ITINERIS

How to manage an atmospheric station

Ferdinando Pasqualini– ferdinando.pasqualini@cnr.it

Francescopiero Calzolari – francescopiero.calzolari@cnr.it

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani

The **goal** of this presentation is to share some of the core principles, practical strategies and real examples that support the successful operation of atmospheric laboratories.

Outline

Environmental Setting of an atmospheric laboratory

Outline

Environmental Setting of an atmospheric laboratory

Power Supply-System

Outline

Environmental Setting of an atmospheric laboratory

Power Supply-System

Remote monitoring and control in atmospheric station

Outline

- Environmental Setting of an atmospheric laboratory
- Power Supply-System
- Remote monitoring and control in atmospheric station
- Data Acquisition and Management

Outline

- Environmental Setting of an atmospheric laboratory
- Power Supply-System
- Remote monitoring and control in atmospheric station
- Data Acquisition and Management
- Information Infrastructure and Logbook Systems

Outline

- Environmental Setting of an atmospheric laboratory
- Power Supply-System
- Remote monitoring and control in atmospheric station
- Data Acquisition and Management
- Information Infrastructure and Logbook Systems
- Operational Management and On-Site Presence

Environmental Setting of an atmospheric laboratory

- The design of atmospheric laboratory must account for the specific geographic location and climatic conditions;

Environmental Setting of an atmospheric laboratory

- The design of atmospheric laboratory must account for the specific geographic location and climatic conditions;

- These factors significantly influence equipment choice and infrastructure resilience;

Environmental Setting of an atmospheric laboratory

- The design of atmospheric laboratory must account for the specific geographic location and climatic conditions;

- These factors significantly influence equipment choice and infrastructure resilience;

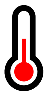
- We will analyze in detail three types of atmospheric stations: high-altitude laboratory, coastal laboratory, and mobile laboratory.

Environmental Setting of an atmospheric laboratory

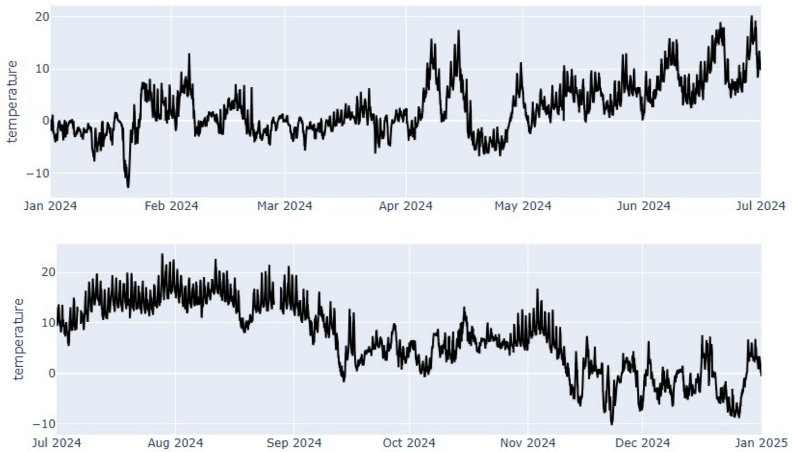
ITINERIS

High-Altitude Laboratories Requirements – Case of Monte Cimone

- The architectural structure must reflect the characteristics of a high-altitude building, with particular attention to thermal insulation, and protection from severe weather conditions.
- The figure below shows the trend of the external temperature over the course of the year 2024.



$$-15°C < T < 20°C$$

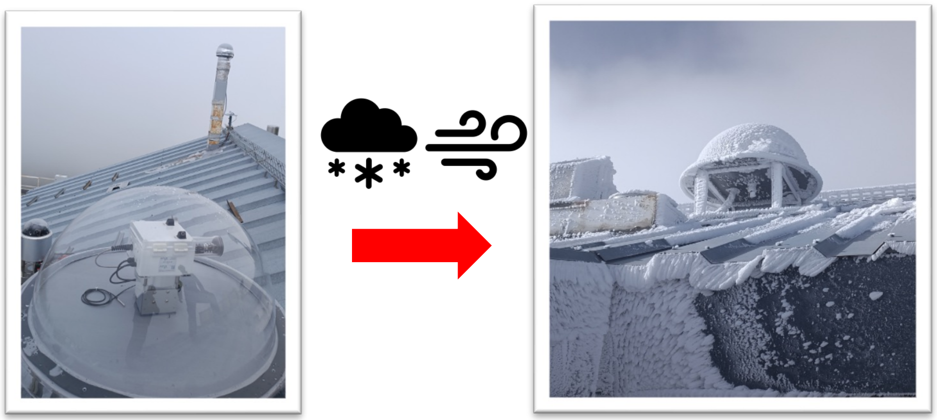


Environmental Setting of an atmospheric laboratory

High-Altitude Laboratories Requirements – Case of Monte Cimone

- The laboratory must be equipped with de-icing systems to prevent ice formation on the sampling lines and to protect the instruments installed outside the observatory;

