# Design guideline for a climate projection data base and specific climate indices for roads: CliPDaR

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**Abstract**

The mission of CliPDaR is to issue a guideline setting a standard regarding the handling of climatological data and methods that shall serve as a basis for pan-European traffic infrastructure risk assessments. This includes a stepwise description of the ensemble approach starting from socio-economic scenarios over Global Climate Models (GCM) and selected downscaling methods to generate regional scale climate change projections, which can be used to drive impact models. Within this study we present this approach by calculating three climate indices that are associated with damages to road surface, supporting structure and drainage systems. These indices are calculated for 20 spots of the TEN and two future periods (2021-2050; 2071-2100) and compared to conditions of a time slice "1961-1990" from the so called "control run".

*Keywords:* climate change; transport infrastructure; changing risks; damages; ensemble approach;

**Résumé**

La mission du CliPDaR consiste à émettre une directive fixant une norme concernant le traitement des données climatologiques, et sur les méthodes qui doivent servir de base à l'évaluation des risques concernant les infrastructures et le trafic paneuropéens. Ceci inclut la description étape par étape d'une approche générale à partir de scénarios socioéconomiques,de modèles climatiques globaux (GCM) et de méthodes de réduction d'échelle sélectionnées pour établir des projections sur le changement climatique à l'échelle régionale, qui pourraient être utilisées pour piloter des modèles d'impact.
Dans cette étude, nous présentons cette approche par le calcul de trois indices climatiques qui sont associés respectivement à l'usure de la surface de la route, de la structure de support, et des systèmes de drainage. Ces indices sont calculés à 20 positions géographiques différentes sur le réseau de transport transeuropéen (RTE) et sur deux périodes futures (2021-2050; 2071-2100) et comparées aux conditions de la période "1961-1990" par une simulation de contrôle.

*Mots-clés*: changement climatique; infrastructures de transport; évolution des risques, dommages et intérêts, approche d'ensemble

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**Nomenclature**

| | |
|---|---|
| CIs Climate Indices | TRUT temp.criteria for potential rutting |
| FTC Freeze-Thaw-Change | TEN Trans-European Transport Network |
| GCMs Global Climate Models | pa. past (1961-1990) |
| RCMs Regional Climate Models | n.f. near future (2021-2050) |
| RCP Representative Concentration Pathway | f.f. farther future (2071-2100) |

## 1. Introduction

Traffic infrastructure is of upmost importance to economy as well as to people. The supply of daily goods or the accessibility of hospitals, for instance, heavily relies on the trafficability of roads all year long. Today about 70% of the total freight is carried across roads and this number is expected to significantly increase in the decades to come. The volume of traffic is estimated to grow by 85% of its current value within the next 25 years. Aside from this enormous increase there are other challenges to future road networks that have to be considered such as climate change, demographic development or new advances in technology. All these changes will affect road infrastructure elements. Changing needs for maintenance and reinforcement works require far-sighted planning. Rutting of asphalt surfaces or 'blow ups' of concrete roads are safety issues. They are related to climate indices (CIs) characterizing heat days coming along with tropical nights, which may become more frequent in the future. Changes in the frequency of freeze-thaw cycles or altering precipitation patterns result in different profiles of risks to e.g. road surfaces, slope support or drainage systems.

Bridges, tunnels, supporting structures, culverts, slope protection measures, road surface, drainages, and pump systems are stationary assets belonging to the road network. If an individual asset fails, the whole system is at risk. As such, it is important to know the probability of damages to such infrastructure elements. In this study we focus on climate related risks affecting maintenance budgets. In this context it is relevant to note that strategic decision making on transport issues (planning and designing, construction and reinforcement works and substantial changes in maintenance and budget strategies) refers to periods of some decades, which is the characteristic time scale on which climate change emerges. Infrastructure cycles are on the same time scale as climate change. Hence, climate change should be considered in today's plans for future transport networks.

This may be illustrated by a simple thought experiment: Rutting, for instance, is controlled by the weight of crossing vehicles and road surface temperatures. If surface temperature values exceed a certain threshold (e.g. 55°C), the risk of damages increases significantly. In case of an increasing summer-temperature, this threshold will be exceeded more often and the economic loss might not be acceptable anymore. To avoid such a situation it might be necessary to alter the asphalt mix in the design of new roads right now.

Similar developments could be expected with several other CIs (e.g. precipitation events exceeding a certain threshold). As it is less expensive to include possible effects of climate change in the planning than to adapt them later, it is mandatory to consider climate change already in the course of planning.

