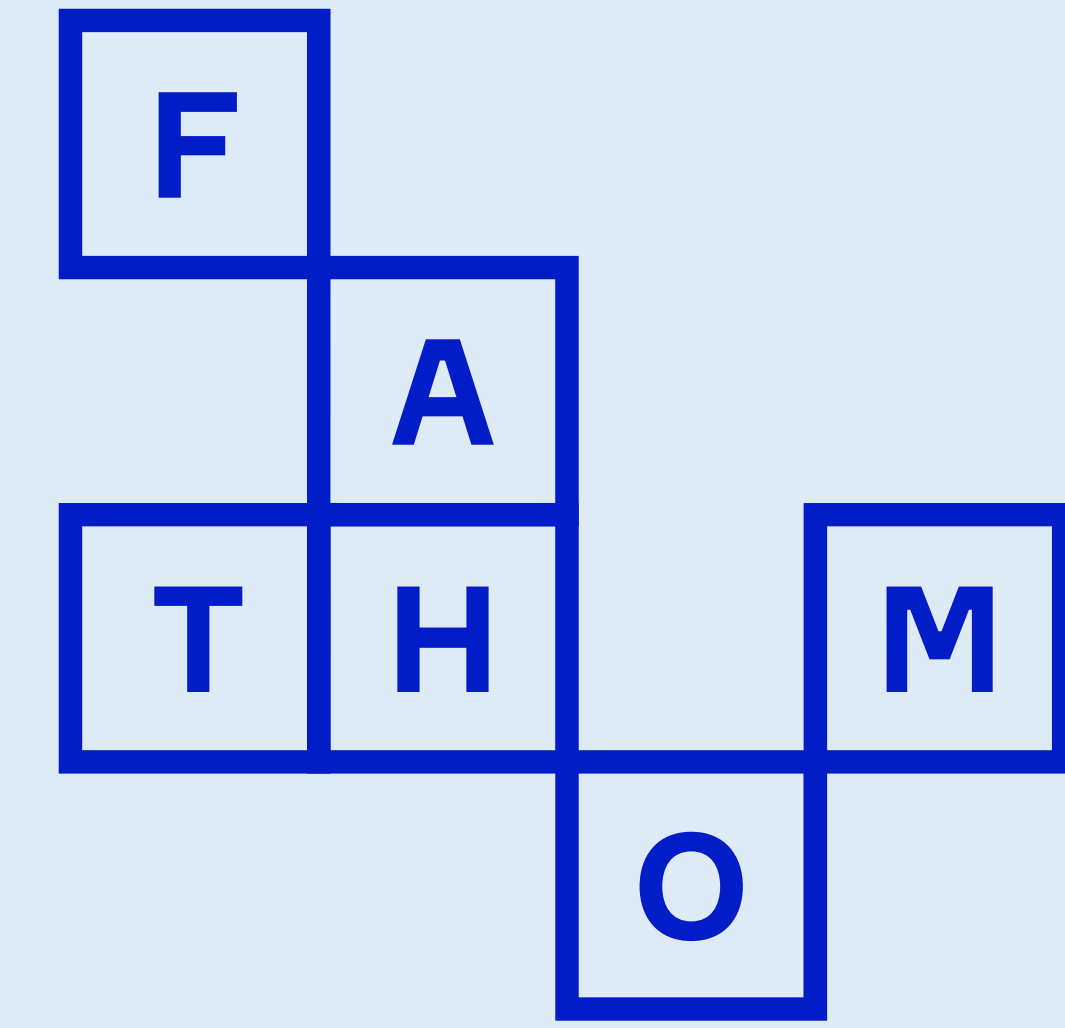


A Comprehensive Review of Coastal Compound Flooding Literature

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Background

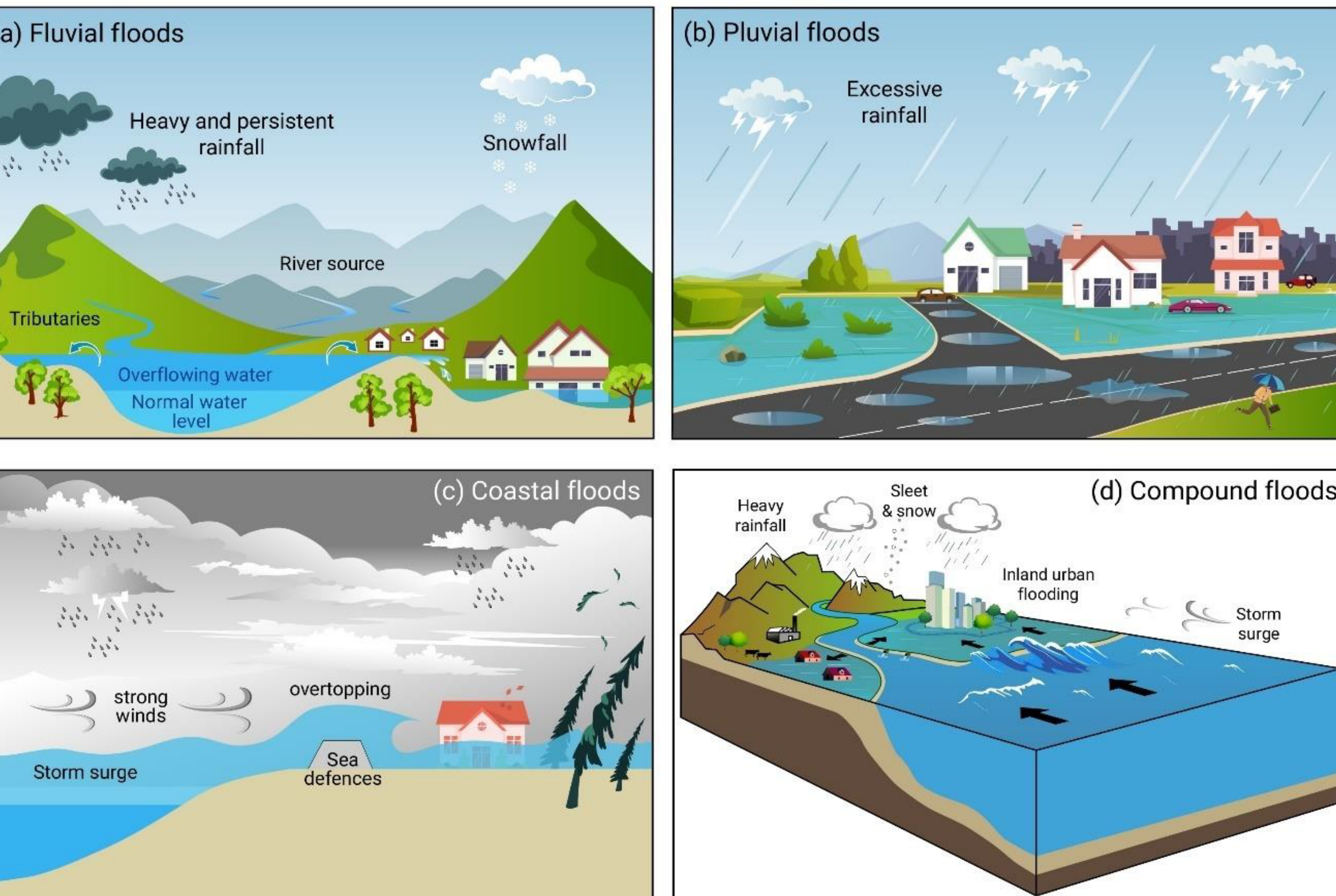
Compound flooding, where the **combination or successive occurrence of two or more flood drivers leads to an extreme impact**, can greatly exacerbate the adverse consequences associated with flooding in coastal regions.

Traditionally, most existing flood risk assessments consider the drivers of flooding separately [1], however the synergy of multiple drivers can result in disproportionately extreme events.

In many coastal and estuarine regions, floods are often caused by more than one driver as the processes are naturally correlated (e.g. storm events)

Compound flooding in coastal regions primarily arises from three main sources:

