ICOLD Technical Committee Y « Climate Change »

Workshop « **Climate Change: Risks & Opportunities for Dams, Reservoirs and Hydropower** » - May 28, 2022

Expérience by Tractebel Engineering on the application of the IHA Climate Resilience Guide

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Summary

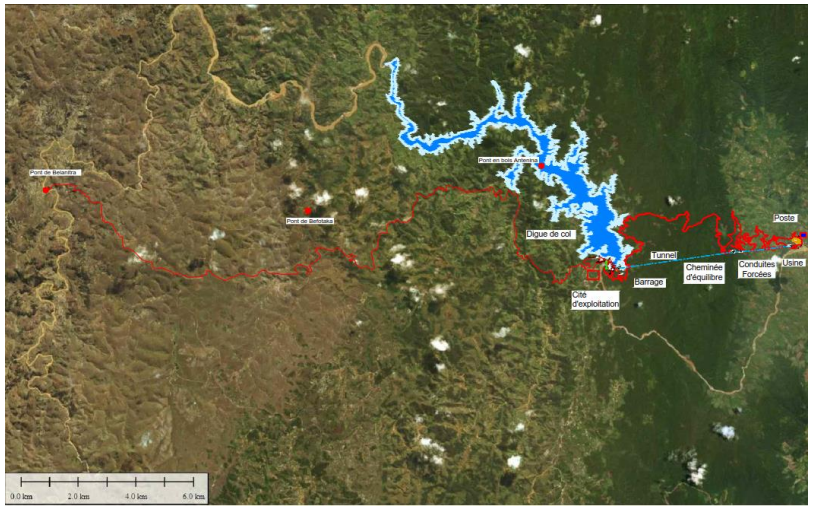
- Introduction
- Presentation of the different experiences of Tractebel in the strict application of the IHA Guide: Main specificities of each study
- Variations around the Guide : Example of applications
- Main comments and perspective
- Conclusions

Where and when do we have applied the Guide?

- Only in Africa for the moment (Tractebel did one presentation for Asian Development Bank in 2021)
- On lenders request more often: MDBs (World Bank, African Development Banks);
- For private developpers sometimes

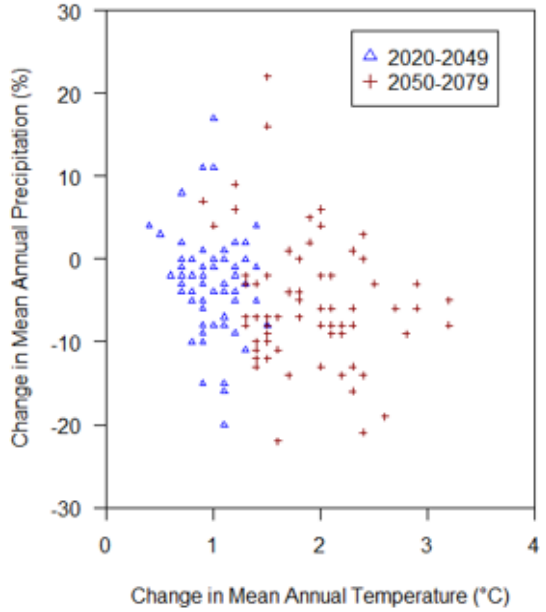
Madagascar 1

Sahofika HPP projet: Full Application (on request from the Lenders)



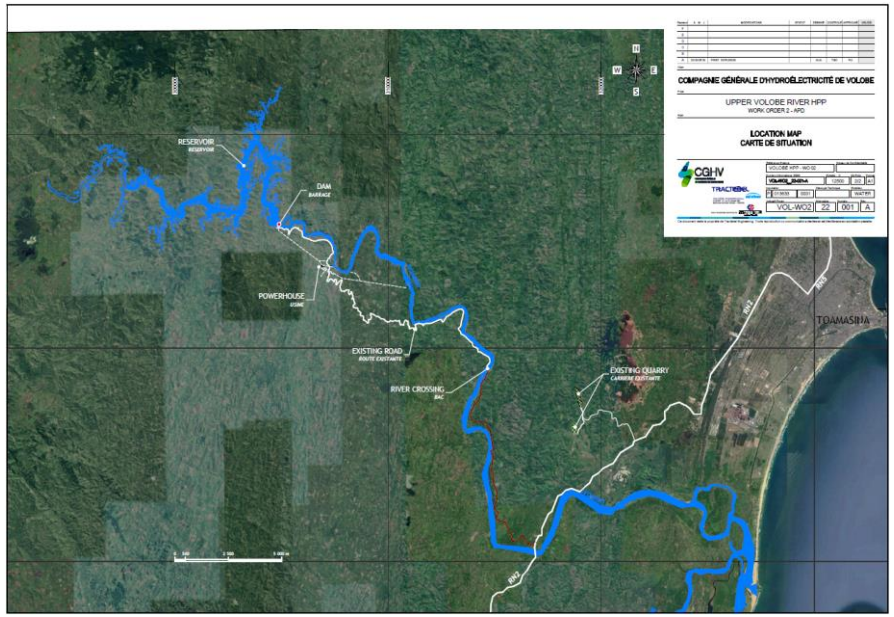
One common base of IPCC models :