## 2. Data and Methods

### *2.1. Data*

As CliPDaR is to support decision making regarding future transport infrastructure, datasets used to describe changes in CIs have to cover past and possible future climatic conditions. Further requirements refer to the spatio-temporal resolution, permitting a more or less detailed view. Here we make use of eight members of the KLIWAS ensemble (Imbery et al., 2013), describing past and future conditions until the end of the 21st century. KLIWAS-8 is an eight-member ensemble based on Regional Climate Model projections (RCMs, Table1) providing daily values of mean temperature, precipitation sum, relative humidity and sum of global radiation on a 25km grid. These climate variables are statistically downscaled to a 5-km-grid and bias-corrected. The spatial (5 km) resolution of the KLIWAS-8 ensemble is exceptional. This is essential for e.g. a profound downscaling of climate (projection) data to selected parts of the road infrastructure, like bridges or box-cuts by the help of e.g. local ("microscale") thermo-dynamic climate models.

Daily maximum and minimum temperatures are approximated by a parameterisation function driven by daily mean temperature, ratio of daily actual over daily maximum global radiation and by a sinus-function of a daily maximum temperature range from minimal 4°C in the winter period up to maximal 14°C in the summer period, drawn from climate statistics of averaged measured extreme temperature data for a "typical" Mid-European climate station.

KLIWAS is based on the socio-economic scenario abbreviated as 'A1B' (IPCC, 2007) that describes a future world of fast economic growth, a rapid spread of innovative and efficient technology around the globe, a population that increases until the middle of the century and decreases afterwards and an energy consumption that is supplied by fossil as well as non-fossil energy sources to equal parts.

Table 1: Overview of climate simulations of (i) the years 1961-2000 for the control run (C20), (ii) projection runs for the years 2001-2100 based on the scenario A1B (special 8 member ensemble (5-km-scale) of daily values used in KLIWAS, original data 25-km-scaled; Imbery et al., 2013, modified).

| **Control run / SRES scenario** | **GCM** | **RCM** | **No.** |
|---|---|---|---|
| C20 / A1B | HadCM3Q0 (HC) | CLM2.4.6 (ETHZ) | 1 |
| | | HadRM3Q0 (HC) | 2 |
| | BCM2 (NERSC) | RCA3 (SMHI) | 3 |
| | ECHAM5-r3 (MPI-M) | RegCM3 (ICTP) | 4 |
| | | HIRHAM5 (DMI) | 5 |
| | | RACMO2 (KNMI) | 6 |
| | | REMO5.7 (MPI-M) | 7 |
| | ECHAM5-r1 (MPI-M) | CLM2.4.11 (GKSS) | 8 |

*2.2. Methods*

*2.2.1. Cause-effect relations*

Relationships between CIs and road infrastructure elements are of central importance. An objective way to isolate them is to analyze the functional dependency between time series of damages and climatological variables (e.g. road surface damages and temperature evolution). Another way involves expert knowledge on physical processes and experience. As no time series of damages were on hand, expert knowledge was gained through workshops and interviews. Fig. 1 lists infrastructure elements together with CIs potentially harming them. Concerning climate change this 'cause-effect tensor' (CET2) is the very centre of the whole task scope ensuring the smooth functioning of transport networks in the future.

