The sensitive interface of climate change and energy systems – perspectives from the ClimEx-initiative

Alain Bourque
Ralf Ludwig
& Anton Frank
for the ClimEx-Team

RLS Energy Network
17 May 2018
Château Frontenac, Québec

9th Regional Leaders' Summit

OUTLINE

1- Ouranos and renewable energies
(Alain Bourque (ED, Ouranos, Québec))

2- Quebec – Bavaria collaboration on climate change
(Ralf Ludwig (Professor, LMU, Bavaria))

3- The ClimEx project on hydroclimatic extreme events
(Ralf Ludwig (Professor, LMU, Bavaria))

4- Perspective for multilateral collaboration on renewable energies
(Alain Bourque (ED, Ouranos, Québec))

5- Questions and discussion

6- Data visualization
(Anton Frank (Research coordinator, LRZ, Bavaria))

Weather/Climate and power companies

HYDRO

Which rain + snow ratio?
How will seasonal flows change?
High winter/low summer flows?

NUCLEAR/THERMAL

Will water intake cool sufficiently?
Which impacts on efficiency?
Cooling water access? (regulations)

SOLAR

Evolution of cloud cover?
Will efficiency decrease
with rising temperatures?

WIND

How will wind speed change?
Will icing events change?

TRANSPORTATION TOWARDS MARKETS:

Will icing become a bigger problem for transmission and distribution?
How will seasonal energy demand vary vs energy production?
Will new, more intense/complex extreme events cut power at critical times?
Will weather patterns constrain the green energy mix required?

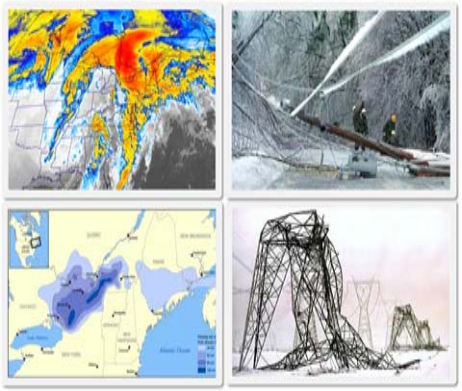
Pivotal climatic events leading to creation of Ouranos

1996 Saguenay Flood

- First 1B$ CAN natural disaster
- 10 deaths
- 2 600 buildings and numerous dams destroyed or damaged

1998 Ice Storm

- 4+B$ CAN
- 25 deaths
- Over 1 000 pylons & 35000 utility poles collapsed during coldest month of the year



Other less mediatized regional challenges

Water

Energy demand

Northern infrastructures

Environmental regulations

Coastal infrastructures

Risks from forests fires

Wind energy

Pivotal climatic events leading to creation of Ouranos

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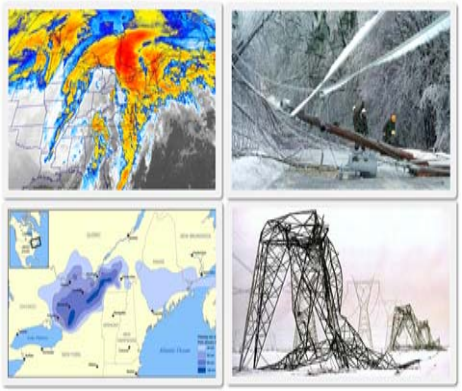
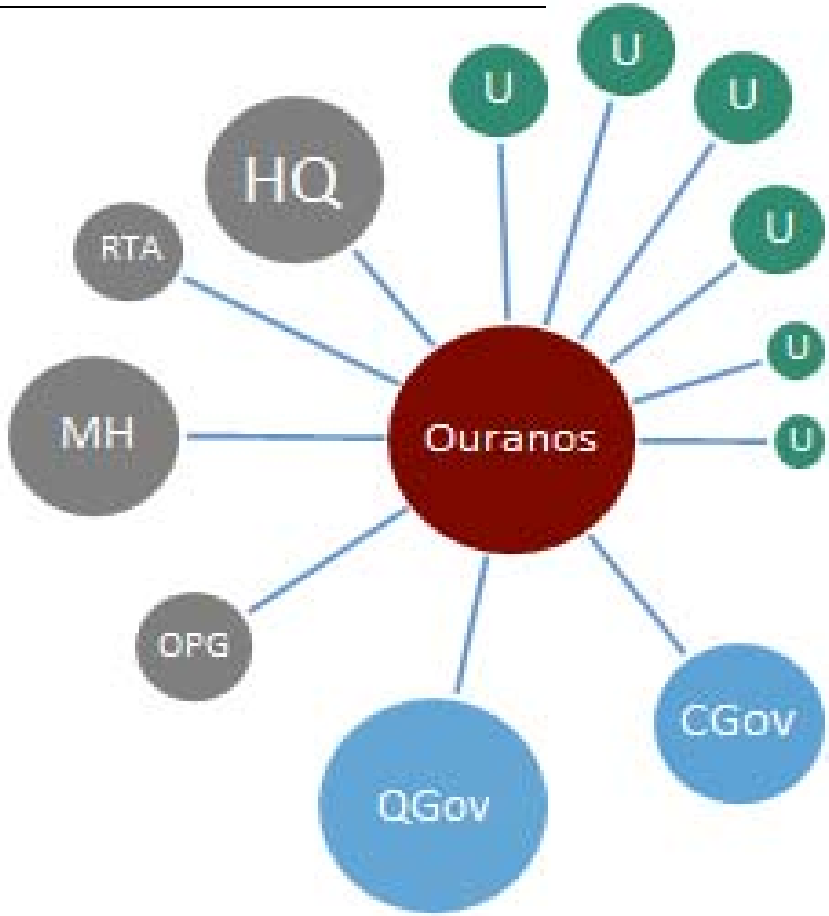


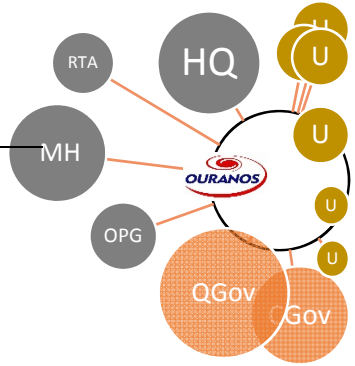


… and Ouranos was created

- Boundary organization (Cash et al., 2003)
- Multidisciplinary and user driven R&D
- Climate scenarios at regional scales
- Vulnerability / Impacts / adaptation studies

- Annual budget of approx 10 M$
- + 150 projects completed since 2002
- Including many partners concerned by facets of renewable energy production, distribution, demand

Ouranos is a boundary organization



Climate Science

Simulations & Analyses

Produce and validate regional climate simulations.

Study of variability, and uncertainty.

Scenarios & Services

Develop climate scenarios and provide expertise for I&A projects.

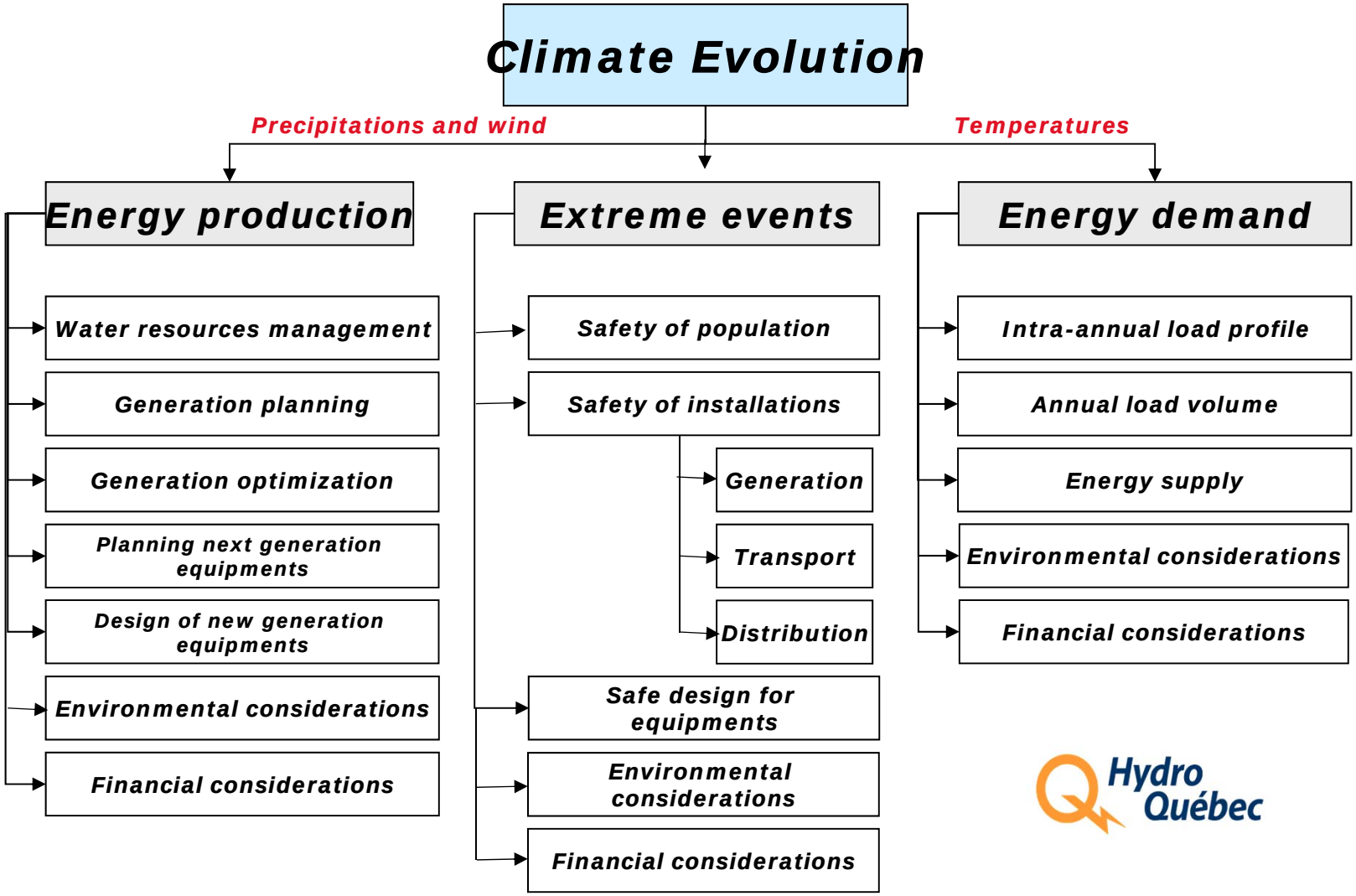
Vulnerability, Impacts & Adaptation

Coordinate vulnerability and impact assessments and cooperate on developing adaptation measures and strategies.

- Northern environment
- Energy
- Maritime Environment
- Built Environment
- Water Resources
- Health
- Ecosystems & Biodiversity
- Forest Resources
- Agriculture
- Tourism

Climate science ⟷ **Decision making**

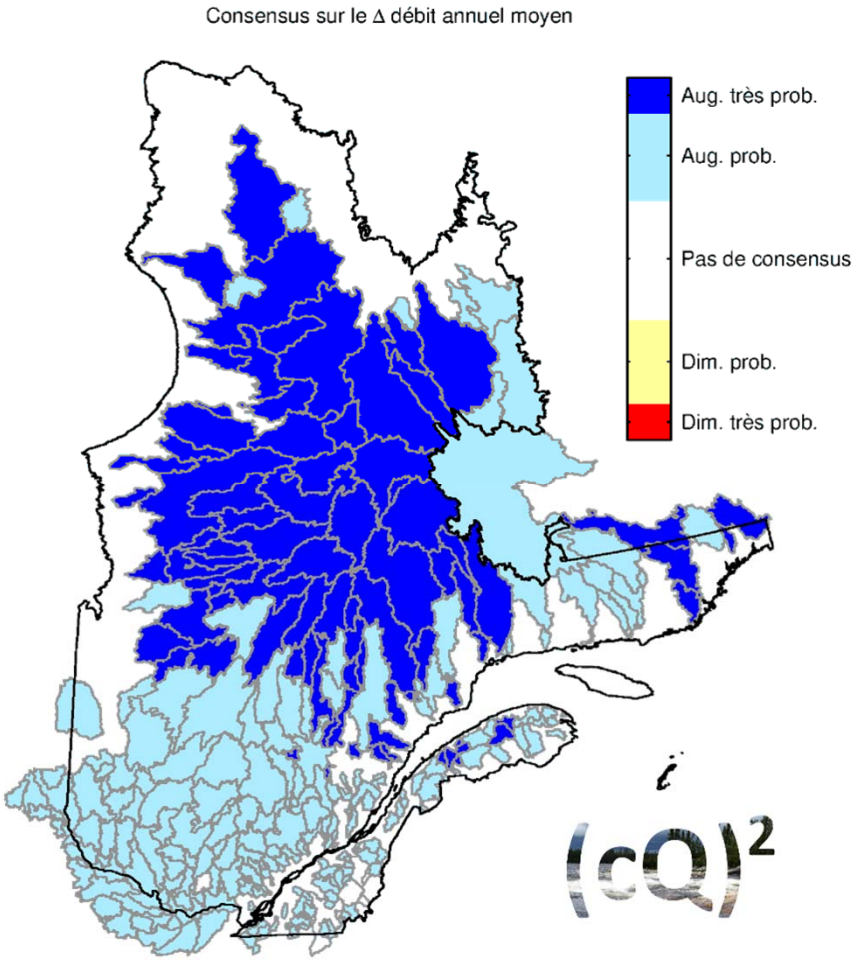
Energy major concerns related to climate change



Connecting science to decision for increased resilience

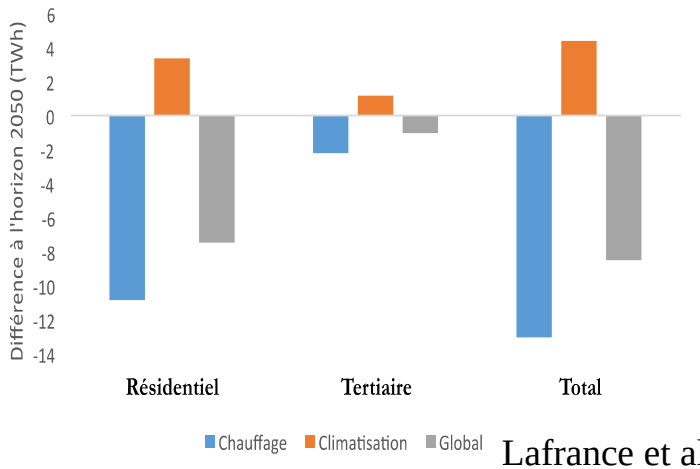
ENERGY PRODUCTION

Expected inflow changes (horizon 2050)



Hydro Québec, 2015

ENERGY DEMAND



Lafrance et al.

