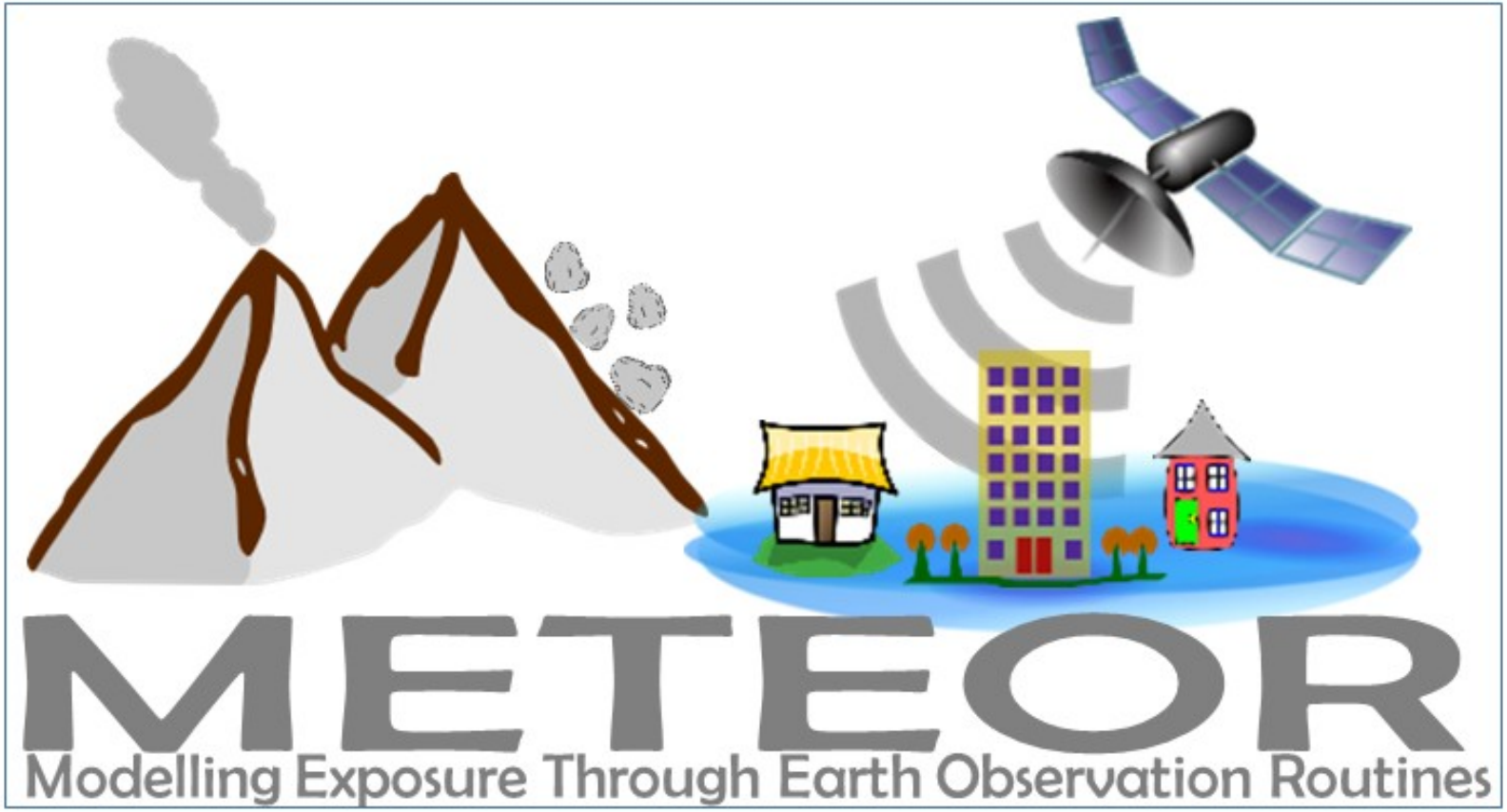
METEOR
Modelling Exposure Through Earth Observation Routines

