

Spatiotemporal hydrological analysis

Abstract

Hydrological studies need an essential forward movement in the area of spatiotemporal modelling and data analysis. During the last years, there has been a significant increase in global spatial data available from different sources. This considerable amount of data is creating the need for a change in how to approach the spatiotemporal analyses of hydrological events (e.g., floods and droughts). Currently, ones often not consider the heterogeneity of the hydrological basins and the time dimension of the processes is also lacking. Hydrological requirements seem to fit clearly with the advances on hybrid data-driven, and physically-based models. This manuscript addresses the idea of spatiotemporal hydrological analysis by integrating the use of pattern recognition techniques and clustering and how this can be used for droughts and floods.

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Gerald A Corzo P, Vitali Diaz, Miguel Laverde

Integrated Water Systems and Governance, IHE Delft Institute for Water Education, Netherlands

Correspondence: Gerald A Corzo, Integrated Water Systems and Governance, IHE Delft Institute for Water Education, Netherlands, Email G.corzo@un-ihe.org

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Introduction

Many studies have developed the concept of hydrology in space and time showing the need for this type of studies.¹⁻⁷ However, few have explored the development of the interactions between the spatial and temporal characteristics of the studied hydrological variable, i.e., its extent, severity (intensity), duration. Traditionally, this multivariate characterisation is conducted by developing curves that integrates three features of the analysed hydrological component, for instance, the severity-area-duration (SAD) curves.⁸ Although these curves provide an overall overview of the hydrological phenomenon, the way in space-time characteristics develop and interact is not fully represented in these curves. When the data analysis is aggregated into statistical results, the hydrology often lacks of a clear framework of integration of characteristics, limitation and list of associated assumptions regarding the space and time.⁶⁻¹⁰ Although the accuracy or applicability of the different products to different locations around the globe is a matter of studies, in this manuscript the opinion refers only to the analysis component. As it has been presented in many studies, the conventional approach to simply evaluate spatial information, after making monthly, seasonal or annual information, is limited. In the space and time analysis, the whole study region may be seen as a matrix of three dimensions (i.e., longitude, latitude, time), which can be used to schematize the spatiotemporal information available from a hydrological variable as follows:

- Spatio-temporal analysis often is carried out by using hydrological time series (Figure 1). After characterising the hydrological events (e.g., floods, droughts), the spatial distribution is obtained by interpolation.
- In a given instant of time, the hydrological variable is analysed, and after, regions with similar behaviour are clustered (Figure 1).
- The proposed spatiotemporal approach makes use of two procedures (Figure 1).

One is the analysis of the total areas inside the region that are in the state of the event (above the threshold), and then average them with the total area. The event areas are added together without discriminated groups, so including all Non-Contiguous Areas (NCA). This result at each time step can be used to represent a percentage of area in event state.^{1-4,11-13} This method was applied to quantify an extreme global event that related to El NINO and La NINA years.¹

The second procedure defines clusters (groups of cells) that can be linked (connected) into objects in three dimensions. These clusters in two or three dimensions (i.e., longitude, latitude, time) are calculated by using the algorithm called Connected Component Labelling.¹⁴ Characteristics of the events and how they grow as objects can be studied. This concept is relatively new, and only a few studies have applied it.^{1,3,11,15}

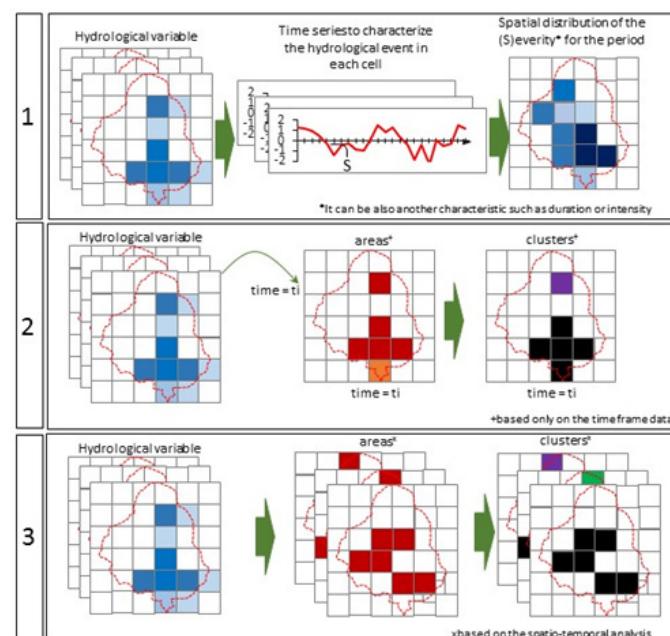


Figure 1 Spatiotemporal analysis approaches.

Conclusion

The current trend of hydrology has an important area of opportunity in the spatiotemporal interpretation of its hydrological processes. Areas of important development are the inter-process scales interactions that occur in the hydrological events and the multivariable characterisation of event features, which relates to the location and time. This inter-process scales are interpreted here as the difference in the spatial scales of processes in hydrology as well as the time scale of the process. The spatial information, now supplied mainly by remote sensing and global hydrological models, requires a further development of how to approach the spatiotemporal analysis

of hydrological events. These problems require the implementation of more time-dependent analysis.

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Conflict of interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter discussed in this manuscript.

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