Challenges for CORDEX:

regional climate change research and production runs for CC adaptation

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Eine Einrichtung des Helmholtz-Zentrums Geesthacht

Adaptation to climate change is not cheap

in cases like:

conversion of a company, urban water management,

construction of dikes, …

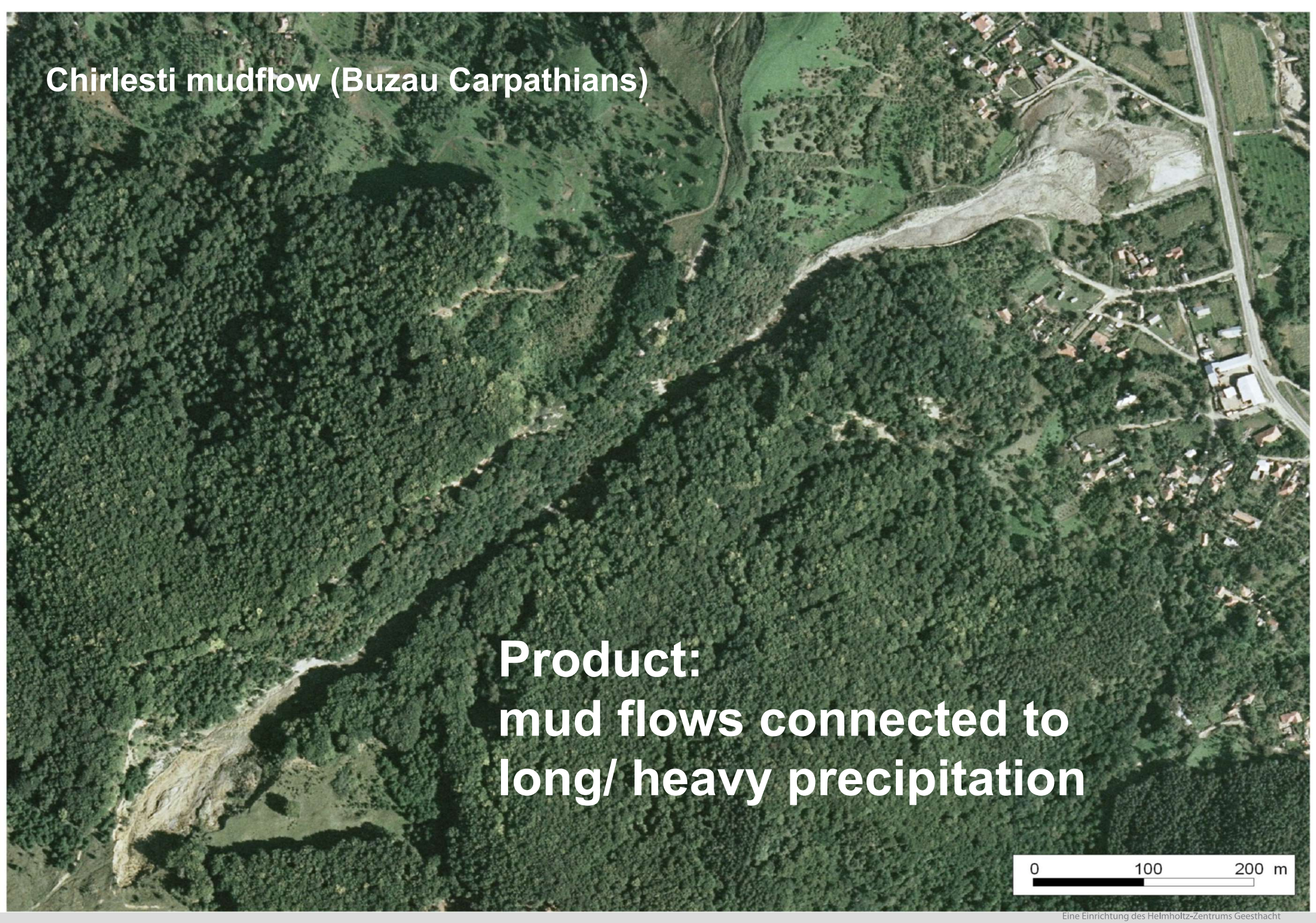
the decision makers, the engineers and other

stakeholders need interest in the topic and

must be sure to have

the best available information on climate change

-> research and communication are essential!


Chirlesti mudflow (Buzau Carpathians)
Product:
mud flows connected to
long/ heavy precipitation
0
100
200 m

Product: **ice loads**

Sector: **infrastructure, construction sector**

Electrical tower in eastern Thuringia

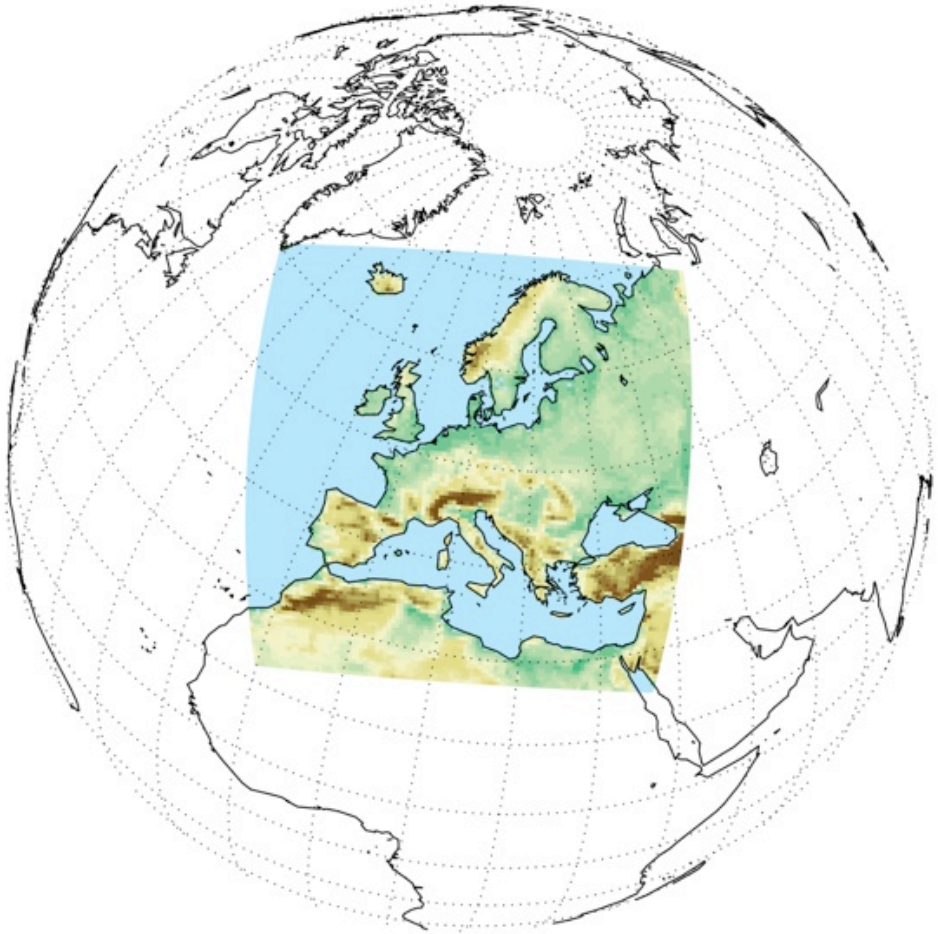
dpa_kreiszeitung.de 09.12.2010

Electrical tower close to Münster
Sueddeutsche.de 04.12.2005

where and how often?

How can we fulfill the demand?

