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Soil Water Balance for 3 contrasting soil types as calculated by Ogden et al., (2015) method

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1- Objective

The comparison of soil moisture contents of 3 contrasting soil types using Ogden et al. (2015) method.

2- Rationale

The NERC Case PhD research involves testing, extending and possible implementation of two relatively new 1-D unsaturated zone flow solution methods into JULES.

1. The Ogden Soil Moisture Velocity Equation (SMVE) approach
2. Conservation of Mass Fractions (CMF) approach

3- Materials and Methods

- Soil water balance of a soil provides information on the amount of moisture content stored in that particular soil.
- The following fluxes play a key role in the soil water balance
  - Infiltration(I)
  - Evapotranspiration(ET)
  - Ground water(gw) recharge/deep percolation
- The water that does not infiltrate constitutes surface run-off

Soil Moisture Content(θ), at timestep i:

$$\theta_i = \theta_{(i-1)} + I - ET - \text{gw\_recharge} \quad (1)$$

Model timesteps of 60 sec duration were used.

4- Data

- The fluxes in Eq. (1) are obtained from the C program (OEA15) which accompanies Ogden et al. (2015).

- Ogden et al. (2015) describes the 1D vertical flow of water in homogeneous soil layers under the action of capillarity and gravity using:

  - Finite Moisture Content(FMC) discretization method

  In FMC method, the soil pore space is divided into uniform layers of moisture content ($\Delta\theta$) which are referred to as bins (Fig. (1)).

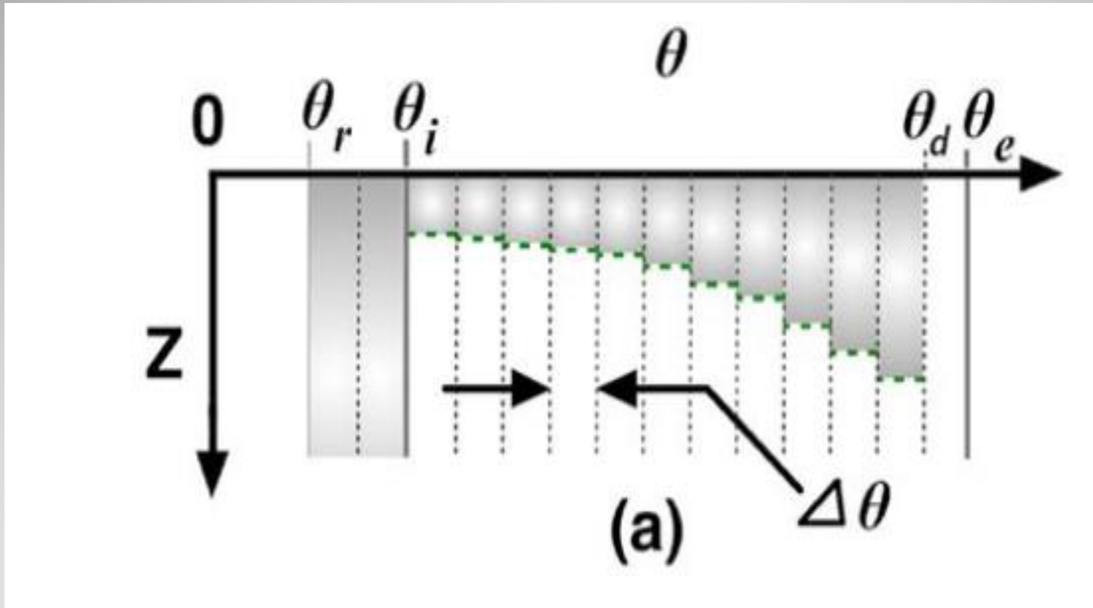

Fig. (1) Finite moisture content solution after infiltration

- OEA15 method attains accuracy, conserves mass and is computationally less expensive compared to the numerical solution of Richards(1931) partial differential equation.

5- Model Execution

Here the OEA15 program is executed and the SWB fluxes, and total root zone SMC calculated are discussed, for 3 contrasting soil types (see Table 1 on next slide for the hydraulic parameters):

- Sandy loam
- Silt loam
- Silty clay soil

OEA15 model is driven by rainfall and potential evaporation (15 min. timesteps, for a duration of 250 days) data collated for a riparian area in central Panama.

Throughout the simulation, a constant ground water table is assumed at a depth of 1m from the soil surface.

