

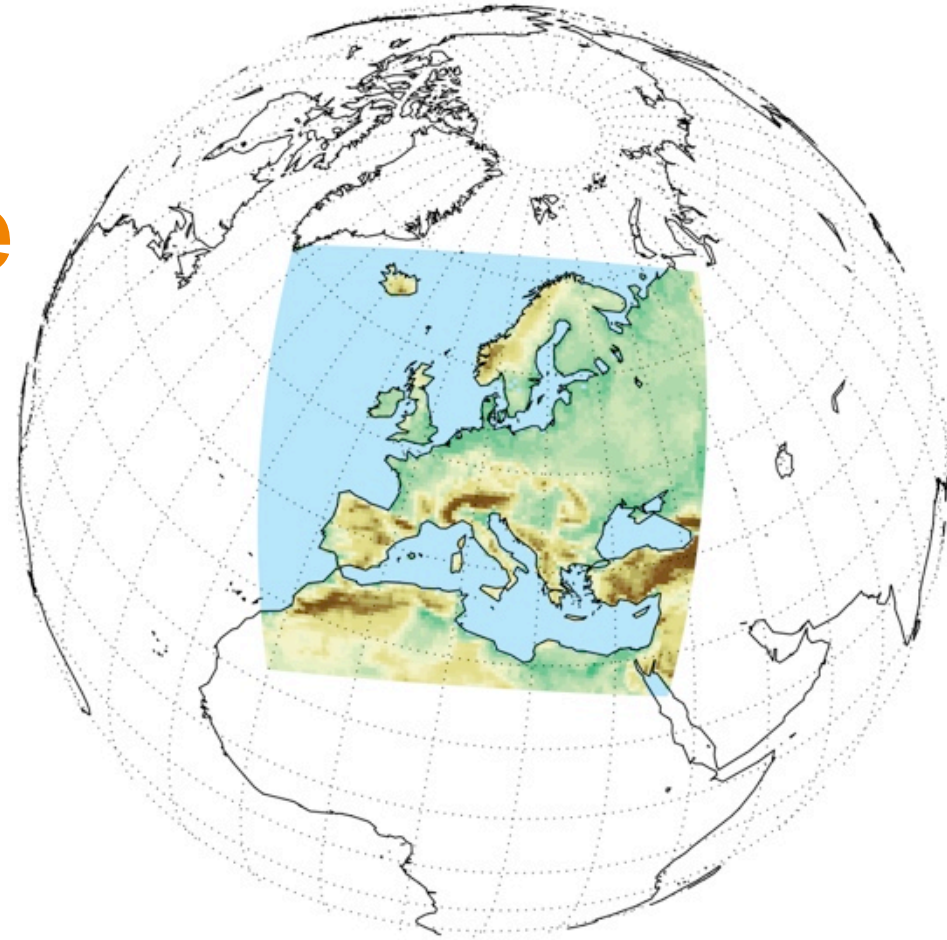
The Euro-CORDEX Initiative

A new generation of regional climate scenarios for Europe

A. F. Prein¹, A. Gobiet¹, D. Jacob²,
C. Teichmann², H. Truhetz¹

¹ Wegener Center for Climate and Global Change,
University of Graz, Austria

² Climate Service Center, Hamburg, Germany

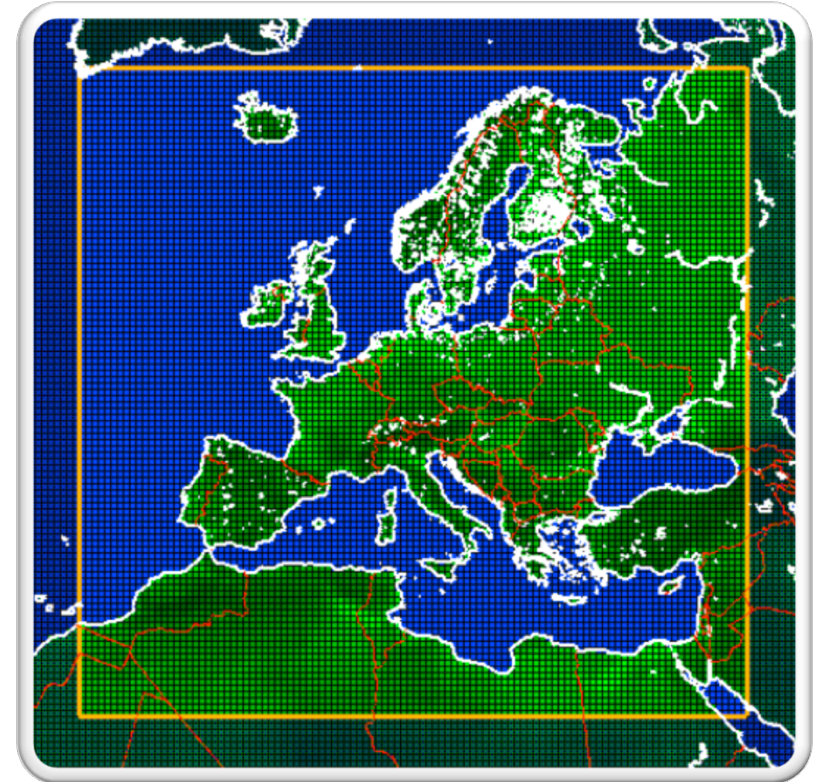




EURO-CORDEX Basics

Specifications

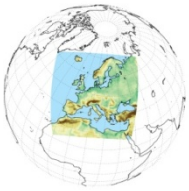
- **Spatial resolution:**
 - **EUR-11: 0.11 degree (12.5 km)**
 - **EUR-44: 0.44 degree (50 km)**
- **Driving GCMs: CMIP5**
- **GHG scenarios:**
 - **rcp4.5, rcp8.5** (focus)
 - **rcp2.6** (few simulations)
- **Periods:**
 - Hindcast (ERA Interim): 1989 – 2008
 - Control: 1951 – 2005
 - Scenario: 2006 – 2100



Region (center of boundaries):

~ 27° N – 72° N, ~338° W – 45° E

(details: http://wcrp.ipsl.jussieu.fr/SF_RCD_CORDEX.html)



EURO-CORDEX Basics

Community and Models

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 (CSC Germany) and A. Gobiet (University of Graz, Austria)

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
- Inclusion of Empirical Statistical Downscaling (ESD) → under discussion

