Modelling Streamflow under Different Land Use Conditions with SWAT: Preliminary Results from a Chilean Case Study

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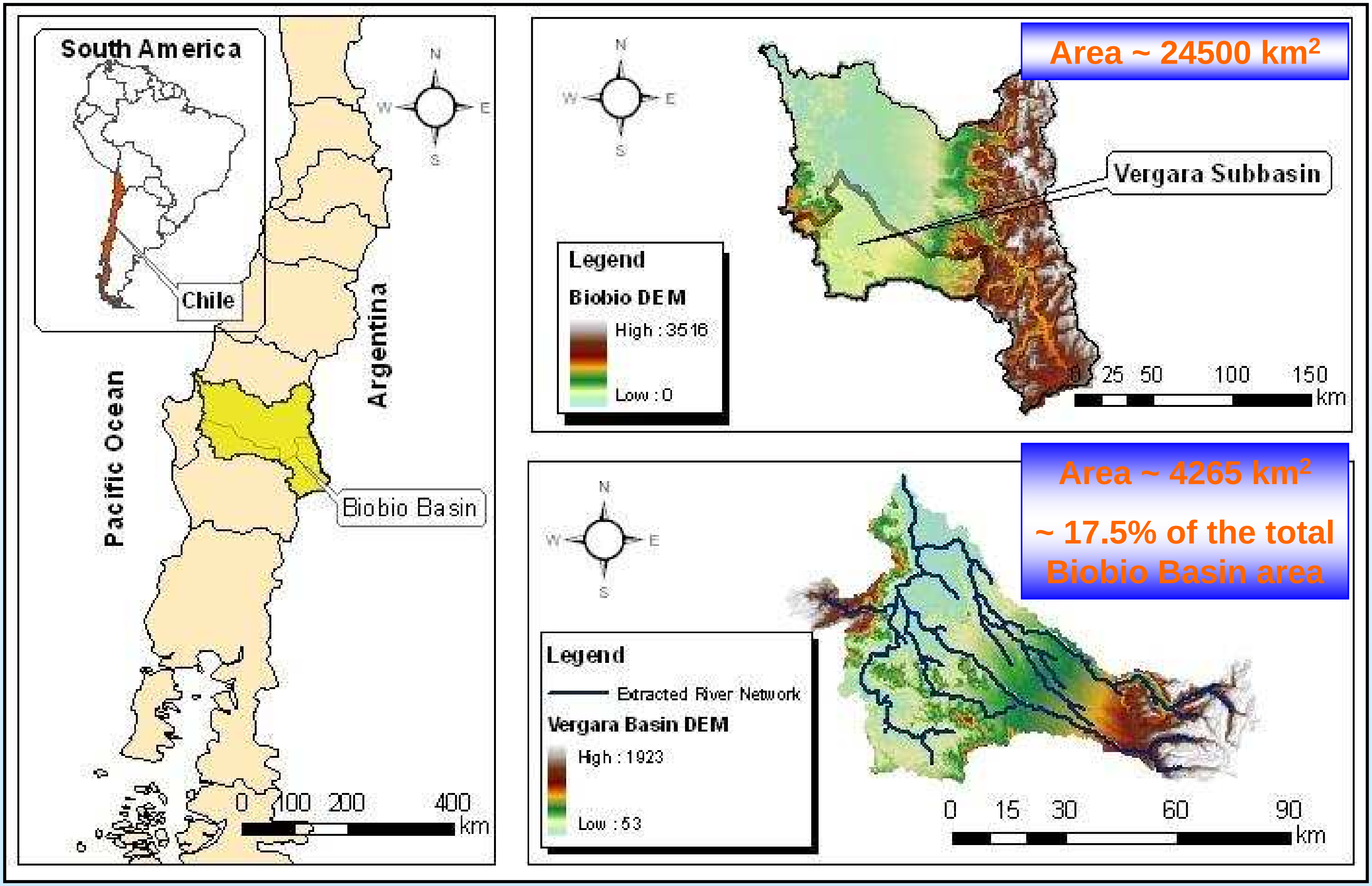
TOPICS

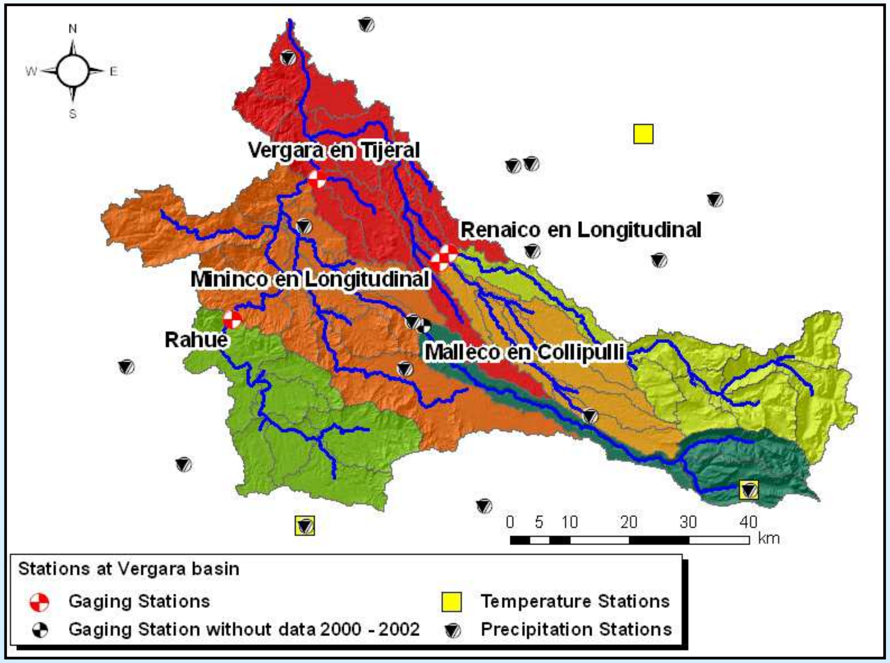
- Study Area
- Calibration and validation 1994 – 2002
  - ✓ Model set-up
  - ✓ Results
- Validation 1975 – 2002
- Model Sensitivity to land use changes
- Conclusions