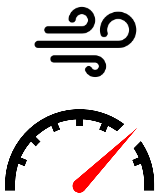
- The figure below shows a composite material dome installed above the MAX-DOAS (ground-based passive spectrometer) to protect it from **ice formation**;



Environmental Setting of an atmospheric laboratory

High-Altitude Laboratories Requirements – Case of Monte Cimone

- The figure shows the severity of high-altitude winter conditions, where both precipitation and wind can reach critical thresholds.



Environmental Setting of an atmospheric laboratory

High-Altitude Laboratories Requirements – Case of Monte Cimone

- The figure shows the severity of high-altitude winter conditions, where both precipitation and wind can reach critical thresholds.

Environmental Setting of an atmospheric laboratory

Coastal laboratories Requirements - Case of Capo Granitola

- The infrastructure must be equipped with appropriate thermal insulation and air conditioning systems to ensure the maintenance of environmental conditions (temperature and relative humidity) within the optimal ranges required for the proper functioning of the scientific instrumentation;

- Protective systems against marine corrosion, such as specialized surface treatments for the most exposed components, are implemented to ensure long-term resistance to corrosive environments;

Environmental Setting of an atmospheric laboratory

Coastal laboratories Requirements - Case of Capo Granitola

- Regular maintenance for the infrastructure and external instrumentation (Cleaning of sampling lines from sea-salt) is key to ensure long-term performance;

- The figure highlights how critical corrosion effect can be;

Environmental Setting of an atmospheric laboratory

ITINERIS

Mobile laboratories requirements

- Mobile laboratory specifications must be adapted to the nature of the deployment site (marine, terrain or polar region), including its environmental, infrastructural, and logistical constraints;

- Must be equipped with vibration dampers and fixing system to stabilize instruments during transport or operation;

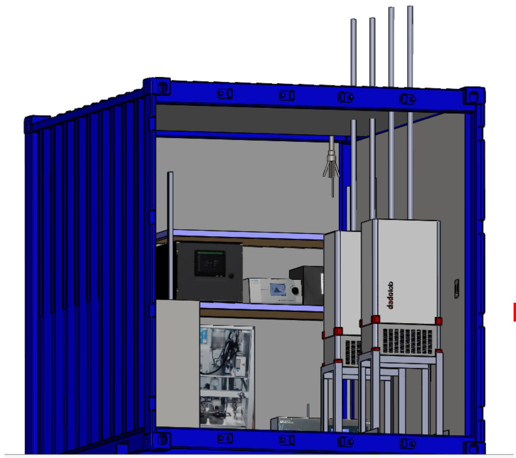
- Modular layout enables flexible arrangement of the instruments based on specific field campaign.

Environmental Setting of an atmospheric laboratory

ITINERIS

Mobile laboratories requirements – Case of AEROLAB Marine Version

- Creating a CAD assembly of the mobile laboratory through reverse engineering enables the virtual testing of multiple instrumentation layouts, facilitating early-stage evaluation and optimization of internal spatial configurations;
- The digital model allows for mechanical and thermal simulations under various operating conditions, supporting performance analysis, structural integrity checks, and thermal management studies before physical modifications are implemented.



Power Supply System

Securing a reliable and protected power supply is critical for the continuous operation of atmospheric laboratories, especially in remote or extreme environments;

Power Supply System

Securing a reliable and protected power supply is critical for the continuous operation of atmospheric laboratories, especially in remote or extreme environments;

The installation of Uninterruptable Power Supply (UPS) systems is essential to avoiding data loss or damage to scientific equipment;

Power Supply System

Securing a reliable and protected power supply is critical for the continuous operation of atmospheric laboratories, especially in remote or extreme environments;

The installation of Uninterruptable Power Supply (UPS) systems is essential to avoiding data loss or damage to scientific equipment;

Effective lightening protections systems, particulary at high altitudes must be designed to prevent transient overvoltages.

Power Supply and Network Infrastructure

Monte Cimone UPS system

Equipped with 2 x 15 kVA UPS units configured in a redundant setup, ensuring power supply availability in case of a single unit failure

Battery packs supporting 11kW continuous load for 6 hours autonomy;

The laboratory is grouded to a single star-point equipotential reference, minimizing voltage differences across the system.