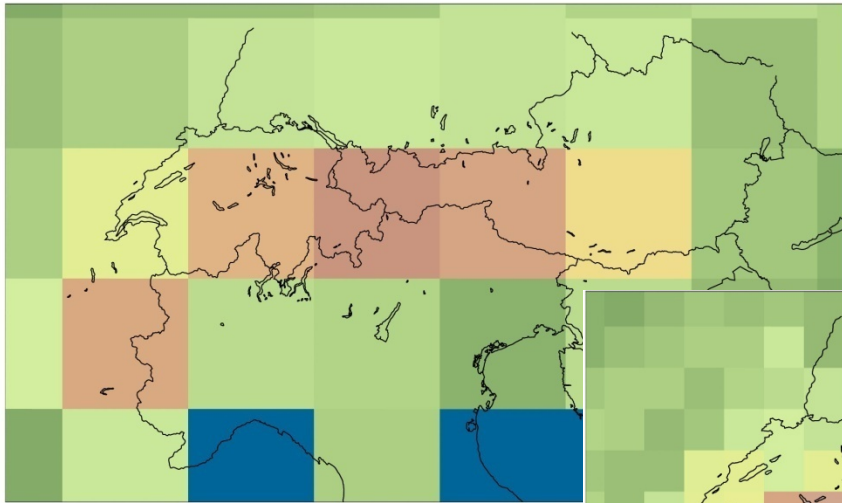


EURO-CORDEX Basics

0.44° vs. 0.11° Simulations

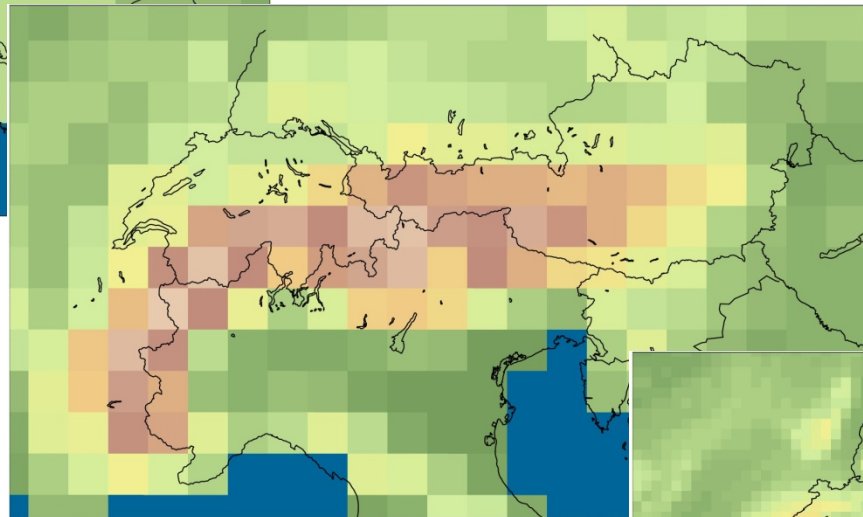
GCM

~150 km

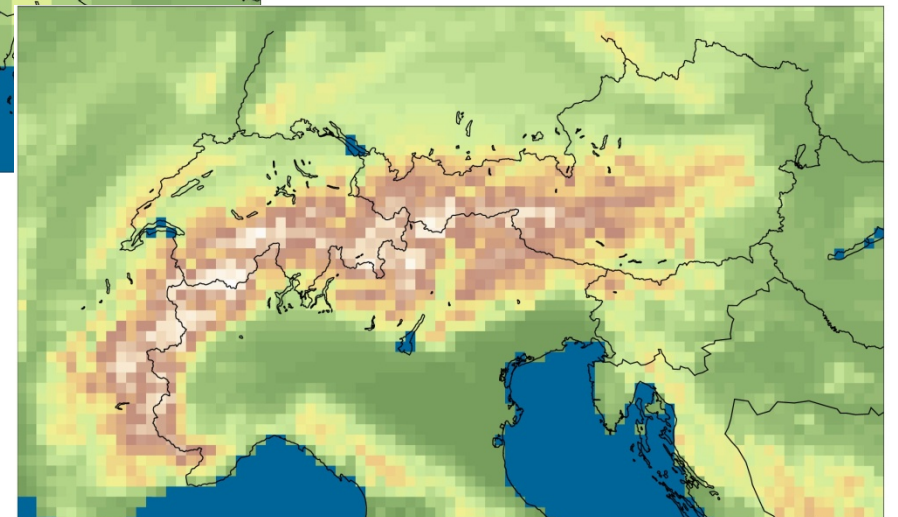


Representation of orography
e.g., European Alps

EURO-CORDEX 0.44
50 km



EURO-CORDEX 0.11
12.5 km





EURO-CORDEX Basics

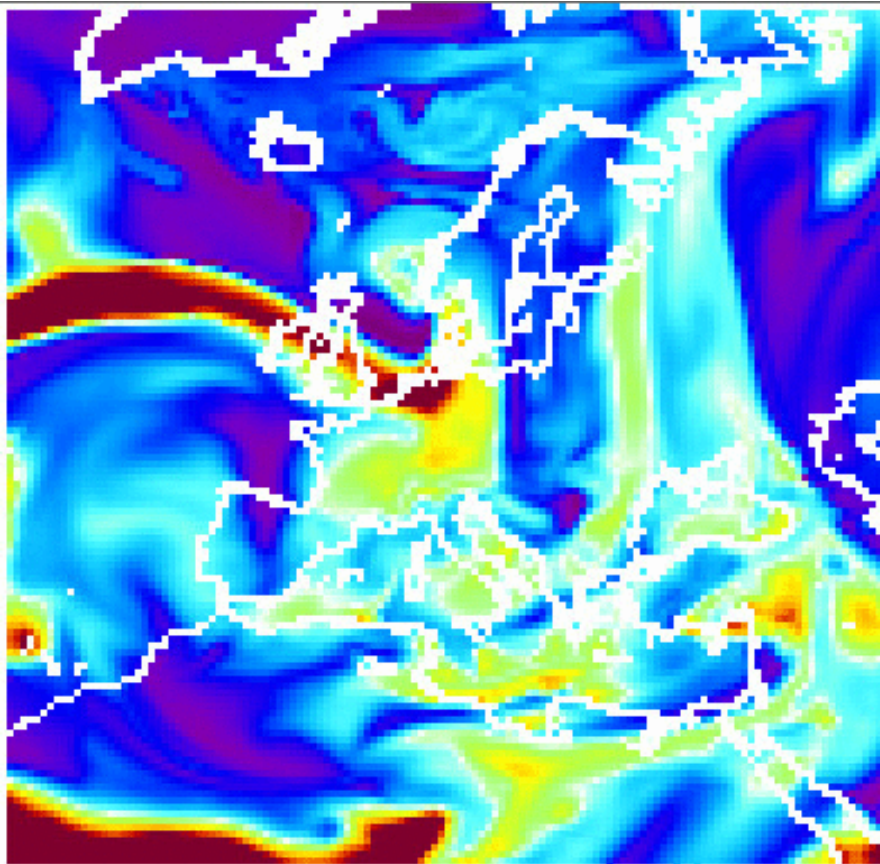
0.44° vs. 0.11° Simulations

Atmospheric Dynamics
Specific Humidity ~3000 m

20.-24. Dec. 2008

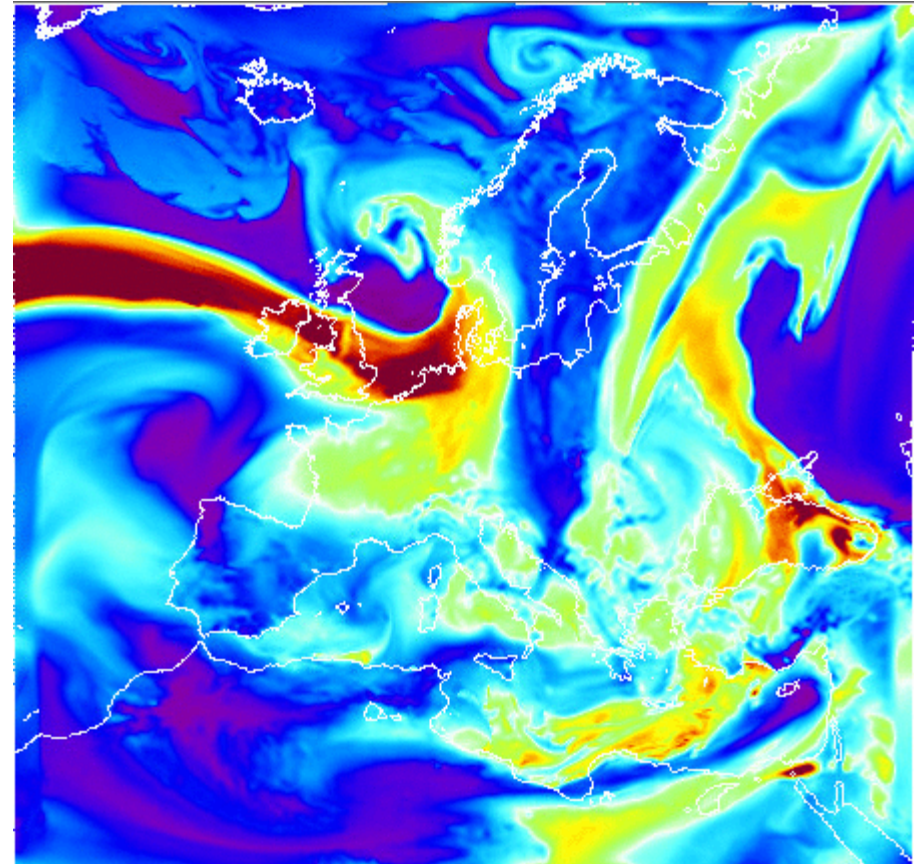
EURO-CORDEX 0.44

~64 x computational costs

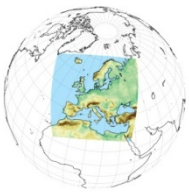


[CCLM-COM 0.44° Hindcast (WEGC)]

EURO-CORDEX 0.11



[CCLM-COM 0.11° Hindcast (BTU)]



