With a research output that rivals that of most universities, Fathom forms the bridge between academic research and flood risk technology.

All of our research is published in the world's leading academic journals and can be accessed for free online. You can find all of our papers on our website at www.fathom.global/research-papers.

Increased population exposure to Amphan-scale cyclones under future climates. *Climate Resilience and Sustainability.* Mitchell, D., Hawker, L., Savage, J., Bingham, R., Lord, N., Khan, J., Bates, P., Durand, F., Hassan, A., Huq, S., Islam, A., Krien, Y., Neal, J., Sampson, C., Smith, A., Testut, L.

In 2020 Cyclone Amphan made landfall in the Bay of Bengal and was the first super tropical cyclonic storm to occur in the area in over 20 years. This paper explores what would happen if this event were to occur in the future, asking: would the risks associated with it change? Access the paper here.

A 30 m global map of elevation with forests and buildings removed. *IOP Science* Hawker, L**.,** Uhe, P.,Paulo, L.,Sosa, J.,Savage, J.,Sampson, C.,Neal, J. C2022

A new complete map of the Earth's terrain that is shown to be more accurate than existing global elevation datasets.

Following public release of the Copernicus GLO-30 DEM last year, lead researchers from the University of Bristol and Fathom have used machine learning to remove buildings and forests from the Copernicus Digital Elevation Model. This has produced, for the first time, a global map of elevation with buildings and forests removed at 1 arc second (~30 m) grid spacing.

Inequitable patterns of US flood risk in the Anthropocene. *Nature Climate Change.* Wing, O., Lehman, W., Bates, P., Sampson, C., Quinn, N., Smith, A., Neal, J., Porter, J., Kousky, C. 2022.

Climate change could result in the financial toll of flooding rising by more than a quarter in the United States by 2050 – and disadvantaged communities will bear the biggest brunt, according to new research. Access the paper here.

Flood inundation prediction. *Annual Review of Fluid Mechanics.* Bates, P. 2022.

This review surveys recent progress made to address fundamental issues surrounding globally consistent mapping of flood hazard in underdeveloped countries. This is achieved through a novel combination of appropriate physics, efficient numerical algorithms, high-performance computing, new sources of big data, and model automation frameworks. Access the paper here.

Voluntary purchases and adverse selection in the market for flood insurance. *Journal of Environmental Economics and Management*. Bradt, J., Kousky, C., Wing, O. 2021.

Insurance is mandatory for those residing in FEMA flood zones with a federally-backed mortgage. Less understood is what motivates people to voluntarily obtain flood insurance in areas outside these zones. In a wide-ranging analysis in collaboration with Jacob Bradt (Harvard) and Carolyn Kousky (Wharton), we find voluntary insurance purchases are preferentially taking place in areas where Fathom's model deviates from FEMA flood maps. This implies that our model is correctly identifying places at risk which FEMA misses, and that people have pretty good understanding (or, at least, better than the NFIP) of their local flood risk, leading to 'adverse selection' in the programme. Access paper here.

Causes, impacts and patterns of disastrous river floods. *Nature Reviews Earth & Environment*. Merz, B., Blöschl, G., Vorogushyn, S., Dottori, F., Aerts, J., Bates, P., Bertola, M., Kemter, M., Kreibich, H., Lall, U., Macdonald, E. 2021.

This research reviews over 200 papers investigating the causes and impacts of disastrous river flooding, and their past and projected trends. Access paper here.

Environmental Impact Bonds: a common framework and looking ahead. *Environmental Research: Infrastructure and Sustainability, 1*. Brand, M., Quesnel, K., Saksa, P., Ulibarri, N., Bomblies, A., Mandle, L., Allaire, M., Wing, O., Tobin-de la Puente, J., Parker E. 2021.

Environment Impact Bonds (EIBs) are in their infancy, yet are increasingly recognised as a funding solution to tackle the world's most pressing environmental challenges. Our contribution, alongside colleagues at The Nature Conservancy, discusses how recent developments to flood models at scale can help to inform both the principal and the repayment interest rate for flood mitigation projects, such as floodplain conservation. Access paper here.

