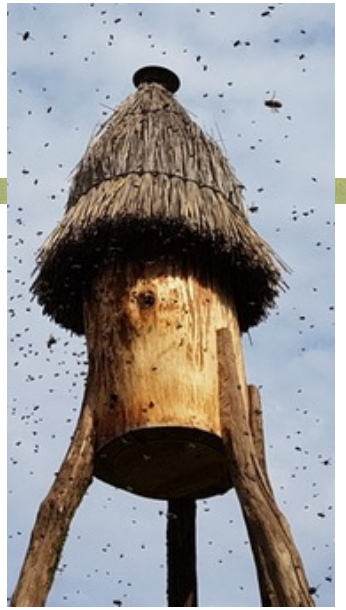
Public event – Wageningen

Beekeeping with thermal sensors: from beekeeping practices to science

Better-B
FOR RESILIENT BEEKEEPING

Table of content



Context and objectives

CO-Actions (COA) hosts a French research team specialised in thermal sciences, wood sciences and social sciences. 3 researchers: Emmanuel Ruffio, Anna Dupleix-Marchal and Anne Lavalette work on hives thermal properties.

COA is partner of Better-B project to study **thermal interactions between hives and their environment**.

OBJECTIVES

– Identify the physical parameters that improve the passive thermal robustness of hives
– Provide knowledge to help beekeepers adapt their hives to local environmental factors
– Develop digital tools for remote monitoring of hives based on temperature readings (later in the project)

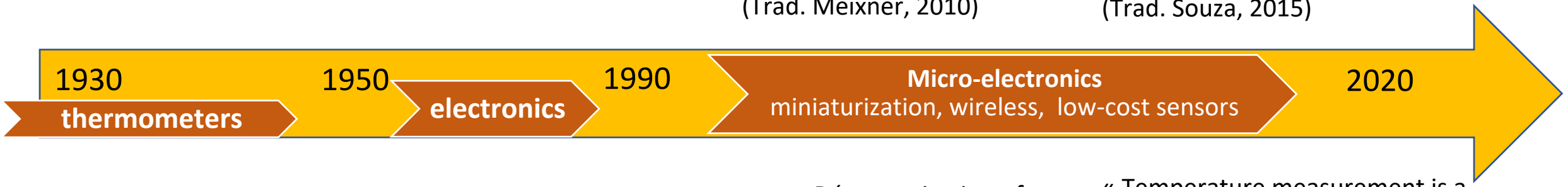
Context and objectives

History of temperature researches

Researchers first interested in the role of temperature in modifying bees behavior, weather in inducing stress factors and climatic conditions responsible for mortality. (Dunham, 1931)

«Severe winter weather has been identified as the fourth most important factor in winter mortality in the United States.» (Trad. Meixner, 2010)

«Climatic variations have a direct effect on the maintenance and control of the colony's internal temperature, influencing the development of offspring. » (Trad. Souza, 2015)



Démocratisation of hives modifications, hives monitoring

« Temperature measurement is a method for remote monitoring of the wintering process » (Trad. Stalidzans, 2017).

Temperature measurements are very accessible today. This is the second parameter integrated into connected beehives.

Context and objectives :

Motivations for our researches on hive temperatures

Problematics

- **Thermoregulation of the nest** (ventilation, evaporation, heating) **is costly in terms of energy** (nectar), water supply and time (mobilization of workers and demobilization for other tasks).
- **Biological risks**
- **Emergency situations = stress factors** that impact the bee's biological rythm.
- **In-hive temperature affects honey quality** (HMF level)

Statements

- Microclimate inside the hive : T°C (Brood temperature) ≈ 34-36°C, 70% RH
- Colony dynamics depending on seasons
- Beekeepers are concerned about the colony’s energy consumption (thermoregulation)

Context and objectives

Parameters influencing hives temperature

Our studies until now

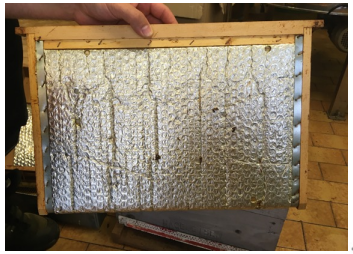
Hive close environment

Physical parameters of the hive

Beekeper activity

Work to come

Physical content of the hive



Bees behaviour

Work methods overview

Combining social and thermal sciences

Social sciences

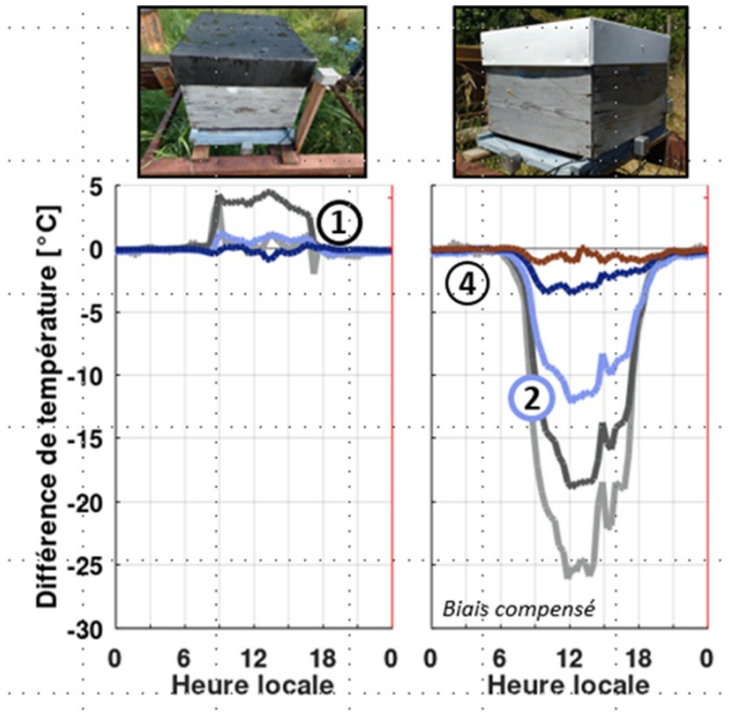
Tools: **Interviews of professionals (beekeepers, sellers, manufacturers)**