EURO-CORDEX Basics

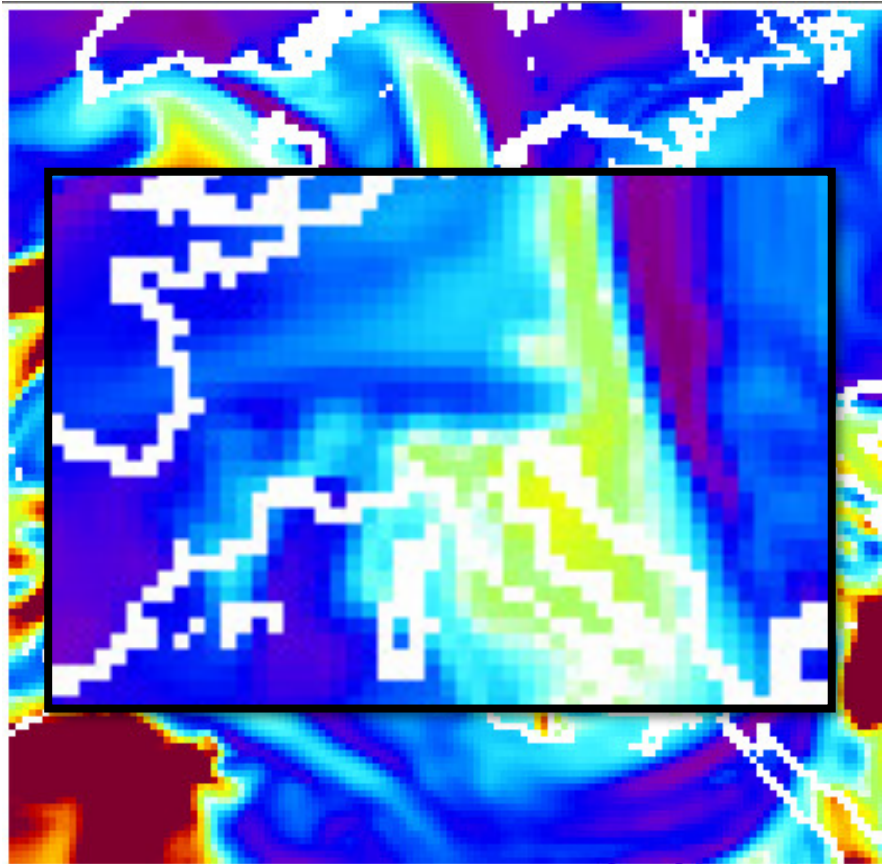
0.44° vs. 0.11° Simulations

Atmospheric Dynamics
Specific Humidity ~3000 m

20.-24. Dec. 2008

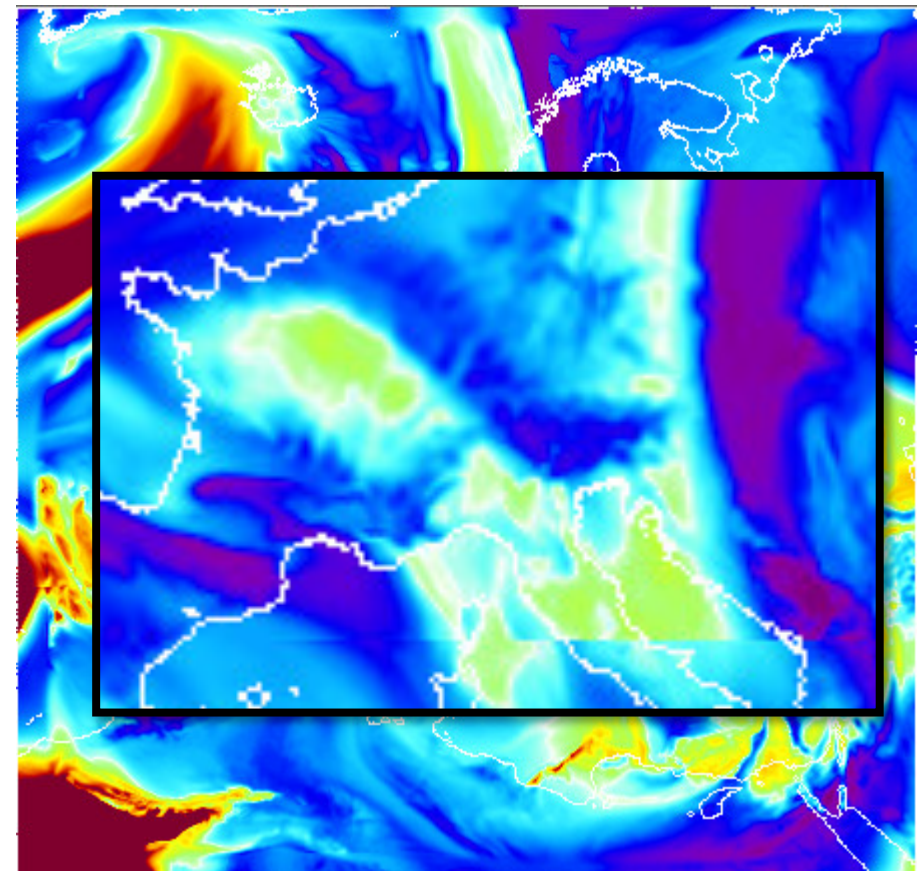
EURO-CORDEX 0.44

~64 x computational costs



[CCLM-COM 0.44° Hindcast (WEGC)]

EURO-CORDEX 0.11



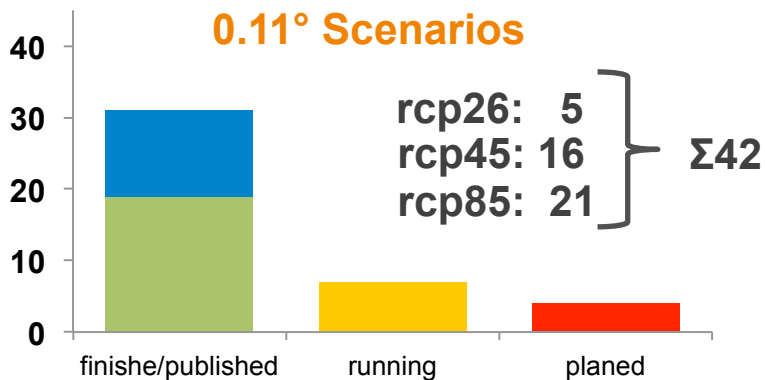
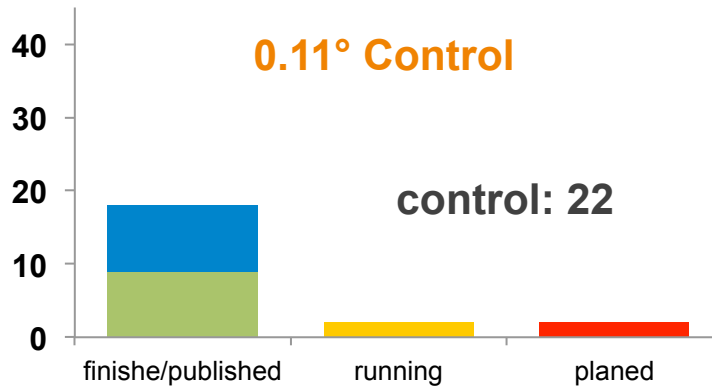
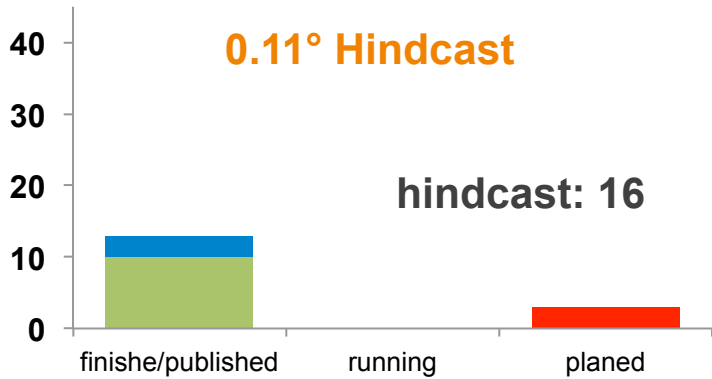
[CCLM-COM 0.11° Hindcast (BTU)]



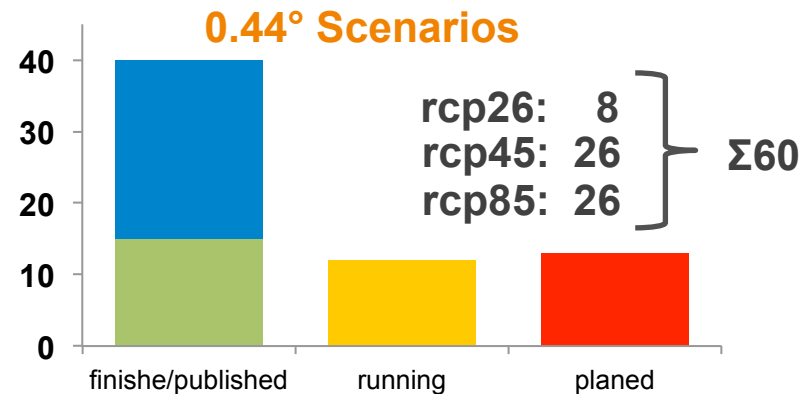
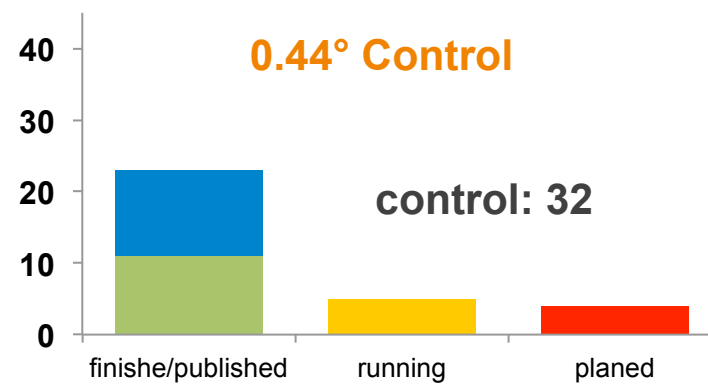
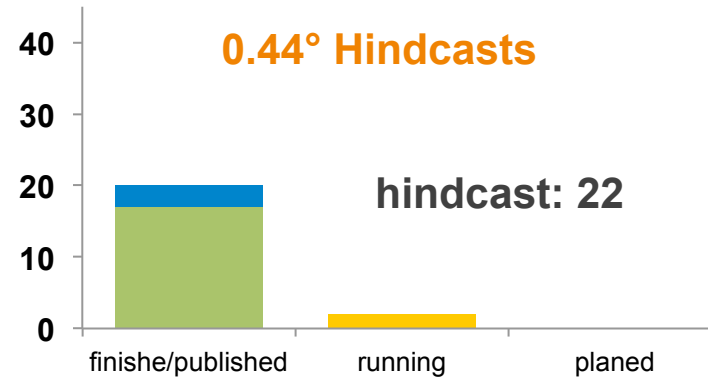
EURO-CORDEX Basics