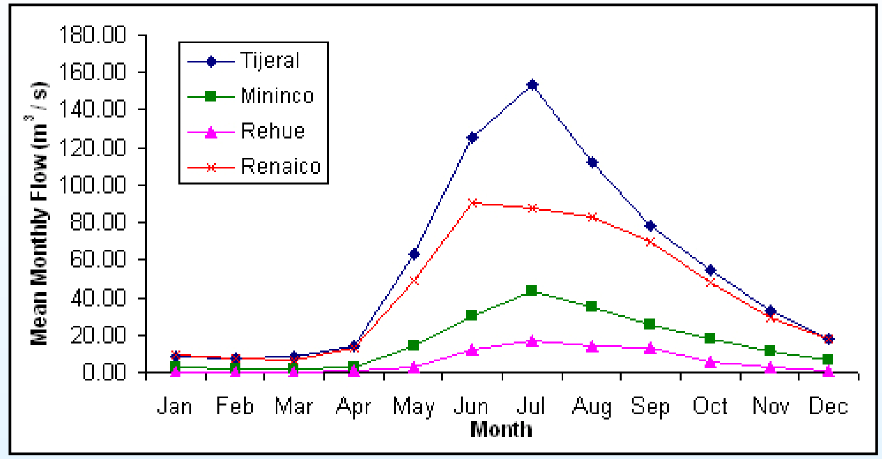
STUDY AREA


South America
Chile
Pacific Ocean
Argentina
Biobio Basin
0 100 200 400
km
N
W
E
S
Area ~ 24500 km²
Vergara Subbasin
Legend
Biobio DEM
High : 3516
Low : 0
0 25 50 100 150
km
Area ~ 4265 km²
~ 17.5% of the total Biobio Basin area
Legend
Extracted River Network
Vergara Basin DEM
High : 1923
Low : 53
0 15 30 60 90
km

Calibration and Validation 1994 - 2002

Meteorological and Flow Data



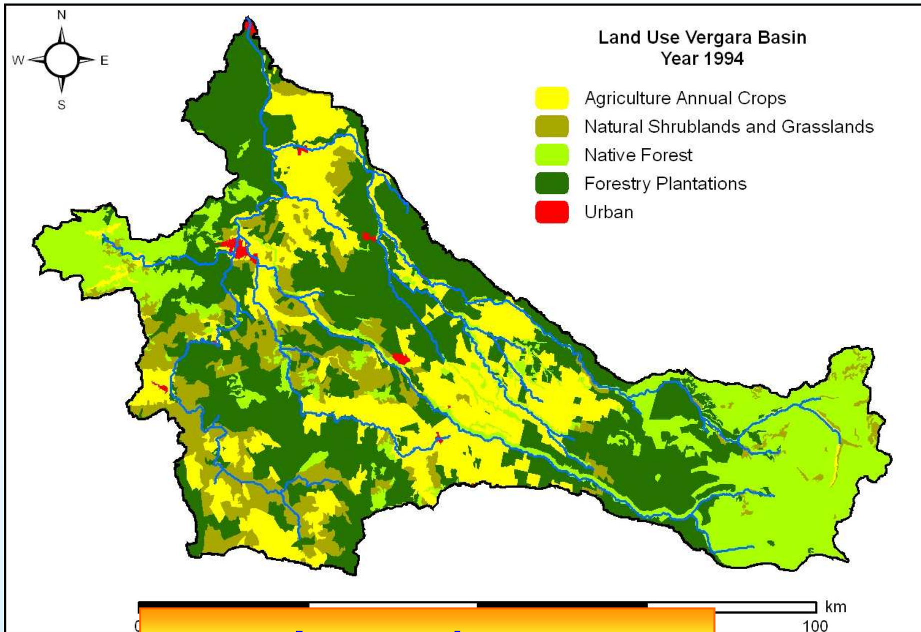


Percentage covered by each gaging station

Gaging Station	%	%
Tijeral	29.0	
Rehue	15.7	**54.2**
Malleco	9.5	
Mininco	10.3	
Renaico	16.0	
Total	**80.5**	

