

Henk Schellen
Edgar Neuhaus

**Klimatiseren van grote monumentale ruimten
en BaOpt**



Inhoud lezing

- Luchtverwarming en schade aan monumentale interieurs, zoals orgels
- Mogelijke innovatieve oplossingen:
 - Verlagen Archimedesgetal
 - Bankverwarming
 - Intelligente regeling (zoals BaOpt?)

Waalse Kerk Delft



Waalse Kerk Delft: Bätz/Witte orgel 1869



Bätz/Witte orgel 1869



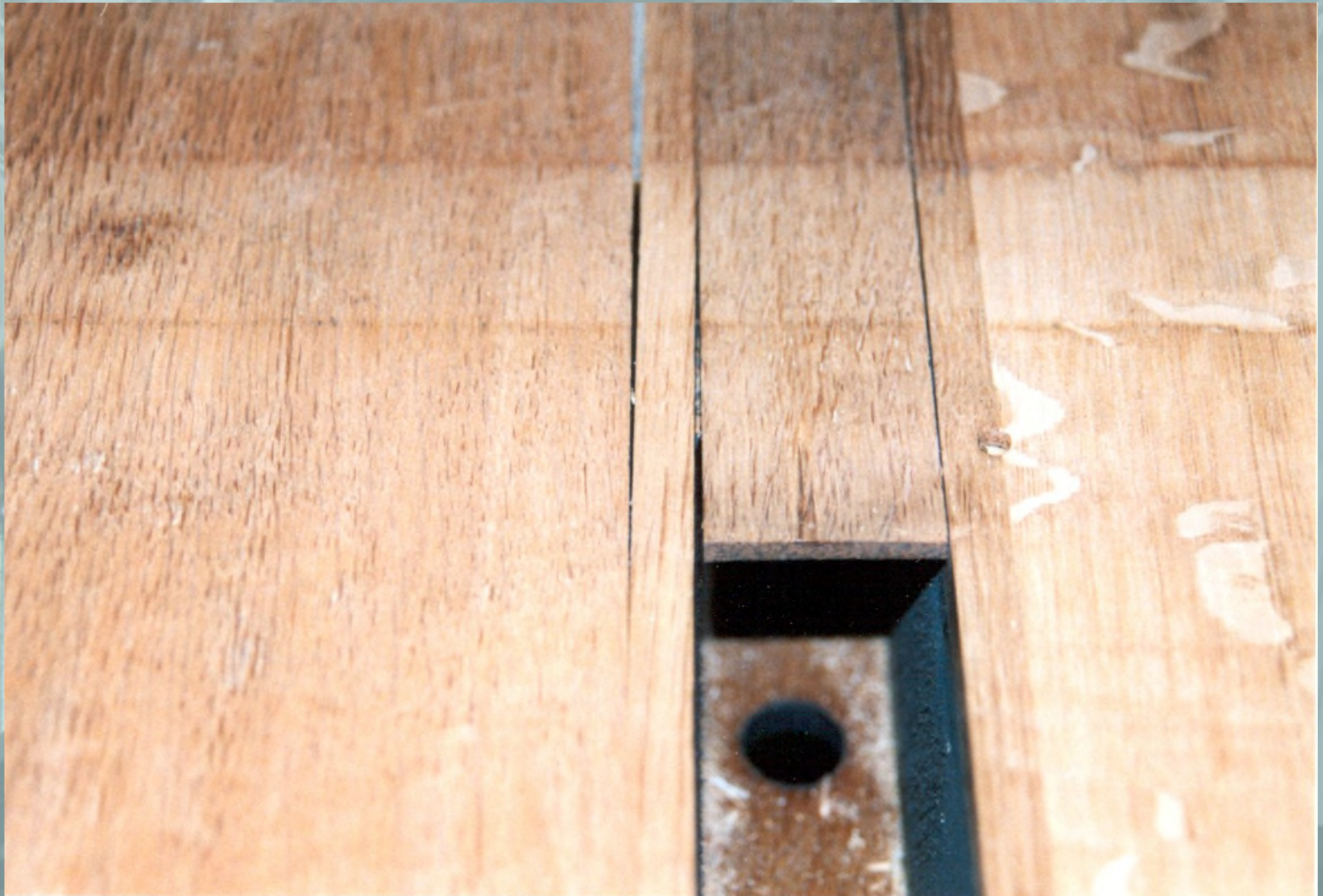
Probleem definitie

- ‘Hete’ luchtverwarming
- Temperatuur stratificatie
- Orgel schade
- Scheurvorming in hout

