A framework for validating probabilistic (flood) models

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Flood models with a probabilistic component allow users to better understand how much confidence they can have in the overall model results given the uncertainties involved, such as natural variability in flood flows and how flood defences are likely to perform. This note explores how such probabilistic flood models can be validated within a wider framework.

Results from deterministic flood models can be validated relatively easily against observations, such as river levels and flood extents. However, there is often no obvious way of assessing how well a probabilistic model has performed. For instance, It is very difficult to judge *whether "there is a two per cent chance of being flooded (probability of occurrence)"* or *"there is a 50 per cent chance of damages (probability of consequence) greater than £n"*.

Users typically want to know how much confidence they can place in these types of probabilistic model results. However, actual data collected from observations of severe flood events is sparse, while observations of failure mechanisms, such as the breaching of flood defences, are rare. This limits opportunities for direct validation of the model results. Instead, qualitative or judgement-based approaches have been used to assess whether results are 'reasonable'. In addition, quantitative studies have investigated the uncertainty in particular model components or the sensitivity to input data.

Despite these welcome first steps, a wider coherent framework is needed to validate probabilistic models from a users' perspective to support confident use and continuous improvements in these models.

A set of eight overarching principles is proposed to guide future validation efforts. Validation should:

1. Distinguish between model error and parameter/input uncertainty.
2. Be aligned with the intended uses of the model outputs, and must improve decision making.
3. Aid the creation of statements of confidence that are specific in terms of output and scale.
4. Be based on sound, defensible evidence.
5. Be transparent, readily understood by end users and consistent.
6. Use available data and be practical for operational flood risk modelling.
7. Help define the requirements for future improvements to: input data, modelling methods, validation approaches and communication of results.
8. Examine evidence on both the accuracy of model predictions and the quality of the modelling process.

These principles form the basis of a new framework for validating probabilistic flood models, as set out in Figure 1.

This framework involves several steps. It starts by defining the probabilistic model outputs and their intended uses. This is followed by an assessment of the desired accuracy of and confidence in the results in light of these uses, which are used to set validation targets. Depending on the model processes and data available, a range of suitable validation techniques can be applied. The validation results then form the evidence base for developing confidence statements and assessing whether the validation targets for the desired uses have been met. If they have not, a number of options are available, ranging from improving data and models and/or repeating the validation to reviewing the validation targets in light of the achievable accuracy.

This framework was trialled in a number of case studies which highlighted its utility and potential benefits.

