Water Movement and Balance in Soil

Using the 1-D Richards Equation:

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial z}(D\frac{\partial\theta}{\partial z} + K) + S$$

Or

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial z}[K(\frac{\partial\theta}{\partial z}\frac{d\psi}{d\theta} + 1)] + S$$

Where θ is volumetric water content (cm^3/cm^3), ψ is soil matric water potential, D and K is soil water diffusivity and conductivity respectively. S is source or sink of soil water (=0).

1. Building one dimension model to solve the equation, the vertical soil depth is 200 cm, the number of soil layers is 40 with even layer depth 5 cm.
2. The inputs include:
    a. Soil properties: sand, clay percentage and organic matter (used to calculate the D, K and soil water-retention). For organic matter, use a constant value such as 1-2% in the model.
    b. Forcing data: precipitation, evaporation (top boundary forcing on the surface; depth equal zero; assuming water come from/to soil surface freely).
3. The initial soil status is in the field capacity (water potential at field capacity is -340 cm).
4. No water flux in the bottom (depth: 200 cm) and surface runoff is omitted.
5. The outputs include the soil volumetric content, soil water potential in each layer.
6. Modulating the soil water-retention calculations.

D, K and soil water-retention equations please refer to the Saxton and Rawls [2006].

Saxton, K. E., and W. J. Rawls (2006), Soil water characteristic estimates by texture and organic matter for hydrologic solutions, *Soil Sci. Soc. Am. J.*, *70*, 1569–1578.

The sand, clay percentage for top to bottom:(w%?)

Layer number sand clay
1 16.65290069580078 17.5093994140625
2 16.471480568809603 18.220922770449032
3 15.687899589538574 21.294099807739257
4 14.616191512573277 25.307830305786048
5 14.134699821472168 27.111099243164062
6 13.752197061398329 28.486112581097405
7 12.38010025024414 33.41849899291992

8 12.38010025024414 33.41849899291992
9 12.38010025024414 33.41849899291992
10 12.328880830053823 33.57273929543444
11 12.019399642944336 34.50469970703125
12 12.019399642944336 34.50469970703125
13 12.019399642944336 34.50469970703125
14 12.019399642944336 34.50469970703125
15 12.019399642944336 34.50469970703125
16 12.019399642944336 34.50469970703125
17 12.666410341500887 32.61599626076058
18 13.552599906921387 30.02910041809082
19 13.552599906921387 30.02910041809082
20 13.552599906921387 30.02910041809082
21 13.552599906921387 30.02910041809082
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26 13.552599906921387 30.02910041809082
27 13.552599906921387 30.02910041809082
28 14.012700102233794 28.64742327478016
29 14.89009952545166 26.01259994506836
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40 14.89009952545166 26.01259994506836

Cumulative Precipitation and Evaporation in every 3 hour:

1 2.254384 0.1742023
2 9.599644 0.103058204
3 5.581941 0.11124762
4 6.3675565 0.14041081
5 4.987669 0.46073582
6 2.1978647 0.84638243
7 1.6509145 0.6186626
8 1.73228 0.26682993
1 2.3860843 0.1100523
2 7.8709535 0.084613725
3 5.824722 0.11205195
4 5.788659 0.1511167
5 3.6029605 0.34751266
6 2.2401025 0.54860424

7 2.2869725 0.73874545
8 2.4428751 0.27142032

数值方案：
分40层，每层5cm。用基于欧拉后向公式的有限差分法加皮卡德迭代求解。
（Celia，1990）
设定30分钟为一个步长，把降水和蒸散均分到每个步长。
上边界，最上层水通量为降水-蒸发。
初始场，每层的VWC为田间持水量VWCFC，从VWC按照Saxton描述的方案推求每层的土水势
下边界，200厘米深土壤处，水通量=0。
K的计算可以看那篇文献，非常详细。
总土水势=吸力势（soil moisture tension）+重力势（以地表为参考高度0）
土质参数（砂质和黏土质百分比）视为质量百分比。