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Environmental lapse rate as a wildfire tool: Next steps for tool delivery

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Previous work

Previous work completed by FPInnovations researchers Greg Baxter and Jim Thomasson demonstrated a correlation between wildfire blow up scenarios and conditions of super adiabatic lapse rates. Furthermore, it was demonstrated that the OAT sensors present on Conair's RJ85 aircraft can deliver accurate temperature readings in correlation with their altitude. Super adiabatic lapse rates are described as having a lapse rate greater than 9.8°C/km, a condition meteorologists describe as an absolutely unstable atmosphere.

The data from each flight is available and displayed on Latitude Systems WebSentinel, a password protected private platform. In the previous report it was indicated that data delivery time would need to be decreased as the data was only available for download two days after the flight time. This length of delay would not be suitable for decision making on a wildfire and thus would need to be shortened.

Raw data processing steps

Assuming the data can be delivered expediently, the following processing steps should be applied to the raw data. During the processing of the data it became evident that reducing the volume and noise is a key part in allowing it to be useful. Several crucial steps were identified for cleaning the data that will be displayed:

- Remove incomplete data rows
- Removal of noise due to take off and landing and associated micro climates at the airports
- Removal of noise from long flight distances to the drop location
- Setup a pre-determined radius from the drop location and omit data outside of that radius
- Setup a time before and after the drop time and omit data outside of that time for that particular drop as the plane might come back within the radius of that drop later in the flight
- Create a moving average of the altitude and OAT to get rid of noise and smooth out the data.
- Treat each drop as a separate data set
- Work done by Tikhomirov et al. (2021) found that drone temperature measurements were more accurate when ascending than descending, therefore only ascending lapse rate profiles should be considered

Desired outputs

- Tabular and graphical representations of the data
- If tabular data is not possible with an automated workflow then graphical representation of lapse rate per drop on a tephigram/thermodynamic diagram/Stuve diagram
- Lapse rate values per drop when ascending and averages for drops per flight

Data display

The data needs to be displayed in an easily digestible format and as such a table or figure should be used. If a figure is used it is recommended that altitude be on the y axis and temperature should be placed on the x axis. The figure should have lines representing the threshold for super adiabatic lapse rate placed at every 5 or 10°C so that the practitioner could place a ruler on the observed lapse rate and easily determine if it is above or below the super adiabatic threshold.

If a process for automatic identification of super adiabatic lapse rates is developed the data should be displayed in tabular format. This output should include columns for the following:

1. Date
2. Time
3. Altitude range
4. GPS location
5. Lapse rate
6. Average lapse rate for drops within a specified radius and elapsed time

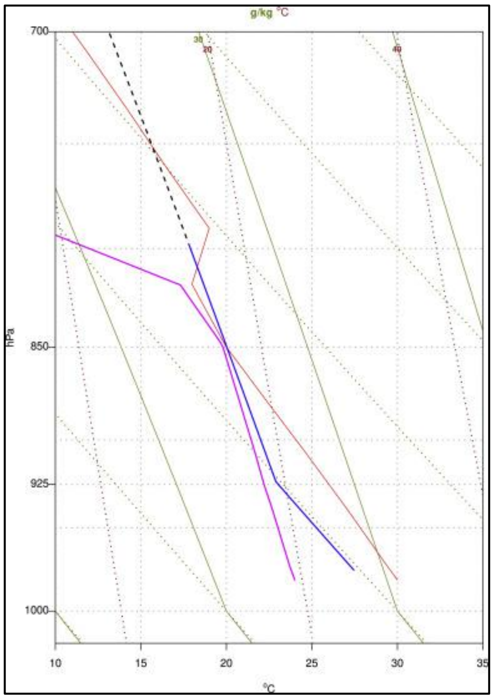

Figure 1: Example of a Stuve diagram by Saenz et al. (2019). The pink, blue, and red lines represent atmospheric data while the other lines represent reference lapse rate lines for easy comparison.

Options for remotely piloted aircraft implementation

Remotely piloted aircraft (RPA) have become easy to fly, cheap, and mobile and current regulations would allow suitable atmospheric sampling within wildfire controlled airspace up to 2000 ft AGL. Sensors can be carried on consumer level RPA such as a DJI Phantom 4 but would require a special mounting bracket be made to attach the sensor package. Larger commercial sized RPA would still need a custom bracket though weight would be less of a priority since they have much larger payload capacities. A light weight bracket could be designed and 3D printed to suit any drone that can lift it.

The sensor package could be manufactured around an Arduino or Raspberry Pi as the processors. In this application the capacity of a Raspberry Pi is not required and an Arduino with several components should suffice. An Arduino would need to be connected to the following sensors and peripherals at minimum:

1. Real Time Clock (RTC)
2. SD module
3. Temperature sensor
4. Pressure Sensor
5. Power source

The real time clock (RTC) serves to keep track of time in a very precise manner. The SD module stores the data while the RPA is in the air and allows the user to download the data upon landing. The temperature and pressure sensors allow collection of the desired data. Finally, a power supply that is separate from the RPA will allow for greater flexibility when choosing an RPA platform and assist in simplifying the design. Suggested sensors and models for each component can be seen below in Table 1.

Table 1: Lapse rate RPA sensor components

Sensor	Model
RTC	DS3231 (I2C) or DS3234 (SPI and 256B SRAM)
SD module	SparkFun DEV-13743 or other
Temperature	Adafruit TMP117 (more accurate) or MCP9808
Pressure	DPS310 (more accurate) or BMP388
Battery	16340, 18350, or AAA
Boost module	Convert 3.3v-5v from battery to 5v for powering electronics

Bibliography

Sáenz, J., González-Rojí, S. J., Carreno-Madinabeitia, S., & Ibarra-Berastegi, G. (2019). Analysis of atmospheric thermodynamics using the R package aiRthermo. Computers & Geosciences, 122, 113-119.

Tikhomirov, A. B., Lesins, G., & Drummond, J. R. (2021). Drone Measurements of Surface-Based Winter Temperature Inversions in the High Arctic at Eureka. Atmospheric Measurement Techniques Discussions, 1-27.

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