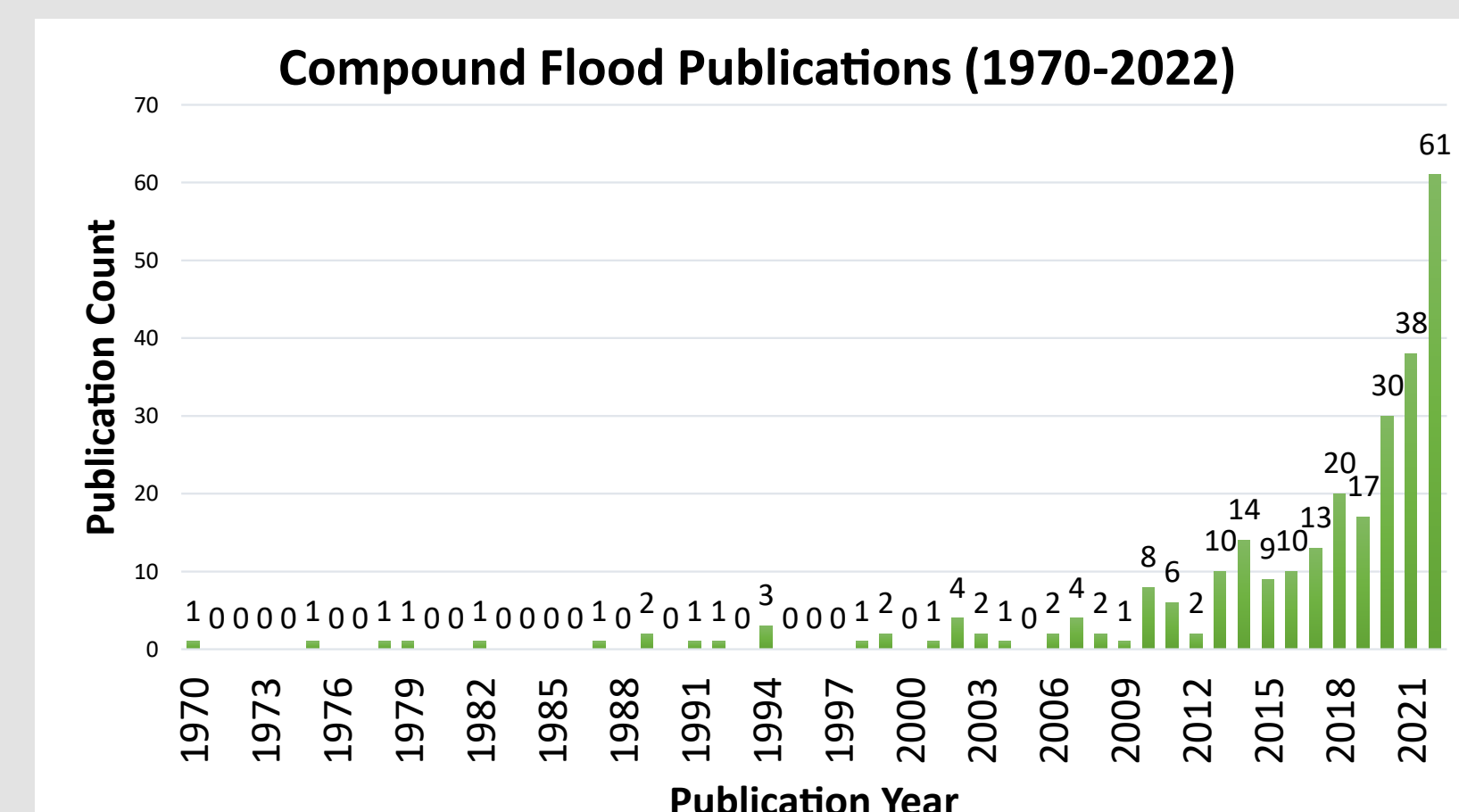
- river discharge (**fluvial**);
- precipitation surface runoff (**pluvial**); and
- coastal oceanographic processes including storm surge, astronomical tides, wave action, and relative sea level rise (SLR) (**coastal**)



Motivations

In recent decades, the field of compound event-based research has experienced considerable development, once formally defined in the 2012 IPCC SREX [2]. Later definitions proposed by Leonard 2014 [3] and Zscheischler 2018 [1] have further driven discussions and adoption of compound event approaches.

Compound flooding research has seen substantial advancements and growing recognition, particularly since 2020. However, to-date, there has been no complete synthesis of the full compound flood research space.



Objectives

We present the first detailed state-of-the-art review of the entire body of compound flood literature.

This paper reviews the practices and trends in coastal compound flood research methodologies and applications, synthesizes key findings at regional and global scales, and considers the influences of climate change and urban environments.

The key objectives of this review are to:

- 1) Survey compound event definitions and terminologies related to compound flooding
- 2) Examine the key physical processes contributing to flood events for individual drivers
- 3) Develop an extensive compound flood literature database
- 4) Identify trends in the characteristics of compound flood research
- 5) Synthesize the key findings, considerations, and practices of compound flood research
- 6) Reflect on the knowledge gaps and directions for future research

Methodology & Literature Database

This review involved the development of a database of 271 English-written scientific papers on compound flood research up until the year 2022.