Soil Hydraulic parameters (Van Genuchten) used for soil water balance comparison

Table 1. Average values of soil water retention and hydraulic conductivity parameters for 12 USDA soil types according to Carsel and Parrish[1988] and Panama soil.

Texture	θ_r ($cm^3\ cm^{-3}$)	θ_s ($cm^3\ cm^{-3}$)	α (1/cm)	n (-)	K_s (cm/day)
Panama soil	0.027	0.4	0.036	1.56	24
Sand	0.045	0.43	0.145	2.68	712.8
Loamy sand	0.057	0.41	0.124	2.28	350.2
Sandy loam	0.065	0.41	0.075	1.89	106.1
Loam	0.078	0.43	0.036	1.56	24.96
Silt	0.034	0.46	0.016	1.37	6.00
Silt loam	0.067	0.45	0.02	1.41	10.80
Sandy clay loam	0.1	0.39	0.059	1.48	31.44
Clay loam	0.0	0.41	0.019	1.31	6.24
Silty clay loam	0.089	0.43	0.01	1.23	1.68
Sandy clay	0.1	0.38	0.027	1.23	2.88
Silty clay	0.07	0.36	0.005	1.09	0.48
Clay	0.068	0.38	0.008	1.09	4.80

6- Results and Discussion

Graphical representation of all fluxes for the 3 soils mentioned above are given in Fig. (2)-(4), followed by soil moisture content.

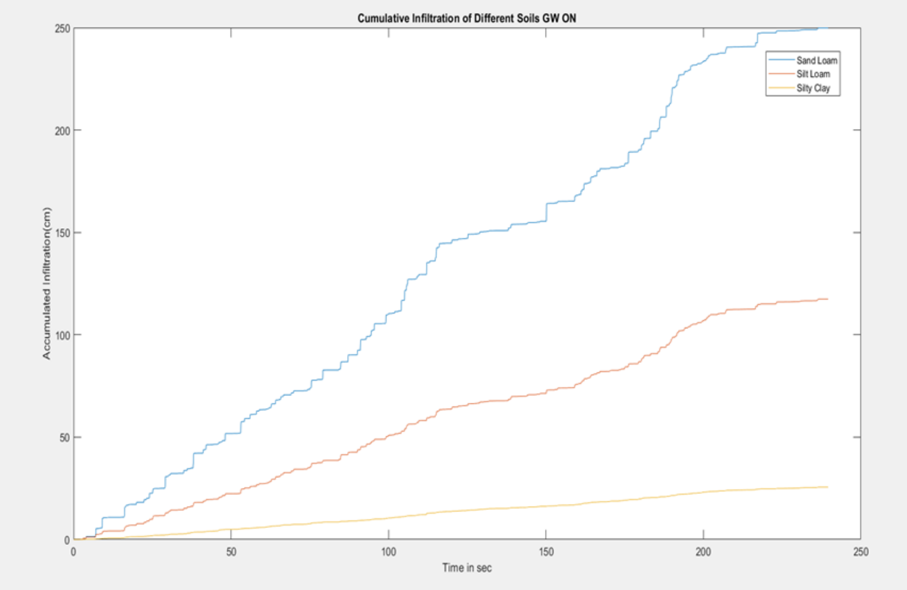

Fig. (2) Cumulative amounts of **infiltration** for Sandy loam, Silt loam and Silty clay soil.

