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US: secondary peril flood and wildfire risks

Climate change is leading to more extreme rainfall in the US, including from hurricanes. This, together with changes to coastal flood risk due to rising sea levels and urbanisation, has raised the profile of flood as a secondary peril. The threat of wildfires has also changed due to several factors: climate change, rising exposure in the wildland-urban interface (WUI), forest management and public utility practices. We maintain our view that long-term insurability of wildfire risk requires appropriate mitigation measures, together with a focus on developing a realistic view of the exposures (e.g. those in the WUI).

Flood risk

Inland

The US is highly exposed to flood risk, from several sources: in coastal states from storm surge, and inland from pluvial flooding (flash and surface water floods) and river flooding. Climate change will likely impact flood risk, and there will be regional differences. Inland river and pluvial flood risks will likely rise significantly due to changing patterns of extreme precipitation. As the atmosphere warms, it can hold more water vapour. This thermodynamic phenomenon, combined with changes in dynamic processes (eg, hurricanes, extratropical cyclones) will affect precipitation extremes. Additionally, if the speed of forward progression of hurricanes slows, as recent research suggests, locally experienced precipitation totals and associated flood risk, are expected to increase.[1]

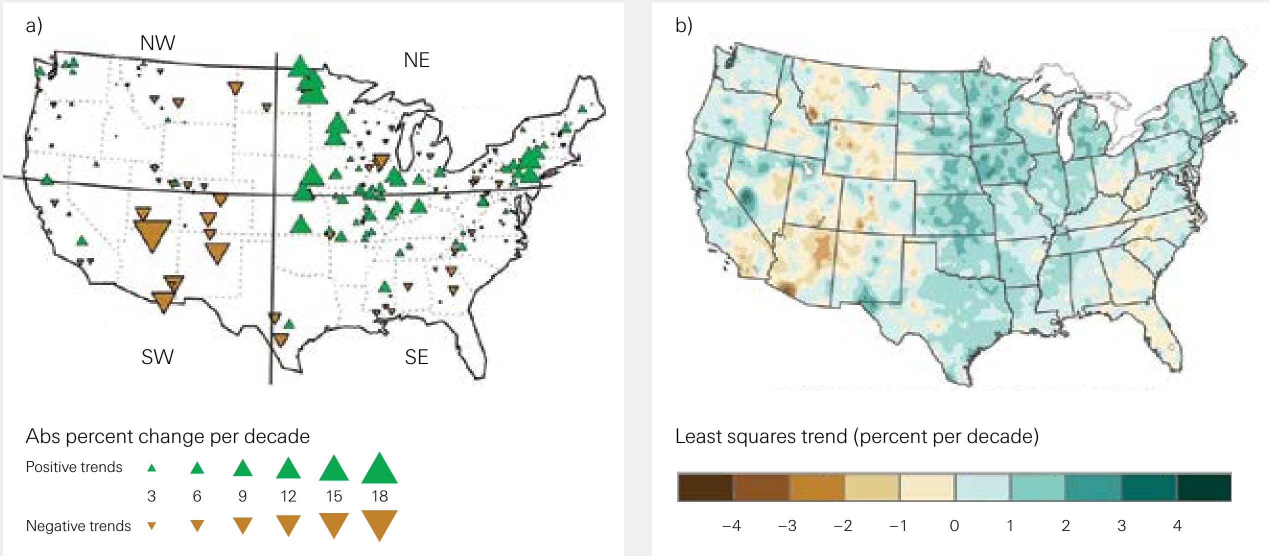
Studies suggest an increase of heavy rains, mainly in the northeast and central US.[2,3] However, trends vary by region, with less heavy rainfall observed in some southern states.[4] Also, changes in precipitation do not directly translate into similar changes in flood intensity due to complex interactions between climate, catchments, rivers and water management practices. This has led to little or no observed change in flood magnitude across most of the US, alongside increased intensity in parts of the Midwest and from the northern Appalachian Mountains to New England, and a decrease in magnitude in the Southwest (see Figure 1).[5] The trends cannot be entirely attributed to climate change: land management practices and long-term cycles likely also contribute to the observed flooding patterns.