Systematic review approaches involving academic search engines and bibliographic mapping tools were used to source potential compound flood literature

Content analysis was employed to select appropriate literature that:

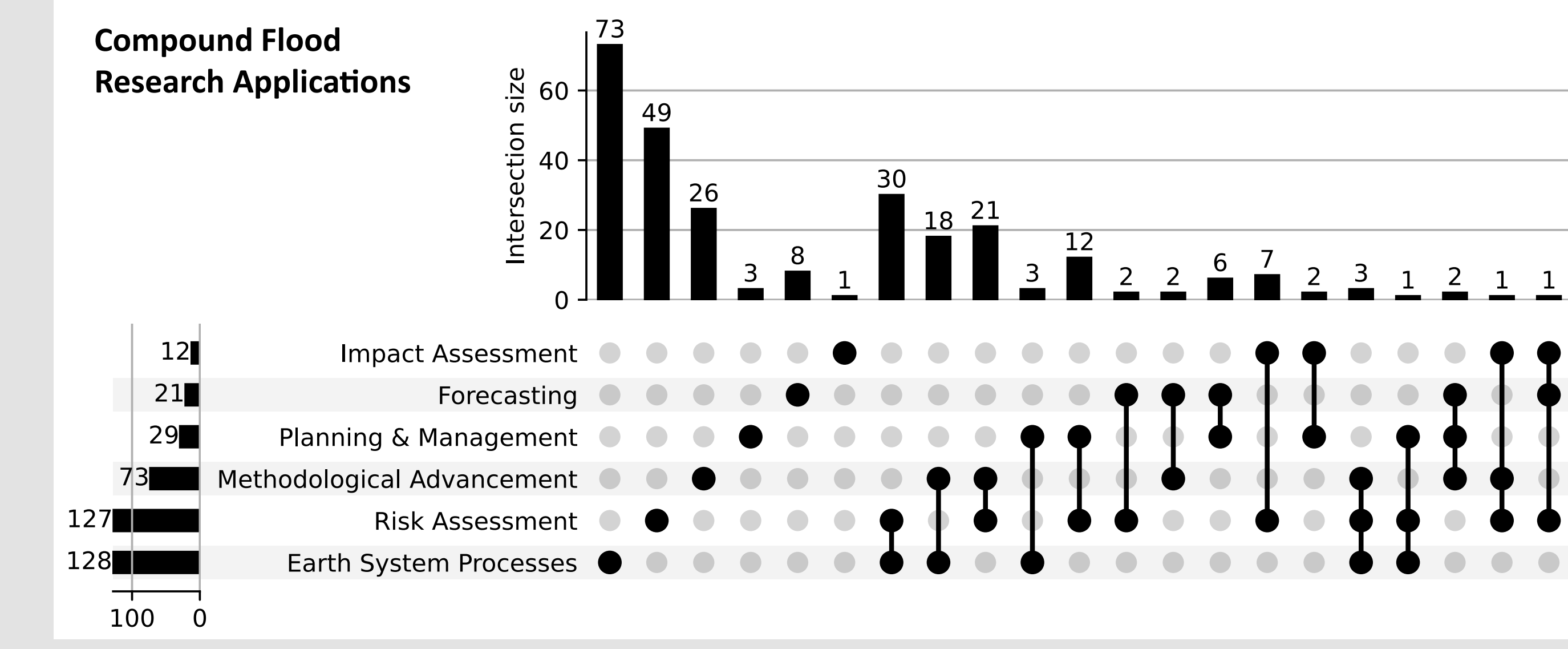
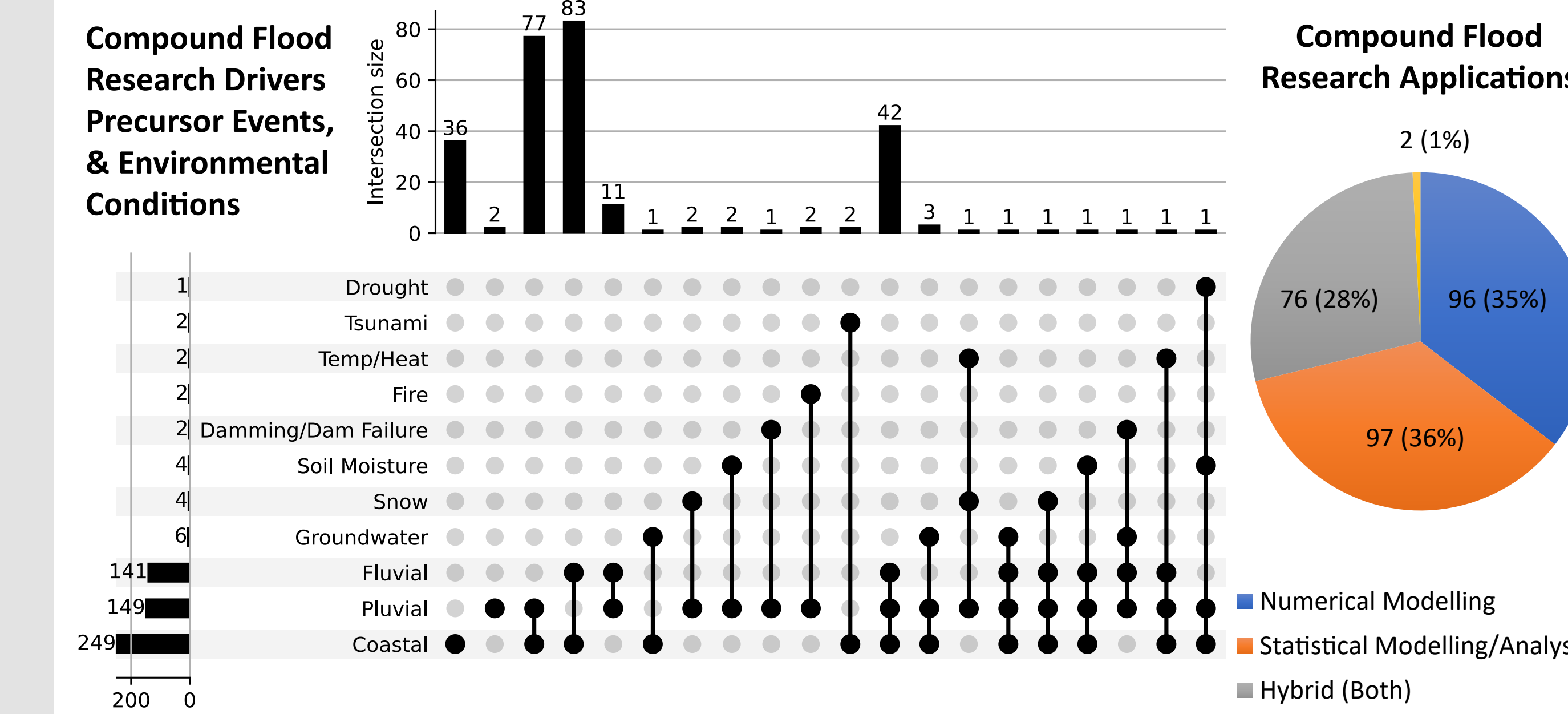
