CASE STUDY 5

STRONG EL NIÑOS AND ENERGY MIX PLANNING

Focus: Strong El Niños in a South America context and energy mix planning

Industry partners

The SECLI-FIRM project aims to demonstrate how improving and using long-term seasonal climate forecasts can add practical and economic value to decision-making processes and outcomes, in the energy and water sectors. To maximise success, each of the nine SECLI-FIRM case studies is co-designed by industrial and research partners.

For this case study, two approaches/users are addressing the same problem. For the first approach, the industrial partner is Emgesa, part of the ENEL group, while Celsia is the user for the second approach – both big utilities with important assets in Colombia. The main research partner working with Celsia is UL, a company which brings expert knowledge in the use of meteorological information for the renewable energy industry. The University of East Anglia (UEA) is also a research partner.

Boosting decision making

- The main objective of this case study is to illustrate the benefits of designing adequate decision-support products to predict the expected amount of flow of the hydro resources.
- As a complementary study, the case study will estimate how an optimum mix of hydro, wind and solar technologies can be achieved in Colombia. This could help to overcome the negative effects of events such as strong El Niños when relying on a single energy source.

The seasonal forecasting context

- This case study focuses on demonstrating the impact of using seasonal forecast rainfall information for big utilities with a large proportion of hydro power in their portfolio.

Sectoral challenges and opportunities

- To plan the future hydro resources during El Niño-La Niña events.
- To buy fossil fuels options in advance at lower prices to compensate for low hydro generation.
- To design a future energy mix adapted to the local climate variability and based on renewable sources.

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El Niño and La Niña phenomena

El Niño (La Niña) is a phenomenon in the equatorial Pacific Ocean that can be characterized by a five consecutive 3-month running mean of sea surface temperature anomalies in the Niño 3.4 region (Figure 1) that is above (below) the threshold of +0.5°C (-0.5°C). This standard measure is known as the Oceanic Niño Index (ONI).

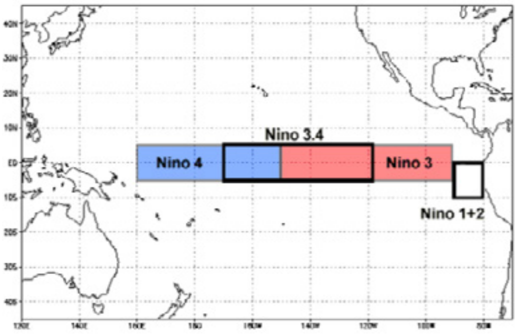

Figure 1: The Niño 3.4 region of the Pacific Ocean

Figure 2: The regions of Colombia

The El Niño phenomenon effects in Colombia are strongest in the north of the Pacific region (west of the country), parts of the Andean region (center) and the Caribbean region (north) (Figure 2), drastically decreasing the levels of rainfall accompanied by an increase in temperature, affecting the agricultural and electricity sectors, among others.

The 2015-2016 El Niño event

In this case study the focus is on the severe drought in 2015-2016, which, in March 2016, led to an emergency plan requesting the Colombian population to reduce daily electricity consumption by 5-10% in order to avoid a complete blackout. During 2015 and 2016, the Colombian electricity system faced one of the longest and most intense dry seasons ever registered, putting pressure on and testing the Colombian energy regulation framework. With such critical hydrological conditions, the average share of thermoelectric generation went from 49 GWh/day (28% of total energy) in the first half of 2015, to 88 GWh/day (48%) in Q1/2016, and later it exceeded 100 GWh/day. Given the low levels of the reservoirs reached by early March 2016, XM (Colombian TSO and Wholesale Electricity Market Operator) recommended a program of energy cuts for at least six weeks in order to save 5% of the daily demand.

The industry context

In Colombia, the deregulation of the electricity sector started in 1994, and the spot market initiated operations in July 1995. This deregulation process has faced some particular challenges in Colombia. The Colombian electricity system has an important penetration of traditional renewable energy technologies. In terms of installed capacity, 64% is hydro-generation, and nearly 80% of its energy consumption is covered by hydro resources.

