Distr.: General
10 April 2019

English only

Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Group of Experts on Climate Change Impacts and Adaptation for Transport Networks and Nodes

Seventeenth session
Geneva, 24 and 25 April 2019
Item 4 of the provisional agenda
Discussions on the final report of the Group of Experts

Analysing future climate impacts

Submitted by the Climate Service Center, Germany

I. Introduction

1. This document describes the indices and the various choices that were made by the Group of Experts when seeking to analyse the potential climate impacts that the inland sector may be exposed to within the United Nations Economic Commission for Europe (ECE) region. The Group decided to analyse regional climate model (RCM) data from the Euro-Cordex project. The spatial resolution of the data is approximately 12.5km, and data relating to six climate indices of most relevance for potential climate impacts on transport infrastructure were analysed. Consequently, this document describes the six selected indices, the rationale for the time period analysed, the emissions scenarios analysed, quantification of uncertainty, and multi-model ensembles. The Group of Experts requested the secretariat at its sixteenth session that this document is tabled as an official document at the future sessions.

II. Climate indices

2. Climatic impacts such as heatwaves, downpours and flashfloods, flooding, permafrost thaw and low river flows were considered to be the most relevant climatic impacts on transport infrastructure. Six indices were selected to analyze the impacts. They are summarised and described in table 1. More information about these indices can be found at: etccdi.pacificclimate.org/list_27_indices.shtml.

Table 1
Summary and description of the six climate indices that were analysed with the EURO-CORDEX RCM data

Climate impact	*Proxy variable*	*Network*
Heatwave	WSDI: warm spell duration index. Annual count of days with at least 6 consecutive days when daily maximum temperature is > 90th percentile	Road and rail networks
Downpours/ flashfloods	R20mm: annual count of days when precipitation is > 20mm	Road and rail networks
Flooding	Rx5day: maximum 5-day consecutive precipitation amount	Road and rail networks
Permafrost thaw	ID: number of icing days. Annual count of days when daily maximum temperature < 0^{o}C	Road network
Heat on rail	SU: number of summer days. Annual count of days when daily maximum temperature > 30^{o}C	Rail network
Low river flow	CDD: maximum length of dry spell. Maximum number of consecutive days when daily precipitation is < 1mm	Waterways

III. Future time period and reference time period

3. Given that much infrastructure in the inland transport sector will have a design lifetime of up to fifty years, the Group of Experts decided upon a future time period for the calculation of changes in the selected indices, of 2051–2080. Changes in the indices were then calculated using a reference time period of 1971–2000.

IV. Emissions scenarios

4. As the future time period for calculating changes was 2051–2080, there is likely to be significant differences in the projected changes between different emissions scenarios. In order to account for this source of uncertainty in future changes, two emissions scenarios were analysed. Both of these come from the representative concentration pathways (RCP) scenarios (Moss et al. 2010). One is RCP2.6 which represents an emissions scenario in which major reductions in greenhouse gas emissions are seen; the other is RCP8.5, which can be considered a 'business as usual' scenario.

V. Quantification of uncertainty in the climate projections

5. In order to quantify the uncertainty in the projected changes, output from multiple regional climate models was used, in what is referred to as a multi-model ensemble. For each variable, the multi-model mean, and the 10th and 90th percentile values, were analysed.

VI. Regional climate models in the multi-model ensemble

6. In order to provide transparency on the models that the ensembles are composed from, tables 2 and 3 list the models that are used for each variable, in the RCP2.6 and RCP8.5 emissions scenarios, respectively.

Table 2
A listing of the regional climate models that are used in the generation of the multi-model mean and percentile values, for each variable under the RCP 2.6 emissions scenario

Climate index	*Models*
WSDI	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015
	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
R20mm	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015
Rx5day	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015

Climate index	*Models*
	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5
ID	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
SU	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17

Climate index	*Models*
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015
	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
CDD	ICHEC-EC-EARTH_rcp26_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp26_r12i1p1_KNMI-RACMO22E
	IPSL-IPSL-CM5A-LR_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_KNMI-RACMO22E
	NOAA-GFDL-GFDL-ESM2G_rcp26_r1i1p1_GERICS-REMO2015
	MIROC-MIROC5_rcp26_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp26_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp26_r1i1p1_SMHI-RCA4
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp26_r2i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp26_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp26_r3i1p1_DMI-HIRHAM5

Table 3

A listing of the global climate models that are used in the generation of the multi-model mean and percentile values, for each variable under the RCP 8.5 emissions scenario

Index	*Models*
WSDI	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015

Index	*Models*
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
R20mm	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
Rx5day	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17

Index	*Models*
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
ID	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
SU	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E

Index	*Models*
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
CDD	ICHEC-EC-EARTH_rcp85_r12i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r12i1p1_KNMI-RACMO22E
	IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4
	ICHEC-EC-EARTH_rcp85_r1i1p1_KNMI-RACMO22E
	MOHC-HadGEM2-ES_rcp85_r1i1p1_KNMI-RACMO22E
	ICHEC-EC-EARTH_rcp85_r12i1p1_SMHI-RCA4
	CCCma-CanESM2_rcp85_r1i1p1_GERICS-REMO2015
	MOHC-HadGEM2-ES_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	CCCma-CanESM2_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MOHC-HadGEM2-ES_rcp85_r1i1p1_GERICS-REMO2015
	ICHEC-EC-EARTH_rcp85_r3i1p1_DMI-HIRHAM5
	NCC-NorESM1-M_rcp85_r1i1p1_DMI-HIRHAM5
	MIROC-MIROC5_rcp85_r1i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_MPI-CSC-REMO2009
	MPI-M-MPI-ESM-LR_rcp85_r2i1p1_MPI-CSC-REMO2009
	ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17
	MPI-M-MPI-ESM-LR_rcp85_r1i1p1_SMHI-RCA4
	MIROC-MIROC5_rcp85_r1i1p1_GERICS-REMO2015

VII. References

Moss, R., et al., 2010, The next generation of scenarios for climate change research and assessment, Nature, 463, doi:10.1038/nature08823