CEDR Transnational Road Research Programme
Call 2012: Road owners adapting to Climate Change

funded by Denmark, Germany,
Norway, the Netherlands

Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

Climate projection data base for roads: CliPDaR

Report on the outcome of the combined meeting (CliPDaR and ROADAPT), 3-4 April 2013, Langen, Germany, DWD Education and Training Centre

Deliverable D 1.2

The **CliPDaR** Consortium:

Deutscher Wetterdienst

ZAMG

CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME
Call 2012

Design guideline for a transnational database of downscaled climate projection data for road impact models

Start date of project: 22.02.2013

Fulfillment of all contractual tasks: April 2014

Author(s) of this deliverable:
Christoph Matulla
Central Institute of Meteorology and Geodynamics (ZAMG)
Hohe Warte 38
1190 Vienna
Austria

Joachim Namyslo
German National Meteorological Service (DWD)
Frankfurter Straße 135
63067 Offenbach am Main
Germany

July 2013

Table of contents

Executive summary

The Langen meeting (the "combined meeting") was devoted to defining a proper cooperation-interface between the two projects CliPDaR and ROADAPT of the CEDR call 2012. This is to be found in the minutes below. CliPDaR has the contractual duty to set up a design guideline defining the basis for Europe wide risk assessment of traffic infrastructure regarding climate change. KNMI will contribute to that. KNMI will focus in particular on the communication of the uncertainties (inherent in climate projections) to the stakeholders. KNMI will generate climate data for case studies (to be used in ROADAPT) and guide end users how to treat these data.

Therefore an important result of the combined meeting was to make the proposal for the next meeting of PEB (aside the ROADAPT workshop in April 2013, Delft) to prepare for only one guideline. This would imply that the design guideline – as the final deliverable of CliPDaR – will be a significant part of the combined result. This cooperation between the DWD-ZAMG consortium and the KNMI was later approved by the PEB (see the minutes of the ROADAPT meeting in Delft, April 2013).

DWD, KNMI and BASt gave presentations (available on request) launching active debates. The presentation setting or launching focal points of the debates is presented in Annex C. The agenda of the meeting and a list of participants is given with Annexes A and B, respectively.

1 Preliminary remark

Concerning the CEDR Call 2012 "Road owners adapting to Climate Change" the Project CliPDaR ("Design guideline for a transnational database of downscaled climate projection data for road impact models" (long title)) refers exclusively to the objective "A.1 – Review, analysis and assessment of existing (regional) Climate Change projections regarding transnational highway networks (TEN-T) needs". Regarding the questions of this objective the project CliPDaR is engaged in

- Assessment of statistical/dynamical downscaling: to facilitate a proper procedure that deals with the uncertainties of the future climate with respect to the needs of future budgets and maintenance issues
- Assessment of ensemble simulations and climate projections as well as the definition of a pragmatic data provision for decision making
- Assessment of return periods of e.g. cold winters or hot summers.

Because of the given short time line a provision of data is not foreseen within the frame of this project and emphasis is given to the results from already ongoing projects, in particular VALUE and KLIWAS, to contribute to a paper of recommendations for the involved national road agencies.

The mission of CliPDaR is creating a design guideline setting standards for the handling with climate change data and downscaling methods used in pan-European traffic infrastructure risk assessment.

2 Introduction

Obviously, reliable road assets are of considerable importance to the functioning of everyday life. Traffic infrastructure faces lots of challenges: globalization, a strong increase in freight traffic, the technological and demographic change as well as climate change. At the same time reinforcement works, planning, building and the roll out of new infrastructure has cycles of several decades. *Infrastructure cycles are on the scale relevant for climate change*. Many bridges across Europe that were built a century ago are still in place and exposed to loads that might not have been expected. So, *todays decisions have to consider climate change*, which is expected to take increasingly effect.

Rutting, for instance, is controlled by the weight of the lorries and the temperature of the road surface. If surface temperature values exceed a threshold (e.g. 55°C) the risk of damages to the road gets very high. Either the road is closed for freight traffic or roadway damages would result. Let us assume this situation happens presently two times per year and the appendant economic loss manageable. If air temperatures increase by two degrees in the decades ahead the threshold value of 55°C could be exceeded 12 times per year (see sketch below, **Figure 1**). As for the extreme events Katz and Brown (1992) point out that climate variability is more important than averages.

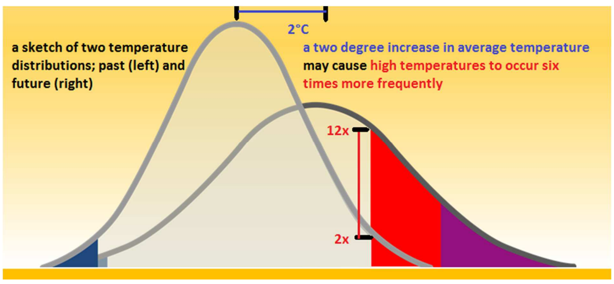

Figure 1: This sketch shall illustrate that a shift in average temperature of e.g. +2° C can lead to a substantial change in the occurrence of seldom events. In this example very hot events would occur about six times more often than observed so far.

The situation is now unacceptable and expensive reinforcement works have to be carried out. Hence it is mandatory to consider climate change already during planning. Simply as the assets are in place for many decades and that is the time span on which climate change emerges. The same applies to the flooding of infrastructure. It is certainly less expensive to include the possible effects of climate change in the planning of the dimensioning of drainage systems than to adapt them later.

