Radiation monitor

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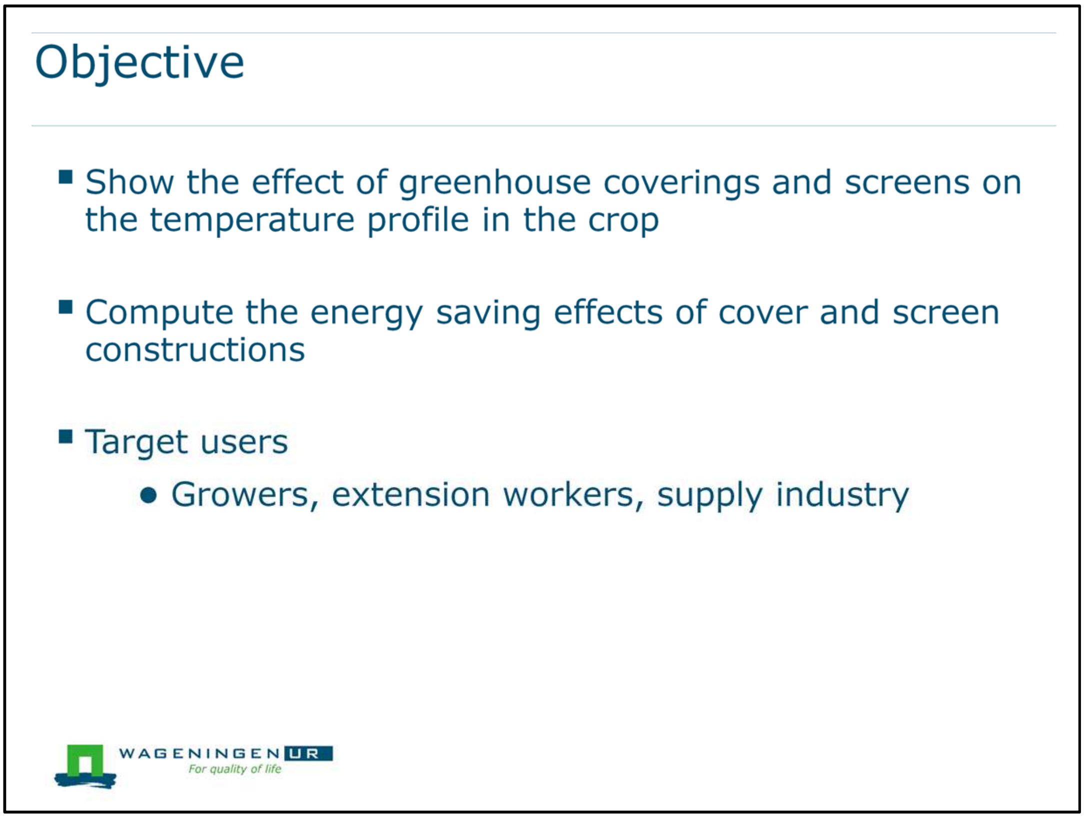
Goede afternoon,

I am Feije de Zwart and I am pleased to have the opportunity to present the recently developed Radiation monitor.

The Project "radiation monitor" was started because many growers in the Netherlands, and in the rest of the world, have questions about the effects of screens and covering materials on the energy consumption of greenhouses, but also on the temperature distribution within the crop.

The project resulted in a software tool and today I will tell about the physics in the model and show some results.



