NATURAL FLOOD MANAGEMENT RESEARCH PROGRAMME

Q-NFM
The Challenges of Modelling NFM

Barry Hankin

with thanks to Nick Chappell (PI), Trevor Page, Ann Kretzschmar, Keith Beven, Rob Lamb, John Quinton, Gareth McShane, Phil Haygarth and all our partners

Q-NFM NATURAL FLOOD MANAGEMENT RESEARCH PROGRAMME Lancaster University The Rivers Trust JBA consulting

Building evidence into modelling

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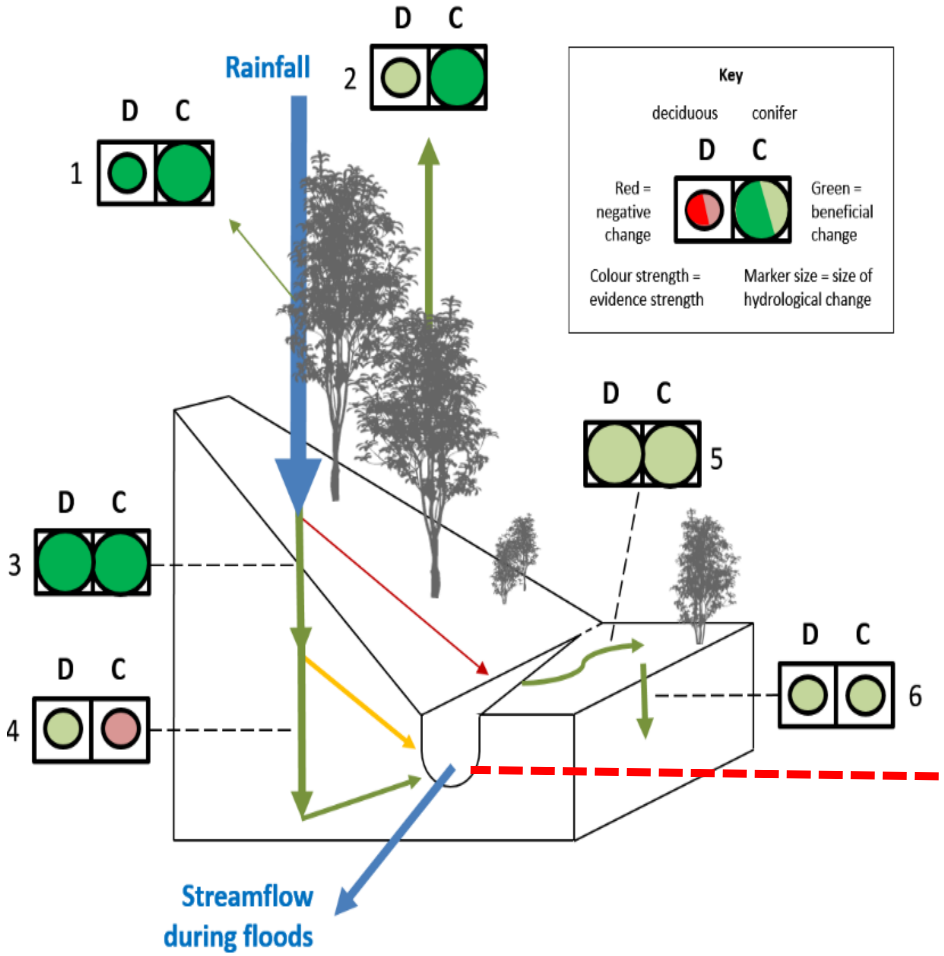
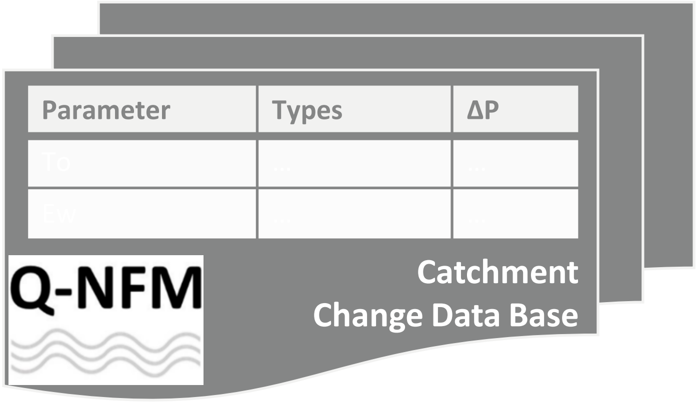
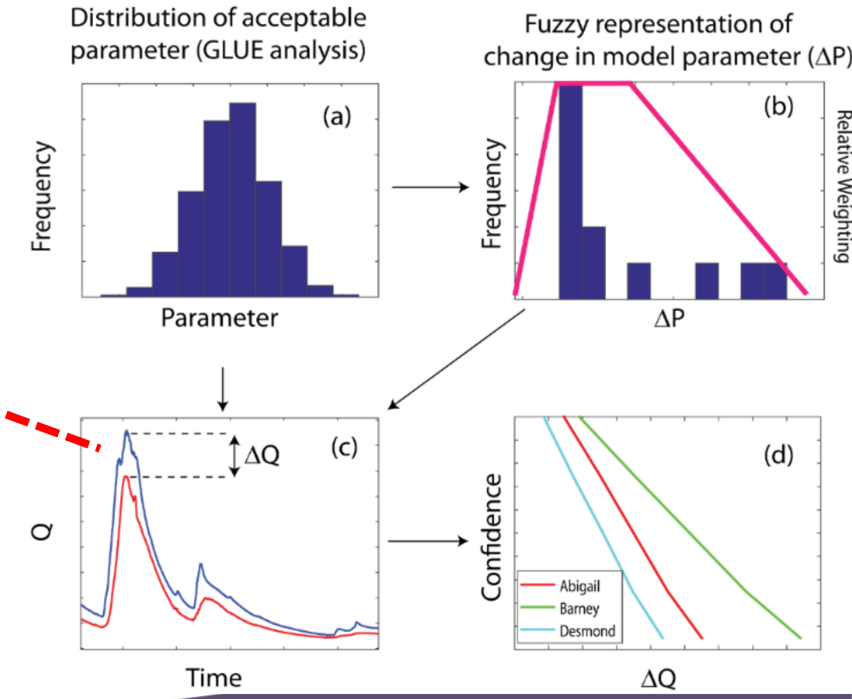


#	Hydrological function	Experimental evidence (examples only)
1	Enhanced wet-canopy evaporation	e.g., Komatsu et al (2011) etc...
2	Enhanced transpiration	e.g., Brown et al (2005) etc...
3	Enhanced infiltration	e.g., Chandler & Chappell (2008) etc...
4	Enhanced deep percolation	e.g., Chappell et al (1996) etc...
5	Enhanced floodplain roughness	e.g., Medeiros et al (2012) etc...
6	Enhanced floodplain infiltration	e.g., Heeren et al (2005) etc...



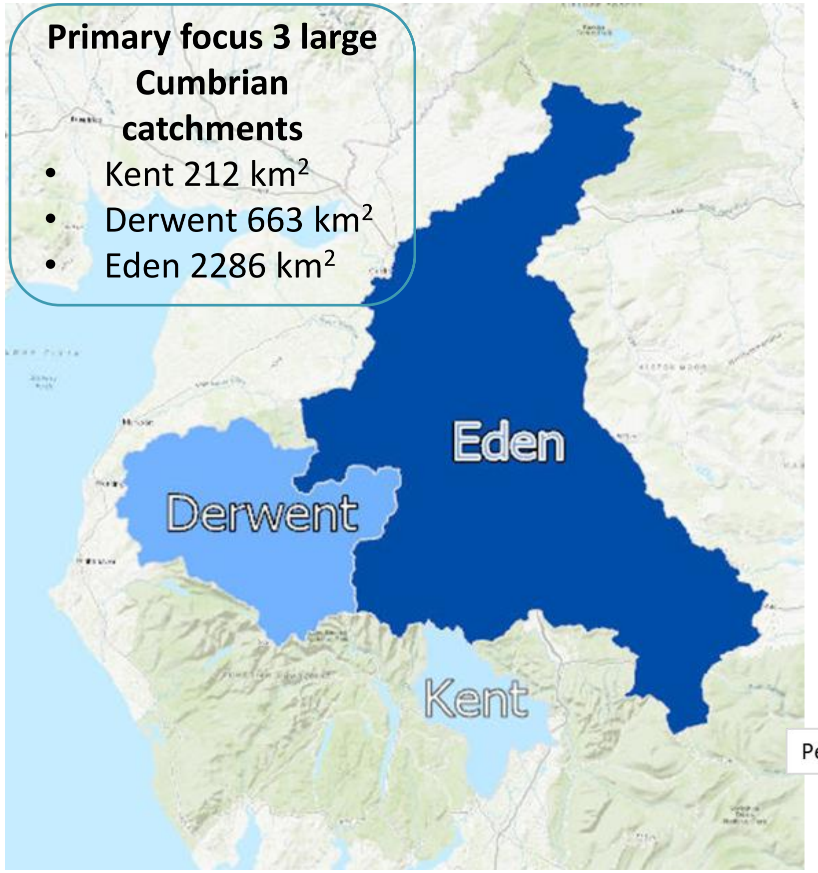


How do we map landscape changes to effective model parameter changes to reflect distributed catchment measures?