Schalke Arena
DAPD_Welt Online_28.12.2010



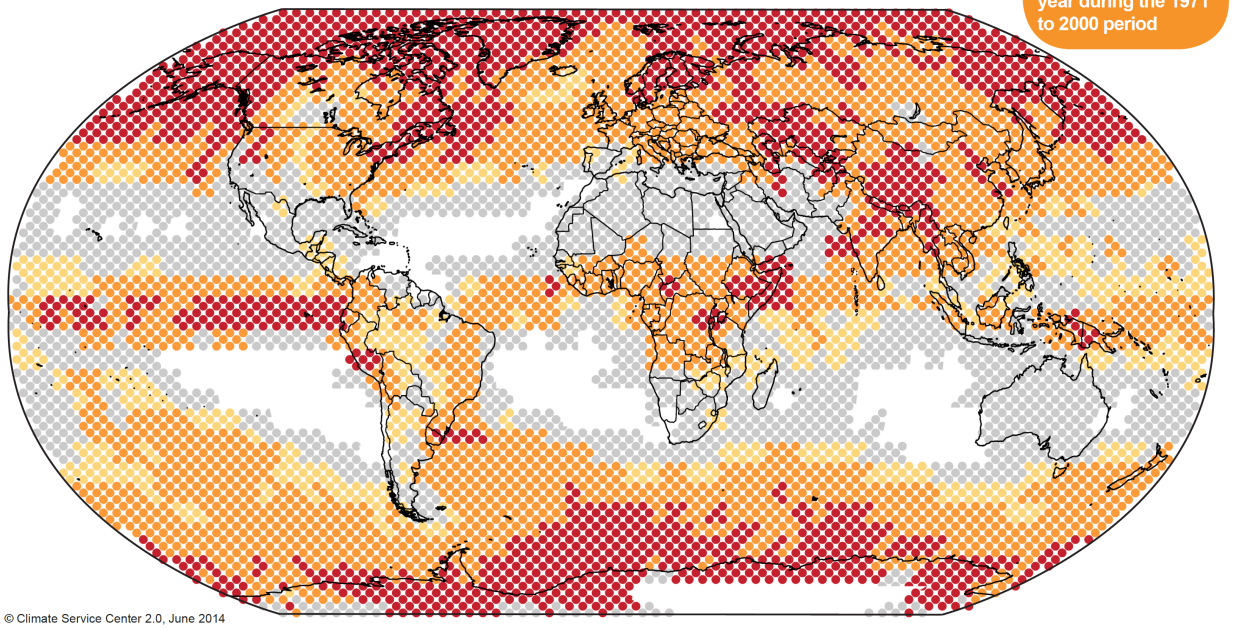
Climate-Change-Spot-Maps

Example: Prototype development and innovation

Climate-Change-Spot-Map

Increase in the occurence of extremely wet days per year

The amount of rain falling on a extremely wet day is reached only at five percent of all rainy days a year during the 1971 to 2000 period



Background information:

Climate-Change-Spot-Maps show the mean projected change of a climate parameter averaged for the time period 2036 to 2065 compared to the average of the time period from 1971 to 2100.

The map is based on a set of 66 climate change projections from a multitude of recent global climate models and combine simulations following three different emission scenarios.

Projected changes are regarded robust, if at least 2/3 of all model projections do project changes that are:
- in the same direction (decrease/increase), and
- statistically significant, and
- insensitive to small shifts of the reference time period.

All areas with robust climate change signals are highlighted with colored stipples.

All areas with non-robust changes are marked with grey stipples. White areas define regions with a change in the opposite direction than indicated in the map.

More details on the method can be found under www.climate-service-center.de/climate-signal-maps

Legend

- Decrease in occurence of extremely wet days
- Projected changes are not robust
- Increase in occurence of extremely wet days:
  - less/equal than 10 percent
  - more than 10 and less/equal 25 percent
  - more than 25 percent

On behalf of

KFW

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Climate Service Center Germany 2.0

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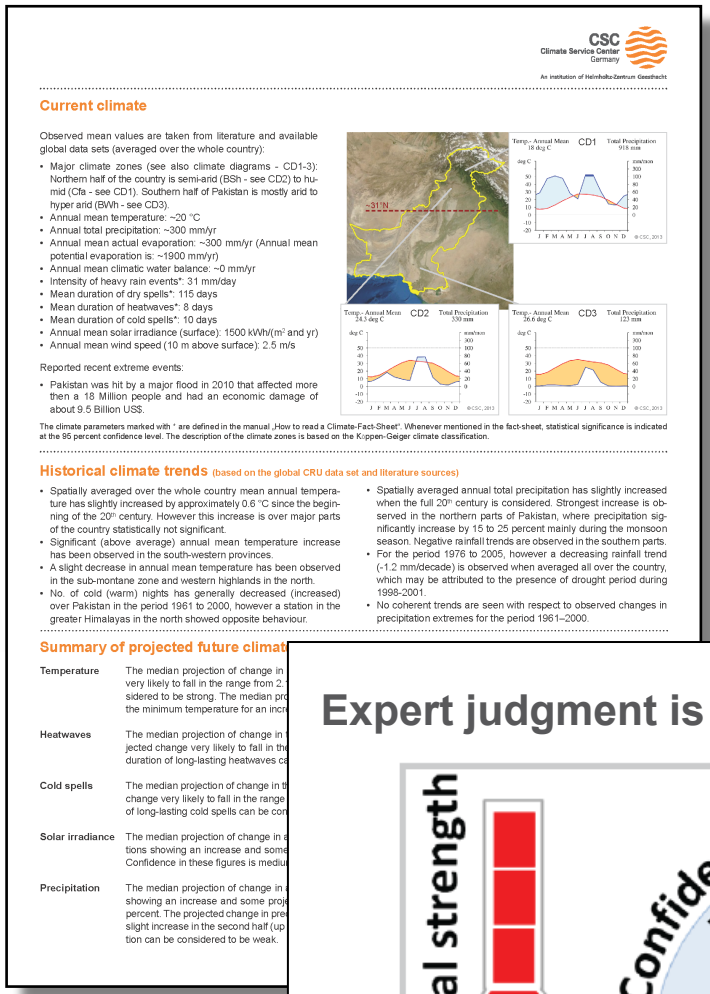
Examples: Prototype development

Climate-Fact-Sheets

Aim: Concise summary of available state-of-the-art climate change information for a country/ region

Example pages of the Climate-Fact-Sheet for Pakistan



Current climate

Observed mean values are taken from literature and available global data sets (averaged over the whole country):

- Major climate zones (see also climate diagrams - CD1-3): Northern half of the country is semi-arid (BSh - see CD2) to humid (Cfa - see CD1). Southern half of Pakistan is mostly arid to hyper arid (BWh - see CD3).
- Annual mean temperature: ~20 °C
- Annual total precipitation: ~300 mm/yr
- Annual mean actual evaporation: ~300 mm/yr (Annual mean potential evaporation is: ~1900 mm/yr)
- Annual mean climatic water balance: ~0 mm/yr
- Intensity of heavy rain events*: 31 mm/day
- Mean duration of dry spells*: 115 days
- Mean duration of heatwaves*: 8 days
- Mean duration of cold spells*: 10 days
- Annual mean solar irradiance (surface): 1500 kWh/(m² and yr)
- Annual mean wind speed (10 m above surface): 2.5 m/s

Reported recent extreme events:

- Pakistan was hit by a major flood in 2010 that affected more then a 18 Million people and had an economic damage of about 9.5 Billion US$.

The climate parameters marked with * are defined in the manual „How to read a Climate-Fact-Sheet". Whenever mentioned in the fact-sheet, statistical significance is indicated at the 95 percent confidence level. The description of the climate zones is based on the Köppen-Geiger climate classification.

Historical climate trends (based on the global CRU data set and literature sources)

- Spatially averaged over the whole country mean annual temperature has slightly increased by approximately 0.6 °C since the beginning of the 20th century. However this increase is over major parts of the country statistically not significant.
- Significant (above average) annual mean temperature increase has been observed in the south-western provinces.
- A slight decrease in annual mean temperature has been observed in the sub-montane zone and western highlands in the north.
- No. of cold (warm) nights has generally decreased (increased) over Pakistan in the period 1961 to 2000, however a station in the greater Himalayas in the north showed opposite behaviour.
- Spatially averaged annual total precipitation has slightly increased when the full 20th century is considered. Strongest increase is observed in the northern parts of Pakistan, where precipitation significantly increase by 15 to 25 percent mainly during the monsoon season. Negative rainfall trends are observed in the southern parts.
- For the period 1976 to 2005, however a decreasing rainfall trend (-1.2 mm/decade) is observed when averaged all over the country, which may be attributed to the presence of drought period during 1998-2001.
- No coherent trends are seen with respect to observed changes in precipitation extremes for the period 1961–2000.

Summary of projected future climat

Temperature — The median projection of change in … very likely to fall in the range from 2.… sidered to be strong. The median pro… the minimum temperature for an incr…

Heatwaves — The median projection of change in … jected change very likely to fall in th… duration of long-lasting heatwaves cs…

Cold spells — The median projection of change in t… change very likely to fall in the range … of long-lasting cold spells can be cor…

Solar irradiance — The median projection of change in … tions showing an increase and some… Confidence in these figures is mediu…

Precipitation — The median projection of change in … showing an increase and some proje… percent. The projected change in pre… slight increase in the second half (up… tion can be considered to be weak.

