NEW SHALLOW WATER TABLE DEPTH ALGORITHM IN SWAT2005: RECENT MODIFICATIONS

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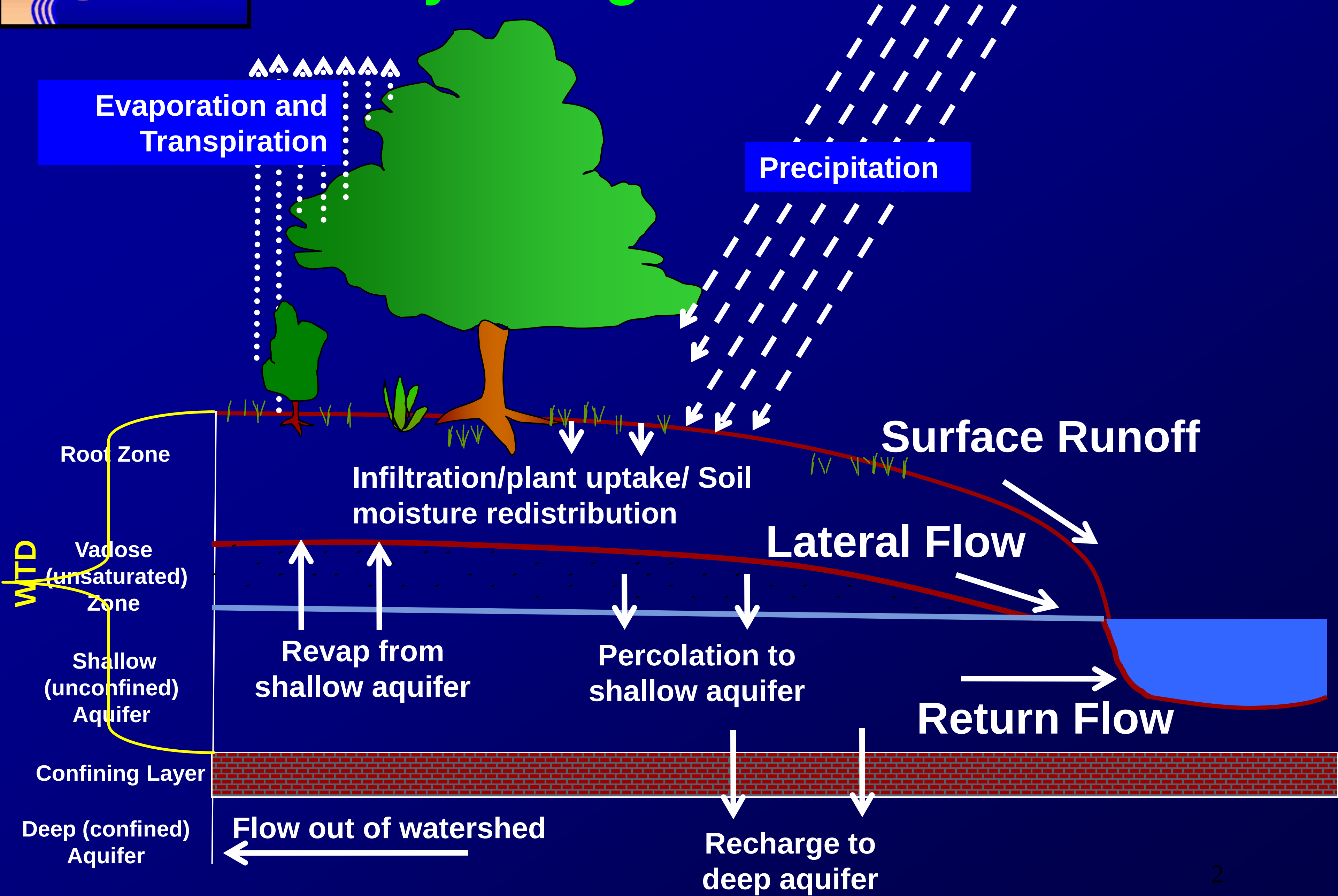
Hydrologic Balance



WTD Algorithms Used in SWAT2005

- SWAT-M (Current)
- SWAT2005 (Antecedent Climate, AC)
- DRAINMOD (WB-DV)
- Modified DRAINMOD (MDV-WTD)
    - New Algorithm

Moriasi et al. (2009)

Study Area and Data

- **Muscatatuck River basin (MRB) is located in Decatur, Jennings, Ripley, Jefferson, Scott, and Jackson counties in southeast Indiana (Vazquez-Amábile and Engel, 2005) (fig)**
- **Measured Streamflow data from 3 USGS stream gauges within the watershed located at Vernon, Deputy, and Harberts Creeks to calibrate and validate stream flow (Vazquez-Amábile and Engel, 2005)**
- **wtd data measured at three observation wells located in forest fields without tile drainage within the Storm Creek lower watershed were used to evaluate the wtd algorithms**

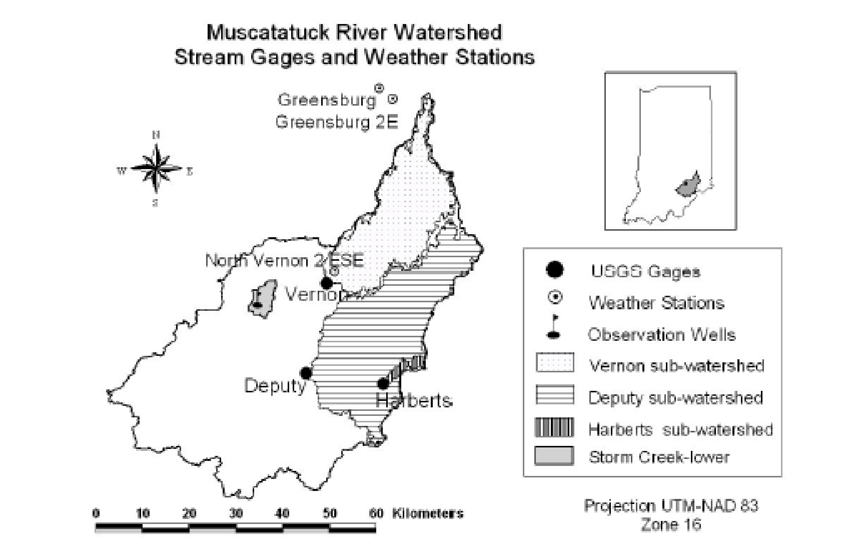


Figure 2. Weather stations and USGS gauges for the Muscatatuck River watershed.