Scheurvorming windladen



Scheurvorming windladen



Scheurvorming houten constructiedelen



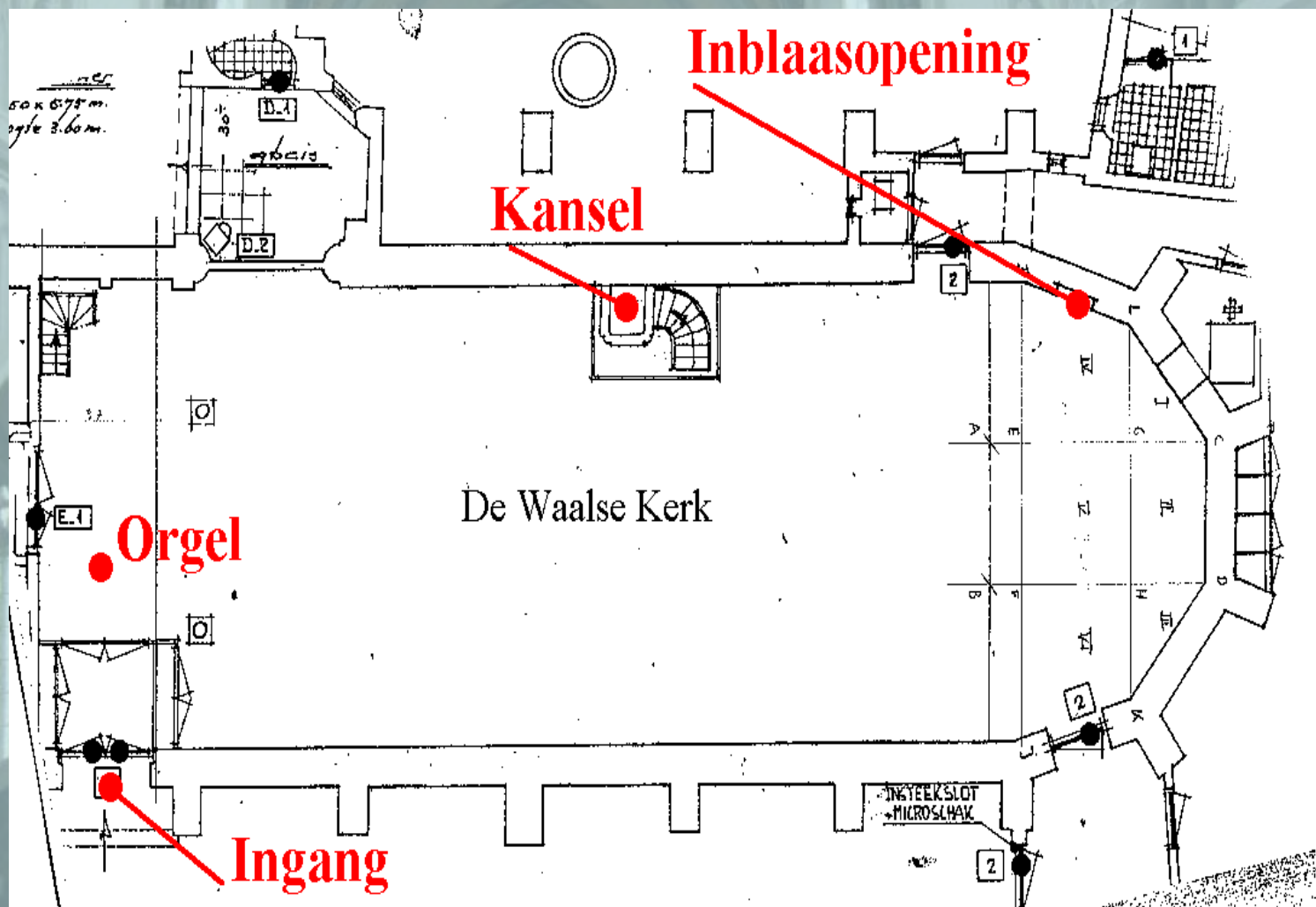
Deformatie houten panelen cabinet



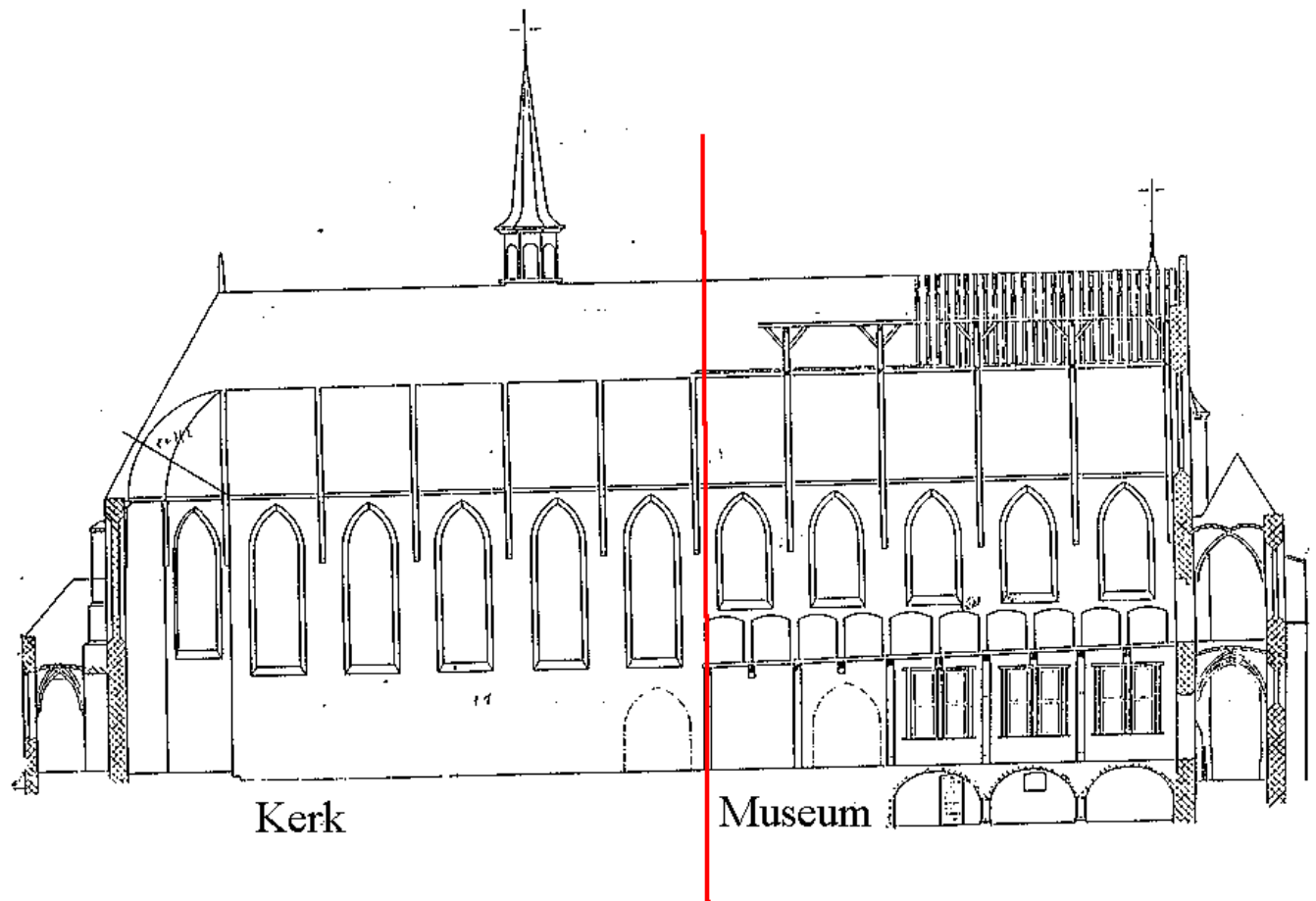
Afbladderen verf kabinet



Plattegrond



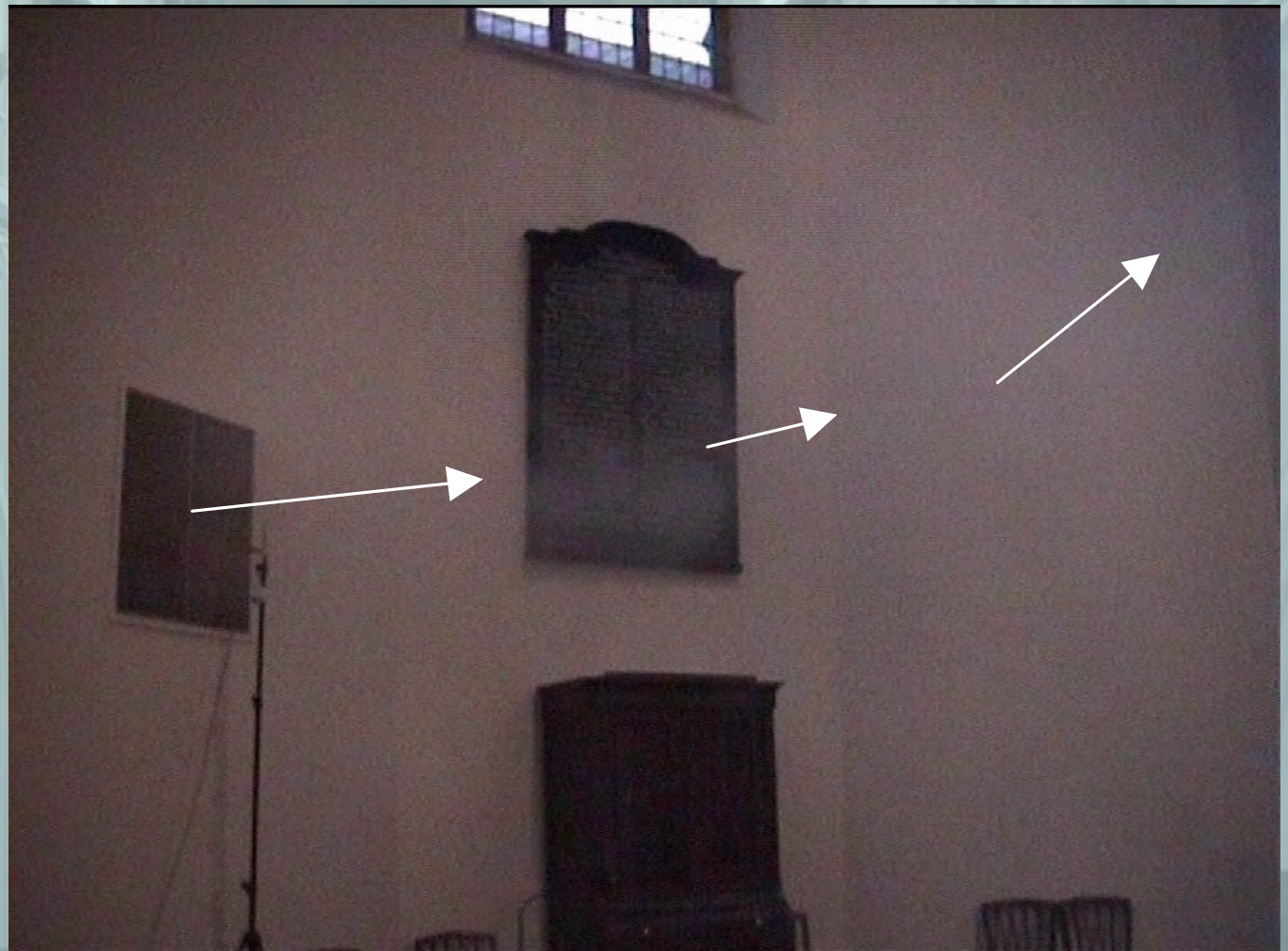
Langsdoorsnede



Visualisatie luchtstroming

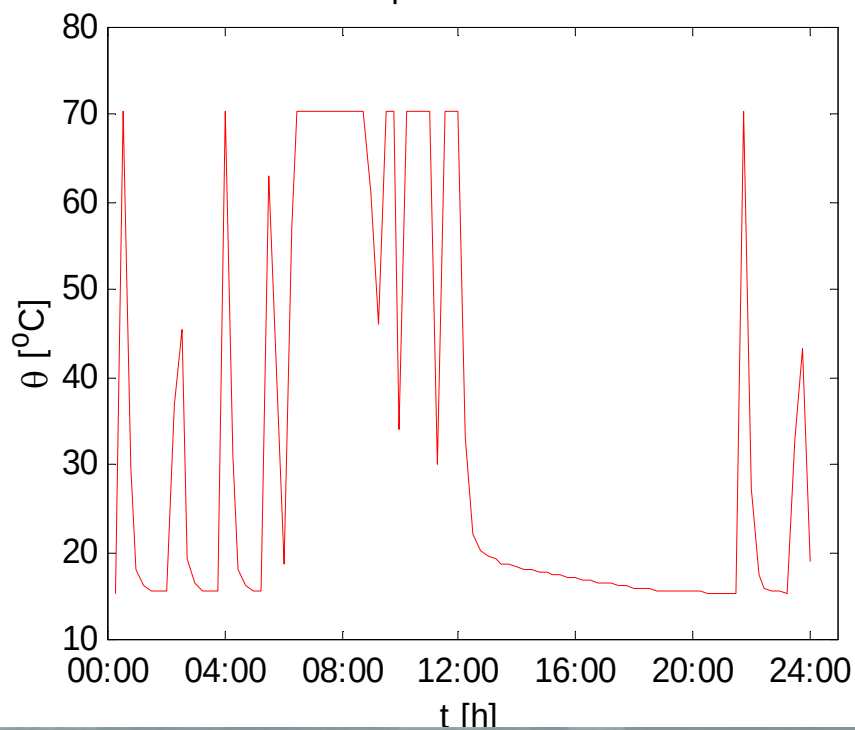


Visualisatie luchtstroming

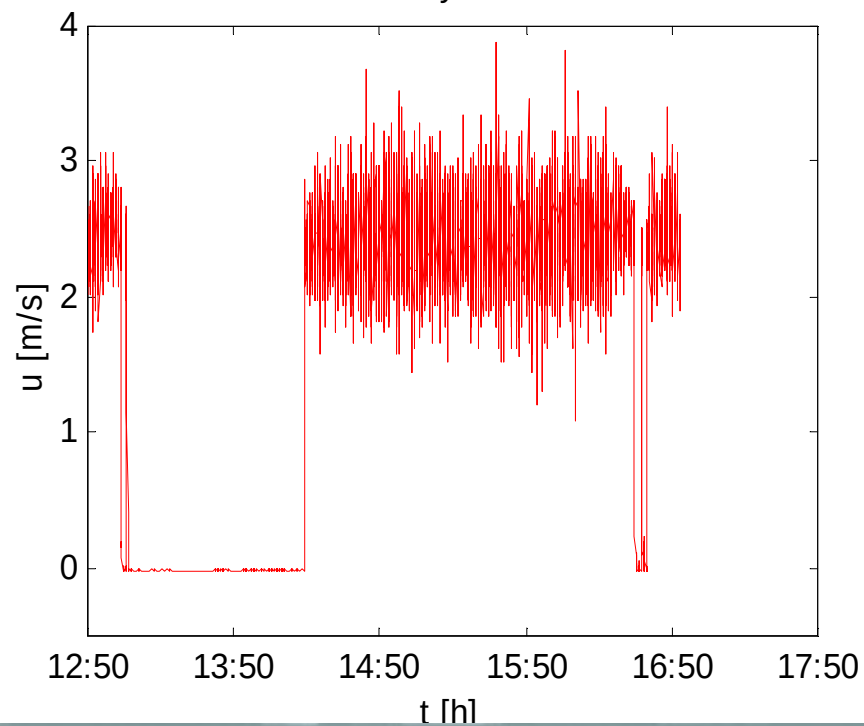


Lucht inblaascondities

Air temperature near inlet

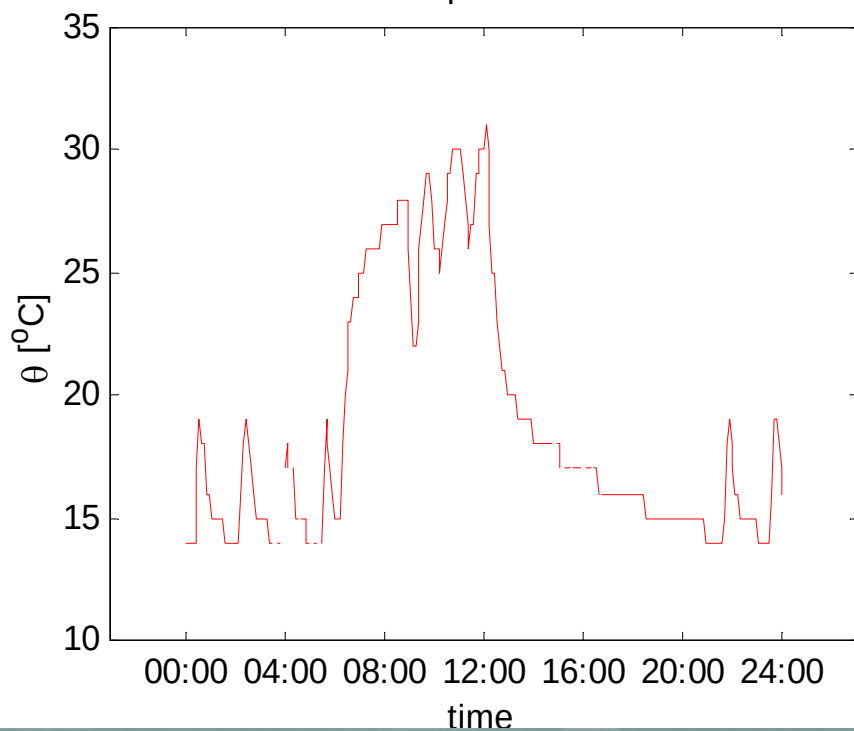