Data -> Feedback on beekeepers innovations

Thermal sciences

Tools: **Measures, models, simulations**

Data -> Quantitative results on temperature measurements



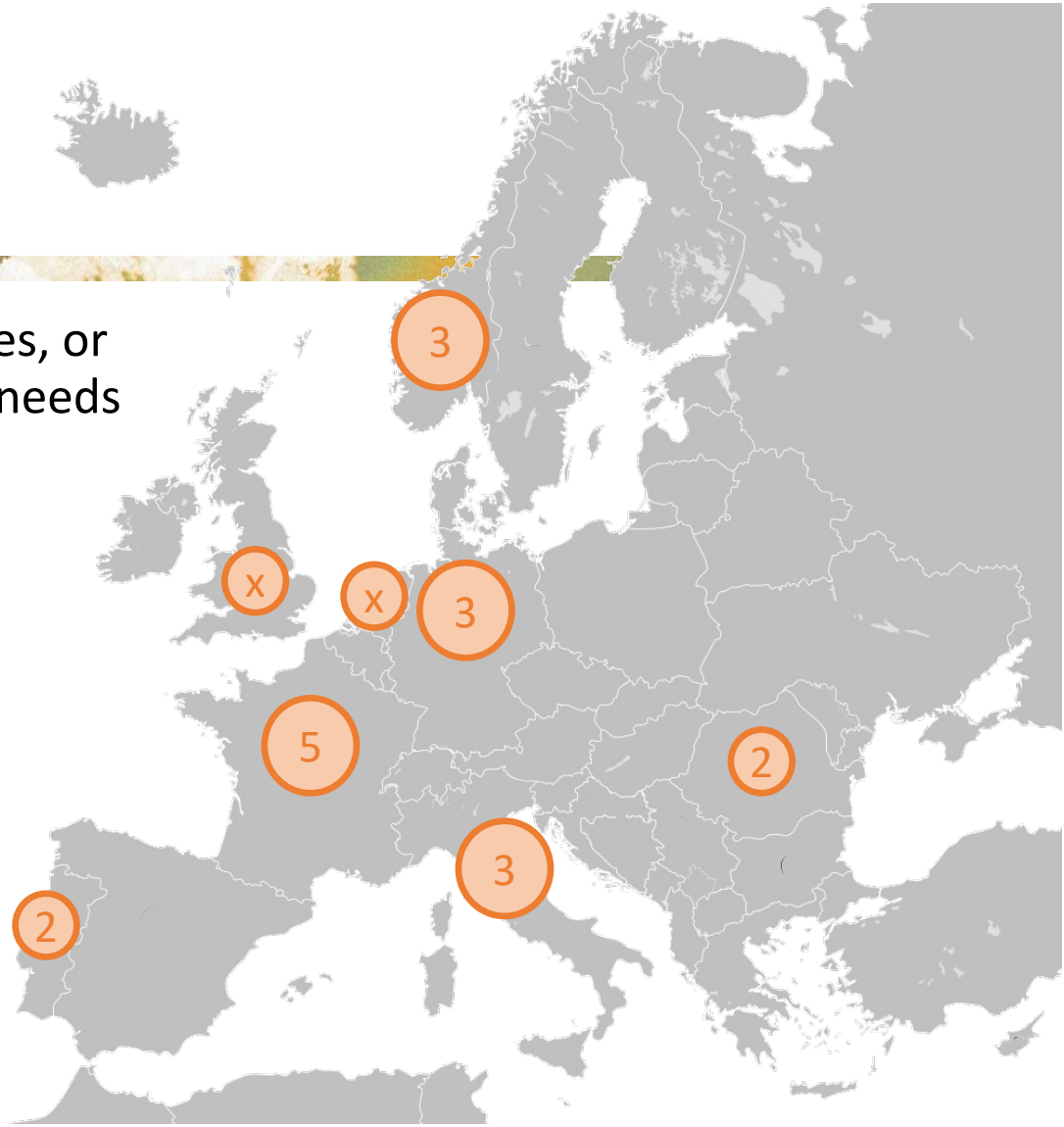
Cross-disciplinary approach designed to ensure that the knowledge acquired is meaningful for beekeeping

Work methods - Interviews

- **Identify innovative beekeepers** in Europe who modify their hives, or their environment, to adapt the temperature in the hive to the needs of the bees.
- **Interviews (2 to 3h) – conversation** using an interview guide.
  In-person interviews/Video meeting
- **Transcriptions** and speech analysis

OBJECTIVES

— Gather experiences and feedback of beekeepers' initiatives to insulate their hives.
– Identify beekeepers' position on climate issues
— Better understand beekeepers needs
– Test beekeepers' hive configurations on empty hives on COA experimental apiary.



15 interviews realised (20 in 2025)
in 6 countries (8 countries in 2025)

Work methods

Interview guide sections

Section 1) **Beekeeper sociography/background/ education/ network**

Section 2) **Beekeeper goals and ideals in terms of beehive**

- What's the ideal beehive. From beekeeper' point of view. From bee point of view.
- Opinion on actual beehive market, what's currently available (incl. regarding extreme temperatures)

Section 3) **Thermal regulation practices**

- Modifications techniques (hives, environment)
- Motivations for modifications practices, origins and evolution (trials)
- Experimental knowledge (acquired from own trials and practices)
- Sources of ideas; sharing knowledge
- Efficiency evaluation
- Bad results, errors and precautions

Section 4) **Wood protection practices**

Section 5) **Interest in participatory research**

- Questions to researchers
- Suggestions of material for scientific testing in COA experimental apiaries (empty hives)

Work method:

Thermal interactions between hives and environment

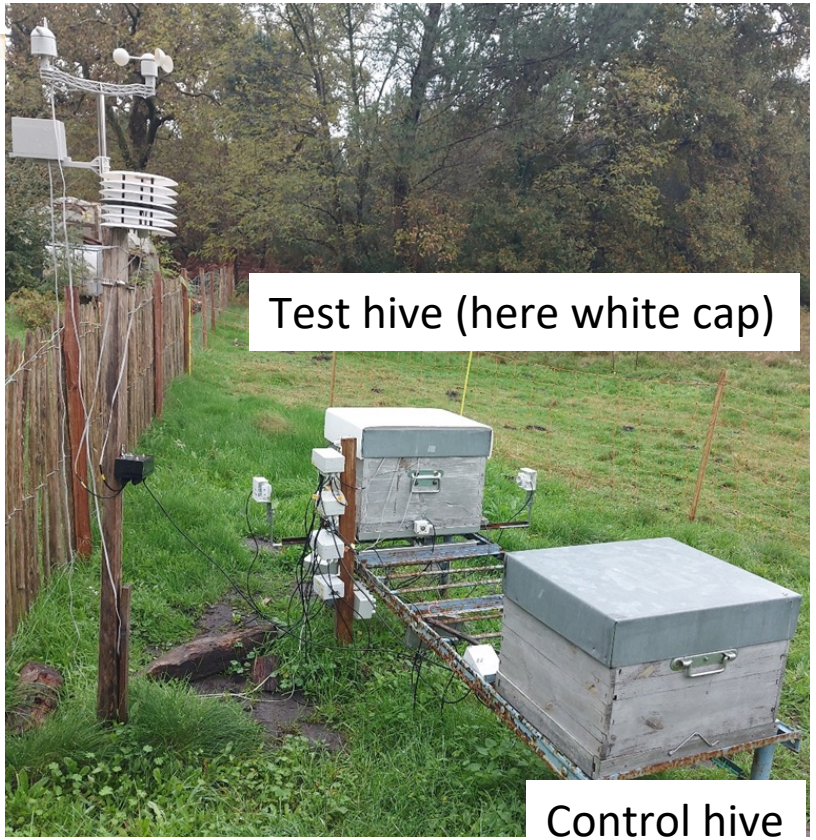
2 experimental apiaries

Hives equipped with sensors (temperature, humidity, luminosity, infrared cameras, weather station, etc.)

South-East of France

Objectives: Comparing different types of hives

- 1 Dadant plastic
- 2 Dadant wood
- 1 Kenyan Top Bar Hive
- 1 Trunk hive
- 1 « Ecological » hive



