CHAM Case Study – Building HVAC

PHOENICS 2006 applied to Steady-state Simulations of the Internal Flow within a Multi-storey Building

Introduction

- CHAM's Consultancy Team used PHOENICS/FLAIR for the analysis of a multi-storey building in the Kista region of Stockholm, Sweden.
- A model was created for testing the internal temperature distribution when subjected to worst-case winter and summer conditions (i.e. very cold or very hot).

Introduction

- There was concern about:
  - the production of cold downdrafts in the atrium or along the large glassed façades during the winter
  - whether there were regions of unacceptably high air temperature during the summer time.

Introduction

- The building design was supplied in the form of a number of AutoCAD.DWG (Drawing) files of the building and its location, along with the operational boundary data, such as:
  - the glass specification,
  - the building material,
  - internal heat sources, together with an estimate of the number of people, and supplementary heating and cooling baffles.

Geometry Creation

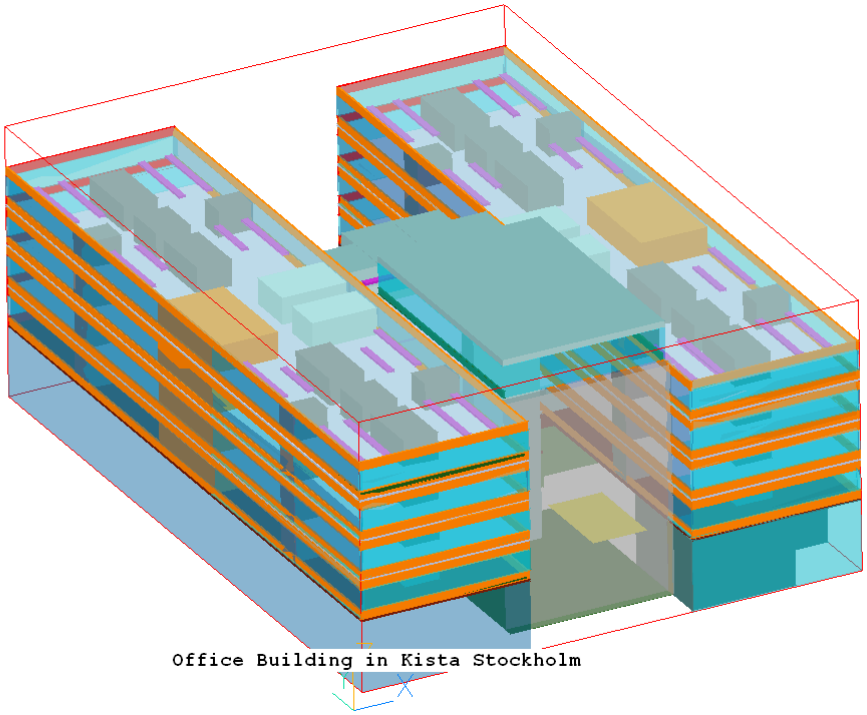
- Eight offices are located on four floors on either side of the atrium.
- AC3D was used to create ‘bespoke’ objects for the office floor

Geometry Creation

- Included within the model are some 650 objects representing doors, walls, roof, ceilings, glass windows, computers, persons, office furniture and various types of heat-sources.
- The distribution of these objects in all offices on each floor is similar.

Geometry Creation

- Once one floor had been created, the ‘Array Copy’ feature was used to quickly generate the remaining floors.



Problem Specification

- To represent summertime conditions, a total solar heat gain of 46,580 Watts is specified through the glass doors and windows, with the radiation projected onto the floors and internal walls.
- This is in addition to the normal heat generated by people in the conference room and offices, and by lights and machines inside the building.