METEOR FLOOD MODELLING
NATIONAL SCALE DATA AND METHODS

Dr Christopher Sampson
Fathom

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Overview

- Introduction
- Data
- Methods
- Applications
- References

Introduction

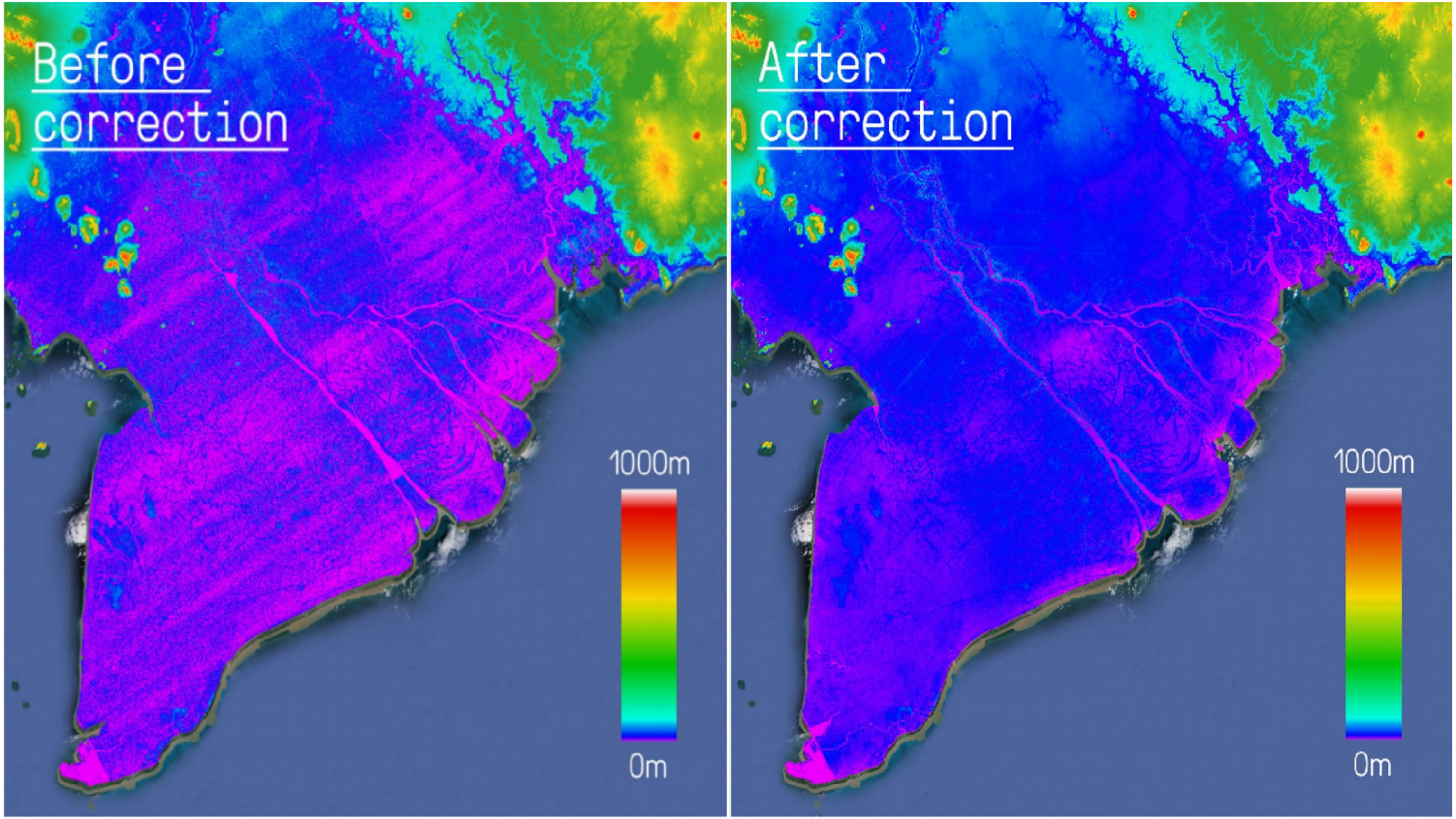
- National scale model requires consistent methodology
- Local observations are not available for most locations
- Model must be able to operate using open-access, nationally available data