- 38 GCM from CMIP5 project
- 3 RCPs scenario
  - RCP 4.5 (optimistic)
  - RCP 6.0 (middle)
  - RCP 8.5 (pessimistic)
- Finally **229 precipitation projections and 234 temperature projections**
- 2 analyzed horizons: **2020-2049** (short term) et **2050-2079** (long term)



Madagascar 2

Volobe HPP: Phase 1-3 only, due to the low sensitivity to Climate Change of the project



- Ensemble from CMIP5
- RCP 6.0: Intermediary model
- Monthly scale modelling (semi-comprehensive approach
- Analysis up to 2100 with 3 periods of 20 years long each)

Rwanda

Ruzizi III HPP: Full application (on request of the Private Développer)

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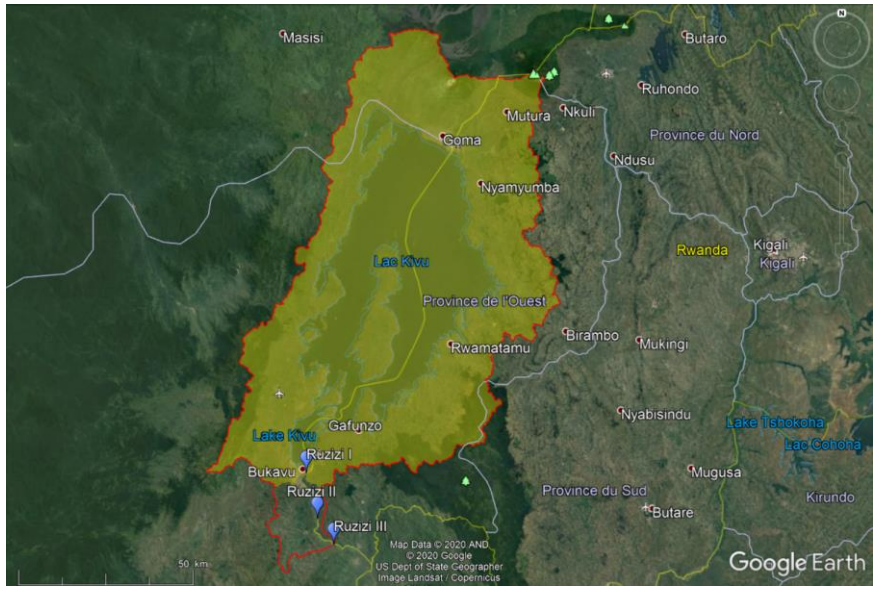
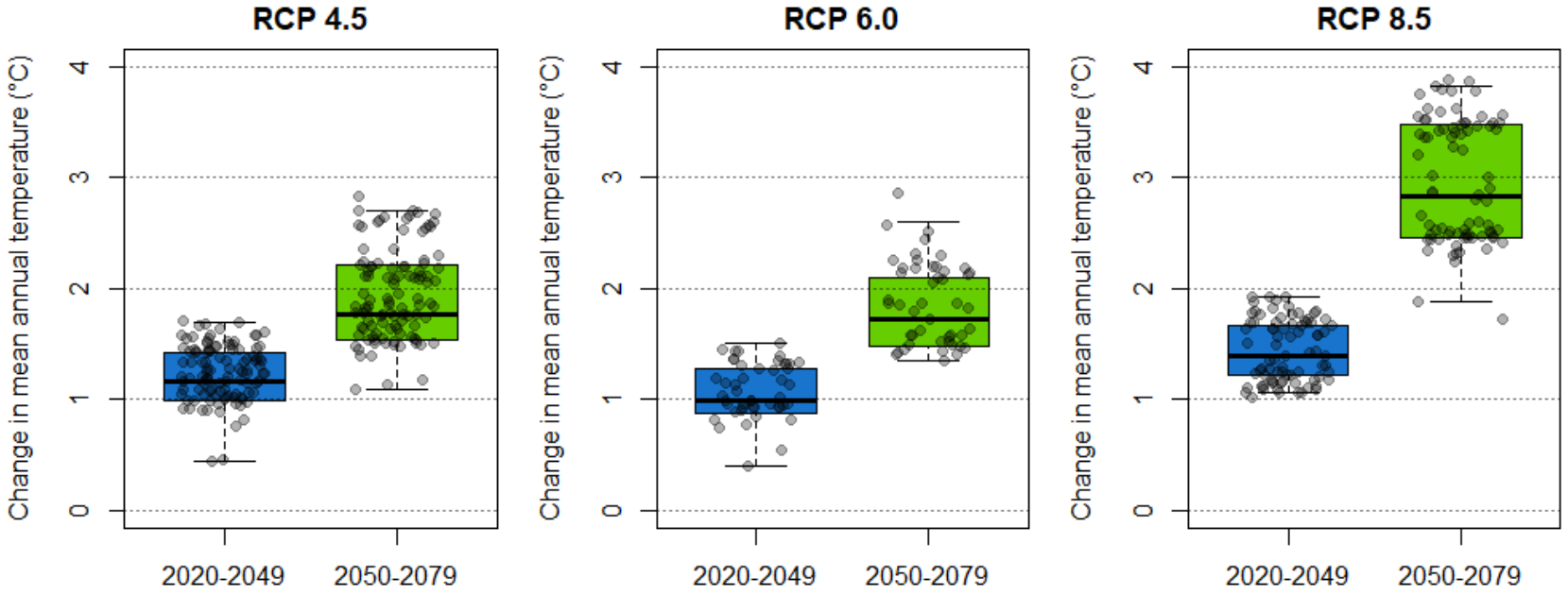