Problem Specification

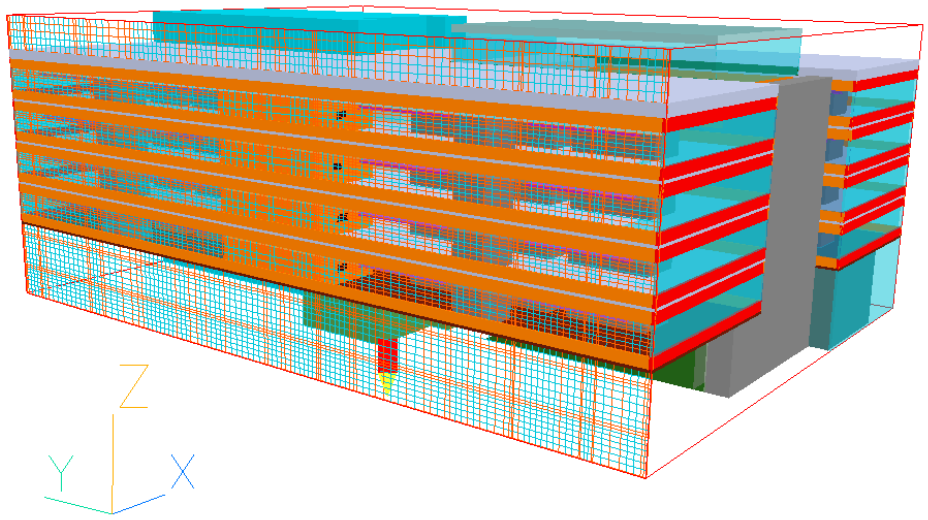
- The temperature within the building is regulated by an air conditioning system introducing cooled air at 15°C, and a ventilation system generating a total air exchange of 2300 l/s throughout the building.

Problem Specification

- The winter case differs in that there is no solar heat affecting the temperature in the building.
- Due to the low temperature outside, the glass door and all the glass windows take heat away from the building.
- The temperature of the ventilation air in the building is increased from 15°C to 18°C.

Results

- A total mesh size of 1.1M cells (108 * 123 * 85) was used, non-uniformly distributed over the entire calculation domain.