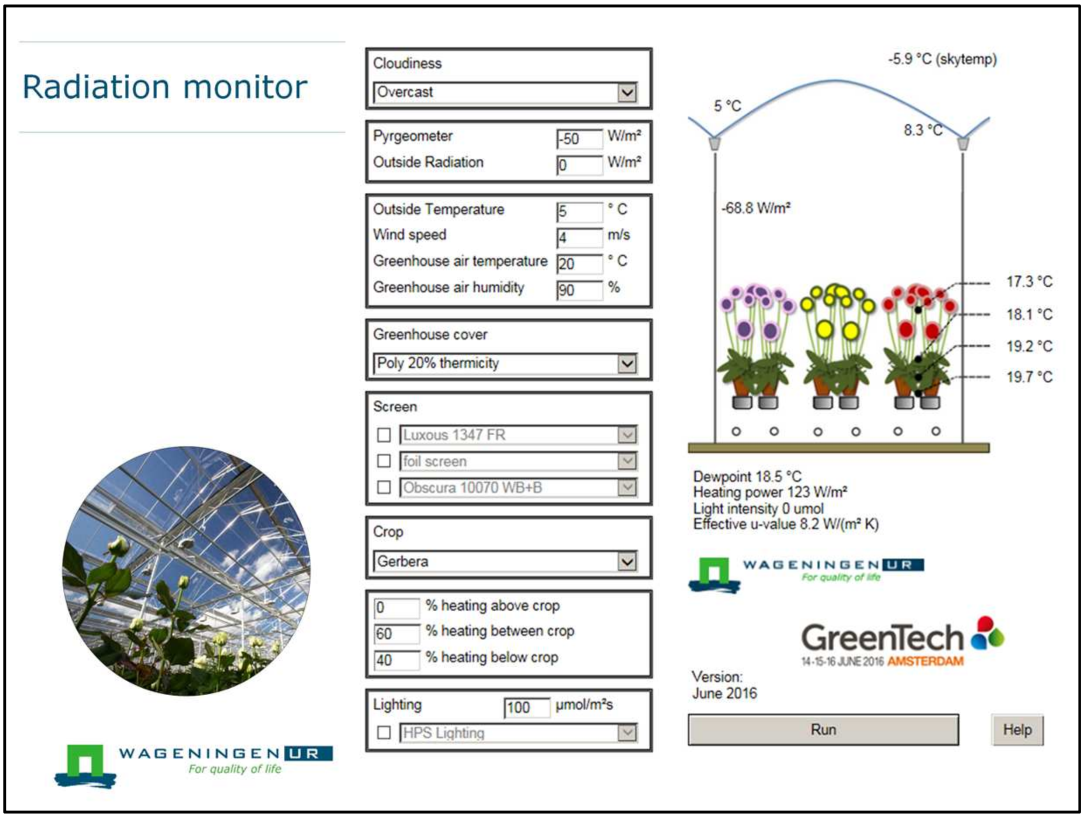
Although many of you will think of energy saving as the primary function of energy screens, this sheet puts the effects on the temperature profile as the primary objective.

This is because currently here in the Netherlands this aspect of thermal screens gets the most attention from growers. Actually this is a side-effect of intensive work on energy saving by using screens and/or double layered coverings.

Until recently, many growers hesitated a lot in the application of double layered covers or insulating screens, but when applying such energy saving measures in research it showed that actually most crops benefit from high insulation.

The only requisite is that a highly insulated greenhouse uses some techniques to carry off excess humidity since insulation will limit the moisture withdrawal from condensation and leakage, but I will leave the topic of dehumidification out of this presentation.

Since it are growers who are making decisions when installing or using screens, they are mentioned as the primary target users.
Besides them, extension workers might use the tool when discussing the operational management of their greenhouse and members of the supply industry can use this tool to illustrate novelties in horticulture.



The tool as I will present it today is practically finished.

It is only lacking the help functionality and we still have to do additional validations.

Moreover, the database with properties behind the computations might expand in future, but of course this doesn't count when talking about finishing the work.

Internet application

- Advantage
  - There is always only one version (easy updates)
  - Works on different platforms like PC’s and tablets
- Disadvantage
  - You have to have internet access to get it working
  - Sometimes, you may encounter that the outcome of a calculation is somewhat different than when you made the same calculation earlier

