LES ORRES 10-11 May 2021

Smart Mountain for tomorrow

ENERGETIC AND CLIMATE IMPACTS OF ALPINE SKI TRACKS

Data and proposals from the PITER Alpimed INNOV project

Interreg Alpine Space

smartALTITUDE

EUSALP EU STRATEGY FOR THE ALPINE REGION

FRANCE 20/21 Presidency

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RÉGION BOURGOGNE FRANCHE COMTE

Hautes-Alpes le département

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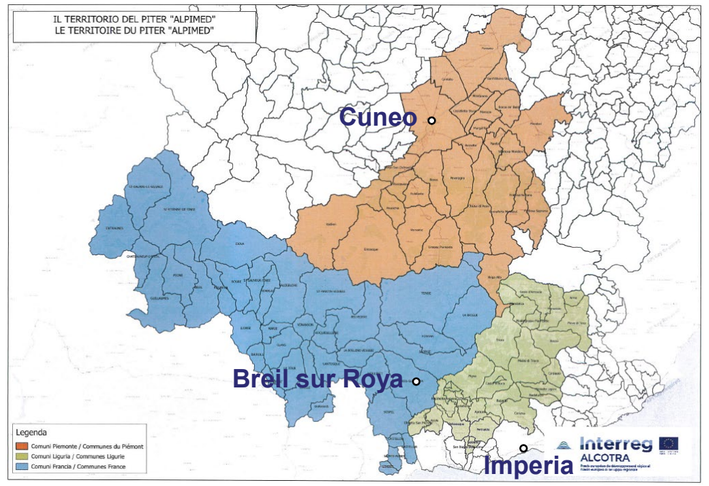
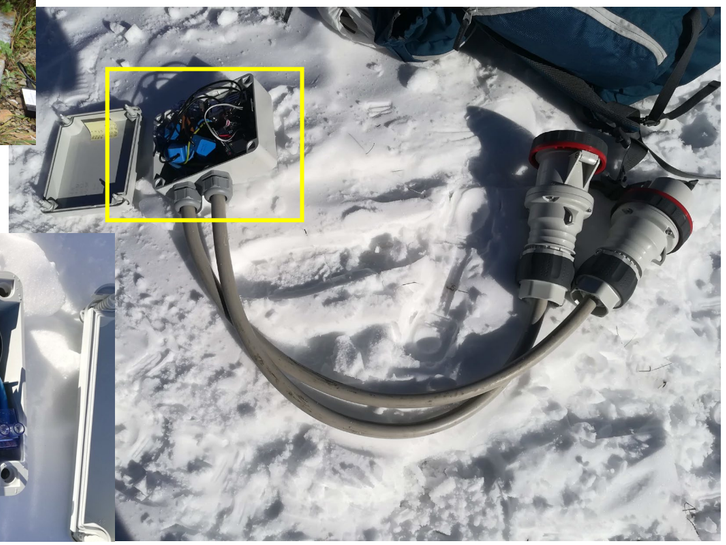
THE PITER ALPIMED PROJECT

- Basic info:
  - Involving CN, IM (Italy) and Dept.06 (France)
  - Funded by the EU INTERREG Alcotra
- Objectives:
  - Strengthening innovation in the Mediterranean Alps
  - Applying innovations in living labs:
    - Energy saving in ski resorts
    - Water saving in agriculture
- Figures:
  - 9 partners + 10 collaborating institutions
  - 3+1 years (10/2018-10/2022)
  - Budget 1.764 M€



INITIATIVES OF PITER ALPIMED (1/2)