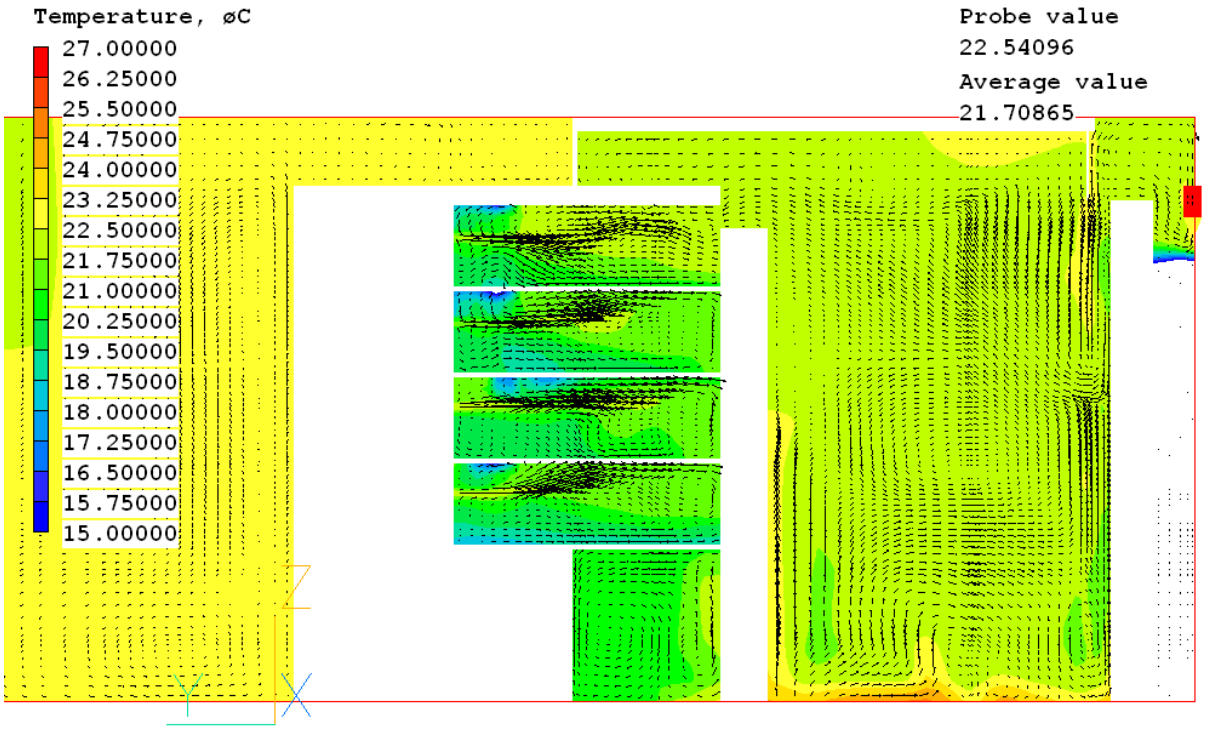
Office Building in Kista Stockholm

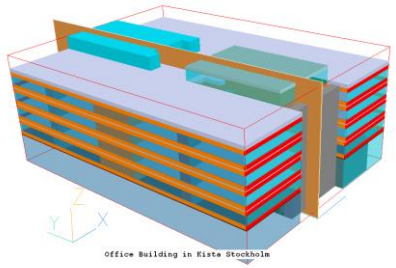
Results

- A converged solution was obtained after 2000 iterations, which took 22 hours to complete on a 3MHz PC, and 8.5 hours on an equivalent 4-processor cluster using the parallel version of PHOENICS.