Air velocity near inlet

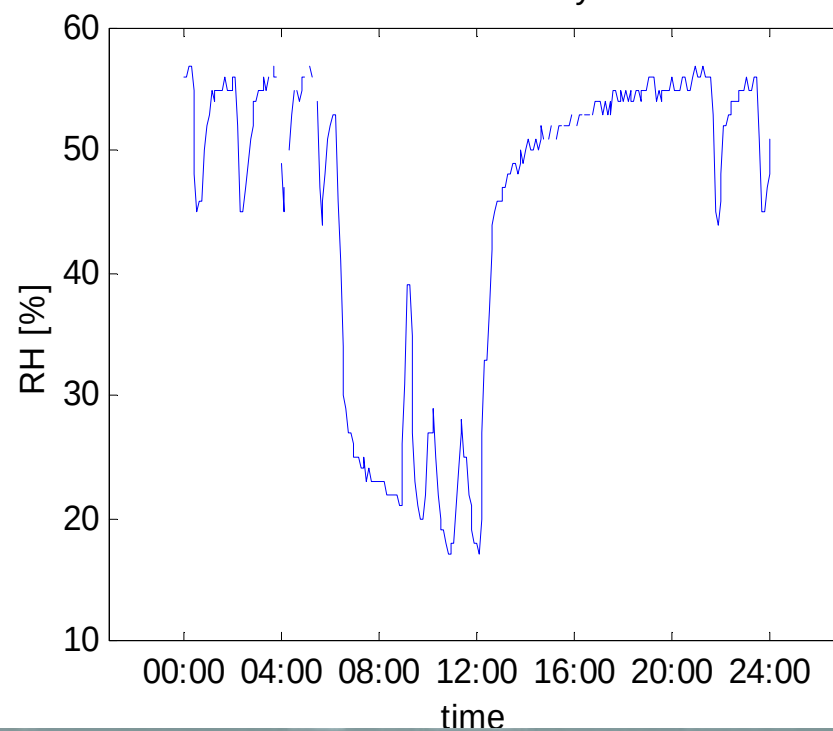


Luchtcondities nabij het orgel

Temperature

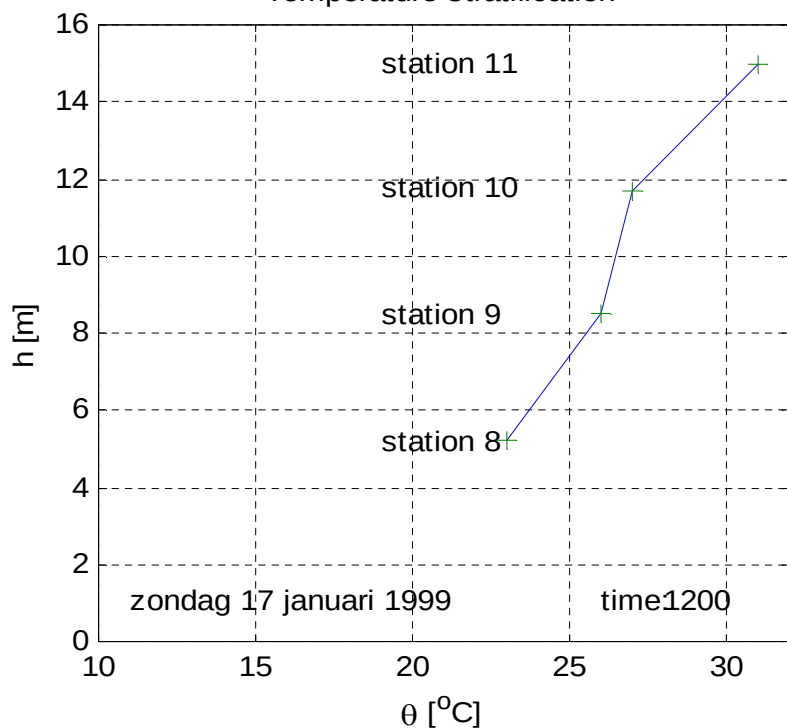


Relative humidity

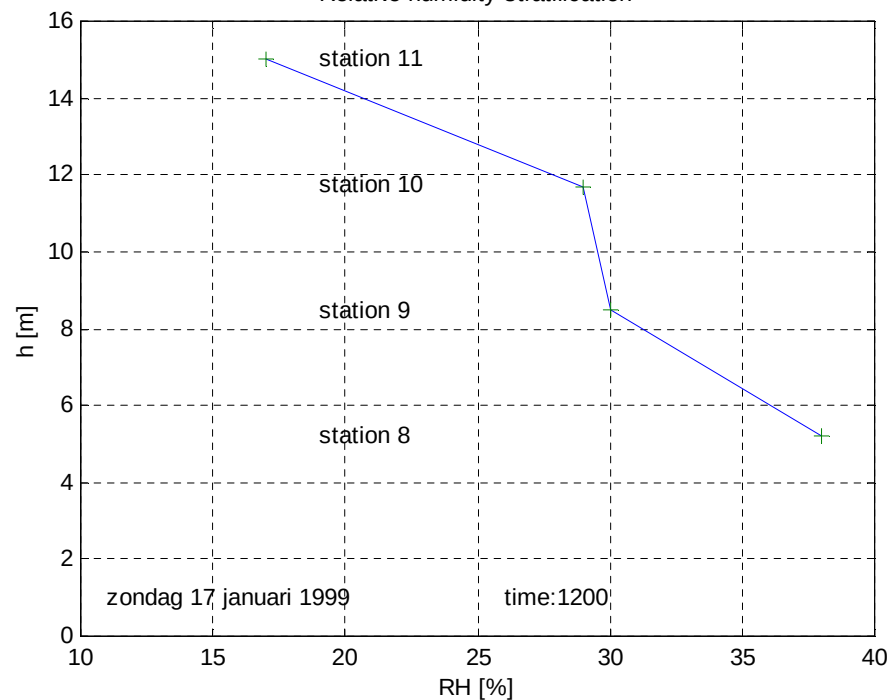


Temperatuur- en RV stratificatie

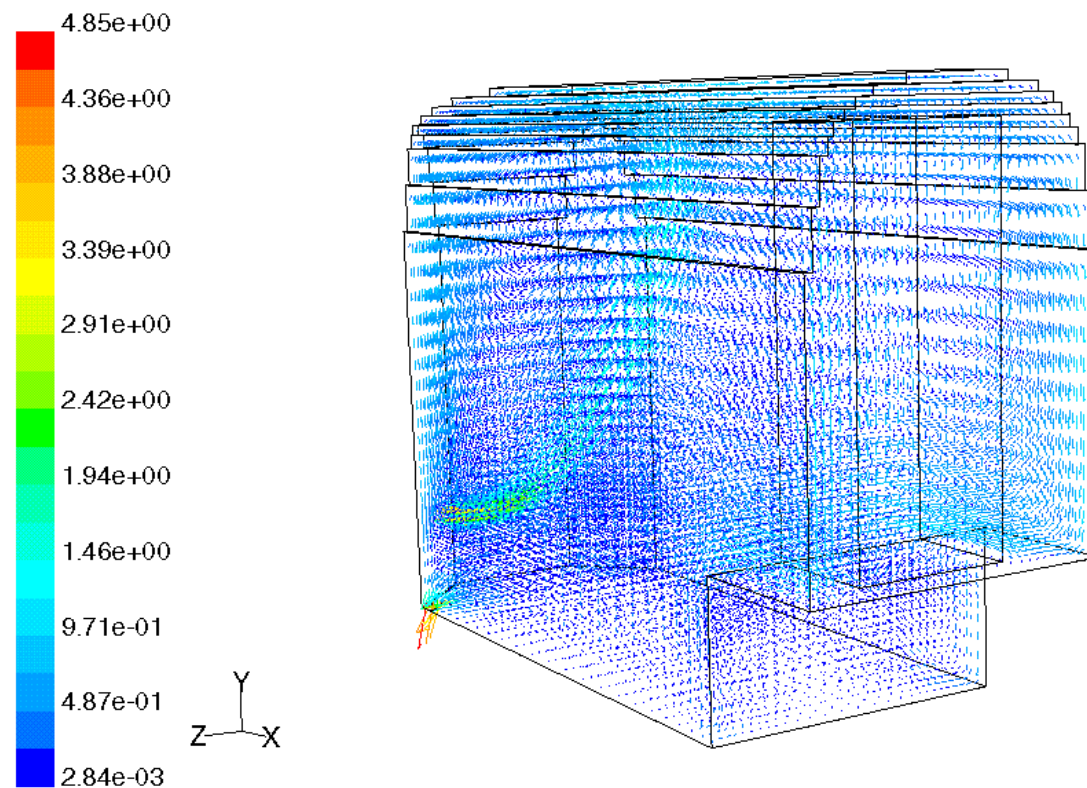
Temperature stratification



Relative humidity stratification



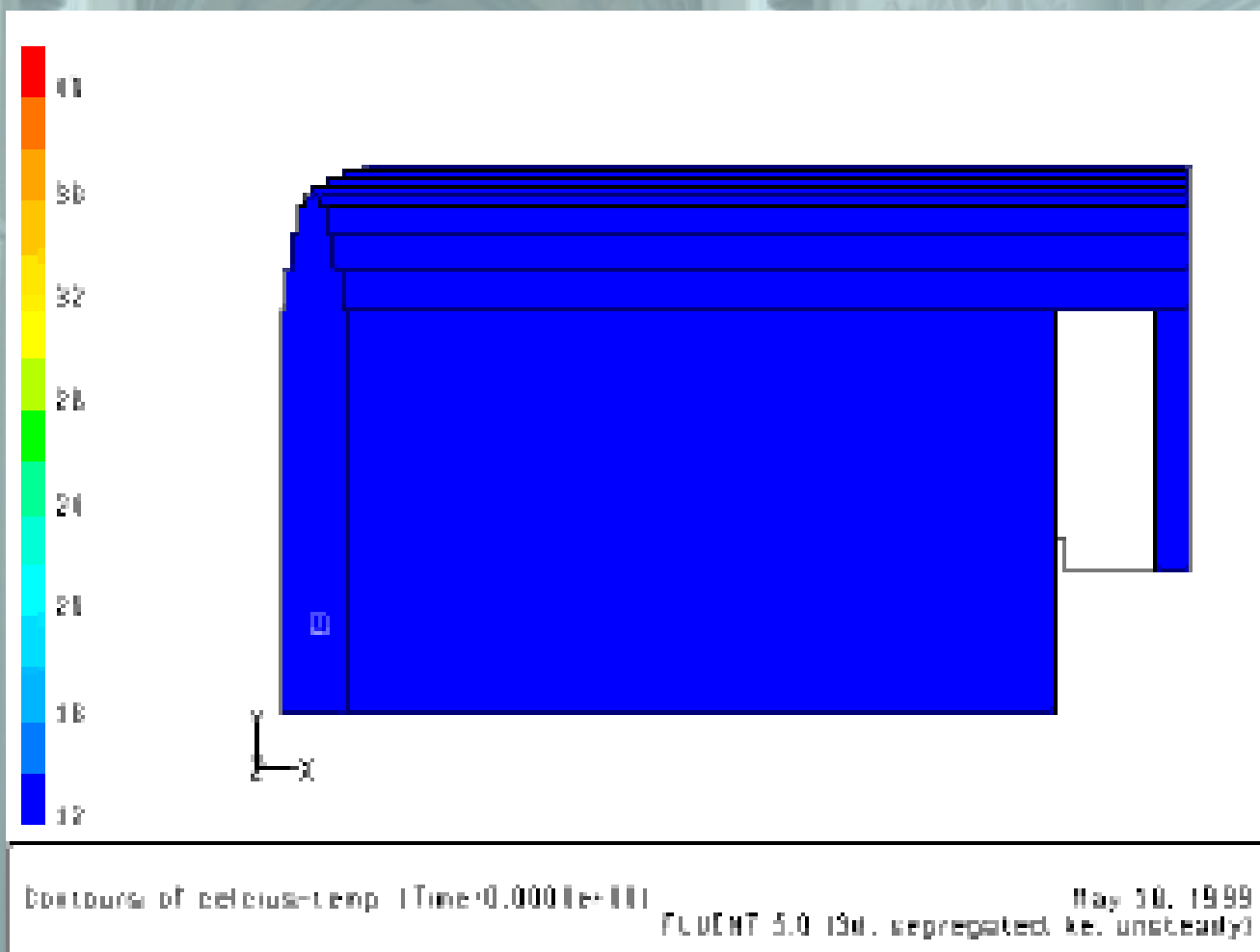
Simulatie luchtstroming via CFD



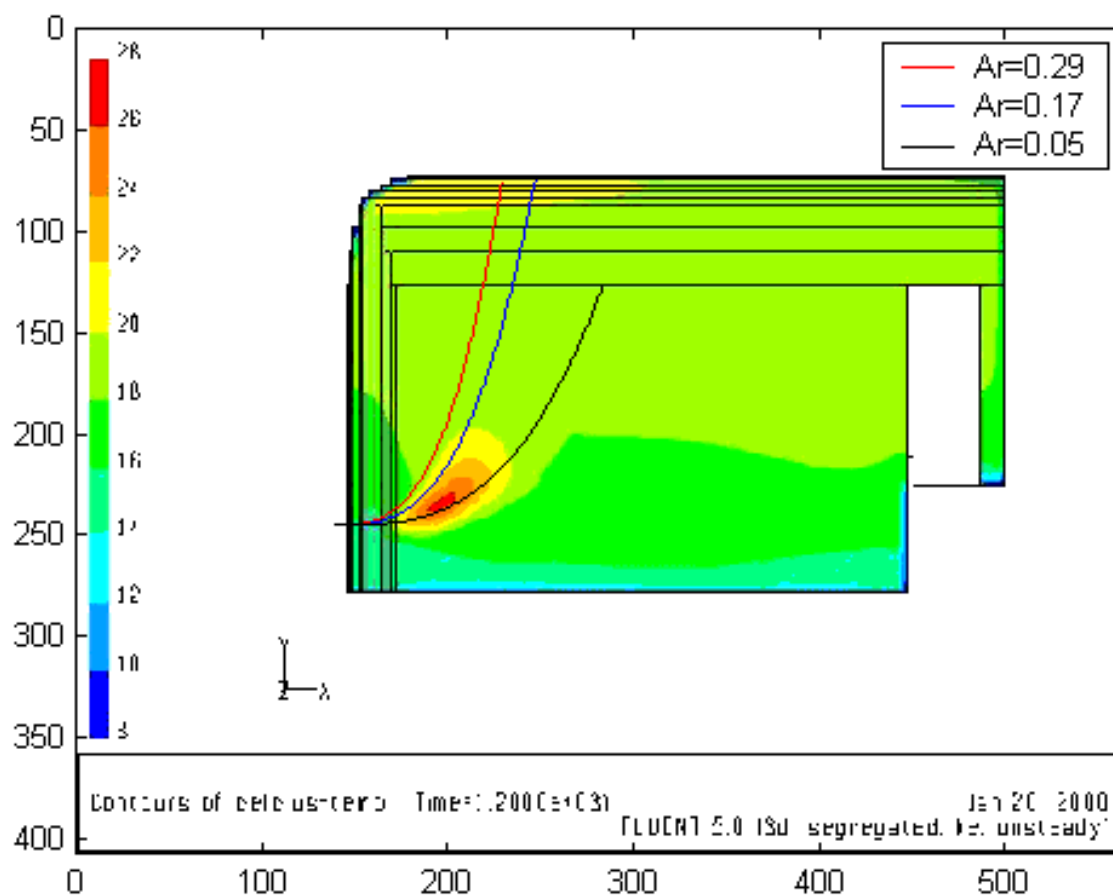
Velocity Vectors Colored By Velocity Magnitude (m/s) (Time=1.5000e+04)