Courtesy of Vazquez-Amábile and Engel (2005)

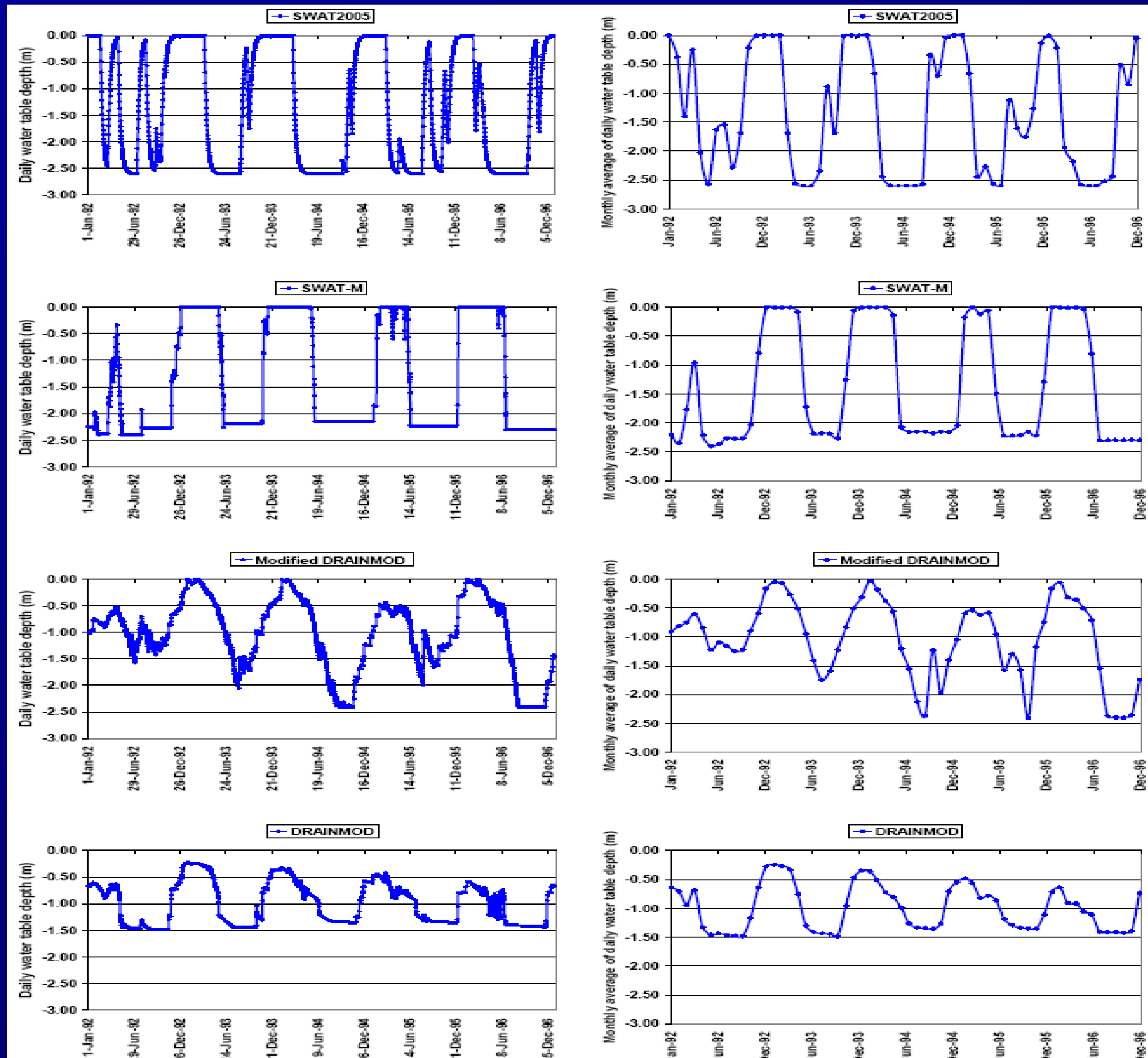
Moriasi et al. (2009)

WTD Algorithms Used in SWAT2005: Comparisons of wtd Predictions

	Method	Daily water table depth				Monthly water table depth			
		NSE	PBIAS (%)	RMSE (m)	R	NSE	PBIAS	RMSE (m)	R
Calibration (1992 -1994)	MDV-WTD	0.66	-18	0.41	0.83	0.73	-12	0.38	0.87
	WB-DV	-0.12	-44	0.74	0.60	0.36	-25	0.59	0.71
	Current	-3.88	-223	1.54	0.56	-0.15	-42	0.87	0.66
	Antecedent Climate (AC)	-1.85	-103	1.18	0.54	-1.04	-74	1.06	0.60
Validation (1995 -1996)	MDV-WTD	0.36	5	0.56	0.61	0.30	6	0.57	0.56
	WB-DV	-0.74	-86	0.92	0.41	-0.51	-71	0.84	0.45
	Current	-3.21	-175	1.43	0.32	0.36	-8	0.69	0.76
	Antecedent Climate (AC)	-2.68	-91	1.34	0.17	-2.00	-65	1.17	0.32

Moriasi et al. (2009)

Complete Predicted WTD Time Series: Rossmoyne Soil Series



Moriasi et al. (2009)

New Wtd Algorithm - Approach

- **Based on the *wtd* and drainage volume (*vol*) relationship**
  - ***vol* is the total air volume above the water table.**

$$vol = vol_i - \inf lpcp + sepbtm + qtile + latq + etday + gw\_q + wushall$$

$$vol_i = avolmx(1. - FFCB)$$

$$avolmx = (dep\_imp)/(vwt\_convtr_p)$$

Infiltration, deep seepage, tile drainage, lateral flow, ET, shallow aquifer contribution to streamflow for a nearby stream (baseflow), and consumptive use through pumping (if any), FFCB = initial soil water