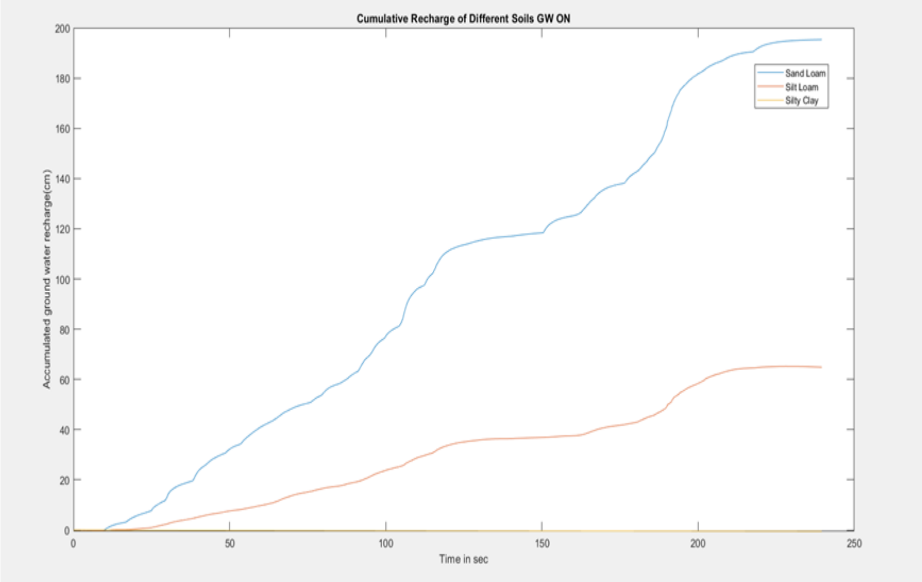

Fig. (3) Cumulative amounts of **gw recharge** for Sandy loam, Silt loam and Silty clay soil.

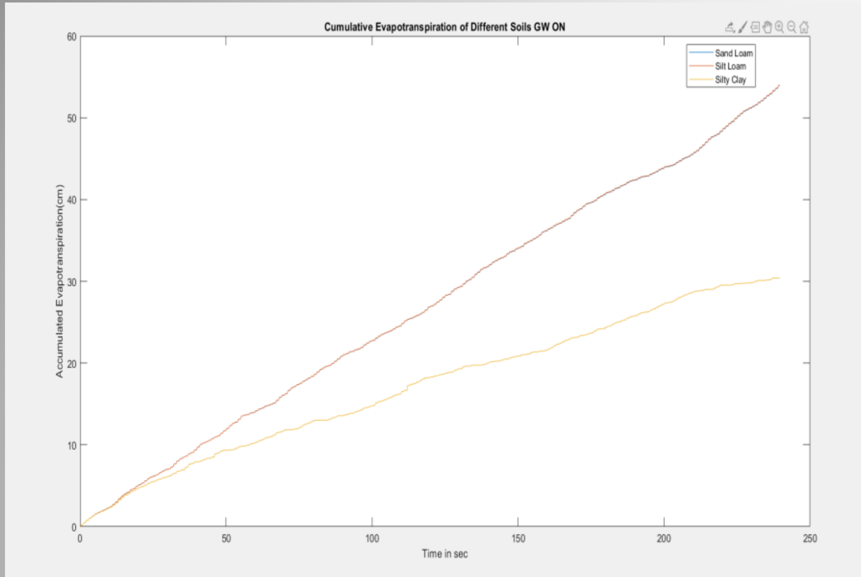

Fig. (4) Cumulative amounts of **evapotranspiration** for Sandy loam, Silt loam and Silty clay soil.

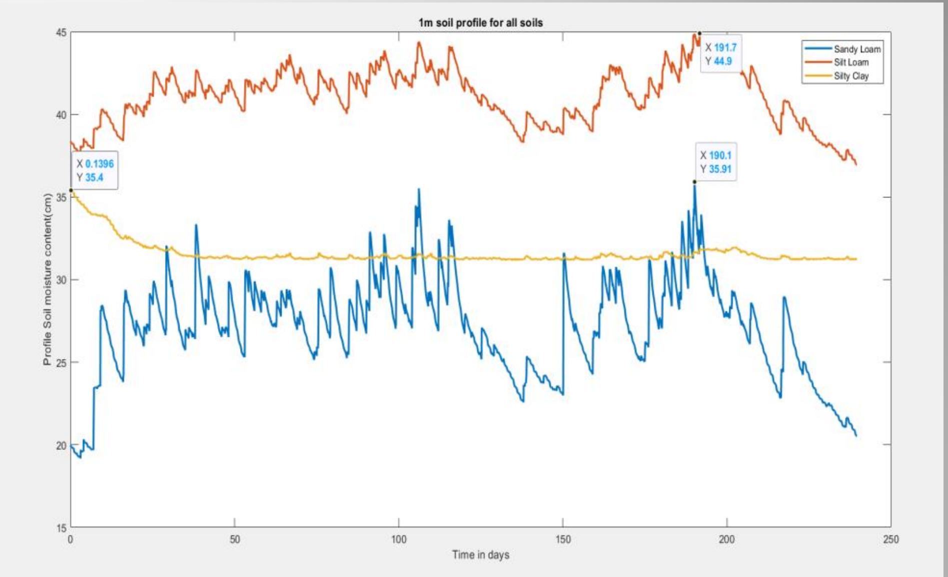

Fig. (5) **Soil Moisture Content** calculated using Eq. (1) for Sandy loam, Silt loam and Silty clay soils with GW_ON.

