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VizumApp: A tool for visualising predictions and uncertainties from spatial models

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Abstract: VizumApp is a tool written in R Shiny that allows a user to visualise predictions and uncertainties from spatial models on maps. The tool is underpinned by the Vizumap R package (Lucchesi et al. 2021) that comprises four visualisations. Methods consist of a bivariate choropleth map, pixel map, glyph map and exceedance probability map. These have been applied to environmental problems including pollutant loads in the Great Barrier Reef (Lucchesi et al. 2021), small area estimation of child undernutrition rates in Bangladesh (Das et al. 2022), and estimation of Australian plague locust abundance (Mangeon et al. 2020). We also introduce a fifth approach not yet implemented that allows equal representation of all regions mapped using an equal area cartogram and concepts derived in the surgarbag R package (Kobakian and Cook 2019). VizumApp extends the utility of Vizumap by offering an interactive tool that allows users to easily map the outputs from a spatial model (predictions and uncertainties) on a map using one of four visualisations described above. The tool overlays each visualisation on a satellite map with options to adjust the map transparency. It provides an interface for zooming in and out, choosing colours and styles of blending, exporting maps, and outputting code and R Markdown scripts to enable specific tailoring of maps for the more experienced R user. Earlier attempts at visualising uncertainties on maps have been outlined in Lucchesi et al. (2021) and ranged from side-by-side maps of predictions and uncertainties, to blurring of regions where uncertainty was greatest.

Spatial modelling of complex environmental processes is important to determine impacts from a changing climate. While methods for quantifying uncertainties from spatial models exist, often the focus is on modelling rather than the visualisation and interpretation and this is suboptimal. VizumApp is a tool that fills this gap by providing options for interpreting predictions and their uncertainties using visualisations. Interpreting predictions and their uncertainties from spatial models is complex. This is especially true through the lens of a decision-maker who may not understand the model used to generate the predictions and their uncertainties or what the uncertainties represent. Visualising spatial predictions and their uncertainties can enable faster dissemination of outputs from complex spatial models, highlighting spatial regions where the predictions are certain and the converse, i.e. where more information is required (Kuhnert et al. 2018).

We showcase VizumApp using a case study of groundwater depth in the Indo-Gangetic Basin in Bangladesh and explore changes in groundwater levels between 1995 and 2010. Predictions of groundwater depth were provided by Pagendam et al. (2023) and explored through VizumApp. We further discuss how decision-making is enhanced through visualisations that account for uncertainties and discuss future work for formally comparing and assessing the effectiveness of these and other proposed visualisation approaches.

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