Key Data: Terrain

- Terrain data is critical
- Have to use remotely sensed global data (because local data is not available)
- Global terrain datasets are generally collected by satellite and require processing to prepare them for use in a flood model

Key Data: Terrain

- MERIT Digital Elevation model (DEM)
- Global 3 arcsecond (~90m) DEM
- Removed many errors and biases from previous global DEMs, including:
  - Absolute bias
  - Stripe noise
  - Speckle noise
  - Tree height bias
- Significantly improved elevations in flat regions (i.e. floodplains) and the representation of river networks globally



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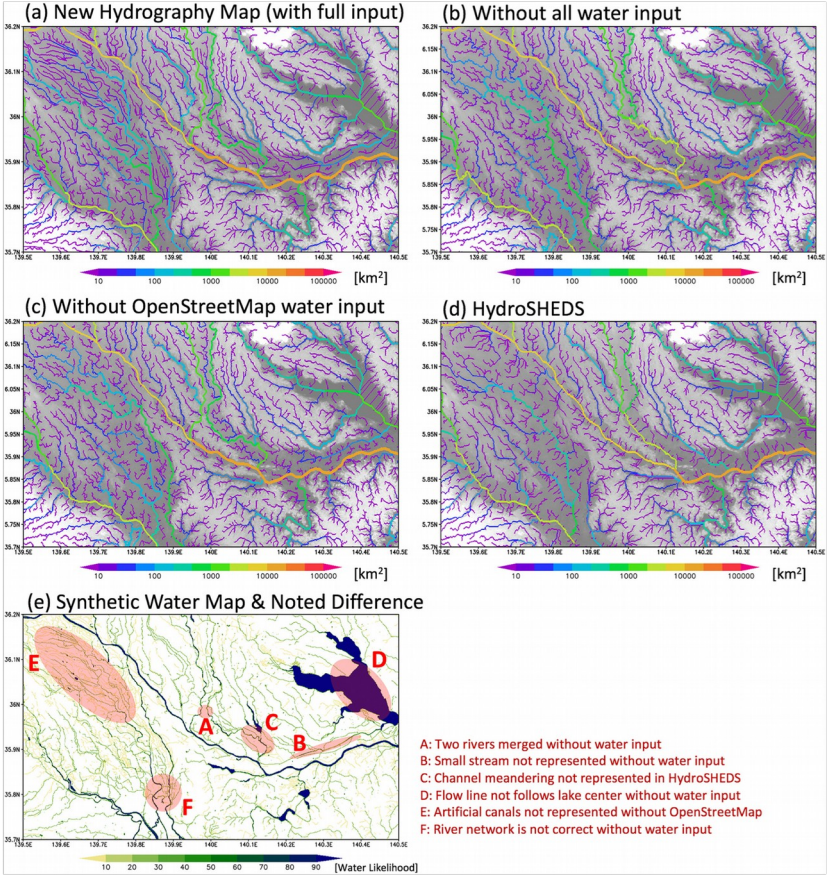
Key Data: Hydrography

- Where are rivers located?
- How big are they?
- Derived from DEM
- Conditioned using existing river network data if available