- **Wtd is computed from the *vol* as follows**

$$wtd = vwt\_convtr_p * vol$$

  - **vwt_convtr_p is a function of soil type, larger for course textured and smaller for fine textured; calibration factor**

Moriasi et al. (2009)

SWAT

Recent Modifications: Goals

- **1) To modify the new wtd algorithm in so that *vwt_convtr* is automatically computed as a function of soil physical properties**
  - **eliminate determination of *vwt_convtr* through the calibration process**

- **To evaluate the modified new *wtd* algorithm in SWAT2005 using measured water table depth data for three soils located in forest fields without tile drainage within Muscatatuck River basin in southeast Indiana.**

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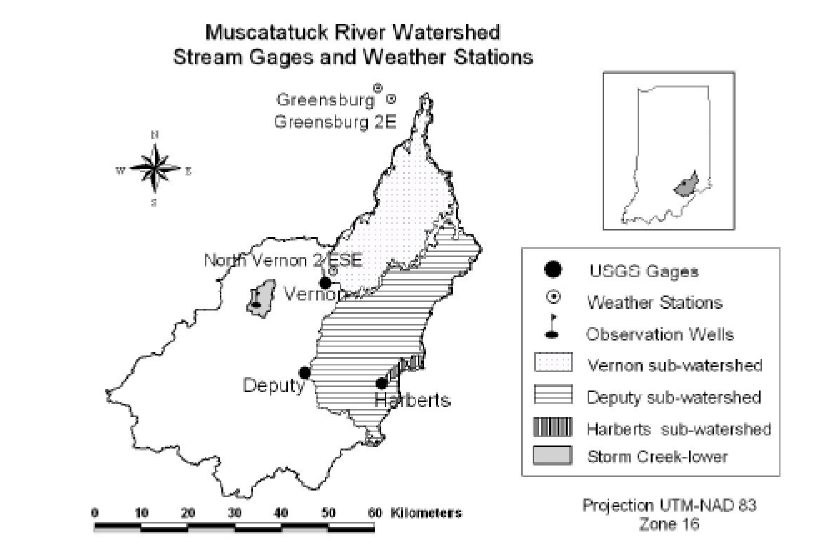


Figure 2. Weather stations and USGS gauges for the Muscatatuck River watershed.

Courtesy of Vazquez-Amábile and Engel (2005)

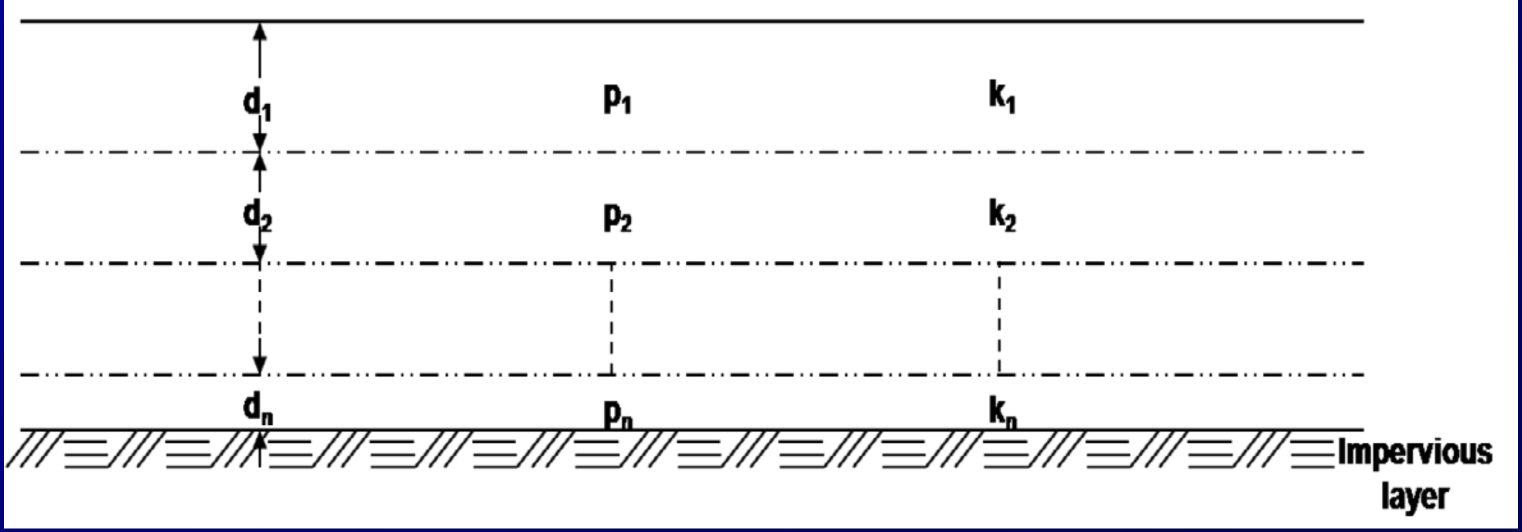
Moriasi et al. (2009)

Modification Methods: Soil Properties

Soil Series	P_e	K_{eratio}	Cal vwt_convtr
Avonburg	0.393	1.17	3.6
Cobbfork	0.347	3.39	5.4
Rossmoyne	0.316	1.95	6.5

Modification Methods: Soil Properties

- **Based on effective porosity (p_e) and effective saturated hydraulic conductivity (k_e) of soil layers above water table**



$$p_e = \frac{p_1 * d_1 + p_2 * d_2 + \ldots\ldots + p_n * d_n}{d_1 + d_2 + \ldots\ldots + d_n}$$

$$k_e = \frac{k_1 * d_1 + k_2 * d_2 + \ldots\ldots + k_n * d_n}{d_1 + d_2 + \ldots\ldots + d_n}$$

