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

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CEDR
Conférence Européenne des Directeurs des Routes
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Climate projection data base for roads: CliPDaR

Design Guideline

Annex of Final Report (D 3.2)

The **CliPDaR** Consortium:

Deutscher Wetterdienst DWD

ZAMG

CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME
Call 2012

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

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Executive summary

This guideline wants to help to avoid the most current errors dealing with the analysis of climate data and climate projection data. Therefore this guideline is to be a practical assistance for all European road authorities concerning the analysis of climate projection data (CP).

How to deal with the results of statistical and dynamical downscaling, built-up of ensembles of CP, the uncertainty of the model chain and the Climate Index approach is the focus of the various CliPDaR deliverables, esp. D1.3, D2.2 and D3.1. Therefore emphasis is given here for an overview of selected rules and to some additional points concerning e.g. the comparison of RCP and SRES scenarios. For this context a good overview and explanation of terms is given in Kreienkamp et.al. (2012). Therefore this literature will be highly recommended here.

The principles concern with:

- For Europe should be used the Regional Climate (RC) Projections prepared by the EU-7-Programme ENSEMBLES (based on the SRES-Emission-scenarios) or the newer RC Projections of the project EURO-CORDEX, based on the RCP (Representative Concentration Pathways)
- The Ensemble Approach (make ensemble statistics)
- Ensemble building: consider model diversity, many members (at least 17 members enable 15th/85th percentiles)
- The proposal to use further Downscaling as “statistical regionalisation followed by bias correction (if appropriate)” and consider the produced unconsistency between the climate elements themselves
- To consider climate variability: Provide averaging of climate projection data for periods of 30 years, at least 10 years
- Use preferably simple impact models (otherwise: only a case study may be possible)
- Use the threshold approach (index days) for climate extremes like Hot days, Ice days or e.g. the daily sum of precipitation or combination of index days to perform climate indices. A bias-correction should be applied before, if necessary.

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" (full 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 handling climate change data and downscaling methods used in pan-European traffic infrastructure risk assessment.

2 Introduction

This guideline does not demand to be a comprehensive composition of all available hints concerning the subject “how to deal with data of climate projections”, but it wants to help to avoid the most current errors which could be done by dealing with the analysis of climate data and climate projection data. Therefore this guideline is to be a practical assistance for all European road authorities concerning the analysis of climate projection data (CP).

How to deal with the results of statistical and dynamical downscaling, built-up of ensembles of CP, the uncertainty of the model chain and the Climate Index approach is the focus of the various CliPDaR deliverables, esp. D1.3, D2.2 and D3.1. Therefore emphasis is given here for a short overview of selected rules and to some additional points (e.g. concerning the comparison of RCP and SRES scenarios). For this context a good overview and explanation of terms is given in Kreienkamp et.al. (2012). Therefore this literature will be highly recommended here.

