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EDITORIAL

Vulnerability of transportation to extreme weather and climate change

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I am very glad to have been invited to act as the Guest Editor for this Special Issue of Natural Hazards entitled "Vulnerability of Transportation to Extreme Weather and Climate Change". I consider it a privilege to deliver this volume after a long, strict, and anonymous review process.

The Special Issue is forwarded by the coordinators of three European funded projects that have been completed recently and that form the source for most of the research papers presented here. The Foreward is followed by twelve original research papers focusing on weather and climate-related impacts on various modes of transportation, with emphasis on the European region.

The first paper by Juha Schweighofer presents an overview of the impact of extreme weather events on inland waterway transport in Europe. The study focuses on the Rhine-Main-Danube corridor where the highest amount of cargo transported via inland waterways in Europe is conducted and a variety of different geographical, meteorological, and hydrological domains are present. Various critical weather phenomena are discussed, such as high and low water, ice, visibility, and wind, and thresholds of critical values are presented. Furthermore, the study examines the impacts of these phenomena on safety and weather-related accidents, as well as how they affect the flow of traffic, cargo-carrying capacity, and the impact on infrastructure. The paper concludes by offering a projection of the inland waterways transport performance in the future, presenting an evaluation of the critical weather events which demand attention.

The paper by Athanasatos et al. forms an attempt to identify and register hazardous weather trends in the Port of Limassol, Cyprus (used as a case study for Mediterranean ports). In the study, an overview of a general Risk Assessment is presented. With the aim to provide vital information for such a Risk Assessment, both in the short and the long term, an up-to-date picture of the prevailing weather conditions in the area is presented. Trends of the main extreme weather events for the area are also presented (rainfall, wind, and

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discomfort index) and an evaluation of whether these might pose a problem in the near future is given.

Findings of the WEATHER Project ("Weather Extremes: Impacts on Transport Systems and Hazards for European Regions") are revisited and expanded in the third paper in this volume by Doll et al. The cost estimation and forecast methodology used in the WEATHER project is presented along with the findings on current damage costs and cost developments. The analysis of adaptation strategies carried out and the pros and cons of investment-based adaptation strategies versus soft measures are discussed. The top ten adaptation strategies identified in the WEATHER adaptation database are also presented. Two specific cases are included in the following: a) how road weather information systems are currently organized in roads of the German federal state of Baden-Wuerttemberg along with their future potential with reference to the impact of extreme winter conditions; b) a review of the damage cost estimates of Alpine rail transport and the corresponding adaptation options.

In his paper, Mitsakis deals with the 2007 wildfires that hit Peloponnesus, the southern peninsula of Greece. An overview of the impacts in terms of infrastructural damages and human losses and injuries is presented. By using network performance and components' criticality analyses, the effects of the fires in vehicular traffic and the overall transport network are assessed. An in-depth discussion of the crisis and emergency management of the event highlights potential gaps and possibilities for future improvement. Adaptation measures that succeeded the event in terms of recovery plans, national efforts on fire prevention programs, and wildfire management are also included.

The use of recycled aggregate concrete as a paving material in roads and its properties related to weather effects are examined in the study by Perdikou and Nicolaides. The study focuses on the road network of Cyprus where, according to a nine-year period research, extreme weather conditions led to a 5.8 % increase in fatalities on the roads. It is well known that the road transportation network is the most vulnerable when extreme weather events are considered, and there is considerable pressure to develop more environmentally sustainable materials to be used in construction. Eight different concrete mixtures containing recycled concrete aggregates were tested for the weather-related parameters of sorptivity, porosity, and permeability. Results showed that the use of recycled aggregate concrete will eventually affect the behavior of road pavements, due to their higher sorptivity, porosity, and permeability. However, it is considered that this will not be detrimental to the quality of road surfaces.

The impact of landslides on transportation pavements in rural road network of Cyprus using Remote Sensing and geographical information system (GIS) techniques is analyzed in the research by Alexakis et al. Landslide locations in Cyprus were identified from the interpretation of satellite images, and geomorphological factors, such as aspect, slope, distance from the watershed, lithology, distance from lineaments, topographic curvature, land use, and vegetation regime derived from satellite images, were selected and incorporated in GIS environment. Thus, a decision support and continuous landslide monitoring system of the area was developed. The same parameters were used in the final landslide hazard assessment model based on the analytic hierarchy process (AHP) method. The results indicate good correlation between classified high-hazard areas and field-confirmed slope failures. The CA Markov model was also used to predict the landslide hazard zonation map for the year 2020 and the possible future hazards for transportation pavements.