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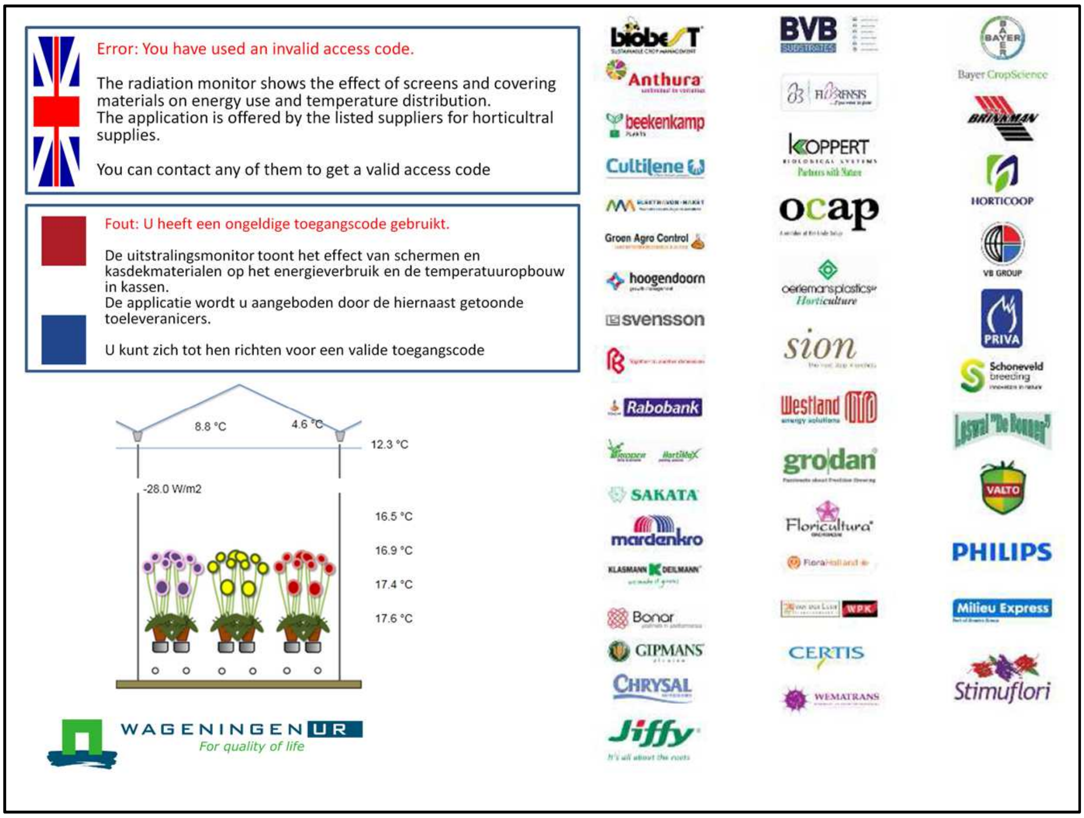
It is because of this possible future expansion that the tool is developed as a web-application.
There is always only one version available and when we change something, all users will directly have the latest version.

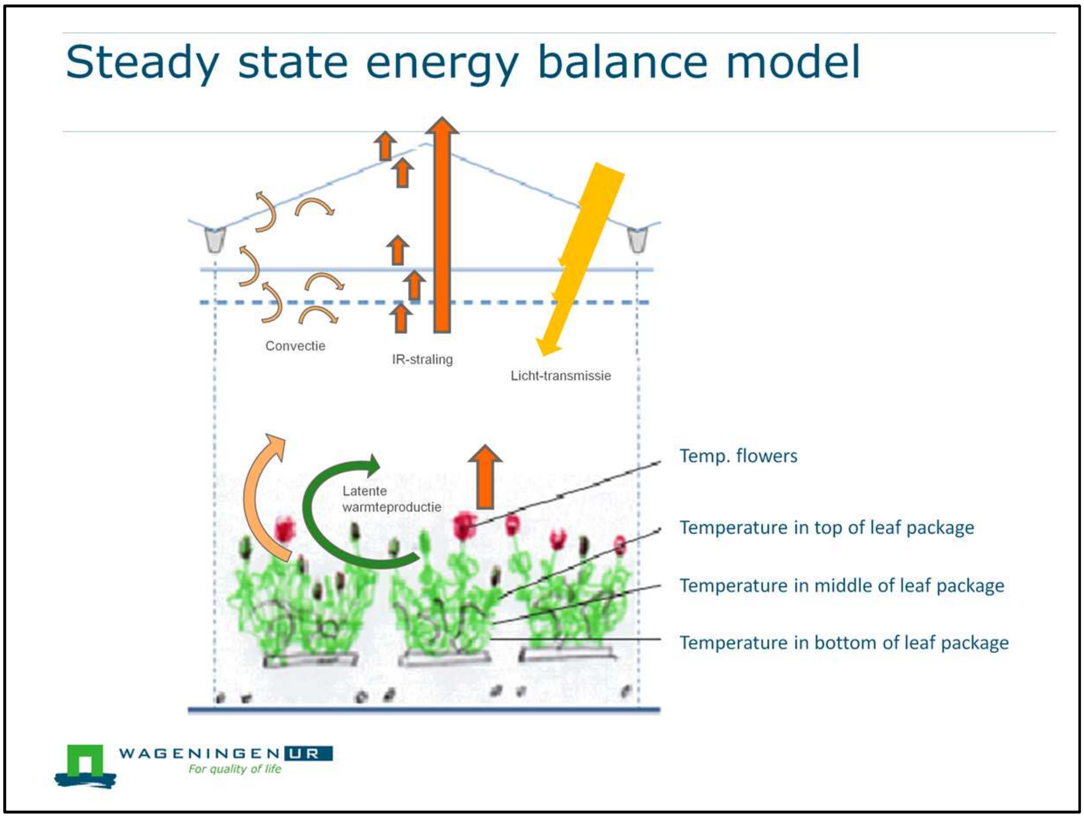
Of course, there are disadvantages of such an approach as well.
You will need internet access to use the tool and when you have made a screen dump of the results a re-run with the same inputs might show an unexpected slightly different output.

