, is often insufficient for providing the high-quality measurements necessary for scientific applications (e.g. Cassano 2014). While the research community has begun to develop their own instrument options, the accuracy of these research instruments is generally poorly characterized, and extensive testing of instrumentation is necessary to advance the scientific use of these platforms in the future. However, with ongoing characterization of instrumentation, these platforms will continue to be an invaluable asset for the Arctic observing community, providing previously unattainable measurements of the high-latitude environment at a relatively low-cost.

References:

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