1 J. P. Kossin, "A global slowdown of tropical-cyclone translation speed", *Nature*, vol 558, 2018.
2 H. Huang et al., "Total and extreme precipitation changes over the Northeastern United States", *Journal of Hydrometeorology*, vol 18, no 6, 2017.
3 G. Villarini, J.A. Smith and G.A. Vecchi, "Changing frequency of heavy rainfall over the central United States", *Journal of Climate*, vol 26, no1 2013.
4 M. Hoerling et al., "Characterizing recent trends in US heavy precipitation", *Journal of Climate*, vol 29, no 7, 2016.
5 T.C. Peterson et al., "Monitoring and understanding changes in heat waves, cold waves, floods, and droughts in the United States: state of knowledge", *Bulletin of the American Meteorological Society*, vol 94, no 6, 2013.

The expectation is that climate change will lead to more frequent flood events. The annual number of 100-year flood events is forecast to rise by 50% by 2100 under RCP 4.5,[6] and by 150% under RCP 8.5.[7] Regionally, the largest fractional changes in flood frequency are expected to occur in the southern Appalachians and Ohio River Valley, the northern and central Rocky Mountains, and the Northwest, with historical 1-in-100 year flood events becoming 2–5 times more frequent by 2100. In terms of magnitude, there is no spatially coherent trend for the US.[8] However, some models suggest increases in the Missouri River basin and Pacific Northwest. Climate change effects are further exacerbated by other trends, including urbanisation, as highlighted by attribution studies for Hurricane Harvey's flooding.[9]

Figure 1

Geographic distribution of observed 20th century changes in flooding (a), and precipitation (b)



Source: T.C. Peterson, R R. Heim Jr, R. Hirsch et al., "Monitoring and understanding changes in heat waves, cold waves, floods, and droughts in the United States: state of knowledge", Bulletin of the American Meteorological Society, vol 94 (6), 2013.

Coastal

Climate change also impacts coastal flood risk, principally via global warming-induced sea-level rise and changes to the activity of storms associated with surge (eg, changes in hurricane frequency and intensity). Substantial but gradual changes in the probability of extreme storm surge events may take a long time to detect. However, observations of coastal flooding along the east coast over the last century already point to an increase in risk.[10] Increased coastal flood risk can also compound river flood risk: there is evidence to suggest an increase in the number of compound flood events (flooding caused by co-occurring storm surge and heavy rainfall) over the past century at many of the major coastal cities of the US.[11] That includes New York City, where coastal flooding has become more frequent in the past century, with

6 Representative Concentration Pathways (RCP) are time-dependent projections of atmospheric greenhouse gas (GHG) concentrations adopted by the IPCC to represent several scenarios.
7 C. Wobus et al., "Climate change impacts on flood risk and asset damages within mapped 100-year floodplains of the contiguous United States", *Natural Hazards & Earth System Sciences*, 2017.
8 N.W. Arnell and S.N. Gosling, "The impacts of climate change on river flood risk at the global scale", *Climatic Change*, no 3, 2016.
9 W. Zhang et al., "Urbanization exacerbated the rainfall and flooding caused by hurricane Harvey in Houston", *Nature*, vol 563, 2018.
10 A. Grinsted, J.C. Moore, and S. Jevrejeva, "Homogeneous record of Atlantic hurricane surge threat since 1923", *Proceedings of the National Academy of Sciences*, vol 109, no 48, 2012.
11 T. Wahl et al., "Increasing risk of compound flooding from storm surge and rainfall for major US cities", *Nature Climate Change*, vol 5, no 12, 2015.