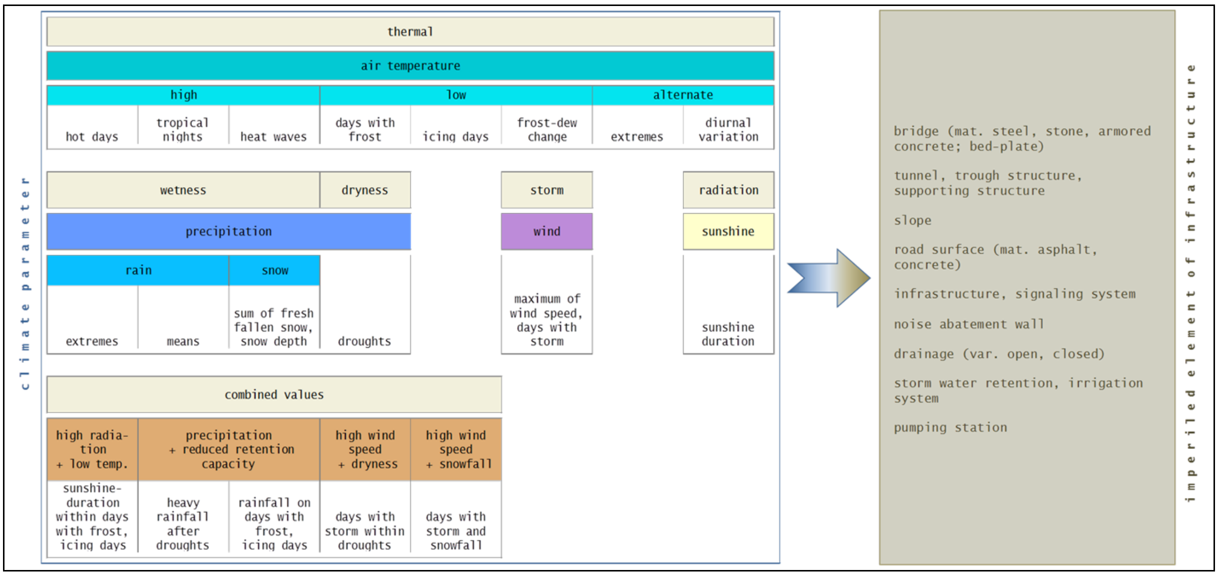


Fig. 1: Cause-Effect Tensor (CET2). Left: climatological elements, right: traffic infrastructure (example)

The opportunity to estimate changing risks depends on the capacity of climate change projections. In the following the generation of local scale climate change projections is elaborated. Therefrom the future behaviors of the CIs are calculated, which are needed to assess the impact on transport infrastructure. CIs vary in space, time and complexity. Depending on the climatic phenomena, CIs can be valid for regions extending from hectares to thousands square kilometers and can be made up by one or more parameters averaged over different periods of time.

### *2.3. The "downscaling-cascade" and the appendant uncertainty*

Since it became more and more evident that mankind is partly responsible for the observed climate change (see the succession of the IPCC assessment reports), the demand for climate change projections increased continuously. In order to assess the impact of climate change taking place on the regional scale (e.g. transport networks), it is indispensable to work with climate change projections on small scales. The generation of regional scale climate change projections and the subsequent impact assessment involve several methodological steps and datasets. Fig. 2 sketches the whole process, which is part of CliPDaR, and will be elaborated step by step for 3 CIs (responsible for rutting, flooding and damages to road surfaces caused by frost-thaw cycles) in the following.

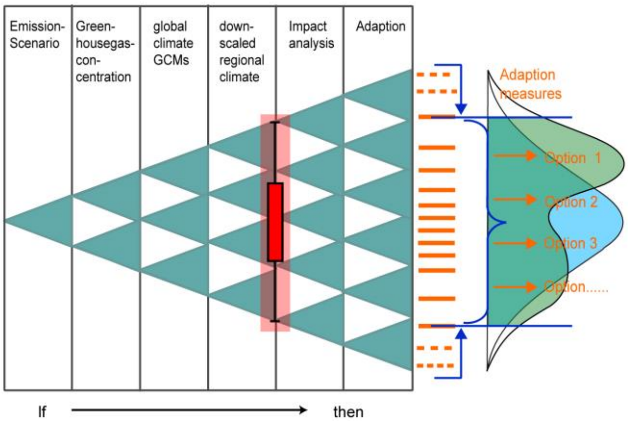


**Fig. 2:** Starting from a particular emission scenario (explained in the text) the uncertainty grows with every step that is required to derive different adaptation measures mitigating the impact of climate change (schematic diagram) after Viner 2002.The two curves on the right are representative for all possible frequency distributions of climate change impacts.

The process starts with the selection of a so called socio-economic scenario (indicated by the leftmost column in Fig. 2). Ever since it was demonstrated that mankind affects climate by altering the chemical composition of the atmosphere, questions about the consequences of contrasting human behaviours were raised. Possible future pathways of mankind are presented as socio-economic scenarios that are based i.a. on assumptions about the political, demographic, technological development, on changes in land use patterns and on how the energy demand is met through the 21st century (IPCC 2007).

Socio-economic scenarios are translated into emission scenarios, telling the time dependent release of greenhouse gases into the atmosphere, coming along with a particular pathway of mankind. These emissions are translated via gas-cycle models into concentrations (second column from the left), forcing the climate system via the radiation transfer in the atmosphere. This step introduces uncertainties coming from the application of models, which are an approximation to the physical processes. Different models give rise to somewhat different greenhouse gas concentrations.

The next step is to drive GCMs with the temporal development of greenhouse gas concentrations in the atmosphere but constant external radiative forcings. GCMs are three-dimensional numerical approximations of the Earth consisting of climate components (e.g. atmosphere, ocean, cryosphere, etc.). They simulate processes within and in between the components, which take place on very different spatio-temporal scales. Different GCMs, designed at various climate research centres around the globe, produce a diversity of climate change projections. This means that the same socio-economic scenario results in somewhat different global scale climate change projections. This is indicated by a further increasing amount of uncertainty in Fig. 2. A climate change projection is one possible future development of the climate.

The simulated global climate projections pose the boundary conditions for the RCM-runs. Hence the next step is to cascade the GCM projections down from a continental scale (200 - 350 km) to the regional scale (25km – 50 km). This can be done by a strategy called downscaling. There are essentially two approaches: statistical and dynamical downscaling. The downscaling step from the continental scale to the regional scale introduces yet more uncertainties (see Fig. 2). Different downscaling techniques have their pros and cons, depending on e.g. which climate variable shall be analysed.

