Developments in SWAT modelling

Erik Querner



Environmental Modelling

- SWAT model
- SWAT use in the Limpopo basin > SWAT-CUP
- New developments:
  - Link SIMGRO – SWAT
  - Rainfall-runoff module for shallow groundwater levels in SWAT
  - Crop factors
- Discussion

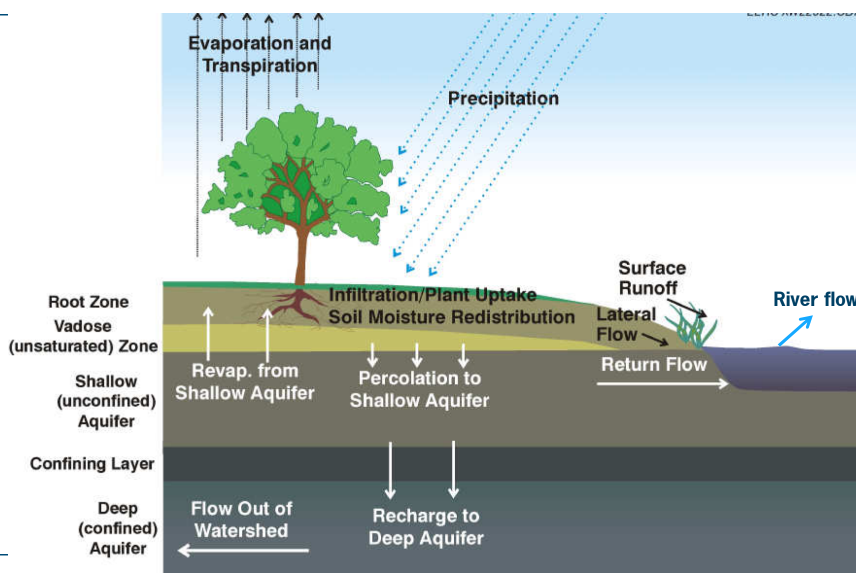
Introduction to SWAT

- 'Soil and Water Assessment Tool' basin scale, distributed, physically based model based on the water balance
- Developed mid '90 by USDA Agricultural Research Service and Texas A&M AgriLife research in Texas, USA, designed to

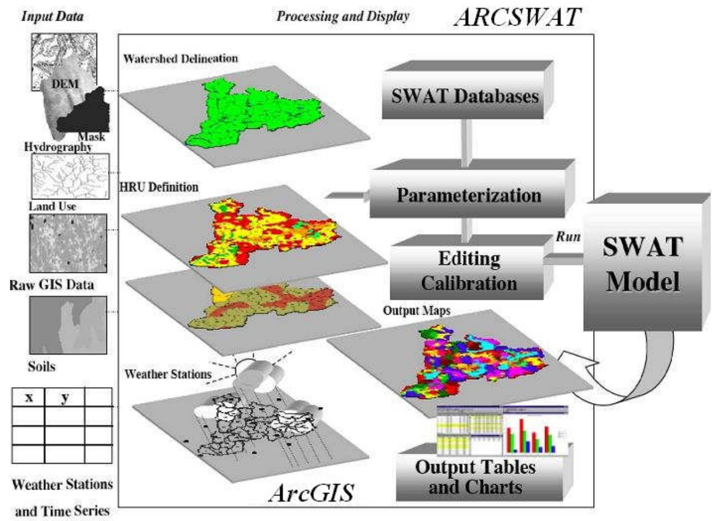
  "Predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions"

