GEO-PUMMA: représentation des paysages urbains et périurbains pour les modèles hydrologiques distribués

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Introduction and Objectives

Geo-PUMMA is a GIS toolbox to represent the terrain used in distributed hydrological modeling in urban and peri-urban areas, which preserves the hydrological connectivity and extracts a realistic drainage network.

Geo-PUMMA uses a vectorial approach that generates a polygon mesh composed of physiographic units. Urban areas are represented using Urban Hydrological Elements (UHE) (Rodriguez et al., 2008). Rural and peri-urban areas are depicted using Hydrological Response Units (HRU) (Flügel, 1995).

Geo-PUMMA improves the numerical stability of hydrological models as it considers several segmentation processes to address the following issues in mesh representation: thin units, elements extremely non-convex, too large elements and homogeneous properties within an HRU (slope, aspect, etc.).

Study site, available data

The Mercier sub-catchment, France (7 km², 10% urban) is covered with forests and crops. The peri-urban basin Estero El Guindo, Chile (6.5 km², 50% urban) is covered by native vegetation (Figure 2).

3 Geo-PUMMA

The proposed methodology has four steps. Step 1 (A): data collection, digitalization and quality improvement of all the maps (Figure 3) was developed using ArcGIS. The initial mesh (without applying the recommended mesh defined in section 3.2) was based on Smallfoot (Sanzana et al., 2011) using the recommended mesh defined in section 3.2 (PUMMA: Urban and peri-urban Hydrological Connectivity).

3.1 Step A: data collection, digitalization and quality improvement of all maps (Figure 3)

3.2 Step B: extraction of the hydrological connectivity between the different units, using a recursive algorithm for identifying surface flow directions.

3.3 Step C: drainage network is composed of channelized and non-channelized elements.

3.4 Step D: drainage network is represented using a two-meter resolution boolean grid (Lidar). The Shuttle Radar Topography Mission (SRTM) data was used for the 30-m resolution bathymetry.

Figure 4 - Step B: UHE → Step B: HRU → Step B: Hydrological Connectivity

4 Results

Evaluation of the mesh improvement using the width and channel lengths and spectral analysis (Figure 8).

• Improvement visible at the largest distance from the outlet where initial mesh is coarser.

• Nash value (NS) between the reference mesh and the others is larger for the width function than for the area function.

• Cross Spectral Analysis (CPDS): shows improvement from 120 m to 60 m for CPDS of W(x) and from 150 m to 100 m for CPDS of A(x) (vertical bars in Figures 8 and 9).

Illustration of the improvement led by the Geo-PUMMA vectorial approach, as compared to standard raster approaches (HRU Delin derived from Grass-HRU, Schwartz, 2008).

• Necessarily to use high resolution (~2 m) cell size and minimum area threshold of 10 m² with the raster approach.

• Large number of HRUs (more than 30,000 units) as compared to about 2400 for Geo-PUMMA.

But some less-useful features such as streets and irregular boundaries between lots are lost. (Figure 9)

5 Conclusions

Geo-PUMMA was successfully used in the Mercier and El Guindo catchment.

This toolbox allows getting the drainage network from a polygonal mesh, with a novel approach that extracts the hydrological connectivity from a terrain represented only by HRUs and UHEs, considering elements, such as channels and vegetation, that are not treated in other approaches. Geo-PUMMA improves numerical stability of hydrological models as it considers several segmentation processes to address the following issues in mesh representation: thin units, elements extremely non-convex, too large elements and homogeneous properties within an HRU (slope, aspect, etc.).

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