Apr 19, 1999
FLUENT 5.0 (3d, segregated, ke, unsteady)

Simulatie luchtstroming via CFD



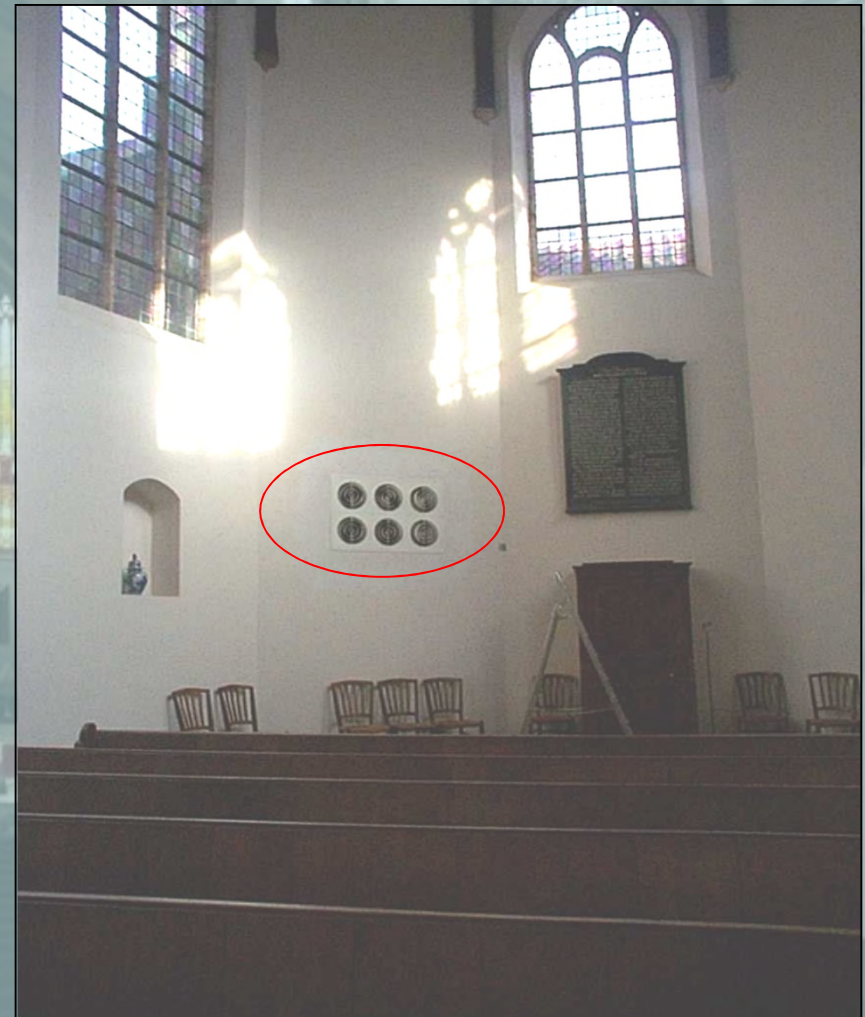
Archimedes Nummer



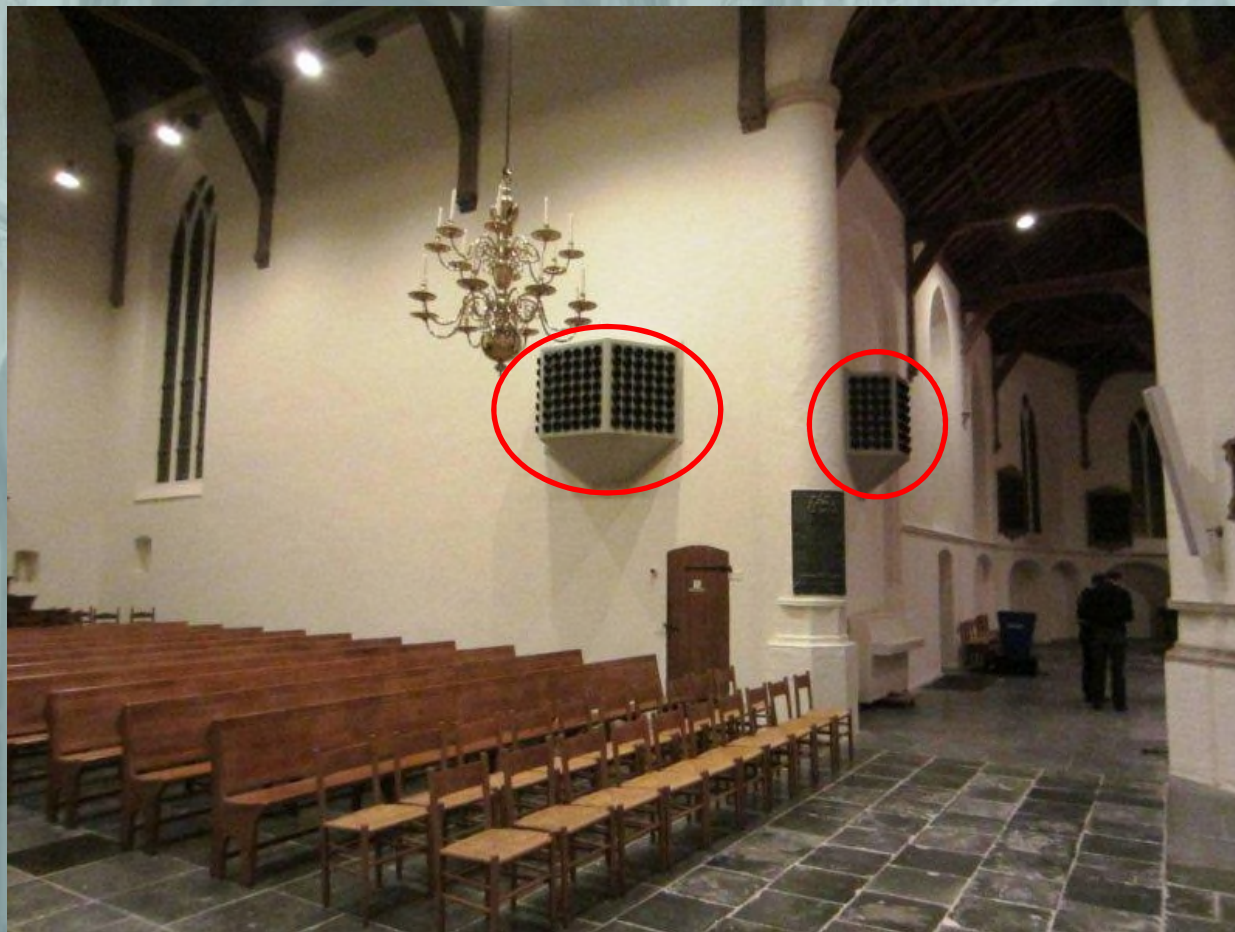
Mogelijke oplossingen St. Petruskerk?



Verlagen Archimedes Nummer? (Waalse kerk, Delft)



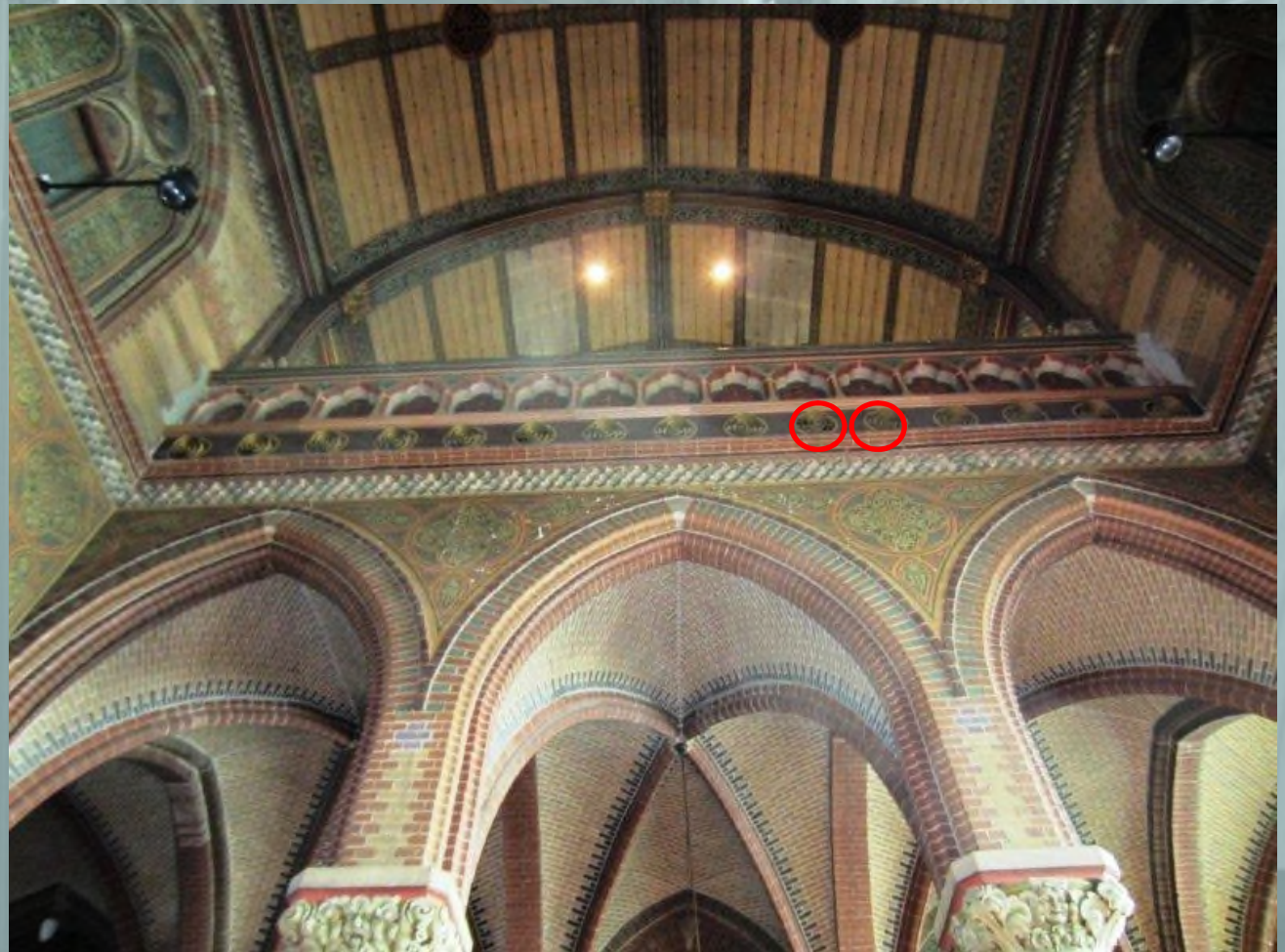
Verlagen Archimedes Nummer? (Grote of Barbarakerk Culemborg)



Verlagen Archimedes Nummer? (Bonifaciuskerk, Alphen a/d Rijn)



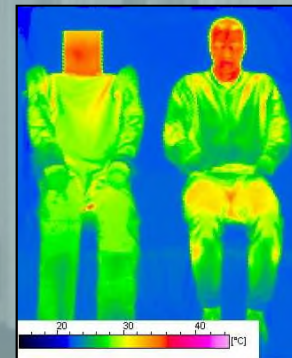
Verlagen Archimedes Nummer? (Bonifaciuskerk, Alphen a/d Rijn)



