Instrument: **SP1 Cooperation**

Thematic Priority: **Priority Area 1.1.6.3 "Global Change and Ecosystems"**

FP7 Collaborative Project – Grant Agreement 212492

CLARIS LPB
A Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin

DELIVERABLES

D9.1: Distributed hydrological models of La Plata basin, describing the present water balance of the river basin, with focus on special variables of interest to other tasks and deliverables of the project

Due date of deliverable: Month 18

Start date of project: **01/10/2008** Duration: 4 **years**

Organisation name of lead contractor for this deliverable: Swedish Meteorological and Hydrological Institute

Deliverable No	Deliverable title	WP	Lead beneficiary	Estimated indicative person-months (permanent staff)	Nature	Dissemination level	Delivery date
D9.1	Distributed hydrological models of La Plata basin, describing the present water balance of the river basin, with focus on special variables of interest.	WP9	P8-SMHI	7,80	O	CO	18

Summary

Two distributed hydrological models, the HYPE and the VIC models, were set up for the La Plata basin. These hydrological models, which were calibrated against streamflow observations, will in the next step be forced by meteorological data from regional climate models from other CLARIS-LPB work packages, in order to evaluate the effect of climate change on hydrological resources in the basin. Results from this deliverable will hopefully also be valuable input to the work carried out within other WP9 tasks.

HYPE model

The HYPE-model is a daily time-stepping distributed hydrological model. In a model application, the river basin is divided into a number of subbasins using topographic data to delineate the basin boundaries. Each such subbasin is in turn divided into a set of classes with a unique combination of soil type and land use. The model has a vertical resolution for each class with a maximum of three soil layers, with arbitrary depths. Water holding capacities (e.g. the plant available water and the total porosity) are linked to soil type. Water balance computations for each soil layer give the soil wetness within each layer, and when the largest pores begin to fill corresponding groundwater outflow begins. The groundwater level is calculated based on the fraction of the largest pores that is filled in a layer. Drainage can also take place through tile drains in agricultural soils (if present). Surface runoff and macro-pore flow are also modelled. The water outflows from all classes are added together and routed through a system of rivers and lakes and regulated reservoirs, which connect the different subbasins. Waterbodies in the river network may have individual or general rating curves, or a simple regulation rule. The model is forced by daily precipitation and mean temperature. Potential evapotranspiration is in the model a function of air temperature which has been adjusted for seasonal variations in relative humidity. Parameters in the model are either general for the modelled domain or linked to soil type or land use/cover.

Model set up and databases

The HYPE-model was set up for the La Plata Basin with an average sub-basin size of approximately 500 km^2. A hydrologically corrected topographic database, HydroSHEDS, was used to derive basin boundaries and river routing (Figure 1). Land cover and soils data was taken from the Global Land Cover 2000 and ISRIC World Soil Information, respectively. Precipitation and temperature data used as model forcing was taken from the ERA40 and ERAinterim (European Centre for Medium-range Weather Forecasts). Data from these data sets were scaled using monthly data from the Global Precipitation and Climate Centre (GCPP). Information on dams was gathered from the World Register of Large Dams from the International Commission Of Large Dams. Calibration data was obtained from CLARIS- LPB partners and the Global Runoff Data Centre.

The model was set up and calibrated to obtain an as good fit as possible to streamflow observations in terms of long term water balances and streamflow variation. The calibration was not performed for individual streamflow gauging sites, but for the whole basin simultaneously aiming to obtain an as good overall fit as possible. This calibration strategy is made easier due to the use of model parameters linked to soil type and land use. The assumption is that differences in physiographical characteristics and forcing data are sufficient to account for spatial variability.

