Instituto Veneto di Science Lettere ed Arti
Summer School BEES 2012

Working group on termodynamics
led by Prof. Axel Kliedon

Surface Energy Balance With Diurnal Forcing

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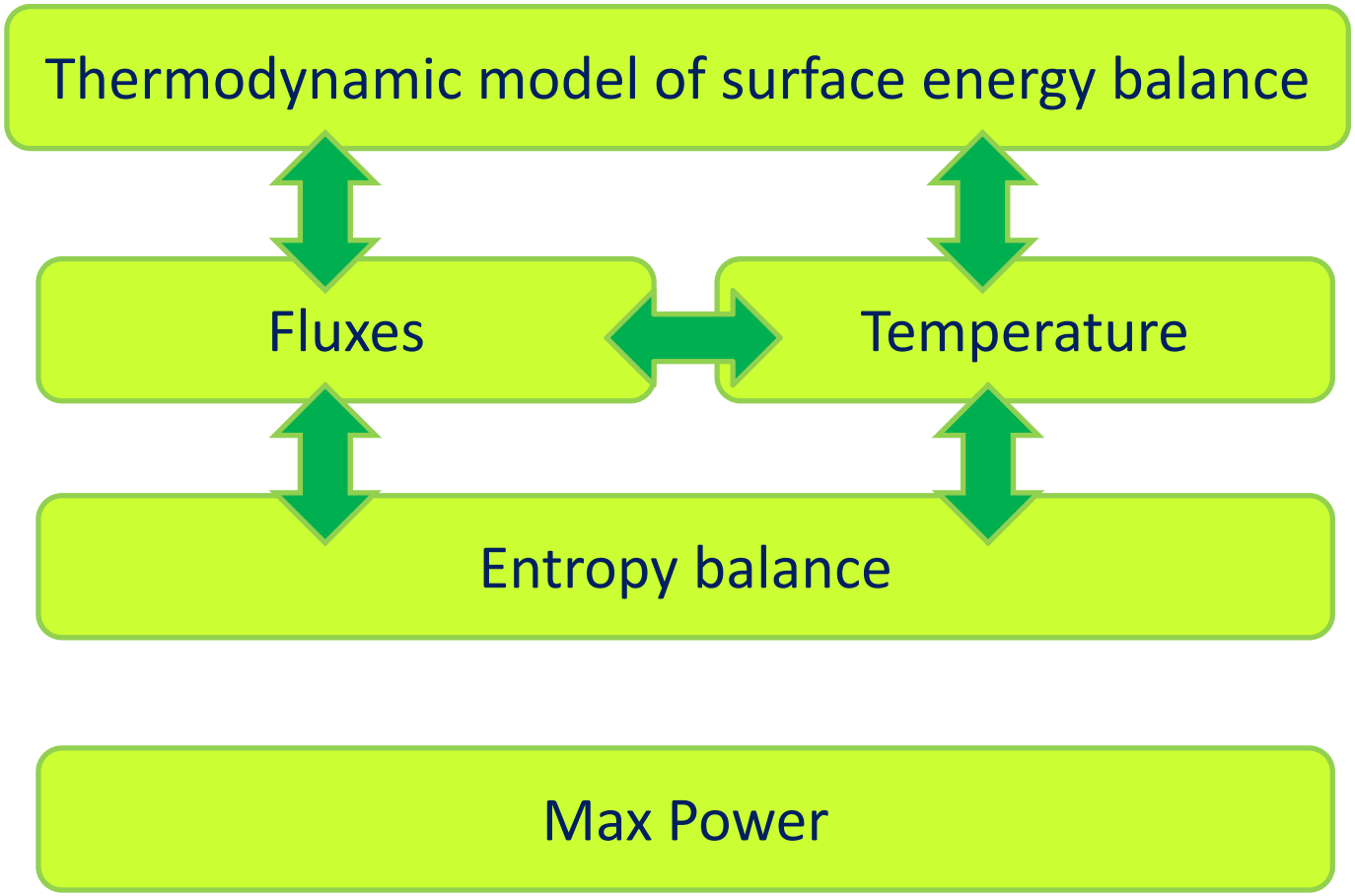
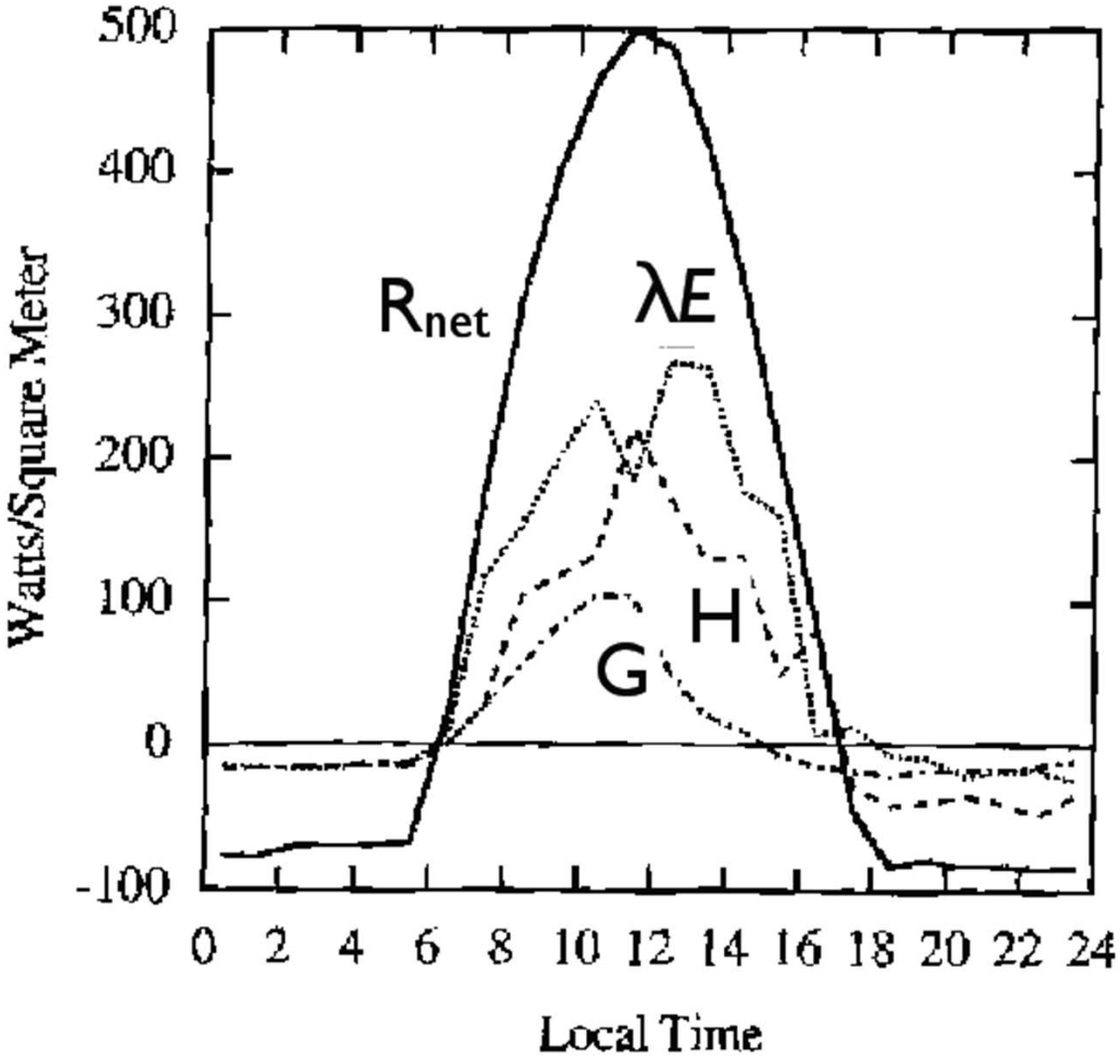
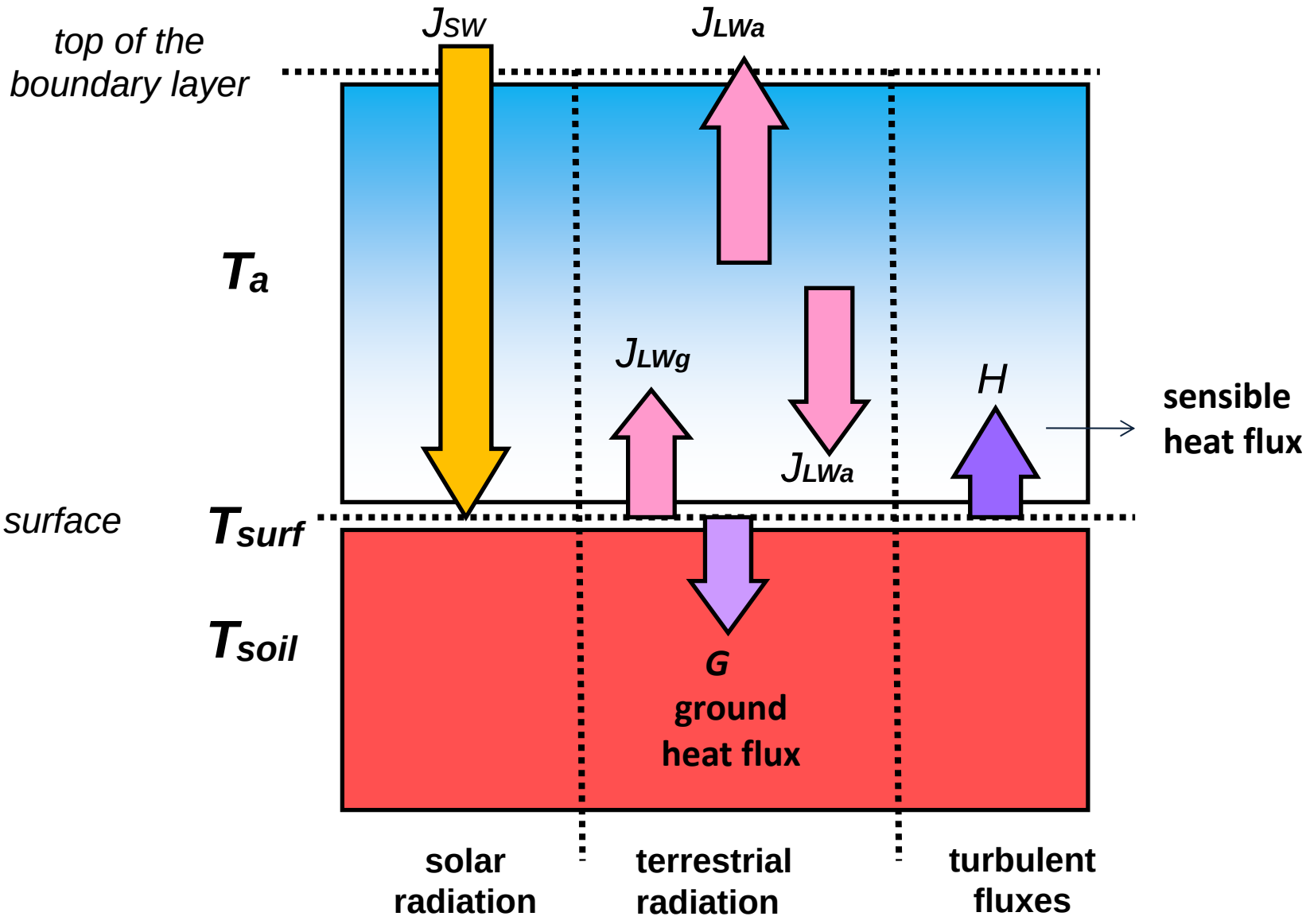
Surface energy balance



