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Calibration of the Floodplain Ecological Response Model

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Abstract: The Floodplain Ecological Response Model (FERM) is a conceptual model that takes a time series of spatial flood inundation data as input to model the condition of ecological targets across a floodplain, over time. FERM develops wetting and drying periods (referred to as "spells") from the flood inundation data for a given grid cell and subsequently fits different preference curves depending on the type of spell. The parametrization of the preference curves is physically based allowing for calibration using expert knowledge or from data. Notably, the preference functions are infinitely differentiable, which reflects the smooth nature of the ecological response.

Due to data constraints, daily Leaf Area Index (LAI) data for *Eucalyptus lagiflorens* (Black Box) was obtained from the WAVES (Zhang and Dawes, 1998) mass and energy balance model as a proxy for condition score from 1928 to 2017 for calibration. WAVES is parametrized using vegetation and soil parameters and requires meteorological data as input. The flood inundation data was taken from the Teng-Vaze-Dutta flood inundation model (TVD) (Teng et al., 2018) which uses gauge-flow timeseries data to model flooding. WAVES was run at three different proximities to the main river channel. Three parametrisations of FERM for Black Box were calibrated for each location. Condition scores calculated from remote sensing data using the method described in Cunningham et al. (2009) were used to validate FERM yearly, from 2009 to 2017 excluding 2011 (data for 2011 was unavailable).

The Shuffled Complex Evolution algorithm (SCE-UA) (Duan et al., 1993) was used to calibrate FERM with the Nash Sutcliff Efficiency (NSE) metric. Prior to calibration, LAI values from WAVES (the calibration data) were smoothed with a yearly moving average to remove seasonality. The calibration ran with FERM's seasonal oscillation amplitude parameter fixed to 0 (calibrated after) whilst all other parameters were free to be optimised. The seasonality removal allowed for faster convergence and better performing resultant parametrisations. Calibration ended with an NSE of approximately 0.55 and a Root Mean Squared Error of 0.14. Incorporating meteorological variables would improve performance but make forecasting significantly more difficult on large timescales. The parametrization for Black Box maintained a correlation coefficient of 0.8 on the validation data, demonstrating the model's ability to capture spatial and temporal trends.

FERM is currently implemented in Python and uses Cython to speed up computation. Consequently, FERM can compute yearly condition scores across the entire floodplain in under 10 minutes and can run 50,000 iterations of the Shuffled Complex Evolution Algorithm at a daily timestep in 45 minutes, both over a 100-year timespan. The speed of calibration presents an improvement on large regression models and executes significantly faster than complex process-based models. Future improvements to the model are possible and will be discussed.

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