MASTER'S DEGREE IN METEOROLOGY & OCEANOGRAPHY · 2025/2026

Analysis of *Thermal Inversion* on the Pedemontana Buschese (CN) Using a Quasi-Climatic Laboratory at the Foot of Monviso

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NETWORK
DATAMETEO Educational OdV
"Clima Km Zero" project

ABSTRACT

The solar-powered IoT weather stations in **Busca (501 m)** and **Roccabruna (690 m)** analyze the local microclimate over **Jan 2024 – Dec 2025** (730 days). The stations are strongly coupled in spring (**R = 0.95**) but decouple in winter due to thermal inversion. The case of **31 Jan 2024** is confirmed by the Cuneo Levaldigi radiosounding (WMO 16113). ERA5 & METAR confirm the anticyclonic subsidence. MADIS quality controls validate the data. Low-cost IoT stations serve as **quasi-climatic laboratories** for boundary-layer monitoring in Alpine valleys.

189 m
Elevation differential (stations ~5 km apart)

16.0 %
Days with inversion (117 of 730)

+8.3 °C
Increase over the 189 m differential, 31 Jan 2024

97 %
MADIS quality-control pass rate

1 STUDY AREA



Fig. 1 — Study area: North-West of Italy — Piedmont Region and the Alps.



Fig. 2 — These zones correspond to the flat fruit-growing areas of the municipality of Tarantasca, the urban centre of Busca, and the hilly and foothill areas of Roccabruna.

A semi-enclosed plain fringed by the **Cottian Alps (W)**, **Maritime Alps (S)** and **Langhe hills (E)**, with a narrow opening to the Po valley. Humid temperate climate (Köppen Cfa/Cfb), with foggy winters and hot summers, providing an ideal setting for surface inversions.

2 STATIONS & SENSORS

Busca: 501 m, urban area · **Roccabruna**: 690 m, hilly area · **Elevation difference: 189 m**



Fig. 3 — QUIDO weather station and the MET mast.



Fig. 4 — Vaisala radiosounding automated launching system.



Fig. 5 — AWOS ultrasonic, ENAV airport weather station.

Device	Measurements	Freq.	Telemetry
QUIDO	wind, temperature, RH, leaf wetness	15 min	Sigfox
Radiosounding	wind, temperature, dew point (vertical profile)	00/12 UTC	—
AWOS	wind, visibility, clouds, temperature, dew point, QNH	30 min	internet

Solar-powered, low-consumption, no mains, no data logger.

3 STATISTICAL ANALYSIS OF TEMPERATURES

Quality-checked records from Busca and Roccabruna were aggregated to daily means over 1 Jan 2024–31 Dec 2025 (730 days), then to monthly means for boxplots and standard deviation. Monthly distributions (Figs. 6 and 7) are box-and-whisker plots (Tukey, 1977); the box spans the interquartile range (Q1–Q3) with the median, whiskers extend to 1.5×IQR and points beyond are outliers. The median position indicates skewness: near Q1 → positive, near Q3 → negative.

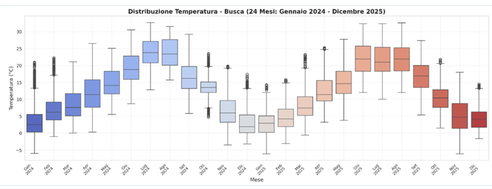


Fig. 6 — Monthly temperature distribution at Busca (501 m), Jan 2024–Dec 2025.

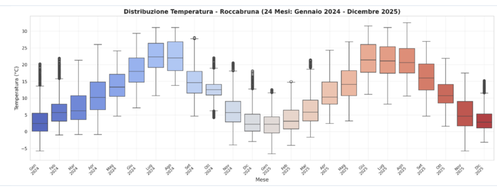


Fig. 7 — Monthly temperature distribution at Roccabruna (690 m), same period.

KEY RESULTS

- **Highest variability in spring:** April STD up to 5.8 °C (Roccabruna) and 5.7 °C (Busca).
- **Highest stability in October 2024:** minimum STD ≈ 2.9 °C at both stations.
- **Strong coupling** in spring (R = 0.95) and winter (R = 0.90); autumn R = 0.79.
- **Summer nocturnal decoupling:** R drops to 0.56 from differential cooling of the valley floor.

4 INVERSION CLIMATOLOGY

At a standard lapse rate (−0.65 °C/100 m), the expected ΔT for a 189 m elevation difference is around ~ −1.3 °C.

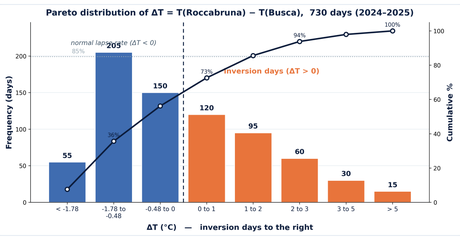


Fig. 8 — ΔT distribution (Pareto): ≈85% of days in the normal lapse-rate classes; the positive tail (orange) collects inversion days, predominantly weak-to-moderate.

