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Spatial variation patterns of drainage density within a basin as a key hydrological signature for river runoff regime

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The study investigates the hydrological effects related to the existence of an easy detectable morphologic signature, embedded in the patterns of systematic spatial variations of the drainage density *Dd* within different zones of the same catchment. It is shown how this feature - which is synthetically described by the value of the correlation between hillslope and channel lengths $\rho(L_h, L_c)$ - can heavily affect the concentration and dispersion of arrival times at an assigned outlet in a wide range of basin sizes, thus suggesting that it could be usefully employed in the search for a quantitative connection between river runoff regime and basin morphologic parameters (Di Lazzaro, 2008).

The analysis is carried out in the geomorphologic framework of the rescaled width function, according to which the Instantaneous Response Function (IRF) is completely determined once the distributions of hillslope and channel lengths in addition to flow velocities are assigned. Through this approach the effects of the existence of different zones with respectively high and low drainage densities are assessed. When *Dd* varies systematically within a basin, a significant correlation between hillslope and channel lengths arises. The sign of this correlation is related to the distribution of slopes within the basin, thus appearing to be influenced by typical morphologic signatures such as the presence of canyons or alluvial valleys. Correlation effects are of geomorphic nature. However they are emphasized by the difference between hillslope and channel velocities, thus the resulting variance-producing mechanism should be rather considered a kinematic effect (Saco and Kumar, 2004).

It is shown how basins with mountainous and steep channel heads followed by large flat areas located near the outlet generally are associated with negative values of correlation. In this case the variance of the travel time distribution is reduced, and these basins are consequently more prone to produce peaked flow hydrographs. On the contrary, when a flat upper plateau is followed by a narrow valley the correlation coefficient increases, since paths with short hillslopes correspond to short channel lengths.

Since the passage from narrow mountainous valleys to a flat alluvial valley is the typical case, negative values of correlation are more likely to occur, especially when the size of the basin is quite large (> 100 km^2). However, many exceptions to this typical behaviour were found.

Finally an analytical expression is proposed to investigate the size of the catchments whose hydrologic response can be considerably affected by the hillslope-channel correlation. A broad spectrum of basin sizes were found to be influenced by $\rho(L_h, L_c)$. In particular, basins with catchment area between 25 and 2000 km^2 are affected by the correlation for any velocity ratio. This result demonstrates that the $\rho(L_h, L_c)$ is important in basins where hillslopes and channels contributions are relevant, while it becomes negligible for completely hillslope or channel dominated basins.

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