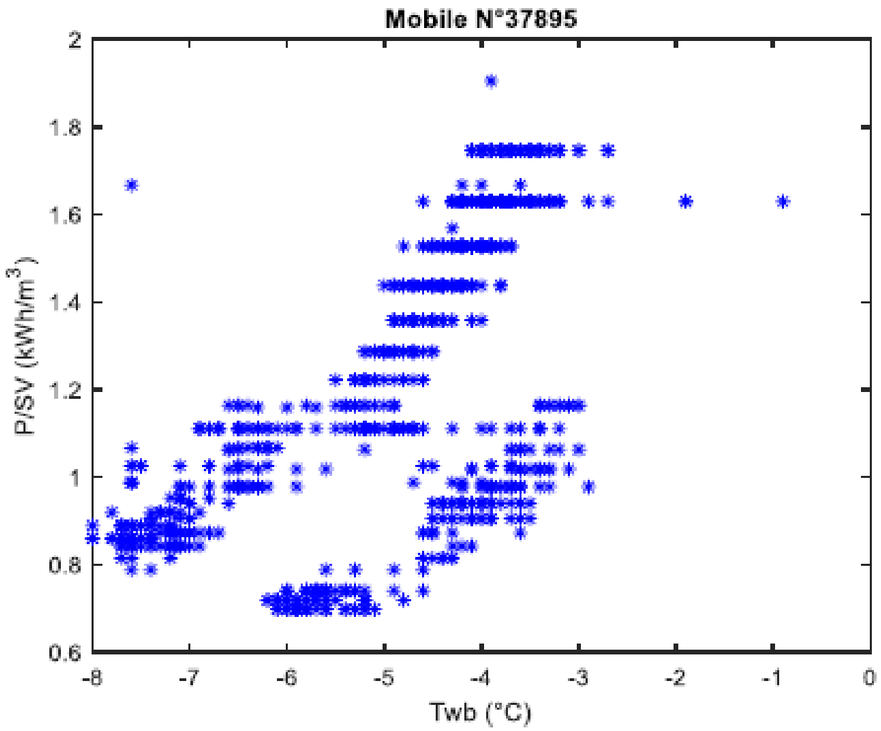
- Drone-based measure of snow cover thickness



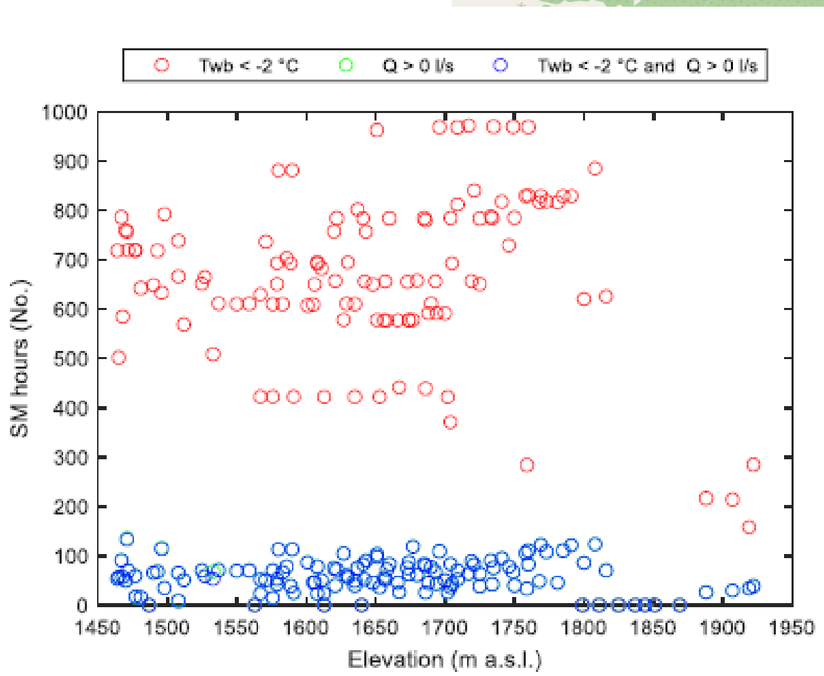
- Monitoring of energy and water consumption of snow guns:
  - Processing of recorded data
  - Development/testing of dataloggers

INITIATIVES OF PITER ALPIMED (2/2)

