Examination of PRZM5.0 Storm Rainfall Depth and Distribution Algorithms Compared to Current U.S. Storm Trends

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Objective

Climate change is affecting rainfall intensity distributions in the U.S. Thus, it is important to revise the internal rainfall intensity algorithms in the EPA model PRZM5.0 to represent these changes to adequately predict off-field movement of pesticide residues from agricultural fields in runoff and eroded sediment for regulatory risk assessment.

PRZM5.0

PRZM5.0 (Pesticide Root Zone Model - version 5.0)

EPA model first developed in the early 1980's to simulate the movement in an agricultural field of:

Hydrology

Chemical

Used by EPA to estimate off-field loadings of:

- Runoff
- Eroded sediment
- Pesticide mass

- **Daily Time Step Model**
  - **PRZM5.0 uses daily rainfall totals to estimate off-field runoff, erosion and chemical estimates**
  - **Internal algorithms estimate rainfall intensity**

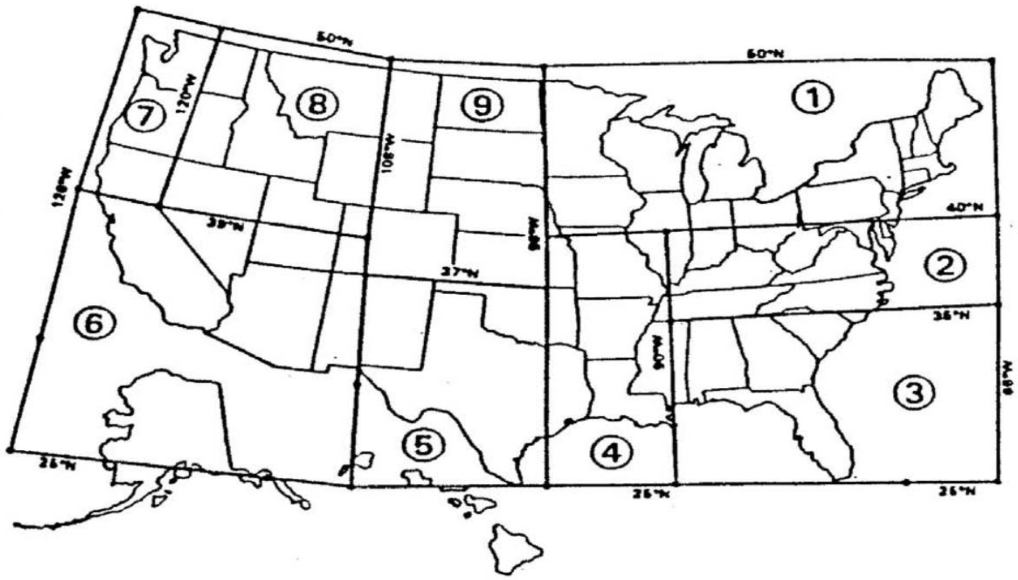
Runoff and Erosion Algorithms in PRZM5.0

The EPA Model PRZM5.0 uses the
Modified Runoff Curve Number Method (Haith and Loehr 1979)
Modified Universal Soil Loss for Small Watershed (MUSS) (Singh, 1995)
algorithms for simulating off-field runoff, erosion and sorbed pesticide loss during rainfall events.

Runoff Curve Number Method were originally based on field studies from the 1940's and 1950's.

Both methods are based on rainfall intensity (i.e. inches of rainfall/hr] parameters developed from observed rainfall intensity data that is more than 30 years old.

Change in Rainfall Intensity over time



U.S. Mean Storm Duration in the Summer (hours)									
	Zone								
	1	2	3	4	5	6	7	8	9
PRZM5.0 User's Manual (based on 1986 IREG data)	4.4	4.2	4.9	5.2	3.2	2.6	11.4	2.8	3.1
Palecki et al. (2004)	2	2.3	2.1	2.5	2.4	2.8	1.9	2.6	3.4

Like many models used over many years, model assumptions may be forgotten over time….

To address changes in rainfall intensity, revisions to the internal algorithms of PRZM5.0 must be made, not just update daily weather time series.

What does this mean???

Off-field runoff and erosion may be under-estimated by PRZM5.0 for much of the U.S…..

Revisions to NRCS Runoff Curve Number Method

NRCS has published a revised Chapter 10 of the Hydrology section of the Engineering Handbook on Runoff Curve Number Methods

Comparison of PRZM5.0 formulas with formulas in current manual

- Literature search for newer runoff curve methods
- Are new runoff studies being conducted to estimate new curve numbers?

CN2 from USER Input

$$CN1 = \frac{4.2\ CN2}{10 - 0.058\ CN2}$$

$$CN3 = \frac{23\ CN2}{10 + 0.13\ CN2}$$

MUSS Equation for estimating erosion

$$X_e = 0.79(V_r * q_p)^{0.65} * Area^{0.009} * K * LS * C * P$$

X_e = soil erosion (metric tons/day)

V_r = volume of event (daily) runoff (mm)

q_p = peak flow rate (mm/hr)

Area = field area (hectares)

K, LS, C, and P are all dimensionless soil and land use parameters supplied by the user

Rainfall Intensity Parameter, q_p

Peak storm runoff rate, q_p, is calculated using the Graphical Peak Discharge Method (Soil Conservation Service, (Soil Conservation Service 1986):

$$q_p = a\, q_u\, A\, V_r\, F_p \tag{6.46}$$

in which

q_u = unit peak discharge rate, and
F_p = pond and swamp adjustment factor.

The parameter a is a units conversion factor. F_p has been preprogrammed to have a value of 1.0 in PRZM release 3. The unit peak discharge rate, q_u, is calculated by:

$$\log(q_u) = C_0 + C_1 \log(T_c) + C_2[\log(T_c)]^2 \tag{6.47}$$

T_c is the time of concentration (hr), and C_0, C_1 and C_2 are all regional coefficients from SCS IREG regional storm distributions

SCS IREG Rainfall Distributions

Original SCS Rainfall Distributions were developed for flood control design
Rainfall is assumed to occur according to design 1986 SCS developed IREG regional storm distributions

- Distributions developed from historic storm intensity data from National Weather Service duration-frequency data

- In 2015, NRCS revised these distributions based on storm intensity based on NOAA Atlas 14 (NOAA 14) data
  - In the near future, these distributions will replace the IREG Type II and Type III distributions
  - NOAA 14 divides the U.S. into much smaller rainfall distribution regions
    - Including subdividing state
    - NOAA EFH-2 Program used to generate peak runoff and discharge estimates using NOAA-14 regional specific coefficients

1986 vs 2015 IREG Regions

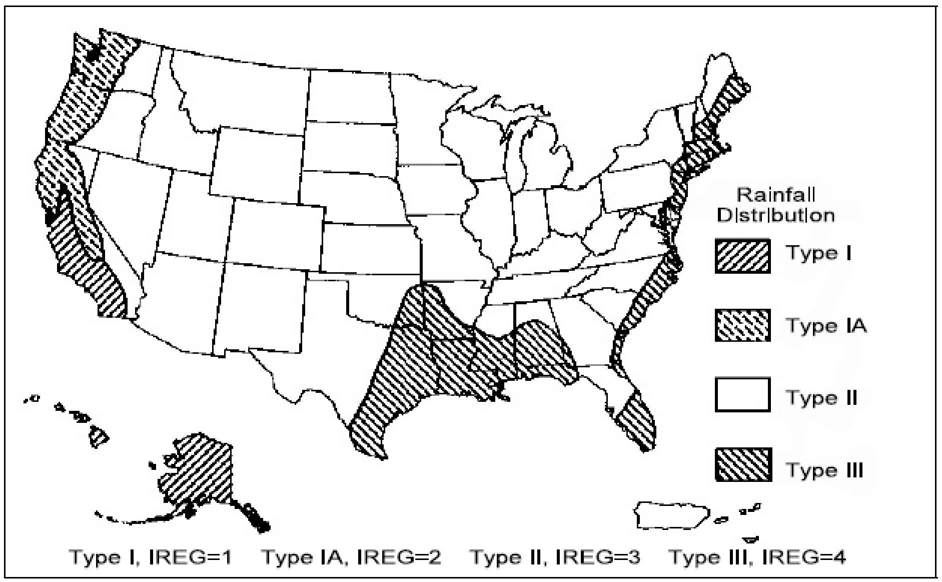
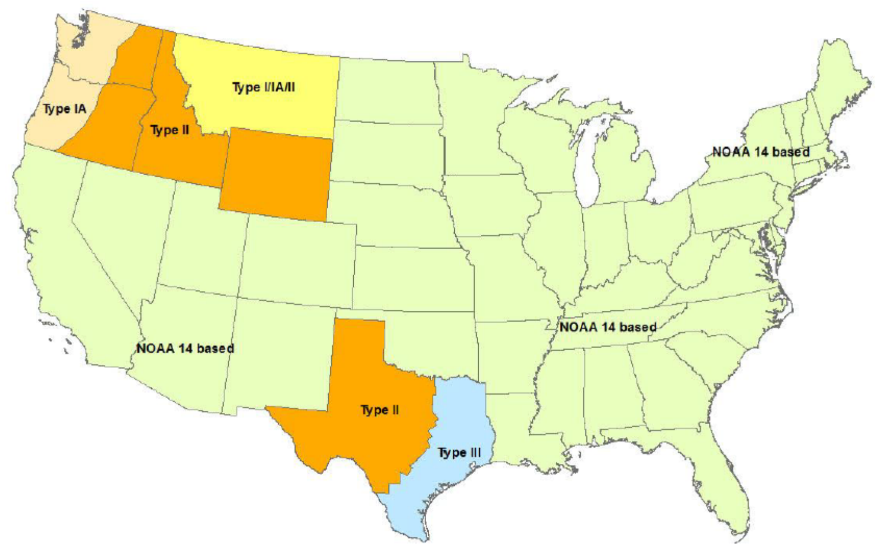


Figure 5.8 Approximate geographic boundaries for SCS rainfall distribution (from Soil Conservation Service {1986 #220}).

Figure 4- 25. United States map with updated synthetic rainfall distributions as of January 2016



Source: PRZM5.0 User’s Manual

A working example - Pennsylvania

Previously in IREG Rainfall Distribution Type II
With NOAA-14, Pennsylvania divided into 4 Rainfall distribution types

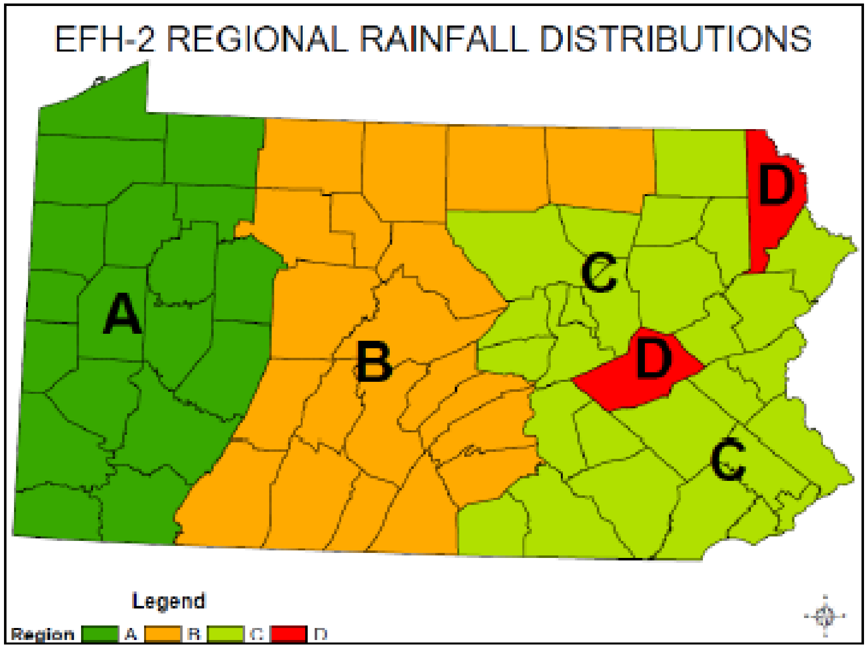


Figure 1 Map showing designated rainfall distribution for Pennsylvania Counties.

Example Application of the EFH-2 Computer Program in Pennsylvania

Example for Pennsylvania Regions A and C

$$\log(q_u) = C_0 + C_1 \log(T_c) + C_2[\log(T_c)]^2$$

Note: T_c will not change – depends on surface roughness, hydraulic flow length, slope and daily rainfall

	1986 IREG II			NOAA-14 A		
Non-Infiltrated Precipitation (cm)	C_0	C_1	C_2	C_0	C_1	C_2
0.10	2.5532	0	-0.164	2.5796	-0.6312	-0.1451
0.30	2.4653	0	-0.1166	2.5126	-0.6315	-0.1087
0.40	2.3641	0	-0.0562	2.4423	-0.5887	-0.0921
0.50	2.2028	0	-0.0126	2.3435	-0.4789	-0.01246

	1986 IREG II			NOAA-14 B		
Non-Infiltrated Precipitation (cm)	C_0	C_1	C_2	C_0	C_1	C_2
0.10	2.5532	0	-0.164	2.4928	-0.5850	-0.1370
0.30	2.4653	0	-0.1166	2.4182	-0.5857	-0.1018
0.40	2.3641	0	-0.0562	2.3289	-0.5381	-0.0754
0.50	2.2028	0	-0.0126	2.1955	-0.3952	-0.1077

Example for Pennsylvania Regions A and C

Precipitation 5 cm

Let's assume Tc = 2 minutes, i.e. 0.033 hours

$$\log(q_u) = C_0 + C_1 \log(T_c) + C_2[\log(T_c)]^2$$

	q_u
1986 IREG	149.6737046
NOAA-14 Region A	1060.807189
NOAA-14 Region B	350.4315738

Conclusion

Rainfall intensity patterns are changing in the U.S.

The regulatory model PRZM5.0 uses old internal algorithms rainfall intensity algorithms to estimate off-field estimates of runoff, erosion and pesticide mass

NOAA has generated new regression coefficients for the rainfall intensity regression equations with more geographically specific coefficients and revised algorithms

This research project is working on developing a version of PRZM5.0 which includes these coefficients and algorithms

Thank you.

For more information

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