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Flood impacts on road transport infrastructure

An overview of novel assessment tools

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With contributions of Elco Koks, Frederique de Groen and Margreet van Marle

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What do you mean: flood impacts to road transport infrastructure?

- *Flood types*
  - Pluvial: cloudburst locally causing flooding ~ hours
  - Fluvial: river flood caused by water from upstream ~ days/weeks
  - Coastal: storm surges

- *Types of damage*
  - Direct infrastructural damage (for road operator)
  - Travel time losses
  - Indirect economic damage

- *Types of damage*

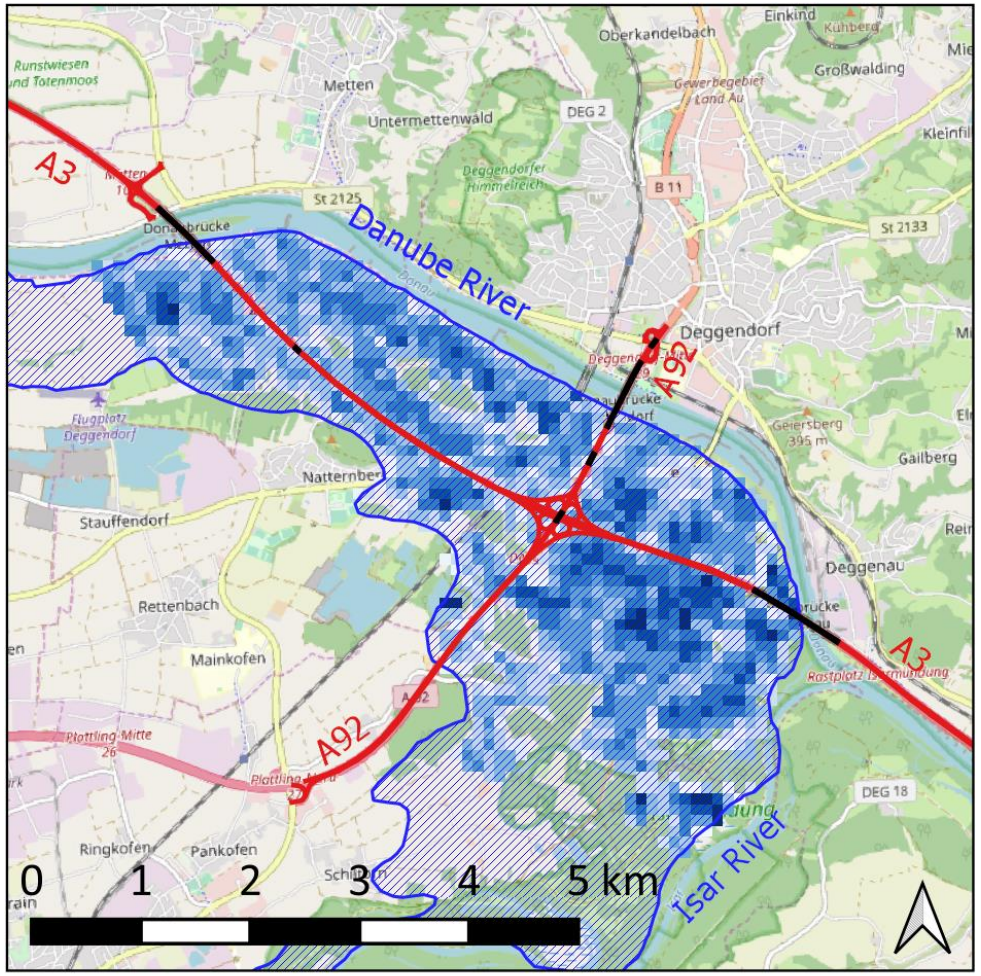
Table 1 – Different dimensions of flood damages

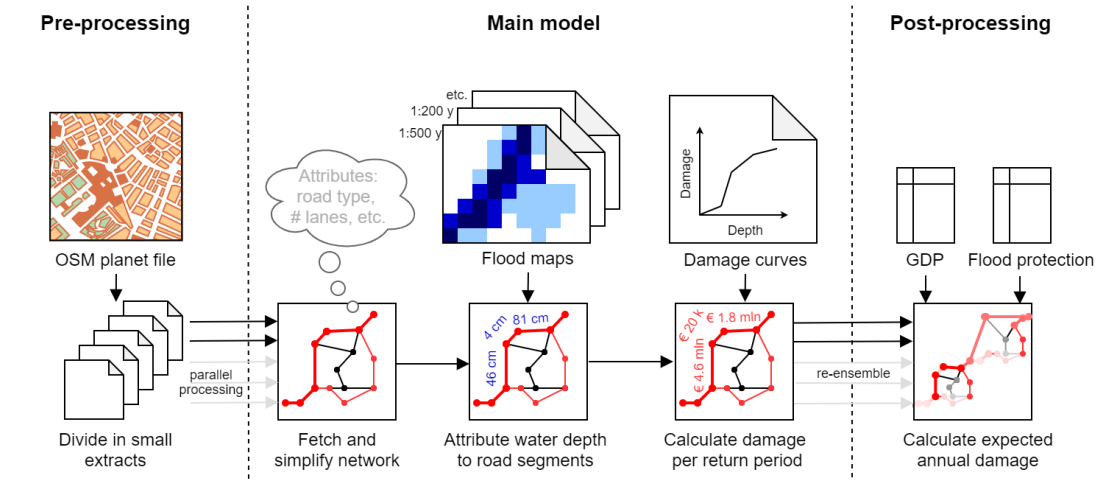
	Tangible and priced	Intangible and unpriced
Direct	• Residences • Capital assets and inventory • Business interruption (inside the flooded area) • Vehicles • Agricultural land and cattle • Roads, utility and communication infrastructure • Evacuation and rescue operations • Reconstruction of flood defences • Clean up costs	• Fatalities • Injuries • Inconvenience and moral damages • Utilities and communication • Historical and cultural losses • Environmental losses
Indirect	• Damage for companies outside the flooded area • Adjustments in production and consumption patterns outside the flooded area • Temporary housing of evacuees	• Societal disruption • Psychological traumas • Undermined trust in public authorities

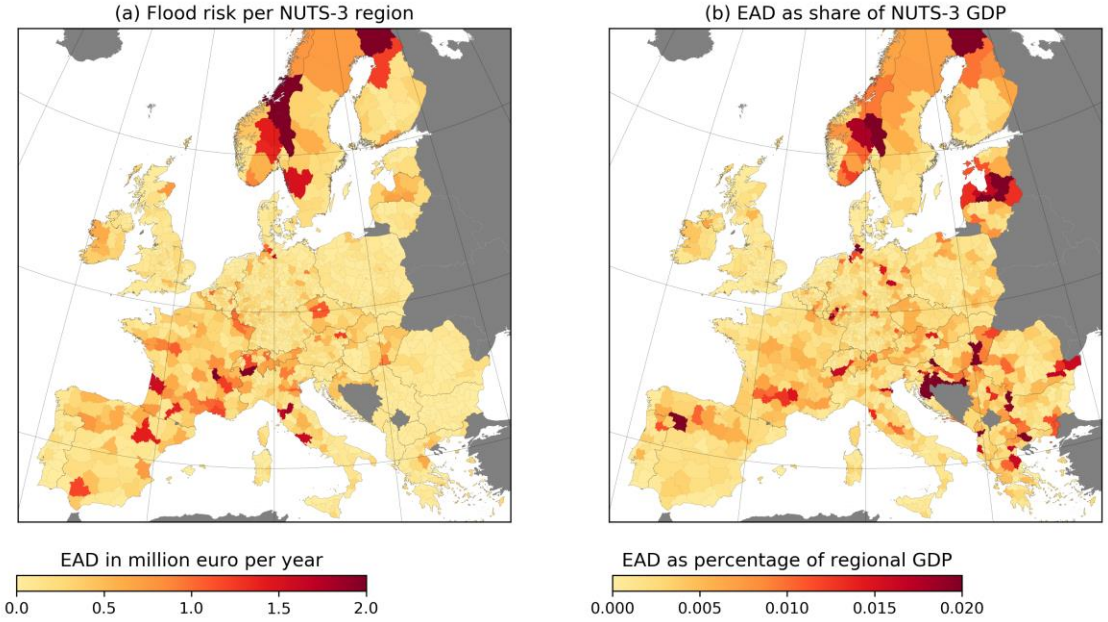
Jonkman, S.N. & Bockarjova, Marija & Kok, Matthijs & Bernardini, P.. (2008). Integrated Hydrodynamic and Economic Modelling of Flood Damage in The Netherlands. Ecological Economics. 66. 77-90. 10.1016/j.ecolecon.2007.12.022.