Calibration and Validation 1994 - 2002

Land Cover / Use & Soil Type

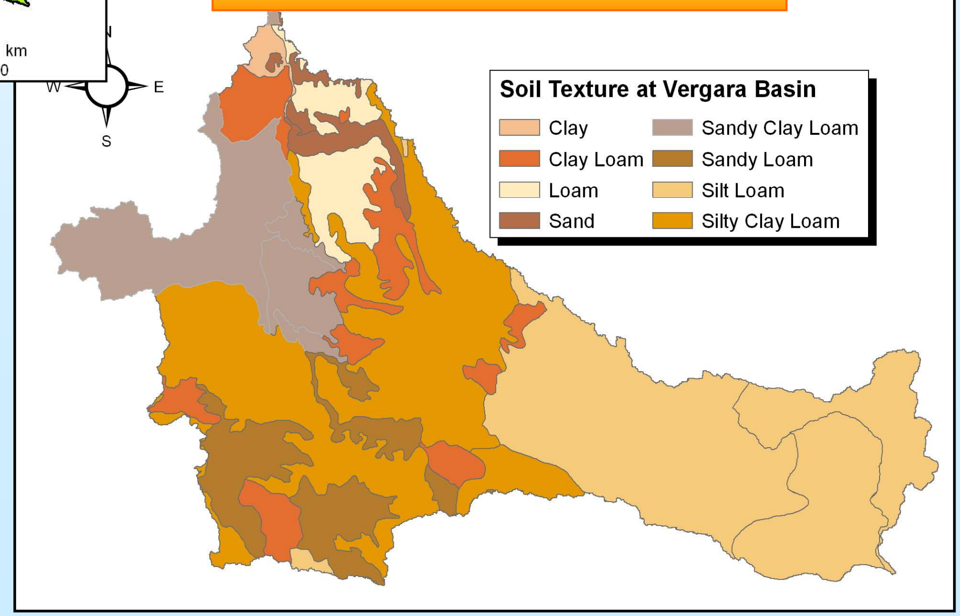


Land cover/use 1994

Land use/cover	%
Agriculture	21.1
Natural Shrubland and Grassland	12.8
Native Forest	23.4
Forestry Plantation	39.4

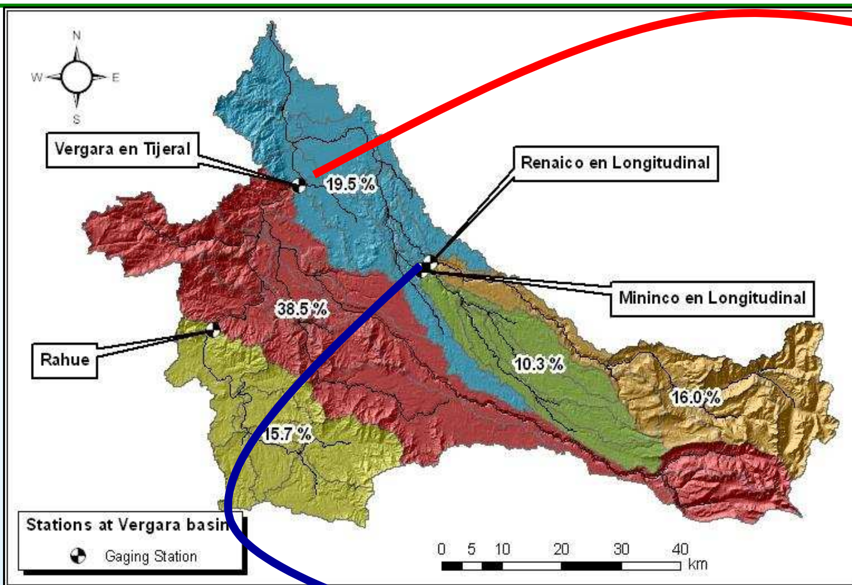
Soil Texture	%	S. T.	%
Clay Loam	8.80	Clay	0.71
Sandy Clay Loam	13.26	Sand	2.22
Sandy Loam	8.78	Loam	4.47
Silt Loam	33.01		
Silty Clay Loam	28.74		

