Towards wind machines park management automatization to improve fight against spring frost events

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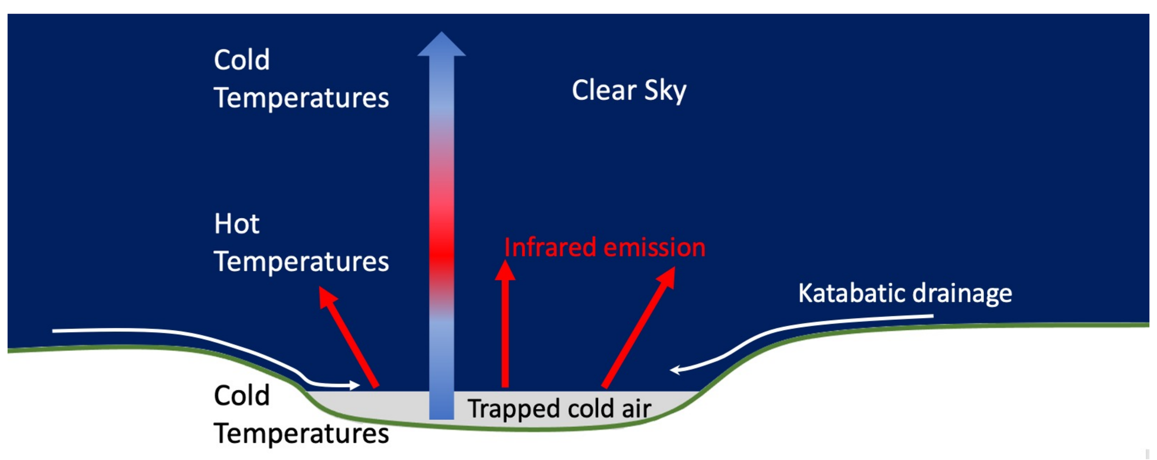
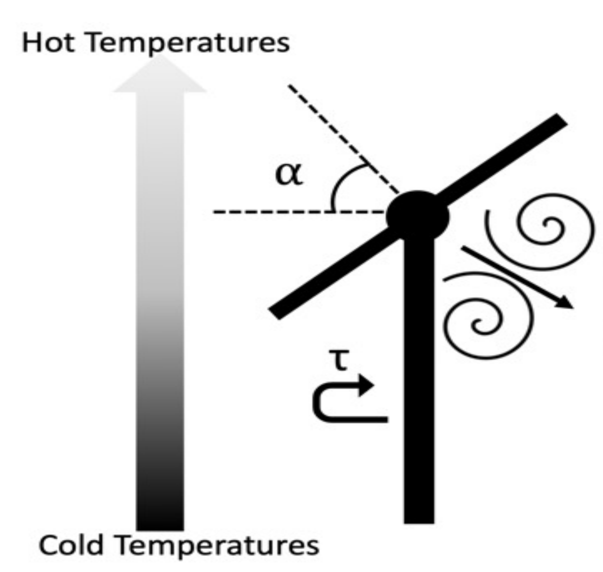
In the Quincy vineyard, nearly 60 wind machines are disseminated offering protection against spring frost for 85% of the crop. However, a finer understanding of the physical phenomena and a better data mining process of field measurements are needed to improve their efficiency. Hence wine-growers gathered different kinds of partners such as industrials, and scientific researchers in the SICTAG project ("Innovant System of Connected decision support and efficient real-time management of wind machine of the Centre Val de Loire") to investigate how the wind machine warms the crops and the most efficient way to use it.