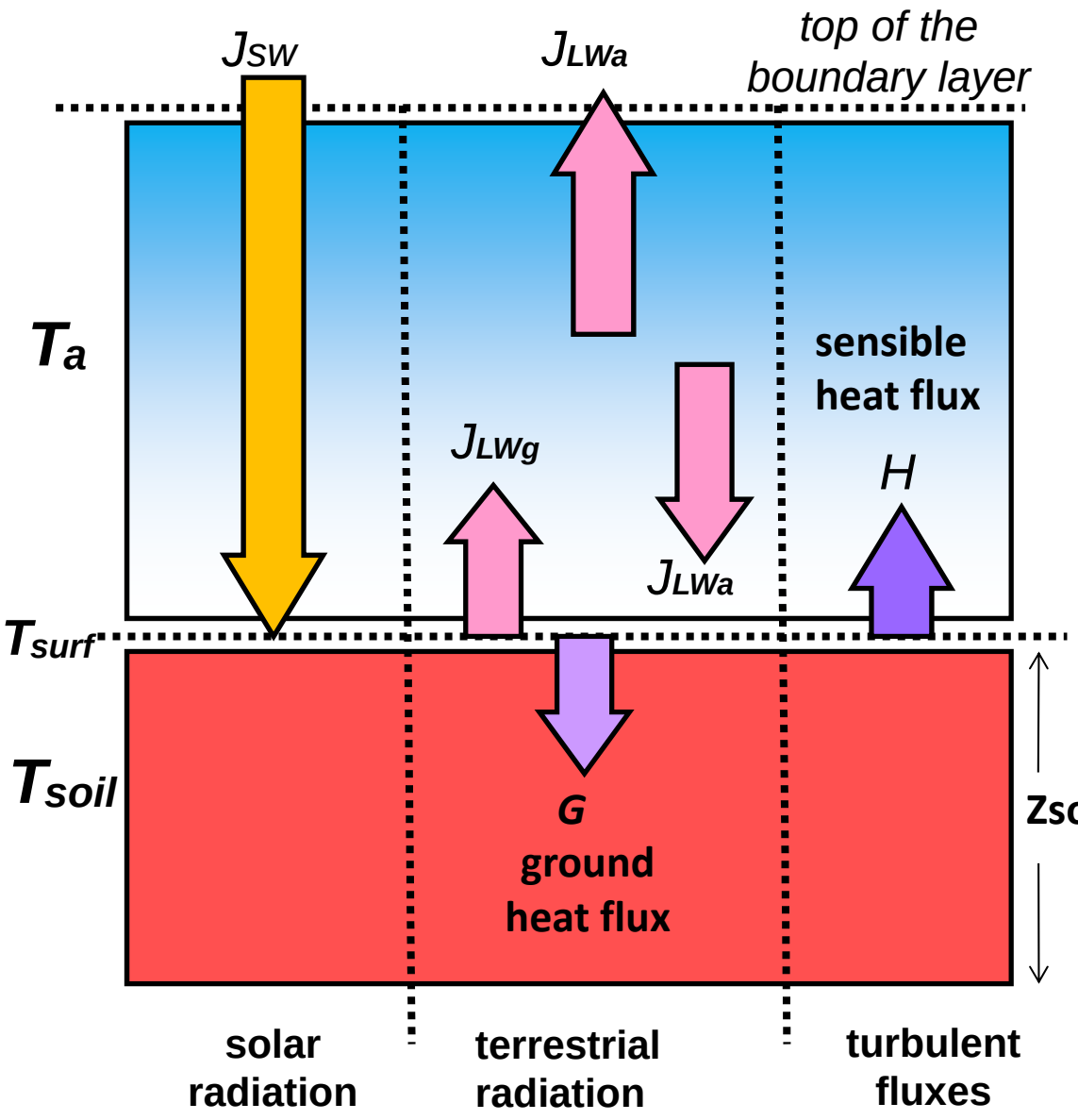
Observed energy balance



Model description



Energy balance equation and parametrisaton



Assumptions: sunny day, no cloudy, no rain

atmosphare heat balance
$dQa/dt=\varepsilon J_{Lws} - 2\varepsilon J_{Lwa} + H$

$H=Cp\ \rho\ \delta\ w\ (Tsurf-Tatm)$

vertical velocity of the turbulent heat flux

balance equation of the surface
