Entropy approach as a tool of discharge measurements in Algerian watersheds

L'approche entropique comme outil de mesure du débit dans les bassins versants algériens

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ABSTRACT

La surveillance des rivières est d'une importance capitale dans toute stratégie de gestion des bassins versants, cependant, la plupart du temps, le réseau de surveillance des rivières ne couvre pas l'ensemble du bassin versant, en particulier en ce qui concerne les stations de jaugeage où des données d'une précision acceptable sont requises, en particulier lors de fortes crues. Pour estimer le débit, l'approche entropique basée sur l'estimation d'un seul paramètre $\phi(M)$ a été testée pour le réseau de drainage d'une vaste région du centre et de l'est de l'Algérie. Le réseau couvre 1115 oueds avec une longueur totale de 14137 km. $\phi(M)$ représente le rapport entre la vitesse d'écoulement moyenne et maximale dans une section jaugée et il est donc très important si on pouvait mesurer le débit à partir de la seule mesure de la vitesse maximale. $\phi(M)$ est également liée à la rugosité Manning (Greco, 2014) et à la topographie du tronçon fluvial (Moramarco, 20218). Trois modèles différents ont été étudiés afin d'obtenir une cartographie de $\phi(M)$ utilisable le long du réseau de drainage, pour n'importe quel site fluvial : modèle régressif, modèle d'élévation et de pente et enfin le modèle NDEI (Index de différence Normalisée d'Entropie). Un ensemble de données de champs de vitesses de 50 stations jaugées dans plusieurs oueds impliquant 10 000 mesures a été utilisé pour l'analyse. 2/3 et 1/3 de l'ensemble de données des sites jaugés ont été pris en compte au hasard pour la calibration et la validation. L'étude des erreurs montre une bonne estimation de $\phi(M)$ par le modèle de régression et d'élévation et de pente.

MOTS CLES

Entropie, surveillance des rivière, Mesure des débits, Bassins versants nord Algérie

Abstract

River monitoring is of considerable importance in any watershed management strategy, however, most of the time the river monitoring network doesn't cover the entire watershed, especially concerning gauging stations where data with acceptable accuracy is demanded, particularly during high floods. Herein, to estimate the discharge rate, the entropy approach based on the estimate of a single parameter $\phi(M)$ was tested for the drainage network of a wide region of the central and east part of Algeria. The network covers 1115 Wadis (rivers) with total length is 14137 km. $\phi(M)$ represents the ratio between the mean and maximum flow velocity at a gauged site and it is of paramount importance to monitor discharge just starting from the measure of maximum velocity. It is also linked to the Manning roughness (Greco, 2014) and the topography of the river section (Moramarco,2010). Three different models were investigated in order to get a mapping of $\phi(M)$ usable along channels for any ungauged river sites: regressive model Slope elevation model and finally NDEI model (Normalized Difference Entropy Index). Velocity dataset of 50 gauged stations in several Wadis involving 10000 measurements were used for the analysis. 2/3 and 1/3 of the dataset of the gauged sites were randomly considered for calibration and validation. The errors study shows a good $\phi(M)$ estimation by regression and slope elevation model.

Key words:

Entropy, River monitoring, Discharges estimation, North Algerian watersheds

1. BRIEF THEORETICAL BACKGROUND

The entropy approach dates back to the work by Chiu (1987) and has been considered as an alternative to the classical techniques by describing the velocity profile according to a probabilistic approach which is free of hydrodynamic restriction and depends on the measurement of *u_{max}*:

$$u = \frac{u_{max}}{M}\ln\left[1+\left(e^{M}-1\right)\frac{\xi-\xi_0}{\xi_{max}-\xi_0}\right] \qquad (1)$$

.M is an intrinsic Entropic parameter that describes the hydraulics behavior of the river flow pattern.

$$\Phi(M)=\frac{u_m}{u_{max}}=\frac{e^M}{e^M-1}-\frac{1}{M} \qquad (2)$$

2. STUDY AREA

The study area involves the North center and West part of Algeria, including the main watersheds of North Algeria. Figure 1 illustrates the map of all watersheds.

