Supplement: Light-weight Observatory for sOuNdIng clouds and aeorSol, LOONIS: a balloon lifted platform for atmospheric aerosol research

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S1 Support elements

The platform (Fig. S1) structure consists of three primary components.

First, a 3D-printed rack, designed to hold five impactors, serves as the payload's central support. This rack consists of two main frames, each with a rectangular base and a trapezoidal top. These frames are interconnected by X-shaped cross-members and a central base plate, forming a framework that houses the impactors.

Second, three carbon tubes extend from this central structure. The tubes are cylindrical with 6mm x 4mm cross-sections and a length of 800 mm. One tube is oriented vertically, acting as the central rod, while the other two extend horizontally. The vertical central rod is used to attach the unwinder, which deploys the payload beneath the balloon.

Third, two polystyrene boxes are mounted on the tips of the horizontal carbon rods to protect sensitive electronics from environmental conditions. The first box houses the ozone sonde and holds the radiosonde ouside. The second box contains the batteries, the main Printed Circuit Board (PCB), and various other sensors, excluding the optical particle counters (OPCs) with the thermal flow sensor (TFS). Inside this second box, a wooden frame creates two layers, facilitating cable management and allowing for easy extraction of components if last-minute replacements are necessary. Additionally, the vertical central rod supports two Universal Cloud and Aerosol Sounding System (UCASS) units, which are attached using two 3D-printed arms and touch fastener strips.

The 3D-printed rack, additional supporting elements, and the internal frame for the polystyrene box are available as a download.

Figure S1. Frontal view of the fully assembled LOONIS Platform. From left to right: the electronics enclosure (containing batteries, pumps, and auxiliary sensors), the POPS unit, and the ozone sonde with an attached radiosonde. The central red frame holds the impactor rack, while a supporting rod extends upward to mount two UCASS instruments.

S2 Central printed circuit board

The central printed circuit board (PCB) interfaces directly with the Raspberry Pi single-board computer (SBC) via a 40-pin header with a 2.54 mm pitch. The PCB functions as the hub for all cable and sensor connections, as well as power distribution. Physical connectivity between the electronics and the Raspberry Pi is managed through three distinct methodologies. Pumps, batteries, the Universal Cloud and Aerosols System (UCASS), the Pulse Per Second (PPS) signal from the GPS, and the xData output utilize a Molex 6373 socket for cable connection. The remaining sensors, excluding the GPS module, connect directly to the PCB via a standard 2.54 mm socket without intervening cables. Finally the GPS is connected using the USB interface. A schematic overview of the board is available in Fig. S2.

S2.1 Interfacing

The system primarily utilizes the Serial Peripheral Interface (SPI) and Inter-Integrated Circuit (I2C) protocols for sensor data. The relays activating and deactivating the impactors are linked directly to a general-purpose input/output (GPIO). Analog sensors, such as the CO sensor, are dependent on an analog-to-digital converter (ADC) with 4 different addresses to choose from. The O_3 sonde remains independent of the PCB and relies on serial communication, also using the xData protocol. For details, each schematic of the input/output for the sensor is included, as well as Table S1 detailing the different communication buses that each sensor utilizes.

S3 Programming

The system employs a multi-process architecture to concurrently acquire data from diverse sensors, process it, and manage its transmission. Sensor modules operate asynchronously, each capturing data at its designated rate. These readings, structured as timestamped records, are immediately funneled through inter-process communication channels to a central data management routine.

This central routine aggregates the incoming data, maintaining separate buffers for local logging and for remote transmission. Approximately once per second, data intended for transmission is processed. During this step, the buffered records are converted into a compact byte-string format using a custom encoding scheme. This scheme applies predefined formatting rules, tailored to each data type, ensuring efficient representation.

The resulting encoded byte-strings are then queued for the final transmission stage. A dedicated communication handler retrieves these byte-strings, frames each by adding a defined header and a terminator, and subsequently transmits the complete frame over a serial link. A scheme of how the code works is showed in Fig. S3. The code is available on request.