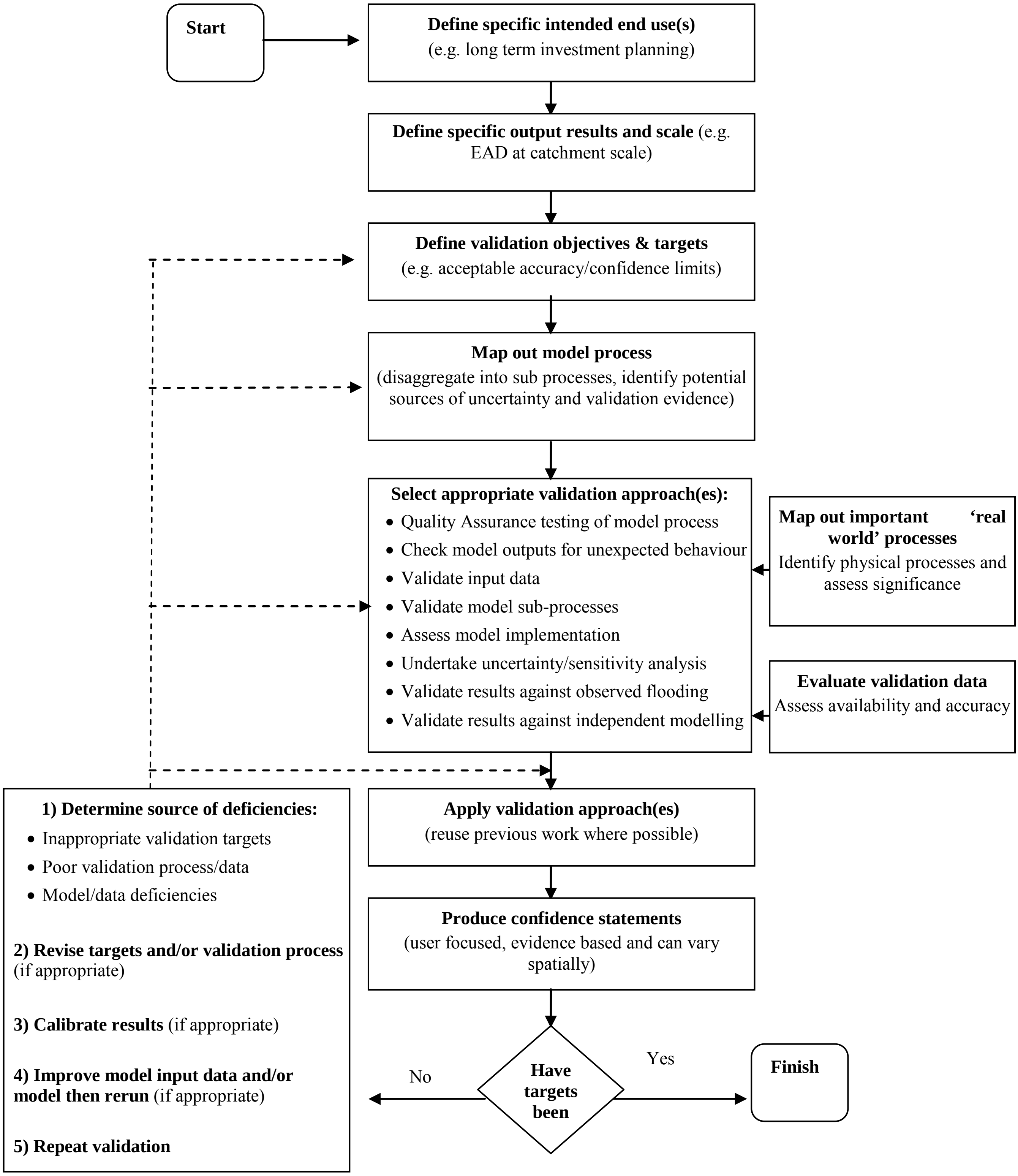

Figure 1: High level validation framework for probabilistic flood models.

The main conclusions were:

- In order to assess overall confidence, any validation of probability models should link to the intended uses of the model outputs and the desired confidence/accuracy in these.
- Forward uncertainty propagation and sensitivity analysis play an important role in validation and steering improvements. However on their own, they only provide a partial picture since they do not capture the overall uncertainty which can be influenced by the model structure and its performance.
- Despite their limitations, validating probabilistic model results against suitable observations will be crucial for users to gain confidence in probabilistic outputs. Indirect validation alone, such as of input data or model components, is unlikely to gain sufficient confidence from users.
- Validation is greatly aided by the provision of easily recognisable information, such as flood depths (and overtopping flows/volumes) rather than just probabilities. Practitioners find these easier to check against their knowledge of how particular catchments/locations respond to flooding.
- Overall, the validation framework is a useful aid for practitioners to maximise the benefits of probabilistic flood models at a range of scales. It allows users to:
    a) assess the fitness for purpose of probabilistic flood models in light of the required accuracy;
    b) communicate confidence in the results; and
    c) plan and prioritise future data and method improvements.

However, validating probabilistic model results for rare flood events and defence conditions, such as breaching, remains challenging. Suitable observation data is sparse and validation data is often only available for selected locations. To enable practitioners to use probabilistic results with confidence, validation of overall through model performance with both direct and indirect means is therefore essential.

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