http://www.swat.tamu.edu

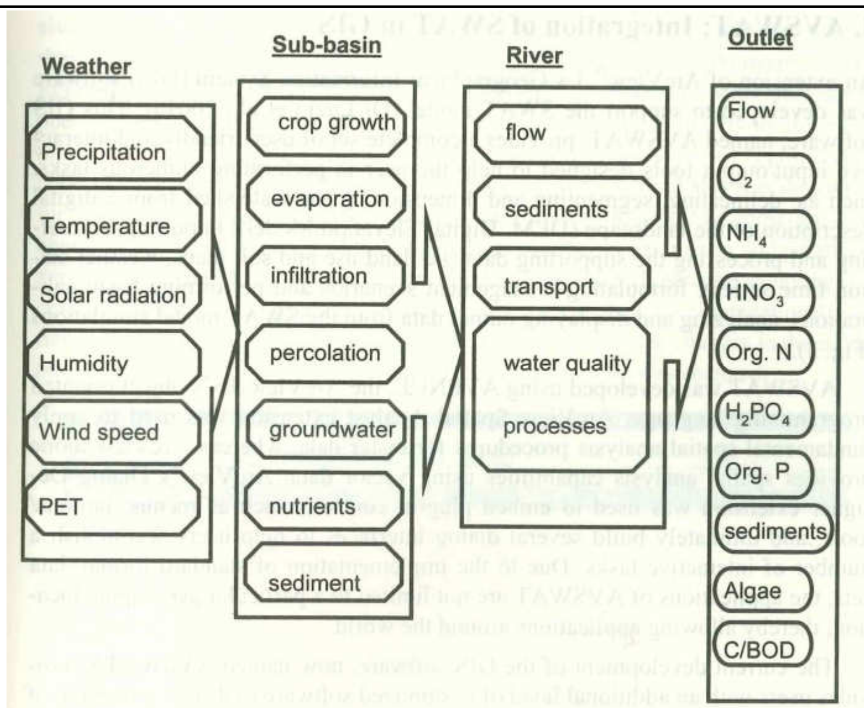
SWAT model

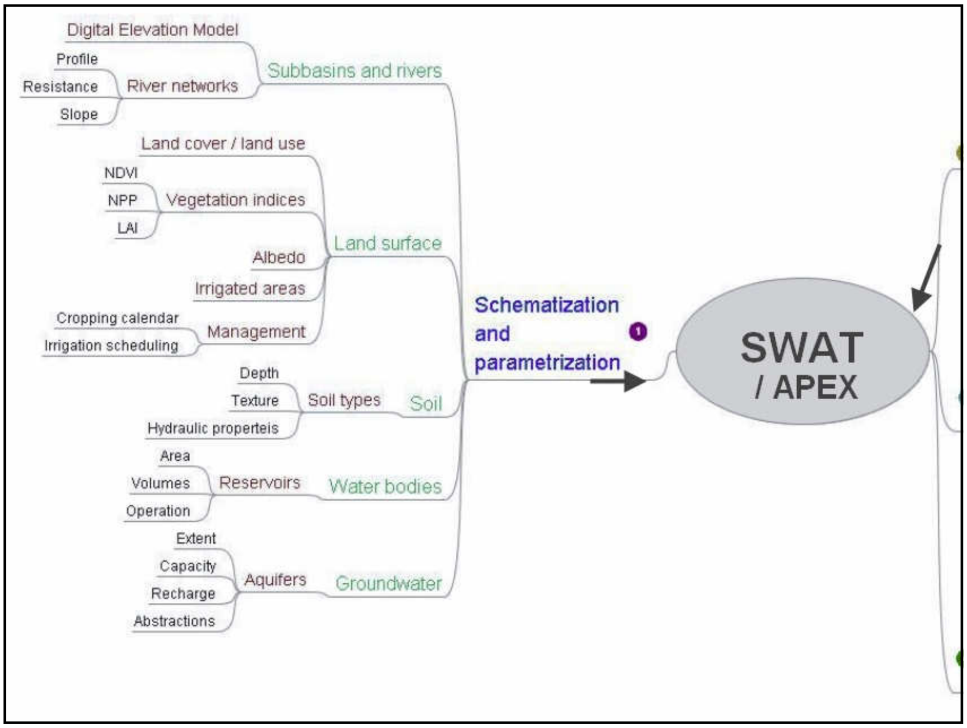


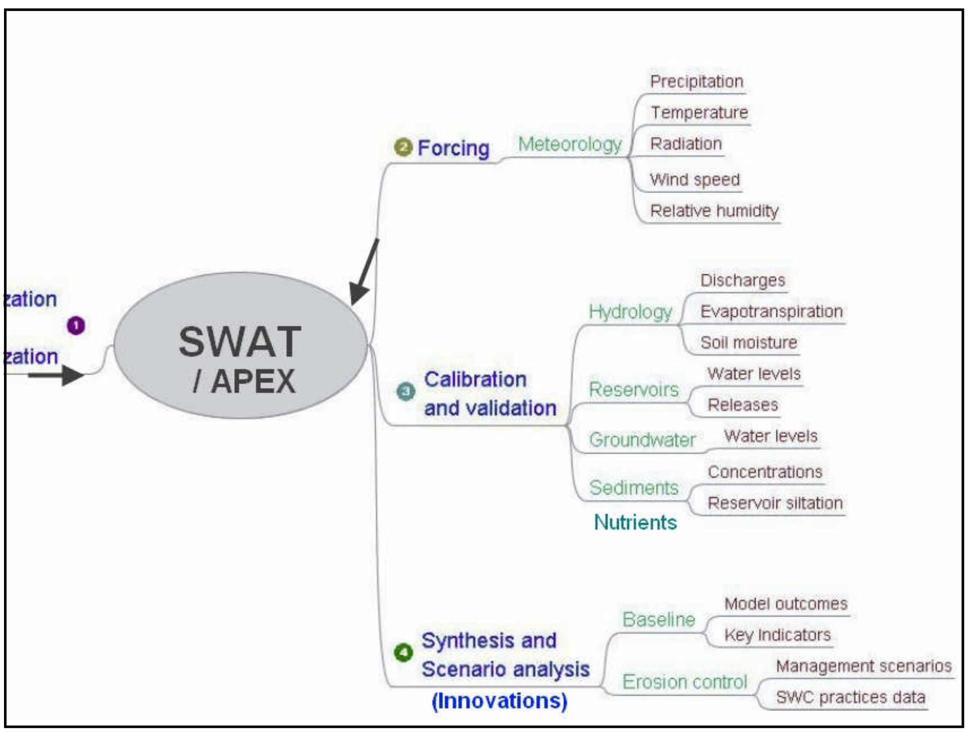
GIS environment

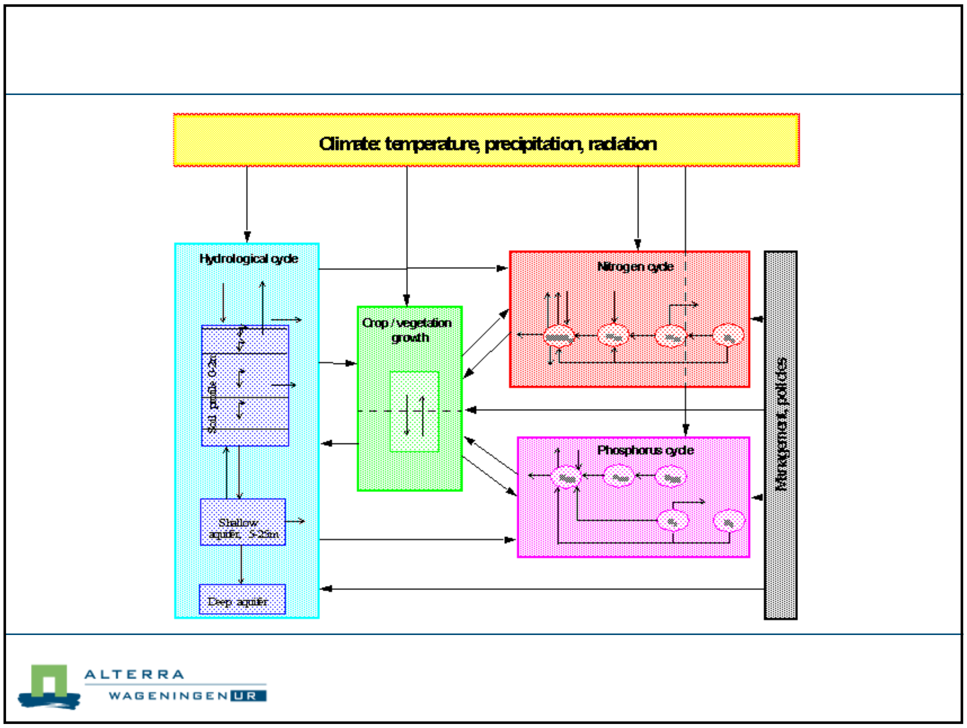


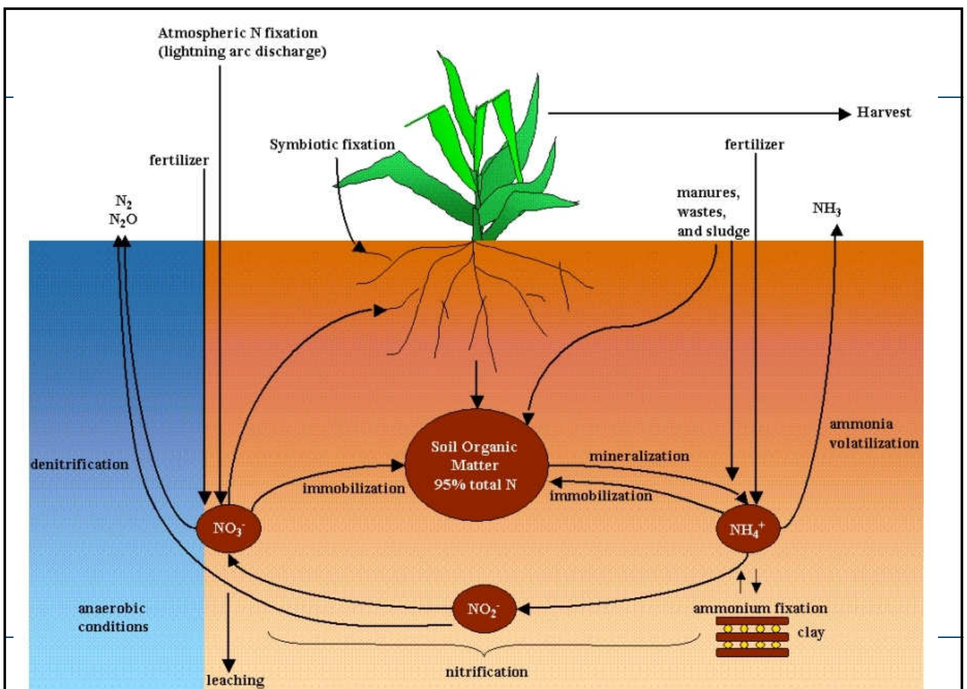
ALTERRA
WAGENINGEN UR




Digital Elevation Model
Profile
Resistance
Slope
River networks
Subbasins and rivers
Land cover / land use
NDVI
NPP
LAI
Vegetation indices
Albedo
Irrigated areas
Cropping calendar
Irrigation scheduling
Management
Land surface
Depth
Texture
Hydraulic properteis
Soil types
Soil
Area
Volumes
Operation
Reservoirs
Water bodies
Extent
Capacity
Recharge
Abstractions
Aquifers
Groundwater
Schematization and parametrization
1
SWAT / APEX