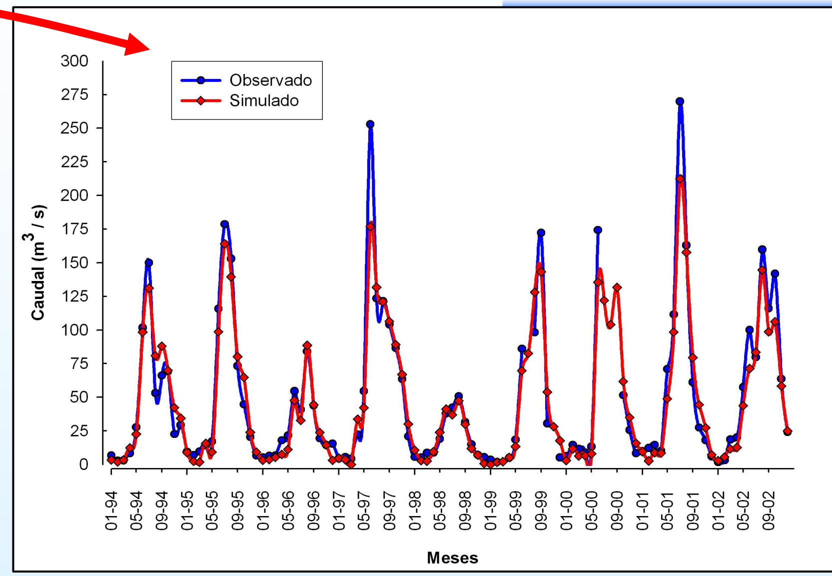
Soil texture

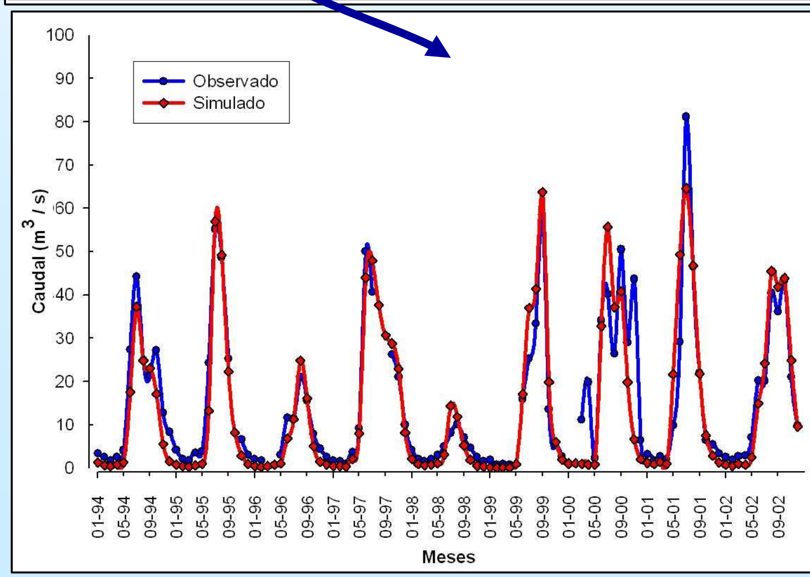


Calibration and Validation 1994 - 2002

Results







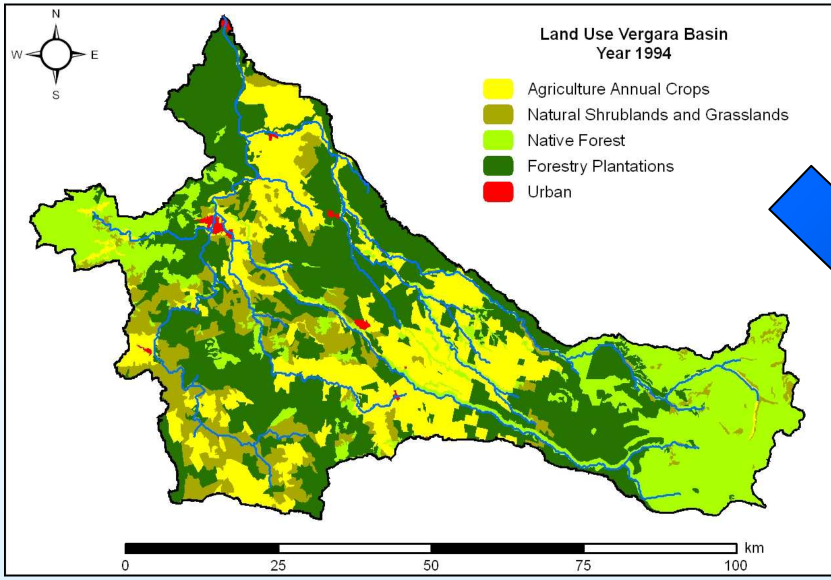
Monthly evaluation calibration / validation

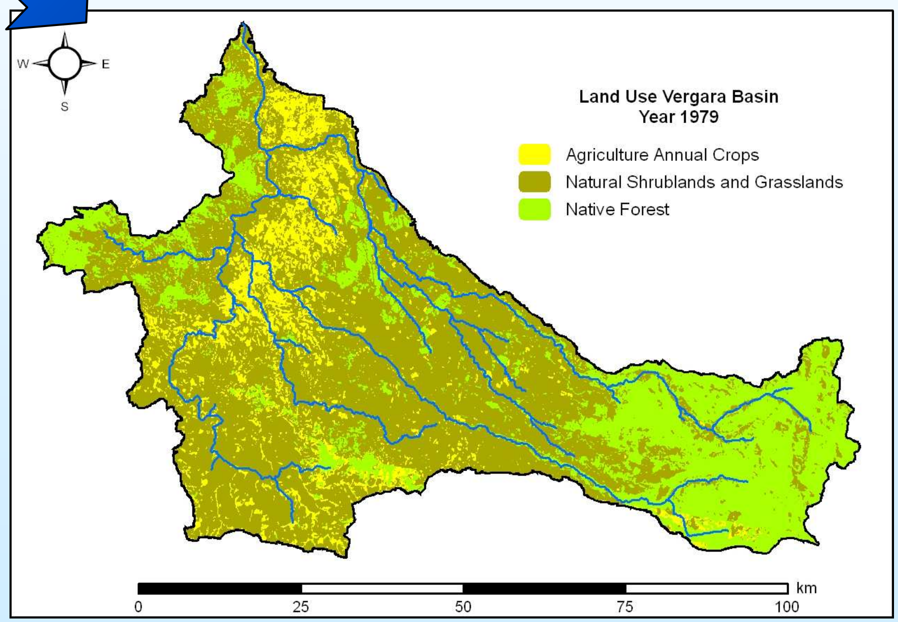
Indices	Nash-Sutcliffe	PBIAS
Tijeral	0.93 / 0.93	11.78 / 2.77
Rehue	0.82 / 0.75 *	21.35 / 32.75*
Mininco	0.72 / 0.92	8.32 / 9.13
Renaico	0.54 / 0.82	32.04 / 7.88

