Earth - air exchanger system applied 1D Heat-transfer Model (with 3D ground)

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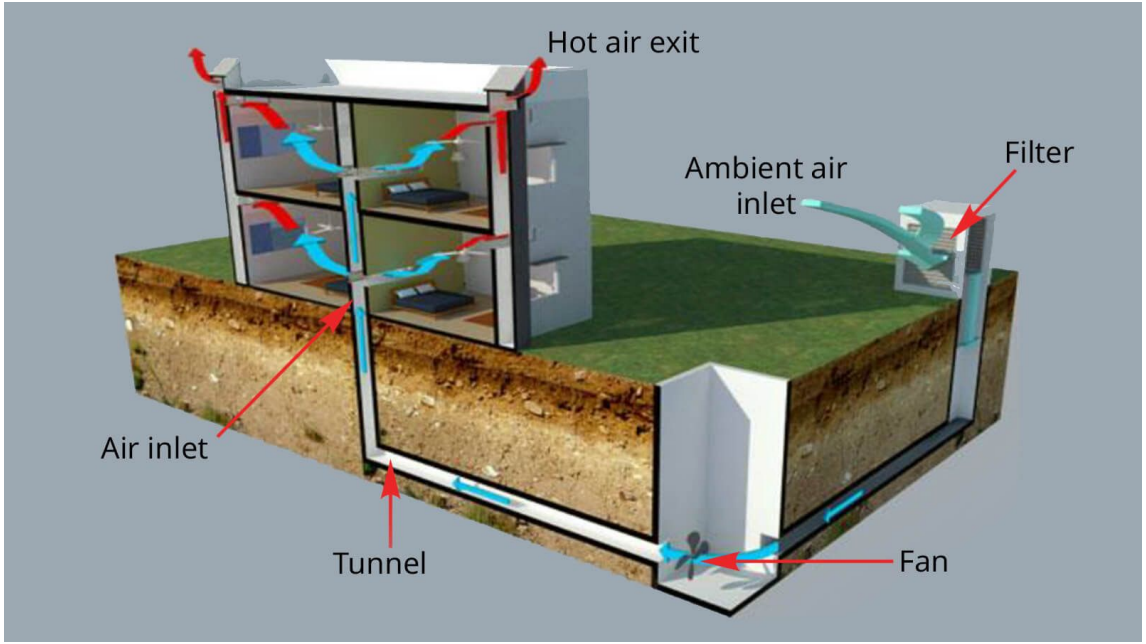
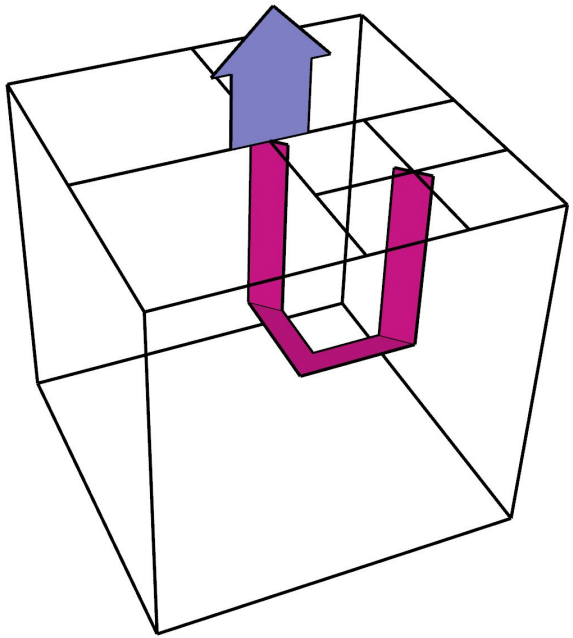
Earth-air heat exchanger system on model



