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 the industrial partners are Emgesa, part of the ENEL group, Celsia and AES Chivor – all big utilities with important assets in Colombia. The main research partner 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.

SECLi FIRM

Grant Agreement n. 776868

www.secli-firm.eu

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).

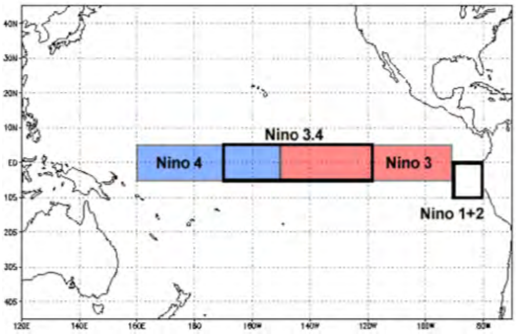

Figure 1: The Niño 3.4 region of the Pacific Ocean

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 will be 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

Progress update - Enel

To study the consequences of the severe drought due to the 2015-2016 El Niño event in terms of temperature and total precipitation in Colombia, climatologies over 1993-2014 period and anomalies in the months of interest have been estimated for ERA5 and C3S ECMWF seasonal forecast database. Anomalies of ERA5 2m temperature and total precipitation are shown in Figure 4.

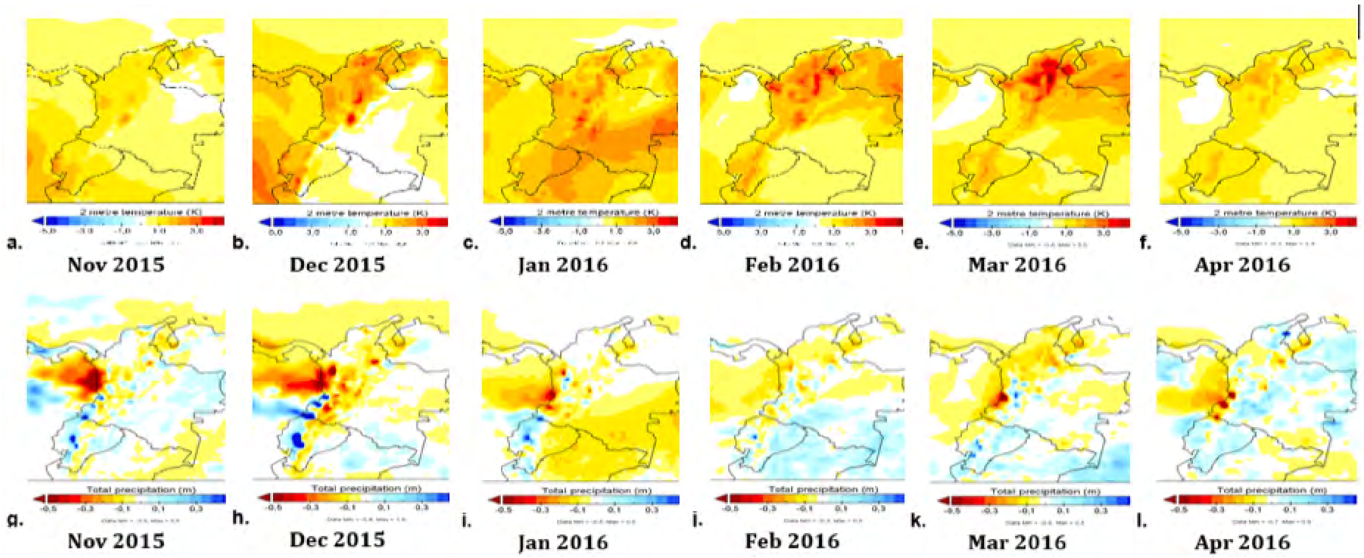

Figure 4: ERA5 anomalies of (a-f) 2m temperature and (g-l) total precipitation on (a, g) November 2015, (b, h) December 2015, (c, i) January 2016, (d, j) February 2016, (e, k) March 2016 and (f, l) April 2016

Progress update - UL

We have created a first simple Multi Model Ensemble (MME) consisting of monthly means of precipitation rates from five of the models available at the moment. This is done by combining the standardized data for precipitation rates into a simple Multi-Model Ensemble by giving each member equal weight and including all members from each model.