DEVELOP ADAPTATION PLANNING

New project: wind energy and climate change

Methodology

1. Projected changes in wind, icing and energy
   - Canada wide
   - In-depth analysis for selected wind farms

2. Economic analysis (Québec)
   - Cost-benefit analysis

Map of Main Actual Wind Farms Installed in Québec, Ontario and Manitoba

Hydro Québec · Manitoba Hydro · ONTARIO POWER GENERATION · ACCORD Wind Energy Cluster · Fondsvert Québec · CRSNG NSERC · 9th Regional Leaders' Summit

Québec-Bavarian Partnership

Q-BIC³

Bavarian Environment Agency

OURANOS

UNIVERSITÉ LAVAL

Développement durable, Environnement et Lutte contre les changements climatiques

Québec

McGill

LMU

LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

INRS
UNIVERSITÉ DE RECHERCHE

ÉTS
Le génie pour l'industrie

lrz Leibniz-Rechenzentrum
der Bayerischen Akademie der Wissenschaften

9th Regional Leaders' Summit

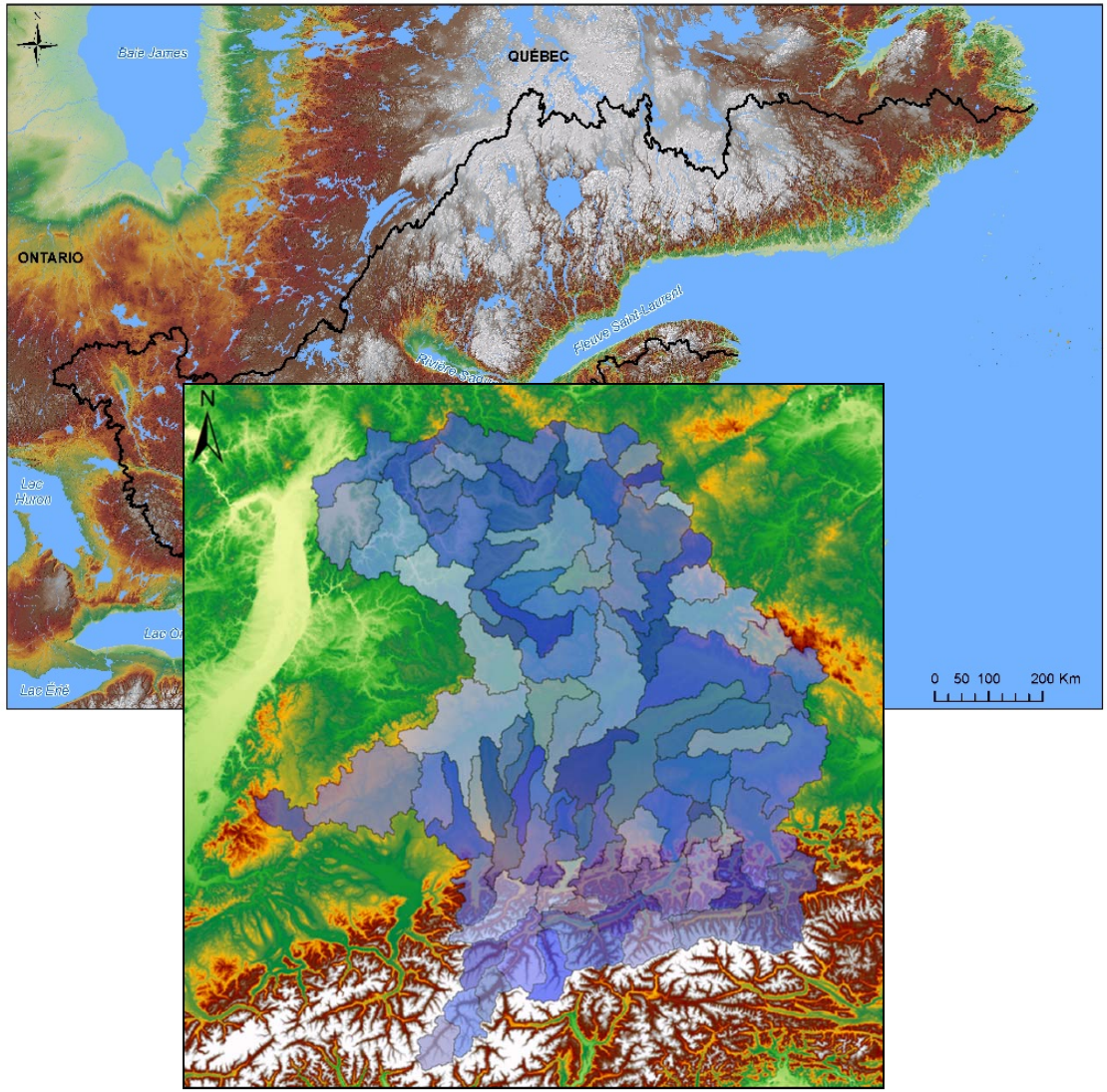
Core topics of collaboration

Central theme:
Climate change and water

Contents:

Waterbalance
River basin management
Reservoir/dam management
Natural Hazards
(floods/droughts)

Documentation and
decision support for
river basin authorities



Milestone

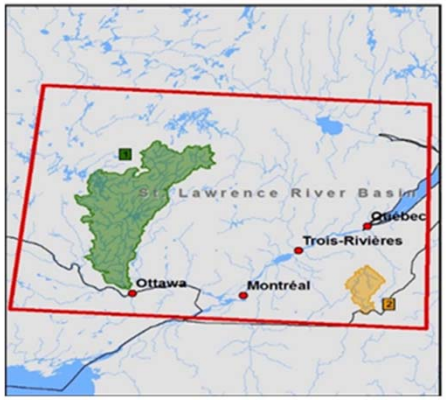
- Signing of collaboration agreement between LMU and Ouranos
  « Research towards adapting to climate change »
  (Québec National Assembly, May 2008)

Phase 2 – Q-BIC³ (2009-2013)

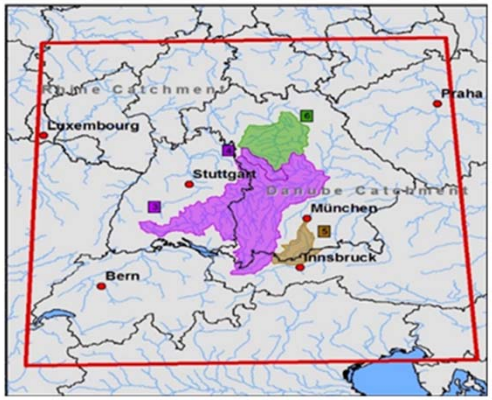
Theme :
Dam and reservoir management and catchment hydrology

Contents :
- Bias-correction
- Scale investigations
- Multi model ensembles

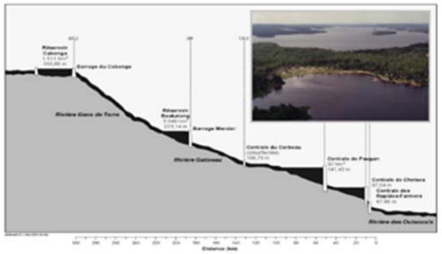
Core messages:
- Severe impacts of climate change on reservoir management and hydropower generation



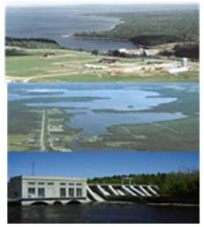
Gatineau



Altmuehl-Regnitz



Haut Saint-François



Isar

ClimEx

Background

Major flood events in Québec
1996/2011/2017

Major flood events in Bavaria
1999/2002/2005/2013/2016

« 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 gaps

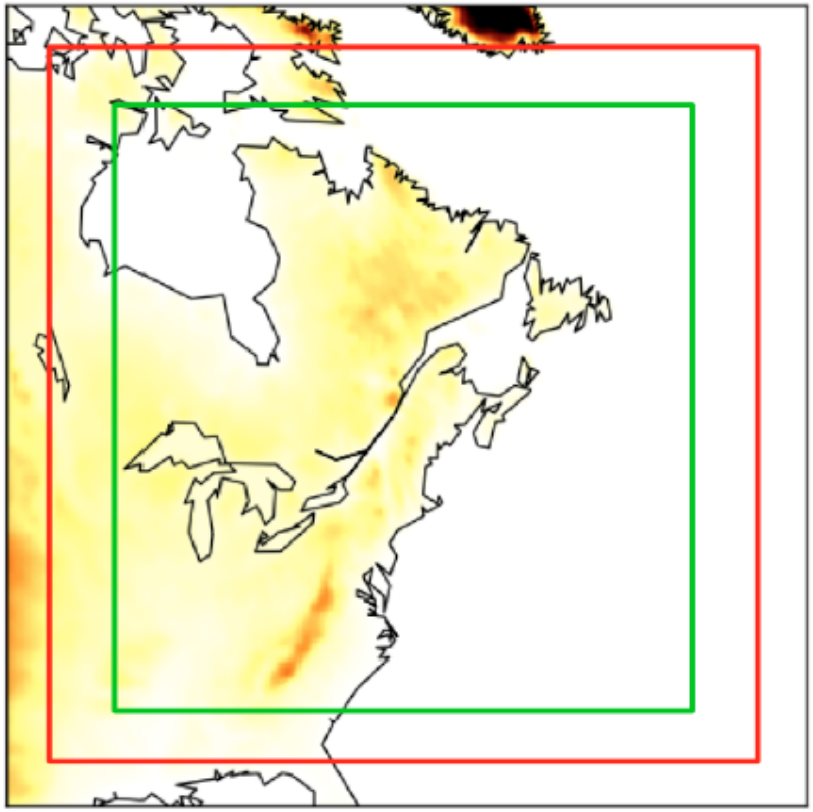
- Confirm knowledge on whether and how climate change contributes to higher magnitudes and frequencies of extreme events
- Distinguish between the effects of climate variability and a 'clear' climate change signal
- Improve methods to analyse hydro-meteorological extreme events

ClimEx…

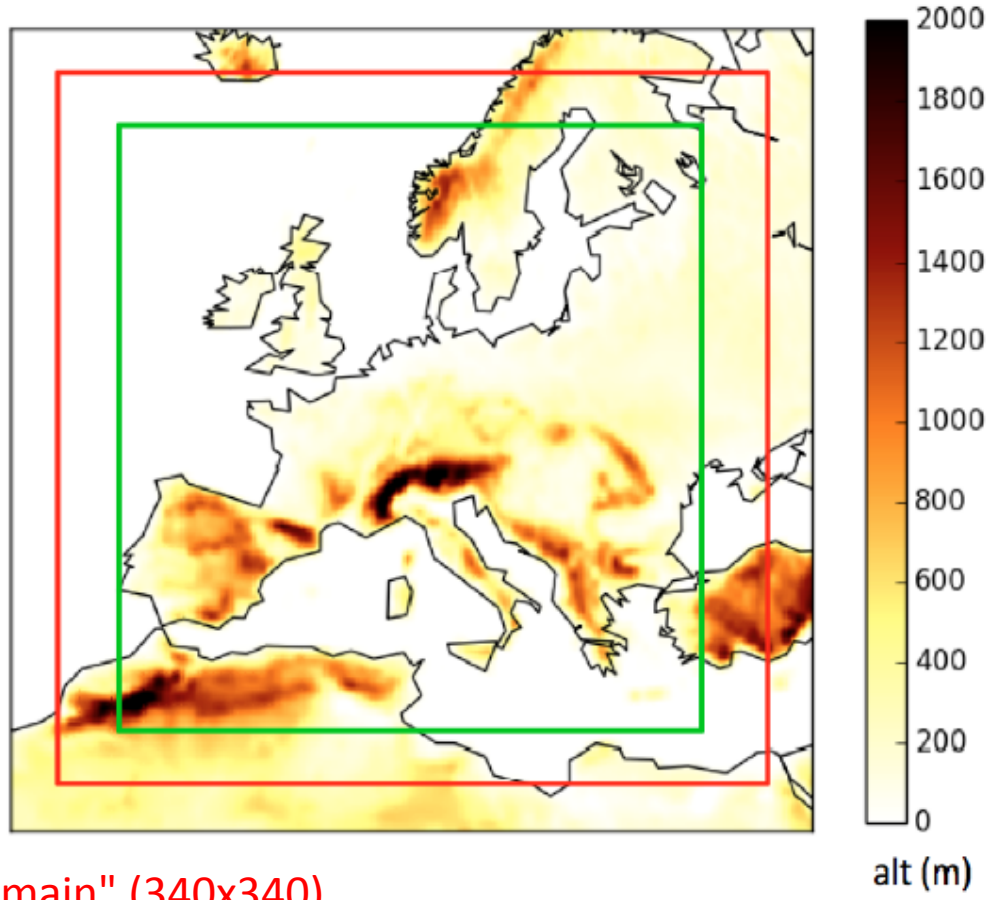
- employs High Performance Computing (HPC) to produce a large scale single model ensemble (CanESM2-CRCM5, 50 members), resulting in a high-resolution (0.11°), transient climate dataset (1955-2100)
- builds on a hydro-meteorological model processing chain to assess the dynamics of hydrological extremes under climate change