Possible future changes of seasonal minimum and maximum temperature for Northern Italy for two distinctive periods of the twenty-first century (2021–2050 and 2070–2099) are assessed in the study by Tomozeiu et al. This is achieved through the use of a statistical downscaling technique applied to the ENSEMBLES-Stream1 and CIRCE global simulations (A1B scenario). A multivariate regression based on Canonical Correlation Analysis is used, and the setup of this particular statistical scheme is done using large-scale fields derived from observational data (seasonal mean minimum and maximum temperature) from 75 stations, distributed over Northern Italy, over the period 1960–2002 and ERA40 reanalysis. In order to construct projections on change of selected extreme temperature indices for the 2021–2050 and 2070–2099 periods, a similar technique is also applied but considering the number of frost-days and ice-days.

In the study by Vajda et al., a European-wide climatology of adverse and extreme weather events that can be expected to affect the transport network is delineated. The relevant severe weather events are defined and classified according to the effects that they have on different transportation modes and infrastructure. Phenomena such as snowfall, heavy precipitation, heat waves, cold spells, wind gusts, and blizzards are considered, as well as their frequency and changes in their spatial distribution and intensity. Furthermore, by using the E-OBS dataset (1971–2000) and the ERA-Interim re-analysis dataset (1989–2010), their observed trends are analyzed. The results show that, on the one hand, Northern Europe and the Alpine region are most affected by winter extremes (snowfall, cold spells, and winter storms) with the latter also being affected by extreme precipitation rainfall. On the other hand, the frequency of hot days is highest in the areas of Southern Europe. The Atlantic region, particularly along its shores, is affected by extreme winds and blizzards as well as extreme precipitation. Also, it is shown that heavy rainfall may affect the whole continent.

In her paper, Molarius (2013) describes the development and application of an Extreme Weather Risk Indicator (EWRI), applicable separately to each major transport mode and EU countries. The application is based on a risk panorama, derived from a holistic analysis of extreme weather risks for the European transport system. A probabilistic approach of extreme weather phenomena occurrences was utilized along with a vulnerability analysis based on selected macro-level economic and transport system indicators of the member states of EU. All the major transport modes are examined along with risks related to infrastructure, time delays, and accidents. The most significant extreme weather events in different parts of Europe are noted, as well as the transport modes that they affect the most, in an attempt to assist local governments and their agencies to analyze the risks associated with adverse weather in a structured manner.

The future of the exposure of European transport systems to the consequences of climate change and weather extremes is examined in another paper by Doll et al. The main drivers of weather-related costs of road, rail, and air transport and the way they will most likely develop, along with the uncertainties of their development, are the main focus of the study. An overview of existing studies on the costs of extremes on transport systems, as well as on the economy in general, is used. The critical issues of appropriate data sources, assessment principles, and the definition of extremes are discussed by mode of transport and hazard category. The results of the damage estimates for the period 1998–2010 and the forecasts for 2040–2050 by European climate regions are presented.

A general assessment of the climate change and its impacts on the hydrological conditions of the Rhine and Upper Danube rivers is presented in the study by Szépszó. For this purpose, hydrological model simulations (an ensemble of 20 runoff projections for the two rivers) along with bias-corrected Regional Climate Model outputs (as meteorological input) were used. Also, special attention was given to quantify the uncertainties of the scenarios in a simple and effective way. Using runoff time series, the climate projections generating the lower and upper boundaries of hydrological parameters were selected as representative projections. Besides the validation and projection assessments, some insights are also presented into the main characteristics of climate model simulations over the target regions through a comparative analysis of the raw and bias-corrected climate model outputs. The resulting discharge scenarios are evaluated to describe changes in the hydrological system due to an expected climate change.

The last paper in this volume is by Leviäkangas and Michaelides who review the present knowledge on financial and economic aspects of weather-related transportation vulnerabilities. New views of cost–benefit analysis, project appraisal, and asset value protection for the management of transport systems under extreme weather risks are proposed. New approaches and ways of thinking in preserving asset's residual value, return periods, sustainability, and equity and formal methods supplementing cost–benefit analysis and project appraisal are also presented. The level of costs and risks to societies as a result of extreme weather are discussed, with special emphasis to those of the European area. The society's preparedness and some fundamental ideas of cost–benefit analysis under extreme weather scenarios are put forward. The authors stress the need to propose normative guidelines and how to implement them in practice for a more integrated management of transport. Synthesizing these new ideas and discussing how transport system management should take into account the extreme weather risks in a holistic manner are also considered.

I expect that this Special Issue will help Journal readers to understand better the impacts of various aspects of weather and climate-related hazards on different modes of transportation. I trust that this volume will be a valuable reference to researchers, academics, practitioners, and policy makers.

As the Guest Editor of this Special Issue of Natural Hazards, I would like to thank all the authors for their contributions to this volume and their adherence to the strict reviewing rules. I also wish to express my sincere appreciation to the international panel of reviewers for making available their expertise in the effort to achieve the highest scientific value of this volume. I wish to express my special thanks to the editorial team and in particular to Prof. Tad Murty, the editor-in-chief of Natural Hazards, for their valuable support during all the stages of producing this volume. I also extend my thanks to the members of the staff of the Publisher for their professional technical assistance.