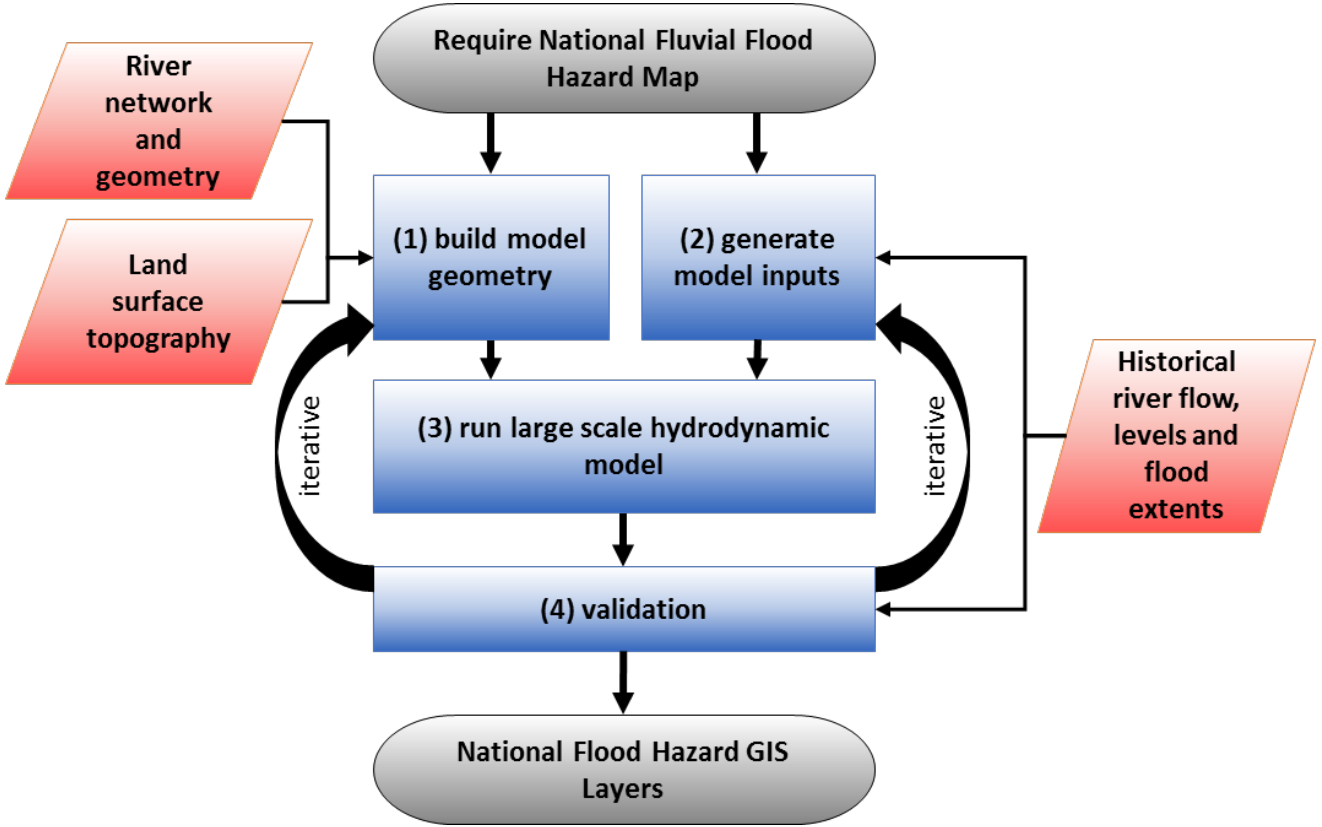
Key data: MERIT Hydro

The most accurate global hydrography dataset

Fusion of MERIT DEM with supplementary water-body datasets (OpenStreetMap; Landsat satellite imagery (G1WBM; GSWO)