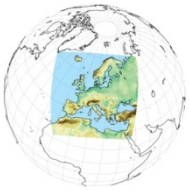
Status EURO-CORDEX Simulations

0.11° Simulations



0.44° Simulations

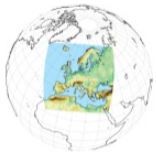




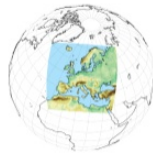
EURO-CORDEX Basics

Aims of EURO-CORDEX

1. JOINT MODEL EVALUATION

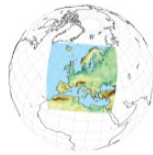


1

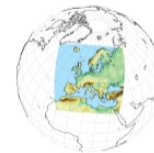


1. JOINT MODEL
EVALUATION

2A. GCM SELECTION

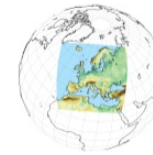


2

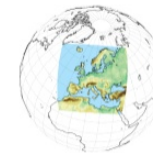


2B. JOINT ANALYSIS
OF PROJECTIONS

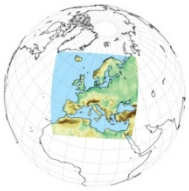
3A. INTERFACE TO USERS



3



3B. DISSEMINATION OF
RESULTS



EURO-CORDEX Basics

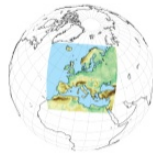
Aims of EURO-CORDEX

1. JOINT MODEL EVALUATION

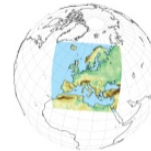
- I. RCM evaluation (multi-model)
- II. Reference datasets

1. JOINT MODEL EVALUATION

2A. GCM SELECTION

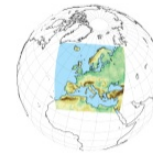


2

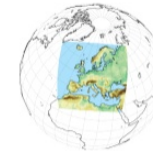


2B. JOINT ANALYSIS OF PROJECTIONS

3A. INTERFACE TO USERS



3

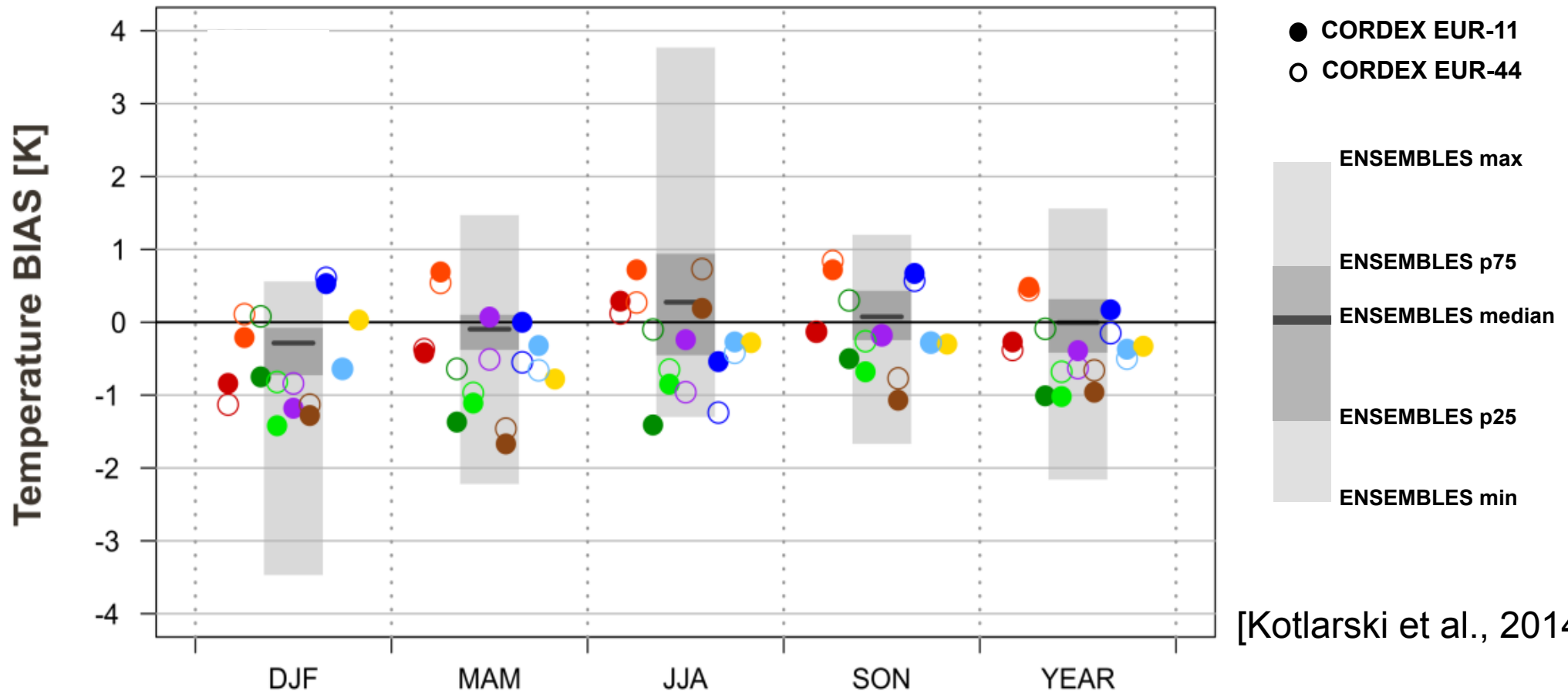


3B. DISSEMINATION OF RESULTS

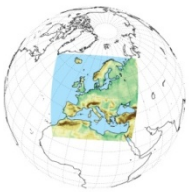


EURO-CORDEX Evaluation

“Standard” Evaluation [Kotlarski et al., 2014]