Up to this point in the assessment of possible impacts that mankind may exert on regional scale ecosystems or economic structures (e.g. transport networks), quite some uncertainty has accumulated. This should not be seen as a drawback. In fact the span represents a variety of possible local scale climate change reactions that may come along with a specific development of mankind. That means that all conclusions on the “adaptation level” depend on “if-then-relations”, achieved by applying reasonable models. Because the “Emission Scenario level” reflects only a more or less reasonable statement, results of following levels can only be checked for their plausibility from e.g. a climatological or geophysical point of view. That is why so called “no regret or low regret actions” are frequently proposed in national strategies for adaptation to climate change. The following steps in Fig. 2 describe (i) how a particular regional climate change projection affects systems (e.g. the surface temperature of road surfaces) and (ii) what measures may be set to manage the impact (e.g. research for new materials or other adaptation actions). These steps are reached by impact models introducing further uncertainty.

## 3. The ensemble approach

With the accelerating advancement in computer technology (increasing velocity of the computational infrastructure and the storage facilities), it became possible to consider several local scale climate change projections based on a number of GCM runs when investigating future climate states, instead of just using one GCM realization. Such a set of projections is called an ‘ensemble’. An ensemble is described by the statistics (median, variation, spread, etc.) of its members (=projections). There are different kinds of ensembles, depending on the question under consideration:

(i) ‘initial condition ensembles’: based on same model and emission scenario but different initial conditions;
(ii) ‘multi model ensembles’: different models but the same scenario (Fig. 3);
(iii) ‘multi model multi scenario ensembles’: different models and scenarios.

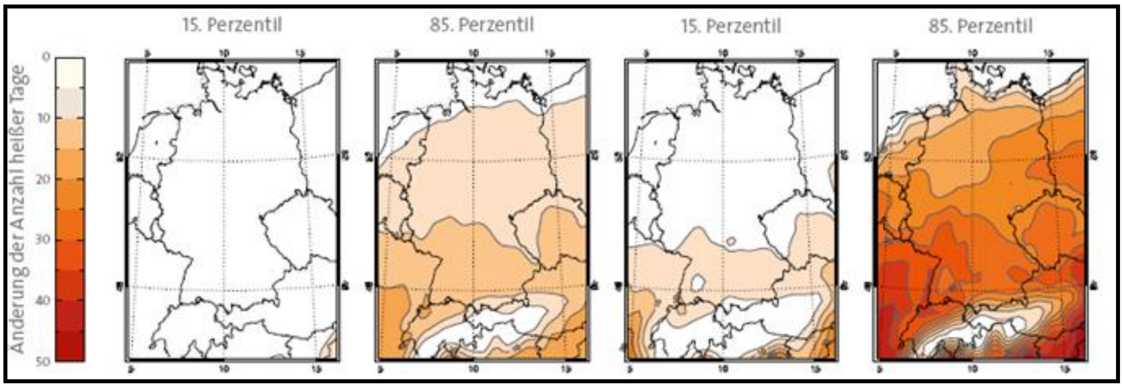


Fig. 3: One possibility to illustrate the findings from an ensemble of projections (a multi model ensemble for A1B). The panels show the increase in the number of hot days per year. The left two panels refer to the 15th and 85th percentile for the n.f., the right two the same for the f.f. Source: DWD (www.dwd.de/klimaatlas).

Table 1 lists the KLIWAS-8 ensemble based on different GCMs and downscaling methods (RCMs). Assuming a meaningful sample size, the median of an ensemble is rather stable against outliers (=climate projections yielding values far from the others). Therefore, the median of an ensemble of projections is rated higher, when approximating the probable future state of the climate system, than a single projection alone. Next to the median the average and the variation amongst the ensemble members are of importance (as well as further statistical features of the probability distribution of the ensemble). Experience indicates that different GCMs introduce more variability into a regional scale ensemble than different downscaling models do. Consequently, a multi GCM ensemble together with several downscaling methods should exhibit enhanced bias values compared to an initial condition ensemble.

Fig. 3 shows one possible way to display ensemble results (here for the annual number of hot days (Tmax ≥ 30°C). The 15th and the 85th percentile are shown for two future periods (2021-2050 and 2071-2100). Thus 70 percent of the projections are in between the panels (the probability to draw a projection from the ensemble that gives values between those shown in the panels is 70%). Fig. 3 relies on the full KLIWAS ensemble (Imbery et al, 2013).