Case studies - Climate model domains

North American Domain

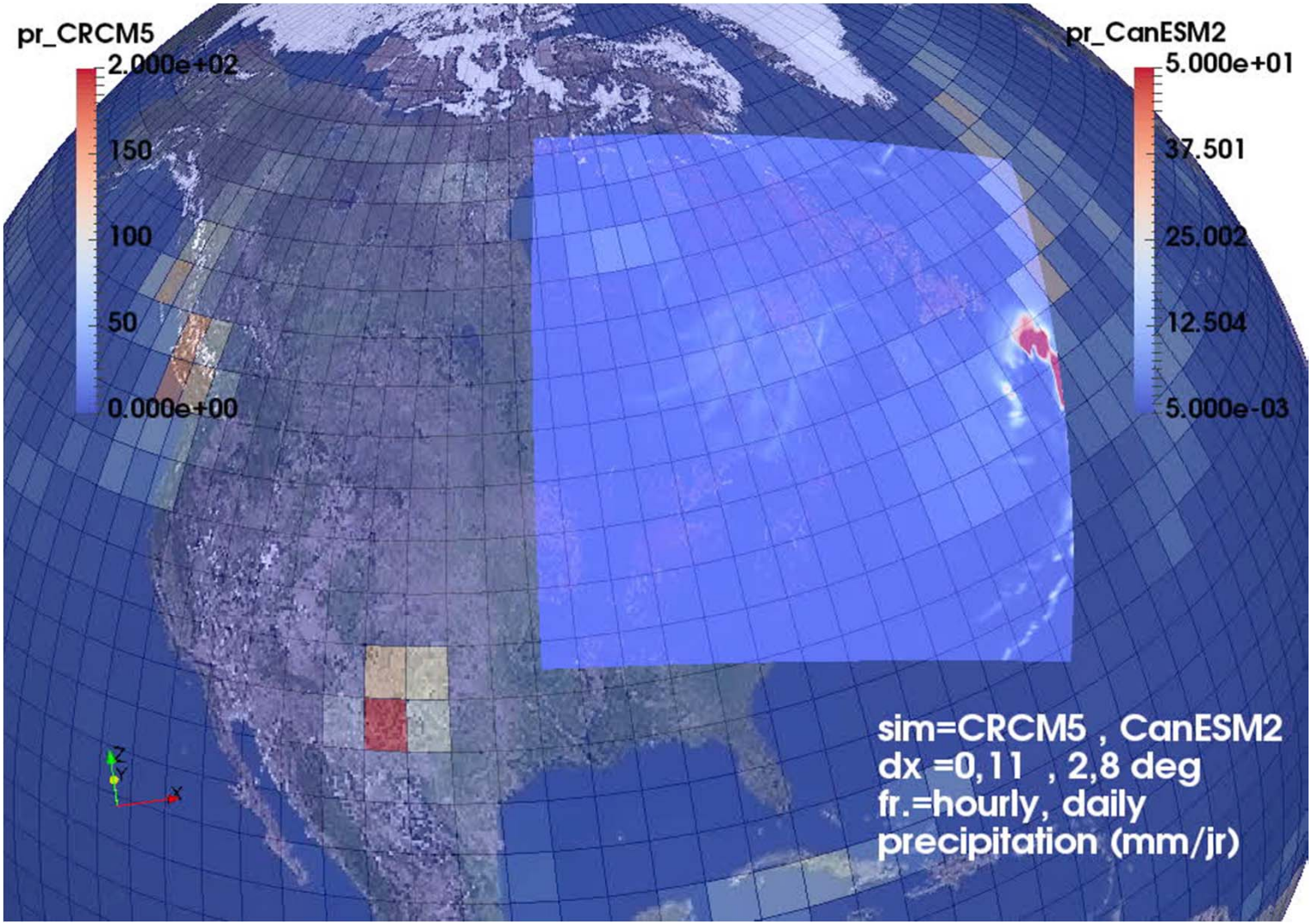


European Domain



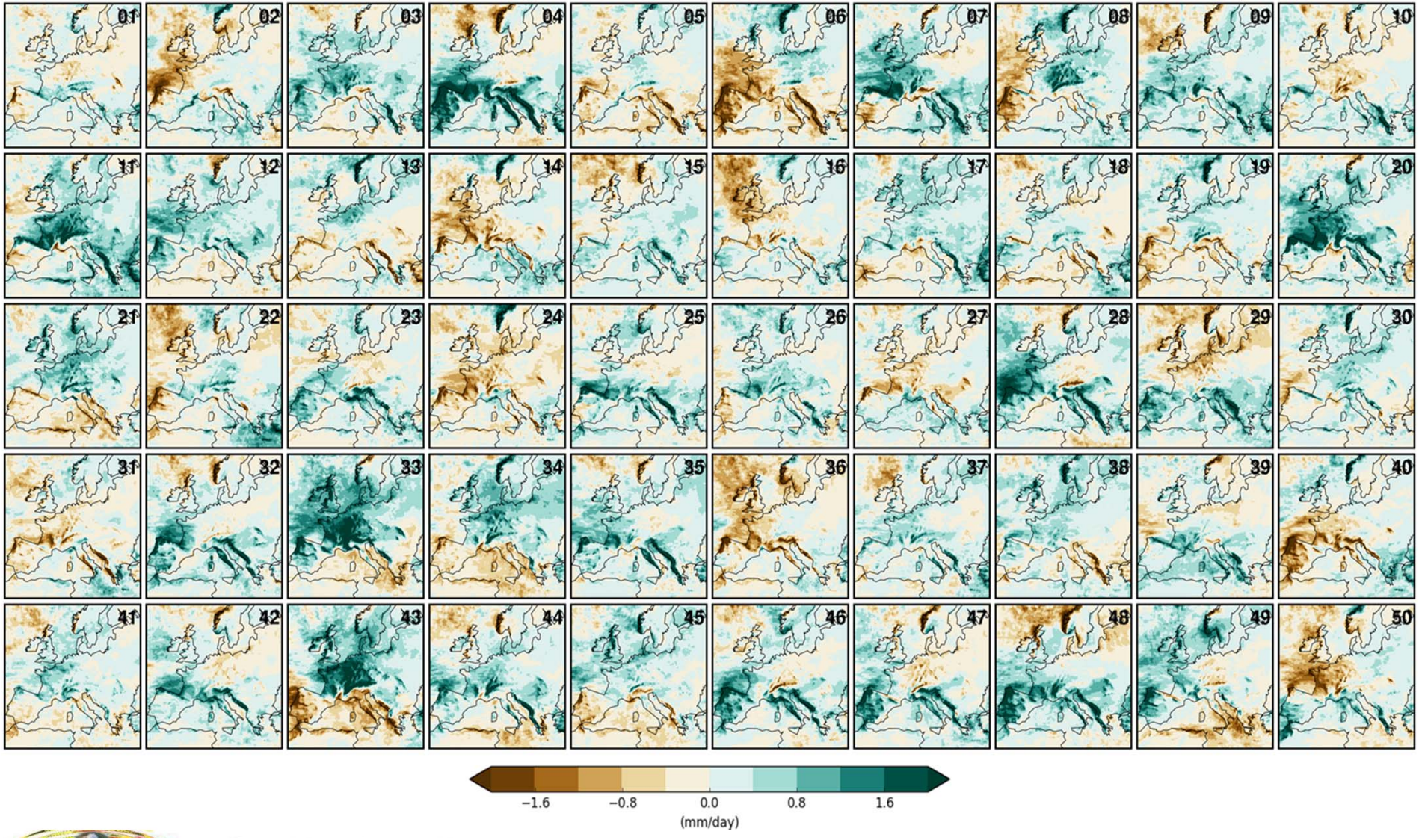
"free domain" (340x340)
"analysis domain" (280x280)

Regional Climate Modeling



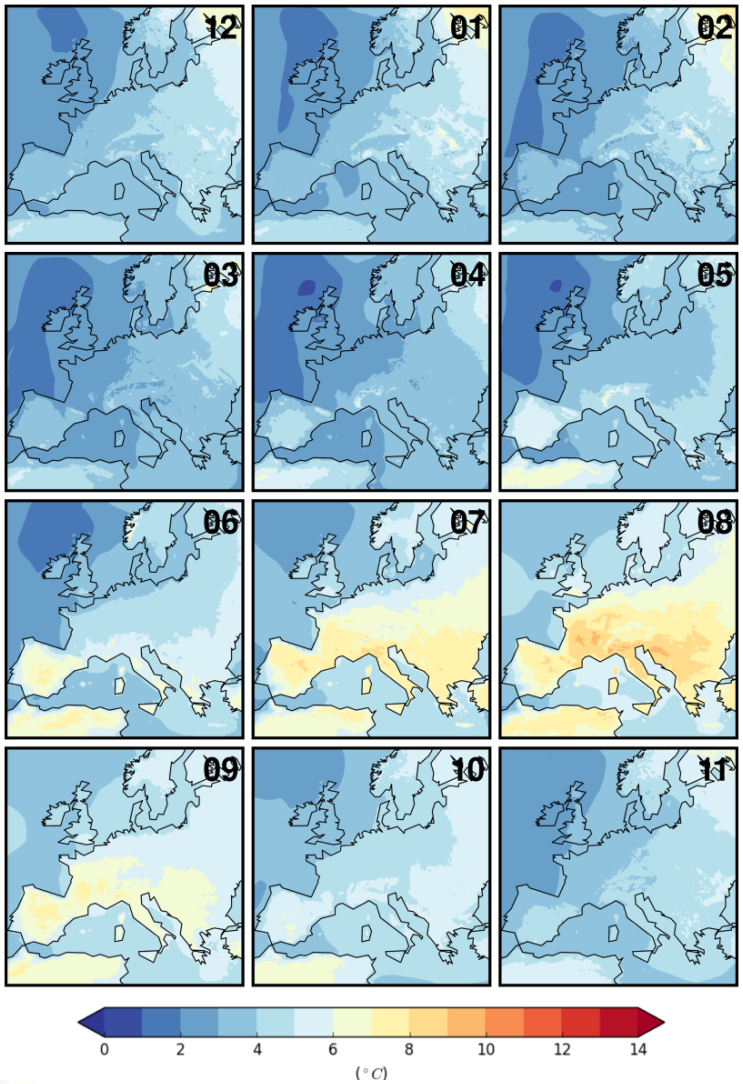
Giguère, Ouranos 2017

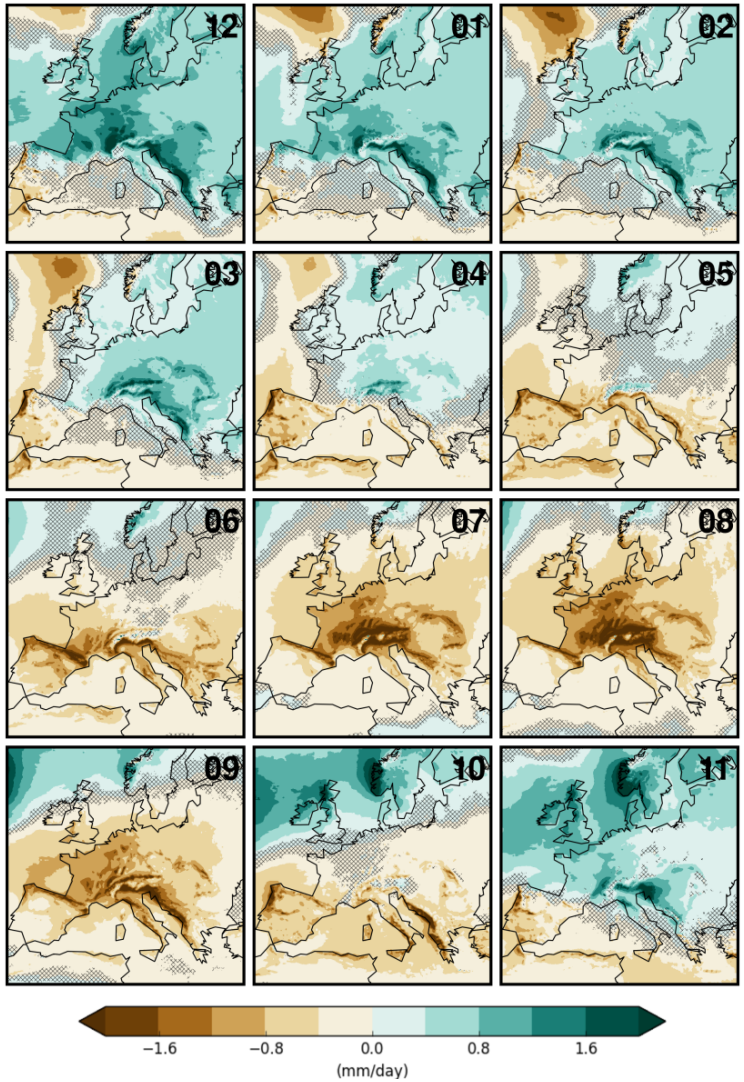
Natural variability…



50 possible future changes for PRC (in %) between 2020-2039 and 2000-2019 over Europe from CanESM2-CRCM5 at a 12-km resolution

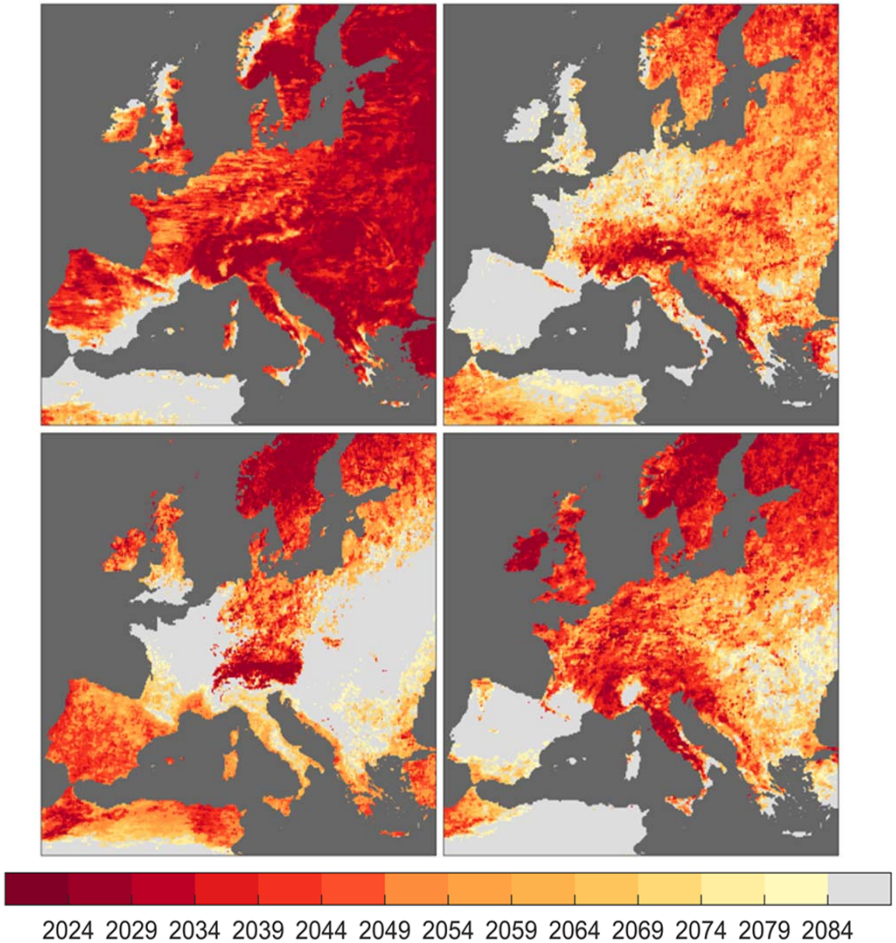
Climate change signals – T & P over Europe



