TIME-SCALE OF GROUNDWATER RECHARGE IN COASTAL PLAIN SOILS

Qing Du
Advisor: Dr. Mark Ross
Department of Civil & Environmental Engineering
College of Engineering

UNIVERSITY OF SOUTH FLORIDA

Introduction

Modeling groundwater recharge in the coastal plain and other settings is crucial to understand and utilize water resources wisely in the face of increased demand and climatological changes in these regions. West-Central Florida, with a high reliance on groundwater resources for portable water supply, faces seawater intrusion and surface wetland/streamflow impacts (SWFWMD, 2017).

Literature Review

The accurate estimation of groundwater recharge from rainfall infiltration has always been a challenge in groundwater modeling (Gebreyohannes, 2008). Richards' equation can be used to study water movement but it is considered as computationally expensive and unpredictable (Short, Dawes, White,1995) over a large scale for a long-term simulation. Modern groundwater recharge models are often overly simplistic or flawed (Gosses, Wöhling, 2019)

Research Objectives

To use Hydrus solutions to examine a more simplistic means to characterize the timing and parameters affecting recharge in shallow to medium (1-10m) water table settings typical of coastal plain environments. Non-dimensional timing characteristics are identified for arrival and bulk recharge which may prove useful for understanding the relationship between rainfall infiltration and saturated water-table recharge.

Methodology

HYDRUS-1D (Šimůnek, 2013) was used to simulate the progression of water through the vadose zone with West-Central Florida MYAKKA sand (Virdi, 2013).

Preliminary tests at equilibrium moisture profile on shallow water table depth to estimate a 'wet equilibrium' pressure.

Based on the preliminary test results to investigate the flux and water table behavior on shallow to medium water table depth with the wet equilibrium initial condition without ET uptake on other scenarios including different Ks, rainfall intensity, duration, rainfall volume.

Ambient run (without rainfall event) for each depth to water table are also tested, to reduce the background noise from the wet equilibrium initial condition.

Conclusion

The timing of arrival flux (1%) has a linear relationship with depth in the root zone, below the root zone, the linear relationship transitioned to a polynomial relationship.

The bulk recharge (80%) has a exponential relationship with depth.

Both of timings are independent of Ks and rainfall intensity, but heavily dependent on pulse magnitude.

Flux arrive around the same time at middle of capillary zone and water table.

Future Work

The future research can be focusing on investigating of different n from Van Genuchten parameter.

Model Setup

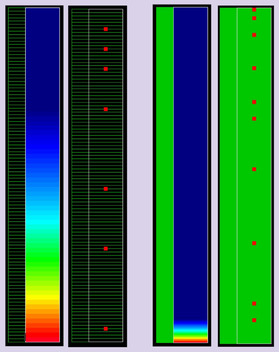
MYAKKA sand soil parameters:

θ_r	θ_s	α (1/cm)	n	l
0.045	0.36	0.018288	6.378	0.5

Scenarios:

DTWT (m)	K_s (cm/min)	Rainfall Intensity (cm/min)	Duration (min)	Total Volume (cm)
1	0.0106	0.05	100	5
	0.0212	0.05	100	5
		0.1	50	5
	0.0424	0.05	100	5
		0.2	25	5
2	0.0106	0.05	100	5
	0.0212	0.05	100	5
	0.04	0.05	100	5
		0.1	50	5
		0.2	25	5
3	0.0106	0.05	100	5
	0.0212			
	0.0424			
4	0.0106	0.05	100	5
	0.0212			
	0.0424			
10	0.0212	0.05	100	5
			200	10
			400	20

Soil column diagram example:
(pressure and the location of the observation points)

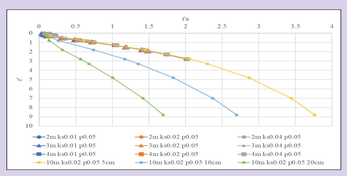


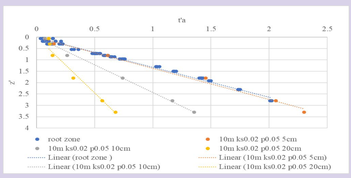
Results

Ambient run water table rise results (K_S=0.0212 cm/min):