Attributable human-induced changes in the magnitude of flooding in the Houston, Texas region during Hurricane Harvey. *Climate Change,* 166. Wehner, M., Sampson, C. 2021.

Using Fathom's US flood model to examine how climate change exacerbated the impact of Hurricane Harvey, which devastated Houston in 2017. Access paper here.

Flood exposure and social vulnerability in the United States. *Natural Hazards*, 106. Tate, E., Rahman, M.A., Emrich, C.T., Sampson, C.C. 2021.

This study explores the geography of flood exposure and social vulnerability in the conterminous United States, and finds racial minorities and mobile-home occupiers in rural Southern communities to be over-represented where exposure and social vulnerability converge. Access paper here.

Combined modeling of US fluvial, pluvial, and coastal flood hazard under current and future climates. *Water Resources Research*, 57. Bates, P., Quinn, N., Sampson, C., Smith, A., Wing, O., Sosa, J., Savage, J., Olcese, G., Neal, J., Schumann, G., Giustarini, L., Coxon, G., Porter, J., Amodeo, M., Chu, Z., Lewis-Gruss, S., Freeman, N., Houser, T., Delgado, M., Hamidi, A., Bolliger, I., McCusker, K., Emanuel, K., Ferreira, C., Khalid, A., Haigh, I., Couasnon, A., Kopp, R., Hsiang, S., Krajewski, W. 2021.

Paper describing our most recent iteration of the US model, covering inland and coastal flooding across multiple time horizons. Access paper here.

Simulating historical flood events at the continental scale: observational validation of a large-scale hydrodynamic model. *Natural Hazards and Earth System Sciences,* 21. Wing, O.E., Smith, A.M., Marston, M.L., Porter, J.R., Amodeo, M.F., Sampson, C.C., Bates, P.D. 2021.

This paper discusses the challenges of using observed historical flood events to validate large-scale models due to the limitations inherent in the observed data itself. Access paper here.

Toward global stochastic river flood modeling. *Water Resources Research*, 56. Wing, O., Quinn, N., Bates, P., Neal, J., Smith, A., Sampson, C., Coxon, G., Yamazaki, D., Sutanudjaja, E., Alfieri, L. 2020.

In this paper we explore the applicability of global hydrological models to the problem of defining spatial correlation between catchments at the global scale. Access paper here.

New insights into US flood vulnerability revealed from flood insurance big data. *Nature Communications*, 11. Wing, O., Pinter, N., Bates, P., Kousky, C. 2020.

Nature Comms paper describing our work on flood vulnerability functions using >2 million NFIP claims. Access paper here.

Increased Flood Exposure Due to Climate Change and Population Growth in the United States. *Earth's Future*, 8. Swain, D.L., Wing, O.E.J., Bates, P.D., Done, J.M., Johnson, K.A., Cameron, D.R. 2020.

In this paper we explore projected future changes to flood exposure due to anthropogenic climate change and population growth. Access paper here.

A New Automated Method for Improved Flood Defense Representation in Large-Scale Hydraulic Models. *Water Resources Research*, 55. Wing, O., Bates, P., Neal, J., Sampson, C., Smith, A., Quinn, N., Shustikova, I., Domeneghetti, A., Gilles, D., Goska, R., Krajewski, W. 2019.

Paper describing our new automated method of extracting levees from high resolution terrain models. Access paper here.

The Spatial Dependence of Flood Hazard and Risk in the United States. *Water Resources Research*, 55. Quinn, N., Bates, P., Neal, J., Smith, A., Wing, O., Sampson, C., Smith, J., Heffernan, J. 2019.

A paper describing our method for simulating the spatial dependence of realistic flood events across the USA. Access paper here.

A flood inundation forecast of Hurricane Harvey using a continental-scale 2D hydrodynamic model. *Journal of Hydrology,* 4. Wing, O., Sampson, C., Bates, P., Quinn, N., Smith, A., Neal, J. 2019.

A paper describing our rapid flood forecasting model, tested against Hurricane Harvey. Access paper here.

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A Nature Comms publication in which we demonstrate the critical importance of having both high resolution hazard and high resolution population data when assessing at-risk populations. Access paper here.