But we think that the advantages put more weight on the scale than the disadvantages, especially because in this way we can protect consistency.
Moreover, the application can easily be applied on different platforms like smart phones and tablets, just like on the PC.



The application can be used free, but will need an access code. The acces codes can be obtained from the participating companies, or you can get it from a friend or colleague

An invalid code will result in a screen like above (not yet implemented).



The tool is based on solving the energy balance of the greenhouse, giving the outside and inside conditions and the properties of the greenhouse.

The model distinguishes the convective and radiative heat exchange processes, the penetration of solar light into the crop and the energy required for the crop transpiration.

The model calculates the steady state solution, which may need heating or may require ventilation.

For convective and radiative heat exchange, screens play an important role, which can be seen in their effect on energy demand and temperature profile.

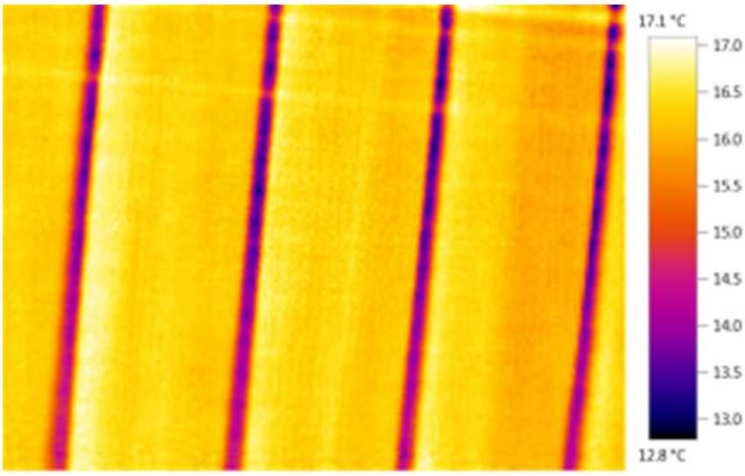
For summer conditions the effect of shade screens can be viewed

Infra-red transmission of materials

The principal objective was a tool to illustrate the effect of thermal screens on temperature distribution.
The temperature distribution is strongly related to the infra red properties of the thermal screens. Therefore, all screens mentioned by name in the tool have been tested on their radiative behaviour, meaning their transmissivity and emissivity for thermal infra red.

To do so, we have used a specially developed ‘suitcase’ where the screen material is placed between a warm and a cold sphere. In both the spheres, an infra red thermometer is viewing the opposite sphere. When a screen material is placed in between the space, the view of the infrared thermometers is obstructed by the screen and the sudden difference in the sensor reading gives the emissivity and transmissivity of the material.

Type of screen effects the infra red transmission



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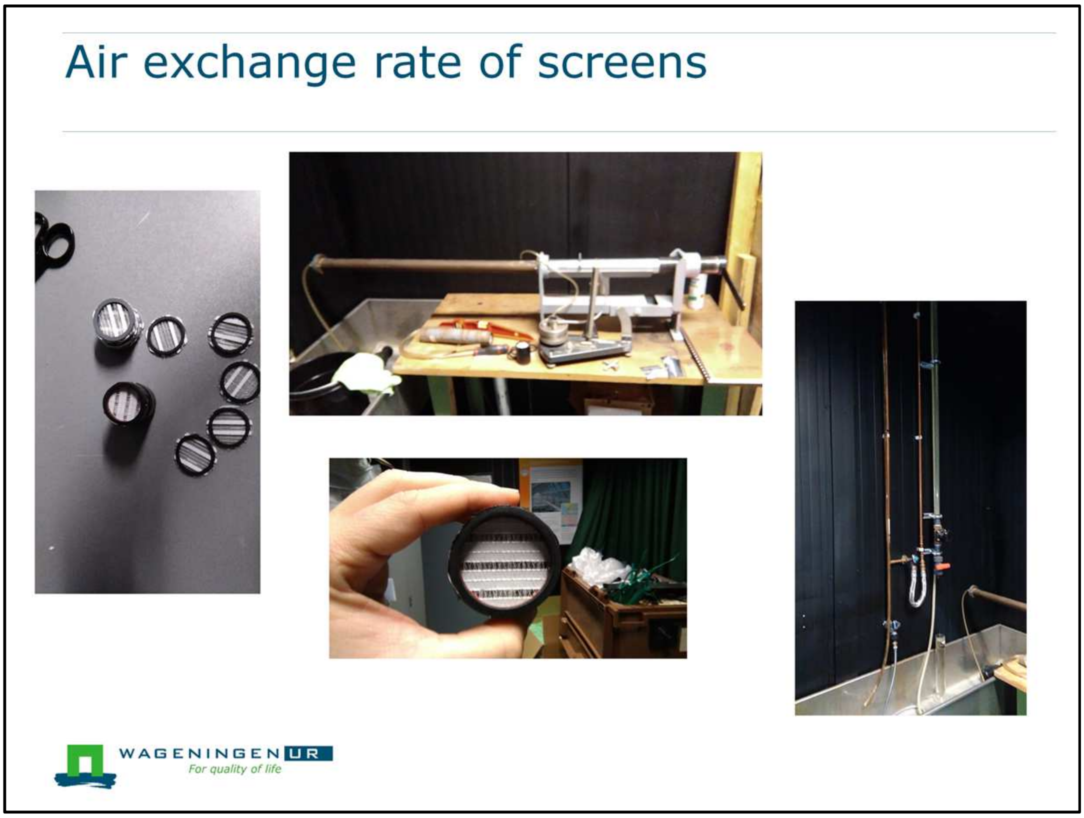
When the screen has a high infra red reflectance, each infrared sensor ‘sees ‘predominantly the temperature of its own sphere, rather than the temperature of the opposite sphere.