Climate event

El Niño and La Niña: The El Niño-Southern Oscillation (ENSO) cycle

Severe drought between 2015-2016 in Colombia the result of a strong El Niño event

Sector impact

Scarcity of water resources in a market with a high dependency on hydro-power increases the prices and the risk of a blackout

Industry context

The energy sector in Colombia relies mostly on renewable energy technologies

Case Study Highlights

UL

This work was focused on developing a deterministic monthly forecast for river flow anomalies for five hydropower plants operated by Celsia in Colombia. Three tested methods utilizing seasonal predictions were developed based on: predicted precipitation over each watershed (“Direct” method), predicted Sea Surface Temperature patterns associated statistically to each river flow state (Teleconnection method), and a combination of both past observations with seasonal predictions (Random Forest method). In the period 1993-2016 the Teleconnection method was the most skillful. All methods were skillful compared to a forecast building on climatic averages, underlining the existing potential for utilizing seasonal forecasts for decision making in this part of the world.

Enel

The SECLI-FIRM Project was a great opportunity to investigate the recent technology of seasonal forecasts. Nowadays, seasonal models provide different scenarios of forecasts that do not give unique information. Therefore, the technique to translate these different forecasts into a deterministic value tends to produce average results that may not reflect the magnitude of large signals observed in the case of extreme events. In this case study, the extreme El Nino event showed different performances in each basin of interest. In addition, problems were encountered with the use of the ERA5 dataset in Colombia, which led to the choice of using the IDEAM station data instead of ERA5 as the reference dataset. The results showed that seasonal forecasts in Colombia would require a longer time horizon to be useful for strategic purposes and although the seasonal models at the present day do not offer performances that are able to perfectly reproduce the extreme events, the use of these models by Enel should be considered as a stepping stone.

Forecast Evaluation

Tailored forecasts are now ready to be run in Enel’s econometric models

Decision trees

To evaluate the impact of seasonal climate forecasting models on the Enel decision-making process, the following steps shall be implemented (Figure 6):

1. Define three input data based on the same information set except for weather variables. The input data set used shall be:
   I. Climatology input for a given delivery period
   II. Seasonal forecasts developed within SECLI-FIRM
   III. Reanalysis ERA 5 (as Actual Weather Data)
2. Perform the decision tree three times based on input data of point 1.
3. Compute the associated Performance Indicator.

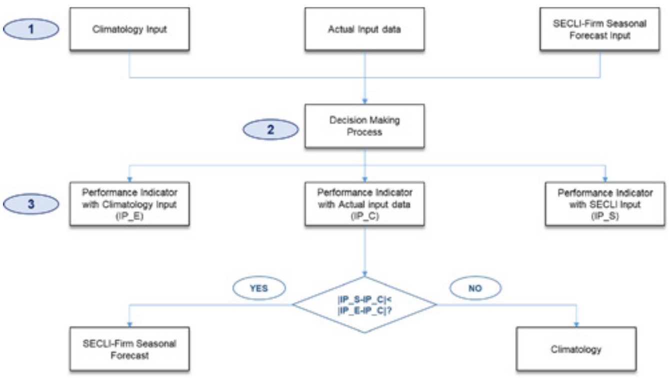

Figure 3: Enel Decision Tree: Performance Indicator Comparison

The Future - UL

Since late spring 2021 the trial service delivers monthly, for all five dams managed by Celsia, a single deterministic forecast of the river flow anomaly. The values are delivered as a graphical illustration of the spread of each of the model's ensemble included in the forecast to provide some information on the uncertainty of the forecast (Figure 4). This will continue throughout the remaining project period, with the potential of continuing this service beyond the end of the project. Future improvements of the trial service will be considered with feedback provided by Celsia on the format, content and other requests.

Decision trees

Evaluating the impact of seasonal forecasting models

Let us denote with IP_E, IP_S and IP_C performance indicators linked to climatology, SECLI-FIRM seasonal forecast and Actual Weather Data, respectively.