Rwanda: Rizizi III

Projections are analyzed per model, RCP scenario and future horizon for the following parameters :

- Temperature
- Mean annual precipitation
- Inter-annual variability of precipitation
- Intra-annual variability of precipitation

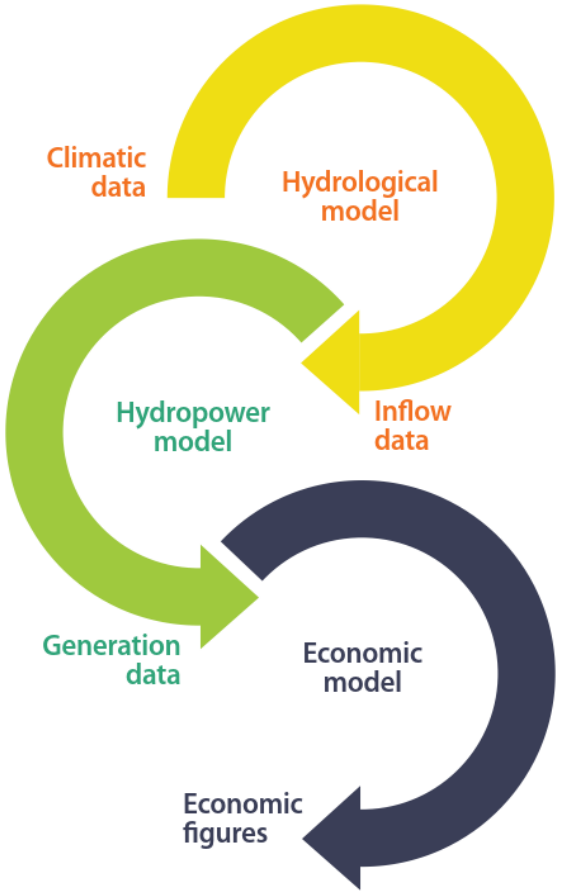
Paramètre	Gamme de changements
Température annuelle moyenne	De 0°C à +4°C
Précipitations annuelles moyennes	De -10% à +50%
Variabilité interannuelle des précipitations	De -20% à +90%
Variabilité intra-annuelle des précipitations	De -20% à +80%



Rwanda: Ruzizi III

Semi comprehensive approach:

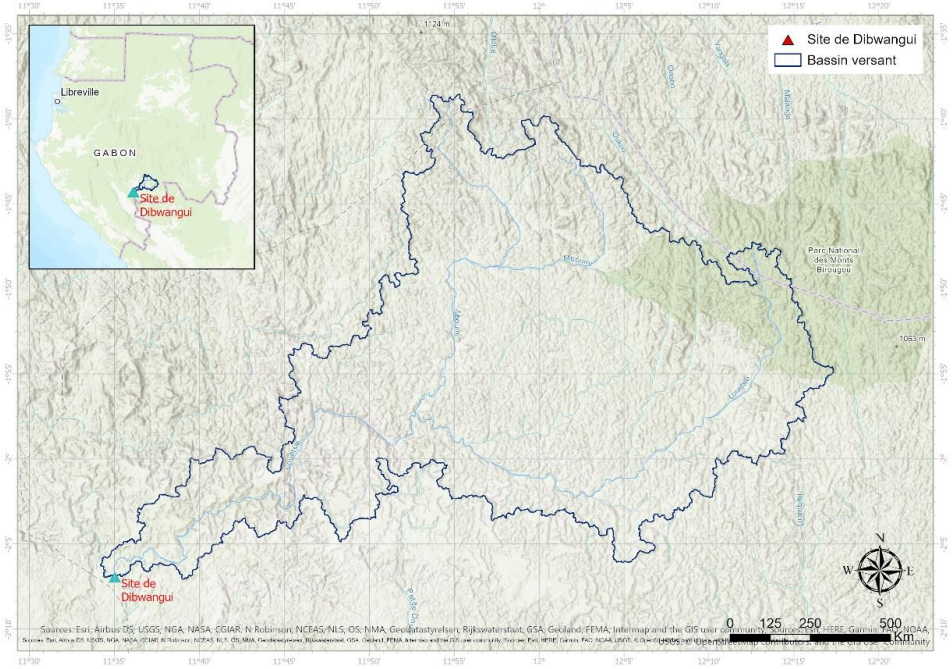
- **Hydrological modelling**. Simple rainfall-runoff model+ Lac Kivu management model (Tractebel, 2020). Monthly scale.
- **Extreme floods**. Unit Hydrograph from NRCS + 3h-long storm rainfall (Super-Clausius Clapeyron).
- **Futures climatic scenarios**. The ensemble of projections from GCM (CMIP 5) + quantile mapping statistical correction
- **Stress tests**. Consideration of the temperature and precipitation variability