Methods: Automated Model Framework

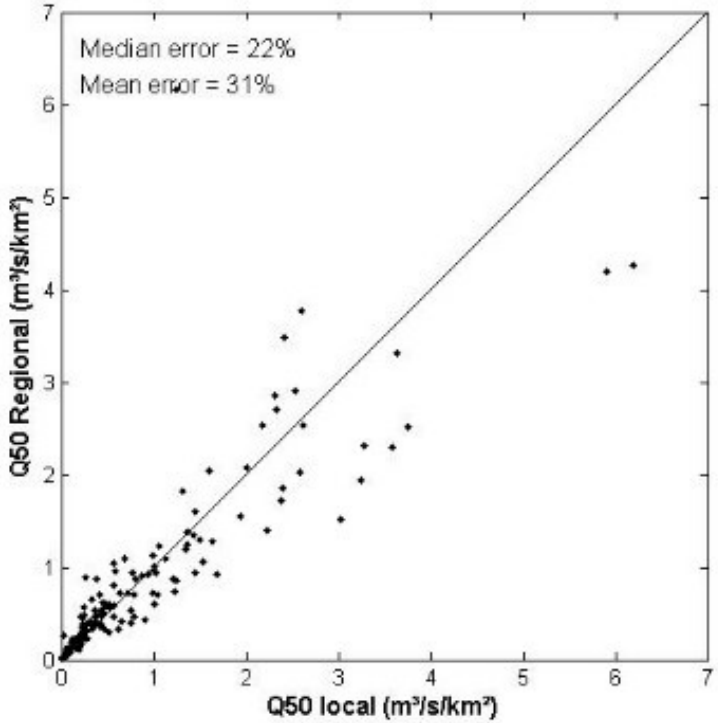


Methods: Terrain

- MERIT DEM is processed into 1x1 degree tiles
- ¼ degree buffers are added to each side (to give total domain of 1.5 x 1.5 degrees)
- Buffers mean that the edges of neighboring tiles overlap, allowing simulation output to be blended to create a seamless dataset without edge artefacts

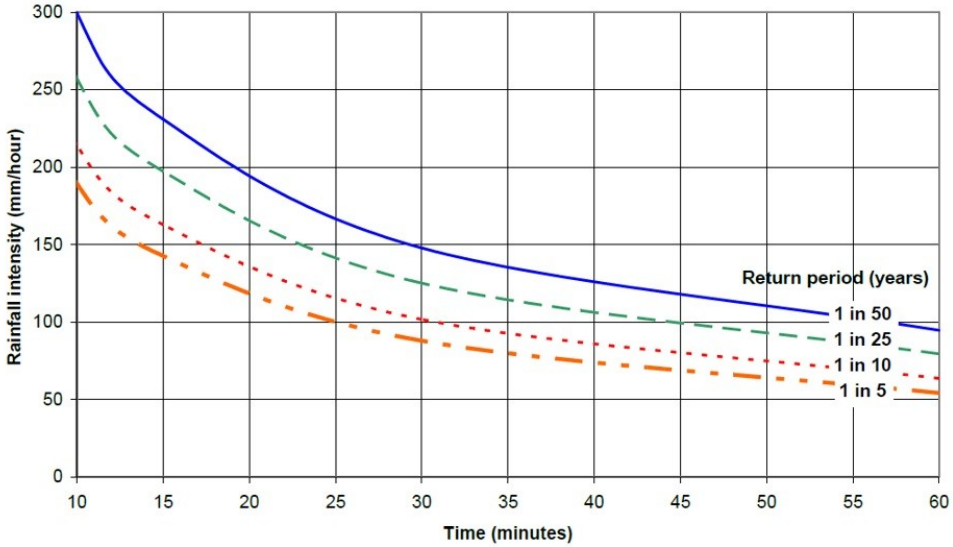
Methods: Discharge

- Model uses Regional Flood Frequency Analysis (RFFA) as local river gauge data is limited
- Use river discharge data directly
- Link flow behavior to climate zone, area, rainfall, slope
- Index flood method - standard technique for ungauged catchments
- It uses a database of river discharge measured for many decades at thousands of river gauging stations all over the globe, representing >100,000 station years of data.
- This method is used to generate robust flood flow estimates at any point along a river network.



