Distr.: General
20 April 2021

English only

Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Group of Experts on Assessment of Climate Change Impacts and Adaptation for Inland Transport

Twentieth session
Geneva, 22 and 23 April 2021
Item 2 of the provisional agenda
Initiatives in climate change impact assessment and adaptation for inland transport

List of case studies used state-of-the art methodologies to assess hazards at different spatio-temporal scales, and available online tools

Submitted by the University of Aegean

Table A-1

List of case studies used state-of-the art methodologies to assess hazards at different spatio-temporal scales, and available online tools. Key: GS, Global scale; ES, European scale; DEM Digital Elevation Model; SLR, mean sea level rise; GCM, Global Circulation Model; RCM, Regional Climate Model. The list is not exhaustive. It is also worthwhile to consult a series of recent reports found in the EU site *https://op.europa.eu/en/publication-detail/-/publication/ca870a9a-7654-11eb-9ac9-01aa75ed71a1/language-en/format-PDF/source-193461344*

Observations/Trends				
Scale	***Objective***	***Technologies used***	***Outputs***	***References /Data sets***
ES	Heatwaves	Data bases of in situ and satellite information	Time series of specific (27) indices can identify extremes and trends	https://climate.copernicus.eu/climate-data-store http://etccdi.pacificclimate.org/list_27_indices.shtml **[1], [2]**
GS ES	Heavy precipitation	Data from precipitation gauges, global observations from Climate Prediction Center -CPC-NOAA (resolution 0.5°). Historic observations for Europe from Copernicus	Historic trends (global and European): subsets can be abstracted for certain areas. Different (11) indices can be used (e.g. Rx5d, max. annual 5-day consecutive rain)	CPC-NOAA https://climatedataguide.ucar.edu/climate-data/cpc-unified-gauge-based-analysis-global-daily-precipitation https://climate.copernicus.eu/climate-data-store
ES	Droughts	Complex causation (meteorological, hydrological and water use); assessments differ by sector	Drought hazard maps based on meteorological/hydrological data (precipitation, temperature, streamflow and soil moisture) at hourly to monthly resolution	European Drought Impact Report Inventory (EDII) http://www.geo.uio.no/edc/droughtdb/index.php
GS ES	Windstorms	Extratropical (mid-latitude) cyclones: wind speeds/gusts from RCMs or observatios. Medicanes: Observations or RCM models. Tropical storms: 2-D parametric wind fields using mean sea-level pressure, maximum wind speeds, eye size, location and background wind	Max. wind speeds, min sea-level pressure at grid cells (1- 12 km resolution) of a polar grid centred at the cyclone eye; hourly or larger temporal resolution. Pan-European WISC datasets on winter storms used to assess bulding damages,	https://wisc.climate.copernicus.eu/wisc/#/help/products#footprint_section **[3], [4]**
GS	Coastal erosion	Satellite imagery-water presence (32 year time series). Global Surface Water Explorer (GSWE) dataset	Overall surface of eroded land up to 28,000 km^2	Shoreline evolution at: http://data.europa.eu/89h/944f6d9b-2fbf-422e-ae3e-4b3aa391ed48 Shoreline change projections at:

		https://data.jrc.ec.europa.eu/collection/LISCOAST		http://data.europa.eu/89h/18eb5f19-b916-454f-b2f5-88881931587e **[5]**
Modeling/projections				
ES	Heatwaves	Climate model simulations: reanalysis and projections	Europe: present/future estimations in Copernicus system. Projections of indices related to temperature extremes. Issues with resolution	https://climate.copernicus.eu/climate-data-store **[6], [7]**
GS ES	Droughts	Simulations depend on drought type and sector. Utilization of GCMs/RCMS meteorological data outputs, and flow data from hydrological models	Drought hazard projections (drought likelihood- probability and return periods	**[8]**
ES	Heavy precipitation	Assessment by GCMs and RCMs; historic and future trends assessed by specific indicators.	Assessment of the (11) indices for rainfall extremes (e.g. Rx5d: maximum annual 5-day consecutive precipitation)	**[7]**
ES	Windstorms	Cyclones: Max. wind speeds, min sea-level pressure (1- 12 km resolution) for a polar grid centred at the cyclone eye; hourly or larger temporal resolution	Projections (pan-European datasets of winter storm events (WISC12)) can be used to assess wind damages to buildings	https://wisc.climate.copernicus.eu/wisc/#/help/products#footprint_section **[9]**
ES	River flood hazard for Europe and the Med 10 to 100 year events)	Inundation along 329’000 km of rivers (100 m resolution), for 6 return periods. Input flow data by the hydrological model LISFLOOD; inundation by the 2=D hydrodynamic model LISFLOOD-FP	Results comparable to large-scale flood models; recently released high-resolution elevation datasets and with better channel geometries can improve future versions.	Flood Hazard Maps at: http://data.europa.eu/89h/1d128b6c-a4ee-4858-9e34-6210707f3c81 **[10]**
GS	Flood hazard for several return periods (10 - 500 years)	Resolution at 30 arc-second (~1 km at the equator). 3’’ SRTM DEM, ASTER DEM, 2D Hydraulic model LISFLOOD-FP	Modelling framework for global flood hazard. Integrated in the Global Flood Awareness System (GloFAS); a first step the focrecasting Glo- FAS systems in flood assessments.	Flood Hazard Maps available at: https://data.jrc.ec.europa.eu/collection/floods [11]
GS	Global flooding risk due to SLR (slow-onset)	DEMs: Shuttle Radar Topography Mission SRTM-DTM, Global Land One-km Base Elevation (GLOBE). Inundation: Dynamic Interactive	Without adaptation, up to 4.6 % of global population projected to be flooded annually in 2100 (annual losses of 0.3 – 9.3 % of the global GDP.	**[12]**