Projections of possible development of temperature, heatwaves and cold spells

Annual mean temperature

- Median projection of change in annual mean temperature is for an increase of 3.8 °C by 2100.
- Likely range: 2.8 to 4.8 °C; very likely range: 2.1 to 5.1°C

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +3.0 °C
- **High-Scenario A2:** Median +4.7 °C

Maximum and minimum temperature

The trends of maximum and minimum temperature are consistent with the trend of annual mean temperature depicted above.

- Median projection of change in maximum temperature is for an increase of 3.4 °C by 2100.
- Median projection of change in minimum temperature is for an increase of 3.8 °C by 2100.

in °C	Scenario	Measure	Max-Temperature	Min-Temperature
2071-2100	ALL	Median	3.4	3.8
		likely	2.9 to 4.4	2.8 to 5.0
		very likely	1.9 to 5.6	2.1 to 5.8
	B1	Median	3.0	3.6
		likely	1.9 to 3.3	2.2 to 3.4
		very likely	1.9 to 4.3	2.1 to 4.3
	A1B	Median	4.1	3.8
		likely	2.9 to 4.4	3.2 to 4.8
		very likely	2.9 to 5.6	3.1 to 5.8
	A2	Median	4.8	4.6
		likely	3.4 to 4.9	3.8 to 5.2
		very likely	*	*

* The amount of available data is not sufficient to project the range for „very likely" for A2

Heatwaves

- Median projection of change in the duration of long-lasting heatwaves is for an increase of 28 days by 2100.
- Likely range: 14 to 51 days; very likely range: 11 to 69 days

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +13 days
- **High-Scenario A2:** Median +42 days

Cold spells*

- Median projection of change in the duration of long-lasting cold spells is for a decrease of 4 days by 2100.
- Likely range: -8 to -3 days; very likely range: -11 to -1 days

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median -4 days
- **High-Scenario A2:** Median -6 days

* Note that it is possible that the absolute decrease in the duration of cold spells might be larger than the actual cold spell length (as given in the current climate section) due to a slight mismatch between models and observations.

…oment of solar irradiance

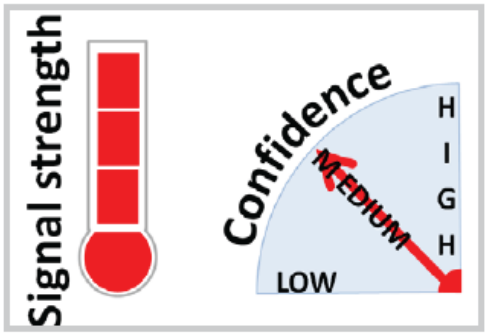
…is for no substantial …ing an increase and …-6 to +1 percent

…are with respect to the reference period from 1961 to 1990. …actual climate change signal but also the statistical signifi-

…jections is based on the models' performance in simulating …mate change. This bandwidth results from the fact that every …ignal.

Climate-Fact-Sheet Pakistan 4

Expert judgment is provided



Climate Service Center Germany 2.0

Eine Einrichtung des Helmholtz-Zentrums Geesthacht

International Workshop (10.-11.3.2015 at CS2.0)
of the European Climate Service Partnership (ECSP):

„How to approach customers or partners“

about 40 Climate Service Providers from Europa. 6 working groups

Outcome

•No sector specific approach

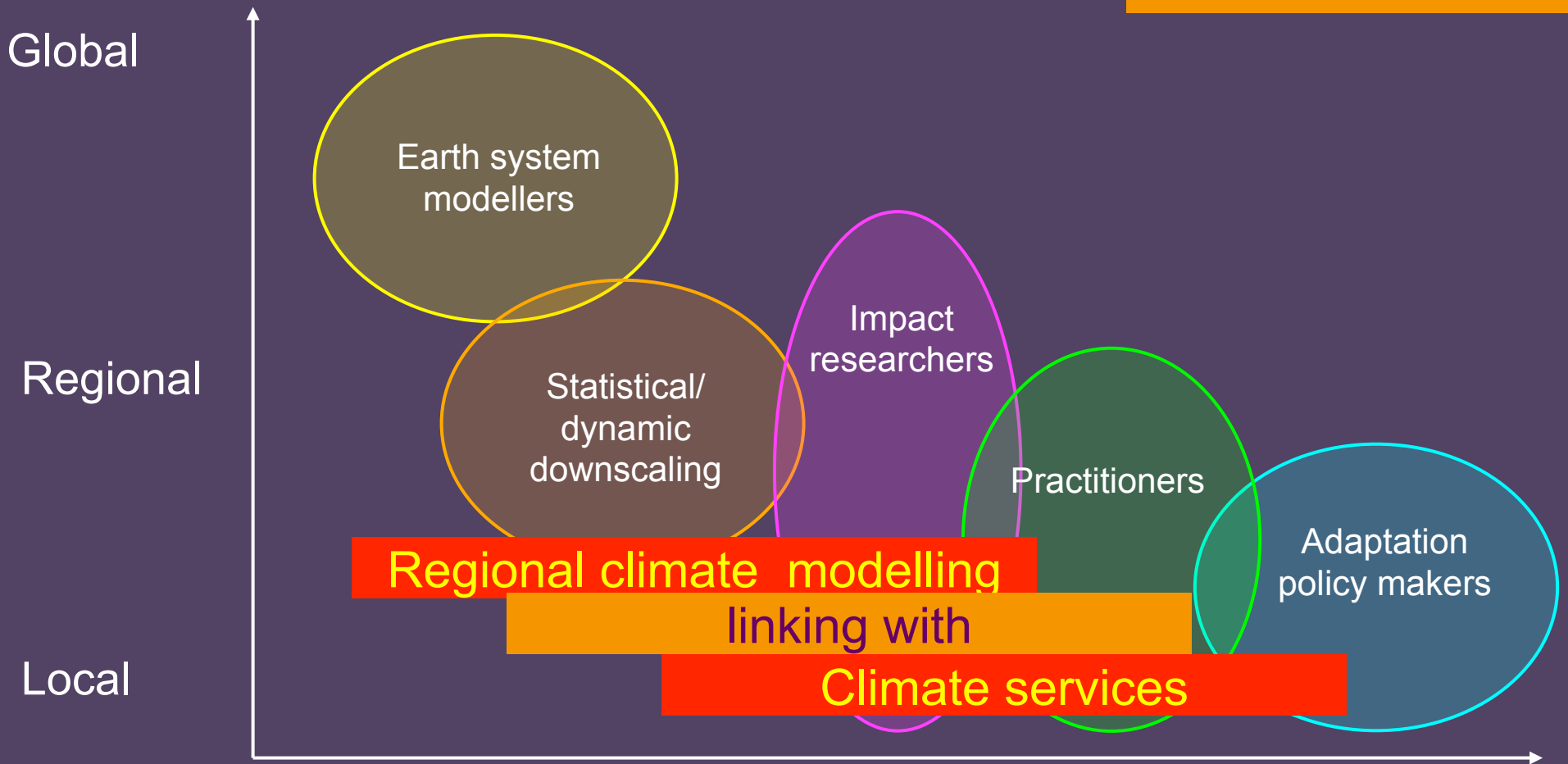
•Honesty, trust and mutual respect

•Webportals are helpful, but need client and case specific consultancy for interpretation and application

•Local, sector and client specific products are needed

Networking in science

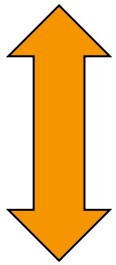
Account for a diverse group of users.