$0=Jsw(1-\alpha_s) - J_{Lws} + J_{Lwa} - G - H$

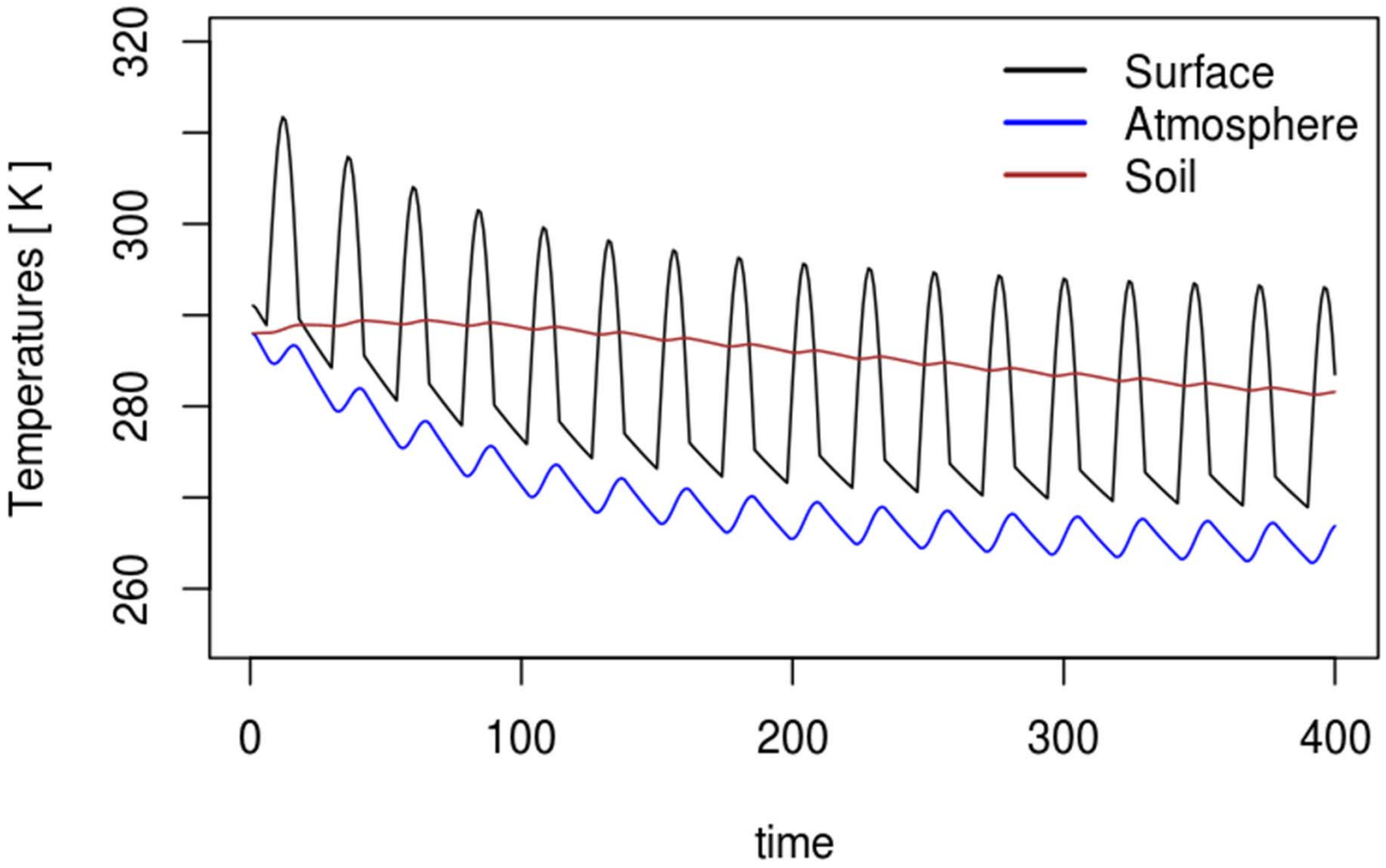
soil heat balance
$dQsoil/dt = G$

$G=k\ /(z/2)\ (Tsurf-Tsoil)$

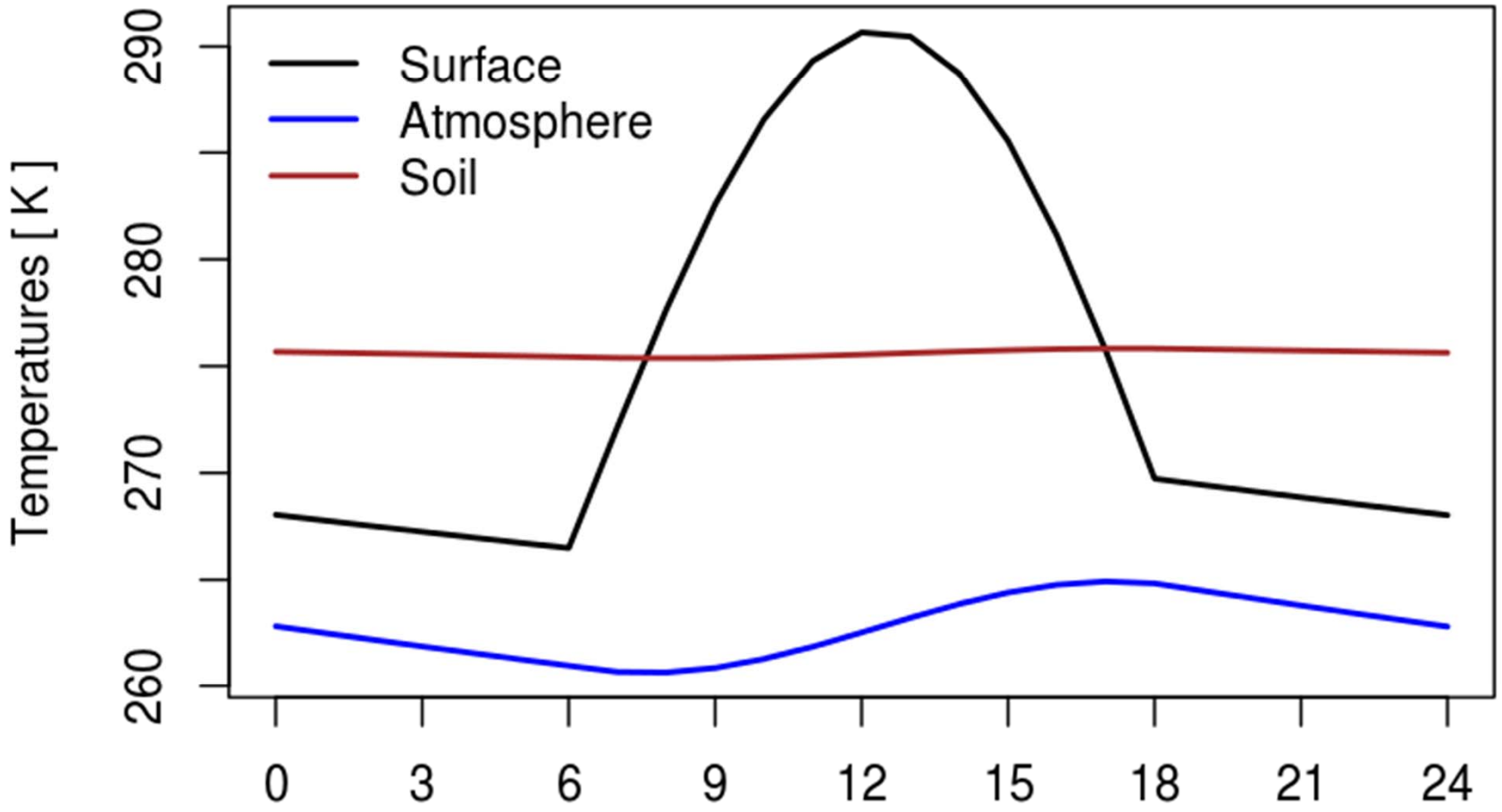
thermal conductivity

Model setup

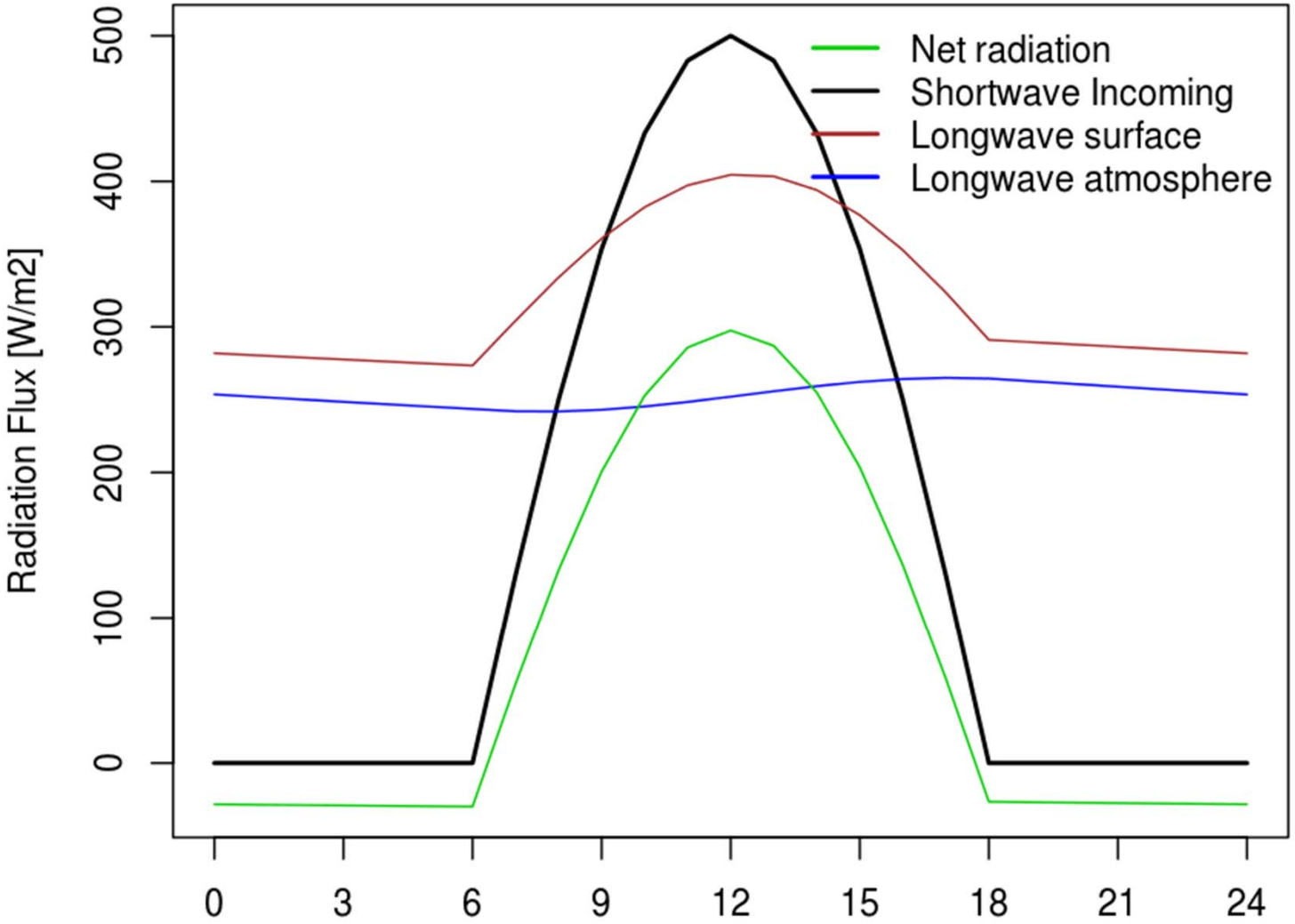
- Diurnal radiation forcing
- Only sensible heat flux → desert condition