Earth - air heat exchanger system

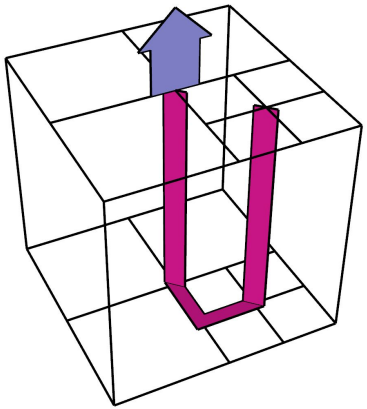
1) Applying Passive Design

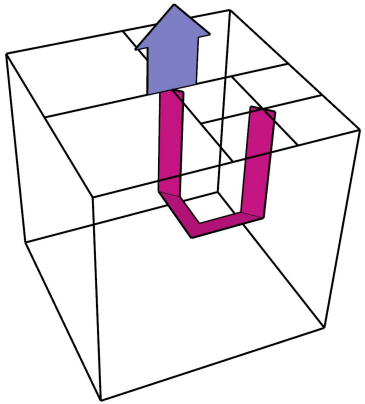
Basic format

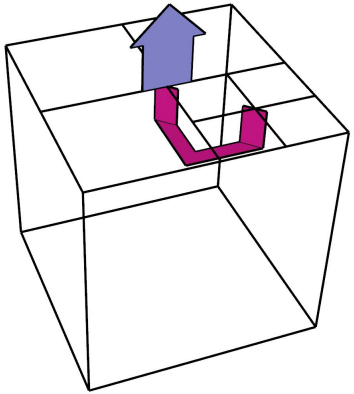


3) Models

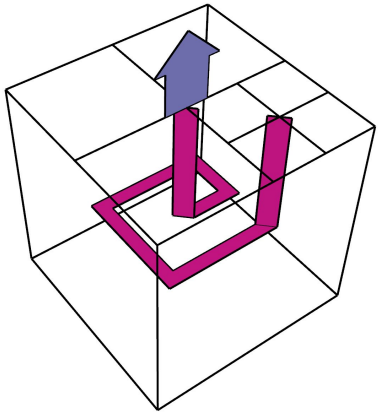
variables by depth







by distance



Assumptions

1) Assumptions

1. Assumptions of the early 1D + 3D model

Soil(ground nodes) is homogeneous
only conduction between the underground nodes

2. Ventilation and convection

not ‘natural’ ventilation influenced by temperature diff, pressure, etc.

h_conv is fixed at 2.5
Infilteration is same with the infilt between 16th and 17th node

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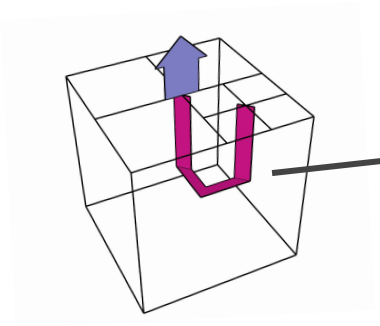
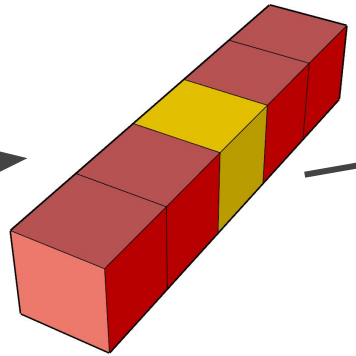
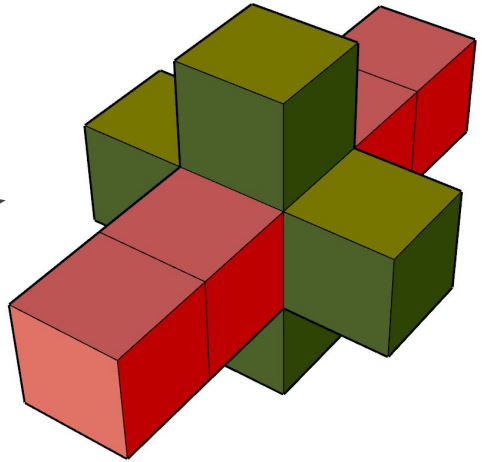
Differences on M, S, f matrix

