Changing transport and traffic risks – a CliPDaR spin off

Christoph MATULLA[(1)], Joachim NAMYSLO[(2)], Konrad ANDRE[(1)], Julia GRINGINGER[(1,3)], Barbara CHIMANI[(1)], Brigitta HOLLÓSI[(1)], Christian Mlinar[(4)], Roland GSCHIER[(5)], Tobias FUCHS[(2)], Ingeborg AUER[(1)], Wolfgang SCHÖNER[(1)]

[(1)]Central Institute for Meteorology and Geodynamics, ZAMG, Vienna – Austria, [(2)]German National Meteorological Service, DWD, Offenbach – Germany, [(3)]University of Vienna, Vienna – Austria, [(4)]Autobahn and highway financing stock corporation, ASFINAG, Vienna – Austria, [(5)]Federal Ministry for Transport, Innovation and Technology, BMVIT, Vienna – Austria

ABSTRACT

Transport infrastructure is one central element of Europe's prosperity. Globalisation, changes in technology, demography and climate as well as the strong increase in freight traffic are fundamental challenges to the reinforcement of transport assets in place and to the planning of future transport corridors. As for climate change we present an approach to estimate the rate and amount of change that has to be managed in the future by transport authorities. This approach relies on the 2nd order Cause-Effect Tensor (CET2) and an ensemble of dynamically produced regional scale climate change projections. Our next step is to enhance this risk change concept through a higher dimensionality of CET2.

CLIMATIC THREATS

Figure 1 shows an example of a CET2 which is made up by transport assets (e.g. prestressed-concrete bridges) and by Climate Indices (CIs e.g. long term rain) that have to be thoroughly synchronized. Based on the fact that occurring CIs potentially harm assets they are central in risk analyses.

In order to evaluate potential changes in the risks of damages to transport infrastructure that are driven by climate change we evaluate the CIs (e.g. summer days, hot days, ice days, frost days) for the present day climate and for two future periods (results shown here refer to the period 2071–2100). Then we can assess the change in the CIs and hence evaluate the change in risk of damages to the transport assets.

