Indoor air humidity of monuments and hygrothermal surface conditions

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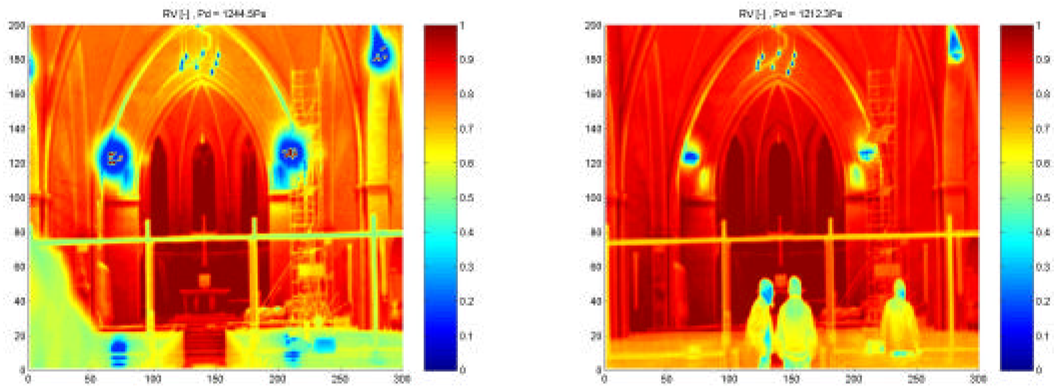
ABSTRACT
The indoor air humidity of monumental buildings is important for the preservation of the building and its valuable interior parts. For mould germination e.g. on an indoor surface the water activity at the surface is an important quantity. A method was developed for a graphical representation of the relative humidity near the surface, by measuring the surface temperatures as a function of time by infrared thermography and simultaneously determining the mean vapor pressure of the air. From these measurements mould germination on indoor surfaces can be predicted in an early state, making use of a representation in so-called hygrographic pictures. The saturation pressure at the indoor surface is related to the indoor surface temperature and can be derived from infrared thermal images of the indoor surface. Each pixel in an infrared thermograph represents an infrared measured surface temperature. A Matlab routine has been written to calculate the relative humidity near the surface at each pixel in the thermograph, from the saturation pressure of the measured surface temperature at that pixel and the measured vapor pressure. The result is, what will be called, a surface hygrograph: a two-dimensional representation of the relative humidity close to the surface.

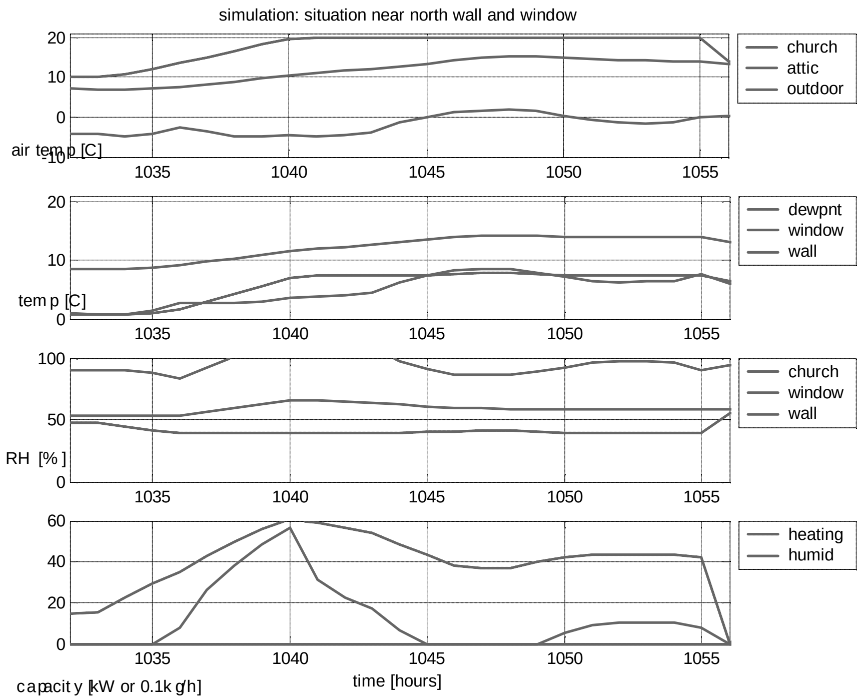
Open air gas infrared heating e.g. produces a lot of vapor, which may lead to high indoor air absolute humidities and therefore to condensation on cold exterior walls and glazing.



Relative humidity near the surface as calculated from absolute humidity and thermographic surface temperatures; during 2 hours of open air gas heating (left), directly after heating (right)

Due to (air) heating under cold winter conditions the relative humidity drops and this may lead to severe low indoor air relative humidities for interior parts like monumental organs. The results are cracking of wooden parts and other drying out problems. Humidification would be a solution, but may lead to high relative humidities near cold exterior surfaces.
To account for the expected behaviour of a church for yearly or more extreme winter weather conditions, and to account for realistic thermal and hygric surface behaviour, the computer program WaVo, a computer simulation program on heat and moisture, has been used. To take into account moisture adsorption and desorption processes near the walls, WaVo has been adapted to account for (Wit 2000). The existing computer simulation model WaVo was adapted for the hygroscopic behaviour and vapor diffusion process in the mostly very thick

church walls, different heating and humidifying systems and controls to describe the temperature and humidity behavior of a monumental church. The model was used for the prediction of the relative humidity near cold surfaces in a church.



Sunday with a service and a minimum outdoor temperature of -5?C

The figure above shows a prediction of the air temperature, dewpoint and relative humidity in a church with air heating and humidification. The relative humidity near the surface is calculated from the absolute humidity and the calculated surface temperatures. A relation with the heating and humidification capacity is given.

The model thus can be used to predict the humidification effects in a church for different strategies of church heating.

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