Simulating the day time and night time urban heat island effect on neighbourhood scale

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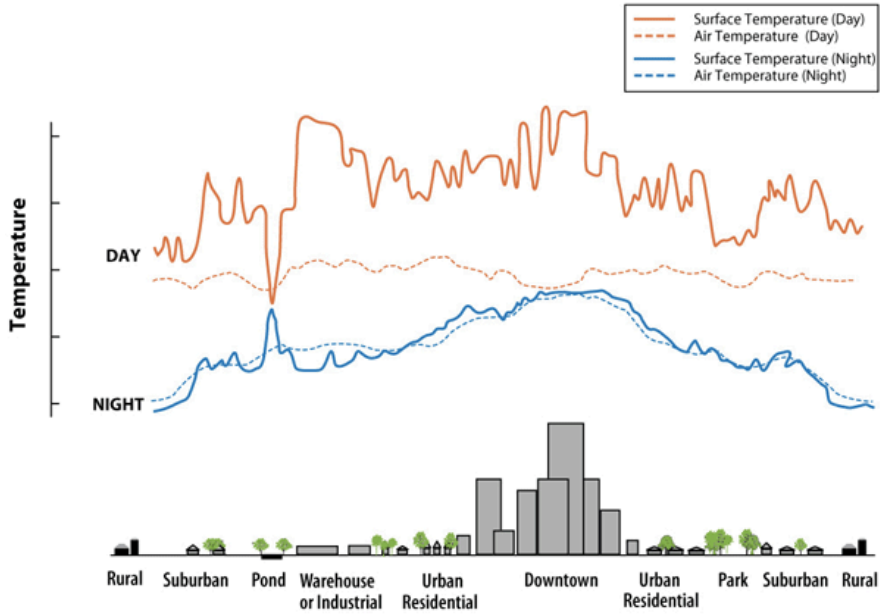
Urban Heat Island effect

Small during day (can even be negative) but large (up to 10K) during night

Causes

1) Lesser ventilation
2) Reduced evaporation
3) Release of stored heat
4) Long wave trapping
5) Anthropogenic heat
6) Multiple reflections
7) Increased LW_{sky}



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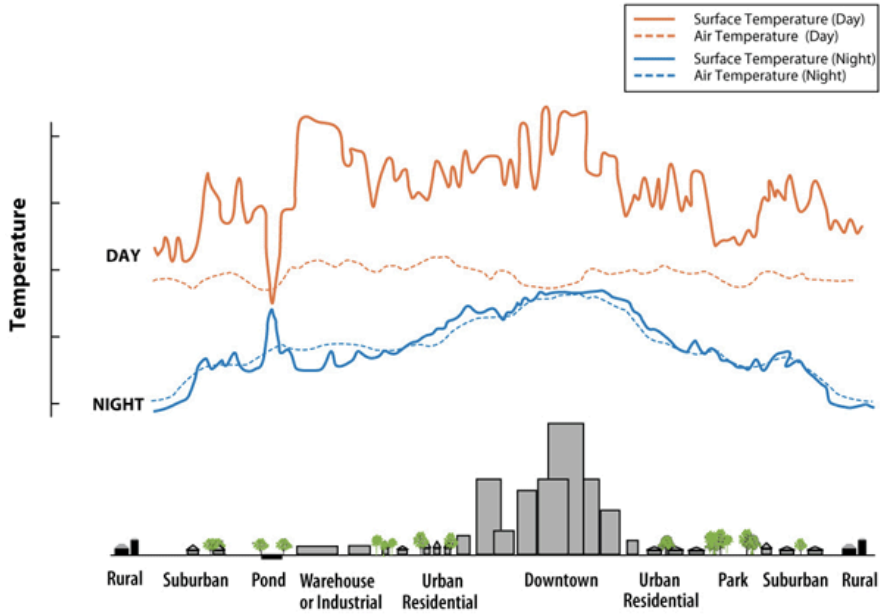

But what is the dominant factor?

Simulation model

Surface energy balance:

$$SW_{dir} + SW_{dif} + LW_{sky} + LW_{trap} = LW_{out} + G + H$$

Spatial resolution = 1 meter
Temporal resolution = 6 minutes

Simulation model

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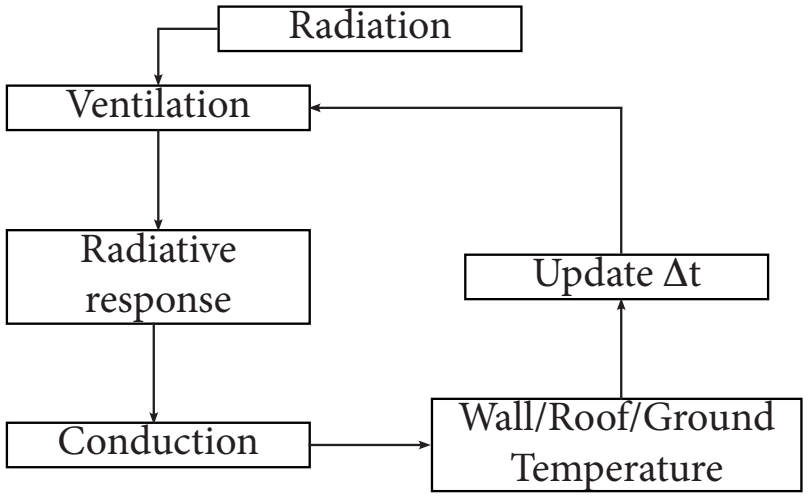
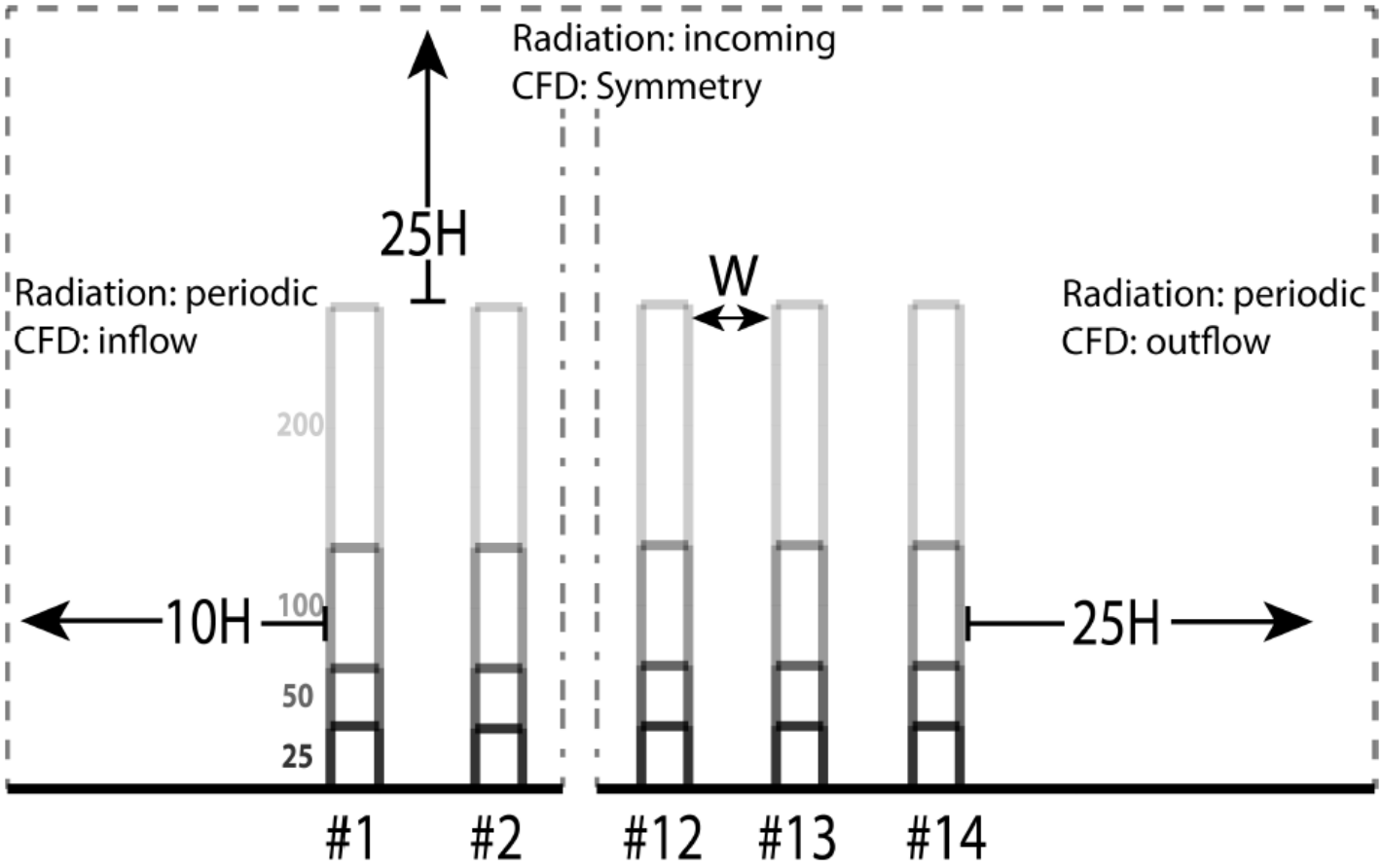
Surface energy balance:

$$SW_{dir} + SW_{dif} + LW_{sky} + LW_{trap} = LW_{out} + G + H$$

Monte-Carlo radiation model
1D transient heat conduction equation
CFD model



Case set-up


Radiation: incoming
CFD: Symmetry
25H
W
Radiation: periodic
CFD: inflow
Radiation: periodic
CFD: outflow
200
100
50
25
10H
25H
#1
#2
#12
#13
#14