1) Added





air tube nodes

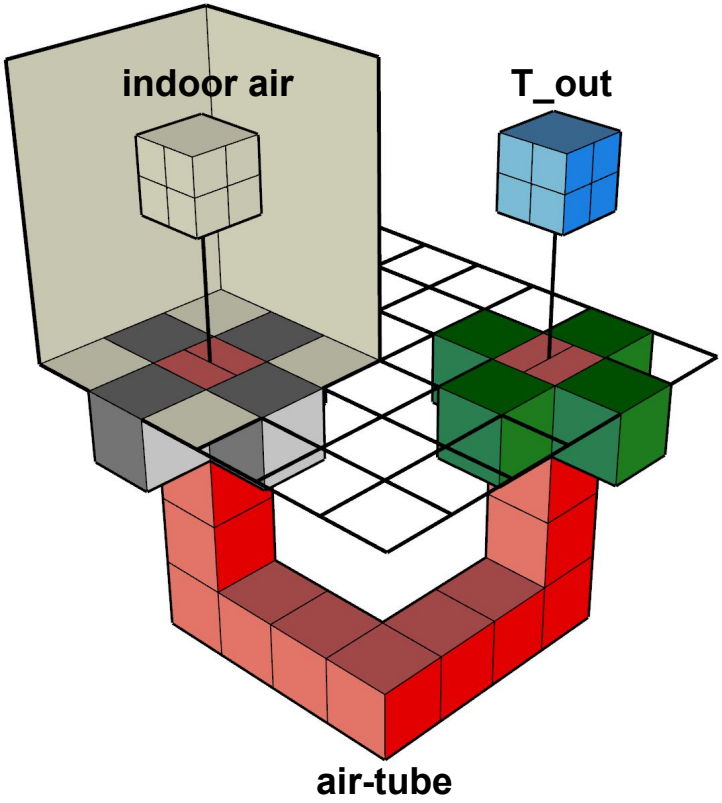


1. **conduction**
   with 4 adjacent ground cubes (green cubes)

2. **convection**
   with 2 adjacent air-tube cubes (red cubes)

3. **ventilation**
   with 2 adjacent air-tube cubes (red cubes)

2) inlet, outlet



- Heat - transfer at **inlet, outlet**

1. **conduction**
   with 4 adjacent ground cubes (green cubes)
   and floor node

2. **convection**
   with 1 adjacent air-tube cube (red cube)
   and T_out node
   and indoor air node

3. **solar radiation**
   can be added based on the design

4. **longwave radiation**
   with T_sky node

5. **ventilation**
   with 1 adjacent air-tube cube (red cube)
   and T_out node
   and indoor air node

2) M, S, f matrix

1. **conduction**
   with adjacent ground cubes (green cubes)
2. **convection & ventilation**
   with adjacent air-tube cubes (red cubes)
   and T_out, T_indoor
3. **longwave radiation**
   with T_sky

→ **S matrix**

4. **thermal mass**
   of the air-tube cubes → **M matrix**

5. **solar radiation**
   at the inlet of the air-tube → **f matrix**

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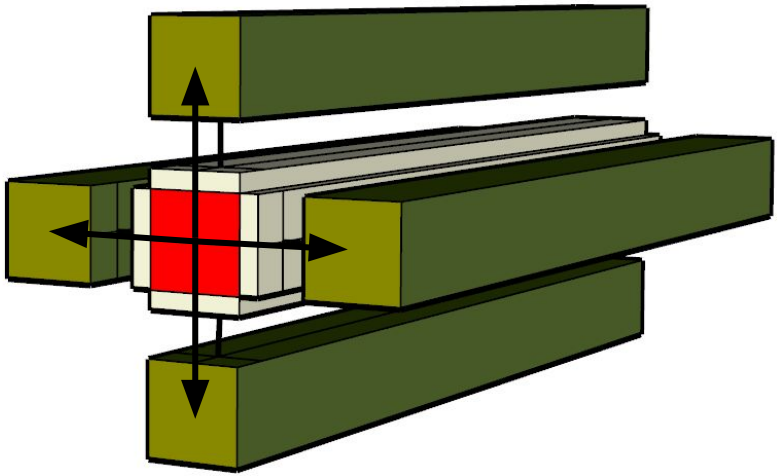
*Adjusted Concept

1) Concept



ground nodes
(boundary conditions)