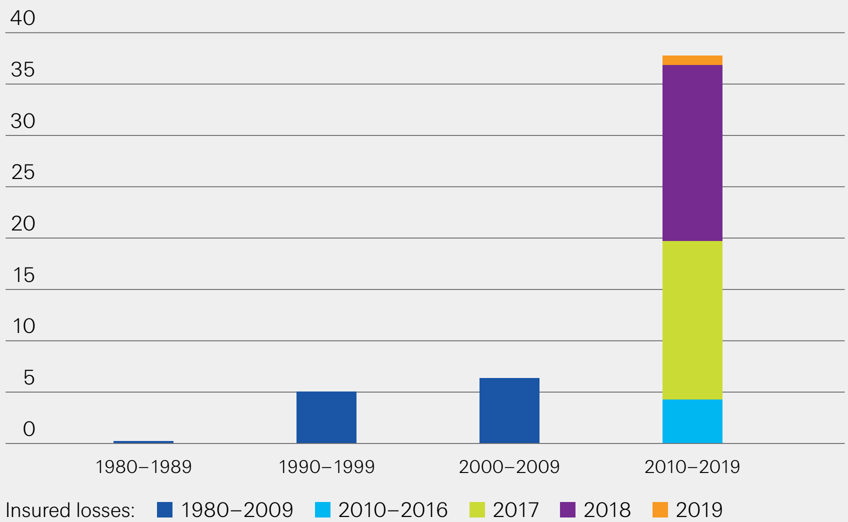
a large contribution from rising sea levels and also more storm surge weather patterns (also associated with high precipitation).

Projections show increases in coastal flood risk for the US, with the largest increases in storm surge damage estimates on the East and Gulf coasts.[12] For the Florida and Gulf coasts, research suggests a median increase in storm surge risk of 25–47% comparing the last two decades of the 20th and 21st centuries under the RCP 4.5 scenario.[13] Under RCP 8.5, the historical 100-year flood level is projected to occur every 1–30 years along the southeast Atlantic and Gulf coasts, and annually in New England and mid-Atlantic region by the end of the century.[14] The relative contribution of tropical cyclone changes to overall changes to coastal flood hazard varies by region. The largest contributions are in the Gulf of Mexico, where the effect is larger than that of sea-level rise for more than 40% of coastal counties. Yet regional differences in coastal flood risk can vary by return period. For example, considering a 50 cm sea-level rise, the increased frequency of historically 1-in-10 year floods is lower in Seattle, WA than Charleston, SC, whereas for 1-in-500 year floods the pattern is reversed.[15]

Wildfire

After two consecutive years of record insured losses from wildfire events in the US, losses from this peril eased in 2019, despite several fire outbreaks. The risk of wildfire is ever present and rising. In the western US, the combination of higher spring and summer temperatures, reduced rainfall in fire seasons, and expansion of the WUI has contributed to the dramatic increase in insured losses. Between 1990 and 2010, the number of houses in the wildland-urban interface grew 41%.[16]

Figure 2
Insured losses from wildfires in the US since 1980 by decade, USD billion (at 2019 prices)