Gabon

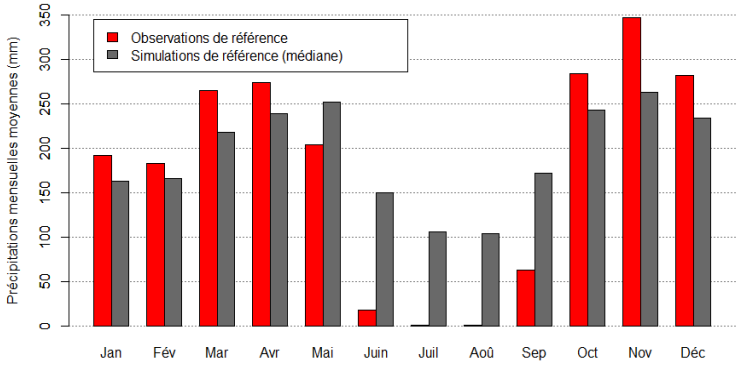
Dibwangui HPP: Full application (on request from the Private Développer)

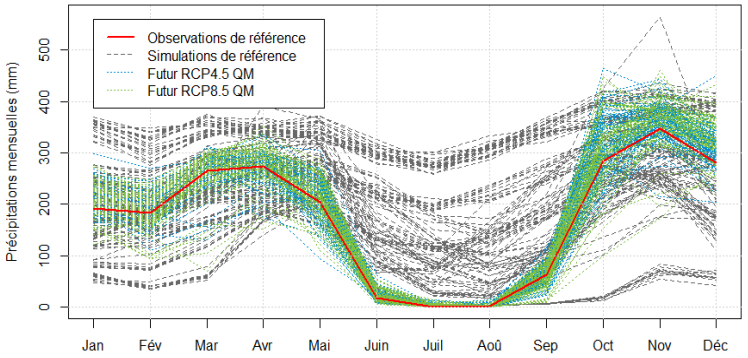
One common base of IPCC GCM models
- 39 GCM from CMIP5
- 2 RCPs scenarios
  - RCP4.5 (optimistic)
  - RCP8.5 (pessimistic)
- Finally 182 projected precipitation and 188 projected temperatures
- Analyzed horizons : 50 years (2070) (period 2055-2084)