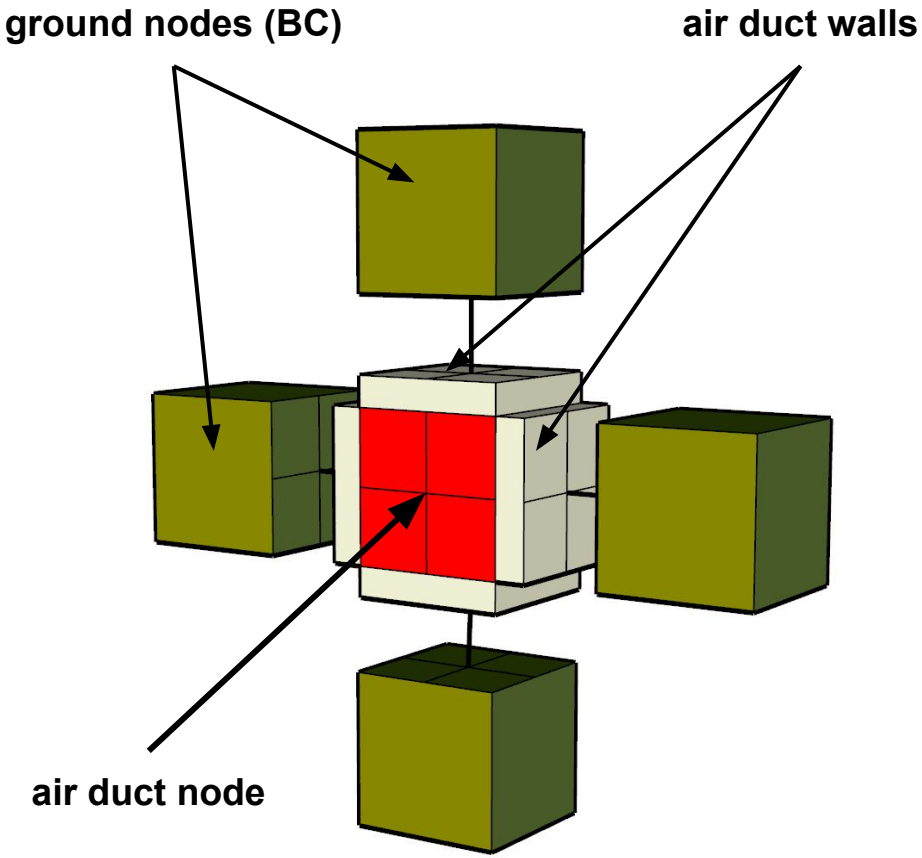
↑

air duct walls X 4

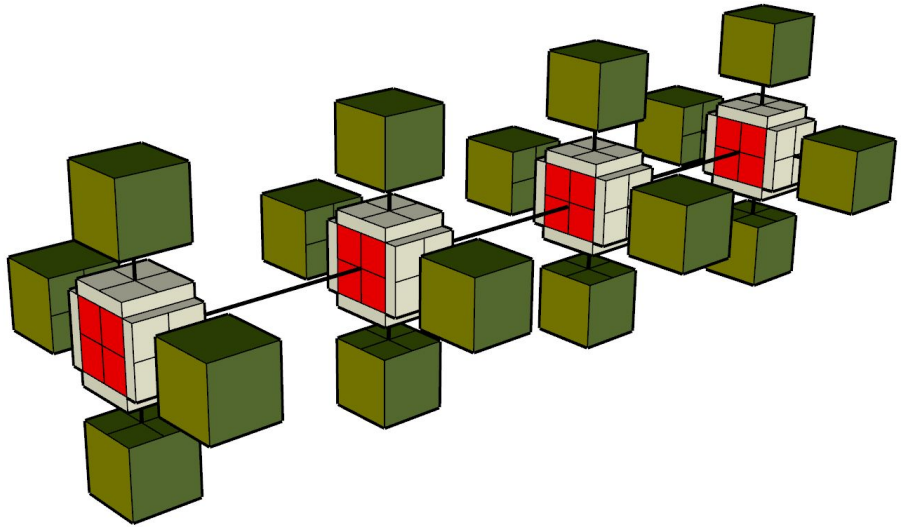
↑

air duct node

1) Concept



1) Concept



ground nodes
(boundary conditions)