Adopted from Guy Brasseur

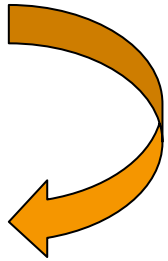
Curiosity driven research

- understanding regional climate (change)
- modelling regional climate (GCM, RCM)



- producing regional climate information

Demand driven activity



EURO-CORDEX community

EURO-CORDEX Community

- **29 actively contribution groups**
- Leading institutions in the field of regional climate modeling in Europe
- Voluntary effort, contributions are funded by the contributors
- Coordination: D. Jacob (CS2 Germany), E. Katragkou (Uni Thessaloniki, Greece), S. Sobolowski (Bjerknes Centre, Norway)

EURO-CORDEX Models

- **12 different GCMs from CMIP 5** (NorESM1-M, HadGEM2-ES, MPI-ESM-LR, CNRM-CM5, EC-EARTH, IPSL-CM5A-MR, ACCESS1-3, CanESM2, MIROC5, GFDL-ESM2M, CISRO-Mk3-6-0, CCSM4)
- **10 different RCMs**: WRF (different configurations), CCLM, ALADIN, REMO, REGCM, HIRHAM, RACMO, ARPEGE, RCA, PROMES
- Cooperation with Empirical Statistical Downscaling (ESD)

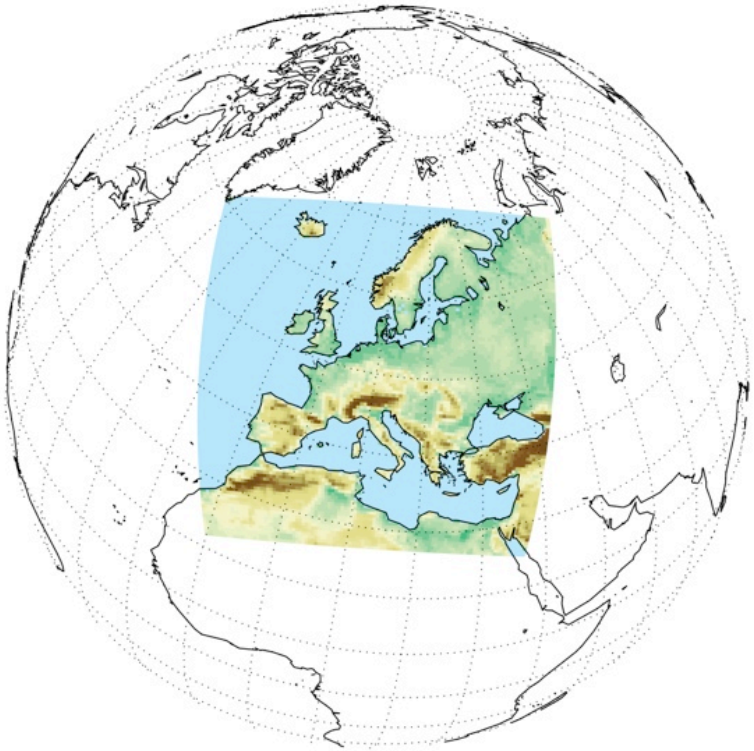
47 scenario simulations at high resolution (EUR-11, 12.5 km):
5 planned, 7 running, 35 finished (23 simulations published)

EURO-CORDEX

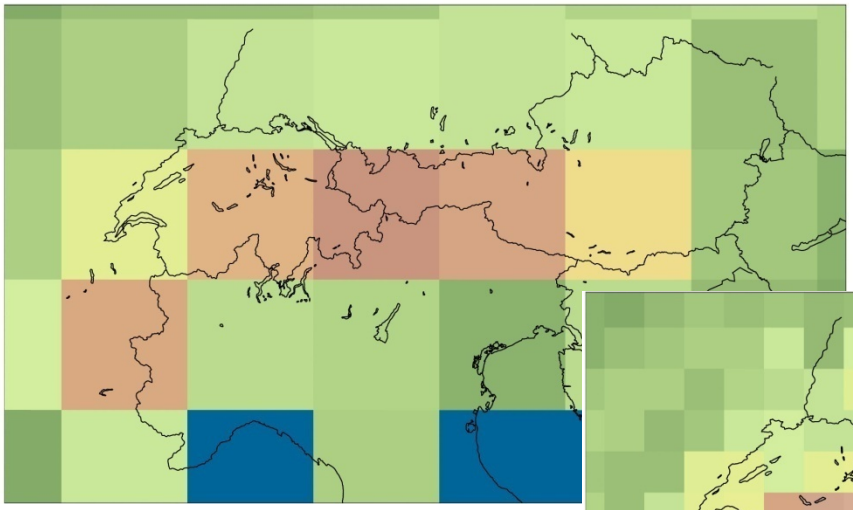
- **Region:**
  - ~ 27° N – 72° N, ~22° W – 45° E

  www.euro-cordex.net

- **Horizontal resolutions:**
  - EUR-11: 0.11° (12.5 km)
  - EUR-44: 0.44° (50 km)
- **Time periods:**
  - Evaluation run (ERA-Interim): 1989 – 2008
  - Historical runs: 1951 – 2005
  - Scenario runs: 2006 – 2100
- **Forcing data:** CMIP5
- **Scenarios:**
  - RCP 4.5, RCP 8.5 (focus)
  - RCP 2.6 (so far: few simulations)

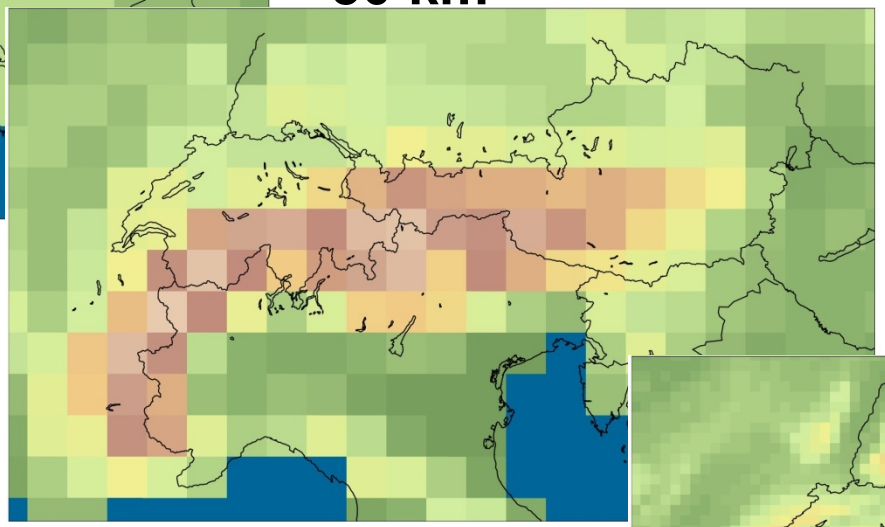


From GCM to 0.11°

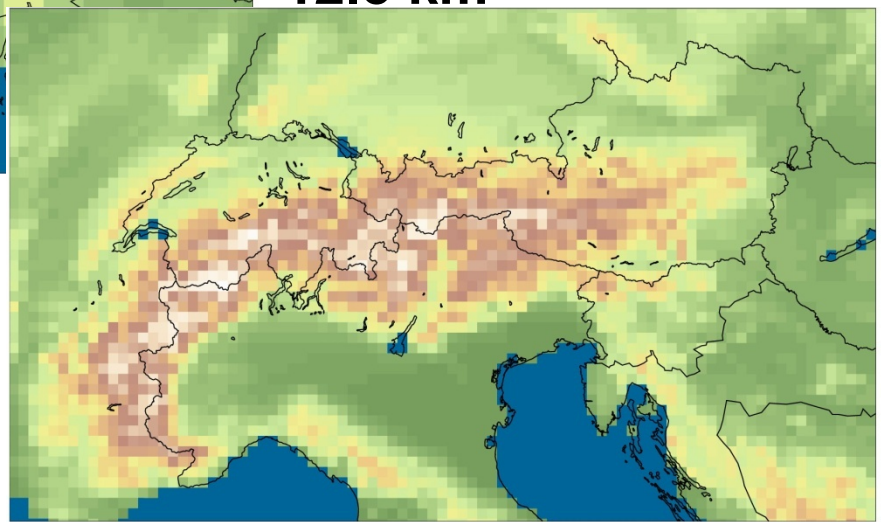


GCM
~150 km

EURO-CORDEX 0.44°
50 km



EURO-CORDEX 0.11°
12.5 km

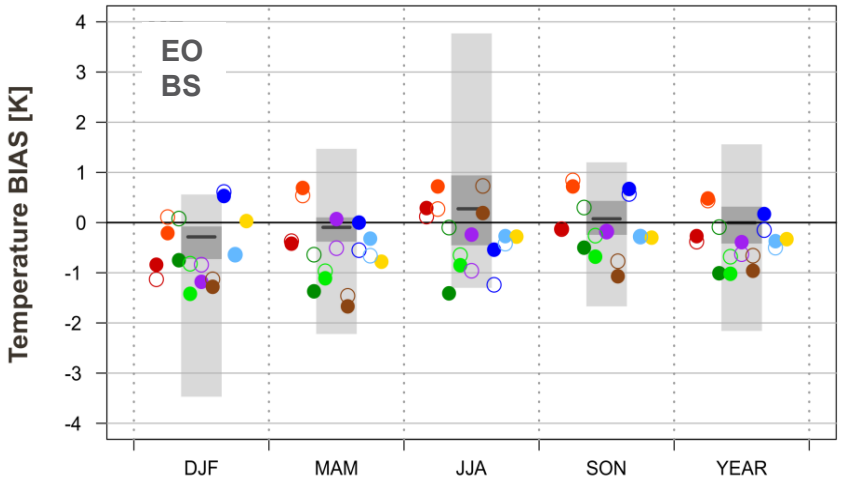


Representation of orography,
e.g., European Alps

EURO-CORDEX joint efforts

1) Evaluation of hindcasts
   a) RCM multi-model ensemble evaluation
   b) Reference datasets
2) Setup and analysis of projections
   a) GCM-RCM matrix
   b) Analysis of projections
3) Interface to users
   a) Guidelines
   b) Data preparation