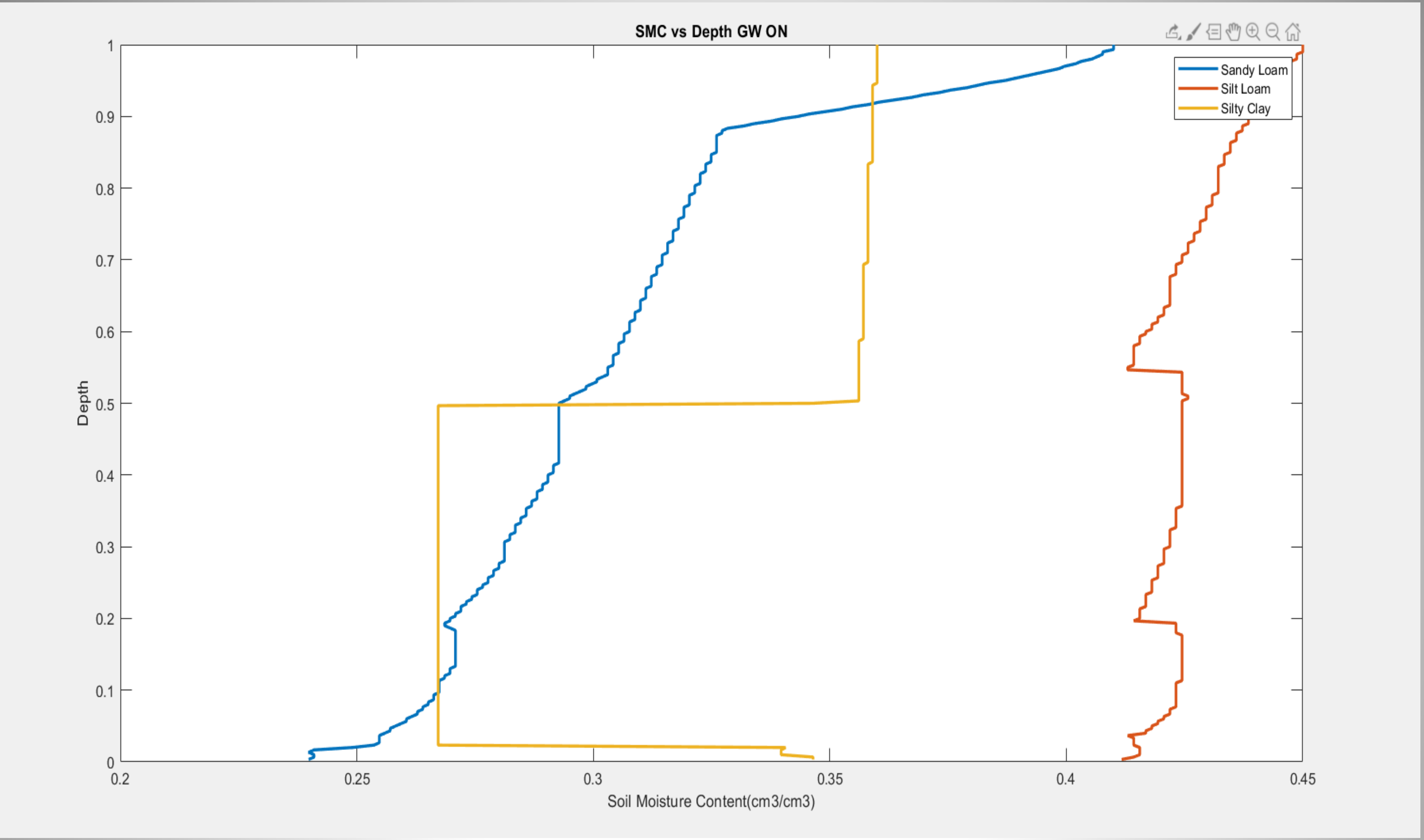

Fig. (6) Soil Moisture Content (from profile files that were part of OEA15 output set) vs depth for Sandy loam, Silt loam and Silty clay soils with GW_ON.

Note the abrupt changes in soil moisture profile for this method. This could be a serious issue in the context of JULES model outputs/stability!

7- Future Objectives

- Execution of OEA15 program with Brooks and Corey parameters instead of VG parameters.
- Comparisons will be made with outputs of the SWAP model and both models compared with bare soil verification data, in first instance.
- If OEA15 model performance is satisfactory, I would like to run the OEA15 program in JULES and compare its performance with standard JULES.