3 Minutes of the meeting

The minutes were taken down during the meeting of the two consortia ROADAPT (represented by KNMI) and CliPDaR (DWD, ZAMG) in Langen, Germany at the Education and Training Center (BTZ) of DWD from 3rd to 4th April 2013 (Agenda and List of participants see Annexes A and B, resp.).

First the duties of the two projects CliPDaR and ROADAPT (as both are based on DoRN of the CEDR Call 2012) were presented. **CliPDaR** has the duties

- to address the field of road-adaptation to climate change;
- to supply research results to the road authorities to support decision making for future road maintenance measures regarding infrastructure elements;
- to address to the so called 'cold winter issue', which is raised by the road authorities. The 'cold winter issue' focuses on the questions if there is lately a conglomeration of cold winters which appears to be not in line with 'global warming'. This question will be answered by an analysis of the most recent cold winter events together with climate model projections for the decades ahead.
- to provide methods and datasets as well as information on the uncertainties involved in climate change projections;
- to propose promising techniques helping to derive relevant climate parameters for road infrastructure;
- to make statistical analysis of return periods (for hot summers and cold winters).
- to explain the ensemble approach. In the case, that it is not feasible to make use of the whole ensemble also ways to choose just some realizations will be introduced. In this regard CliPDaR will give some advice to single out only one realization regarding the given question.

The advice for coherent use of climate data (observations and projections) by the national road authorities is one of the CliPDaR goals. So, it is important to identify relevant, climate controlled indices. Within CliPDaR they shall be collected from the road authorities of Germany and Austria by a workshop at the beginning of May and, if necessary, by additional interviews until the end of May 2013. For analysing climate controlled indices CliPDaR will make use of the projects KLIWAS and VALUE. Concerning the role of DWD as an advisor for climatological data and climate change issues within the framework of the national AdsVIS-Projects of BASt, findings of AdsVIS (adaptation strategy for traffic infrastructure) will be used as well.

For statistical analyses concerning climate indices CliPDaR will focus on an ensemble of eight downscaled (5-km-scale) and evaluated (bias-corrected) regional climate projections of the KLIWAS-project (this ensemble of 8 members will be called from here on 'KLIWAS-8' ensemble).

Markus Auerbach repeated the CliPDaR goal (as agreed upon with CEDR) to provide a design guideline helping to set a basis for EU wide traffic infrastructure risk assessment. This is to be achieved by uniform datasets (no breaks at the borders between countries; at least Austria, Germany and The Netherlands) and general recommendations regarding downscaling techniques.

The **ROADAPT** duties are the identification of sustainable measures and techniques helping the road authorities to make decisions. KNMI has a special focus on the end user needs. Besides workshops, it is planned to meet end users, to enter a thorough discussion with them, highlighting their needs and the way the end users make use of the delivered climate data. KNMI plans a deep connection to the end users. Next to the question ‘what do the end users need?’ is the question ‘how do the end users use our data?’ important. Most recent CORDEX climate change projections will be applied to cover future periods. Thereby the uncertainties and perspectives will be analysed for all types of variables. KNMI will give an overview over the available climate change scenarios and the methods used. KNMI will provide climate change scenarios for case studies in climatic different European regions.

An important result of this "combined meeting" was to propose for the next meeting of PEB (aside the ROADAPT workshop in April 2013, Delft) to prepare only one guideline. This would imply that the design guideline – as the final deliverable of CliPDaR – will be a significant part of the combined result. The combined guideline should content

- an introduction containing (amongst others) a description of the possible impacts of climate change on roads and their constructions;
- the explanation of reference data (e.g. of the HYRAS project);
- advantages / disadvantages of statistical / dynamical downscaling (variable dependent?);
- case study put in context, e.g. bandwidth of ensemble results;
- webpages for data presentation (e.g. webpages of DWD concerning the Climate Data Center (CDC) or the data distribution via WebWerdis and similar webpages of ZAMG and KNMI)

giving answers to questions like

- How to deal with time series of climate projections? (description of methods)
- What is an ensemble; why to use an ensemble? (description and handling of uncertainties).

It was also pointed out that *a guideline has to be updated!*

In the following ***statements*** that were discussed are listed:

a) It is planned to deliver guidelines/recommendations on the use of (present and future) climate data to the road authorities that are the product of CliPDaR and ROADAPT. Hence just *one* guidebook is in the focus (see above). As for organizational matters and the different time frames of the two projects, CliPDaR has the lead on that. This is due to the contractual obligations and the shorter project length.

b) Both projects will check with the PEB (Project Executive Board) if one common guideline is an option (see above). In that case the time frames of both projects have to be extended up to two months;

c) The dissemination process will be carried out by both projects together – ROADAPT and CliPDaR; CliPDaR informed ROADAPT that there is a presentation at the "Klimatag 2013" (4-5 April, Vienna) and at the EGU13 (7-12 April, Vienna). CliPDaR will present results at the FIRM13 (4-6 June, Brussels), DACH2013 (2-6 September, Innsbruck) and at the TAR14 (14-17 April 2014, Paris). Presentations will be exchanged. ROADAPT will inform CliPDaR about a conference in Norway/Sweden later this year – perhaps a joint attendance is of use;

d) HYRAS datasets (5 km spatial resolution, mean temperature, precipitation and global radiation on a daily time scale) shall be used by ROADAPT and CliPDaR as reference; other datasets (ERA, NCEP, HISTALP, E-Obs, CRU, etc.) were mentioned, but no decision was reached;

e) The 30-year period 1961–1990 was fixed as reference period for ROADAPT and CliPDaR as: (i) it is the climate normal period defined by the WMO; (ii) lots of the climate change studies in peer reviewed journals refer to that period; (iii) 1961–1990 is a good reference period regarding roads;

f) Diagrams showing (i) change rates related to the above mentioned reference period in the near (2021-2050) or far future (2071-2100) based on the KLIWAS-8-ensemble and (ii) Taylor diagrams will be used in the guidelines to characterize findings concerning the spread of the results, e.g. of climate signals, and the evaluation of post-processed RCM-data, respectively (see presentation Joachim Namyslo, DWD (Annex C)). (iii) A third type of diagram that will be used is the “DNA-diagram” as it’s easier to understand the content at first glance. An example are the change rates of precipitation for three catchment areas (Elbe, Danube, Rhine), see Annex C.

