Mechanisms involved in the heating of the environment by the aerodynamic action of a wind machine to protect a vineyard against spring frost

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MECHANISMS INVOLVED IN THE HEATING OF THE ENVIRONMENT BY THE AERODYNAMIC ACTION OF A WIND MACHINE TO PROTECT A VINEYARD AGAINST SPRING FROST

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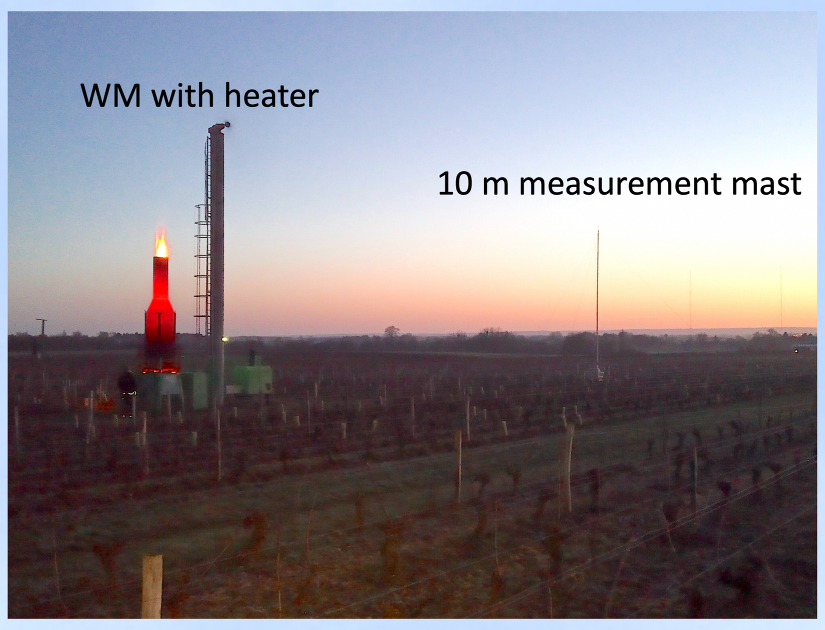
CONTEXT

Spring frosts are devastating for the buds and by a continuous air mixing, the wind machine (WM) allows to avoid this both biological and economical disaster (Le Cap et al, 2021). Today, the wind machine is often associated with a fixed heating system at its base, the efficiency of which is today not well known, leaving the winegrowers uncertain in their decision making.

High frequency measurements were made on a plot during a typical radiative frost night to assess the performance of the wind machine, with and without the help of a supplementary heater. The experiment consisted in measuring the temperature in the vicinity of the WM during the night. The aim was to measure the establishment of the thermal inversion and the WM effect on it by using the machine for 2 hours just before the sunrise and supplemented by alternating periods of 30 min with and without heating.



MATERIAL AND METHODS

Three types of device with high frequency probes :

16 local measurements stations (4 Hz) :

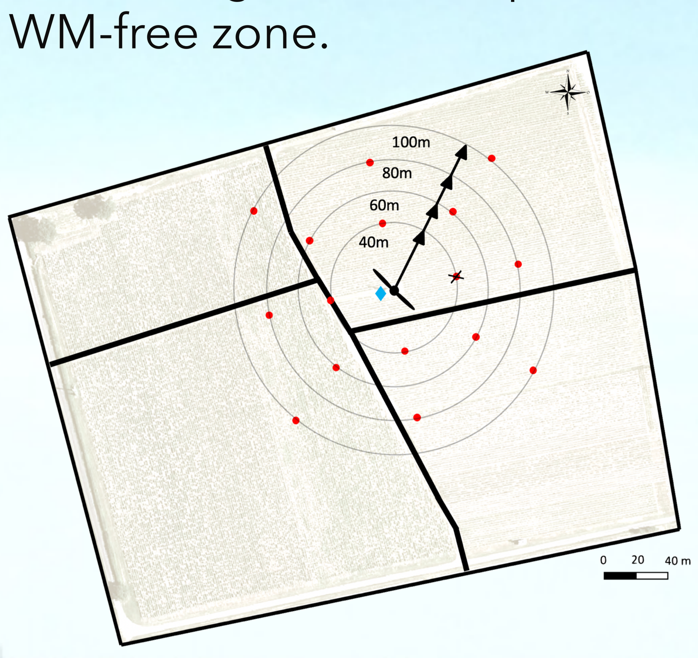
- placed around the WM at different radii, staggered from one radius to the other.
- Vine-height and ground thermocouple
- 1 LCJ® ultrasonic anemometer.

