The AirCore™ Atmospheric Profiler: Observations and Developments

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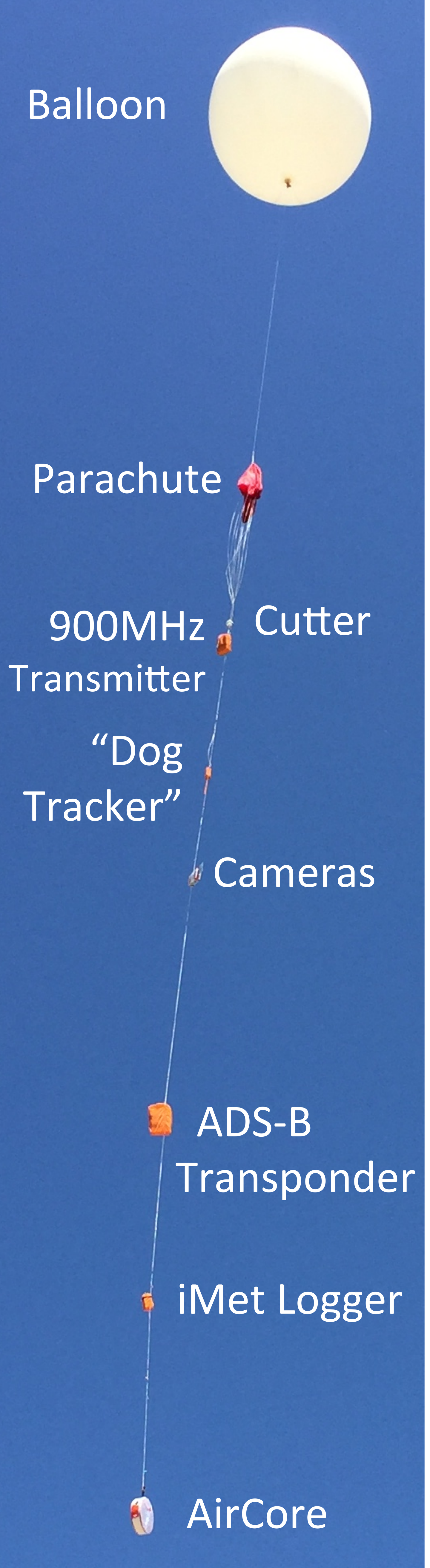


Current AirCore™ Design

Overview: The innovative AirCore atmospheric profiler remains one of the foremost tools for accurately measuring vertical profiles of CO_2, CH_4 and CO. The 100m-long passivated stainless steel tubing coil works as a sort of atmospheric "tape recorder"—it is launched on a balloon with one end open, allowing the tube to empty as it ascends, and fill back up with an atmospheric profile as it descends. The resulting "core" provides concentrations of the three gases from 30 km (~12 mbar) to the surface. Metadata about the launch are stored by an iMet meteorological logger, and the built-in Arduino AirCore logger; tracking and reporting modules allow the recovery team and Air Traffic Control to see the location and bearing of the balloon or parachute as it flies. The AirCore package is typically recovered 2-3 hours after launch, and the resulting core is run on a Picarro Cavity Ring Down Spectrometer (CRDS) for CO_2, CH_4 and CO within 2-3 hours of recovery. Metadata and fluid dynamics models map the sample "core" to the pressure altitude at which a given parcel of air was sampled, determine diffusive mixing, correct for mixing with calibration gases, and produce a final "profile" data product.

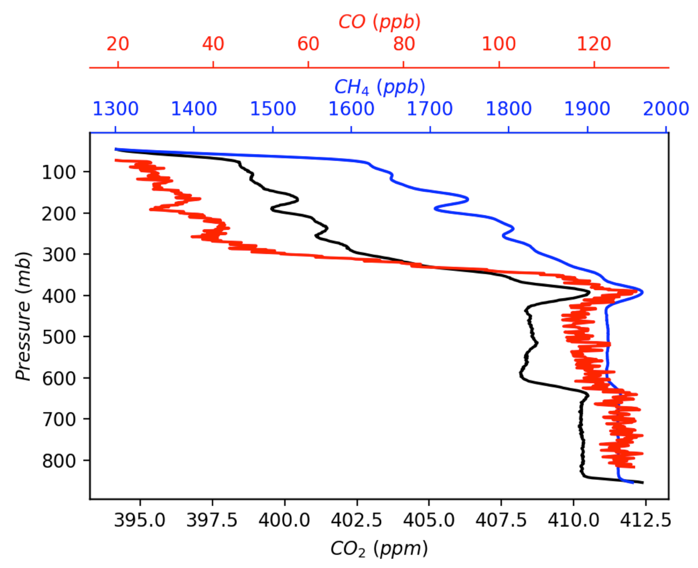


Figure 1. Profiles of CO_2, CH_4 and CO from a January 2017 AirCore launch in northern Colorado