Results

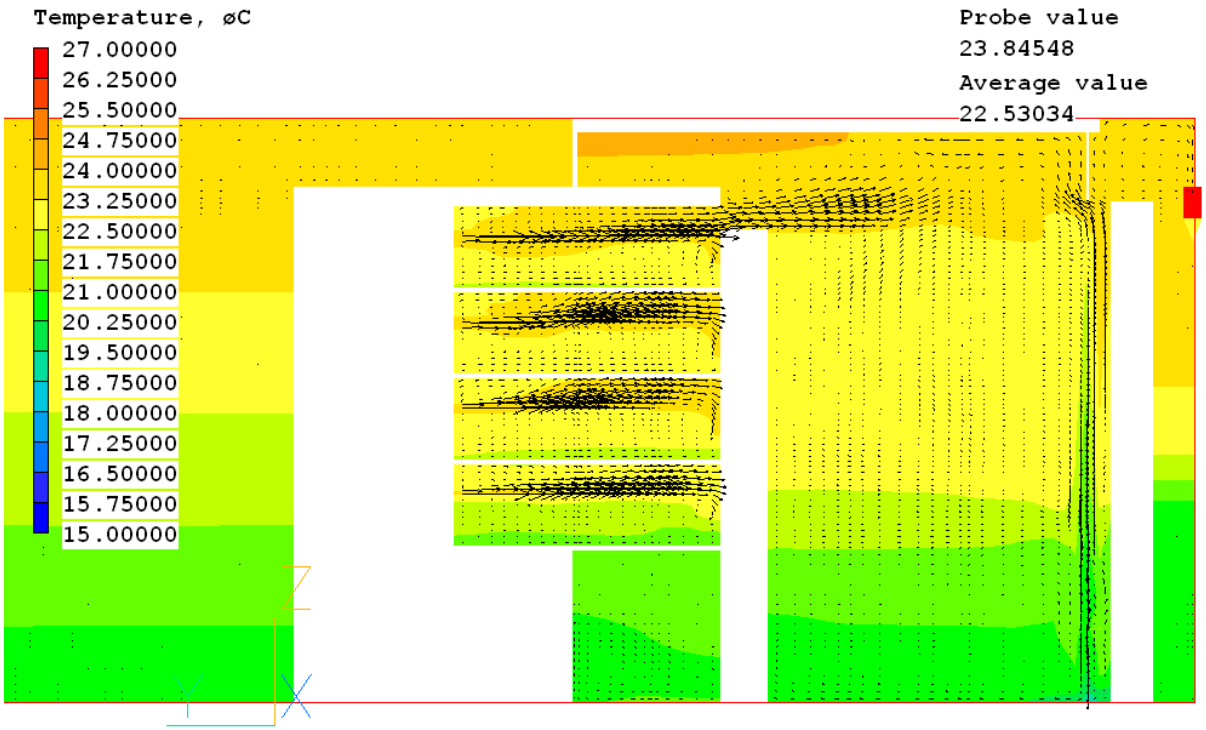
- Summer temperatures – X plane



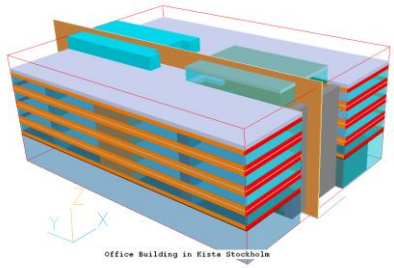


Results