Surface
Atmosphere
Soil
Temperatures [K]
320
300
280
260
0
100
200
300
400
time

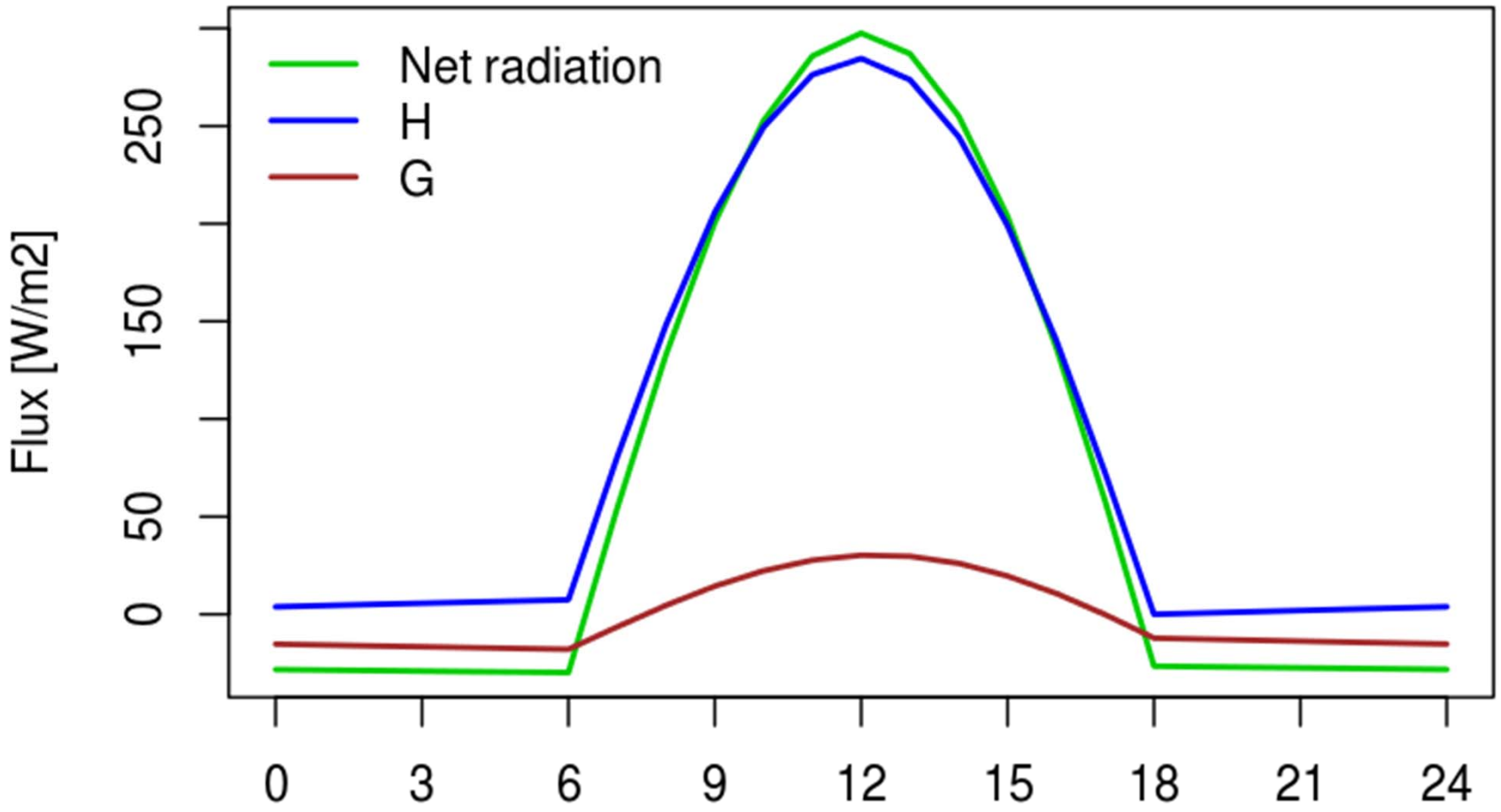
Diurnal temperature cycle



Diurnal radiation cycle



Energy balance components