This is illustrated with this thermal image of a screen with a high reflectance, but with some strips left out to enhance convective exchange through the screen. The majority of the image shows the screen temperature, which is relatively warm, but through the openings the cold greenhouse cover can be seen.



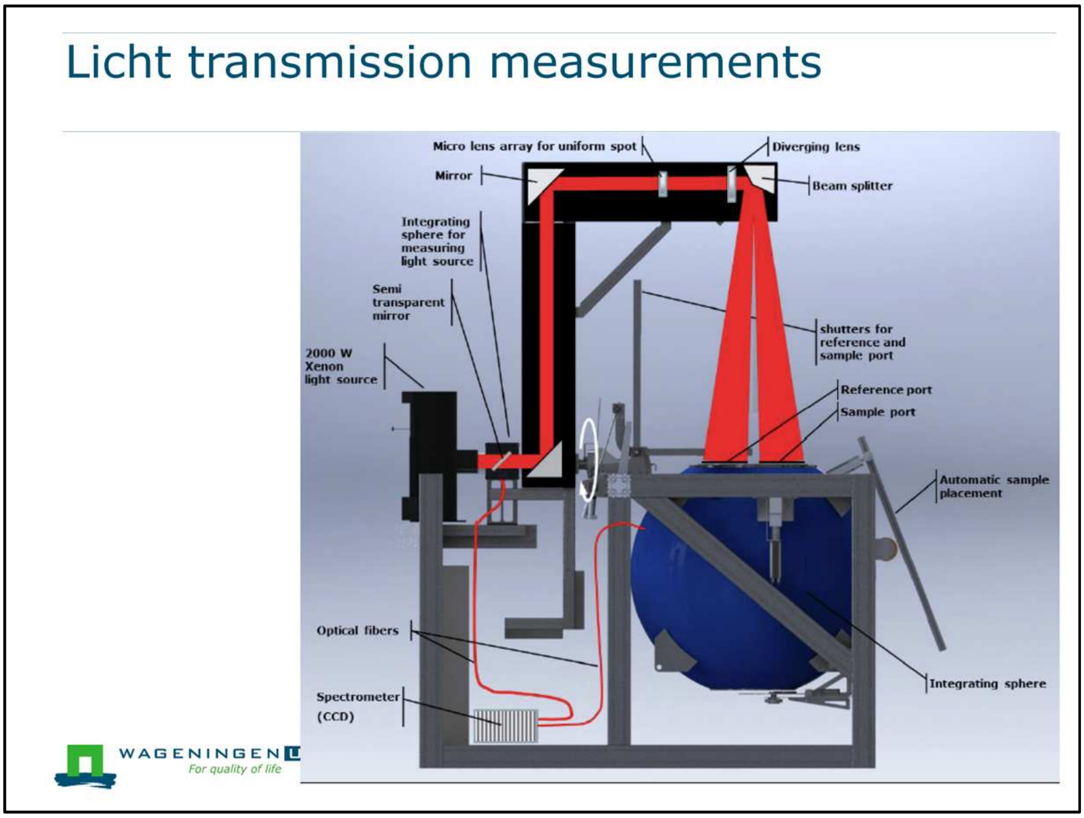
As said, screens with open strips are meant to promote air exchange through the screen, but in order to be able to compute the energy balance around the screen, the amount of air exchange had to be determined.