		Vulnerability Assessment (DIVA) (slow-onset)		
ES	Present coastal flooding (Europe)	SRTM-DTM at (~90 m) resolution, ESL projections, dynamic inundation model LISFLOOD-ACC	Significant differences in risk under different approaches	**[13]**
ES	Coastal risk projections: European coastline	(SRTM) DEM (100 m resolution), ESL projections modular framework CFR model, LISCoAsT (Large scale Integrated Sea-level and Coastal Assessment Tool)	Without coastal adaptation, the present EADs and exposed population will increase by 2-3 orders of magnitude (in 2100)- up to €961 billion and 3.65 million, respectively)	Data sets at: http://data.europa.eu/89h/jrc-liscoast-10009 **[14]**
ES	Multi-hazard assessment flooding, droughts heatwaves, SLR, windstorms, wildfires	Climate hazards from an ensemble of GCM-RCM (A1B scenario). Static coastal inundation approach, inland flooding from earlier works. Probability statistics	Progressive/strong increase in overall climate hazards leads to overall exposure increases. Key hotspots along highly populated and economically pivotal coastlines and floodplains	**[15]**
Online tools/Methodologies				
GS	Short –term forecast of coastal sea levels (with global coverage.	GLOSSIS system; 16,000 DIVA coastal segments; Global Tide and Surge Model (GTSM)	10-day forecasts of total water levels and storm-surges	(https://www.deltares.nl/en/projects/global-storm-surge-information-system-glossis/)
ES	Flood risk assessment of the European road network	Grid-based approach: 1 CORINE land cover and the Huizinga damage curve 2 LUISA land cover and the Huizinga damage curve. Object-based approach: 3 OpenStreetMap and object translation of the Huizinga infrastructure damage curve 4 OpenStreetMap and new object-based damage curves. Per region, every road segment's geometry is simplified to 0.00005° resolution (~5 m in Europe) and intersected with the	The expected annual direct damages from large river floods to road infrastructure in Europe assessed as EUR230 million per year	The Python code for the object-based model can be retrieved from https://doi.org/10.5281/zenodo.4588800 Supplement contains shapefile with the model outputs for the European highway network (motorways and trunk roads). Data for all OSM road classes per NUTS 3 region can be retrieved from the authors. **[16]**

		flood hazard maps per return period		
GS	A global multi-hazard risk analysis of road and railway infrastructure assets	Analysis over 46,566 regions based on the GADM. Transport data based on OpenStreetMap (OSM). Global earthquake and cyclone hazard data available from UNISDR Global Assessment Report 2015 portal (https://risk.preventionweb.net/) Global fluvial and pluvial flood data used with the permission of Fathom Global. Coastal flood maps developed by the Joint Research Centre of the European Commission. Global liquefaction map available to download https://doi.org/10.5281/zenodo.2583745.	Results: ~27% of all global road and railway assets exposed to (at least) one hazard and ~7.5% of all assets exposed to a 1-100 year flood event. Global EADs from direct damage to road/rail assets $3.1 to 22 billion, of which ~73 % is caused by pluvial and fluvial flooding.	Source code is available through https://github.com/ElcoK/gmtra. Results and figures can be reproduced through the source code. **[17], [18]**

References

[1] Pasqui M.,and Di Giuseppe E. (2019). Climate change, future warming, and adaptation in Europe. Animal Frontiers 9(1), 6 – 11.