Case set-up

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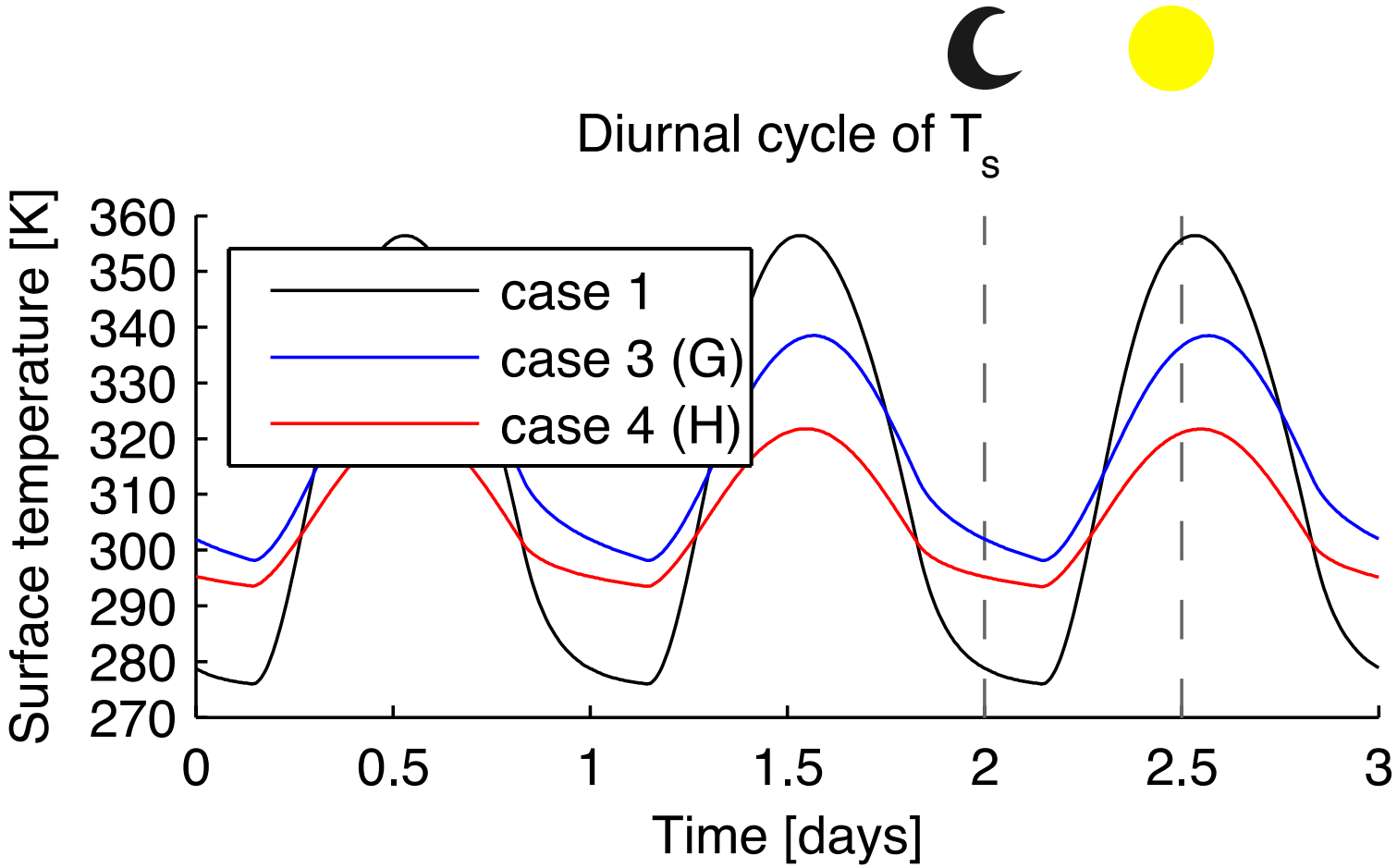
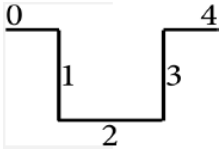
Do not only consider range of H/W ratios (0.0, 0.5, 1.0, 2.0 & 4.0) but also different physical mechanisms

