Event-based erosion modelling - A case study of ex-tropical cyclone Alfred

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Abstract: Tropical cyclones can trigger severe soil erosion, particularly in regions with steep terrain and fragile soils. In early March 2025, ex-Tropical Cyclone Alfred brought intense rainfall to south-west Queensland and north-east New South Wales—the first cyclone to make landfall in the area in over 50 years. This study presents a targeted erosion hazard assessment designed to quantify the impacts of this event and support land and water management responses.

We used 4 weather radars operating at 5-minute intervals and 500 m spatial resolution to drive an event-based erosion model along with fractional vegetation cover, topography, and soil properties. We modelled the evolution of rainfall erosivity and identified areas with elevated erosion risk during the period 6–10 March 2025 for the cyclone affected area. Results indicate that the most vulnerable areas were small catchments with steep slopes and highly erodible soils, particularly around Lismore and parts of Brisbane (Figure 1). The high-resolution rainfall data revealed rapid changes in erosivity, enhancing the timing and accuracy of erosion estimates. On 9 March, the modelled daily erosion risk reached 24.2 MJ mm ha^{-1} d^{-1}, approximately 9 times the New South Wales average of 2.74 MJ mm ha^{-1} d^{-1}. The peak value, observed at a hotspot location, was 334.2 MJ mm ha^{-1} d^{-1}, exceeding the state average by more than 120 times. Comparisons with field observations show a strong correspondence with radar-derived erosivity, indicate the value of radar data with high-temporal resolution in capturing short-duration, high-intensity rainfall events. Outputs from this work include erosion risk maps and site-based time-series analyses, which have already been applied by Local Land Services, councils, and water agencies to inform erosion control and rehabilitation strategies. These tools have supported the prioritisation of immediate interventions and enhanced water quality protection in sensitive catchments.

This study demonstrates how integrating high-resolution rain field data with physical modelling improves real-time erosion risk assessment. The framework offers a practical tool for responding to extreme weather events and can be scaled for forecasting or applied more broadly to assess future risk under climate change scenarios.

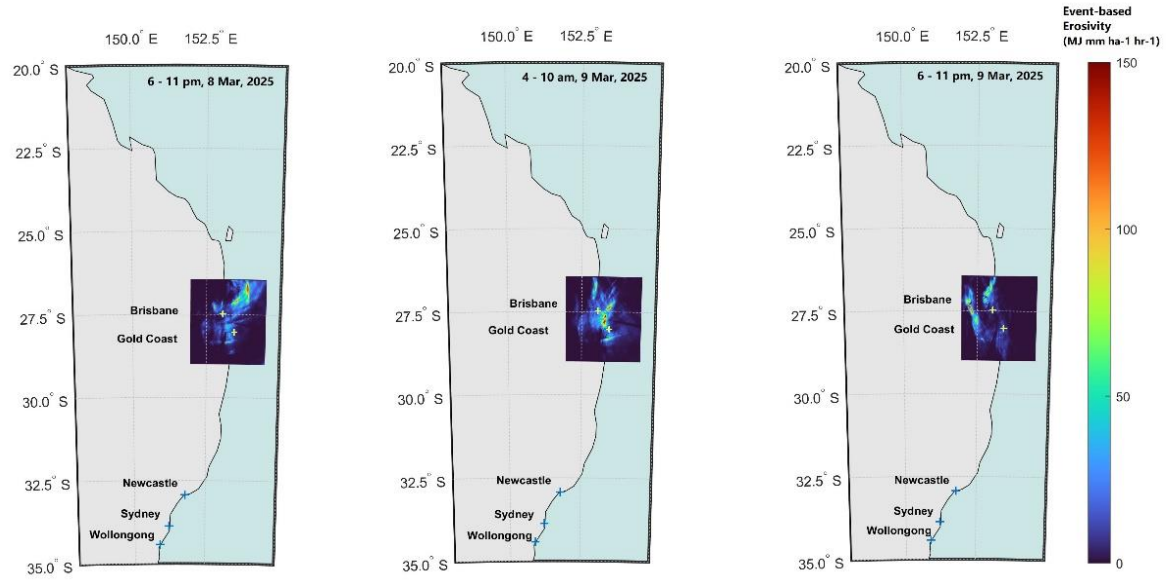

Figure 1. Event-based rainfall erosivity (MJ mm ha^{-1}hr^{-1}) estimated on hourly basis from weather radar data for post ex-Tropical Cyclone Alfred.

Keywords: *Weather Radar, Extreme Rainfall, Tropical Cyclone Alfred, Soil Erosion, Adaptation Strategy*