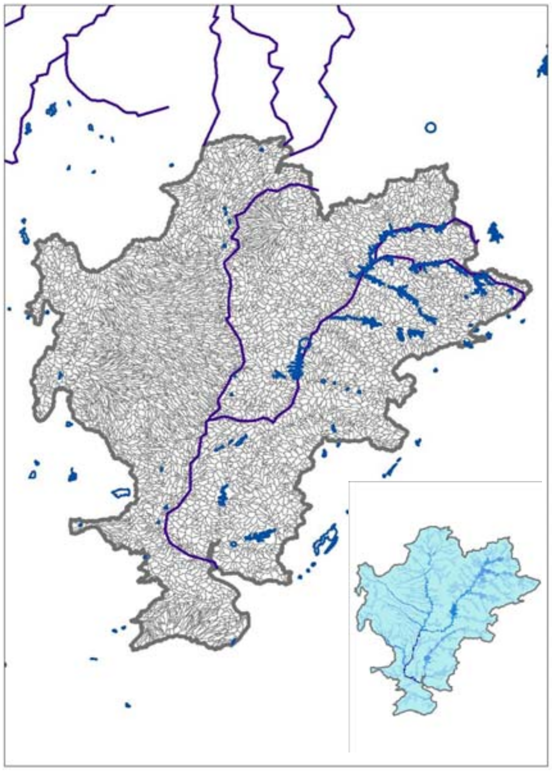

Figure 1. The La Plata Basin divided into subbasins. The inset shows the hydrological drainage network of the basin.

Results and discussion

Simulation results compared with observed data from some key streamflow gauging stations in the basin show that the model generally captures the hydro-climatic variations in the La Plata basin well. In the Uruguay River basin, which has the highest density of temperature and precipitation stations in the basin, the model captures the dynamics of the streamflow well. However, the simulated streamflow signal is too attenuated compared to the observations (Figure 2). This may be an effect of the reservoirs simulated in HYPE which may smoothen the streamflow signal too much. At Jupiá station at the Paraná River (Figure 3), the model simulates the seasonal dynamics well, while the interannual simulation of summer peak flow is worse. At Corrientes, downstream of the confluence of the Paraná and Paraguay rivers, the model results are worse (Figure 4). Streamflow is overestimated some years and underestimated other and the seasonal dynamics is also rather poor. In general, the model overestimates streamflow from around February to July. The model has difficulties of capturing the streamflow dynamics of the Paraguay River, partly as a result of not capturing the effects of the large wetlands in this part of the basin. It may also be an effect of less accurate precipitation data in this part of the basin (the meteorological station network is rather sparse). Overall, comparing the observed and simulated long term water balances, the model generally captures the water balance in the La Plata basin well (Figure 5).

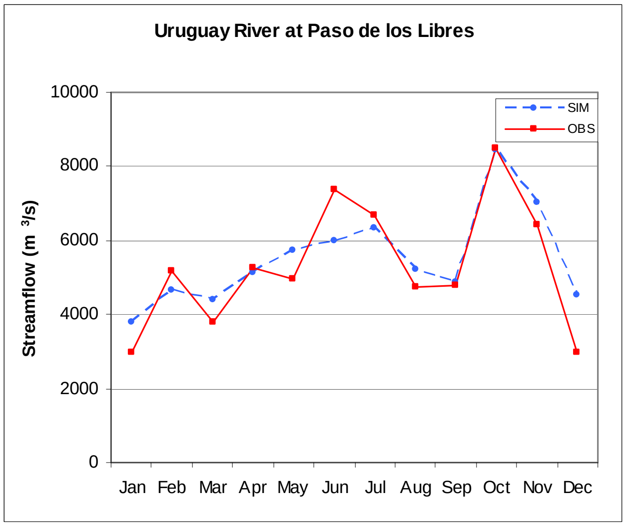

Figure 2. Simulated and observed streamflow, and monthly averages at the Paso the los Libres station at the Uruguay River.