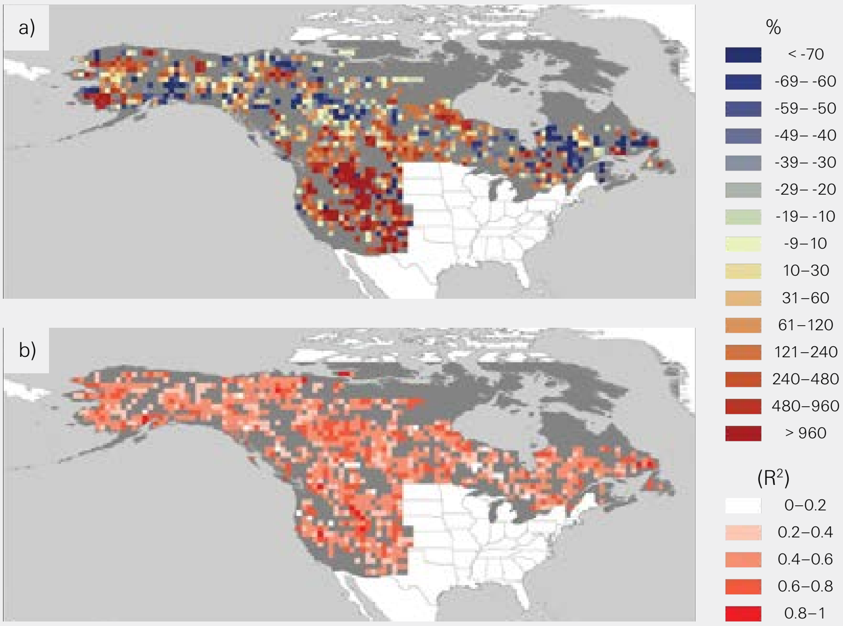
Source: Swiss Re Institute

[12] Neumann, J.E., Emanuel, K., Ravela, S., Ludwig, et. al, "Joint effects of storm surge and sea-level rise on US Coasts: new economic estimates of impacts, adaptation, and benefits of mitigation policy", *Climatic Change*, 129(1-2), 2015.
[13] Balaguru, K., Judi, D.R. and Leung, L.R., "Future hurricane storm surge risk for the US gulf and Florida coasts based on projections of thermodynamic potential intensity," *Climatic Change*, 138(1-2), 2016.
[14] Marsooli, R., Lin, N., Emanuel, K. and Feng, K. "Climate change exacerbates hurricane flood hazards along US Atlantic and Gulf Coasts in spatially varying patterns", *Nature communications*, 10(1), 2019.
[15] M.K. Buchanan, M. Oppenheimer, and R.E., Kopp, "Amplification of flood frequencies with local sea level rise and emerging flood regimes", *Environmental Research Letters*, vol 12, no6 2017,
[16] V. C. Radeloff et al., "Rapid growth of the US wildland-urban interface raises wildfire risk", *Proceedings of the National Academy of Sciences*, vol 115, no 13, 2018.

Human-induced climate change is fuelling increased wildfire risk, particularly in the western US where the average annual forest fire area burned doubled beyond that expected from natural climate variability alone during the period 1984–2015.[17] This region has experienced a tripling of the number of homes burned by wildfire over the past decades.[18] In California, the annual area burned has increased fivefold since the early 1970s.[19]

The annual area burned is expected to increase further in the western US.[20] Comparing the periods 1961–2004 and 2010–2039, some of the increases are expected to be in excess of 700% (eg, in Idaho, Montana, New Mexico and Nevada, see Figure 3), whilst the median increases for California are expected to be more moderate (<150%). Yet patterns may vary widely at small spatial scales, due to their dependence on ecosystem characteristics, which can vary substantially at fine scales, and differences in public utility practices.

Figure 3
Projected changes in Annual Area Burnt (AAB)



Note: Projection rates are for the period 2010–2039 compared to the period 1961–2004 based on ensembles of A1B of emission scenarios. (a) Percent of change in AAB resulting from stepwise selection of individual cell-based models, based on AIB model selection criteria; (b) Proportion of variance explained (R2). Only significant models ($p<0.05$) are plotted.Source: T. Kitzberger et.al. "Direct and indirect climate controls predict heterogeneous early-mid 21st century wildfire burned area across western and boreal North America", Plos One, December. 2017

17 J. T. Abatzoglou and A.P. Williams, "Impact of anthropogenic climate change on wildfire across western US forests", *Proceedings of the National Academy of Sciences*, vol 113, no 42, 2016.
18 T. Schoennagel et al., "Adapt to more wildfire in western North American forests as climate changes", *Proceedings of the National Academy of Sciences*, vol 114, no 18, 2017.
19 A.P. Williams et al., "Observed impacts of anthropogenic climate change on wildfire in California", *Earth's Future*, 2019.
20 T. Kitzberger, et al., "Direct and indirect climate controls predict heterogeneous early-mid 21st century wildfire burned area across western and boreal North America", *PloS one*, vol 12, 2017.

The increased risk profile of wildfire in the US has proven challenging for insurers. Some insurers have responded to the elevated risk by increasing rates, dropping coverage or attempting to mitigate the risk by providing services such as private fire crews. A study in the Sierra Foothills of California found premiums have already been growing faster than those in lower-risk areas: the California Department of Insurance has already cited cases in which premiums have increased by 400%. In response to a reconsideration of their wildfire risk appetite, some insurers have not renewed policies, particularly in higher-risk areas. This prompted imposition of a one-year moratorium on insurers in California in December 2019, to prevent them from dropping customers in or alongside postal codes impacted by recent wildfires.