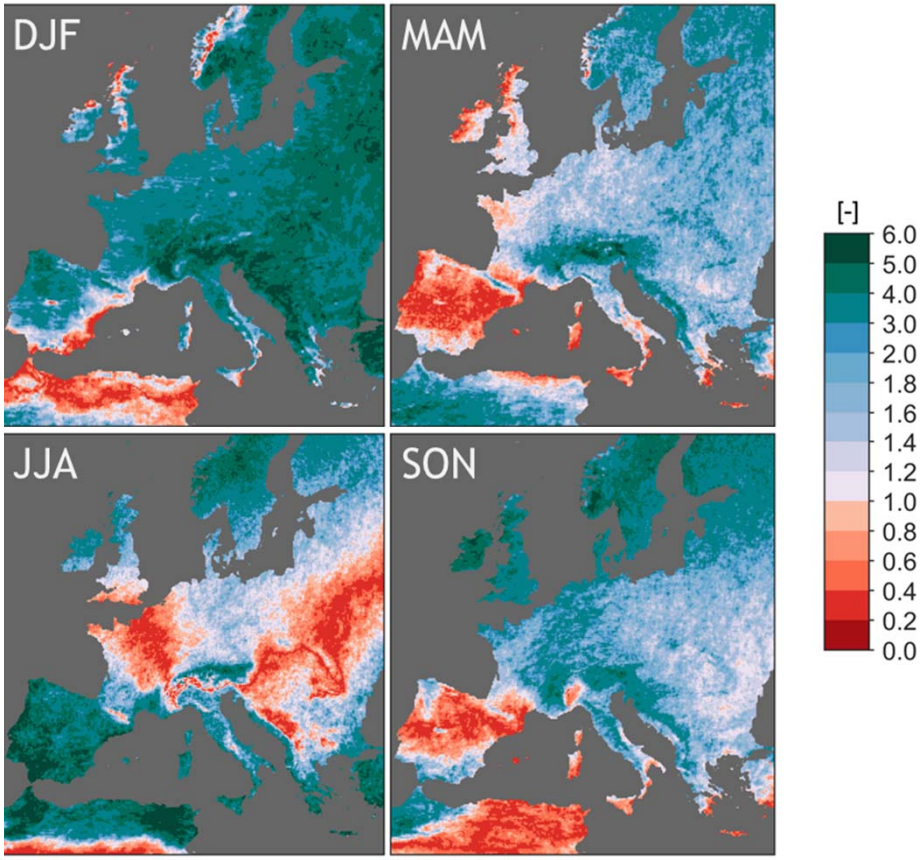


Monthly change of temperature and precipitation (2080-2099 vs. 2000-2019)
(50 member mean)

Climate change signals – Rx3h over Europe



Rx3h Time of Emergence (S/N>1)

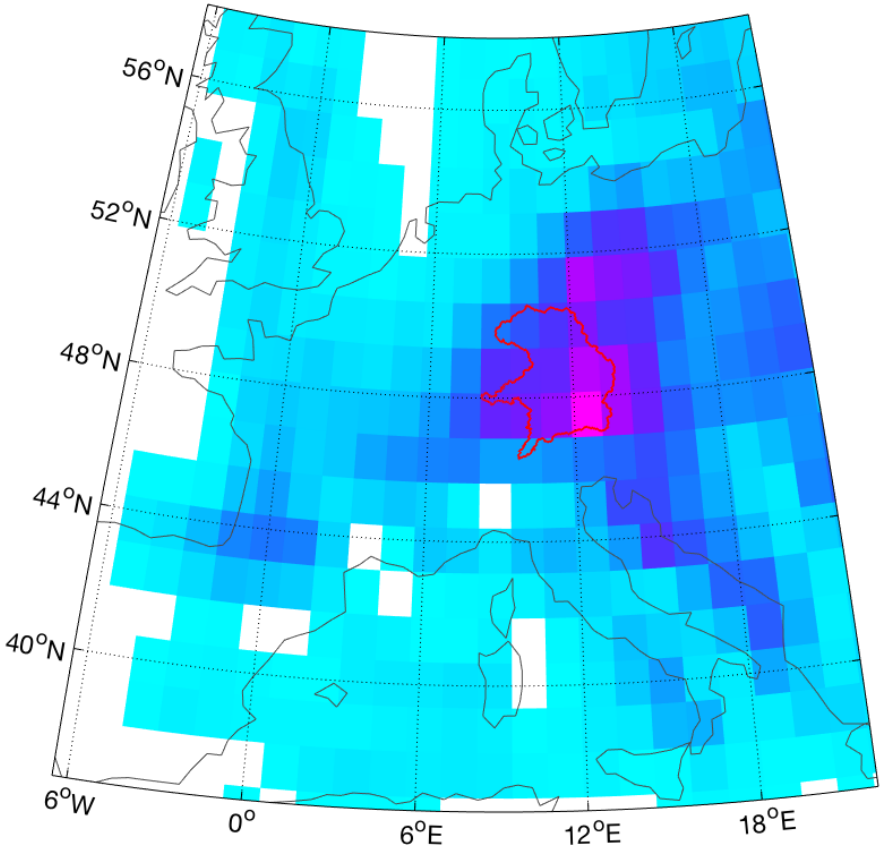


Rx3h S/N ratio (2070-2099)

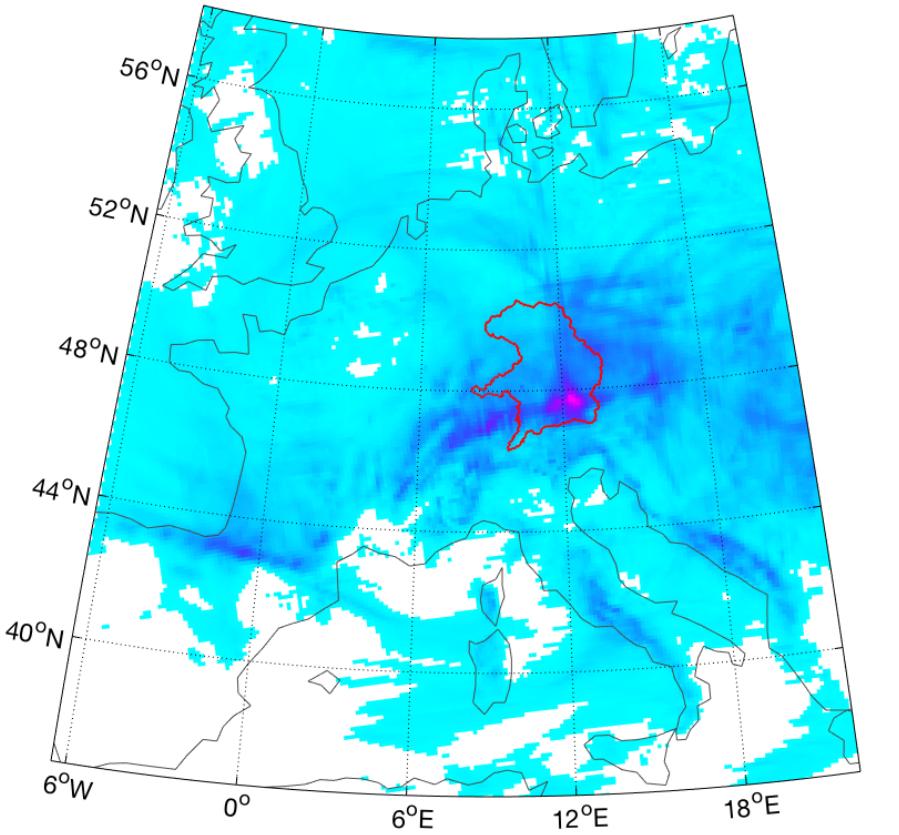
ClimEx – Weather pattern (Vb-Tracking)

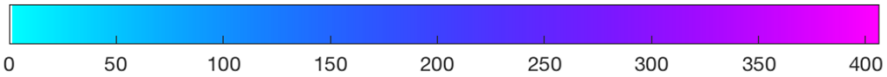
Precipitation sum - 29. May – 02. June 2013