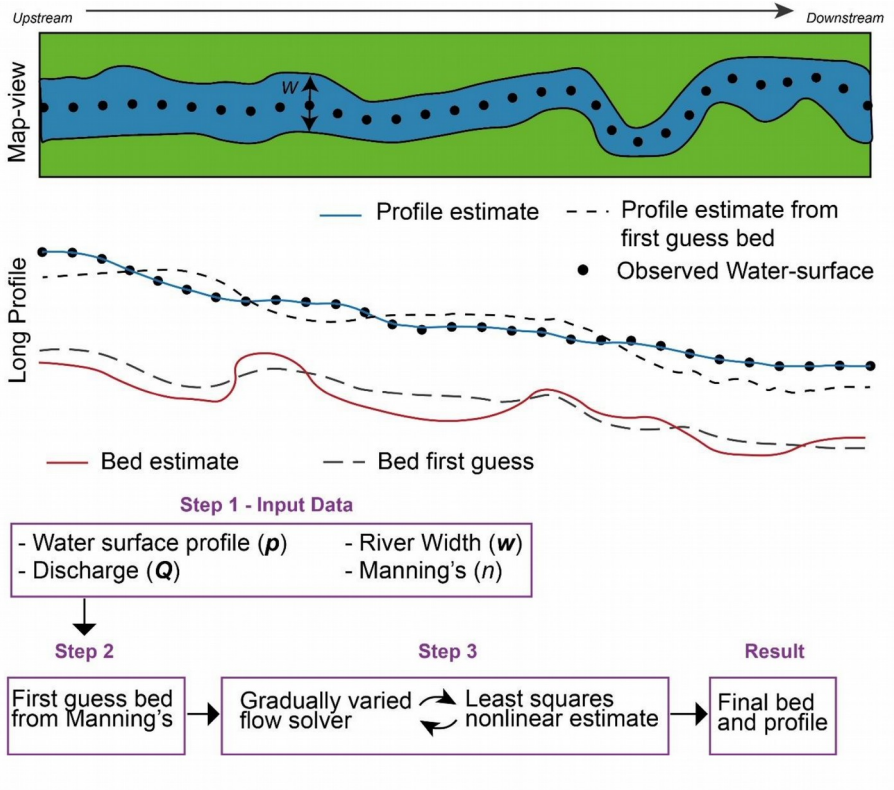
Methods: Rainfall

- Intensity-Duration-Frequency (IDF) relationships are used to define design rainfall events
- 1 hour, 6 hour and 24 hour rainfall totals are estimated for each return period
- Local data used where available; regionalized model used elsewhere



Methods: River Network

- MERIT Hydro is used to define the location of rivers
- River widths are estimated using global river width database data
- Depths are modelled using a 1D channel solver. The 1-in-2 year flow from the RFFA is assumed to be 'bankfull', and the solver calculates the appropriate channel depth to yield a water surface level with the DEM

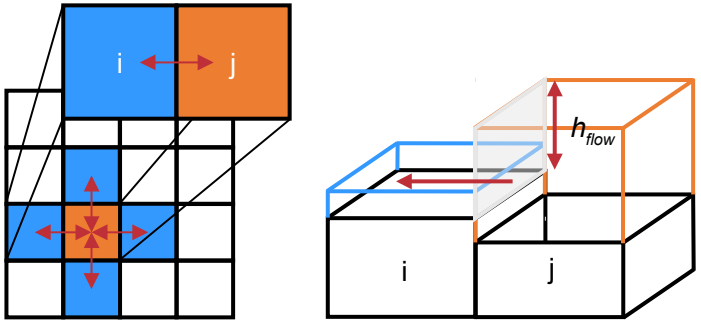


Methods: Boundary Conditions

- River network for each tile split into segments ‘reaches’
- River discharge hydrographs are automatically generated for each reach using RFFA and time-to-peak estimate
- Time-to-peak estimated by using Manning’s equation to calculate mean velocities along the length of the river network to the furthest point.
- Rainfall events generated using IDF model

Methods: Hydrodynamic Model

- The models are executed using a full 2D hydrodynamic model based on a simplified (for speed) momentum-preserving variant of the shallow water equations.
- Model explicitly models channels using a ‘sub-grid’ method that means the channel geometry is independent from the DEM grid resolution, allowing channels of all sizes to be represented (even if smaller than the 90m DEM grid)