MERIT Hydro: A High-Resolution Global Hydrography Map Based on Latest Topography Dataset. *Water Resources Research,* 55. Yamazaki, D., Ikeshima, D., Sosa, J., Bates, P., Allen, G., Pavelsky, T. 2019. Access paper here.

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Paper describing the optimisation of numerical solvers to further increase the computational efficiency of our simulations Access paper here.

Estimates of present and future flood risk in the conterminous United States. *Environmental Research Letters,* 13. Wing, O., Bates, P., Smith, A., Sampson, C., Johnson, K., Fargione, J., Morefield, P. 2018.

A collaboration with the US EPA and The Nature Conservancy to show that: a) previous estimates have significantly underestimated exposure of US population to flood risk; and b) that population and GDP growth are likely to cause this to further increase in future. Access paper here.

Validation of a 30 m resolution flood hazard model of the conterminous United States. *Water Resources Research,* 53. Wing, O., Bates, P., Sampson, C., Smith, A., Johnson, K., Erickson, T. 2017.

The first peer-reviewed validation of a continental-scale, high-resolution flood hazard model; this paper won the prestigious AGU Editors' Choice Award in 2018. Access paper here.

A high-accuracy map of global terrain elevations. *Geophysical Research Letters,* 44. Yamazaki, D., Ikeshima, D., Tawatari, R., Yamaguchi, T., O'Loughlin, F., Neal, J., Sampson, C., Kanae, S., Bates, P. 2017.

A significant set of systematic improvements to the SRTM terrain dataset produced by a project led by our colleague in Japan, Dai Yamazaki. Access paper here.

Rethinking flood hazard at the global scale. *Geophysical Research Letters,* 43. Schumann, G., Stampoulis, D., Smith, A., Sampson, C., Andreadis, K., Neal, J., Bates, P. 2016.

The first continuous long-term (1973-2012) high resolution simulation of river flow and flooding at the continental scale. Access paper here.

A high-resolution global flood hazard model. *Water Resources Research*, 51. Sampson, CC, Smith, AM, Bates, PB, Neal, JC, Alfieri, L & Freer, JE. 2015.

The paper describes the architecture of our Global Flood Model and validates its performance against local data. Access paper here.

Regional flood frequency analysis at the global scale. *Water Resources Research,* 51. Smith, A., Sampson, C., Bates, P. 2015.

This paper describes our method for estimating extreme river flows anywhere on Earth. Access paper here.

The impact of uncertain precipitation data on insurance loss estimates using a flood catastrophe model. *Hydrology and Earth Systems Sciences,* 18. Sampson, C., Fewtrell, T., O'Loughlin, F., Pappenberger, F., Bates, P., Freer, J., Cloake, H., 2014

A paper describing the wide variety of CAT model results produced simply by differing the input rainfall data source. Access paper here.

Investigating the application of climate models in flood projection across the UK. *Hydrological Processes*, 28. Smith, A, Bates, P, Freer, J & Wetterhall, F. 2014.

A paper describing the challenges and uncertainties associated with the linking of climate models to flood models to assess future flood risk. Access paper here.

Probabilistic flood risk mapping including spatial dependence. *Hydrological Processes,* 27. Neal, J., Keef, C., Bates, P., Beven, K., Leedal, D. 2013.

A paper describing the characterisation and stochastic simulation of flood events on three converging rivers while considering the spatial dependence (i.e. correlation) of each river with its neighbours. Access paper here.

A simple inertial formulation of the shallow water equations for efficient two dimensional flood inundation modelling. *Journal of Hydrology,* 387. Bates, P., Horritt, M., Fewtrell, T. 2010.

A hugely influential paper that describes a new mathematical formulation of the equations used to describe the flow of water within 2D flood models such as LISFLOOD-FP. This reduced the time required to simulate a flood event on a computer by an order of magnitude and allowed the concept of high resolution continental and global scale models to be considered for the first time. This paper led to Professor Paul Bates being awarded the 'Science of Risk' prize by the Lloyds insurance market in 2012. Access paper here.