An open question is: How to organize the guidebook? There was a discussion to do it bottom-up – meaning: starting from the problems that end users are facing and going up to the general problem of climate change. It was also mentioned that an approach that starts with the general situation and goes down to the special application is necessary (top-down). Perhaps it is meaningful to put 'turn around sheets' to use with each page referring to one approach. CliPDaR is in charge of that.

4 Traffic infrastructure and climate phenomena

The presentations given by Dr. Auerbach were of particular importance as they state a link to the road owners and companies that are directly involved into the maintenance/planning/rolling-out business. Moreover the CEDR strategy and aims were highlighted.

It is important to understand that climate change is only one factor that impacts traffic infrastructure and perhaps not the most important. Considering the impact on traffic infrastructure globalisation, significant increases in projected freight traffic, changes in technology and demographic structure are at least as important as climate change. **Figure 2** shows a projection of freight traffic development for the decades ahead. This certainly constitutes a major challenge regarding maintenance, reinforcement, planning and building. The growth in freight traffic on roads is expected to be several times higher than the one on inland waterways and on rails.

The costs necessary to provide appropriate transport infrastructure by the end of the 2020s are expected to exceed 1.5 trillion Euros. The completion of the TEN-T network requires about € 550 billion until 2020 out of which approximately € 215 billion will be needed for the removal of main bottlenecks.

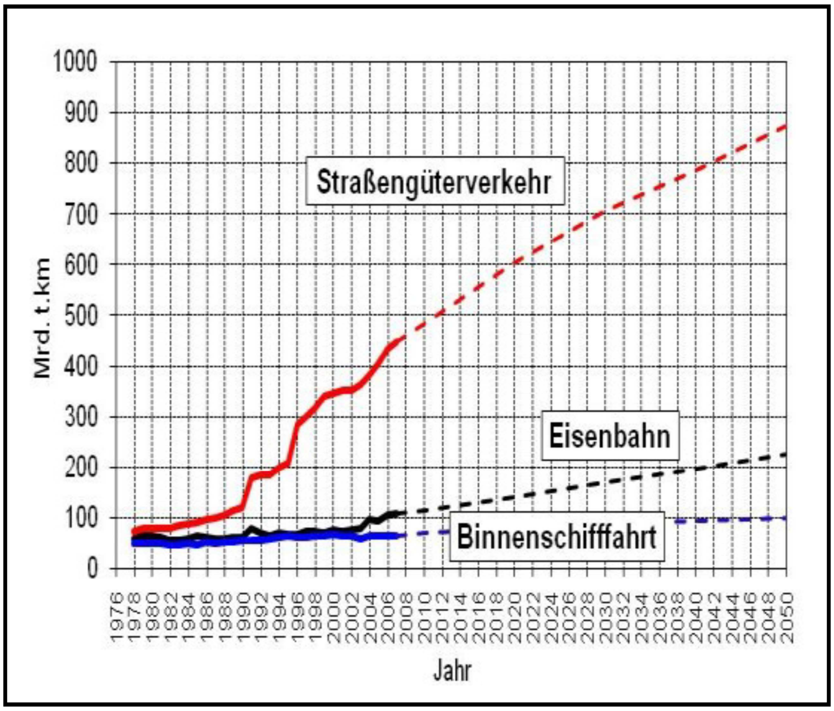

Figure 2: projected changes in freight traffic split up in branches. Source: BASt

The EU of 27 member states has five Mio km of paved roads (61.100 km motorways), 212.800 km of rail tracks (110.458 km electrified) and 42.709 km of navigable inland waterways. To keep the transport links open and trafficable a sizeable extent of new design, maintenance and construction work is necessary. This is particularly the case for old and strained infrastructure requiring enormous efforts to reduce the backlog (see the discussion with the German minister of transport SPIEGELONLINE 1st of July 2013).

Extreme climatic phenomena (e.g. heat spells, heavy precipitation events) in conjunction with increasing loads carried across roads will pose additional problems. Just recently high temperatures caused blow ups in Southern Germany and lead to closures of heavily used motorways just prior the summer holiday time (Frankfurter Rundschau, SÜDKURIER and SPIEGELONLINE, 20th of June 2013). The floodwaters in June this year heavily damaged road infrastructures in Germany and Austria, caused considerable downtimes of roads and adversely affected thousands of people (to be multiply found in almost all media in June 2013).

Hence it is decent to assess the possible consequences of climate change on road infrastructure and to integrate findings already in the course of designing assets. To do so, it is important to have a thorough insight into the relationships between the climate phenomena (e.g. wet spells, long term snowfall) and the affected infra-structure (e.g. slope supporting structure, bridges). These links between climate and infrastructure can be written in a matrix. **Figure 3** shows such a Cause-Effect diagram.

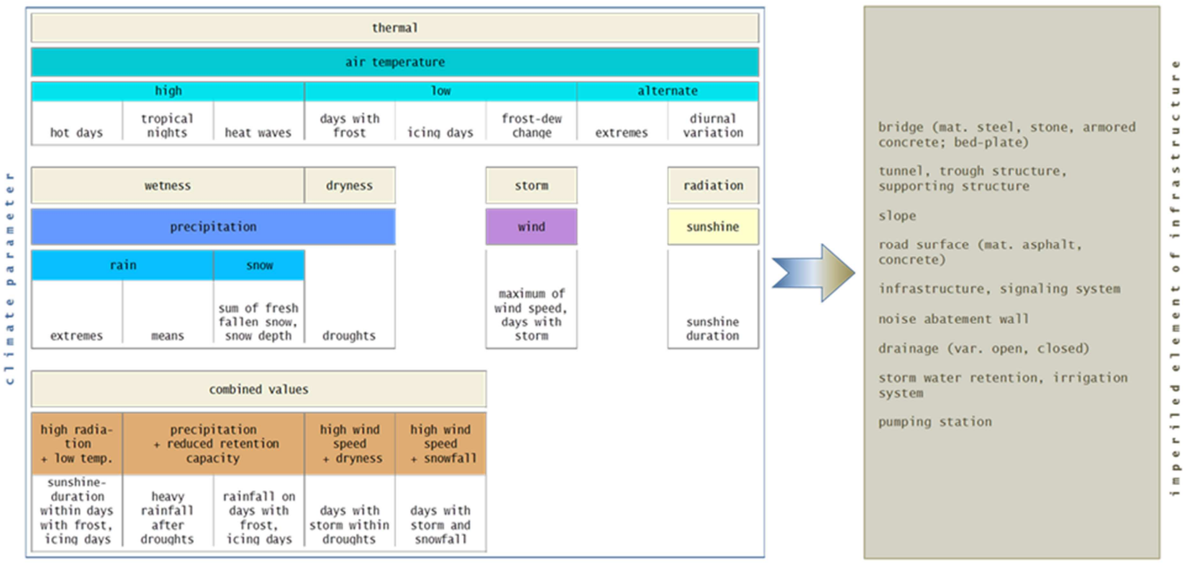

Figure 3: Cause-Effect Diagram. Left: climatological elements, right: traffic infrastructure

Once the Cause-Effect diagram has been established it is essential to derive estimations for future climate change. The Cause-Effect diagram together with a set of climate change projections (see 'The ensemble approach' further down this docu-ment) allows estimating alterations in the vulnerability of traffic infrastructure elements. This sets the basis for developing adaptation measures, helps to mitigate the level of vulnerability and supports effective asset management.

5 Climate Change

5.1 The chain of uncertainty

Within the first deliverable we have already elaborated the model chain necessary to estimate the regional evolution of future climates. **Figure 4** illustrates the increasing uncertainty that is inherent in every step of the chain from the emission scenarios to the regional scale impact.

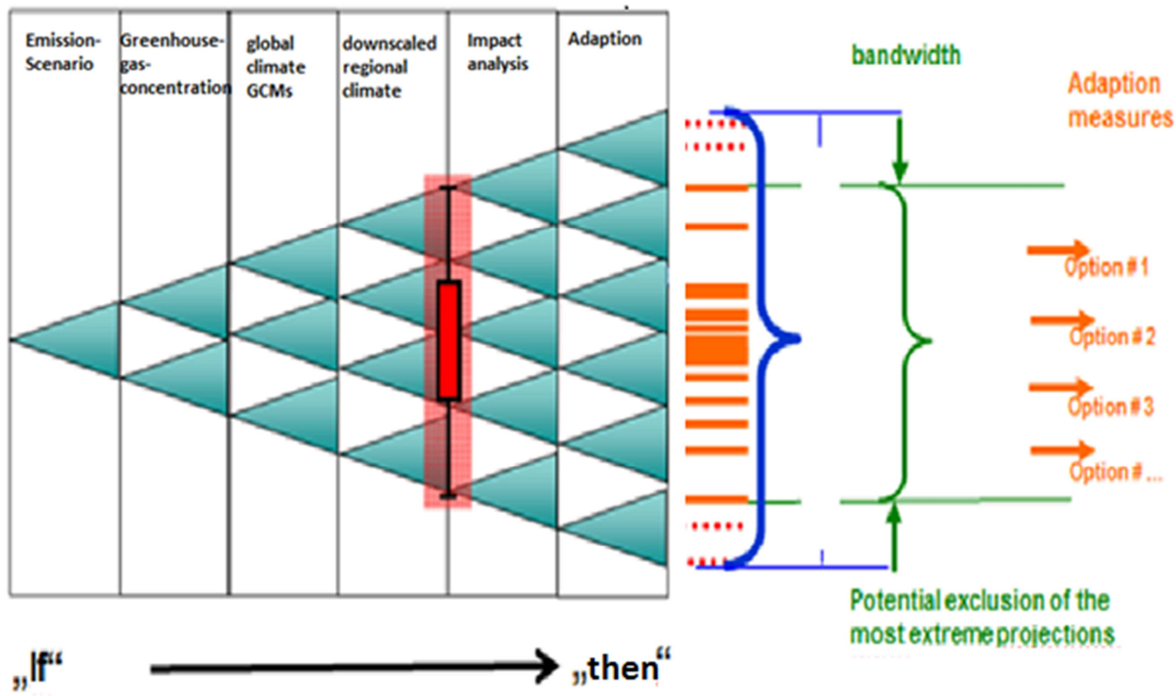

Figure 4: Starting from a particular emission scenario (see deliverable D1.1) the uncertainty grows with every step that is necessary to derive different adaptation measures to mitigate the impact of climate change (schematic diagram). Source: DWD, after Viner (2002).

Figure 4 contains the whole roadmap essential for decision support. Eventually a decision has to be made which adaptation option shall be applied in concordance with the values of the respective (affected) society.

It starts from a socio-economic scenario that is based on assumptions about the political, demographic, technological, etc. evolution of mankind; how future land use may alter the surface of the earth and how the demand in energy is met through the 21st century (see the IPCC scenario tree, shown and discussed in the first deliverable D1.1). This is translated into emission scenarios and already introduces uncertainties (see **Figure 4**). The emission scenarios result in time-dependent greenhouse gas concentrations in the atmosphere. They force Global Climate Models (GCMs) that are three dimensional numerical approximations to the Earth and simulate processes within the climate system (e.g. atmospheric cyclones traveling over the North Atlantic and cause ocean waves).

As there is a number of different GCMs, developed by scientists at different research centres across the globe, there is a set of results (climate change projections for the 21st century). GCMs differ in the way processes within the climate system are approximated. Even a slight alteration of the initial conditions from which a GCM starts the calculation into the future produces different results. This is indicated in **Figure 4** by a further increasing of uncertainty.

A climate projection is one possible future development of the statistics of weather (=climate) based on a scenario describing the possible future behaviour of the climate forcings (e.g. greenhouse gas concentrations). GCMs' climate projections provide information which can be interpreted on a global/continental scale (but not below) and for several decades (but not for single years).

The next step is to cascade the GCM projections down from a continental scale to a regional or local scale. This can be done by a strategy called downscaling (von Storch et al. 1993). There are essentially two approaches: statistical and dynamical downscaling (see deliverable D1.1). The downscaling step from the continental scale to the regional scale introduces yet more uncertainties. Different downscaling techniques have their pros and cons, depending on e.g. which climate variable shall be analysed. There is no 'best' method (see e.g. the reports of the EU-COST Action VALUE).

Up to this point in the assessment (**Figure 4**) of possible impacts that mankind may exert on regional scale ecosystems or economic structures (e.g. inland waterway transport) 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" are results depending on an "if–then–relation", reached from the "if" to the "then" by using reasonable models as geophysical and numerical tools. Because the "Emission Scenario level" (the "if") reflects only a more or less reasonable statement (which can currently not be approved to represent the "real future"), this leads to the fact, that the results of the different levels (**Figure 4**) can "only" be approved to be plausible from e.g. a climatological or geophysical point of view. That is why so called "no regret actions" are frequently proposed in national strategies for adaptation to climate change.

Therefore it is important to outline that different emission scenarios give rise to different climate change projections. This means that there is a range of possible futures and societies can decide (within this range) which climate their descendants will have to live in.

The following steps in **Figure 4** describe (i) how a particular regional climate change projection affects systems (e.g. the surface temperature of street covers) and (ii) what measures may be set to manage the impact (e.g. research for modified or new materials for street covers or other adaptation actions (e.g. cooling of street surfaces)).

At this point different adaptation measures (outlining possible ways to cope with climate change) are available. In some cases the preparation and implementation of these measures have to start now (e.g. protection against flood waters or storm surges) as they take years to be realized and they are expensive (e.g. heighten dykes; recreate flood areas; relocate villages in high risk areas). Again, decisions of great socio-economic importance have to be taken and they are based on inherent uncertainties (**Figure 4**). This situation is called ‘post normal’ (e.g. Krauss et al. 2012; Kraus and von Storch, 2012).

5.2 The ensemble approach

As there is no ‘one best model chain’ to generate regional to local scale climate information for the future, it is scientifically sound to consider a number of ‘GCM + downscaling’ combinations and their appendant climate change projections. Such a set of projections is called an ‘ensemble’. An ensemble is described by the statistics (median, variation, spread, etc.) of its members (=projections).

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 is rated higher to approximate the probable future state of the climate system than a single projection. 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).

Figure 5 shows one possible way to display ensemble results (here for the annual number of hot days ($T_{max} \geq 30$ °C)). The 15^{th} and the 85^{th} 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%).

There are different kinds of ensembles:

(i) ‘initial condition ensembles’ are based on the same model, the same emission scenario but different initial conditions;

(ii) ‘multi model ensembles’: different models but the same scenario (s. **Figure 5**);

(iii) ‘multi model multi scenario ensembles’: different models and scenarios.

The ‘built-up’ of a proper ensemble depends on the question under consideration: (i) initial condition ensembles are used to study model internal and/or climate variability; (ii) if the median or the mean or a span of results given from the same conditions of climate forcings is of interest, multi model ensembles are applied (the prevailing choice); (iii) if the intention is to show the range of possible climatic evolutions a multi model multi scenario is sensible. The projected global temperature evolution can serve as an example for such an intention: all models show that global temperatures are going to rise, no matter which scenario or initial condition is considered. But for this last case it has to be pointed out, that results given from different scenario boundary conditions – and therefore from different possible “worlds” – are analysed together and the span of the results, e.g. from impact models, could be addressed as somewhat “artificial”.

When the investigation of the climate variability is in the focus it is sensible to fix either the scenario or the GCM. In case the systematic error (bias) of the ensemble projections is irrelevant the focus should be on the climate change signal of the 30-year mean of a variable, not on the analysis of thresholds or on the analysis of absolute values. Presentations of results (Figures, Tables) based on a set of projections should always indicate the considered ensemble.

