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Snowmelt mathematical simulation with different climatic scenarios in the Tupungato River basin, Mendoza, Argentina

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Abstract The impact of climate change on water resource availability in the Mendoza River oasis, Argentina where 1 000 000 inhabitants live and 80 000 ha of crops are irrigated was assessed. The snow coverage depletion curve was obtained from the NEVE model using Landsat-TM images for calibration. The possible evidence of climate change and its severity was analysed. The results obtained from the SRM model showed an important peak flow and runoff volume variation.
Key words Argentina; climate change; NEVE model; snowmelt; SRM model

INTRODUCTION

The area under study is the Tupungato River basin (1858 km^2, and 4251 m a.m.s.l. average elevation), a tributary of the Mendoza River in Argentina, located at 70°W and 33°S. The major source of streamflow is snowmelt that takes place between September and February with a negligible precipitation contribution. The objective of this study was to assess the influence of climatic change on the snowmelt-runoff process.

METHOD

NEVE (CaZorzi & Dalla Fontana, 1996) is a morpho-energetic model of apparent sun motion with a very simple distributed snowmelt rate algorithm. Input data (CaZorzi, 1999) are precipitation, temperature and spatial data obtained from a digital elevation model. Initial conditions are snow water equivalent (*SWE*) and a sequence of five energy index (*EI*) maps. The model outputs are a sequence of simulated *SWE* and cumulative snowmelt maps and numeric value files, at selected dates. In this study the combined melt factor (mm $°C^{-1}$ EI^{-1} h^{-1}) was identified by trial-and-error, and a comparison was drawn between observed (December 1997 and March 1998 Landsat-TM images) (Fig. 1(a)) and simulated snow covered area (*SCA*) maps (Fig. 1(b)).

The Snowmelt Runoff Model (SRM) (Martinec *et al.*, 1994) is a continuous simulation model that generates the snowmelt-runoff hydrograph with average daily flows calculated by a simple degree-day based algorithm. The temporal variations of *SCA* for the different elevation zones were determined by means of the NEVE model daily output (Fig. 2). The SRM parameters were calibrated using an average hydrological year (Fig. 3) (R^2 = 0.84) at Punta de Vacas (basin outlet gauge).

To study the possible evidence of climate change in the region in the last 30 years, the Mann-Kendall test was applied to some streamflow time series (Westmacott & Burn, 1997). Results showed a statistically significant increasing trend for α = 10%, whose magnitudes, using the Kendall slope estimator, are less than 0.50 $m^3 s^{-1} year^{-1}$.

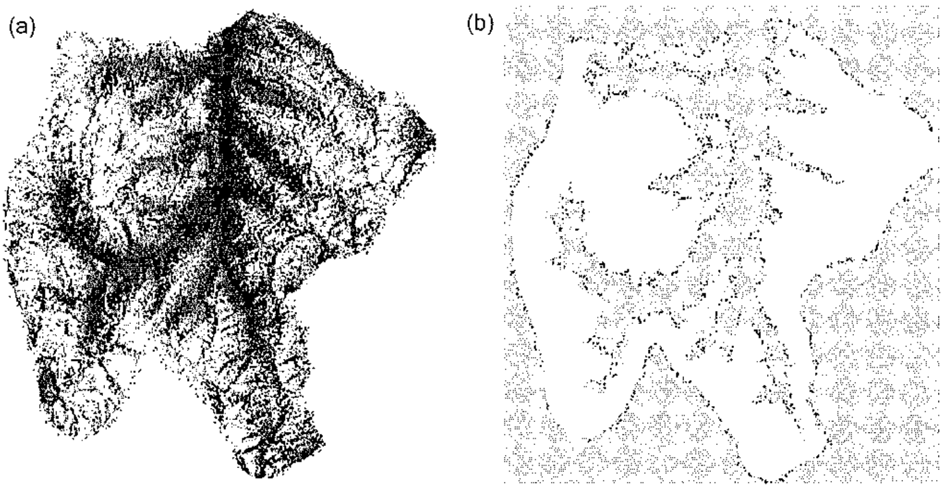

Fig. 1 (a) 15 December 1997 LANDSAT-TM image. (b) 15 December 1997 *SCA* map generated by the NEVE model

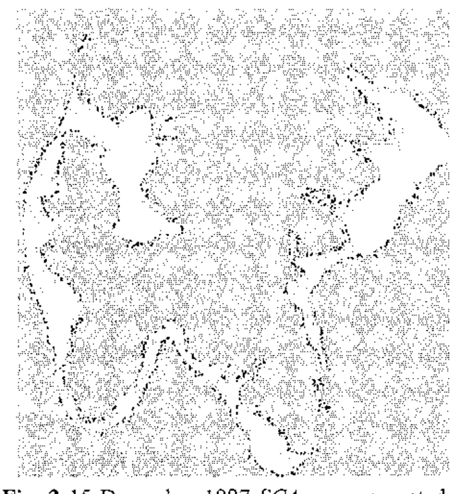

Fig. 2 15 December 1997 *SCA* map generated by NEVE of the zone above 4900 m a.m.s.l.

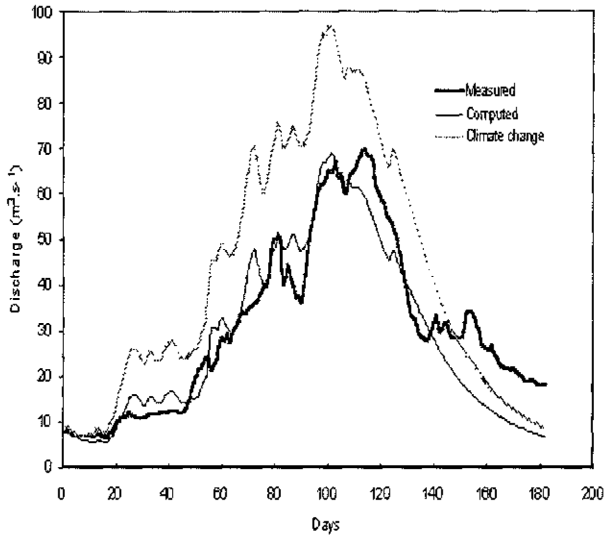

Fig. 3 1997–1998 measured, SRM calibrated hydrographs and computed hydrograph with $\Delta T = 1.4°C$ climate change hypothesis.

Mean monthly temperature changes, simulated with the HadCM2 model (Hadley Centre for Climate Prediction and Research, UK), were used without downscaling. Using a forcing scenario of greenhouse gases with a 1% annual growth in concentration, predicted values were taken into account to define an increase in temperature ($\Delta T < 2°C$) at Punta de Vacas in order to specify a climate change scenario for the 2010–2039 period.

CONCLUSIONS

NEVE output provides information needed by SRM on *SCA* evolution. SRM outputs with climate change scenarios ($\Delta T = 1.4°C$) showed an important peak flow and runoff volume increase (39%) when compared with the 1998 hydrological year (Fig. 3).

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