## 4. Results and Discussion

### *4.1. General comments*

Within this section the CIs, explained and motivated above, are presented. They are significant examples taken from the CET2 displayed in Fig. 1. The first CI (Fig. 4) refers to freeze-thaw cycles, which are responsible for quite a range of damages to transport infrastructure elements including rock fall and cracks in the road surface (leading to consequential damages). The second one refers to precipitation events of and above 30mm, which affect drainage systems. The third CI describes days made up by heat during daytime (Tmax>30°C) followed by tropical nights (Tmin>20°C). This calculation process is drafted in the fifth column of Fig. 2 and completes the approach to be guided by CliPDaR.

The result values are displayed in so called boxplots, giving a comprehensive view on the data. Bottom and top of the box are the first and third quartiles; the blue line inside the box is the average over the value; the red line with the diamonds on it is the second quartile (i.e. the median). The vertical lines, called whiskers, are 1.5 times the interquartile range. In case there are no results showing deviations that far from the median, the whiskers end at the maximum deviations. Triangles indicate result values (outliers) being farther away from the median than 1.5 times the interquartile range (25%-75%). High interquartile ranges embody more dispersion of the results than small ranges. In the context of the CIs, high ranges indicate rather low levels of consensus among the ensemble realizations, which in turn points to enhanced uncertainty. Low interquartile ranges on the other hand hint to confidence.

Figures 4, 5 and 6 show three groups of boxplots. The leftmost group refers to a past period, the middle one to the n.f. and the right group the f.f.. Each local scale realization of KLIWAS-8 is depicted by one boxplot just as the mean of the ensemble, which is matched by the filled light-red boxplot.

Table 2: Transport spots for which the climate indices are calculated. This calculation involves 9 points of the KLIWAS-8 ensemble considered for averaging.

| nr. | Name | Lon [°E] | Lat [°N] | Alt [m] | nr. | Name | Lon [°E] | Lat [°N] | Alt [m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Munich | 11.58 | 48.15 | 517 | 11 | Berlin | 13.39 | 52.52 | 36 |
| 2 | Stuttgart | 9.20 | 48.80 | 335 | 12 | Praha | 14.44 | 50.08 | 327 |
| 3 | Passau | 13.41 | 48.58 | 303 | 13 | Linz | 14.32 | 48.30 | 561 |
| 4 | Salzburg | 13.05 | 47.81 | 420 | 14 | Zurich | 8.54 | 47.37 | 478 |
| 5 | Innsbruck | 11.40 | 47.27 | 581 | 15 | Nuremberg | 11.08 | 49.45 | 398 |
| 6 | Frankfurt on the Main | 8.68 | 50.11 | 106 | 16 | Dresden | 13.74 | 51.05 | 140 |
| 7 | Cologne | 6.96 | 50.94 | 42 | 17 | Hannover | 9.73 | 52.38 | 58 |
| 8 | Dortmund | 7.45 | 51.50 | 107 | 18 | Leipzig | 12.38 | 51.34 | 119 |
| 9 | Amsterdam | 4.90 | 52.37 | -22 | 19 | Brno | 16.62 | 49.18 | 313 |
| 10 | Hamburg | 10.00 | 53.54 | 15 | 20 | Kiel | 10.15 | 54.38 | 12 |

The CIs are evaluated for 20 ‘transport spots’ in Europe. The calculation of the CIs for the transport spots involves 9 points of the KLIWAS-8 grid. So, the transport spots reflect conditions representative for small regions, named after the city contained inside these regions. The transport spots and the associated cities are listed in Table 2.

*4.2. Distinct zero temperature crossings (freezing-thaw crossings FTC)*

Fig. 4 shows the number of distinct zero temperature crossings. The label ‘distinct’ means that only days featuring Tmin≤ -2°C and Tmax≥ 2°C are considered. This temperature interval should very roughly signify the availability of enough energy to enforce the phase transition from liquid to solid or back. The overall message, which is present in all KLIWAS-8 ensemble members, is that FTC is projected to decrease in the future. The variance of the mean over all spots decreases from 4.5 to 1.7 between 1961-1990 and 2071-2100. Decreases are somewhat more pronounced in the East and South of the domain.

In 1961-1990 most ‘distinct’ zero temperature crossings are to be found in the East and South of the domain. The result for Innsbruck is different from the results of the neighbouring traffic spots, which show more crossings (Table 3). A comparison of FTC calculated from measurements for Innsbruck and Linz shows that the low FTC value calculated from the KLIWAS-8 ensemble does not match reality. The too low FTC value in Innsbruck may be caused by the coarse model topography, the location of Innsbruck close to the edge of the model domain or the effect of irradiation, which is not realistically reproduced (perhaps due to the valley character). This example shows the necessity to validate the model output against observations, in order to be able to judge the model output (e.g. the generated scenarios) in the right way.