A 10m mast (4 Hz) :

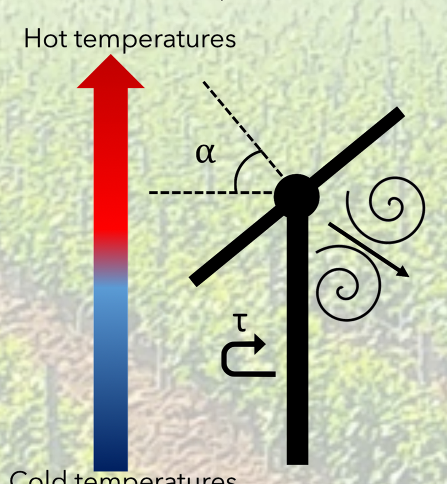
- placed at 40 m from the WM
- 11 thermocouples distributed from the ground to 10.50 m high.

A Campbell® METSENS500 weather station (1 Hz) :

- placed on the nearby plot
- monitoring of the temperature in a WM-free zone.



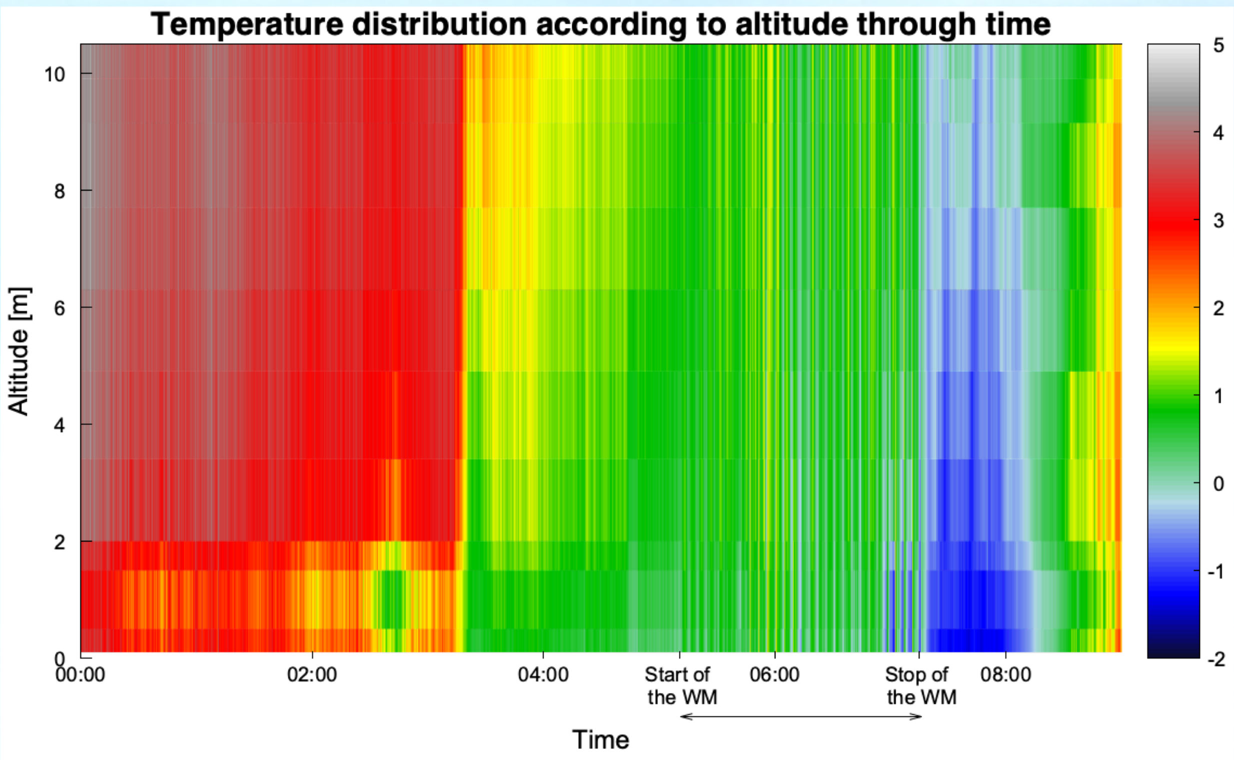
Schematic of the location of the 16 stations (red dots), the 10-m mast (cross), the WM (propeller scheme) and the heater (blue diamond).