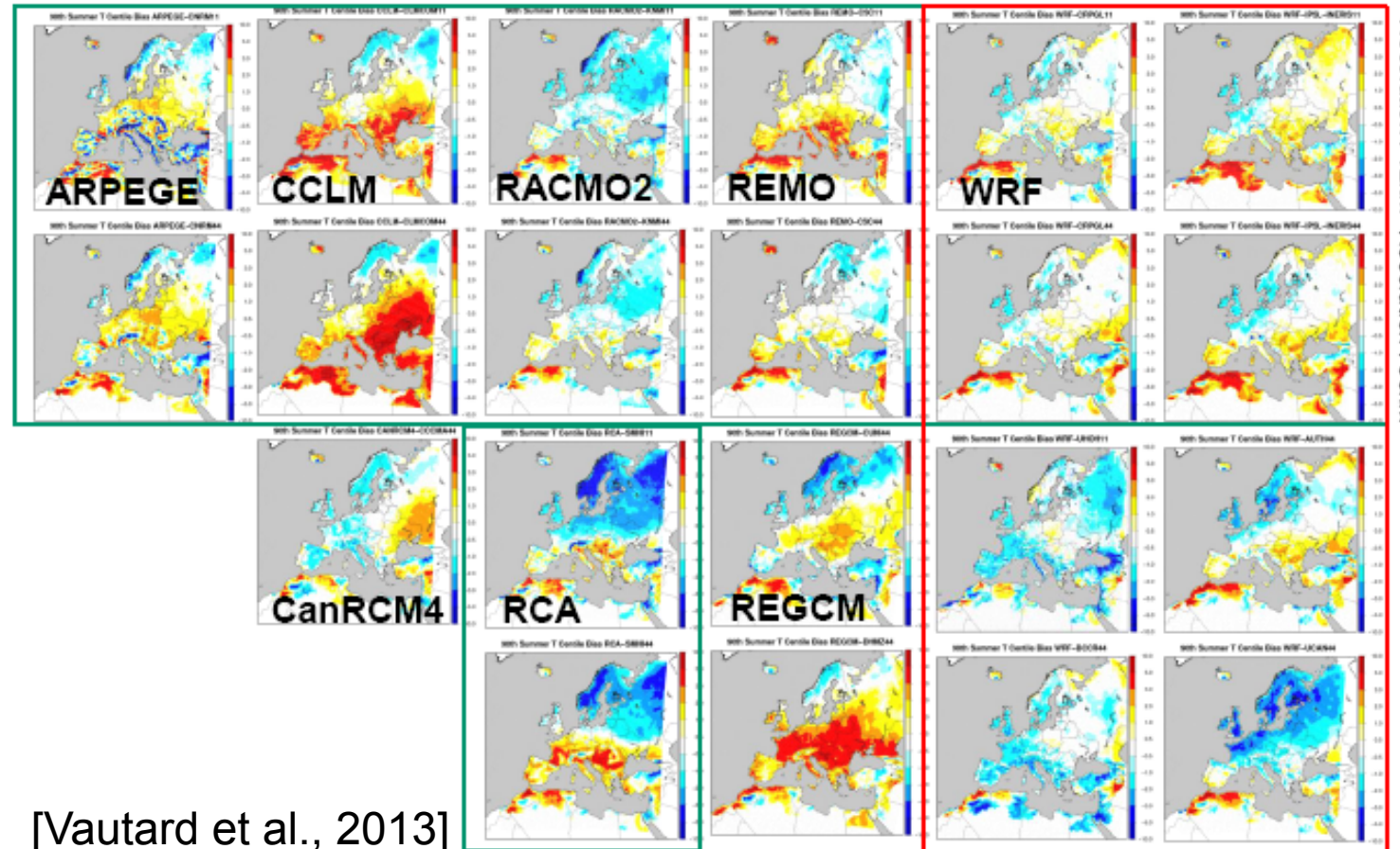
- Basic features of European climate captured
- Shortcomings for selected metrics, seasons and regions.,
- Comparison with ENSEMBLES: Comparable, partly smaller error ranges.



EURO-CORDEX Evaluation

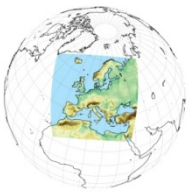
Heat Waves Evaluation [Vautard et al. 2013]

Bias of
90th centile



[Vautard et al., 2013]

- Heat waves well captured, but modulations in strengths
- Strong dependence on land-atmosphere processes and convection
- No improvement at higher resolution



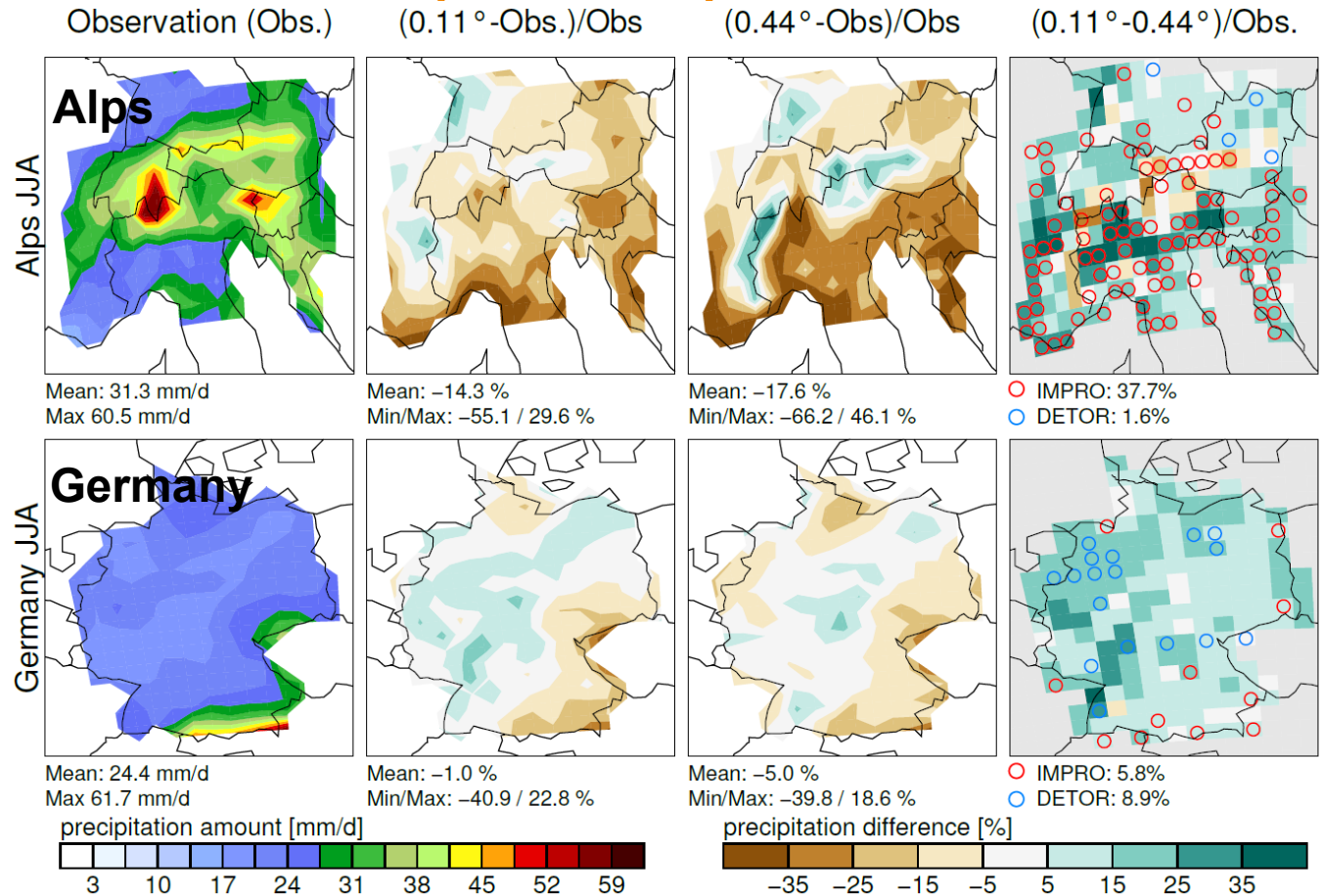
EURO-CORDEX Evaluation

Added Value of High Resolution (EUR-11) Simulations

[Prein et al. 2014]

Precipitation Extremes (Q97.5)

- 8 RCMs in 0.44 and 0.11 deg. resolution
- Analysis of various aspects of extreme precipitation.
- Analysis on 0.44 deg. grid



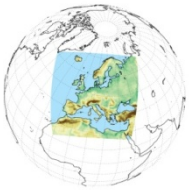
- Clearly added value (red circles) in orographically influenced areas
- Less added value in flat regions



EURO-CORDEX Evaluation

Evaluation Summary

- **“Standard evaluation”**
 - Ensemble mean biases comparable to ENSEMBLES (partly smaller error ranges)
- **Simulations have skill to represent specific aspects like:**
 - heat waves
 - climate classifications
- **Added value of high resolution (EUR-11 compared to EUR-44)**
 - demonstrated for mean and extreme precipitation.
- **More studies in preparation**



EURO-CORDEX Basics

Aims of EURO-CORDEX

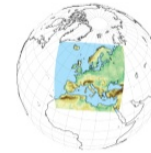
1. JOINT MODEL EVALUATION

- I. RCM evaluation (multi-model)
- II. Reference datasets

1. JOINT MODEL EVALUATION

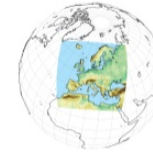
2A. GCM-RCM MATRIX

- I. GCM evaluation
- II. GCM-RCM Matrix

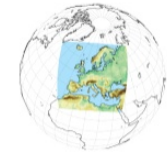


2B. JOINT ANALYSIS OF PROJECTIONS

3A. INTERFACE TO USERS



3



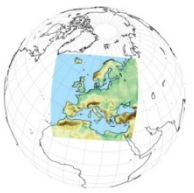
3B. DISSEMINATION OF RESULTS



EURO-CORDEX GCM Selection

Principles of GCM selection in EURO-CORDEX

- 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**



EURO-CORDEX GCM Evaluation

1. GCM Performance [UNICAN, ETHZ, UNIGRAZ, ...]

Spatial biases, annual cycles, upper air parameter evaluation, multi-parameter model performance indices, ...