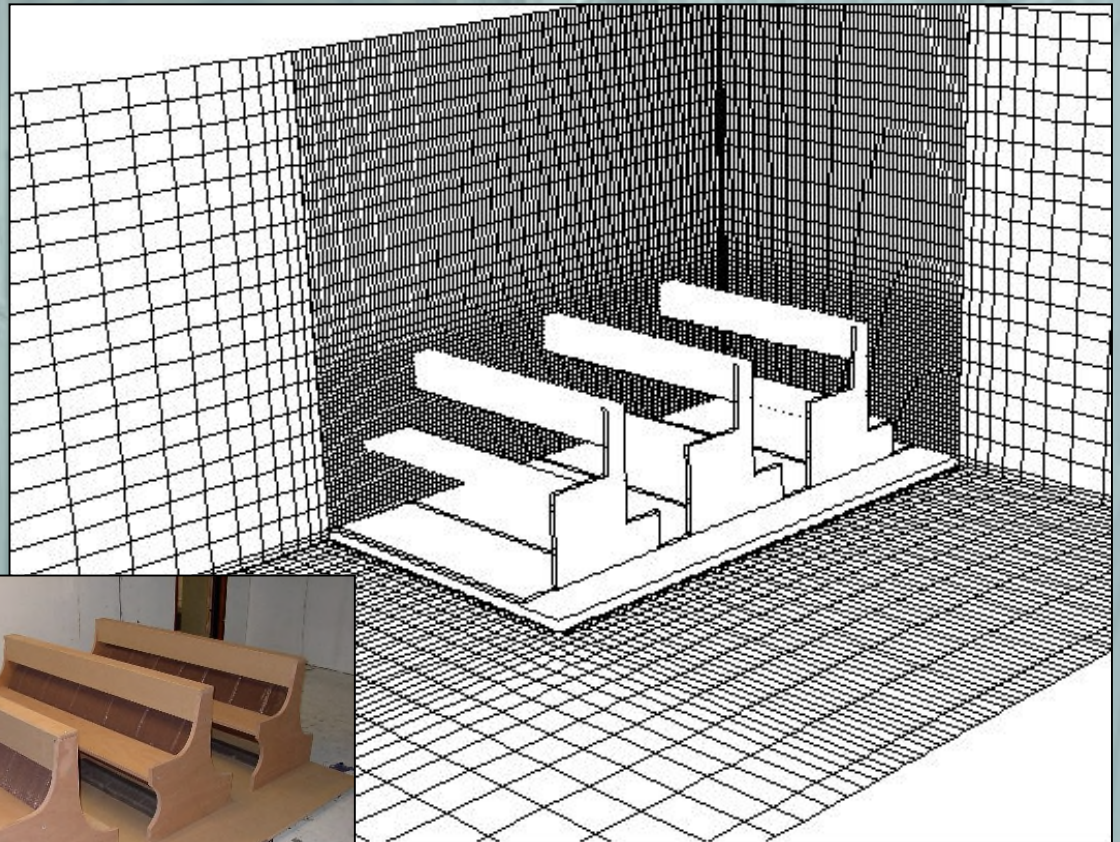
Verlagen Archimedes Nummer? (Bovenkerk Kampen)



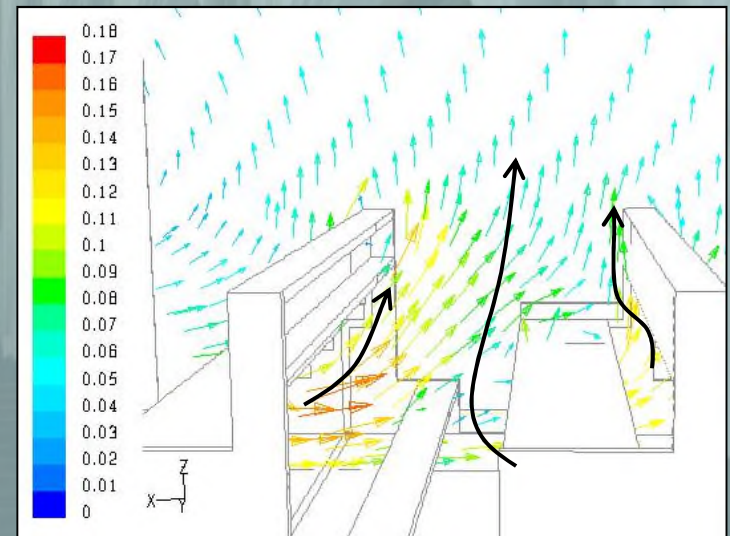
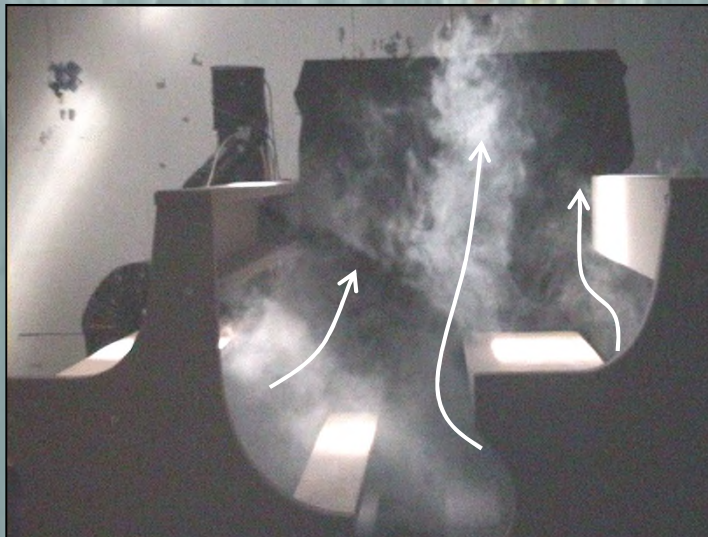
More friendly heating?



EU project Friendly Heating

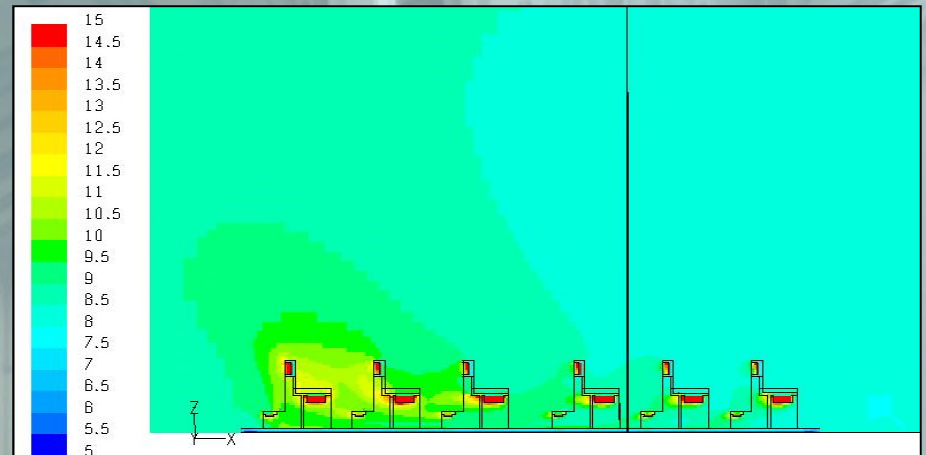


EU project Friendly Heating

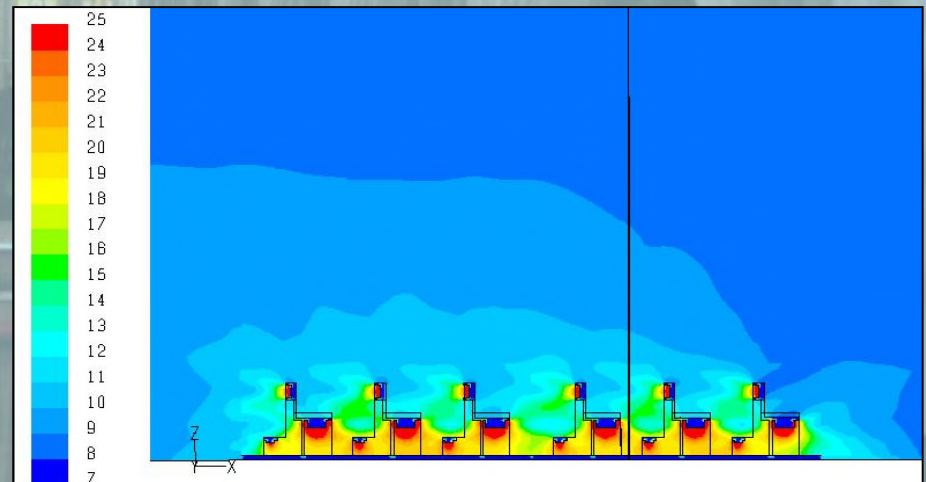


EU project Friendly Heating

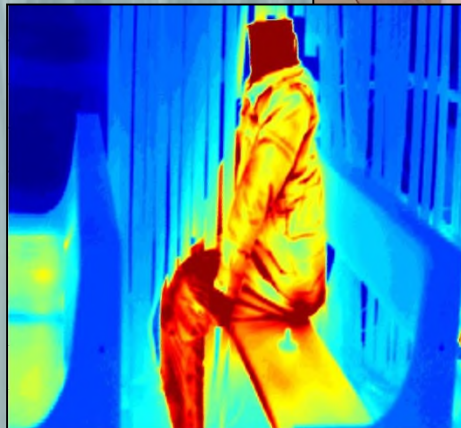
Air temperature [°C]



Radiant temperature [°C]



Waardering thermisch comfort



Intelligente regeling? BaOpt: Bauer Optimierung



Rijksdienst voor het Cultureel Erfgoed
Ministerie van Onderwijs, Cultuur en
Wetenschap



rijksuniversiteit
 groningen

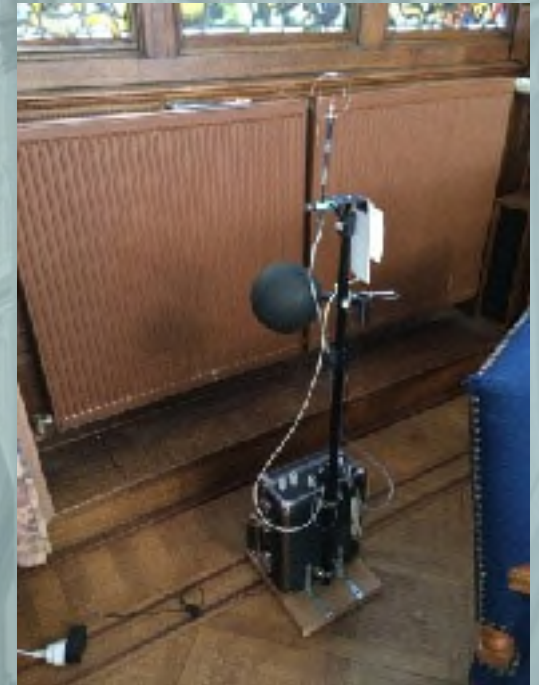


Technische Universiteit
Eindhoven
University of Technology



Aula





- 'Inversie is een natuurverschijnsel waarbij warme koude (relatief zware) lucht over warmere lucht heen schuift en deze opsluit.'
- 'Moleculen in een gas onder druk gedragen zich anders dan bij vrije stroming. De kans op botsingen neemt toe en energie wordt sneller doorgegeven'.
- 'Bij de juiste combinatie van druk & temperatuur ontmengen de lagen zich en ontstaat een geheel van chaotisch bewegende deeltjes. Druk en temperatuur zijn dan overal gelijk.'
- 'BaOpt bootst dit evenwicht na in houdt de ruimte constant in een chaotische luchtverdeling met gelijke eigenschappen door de hele ruimte.'



De natuur als inspiratie

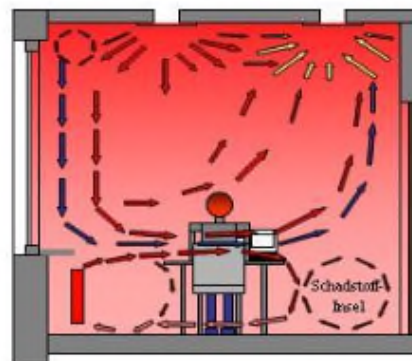


Inversie in luchtlagen



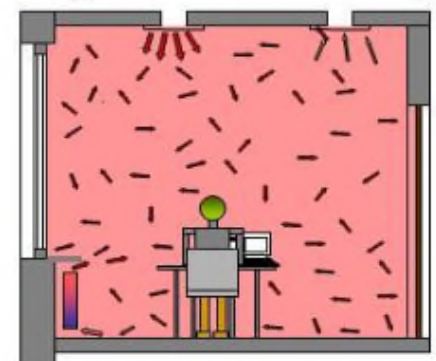
- Temperatuurverdeling bij inversie
- Temperatuurverdeling bij doorbreken inversie
- Normale temperatuurverdeling