- Winter temperatures – X plane

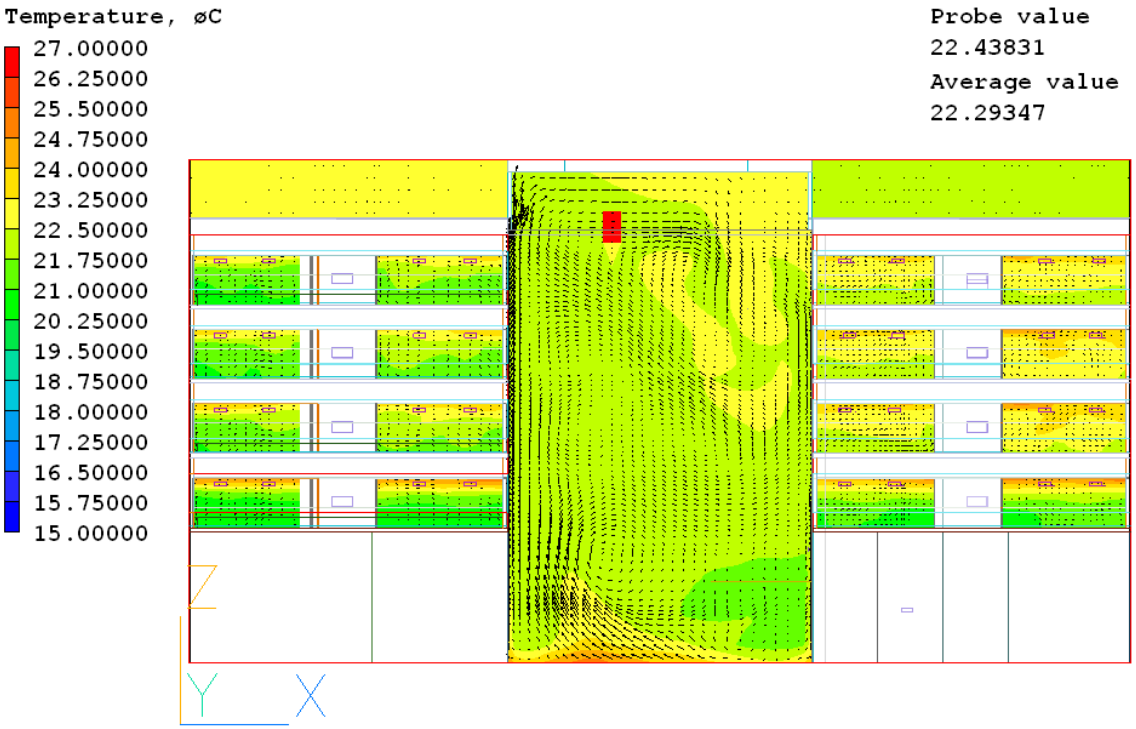


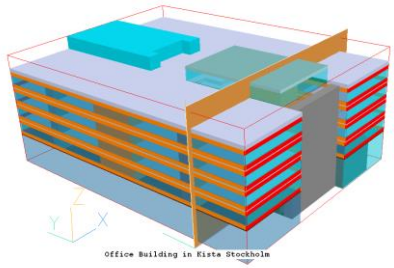
Office Bldg in Kista Stockholm (Winter)