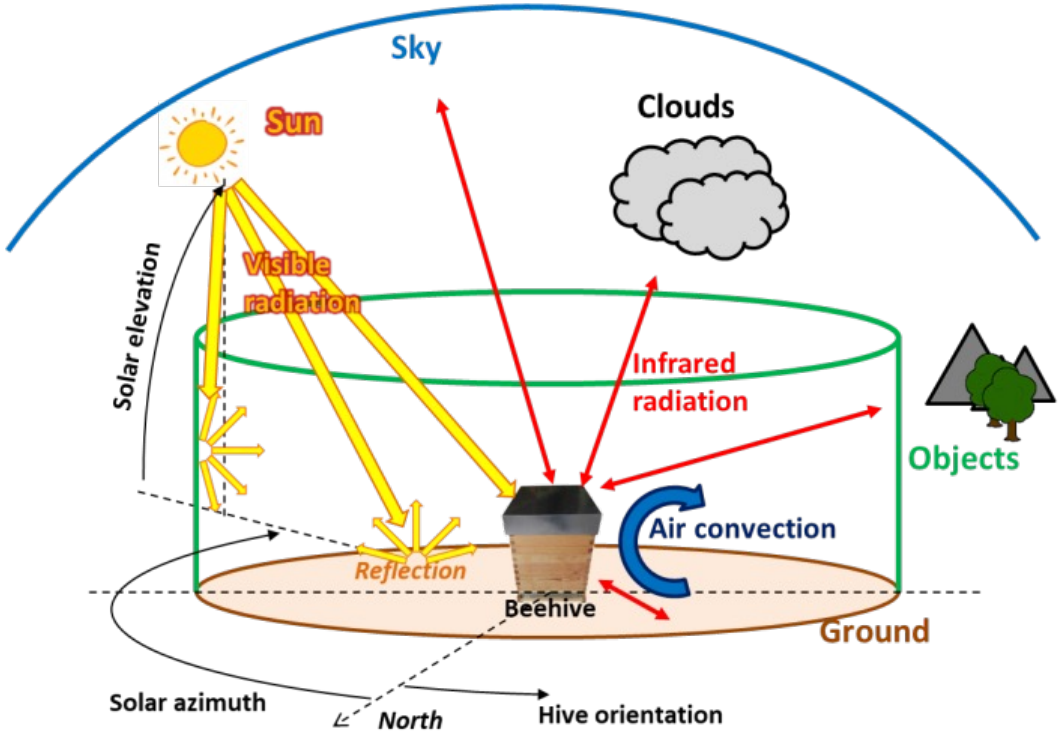
South-West of France

Objectives: Analysis of beekeeping equipment and/or structural modifications on wooden Dadant hives

Work method:

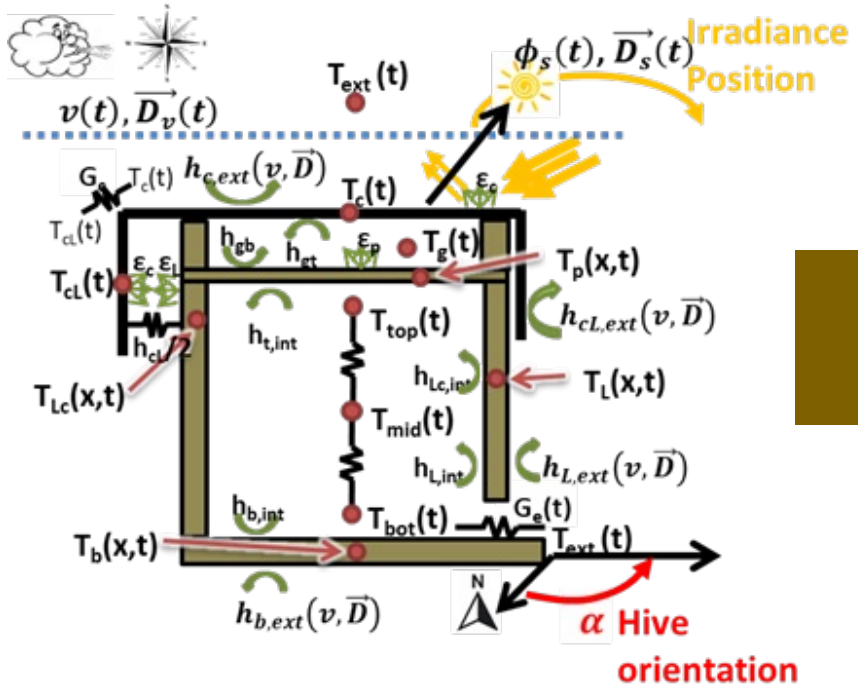
Thermal interactions between hives and environment

Close environment modelling



OBJECTIVES

- Identify the physical parameters that influence temperature in the hive.
- Giving beekeepers tips on how to modify hive thermal properties, « minimal change » for « maximum effect »

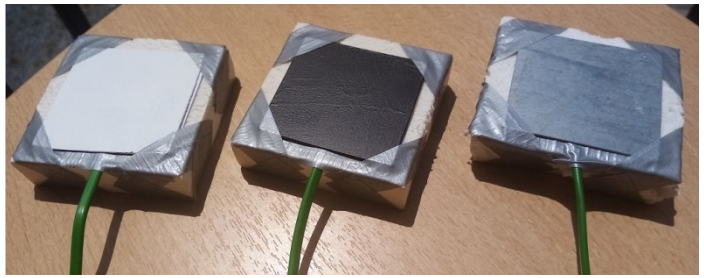


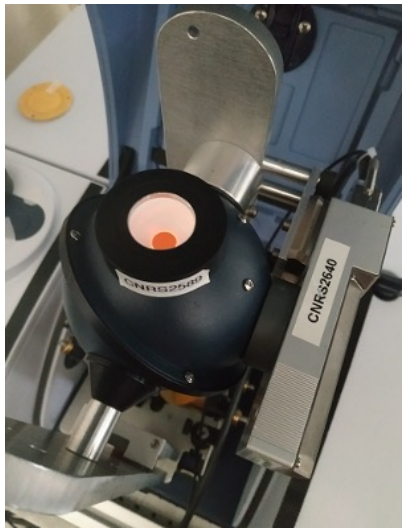
In-hive modelling

Work methods

Lab experiments: radiative properties of coatings

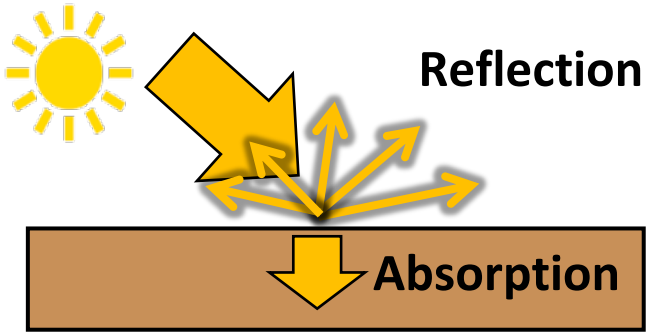
Spectral absorption/reflection measurements of coatings





Integrating sphere

The “lighter” the coating is, the more it reflects solar radiation



BEEKEEPERS PORTRAITS VS THERMAL MEASUREMENTS

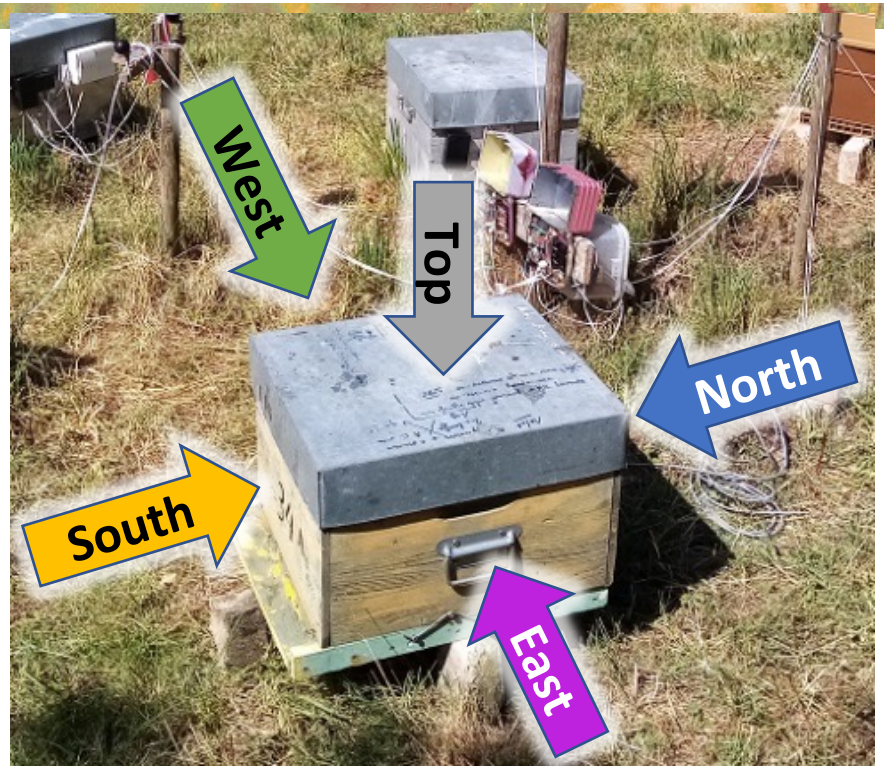
First Portrait : white cap

1) David B., ca. 50 y old, since 2009,
   150 beehives, former Building& Civil Engineering material seller.