*Only considering data since July 1997

Validation 1975 - 1982

Land Cover / Use



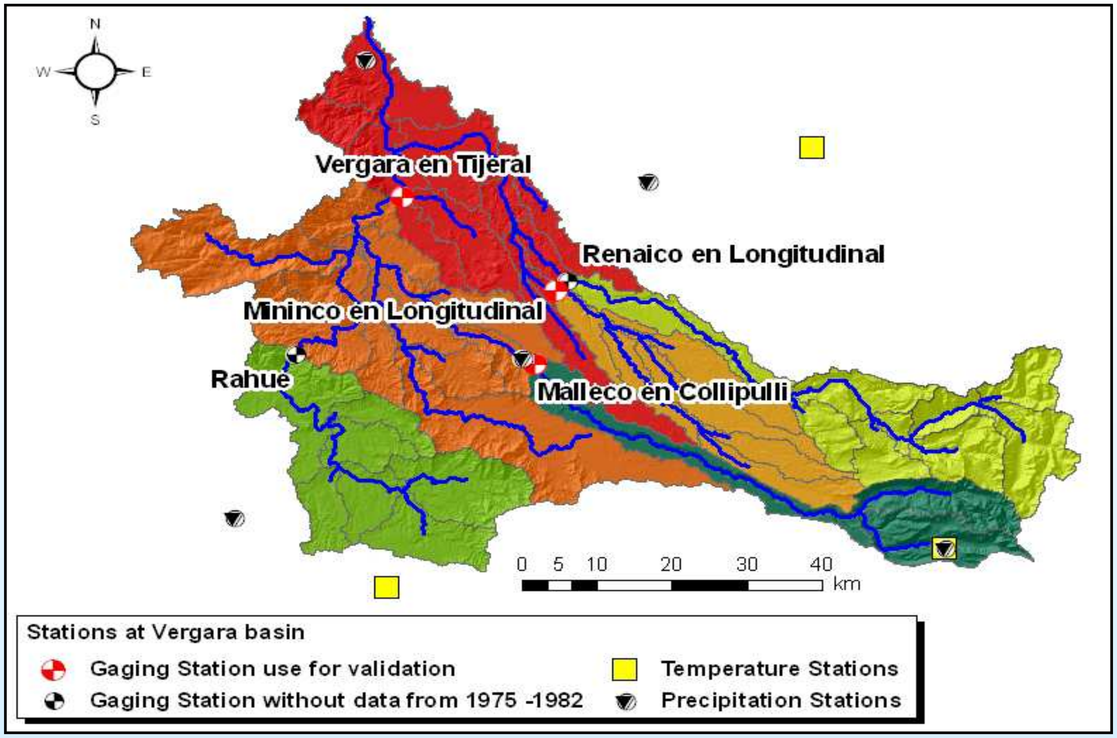


Change in land use/cover period: 1979 ⇒ 1994

Native Forest	↓	3%
Forest Plantation	↑	**39%**
Agriculture Land	↑	9%
Natural Shrub & Grassland	↓	**49%**

Validation 1975 - 1982

Meteorological and Flow Data

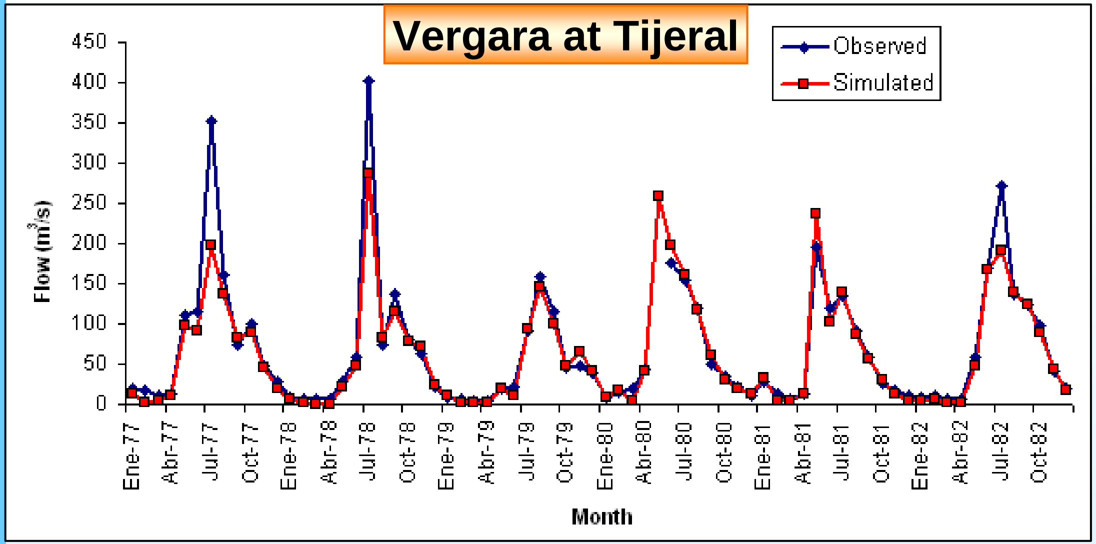


- 1994 – 1999 ⇒ Gaging station Malleco at Collipulli included
- 1975 – 1982 ⇒

  3 Gaging station use

- Calibration and Validation 1994 – 1999 ⇒ 16 Precipitation Station
- Validation 1994 – 1999 ⇒ 5 Precipitation Station
- Validation 1975 – 1982 ⇒ 5 Precipitation Station