Observation



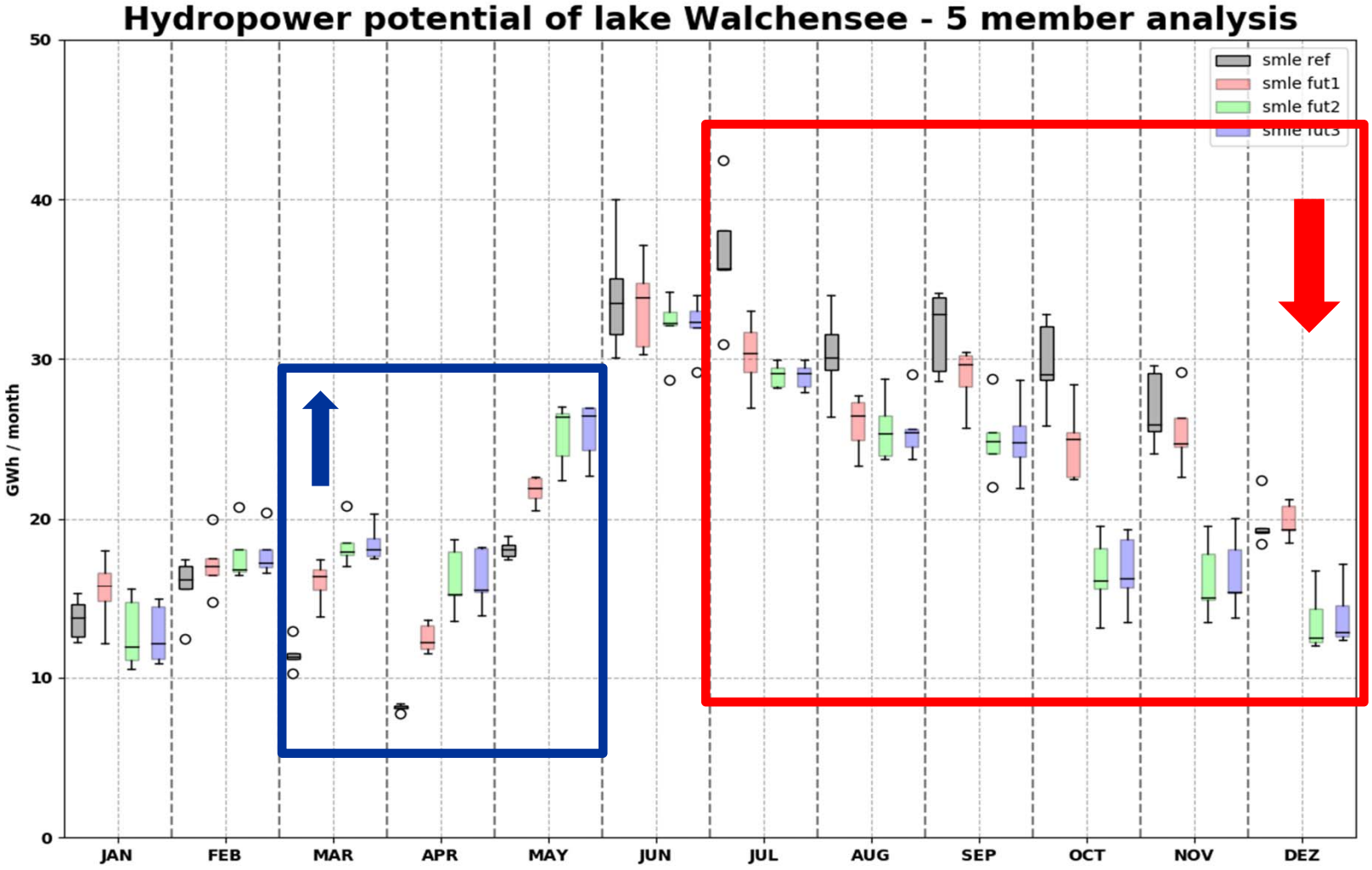
ClimEx





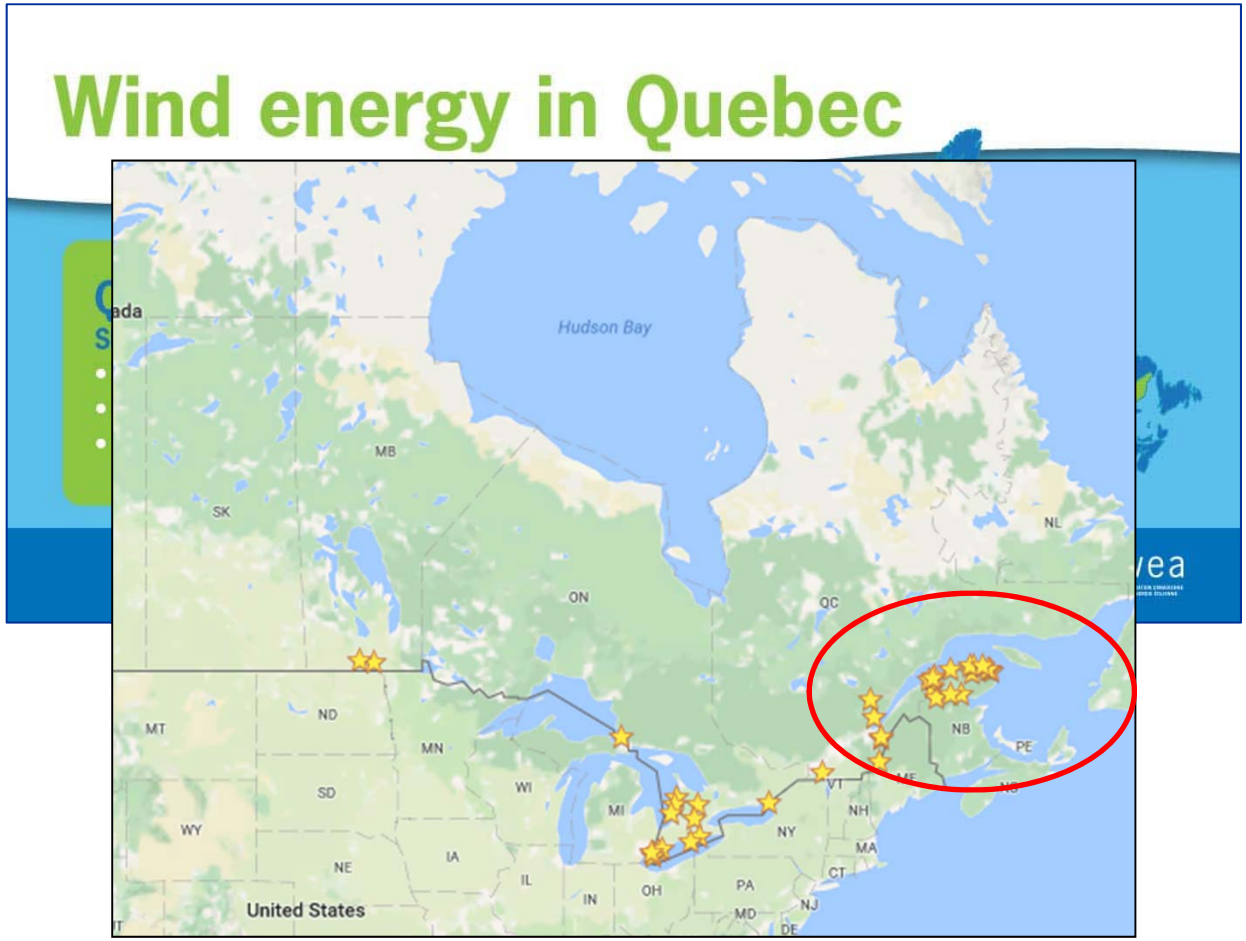
Applications for renewable energies - I

ClimEx example – Hydropower (Walchensee, Bavaria)



Applications for renewable energies - II

ClimEx example - Wind fields (Gulf of St. Lawrence)



Surface winds (m/s) from a January month in recent climate

from CRCM5 at 12-km resolution

Arrows shown every 6 tile for clarity

Special thanks to LRZ (J.Weismuller) for training with Paraview

Giguère, Ouranos 2018

Applications for renewable energies - II

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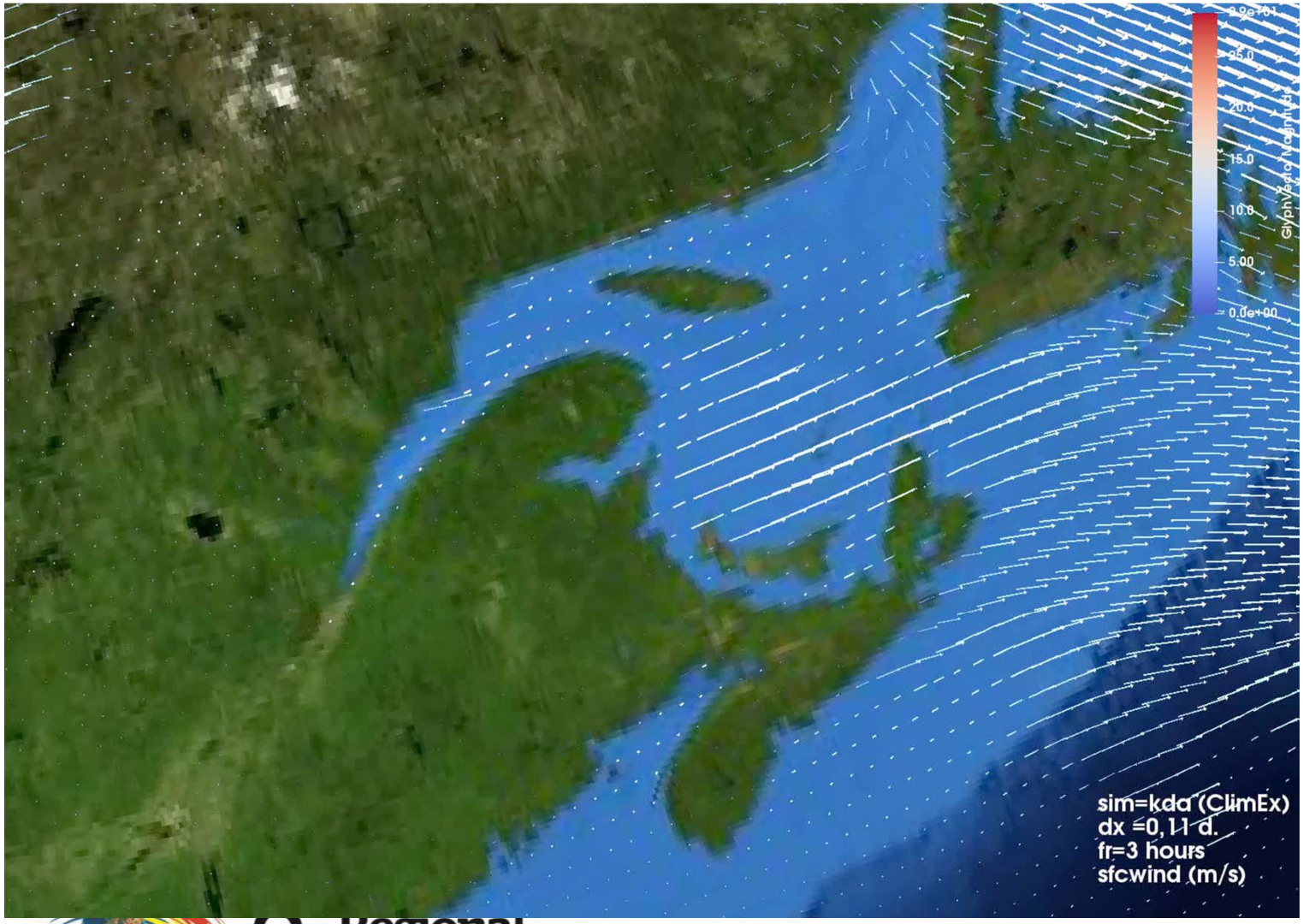

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Applications for renewable energies - III

Results/ideas from the ClimEx-Symposium (15./16. May 2018)

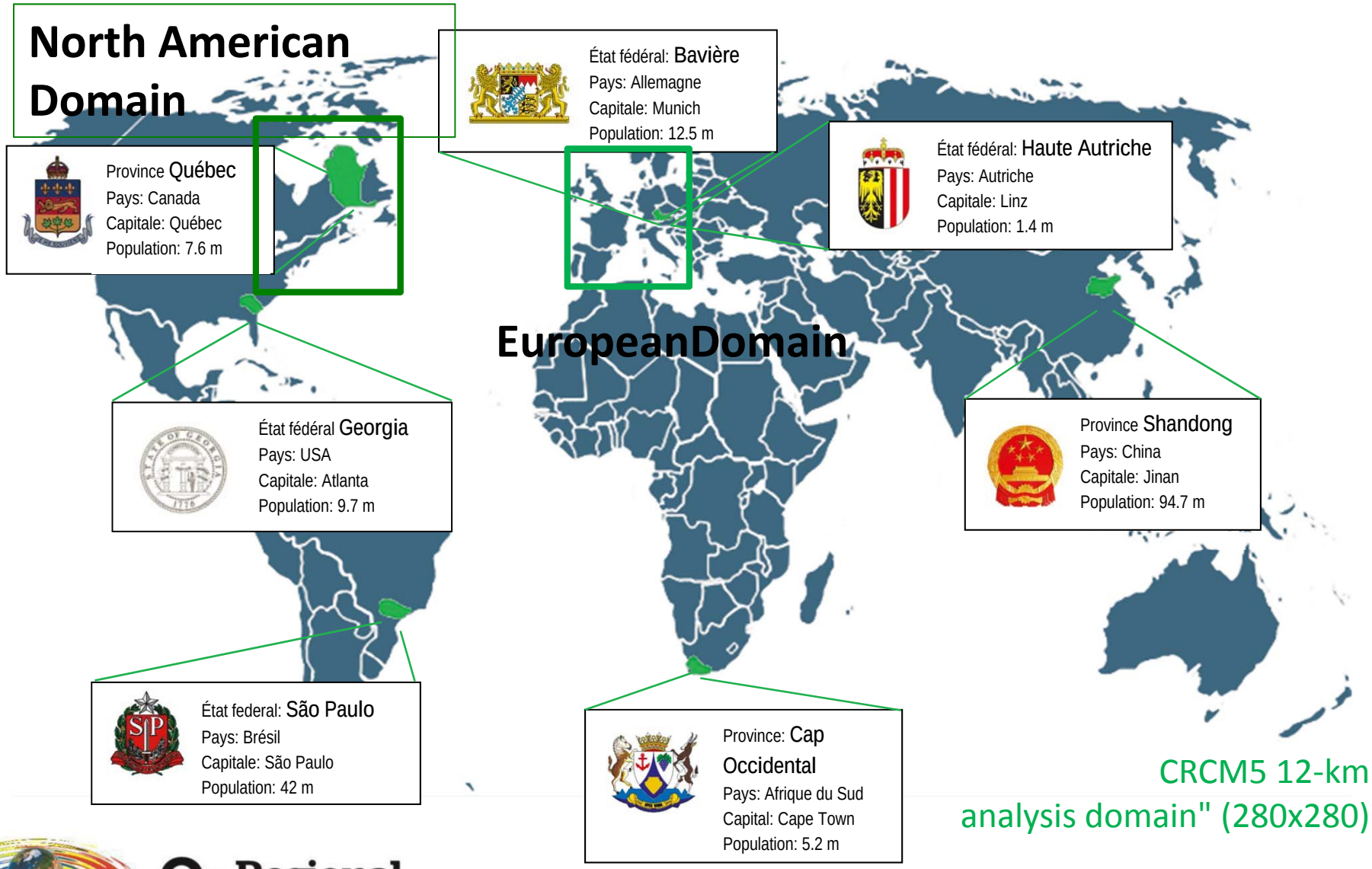
Securing energy supply with renewables under climate change conditions

- Guidance for system adaptation to solve « Dunkelflaute » situations
- Support system shift to flexible demand (consumption following supply)
  → « intelligent demand »
- build an « Energy Layer » for ClimEx dataset;
  → Deliverable: « Regional Energy and Climate (Change) Atlas »

Vulnerability of energy infrastructure to combined meteorological extremes under climate change (« Compound events »)

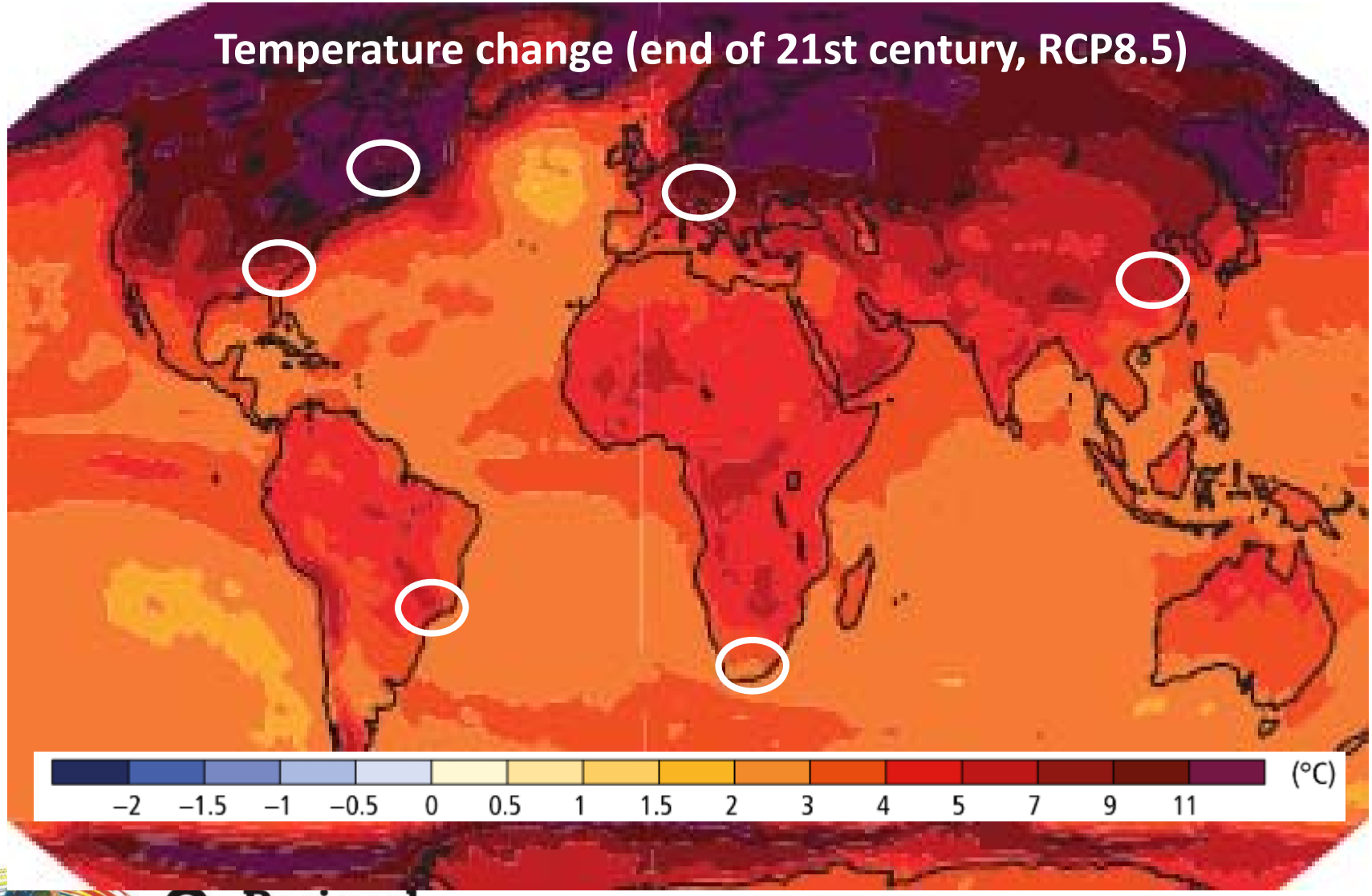
- Evaluate the impact on electricity production and security
- Assess risk for dams, wind farms, solar panel infrastructure and grid & detect most affected sites and areas (« hotspots »)
- Define vulnerability indicators and provide interactive impact maps