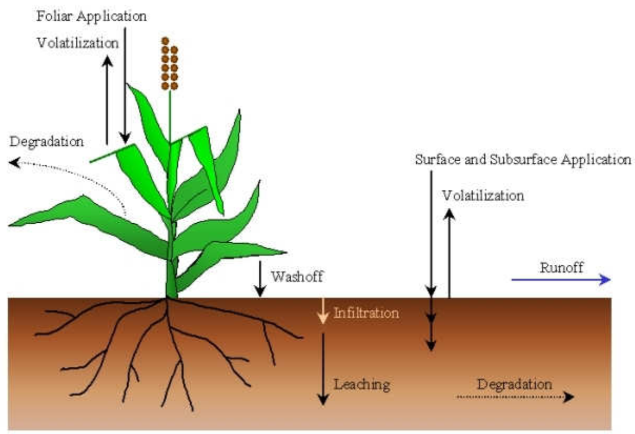

zation
1
zation
SWAT / APEX
2 Forcing
Meteorology
Precipitation
Temperature
Radiation
Wind speed
Relative humidity
3 Calibration and validation
Hydrology
Discharges
Evapotranspiration
Soil moisture
Reservoirs
Water levels
Releases
Groundwater
Water levels
Sediments
Concentrations
Reservoir siltation
Nutrients
4 Synthesis and Scenario analysis
(Innovations)
Baseline
Model outcomes
Key Indicators
Erosion control
Management scenarios
SWC practices data