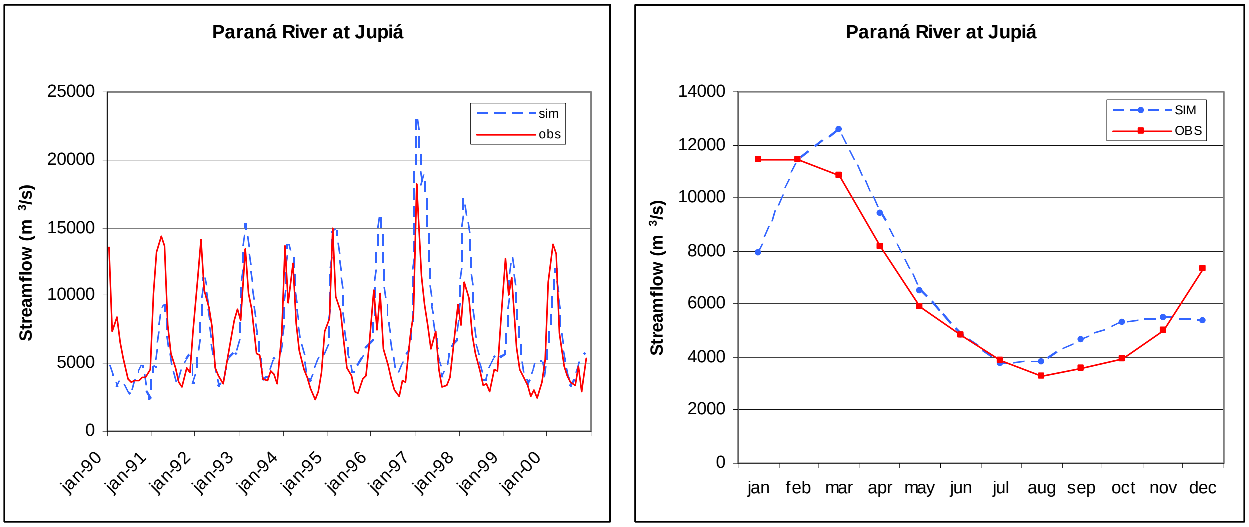

Figure 3. Simulated and observed streamflow, and monthly averages at Jupiá station at the Paraná River.

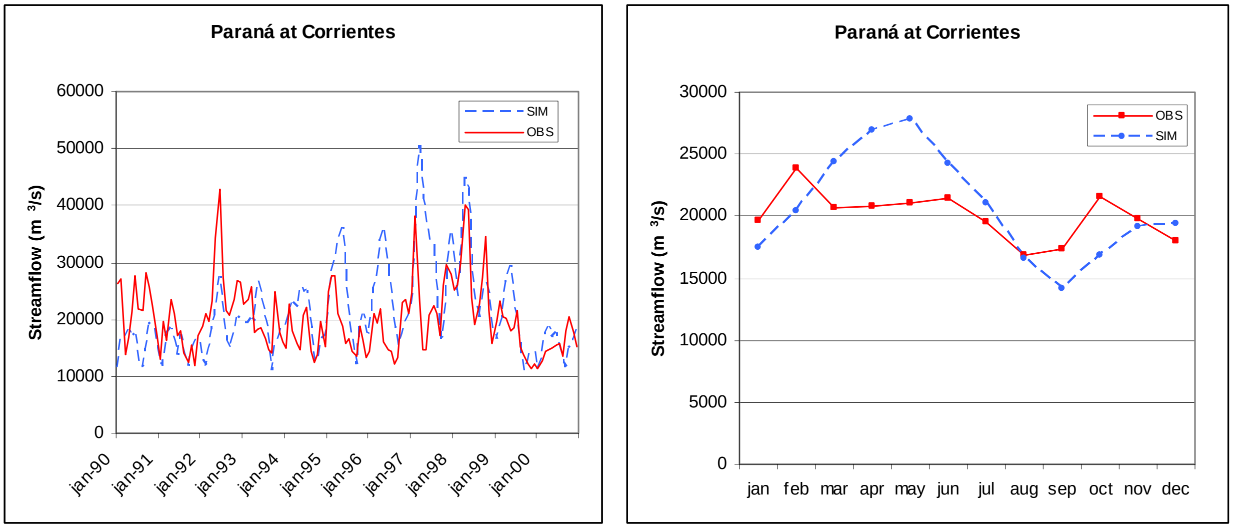

Figure 4. Simulated and observed streamflow, and monthly averages at Corrientes station at the Paraná River.

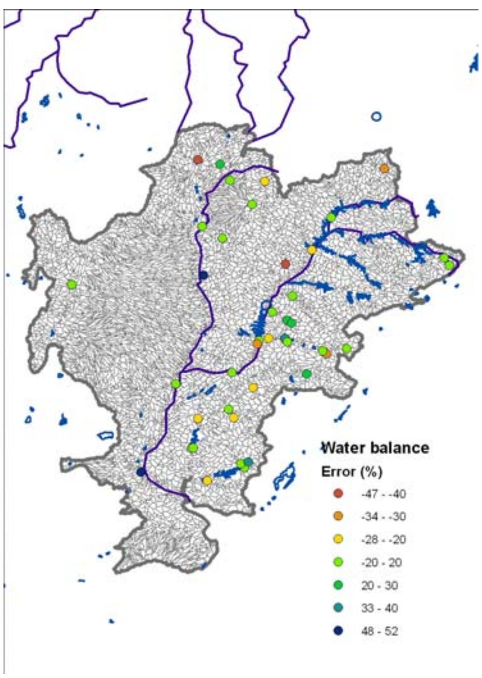

Figure 5. Comparison of simulated and observed long term water budgets at a number of streamflow gauging stations in the La Plata basin.

