**A new general 1-D vadose zone flow solution method Federico**

Fred L. Ogden, Wencong Lai, Robert C. Steinke, Jianting Zhu, Cary A. Talbot, and John L. Wilson

2015a

http://dx.doi.org/10.1002/2015WR017126

This is the main reference for the finite water-content solution developed as an efficient, converging, mass conserving and accurate alternative to Richards’ Equation. Section 3.3 is about groundwater table movement and mentions **specific yield**. Section 3.7 describes how the equations are applied in the unsaturated area to the infiltration front (in contact with land surface, gravity), falling slugs (no contact, gravity) and groundwater front (in contact with groundwater table, capillarity), in a way that conserves mass. Several equations and a couple of applications that show the goodness of the method.

**Why it matters:** this paper should connect to our use of specific yield and how we model, in a simpler way, what happens when the groundwater table moves up and down. Still unclear how we make the connection to this paper, need to retrieve SI notes, study the column paper (Ogden 2015b) and discuss with Fred.

**Validation of finite water‐content vadose zone dynamics method using column experiments with a moving water table and applied surface flux Brittany**

[Fred L. Ogden](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Ogden%2C+Fred+L), [Wencong Lai](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Lai%2C+Wencong), [Robert C. Steinke](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Steinke%2C+Robert+C), [Jianting Zhu](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Zhu%2C+Jianting)

2015b

<https://doi.org/10.1002/2014WR016454>

**Useful quotes**:

The *Richards* [equation (RE) for variably saturated soil water flow is still the most rigorous way to describe interaction between unsaturated and saturated zones Numerical solution of the RE is computationally expensive due to its highly nonlinear nature, required high vertical resolution on the order of mm to dm to correctly model land‐surface partitioning. Furthermore, the RE can exhibit difficulties with numerical convergence near saturation [*Vogel et al*., [**2000**](https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014WR016454#wrcr21413-bib-0032)].

*Talbot and Ogden* proposed a new 1-D infiltration and capillary redistribution method (T‐O method) using a finite water‐content formulation. The finite water‐content discretization is different from the “bundle of tubes” analogy, in that all of the Δ*θ* “bins” in the finite water‐content discretization are in intimate contact with each other and fully interacting. The T‐O method does not require spatial discretization, employs an explicit finite‐volume solution of an ordinary differential equation, and is therefore unconditionally mass conservative. Comparisons against the Richards equation solution on 11 USDA soil types showed that the T‐O method is capable of providing accurate estimates of infiltration rates in the case of a deep well‐drained soil during multiple infiltration periods.

finite water content *T-O* vadose zone simulation method was improved and modified to include groundwater table dynamics and validated using data collected in a column experiment patterned after that by *Childs and Poulovassilis*[[**1962**](https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014WR016454#wrcr21413-bib-0005)] with moving water table and specified flux upper boundary conditions. The improved T‐O formulation was found to agree satisfactorily with experimental data for the evolution of soil water content above a moving water table. The ordinary differential equation T‐O method was also compared with the Hydrus‐1D numerical solutions of the *Richards* [[**1931**](https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014WR016454#wrcr21413-bib-0022)] partial differential equation. Results showed similar performance for both methods in simulating water content evolution. The T‐O method on average had higher Nash‐Sutcliffe efficiencies and lower absolute bias than Hydrus‐1D.

These properties make the improved T‐O method presented in this paper a robust and computationally efficient alternative to the numerical solution of the *Richards*[[**1931**](https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014WR016454#wrcr21413-bib-0022)] equation, which is occasionally subject to stability and mass conservation limitations that affect its robustness and computational efficiency in the context of hydrological modeling.

**2) Where should we cite it?** This should be in discussions and maybe intro since our study is similar to his in regards to creating a moving water table model (method as stated in the paper) similar to this paper.

**3)Should we take inspiration from it? Does it suggest potential expansion or improvement?**

Very much yes. In includes the moving water table concept like us.