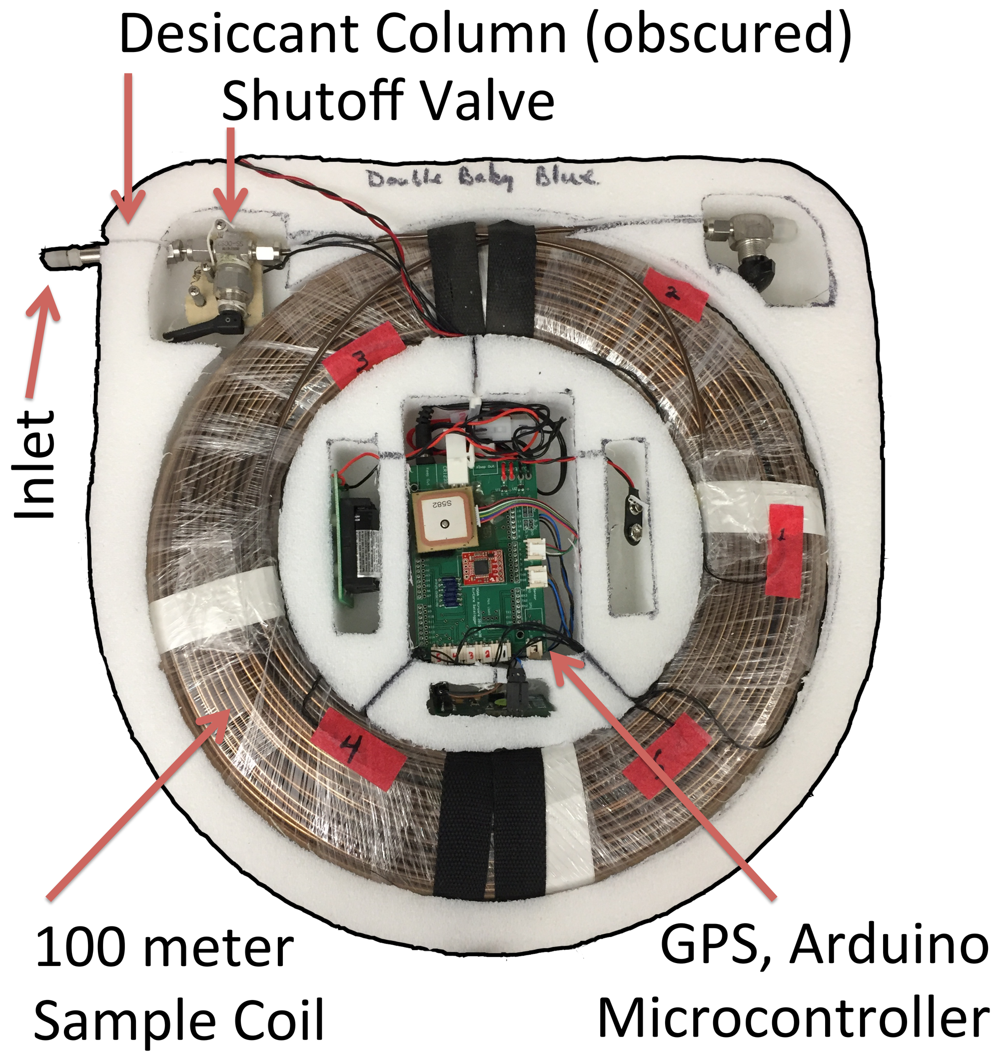


Figure 2. Current AirCore design, with 100 m 1/8" SS coil

Proposed "AirCore™ Active" Design

Figure 3. Altavian Nova Fixed Wing UAS (top) with Fusion module for AirCore (bottom).

