

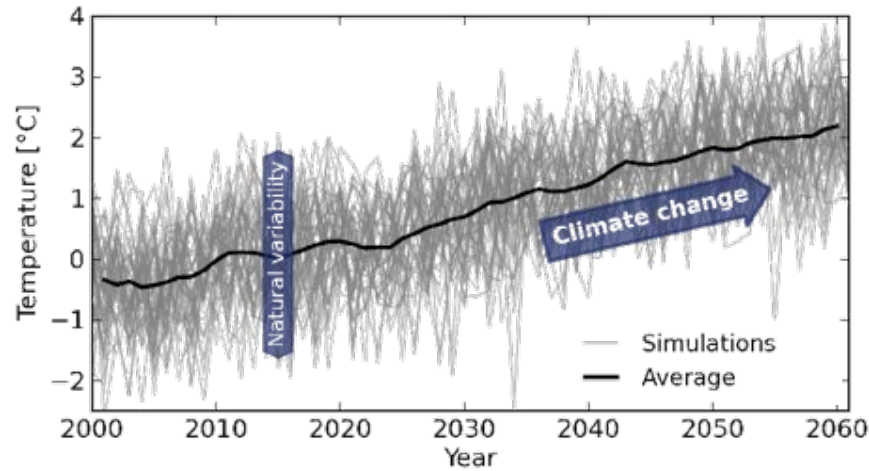
Synthesis

A first synthesis - ClimEx and the broader picture: new topics and interdisciplinary approaches

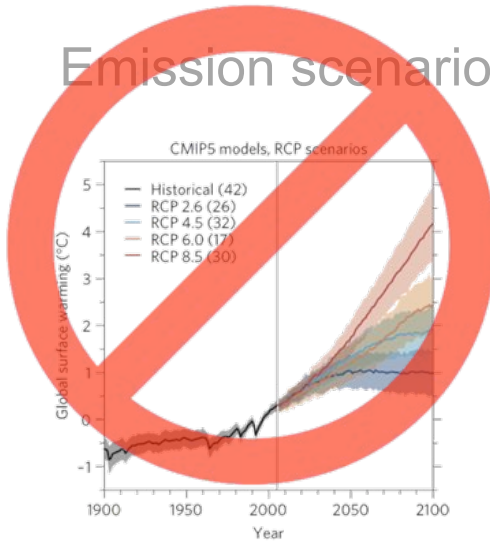
- Marco Braun, Ouranos -

- High spatial resolution (12km)
- High temporal resolution (1-3h)
- Many variables archived
- Very large sample (50 x 150 years = 7500 years; 1500 years per climate period of 30 years)
- Expected to capture robust statistics of "low probability - high impact events"
- Homogeneity facilitates analysis and impact modeling

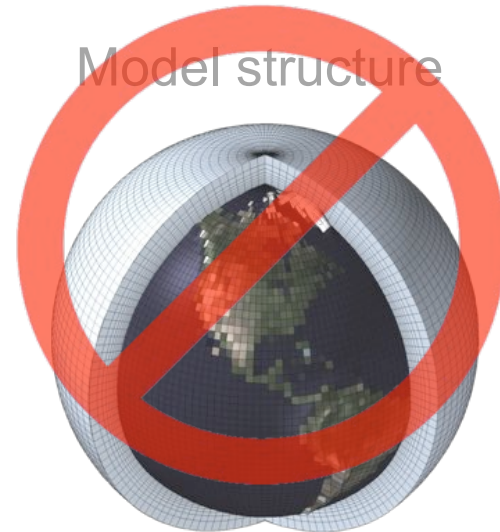
Natural Variability



Emission scenario



Model structure



17 ongoing projects in Quebec are using ClimEx data

ClimEx projects at Ouranos (in no special order)

- Leduc**, Ouranos, Pechenova, Hüttenhofer, LMU, Mailhot, INRS-ETE, Jalbert (Poly), Frigon & Ludwig
- Compound events (humidex)
- Mailhot, **Innocenti (PhD student)**, INRS-ETE, **Frigon, Leduc** (Ouranos), Cannon (ECCC)
- Spatial and temporal scaling of extreme precipitation (IDF): validation with stations and future evolution
 - Has also compared to WRF 4km convection-permitting outputs from NCAR (Liu et al. 2016) and shows that extreme sub-daily precipitation from ClimEx is acceptable, compared to WRF-4km
- René Laprise, UQAM, **Moussa Bop (MSc student)**, **Leduc** (Ouranos)
- Quantify the added value based on a multi-resolution/multi-member analysis: Comparing the CRCMS-LE product with a variety of other lower resolution versions of itself (aggregated) and with the coarse-resolution driving data to identify cases where value is added and how it could benefit to climate data users.
- Merleau, HQ-IREQ, **Fournier/Rondeau** (Ouranos) P66
- Create a richer database of historical extreme events for hydro forecasting (with HSAMI)
 - Need a large ensemble, and ClimEx represents a large sample
- Mathews, UConcordia, **Chavaillez (Post-doc)**, **Roy** (Ouranos)
- Assessing the risk of abrupt climate changes and their effect on the occurrence of extreme events:



ClimEx projects at Ouranos (in no special order)

- Gavin Schmidt, NASA/GISS, **Paquin & Leduc**, Ouranos
- 1- Evolution of US East coast snowfalls (daily) that affects major cities' resilience: as a function of time horizon and regionally, detectability (spread of ensemble)
 - Knowing that any absolute threshold means something very different in Virginia than in Maine, and in Québec, and that impacts on society are not linear functions of accumulation.
 - 2- Ouranos would like to evaluate the ability in reproducing major snowfall ev
- Demers, **Bresson (Post-doc)**, UQAT, **Roy**, Ouranos
- Abitibi-Témiscamingue for mining reclamation structures: precipitation extremes (PMP: probable maximum precipitation?) and drought index by 2100 (for 3 sites)
 - Droughts can induce a desaturation of tailings and thus lead to acid generation: extreme precipitation can provoke failure of the dams surrounding tailings.

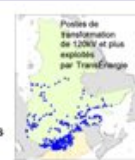


ClimEx data used in hydrology projects

- Ouranos for Info-Crue for DEH/MELCC (**Braun, Roy et al.**)
- Developing a new approach to post-process extreme precipitation
 - Will be integrated in the 2020 hydroclimatic atlas at DEH that will contain also extreme floods
- DEH for Info-Crue
- Evaluate the impact of climate change on peak factors between the 3-hourly flows and flows aggregated at the daily scale from hydrological simulations with HYDROTEL.
 - Peak factors are used to correct daily to sub-daily flows.
- Arsenault, **Lucas-Picher**, ETS-DEH for International Joint Commission (IJC)
- Lake Champlain & Richelieu River: evaluate flood risk projections and measures to mitigate flood impacts
 - Will apply bias correction to climate runs following the (cQ)² approach before using them to force HYDROTEL.
- Arsenault, ETS
- Hydropower reservoir optimization for the Rio Tinto Lac St-Jean reservoir.
 - The SDP (Stochastic Dynamic Programming) algorithm needs long time-series of observations to estimate the best possible decision in managing reservoir levels according to the current state and future expected inflows, including uncertainty.
 - Post-processed ClimEx data will be used to calibrate a SDP-derived reservoir management policy in historical climate, and to study its future evolution

Projects using the ClimEx dataset

- Jalbert (Polytechnique), Perreault (IREQ), **Leduc** (Ouranos) for IREQ-HQ Transport
- IDF curves to update conception criteria of oil recuperators transformers >120kV
 - Link intensity of extreme events (30min-24h) with frequency of occurrence



- Leconte, **Larabi (student)**, USherbrooke for Quebec Transport ministry (MTQ)
- Small watersheds (25-500km²) south of the 52nd parallel, for bridges, culverts
 - Evolution of spring and summer floods using HYDROTEL on selected watersheds

- Mailhot, Talbot, INRS-ETE for Ville de Montréal
- Evolution of precipitation regimes for greater Montréal for overflow of sewer system.
 - Rainfall events are grouped in categories (intensity, spatial extent, duration) to study intense short-duration and long-duration events, and to see how their characteristics evolve in time (duration, maximum intensity, frequency). IDF curves will also be analyzed.

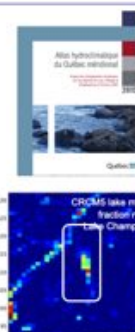
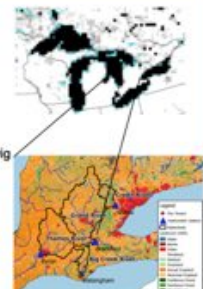
- Mailhot, Talbot, **Vallinada Avar, Pradeeshang**, INRS-ETE, **Paquin** (Ouranos)
- How will precipitation event characteristics evolve in the future?
 - Looking at how wet event characteristics (number, duration, depth, maximum intensity, and frequency) will evolve in a changing climate. More specifically the following questions will be addressed: 1) how to compare event characteristics estimated from record and high resolution RCM precipitation series? 2) how will event precipitation characteristics change in a future climate? 3) what is the impact of natural variability on the future evolution of event characteristics?



ClimEx - eMeeting - November 2018

ClimEx data used in hydrology projects

- Arain, **Olivier Champagne (PhD student)**, McMaster U
- Studies uncertainties associated to extreme streamflow and hydrological processes in the context of climate change: How will natural variability influence future hydrology?
 - Uses the coupled Ground-Water and Surface-Water Flow model, GSFLOW, developed by the US Geological Survey (USGS) on three different small watersheds in Southern Ontario
- Brissette, Poulin, Arsenault, Boucher, **Braun, Huard, Leduc**, Turcotte, Ludwig
- Évolution du risque hydrologique lié aux événements pluvieux extrêmes – Application des données ClimEx (Québec-Bavière)
 - Mettre en place une chaîne de modélisation hydrologique à l'échelle sous-journalière pour étudier les impacts du pas de temps de modélisation sur la reproduction des crues extrêmes d'été et d'automne
 - Étudier l'impact de la variabilité naturelle et du changement climatique sur le risque hydrologique lié aux événements pluvieux extrêmes sur les bassins versants de petite taille en Bavière et au Québec



