Hydrol. Earth Syst. Sci. Discuss., 7, C2014–C2034, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C2014/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling the hydrologic response of a mesoscale Andean watershed to changes in land use patterns for environmental planning" *by* A. Stehr et al.

A. Stehr et al.

astehr@udec.cl

Received and published: 27 August 2010

Comment 1. At p. 3076, l. 3-5 you notice a lack of case studies for the southern hemisphere. For the scientific readers it is very interesting to get information about possible problems of the SWAT model structure for your region. Recommended ranges for parameters, which have not yet been reported elsewhere, are also worth reporting. We do not get much information in the paper. Some possible questions to address: a. Applicability of the SCS CN approach for your region. Your model was very sensitive against the CN values (table 4). This needs more consideration. b. Vegetation parameters. Your study is about land use change, respectively change in vegetation. Can you work with the (mainly US based) database of the original SWAT model, or did you expand the vegetation/parameter databases? c. How good are the incorporated evaporation/evapotranspiration approaches for your region, which one did you use?

Reply 1. As stated in the paper a lack of case studies for the southern hemisphere is detected. The parameters involved in the computation of surface runoff in the Vergara watershed from precipitation data with SWAT are shown in Table R-4. For the northern hemisphere Van Liew et al. (2005) established the upper and lower limit of the following parameters: Gwqmn, Gw_revap, ESCO, Gw_delay, and Surlag, while Muleta and Nicklow (2005) established the range of the parameters: Canmx, Revapmn, rchrg_dp, CN2, Epco, Smtmp, Timp and OV_n. Plaps was initially obtained from Fontaine et al. (2002), Sol_K from Liu et al. (2002) and Sol_Awc from Kannan et al. (2003). For central Chile, Escobar and Vidal (1992) established Sftmp, Smfmn and Smfmx, whereas Peña et al. (1985) Tlaps. The baseflow recession constant was obtained using a baseflow filter program (Arnold et al., 1995; Arnold and Allen, 1999). After calibration of the model following PARASOL (van Griensven and Bauwens, 2003), we obtain a modified range of SWAT parameters that better reproduce discharges from precipitation data in our region. These ranges might be applicable in other similar regions of the world like Himalaya. Reply 1 a). Several previous studies show the applicability of the SCS CN approach for the study region. The SCS CN method has been extensively tested and modified in order to represent local conditions. For details, please refer to: Iroumé et al. (1999), Saavedra and Stowhas, (2003), Stowhas (2003), Pizarro et al. (2006). A rainfall-runoff model based on the curve number method is very sensitive against CN values, which control the portion of rainfall that is converted to runoff. The CN value depends on land cover, soil type, slope and antecedent soil moisture and is expressed as: Equation 1

where S is the surface runoff (mm day-1), P is the rainfall depth (mm day-1), I is the initial abstraction including surface storage, interception and infiltration prior to runoff (mm day-1) which is approximated to 0.2 R, and R is the retention parameter (mm day-1), which varies spatially due to changes in land cover, soil type and slope, and temporally due to antecedent soil moisture conditions: Equation 2

where CN is the curve number for the day. Equation 3

Reply 1 b). As already mentioned in reply 1 of referee # 1, we did not expand the SWAT database of land uses. In SWAT, land uses are classified according to the land cover database proposed by Neitsch et al. (2002). The land cover database includes the description of 97 different land uses. Each land use is identified with a code. In the particular study case, the observed land uses where compared with those described by Neitsch et al. (2002). It was found that all the observed land uses are present in the database by Neitsch et al. (2002). Thus, the observed landuses were codified following the standard database.

Reply 1 c). SWAT includes three different methods for computation of evaporation/evapotranspiration, namely: Penman-Monteith, Priestley-Taylor and Hargreaves. As there are no records of wind speed, relative humidity and solar radiation in the basin, but maximum and minimum temperatures are available from meteorological stations we used the Hargreaves method. The Hargreaves method has shown good results in different type of climates (Jensen et al. 1990; Allen et al., 1998, Antonioletti et al. 1998, Droogers et al., 2002, Saghravani et al. 2009). Moreover, Jensen et al. (1990) (in Saghravani et al., 2009) compared different 20 evapotranspiration methods against lysimeter data. Of all methods that required only air temperature, namely, the Hargreaves method showed the best results.