In order to also obtain probabilistic information, we have as a first step chosen to calculate the risk of lower than average precipitation rates. For each model, at each grid point, this risk is found by dividing the number of ensemble members with lower than average precipitation rates with the total number of ensemble members.

Figure 5 shows an example of such an early stage probabilistic forecast of the risk of precipitation rates lower than normal. It has allowed us to build a system that provides first primary results that allows verification using ERA5 reanalysis data as observation reference.

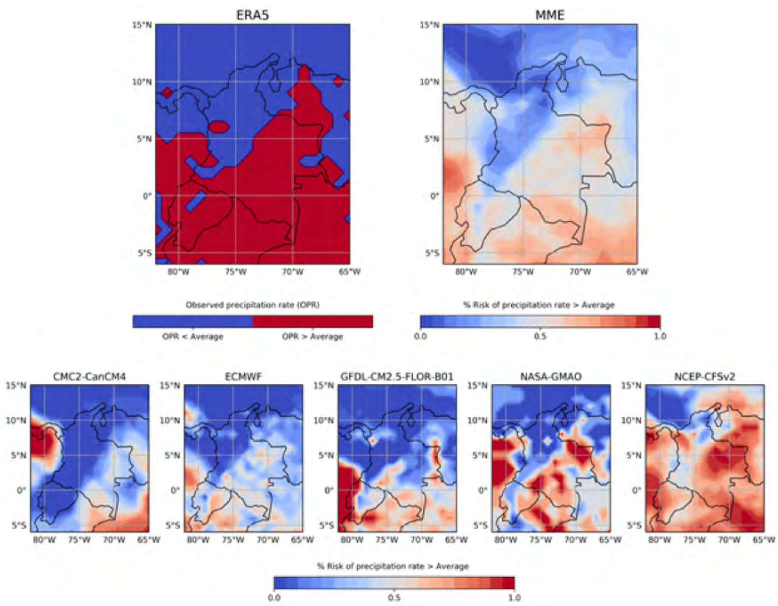

Figure 5: The ERA5 plot shows the observed precipitation rate compared with climatic average (1993-2014) for August 2010, divided in two categories of higher than normal and lower than normal. The MME plot shows the risk of precipitation rates lower than the climatic average for August 2010 forecasted one month before. Bottom row show the same risk as for the MME for each model contribution to the MME for the same month and lead time.

SECLi FIRM

Decision trees

To evaluate the impact of seasonal climate forecasting models on the 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.

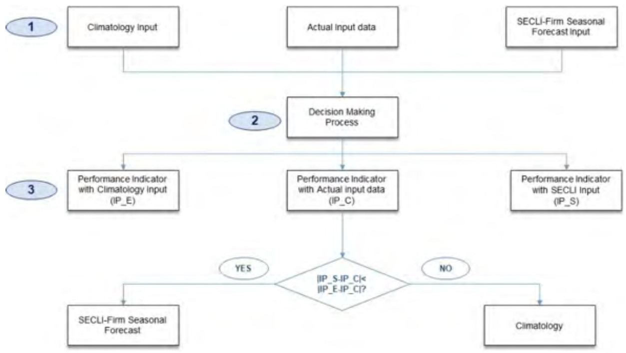

Figure 6: Enel Decision Tree: Performance Indicator Comparison

Next steps - Enel

- Perform the error analysis with seasonal forecast data.
- Deterministic application of seasonal forecast to internal econometric models.
- Probabilistic application of seasonal multi-model forecast to internal econometric models.
- Estimate the added value from the decision tree with the new SECLI-FIRM weather input.

Next steps - UL

The next part of the process is to refine and tailor this MME in order to optimize it and make it suitable for the specific areas of interest for the end user. Some of the work involved is:

- Investigate different methods of MME combinations in order to improve skill of the forecast.
- Investigate possibility of obtaining better forecasting skill by utilizing teleconnections, possibly directly between different Niño index regions and observed flow.
- Find relationship/link function between forecasted meteorological variables and river flow and thereby potential energy production, or incorporate a simple hydrological model to estimate the flow scenarios.
- Downscaling of the forecasted variables.

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

For more information visit:
www.secli-firm.eu

or contact the SECLI-FIRM team at: **info@secli-firm.eu**

SFCS5: 07.2019

University of East Anglia
Met Office
WEMC World Energy & Meteorology Council
eurac research
alperia

Grant Agreement n. 776868