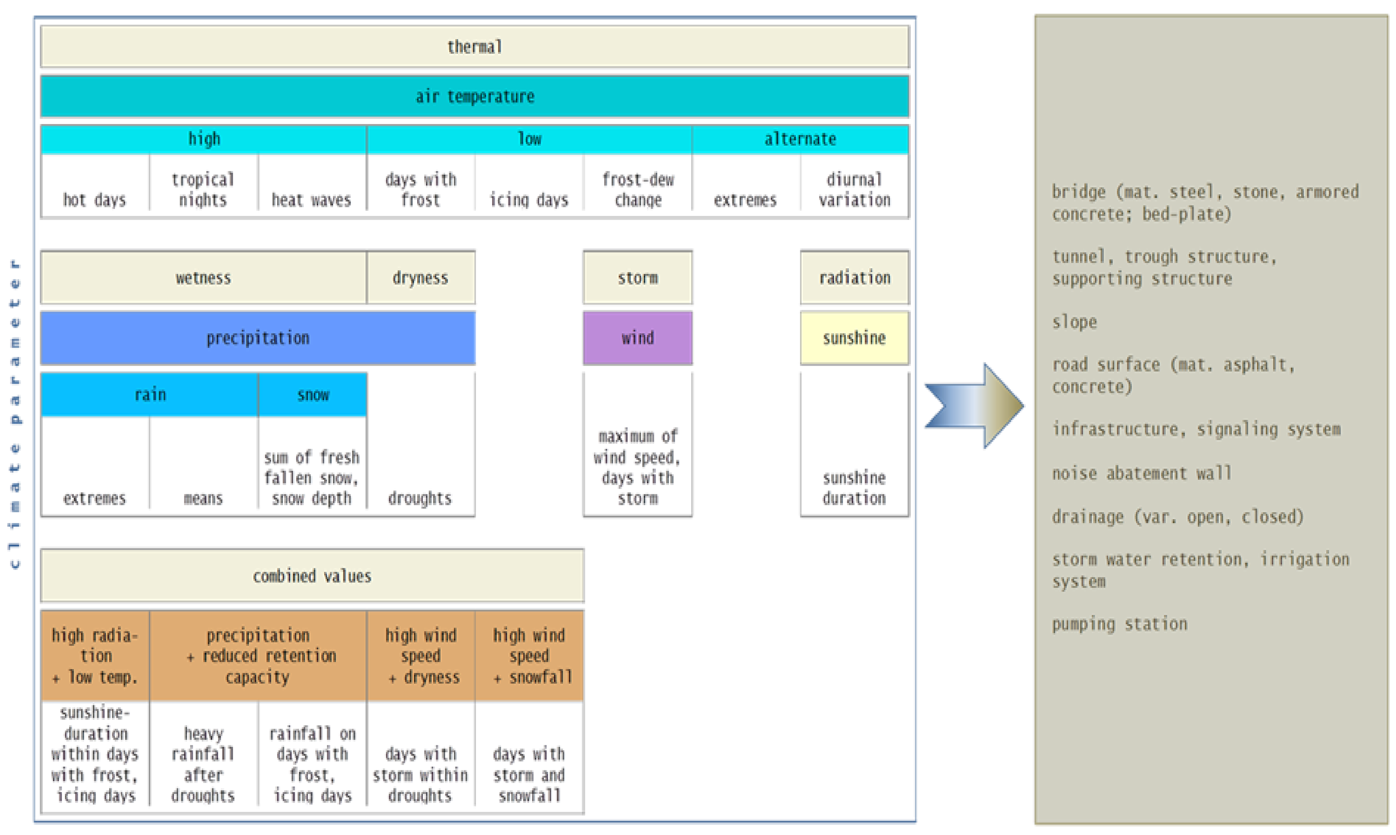

Figure 1. The Cause-Effect Tensor. Left: climatological elements, right: traffic infrastructure elements.

CLIMATE DATASET

The assessment of future CI values are based on an ensemble of regional scale climate change projections (in our case the ensemble is driven by the SRES A1B scenario – estimated CO_2 level by 2100 is 717 ppm). Figure 2 shows the regions of interest. The simulations for Central Europe used the KLIWAS17 ensemble, which is based on Regional Climate Model projections 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. Results for two CIs are displayed in Figure 3 and 4. To estimate very cold winter seasons in Fennoscandia (Figure 5 and 6) and heat wave summers over the Iberian Peninsula, projections of Global Models (forced by the socio-economic scenarios A1B and A2) were used and via an EOF approach compared to NCEP/NCAR reanalysis data.