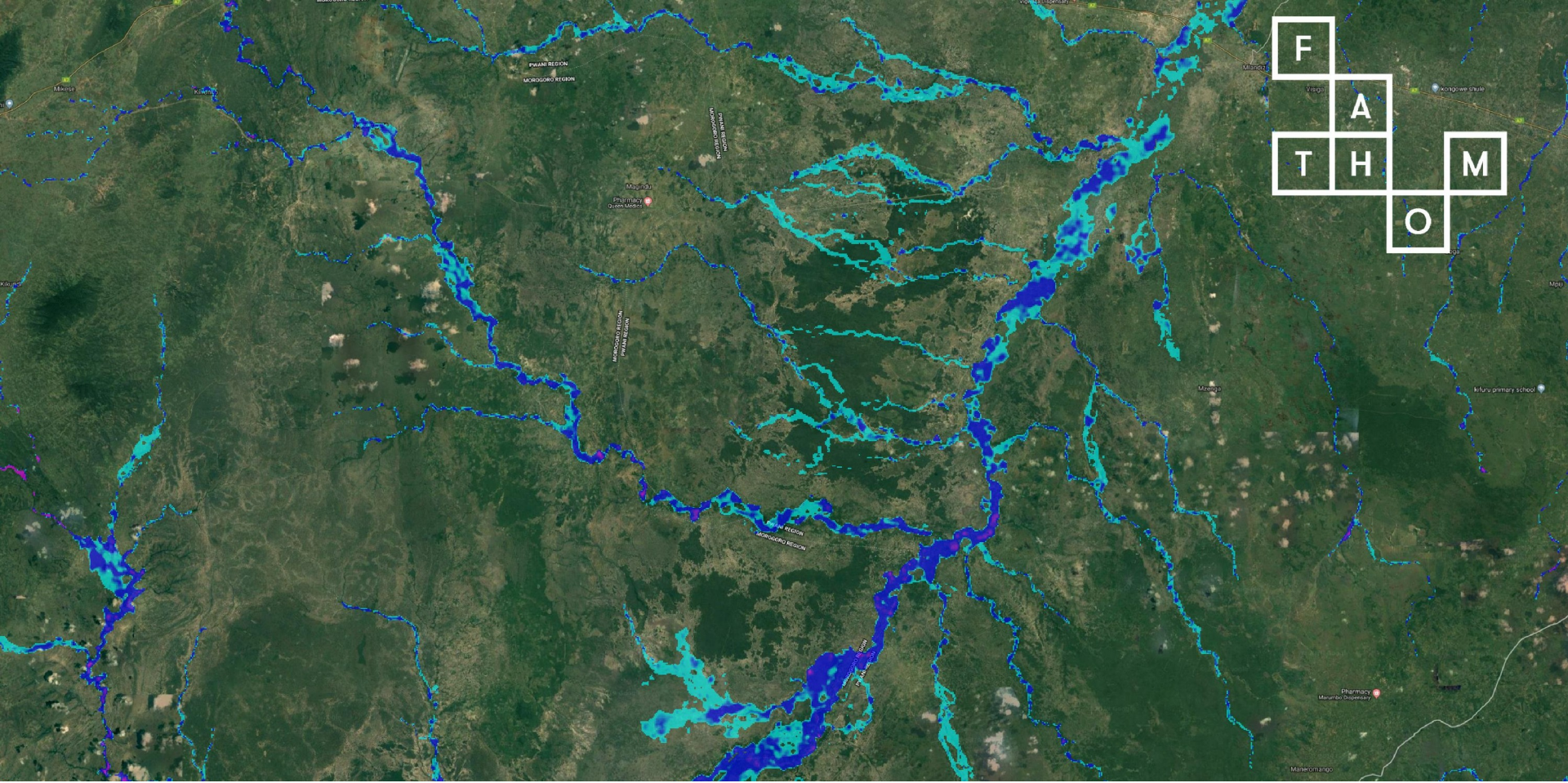


$$\frac{\Delta h^{i,j}}{\Delta t} = \frac{Q_x^{i-1,j} - Q_x^{i,j} + Q_y^{i,j-1} - Q_y^{i,j}}{\Delta x^2}$$

$$Q = \frac{q - gh_{flow}\Delta t \frac{\Delta(h+z)}{\Delta x}}{\left(1 + gh_{flow}\Delta t n^2 q / h_{flow}^{10/3}\right)} \Delta x$$