Case	RAD	LW_{trap}	G	H
1	+			
2	+	+		
3	+	+	+	
4	+	+	+	+

Time-evolution H/W = 0.0



Radiation



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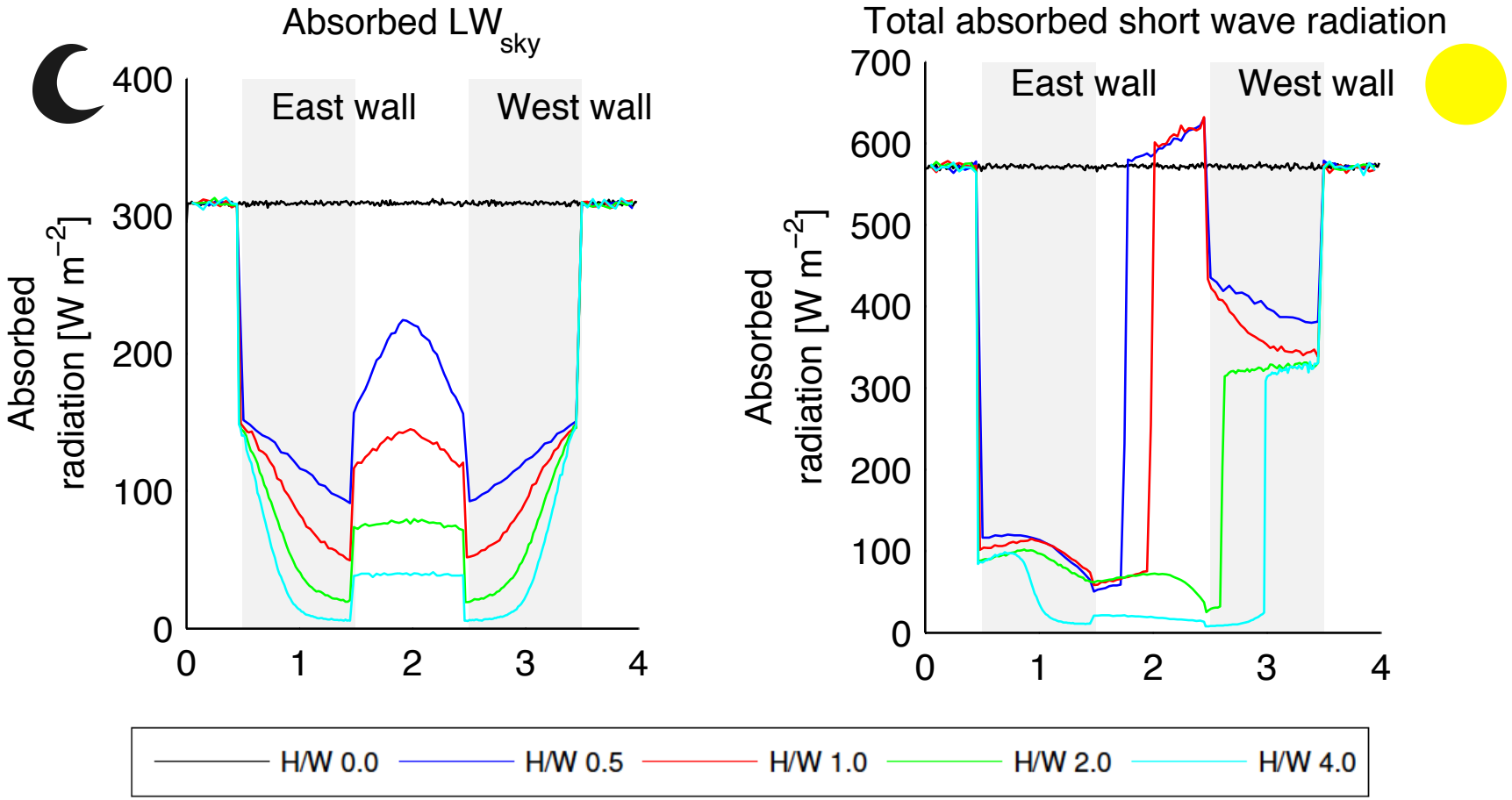
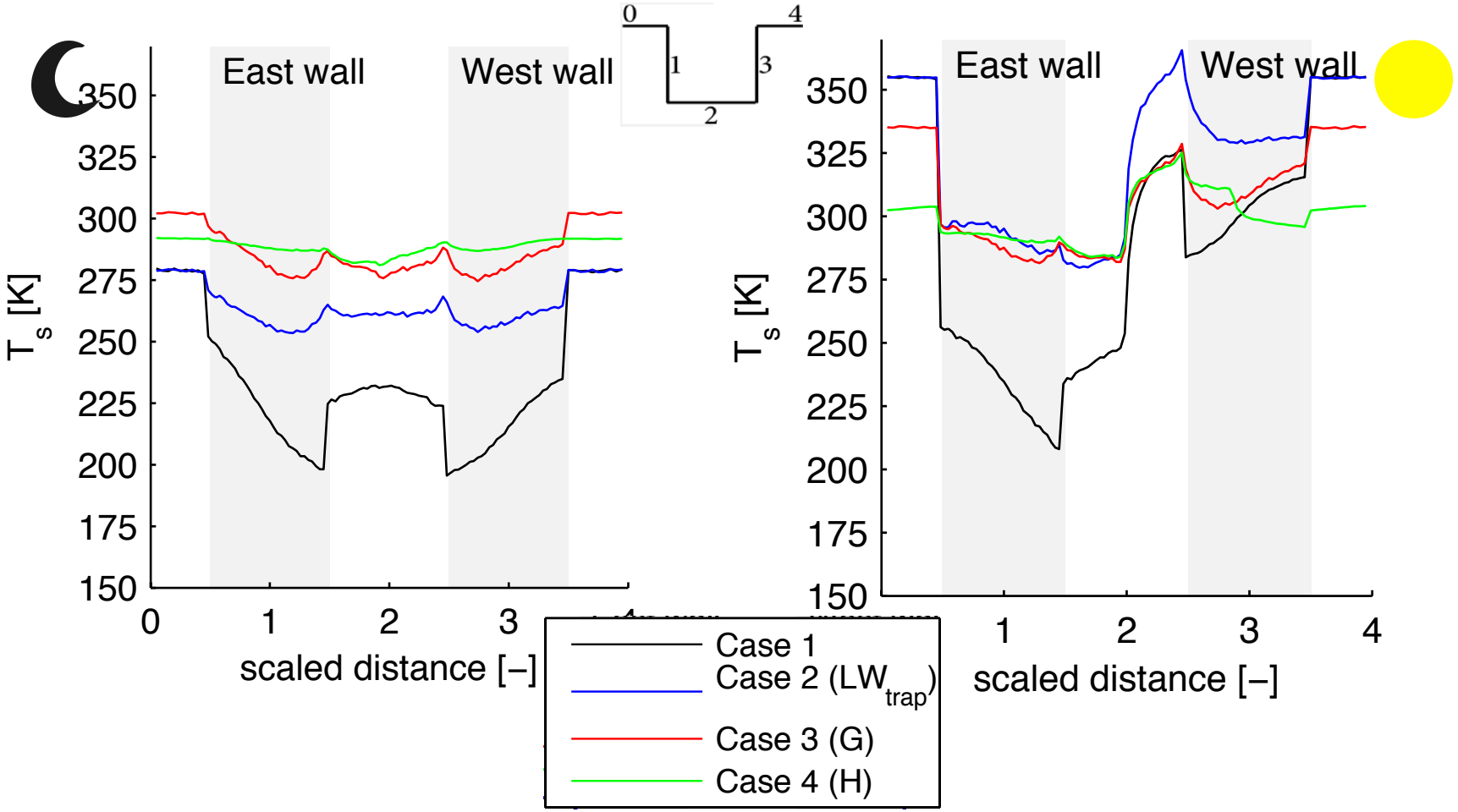
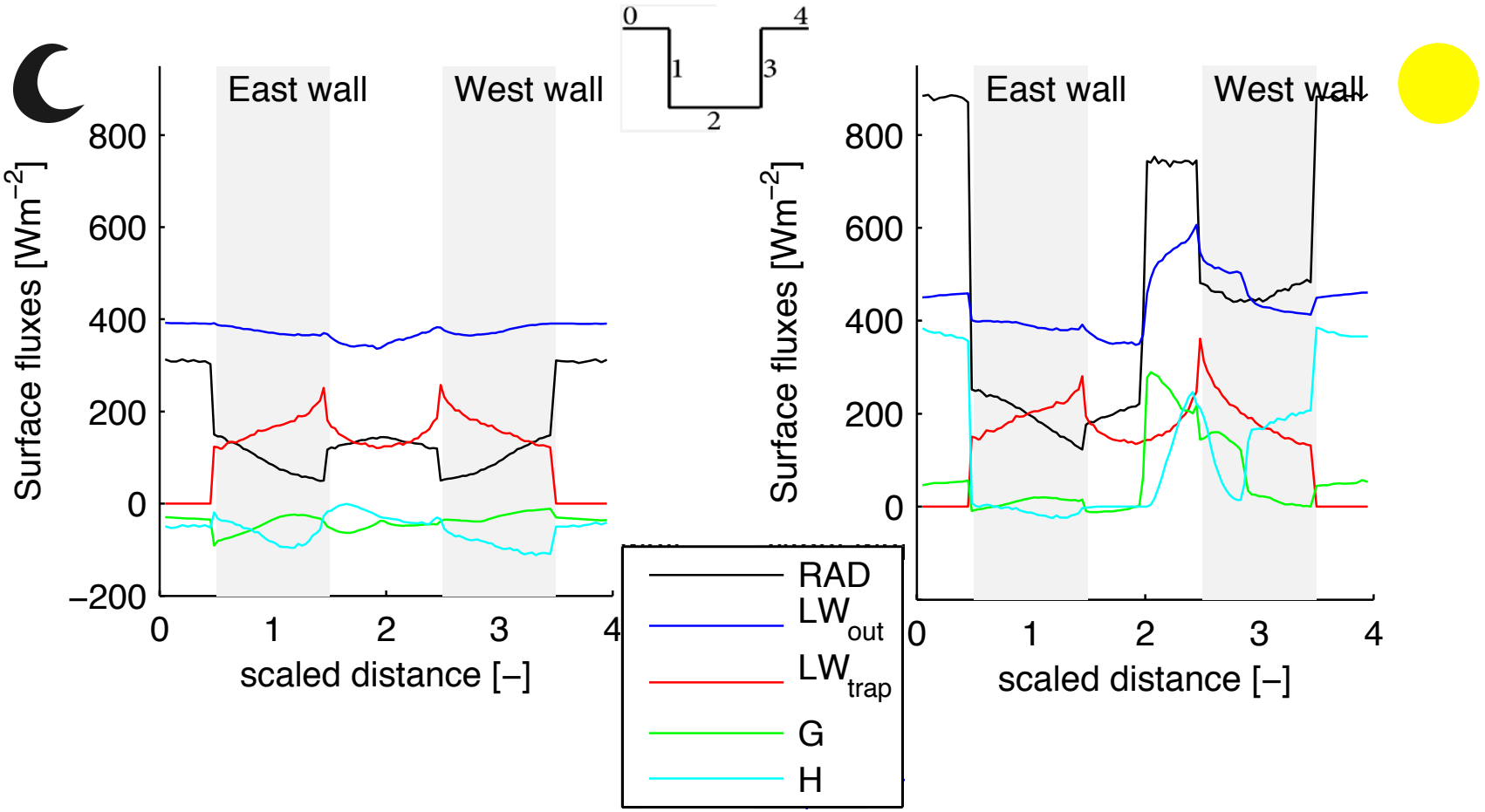