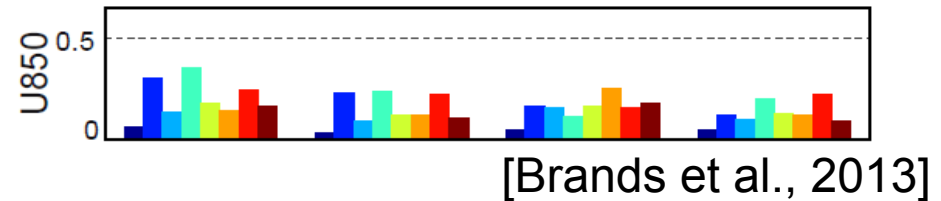
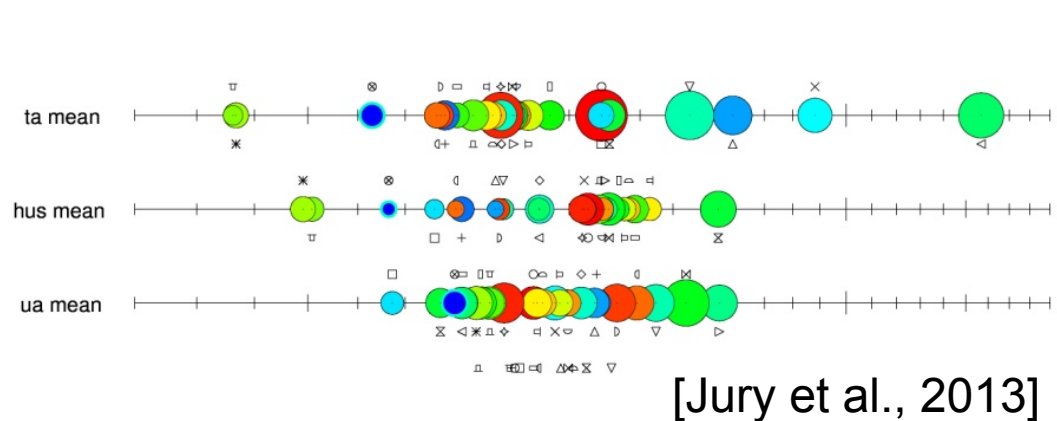
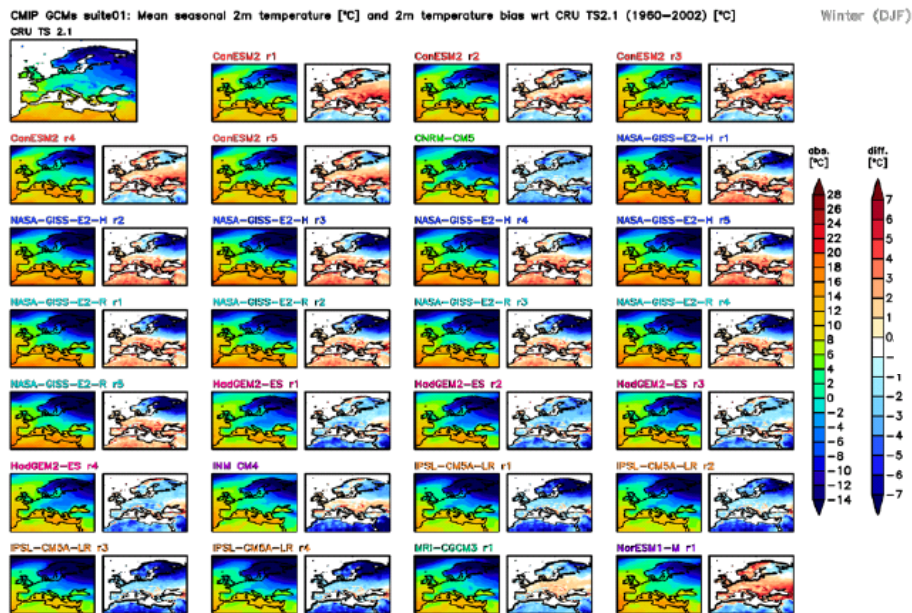


Figure 1 Mean winter 2m temperature (1960-2002) in the CMIP GCMs (s (left panels) and model bias wrt. to CRU TS 2.1 [°C] (right panels). Note t [Kotlarski, 2011] nce [°C] erature

CMIP5 GCMs feature a range of performances

→ No distinct outlier

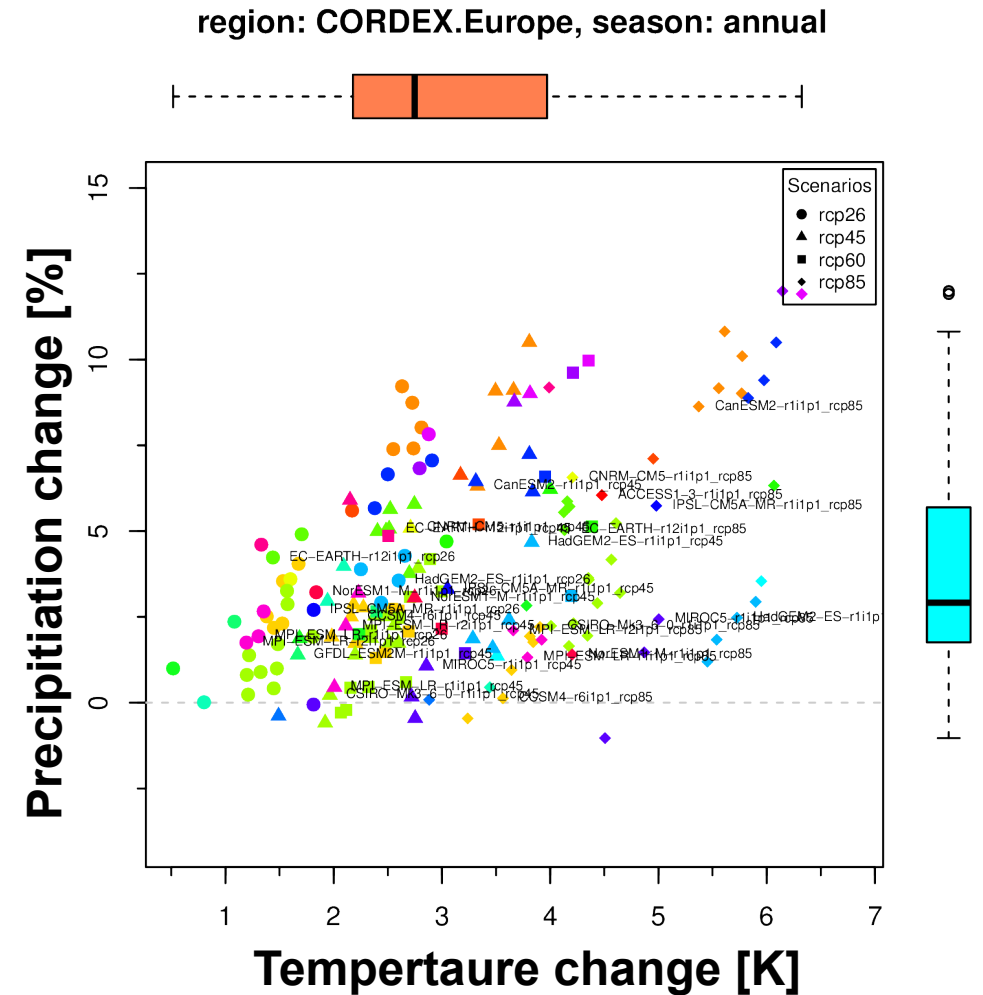
→ No imperative reason to disqualify specific GCMs as drivers for the EURO-CORDEX RCMs.