Large Scale and Paired Catchments

Primary focus 3 large Cumbrian catchments

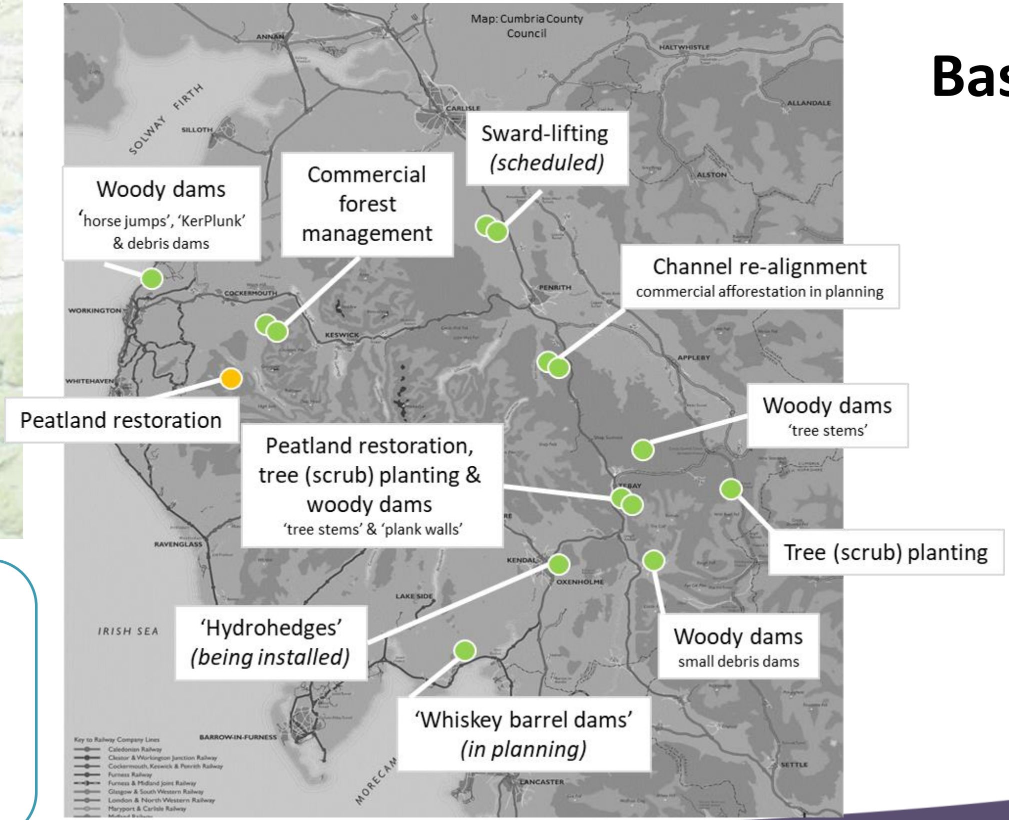
- Kent 212 km^2
- Derwent 663 km^2
- Eden 2286 km^2



- Up to 30 years of EA data
- High resolution in space and time necessary
- Complex processes must be represented
- Baseline modelling
- modelling the effects of NFM changes / interventions

Understanding the processes:

- Core catchments extremely complex >200 km^2 to >2000 km^2
- Micro catchments <1 km^2 help us to represent processes
- **With partner help** - paired catchments help us understand possible effects of NFM interventions
- Baseline modelling of micro-catchments to ensure the model representing processes effectively



Baseline / NFM modelling

After intervention:

- Can we quantify change?
- How do we represent change in model parameter values?

Distributed modelling framework

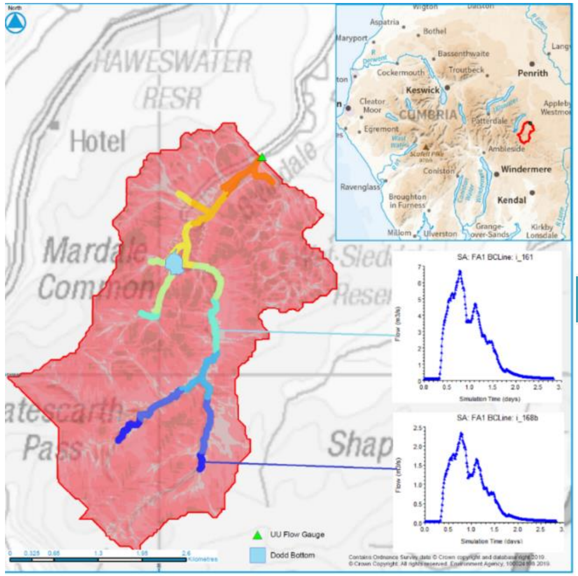
Distributed rainfall-runoff + 2D Hydrodynamic Model

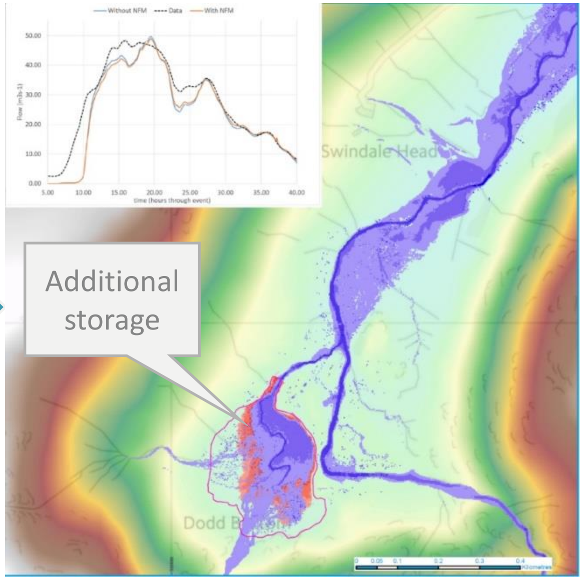
Parsimonious hillslope hydrology using interacting Hydrological Response Units

Capture different processes influenced by NFM

Surface / sub-surface interactions

Efficiency allows time undertake uncertainty analysis





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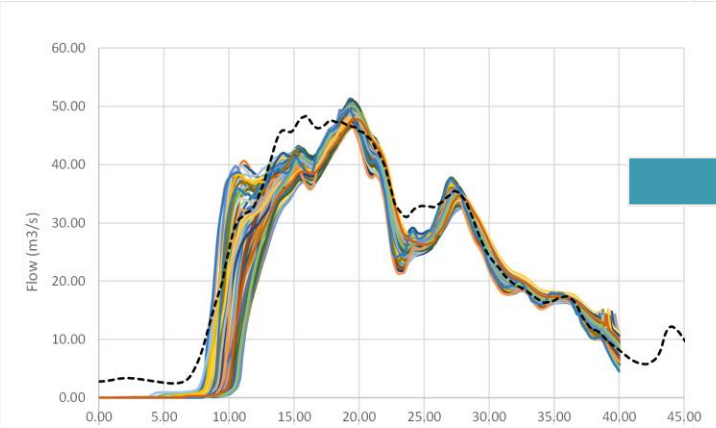
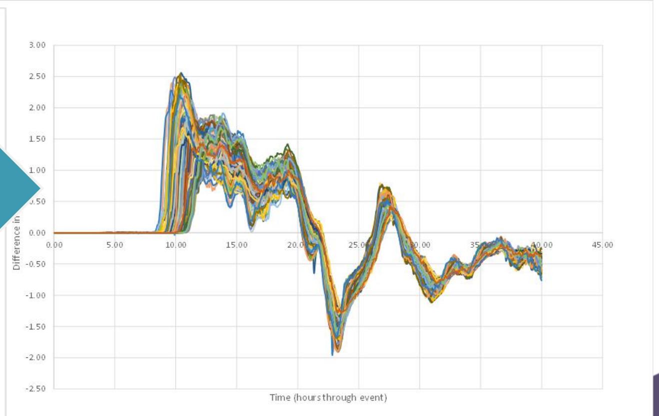
RESEARCH ARTICLE | JULY 17 2019

Integration of hillslope hydrology and 2D hydraulic modelling for natural flood management

Barry Hankin ; Peter Metcalfe ; Keith Beven ; Nick A. Chappell

Hydrology Research (2019) 50 (6): 1535–1548.
https://doi.org/10.2166/nh.2019.150 **Article history**