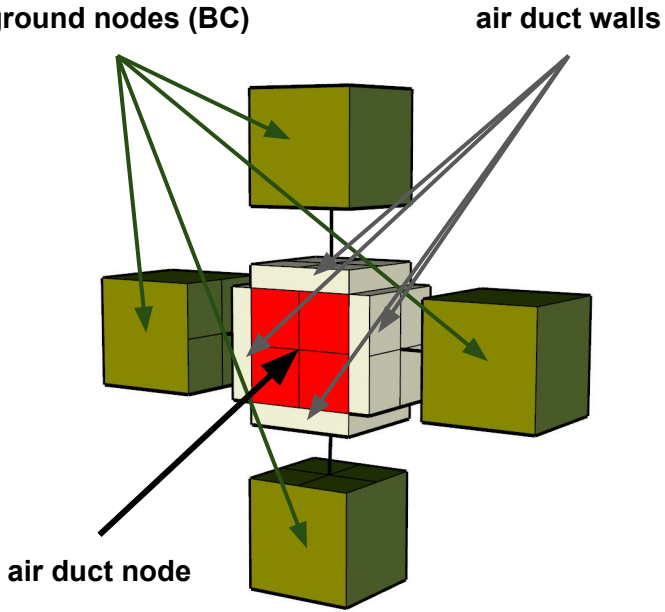
↑

air duct - surface X 4 X 4

↑

air duct - air

2) M_ductcube



a : conv + longwave
b : cond

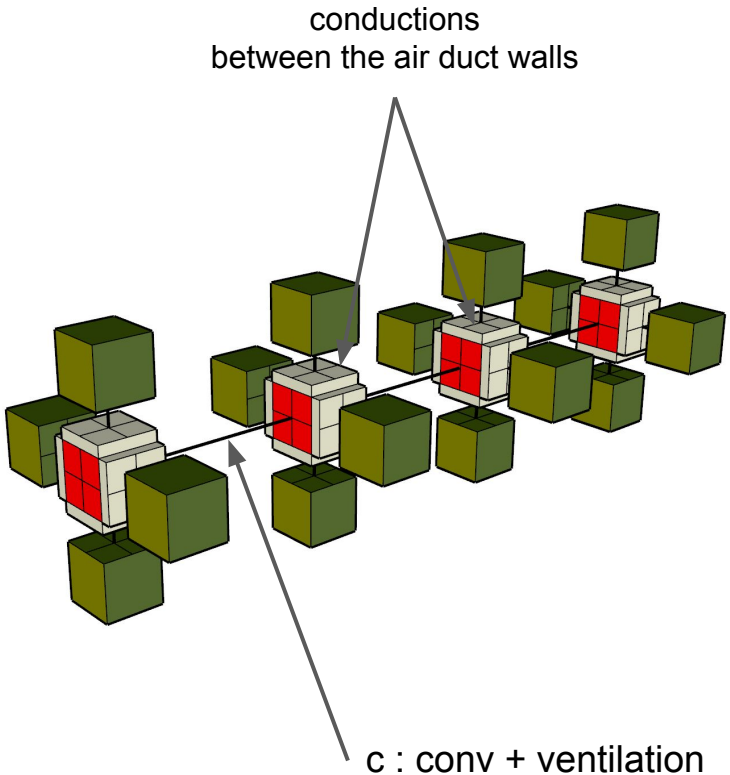
air duct node

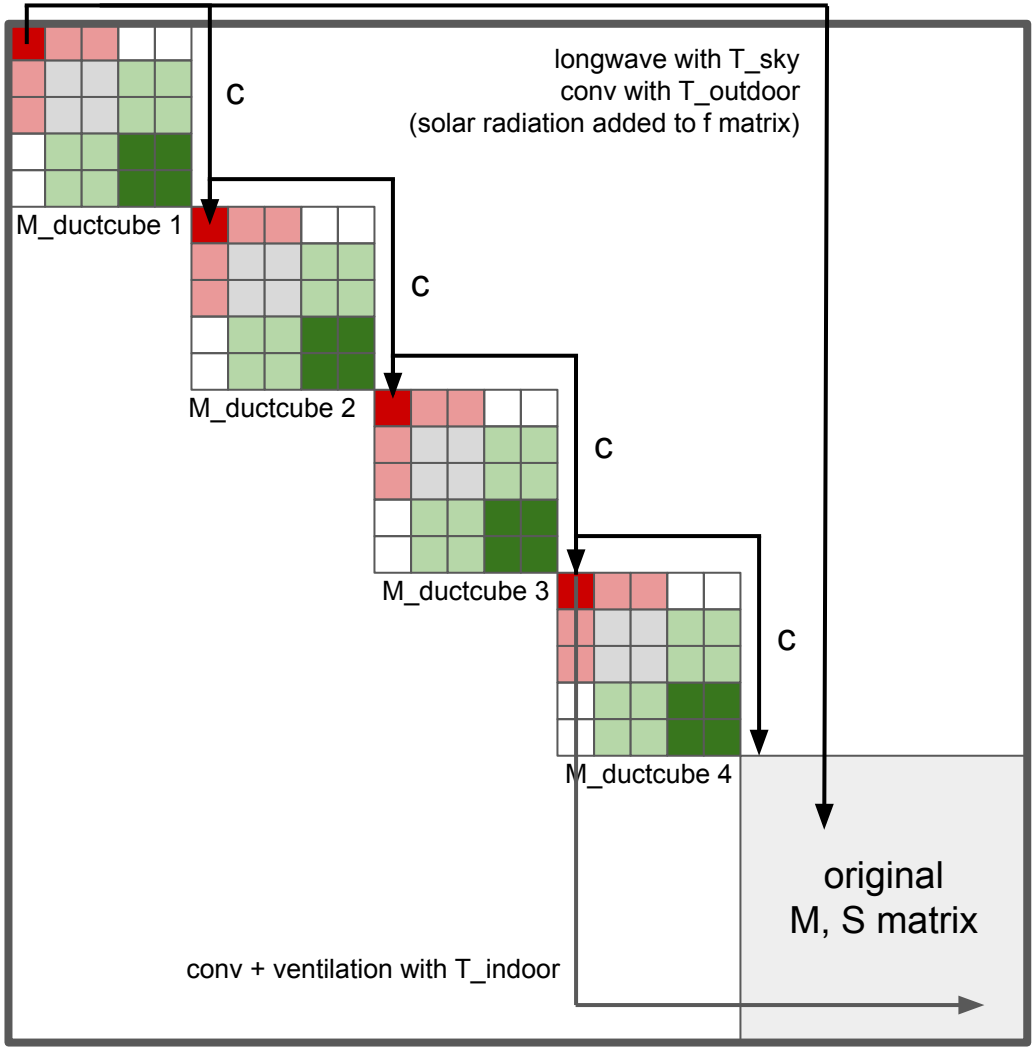
a	a	a	a	a				
a	a + b	a + b	a + b	a + b	b	b	b	b
a	a + b	a + b	a + b	a + b	b	b	b	b
a	a + b	a + b	a + b	a + b	b	b	b	b
a	a + b	a + b	a + b	a + b	b	b	b	b
	b	b	b	b	b	b	b	b
	b	b	b	b	b	b	b	b
	b	b	b	b	b	b	b	b
	b	b	b	b	b	b	b	b