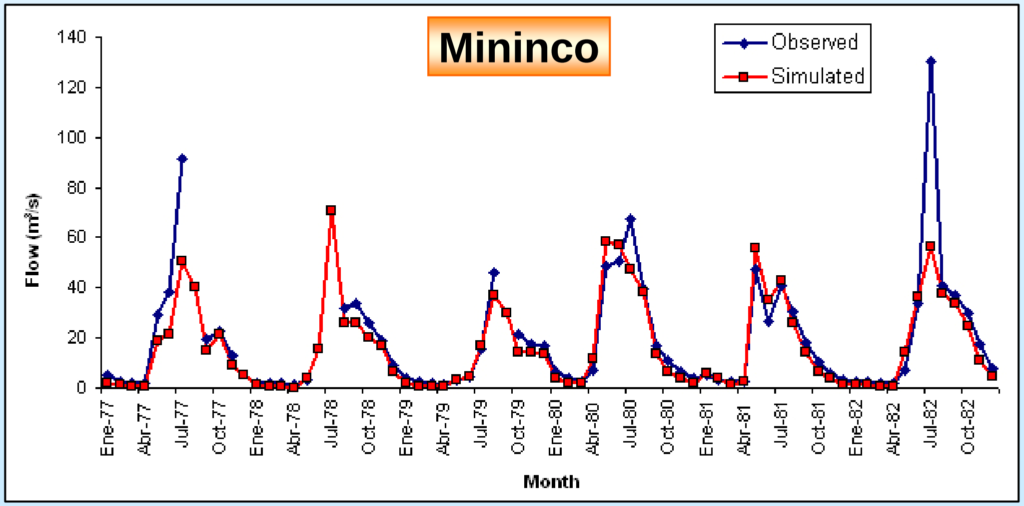
Validation 1975 - 1982



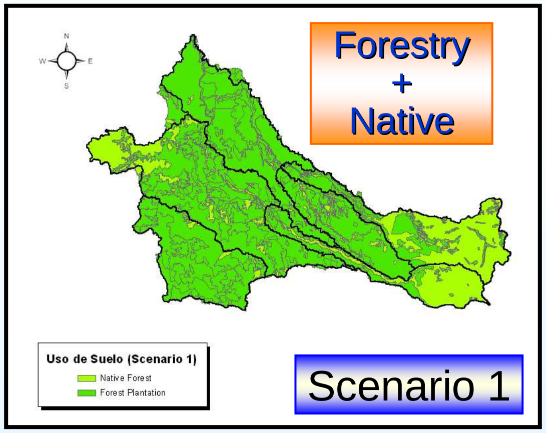
Model results using land use map from 1979 & precipitation / flow data from 1977-1982
+
Parameters calibrated/validated from the period 1994 -2002

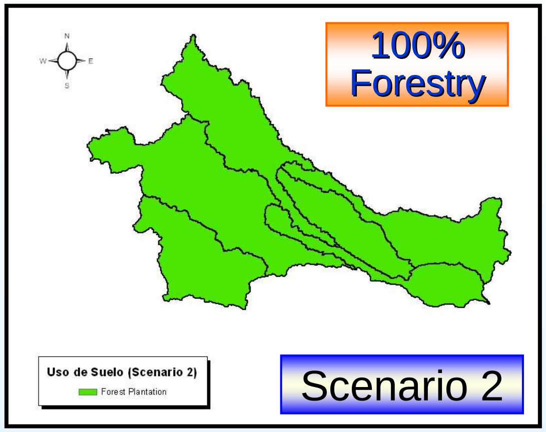
Nash Sutcliffe efficiency / PBIAS from the periods 1994 – 1999 (**1**) and 1979 – 1982 (**2**)

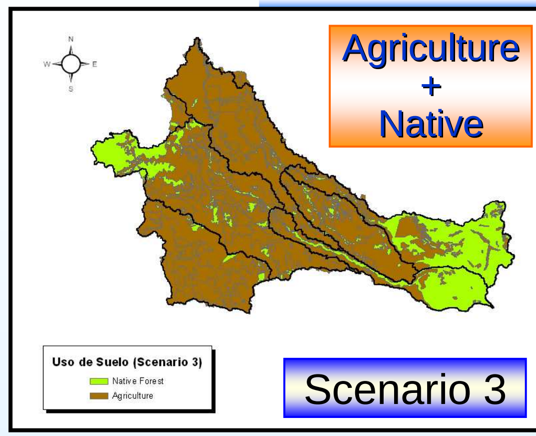
P	Index	Tijeral	Mininco	Malleco
1	EF	0.90	0.90	0.80
2		0.88	0.74	0.77
1	PBIAS	9.28	21.28	22.55
2		10.95	19.47	17.15