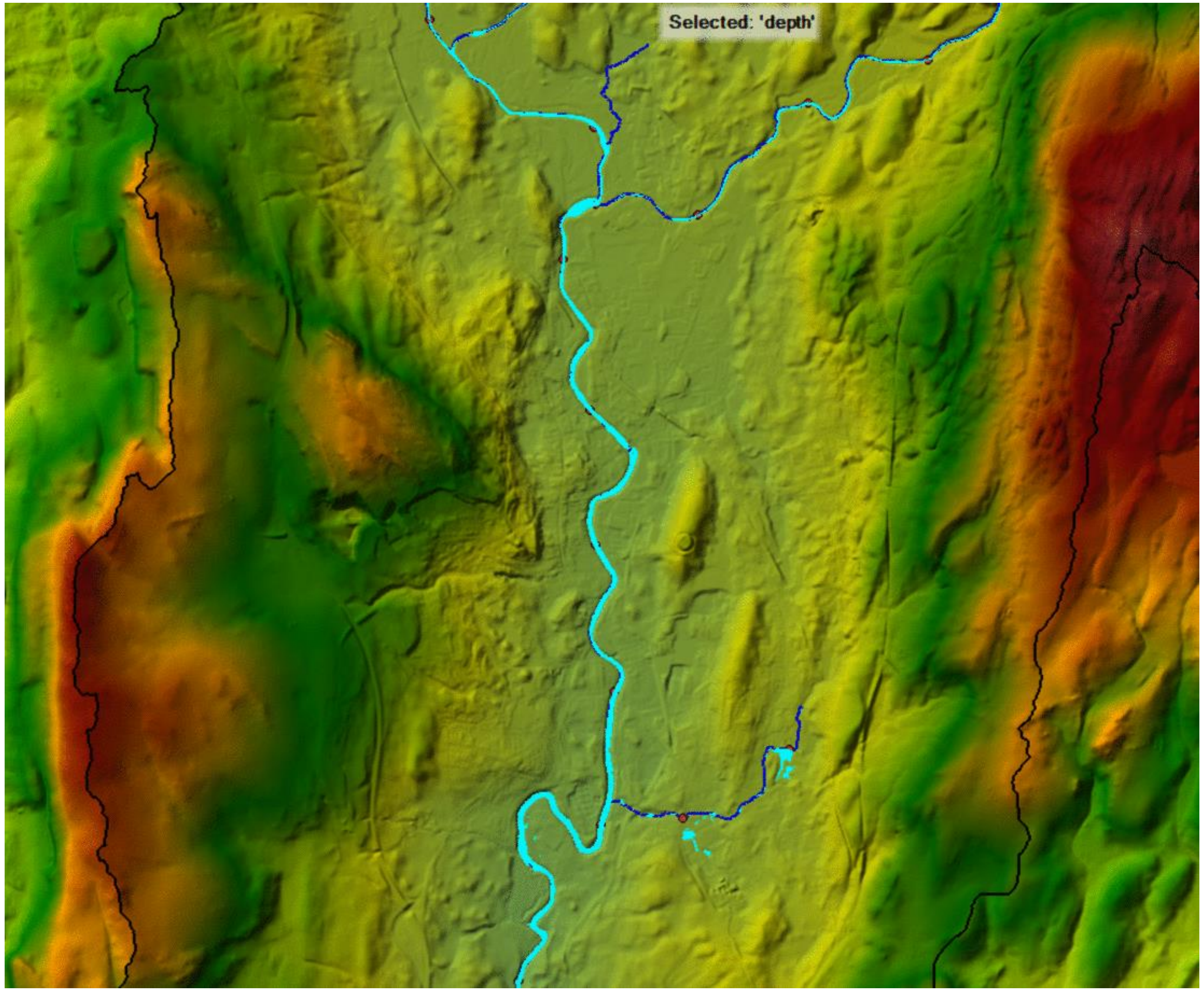


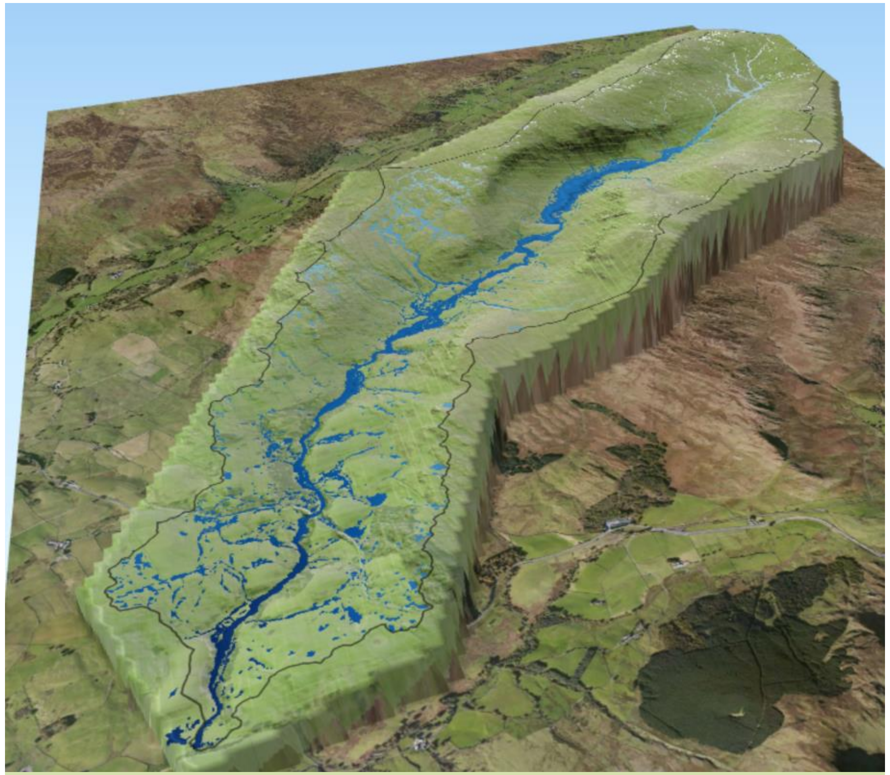


Peak flow difference (Baseline- NFM) ***= 1.8 m^3/s ±1.4 m^3/s***

Scaling-up

....same technique applied to the Kent (EGU2019)

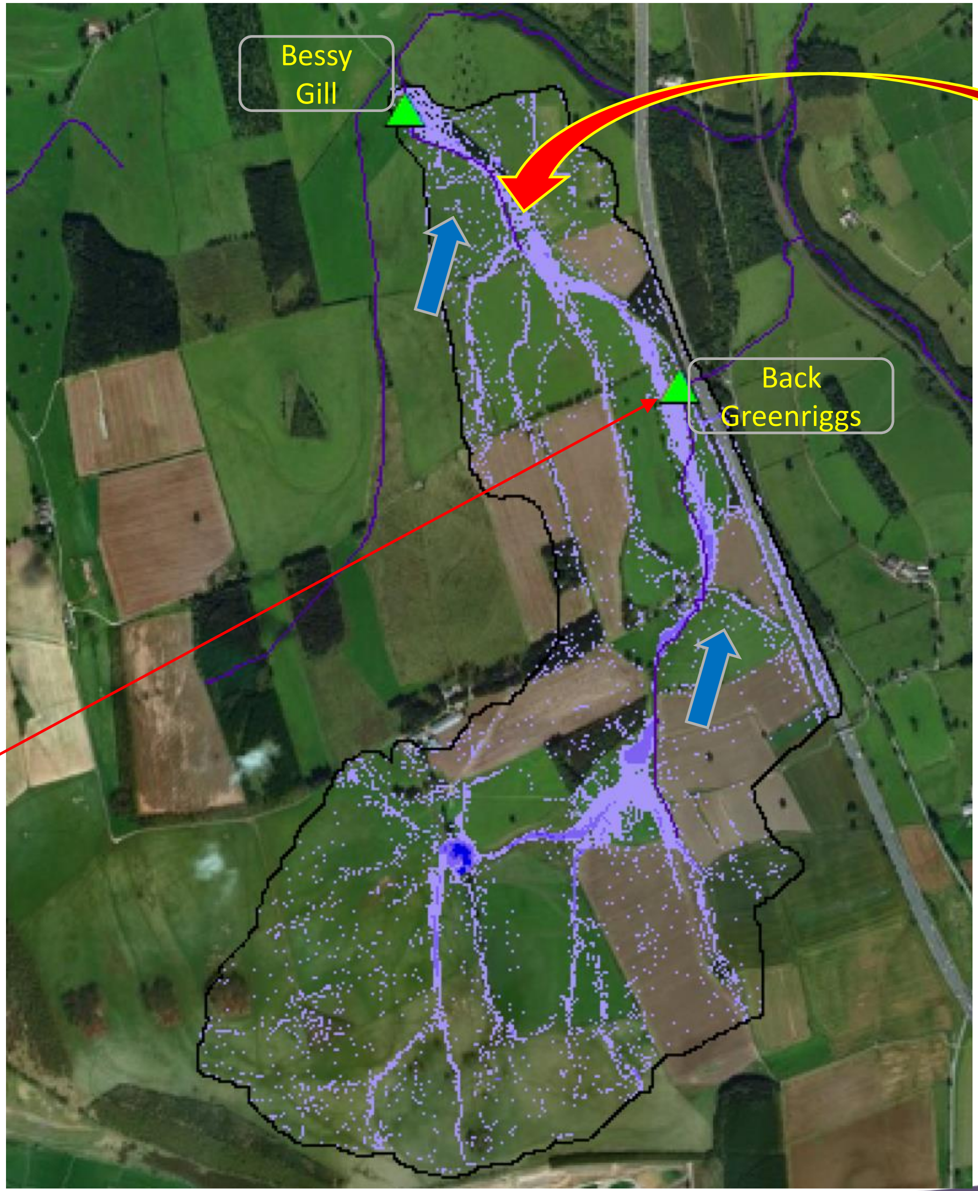




Finding that whilst the large-scale model useful, focussing in on smaller domains with faster runtimes also helps