Fig.1. Geographic localization of the study zone Fig.1. Geographic localization of the study zone

3. METHODS

In our case, the target is to relate the ϕ(M) parameter to some geomorphological parameters estimated from a DEM, such as river slope, river site elevation, channel width. The approach concerns regionalization through the channels network, the first of the three is a regressive model, based on the relationship between ϕ(M) and some geomorphological key parameters. The second one considers a relationship between ϕ(M) and topographical characteristics and the third one introduces the Normalized Difference Entropy Index, NDEI, and assesses its correlation with channel slope. Notably, CAL/VAL was conducted based on 36 gauged sites, randomly chosen, for calibration and 14 for validation.

4. RESULTS

Therefore, the correlated multilinear relationship between the basin parameters (drainage factor F_d and length of the longest watercourse L) and the entropy function was given by:

$$\Phi(M)=\frac{V_{mean}}{V_{max}}=0.6347-0.0000306\,L(km)+0.03587\,F_d \qquad (3)$$

For calibration, the mean error on ϕ(M) estimation was found around 4% and with a maximum error less than 10%.

The second model was developed considering also the channel bed slope, (i %), along with the altitude of each site, (Z), yielding:

$$\phi(M) = 0.5676 * i\left(\frac{i}{Z^{0.03}}\right)^{-0.992} \quad (4)$$

The third model was developed based on the NDEI (Normalized Difference Entropy Index):

$$NDEI = \frac{\Phi(M) - i}{\Phi(M) + i} \quad (5)$$

The regionalization consists to apply that developed models on the entire drainage network of the study zone. It gave the following maps:

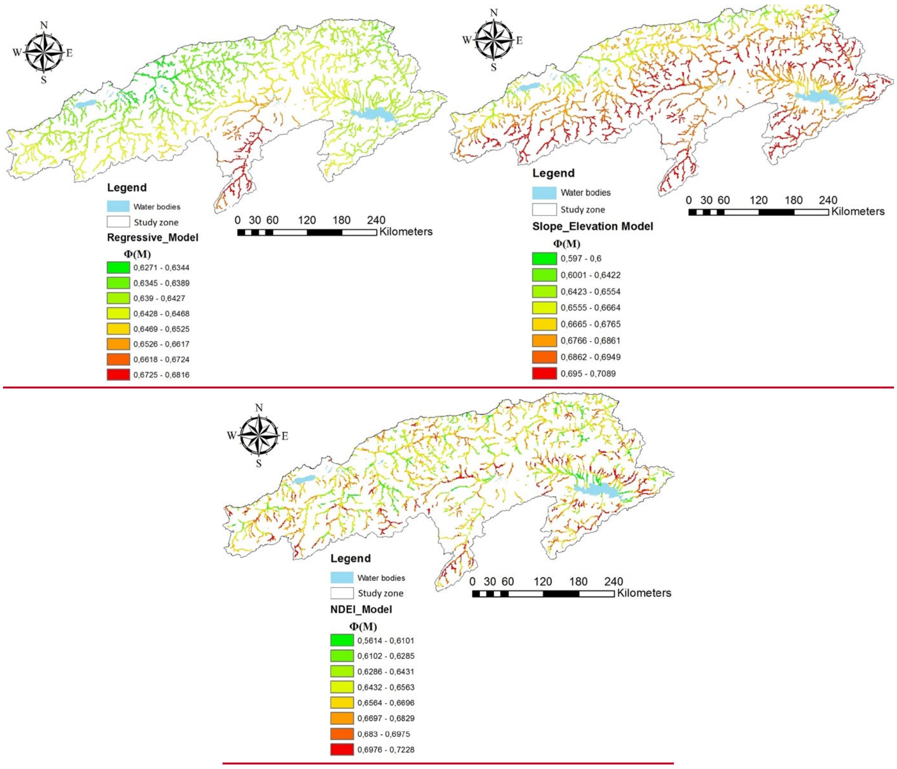

Figure 2. The kriging maps of the ϕ(M) models over the drainage network.

I the analysis of the ϕ(M) estimation errors resulting from the kriging maps chows that the mean values for regression, slope elevation and NDEI models are respectively: 4.18%, 5.81% and 5.28%, which is acceptable.

CONCLUSION:

The kriging models developed allow us to estimate the entropy function at any site of the drainage network with a mean error of 5% especially for the regression and slope elevation ones.

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