Environmental Research Letters

OPEN ACCESS

RECEIVED
31 October 2017

REVISED
23 January 2018

ACCEPTED FOR PUBLICATION
1 February 2018

PUBLISHED
28 February 2018

LETTER

Estimates of present and future flood risk in the conterminous United States

Oliver E J Wing[1,2,5], Paul D Bates[1,2], Andrew M Smith[1,2], Christopher C Sampson[1,2], Kris A Johnson[3], Joseph Fargione[3] and Philip Morefield[4]

[1] School of Geographical Sciences, University of Bristol, Bristol, BS8 1SS, United Kingdom
[2] Fathom, Engine Shed, Station Approach, Bristol, BS1 6QH, United Kingdom
[3] The Nature Conservancy, 1101 West River Parkway Suite 200, Minneapolis, MN 55415, United States of America
[4] US Environmental Protection Agency, National Center for Environmental Assessment, 1200 Pennsylvania Avenue, NW Washington, DC 20460, United States of America
[5] Author to whom any correspondence should be addressed.

E-mail: oliver.wing@bristol.ac.uk

Keywords: flood risk, large-scale flood models, flooding, USA

Supplementary material for this article is available online

Abstract

Past attempts to estimate rainfall-driven flood risk across the US either have incomplete coverage, coarse resolution or use overly simplified models of the flooding process. In this paper, we use a new 30 m resolution model of the entire conterminous US with a 2D representation of flood physics to produce estimates of flood hazard, which match to within 90% accuracy the skill of local models built with detailed data. These flood depths are combined with exposure datasets of commensurate resolution to calculate current and future flood risk. Our data show that the total US population exposed to serious flooding is 2.6–3.1 times higher than previous estimates, and that nearly 41 million Americans live within the 1% annual exceedance probability floodplain (compared to only 13 million when calculated using FEMA flood maps). We find that population and GDP growth alone are expected to lead to significant future increases in exposure, and this change may be exacerbated in the future by climate change.

Introduction

In 2016, global economic losses as a result of flooding totalled $56bn (all values are 2017 USD), with $10bn of this accounted for by the August floods in Mississippi and Louisiana alone [1]. In the US over the past 30 years, freshwater flooding has caused an average of $8.2bn in damages each year, though this average masks an upward trend in flood losses over time [2–4]. This is also the case globally, with the major driver thought to be the increased exposure of people and assets [5, 6].

The Federal Emergency Management Agency (FEMA) has produced maps delineating the Special Flood Hazard Area for nearly all current coastal flood hazard areas in the US, and rigorous estimates have been published indicating how many people are exposed and how exposure is distributed nationally [7, 8]. Maps delineating fluvial (riverine) and pluvial (rainfall-driven) flooding, however, are only partially complete nationwide, and no comprehensive estimate of US population exposure currently exists. Where they are available, FEMA flood maps are of varying age and levels of quality. They also have notably poor coverage of smaller catchments, which is a trait shared by many of the hazard maps that are used to inform risk calculations at global or continental scales. For example, the framework for flood risk assessments set out by Winsemius *et al* [9] which is the current state-of-the-art in large-scale flood risk analytics [10–13], excludes rivers below Strahler [14] order 6 (catchments smaller than roughly 10 000 km^2). This means that risk generated by these smaller streams, which may be situated in or around residential or commercial areas, is not captured. Further, coarse-resolution terrain data and the simplistic representation of the physics of flood spreading are characteristics shared by a majority of existing large-scale models [15]. It is evident, therefore, that previous large-scale efforts to quantify flood exposure (in terms of population and economic assets)