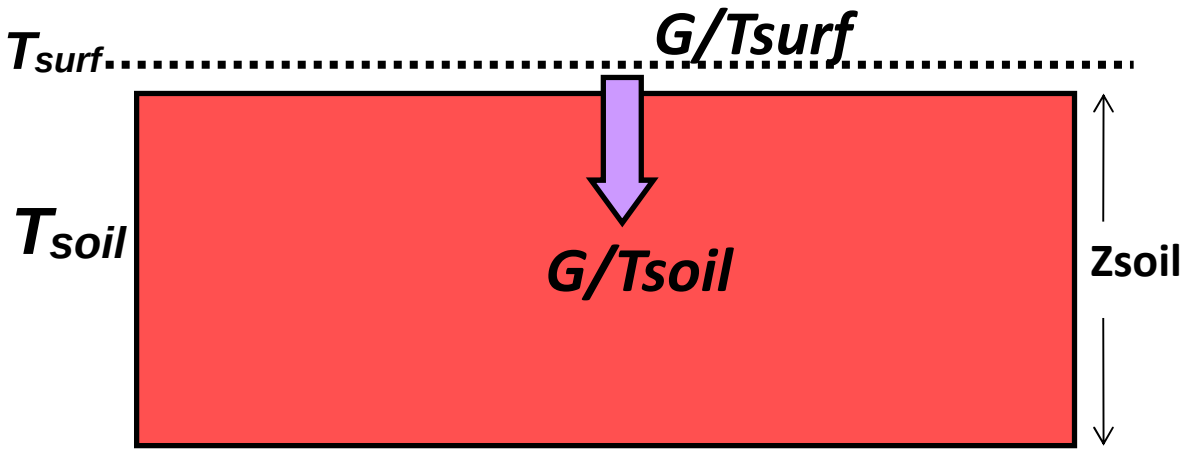


Soil entropy balance

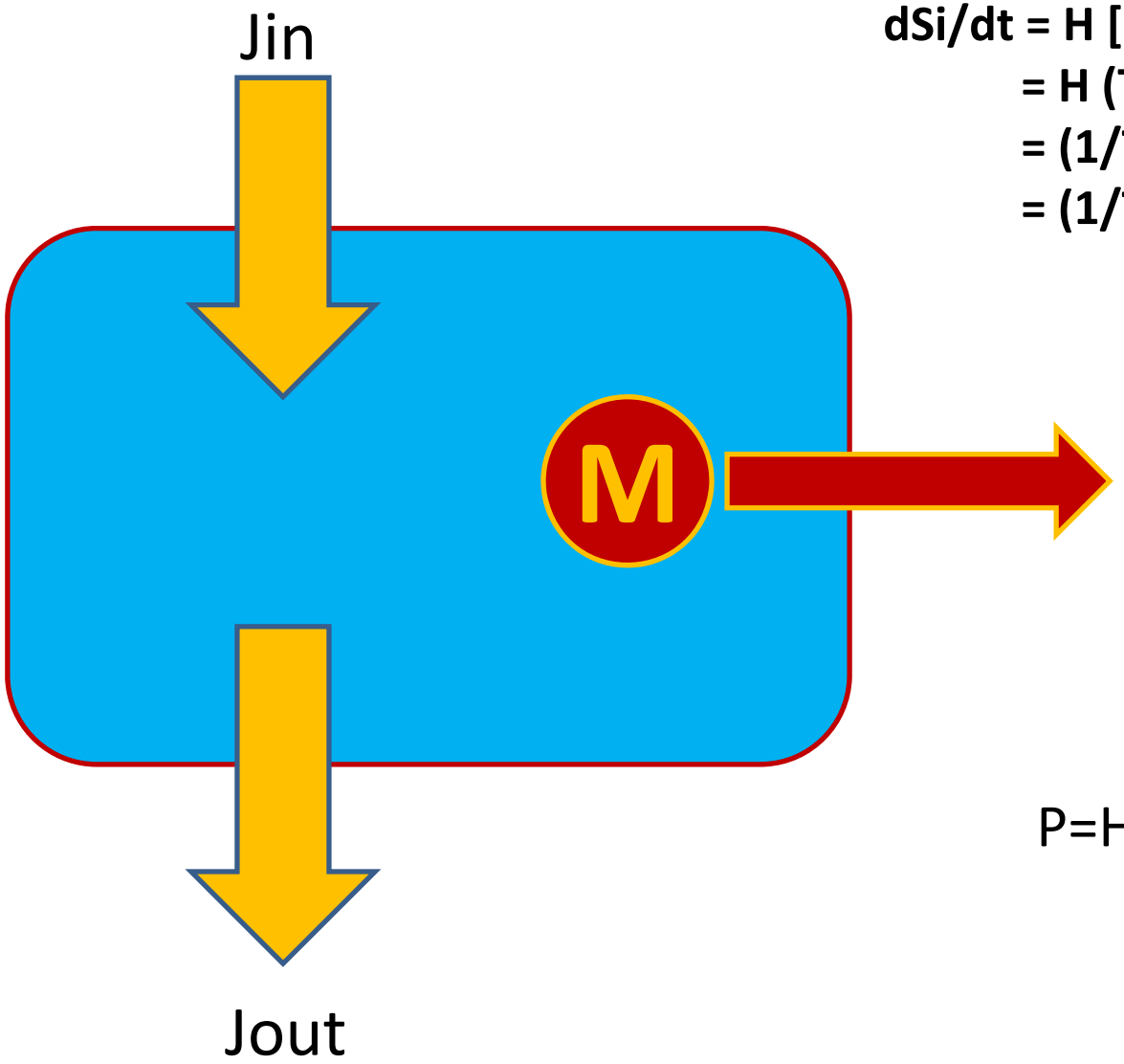
Entropy production
dS/dt = dSi/dt + dSe/dt

Internal entropy production
dSi/dt=**σ** = G [(1/Tsoil)-(1/Tsurf)]