3 Composition of the main principles

a. Building an ensemble under consideration of the model diversity: A great number of GCM-RCM-combinations should be used. Source: EU-FP7 ENSEMBLES (SRES) and/or EURO-CORDEX (RCP)
b. For Central Europe the HYRAS dataset (Rauthe et al., 2013) provides daily estimates of air temperature, precipitation and global radiation on a 5-km-grid (the so called "KLIWAS[1]-grid") as reference data.
c. Averaging of climate projection data over a time period of 30 years, but at least over a period of 10 years (climate variability).
d. Averaging over time slices with time interval 30-year: the WMO standard climate reference period 1961 – 1990 is normally used. For reasons of comparability with published research, 2021 - 2050 and 2071 – 2100 should be chosen as preferred future climate periods in the 21st century.
e. In some cases it can be advisable to base climate analysis even on periods longer than 30 years. E.g. statistically robust analysis of extreme values requires consideration of longer periods than analysis of mean climate parameters.
f. The number of ensemble members should be as great as possible – up to the greatest available. At least the number should be 17 members or more for presenting results for the 15th and 85th percentile (span of 70% between this two thresholds).
g. There is no way to calculate a definite magnitude of future climate change. Options for climate adaptation should therefore always be based on the spread of climate change signals derived from all available climate projections
h. Use preferably simple impact models, otherwise only a case study may be possible.
i. The application of different climate impact models is recommended to ensure consideration of the diversity in available state-of-the-art models and methods.
j. Some climate impact models cannot cope with bias-afflicted climate projections and can only be run with bias-corrected climate projections.
k. The simplest way to deal with a systematic model bias is to determine the magnitude of the climate change signal by subtracting the climate parameters (e.g. temperature or precipitation) projected for a past period from the climate parameters projected for a future period. The length of both periods should be the same and sufficient for climate signals to be statistically robust (multi-decadal periods). This approach is based on the assumption that the model bias for past and future climate projections is stationary and of identical magnitude.
l. Dynamical RCM, that means thermodynamical, numerical models, downscale from the global scale of a GCM to provide for timeseries of climatological elements which are consistent among themselves.
m. It has to be considered, that a further regionalisation by the use of statistical regionalisation or bias correction techniques reduces the consistency of the climatological parameter among themselves.
n. It should be noted that many climate impact models do need climate input data with high temporal and spatial resolution and cannot be run with aggregated climate projection

[1] Joint research programme „Impacts of Climate change on Waterways and navigation - Searching for options of adaptation“ of the German Federal Ministry of Transport, Building and Urban Development (BMVBS), 2009-2013 (http://www.kliwas.de).

data. For such cases it is recommended to aggregate the impact model output data (spatial and temporal aggregation after impact modelling).

4 The chain of uncertainty

An emission scenario gives the possible future behaviour of the climate forcings. On a global scale the climate projections from GCM provide information which can be interpreted on a global or 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. 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.

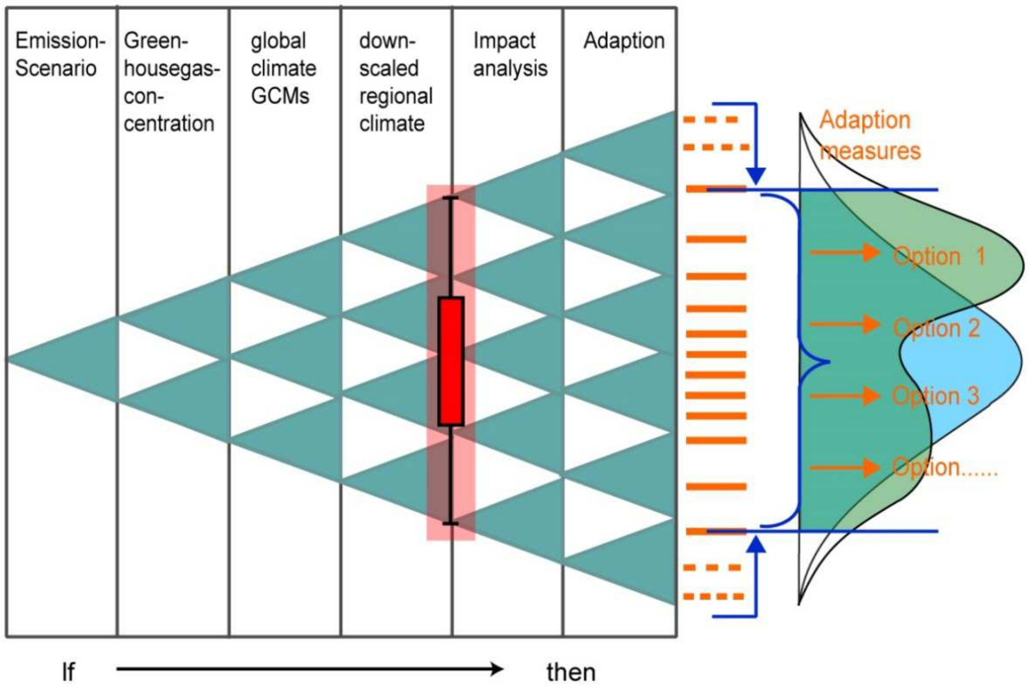

Figure 1: Starting from a particular emission scenario the uncertainty grows with every step that is necessary to derive different adaptation measures to mitigate the impact of climate change (schematic diagram). Source: DWD, after Viner 2002.