Lowther stream diversion

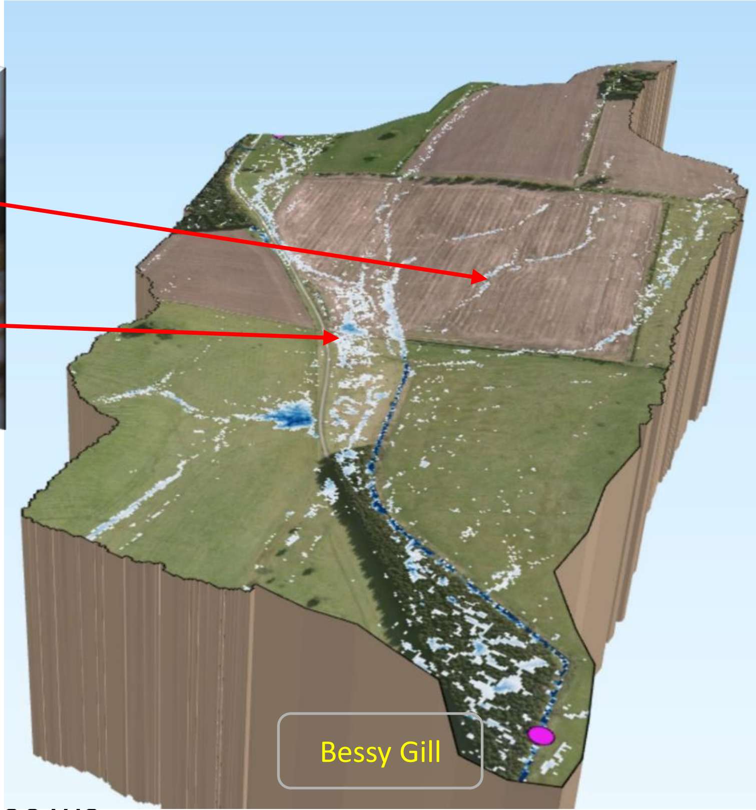
Stream diversion over meadows from Back Greenriggs micro-flume

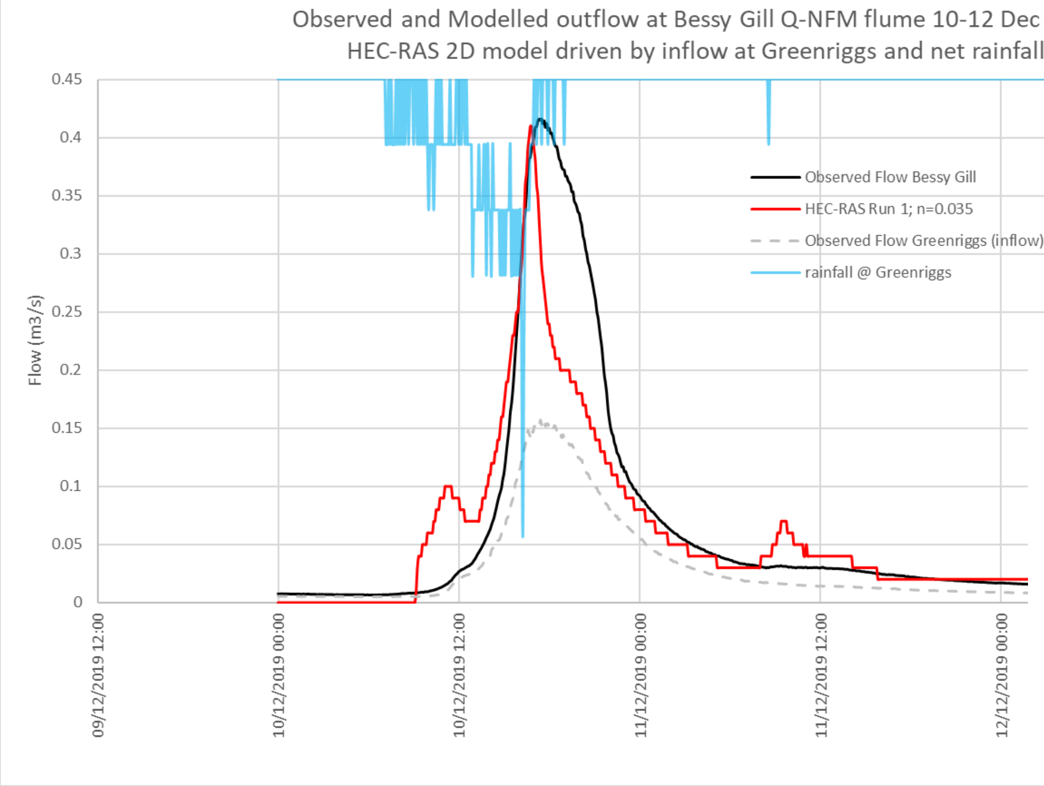


Ponding near the road after Dec 2019 event

Stock Beck East (…if all those gaps blocked)

NFM designed to enhance floodplain storage can improve climate change resilience using the landscape as a natural adaptation pathway





Lowther

With newly captured data for Nov/Dec we calibrated a direct runoff and losses model

We drove the model with Greenriggs flows and direct rainfall on the catchment between the gauges…We have to deal with bypass flow and sub-surface losses

Micro-catchment modelling: Hydro-hedges

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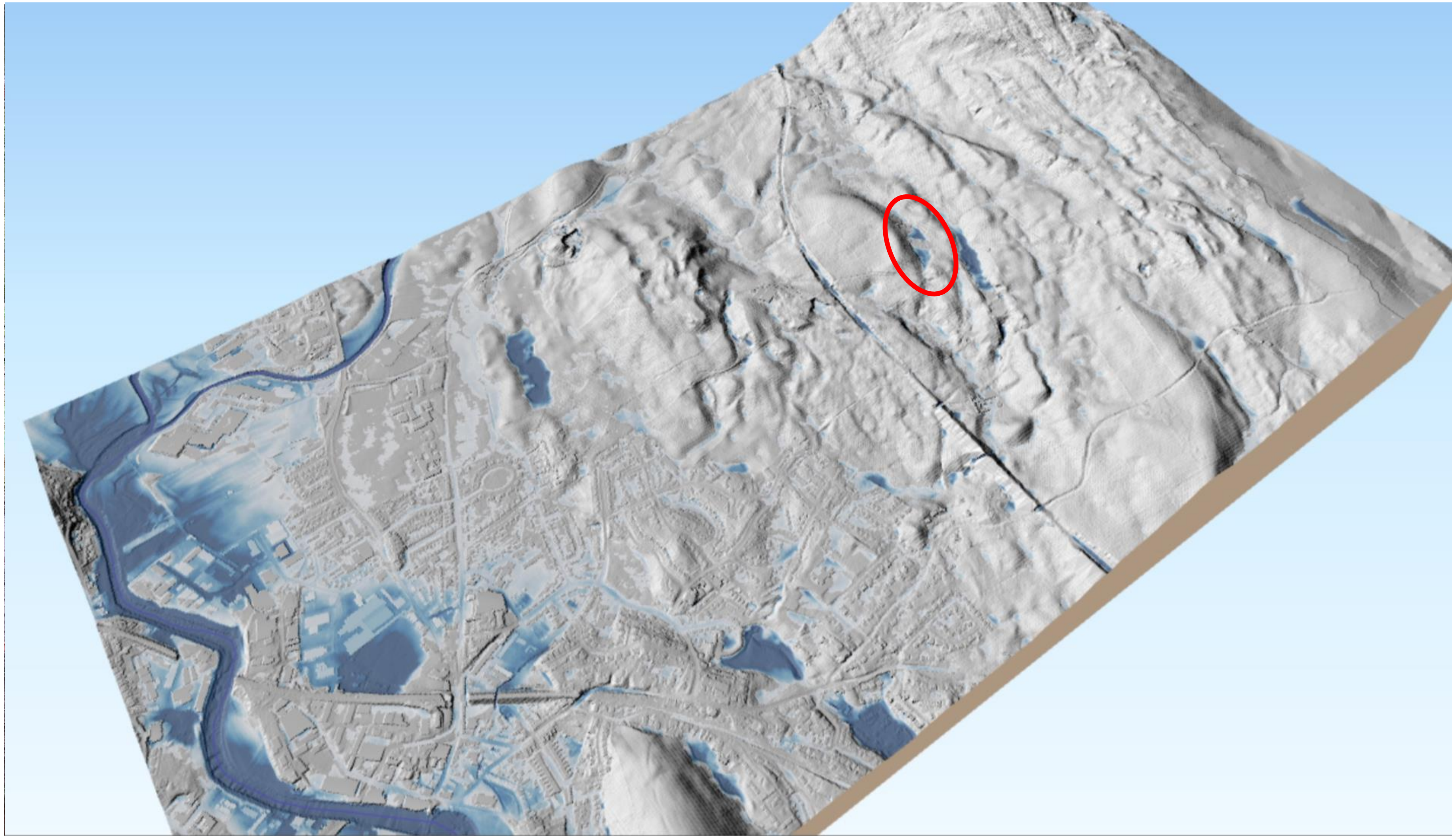

