Summary

Protected crops, such greenhouses, have high energy costs due to forced ventilation. Hence, natural ventilation can be a reasonable solution to reduce energy consumption. However, a design that allows natural ventilation of the greenhouse is a challenge due to the complexity of the physical phenomena. Contrasting other design methods, such as experimental or analytical methods, in recent times the computational fluid dynamics (CFD) has become the most widely used tool to study the phenomena, thanks to its relative low cost and speed of obtaining results. However, CFD models must be endorsed by validations carried through experimental data. A detailed literature review of the use of CFD applied to greenhouses shows that the work lack sufficient experimental data, probably due to the high cost to acquire experimental data in field conditions. Moreover, it is observed that the CFD simulations are not performed in greenhouses with a systematic procedure. Therefore, this thesis on the one hand describes a device and a simple and inexpensive method to gather atmospheric data, and on the other hand, it proposes a critical view on the research conducted so far, in order to systematize the way to generate CFD models applied to natural ventilation in greenhouses. Finally, the thesis is complemented by an example of a case study.

To do this, first, a review of good practices guides in different fields of technology was performed, mainly in environmental building engineering, with the intention to systematize and adapt these recommendations to generate CFD models from build engineering to greenhouses. Second, a simple data acquisition system, consisting of a network of sensors that can simultaneously measure the wind speed and direction at 20 points was developed. This system was calibrated and tested at field conditions successfully with similar accuracy than commercial anemometers (with a price 30 times inferior). Third, 24 model cases were generated to analyse their differences and show their advantages and disadvantages. The cases are the result of the combination of four turbulent models (k-ε; RNG k-ε; SST k-ϖ y RSM); two discretization schemes (first and second order) and three external wind speeds (3, 3.5 and 4 m/s). Fourth, to analyse the performance of the models a validation procedure was perform: computational data and experimental data was compared by using linear regression analysis. This validation revealed that the SST k-ω and RSM models (second order) are those that best represent the ventilation flow and demonstrated that the k-ε standard (first order), the most widely used in the literature, not only gives different results to other models, but their performance is poor for predicting ventilation flow.