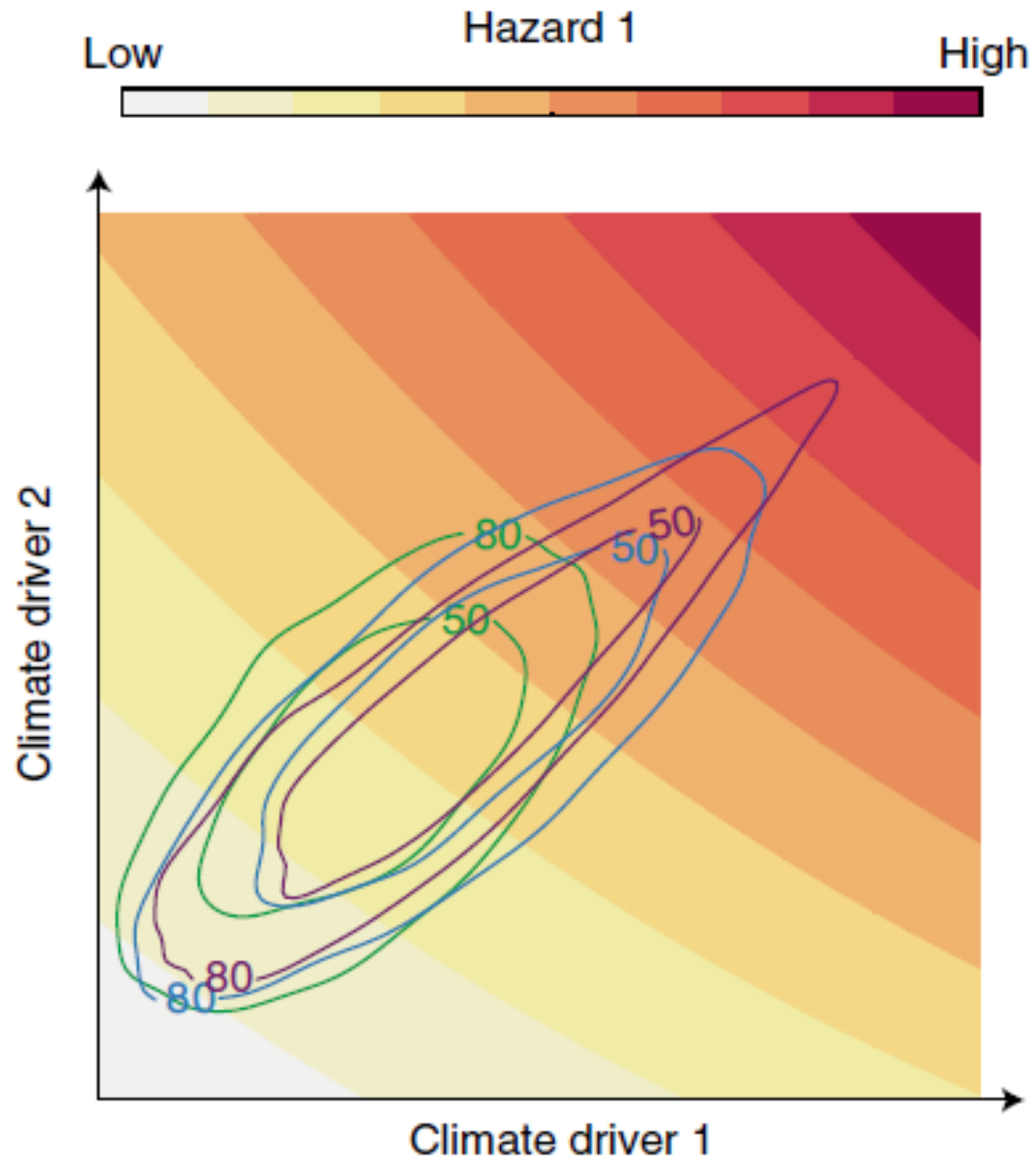


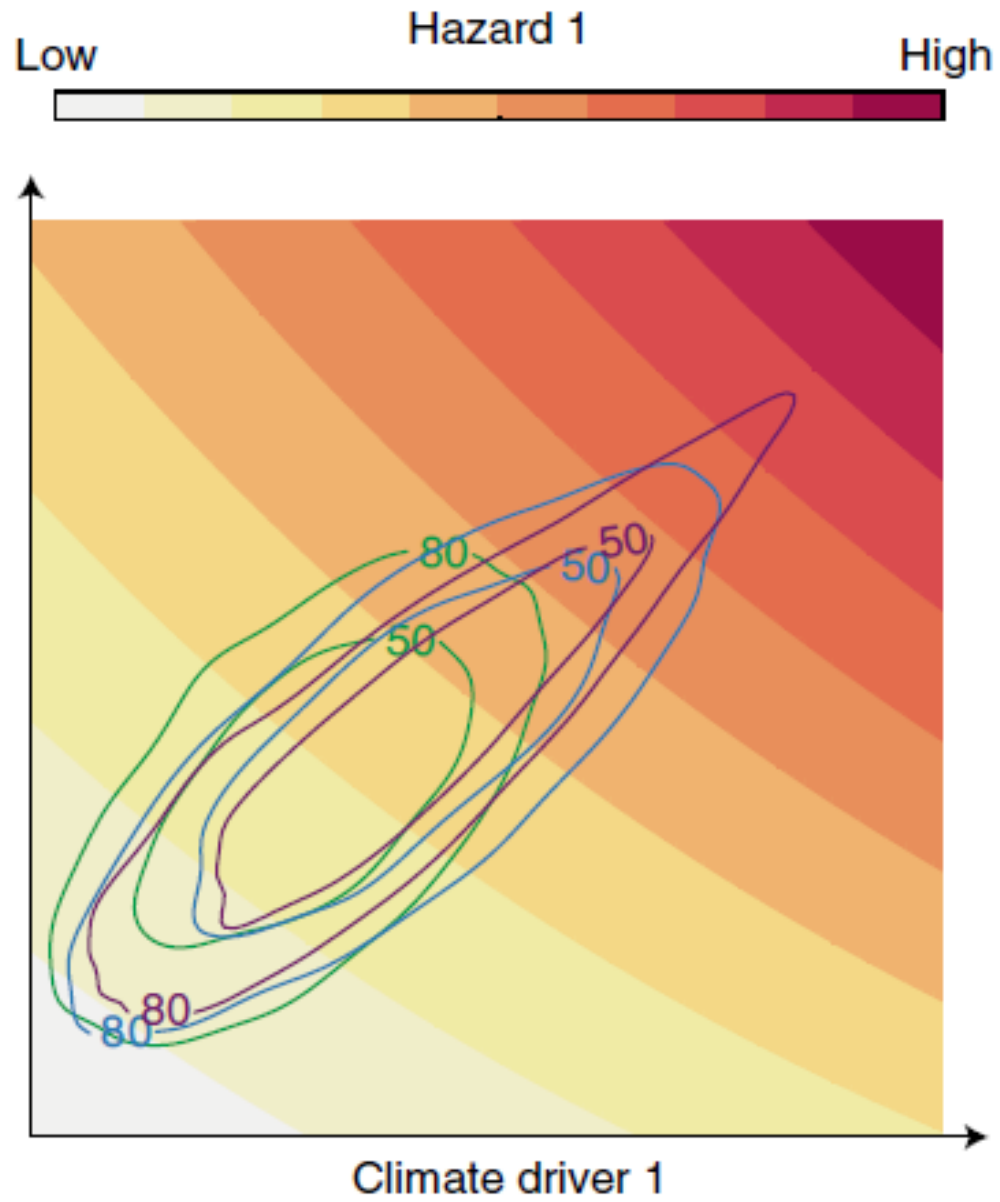
# Deltares



## Diagnosing and analysing compounding hazard-impact pathways

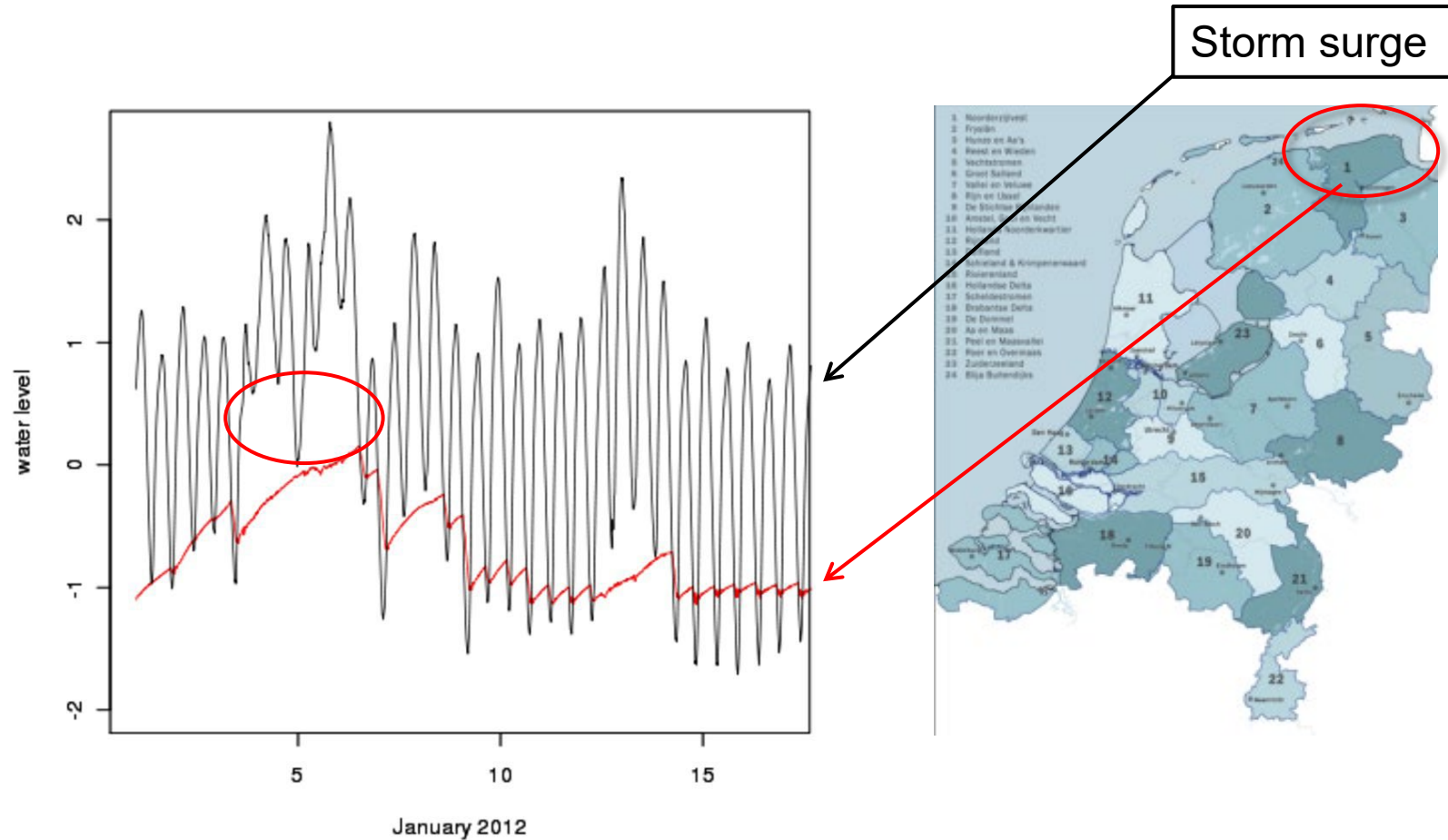
Bart van den Hurk  
Jakob Zscheischler  
&  
DAMOCLES team members

# Deltares

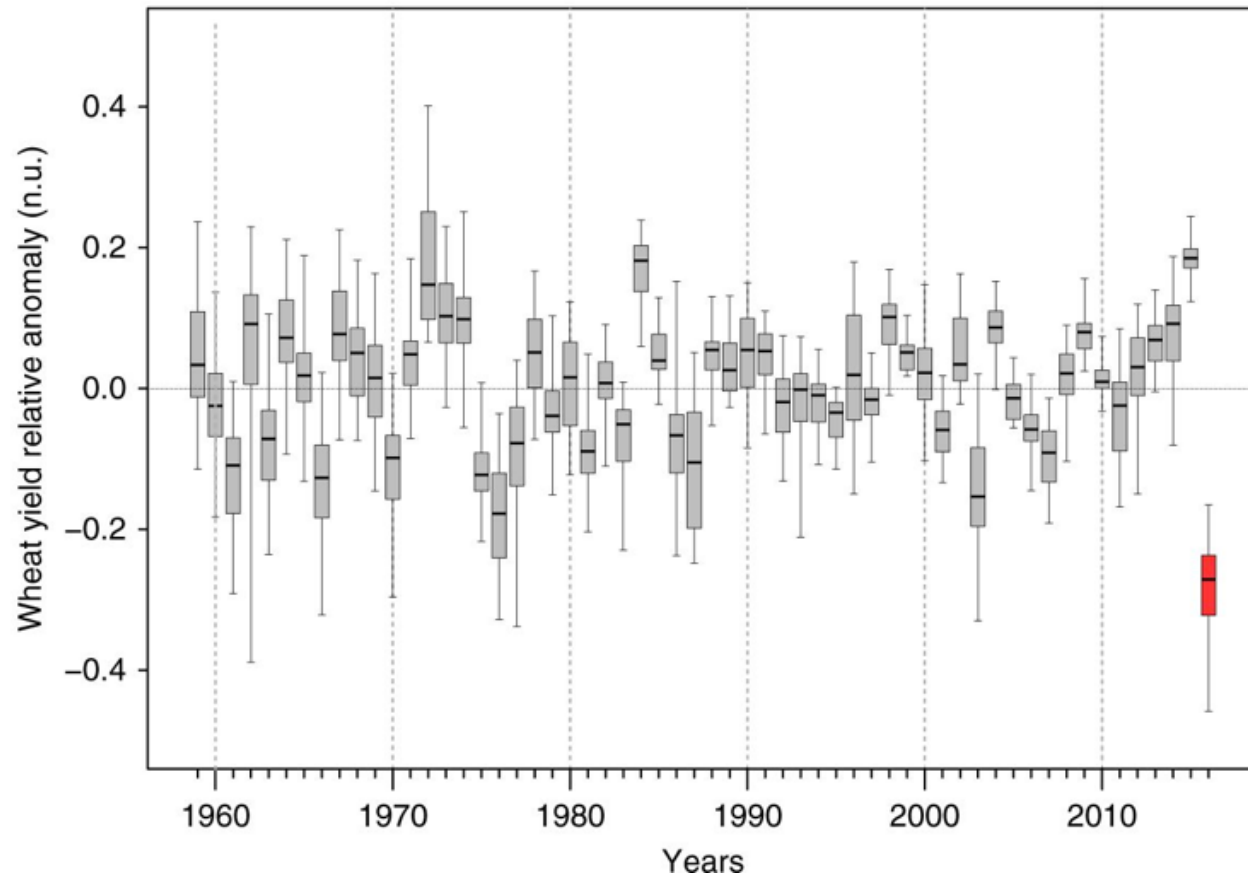