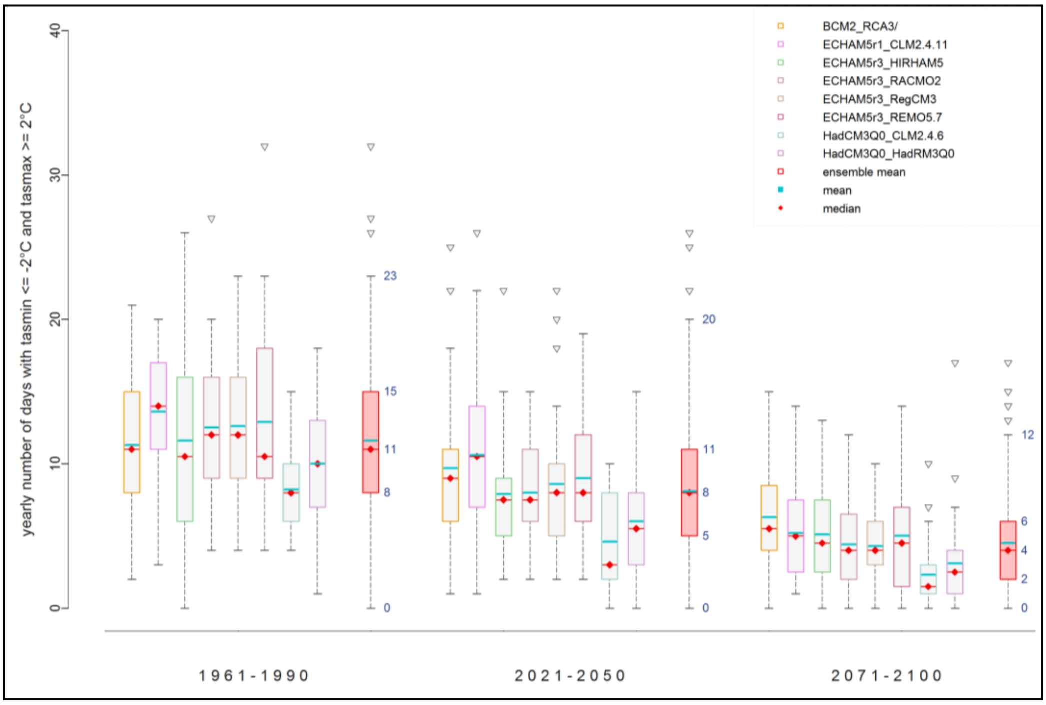


Fig. 4: Boxplots of the yearly number of FTC for Praha (a detailed explanation of the plot is given in the “General comments” at the beginning of this section).

The differences between the ensemble members, and therefore the uncertainties, vary between the traffic spots and hence through space. No single ensemble member is suspiciously different from the others at all transport spots. In some cases enhanced differences between the HadCM driven model runs and the other ensemble members can be seen, as in the case of Praha (Fig. 4), where the median HadCM FTC value is about 4 days (which is about 50%) below the other models. Single ECHAM runs, however, can differ significantly as well (not shown). The structure of the differences between the ensemble means does not have to be the same in all three considered periods.

Table 3: Median for FTC of the KLIWAS ensemble mean for 20 sites and 3 time period

| FTC | Median of Ensemble Means | | | FTC | Median of Ensemble Means | | |
|---|---|---|---|---|---|---|---|
| nr. | pa. | n.f. | f.f. | nr. | pa. | n.f. | f.f. |
| 1 | 10.9 | 8.0 | 4.6 | 11 | 8.7 | 5.6 | 3.1 |
| 2 | 8.5 | 6.4 | 2.9 | 12 | 10.9 | 8.0 | 4.1 |
| 3 | 10.7 | 7.9 | 4.1 | 13 | 15.0 | 10.8 | 6.5 |
| 4 | 9.2 | 6.5 | 3.6 | 14 | 9.3 | 7.0 | 3.2 |
| 5 | 6.7 | 4.7 | 1.9 | 15 | 11.3 | 8.0 | 4.6 |
| 6 | 7.3 | 5.1 | 2.5 | 16 | 8.9 | 6.3 | 3.0 |
| 7 | 6.3 | 3.5 | 1.6 | 17 | 8.9 | 5.9 | 2.7 |
| 8 | 6.7 | 4.5 | 2.1 | 18 | 9.4 | 6.0 | 3.1 |
| 9 | 5.0 | 3.4 | 1.4 | 19 | 11.9 | 8.5 | 4.8 |
| 10 | 8.9 | 5.8 | 2.8 | 20 | 8.4 | 5.2 | 2.1 |