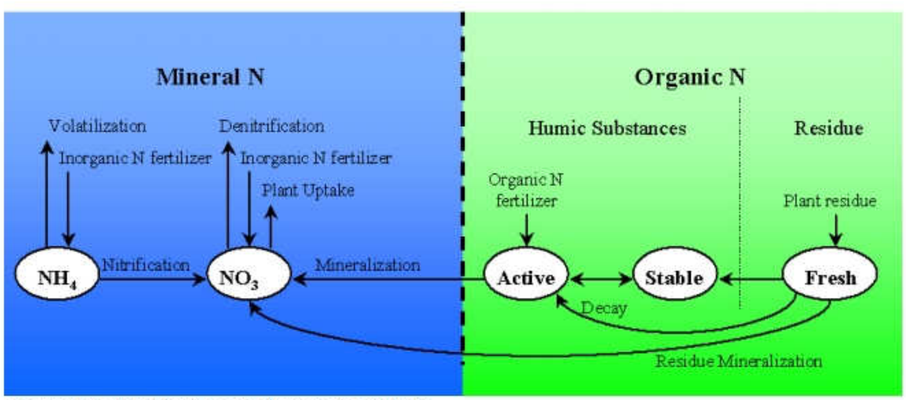
The nitrogen cycle

PESTICIDES



ALTERRA WAGENINGEN UR

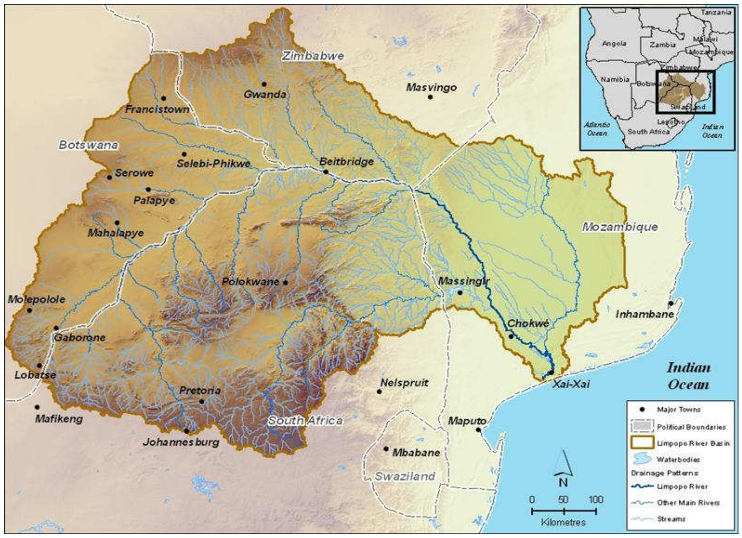
NITROGEN



Partitioning of Nitrogen in SWAT

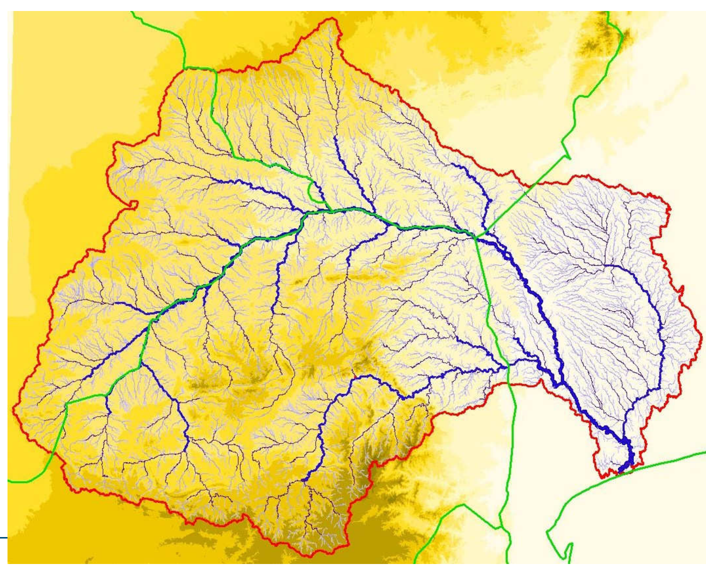
ALTERRA WAGENINGEN UR

SWAT model applied to Limpopo basin



ALTERRA WAGENINGEN UR

Limpopo basin



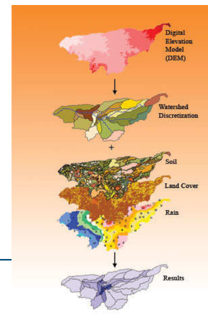
ALTERRA WAGENINGEN UR

Goal Limpopo study

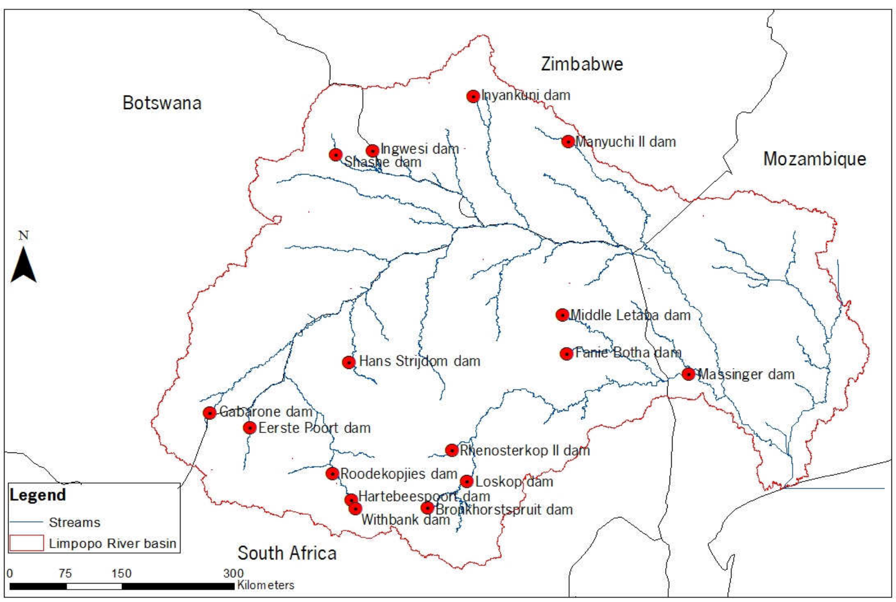
Main goal:

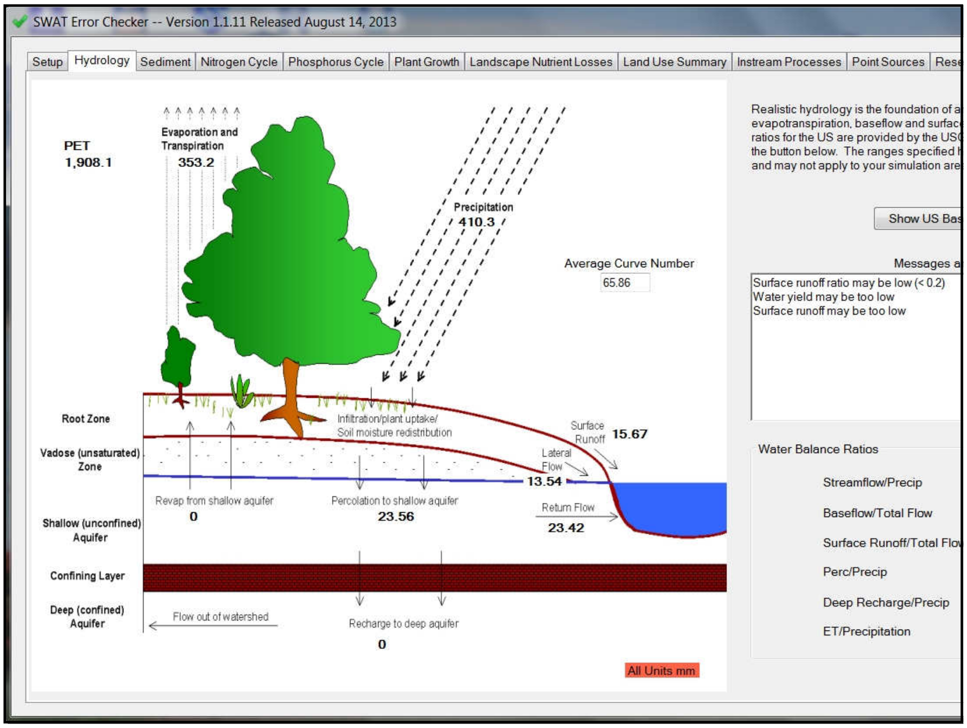
- To set up the SWAT model for the Limpopo River basin, focussing on smallholder farming
- Modelling different irrigation and fertilizer application management scenarios for smallholder farms
- Linking crop production to hydrology