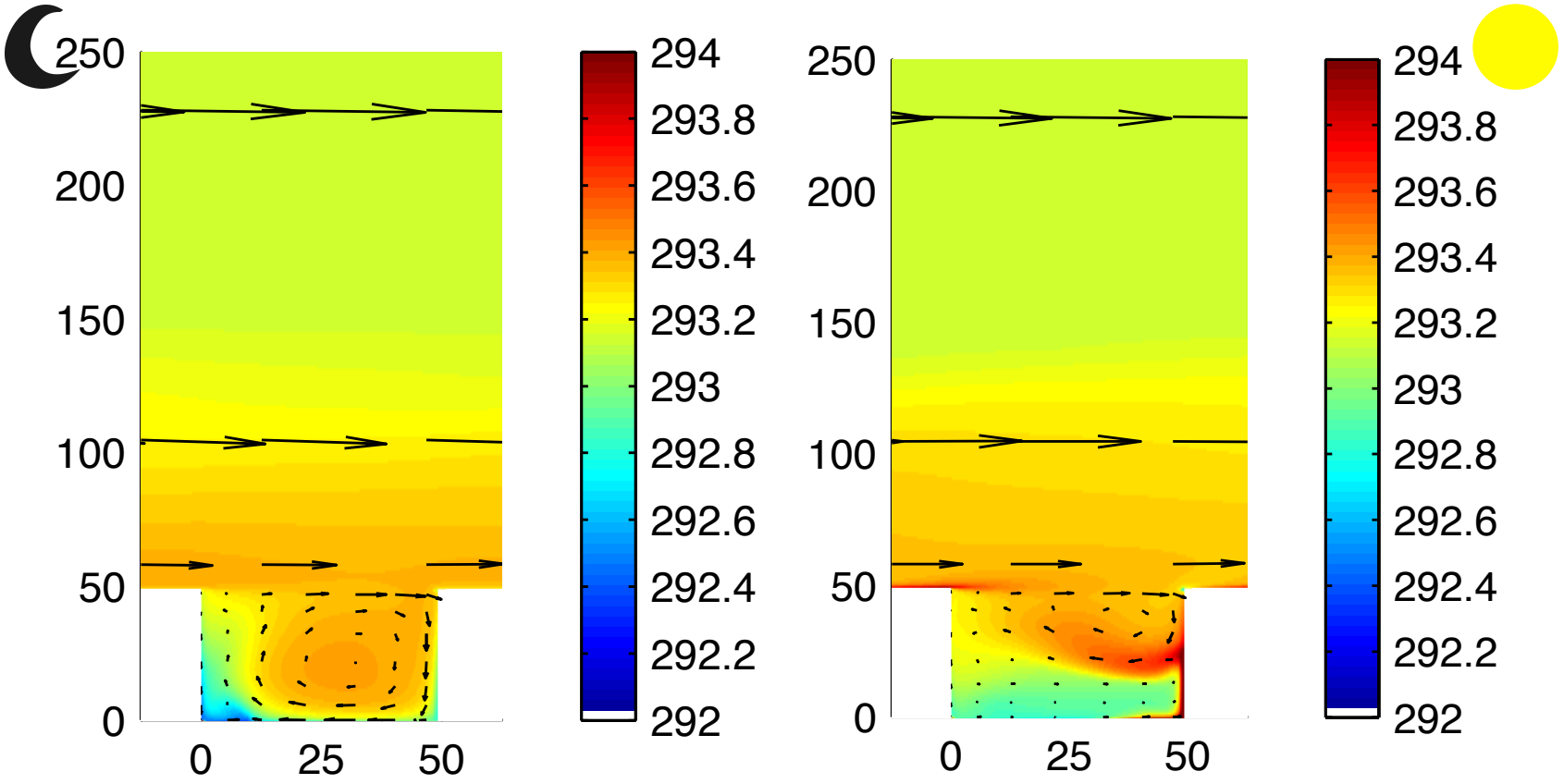
Surface temperature H/W=1.0



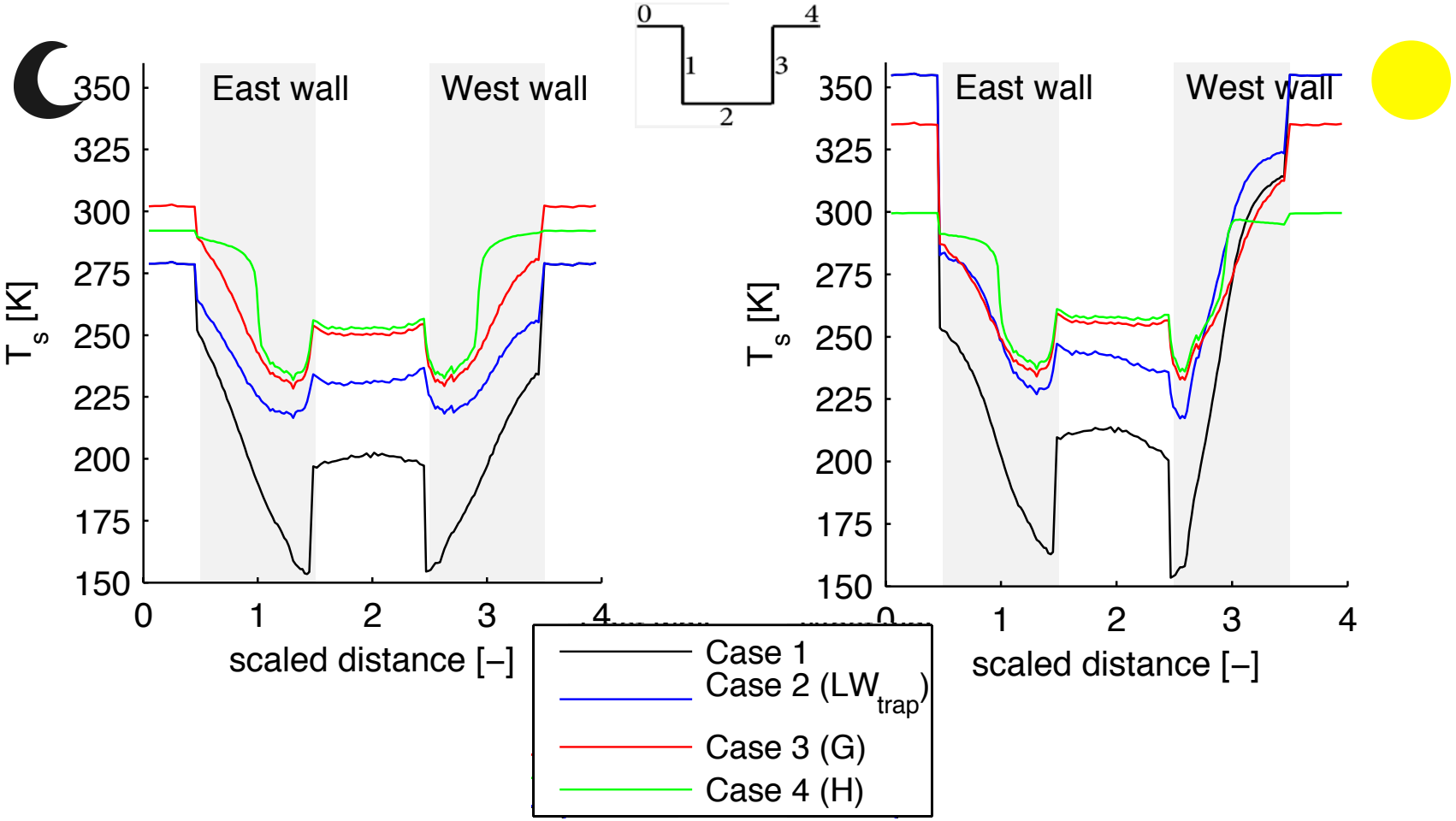
Surface fluxes H/W=1.0



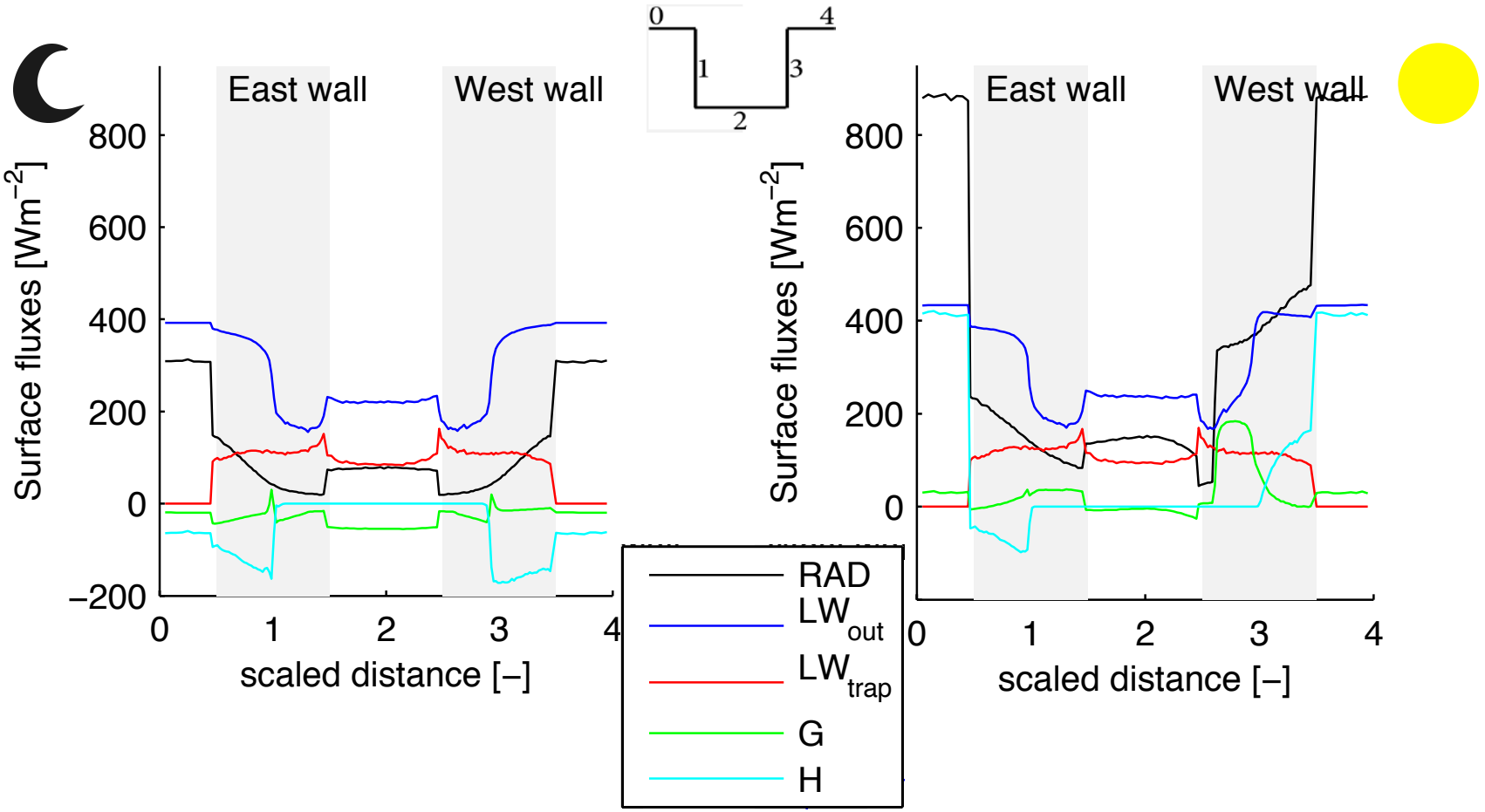
Air temperature H/W=1.0



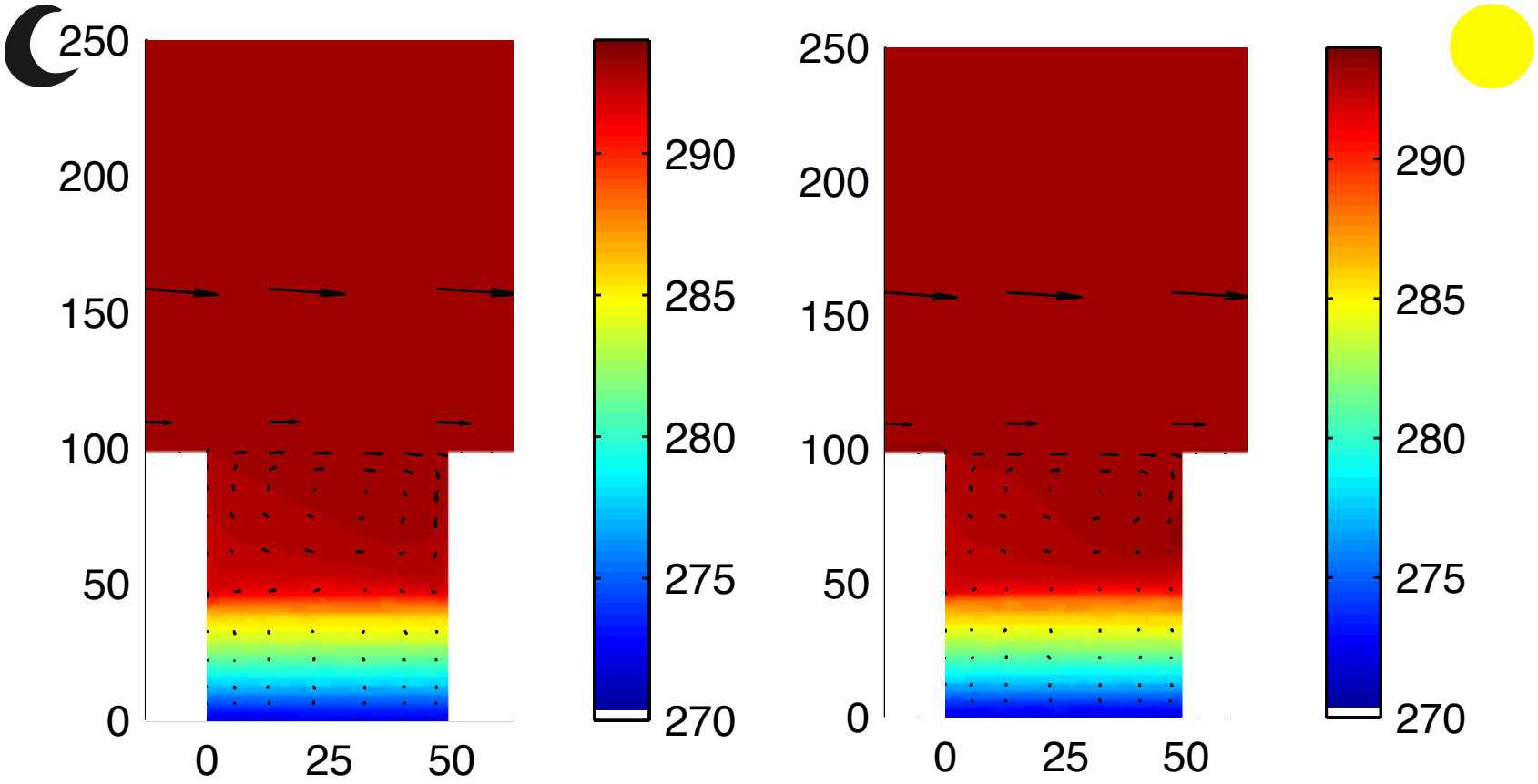
Surface temperature H/W=2.0



Surface fluxes H/W=2.0



Air temperature H/W=2.0



Concluding remarks

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New simulation model with 1 meter spatial resolution

LW_{trap} = main mechanism during night
SW = main mechanism during day

G = more important for H/W=2.0 during night

H shows different behaviour for H/W=1.0 and H/W=2.0

H/W=1.0 will mixed
H/W=2.0 only upper part well mixed and stable stratification

Questions?

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Thank you for your attention.

Questions?

This study is funded by the Climate Proof Cities program