The impact of the seasonal climate forecasting model has added value to the decision tree if $[IP_S - IP_C] < [IP_E - IP_C]$.

Indeed, seasonal forecasts add value, even when the decision taken is as similar as possible to the one that would be taken knowing the exact weather variables actually measured at delivery.

The Future

For UL, testing methods for forecasting river flow anomalies in Colombia that can skillfully predict low water availability for hydro power generation. Further development of a trial service forecasting monthly river flow anomalies.

For ENEL, the implementation of seasonal forecasts within the Teal Tool

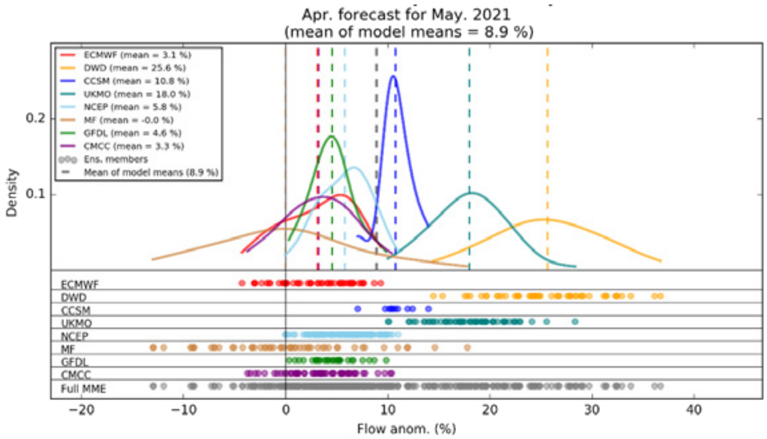

Figure 4: Example of the current design of the trial service developed by UK. The figure illustrates a forecast of river flow anomaly for May predicted in April. The grey dashed line indicates the mean of the multi-model ensemble and the deterministic prediction provided. The probability distribution for each of the individual models involved in the prediction is shown with colored solid lines. Dashed vertical lines indicate the mean of each individual model. The bottom panel shows the individual distribution of each of the models and the multi-model (bottom rows).

The Future - Enel

The Climate Service Teal Tool was customized to Enel's needs (Figure 5) and going forward it will be fed by the ERA5 dataset, for historical analyses, with the seasonal forecasts (ECMWF and NMME) and with the operational short term forecasts. Enel remains committed to following the future technological and scientific evolution of seasonal models in order to use them as a tool for improving operational skills.

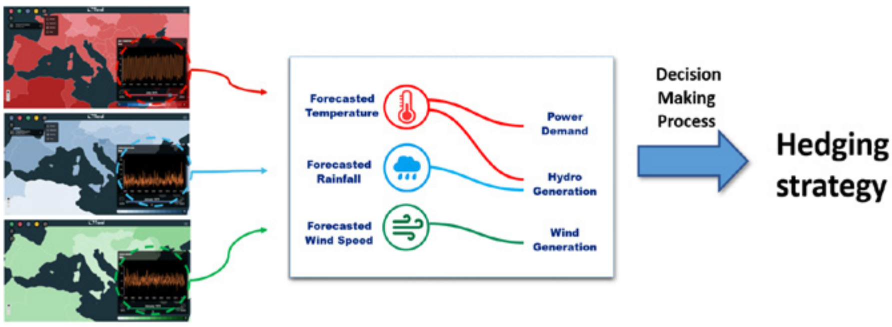

Figure 5: Example of the use of Teal Tool weather forecasts in Enel's decision-making process

The Added Value of Seasonal Climate Forecasting for Integrated Risk Management (SECLI-FIRM)

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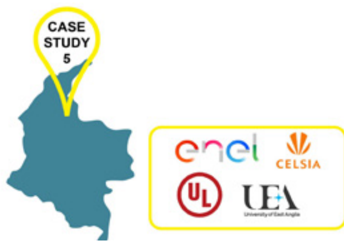

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