Additional protection is provided by internal and external Faraday cages.

Monte Cimone UPS systems with battery packs

Remote monitoring and control in atmospheric station

- Implementing remote control and monitoring systems is essential for the effective operation of atmospheric laboratories.
- A remote control systems include:
  - **Remote Instrument Control**: Network-enabled interfaces allow operators to remotely power on/off instruments, adjust operational parameters, and perform routine calibrations. This capability reduces the need for on-site interventions and ensures timely responses to any anomalies.
  - **Continuous Environmental Monitoring**: Sensors connected via Ethernet or wireless networks monitor ambient conditions such as temperature, humidity, and pressure.
- By integrating these technologies, atmospheric laboratory can maintain high levels of data quality and operational reliability, even in challenging locations

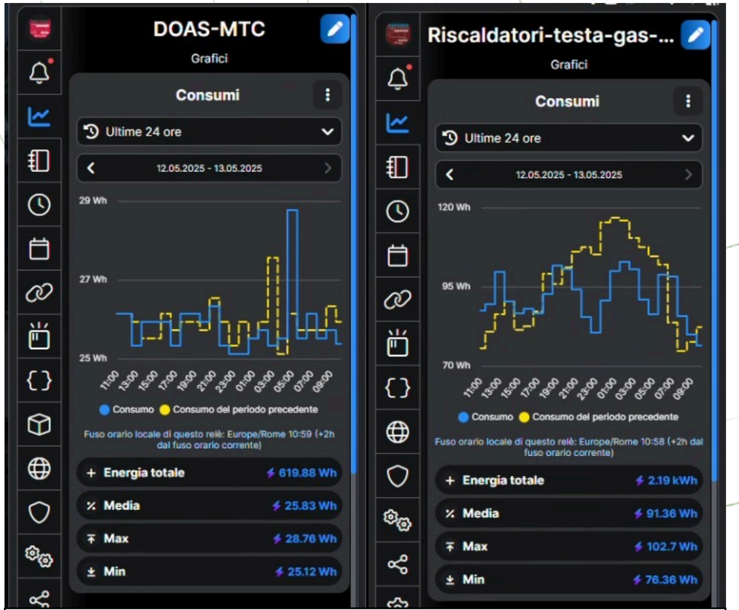
Remote Instrument and Laboratory Control

ITINERIS

Devices for remote control

- **LAN controlled Power outlets**: enabling on/off switching via web interface or API , typically used for critical instrumentation such as pumps or acquisition PCs;

- **WI-FI Smart Devices:** enabling remote controls and monitoring of electrical loads up to 16A, offering built-in power metering and support for automation triggered by temperature, humidity and energy consumption.



Measured voltage and power consumption of the DOAS unit and gas sampling head heaters during operation. These values are used to monitor system performance and trigger safety or energy-saving automation if thresholds are exceeded.

Remote Instrument and Laboratory Control

Devices for remote control

- **IP camera system**: High-resolution IP cameras provide continuous visual monitoring of laboratory equipment and environmental conditions. These cameras can be integrated into existing networks, offering real-time imagery and alerts.

Data Acquisition system and internet connections

- The **data acquisition systems** in atmospheric laboratories are designed to collect data from various measurement instruments;

- The control and management of these instruments and data are typically handled by proprietary software or custom-developed software that enables data integration from various devices, real-time monitoring, and configuration of measurements.

- **Key interfaces for Data Acquisition:**
  - Serial interfaces RS-232m RS-485;
  - USB interfaces;
  - LAN interfaces for advanced instruments, like remote sensors (radar, lidar), send data via Ethernet, allowing for high-speed, long-distance data transmission.

Data Acquisition system and Internet connections

The data from all measurement instruments are sent to the **local observatory server**. This server acts as the central collection and initial processing point. At this stage, the data may undergo basic pre-processing to ensure proper formatting and eliminate obvious errors;

After initial processing, the data is securely transmitted to the headquarters servers. These can be part of European research infrastructures (e.g., ACTRIS, ICOS) or specific scientific institutions;

Data Acquisition system and Internet connections

- Internet connectivity is selected based on the laboratory configuration and the characteristics of the measurement site

Wired Broadband (Fiber / DSL / Ethernet)	High speed, low latency, stable connection Fixed laboratories in urban or semi-urban areas
GSM / LTE / 5G Mobile Networks	Portable, good coverage in many areas Variable speed and reliability depending on signal strength Mobile stations, temporary setups, or rural areas with mobile coverage
Satellite	Wide availability Remote observatory, polar station