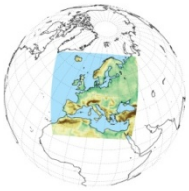


EURO-CORDEX GCM Selection

2. Sampling the range of climate change projected in CMIP5 [UNIGRAZ, ETHZ]

- Analysis of CMIP5 climate change signals of temperature and precipitation over Europe
- Aims:
 - Avoid giving too much weight to specific GCMs
 - Avoid biases in the ensemble mean
 - Avoid underestimation of the ensemble spread





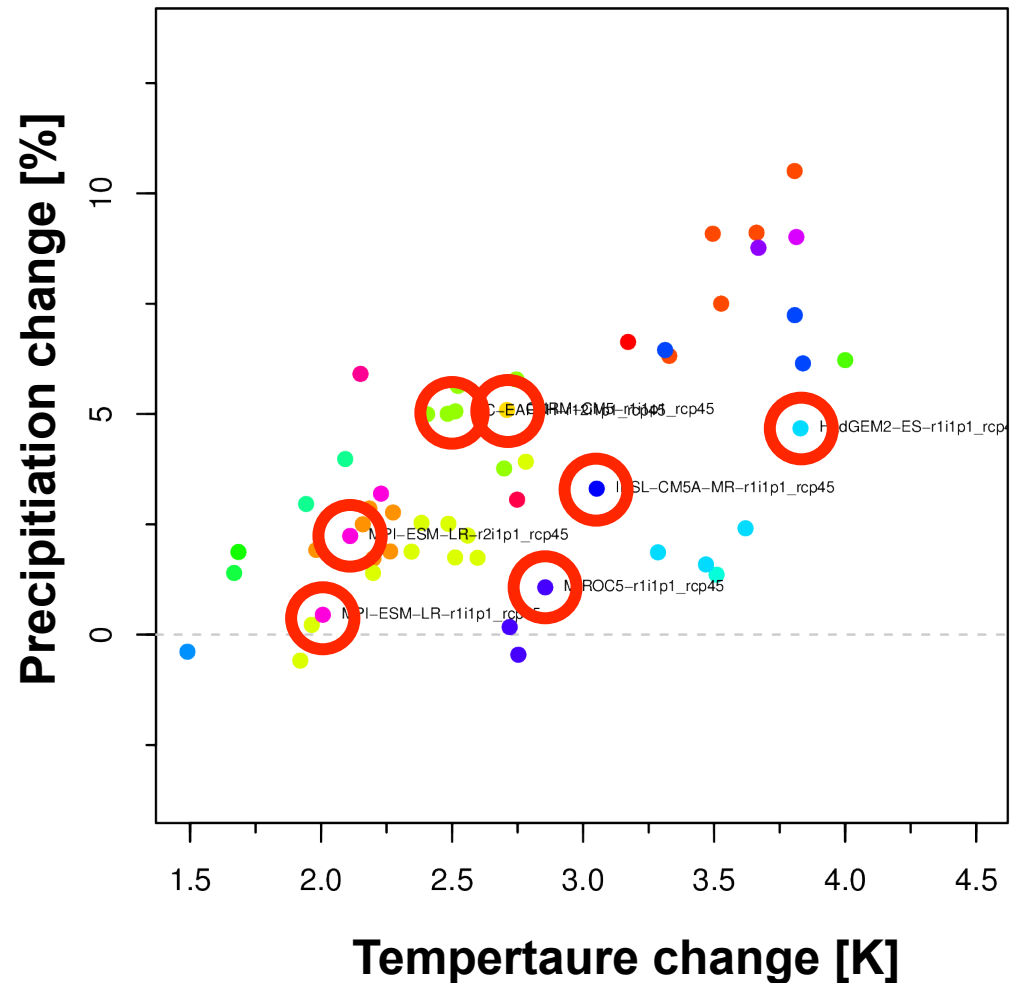
EURO-CORDEX GCM Selection

2. Sampling EUR-11:

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

GCM
● BCC-CSM1.1
● CanESM2
● CCSM4
● CNRM-CM5
● CSIRO-Mk3-6-0
● EC-EARTH
● GFDL-CM3
● GFDL-ESM2G
● GFDL-ESM2M
● GISS-E2-R
● HadGEM2-CC
● HadGEM2-ES
● Inmcm4
● IPSL-CM5A-LR
● IPSL-CM5A-MR
● MIROC5
● MIROC-ESM
● MIROC-ESM-CHEM
● MPI-ESM-LR
● MRI-CGCM3
● NorESM1-M

EUR-11 RCP4.5 GCMs
2071-2100 against 1961-1990
region: CORDEX.Europe, season: annual





EURO-CORDEX GCM Selection

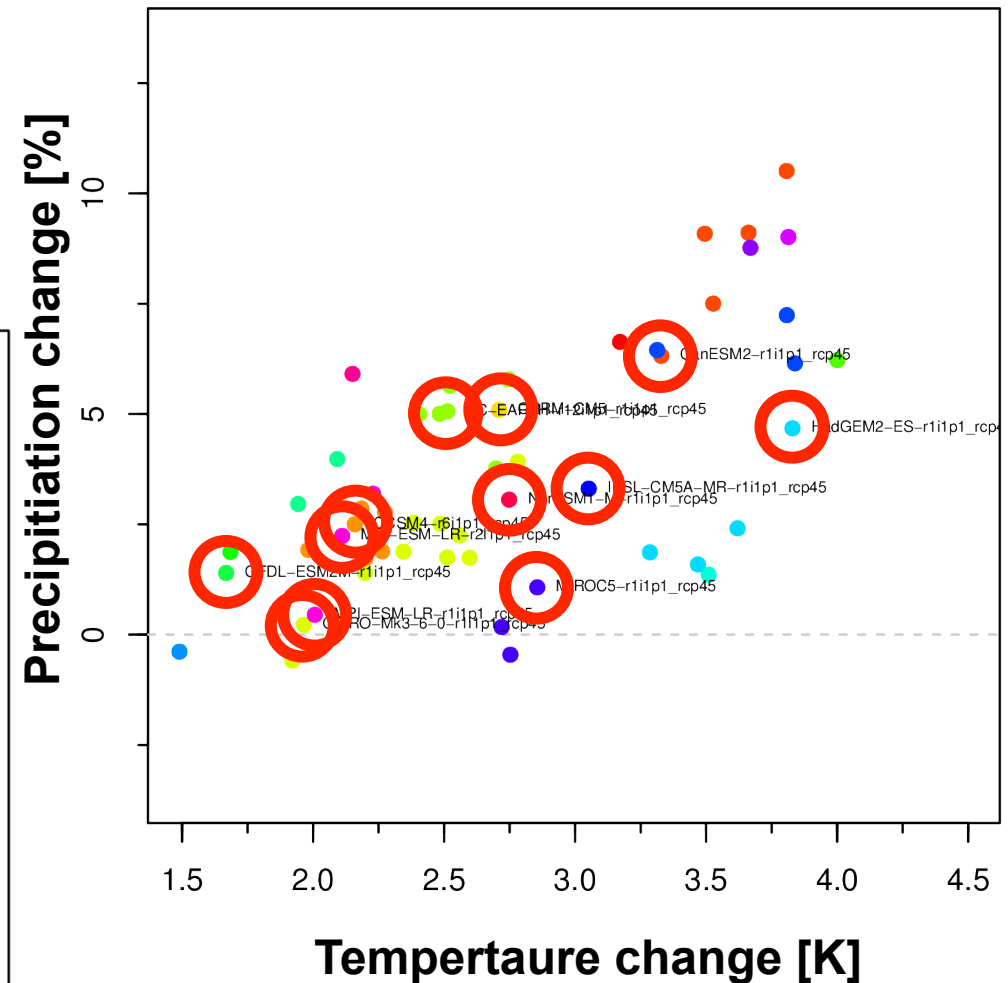
2. Sampling

EUR-44:

- 12 GCMs
- Temperature change range fully sampled
 - More cooler GCMs
- Extremely wet GCMs missing

GCM
• BCC-CSM1.1
• CanESM2
• CCSM4
• CNRM-CM5
• CSIRO-Mk3-6-0
• EC-EARTH
• GFDL-CM3
• GFDL-ESM2G
• GFDL-ESM2M
• GISS-E2-R
• HadGEM2-CC
• HadGEM2-ES
• Inmcm4
• IPSL-CM5A-LR
• IPSL-CM5A-MR
• MIROC5
• MIROC-ESM
• MIROC-ESM-CHEM
• MPI-ESM-LR
• MRI-CGCM3
• NorESM1-M

EUR-44 RCP4.5 GCMs
2071-2100 against 1961-1990
region: CORDEX.Europe, season: annual