Comment 2. The land use change from 1979 to 1994 is rather dramatic compared to other regions. From 1979 to 1994 it is 15 years, and now you might even have data for the next 15 years (-2009)? Can you evaluate your scenarios against recent observation data? Which of the five scenarios is closest to reality so far?

Reply 2. Unfortunately, the most recent available landuse data are those presented in the paper for the year 1994. Thus it is not possible to perform a hard evaluation of the predicted scenarios against recent observation data. We agree with the comment of referee #2 on the dramatic observed landuse change between years 1979-1994. That fact make the presented study case a very interesting one and is one of the main motivations for the publication of this paper. Currently, researchers of the Environmental Research Center EULA-Chile are working on the image processing in order to generate actual landuse maps from satellite imagery. In the near future we expect to be able to submit a new paper with those results and the evaluation of the predicted scenarios.

Comment 3. Scenarios 1 and 5 seem to have a logical background, while scenarios 2 to 4 seem to be more a kind of sensitivity analysis. These three are not realistic, are they? The way how you developed the scenarios, mainly scenario 5, should be documented in more detail. Please describe the regression model (e.g. formulae) and document your assumptions. The generation of the scenarios should be reproducible.

Reply 3. We agree with referee #2: Scenarios 2 and 4 do not have a logical background. However, they provide a good idea of the limits inbetween discharge, i.e. water availability in the watershed, could change following landuse patterns. As those scenarios are not realistic, we decide to eliminate them in the paper. Analysis of scenarios 1, 3 and 5 provide the relevant information as well. Scenario 5 was obtained using a set of prediction variables such as elevation, slope, distance from native forest, distance of forest plantations, distance from urban areas and size ownership. The documentation and explanation of the development of this scenario has been incorporated on the manuscript at "4 Generation of probable land use scenarios" and reads as follows:

To quantify the relationship between land cover changes and its causal factors, the maps of 1979–1994 were sprawl and results related to a set of predictor variables (change and non change) that were selected based on current knowledge of landuse changes process in the Vergara watershed (Echeverría et al., 2006; Echeverría et al., 2007; Altamirano et al., 2007; Aguayo et al., 2009), Table 4 shows this variables. An

HESSD

7, C2014–C2034, 2010

appropriate binary response variable was constructed from the observed forest expansion pattern and a logistic regression model were used to predict the probability of land cover change depending on the various predictor variables (equation 1; Table R-5).

Equation 4

Table R-5. Results of the adjustment of the logistic regression for forest plantation sprawl (** = $p < 0.01$).

Comment 4. In table 8 you show results for the scenarios 1 to 4, but not 5 – why? Scenario 5 is very interesting. The caption of fig. 10 is incomplete: is f) scenario 5?

Reply 4. We agree with referee #2. Table 8 has been completed, showing scenarios 1-5 for all the subbasins. The table is:

Table 8. Percentage of change respect to the baseline scenario for mean annual, wet season (May – October) and dry season (November –April) flows.

Comment 5. The description of the SWAT model should be carefully revised. Interception is not computed with the CN method, you mention surface runoff twice, but I think you mean generation and concentration of surface runoff etc.

Reply 5. We agree with referee #2. Interception is not directly computed when the CN method is use. It is consider together with infiltration and surface storage in a term called initial abstraction (I) which is approximated to 0.2 of the retention parameter (R), accordingly to:

Equation 5

In the text, we corrected: Interception, surface runoff and infiltration were computed with the curve number method. The surface runoff is computed following the kinematic wave approach, using Manning's relation for estimation of the runoff speed. By Surface runoff was computed with the curve number method. Water is routed using the kinematic wave approach, using Manning's relation for estimation of the runoff speed.

HESSD

7, C2014–C2034, 2010

Interactive Comment

Comment 6. The deep aquifer in SWAT should be handled with care. You can remove a lot of water from your watershed when you set a high value for the rchrg_dp parameter – as you did (0.5 – 1 as reported, that means up to 100% of the percolating water!). Does this correspond with the local hydrogeologic situation? When removing so much water (violating the continuity equation for your watershed), it should be documented where the water is transferred and why it is. Reading such parameter values for rchrg_dp and a relatively high bias of your model results gives cause for serious concern.