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 (Fig. 1) can "only" be approved to be plausible from e.g. a clima-tological 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.

5 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’.

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;

(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”.

Presentations of results (Figures, Tables) based on a set of projections should always indicate the considered ensemble (see e.g. Tab. 1 for the KLIWAS-17 Ensemble)

For an ensemble of more than seven members it is recommended to present the results by percentiles. In the case of a climate projection ensemble of at least 17 members the analysis of 15th and 85th percentiles is possible. These percentiles have to be determined for each grid point and then should be visualised in a map: At each grid point the values of the chosen climate parameter from all “n” members of the given ensemble of climate projections are present. After these “n” values have been arranged increasingly, from this distribution the values of the percentiles can be derived – if necessary by interpolation (see e.g. the corresponding explanations of the climate atlas of DWD (www.dwd.de/klimaatlas)). The derived values should then be assigned to reasonable classes in order to be able to plot spatial areas with interpretable ranges. In principle, these can be interpreted as follows:

15th percentile: There is an 85 % probability that the change signals cited will be exceeded in the ensemble; i.e. 85 % of the projections values are higher and 15 % of the values suggest lower rates of change.

85th percentile: There is an 85 % probability that the change signals cited in the ensemble will not be exceeded, i.e. 85 % of the ensemble values suggest lower rates of change and 15 % project higher rates of change.

The field between the lower and upper limits chosen therefore encompasses a probability of occurrence of 70 % *relative to the ensemble under examination*. But it has to be emphasized that, as used here, the terms 'probability' and 'percentile' or 'quantile' merely relate to the climate projection ensemble in question. This ensemble only represents a subset of the future climatic developments that are possible, which means the results presented (i.e. in D3.1 the figures of the KLIWAS-17 Ensemble) are not statistical probabilities of occurrence in a strict sense. This is the reason why ensembles are often called as „collections of models“ and therefore are denoted as „ensembles of opportunity“.

SRES scenario	GCM	RCM	
A1B	ARPEGE	HIRHAM5 RM5.1	EU-ENSEMBLES EU-ENSEMBLES
	BCM2	HIRHAM5 RCA3	EU-ENSEMBLES EU-ENSEMBLES
	ECHAM5r1	CLM2.4.11	BMBF
	ECHAM5r2	CLM2.4.11	BMBF
	ECHAM5r3	HIRHAM5 RACMO2 RCA3 RegCM3 REMO5.7	EU-ENSEMBLES EU-ENSEMBLES EU-ENSEMBLES EU-ENSEMBLES EU-ENSEMBLES
	HadCM3Q0	CLM2.4.6 HadRM3Q0	EU-ENSEMBLES EU-ENSEMBLES
	HadCM3Q3	RCA3 HadRM3Q3	EU-ENSEMBLES EU-ENSEMBLES
	HadCM3Q16	RCA3 HadRM3Q16	EU-ENSEMBLES EU-ENSEMBLES

Table 1: Used climate projections for the analysis of the ensemble. The combinations of the global and regional climate models on the basis of the A1B-emissionscenario are represented.

6 The climate indices approach

The time series of climate projection data provide physical resilient results in particular for averages of climate elements. The analysis of climate projection data with help of modern statistical methods with regard to meteorological extremes is therefore still the topic of actual research. Hence the so called “index days”, which are days with values of selected meteorological elements exceeding or undercutting a threshold value, represent a practicable approach of the analysis of climate projections with regard to extreme meteorological events. For example, this are days at which the daily maximum temperature reaches or exceeds the threshold value of 30 °C, called “Hot Days”. Also a commission of experts of the World Meteorological Organization (WMO) advises in this regard the application of index days to observe the changes of meteorological extremes (WCRP, 2011).

As an example three climate indices (CI) which are associated with damages to road surface, supporting structure and drainage systems, are mentioned (Matulla et.al., 2014):

(i) The first CI 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). For this CI 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.