air duct walls

ground nodes

2) M_all


conductions
between the air duct walls
c : conv + ventilation


longwave with T_sky
conv with T_outdoor
(solar radiation added to f matrix)
c
M_ductcube 1
c
M_ductcube 2
c
M_ductcube 3
c
M_ductcube 4
original
M, S matrix
conv + ventilation with T_indoor

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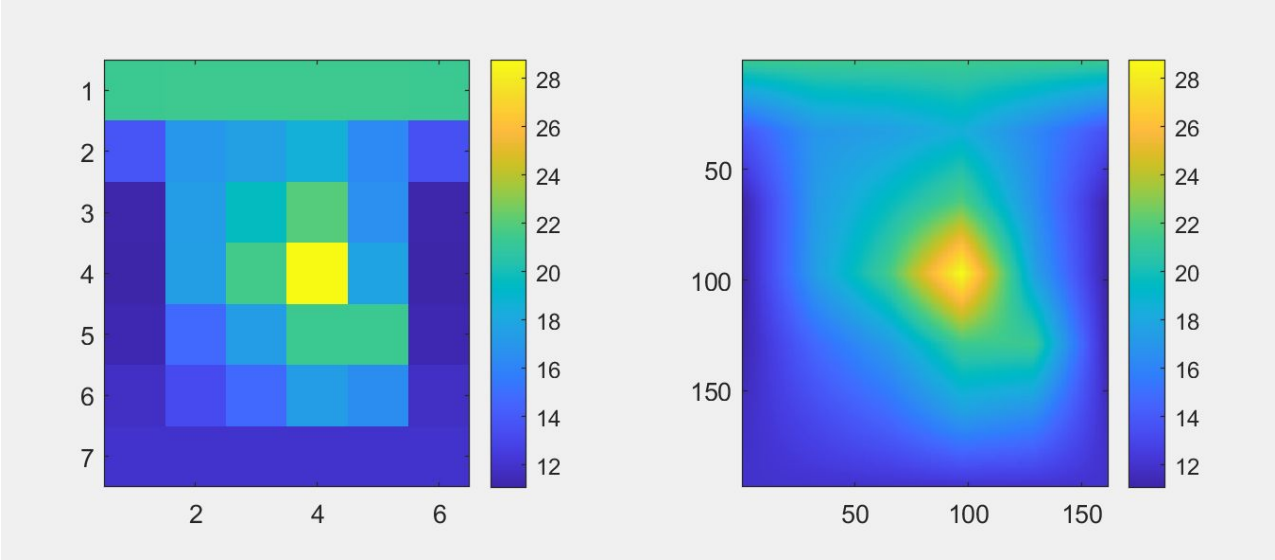
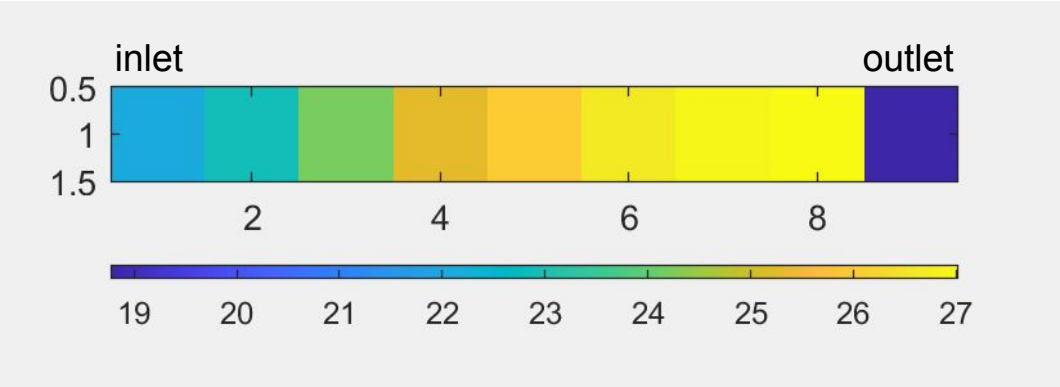
Result | Plot