Description of delivered data sets

Number	Name/variable	Unit	type	Temporal resolution	Spatial resolution	File format	Description
9.1.1	LPB subbasins	-	GIS shape-file	n/a	~500 km^2	.shp file	Delineated subbasins of the La Plata basin including stream flow paths
9.1.2	Stream flow	m3/s	time-series	daily	Subbasin level	.txt file	Simulated streamflow at the outlet of the La Plata

						basin subbasins
9.1.3	Soil moisture	Mm	time-series	monthly	.txt file	Simulated soil moisture content in the La Plata basin subbasins (average for subbasin)
9.1.4	Groundwater table	M	time-series	monthly	.txt file	Simulated groundwater table in the La Plata basin subbasins (average for subbasin)

VIC model

VIC model set up and databases

The VIC model is a daily time stepping distributed hydrology model. It solves both water and energy balances on a grid mesh and uses a mosaic-like representation of land cover and a subgrid parameterization for infiltration; it requires information on soil texture, topography and vegetation. Soil data was derived from the 5-min Global Soil Data Task and vegetation information was obtained from the University of Maryland's 1-km Global Land Cover product. The model is forced with atmospheric data that can be determined by the user (depending on its availability). In the context of CLARIS-LPB simulations, VIC was forced over the entire LPB domain using daily information of observed minimum and maximum temperature and precipitation (Figs. 6 and 7, respectively). The simulations were performed using a horizontal resolution of 0.125° x 0.125°. For each time step (both daily and monthly), VIC outputs are surface runoff, evapotranspiration and baseflow. Then, a routing scheme is applied to VIC runoff outputs to obtain basin-integrated total discharges at selected points, so that these streamflow data can be compared with observed streamflow at the same closing points as a way to determine the performance of VIC in the different sub-basins. VIC usually performs well in steep terrain, characterized by rapid runoffs, while the model tends to have large biases when used to simulate the hydrological cycle of river lying in flat regions (as the case of the Paraguay River in the Pantanal region, for example). VIC was calibrated separately for the different main sub-basins: Paraná River, Uruguay River, Paraguay River and Iguazú River. Observed streamflow data were obtained from the Subsecretaría de Recursos Hídricos (Argentina) and the Operador Nacional do Sistema Elétrico (Brazil).
The performance assessment was done by computing, for each grid point and at a monthly time step, the E parameter proposed by Nash and Sutcliffe. E values larger than 0.5 are indicative of a good performance.

Results and discussion

VIC is capable of properly reproducing the main hydrological features across LPB. For instance, the calibrations obtained at both the Paraná and the Uruguay Rivers are above the 0.5 threshold and, thus, indicate the calibration is good.
Figure 8 shows the time series of the observed and modeled streamflows at Jupiá (Paraná River) for the period 1990-1999. It can be seen that the model tends to overestimate the summer streamflow by about 20-25%, and the autumn-winter-spring streamflow is very well represented by the model. This leads to a slight overestimation of the annual mean streamflow, explained mainly by the summer misrepresentation. In the case of the Uruguay River at Paso de los Libres, the VIC model is very accurate at representing the month-to-month variability. The hydrograph obtained with VIC is very similar to that derived from the observations, and in fact this basin is the one which has the largest E value, exceeding 0.95 in the simulations validated at both Paso de los Libres and Concordia (not shown).