(ii) The second one refers to precipitation events of and above 30mm/day, which affect drainage systems.

(iii) The third CI describes days that is characterized by high daily temperatures (T_{max}≥30°C, Hot Days) together with T_{min} ≥20°C (Tropical Nights). Such days bear the potential of harming road surfaces.

For this approach bias-corrected time series of the required climate elements are needed. If no bias-corrected data are available, percentile-based thresholds have to be used.

7 Additional remarks

7.1 Temporal aspects

As a basic principle climate data should be evaluated (and presented) for longer periods of time, because of the longterm variability of climate parameters. It is recommended to process observed and projected data for selected periods of at least 30 years (3 decades). Due to the superior availability of climate observations the period 1971 – 2000 is recommended as reference period for climate change signals, but the WMO standard climate reference period 1961 – 1990 can be used alternatively (overall station density was higher during 1971 – 2000, but strong trends in mean temperature during this period could be a drawback for some studies). For reasons of comparability with published research, 2021 - 2050 and 2071 – 2100 should be chosen as preferred future climate periods in the 21st century. The analysis of seasonal climate variations should be based on the meteorological definition of winter (December, January, February – DJF), spring (March, April, May – MAM), summer (June, July, August – JJA), and autumn (September, October, November – SON).

For some research questions it also might be acceptable to base climate analysis on 10 year periods (single decades), but it should be noted that this could lead to misleading results, particularly for the near future (e.g. 2020 – 2030). We therefore want to point out that climate projections are not to be mixed up with climate predictions.

7.2 Spatial aspects

Besides consideration of multi-decadal periods, analysis of climate projections also requires spatial aggregation of the climate model outputs. The spatial aggregation is necessary because the effective resolution of numerical climate models is significantly lower than the mesh size of the model grid used for the climate simulations. Major reasons for this are the necessary numerical discretisation and simplification of topography and natural processes in the atmosphere and other components of the climate system. Analysis of projections from numerical climate models should therefore always encompass multiple (neighbouring) model grid points. It is recommended to aggregate at least data over 3 x 3 model grid boxes (e.g. over 900 km^2 for the case of 10 km grid spacing). Similar considerations hold for station based climate data derived from statistical downscaling techniques, where time series of several stations must be aggregated to calculate robust climate trends.

7.3 Reference values for climate change signals

Climate re-simulations with RCM for the observed climate driven by reanalysis data (e.g. ERA-interim), often reveal systematic bias (deviations) when compared with climate observations. The systematic bias due to the combination of GCM and RCM can be shown based on 20C/historical simulations. Such systematic bias will also be inherent in climate simulations for future periods. Analysis of future climate conditions should therefore in general be based on bias-corrected climate projections. The simplest way to deal with a systematic model bias is to determine the magnitude of the climate change signal by subtracting the climate parameters projected for a past period from the climate parameters projected for a future period. The length of both periods should be the same and sufficient for climate signals to be statistically robust (multi-decadal periods). For some parameters (e.g. precipitation) it is common to divide the calculated climate change signal by the climate parameter of the past period (normalisation), i.e. the climate change signal is expressed as percentage change. This approach is based on the assumption that the model bias for past and future climate projections is of identical magnitude.

For bias correction the linear scaling and/or quantile mapping approach was adopted within the KLIWAS project (Imbery et. al., 2013).

7.4 Interpretation

Following hints should also be taken into account for interpretation and communication of climate projections:

- There is no way to calculate a definite magnitude of future climate change. Options for climate adaptation should therefore always be based on the spread of climate change signals derived from all available climate projections
- In cases of inconclusive trends of climate parameters (unclear sign of expected climate change, no statistical robustness) recommendations for adaptation to climate change should be limited to actions that will improve situations also under current conditions (no-regret adaptation measures).