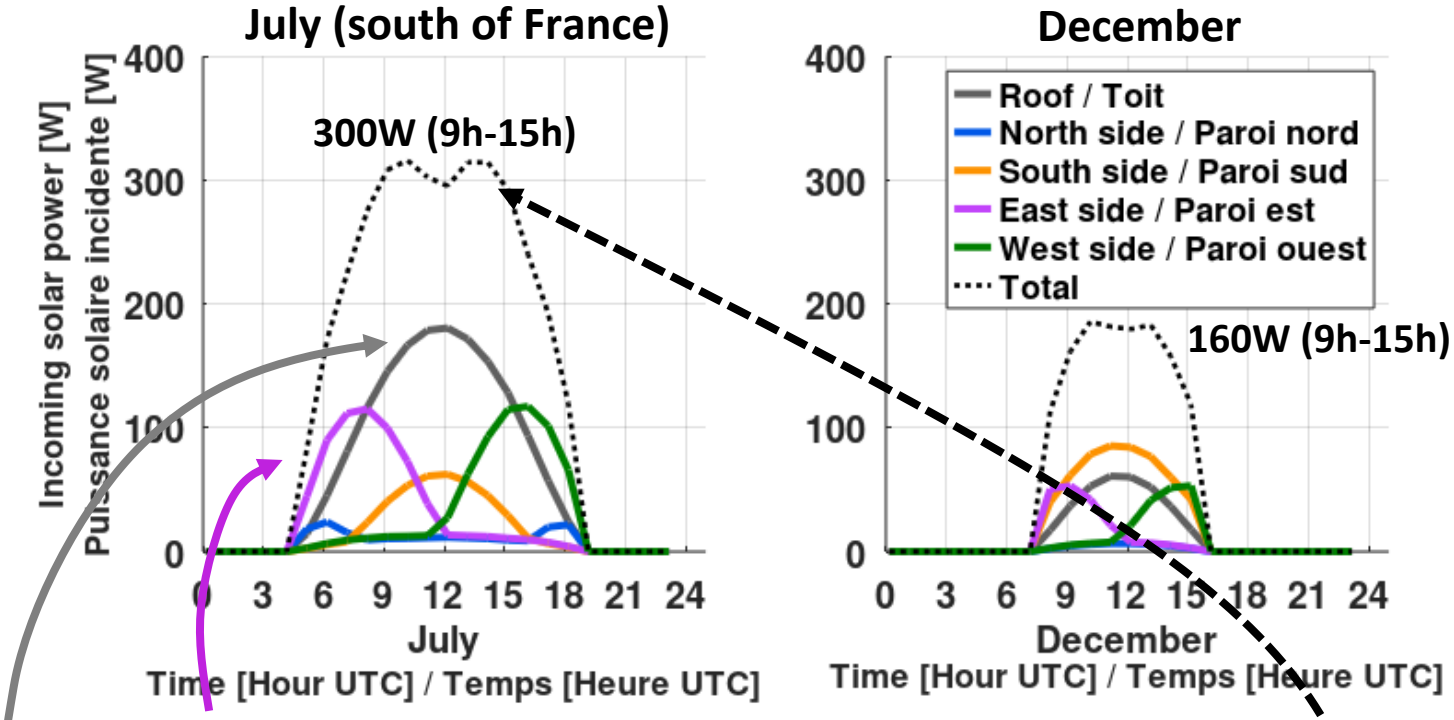
2) Has to do with **what the market offers**:
   10-frame Dadants which deform mechanically

3) Lightweight, white, UV-resistant PPP (polypropylene) **cap prototype :**
 - acting as white roof in summer to limit the sun absorption
 - acting as insulation board underneath the roof in winter