Perspectives for collaboration - I

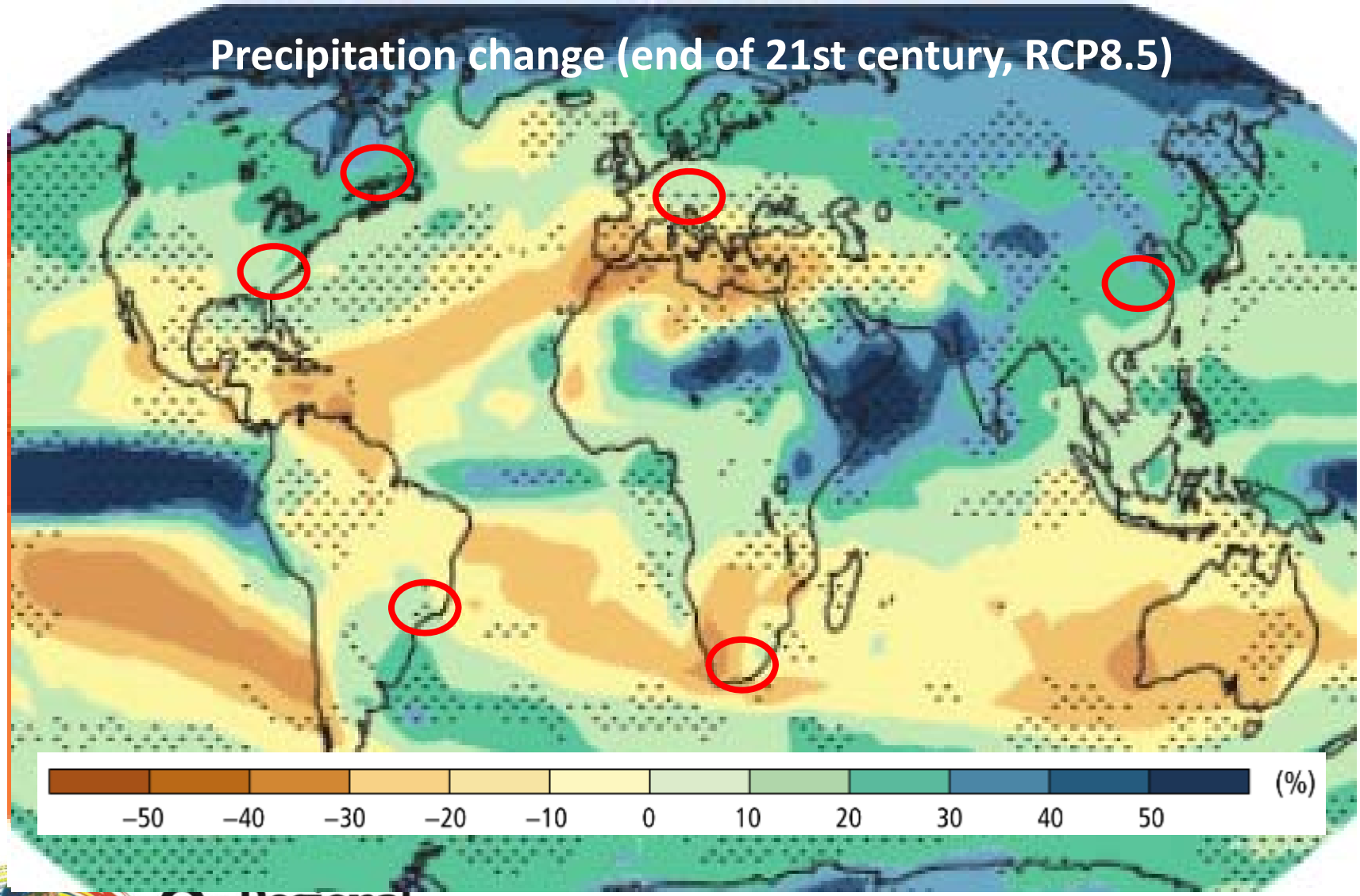


CRCM5 12-km analysis domain" (280x280)

Perspectives for collaboration - I

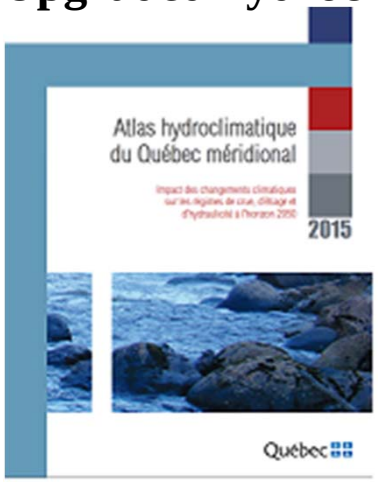


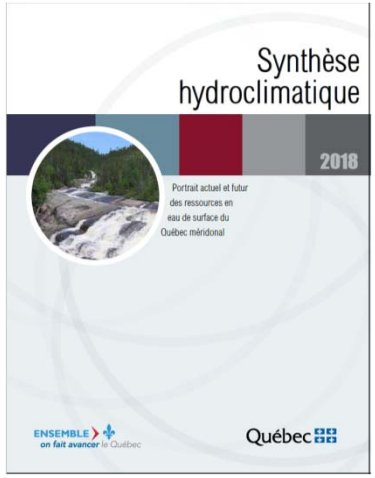
Perspectives for collaboration - I



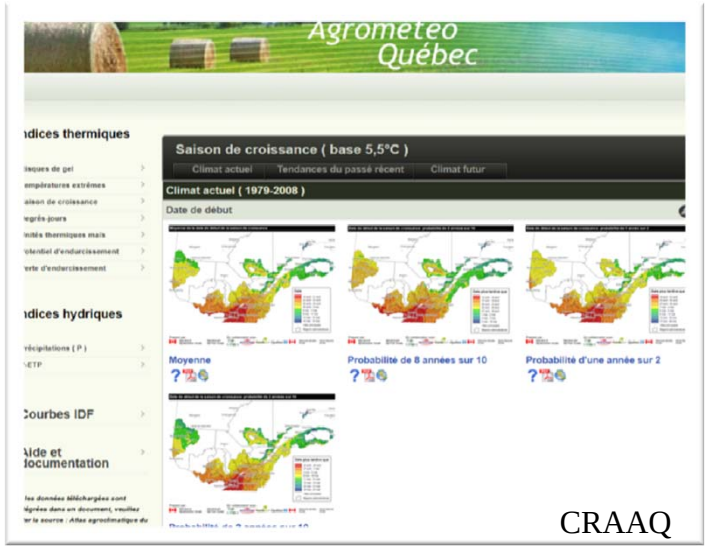
Perspectives for collaboration – II

Upgraded hydroclimatic atlas?



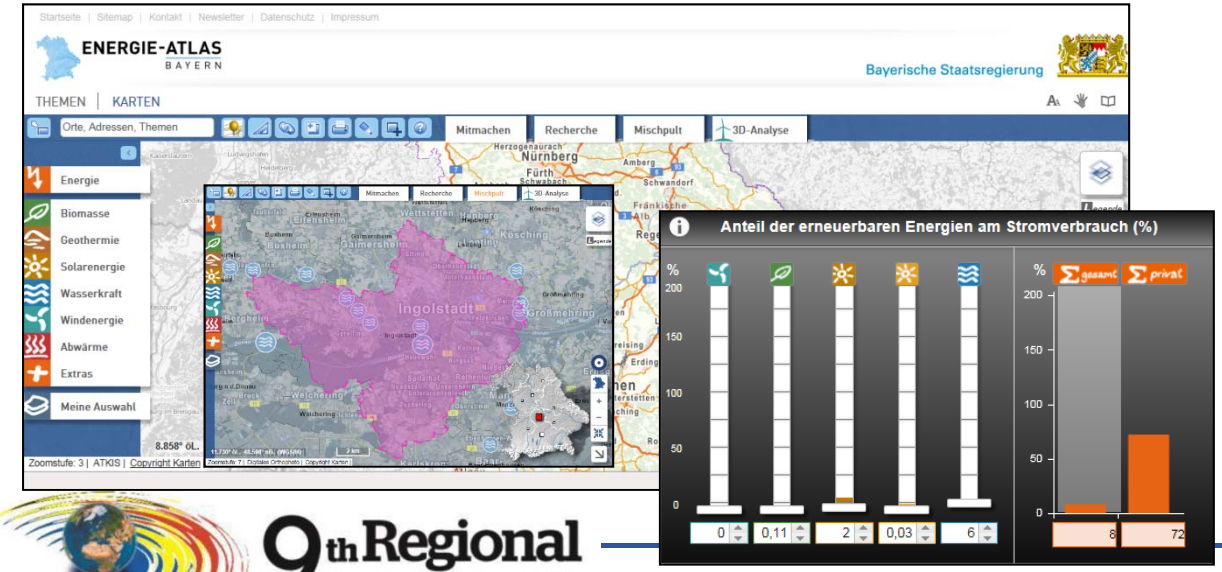


Agroclimatic atlas?



CRAAQ

Joint products with Energy atlas?



Connections between:

- **Researchers**
- **Practitioners**
- **Water managers**
- **Various disciplines**
- **Gvmnt officials**
- **Exchanges in 2 regions**
- **Students ⟶ HQP**

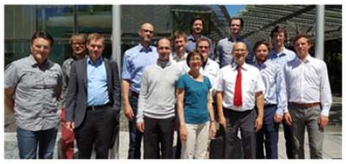
Perspectives for collaboration - III

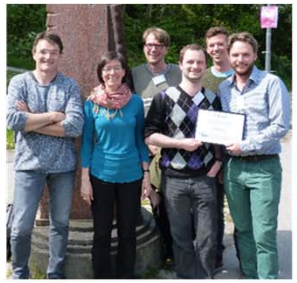
Human Resources and Highly Qualified Personel …

Alain Mailhot (INRS)
Andi Jobst (LMU)
Anton Frank (LRZ)
Anne Frigon (Ouranos)
Bano Mehdi (U McGill)
Blaise Gauvin St-Denis (Ouranos)
Claude Demers (HQ)
Daniel Caya (Ouranos)
Diane Chaumont (Ouranos)
Dieter Kranzlmüller (LRZ)
Fabian von Trentini (LMU)
Florian Willkofer (LMU)
François Anctil (U Laval)
François Brissette (ETS)
Frank Bäse (LFU)
Frank Ferber (LMU)
Gilbert Brietzke (LRZ)

Gregory Seiller (U. Laval)
Hans Weber (LFU)
Holger Komischke (LFU)
Isabelle Chartier (IREQ)
Jens Weismüller (LRZ)
Jean-François Cyr (MDDELCC)
Juan Alberto Velazquez (Ouranos)
Louis-Guillaume Fortin (MDDELCC)
Luc Vescovi (Ouranos)
Marco Braun (Ouranos)
Marie Minville (IREQ)
Markus Muerth (LMU)
Martin Leduc (Ouranos)
Michel Giguère (Ouranos)
Michael Altmayer (StMUV)
Mourad Labassi (Ouranos)
Ralf Ludwig (LMU)

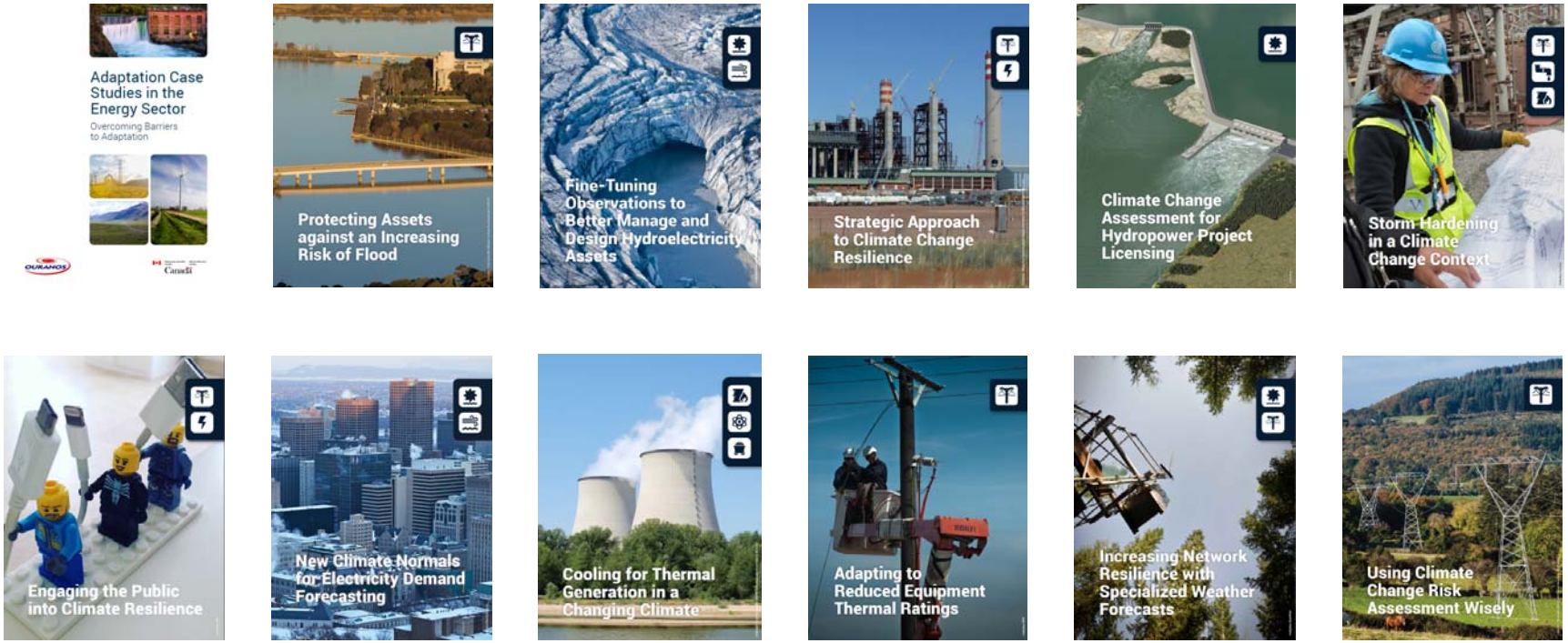
Raul Wood (LMU)
René Roy (Ouranos)
Richard Turcotte (MDDELCC)
Sacha Berger (LMU)
Seppo Schmid (LMU)
Simon Lachance-Cloutier (MDDELCC)
Simon Ricard (MDDELCC)
Wolfram Mauser (LMU)