Gerichtete Strömung



konventionell

Ungerichtete Strömung



BAOPT®

Links: Konventionelles Raumklima mit gerichteter Strömung

Rechts: Unggerichtete, chaotische Strömung mit BAOPT®

Oud

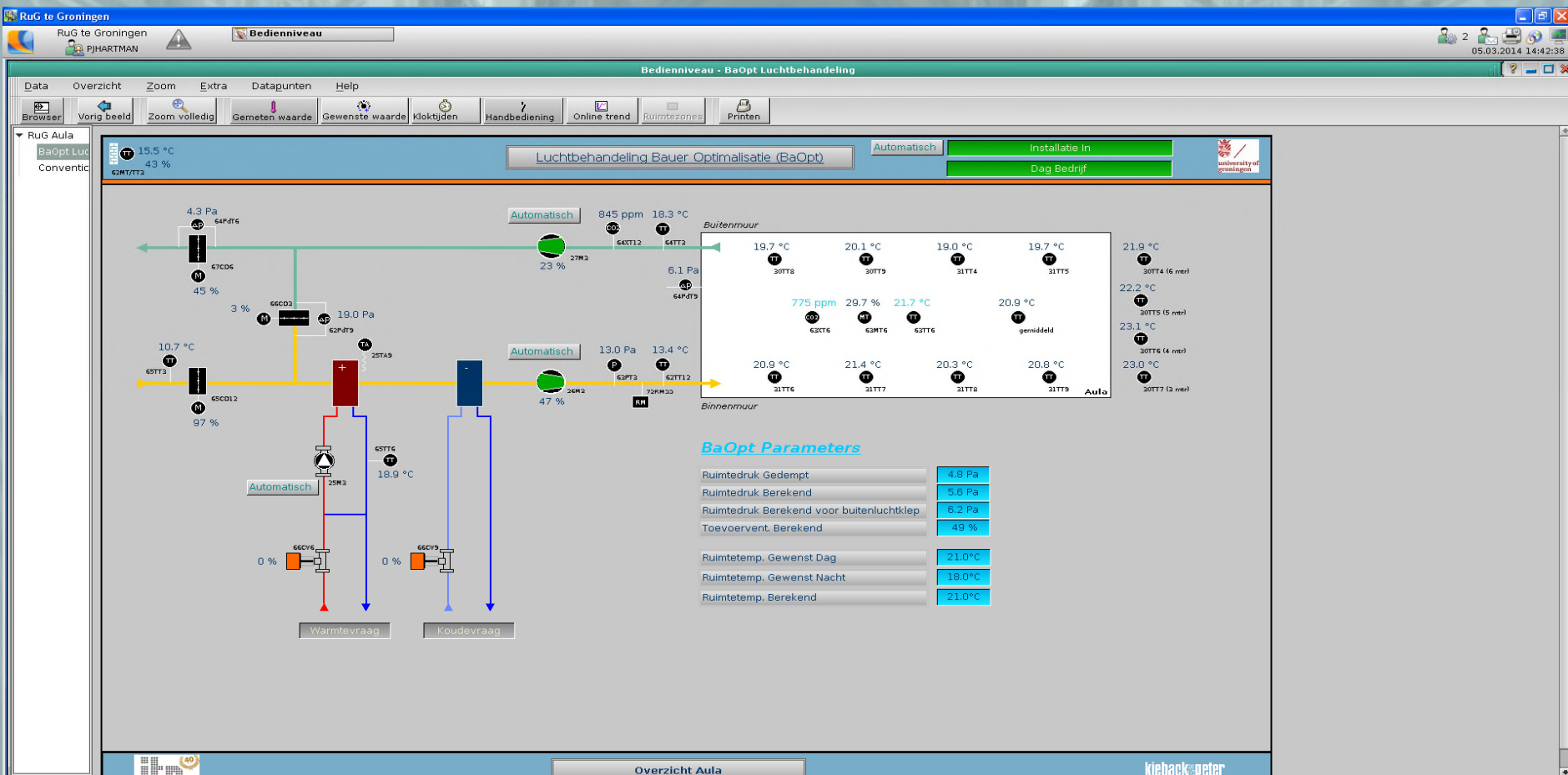


BaOpt

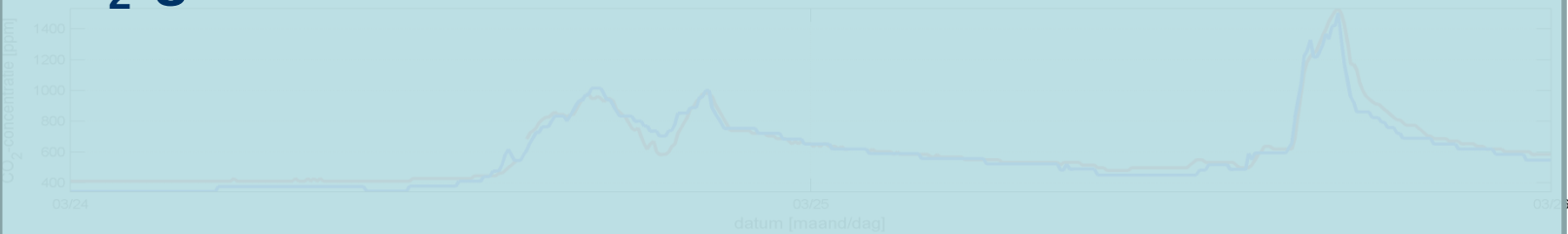




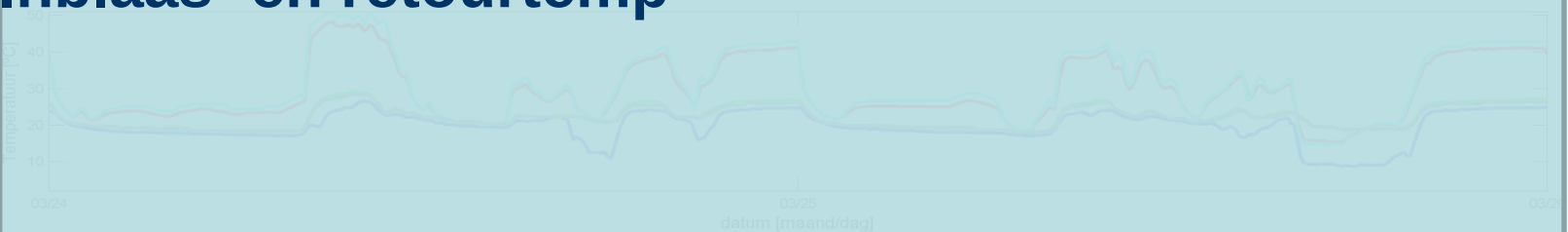
Installatie



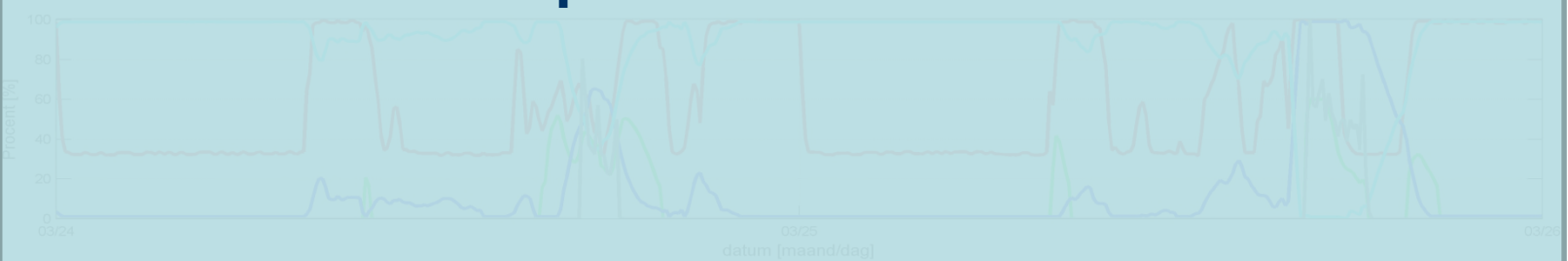
CO₂-gehalte



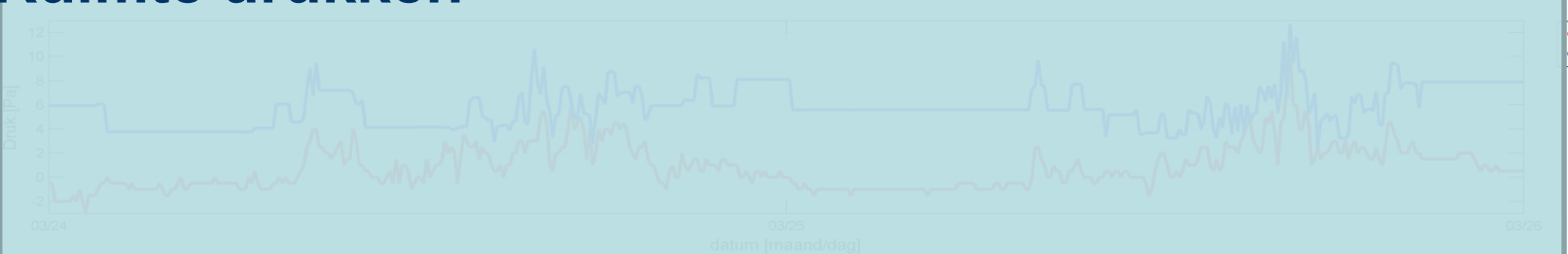
Inblaas- en retourtemp



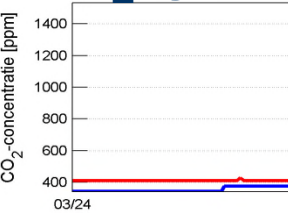
Ventilatoren en klepstanden



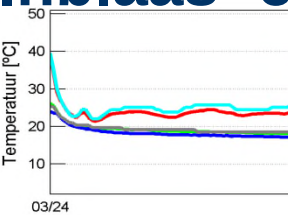
Ruimte drukken



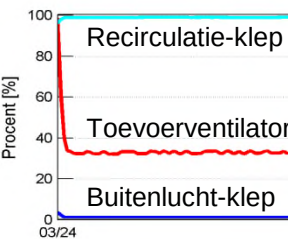
CO₂-gehalte



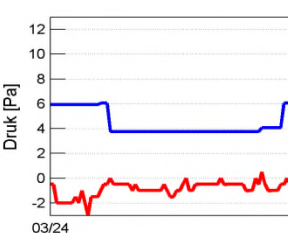
Inblaas- en retourtemp



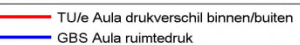
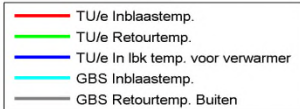
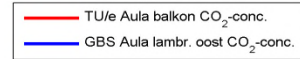
Ventilatoren en klepstanden



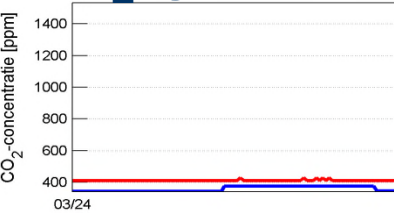
Ruimte drukken



**Volledige recirculatie,
Toevoer-ventilator laag
Retour-ventilator uit
Recirculatieklep open
Buitenluchtklep dicht**

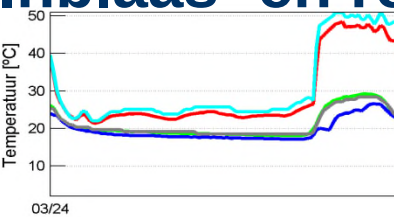


CO₂-gehalte

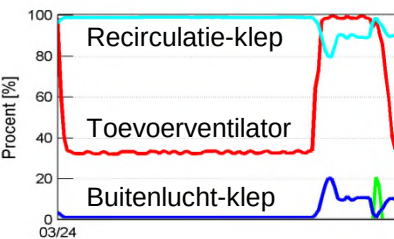


**Verwarmen:
optoeren toevoer-ventilator,
Recirculatie-klep 90%
Buitenlucht-klep 10%**

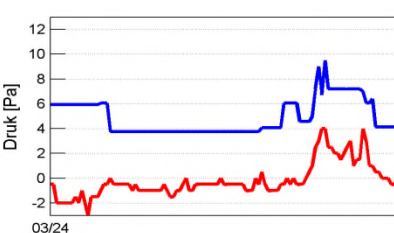
Inblaas- en retourtemp



Ventilatoren en klepstanden



Ruimte drukken



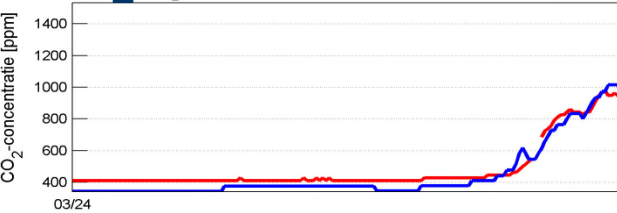
TU/e Aula balkon CO₂-conc.
GBS Aula lambr. oost CO₂-conc.