The sun effect

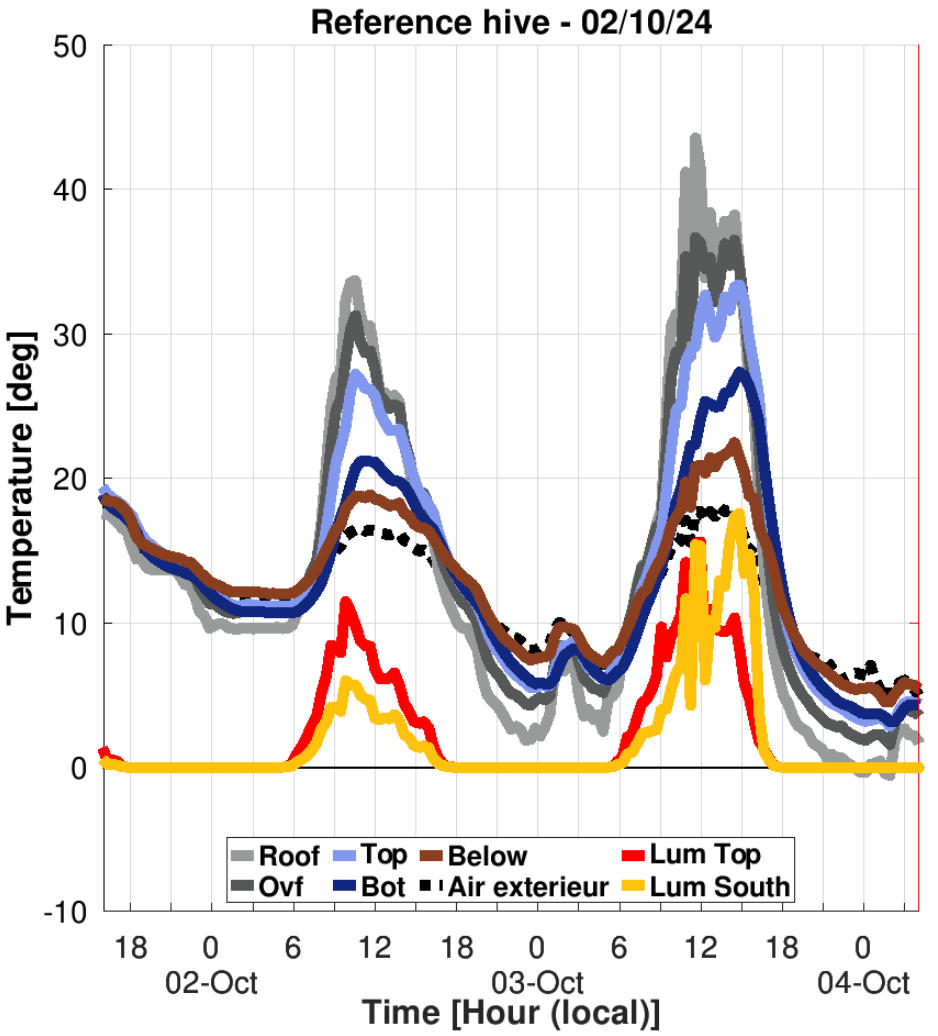


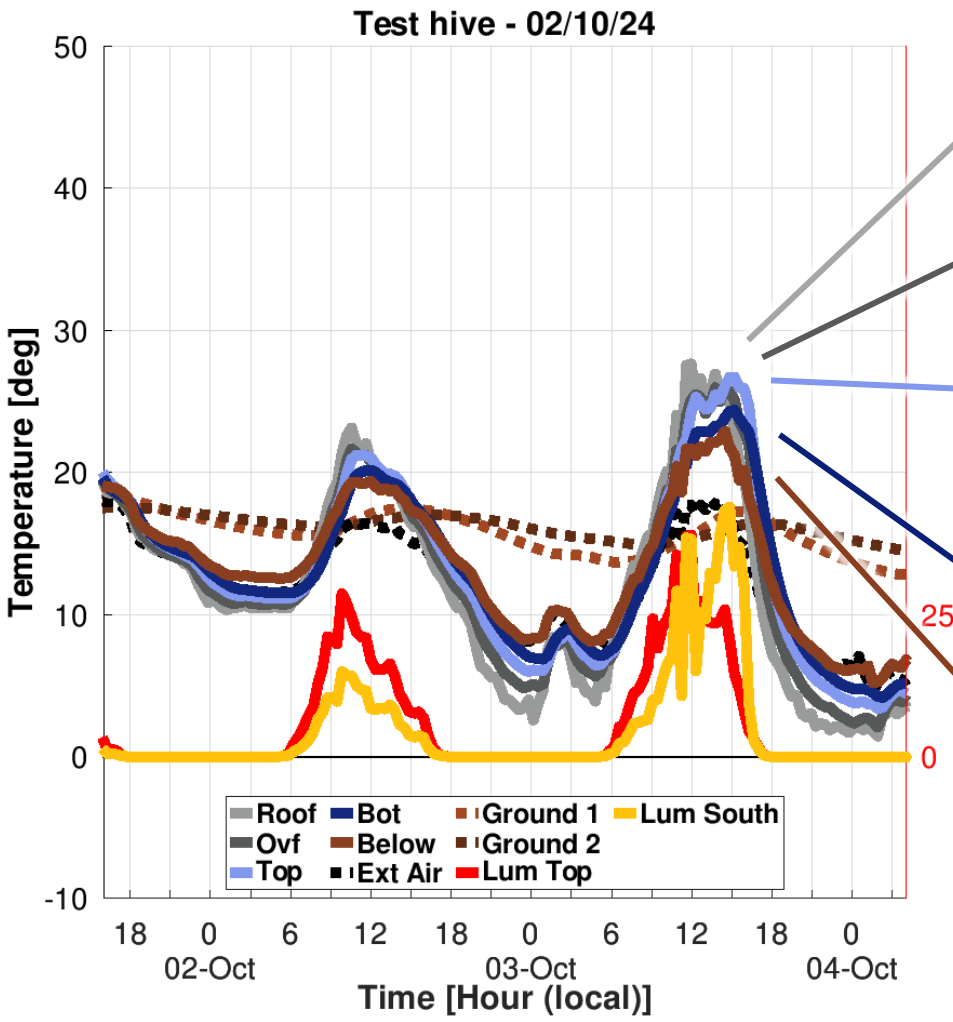
Common Dadant Hive

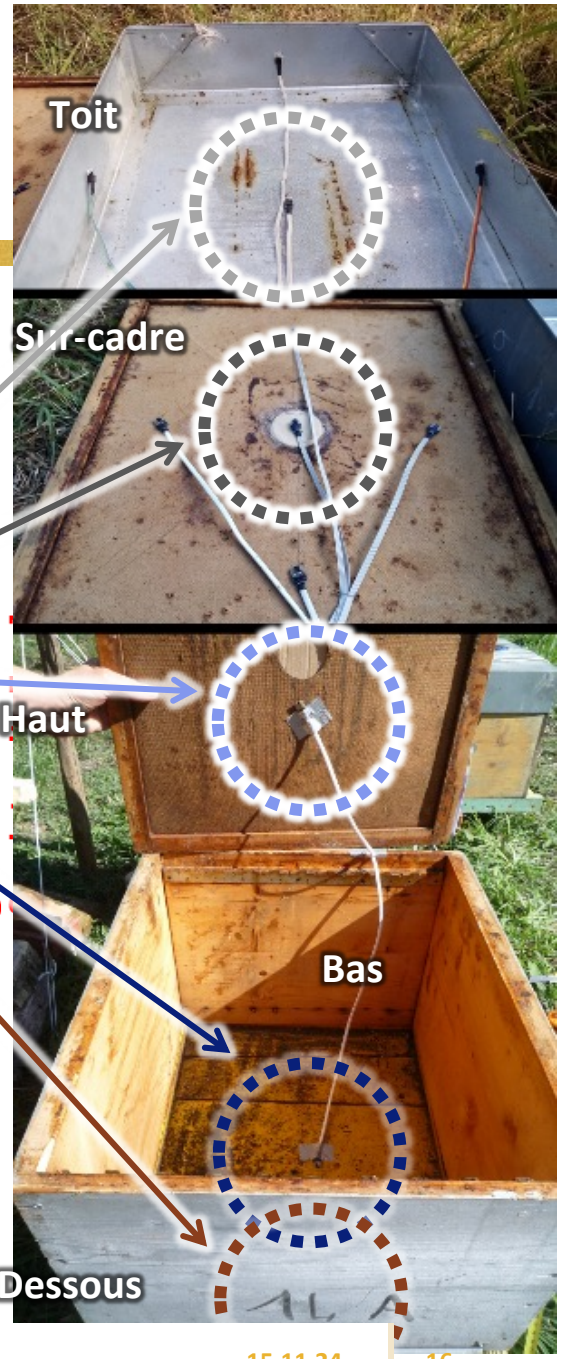


- In summer, in the morning, **the east face receives up to 100 W**
- In summer, between 9h and 15h, the hive receives around **300 W**
- In summer, **at midday, the roof** receives **180 W** (60W in winter)
- In summer, **the roof** receives **most of the sun energy**
- In winter, it's the south face.