**A few examples**

# Near-flooding event Jan 2012: a compound event



# 2016 crop failure in France



- Not forecasted
- What caused the crop loss?



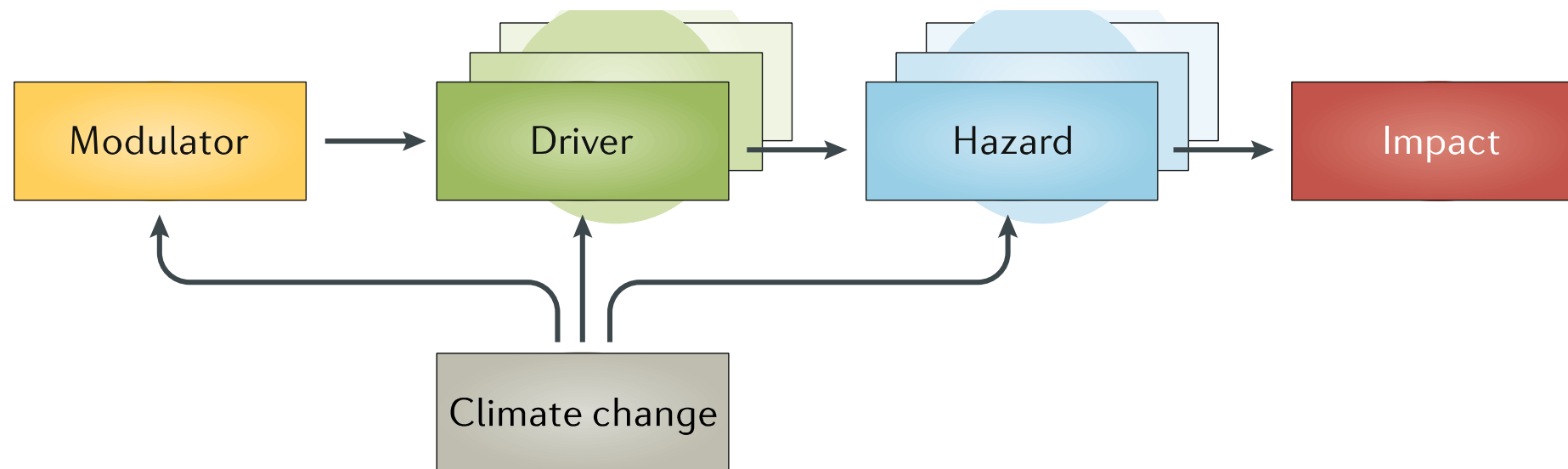
# 2016 crop failure in France

Main drivers



# Compound weather and climate events

...refer to the **combination of multiple drivers and/or hazards** that contributes to **societal or environmental risk**.



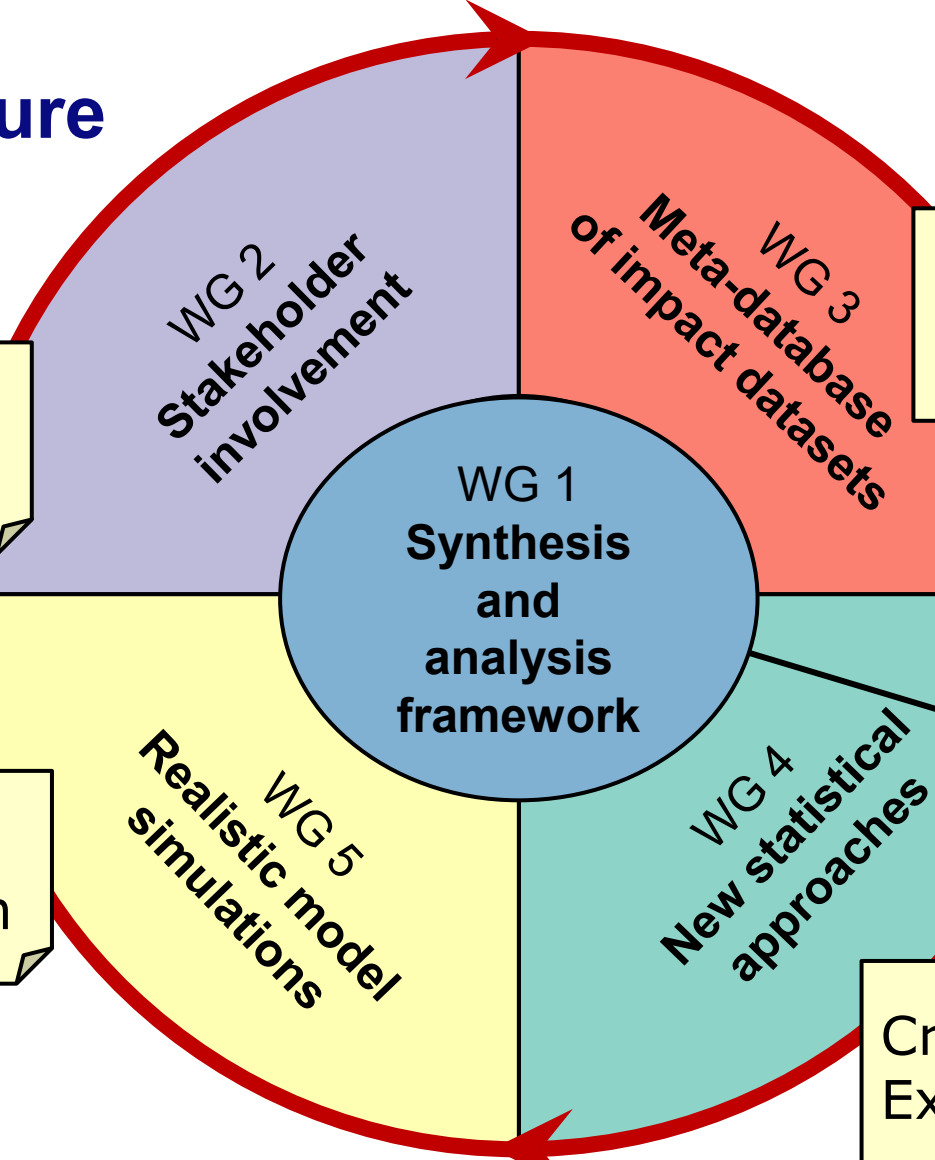
**Core Group:** Chair: Jakob Zscheischler  
Vice Chair: Bart van den Hurk  
2 leaders per WG  
Science Communication Manager  
STSM Manager

# DAMOCLES Structure

9/2018-9/2022  
38 countries

Adjusting scientific approach  
to applications

Quality assessment  
Experimental design



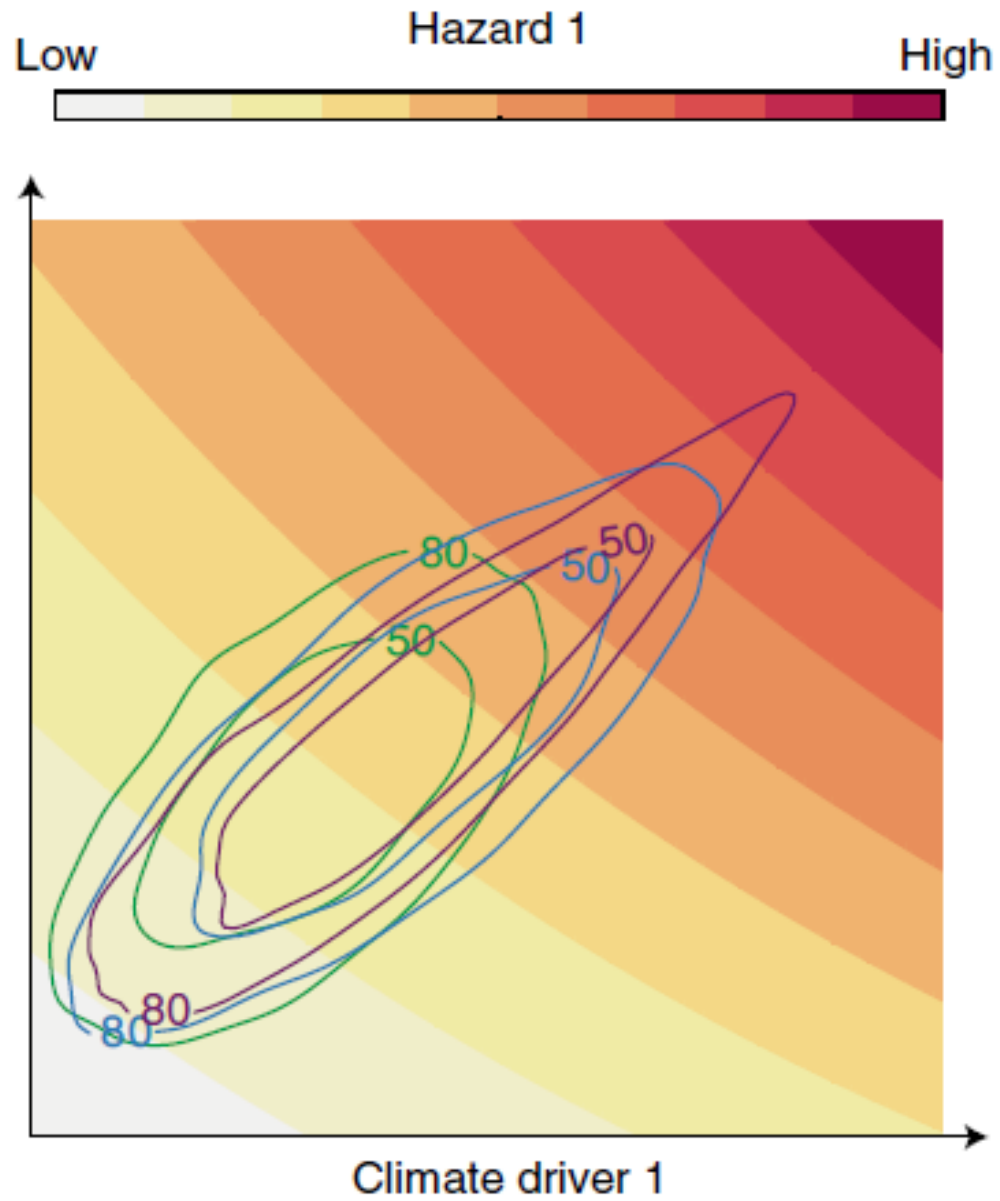
Criteria for usefulness  
Event-impact relationships

Classification of events  
Compendium of methods

Criteria for usefulness  
Explicit hypothesis testing?



# Deltares



**Typology of compound events**



# A typology of compound events

1. Preconditioned events
2. Multivariate events
3. Temporally compounding events
4. Spatially compounding events

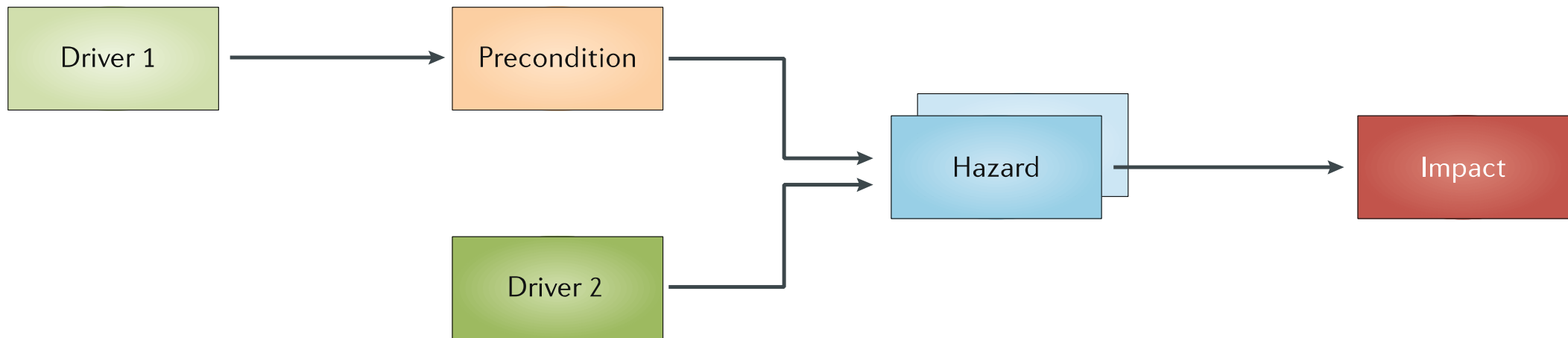
 Check for updates

## A typology of compound weather and climate events

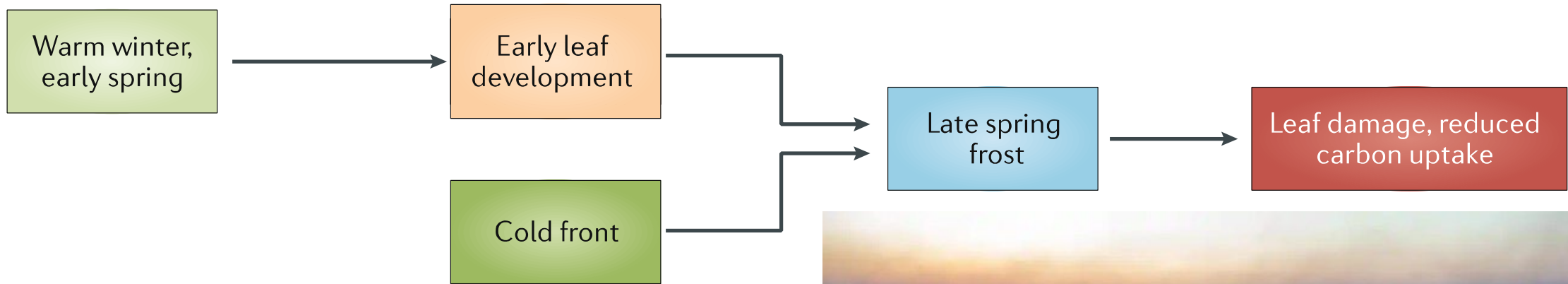
*Jakob Zscheischler<sup>1,2</sup>✉, Olivia Martius<sup>1,3,4</sup>, Seth Westra<sup>5</sup>, Emanuele Bevacqua<sup>6</sup>, Colin Raymond<sup>7,8</sup>, Radley M. Horton<sup>9</sup>, Bart van den Hurk<sup>10,11</sup>, Amir AghaKouchak<sup>12,13</sup>, Aglaé Jézéquel<sup>14,15</sup>, Miguel D. Mahecha<sup>16,17</sup>, Douglas Maraun<sup>18</sup>, Alexandre M. Ramos<sup>19</sup>, Nina N. Ridder<sup>20</sup>, Wim Thiery<sup>21</sup> and Edoardo Vignotto<sup>22</sup>*

# 1. Preconditioned events

One or more hazards can cause an impact, or lead to an amplified impact, only because of a pre-existing, climate-driven condition.



# False spring

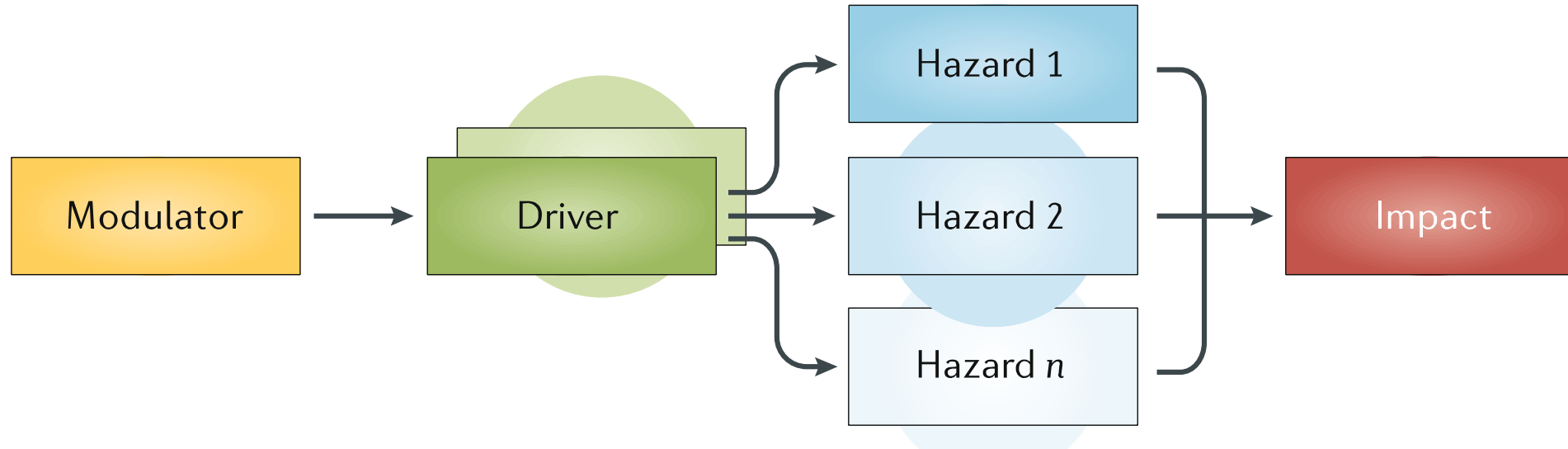


Damaged vineyard in France (2021)



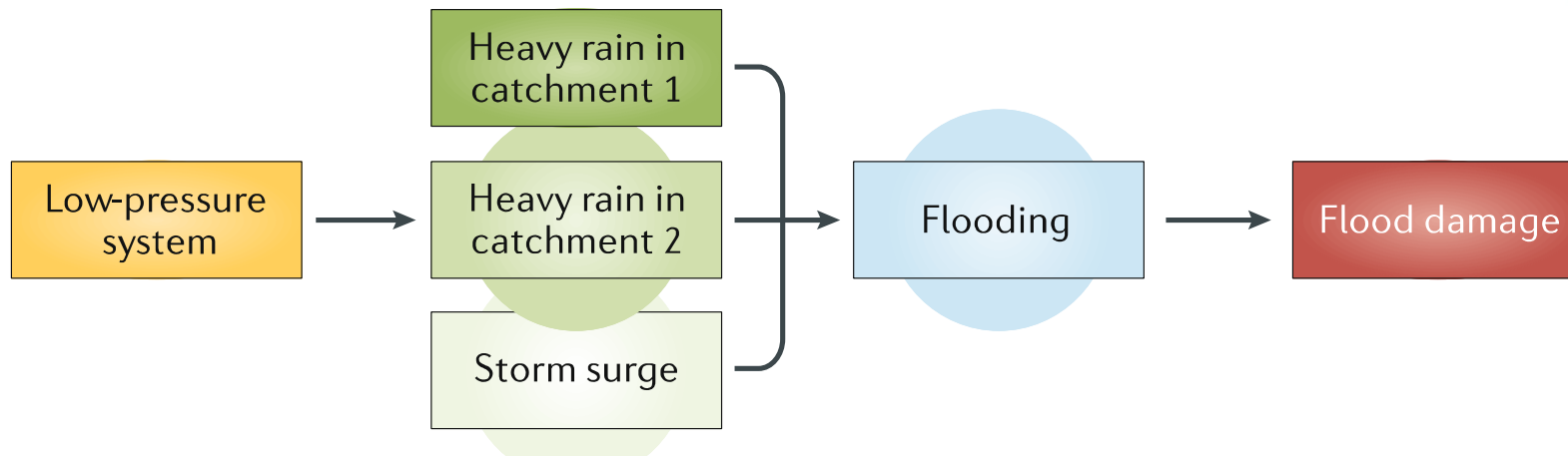
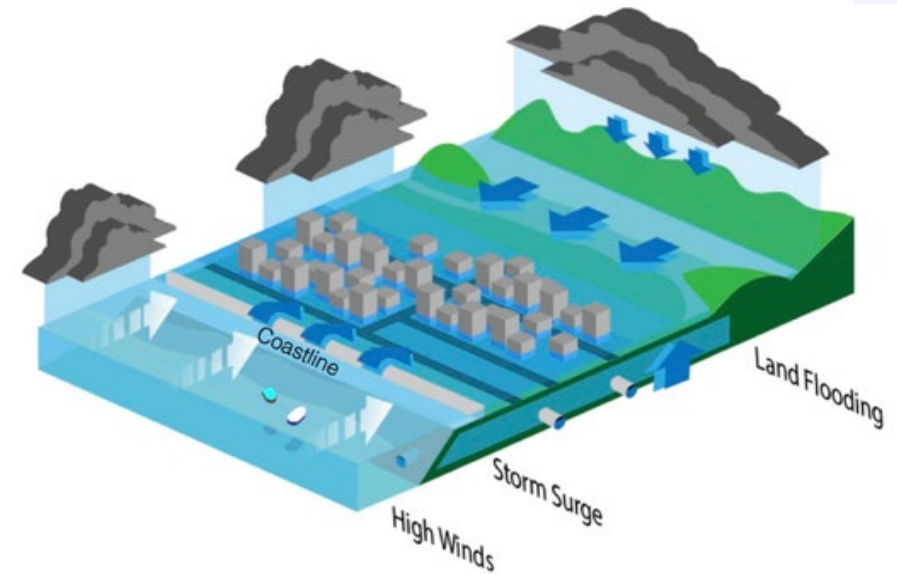
## 2. Multivariate events

Co-occurrence of multiple climate drivers and/or hazards in the same geographical region, causing an impact.

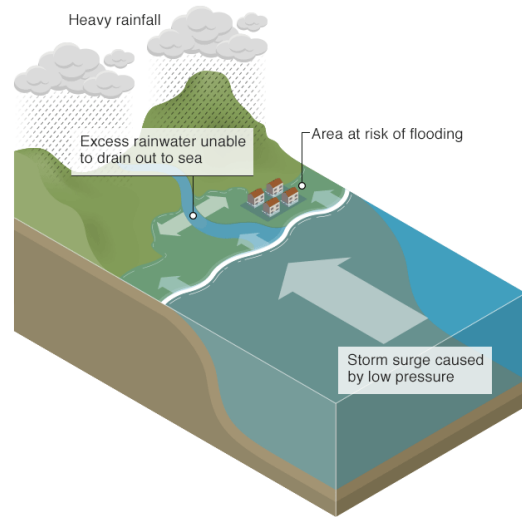


# Examples of multivariate events

- Concurrent drought & heat
- Concurrent wind & precipitation extremes
- Compound flooding

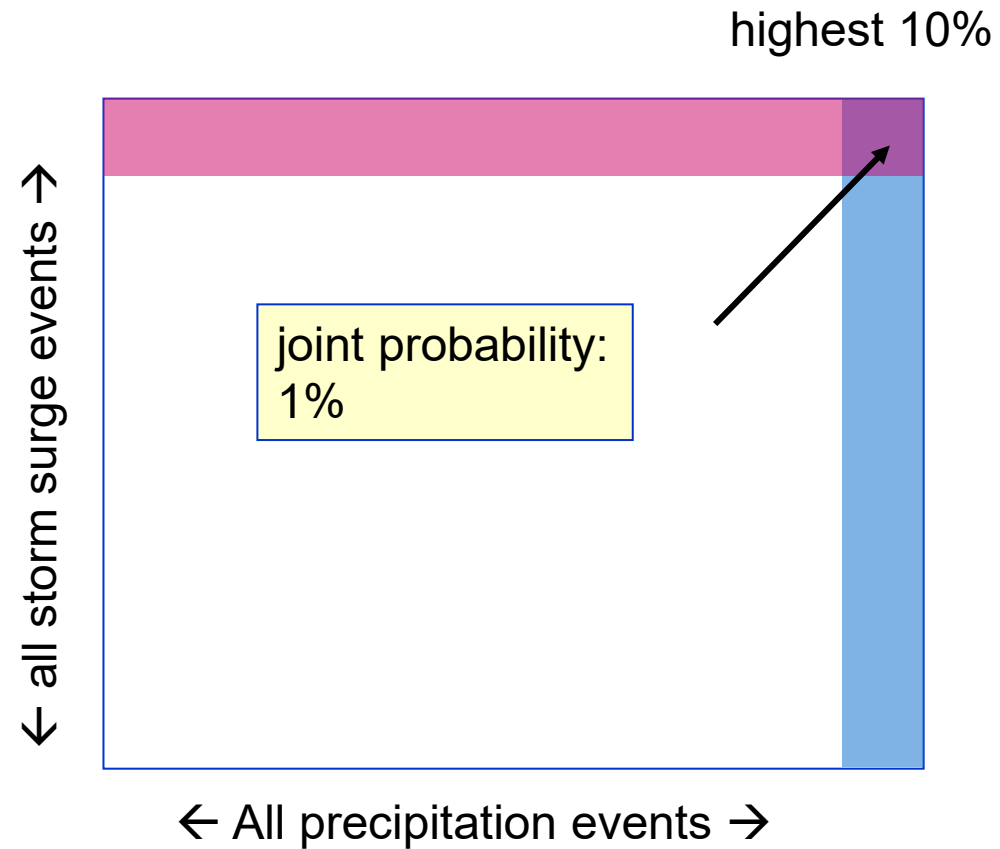


# Multivariate compound events

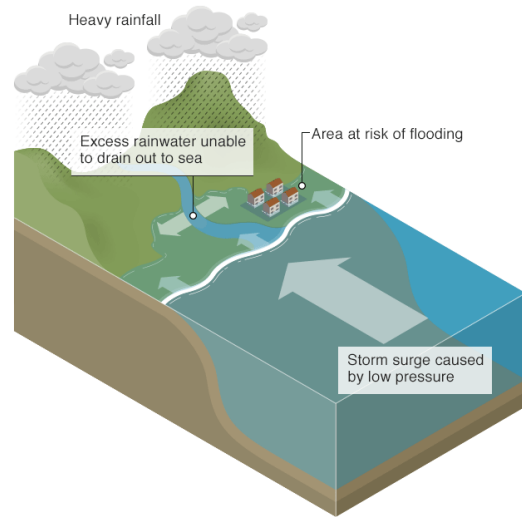


Source: Douglas Maraun/Science Advances

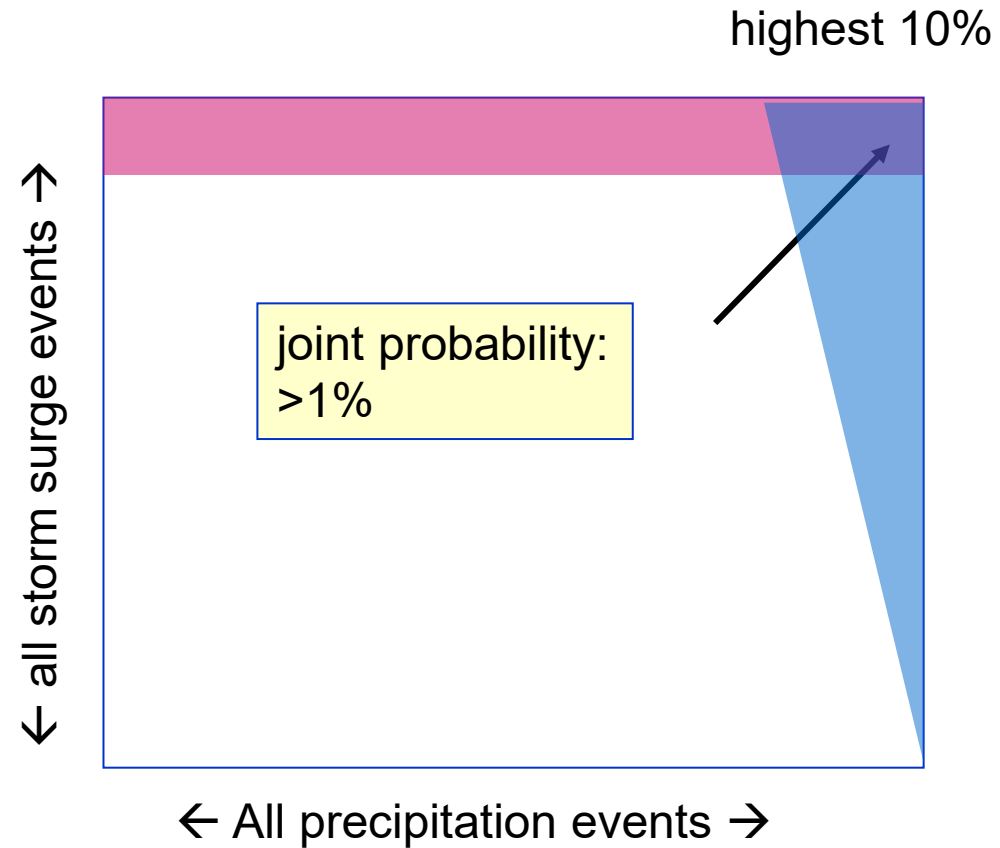
BBC



# Multivariate compound events



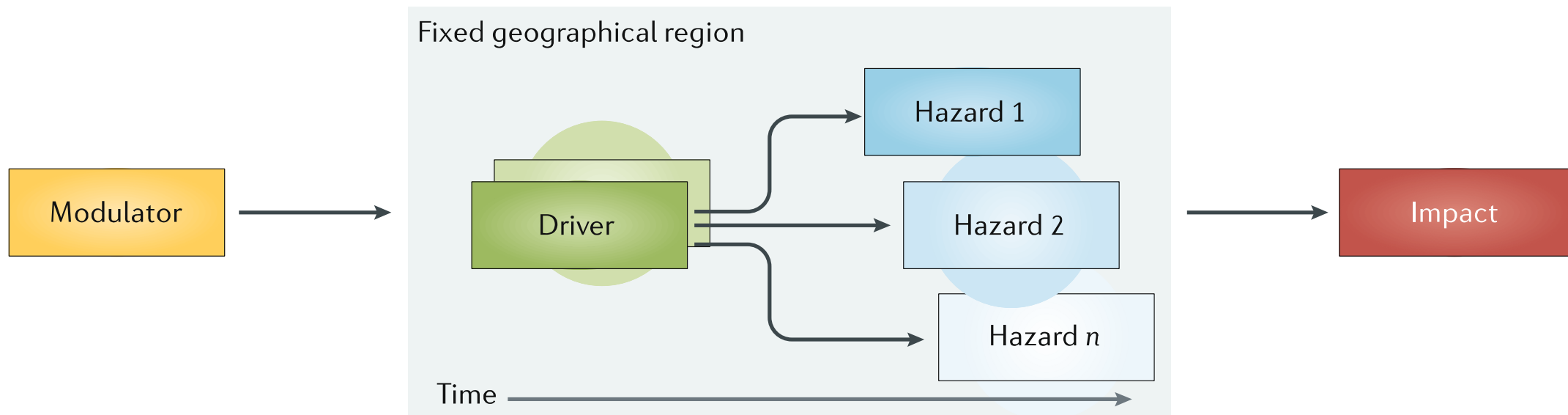
Source: Douglas Maraun/Science Advances





### 3. Temporally compounding events

Succession of hazards that affect a given geographical region, leading to, or amplifying, an enhanced impact.







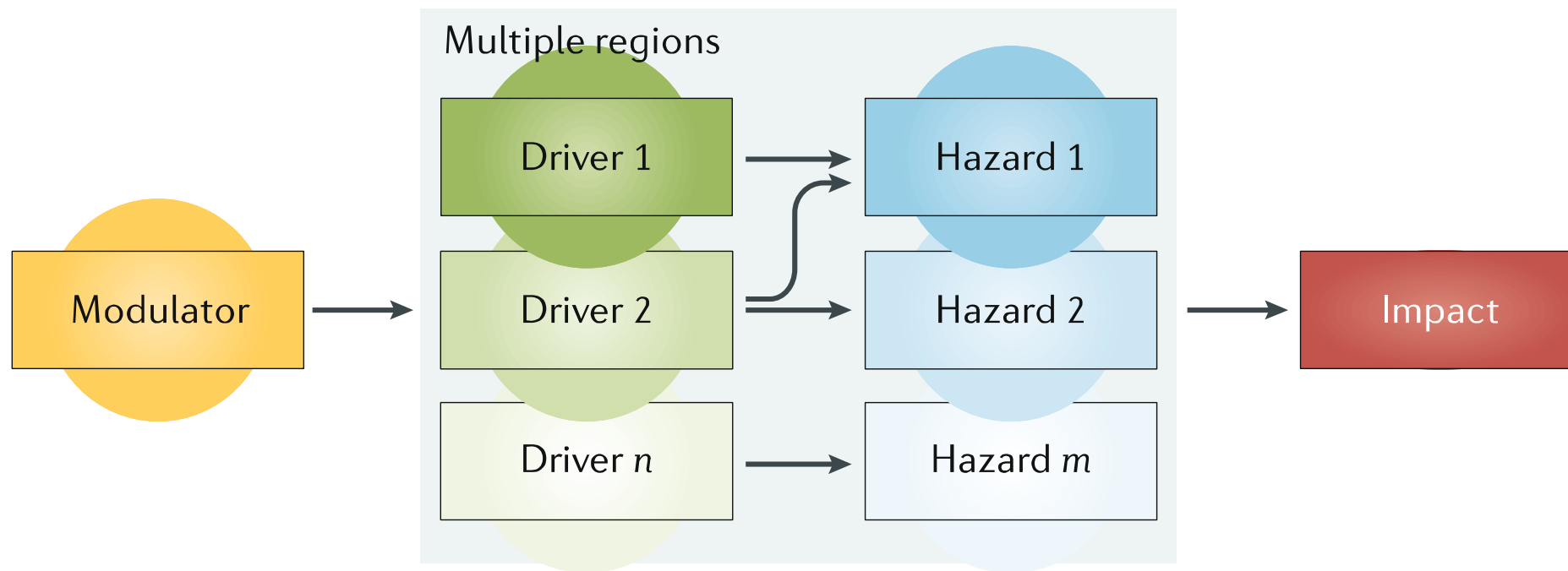
Katia, Irma, Jose

**Deltares**

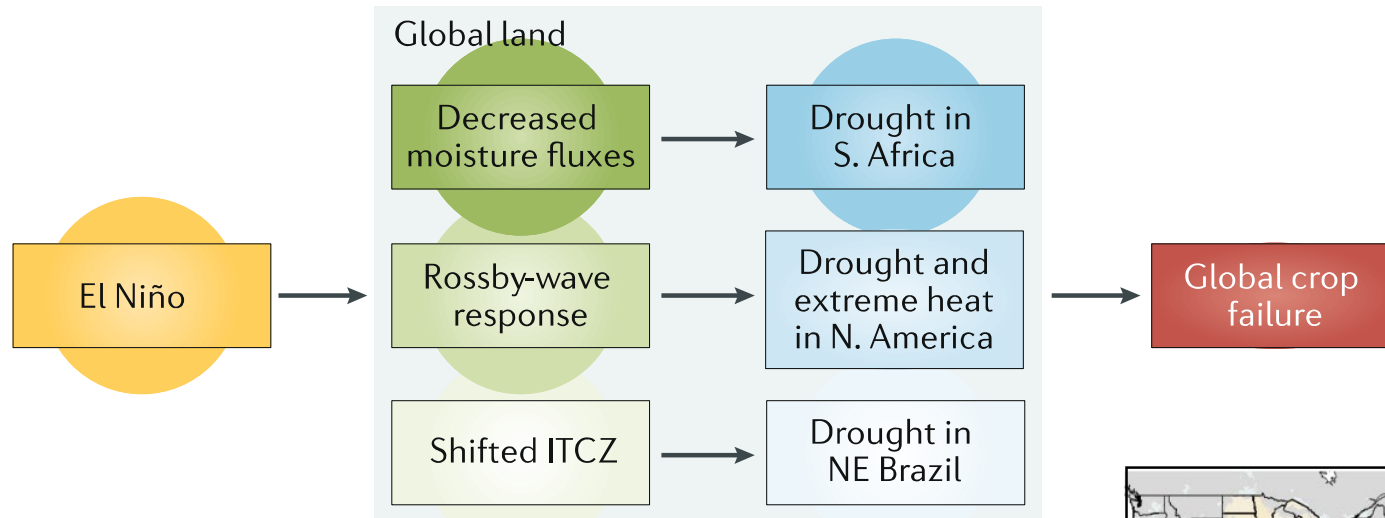


## 4. Spatially compounding events

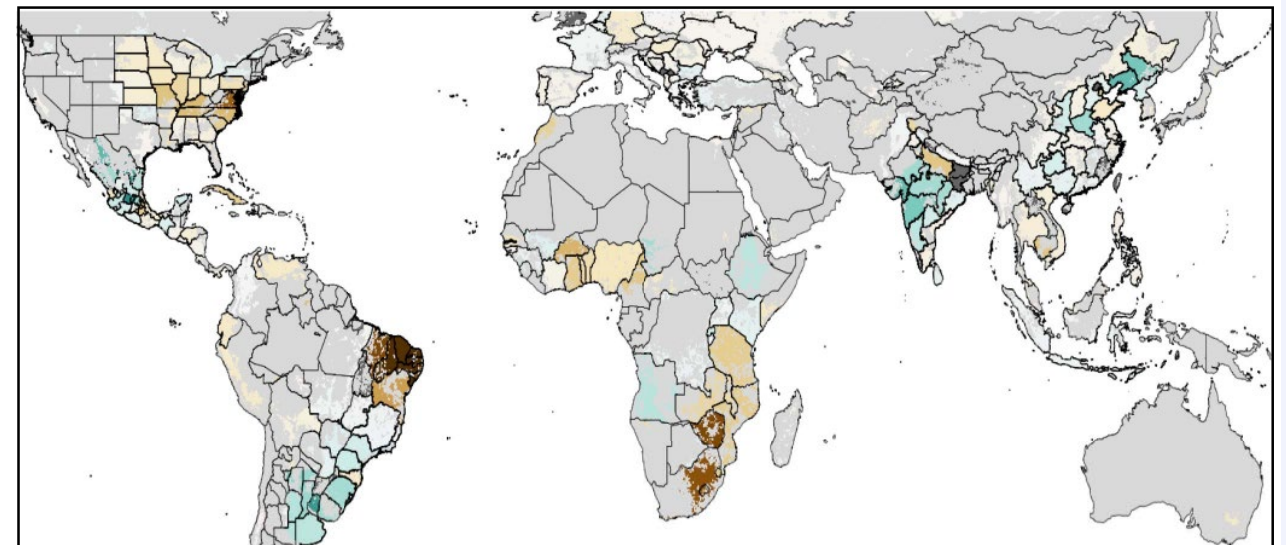
Multiple connected locations are affected by the same or different hazards within a limited time window, thereby causing an impact.



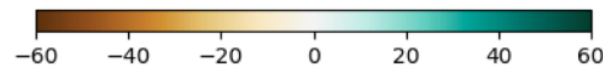
# Concurrent impacts of El Niño on crop yields



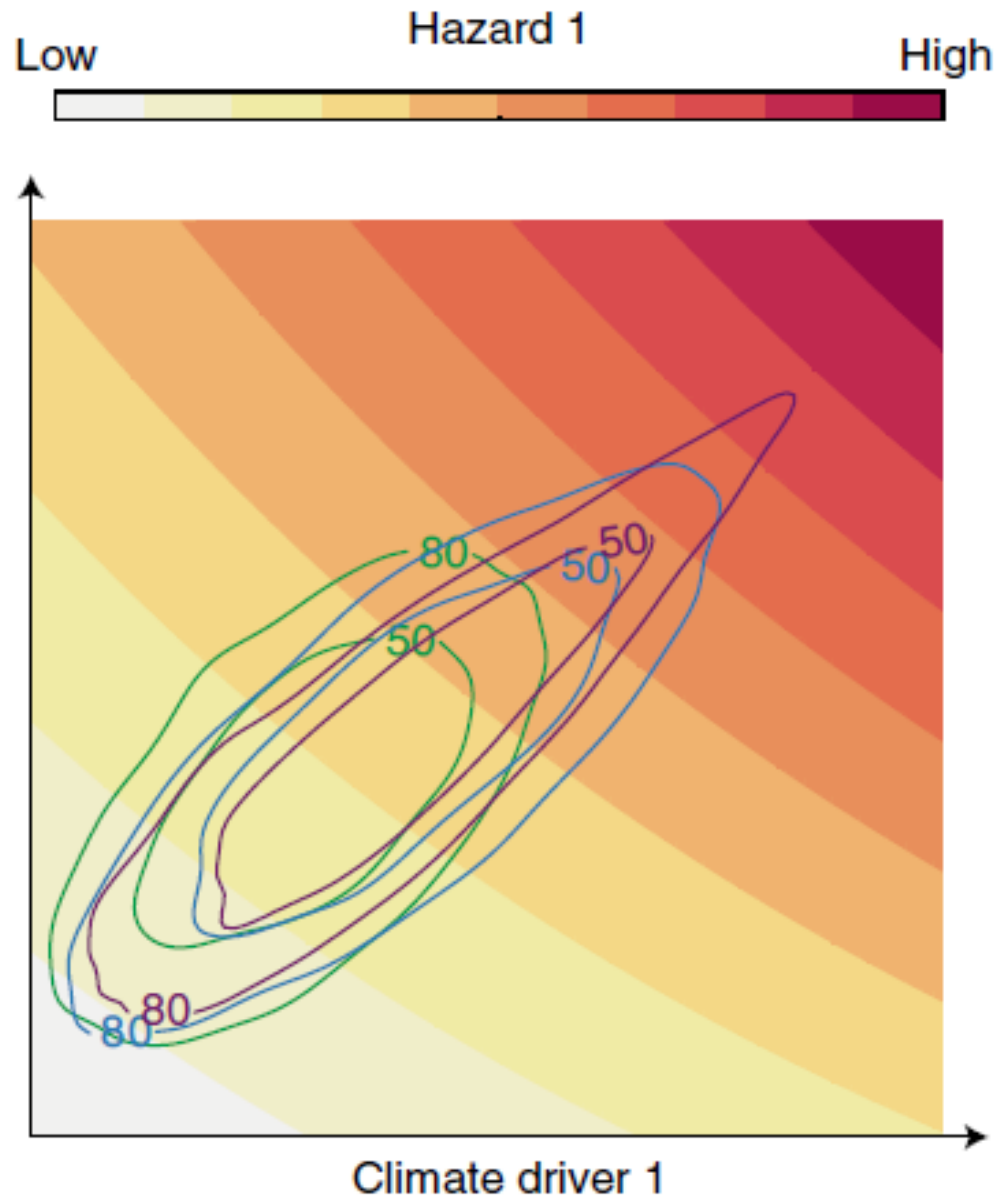
Maize production anomalies in 1983



Largest synchronous crop failure event in modern history



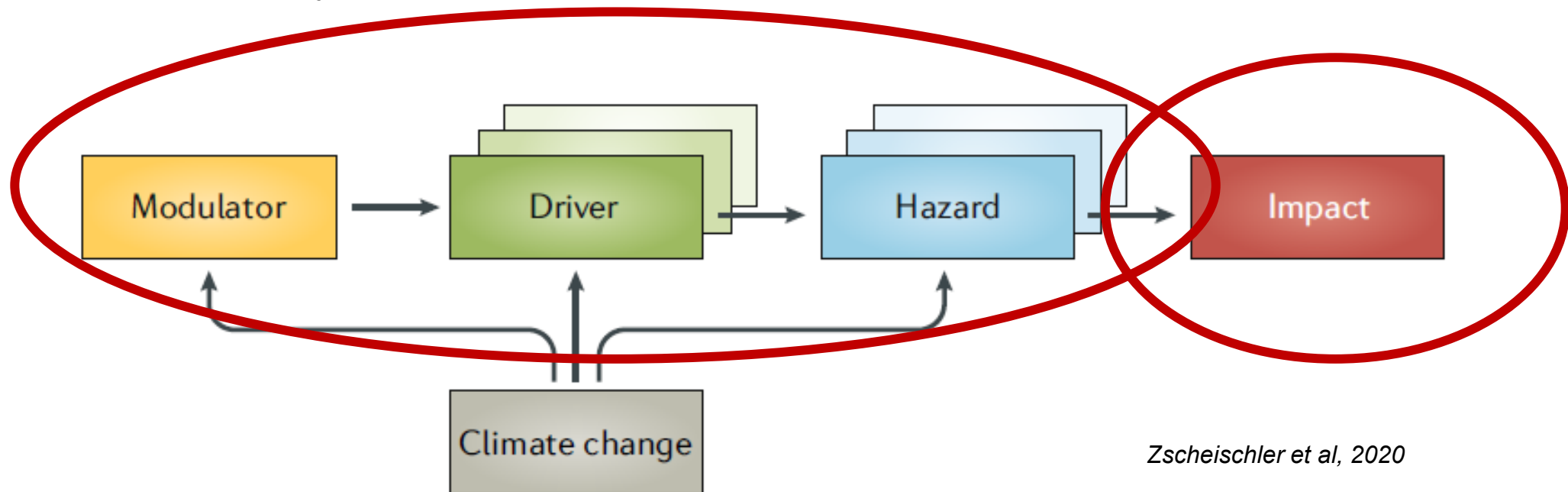
# Deltares



**Typology of compound event impacts**

# Compound event classification

- Categorizes different links between modulators, drivers & hazards
  - Z2020 classification helps understanding & analysis “Climatic Impact Drivers”
- Why care about it when analysing climate impacts?
  - Classification may help **impact assessment**



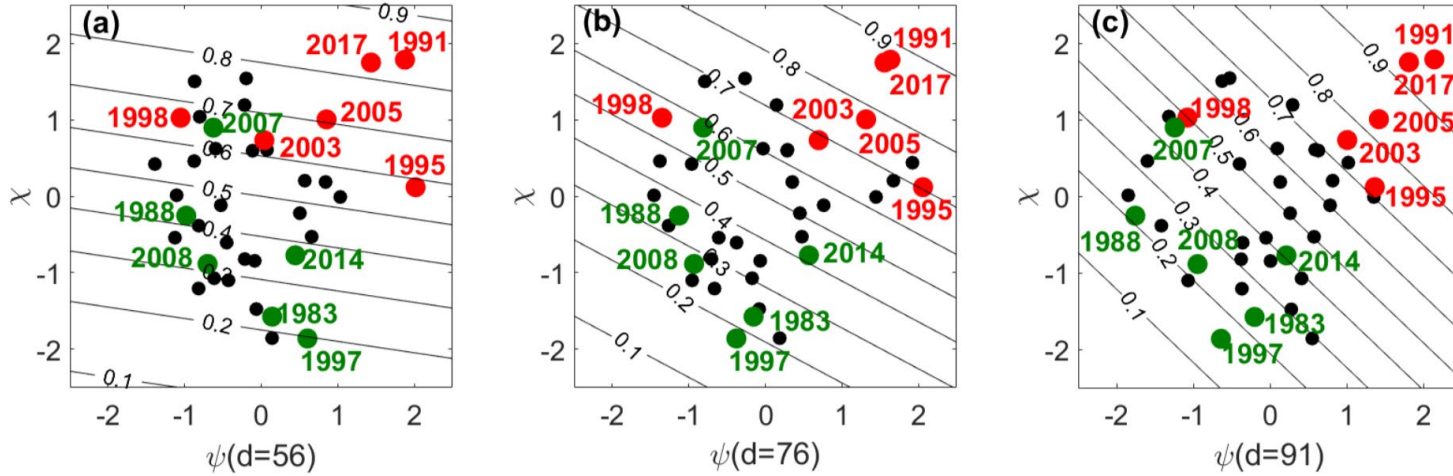
# Impact application domains found in literature

- **(Impact) forecasting**
  - (Extreme) weather, hydrological extremes
- **Emergency response**
  - Training, informed response strategies
- **Risk management**
  - Standard operation protocols, exposure mapping
- **Spatial planning/infrastructure design**
  - Mapping hazard/exposure/vulnerability, climate change impacts
- **Process understanding**
  - Theory & model development, observational strategies



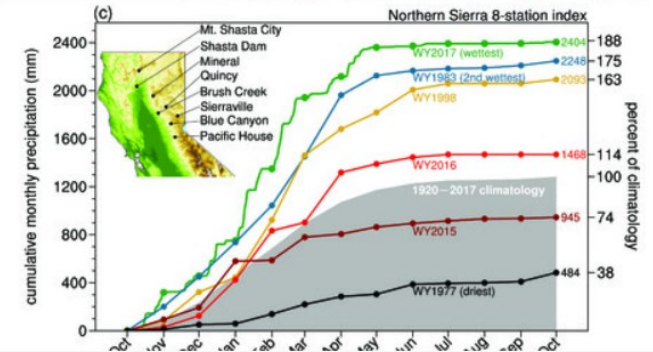
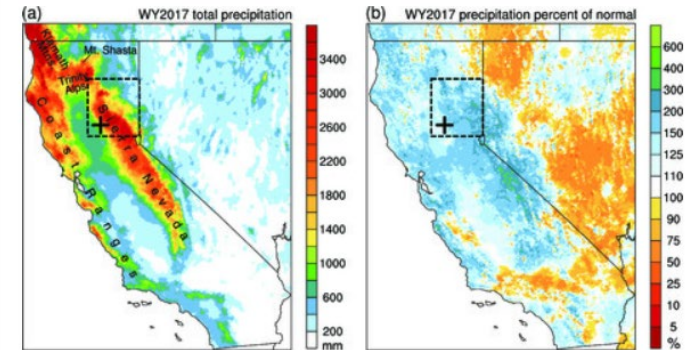
# Some examples

## Impact forecasting



Wild fire forecasting (Nunes et al, 2019)

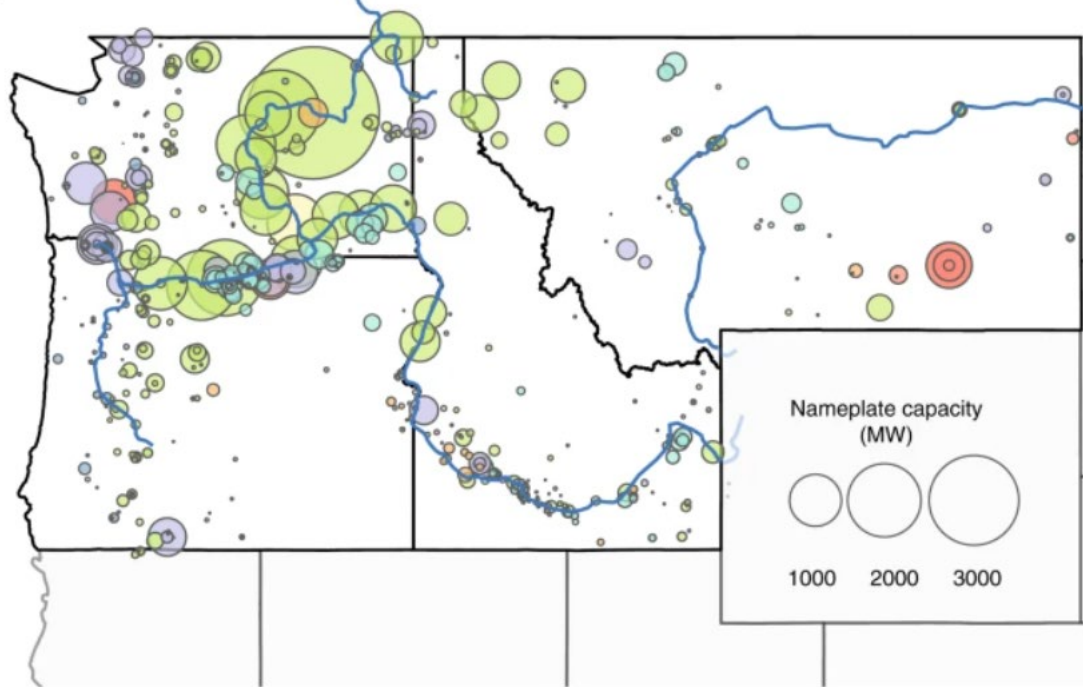
## Risk management



Heavy precipitation and dam security (White et al, 2019)

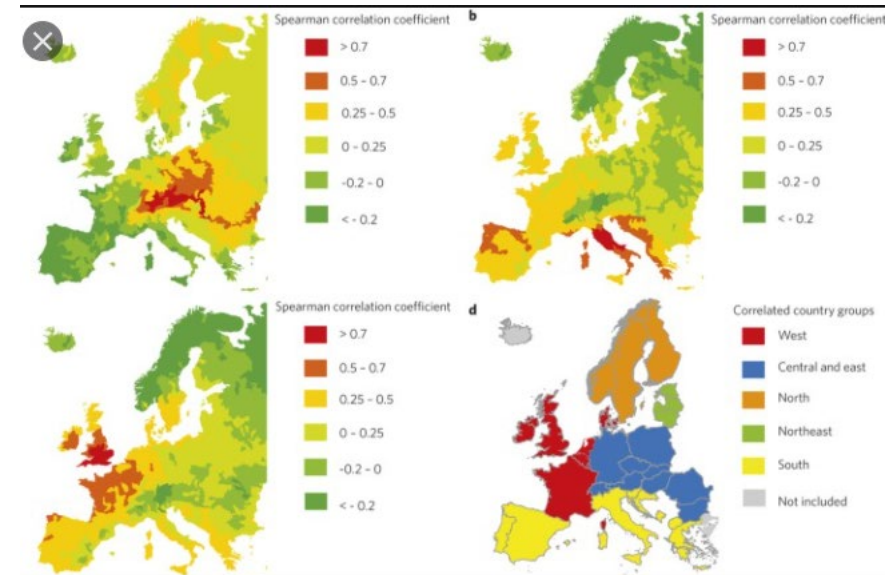
# Some examples

## Infrastructure planning



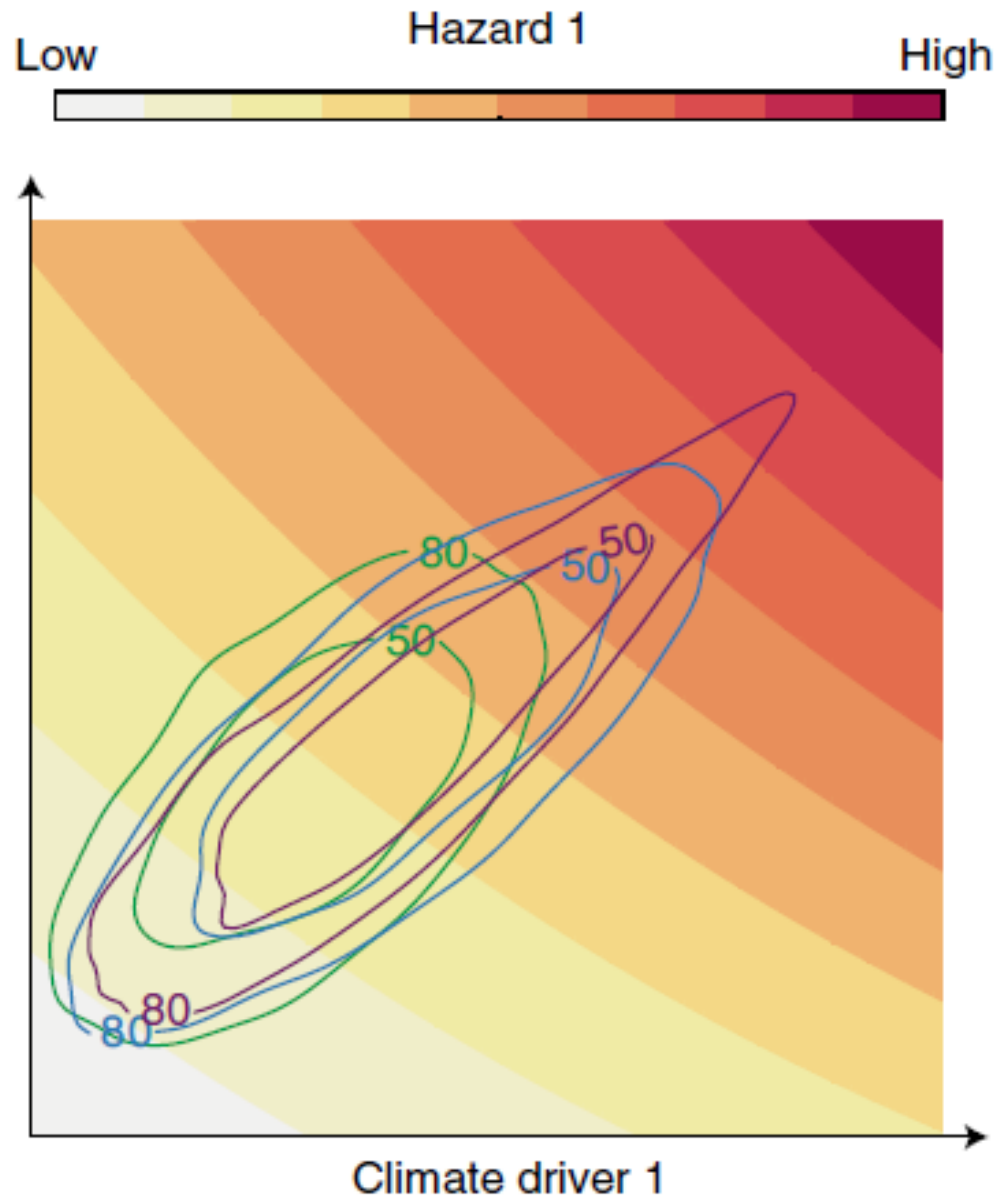
*Power disruption (Turner et al, 2019)*

## Emergency response



*Correlated hazards (Jongman et al, 2014)*

# Deltares




**What's in it for (space) observations?**

# Observational considerations

- **Observing impacts...**
  - Flooding, crop impacts, storm damage, surge impacts on erosion
- **... that allows attribution of their drivers**
  - Synchronized with data on hydrometeorological hazards
- **... enables model development and scenario analysis**
  - E.g. Digital Twins allowing conditioning on multiple drivers
- **... and contributes to the sparse data set on impacts**
  - Weak spot in observational coverage, including links to exposure/vulnerability
- **Think of compounding observation systems**
  - Space, meteo, in situ, model scenarios: a multihazard, multi-impact and multifunctional compound data lake



## Online presence

- Website: [damocles.compoundevents.org](https://damocles.compoundevents.org)
-  @Compound\_Event
- Blog: [compoundevents.org/category/blog/](https://compoundevents.org/category/blog/)



## Blog

blog parent



Guest blog by Milan Gazdic, University of Belgrade (Serbia) In Montenegro, forests and forest land occupy approximately 70% of the territory of the country. Montenegro forests provide many benefits and services to society, including clean water and air, recreation, wildlife habitat, carbon storage, climate regulation, and a variety of forest products. Climate influences the ... [Continue reading](#)

December 4, 2019 / fire, STSM