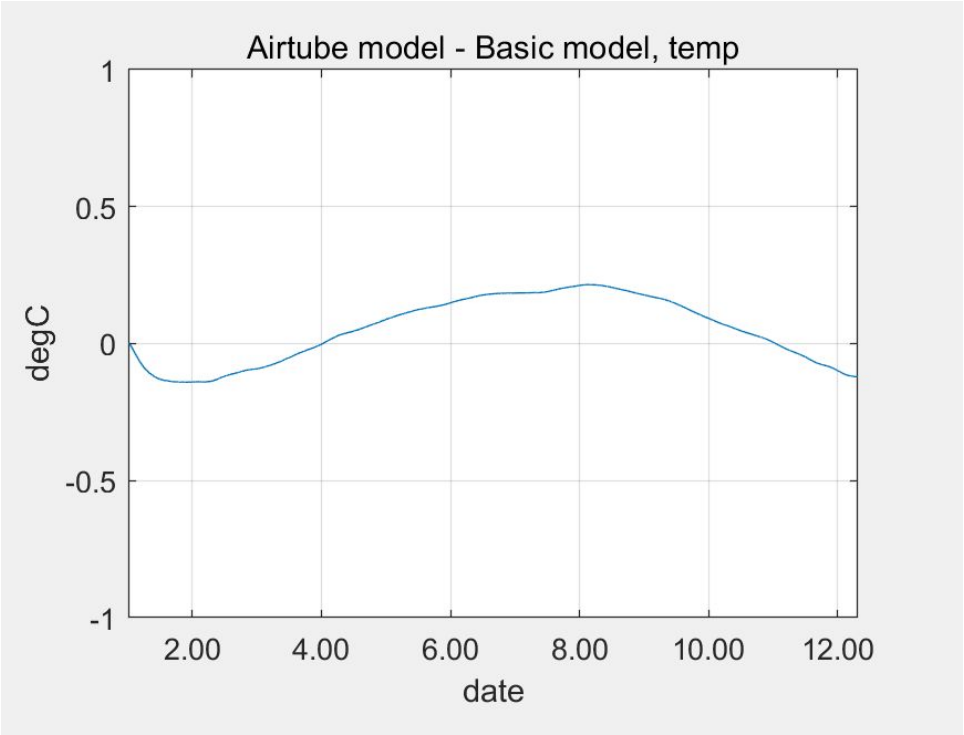
2) result


1
2
3
4
5
6
7
2
4
6
28
26
24
22
20
18
16
14
12
50
100
150
50
100
150
28
26
24
22
20
18
16
14
12

2) result



2) result


Airtube model - Basic model, temp
1
0.5
0
-0.5
-1
degC
2.00
4.00
6.00
8.00
10.00
12.00
date