Inga May (2006) - Montréal
Anne Boetcher (2009) - Montréal
Audrey Lavoie (2010) - Munich
Richard Arsenault (2010) - Munich
Felix Wiss (2010) - Québec
Juan Alberto Velasquez (2011) - Munich
Josef Schmid (2011) - Montréal
Markus Muerth (2011) - Montréal
David Gampe (2014) - Québec/Montréal
Simon Ricard (2015) - Munich
Jean-Luc Martel (2016) - Munich
Magdalena Mittermeier (2017) - Montréal

RELIABLE RENEWABLES: SCIENCE TO DECISION FOR INCREASED RESILIENCE

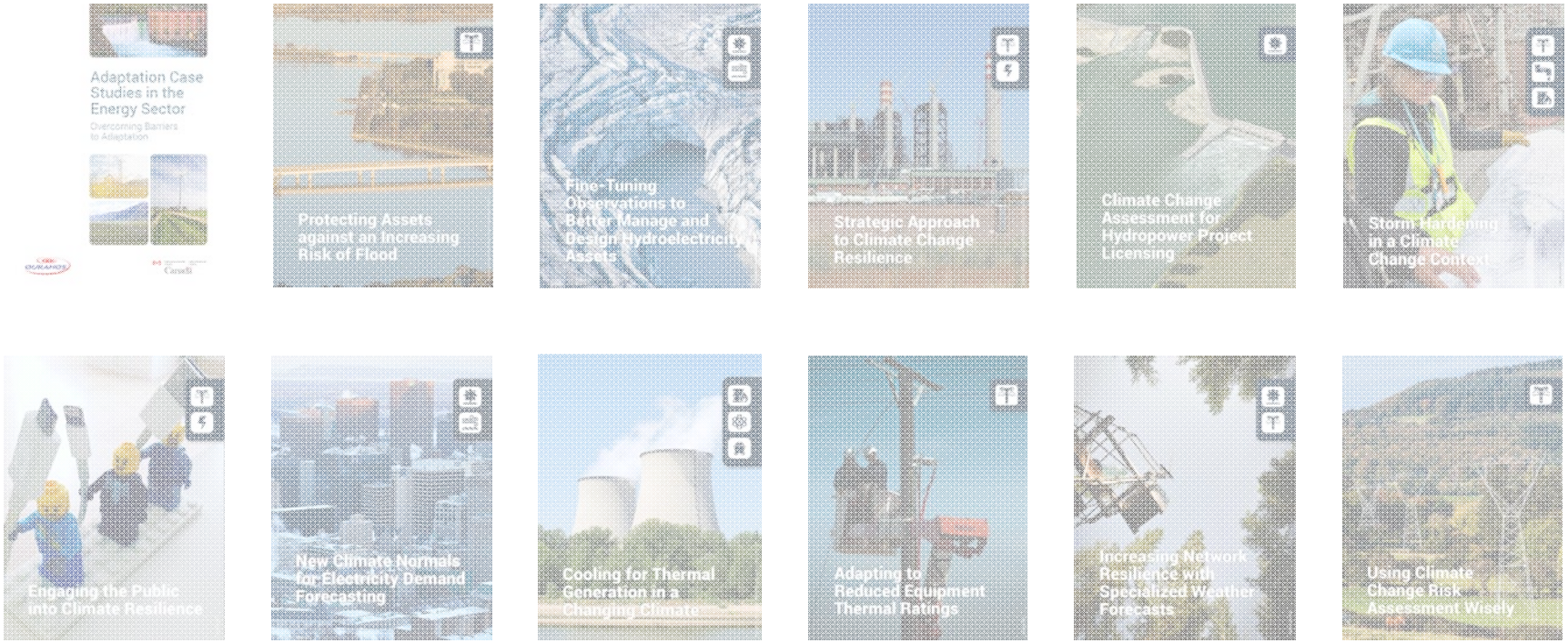


Source: Braun et Fournier (2017)

https://www.ouranos.ca/en/programs/energy-adaptation-case-studies
https://energyadaptation.ouranos.ca/placemarks/maps

Questions / Discussion

RELIABLE RENEWABLES: SCIENCE TO DECISION FOR INCREASED RESILIENCE



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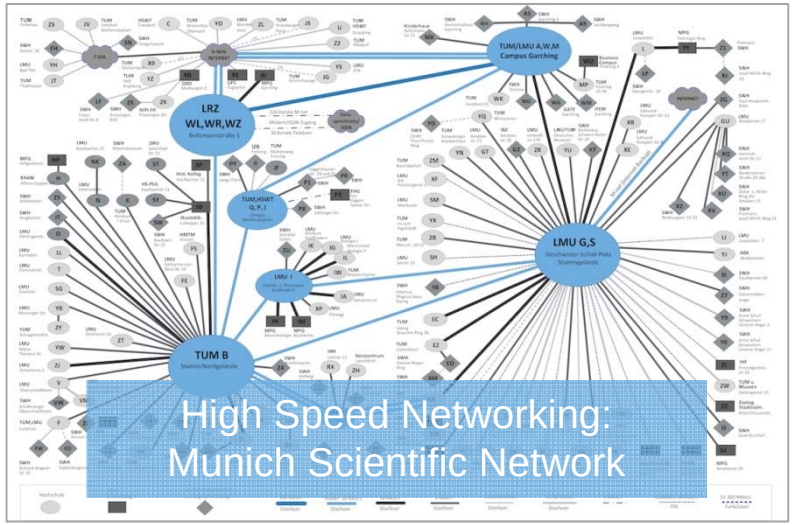
The Leibniz Supercomputing Centre

in Garching near Munich, Bavaria

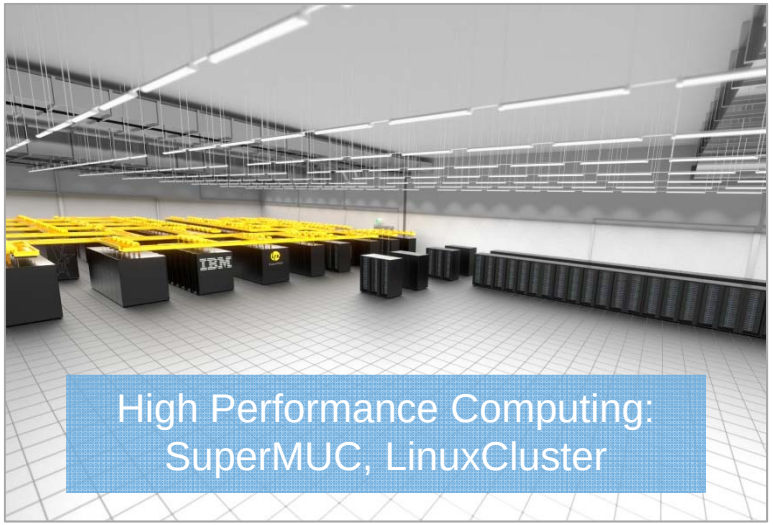
Academy Institute of the Bavarian Academy of Science and Humanities

- ✓ IT Service Provider for the **Munich** Universities
- ✓ Regional Computing Centre for Research Institutions in **Bavaria**
- ✓ **German** National Supercomputing Centre
- ✓ **European** Supercomputing Centre

Providing Top-Level IT Services to Academia and Research



High Speed Networking:
Munich Scientific Network



High Performance Computing:
SuperMUC, LinuxCluster

Bavarian Big Data
Competence Centre

Virtual Reality & Visualisation:
V2C (CAVE, Powerwall)

9th Regional Leaders' Summit

SuperMUC: Energy-efficient High Performance Computing

Largest European General Purpose Supercomputer

Peak performance 6.8 PFlop/s

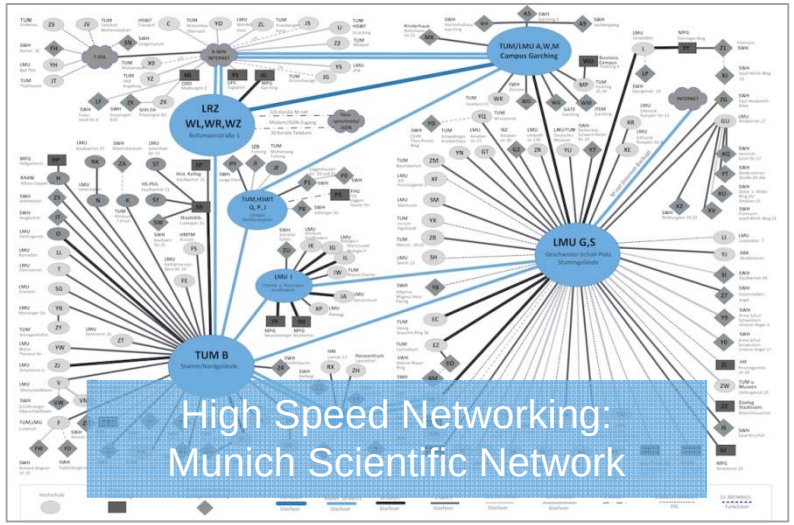
Energy consumption 3.4 MWatt on average

Hot liquid cooling => 85% less energy
Adsorption chillers for waste heat reuse
100% renewable energy

All Pictures © LRZ

1st system of this kind globally

Providing Top-Level IT Services to Academia and Research



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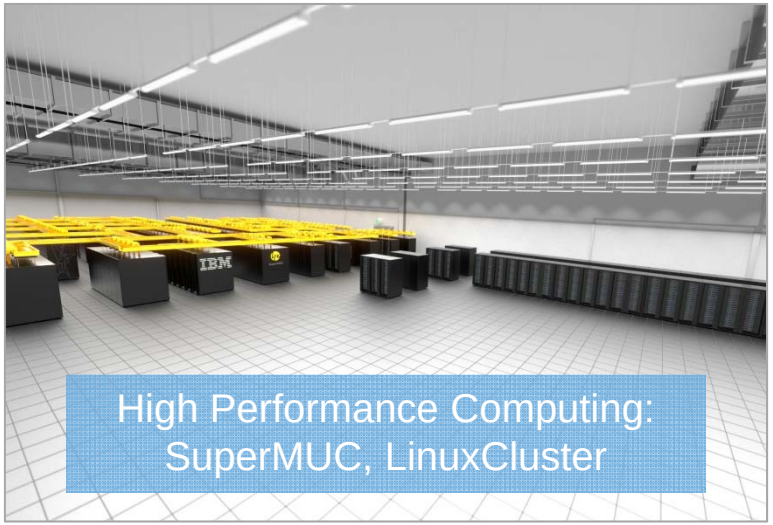