5 CASE STUDY — 31 JAN 2024

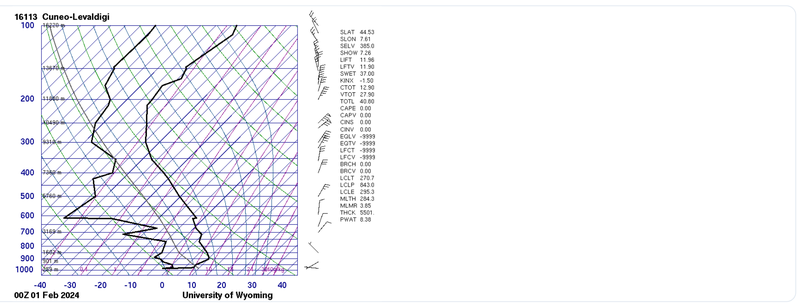


Fig. 9 — Skew-T ln-P radiosounding, Cuneo Levaldigi, 00Z 1 Feb 2024.

- **Surface (385 m): T = −0.9 °C**
- **468 m (975 hPa): T = +8.0 °C**
- **+8.9 °C over 83 m → Γ = +10.7 °C/100 m**

Anticyclone > 1030 hPa, subsidence and a surface cold-air pool. Stations confirm ≈ 8.3 °C across the 189 m differential.

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METAR LIMZ 312320Z AUTO 22003KT 190V250 8000 NCD M00/M01 Q1030
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SYMBOL LEGEND

T_d dew-point temp. (here −1 °C → RH ≈ 93%)
QNH pressure reduced to mean sea level (1030 hPa)
NCD "no cloud detected" (automatic sensor)
AUTO automated observation · **22003KT** = wind 220°/3 kt

6 ERA5 SYNOPTIC VALIDATION

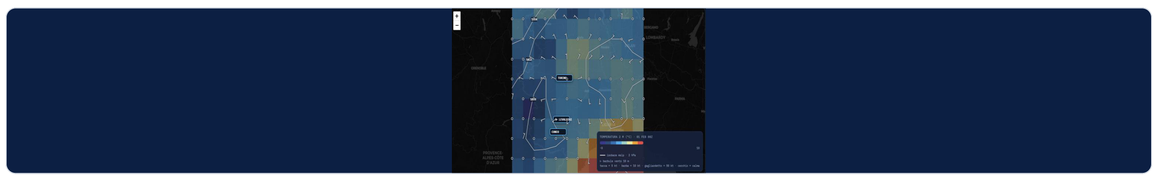


Fig. 10 — Temperature field over the Cuneo area from ERA5. Synoptic thermal & wind situation at 22 UTC, 31 January 2024: cold-air pool on the valley floor (Busca–Levaldigi); isobars ≈ 1030 hPa.

- **Radiosounding: WMO 16113 Cuneo-Levaldigi (Skew-T log-P chart highlighting the low-level inversion layer).**
- **METAR data: semi-hourly airport observation code (LIMZ) confirming atmospheric stability and anticyclonic subsidence.**
- **MADIS quality-control validation.**

7 CONCLUSIONS & PROSPECTS

RESULTS OBTAINED

- **Thermal inversion on 117 of 730 days (16.0%), predominantly weak-to-moderate.**
- **Marked seasonal coupling: strong in spring (R = 0.95) and winter (R = 0.90); weak in summer (R = 0.56).**
- **Extreme event of 31 Jan 2024: +8.3 °C over the 189 m differential, confirmed by radiosounding (+8.9 °C / 83 m), ERA5 and METAR.**
- **MADIS-validated data (three tiers): >97% Verified (V), suitable for climatology and assimilation.**
- **Validation of a thermal network of low-cost IoT sensors for research purposes.**
- **Marked thermal-inversion climatology during winter anticyclonic regimes, fully confirmed by radiosounding, ERA5 reanalysis and METAR data.**

POTENTIAL OF THE IOT NETWORK

- **Resolves the boundary layer (inversions, cold-air pools) that operational networks spaced 10–30 km miss.**
- **Solar, low-cost, no data logger: a sustainable, replicable observatory for complex Alpine terrain.**
- **Data ready for NWP assimilation and AI-based nowcasting once validated.**
- **Operational value: early warning for fog and inversions — air quality, aviation, HEMS, agriculture, climate resilience.**

PARTNERS

DATAMETEO EDUCATIONAL · ENAV · ARPA Piemonte · Copernicus ERA5 · NOAA MADIS

REFERENCES

Hersbach et al. (2020) *The ERA5 global reanalysis*, QJRMS 146. · Whiteman (2000) *Mountain Meteorology*, OUP. · Wallace & Hobbs (2006) *Atmospheric Science*. · Pernigotti et al. (2012) *Atmos. Environ.* 51. · Vosper & Brown (2008) *Boundary-Layer Meteorol.* 127. · Miller & Benjamin (2008) *MADIS*, AMS. · Tukey (1977) *Exploratory Data Analysis*.