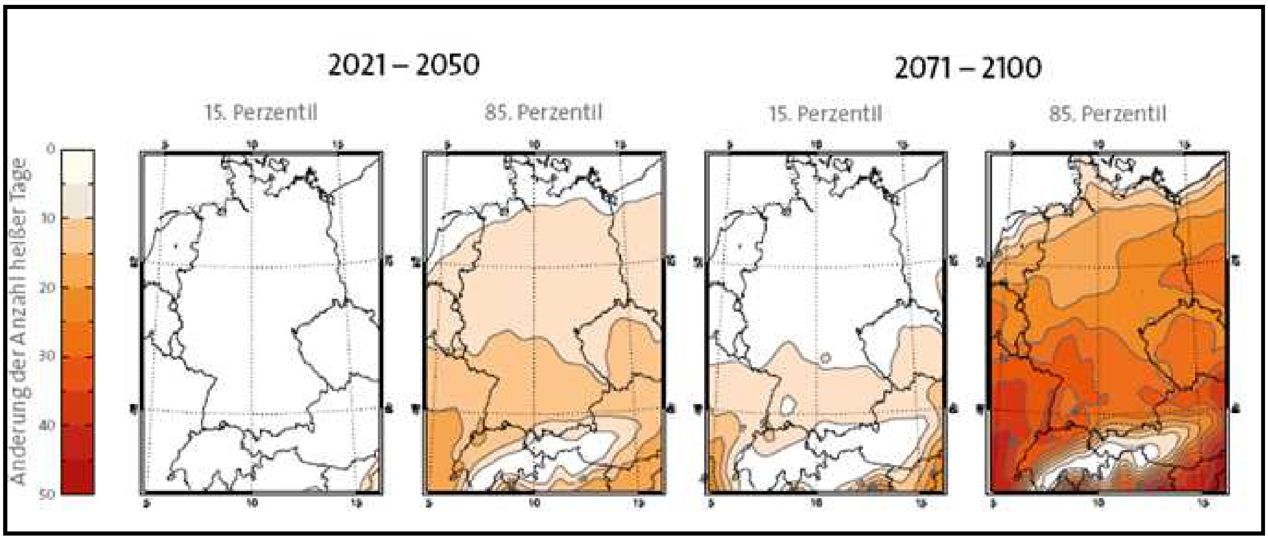

Figure 5: One possibility to illustrate the findings from an ensemble of projections (a multi model ensemble for A1B). The panels show the increase in the number of hot days per year. The left two panels refer to the 15th and 85th percentile for the near future (2021-2050), the right two the same for the farther future (2071-2100). Source: DWD (www.dwd.de/klimaatlas).

Some **additional remarks** on the ensemble approach:

Since about ten years it is a scientifically standard to use ensembles of model runs (projections). The GCMs are developed at several modelling centres across the globe. With the accelerating advancement in computer technology (the velocity of the computational infrastructure gets increasingly faster and the storage facilities are getting bigger and bigger) it became possible to consider several projections (an ensemble) when investigating possible climate states of future periods. This advancement made it possible to do descriptive statistics with an ensemble.

GCM developed at different climate research centres are not totally independent from each other. This is since processes within the climate system are ruled by physics *and*, as related numerical methods are used, by all groups to approximate the solutions of (partial differential) system equations.

This picture changes somewhat when procedures, used to estimate the effect of climate processes which are not explicitly resolved by GCM, are under consideration. These procedures differ between the centres.

Thus there are differences between the projections of different centres, albeit they are not very large. As a result, the median of an ensemble can be expected to fit the probable evolution (appendant to a particular emission scenario) closer than a single run. Consequently, a multi model ensemble should exhibit enhanced bias values compared to an initial condition ensemble.

Control run / SRES scenario	GCM	RCM	KLIWAS-8 ensemble
C20 / A1B	HadCM3Q0 (HC)	CLM2.4.6 (ETHZ)	X
		HadRM3Q0 (HC)	X
	HadCM3Q16 (HC)	HadRM3Q16 (HC)	
		RCA3 (C4I)	
	HadCM3Q3 (HC)	HadRM3Q3 (HC)	
		RCA3 (SMHI)	
	BCM2 (NERSC)	RCA3 (SMHI)	X
		HIRHAM5 (DMI)	
	ECHAM5-r3 (MPI-M)	RCA3 (SMHI)	
		RegCM3 (ICTP)	X
		HIRHAM5 (DMI)	X
		RACMO2 (KNMI)	X
		REMO5.7 (MPI-M)	X
	ECHAM5-r2 (MPI-M)	REMO5.8 (MPI-M)	
		CLM2.4.11 (GKSS)	
	ECHAM5-r1 (MPI-M)	CLM2.4.11 (GKSS)	X
		REMO5.7 (MPI-M)	
	ARPEGE (CNRM)	HIRHAM5 (DMI)	
		RM5.1 (CNRM)	

Figure 6: 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 (19 member ensemble, 25-km-scale) used in KLIWAS. The symbol X in the last column indicates the regionalised projections (via a RCM) which are statistically downscaled (5-km-scale) and bias-corrected (denoting the KLIWAS-8 ensemble; Imbery et al., 2013, modified).

For that reason CliPDaR is to make use of the KLIWAS ensemble (Imbery et al., 2013). **Figure 6** shows the 19 member ensemble providing daily temperature, precipitation, radiation and relative humidity on the original scale of 25 km. The downscaled output of HYRAS dataset and all the model projections of the KLIWAS-8 ensemble listed are also accomplished for a resolution of 5 km x 5 km. The ensemble size is rather comfortable, which is scientifically important (Christensen et al. 2010, Giorgi et al., 2009) and a solid basis for the calculation of relevant climate indices (see **Figure 3**). Moreover, the spatio-temporal resolution is well suited to characterize the relationships between the climate indices and the traffic infrastructure elements (again **Figure 3**). Another important point is that the KLIWAS-8 ensemble as well as HYRAS covers the western parts of Austria and Germany and the Netherlands as a whole.

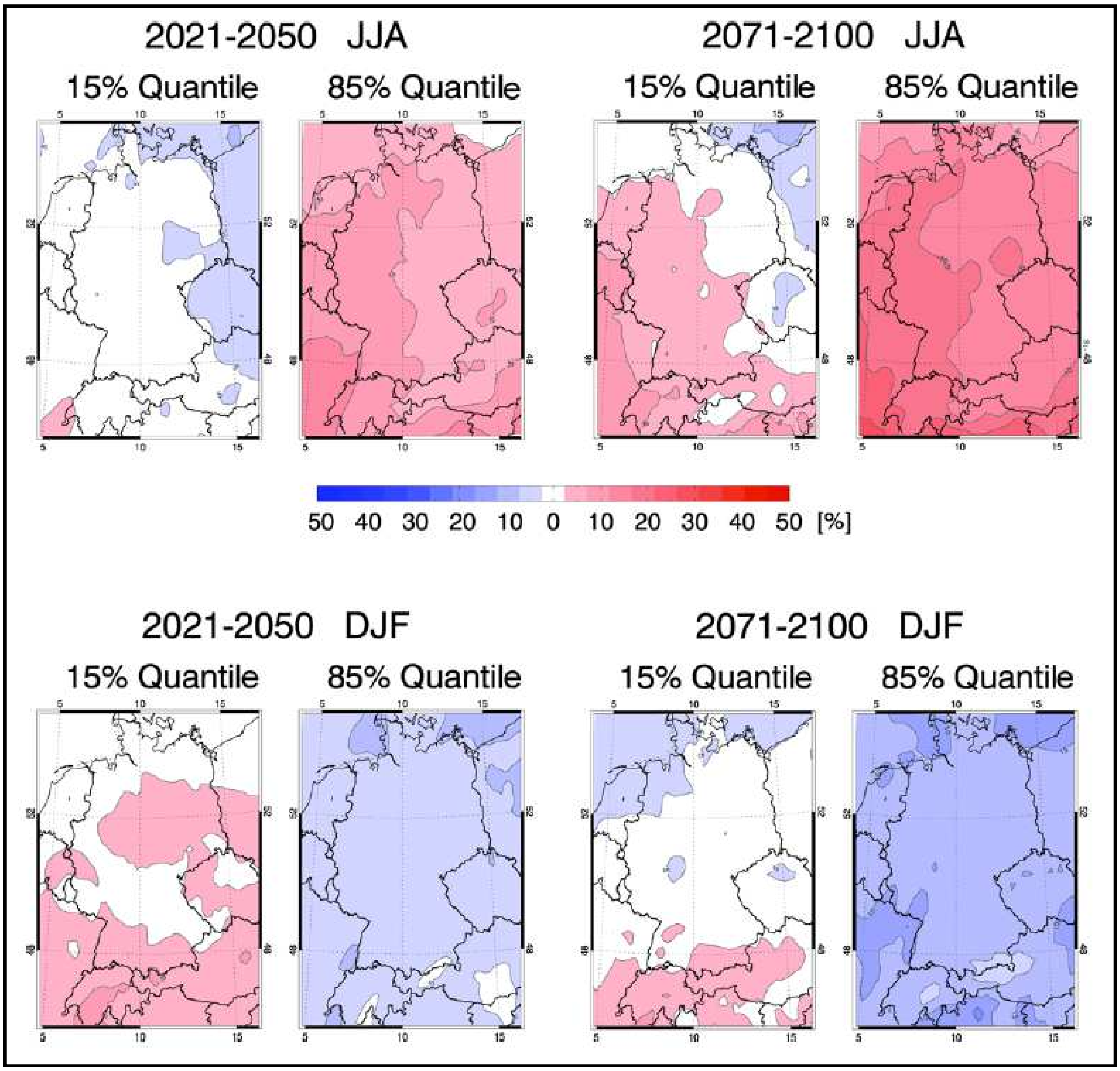

Figure 7: 15th and 85th percentile of precipitation changes for summer (upper row) and winter (lower row) relative to 1961-1990. The left/right two panels refer to the near/farther

future. The analysis is based on the original data with a spatial resolution of 25 km of the 19 member KLIWAS ensemble (Imbery et al. 2013). Blue/red colors indicate increasing/ decreasing precipitation.

Altogether, (i) the sample size of the KLIWAS ensemble, (ii) its spatio-temporal resolution and (iii) the particular spatial resolution of the KLIWAS-8 ensemble is exceptional. The points (i) and (ii) are necessary to meet CEDR requirements. Point (iii) is essential for e.g. a profound downscaling of climate (projection) data to selected parts of the road infrastructure like bridges or box-cuts with the help of local ("microscale") thermodynamic climate models.

Figure 7 shows (just as **Figure 5**) the advantages of using the full 19-members KLIWAS ensemble of RCM results, albeit they are on the lower resolution of the original scale (25 km). A quantity of 70% of the projections is enclosed by the two quantiles. Thus for summer and the farther future (2071-2100) there is a broad agreement among the ensemble members that precipitation totals may significantly decrease. To a lesser extent the KLIWAS ensemble shows increasing totals in the North during winter by the end of the century. For the near future (2021-2050) there is no clear signal. At the homepage of DWD (www.dwd.de/klimaatlas) several other climatic variables can be studied interactively.

For any kind of risk assessment across Europe it is essential to rely on the same database. Otherwise breaks and inhomogeneities occur across the borders between the countries, which are not related to changing risks but to changing datasets. As such, for example, the application of the downscaled and bias-corrected KLIWAS-8 ensemble and the HYRAS dataset warrants the development of a proper cross-border risk assessment. This is essential when comparing risks to traffic infrastructure in Germany to those in Austria or The Netherlands. Such comparisons cannot be done on the basis of different datasets as it remains unclear whether differences are due to the different datasets or not. Hence, the KLIWAS-8 ensemble and HYRAS dataset state a scientifically solid basis for cross-border traffic infrastructure risk assessment for an important part of Central Europe, which means from Austria to The Netherlands.

6 Concluding remarks

CliPDaR will establish a design guideline treating climate change scenarios, downscaling techniques and statistical methods necessary for the generation of regional scale scenarios across Europe. This sets the basis for consistent, Europe wide risk assessments of road infrastructure regarding climate change.

As such it is important to identify climate indices (e.g. long term rain events, hear spells) harming road assets. This is to be done in cooperation with the road administrations, people in charge and constructional engineers. The Austrian - German Workshop in Vienna (6th to 8th May 2013) is devoted to that. Additionally, interviews with road experts have been arranged. Thus CliPDaR will address this with workshops, interviews and participation in international meetings (e.g. FEHRL FIRM13 in Brussels). 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.

These sources will be completed by the German Federal expert discussions on "Climate impacts" and on "guidelines 'dealing with climate projection data'". All these documents will be considered when preparing the CliPDaR guidelines.

7 Acknowledgements

The research within CliPDaR is carried out as part of the CEDR Transnational Road research Programme Call 2012. The funding for the research is provided by the national road administrations of the Netherlands, Denmark, Germany and Norway.

8 References

Christensen, J., Kjellstrom, E., Giorgi, F., Lenderink, G., and Rummukainen, M., 2010: Weight assignment in regional climate models, Clim. Res., 44, 179–194

Giorgi, F., Jones, C., and Asrar, G. R., 2009: Addressing climate information needs at the regional level: the CORDEX framework, WMO Bulletin, 58, 175–183.

Imbery, F. and S. Plagemann, J. Namyslo, 2013: Processing and Analysing an Ensemble of Climate Projections for the Joint Research Project KLIWAS. *Advances in Science and Research*, Vol. **10**, 91-98, doi:10.5194/asr-10-91-2013, 2013.

IPCC: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, New York, USA, 2007.

Katz, R.W., and B.G. Brown, 1992: Extreme events in a changing climate: Variability is more important than averages. *Climatic Change*, **21**, 289–302.

Krauss, W., and H., von Storch, 2012: Post-Normal Practices Between Regional Climate Services and Local Knowledge. *nature and culture* **7**: 213-230

Krauss, W., M.S. Schäfer and H., von Storch, 2012: Post-normal Climate Science. *nature and culture* **7**: 121-132

von Storch, H. and E. Zorita, U. Cubasch, 1993: Downscaling of global climate change estimates to regional scales : an application to Iberian rainfall in wintertime. *Journal of Climate* **6**, 1161-1171.

Viner, D., 2002: A qualitative assessment of the sources of uncertainty in climate change impacts assessment studies. In M. Beniston (ed.): Climatic Change: Implications for the Hydrological Cycle and for Water Management Advances in Global Change Research, 2003, Volume 10, 139-149.

9 List of Figures

Annex A: Time Schedule

Project "Climate **P**rojection **Da**ta base for **R**oads **- CliPDaR"**

Combined Workshop (WS) of CliPDaR- and ROADAPT-Consortia (CliPDaR-M1.3)

Place: Langen (BTZ of DWD), Room B1.14
Duration: From Wednesday, 03.04. (10:30 hrs) until Thursday, 04.04.2013 (14:15 hrs)

Agenda

Time (hrs)	Theme	
03.04.2013		
10:30 - 10:35	**1 Adress of welcome**	Fuchs
10:35 - 10:50	**2 Introduction of participants**	all
10:50 - 11:00	**3 Agenda of the WS / Scope of the Meeting**	Namyslo
11:00 - 11:30	**4 The project CliPDaR** - an introduction	Namyslo, Matulla
11:30 - 12:00	**5 The project ROADAPT** - an introduction	Bessembinder, Bakker
12:00 - 12:20	**6 Special explanatory notes from PEB**	Auerbach
ca. 12:20-13:30	*Lunch Break*	
13:30- 14:00	**7 End user needs - the AdsVIS-Projects of BASt**	Auerbach
14:00- ca. 15:30 (incl. Coffee-Break)	**8 Discussion on requirements of ROADAPT / planned methods of CliPDaR**	all
ca. 15:30-15:50	**9 Understandings, additionally dates**	all
ca. 15:50-16:00	**10 Any other business**	all
ca. 16:00-16:15	**11 Wrap up**	Matulla
ca. 16:15	***end of first day***	
04.04.2013		
09:00-14:00	**12 Discussion on methods and open questions (ROADAPT/CliPDaR)**	Bessembinder, Bakker, Matulla, Chimani, Namyslo
ca. 10:30-10:50	*Coffee Break*	
ca. 12:00-13:00	*Lunch Break*	
ca. 14:00-14:15	**13 Wrap up**	Matulla
14:15	***end of Workshop***	

Annex B: List of Participants

Name of participant	03-04-2013	04-04-2013
Markus Auerbach, BASt	x	
Tobias Fuchs, DWD	x	
Janette Bessembinder, KNMI	x	x
Alexander Bakker, KNMI	x	x
Barbara Chimani, ZAMG	x	x
Christoph Matulla, ZAMG + VALUE	x	x
Joachim Namyslo, DWD + KLIWAS	x	x

Annex C: Powerpoint Sheets (pdf-Format) of the presentation titled "KLIWAS for CliPDaR" as an introduction to TOP 8 (and TOP 12)