Supplemental Material

1. Coupling low-resolution HEC-RAS with cGAN-Flood

The overall steps for predicting high-resolution flood maps with a coarse HEC-RAS model (mesh-based) are highlighted in Figure 1a. Breaklines are integrated to capture the specific stormwater channels and transportation infrastructure features. The incorporation of breaklines for the channels serves a dual purpose. Firstly, they reduce the cell size and align cell faces along the channel more accurately, thereby improving the representation of the channel's characteristics and flow dynamics. Breaklines for transportation infrastructure are inserted to depict the elevation of streets along the cell faces, generally indicating high landforms and water dividers. However, it's important to note that the coarse resolution of the cells can often lead to inaccurate representation of these elevated areas. Consequently, the model may not properly recognize these as barriers to water flow, leading to water being erroneously modeled as "leaking" through these cells. This misrepresentation reduces the flow path incorrectly, impacting the flow dynamics representation. Furthermore, it inaccurately decreases the total volume to be distributed (v_t), which may lead to underestimation of flood extents and depths. Although enforcing breaklines reduces the average cell size of the mesh and increases computational time, our previous investigations showed that they were essential for estimating v_t.

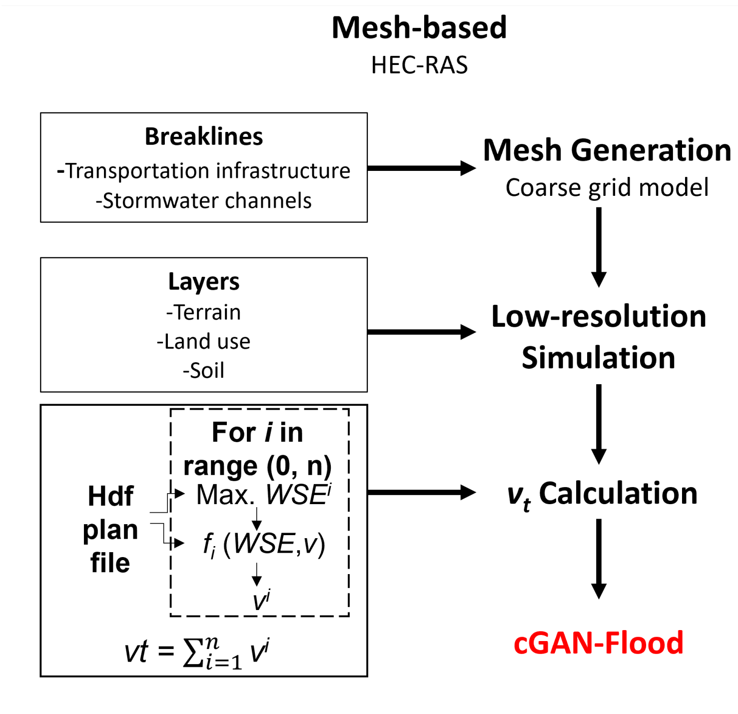

Figure S1: Flowchart depicting how HEC-RAS model is set up and coupled with cGAN-Flood

Terrain, land use, and infiltration layers were also used in our HEC-RAS simulations. The terrain layer is essential for computing elevation versus volume for each cell and generating hydraulic properties tables for their faces Brunner (2016). These hydraulic properties tie in the elevation of every cell face with corresponding variables such as area, wetted perimeter, and roughness. The land-use layer furnishes the model with critical information, including roughness values and the proportion of impervious area. This data is essential for accurately estimating the frictional resistance to flow and understanding the percentage of the area where water infiltration into the ground is minimal or non-existent. Conversely, the soil or infiltration layer imparts parameters related to the rate and extent of water infiltration into the ground. It is a critical element in modeling the portion of the rainfall that will contribute to the runoff and the portion that will infiltrate into the soil, significantly influencing the simulated flood's volume and timing.