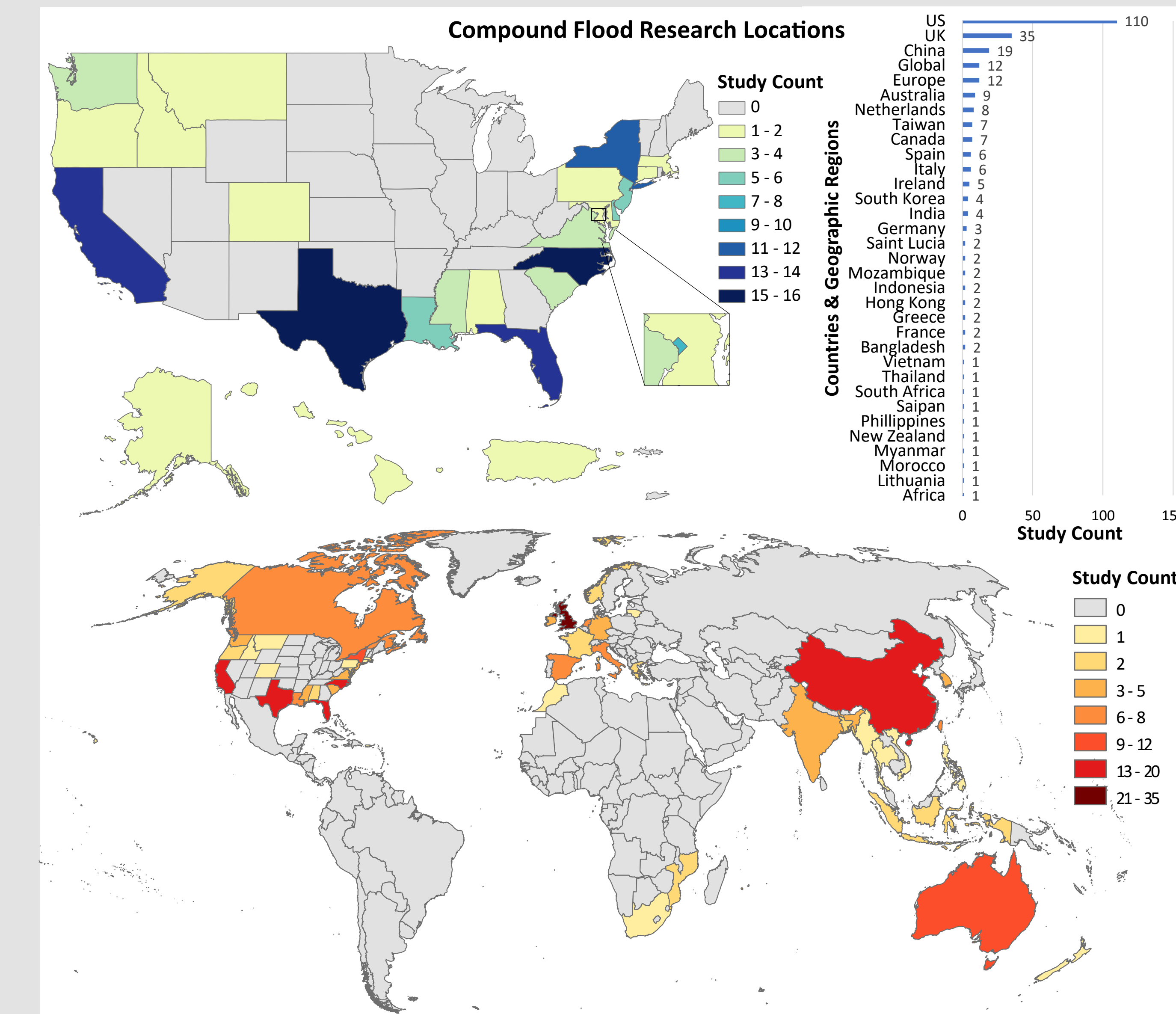
- 1) focus primarily on compound flooding; and
- 2) involve multivariate statistical analysis and/or numerical modelling (or discussion) of two or more flood drivers, precursor events, or environmental conditions, one of which being a main flood driver (i.e., fluvial, pluvial, coastal).