ClimEx - eMeeting - November 2018



ClimEx - eM

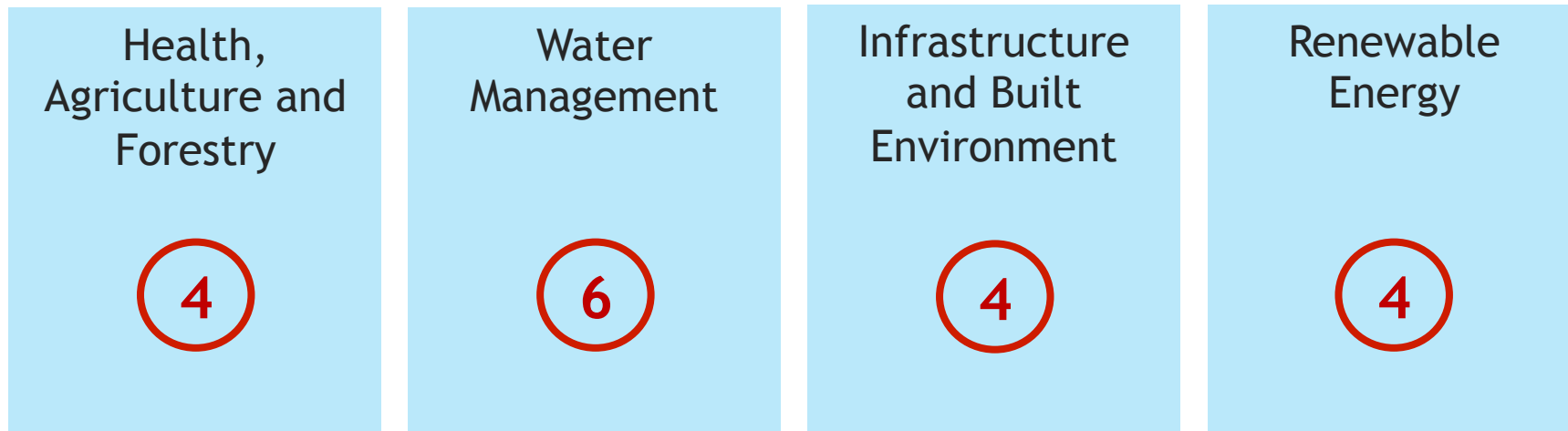
ClimEx - eMeeting - November 2018



Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften



A reflection on the wider application of ClimEx data



Project ideas

Supporting interdisciplinary integration in Bavaria and Québec ...?

Integrative element of issues in BY & QC:



“Rare events of the past and their future analogues in time & space”

- Example “infrastructure and built environment”
 - Find events in the future climate that have similar characteristics to certain historical events to establish their probability of reoccurrence in future climate and to estimate the associated costs.
 - e.g. 1996 Saguenay flood, 1998 Ice Storm, 1999 Pfingsthochwasser, 2016 flash floods in Bavaria, Quebec 2019



Integrative element of issues in BY & QC:

“Improvement of statistical estimates of rare events”



- Example “health, agriculture and forestry”
 - Heat waves health impacts on humans, animals and crops: Improved estimates of occurrence/frequency/intensity to better manage risk and adapt
 - explore the probability of recurrence of historical extreme events (Montreal 2010, Paris 2003) in the long + medium term
 - off-season heat waves



Integrative element of issues in BY & QC:
“Compound events and specific sequences”



- Example “forest fires and forest productivity”
 - Evaluation of frequency of conditions that trigger forest fires (drought, lightning, snow pack, soil moisture)
 - Damage from ice load; damage to access roads
 - Late spring and early fall frost impacts on tree phenology and physiology





Integrative element of issues in BY & QC:

“Rare events of the past and their future analogues in time & space”

“Improvement of statistical estimates of rare events”

“Compound events and specific sequences”

- Example “renewable energy (transition)”
 - Safety during combined events: "wind"+"high reservoir level" > waves
 - Explore natural variability of inflows for multi-annual reservoir management
 - periods at risk for environmental flow management and their frequency
 - Idea of studying an “energy security layer” (Dunkelflaute)



Prospects of using the ClimEx database

- Benefit from the specific qualities of this large ensemble
 - Integrate the advantages of different types of ensembles (ClimEx vs CORDEX/CMIP5/CMIP6)
 - Smart access:
Interdisciplinary applications and intelligent algorithms
- Beyond the project, the ClimEx database has garnered widespread attention and interest

- Continued exploitation of the large potential of the ClimEx ensemble (including innovative AI and machine learning techniques)
- Attribution studies of extreme events
- Enhancement of the large ensemble to address additional important uncertainties (e.g. climate sensitivity)

- Flipping coins: Drought and low flow management
- Introduction of land management scenarios to support the development of adaptation options
- Improve methods and tools for risk analysis and management
- Open the collaboration to other disciplines and scientific domains