7.5 Application of climate impact models

Following aspects should be considered for forcing and interpretation of climate impact models:

- State-of-the-art climate impact studies are based on the ensemble approach. The validity of a climate impact simulation driven only by one climate projection (“case study”) is poor because the range of possible climate impacts cannot be determined. It is therefore recommended to calculate the range of possible impacts through an ensemble of simulations based on several emission scenarios, multiple global and regional climate models, and different impact models. In cases where such a multi-scenario and multi model approach is not feasible, the calculation of recent trends and/or worst case and best case projections may allow some initial assessment of climate change impacts.
- Climate impact models (e.g. hydrological models) often inherit different levels of complexity and impose different requirements on climate data to drive the models. As is the case for climate models, the validity of climate impact models has also to be proven for a reference period. However, some climate impact

models which have been calibrated and evaluated with climate observations cannot automatically be driven by climate projections.

- Some climate impact models cannot cope with bias-afflicted climate projections and can only be run with bias-corrected climate projections.
- Climate impacts models and driving climate projections or climate observations have to match in terms of spatial and temporal resolution. Effects of possible mismatch have to be considered for interpretation of simulated climate impacts. The data or the models in the processing chain with the lowest resolution determine the resolution of simulated climate impacts. For some applications it is advisable to aggregate high resolution data to lower resolution to minimise adverse effects resulting from mismatch in resolution.
- The application of different climate impact models is recommended to ensure consideration of the diversity in available state-of-the-art models and methods.

8 The new RCP Scenarios

8.1 Comparison of SRES and RCP Scenarios

The following text is based on the first Newsletter of the German project ReKliEs-De (HLUG, 2013), where DWD is one of the authors. The cited text (original in German) is set in italic type (also if slightly changed by editorial freedom):

*“For the **SRES-scenarios** used until now, in a first step the evolution of worldwide greenhouse gas (GHG) emissions were derived from socio-economic scenarios. These evolutions were fed into carbon-cycle-models, which calculate the rations of the emissions that can be bound in terrestrial biomass and in the oceans, and the ratio that adds up to greenhouse gas concentration. SRES-A1B is the most frequently analyzed scenario; it supposes a further increase of the world’s population in the first half of the century and a slight decrease in the second half, moreover an intense globalization and fast technological progress is assumed. The SRES-A1B scenario is characterized by a steep increase of the greenhouse gas emissions in the first half of the 21st century, followed by a slowdown of the emissions in the second half. However, this kind of evolution leads to a further considerable increase in greenhouse gas concentration until the end of the century. The flattened emissions curve of this scenario is partly owed to the assumption of the development and distribution of non-fossil energy sources.*

The greenhouse gas concentration data of the scenarios are then fed into global climate models as a forcing to calculate the resulting climate change.

*The new **RCP scenarios** assume in the first step a so-called **representative concentration pathway** (Moss et al. 2010). Here the concentrations of the GHG are expressed through their radiative forcing in W/m², which describes its warming effect.*

From the evolution of the atmospherical GHG concentration, carbon-cycle-models calculate – backwards – which maximal GHG emissions are still compatible with the given concentration pathways. In this respect, also mitigation and adaptation strategies, i.e. active climate policy, can be taken into account.

The ***nomenclature of the RCP scenarios*** *relates to the already mentioned* ***radiative forcing****. Under RCP6.0, an additional radiative forcing of 6.0 W/m^2 is expected until the end of this century, under RCP8.5 and RCP4.5 8.5 and 4.5 W/m^2, respectively. The RCP2.6 describes a development, where the radiative forcing initially increases up to a value of around 3 W/m^2, but decreases then again (after 2100) to 2.6 W/m^2[2]. Only under the RCP2.6 scenario, the global community could be able to meet the 2°C-climate goal. However, it has to be noted that even under the 2°C-goal, we cannot count on exactly 2°C regional warming over Europe, because the warming vary from one region of the globe to others.*

The GHG concentration are fed, just like in the SRES scenarios, into global climate models, which calculate the resulting climate change for each scenario.

For comparison between SRES and RCP scenarios, the assumed CO_2 emissions and the resulting radiative forcings from both families of scenarios have been identified. Figure 2, created by the Bavarian State Office for Environment, shows this comparison.

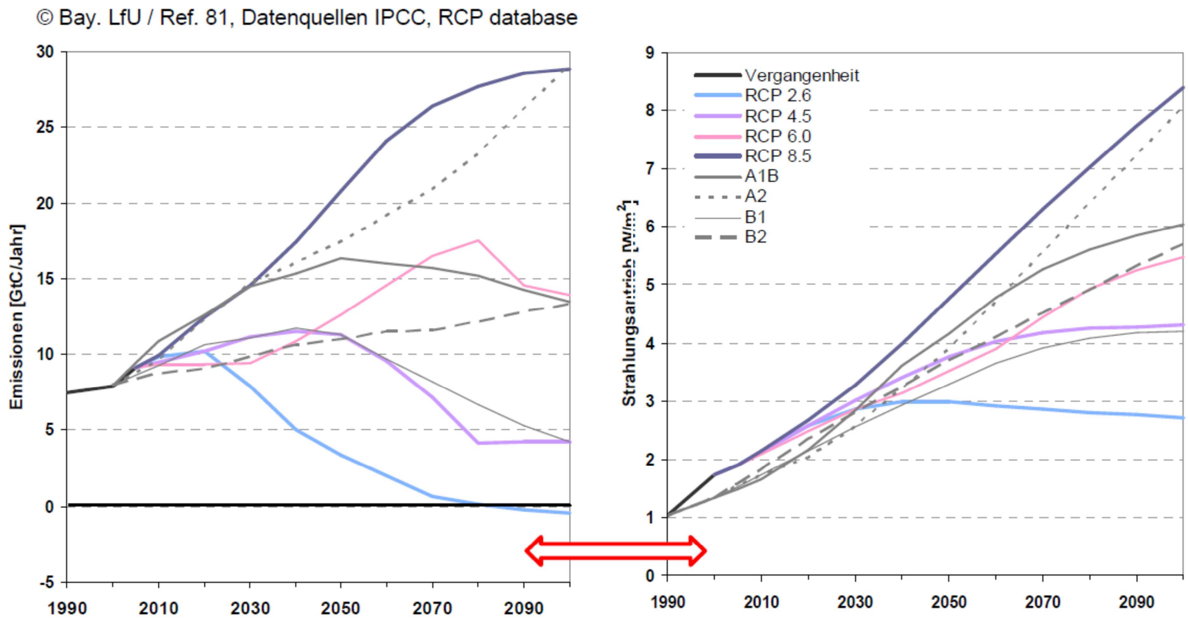

Figure 2: CO_2 emissions (GtC/year) and radiative forcing (W/m^2) for SRES and RCP scenarios until year 2100. For the SRES scenarios, the radiative forcing was calculated from the emissions, for the RCP scenarios vice versa. Bay.LfU, Ref. 81.

[2] Therefore, the RCP2.6 scenario is sometimes also called RCP3PD (peak-and-decline).

The figure shows that the radiative forcings for SRES-B2 (gray, dotted line) and RCP6.0 (pink), despite differences in the temporal evolution of the CO2 emissions (Fig. 2, left), are quite similar.

8.2 Essential Differences between SRES and RCP scenarios

An essential difference between the SRES and the RCP scenarios lies – besides the methodology of their generation – also in the ***temporal evolution of the emissions****. At the moment of the formulation of the RCP scenarios (from 2007), the actual global GHG concentration was already higher than assumed in the SRES scenarios for the 1st decade of this century. During the 1st decade, the RCP scenarios follow the observed values and exceed therefore the SRES scenarios B1 and B2 (fig. 1, left). In the further evolution, the RCP scenarios split up – similarly to the SRES scenarios. The RCP scenarios define the concentration pathways in the first place; it is thus possible to reach these path ways by a number of different measures for climate protection. The choice between those measures is left to the political and economic system; the scenarios only present the causal relation GHG concentration and global warming.* ***Examples for climate protection measures****, which may lead to the RCPs, are an* ***increase of energy efficiency****, the* ***decarbonization of energy generation****, the* ***reduced production of methane*** *in energy generation and agriculture, an* ***increase of the productivity in agriculture*** *(simultaneously securing nutrition and biodiversity), and a* ***decelerated deforestation****. All these measure can, to a varying extent, contribute to the adherence to the RCP scenarios.*

In the SRES scenarios, no explicit climate protection measures have been taken into account.