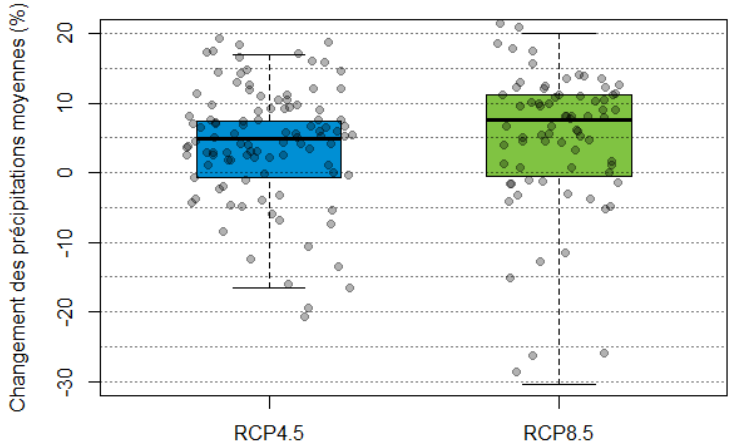


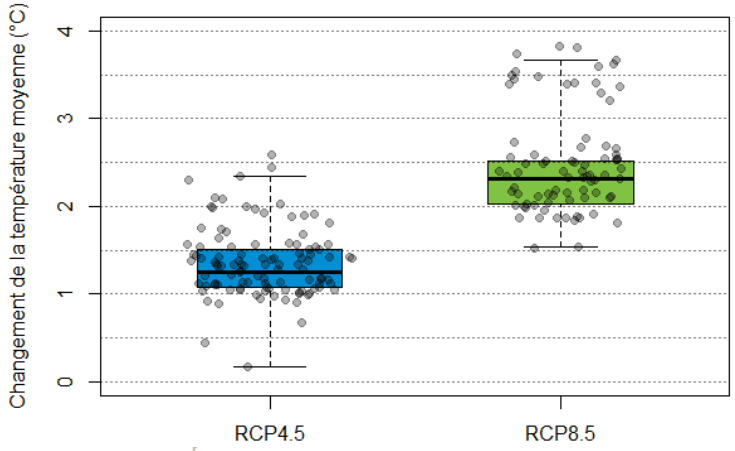
Gabon: Dibwangui

One additionnal step : quantile mapping due to biased projected precipitation









Gabon: Dibwangui

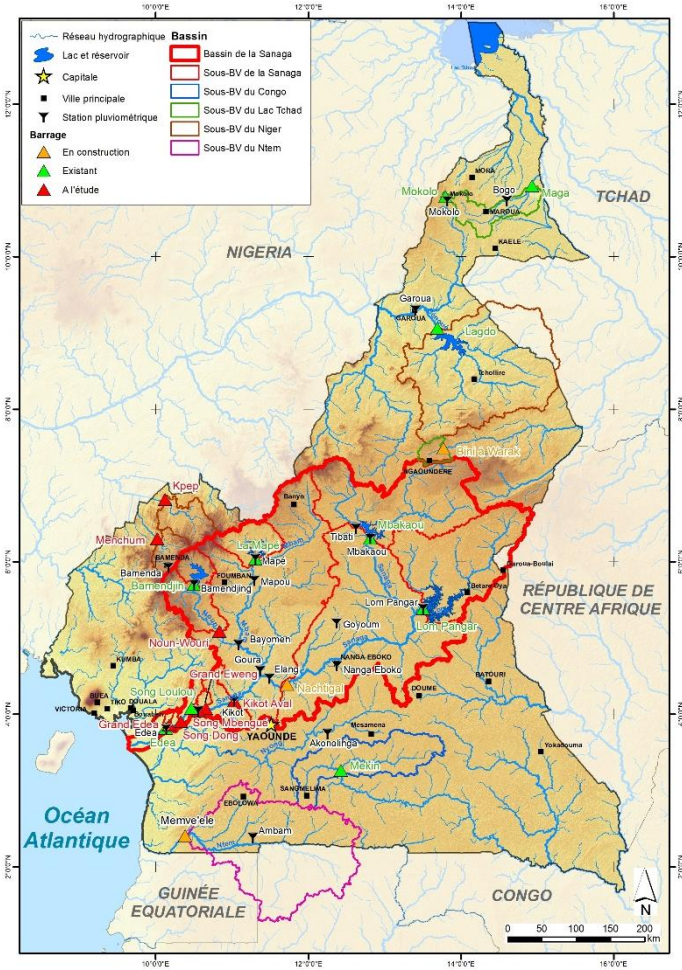
Intermediary approach between comprehensive and semi-comprehensive approaches for the stress test phase

- **System modelling: Hydrological and energy production modellings at the monthly scale (Tractebel, 2021)**
- **Floods : Gradex + Clausius-Clapeyron method**
- **Climatic projections: CMIP5 ensemble + « quantile mapping » correction**
- **Stress tests: Sensitivity analyses + ensemble projections simulations**

Cameroon

Analysis of the vulnerability of Hydrology and Hydropower sector of the Cameroon: Following the IHA phases and recommendations

- 5 large hydrographic catchments
- 21 facilities (not only Hydropower)
- Sanaga catchment
  - 140 000 km^2 = 30% of Cameroun
  - 1 050 km – slope 3 m/km
  - Edea : T_c = 5,3 jours
- Small land cover evolution
  - 66% natural forests
  - -5% between 2001 and 2020