TU/e Inblaastemp.
TU/e Retourtemp.
TU/e In lbk temp. voor verwarmr.
GBS Inblaastemp.
GBS Retourtemp. Buiten

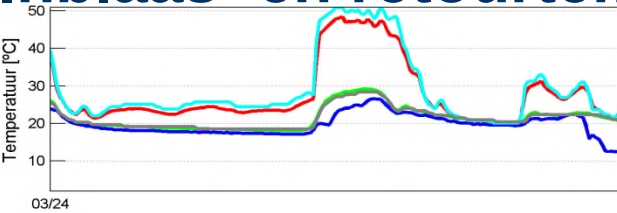
GBS Toevoerventilator sturing
GBS Retourventilator sturing
GBS Buitenluchtklep open
GBS Recirculatieklep lbk open
GBS Afblaasluchtklep open

TU/e Aula drukverschil binnen/buiten
GBS Aula ruimtedruk

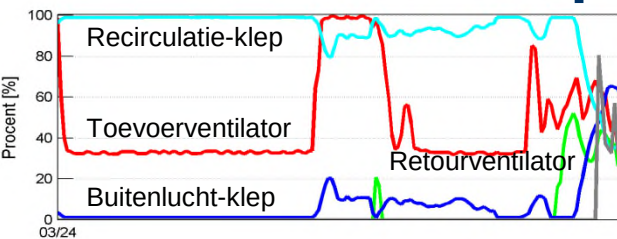
CO₂-gehalte



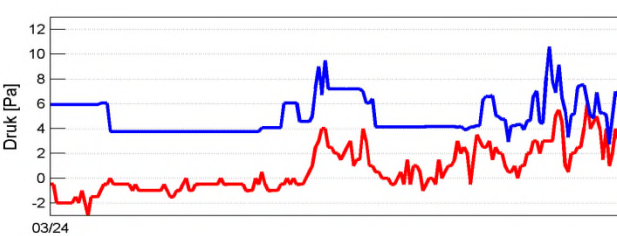
Inblaas- en retourtemp



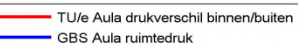
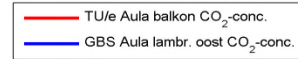
Ventilatoren en klepstanden



Ruimte drukken

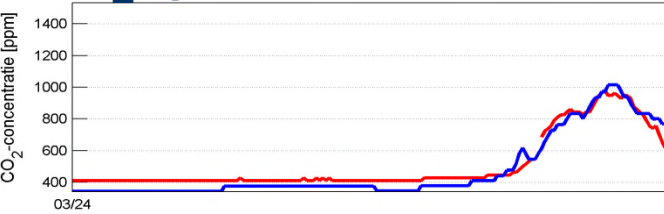


CO₂ gehalte hoog:
Buitenlucht-klep open,
Toevoer-ventilator
optoeren
Retour-ventilator aan,
Recirculatieklep-dicht