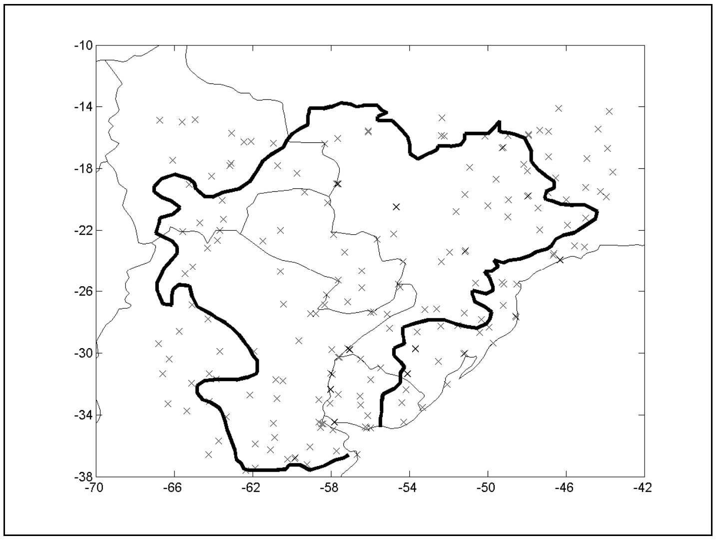

Figure 6. Daily minimum and maximum temperature stations used in the calibration of VIC throughout LPB. Period: 1990-1999.

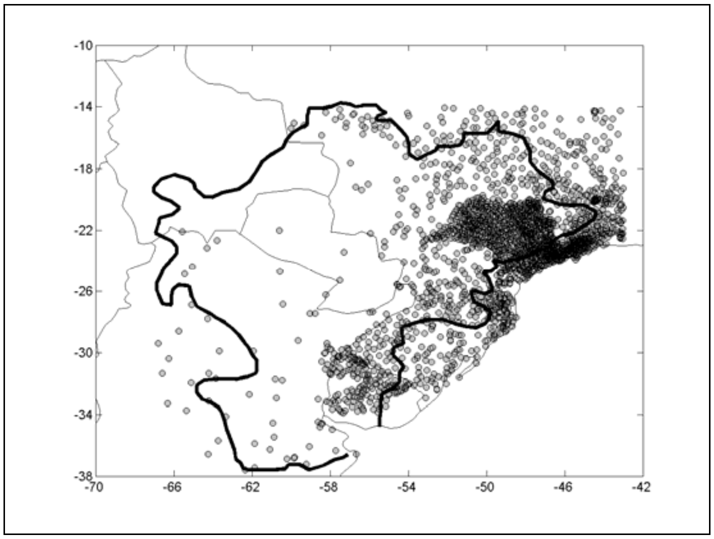

Figure 7. As in figure 6 but for the precipitation stations.

The case of the Paraguay River at Ladario is problematic. VIC is known to have large biases when modeling rivers running in flat terrain and this is also seen in this case. The amplitude of the streamflow wave is very exaggerated with huge overestimations in autumn and slight underestimations during the dry season (mainly from September to December).

Results obtained with VIC then suggest that the model is a good tool to be used to simulate the water cycle of LPB. The model is particulary good in the Uruguay and Paraná rivers, and in the case of the Paraguay River the simulations are less accurate, but this is a problem that is intrinsic of the model itself and is not related to errors related to, for example, the small quantity of precipitation and temperature stations in that area (see figures 6 and 7).

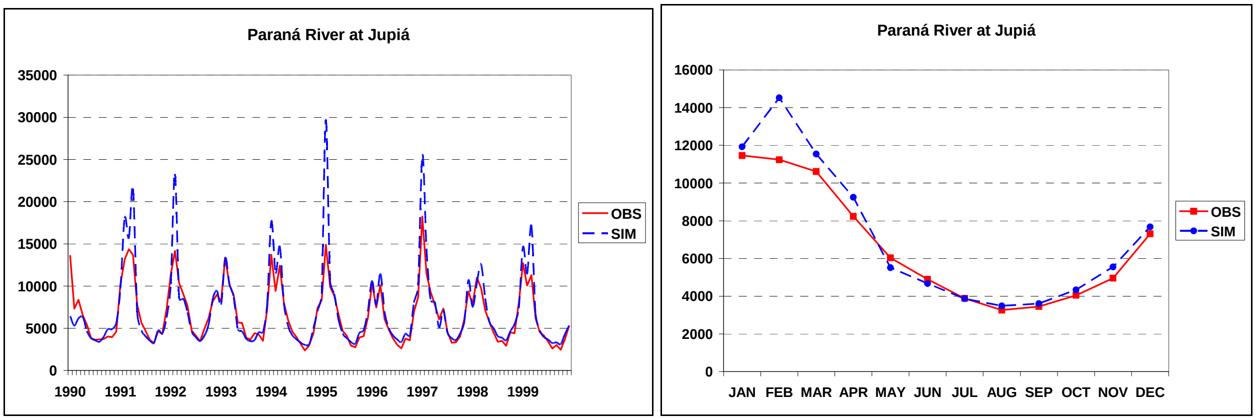

Figure 8. Simulated and observed streamflow, and monthly averages at Jupiá station at the Paraná River, as simulated by VIC.