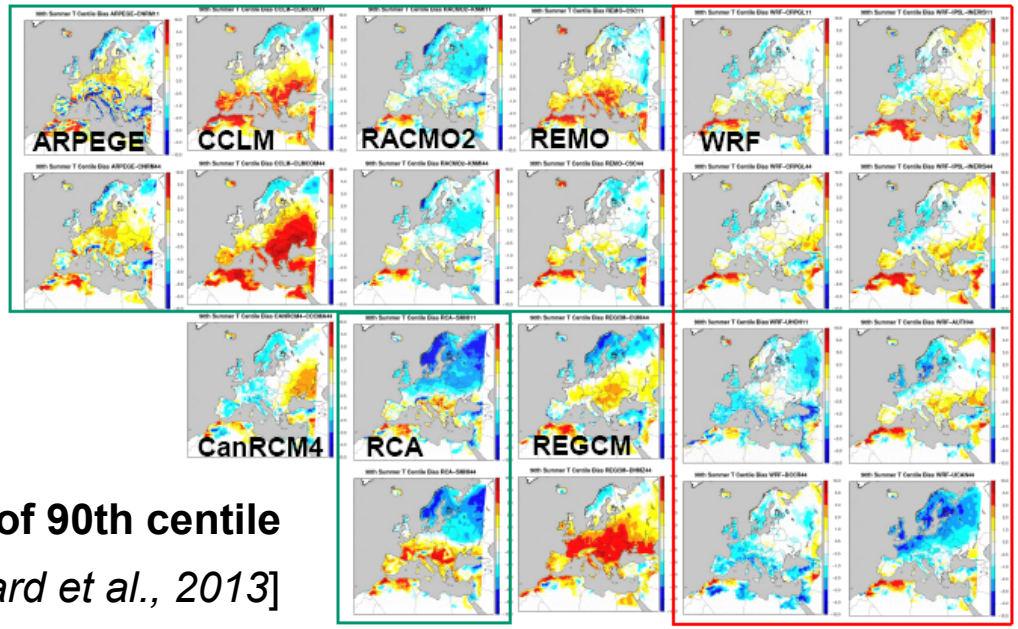
Evaluation of hindcasts
RCM multi-model ensemble evaluation



CORDEX EUR-11
CORDEX EUR-44
"Standard" Evaluation [*Kotlarski et al., 2014*]

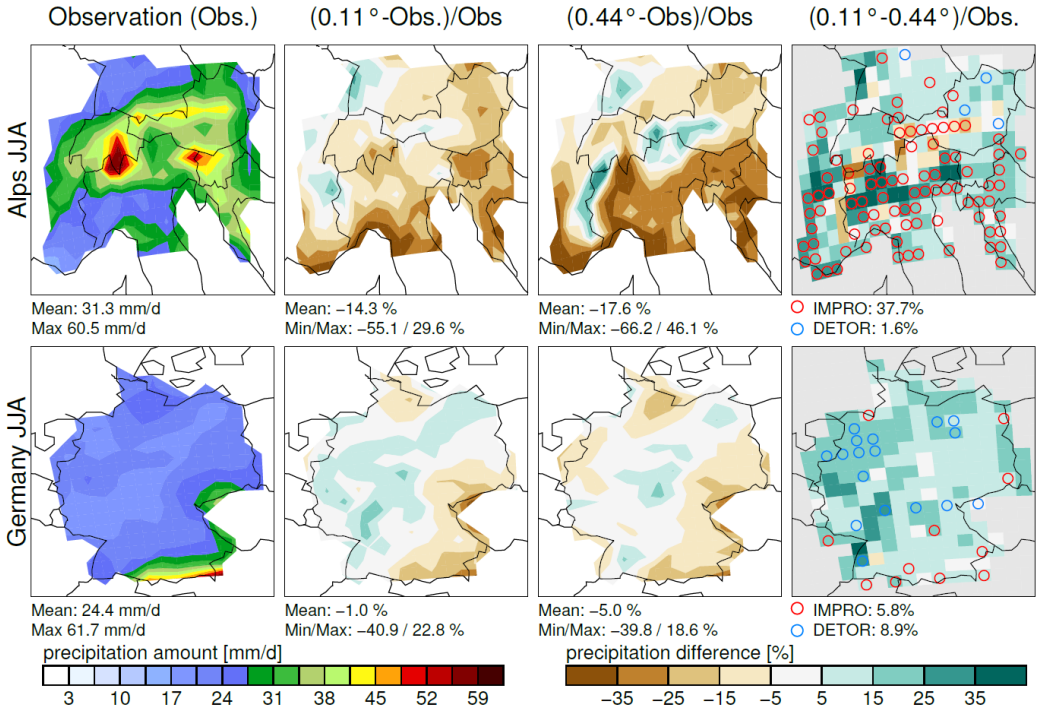
ENSEMBLES max
ENSEMBLES p75
ENSEMBLES median
ENSEMBLES p25
ENSEMBLES min

Added Value of High Resolution (EUR-11) Simulations [*Prein et al. 2014*]



Bias of 90th centile
[*Vautard et al., 2013*]

Precipitation Extremes (Q97.5)

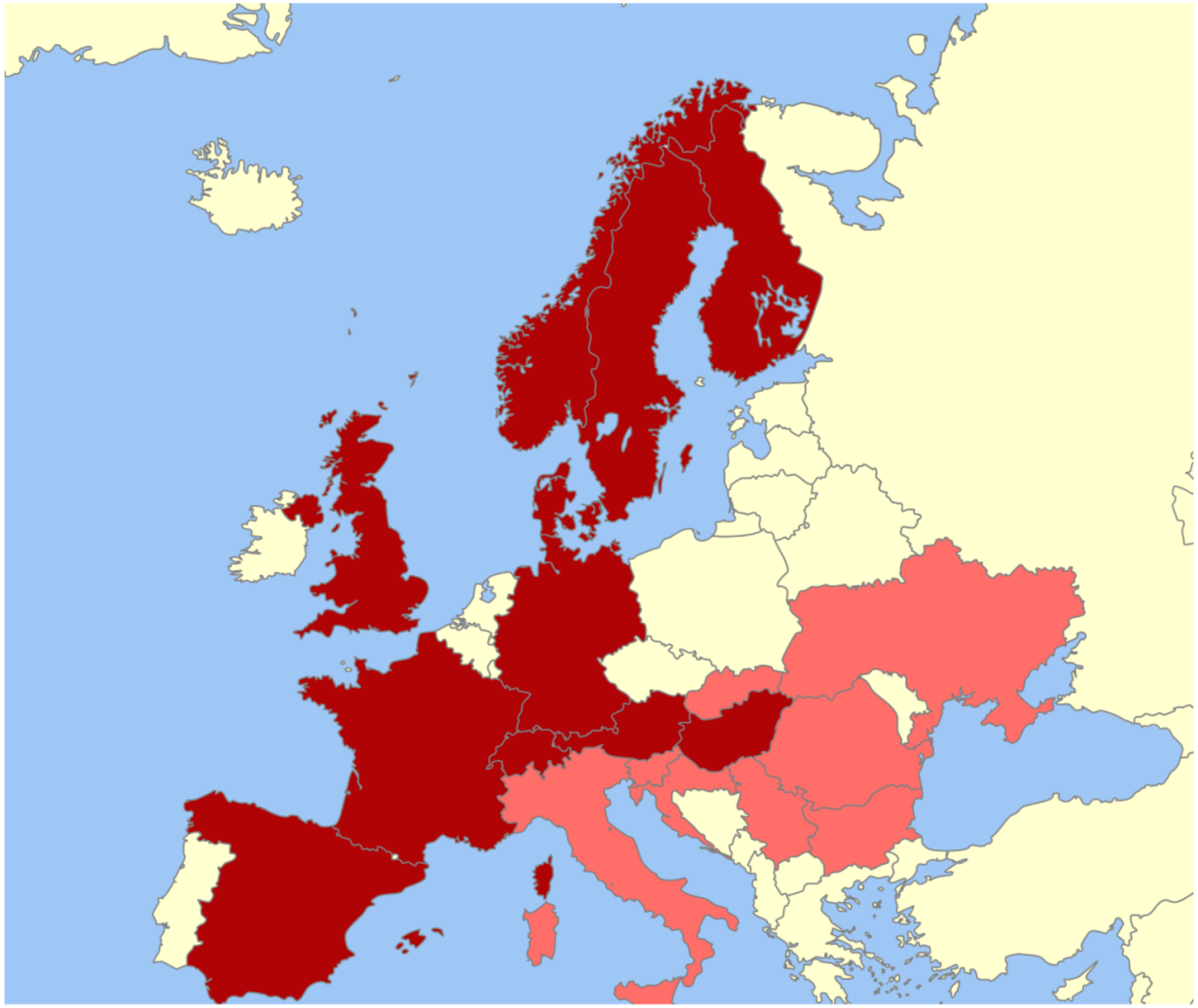


Evaluation of hindcasts

Reference datasets

Regional gridded evaluation data for temperature and precipitation (grid resolution higher than 12 km)