Reply 6. We agree with referee #2. The parameter rchrg_dp bounds indicate the minimum and maximum value that this parameter can take, and certainly 1 is a very high value. There is a typographic error in the next. In fact, the value of the lower limit of rchrg_dp parameter is 0.05 instead of 0.5. In the presented simulations rchrg_dp parameter ranged between 0.05 and 0.1.

Comment 7. The results of the sensitivity analysis (Section 6.1) are not discussed. How do they compare with the results of others? Did you observe a specific behavior of the model, which can be related to the local situation? Is there a recommendation to use different parameter ranges for PARASOL in your region?

Reply 7. The most sensitive parameter is the CN2 value. Other sensitive parameters are Gwqmn, Sol_Awc and rchrg_dp. This results are in agreement with those by Arnold et al. (2000), Spruill et al. (2000), White and Chaubey (2005), Holvoet et al. (2005), Van Griensven et al. (2006), and Kannan et al. (2007). Table R-6 shows the sensitive parameters obtained in the referred studies.

Table R-6. Sensitive parameters obtained in the referred studies

According to table 6 we observed a similar behaviour of SWAT for applications in the basins located in south-central Chile, i.e. Vergara and subbasins, to that reported for watershed located in the northern hemisphere by the aforementioned researchers.

HESSD

7, C2014–C2034, 2010

The use of the parameter ranges showed in reply #1 of referee #2 is strongly recommended.

Table 4 in the manuscript will be replaced by the following table; in order to avoid redundance of information provided in reply # 1 of referee #2. It shows the ranking of the 4 most sensitive parameters in Tijeral, Rehue, Renaico, Mininco and Malleco.

Table 7. Ranking of the 4 most sensitive parameters in Tijeral, Rehue, Renaico, Mininco and Malleco

Comment 7. In section 6.2 you discuss the calibration results for 2000-2002. You report that the model "satisfactorily reproduced the order of magnitude of the observed discharges". This does not sound convincing. Model and data uncertainty should be analyzed in more detail. For example: you report that the model subestimates (underestimates) peak discharge. I am not surprised when I see the availability of rainfall data: only one station within the mountain area and that station has a lot of missing values even within the calibration period. Which method did you apply to interpolate (?) rainfall data?

Reply 7. We are surprised that our statement "the model satisfactorily reproduced the order of magnitude of the observed discharges" does not sound convincing to the referee #2. Also, it is rare that one expect an underestimation of discharges when data availability is scarce; why not an overprediction? The presented simulations of the Vergara watershed with SWAT calculate complex non-linear hydrological process in a semidistributed manner solving a mathematical problem without analytical solution. Thus, it is reasonable to expect some differences between observed and calculated values. Based on our experience with hydrological modeling, there is no clear tendency to under or overpredict discharges depending on the data availability. Influence of hydrologic regime of the watershed, as well as the soil type, land uses might control model response.

Rainfall data where assigned to the different subbasins using the methodology incorporated in ArcSWAT, i.e. rainfall data use to calculate runoff are obtained from the precipitation station centroid that is closest to the subbasin under consideration. Additionally, to model snow accumulation and melt each sub-basin generated in SWAT can be divided into 10 elevation bands in order to incorporate temperature and precipitation variations with respect to altitude (Hartman et al., 1999). For each sub-basin, different lapse rates for precipitation plaps (mm H2O/km) temperature tlaps (°C/km) can be defined, which are then used to account for the differences in precipitation and temperature between these elevation bands. Figure R-1 shows the subbasins and the location of the corresponding meteorological station.

Figure R-1. Subbasins and the location of the corresponding meteorological station

Comment 8. In 6.2 and 6.3 you mention "changes tendency in time" – what do you mean with that? Are you able to say anything about trends in runoff, based on the short calibration/validation periods?

Reply 8. As referee #2 enunciates the sentence, it seems to make no sense. The sentence "changes tendency in time" in 6.2 and 6.3 read: "The model satisfactorily reproduced the order of magnitude of the observed discharges, and their changes tendency in time." Observed discharges exhibit a seasonal dynamics with a mean value that is about an order of magnitude higher in winter than in summer, with significant winter highwater events of about 8 days.

Comment 9. P. 3082, l. 20: "calibration period" – isn't it validation period here?