### *4.3. Precipitation totals above 30 mm*

The boxplots showing the number of precipitation events of and above 30 mm are located at low values. This applies to all spots and the whole ensemble indicating a rather robust signal. For the past period highest values (3-4 days/year) are to be found in Salzburg (see Fig. 5). The mean over all traffic spots and the whole ensemble is 0.6, which is increasing towards the end of the century to 1 day per year. In case of Salzburg, the increase (i.e. one day per year) is more pronounced, yielding 4-5 days per year for the period from 2071 to 2100. The spatial pattern of the increasing values outlines a region at the northern edge of the Alpine chain featuring largest growing rates. This region is prominent for precipitation events triggered by the advection of air masses from the North-West climbing the mountain ridges (‘Staulagen’). So, the increase may point to a more often occurrence of such meteorological events. The interquartile ranges do not change with time, pointing to unchanged confidence as measured by the behaviour of the projections among each other. No significant changes in the mean and variance of the ensemble members can be found between 1961-1990 and 2071-2100 (Table 4).

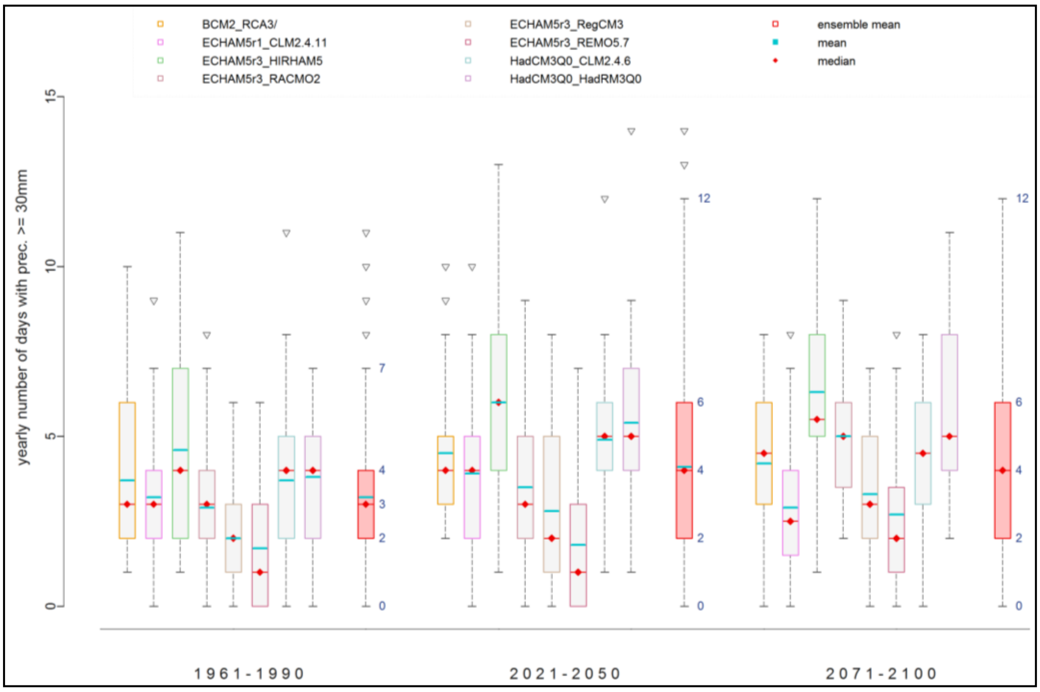


Fig. 5: Boxplots for the yearly number heavy precipitation days (precipitation amount >=30mm) for Salzburg (a detailed explanation of the plot is given in the “General comments” at the beginning of this section).

Table 4: Differences in mean and variance of the model results averaged over all sites and the appendant significance (on the 0,95-level) of the changes for the three CIs. The time periods 2071-2100 and 1961-1990 have been compared.

| Parameter | Mean pa. / f.f. | Significant | Variance pa. / f.f. | Significant |
|---|---|---|---|---|
| FTC | -6.0 | yes | -3.2 | no |
| RR | 0.5 | no | 0.5 | no |
| TRUT | 6.3 | yes | 6.3 | yes |

*4.4. Temperature indices isolating meteorological phenomena causing rutting*

Temperature related CIs cover a large proportion of CET2 (Fig. 1) and hence are responsible for a multitude of damages to transport infrastructure. Here we focus on a CI (henceforth called TRUT) that is characterized by high daily temperatures (≥30°C) together with Tmin ≥20°C. Such days bear the potential of harming road surfaces (pers. comm. M. Auerbach).

