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Rijkswaterstaat
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Recent advances in model-based assessment of flood damage to road networks

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With contributions of Elco Koks, Frederique de Groen and Margreet van Marle (and other Deltares colleagues)

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Outline

Road repair costs

- A new approach to bridge the gap between continental-scale and local-scale models
  - River flood risk assessment of all road segments in Europe
  - Open-source and OpenStreetMap
  - Development of new damage curves

Costs of disrupted traffic

- A high-resolution application to the road network of the Netherlands

Indirect economic effects

- Research agenda

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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 (societal costs)
  - Indirect economic 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.

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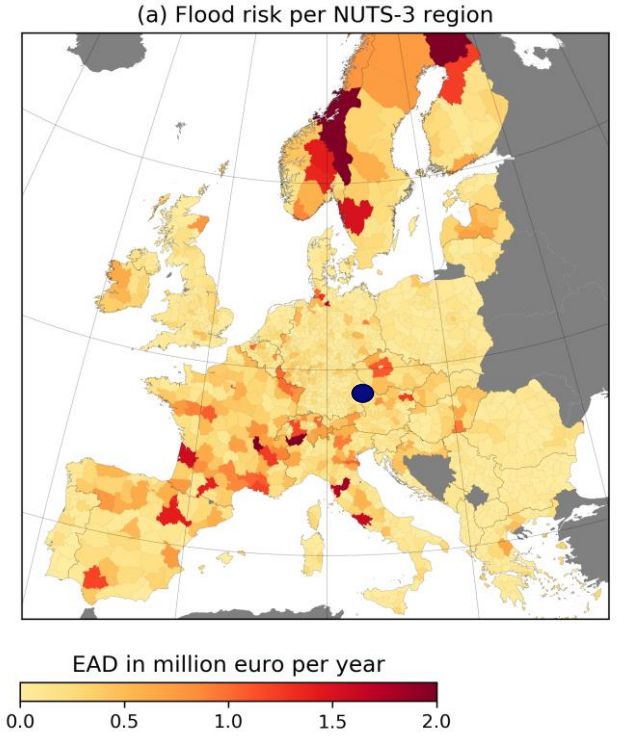
Part 1:
Direct tangible infrastructural damage

What would it cost the road operator to repair the road (including embankments, noise barriers, electronic signaling) after a flood?

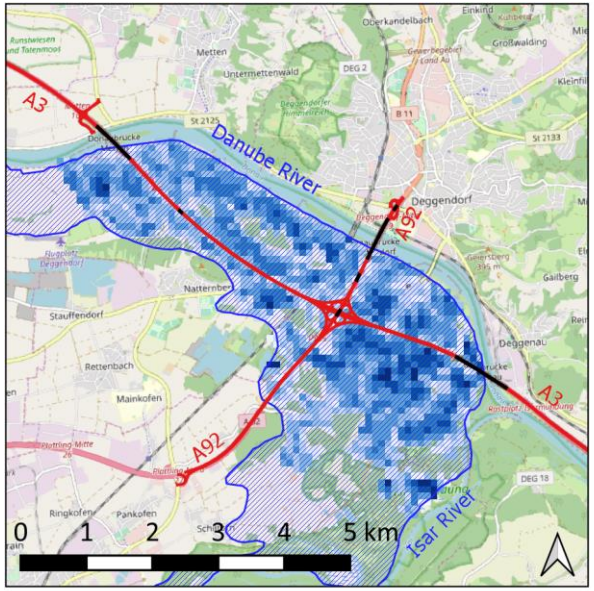
Excludes: emergency response costs

Previously: two separate worlds

Continental-scale grid-based models



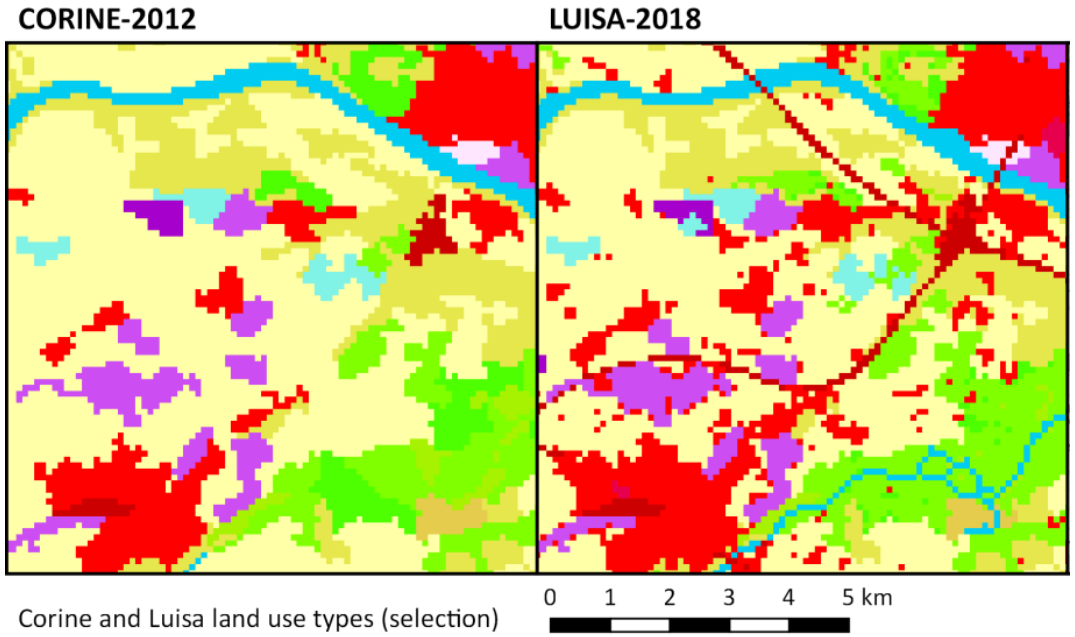
Local-scale object-based models



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

Previously: two separate worlds

Continental-scale grid-based models

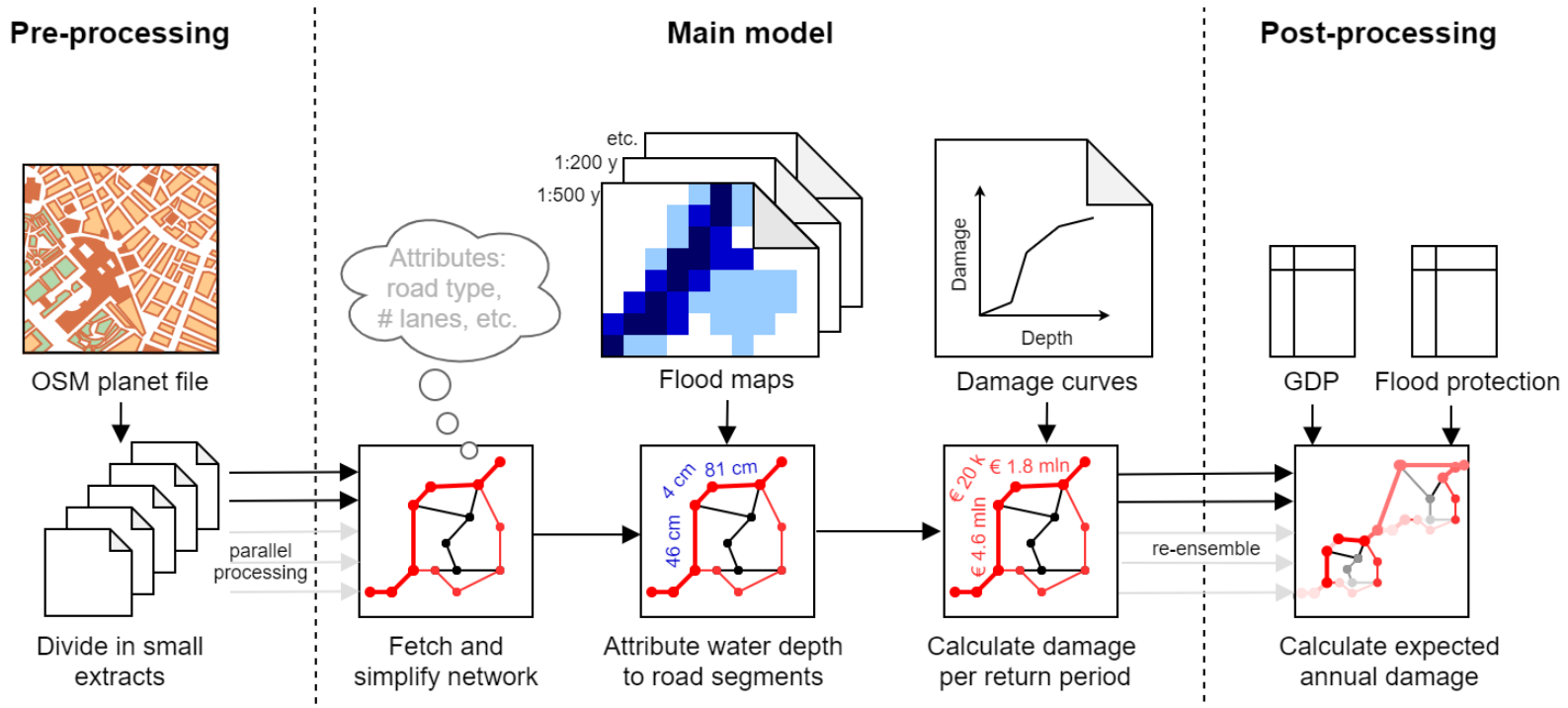


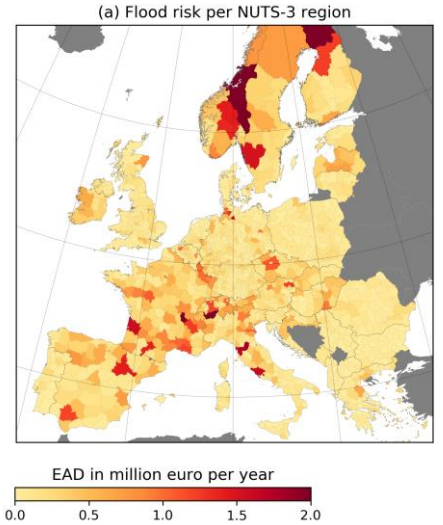
Corine and Luisa land use types (selection)

Local-scale object-based models

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

New method: object-based on the continental scale





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

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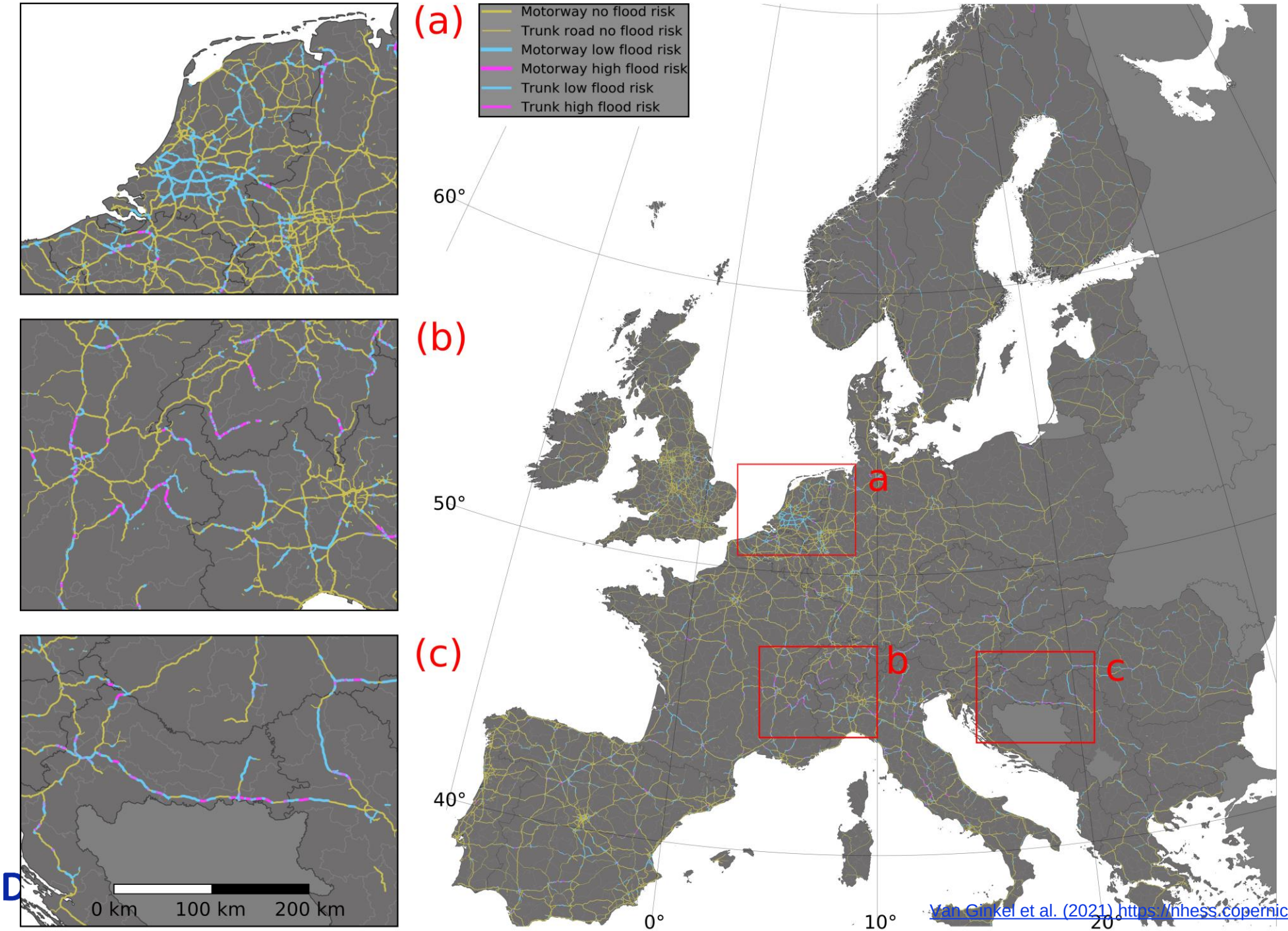

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van Ginkel et al. (2021) https://nhess.copernicus.org/articles/21/1011/2021/

One approach for continental to local scale

- New object-specific damage curves
- Better use of OSM metadata on road type, # lanes, GDP data, street lighting
  - E.g. Motorways are typically located on embankments
  - Large differences in road design and soil conditions
- Large collection of open-access construction and repair data
- Call for collaboration on improvement of damage curves: compare **reported** and **modelled** damage for actual floods





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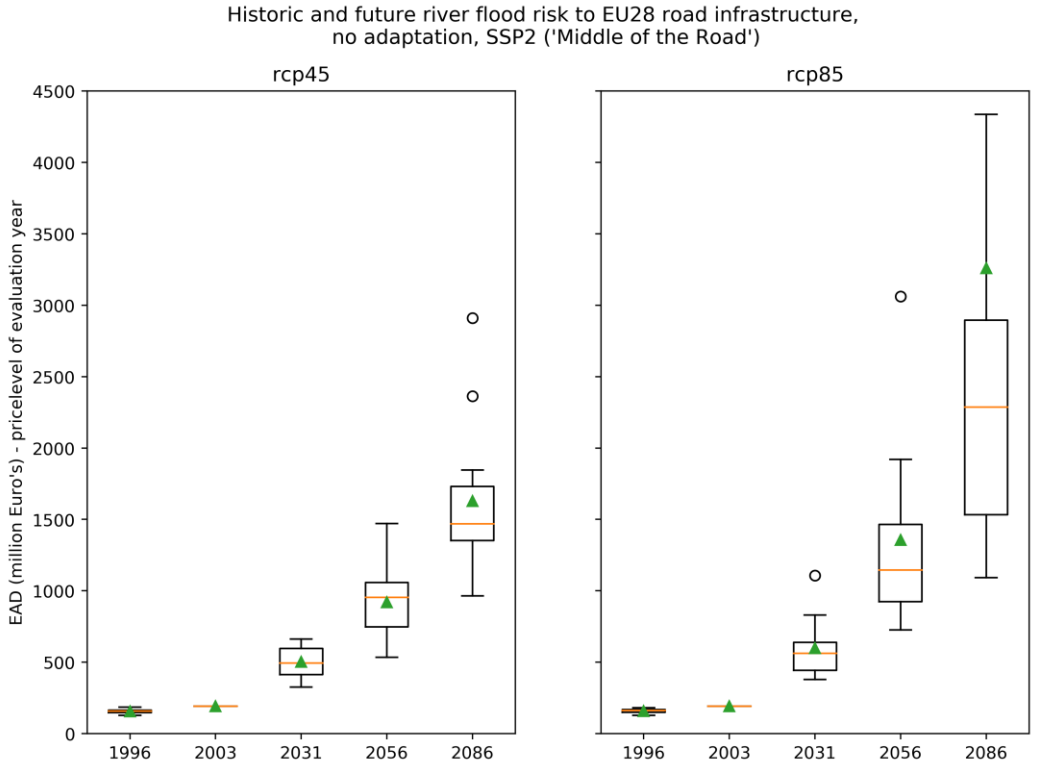
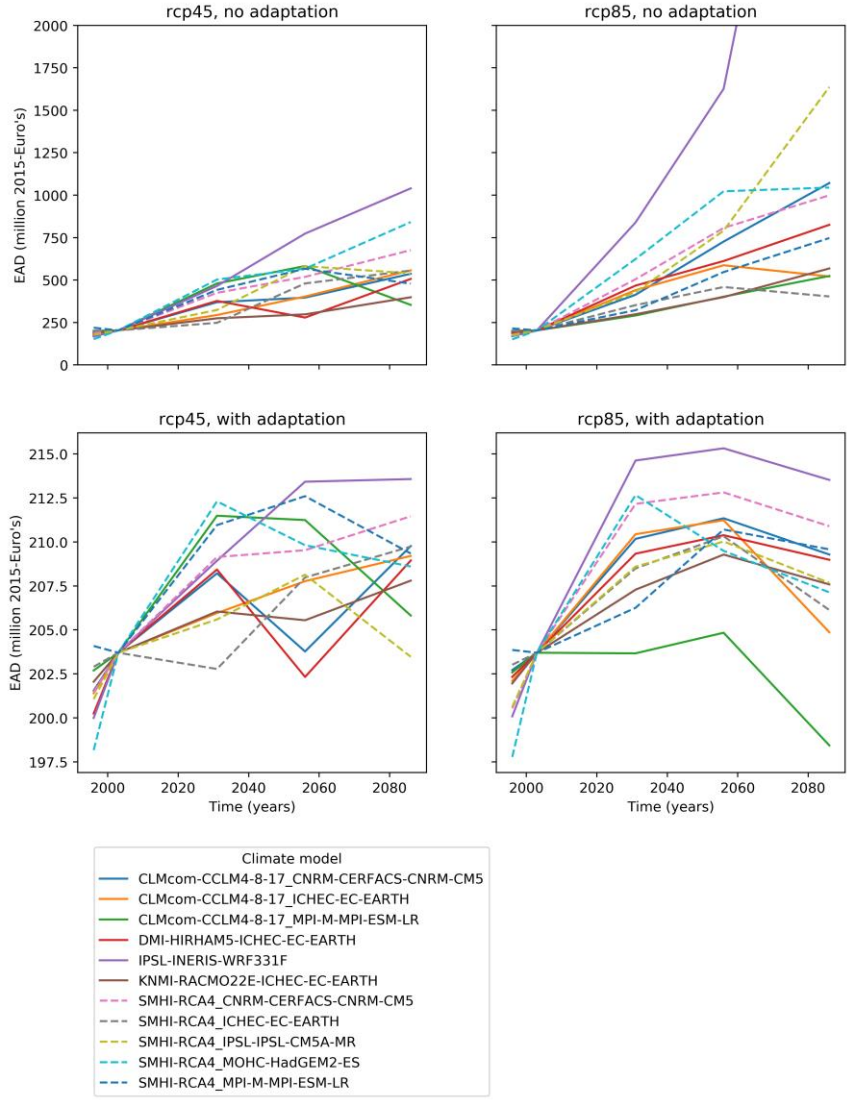
Van Ginkel et al. (2021) https://nhess.copernicus.org/articles/21/1011/2021/

Results: climate change

- Adaptation is key: may avoid a large increase of cost
- Need for targeted investments: **where to invest**





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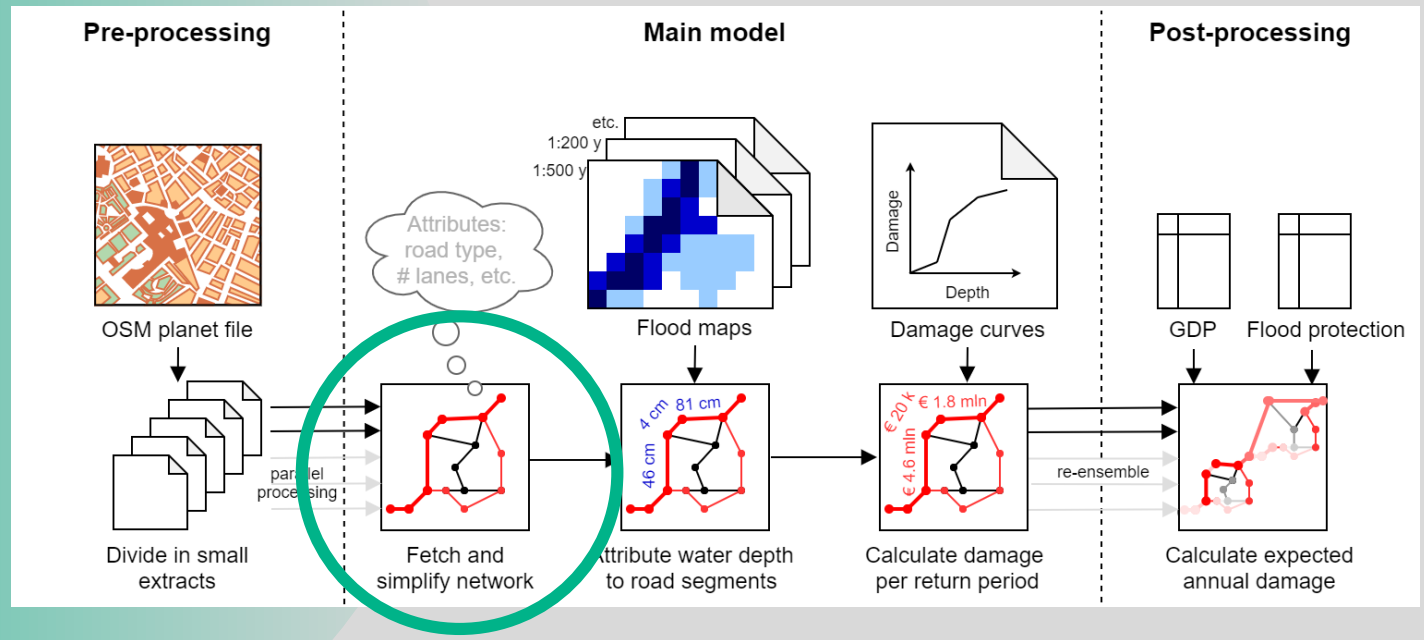
Lincke, D., Hinkel, H., van Ginkel, K., Jeuken, A., Botzen, W., Tesselaar, M., Scoccimarro, E., Ignjacevic, P. (2018). D2.3 Impacts on infrastructure, built environment, and transport Deliverable of the H2020 COACCH project.

Summary

- New approach to bridge continental and local scale assessments
- Helps to make targeted adaptation investments in road infrastructure
- Very important to improve the damage functions; validation data is needed
- You can freely use the approach to apply it to your own road network and with your own hazard data

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/

Part 2:
Modelling repair costs + costs of disrupted traffic

Can we coherently model both sources of damage?

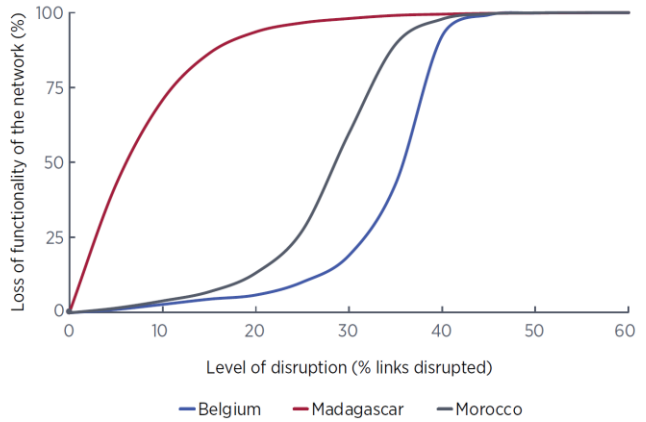
Climate-proof networks: examining the Dutch highway

- Regional floods (~ not from big rivers, but from smaller creeks and canals)
- Direct damage: similar object based approach as European study, but refined:
  - From 100*100 m flood resolution (Europe) to up till 5*5 m flood resolution (Netherlands)
  - Road widths derived from the database of the road operator
  - Explicit accounting for local road embankment height
  - Split embankment damage and pavement damage
- Indirect damage: event-based approach
  - 1500 simulations of possible flood events (batch-processing)
  - Evaluating possible detours, and surplus travel time
  - Cost estimation by multiplication with vehicle loss hours and traffic intensity

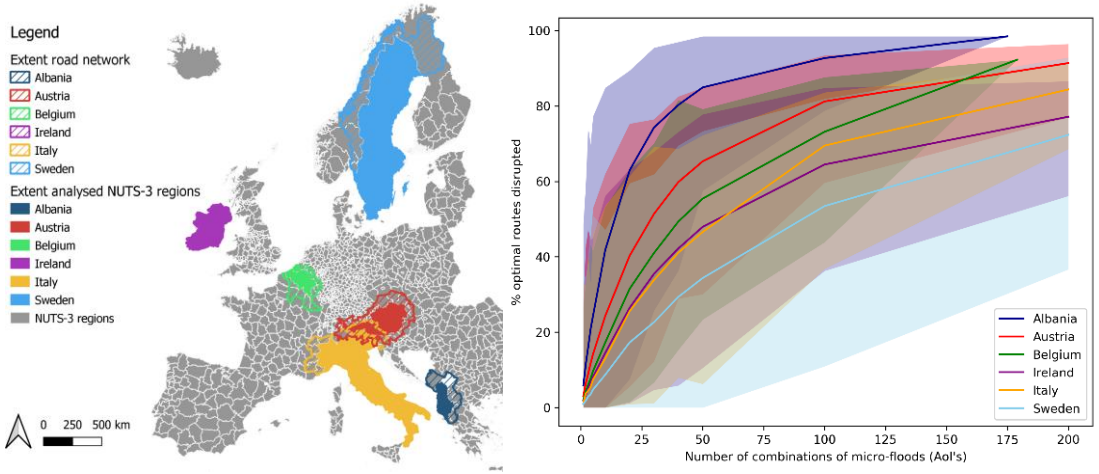
Research agenda

- Alternative approach to assessment of robustness of national road networks:
  - Study with VU University World Bank: assessment of national road networks (see WorldBank lifelines report)
  - More detailed assessment of European countries against river floods
- Idea: possible application to European trade corridors
- Assessment of supply chains of individual factories; or specific critical infrastructure in general: Accessibility of hospitals: https://storymaps.arcgis.com/stories/9a130a0e8c424dceb91a42839662c1f3
- Deltares RA2CE: toolkit for various assessment of road networks

FIGURE O.9 Belgium's and Morocco's transport systems can absorb much larger road disruptions than Madagascar's



Source: Rozenberg et al. 2019b.



Questions

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