S4 Data Acquisition and Telemetry

The secondary ground station electronics constitute a custom-built, automated reception system based on the "radiosonde_auto_rx" project infrastructure. This system employs a single-board computer (Raspberry Pi 4) coupled with a dedicated RTL-SDR re-

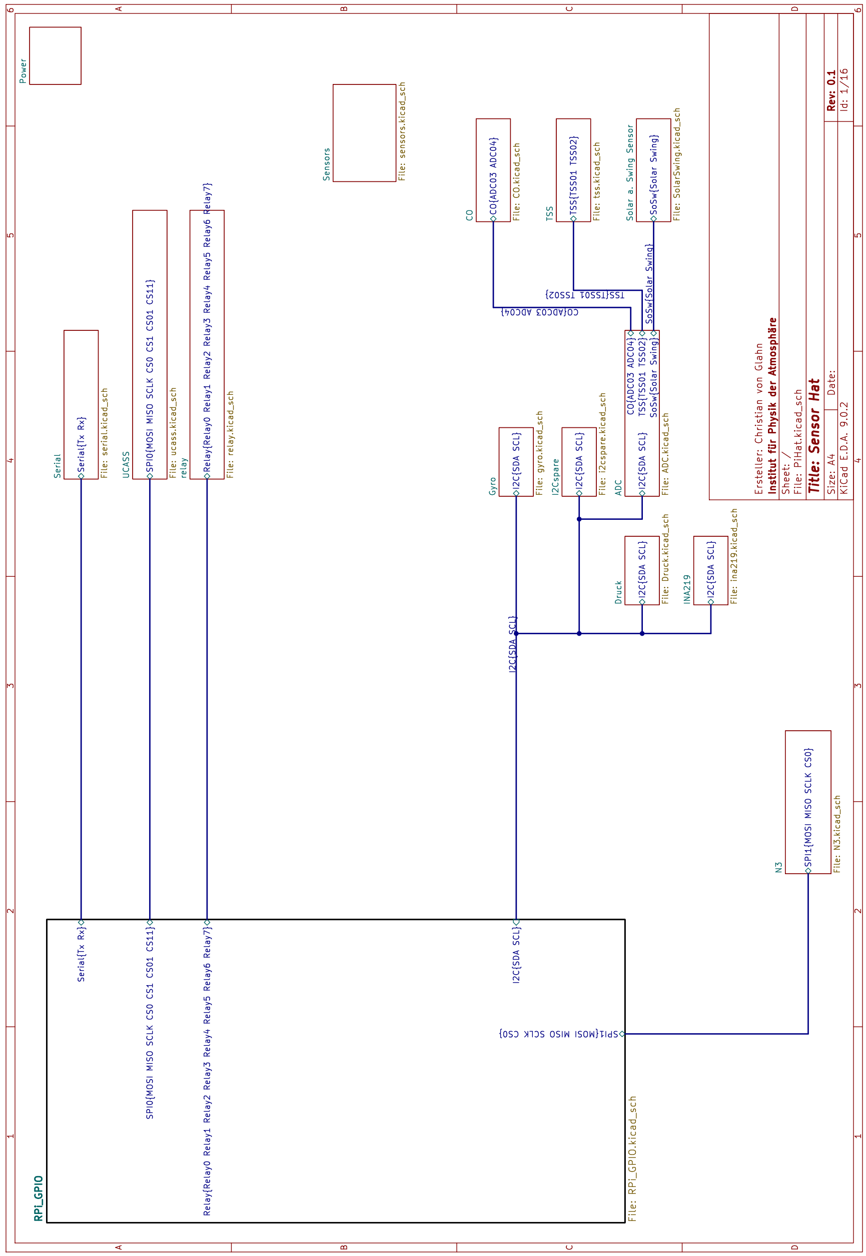

Figure S2. Schematic of the board. A simplified block diagram illustrating the major components and their electrical interconnections, including I2C, SPI, and various digital and analog signal paths.

