Climate Change and Hydrological Extreme Events

Risks and Perspectives for Water Resources Management in Bavaria and Québec


gefördert durch Bayerisches Staatsministerium für Umwelt und Verbraucherschutz

ClimEx Symposium 2019
A short history of collaboration

Q-BIC³ - Québec-Bavaria collaboration on climate change since 2006...
A short history of collaboration

Central Theme:
Research towards adapting to climate change

Major topics:
- Water balance
- River basin management
- Dam and reservoir management
- Natural hazards (floods/droughts)

Goals:
Understanding the course and impacts of climate change in Québec and Bavaria
- Develop tools and methods to support decision makers
- Train young researchers in this domain
- Communicate results to scientific community and users
Overview & Acknowledgements

Runtime: 05/2015 – 08/2019

Partners: LMU, Ouranos, ETS, INRS, LRZ, MELCC-DEH, Bavarian Environmental Agency

Funding: Bavarian State Ministry for the Environment and Consumer Protection

Acknowledgements: ESCER centre at Université du Québec a Montréal (www.escer.uqam.ca) and Environment and Climate Change Canada for providing CRCM5 Environment and Climate Change Canada CCCMA for making available the CanESM2 Large Ensemble simulations Gauss Centre for Supercomputing (www.gauss-centre.eu) for providing computing time on the GCS Supercomputer SuperMUC at LRZ (www.lrz.de)
ClimEx Symposium 2019

Climate Change and Hydrological Extreme Events

Risks and Perspectives for Water Resources Management in Bavaria and Québec
Background

« Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent. » - IPCC AR5 report
Research objectives

Provide unprecedented high-resolution climate model datasets to ...

- Confirm knowledge on whether and how climate change contributes to higher magnitudes and frequencies of extreme events
- Distinguish between the effects of internal variability and a ‘clear’ climate change signal
- Improve methods to analyse hydro-meteorological extreme events and provide robust estimates of HQx floods

ClimEx...

- employs High Performance Computing (HPC) to produce a large scale single model ensemble (CanESM2-CRCM5, 50 members), resulting in a high-resolution (0.11°, up to 1h), transient climate dataset (1951-2100) under RCP8.5 (7500 model years)
- will provide, for the first time, a statistically robust analysis and comparison of extremes under climate variability and climate change
HPC challenges and implementation

Experiment requires great computing power, storage and IT expertise

- GCS project granted in 2016 (88 MCPU-h, 500 Tbyte)
- Climate simulations lasted one year!
- Data storage and sharing
- Visualization of model results
- Science communication

www.lrz.de/services/datenhaltung/bigdata/
Case studies - Climate model domains

North American Domain

European Domain

"free domain" (340x340)
"analysis domain" (280x280)
Case studies - Hydrological model domains

On which spatial and temporal scales do we need to investigate hydrometeorological extreme events?

• Challenge:
  Investigate the variability and climate change dependency of extreme events in 98 Bavarian river basins (~100,000 km²)

• Goal:
  Improved process understanding and provisioning of measures for water resources management and river authorities to reduce extreme risks

• Conduct:
  Hydrological simulations using WaSiM, 500m and 3h resolution (driven by 50 members CRCM5, 1950-2100)
Project structure

Module A: CLIMATE

Module Z: Information Technology / Super Computing

Module B: HYDRO
Project structure - workflow

- Complexity of the model chain
  - Reference climate data set
  - QQ-Mapping
  - GCM
  - RCM
- Uncertainty about results
  - RCP
  - 50x CanESM2
  - 50x CRCM5
  - Spatial downscaling
  - Runoff modelling
  - Impact assessment
  - VPP
- 98 catchments
- ClimenEx approach
- Linux Cluster & SuperMUC
- Linux Cluster
- SuperMUC
...in a model chain using a Large Scale Single Model Ensemble?

50 model members → 50 time series
[i.e. to estimate the robustness of natural variability in the time frame of 1981-2010, we possess not 30 but 1500 (model) years]

Estimation of rare extreme events in a given time period becomes much more robust...
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Climate change - Temp & Precip in Europe

Monthly change of temperature and precipitation (2080-2099 vs. 2000-2019)
(50 member mean)

Leduc et al. (2019)
Does the data make sense? Is it valid?

How are CRCM5 signals comparing to other climate model experiments?
Relative signals of precipitation and temperature in 2070-99 compared to 1980-2009 (CEUR)
Does the data make sense? Is it valid?

Can we use the hydrological model WaSiM for climate change impact analyses?

Evaluation of model performance

- WaSiM is spatially explicit and “physically based”
- global calibration applied, i.e. one setup for 98 gauges
- model performance “good” to “very good” for most gauges
- weaker results related to management practices (gauges are marked for further analysis)

- Analysis of extreme events and its causes in future periods
Under future climatic and hydrological conditions, there is a severe increase in intensity and frequency of extreme flood events!
Changes of extremes - compound events under climate change

An example of a gauge at the Inn river - single extreme event triggered by...

Heavy precipitation falling on...

melting snow...

and saturated soils...

HQ Ereignis aus member kbc im Jahr 2091 (Okt / Nov) am Pegel Innsbruck-Reichenau

runoff, geroutet [mm]

precip

snowmelt

snowstorage

airtmp

soil water content root zone

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Key messages

ClimEx ...

• employs HPC to analyze climate variability and climate change over Eastern North America and Europe

• provides robust estimates for the dynamics of hydrometeorological extremes in Québec and Bavaria

• delivers simulation and visualization tools to support water resources management and civil security

• makes data and results available to the scientific community and stakeholders

• uses data from a sensitive climate model under an extreme climate change scenario
Program and Logistical Information
Program of the Symposium

06 May 2019 – ClimEx Policy Day
Bavarian Academy of Sciences

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“Angry weather? How to find out to what extent climate change is affecting extreme weather.”

Eight short talks to highlight some of the ClimEx findings

Visit the posters & sign-up for parallel workshops on Tuesday!

“Ist der Zug schon abgefahren? - Klimawandel, Extremereignisse und was wir (noch) dagegen tun können.”
An in-depth view on ClimEx results

Four parallel workshops to discuss scientific advance and novel applications of ClimEx and related data

Sign-up for guided tours to SuperMUC-NG (identification required)

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### 07 May 2019 – ClimEx Science Day
Leibniz Rechenzentrum

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