Design Project – SIE 2013

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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Towards Intelligent Pest Monitoring Using a Wireless Camera Network: A Preliminary Study on the Codling Moth

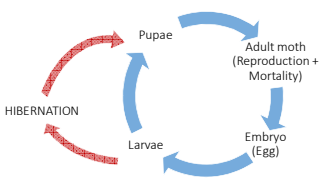
Context

Sensorscope Sàrl and Andermatt Biocontrol collaborate to equip adhesive pheromone traps with cameras to enable automatic monitoring of insect pests. Due to power consumption issues and a trap that degrades when exposed to the environment, it is desirable to make only selective use of these traps. Modelling insect pests can help to decide when and where to use such traps.
The regional Swiss prediction tool SOPRA from Agroscope models insect development on a regional scale using MeteoSwiss data. However, environmental conditions may change even from one fruit orchard to another within the same climate region. Therefore, it should be evaluated if these local climate differences do also result in significant differences in insect pest development and so in different use of the traps. Local data is available from Sensorscope, but is less accurate than regional data from MeteoSwiss.

Project Objectives

- Build a simple degree-day model for the development of the Codling Moth (a major fruit pest), based on local temperature measurements in Valais.
- Build a model to correct inaccurate local temperature measurements
- Use the models to examine if differences in the development stages of the codling moth from one orchard to another are significant enough to justify future local modelling.

Biology of the Codling Moth



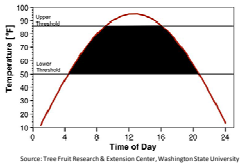
Adult stage: Monitoring and Treatment phase

Damage causing larval stage

Source: Wikimedia, Gartenwelt.de

Depending on the climate region, in Switzerland the blue cycle may be run through once or twice in a year before hibernation!

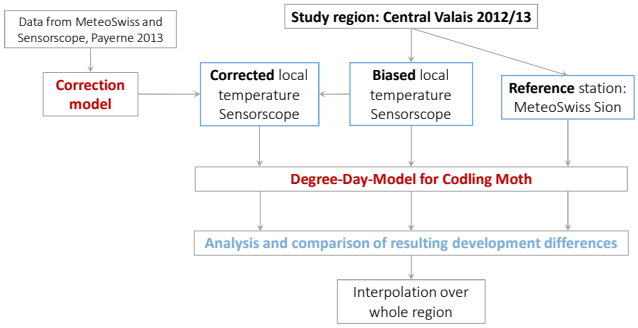
Degree-Day accumulation model



Source: Tree Fruit Research & Extension Center, Washington State University

- Models heat accumulation of insects
- If enough heat is accumulated a new stage is reached
- Integration of insect body temperature over time
- Minimum development temperature (lower threshold)
- Maximum development temperature (upper threshold)

Methodology



Results

Correction of local Sensorscope temperature measurements

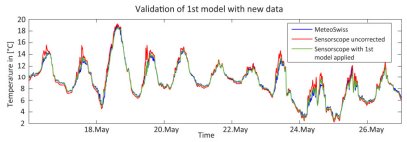
- Sensorscope data is compared to MeteoSwiss from 26 April to 16 May, 2013
- Temperatures are too high during day because of solar radiation
- Temperatures are too low at night due to condensation (humidity)
- High wind velocities reduce the effect of solar radiation
- The local station's battery voltage can replace solar radiation (similar behaviour)
- The constants C_i are determined minimizing the sum of temperature differences

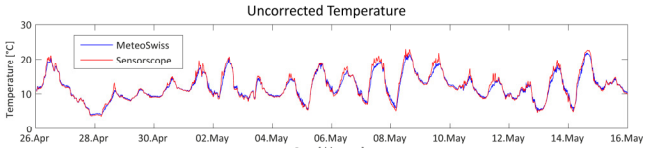
1st model: $Temperature_{corrected} = Temperature - C_1 \cdot \frac{Radiation_{global}}{\left(\frac{Wind}{5}+1\right)} + C_2 \cdot \max(0, Humidity - 75)$

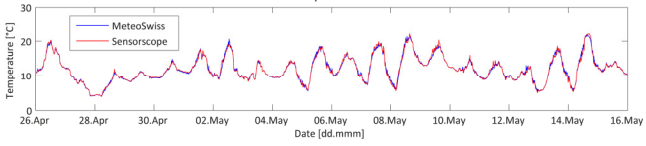
2nd model: $Temperature_{corrected} = Temperature - C_3 \cdot Battery^2 + C_4 \cdot \max(0, Humidity - 75)$

Units: Radiation in [W/m²], Wind in [km/h], Humidity in [%], Battery in [V]

	$\sum\lvert T_{Sens} - T_{MetSwi}\rvert$
Before correction	10.568 °C
1st model	5.393 °C
2nd model	7.089 °C

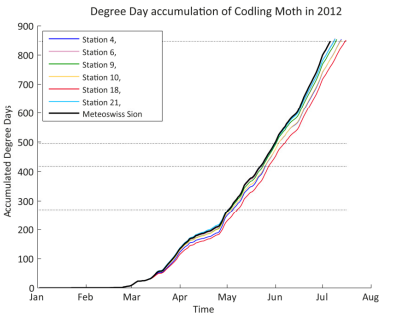






Degree-Day model for prediction of Codling Moth development

- Minimum development temperature and development period for each stage are taken from literature
- For most stages, insect body temperature can be approached by air temperature
- For hibernating stage, tree bark temperature is needed and derived from air temperature and solar radiation according to literature



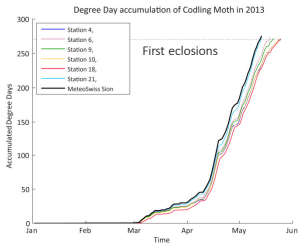
50% of larvae fully developed

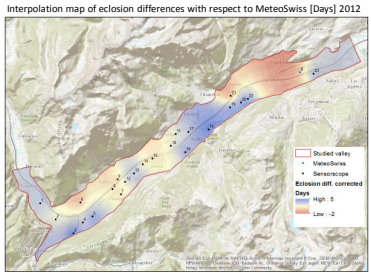
50% of eggs fully developed

Eclosion of 50% of adult moths

First eclosions of adult moths

Hibernating larvae





Discussion of results

- The correction model proves to be useful for the place it has been developed for
- After data correction, the codling moth model shows a **delay** in insect development **for all stations with respect to the reference station** in Sion for 2012 (between 3 and 11 days for the whole model)
  - ➢ Is the microclimate in orchards very different from open area?
  - ➢ Is the correction model not well adapted to conditions in Valais?
- In 2013, development delays are even larger compared to the reference station: up to 11 days for first eclosion
- But, **differences between local stations** are not affected by bias and are significant: **up to 8 days** for the whole model and up to 5 within a development stage for 2012
- Local differences are similar in 2012 and 2013 (significant correlation of 62%)

Conclusion

Temperature data correction for less accurate sensors is very promising if done in the right place under the right conditions

It would make sense to install precise temperature sensors in orchards to evaluate possible biases with respect to open area

Microclimate can vary a lot within the same climate region and affects development of insect pests

Modelling insect development using local data to decide the moment of trap use seems justified

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