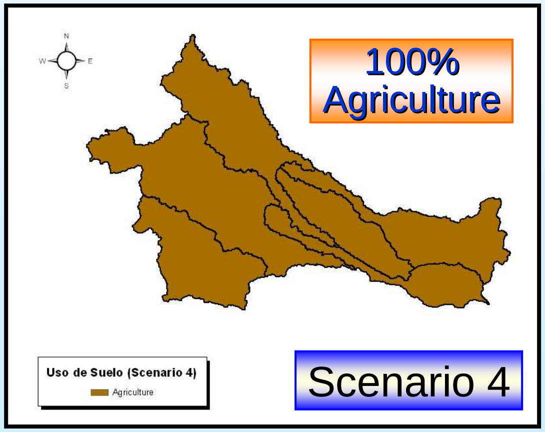


Model Sensitivity to Land Use/Cover





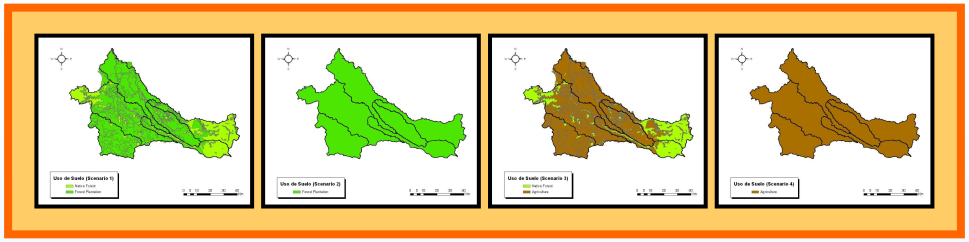


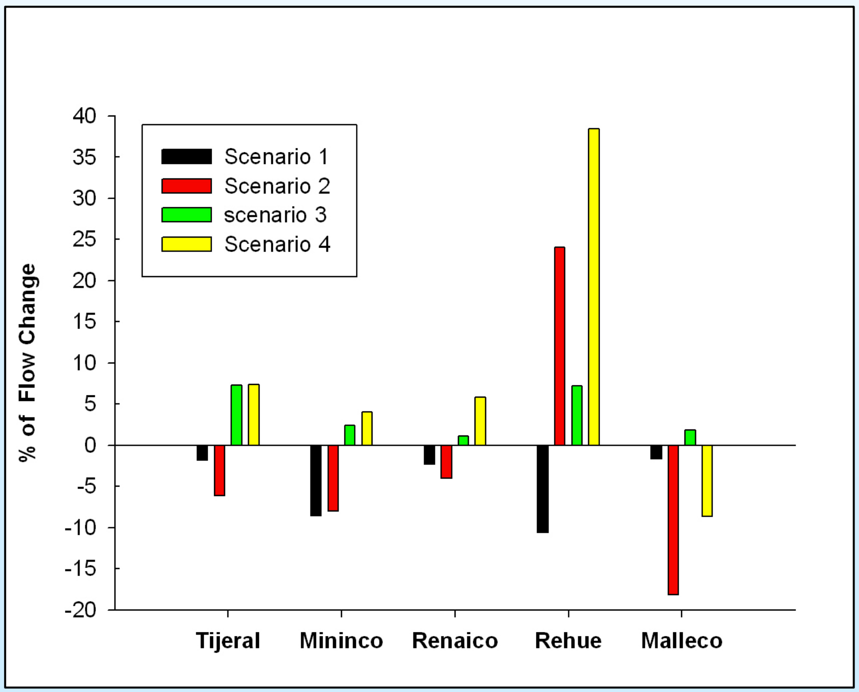


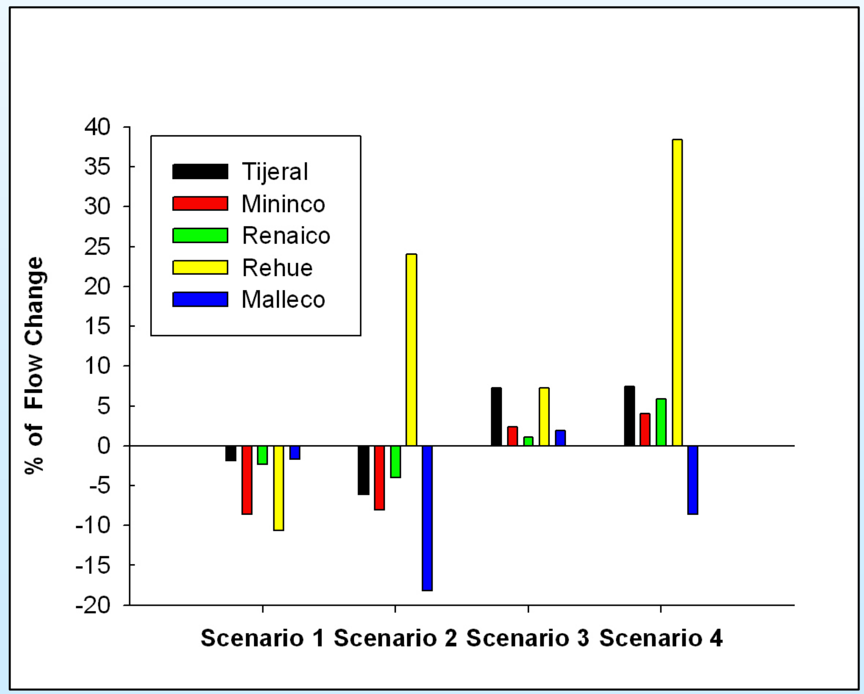
Percentages of the different land use classes at Vergara and its sub-basins, for the baseline scenario