cGAN-Flood is a tool capable of enhancing the resolution of coarse flood maps by redistributing a predetermined flood volume. This volume for being redistributed is calculated after the hydraulic simulation is concluded. However, deriving these flood volumes directly from the output depth maps of HEC-RAS presents a challenge. The HEC-RAS model operates on a mesh-based system with cells that vary in shape and size, with each cell potentially containing multiple raster pixels. The model calculates depths by interpolating each cell face's computed water surface elevation and subtracting it from the terrain elevation. While HEC-RAS does not include a feature for generating volume outputs for individual cells, a workaround is available through the plan HDF file, allowing maximum volumes to be computed. The model calculates and stores each cell's Water Surface Elevation (WSE) during each simulated timestep. This data, accessible via the plan HDF file, also includes an elevation-volume curve for each cell. Consequently, each cell's volume (v) can be approximated from the elevation-volume curve given a specific WSE. The sum of the maximum volume in each of the n cells of a given domain is the v_t to be redistributed with cGAN-Flood.

2. Coupling low-resolution Hydropol2D with cGAN-Flood

Unlikely mesh-based model, which computes flow dynamics across cells according to the hydraulic properties calculated with terrain, land use, and soil layers, raster-based models compute water balance and calculate mass exchange in each pixel of the input rasters. This study used Hydropol2D (Gomes Jr et al., 2023) as a raster-based model for calculating v_t.

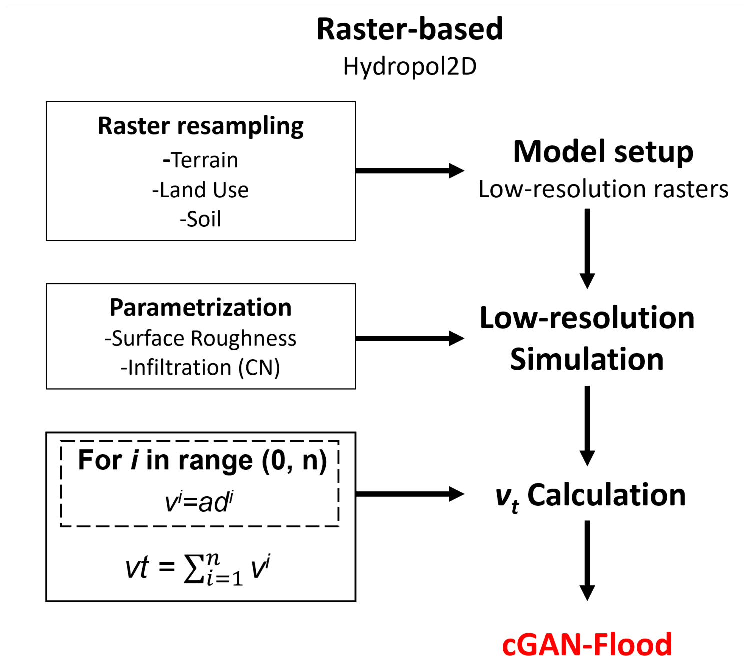

Figure S2: Flowchart describing how Hydropol2D was used to compute v_t and coupled with cGAN-Flood

The input data for the Hydropol2D simulations comprise terrain, land use, and soil raster datasets. The parameters within Hydropol2D are configured independently to link surface roughness and infiltration properties with pixel values corresponding to various land uses and soil types. All input rasters must maintain the same cell size and identical quantities of rows and columns. These rasters were downsampled for the low-resolution simulations conducted with Hydropol2D, effectively reducing the number of cells and the number of computational calculus. This downsampling process has the additional benefit of decreasing the Courant number, thereby allowing for larger time steps and expedited simulations. However, the terrain's hydraulic properties, especially the channels, can be lost after reducing the terrain resolution. As such, the terrain was treated with smoothening (Schwanghart and Scherler, 2017) and burning (De Paiva et al., 2013).

As raster-based models compute water balance between pixels directly, the volume in each cell can be calculated directly from the output depth map. The volume in each cell (v) is calculated by multiplying the water depth in that particular cell (d) by its area (pixel resolution squared). Therefore, the v_t to be redistributed with cGAN-Flood is the sum of the flood volume of all n cells within the area of interest.

References

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