Reply 9. We agree with referee #2. There is a typographic error in the manuscript. It read: calibration period

Might read: validation period

Comment 10. Table 2: what do the numbers mean? I'm not sure if I understood the table. It needs some explanation in the capture, also provide units (ha?)

Reply 10. A landuse transition matrix shows the changes of landuse for different years.

HESSD

7, C2014–C2034, 2010

Interactive Comment

Table 2 present values in [ha]. The total of each column and row indicates the area of the land covers for the years 1979 and 1994, respectively. The values of the columns indicate the land cover changes occurred between 1979 and 1994 (e.g. 30428 ha of native forest for a total of 133096 ha were converted to forest plantations). The values of the diagonal indicate the area that remained the same during the period (e.g. 92 533 ha of native forest from a total of 133096 ha were maintained during the period 1979-1994).

Comment 11. Only three of the five gauging stations have been operated in 1977, so are the data presented in table 3 really related to the period 1977-2002? Why do you include the two stations Rehue and Renaico in your study, could they even be left out?

Reply 11. In fact the gauging station Rehue and Renaico have been operated since 1997 and 1982, respectively. This stations could be left out in the paper. Nevertheless we consider that it is important to present all the data, because it illustrates a real situation of a basin with scarce hydrometeorological data, which is a characteristic feature in the region and represents a challenging topic in hydrological modeling: development, application, and/or modification/adaption of modeling tools for the correct estimation of the water balance components in basins with scarce data availability. In the text, we modified Table 3 in order to explicitly show the period used in the computations for each subbasin.

Table 3. Mean monthly discharges [m3/s] at the different control points in the Vergara basin (1977-2002).

Comment 12. P. 3083, l. 2: From your model results, you assume that the model can be applied to analyze the impact of land use changes on the hydrologic response. Table 5: In my opinion the model bias is rather high. The percentage of change caused by the different land use scenarios is within a similar magnitude (table 8). This needs to be discussed in detail.

Reply 12. We disagree with Referee #2. Usually an absolute value for PBIAS of less

HESSD

7, C2014–C2034, 2010

than 20% is considered "good", values between ±20% and ±40% are considered "satisfactory", and those greater than ±40% are considered "not satisfactory", as reported e.g. van Liew et al. (2005). Moreover, graphic comparison (see figs. 7, 8 and 9), and RRMSE, ABSERR, EF and R2 (see Tables 5, 6 and 7) indicate that model results are good for three periods of 3, 6, and 6 years duration, respectively.

Technical Corrections:

Language is understandable, but grammar and spelling need a revision to meet publication standards. Asking a native speaker is recommended.

References

Aguayo, M., Pauchard, A., Azocar, G., and Parra, O.: Land use change in South-central Chile by the end of the XX century. Understanding spatial and temporary landscape dynamics (in spanish), Rev. Chil. Hist. Nat., 82, 361-374. 2009. Allen, R.G., Pereira, L.S., Raes D., and Smith, M.: Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements. FAO Irrigat. Drainage, Rome, 1998. Altamirano, A., Echeverría, C., and Lara, A.: Effect of forest fragmentation on the vegetation structure of threatened populations of Legrandia concinna (Myrtaceae) in the center-south of Chile (in spanish), Rev. Chil. Hist.a Nat., 80, 27-42, 2007. Antonioletti, R., Gonzalez, P., and Ortega, S.: Comparative analysis of methods for estimating evapotranspiration in the Maule region of Chile (in spanish), Agro-Ciencia (Chile), 14, 435-440, 1998. Arnold, J.G., Allen, P.M. Muttiah, R., and Bernhardt, G.: Automated base flow separation and recession analysis techniques. Ground Water 33, 1010-1018, 1995. Arnold, J.G., and Allen.P.M.: Automated methods for estimating baseflow and ground water recharge from streamflow records. JAWRA, 35, 411-424, 1999. Arnold, J.G., Muttiah, R.S, Srinivasan, R., and Allen, P.M.: Regional estimation of base flow and groundwater recharge in the upper Mississippi basin, J. Hydrol., 227, 21-40, 2000. Droogers, P., and Allen, R.G.: Estimating reference evapotranspiration under inaccurate data conditions. Irrigat. Drainage Syst., 16, 33-45, doi: 10.1023/A:1015508322413, 2002. Echeverría