[2] Hov Ø., et al (2013). Extreme weather events in Europe: preparing for climate change adaptation. Norwegian Meteorological Institute

[3] Bonazzi A. et al., (2012). The spatial structure of European wind storms as characterized by bivariate extreme-value Copulas. Natural Hazards & Earth System Sciences 12, 1769–1782, www.nat-hazards-earth-syst-sci.net/12/1769/2012/

[4] Nastos P. et al (2018). Mediterranean tropical-like cyclones: Impacts and composite daily means and anomalies of synoptic patterns. Atmospheric Research, 208, 156-166.

[5] Mentaschi L et al., 2018. Global long-term observations of coastal erosion and accretion. Scientific Reports 8, Article number: 12876. https://www.nature.com/articles/s41598-018-30904-w.pdf

[6] Pasqui M. and Di Giuseppe E. (2019). Climate change, future warming, and adaptation in Europe. Animal Frontiers, 9(1), 6 – 11

[7] ECE (2020). Climate Change Impacts and Adaptation for Transport Networks and Nodes. United Nations Economic Commission for Europe (UNECE), Expert Group Report ECE/TRANS/283. 216 pp

[8] Mishra A K. et al (2015) Drought processes, modeling, and mitigation. Journal of Hydrologyl 526, 1-2.

[9] Welker C. et al (2021). Comparing an insurer's perspective on building damages with modelled damages from pan-European winter windstorm event sets: a case study from Zurich, Switzerland. Nat. Hazards Earth Syst. Sci. 21, 279–299.

[10] Dottori F.et al. (2021). A new dataset of river flood hazard maps for Europe and the Mediterranean Basin region, Earth Syst. Sci. Data Discuss. [preprint], https://doi.org/10.5194/essd-2020-313 , in review

[11] Dottori F. et al. (2016). Development and evaluation of a framework for global flood hazard mapping. Advances in Water Resources 94, 87-102. http://dx.doi.org/10.1016/j.advwatres.2016.05.002

[12] Hinkel J. et al., 2014. Coastal flood damages and adaptation costs under 21st century sea-level rise, Proceedings Natl. Acad. Sci. USA, 111, 3292–3297. https://www.pnas.org/content/pnas/111/9/3292.full.pdf.

[13] Vousdoukas, M. I., Voukouvalas, E., Mentaschi, L., Dottori, F., Giardino, A., Bouziotas, D., Bianchi, A., Salamon, P., and Feyen, L., 2016: Developments in large-scale coastal flood hazard mapping, Nat. Hazards Earth Syst. Sci., 16, 1841–1853, https://doi.org/10.5194/nhess-16-1841-2016

[14] Vousdoukas, M. I., Bouziotas, D., Giardino, A., Bouwer, L. M., Mentaschi, L., Voukouvalas, E., and Feyen, L.: Understanding epistemic uncertainty in large-scale coastal flood risk assessment for present and future climates, Nat. Hazards Earth Syst. Sci., 18, 2127–2142, https://doi.org/10.5194/nhess-18-2127-2018 , 2018.

[15] Forzieri G., et al., 2016. Multi-hazard assessment in Europe under climate change. Climatic Change 137, 105–119. DOI 10.1007/s10584-016-1661-x

[16] van Ginkel K. C. H. (2021). Flood risk assessment of the European road network, Nat. Hazards Earth Syst. Sci., 21, 1011–1027, https://doi.org/10.5194/nhess-21-1011-2021, 2021.

[17] Koks, E.E., Rozenberg, J., Zorn, C. *et al.* A global multi-hazard risk analysis of road and railway infrastructure assets. *Nat Commun* **10,** 2677 (2019). https://doi.org/10.1038/s41467-019-10442-3

[18] van Ginkel, K.: keesvanginkel/OSdaMage: v2.0_NHESS_final_publication (Version 2.0), Zenodo, https://doi.org/10.5281/zenodo.4588800, 2021.

See also a series of recent reports

Modelling- Comprehensive desk review – concise summary https://www.preventionweb.net/files/7845_GEF20final20report20Oct20081.pdf

Comprehensive desk review – climate adaptation models and tools https://op.europa.eu/en/publication-detail/-/publication/9383d16e-7651-11eb-9ac9-01aa75ed71a1/language-en

Comprehensive desk review annex – climate adaptation models and tools https://op.europa.eu/en/publication-detail/-/publication/cfa86c26-764e-11eb-9ac9-01aa75ed71a1/language-en/format-PDF/source-search

Recommended approach to analysis and modelling https://op.europa.eu/en/publication-detail/-/publication/190face7-7654-11eb-9ac9-01aa75ed71a1/language-en/format-PDF/source-search

Report on use cases and rapid analysis (6) 24 cases of rapid analysis *https://op.europa.eu/en/publication-detail/-/publication/ca870a9a-7654-11eb-9ac9-01aa75ed71a1/language-en/format-PDF/source-193461344*