Most of the data is available for scientific use



Setup and analysis of projections

GCM-RCM matrix

1) Avoid GCMs with very weak performance over Europe

2) Spread of CMIP5 simulations should be sampled adequately

3) Modeling groups decide independently on the choice of GCM

Setup and analysis of projections

GCM-RCM matrix

GCM performance [UNICAN, ETHZ, UNIGRAZ, …]

Spatial biases, annual cycles, upper air paramter evaluation, multi-parameter model performace indices, …

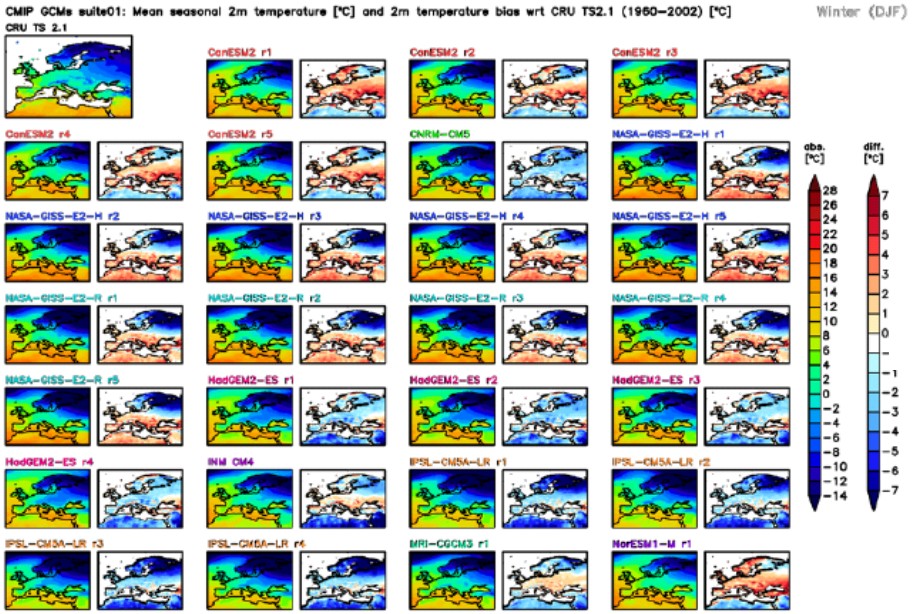
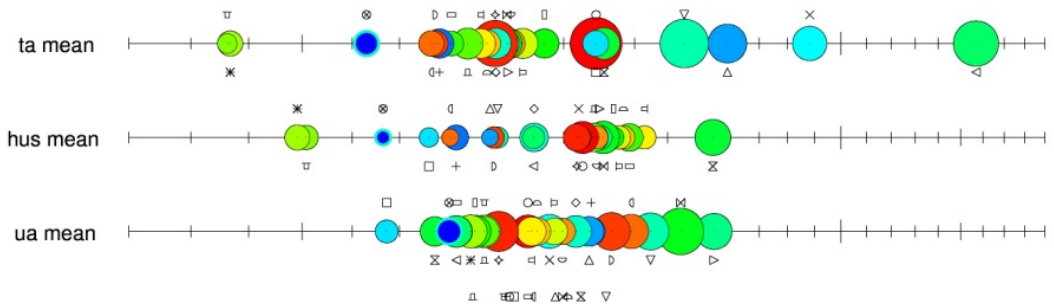
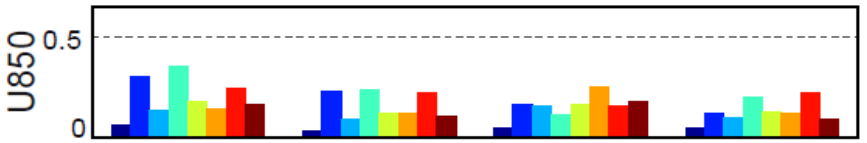


Figure 1 Mean winter 2m temperature (1960-2002) in the CMIP GCMs (s … eference [°C] (left panels) and model bias wrt. to CRU TS 2.1 [°C] (right panels). Note tl … temperature

[*Kotlarski, 2011*]



[*Jury et al., 2013*]



[*Brands et al., 2013*]

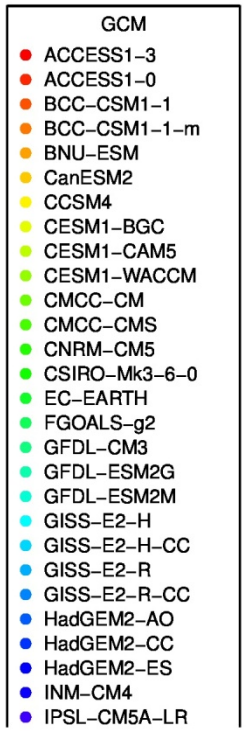
Setup and analysis of projections

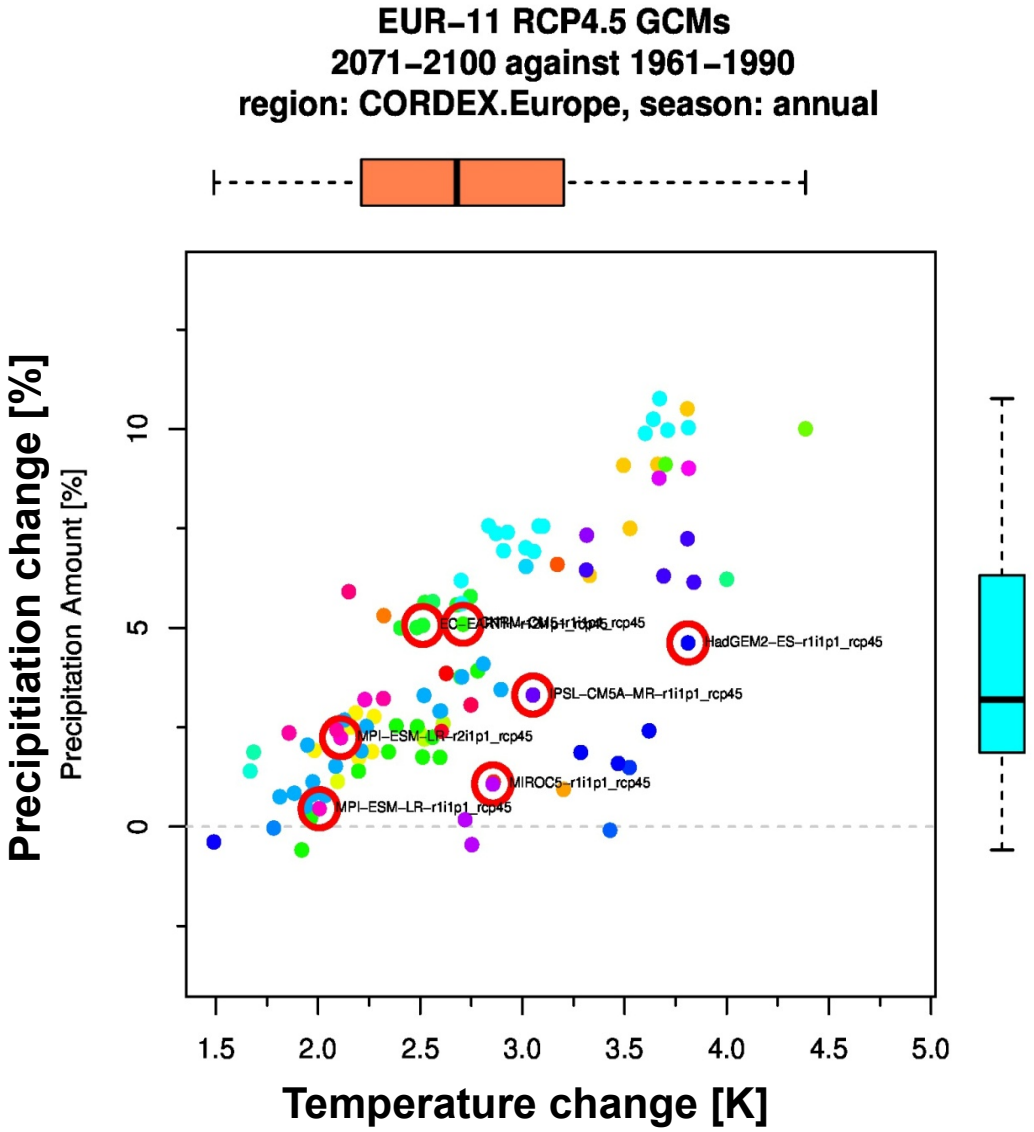
GCM-RCM matrix

GCM selection [UNIGRAZ, ETHZ]