C, Coomes, D., Salas, J., Rey-Benayas, J. M. Lara, A., and Newton, A.: Rapid deforestation and fragmentation of Chilean temperate forests, Biol. Conserv., 130, 481-494, 2006. Echeverría, C, Newton, A., Lara, A., Rey-Benayas, J. M., and Coomes, D.: Impacts of forest fragmentation on species composition and forest structure in the temperate landscape of southern Chile, Global Ecol. Biogeogr., 16, 426-439, 2007. Escobar, F., and Vidal, F.: Experience on the determination of the snowline in drainage basins of central Chile (in spanish), Sociedad de Ingeniería Hidráulica Revista (Santiago), 2, 5-18, 1992. Fontaine, T.A., Cruickshank, T.S., and Arnold, J.G.: Development of a snowfallâĂŤsnowmelt routine for mountainous terrain for the soil water assessment tool (SWAT), J. Hydrol, 262, 209–223, 2002. Holvoet, K., van Griensven, A., Seuntjens, P., and Vanrolleghem, P.A.: Sensitivity analysis for hydrology and pesticide supply towards the river in SWAT, Phys. Chem. Earth, 30, 518-526, 2005. Iroumé, A., Huber, A., Salazar, C., and Arriagada, A.: Monitoring and quantification of the hydric processes in an Andean watershed, IX Region, Chile (in spanish) VI Jornadas del CONAPHI-Chile, Santiago, Chile, 1999. Jensen, M.E., Burman R.D., and Allen,R.G.: Evapotranspiration and irrigation wáter requirements, ASCE Manuals and Reports on Engineering Practice No. 70, ASCE, New York, USA, 332 pp, 1990. Kannan, N., White, S., Worrall, F. and Whelan, M.: Modelling pollutants in runoff from the Colworth experimental Catchment, Proceedings of the 2nd International SWAT Conference, Bari, Italy, 149 – 154, 2003. Kannan, N., White, S.M., Worrall, F, and Whelan, M.J.: Sensitivity analysis and identification of the best evapotranspiration and runoff options for hydrological modelling in SWAT-2000, J. Hydrol., 332, 456-466, 2007. Liu Y.B., Gebremeskel S., De Smedt F., and Pfister L.: Flood prediction with the WetSpa model on catchment scale, Flood Defence 2002, Wu. et al (eds), Science Press, New York Ltd., ISBN 1-880132-54-0, 2002. Neitsch, S. L., Arnold, J. G., Kiniry, J. R., Srinivasan, R., and Williams, J. R.: Soil and Water Assessment Tool User's Manual Version 2000, Texas Water Resources Institute TR-192, College Station, TX., 2002. Peña, H., Vidal, F., Escobar, F., and Stowhas, L.: Snowmelt rates estimation (in spanish), VII Congreso de Ingeniería Hidráulica, Concepción, Chile, 1985. Pizarro, R., Tapia, M., Román, L., Jordán, C., and

HESSD

7, C2014–C2034, 2010

Interactive Comment

Farías, C.: Chile. Instantaneous runoff coefficients for Tutuvén river basin (in spanish), Maule Region, Chile, Bosque, 27, 83-91, 2006. Saavedra, C., and Stowhas, L.: Calculation and critical analysis of the curve number method for watershed of the country (in spanish), XVI Congreso de Ingeniería Hidráulica, Santiago, Chile, 2003. Saghravani, S., Mustapha, S., Ibrahim, S., and Randjbaran, E.: Comparison of Daily and Monthly Results of Three Evapotranspiration Models in Tropical Zone: A Case Study, Am. J. Environ. Sci., 5, 698-705, 2009. Spruill, C.A., Workman, S.R., and Taraba, J.L.: Simulation of daily and monthly stream discharge from small watersheds using the SWAT model, Trans. ASAE, 43, 1431-1439, 2000. Stowhas, L.: Use of the curve number method in heterogenous watersheds (in spanish), XVI Congreso de Ingeniería Hidráulica, Santiago, Chile, 2003. van Griensven, A. and Bauwens, W.: Multiobjective autocalibration for semidistributed water quality models, Water Resour. Res., 39, 1348, 2003. van Griensven, A., Meixner, T., Grunwald, S., Bishop, T., and Srinivasan, R.: A global sensitivity analysis tool for the parameters of multi-variable catchment models, J. Hydrol., 324, 10–23, 2006. Van Liew, M.W., Arnold, J.G., and Bosch, D.D.: Problems and potential of autocalibrating a hydrologic model, Trans. Am. Soc. Agric. 48, 1025–1040, 2005.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 3073, 2010.