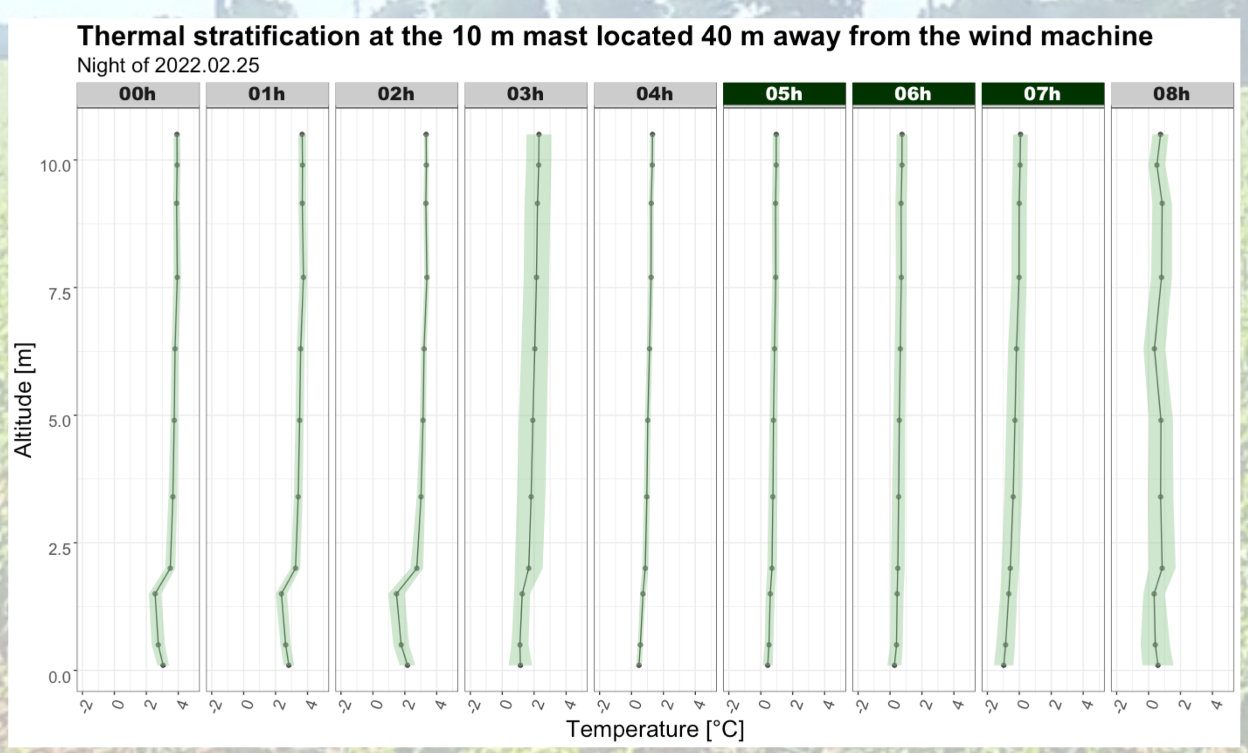


Schematic of the operation of the WM. τ is the rotation time and α is the rotor tilt angle. Adapted from Heusinkveld et al. (2020)

THERMAL INVERSION

- The thermal inversion increases progressively until 2:00 am then fades during the night.
- A 3:00 am a large standard deviation for all temperature sensors appears as the temperature decreases between 2:00 am and 4:00 am
- Thermal inversion reaches its minimum at 6:00 am, when the wind machine has been operated continuously.
- The significant temperature deviation is due to the natural restratification of the atmosphere after each rotation of the tower.
- At 7:00 am, the temperature cools down and the inversion is enhanced due to the shutdown of the tower at 7:15 am.
- Finally, at 8:00 am the inversion becomes chaotic with a strong dispersion of temperatures.