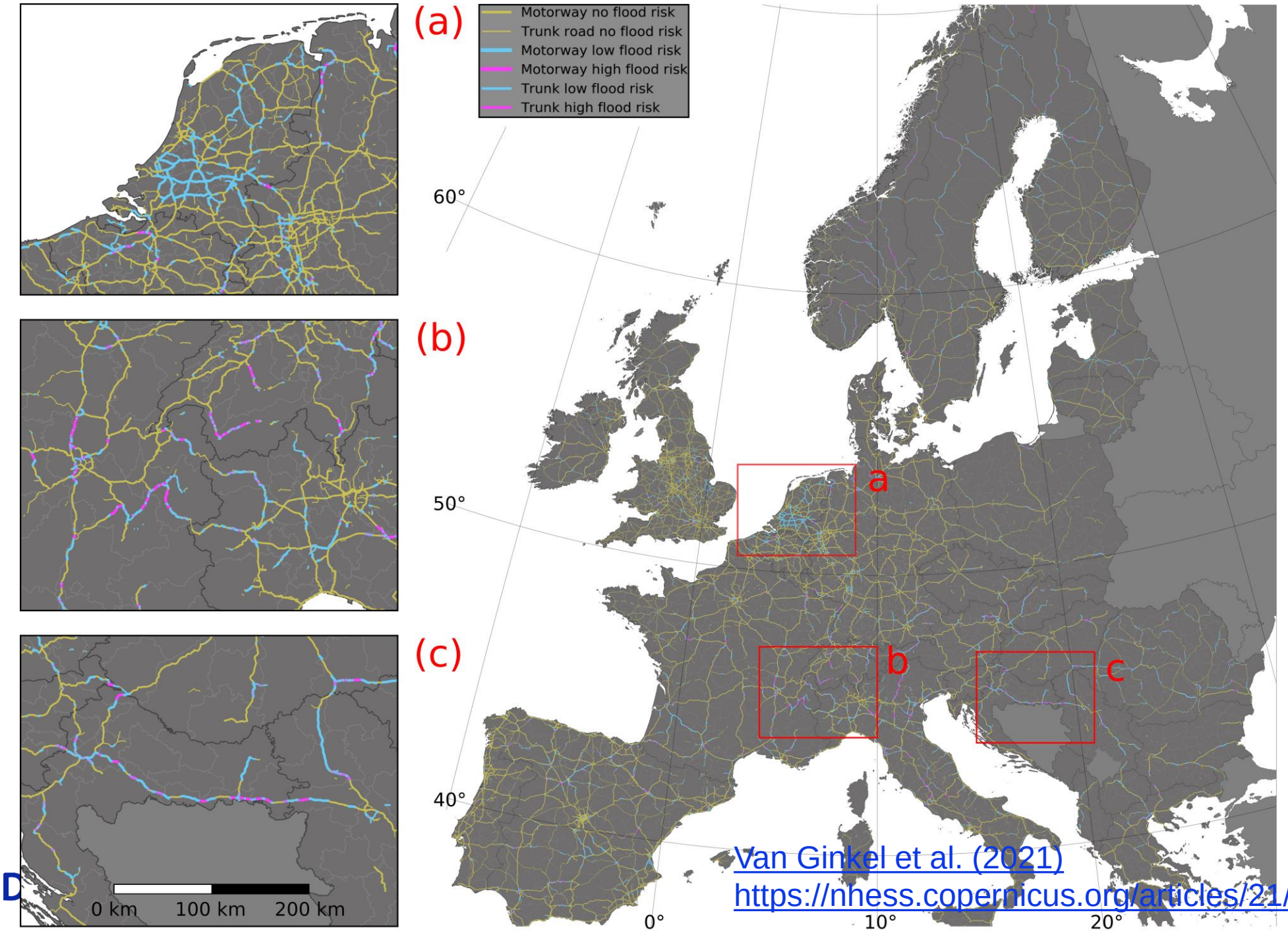
Assessing direct tangible infrastructural damage

Van Ginkel et al. (2021) https://nhess.copernicus.org/articles/21/1011/2021/







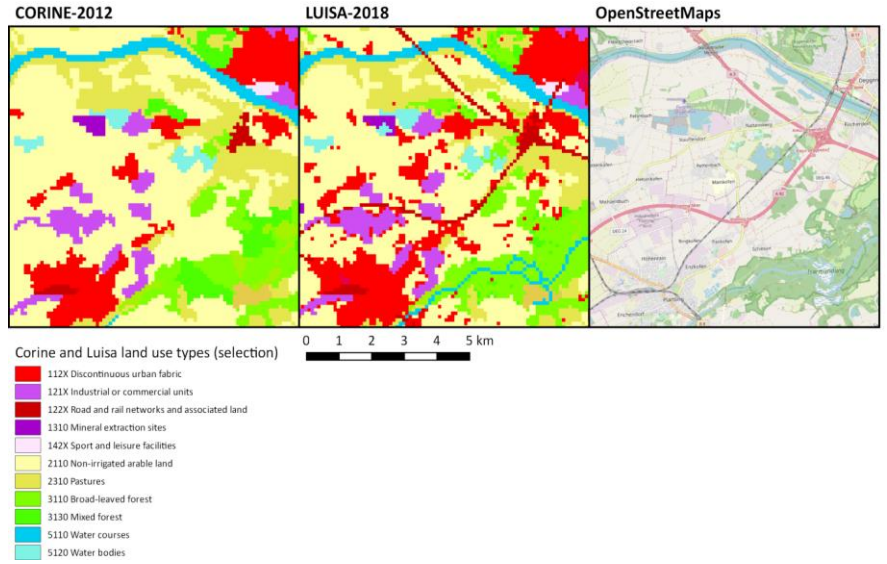


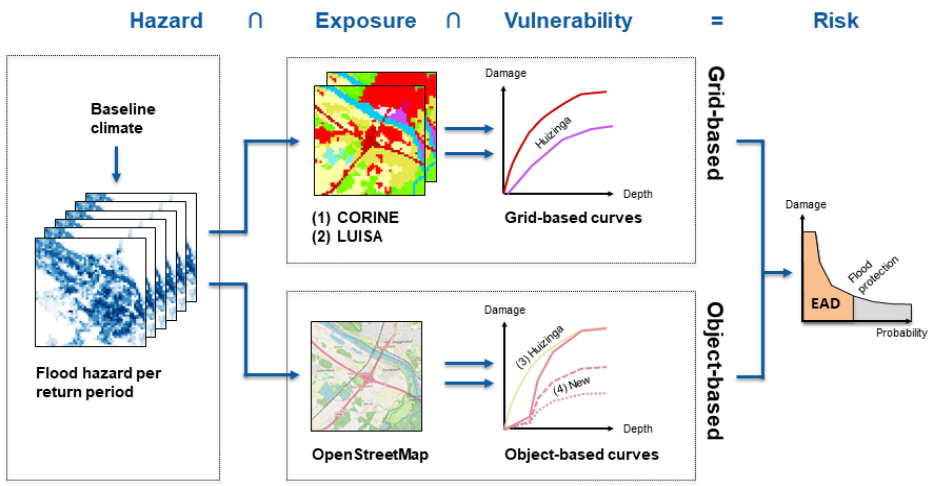
D

[Van Ginkel et al. (2021) https://nhess.copernicus.org/articles/21/1011/2021/](https://nhess.copernicus.org/articles/21/1011/2021/)

One approach for continental to local scale

- Object-based rather than grid-based approach
- New object-specific damage curves
- Better use of OSM metadata on road type, # lanes, GDP data, street lighting
- Call for collaboration on improvement of damage curves: compare **reported** and **modelled** damage for actual floods