Information Infrastructure and Logbook Systems

Maintaining a proper observatory Logbook plays a key role in ensuring the traceability of:

- Instruments **calibration**;

Information Infrastructure and Logbook Systems

Maintaining a proper observatory Logbook plays a key role in ensuring the traceability of:

- Instruments **calibration**;
- Instruments **maintenance**;

Information Infrastructure and Logbook Systems

Maintaining a proper observatory Logbook plays a key role in ensuring the traceability of:

- Instruments **calibration**;
- Instruments **maintenance**;
- critical infrastructure-related events such as **electrical faults** or maintenance work;

Information Infrastructure and Logbook Systems

- Maintaining a proper observatory Logbook plays a key role in ensuring the traceability of:
  - Instruments **calibration**;
  - Instruments **maintenance**;
  - critical infrastructure-related events such as **electrical faults** or maintenance work;
- Supports data validation, helping to identify anomalies or explain irregularities in measurement series.

" A well- maintained logbook turns raw data into reliable scientific information"

Information Infrastructure and Logbook Systems

ITINERIS

Logbook example for Monte Cimone

Instrument information:
- Model
- Scientific PI
- User Manual

SMPS tropos cimone

Visualizza | Modifica | Revisioni

marca: tropos
modello: smps
osservatorio: Monte Cimone

assegnazione: Angela Marinoni
tipo misura: aerosol online

misura: size distribution

stato: funzionante
stato di attività: In misura

Manuali: User manual_TROPOS-SMPS_Package.pdf , Manuale software controllo SMPS

AGGIUNGI EVENTO IN LOGBOOK PER QUESTO STRUMENTO -> Strumento: SMPS tropos cimone

AGGIUNGI CONSUMABILE PER QUESTO STRUMENTO -> Strumento: SMPS tropos cimone

AGGIUNGI MANUALE PER QUESTO STRUMENTO -> Strumento: SMPS tropos cimone

Instrument operation:
- Description activity
- Data activity
- Operator

data	Titolo	operatore	Descrizione
2025-03-17	Manutenzione - sporadic aerosol flow and acquisition issues	Mazzini Martina	Around 10:00 UTC, the capillary was bypassed and directly connected to the inlet. This allows for outdoor air sampling, ensuring valid data; however, flow measurement will no longer be available.
			08:40 UTC Disconnected SMPS from the line. **08:50 UTC** Measured flows: • Aerosol flow (SMPS inlet): 1024 • Flow between DMA and CPC-SMPS: 1024 • CPC-TOT flow: 980-985 **09:44 UTC** Reconnected SMPS to the line. **10:02 UTC** Measured flows: • Aerosol flow (SMPS inlet): 1300-1000-1200-110 • CPC-TOT flow: 700-730-720 **10:11 UTC** Connected new pump to CPC-TOT, previous pump remains connected only to SMPS. CPC-TOT pressures are adjusted, but not for CPC-SMPS.

Instrument position:
- data
- position
- description

posizione	data evento	Desrizione
in osservatorio	2024-05-03	MPSS installed, the CPC used is now the TSI_3772, previously used as totCPC. Sheathflow pump installed as compressed air, not in vacuum (as it was before), following WCCAP suggestion. Flow 4.8L/min (ambient) HV voltage calibration: • 0.4mV: ◦ from -0.0039 (1.8v) ◦ to -0.0016 (5.2V) • 800mV: ◦ 0.789 oscillating a bit between 996V to 1002V • 200mV: ◦ 249V PSL cal, sheath flow slope re-adjusted from 1.3 (peak 196nm) to 1.2 (peak 200nm) Back to UTC time (UTC+2 used while at WCCAP) Measurment mode ON Next step: grounding DMA

Operational Management and On-Site Presence

ITINERIS

The implementation of remotely controllable systems reduces the need for daily on-site operator;

A technician or researcher visits the observatory every two days to perform standard operational tasks (check sampling line, butanol refill etc);

Operational Management and On-Site Presence

The implementation of remotely controllable systems reduces the need for daily on-site operator;

A technician or researcher visits the observatory every two days to perform standard operational tasks (check sampling line, butanol refill etc);

The **continuous operation** of an atmospheric laboratory, operating 24/7, requires the capability for rapid response in case of unexpected failure instruments or operational anomalies;

Operational Management and On-Site Presence

“A man in Havana”
mandatory figure

Operational Management and On-Site Presence

- **Consistency**, **continuity** and **participation** are essential to ensure long-term value of atmospheric observations

- This is only possible through the integration of different and complementary skills, where everyone, from senior researchers to technical staff plays a crucial role in atmospheric laboratory management.

THANKS!

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani