# SWATing your APEX model: A how to from the trenches

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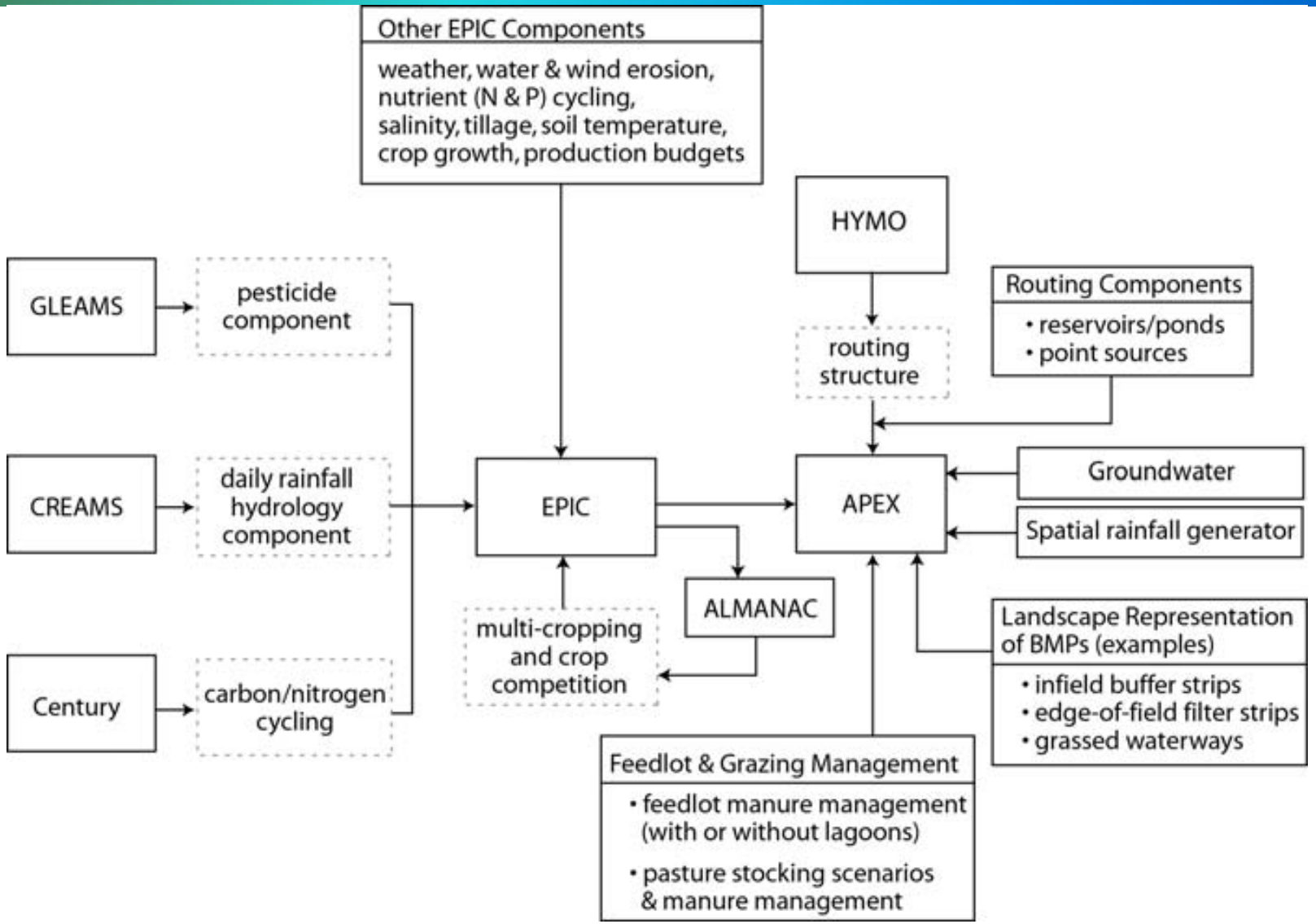
# Introduction

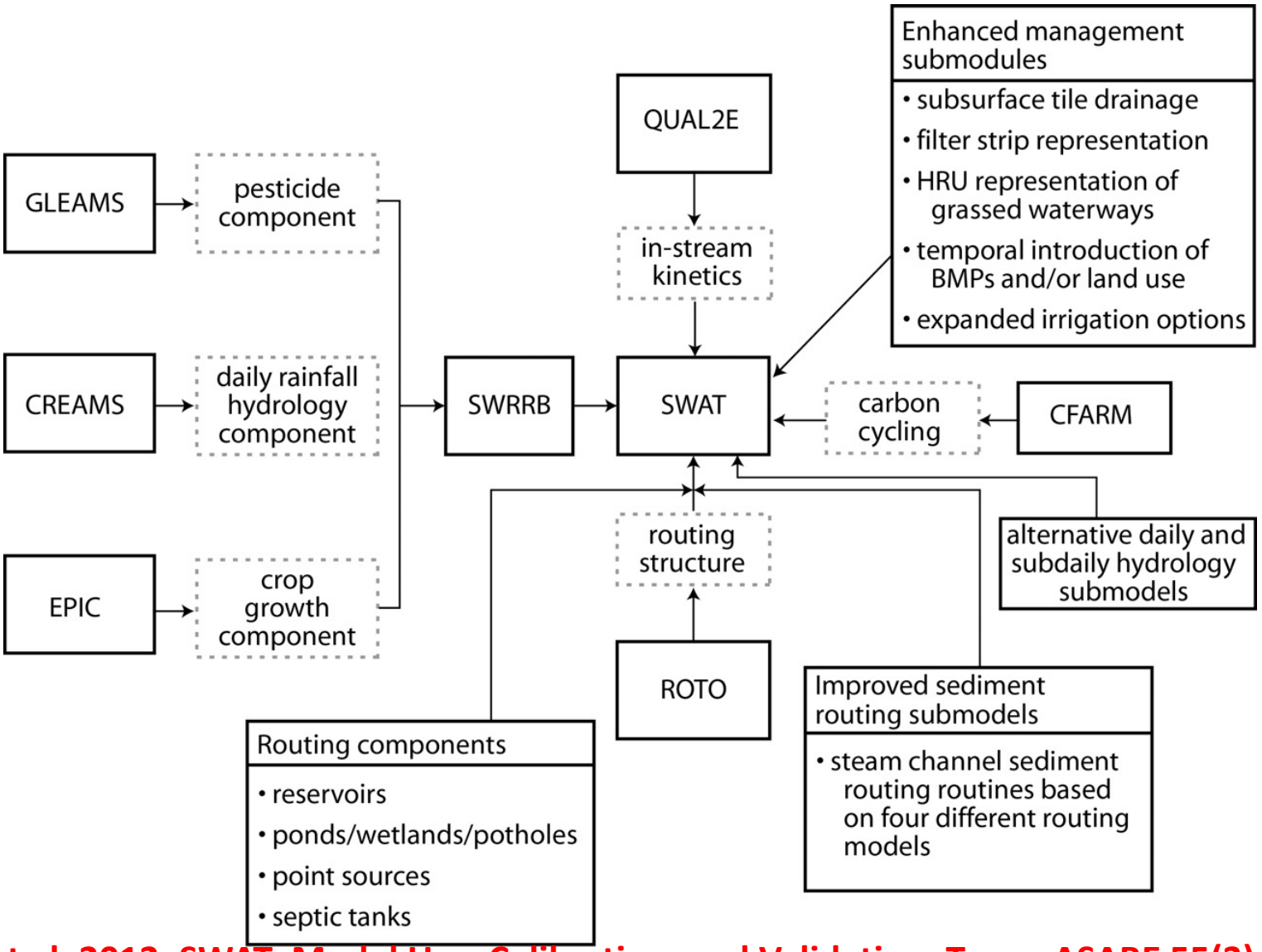
- EPIC
  - field scale
  - developed in the 1980's from CREAMS, GLEAMS and CENTURY with crop growth routines
- APEX
  - Small watersheds
  - developed in the 1990's from EPIC and additional routing and groundwater routines.
- SWAT
  - Watersheds
  - developed in the 1990's from EPIC, CREAMS and GLEAMS with additional routing routines.

# Historical Development of APEX




**Wang et al. 2012. EPIC and APEX: Model Use, Calibration, and Validation. Trans. ASABE 55(3).**

# Historical development of SWAT




Arnold et al. 2012. SWAT: Model Use, Calibration, and Validation. Trans. ASABE 55(3).

# Rationale

***Context: use of APEX and SWAT within the same study***

- Understanding scale effects
- Water quality trading
- Use of the flexibility of APEX with the scale possibility of SWAT for larger watersheds.
  - Semi-distributed aspect of SWAT
  - Lumping of HRUs

***Need for APEX and SWAT to be equivalent***

- When calibration/validation data are available at only one scale.
- To ensure that there is no bias between flow, sediment loads, or pollutant transport out of HRUs simulated with APEX and SWAT.

# Objectives

***Provide guidance to parameterize APEX and SWAT in such a way thay they are as equivalent as possible***

- Selection of algorithms
- Parameterization

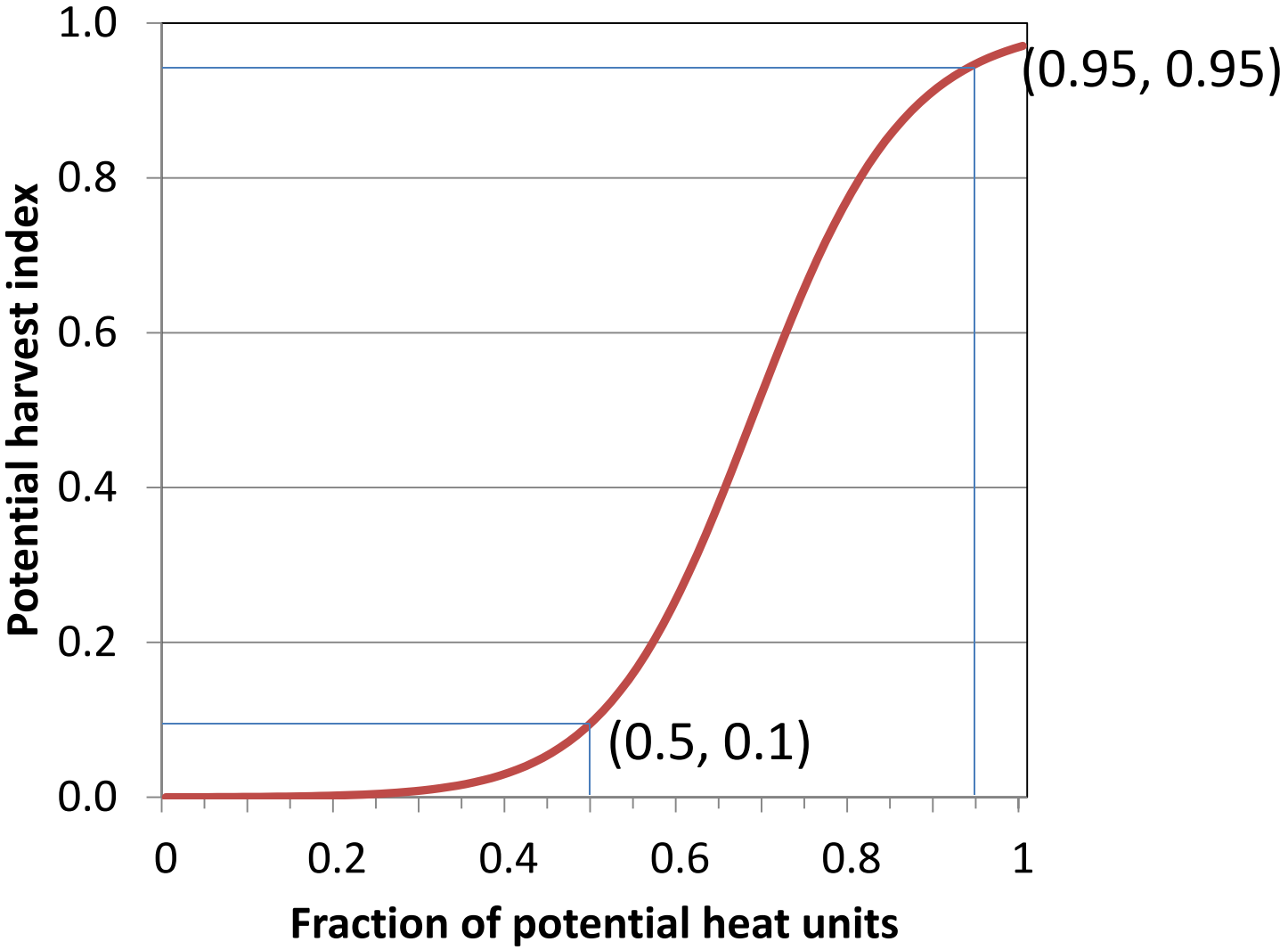
# Methods

- *Find hard-coded values in the SWAT code of many APEX input parameters: the APEX parm file.*
- *Compare algorithms using theoretical documentation and code: APEX 0806, dated October 2012, SWAT v581, also dated from October 2012.*
- *In some instances, demonstrate the effect of the differences.*

# Outcomes

- *Options to select in APEX, or sometimes in SWAT, so that both models use the same algorithms.*
- *Values that the APEX S-shape parameters should have.*
- *Values that the APEX and SWAT input parameters should have: the APEX parm file and the SWAT bsn file and a few miscellaneous parameters.*
- *Identify unresolvable differences and demonstrate their effect.*

# S-shape parameters: definition



# Outcome 1: S-shape parameters

| APEX parameter | Description | SWAT parameter | APEX Parm1 | APEX Parm2 | Comment |
|---|---|---|---|---|---|
| SCRP(9) | Pest damage | Not simulated | NR | NR | Set PSTX to 0 in control file. |
| SCRP(1) | Root growth restriction by rock or coarse soil fragments | Not simulated | 50.010 | 100.02 | Eliminates the effect |
| SCRP(3) | Potential harvest index as a function of the fraction of the growing season | Hard coded | 50.1 | 95.95 | SWAT: 5:2.4.1<br>APEX: 282 |
| SCRP(12) | Effect of soil depth on N volatilization | Hard coded | 5.037 | 100.041 | Very different from default APEX values |
| SCRP(10) | Effect of water stress on harvest index | Water stress quantified by different variables | | | SWAT: 5:3.3.1<br>APEX: 282 |

# Outcome 2: Similarities and differences in runoff calculation

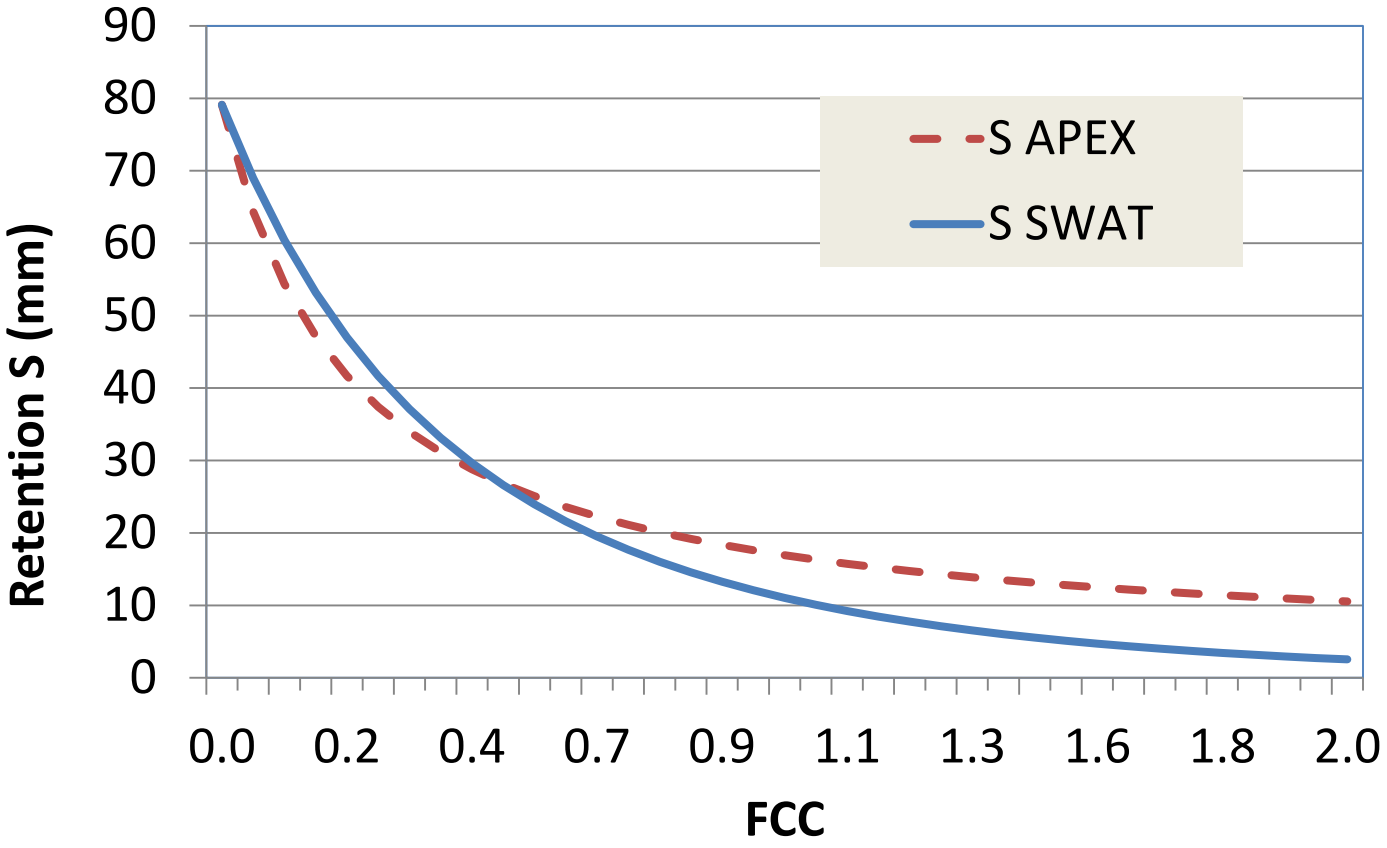
**Similarities**

- Both allow the curve number method
- Both vary soil water retention with either soil water content or ET.