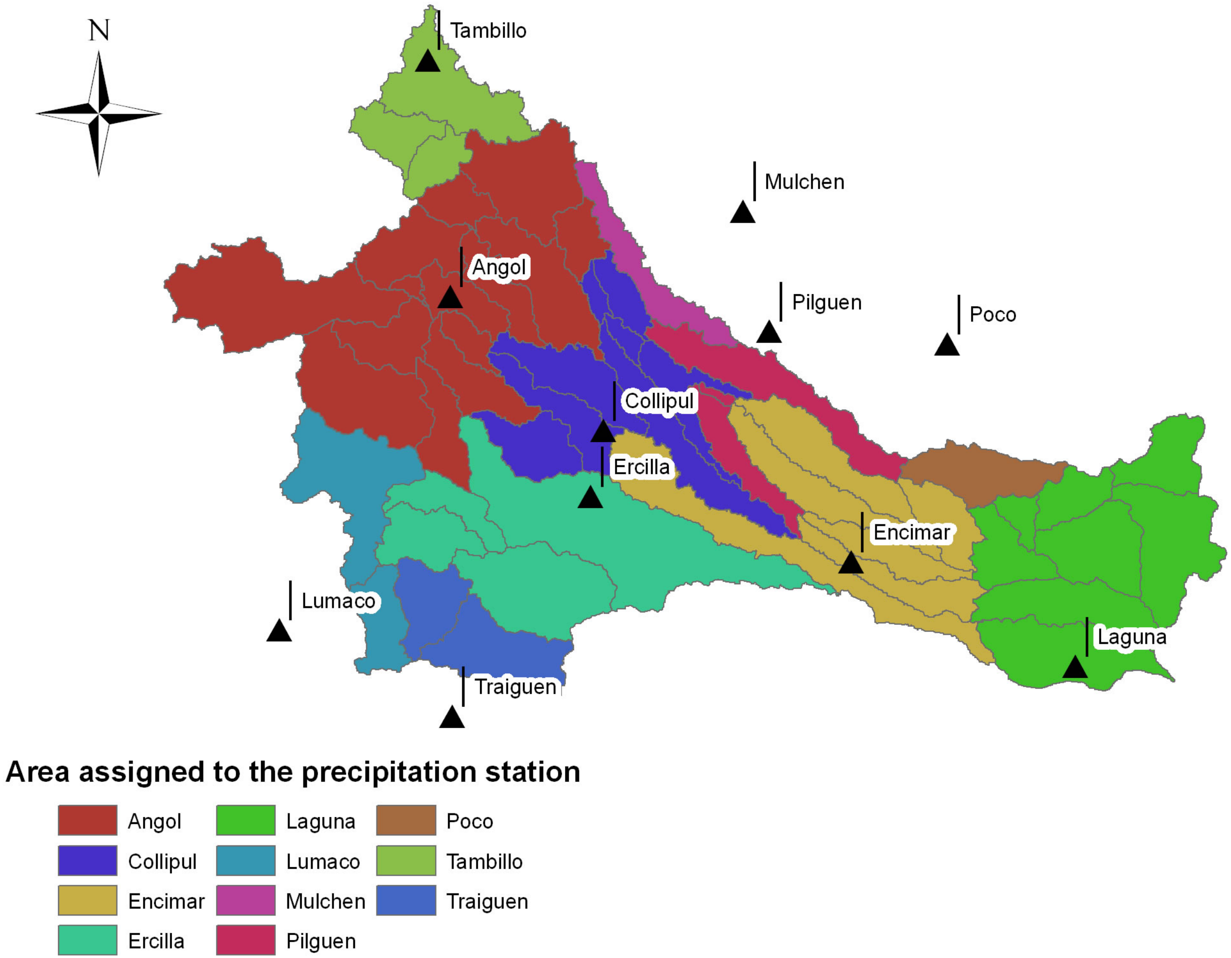

Fig. 1.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Table R-4. Parameters involved in the computation of surface runoff in the Vergara watershed.