To do so, we have built a measuring device that enables to record the pressure difference across a stack of screen pieces as a function of a constant air velocity through this stack of screens.

We used a stack of screens to improve the accuracy of the measurements because at the air velocities that can be expected to go through thermal screens, typically around 1 cm per second, the pressure difference is only very small, around 1 to 2 Pa.

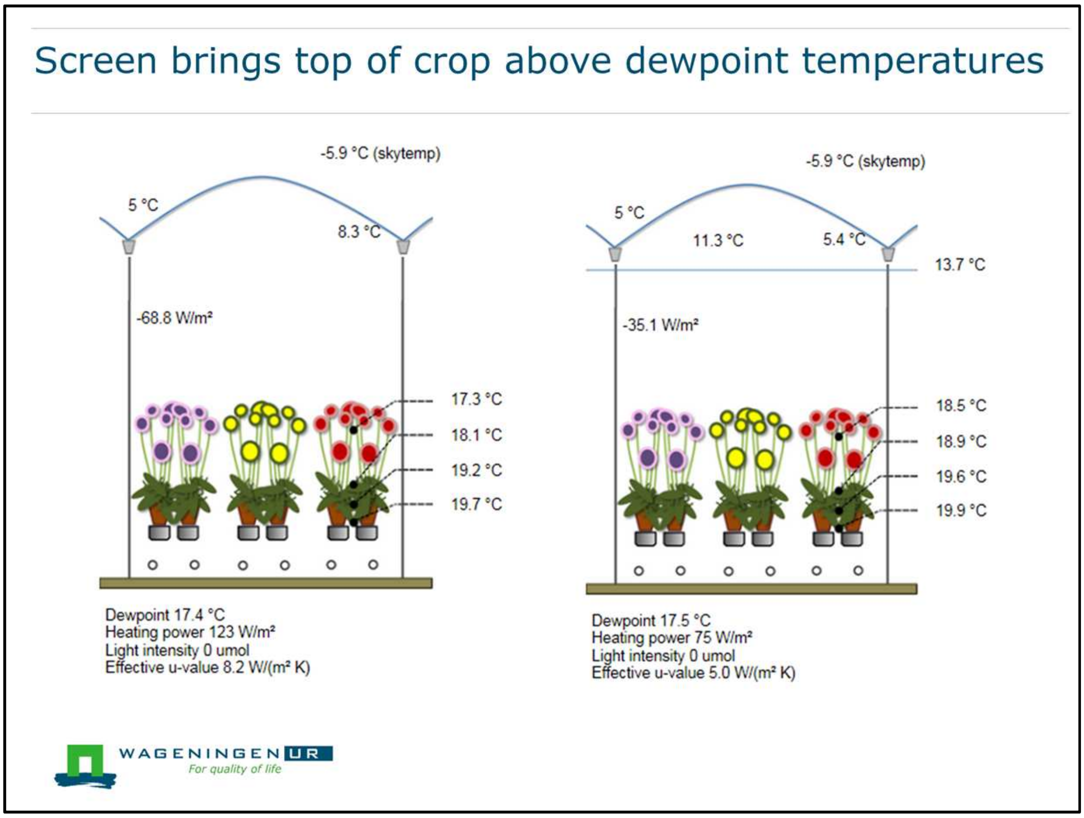
Especially for shade screens the air exchange capacity is very large, so for those screens we had to stack around 20 layers in order to be able to do an accurate measurement.

And to even improve the figures in the database behind the Radiation monitor, currently a number of shading screens are measured in a dedicated wind tunnel facility in Almeria.



For day-time properties of screens, the transmissivity for PAR radiation is of course an important property of a screen. A screen with a high transmittance can be used for energy saving during cold days .