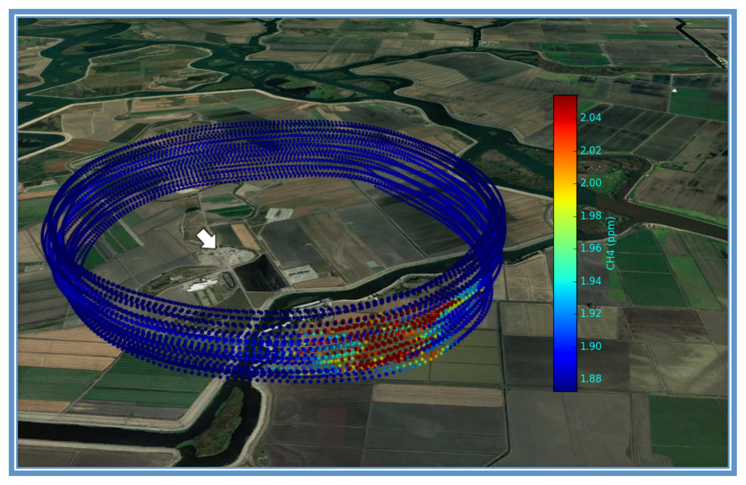


Figure 4. Proposed sampling approach around a point source of CH_4 noted by small white arrow. Figure from Conley et al. (2017, submitted).

Proposed work: Active (pumped/flow controlled) sampler to sample point sources, e.g. methane leaks from oil wells.
Platform: Altavian Nova fixed wing unmanned aerial system (UAS) remotely piloted by NOAA employees.
Profiles: Spiral, around point sources, up to the max allowable altitude in Class G (unregulated) airspace, typically 1200ft
Design: 50+ meter coil of passivated stainless steel, miniaturized into a small module in UAS fuselage, with active pumping and flow control
Instruments, Control: Pressure, RH, Temp, from small internal sensors, Arduino "bottom" valve closure, triggered by program

Altavian Nova	
Platform	Fixed Wing
Cost	$19K
Cruise Speed	15 m/s
Distance Travelled at cruise speed	81 km
Flight Time	90 mins
AirCore Coil Length	50 m
AirCore Weight	0.5 kg
Flow	9 sccm
# of samples given mixing volume of instrument cell	133
Horizontal res	607 m
1 km radius spirals per aircraft range	~13
Vertical res [m] for the above assuming a max alt of 1200 ft	~30 m

Table 1. Details of platform and sampling approach

Overview: The AirCore Active platform seeks to strengthen the current NOAA measurement platform arsenal with a sampler capable of making high accuracy measurements of atmospheric CO_2, CH_4, and CO (and eventually other) concentrations and fluxes in locations where piloted aircraft cannot reach, with a platform that can be mobilized in a day or two to target ongoing or urgent/time sensitive flux events from point sources such as leaking oil wells and cattle feed lots. The AirCore Active profiler can be operated in a variety of ways depending on the mission objectives, but we currently propose to calculate localized fluxes using a simple mass balance approach where the width and height of an emissions plume are estimated by flying a tight (1 km radius) spiral around a given point source.