Parameter	Description	Units	Recommended Range	Reference	Range after PARASOL
ALPHA_BF	Baseflow recession constant		0.01 - 0.05	Arnold et al. (1995); Arnold and Allen (1999)	0.01 - 0.05
CN2	Initial SCS CN II value		39 - 68	Muleta and Nicklow (2005)	35 - 92
EPCO	Plant uptake compensation factor		0.001- 1	Muleta and Nicklow (2005)	1
ESCO	Soil evaporation compensation factor		0.13 - 0.95	Van Liew et al. (2005)	0.1 – 0.95
GW_DELAY	Delay time for aquifer recharge	days	0 - 380	Van Liew et al. (2005)	31
GW_REVAP	Groundwater revap coefficient		0.02 - 0.2	Van Liew et al. (2005)	0.02
GWQMN	Threshold water depth in the shallow aquifer for base flow	mm	0 - 3560	Van Liew et al. (2005)	0 – 200 mm
REVAPMN	Threshold water depth in the shallow aquifer for revap	mm	0 - 100	Muleta and Nicklow (2005)	1
RCHRG_DP	Deep aquifer percolation fraction		0.01 – 0.75	Muleta and Nicklow (2005)	0.05 – 0.1
SFTMP	Snowfall temperature	ºC	1.0	Escobar and Vidal (1992)	1.0
SMFMN	South hemisphere: Maximum melt rate for snow during the year (occurs on winter solstice)	mm/(ºC day)	6.5	Escobar and Vidal (1992)	6.5
SMFMX	South hemisphere: Minimum melt rate for snow during year (occurs on summer solstice)	mm/(ºC day)	3.5	Escobar and Vidal (1992)	3.5
SMTMP	Snow melt base temperature	ºC	-2 - 20	Muleta and Nicklow (2005)	0.5
SOL_AWC	Available water capacity	mm H_2O/mm soil	0.08 – 0.16	Kannan et al. (2003)	0.2 - 0.55

Fig. 2. Table R-4. Parameters involved in the computation of surface runoff in the Vergara watershed.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Table R-4. Parameters involved in the computation of surface runoff in the Vergara watershed. (continued)

Parameter	Description	Units	Recommended Range	Reference	Range after PARASOL
SOL_K	Saturated hydraulic conductivity	mm/hr	0 - 208	Liu et al. (2002)	1.5 - 208
TIMP	Snow pack temperature lag factor		0.5 - 1	Muleta and Nicklow (2005)	1
PLAPS	Precipitation lapse rate	mm/km	0.5	Fontaine et al. (2002)	0
TLAPS	Temperature lapse rate	ºC/km	-7.5 - -6.5	Peña et al. (1985)	-6
OV_N	Manning's "n" value for overland flow		0.2 – 0.8	Muleta and Nicklow (2005)	0.15-0.8
CANMX	Maximum canopy storage	mm	2 – 6.5	Muleta and Nicklow (2005)	1.9
SURLAG	Surface runoff lag coefficient		0.53 - 4	Van Liew et al. (2005)	0.75

Fig. 3. Table R-4. Parameters involved in the computation of surface runoff in the Vergara watershed. (continued)

HESSD

7, C2014–C2034, 2010

Interactive Comment

Table R-5. Results of the adjustment of the logistic regression for forest plantation sprawl (** = p < 0.01).

Variables	β(i)	Standard error	Wald[1]	p
Elevation	-0.00193	0.000096	404.52	**
Slope	-0.00653	0.001926	11.48	**
Distance from native forest	-0.00097	0.000053	341.39	**
Distance of forest plantations	-0.00005	0.000003	271.19	**
Distance from urban areas	0.00006	0.000003	314.29	**
Size ownership	-0.00001	0.000001	66.08	**
Constant (β_0)	1.13899	0.049907	520.85	**

[1] Wald test is used to test the statistical significance of each coefficient (b) in the model

Fig. 4. Table R-5. Results of the adjustment of the logistic regression for forest plantation sprawl (** = p < 0.01).

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

HESSD

7, C2014–C2034, 2010

Interactive Comment

Table 8. Percentage of change respect to the baseline scenario for mean annual, wet season (May – October) and dry season (November –April) flows.