Results

- Summer temperatures – Y plane





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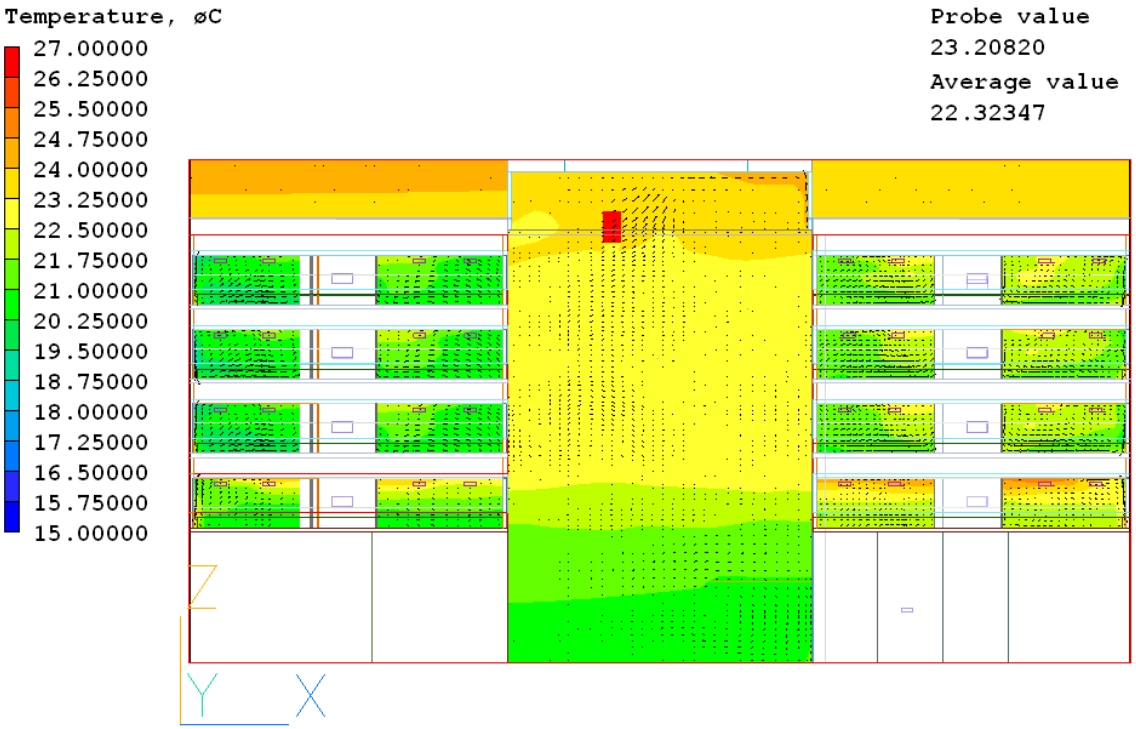
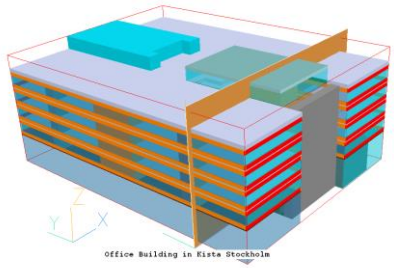
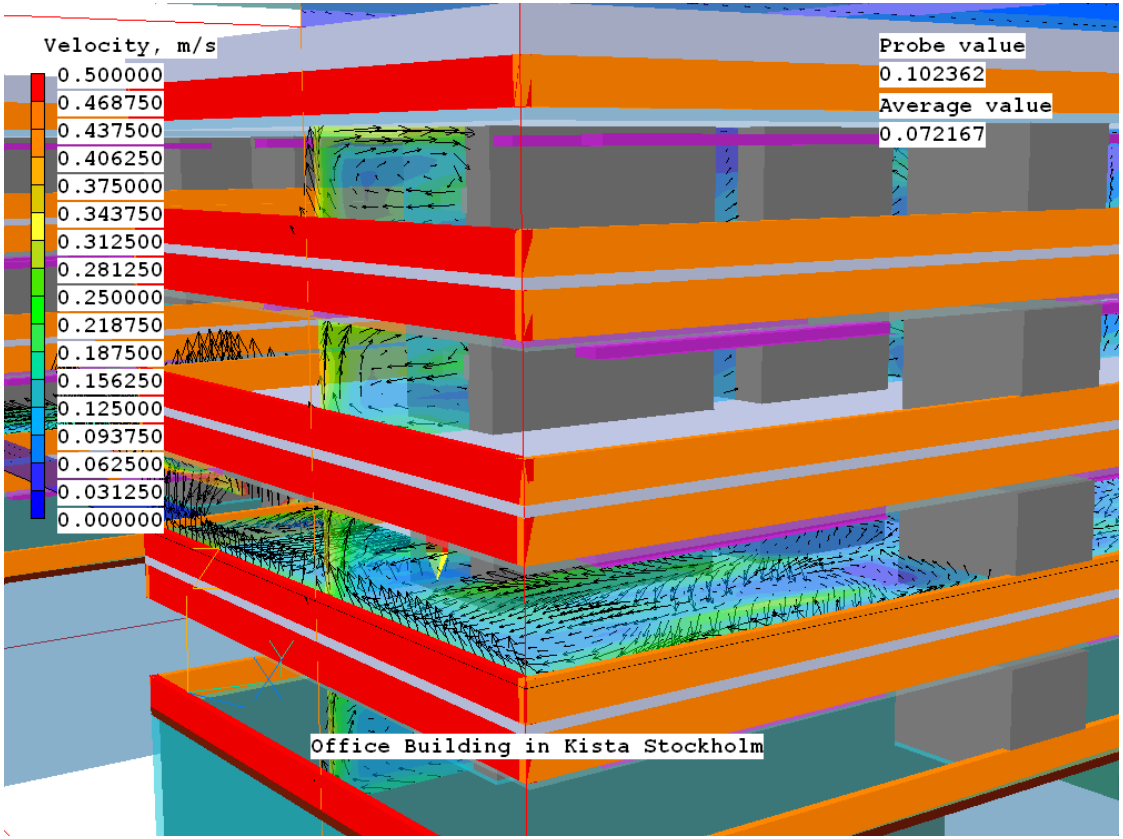