Modification Methods: Automatic *vwt_convtr*

- k_e is used to compute a numerator parameter *cfact* as follows:

$$k_{eratio} = \frac{k_e * 1000}{dep\_wtb}$$

- $K_{eratio} > 2.8$

$$cfact = -0.8616 * k_{eratio}{}^2 + 4.2709 * k_{eratio} - 2.2859$$

- $K_{eratio} <= 2.8$

$$cfact = -0.9122 * k_{eratio}{}^2 + 4.5221 * k_{eratio} - 2.4203$$

Modification Methods: Automatic *vwt_convtr*

- ***cfact*** **and** p_e **are used to compute** ***vwt_convtr*** **follows:**

- **For whole soil profile layers**

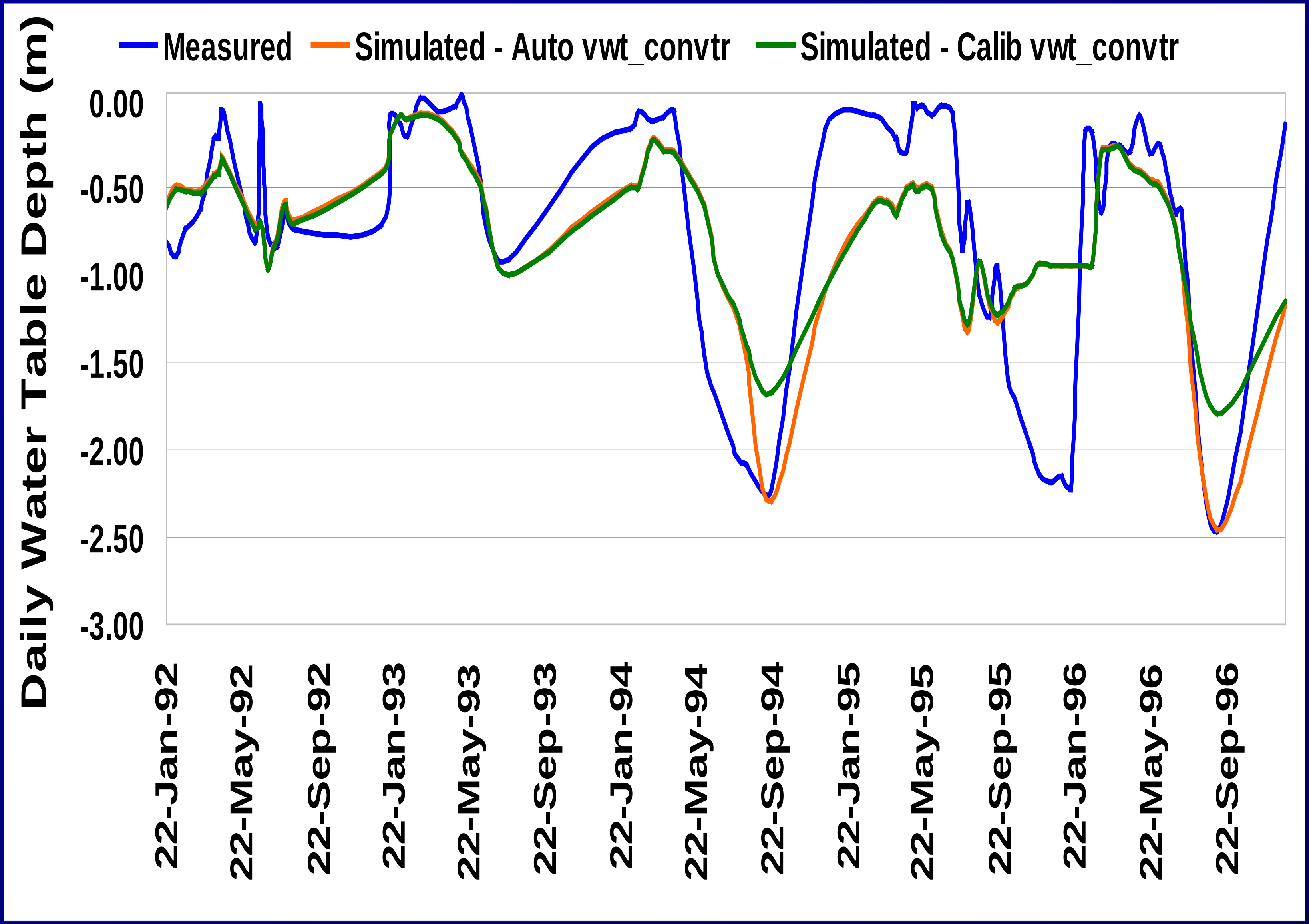
$$vwt\_convtr_p = \frac{cfact_p}{p_{ep}}$$

- **For soil layers above wtd**

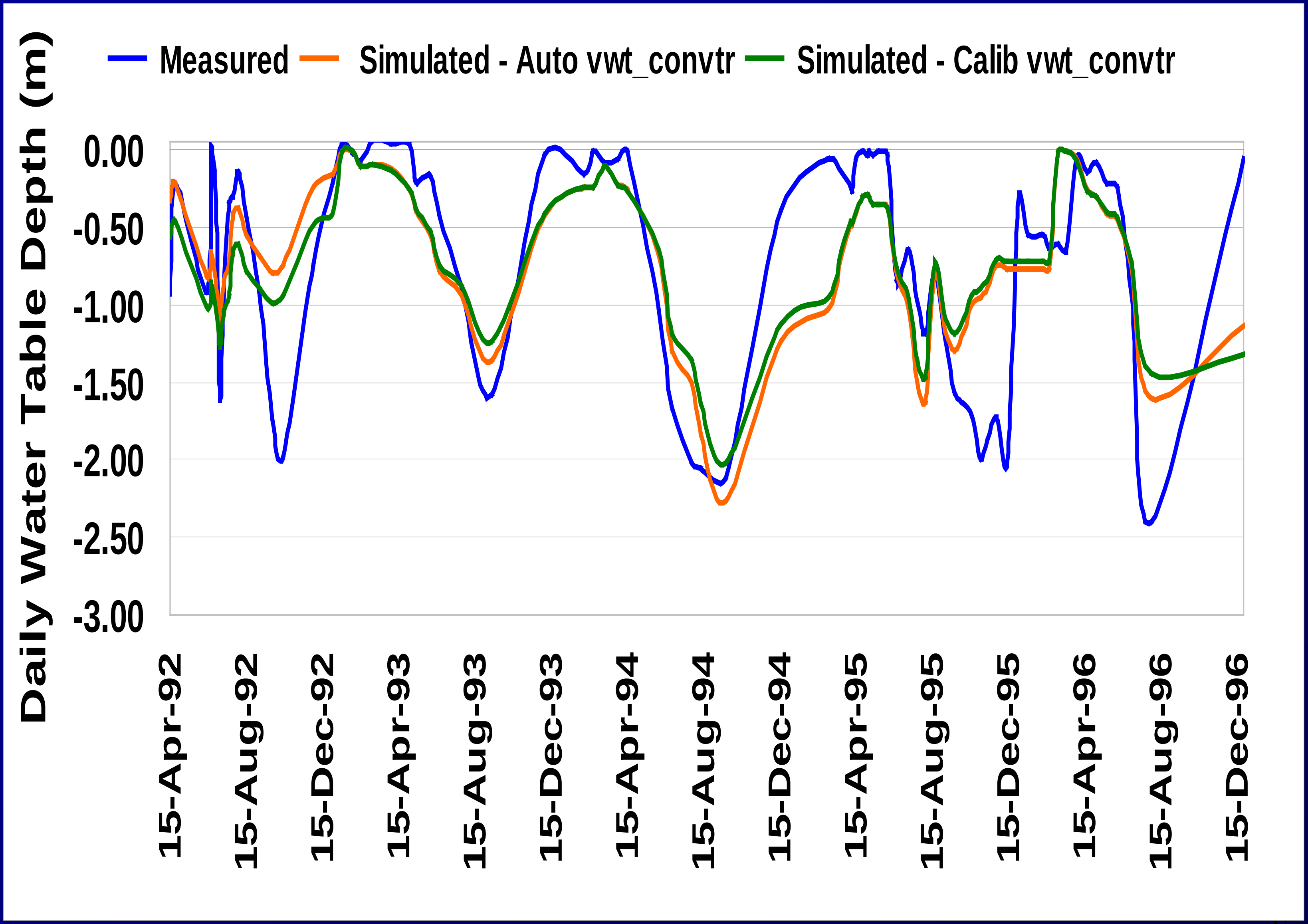
$$vwt\_convtr_w = \frac{cfact_w}{p_{ew}}$$

- $vwt\_convtr = vwt\_convtr_w$; if vwt_convtr_w is within 50% of vwt_convtr_p otherwise, $vwt\_convtr = vwt\_convtr_p$

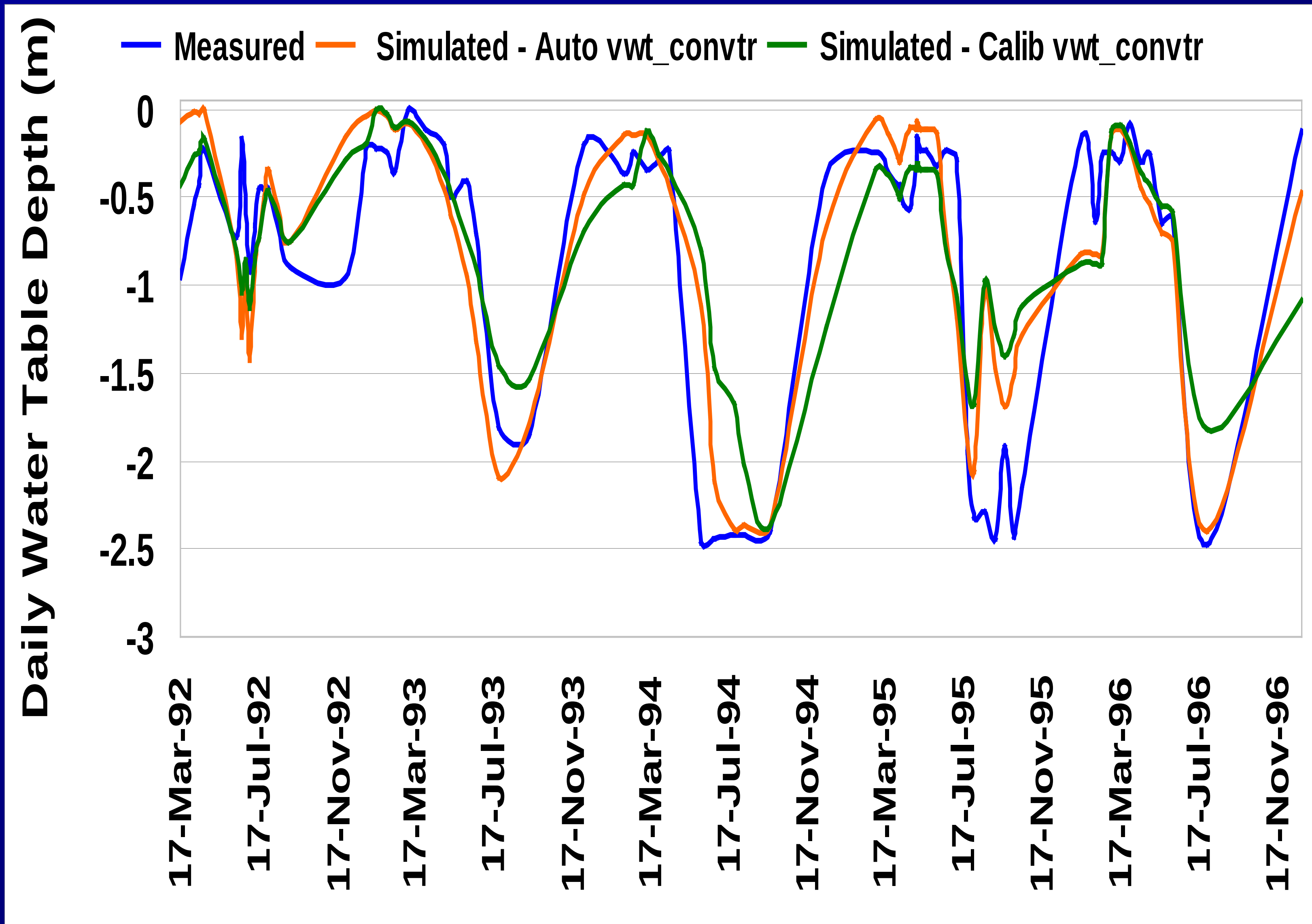
Evaluation Results: Avonburg Soil Series



