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

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GEO-PUMMA: Urban and periurban landscape representation for distributed hydrological modelling

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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 (Figure 2).
- The urban basin Ester El Guindo, Chile (6.5 km², 50% urban) is covered by native vegetation (Figure 2).

Figure 1 - Polygonal Mesh composed of HRUs and UHEs

The initial HRUs were obtained using:
- Land use map (Jacqueminet et al., 2011; Guzman 2014)
- Pedology map (SRA, 2011; DGA-AC, 2000)
- Geology map (BIRMG, 2011; DGA-AC, 2000)
- Subcatchments (Jankowfsky et al., 2013; Sanzana et al., 2015)
- Ditch network (Jankowfsky et al., 2011; DHO-EIC, 2004)
- DEM (U3R, 2 m; Sanzana, 2012) and contour lines (1 500, 2 m; DHO-EIC, 2004).

Figure 2 - Catchments Mercier (a) and El Guindo (b)

Results

- Sensitivity of the drainage network to various options in Geo-PUMMA (Figure 7): illustration for the El Guindo catchment.
- Three meshes presented: the recommended mesh defined in section 3 (2057 HRUs).
- The initial mesh (without applying STEP B on HRUs) (2016 HRUs).
- A reference mesh (with high values of geometric criteria) and large number of elements (2745 HRUs).

Figure 7. Initial, Reference and Recommended Mesh for El Guindo (a). Drainage Network from Initial (b), Recommended (c) and Reference (d) Mesh for Mercer.

Figure 8. (a) With Function, W(x), and (b) Area-Function, A(x), of three meshes of El Guindo. In both drainage networks came from initial mesh (segmented gray line), recommended mesh (red) and reference (black). (c) CPSD of With-Function and (d) CPSD of Area-Function of El Guindo. In both cases, comparing reference vs reference (PyO0, black line), reference vs initial (PyO1, grey segmented line) and reference vs recommended (PyO2, red line).

Evaluation of the mesh improvement using the width and polygonal functions and spectral analysis (Figure 8).

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 loss features such as streets and irregular boundaries between lots are lost. (Figure 9)

Figure 9. Middle: HRU generation by HRU-DELIN (raster approach). Zooms comparing HRU-DELIN (raster) and Geo-PUMMA (vectorial approach).

Conclusions

- Geo-PUMMA was successfully tested 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 elements, considering different hydrological infrastructures present in the urban and peri-urban catchment.
- Hydrological features are not limited by a cell size.
- The recommended mesh allows preserving the physiographic units and improving the drainage representation without increasing significantly the final number of elements.

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