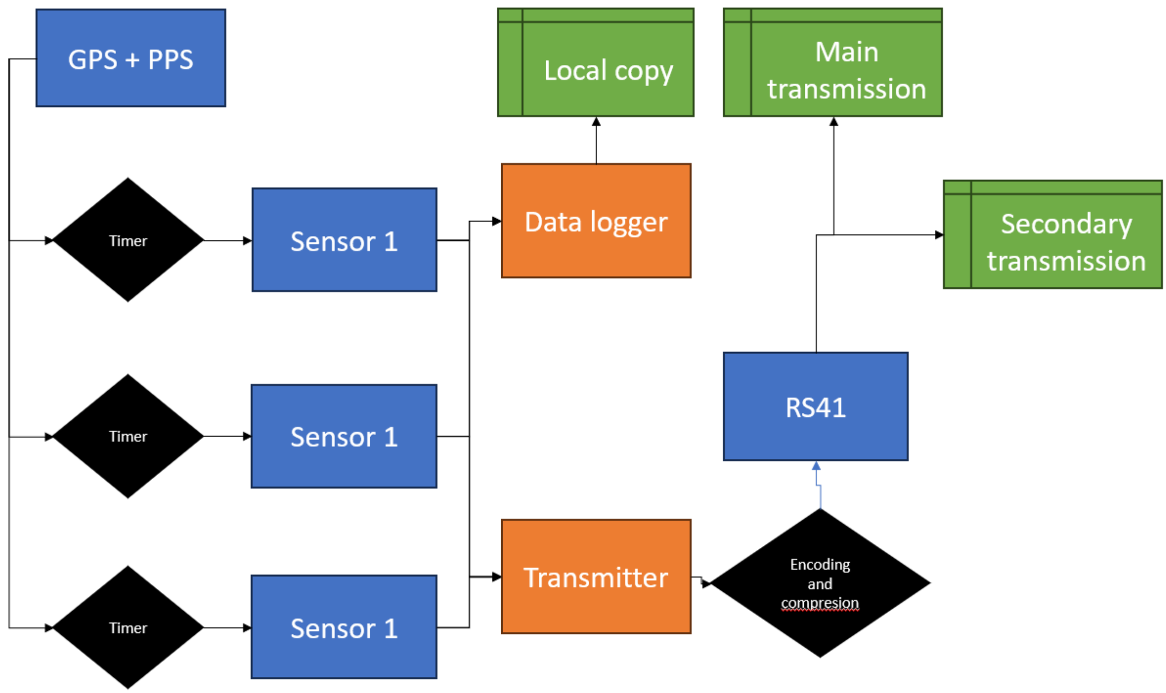

Figure S3. In a typical one-second interval, various sensors contribute multiple readings to the central data queue. At a consistent point within that second (e.g., during a specific 0.5-second window), the data management routine processes the batch of data collected over the preceding second. This batch is encoded and the resulting compact byte-strings are sent to the transmission handler. Consequently, a series of framed data packets, representing the system's activity during that second, is dispatched via the serial interface.

ceiver equipped with a temperature-compensated crystal oscillator (TCXO) for enhanced frequency stability. An antenna tuned for the 400-406 MHz radiosonde band is utilized, with optional integration of a low-noise amplifier and band-pass filter to optimize signal acquisition. This setup allows for autonomous scanning, detection, and demodulation of radiosonde signals. This has two main objectives: to ensure data integrity through redundant storage, acting as a backup against primary system issues, and to provide the capacity for continuous monitoring of at least two sequential radiosonde flights. This capability allows for uninterrupted data logging and tracking across successive launches without requiring immediate manual reset or reconfiguration, thereby enhancing the reliability and scope of data acquisition during flight campaigns.