Evaluation Results: Cobbsfork Soil Series



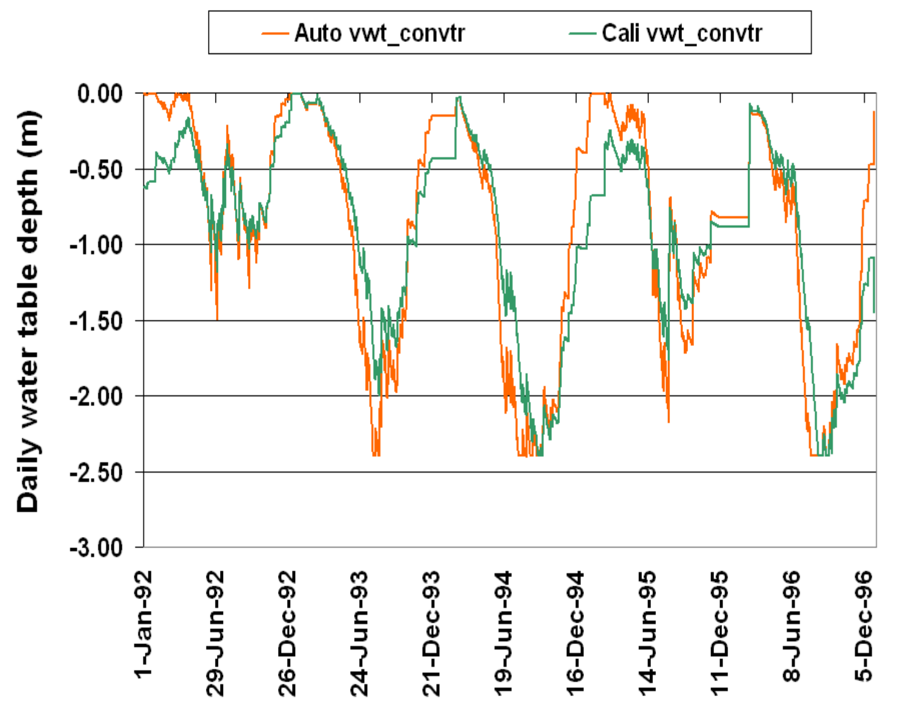
Evaluation Results: Rossmoyne Soil Series

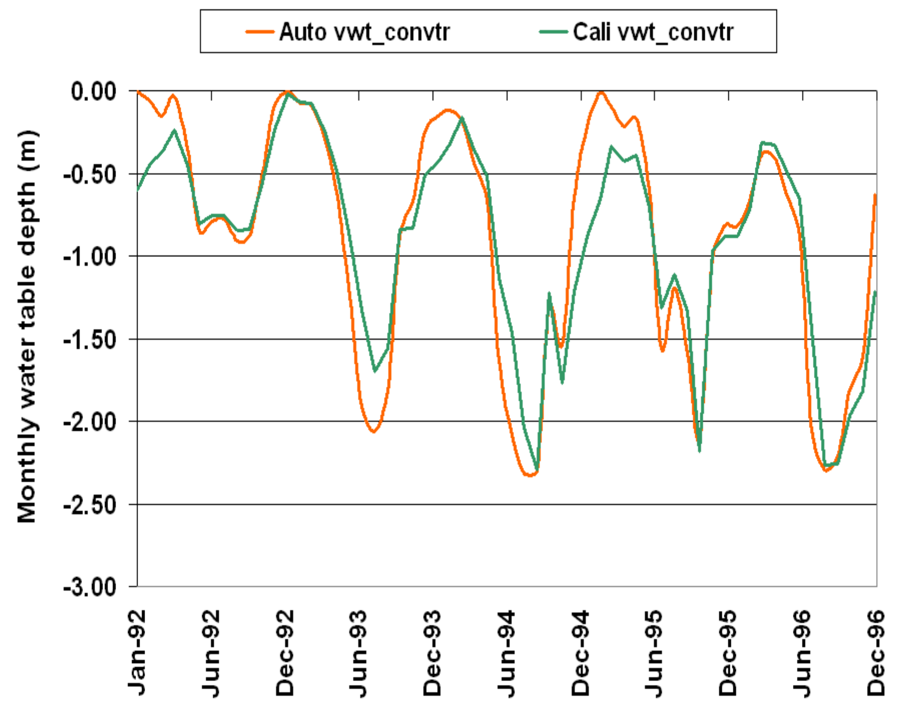


Evaluation Results: Statistics

Soil Series	Period	Method	Daily water table depth			Monthly water table depth		
			NSE	PBIAS (%)	RMSE (m)	NSE	PBIAS (%)	RMSE (m)
Avonburg	Calibration (1992-1994)	Calib *vwt_convtr* (**3.6**)	0.61	-1	0.37	0.65	4	0.40
		Auto *vwt_convtr* (**3.5 -5.0**)	0.64	-2	0.36	0.69	0	0.37
	Validation (1995-1996)	Calib *vwt_convtr* (**3.6**)	0.36	-7	0.63	0.37	-3	0.65
		Auto *vwt_convtr* (**3.5 -5.0**)	0.38	-9	0.62	0.40	-7	0.63
Cobbsfork	Calibration (1992-1994)	Calib *vwt_convtr* (**5.4**)	0.66	-10	0.41	0.70	-4	0.41
		Auto *vwt_convtr* (**5.3 -6.1**)	0.66	0	0.41	0.67	1	0.42
	Validation (1995-1996)	Calib *vwt_convtr* (**5.4**)	0.36	4	0.56	0.32	2	0.56
		Auto *vwt_convtr* (**5.3 -6.1**)	0.40	-2	0.54	0.41	-3	0.52
Rossmoyne	Calibration (1992-1994)	Calib *vwt_convtr* (**6.5**)	0.66	10	0.43	0.72	12	0.43
		Auto *vwt_convtr* (**7.5 -9.6**)	0.72	4	0.39	0.80	7	0.36
	Validation (1995-1996)	Calib *vwt_convtr* (**6.5**)	0.56	9	0.56	0.57	5	0.57
		Auto *vwt_convtr* (**7.5 -9.6**)	0.67	11	0.48	0.75	3	0.43
Average	Calibration (1992-1994)	**Calib *vwt_convtr***	**0.64**	**0**	**0.41**	**0.69**	**4**	**0.41**
		Auto *vwt_convtr*	**0.67**	**1**	**0.39**	**0.72**	**3**	**0.39**
	Validation (1995-1996)	**Calib *vwt_convtr***	**0.42**	**2**	**0.58**	**0.42**	**2**	**0.59**
		Auto *vwt_convtr*	**0.49**	**0**	**0.55**	**0.52**	**-2**	**0.53**