- NFM Modelling: Hydro-Hedges
- Thanks to Peter Bullard and Dave Kennedy

Stock Beck East (...if all those gaps blocked)

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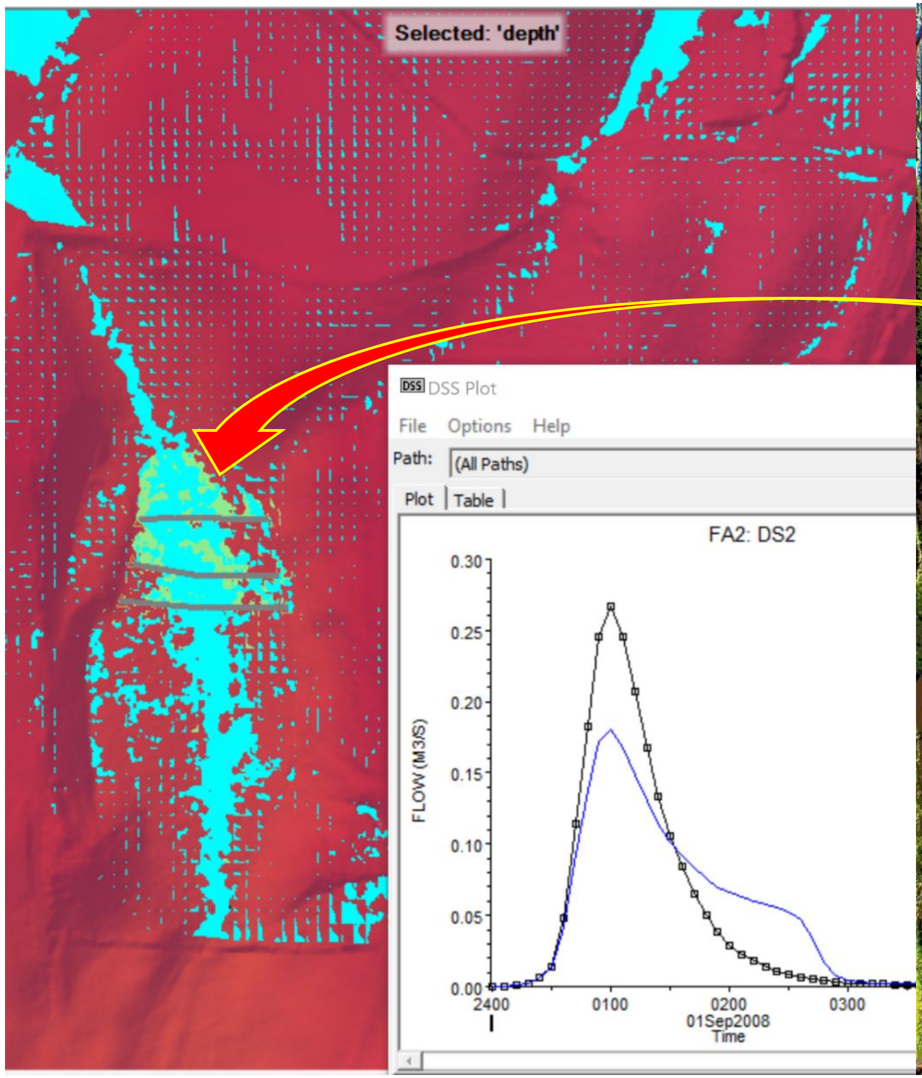
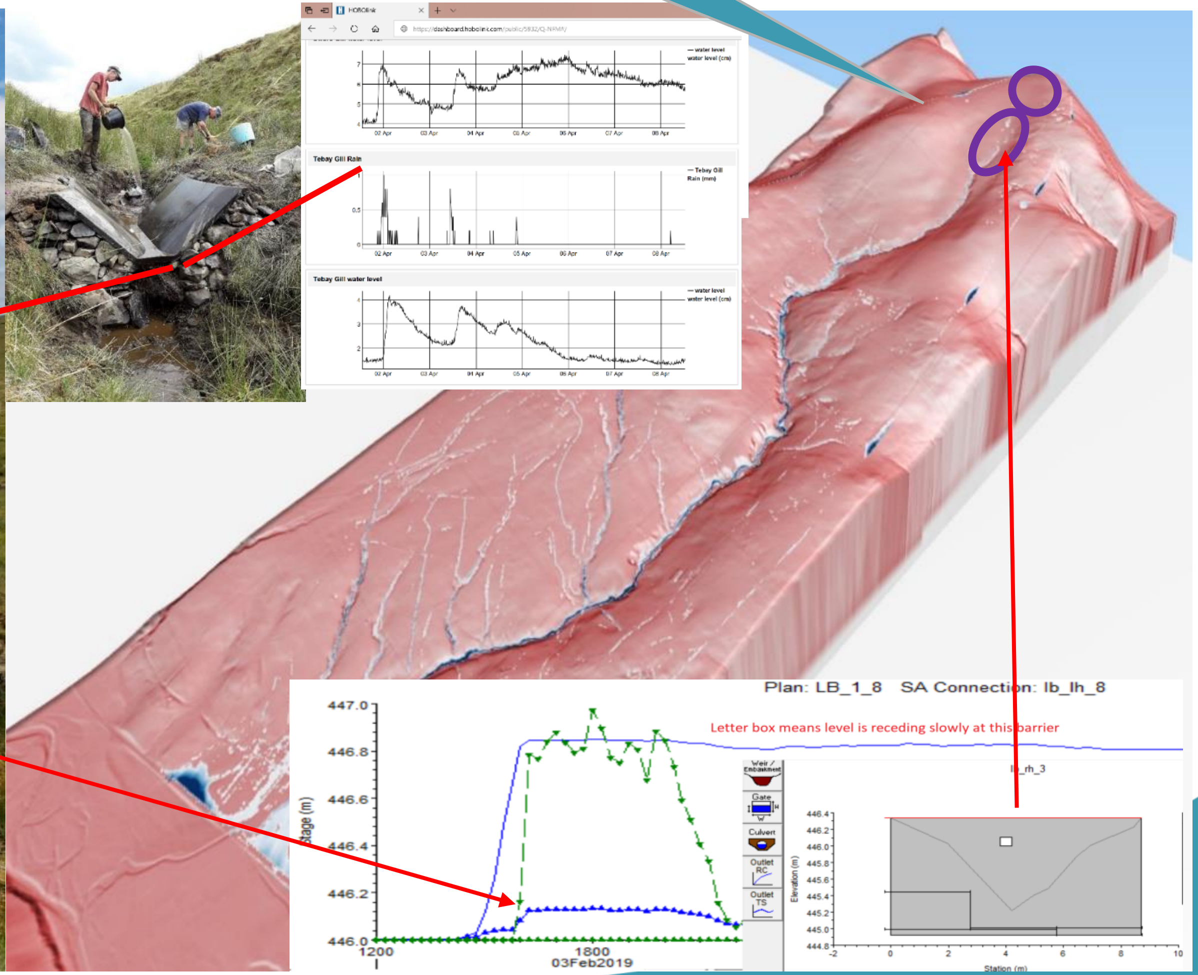