Cameroon

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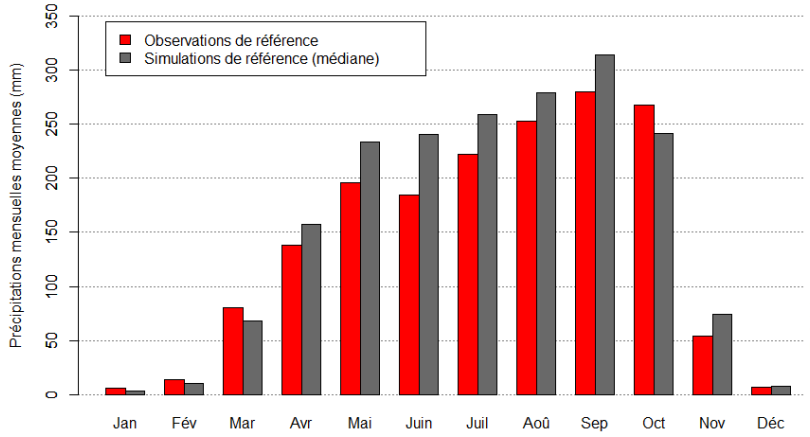
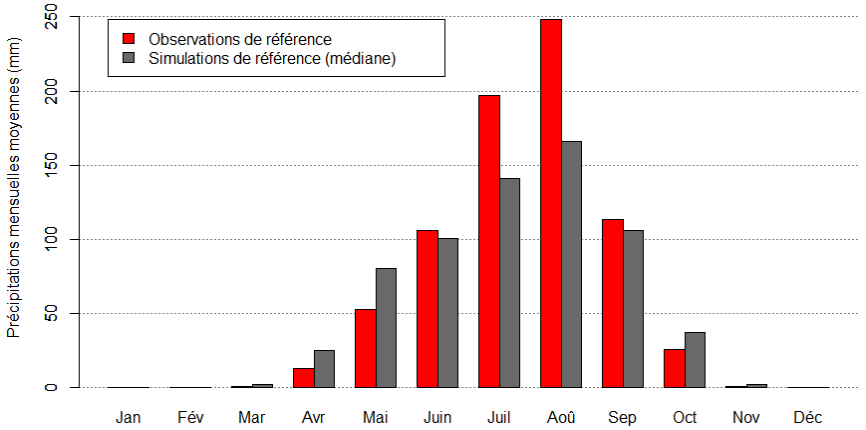
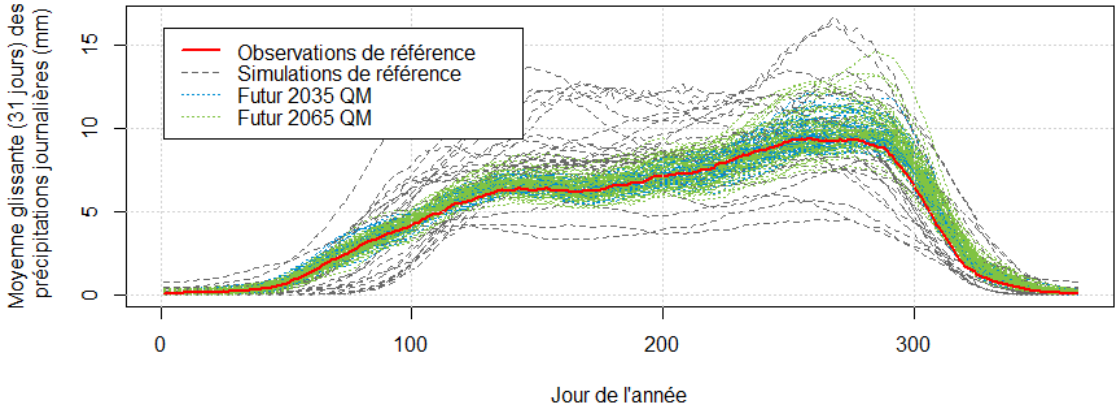
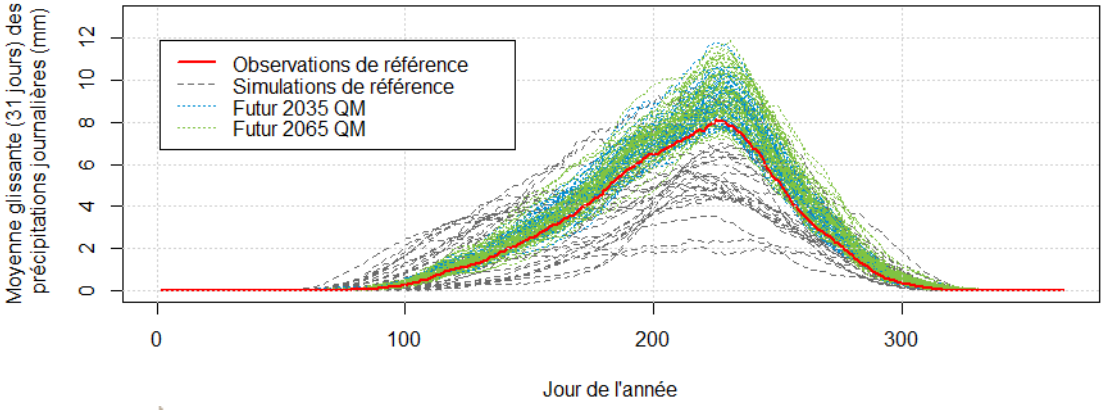








Cameroon

System modelling	Extreme floods	Future climatic projections	Stress tests
Hydrological modelling Energy production modelling Agricultural need for water supply Reservoir modelling with multipurpose uses Daily scale modelling	Gradex + Clausius Clapeyron approach Modelling for several days floods	CMIP 6 ensemble projections for rainfall and temperature Daily scale	Bidimensionnal analysis of climate changes impact (using Performance Index) Whole range of projections is modelled in order to consider the whole changes from enesmble projections

Variations around the Guide :