**An efficient and guaranteed stable numerical method for continuous modeling of infiltration and redistribution with a shallow dynamic water table Brittany**

[Wencong Lai](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Lai%2C+Wencong), [Fred L. Ogden](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Ogden%2C+Fred+L), [Robert C. Steinke](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Steinke%2C+Robert+C), [Cary A. Talbot](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Talbot%2C+Cary+A)

2015c

<https://doi.org/10.1002/2014WR016487>

**1)In the context of our study, is it useful to cite?** More yes than no, it is similar to our objective in creating a new model by building from different ones. This uses both Green-Ampt w/ Redistribution (GAR) and Talbot-Ogden (T-O) method.

**2) Where should we cite it?** This could be in the intro in the sense that we are doing something similar by incorporating previously existed models/ideas into our alternate model.

**3)Should we take inspiration from it? Does it suggest potential expansion or improvement?**

Not as much compared to the primary Ogden citation.

**Useful quotes**:

We have developed a one‐dimensional numerical method to simulate infiltration and redistribution in the presence of a shallow dynamic water table.

This method builds upon the Green‐Ampt infiltration with Redistribution (GAR) model and incorporates features from the Talbot‐Ogden (T‐O) infiltration and redistribution method in a discretized moisture content domain. We present results from numerical tests on 11 soil types using multiple rain pulses with different boundary conditions, with and without a shallow water table and compare against the numerical solution of Richards' equation (RE).  The Green‐Ampt infiltration model was derived to predict infiltration under ponded conditions into homogeneous soil with uniform initial water content, assuming a sharp and piston‐like wetting front having a constant matric suction. The Green‐Ampt equation is derived under these assumptions using saturated Darcy's law in the vertical dimension and conservation of mass. The Green‐Ampt equation is applicable for a single ponding period. In reality, soil water redistribution occurs when there is no ponded surface water and the rainfall intensity is less than saturated hydraulic conductivity. During this rainfall hiatus period, the GAR method assumes that when redistribution occurs, the rectangular wetting front thins in the *θ*direction, and deepens in the *Z* direction due to unsaturated flow under the action of capillary and gravitational forces.

GARTO method extends the Green‐Ampt methodology beyond the continuous simulation domain, into the surface/subsurface water interaction domain, making the approach suitable for use in hydrologic models where coupling between the surface and groundwater table is important.

In the absence of a shallow groundwater table, results from the GARTO method were in satisfactory agreement with RE solutions in term of ponding time, deponding time, infiltration rate, and cumulative infiltrated depth. In the presence of a shallow water table, the differences between the GARTO and FUCG RE solutions increased as the water table approached the soil surface. In a large‐scale watershed model, uncertainties in soil hydraulic parameters are likely to have a greater impact than differences between the GARTO and FUCG RE solutions. In summary, the GARTO method can be used in large‐scale hydrologic modeling as a soil moisture accounting submodel where infiltration flux or cumulative infiltrated water are of primary concern, with or without a shallow water table. However, this one‐dimensional method has limits as does its foundation, the Green‐Ampt model, namely that homogeneous soil is assumed (i.e., soil layers with vertical variability of soil properties is not considered) without hysteresis effects. We are presently developing a multilayered GARTO scheme.

**An explicit approach to capture diffusive effects in finite water-content method for solving vadose zone flow Federico**

Jianting Zhu, Fred L. Ogden, Wencong Lai, Xiangfeng Chen, Cary A. Talbot

2016

<https://doi.org/10.1016/j.jhydrol.2016.01.078>

Talbot and Ogden developed the TO method to work around Richards’ Equation (Partial Differential Eq.) and model flow in unsaturated (=vadose) zone using an Ordinary Differential Eq. instead easier to solve, more feasible in hydrologic model, can use at larger, watershed scale. Here they add diffusivity to their model. They treat advection and diffusion separately (assumption, actually their effects are coupled). They find that TO+Diffusion produces more accurate water content profiles than just TO.

**Why it matters:** not very relevant, but part of the studies that seek a simple-to-solve, efficient and sufficiently accurate solution to the problem of water flowing in the soil (here unsaturated; our study neglects that, because we are more about saturated and water table oscillations). Values of sandy loam and other coarse soils might be of interest.