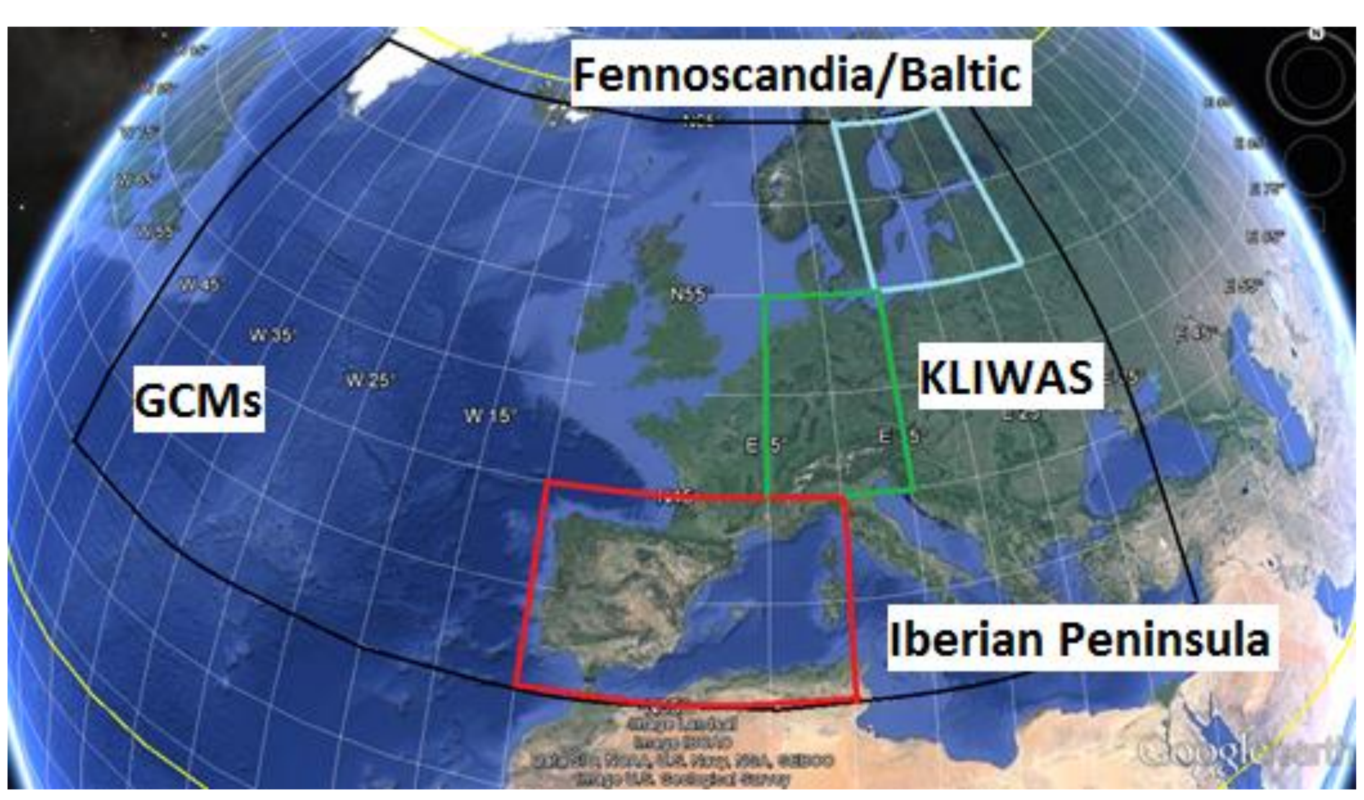

Figure 2. Geographical location of the target region: Fennoscandia/Baltic, Central Europe and the Iberian Peninsula.

RESULTS

Rutting of asphalt surfaces or "blow ups" of concrete roads are safety issues. Here we focus on a CI that is characterized by high daily temperatures (≥30°C, hot day) together with tropical nights (Tmin≥20°C). Such periods potentially harm road surfaces. Figure 3 shows the projected changes of rutting days for the remote future. The simulations suggest an increase of "potential rutting days" with a north-south spatial gradient for the 85th percentile. The largest alteration (+20 days) is projected in the River Rhine valley, while in the northern regions the changes are considerably lower (≤+5 days).