Sampling for EUR-11

- 7 GCMs
- (MPI-ESM, CNRM-CM5, and EC-EARTH in 4 realizations each)
- Temperature change range fully sampled
- Extremely wet GCMs missing

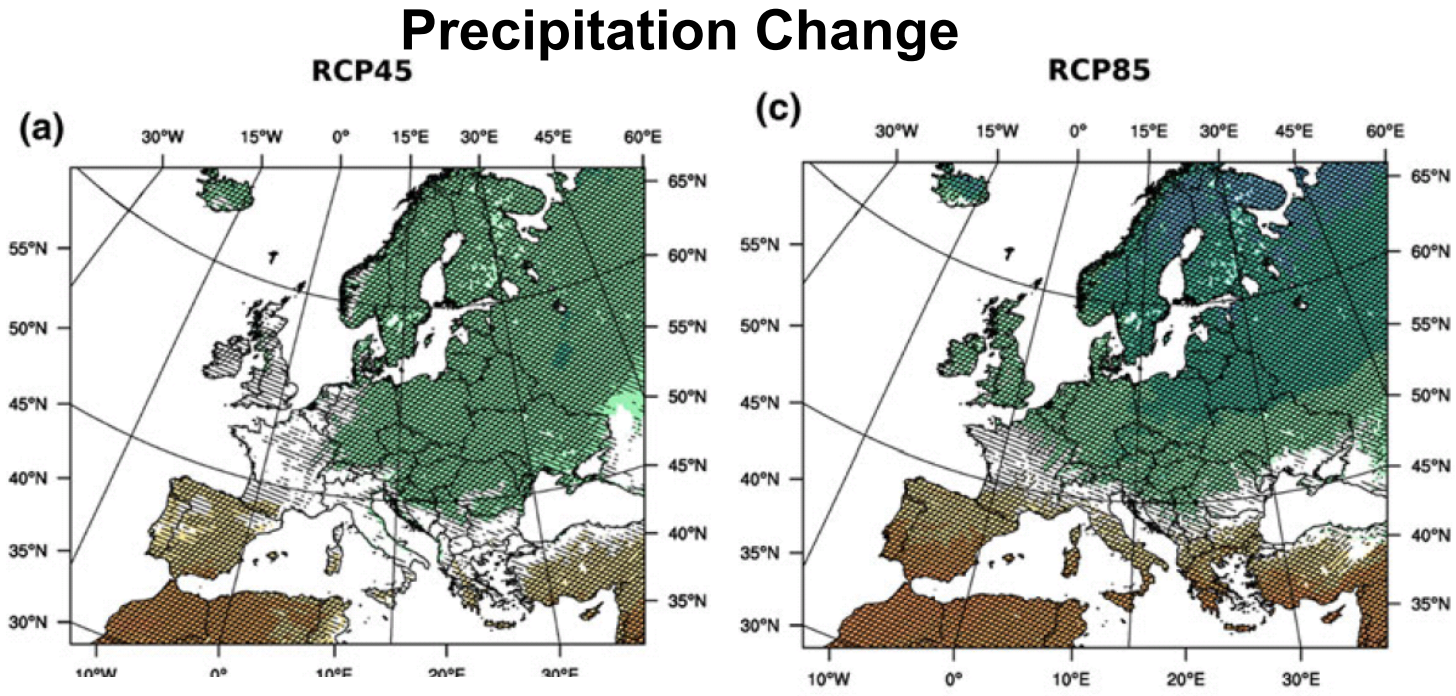




Setup and analysis of projections

Analysis of projections

First Analysis of EUR-11 Climate Change Signals [*Jacob et al., 2014*]

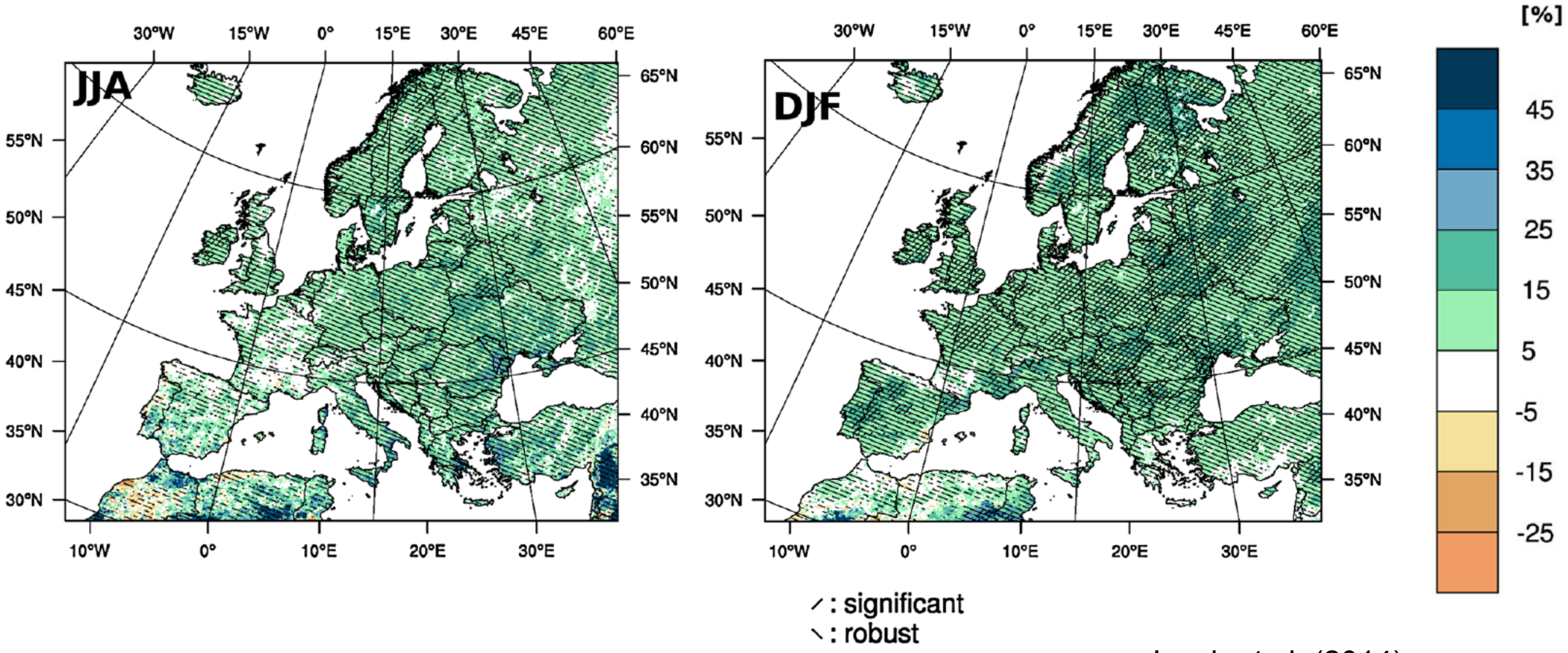


More studies in preparation

- Climate Types – Integrated Assessment [*Belda et al.*]
- Mediterranean cyclone simulation [*Gaertner et al.*]
- Snow Cover Analysis [*S. Kotlarski et al.*] [*C. Teichmann et al.*]
- ...