Office Bldg in Kista Stockholm (Winter)



Results

- Velocities in one of the rooms



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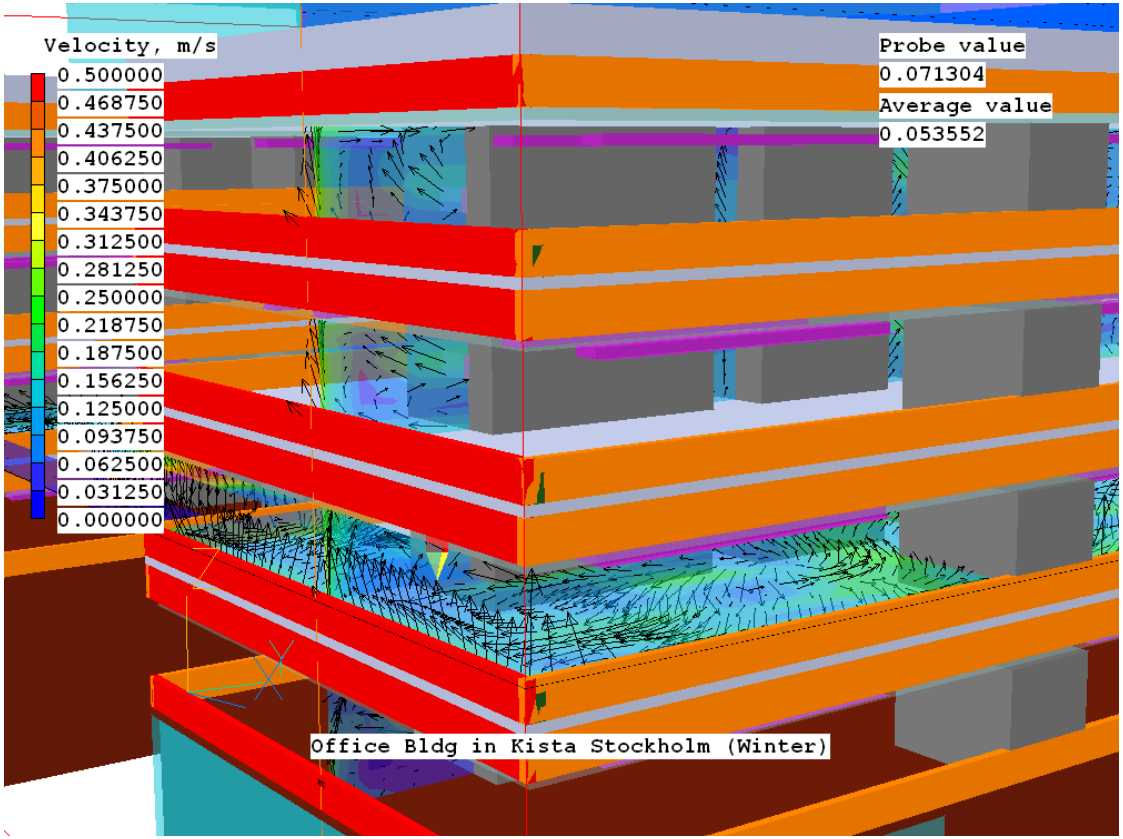
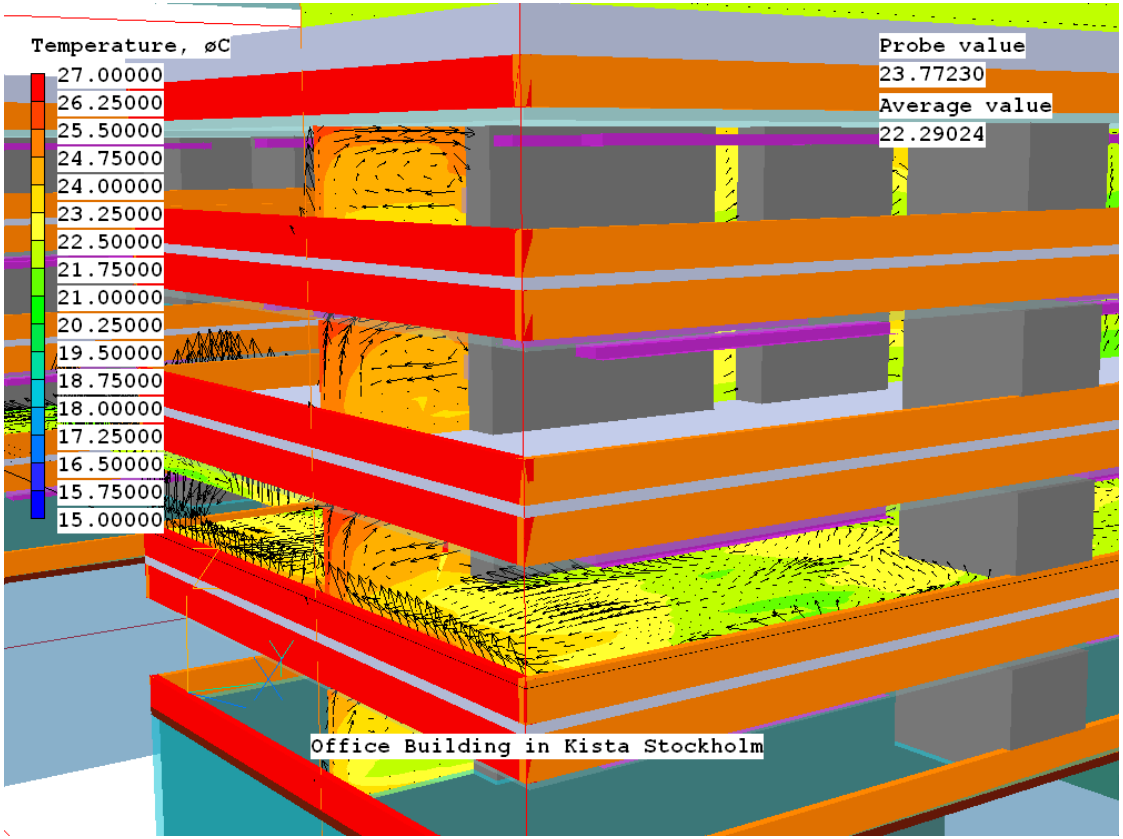