Tebay Gill: Peat restoration and Letterbox leaky barriers

- Thanks to the Cumbria Wildlife Trust

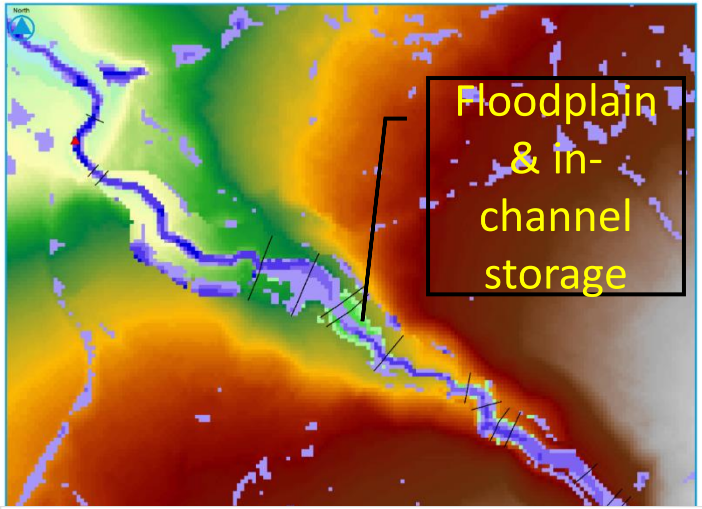
Very coarse DTM based on SAR not good enough so additional surveys undertaken

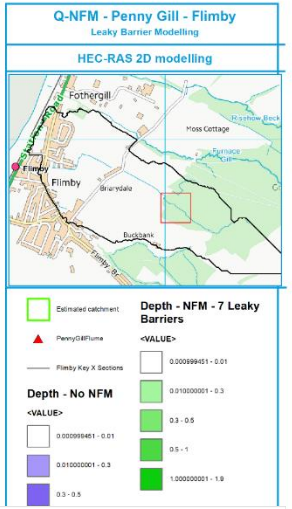


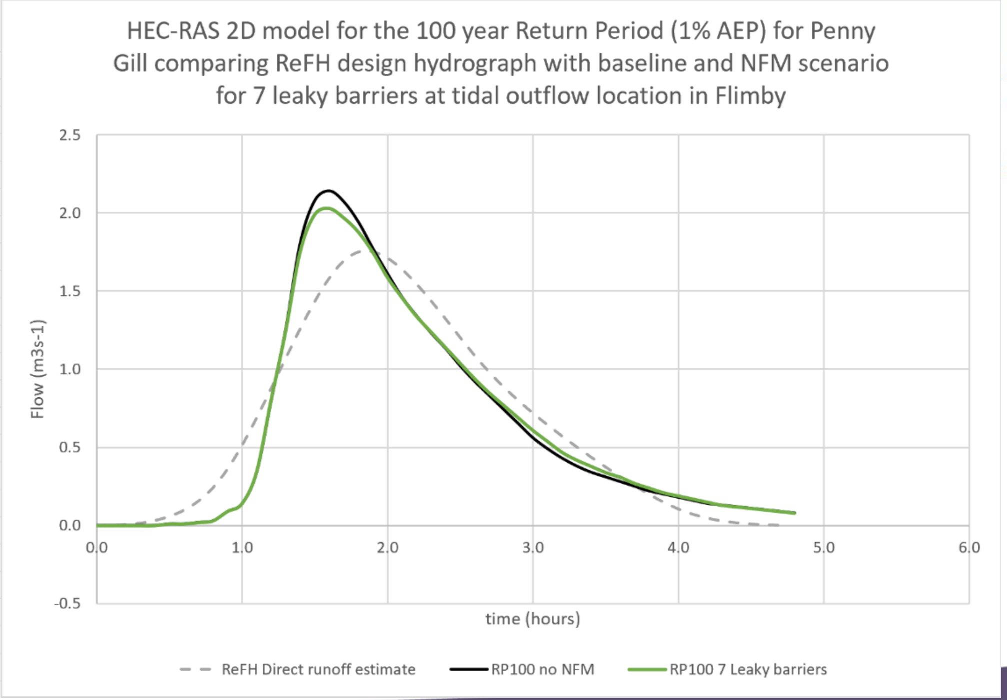
Penny Gill above community at risk Flimby

Modelling so far

- With 8 of 10 Leaky Barriers modelled (without the in-river logs) we initially estimated 5% change downstream at Flimby (larger change at flume)
- 1% AEP design event







Modelling Issues

- There has been a BIG problem gaining an accurate DTM here.
- Our next step is to include all features and calibrate once there is a big calibration event
- We also collaborated to investigate performance and provide guidance on siting leaky barriers in a larger system

Landowner

West Cumbria Rivers Trust

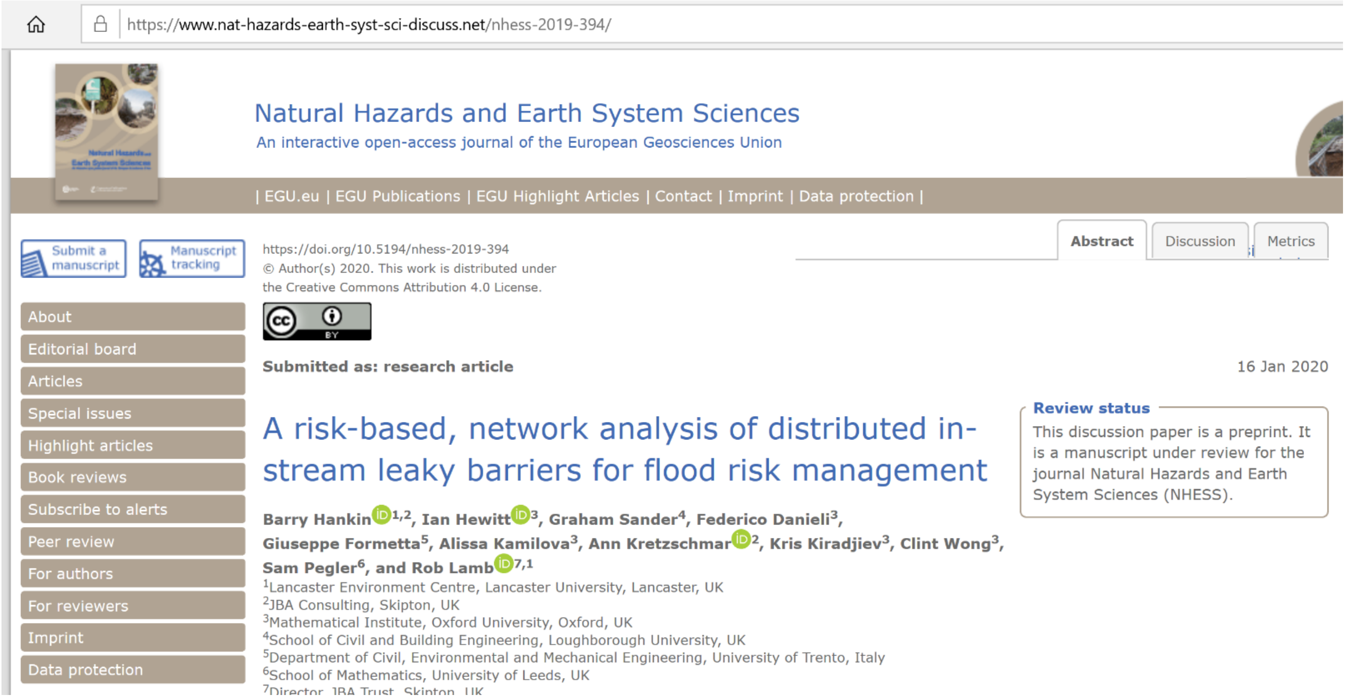
Caring for our Lakes and Rivers

Understanding performance

We teamed up with Maths Foresees network and highlighted some useful rules:

- Avoid siting of leaky-barriers on main stem unless mitigations such as engineered log jams
- Seek areas of lower slope and wide channel rather than putting in lots of barriers in

https://doi.org/10.5194/nhess-2019-394



https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-394/

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Submitted as: research article — 16 Jan 2020

A risk-based, network analysis of distributed in-stream leaky barriers for flood risk management

Barry Hankin[1,2], Ian Hewitt[3], Graham Sander[4], Federico Danieli[3], Giuseppe Formetta[5], Alissa Kamilova[3], Ann Kretzschmar[2], Kris Kiradjiev[3], Clint Wong[3], Sam Pegler[6], and Rob Lamb[7,1]

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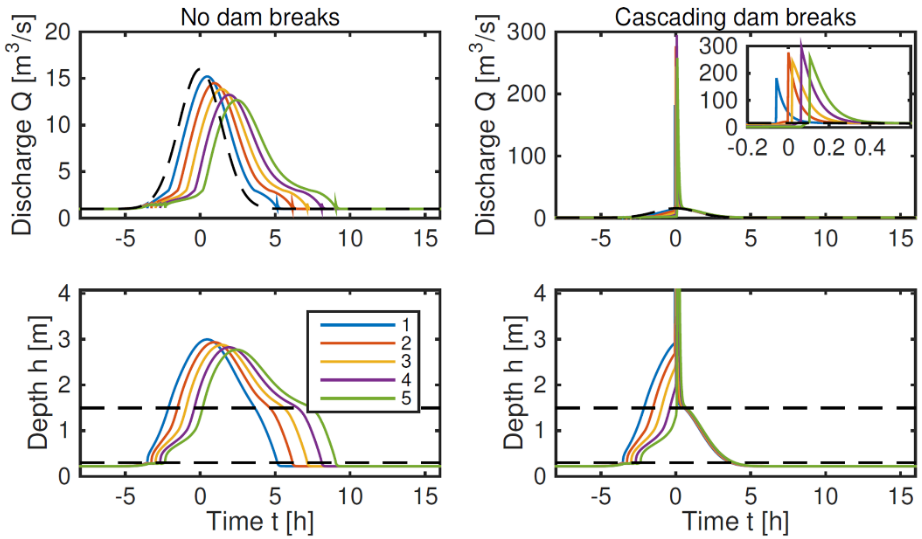
[7]Director, JBA Trust, Skipton, UK

Review status
This discussion paper is a preprint. It is a manuscript under review for the journal Natural Hazards and Earth System Sciences (NHESS).