Methods: Post-Processor

- The many reach simulations on each tile are merged to create a single layer for a given return period for each tile
- The tiles are then stitched together (using a blend across overlapping areas at tile margins) to create a seamless national scale map
- The national data are output into standard GIS format files (GeoTIFF)



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Data Application

Stakeholder	Information	Planning	Action
General Public	Flood awareness	General area to avoid - NOT individual property level	What areas require more detailed engineering studies
National and local government planning	Preparedness and resilience investment needs. National view of most likely risk	Identify new flood defence and warning schemes. Planning zone definitions	Commission specific detailed studies in high risk areas/catchments
National and local government infrastructure	Avoidance areas for new infrastructure. Asset Management scenarios	Identify assets at highest risk and mitigation investment required. Investment in assets where damage is greatest	Locating and targeting post event repairs. Identify and target maintenance investment
National natural resources monitoring agencies	Sensitive regions and locations or river reaches	Identify new information, (data collection) needs e.g. gauging stations.	Install new monitoring and flood warning systems. Collect long term flood records.
National emergency management	Flood hazard communication	Location of evacuation centres and routes. What areas require more detailed engineering studies.	Targeting event/incident response
Commercial concerns (e.g. agriculture)	Exposure of existing assets	Identify less risky locations for investment	Invest in local protection/preparedness
Academia and consultancy	Areas and mechanisms to study further	Targeted research proposals. New data collection	Study, analyse, and publish findings relevant to flood risk.
Insurance	Exposure of portfolio (customers)	New markets or tailored insurance products to risk	Set premiums relative to risk

	Application Topic	Size range (km^2)	Application of NFHM	Suitability	Limitations
Regional areas	National	>10,000	**Yes**	National risk assessment	Should represent a good assessment of hazard at a national scale
	Catchment	10 - 10,000+	**Yes**	Identifying areas with natural vulnerability to flood, deepest and most frequently.	Good assessment of hazard at catchment scales, accuracy will reduce for smaller catchments and sub-catchments. Dynamics of flooding not captured in output as not event based output.
	District	1000-10,000	**Yes**	Identifying which districts are at risk, or have the most risk.	Should represent a good assessment of hazard at a district scale.
	Settlements	0.01-100	**Only largest**	Identifying which settlements are at risk, or have the most risk.	Towns and cities are fine; assessment of smaller villages may be beyond model skill
	Buildings	<0.01	**No**	Not suitable	Data is not sufficiently accurate or precise for application at individual building scale

	Application Topic	Size range (km²)	Application of NFHM	Suitability	Limitations
Infrastructure	Road	Linear feature. Width ~10-20 m, length 1 km +	**Limited to planning**	Can be used for route planning and avoidance of obviously hazardous areas or identify the requirement for more detailed flood study. Also national and district level exposure and risk assessment of linear length of roads intersecting with hazard.	Not to be used for road infrastructure design. This would require a detailed hydraulic assessment with accurate DEM.
	Bridges-culverts	~10-20m	**Limited to planning**	Identification of Bridges and culverts that might require appraisal for capacity issues and design. Not a design tool!	Not to be used for bridge or culvert infrastructure design. This would require a detailed hydraulic assessment with accurate DEM.
	Industrial or housing estate	~1+	**Limited to planning**	Identification of estates that may require further detailed assessment or planning zone control.	Only a general assessment of whether a location is exposed to a hazard or not and the proximity to the hazard is possible at this scale. Quantifying risk may be not be possible with any accuracy.
	Agricultural fields	~0.5+	**Limited to planning**	Identification of fields that may require further detailed assessment.	Only a general assessment of whether a location is exposed to a hazard or not and the proximity to the hazard is possible at this scale. Quantifying risk may be not be possible with any accuracy.
	Buildings	~10x10m	**NO**	-	Not ideal at this scale and best not used for individual buildings

References

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Thank you for your interest

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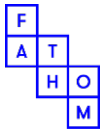

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