Appropriate research papers were added to the database and categorized according to:

- case study geographic scope
- case study scenario
- flood drivers, precursor events, and/or environmental conditions considered
- research approach
- research application

Flood Drivers	Precursor Events, & Environmental Conditions	Research Applications	Research Approaches
Coastal	Soil Moisture	Earth System Processes	Numerical Modelling
Pluvial	Snow	Risk Assessment	Statistical Modelling
Fluvial	Fire	Planning & Management	
Groundwater	Drought		
Damming/Dam Failure	Temp/Heat	Impact Assessment	Hybrid (Both)
Tsunami		Methodological Advancement	

Results



Key Findings

- **Global compound flood hotspots** and regions with flood driver dependence include: the US East Coast, the Gulf of Mexico, Northern Europe, East/South/Southeast Asia, Southeast Africa, Northern Australia, and global low-lying deltas and estuaries [4-10]
- Social, environmental, and economic risks are **underestimated when the compound flood processes are not considered in combination** [12-16]
- Compound floods are likely to have **increased frequency and severity in the future due to climate change** [11, 17, 18]
- **Urban and coastal areas are at heightened risk from compound flooding** due to the built environment and concentration of populations and infrastructure [19-22]

Knowledge Gaps & Recommendations

- 1) Adopt consistent definitions, terminology, and research approaches
- 2) Expand the limited geographic coverage of research
- 3) Pursue more inter-comparison projects
- 4) Develop modelling frameworks that better couple dynamic earth systems
- 5) Design urban and coastal infrastructure with compound flooding in mind

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Portfolio

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