- Framework: water for food



SWAT application – Dams in Limpopo River basin

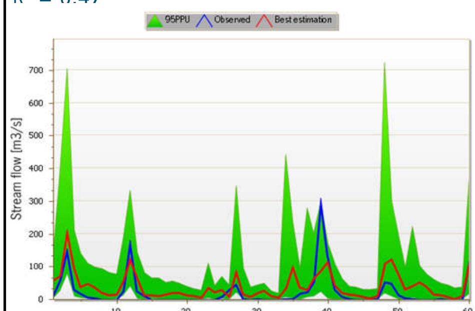




Observed vs simulated stream flow – using SWAT-CUP2012

Nash-Sutcliffe[1] = 0.35

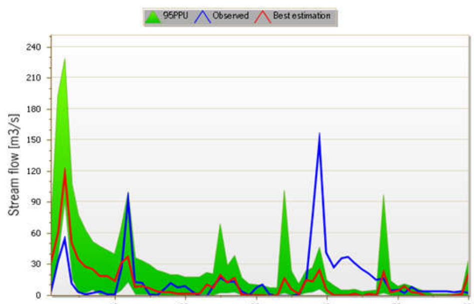
R^2 = 0.47



Beitbridge gauge station

Nash-Sutcliffe[1] = -0.07

R^2 = 0.11



Engelhart dam gauge station

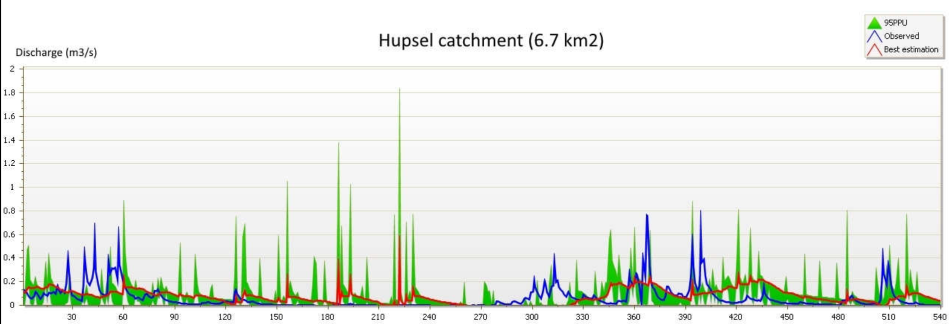
[1] Nash-Sutcliffe efficiency coefficient: assess the predictive power of hydrological models

ALTERRA
WAGENINGEN UR

SWAT application – Limpopo River basin

Scenario			Management operation Description
I	BS	No irrigation, no fertilizer appl.	Baseline
II	IA	Application of irrigation	Auto irrigation (plant water stress)
III	FA	Application of fertilizer	Manure as fertilizer (100 kg/ha/year)
IV	CS	Appl. of fertilizer and irrigation	Manure as fertilizer (100 kg/ha/year) and auto irrigation (plant water stress)

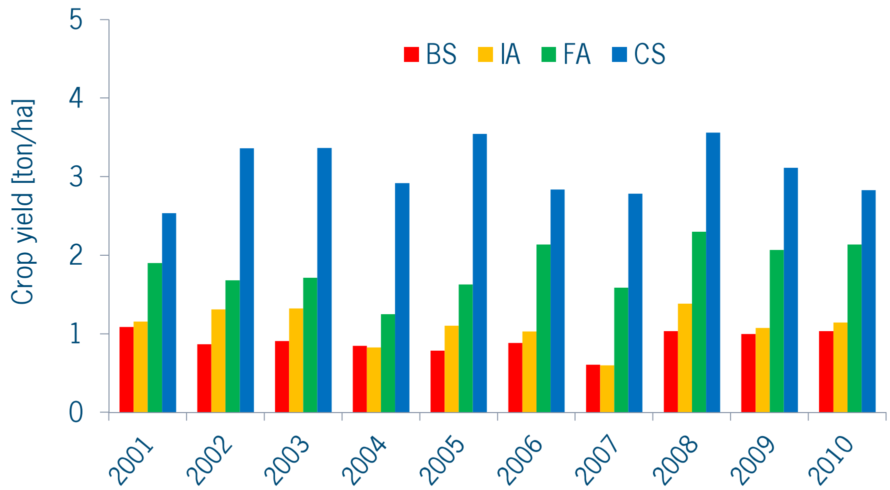
SWAT-CUP2012 analysis Hupsel



SWAT-CUP analysis monthly time step see above

on a daily time step did not work well

Results – Scenario analysis



ALTERRA WAGENINGEN UR

SWAT – strengths and weaknesses

Strengths

- Combination of upland and channel processes into one simulation package
- Applicable for many case studies in different environments
- Water quality
- 'User friendly' by its ArcGIS interface

Weaknesses

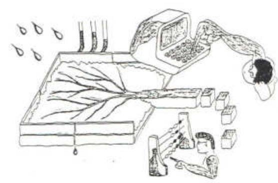
- Simplification of reality
- Many inputs and outputs can be overwhelming
- Insufficient scientific understanding
- Weak in regional hydrology
- Shallow groundwater conditions

ALTERRA WAGENINGEN UR

New developments

Regional hydrology:

- Link SWAT and SIMGRO



Shallow groundwater levels:

- Use other rainfall-runoff concept

Crop Kc factor concept

- Use reference crop evapotranspiration and Kc factors for other crops

ALTERRA WAGENINGEN UR

Model selection

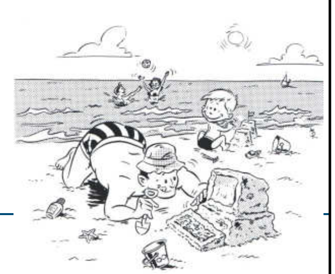
Project goal → Ideal schematisation (hydrological and hydraulic processes)
Consider the scenarios to analyse
Is the regional hydrology important?