Applying the network model to Penny Gill

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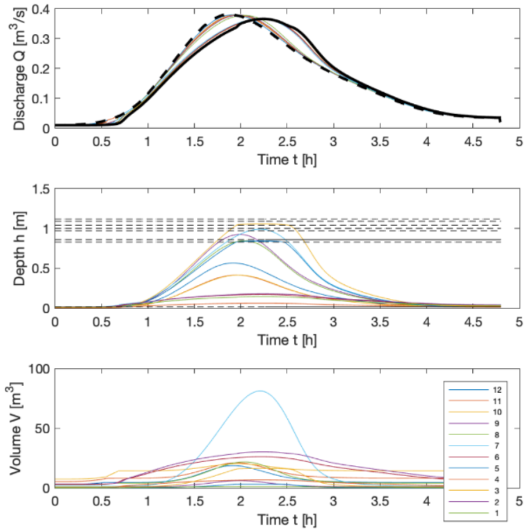
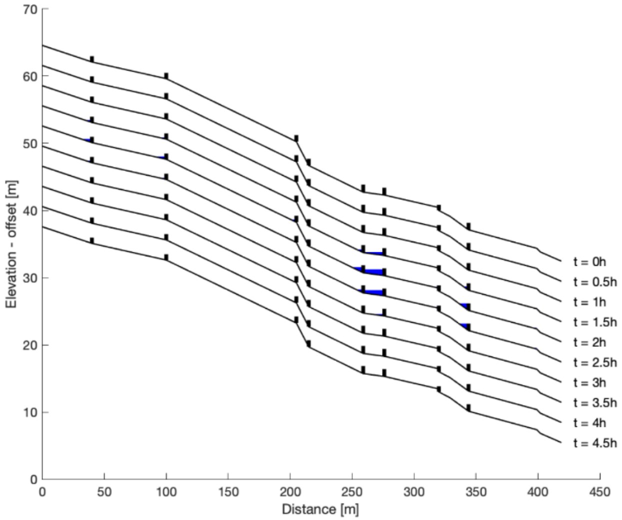
Simulations

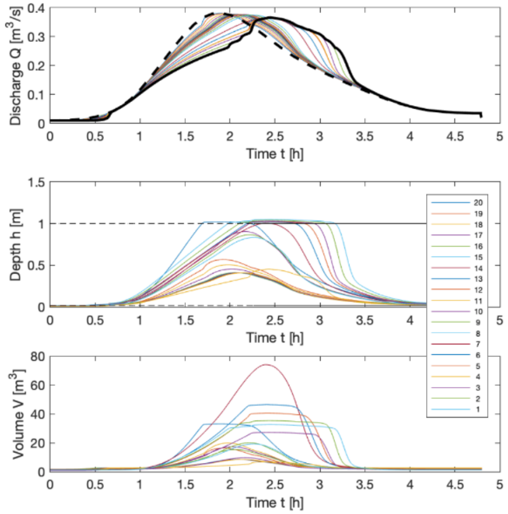
Current dam positions
245m^3 stored, 4% reduction

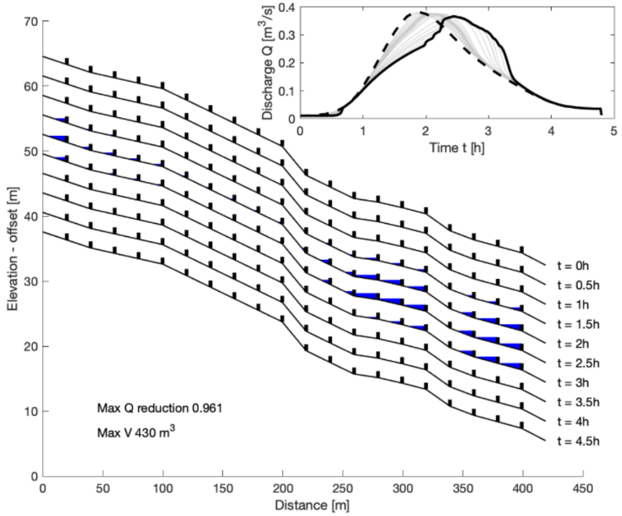




20 dams
457m^3 stored 3% reduction

A lot more work, more storage but not necessarily as good performance!