Another important difference between the two groups of scenarios lies in the ***consideration of sulphate aerosols****. Particles of sulphate aerosol form during combustion processes and have a cooling effect onto the climate. At the same time, however, they cause "acid rain" and thereby a significant environmental stress for the forests. Since the large-scale introduction of efficient desulphurization facilities this kind of air pollution has decreased considerably. Especially in the SRES scenarios A1 and A2 the concentration of sulphate aerosol in the atmosphere is supposed to continue increasing strongly, which has not occurred (Streets et al. 2006; Mischchenko et al. 2007). Therefore, in the RCP scenarios decreasing aerosol concentrations are assumed: In RCP8.5, RCP4.5 and RCP2.6 the aerosol concentration reaches a peak in 2010 and after that decreases clearly and monotonously; in RCP6.0 the aerosol concentration remains static at the actual level until the mid-century and decreases thereafter (Szopa et al. 2013). This evolution leads to a weakened cooling effect of sulphate aerosol during the course of this century.*

Besides *the* ***application of the new RCP scenarios, the result published in the 5th IPCC report differ from previously published results in the number of***

climate models used to derive these results and that the climate models had been developed further since the publication of the 4th IPCC report (2007). *In particular, some of the global climate models contain an* ***integrated carbon-cycle-model****. In such a model, the bonding of CO2 in plants and the solution in sea water can be simulated directly in the climate model (in contrast to separated models, as were routinely applied during the compilation of the 4th IPCC report), such that resulting changes in plant growth have got a recoupling effect onto the simulated climate. Likewise, the* ***simulation of the effects of aerosols has been refined*** *in some models."* Because more and improved models have been considered, it can be assumed, *"that the analyses of the 5th IPCC report are both statistically and physically more reliable than previous results."*

It has to be emphasized that the existence of scenarios is not linked to whatever probability of scenarios. Even there have been defined three new scenarios (RCP2.6, RCP4.5 and RCP6.0) which project a lower increase of GHG concentration than SRES-A1B, this does not mean that the probability for optimistic scenarios has increased. The new scenarios explicitly include mitigation strategies; only by those means it is (technically still) possible not to exceed the GHG concentration limits assumed.

The results of the 5th IPCC report (working group 1) confirm the results of previous reports about the effects of GHG in the atmosphere. The most recent findings on the intensity of the effect, which a certain concentration of GHG exerts on the climate system, also lie in the same range as assume before. New insights gained by the 5th IPCC report consist in the improvement of the applied and analyzed models, which take into account more components of the climate system than 6 years before (IPCC AR4, 2007). The results are therefore more reliable. Furthermore, more models have been included than in any former IPCC report, such that the evaluation of the spread of possible changes under a certain scenario becomes more reliable, too.

8.3 First comparisons of the new climate projection results

Based on the new scenario set up (RCP) an extensive computation of climate change projections has been done. Results are available at the global and the regional scale. The projected climate change based on RCPs at the global scale is similar to SRES in both patterns and magnitude, after accounting for scenario differences (IPCC, 2013).

An analysis of already available highly resolved simulations from EURO-CORDEX for Europe was performed within a project of the DWD. The results for Germany from the simulation from the ENSEMBLES project based on SRES A1B where compared to the results from EURO-CORDEX based on RCP8.5. For temperature it can be shown that the results based on RCP8.5 are at the same level as the old SRES A1B based results from the ENSEMBLES project, keeping in mind that at the global scale the RCP8.5 temperature signal is higher. At the annual scale the results for rainfall are comparable. In the meteorological season summer, first analyses of the RCP8.5

results show a slighter decrease than the old SRES A1B results. But it has to be remembered that the EURO-CORDEX Ensemble is still incomplete.

9 Acknowledgements

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