Change in heavy precipitation

RCP4.5: Projected changes of heavy precipitation 2071–2100 vs. 1971–2000

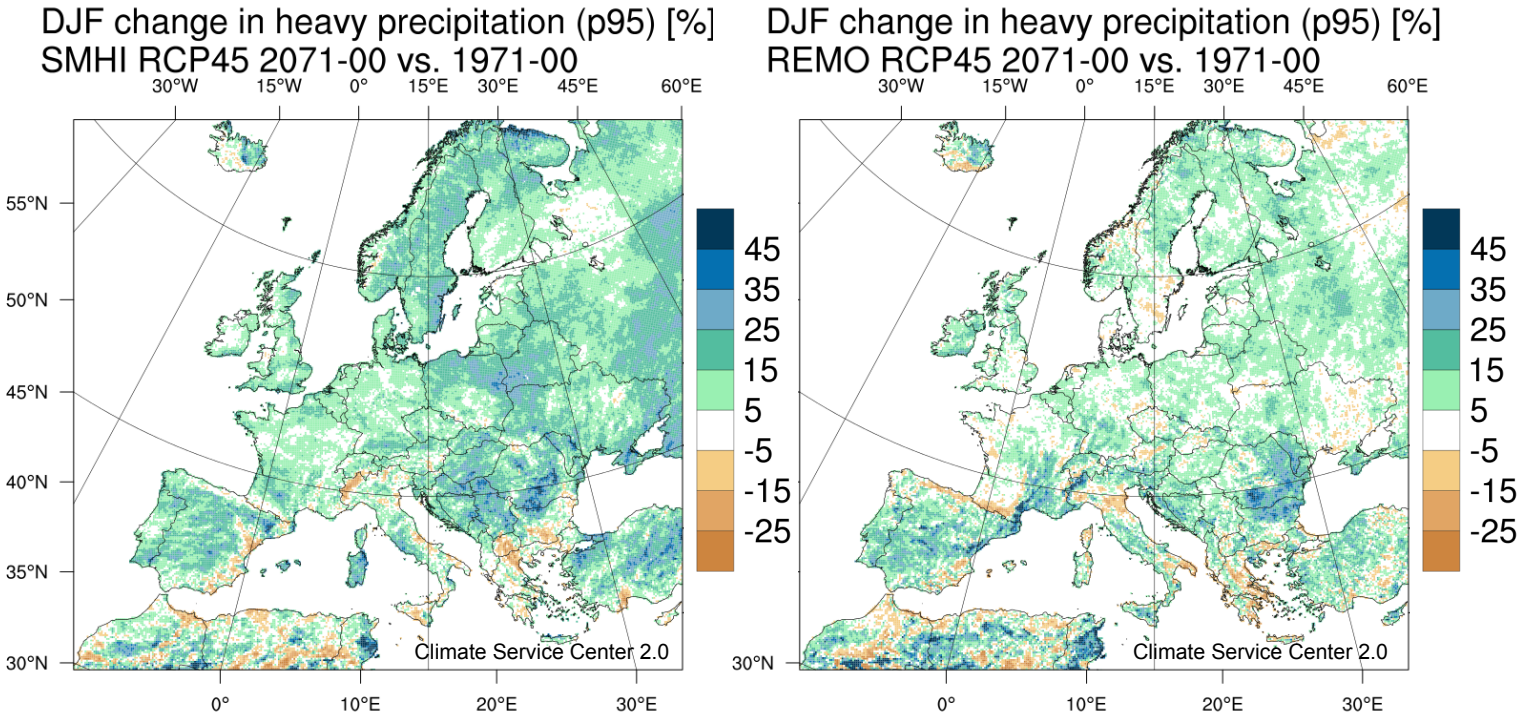


Jacob et al. (2014)

- Up to 15 % increase in large areas with isolated spots up to 25 %
- no decrease of heavy precipitation

Change in heavy precipitation

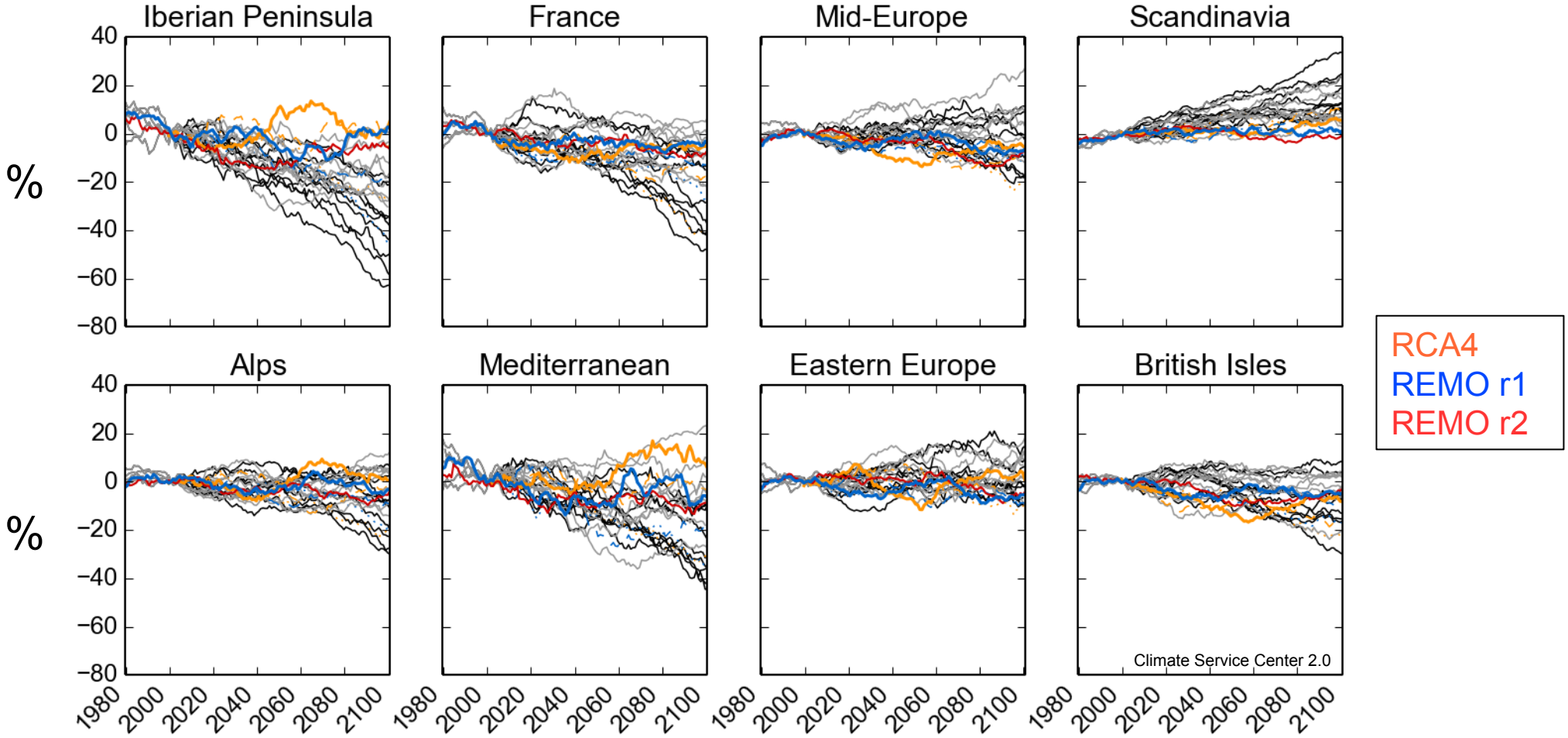
RCP4.5: Projected changes of heavy precipitation 2071–2100 vs. 1971–2000



- Single model simulations of RCA4 and REMO show similar large areas of around 15 % increase as the ensemble analysis for RCP4.5

Summer mean precipitation change

Precipitation climate change signal (vs. 1971-2000): 30-year running mean



- No strong trend for precipitation for RCP2.6 in all regions
- Clear decrease in precipitation in Southern regions for RCP4.5 and RCP8.5

From FP7 Eu-project IMPACT2C

Summing up:

There is a clear need for research for climate services

- Refer climate knowledge to **local scale**
- Develop **interfaces** from generic large databases to individual applications
- Information on **robustness** of climate data and associated **uncertainties**
- **Expert judgement** on climate related information
- Support for regional and local **adapation processes**
- **General concepts** for climate service products evaluation

EURO-CORDEX can act as platform/provider/facilitator/ initiator.....

Let us start networking better and together

- define the roles of the involved communities (users, practitioners, science, services and more)
- create mutual understanding for each others needs: providers and users, GCM and RCM CC modelers ☺
- respect needs for spatial scales for information and time scales in research and practice
- define the linkages/interfaces/gaps
- develop products and close gaps through joint activities in the translation layers

Towards a European Market on Climate Services!