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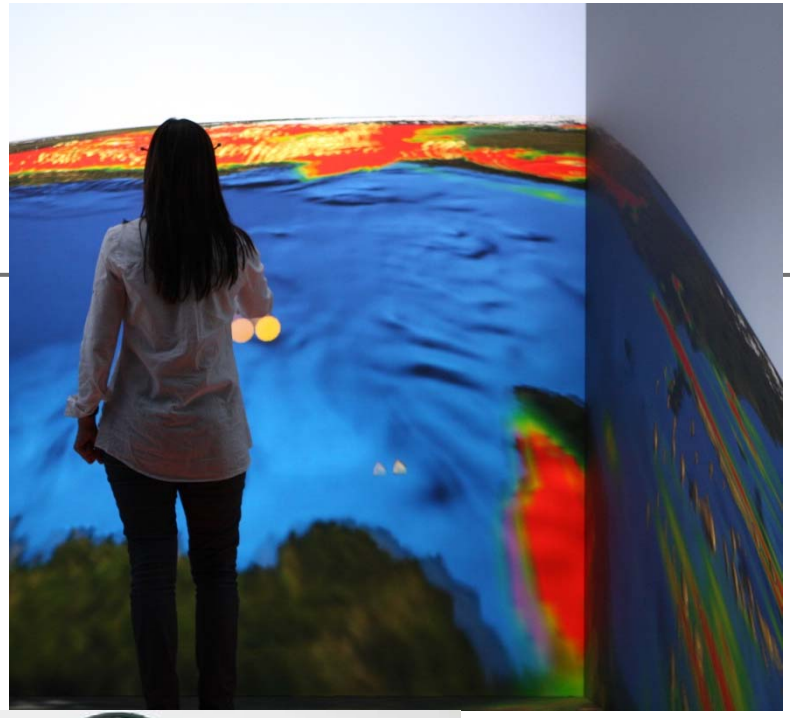
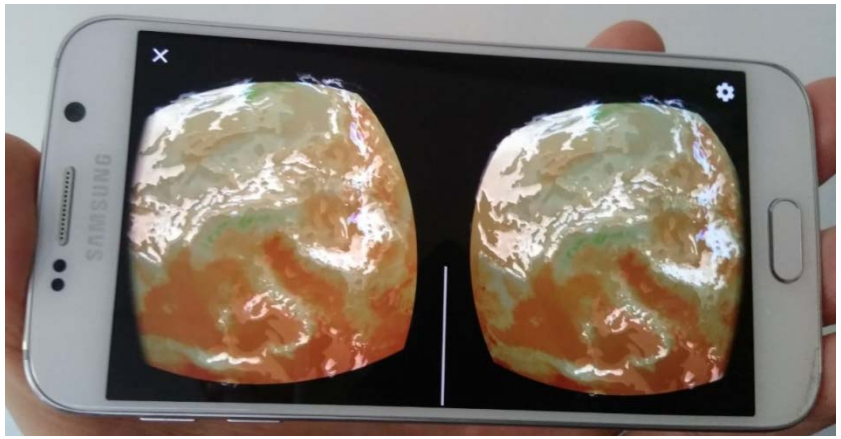
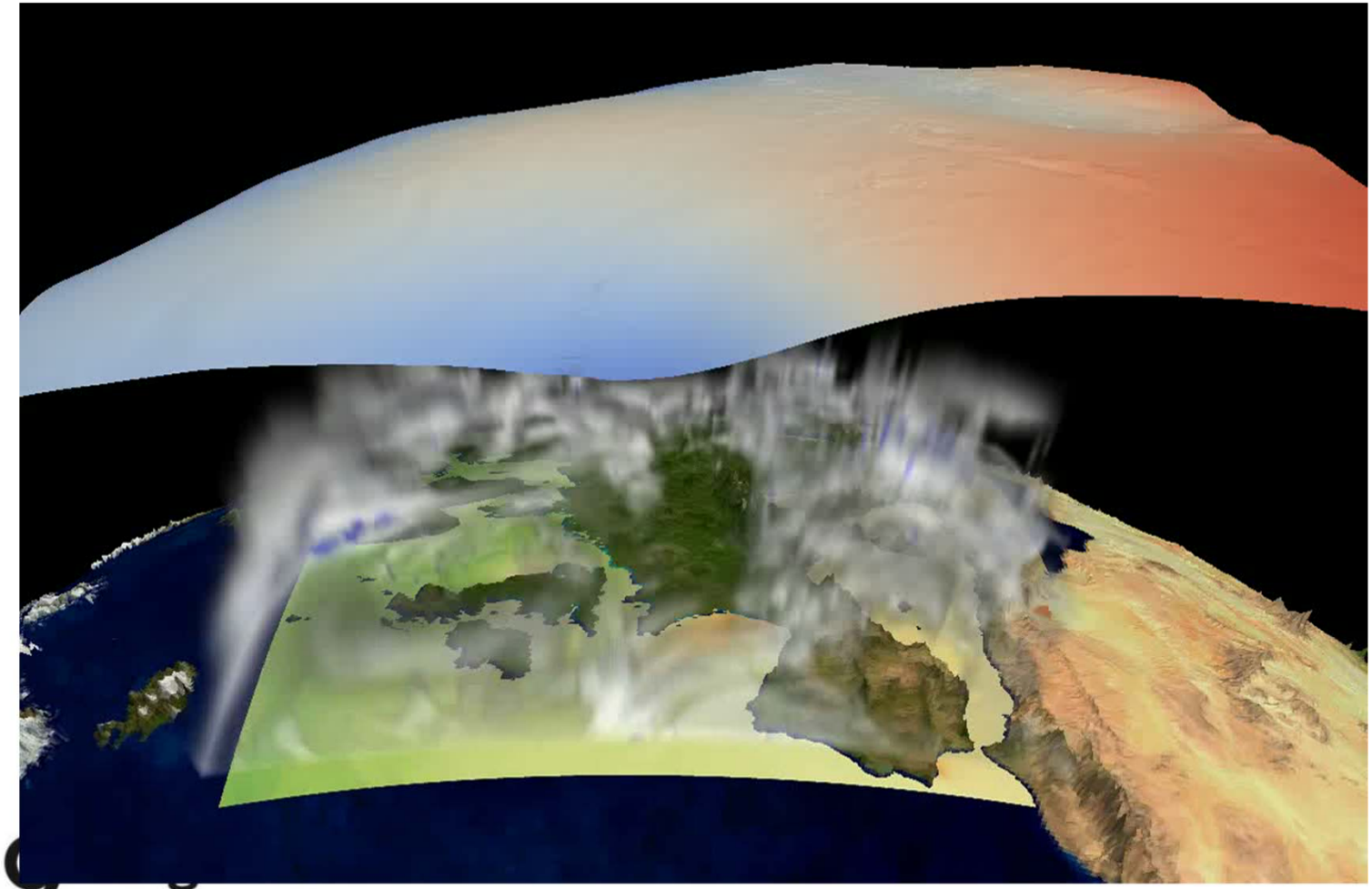




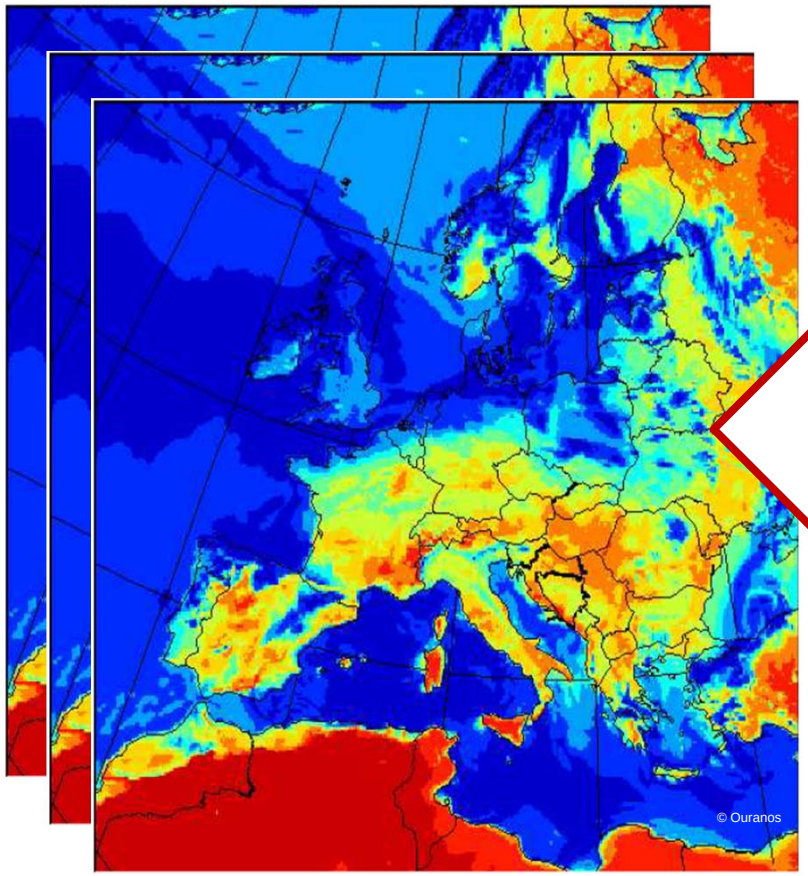
9th Reg
Leaders'

Enhancing ClimEx Data with Terrain model and iso surface

Weather patterns – Vb tracking – May 1999 (Reanalysis)



Visualization:
Colouring of data, is this it?

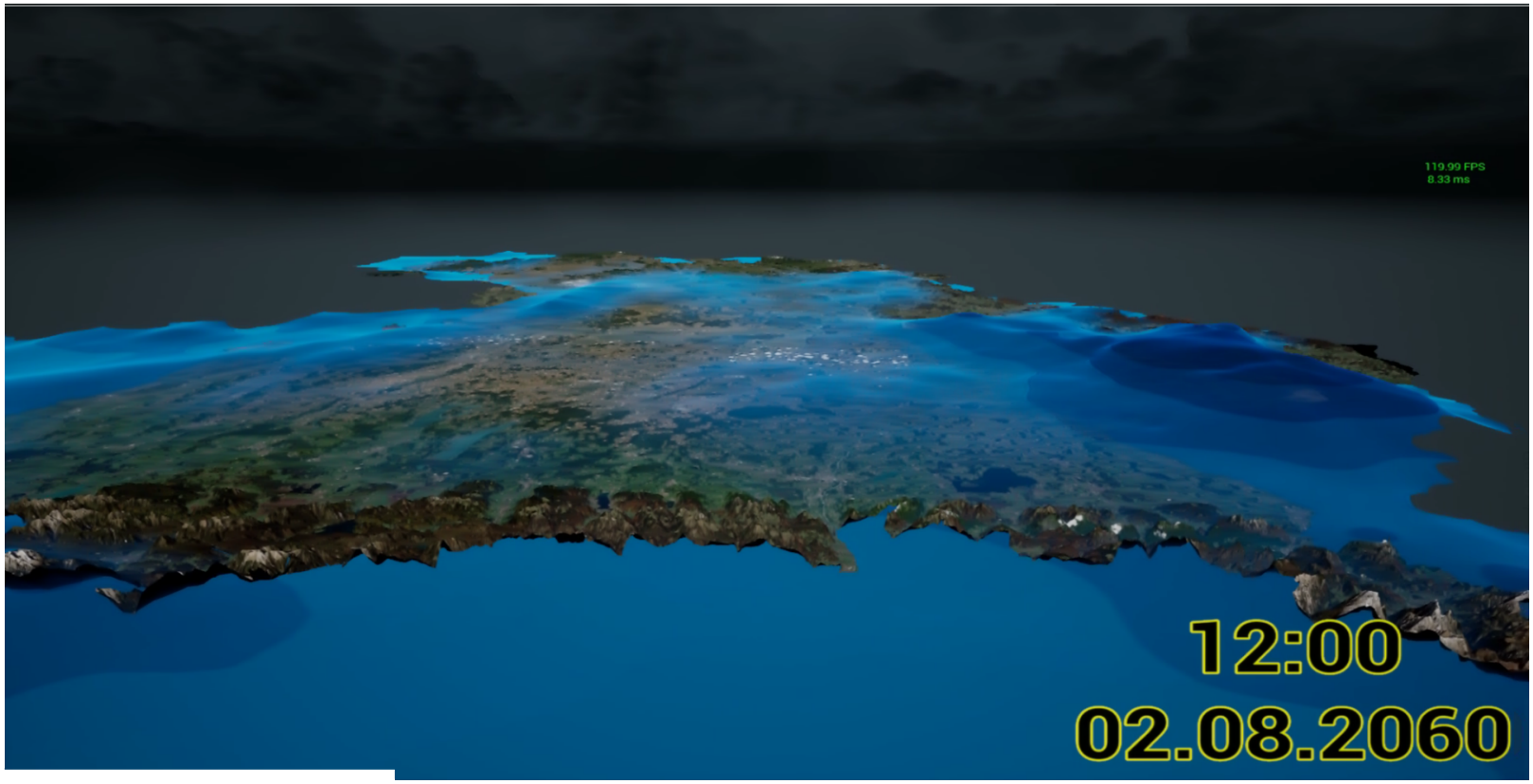


?

Science Communication

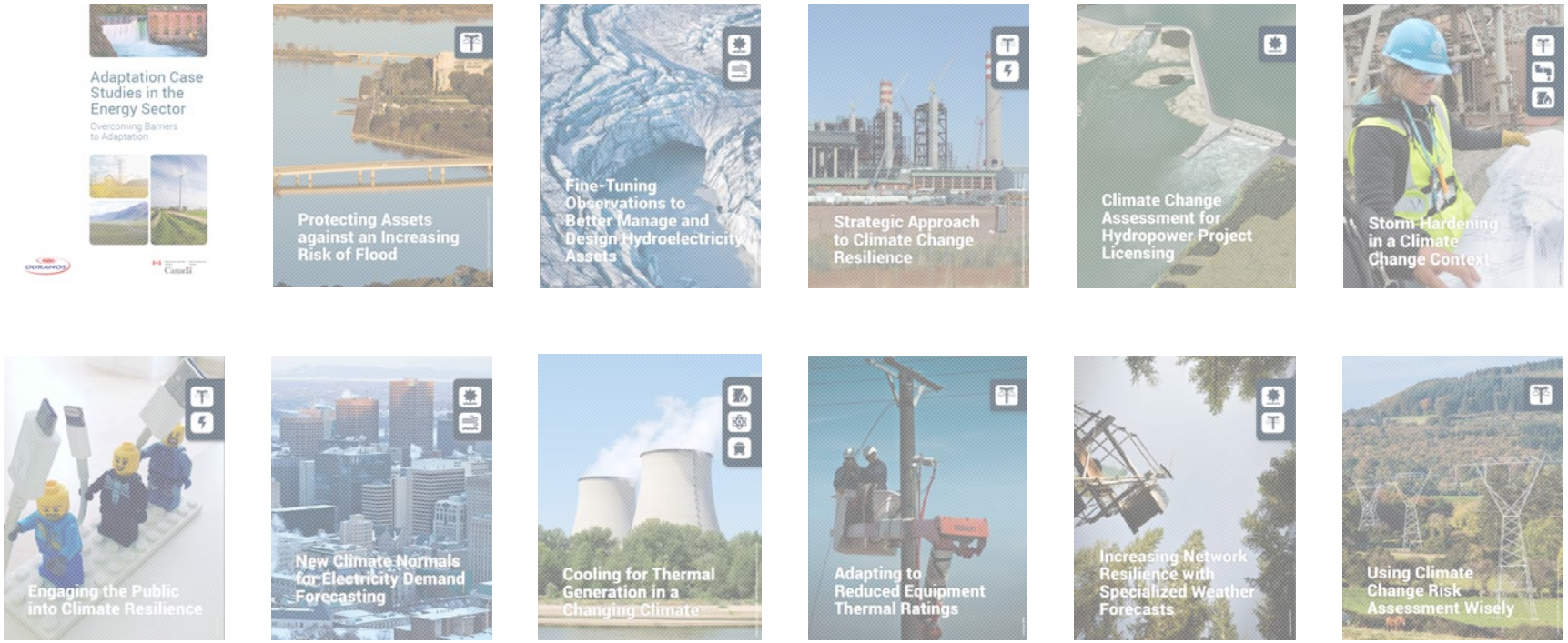
- Need to visualize evidence, not data
- Match visualization to the viewer's experiences
  - Make clouds look like clouds
  - Water normally is blue/transparent, not red or green
  - What does an isosurface of air pressure mean?
- Simplification is NOT evil!
- Dropping certain aspects is NOT a lack of knowledge!
- Don't pick the scientifically most impressive result, but rather an instructive example

Accumulated precipitation over Bavaria



Thank you!

RELIABLE RENEWABLES: SCIENCE TO DECISION FOR INCREASED RESILIENCE



Source: Braun et Fournier (2017)

https://www.ouranos.ca/en/programs/energy-adaptation-case-studies
https://energyadaptation.ouranos.ca/placemarks/maps