With thanks to Prof Ian Hewitt, University of Oxford

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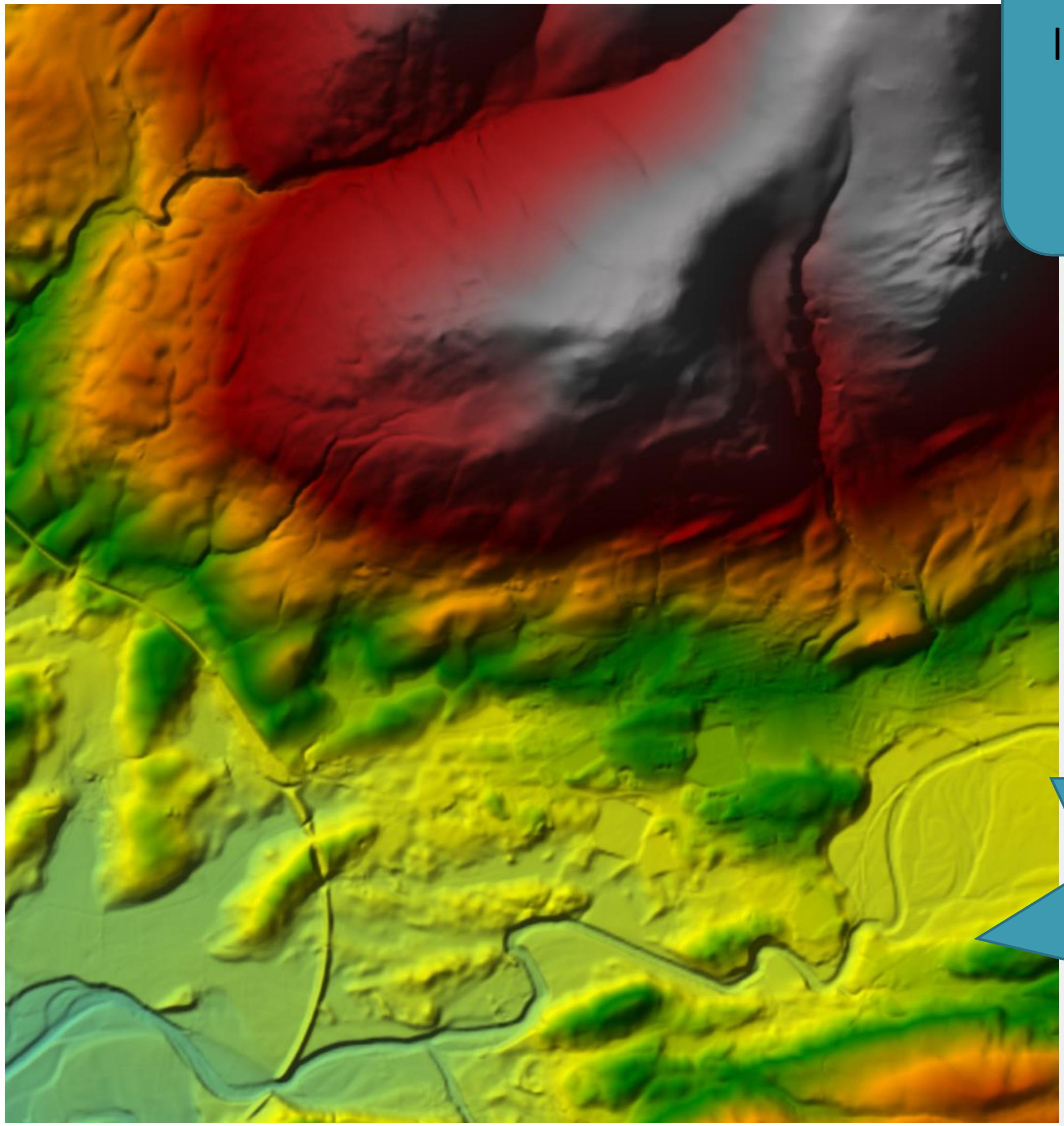
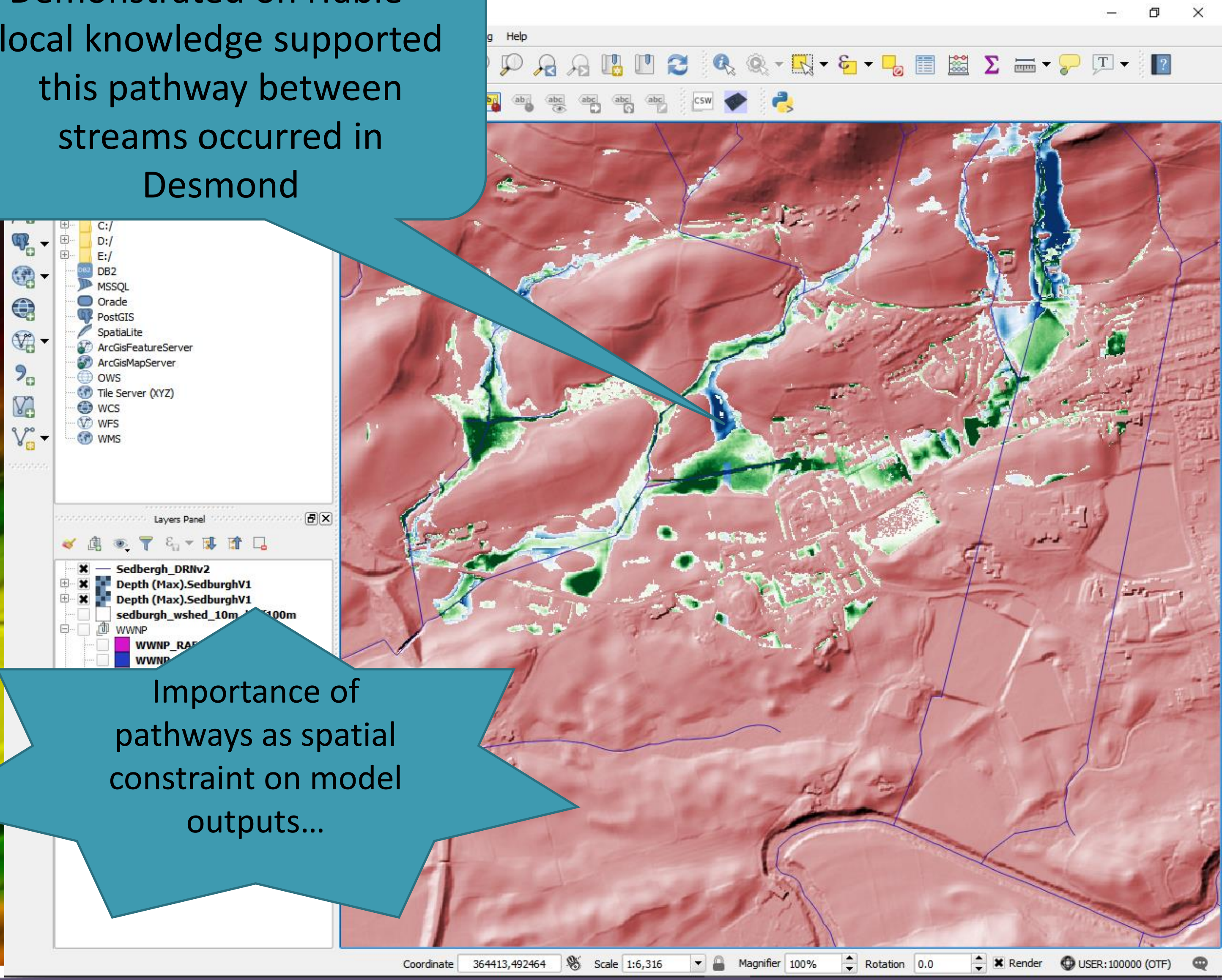
Sedbergh (community at risk)



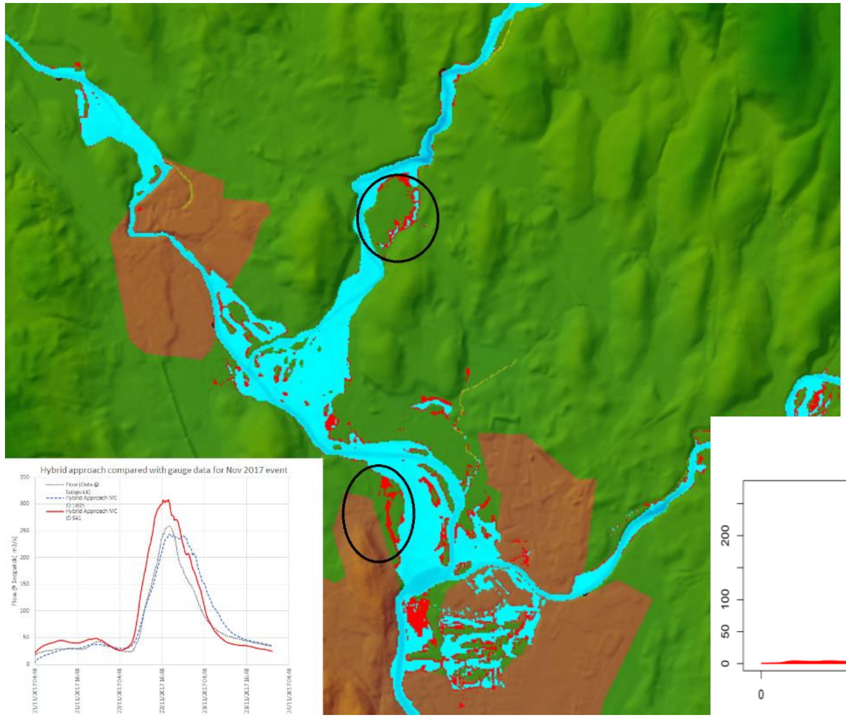


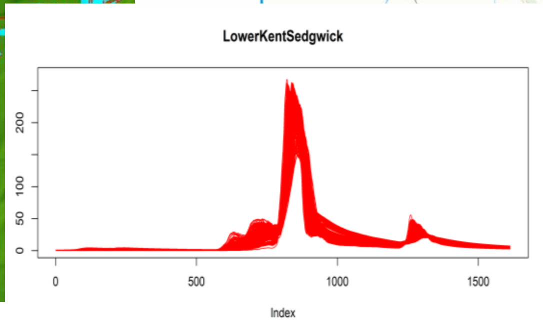
Demonstrated on iTable – local knowledge supported this pathway between streams occurred in Desmond

Importance of pathways as spatial constraint on model outputs…

Future work: Scaling up and macro-scale constraints (future work)

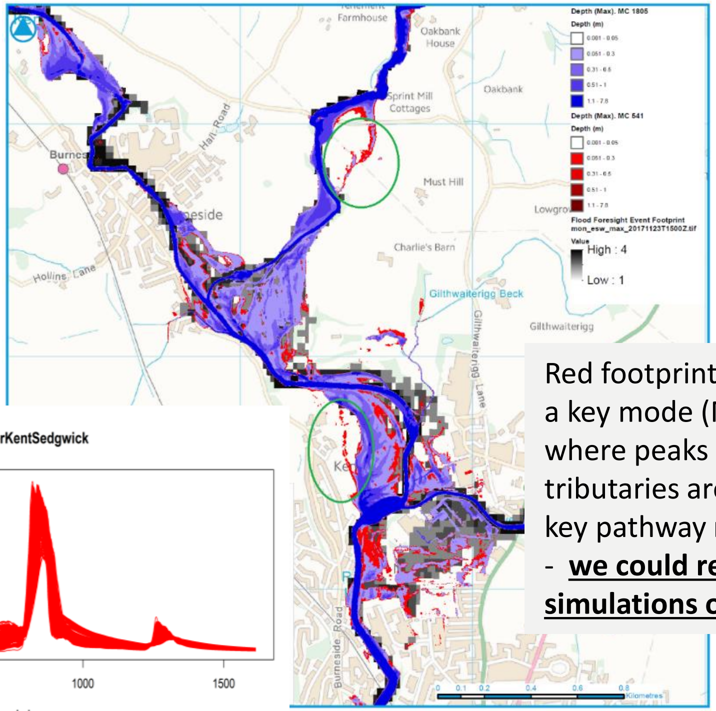
Add constraints based on spatial evidence





Ensemble predictions

Comparing with a surrogate for satellite Flood Foresight* flood event footprint



Red footprint comes from a key mode (MC 541) where peaks on all tributaries are high – but key pathway not observed - **we could reject 27 simulations or 10%**

Presented at EGU 2019

- **Key modes used to drive HEC-RAS 2D model and pattern of flooding assessed**
- **Accept or reject clusters of simulations based on remotely sensed spatial patterns**

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THANKS!

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