**See also, more important:** Ogden, F.L., Lai, W., Steinke, R.C., Zhu, J., Talbot, C.A., Wilson, J.L., 2015c. A new general 1-D vadose zone flow solution method. Water Resour. Res. 51, 4282–4300. http://dx.doi.org/10.1002/2015WR017126.

**The soil moisture velocity equation Federico**

Fred Ogden, Myron Allen, Wencong Lai, Jianting Zhu, Mookwon Seo, Craig Douglas, Cary Talbot

2017

https://doi.org/10.1002/2017MS000931

Equation for calculating the speed of travel of discrete moisture contents in the soil.

*Neglecting the diffusion-like term resulted in slightly different wetting front profile shapes, but* ***cumulative infiltration*** *values in each case tested differed from the exact solutions by less than 1%. So, the SMVE advection-like flux term is sufficiently accurate as a replacement for the numerical solution of the one-dimensional Richards* ***equation for calculating vertical fluxes of water*** *in homogeneous soil layers.*

**Why it matters:** why does the above paper matter then?? Cite this and Ogden et al 2015 papers.

**Numerical Solution of Richards’ Equation: A Review of Advances and Challenges Federico**

Matthew W. Farthing, Fred L. Ogden

2017

https://doi.org/10.2136/sssaj2017.02.0058

Review of the many problems of Richards’ Equation (hard to solve, varying irregular soil, variables like hydraulic conductivity in unsaturated and capillary head can change very quickly in space, large gradients, instability, does not converge, boundary conditions hard to determine in practice) and techniques used to overcome and improve solution (most important: adaptive spatial and temporal discretization, i.e. increase resolution where things change the most).

**Why it matters:** just to provide a reference for Richards’ Eq., no need to say anything.

**Water’s Way at Sleepers River watershed – revisting flow generation in post-glacial landscape, Vermont USA Brittany**

James B. Stanley, Stephen D. Sebestyen, Jeffrey J. McDonnell, Brian L. McGlynn, Thomas Dunne

2014

<https://doi.org/10.1002/hyp.10377>

**1)In the context of our study, is it useful to cite?**

Only in respect to Sleeper’s river. It would not help the study overall because if goes into depths about other hydrologic processes that we have not discussed in our paper that affects overland flow (FDOM CDOM, and quick EMMA).

**2) Where should we cite it?**

This might be useful for study area or discussion in our paper since it talks about the surface overland flow for Sleeper’s river in respect to the landscape.

**3)Should we take inspiration from it? Does it suggest potential expansion or improvement?**

Not really, first half of paper were using DOC and isotopic hydrograph separation for the sites

**Useful quotes**: “A possible explanation for the lack of the expected scale effect at Sleepers River is that the relatively narrow valleys in rugged topography do not support extensive aquifers, yet these valleys have well‐developed flood plains that allow SOF over extensive VSAs (variable source area)”

Soil compaction and patterns of snow accumulation/ground frost development in pastures, which are a greater fraction of the SRRW landscape area at larger spatial scales, may have contributed to increases in new water runoff (Shanley and Chalmers, [**1999**](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.10377#hyp10377-bib-0077)). A notable result from that study was the finding of much greater new water runoff in one of the two snowmelt years studied, which they attributed to deep ground frost that prevented the infiltration of meltwater in spring. Overall, new water inputs ranged from 41 to 74% in the deep‐frost year compared with 30 to 36% in the low‐frost year (Shanley *et al*., [**2002**](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.10377#hyp10377-bib-0078)). Overland flow on frozen ground was directly observed at the small agricultural W‐2 catchment, which had the highest fraction of open land (73%) and the highest fraction of new water (74%).

Relative to the Scandinavian catchments of Water's Way, the SRRW has more rugged topography; thus, steeper hydraulic gradients are a greater consideration in water delivery from hillslope to stream. Another important factor in the hydrology is the jointing and fracturing, which form primary controls on drainage patterns (Newell, [**1970**](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.10377#hyp10377-bib-0066)) and spring locations (Dunne, [**1980**](https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.10377#hyp10377-bib-0024)).