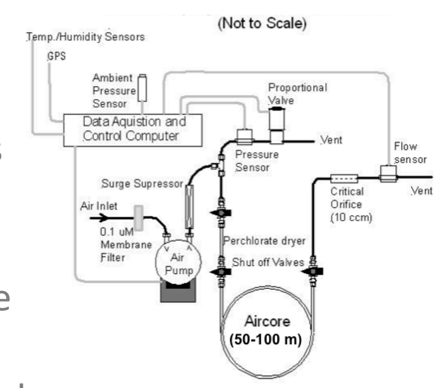
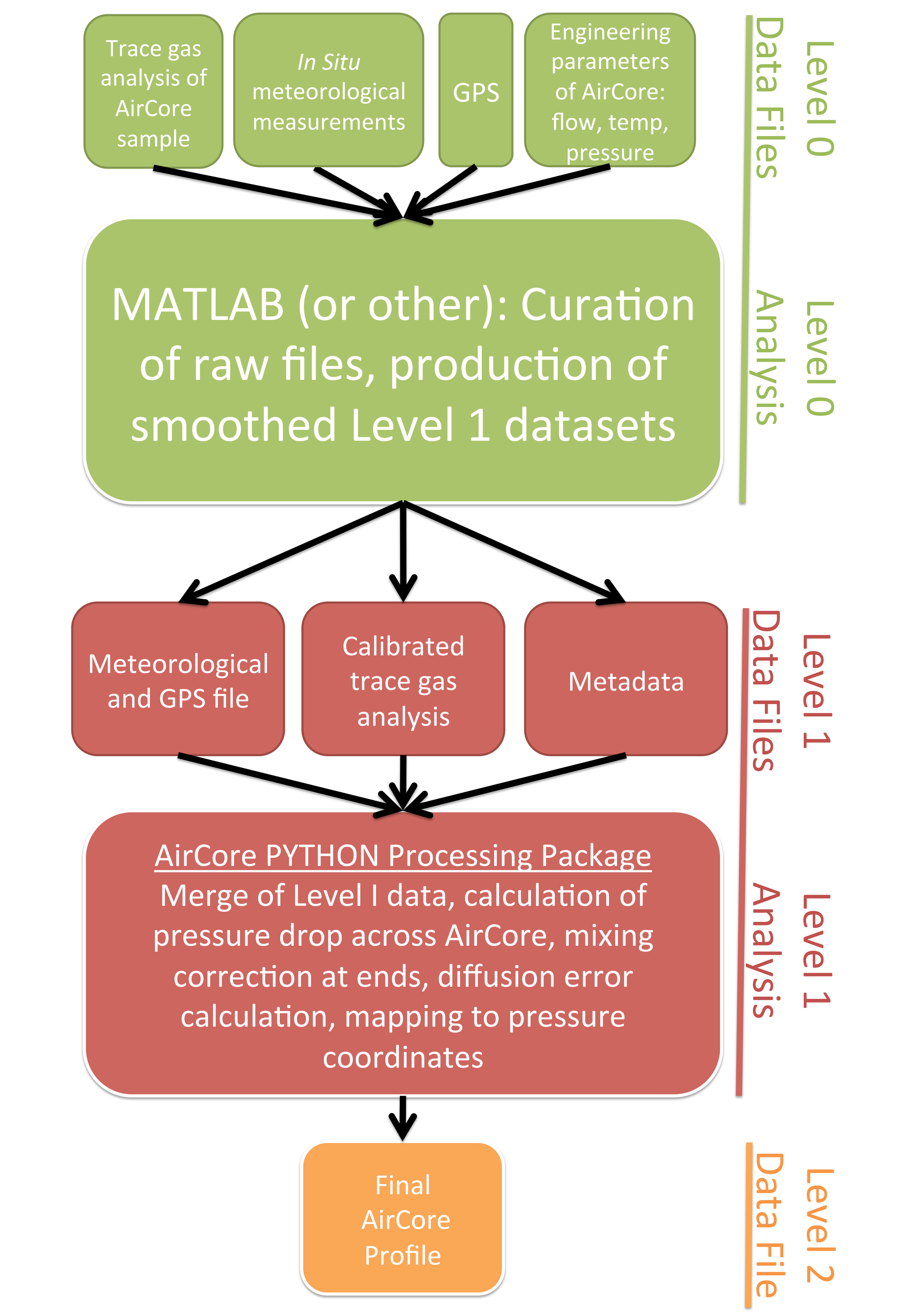


Figure 5. One proposed flow diagram for AirCore Active

AirCore™ Python Processing Package

Overview: The AirCore Python Processing Package has been developed as an open source platform for AirCore data processing. This allows for standardization of analysis approach among the various labs who currently fly the sampler, and also allows third parties to understand and improve upon the current fluid dynamics model and corrections if needed as part of a greater effort to compare *in situ* and remote sensing data. At the "Level 0" step, data and metadata are merged, and meteorological metadata are formatted and processed for Level 1 model analysis. Instrument data is also calibrated using a instrument-specific methodology appropriate for a given lab. Individual labs are responsible for outputting required data and metadata into three specifically-formatted "Level 1" files, which are fed into the Python code. The Python code models the pressure drop across the AirCore during flight and analysis to map the sample points to pressure coordinates, and to estimate diffusive and Taylor dispersion mixing of the sample. The Python code produces a "Level 2" AirCore profile against pressure and altitude, with error calculated in both the concentrations and the vertical axis. This final product is used for model and remote sensing validation.



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