Table S1. Specifications for various sensors and system components, detailing their required operating voltage (12 V or 5 V) and their respective communication interface

Sensor	Voltage	Interface
UCASS	12v	SPI
TFS	12v	SPI
ADC	5v	I2C
Gyro	5v	I2C
O	5v	Serial
Pressure	5v	I2C
GPS	5v	USB + Pin
Relay	12v	Pin
CO	5v	Analog to digital sensor

Table S2. Aerosol UCASS size bin boundaries

ADC	Lower size boundary	Upper size boundary
19	0	0.3
101	0.3	4.4
217	4.4	6.7
337	6.7	8.6
460	8.6	10.3
587	10.3	11.6
717	11.6	13
851	13	14.2
988	14.2	15.4
1128	15.4	16.7
1272	16.7	17.7
1420	17.7	18.7
1571	18.7	19.8
1725	19.8	20.7
1883	20.7	21.7
4095	21.75	32.5

Table S3. UCASSd size bin boundaries

ADC	Lower size boundary	Upper size boundary
10	0	9
92	9	11.5
208	11.5	14.2
328	14.2	16.7
451	16.7	18.8
578	18.8	20.8
708	20.8	22.6
842	22.6	24.4
979	24.4	26.1
1119	26.1	27.7
1263	27.7	29.3
1411	29.3	30.9
1562	30.9	32.4
1716	32.4	33.8
1874	33.8	35.4
4095	35.4	51.5

Table S4. POPS size bin boundaries

Lower size boundary	Upper size boundary
0.14	0.14614
0.14614	0.15256
0.15256	0.15925
0.15925	0.16624
0.16624	0.17354
0.17354	0.18116
0.18116	0.18911
0.18911	0.19741
0.19741	0.20607
0.20607	0.21512
0.21512	0.22456
0.22456	0.23441
0.23441	0.24470
0.24470	0.36130
0.36130	0.47280
0.47280	0.567
0.567	0.61066
0.61066	0.65769
0.65769	0.70833
0.70833	0.76288
0.76288	0.82162
0.82162	0.88489
0.88489	0.95303
0.95303	1.102642
1.102642	1.10546
1.10546	1.19059
1.19059	1.28227
1.28227	1.38101
1.38101	1.48736
1.48736	1.60189
1.60189	1.7255
1.7255	1.85810
1.85810	2.00118
2.00118	2.15528
2.15528	2.32125
2.32125	2.5

Table S5. Summary of BISTUM23 instrument status for each flight day.

Date	Time UTC (hh:mm)	Ancillary	UCASS$_A$	UCASS$_D$	Impactors
4th August	12:40	Yes	No	No	No
8th August	10:30	Yes	No	Yes	Yes
	08:30	Yes			No
10th August	11:00	Yes	Yes	Yes	Yes
	09:50	Yes	No	No	Yes
12th August	12:30	Yes	Yes	Yes	Yes
	14:00	Yes	Yes	Yes	Yes
	16:40	Yes	Yes	Yes	Yes
	12:30	Yes	Yes	Yes	Yes
13th August	12:30	Yes	Yes	Yes	No
	14:00	Yes	Yes	No	Yes
	16:00	Yes	Yes	No	Yes
16th August	11:50	Yes	Yes	Yes	Yes
	13:40	Yes	Yes	Yes	Yes
	15:00	Yes	Yes	Yes	Yes
17th August	10:15	Yes	Yes	Yes	No
	12:00	Yes	No	No	No

Table S6. Summary of BISTUM2024 instrument status for each flight day.

Day	Time UTC (hh:mm)	Ancillary	UCASS$_A$	UCASS$_D$	POPS	Impactors
7th June	07:30	Yes				
8th June	12:55	Yes	No	Yes		Yes
11th June	12:15	Yes	No	No		No
14th June	14:00	Yes	Yes	Yes	Yes	Yes
15th June	04:00	Yes	No	Yes	Yes	Yes
	08:00	Yes	No	No	Yes	Yes
17th June	12:45	Yes	No	No		Yes
18th June	12:00	Yes	Yes	Yes		Yes
	14:00	Yes	Yes	Yes		Yes
19th June	10:00	Yes	Yes	Yes		Yes
20th June	09:15	Yes	Yes	Yes	Yes	Yes
21st June	08:20	Yes	No	No		Yes