White cap effect on temperatures *(in october)*

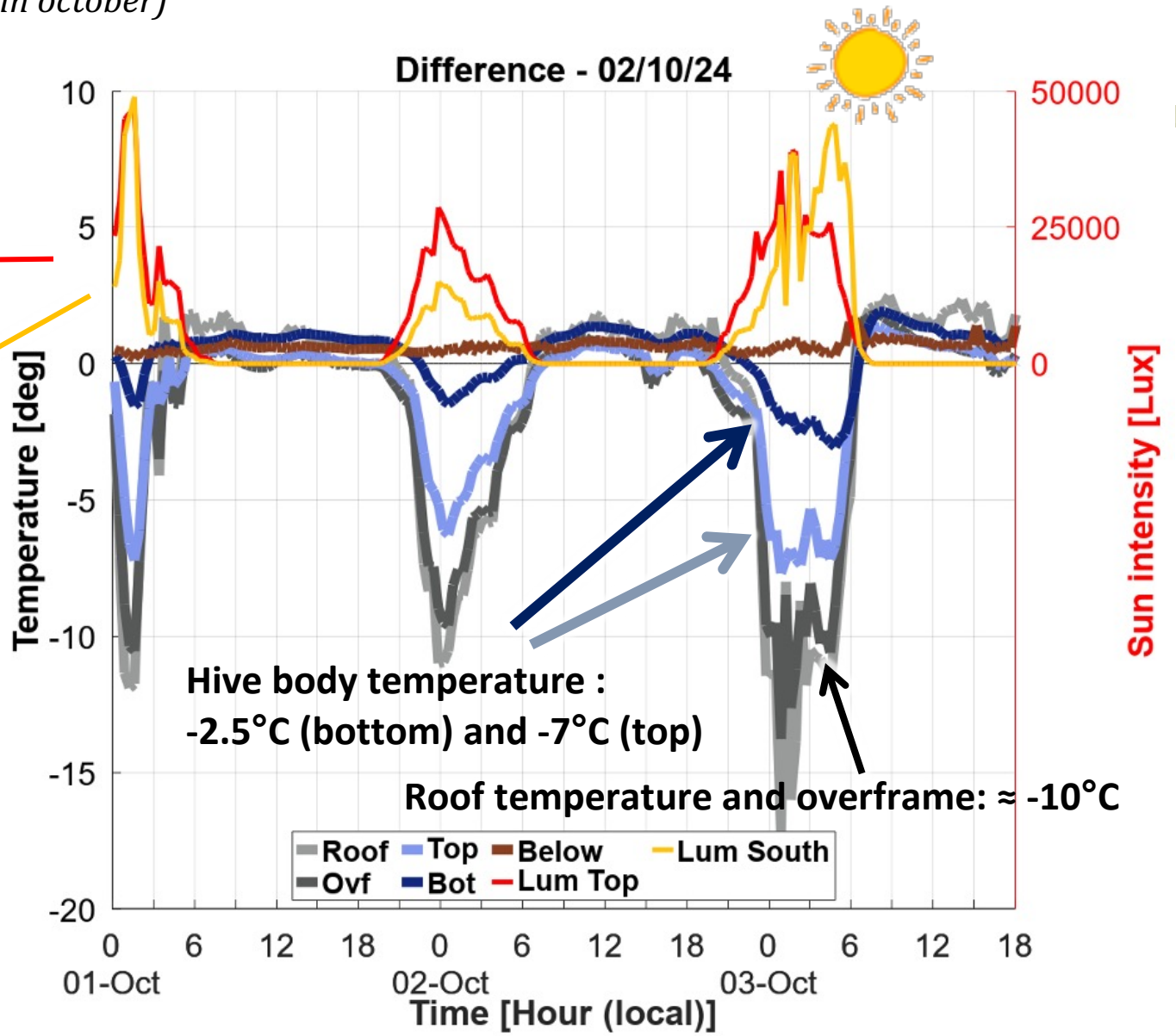






White cap experiments *(in october)*

In july, the sun is stronger and effect of white cap will have been larger.
A compensated value can be computed



Second portrait : air gap under the roof

1) **Jérôme N.**, ca. 40 y old, for 5 years, 450 beehives, since 2009

2) **Ideal beehive** centered on the colony best yield expression : to express maximum potential yield when production crops blossoms starts (early spring on rapseed)

3) Dynamical insulation practices

Use of supper as blocked **air gap** and apifoam® :
- in summer to insulate the hive from the sun
- in winter to limit the cluster heat losses

Second portrait : air gap under the roof

In summer,
the hot air is at the top part of the air gap
the cold air is at the bottom part of the air gap

-> the air gap is a good insulator and may reduce heat transfer between roof and overframe by 50%
-> only heat conduction is modified, not heat radiation

In winter,
the hot air is in the bottom part of this airgap
-> Due to convection effect, the insulating property of air is largely reduced

Summer

Warmer part (sun)
(up to 100°C)

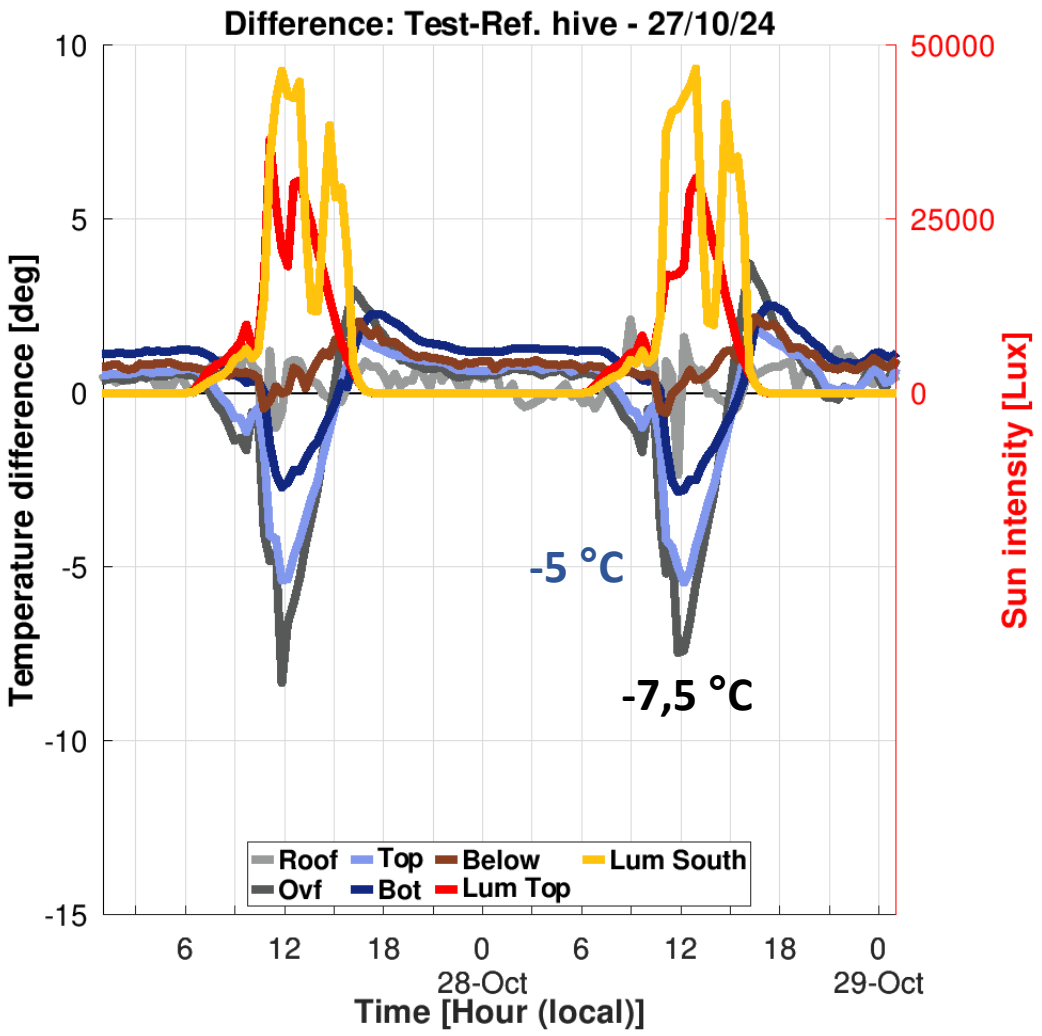
Colder part
(overframe)