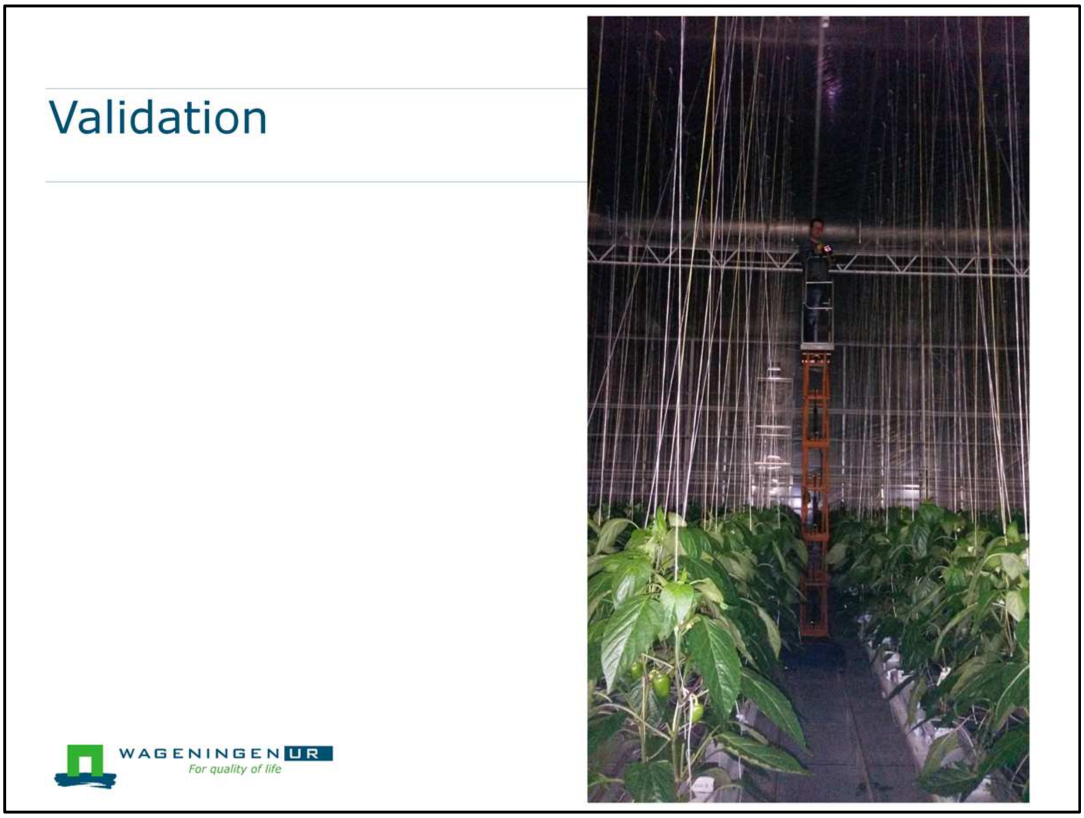
Wageningen Greenhouse Horticulture has a standardized measuring method to determine the perpendicular, but also the hemispherical transmittance of screen materials.



Having all these parameters determined, users can play around with the software and watch what happens under different circumstances.
Here I show a typical example of a night time situation in cold climate conditions. Without a thermal screen, the greenhouse looses a lot heat due to radiation and convective heat loss.

Especially the radiative heat loss, whch is almost 70 W/m2 at the top of the crop, makes that the free standing flower bulbs may become quite cold, even below dew point temperature.

Closing a thermal screen reduces the radiative heat loss causing the flower temperature to get well above dew point temperature

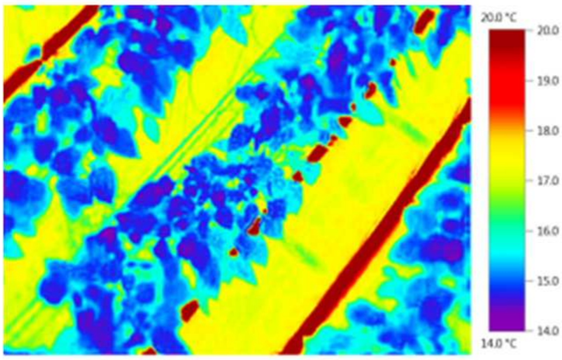


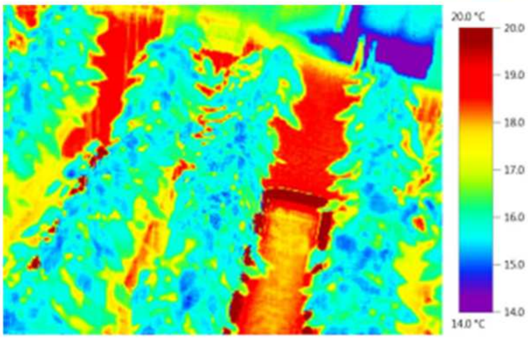
In order to validate the computations we took images of crops during winter nights.

Here you see my colleague Esteban standing high in the greenhouse with at thermal image camera looking down onto a sweet pepper crop.

Screen stowed:

clear temperature differences in the crop





Screen deployed:

Much smaller differences

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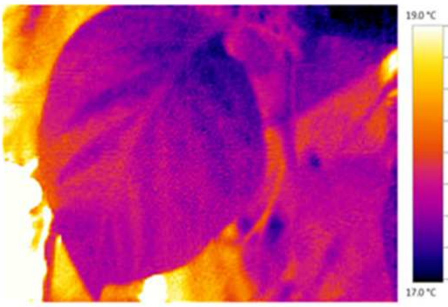
And here you see the image with the thermal screen stowed and with the thermal screen deployed.
With a deployed screen, temperature differences in the crop diminish almost instantly.

