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Groundwater flood mapping in Ireland using multi-temporal synthetic aperture radar imagery

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Identifying and mapping areas vulnerable to flooding is a key step in the management of flood risks. However, the nature of flooding on the lowland karst limestone plains of Ireland pose significant technical challenges in this respect. Drainage on the lowlands is principally underground and circulation between groundwater and surface water widespread. Consequently, groundwater flooding is the prevalent flood type; flooding typically occurs in isolated basins across the landscape making it impractical to monitor using traditional hydrometry. Synthetic Aperture Radar (SAR), such as is provided by the Sentinel-1 constellation, is a particularly powerful tool for flood mapping in this setting because of its ability to differentiate flooded from dry land and provide an all-weather, day-and-night supply of imagery.

The winter of 2015/2016 saw unprecedented flooding across western Ireland. The sustained nature of flooding, lasting from weeks to months, causing widespread damage and disruption to property and infrastructure. Very little hydrometric data were recorded during this flood event, making flood mapping a challenge. Remote sensing imagery collected by the ESA Sentinel Programme provided a practical and cost-effective solution to this otherwise insurmountable problem. A methodology combining change detection and thresholding was applied to multi-temporal SAR imagery acquired during the peak winter flood period. Results were validated against water extents derived from a combination of field measurements taken during the flooding and high resolution LiDAR topographic data.

Flood extents were compared against the extreme groundwater flood maps prepared as part of the EU Floods Directive Preliminary Flood Risk Assessment; results showed a substantial underestimation of areas liable to groundwater flooding. Significant lags in the timing of peak flood extents were found across the study area, reflecting the diverse hydrogeological characteristics of karst groundwater systems in the region. Identified flood receptors were widely dispersed and densities were low. However, cumulatively they made up a significant portion of the households and properties affected by the severe nationwide winter flooding.

This study demonstrates the value of Earth Observation in groundwater flood risk management, and represents a significant contribution in the assessment and management of groundwater flood risk in Ireland. Critical flood data has been gathered at a scale that was previously unachievable, and flood maps derived from SAR imagery will aid in regional planning and development and limiting future flood vulnerability.