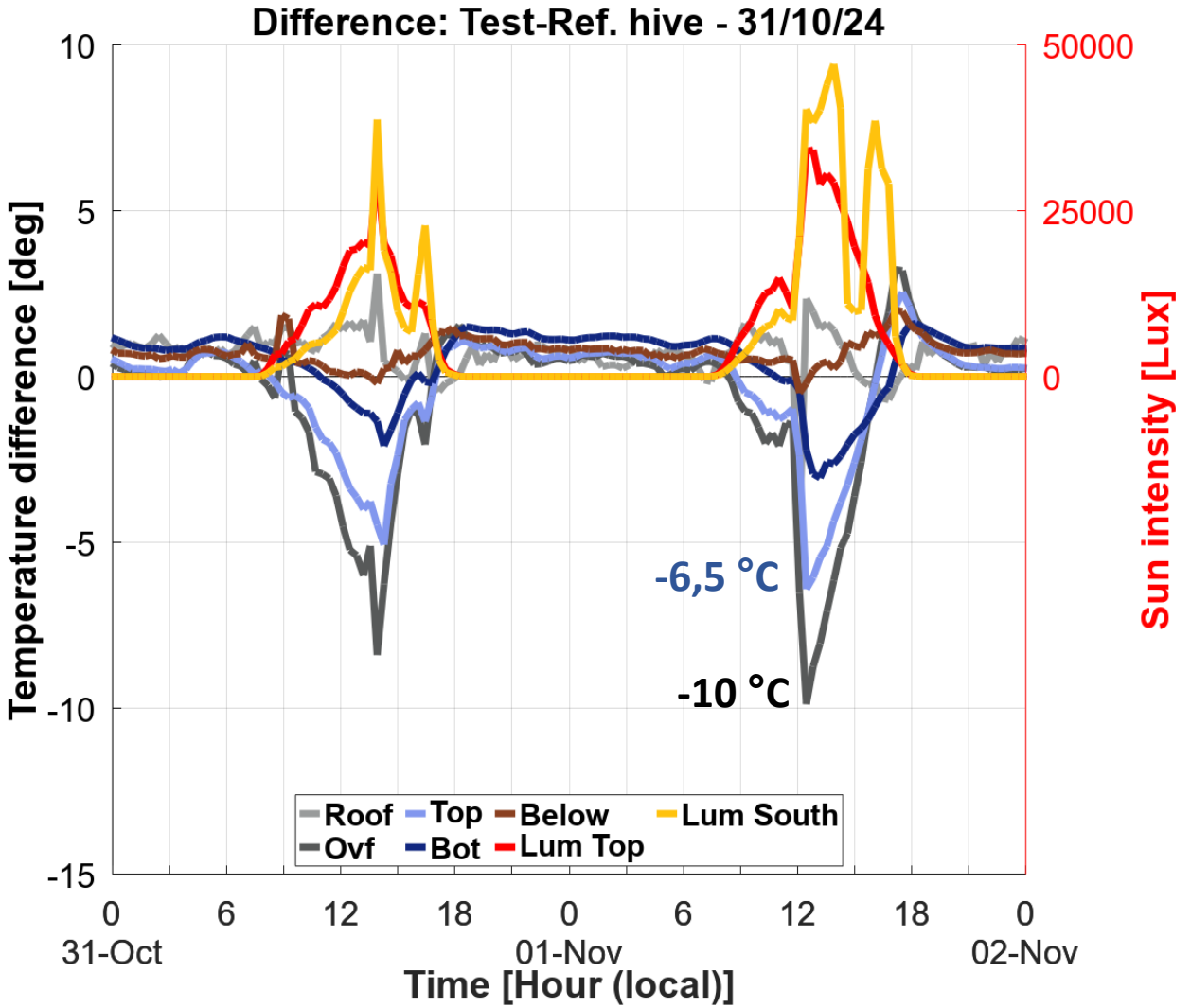
Winter

Colder part (outside air)

Warmer part (bee colony)

Air gap: 1,5cm vs 3cm (8 cm test is currently running)





BONUS: the trunk hive

1) Paul D., ca. 50 y old, looking after an old chestnut trunk hives traditional apiary (regional heritage, XVIth century). Unuseable for today beekeeping business constraints.

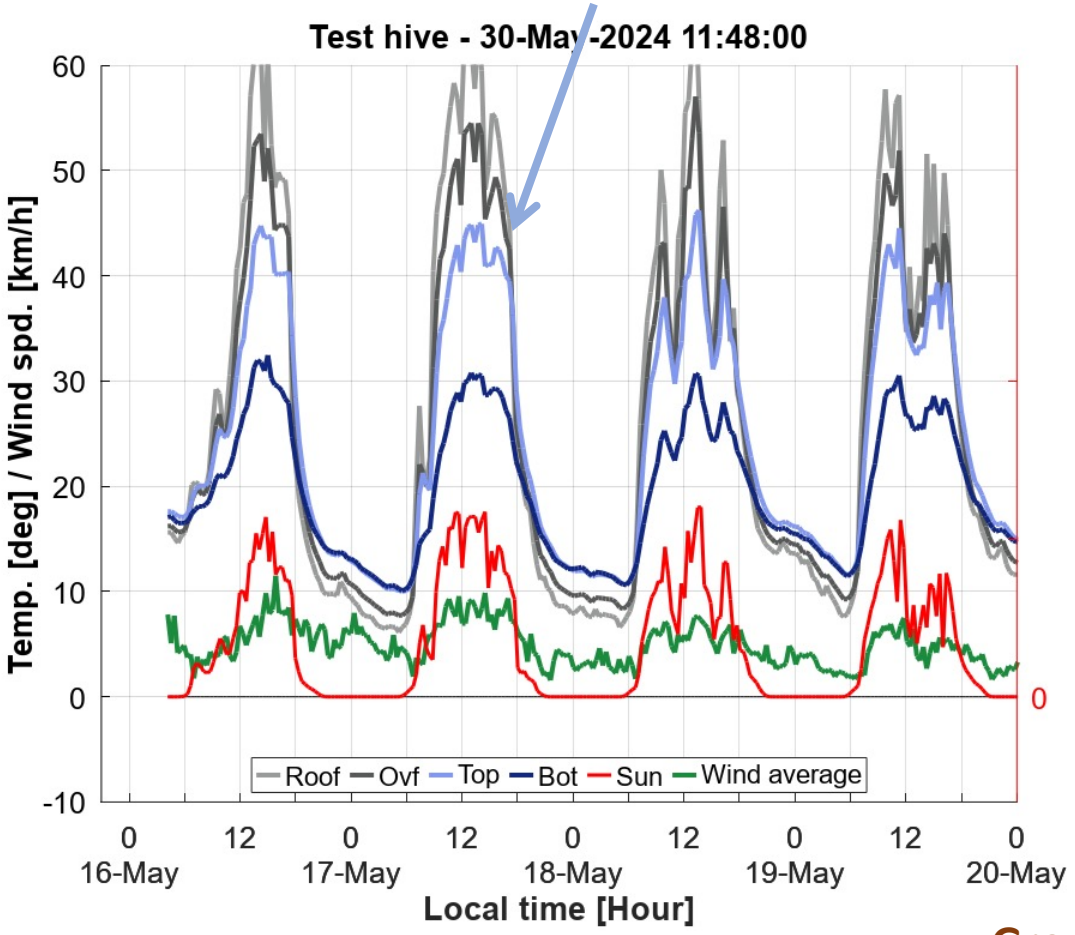
2) Ideal beehive mimic of bees natural conditions in trees