Complete Predicted WTD Time Series: Rossmoyne Soil Series





Reasons for Differences between the Daily Observed and Simulated wtd Fluctuations

- **Uncertainty in soils data**
  - ✓ **DRAINMOD poorly simulated *wtd* when the model was not calibrated using *in situ* soil measurements (Amatya et al., 2003)**

- **Uncertainty in precipitation data**
  - ✓ **great spatial precipitation variability (Chaubey et al., 1999)**

- **Uncertainty in the model equations**

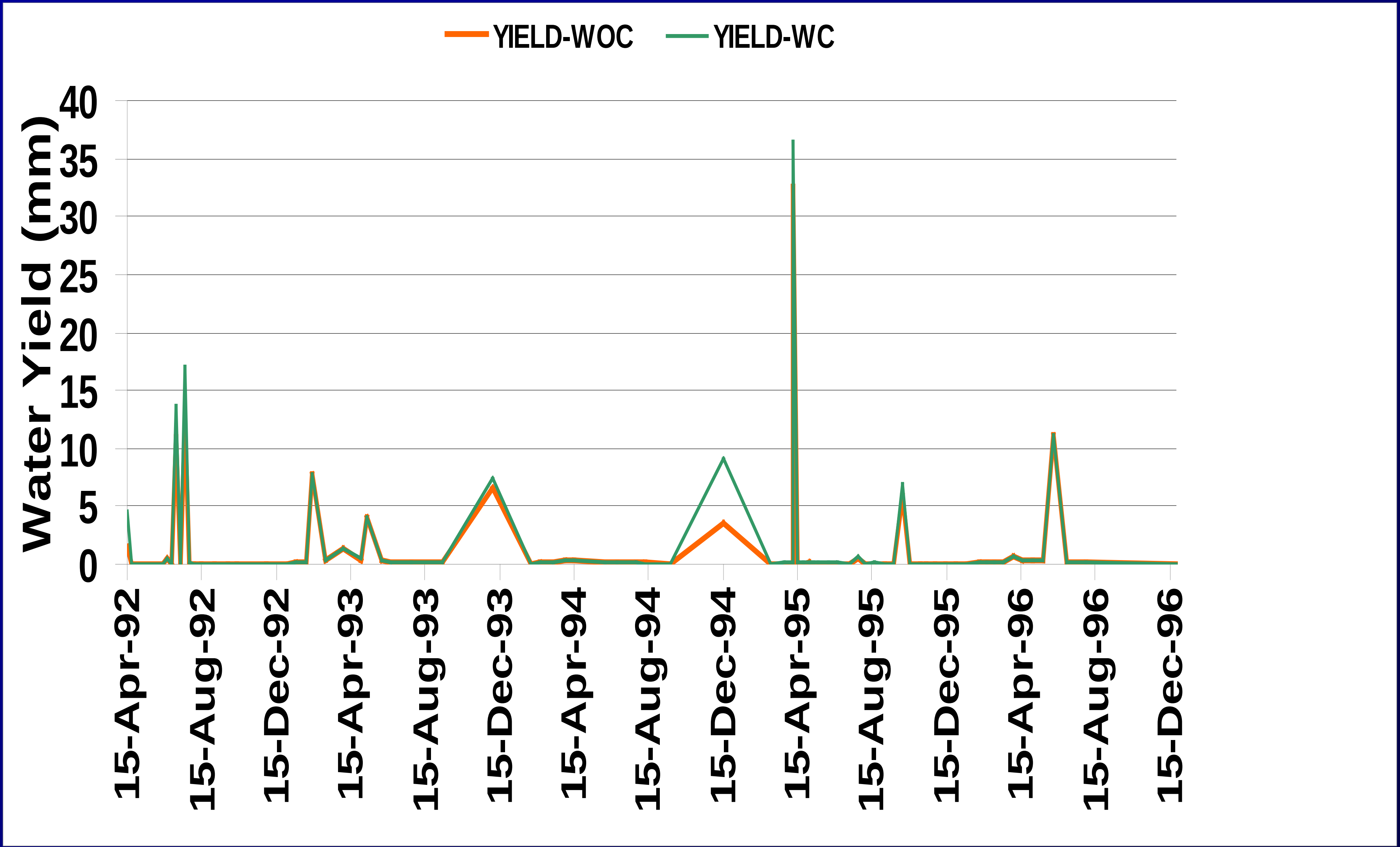
Conclusions

- **Wtd predicted by the automatically computed *vwt_convtr* coefficients fitted measured wtd slightly better than wtd predicted by the manually calibrated *vwt_convtr* coefficients.**
  - **Statistics and graphic**
- **Based on these model outputs, there were no significant differences between the wtd simulated using the manually calibrated and the automatically computed *vwt_convtr* coefficients.**
- **Automatically computed *vwt_convtr* values will enable this alternative shallow wtd algorithm to be used at the watershed scale.**
- **Automatic *vwt_convtr* equations developed based on the parameters determined from the properties of the 3 soils in Indiana – mainly silt textured**
- **Additional tests are underway to determine applicability of the automatically derived *vwt_convtr* factors under different soils and make the necessary changes where needed.**

Thank You!

Questions?