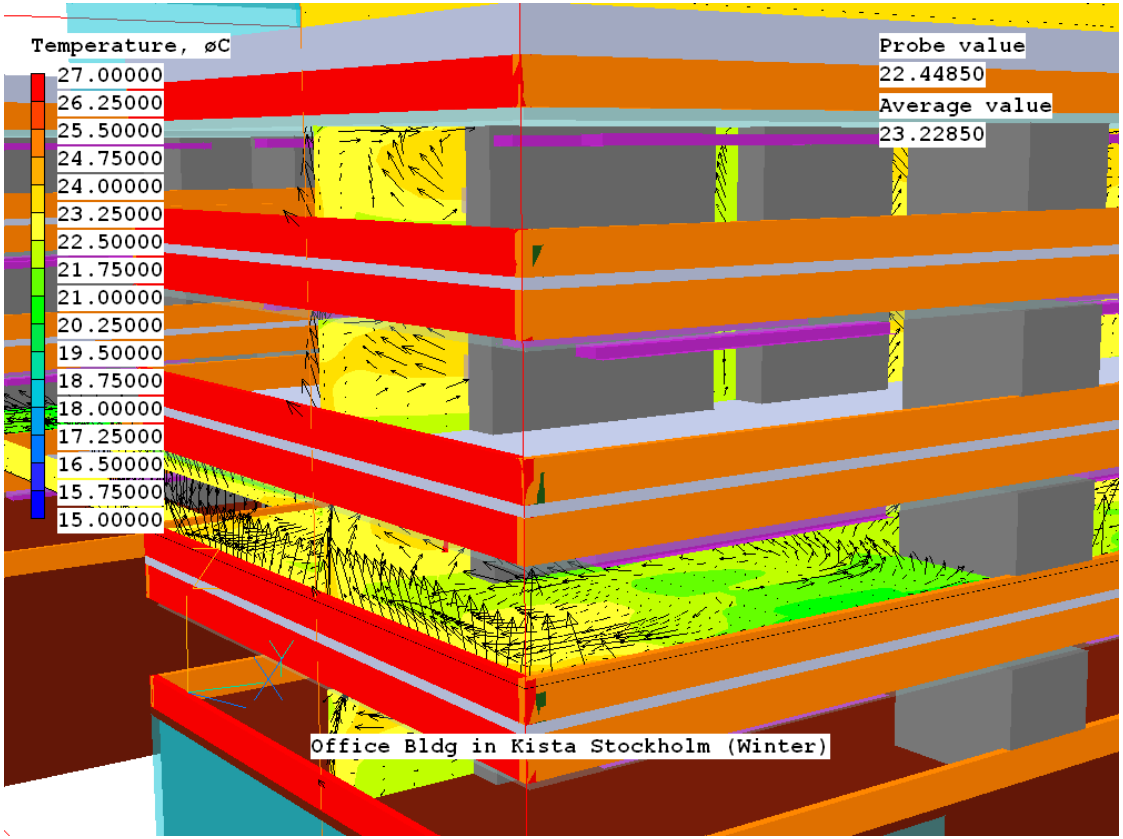
Results

- Temperatures in one of the rooms



Results

- Temperatures in one of the rooms



Conclusion

- These, and more-detailed, results were supplied to support evidence from CHAM's customer to demonstrate the effectiveness of the building's HVAC design under atypical weather scenarios.

END