	Vergara			Tijeral			Rehue			Mininco			Renaico			Malleco		
	Year	**Wet**	**Dry**	**Year**	**Wet**	**Dry**	**Year**	**Wet**	**Dry**	**Year**	**Wet**	**Dry**	**Year**	**Wet**	**Dry**	**Year**	**Wet**	**Dry**
Scenario 1	-4.09	-4.83	0.24	-1.86	-2.81	2.93	-10.61	-10.67	-9.94	-8.57	-9.02	-4.42	-2.32	-2.81	0.06	-1.69	-2.48	1.19
Scenario 2	5.08	5.41	3.06	7.30	7.28	6.32	7.23	7.70	1.55	2.38	2.63	-1.06	1.13	1.27	0.81	1.86	1.37	3.86
Scenario 3	-2.40	-2.86	0.28	-0.48	-1.25	3.21	-9.37	-9.34	-9.83	-6.30	-6.55	-4.03	-1.62	-1.96	0.07	-1.66	-2.46	1.26

Fig. 5. Table 8. Percentage of change respect to the baseline scenario for mean annual, wet season (May – October) and dry season (November –April) flows

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

HESSD

7, C2014–C2034, 2010

Interactive Comment

Table R-6. Sensitive parameters obtained in the referred studies

Author	Country	Most sensitive parameters
Kannan et al. (2007)	UK	AWC, Sol_K, ESCO, GWQMN and CN2
Spruill et al. (2000)	USA	Sol_K, Alpha_Bf
Arnold et al. (2000)	USA	CN2, Sol_Awc, ESCO
Holvoet et al. (2005)	Belgium	CN2, surlag, rchrg_dp, GWQMN
Van Griensven et al. (2006)	USA	CN2, Gwqmn, Alpha_Bf, Sol_Awc, Sol_z, Smfmx, ESCO, CANMX
White and Chaubey (2005)	USA	CN2, ESCO, Sol_AWC,

Fig. 6. Table R-6. Sensitive parameters obtained in the referred studies

Table 7. Ranking of the 4 most sensitive parameters in Tijeral, Rehue, Renaico, Mininco and Malleco

Parameter	Description	Tijeral	Rehue	Renaico	Mininco	Malleco
GWQMN	Threshold water depth in the shallow aquifer for flow	**2**	3	4	**2**	**2**
GW_REVAP	Groundwater revap coefficient		4			
CN2	Initial SCS CN II value	**1**	**2**	**1**	**1**	**1**
SOL_AWC	Available water capacity	3		**2**	4	3
rchrg_dp	Deep aquifer percolation fraction	4	**1**	3	3	4

Fig. 7. Table 7. Ranking of the 4 most sensitive parameters in Tijeral, Rehue, Renaico, Mininco and Malleco

HESSD

7, C2014–C2034, 2010

Interactive Comment

Table 7. Ranking of the 4 most sensitive parameters in Tijeral, Rehue, Renaico, Mininco and Malleco

Parameter	Description	Tijeral	Rehue	Renaico	Mininco	Malleco
GWQMN	Threshold water depth in the shallow aquifer for flow	**2**	3	4	**2**	**2**
GW_REVAP	Groundwater revap coefficient		4			
CN2	Initial SCS CN II value	**1**	**2**	**1**	**1**	**1**
SOL_AWC	Available water capacity	3		**2**	4	3
rchrg_dp	Deep aquifer percolation fraction	4	**1**	3	3	4

Fig. 8. Table 3. Mean monthly discharges [m3/s] at the different control points in the Vergara basin (1977-2002)

HESSD

7, C2014–C2034, 2010

HESSD

7, C2014–C2034, 2010

Interactive Comment

$$S = \frac{(P - I)^2}{(P - I + R)}$$ **Equation 1**

$$R = 25.4\left[\frac{1000}{CN} - 10\right]$$ **Equation 2**

$$CN = \frac{25400}{(R + 254)}$$ **Equation 3**

$$P(y = 1| x) = \frac{e^{\beta_0 + \sum_{i=1}^{n} \beta_i x_i}}{1 + e^{\beta_0 + \sum_{i=1}^{n} \beta_i x_i}}$$ **Equation 4**

where, P (y = 1| x) is the Probability, x_i are the different variables, β_0 is a Constant, β_i are the variable coefficients and n number of variables.

$$I = 0.2\,R = 5.08\left[\frac{1000}{CN} - 10\right]$$ **Equation 5**

Fig. 9. Equations