JULES
Joint UK Land Environment Simulator

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Thank you for your attention

University of Reading

Met Office

UCAR

SMC of all the 12 USDA soil types including Panama soil is shown below.

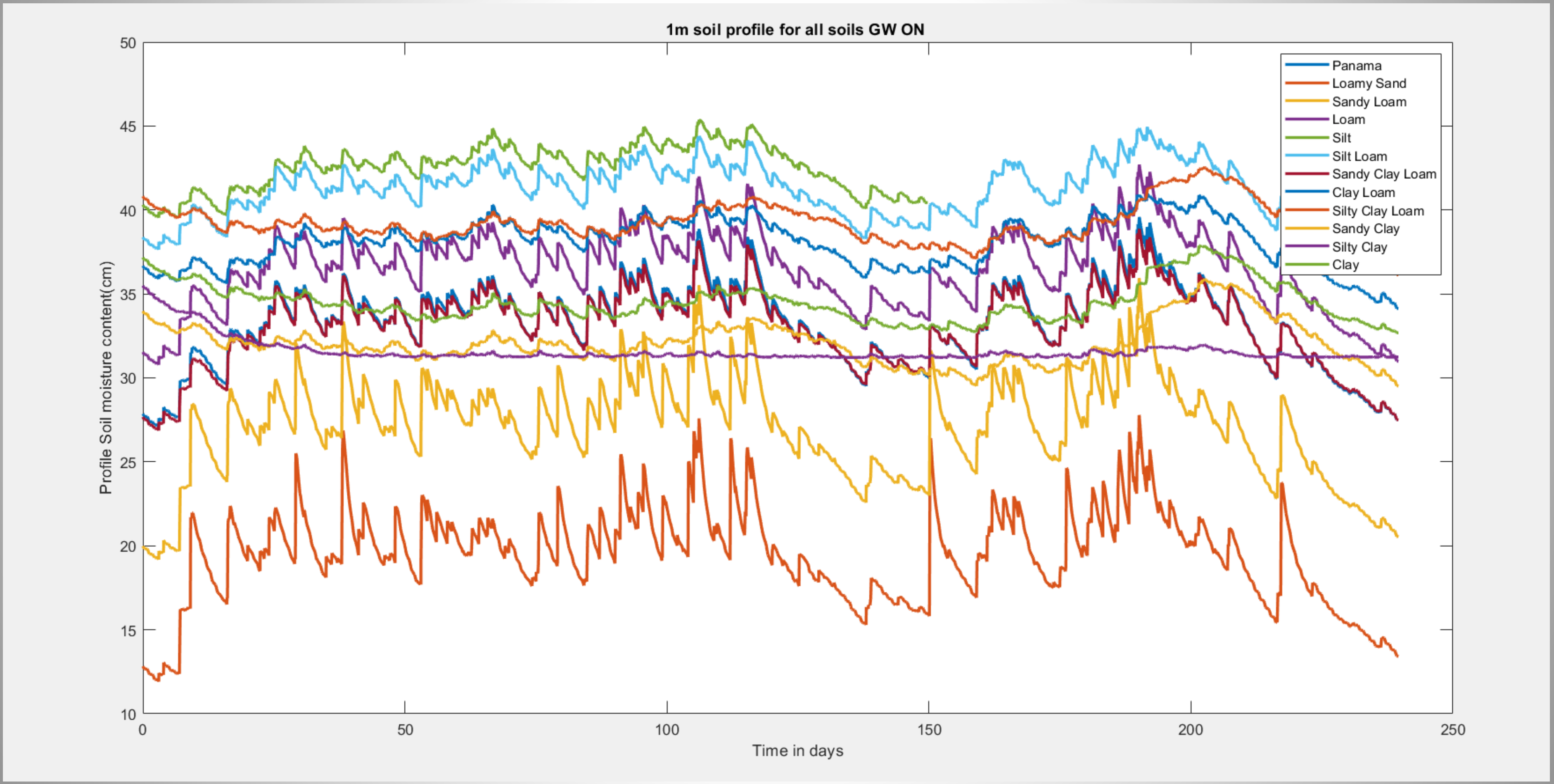

Fig. (7) Soil Moisture Content for 250 days calculated from the various soil water balance fluxes using Eq. (1) for Panama and 12 USDA soil types with GW_ON.