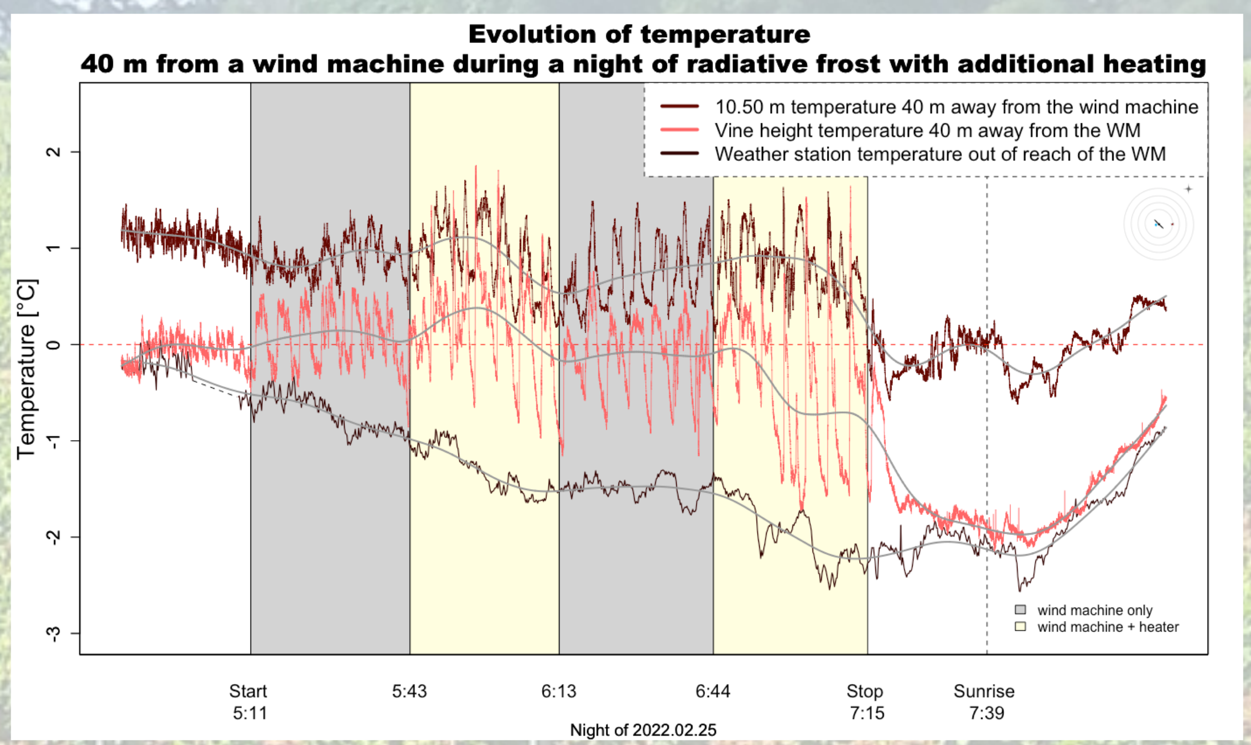
TEMPERATURE DESCRIPTION

The analysis focuses on the red curve representing the temperature at 1.5 m height, 40 m away from the wind machine. During the whole experiment, it is surrounded by two darker curves, the upper one representing the temperature at 10.50 m height and the lower one the temperature on the nearby plot, out of the wind machine's reach.

On the nearby plot, the temperature decreases progressively throughout the night and warms up shortly after sunrise.
The temperature at 10.50 m height feels the effect of the machine gust since a peak is recorded for each rotation.

Before and at the beginning of the experiment, the temperature at 1.5 m height is close to the one out of the WM reach.
During the WM operation, it remains higher than the unprotected thermocouple. After the switch-off of the WM the two temperatures get closer again and increase with the sunrise.
During the using of the heater 1.5 m temperature peaks reach those at 10.50 m. However, the average temperature remains lower than the one at the top of the 10 m mast

The burner, placed at the suction of the tower, seems to increase the peaks of temperature but also their magnitude of decrease.



CONCLUSION

Only a few of the results are presented in this poster :
- With a smaller thermal inversion than recommended in literature;
- The wind machine, with or without heating, maintained a local atmosphere favorable to the protection of the bud.

Next steps:
- Quantify the protective surface with and without heating thanks to simultaneous high-frequency acquisitions at different radii;
- Estimate the amount of heat transferred to the bud with a smaller time step than the rotation period of the wind machine.

REFERENCES

Heusinkveld, V.W.J., van Hooft, J., Schilperoort, B., Baas, P., Veldhuis, M. ten, van de Wiel, B.J.H., 2020. Towards a physics-based understanding of fruit frost protection using wind machines. Agric. For. Meteorol. 282-283, 107868.

Le Cap C., Carlier J., Quénol H., Heitz D., Buisson E., 2021. Joint study of spatial variability of temperatures and wind machine performance in the Quincy vineyard to improve fight against spring frost events. 2021 AIC Conference