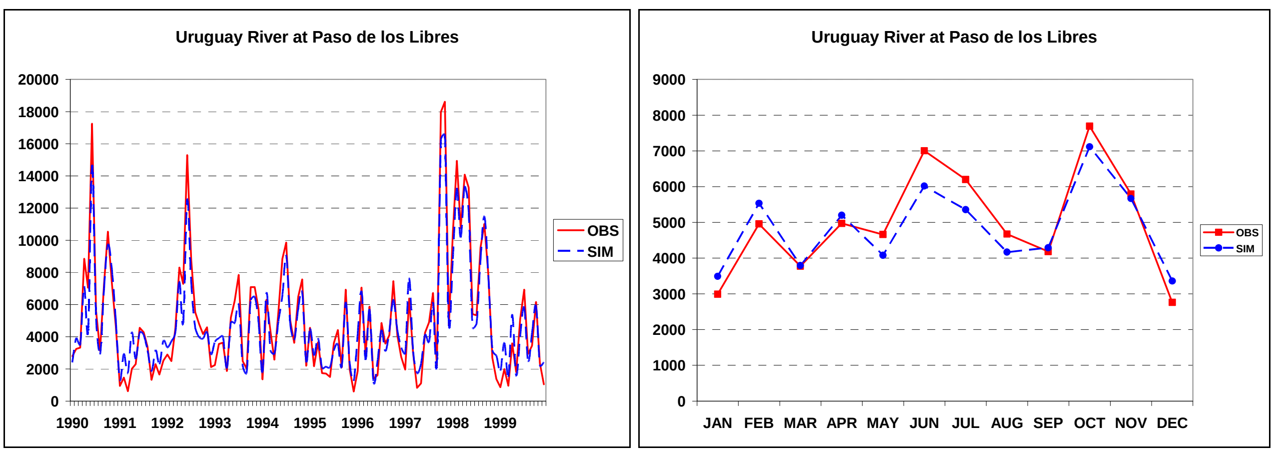

Figure 9. Simulated and observed streamflow, and monthly averages at the Paraná River in Paso de los Libres, as simulated by VIC.

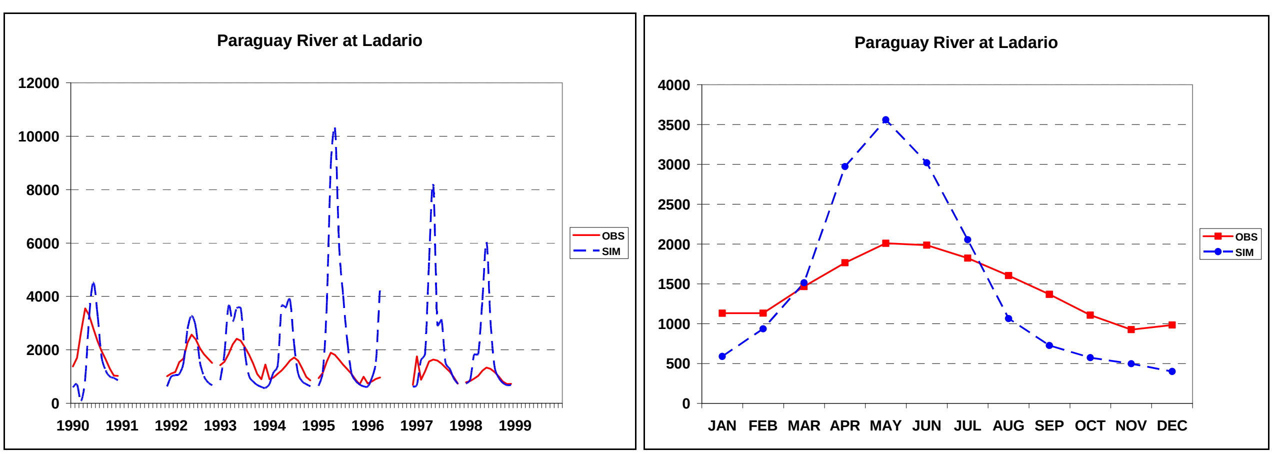

Figure 10. Simulated and observed streamflow, and monthly averages at the Paraguay River in Ladario, as simulated by VIC.