EURO-CORDEX Basics

Aims of EURO-CORDEX

1. JOINT MODEL EVALUATION

- I. RCM evaluation (multi-model)
- II. Reference datasets

1. JOINT MODEL EVALUATION

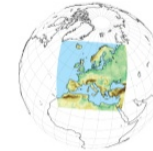
2A. GCM-RCM MATRIX

- I. GCM evaluation
- II. GCM-RCM Matrix

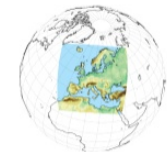
- III. Projections analysis

2B. JOINT ANALYSIS OF PROJECTIONS

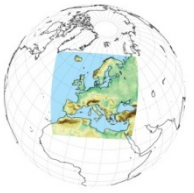
3A. INTERFACE TO USERS



3



3B. DISSEMINATION OF RESULTS



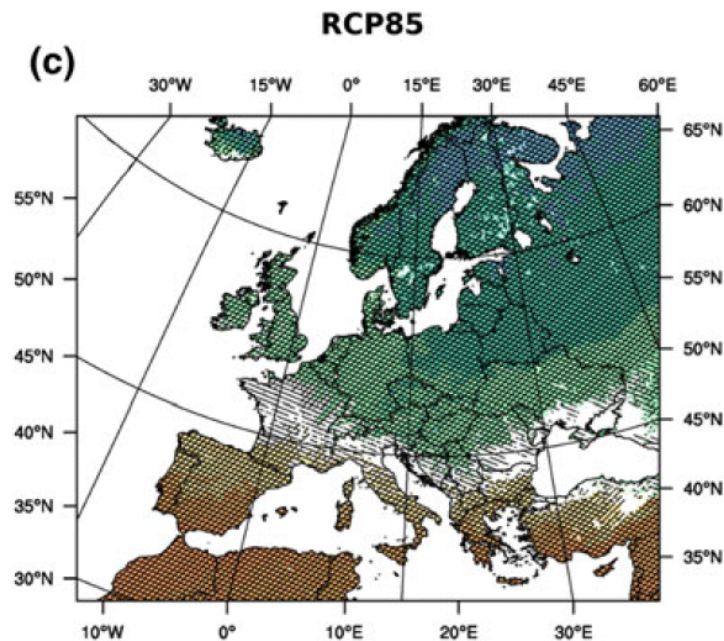
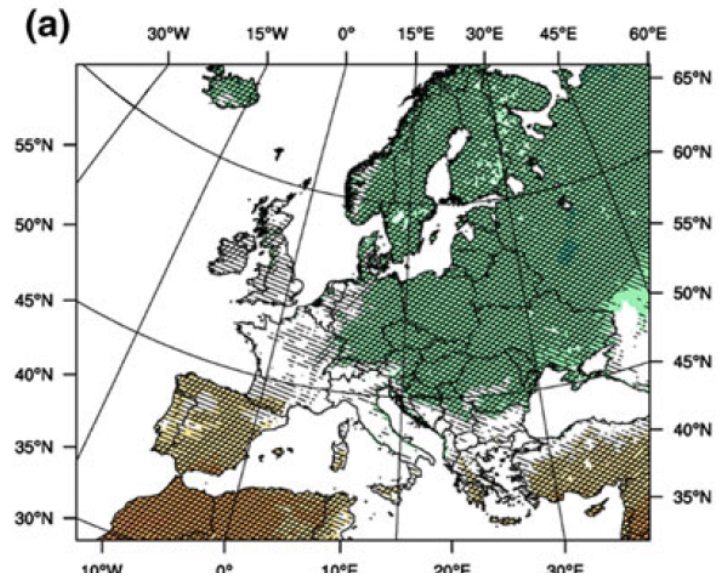
EURO-CORDEX Climate Projections

First Analysis of EUR-11 Climate Change Signals [Jacob et al., 2013]

- Analysis based on 9 (RCP45) and 10 (RCP85) 0.11 simulations
 - Mean climate change
 - Change in various indices relevant for Impacts, Adaptation, and Vulnerability (IAV) studies
 - Results tested for robustness and significance
- EUR-11 confirms earlier findings (ENSEMBLES)
 - More spatial detail
 - RCMs provide higher daily precipitation intensities than GCMs

[Jacob et al., 2013]

Precipitation Change RCP45





EURO-CORDEX

Climate Projections

Climate Projections Summary

- **First analyses of EURO-CORDEX (EUR-11) scenarios are available and published (Jacob et al., 2013)**
 - So far no large surprises compared to earlier studies (ENSEMBLES).
 - **More spatial details**
- **More studies in preparation**
 - Hydrological Cycle [Georgievski et al.]
 - Climate Types – Integrated Assessment [Halenka et al.]
 - Mediterranean cyclone simulation [Gaertner et al.]
 - Snow Cover Analysis [S. Kotlarski et al.] [C. Teichmann et al.]
 - ...



EURO-CORDEX Basics

Aims of EURO-CORDEX

1. JOINT MODEL EVALUATION

- I. RCM evaluation (multi-model)
- II. Reference datasets

1. JOINT MODEL EVALUATION

2A. GCM-RCM MATRIX

- I. GCM evaluation
- II. GCM-RCM Matrix

- III. Projections analysis

2B. JOINT ANALYSIS OF PROJECTIONS

3A. INTERFACE TO USERS

- I. Interfaces to user community
- II. Dissemination

3B. DISSEMINATION OF RESULTS



EURO-CORDEX

User Interface

User Interface Activities

- Definition and analysis of **impact relevant indices and ensemble-based derived products** (ongoing, results partly already available)
- Provision of a **bias corrected EURO-CORDEX dataset** (ongoing)
 - **Inter-comparison of BC Methods**
- **User guideline** document (under development)



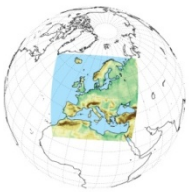
EURO-CORDEX Dissemination

Published Papers (several more submitted or in preparation):

- **Vautard**, Robert, et al. "The simulation of European heat waves from an ensemble of regional climate models within the EURO-CORDEX project." *Climate dynamics* (2013): 1-21.
- **Kotlarski**, Sven, et al. "Regional climate modeling on European scales: A joint standard evaluation of the EURO-CORDEX RCM ensemble." *Geoscientific Model Development Discussions* 7 (2014): 217-293.
- **Jacob**, Daniela, et al. "EURO-CORDEX: new high-resolution climate change projections for European impact research." *Regional Environmental Change* (2013): 1-16.
- Additional Studies close to or already submitted

User Workshops

- National user workshops (organized by EURO-CORDEX community members together with suitable national institutions, Spring 2014)



EURO-CORDEX Basics Status

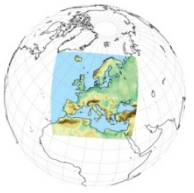
Availability for Users

- **Data-Access**
(similar to CMIP5):
 - Connect to and register at one of the ESGF nodes
 - Select project “CORDEX”
 - Select domain “EUR-44”, “EUR-44i”, “EUR-11”, or “EUR-11i”

The screenshot shows the ESGF (Earth System Grid Federation) website. The header includes the ESGF logo, the is-enes logo (Infrastructure for the European Network for Earth System Modelling), and logos for the German Federal Government (Bundesministerium für Bildung und Forschung) and DKRZ (Deutsches Klimarechenzentrum). A navigation bar contains links for Home, Search, Tools, Login, and Help. Below the navigation bar is a large satellite-style map of the world. A green banner below the map reads "Welcome to the ENES archive at DKRZ".

The main content area is divided into three columns:

- Peer Nodes:** A list of 15 nodes with their respective country flags and names: ANL Node, BADC Node, BNU Node, CMCC Node, DKRZ Node, IPSL Node, NASA-GSFC Node, NASA-JPL Node, NCI Node, NERSC Node, NOAA-ESRL Node, NOAA-GFDL Node, ORNL Node, and SMHI-LIU-NSC Node.
- About WDCC/DKRZ:** A text block describing DKRZ as the German Climate Computing Centre, providing tools and services for climate system investigation. It mentions that DKRZ operates a supercomputer center for climate simulation and provides technical infrastructure for data processing and analysis. A small image of a building is included. A "Learn More" link is at the bottom.
- Resources:** A section with a "Quick Links" sub-section containing: Create Account, MyProxyLogin, Expert Search (XML), Wget Script Generator, ESGF aggregated RSS feed, and Contact ESGF. Below this is an "Instructions" sub-section with: ESGF Full User Guide, Search Help, Search Controlled Vocabulary, Wget Scripts Info, ESGF Scripting, Tutorial: Download Strategies, Using Globus Online, and Subscribing to RSS Notification.



EURO-CORDEX Status

Status of the EURO-CORDEX simulations and their analysis

- **71** EUR-11 and EUR-44 scenario simulations finished, ~100 planned in total
- EUR-44 **40** simulations published on ESGF
- EUR-11 **24** simulations published on ESGF

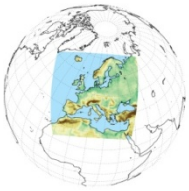


EURO-CORDEX

Summary

Summary

- EURO-CORDEX is a progress compared to earlier activities:
 - spatial resolution (EUR-11: 12.5 km)
 - ensembles size (100 simulations planned)
 - community involvement (27 groups)
 - user interface
- First studies clearly indicate **added value** of high resolution.
- The **large ensemble** will allow statistically more sound estimation of expected climate change and its uncertainty.
- **First** joint evaluation **studies** [Kotlarski et al. 2014] and climate change analysis are **finished** [Jacob et al., 2013] and confirm previous studies (ENSEMBLES).
- Bias corrected datasets, derived indices and products, and a user guide will facilitate the dissemination in **IAV assessment**.



EURO-CORDEX

Thanks for your attention!

Visit EURO-CORDEX at: **www.euro-cordex.net**