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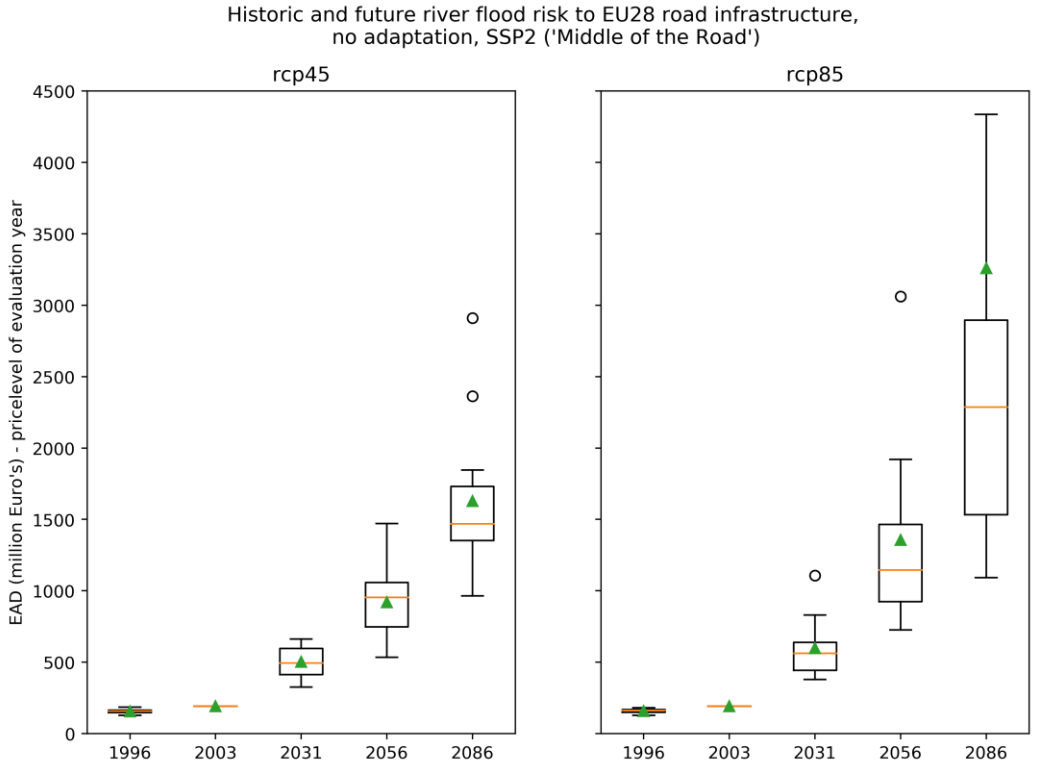
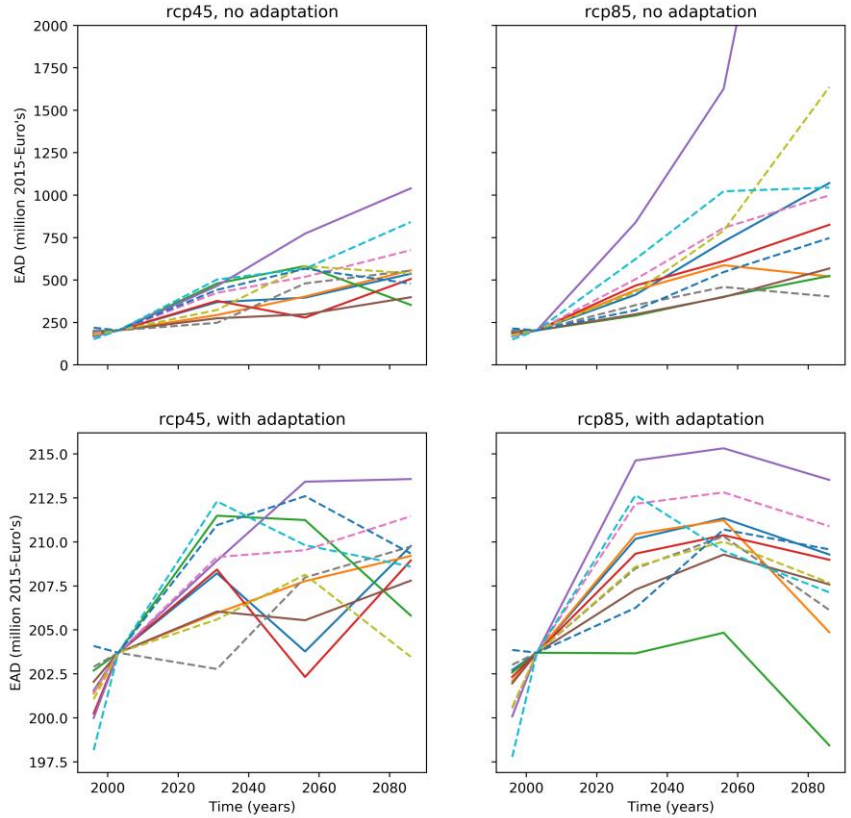
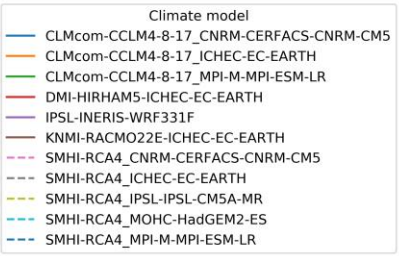
[Van Ginkel et al. (2021) https://nhess.copernicus.org/articles/21/1011/2021/](https://nhess.copernicus.org/articles/21/1011/2021/)

Results: climate change

- Adaptation is key
- Need for targeted investments







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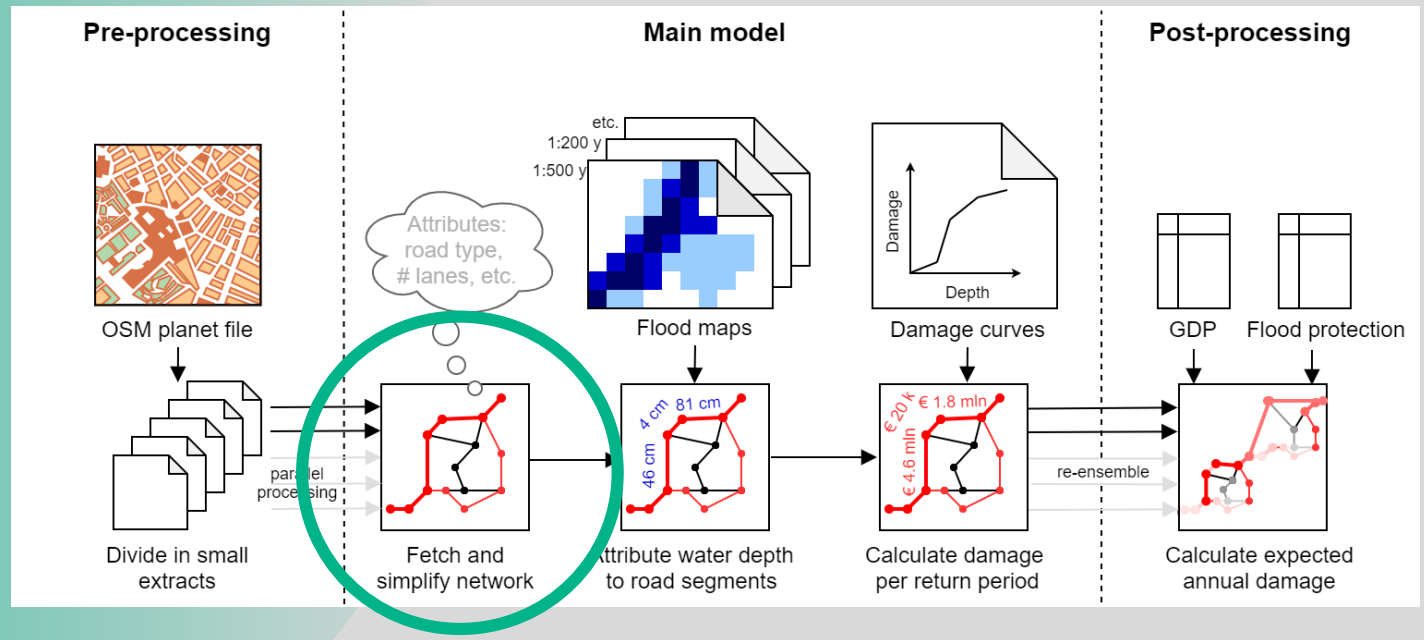
Lincke, D., Hinkel, H., van Ginkel, K., Jeuken, A., Botzen, W., Tesselaar, M., Scoccimarro, E., Ignjacevic, P. (2018). D2.3 Impacts on infrastructure, built environment, and transport Deliverable of the H2020 COACCH project.

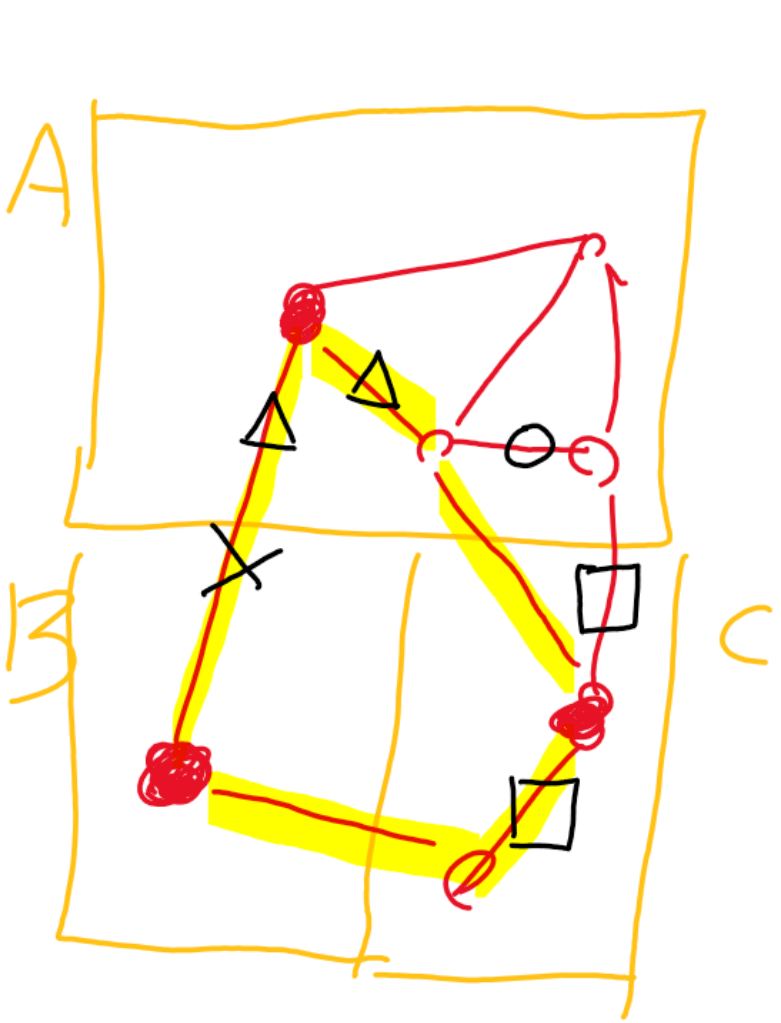
Key insight: graph-properties of road networks are maintained in the new object-based approach

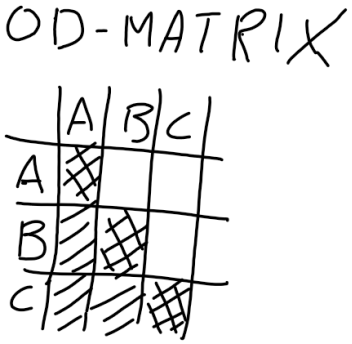


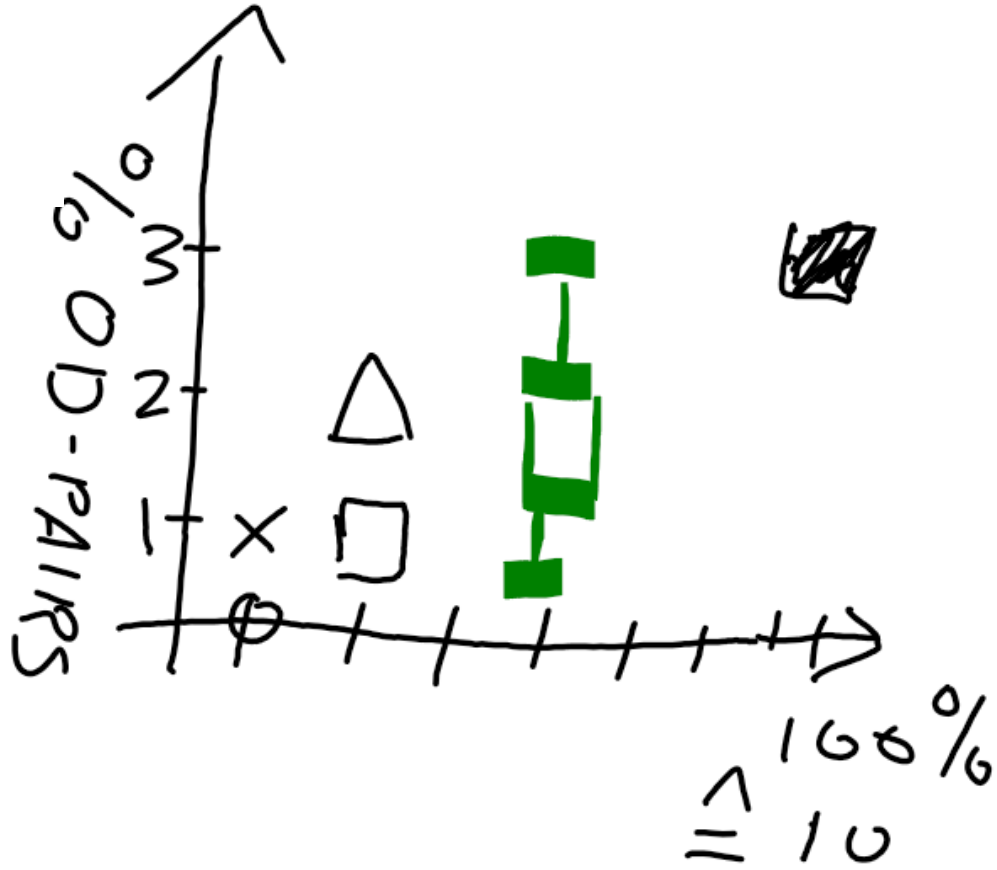
Network graph

Van Ginkel et al. (2021)
https://nhess.copernicus.org/articles/21/1011/2021/

Percolation analyis of national road networks







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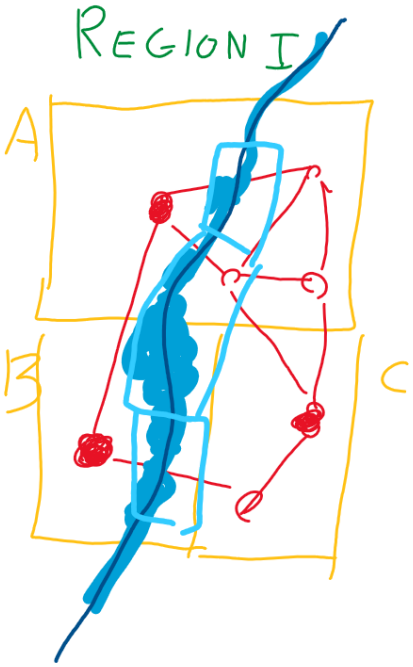
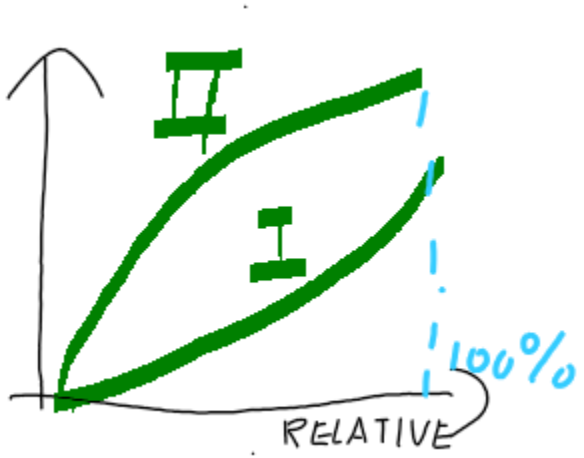
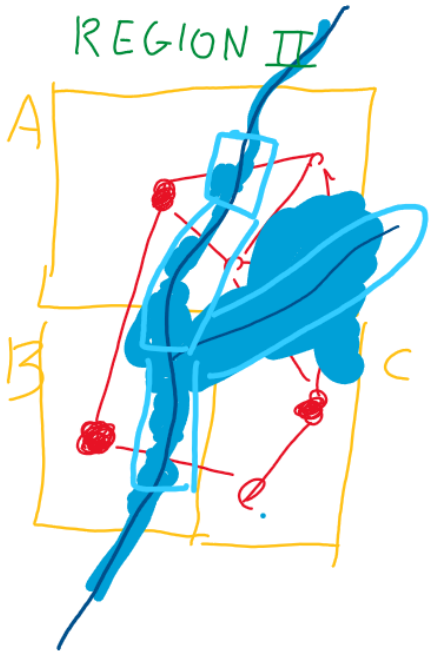
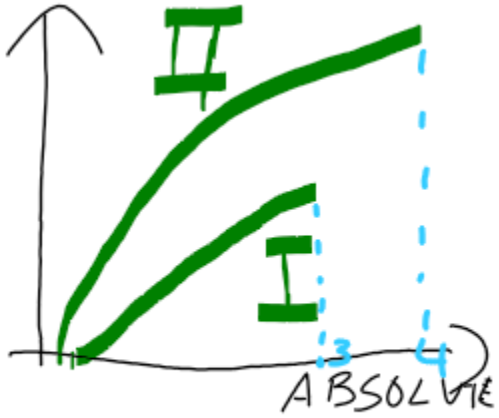
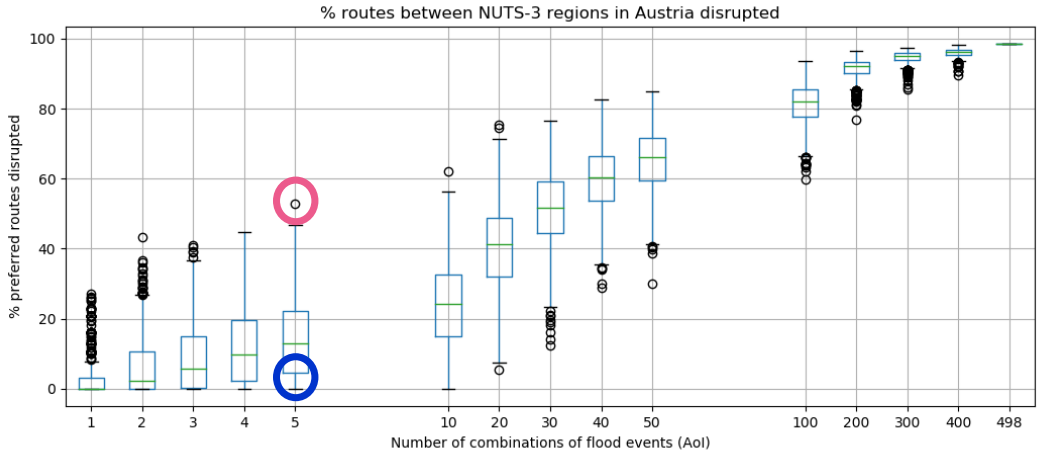

REGION I
A
B
C

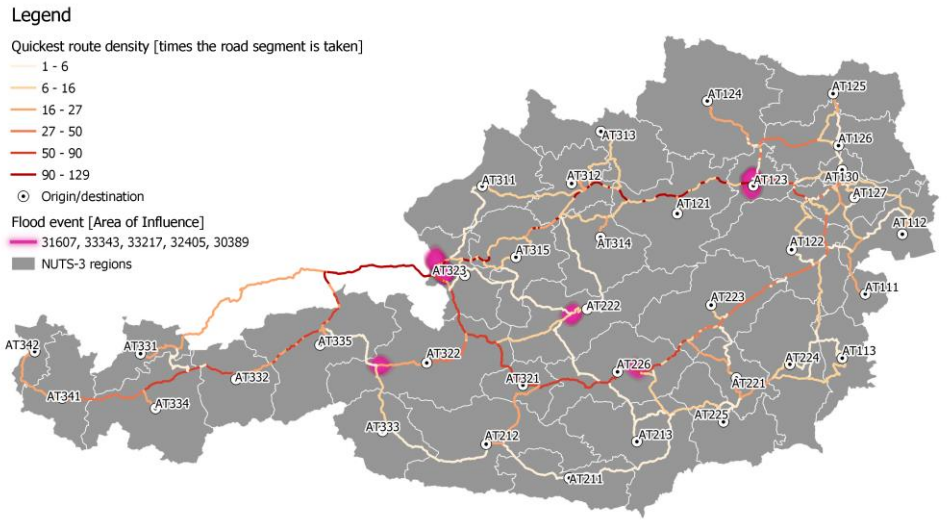

II
I
100%
RELATIVE


REGION II
A
B
C

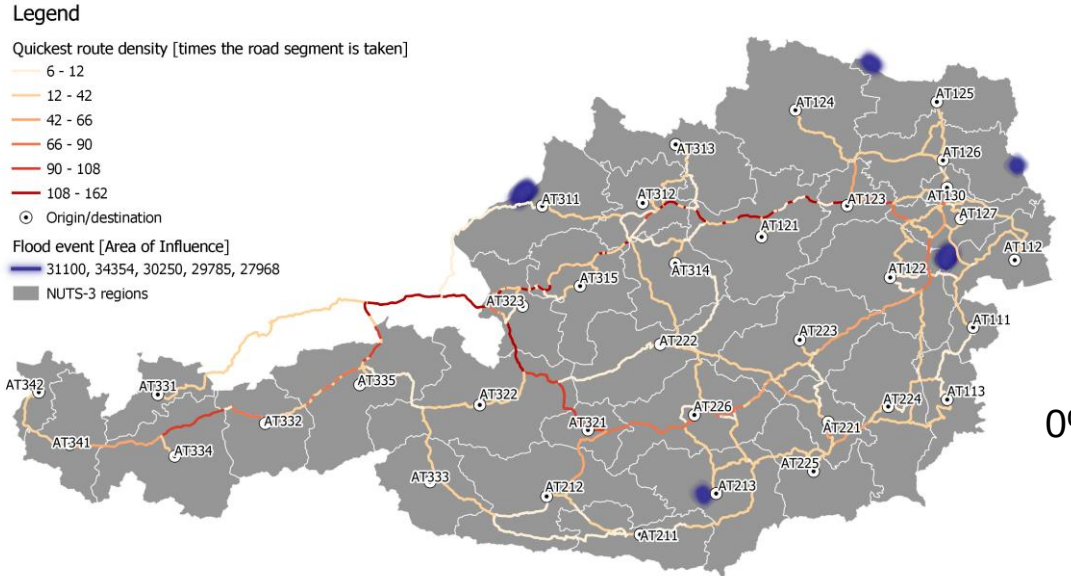

II
I
3
4
ABSOLUTE

Network approach: comparison EU-countries (Percolation analysis)





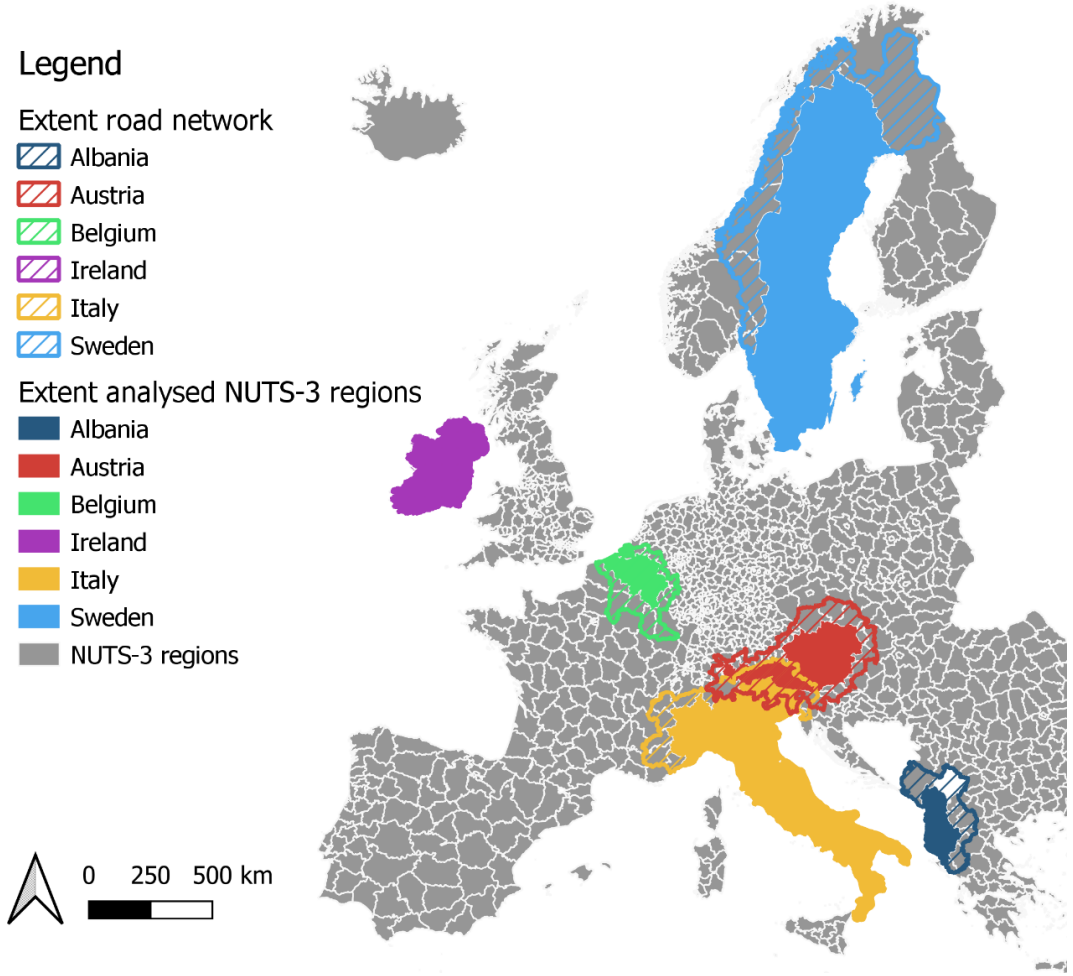
53% disrupted quickest routes
of which 94% has a detour option

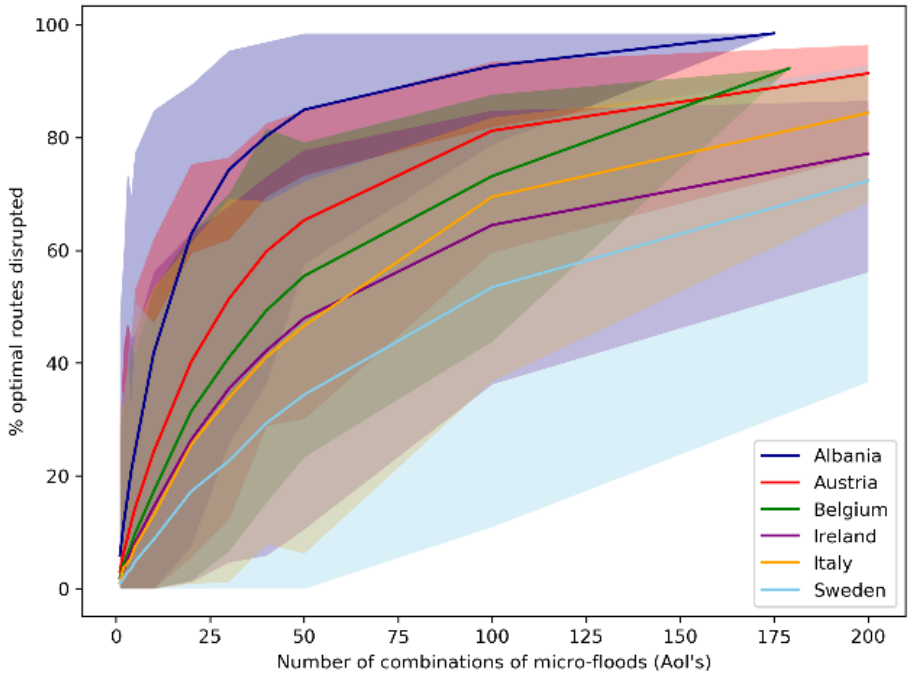


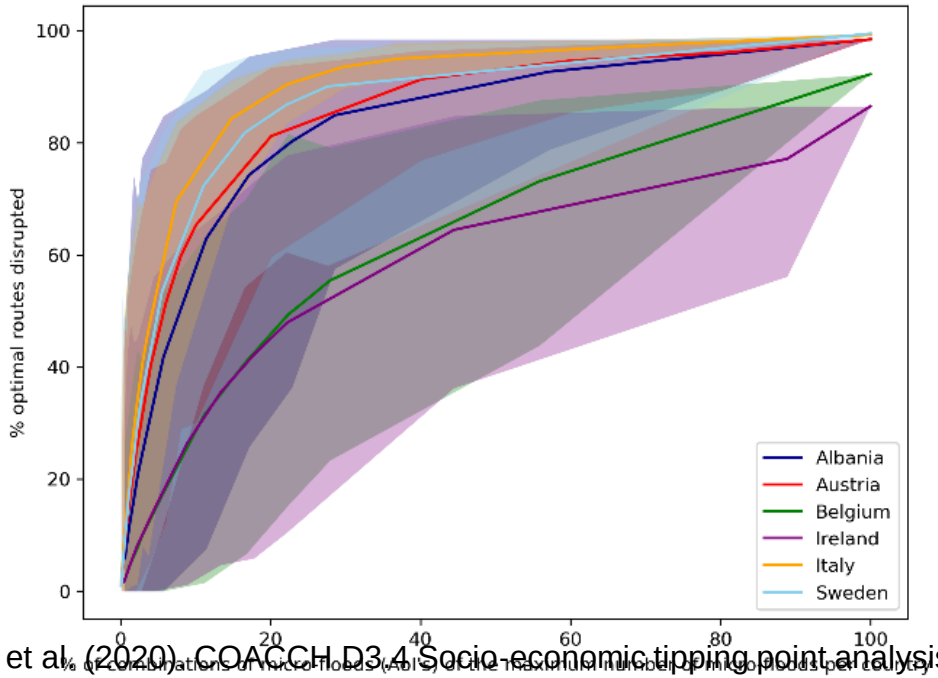
0% disrupted quickest routes

Botzen et al. (2020). COACCH D3.4 Socio-economic tipping point analysis

COACCH: analysed networks



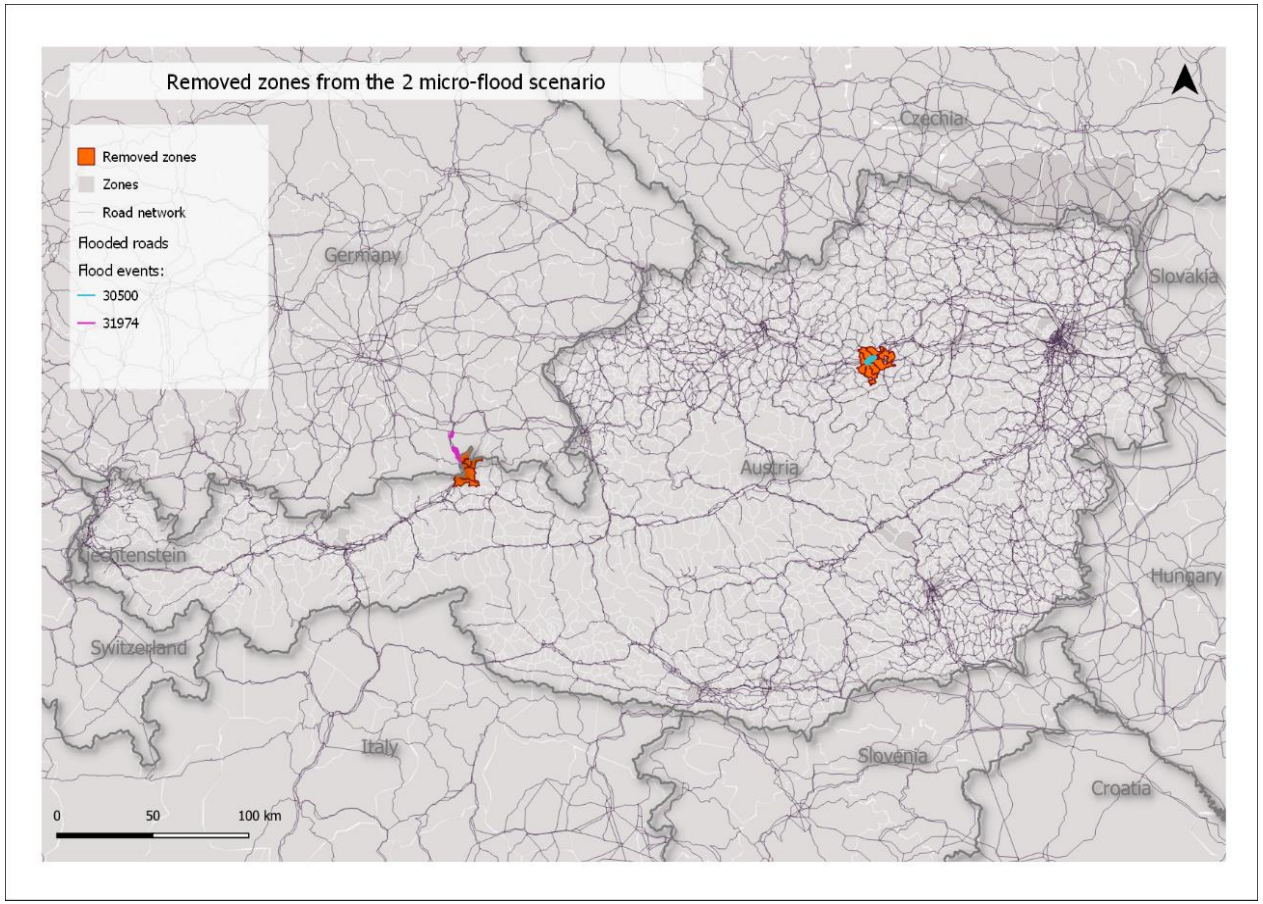




Botzen et al. (2020). COACCH D3.4 Socio-economic tipping point analysis

Combination with national transport model

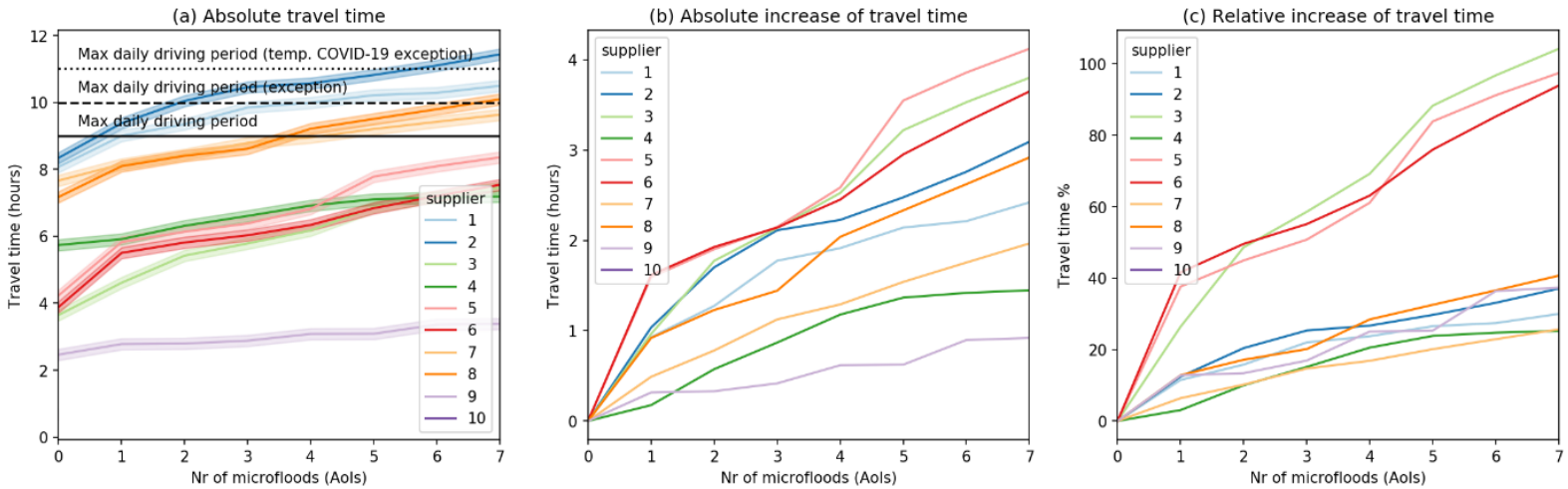
- Austria: detailed calculation of detour times, travel time losses, change in in trip generation/attraction => costs per event.

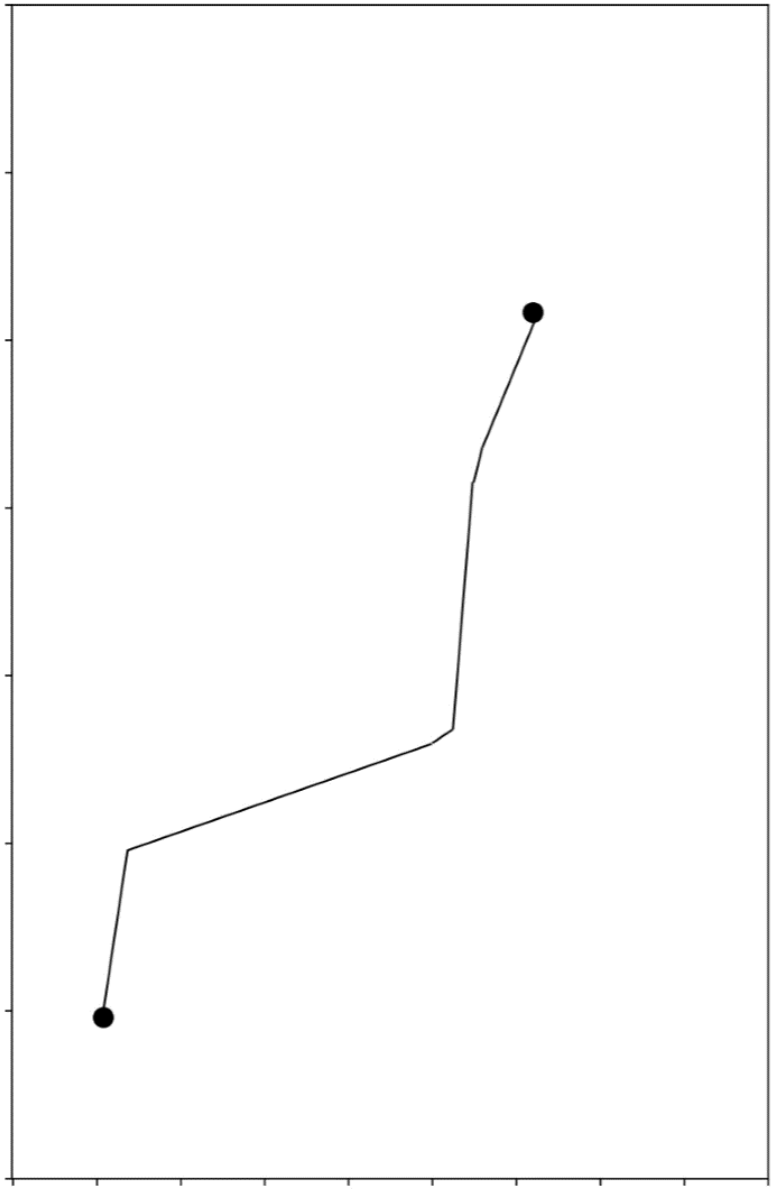


Botzen et al. (2020). COACCH D3.4 Socio-economic tipping point analysis

Perspective: car manufacturer

- How can floods hamper the supply chains of one particular car and truck manufacturer?
- Just-in-time delivery can cause large damage
- Legal driving times can be a source of damage





Botzen et al. (2020). COACCH D3.4 Socio-economic tipping point analysis

Climate-proof networks - Dutch Highway

Preparation

OSM primary roads + underlying secondary road network

Traffic intensities

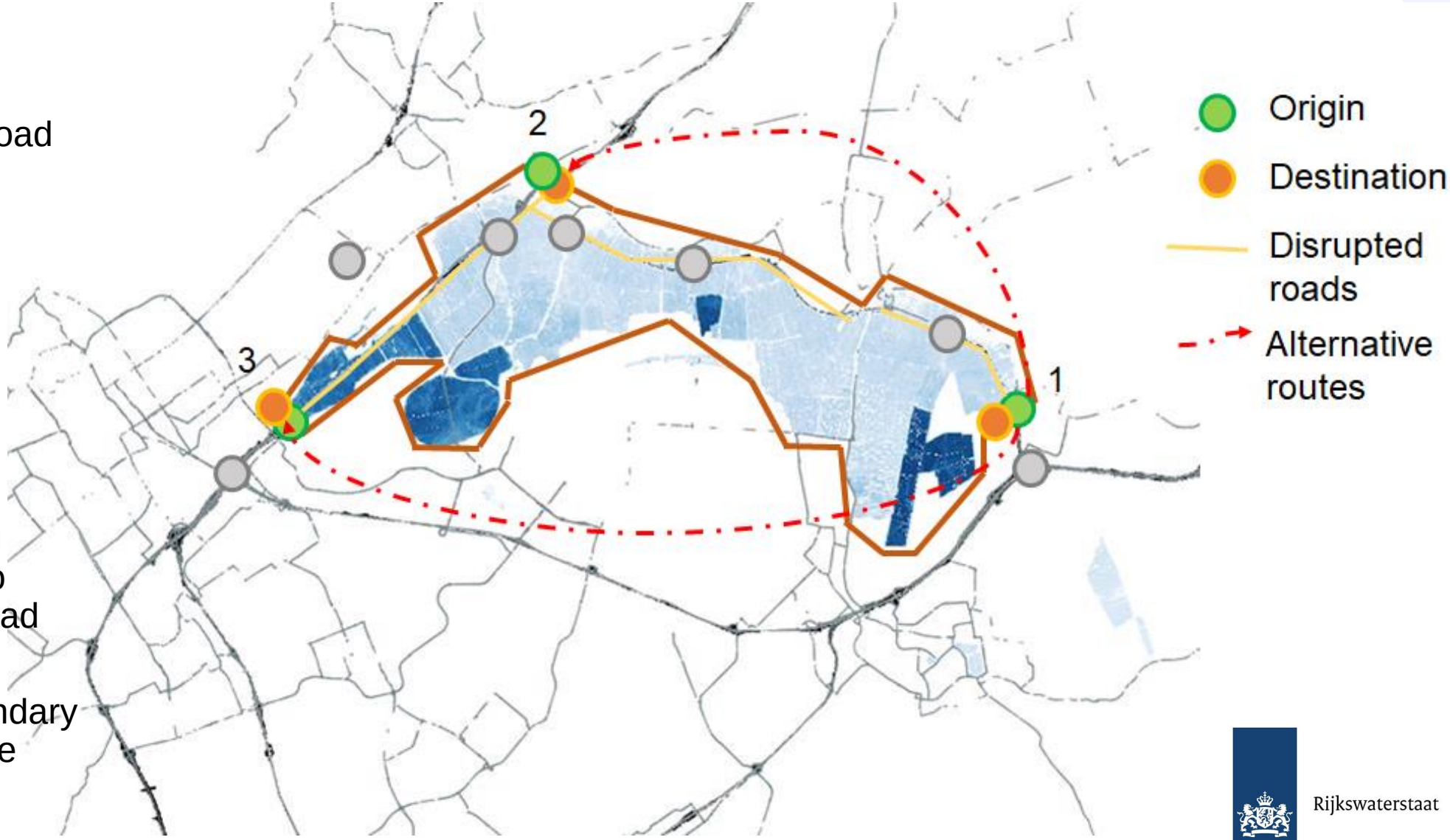
Regional flood maps

Based on 1500 flood scenarios -> batch-processing

Results

Vehicle Loss hours and economic losses due to failure of the primary road network

Rerouting via the secondary road network is possible



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Rijkswaterstaat

General finding: the EU road network seems quite resilient

- What still keeps you awake at night? What concerns you most? [MENTIMETER]
- Which approaches are most suitable for which applications?
- What is lacking?

User need - …….. | Technique - …….

Presented techniques:

- Assessment of direct tangible infrastructural damage (continental-local scale)
- Coarse network-level approach (percolation analysis)
- Detailed national transport model (economic impacts)
- Accessibility/detour analysis for one factory/hospital (e.g. car manufacturer)

Questions

NEW EU Study: https://nhess.copernicus.org/articles/21/1011/2021/

MORE INSPIRATION: https://storymaps.arcgis.com/stories/9a130a0e8c424dceb91a42839662c1f3

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NRT Flood Impact Analysis on Road Networks

Preparation

OSM roads + health care centers

Population density

Near-real-time

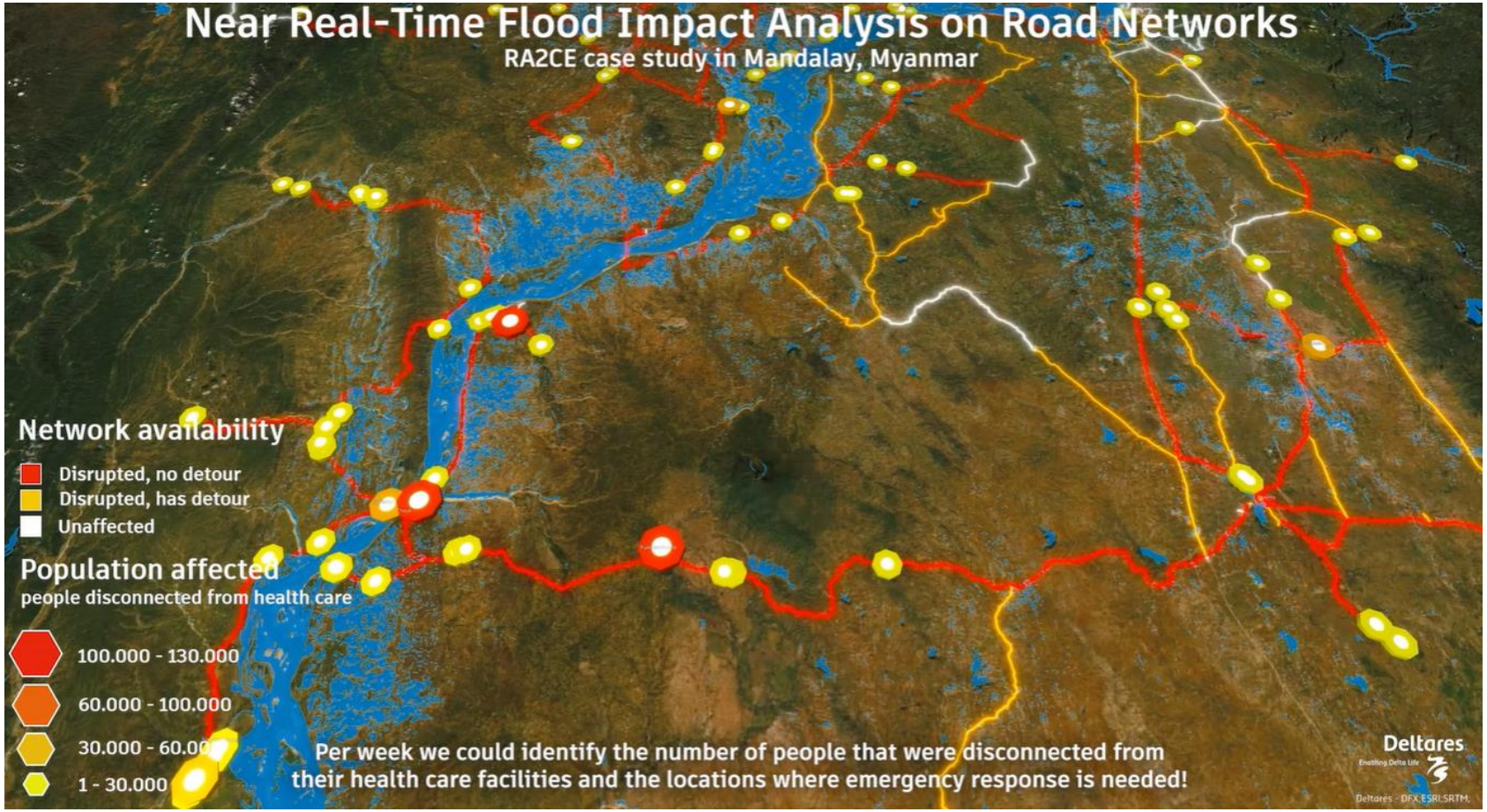
Inundation maps from satellite imagery

Results

Disrupted roads

Accessibility from population centers to health care.

Road intensity



Arjen Haag, Frederique de Groen, Herman Haaksma, Margreet van Marle, Martijn Kwant

https://storymaps.arcgis.com/stories/9a130a0e8c424dceb91a42839662c1f3

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