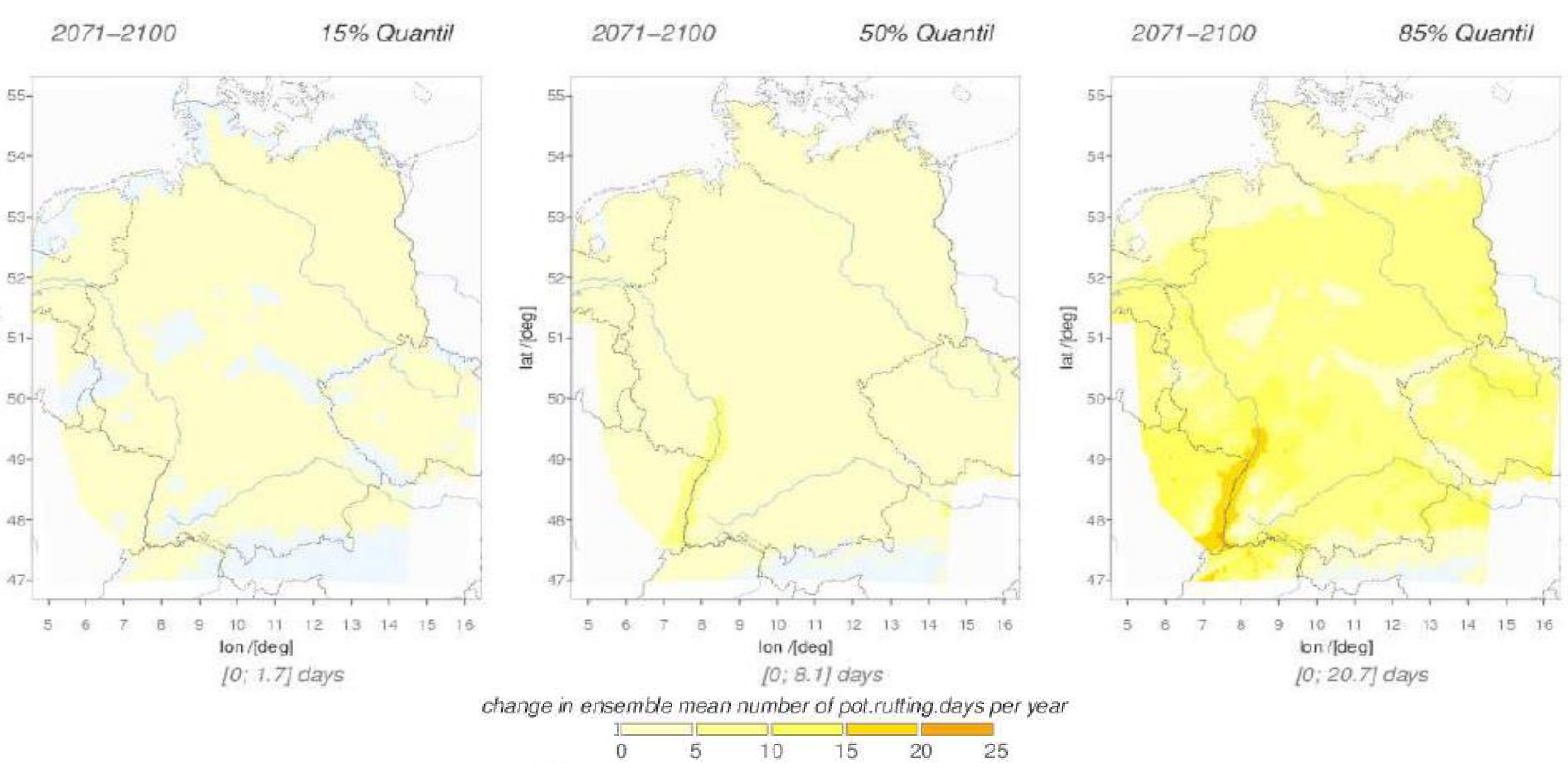

Figure 3. The projected increase of rutting days (hot days with tropical nights) for 2071–2100 compared to the reference period (1961–1990). The panels show the 15th, 50th and 85th percentile. The numbers in brackets below each panel are minimum and maximum values.

Regarding landslides (Figure 4) there are regions showing no change and other areas with substantial increases. These occur predominantly close to topographic complex terrain. Such regions are characterized by precipitation induced by orographic lifting. Increases can be caused by the more frequent advection of moist air masses carrying more water vapour than observed so far, which may be expected from the saturation vapour pressure at higher temperatures.

