An analytical solution for a surface energy balance model including water transport

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We develop an analytical solution that describes the response of the temperature in an urban neighbourhood to diurnal cycles. The surface energy balance is given by

$$Q^* - \Delta Q_S = Q_H + Q_E.$$

Here, Q^* is the net all-radiation, Q_H is the sensible heat-flux, Q_E is the latent heat flux and ΔQ_S is heat storage into the ground. The heat transport inside the soil is modelled using a one-dimensional enthalpy equation which includes water transport effects. We model each of the terms in the energy balance appropriately and impose a diurnal cycle to the shortwave radiation and atmospheric temperature. We show that this problem governed by six dimensionless parameters. The results from the analytical model are in good agreement with the non-linear full system, as shown in Figure 1.

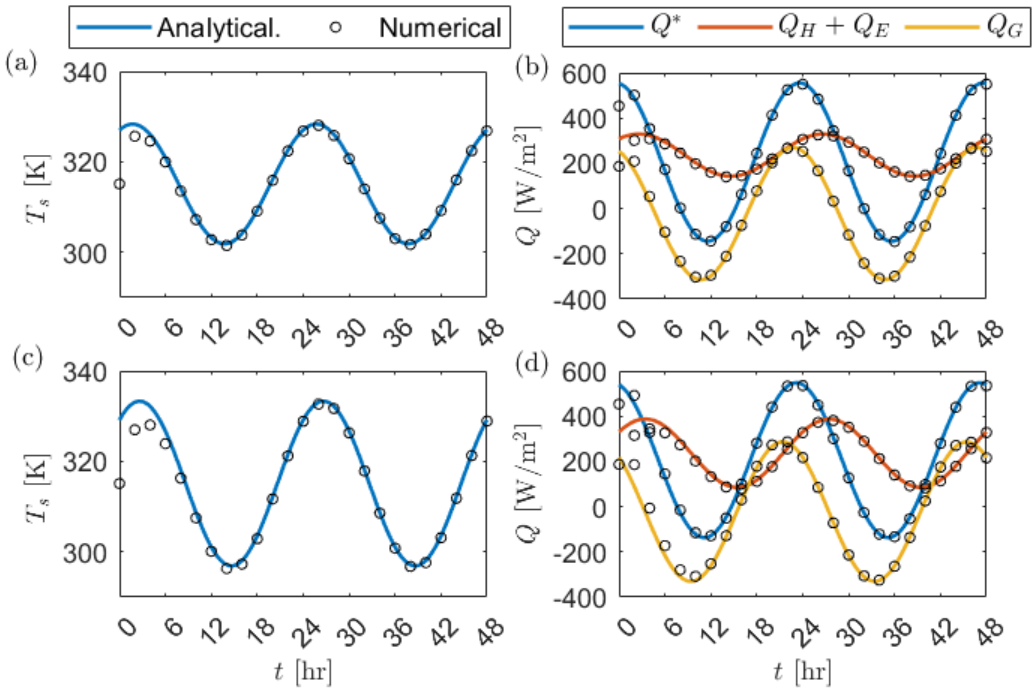

Figure 1: A comparison of the analytical solution with the numerical model for both an infinitely thick soil layer (top row) and a finite thickness soil layer (bottom row). The analytical solution is shown in solid lines and the numerical solution is shown with black dots.