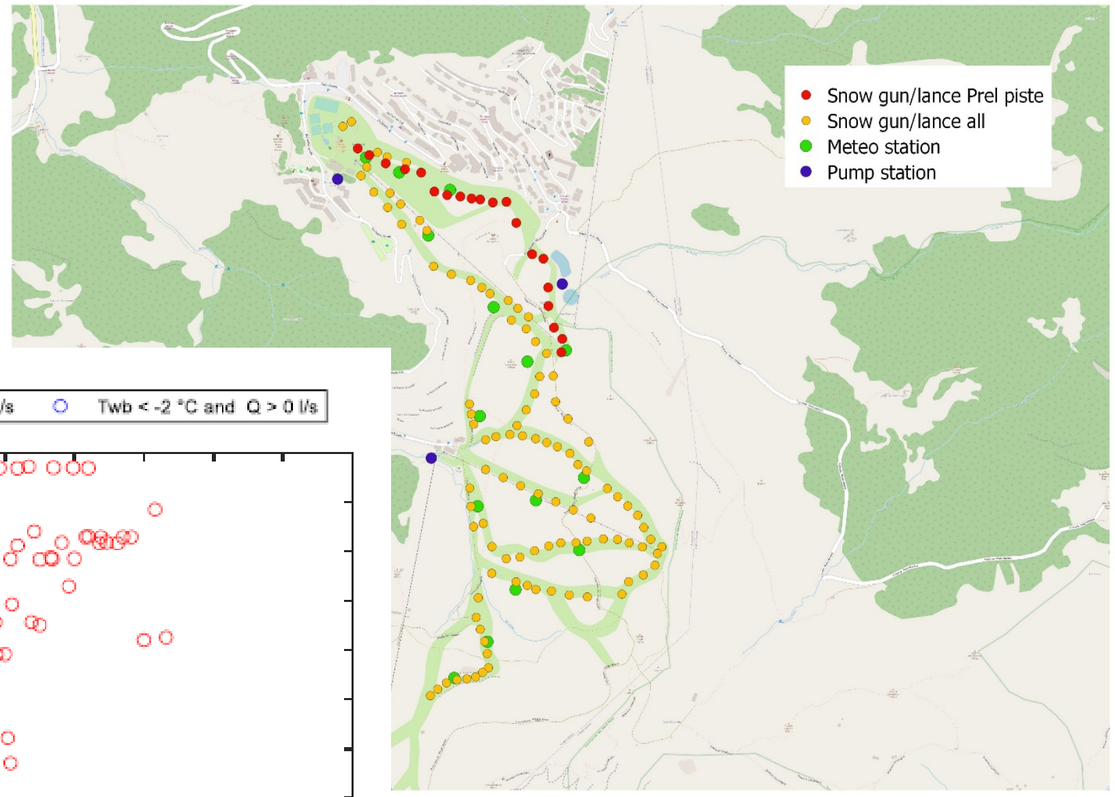
- Monitoring data of snow making system in Prato Nevoso (CN), winter 2019-20



Correlation between wet bulb temperatures and the electrical demand per cubic meter of snow



How much are potential snow making hours (T_{WB}<-2°C) exploited?



SKI TRACKS: ENERGY DEMAND ITEMS

Ropeways:

- Elevation gain
- Chair / cabin size
- Speed
- Efficiency

Snow making:

- Snow quality requirements
- Temperature and RH (→ WB temperature)
- Efficiency

Snow grooming:

- Track quality requirements
- Slope
- Snow cover thickness
- Driver skills

SKI TRACKS: ENERGY DEMAND (1/2)

- Power required

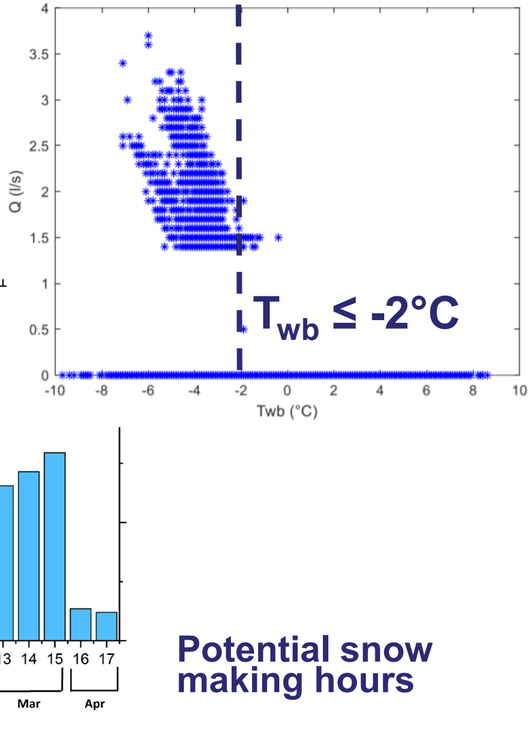
$P \sim P0 + aL + b\Delta h$,
e.g. 4-seater, b~0.81 kW/m (N=23)

Skilift b~0.16 kW/m (N=32)

- Power: 20 – 25 kW/gun
- Flow rate $\propto T_{WB}$
- 1 m^3 water~2.5 m^3 snow
- 1 l/s ~ 9 m^3/h snow

3-5 h/km

20-25 l/h



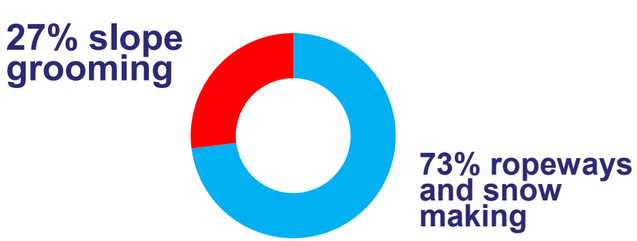
Potential snow making hours

SKI TRACKS: ENERGY DEMAND (2/2)