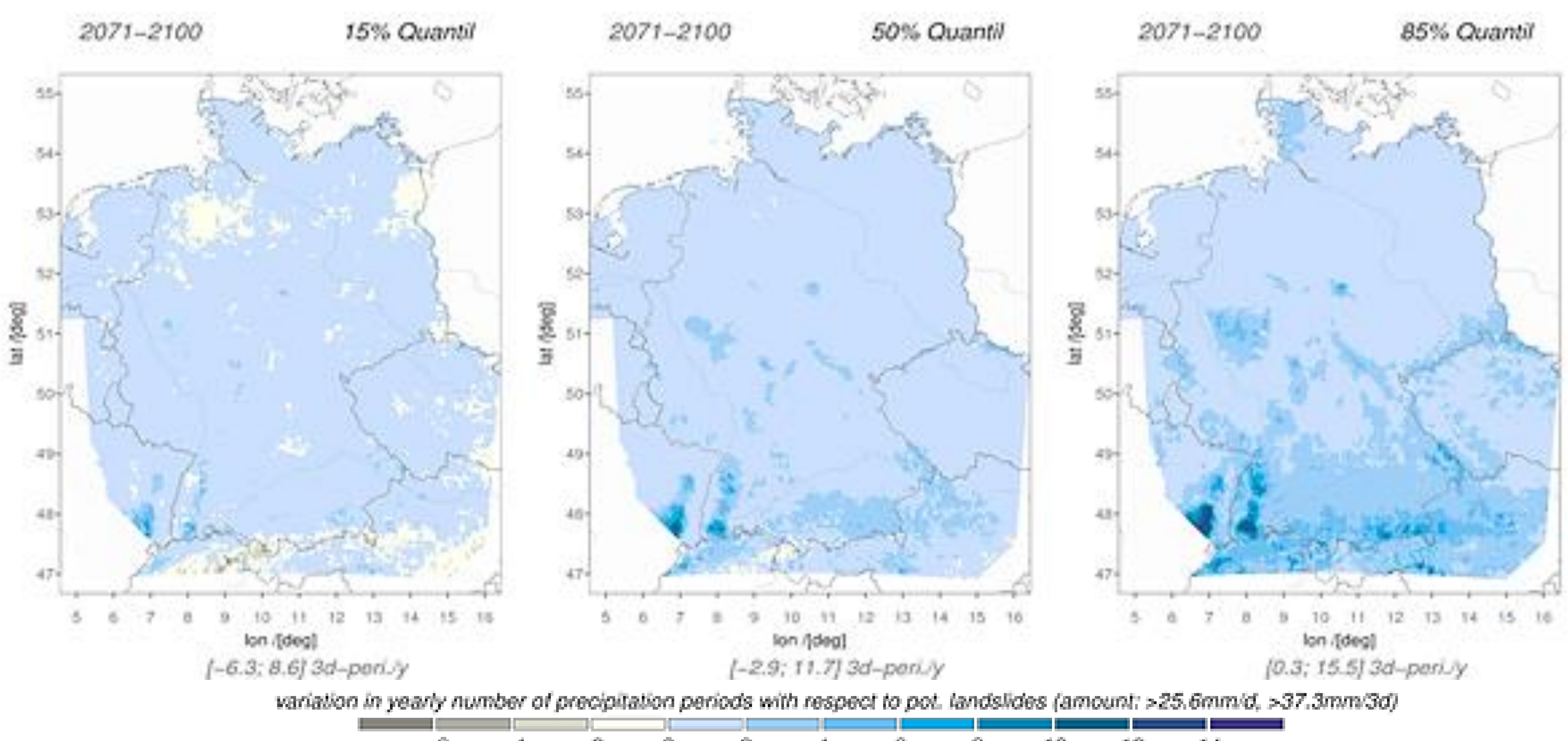

Figure 4. Projected changes in the CI that may be responsible for landslides for 2071–2100 compared to the reference period (1961–1990). The panels show the 15th, 50th and 85th percentile. The numbers in brackets below each panel are minimum and maximum values.