**Differences**

- Variable used to calculate retention:
  - SWAT: Soil water – wilting point
  - APEX: $\frac{Soil\ water - wilting\ point}{Field\ capacity - wilting\ point}$
- Points to calculate the S-shape curve:
  - SWAT:
    - Wet conditions -> CN3
    - Saturation
  - APEX:
    - Average conditions -> CN2
    - Wet conditions -> CN3
- Wet conditions:
  - SWAT: field capacity
  - APEX: a user-defined point between field capacity and saturation

# Calculation of retention




$$FCC = \frac{soil\ water - wilting\ point}{field\ capacity\ - wilting\ point}$$

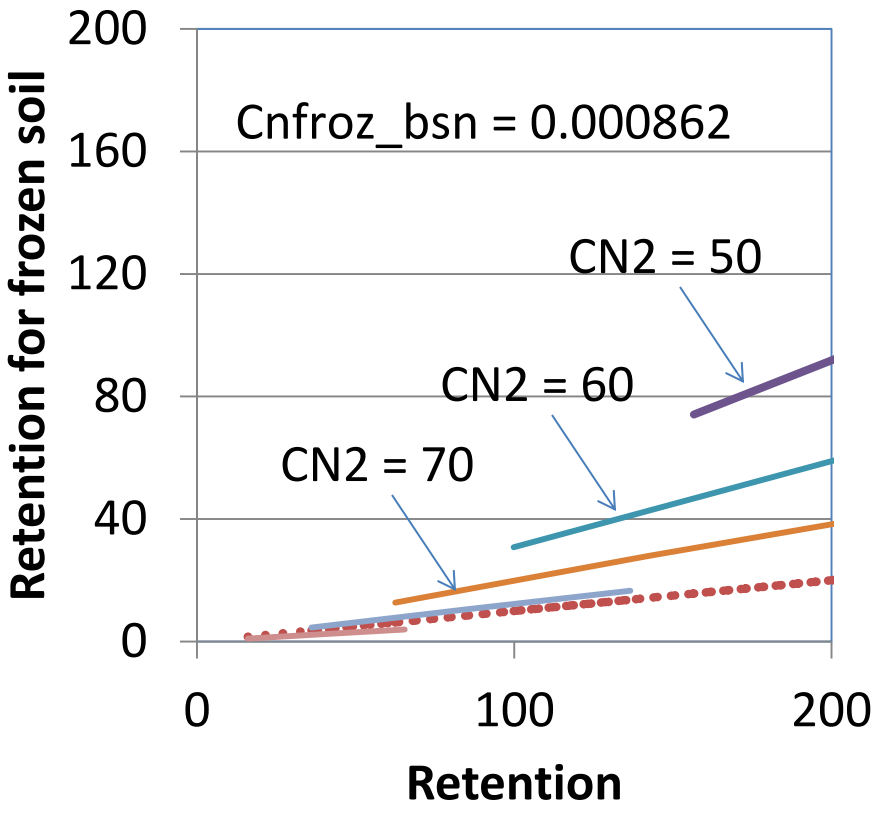
# Frozen soil adjustment of retention

APEX

$S_{froz}$ (S)= 0.1 * S(CN)

SWAT

$S_{froz}$ (S) =
$S_{max}$ [1–exp(-cnfroz_bsn*S(CN))]




Adjust cnfroz_bsn as a function of dominant soils' curve numbers and desired effects.

# Gaps

- *A much larger undertaking than initially thought*
  - Many differences.
  - Differences are sometimes subtle.
- *Not all the code has been reviewed and I invite others to participate in the effort and improve the document as differences are better understood or resolved.*

# Limitations

- *APEX 0806, October 2012*
- *SWAT v581, ~ fall 2012*
- *Processes reviewed so far.*

# Challenges

- *Typically, the theoretical documentation and the manuals lag behind the code.(true of any model).*
- *The APEX code is somewhat difficult to read.*

# Next Steps and Recommendations

- *Continue to fill in this document.*
- *Understand the rationale for the APEX and SWAT expressions.*
- *Decide whether we want to make APEX and SWAT more similar:*
  - *Would produce very useful tools to study scale issues.*
  - *Link edge-of-field losses to watershed transport.*