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## Monthly flood frequency regionalization for comprehensive flood damage assessment to crops

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Quantitative flood risk assessments rely on damage models, which relate information on flood hazard and vulnerability of exposed assets to estimate expected losses. Differently from other sectors, crop damage depends not only on typical hazards variables (including water depth, flow velocity, inundation duration, water salinity, yield of sediments and/or contaminants) but also on the month of flood occurrence. Indeed, plant vulnerability changes over the different phenological phases that are strictly related to the seasonality of crop production. Considering the time of occurrence of the flood would imply a shift from the traditional representation of inundation scenarios based on annual probability to monthly-based hazard estimations. When risk assessment is carried out at large spatial scale, a detailed understanding of seasonal flood patterns is then required for the different sub-catchments of the basins, including un-gauged ones. In this study we present a clustering approach to flood frequency regionalization applied to the Po River District in Northern Italy, within the risk assessment process required by the European Floods Directive. The area is characterized by complex climatic and topographic conditions, highlighting the representativeness of the case study for the implementation of the proposed approach in other geographical contexts. Utilizing observed monthly flow data from over 100 gauging stations, the approach combines both physical and statistical criteria to identify homogeneous regions in terms of flood generation mechanisms and seasonality. The process enables the assignment of distinct monthly flood probabilities to all catchments within the district, thereby supporting a comprehensive flood risk assessment for the agricultural sector.