Figure 5 depicts the NCAR/NCEP air temperatures in 850 hPa over Fennoscandia and other parts of the North Atlantic and Europe. Almost all of the 25 most recent years exhibited temperatures way above the long-term average, except for the most recent past, when Fennoscandian temperatures fall below the long-term average. This proves one CEDR claim.

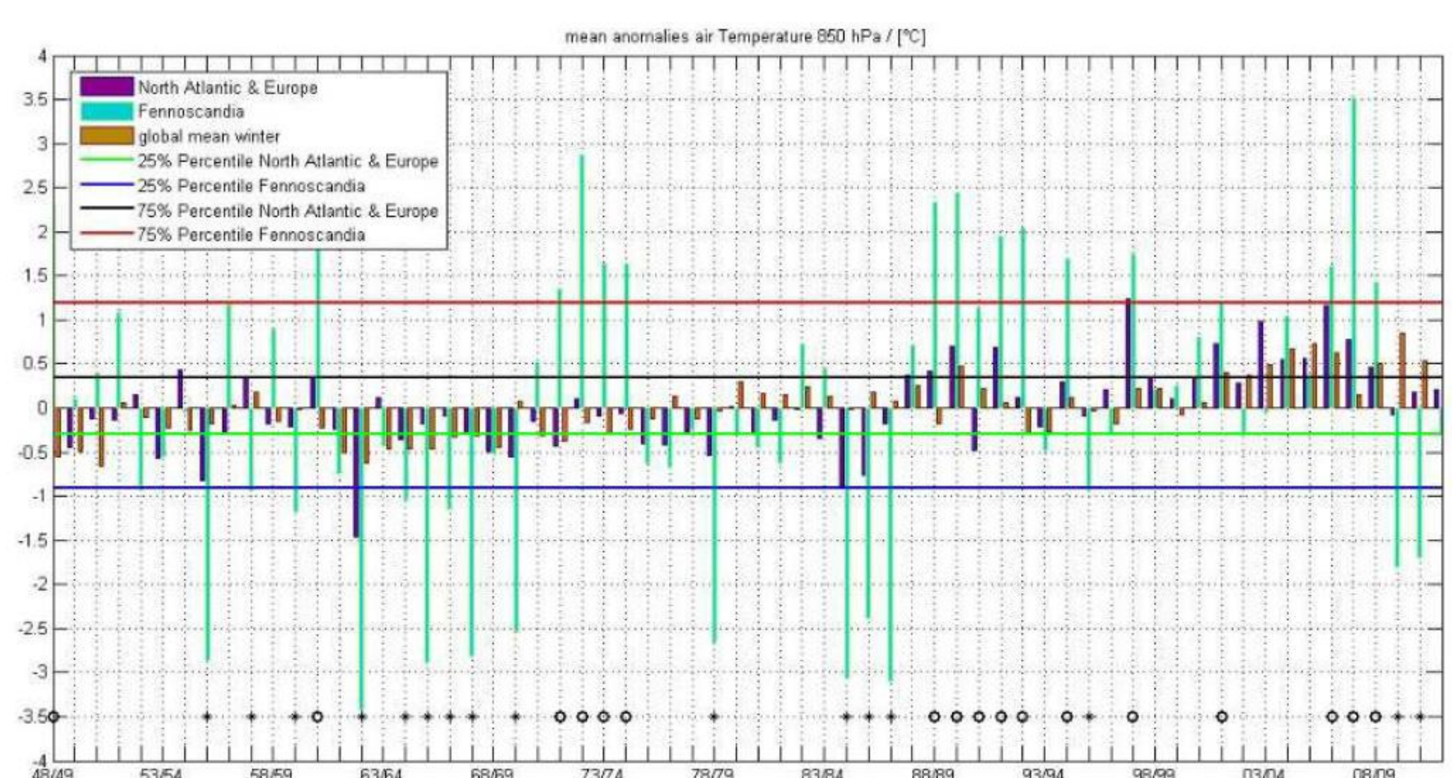

Figure 5. Time series of winter temperature anomalies (to the period 1948-2013) averaged over (i) the North Atlantic and Europe (purple) as well as (ii) Fennoscandia (turquise) and (iii) globally averaged. Horizontal lines indicate the percentiles below/above wich winters are called very cold/warm. Asterisks/circles mark very cold/warm winter seasons.

