

Development of a Simple PCRaster-based Model for Rainfall-runoff Assessment in the Northern Mountainous Region of Vietnam

Zöllmer, C.¹, Lippe, M.¹, Vien, T. D.², Dung, N.V.², Hilger, T.H.¹, Cadisch, G.¹

¹ University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany.
² Hanoi Agricultural University, Vietnam

Introduction



Land degradation is a severe problem worldwide, particularly in resource-poor regions of the tropics when non-adapted cropping systems are used. To date, many studies have been undertaken to find solutions and to identify sustainable land-use options. When looking at landscape level, our understanding of the underlying processes is limited which are often very complex. A modeling approach may, therefore, help to better understand the impact of land-use changes on the entire system.

Objectives

- to develop a simple rainfall and runoff model and
- to test its applicability for mountainous regions in NW Vietnam.

Materials & Methods

- The model was built by using PCRaster environmental software (<http://www.pcraster.nl/>) and followed an approach proposed by Karszenberg et al. (1997).
- PCRaster is an environmental modeling language for building dynamic spatial environmental models developed by the Department of Physical Geography, Utrecht University, The Netherlands.
- Data collected at the Tat Hamlet, Da Bac district, Hoah Binh province NW Vietnam (20°92'N, 105°1'E) were used for model parameterisation.
- The research site is characterised by a tropical monsoon climate with a mean annual temperature of 23.2°C and a mean annual precipitation of 1825 mm, Ferralic Acrisols in the uplands and Gleyic Acrisols in the valleys. The land use is *Composite Schwiddening Agriculture* (= integration of paddy rice fields in the valley, rotating swidden fields on hillsides and the use of wild resources from the forest).
- A sensitivity analysis of the model was carried out on:
 - runoff and
 - land cover changes.



Location map of the research site Tat Hamlet, Hoa Binh province, NW Vietnam.



View of the research area with paddy fields in the foreground and swidden agriculture in the background, Tat Hamlet, Hoa Binh province, NW Vietnam.

Results

How does the PCRaster based rainfall-runoff model work?

```

# input timeseries
RainTSS01=rainmon01.tss;
EvapoTSS=evaref.tss;
VegCoverTSS=vegcover.tss;
# input tables
CropCoef=cropcoef.tbl;
# input maps
Localdd=ldd.map;
RainArea=rainarea.map;
LanCov01=lancov01.map;
OutFlow=outflow.map;
# output files
# Rainfall per year
Rain2001=rain01;
# Throughfall and Interception
VegCover01=vegcover01;
ThroFall01=throfall01;
# Evaporation
K01=cropcoef01.map;
Evapo01=evap01;
# Precipitation Surplus
PreciSurp01=surp01;
# runoff and infiltration
RunOff01=flux01;
State01=state01;
# runoff at outflowpoints
OutFlow01TSS=outflow01.tss;
areamap
area.map;
# timer
1 12 1;
initial
K01=lookupscalar(CropCoef,LanCov01);
# dynamic
# Rainfall per year
Rain2001=timeinputsalar(RainTSS01,RainArea);
# Throughfall and Interception
VegCover01=timeinputsalar(VegCoverTSS,LanCov01);
ThroFall01=Rain2001-(Rain2001*VegCover01);
# Evapotranspiration
EvapoRef=timeinputsalar(EvapoTSS,1); # Evapotranspiration reference factor
Evapo01=K01*EvapoRef;
# Precipitation Surplus
PreciSurp01=max(ThroFall01-Evapo01,0);
# runoff and infiltration amount
RunOff01_State01=accufractionflux,accufractionstate(Localdd,PreciSurp01,0,5);
# runoff at outflowpoint
report OutFlow01TSS=timeoutput(OutFlow,RunOff01);
            
```

The total information of the cell at one location is represented by the values of the different layers at that cell.

Stack of maps (Source: PCRaster manual Vers. 2, 2003)

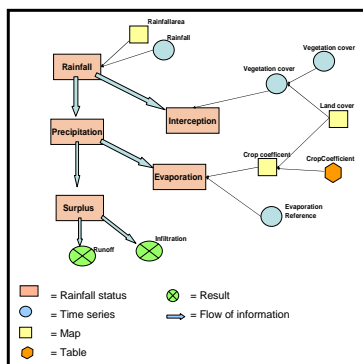
Local drain direction map

Timeseries table

Land cover map

Operators for data management, point, neighborhood, area and operations maps, tables, timeseries and point data column files

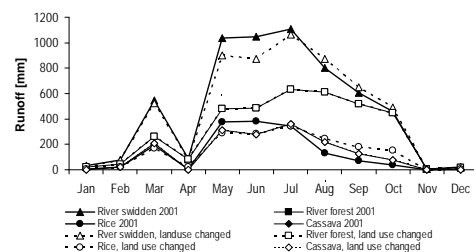
Structure of the rainfall-runoff model



Observed and simulated runoff as affected by land cover

Year	Rainfall (mm)	Runoff in mm							
		Rice Obs.	Rice Sim.	Cassava Obs.	Cassava Sim.	Forest Obs.	Forest Sim.	Fallow Obs.	Fallow Sim.
2000	1756*	667	917	-	-	485	113	-	-
2001	2547	1150	1650	1081	1506	818	108	1074	-
2002	2163	-	-	770	950	381	24	655	-
2003	2048	-	-	773	733	503	102	543	1187
2004	2010	-	-	-	-	80	26	303	591

*Rainfall was recorded from May to December 2000



Simulated runoff based on the land cover of 2001 and after exchanging the position of cassava and upland rice fields within the Tat hamlet micro watershed.

Conclusions

PCRaster

Advantages

- Public domain, manual available;
- Easy to use; pre-build functional blocks are available, flexible in application;
- Coupling of GIS and biophysical models;
- Visualization of results.

Disadvantages

- Problems in converting some map formats (raster vs. vector format);
- Display of simulation results in table format requires further software (e.g. VBA).

Model performance

- Runoff simulation sensitive to amount of rainfall, land use, and crop cover changes;
- Runoff overestimated by the model, particularly for cropped fields;
- Limited model reliability: model validation was not possible due to lack of data.