- Less influence of external environment

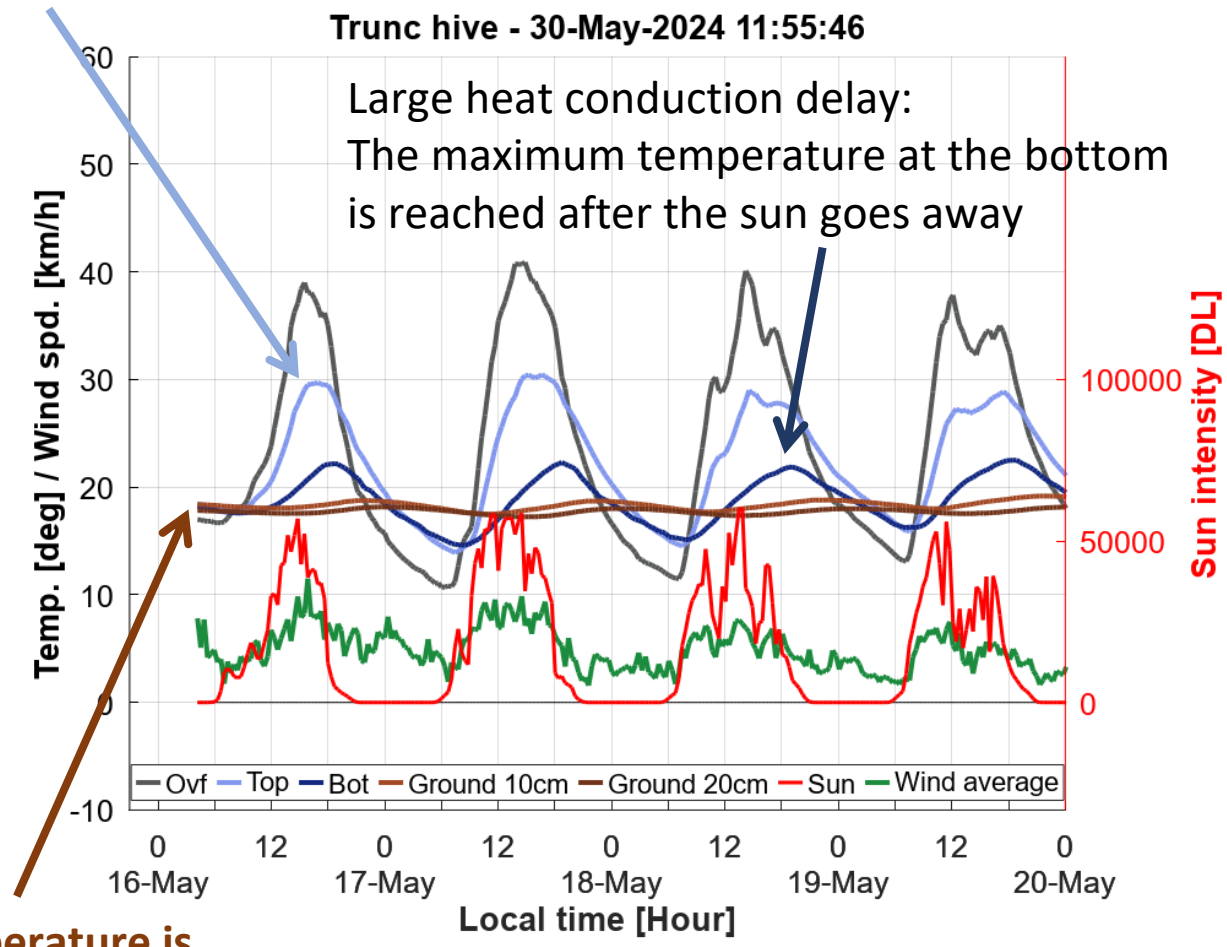
BONUS: the trunk hive

Trunk vs Dadant hive

Daily T°C variations inside the hive are about 35°C/20°C,



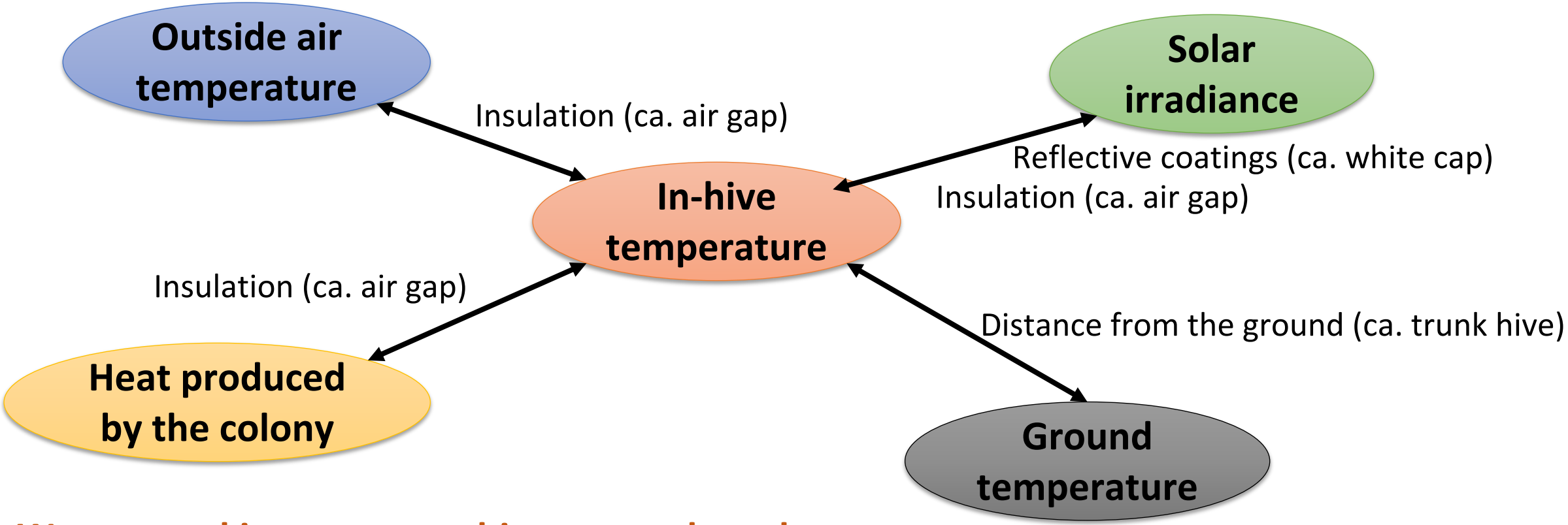
about 16°C/8°C for the trunk hive



Ground temperature is nearly constant

Conclusion

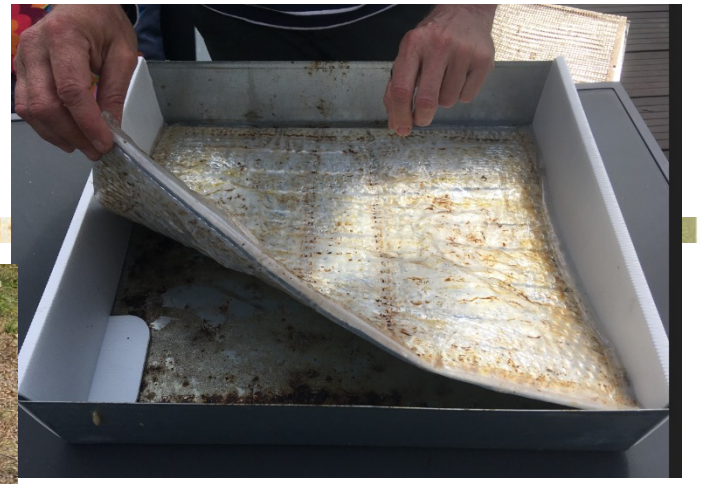
Insulation depends on situations, environmental factors and beekeeper's objectives.



We are working on empty hives to analyse the behaviour of the hive only, without colony influence

Conclusion

White paint on the roof or a white cap reduces the T°C in the hive



The working method used (transdisciplinary study) allows us to measure the effect of beekeepers' innovations on hive thermal properties.

Soil can increase the heat received by the hive

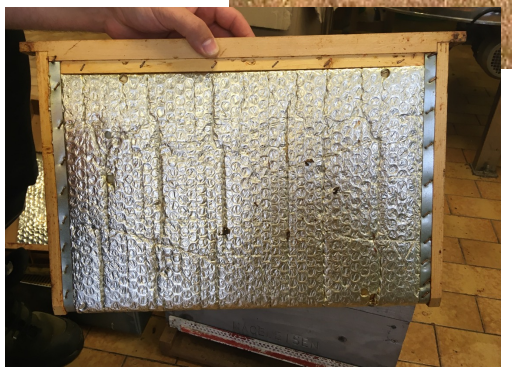
Paint on walls: no noticeable effect

To come: A lot of other innovations repertoried ready to test on our apiary

(Self)shading reduces the amount of heat received

Coatings reduce the amount of heat absorbed

Air gap insulates the hive



Questions

- Can you see any links between the statements we presented and your own practices?
- Do you insulate in winter? Part of the winter?
- Outside or inside (insulating walls)?
- When do you remove this insulation?
- Do you change the roof during the year?
- Do you modify the thermal mass of your hives:

  - placing the hive on the ground (like the Tronc hive) to benefit from the thermal mass of the ground ?
  - adding mass to the hive?

Any questions?

This work was supported by the Better-B project, which has received funding from the European Union, the Swiss State Secretariat for Education, Research and Innovation (SERI) and UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee.

UK Research and Innovation

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation