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Floodplain inundation modelling using CaMa-Flood across the Murray-Darling Basin

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Abstract: The Murray–Darling Basin (MDB) is Australia's largest river system and a region of high economic, ecological, and cultural significance. Reliable projections of inundation are critical for water resources management and disaster risk reduction. Current approaches for estimating flood inundation from discharge at the basin scale typically rely on proxy models, such as annual maximum 30-day runoff (Teng et al., 2025), which can capture broad patterns but are unable to represent the complex hydrodynamics of river–floodplain interactions. Large-scale hydrodynamic modelling can offer greater physical realism but remains challenging for a basin as vast and diverse as the MDB due to high computational demands.

The Catchment-based Macro-scale Floodplain (CaMa-Flood) model potentially provides a computationally efficient solution (Yamazaki et al., 2013). The CaMa-Flood model is based on the local inertial approximation of the Saint-Venant equations and simulates river–floodplain interactions, including discharge, storage, and inundation extent (Yamazaki et al., 2013). It routes runoff from land surface or hydrological models along a predefined river network, enabling consistent large-scale applications without extensive parameterisation.

In this study, we applied CaMa-Flood at 0.05° (~5 km) resolution across the entire MDB. Surface roughness was represented using a Manning's roughness coefficient (n) of 0.03 for rivers and 0.10 for floodplains. The input daily runoff was simulated using the GR4J hydrological model. Model outputs were evaluated against satellite-derived two-monthly maximum surface water extent (1988–2022) at ~30 m resolution, mapped from Landsat imagery using a multi-index method (MIM). Comparisons showed strong spatial correlation between CaMa-Flood simulated inundation and satellite observations, outperforming proxy inundation models based on annual maximum 30-day runoff (Figure 1).

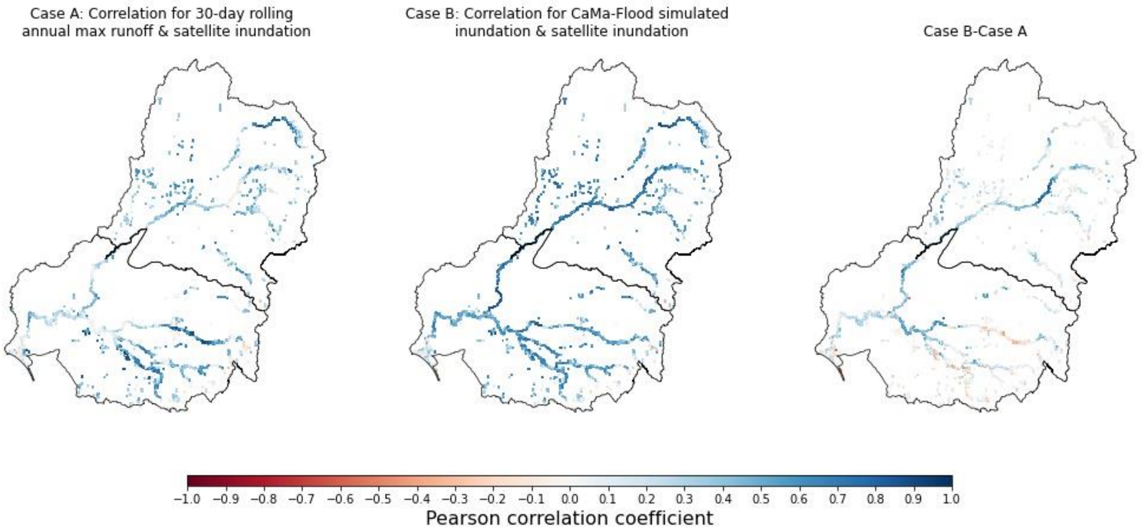

Figure 1: Case A: Pearson correlation coefficient between 30-day rolling annual maximum runoff and satellite inundation extent (Left); Case B: Pearson correlation coefficient between CaMa-Flood simulated inundation and satellite inundation extent (Middle); Difference between Case B and Case A (Right).

Beyond historical evaluation, we examined future floodplain inundation extent forced with GR4J runoff simulations informed by the projections from the CMIP6 global climate models. We assessed changes in inundation frequency and extent under possible future scenarios relative to a historical baseline of 1895–2023. Our results show that floodplain inundation frequency in the northern MDB may increase slightly for rarer events. In the southern MDB, rarer events are expected to stay below the baseline.

Our findings highlight CaMa-Flood's capability for basin-scale floodplain analysis and demonstrate its potential as a tool for assessing climate-driven changes in floodplain inundation frequency across the MDB. This study provides an essential step toward integrating large-scale hydrodynamic modelling into regional water management and adaptation planning, which can offer new insights into how the MDB's floodplains may respond to future climate change.

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