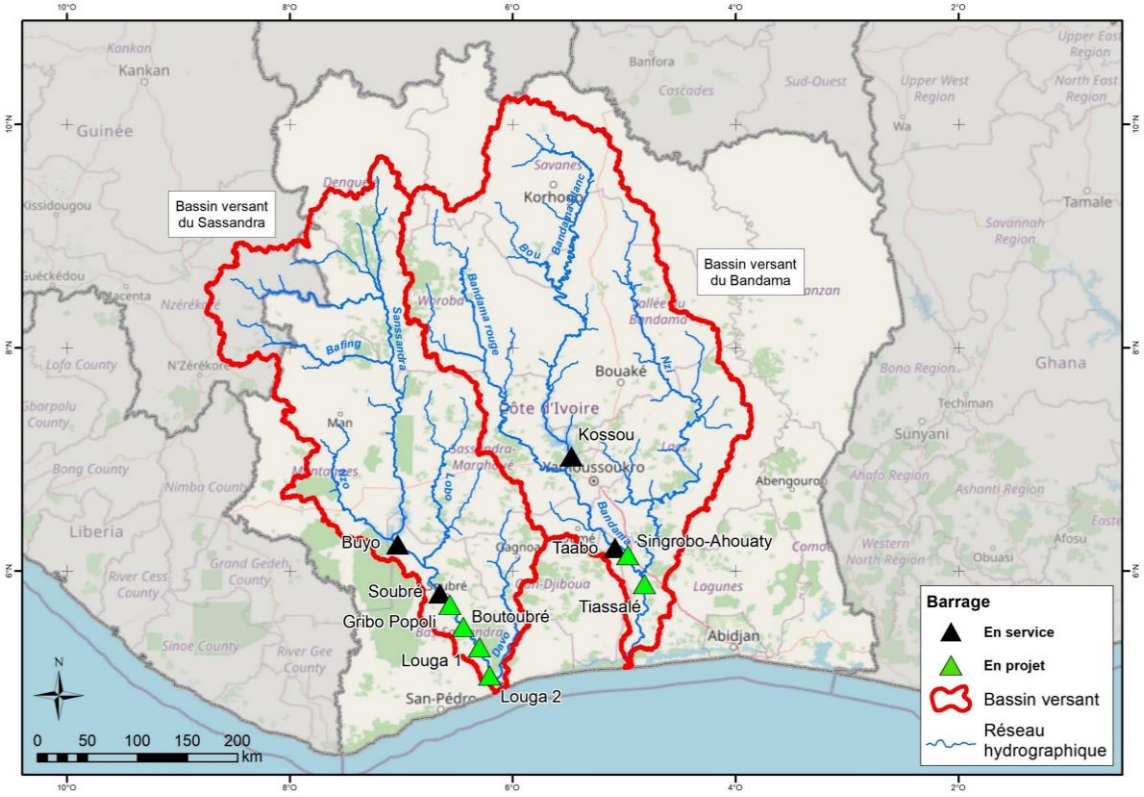
For all climate sensitivity analyses of HPP project, we try to apply approaches and methodologies that are recommended in the Guide

- Ivory Coast
- Cameroon
- Vulnerability to Climate Change of a portofolio of hydropower assets for Engie Group

Ivory Coast

Analysis of the vulnerability to Climate Change of the Hydroelectric sector in Ivory Coast :

- 2 large catchments (Sassandra and Bandama);
- 4 existing assets and 6 new projects to consider in the system;