- Study area
- Available data
- Time and money

Acceptable schematisation

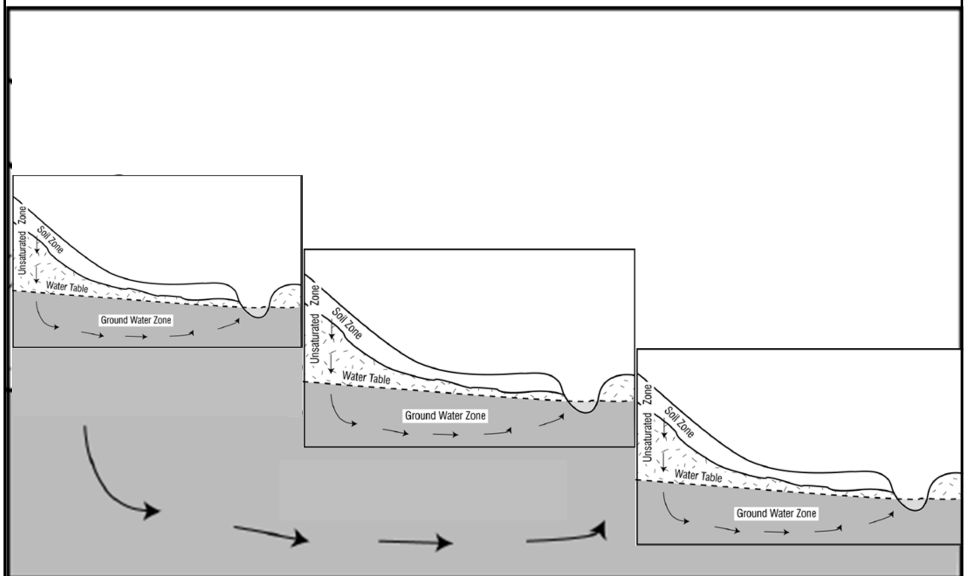
Select type of model(s)

SWAT or SIMGRO?



ALTERRA GREEN WORLD RESEARCH

Regional hydrological system

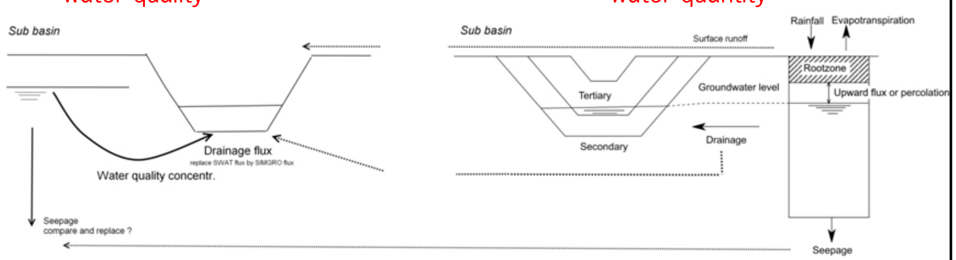


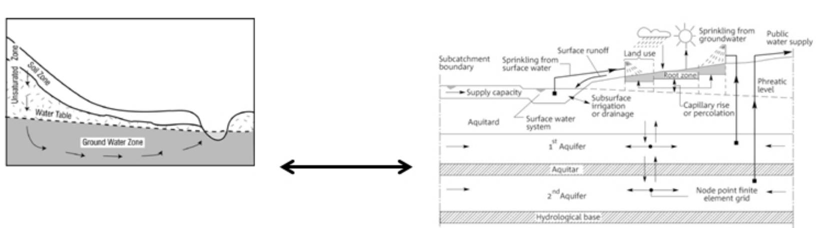
SWAT

water quality

SIMGRO

water quantity





ALTERRA
WAGENINGEN UR

Integration of SIMGRO and SWAT model at the time scale of both groundwater models, being in general one day.

Exchange of fluxes:

drainage flux

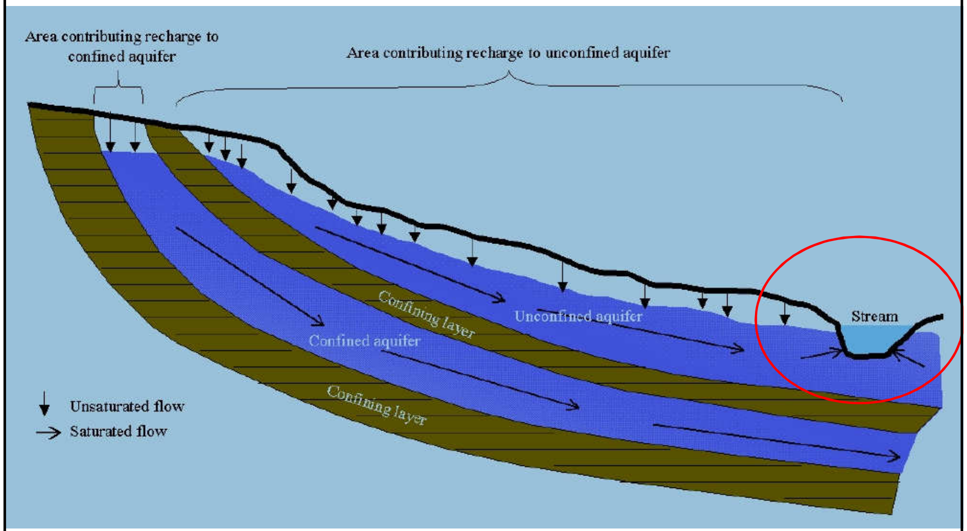
seepage / leakage

Data transfer using same procedure as in Querner (1993):