A substantial fraction of the Fennoscandian values, which were experienced in the past, still appear in the near future (Figure 6). The peaks of the distributions are shifted to larger values whereby the A2 distribution features largest values with a higher probability than the A1B ensemble does. Warm winters will appear significantly more often. This situation changes in the remote future. Very cold winters as experienced in the climate normal period will not appear. A very cold season in the far future will be like an average winter of the past and a very warm winter seasons in 2071-2100 has never been observed in the climate normal period. The difference between the socio-economic scenarios increases with time and the variance of the A2 distribution is considerably larger than the A1B variance.

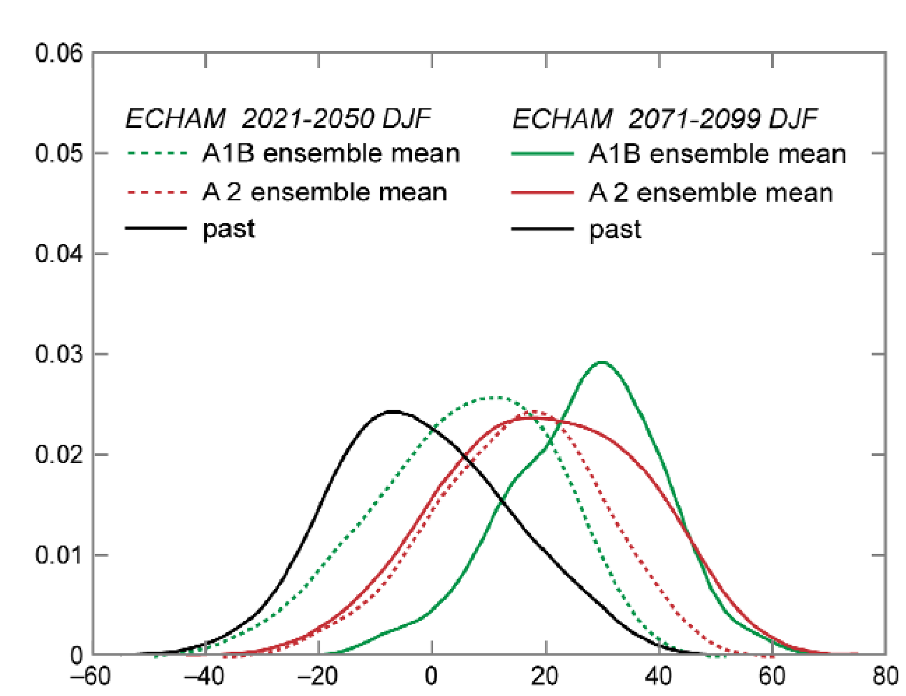

Figure 6. Probability distribution of the first EOF's appearences throughout the climate normal period (1961–1990) (black, solid line) the near future (coloured dashed lines) and the far future (solid, coloured lines). Red lines refer to the A2 and green lines to the A1B SRES scenario.

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. We want to express our gratitude to Beate Gardeike from the HZG, to Christine Hagen and Nathalie Nosek from ZAMG for helping us with the Figures and arranging CliPDaR deliverables. We are thankful for the good cooperation with the Project Executive Board and the NRA.

KONTAKT: Mag. Dr. Christoph Matulla, Central Institute for Meteorology and Geodynamics (ZAMG) – Climate Research Section, Vienna – 1190 Hohe Warte 38, christoph.matulla@zamg.ac.at (0043-1-360-26/2217)