External entropy production
dSe/dt= **NEE**= G/Tsurf

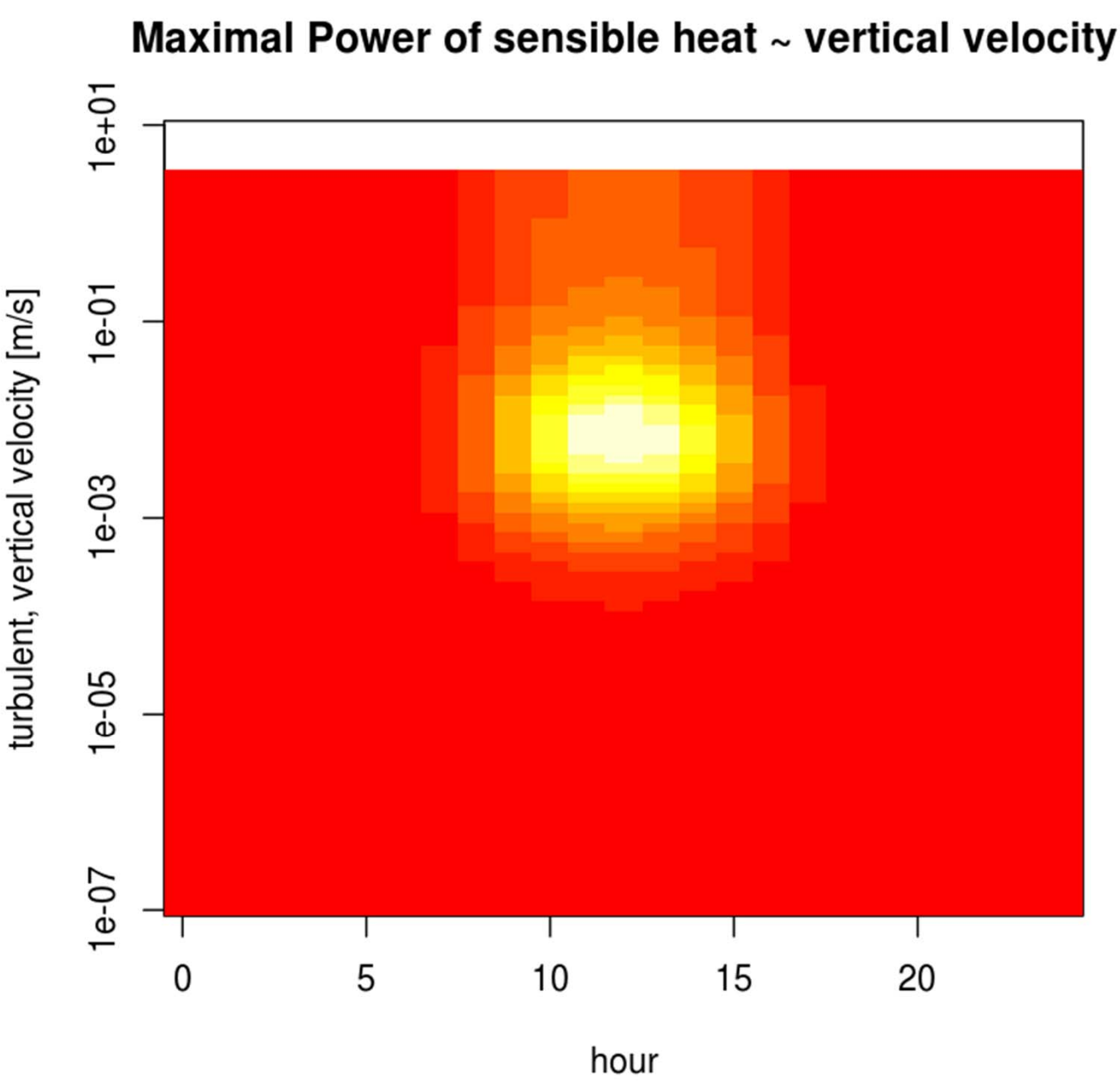


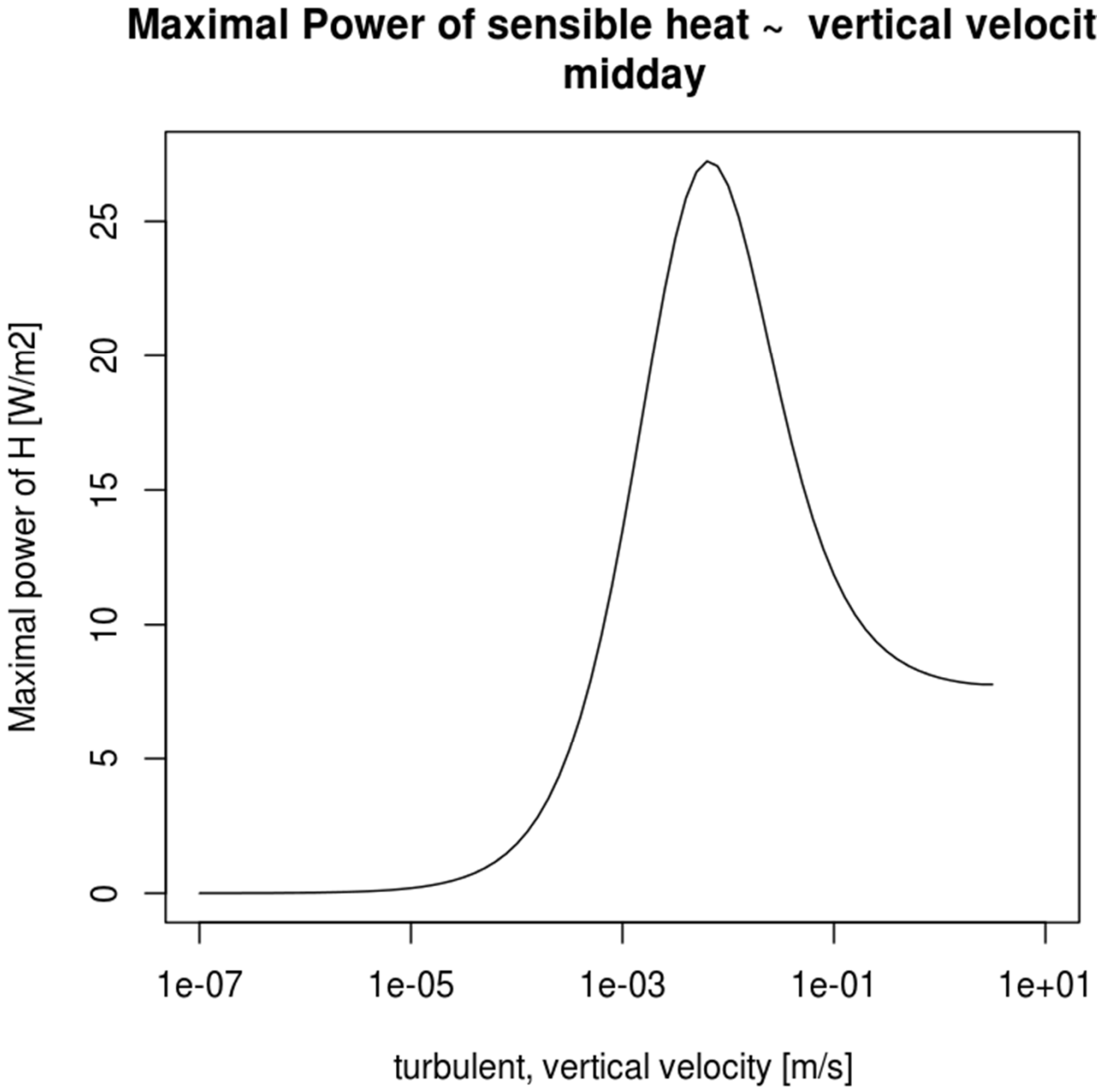
Convective power

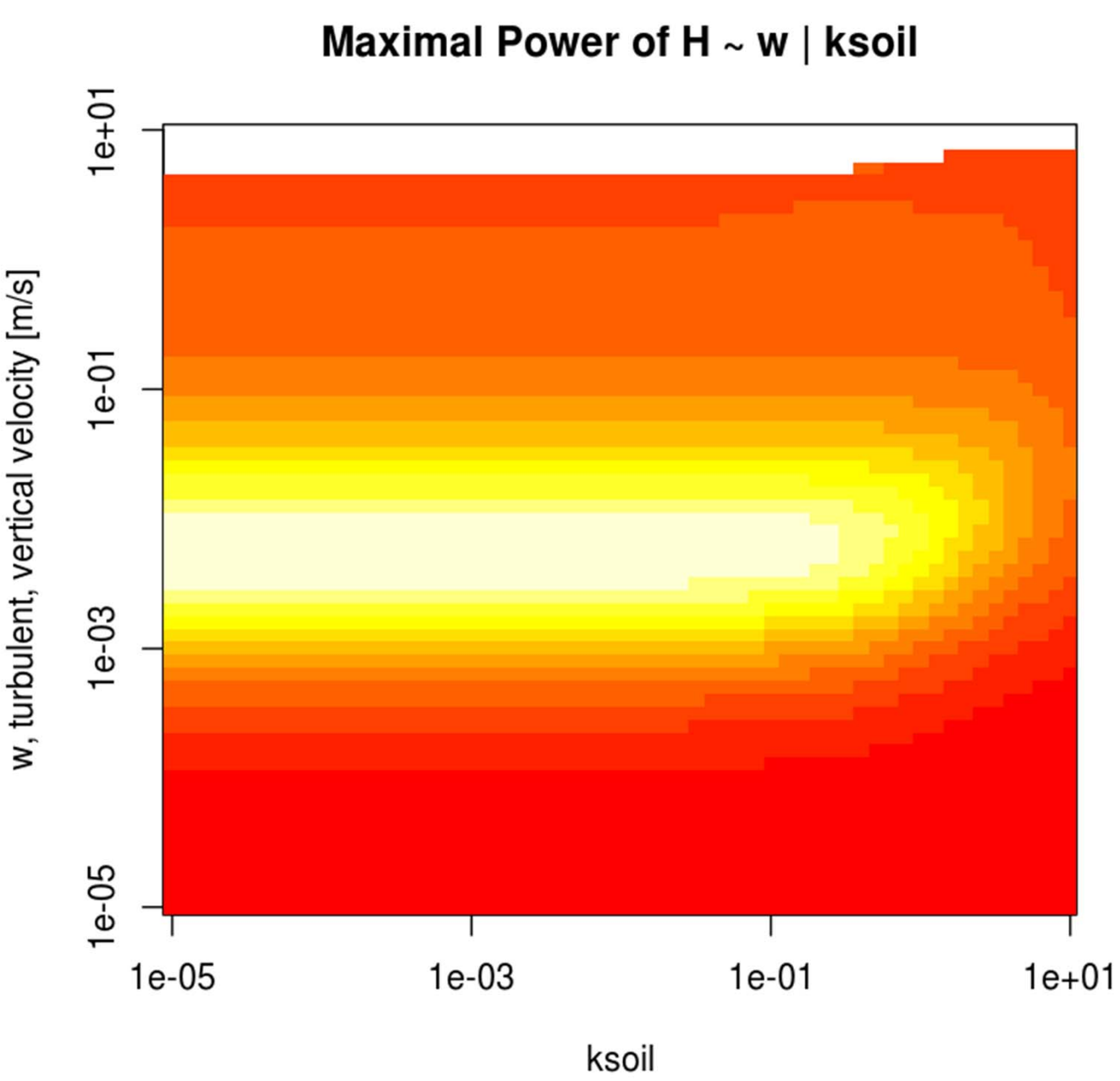


$$dSi/dt = H\,[(1/Tatm)-(1/Tsurf)]$$
$$= H\,(Tsurf-Tatm)/TatmTsurf)$$
$$= (1/Tsurf)\,H\,(Tsurf-Tatm)/Tatm$$
$$= (1/Tsurf)\,H\,\eta$$

$$P=H\,(Tsurf-Tatm)/Tsurf$$


Maximal Power of sensible heat ~ vertical velocity
turbulent, vertical velocity [m/s]
1e+01
1e-01
1e-03
1e-05
1e-07
0
5
10
15
20
hour


Maximal Power of sensible heat ~ vertical velocity midday
Maximal power of H [W/m2]
0
5
10
15
20
25
1e-07
1e-05
1e-03
1e-01
1e+01
turbulent, vertical velocity [m/s]


Maximal Power of H ~ w | ksoil
w, turbulent, vertical velocity [m/s]
1e+01
1e-01
1e-03
1e-05
1e-05
1e-03
1e-01
1e+01
ksoil

Summary

- Energy balance model
- Thermodynamic description
- Model parameters → maximisation of power

Outlook

- Include latent heat
- Study the effect of vegetation on turbulence