During these validations we observed that the difference between model computations and measurements were very small (about 0.5 deviation between computed and measured leaf temperatures and not more than 5 W/m2 difference between measured and computed infra red radiation losses)

Comparison of thermal imaging temperatures with thermocouple readings



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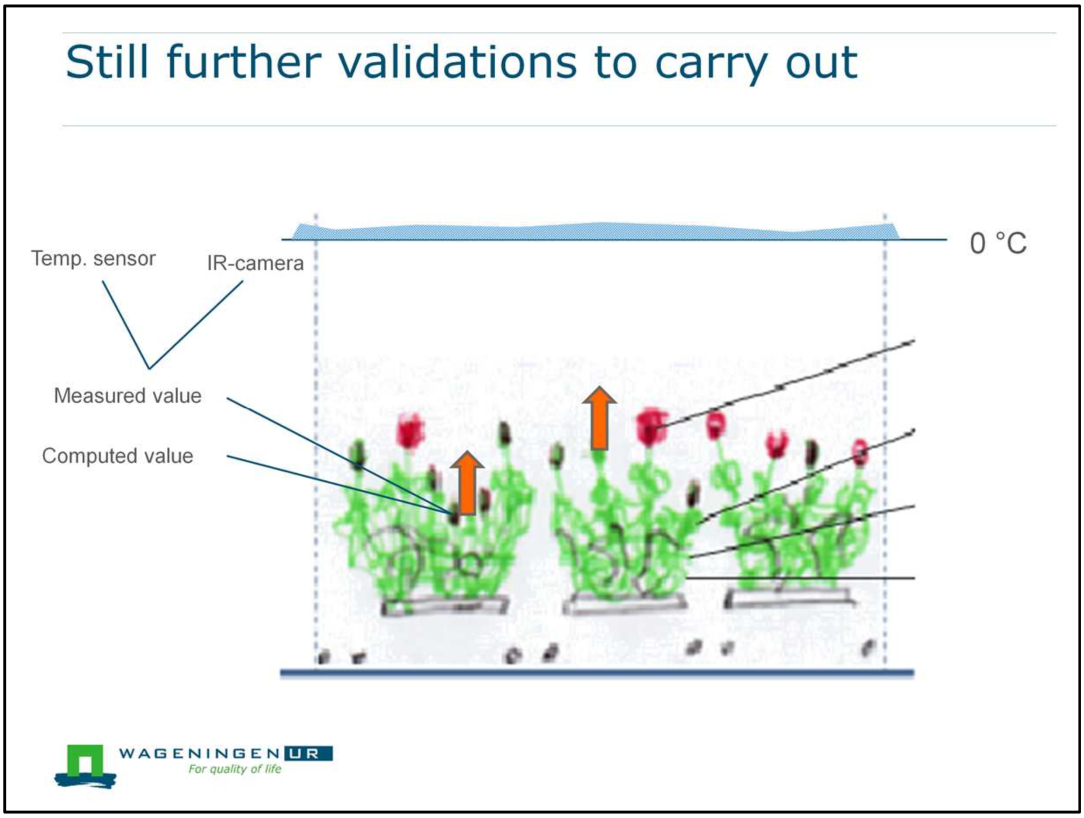
We also checked to what extent the thermal camera readings correspond to the real leaf tempertaures. When using a quite low emission coefficent as camera setting (0.70) the difference between the camera reading and a thermocouple reading for sweet pepper leaves appear tp be between + of – 0.2 oC..



Arithmically, the radiation monitor is now ready, but we will do still further validations on the parameters.
As said, air exchange parameters for shade screens are currently taking place and we will do another round of obsevations on the temperature distribution in the crop.

We expect that this will give some small refinements, but that the general results are already now sound and realistic.

Finally I want to thank you for your attention, but also I want to express my gratitude to the large amount of financers of the project that lead to this application.

Half of the amount was funded by public research program of the Ministry of Economic affairs and representatives of the Dutch horticultural sector.

The other half was funded by a large number of companies in the Dutch horticultural supply industry. These Club van 100 members are convinced that joined efforts in research and development will benefit all.

We, as Wagenignen UR greenhouse horticultere are very happy with this initiative and we are glad that, amoung other output, we can provide them, and you, with tools like this that will contribute to the professional level of the horticultural sector.

If you want access to this tool too, you can contact any of these members to get a valid access code,
Most of the companies have a booth on this fair.