Schematic of the thermal inversion establishment

WIRELESS SENSORS NETWORK

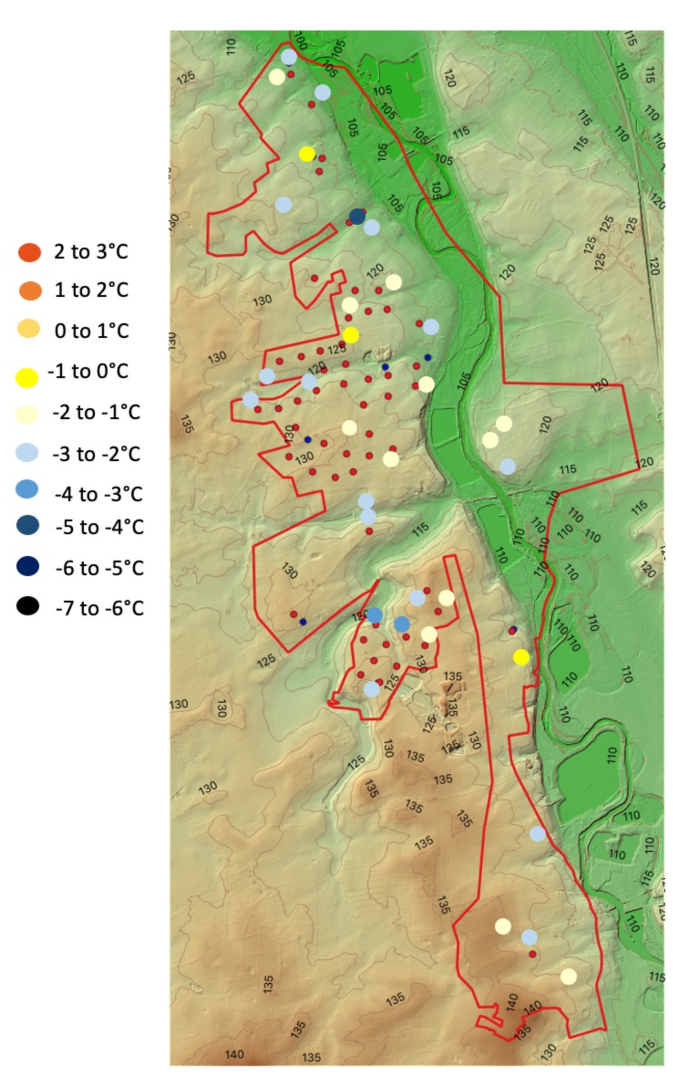
Each plot of the vineyard includes a wireless temperature sensor which in turn forms a measurement network. This network aims to control the operation of the wind machines to maintain the local climate out of frost occurrence risk. It is achieved at a lower cost and noise disturbance by continuously considering meteorological parameters (temperature, wind, humidity…). As a perspective, data-matching coming from a wireless sensors network and numerical simulations could be set up. Therefore, it could evaluate and manage micro-meteorological flows at an agricultural plot or building scale to control the atmosphere in a confined environment.



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

SPRING FROST

Frost events can be distinguished as advective and radiative frost. Radiative frost is characterized by clear skies and very low winds (wind < 2m/s), resulting in energy loss near the ground after sunset. Soil heatwaves gradually fade away to the sky, thus producing a thermal stratification in the low part of the atmosphere (from a few meters to several hundreds of meters above the ground). As cold air is denser than ambient air, it flows slowly downward along the slope and accumulates in the bottom areas, creating lakes of cold air and amplifying the inversion or reducing it in the highlands. It explains the high spatial variability of the minimum temperature due to the topography (Le Cap et al., 2021).



Cartography of the TSV during a frost night in the vineyard of Quincy. Big dots represent temperature measurements, blue dots are remote temperature sensors without measurements data, while red dots represent WM implementation.

WIND MACHINE OPERATION

A wind machine (WM) is commonly composed of a 10m-mast and a 2-blade-hub blowing fan at its peak. The wind machine turns on itself for 4-5min. The use of the wind machine is conditioned by the state of the atmosphere during a radiative frost (Le Cap et al., 2021) by being efficient with a minimum thermal inversion of about 1.5°C and 2°C between 1.5m and 15m high and for a weak wind. The blowing fan sweeps the crop by blending quickly warm air above with the cold air (of few degrees below 0) near the ground. Hence the thermal stratification is suppressed. The air temperature is slightly positive and homogeneous, and the frost injury is momentarily avoided.

TEMPERATURE SPATIAL VARIABILITY CARTOGRAPHY

There are 38 temperature sensors through the vineyard that measure hourly temperature day after day. It is then possible to study temperature spatial variability (TSV) regarding the type of frost and investigate which plots require more attention in the frost fight. By creating temperature cartography, it becomes easy to identify such parcels or, on the contrary, those that can be put on the back burner.

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.

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