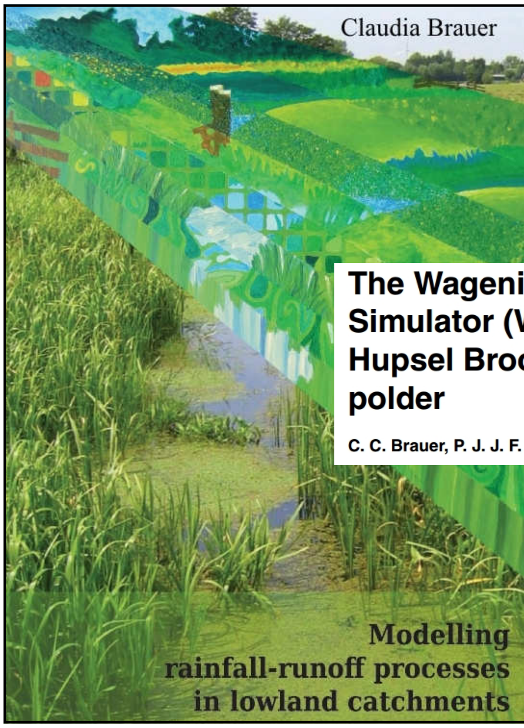
SIMGRO <> SIMWAT .... SWAT

ALTERRA WAGENINGEN UR

Shallow groundwater levels in SWAT ?



ALTERRA WAGENINGEN UR

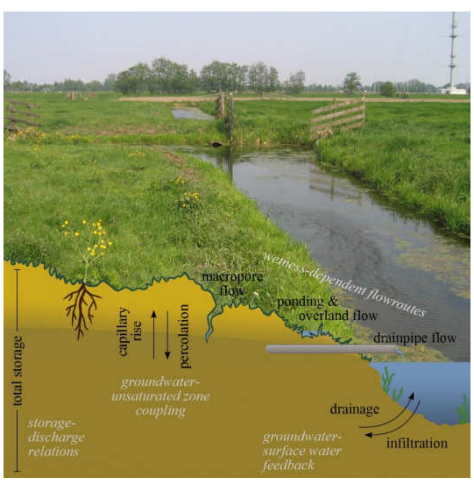


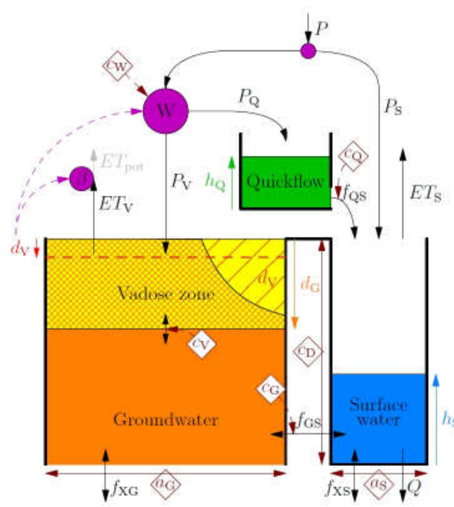
Shallow groundwater levels

The Wageningen Lowland Runoff Simulator (WALRUS): application to the Hupsel Brook catchment and Cabauw polder

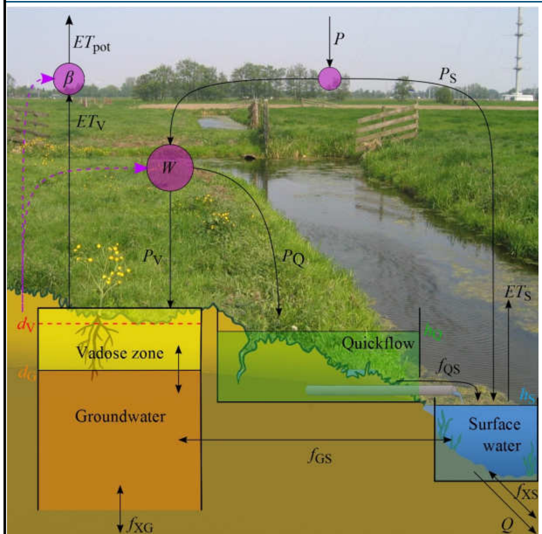
C. C. Brauer, P. J. J. F. Torfs, A. J. Teuling, and R. Uijlenhoet

Hydrol. Earth Syst. Sci. Discuss., 11, 2091–2148, 2014
www.hydrol-earth-syst-sci-discuss.net/11/2091/2014/
doi:10.5194/hessd-11-2091-2014





Shallow groundwater levels



In SWAT ! no feedback from surface water to groundwater

Use this module in SWAT

Challenge > describe the surface water level in SWAT

Crop factor concept

SWAT uses heat units for crop growth and potential evapotranspiration

Use the reference evapotranspiration (ET0) to calculate the actual evapotranspiration through the following steps:

1. The <u>potential</u> evapotranspiration for a particular crop is derived from the reference crop evapotranspiration using crop factors. A crop factor is a correction factor containing all variation of evapotranspiration with crop type, growth stage or management practice (Allen et al., 1998).
2. <u>Actual</u> evapotranspiration of each crop is determined, depending on the moisture content in the root zone.

SWAT code:

Fortran – version 588 (Feb. 2013)

version 591 (April 2013)

....

version 622 (June 2014)

version 629 (30 Sept 2014)

Updates available very frequently ‼

ALTERRA WAGENINGEN UR

Discussion

ALTERRA WAGENINGEN UR

For further questions contact me at:

erik@querner.eu or erik.querner@wur.nl

www.querner.eu