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Using flood-excess volume to assess and communicate flood-mitigation schemes

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We outline a straightforward and creative methodology that offers both (i) a complementary diagnostic for classifying flood events (from gauge data and/or simulations) and (ii) a protocol to optimise the assessment of flood-mitigation measures via concise cost-effectiveness analyses. It is based on the concept of flood-excess volume (FEV), namely the volume of water exceeding a threshold and generating flood damage, and is exemplified for recent extreme-flood events in the UK and France. We are motivated by, and address herein, the following questions: (i) how can we express FEV (which is typically many million cubic metres) in a comprehensible way? and; (ii) what fraction of FEV is reduced, and at what cost, by a particular flood-mitigation measure? Our methodology allows direct comparison of the technical efficacy of a suite of measures, typically nature-based (e.g., tree planting, flow-attenuation features) or civil engineering-based (e.g., flood-storage basins, walls), that constitute a catchment- or city-wide flood-alleviation scheme. Quantification and interpretation of the schemes is facilitated using a novel visualisation of flood-alleviation basins as partially filled, 2m-deep square 'flood-excess' lakes with the same capacity as the FEV. The size of the lakes, typically with side-lengths of circa 1-2km, conveys the magnitude of the flood and places it in context of the geography of the river valley concerned.

We introduce the proposed concept with analysis of an extreme flood event of the River Aire in Yorkshire, UK, and interpretation of several competing hypothetical flood-alleviation schemes for the city of Leeds. Our method illuminates the contribution and cost-effectiveness of several scenarios involving combinations of storage basins and flood-walls. Two further 2015 floods — the River Calder in Mytholmroyd (Yorkshire, UK) and the River Brague in Biot (Alpes-Maritimes, France) — are analysed with respect to exploratory flood-alleviation schemes. Each scheme has different flood-mitigation measures: flow-attenuation features, tree planting and peat restoration, and reservoir storage (Calder), and; retention measures, flood-walls, and bed-widening (Brague). We show that major upscaling of so-called leaky dams can have a significant impact in the Calder catchment, but the most effective contribution to reduce the FEV comes from the draw-down and control of drinkwater reservoirs. For the Brague, bed-widening leads to a major and cost-effective reduction in the FEV and lowers the need for high flood-defence walls.

The results for all three cases are presented in a novel self-consistent graphical ensemble, thereby enabling flood-practitioners and policy makers to assess and choose between flood-mitigation measures in a direct and visual manner, and hence offering better prospects of being understood by both the general public and city-council planning departments. We stress that our approach is a complementary method, to be used either prior to, or in tandem with, more detailed hydrodynamic modelling of river flows, and it offers great potential to assist with and to encourage evidence-based decision-making.