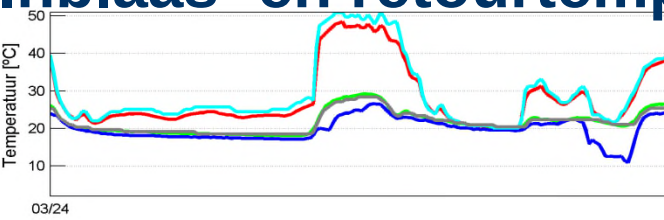


Herhaling

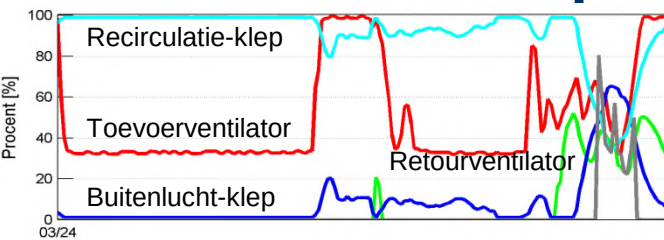
CO₂-gehalte



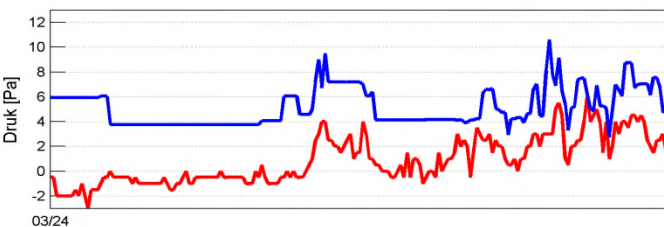
Inblaas- en retourtemp



Ventilatoren en klepstanden

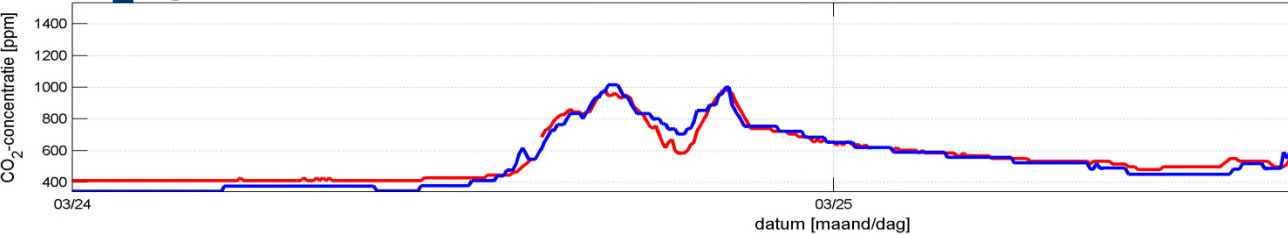


Ruimte drukken

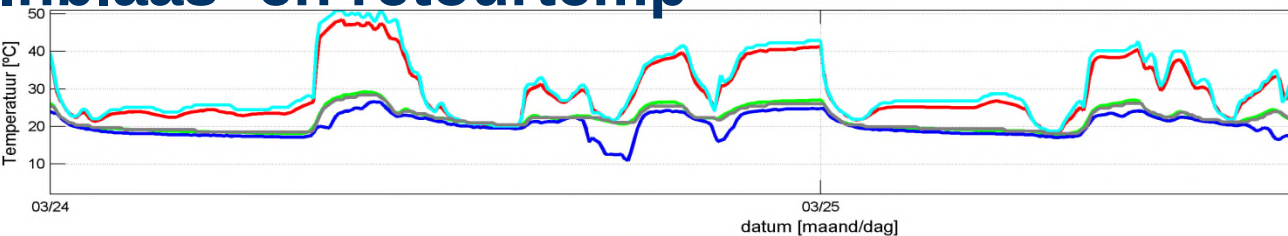


Druk in stand
houden door
Buitenluchtklep
te openen

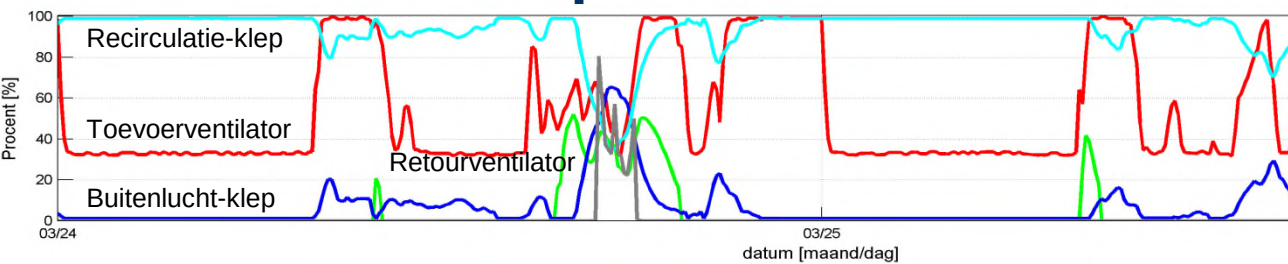
CO₂-gehalte



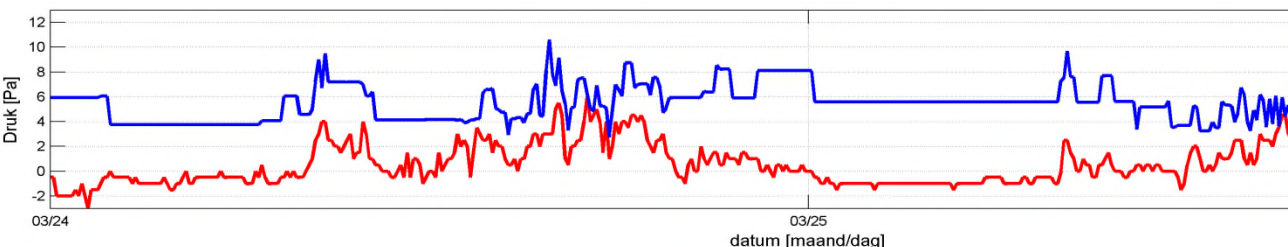
Inblaas- en retourtemp



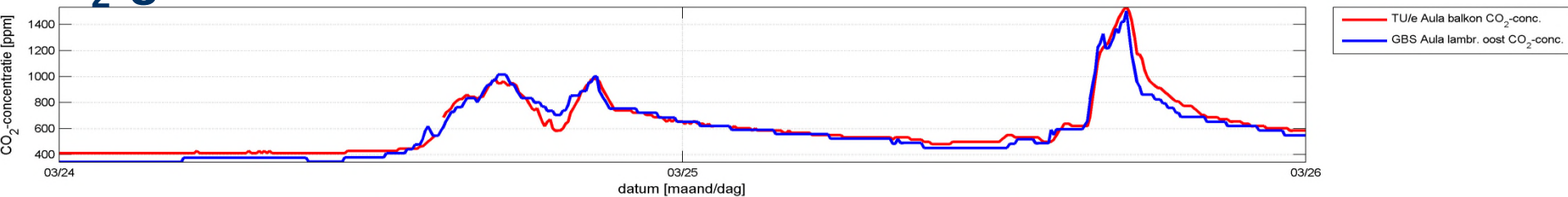
Ventilatoren en klepstanden



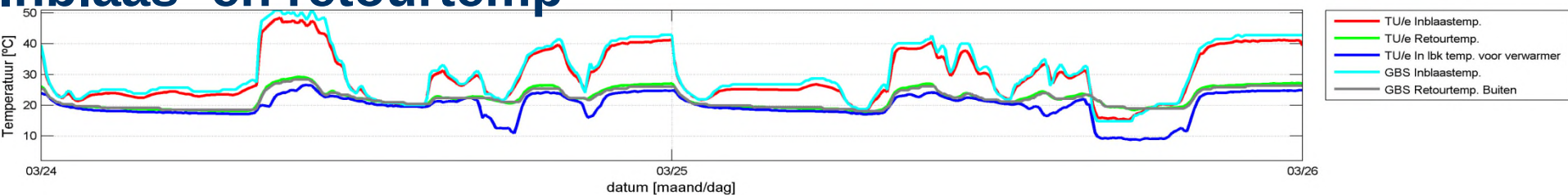
Ruimte drukken



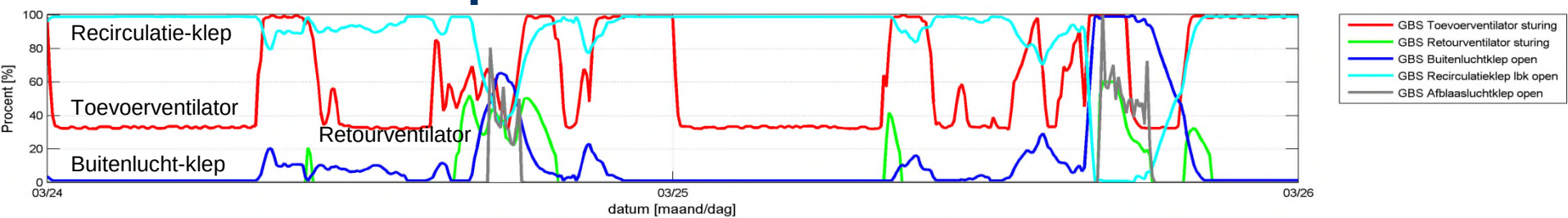
CO₂-gehalte



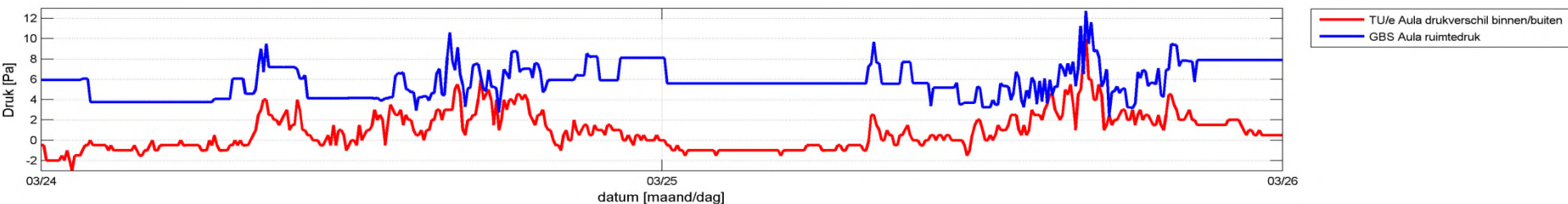
Inblaas- en retourtemp



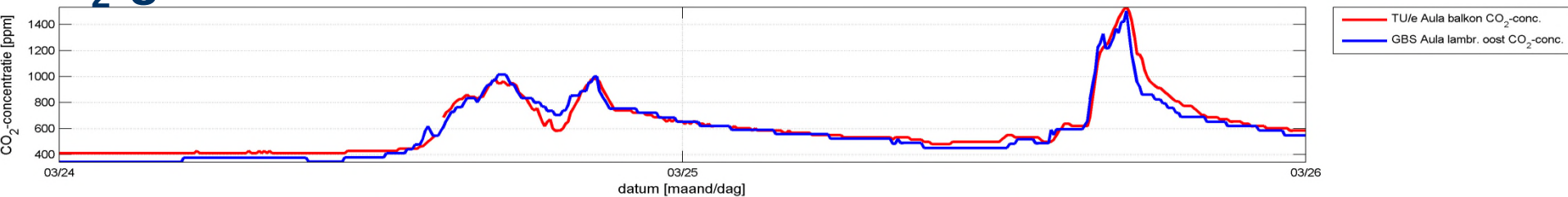
Ventilatoren en klepstanden



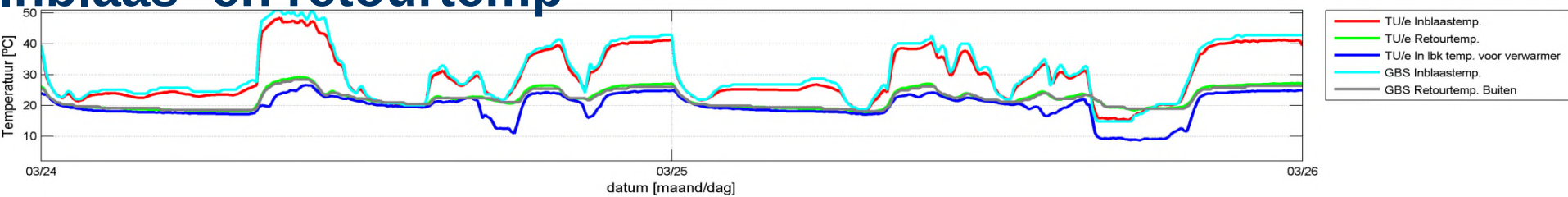
Ruimte drukken



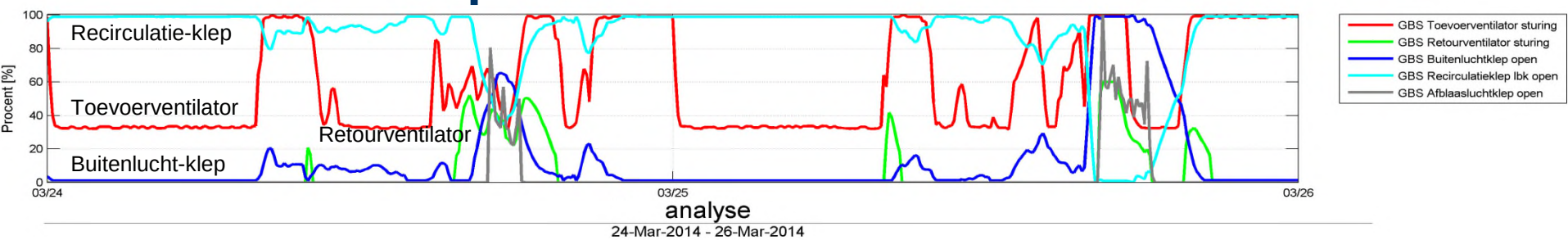
CO₂-gehalte



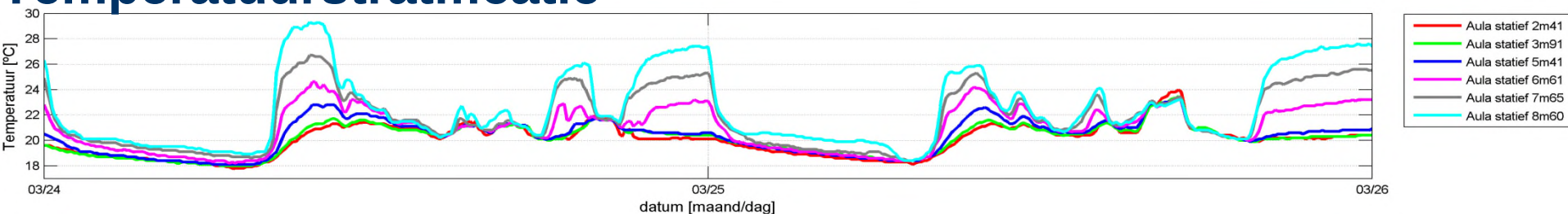
Inblaas- en retourtemp



Ventilatoren en klepstanden



Temperatuurstratificatie



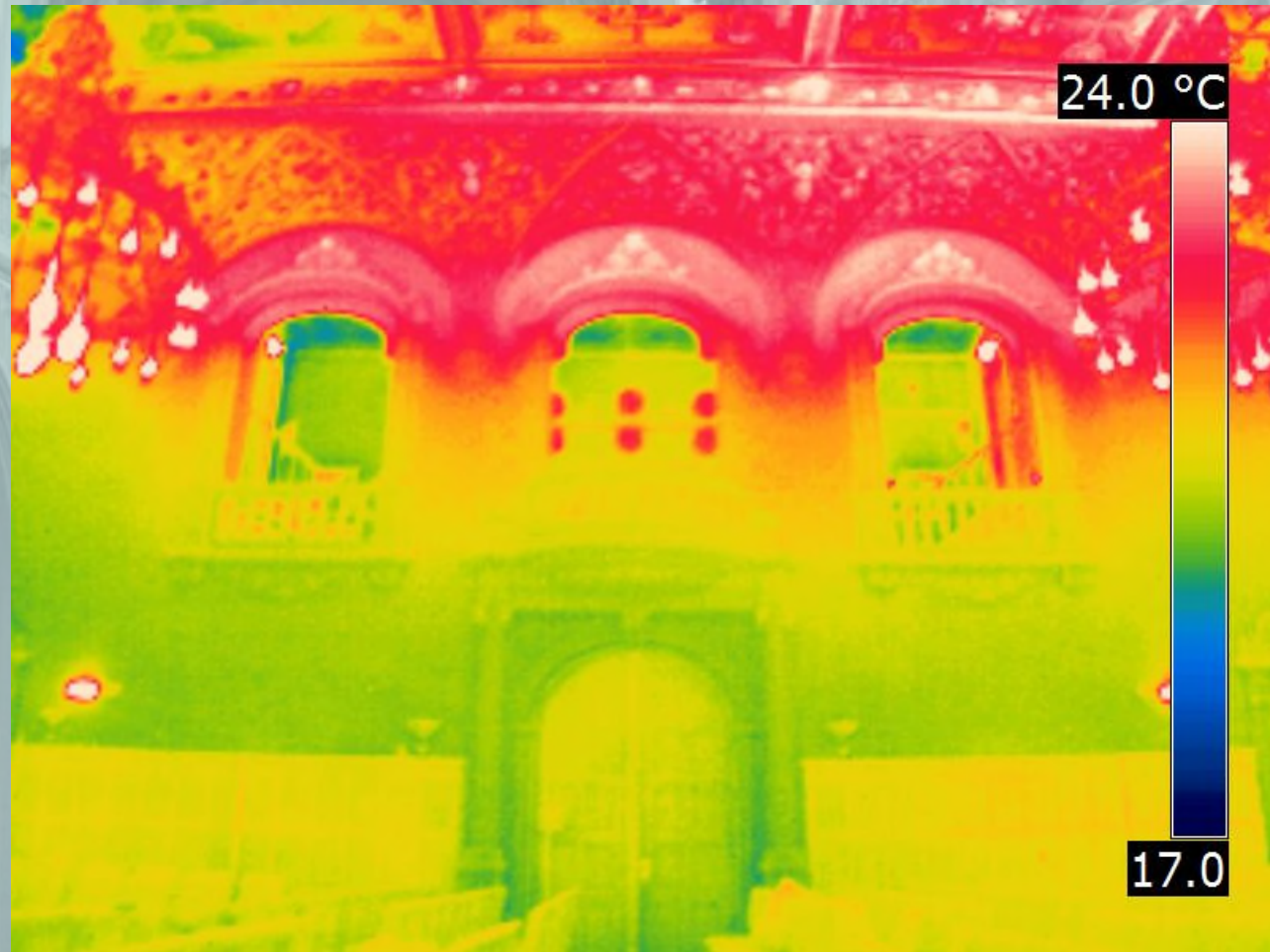
Stratificatie



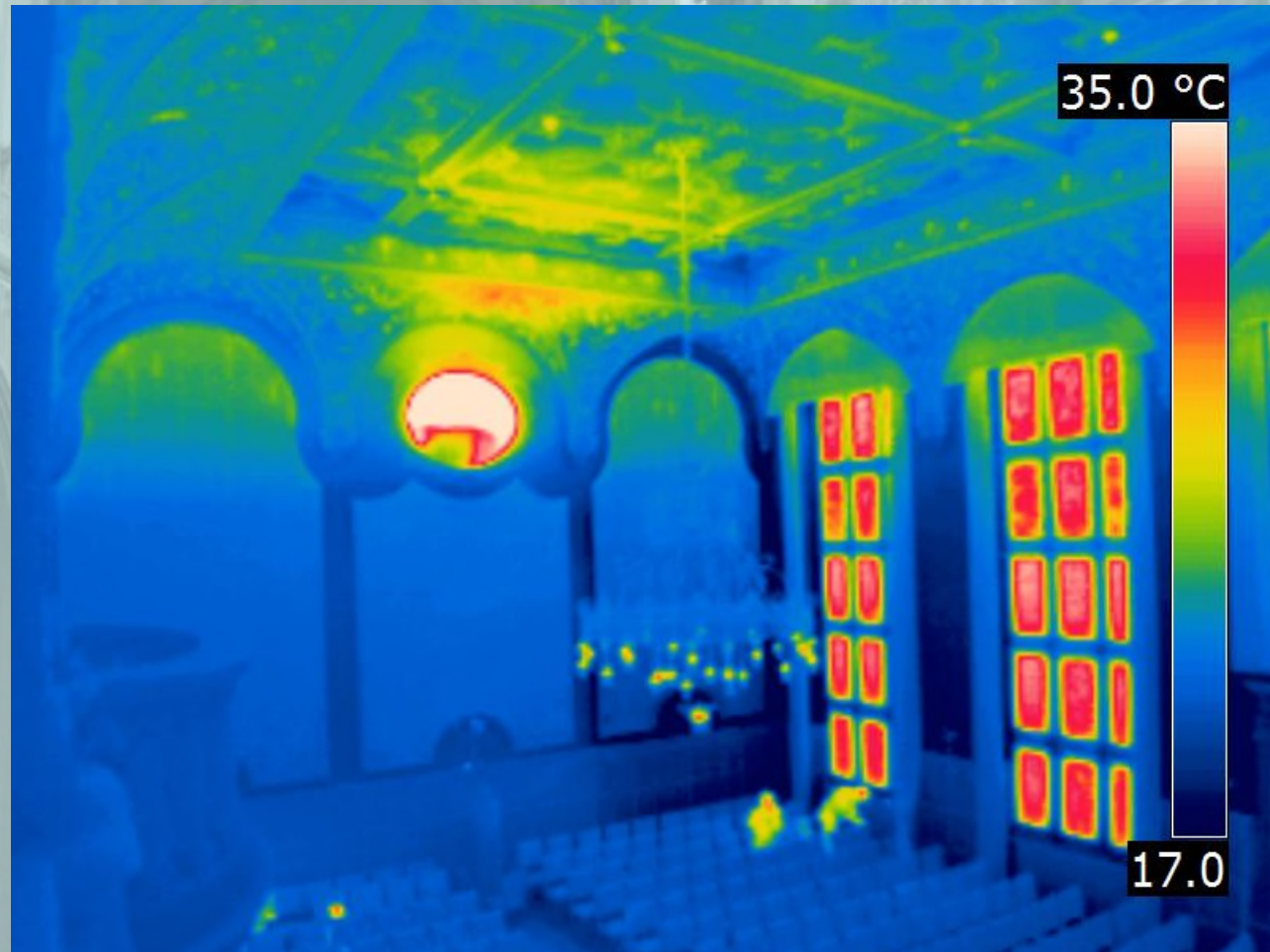
Stratificatie



Stratificatie



Stratificatie



Conclusies

- Energie gebruik
 - CO₂ regeling
 - Exfiltratie
 - Stratificatie
- Effecten op buitenschil
- Thermisch comfort
 - Tocht?
 - Koudeval?
- Fysica