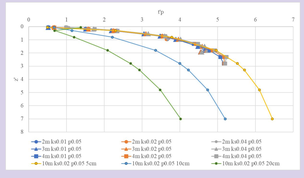
Initial DTWT (m)	95% WT Rise (cm)	95% WT Rise (day)
1	0.945	20
2	9.637	149
3	16.485	165
4	24.649	247
10	83.375	1299

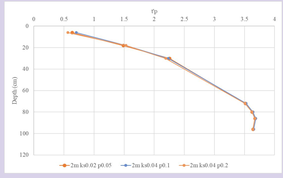
Arrival time t'_a results:

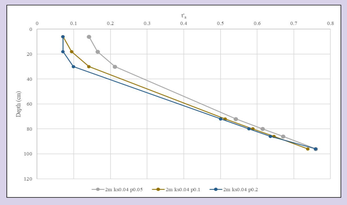


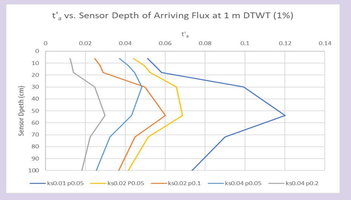


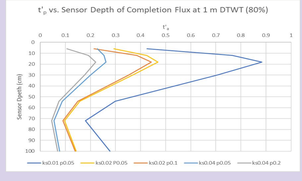
Bulk recharge t'_p results:



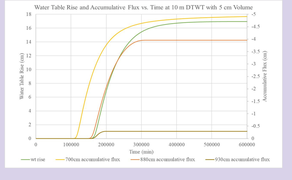


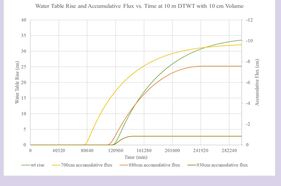


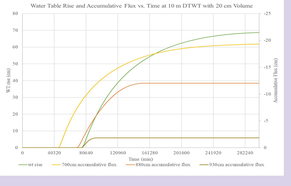


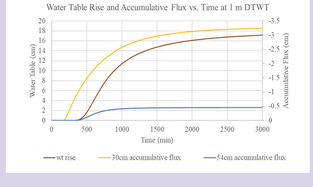


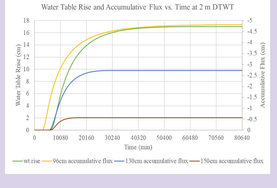
The flux arriving at half of capillary zone and at water table results:

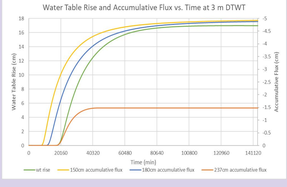


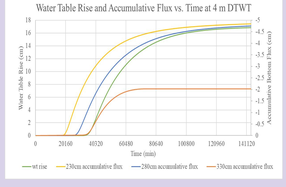












*key time: 1440 min - 1 day; 10080 min - 7 day; 20160 min - 14 day; 4030 min - 28 day; 120960 min - 84 day; 144000 min - 100 day; 432000 min - 300 day

References

Southwest Florida Water Management District. (2017, October 1). *West-central Florida's aquifers.* Southwest Florida Water Management District. https://www.swfwmd.state.fl.us/sites/default/files/store_products/flas_aquifers.pdf

Šimůnek, J., Šejna, M., Sakai, M., & van Genuchten, M. T. (2013, June). *The HYDRU-1D Software Package for Simulating the One-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media.* https://www.pc-progress.com/en/Default.aspx?h1d-downloads

Short, D., Dawes, W. R., & White, I. (1995). *The practicability of using Richards' equation for general purpose soil-water dynamics models.* Environment International, 21(5), 723–730. https://doi.org/10.1016/0160-4120(95)00065-S

Gosses, M., & Wöhling, T. (2019). Simplification error analysis for groundwater predictions with reduced order models. *Advances in Water Resources*, 125, 41–56. https://doi.org/10.1016/j.advwatres.2019.01.006

Gebreyohannes, H. G. (2008, February). (thesis). *Groundwater Recharge Modelling A case study in the Central Veluwe, The Netherlands.* Retrieved from https://webapps.itc.utwente.nl/librarywww/papers_2008/msc/wrem/hiwot.pdf.