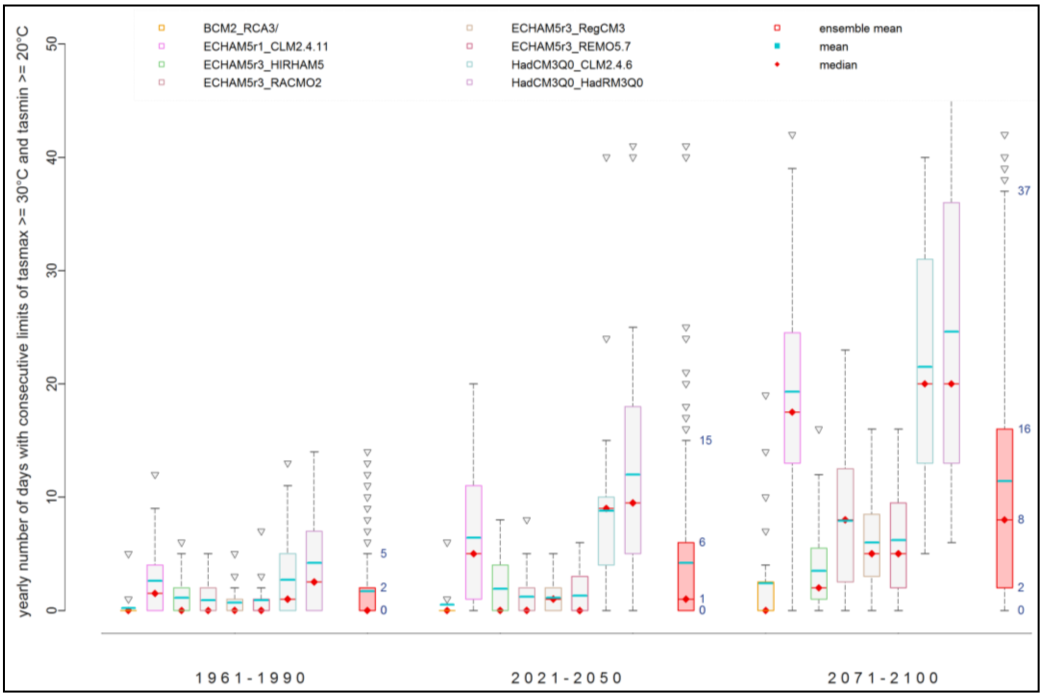


Fig. 6: Boxplots for the yearly number of potential 'rutting days' (Tmax>=30°C and Tmin>=20°C) for Frankfurt am Main (a detailed explanation of the plot is given in the "General comments" at the beginning of this section). Low occurrences appear near zero-level.

Presently such days are rather rare throughout the considered parts of Europe (Fig. 6). Taking the average over the median at all transport spots of KLIWAS-8, less than one event per year is to be expected. Frankfurt am Main shows the highest frequency (1.6 occurrences/year). This number is increasing to 7.4 days/year in 2071-2100. This time slice, however, exhibits pronounced differences within KLIWAS-8. This behavior is particularly apparent for the two HadCM runs and the CLM run driven by ECHAM5 (see Table 1). While these three projections point to 14 occurrences per year, the other five projections give two days per year. This difference is to be seen at most sites, slightly more pronounced in the South than in the North of the domain and already detectable (albeit distinctly less expressed) in the near future (2021-2050). The variance of KLIWAS-8 changes significantly (Table 4) between 1961-1990 and 2071-2100, meaning, that the uncertainties increase towards the end of the century too.

## 5. Conclusion

Changes on temperature based climate indices are more reliable than those based on precipitation. The evolution of FTCs in the future indicates decreasing damages from appendant events. These, however, may be outbalanced by increases in the TRUT frequency. Which effect will be of more impact to the transport infrastructure varies between regions. Even the slight changes in the number of days with heavy precipitation might exert a noticeable effect in some regions and may further depend on changes in the intensity of the precipitation (which was not analysed in this paper).It will need the expert knowledge of road authorities to decide on the measures to be taken in the different regions for maintenance and reinforcement of road infrastructure.

## 6. Outlook

The actual work has its focus on the evaluation of the three calculated CIs for the reference time period 1961 – 1990 with HYRAS, a gridded data based on observed conditions with a 5 km grid spacing (Rauthe et al, 2013). Therefore the climate signals, as differences of the number of days of the future time periods to the reference period, have to be added to the number of days drawn from HYRAS for each selected CI. These results will be compared with measured data from representative stations.

It is still necessary to identify further climate indices harming road assets in cooperation with the road administrations, people in charge and constructional engineers. Next to that, KLIWAS and VALUE as well as the German Adaptation Strategy (DAS), the Austrian Adaptation Strategy and the IPCC Recommendations (IPCC 2007) regarding adaptation measures will be taken into account.

Furthermore the new outcomes of the 5$^{th}$ report of the IPCC with the next generation of (global and) regional climate projections with higher spatial resolutions in space (up to 10 km) and time (up to hourly values) based on the RCP scenarios will be used to enlarge the given ensembles in the next years.

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