- Carbon footprint of a skiing day?

$$\frac{(RW + SM) \cdot EF_{el} + SG \cdot EF_{fuel}}{N_{skiers}}$$

- Ropeways (+ snow making): 0.37 – 1.3 MWh/y per meter of elevation gain
- Fuel consumption: 1892 – 5405 l/km
- Carbon footprint of a skiing day: 3.61 – 11.62 $kgCO_2eq$



	Resort 1	Resort 2	Resort 3	Resort 4	Resort 5
Overall track length (km)	80	150	50	50	152
N° of ropeways	14	58	13	12	38
N° of skiers	199 890	1 203 741	128 537	481 000	455 000
Skiers / km track	2 499	8 025	2 571	9 620	2 993
Overall ropeway elevation gain (m)	4 491	19 017	2 825	4 534	11 075
Fuel consumption (l/y)	241 188	333 554	94 641	270 270	326 568
Electricity consumption (MWh/y)	3 426	7 024	1 542	5 878	5 045
Fuel consumption / km track	3 014	2 223	1 892	5 405	2 148
Electricity demand / meter of elevation gain	0,76	0,37	0,55	1,30	0,46
$KgCO_2$/skier	11,62	3,61	7,85	7,50	7,35

SKI TRACKS: REDUCING THE CARBON FOOTPRINT

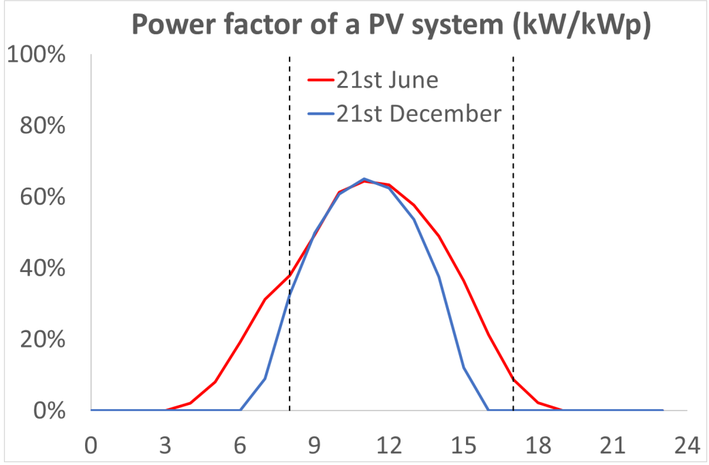
Reducing energy demand with speed regulation based on attendance

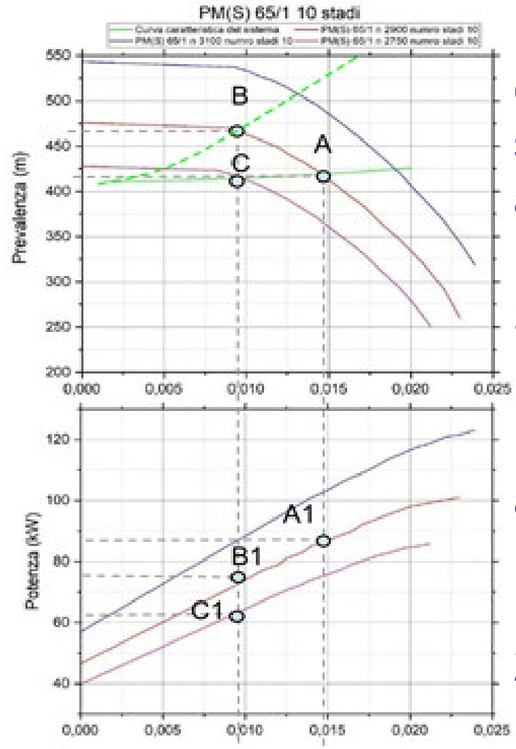
source: EURAC
https://bit.ly/3etNZk5

Reducing the CF with photovoltaic systems

Opening: 1 Dec-31 Mar h.8-17, 15 Jun – 15 Sep (Fri-Sab-Sun) h. 8-17

→Self-consumption ~ 40%





Reducing energy demand with variable speed pump arrays and optimizing the reservoir locations.

Snow making ~ pumping

E.g. cannon at 6 l/s absorbing 25 kW vs pump at 6 l/s, Δh=300 m, η=65% absorbing 27 kW

Reducing energy demand with hybrid snow grooming machines with downhill energy recovery → 25-30% reduction of fuel consumption

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THANK YOU FOR YOUR ATTENTION

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