WTD Algorithms Used in SWAT2005



Evaluation Results: Calibrated Statistics

Soil Series	Period	Method	Daily water table depth			Monthly water table depth		
			NSE	PBIAS (%)	RMSE (m)	NSE	PBIAS (%)	RMSE (m)
Avonburg	Calibration (1992-1994)	Calib *vwt_convtr* (*3.6*)	0.61	1	0.37	0.65	5	0.40
		Auto *vwt_convtr* (*3.5-5.0*)	0.65	-1	0.36	0.70	2	0.37
	Validation (1995-1996)	Calib *vwt_convtr* (*3.6*)	0.37	-6	0.62	0.38	-1	0.65
		Auto *vwt_convtr* (*3.5-5.0*)	0.39	-8	0.61	0.42	-5	0.62
Cobbsfork	Calibration (1992-1994)	Calib *vwt_convtr* (*5.4*)	0.67	-2	0.40	0.70	3	0.40
		Auto *vwt_convtr* (*5.3-6.1*)	0.69	-6	0.39	0.74	-2	0.38
	Validation (1995-1996)	Calib *vwt_convtr* (*5.4*)	0.40	10	0.54	0.41	9	0.52
		Auto *vwt_convtr* (*5.3-6.1*)	0.44	7	0.52	0.46	5	0.50
Rossmoyne	Calibration (1992-1994)	Calib *vwt_convtr* (*6.5*)	0.65	3	0.44	0.73	8	0.42
		Auto *vwt_convtr* (*7.5-9.6*)	0.72	1	0.39	0.81	4	0.35
	Validation (1995-1996)	Calib *vwt_convtr* (*6.5*)	0.58	1	0.55	0.58	-1	0.56
		Auto *vwt_convtr* (*7.5-9.6*)	0.70	6	0.47	0.76	-1	0.42
Average	Calibration (1992-1994)	Calib *vwt_convtr*	0.64	1	0.41	0.69	5	0.41
		Auto *vwt_convtr*	0.69	-2	0.38	0.75	2	0.37
	Validation (1995-1996)	Calib *vwt_convtr*	0.45	2	0.57	0.46	2	0.57
		Auto *vwt_convtr*	0.51	2	0.53	0.55	0	0.51

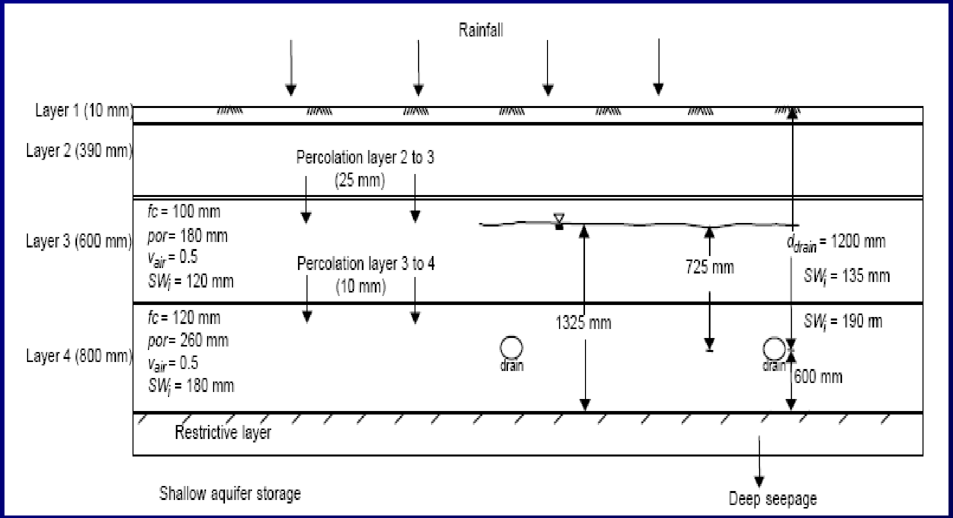
SWAT2005-Approach

- **Based on antecedent climate**
- **computes *wtd* using 30 day moving summations of precipitation, surface runoff, and ET**
- ***Wtd* is computed as the depth of water table below the ground service**
- **Max. *wtd* is set at 2.6 m**
- **Use -master soil percolation component**

Neitsch et al. (2002): Theoretical Documentation

SWAT-M-Approach

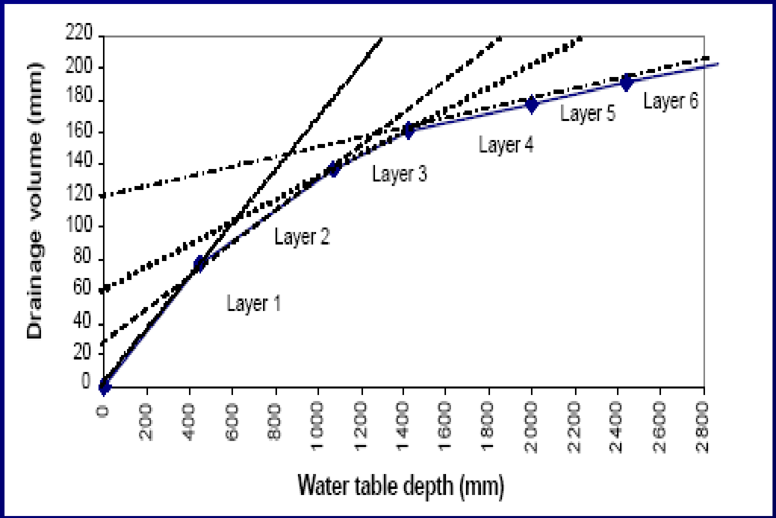
- **The restrictive layer – max. *wtd***
- **Soil profile above the restrictive layer to fill to field capacity**
- **Water fills profile from the bottom soil layer upward**
- **Height of the water table (above the impermeable layer) is calculated**
- **Use -Tile drainage**



Du et al. (2005)

DRAINMOD-Approach

- **Based on the wtd and drainage volume (Dv) relationship**
  - **Dv (water yield) is the effective air volume above the water table defined as the void space that holds water between field capacity and saturation (Skaggs, 1980).**
- **Using SWAT soil input data, the cumulative Dv of the soil is computed from top to bottom (drainage porosity *layer thickness)**
- **Intercept corresponding to the linear function of each layer is calculated (as shown in figure)**
- **Daily Dv of the soil profile is computed using soil water output from SWAT**
- **Daily Dv used to graphically intercept the curve to obtain the daily groundwater table depth**



Courtesy of Vazquez-Amábile and Engel (2005)

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