	Basin	Tijeral	Mininco	Renaico	Rehue	Malleco
Rangeland	12.79	19.71	2.31	5.31	33.90	3.71
Native Forests	23.37	22.64	9.49	61.03	3.07	60.25
Forestry Plantations	39.44	35.99	49.07	23.95	40.45	23.81
Agriculture	21.11	20.92	39.12	6.48	22.22	11.89
Total sub-basin area [km^2]	***4.265***	***2.311***	***438***	***683***	***668***	***407***

Model Sensitivity to Land Use/Cover



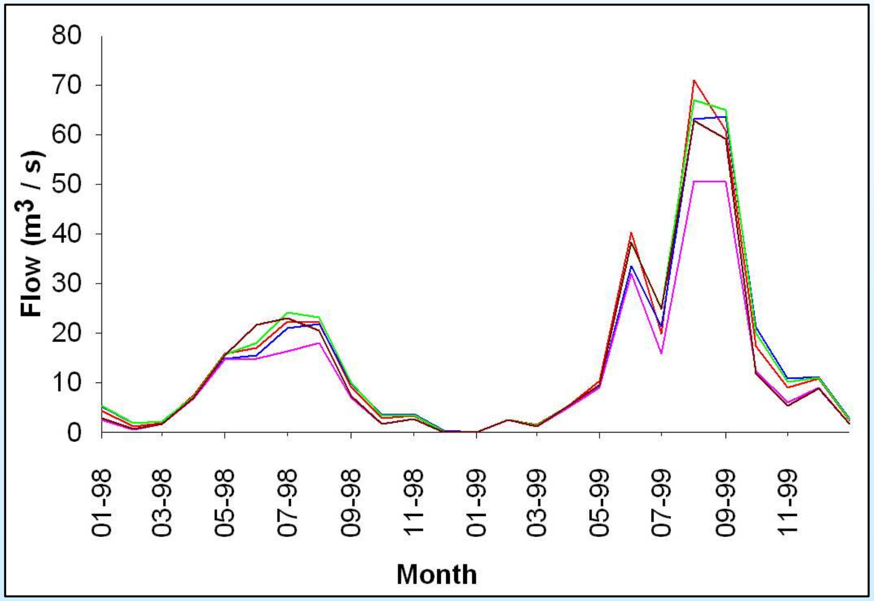




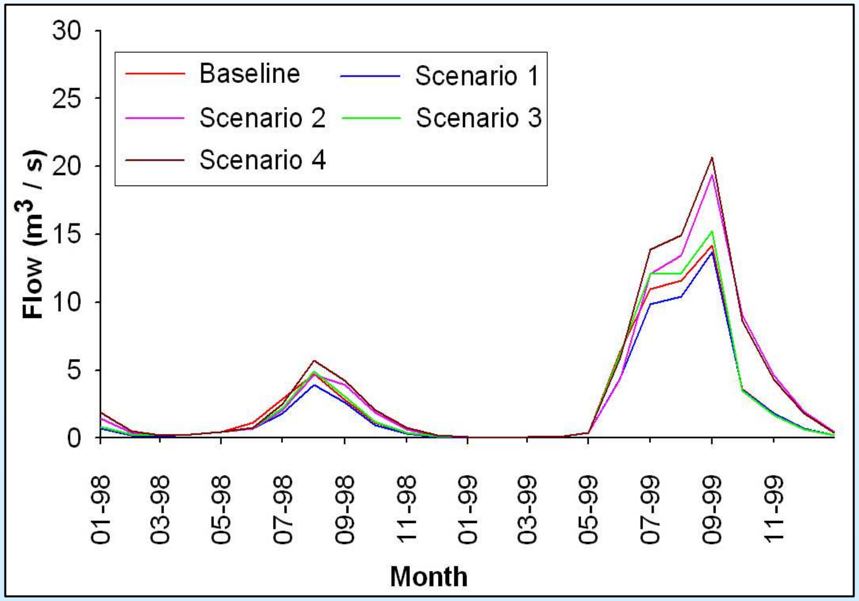
Model Sensitivity to Land Use/Cover

Monthly hydrographs for the different land use/cover scenarios for a two year period (1998-1999)

Vergara at Tijeral



Rehue



Model Sensitivity to Land Use/Cover

- Increasing the area covered by forestry plantations will in general produce a reduction of the mean annual flow.

- Increase of the of area under agriculture will produce a increase in mean annual flows.

- Mayor relative changes are expected to happen at Rehue sub-basin followed by Malleco sub-basin and Tijeral sub-basin (Rehue and Malleco are nested sub-basins of Tijeral).

- The conversion of all the basin in agriculture provoke the mayor relative changes

Conclusions

- The current model version successfully passed two validation exercises considering monthly outputs, in which 2 different land use conditions were considered (actual vs. past).
- However, further research is required in order to confirm the explanatory power of the model with respect to land use impacts on basin hydrology, considering daily outputs.
- The results shows in this study are an examination of the sensitivity of hydrology to a particular aspect of the ecosystem dynamics. This results only includes the response of the hydrology to changes in vegetation, to have more accurate results for plausible future scenarios changes precipitation and temperature must also be included.
- However, this is a first step which provides an approach into how hydrology responds to land use change and will be valuable when analyzing relations between land use change, climate and hydrology.

Acknowledgments

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