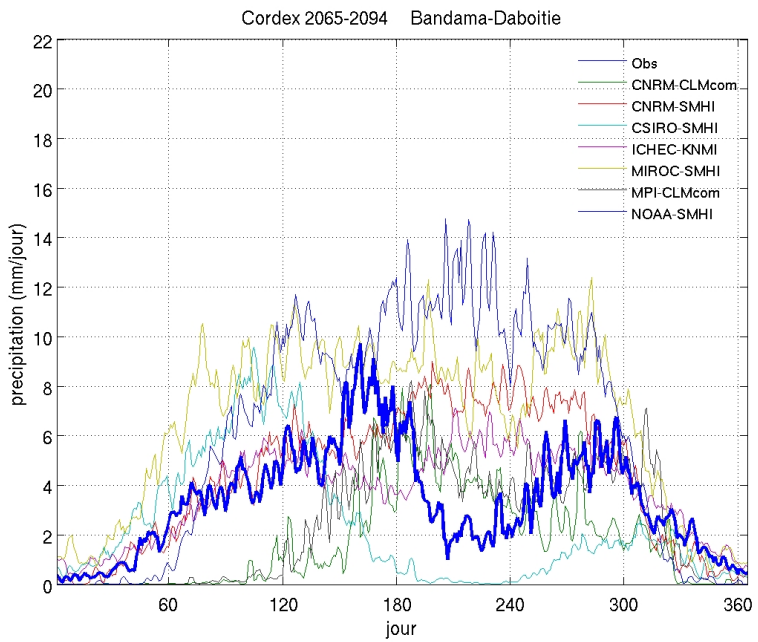


Ivory Coast

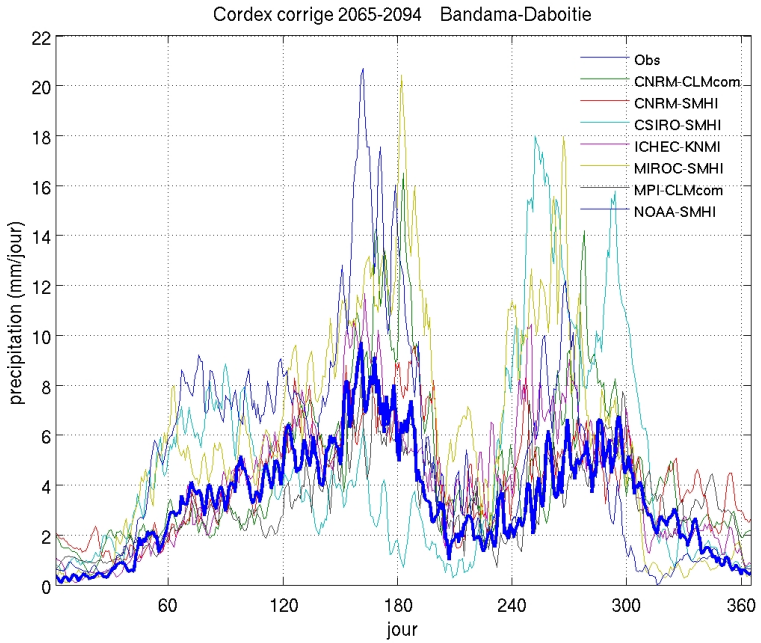
- 4 existing assets and 4 new projects to consider in the system;
- Stakeholders consultations;
- Stress tests for energy production and extreme floods;
- Modelling of the whole system (daily scale) with the ensemble CORDEX projections (CMIP5): 7 CORDEX models and 2 futures horizons (2040 and 2080)

Ivory Coast

Quantile mapping correction for CORDEX projections



Données Cordex



Données Cordex corrigées

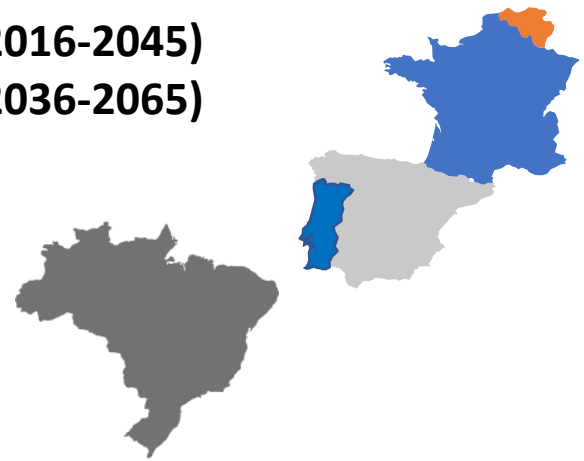
Vulnerability of a Hydropower asset Portfolio

Development of a macro approach for the analysis of the vulnerability to Climate Change of ENGIE Hydropower assets: No request to apply IHA recommendations but application of the main principles

Assets : **115 assets from 5 countries***

Reference year : **2020 (2006-2035) = current climate**

Future horizons : **2030 (2016-2045)**
2050 (2036-2065)



Climate models : **Couples Global Climate Models CMIP5 - Regional models CORDEX**

10 models for Europe (55 models for Extreme precip)

8 models for Brazil

Scenario : **RCP8.5:**

Vulnerability of a Hydropower asset Portfolio

Selection of the climatic indicator

- Collection of GCM/RCM projections
- Computation of the indicator (if not directly provided by RCM) 2020, 2030 and 2050 context (30 years long period)

Comparison of statistical parameters: can be different for different climatic indicator

- The comparison between current context and future context will be based on statistical parameters

Determination of the global and specific exposure/Mapping of the exposure (large regions)

- Quantification of the exposure (scoring) related to the indicator
- Ranking/classification of the most significant exposure (based on the sensitivity of the asset to this parameter)

Depending on the ranking:

- High risk and high impact: Financial risk estimation (quantitative) :Cost estimation if no adaptation is implemented;
- Low to medium risk and impact Qualitative risk estimation.

Vulnerability of a Hydropower asset Portfolio

Data: Raw precipitation data samples for 2020, 2030 and 2050 context (time series and computed indicators, gridded and basin rainfall). Daily annual discharge.

Analysis:

- **Estimation of statistical parameters: mean, max, min, standard deviation and distributions**
- **Frequency analysis (with 95% confidence interval) for max annual data samples**
- **Date of occurrence for maximum annual bassin rainfall**
- **Maximum annual discharge at the inlet of the asset**
- **Duration of the rainfall**

Comparison of Statistics

- **Statistical laws ;**
- **Estimates**
- **Statistical parameters**

Exposure/ Risk evaluation

Impact quantification:

- Spill capacity overpassed: overflowing of the dam – Dam break or dam breach;
- Loss of the Power plant;
- Disruption of the energy production;
- Access road – Loss or damages

Exposure qualification:

- Landslides: sudden waves;
- Proliferation of cyanophilic algae.

Main comments and perspectives

- The Guide is well known by MDBs, and some Private developpers in Africa;
- Not known by all significant hydro operators or National or Bilateral Development Banks;
- Still a need for official comments about variations that could be applied depending on the context:
  - stakeholders consultations each time?
  - Which variable can be quantified and projected or not?
- Depending on the data quality, it should be clearly mentionned that the full comprehesive approach has no sense…

Conclusions

- A very efficient tool to help developpers and industrial understand the risk and opportunities brought by climate change;
- A strong help in making decision for new dams and green field projects;
- Importance of the bias correction seems high, when dealing with values and not relative changes